



Memo

Date: 17 September 2015

To: The Collaborative Stakeholder Group

From: Technical Leaders Group

Subject: TLG response on Lake Type FMU's

Background

At CSG #14 the CSG decided that the lakes present in the Waikato-Waipā catchment would be managed within 4 FMUs relating to lake type (Dune, Peat, Volcanic and Riverine). A number of questions arose from CSG#14 following this decision:

- What is the current water quality state measured against recommended attributes for lakes within each of these FMUs?
- How representative is the current WRC monitoring network for each of these FMUs?
- What management options exist for these lakes?
- What current restoration activities are underway?
- Should the same attributes and bands as for the Waikato main stem be used and should this vary by lake type?
- What end state could be achievable in the different lake types?

This brief paper outlines background material and interim information to address those questions.

Waikato-Waipā Lakes

There are 59 named lakes in the Waikato/Waipā catchment (Table A2). There are also three geothermal lakes that have been excluded, as geothermal waters are outside the scope of HRWO process.

The peat lakes are the most numerous (35). They tend to be small, with 23 of the peat lakes less than 10 ha in area. All 35 peat lakes have catchments dominated by non-native vegetation. Eight are currently monitored by WRC.

There are 4 dune lakes, all less than 10 ha in size and all with nearly 100% non-native vegetation. None are currently monitored by WRC, but three have historic data available.

The 15 riverine lakes include the largest shallow lakes in the catchment (Waikare, Whangape, Waahi). Four of the lakes are currently monitored.

The five volcanic lakes in the catchment are relatively poorly known. Only two of the five have any environmental data available.

Current state

The following lake water quality attributes have previously been recommended to CSG by TLG:

- Phytoplankton biomass (Chla)
- Total N
- Total P
- Planktonic cyanobacteria
- Clarity

All except clarity are nationally-mandated Attributes representing Ecosystem Health (nutrients & Chlorophyll a) and Human Health (Cyanobacteria) as per the National Objectives Framework within the National Policy Statement for Freshwater Management (NPS-FM).

Most of the Waikato-Waipā lakes where data exists breach the National Bottom line for TP, TN and Chlorophyll a (Table 1). Water quality is best at the two dune lakes (based on historic monitoring data), whereas riverine lakes have the worst water quality. All riverine lakes breach the national Bottom Line for TN (800 ppb), TP (50 ppb) and Chla (12 ppb). All peat lakes breach the national bottom line for TN (i.e. 800 ppb).

Table 1: Lake water quality state (2010-2014) by lake type for median total phosphorus (TP), total nitrogen (TN), Chlorophyll a (Chla) and cyanobacteria (80% biovol.). Colours relate to NOF bands – red is D (i.e. does not meet national bottom line), orange is C, green is B and blue is A-band. Data provided by WRC. The cell in grey (Chla at Whakatangi) is an outlier, currently being checked with WRC.

Type	Name	TP	TN	Chla	80% biovol
Dune	Otamatearoa	10	471	2	
Dune	Puketi	14	493	2	
	Mean	12	482	2	
Peat	Rotomanuka	18	1073	11	
Peat	Rotoroa	20	809	8	
Peat	Serpentine East	22	1496	9	
Peat	Maratoto	25	1777	5	
Peat	Serpentine North	30	1191	13	
Peat	Serpentine South	31	934	12	
Peat	Rotokotuku	65	1107	31	
Peat	Kainui	75	1576	28	
Peat	Areare	82	1747	25	
Peat	Horseshoe	108	1497	54	
Peat	Milicich	113	2361	138	
Peat	Ngaroto	119	2287	70	6
Peat	Mangakaware	186	1675	46	
Peat	Whakatangi	187	3240	5	
Peat	Tunawhakaheke	260	1665	19	
Peat	Mangahia	640	3102	59	
	Mean	124	1721	33	

Riverine	Waahi	66	1061	23	1
Riverine	TeKappa	82	1709	14	
Riverine	Hakanoa	99	1482	38	4
Riverine	Ohinewai	111	1900	45	
Riverine	Whangape	119	1860	57	20
Riverine	Okowhao	124	1822	21	
Riverine	Waikare	145	2502	94	21
Riverine	Penewaka	535	4170	35	
	Mean	160	2063	41	
Volcanic	Tutaeinanga	121	1522	30	
Volcanic	Nгахewa	155	843	41	
	Mean	138	1183	36	

Only three lakes (Serpentine East, Rotoroa and Serpentine North) achieve a C band for water clarity (Fig. 1). The remainder breach the Minimum Acceptable State for clarity agreed by the CSG (i.e. 1m).

