Rotorua Te Arawa Lakes Aquatic Plant Management Plan

Prepared for Bay of Plenty Regional Council & Land Information New Zealand

8 May 2020

Boffa Miskell

Document Quality Assurance

Bibliographic reference for citation: Boffa Miskell Limited 2020. *Rotorua Te Arawa Lakes: Aquatic Plant Management Plan.* Report prepared by Boffa Miskell Limited for Bay of Plenty Regional Council & Land Information New Zealand.		
Prepared by:	Kieran Miller Ecologist Boffa Miskell Limited	
Reviewed by:	Dr Sharon De Luca Associate Partner | Senior Ecologist Boffa Miskell Limited	
Status: [Status]	Revision / version: 3	Issue date: 8 May 2020

Use and Reliance

This report has been prepared by Boffa Miskell Limited on the specific instructions of our Client. It is solely for our Client's use for the purpose for which it is intended in accordance with the agreed scope of work. Boffa Miskell does not accept any liability or responsibility in relation to the use of this report contrary to the above, or to any person other than the Client. Any use or reliance by a third party is at that party's own risk. Where information has been supplied by the Client or obtained from other external sources, it has been assumed that it is accurate, without independent verification, unless otherwise indicated. No liability or responsibility is accepted by Boffa Miskell Limited for any errors or omissions to the extent that they arise from inaccurate information provided by the Client or any external source.

Template revision: 20150331 0000

File ref: Rotorua Lakes Aquatic Plant Management Plans_July2020_FINAL.docx

Cover photograph: Lake Rotorua waterfront

Contents

Executive summary

Rotorua Te Arawa lakes are iconic features to Rotorua and are nationally significant to New Zealand. They provide a wealth of importance with extensive environmental, cultural and social values. Many of the lakes are subject to environmental issues such as poor water quality, establishment of aquatic pest plants and/or introduction of aquatic pest animals, which compromise lake values.

Rotorua Te Arawa Lakes Programme was established to fulfil the obligations of the Crown relating to the restoration and protection of the Rotorua Te Arawa lakes. The programme has recently focused on improving water quality within several of the lakes. However, the issue of aquatic pest plants has become increasingly problematic across the lakes, which has led to the creation of the aquatic plant management plan.

Each of the lakes contains at least one invasive aquatic pest plant species, with most lakes containing multiple species. The distribution and coverage of invasive plant species also differs between each lake. Recent management efforts by BOPRC and LINZ have targeted lagarosiphon, egeria and hornwort as these species are the most invasive and most prolific across the lakes. Canadian pondweed or elodea has also been controlled in certain areas as a result of targeted control efforts.

Management of aquatic pest plants within the Rotorua lakes dates back to the 1950s when pest plants first became problematic in Lake Rotorua. Many options were trialled, including both mechanical and chemical, of which diquat was found to be the most effective (Clayton & Wells, 1989). Aquatic pest plants have continued to spread since the 1950s with new incursions discovered within the past 10 years. The Te Arawa Lakes Settlement Act (2004) makes it clear that Te Arawa Lakes Trust are not responsible for the management of aquatic pests. This Act was a catalyst for the allocation of funding for managing aquatic pest plants from the Crown.

Pest plant control has mostly been on an ad hoc basis and aimed at containing aquatic pest plants, due to the limited resources. Diquat remains the most widely used tool, while the weed harvester is also used in some lakes. There is an increasing range of tools available for which to combat aquatic pest plants. Effective control is dependent on lake characteristics (such as type and distribution of aquatic pest plant species), the overall vision, goals, targets and objectives for the lake and the cost effectiveness of each method.

A consultation programme contributed to the preparation of the aquatic plant management plans. The programme involved obtaining perceptions of lake values, problem aquatic pest plant locations and management of Rotorua lakes from government and statutory organisations, iwi and hapu, ratepayer groups and societies, tourism operators and recreational groups. Views and opinions from the consultation programme have contributed to the vision, goals and objectives within the aquatic plant management plans. This document provides aquatic plant management plans for each of the 12 Rotorua Te Arawa lakes within the Bay of Plenty region.

The purpose of these management plans is to provide an overarching framework to assist in working towards achieving the overall vision. The vision for Rotorua Te Arawa lakes is:

The eradication of invasive aquatic pest plants and restoration of native plant communities.

A specific management plan has been developed for each of the 12 lakes with each plan catering to a different lake with a distinctive goal and targets that guides the objectives and actions as well as subsequent management for that lake. Management plans will be a living document that will be updated at least once every three years. The goals, targets, objectives, actions and proposed management will be updated over the years as each lake progresses towards the vision.

Monitoring is pivotal to direct pest plant control efforts and assess the effectiveness of control activities. Monitoring includes pre-and post pest plant control and LakeSPI monitoring. Monitoring results will show progress of each lake towards their respective LakeSPI targets and assist in reviewing lake management plans. In addition, a cultural monitoring plan is being developed as a result of the resource consent for the use of endothall.

There are several risks which may hinder the implementation of these aquatic plant management plans including total or partial loss of funding, insufficient funding, maintaining stakeholder/public satisfaction and dynamic environmental conditions. These risks are likely to be on-going and will need to be continually managed along with other risks that may arise.

1 Management plan vision

This Te Arawa Rotorua lakes aquatic plant management plan has been created to address the ongoing, and arguably increasing, adverse impacts and concerns of aquatic pest plants on lake values. The purpose of this management plan is to provide an overarching framework to assist in working towards achieving the overall vision. The vision describes what the management plans would like to achieve in the long-term future and needs to align with the purpose of the Rotorua Te Arawa Lakes Strategy Group.

The Rotorua Te Arawa lakes aquatic plant management plan vision is:

The eradication of invasive aquatic pest plants and restoration of native plant communities.

The vision aligns with purpose of the strategy group as eradicating invasive aquatic pest plants and restoring native plant communities will:

- Promote the sustainable management of the Rotorua Lakes and catchments,
- Allow for the use and enjoyment of present and future generations, and
- Recognise and provide for the traditional relationship of Te Arawa with their ancestral lakes.

A specific management plan has been developed for each of the 12 lakes and are all contained within this document. Each management plan caters to a different lake with a distinctive goal and LakeSPI targets that guides the objectives and outcomes as well as subsequent management for that lake. The goals, LakeSPI targets, objectives and actions are based on the overarching vision. This document does not replace existing legislation or plans, policies or statements but seeks to build on agencies existing goals and legislative requirements to achieve integrated, effective and efficient management of aquatic plants within Rotorua Te Arawa lakes.

Lake ecosystems are dynamic environments and to ensure there is enhancement of lake values as communities change and new technologies are developed, aquatic plant management plans will be a living document that will be updated at least once every three years. The goals, LakeSPI targets, objectives, actions and proposed management will be updated over the years as each lake progresses towards the vision.

2 Introduction

Rotorua Te Arawa lakes are a unique assemblage of naturally formed lakes located in the wider Rotorua region. Each of the lakes is distinctive, varying in formation, size, depth, biodiversity, water chemistry and other variables. The lakes are iconic features to Rotorua and are nationally significant to New Zealand. They provide a wealth of importance with extensive environmental, cultural and social values. Many of the lakes are subject to environmental issues such as poor water quality, establishment of aquatic pest plants and/ or introduction of aquatic pest animals, which add pressure to lake values.

Following the Treaty of Waitangi settlement between the Crown and Te Arawa Lakes Trust (TALT), the Rotorua Te Arawa Lakes Programme was established to fulfil the obligations of the Crown relating to the restoration and protection of the Rotorua Te Arawa lakes. The Rotorua Te Arawa Lakes Programme is a partnership between Rotorua Te Arawa Lakes Trust (owner of the lake beds), Rotorua Lakes Council (RLC) and Bay of Plenty Regional Council (BOPRC) and targets the 12 Rotorua Te Arawa lakes within the Bay of Plenty region.

The programme has recently focused on improving water quality within several of the lakes, however, aquatic pest plants were a common theme in submissions to BOPRC for the development of the 2015 – 2025 Long Term Plan. Invasive aquatic pest plants have created environmental, social and cultural issues within the Rotorua Te Arawa lakes since the 1950s and have continued to spread within and between lakes. In addition to the submissions, it is also acknowledged by the Rotorua Te Arawa Lakes Programme, aquatic pest plant growth will likely increase as a result from improved water quality. BOPRC, together with Land Information New Zealand (LINZ), see merit in developing aquatic plant management plans to provide clarity and guide restoration efforts to reduce the impacts of aquatic pest plants and improve native diversity.

A management plan has been prepared for each of the 12 Rotorua Te Arawa lakes with set goals, targets, objectives and actions as well as methods on how these parameters will be achieved. This document is intended to be used by not just BOPRC and LINZ, but by iwi, stakeholders and the public to restore Rotorua Te Arawa lakes.

3 Existing lake environments

The existing state of lake ecosystems is a result of numerous interactions and influences both within the respective lake and surrounding catchment as well as external factors causing change. Lake ecosystems should be viewed as part of a holistic environment comprising numerous components, including aquatic flora. As previously mentioned, each of the Rotorua Te Arawa lakes are unique and their existing aquatic plant community is the product of natural and anthropogenic interactions.

Each of the Rotorua Te Arawa lakes contains at least one invasive aquatic pest plant species, with most lakes containing multiple species. The distribution and coverage of invasive plant species also differs between each lake. Recent management efforts by BOPRC and LINZ have targeted lagarosiphon (*Lagarosiphon major*), egeria (*Egeria densa*) and hornwort (*Ceratophyllum demersum*) as these species are the most invasive and most prolific across the lakes. Canadian pondweed or elodea (*Elodea canadensis*) has also been controlled in certain areas as a result of targeting lagarosiphon, egeria and/ or hornwort. Other aquatic pest species such as water buttercup (*Ranunculus trichophyllus*) and curly pondweed (*Potamogeton crispus*) are also present but are comparatively less invasive.

3.1 Current and historical management

Management of aquatic pest plants within the Rotorua lakes dates back to the 1950s when pest plants first became problematic in Lake Rotorua. The Department of Lands and Survey was the Crown agency initially made responsible for the control of pest plants growing on Crown lake beds. Many options were trialled, including both mechanical and chemical, of which diquat was found to be the most effective within the lakes (Clayton & Wells, 1989).

Over the ensuing decades, egeria, lagarosiphon, elodea and hornwort continued to colonise new areas and spread within and between lakes. Further options were tested and trialled, while gel formulations were developed to improve the efficiency of diquat control. In the late 1980s, the Department of Conservation became the agency responsible for managing and controlling aquatic pest plants on Crown owned lakes, before LINZ took over in 1996 (Clayton & Wells, 1989).

Over the past ten years, aquatic pest plants have continued to invade new areas with hornwort found in Lake Ōkāreka in 2012, the most recent incursion identified. Recent management by LINZ and BOPRC has mostly focused on biosecurity to prevent and remove new incursions, and to a lesser extent amenity values or areas of high public use.

Pest plant control, aimed at containing aquatic pest plants within the current extents, has mostly been on an ad hoc basis, due to the limited resources and information available. Diquat remains the most widely used tool across the Rotorua lakes. The weed harvester is also used in dense pest plant areas on some lakes, often for the purposes of nutrient remediation, rather than control. Weed cordons have also been developed and deployed on some lakes to reduce inter-lake spread of aquatic pest plants.

A biosecurity programme is also implemented by BOPRC and was established in 2005, focusing on monitoring and detecting new incursions (Champion, 2009). The programme discovered the presence of hornwort in Lakes Rotomāhana, Ōkataina and Ōkāreka, with hornwort discovered early enough in Lake Ōkāreka for potential eradication.

3.2 Existing problematic invasive plant species

Egeria is a submerged aquatic plant with 10-30 mm long leaves in whorls of four or five. Plants produce white flowers but only reproduce from stem fragments in New Zealand as only male plants are present. Plants can grow in moderate flowing to still water bodies. Egeria has a major impact on indigenous plant biodiversity and other values (Champion *et al*. 2013).

Elodea is a submerged aquatic plant with 6-12mm long leaves in whorls of three or in opposite pairs on lower stems. Plants can grow in moderate flowing to still water bodies and spread through vegetative fragmentation of stem material. Elodea has a minor impact on indigenous biodiversity (Champion et al. 2013).

Hornwort is a submerged aquatic plant with 10-40mm long linear leaves in whorls around the stem. Hornwort doesn't have any roots and can survive in waterbodies as a free-floating mat. Plants can grow in moderate flowing to still water bodies and spread through fragmentation of stems. Hornwort has a major impact on indigenous plant biodiversity and other values (Champion et al. 2013).

Lagarosiphon is a submerged aquatic plant with alternate and downward curving leaves ranging from 6-20mm in length. Plants can grow in moderate flowing to still water bodies with new plants able to spread and develop from stem fragments. Lagarosiphon has a major impact on indigenous plant biodiversity and other values (Champion et al. 2013).

Lagarosiphon, egeria and hornwort will all managed differently under the proposed regional pest management plan for Bay of Plenty. Management of these aquatic pests is dependent on their existing distribution, as well as absence, across Rotorua Te Arawa Lakes. Management of these three pests includes exclusion (from areas where the pest is currently absent) and progressive containment (prevent pest from spreading, reduce distribution and/or eradicate pest from parts of the area). Eradication is also proposed for hornwort in Lakes Ōkareka and Ōkataina. Exclusion is also proposed for elodea as well as sustained control (reducing the general impacts of the pest (BOPRC 2020).

3.3 Community concerns

Improving water quality across the Rotorua Te Arawa lakes has been the recent focus, with the preparation of action plans to guide nutrient management within catchments. Actions to reduce nutrient inputs include improving land use and management practices, developing reticulated wastewater for lakeside communities and constructing detainment bunds and floating wetlands (Bay of Plenty Regional Council et al. 2009b).

With the improvement in water quality across many of the lakes, aquatic pest plant distribution and density may increase, growing in areas where previously light penetration was not sufficient to support plant growth. Organisations, community groups and individuals have voiced their concerns about aquatic pest plants. The most recent occasion was during submissions for the BOPRC's Long-Term Plan as well as the proposed Regional Pest Management Plan, with aquatic pest plants a common theme in many submissions.

A variety of concerns regarding aquatic pest plants have been raised by the community including potential health and safety issues as well as impacts on the values of Rotorua Te Arawa lakes. More specifically, concerns were raised on the impacts invasive aquatic pest plants were having on the recreational, tourism and amenity values across the lakes. Additional sites requiring aquatic plant management were identified through consultation and have been included as part of this management plan.

The preparation and implementation of these aquatic plant management plans for Lake Rotorua and the remaining Rotorua Te Arawa Lakes is a response from BOPRC and LINZ to address these concerns.

4 Consultation overview

A consultation programme was undertaken prior to the preparation of the aquatic plant management plans. The programme involved obtaining perceptions of Iwake values, problem aquatic pest plant locations and management of Rotorua lakes from government and statutory organisations, ratepayer groups and societies, tourism operators and recreational groups.

Iwi and hapu were also consulted with through a series of hui organised by TALT. In addition to directly approaching specific organisations, the public were also provided the opportunity to share their opinions at a local market in Rotorua. Views and opinions from the consultation programme have contributed to the vision, goals, targets and objectives within this aquatic plant management plan.

5 Related projects

Numerous studies and research projects have been conducted over Rotorua Te Arawa lakes to obtain data from one or multiple lakes and investigate a variety of lake constituents. Several projects are relevant to the preparation of these aquatic plant management plans.

5.1 Prioritising aquatic pest plant control in the Rotorua lakes

In mid-2016, Dragten consulting prepared a document for BOPRC which prioritised weed control at a selection of sites throughout the Rotorua Te Arawa lakes. Biosecurity and amenity criteria were used to create a prioritised order of sites. The project was intended to assist BOPRC with making decisions about where to best direct aquatic pest plant control efforts with limited resources (Dragten 2016).

5.2 Lake action plans

Over the past 10 years BOPRC, RLC and TALT have created action plans for some of the Rotorua Te Arawa lakes to restore water quality. The action plans identify tasks that should be undertaken to reduce nutrient inputs into selected lakes with specific nutrient reduction aims and trophic level targets. The documents are active, providing the ability to be reviewed and updated with changes in technology, best management practices and regulatory framework. The aquatic plant management plans have been structured to allow for potential integration with action plans at a later stage and take a more holistic approach.

5.3 NIWA LakeSPI

LakeSPI (Lake Submerged Plant Indicators) was developed by National Institute of Water and Atmospheric Research (NIWA) and is used for assessing the ecological condition of New Zealand lakes. LakeSPI characterises the composition of native and invasive plants growing in the lakes and the depths to which they grow. All Rotorua Te Arawa lakes have been assessed numerous times in the past with monitoring becoming more frequent over the past 10 years (each lake is assessed approximately every two years) (NIWA 2016a). The aquatic plant management plans use LakeSPI information which is also included as part of the monitoring and plan review section of this document.

5.4 Aquatic pest plant control for amenity purposes on Rotorua lakes

In 2011, APR consultants prepared a series of reports on aquatic pest plant control for amenity purposes on Rotorua lakes. The reports focused on identifying areas with high amenity values that were potentially impacted by the presence of aquatic pest plants, stakeholder's thoughts on management of aquatic pest plants and assessing the control and prioritisation options as well as associated risks (APR consultants 2011a, b & c). Some of the findings from the reports have been used in the preparation of these aquatic plant management plans.

5.5 Cultural monitoring

A cultural monitoring plan is being developed as part of the resource consent for the use of endothall and diquat within Te Arawa Rotorua Lakes. Data and results from the monitoring over time will assist and influence future decisions for prioritising management.

6 Roles and responsibilities

In 2004, the Crown and the Arawa Maori Trust Board (now TALT) entered into a deed of settlement to give effect to the final settlement of all Te Arawa's historical lakes claims and remaining annuity issues. Part of that deed of settlement included the transfer of 13 lakebeds, including the following Rotorua Te Arawa lakes; Rotoehu, Rotomā, Rotoiti, Rotorua, Ōkataina, Ōkareka, Rerewhakaaitu, Tarawera, Rotomāhana and Tikitapu (Te Arawa Lakes Settlement Act 2006). Ownership of Lake Okaro has been transferred to TALT (Rotorua Daily Post 2014), while Lake Rotokakahi is privately owned by local iwi (Bay of Plenty Regional Council *et al*. 2015).

Te Arawa Lakes Settlement Act was legislated in 2006 to acknowledge and give effect to the provisions of the deed of settlement. The Act describes ownership details of Rotorua Te Arawa lakes which includes Te Arawa as the owner of the lakebed and subsoil, which leaves the Crown responsible for the water and air stratum above the lake beds. The Act also states that Te Arawa is not liable for the pest plants present in the lakes or responsible for their control or removal (Te Arawa Lakes Settlement Act 2006).

Te Arawa has had ownership of the Lakebeds vested in the Trust as owner (fee simple). This concept acknowledges the significant and customary relationship of Te Arawa with the Lakes. The development of Te Tūāpapa o ngā Wai o Te Arawa – the Te Arawa Cultural Values Framework – endrosed by the Rotorua Te Arawa Lakes Stategy Group embeds the role of Te Arawa as hunga tiaki of the Te Arawa Lakes and provide guidance on the principles that apply to the role of Te Arawa in the management of the Lakes. Following 2006, Te Arawa still expect to be involved in decision making and management processes associated with aquatic pest plant removal to ensure the values of Te Arawa are considered and provided for.

As the Crown's land manager, LINZ has a responsibility to maintain and safeguard New Zealand's unique biodiversity from the threat of plant and animal pests (LINZ n.d), which includes the water and air stratum above Rotorua Te Arawa lake beds. BOPRC have adopted a regional pest management plan that provides a strategic and statutory framework for efficient and effective management of pest plants and animals in the region (LINZ 2015).

Bay of Plenty Regional Council has a regulatory responsibility to provide leadership within the region for pest management under the Biosecurity Act (s12B). BOPRC delivers its leadership role primarily through the Regional Pest Management Plan. The plan sets out objectives, rules and roles and responsibilities for managing pest plants and animals within the region. Within the plan, specific pest plant and animal species are identified and categorised into different levels of management (BOPRC 2011). The Regional Pest Management Plan is currently being reviewed and a new plan is expected to be adopted in 2020.

Rotorua Lakes Council is responsible for managing park and lake reserves, including associated structures within these reserves. As part of their management, RLC actively clears and removes aquatic pest plants that have become stranded within the lake reserves and washed up on the structures. RLC is also a member of the Rotorua Te Arawa Lakes Programme, which is responsible for improving and protecting the water quality in the Rotorua Te Arawa lakes (Rotorua Lakes Council 2014).

Managing aquatic pest plants within the Rotorua Te Arawa lakes will require a collaborative approach from the above agencies and the local community.

7 Legislation and planning framework

There are a range of statutory and non-statutory 'checks and balances' relevant to day-to-day management, maintenance and enhancement of the Rotorua lakes.

The following legislative instruments set the scene for the planning framework applicable to the Rotorua lakes:

- Te Arawa Lakes Deed of Settlement
- Te Arawa Lakes Settlement Act 2006
- Local Government Act 2002
- Biosecurity Act 1993
- Conservation Act 1987
- Resource Management Act 1991
- Hazardous Substances and New Organisms Act 1996

The Te Arawa Lakes Deed of Settlement was signed in 2004. This transferred ownership of 13 Rotorua lakebeds and provided financial redress to Te Arawa Maori Trust Board (now Te Arawa Lakes Trust). Te Arawa Lakes Deed of Settlement makes it clear that Te Arawa Lakes Trust are not responsible for the management of aquatic pest plants.

The primary governing legislation for BOPRC is the Local Government Act (LGA) 2002. Under Section 10 of the Act, the purpose of local government is (a) to enable democratic local decision-making and action by, and on behalf, of communities; and (b) to promote the social, economic, environmental, and cultural well-being of communities, in the present and for the future. Hence, since 2002, regional councils and other territorial authorities (city and district councils) have had a wide mandate to contribute to community well-being. The LGA (and RMA) includes specific obligations relating to the management of resources significant to Maori.

Regional Pest Management Plans, underpinned by the Biosecurity Act 1993 provide access powers and rules to manage pests. Pests that are classified as 'unwanted organisms' are also subject to direct management under the Act.

The Conservation Act 1987 has only limited relevance to aquatic pest plant management for amenity values. Part 4, Section 23A, outlines how areas of amenity values should be managed, but does not outline responsibilities for doing so.

The purpose of the Resource Management Act 1991 (RMA) is to promote the sustainable management of natural and physical resources. Section 5 states that resources may be used in a manner that enables people and communities to provide for their social, economic and cultural well-being, and for their health and safety while:

(a) *Sustaining the potential of natural and physical resources (excluding minerals) to meet the reasonably foreseeable needs of future generations;*

(b) *Safeguarding the life-supporting capacity of air, water, soil and ecosystems; and*

(c) *Avoiding, remedying or mitigating any adverse effects of activities on the environment.*

Schedule 1 of the RMA sets out the relevant criteria to be considered by regional councils and other territorial authorities when preparing and/or changing policy statements or plans.

Te Tūāpapa o ngā Wai o Te Arawa and He Mahere Taiao is an Iwi management plan to be provided for under the RMA – this Plan has statutory weight under sections 5-8, 35A, 61, 66, 74 and 108 of the Resource Management Act.

Of relevance moving forward; the Resource Management Legislation Amendment Act 2017 sets a new national planning direction with the introduction of national planning standards. These standards will apply to the structure, format and content of regional policy statements and plans to address matters which the Minister considers:

- Require national consistency
- Required to support implementation of NES, NPS, NZCPS or regulations
- Required to address procedural principles

National planning standards can be applied generally or to a specified area; and further, they can specify where local provisions must or may be included in regional policy statements or plans.

The Resource Management Legislation Amendment Act 2017 also sets out a framework for greater Maori participation in resource management processes and decision making processes – Mana Whakahono a Rohe Iwi Participation Arrangements.

The use of aquatic herbicides in New Zealand is regulated by the Hazardous Substances and New Organisms Act 1996 (HSNO Act). The HSNO Act addresses risks to the environment, people and communities by conducting thorough risk, cost and benefit assessments on specific hazardous substances so that the overall benefits are balanced against potential risks. Through this assessment, controls are applied to the hazardous substance to prevent or manage the adverse effects of its use.

Under the ambit of the above-mentioned legislative instruments, the following planning documents contain a range of issues, objectives, policies and methods to achieve sustainable outcomes for the Rotorua lakes environs:

- National Policy Statement for Freshwater Management 2014
- Bay of Plenty Regional Policy Statement
- Bay of Plenty Regional Natural Resources Plan
- Tarawera River Catchment Plan
- Rotorua District Plan
- Regional Pest Management Plan (currently under review)

8 Management tools available

There is an increasing range of tools available for which to combat aquatic pest plants. The best approach (or methods) is dependent on lake characteristics such as type and distribution of aquatic pest plant species, the overall vision and goals, targets and objectives for the lake and the cost effectiveness of each method. Figure 8.1 shows a conceptual outline of aquatic pest plant control tools used in New Zealand with the most appropriate options dependent on the levels/ density of aquatic pest plants (NIWA 2016b). Many of the Rotorua Te Arawa lakes (or selected areas within lakes) are saturated with aquatic pest plants and require either harvesting, biocontrol, herbicide use or a combination of tools. Management tools can be divided into three categories; biological, chemical and mechanical.

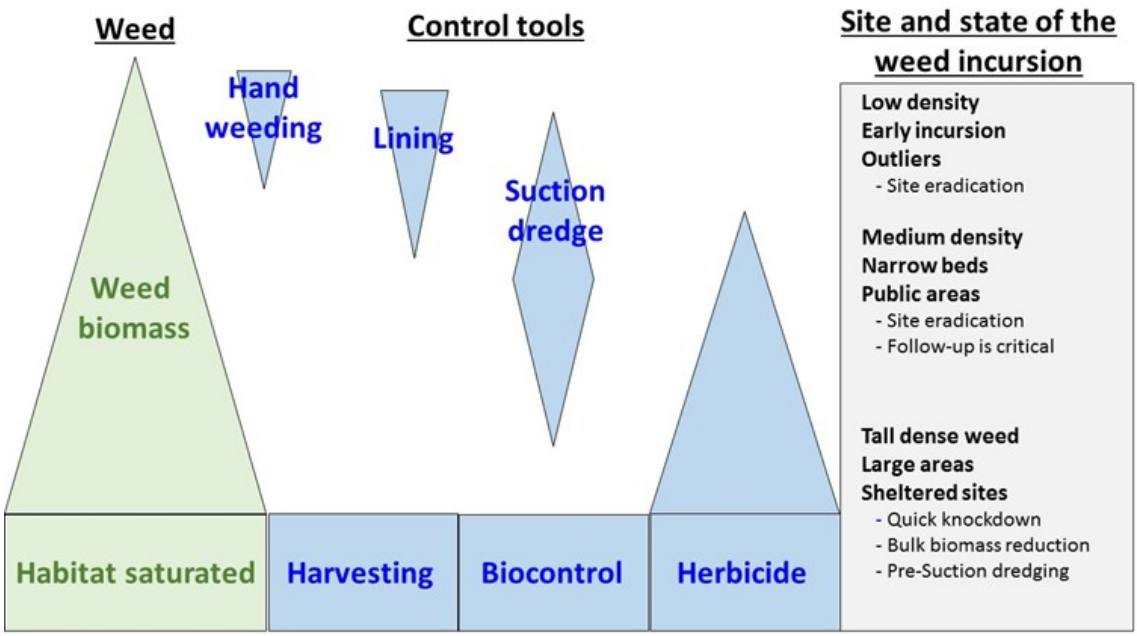

Figure 8.1 *Conceptual outline of aquatic pest plant control tools used in New Zealand over varying levels of aquatic pest plant densities (NIWA 2016b).*

8.1 Biological control

Currently, biological options are limited to grass carp for controlling aquatic pest plants. Grass carp are herbivorous non-selective grazers that can control aquatic pest plants depending on stocking rates and the duration for which the fish are present in the waterway (Burton 2015). Grass carp are mostly used in New Zealand to control aquatic pest plants in small waterways. There are risks with using grass carp such as containing fish within the desired areas and potential unknown adverse ecological effects. An ecological impact assessment would be required for any waterways where grass carp are proposed for release (NIWA 2002).

8.2 Physical control

There are a range of options for physical control/ removal of aquatic pest plants within New Zealand including: cutting and harvesting, rototilling, dredging, suction dredging, bottom lining and hand weeding. These options are discussed below individually.

Cutting and harvesting involves using a machine on the waterway to cut the upper, approximately, 2 m off weed beds. This method removes large amounts of nutrients from the system but only provides a temporary relief from dense weed beds. Weed harvesting also results in the capture of aquatic organisms present within the weed (NIWA 2002). This option is currently used on some Rotorua Te Arawa lakes to remove nutrients and provide temporary relief from dense weed beds.

Rototilling is an underwater rotary hoe that cuts and uproots plants growing in the bottom sediments (Chisholm n.d.). Similarly to harvesting, this method only provides a temporary relief and is costly and ineffective compared to other control methods (Clayton et al. 2000).

Suction dredging uproots aquatic pest plants and discharges the plants into a collection bag. Success using this technique is variable depending on the target aquatic pest plant species. There is potential to use this technique with smaller infestations (NIWA 2002).

Bottom lining involves excluding or reducing light levels to prevent growth of aquatic plants. The success of this method is dependent on the targeted species, scale of pest plant infestation and type of material used. This technique is best used for smaller infestations (Burton 2015).

Hand weeding uses a diver to physically pull out and remove aquatic pest plants from the waterway. This method is labour intensive and only suitable for small infestations and new incursions (Burton 2015).

8.3 Chemical control

There are currently two herbicides registered for use in water in New Zealand, diquat and endothall (NIWA 2002). Diquat has been used extensively throughout many of the Rotorua Te Arawa lakes, while BOPRC and LINZ have recently obtained resource consent for the use of endothall.

Diquat is a short-lived and selective contact herbicide that is commonly used to control extensive weed beds. Egeria and elodea are highly susceptible to the herbicide, while lagarosiphon and hornwort are moderately susceptible. Native charophyte species are mostly tolerant to diquat when applied at the recommended rates (NIWA 2002). This has been the most commonly used method to control aquatic pest plants throughout many Rotorua Te Arawa lakes due to its cost effectiveness and being environmentally safe to use.

Endothall, like diquat, is a short-lived and selective contact herbicide that has been used in New Zealand since 2004. Endothall has been used in New Zealand to control weed beds of lagarosiphon and hornwort which are both susceptible to endothall, while native charophyte species are mostly tolerant (NIWA 2002). However, endothall is not efficacious against egeria or elodea, an important consideration for Rotorua Lakes when determining herbicide treatments (M. de Winton 2017, pers. comm, 22/08/2017). Research suggests that, when applied at the correct rates, endothall has limited adverse effects on the environment and non-target aquatic

species (Hofsta & Champion 2008). Endothall is also not deactivated by turbid water or dirt covering the plant surface, as opposed to diquat (M. de Winton 2017, pers. comm. 12/10/2017). Endothall requires extended contact time, relative to diquat, to be effective. Trials using endothall began in 2019 and were conducted in Lakes Rotoiti, Rotomā and Ōkataina with limited success. Further trials will be required to optimise it's use in lake environments.

9 Lake management plans

9.1 Lake Rotorua Aquatic Plant Management Plan

9.1.1 Lake Rotorua

Lake Rotorua (Te Rotorua nui a kahumatamomoe – The basin like lake of Kahumatamomoe) is the largest lake within the Rotorua (and Bay of Plenty) region with a surface area of just over 8,000 ha and a maximum depth of 125 m (Bay of Plenty Regional Council et al. 2015). Lake Rotorua is located immediately north of Rotorua city and to the west of Lake Rotoiti.

Streams throughout the catchment surrounding Lake Rotorua flow into the lake. Water discharges from Lake Rotorua to Lake Rotoiti via the Ohau Channel, which means that water quality within Lake Rotoiti is influenced by Lake Rotorua (Bay of Plenty Regional Council et al. 2009b).

9.1.2 Importance of lake

Lake Rotorua and the surrounding catchment provides several important values including cultural, biodiversity, environmental, economic and recreational with the lake catchment containing the largest population of the surrounding lakes with Rotorua City adjacent to the shore. Lake Rotorua often provides tourists with their first glimpse of the wider Rotorua area and the waterfront is an iconic venue for visitors.

Lake Rotorua, along with the remaining lakes nearby, are of significant cultural importance to iwi and hapu with the lakes and surrounding environment being a central component to iwi and hapu traditions and beliefs. There are a number of significant cultural landmarks, pa sites and food gathering areas as well as urupa around Lake Rotorua. The lake contains populations of koura, kakahi, tuna and inānga for which Te Arawa have a role to sustainably manage these fisheries. There are wetlands, geothermal areas and of course Mokoia Island providing important habitat for plants, freshwater fish and birds.

Te Tūāpapa o ngā Wai o Te Arawa outlines the values of Te Arawa associated with the Lakes and also provides guidance on the principles to be applied to all decision-making processes and management activities (Te Arawa Lakes Trust & Conroy and Donald Consultants Limited 2016).

The lake is home to many people who live not only within Rotorua City but also in nearby local settlements. The lake is also the most productive trout fishery in New Zealand (Bay of Plenty Regional Council *et al*. 2009).

9.1.3 What is the problem?

Lake Rotorua has a widespread problem with the coverage and diversity of aquatic pest plant species. During the latest round of LakeSPI (submerged plant indicators) monitoring, a tool used to assess and report on the aquatic plant condition of New Zealand lakes, the lake condition status was documented as “moderate”. Most notably, the invasive impact percentage was 80%, although this is down from 90% recorded in 1988. Native condition has improved over recent years and is the highest it’s been since monitoring began in Lake Rotorua in 1982 (NIWA 2016a).

Lake Rotorua contains several prominent aquatic pest plant species including hornwort, lagarosiphon, egeria and elodea. While these submerged aquatic pest plants differ slightly in their ecological characteristics, they share a similar trait in which they outcompete and displace native aquatic species, creating large dense weed beds. These four pests have been identified as the most problematic pest plant species within Lake Rotorua, and in the wider Rotorua lakes, and have been the target species of recent control programmes.

9.1.4 Goal, targets, objectives and actions

The goal for Lake Rotorua is:

Shore strandings and existing exotic weed beds do not detract from hapū / iwi, local community and visitor experiences of Lake Rotorua.

LakeSPI targets have also been set for Lake Rotorua to quantitatively assess changes in aquatic plant species and distribution and will assist in measuring progress towards achieving the goal. Lake Rotorua has three LakeSPI targets including a minimum threshold - which the lake is precluded from falling below, 10-year target and a long-term target. The minimum threshold and targets have been developed in consultation with NIWA.

- The minimum threshold is the lowest LakeSPI value recorded from the past 15 years of monitoring (when regular LakeSPI monitoring of Rotorua Te Arawa lakes began). If the minimum threshold is breached, the plan and control activities will be reviewed. Outcomes from the review may include seeking further technical advice, amending pest plant management activities and/or gathering feedback from stakeholders. Any decisions or recommendations will be made in the wider context of control activities and programmes across Te Arawa Rotorua Lakes.
- The 10-year target is based on an improvement of five percentage points over the duration of two LakeSPI monitoring occasions beginning from the 2017 LakeSPI value (monitoring is undertaken every two years – i.e. an improvement of five percentage points every four to five years).
- The long-term target is based on the likely LakeSPI values from Lake Rotorua during the 1960s.

Table 9.1.1 provides an overview of the minimum threshold and targets and Table 9.1.2 describes the objectives and actions for Lake Rotorua.

Table 9.1.1 LakeSPI targets and minimum threshold for Lake Rotorua

Site	LakeSPI value
Current Lake SPI value (2017)	26
Minimum threshold	20
10-year target	36
Long term target	64

Table 9.1.2 Lake Rotorua aquatic plant management plan objectives and actions

Objective	Actions
Plan is supported by central, regional and local government, Te Arawa and the local community.	Obtain endorsement for the plan from Te Arawa Lakes Strategy Group.
	Seek and secure adequate funding to implement control work programmes.
	Actively involve Iwi and the local community in carrying out the plan (i.e. reporting incursions and unusual findings, and providing feedback).
	Align aquatic pest plant control objective with appropriate programmes in BOP Regional Pest Management Plan.
	Review and update aquatic plant management plan at least once every three years.
	Prepare an annual plan of works by 30 June each year.
	Report progress to Te Arawa Lakes Strategy Group and communities annually.
Improve and increase Te Arawa hapū and iwi use of the lake.	Engage with Te Arawa hapū and iwi in management of biosecurity issues.
	Engage with Te Arawa hapū and iwi on use of the Lake for cultural practises and connection to the Lakes.
	Work with Te Arawa hapū and iwi to improve access to cultural materials and mahinga kai where access is hindered by aquatic pest plants.
	Work with Te Arawa hapū and iwi to improve mahinga kai habitats where they are impacted or threatened by aquatic pest plants.
	Engage Te Arawa hapū and iwi to actively report new and unusual weed findings.
	Provide support for Te Arawa hapū and iwi to conduct cultural monitoring of the lake.
Enhance biodiversity and improve and increase local communities and visitors use of the lake.	Implement annual control programme to schedule and budget.
	Restore aquatic native plant communities through controlling aquatic pest plants.
	Ensure control works do not unreasonably hamper lake use.
	Ensure control work is effective and does not cause unintended environmental harm.
	Ensure Iwi, the local community and lake users are aware of planned control works and support programme.
	Engage community to actively report new and unusual pest plant findings.

