# Delimitation of Submerged Weed Bed Areas in Lake Horowhenua

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**Prepared for:**


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*Rob Warrington (Lake Horowhenua Trust) retrieves a clump of elodea (Elodea canadensis) from the lake. [Aleki Taumoepeau, NIWA].*

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# Executive summary

Horizons Regional Council commissioned NIWA to undertake a sonar survey of the bed of Lake Horowhenua, to map areas of high weed cover and to estimate required areas for weed harvesting. This report presents calculated areas for dense weed beds, provides maps of their distribution and a brief description of weed bed features.

The sonar survey was undertaken in January 15th to 17th 2014 at a lake height of 1064.8 mm. Recorded sonar signals were processed using an automated GIS processing engine to provide mapped vegetation biovolume, depth and sediment hardness. The main areas of high weed density were delimited and defined as polygons (a closed shape defined by GIS coordinates) using the GIS service, and their surface area calculated.

Three main areas of dense weed (≥65% biovolume) were apparent that occupied at total of 48.86 ha. The largest weed bed (20.31 ha) was in the western sector of the lake.

Weed beds were dominated by the alien weed, *Elodea canadensis (*elodea), with much lower amounts of *Potomogeton crispus* (curled pondweed). This indicates a change in weed dominance has taken place since last available plant survey information in 2000.

Previous considerations for weed harvesting were based on curled pondweed, which is more seasonal than elodea and which has a different reproductive strategy. Earlier assumptions made in harvesting calculations for Lake Horowhenua may now need to be reconsidered. Additional information about temporal changes in standing weed bed biomass (which could be linked to sonar biovolume measures), nutrient content, and growth/recovery rates would enable a harvesting regime to be optimised and avoid risks such as total vegetation collapse.

We recommend a repeat sonar survey for weed bed development in winter and spring, to be accompanied by biomass sampling across a range of corresponding biovolume measures. We also recommend harvesting and recovery potential by weed beds be determined experimentally before large scale harvesting is undertaken.

# 1 Introduction

Lake Horowhenua has experienced boom-bust cycles of nuisance submerged weed growth in the past that have interfered with lake utility and that may have deleterious impacts on lake condition and ecology (Gibbs 2011). To manage this problem, Horizons Regional Council (HRC) has sought a comprehensive weed survey and mapping of Lake Horowhenua in order to investigate requirements for a weed harvester.

HRC commissioned NIWA to undertake a sonar survey of the bed of Lake Horowhenua, focused on mapping the areas of high weed cover, so as to estimate areas for harvesting. This brief report confirms the methodology employed, provides maps of the lake bed distribution of weed beds, a description of weed bed features and calculated areas of dense vegetation.

# 2 Methodology

## Field work

A GIS referenced survey of weed bed presence and development, together with bed bathymetry, was undertaken using sonar (Lowrance™ HDS9 depth sounder/GPS/chart plotter) over 15 to 17$^{th}$ January 2014. Navigation software (HYPACK 2012) generated GIS referenced run lines at appropriate intervals (<50 m) to guide the boat and ensure as full coverage of the waterbody as possible within navigation and weather constraints.

Digital data as position and signal return (vegetation and depth) were simultaneously logged along each run line using a transducer (LSS-2 HD) with a dual frequency of 200 and 455 kHz. Position was logged using the point 1 antenna.

Sonar settings (offset, sensitivity and greyline) were calibrated to optimise bed and vegetation detection. A ground truth of water depth was undertaken at five sites by plumbing with a weighted disc on a measuring line, and sonar outputs were also checked against plant cover at 12 sites with contrasting plant presence via rake samples. Stage height at the water level gauge was requested to provide a height datum for bathymetry and weed depths.

Ambient wave conditions late in the afternoon of survey days interfered with sonar signals (i.e., 'noise' in the depth signal), therefore the shallower weed covered areas were covered in detail during calmer conditions, and the deeper, weed bed-free areas were covered at a lower spatial resolution (Figure 1). Shallow areas (<0.7 m depth) limited boat access and the operation of sonar. Development of algal cover in shallow areas also returned a signal that could be confused with weed presence. In these cases observation was used to further define the shoreward extent of high cover vegetation, as well as the general notes on the composition of the submerged vegetation.