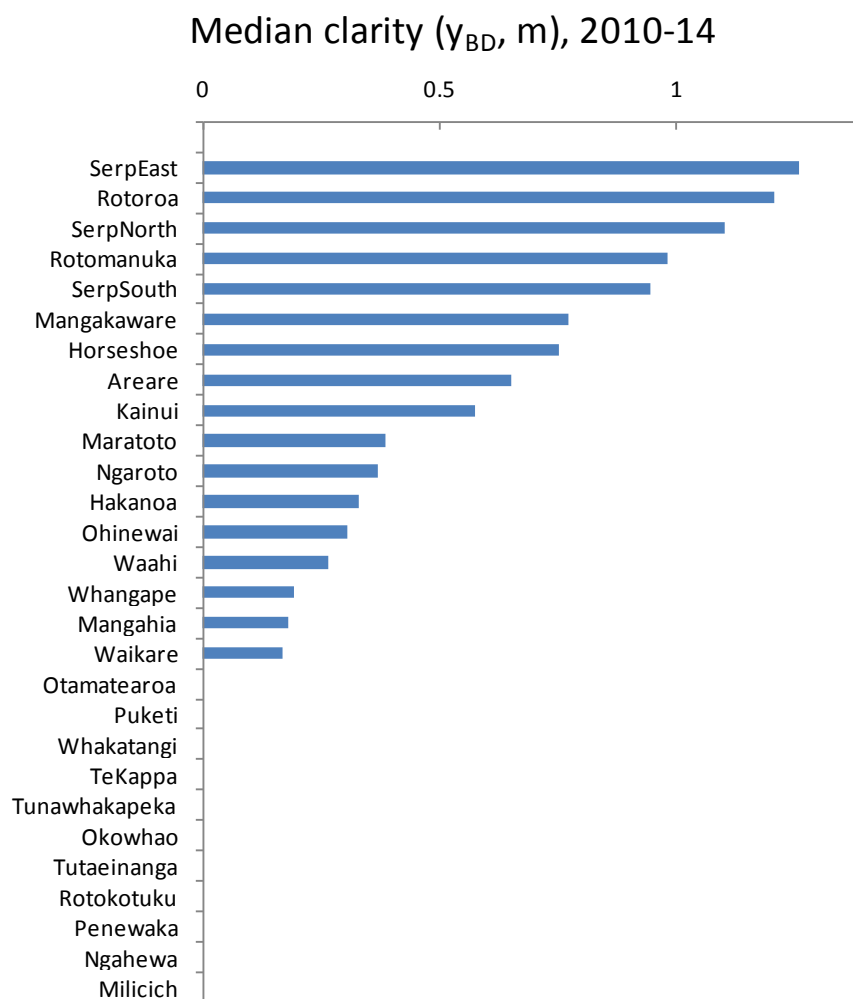


Figure 1. Median water clarity (2010-14). Figure produced by WRC.

Catchment land use has a significant effect on lake water quality, although the relationship can be modified by a range of factors including lake size and depth, intactness of riparian margins and the presence of macrophytes. Across the 59 lakes the average %native catchment vegetation is only 6.4% (maximum is 41% for Lake Kimihia).

For peat lakes with more than 5% native vegetation in their catchment (N=6) average TP was 32 ppb and Chlorophyll was 14 ppb, whereas peat lakes with less than 5% native vegetation in their catchment had an average TP of 179 ppb and Chlorophyll of 45 ppb. TN varied to a lesser extent, with 1263 ppb in the lakes with >5% native and 1996 ppb in those with less native vegetation.

Representativeness

Lakes monitored by WRC are a subset of all lakes and, without an extraordinary increase in monitoring resources, this will always be the case. The NPS-FM requires that monitoring against freshwater objectives need only be undertaken at representative sites within FMUs.