Objective	Actions
New pest plant incursions are detected early enough to be eradicated or controlled.	Carry out annual passive and proactive surveillance to detect new pest incursions.
	Prevent lagarosiphon, egeria, hornwort and elodea from being transferred from Lake Rotorua to any other waterbodies.
Effectiveness and effects of pest plant control are measured and results are incorporated into future works.	Undertake operational monitoring to assess whether aquatic pest plant control has been successful.
	Undertake monitoring to detect unintentional outcomes (e.g. adverse effects to non-target plant and animal species).
	Incorporate results from monitoring into reviews and work programmes to improve future control programmes.
Research improves methods for surveillance, monitoring and control of aquatic pest plants.	Use research for the basis for decisions on aquatic pest plant management.
	Support research in aquatic pest plant management.

9.1.5 No management scenario

Invasive aquatic pest plants are present throughout Lake Rotorua with large proportions of available habitat saturated by either one or multiple pest plant species. Without active management and monitoring, aquatic pest plants will continue to spread and create dense weed mats. Improved water quality from surrounding catchment management will also allow pest plants to grow to greater depths.

Any further spread of invasive pest plants would potentially reduce the extent of aquatic native habitat as well as apply additional biosecurity pressures to neighbouring lakes. Without surveillance, new incursions could easily become established before being identified. The scenario of not undertaking any management or monitoring is not acceptable to stakeholders or the wider public.

9.1.6 Proposed management

NIWA (2017i) established the most efficient and cost-effective methods for which to manage aquatic pest plants in Lake Rotorua for the next three years (sites identified in Figure 9.1.1). Unless stated otherwise, the proposed methods and associated diagrams/figures have been developed by NIWA.

Lake Rotorua has the full range of problem invasive aquatic pest plants affecting the Rotorua Te Arawa lakes. An aquatic pest plant issue was first perceived by the public in the mid-1950's (Chapman 1970) following incursions and establishment of lagarosiphon. Egeria was first found in the lake in 1983 and is now the most abundant. It spread rapidly to form extensive surface reaching beds in 1988 (Figure 9.1.2) and has been the focus of control activities in the lake since. Hornwort is usually the most problematic pest plant in lakes, but it is scarce in Lake Rotorua, most likely due to the effects of a 10 km wind fetch on this poorly anchored plant. Elodea has been displaced by the more aggressive pest plants and is only found as a minor component of the vegetation, persisting in shallow water (<2.5m) where it is competitive in a short-growing form in this wave wash zone. Water net (*Hydrodictyon reticulatum*), a macroscopic green filamentous alga, was present in the lake at nuisance levels from 1988 to 1995 and very extensive growths caused major problems in the city foreshore area and at Ngongotaha (Figure 9.1.2).

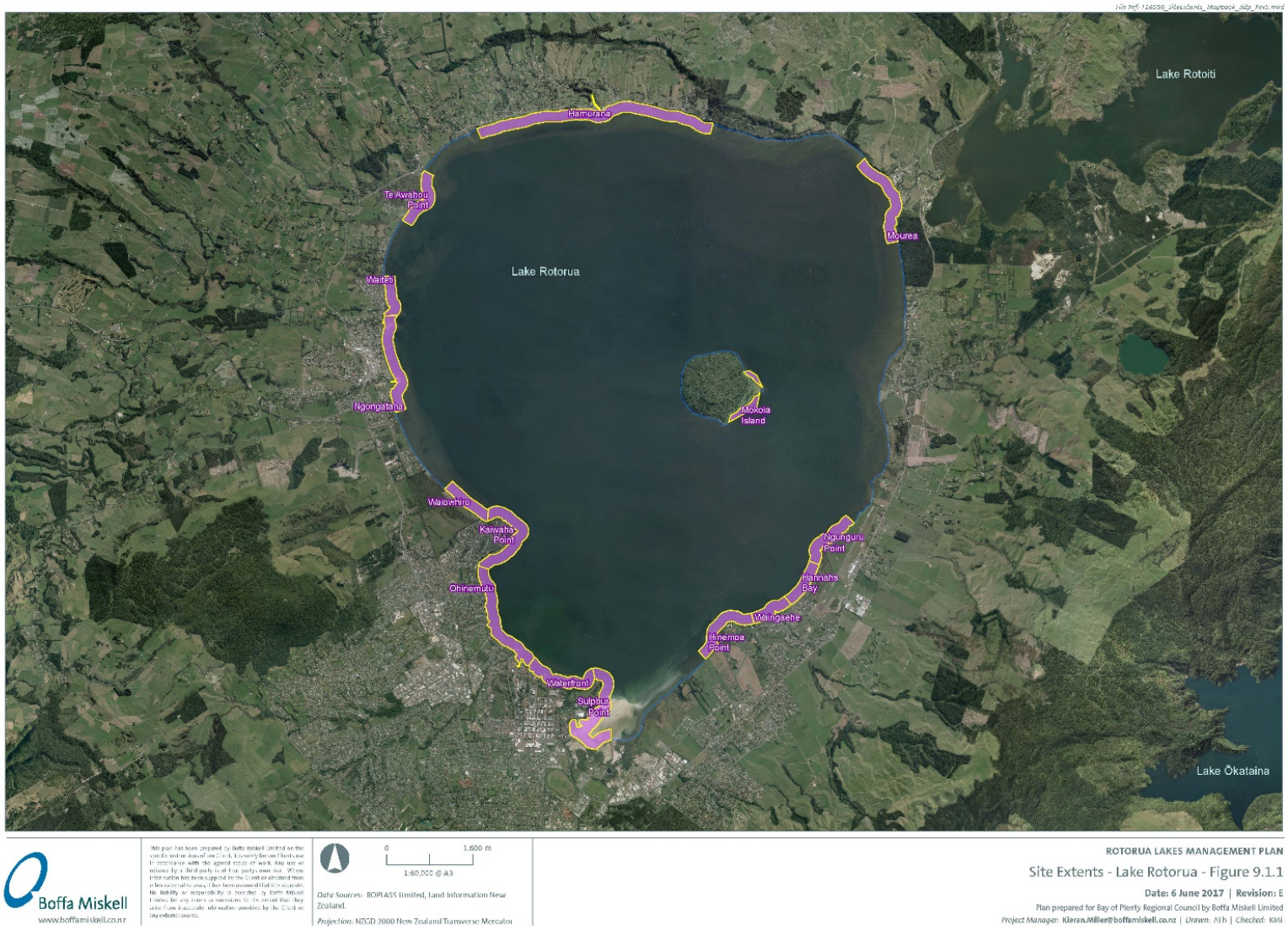
Lake Rotoiti
Hamurana
Te Awahou Point
Lake Rotorua
Mourea
Waitetī
Ngongotaha
Mokoia Island
Waiowhiro
Kaiwaha Point
Ngunguru Point
Hannahs Bay
Ohinemutu
Waingaehe
Hinemoa Point
Waterfront
Sulphur Point
Lake Ōkataina
Boffa Miskell
www.boffamiskell.co.nz
0
1,600 m
1:60,000 @ A3
Data Sources: BOPLASS limited, land Information New Zealand.
Projection: NZGD 2000 New Zealand Transverse Mercator
ROTORUA LAKES MANAGEMENT PLAN
Site Extents - Lake Rotorua - Figure 9.1.1
Date: 6 June 2017 | Revision: E
Plan prepared for Bay of Plenty Regional Council by Boffa Miskell Limited
Project Manager: Kieran.Miller@boffamiskell.co.nz | Drawn: NTh | Checked: KMi

Figure 9.1.1

Figure 9.1.2 Lake Rotorua (late 1980's) with extensive weed beds of egeria covered in water net.

Shoreline locations (Figure 9.1.1) ranked as high priority for pest plant management based on biosecurity concerns are Kawaha Point to Sulphur Point (Dragten Consulting 2016). Areas ranked as medium priority due to biosecurity include Ngongotaha, Hannahs Bay, Ohinemutu (as Utahina) and Hamurana (Figure 9.1.1), with Waingaehe ranked as medium priority due to amenity impacts (Dragten Consulting 2016).

Biosecurity focused pest plant management at boat ramps has less application at Lake Rotorua than other Te Arawa lakes due to less frequent use of boats on the lake. The lake also has numerous boat ramps that are mostly all on hard, bare, sandy shores where pest plants are unable to grow close in-shore. This habitat therefore affords little likelihood of pest plant transfer to other lakes, except when fragments drift from beds further off-shore and accumulates on boat ramps. Pest plant removal or diversion of drift from the ramps is important, as eliminating all plants at the source is difficult with large areas potentially contributing efflux material.

The main areas of pest plants are indicated in Figure 9.1.3 and are restricted to shores sheltered from the prevailing south west winds, with this pattern remaining unchanged over many decades (Clayton et al. 1990). The littoral zone of Lake Rotorua is very large due to gentle slopes (6 m depth contour >1 km offshore in many places) and favourable substrates that create extensive (>500 ha) of suitable habitat for aquatic plants.


File Ref: T16056_NuisanceWeedBeds.mxd
Lake Rotoiti
Lake Rotorua
Ngongotaha and Waiteti 240 ha
Mokoia Island 6 ha
Kawaha Point to Waterfront 240 ha
Owhatiura Bay to Ngunguru Point 70 ha
Lake Ōkataina
Boffa Miskell
www.boffamiskell.co.nz
This plan has been prepared by Boffa Miskell Limited on the specific instructions of our client. It is solely for our client's use in accordance with the agreed scope of work. Any use or reliance by a third party is at that parties own risk. Where information has been supplied by the Client or obtained from other external sources, it has been assumed that it is accurate. No liability or responsibility is accepted by Boffa Miskell Limited for any errors or omissions to the extent that they arise from inaccurate information provided by the Client or any external source.
0
1,600 m
1:60,000 @ A3
Data Sources: BOPLASS Limited, Land Information New Zealand
Projection: NZGD 2000 New Zealand Transverse Mercator
ROTORUA LAKES MANAGEMENT PLAN
Nuisance Weed Beds - Lake Rotorua - Figure 9.1.3
Date: 6 June 2017 | Revision: E
Plan prepared for Bay of Plenty Regional Council by Boffa Miskell Limited
Project Manager: Kieran.Miller@boffamiskell.co.nz | Drawn: ATh | Checked: KMi

Figure 9.1.3

Kawaha Point to Waterfront

The area of highest priority for pest plant control is the city foreshore area from Kawaha Point to the waterfront due to high public use and a focal point for tourism. The area suitable for pest plant growth is large (over 200 ha). Weed strandings are common and require regular clean up to prevent large scale accumulations of rotting pest plants on the shore (Figure 9.1.4). Adjacent Sulphur Point does not have an aquatic pest plant problem, with geothermal inputs unsuitable for weed bed development.

Effective control of lagarosiphon and egeria in this area has been achieved in the past by treatment of up to 60ha with diquat (Wells & Clayton 1997). Diquat is the only herbicide registered for aquatic use in New Zealand that is effective against all the target pest plants in Lake Rotorua. Diquat has a long history of use in Lake Rotorua (Chapman 1970, Wells & Clayton 1997), with this method of pest plant control used successfully for management for over 57 years.

The herbicide endothall has limited effect against egeria and elodea, but could be used in areas dominated by lagarosiphon where it may achieve a greater and more long lasting level of control than diquat. Endothall was trialled in Lakes Rotoiti, Rotomā and Ōkataina in 2019 with limited success. Further trials are required to optimise the use of endothall before it can be used more widely. For this reason, it is not included in recommended control approaches at this time.

Figure 9.1.4 Aquatic weed stranding rotting on a sandy beach.

Diquat efficacy can be markedly enhanced by delivering a follow up treatment several months later (Figure 9.1.5, Table 9.1.3). In Lake Ōkāreka this strategy has been highly effective in reducing lagarosiphon to low abundance in treated areas. These results suggest there is potential for further aspirational goals to be considered over the next five to ten years in Lake Rotorua as this treatment strategy could have similar outcomes. The cost is higher initially with a double treatment, but with minimal pest plants subsequently, it is likely cost will reduce with fewer subsequent treatments required.

Pre- and post-treatment assessments (Figure 9.1.5) are necessary to evaluate outcomes and further refine treatment strategies. Sonar and/or remote operated vehicle (ROV) recordings with SCUBA/snorkel spot checks to ground truth the sonar results, is an effective method for rapidly assessing and documenting the efficacy of treatments.

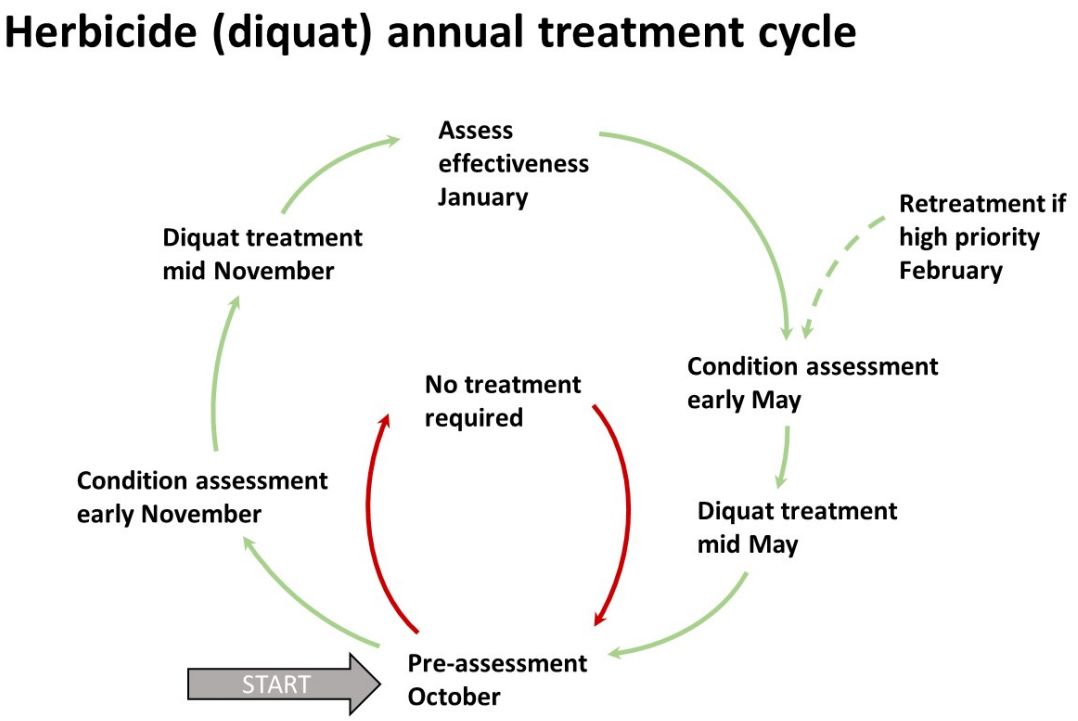

Figure 9.1.5 Annual cycle of treatment and assessment of egeria and lagarosiphon using diquat.

Ngongotaha and Waiteti

Ngongotaha and Waiteti along the western shore have aquatic pest plant problems emanating from an offshore bed (Figure 9.1.3) affecting recreational use and residential properties when it drifts on shore following storms.

An annual assessment for diquat treatment is recommended to address those years where weed bed development may cause an issue (Figure 9.1.6, Table 9.1.3).

Hamurana to Mourea

Northern sites from Hamurana to Mourea, are usually too exposed for weed beds to develop. In the past in less windy years an egeria bed has developed off-shore at Hamurana but the next strong southerly removes it. The few plants that do grow are short-growing elodea and milfoil which cause minimal issues. Pest plant control is likely to be unnecessary (Table 9.1.3).

Hinemoa Point to Ngunguru Point

The shorelines from Hinemoa Point to as far north as the airport have moderate pest plant problems affecting recreational use and residential properties. As for the southern and western shores, the wide shallow margins (up to 100 m or more wide and less than 2 m deep) are comprised of bare sand with only a few short growing plants due to high energy wave action resulting from a 10 km wave fetch. Weed stranding results from weed beds further out when strong winds blow on shore.

An annual assessment for diquat treatment at Hannah's Bay and Waingaehe is recommended (Figure 9.1.6, Table 9.1.3).

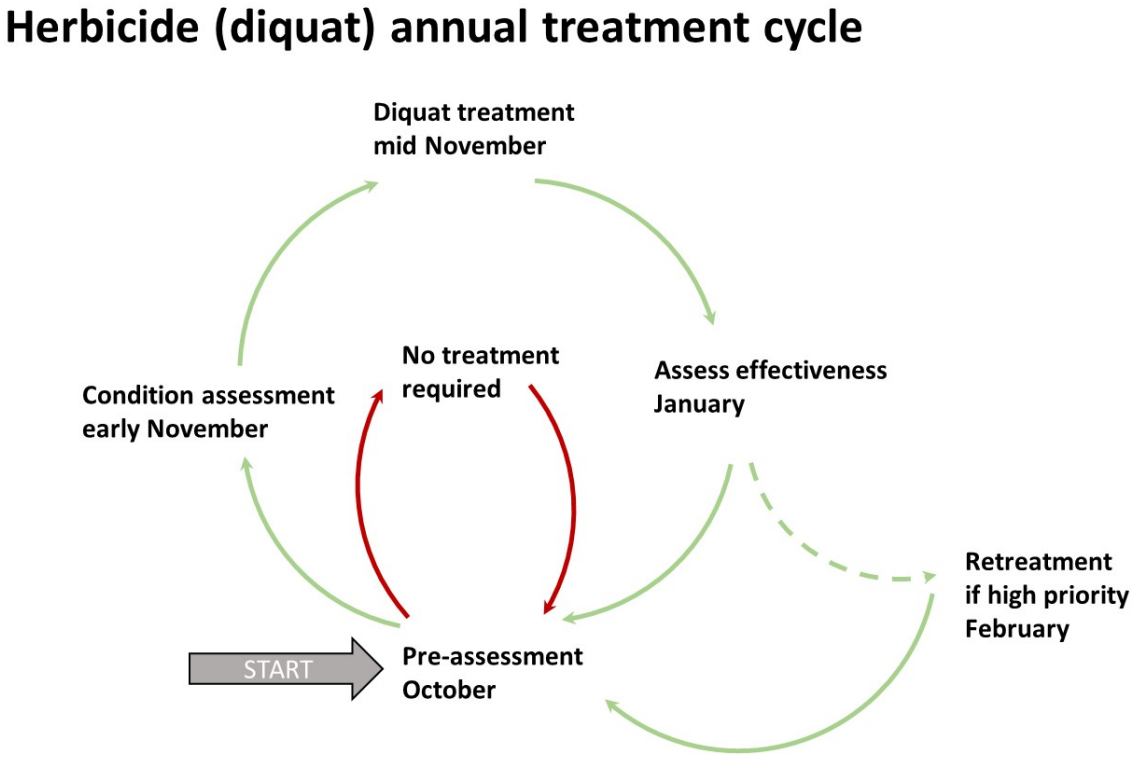

Figure 9.1.6 Annual cycle of assessment and treatment using diquat.

Mokoia Island

Mokoia Island has about 6ha of pest plants (lagarosiphon and egeria) on the eastern shoreline of the island. While this area is of limited recreational use, the island is of high cultural significance and is also a wildlife sanctuary. Of ecological significance is the recent rediscovery of *Isoetes kirkii*, a short-growing shallow water plant. This is a relic of what would have been a widespread shallow water eco-dominant in the Rotorua Te Arawa lakes in pre-European times, but is now close to extinction in Lake Rotorua. It is nationally regarded as an At-Risk Declining plant (de Lange *et al*. 2013). Control of aquatic pest plants at Mokoia Island could become a high priority if there is a desire to extend the sanctuary concept into the lake to enhance native submerged vegetation and preserve the presence of isoetes in the lake.

A double application of diquat (Figure 9.1.5, Table 9.1.3) is recommended, with monitoring to assess outcomes for native vegetation, particularly for isoetes.

Table 9.1.3 Proposed control in Lake Rotorua for the next three years (as growth year, spring through winter) for sites identified for pest plant management listed below

Site	Year 1	Year 2	Year 3
Sulphur Point	No control.	No control.	No control.
Waiowhiro			
Hamurana			
Te Awahou Point			
Mourea			
Ngunguru Point			
Hinemoa Point			

Site	Year 1	Year 2	Year 3
Waterfront	Double diquat application.	Assess outcome before continuing.	Assess outcome before continuing.
Ohinemutu			
Kawaha Point			
Mokoia			
Ngongotaha	Assess for diquat treatment.	Assess for diquat treatment.	Assess for diquat treatment.
Waiteti			
Hannah's Bay			
Waingaehe			

9.1.7 Surveillance

Lake Rotorua is currently not part of the surveillance programme as it contains the four most invasive aquatic pest plants found within the Rotorua Te Arawa Lakes area. Monitoring is still conducted within Lake Rotorua as part of the pre-and post spray assessments which assists in identifying aquatic pest plant incursions outside of the species already present. In the event of a new incursion, an incursion response plan will be developed by BOPRC in consultation with TALT and LINZ.

In addition to the surveillance programme, BOPRC also undertake an annual awareness campaign/ survey and regularly interact with the public.

9.2 Lake Rotoiti Aquatic Plant Management Plan

9.2.1 Lake Rotoiti

Lake Rotoiti (Te Rotoiti-kite-a ihenga – *The small lake seen by Ihenga*) is one of the larger lakes within the Rotorua region with a surface area of approximately 3400ha and a maximum depth of 94m (Bay of Plenty Regional Council *et al*. 2009). Lake Rotoiti is located approximately 15 km northeast of Rotorua city, between Lake Rotorua to the west and Lake Rotoehu to the east.

Water flows into the western end of Lake Rotoiti from Lake Rotorua via the Ohau Channel, which means that water quality within Lake Rotoiti is influenced by Lake Rotorua. Water discharges into the Kaituna River which flows in a northerly direction towards Maketu. In 2008, a diversion wall was constructed near the Ohau Channel to direct high nutrient water away from the main body of Lake Rotoiti. Water also drains from Lake Rotoiti to Lakes Rotoehu and Rotomā via subsurface flows (Bay of Plenty Regional Council *et al*. 2009b).

9.2.2 Importance of lake

Lake Rotoiti and the surrounding catchment provides many important values including cultural, biodiversity, environmental, economic and recreational with the lake being one of the most popular lakes for numerous sport and leisure activities. The lake is also home to many people who live along the lake front and/or in nearby local settlements. The lake provides additional values, which are perhaps less obvious to those previously described, including an important food and water source as well as encouraging social, family and community interaction.

Lake Rotoiti, along with the remaining lakes nearby, are of significant cultural importance to iwi and hapu with the lakes and surrounding environment being a central component to iwi and hapu traditions and beliefs. There are a number of significant cultural landmarks, pa sites, food gathering areas and as well as urupa around Lake Rotoiti. The lake contains populations of koura, kakahi, tuna and inānga for which Te Arawa have a role to sustainably manage these fisheries. There are wetlands and geothermal areas that provide important habitat for plants, freshwater fish and birds.

Te Tūāpapa o ngā Wai o Te Arawa outlines the values of Te Arawa associated with the Lakes and also provides guidance on the principles to be applied to all decision-making processes and management activities (Te Arawa Lakes Trust & Conroy and Donald Consultants Limited 2016).

9.2.3 What is the problem

Of all the Rotorua Te Arawa lakes, Lake Rotoiti has one of the worst problems with aquatic pest plants, due to the range of invasive species present and their distribution and coverage. During the latest round of LakeSPI (submerged plant indicators) monitoring, a tool used to assess and report on the aquatic plant condition of New Zealand lakes, the lake condition status was documented as "poor". Most notably, the invasive impact percentage was 92%, the highest score recorded since monitoring began in Lake Rotoiti in 1981 (NIWA 2016a).

Lake Rotoiti contains several prominent aquatic pest plant species including hornwort, lagarosiphon, egeria and elodea. While these submerged aquatic pest plants differ slightly in their ecological characteristics, they share a similar trait in which they outcompete and displace native aquatic species below the shoreline and create large dense weed beds. These four pests have been identified as the most problematic plant species within Lake Rotoiti, and in the wider Rotorua lakes, and have been the target species of recent control programmes.

9.2.4 Goal, targets, objectives and actions

The goal for Lake Rotoiti is:

Absence of aquatic pest plants allows hapū/iwi, local community and visitors to use and enjoy Lake Rotoiti.

LakeSPI targets have also been set for Lake Rotoiti to quantitatively assess changes in aquatic plant species and distribution and will assist in measuring progress towards achieving the goal. Lake Rotoiti has three LakeSPI targets including a minimum threshold - which the lake is precluded from falling below, 10-year target and a long-term target. The minimum threshold and targets have been developed in consultation with NIWA.

- The minimum threshold is the lowest LakeSPI value recorded from the past 15 years of monitoring (when regular LakeSPI monitoring of Rotorua Te Arawa lakes began). If the minimum threshold is breached, the plan and control activities will be reviewed. Outcomes from the review may include seeking further technical advice, amending pest plant management activities and/or gathering feedback from stakeholders. Any decisions or recommendations will be made in the wider context of control activities and programmes across Te Arawa Rotorua Lakes.

- The 10-year target is based on an improvement of five percentage points over the duration of two LakeSPI monitoring occasions beginning from the 2017 LakeSPI value (monitoring is undertaken every two years – i.e. an improvement of five percentage points every four to five years).

- The long-term target is based on the likely LakeSPI values from Lake Rotoiti during the 1960s.

Table 9.2.1 provides an overview of the minimum threshold and targets and Table 9.2.2 describes the objectives and actions for Lake Rotoiti.

Table 9.2.1 LakeSPI targets and minimum threshold for Lake Rotoiti

Site	LakeSPI value
Current Lake SPI value (2017)	19
Minimum threshold	18
10-year target	29
Long term target	70

Table 9.2.2 Lake Rotoiti aquatic plant management plan objectives and actions

Objective	Actions
Plan is supported by central, regional and local government, Te Arawa and the local community.	Obtain endorsement for the plan from Te Arawa Lakes Strategy Group.
	Seek and secure adequate funding to implement control work programmes.
	Actively involve Iwi and the local community in carrying out the plan (i.e. reporting incursions and unusual findings, and providing feedback).
	Align aquatic pest plant control objective with appropriate programmes in the BOP Regional Pest Management Plan.
	Review and update aquatic plant management plan at least once every three years.
	Prepare an annual plan of works by 30 June each year.
	Report progress to Te Arawa Lakes Strategy Group and communities annually.
Improve and increase Te Arawa hapū and iwi use of the lake.	Engage with Te Arawa hapū and iwi in management of biosecurity issues.
	Engage with Te Arawa hapū and iwi on use of the Lake for cultural practises and connection to the Lakes.
	Work with Te Arawa hapū and iwi to improve access to cultural materials and mahinga kai where access is hindered by aquatic pest plants.
	Work with Te Arawa hapū and iwi to improve mahinga kai habitats where they are impacted or threatened by aquatic pest plants.
	Engage Te Arawa hapū and iwi to actively report new and unusual weed findings.
	Provide support for Te Arawa hapū and iwi to conduct cultural monitoring of the lake.
Enhance biodiversity and improve and increase local communities and visitors use of the lake.	Implement annual control programme to schedule and budget.
	Restore aquatic native plant communities through controlling aquatic pest plants.
	Ensure control works do not unreasonably hamper lake use.
	Ensure control work is effective and does not cause unintended environmental harm.
	Ensure Iwi, the local community and lake users are aware of planned control works and programme.
New pest plant incursions are detected early enough to be eradicated or controlled.	Engage community to actively report new and unusual pest plant findings.
	Carry out annual passive and proactive surveillance to detect new pest incursions.
	Prevent lagarosiphon, egeria, hornwort and elodea from being transferred from Lake Rotoiti to any other waterbodies.

Objective	Actions
Effectiveness and effects of pest plant control are measured and results are incorporated into future works.	Undertake operational monitoring to assess whether aquatic pest plant control has been successful.
	Undertake monitoring to detect unintentional outcomes (e.g. adverse effects to non-target plant and animal species).
	Incorporate results from monitoring into reviews and work programmes to improve future control programmes.
Research improves methods for surveillance, monitoring and control of aquatic pest plants.	Use research for the basis for decisions on aquatic pest plant management.
	Support research in aquatic pest plant management.

9.2.5 No management scenario

Invasive aquatic pest plants are present throughout Lake Rotoiti with habitat saturated by either one or multiple pest plant species. Without active management and monitoring, aquatic pest plants levels will not decline and dense weed mats will remain. Improved water quality from surrounding catchment management will also allow pest plants to grow to greater depths.

Any further spread of invasive pest plants would potentially reduce the extent of aquatic native habitat as well as apply additional biosecurity pressures to neighbouring lakes. Without monitoring, additional pest plants could easily become established before being identified. The scenario of not undertaking any management or monitoring is not acceptable to stakeholders or the wider public.

9.2.6 Proposed management

NIWA (2016b) established the most efficient and cost-effective methods for which to manage aquatic pest plants at the 23 sites requiring aquatic plant management in Lake Rotoiti for the next three years (sites identified in Figure 9.2.1). Unless stated otherwise, the proposed methods and associated diagrams/ figures have been developed by NIWA.

Proposed management is similar for 21 of the 23 sites, with different approaches for Otaramarae boat ramp and the surrounding bay and Okawa Bay.

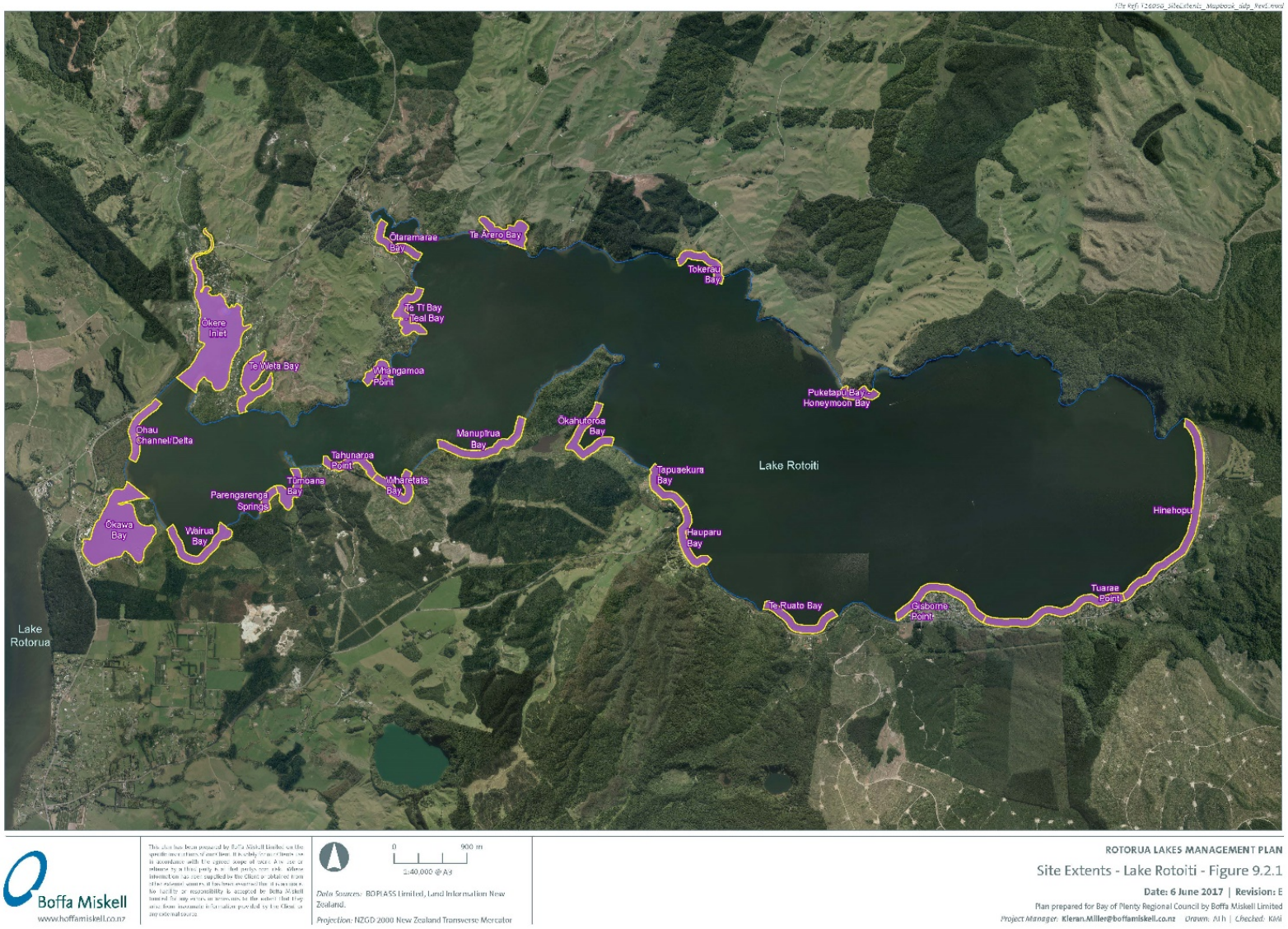
Lake Rotoiti
Lake Rotorua
Otaramarae Bay
Te Arero Bay
Tokerau Bay
Te Ti Bay - Teal Bay
Okere Inlet
Te Weta Bay
Whangamoa Point
Puketapu Bay
Honeymoon Bay
Okahutoroa Bay
Manuptrua Bay
Ohau Channel/Delta
Tahunaroa Point
Tapuaekura Bay
Tumbana Bay
Wharetata Bay
Parengarenga Springs
Hinehopu
Okawa Bay
Wairua Bay
Hauparu Bay
Tuaraa Point
Te Ruato Bay
Gisborne Point
Boffa Miskell
www.boffamiskell.co.nz
0
900 m
1:40,000 @ A3
Data Sources: BOPLASS Limited, Land Information New Zealand.
Projection: NZGD 2000 New Zealand Transverse Mercator
ROTORUA LAKES MANAGEMENT PLAN
Site Extents - Lake Rotoiti - Figure 9.2.1
Date: 6 June 2017 | Revision: E
Plan prepared for Bay of Plenty Regional Council by Boffa Miskell Limited
Project Manager: Kieran.Miller@boffamiskell.co.nz Drawn: AHh | Checked: KMi

Figure 9.2.1

Management of 21 Lake Rotoiti sites

All the aquatic pest plant species present in Lake Rotoiti are well established and quite widespread (habitat saturated with aquatic pest plants). Grass carp, harvesting and chemical control are currently the only options for managing aquatic pest plants on a large scale such as that found in Lake Rotoiti. Grass carp are unlikely to be appropriate due to difficulties with containment and high costs, and this method is also unlikely to be publicly and/or culturally acceptable. Harvesting has limited application due to boat ramp and shoreline access with only three sites, Okawa Bay, Okere Inlet and Te Weta Bay, suitable for harvesting. Chemical options, including diquat and endothall, are the most cost effective and efficient methods of the three options. However, further endothall trials (initial trials were conducted in Lakes Rotoiti, Rotomā and Ōkataina in 2019 with limited success) will need to be conducted first to improve the success of endothall treatment.

Aquatic pest plant programmes for 21 of the 23 sites should consist of an annual herbicide (diquat) treatment cycle whereby:

1 A pre-assessment, based on a site inspection, is undertaken in October to early November.

2 Sites are prioritised based on biosecurity outcomes, results from cultural monitoring, budgets and best achievable outcomes in early November.

3 Condition assessment and confirmation of spray areas.

4 Herbicide application prior to residential population build up and associated summer recreational holiday boat traffic on the lake.

5 An assessment is undertaken in January to evaluate the effectiveness of diquat treatment at key or representative sites (including cultural monitoring sites) to facilitate and help refine future treatment protocols.

