Attachment (2) to Item 4

Kai Iwi Lakes

Catchment Description

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Executive Summary

The Northland Regional Council (NRC) identified the Kai Iwi Lakes as one of several priority catchments for the Northland Water Programme. The main purposes of this document are to provide an up-to-date summary of water quality and quantity, the use and values and the pressures on the Kai Iwi Lakes and their catchments and to identify information gaps that will need addressing in order to better manage pressures on the Lakes and better allocate resources.

The Kai Iwi Lakes are located on the West Coast of Northland, approximately 25 km North West of Dargaville in the Kaipara District. The Kai Iwi Lakes includes the three lakes within the Taharoa Domain; Taharoa, Waikare and Kai Iwi. The Lakes vary in size and depth from the smallest, Kai Iwi, which is 16 metres deep and covers an area of 30 Ha, to the largest Taharoa with a maximum depth of 37 m and area of 217 Ha. The total surface water catchment for the three Lakes is relatively small (709 Ha). The entire catchment of the Lakes is within the rohe of Te Roroa. A large proportion of the Lakes' catchment sits within the Taharoa Domain Recreation Reserve, which has a total area of 538 Ha.

With no significant inflows and outflows from the Lakes, rainfall directly on to the lake surface is the main source of water. As a result, the lakes' levels fluctuate considerably with climatic conditions. The average air temperature and average annual open water evaporation in Dargaville is 15.3°C and 1,018 mm respectively. Average annual rainfall at Kai Iwi Lakes is estimated to be in the region of 1400 mm, with the driest months being November to February and the wettest being June and July. The three Lakes are basin dune lakes formed by the accumulation of rain water in depressions of consolidated sand underlain by a relatively impermeable pan. The major soils types in the catchment are derived from late Pleistocene Sedimentary sands and include Te Kopuru Sands and Tangitiki Sandy Loam-sands. Both are moderately to highly erodible, especially in the absence of vegetation cover and on steeper slopes.

Pre-human vegetation around Kai Iwi Lakes would have been mostly shrub heaths dominated by scattered shrubs, sedges and ferns and forest with a mix of species, such as rewarewa, kowhai, pohutukawa, kauri, totara and tanekaha, both of which there are still remnants of around the Lakes today. The present day land cover is 33% pasture, 14% exotic forest and 10% indigenous forest/shrub. The surface area of the Lakes is 39% of the catchment area. The majority of the exotic forest in the Domain has recently been harvested, with most of the area being replanted into pines. The pastoral land cover is mainly used for sheep and beef dry stock farming. There are three camping grounds on the shores of the lakes and less than 15 dwellings within the catchment.

The lakes are valued for their excellent water quality, ecological and cultural significance and recreational use. The Kai Iwi lakes have excellent water quality with all three lakes having an oligotrophic status for at least the last 25 years, meaning they have low nutrient and algal levels and excellent water clarity. However, recent data shows that water quality in Lake Kai Iwi, particularly nitrogen, clarity and algal biomass, has deteriorated over the last 10 years and is moving towards a mesotrophic (more enriched) state. While the lakes have good to excellent dissolved oxygen levels the majority of the time, all three lakes do stratify naturally

in most summers, with moderate to severe de-oxygenation of bottom waters and occasional release of nutrients from the lake sediments. Monitoring data for Lakes Taharoa and Waikare shows that bacterial water quality in summer is consistently excellent providing for the high recreational values of the lakes.

The Lakes have been identified as having high ecological significance in DOCs Protected Natural Areas Programme, with four ecological units in total identified for protection. Combined the Lakes have 60 Ha of land environments that are priority for protecting rare and threatened native biodiversity. All three lakes have been identified by NIWA as having 'Outstanding' native biodiversity value, which means they are nationally important, containing a diverse indigenous biota with sustainable populations of endangered species. In 2010, the three Lakes were all ranked in the top 70 for ecological value of 255 Northland wetlands and in the top 20 for specifically lake type wetlands. At least 35 indigenous aquatic plants have been recorded in the lakes over the last 30 years, many of which are nationally or regionally significant. All three Lakes were classed as having 'Excellent' ecological condition in 2005 and 2007 based on their submerged plant communities (LakeSPI), however, only Taharoa was excellent in 2011, with both Waikare and Kai Iwi deteriorated to having 'high' ecological condition. Six native fish species in total have been recorded from the three Lakes. The endangered dune lake galaxid (DLG) is the most significant, as it is only found in the Kai Iwi Lakes. Formerly present in in all three lakes, it is now apparently confined to Lakes Waikare and Taharoa. At least 15 different species of water birds have been recorded on the Kai Iwi Lakes in the past, including species that are regionally and nationally significant.

The Lakes and their catchment are a popular destination for many reasons, to the point where they have been identified as nationally important for their recreational value. The lakes are used for swimming, water skiing and jet skiing, fishing, yachting, diving, sail boarding, canoeing/kayaking and waka ama. Lake Waikare is currently one of the top five tournament water ski sites in New Zealand and the Lakes have been identified as the most important trout fishery north of the Central North Island lakes. The surrounding catchment is used for camping, picnicking, walking and mountain biking.

The Lakes and their catchment also have high cultural and historical values. The Kai Iwi Lakes are culturally and spiritually significant to tangata whenua. Maori have a long association with the Lakes and the Domain is recognised by tangata whenua as taonga and a traditionally valuable food source. Lake Kai iwi was historically important as a seasonal source for eels, whitebait and crayfish and still is today. As a result of the long association and use that Maori have had with the lakes and the history of gumdigging in the area, there are over 30 archaeological sites in the small catchment.

The main pressures on the lakes are the dominance of pastoral farming and pine forestry in the Lakes' catchments and recreational use. The main potential impacts from pastoral farming are contaminant inputs into the lakes from surface run-off, possibly groundwater inflows and stock access to waterways and stock damage to lake margin vegetation. The major potential impacts from forestry include sediment run-off, nutrient inputs from fertiliser use, declines in lake water level, loss of terrestrial biodiversity and damage to archaeological sites in the catchment. These risks are greater during harvesting. The majority of the pines in the catchment have recently been harvested and there does not appear to have been any

significant and/or long term adverse effects on the Lakes. There are many potential impacts associated with the high recreational use of the Lakes, the most significant of which is the risk of introducing pest fish and plant species. The risk of pest fish introduction is high for all three lakes. Mosquito fish are already present in all three lakes and are thought to have led to the extinction of the endangered dune lake galaxid in Lake Kai Iwi and its decline in the other two lakes. If coarse fish species, such as koi carp, perch and catfish, became established in the Lakes they would have a large detrimental effect on water quality, the natural lake ecosystems and/or trout fishery. Other potential pressures related to recreational use are damage to lake margin vegetation, wastewater disposal, water supply, rubbish, run-off from paved and unpaved surfaces and environmental incidents. Visitor numbers to and recreational use of the Kai Iwi Lakes is already high and is expected to increase, with this comes increasing pressure on the Lakes.

While there have been reasonable amounts of monitoring and research on the Kai Iwi Lakes over the last 25 years, there is still some significant knowledge gaps, including:

- The source of nitrogen resulting in an increasing trend in nitrogen in Lake Kai Iwi. The groundwater monitoring plan prepared by Golder Associates (2012) for the Regional council was specifically done to address information gaps with groundwater and the increasing trend in nitrogen in Lake Iwi. The proposed plan clearly identifies the current gaps and what monitoring is required to address them, so if this monitoring is implemented as proposed it is likely to fill these knowledge gaps and assist in identifying the sources of nitrogen. However, this study is focused on groundwater. Contaminant loads in surface inflows and surface run-off will also need investigating and with this information on farming practices in the catchment is needed. Nitrogen fixing by plants on the lake margins, especially exotic species, is also another potential source of nitrogen that needs investigating.
- Bacterial data for Lake Kai Iwi
- Algal community assemblages, as these can be a useful early indicator of changes in water quality
- Health of DLG populations and extent and impacts of exotic fish species, especially rudd and mosquito fish
- Recent detailed analysis of hypolimnion (bottom water when lake is stratified) water quality data, which may identify the need for lake-bed sediment sampling and/or more frequent monitoring in spring to autumn for a several years to accurately determine the length of time the lakes are stratified for, the level of de-oxygenation and nutrient release from lake sediments. There is very little data available, especially recent data, on the levels of nutrients in the lake bed sediments. This is one of several potential sources of the increasing nitrogen in Lake Kai Iwi.
- Climatic data, particularly rainfall, and hydrological data including routine lake level monitoring and surface water and groundwater inflows and outflows.

1 Introduction

1.1 Background

The Kai Iwi Lakes are located on the West Coast of Northland, approximately 25 km North West of Dargaville. The Kai Iwi Lakes includes the three lakes within the Taharoa Domain; Taharoa, Waikare and Kai Iwi. The Lakes and their catchment have high cultural, recreational, ecological and environmental values. The Lakes have excellent water quality and outstanding ecological condition, providing habitat for a range of endangered plants and animals. They are one of the most important recreational areas in Northland. For these reasons the Northland Regional Council (NRC) identified the Kai iwi Lakes as one of several priority catchments for the Northland Water Programme.

1.2 Purpose of this document

The main purposes of this document are to:

- provide an up-to-date overview of Lake water quality and the use and values associated with the Lakes
- identify knowledge gaps that will be required to be addressed in order to better manage pressures on the Lakes and their catchment and better allocate resources.

This document will inform the Northland Water Programme.

1.1.1 Northland Water

Northland Water is a programme for improving the management of water quality and quantity across the region. It brings together and coordinates a number of Northland Regional Council's water management responsibilities, including its programme for implementing the National Policy Statement for Freshwater Management 2011 (NPS).

The NPS requires Northland Regional Council to establish freshwater objectives and set associated water quality and quantity limits for every stream, river, lake, wetland, and aquifer across the region. It then requires Northland Regional Council to implement regulatory and non-regulatory actions to achieve the freshwater objectives.

Northland Regional Council has committed to an approach that involves setting a combination of specific limits in priority catchments and region-wide interim and/or default limits for other freshwaters. Northland Regional Council is also aware of the strong correlation between freshwater and coastal water in Northland, especially given that all of region's major river systems drain to estuaries and harbours. The proposed Regional Policy Statement for Northland (proposed RPS), notified in October 2012, establishes a framework for the integrated management of fresh and coastal waters, including by identifying a number of regulatory and non-regulatory actions to be implemented by Northland Regional Council.

Actions include policies, regulations, and incentives. Achieving objectives is also dependent on a good deal of landowner and community commitment. Robust information is critical to the limits setting process and very important to assess the on-going achievement of freshwater objectives.

Northland Regional Council identified the Kai Iwi Lakes as one of several priority catchments for establishing catchment specific freshwater objectives and freshwater quality and quantity limits.

1.3 Document structure

This document is structured as follows:

- Section 2 provides an overview of the Lakes and their catchments, including information about their related uses and values. It also outlines the current policy framework for managing activities that can have an impact on the Lakes and their catchment.
- Section 3 describes the quality and quantity of water in the Lakes, the lake ecosystem and freshwater biodiversity, and identifies information gaps.
- Section 4 identifies known and likely pressures on the Lakes and their catchment. This section also identifies information gaps.

Generally speaking, this document has been prepared for a wide audience. Whenever possible, technical details and background information has been minimised but some is still required.

2 The Lakes and their catchment

2.1 Overview

The Kai Iwi Lakes are located on the West coast of Northland, approximately 25 km North West of Dargaville (McLellan 1985) in the Kaipara District. The entire catchment of the Lakes is within the rohe of Te Roroa. Historically, the Kai Iwi Lakes were known by Maori as the Rotorima Lakes, as they consider the two nearby Lakes; Shag and Black, to be part of the Kai Iwi Lakes. However, for most people today and for this report, the Kai Iwi Lakes refers to the three lakes within the Taharoa Domain (Figure 1). Waikare means ‘rippling water’, Taharoa is named due to its shape resembling a ‘long calabash’ and Kai Iwi is ‘food for the people’ (KDC 2002).

The three Lakes are basin dune lakes formed by the accumulation of rain water in depressions of consolidated sand underlain by relatively impermeable ironstone pans (McLellan 1985, Dunn 1985). The Kai Iwi lakes are the oldest dune lakes in the Pouto Peninsula considered to be about 10,000 years old (Kokich 1991).

The Lakes vary in size and depth from the smallest, Kai Iwi, which is 16 metres deep and covers an area of 30 Ha, to the largest Taharoa with a maximum depth of 37 m and area of 217 Ha (Table 1). Lake Taharoa is the deepest dune lake and third largest by surface area and Lake Waikare is the second deepest dune lake in New Zealand (KDC 2002). The total surface water catchment for the three Kai Iwi Lakes is approximately 709 Ha (Table 1). This is a relatively small catchment area considering the surface area of the lakes is 278 Ha (39%) of this. It is not surprising then that there are no significant inflows and outflows from the lakes and that rainfall directly on to the lake surface is the main source of water to the lakes. As a result, lakes levels fluctuate considerably with climatic conditions. It is also

possible that there are some groundwater inflows and if this is the case the catchment area of the lakes may be much larger if you consider the groundwater system. This is currently unknown and discussed further within this report as an information gap. There is also variation in the surface catchment boundary. The boundary used for this report (Figure 1) has been re-digitised from the catchment in the Freshwater Environments of New Zealand GIS layer, using aerial photography and the NZMS topographic map. As the catchment is so small, there would be value in confirming this catchment boundary, possibly with ground surveying. In conjunction with this, surveys to confirm inflows into and outflows from the lakes would also be beneficial (see section 3.4).

Table 1: Characteristics of the Kai Iwi Lakes (McLellan 1985, KDC 2002, LCDB3)

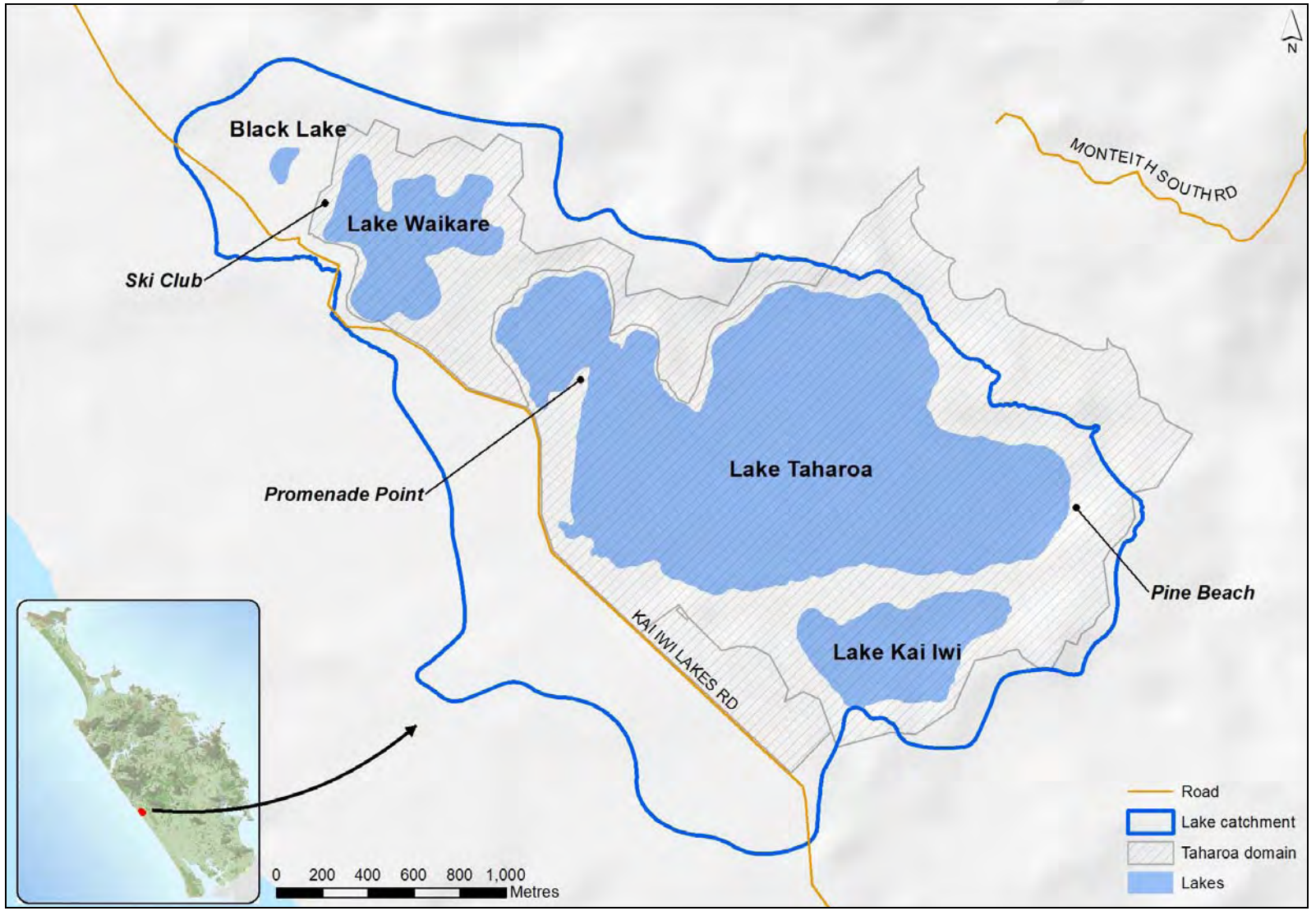
Lake	Lake depth (m)	Lake height at water surface (masl)	Lake surface area (Ha)*	Approximate surface catchment area (Ha)**
Kai Iwi	16	70	30	122
Waikare	30	79	31	130
Taharoa	37	70	217	457
Total	-	-	278	709

* 'Lakes/ponds' from LCDB3, figure for Waikare excludes area of Black Lake
** based on redigitised FENZ catchment boundary

There is limited climate data for the Kai Iwi lakes but estimates can be made from nearby climate stations. The average air temperature in Dargaville is 15.3°C, ranging from 11.3°C in July to 19.8°C in February (Appendix 1). There is unlikely to be much difference in air temperature between Kai iwi Lakes and Dargaville. DOC (2011) reported the average annual rainfall at the Maitahi Wetland Scientific Reserve, just south of the Kai Iwi Lakes is about 1500 mm. This and recent rainfall data near Kai Iwi Lakes (Appendix 1), suggests that average annual rainfall at Kai Iwi lakes is about 1,400 mm with the driest months being November to February and the wettest months being June and July. This is consistent with historical rainfall data from Kai Iwi lakes. Historical average annual rainfall for Kai iwi Lakes includes 1,297 mm based on an 18 year record at Fanning rainfall station (McLellan 1985) and 1,226 mm at McLeods at Kai Iwi based on data from 1986 to 1993. Average annual open water evaporation in Dargaville is 1,018 mm, with the highest evaporation rates in December and January and the lowest in June and July (Appendix 1).