## Data processing

Raw sonar data files (.sl2) are stored on NIWA's project management system and will be provided upon request.

Raw data was processed using ciBioBase.com, an automated GIS processing engine for Lowrance™ HDS acoustic data. ciBioBase is the property of Contour Innovations, LLC a Minnesota Company headquartered in Minneapolis, MN USA. Collected data remains the property of Horizons Regional Council, but is stored and managed on the ciBioBase system and accessed by NIWA as a service subscriber.

A spatial map of vegetation biovolume (percent of the water column occupied by plant matter) was generated to provide the basis of estimates of the densely vegetated area. Using ciBiobase, polygons (a closed shape defined by connected GIS coordinates) were generated to delimit areas of weed density ≥65% biovolume and calculate areas for potential harvesting (Appendix A). Generation of polygons excluded shallow areas <0.6 m and areas of high algal development, where sonar readings were not reliable. Other metrics were generated to provide information on the extent of the lake surveyed, and average vegetation biovolume in the selected areas.

Additional map graphics generated from ciBioBase include spatial mapping of bathymetry and relative sediment hardness (Appendix B and C).

# 3 Results and discussion

Lake conditions at the time of the survey allowed navigation coverage of 79.5% of the known lake area (ciBioBase metric), with shallow margins and the inner part of the north-eastern bay being inaccessible by boat (Figure 1). A lower resolution of run lines was made in the deeper central area (Appendix B: Bathymetry), where vegetation was absent, because the survey was restricted by wave development late in the day. Unchecked data (supplied by Horizons Regional Council) for the stage height over this time averaged 1064.8 mm (range 1006 – 1083 mm) over the three survey days.

Mapped plant biovolumes (Figure 2) showed there were three main areas of high weed bed occupancy (≥65% biovolume, red colour). A total of 48.86 ha had a biovolume ≥65%. Of these areas the biggest area, weed bed 2, was in the western sector of the lake. Most vegetation signals were returned from depths ≤1.2 m. See Appendix A for a breakdown of areas, average biovolume and depth range of dense weed beds.

**Table 1: Estimates of areas of high submerged plant biomass (≥65% biovolume).**

| Location polygon | Area (ha) |
|---|---|
| Weed bed 1 | 12.82 |
| Weed bed 2 | 20.31 |
| Weed bed 3 | 15.73 |
| Total | 48.86 |

Observations showed the three submerged weed beds were dominated by elodea (*Elodea canadensis*), with curled pondweed (*Potamogeton crispus*) as occasional plants only (Figure 3). Although egeria (*Egeria densa*) has been reported in the lake (Champion et al. 2002), it was not seen during this survey. Average bed covers of elodea were estimated at between 26 to 75%, and it was surface reaching within the southern edge of weed bed 3 (Figure 4). At several sites the canopy of the weed beds had been grazed by waterfowl (Figure 5).


