LAKE MONITORING

The large number of small and generally shallow lakes and wetlands in Northland are a precious resource to our region. Many of these are small dune lakes near the coast of which Lake Taharoa north of Dargaville is one of the largest with a few larger volcanic lakes inland such as Omapere and Owhareiti.

These lakes and wetlands provide important habitat for a range of plant and animal species, many of which are regionally or nationally significant. Many of these lakes are also valuable for recreational users, cultural reasons, as water supplies and for their own natural beauty.

Performance targets

- Operate a region-wide water quality network for the measurement, recording and reporting of lake quality trends

- Water quality, weed and algae monitoring of Lake Omapere and associated community liaison and advice, including the ongoing development and co-ordination of a lake catchment management plan

Outcomes for 2005-2006

- A Lake Water Quality Monitoring Network for Northland has been developed and water quality monitoring on the 31 lakes in the network started in 2005 -2006 (refer to page 2). The 2005 – 2006 results showed that of the 31 lakes sampled 71% of them are in a eutrophic state or worse, meaning they have high nutrient and algae levels and poor water clarity.

- Ongoing monitoring of water quality, algae, fish and plants in Lake Omapere has been carried out as part of the Lake Omapere Restoration and Management Project (refer to page 10).

Lake Water Quality Monitoring Network

In 2004-2005, Northland Regional Council engaged the National Institute of Water and Atmospheric Research (NIWA) to assist the council with gathering information to determine the status of 65 lakes throughout Northland. For a summary of the detailed report produced from this survey work check out the lakes section of the 2004-2005 Annual Monitoring Report. From this a Lake Water Quality Monitoring Network has been established, which includes 31 lakes throughout Northland. In 2005-2006 water quality monitoring on these 31 lakes, found that 71% of them are in a eutrophic state or worse (refer to page three for more information).

LakeSPI (Submerged Plant Indicators), which is used to assess the ecological condition of a lake, will be carried out on all lakes in the Network every five years. In 2005-2006, NIWA gathered ecological information on a further five lakes, as well as updating the information on six of the 65 lakes previously surveyed (refer page 9).

As recommended by NIWA in 2005, pest plant surveillance is carried out on 11 of the 31 lakes in the Lakes Water Quality Monitoring Network, for seven of these it is on an annual basis. These seven were surveyed in 2005-2006, which involves a visual inspection at all access points to the lake, such as boat ramps and beaches (refer page 9).

Water Quality Monitoring

All lakes in the Lake Monitoring Network are monitored four times a year. Parameters tested include secchi disk depth (water clarity), chlorophyll *a* (algal biomass), temperature, dissolved oxygen, pH, suspended solids (total and volatile), total nutrients (phosphorus (TP) and nitrogen (TN)) and dissolved nutrients, including dissolved reactive phosphorus, organic phosphorus, nitrate nitrogen, ammoniacal nitrogen and organic nitrogen. Temperature and dissolved oxygen are measured concurrently throughout the water column from the water surface to the lake bottom, to determine whether the lake is thermally stratified.

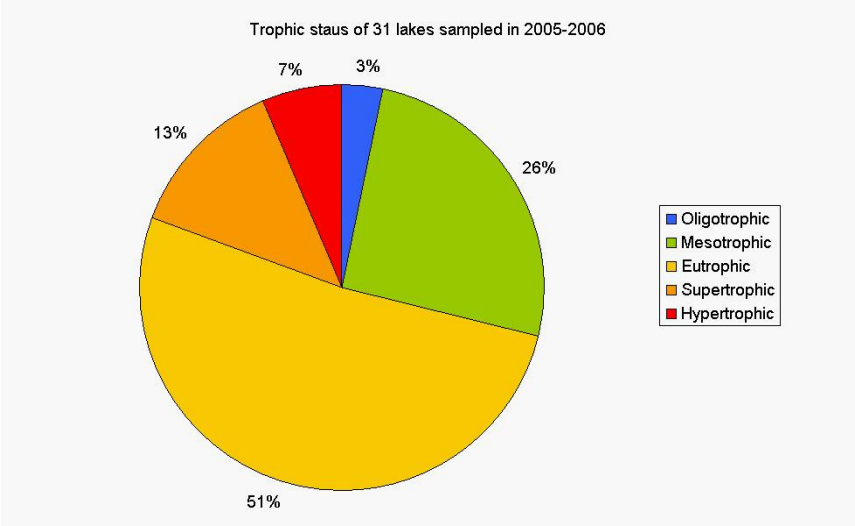
The life supporting capacity of a lake can be estimated using the Trophic Level Index (TLI). The four variables that are used to obtain the trophic level of a lake are secchi disk depth, chlorophyll *a*, total phosphorus and nitrogen as shown in the table below.