The Lakes are an outstanding freshwater environment, with good to excellent water quality, providing habitat for rare aquatic plants and animals, as a popular recreational reserve and with many archaeological sites in the Lakes' catchment.

Figure 1 The Kai Iwi Lakes and their surface water catchment, showing the Taharoa Domain and camping grounds



2.2 Catchment description

Pre-human vegetation around Kai Iwi Lakes would have been mostly shrub heaths dominated by scattered shrubs (eg, manuka), sedges and ferns (Smales et al. 2009) and forest with a mix of species, such as rewarewa, kowhai, pohutukawa, kauri, totara and tanekaha (NRC 2012), both of which there are still remnants of around the Lakes today.

As mentioned, the geology of the catchment is early Pleistocene (Awhitu Group) cemented dune sand with a consolidated dune belt of mid-late Pleistocene (Karioitahi Group) (Smales et al. 2009). There are two major soils types in the catchment, both derived from late Pleistocene Sedimentary sands:

- Te Kopuru Sands, which are strongly podzolised and underlain with a silica pan which limits drainage
- Tangitiki Sandy Loam-sands (hill soils), which are moderately podzolised with a slightly higher natural fertility

Both are moderately to highly erodible, especially in the absence of vegetation cover and on steeper slopes (KDC 2002).

In 1928 8.5 Ha on the eastern shores of Lake Taharoa were made into a scenic reserve, by 1952 the surrounding land was added. In 1962 Lake Kai iwi was included and gazetted as the Taharoa Domain Recreation Reserve and by 1968 Lake Waikare and its adjacent land was added (KDC 2002). A large proportion of the Lakes' catchment sits within the Taharoa Domain, which has a total area of 538 Ha (a small amount of the Domain is not in the surface water catchment of the Lakes). Within the Domain there are two popular camping grounds and a Water Ski Club and associated campground. See section 2.4.2 for more information on Reserve management.

The present day land cover is a mixture of exotic forest (14%), pasture (33%) and indigenous forest/shrub (10%) (Table 2 and figure 2). The majority of the exotic forest in the Domain has been harvested from 2004/05 (Taharoa Domain Governance Committee 2003) to late 2010 (Reid 2010), with most of the area being replanted into pines. The pastoral land cover is mainly used for sheep and beef dry stock farming. There are no dairy sheds or dairy farms in the catchment, however, some areas of pasture are used for dairy support (run-off) (D. Wright, pers. comm). There are very few dwellings within the catchment.

2.2.1 Lake Kai Iwi

Kai Iwi is the smallest of the three lakes by area and depth (table 1). This lake is approximately 70 metres above sea level (masl). The total surface catchment area for Lake Kai Iwi is about 122 Ha (Table 2). The most dominant land cover is pasture (38%), followed by the lake and wetland areas (27%), indigenous forest/scrub (21%) and exotic forestry, being predominantly pine (14%) (Table 2).

There is currently only one dwelling in the surface catchment of Lake Kai Iwi on Kai Iwi Lakes Road. There is no road access to the lake, with a locked gate that has been in place since 2006 and no formed boat ramp.

Table 2: Land cover (LCDB3) of the Kai Iwi Lakes catchment using a redigitised version of the FENZ catchment boundary. Note numbers may not equate due to rounding.

Land cover	Kai Iwi	Taharoa	Waikare	TOTAL
Lakes/wetlands*	33 (27%)	226 (50%)	36 (27%)	280 (42%)
Exotic forest	17 (14%)	72 (16%)	12 (9%)	100 (14%)
High producing pasture	44 (36%)	126 (28%)	58 (44%)	228 (32%)
Low producing pasture	3 (2%)	3 (0.6%)	2 (1%)	8 (1%)
Indigenous forest	11 (9%)	1 (0.3%)	7 (6%)	19 (2%)
Manuka/Kanuka	14.8 (12%)	29 (6%)	16 (12%)	59 (8%)
Total (Ha)	122	457	130	710

* Includes 'Lakes/ponds' and 'herbaceous freshwater vegetation' from LCDB3

The extent of surface inflows and outflows is unclear, although if any they will be minor. Champion et al. (2005) states that there are two small inflows; one from Lake Taharoa and the other at the south end of Kai Iwi, and no outflows. Golder Associates (2005) states that there are no major surface inflows but there is a small surface outflow to the South, which flows periodically when lake levels are high and a small channel that connects Lakes Kai Iwi and Taharoa. Tanner and Sutton (2010) mention a watercourse with a 6m waterfall on the SW side of the lake. Aerial photography and topographic maps would suggest that there is one small inflow on the south west side of Kai Iwi and outflow to the South. As mentioned previously, there is currently insufficient information to establish the extent of groundwater inflows and outflows into Lake Kai Iwi. However, existing information for Lake Taharoa suggests that there are substantial groundwater inflows and outflows (Golder Associates 2005) and that lakes in the vicinity are likely to be connected to the groundwater system in a similar way.

2.2.2 Lake Waikare

Waikare is about 31 Ha in size, with a maximum depth of 30 m. This lake is approximately 79 masl (Table 1). The total catchment area for Lake Waikare is about 130 Ha (Table 2). Lake Waikare, small Black Lake to the NW of Waikare and wetland areas are 36 Ha (27%) of the catchment. The remaining land cover in the catchment is dominated by pasture (45%), followed by indigenous forest/scrub (18%) and exotic forest (9%). There are approximately 3 to 5 dwellings in the Lake Waikare catchment, as well as the Water Ski Club and associated camping ground. There is access to the Lake by a public sealed road and a concrete boat ramp.

There are no outflows from the lake and one minor inflow near the ski club, which appears to have drainage from Black Lake probably when water levels are high.

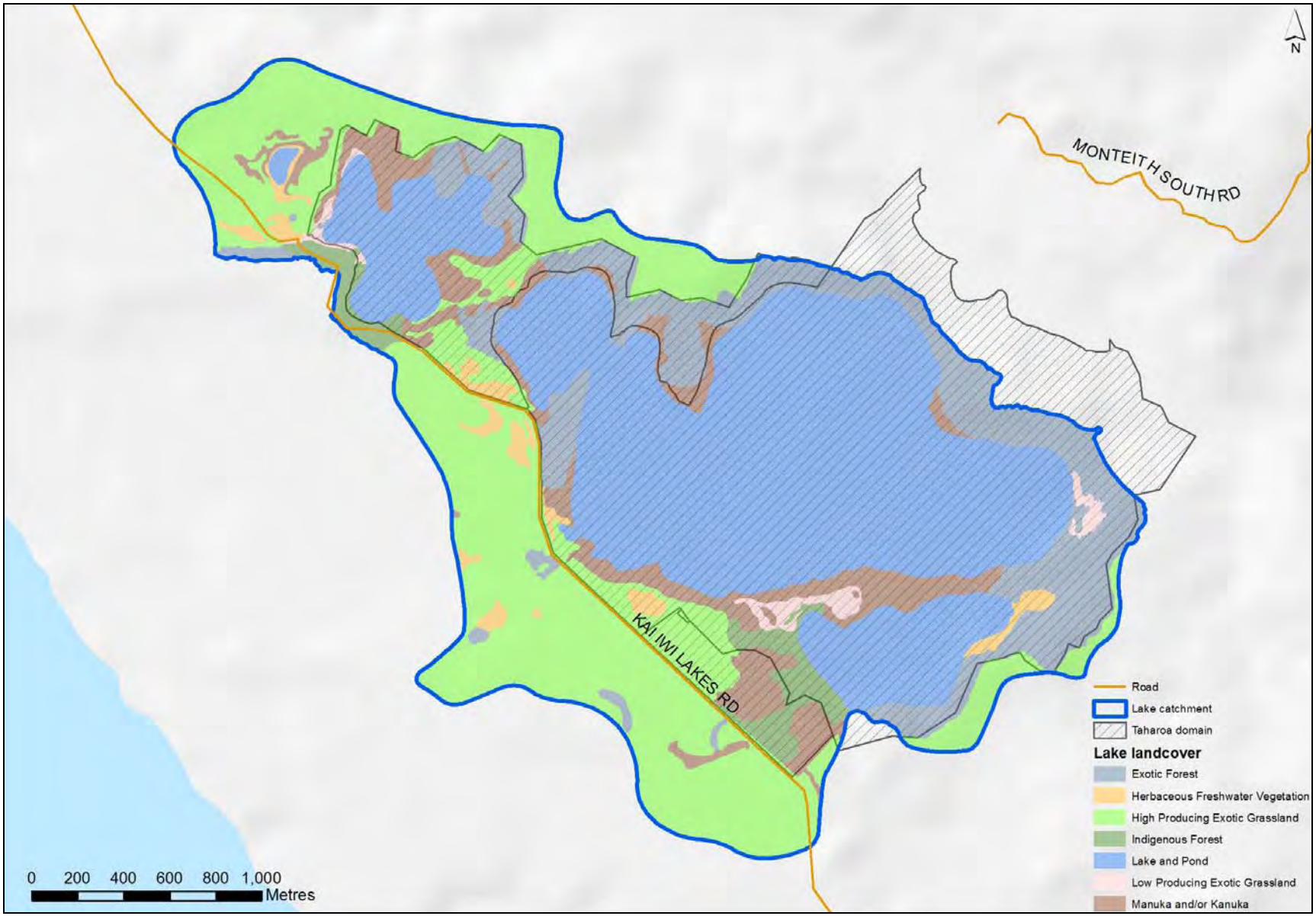
2.2.3 Lake Taharoa

Taharoa, the largest of the three lakes, is about 217 Ha in size with a maximum depth of 37 m. This lake is approximately 70 masl. The total catchment area for Lake Taharoa is about

457 Ha (Table 2). The lake is about half of the catchment area, the next most dominant land cover is pasture at 129 Ha (29%), followed by exotic forestry (16%) and indigenous forest/scrub (6%). There are approximately 5 to 7 dwellings in the Lake Taharoa catchment, including the Wai Hou Oma Lodge, which sleeps a maximum of 18 guests and the two camping grounds on the lake edge. There is public road access to several locations on the lake shore with three boat launching areas but no formed boat ramps.

There is two minor surface inflows at the SW side of Lake Taharoa. There are no outflows, other than the small channel connecting Taharoa to Lake Kai Iwi. There is some data that suggests Lake Taharoa has substantial groundwater inflows and outflows (Golder Associates 2012). A study on Kai Iwi lakes by Wells et al. (1998) concluded that there are substantial groundwater inputs into Lake Taharoa, estimated to be about 425mm/year. Groundwater inflow rates were found to vary at the five locations sampled around the lake. Kokich (1991) produced a simple water balance for Lake Taharoa and found that calculated lake levels were reasonably consistent with measured levels. The model did not include groundwater flows and a surplus groundwater outflow of 400 mm was required to reach a balance for the lake. When considering Well et al.'s (1998) results it was suggested that a groundwater inflow of 400 mm/year and outflow of 800 mm/year would achieve this (Kokich 1991). Groundwater outflows would most likely be in the direction of Ngakiriparauri Stream to the East.

Figure 2 Kai Iwi Lakes, showing main land covers



2.3 Values and uses of the Lakes

The three Kai Iwi Lakes have excellent water quality and high ecological value with the presence of several endangered species of flora and fauna. The Lakes and their catchment have high recreational value, to the point where they have been identified as nationally important for their recreational value (MfE 2004, DOC 2012). The Lakes and their catchment also have high cultural and historical values with many archaeological sites.

2.3.1 Water quality

The Kai Iwi lakes have excellent water quality with all three lakes having an oligotrophic status, meaning they have low nutrient and algal levels and excellent water clarity. Lakes Waikare and Taharoa are renowned for their clear blue water making them a popular destination for tourists and a range of recreational activities (KDC 2002, DOC 2012). The excellent clarity also contributes to Taharoa having the deepest record of submerged aquatic vegetation in the North Island (Champion et al. 2005).

All three lakes stratify for part of the year, mainly in the warmer summer months due to natural differences in the density of water with temperature. When stratified the lake water splits into three layers the top warm layer (epilimnion), the separating layer that prevents mixing (thermocline) and the cooler bottom waters (hypolimnion). While stratified, oxygen levels in the bottom waters can become low, which causes nutrients to be released from the lake sediments. When water temperatures drop the lake mixes making these nutrients available to algae. There has been no data analysis of nutrients levels in samples from the hypolimnion in recent years, so a brief visual scan of the data was carried out for this report. This found that there is the odd occasion where elevated nutrient levels in the hypolimnion coincide with low oxygen levels, especially for ammoniacal nitrogen and Lake Waikare. This suggests that a detailed analysis of the dissolved oxygen profile and hypolimnion data would be valuable. This may identify that more frequent monitoring is required in spring to autumn for several years to accurately determine the length of time the lakes are stratified for and the extent of de-oxygenation and release of nutrients. Data loggers could also be used for investigating the level of deoxygenation in the hypolimnion.

Another potential information gap for the lakes could be information on the amount of nutrients in the lake bed sediments. The only data currently available is from a small study of lake bed sediments and sediment interstitial water by Wells et al. (1998). Most nutrient results were low for all three lakes, except ammoniacal nitrogen, but of more significance alkalinity (inorganic carbon) was found to be very low and likely to limit the growth of invasive aquatic plants such as oxygen weed. Their management recommendations included the importance of minimising inputs of both nutrients and sources of dissolved inorganic carbon and other ions, such as lime.

2.3.2 Ecology

All three lakes are located in the Kaipara Ecological District (ED) and were assessed as part of DOCs Protected Natural Areas Programme (PNAP). All three lakes were categorised as level 1 sites due to their high ecological significance (Smales et al. 2009). As part of the

PNAP, in total the three lakes have four representative ecological units identified for protection:

- Kanuka/manuka shrubland on hillslope (Waikare)
- Sandfield on alluvium (Waikare)
- Manuka shrubland on hillslope (Taharoa)
- Oioi - *Baumea arthrophylla* - *B. juncea* - *B. articulata* - *Eleocharis sphacelata* reedland on alluvium (Kai Iwi).

In addition, analysis for the PNAP (Smales et al. 2009) showed that the Kai Iwi lakes and their catchment contain substantial areas of land environments that are priority for protecting rare and threatened native biodiversity (MfE 2007 in Smales et al. 2009). The Lake Waikare, Taharoa and Kai Iwi sites have 8.5, 30.8, and 6.5 Ha of 'Chronically Threatened' land environments respectively, and 10.3, 1.1 and 2.5 Ha of 'At Risk' environments respectively.

The Kai Iwi Lakes have been assessed by NIWA in 2005, 2007 and 2011 for their native biodiversity values (Wells and Champion 2011). The 'lake native biodiversity value' assessments are based on indigenous biodiversity, endangered species and habitat availability and each lake is assigned a ranking of either: Outstanding, High, Moderate to high, Moderate, Low to moderate or Low (Wells and Champion 2012).

All three lakes have consistently had 'Outstanding' native biodiversity value (Champion et al. 2005, Wells et al. 2007, Wells and Champion 2011). Outstanding lakes are nationally important, containing a diverse indigenous biota with sustainable populations of endangered species. Low ranked lakes are either de-vegetated with poor water quality or severely impacted by exotic pest species (Wells and Champion 2012). A total of 85 lakes in Northland have been assessed, of which 15 are ranked as Outstanding.

A more detailed ecological assessment of 76 lakes in Northland was done in 2012. This assessment was based on aquatic vegetation diversity and integrity, endangered species, habitat size, buffering, water quality, key biota and connectivity (Champion and de Winton 2012). Again all three Kai Iwi Lakes obtained a rating of 'Outstanding'. Of the 76 lakes assessed, 12 were rated as outstanding.

In 2010, 255 freshwater wetlands in Northland were ranked according to their ecological values (Wildland Consultants 2011). Lake Kai Iwi was ranked 32nd of the 255 wetlands, with an overall score of 70.4 out of 100. It is not ranked as highly as other wetlands as it only contains one representative wetland vegetation type in the PNAP but is a 'nationally important' geological site (Kenny & Hayward 1996 in Wildlands consultants 2011) and threatened species are present.