**Figure 1: Trace of run lines over the navigable lake area.**

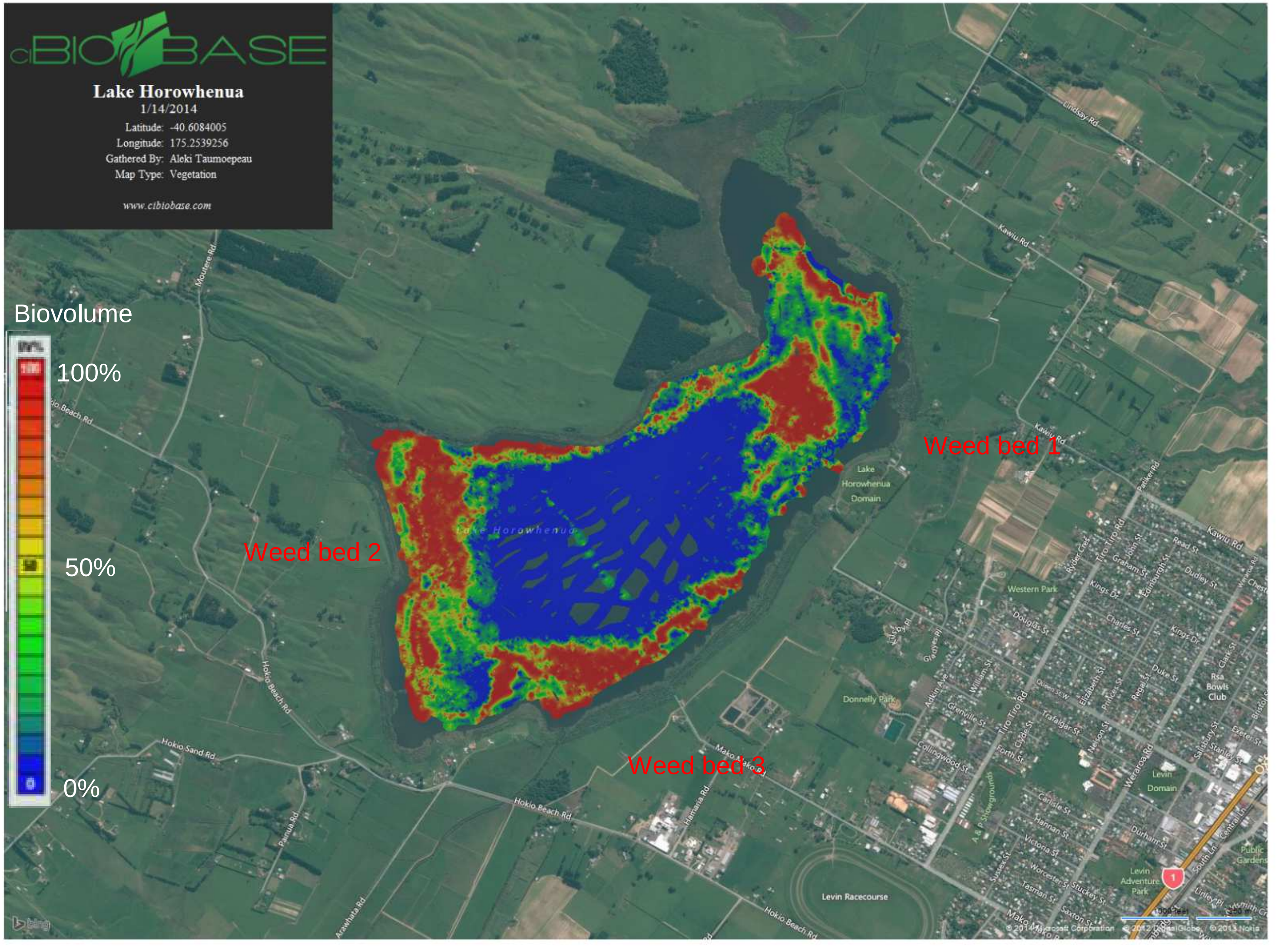


**Figure 2: Plotted biovolume of submerged vegetation, with three main areas of high cover beds (red or ≥65% biovolume).**