Figure 9.2.2: visually depicts the proposed treatment cycle for 21 of the 23 Lake Rotoiti sites.

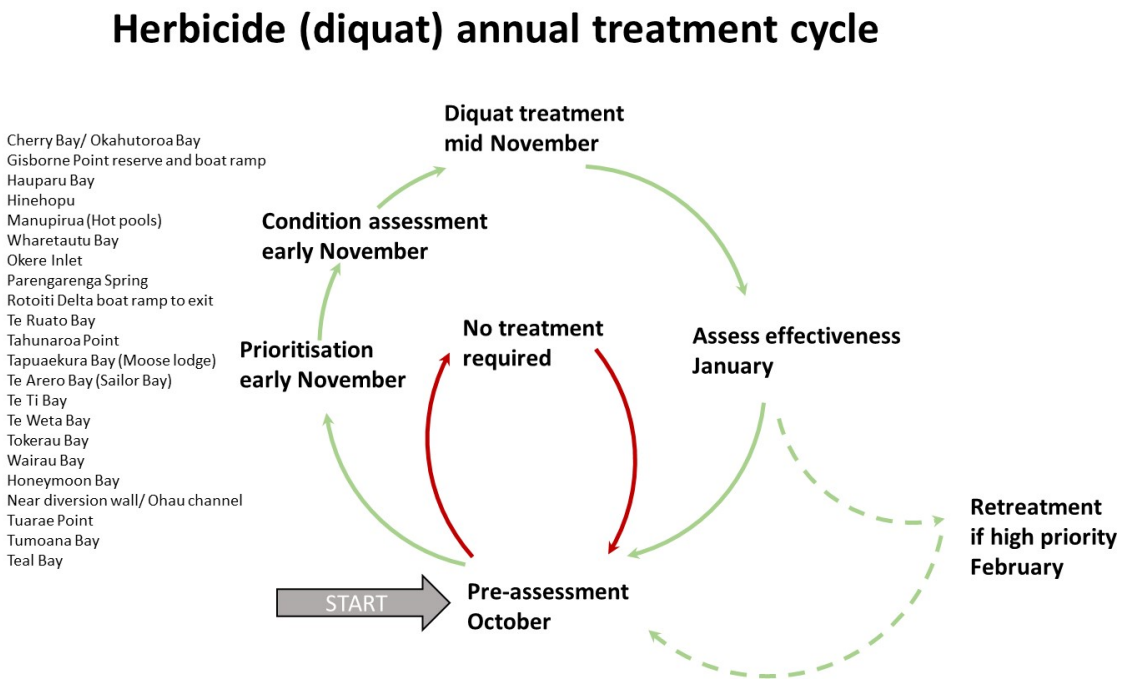

Figure 9.2.2 Proposed annual treatment cycle for 21 of the 23 Rotoiti Lake sites.

Otaramarae Boat Ramp and surrounding bay

It is recommended to bottom line the area behind (left of) the red line in Figure 9.2.3 (c. 60 m x 100 m); including the erection of a surface boom (red line) or weed cordon, with a drop net weighted at the bottom. Initial diquat treatment of the area would be required first to reduce biomass and facilitate bottom placement of lining material. There are a range of potential products suitable for bottom lining, including hessian and butanol rubber. However, product selection is dependent on siltation rates and likely maintenance requirements. Advantages of using hessian lining include reduced cost, as well as the potential for native charophyte plants to re-establish through the hessian lining, creating a deep-water carpet of native vegetation. If this proves successful then periodic (two to three years) diquat treatment will help ensure a long lasting native bottom-dwelling vegetation, while inhibiting the progressive invasion from tall invasive aquatic pest plant species.

An alternative option to bottom lining is to spray the area with endothall. A weed cordon would still be set up as per the red line in Figure 9.2.3. If endothall has the desired results, then periodic (two to three years) diquat treatment will be required to ensure egeria does not become dominant.

A boat passageway near the midpoint of the boom would enable boats to enter and exit. Periodic localised diquat treatment would likely be still required. However, the ability to keep the area largely weed free would be greatly enhanced and the transfer of pest plant fragments from the boat ramp site would be minimised.

Figure 9.2.4 visually depicts the proposed treatment sequence for the Otaramarae Bay boat ramp area. The remaining area of Otaramarae Bay (not treated by endothall or bottom lining), should be added to the list of annual herbicide treatment described for most of the Lake Rotoiti sites.

Figure 9.2.3 Lake Rotoiti Otaramarae boat ramp - area behind the red line proposed for bottom lining (Image sourced from: Google 2016).

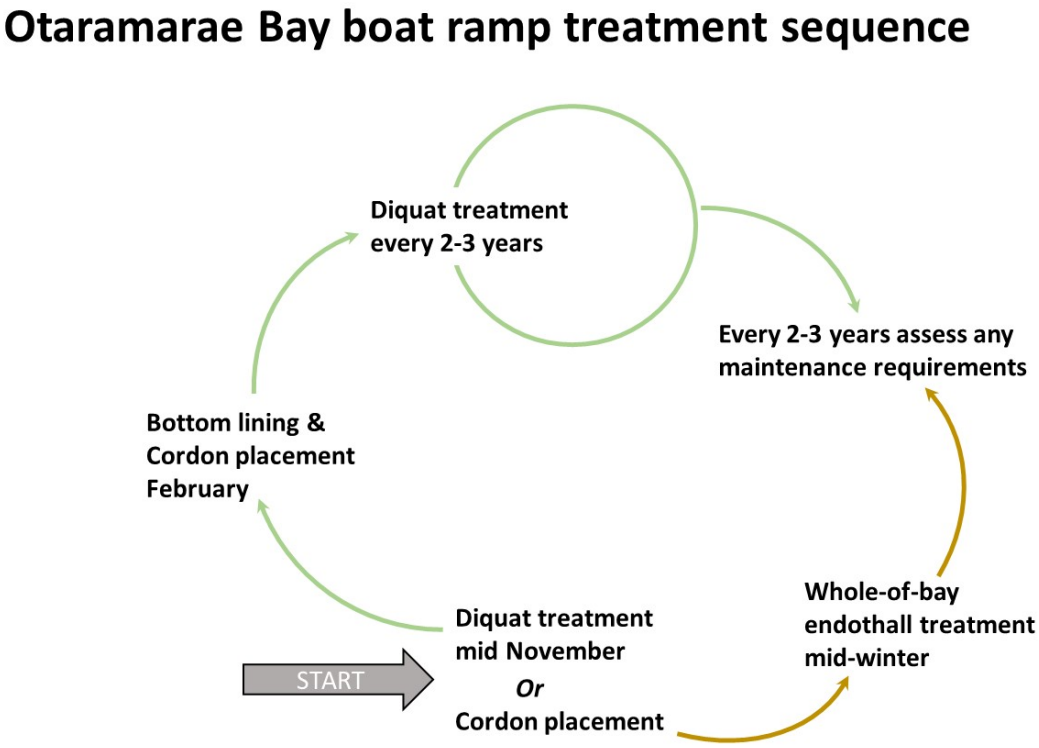

Figure 9.2.4 Proposed treatment sequence for Otaramarae Bay boat ramp.

Okawa Bay

An aspirational objective for Okawa Bay is the broad-scale suppression of all aquatic pest plant species followed by the widespread recovery of native submerged plants (including low profile charophyte species), which provide better habitat for biota and would substantially reduce the frequency and costs of future pest plant control required in this area.

Okawa Bay (Figure 9.2.5) is c. 1.8 km^2 with an average depth of c. 4-5 m. The area is largely covered in submerged vegetation, which requires periodic removal or control. The most common methods of control have been application of herbicide and cutting with a weed harvester. There has been debate over the choice and consequences of these two control methods, with suggestions that harvesting is best as this physically removes the pest plant and in doing so removes nutrients; as opposed to use of herbicide, which allows the plants to decay in situ with the potential for nutrient release and encouragement of algal blooms. The evidence is mostly inconclusive and both options have benefits and draw backs. The advantage of cutting the pest plant is that nutrient is removed from the bay. The process is slow and costly, with the same species re-growing faster than if they were sprayed. On the other hand, herbicide treatment is quick, cheaper than harvesting and offers the potential for native vegetation to recover from seed bank material in the sediment (which has been observed here and elsewhere on previous occasions).

One option would be to sequentially treat the area with diquat in stages (e.g., 1/3 or 1/2) depending on the pest plant volume to be treated. To reduce the risk of algal blooms, there is a further option to harvest pest plants before spraying to reduce the amount of biomass.

Consideration should also be given to endothall treatment of the whole bay during winter when water temperatures are low and the risk of any algal bloom would be minimised.

Figure 9.2.6 visually depicts the proposed treatment cycle for Okawa Bay.

Figure 9.2.5 Okawa Bay – a sheltered semi-enclosed shallow bay that supports widespread submerged vegetation (Image sourced from: Google 2016).

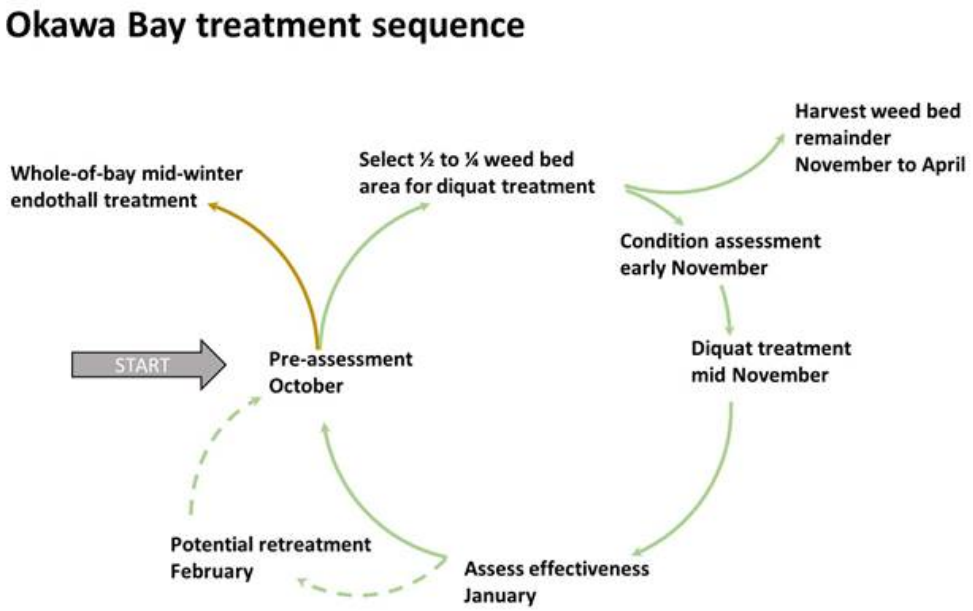

Figure 9.2.6 Proposed treatment cycle for Okawa Bay.

If initial results from endothall treatment in Okawa Bay and Otaramarae prove successful, then other sites within Lake Rotoiti may be selected for endothall treatment.

9.2.7 Surveillance

Lake Rotoiti is currently not part of the surveillance programme as it contains the four most invasive aquatic pest plants found within the Rotorua Te Arawa Lakes area. Monitoring is still conducted within Lake Rotoiti as part of the pre and post spray assessments which assists in identifying aquatic pest plant incursions outside of the species already present. In the event of a new incursion, an incursion response plan will be developed by BOPRC in consultation with TALT and LINZ.

In addition to the surveillance programme, BOPRC also undertake an annual awareness campaign/ survey and regularly interact with the public. They provide a portable wash down facility from time to time during the summer months. Cultural monitoring also provides a form of surveillance. BOPRC will engage with Te Arawa hapū and iwi to actively report new and unusual aquatic pest plant findings.

9.3 Lake Rotoehu Aquatic Plant Management Plan

9.3.1 Lake Rotoehu

Lake Rotoehu (meaning “murky waters”) is a moderate sized lake within the Rotorua region with a surface area of approximately 800 ha and a maximum depth of 13 m (Bay of Plenty Regional Council *et al*. 2015). Lake Rotoehu is located approximately 27 km northeast of Rotorua City, between Lake Rotoiti to the west and Lake Rotomā to the east.

The lake contains numerous arms to the north with multiple bays whereas the shoreline along the south follows a more rounded path. Numerous streams flow into the lake with no surface outlets. Water exits the lake through a sinkhole in one of the northern arms (Bay of Plenty Regional Council *et al*. 2007).

9.3.2 Importance of lake

Lake Rotoehu and the surrounding catchment provides several important values including cultural, biodiversity, environmental and recreational. The lake is also home to several small communities near Otautu Bay and Ngamimiro Bay.

Lake Rotoehu, along with the remaining lakes nearby, are of significant cultural importance to iwi and hapu with the lakes and surrounding environment being a central component to iwi and hapu traditions and beliefs. There are a number of significant cultural landmarks, food gathering areas as well as urupa around the lake. Lake Rotoehu in particular, was populated with many pa sites around the shores (Bay of Plenty Regional Council *et al*. 2015). The lake contains populations of koura, kakahi, tuna and inānga for which Te Arawa have a role to sustainably manage these fisheries. There are wetlands and geothermal areas that provide important habitat for plants, freshwater fish and birds.

Te Tūāpapa o ngā Wai o Te Arawa outlines the values of Te Arawa associated with the Lakes and also provides guidance on the principles to be applied to all decision-making processes and management activities (Te Arawa Lakes Trust & Conroy and Donald Consultants Limited 2016).

9.3.3 What is the problem?

Lake Rotoehu is known to have the biggest issues with aquatic pest plants of all the Rotorua Te Arawa lakes. It is not uncommon to see dense mats of hornwort on the surface of the lake particularly at the southern end. As well as hornwort, Lake Rotoehu also contains lagarosiphon, and elodea (egeria has not been found in the lake). These submerged aquatic pest plants outcompete and displace native aquatic species below the shoreline and create large dense weed beds. These three pests have been identified as the most problematic plant species within Lake Rotoehu.

During the latest round of LakeSPI (submerged plant indicators) monitoring, a tool used to assess and report on the aquatic plant condition of New Zealand lakes, the lake condition status was documented as “poor”. Most notably, the invasive impact percentage was 92%, a fraction below the highest score recorded (93% in 2010) since monitoring began in Lake Rotoehu in 1988 (NIWA 2016a).

9.3.4 Goal, targets, objectives and actions

The goal for Lake Rotoehu is:

Reduce the impact of hornwort in the northern arms of Lake Rotoehu over the next 10 years and reduce the risk of aquatic pest plants from spreading to other lakes.

LakeSPI targets have also been set for Lake Rotoehu to quantitatively assess changes in aquatic plant species and distribution and will assist in measuring progress towards achieving the goal. Lake Rotoehu has three LakeSPI targets including a minimum threshold - which the lake is precluded from falling below, 10-year target and a long-term target. The minimum threshold and targets have been developed in consultation with NIWA.

- The minimum threshold is the lowest LakeSPI value recorded from the past 15 years of monitoring (when regular LakeSPI monitoring of Rotorua Te Arawa lakes began). If the minimum threshold is breached, the plan and control activities will be reviewed. Outcomes from the review may include seeking further technical advice, amending pest plant management activities and/or gathering feedback from stakeholders. Any decisions or recommendations will be made in the wider context of control activities and programmes across Te Arawa Rotorua Lakes.
- The 10-year target is based on an improvement of five percentage points over the duration of two LakeSPI monitoring occasions beginning from the 2016 LakeSPI value (monitoring is undertaken every two years – i.e. an improvement of five percentage points every four to five years).
- The long-term target is based on the likely LakeSPI values from Lake Rotoehu during the 1960s.

Table 9.3.1 provides an overview of the minimum threshold and targets and Table 9.3.2 describes the objectives and actions for Lake Rotoehu.

Table 9.3.1 LakeSPI targets and minimum threshold for Lake Rotoehu

Site	LakeSPI value
Current Lake SPI value (2016)	19
Minimum threshold	18
10-year target	29
Long term target	62

Table 9.3.2 Lake Rotoehu aquatic plant management plan objectives and actions

Objective	Actions
Plan is supported by central, regional and local government, Te Arawa and the local community.	Obtain endorsement for the plan from Te Arawa Lakes Strategy Group.
	Seek and secure adequate funding to implement control work programmes.
	Actively involve iwi and the local community in carrying out the plan (i.e. reporting incursions and unusual findings, and providing feedback).
	Align aquatic pest plant control objective with appropriate programmes in the BOP Regional Pest Management Plan.
	Review and update aquatic plant management plan at least once every three years.
	Prepare an annual plan of works by 30 June each year.
	Report progress to Te Arawa Lakes Strategy Group and communities annually.
Improve and increase Te Arawa hapū and iwi use of the lake.	Engage with Te Arawa hapū and iwi in management of biosecurity issues.
	Engage with Te Arawa hapū and iwi on use of the Lake for cultural practises and connection to the Lakes.
	Work with Te Arawa hapū and iwi to improve access to cultural materials and mahinga kai where access is hindered by aquatic pest plants.
	Work with Te Arawa hapū and iwi to improve mahinga kai habitats where they are impacted or threatened by aquatic pest plants.
	Engage Te Arawa hapū and iwi to actively report new and unusual weed findings.
	Provide support for Te Arawa hapū and iwi to conduct cultural monitoring of the lake.
Enhance biodiversity and improve and increase local communities and visitors use of the lake.	Implement annual control programme to schedule and budget.
	Restore aquatic native plant communities through controlling aquatic pest plants.
	Ensure control works do not unreasonably hamper lake use.
	Ensure control works is effective and does not cause unintended environmental harm.
	Ensure iwi, the local community and lake users are aware of planned control works.
New pest plant incursions are detected early enough to be eradicated or controlled.	Engage community to actively report new and unusual pest plant findings.
	Carry out annual passive and proactive surveillance to detect new incursions.
	Prevent lagarosiphon, hornwort and elodea from being transferred from Lake Rotoehu to any other waterbodies.
	Prevent egeria from establishing within Lake Rotoehu.
Effectiveness and effects of pest plant control are measured and	Undertake operational monitoring to assess whether aquatic pest plant control has been successful.

Objective	Actions
results are incorporated into future works.	Undertake monitoring to detect unintentional outcomes (e.g. adverse effects to non-target plant and animal species).
	Incorporate results from monitoring into reviews and work programmes to improve future control programmes.
Research improves methods for surveillance, monitoring and control of aquatic pest plants.	Use research for the basis for decisions on aquatic pest plant management.
	Support research in aquatic pest plant management.

9.3.5 No management scenario

Invasive aquatic pest plants are present throughout Lake Rotoehu with habitat saturation by either one or multiple pest plant species. Improved water quality from surrounding catchment management will result in the pest plants growing to greater depths.

Without surveillance, additional pest plants, such as egeria, could easily become established before being identified. The scenario of not undertaking any management or monitoring is not acceptable to stakeholders or the wider public.

9.3.6 Proposed management

NIWA (2017e) established the most efficient and cost-effective methods for which to manage aquatic pest plants in Lake Rotoehu for the next three years (sites identified in Figure 9.3.1). Unless stated otherwise, the proposed methods and associated diagrams/ figures have been developed by NIWA.

Hornwort dominates the submerged vegetation in Lake Rotoehu, with elodea, lagarosiphon, curly pondweed and water buttercup recorded in the past (Burton 2016, Clayton *et al*. 1990). Egeria has not been recorded in the lake. While egeria is unlikely to be competitive against well-established hornwort, it should continue to be excluded because management options will be more limited if it invades (e.g. low susceptibility of egeria to the herbicide endothall).

Te Pōhue Bay (Figure 9.3.1) was ranked as medium priority for pest plant management due to amenity, while Ōtautū Bay and Kennedy Bay (see arrow at Ngāmimiro shoreline) were ranked as medium priority for biosecurity considerations (Dragten Consulting 2016). A considerable number of additional shoreline sites were identified for possible pest plant management (Figure 9.3.1) as all of those sites have high pest plant presence.

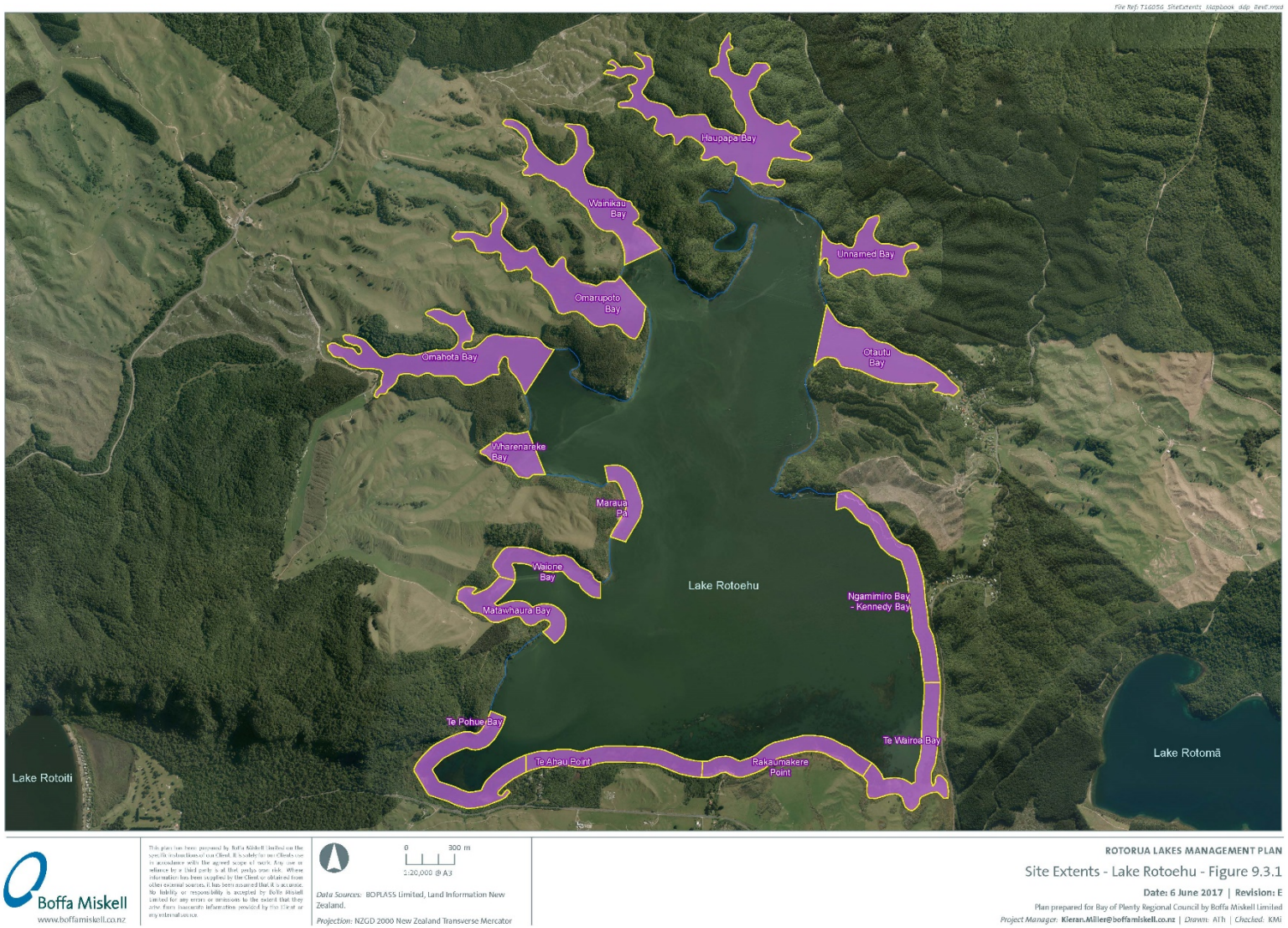
Haupapa Bay
Wainikau Bay
Unnamed Bay
Omarupoto Bay
Omahota Bay
Otautu Bay
Wharenareke Bay
Maraua Pā
Waione Bay
Lake Rotoehu
Ngamimiro Bay - Kennedy Bay
Matawhaura Bay
Te Pohue Bay
Te Wairoa Bay
Te Ahau Point
Rakaumakere Point
Lake Rotomā
Lake Rotoiti
Boffa Miskell
www.boffamiskell.co.nz
0 300 m
1:20,000 @ A3
Data Sources: BOPLASS Limited, Land Information New Zealand.
Projection: NZGD 2000 New Zealand Transverse Mercator
ROTORUA LAKES MANAGEMENT PLAN
Site Extents - Lake Rotoehu - Figure 9.3.1
Date: 6 June 2017 | Revision: E
Plan prepared for Bay of Plenty Regional Council by Boffa Miskell Limited
Project Manager: Kieran.Miller@boffamiskell.co.nz | Drawn: ATh | Checked: KMi

Figure 9.3.1

Pest plant control methods need to consider the goal statement for Lake Rotoehu to reduce hornwort in the northern arms, as well as control at biosecurity hot spots (boat ramps, jetties, popular beaches). Mechanical harvesting of drift accumulations of hornwort (Figure 9.3.2) has been carried out in Te Wairoa Bay for many years, not for amenity or biosecurity management but for nutrient remediation. Pest plant management recommendations are cognisant of and are not expected to compromise the continuation of weed harvesting initiative at the Te Wairoa site.

Figure 9.3.2 Drift hornwort accumulates in shallow bays and strands on the shoreline of Lake Rotoehu in 2016.

Ōtautū Bay and Kennedy Bay

Pest plant management at these sites should be focused on biosecurity and amenity near access points and infrastructure. Both the sites have a boat ramp and adjacent jetty. Ōtautū Bay is a deep, sheltered arm and has a weed cordon located c. 300 m from the ramp at the head of the bay (Figure 9.3.3). Kennedy Bay ramp is located at an open lake site.

Figure 9.3.3 Ōtautū Bay showing the configuration of the weed cordon (Image sourced from: Google 2016).

An annual treatment of weed beds with diquat is recommended within the cordon at Ōtautū Bay and the beach front at Kennedy Bay (Figure 9.3.4, Table 9.3.3).

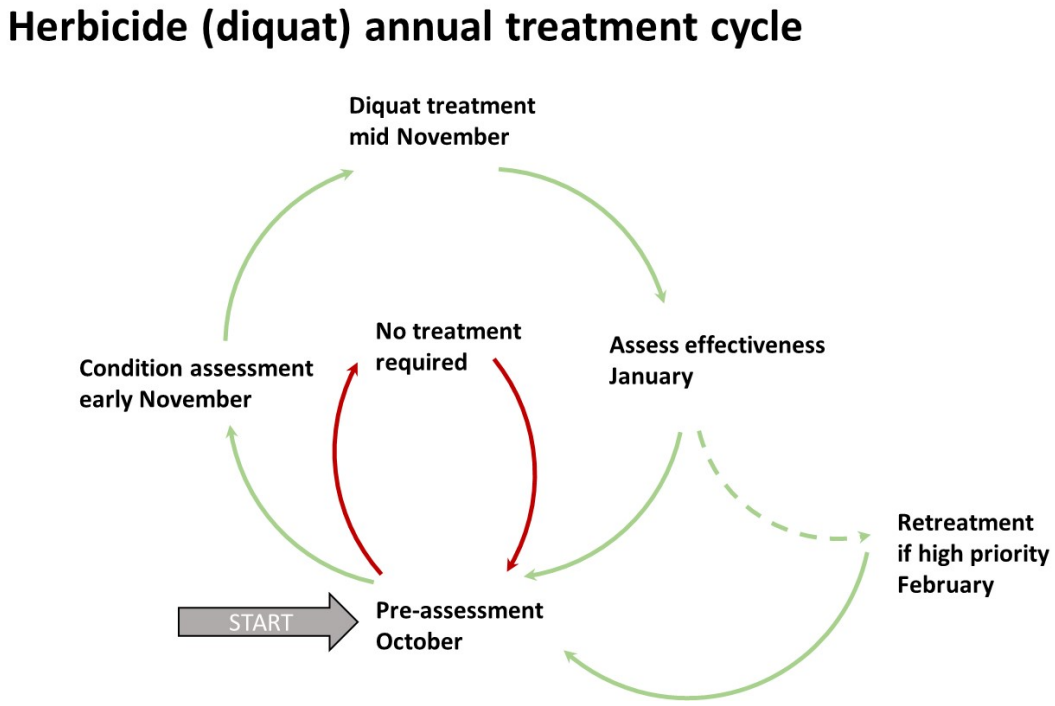

Figure 9.3.4 Annual cycle of treatment and assessment of pest plants in Lake Rotoehu using diquat.

Te Pōhue Bay

Access points at Te Pōhue Bay and use of the shoreline adjacent to Morehu Road may also benefit from ongoing control with diquat (Figure 9.3.4, Table 9.3.3).

Haupapa Bay and Unnamed Bay

The long arms with constricted entrances at the north-west of the lake offer an opportunity to intensively control hornwort and lagarosiphon, with the aim of rehabilitating native vegetation with improved conditions for amenity and ecology. Water quality has also been noted as better in these arms (Clayton et al. 1990), which will assist in native vegetation recovery. The best method is for a test rehabilitation approach in Haupapa Bay and Unnamed Bay that could then be expanded to other arms of Lake Rotoehu.

A 'drop-boom' style cordon should be installed at the narrowest constriction to each bay. This distance is approximately 40 m at Haupapa Bay and 100 m at Unnamed Bay. Shallow bathymetry at each site means boat speeds will already be greatly reduced if attempting passage and therefore the cordons should not pose a navigation hazard.

Treatment using endothall at maximum label rates (5 ppm) is recommended following cordon installation. However, endothall was trialled in Lakes Rotoiti, Rotomā and Ōkataina in 2019 with limited success. Further trials are required to optimise the use of endothall before it can be used more widely within this lake. The cordon will act to partially isolate the arms, reducing water exchange with the remainder of Lake Rotoehu and therefore maintain herbicidal concentrations of endothall for longer. Treatment is also recommended at a time of decreased rainfall/inflow to reduce dilution. The estimated areas of Haupapa Bay and Unnamed Bay are 36 ha and 10 ha respectively.

The outcome from an endothall treatment should be assessed three to four months after treatment, and at one and two years after treatment (Table 9.3.3). If a significant, long-lasting reduction in pest plants is achieved, the approach should be considered at additional sites where conditions are suitable.

Table 9.3.3 Proposed control in Lake Rotoehu for the next three years (as growth year, spring through winter) for sites identified for pest plant management (Figure 9.3.1) listed below.

Site	Year 1	Year 2	Year 3
Te Pohue Bay	Assess for diquat treatment.	Assess for diquat treatment.	Assess for diquat treatment.
Ōtautū Bay			
Ngamimiro Bay (Kennedy Bay)			
Haupapa Bay	Install cordon, treat with endothall.	Assess outcome.	Assess outcome.
Unnamed Bay	Install cordon, treat with endothall.	Assess outcome.	Assess outcome.
Te Wairoa Bay	No control.	No control.	No control.
Rakaumakere Point			
Te Ahau Point			
Matawhaura Bay			
Waione Bay			
Maraua Pa			
Omahota Bay			
Omarupoto Bay			
Wainikau Bay			

9.3.7 Surveillance

Lake Rotoehu is currently not part of the surveillance programme as it contains established populations of the most invasive aquatic pest plant (hornwort) found within the Rotorua Te Arawa Lakes area. Monitoring is still conducted within Lake Rotoehu as part of the pre-and post-spray assessments which assists in identifying aquatic pest plant incursions outside of the species already present. In the event of a new incursion, an incursion response plan will be developed by BOPRC in consultation with TALT and LINZ.

In addition to the surveillance programme, BOPRC also undertake an annual awareness campaign/survey and regularly interact with the public. They have also installed and maintain a weed cordon. Cultural monitoring also provides a form of surveillance. BOPRC will engage with Te Arawa hapū and iwi to actively report new and unusual aquatic pest plant findings.

9.4 Lake Rotomā Aquatic Plant Management Plan

9.4.1 Lake Rotomā

Lake Rotomā (meaning “lake of exceptionally clear water”) is a moderate sized lake within the Rotorua region with a surface area of approximately 1,100ha and a maximum depth of 83 m (Bay of Plenty Regional Council *et al*. 2015). Lake Rotomā is located approximately 30 km northeast of Rotorua City and 1 km east of Lake Rotoehu.

The lake contains two distinct basins, the northern and southern basin which have similar maximum depths. Numerous streams flow into the lake with water exiting the lake via porous pumice substrate to Lake Rotoehu and into groundwater. Lake Rotomā contains the greatest water clarity of all the Te Arawa Lakes with visibility up to 11 m (Bay of Plenty Regional Council *et al*. 2009a).

9.4.2 Importance of lake

Lake Rotomā is known for its clear and pristine water as well as providing many important values including cultural, biodiversity, environmental and recreational. The lake is also home to several small communities near the Whangaroa Inlet/ Bay and Te Oneroa Bay.

Lake Rotomā, along with the remaining lakes nearby, are of significant cultural importance to iwi and hapu with the lakes and surrounding environment being a central component to iwi and hapu traditions and beliefs. There are a number of significant cultural landmarks, pa sites, food gathering areas as well as urupa around the lake. Lake Rotomā in particular, contains a submerged pa site towards the centre of the lake which is marked by buoys (Bay of Plenty Regional Council *et al*. 2015). The lake contains populations of koura, kakahi, tuna and inānga for which Te Arawa have a role to sustainably manage these fisheries. There are wetlands that provide important habitat for plants, freshwater fish and birds.

Te Tūāpapa o ngā Wai o Te Arawa outlines the values of Te Arawa associated with the Lakes and also provides guidance on the principles to be applied to all decision-making processes and management activities (Te Arawa Lakes Trust & Conroy and Donald Consultants Limited 2016).

9.4.3 What is the problem?

Lake Rotomā does not share the same aquatic pest plant issues that the adjacent Lake Rotoehu suffers from. Instead, the biggest concern for Lake Rotomā is keeping hornwort and egeria out of the lake as well as controlling existing beds of lagarosiphon and elodea. Lagarosiphon and elodea outcompete and displace native aquatic species and have been identified as two of the most problematic species within Lake Rotomā and in the wider Rotorua lakes. Current pest plant issues would be compounded through the introduction and establishment of hornwort and egeria, particularly with the clear water in the lake allowing growth at deeper levels, relative to other lakes.

During the latest round of LakeSPI (submerged plant indicators) monitoring, a tool used to assess and report on the aquatic plant condition of New Zealand lakes, the lake condition status was documented as “high”. Lake Rotomā is just one of three lakes with a “high” condition status. Native condition has remained at similar levels since 1988, while invasive impact has fluctuated, recorded at 43% in 2015 from a high of 56% in 2009 (NIWA 2016a).

9.4.4 Goal, targets, objectives and actions

The goal for Lake Rotomā is:

Absence *of aquatic pest plants improves biodiversity and allows hapū / iwi, the local community and visitors to use and enjoy Lake Rotomā.*

LakeSPI targets have also been set for Lake Rotomā to quantitatively assess changes in aquatic plant species and distribution and will assist in measuring progress towards achieving the goal. Lake Rotomā has three LakeSPI targets including a minimum threshold - which the lake is precluded from falling below, 10-year target and a long-term target. The minimum threshold and targets have been developed in consultation with NIWA.

- The minimum threshold is the lowest LakeSPI value recorded from the past 15 years of monitoring (when regular LakeSPI monitoring of Rotorua Te Arawa lakes began). If the minimum threshold is breached, the plan and control activities will be reviewed. Outcomes from the review may include seeking further technical advice, amending pest plant management activities and/or gathering feedback from stakeholders. Any decisions or recommendations will be made in the wider context of control activities and programmes across Te Arawa Rotorua Lakes.
- The 10-year target is based on an improvement of five percentage points over the duration of two LakeSPI monitoring occasions beginning from the 2017 LakeSPI value (monitoring is undertaken every two years – i.e. an improvement of five percentage points every four to five years).
- The long-term target is based on the likely LakeSPI values from Lake Rotomā during the 1960s.

Table 9.4.1 provides an overview of the minimum threshold and targets and Table 9.4.2 describes the objectives and actions for Lake Rotomā.

Table 9.4.1 LakeSPI targets and minimum threshold for Lake Rotomā

Site	LakeSPI value
Current Lake SPI value (2017)	52
Minimum threshold	47
10-year target	62
Long term target	98

Table 9.4.2 Lake Rotomā aquatic plant management plan objectives and actions

Objective	Actions
Plan is supported by central, regional and local government, Te Arawa and the local community.	Obtain endorsement for the plan from Te Arawa Lakes Strategy Group.
	Seek and secure adequate funding to implement control work programmes.
	Actively involve iwi and the local community in carrying out the plan (i.e. reporting incursions and unusual findings, and providing feedback).
	Align aquatic plant control objective with appropriate programme in the BOP Regional Pest Management Plan.