Trophic status	Chlorophyll a (mg/m^3)	Secchi depth (m)	Total phosphorus (mg/m^3)	Total nitrogen (mg/m^3)
Oligotrophic	< 2	> 7.0	< 9	< 157
Mesotrophic	2 – 5	7 – 2.8	9 - 20	157 - 337
Eutrophic	5 – 12	2.8 – 1.1	20 - 43	337 - 725
Supertrophic	12 – 31	1.1 – 0.4	43 - 96	725 - 1558
Hypertrophic	> 31	< 0.4	> 96	> 1558

Table adapted from 'Protocols for monitoring trophic levels of New Zealand lakes and reservoirs' developed by Noel Burns, Graham Byers and Eddie Bowman in 2000.

Summary of water quality results

Overall, the annual water quality results indicate that 71% of the 31 lakes in the Network are in a eutrophic state or worse as shown in the graph below. Eutrophic lakes generally have high algal biomass, nutrients and sediment and low water clarity.



A summary of the water quality results for each of the 31 lakes sampled in 2005-2006 is presented next. The lakes are split into four main geographical areas; Aupouri and Karikari peninsulas, Kai iwi lakes and Poutu Peninsula.

Aupouri Lakes

Lake Carrot
Summer thermal stratification was observed with moderate deoxygenation (1.4 mg/L) of bottom water with higher concentrations of nutrients (TN 1160 mg/m³; TP 94 mg/m³) in relation to the upper water column (TN 707 mg/m³; TP 82 mg/m³). Water clarity is poor (secchi depth of 1.5 - 2.9 m) due to the humic-stained water. The current data suggests a eutrophic status, however bottom water nutrient concentrations are very high.

Lake Heather
The lake stratified over summer with moderate deoxygenation (1.4 mg/L) of bottom water with higher concentrations of nutrients (TN 548 mg/m³; TP 92 mg/m³) in relation to the upper water column (TN 348 mg/m³; TP 11 mg/m³). Secchi disk reading of 3.8 m indicates moderate water clarity. Secchi, nutrient and algal biomass data indicates a mesotrophic status, however bottom water nitrogen and phosphorus concentrations are high.

Lake Morehurehu
The lake stratified over summer with moderate deoxygenation (1.2 mg/L) of bottom water with higher concentrations of nitrogen (TN 635 mg/m³) compared with the upper water column (TN 286 mg/m³). Secchi, nutrient and chlorophyll a measurements (Secchi 2.7 - 3.3 m; TP 5 - 65 mg/m³; chlorophyll a 2.9 - 6 mg/m³) indicate a eutrophic status.

Lake Ngakapua (North Basin)
The lake was stratified in December with moderate deoxygenation (1.4 mg/L) of bottom water with higher concentrations of nutrients (TN 1050 mg/m³; TP 128 mg/m³) in relation to the upper water column (TN 621 mg/m³; TP 37 mg/m³). Annual average secchi disk reading of 3.0 m indicates moderate water clarity. The data suggests a eutrophic status; however, bottom water nutrient concentrations are very high.

