

Technical Memo – Submerged plants (native and invasive)

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Purpose

The purpose of this memorandum is to provide an assessment of the baseline state of the lake submerged plants (native and invasive species) attributes as a measure of ecosystem health, as required by the National Policy Statement for Freshwater Management 2020 (NPS-FM).

Overview of submerged plants (native and invasive)

Submerged plants are aquatic plants that grow entirely underwater. They are an important part of the freshwater ecosystem, providing food and habitat for fish and other aquatic animals. Submerged plants also help to improve water quality by filtering pollutants and sediments. However, invasive submerged plants are undesirable because they have the potential to displace native plant species and can have negative impacts on a lake ecosystem. Therefore, submerged plants are a valuable indicator of the ecological health of lakes.

The LakeSPI (Lake Submerged Plant Indicators) method is a tool commonly used to assess the ecological condition of a lake, during which the degree of development of native submerged plants and the level of impact of non-native, invasive weeds is assessed. Features of aquatic vegetation structure and composition are recorded and entered into the NIWA LakeSPI database, which calculates a Native Condition Index, an Invasive Impact Index and an overall LakeSPI Index. A higher LakeSPI and Native Condition Index denotes better lake ecological condition and higher Invasive Impact Index denotes poorer Lake Condition. Theoretically, a pristine lake with diverse native submerged vegetation, unimpacted by human activities or invasive species, would score a LakeSPI Index of 100%, a Native Condition Index of 100% and an Invasive Impact Index of 0% (de Winton *et al.*, 2022).

Submerged plants and the National Objectives Framework

The NPS-FM sets out requirements for councils and communities to maintain or improve freshwater (where it is degraded). The NPS-FM provides a National Objectives Framework (NOF) that specifies nationally applicable standards for particular water quality parameters (referred to as 'attributes') for both rivers and lakes. Submerged plants (native) and submerged plants (invasive species) are two attributes that apply to lake ecosystems, along with nutrients (nitrogen, ammonia and phosphorus), phytoplankton, dissolved oxygen (mid-hypolimnetic and lake bottom), *Escherichia coli* (*E. coli*), and cyanobacteria.

The NPS-FM has adopted two LakeSPI indices (i.e. Native Condition Index and Invasive Impact Index) derived from the LakeSPI method as new ecosystem health NOF attributes with national bottom lines (Table 1 and Table 2). As such, the results of LakeSPI surveys can be used, along with an assessment of other lake attributes, to assess the health of lakes against national policy requirements.

Table 1: NOF attribute – Submerged plants – native condition index. As physical characteristics influencing the extent and type of submerged vegetation are lake specific, the LakeSPI indices are expressed as a percentage of a lake's maximum scoring potential.

Value (and component)	Ecosystem health (Aquatic life)
Freshwater body type	Lakes
Attribute unit	Lake Submerged Plant (Native Condition Index)
Attribute band and description	Numeric attribute state
	(% of maximum potential score)
A Excellent ecological condition. Native submerged plant communities are almost completely intact	>75%
B High ecological condition. Native submerged plant communities are largely intact.	>50 and ≤75%
C Moderate ecological condition. Native submerged plant communities are moderately impacted.	>20 and ≤50%
National Bottom Line	20%
D Poor ecological condition. Native submerged plant communities are largely degraded or absent.	<20%
Monitoring to be conducted, and numeric attribute state to be determined, following the method described in Clayton J, and Edwards T. 2006. LakeSPI: A method for monitoring ecological condition in New Zealand lakes. User Manual Version 2. National Institute of Water & Atmospheric Research: Hamilton, New Zealand. (see clause 1.8) Lakes in a devegetated state receive scores of 0.	

Table 2: NOF attribute – Submerged plants – invasive impact index. As physical characteristics influencing the extent and type of submerged vegetation are lake specific, the LakeSPI indices are expressed as a percentage of a lake's maximum scoring potential.

Value (and component)	Ecosystem health (Aquatic life)
Freshwater body type	Lakes
Attribute unit	Lake Submerged Plant (Invasive Impact Index)
Attribute band and description	Numeric attribute state
	(% of maximum potential score)
A No invasive plants present in the lake. Native plant communities remain intact.	0
B Invasive plants having only a minor impact on native vegetation. Invasive plants will be patchy in nature co-existing with native vegetation. Often major weed species not present or in early stages of invasion.	>1 and ≤25%
C Invasive plants having a moderate to high impact on native vegetation. Native plant communities likely displaced by invasive weed beds particularly in the 2 – 8 m depth range.	>25 and ≤90%
National Bottom Line	90%
D Tall dense weed beds exclude native vegetation and dominate entire depth range of plant growth. The species concerned are likely hornwort and Egeria.	>90%
Monitoring to be conducted, and numeric attribute state to be determined, following the method described in Clayton J, and Edwards T. 2006. LakeSPI: A method for monitoring ecological condition in New Zealand lakes. User Manual Version 2. National Institute of Water & Atmospheric Research: Hamilton, New Zealand. (see clause 1.8)	

Lake SPI surveying in the Taranaki Region

In 2021, Taranaki Regional Council (TRC) engaged NIWA to survey three lakes (Lakes Kaikura, Mangawhio, and Rotokare;) using LakeSPI (Table 3, Figure 1). These lakes were the first in the region to be assessed using this method. Lake SPI surveys were completed over November – December 2021. Detailed descriptions of the LakeSPI survey can be viewed on <https://lakespi.niwa.co.nz>.