How might we judge representativeness?

The first step would be to ensure all lake types are covered within the current monitoring network. Dune and volcanic lakes have no current WRC monitoring sites, although both types have historic monitoring data. Eight of 35 peat lakes and four of fifteen riverine lakes are currently monitored. The coverage of these latter lake types (approx. ¼ of lakes within each type are monitored) seems a reasonable sample.

Another approach would be to compare characteristics of monitored and unmonitored lakes. If both groups are reasonably similar then the monitored subset can be assumed to be representative. Monitored lakes are larger and have greater catchment areas than unmonitored lakes (Table 3). The extent of native vegetation in the catchment is relatively similar.

Table 3. Characteristics of peat and riverine lake types for monitored and unmonitored lakes.

Type	Monitoring data	Size (ha)	Catchment area (ha)	%Native
Peat	Y	25.1	413	6.6
	N	8.4	300	4.4
Riverine	Y	1367	15664	10.5
	N	47	1092	11.6

A more detailed analysis could be undertaken by the WRC on the representativeness of the lake monitoring network so as to determine the cost-benefit of adding extra lakes to that network. If further monitoring sites were to be added it would seem useful to include some of the smaller lakes across both lake types. WRC may be able to undertake more extensive, synoptic surveys of lakes to get more robustness around representativeness of the network.

A final option for assessment of current state and trends across unmonitored lakes would be to model water quality based on established relationships between water quality and easily obtainable external drivers (e.g. land use). This approach would be subject to the

uncertainties inherent in any modelling, but is likely to become more robust over time as knowledge grows.

Management options

The complexity of lake management is highlighted in the Knowledge Network in Appendix 1. The Network shows the central role played by nutrients and sediment in achieving ecological outcomes, but there are multiple modifying factors that need to be taken into account. Each lake is likely to require an individually-tailored management plan. The CSG has previously received presentations from Professor Hamilton (University of Waikato) and Tracie Dean-Spiers (Waikato Regional Council) on lake management options and current actions.

Despite the need for tailored solutions for each lake there are a range of mitigation options that should be considered for all shallow lakes. These mitigation options include active management actions within the lake and around the margins, and catchment management.

In-lake management options include wave booms, lake level management, dredging, chemical stripping of nutrients (e.g. alum dosing), netting & fish traps/gates and replanting of native macrophytes. At the lake margins, sediment traps, riparian restoration and wetland enhancement or construction will help ameliorate land use impacts. Increased flows can aid flushing of the lake, although the introduction of additional water can create other issues (e.g. changes in water level) and may be culturally unacceptable.

Catchment management that targets nutrient and sediment loads to the lakes will be required in order to achieve improved ecological health long-term. External sources of nutrients and sediment will need to be targeted. However, given the levels of exceedances of concentrations of N and P (see Table 1) and the dominance of non-native land use in all lake catchments it is unlikely that catchment-based mitigation of N, P and sediment will achieve desired lake states without major shifts in land use.

Many of the lakes within the Waikato-Waipā catchment have lost their native macrophyte beds and have “flipped” into a phytoplankton dominated state. Restoring these lakes to a more natural state may not be possible, as sediment resuspension by wind and introduced pest fish (e.g. koi carp) create a light climate that precludes re-establishment of macrophyte beds. Introduced macrophytes also outcompete native species.

Current restoration activities

Rehabilitation of Waikato’s shallow lakes is likely to be a multi-generational issue and the Healthy Rivers Wai Ora plan change is only one of a number of rehabilitation initiatives currently underway.

The Waikato-Waipā Restoration Strategy (a partnership between Waikato River Authority, Waikato Regional Council and DairyNZ) is developing a 5-15 year restoration strategy for the Waikato-Waipā catchment. Shallow lakes in the catchment are a specific area of focus for the project, with a Technical Advisory Group formed to develop recommendations on future restoration and lake management.

Waikato Regional Council recently developed the “Waikato Regional Shallow Lakes Management Plan”. Much of the information presented by TLG to CSG has come from this plan. The Plan contains a number of important objectives that need to be considered by CSG:

Policy & planning objectives

- Appropriate objectives, targets and limits are established for the future management and enhancement of shallow lakes
- Water levels of shallow lakes and associated wetland margins are adequate to support hydrological and ecological processes and functions, and maintain or enhance the values associated with these.
- The hydrology of shallow lakes (and their associated wetland margins) is protected from the effects of further wetland drainage.
- Shallow lakes and their associated wetland margins are protected from the effects of stock access.