Lake Ngakapua (South Basin)
The lake was not stratified at the time of sampling; however, stratification has been previously recorded. Secchi, nutrient and chlorophyll a measurements (secchi 3.0 - 3.8 m; TN 555 – 648 mg/m³; TP 7 - 60 mg/m³; chlorophyll a 3.3 - 6 mg/m³) suggest a eutrophic status.

Lake Ngakeketa North
The lake stratified over summer with moderate deoxygenation (down to 1.3 mg/L) of bottom water with higher concentrations of nitrogen (TN 1020 mg/m³) and lower concentrations of phosphorus (TP 20 mg/m³) compared with the upper water column (TN 295 mg/m³; TP 60 mg/m³). Water clarity is poor (secchi 1.8 - 2.2 m) due to the humic-stained water. Current results suggest a eutrophic status, however bottom water nitrogen concentrations are very high.

Lake Ngatu
Thermal stratification of the lake has not been detected. Annual average secchi disk reading of 4.1 m indicates moderate water clarity. Secchi, nutrient and algal biomass data (TN 650 - 713 mg/m³; TP 41 - 61 mg/m³; chlorophyll a 0.8 - 2.3 mg/m³) indicates a mesotrophic status.

Lake Rotokawau
The lake was not stratified at the time of sampling. Secchi, nutrient and chlorophyll a measurements (secchi 2.1 - 2.5 m; TN 758 - 843 mg/m³; TP 25 - 75 mg/m³; chlorophyll a 4.8 - 6.1 mg/m³) indicate a eutrophic status.

Lake Rotoroa
Thermal stratification has not been detected in this lake. Annual average secchi reading of 3.6 m indicates moderate water clarity. Secchi, nutrient measurements and algal biomass (TN 589 - 706 mg/m³; TP 33 - 60 mg/m³; chlorophyll a 0.9 - 3.3 mg/m³) suggests a eutrophic status.

Lake Te Kahika
Thermal stratification has not been detected in this lake. Current secchi, nutrient and chlorophyll a measurements (secchi 5.6 - 6.5 m; TN 89 - 283 mg/m³; TP 1 - 93 mg/m³; chlorophyll a 1.5 - 3.6 mg/m³) suggest a mesotrophic status. Lake Te Kahika is shown in the photograph below set in a forestry catchment with a margin of emergent vegetation.

Lake Te Paki Dune
Thermal stratification has not been detected in this lake. Secchi, nutrient measurements and algal biomass (secchi 0.7 m; TN 1360 mg/m³; TP 232 mg/m³; chlorophyll a 2.6 mg/m³) suggest a supertrophic status.

Lake Wahakari
Thermal stratification has not been detected in this lake. Secchi, nutrient and chlorophyll a measurements (secchi 4 m; TN 343 mg/m³; TP 51 mg/m³; chlorophyll a 2.1 mg/m³) currently suggest a mesotrophic status.

Lake Waihopo
Thermal stratification has not been detected in this lake. Secchi, nutrient and chlorophyll a measurements (secchi 2.2 - 3.5 m; TN 663 - 726 mg/m³; TP 18 - 41 mg/m³; chlorophyll a 1.6 - 4.6 mg/m³) currently suggest a eutrophic status.

Lake Waipara
The lake was not stratified at the time of sampling. Current secchi disk reading was greater than the maximum recorded depth of 4.1 m, which indicates an improvement in water clarity compared to previous readings (2.3 m). Secchi, nutrient and chlorophyll a measurements (TN 313 - 417 mg/m³; TP 4 - 50 mg/m³; chlorophyll a 0.4 - 1.2 mg/m³) currently suggest a mesotrophic status.

Lake Waiparera
The lake was not stratified at the time of sampling. Secchi, nutrient and chlorophyll a measurements (secchi 2.4 - 2.9 m; TN 703 - 775 mg/m³; TP 8 - 73 mg/m³; chlorophyll a 3.3 - 7.5 mg/m³) currently suggest a eutrophic status.

