Earth Sciences New Zealand

Status of macrophytes in Lakes Tahaaroa, Numiti and Rotoroa

Prepared for Tahaaroa Lakes Trust

November 2025

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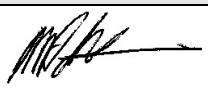
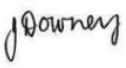
Client Report No: 2025386HN
Report date: November 2025
Project No: TKIL2502

Quality Assurance Statement		
	Reviewed by:	Mary de Winton
	Formatting checked by:	Jo Downey
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Ko te whenua, ko te wai, ko te mauri o te tangata. Land and water are the lifeforce of the people [Ngahuia Herangi and Stu Mackay, NIWA].

Herangi, N., Zabarte-Maeztu, I., Taumoepeau, A., Dransmann, C. (2025) Status of macrophytes in Lakes Tahaaroa, Numiti and Rotoroa. Client Report 2025386HN, June 2025: 64.

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Executive summary

E rere ana te mauri o ngaa wai o ngaa roto o Tahaaroa hei oranga moo te roto, moo ngaa koiora katoa, moo te whenua, moo te tangata, aa, hei painga hoki moo ngaa uri whakaheke o Ngaati Mahuta ki te Hauaauru.

The mauri of the waters of the Tahaaroa lakes flows to sustain the lake, all living beings, the land, and the people, and to uphold the wellbeing of future generations of Ngaati Mahuta ki te Hauaauru (Herangi et al. 2025a).

This report presents the results of the 2024 macrophyte survey undertaken for the Tahaaroa Lakes Trust (The Trust), forming part of the wider kaupapa titled, Ngaa taonga tuku iho o ngaa roto o Tahaaroa. Together with companion studies on tuna (Herangi et al. 2025b) and kaiaua (Melchior et al. 2025), this work supports a holistic understanding of lake health where native vegetation (tupu wai), taonga species, and water quality collectively express the mauri of the roto.

This 2024 survey provides the first full reassessment of aquatic vegetation in the Tahaaroa lakes since 2014 and establishes the baseline for The Trust's Mauri Assessment Framework and Ngaa Parenga Aroturuki Wai o Tahaaroa (Catchment Monitoring Plan). The survey was conducted collaboratively between Earth Sciences New Zealand (ESNZ) and The Trust, combining scientific data and maatauranga Maaori to assess the condition of tupu wai across Lakes Tahaaroa, Numiti, and Rotoroa.

Ecological Findings

Monitoring results confirm that all three lakes remain in moderate ecological condition under the LakeSPI index, though trends differ between lakes. Tupu wai such as *Chara australis, Nitella cristata*, and *Potamogeton ochreatus* persist in shallow margins but have declined in depth and extent relative to 2014. Invasive species particularly *Lagarosiphon major* and *Elodea canadensis* dominate submerged vegetation, displacing native plant communities and competing for light availability.

Invasive Detection

A major development in 2024 was the first detection of *Ceratophyllum demersum* (Hornwort) at the outlet of Lake Tahaaroa (Wainui Stream). Hornwort is one of Aotearoa's most aggressive aquatic weeds, and its discovery elevates the biosecurity risk for the entire lake complex. Hornwort is classified as an Unwanted Organism (UO) under the Biosecurity Act 1993 and is restricted under the National Pest Plant Accord (NPPA), which reinforces the need for immediate containment and strict prevention measures across the Tahaaroa lake system.

Management Implications

Results highlight the need for strengthened biosecurity, invasive-species control, and catchment-based restoration. Priority actions include implementing "Check, Clean, Dry" protocols, restoring tupu wai meadows, enhancing riparian buffers, and integrating cultural and scientific monitoring through the Rongo App. These actions are consistent with the Department of Conservation's Ngā Riha Wai Māori Strategy 2023–2050 (NRWMS 2023-2050) and The Trust's Catchment Monitoring Plan (CMP).

Cultural Interpretation

From a Ngaati Mahuta ki te Hauaauru (Ngaati Mahuta) perspective, the health of tupu wai reflects the mauri and balance of the lakes. Using the Rongo App Mauri Assessment Framework, the current states are interpreted as:

- **Lake Tahaaroa – Mauri tuu:** Stable but under stress from invasive species.
- **Lake Numiti – Mauri kino:** Declining native vegetation and high sediment load.
- **Lake Rotoroa – Mauri tuu:** Stable showing relative improvement in tupu wai cover, but underlying stress is evident from kaiaua mortality and fine, anoxic substrate. While vegetation shows signs of recovery, the lake remains vulnerable.

These assessments provide a shared cultural and scientific understanding of lake health, forming the foundation for future restoration, monitoring, and co-management efforts.

Summary of Lake Conditions

The table below summarises the 2024 LakeSPI results for each lake, showing changes in native and invasive vegetation indices and overall ecological condition compared with 2014.

Lake	LakeSPI Results (2024)	Interpretation
Tahaaroa	LakeSPI Index 33%, a 7% decline since 2014. Native Condition Index decreased from 53% to 38%, while Invasive Impact Index remained stable (67–68%). Maximum vegetation depth reduced from 5.7 m to 4.4 m.	Ecological condition remains moderate but unstable. Native charophyte meadows have contracted, while *Lagarosiphon major* and *Elodea canadensis* dominate. The detection of Hornwort (*Ceratophyllum demersum*) represents a high biosecurity threat requiring urgent containment and public awareness.
Numiti	LakeSPI Index 29%, an 11% decline since 2014. Native Condition Index dropped from 37% to 30%; Invasive Impact Index increased from 56% to 66%. Vegetation depth reduced from 6 m (1983) to 3 m.	Indicates a continuing ecological decline and increasing dominance of invasive species (*Elodea canadensis*, *Lagarosiphon major*). Anoxic sediments and poor water clarity constrain tupu wai recovery.
Rotoroa	LakeSPI Index 34%, a 7% improvement from 2014. Native Condition Index increased from 22% to 34%, while Invasive Impact Index decreased from 69% to 62%.	Reflects gradual ecological improvement, with early re-expansion of tupu wai and reduced invasive pressure. Ongoing surveillance will confirm whether these positive trends continue.

Key Pressures and Risks

The principal stressors affecting the lakes include nutrient and sediment inflows from the surrounding catchment, expansion of invasive aquatic weeds, and increasing climate variability. Together these reduce light penetration, alter ecological function, and threaten the integrity of tupu wai communities that sustain the lake ecosystem and its mauri.

Management and Restoration Pathway

Management priorities identified through this survey align with the legislative and policy settings that guide freshwater pest management in Aotearoa. Hornwort is an Unwanted Organism under the Biosecurity Act 1993 and is listed on the National Pest Plant Accord, meaning it cannot be sold, propagated, or distributed. The National Policy Direction for Pest Management provides the framework that ensures regional pest management plans set clear, consistent objectives for exclusion, eradication, or progressive containment. Within the Waikato Regional Pest Management Plan 2022–2032, these settings support site-led approaches that enable targeted management of high value ecosystems such as the Tahaaroa lakes. The immediate focus for the lake system is therefore on biosecurity and invasive species containment, supported by native vegetation restoration and strengthened catchment management.

Key actions include:

- Immediate containment and eradication of Hornwort.
- Mapping and protection of remnant charophyte meadows and re-establishment trials using native propagules.
- Enhancement of riparian and wetland buffers to reduce nutrient and sediment inflows.
- Biennial kaitiaki-led monitoring.
- Development of a Mana Whakahono aa Rohe or co-management agreement between The Trust and WRC.

These actions give practical effect to The Trust's CMP, ensuring that scientific monitoring and maatauranga Maaori operate side by side.

Alignment with Wider Research

This report complements:

- Ngaa taonga tuku iho o ngaa roto o Tahaaroa (Herangi et al. 2025a), which defines the cultural indicators (tohu) and frameworks underpinning lake health assessment.
- Lake Tahaaroa Customary Tuna Research (Herangi et al. 2025b), which investigates tuna condition and habitat quality.
- Status of Kaiaua in the Tahaaroa Lakes (Melchior et al. 2025), which assesses the wellbeing of freshwater mussels (*Echyridella menziesii*).

Together, these reports provide a unified evidence base for decision-making and guide The Trust's long-term restoration programme.

Pathway to Restoration

The 2024 survey marks a pivotal step in restoring balance to the Tahaaroa lakes. Implementation of biosecurity controls, tupu wai restoration, and integrated kaitiaki-led monitoring will ensure that both scientific evidence and maatauranga Maaori guide decisions. Through continued partnership between The Trust, ESNZ, MPI, and WRC, the vision *"E rere ana te mauri o ngaa wai o ngaa roto o Tahaaroa"* will be realised, restoring mauri ora to the lakes, their ecosystems, and their people for generations to come.

Integrated Summary of LakeSPI and Mauri Metrics for the Tahaaroa Lakes 2024

A summary of the key ecological and cultural metrics from the 2024 LakeSPI survey is provided below. These indicators show the relative condition and recent trends of each lake, integrating both scientific and maatauranga-based assessments of lake health.

Table 1: Summary of LakeSPI results and mauri metrics for Tahaaroa lakes 2024.

Lake	LakeSPI Index (%)	Native Condition (%)	Invasive Impact (%)	Max Vegetation Depth (m)	Mauri Assessment (Rongo App)	Ecological Trend (Since 2014)
Tahaaroa	33	38	68	4.4	Mauri tuu – stable but under stress	Declining (tupu wai loss, Hornwort detected)
Numiti	29	30	66	3.0	Mauri kino – Declining	Continued degradation
Rotoroa	34	34	62	4.8	Mauri tuu – stable with signs of recovery	Positive improvement (tupu wai expansion, reduced invasive cover)

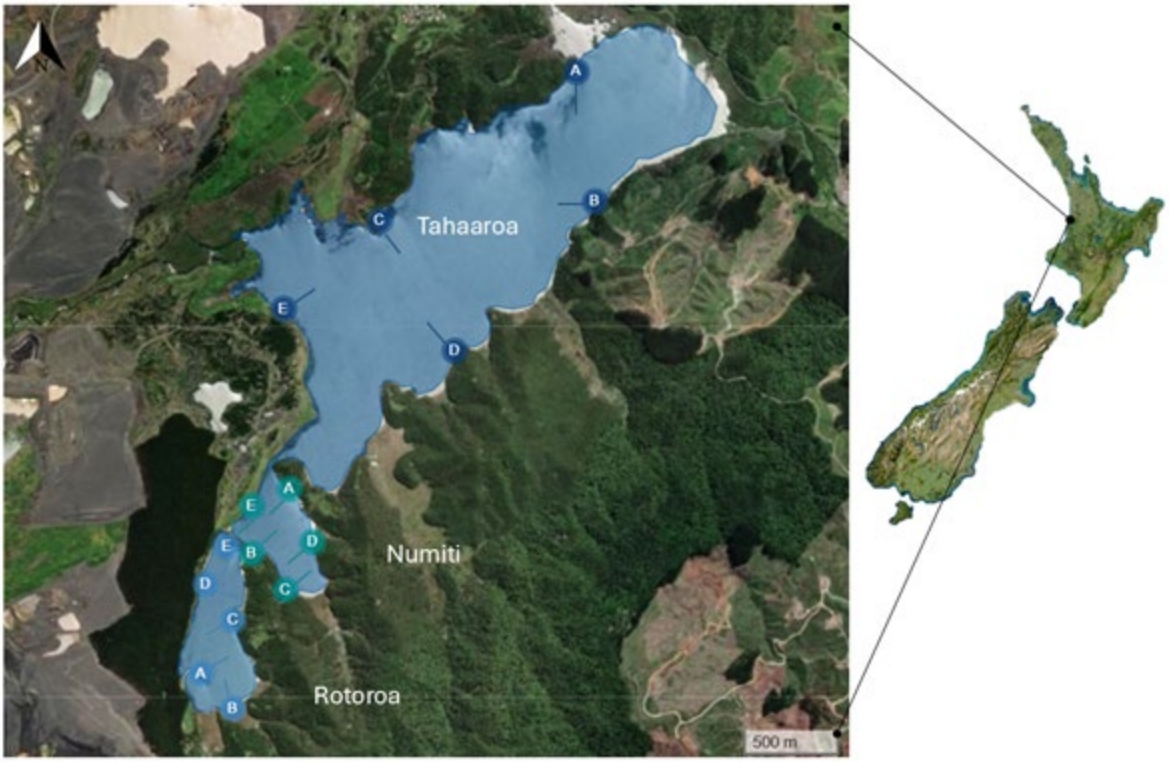


Figure 1: Location of Lakes Tahaaroa, Numiti and Rotoroa within the Tahaaroa dune-lake complex, south of Kaawhia Harbour.

1 Introduction

1.1 Background

The Tahaaroa lakes (Tahaaroa (220 ha), Numiti (15.8 ha) and Rotoroa (22.4 ha)) are a chain of shallow coastal dune lakes situated approximately 3 km from the Tasman Sea, south of Kaawhia Harbour, within the rohe of Ngaati Mahuta (Figure 2). The lakes drain westward to the sea through Wainui Stream (Bayler et al. 2020).

Further south within the same dune complex lies several smaller, more isolated water bodies, including Lakes Piopio (0.2 ha), Rototapu (2 ha), and Harihari (18.4 ha). Of these, only Piopio and Rototapu are occasionally connected during high-flow or groundwater events, while Harihari remains hydrologically separate. These lakes collectively represent one of the most significant coastal freshwater systems remaining between the Kaipara Harbour and the South Taranaki Bight (Scott, 1996; David et al. 2014).

The Tahaaroa lakes hold both ecological and cultural value for Ngaati Mahuta. They provide habitat for diverse native flora and fauna and are traditional mahinga kai sites for tuna and kaiaua (Chisnall & Ruru, 2008; David et al. 2014). Dune lakes are internationally uncommon, occurring in New Zealand, on the eastern coastline of Australia, the Florida Panhandle and Pacific Northwest of the USA, Madagascar, the Netherlands and UK (Hadwen 2002; Porter 2009).

In recent decades, land-use intensification, stock access, and nutrient enrichment have led to declines in water clarity and ecological integrity. Monitoring has recorded increasing Trophic Level Index (TLI) values from oligotrophic conditions in the early 1980s to eutrophic or supertrophic conditions since 2014 (Dean-Speirs et al. 2014; LAWA, 2024). These changes coincide with the expansion of invasive aquatic plants such as *Lagarosiphon major*, *Elodea canadensis*, and *Potamogeton crispus* (Edwards et al. 2005). Elevated nutrient and sediment inputs have increased the risk of algal blooms, reduced light penetration, and loss of native vegetation (Bayler et al. 2020).

Within this environmental and cultural context, the Trust identified the need for updated information on aquatic vegetation to support restoration and management planning. Established under the Māori Affairs Act 1953, The Trust continues to uphold mana whakahaere and kaitiakitanga over the lake system on behalf of Ngaati Mahuta beneficial owners (Taharoa A7A2A Trust, 2021).

The Trust's monitoring and restoration approach is guided by He Anga Aroturuki Wai Maaori, the overarching framework that underpins the CMP. The framework weaves together three pou; Pou Taiao (environmental integrity), Pou Taangata (people and wellbeing), and Pou Taawhirimatea (climate and natural forces). These are enlivened by six hau, collectively known as Ngaa Hau o te Hauaauru, representing kaitiakitanga, hauora, auahatanga, tuakiritanga, kotahitanga, and maatauranga.