Further, TRC has commissioned NIWA to conduct LakeSPI surveys at the following lakes: Lake Rotokawau, Barrett Lagoon, Lake Herengawe, and Lake Waikare (Table 3, Figure 1). The surveys will be completed between 18th and 21st of September 2023. This memorandum will be updated as these lake survey results become available, and will inform the development of target attribute states for these additional lakes.

In regards to the frequency of re-surveying lakes using LakesSPI, NIWA generally recommends five-yearly surveys, with an increase of re-sampling frequency if large changes in ecological conditions are identified. However, this recommendation is a departure from the NPS-FM requirement of a three-yearly surveying frequency (NIWA, 2022b), and it is recommended that initial surveying is undertaken in line with NPS-FM requirements until a full monitoring programme is established and a second round of sampling data has been collected and further advice can be provided.

Table 3: Lakes surveyed for submerged plant indicators in Taranaki.

Freshwater Management Unit (FMU)	Lake	Lake ID	LakeSPI survey completed	Lake area (hectares)	Lake depth (m)	Location (NZTM)	
						Easting	Northing
Southern Hill Country	Lake Mangawhio	16224	02/12/2021	8.6	15.6	1753794	5609380
Southern Hill Country	Lake Rotokare	7512	31/11/2021	15.7	11.6	1721453	5631971
Coastal Terraces	Lake Kaikura	15795	01/12/2021	5.3	5.1	1720486	5604553
Southern Hill Country	Lake Waikare	16222		7.4	18.9	1754873	5607388
Coastal Terraces	Lake Herengawe	15902	Pending, due September 2023	14.3	3.9	1740432	5593938
Volcanic Ring Plain	Barrett Lagoon	20893		5.1	5.7	1690018	5672617
Northern Hill Country	Lake Rotokawau	7445		1.3	11.9	1748508	5692929