Lake West Coast Road
The lake was not stratified at the time of sampling. Secchi, nutrient and chlorophyll a measurements (secchi > 0.5 m; TN 1390 mg/m³; TP 49 mg/m³; chlorophyll a 79.1 mg/m³) currently suggest a supertrophic status.

Karikari Lakes

Lake Waiporohita
The lake was not stratified at the time of sampling. Secchi, nutrient and chlorophyll a measurements (secchi 0.3 - 0.7 m; TN 2210 - 3020 mg/m³; TP 7 - 832 mg/m³; chlorophyll a 10 - 99.9 mg/m³) currently suggest a hypertrophic status.

Kai Iwi Lakes

Lake Kai Iwi
The lake stratified in summer with moderate deoxygenation (down to 0.5 mg/L) of bottom water and higher concentrations of nitrogen but not phosphorus (TN 570 - 1040 mg/m3; TP 35 - 70 mg/m^3) in relation to the upper water column (TN 337 - 366 mg/m3; TP 11 - 74 mg/m^3). An annual average secchi disk reading of 8 metres indicates good water clarity. Current data indicates a mesotrophic status; however, bottom water nitrogen and upper water phosphorus concentrations are high.

Lake Taharoa
The lake stratified in summer with moderate deoxygenation of bottom water (down to 2.2 mg/L) with higher concentrations of Nitrogen but not Phosphorus (TN 340 mg/m³; TP 11 mg/m³) compared with the upper water column (TN 102 - 166 mg/m³; TP 3 - 50 mg/m³). The data indicates an oligotrophic status.

Lake Waikere
The lake stratified over summer with anoxia of bottom water (down to 0.3 mg/L) with higher concentrations of Nitrogen but not Phosphorus (TN 727 - 1110 mg/m³; TP 9 - 17 mg/m³) in relation to the upper water column (TN 216 - 305 mg/m³; TP 5 - 83 mg/m³). A secchi disk reading of 7.2 metres indicates good water clarity. Data indicates a mesotrophic status, however bottom water nitrogen concentrations are high. The photo below of Lake Waikere, quite clearly shows the green colour of the higher algal biomass present in the lake.

Poutu Lakes

Lake Humuhumu
Summer thermal stratification was observed with moderate deoxygenation of bottom water (1.1 mg/L) with a slightly higher concentration of nitrogen (TN 421 mg/m³) compared to the upper water column (TN 292 - 299 mg/m³). Secchi, nutrient (TP 48 - 77 mg/m³) and chlorophyll a measurements (4.9 - 2.4 mg/m³) suggest a eutrophic status.

Lake Kahuparere
The lake stratified over summer with moderate deoxygenation of bottom water (1.3 mg/L) with higher concentrations of nutrients (TN 619 – 807 mg/m³; TP 53 - 80 mg/m³) in relation to the upper water column (TN 367 - 407 mg/m³; TP 18 - 27 mg/m³). Current data indicates a eutrophic status; however, bottom water nutrient concentrations are high.

Lake Kanono
The lake stratifies over summer with moderate deoxygenation of bottom water with higher concentrations of nutrients (TN 414 - 869 mg/m³; TP 18 - 66 mg/m³) in relation to the upper water column (TN 270 - 351 mg/m³; TP 11 - 47 mg/m³). Annual average secchi disk reading of 2.8 metres indicates moderate water clarity. The data suggests a eutrophic status; however, bottom water nutrient concentrations are high.

Lake Kapoai
Summer thermal stratification was observed with deoxygenation of bottom water (down to 0.5 mg/L) with higher concentrations of nutrients (TN 4740 - 8960 mg/m³; TP 440 - 917 mg/m³) in comparison to the upper water column (TN 1310 - 1980 mg/m³; TP 27 - 118 mg/m³). Annual average chlorophyll a concentrations and secchi disk reading, 40 mg/m³ and 0.76 m respectively, indicates very low water clarity. Current data suggest a supertrophic status; however, bottom water nutrient concentrations are very high.