**Figure 3: Retrieved handful of weed showing a mix of elodea (yellow arrow) and curled pondweed (red arrow).**

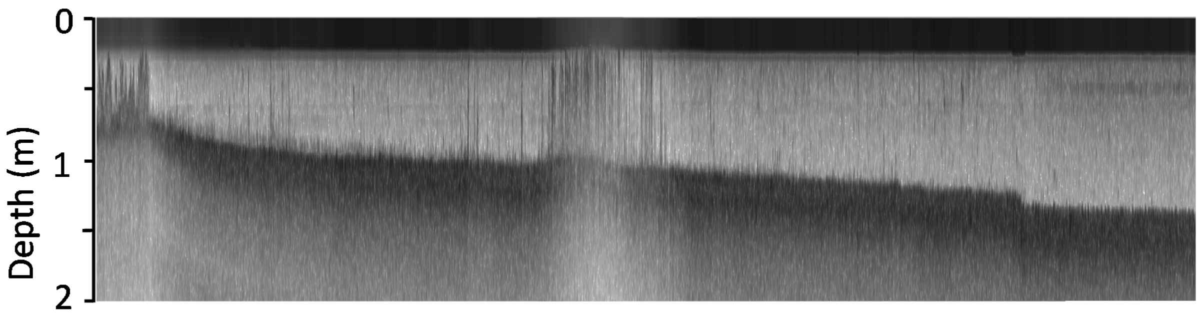


**Figure 4: Lake profile from in front of Kohuturoa Marae showing two areas of dense, surface reaching weed bed.**

**Figure 5: Surface reaching weed bed in a shallow area where it has been grazed by waterfowl.**

It is apparent that curled pondweed is not as dominant as documented in the 1970’s (i.e., Gilliland 1978) and in 2000 (Champion et al. 2002). Nevertheless, we noted similarity in the areas of maximum plant development mapped at that time (Gilliland 1978), to current weed bed distribution.

Elodea was the dominant plant in Lake Horowhenua at the time of the survey (summer). It has a similar growth habit to curled pondweed in that it is a rooted plant that forms a canopy at the water surface in shallow locations. However, elodea does not have such a strong tendency for seasonal variation and it can only reproduce vegetatively (does not produce seed). Recovery of elodea after a large reduction in biomass would be more limited than curled pondweed, as it needs to regrow from distributed viable vegetative fragments. In comparison curled pond weed can recover from specialised vegetative propagules (turions) that deposit and can overwinter in the sediment, as well as from seed. Harvesting and removal of large amounts of biomass of elodea may slow ability to regenerate, and this should be considered in any harvesting strategy. In terms of alternative weed control methods, elodea is known to be much more susceptible to the aquatic herbicide diquat than pondweed.

There remains a risk that over-harvesting of weed beds could drive the lake system to algal dominance. Lake Horowhenua is a challenging environment for submerged plant growth due to high water turbidity and wave disturbance. Harvesting, by removing the photosynthetically active surface canopy of weed beds, could overstress the vegetation by limiting plant access to light at critical times.

Fragmentation by proposed harvesting will not accelerate the spread of elodea to new areas of the lake, as is already dispersed after wave disturbance or waterfowl grazing, and all available habitat is likely to already be saturated. Large areas of the centre of the lake are as yet un-colonised by dense beds, indicating that light availability limits the habitat available for submerged plants here.

The dense weed beds were associated with softer sediment (Appendix C). This is likely the result of sedimentation of fine material being enhanced by quiescent conditions in dense weed beds rather than a requirement by plants for soft sediment for anchorage. In contrast, the hardest sediments predominantly mapped along the wind/wave exposed north-eastern to southern shoreline, and the point along the western shore.

# 4 Recommendations

Feasibility and calculations of weed biomass, harvesting rates, and potential nutrient removal have been based on curled pondweed, not elodea, as the dominant weed bed species (Gibbs and Quinn 2012). A reconsideration of these conclusions (e.g., Matheson and Clayton 2002), is warranted in light of current vegetation composition.

We recommend that an optimised strategy of harvesting is developed, that clearly identifies areas to be cleared for amenity purposes and areas to be retained in a vegetated state as waterfowl habitat, for wave buffering and to retain a vegetated status. Timing of harvesting also needs to be considered in light of dominance by a perennial species, as elodea does not regenerate from seed reserves.

Temporal variation in weed bed presence is not well documented for Lake Horowhenua, with only 'snapshot' accounts of weed development and distribution since the late 1970's. Optimisation of a weed harvesting regime would benefit from results of repeated sonar surveys in winter and spring. Additional scuba sampling would link sonar biovolume measures to vegetation standing biomass (g dry weight $m^2$) and nutrient content, as well as confirm species composition. This would add more certainty to the calculations of achievable results from harvesting. Recovery times for plant growth after harvesting, under the lake environmental conditions, should also be sought if the risk of overharvesting and total vegetation collapse is to be considered.