Together, these pou and hau express a holistic vision of balance between people, place, and practice, ensuring that all monitoring and management actions support the flow of mauri within the Tahaaroa lake system.

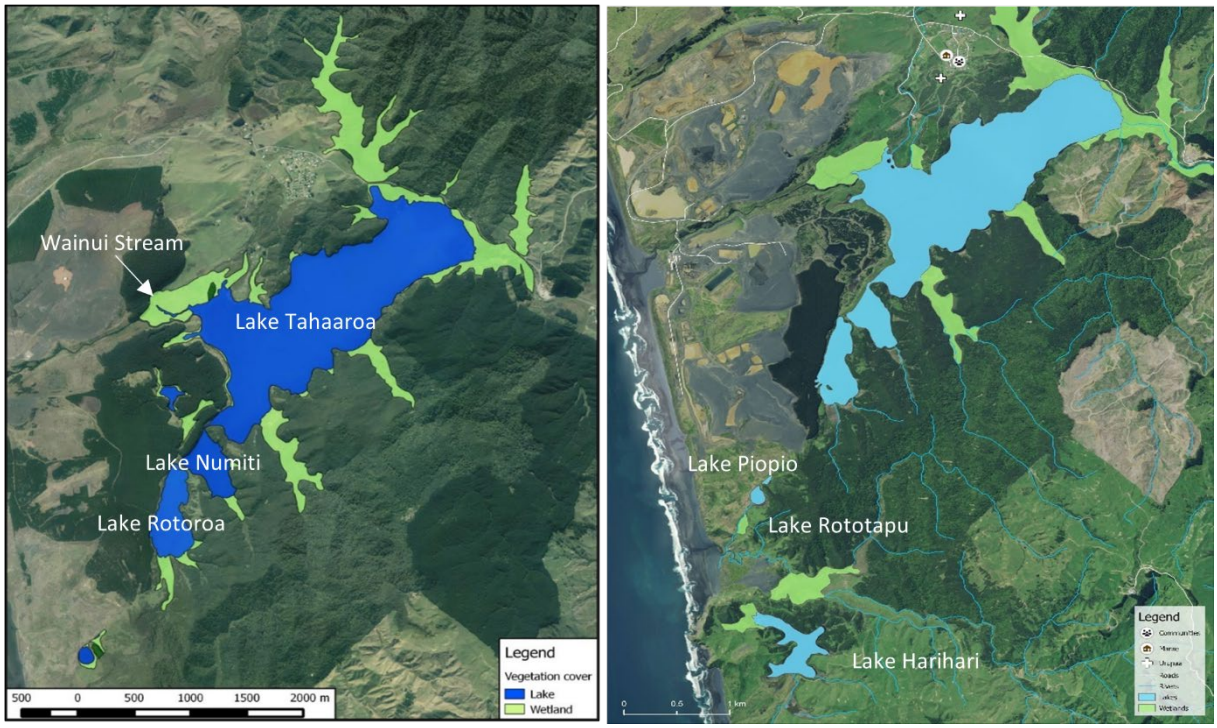


Figure 2: Location of Lakes Tahaaroa (220 ha), Numiti (15.8 ha), Rotoroa (22.4 ha), Piopio (0.2 ha), Rototapu (2 ha), and Harihari (18.4 ha), situated approximately 3 km and 1 km inland from the Tasman Sea, south of Kaawhia Harbour, within the rohe of Ngaati Mahuta. [Map: Ruby Mckenzie Sheat, ESNZ]

1.2 Cultural and Environmental Context

Within the worldview of Ngaati Mahuta, the lakes and their tupu wai are living entities that embody the mauri of the landscape and express Ngaa Hau o te Hauaauru, the life-sustaining winds and energies of the west. The health, composition and vigour of these plant communities are recognised as tohu of both ecological balance and cultural wellbeing (Harmsworth & Awatere, 2013).

The Trust's kaupapa, Ngaa Hau o te Hauaauru, provides the guiding foundation for how the cultural and environmental values of the Tahaaroa lakes are understood. It emphasises balance, renewal, and interconnection between people, land, and water, recognising that when one element is disturbed, all are affected. Within this framework, kaitiaki assess lake health not only through ecological indicators but also through the flow of mauri and the expression of tupu wai as living markers of wellbeing. Tupu wai stabilise sediment, maintain clear water, and provide refuge for taonga species, whereas the dominance of invasive weeds reflects imbalance and loss of mauri (Harmsworth et al. 2016).

Surrounding wetlands and gully systems perform essential ecological functions, buffering the lake edges from erosion and filtering nutrient and sediment-laden inflows (Bayler et al. 2020). These natural systems are now compromised by land-use change and reduced vegetative cover, diminishing their capacity to maintain water quality. Nutrient loading, particularly total nitrogen (TN) and total phosphorus (TP), has increased over time, driving eutrophication and favouring algal and weed growth.

Sediment accumulation further decreases light availability, limiting the depth at which submerged vegetation can survive (Dean-Speirs et al. 2014). Periodic bacterial contamination from livestock and runoff also poses health risks to both humans and aquatic organisms (Dean-Speirs et al. 2014; Bayler et al. 2020).

The current study provides an updated assessment of macrophyte extent and condition as a biological indicator of lake health.

1.3 Aims and Objectives

The 2024 survey was designed to provide The Trust with a comprehensive assessment of aquatic vegetation condition and change within Lakes Tahaaroa, Numiti, and Rotoroa. It builds on previous ESNZ and WRC macrophyte surveys undertaken between 1983 and 2014 (Edwards et al. 2005; Edwards et al. 2010; Dean-Speirs et al. 2014; David et al. 2014) and forms part of The Trust's broader kaupapa Ngaa Hau o te Hauaauru, a programme committed to restoring ecological balance, cultural wellbeing, and the mauri of the Tahaaroa lake system.

The survey also provides the biological foundation for The Trust's CMP, integrating scientific indicators such as LakeSPI with maatauranga Maaori based assessments recorded through the Rongo App Mauri Assessment Framework. Together these approaches strengthen kaitiakitanga and enable The Trust to monitor lake health through both ecological and cultural lenses.

The specific objectives of the study were to:

- Determine the current composition, extent, and depth range of aquatic vegetation in Lakes Tahaaroa, Numiti, and Rotoroa, including the relative dominance of tupu wai and invasive species, using the nationally standardised LakeSPI (Lake Submerged Plant Indicators) methodology (Clayton et al. 2006; de Winton et al. 2013).
- Compare 2024 results with historical surveys to identify long-term trends in vegetation structure, depth limits, and overall ecological condition expressed through LakeSPI indices (Edwards et al. 2005; Dean-Speirs et al. 2014).
- Assess the extent of invasive aquatic-plant species, particularly *Lagarosiphon major, Elodea canadensis*, and *Potamogeton crispus*, report new detections, and evaluate associated biosecurity risks (Champion et al. 2019; Champion et al. 2020).
- Interpret ecological patterns within a cultural and environmental framework, linking observed changes in aquatic vegetation to indicators of mauri and kaitiaki observations recorded through the Rongo App Mauri Assessment Framework.
- Provide management and monitoring recommendations to support The Trust's CMP and to guide future control, restoration, and surveillance activities consistent with regional and national biosecurity strategies (Biosecurity Act 1993; Waikato Regional Council, 2022a, 2022b; DOC, 2023).

By achieving these objectives, this study establishes an updated baseline for tupu wai distribution and lake health, providing the information required to prioritise management actions, support funding proposals, and protect the ecological and cultural integrity of these taonga for future generations.

2 Project Scope

This project was a partnership between The Trust and ESNZ, bringing together the technical expertise of the Aquatic Plant Group and Te Kūwaha (Maaori Research Team) with the cultural and environmental knowledge of Ngaati Mahuta kaitiaki (Figure 3). The mahi formed part of The Trust's wider environmental monitoring programme designed to restore and protect the mauri of the Tahaaroa lake system.

The work continues a series of collaborative studies including Ngaa taonga tuku iho o ngaa roto o Tahaaroa, customary tuna research, kaiaua assessments, and kaitiaki-led monitoring that together provide a holistic understanding of the roto as interconnected ecosystems where tupu wai, taonga species and mauri collectively indicate lake health. The macrophyte component complements these companion studies, creating a multi-layered evidence base to guide management decisions.

The scope of the 2024 macrophyte survey focused specifically on:

- Resurveying macrophyte communities at previously established LakeSPI sites within Lakes Tahaaroa, Numiti and Rotoroa.
- Updating quantitative indices of native and invasive vegetation condition.
- Identifying any new incursions of invasive species requiring immediate biosecurity response.

2.1 Report Structure

This report presents the results of the 2024 macrophyte survey conducted across the interconnected dune lakes of Tahaaroa, Numiti, and Rotoroa. The report is structured into seven main sections and three appendices, as outlined below:

- **Section 1: Introduction and Background** – Provides the environmental and cultural context for the study, including the ecological significance of the Tahaaroa lakes, their maatauranga Maaori foundations, and the aims and objectives of the 2024 survey.
- **Section 2: Project Scope** – Outlines the collaborative framework between The Trust, ESNZ, and Ngaati Mahuta kaitiaki, describing how the macrophyte survey integrates with wider kaupapa such as Ngaa Hau o te Hauaauru and the Catchment Monitoring Plan.
- **Section 3: Methods** – Describes the LakeSPI methodology and tikanga-based field protocols used to assess vegetation condition, including site design, data analysis, and integration with the Rongo App Mauri Assessment Framework.
- **Section 4: Results** – Presents detailed findings for each lake, including native and invasive species composition, vegetation depth ranges, LakeSPI indices, and site-specific observations.
- **Section 5: Data Analysis** – Examines long-term trends in tupu wai and invasive species, summarising national and regional LakeSPI rankings and their ecological significance.

- **Section 6: Discussion** – Interprets results within both scientific and cultural frameworks, exploring the drivers of change, expressions of mauri, and implications for management.
- **Section 7: Management and Recommendations** – Synthesises findings into a set of priority actions for restoration, monitoring, and co-management, aligned with The Trust's vision for the mauri of the Tahaaroa lakes.
- **Section 8: Conclusion** – Summarises key findings, reflects on the current ecological and cultural status of the lakes, and identifies the next steps required to restore tupu wai and sustain the flow of mauri within the Tahaaroa lake system.
- **Appendix A-C** – Provide detailed species lists, historical summaries of macrophyte records, and comparative LakeSPI results from 1983–2024.

Figure 3: Ecologists and Technicians from ESNZ L-R: Michele Melichior, Inigo Zabarte-Maeztu, Constantin Dransmann, Aleki Taumoepeau. [Photo: Fleur Passau, Tahaaroa Lakes Trust]

3 Methods

Fieldwork and analysis for the 2024 macrophyte survey were undertaken collaboratively by ESNZ and The Trust in partnership with Ngaati Mahuta kaitiaki (Figure 4). The approach followed both scientific protocols and tikanga-based processes consistent with The Trust's He Anga Aroturuki Wai Maaori guiding framework for the CMP.

Methods for this report are based on the nationally standardised LakeSPI framework and other observations used to assess aquatic vegetation composition, depth extent and ecological condition across Lakes Tahaaroa, Numiti and Rotoroa (Clayton et al. 1983). Tohu aa-hapuu observations recorded through the Rongo App to assess mauri, were undertaken separately as part of The Trust's wider CMP. Together, these complementary approaches provide both scientific and cultural perspectives on lake health, enabling The Trust to track ecological change alongside expressions of mauri and tupu wai vitality.

The study sits within The Trust's He Anga Aroturuki Wai Maaori guiding framework, which integrates scientific and cultural monitoring through the three pou: Pou Taiao, Pou Taangata, and Pou Taawhirimatea and the six hau of Ngaa Hau o te Hauaauru.

Figure 4: Collaborative fieldwork during the 2024 macrophyte survey at Lake Tahaaroa, undertaken by The Trust and Ngaati Mahuta kaitiaki and ESNZ. Complementary to LakeSPI, The Trust developed and tested the Rongo App to record observations and tohu. This mahi was undertaken separately as part of The Trust's wider CMP. [Photo: Stu McKay, ESNZ]

3.1 Tikanga and Cultural Protocols

All field activities were conducted under the guidance of kaitiaki from Ngaati Mahuta in accordance with tikanga and the principles of mana whakahaere and kaitiakitanga. Prior to each day, karakia were conducted to acknowledge the mauri of the roto and to ensure spiritual and cultural safety of everyone involved.

Work was coordinated to align with Trust tikanga regarding access, timing, and the handling of taonga species. No destructive sampling or disturbance of culturally significant areas occurred. All datasets generated through this mahi are regarded as taonga and are held under the custodianship of The Trust, consistent with data-sovereignty and partnership principles established through Ngaa taonga tuku iho o ngaa roto o Tahaaroa. Any sharing, publication, or secondary use of these data requires prior approval from the Trust.

By embedding tikanga at every stage from planning through to fieldwork, analysis, and reporting, the study ensured that monitoring upheld both cultural integrity and scientific rigour. This approach reflects The Trust's monitoring framework through which cultural and environmental wellbeing are interwoven.

3.2 Study Area

Fieldwork was undertaken across Lakes Tahaaroa, Numiti, and Rotoroa between 25 and 27 November 2024 by ESNZ, in partnership with The Trust and representatives of Ngaati Mahuta. All activities were completed under approved Health and Safety, Fieldwork, and Boat Safety Plans, following ESNZ Standard Operating Procedures to ensure the wellbeing of all participants and the safe deployment of equipment under variable lake and weather conditions.

The three study lakes form a chain of shallow coastal dune lakes located approximately 3 km inland from the Tasman Sea, within the Tahaaroa dune complex on the west coast of the North Island (Figure 5). The lakes are connected through both surface and subsurface hydrological pathways and drain to the sea via Wainui Stream. Surrounding dunes, wetlands, and gully systems influence local hydrology and sediment inputs, contributing to the ecological character of each lake.

Guided by both kaitiaki knowledge and previous ESNZ survey design, five representative LakeSPI sites were established within each lake to provide broad spatial coverage of the main vegetation zones and to maintain consistency with long-term monitoring locations (Clayton & Edwards, 2006; Edwards et al. 2005; Edwards et al. 2010). Sites were positioned away from stream inflows and other localised disturbances to represent undisturbed vegetation patterns.

At each site, divers recorded aquatic-vegetation characteristics on waterproof data sheets, including species composition, the depth extent of vegetation, and the relative abundance of invasive macrophytes. These data provide quantitative measures of vegetation diversity, native cover, and long-term ecological change across the lake system, supported by kaitiaki observations that complement scientific analysis and interpretation of lake health.