Lake Karaka
The lake was not stratified at the time of sampling; however, stratification of the lake has been recorded previously. Annual average secchi disk reading of 2.97 m indicates moderate water clarity. Secchi, nutrient and chlorophyll a measurements (TN 257 - 536 mg/m³; TP 40 - 64 mg/m³; chlorophyll a 4.5 - 51 mg/m³) currently suggest a eutrophic status.

Lake Mokeno
Stratification was not detected in the 2005-2006 financial year; however, stratification has previously been recorded. Annual average secchi disk reading of 3.2 metres indicates moderate water clarity. Secchi, nutrient and algal biomass data (TN 450 - 606 mg/m³; TP 13 - 87 mg/m³; chlorophyll a 2.1 - 7.2 mg/m³) currently suggest a eutrophic status.

Lake Rotokawau
Summer thermal stratification was not detected during the 2005 - 2006 financial year; however, stratification has previously been observed. Current secchi, nutrient and chlorophyll a measurements (Secchi 4.3 - 5.1 m; TN 363 - 374 mg/m³; TP 5 - 26 mg/m³; chlorophyll a 2.6 - 3.8 mg/m³) suggest a mesotrophic status.

Lake Rototuna
The lake stratified over summer with moderate deoxygenation of bottom water (0.8 mg/L) with higher concentrations of nutrients (TN 998 mg/m³; TP 83 mg/m³) compared to the upper water column (TN 508 - 607 mg/m³; TP 8 - 44 mg/m³). Annual

average secchi disk reading of 2 m indicates low water clarity. The data indicates a eutrophic status; however, bottom water nutrient concentrations are high.

Lake Wainui
The lake stratified over summer with moderate deoxygenation of bottom water (down to 0.5 mg/L) with higher concentrations of nutrients (TN 1570 - 3060 mg/m^3; TP 213 - 476 mg/m^3) in relation to the upper water column (TN 593 - 725 mg/m^3; TP 13 - 94 mg/m^3). Current data suggests a eutrophic status; however, bottom water concentrations of nitrogen and phosphorus are very high.

Lake Wairere
The lake stratified with moderate deoxygenation (0.5 mg/L) of bottom water with higher concentrations of phosphorus (TP 252 mg/m^3) in relation to the upper water column (TP 50 mg/m^3). Secchi disk readings (0.7 - 2.8 m) indicate poor water clarity and summer time chlorophyll a levels indicate algal blooms (up to 71.7 mg/m^3). Secchi, nutrient (TN 413 - 1240 mg/m^3) and chlorophyll a measurements suggest a supertrophic status; however, bottom phosphorus concentrations are high.

Lake Whakaneke
Stratification has not been detected in this lake. Annual average secchi disk reading of 0.8 m indicates poor water clarity. Current secchi, nutrient and chlorophyll a measurements (TN 505 - 2050 mg/m^3; TP 51 - 829 mg/m^3; chlorophyll a 22.8 - 154 mg/m^3) indicate a hypertrophic status.

Ecological Monitoring

In February 2006, NIWA carried out aquatic vegetation surveys on 11 Northland lakes; five of which had not previously been surveyed. The LakeSPI method of assessing the ecological condition of a lake was carried out on eight of these 11 lakes along with wetland vegetation descriptions, and fish, bird and invertebrate observations. Reconnaissance surveys and vegetation descriptions were carried out on the other three lakes. The LakeSPI index score is a measure of how close a water body is to its potential un-impacted state i.e. the closer the LakeSPI score is to 100% the less impacted or more pristine the lake is.

NIWA found that the LakeSPI index score for the resurveyed lakes (Lakes Morehurehu, Morehurehu South, Ngakeketa North and Waihopo) were similar. Lakes Owhareiti, Te Riu, Waingata and Waro had LakeSPI index scores of 16%, 96%, 80% and 50%, respectively. Reconnaissance surveys were carried out on Lakes Ora, Te Arai and Te Kahika. Lake Ora and Te Arai were given a low ranking due to low water clarity and the absence of submerged aquatic vegetation. The photo below shows NIWA staff getting ready to undertake a survey of the lake vegetation in Lake Owhareiti.