Lake Taharoa was ranked 45th with an overall score of 67 out of 100 (Wildland Consultants 2011). It is the best example of a clear water lake with the deepest record of submerged vegetation in the North Island. Like Kai Iwi Lake it is a 'nationally important' geological site (Kenny & Hayward 1996). The margins support degraded ecological sequences from open water to lake margin wetlands to manuka shrubland. It supports many indigenous flora and fauna species, including six "Threatened", five "At Risk" and three regionally significant. However, it was noted to be degraded by cattle.

'Lake Waikare Wetland and Shrubland' was ranked 65th with an overall score of 62.9 (Wildland Consultants 2011). It is a representative site for a wetland on a littoral (lake margin) sand-field in the PNAP, which are a historically rare ecosystem. This wetland system, which comprises two lakes (Waikare and Black), supports five "Threatened", six "At Risk" and two "regionally significant" species.

All three lakes were in the top 20 lacustrine (lake) type wetlands for ecological value, with rankings of 6th for Kai Iwi, 8th for Taharoa and 11th for Waikare. Both Lake Kai Iwi and Lake Taharoa featured in the top 20 'freshwater wetlands on dunes' with rankings of 14th and 18th respectively and in the top 10 wetlands for the Kaipara Ecological District with rankings of 5th and 7th respectively.

2.3.2.1 Aquatic plants

A diverse range of indigenous aquatic plants have been recorded in the Lakes over the last 30 years, many of which are nationally or regionally significant, including the:

- Wetland plants; *Apodasmia similis, Drosera pygmaea, Baumea Arthrophylla, B. articulata, B. juncea, B. huttonii, B. rubiginosa, Eleocharis acuta, E. sphacelata, Schoenus brevifolius, Ficinia nodosa, Isachne globosa, Isolepis prolifer, Juncus pallidus, Typha orientalis, Centrolepis strigosa, Lilaeopsis novae-zelandiae, Schoenoplectus validus, Machaerina teretifolia*, *Glossostigma elatinoides, G. diandrum, Centipeda minima ssp. Minima and Spiranthes aff. novae-zelandiae.*
- Submerged plants; *Trithuria inconspicua, Chara australis, C. fibrosa, Potamogeton cheesemanii, P. ochreatus, , Nitella hookeri, N. leptostachys, N. pseudoflabellata, Triglochin striata, Myriophyllum peduculatum, M. propinquam and M. votschii* (Wells and Champion 2011, Smales et al. 2009, Champion et al. 2002, KDC 2002).

The Sneezeweed *C. minima* ssp. *minima* recorded in the lakes by Forester & Townsend (2004, in Smales et al. 2009) is 'Nationally Critical' (Acutely threatened). The nationally rare *T. inconspicua* (formerly *Hydatella inconspicua)* is present in all three lakes (Wells and Champion 2011) and is categorised by DOC as 'Serious decline' – 'Chronically threatened' (Smales et al. 2009). *Drosera pygmaea* is categorised as Gradual decline (Smales et al. 2009). The nationally 'At-risk' *C. strigosa* and two 'Regionally significant' species; *T. striata* and *M. votschii* were recorded in Lake Taharoa (Wells and Champion 2011). The depth to which *C. fibrosa* grows varies from 18 to 25 m with it recorded to a depth of 24 m in 2011. This is the deepest recorded submerged vegetation in the North Island (Wells and Champion 2011).

Isolated plants of the exotic rush *Juncus bulbosus* were recorded in shallow areas of Lakes Taharoa and Waikare and the exotic plant *Utricularia gibba* has been recorded in all three lakes (Wells and Champion 2011).

From the surveys carried out in 2005, 2007 and 2011, NIWA have calculated the Lake Submerged Plant Indicator (LakeSPI) for all three lakes. LakeSPI is a bio-assessment tool that uses submerged plants to assess ecological condition and monitor trends in New Zealand lakes (Wells and Champion 2012). The overall LakeSPI Index provides a measure of how close a lake is to its potential (unimpacted by human) state. It is calculated from two

indices the Native Condition Index, which is a measure of the diversity, quality and abundance of indigenous submerged vegetation and the Invasive Impact Index, which measures the impact by any of ten invasive exotic plants. Lakes are assigned to five classes of lake ecological condition based on their LakeSPI Index score: Non-vegetated (0%), Poor (>0-20%), Moderate (>20-50%), High (>50-75%) and Excellent (>75%).

All three lakes were classed as having 'Excellent' ecological condition in 2005 and 2007, however, only Taharoa was excellent in 2011, with both Waikare and Kai Iwi deteriorated to have 'high' ecological condition (Table 3). The high LakeSPI score for Kai Iwi reflects the extent of indigenous vegetation, the presence of several key native plant communities but also the presence of *U. gibba* which has reduced the LakeSPI score from 83% in 2007 to 69% in 2011 (Wells and Champion 2011). The excellent LakeSPI score for Taharoa reflects the depth of native vegetation, the dominance of the native charophyte community and the limited impact by invasive exotic plants. The LakeSPI score for Waikare has dropped from 79% in 2007 to 75% in 2011 due to the presence of U. gibba but is still high because of the large extent of native vegetation and presence of charophyte meadows with little impact from invasive exotics.

Table 3: LakeSPI, Native Condition and Invasive Impact index scores as a percentage of their potential score for the Kai Iwi Lakes in 2005, 2007 and 2011 (Date source: Wells and Champion 2011)

	Survey year	Kai Iwi	Taharoa	Waikare
LakeSPI index (% of potential score)	2005	81	84	76
	2007	83	82	79
	2011	69	84	75
Native condition index (% of potential score)	2005	67	77	66
	2007	71	75	67
	2011	66	77	74
Invasive impact index (% of potential score)	2005	0	3.7	3
	2007	0	9	7.4
	2011	22	6	20

2.3.2.2 Freshwater fish

Six native fish species in total have been recorded from the three Kai Iwi lakes (Table 4). The endangered dune lake galaxid (Galaxias sp.) is the most significant. As it is only found in the Kai Iwi Lakes it is nationally vulnerable (acutely threatened). Genetic testing has shown that the dune lake galaxid (DLG) has evolved separately from the dwarf inanga (Galaxias gracilis) and DOC considers it to be a different species (Smale et al. 2009, Pingram 2005). Formerly present in in all three lakes, DLG is now apparently confined to Lakes Waikare and Taharoa, where numbers are thought to have declined (Pingram 2005). Introduced fish species, such as rainbow trout and mosquito fish have been documented to lead to the decline of DLG (Pingram 2005). Pingram (2005) studied DLG, common bully and

mosquito fish in Lake Waikare, which included trapping and visual observations on over 30 occasions in total spanning 14 months. Numbers recorded for each species were 1,329 DLG, 8,321 mosquito fish and 3,422 common bullies.

The long fin eel is categorised as in gradual decline (Chronically Threatened) (Smales et al. 2009).

The exotic mosquito fish has been recorded in all three lakes and rainbow trout have been stocked in all three lakes, although the last release into Lake Kai Iwi was in 2002 (see section 2.3.3.2). The pest fish rudd has also been recorded in Lake Kai Iwi, however the record is for one fish caught in 1986.

A detailed fish survey of the lakes is recommended to confirm whether DLG are in fact extinct from Kai Iwi and the extent of the rudd population in Lake Kai Iwi and whether they have found their way into Lake Taharoa through the drain that connects these lakes. Also ongoing routine monitoring of the DLG galaxid population in recommended.

Table 4: Fish species in the Kai iwi Lakes and their frequency of record (Data source: NZFFD, Wells and Champion 2011)

Scientific name	Common name	Kai iwi	Taharoa	Waikare
Anguilla australis	Shortfin eel		2	3
Anguilla dieffenbachii	Longfin eel		1	1
Anguilla sp.	Unidentified eel		1	
Galaxias brevipinnis	koaro		1	
Galaxias sp.	Dune lake galaxid	1	2	2
Galaxias sp.	Unidentified Galaxiid		1	
Gambusia affinis	Gambusia	3	1	3
Gobiomorphus breviceps	Upland bully			1
Gobiomorphus cotidianus	Common bully	3	5	3
Gobiomorphus sp.	Unidentified Bully		1	
Oncorhynchus mykiss	Rainbow trout	1	3	1
Paranephrops sp.	Koura		3	2
Scardinius erythrophthalmus	Rudd	1		

2.3.2.3 Water birds

At least 15 different species of water birds have been recorded on the Kai Iwi Lakes in the past, including species that are ‘regionally significant’, ‘at risk’, ‘chronically threatened’ and ‘nationally endangered’ (Smales et al. 2009). Lake Kai Iwi is thought to be the best of the lakes for providing habitat for water birds, due to its more isolated nature, extensive emergent wetland and scrub vegetation and lower recreational use (Wells and Champion 2011). Pied shags were noted on Lake Kai Iwi during the NIWA survey and there are earlier reports of large number of a diverse range of waterfowl using this lake, including the nationally threatened bittern and regionally rare dabchick (Wells and Champion 2011). The Nationally Critical grey duck has also been recorded on Lake Kai Iwi (Wildlands Consultants 2011, p. 27).

2.3.2.4 Freshwater invertebrates and algae

There have been no detailed surveys of aquatic invertebrates in the lakes but there are various studies that include observations of invertebrates. Wells and Champion (2011) commented that invertebrates were abundant in Lake Kai iwi. Invertebrates (including zooplankton) recorded in the lakes or in the stomachs of fish from the lakes, include koura (freshwater crayfish, *Paranephrops planifrons*), freshwater crabs (*Amarinus lacustris* and *Halicarcinus lacustris*), torewai (freshwater mussels, *Hyridella menziesi*), pea mussels (*Pisidium novae-zelandiae* and *Sphaerium* spp.), snails (*Potamopyrgus antipodum*), beetles, damselfly, dragonfly, midge, fly (dipteran) and beetle larvae, bloodworm, water fleas (cladocera), water mites (Hydracarina), ostracods, copepods, collembolan, rotifers and nematodes (Wells and Champion 2011, Troup 2003, Pingram 2005, Dunn 1985).

There is no recent data on algae (phytoplankton) in the lakes. However, Cassie and Freeman (1980) carried out a detailed study of algae in Lakes Taharoa and Waikare in 1976/77. They found that the algae population was small in both lakes and dominated by desmids and dinoflagellates. The main species in Lake Taharoa were the dinoflagellate, Ceratium lirundinella f. robustum, the colonial chlorococcalean Nephrocytium agardhianum and four species of Staurastrum desmids. The main species in Lake Waikare were the dinoflagellate Peridinium sydneyense and the desmids Hyalotheca dissliliens and Staurastrum avicula. Richmond (1983, in Dunn 1985) found an abundant zooplankton population in Lake Taharoa dominated by the cladocera, *Bosmina* sp., followed by calonoid and cyclopoid copepods. In contrast the phytoplankton and zooplankton population in Lake Waikare was sparse. A detailed study phytoplankton in Lakes Taharoa and Waikare was also done from 1992 to 1995, with desmids and dinoflagellates dominating the community (Burns and Rutherford 1998). The dinoflagellate Peridinium playfairii was consistently the most dominant species in Taharoa, followed by *Ceratium hirundinella* and *Dinobryon divergens*. The most dominant species in Waikare was *Pediastrum duplex.* There is no algae data for Lake Kai Iwi. This is a significant information gap, given this is the lake with the greatest change in water quality and changes in algal community assemblages can be an early indicator of changes in lake status.

2.3.2.5 Ecology in the surrounding catchment

The Taharoa Domain Reserve Management Plan includes an extensive list of plant species found in the Domain (KDC 2002, p.97-101). It includes 14 native trees species, an additional 29 native shrub and vine species, including the threatened *Dracophyllum viride* and 28 native dicot herb, grass and fern species. However, it also shows that there is about 60 exotic species in the Domain Reserve, including trees, shrubs, vines, herbs, grasses and ferns.

In addition to the water birds (section 2.3.2.3), at least another 10 native bird species have been identified in the Kai Iwi Lakes area (Smales et al. 2009). The most significant is the North Island brown kiwi, categorised as ‘Serious Decline’ (Chronically threatened). It was recorded between Lakes Kai Iwi and Taharoa in 2002 (Smales et al. 2009) and tracks and droppings have been seen recently in two locations on the edge of Taharoa (NRC 2012).

There has been no detailed surveys of reptiles in the catchment but skinks, the common gecko and bell frog are present (NRC 2012).

2.3.3 Recreation and aesthetics

The Kai Iwi Lakes are a popular destination for many reasons. The lakes are used for a range of water recreational activities, including swimming, water skiing and jet skiing, fishing, yachting, diving, sail boarding, canoeing/kayaking and waka ama (KDC 2002). The surrounding catchment is used for a range of activities, such as camping, picnicking, walking and mountain biking (Figure 3). A survey of 163 visitors to the Kai Iwi lakes in 2000/2001 identified swimming as the main recreational activity (98%), followed by walking (62%), water skiing (46%) and fishing (12%). Of the 163 visitors about 25% were day visitors.

Over the 1969-1970 year, roading and amenity facilities were developed in the Taharoa Domain, leading to increased visitor numbers (KDC 2002). Dunn (1985) estimated the number of visitors to the Domain to be in the region of 7,000 people in 1984. It is likely to at least three times this now. Visitor numbers are highest in the summer months, particularly over the Christmas and New Year period (KDC 2002). Traffic numbers for Kai Iwi Lakes Road from August 1998 to October 2000, show that vehicle numbers are 100-200 vehicles per week for most of the year, increasing to 400–800 vehicles/week over the Christmas/New Year period, with over 1,000 vehicles in one week in January 1999 (KDC 2002, p. 41).

The Kai Iwi Lakes were identified as nationally important for their recreational value (MfE 2004). This research identified 105 water bodies throughout New Zealand of potential national importance for recreation, of which only 3 are in Northland. Of the three water bodies identified in Northland, Kai Iwi Lakes was the only one which was identified by the public in the random telephone survey (the other two were included as they had already been identified as '*Wetlands of national importance for fisheries*'). 31 people responded that they use Kai Iwi Lakes for recreational activities, ranking it 8th out of the 105 water bodies, following internationally renowned waters such as Lakes Taupo, Wanaka and Rotorua and the Waikato River. The most common recreational activities identified for the Kai Iwi Lakes were walking (17), fishing (15), general sightseeing (11), canoeing/kayaking, water skiing/wake boarding and picnicking (all 6) and swimming (2). The Kai Iwi Lakes were also recently identified as one of the 40 best wetlands in New Zealand to visit, as part of a Programme to raise awareness of the value of wetlands (DOC 2012).

2.3.3.1 Watersports

Kai Iwi Lakes Water Ski Club has been located on Lake Waikare since 1968. It is currently one of the top five tournament water ski sites in New Zealand (Sportsground 2012). The New Zealand Waterski Championships are held there every 5 years (Sport Northland 2012), with the last one being in April 2012 (Curran 2012). The Club facilities include a club house and camping ground for caravans, mooring jetties, shalom course and ski jump. Dargaville Yacht Club also bases most of their club activities from Marina Bay in Lake Taharoa (Yachting New Zealand 2012, Taharoa Domain Governance Committee 2012). The Hikuwai O Kaipara Waka Ama Club, recently established in 2011 (Sport Northland 2011), also use the Kai Iwi Lakes (Dargaville District News 2012). Waka ama events are held at the Kai Iwi

Lakes, such as the recent Tai Tokerau Polynesian Canoe Association W1 Trials in December 2012 (Wakaama 2012).

Most yachting, diving, sailboarding, kayaking/canoeing and waka-ama is done on Lake Taharoa, probably because of Waikare's smaller size and popularity for water skiing and jet-skiing. Lake Taharoa is also used for water skiing and jet-skiing. The use of engine-based water craft is subject to rules and routes based on the Northland Regional Council's Kai Iwi Lakes Bylaw No. 1, 2000 and motorised boat use is prohibited on Lake Kai Iwi (Taharoa Domain Governance Committee 2012). Most of the shoreline of Lakes Taharoa and Waikare are used for swimming, particularly on the Southern and Eastern sides and in the Sin bin Basin of Lake Taharoa. Lake Kai Iwi is less popular for swimming due to the browner coloured water.

2.3.3.2 Fishing

The Kai Iwi Lakes have been identified as the most important trout fishery north of the Central North Island lakes (KDC 2002, R. Hoetjes, Northland Fish and Game Council, Pers. Comm., Fish and Game New Zealand, undated). Rainbow trout were first released in Kai Iwi Lakes in 1968, with a total of about 62,000 juvenile trout released into Lakes Taharoa and Kai Iwi up to 1984 (McLellan 1985). At this time, it was thought 500 - 600 anglers used the lakes every year, of which about half bought their license outside of the Hobson Acclimatisation Society District (Dunn 1985). The number of anglers using the lakes today is likely to be similar, as the most significant trout fishery in Northland (Fish and Game New Zealand, undated) and with an average of 400 License Sales per year in Northland alone, over the last 10 years (Appendix 2).

Liberation into Lake Kai Iwi ceased in 2002 (Appendix 2). Since 1987, an average of 2,400 and 200 trout have been released annually into Lakes Taharoa and Waikare respectively (Appendix 2). Stocking rates have been reduced in response to trout predation on dune lake galaxids, freshwater crabs and koura (KDC 2002). Fishing is predominately a winter activity (KDC 2002). A trout fishing contest is held at Kai Iwi Lakes annually with an average of 67 contestants (Appendix 2). Trout are caught using various methods from both shore and boat in various locations on both Waikare and Taharoa (Figure 3).