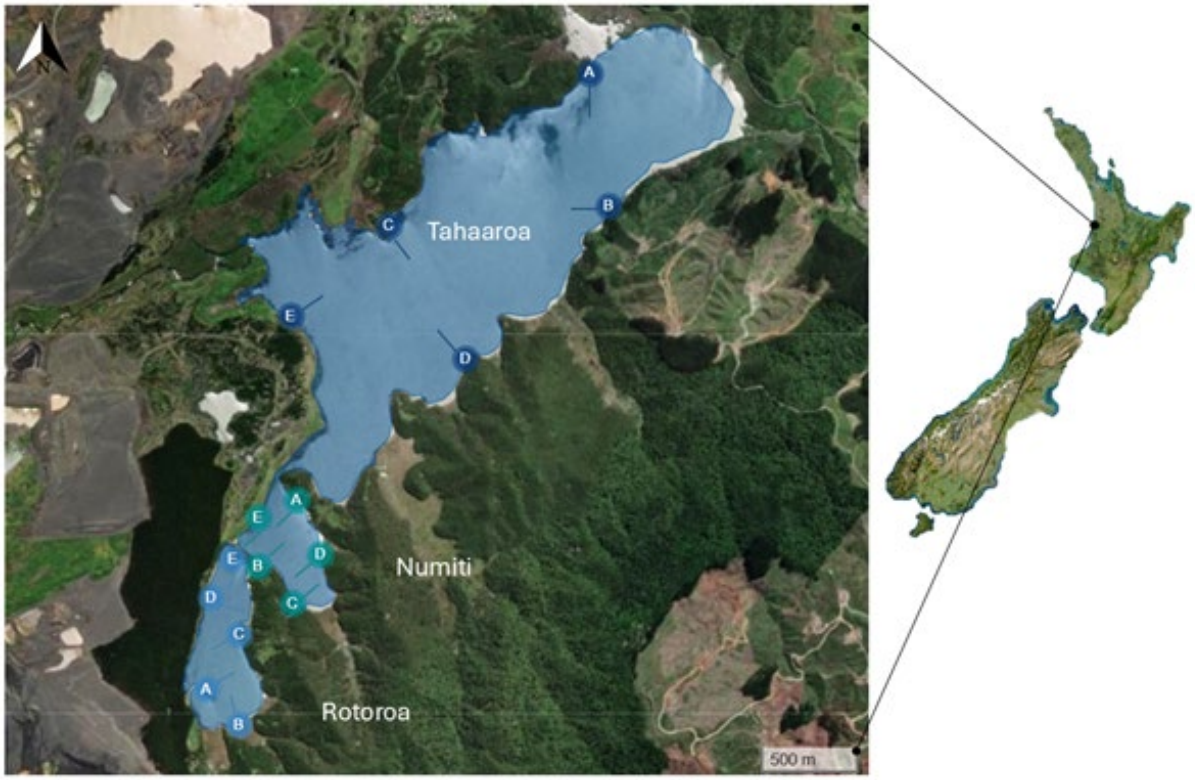


Figure 5: Location of lakes Tahaaroa, Numiti, and Rotoroa within the coastal dune lakes complex on the west coast of the North Island. Survey sites (A–E) were established in each lake to represent the main vegetation zones and ensure consistency with historical LakeSPI monitoring locations. [Map: Michele Melchior].

3.3 Data Analysis

Data from each site were processed using ESNZ's LakeSPI database and analytical framework. Three indices were calculated for each lake:

- Native Condition Index – indicates the overall ecological condition of the lake's native plant character/tupu wai by assessing their depth range, structural integrity, and species diversity. This index reflects both the occupation and the representation of native macrophyte communities, providing a direct measure of how well these plants are performing as ecological anchors within the lake.
- Invasive Impact Index – measures the abundance and dominance of invasive species and indicates the degree to which exotic weeds affect lake condition. Higher scores signal greater invasive pressure, which reduces ecological quality.
- Overall LakeSPI Index – integrates native/tupu wai and invasive attributes, to provide a combined measure of lake ecological condition. Higher scores indicate better ecological condition (Clayton & Edwards, 2006; de Winton et al. 2013).

Indices were calculated per site and averaged to generate lake-level scores. The 2024 results were compared with historical LakeSPI data from 1983–2014 to assess change in ecological condition. Where suitable paired data existed, a paired t-test ($p < 0.05$) was used to determine statistical significance of observed differences.

In addition to statistical testing, the likelihood of ecological change was interpreted following LakeSPI significance guidelines. These provide a standardised scale for assessing whether shifts in index scores represent meaningful ecological change. Where a new incursion of a more invasive weed is detected, a change is predicted. Otherwise, the degree of difference between surveys is interpreted as follows:

0–5 % = change not indicated
>5–10 % = change possible
>10–15 % = change probable
>15 % = change indicated

Applying these thresholds helps determine whether observed differences in LakeSPI indices reflect natural variation, measurement variability, or a genuine ecological shift.

Quality assurance measures included duplicate data entry and verification, independent species confirmation by ESNZ analysts, and validation of GPS coordinates and depth data. In addition to standard LakeSPI metrics, observations of tohu such as lakeside water clarity and vegetation assessments were systematically recorded during the current and previous surveys. This ensured that the assessment both reflected maatauranga Maaori and ecological science. The dual-knowledge approach strengthens the reliability and cultural relevance of findings, providing a sound evidence base for management, restoration, and ongoing kaitiakitanga of these taonga.

4 Results

4.1 Overview

This section presents the ecological results of the 2024 macrophyte survey across Lakes Tahaaroa, Numiti, and Rotoroa (Figure 6). A total of eleven aquatic-plant species were recorded, five native and three invasive (Table 2, Table 5, Table 8). Tupu wai remains a defining feature of all three lakes; however, submerged charophyte meadows have continued to decline in both depth and extent compared with earlier surveys (2010–2014).

Invasive species, particularly *Lagarosiphon major* and *Elodea canadensis*, are now widespread and occur at most if not all LakeSPI sites. Of most concern is the detection of Hornwort at the outlet of Lake Tahaaroa and Wainui Stream. Although currently restricted, this species represents a significant biosecurity threat to the wider lake system.

The survey forms part of The Trust's CMP under Ngaa taonga tuku iho o ngaa roto o Tahaaroa. Consistent with the principles of kaitiakitanga and mana whakahaere, the assessment combines maatauranga Maaori and scientific methods to evaluate the health of tupu wai, key indicator of mauri within the lakes. Ecological results are interpreted through both LakeSPI indices and tohu aa-hapuu observed by kaitiaki, providing a comprehensive understanding of each lake's current state and trends since earlier surveys (1983–2014).

The following sections describe lake-specific conditions, vegetation depth limits, species distributions, and LakeSPI indices, providing an updated assessment of ecological condition and long-term change.

Figure 6: ESNZ team make their way to the next LakeSPI site. [Photo: Stu McKay, ESNZ]

4.2 Lake Tahaaroa

4.2.1 Site Conditions

Field surveys at Lake Tahaaroa were completed 25 November 2024 under calm conditions with moderate cloud cover and light winds. Water temperatures averaged 18 °C, and underwater visibility ranged between 0.5 and 1.0 m across the five sites. Substrates were dominated by fine sand and silt, with scattered peat and organic material in sheltered bays. These conditions are typical of shallow dune lakes but indicate higher suspended solids and reduced clarity compared with previous surveys in 2014.

Table 2 summarises the physical characteristics and vegetation recorded at each site. Visibility and substrate data confirm continuing turbidity stress across the littoral zone, likely associated with sediment resuspension and catchment runoff. The abbreviation sp. aff. comes from the Latin *affinis*, meaning related or similar (Table 2). In taxonomy it is used when a specimen closely resembles a named species but is considered distinct, often representing a potentially new species that has not yet been formally described (Turland et al. 2018).

Table 2: Lake Tahaaroa site details, native and invasive species recorded, substrate, maximum transect depth, vegetation cover and visibility (25 November 2024).

Site	Coordinates (NZTM)	Native Species	Invasive Species	Max Depth (m)	Total Veg. Cover	Visibility (m)
A	266 3264 E 633 6988 N	*Chara australis, Potamogeton ochreatus, Nitella* sp. aff. *cristata, Myriophyllum triphyllum*	*Lagarosiphon major, Elodea canadensis*	4.7	40%	0.5
B	266 3359 E 633 6319 N	*Chara australis, Potamogeton ochreatus, Myriophyllum triphyllum*	*Lagarosiphon major, Elodea canadensis*	4.5	25%	1.0
C	266 2233 E 633 6240 N	*Chara australis, Potamogeton ochreatus, Myriophyllum triphyllum, Nitella* sp. aff. *Cristata*	*Lagarosiphon major, Elodea canadensis*	5.1	85%	1.0
D	266 2621 E 633 5575 N	*Chara australis, Potamogeton ochreatus, Nitella* sp. aff. *cristata*	*Lagarosiphon major, Elodea canadensis*	5.9	85%	1.0

Site	Coordinates (NZTM)	Native Species	Invasive Species	Max Depth (m)	Total Veg. Cover	Visibility (m)
E	266 1836 E 633 4953 N	*Typha orientalis, Chara australis, Potamogeton ochreatus, Myriophyllum triphyllum, Nitella* species aff. *cristata*	*Lagarosiphon major, Elodea canadensis*	6.0	85%	1.0

4.2.2 Depth Extent of Vegetation

In 2024, vegetation with ≥ 10 % cover extended to an average depth of 4.4 m (range 3.3–4.8 m), compared with an average of 5.7 m in 2014 (Table 3). This reduction of more than one metre suggests decreased light penetration and increased turbidity, contracting the photic zone available for charophyte growth and other tupu wai.

Table 3: Average depth extent of aquatic vegetation in Lake Tahaaroa between 1983 and 2024.

Survey Year	Average Depth (m)
1983	–
2001	5.6
2007	3.3
2010	6.0
2014	5.7
2024	4.4

4.2.3 Aquatic-Plant Diversity and Distribution

Tupu wai

Dense charophyte meadows of *Chara australis* were observed at four of the five sites, forming beds of > 75 % cover between 2 – 4 m depth (Figure 7). *Nitella* sp. aff. *cristata* occurred at three sites in similar depth ranges. *Potamogeton ochreatus* (native pondweed) and *Myriophyllum triphyllum* (native milfoil) contributed additional structure, with localised patches of 5 – 75 % cover. Emergent *Typha orientalis* (raupoo) encircled much of the shoreline, extending to 1.3 m depth with cover up to 95 %. The dominance of charophytes indicates that portions of the lake still retain high ecological value despite declining depth extent.

Invasive Vegetation

Lagarosiphon major and *Elodea canadensis* were present at all sites, growing from approximately 1 m to 5 m depth and forming tall, canopy-like stands up to 1.8 m high (Figure 7). *Potamogeton crispus* was not observed in this lake. For the first time, Hornwort was detected at the outlet of Wainui Stream (38° 10' 18.65" S; 174° 42' 29.79" E). This species was absent from previous surveys and represents a new incursion of significant biosecurity concern.

It's also important to note that the location was outside of the five LakeSPI sites in Lake Tahaaroa.

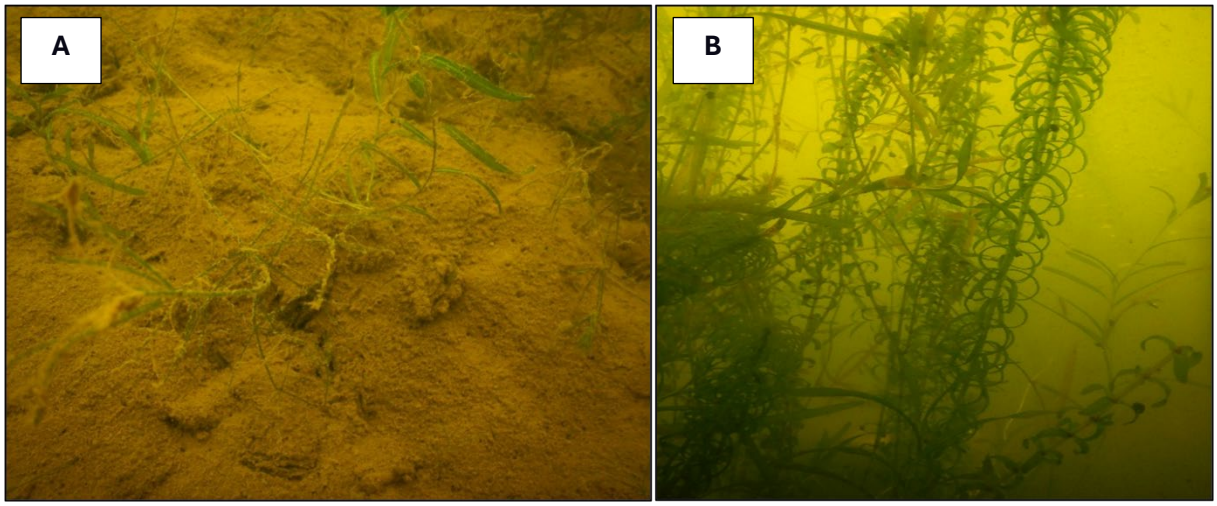


Figure 7: Photo A: Native pondweed (*Potamogeton ochreatus)* and sparse charophyte (*Chara australis)*. Photo B: Invasive *Lagarosiphon major* plant with a mix of native pondweed. [Photos: Inigo Zabarte-Maeztu, ESNZ]

4.2.4 LakeSPI Results

LakeSPI analysis indicates a gradual decline in the overall ecological condition of Lake Tahaaroa (Table 4, Figure 8). The Native Condition Index declined from 52 % (2014) to 38 % (2024), while the Invasive Impact Index remained stable at ≈ 68 %.

Table 4: Summary of LakeSPI results for Lake Tahaaroa (1983-2024), showing changes in overall LakeSPI Index, Native Condition, and Invasive Impact scores. Ecological status classifications are based on national LakeSPI thresholds.

Year	Ecological Status	LakeSPI Index (%)	Native Condition (%)	Invasive Impact (%)
1983	Moderate	43.2	58.3	66.7
2001	Moderate	39.1	48.3	70.4
2007	Moderate	36.8	42.5	63.0
2010	Moderate	33.6	45.0	77.0
2014	Moderate	40.0	52.5	67.4
2024	Moderate	33.2	37.5	68.1

These results highlight a persistent loss of native charophyte meadows and reduced water clarity, likely driven by nutrient enrichment and sediment resuspension. Although invasive dominance appears stable, the Hornwort detection signals an emerging high-risk phase for ecological degradation if unmanaged.

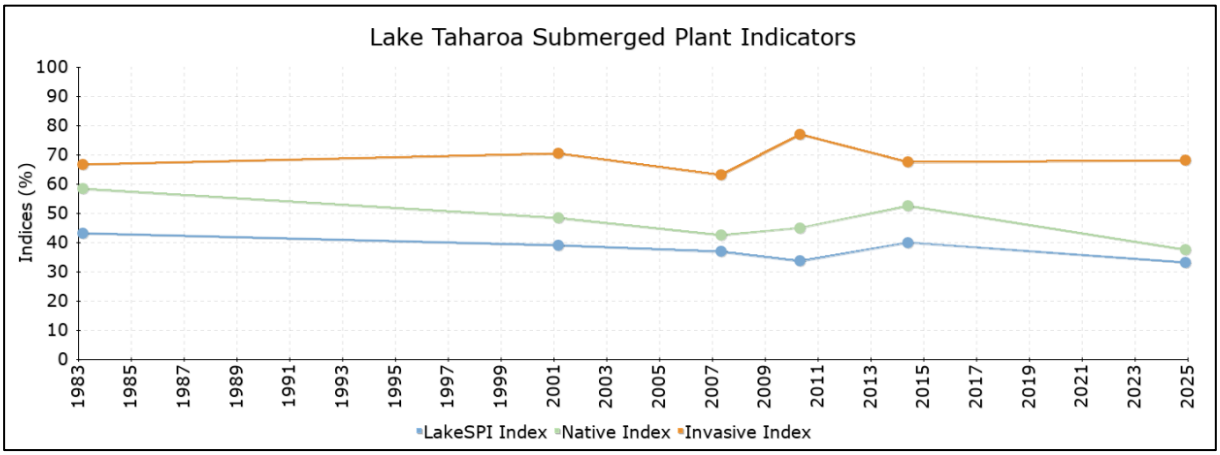


Figure 8: Summary of Lake Tahaaroa LakeSPI scores, expressed as a percentage, for surveys conducted between 1983 and 2024.