Pest Plant Surveillance

In February 2006, NIWA resurveyed seven lakes, of the 11 recommended for ongoing pest plant surveillance, for new introductions of pest plants. No new weeds were found at any of the seven lakes surveyed, however, a large handful of relatively fresh and still viable *Elodea canadensis* was found on the foreshore of Lake Taharoa. The source of the weed was tracked down to the owners of a boat who had launched earlier in Lake Tarawera. This shows just how easily and far a weed can be unintentionally transported.

Lake Omapere

The Lake Omapere Trust and Northland Regional Council are working in partnership on the Lake Omapere Restoration and Management Project funded by the Ministry for the Environment's Sustainable Management Fund. The overall aim of this project is to improve water quality and the overall health of Lake Omapere in the long term.

The project includes:

- The development of a lake management strategy,
- Water quality monitoring,
- Enhancement of indigenous biodiversity including terrestrial and aquatic plants, freshwater mussels and fish,
- Surveillance monitoring for the invasive aquatic weed, *Egeria densa*
- Working with landowners to reduce nutrient inputs into the lake
- Community involvement in planting days
- Relationship building between Lake Omapere trustees, key stakeholders (including the Regional Council, Far North District Council, Te Runanga a iwi o Ngapuhi, Department of Conservation and the Ministry for the Environment), landowners and the community (including local schools, landcare and iwi groups)

The following report is purely a summary of the water quality monitoring carried out in Lake Omapere. More information on the work being carried out as part of the Lake Omapere Restoration and Management Project is available on the Regional Council website.

Water Quality Monitoring

Water quality sampling is carried out monthly at two locations on the lake, each with two sites (75 and 25% depth), and at the lake outlet. Field measurements of temperature, dissolved oxygen, conductivity and water clarity (using a secchi disc) are taken at these five routine sites and samples are collected for analysis of suspended solids (total and organic), chlorophyll α (indication of algal biomass), pH, nitrogen and phosphorus. Since December 2003 extra samples have been collected to determine the number of cyanobacterial (blue-green algae) cells and cyanobacterial toxin levels, from one lake site and the outlet.

The results from July 2005 to June 2006 are summarised below. A full report is available on the Regional Council website.

Summary of results

Water quality in Lake Omapere remained poor over the last financial year. Based on the average results for 2005-2006 year, total phosphorus, secchi depth and chlorophyll α indicate that Lake Omapere is in a hypertrophic state as shown in the table below, meaning it is highly enriched with poor water clarity and frequent algal blooms and surface scums. While total nitrogen indicates a slightly better trophic level of supertrophic. However, when you take the average of the four tropic levels to calculate the overall trophic level index (TLI), Lake Omapere is clearly in a hypertrophic state.

Parameter	Average for 2005-2006	For hypertrophic lake	Trophic level
Total nitrogen (g/m^3)	1.45	> 1.558	5.91
Total phosphorus (g/m^3)	0.117	> 0.096	6.26
Secchi depth (m)	0.33	< 0.4	6.18
Chlorophyll α (g/m^3)	0.060	> 0.031	6.73
Overall Trophic Level Index (TLI)	-	6.0 -7.0	6.27

The trend analysis showed that water quality has not improved in Lake Omapere in the last 10 years and in fact with the shift from a weed dominated lake to an algal dominated lake in the end of 2001, water quality has deteriorated.

Water quality monitoring is closely linked to the other components of the Lake Omapere Restoration and Management Strategy. The integrated catchment component, enhancement of the freshwater mussel population and re-establishment of native aquatic plants are all vital in improving water quality in Lake Omapere. However, the freshwater mussels and native aquatic plants are also dependent on water quality improving, particularly clarity, before successful enhancement can occur.