Information & monitoring objectives

- Sufficient information is collected by WRC to assess and rank the biodiversity (SNA) values of all shallow lakes, and this information is analysed, reported, and used as the basis of effective lake management programmes.
- Sufficient information is collected from shallow lakes to assess and report upon their condition (water quality and ecological health), and to assess the effectiveness of WRC's policy and planning framework and shallow lake management programmes.
- WRC's lake level setting programme is underpinned by quality information, to ensure that shallow lake water levels are adequate to support hydrological and ecological processes and functions, and the values identified at these lakes.

Lake restoration & rehabilitation objectives

- WRC supports the development, testing and implementation of methods and techniques to maintain and/or enhance the values of shallow lakes.
- In conjunction with co-management partners, other agencies, stakeholders and landowners, WRC develops and implements integrated management and restoration programmes to protect and enhance priority shallow lakes, or valued aspects of these sites.

Lake Attributes and Bands

The NPS-FM has identified national attributes with associated bands in relation to ecosystem health and human health in lakes. For Ecosystem Health the Attributes are Phytoplankton biomass (Chl. a), Total N and Total P. For Human Health the levels of planktonic cyanobacteria are mandated.

The TLG recommend that Chl. a, TN and TP be applied across all four lake FMUs and use the banding structure provided in the National Objectives Framework. We also recommend the application of a planktonic cyanobacteria attribute and its associated bands as a measure of Human Health.

Water clarity has been proposed as an Attribute specific to the Waikato. The TLG recommends its inclusion as a measure of both Ecosystem Health and as a measure relating to recreation and aesthetics across the four lake types. Water clarity does vary naturally with lake type. For example, peat lakes tend to have lower water clarity as a result of the organic material dissolved and/or suspended in the water column. Despite these differences the TLG recommends that the clarity bands established for riverine sites also be applied across the four lake types. Most monitored lakes fall into the D band (<1 m clarity) - we do not recommend changing this minimum acceptable state as it is related to the values/use aspired to. For lakes with clarity >1 m it could be assumed that the desire is for clarity to be

maintained or improved as a result of Healthy Rivers and the proposed A-C bands for clarity in the rivers are appropriate for lakes too.

Nutrient levels, Chl. a, and water clarity are widely recognised as valuable measures of lake trophic status. There are a number of other measures relating to the “naturalness” of lakes including the species composition of macrophyte communities, but the TLG suggests these fall outside the scope of Healthy Rivers.

Achievable end points for lake rehabilitation

Restoring a degraded lake to a more natural state is complex and difficult and there are few examples of successful restoration. Lakes are natural sinks for nutrients and sediments and current state often reflects historical legacies as well as current catchment land use - internal recycling of nutrients from past inputs can be a significant driver of current state. However, it is reasonable to expect that reductions in catchment loadings of nutrients and sediment will, over time, change lake trophic status and improve ecosystem health and recreation values.

When the National Bottom Lines for TP (50 ppb), TN (800 ppb) and chlorophyll (12 ppb) are compared with current state of the lakes in Table 1 one can appreciate the size of the task for many peat lakes and all of the riverine lakes.

Dramatic land use changes in a lake catchment may be required to achieve such desired environmental outcomes. For example, Lake Waiwakareke (Horseshoe Lake) is a small (3 ha), Waikato peat lake on the western fringe of Hamilton City. 76% of the 66 ha catchment is being retired and revegetated. Modelling by University of Waikato predicts that the lake could return to a mesotrophic state (equates to B-C bands) over a 10-15 year timeframe following restoration work.

Achieving these National Bottom Lines are mandatory and, perhaps, when combined with a requirement to improve to the 1m bottom-line for clarity and a need to maintain in current state for those lakes/attributes in A to C bands forms a set of attribute limits for the lakes that the CSG might wish to consider. If desired, the TLG could develop a set of recommendations along these lines for CSG consideration.