4.2.5 Summary

Lake Tahaaroa shows continuing stress, with reduced light penetration and contraction of charophyte beds. Invasive species dominate, and the recent detection of Hornwort presents a major biosecurity concern.

Sustained surveillance, collaborative biosecurity management, and proactive restoration of tupu wai are recommended to safeguard both the ecological integrity and cultural value of Lake Tahaaroa and the wider Tahaaroa lake system.

4.3 Lake Numiti

4.3.1 Site Conditions

Field surveys were conducted on 26 November 2024 under calm weather with light onshore wind. Surface water temperature averaged 19 °C and underwater visibility was consistently 0.5 m across all sites. The lakebed was composed mainly of soft, black, anoxic organic sediment, particularly near the southern and eastern margins. These conditions are likely to place additional stress on submerged vegetation by reducing light penetration and oxygen availability in the root zone.

Table 5 summarises the physical characteristics and vegetation recorded at each site. Widespread anoxic sediment and low clarity confirm continuing stress conditions that limit tupu wai recovery.

Table 5: Lake Numiti site details, native and invasive species recorded, substrate, maximum transect depth, vegetation cover and visibility (26 November 2024).

Site	Coordinates (NZTM)	Native Species	Invasive Species	Max Depth (m)	Total Veg. Cover	Visibility (m)
A	266 1745 E 633 4870 N	*Typha orientalis*, *Potamogeton ochreatus*	*Elodea canadensis*, *Lagarosiphon major*, *Potamogeton crispus*	5.0	80%	0.5

Site	Coordinates (NZTM)	Native Species	Invasive Species	Max Depth (m)	Total Veg. Cover	Visibility (m)
B	266 1537 E 633 4547 N	*Chara australis*, *Typha orientalis*, *Potamogeton ochreatus*	*Elodea canadensis*, *Lagarosiphon major*, *Potamogeton crispus*	5.0	90%	0.5
C	266 1715 E 633 4336 N	*Typha orientalis*, *Potamogeton ochreatus*	*Elodea canadensis*, *Lagarosiphon major*, *Potamogeton crispus*	5.3	85%	0.5
D	266 1866 E 633 4585 N	*Typha orientalis*, *Potamogeton ochreatus*	*Elodea canadensis*, *Lagarosiphon major*, *Potamogeton crispus*	5.6	75%	0.5
E	266 1541 E 633 4771 N	*Typha orientalis*, *Potamogeton ochreatus*	*Elodea canadensis*, *Lagarosiphon major*, *Potamogeton crispus*	5.0	80%	0.5

Overall, vegetation remained widespread but appeared shallower and less structurally complex than in earlier surveys.

4.3.2 Depth of Extent of Vegetation

The average maximum depth of submerged vegetation with ≥ 10 % cover in 2024 was 3.0 m, compared with 3.7 m in 2014 and 5.6 m in 1983 (Table 6). This long-term regression of approximately 2–3 m indicates a continuing loss of light penetration and increasing turbidity. Complete vegetative cover once extended through much of the water column but is now restricted to shallower margins.

Table 6: Average depth extent of aquatic vegetation in Lake Numiti between 1983 and 2024.

Survey Year	Average Depth
1983	5.6
2014	3.7
2024	3.0

4.3.3 Aquatic-Plant Diversity and Distribution

Tupu wai

Tupu wai was present at all sites but confined largely to shallower zones (< 3 m). *Potamogeton ochreatus* and emergent *Typha orientalis* dominated, forming patchy stands with moderate cover (50–90 %) (Figure 9). *Chara australis* was recorded only at one site, indicating localised survival of charophytes that once formed extensive meadows. Overall, native diversity remains lower than recorded in 2010–2014, with fewer species and reduced depth range.

Invasive Vegetation

Elodea canadensis, *Lagarosiphon major*, and *Potamogeton crispus* were abundant throughout the lake, occupying depths from 1–5 m and forming continuous beds with 70–95 % cover. These species frequently overtopped remaining tupu wai, restricting light availability and space for regeneration. Observations were recorded during the 2024 survey using a datasheet at each of the five sites within each lake (Figure 9).

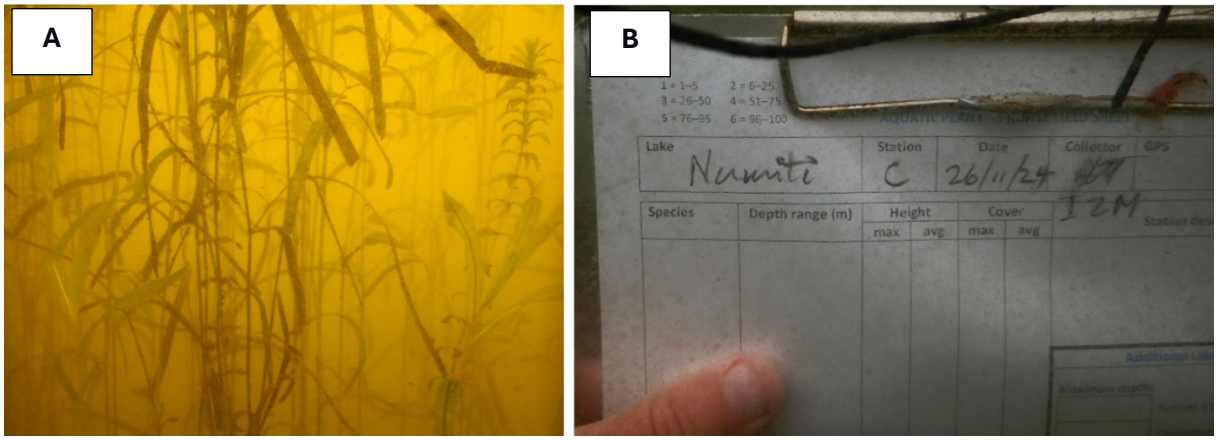


Figure 9: Photo A: Native pondweed *(Potamogeton ochreatus)* with invasive *Elodea canadensis* in the background. Photo B: Lake Numiti datasheet. [Photos: : Inigo Zabarte-Maeztu, ESNZ]

4.3.4 LakeSPI Results

The 2024 LakeSPI Index for Lake Numiti was 29 %, representing a decline of 10 % since 2014 (Table 7, Figure 10). The Native Condition Index decreased from 37 % to 30 %, indicating contraction of tupu wai and reduced diversity. Conversely, the Invasive Impact Index rose from 56 % to 66 %, reflecting greater dominance by *Lagarosiphon major* and *Elodea canadensis*. Ecological status therefore remains Moderate, though trending downward.

Table 7: Summary of LakeSPI results for Lake Numiti (2014–2024).

Year	Ecological Status	LakeSPI Index (%)	Native Condition (%)	Invasive Impact (%)
2014	Moderate	38.6	37.4	55.6
2024	Moderate	29.0	29.6	65.9

Figure 10 presents LakeSPI indices for Lake Numiti in 2014 and 2024, showing decline in native condition and increase in invasive impact. The downward trend in LakeSPI scores illustrates a steady decline in ecological condition over the past decade. If current patterns of invasive spread and sediment accumulation continue, long-term recovery of tupu wai may become increasingly difficult.

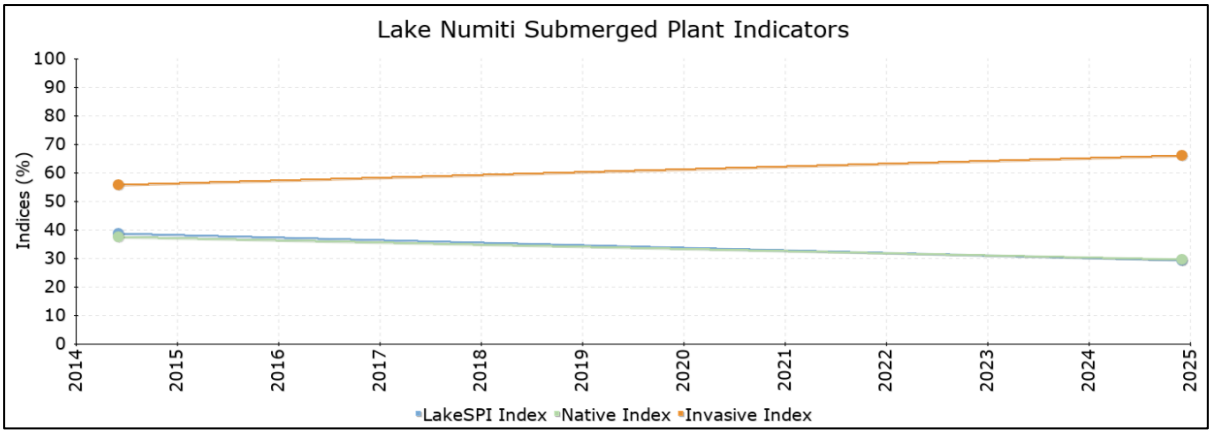


Figure 10: Summary of Lake Numiti LakeSPI scores, expressed as a percentage, for surveys conducted between 2014 and 2024.

4.3.5 Summary

Lake Numiti continues to decline, with shallow vegetation zones and high sediment accumulation limiting native recovery. Invasive macrophytes now dominate most of the lakebed, outcompeting native species and reducing biodiversity. Persistent anoxic sediments and low water clarity are likely contributing factors.

Without intervention to manage nutrient inputs and control invasive species, further ecological decline is expected. Sustained monitoring and collaborative management are recommended to protect the ecological integrity and cultural value of Lake Numiti.

4.4 Lake Rotoroa

4.4.1 Site Conditions

Field surveys at Lake Rotoroa were completed on 26 November 2024 under fine, calm weather with visibility for boating conditions. Surface-water temperature averaged 18 °C, and underwater visibility was approximately 0.5 m at all five sites. Substrates were composed mainly of fine sand and silt with occasional peat deposits in sheltered bays.

Compared with 2014, overall water clarity remained low, limiting the maximum depth of vegetation growth and contributing to an overall reduction in submerged-plant diversity. Table 8 summarises GPS coordinates, species recorded, substrate type, maximum transect depth, vegetation cover, and visibility. Observed turbidity and sediment composition indicate persistent light limitation across the littoral zone, although vegetation remains relatively stable compared with the previous survey.

Table 8: Lake Rotoroa site details, native and invasive species recorded, substrate, maximum transect depth, vegetation cover, and visibility (26 November 2024).

Site	Coordinates (NZTM)	Native Species	Invasive Species	Max Depth (m)	Total Veg. Cover	Visibility
A	266 1271 E 633 3926 N	*Chara australis*, *Potamogeton ochreatus*, *Typha orientalis*	Elodea canadensis	4.8	65%	0.5
B	266 1360 E 633 3742 N	*Potamogeton ochreatus*, *Typha orientalis*	*Elodea canadensis*, *Potamogeton crispus*	5.4	75%	—
C	266 1431 E 633 4191 N	*Potamogeton ochreatus*, *Typha orientalis*	*Elodea canadensis*, *Potamogeton crispus*	4.8	85%	0.5
D	266 1786 E 633 4398 N	*Potamogeton ochreatus*, *Typha orientalis*	*Elodea canadensis*, *Potamogeton crispus*	5.2	75%	0.5
E	266 1794 E 633 4274 N	*Chara australis*, *Myriophyllum triphyllum*, *Potamogeton ochreatus*, *Typha orientalis*	*Elodea canadensis*, *Potamogeton crispus*	3.0	80%	0.5

4.4.2 Depth Extent of Vegetation

In 2024, vegetation with ≥ 10 % cover extended to an average depth of 4.8 m, similar to the 2014 mean of 5.0 m (Table 9). The relatively stable depth range suggests that water clarity and light penetration have not worsened since the previous survey.

Table 9: Average depth extent of aquatic vegetation in Lake Rotoroa (2014-2024).

Survey Year	Average Depth (m)
2014	5.0
2024	4.8

4.4.3 Aquatic-Plant Diversity and Distribution

Tupu wai

Tupu wai remained widespread throughout Lake Rotoroa. *Potamogeton ochreatus* and *Typha orientalis* were present at all sites, forming moderate to high cover (65–85 %) in the littoral zone. *Chara australis* and *Myriophyllum triphyllum* occurred sporadically, mainly in shallower areas (≤ 3 m). Overall, native diversity shows a positive trend since 2014.

Invasive Vegetation

Elodea canadensis and *Potamogeton crispus* were recorded at four of the five survey sites (Figure 11). These species occurred between 3–5 m depth but were less dominant than in 2014, suggesting a gradual reduction in invasive cover. *Lagarosiphon major* were not observed in Lake Rotoroa during the 2024 survey.

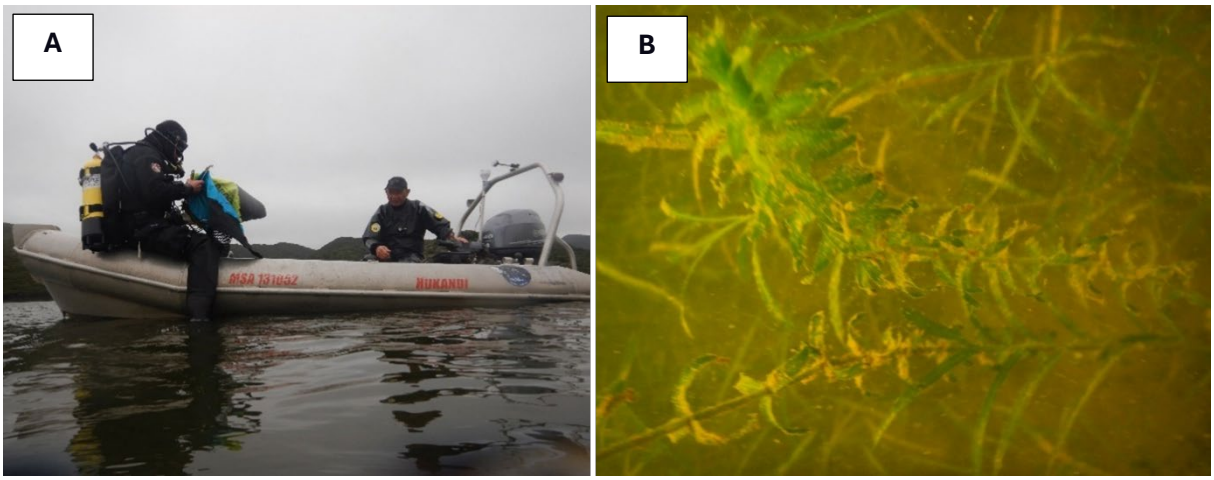


Figure 11: Photo A: Divers preparing to disembark the vessel to undertake LakeSPI survey in Lake Rotoroa. Photo B: Invasive species *Elodea canadensis* in shallows of Lake Rotoroa. [Photos: Inigo Zabarte-Maetzu, ESNZ]

4.4.4 LakeSPI Results

The LakeSPI Index for Lake Rotoroa in 2024 was 34 %, representing a 7 % increase from 2014 (Table 10; Figure 12). The Native Condition Index rose from 22 % to 34 %, indicating measurable improvement in tupu wai extent and quality. The Invasive Impact Index decreased from 69 % to 62 %, reflecting reduced dominance of *Elodea canadensis* and *Potamogeton crispus*. Overall ecological status therefore remains Moderate.