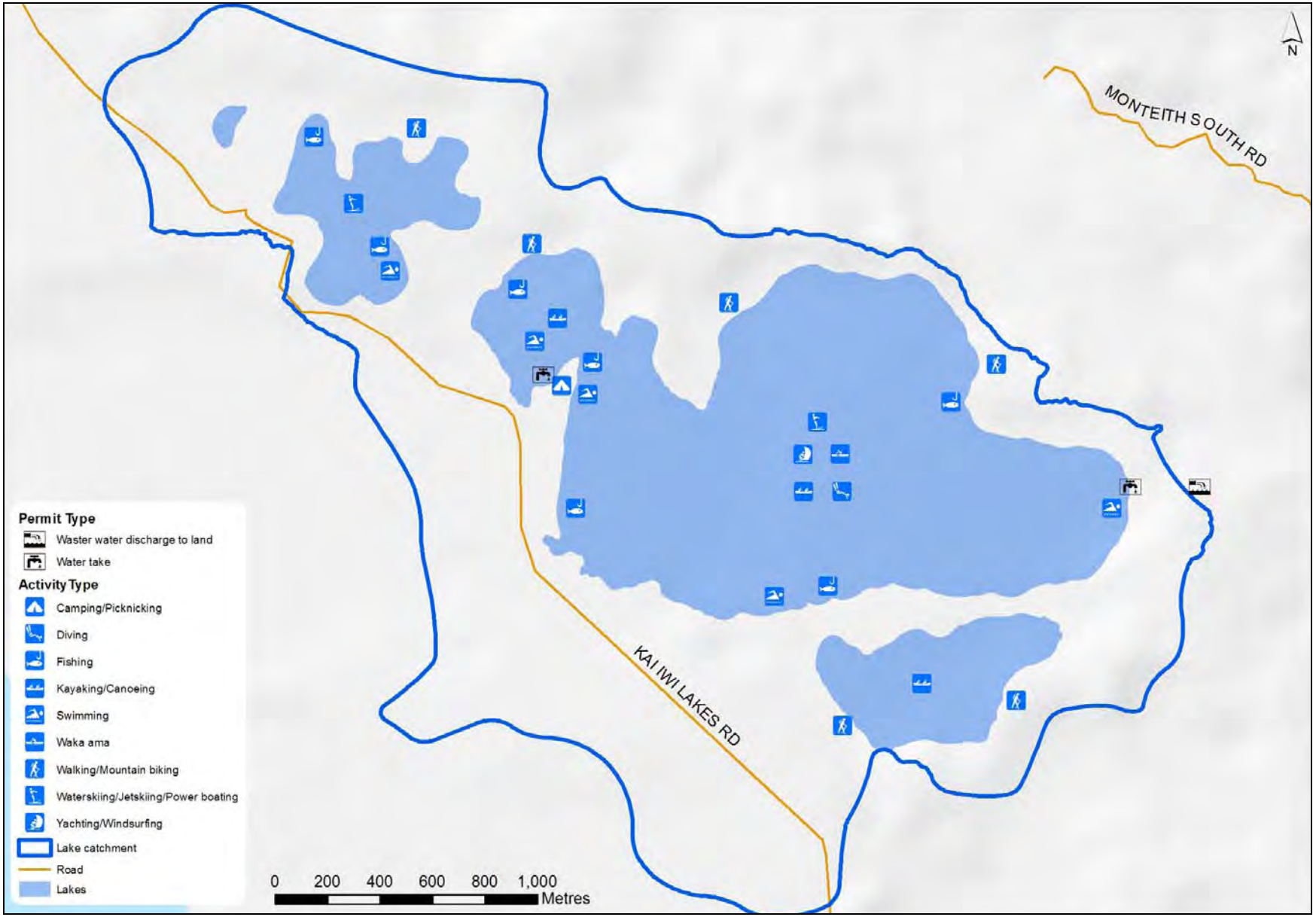
Eel fishing is discussed below in section 2.3.4.

2.3.3.3 Other uses

The lakes are a popular destination for national and international holiday makers, for both day visitors and campers. The Kai Iwi Lakes have been a popular camping destination since the 1970s. The two camping grounds on the edge of Lake Taharoa; Pine Beach and Promenade Point have limits of 500 and 100 campers at any one time respectively. However, numbers are exceeded in peak season (KDC 2002). There is also limited camping at Lake Waikare, with campervan hook-ups for approximately 100 people.

There are tracks around all of the lakes, which are used for both walking and mountain biking, from which there are amazing viewpoints of the Lakes and the Coast (KDC 2002). There is also a 2.5 km walkway to Ripiro Ocean Beach and onto Manganui Bluff from the Lakes (Taharoa Domain Governance Committee 2012).

Figure 3 Common uses of the Kai Iwi Lakes



2.3.4 Maori cultural values

The Kai Iwi Lakes are culturally and spiritually significant to tangata whenua (KDC 2002). Maori have a long association with the lakes and the Domain is recognised by the tangata whenua (Te Roroa and Te Kuihi as recognised by the Waitangi Tribunal in the Te Roroa report on the Wai 38 Claim) as taonga and a traditionally valuable food source and a seasonal mahinga kai. Lake Kai iwi was historically important as a seasonal source for tuna (eels), inanga (whitebait) and koura (crayfish) and still is today (KDC 2002).

A summary of historical use of the lakes by Maori is taken from the Taharoa Domain Reserve Management Plan (KDC 2002). The first Maori ancestor probably associated with the lakes is Tuputupu (Tumutumu) Whenua, who lived at Rangirerekura Pa in the nearby waihopai Valley at Maunganui Bluff. Tuputupu descendent, Ngaengae lived in the same pa and is known to have made use of the lake for fishing purposes, followed by his son, Rangiwhatuma, and grandson, Ikataora.

Ikataora's son, the High chief Toa, lived around Lakes Taharoa and Kai iwi in the summer months. He also used the area which is now Pine Beach camping ground as a convalescent camp for wounded warriors. These practices were probably maintained by future generations because Toa's great Grandson, the High Chief Taoho, who died about 1838, is also known to have used the Lakes in a similar way. In Chief Taoho's lifetime, oral tradition makes first mention of large Maori eeling parties at the lakes in the migration season, particularly on the drain between Lakes Taharoa and Kai iwi.

Much of the area of the lakes shifted from Maori to Crown ownership in the 1876 sale of the Maunganui Block by the Chiefs Tiopira Kinaki and Parore Te Awha, with the exception of the Taharoa Native Reserve centred on Lake Kai Iwi, which became the subject of a Treaty of Waitangi Claim. The 250 Ha Taharoa Native Reserve was set aside as a Reserve by Parore Te Awha in 1876 (Archaeology North 2010).

In the 1870s the Kai iwi area was considered a major gum digging area, with the largest gum digging camp located at Johnson's swamp South of Lake Kai Iwi. By 1892, the gum digging operations had extended to the eastern shores of Lake Taharoa and included a general store. In the early 1920s about 100 people, mostly gumdiggers, lived on the shores of the lake. The people were from Kaihu and included Te Roroa, Te Kuihi, Waiariki and Te Hokokeha. Flax was also harvested as a local industry.

Given the long association and use that Maori have had with the lakes and the history of gumdigging in the area, it is not surprising that there are a substantial number of archaeological sites in the small area of the catchment. There are over 30 archaeological sites registered in the New Zealand Archaeological Association (NZAA) database, most of which were added following surveys by Taylor and Sutton (2010). These surveys were restricted to five recreational areas where forestry harvesting was planned. Therefore, there is likely to be more sites in the catchment that are not registered in the NZAA database. The most significant archaeological sites (not all of which are registered in the NZAA) are probably the Pa site on the main ridge overlooking Lake Kai Iwi, burial grounds (urupa) at Promenade Point and Pine Beach and a wahi tapu site on the northern side of Lake Waikare (Dunn 1987, Taylor and Sutton 2010). These are the oldest of the sites and of Maori origin.

The rest of the sites are locations of whares, houses, camps and gumstores, gum holes, drains and horse tracks, which are all associated with the gum-digging history of the area (Taylor and Sutton 2010, NZAA).

Today, tangata whenua have equal partnership in the management of the Taharoa Domain under the governance structure of the Reserve Management Plan.

2.3.5 Economic and other values

Relative to the high ecological, environmental, recreational and cultural values of the Lakes the economic values are reasonably low and in most cases are a result of the high ecological value and water quality of the lakes eg, economic value associated with tourism and recreational use.

There is some economic value in the pine forestry in the catchment. Development of plantation forestry began in the Domain in 1964 with the planting of 10,000 seedlings. At this time recreational use of the reserve was also promoted. Plantings of pines continued up to and in 1983. The pines were harvested from 2004/05 (Taharoa Domain Governance Committee 2003) to late 2010 (Reid 2010), with the majority of the area being replanted into pines. However, as part of the harvesting there has been a native re-vegatation plan being implemented, particularly around the lake foreshore (Taharoa Domain Governance Committee 2012) and associated weed and pest control (NRC 2012).

Other values include water supply and Lakes Kai Iwi and Taharoa have been identified by Kenny and Hayward (1996) as a nationally important geological site (Wildlands Consultants 2011). Water is currently taken from Lake Taharoa to supply the camping grounds (see section 4.4 for more detail on water takes).

2.4 Managing the Lakes and their catchment

2.4.1 Management of the Lakes

Under the Resource Management Act 1991 (RMA) Northland Regional Council is responsible for managing the region's freshwater quality and quantity by controlling discharges, water takes and land use activities that impact on water. Under the Local Government Act 2002, Kaipara District Council is responsible for the provision and operation of wastewater, stormwater, and potable water infrastructure, as well managing use and development of land generally. Integrating the functions of the two councils for managing the use of land is important for ensuring effective management of water quality.

Contaminants can enter waterbodies from direct and diffuse discharges. Direct discharges are sources of contaminants that discharge from discrete points or identifiable localised areas. Direct discharges, including stormwater and wastewater, to streams, rivers, and land are controlled by rules in the Regional Water and Soil Plan. Diffuse discharges typically arise from land use activities that are spread across a catchment. Diffuse contaminants can enter waterbodies by sub-surface drainage (leaching) and surface run-off. Diffuse discharges can include fertilisers, animal faeces and soil from agricultural land, and soil and fertilisers from forestry and horticultural land use. Diffuse discharges also includes stormwater from areas that are not reticulated, including from some roads (without drains) and road banks, which

can be a significant source of sediments. All three Kai Iwi Lakes are included in Schedule E of the RWSP, meaning that special rules apply.

2.4.2 Management of the Domain

Land was set aside as a scenic reserve between 1928 to 1968, initially under the *Reserves and Domains Act* 1953 (KDC 2002). The present day Taharoa Domain is 538 Ha of Crown owned land set aside as a 'recreation reserve' under the provisions of the *Reserves Act 1977*. Kaipara District Council has been delegated management under the Reserves Act (KDC 2002).

The Reserves Act defines the purpose of a recreation reserve as "*providing areas for the recreation and supporting activities and the physical welfare and enjoyment of the public, and for the protection of the natural environment and beauty of the countryside, with emphasis on the retention of open spaces, indoor and outdoor recreational activities including recreational tracks in the countryside*" (KDC 2002). The Reserves Act also provides for the survival of all indigenous species of flora and fauna, both rare and commonplace in their communities and habitats, as far as possible (KDC 2002).

The Kaipara District Council adopted the Taharoa Domain Reserve Management Plan (DJ Scott Associates 2002 and KDC 2002) in January 2002 (Taharoa Domain Governance Committee 2003). Under the plan the Taharoa Domain Governance Committee was established to manage the Domain. The governance is an equal partnership between KDC and tangata whenua, with two members from KDC and two nominated representatives from Treaty of Watangi claimants (WAI 38). "*Under its Terms of Reference the Governance Committee has fairly wide, but not unusual powers and responsibilities to manage the Domain*" (Taharoa Domain Governance Committee 2003, p. 2).

The main vision for the Taharoa Domain, as set out in the Taharoa Domain Reserve Management Plan, is to "*to protect and sustain the Kai Iwi Lakes (Taharoa Domain) as taonga of the Kaipara District for the benefit of all people*" (DJ Scott Associates 2002).There are five aims in the Plan:

1. *Partnership: To establish an equal organisational partnership between tangata whenua and Council to govern the Domain*
2. *Cultural: To recognise the relationships of people, their history, culture and traditions when managing the use, development and protection of the natural and physical resources of the Domain and surrounding areas*
3. *Environment and sustainability: To protect and enhance the natural environment of the Domain for the benefit of all people*
4. *Social and recreational: To enable a diverse range of sustainable recreational activities*
5. *Economic development: To promote and manage the Domain as an essential part of the economic development strategy of the District* (DJ Scott Associates 2002).

Key sections from the Plan that are relevant to this report are included in Appendix 3.

The Taharoa Domain Governance Committee meets regularly and considerable work has been done over the last 10 years to manage the Domain, including for example, the

development of a Business Plan (Taharoa Domain Governance Committee 2003), forest harvesting, archaeological surveys (Talyor and Stutton 2010), native plant restoration (Mitchell Partnerships 2003 in Taylor and Sutton 2010, Fox 2010), pest/weed control (Fox 2010, NRC 2012) and upgrades or camping facilities (Taharoa Domain Governance Committee 2012).

2.4.3 Iwi environmental management

Te Iwi O Te Roroa and Te Kuihi are tangata whenua for the Kai Iwi Lakes as recognised by the Waitangi Tribunal in the Te Roroa report on the Wai 38 Claim (KDC 2002).

Te Roroa ratified their environmental plan in 2009 (Te Roroa Manawhenua Trust 2009 unpublished). The plan identifies issues, policies and methods for management of resources important Te Roroa, such as waahi tapu sites and cultural landscapes, water, land and biodiversity. Te Roroa identifies water as a sacred resource and a taonga to be given the highest level of protection. One objective for example, under section 8: water is the development and implementation of water quality standards relevant to Te Roroa.

Under the Treaty of Watangi (Wai 38) claim, the Waitangi Tribunal have recommended that the Taharoa Native Reserve of 250 acres, comprising Lake Kai Iwi and surrounding land (including a pa site and urupu) be returned to tangata whenua.

3 Water quality, water quantity and ecosystem health

The excellent quality of the water and ecosystems and many of the unique features of the Lakes has led to them being well studied over the last 50 years, with routine data being collected in the last 10 years. This data shows that while the quality of the lakes is high there are some deteriorating trends being detected. However, one of the information gaps for the lakes is accurate and recent hydrological (water quantity) data.

3.1 Current monitoring of the Lakes

Northland Regional Council currently undertakes a range of monitoring in the Kai Iwi Lakes, including:

- **Lake Water Quality Monitoring Network** (LWQMN) established in 2005. 28 lakes throughout Northland are monitored four times a year for a range of parameters including total and dissolved nutrients, chlorophyll α, suspended solids, water clarity, pH, temperature and dissolved oxygen. This monitoring includes one location at the deepest point in each lake. Each lake is sampled at the surface and bottom and temperature/dissolved oxygen profiles are done. There was also reasonably regular monitoring of the Kai Iwi lakes prior to the Network being established. Annual reports are available here:

  http://www.nrc.govt.nz/Resource-Library-Summary/Environmental-Monitoring/State-of-the-Environment-Monitoring/

- **Lake Ecological Condition** (LakeSPI) monitoring, started in 2004/05, is now carried out on 85 lakes throughout Northland, on a rotational basis, including all the lakes in the LWQMN. Annual reports are available here:

  http://www.nrc.govt.nz/lakedata

- **Weed surveillance** began in 2007/08 and is carried out annually on 11 lakes in the LWQMN. This includes all three Kai Iwi Lakes. Annual reports are available here:

  http://www.nrc.govt.nz/lakedata

- **Recreational Water Quality Programme** (2002/03 - present). The programme is coordinated by Northland Regional Council in partnership with Northland Health Board and the region's three district councils. The aim of the programme is to provide information on bacterial levels at popular freshwater and coastal swimming sites in Northland to allow the public to make an informed decision about where to swim. Currently one location on Taharoa is monitored as part of this programme. Monitoring reports and more information can be found at:

  http://www.nrc.govt.nz/Resource-Library-Summary/Research-and-reports/Recreational-swimming-programme/