Table A2 – Lake summary by type

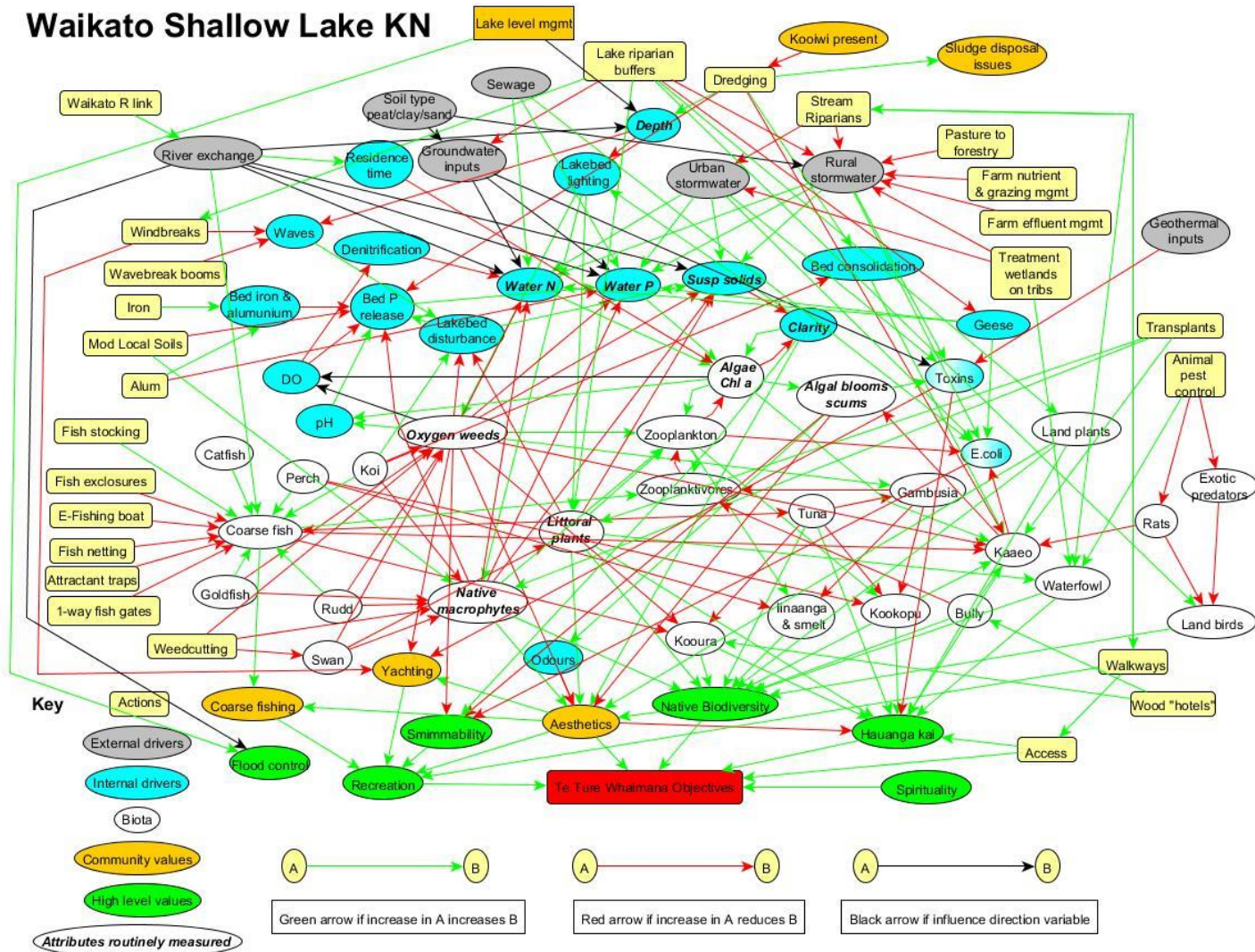
LAKE NAME	LAKE TYPE	Size (ha)	Estimated catchment size (ha)	% native veg in catchment	Historic Monitoring (Y/N)	Current WRC Monitoring	Estimated Nutrient Enrichment	ID in WRP as a significant wetland (Y/N)
Rotoiti	Dune	1.2	41.93	0	N	N	?M	N
Puketi	Dune	6.4	114.1	1	Y	N	M	N
Otamatearoa	Dune	4.9	68.3	0	Y	N	M	N
Parkinson (Kohahuake)	Dune	1.9	107.72	1	Y	N	M	N
Opuatia	Peat	6-7	?	7	N	N	?	Y
Rotokawau	Peat	22	1804	34	Y	N	H	Y
Rotokaraka	Peat	c. 6-7	?	?	N	N	?H	N
Hotoananga	Peat	19	71	0	Y	N	?	Y
Pikopiko	Peat	6.4	94	0	N	N	?H	Y
Areare	Peat	33	262	0	Y	Y	high	Y
Kainui	Peat	25	132	0	Y	N	high	N
Komakorau	Peat	2.6	619	2	N	N	?high	N
Kaituna	Peat	12	580	1	Y	N	high	Y