Objective	Actions
	Review and update aquatic plant management plan at least once every three years.
	Prepare an annual plan of works by 30 June each year.
	Report progress to Te Arawa Lakes Strategy Group and communities annually.
Improve and increase Te Arawa hapū and iwi use of the lake.	Engage with Te Arawa hapū and iwi in management of biosecurity issues.
	Engage with Te Arawa hapū and iwi on use of the Lake for cultural practises and connection to the Lakes.
	Work with Te Arawa hapū and iwi to improve access to cultural materials and mahinga kai where access is hindered by aquatic pest plants.
	Work with Te Arawa hapū and iwi to improve mahinga kai habitats where they are impacted or threatened by aquatic pest plants.
	Engage Te Arawa hapū and iwi to actively report new and unusual weed findings.
	Provide support for Te Arawa hapū and iwi to conduct cultural monitoring of the lake.
Enhance biodiversity and improve and increase local communities and visitors use of the lake.	Implement annual control programme to schedule and budget.
	Restore aquatic native plant communities through controlling aquatic pest plants.
	Ensure control works do not unreasonably hamper lake use.
	Ensure control work is effective and does not cause unintended environmental harm.
	Ensure iwi, the local community and lake users are aware of planned control works.
New pest plant incursions are detected early enough to be eradicated or controlled.	Engage community to actively report new and unusual pest plant findings.
	Carry out annual passive and proactive surveillance to detect new pest incursions.
	Prevent lagarosiphon and elodea from being transferred from Lake Rotomā to any other waterbodies.
	Maintain weed cordons to contain any release of pest plant fragments from boat launchings.
	Prevent egeria and hornwort from establishing within Lake Rotomā.
Effectiveness and effects of pest plant control are measured and results are incorporated into future works.	Undertake operational monitoring to assess whether aquatic pest plant control has been successful.
	Undertake monitoring to detect unintentional outcomes (e.g. adverse effects to non-target plant and animal species).
	Incorporate results from monitoring into reviews and work programmes to improve future control programmes.
Research improves methods for surveillance, monitoring and control of aquatic pest plants.	Use research for the basis for decisions on aquatic pest plant management.
	Support research in aquatic pest plant management.

9.4.5 No management scenario

Lagarosiphon and elodea are currently the only invasive aquatic pest plants present within Lake Rotomā. These species, although still an issue, are not widespread within Lake Rotomā. Without active management and monitoring, these aquatic pest plants will continue to spread to other parts of the lake, reducing the extent of aquatic native habitat.

In addition to further spread of lagarosiphon and elodea, a lack of management and monitoring could result in the introduction and establishment of hornwort and egeria. This is a particularly high threat to Lake Rotomā with the presence of hornwort in Lake Rotoehu 1 km away. The scenario of not undertaking any management or monitoring is not acceptable to stakeholders or the wider public.

9.4.6 Proposed management

NIWA (2017 g) established the most efficient and cost-effective methods for which to manage aquatic pest plants in Lake Rotomā for the next three years (sites identified in Figure 9.4.1). Unless stated otherwise, the proposed methods and associated diagrams/ figures have been developed by NIWA.

Lake Rotomā is an exceptional lake with excellent water quality and minimal impact from invasive aquatic pest plant species. The only pest plant species of ecological and recreational significance in Lake Rotomā is lagarosiphon.

Two shoreline areas; Matahi Spit and Whangaroa Bay (Figure 9.4.1), were identified as high priority for aquatic pest plant management on biosecurity grounds (Dragten Consulting 2016). Lake Rotomā has two boat ramps along the southern shoreline; one at the western end of the lake just outside of the Whangaroa Inlet; and one at the south-eastern end of the lake off Matahi Road. These two boat ramps both have cordons established, which provide the first key line of defence against invasive aquatic pest plant species introductions from boats and trailers. These cordons have already proven effective in intercepting invasive species. The key to effective prevention consists of public and lake user education, boat/trailer inspections and regular monitoring within the cordoned areas. Spraying within these cordon areas is not recommended, unless there is a substantial presence of newly established invasive species or if there are dense beds of lagarosiphon that may obstruct detection of new invasive aquatic pest plant species. The presence of native charophytes and rooted lagarosiphon within the cordon areas helps to prevent drift and escape of any introduced, non-rooted hornwort or egeria fragments. Regular diver inspection within both cordoned areas is essential to identify early intrusion and ensure effective removal.

Herbicide treatment using diquat at the shoreline units identified in Figure 9.4.1 would be appropriate if there was a realistic prospect of achieving an effective control outcome for lagarosiphon, but there are few if any sites in Lake Rotomā where this is likely to be the case due to site limitations on the efficacy of herbicide use. Herbicides would likely be diluted by the water column overlying the deep weed beds. Another key issue in deciding the scale and location of proposed diquat treatment in Lake Rotomā, is what biosecurity benefits and/or ecological gains can be achieved, as there is generally a low probability of contact by recreational boating with existing weed beds.

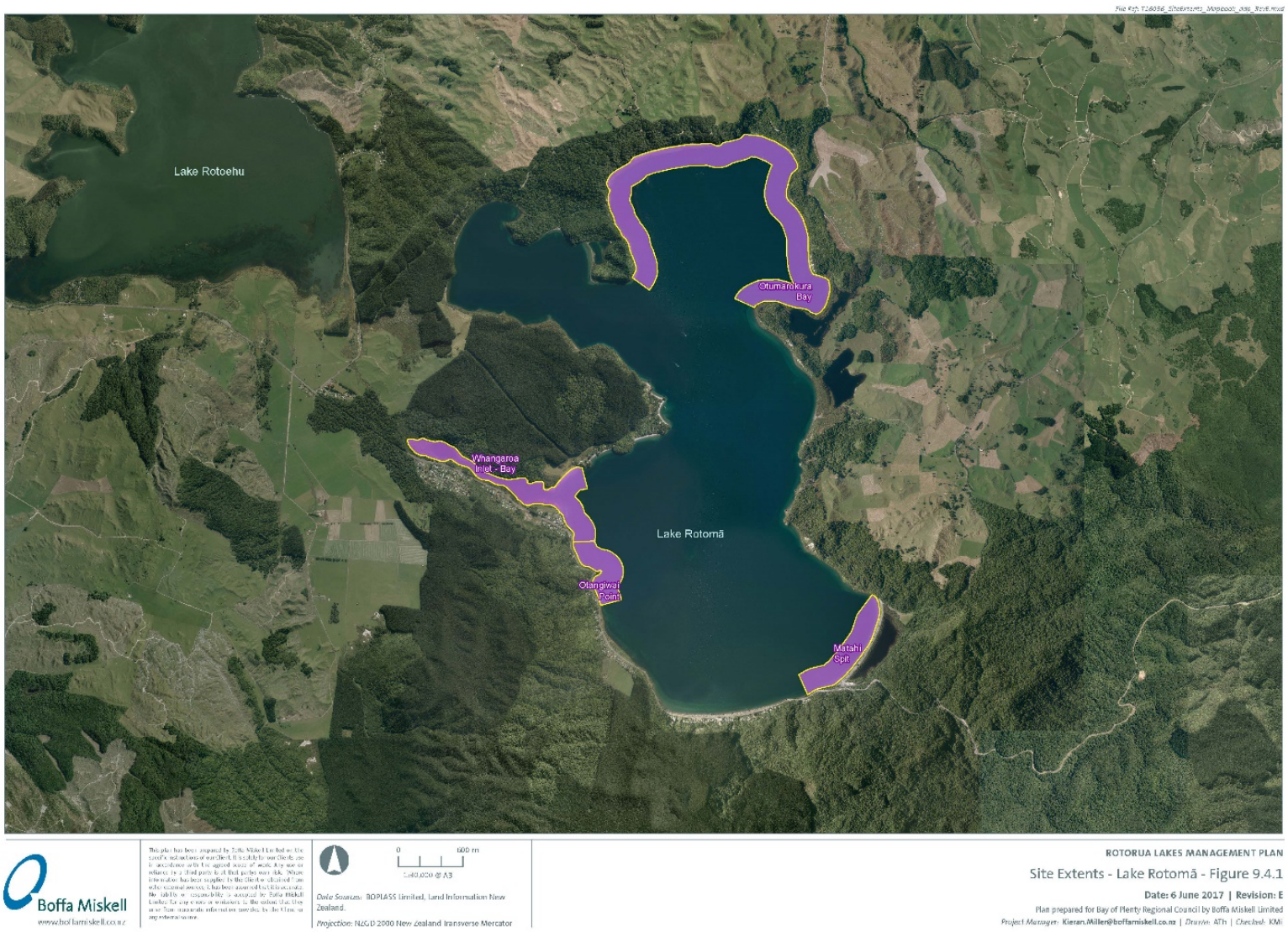
Lake Rotoehu
Otumaraikura Bay
Whangaroa Inlet - Bay
Lake Rotomā
Otangiwai Point
Matahi Spit
Boffa Miskell
www.boffamiskell.co.nz
0
600 m
1:40,000 @ A3
Data Sources: BOPLASS Limited, Land Information New Zealand.
Projection: NZGD 2000 New Zealand Transverse Mercator
ROTORUA LAKES MANAGEMENT PLAN
Site Extents - Lake Rotomā - Figure 9.4.1
Date: 6 June 2017 | Revision: E
Plan prepared for Bay of Plenty Regional Council by Boffa Miskell Limited

Figure 9.4.1

Otumarokura Bay

The road access site at the northern end of the lake has no boat ramp and only small craft can access the lake from this site. Few boats are launched here. This location poses a relatively low risk for entry of new pest plant species, compared to access sites along the southern end of Lake Rotomā. The treatment of approximately 5 km of lake shoreline at the northern end of Lake Rotomā, would provide questionable benefit for reducing biosecurity risk (e.g. minimal boat launching). The potential to enhance submerged native species recovery in place of lagarosiphon is questionable because of the depth of lagarosiphon beds and the degree of exposure to open water which would reduce diquat contact times. Diquat treatment of c.150 m of shoreline in the north-eastern corner of the lake could be considered for reducing lagarosiphon in the area were boats are occasionally launched or beached. Here, lagarosiphon is mostly present in 2-5 m depth of water, so the potential benefits of diquat treatment would be limited.

Matahi Spit

Treatment of diquat along the south-eastern shoreline of Lake Rotomā is also not recommended. This is a relatively exposed length of shoreline with bare sand extending out 20-30 m from the water margin. Furthermore, the boat ramp does not come close to any submerged weed beds. Beyond the bare sandy zone there are extensive native charophyte beds extending out to the 'drop-off' at c. 3-4 m, which is where the invasive lagarosiphon weed beds grow. The wind and wave exposure in this area ensures no lagarosiphon grows anywhere near the surface and there is no interference to boaties or recreational swimmers.

The wide-scale diquat treatment proposed for this and other areas in Lake Rotomā would be of relevance if widespread native vegetation recovery was feasible. However, the costs would be high, on-going, and the benefits insubstantial. If egeria and/or hornwort were to establish outside of the cordoned areas in Lake Rotomā, then targeted treatment (such as underwater diver application from a surface spray boat) would be appropriate. Weed cordons will need to be continually maintained to provide the best chance of preventing Egeria and/or hornwort incursions.

Otangiwhai Point

Otangiwhai Point (c. 150 m south east of the south west cordon) should be regularly inspected using SCUBA divers as this is a popular training site for SCUBA Dive School instructors. Periodic reminder of appropriate "Check, Clean & Dry" procedures should be reinforced with SCUBA instructors, as this activity could pose a risk where any introduced fragments could drift and spread without easy detection. Clearly "Prevention is better than cure"; but early detection is the next best thing.

Whangaroa Bay

The south west arm of Lake Rotomā once had a boat ramp at the western end, but now there are no boats launched here. There is one resident boat that remains on the shoreline and likely has no contact with other lakes. Kayakers also enter this sheltered arm, but these activities pose little risk of introducing new invasive aquatic pest plant species to the lake.

In summary, Lake Rotomā is a special lake with considerable ecological and recreational values. The established lagarosiphon beds that have dominated the mid-depth zone of this lake since the early 1970's is the least ecologically and recreationally disruptive of all the major invasive species in the Rotorua lakes region. Management priorities should therefore focus primarily on preventing incursion of hornwort and egeria, along with surveillance for early detection within the lake at identified sensitive sites and increased funding would be more appropriately focussed on surveillance for those species.

9.4.7 Surveillance

Surveillance monitoring is conducted in Lake Rotomā twice a year using a variety of methods including:

- SCUBA searches using manta board tows with the boat operator controlling the search pattern,
- Spot diving,
- Snorkelling,
- SCUBA diving using an underwater scooter, and/or
- Shoreline searches.

Surveillance monitoring sites are pre-determined using a prioritisation model which assesses lake specific sites based on parameters such as likely pest plant entry, recreational use and ability to detect new incursions. Records are kept from each surveillance monitoring occasion.

Monitoring is also conducted within Lake Rotomā as part of the pre-and post spray assessments which assists in identifying aquatic pest plant incursions outside of the species already present. In the event of a new incursion, an incursion response plan will be developed by BOPRC in consultation with TALT, LINZ and other stakeholders.

In addition to the surveillance programme, BOPRC also undertake an annual awareness campaign/ survey and regularly interact with the public. They also provide a portable wash down facility during the summer months and have installed weed cordons. Cultural monitoring also provides a form of surveillance. BOPRC will engage with Te Arawa hapū and iwi to actively report new and unusual aquatic pest plant findings.

9.5 Lake Ōkataina Aquatic Plant Management Plan

9.5.1 Lake Ōkataina

Lake Ōkataina (Te Moana-i-kataina-a-Te Rangitakaroro – *The ocean where Te Rangitakaroro laughed)* is a moderate sized lake within the Rotorua region with a surface area of approximately 1,080 ha and a maximum depth of 79 m (Bay of Plenty Regional Council *et al*. 2015). Lake Ōkataina is located approximately 12 km east of Rotorua City and 2 km north of Lake Tarawera.

Lake Ōkataina only contains two permanent streams flowing into the lake and no surface outlets, with water draining into Lake Tarawera through sub-surface flows. Water levels are largely influenced by rainfall with sub-surface springs also assumed to be a source of water entering the lake. Lake Ōkataina has a relatively high water clarity compared to other lakes within the region and is unique in that it is the only lake where most of the catchment is native forest (Bay of Plenty Regional Council et al. 2012).

9.5.2 Importance of lake

Lake Ōkataina and the surrounding catchment provides several important values, particularly biodiversity with a scenic reserve surrounding large portions of the lake. Other values include cultural, environmental and recreational.

Lake Ōkataina, along with the remaining lakes nearby, are of significant cultural importance to iwi and hapu with the lakes and surrounding environment being a central component to iwi and hapu traditions and beliefs. There are a number of significant cultural landmarks, pa sites, food gathering areas as well as urupa around the lake. Lake Ōkataina in particular, is an important place for Ngāti Tarāwhai and Ngāti Kohuūpoko tribes who both lived around the shores (Bay of Plenty Regional Council et al. 2012). The lake contains populations of koura, kakahi, tuna and inānga for which Te Arawa have a role to sustainably manage these fisheries. There are wetlands that provide important habitat for plants, freshwater fish and birds.

Te Tūāpapa o ngā Wai o Te Arawa outlines the values of Te Arawa associated with the Lakes and also provides guidance on the principles to be applied to all decision-making processes and management activities (Te Arawa Lakes Trust & Conroy and Donald Consultants Limited 2016).

9.5.3 What is the problem?

Aquatic pest plant species present within Lake Ōkataina include lagarosiphon, elodea and hornwort. These species have been identified as three of the most problematic species within Lake Ōkataina and in the wider Rotorua lakes. Lagarosiphon, elodea and hornwort are not as widespread in Lake Ōkataina, compared to other lakes within the region. However, there is potential that these species will continue to spread, creating dense weed beds and displacing native aquatic species. Issues would be further compounded through the introduction and establishment of egeria.

During the latest round of LakeSPI (submerged plant indicators) monitoring, a tool used to assess and report on the aquatic plant condition of New Zealand lakes, the lake condition status was documented as “moderate”. Invasive impact and native condition scores have fluctuated marginally since 1988 and were recorded at 63% and 42%, respectively, during the latest monitoring round in 2014 (NIWA 2016a).

9.5.4 Goal, targets, objectives and actions

The goal for Lake Ōkataina is:

Improved native plant biodiversity and taonga species of the Lake Ōkataina enhances hapū/iwi, local community and visitor enjoyment.

LakeSPI targets have also been set for Lake Ōkataina to quantitatively assess changes in aquatic plant species and distribution and will assist in measuring progress towards achieving the goal. Lake Ōkataina has three LakeSPI targets including a minimum threshold - which the lake is precluded from falling below, 10-year target and a long-term target. The minimum threshold and targets have been developed in consultation with NIWA.

- The minimum threshold is the lowest LakeSPI value recorded from the past 15 years of monitoring (when regular LakeSPI monitoring of Rotorua Te Arawa lakes began). If the minimum threshold is breached, the plan and control activities will be reviewed. Outcomes from the review may include seeking further technical advice, amending pest plant management activities and/or gathering feedback from stakeholders. Any decisions or recommendations will be made in the wider context of control activities and programmes across Te Arawa Rotorua Lakes.
- The 10-year target is based on an improvement of five percentage points over the duration of two LakeSPI monitoring occasions beginning from the 2016 LakeSPI value (monitoring is undertaken every two years – i.e. an improvement of five percentage points every four to five years).
- The long-term target is based on the likely LakeSPI values from Lake Ōkataina during the 1960s.

Table 9.5.1 provides an overview of the minimum threshold and targets and Table 9.5.2 describes the objectives and actions for Lake Ōkataina.

Table 9.5.1 LakeSPI targets and minimum threshold for Lake Ōkataina

Site	LakeSPI value
Current Lake SPI value (2016)	38
Minimum threshold	38
10-year target	48
Long term target	72

Table 9.5.2 Lake Ōkataina aquatic plant management plan objectives and actions

Objective	Actions
Plan is supported by central, regional and local government, Te Arawa and the local community.	Obtain endorsement for the plan from Te Arawa Lakes Strategy Group.
	Seek and secure adequate funding to implement control work programmes.
	Actively involve iwi and the local community in carrying out the plan (i.e. reporting incursions and unusual findings, and providing feedback).
	Align aquatic pest plant control objective with appropriate programmes in the BOP Regional Pest Management Plan.
	Review and update aquatic plant management plan at least once every three years.
	Prepare an annual plan of works by 30 June each year.
	Report progress to Te Arawa Lakes Strategy Group and communities annually.
Improve and increase Te Arawa hapū and iwi use of the lake.	Engage with Te Arawa hapū and iwi in management of biosecurity issues.
	Engage with Te Arawa hapū and iwi on use of the Lake for cultural practises and connection to the Lakes.
	Work with Te Arawa hapū and iwi to improve access to cultural materials and mahinga kai where access is hindered by aquatic pest plants.
	Work with Te Arawa hapū and iwi to improve mahinga kai habitats where they are impacted or threatened by aquatic pest plants.
	Engage Te Arawa hapū and iwi to actively report new and unusual weed findings.
	Provide support for Te Arawa hapū and iwi to conduct cultural monitoring of the lake.
Enhance biodiversity and improve and increase local communities and visitors use of the lake.	Implement annual control programme to schedule and budget.
	Restore aquatic native plant communities through controlling aquatic pest plants.
	Ensure control works do not unreasonably hamper lake use.
	Ensure control work is effective and does not cause unintended environmental harm.
	Ensure iwi, the local community and lake users are aware of planned control works.
	Eradicate hornwort from Lake Ōkataina.
New pest plant incursions are detected early enough to be eradicated or controlled.	Engage community to actively report new and unusual pest plant findings.
	Carry out annual passive and proactive surveillance to detect new pest incursions.
	Maintain weed cordon to contain any release of pest plant fragments from boat launchings.
	Prevent hornwort, lagarosiphon and elodea from being transferred from Lake Ōkataina to any other waterbodies.

Objective	Actions
	Prevent egeria from establishing within Lake Ōkataina.
Effectiveness and effects of pest plant control are measured and results are incorporated into future works.	Undertake operational monitoring to assess whether aquatic pest plant control has been successful.
	Undertake monitoring to detect unintentional outcomes (e.g. adverse effects to non-target plant and animal species).
	Incorporate results from monitoring into reviews and work programmes to improve future control programmes.
Research improves methods for surveillance, monitoring and control of aquatic pest plants.	Use research for the basis for decisions on aquatic pest plant management.
	Support research in aquatic pest plant management.

9.5.5 No management scenario

Lagarosiphon, hornwort and elodea are not as widespread within Lake Ōkataina, compared to other Rotorua Te Arawa lakes. Without active management and monitoring, these aquatic pest plants will continue to spread to other parts of the lake, reducing the extent of aquatic native habitat.

In addition to the further spread of hornwort, lagarosiphon and elodea, a lack of management and monitoring could result in the introduction and establishment of egeria. This is a particularly high threat to Lake Ōkataina with the presence of egeria in nearby Lake Rotorua, Lake Rotoiti and Lake Tarawera. The scenario of not undertaking any management or monitoring is not acceptable to stakeholders or the wider public.

9.5.6 Proposed management

NIWA (2017c) established the most efficient and cost-effective methods for which to manage aquatic pest plants within Lake Ōkataina for the next three years. Unless stated otherwise, the proposed methods and associated diagrams/ figures have been developed by NIWA.

Key aquatic pest plant species recorded from Lake Ōkataina are lagarosiphon and hornwort (Clayton *et al.* 1990, Burton, 2016). Although elodea is present, it has minimal impact on lake vegetation or public lake usage. Lagarosiphon has dominated the submerged vegetation in this lake since the 1970's, while hornwort was first recorded in 2009 near the boat ramp/jetty (Burton 2016). Hornwort was subsequently found as drift fragments near the Log Pool stream, later followed by large beds at the head of the lake (Motuwhetero Island Bays). Both infestation sites are thought to have originated either from a boat anchor well or fly fishing equipment. An intensive pest plant control programme was launched with the installation of a boom at the south-west head of the lake to help contain hornwort; along with surface applied and diver injected diquat on all known hornwort infestation sites. Diver surveillance for hornwort presence has been (and continues to be) widespread and thorough. The success of the hornwort control programme in Lake Ōkataina has been quite exceptional and beyond expectations.

Based on management actions in other Rotorua lakes it was assumed that hornwort in Ōkataina would continue to spread. However, it now appears possible to substantially reduce and even eliminate hornwort infestation sites. Lake water chemistry could be a key factor in inhibiting prolific growth, as well as exceptional native plant recovery following pest plant control measures using herbicide. It is also possible that stream inflows from the forested catchment provide higher nutrient concentrations than the lake water, which could explain the prolific growths at the head of the lake (Motuwhetero Island Bays) and Tahunapo Bay (Log Pool Bay) (Figure 9.5.1). Hornwort drift from these likely source sites has been found at Tauranganui Bay (Boat Ramp Bay), Ngahaua Bay (eradicated by hand weeding) and areas within Oruaroa and Otangimoana Bays (south-east bay), especially in deep water. Although these deep water infestations have been sprayed with diquat, it appears their growth may be nutrient and/or light limited and potentially easily controlled or even eradicated using herbicide.

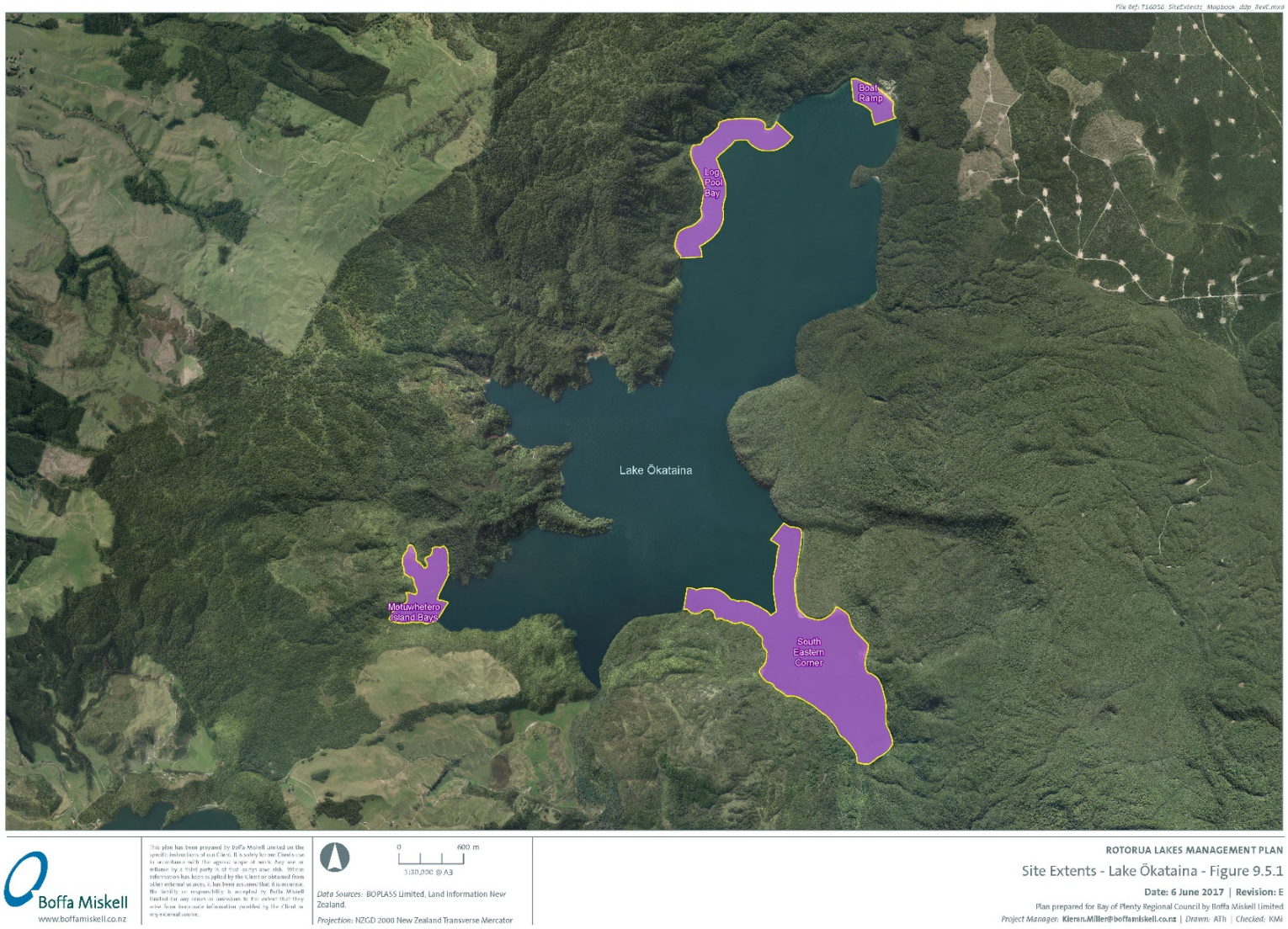
Boat Ramp
Log Pool Bay
Lake Ōkataina
Motuwhetero Island Bays
South Eastern Corner
Boffa Miskell
www.boffamiskell.co.nz
0
600 m
1:30,000 @ A3
Data Sources: BOPLASS Limited, Land Information New Zealand.
Projection: NZGD 2000 New Zealand Transverse Mercator
ROTORUA LAKES MANAGEMENT PLAN
Site Extents - Lake Ōkataina - Figure 9.5.1
Date: 6 June 2017 | Revision: E
Plan prepared for Bay of Plenty Regional Council by Boffa Miskell Limited
Project Manager: Kieran.Miller@boffamiskell.co.nz | Drawn: ATh | Checked: KMi

Figure 9.5.1

Priority rankings for aquatic pest plant management (Dragten Consulting 2016) reflect the risk of pest plant transfer in and out of Lake Ōkataina rather than ongoing management of hornwort incursion. Tauranganui Bay (Boat Ramp Bay) (Figure 9.5.1) is considered high priority and Tahunapo Bay (Log Pool Bay) medium priority based on biosecurity considerations.

Hornwort incursion response

Since hornwort is the most immediate threat to vegetation composition in Lake Ōkataina it is recommended that targeted surveillance is continued for all historical and high risk sites at least annually, with more regular inspection of currently known infestation sites. Diquat has proven to be a cost effective management tool and should continue to be applied to known active infestation sites up to twice a year (Figure 9.5.2, Table 9.5.3). However, the frequency, location and extent of diquat treatment should be guided by the results of prior inspection. For example, there are areas where hornwort plants have been found anchored in the sediment, but once removed there has been no further sighting or control works required.

Tauranganui Bay (Boat Ramp Bay)

The ability to restore native aquatic vegetation along the entire length of the northern bay (boat ramp access) using diquat herbicide, has already been demonstrated in earlier years. Lagarosiphon is the primary invasive aquatic plant species dominating the littoral margins around Lake Ōkataina. Previous diquat application has resulted in a substantial collapse of lagarosiphon; followed by the recovery of desirable native plants, including pondweeds, milfoils and charophytes. Diquat application in this lake has demonstrated the potential to rejuvenate the native vegetation along the entire treated shoreline and in doing so, also replenish native plant seed banks in the bottom sediments. Once rejuvenation of the native vegetation and the duration achieved is confirmed (Figure 9.5.2, Table 9.5.3), this tactic can be considered for other shorelines of Lake Ōkataina.

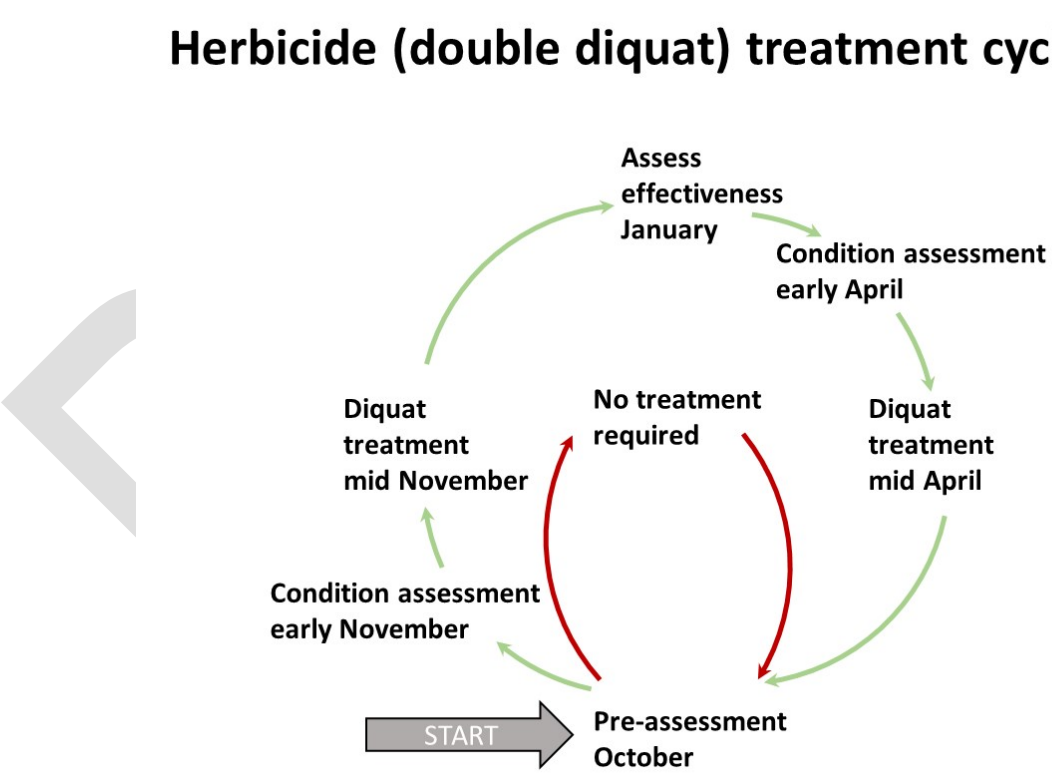

Figure 9.5.2 Annual cycle of treatment for hornwort incursion using diquat.

Monitoring and Research

Lake Ōkataina requires regular monitoring since the drivers of hornwort growth and decline are not well understood. The ability of hornwort to spread around the lake from drift fragments is a major threat, requiring as much emphasis on surveillance as it does on diquat control of known established beds. Lake Ōkataina has many similarities to Lake Rotomā in terms of vegetation composition and pest plant threats. Although hornwort appeared initially to pose a major threat to Ōkataina, there is some uncertainty over its sustainability or level of threat, hence pest plant control measures for this species need to be evidence-based, and supported by regular monitoring. Experimental evaluation of the role and importance of nutrient limitation in water and sediment would be helpful in determining under what conditions hornwort simply 'survives' or exhibits 'vigorous weed growth'. The same applies to egeria, which could also be easily confirmed, based on secure in situ or mesocosm testing (outdoor experimental system that examines the natural environment under controlled conditions).

The findings from the proposed initiatives above could also have considerable relevance to Lake Rotomā, since this lake is on high alert for threats from hornwort and egeria invasion. It is possible that nutrient limitation in Lake Rotomā has been the sole reason for hornwort and egeria not having established in that lake. It is interesting to note that Lake Tikitapu has never recorded hornwort or egeria; despite high boat traffic and easy access. Earlier research had already indicated that low nutrient status of the water was likely responsible for the absence of both species in Lake Tikitapu, as well as explaining the stunted growth form of lagarosiphon. The role of nutrient limitation is particularly relevant for evaluating future and on-going pest plant threats (egeria and hornwort) in Lakes Ōkataina and Rotomā. For example, mesocosm studies using lake water and lake bottom sediments from Lakes Rotomā and Ōkataina, could be used to assess hornwort and egeria growth responses to help better prioritise risk and pest plant management actions.

Lakes Ōkataina and Rotomā pose relevant questions regarding the risk and sustainability of egeria and hornwort growth, especially for hornwort where absence of roots results in a greater dependency on lake water nutrient concentrations for growth.

Table 9.5.3 Proposed control for the next three years (as growth year, spring through winter) for sites identified for pest plant management (Figure 9.5.1) listed below

Site	Year 1	Year 2	Year 3
(Tauranganui Bay) Boat Ramp Bay	Annual diquat control.	Annual diquat control.	Pre-inspection validation.
SW corner Motuwhataro Bay			
Tahunapo Bay (Log Pool Bay)	Annual diquat control.	Annual diquat control.	Annual diquat control.
SE Corner Otangimoana Bay	Pre-inspection validation.	Pre-inspection validation.	Pre-inspection validation.

9.5.7 Surveillance

Surveillance monitoring is conducted in Lake Ōkataina twice a year using a variety of methods including:

- SCUBA searches using manta board tows with the boat operator controlling the search pattern,
- Spot diving,
- Snorkelling,
- SCUBA diving using an underwater scooter, and/or
- Shoreline searches.

Surveillance monitoring sites are pre-determined using a prioritisation model which assesses lake specific sites based on parameters such as likely pest plant entry, recreational use and ability to detect new incursions. Surveillance monitoring sites within Lake Ōkataina have also been determined from known hornwort locations and sites identified by the hornwort incursion response plan (BOPRC 2010). Records are kept from each surveillance monitoring occasion.

Monitoring is also conducted within Lake Ōkataina as part of the pre-and post spray assessments which assists in identifying aquatic pest plant incursions outside of the species already present. In the event of a new incursion, an incursion response plan will be developed by BOPRC in consultation with TALT, LINZ and other stakeholders.

In addition to the surveillance programme, BOPRC also undertake an annual awareness campaign/survey and regularly interact with the public. They also provide a portable wash down facility during the summer months and have installed a weed cordon. Cultural monitoring also provides a form of surveillance. Bay of Plenty Regional Council will engage with Te Arawa hapū and iwi to actively report new and unusual aquatic pest plant findings.

9.6 Lake Ōkāreka Aquatic Plant Management Plan

9.6.1 Lake Ōkāreka

Lake Ōkāreka (meaning “The lake of sweet food”) is a small sized volcanic lake within the Rotorua region with a surface area of approximately 350 ha and a maximum depth of 34 m (Bay of Plenty Regional Council *et al*. 2015). Lake Ōkāreka is located approximately 9 km east of Rotorua City and just over 1 km west of Lake Tarawera. In the past, water quality has been affected by excessive nutrient inputs; however, current water quality is showing a stable trend and the lake is now considered a mesotrophic lake due to its moderate levels of algal productivity and reasonably clean water.

Water flows into Lake Ōkāreka via several streams within the catchment, with two outflows to Lake Tarawera including Waitangi Springs and an artificial surface channel (Bay of Plenty Regional Council *et al*. 2015).