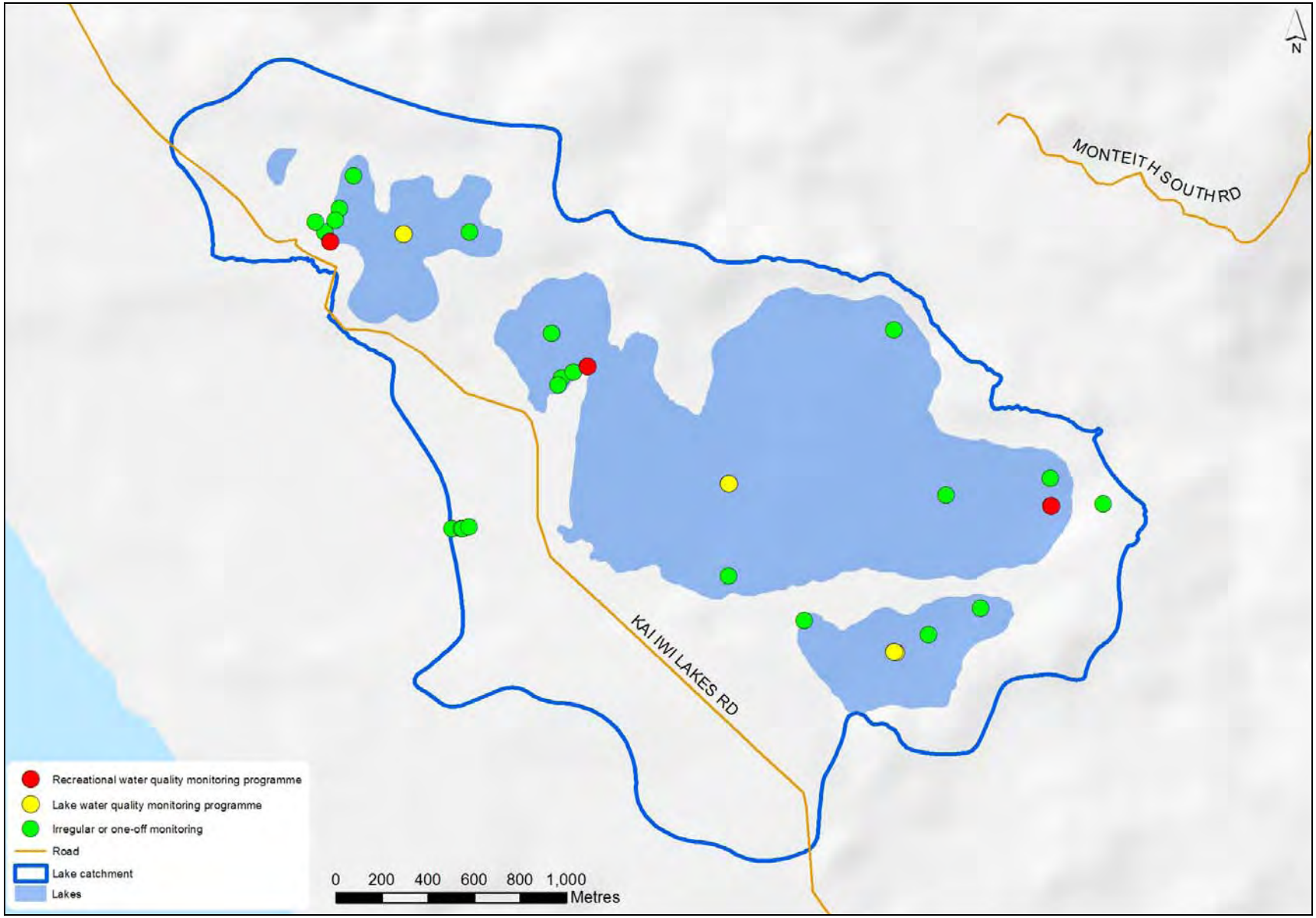
  http://www.nrc.govt.nz/Living-in-Northland/At-the-beach/Swimming-water-quality/

- **Hydrological monitoring.** Water levels are manually measured monthly for Lakes Taharoa and Waikare. Records began in 1970 and 1987 respectively but there are some large gaps in the record and stage shifts during this period. There is no recent and long term rainfall record in the vicinity of the Lakes.

As well as specific monitoring programmes some ad hoc monitoring as also been carried out to check compliance with resource consent conditions and to investigate environmental incidents. There have also been a large number of one-off studies undertaken over the last 50 years, the majority of which are referenced in this report.

Together, the information is central to assessing the state of the lakes. The data obtained through these programmes and consent monitoring has been used to provide an overview of water quality and ecosystem health in the Lakes. Figure 4 below shows the sites currently monitored in the three lakes.

Figure 4 Monitoring sites in the Kai Iwi Lakes



3.2 Water quality and the lake ecosystem

The ecological health, or integrity, of the Lakes' ecosystems are related to a number of environmental factors including, but not limited to, the availability of suitable habitat types (e.g. diverse range of emergent and submerged indigenous plants), lack of invasive exotic species, disturbance and high water quality. It is important to note that the relationship between ecosystem health and environmental factors is often very complex and unpredictable.

In the Lakes the water quality parameters of concern in terms of ecological health are, in no particular order, temperature and dissolved oxygen, clarity, nutrients, suspended solids and chlorophyll a levels. Faecal pathogens are not known to affect aquatic ecosystems. The state of water quality from a human health perspective is discussed in section 3.3 below.

Nitrogen and phosphorus are the two main nutrients required by algae, plants, and animals for metabolism and growth. Nitrogen and phosphorus naturally occur in water as a result of natural processes such as the erosion of soil, atmospheric deposition, and the breakdown of organic matter. Nitrogen is highly soluble and can leach through soil, whereas phosphorus usually enters water in direct discharges or associated with sediment. While they are necessary for life, high levels of nitrogen and phosphorus can cause excessive growth rates of aquatic algae and plants, such as invasive aquatic plants or toxic blue-green algal blooms. The current water chemistry of the Kai Iwi Lakes is thought to be unique. The water quality may assist in limiting the growth of invasive weeds that are introduced.

The Trophic Level Index (TLI) can be used to determine the state of lakes (Burns et al. 2000). The TLI is calculated using four key variables: chlorophyll *α* (an indicator of algal biomass), water clarity, total nitrogen (TN) and total phosphorus (TP) (Table 5). Together, these provide an indication of a lake's overall health. The overall score is categorised into seven trophic states indicating progressively more nutrient enrichment, more algal productivity and reduced water clarity. The states of most relevance to the Kai Iwi Lakes are:

- Microtrophic lakes, which are very clean
- Oligotrophic lakes, which have low levels of nutrients and algae.
- Mesotrophic lakes, which have moderate levels of nutrients and algae.
- Eutrophic lakes, which are green and murky, with higher amounts of nutrients and algae.

Table 5 Trophic states relevant to the Kai Iwi lakes and the water quality ranges that define each trophic level (Burns et al. 2000).

Lake state	Trophic level	Chlorophyll α (mg/m^3)	Clarity (m)	TP (mg/m^3)	TN (mg/m^3)
Microtrophic	1.0 - 2.0	0.33 - 0.82	25 - 15	1.8 – 4.1	34 - 73
Oligotrophic	2.0 - 3.0	0.82 - 2.0	15 - 7.0	4.1 – 9.0	73 - 157
Mesotrophic	3.0 - 4.0	2.0 - 5.0	7.0 - 2.8	9.0 - 20	157 - 337
Eutrophic	4.0 - 5.0	5.0 - 12	2.8 - 1.1	20 - 43	337 - 725

3.2.1 Lake Kai Iwi

Lake Kai Iwi usually stratifies annually in spring and/or summer with moderate to severe de-oxygenation of the bottom water and the thermocline forming at between 9 to 13 metres depth. A visual scan of the data found two occasions where elevated ammoniacal nitrogen and dissolved inorganic nitrogen levels in the hypolimnion coincided with low oxygen levels.

Kai Iwi, with a median TLI score of 2.99 for five years data from 2005 to 2011, has an oligotrophic status (Table 6), which means that nutrient and chlorophyll a levels are reasonably low and water clarity is reasonably good. Historical data suggests that water quality is unlikely to have changed much over the last 25 years with the lake remaining oligotrophic (Wells et al. 1988, Kokich 1991, Livingston et al. 1986, DHS undated). However, more recent data suggests that the Lake may be moving towards a mesotrophic status, with a TLI score of 3.17 for the 2010/11 year (NRC 2013).

Table 6: Median, minimum and maximum results for 2005/06 to 2010/11 for the surface of Lake Kai Iwi (NRC 2013)

Parameter	Median	Minimum	Max
Temperature (°C)	17.75	12.5	25
Dissolved Oxygen (% sat)	96.8	68.3	105
Chlorophyll a (mg/l)	1.5	0.44	3.7
Water Clarity (m)	8.2	4.5	10.85
Total Nitrogen (mg/m^3)	311	158	425
Total Phosphorus (mg/m^3)	6	3	74
Ammoniacal Nitrogen (mg/m^3)	2	0.5	33
Nitrate Nitrogen (mg/m^3)	0.5	0.5	37
Dissolved Reactive Phosphorus (mg/m^3)	0.5	0.5	65
Total Suspended Solids (g/m^3)	0.9	0.25	2.3
Conductivity (ms/m)	20.25	17.6	30.4
pH	7.05	6.4	7.9
Trophic Level Index	2.99	2.50	3.71

Trend analysis indicates water quality has declined in Lake Kai Iwi between 2002 and 2011 (NRC 2013). A significant deteriorating trend was detected in water clarity with it decreasing at a rate of 14 cm/year (Table 7). This could be related to the deteriorating trend detected for algal biomass, with chlorophyll α increasing at a rate of 0.09 mg/m^3 per year. A deteriorating trend was also found for total nitrogen with it increasing at 5.8 mg/m^3 per year. These deteriorating trends in three of the four variables used to calculate TLI, have resulted in a deteriorating trend in TLI overall. TLI is increasing at a rate of 0.03 per year.

Table 7: Trends for the Kai Iwi Lakes based on surface samples from 2002 to 2011 (NRC 2013), showing rate of change and in parentheses' the p-value. Results in bold are statistically significant (ie, p-value less than 0.05). BD = Below detection limit.

	Kai Iwi	Taharoa	Waikare
Temperature (10^{-3} °C/yr)	-10 (0.88)	210 (0.11)	30 (0.63)
Dissolved reactive phosphorus	BD	BD	BD
Dissolved Oxygen (10^{-3} % sat/yr)	1080 (0.14)	2120 (0.21)	1590 (0.35)
Conductivity (10^{-3} (ms/m)/yr)	-150 (0.23)	-110 (0.69)	-140 (0.46)
Chlorophyll a (10^{-3} (mg/m^3)/yr)	90 (0.027)	70 (0.005)	-130 (0.084)
pH (10^{-3} /yr)	-10 (0.40)	-20 (0.90)	0 (0.86)
Water clarity (10^{-3} m/yr)	-140 (0.049)	-10 (0.87)	60 (0.50)
Ammoniacal Nitrogen (10^{-3} (g/m^3)/yr)	-0.1 (0.87)	0.2 (0.59)	0 (0.81)
Total Nitrogen (10^{-3} (g/m^3)/yr)	5.8 (0.016)	-2.6 (0.072)	-2.4 (0.51)
Total Phosphorus (10^{-3} (g/m^3)/yr)	0.1 (0.93)	-0.2 (0.73)	-0.2 (0.83)
Total Suspended Solids (10^{-3} (g/m^3)/yr)	17 (0.51)	-27 (0.32)	-75 (0.21)
Trophic Level Index (10^{-3} unit/yr)	30 (0.019)	-10 (0.58)	-30 (0.13)

Good water clarity is important for light availability for submerged aquatic plant growth. Clear water is also important for feeding by fish and invertebrates. Water clarity is influenced by suspended solids and algal biomass. The decreasing trend for clarity is most likely as a result of an increase in algal biomass but is also influenced by suspended solid levels (Figure 5). However, it is important to note that suspended solids include both organic matter, such as decaying plant material and algae, and suspended sediment (inorganic material). In Lake Kai Iwi, organic material (eg, algae) is the dominant component of the suspended solids. The consistently low suspended solid results suggest that it is unlikely that recent harvesting in the catchment has led to an increase in suspended sediment in Lake Kai Iwi.

The reasons for an increasing trend in chlorophyll α are unclear but is likely to be related to the increasing trend in total nitrogen (Figure 6). The source of this nitrogen is unknown but possible sources include surface run-off and groundwater inputs from pastoral farming and/or is being fixed from the atmosphere by plants on the lake edge (see section 4.1). Northland Regional Council are currently scoping a project to investigate the extent of groundwater inputs into Lake Kai Iwi (Golder Associates 2012). Caution does need to be taken when interpreting the trend in chorophyll α as there was a change in sampling method in 2005.

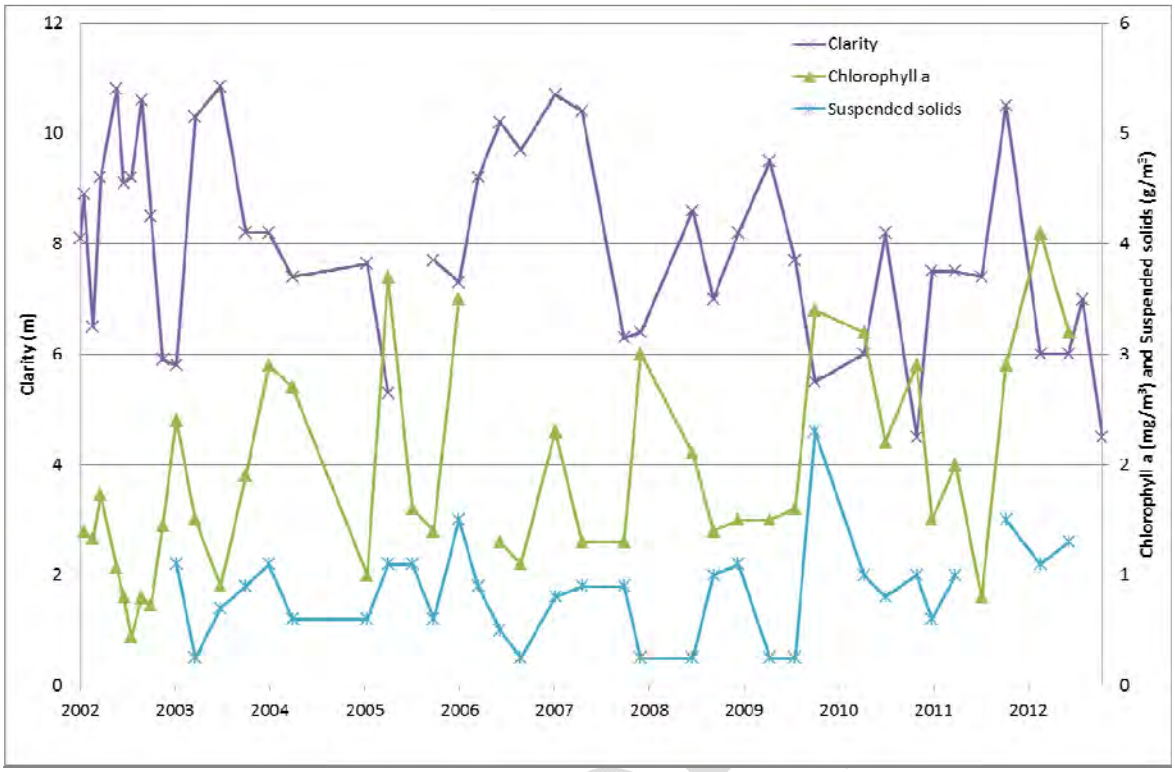


Figure 5 Clarity (m), chlorophyll α (mg/m^3) and suspended solids (g/m^3) in Lake Kai Iwi at the surface from February 2002 to December 2012

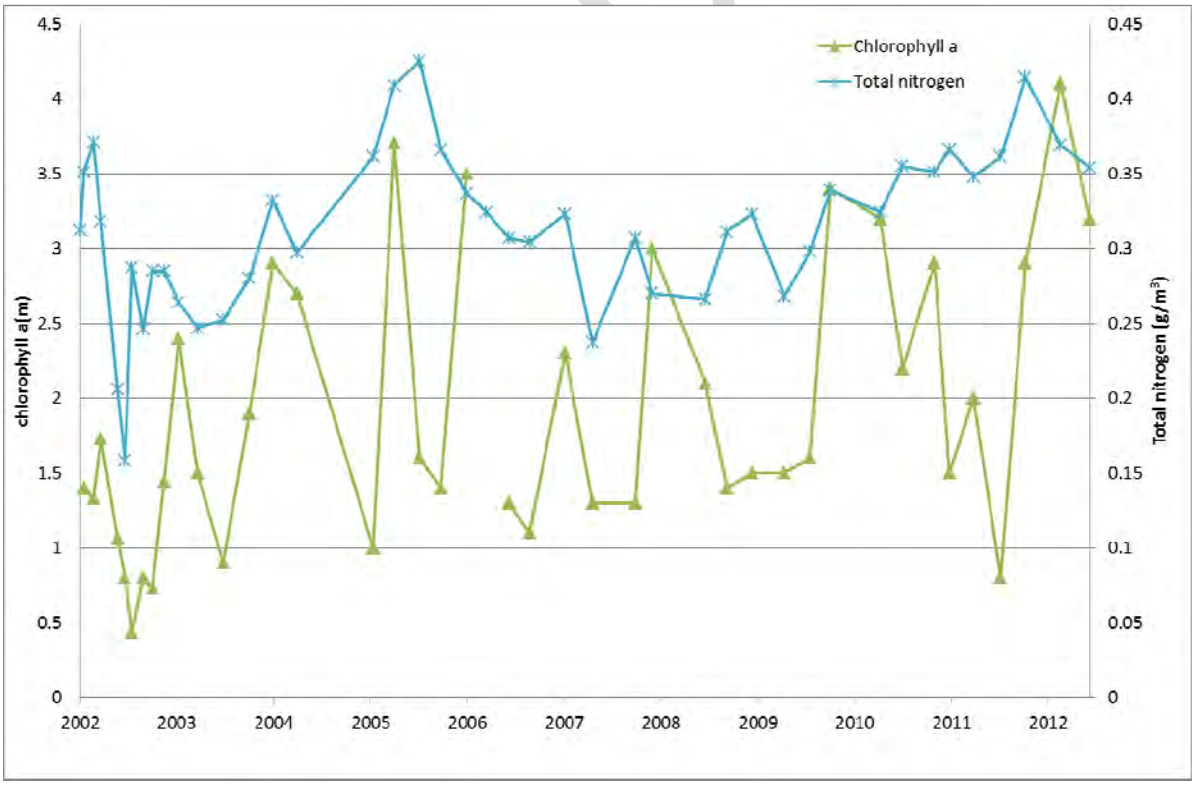


Figure 6 Chlorophyll α (mg/m^3) and total nitrogen (mg/m^3) in Lake Kai Iwi at the surface from February 2002 to July 2012

3.2.2 Lake Taharoa

Lake Taharoa often stratifies annually in summer with mainly moderate de-oxygenation of bottom water and a thermocline forming at between 23 and 34 metres depth. A visual scan of the data found two occasions where elevated ammoniacal nitrogen levels in the hypolimnion coincided with low oxygen levels. This is consistent with the findings of monitoring from 1992 to 1996 (Burns and Rutherford 1998).