Table 10: Summary of LakeSPI results for Lake Rotoroa (2014-2024).

Year	Ecological Status	LakeSPI Index (%)	Native Condition (%)	Invasive Impact (%)
2014	Moderate	26.7	21.6	68.9
2024	Moderate	33.8	33.6	61.5

The upward trend in both LakeSPI and Native Condition indices suggests positive trend of tupu wai since 2014. Although overall ecological condition remains moderate, the reduction in invasive impact is encouraging and consistent with local kaitiaki observations of improved water clarity and vegetation balance. Figure 12 presents LakeSPI indices for Lake Rotoroa (2014 and 2024).

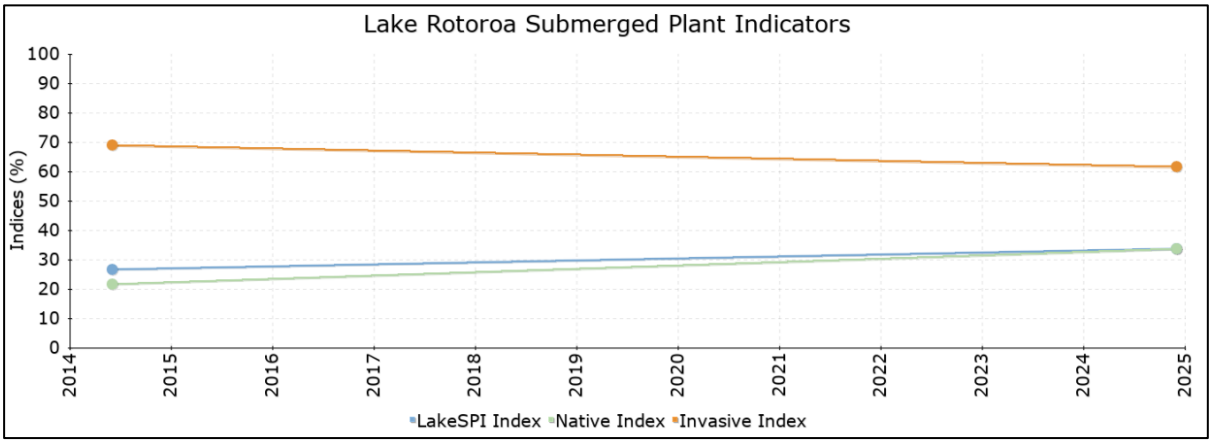


Figure 12: Summary of Lake Rotoroa LakeSPI scores, expressed as a percentage, for surveys conducted between 1983 and 2024.

4.4.5 Summary

Lake Rotoroa shows partial recovery, with expanding native vegetation and reduced invasive impact. Tupu wai has expanded slightly, and invasive dominance has declined. The absence of *Lagarosiphon major* was a positive development.

Continued surveillance, catchment-management efforts, and coordinated biosecurity measures are recommended to sustain recovery and prevent reinvasion by aquatic pests. With ongoing care and monitoring, Lake Rotoroa has the potential to serve as a model for ecological restoration within the Tahaaroa lake system.

5 Data Analysis

Across the Tahaaroa lakes, ecological condition remains within the mid-range LakeSPI band, but trajectories differ, two lakes are declining while one shows positive signs. These findings confirm the importance of continued kaitiaki-led monitoring and integrated management to restore ecological balance and uphold the mauri of the lake system. The following section interprets these results in relation to environmental drivers, cultural values, and management priorities, outlining recommended actions for restoration, biosecurity control, and long-term governance.

5.1 Overview

This section interprets long-term changes in tupu wai across the Tahaaroa lakes, drawing on ESNZ's LakeSPI dataset (1983–2024) to identify ecological trends and management implications. The analysis connects quantitative indices with field observations and tohu aa-hapuu, providing insight into how native and invasive species dynamics influence lake health and mauri.

Results from the LakeSPI survey provide a continuous record of vegetation condition spanning more than four decades. Patterns in biodiversity, ecological status, and functional change are examined at both lake and regional scales, and findings are interpreted in the context of management priorities for The Trust and the wider Ngaa taonga tuku iho o ngaa roto o Tahaaroa kaupapa.

5.2 Trends in Native and Invasive Species

ESNZ's online LakeSPI web-reporting system and databases archives data for Lakes Tahaaroa, Numiti and Rotoroa, providing long-term visibility of changes in submerged vegetation. The dataset confirms that native charophytes (*Chara australis, Nitella cristata*) and pondweeds (*Potamogeton ochreatus*) remain widespread, although their depth range and frequency have declined compared with earlier surveys (Table 11).

Invasive species have progressively expanded since the first records of *Elodea canadensis* in 1983. *Lagarosiphon major* became established by 2007 and is now dominant in two of the three lakes. *Potamogeton crispus* occurs intermittently, while Hornwort was detected for the first time in 2024 at the outlet of Lake Tahaaroa (Wainui Stream). The incursion of Hornwort marks an escalation in invasion risk because of its capacity to tolerate low light, reproduce vegetatively, and form dense canopies that exclude tupu wai.

Table 11: Native and invasive species recorded in the Tahaaroa lakes (1983-2024).

Year	Native Species Recorded	Invasive Species Recorded
1983	*Chara australis*, *Myriophyllum triphyllum*, *Potamogeton ochreatus*	*Elodea canadensis*, *Ranunculus trichophyllus*
2007	+ *Nitella cristata*, *Typha orientalis*	+ *Lagarosiphon major*, *Potamogeton crispus*
2010	+ *Eleocharis sphacelata*, *Chara globularis*	*Elodea canadensis*, *Lagarosiphon major*, *Potamogeton crispus*

Year	Native Species Recorded	Invasive Species Recorded
2014	same as 2010	*same as 2010*
2024	Same as 2014	+ *Ceratophyllum demersum (Hornwort)*

Interpretation

Tupu wai remains diverse but is increasingly confined to shallower depths, reflecting declining light penetration and sediment accumulation. Invasive macrophytes now dominate large portions of each lake, reducing habitat quality for native species and altering ecosystem function. Hornwort's detection represents a high-priority biosecurity issue requiring early-response management.

5.3 Aquatic Plant Categories and Ecological Function

Aquatic plants fulfil critical ecological functions within dune-lake ecosystems. They stabilise sediment, filter and recycle nutrients, oxygenate water, and provide habitat for tuna, kaiaua, and other taonga species. Their decline has cascading effects on water quality and biodiversity. Aquatic plants can be grouped by growth form and position in the water column (Table 12).

Table 12: Functional categories of aquatic plants recorded in the Tahaaroa lakes (2024).

Category	Native Species (2024)	Invasive Species (2024)
Emergent	*Typha orientalis*, *Eleocharis sphacelata*	–
Submerged	*Chara australis*, *Chara globularis*, *Nitella* sp. aff. *cristata*, *Myriophyllum triphyllum*, *Potamogeton ochreatus*	*Elodea canadensis*, *Lagarosiphon major*, *Potamogeton crispus*, *Ceratophyllum demersum*

The loss of deep-water charophyte meadows has reduced sediment binding and light availability, increasing vulnerability to turbidity and eutrophication. At the same time, canopy-forming invasives such as *Lagarosiphon major* intensify shading, further suppressing native regeneration and disrupting ecosystem balance.

5.4 National and Regional LakeSPI Rankings

5.4.1 National Context

As of 2024, 314 lakes across Aotearoa have been assessed using LakeSPI. Lake Tahaaroa ranks 176th, Lake Numiti 186th, and Lake Rotoroa 207th (Figure 13). These positions place the Tahaaroa lakes in the moderate condition band, with LakeSPI scores between 25–50 %. Nationally, only about 14 % of assessed lakes fall into the *excellent* category, emphasising the relative vulnerability of dune lakes such as those at Tahaaroa.

5.4.2 Regional Context

Within the Waikato Region, where 69 lakes have been assessed, the Tahaaroa lakes rank among the upper third for ecological condition: Tahaaroa 14th, Numiti 16th, and Rotoroa 20th (Figure 14). Their continuing moderate status reflects the persistence of tupu wai but also the growing dominance of invasive species and catchment-driven nutrient enrichment.

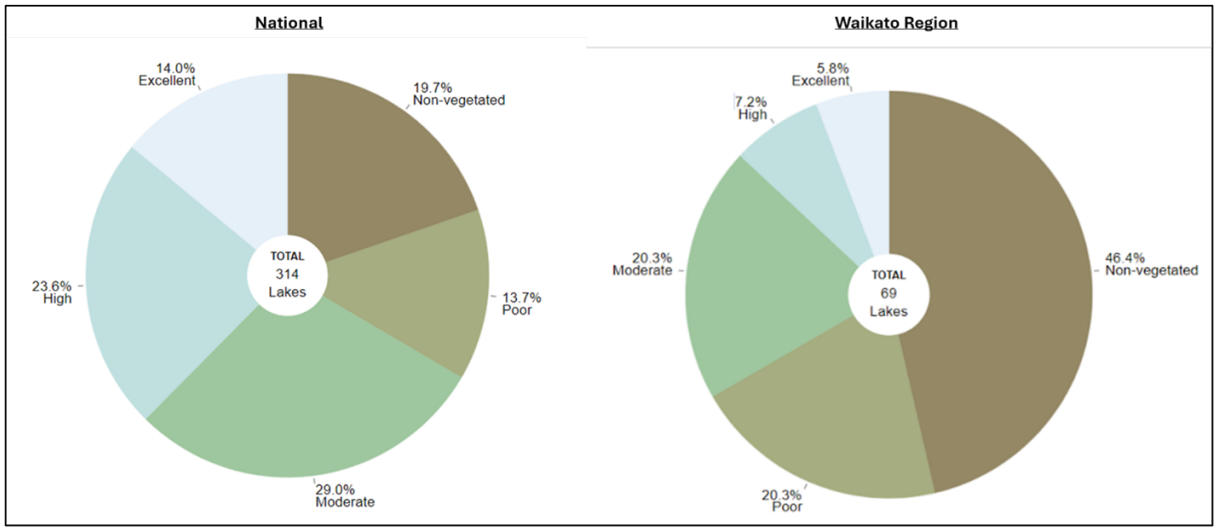


Figure 13: Distribution of LakeSPI ecological-condition classes for 314 lakes assessed nationally and 69 lakes within the Waikato Region.

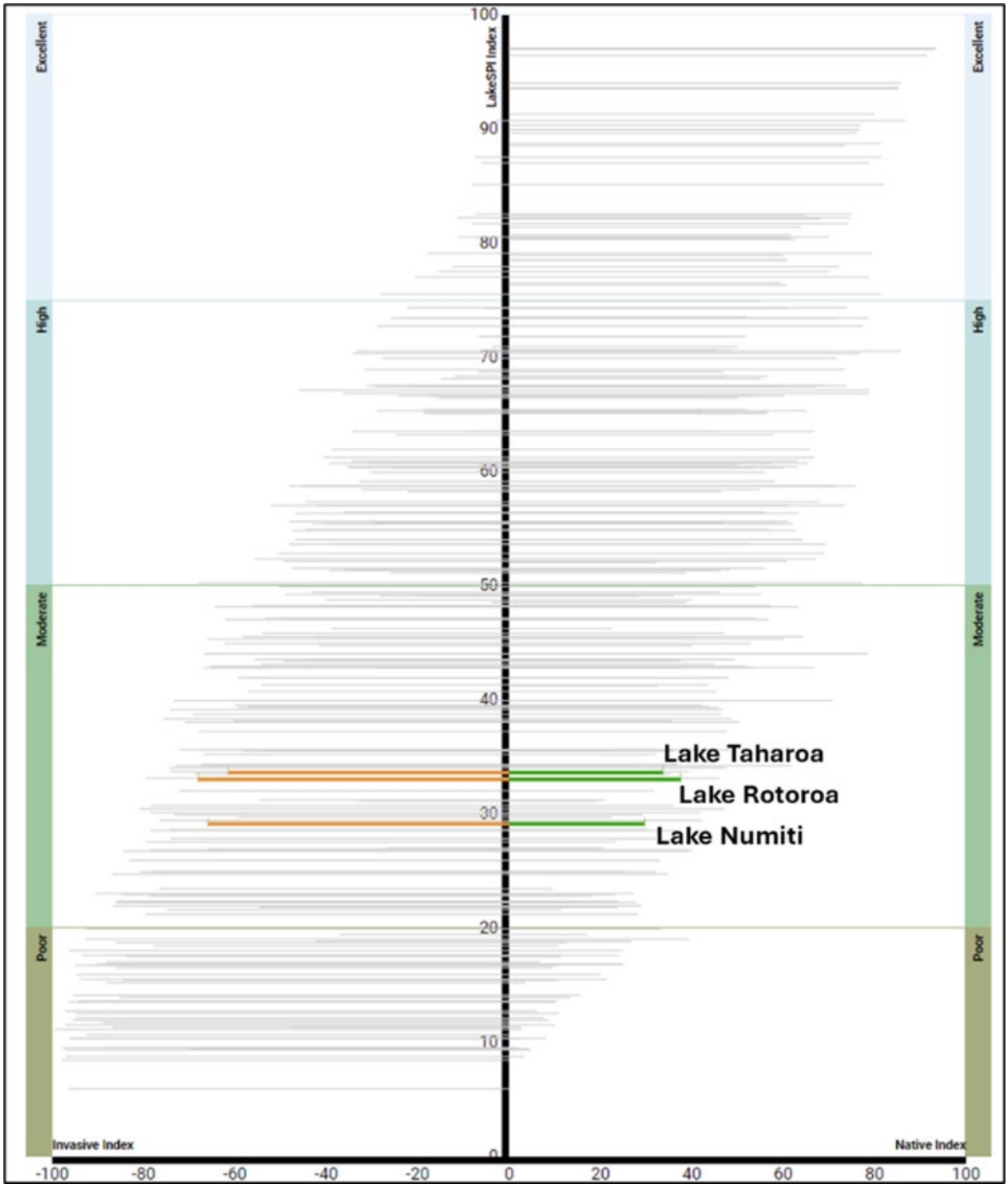


Figure 14: Latest LakeSPI indices for 314 lakes showing Native Condition Index (right axis) and Invasive Impact Index (left axis). The Tahaaroa lakes fall within he moderate-condition cluster.

Interpretation

The Tahaaroa lakes remain regionally significant as some of the larger and more intact dune lakes in Waikato. Their rankings indicate that they still support functioning tupu wai but are trending downward relative to less-disturbed systems. Continued monitoring and early pest control are required to prevent further decline and to maintain their moderate ranking.

5.5 Summary and Implications

Analysis of long-term LakeSPI record for the Tahaaroa lakes identifies the following key insights and implications.

Key findings

- Native persistence: Despite pressures, native charophyte and pondweed communities continue to provide ecological stability.
- Progressive invasion: Invasive species have expanded steadily, with *Lagarosiphon major* and *Elodea canadensis* now ubiquitous and Hornwort newly detected.
- Functional decline: Loss of deep-water charophyte meadows has reduced sediment binding and water clarity, increasing vulnerability to eutrophication.
- Moderate yet vulnerable: All three lakes remain in the moderate ecological category, underscoring both their resilience and their susceptibility to further degradation.