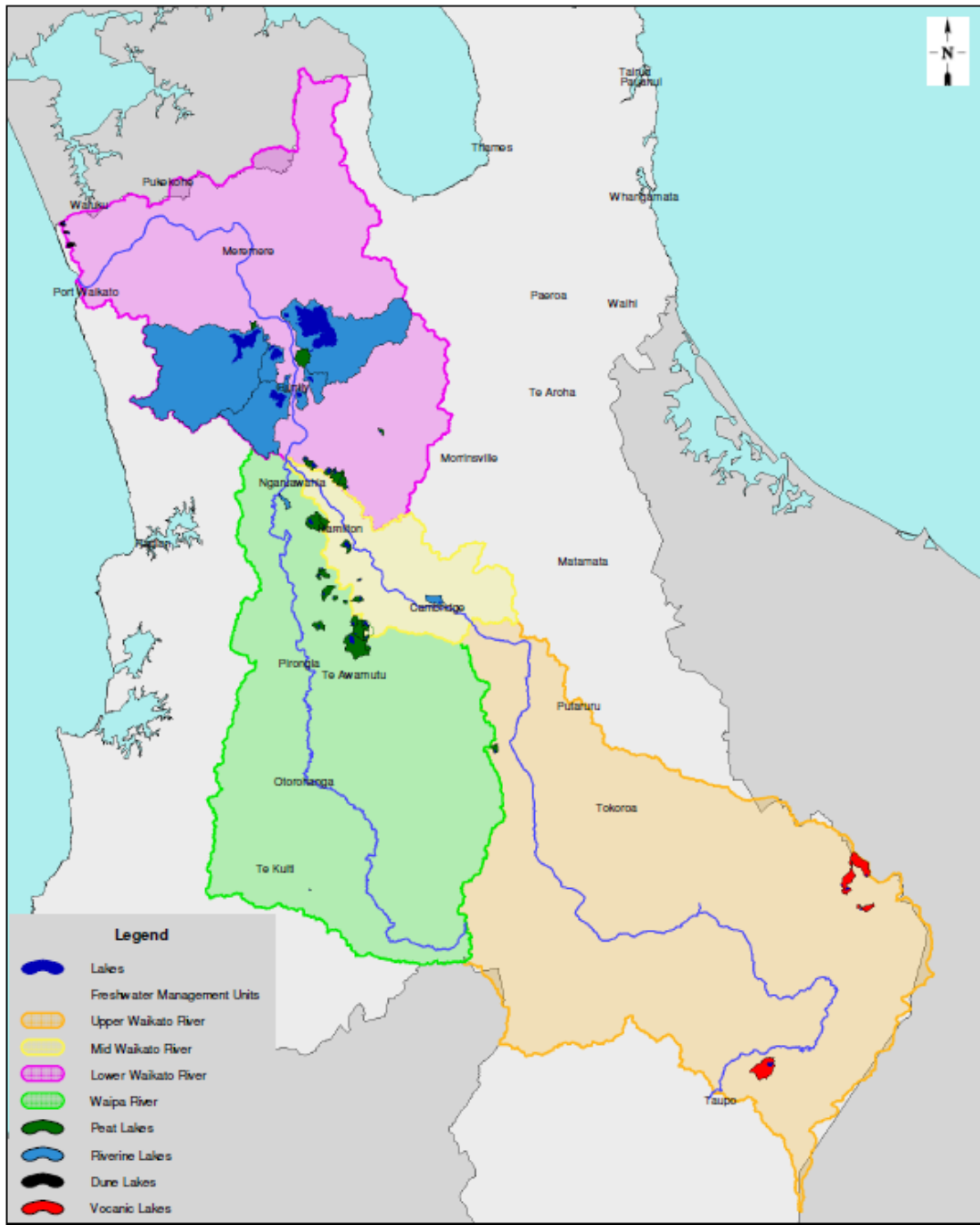
Whakatangi	Peat	2.7	170	0	Y	N	high	N
Tunawhakaheke	Peat	6.7	100	0	Y	N	high	Y
Rotokauri	Peat	41.7	933	0	Y	N	high	N
Waiwhakareke Horseshoe	Peat	3	66	0	Y	Y	high	N
Rotokaeo	Peat	3.1	?	0	N	N	?	N
Rotoroa	Peat	55	258	3	Y	?	moderate	N
Koromatua	Peat	9.9	200	3	Y	N	high	N
Pataka	Peat	4.6	55	13	Y	N	?high	N
Posa	Peat	2.05	95	10	Y	N	?high	N
Cameron	Peat	3.4	31	0	Y	N	?high	Y
Mangahia	Peat	8.4	354	4	Y	N	high	Y
Milicich	Peat	2.2	54	5	Y	N	high	N
Henderson's Pond	Peat	0.88	31	0	Y	N	?high	N
Maratoto	Peat	18	88	25	Y	y	high	Y
Mangakaware	Peat	12.9	238	0	Y	y	high	Y
Ruatuna	Peat	13	190	0	Y	N	high	Y