9.6.2 Importance of lake

Lake Ōkāreka is one of the Rotorua Te Arawa Lakes best known for its clear and pristine water as well as providing several important values including cultural, biodiversity, environmental, economic and recreational. The lake is also home to a small community along the western shores of the lake.

Lake Ōkāreka, along with the remaining lakes nearby, are of significant cultural importance to iwi and hapu with the lakes and surrounding environment being a central component to iwi and hapu traditions and beliefs. There are a number of significant cultural landmarks, pa sites, food gathering areas as well as urupa around the lake. Lake Ōkāreka in particular, is a known site where Maori grew kumara on the lake margins (Bay of Plenty Regional Council *et al*. 2015). The lake contains populations of koura, kakahi, tuna and inānga for which Te Arawa have a role to sustainably manage these fisheries. There are wetlands that provide important habitat for plants, freshwater fish and birds.

Te Tūāpapa o ngā Wai o Te Arawa outlines the values of Te Arawa associated with the Lakes and also provides guidance on the principles to be applied to all decision-making processes and management activities (Te Arawa Lakes Trust & Conroy and Donald Consultants Limited 2016).

9.6.3 What is the problem?

The first invasive pest plant species to establish in Lake Ōkāreka was elodea, likely in the mid 1950-60’s, followed by lagarosiphon in the 1970’s and egeria in the early 2000’s. Hornwort plants were discovered growing within the lake in 2012, with subsequent actions to survey the extent and eradicate plants (Bay of Plenty Regional Council 2015a). Monitoring subsequent to an extensive diquat operation has not found any further hornwort plants.

These species have been identified as four of the most problematic species within Lake Ōkāreka and in the wider Rotorua lakes. Currently in Lake Ōkāreka, native charophyte beds dominate the deeper depth bands (seven to 12 m) with lagarosiphon forming dense weed beds between 2 m and 7 m and egeria at 8 m-9 m. Currently, the charophyte meadows are not being impacted on by invasive weeds due to lagarosiphon and egeria being pressure sensitive and do not typically inhabit these depths. However, hornwort can grow to depths exceeding the current depth limit of native plants in Lake Ōkāreka and therefore pose a significant threat to the remaining native vegetation.

During the latest round of LakeSPI (submerged plant indicators) monitoring, a tool used to assess and report on the aquatic plant condition of New Zealand lakes, the lake condition status was documented as “high”. Lake Ōkāreka is just one of three lakes with a “high” condition status. Over the most recent monitoring occasion in 2015, native condition improved to 53% while invasive impact declined to 36% (NIWA 2016a). This is a result of an intense campaign to remove canopies of egeria and lagarosiphon to allow better surveillance of hornwort.

9.6.4 Goal, targets, objectives and actions

The goal for Lake Ōkāreka is:

Eradication of hornwort, lagarosiphon, elodea and egeria from Lake Ōkāreka.

Lake Ōkāreka has been selected as a trial lake to eradicate hornwort, lagarosiphon, elodea and egeria using a combination of aquatic pest plant control methods. Selection of Lake Ōkāreka was based on several factors including:

- the presence of multiple problem weed species at relatively high densities,
- a community presence adjacent to the lake as well as it being a popular recreational lake for both locals and tourists,
- it being a moderate sized lake which is a scale of magnitude larger from other waterbodies where local eradications have been achieved within Bay of Plenty, but small enough to test the feasibility of lake-scale eradication without resource requirements being unrealistically high.

The results of eradication activities will be assessed, with effective techniques applied to other lakes or lake areas where suitable.

A long term LakeSPI target has been set for Lake Ōkāreka to quantitatively assess changes in aquatic plant species and distribution and to assist in measuring progress towards achieving the goal. The LakeSPI target has been developed in consultation with NIWA and is based on the lake being in a native state with no invasive weeds as it likely was during the 1950s/60s.

Table 9.6.1 provides an overview of the existing LakeSPI values and long-term target and Table 9.6.2 describes the objectives and actions for Lake Ōkāreka.

LakeSPI targets have also been set for Lake Ōkāreka to quantitatively assess changes in aquatic plant species and distribution and will assist in measuring progress towards achieving the goal. Lake Ōkāreka has three LakeSPI targets including a minimum threshold - which the lake is precluded from falling below, 10-year target and a long-term target. The minimum threshold and targets have been developed in consultation with NIWA.

- The minimum threshold is the lowest LakeSPI value recorded from the past 15 years of monitoring (when regular LakeSPI monitoring of Rotorua Te Arawa lakes began). If the minimum threshold is breached, the plan and control activities will be reviewed. Outcomes from the review may include seeking further technical advice, amending pest plant management activities and/or gathering feedback from stakeholders. Any decisions or recommendations will be made in the wider context of control activities and programmes across Te Arawa Rotorua Lakes.

- The 10-year target is based on an improvement of five percentage points over the duration of two LakeSPI monitoring occasions beginning from the 2013[1] LakeSPI value (monitoring is undertaken every two years – i.e. an improvement of five percentage points every four to five years).
- The long-term target is based on the likely LakeSPI values from Lake Ōkāreka during the 1950s/60s.

Table 9.6.1 provides an overview of the minimum threshold and targets and Table 9.6.2 describes the objectives and actions for Lake Ōkāreka.

Table 9.6.1 LakeSPI targets and minimum threshold for Lake Ōkāreka

Site	LakeSPI value
Current Lake SPI value (2017)	50
2013 Lake SPI value	36
Minimum threshold	34
10-year target	46
Long term target	76

Table 9.6.2 Lake Ōkāreka aquatic plant management plan objectives and actions

Objective	Actions
Plan is supported by central, regional and local government, Te Arawa and the local community.	Obtain endorsement for the plan from Te Arawa Lakes Strategy Group.
	Seek and secure adequate funding to implement eradication work programmes.
	Actively involve iwi and the local community in carrying out the plan (i.e. reporting incursions and unusual findings and providing feedback).
	Align aquatic pest plant eradication objective with appropriate programmes in the BOP Regional Pest Management Plan.
	Review and update aquatic plant management plan at least once every three years.
	Prepare an annual plan of works by 30 June each year.
	Report progress to Te Arawa Lakes Strategy Group and communities annually.
Improve and increase Te Arawa hapū and iwi use of the lake.	Engage with Te Arawa hapū and iwi in management of biosecurity issues.
	Engage with Te Arawa hapū and iwi on use of the Lake for cultural practises and connection to the Lakes.
	Work with Te Arawa hapū and iwi to improve access to cultural materials and mahinga kai where access is hindered by aquatic pest plants.
	Work with Te Arawa hapū and iwi to improve mahinga kai habitats where they are impacted or threatened by aquatic pest plants.

[1] The 2013 LakeSPI value has been used to take into account the recent control efforts undertaken within Lake Ōkāreka.

Objective	Actions
	Engage Te Arawa hapū and iwi to actively report new and unusual weed findings.
	Provide support for Te Arawa hapū and iwi to conduct cultural monitoring of the lake.
Enhance biodiversity and improve and increase local communities and visitors use of the lake.	Implement eradication programme to schedule and budget each year.
	Ensure eradication management do not unreasonably hamper lake use.
	Ensure eradication management does not cause unintended environmental harm.
	Ensure iwi, the local community and lake users are aware of planned eradication activities.
	Eradicate hornwort, lagarosiphon, egeria and elodea from Lake Ōkāreka.
	Restore aquatic native plant communities through eradicating hornwort, lagarosiphon, egeria and elodea from Lake Ōkāreka.
New pest plant incursions are detected early enough to be eradicated or controlled.	Engage community to actively report new and unusual pest plant findings.
	Carry out annual passive and proactive surveillance to detect new pest incursions.
	Maintain weed cordon to contain any release of pest plant fragments from boat launchings.
	Prevent hornwort, lagarosiphon, egeria and elodea from being transferred from Lake Ōkāreka to any other waterbodies.
Effectiveness and effects of pest plant control are measured and results are incorporated into future works.	Undertake operational monitoring to assess the success and progress of aquatic pest plant eradication.
	Undertake monitoring to detect unintentional outcomes (e.g. adverse effects to non-target plant and animal species).
	Incorporate results from monitoring into reviews and work programmes to improve future control programmes.
	Assess appropriateness of applying effective pest plant control techniques to other lakes or lake areas.
Research improves methods for surveillance, monitoring and control of aquatic pest plants.	Use research for the basis for decisions on aquatic pest plant management.
	Support research in aquatic pest plant management.

9.6.5 Previous and existing aquatic pest plant management

2011 weed cordon installed

A weed cordon designed to prevent the spread of invasive aquatic weeds was installed at the Acacia Road boat ramp on 22 November 2011. At the time of weed cordon installation, Lake Ōkāreka was known to contain three aquatic pest plant species; elodea, lagarosiphon and egeria. The cordon installation was done with the intention of reducing the risk of any hornwort incursions along with managing the vectoring of elodea, lagarosiphon and egeria from the lake.

2012 hornwort incursion

Hornwort fragments were detected and reported to BOPRC in April 2012. The report was followed up with surveillance by BOPRC divers and NIWA scientists. Several fragments were found; one within the weed cordon in emergent raupo, one in front of the Steep Street Reserve and scattered plants and fragments throughout the north-western bays from Boyes Beach along to the Department of Conservation (DOC) campsite.

2013 hornwort delimitation survey

Surveillance was undertaken by BOPRC divers in March 2013 using a variety of dive techniques including; manta boarding, spot diving, snorkelling and underwater scooter. Results of the surveillance revealed two additional hornwort infestation areas to those detected in 2012 (Figure 9.6.1).

The majority of the new infestations occupied the northern end of the lake and ranged from scattered plants (5 m^2-10 m^2) to established beds approximately 50 m^2 in size, plants were found in depths ranging from 2 m-8 m. The entire Boyes Beach area has been classed as one site as it contained scattered plants, some up to 50 m^2 in size.

Two plants were found at the southern reach of the lake; one small plant at the outlet that connects to Lake Tarawera, and one small plant within the bay to the eastern side of Acacia Road point. Plants here were found in depths ranging from 4-8 m.

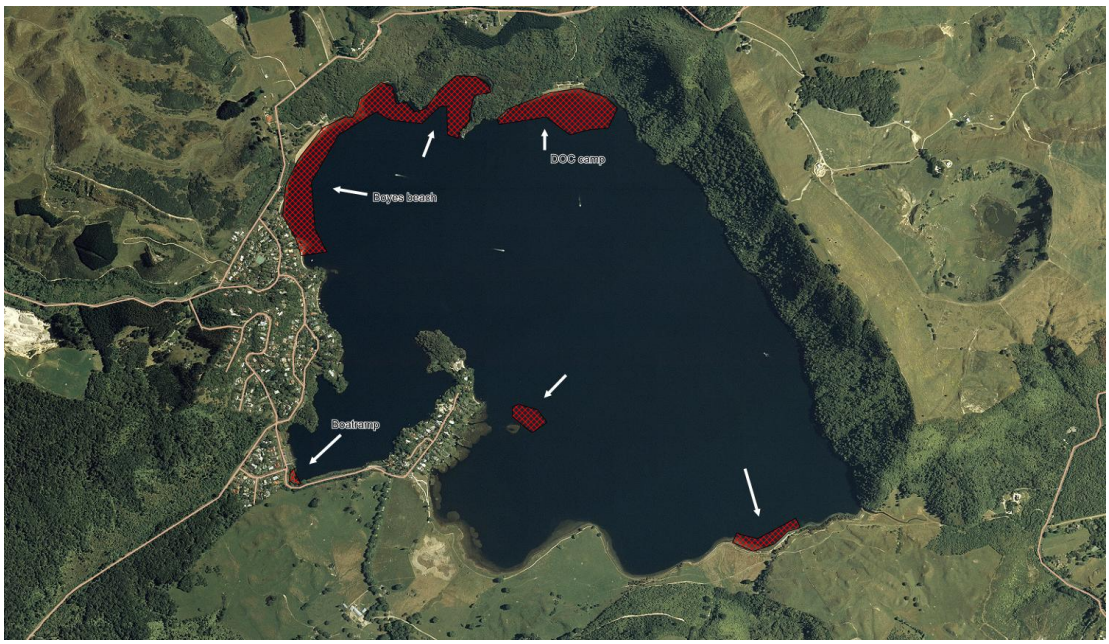

Figure 9.6.1 Lake Ōkāreka with areas marked where hornwort was located during 2012 and 2013 surveillance period.

2013 – 2018 aquatic pest plant control programme

An extensive weed spray programme using diquat was launched with the objective of removing the dense weed canopy of lagarosiphon and egeria to enable better detection and control of hornwort. The outcome of this control programme greatly exceeded expectations with widespread control of all three weed species, followed by an extensive resurgence of native plant species regenerating from the native seed bank within lake sediments. Recolonisation by invasive weed species has been remarkably slow following the control program due to the excellent result achieved with diquat followed by the fast and dense regeneration of a native plant cover over larger areas of the lake. It should be noted that many of the Rotorua Te Arawa lakes have compromised native seed banks in lake sediments following years of dense weed bed domination, combined with sedimentation, burial and non-replenishment of native seeds. Burial of native seed banks reduces recovery to a native condition, resulting in rapid regrowth and spread of invasive weeds within a lake.

The positive outcomes of the scaled up diquat spraying programme on Lake Ōkāreka to control hornwort, egeria and lagarosiphon were also reflected in the LakeSPI scores. The LakeSPI Index for Lake Ōkāreka improved from 36% in 2013 to 50% in 2017, reflecting both the successful reduction in invasive species; and widespread recovery and extent of native plant species.

Current state of aquatic pest plants in Lake Ōkāreka

Established populations of lagarosiphon and egeria minimise the ability to detect low density infestations of hornwort. Lake Ōkāreka also has relatively low visibility compared to some other lakes which reduces the effectiveness of surveillance. The potential habitat for lake weeds in Lake Ōkāreka is considered to be 135 ha. Calculations suggest hornwort currently inhabits <5% of the potential habitat due to the excellent control undertaken during 2013-2018. The northern bays have beds of lagarosiphon growing within depth bands of five to 7 m, shallower depth bands (2 m-5 m) are still primarily dominated by native charophytes.

The lake bed within the southern bays of the lake is heavily infested by surface reaching lagarosiphon, particularly the bay encompassing the outlet to Lake Tarawera. Here, lagarosiphon and egeria are well established and easily dominate the plant community. Stands here are dense, tall, and surface reaching in depths of approximately 10 m. Lagarosiphon currently inhabits 25-35% of the potential habitat and egeria inhabits 20-35% of Lake Ōkāreka.

9.6.6 Eradication management approach

Overview

It is probable that any decision not to actively manage lake weeds in Lake Ōkāreka will be strongly opposed by the community. However, challenges to eradication are present due to;

- High level of current infestation of pest plants.
- High recreational use of the lake which increases the likelihood of re-infestation of pest plants from existing populations within Lake Ōkāreka as well as other lakes and waterbodies nearby.
- Limitations around visual ability for dive surveillance to locate every fragment and plant.
- High costs associated with control.

The popularity of the lake also means leaving invasive pest plants to colonise further would increase vector risks to surrounding lakes (particularly Lake Tikitapu) which would further impact on the overall invasive weed statuses of Rotorua's lakes. Furthermore, if aquatic pest plants are left uncontrolled throughout Lake Ōkāreka, the recreational, cultural and economic implications are likely to be significant.

Control of pest plants is likely to predominantly consist of herbicide application with some mechanical methods also used as progress is made. It is worth acknowledging that current control methods of herbicide spray may be superseded by improved management options in the future and may allow for this approach to be reviewed.

It should also be acknowledged that any attempt at eradication of aquatic pest plants in Lake Ōkāreka, despite the final result, would have only positive outcomes for overall lake biodiversity and condition values for this lake.

Eradication control programme

Planned control

If eradication is to be successful, the following criteria must be met:

1 All plants must be exposed to the control,

2 The plants must be vulnerable to the control,

3 The plants must be found and killed faster than they can spread,

4 Re-invasion must be managed, and

5 The programme needs to be supported by all affected parties.

To meet these criteria intensive control of all known invasive plant populations (including appropriate buffers) would be carried out using proven herbicides and application techniques. Containment mechanisms and regulatory powers would be used to minimise the potential of further human and weather-related spread within the lake.

Eradication is currently deemed possible, assuming appropriate funding is available as:

- Reasonable evidence exists to suggest that all invasive plant populations within lake Ōkāreka have been identified (though we acknowledge this assumption may not be correct – see Risks below) and will be exposed to control.
- Diquat herbicide and application techniques have a proven track record of success against invasive plant species such as egeria and hornwort, including with Te Arawa Lakes. Endothall was approved for use by EPA in 2004 as an alternative herbicide. A contact-type herbicide that causes defoliation and stem die-off in aquatic plants. Endothall has been used to effectively control New Zealand's worst aquatic weed, hydrilla, as part of a Biosecurity New Zealand eradication programme centred on four Hawke's Bay lakes. Subsequent studies have shown the herbicide can eradicate hornwort and lagarosiphon as well.
- Improved surveillance techniques (including increased biosecurity checks at boat ramps), weed cordons and regulatory powers are available to manage the risk of spread.
- Local community is well engaged with aquatic pest issues. On-going public awareness programmes will reduce the risk of invasive aquatic pest plants being reintroduced to Lake Ōkāreka.

Risks to achieving eradication

There are several risks associated with proposed eradication which will need to be managed on an ongoing basis. Risks include:

- Failure of delimitation survey to detect all aquatic invasive plants present – current surveillance techniques (integration of manta board, underwater scooter, boat, snorkel and shoreline searches) are estimated by BOPRC monitoring staff to have an 80% chance (depending on water clarity, other vegetation present, terrain etc) of detecting an established invasive aquatic plant. Surveillance techniques are continually being refined and calibrated.
- Failure of herbicide control programmes to kill all plants – diquat has proven record of success against invasive aquatic plants though relies on contact with the plant which can be limited by depth, water movement, poor application and water turbidity. If any of these factors prevent total control of all plants, surviving individuals can be successfully killed by "shading" (this method proved successful in 2007) or hand weeding.
- Re-introduction of invasive aquatic plants by human related activity – while public awareness programmes continue to raise awareness of how to prevent transporting aquatic pests, this will continue to be a risk. The weed cordon at Acacia bay boat ramp (which has shown to be 80% effective at containing weed fragments from boats and trailers) will provide increased assurances against re-introduction.

Control costs estimate (year 1–5)

Diquat and/or Endothol treatment would occur in November and February/March (Figure 9.6.2) as per recommendation from NIWA. Control costs may substantially reduce during the programme depending on the effectiveness of initial control work.

Pre and post spray monitoring would need to be undertaken to determine the size of the weed bed (pre) and the result of the spray operation (post). This information will then be analysed to determine the effects of the spray programme and provide information for management decisions on further control operations.

In addition to monitoring, follow up surveillance will be conducted in Lake Ōkāreka twice a year using best practice methods. Surveillance will consist of systematically checking all areas of Lake Ōkāreka. All depth bands from the deepest edge of the known weed bed to the surface will be checked. Surveillance would be undertaken in November (five days) and April (five days).

Records will be kept from each surveillance and monitoring occasion. Monitoring and surveillance methods may include:

- SCUBA searches using manta board tows with the boat operator controlling the search pattern,
- Spot diving,
- Snorkelling,
- SCUBA diving using an underwater scooter, and/ or
- Shoreline searches.

Based on the lake size (350 ha), allowable spray of lake per round (25%) and potential habitat (Figure 9.6.3) as well as proposed control, monitoring and surveillance, total costs are estimated to be between $212,000 to $594,000 per year for the first three years. It is anticipated costs would decline as progress continues.

Increased public awareness programmes

A comprehensive communication strategy specifically aimed at Lake Ōkāreka users' will be developed with the local community, lake users and Te Arawa Lakes Trust to highlight the threats of aquatic pests and the measures lake users can take to prevent the vectoring of invasive aquatic pests to other lakes. It will also aim to reduce barriers to herbicide use by ensuring stakeholders and local community are adequately informed about control programmes.

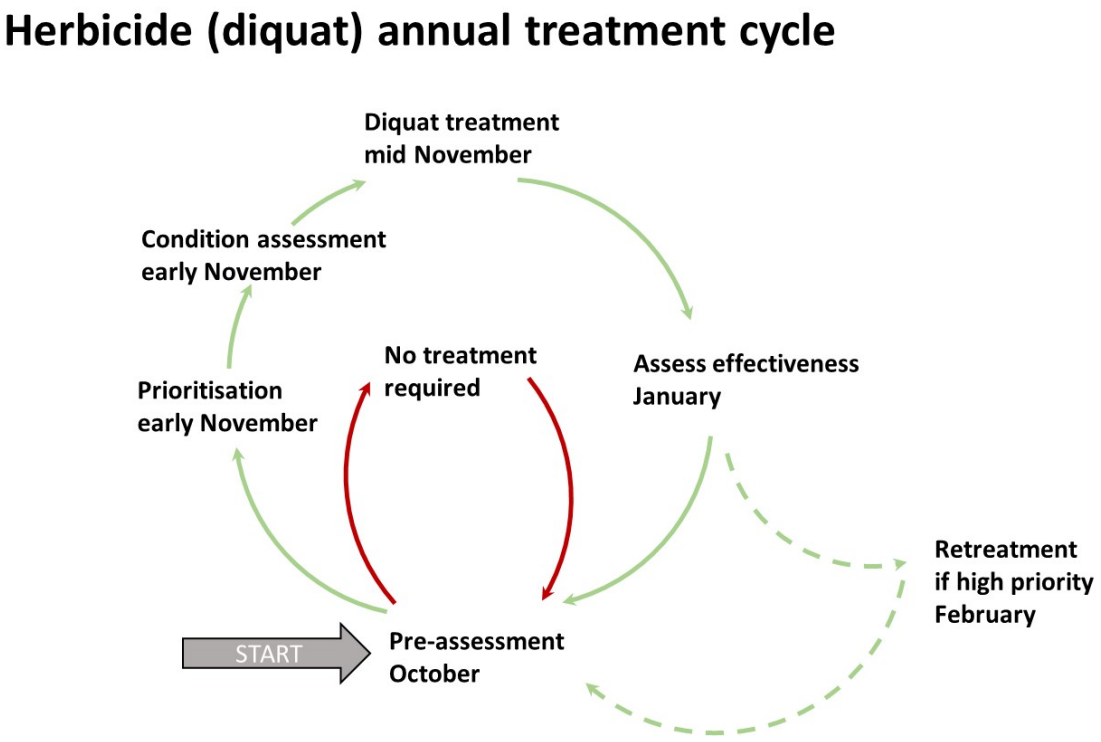

Figure 9.6.2 Annual cycle of treatment and assessment of using diquat (NIWA 2017a).

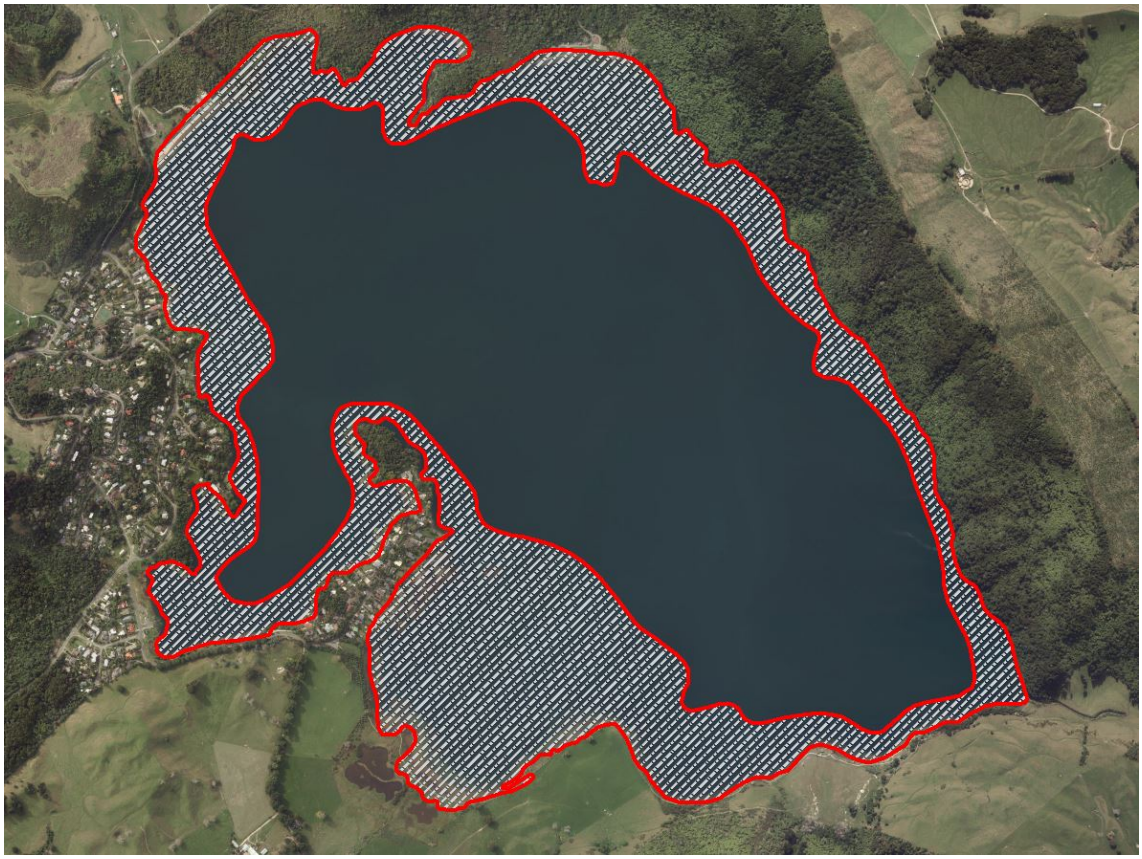

Figure 9.6.3 Lake Ōkāreka showing potential habitat (135 ha) for aquatic invasive plants.

9.7 Lake Tikitapu Aquatic Plant Management Plan

9.7.1 Lake Tikitapu

Lake Tikitapu (meaning “sacred greenstone neck ornament”) is a small sized lake within the Rotorua region with a surface area of approximately 150ha and a maximum depth of 28 m (Bay of Plenty Regional Council *et al*. 2015). Lake Tikitapu is located approximately 8 km south east of Rotorua City with Lake Tarawera 4 km to the east and Lake Rotokakahi less than 0.5 km to the south.

Water flows into Lake Tikitapu via several streams within the catchment, with no surface outlets. Water likely exits the lake via groundwater to Lake Rotokakahi. Lake Tikitapu has a high water clarity compared to other lakes within the region and is surrounded mostly by native and exotic forestry (Bay of Plenty Regional Council *et al*. 2011).

9.7.2 Importance of lake

Lake Tikitapu is one of the Rotorua Te Arawa lakes best known for its clear and pristine water as well as providing many important values including cultural, biodiversity, environmental, economic and recreational. The lake is also known as the “blue” lake and is often used for local, regional and national sporting events.

Lake Tikitapu, along with the remaining lakes nearby, are of significant cultural importance to iwi and hapu with the lakes and surrounding environment being a central component to iwi and hapu traditions and beliefs. There are a number of significant cultural landmarks, pa sites, food gathering areas and urupa around the lake. Lake Tikitapu in particular, is known for the daughter of a high born chief losing a sacred greenstone neck ornament in the lake (Bay of Plenty Regional Council *et al.* 2015). The lake contains populations of koura, kakahi, tuna and inānga for which Te Arawa have a role to sustainably manage these fisheries. There are wetlands that provide important habitat for plants, freshwater fish and birds.

Te Tūāpapa o ngā Wai o Te Arawa outlines the values of Te Arawa associated with the Lakes and also provides guidance on the principles to be applied to all decision-making processes and management activities (Te Arawa Lakes Trust & Conroy and Donald Consultants Limited 2016).

9.7.3 What is the problem?

Lake Tikitapu does not share the same aquatic pest plant issues that neighbouring lakes suffer from. Instead, the biggest concern for Lake Tikitapu is keeping hornwort and egeria out of the lake as well as controlling existing beds of lagarosiphon and elodea. Lagarosiphon and elodea outcompete and displace native aquatic species and have been identified as some of the most problematic species within Lake Tikitapu and in the wider Rotorua lakes. Current pest plant issues would be compounded through the introduction and establishment of hornwort and egeria, particularly with the clear water in the lake allowing growth at deeper levels, relative to other lakes.

During the latest round of LakeSPI (submerged plant indicators) monitoring, a tool used to assess and report on the aquatic plant condition of New Zealand lakes, the lake condition status was documented as “moderate”. Invasive impact has declined since 2008 from 63% to 40% during the 2014 monitoring round, while native condition has improved since 2010 from 24% to 37% (NIWA 2016a).

9.7.4 Goal, targets, objectives and actions

The goal for Lake Tikitapu is:

Local, regional and national events in Lake Tikitapu are not impeded by aquatic pest plants and the threat of spread is well managed.

LakeSPI targets have been set for Lake Tikitapu to quantitatively assess changes in aquatic plant species and distribution and will assist in measuring progress towards achieving the goal. Lake Tikitapu has three LakeSPI targets including a minimum threshold - which the lake is precluded from falling below, 10-year target and a long-term target. The minimum threshold and targets have been developed in consultation with NIWA.

- The minimum threshold is the lowest LakeSPI value recorded from the past 15 years of monitoring (when regular LakeSPI monitoring of Rotorua Te Arawa lakes began). If the minimum threshold is breached, the plan and control activities will be reviewed. Outcomes from the review may include seeking further technical advice, amending pest plant management activities and/or gathering feedback from stakeholders. Any decisions or recommendations will be made in the wider context of control activities and programmes across Te Arawa Rotorua Lakes.
- The 10-year target is based on an improvement of five percentage points over the duration of two LakeSPI monitoring occasions beginning from the 2016 LakeSPI value (monitoring is undertaken every two years – i.e. an improvement of five percentage points every four to five years).
- The long-term target is based on the likely LakeSPI values from Lake Tikitapu during the 1960s.

Table 9.7.1 provides an overview of the minimum threshold and targets and Table 9.7.2 describes the objectives and actions for Lake Tikitapu.

Table 9.7.1 LakeSPI targets and minimum threshold for Lake Tikitapu

Site	LakeSPI value
Current Lake SPI value (2016)	44
Minimum threshold	32
10-year target	54
Long term target	98

Table 9.7.2 Lake Tikitapu aquatic plant management plan objectives and actions

Objective	Actions
Plan is supported by central, regional and local government, Te Arawa and the local community.	Obtain endorsement for the plan from Te Arawa Lakes Strategy Group.
	Seek and secure funding to implement control work programmes.
	Actively involve iwi and the local community in carrying out the plan (i.e. reporting incursions and unusual findings and providing feedback).
	Align aquatic pest plant control objective with appropriate programmes in the BOP Regional Pest Management Plan.
	Review and update aquatic plant management plan at least once every three years.
	Prepare an annual plan of works by 30 June each year.

Objective	Actions
	Report progress to Te Arawa Lakes Strategy Group and communities annually.
Improve and increase Te Arawa hapū and iwi use of the lake.	Engage with Te Arawa hapū and iwi in management of biosecurity issues.
	Engage with Te Arawa hapū and iwi on use of the Lake for cultural practises and connection to the Lakes.
	Work with Te Arawa hapū and iwi to improve access to cultural materials and mahinga kai where access is hindered by aquatic pest plants.
	Work with Te Arawa hapū and iwi to improve mahinga kai habitats where they are impacted or threatened by aquatic pest plants.
	Engage Te Arawa hapū and iwi to actively report new and unusual weed findings.
	Provide support for Te Arawa hapū and iwi to conduct cultural monitoring of the lake.
Enhance biodiversity and improve and increase local communities and visitors use of the lake.	Implement annual control programme to schedule and budget.
	Restore aquatic native plant communities through controlling aquatic pest plants.
	Ensure control works do not unreasonably hamper lake use.
	Ensure control work is effective and does not cause unintended environmental harm.
	Ensure iwi, the local community and lake users are aware of planned control works.
New pest plant incursions are detected early enough to be eradicated or controlled.	Engage community to actively report new and unusual pest plant findings.
	Carry out annual passive and proactive surveillance to detect new pest incursions.
	Prevent lagarosiphon and elodea from being transferred from Lake Tikitapu to any other waterbodies.
	Prevent hornwort and egeria from establishing within Lake Tikitapu.
Effectiveness and effects of pest plant control are measured and results are incorporated into future works.	Undertake operational monitoring to assess whether aquatic pest plant control has been successful.
	Undertake monitoring to detect unintentional outcomes (e.g. adverse effects to non-target plant and animal species).
	Incorporate results from monitoring into reviews and work programmes to improve future control programmes.
Research improves methods for surveillance, monitoring and control of aquatic pest plants.	Use research for the basis for decisions on aquatic pest plant management.
	Support research in aquatic pest plant management.

9.7.5 No management scenario

Lagarosiphon and elodea are currently the only problematic invasive aquatic pest plant present within Lake Tikitapu. These species, although still an issue, are not as widespread within Lake Tikitapu compared to other Rotorua Te Arawa lakes. Without active management and monitoring, this aquatic pest plant may continue to spread to other parts of the lake, reducing the extent of aquatic native habitat.

In addition to further spread of lagarosiphon, a lack of management and monitoring could result in the introduction and establishment of hornwort and egeria. This is a particularly high threat to Lake Tikitapu with the presence of hornwort and egeria in nearby lakes. The scenario of not undertaking any management or monitoring is not acceptable to stakeholders or the wider public.

9.7.6 Proposed management

NIWA (2017k) established the most efficient and cost-effective methods for which to manage aquatic pest plants within Lake Tikitapu for the next three years. Unless stated otherwise, the proposed methods and associated diagrams/figures have been developed by NIWA.

Two shoreline sites are proposed for pest plant control consideration in Lake Tikitapu. The first site is the combined boat ramp and swimming beach at the north of the Lake (Figure 9.7.1). This site was ranked as medium priority for biosecurity reasons (Dragten Consulting 2016). The second site is the 'Green Lake' carpark, which was ranked as medium priority for amenity reasons (Dragten Consulting 2016).

Lake Tikitapu has recorded two aquatic pest plants; elodea and lagarosiphon. However, pest plant-related issues are not ordinarily reported for this lake. When Lake Tikitapu water was analysed in the early 1970s, it had an unusual chemistry compared to the other Rotorua lakes (McColl 1972). The non-vigorous growth form of lagarosiphon noted in this lake since at least the 1980s (Silvester 1981) was suggested to be related to this water chemistry (Clayton *et. al* 1990). The short, stunted nature of lagarosiphon (Figure 9.7.2) in this lake is generally of low amenity impact, but there also need to be consideration for the potential for lagarosiphon transfer to un-infested lakes (e.g., neighbouring Lake Rotokakahi) and ecological benefits (i.e., improved lake 'health') achieved by pest plant control as part of the proposed management.