Management implications

- Implement rapid containment and eradication of Hornwort.
- Continue suppression of *Lagarosiphon major* and *Elodea canadensis* through coordinated biosecurity programmes.
- Reduce nutrient and sediment inflows from surrounding catchments.
- Strengthen kaitiaki-led surveillance and integrate cultural and scientific monitoring data via the ESNZ LakeSPI web portal.

Cultural framing

Restoring and strengthening tupu wai is fundamental to re-establishing the mauri of the Tahaaroa lake system. These analytical results provide a robust evidence base for decision-making under Ngaa taonga tuku iho o ngaa roto o Tahaaroa and for future collaborative management with regional and national partners.

These results provide a quantitative foundation for Tahaaroa Lakes Trust management planning. Priority actions include containment of Hornwort, suppression of invasive macrophytes, and catchment measures to reduce nutrient and sediment inputs. Strengthened kaitiaki-led surveillance and data integration through ESNZ LakeSPI web portal will enable ongoing tracking of change and support restoration of the mauri of the Tahaaroa lake system.

6 Discussion

6.1 Overview

This section interprets the results of the 2024 LakeSPI surveys for Lakes Tahaaroa, Numiti, and Rotoroa, exploring the ecological and cultural implications of observed changes in aquatic vegetation. The discussion integrates long-term data trends, kaitiaki observations, and known drivers of change to highlight management priorities for restoring the mauri of the Tahaaroa lake system.

The interpretation of results is informed by He Anga Aroturuki Wai Maaori, which recognises that the condition of the roto reflects the balance across Pou Taiao, Pou Taangata, and Pou Taawhirimatea. When the flow of Ngaa Hau o te Hauaauru; kaitiakitanga, hauora, auahatanga, tuakiritanga, kotahitanga, and maatauranga are disrupted, the mauri of the lakes diminishes. Conversely, positive trends of tupu wai, signal the return of mauri across these dimensions.

This discussion therefore aligns with the guiding principles of 'Ngaa Hau o te Hauaauru', balance, renewal, and interconnected wellbeing between people, water and place.

6.2 Patterns of Change in Aquatic Vegetation

Pou Taiao focuses on the health and balance of the natural world, the integrity of ecosystems, the vitality of tupu wai, and the conditions that sustain mauri across the roto.

The 2024 survey confirms that the Tahaaroa lakes continue to support diverse tupu wai vegetation but show ongoing decline in depth extent and species richness relative to earlier surveys. Native charophytes such as *Chara australis* and *Nitella* sp. aff. *cristata* remain key components of the lake ecosystems, but their vertical and spatial coverage has contracted since 2014. The reduction of tupu wai vegetation signals stress within the Pou Taiao domain, a weakening of the ecological foundations that maintain clarity, stability, and biodiversity.

In contrast, invasive species particularly *Lagarosiphon major* and *Elodea canadensis,* have expanded their dominance across all three lakes, displacing native communities and altering ecological processes. The recent detection of Hornwort at the outlet of Lake Tahaaroa represents a further disruption to Pou Taiao, as it threatens to overwhelm remaining tupu wai and reduce habitat quality for taonga species.

While all three lakes remain in the *moderate* ecological category, their trajectories differ:

- Lake Tahaaroa shows signs of decline relative to 2014.
- Lake Numiti continues to deteriorate.
- Lake Rotoroa appears stable but remains vulnerable.

From a Pou Taiao perspective, these differences illustrate both vulnerability and resilience within the lake system. The persistence of tupu wai vegetation, though diminished, shows that the potential for mauri remains, if pressures can be reduced and balance restored between native and invasive species.

6.3 Drivers of Change

Pou Taawhirimatea represents the influence of natural forces; wind, rain, light, and climate, that shape the lakes' behaviour and resilience. Within He Anga Aroturuki Wai Maaori, this pou reminds us that the balance of mauri is continually tested by both environmental variability and human activity.

6.3.1 Catchment Pressures

The primary drivers of declining tupu wai are nutrient enrichment, sedimentation, and reduced water clarity, largely influenced by catchment land use. Elevated total nitrogen (TN) and total phosphorus (TP) promote algal and weed growth, reducing the light available to support submerged vegetation (Dean-Speirs et al. 2014). Sediment inputs from stock access and erosion smother charophyte beds and limit seedbank viability (Bayler et al. 2020). These pressures represent sustained disturbance within Pou Taawhirimatea, disrupting the natural cycles of wind, light, and water movement that once maintained balance in the roto.

6.3.2 Biological Interactions

Once established, invasive macrophytes form dense canopies that trap sediments and further reduce light, reinforcing a self-perpetuating feedback loop. *Lagarosiphon major* and *Elodea canadensis* have become entrenched under these conditions, and the recent detection of Hornwort signals potential for rapid expansion due to its high growth rate and tolerance of low light (Champion et al. 2019). Such shifts indicate how Pou Taawhirimatea can become unbalanced when ecological processes are altered by introduced species.

6.3.3 Climate and Hydrological Variability

Increasing air temperatures and fluctuating lake levels associated with climate variability are also influencing plant community composition. Extended periods of low water level can expose shallow charophyte beds to desiccation, while rapid refilling introduces turbidity and nutrient loading. These climatic shifts intensify existing nutrient and sediment pressures, creating compounding stress across Pou Taawhirimatea.

From a He Anga Aroturuki Wai Maaori perspective, the resilience of Pou Taawhirimatea lies in restoring harmony between these natural forces and human activity. Efforts to stabilise sediments, reduce nutrient inflows, and control invasive species will help re-establish the environmental rhythms through which mauri can return to the Tahaaroa lakes.

6.4 Cultural Interpretation of Mauri

Pou Taangata acknowledges the relationships between people, the roto, and the life that depends on them. Within He Anga Aroturuki Wai Maaori, this pou reminds us that the wellbeing of the lakes and the wellbeing of the people are inseparable; when one thrives, so too does the other.

From the perspective of Ngaati Mahuta, the condition of tupu wai is a direct reflection of the health, balance, and mauri of the roto. Native charophyte meadows are declining while invasive species continue to spread. Together these changes weaken the mauri of the roto and signal ecological imbalance.

Although LakeSPI results for Lake Rotoroa suggest a positive trend, field observations during the 2024 survey indicated reduced clarity, high kaiaua mortality and fine, organic-rich sediment. This suggests that parts of the lakebed may experience low-oxygen or intermittently anoxic conditions, particularly in deeper zones where circulation is limited.

In this context, mauri tuu which is a state of standing but not yet thriving, more accurately reflects the lake's condition than mauri ora. It recognises the lake's resilience and capacity for renewal while acknowledging that continued turbidity and sediment stress limit full ecological and spiritual vitality.

> *Ngaati Mahuta understand lake health not only through scientific measures, but through the condition and behaviours of taonga species, seasonal patterns, and the mauri of places. This knowledge is embedded in the lived experience of whaanau who actively engage with the lakes for kai, waananga, and ceremony.*
> — Herangi et al. 2025a.

Within Pou Taangata, this interpretation also affirms the role of people in supporting that recovery. The active participation of kaitiaki in survey planning, monitoring, and interpretation demonstrates kaitiakitanga in action, sustaining community identity and wellbeing while helping guide the lake toward mauri ora in the future.

The alignment between the mauri assessment framework and LakeSPI indices provides a clear bridge between cultural and scientific perspectives. For instance, lakes assessed as mauri tuu or mauri kino generally correspond with moderate LakeSPI scores (20–50 %), reflecting systems that retain some ecological function but are under stress from invasive species and nutrient pressure. By contrast, mauri ora or mauri kaha conditions would be expected where LakeSPI indices exceed 50 %, indicating clearer water, deeper native-plant beds, and balanced ecological processes. Integrating both measures enables kaitiaki and scientists to interpret lake health holistically, linking the flow of mauri with quantifiable ecological trends.

6.5 Management Implications

The integration of Pou Taiao, Pou Taangata, and Pou Taawhirimatea provides a holistic lens through which to interpret management needs for the Tahaaroa lakes. Within He Anga Aroturuki Wai Maaori, these pou are not separate domains but interwoven dimensions of one system, the environment, the people, and the forces that bind them through mauri.

6.5.1 Restoring Balance in Pou Taiao – Stewardship of the Environment

The continued dominance of invasive species and declining native vegetation depth limits reflect imbalance within Pou Taiao. Protecting and re-establishing tupu wai must remain a central management priority. Containment of Hornwort and control of *Lagarosiphon major* and *Elodea canadensis* are critical for preventing further ecological degradation. Restoring clear-water conditions through catchment management, reducing sediment and nutrient inputs, will allow tupu wai to recover and re-anchor mauri within the physical landscape.

6.5.2 Strengthening Pou Taangata – Wellbeing of People

Active participation of Ngaati Mahuta kaitiaki in monitoring, decision-making, and restoration reaffirms that people are part of the solution, not separate from it. Supporting hapuu-led monitoring, waananga, and the use of the Rongo App Mauri Assessment Framework will continue to build capability and intergenerational knowledge. This work expresses kaitiakitanga, nurtures hauora and tuakiritanga, and restores the cultural relationships that give the lakes meaning and identity.

> *The Trust asserts that all information and data generated from research... constitutes taonga and remains under the stewardship of the Trust... Effective collaboration must begin with recognition of the Trust's authority to lead research agendas.*
> — Herangi et al. 2025a.

6.5.3 Stabilising Pou Taawhirimatea – Balance and Adaptation

Climate and hydrological variability continue to influence the lakes' stability. Future management should account for seasonal and long-term climatic effects, including temperature increases, fluctuating lake levels, and extreme weather events. Riparian and wetland buffers, sediment controls, and adaptive management plans will help absorb these impacts. In He Anga Aroturuki Wai Maaori, restoring Pou Taawhirimatea means working with, rather than against, the natural rhythms of wind, water, and weather.

6.5.4 Weaving the Pou Together – Towards Mauri Ora

When these three pou are strong and balanced, the six hau of Ngaa Hau o te Hauaauru; kaitiakitanga, hauora, auahatanga, tuakiritanga, kotahitanga, and maatauranga, can flow freely across the landscape. Management actions therefore need to be coordinated, not isolated: ecological restoration should enhance community wellbeing, and cultural practice should guide environmental decision-making. Reinforcing this balance is the pathway to mauri ora; a living, resilient lake system sustained through unity of science, maatauranga, and the collective purpose of Ngaati Mahuta.

6.5.5 Biosecurity and invasive control

The discovery of Hornwort represents a significant escalation in biosecurity risk for the entire Tahaaroa lake complex. Immediate containment and eradication efforts are required to prevent its spread into connected lakes.

Management of Hornwort and *Lagarosiphon major* should align with the WRPMP 2022–2032 (Waikato Regional Council, 2022), which classifies both species as Exclusion or Eradication pests within high-value freshwater ecosystems. Under this plan, the Tahaaroa lakes are identified as a priority management zone for aquatic-pest surveillance and control.

Mechanical weed-harvesting equipment has been widely used in the Te Arawa Lakes for the management of invasive macrophytes such as Hornwort and Lagarosiphon major (BOPRC, 2020). The BOPRC-owned Aquarius HM420 harvester operates across multiple freshwater systems and was photographed at the Tahaaroa ironsand mine site in 2020 (Figure 15). While there is no evidence directly linking harvesting activities to the introduction of Hornwort into the Wainui Stream (and subsequently Lake Tahaaroa), the movement of weed harvesters between catchments represents a recognised biosecurity risk (de Winton et al. 2009).

Under the Biosecurity Act 1993, all aquatic-plant control operations must follow strict cleaning and decontamination protocols. However, given that Hornwort fragments can remain viable for extended periods and establish from small pieces, machinery movement remains a plausible vector. This reinforces the need for the Trust to implement localised “Check, Clean, Dry” protocols and require certified decontamination for any external contractors operating within the Taharoa lake system.

In accordance with the plan’s objectives, response actions should include:

- Delimiting surveys to confirm the extent of Hornwort.
- Containment and physical removal where feasible, under WRC and MPI biosecurity guidance.
- Cleaning and decontamination protocols (“Check, Clean, Dry”) for boats, trailers, and field gear.
- Public and kaitiaki awareness campaigns to reduce risk of spread between lakes.
- Data sharing with WRC’s Biosecurity and Biodiversity teams to maintain coordinated surveillance records.

This alignment ensures that local management responses are regionally consistent and benefit from access to WRC’s biosecurity expertise, technical resources, and regulatory framework. It also reinforces the Trust’s role as a partner in implementing pest-management objectives under Section 100 of the Biosecurity Act 1993, which supports iwi collaboration in managing taonga species and ecosystems.

Figure 15: Bay of Plenty Harvester operating in Wainui Stream outlet to Lake Tahaaroa for Taharoa Ironsand Ltd, demonstrating potential pathways for the spread of invasive macrophytes such as Hornwort and *Lagarosiphon major* through shared machinery and water movement. Source https://atlas.boprc.govt.nz/api/v1/edms/document/A3545264/content [Photo: Howard Emery]

6.5.6 Restoration and monitoring

Enhancing riparian and wetland buffers would help intercept nutrient and sediment runoff, improving light conditions for submerged vegetation. Re-establishing native charophyte meadows should be prioritised to stabilise sediments and suppress algal blooms. Continued annual or biennial LakeSPI assessments will provide quantitative measures of recovery, while maatauranga-based indicators such as changes in water smell, clarity, and sound should remain central to monitoring frameworks.

6.5.7 Integration with catchment management

Results should feed directly into The Trust's CMP. Collaborative management with Waikato Regional Council (WRC), ESNZ, and kaitiaki can ensure that invasive-species control and nutrient management are aligned across both science and tikanga perspectives.

6.5.8 Integration with Regional Policy

Collaboration with WRC and MPI/Biosecurity New Zealand ensures consistency with regional objectives, access to technical expertise, and eligibility for national eradication support. Integration with the Trust's CMP ensures that these regulatory tools are applied within a kaitiaki-led and tikanga-based framework.

6.6 Summary

The Tahaaroa lakes remain ecologically and culturally significant taonga. Despite sustained pressures, tupu wai persist, offering a foundation for recovery. However, the spread of invasive species, particularly Hornwort, signals an urgent need for collective and proactive management (Table 13).

Reconnecting science with maatauranga Maaori through kaitiaki-led monitoring and restoration provides the most effective pathway to advance from dying (mauri mate) to thriving (mauri kaha) and ensuring that the lakes of Tahaaroa continue to support life, identity, and wellbeing for generations to come.

Table 13: Summary of key messages from the Discussion chapter highlighting ecological condition, environmental pressures, management priorities, and cultural significance for the Tahaaroa lakes system.

Theme	Key Message
Ecological condition	The Tahaaroa lakes remain in moderate ecological condition. Native tupu wai persist but are increasingly confined to shallower margins.
Invasive species	*Lagarosiphon major* and *Elodea canadensis* dominate across all lakes, while newly detected Hornwort poses a high-risk incursion requiring immediate containment.
Environmental pressures	Nutrient enrichment, sedimentation, and declining clarity are primary drivers of ecological stress, compounded by climate variability and invasive feedback loops.
Restoration potential	Positive signals in Lake Rotoroa demonstrate the potential for mauri ora when catchment and biosecurity pressures are reduced.