# 5 Acknowledgements

Many thanks to Jon Roygard, Logan Brown (Horizons Regional Council), Rob Warrington (Lake Horowhenua Trust) and Marakopa Wiremu-Matakatea (Lake Horowhenua Trust) for assistance during the lake survey.

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Gilliland, B.W. (1978) Development of weed beds over summer 1976 and brief description. *In: Lake Horowhenua current condition, nutrient budget and future management.*

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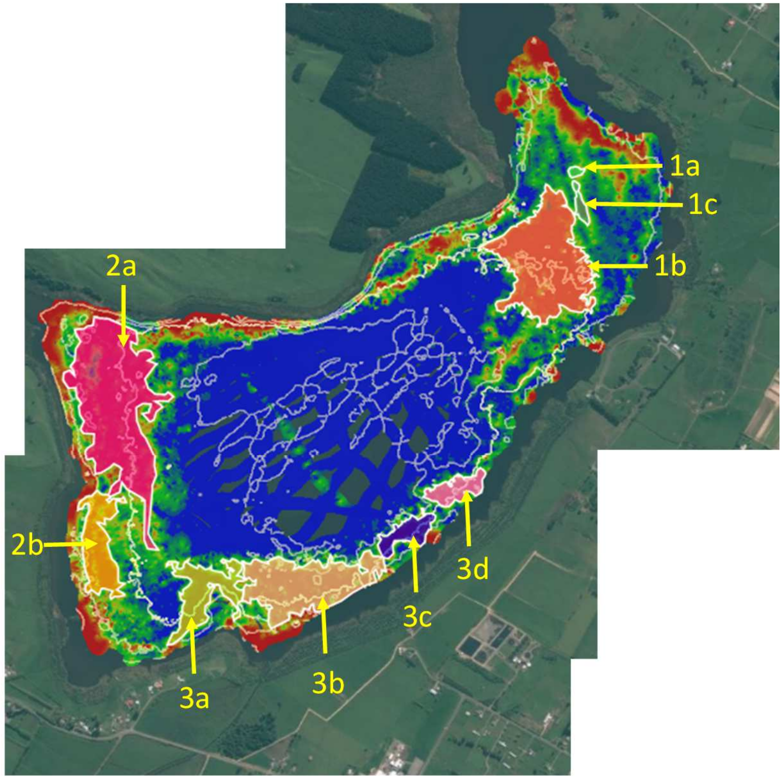
# Appendix A  Weed bed polygons; location and metrics