Rotomanuka	Peat	12.3	479	11	Y	Yes (from 1995)	moderate	Y
Rotomanuka South	Peat	5.4	479	11	Y	N	high	Y
Ngarotoiti	Peat	3.4	504	0	Y	N	high	Y
Ngaroto	Peat	108	1846	1	Y	y	high	Y
Rotopiko Serpentine - N Lake	Peat	5.3	163	8	Y	y	Moderate	Y
Rotopiko Serpentine - E Lake	Peat	1.6	163	8	Y	N	Moderate	Y
Rotopiko Serpentine - S Lake	Peat	8.3	163	8	Y	y	Moderate	Y
Rotopotaka	Peat	2.8	76	1	Y	N	?high	N
Rotongata	Peat	5.3	144	0	Y	N	?	N
Rotokotuku	Peat	1.1	18.5	11	Y	N	high	N
Whangape	Riverine	1450	31767	8	Y	y	high	Y
Te Kapa	Riverine	1	?	?	Y	N	high	N
Waiwhata	Riverine	8.9	?	15	N	N	high	N
Rotongaroiti	Riverine	53	2105	2	N	N	?high	y
Rotongaro	Riverine	292	1950	2	Y	N	high	Y

Kopuera	Riverine	52	250	25	Y	N	?high	Y
Penewaka	Riverine	4	?	?	Y	N	high	y
Waikare	Riverine	3442	21055	8	Y	Yes (from 1996)	high	Y
Ohinewai	Riverine	16	347	3	Y	N	high	Y
Okowhao	Riverine	21	?	5	Y	N	high	Y
Kimihia	Riverine	58	1485	41	Y	N	high	N
Waahi	Riverine	522	9221	6	Y	Y	high	N
Hakanoa	Riverine	52	613	20	Y	Y	high	N
Te Otamanui Lagoon	Riverine	5.4	?	7	Y	N	?high	N
Te Koutu	Riverine	6	416	4	Y	N	high	N
Opouri	Volcanic	23.5	636	2	?	?	?	?
Rotokawa	Volcanic	62	1090	7	?	?	?	?
Ngahewa	Volcanic	8.4	746	5	Y	N	high	N
Tutaeinanga	Volcanic	3.1	501	1	Y	N	high	N
Orotu	Volcanic	?	582	30	?	?	?	?

Waikato Shallow Lake KN





<h3>Freshwater Management Units</h3>		<p>Kilometres</p> <p>Scale - 1:650,000</p>	<p>A3</p>
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