Theme	Key Message
Management priorities	Urgent Hornwort response, invasive-species control, riparian restoration, and strengthened kaitiaki-led monitoring are central to protecting the lakes' ecological and cultural integrity.
Cultural significance	The health of tupu wai reflects the mauri of the roto. Restoring balance between people, water, and tupu wai is key to sustaining wellbeing for future generations of Ngaati Mahuta.

7 Management and Recommendations

This section builds on the findings of the 2024 Status of Macrophytes in Lakes Tahaaroa, Numiti and Rotoroa survey and sets out a pathway for restoration and co-management actions that give practical effect to He Anga Aroturuki Wai Maaori. It translates the principles of the three Pou; Pou Taiao, Pou Taangata, and Pou Taawhirimatea into coordinated actions that uphold Ngaa Hau o te Hauaauru: kaitiakitanga, hauora, auahatanga, tuakiritanga, kotahitanga, and maatauranga.

These recommendations are guided by the vision of The Trust:

Tahaaroa Lakes Trust Vision

E rere ana te mauri o ngaa wai o ngaa roto o Tahaaroa hei oranga moo te roto, moo ngaa koiora katoa, moo te whenua, moo te tangata, aa, hei painga hoki moo ngaa uri whakaheke o Ngaati Mahuta ki te Hauaauru.

The mauri of the waters of the Tahaaroa lakes flows to sustain the lake, all living beings, the land, and the people, and to uphold the wellbeing of future generations of Ngaati Mahuta ki te Hauaauru. — (Herangi et al. 2025a)

This vision expresses the interdependence between ecological integrity and cultural wellbeing. It provides the guiding kaupapa for all recommendations that follow, ensuring that management actions enhance not only the physical condition of the roto but also the mauri that binds lake, land, and people.

7.1 Monitoring and Ecological Condition

Pou Taiao focuses on restoring the integrity of the natural world, the ecological health of the roto, the vitality of tupu wai, and the conditions that sustain mauri ora within the lake system. LakeSPI results show differing ecological trends across the Tahaaroa lakes, with one showing stability, one gradual decline and one continuing degradation. While LakeSPI scores suggest a marginal improvement in Lake Rotoroa since 2014, other observations such as high kaiaua mortality and sediment substrate reveals a more complex picture of underlying stress. This highlights the importance of interpreting scientific indices alongside biological and cultural indicators to provide a fuller understanding of lake health.

Key findings are summarised below:

- **Native vegetation:** Charophytes (*Chara australis, Nitella* sp. aff. *cristata*), milfoils (*Myriophyllum triphyllum)* and pondweeds (*Potamogeton ochreatus*) persist but are increasingly confined to shallow margins due to declining clarity and sediment accumulation.
- **Invasive species:** *Lagarosiphon major* and *Elodea canadensis* dominate submerged vegetation across all lakes. Hornwort was newly detected at the outlet of Lake Tahaaroa.
- **Environmental pressures:** Nutrient enrichment, sediment inputs, and low light availability are the main stressors limiting native-plant recovery. Anoxic sediments in Lake Numiti further stress submerged vegetation.

- **Cultural interpretation:** The vigour of tupu wai reflects the strength of mauri within Pou Taiao. Decline signals imbalance and loss of vitality.

These findings show that Pou Taiao is under continued pressure. Apparent stability in vegetation cover does not necessarily equate to ecosystem recovery. Restoration under Pou Taiao must therefore address not only plant composition but also sediment quality, nutrient inflows, and habitat conditions critical for taonga species such as kaiaua and tuna.

7.2 Biosecurity and Species Containment

The detection of Hornwort represents a significant escalation in biosecurity risk for the entire Tahaaroa lake complex, containment and eradication an immediate priority. Preventing further spread is essential to maintaining Pou Taiao, the integrity of native habitats, tupu wai, and the mauri of the roto.

7.2.1 Potential Pathways of Introduction

Mechanical weed-harvesting operations are a recognised vector for the transfer of aquatic weeds between catchments. Such equipment has been widely used in the Te Arawa lakes to manage invasive macrophytes including Hornwort and *Lagarosiphon major* (BOPRC, 2020). The Bay of Plenty Regional Council's harvester, shown in Figure 10, was photographed at the Tahaaroa Ironsand mine site in 2020. While there is no direct evidence linking that activity to the 2024 Hornwort incursion at Lake Tahaaroa, the movement of the weed harvester between regions is a plausible introduction pathway, which has been apparent for aquatic weed incursions elsewhere (de Winton et al. 2009).

Hornwort spreads easily through small viable fragments. To mitigate this risk, all equipment operating within the Tahaaroa lakes should be subject to certified decontamination and the "Check, Clean, Dry" protocol before and after use. Strengthening these biosecurity controls will help protect tupu wai integrity and sustain the flow of mauri within Pou Taiao.

7.2.2 Legislative and National Frameworks Relevant to Hornwort

Ceratophyllum demersum is currently ranked as New Zealand's worst submerged weed (Champion et al. 2014) which, together with Lagarosiphon major, has been designated an UO under the Biosecurity Act 1993 as a pest capable or potentially capable of causing unwanted harm to natural and physical resources. In recognition that they could seriously damage the New Zealand economy and environment, these UO species are included under the NPPA, meaning they cannot be distributed or sold in New Zealand.

Ngā Riha Wai Māori freshwater pests programme is focussed on managing invasive freshwater species. This programme includes hornwort as a national priority species[1]. Objectives under this programme have direct relevance for hornwort management at the Tahaaroa Lakes[2].

The National Policy Direction for Pest Management[3] identifies five intermediate outcomes from management plans: exclusion, eradication, progressive containment, sustained control and protecting values in places. Outcomes with relevance to the Tahaaroa Lakes is that pests such

[1] https://www.doc.govt.nz/globalassets/documents/conservation/land-and-freshwater/freshwater/nga-riha-wai-maori/mapping-the-incorporation-of-te-ao-maori-in-the-freshwater-biosecurity-system.pdf
[2] https://www.doc.govt.nz/globalassets/documents/conservation/land-and-freshwater/freshwater/nga-riha-wai-maori/nga-riha-wai-maori-national-strategy.pdf
[3] https://www.mpi.govt.nz/dmsdocument/9464-National-Policy-Direction-for-Pest-Management-2015

as hornwort that are capable of causing damage are excluded or eradicated, or contained, reduced, or controlled to an extent that protects values of the lakes.

Hornwort is listed in Regional Pest Management Plans (RPMP) for eight regional councils and organism of interest for a further four regions[4]. Although hornwort is not included in the RPMP for Waikato region, there are provisions for the development of agreements for the effective management of pests to protect the values of specific sites, such as in site-led programmes.

7.2.3 Alignment with National and Regional Frameworks

The Department of Conservation's NRWMS 2023-2050 provides an active national framework guiding surveillance, research, and control of invasive freshwater species with hornwort being a priority pest for management (Doc, 2023). The strategy emphasises collaborative management with iwi, hapuu, and community partners, integrating maatauranga Maaori into freshwater biosecurity responses. Alignment with the Trust's actions contribute to a coordinated effort to protect tupu wai and uphold the mauri in freshwater ecosystems.

Recommend Actions

- Implement containment and eradication in line with the Biosecurity Act 1993, NPPA and NRWMS.
- Undertake delimiting surveys at Wainui Stream and adjoining wetland margins.
- Install signage and cleaning stations and prepare an Aquatic Pest Response Plan for The Trust.
- Engage kaitiaki and community through awareness initiatives such as "Check, Clean, Dry."

These activities uphold Pou Taiao by protecting the integrity of the lakes' ecological systems, reducing risk pathways, and preventing further spread of invasive species that threaten both tupu wai and mauri ora.

7.3 Maatauranga Maaori and Cultural Indicators

Building on the framework established in Ngaa taonga tuku iho o ngaa roto o Tahaaroa, this section integrates maatauranga Maaori indicators that guide kaitiaki in assessing the health and vitality of the roto alongside scientific measures such as LakeSPI indices. Within He Anga Aroturuki Wai Maaori, these indicators sit within Pou Taangata, acknowledging that people, place, and mauri are inseparable, when the wellbeing of the lakes improves, so too does that of the community (Table 14).

> *Tohu as a legitimate and necessary basis for environmental monitoring... changes in water clarity, abundance or absence of specific species, shifts in bird and insect behaviour, and other sensory or experiential markers that signal imbalance or resilience.*
> — Herangi et at., 2025a.

[4] https://pce.parliament.nz/media/fx4pjock/hutchison-et-al-review-of-weed-management-programmes-pdf-6mb.pdf

Table 14: Cultural indicators used by kaitiaki to interpret lake health.

Tohu/Indicator	Description and Expression	Scientific Link
Mauri of the roto	Assessed through clarity, smell, and the energetic feel of the water, whether it is waiora (life-giving) or waikino (degraded).	Aligns with LakeSPI native and invasive indices, and water-quality parameters influencing clarity.
Tupu wai (tupu wai)	The presence, vigour, and diversity of native *tupu wai* such as *Chara australis* and *Nitella cristata* are interpreted as signs of balance and vitality.	Correlates with LakeSPI Native Condition Index and light-penetration data.
Whakapapa and koorero tuku iho	Historical knowledge, stories, and names associated with each roto reflect ongoing relationships and responsibilities to care for these taonga.	Provides context for long-term management and restoration priorities.
Taonga species (tuna, kaiaua)	Changes in abundance, behaviour, or accessibility of these species indicate shifts in ecological balance and mauri.	Links to companion tuna and kaiaua research programmes.
Wairua o te roto	The overall sense of peace, vitality, and energy experienced during engagement with the lake, observed during karakia, waiata, or monitoring activities.	Provides qualitative corroboration of physical and biological metrics.

These tohu provide the cultural dimension of monitoring under Pou Taangata, allowing kaitiaki to read signs of imbalance or renewal that may not be visible through scientific measures alone.

7.3.1 Mauri Assessment Framework

Building on the CMP, The Trust now applies a Mauri Assessment Framework through the Rongo App to evaluate the health and vitality of each lake using six mauri states. These provide a standardised cultural scale for interpreting environmental observations and tohu aa-hapuu.

Mauri State	Interpretation	Ecological Expression	Cultural Expression
Mauri kaha (thriving)	The system is flourishing; all elements are in balance.	Clear water, abundant tupu wai and taonga species.	Strong sense of vitality, joy, and connection; mauri radiates.
Mauri ora (well)	The system is healthy and resilient. Minor stressors may be present.	Stable tupu wai, good light penetration.	Calm, life-giving energy; mauri flows freely.
Mauri tuu (settled)	The system is steady but under noticeable stress.	Moderate clarity; invasive species visible.	Energy feels subdued but stable; mauri holding its ground.

Mauri State	Interpretation	Ecological Expression	Cultural Expression
Mauri Maaori (normal / baseline)	The system functions within natural variation but is neither flourishing nor declining.	Typical seasonal variability; balance between native and invasive species.	The lake feels familiar, ordinary, carrying its usual energy.
Mauri kino (diminishing)	The system is declining; imbalance evident.	Reduced native-plant depth, poor clarity, algal presence.	Heavy or dull feeling; loss of vibrancy and connection.
Mauri mate (dying)	The system is failing; urgent intervention needed.	Collapsed vegetation structure, high turbidity, loss of taonga species	Sense of sadness or detachment; mauri weakened or withdrawn.

These mauri states are applied by kaitiaki during lake surveys and stored in the Rongo App, allowing cultural observations to be recorded, visualised, and compared alongside scientific data such as LakeSPI indices and water-quality metrics.

Together, these dual frameworks, maatauranga Maaori and science, strengthen The Trust's capacity to interpret ecological change holistically. They ensure that mauri remains the central measure of lake wellbeing within He Anga Aroturuki Wai Maaori, and that Pou Taangata continues to anchor community-led restoration and intergenerational learning.

> *Ngaati Mahuta understand lake health not only through scientific measures, but through the condition and behaviours of taonga species seasonal patterns, and the mauri of places. This knowledge is embedded in the lived experience of whaanau who actively engage with the lakes for kai, waananga, and ceremony.*
> — Herangi et al. 2025a.

Note: Many tohu recorded by kaitiaki have scientific equivalents within the LakeSPI framework. For example, water clarity relates to the Native Condition Index, the dominance of invasive species aligns with the Invasive Impact Index, and overall tohu of mauri correspond to the composite LakeSPI score. Recognising these relationships ensures both knowledge systems contribute equally to interpreting lake health.

7.4 Pathway for Restoration and Co-Management

Effective management of the Tahaaroa lakes depends on strong partnership between iwi and science. Within He Anga Aroturuki Wai Maaori, this partnership gives expression to Pou Taangata, affirming that people, knowledge, and collaboration are central to restoring mauri. Kotahitanga and maatauranga underpin this work, ensuring that each organisation contributes its unique strengths to a collective purpose.

> *All data and research related to Tahaaroa Lakes must be handled with the same reverence as one would treat a waka huia, a vessel of treasures, held close to the heart.*
> — Herangi et al. 2025a.

The Trust is the central coordinating body, exercising mana whakahaere for the Tahaaroa lakes system. Partner agencies provide complementary expertise and statutory functions: MPI through national biosecurity initiatives such as Check, Clean, Dry; WRC through technical advice; ESNZ and Te Kūwaha through scientific and cultural research; and DOC through technical advice and native-species restoration guidance. Each role contributes to the shared goal of restoring the mauri of the Tahaaroa lakes through integrated cultural and scientific management (Table 15).

Table 15: Priority management actions and responsible organisations.

	Priority	Actions	Why it matters	Responsibility
1.	Biosecurity and Invasive Control	Implement containment and eradication in line with NPDPM. Conduct delimiting surveys and prepare an Aquatic Pest Response Plan. Engage kaitiaki and community in awareness campaigns (e.g., "Check, Clean, Dry").	The discovery of Hornwort presents an urgent biosecurity threat. Containment and eradication will prevent its spread, protect native *tupu wai*, and safeguard lake mauri.	**The Trust** - lead coordination, kaitiaki oversight, and local implementation. **MPI** – provides national biosecurity policy, and technical support. **WRC** – delivers technical advice, and monitoring operations. **ESNZ** – supports delimiting surveys, ecological advice, and data analysis.
2.	Tupu wai Restoration	Protect and map remnant charophyte beds. Trial re-establishment using native propagules following invasive control. Integrate outcomes with CMP and LakeSPI monitoring.	Restoring native tupu wai rebalances lake ecosystems, enhances water clarity, and strengthens cultural and ecological resilience.	**The Trust** – leads site selection and restoration planning under tikanga. **ESNZ** – provides scientific design and performance monitoring. **DOC** – offers technical advice, restoration guidance and native species propagation support.
3.	Catchment Management	Enhance riparian buffers and wetlands. Maintain stock exclusion.	Reducing sediment and nutrient inflows improves light penetration and	**The Trust** – coordinates catchment works with

Priority		Actions	Why it matters	Responsibility
		Integrate pest control with sediment and nutrient mitigation.	supports long-term lake recovery.	landowners and monitors outcomes. **WRC** – provides technical advice and compliance. **Local Landowners** – implement on-ground improvements such as fencing, planting, and pest control.
4.	Monitoring and Reporting	Continue biennial LakeSPI and *tohu*-based monitoring. Hold annual hui with MPI, WRC, and ESNZ. Report progress through EMP and LakeSPI portal.	Coordinated monitoring connects cultural and scientific indicators, ensuring accountability and tracking the return of mauri ora.	**The Trust** – coordinates cultural and technical monitoring and leads data stewardship. **ESNZ** – maintains LakeSPI datasets and provides analysis. **MPI** – ensures biosecurity integration and national reporting alignment. **WRC** – supports data management and regional reporting.
5.	Advance Co-Governance and Te Tiriti Based Decision Making	Formalise a Mana Whakahono aa Rohe or co-management agreement over the lake system. Share data and coordinate joint funding applications. Align EMP updates with WRPMP review cycles.	Strengthened partnerships ensure decisions reflect both science and tikanga, fostering long-term collaborative stewardship.	**Ngaati Mahuta / The Trust** – leads governance under tikanga and represents shareholder interests. **MPI** – aligns national biosecurity mechanisms. **WRC** – provides regional integration with council planning processes.