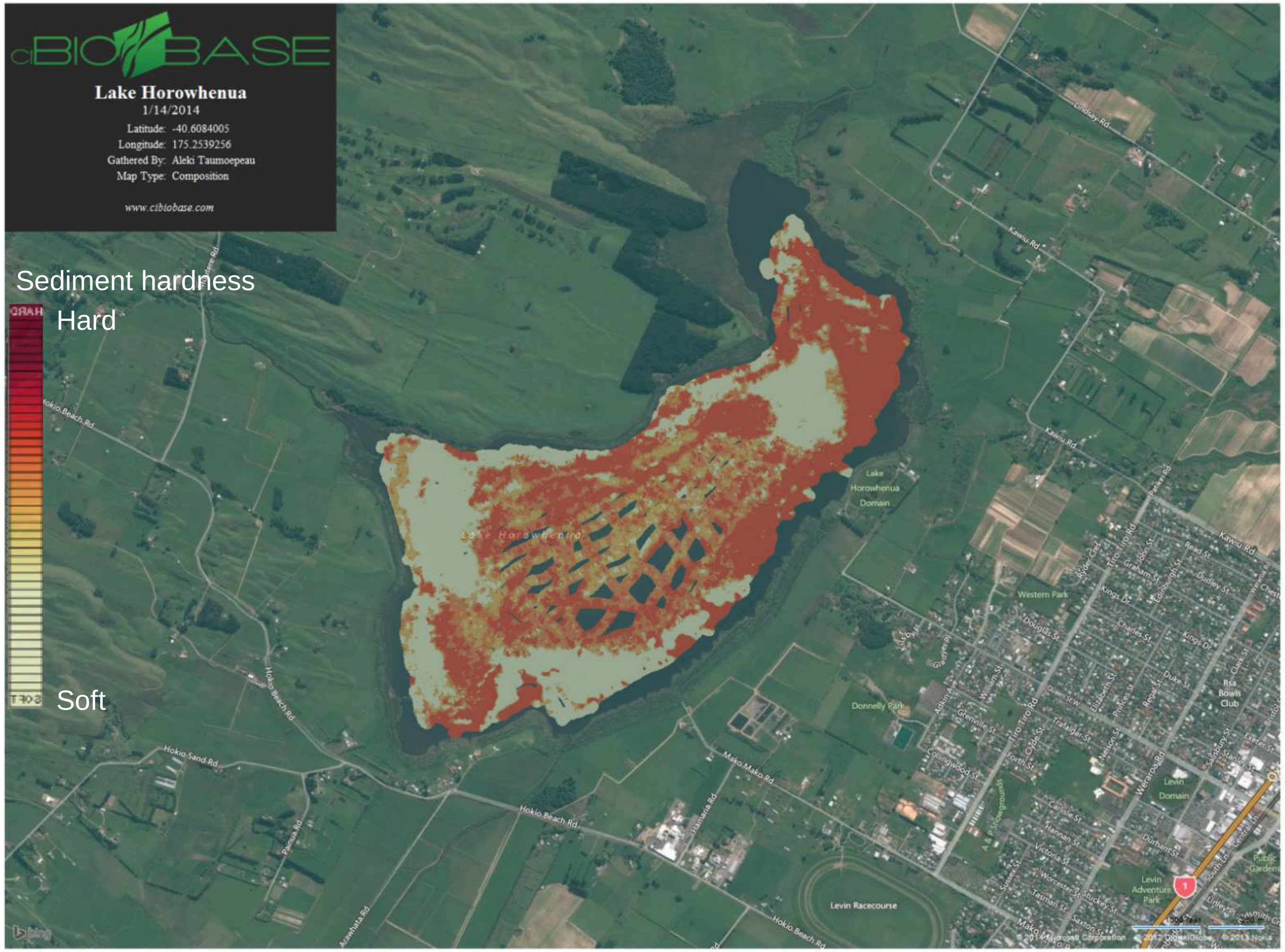



| Weed bed | Surface area (ha) | Average biovolume (%) | Minimum depth (m) | Minimum depth (m) |
|---|---|---|---|---|
| 1a | 0.18 | 67.32 | 0.90 | 1.04 |
| 1b | 12.19 | 89.23 | 0.84 | 1.10 |
| 1c | 0.46 | 71.85 | 0.90 | 1.04 |
| 2a | 16.24 | 86.32 | 0.69 | 1.39 |
| 2b | 4.07 | 81.99 | 0.76 | 1.07 |
| 3a | 3.95 | 85.7 | 0.78 | 1.42 |
| 3b | 8.47 | 89.72 | 0.71 | 1.52 |
| 3c | 1.66 | 86.89 | 0.78 | 1.47 |
| 3d | 1.65 | 85.68 | 0.738 | 1.37 |

# Appendix B Bathymetry of Lake Horowhenua


Bathymetry from the sonar output at a lake level of 1064.8 mm displaying a contour equivalent to c. 0.3 m (ciBioBase.com output is in imperial measurements as feet). The lake centre shows some gaps in sonar coverage across the non-vegetated deeper sector of the lake and the result of interference on bed detection by wave action.

# Appendix C Relative sediment hardness




Plotted relative hardness of sediment within Lake Horowhenua from softer (pale) to harder (darker).

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