The median TLI score for 2005/06 to 2010/11 of 2.21 indicates an oligotrophic status for Lake Taharoa (Table 8). Historical data suggests that water quality is unlikely to have changed much over the last 25 years with the lake remaining oligotrophic (Cassie and Freeman 1980, Kokich 1991, Livingston et al. 1986, Burns and Rutherford 1998, DHS undated).

Table 8: Median, minimum and maximum results for 2005/06 to 2010/11 for the surface of Lake Taharoa (NRC 2013)

Parameter	Median	Minimum	Max
Temperature (°C)	17.85	12.7	24.2
Dissolved Oxygen (% sat)	100.2	7.7	115.4
Chlorophyll a (mg/l)	0.75	0.3	2.8
Water Clarity (m)	10.3	6.5	13
Total Nitrogen (mg/m³)	141	102	257
Total Phosphorus (mg/m³)	2	0.5	50
Ammoniacal Nitrogen (mg/m³)	1	0.5	32
Nitrate Nitrogen (mg/m³)	0.5	0.5	9
Dissolved Reactive Phosphorus (mg/m³)	0.5	0.5	16
Total Suspended Solids (g/m³)	0.55	0.25	2.1
Conductivity (ms/m)	19.5	17.6	49
pH	6.46	5.8	6.8
Trophic Level Index	2.21	1.71	3.18

Trend analysis indicates that water quality in Lake Taharoa has remained relatively stable between 2002 and 2011 (NRC 2013). Only one significant trend was found (Table 7); an increasing trend in chlorophyll α (algal biomass) at a rate of 0.07 mg/m³ per year. This is seen as a deterioration in water quality but no other results suggest deterioration. As for Lake Kai Iwi the reason for this increase is unknown. Recent information on algal community assemblages would be useful as they can be an early indicator of changes in lake status.

3.2.3 Lake Waikare

The lake stratifies annually over spring and summer with moderate to severe deoxygenation of bottom water and thermocline at between 12 and 25 metres depth. Of the three lakes Waikare stratifies for the longest period each year, with it remaining stratified into autumn in some years. A visual scan of the data found nine occasions where elevated nutrient levels in the hypolimnion coincided with low oxygen levels, with ammoniacal nitrogen being particularly high but also dissolved inorganic nitrogen.

The median TLI score for 2005/06 to 2010/11 of 2.74 indicates an oligotrophic status for Lake Waikare (Table 9). Historical data suggests that water quality is unlikely to have changed much over the last 25 years with the lake remaining oligotrophic (Cassie and Freeman 1980, Kokich 1991, Livingston et al. 1986, Burns and Rutherford 1998, DHS undated).

Table 9: Median, minimum and maximum results for 2005/06 to 2010/11 for the surface of Lake Waikare (NRC 2013)

Parameter	Median	Minimum	Max
Temperature (°C)	17.8	12.6	24.7
Dissolved Oxygen (% sat)	96.95	82.8	109.8
Chlorophyll a (mg/l)	1.6	0.5	8.3
Water Clarity (m)	9.1	3.55	12.4
Total Nitrogen (mg/m^3)	203.5	105	570
Total Phosphorus (mg/m^3)	4.5	2	83
Ammoniacal Nitrogen (mg/m^3)	2	0.5	21
Nitrate Nitrogen (mg/m^3)	0.5	0.5	8
Dissolved Reactive Phosphorus (mg/m^3)	0.5	0.5	67
Total Suspended Solids (g/m^3)	0.7	0.25	4
Conductivity (ms/m)	18.4	17	38
pH	7.095	6	7.7
Trophic Level Index	2.74	1.51	4.11

Trend analysis indicates that water quality in Lake Waikare is reasonably stable as no significant trends were recorded (Table 7).

3.3 Water quality and human health

Faecal pathogens (sickness-causing organisms) could enter the Kai Iwi Lakes in leakage from wastewater infrastructure for the camping grounds and Ski Club, from wildlife, such as waterfowl, possums or pigs, and/or in run-off from pastoral farm land.

These organisms can pose risks to human health when water is used for contact recreation, such as swimming, waka ama and waterskiing. In these activities there is a reasonable risk that water will be swallowed or inhaled, or come in to contact with ears, nasal passages, mucous membranes, or cuts in skin, allowing pathogens to enter the body (MfE 2003).

Health effects are generally minor and short-lived. However, there is the potential for more serious diseases, such as hepatitis A, giardiasis, cryptosporidiosis, campylobacteriosis, and salmonella (MfE 2003).

It is difficult to measure the level of faecal pathogens in water. Instead, like other agencies, Northland Regional Council measures the levels of indicator micro-organisms in accordance with the national microbiological water quality guidelines published by the Ministry for the Environment and the Ministry of Health (2003).

The Recreational Guidelines use bacteriological indicators associated with the gut of warm-blooded animals to assess the risk of faecal contamination and therefore the potential presence of harmful pathogens. Compliance with the guidelines should ensure that people using water for contact recreation are not exposed to significant health risks. The bacteriological indicator used for freshwater is *Escherichia coli (E. coli).*

The Recreational Guidelines work with a defined 'tolerable risk' rather than no risk at all. For most healthy people coming into contact with water within the guideline value will pose a minimal level of health risk. However, the same water may still pose a greater health risk to high-risk user groups such as the very young, the elderly, and those with impaired immune systems (MfE 2003). Health risks associated with levels of bacteriological indicators are discussed in further detail in the following sections.

In addition, while it is correct to infer that water exceeding the guideline values pose an unacceptable health risk, the converse is not necessarily true. This is because wastewater effluent may be treated to a level where the indicator bacteria concentrations are very low, but pathogens such as viruses and protozoa may still be present at substantial concentrations.

3.3.1 Contact recreation

For contact recreation (eg, swimming, water skiing) the Recreational Guidelines are summarised in Table 10 below. They are based on keeping sickness risks associated with recreational water use to less than 2 percent (i.e. ≤19 people in 1,000).

When levels of *E. coli* are within the surveillance (green) category, the risk of sickness from swimming is acceptable, ie, sickness risks are below 19 per 1,000 swimming events (MfE 2003). If levels fall into the alert category, there is an increased risk of illness from swimming, but still within an acceptable range. However, if levels enter the action category (>550 *E. coli* per 100 mL) then the water poses an unacceptable health risk from swimming.

At this point, if the high levels persist, warning signs are erected and the community informed that it is “unsafe” to swim at this location.

Table 20 Surveillance, alert, and action levels for freshwater

Status	*E. coli* per 100mL	Management action
Surveillance (Green)	<260	Routine monitoring (i.e. weekly)
Alert (Amber)	260-550	Increased monitoring (i.e. daily), investigation of source and risk assessment
Action (Red)	>550	Closure, public warnings, increased monitoring (i.e. daily) and investigation of source

Northland Regional Council currently monitors *E. coli* levels by the pump house in Lake Taharoa over the summer period (December - March) as part of the Recreational Swimming Water Quality Monitoring Programme. This programme follows the methodology set out in the Recreational Guidelines, and sampling is usually weekly. They have also sampled previously at Promenade Point and in Lake Waikare for the 2003/04 summer.

The results for the all available routine data are shown in Table 11 below. Please note that the percentage of samples within the guideline value are indicative of the percentage of the summer season when sites are suitable for swimming. They do not represent the actual time the sites were in compliance with the guideline value. Numbers in red show counts that exceed “safe” for contact recreation levels.

Table 11 Recreational water quality compliance for *E. coli* levels at three sites in the Kai Iwi Lakes

Site name (number)	Summers sampled	Number of samples	Range	Median	% of samples within the guideline (<550 E. coli/100ml)
Taharoa at pump shed (105434)	Dec 00 - Nov 12	110	1 - 770	<10	99
Taharoa at Promenade Point (100452)	Dec 99 - Mar 07	74	1 – 359	<10	100
Waikare at entrance corner (104682)	Nov 03 - Feb 04	7	<10 – 10	<10	100

The results show that water quality at these sites is always suitable for swimming. The only exceedance of the guideline was at the pump shed site in January 2002. Therefore it is not surprising that the ‘Suitability For Recreation Grade’ for both Lake Taharoa sites is ‘very good’ (NRC 2011, NRC 2008a). There is insufficient data to calculate a grade for Lake Waikare. As the majority of results are consistently low there does not appear to be any changes in microbiological levels over time. However, this is only based on summer sampling and this may not be the case if there was data from the wetter winter months.

Various locations on all three lakes were sampled for *E. coli* on 22 occasions in total, mostly dating from 2003-04. All 22 results were 10 *E. coli*/100mL or less. There is very little microbiological data for Lake Kai Iwi.

3.4 Water quantity

As discussed previously, the Lakes have relatively small surface catchments and only small inflows, with rain onto the Lakes' surface being the main source of water. Some studies have shown that all three lakes are likely to have significant groundwater inflows and outflows. There is some monthly lake level data but no recent rainfall data for the Lakes. Due to signs of deterioration in Lake Kai Iwi, NRC has initiated work to investigate groundwater influences for Lake Kai Iwi.

While there have been routine monthly lake level measurements for Lakes Taharoa and Waikare since 1970 and 1987 respectively, there is no datum available for this data, several gaps in the record and possible shifts in the stage datum (definitely for Lake Waikare) (Figures 7 and 8). However, the data is still useful. Water levels in both lakes are seasonal, peaking at similar times. Annual fluctuations are about 50 cm, generally peaking in October/November and being lowest in April/May (Golder Associates 2012). There is no data for Lake Kai Iwi. Accurate and routine (more frequent than monthly if possible) lake level data is needed for all three Lakes, which could be obtained using data loggers.

There is no recent climatic data for Kai Iwi Lakes and rainfall estimates have been made based on data from nearby stations. As rain is reasonably variable in a short distance across Northland, at least daily rainfall data at the Lakes is needed to gain a better understanding of the hydrology of the Lakes.

There is only one bore within 4 km of the Lakes and this was identified by Golder Associates (2012) as irrelevant to the Kai Iwi Lake groundwater investigation. Golder Associates (2012) have come up with a conceptual model for Lake's groundwater system. They describe Lake Kai Iwi as a 'groundwater window' rather than a significant groundwater seepage or discharge zone in their model, however, they also say that there is a chance the Lake is perched above the groundwater table. The predict that there may be significant seepage between Lakes Taharaoa and Kai Iwi, the majority of groundwater inflow into Kai Iwi is likely to be from the west, with possible minor seepage from the East and the main outflow is likely to be to the south east. They identify several information gaps: groundwater levels around the Lake, seepage rates between Kai iwi and Taharoa, nutrient levels in the groundwater and potential nutrient sources. Monitoring recommendations to clarify and validate the conceptual model are provided (Golder Associates 2012).

Also as mentioned previously there would be significant value in validating the surface catchment boundary, possibly with ground surveying. In conjunction with this water flow and water quality monitoring of any streams and drains flowing into the lakes to calculate accurate water balances for the lakes but also to determine nutrient and sediment loads is recommended.

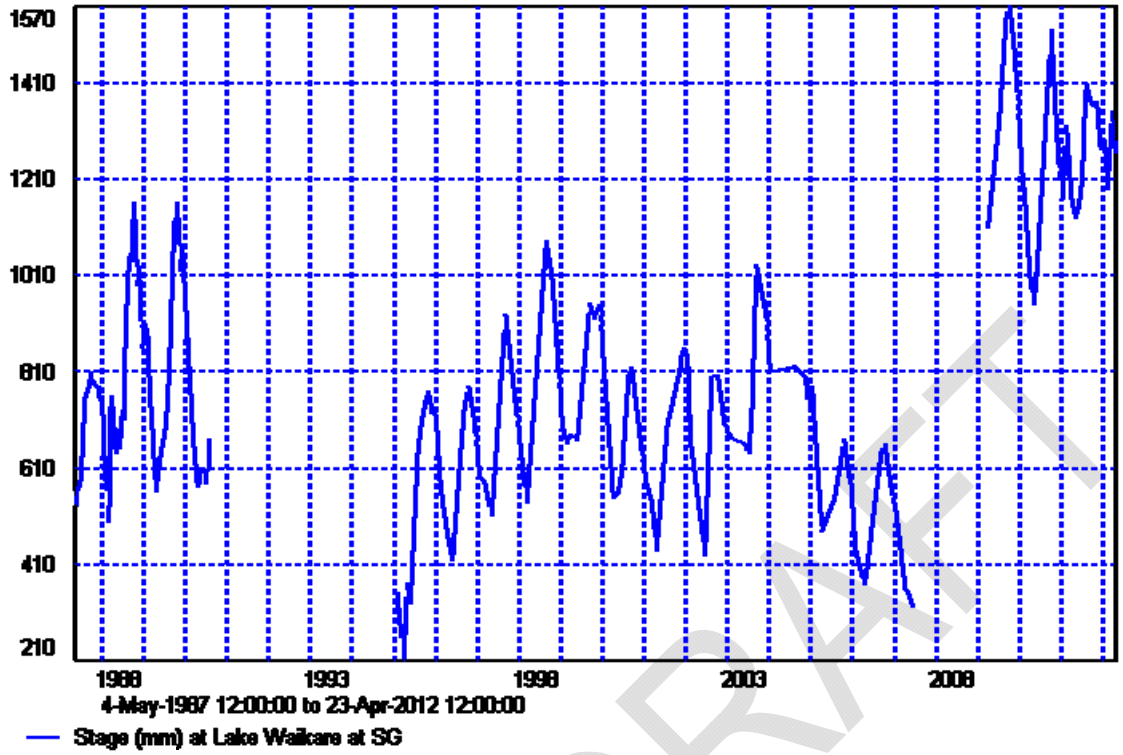


Figure 7 Lake level (mm) for Lake Waikare from May 1987 to April 2012. Note there is a datum shift in 2009.

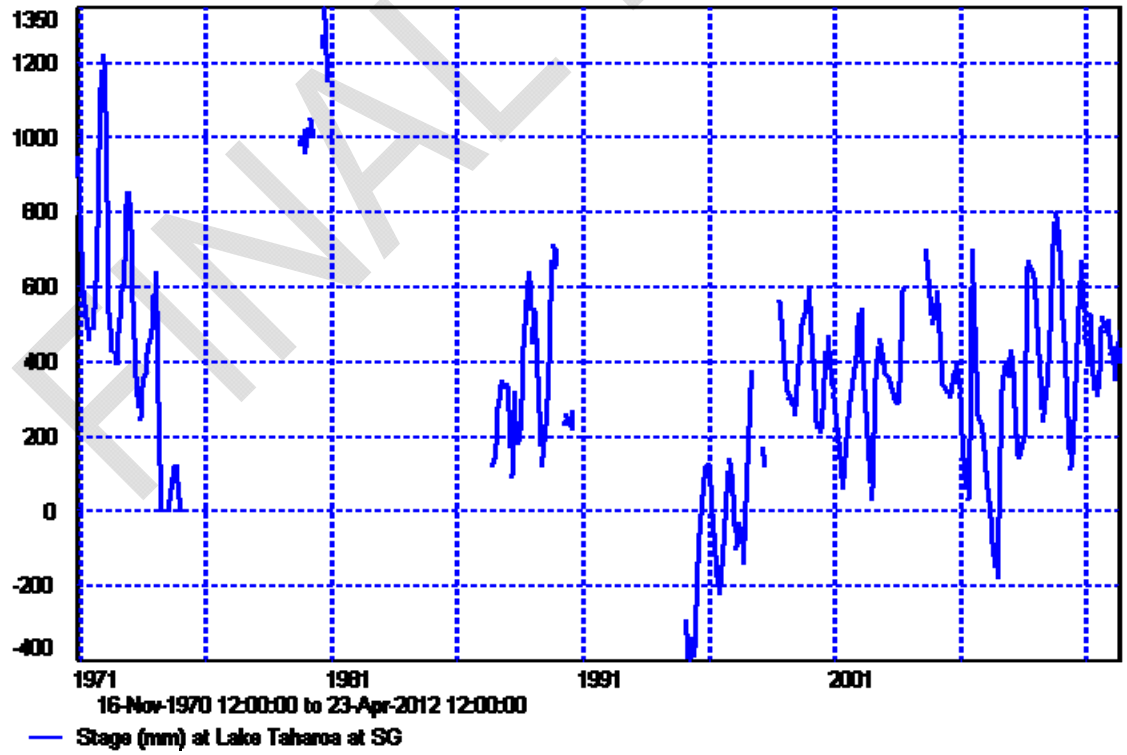


Figure 8 Lake level (mm) for Lake Taharoa from November 1970 to April 2012.

3.5 Summary and considerations

Monitoring data shows that all three lakes have excellent water quality to support the high ecological values of the lakes. The lakes are classified as oligotrophic with low nutrient levels, low algal biomass and good to excellent water clarity. While the lakes have good to excellent dissolved oxygen levels the majority of the time, all three lakes do stratify in most years, with de-oxygenation of the hypolimnion being moderate to severe and elevated nutrient levels detected on some occasions, especially for Lake Waikare.