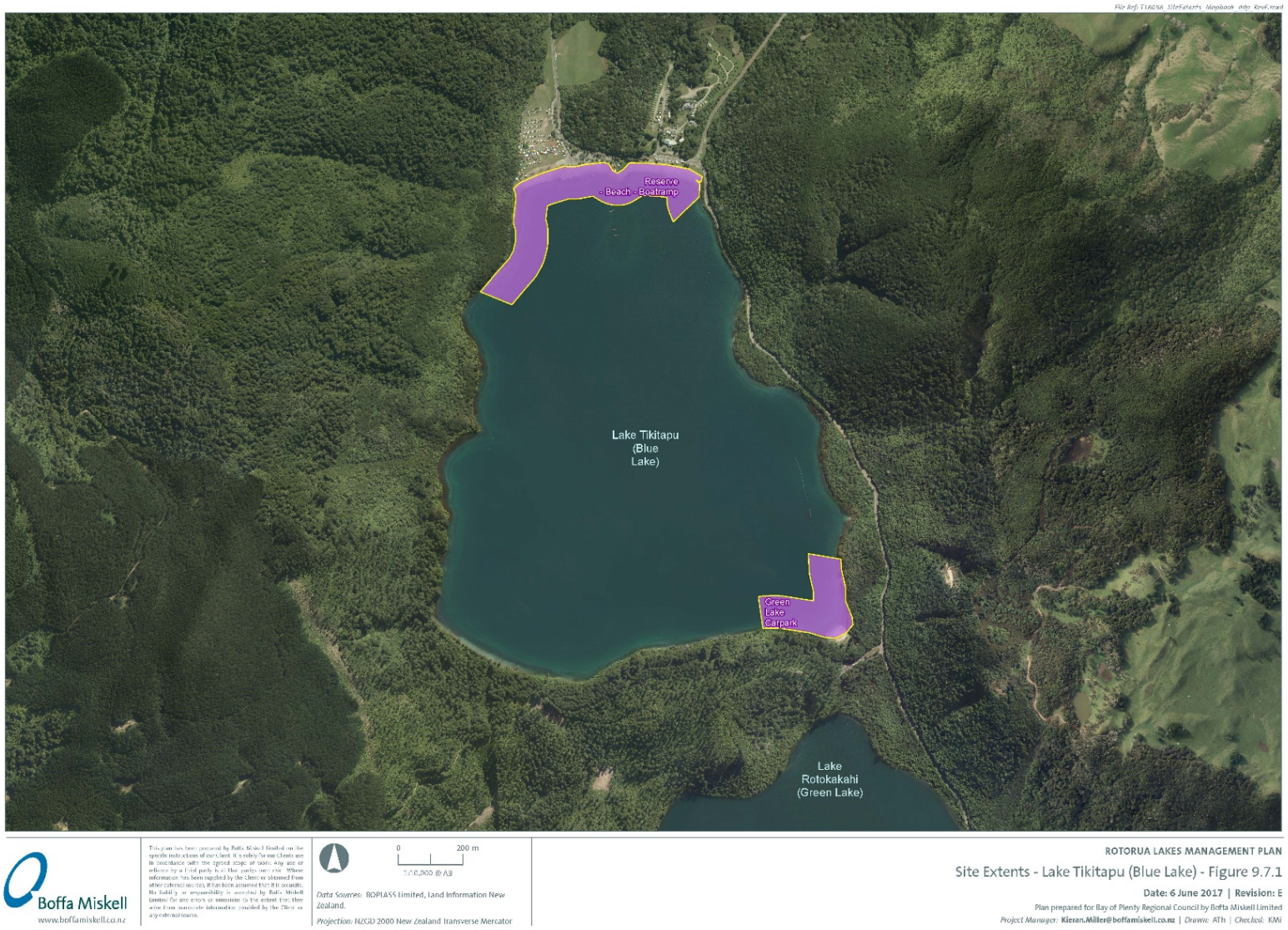
Reserve
Beach
Boatramp
Lake Tikitapu
(Blue
Lake)
Green
Lake
Carpark
Lake
Rotokakahi
(Green Lake)
Boffa Miskell
www.boffamiskell.co.nz
0
200 m
1:5,000 @ A3
Data Sources: BOPLASS Limited, Land Information New Zealand.
Projection: NZGD 2000 New Zealand Transverse Mercator
ROTORUA LAKES MANAGEMENT PLAN
Site Extents - Lake Tikitapu (Blue Lake) - Figure 9.7.1
Date: 6 June 2017 | Revision: E
Plan prepared for Bay of Plenty Regional Council by Boffa Miskell Limited
Project Manager: Kieran.Miller@boffamiskell.co.nz | Drawn: ATh | Checked: KMi

Figure 9.7.1.

Figure 9.7.2 Typical lagarosiphon growth form in Lake Tikitapu.

An application of diquat along the northern foreshore is recommended (Reserve Beach/Boat ramp/swimming beach). If a good reduction in lagarosiphon biomass is achieved, control may be long-lived (>1 years control) due to unsuitable growth conditions for pest plant re-establishment. On the other hand, unusual lagarosiphon growth forms, such as older hardened ('woody') stems, can be resistant to herbicide action. Monitoring the outcome of a trial diquat application after one year would determine the next steps as either an annual treatment or reassessment after a following year. The suggested cycle of diquat treatment is represented in Figure 9.7.3, and summarised for this site in Table 9.7.3.

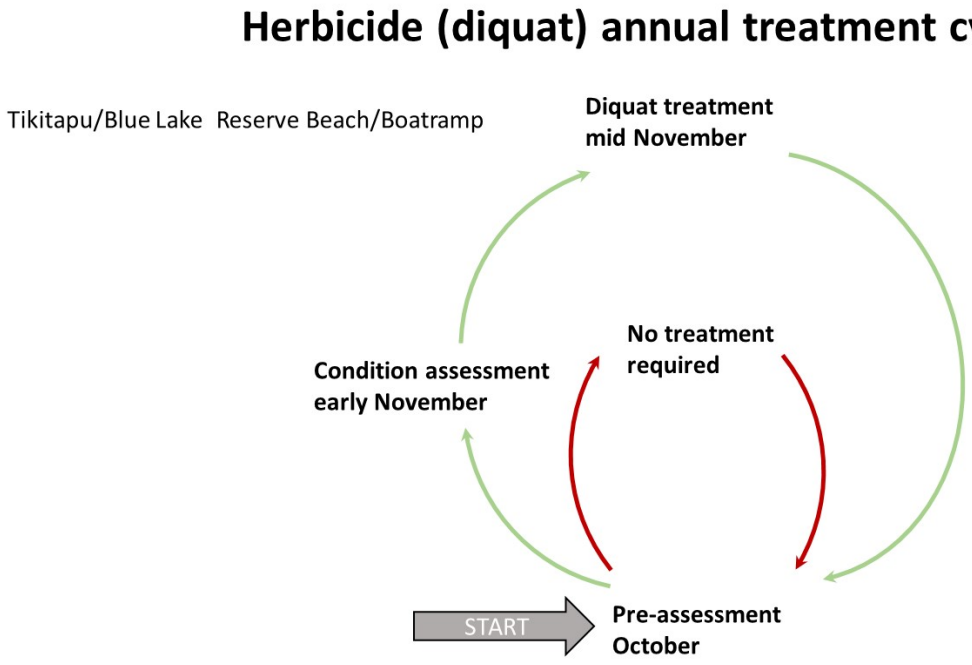

Figure 9.7.3 Annual cycle of treatment using diquat and assessment of lagarosiphon.

In addition, there may be an opportunity to use weed mats to suppress the older hardened ('woody') stems if it proves they are resistant to herbicide action. This option will be further explored depending on outcomes from the proposed herbicide treatment.

No control is recommended at Green Lake Carpark until the outcome of treatment and longevity of control is established at Reserve Beach/Boat ramp/swimming beach. Amenity impact would be low at this site and accordingly gains would be low unless a good and sustained control could be achieved.

Table 9.7.3 Proposed control at Lake Tikitapu for the next three years (as growth year, spring through winter) for sites identified for pest plant management (Figure 9.7.1) listed below

Site	Year 1	Year 2	Year 3
Reserve Beach/Boat ramp	Low.	Assess condition for diquat treatment.	Assess for diquat treatment.
Green Lake Carpark	No action.	No action.	Assess in light of control achieved at other site.

9.7.7 Surveillance

Surveillance monitoring is conducted in Lake Tikitapu twice a year using a variety of methods including:

- SCUBA searches using manta board tows with the boat operator controlling the search pattern,
- Spot diving,
- Snorkelling,
- SCUBA diving using an underwater scooter, and/ or
- Shoreline searches.

Surveillance monitoring sites are pre-determined using a prioritisation model which assesses lake specific sites based on parameters such as likely pest plant entry, recreational use and ability to detect new incursions. Records are kept from each surveillance monitoring occasion.

Monitoring is also conducted within Lake Tikitapu as part of the pre-and post spray assessments which assists in identifying aquatic pest plant incursions outside of the species already present. In the event of a new incursion, an incursion response plan will be developed by BOPRC in consultation with TALT, LINZ and other stakeholders.

In addition to the surveillance programme, BOPRC also undertake an annual awareness campaign/survey and regularly interact with the public. They also provide a portable wash down facility from time to time during the summer months. Cultural monitoring also provides a form of surveillance. BOPRC will engage with Te Arawa hapū and iwi to actively report new and unusual aquatic pest plant findings.

9.8 Lake Rotokakahi Aquatic Plant Management Plan

9.8.1 Lake Rotokakahi

Lake Rotokakahi (meaning "lake of the shellfish") is a small sized lake within the Rotorua region with a surface area of approximately 440 ha and a maximum depth of 32 m (Bay of Plenty Regional Council *et al*. 2015). Lake Rotokakahi is located approximately 10 km south east of Rotorua City with Lake Tarawera 3 km to the east and Lake Tikitapu less than 0.5 km to the north.

Water flows into Lake Rotokakahi via a single permanent stream within the catchment as well as ephemeral streams and groundwater. Water exits the lake to Lake Tarawera through Te Wairoa Stream. Lake Rotokakahi is iwi-owned and administered by the Lake Rotokakahi Board of Control (Butterworth 2012). No swimming or boating is permitted on the lake (Bay of Plenty Regional Council *et al*. 2015).

9.8.2 Importance of lake

Lake Rotokakahi and the surrounding catchment provides a number of important values including biodiversity and environmental. Lake Rotokakahi also has significant cultural value, as it was once heavily populated by Maori, who collected kakahi (an edible shellfish) from the lake shores. There is also an island (Motutawa) towards the southern end of the lake which is a burial ground of many Maori ancestors (Bay of Plenty Regional Council *et al*. 2015). Lake Rotokakahi, along with the remaining lakes and surrounding environment nearby, are a central component to iwi and hapu traditions and beliefs (Te Arawa Lakes Trust & Conroy and Donald Consultants Limited 2016).

9.8.3 What is the problem?

Lake Rotokakahi does not share the same aquatic pest plant issues that neighbouring lakes suffer from. Instead, the biggest concern for Lake Rotokakahi is keeping hornwort, lagarosiphon and egeria out of the lake as well as controlling existing beds of elodea. Elodea outcompete and displace native aquatic species and has been identified as the most problematic species within Lake Rotokakahi. Current pest plant issues would be compounded through the introduction and establishment of hornwort, lagarosiphon and egeria particularly with the clear water in the lake allowing growth at deeper levels, relative to other lakes.

During the latest round of LakeSPI (submerged plant indicators) monitoring, a tool used to assess and report on the aquatic plant condition of New Zealand lakes, the lake condition status was documented as “moderate”. However, LakeSPI has continued to decline since monitoring began in 1988 from 52% to 26% recorded in 2014. This is as a result of decreasing native condition and increasing invasive impact, recorded at 19% and 77%, respectively, during the latest monitoring round (NIWA 2016a).

9.8.4 Goal, targets, objectives and actions

The goal for Lake Rotokakahi is:

Hornwort, lagarosiphon and egeria are prevented from establishing within Lake Rotokakahi to maintain all lake values.

LakeSPI targets have been set for Lake Rotokakahi to quantitatively assess changes in aquatic plant species and distribution and will assist in measuring progress towards achieving the goal. Lake Rotokakahi has three LakeSPI targets including a minimum threshold - which the lake is precluded from falling below, 10-year target and a long-term target. The minimum threshold and targets have been developed in consultation with NIWA.

- The minimum threshold is the lowest LakeSPI value recorded from the past 15 years of monitoring (when regular LakeSPI monitoring of Rotorua Te Arawa lakes began). If the minimum threshold is breached, the plan and control activities will be reviewed. Outcomes from the review may include seeking further technical advice, amending pest plant management activities and/or gathering feedback from stakeholders. Any decisions or recommendations will be made in the wider context of control activities and programmes across Te Arawa Rotorua Lakes.
- The 10-year target is based on an improvement of five percentage points over the duration of two LakeSPI monitoring occasions beginning from the 2016 LakeSPI value (monitoring is undertaken every two years – i.e. an improvement of five percentage points every four to five years).
- The long-term target is based on the likely LakeSPI values from Lake Rotokakahi during the 1960s.

Table 9.8.1 provides an overview of the minimum threshold and targets and Table 9.8.2 describes the objectives and actions for Lake Rotokakahi.

Table 9.8.1 LakeSPI targets and minimum threshold for Lake Rotokakahi

Site	LakeSPI value
Current Lake SPI value (2016)	30
Minimum threshold	26
10-year target	40
Long term target	76

Table 9.8.2 Lake Rotokakahi aquatic plant management plan objectives and actions.

Objective	Actions
Plan is supported by central, regional and local government and the Rotokakahi Board of Control.	Obtain endorsement for the plan from Te Arawa Lakes Strategy Group and Rotokakahi Board of Control.
	Seek and secure adequate funding to implement control work programmes.
	Actively involve iwi and the local community in carrying out the plan (i.e. reporting incursions and unusual findings, and providing feedback).
	Align aquatic pest plant control objective with appropriate programmes in the BOP Regional Pest Management Plan.
	Review and update aquatic plant management plan at least once every three years.
	Prepare an annual plan of works by 30 June each year.
	Report progress to Rotokakahi Board of Control, Te Arawa Lakes Strategy Group and communities annually.
Aquatic pest plant control allows iwi, local communities and visitors to use and enjoy the lakes.	Implement annual control programme to schedule and budget.
	Ensure control works do not unreasonably hamper lake use.
	Ensure control work is effective and does not cause unintended environmental harm.
	Ensure iwi, the local community and lake users are aware of planned control works.
	Work with iwi to improve access to cultural materials and mahinga kai where access is hindered by aquatic pest plants.
	Work with iwi to improve mahinga kai habitats where they are impacted or threatened by aquatic pest plants.
New pest plant incursions are detected early enough to be eradicated or controlled.	Engage community to actively report new and unusual pest plant findings.
	Carry out annual passive and proactive surveillance to detect new pest incursions.
	Prevent elodea from being transferred from Lake Rotokakahi to any other waterbodies.
	Prevent lagarosiphon, hornwort and egeria from establishing within Lake Rotokakahi.

Objective	Actions
Effectiveness and effects of pest plant control are measured and results are incorporated into future works.	Undertake operational monitoring to assess whether aquatic pest plant control has been successful.
	Undertake monitoring to detect unintentional outcomes (e.g. adverse effects to non-target plant and animal species).
	Incorporate results from monitoring into reviews and work programmes to improve future control programmes.
Research improves methods for surveillance, monitoring and control of aquatic pest plants.	Use research for the basis for decisions on aquatic pest plant management.
	Support research in aquatic pest plant management.

9.8.5 No management scenario

Elodea is currently the only invasive aquatic pest plant present within Lake Rotokakahi. This species has become widespread within the lake. A lack of management and monitoring could result in the introduction and establishment of hornwort, lagarosiphon and egeria. This is a threat to Lake Rotokakahi with the presence of hornwort, lagarosiphon and egeria in nearby lakes, although prohibiting access to the lake assists with preventing the spread of invasive aquatic species. The scenario of not undertaking any management or monitoring is not acceptable to stakeholders or the wider public.

9.8.6 Proposed management

NIWA (2017f) established the most efficient and cost-effective methods for which to manage aquatic pest plants within Lake Rotokakahi for the next three years. Unless stated otherwise, the proposed methods and associated diagrams/figures have been developed by NIWA.

The whole shoreline of Lake Rotokakahi (Figure 9.8.1) was ranked as medium priority for pest plant management due to biosecurity considerations (Dragten Consulting 2016). Elodea is the only invasive aquatic plant species confirmed within the lake and currently dominates the vegetation (Clayton *et al.* 1990, Burton 2016). However, elodea is of lesser concern compared to other more invasive aquatic pest plants (Clayton *et al.* 1990). Invasion by lagarosiphon, egeria or hornwort would create greater impacts for users.

Lake Rotokakahi is privately owned by mana whenua and is predominantly used by tribal members for recreational fishing. Two beach launch sites are most commonly used (Figure 9.8.1). Elodea does not impact on amenity at either site, although there is a risk of its transfer from the lake on trailers, boats or fishing equipment.

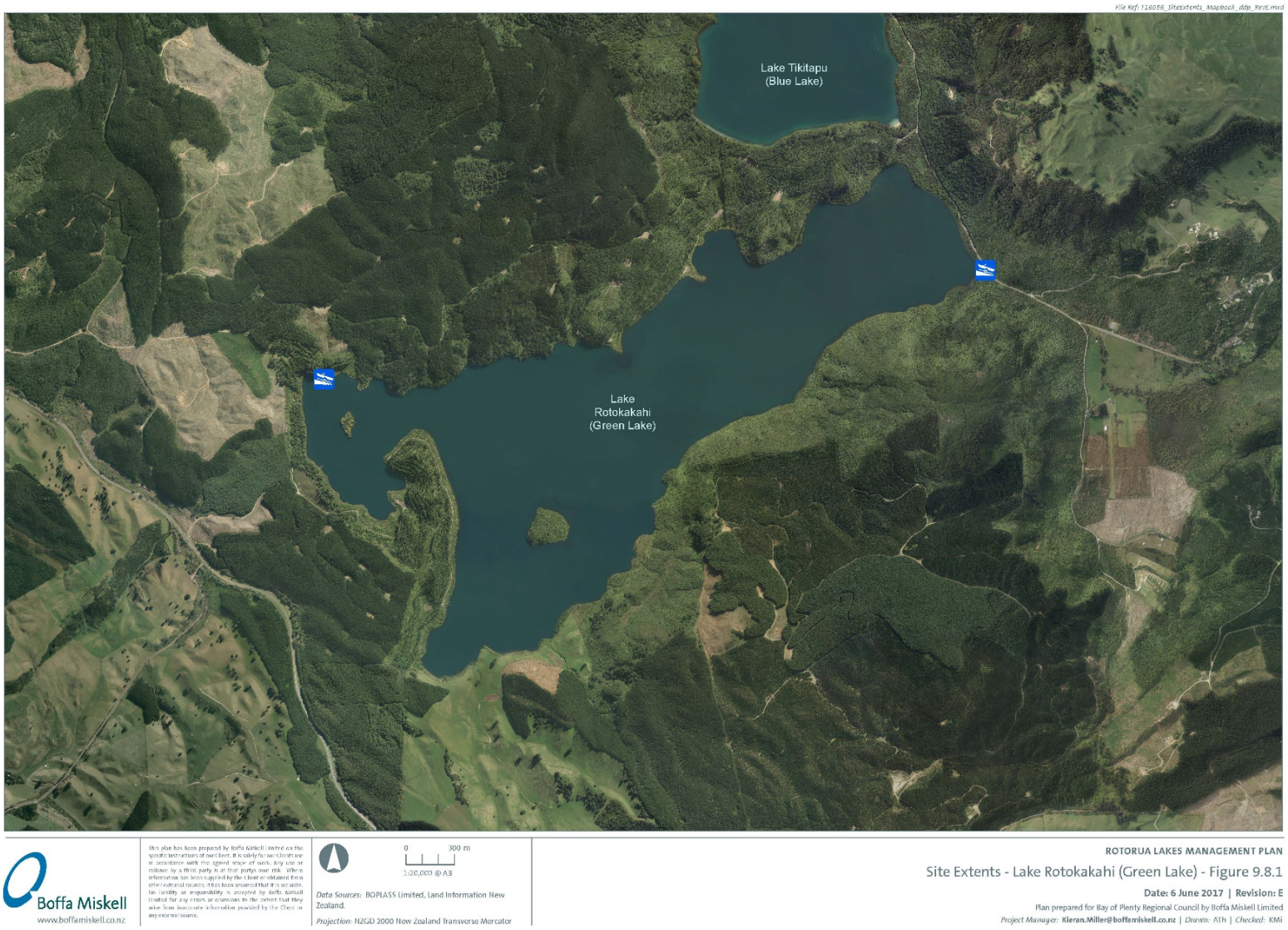
File Ref: 160056_SiteExtents_Mapbook_ddp_Revs.mxd
Lake Tikitapu
(Blue Lake)
Lake
Rotokakahi
(Green Lake)
Boffa Miskell
www.boffamiskell.co.nz
0
300 m
1:20,000 @ A3
Data Sources: BOPLASS Limited, Land Information New Zealand.
Projection: NZGD 2000 New Zealand Transverse Mercator
ROTORUA LAKES MANAGEMENT PLAN
Site Extents - Lake Rotokakahi (Green Lake) - Figure 9.8.1
Date: 6 June 2017 | Revision: E
Plan prepared for Bay of Plenty Regional Council by Boffa Miskell Limited
Project Manager: Kieran.Miller@boffamiskell.co.nz | Drawn: ATh | Checked: KMi

Figure 9.8.1.

Laying biodegradable hessian lining (Caffery *et al*. 2010, Hofstra and Clayton 2012) to form a weed-free passage from each boat access point is recommended. Lining would be deployed from approximately 1.4 m to 4 m depth in a 5 m width over the target weed beds. Bottom lining may require the local clearance of elodea beds by cutting to facilitate laying of the material (Table 9.8.3). The lining should be secured well to the lake bed to prevent dislodgement by waves so it does not become a propeller entanglement hazard for boating. Only the deeper 'drop-off' at the Tarawera Road access point should be lined to minimise wave dislodgement of the lining. Another advantage of bottom lining, is that it will create an area that improves the chances of detecting new pest plants locally introduced from boat traffic.

Table 9.8.3 Proposed control for the next three years (as growth year, spring through winter) for sites identified for pest plant management (Figure 9.8.1) listed below

Site	Year 1	Year 2	Year 3
Rotokakahi boat access points	Cut and line with hessian.	Check lining maintenance with surveillance.	Check lining with surveillance with a view to replacement.

9.8.7 Surveillance

Surveillance monitoring is conducted in Lake Rotokakahi twice a year using a variety of methods including:

- SCUBA searches using manta board tows with the boat operator controlling the search pattern,
- Spot diving,
- Snorkelling,
- SCUBA diving using an underwater scooter, and/ or
- Shoreline searches.

Surveillance monitoring sites are pre-determined using a prioritisation model which assesses lake specific sites based on parameters such as likely pest plant entry, recreational use and ability to detect new incursions. Records are kept from each surveillance monitoring occasion.

Monitoring is also conducted within Lake Rotokakahi as part of the pre and post spray assessments which assists in identifying aquatic pest plant incursions outside of the species already present. In the event of a new incursion, an incursion response plan will be developed by BOPRC in consultation with the Rotokakahi Board of Control, LINZ and other stakeholders.

9.9 Lake Tarawera Aquatic Plant Management Plan

9.9.1 Lake Tarawera

Lake Tarawera (meaning "burnt spear") is one of the larger lakes within the Rotorua region with a surface area of approximately 4,130 ha and a maximum depth of 88 m (Bay of Plenty Regional Council *et al*. 2015). Lake Tarawera is located approximately 13 km southeast of Rotorua city and just over 1 km south of Lake Ōkataina.

Surface water flows (and rainfall) make up approximately 20% of water entering Lake Tarawera, mostly from Te Wairoa Stream and Waitangi Stream originating from Lakes Rotokakahi and Ōkāreka, respectively. Subsurface flows also drain into Lake Tarawera from Lakes Tikitapu, Ōkataina and Rotomāhana. The Tarawera River originates towards the east of the lake and represents the largest surface water outflow. Lake Tarawera has a high water clarity compared to other lakes within the region (Bay of Plenty Regional Council 2015b).

9.9.2 Importance of lake

Lake Tarawera and the surrounding catchment provides several important values including cultural, biodiversity, environmental, economic and recreational with the lake being one of the most popular lakes for numerous sport and leisure activities. The lake is also home to many people who live mostly on the western shores. The lake provides additional values, which are perhaps less obvious to those previously described, including an important food and water source as well as encouraging social, family and community interaction.

Lake Tarawera, along with the remaining lakes nearby, are of significant cultural importance to iwi and hapu with the lakes and surrounding environment being a central component to iwi and hapu traditions and beliefs. There are a number of significant cultural landmarks, pa sites, food gathering areas as well as urupa around the lake. Lake Tarawera in particular, was home to many iwi and provided an array of resources including food and shelter as well as being an important transport route (Bay of Plenty Regional Council *et al*. 2014). The lake contains populations of koura, kakahi, tuna and inānga for which Te Arawa have a role to sustainably manage these fisheries. There are wetlands and geothermal areas that provide important habitat for plants, freshwater fish and birds.

Te Tūāpapa o ngā Wai o Te Arawa outlines the values of Te Arawa associated with the Lakes and also provides guidance on the principles to be applied to all decision-making processes and management activities (Te Arawa Lakes Trust & Conroy and Donald Consultants Limited 2016).

9.9.3 What is the problem

Of all the Rotorua Te Arawa lakes, Lake Tarawera has one of the worst problems with aquatic pest plants, due to the range of invasive species present and their distribution and coverage. During the latest round of LakeSPI, the lake condition status was documented as “moderate”. The invasive impact score was 87% in the latest monitoring round in 2014, slightly lower than the peak of 92% recorded in 2008 (NIWA 2016a).

Lake Tarawera contains several prominent aquatic pest plant species including hornwort, lagarosiphon, egeria and elodea. While these submerged aquatic pest plants differ slightly in their ecological characteristics, they share a similar trait in which they outcompete and displace native aquatic species below the shoreline and create large dense weed beds. These four pests have been identified as the most problematic plant species within Lake Tarawera, and in the wider Rotorua lakes, and have been the target species of recent control programmes.

9.9.4 Goal, targets, objectives and actions

The goal for Lake Tarawera is:

Absence of aquatic pest plants allows hapū/iwi, the local community and visitors to use and enjoy Lake Tarawera and the threat of spread is well managed.

LakeSPI targets have been set for Lake Tarawera to quantitatively assess changes in aquatic plant species and distribution and will assist in measuring progress towards achieving the goal.
Lake Tarawera has three LakeSPI targets including a minimum threshold - which the lake is precluded from falling below, 10-year target and a long-term target. The minimum threshold and targets have been developed in consultation with NIWA.

- The minimum threshold is the lowest LakeSPI value recorded from the past 15 years of monitoring (when regular LakeSPI monitoring of Rotorua Te Arawa lakes began). If the minimum threshold is breached, the plan and control activities will be reviewed. Outcomes from the review may include seeking further technical advice, amending pest plant management activities and/or gathering feedback from stakeholders. Any decisions or recommendations will be made in the wider context of control activities and programmes across Te Arawa Rotorua Lakes.

- The 10-year target is based on an improvement of five percentage points over the duration of two LakeSPI monitoring occasions beginning from the 2016 LakeSPI value (monitoring is undertaken every two years – i.e. an improvement of five percentage points every four to five years).
- The long-term target is based on the likely LakeSPI values from Lake Tarawera during the 1960s.

Table 9.9.1 provides an overview of the minimum threshold and targets and Table 9.9.2 describes the objectives and actions for Lake Tarawera.

Table 9.9.1 LakeSPI targets and minimum threshold for Lake Tarawera

Site	LakeSPI value
Current Lake SPI value (2016)	25
Minimum threshold	22
10-year target	35
Long term target	70

Table 9.9.2 Lake Tarawera aquatic plant management plan objectives and actions

Objective	Actions
Plan is supported by central, regional and local government, Te Arawa and the local community.	Obtain endorsement for the plan from Te Arawa Lakes Strategy Group.
	Seek and secure adequate funding to implement control work programmes.
	Actively involve iwi and the local community in carrying out the plan (i.e. reporting incursions and unusual findings, and providing feedback).
	Align aquatic pest plant control objective with appropriate programmes in the BOP Regional Pest Management Plan.
	Review and update aquatic plant management plan at least once every three years.
	Prepare annual plan of works by 30 June each year.
	Report progress to Te Arawa Lakes Strategy Group and communities annually.
Improve and increase Te Arawa hapū and iwi use of the lake.	Engage with Te Arawa hapū and iwi in management of biosecurity issues.
	Engage with Te Arawa hapū and iwi on use of the Lake for cultural practises and connection to the Lakes.
	Work with Te Arawa hapū and iwi to improve access to cultural materials and mahinga kai where access is hindered by aquatic pest plants.
	Work with Te Arawa hapū and iwi to improve mahinga kai habitats where they are impacted or threatened by aquatic pest plants.
	Engage Te Arawa hapū and iwi to actively report new and unusual weed findings.
	Provide support for Te Arawa hapū and iwi to conduct cultural monitoring of the lake.

Objective	Actions
Enhance biodiversity and improve and increase local communities and visitors use of the lake.	Implement annual control programme to schedule and budget.
	Restore aquatic native plant communities through controlling aquatic pest plants.
	Ensure control works do not unreasonably hamper lake use.
	Ensure control work is effective and does not cause unintended environmental harm.
	Ensure iwi, the local community and lake users are aware of planned control works.
New pest plant incursions are detected early enough to be eradicated or controlled.	Engage community to actively report new and unusual pest plant findings.
	Carry out annual passive and proactive surveillance to detect new pest incursions.
	Prevent lagarosiphon, egeria, hornwort and elodea from being transferred from Lake Tarawera to any other waterbodies.
Effectiveness and effects of pest plant control are measured and results are incorporated into future works.	Undertake operational monitoring to assess whether aquatic pest plant control has been successful.
	Undertake monitoring to detect unintentional outcomes (e.g. adverse effects to non-target plant and animal species).
	Incorporate results from monitoring into reviews and work programmes to improve future control programmes.
	Use research for the basis for decisions on aquatic pest plant management.
	Support research in aquatic pest plant management.

9.9.5 No management scenario

Invasive aquatic pest plants are present throughout Lake Tarawera with large proportions of habitat saturated by either one or multiple pest plant species. Without active management and monitoring, aquatic pest plants will continue to spread to areas not yet colonised, creating dense weed mats. Improved water quality from surrounding catchment management will also provide greater depths at which pest plants can grow.

Any further spread of invasive aquatic pest plants would potentially reduce the extent of aquatic native habitat as well as apply additional biosecurity pressures to neighbouring lakes. Without surveillance, additional pest plants could easily become established before being identified. The scenario of not undertaking any management or monitoring is not acceptable to stakeholders or the wider public.

9.9.6 Proposed management

NIWA (2017j) established the most efficient and cost-effective methods for which to manage aquatic pest plants in Lake Tarawera for the next three years (sites identified in Figure 9.9.1). Unless stated otherwise, the proposed methods and associated diagrams/figures have been developed by NIWA.

Aquatic pest plants recorded from Lake Tarawera are hornwort, lagarosiphon, egeria, elodea, water buttercup and curly pondweed in decreasing order of occurrence (Clayton *et al*. 1990, Burton, 2016). Because hornwort is a highly mobile plant due to its lack of root anchorage, there is less benefit in targeting small areas for control (e.g., 'cutting' or 'bottom lining') and the emphasis in this section is on larger scale herbicide control.

Locations (Figure 9.9.1) reported as high priority for pest plant management on account of biosecurity are Tarawera Landing and Stoney Point, with Rangiuru Bay also ranked highly according to amenity (Dragten Consulting 2016). Two further sites, Boatshed Bay and Otumutu Lagoon were medium priority based on biosecurity, with medium priority for amenity purposes also listed for Te Rata Bay (Hotwater Beach) and Wairua Bay (Dragten Consulting 2016). Four medium to high priority sites for biosecurity are 'currently controlled' (c. 2016) for aquatic pest plants (Dragten Consulting 2016).

Te Wairoa-Tarawera Landing

Tarawera Landing is the first access point for visitors to the lake, the base for a sight-seeing launch trips and a popular swimming beach. This site is within the sheltered Te Wairoa Bay. It has a concrete boat ramp, but has somewhat limited usage due to restricted trailer parking.

Amenity use of the beach front and shallow water are potentially impacted by weed bed presence and onshore drift. This area also encompasses the boat ramp, with maintenance of hygiene important to prevent plant transfer on boats and trailers.

Annual treatment at this location with the herbicide diquat is recommended (Figure 9.9.2, Table 9.9.3), with spraying the shoreline extending approximately 400 m north and 200 m south to limit re-invasion (Figure 9.9.3).

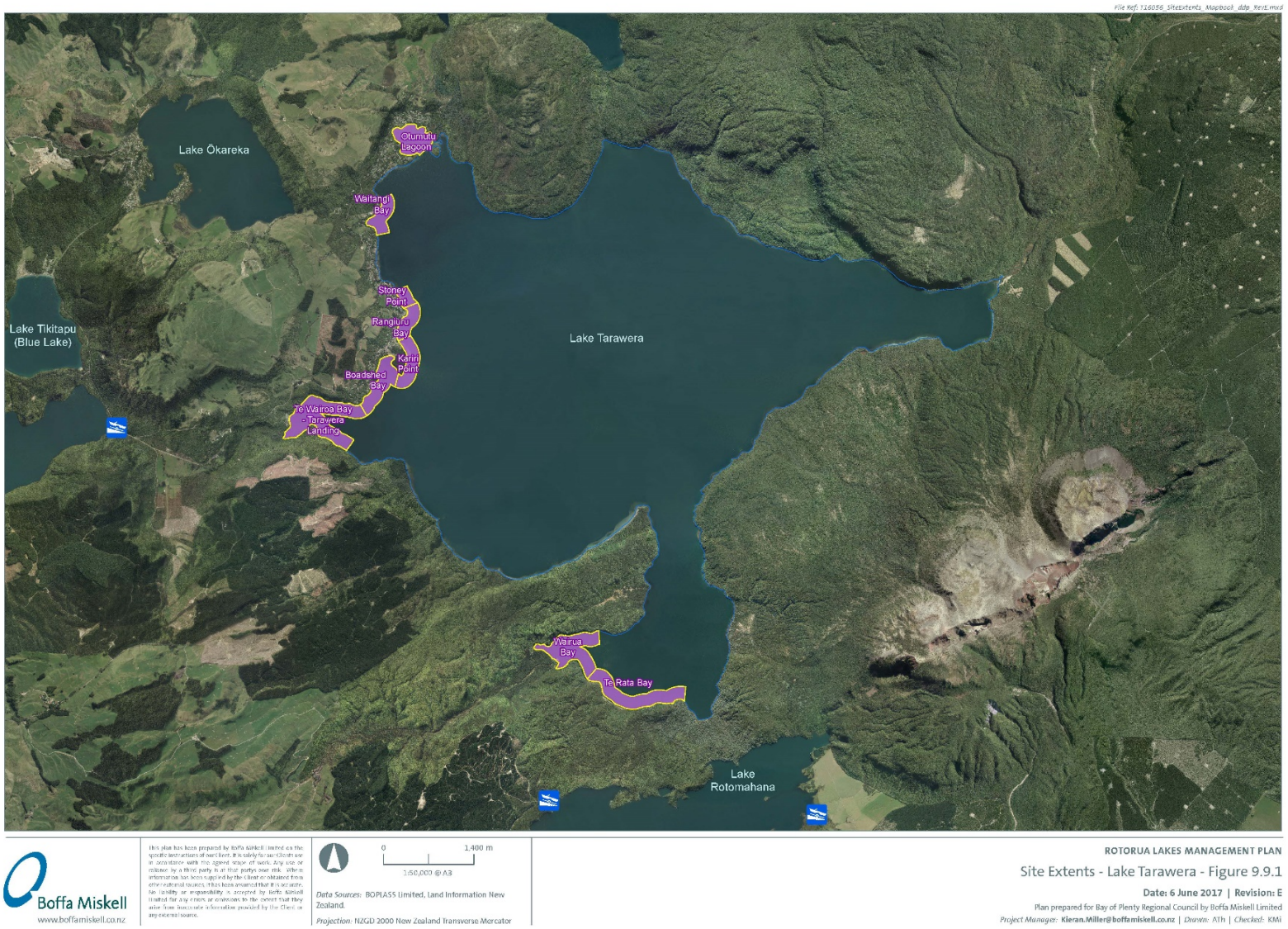
File Ref: 116056_SiteExtents_Mapbook_ddp_Rev1.mxd
Lake Ōkareka
Otumuiu Lagoon
Waitangi Bay
Stoney Point
Rangiuru Bay
Karin Point
Boadshed Bay
Te Wairoa Bay - Tarawera Landing
Lake Tikitapu (Blue Lake)
Lake Tarawera
Wairua Bay
Te Rata Bay
Lake Rotomahana
Boffa Miskell
www.boffamiskell.co.nz
This plan has been prepared by Boffa Miskell Limited on the specific instructions of our Client. It is solely for our Client's use in accordance with the agreed scope of work. Any use or reliance by a third party is at that party's own risk. Where information has been supplied by the Client or obtained from other external sources, it has been assumed that it is accurate. No liability or responsibility is accepted by Boffa Miskell Limited for any errors or omissions to the extent that they arise from inaccurate information provided by the Client or any external source.
0
1,400 m
1:50,000 @ A3
Data Sources: BOPLASS Limited, Land Information New Zealand.
Projection: NZGD 2000 New Zealand Transverse Mercator
ROTORUA LAKES MANAGEMENT PLAN
Site Extents - Lake Tarawera - Figure 9.9.1
Date: 6 June 2017 | Revision: E
Plan prepared for Bay of Plenty Regional Council by Boffa Miskell Limited
Project Manager: Kieran.Miller@boffamiskell.co.nz | Drawn: ATh | Checked: KMi

Figure 9.9.1.