These actions represent the first stage of a shared pathway toward mauri kaha, linking cultural leadership with coordinated technical delivery. Together they embody Pou Taangata in practice: building capability, unity, and shared responsibility for the long-term wellbeing of the Tahaaroa lakes and their people.

7.5 Future Research and Monitoring Roadmap

Building on this 2024 survey, future research will integrate cultural and scientific monitoring to strengthen both knowledge systems and governance. Ngaa taonga tuku iho o ngaa roto o Tahaaroa and the customary tuna and kaiaua research programmes, this roadmap defines a long-term kaupapa to restore mana whakahaere and the mauri through evidence-based and tikanga-led action (Herangi et al. 2025a, 2025b; Melchior et al. 2025).

7.5.1 Strategic Focus

Tupu wai recovery and resilience

- Explore experimental trials to re-establish charophyte, milfoils and pondweed meadows in areas cleared of invasive species.
- Assess sediment composition and light conditions needed for sustained recolonisation.
- Develop a nursery or propagation programme for tupu wai under the guidance of ESNZ and local kaitiaki.

Invasive-species surveillance and biosecurity innovation

- Maintain delimiting surveys for Hornwort and Lagarosiphon expansion.
- Trial eDNA or remote-sensing tools for early detection of aquatic weeds.
- Evaluate the cultural and ecological effectiveness of mechanical and biological control options.

Catchment–lake interactions

- Model the potential benefits of riparian and wetland restoration scenarios on water clarity and lake trophic state.
- Integrate land-use data with monitoring results to prioritise mitigation areas.

Integrated monitoring framework

The Rongo App will serve as the digital platform for recording tohu aa-hapuu and mauri state assessments using the six-tier scale (Mauri kaha, Mauri ora, Mauri tuu, Mauri Maaori, Mauri kino, Mauri mate). Integrating these mauri settings with LakeSPI and water-quality datasets will enable real-time visualisation of cultural and ecological trends across the Tahaaroa lakes.

- Consider linking LakeSPI to Tahaaroa Lakes Monitoring Dashboard with tohu aa-hapuu, and water-quality indicators.
- Standardise annual and biennial reporting cycles, ensuring data sovereignty remains with the Trust.
- Provide training opportunities for rangatahi in both scientific and cultural monitoring methods.

Knowledge exchange and communication

- Hold seasonal waananga for whaanau, scientists, and agency partners.
- Co-publish annual "State of the Lakes" updates combining scientific and maatauranga Maaori narratives.
- Facilitate knowledge exchange with other iwi-led dune lake projects.

7.5.2 Long-Term Aspirations

Over the next decade, this roadmap seeks to establish a self-sustaining, kaitiaki-led monitoring system that measures both ecological recovery and the return of mauri kaha. Achieving this will honour The Trust's enduring commitment to restore the natural flow of mauri across the Tahaaroa lake system (Table 16).

Table 16: Summary of key messages from the Management and Recommendations chapter highlighting priority actions, partnerships, and long-term aspirations for restoring the mauri of the Tahaaroa lakes system (2024).

Theme	Key Message
Overall vision	The Trust's vision, E rere ana te mauri o ngaa wai o nga roto o Tahaaroa… anchors all management actions in the restoration of mauri and intergenerational wellbeing.
Biosecurity	The detection of Hornwort represents the most significant biosecurity threat to the lake system. Immediate containment, eradication, and prevention of spread is priority.
Tupu wai	Protecting and restoring tupu wai meadows is essential to rebalance lake ecosystems, stabilise sediments, and strengthen cultural and ecological resilience.
Catchment management	Riparian and wetland restoration, stock exclusion, and sediment control are key to improving water clarity and supporting native-plant recovery.
Monitoring and knowledge	Integrated kaitiaki-led and scientific monitoring using both LakeSPI and tohu aa-hapuu will ensure ongoing tracking of ecological and cultural health.
Governance and partnership	Co-management through a Mana Whakahono aa Rohe agreement will align iwi, regional, and national agencies, embedding *tikanga* and Te Tiriti principles in decision-making.
Future direction	The ten-year research and monitoring roadmap aims to create a self-sustaining, co-governed framework that measures both ecological recovery and the return of mauri across the Tahaaroa lakes.

7.5.3 Next steps

Immediate attention should focus on containment of Hornwort and enforcement of biosecurity protocols across the Tahaaroa lakes. Within the next one to three years, emphasis should shift toward re-establishing native charophyte, milfoils and pondweed communities, enhancing riparian and wetland buffers, and consolidating monitoring systems through the Rongo App and LakeSPI programmes. Over the longer term, The Trust, DOC, WRC, and ESNZ will work toward formalising co-management arrangements and securing funding to implement the full restoration roadmap.

8 Conclusion

8.1 Key Findings

Ecological condition: All three lakes remain in Moderate ecological condition based on LakeSPI results. Lake Rotoroa shows early signs of recovery, whereas Lakes Tahaaroa and Numiti continue to decline relative to 2014.

Tupu wai: Charophytes (*Chara australis, Nitella* sp. aff. *cristata*) and pondweeds (*Potamogeton ochreatus*) persist but are now confined mainly to shallow margins due to reduced water clarity and sediment accumulation.

Invasive species: Lagarosiphon major and Elodea canadensis dominate submerged vegetation across all lakes. Hornwort (Ceratophyllum demersum) was newly detected at the Lake Tahaaroa outlet (Wainui Stream). Immediate containment and eradication are required to prevent spread.

Environmental drivers: Nutrient enrichment, sediment inputs and low light availability remain the primary pressures limiting native-plant recovery. Anoxic sediments in Lake Numiti and Rotoroa exacerbate stress on submerged vegetation.

Cultural interpretation: The health and vigour of tupu wai reflect the mauri of the roto. Observed degradation represents a loss of balance, reinforcing the need for integrated restoration founded on both maatauranga Maaori and science.

9 Acknowledgements

Heke iho raa ngaa roimata o Ranginui ki a Papatuaanuku, ko te wai tuku kiri o ngooku maatua tuupuna. Rere ana te wai-oo-rangi, te wai-oo-nuku ki runga i a taatou katoa, tatuu atu ai ki ngoo taatou awa, ngoo taatou puna, ngoo taatou hiirere. Kaiwaka huri noa, teenaa koutou, teenaa koutou, teenaa koutou katoa.

Kei ngaa ringa atawhai, kei ngaa waewae tutuki, kei ngaa tuaraa piikau e haapai nei i a maatou ngaa riporipo o ngaa wai o Tahaaroa, teenei maatou ka mihi ki a koutou katoa. Mei kore ko koutou kua kore teenei kaupapa e koke whakamua, e puta hoki ai ngaa hua o teenei kaupapa nui whakaharahara. Nei raa te whakamaanawa nei ki a koutou katoa, ko te whenua ko te wai ko te mauri o te iwi, teena koutou, teenaa koutou, teena raa taatou katoa.

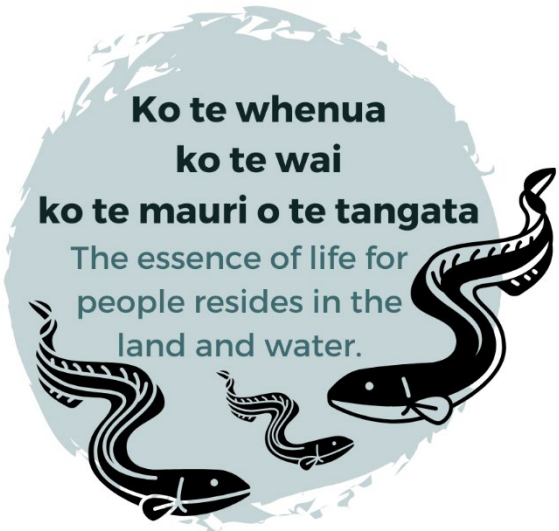
The tears of Ranginui fall upon Papatuuaanuku, the sacred cleansing waters of our ancestors. The waters of the heavens and the waters of the earth flow over us all, reaching our rivers, our springs, and our waterfalls. Warm greetings to you all.

To everyone who gave their time, energy, and heart to this kaupapa. Those who waded through the shallows, carried gear, shared kai, steered the boat and the mahi – ngaa mihi nui.

Special thanks to the team; Inigo Zabarte-Maetzu, Aleki Taumoepeau, Michele Melchior, Constantin Dransmann, Taituwha King, Fleur Passau, and Rhonda Tuaupiki-Kerr for your dedication and care on the water and at the lake edge.

Heartfelt thanks to Te Kooraha Marae for your manaakitanga and ongoing support, your hospitality and guidance carried this kaupapa forward. We acknowledge ESNZ for their partnership, shared knowledge, and unity of purpose in this mahi.

From the mauri of our whenua, our wai, and our people – the mauri that connects us all, we offer our deepest appreciation.



10 Glossary of abbreviations

CMP	Catchment Management Plan
DOC	Department of Conservation
EMP	Environmental Management Plan
ESNZ	Earth Sciences New Zealand
HSW	Health, Safety and Wellbeing
LAWA	Land, Air, Water Aotearoa
MPI	Ministry for Primary Industries
NPPA	National Pest Plant Accord
NPD	National Policy Direction
NRWMS	Ngā Riha Wai Māori Strategy
sp. aff.	The abbreviation sp. aff. comes from the Latin *affinis*, meaning related or similar. In taxonomy it is used when a specimen closely resembles a named species but is considered distinct, often representing a potentially new species that has not yet been formally described.
TLI	Trophic Level Index
TN	Total Nitrogen
TP	Total Phosphorous
UO	Unwanted Organism
WRC	Waikato Regional Council
RPMP	Regional Pest Management Plan

10.1 Glossary of cultural terms

Ahi kaa	Symbolic of ongoing presence of kaitiaki.
Auahatanga	The creative breath that drives renewal and innovation in the care of the roto, enabling both people and ecosystems to flourish again.
Hauora	One of the six hau within Ngaa hau o te hauaauru.
He Anga Aroturuki Wai Maaori	The Trust's guiding framework for environmental monitoring.
Kaiaua	Taonga specie monitored alongside tuna and tupu wai.
Kaitiakitanga	The active care and protection of taonga such as the Tahaaroa lakes.
Kotahitanga	The collective strength that arises when kaitiaki, whaanau, and partner agencies work in unison to restore the mauri of the Tahaaroa lakes. It affirms that enduring recovery depends on unity of purpose, respect for diverse knowledge systems, and shared commitment to future generations.
Mana whakahaere	Authority or manage and make decisions over a particular area or resource.
Mauri kaha, mauri ora, mauri kino, mauri mate	Rongo App mauri assessment framework for states of lifeforce – strong, thriving, stable, diminishing, dying.
Maatauranga	The weaving of ancestral and contemporary wisdom that informs The Trust's understanding of the roto. It enables decisions that are grounded in whakapapa, responsive to scientific evidence, and aligned with the mauri of each lake.
Ngaa hau o te hauaauru	Conceptual foundation connecting people, place and water. The life-sustaining winds and energies of the west.
Pou taiao, pou taangata, pou Taawhirimatea	Three pou underpinning He Anga Aroturuki Wai Maaori. Environmental, people, and climate pillars.
Rongo App	Cultural monitoring tool developed by The Trust to assess mauri and record tohu observations.
Taonga species	Species of importance to Ngaati Mahuta.
Tohu	Observable cues used by kaitiaki to assess lake health.
Tuakiritanga	The strengthening of cultural belonging and self-definition that arises when people are reconnected to their ancestral waters and responsibilities.
Tupu wai	Native vegetation.

10.2 Glossary of scientific and technical terms

Macrophyte	Collective term for aquatic plants, including submerged floating, and emergent species.
Aquatic weeds	Non-native or invasive aquatic plants that grow in or around water and outcompete native species.
Biosecurity	Measures designed to prevent the introduction and spread of harmful organisms.
Charophyte	A group of green algae (e.g., *Chara* and *Nitella*) that form underwater meadows and indicate clear, low-nutrient water.
Eutrophication	Nutrient enrichment of a waterbody leading to excessive plant and algal growth.
Photic zone	The upper layer where light is sufficient for photosynthesis.
Sediment resuspension	Disturbance of bottom sediments by wind, waves or human activity, reducing water clarity.

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Appendix A Macrophytes recorded for Tahaaroa lakes in 2024

Table A-1: Native and invasive macrophyte species recorded in the Tahaaroa lakes during the 2024 survey, showing scientific and common names and their recorded lake locations.

Category	Scientific Name	Common Name	Location
Native	*Chara australis*	Charophyte	Lakes Tahaaroa, Numiti & Rotoroa
Native	*Nitella* sp. aff. *cristata*	Charophyte	Lake Tahaaroa
Native	*Potamogeton ochreatus*	Pondweed	Lakes Tahaaroa, Numiti & Rotoroa
Native	*Myriophyllum triphyllum*	Milfoil	Lake Tahaaroa
Native	*Typha orientalis*	Raupoo	Lakes Tahaaroa, Numiti & Rotoroa
Invasive	*Lagarosiphon major*	Oxygen weed	Lakes Tahaaroa & Numiti
Invasive	*Eloedea canadensis*	Canadian pondweed	Lakes Tahaaroa, Numiti & Rotoroa
Invasive	*Potamogeton crispus*	Curly pondweed	Lakes Numiti & Rotoroa
Invasive	*Ceratophyllum demersum*	Hornwort	Lake Tahaaroa & Wainui Stream

Appendix B Summary of macrophytes recorded for Tahaaroa lakes between 1983-2024

Table B-1: Presence of native and invasive aquatic plant species recorded in the Tahaaroa lakes during LakeSPI surveys from 1983 to 2024. A tick (✓) indicates that the species was recorded in that survey year.

Category	1983	2007	2010	2014	2024
Native species					
Chara australis	✓	✓	✓	✓	✓
Myriophyllum triphyllum	✓	✓	✓	✓	✓
Potamogeton ochreatus	✓	✓	✓	✓	✓
Nitella cristata		✓	✓	✓	✓
Typha orientalis		✓	✓	✓	✓
Eleocharis sphacelate		✓	✓		
Chara globularis			✓	✓	
Invasive species					
Elodea canadensis	✓	✓	✓	✓	✓
Ranunculus trichophyllus	✓				
Lagarosiphon major		✓	✓	✓	✓
Potamogeton crispus		✓	✓	✓	✓
Ceratophyllum demersum					✓