The lakes have remained oligotrophic for at least the last 25 years. However, recent data shows that water quality, nitrogen, clarity and algal biomass in particular, in Lake Kai Iwi has deteriorated over the last 10 years, meaning the lake is moving towards a mesotrophic state. A deteriorating trend for algal biomass was also detected for Lake Taharoa for the last 10 years. No significant trends were found for Lake Waikare.

Monitoring data for Lakes Taharoa and Waikare shows that bacterial water quality is consistently excellent providing for the high recreational values of the Lakes. Kai Iwi is also likely to have water quality suitable for contact recreation the majority of the time given the similarities between the lakes, however, caution should be taken with this due to insufficient data.

There is substantial information on the water quality of the lakes both historic and recent and substantial information on the values associated with this high water quality eg ecological, cultural and recreational. There is also reasonable amounts of research that identifies the potential impacts on the lake ecosystems with changes in water quality (see section 4). However, there is a lack of detailed information to determine the hydrology of the lakes and potential sources of contaminants from both surface and groundwater. The importance of this has increased with the recent deteriorating trends detected.

4 Key threats to the Lakes

This section looks at known and likely future pressures on the Kai iwi Lakes and their catchment. The focus is pressures on water quality and the Lakes' ecosystems, however, potential pressures on terrestrial ecosystems are also included because changes in the terrestrial environment can impact on the quality of the Lakes' water and ecosystems.

While lake systems will naturally change over time, humans have accelerated this process by increasing inputs to lakes from surrounding land and introducing invasive pest fish and plants species (Champion and de Winton 2012). The pressures/threats were assessed on 76 Northland lakes by Champion and de Winton (2012). Lakes were assigned an overall score based on:

- Biosecurity threats, including submerged and emergent weeds, pest fish and risk of spread
- Nutrient enrichment, including percentage of catchment in pasture and forestry and current lake nutrient levels

- Water level change.

Based on their overall pressure score lakes were placed into three categories: low, moderate or high. The three Kai Iwi Lakes were all categorised as having 'moderate' pressure/threats on them. This categorisation is based on quantifiable pressures and Champion and de Winton (2012) identify several potential pressures that require more research. The most relevant of these to the Kai Iwi Lakes are:

- *"impact of nitrogen fixing plants (especially legumes such as Sydney golden wattle (Acacia longifolia), tree lupin (Lupinus arboreua)) in the catchment on nitrogen loading to lakes (especially the Kai-Iwi Lakes)*
- *Impact of harvesting pine plantations in the catchment on the release of nutrients through death of mycorrhizae and erosional and Aeolian mobilisation of nutrients to lakes"*
- *"Impact of drought cycles on the mobilisation of nutrients"*
- *"Although catchment size is estimated by FENZ based on a topographical model, catchments within sandy soils may well be much larger due to more extensive occluded aquifers. Quantification of land-use impacts on each lake requires and accurate assessment of catchment extent."* (Champion and de Winton 2012, p. 28)

4.1 Land use and land cover

As the lakes are basically closed systems (ie, have no significant inflows or outflows) they are extremely sensitive to inputs from surrounding land use. An increase in nutrient levels in the lake would increase the risk of invasive aquatic weeds, such as oxygen weed, becoming established if introduced.

4.1.1 Pastoral farming

While 236 Ha (33%) of the catchment is pasture (LCDB3, Table 2), most of this is a distance from the Lakes. This is predominately used for sheep and beef farming. There are no dairy sheds or dairy farms in the catchment, however, some areas of pasture are used for dairy support (run-off) (D. Wright, pers. comm.). More detailed information on farming practices in the catchment is lacking, such as stock access to streams and wet areas, the use of fertilisers and additional feed and stocking rates.

Run-off from pastoral land can potentially contain nutrients, sediments, faecal pathogens, dissolved organic carbon and also heavy metals. Nitrogen compounds and faecal pathogens can also leach through soil to water bodies, including groundwater. Diffuse sources include, but are not limited to, stream banks and other erosion prone land, stock access to the beds and riparian margins of waterways, general grazing of animals, and fertilisers.

Historically, pasture within the Domain was used for grazing under lease, including about 45 Ha between Lakes Kai iwi and Taharoa and 22 Ha between Lakes Taharoa and Waikare (Dunn 1985). More recently, stock grazing of Domain land adjacent to the lakes has been intermittent for management purposes (KDC 2002). Some areas of Lake Taharoa are still

unfenced with stock access to the lake (Smales et al. 2009). Potential impacts on the lakes from agricultural land uses, include:

- run-off, containing nutrients from fertiliser use and stock effluent, changes in pH and dissolved organic carbon from lime applications, sediment and/or faecal bacteria from stock effluent
- damage to native vegetation, particularly on the lake margins, and archaeological sites from stock trampling (KDC 2002, Taylor and Sutton 2010, Fox 2010).

While overall nutrient levels are low in all three lakes, a significant increasing trend in total nitrogen has been detected for Lake Kai iwi for the last 10 years (see section 3.1.1). As mentioned previously, the source of this nitrogen is unclear. While the surface catchment is dominated by pasture (38%), given the small surface catchment and the distance of this pastoral land use from the lake, suggests that this nitrogen may be coming into the lake through groundwater inputs and/or is being fixed from the atmosphere by plants on the lake edge (see below). Northland Regional Council is currently scoping a project to investigate the extent of groundwater inputs into Lake Kai Iwi (Golder Associates 2012). As mentioned previously, data for contaminant loads in surface inflows is needed to confirm that these are not a significant source of nutrients.

Suspended solid levels in all three lakes are low with no trends over time. Bacterial levels are low in Lake Taharoa and the data (summer months only) suggests that there has been no change over time. There is limited microbiological data for Lakes Kai Iwi and Waikare.

4.1.2 Forestry

About 88 hectares of pines (*Pinus radiata*) were planted in the Domain from 1964 to 1983 and some other trial species, such as Californian redwood and Alaska spruce (KDC 2002). Pines have also invaded many areas of native shrublands. Based on satellite imagery from 2007/08 (LCDB3) the area of the catchment in exotic forest is about 100 Ha (14%), the majority of which is pine forestry. However, the area may be slightly less than this now as some small areas have been replanted in native vegetation following harvesting in 2010, particularly on the edges of Lake Taharoa (Reid 2010, Fox 2010). Taylor and Sutton (2010) found the area below the pa on the South side of Lake Kai Iwi was re-vegetated in native species following a re-vegetation plan (Mitchell Partnerships 2003) after harvesting prior 2010 but the rest of the land was replanted in pines. So while the area in pine forestry is a relatively small area of the catchment, it is all located on the hills that slope into the Lakes.

In general, exotic forestry can have a positive influence on water quality by stabilising land and reducing sediment run-off during forest growth between harvesting periods (approximately every 25-30 years). Possible impacts on the Lakes during this time, include sediment run-off from forestry roads and other areas with little vegetation cover, nutrient inputs from fertiliser usage and declines in lake water level. Wells and Champion (2012) noted lake water level declines in Northland lakes adjacent to pine forestry.

The potential pressures increase during harvesting periods. Sediment can enter water bodies as a consequence of disturbance to land from felling and removing trees and have an impact on aquatic ecosystems. Sediment can continue to enter water following harvesting

until replanting and canopy closure has occurred (up to six years). Another potential impact on lakes from forest harvesting that is currently unknown, is whether nutrients are released into the soil with the death of fungus associated with the pine tree roots.

The majority of the pines were harvested from 2004/05 (Taharoa Domain Governance Committee 2003) to late 2010 (Reid 2010), with the majority of it being replanted into pines. As mentioned, some small areas were replanted in native species. The consistently low suspended solid results for Lake Kai Iwi suggest that recent harvesting in the catchment has not led to an increase in suspended sediment. Based on ecological surveys Wells and Champions (2011, p. 28) comment "*recent removal of pines has not appeared to impact on the lake*".

There is also potential for forestry harvesting activities to impact on terrestrial biodiversity and archaeological sites in the catchment if not carefully managed. Logging carried out on the Southern side of Lake Kai Iwi below the pa site prior to 2010, "*caused no significant disturbance to the slopes below the pa but formed stretches of the horse track were damaged and destroyed by log hauling*" (Taylor and Sutton 2010, p. 3).

There is currently one resource consent to harvest plantation forest around the lakes (CON20041282301). There has been limited monitoring in the last five years, with a few comments that harvesting is not occurring. The comment from the last monitoring of harvesting operations in 2006 was that operations were fully compliant with consent conditions. There was one environmental incident related to harvesting operations in January 2011. Sediment discharged from a harvested area to Lake Taharoa during heavy rain and the impact was noted as minor. Follow up site visits confirmed that sediment and erosion controls had stabilised the site and with vegetation growing quickly there should be no further issues. There was also substantial public criticism of the harvesting in 2010 around the lake margins, especially in the camping grounds (Reid 2010). The tree removal did have a significant visual impact on the lake and is likely to have impacted on recreational use. However, these trees had to be removed due to safety reasons and substantial planting of native species has since been done.

In addition to resource consents, the Regional Water and Soil Plan has a number of controls on harvesting operations including controls on earthworks and the disturbance of riparian margins of streams and rivers, riparian set backs, and discharge rules. In partnership with the RMA Forestry Development Group Northland Regional Council have developed guidelines for plantation forestry (NRC 2012). The intent of the document is to provide the forestry industry (including contractors operating under permitted activity and/or a resource consent) with a document to help with undertaking operations by providing examples of best practice to control and reduce sediment runoff. In addition, Northland Regional Council is working with forestry managers to promote and train forestry operators in the use of the guidelines.

Considerable effort has been made by the Taharoa Domain Governance Committee to minimise and mitigate any impacts of recent forest harvesting, including for example, archaeological surveys (Taylor and Sutton 2010), re-vegetation with native species (Reid 2010, Fox 2010, Taylor and Sutton 2010) and pest/weed control (Fox 2010, NRC 2012).

However, substantial areas have been replanted into pines, which will need careful management in the future.

4.1.3 Other exotic tree species

In addition, to the impacts of pine forestry, there are substantial areas of native shrub that have been invaded by a range of exotic plants (KDC 2002, Fox 2010). Many exotics, planted for ornamental reasons, have since become weeds, especially Hakea and wattle, and pines have invaded many areas of native shrublands (KDC 2002). Sydney Golden wattle (*Acacia longifolia*) is posing a threat to sections of the southern foreshore of Lake Taharoa and parts of the western and southern shores of Lake Kai Iwi. Many of these exotic species are a management problem, they are suppressing native regeneration and some can fix nitrogen, possibly contributing to nutrient levels in the Lakes.

Native lake edge vegetation is important as a buffer strip to protect the Lakes from forestry and pastoral land uses in the catchment. Some areas have good cover and diversity of native vegetation, eg, parts of the north eastern shore of Lake Taharoa, while in other areas exotic species are invading and suppressing native regeneration, especially between Lakes Taharoa and Kai Iwi (KDC 2002, Fox 2010).

Many of the exotic plants found around the lake margins, especially Lake Kai Iwi are able to fix nitrogen from the air, increasing nitrogen levels in the soil over time. This includes Sydney golden wattle, tree lupin, gorse, broom and clover. Some native plants are also capable of fixing nitrogen, such as kowhai, so care should be taken when choosing native species for planting. The potential source of nitrogen loads on the lakes due to nitrogen-fixing plants is currently unclear and further research in this area would be valuable.

Many of these exotic species need removal or control before they spread to other areas and are too difficult to remove (KDC 2002, Fox 2010). Fox (2010) prioritises areas for exotic plant management, details removal/control methods, identifies native species for replanting, including sources, and animal pest control.

4.1.4 Land use change

As discussed above, the current impacts on the Lakes from pastoral and forestry land uses in the catchment are overall reasonably minor, except for a few problem areas identified. However, this could change if there is substantial areas of change in the catchment to more intensive land uses, such as subdivision development and/or intensive pastoral farming, eg dairy farming. While there is unlikely to be much land use change in the catchment, especially given that a large proportion of its falls within the Taharoa Domain, as mentioned above, as closed systems the lakes are extremely sensitive to inputs.

4.2 Recreational use

As discussed previously, visitor numbers to the Kai Iwi Lakes are already high, with peaks in summer. Numbers are likely to increase given the recent promotion of the Lakes (DOC 2012, Taharoa Domain Governance Committee 2012) and as the Domain is continually being improved (KDC 2002, Taharoa Domain Governance Committee 2003). Also visitor

numbers to the Kaipara District and Twin Coast Discovery Highway are predicted to increase if the Waipoua Forest obtains National Park status (DOC 2011).

Boats, boat trailers, fishing and other recreational equipment are all potential vectors for the introduction of invasive flora and fauna, including fish, algae and invertebrates. Given the large amount of recreational use, especially for Lakes Taharoa and Waikare, the risk of exotic plants or animals being introduced is high. The exotic plant *U. gibba* has already been introduced, either through recreational equipment or by water birds, to all three lakes and the extent of it in Kai Iwi has already expanded beyond the emergent plants on the lake margins (Wells and champion 2011). Another example of the ease at which invasive plants can be introduced is the case of a large handful of relatively fresh and viable *Elodea canadensis* (oxygen weed) found on the beach at one launching site on Lake Taharoa in 2006. Further investigation found that it was likely to have come off a boat or trailer that had previously been in Lake Tarawera (Wells et al. 2006).

While the risk of introduction is high for Lakes Taharoa and Waikare, the potential impacts of invasive plants are low due to the conditions not currently being suitable for plant establishment. Wave action on the shallow lake margins prevents plants from establishing and unusual water chemistry (low dissolved carbon levels) is likely to restrict growth of invasive plants, such as oxygen weed (Wells et al. 1998, Wells and Champion 2006). However, changes in water chemistry could make pest plant establishment more likely, highlighting the importance of further research to identify the extent of nutrient loads to the lakes. The risk of pest plant introduction is lower for Lake Kai Iwi, due to motorised boats being prohibited and the lower recreational use, however the conditions in this lake are suitable for pest plants to become established and form large growths (Wells and Champion 2011). So if pest plants, such as oxygen weed, were introduced, there impact on the Lake is likely to be significant.

Annual pest plant surveillance checks have been carried out by NIWA on all three lakes since 2007/08 and are programmed to continue. The Lakes are checked at locations where introductions are most likely. This includes the one access point on Lake Kai Iwi, four locations on Taharoa and two on Waikare (Wells and Champion 2012).

Recreational equipment can also lead to the accidental introduction of pest fish, by eggs or larvae attached to boats, trailers, fishing gear etc. There is also a long history of intentional (illegal) releases of pest fish species into natural water bodies and man-made farm ponds, either to control another species, usually unsuccessfully (eg, mosquito fish) or for fishing (eg, trout, koi carp). Coarse pest fish species, such as perch, tench, koi carp and catfish, can cause catastrophic damage to the ecosystems they are introduced into. Not only would they impact on the ecological and cultural values of the Lakes, they are also likely to impact on water quality and recreational values. These coarse fish have been found to reduce water clarity in other lakes and impact on native fish and trout populations. Koi carp have been observed in farm ponds in the Dargaville area.

The introduction of mosquito fish, rudd and trout to the Kai Iwi Lakes was intentional and these species can also impact on the ecological and cultural values of the lakes. Mosquito fish and trout are both known to impact on the endangered DLG and mosquito fish are thought to be one of the causes for their probable extinction from Lake Kai Iwi (Pingram

2005). While rudd do not yet appear to be having an effect on Lake Kai Iwi, they have been known to reduce native vegetation elsewhere, so remain a threat (Wells and Champion 2011). While rudd have not yet been recorded in Lake Taharoa, they could become established through the channel joining these lakes.

Public education on the risks of spreading pest fish and weeds is important, as it is very difficult to eradicate or manage these pest fish and plants once established in a lake, especially ones with as higher ecological value as the Kai Iwi Lakes. This can include advocacy through media releases, brochures and signage.

Other impacts associated with water activities, include the potential impacts from boat use and disturbance of the lake margins, including erosion and vegetation loss. Disturbance and damage to lake edge vegetation has been reported as a result of informal access to the lake edge by recreational users (KDC 2002). Research by Kingett and Associates looking at impacts of boating on freshwater found little evidence that the Kai iwi Lakes, including water quality and biota, are being affected by existing boating activities, including motor emissions and turbulence (Dunn 1985). However, they concluded that smaller and shallower lakes, such as Kai iwi, are more likely to be effected. Motorised craft are prohibited from using Lake Kai Iwi.

Other recreational uses, such as walking and mountain-biking, are unlikely to impact on the lakes or their catchment, however, tracks need to be developed and maintained to ensure there is no impact on native biodiversity, ecosystems and archaeological sites. Other pressures associated with visitors to the Kai Iwi Lakes and recreational use, are wastewater disposal and demand on water supply (discussed below), rubbish, run-off from paved and unpaved surfaces, including car-parks, roads and walking tracks and environmental incidents. All of these pressures will increase with an increase in visitor numbers.

4.3 Wastewater

There are no reticulated wastewater treatment schemes in the Kai Iwi Lakes catchment. However, there are several septic (onsite) systems (ie, wastewater treatment that is not connected to a reticulated system). Septic systems fit into two main categories: community systems and single premise systems. Examples of community systems include schools, camping grounds and accommodation facilities, recreation facilities and marae.