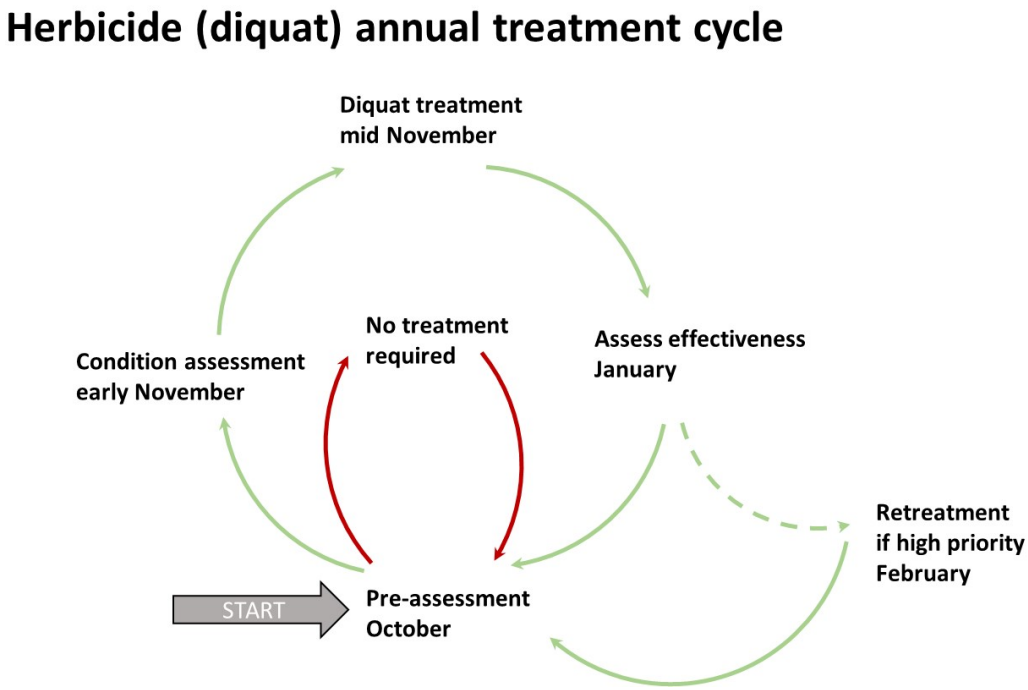

Figure 9.9.2 *Annual cycle of treatment and assessment of hornwort and other submerged pest plants using diquat.*

Figure 9.9.3 *Tarawera landing and the proposed priority pest plant control treatment area (red line) for amenity and biosecurity (Image sourced from: Google 2016 and Bay of Plenty TA's).*

Boatshed Bay

This site is the most utilised launch site at Lake Tarawera on account of the sheltered aspect and ample parking. There are also many boatsheds for semi-permanently moored vessels.

Spraying with diquat around the perimeter of the inner bay (Figure 9.9.4) on an annual basis (Figure 9.9.2, Table 9.9.3) is recommended to prevent hornwort drift from encroaching in front of the ramps, boatsheds and jetties.

Figure 9.9.4 Boatshed Bay and the proposed priority pest plant control treatment area (red line) for amenity and biosecurity (Image sourced from: Google 2016 and Bay of Plenty TA's).

Kariri Point, Rangiuru Bay and Stoney Point

Kariri Point to Stoney Point represent a shoreline open to the lake with a wide shallow littoral zone and weed beds restricted to deeper water. Numerous private jetties are distributed along Rangiuru Bay and Stoney Point shorelines. The priority area for pest plant management is the boat ramp and public jetty at the top of Rangiuru Bay (Figure 9.9.5).

Pest plant control to reduce the risk of plant transfer from this ramp and jetty should involve an annual diquat application (Figure 9.9.2, Table 9.9.3) along a c. 50 m section on either side of the ramp.

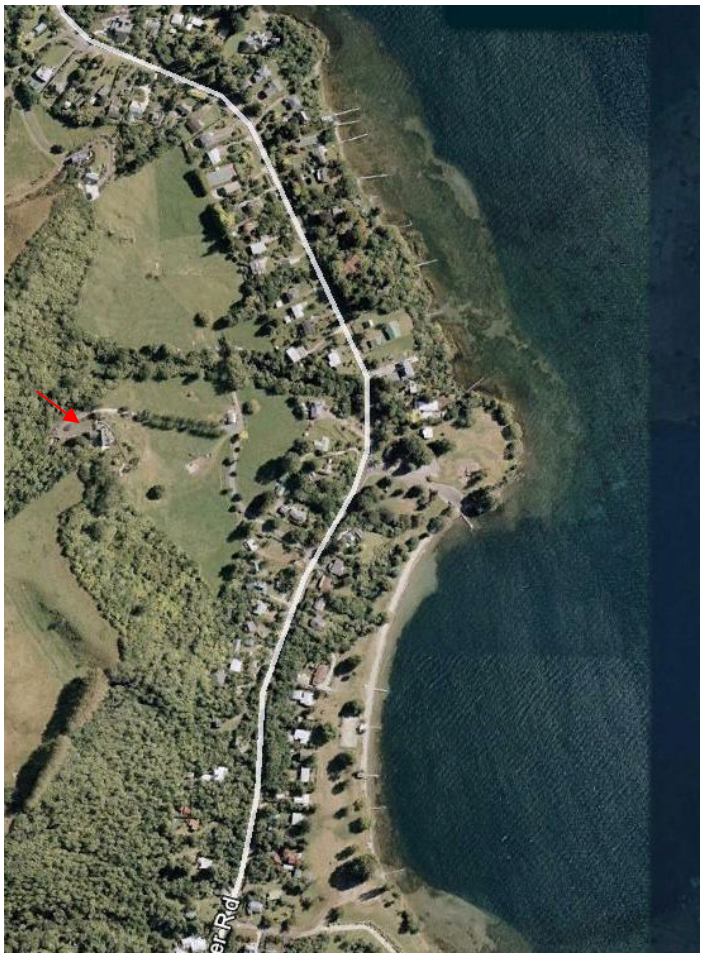

Figure 9.9.5 Location of the boat ramp at Rangiuru Bay shown by a red arrow (Image sourced from: Google 2016 and Bay of Plenty TA's).

Otumutu Lagoon

Located at the north-west end of the lake, Otumutu Lagoon has a public concrete boat ramp, as well as private boat houses and jetties. This semi-enclosed bay has a deep water entrance where pest plant development is limited by depth. However, the inner sections, particularly the southern and western shores, have seasonally abundant hornwort beds.

Diquat treatments have been regularly undertaken in Otumutu Lagoon. A double diquat treatment will achieve a better level of control at this location (Figure 9.9.6). The area for treatment is indicated in Figure 9.9.7. This double diquat application cycle has the advantage of pre-empting hornwort growth before the peak summer amenity season, but also reducing the pest plant at its autumn maxima.

The herbicide endothall may represent an additional method to achieve better control for hornwort and lagarosiphon within Otumutu Lagoon. The enclosed nature of Otumutu Lagoon would help achieve the long contact time required for endothall to be effective. However, outcomes should be assessed from the appropriate use of endothall within other Rotorua Te Arawa lakes (e.g., Lake Rotoiti, Lake Rotoehu) before adapting this approach at Otumutu Lagoon.

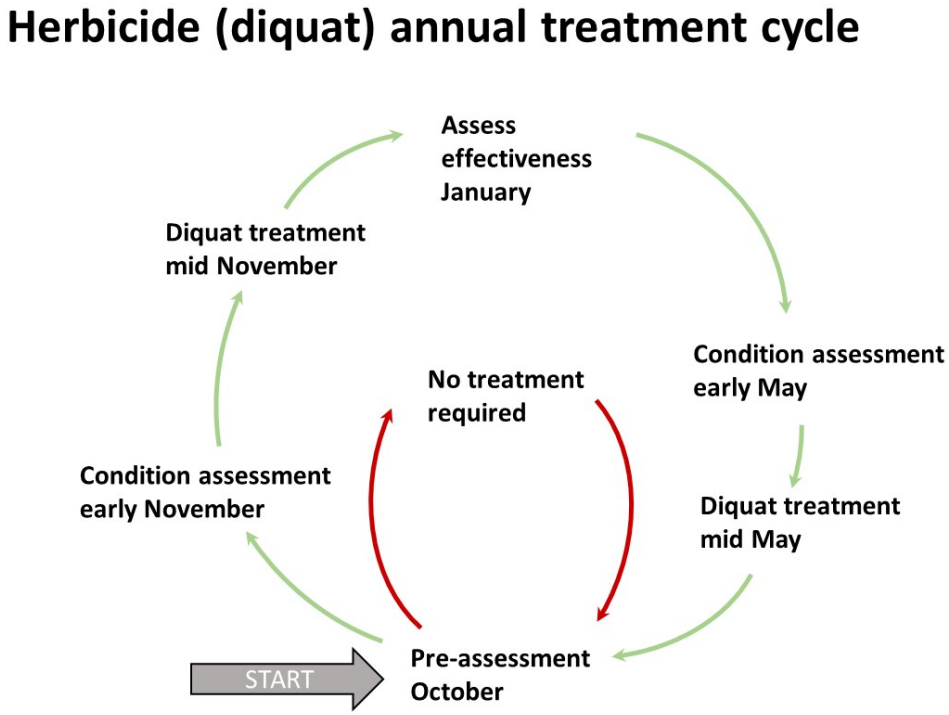

Figure 9.9.6 *Annual cycle assessment of and treatment of hornwort and other submerged pest plants using a double application of diquat.*

Figure 9.9.7 *Otumutu Lagoon with the area of seasonal hornwort enclosed within the red line (Image sourced from: Google 2016).*

Te Rata Bay/Hot Water Beach and Wairua Bay

Te Rata Bay and Wairua Bay in the southern arm of the lake are accessible by boat and walking track only, but include a popular camping ground and natural hot pools. The frontage at Hot Water Beach is a popular parking spot for boats, but the steep littoral slope limits boat contact with plants. Pest plants and drift is unpleasant for bathers along this beach. The other main traffic zone is to the natural hot pools in a small bay within Wairua Bay.

Annual diquat treatment is recommended (Figure 9.9.2, Table 9.9.3) for the sites as marked in Figure 9.9.8.

Figure 9.9.8 *Hot Water Beach and the entrance to popular natural hot pools, showing the recommended extent of diquat treatment (Image sourced from: Google 2016 and Bay of Plenty TA's).*

Table 9.9.3 *Proposed pest plant control in Lake Tarawera over the next three years (as growth year, spring through winter) for sites identified for management (Figure 9.9.1) listed below*

Site	Year 1	Year 2	Year 3
Te Wairoa-Tarawera Landing	Assess for annual diquat control.	Assess for annual diquat control.	Assess for annual diquat control.
Boatshed Bay			
Te Rata Bay/Hot water beach			
Wairua Bay			
Otumutu Lagoon	Double diquat application.	Assess outcome before continuing.	Assess outcome before continuing.
Rangiuru Bay	Diquat treatment at boat ramp.	Diquat treatment at boat ramp.	Diquat treatment at boat ramp.
Stoney Point			
Waitangi Bay	No control.	No control.	No control.
Kariri Point			

9.9.7 Surveillance

Lake Tarawera is currently not part of the surveillance programme as it contains the four most invasive aquatic pest plants found within the Rotorua Te Arawa Lakes area. Monitoring is still conducted within Lake Tarawera as part of the pre and post spray assessments which assists in identifying aquatic pest plant incursions outside of the species already present. In the event of a new incursion, an incursion response plan will be developed by BOPRC in consultation with TALT, LINZ and other stakeholders.

In addition to the surveillance programme, BOPRC also undertake an annual awareness campaign/ survey and regularly interact with the public. They provide a portable wash down facility from time to time during the summer months. Cultural monitoring also provides a form of surveillance. BOPRC will engage with Te Arawa hapū and iwi to actively report new and unusual aquatic pest plant findings.

9.10 Lake Rotomāhana Aquatic Plant Management Plan

9.10.1 Lake Rotomāhana

Lake Rotomāhana (meaning “warm lake”) is a moderate sized lake within the Rotorua region with a surface area of approximately 900 ha and a maximum depth of 125 m (Bay of Plenty Regional Council *et al*. 2015). Lake Rotomāhana is located just under 20 km southeast of Rotorua city and less than 1 km south of Lake Tarawera.

Water flows into Lake Rotomāhana via groundwater and several streams within the catchment, with no surface outlets. Water likely exits the lake via subsurface flows into Lake Tarawera. Lake Rotomāhana was the site of the geothermal “pink and white terraces” until they were destroyed in the 1886 Mt Tarawera eruption (Bay of Plenty Regional Council *et al*. 2015).

9.10.2 Importance of lake

Lake Rotomāhana and the surrounding catchment provides a number of important values including cultural, biodiversity and environmental. Lake Rotomāhana, along with the remaining lakes nearby, is also of significant cultural importance to Iwi and hapu with the lakes and surrounding environment being a central component to iwi and hapu traditions and beliefs. There are a number of significant cultural landmarks, pa sites, food gathering areas as well as urupa around the lake. The lake contains populations of koura, kakahi, tuna and inānga for which Te Arawa have a role to sustainably manage these fisheries. There are wetlands that provide important habitat for plants, freshwater fish and birds.

Te Tūāpapa o ngā Wai o Te Arawa outlines the values of Te Arawa associated with the Lakes and also provides guidance on the principles to be applied to all decision-making processes and management activities (Te Arawa Lakes Trust & Conroy and Donald Consultants Limited 2016).

9.10.3 What is the problem?

Lake Rotomāhana does not share the same aquatic pest plant issues that the adjacent Lake Tarawera suffers from. Instead, the biggest concerns for Lake Rotomāhana is controlling existing beds of hornwort and egeria and keeping lagarosiphon and elodea out of the lake. Hornwort and egeria outcompete and displace native aquatic species and have been identified as two of the most problematic species within Lake Rotomāhana and in the wider Rotorua lakes. Current pest plant issues would be compounded through the introduction and establishment of lagarosiphon and elodea.

During the latest round of LakeSPI (submerged plant indicators) monitoring, a tool used to assess and report on the aquatic plant condition of New Zealand lakes, the lake condition status was documented as “high”. Lake Rotomāhana is just one of three lakes with a “high” condition status. Native condition has decreased since 2005 from 65% to 53% in 2015, while invasive impact declined sharply from 59% in 2013 to 37% in 2015 (NIWA 2016a).

9.10.4 Goal, targets, objectives and actions

The goal for Lake Rotomāhana is:

Aquatic pest plants are contained to maintain biodiversity values within Lake Rotomāhana.

LakeSPI targets have been set for Lake Rotomāhana to quantitatively assess changes in aquatic plant species and distribution and will assist in measuring progress towards achieving the goal. Lake Rotomāhana has three LakeSPI targets including a minimum threshold - which the lake is precluded from falling below, 10-year target and a long-term target. The minimum threshold and targets have been developed in consultation with NIWA.

- The minimum threshold is the lowest LakeSPI value recorded from the past 15 years of monitoring (when regular LakeSPI monitoring of Rotorua Te Arawa lakes began). If the minimum threshold is breached, the plan and control activities will be reviewed. Outcomes from the review may include seeking further technical advice, amending pest plant management activities and/or gathering feedback from stakeholders. Any decisions or recommendations will be made in the wider context of control activities and programmes across Te Arawa Rotorua Lakes.
- The 10-year target is based on an improvement of five percentage points over the duration of two LakeSPI monitoring occasions beginning from the 2017 LakeSPI value (monitoring is undertaken every two years – i.e. an improvement of five percentage points every four to five years).
- The long-term target is based on the likely LakeSPI values from Lake Rotomāhana during the 1960s.

Table 9.10.1 provides an overview of the minimum threshold and targets and Table 9.10.2 describes the objectives and actions for Lake Rotomāhana.

Table 9.10.1: LakeSPI targets and minimum threshold for Lake Rotomāhana

Site	LakeSPI value
Current Lake SPI value (2017)	62
Minimum threshold	42
10-year target	72
Long term target	94

Table 9.10.2: Lake Rotomāhana aquatic plant management plan objectives and actions

Objective	Actions
Plan is supported by central, regional and local government, Te Arawa and the local community.	Obtain endorsement for the plan from Te Arawa Lakes Strategy Group.
	Seek and secure funding to implement control work programmes.
	Actively involve iwi and the local community in carrying out the plan (i.e. reporting incursions and unusual findings and providing feedback).
	Align aquatic pest plant control objective with appropriate programmes in the BOP Regional Pest Management Plan.
	Review and update aquatic plant management plan at least once every three years.
	Prepare an annual plan of works by 30 June each year.
	Report progress to Te Arawa Lakes Strategy Group and communities annually.

Objective	Actions
Improve and increase Te Arawa hapū and iwi use of the lake.	Engage with Te Arawa hapū and iwi in management of biosecurity issues.
	Engage with Te Arawa hapū and iwi on use of the Lake for cultural practises and connection to the Lakes.
	Work with Te Arawa hapū and iwi to improve access to cultural materials and mahinga kai where access is hindered by aquatic pest plants.
	Work with Te Arawa hapū and iwi to improve mahinga kai habitats where they are impacted or threatened by aquatic pest plants.
	Engage Te Arawa hapū and iwi to actively report new and unusual weed findings.
	Provide support for Te Arawa hapū and iwi to conduct cultural monitoring of the lake.
Enhance biodiversity and improve and increase local communities and visitors use of the lake.	Implement annual control programme to schedule and budget.
	Restore aquatic native plant communities through controlling aquatic pest plants.
	Ensure control works do not unreasonably hamper lake use.
	Ensure control work is effective and does not cause unintended environmental harm.
	Ensure iwi, the local community and lake users are aware of planned control works.
New pest plant incursions are detected early enough to be eradicated or controlled.	Engage community to actively report new and unusual pest plant findings.
	Carry out annual passive and proactive surveillance to detect new pest incursions.
	Landowners/managers controlling boat access points to the lake require all boat and equipment used in the lake to be cleaned prior to providing access.
	Prevent egeria and hornwort from being transferred from Lake Rotomāhana to any other waterbodies.
	Prevent lagarosiphon and elodea from establishing within Lake Rotomāhana.
Effectiveness and effects of pest plant control are measured and results are incorporated into future works.	Undertake operational monitoring to assess whether aquatic pest plant control has been successful.
	Undertake monitoring to detect unintentional outcomes (e.g. adverse effects to non-target plant and animal species).
	Incorporate results from monitoring into reviews and work programmes to improve future control programmes.
Research improves methods for surveillance, monitoring and control of aquatic pest plants.	Use research for the basis for decisions on aquatic pest plant management.
	Support research in aquatic pest plant management.

9.10.5 No management scenario

Hornwort and egeria are currently the only problematic invasive aquatic pest plant present within Lake Rotomāhana. Without active management and monitoring, there is potential that these aquatic pest plants will continue to spread to other parts of the lake, reducing the extent of aquatic native habitat.

In addition to the potential further spread of hornwort and egeria, a lack of management and monitoring could result in the introduction and establishment of lagarosiphon and elodea (or another aquatic pest plant species). This is a threat to Lake Rotomāhana with the presence of lagarosiphon and elodea in nearby lakes, although the remoteness to the lake, assists with preventing the spread of invasive aquatic species. The scenario of not undertaking any management or monitoring is not acceptable to stakeholders or the wider public.

9.10.6 Proposed management

NIWA (2017h) established the most efficient and cost-effective methods for which to manage aquatic pest plants within Lake Rotomāhana for the next three years. Unless stated otherwise, the proposed methods and associated diagrams/figures have been developed by NIWA.

Submerged pest plant species recorded from Lake Rotomāhana are egeria, curly pondweed, hornwort and water buttercup in order of reducing occurrence (Clayton *et al.* 1990, Burton 2016). An unexplained reduction in the cover of egeria was noted in 2015 (Burton 2016), although it is not known if this decline has been sustained. Contrary to expectations, hornwort has not dominated the vegetation in this lake, possibly due to an unusual water chemistry within this geothermally-influenced lake. There are many unusual (normally coastal) salt-tolerant, native submerged plants present in the lake due to the lakes water chemistry (Clayton *et al.* 1990). This has resulted in relatively high plant diversity and a species assemblage unique within the Rotorua Te Arawa lakes.

The entire shoreline of Lake Rotomāhana was ranked as low priority for pest plant management (Dragten Consulting 2016). The lake is not heavily used for recreation due to difficult access, although several small aluminium boats are kept at a private access point at the eastern end of the shallow southern arm (Figure 9.10.1).

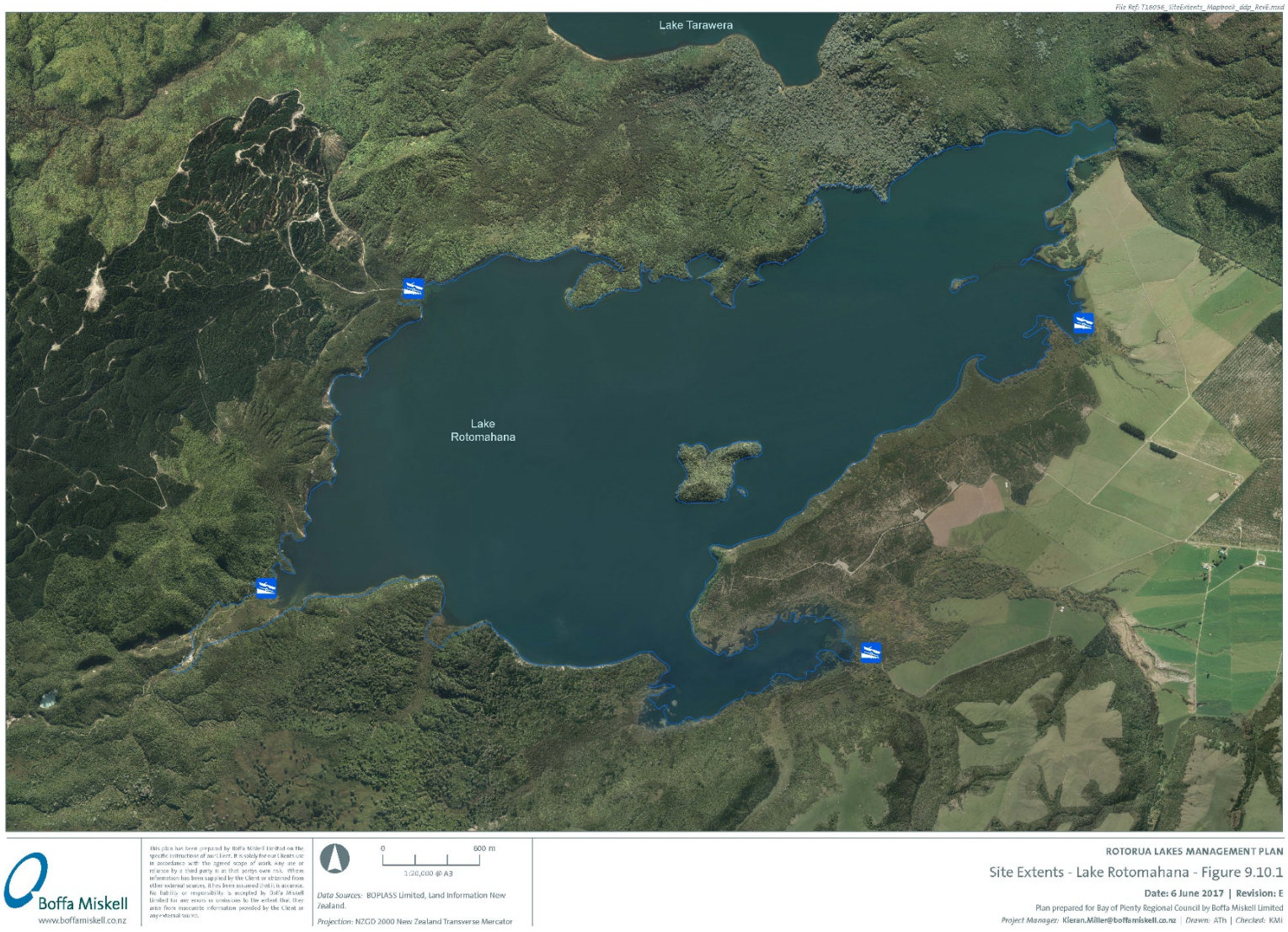
File Ref: T16056_SiteExtents_Mapbook_ddp_RevE.mxd
Lake Tarawera
Lake
Rotomahana
Boffa Miskell
www.boffamiskell.co.nz
This plan has been prepared by Boffa Miskell Limited on the specific instructions of our Client. It is solely for our Clients use in accordance with the agreed scope of work. Any use or reliance by a third party is at that parties own risk. Where information has been supplied by the Client or obtained from other external sources, it has been assumed that it is accurate. No liability or responsibility is accepted by Boffa Miskell Limited for any errors or omissions to the extent that they arise from inaccurate information provided by the Client or any external source.
0
600 m
1:20,000 @ A3
Data Sources: BOPLASS Limited, Land Information New Zealand.
Projection: NZGD 2000 New Zealand Transverse Mercator
ROTORUA LAKES MANAGEMENT PLAN
Site Extents - Lake Rotomahana - Figure 9.10.1
Date: 6 June 2017 | Revision: E
Plan prepared for Bay of Plenty Regional Council by Boffa Miskell Limited
Project Manager: Kieran.Miller@boffamiskell.co.nz | Drawn: ATh | Checked: KMi

Figure 9.10.1

Currently, biodiversity of native submerged vegetation remains high and this is reflected in a high LakeSPI score (2015 assessment). To safeguard this unusual plant composition and associated biodiversity values, a pest plant management protocol should be tested within a confined area to achieve an aquatic 'refuge'. The prime location for this site would be an enclosed bay on the northern shoreline of the lake (Figure 9.10.2) estimated at 2.3 ha in area. Establishing a 'refuge' would require isolation of the bay from the remainder of the lake by a c. 30 m long mesh barrier. It would be important that the mesh size and floating top of the barrier prevent the entry of hornwort and egeria fragments. Boating access might be permitted by drop boom, with the understanding that vessels have been checked for contaminating pest plants, but total exclusion would be the preferred option.

Once the barrier is established we recommend a whole-of-bay diquat application (Figure 9.10.3, Table 9.10.3), with twice-yearly follow up applications as necessary. Egeria and hornwort are more susceptible to diquat action than most native plants. Although the long-term aim is eradication of these pest plants, maintaining a low abundance would be sufficient to safeguard native vegetation composition. It is expected that repeated applications at six monthly intervals will be sufficient to supress these pest plants to low abundance (Figure 9.10.3, Table 9.10.3). Assessment of the submerged vegetation should be undertaken after c. 2-3 applications, and if feasible, hand weeding of egeria and hornwort should be undertaken to attempt eradication. Should this approach result in protection of plant biodiversity, it could be considered for other shorelines within Lake Rotomāhana.

Figure 9.10.2 Enclosed bay on the northern shore of Lake Rotomāhana (Image sourced from: Google 2016 and Bay of Plenty TA's).

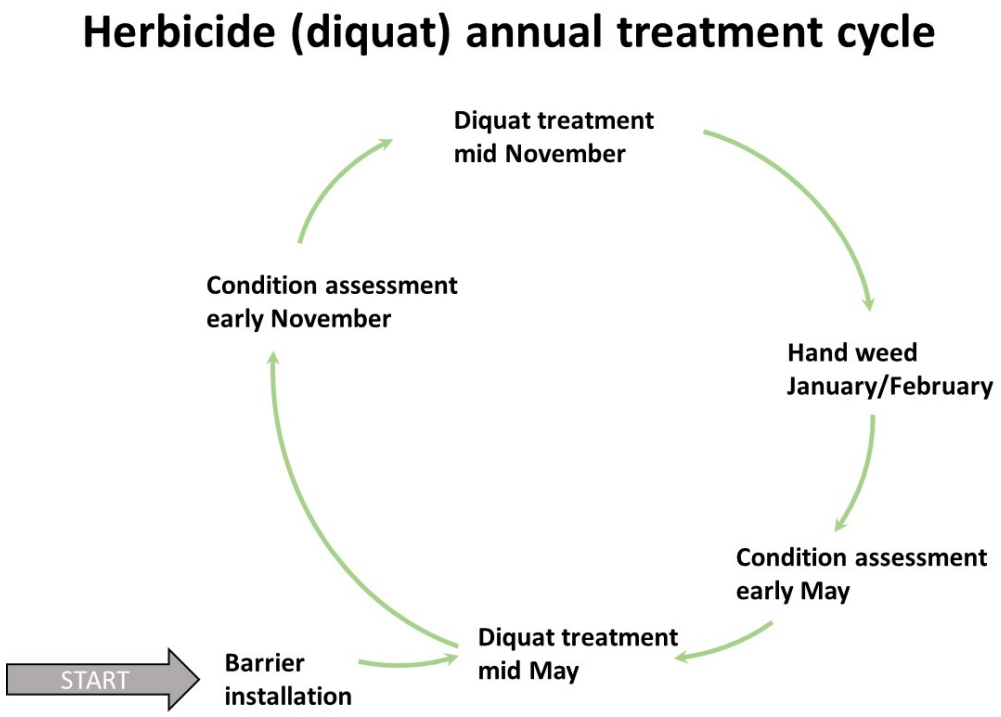

Figure 9.10.3 Proposed diquat and hand weeding treatment to establish a native vegetation refuge in Lake Rotomāhana.

Table 9.10.3 Proposed control for Lake Rotomāhana over the next three years (as growth year, spring through winter) for sites identified for pest plant management (Figures 9.10.1 and 9.10.2) listed below

Site	Year 1	Year 2	Year 3
Enclosed bay as native vegetation refuge.	Installation of barrier *and* Diquat treatment twice a year.	Diquat treatment twice a year *and* Hand weed.	Dependent on outcomes from year 2.
Rotomāhana shoreline.	No control.	No control.	Dependent on outcomes from enclosed bay after year 2.

9.10.7 Surveillance

Lake Rotomāhana is currently not part of the surveillance programme as it contains established populations of the most invasive aquatic pest plant (hornwort) found within the Rotorua Te Arawa Lakes area. Monitoring is still conducted within Lake Rotomāhana as part of the pre-and post spray assessments which assists in identifying aquatic pest plant incursions outside of the species already present. In the event of a new incursion, an incursion response plan will be developed by BOPRC in consultation with TALT, LINZ and other stakeholders. Cultural monitoring also provides a form of surveillance. BOPRC will engage with Te Arawa hapū and iwi to actively report new and unusual aquatic pest plant findings.

9.11 Lake Okaro Aquatic Plant Management Plan

9.11.1 Lake Okaro

Lake Okaro is a small sized lake within the Rotorua region with a surface area of approximately 31 ha and a maximum depth of 18 m (Bay of Plenty Regional Council *et al*. 2015). Lake Okaro is located approximately 20 km southeast of Rotorua city and 3 km southwest of Lake Rotomāhana.

Water flows into Lake Okaro via groundwater and two streams towards the northwest. Water exits the lake via groundwater and the Haumi Stream before eventually discharging into Lake Rotomāhana. Water quality in the lake is poor with algae blooms a common occurrence (Bay of Plenty Regional Council *et al*. 2006).

9.11.2 Importance of lake

Lake Okaro and the surrounding catchment provides several important values including cultural, amenity and recreational. Lake Okaro, along with the remaining lakes nearby, is also of significant cultural importance to Iwi and hapu with the lakes and surrounding environment being a central component to iwi and hapu traditions and beliefs. There are a number of significant cultural landmarks, pa sites, food gathering areas as well as urupa around the lake. There are wetlands that provide important habitat for plants, freshwater fish and birds.

Te Tūāpapa o ngā Wai o Te Arawa outlines the values of Te Arawa associated with the Lakes and also provides guidance on the principles to be applied to all decision-making processes and management activities (Te Arawa Lakes Trust & Conroy and Donald Consultants Limited 2016).

9.11.3 What is the problem?

Lake Okaro does not share the same aquatic pest plant issues that neighbouring lakes suffer from. Instead, the biggest concern for Lake Okaro, in addition to water quality, is keeping hornwort, lagarosiphon and egeria out of the lake as well as controlling existing beds of elodea. Elodea outcompetes and displaces native aquatic species and has been identified as the most problematic species within Lake Okaro. Current pest plant issues would be compounded through the introduction and establishment of hornwort, lagarosiphon and egeria particularly with improving water clarity in the lake.

During the latest round of LakeSPI (submerged plant indicators) monitoring, the lake condition status was documented as “moderate”. LakeSPI has mostly followed the native condition trend, increasing and decreasing at similar magnitudes over the monitoring occasions, while invasive impact has fluctuated (NIWA 2016a). It must be noted that native condition is likely to have been affected by water quality as well as aquatic pest plant species.

9.11.4 Goal, targets, objectives and actions

The goal for Lake Okaro is:

Lagarosiphon, hornwort *and egeria are prevented from establishing within Lake Okaro.*

LakeSPI targets have been set for Lake Okaro to quantitatively assess changes in aquatic plant species and distribution and will assist in measuring progress towards achieving the goal. Lake Okaro has three LakeSPI targets including a minimum threshold - which the lake is precluded from falling below, 10-year target and a long-term target. The minimum threshold and targets have been developed in consultation with NIWA.

- The minimum threshold is the lowest LakeSPI value recorded from the past 15 years of monitoring (when regular LakeSPI monitoring of Rotorua Te Arawa lakes began). If the minimum threshold is breached, the plan and control activities will be reviewed. Outcomes from the review may include seeking further technical advice, amending pest plant management activities and/or gathering feedback from stakeholders. Any decisions or recommendations will be made in the wider context of control activities and programmes across Te Arawa Rotorua Lakes.

- The 10-year target is based on an improvement of five percentage points over the duration of two LakeSPI monitoring occasions beginning from the 2015 LakeSPI value[2] (monitoring is undertaken every two years – i.e. an improvement of five percentage points every four to five years).
- The long-term target is based on the likely LakeSPI values from Lake Okaro during the 1960s.

Table 9.11.1 provides an overview of the minimum threshold and targets and Table 9.11.2 describes the objectives and actions for Lake Okaro.

Table 9.11.1 LakeSPI targets and minimum threshold for Lake Okaro

Site	LakeSPI value
Current Lake SPI value	49
2015 Lake SPI value	28
Minimum threshold	19
10-year target	38
Long term target	73

Table 9.11.2 Lake Okaro aquatic plant management plan objectives and actions

Objective	Actions
Plan is supported by central, regional and local government, Te Arawa and the local community.	Obtain endorsement for the plan from Te Arawa Lakes Strategy Group.
	Seek and secure adequate funding to implement control work programmes.
	Actively involve iwi and the local community in carrying out the plan (i.e. reporting incursions and unusual findings, and providing feedback).
	Align aquatic pest plant control objective with appropriate programmes in the BOP Regional Pest Management Plan.
	Review and update aquatic plant management plan at least once every three years.
	Prepare an annual plan of works by 30 June each year.
	Report progress to Te Arawa Lakes Strategy Group and communities annually.
Improve and increase Te Arawa hapū and iwi use of the lake.	Engage with Te Arawa hapū and iwi in management of biosecurity issues.
	Engage with Te Arawa hapū and iwi on use of the Lake for cultural practises and connection to the Lakes.
	Work with Te Arawa hapū and iwi to improve access to cultural materials and mahinga kai where access is hindered by aquatic pest plants.
	Work with Te Arawa hapū and iwi to improve mahinga kai habitats where they are impacted or threatened by aquatic pest plants.

[2] The 2015 LakeSPI value has been used to take into account the recent decrease in aquatic pest plant cover within Lake Okaro.

Objective	Actions
	Engage Te Arawa hapū and iwi to actively report new and unusual weed findings.
	Provide support for Te Arawa hapū and iwi to conduct cultural monitoring of the lake.
Enhance biodiversity and improve and increase local communities and visitors use of the lake.	Implement annual control programme to schedule and budget.
	Restore aquatic native plant communities through controlling aquatic pest plants.
	Ensure control works do not unreasonably hamper lake use.
	Ensure control work is effective and does not cause unintended environmental harm.
	Ensure iwi, the local community and lake users are aware of planned control works.
New pest plant incursions are detected early enough to be eradicated or controlled.	Engage community to actively report new and unusual pest plant findings.
	Carry out annual passive and proactive surveillance to detect new pest incursions.
	Prevent elodea from being transferred from Lake Okaro to any other waterbodies.
	Prevent lagarosiphon, hornwort and egeria from establishing within Lake Okaro.
Effectiveness and effects of pest plant control are measured and results are incorporated into future works.	Undertake operational monitoring to assess whether aquatic pest plant control has been successful.
	Undertake monitoring to detect unintentional outcomes (e.g. adverse effects to non-target plant and animal species).
	Incorporate results from monitoring into reviews and work programmes to improve future control programmes.
Research improves methods for surveillance, monitoring and control of aquatic pest plants.	Use research for the basis for decisions on aquatic pest plant management.
	Support research in aquatic pest plant management.