Failing and poorly performing septic systems, which can lead to untreated wastewater reaching freshwater and coastal environments, have been an ongoing issue in many areas of Northland (NRC 2008b). Untreated wastewater contains high levels of faecal pathogens and nutrients. It also contains a range of other contaminants, such as household chemicals, pharmaceuticals, heavy metals, and particulate matter. It is difficult to know the state of septic systems in the Kai Iwi Lakes' Catchment due to the lack of data but the majority of systems are located well away from the Lakes and their small inflows.

The toilet block at Promenade Point Camping Ground has recently been upgraded (Taharoa Domain Governance Committee 2012). There is limited information on the disposal system for the Waikare Ski Club and whether this currently complies with the RWSP and RMA. An environmental incident was logged in 2003 requiring the Ski club to apply for retrospective resource consent for wastewater discharge. However, there is still no consent for this

discharge. There has also been public concern with camping on the farmland adjacent to Lake Waikare without adequate toilet facilities, with an environmental incident logged in 2003 and 2004. However, monitoring did not show this to be impacting on lake water quality. There is data and information for one system in the catchment, which has a resource consent.

4.3.1 Pine Beach Campground wastewater

This system has a resource consent to discharge up to 37.5 m^3 per day of tertiary treated wastewater from Pine Beach Camping ground to land (CON20080470201). The wastewater is secondary treated via an Advantex recirculation packed bed reactor and tertiary treated using UV sterilisation. Treated effluent is discharged to land outside of the Kai Iwi Lakes catchment via spray irrigation. A review of the wastewater system for consent renewal in 2008 concluded that any adverse effects on the environment will be no more than minor especially as the system had been recently upgraded to include secondary and tertiary treatment, because:

(a) Monitoring undertaken throughout the previous consent period (1998-2008) has not indicated that the current discharge to land is resulting in an adverse effect on the surrounding environment. Furthermore, it is not considered to pose a significant risk to the environment as:

(i) The disposal site is elevated some 30m above the lake on a ridge. The soil is moderately free draining and groundwater is likely to be more than 2.5m below the surface. Given these factors and the level of treatment the wastewater will receive, this discharge wastewater is unlikely to pose a risk to groundwater quality. The volume of wastewater discharged is also likely to be greatest during the summer months when the clearance to the groundwater table will be greater.

(ii) The disposal site is well setback from the stream below (around 160m). Previous monitoring of the disposal system when effluent was only primary treated found minimal surface runoff beyond the spray area. Large volumes of wastewater will be discharged to land for relatively short periods of time. This will allow the soils of the disposal area to recover during the other periods of the year and should prevent overflows occurring due to clogging of the infiltration surface of the disposal system.

(iii) There are no groundwater bores registered with the Regional Council within 200 m of the discharge, and it is considered there are no groundwater users at risk from the wastewater discharge. The disposal field is fenced from public access with appropriate signage, effluent is tertiary treated and in a separate catchment from the lake. Given this it is considered that the disposal area will not pose any more than minor risk to public health.

The site visit in January 2012 shows the discharge was fully compliant with resource consent conditions, with the wastewater treatment system working well at the time of the visit. Monitoring data showed that the allowable volume of discharge was exceeded on 2 days in the 2011/2012 year over Easter 2012. However, given the disposal area is outside the catchment this is unlikely to have impacted on the Lakes.

4.4 Water takes

There is currently very little information on water takes from the Kai Iwi Lake catchments. Under the Regional Water and Soil Plan and the RMA, water can be taken from surface water resources for stock drinking water and domestic purposes provided specific criteria are

met (NRC 2008b) To meet the permitted activity rules the take cannot be from a dune lake listed in Schedule E (this includes the three Kai Iwi Lakes), unless it is an existing take and must be less than 30 m^3/day (June to November) and 10 m^3/day (December to May). Therefore, there is likely to be very few takes from the Lakes and the total volume taken should be reasonably small. There is anecdotal evidence of unconsented takes from both Lakes Waikare and Taharoa to supply neighbouring farms (Kokich 1991) but no information of the volume taken.

There are currently two consented water takes in the Kai Iwi Lakes catchment, both of which are from Lake Taharoa. One is to take up to 45 m^3/day, not exceeding 6,750 m^3/year, for the purpose of water supply for the Pine Beach Camping Ground (CON20080470201). A take rate of 45 m^3/day would lower the lake level by approximately 0.019 mm/day. It is expected that the maximum take rate would occur around the Christmas period and the holiday period of January. Assuming the maximum take rate over a period of two months (60 days) it would lower the lake by 1.14 mm without any rainfall. The volume taken between August 2011 and March 2012 met consent conditions.

The other consent is to take up to 50 m^3/week, not exceeding 765 m^3/year, for the purpose of water supply for the Promenade Point Camping Ground (CON20122977001). If the maximum annual limit of 765 m^3 is taken, the lake level will drop by 0.42 mm over a year. This equates to a daily reduction of lake levels of 1.15 $x10^{-3}$ mm/day, which is approximately 0.03% of the 4 mm natural drop in lake levels as a result of summer evaporation. NRC considers the adverse effect on lake levels as a result of both takes to be no more than minor.

4.5 Summary and considerations

While the quality of the lakes remains high in terms of providing for their cultural, recreational and ecological values, there are signs of deterioration and impacts on the lakes. Deteriorating water quality has been detected in Lake Kai Iwi. Mosquito fish are present in all three lakes and are thought to have led to the extinction of the endangered dune lake galaxid in Lake Kai Iwi and its decline in the other two lakes. The invasive pest plant *U. gibba* is also now in all three lakes, with a substantial increase in its extent in Lake Kai Iwi. There is substantial research for the lakes that identify the potential pressures and what effect these could have.

The main pressures on the lakes are the dominance of pastoral farming and pine forestry in the lake catchments and recreational use. The main potential impacts from pastoral farming are contaminants inputs into the lakes from surface run-off and possibly groundwater inflows, contaminant inputs from stock access to the lakes and small inflows into the lakes and stock damage to lake margin vegetation. The source of nitrogen resulting in an increasing trend in nitrogen in Lake Kai Iwi is unknown but the findings from extensive research elsewhere in New Zealand, suggests that some at least is likely to be from pastoral land use in the surface (and/or groundwater) catchment. Research into contaminants loads, especially nitrogen, catchment hydrology (including surface and groundwater) and farming practices in the catchment is needed. Nitrogen fixing by plants on the lake margins,

especially exotic species, is also another potential source of nitrogen to the lakes that needs investigating.

The main pressures/impacts from forestry include sediment run-off, nutrient inputs from fertiliser use, declines in lake water level, loss of terrestrial biodiversity and damage to archaeological sites in the catchment. These risks are greater during harvesting. The majority of the pines in the catchment have recently been harvested and there does not appear to have been any significant and/or long term adverse effects on the lakes. A potential impact from forest harvesting that needs further research, is whether nutrients are released into the soil with the death of fungus associated with the pine tree roots.

While the lakes are extremely important regionally and nationally in terms of their recreational value, there are many potential impacts associated with this use. The most significant of which is the risk of introducing pest fish and plant species to the lakes. The risk of pest plant introduction is high for Lakes Taharoa and Waikare but the potential impacts are low due to the conditions not currently being suitable for plant establishment. While the risks of pest plant introduction are lower for Lake Kai Iwi, the conditions are suitable for establishment and growth. The risk of pest fish introduction is high for all lakes, either by accidental introduction of fish eggs or larvae on recreational equipment or intentional (illegal) release for fishing purposes. If coarse fish species, such as koi carp, perch, tench and catfish, became established they are likely to have a significant detrimental effect on water quality, the natural lake ecosystems and/or trout fishery. Other potential impacts/pressures related to recreational use are damage to lake margin vegetation, wastewater disposal, water supply, rubbish, run-off from paved and unpaved surfaces and environmental incidents. Visitor numbers to and recreational use of the Kai Iwi Lakes is already high and is expected to increase, with this comes increasing pressure on the lakes.

5 Conclusion

There is substantial information on the water quality of the Lakes both historic and recent and substantial information on the values associated with the high water quality eg ecological, cultural and recreational. Monitoring data shows that all three lakes have excellent water quality to support the high ecological values of the lakes. The lakes are classified as oligotrophic with low nutrient levels, low algal biomass and good to excellent water clarity. While the lakes have good to excellent dissolved oxygen levels the majority of the time, all three lakes do stratify naturally in most years, with de-oxygenation of the bottom waters being moderate to severe and elevated nutrient levels detected occasionally, especially for Lake Waikare. Monitoring data for Lakes Taharoa and Waikare shows that bacterial water quality in summer is consistently excellent providing for the high recreational value of the Lakes.

The lakes have remained oligotrophic for at least the last 25 years. However, recent data shows that water quality in Lake Kai Iwi, particularly nitrogen, clarity and algal biomass, has deteriorated over the last 10 years and is moving towards a mesotrophic state. A deteriorating trend for algal biomass was also detected for Lake Taharoa for the last 10

years. No significant trends were found for Lake Waikare. Bacterial levels have been low in Taharoa for at least the last 12 summers.

The main pressures on the lakes are the dominance of pastoral farming and pine forestry in the Lakes' catchments and recreational use. The main potential impacts from pastoral farming are contaminants inputs into the lakes from surface run-off and possibly groundwater inflows, contaminant inputs from stock access to the lakes and small inflows into the lakes and stock damage to lake margin vegetation. The major potential impacts from forestry include sediment run-off, nutrient inputs from fertiliser use, declines in lake water level, loss of terrestrial biodiversity and damage to archaeological sites in the catchment. These risks are greater during harvesting. The majority of the pines in the catchment have recently been harvested and there does not appear to have been any significant and/or long term adverse effects on the lakes.

There are many potential impacts associated with the high recreational use of the Lakes, the most significant of which is the risk of introducing pest fish and plant species. The risk of pest fish introduction is high for all three lakes. Mosquito fish are already present in all three lakes and are thought to have led to the extinction of the endangered dune lake galaxid in Lake Kai Iwi and its decline in the other two lakes. If coarse fish species, such as koi carp, perch, tench and/or catfish, became established in the Lakes they would have a large detrimental effect on water quality, the natural lake ecosystems and/or trout fishery. Other potential pressures related to recreational use are damage to lake margin vegetation, wastewater disposal, water supply, rubbish, run-off from paved and unpaved surfaces and environmental incidents. Visitor numbers to and recreational use of the Kai Iwi Lakes is already high and is expected to increase, with this comes increasing pressure on the Lakes.

While there have been reasonable amounts of monitoring and research on the Kai Iwi Lakes over the last 25 years there are still some significant knowledge gaps, including:

- The source of nitrogen resulting in an increasing trend in nitrogen in Lake Kai Iwi. Findings from research elsewhere in New Zealand, suggests that some at least is likely to be from pastoral land use in the surface (and/or groundwater) catchment. Research into contaminants loads, especially nitrogen, catchment hydrology (including surface and groundwater) and farming practices in the catchment is needed. Nitrogen fixing by plants on the lake margins, especially exotic species, is also another potential source of nitrogen to the lakes that needs investigating.
- The potential for nutrients to be released into the soil with the death of fungus associated with the pine tree roots that occurs during forest harvesting.
- Bacterial data for Lake Kai Iwi.
- Recent identification of algal community assemblages
- Health of DLG populations and extent and impacts of exotic fish species, especially rudd and mosquito fish
- Detailed analysis of hypolimnion data, which may identify the need for lake-bed sediment sampling or more regular monitoring in spring to autumn for a few years to more accurately determine the extent of de-oxygenation.

- Climatic data, particularly rainfall and hydrological data, including lake level, surface and flows and groundwater inputs

Abbreviations

DLG	Dune lake galaxid
DOC	Department of Conservation
KDC	Kaipara District Council
LakeSPI	Lake Submerged Plant Indicator
LCDB3	Land Cover Database 3
MfE	Ministry for the Environment
NIWA	National Institute of Water and Atmospheric Research
NRC	Northland Regional Council
NZAA	New Zealand Archaeological Association
PNAP	Protected Natural Areas Programme
TLI	Trophic Level Index

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Appendix 1 - Climatic data

Table 12: Climate data, including air temperature, rainfall and evaporation data

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual average	Site (record length)
Average temperature (°C)	19.2	19.8	18.3	16.3	14.0	12.1	11.3	11.8	13.0	14.3	15.8	17.9	15.3	Dargaville (1981-2010)
Max temperature (°C)	24.2	24.8	23.4	21.1	18.6	16.5	15.7	16.0	17.4	18.4	20.2	22.6	19.9	Dargaville (1981-2010)
Average rainfall (mm)	63.7	68.6	102.4	107.2	97	120.6	140.5	109.4	109	81.5	63	73.9	1136.8	Dargaville (1981-2010)
Average rainfall (mm)	80	87	92	103	128	154	151	139	107	96	81	89	1307	Mamaranui (1951-2012)
Average rainfall (mm)	119	99	102	121	163	220	241	180	151	126	112	123	1770	Whatoro (1995-2012)
Average open water evaporation (mm)	131.1	110.4	104.9	72.9	57.9	49.4	48.5	55.0	69.5	92.7	105.4	120.1	1017.8	Dargaville (2004-2012)

Appendix 2 – Data from Northland Fish and Game Council

Table 13: New Zealand Fish and Game Council fishing licenses sold in Northland (Source: R. Hoetjes, Northland Fish and Game Council).

Fishing License type	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012*	Average
Adult Whole Season (FWA)	120	137	182	208	167	156	145	134	129	129	151
Junior Whole Season (FWJ)	19	29	34	27	37	22	23	17	15	11	23
Adult Winter Licence (FWIA)	61	52	56	48	73	51	49	48	44	58	54
Junior Winter Licence (FWIJ)	4	4	7	3	6	5	4	10	4	1	5
Family Licences (FWF)	35	29	34	56	41	61	52	62	48	30	45
Adult 24 Hour (F24A)	114	88	118	123	109	133	127	137	85	97	113
Junior 24 Hour (F24J)	21	7	40	11	21	22	13	15	3	5	16
TOTAL	374	346	471	476	454	450	413	423	328	331	407

* not complete year as data was provided in December

Table 14: Number of contestants in the annual trout fishing contest held at Kai Iwi Lakes

Year	2001	2003	2004	2007	2008	2009	2010	2011	2012	Average
Number of Contestants	73	68	105	80	61	55	59	45	59	67

Table 15: Annual liberations of Rainbow Trout

Year	Kai Iwi	Taharoa	Waikare
1987	1000	4000	
1988	800	4000	200
1989	1000	3500	500
1990	500	2500	300
1991	300	2500	200
1992	300	2000	200
1993	300	3000	200
1994	300	2400	0
1995	300	2400	0
1996	300	2400	0
1997	300	2400	0
1998	300	3000	200
1999	300	2400	200
2000	300	2400	200
2001	200	2000	200
2002	0	2000	200
2003	0	2000	200
2004	0	2000	300
April 2005	0	2000	300
April 2006	0	2000	300
January and May 2007	0	2000	300
May 2008	0	2000	300
May 2009	0	2000	200
May 2010	0	2000	400
May 2011	0	2000	350
May 2012	0	2200	400
Average	250	2427	217

Appendix 3 – Taharoa Domain Reserve Management Plan

Key sections from the Taharoa Domain Reserve Management Plan (DJ Scott Associates 2002) that are relevant to this report are included below.

> *Vision: To protect and sustain the Kai Iwi Lakes (Taharoa Domain) as taonga of the Kaipara District for the benefit of all people.*

There are five aims in the Management Plan, each with key principles, objectives, policies and outcomes. The five aims are:

1. *Partnership: To establish an equal organisational partnership between tangata whenua and Council to govern the Domain*
2. *Cultural: To recognise the relationships of people, their history, culture and traditions when managing the use, development and protection of the natural and physical resources of the Domain and surrounding areas*
3. *Environment and sustainability: To protect and enhance the natural environment of the Domain for the benefit of all people*
4. *Social and recreational: To enable a diverse range of sustainable recreational activities*
5. *Economic development: To promote and manage the Domain as an essential part of the economic development strategy of the District*

While all five aims are important for the management of the Lakes, the third aim (Environment and sustainability) is the one most relevant to this report. Key principles within this aim include:

- *Balance between protection and utilisation*
- *Managing the environmental quality of the catchment and, in particular, water quality*
- *Pine forestry and vegetation management/enhancement*
- *Management of the Domain within the catchment context*
- *Integrated management of habitat and species*
- *Use of monitoring as a key environmental management tool*

The objectives under the Environment and sustainability aim are:

- *To recognise through appropriate land use strategies the sensitivity, natural values and functions of the Domain and the lakes systems in order to ensure the sustainable use of the reserve*
- *To promote and monitor investigations into the ecology, hydrology and wildlife values of the lakes*
- *To integrate the management of the Domain with adjacent land*

The policies under the Environment and sustainability aim are:

- *To establish environment buffers between sensitive areas and those subject to human activity*
- *To establish a long term vegetation management programme*
- *To identify and remedy non-sustainable activities*
- *To implement monitoring programmes*

- *To promote changes to regulatory systems to ensure integrated management of the catchment*
- *To develop infrastructure which is aesthetically pleasing*
- *To restore, over time, the indigenous ecology of lake Kai Iwi*

Finally, the outcomes under the Environment and sustainability aim are:

- *Selective removal of exotic vegetation from identified areas including lakes*
- *Re-vegetation of identified areas with appropriate native species*
- *Removal of stock and feral faunal species from the Domain*
- *Monitoring programmes established*
- *State of the Environment report produced annually*