9.11.5 No management scenario

Elodea is currently the only problematic invasive aquatic pest plant present within Lake Okaro. Without active management and monitoring, this aquatic pest plant will potentially spread to other parts of the lake, reducing the extent of aquatic native habitat.

In addition to the further spread of elodea, a lack of management and monitoring could result in the introduction and establishment of lagarosiphon, hornwort and egeria. This is a threat to Lake Okaro with the presence of hornwort, lagarosiphon and egeria in nearby lakes. The scenario of not undertaking any management or monitoring is not acceptable to stakeholders or the wider public.

9.11.6 Proposed management

NIWA (2017b) established the most efficient and cost-effective methods for which to manage aquatic pest plants within Lake Okaro for the next three years. Unless stated otherwise, the proposed methods and associated diagrams/figures have been developed by NIWA.

The whole shoreline of Lake Okaro (Figure 9.11.1) was ranked as medium priority for pest plant management due to biosecurity considerations (Dragten Consulting 2016). Elodea and curly pondweed are the only invasive aquatic pest plant species to be recorded in this lake (Clayton *et al.* 1990, Burton 2016), both of which although widespread, are considered to be at the less invasive end of the spectrum compared with lagarosiphon, hornwort and egeria. Impacts are likely to worsen considerably in the event of those aquatic pest plants establishing in Lake Okaro, so preventative biosecurity is a key focus for this lake.


Lake Okaro
Boffa Miskell
www.boffamiskell.co.nz
0
200 m
1:10,000 @ A3
Data Sources: BOPLASS Limited, Land Information New Zealand.
Projection: NZGD 2000 New Zealand Transverse Mercator
ROTORUA LAKES MANAGEMENT PLAN
Site Extents - Lake Okaro - Figure 9.11.1
Date: 6 June 2017 | Revision: E
Plan prepared for Bay of Plenty Regional Council by Boffa Miskell Limited
Project Manager: Kieran.Miller@boffamiskell.co.nz | Drawn: ATh | Checked: KMi

Figure 9.11.1

In the past, submerged vegetation was almost solely comprised of elodea in Lake Okaro. Elodea fluctuated in cover and depth range, apparently in response to fluctuating water quality and clarity in this degraded lake (Burton 2016). Considerable initiatives have been applied to the lake and catchment to improve water quality in recent years. Most recently (early to mid-2017) a large reduction in the dominance of elodea has been observed (NIWA unpublished data) and an increase in native pondweeds (especially Potamogeton ochreatus) has occurred (Figure 9.11.2). This reflects the tendency for elodea to be an early coloniser following disturbance compared to other pest plants. Elodea is an early coloniser following disturbance, but can be outcompeted by other (including native) plants under more stable lake conditions.

Figure 9.11.2 Native pondweed dominated Lake Okaro in March 2017 following a decline in elodea.

No control is recommended at the shoreline of Lake Okaro (Table 9.11.3). Currently elodea is at low abundance and is at little risk of fouling boats or trailers. Actions are recommended to prevent introduction and establishment of additional invasive aquatic pest plants by focusing annual surveillance activities at the boat ramp, and potentially installation of a weed cordon (dependent on regional lake priorities).

Table 9.11.3 Proposed control for Lake Okaro over the next three years (as growth year, spring through winter) for sites identified for pest plant management (Figure 9.11.1) listed below

Site	Year 1	Year 2	Year 3
Okaro (entire shoreline)	No control.	No control.	No control.

9.11.7 Surveillance

Surveillance monitoring is conducted in Lake Okaro when lake conditions allow. Poor visibility within Lake Okaro often prevents surveillance monitoring from being effective:

- SCUBA searches using manta board tows with the boat operator controlling the search pattern,
- Spot diving,
- Snorkelling,
- SCUBA diving using an underwater scooter, and/or
- Shoreline searches.

Surveillance monitoring sites are pre-determined using a prioritisation model which assesses lake specific sites based on parameters such as likely pest plant entry, recreational use and ability to detect new incursions. Records are kept from each surveillance monitoring occasion.

Monitoring is also conducted within Lake Okaro as part of the pre and post spray assessments which assists in identifying aquatic pest plant incursions outside of the species already present. In the event of a new incursion, an incursion response plan will be developed by BOPRC in consultation with TALT, LINZ and other stakeholders. Cultural monitoring also provides a form of surveillance. BOPRC will engage with Te Arawa hapū and iwi to actively report new and unusual aquatic pest plant findings.

9.12 Lake Rerewhakaaitu Aquatic Plant Management Plan

9.12.1 Lake Rerewhakaaitu

Lake Rerewhakaaitu (meaning “the lake of wandering spirits”) is a small sized lake within the Rotorua region with a surface area of approximately 530 ha and a maximum depth of 1 5 m (Bay of Plenty Regional Council *et al*. 2015). Lake Rerewhakaaitu is located approximately 25 km southeast of Rotorua city and just over 4 km southeast of Lake Rotomāhana.

Lake Rerewhakaaitu has a unique catchment with a large proportion of groundwater draining into adjacent catchments. Lake Rerewhakaaitu is fed by the Mangakino and Awaroa Streams, which flow into the southern end of the lake. Water exits mostly via groundwater to Lake Rotomāhana (Bay of Plenty Regional Council *et al*. 2015).

9.12.2 Importance of lake

Lake Rerewhakaaitu and the surrounding catchment provides several important values including cultural, biodiversity, amenity and recreational. The lake and surrounding catchment also provides habitat for the largest breeding population of banded dotterel in the Rotorua region.

Lake Rerewhakaaitu, along with the remaining lakes nearby, is also of significant cultural importance to iwi and hapu with the lakes and surrounding environment being a central component to iwi and hapu traditions and beliefs. There are a number of significant cultural landmarks, pa sites, food gathering areas as well as urupa. The lake contains populations of koura, kakahi, tuna and inānga for which Te Arawa have a role to sustainably manage these fisheries. There are wetlands that provide important habitat for plants, freshwater fish and birds.

Te Tūāpapa o ngā Wai o Te Arawa outlines the values of Te Arawa associated with the Lakes and also provides guidance on the principles to be applied to all decision-making processes and management activities (Te Arawa Lakes Trust & Conroy and Donald Consultants Limited 2016).

9.12.3 What is the problem

Lake Rerewhakaaitu does not share the same aquatic pest plant issues that neighbouring lakes suffer from. Instead the biggest concern for Lake Rerewhakaaitu, in addition to water quality, is controlling existing beds of lagarosiphon, egeria and elodea and keeping hornwort out of the lake. Lagarosiphon, egeria and elodea outcompete and displace native aquatic species and have been identified as three of the most problematic species within Lake Rerewhakaaitu and in the wider Rotorua lakes. Current pest plant issues would be compounded through the introduction and establishment of hornwort particularly with improving water clarity in the lake.

During the latest round of LakeSPI (submerged plant indicators) monitoring, a tool used to assess and report on the aquatic plant condition of New Zealand lakes, the lake condition status was documented as “moderate”. Since 2001, LakeSPI has varied between 35% and 41%. Native condition and invasive impact scores have fluctuated by 13% and 14%, respectively, over the same time period. LakeSPI has mostly followed the native condition trend, increasing and decreasing at similar magnitudes over the monitoring occasions (NIWA 2016a).

9.12.4 Goal, targets, objectives and actions

The goal for Lake Rerewhakaaitu is:

Hornwort is prevented from establishing in Lake Rerewhakaaitu, while hapū/iwi, community and visitor experience is improved.

LakeSPI targets have been set for Lake Rerewhakaaitu to quantitatively assess changes in aquatic plant species and distribution and will assist in measuring progress towards achieving the goal. Lake Rerewhakaaitu has three LakeSPI targets including a minimum threshold - which the lake is precluded from falling below, 10-year target and a long-term target. The minimum threshold and targets have been developed in consultation with NIWA.

- The minimum threshold is the lowest LakeSPI value recorded from the past 15 years of monitoring (when regular LakeSPI monitoring of Rotorua Te Arawa lakes began). If the minimum threshold is breached, the plan and control activities will be reviewed. Outcomes from the review may include seeking further technical advice, amending pest plant management activities and/or gathering feedback from stakeholders. Any decisions or recommendations will be made in the wider context of control activities and programmes across Te Arawa Rotorua Lakes.
- The 10-year target is based on an improvement of five percentage points over the duration of two LakeSPI monitoring occasions beginning from the 2016 LakeSPI value (monitoring is undertaken every two years – i.e. an improvement of five percentage points every four to five years).
- The long-term target is based on the likely LakeSPI values from Lake Rerewhakaaitu during the 1960s.

Table 9.12.1 provides an overview of the minimum threshold and targets and Table 9.12.2 describes the objectives and actions for Lake Rerewhakaaitu.

Table 9.12.1 LakeSPI targets and minimum threshold for Lake Rerewhakaaitu

Site	LakeSPI value
Current Lake SPI value (2016)	31
Minimum threshold	31
10-year target	41
Long term target	94

Table 9.12.2 Lake Rerewhakaaitu aquatic plant management plan objectives and actions

Objective	Actions
Plan is supported by central, regional and local government, Te Arawa and the local community.	Obtain endorsement for the plan from Te Arawa Lakes Strategy Group.
	Seek and secure adequate funding to implement control work programmes.
	Actively involve iwi and the local community in carrying out the plan (i.e. reporting incursions and unusual findings, and providing feedback).
	Align aquatic pest plant control objective with appropriate programmes in the BOP Regional Pest Management Plan.
	Review and update aquatic plant management plan at least once every three years.
	Prepare an annual plan of works by 30 June each year.

Objective	Actions
	Report progress to Te Arawa Lakes Strategy Group and communities annually.
Improve and increase Te Arawa hapū and iwi use of the lake.	Engage with Te Arawa hapū and iwi in management of biosecurity issues.
	Engage with Te Arawa hapū and iwi on use of the Lake for cultural practises and connection to the Lakes.
	Work with Te Arawa hapū and iwi to improve access to cultural materials and mahinga kai where access is hindered by aquatic pest plants.
	Work with Te Arawa hapū and iwi to improve mahinga kai habitats where they are impacted or threatened by aquatic pest plants.
	Engage Te Arawa hapū and iwi to actively report new and unusual weed findings.
	Provide support for Te Arawa hapū and iwi to conduct cultural monitoring of the lake.
Enhance biodiversity and improve and increase local communities and visitors use of the lake.	Implement annual control programme to schedule and budget.
	Restore aquatic native plant communities through controlling aquatic pest plants.
	Ensure control works do not unreasonably hamper lake use.
	Ensure control work is effective and does not cause unintended environmental harm.
	Ensure iwi, the local community and lake users are aware of planned control works.
New pest plant incursions are detected early enough to be eradicated or controlled.	Engage community to actively report new and unusual pest plant findings.
	Carry out annual passive and proactive surveillance programme to detect new pest incursions.
	Confine boat launching to formal lake access points.
	Prevent lagarosiphon, egeria and elodea from being transferred from Lake Rerewhakaaitu to any other waterbodies.
	Prevent hornwort from establishing within Lake Rerewhakaaitu.
Effectiveness and effects of pest plant control are measured and results are incorporated into future works.	Undertake operational monitoring to assess whether aquatic pest plant control has been successful.
	Undertake monitoring to detect unintentional outcomes (e.g. adverse effects to non-target plant and animal species).
	Incorporate results from monitoring into reviews and work programmes to improve future control programmes.
Research improves methods for surveillance, monitoring and control of aquatic pest plants.	Use research for the basis for decisions on aquatic pest plant management.
	Support research in aquatic pest plant management.

9.12.5 No management scenario

Lagarosiphon, egeria and elodea are currently the only problematic invasive aquatic pest plants present within Lake Rerewhakaaitu. Without active management and monitoring, these aquatic pest plants will continue to spread to other parts of the lake, reducing the extent of aquatic native habitat.

In addition to further spread of lagarosiphon, egeria and elodea, a lack of management and monitoring could result in the introduction and establishment of hornwort. This is a threat to Lake Rerewhakaaitu with the presence of hornwort in nearby lakes. The scenario of not undertaking any management or monitoring is not acceptable to stakeholders or the wider public.

9.12.6 Proposed management

NIWA (2017d) established the most efficient and cost-effective methods for which to manage aquatic pest plants within Lake Rerewhakaaitu for the next three years. Unless stated otherwise, the proposed methods and associated diagrams/ figures have been developed by NIWA.

Records show existing invasive aquatic pest plant species present within Lake Rerewhakaaitu include curly pondweed, elodea, lagarosiphon and egeria (Burton 2016). Currently (2016), egeria dominates much of the vegetation.

Site priorities for pest plant management have been ranked as medium based on biosecurity for Homestead Arm and Domain/DOC Ash Pit Road (Dragten Consulting 2016). Department of Conservation Brett Road was ranked as low priority (Dragten Consulting 2016). Also, the informal boat launch area at Half Moon Bay (Figure 9.12.1) is of potential biosecurity concern.

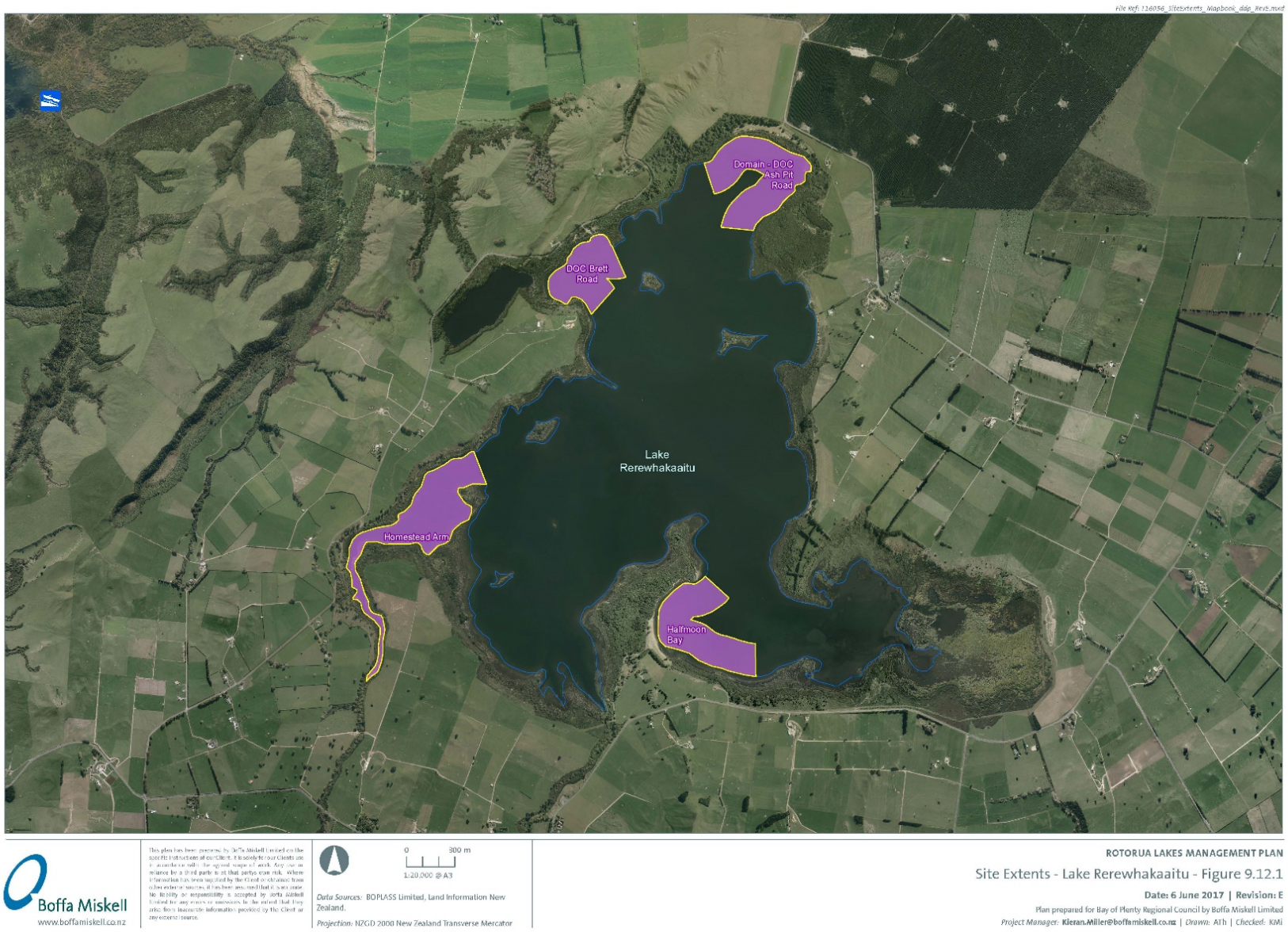
File Ref: 116056_SiteExtents_Mapbook_ddp_Rev5.mxd
Domain - DOC Ash Pit Road
DOC Brett Road
Lake Rerewhakaaitu
Homestead Arm
Halfmoon Bay
Boffa Miskell
www.boffamiskell.co.nz
0 300 m
1:20,000 @ A3
Data Sources: BOPLASS Limited, Land Information New Zealand.
Projection: NZGD 2000 New Zealand Transverse Mercator
ROTORUA LAKES MANAGEMENT PLAN
Site Extents - Lake Rerewhakaaitu - Figure 9.12.1
Date: 6 June 2017 | Revision: E
Plan prepared for Bay of Plenty Regional Council by Boffa Miskell Limited
Project Manager: Kieran.Miller@boffamiskell.co.nz | Drawn: AIh | Checked: KMi

Figure 9.12.1

Homestead Arm

Homestead Arm has an adjacent reserve (a popular campsite) and concrete boat ramp within this sheltered bay, with a weed cordon located across the arm where boat traffic exits to the lake. This arm has high potential for pest plant impacts on amenity use. It is the primary boat launching and retrieval site for the lake so biosecurity considerations should consider the potential for pest plant contamination during boat haul out or the introduction of hornwort on incoming craft or equipment.

An initial treatment with diquat is recommended within the cordon area. Once pest plant biomass is reduced, bottom lining using biodegradable hessian (Caffery *et al.* 2010, Hofstra and Clayton 2012) should be applied to the area around the boat ramp to a distance of 5 to 10 m. The lined area should also incorporate the adjacent jetty. The lining needs to be secured well to the lake bed to prevent dislodgement by waves so it does not become a propeller entanglement hazard for boating. Bottom lining is capable of smothering lagarosiphon and egeria and retarding their reestablishment for over a year. This zone will both limit trailer and boat contact with pest plants during haul-out and also improve conditions for visual surveillance for hornwort.

Ongoing (annual, Figure 9.12.2, Table 9.12.3) retreatment with diquat within the wider cordon area should be sufficient to supress weed bed development from causing amenity impacts. The channel leading to the lake is usually clear of pest plants owing to its depth.

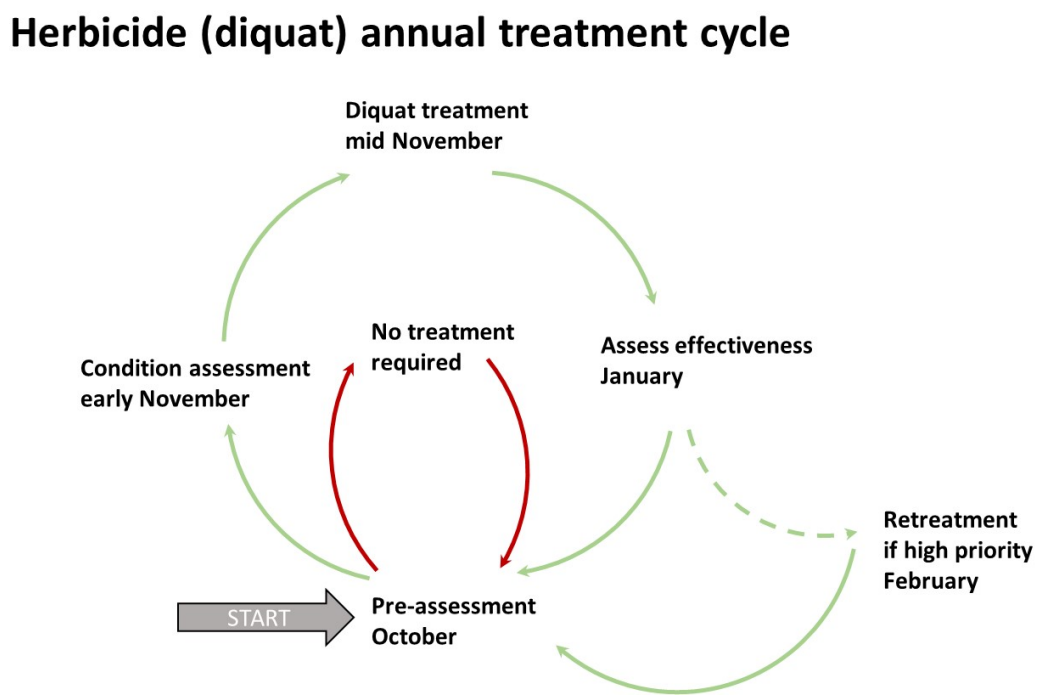

Figure 9.12.2 Annual cycle of treatment and assessment of egeria and lagarosiphon using diquat.

Domain/DOC Ash Pit Road

This site is a popular recreational beach with two or more informal launch places. The width of the shallow sandy beach limits boat and trailer contact with the weed beds during launching and retrieval. However, weed beds pose potential for amenity impacts further offshore and there is biosecurity risk from equipment fouling albeit lower than Homestead Arm (Figure 9.12.3).

We recommend annual diquat treatment (Figure 9.12.2, Table 9.12.3) along 500 m including the most commonly used beach access points, targeting egeria and lagarosiphon in the 2 to 5 m depth zone.

Figure 9.12.3 Egeria and lagarosiphon is cleared from an anchor used in Lake Rerewhakaaitu.

Half Moon Bay

Comprising a sandy beach launch access to a sheltered bay, Half Moon Bay has large weed beds offshore within the wider shallow bay. An annual diquat treatment (Figure 9.12.2) along 250 m of shoreline will assist in reducing pest plant contact for recreation (Table 9.12.3).

Department of Conservation Brett Road

This site also affords access for beach launching, but is less utilised than the Ash Pit Road site. The deeper lake bathymetry in this area also limits weed bed development and therefore with a low probability of amenity impacts and biosecurity risk. Therefore, no control is advocated for this site (Table 9.12.3).

Table 9.12.3 Proposed control for the next three years (as growth year, spring through winter) for sites identified for pest plant management in Lake Rerewhakaaitu (Figure 9.12.1)

Site	Year 1	Year 2	Year 3
Homestead Arm	Assess for annual diquat treatment and Bottom line immediate vicinity of boat ramp.	Assess for annual diquat treatment.	Assess for annual diquat treatment.
Domain/DOC Ash Pit Road	Assess for annual diquat treatment.	Assess for annual diquat treatment.	Assess for annual diquat treatment.
Half Moon Bay			
DOC Brett Road	No control.	No control.	No control.

9.12.7 Surveillance

Surveillance monitoring is conducted in Lake Rerewhakaaitu twice a year using a variety of methods including:

- SCUBA searches using manta board tows with the boat operator controlling the search pattern,
- Spot diving,
- Snorkelling,
- SCUBA diving using an underwater scooter, and/or
- Shoreline searches.

Surveillance monitoring sites are pre-determined using a prioritisation model which assesses lake specific sites based on parameters such as likely pest plant entry, recreational use and ability to detect new incursions. Records are kept from each surveillance monitoring occasion.

Monitoring is also conducted within Lake Rerewhakaaitu as part of the pre-and post spray assessments which assists in identifying aquatic pest plant incursions outside of the species already present. In the event of a new incursion, an incursion response plan will be developed by BOPRC in consultation with TALT, LINZ and other stakeholders.

In addition to the surveillance programme, BOPRC also undertake an annual awareness campaign/survey and regularly interact with the public. They provide a portable wash down facility from time to time during the summer months and have installed a weed cordon. Cultural monitoring also provides a form of surveillance. BOPRC will engage with Te Arawa hapū and iwi to actively report new and unusual aquatic pest plant findings.

10 Risks

There are several risks which may hinder the implementation of these aquatic plant management plans including the following:

- Total or partial loss of funding – BOPRC and LINZ jointly fund aquatic plant management in Te Arawa Rotorua lakes. While it is unlikely all funding would be lost, there is potential that some funds (either LINZ or BOPRC) are re-distributed to different areas/programmes resulting in a scaled back aquatic plant management programme.
- Insufficient funding – the goals and LakeSPI targets outlined in some cases would require a significant increase in funding to see these goals realised. Current budgets would not enable the more ambitious goals and targets to be achieved.
- Maintaining stakeholder/public satisfaction – There are several organisations/landowners/public/lake users which all have different opinions and views about how one or all the lakes should be managed. It will be impossible to please all parties and there will likely be some disagreement with how aquatic plants are managed. Lake management plans and subsequent actions must be transparent with practical justification for decisions.
- Dynamic environmental conditions – Dynamic lake conditions may hamper aquatic plant management resulting in delays or cancelled planned activities. Aquatic plant diversity and abundance will also change (for better or worse) and will require adjustments to proposed management and potentially a change of focus (i.e. a new aquatic pest plant incursion into the Rotorua Te Arawa lakes).

These risks are likely to be on-going and will need to be continually managed along with other risks that may arise.

11 Monitoring and plan review

Monitoring is pivotal to direct pest plant control efforts, assess the effectiveness of control activities and determine if conditions are suitable for herbicide application. Monitoring is conducted as part of NIWA's LakeSPI monitoring programme which assesses ecological health of lakes throughout the country and by BOPRC to determine the extent and density of aquatic pest plants pre-and post spray application. In addition, cultural monitoring will also be conducted by hapū/iwi with data and results used to assist and influence future decisions for prioritising management.

Pre-and post pest plant control monitoring will continue as per the lake management plans using the variety of methods best suited for each lake. BOPRC currently use a scoring system to assess pest plant cover, water clarity, water colour and condition, which assists in guiding pest plant management efforts. LakeSPI monitoring will continue in each lake and provide results on the progress of lakes towards their respective LakeSPI targets.

A monitoring programme for parameters that may be indirectly affected by pest plant control activities (i.e. kākahi and/or koura populations) will be prepared on a per lake basis in collaboration with hapū/iwi. Monitoring results, as well as informal observations made by BOPRC staff or the public that are associated with pest plant control activities, will be used to update aquatic plant management or provide a means for further investigation.

Pre-and post pest plant control, LakeSPI and indirect effects monitoring results will contribute towards the review of lake management plans with strategies and proposed actions updated based on the progress towards the lake goals, objectives and outcomes. Improved and new technology and methods as well as research outcomes will also contribute towards updating lake management plans.

Aquatic plant management plans for each lake will be reviewed at least once every three years as described in the outcomes for each plan. Plans will likely traverse new challenges as aquatic plant management progresses, such as eradication and native plant restoration. Aquatic plant management plans could also be amalgamated with other lake aspects such as reducing nutrient concentrations and controlling pest animal species.

12 References

APR Consultants Ltd 2011a. Aquatic weed control for amenity purposes on Rotorua Lakes: Assessment of need. Report prepared for Bay of Plenty Regional Council.

APR Consultants Ltd 2011b. Aquatic weed control for amenity purposes on Rotorua Lakes: Stage 2 – Consultation with key stakeholders. Report prepared for Bay of Plenty Regional Council.

APR Consultants Ltd 2011c. Aquatic weed control for amenity purposes on Rotorua Lakes: Stage 3 – Assessment of control and prioritisation options. Report prepared for Bay of Plenty Regional Council.

Bay of Plenty Regional Council 2010. Lake Ōkataina incursion management options. Report prepared for Bay of Plenty Regional Council.

Bay of Plenty Regional Council 2015a. Lake Ōkāreka hornwort management plan 2013. Report prepared for Bay of Plenty Regional Council.

Bay of Plenty Regional Council 2015b. Tarawera lakes restoration plan. Report prepared for Bay of Plenty Regional Council.

Bay of Plenty Regional Council, Rotorua Lakes Council, Te Arawa Lakes Trust 2004. Lake Ōkāreka catchment management action plan. Report prepared for the Rotorua Te Arawa Lakes Programme.

Bay of Plenty Regional Council, Rotorua Lakes Council, Te Arawa Lakes Trust 2006. Lake Okaro action plan. Report prepared for the Rotorua Te Arawa Lakes Programme.

Bay of Plenty Regional Council, Rotorua Lakes Council, Te Arawa Lakes Trust 2007. Lake Rotoehu action plan. Report prepared for the Rotorua Te Arawa Lakes Programme.

Bay of Plenty Regional Council, Rotorua Lakes Council, Te Arawa Lakes Trust 2009a. Lake Rotomā action plan. Report prepared for the Rotorua Te Arawa Lakes Programme.

Bay of Plenty Regional Council, Rotorua Lakes Council, Te Arawa Lakes Trust 2009b. Lakes Rotorua and Rotoiti action plan. Report prepared for the Rotorua Te Arawa Lakes Programme.

Bay of Plenty Regional Council, Rotorua Lakes Council, Te Arawa Lakes Trust 2011. Lake Tikitapu action plan. Report prepared for the Rotorua Te Arawa Lakes Programme.

Bay of Plenty Regional Council, Rotorua Lakes Council, Te Arawa Lakes Trust 2012. Lake Ōkataina water quality: Background information 2012. Report prepared for the Rotorua Te Arawa Lakes Programme.

Bay of Plenty Regional Council, Rotorua Lakes Council, Te Arawa Lakes Trust 2013. Lake Ōkataina action plan. Report prepared for the Rotorua Te Arawa Lakes Programme.

Bay of Plenty Regional Council, Rotorua Lakes Council, Te Arawa Lakes Trust 2015. Lakes. Multiple webpages retrieved from http://www.rotorualakes.co.nz/lakes.

Bay of Plenty Regional Council 2020. Proposed Regiona Pest Management Plan for the Bay of Plenty region. Bay of Plenty Regional Council. Whakatane, New Zealand.

Burton T 2015. Control methods for invasive submerged plant species in Lake Ōkāreka. Report prepared for Bay of Plenty Regional Council.

Burton T 2016. Assessment of the Rotorua Te Arawa lakes using LakeSPI – 2016. NIWA Client Report No: 2016019HN, Prepared for Bay of Plenty Regional Council.

Butterworth J 2012. Lake Rotokakahi water quality update 1990 – 2011. Report prepared for the Bay of Plenty Regional Council.

Caffrey JM, Millane M, Evers S, Moron H, Butler M 2010. A novel approach to aquatic weed control and habitat restoration using biodegradable jute matting. *Aquatic Invasions*, 5(2): 123-129.

Champion P 2009. Review of Environment Bay of Plenty aquatic plant pest surveillance and monitoring programme for the Rotorua lakes. Report prepared for Environment Bay of Plenty.

Champion P, Rowe D, Smith B, Wells R, Kilroy C, de Winton M 2013. Freshwater pests of New Zealand: Section 3 – Freshwater pest plants of New Zealand. NIWA. New Zealand.

Chapman VJ 1970. A history of the lake-weed infestation of the Rotorua Lakes and the lakes of the Waikato hydro-electric system. N.Z. DSIR, Information Series 78.

Chishold ND. Review of aquatic weed control methods in New Zealand. Aquatic weed control ltd. Dunedin, New Zealand.

Clayton JS, de Winton M, Wells RDS, Tanner CC, Miller ST, Evans-McLeod D 1990. The aquatic vegetation of 15 Rotorua lakes. 2nd edition. Aquatic Plant Section, Ministry of Agriculture Fisheries, Hamilton.

Clayton J, Edwards T, de Winton M 2005. The condition of twelve lakes in the Rotorua lakes Region using LakeSPI. *NIWA Client Report*: HAM2005-122: 48.

Clayton JS, Wells RDS 1989. Aquatic weed control in the Rotorua Lakes – A technical evaluation. New Zealand Ministry of Agriculture and Fisheries. Hamilton, New Zealand.

Clayton J, Wells R, Champion P, Blair N 2000. Rototilling and alternative options for control of Lagarosiphon major in Paddock Bay, Lake Wanaka. NIWA report.

De Lange PJ, Rolfe JR, Champion PD, Courtney SP, Heenan PB, Barkla JW, Cameron EK, Norton DA, Hitchmough RA 2013. Conservation status of New Zealand indigenous vascular plants, 2012. Report prepared for Department of Conservation.

Dragten R 2016. Prioritising aquatic pest plant control in the Rotorua Lakes. Report prepared for Bay of Plenty Regional Council.

Hofstra DE, Champion PD 2008. Assessment of environmental effects for the use of endothall in four hydrilla affected lakes in Hawke's Bay. Report prepared for MAF biosecurity New Zealand.

Land Information New Zealand n.d. Crown property. Retrieved from http://www.linz.govt.nz/crown-property.

Land Information New Zealand 2015. Policy and management. Retrieved from http://www.linz.govt.nz/crown-property/using-crown-property/biosecurity/policy-and-management.

McColl RHS 1972. Chemistry and trophic status of seven New Zealand lakes. *New Zealand Journal of Marine & Freshwater Research,* 6(4): 399–447.

NIWA 2002. Weed management: control methods. Retrieved from https://www.niwa.co.nz/our-science/aquatic-biodiversity-and-biosecurity/our-services/aquaticplants/outreach/weedman/control#biological.

NIWA 2016a. NIWA lake submerged plant indicators. Multiple webpages retrieved from https://lakespi.niwa.co.nz/lake/54730.

NIWA 2016b. Technical input on weed control approaches in Lake Rotoiti. Unpublished report prepared for Boffa Miskell Ltd.

NIWA 2017a. Technical input on weed control approaches in Lake Ōkāreka. Unpublished report prepared for Boffa Miskell Ltd.

NIWA 2017b. Technical input on weed control approaches in Lake Okaro. Unpublished report prepared for Boffa Miskell Ltd.

NIWA 2017c. Technical input on weed control approaches in Lake Ōkataina. Unpublished report prepared for Boffa Miskell Ltd.

NIWA 2017d. Technical input on weed control approaches in Lake Rerewhakaaitu. Unpublished report prepared for Boffa Miskell Ltd.

NIWA 2017e. Technical input on weed control approaches in Lake Rotoehu. Unpublished report prepared for Boffa Miskell Ltd.

NIWA 2017f. Technical input on weed control approaches in Lake Rotokakahi. Unpublished report prepared for Boffa Miskell Ltd.

NIWA 2017g. Technical input on weed control approaches in Lake Rotomā. Unpublished report prepared for Boffa Miskell Ltd.

NIWA 2017h. Technical input on weed control approaches in Lake Rotomāhana. Unpublished report prepared for Boffa Miskell Ltd.

NIWA 2017i. Technical input on weed control approaches in Lake Rotorua. Unpublished report prepared for Boffa Miskell Ltd.

NIWA 2017j. Technical input on weed control approaches in Lake Tarawera. Unpublished report prepared for Boffa Miskell Ltd.

NIWA 2017k. Technical input on weed control approaches in Lake Tikitapu. Unpublished report prepared for Boffa Miskell Ltd.

Rotorua Daily Post 2014. Lake Okaro ownership to be transferred back to Te Arawa. News article published in Rotorua Daily Post on 19/12/2014.

Rotorua Lakes Council 2014. Lakes. Retrieved from http://www.rotorualakescouncil.nz/our-city/Lakes/Pages/default.aspx.

Silvester WB 1981. Water weeds and algae. Report 11. In: Future options for the Rotorua Lakes District: Environmental Studies Unit, Waikato University.

Te Arawa Lakes Settlement Act 2006. Retrieved from http://www.legislation.govt.nz/act/public/2006/0043/latest/DLM381398.html

Te Arawa Lakes Trust, Conroy & Donald Consultants Limited 2016. Te Tūāpapa o ngā wai o Te Arawa: Te Arawa cultural values framework. Report prepared for Te Arawa Lakes Trust.

Wells RDS, Clayton JS 1997. An assessment of the Rotorua Lakes for aquatic weed control and recommended programme for 1997/98. Report prepared for Land Information New Zealand.

Wells R.D.S., Champion P.D., Clayton J.S. (2014). Potential for lake restoration using the aquatic herbicide endothall. Proceedings of the Nineteenth Australasian Weeds Conference Hobart. 143-146. http://caws.org.au/awc/2014/awc201411431.pdf.