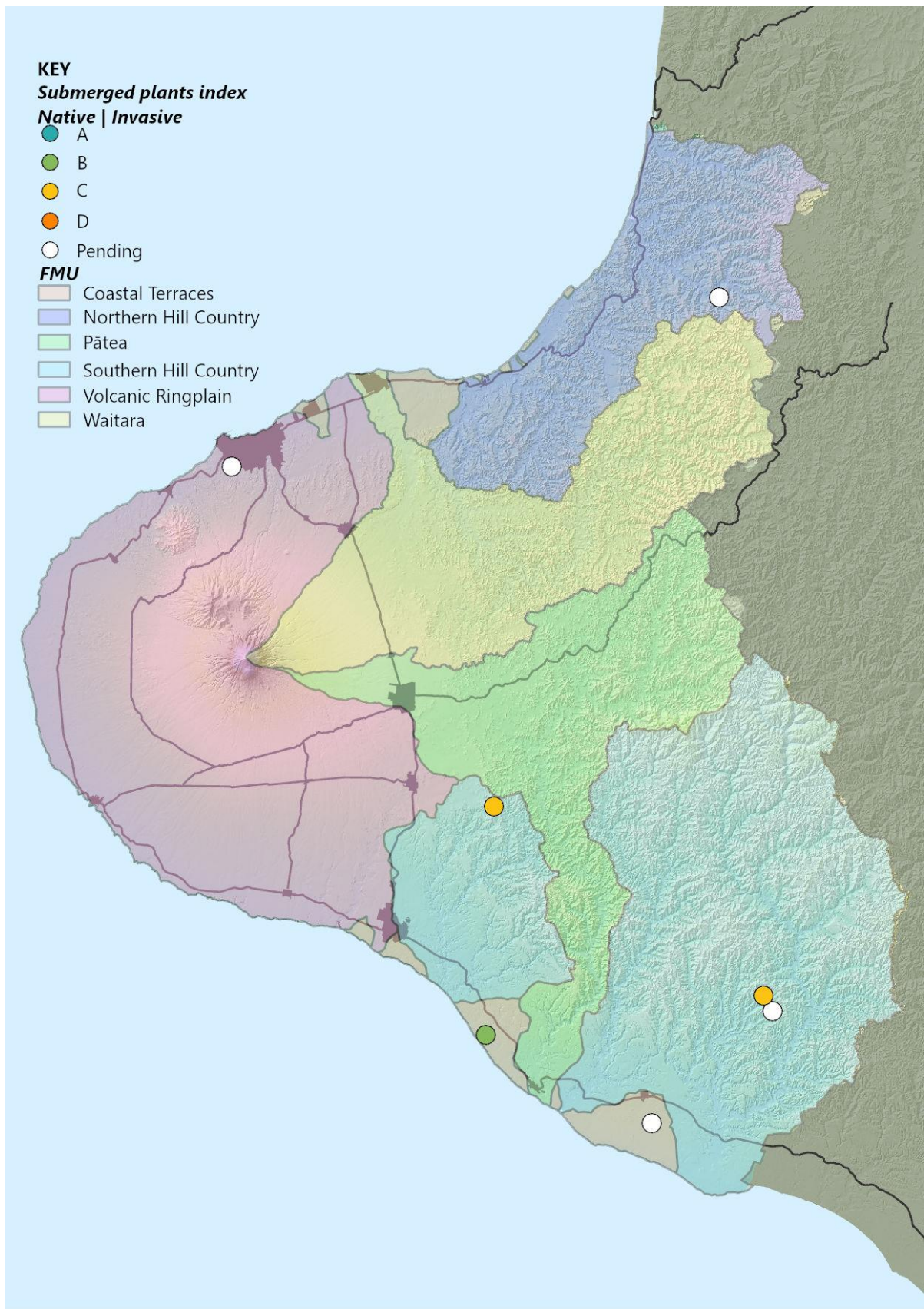


Figure 1: Map showing the three surveyed lakes in relation to the FMUs in Taranaki.

Baseline states for submerged plants

The NPS-FM requires all regional councils to identify baseline states for all attributes described in Appendix 2A and 2B of the NPS-FM 2020 within each Freshwater Management Unit (FMU). When compared against national bottom lines and the relevant objectives for an FMU, baselines provide the reference point from which councils must either maintain or improve an attribute, which in turn will contribute toward achieving freshwater objectives for each compulsory and non-compulsory value. Waterbodies must not be allowed to degrade, or remain below an identified baseline state unless that state is determined to be naturally occurring. If a waterbody is already at or below the national bottom line, then it must be improved to either achieve the national bottom line or better.

Under Clause 1.4 of the NPS-FM 2020, the baseline state, in relation to an attribute, is the best state out of the following:

- a) the state of the attribute on the date it is first identified by a regional council under Clause 3.10(1)(b) or (c);
- b) the state of the attribute on the date on which a regional council set a freshwater objective for the attribute under the National Policy Statement for Freshwater Management 2014 (as amended in 2017);
- c) the state of the attribute on 7 September 2017.

The Council has not previously set freshwater objectives under the NPS-FM 2014 (amended 2017) nor identified the state of submerged plants on 7 September 2017, so the state of these attributes under 1.4 (b) and (c) could not be calculated and were excluded from identification of baseline states. Hence, Clause 1.4 (a) was used to identify baseline states for native and submerged plants.

Under Clause 1.6 of the NPS-FM 2020, local authorities must use the best information available at the time (and if practicable, using complete and robust data) to give effect to the NPS-FM 2020. In the absence of complete and robust data, the best information available should be use which may include modelling, partial data, and local knowledge, and preferably use sources that provide the greatest level of certainty (or take all practicable steps necessary to reduce uncertainty).

Under the NPS-FM 2020, lake submerged plants (both native and invasive) are associated with the 'Ecosystem Health' value, which is a compulsory value within the NOF (NPS-FM 2020, Appendix 1A). It is included as an attribute that requires action plans to maintain or improve the state of health in relation to submerged plants (NPS-FM, Appendix 2B). It is necessary for baseline states to be identified by TRC for the Taranaki region to ensure that target attribute states are set at a level that either achieve or exceed the best baseline state for that attribute and (at a minimum) achieve the national bottom line¹.

The remainder of this memo summarises the monitoring and work carried out by TRC to identify baseline states for native and invasive submerged plants in the region's lakes.

Criteria for identifying site-based baseline states for phytoplankton in lakes

Draft baseline states for Lake SPI (native and invasive) have been identified for individual lake monitoring sites. These site-specific baseline states correspond to the NOF attribute bands set out in NPS-FM 2020, Table 11 and 12, and have been identified using data from lake surveys undertaken in 2021.

The NPS-FM 2020 requires Lake SPI attribute states be determined following the method described in Clayton and Edwards (2006). Lakes in a devegetated state receive a score of zero, while lakes in poor

¹ See NPS-FM clauses 3.31, 3.32, and 3.33 for exceptions to this.

ecological condition with largely degraded or absent native species (<20% of maximum potential score) or dominated by invasive plant growth (>90% of maximum potential score) are assigned band D and require improvement to move above the national bottom line.

Presently there is little available data in relation to Taranaki lakes in regard to Lake SPI NOF attributes. Thus, incomplete/partial data (Clause 1.6 NPS-FM 2020) have been included in the identification of site-specific baseline states, with further data to be included as further lakes are surveyed. In the future these sites will have additional data which will be considered complete and scientifically robust in assessing progress toward target attribute states.

Site-based baseline states

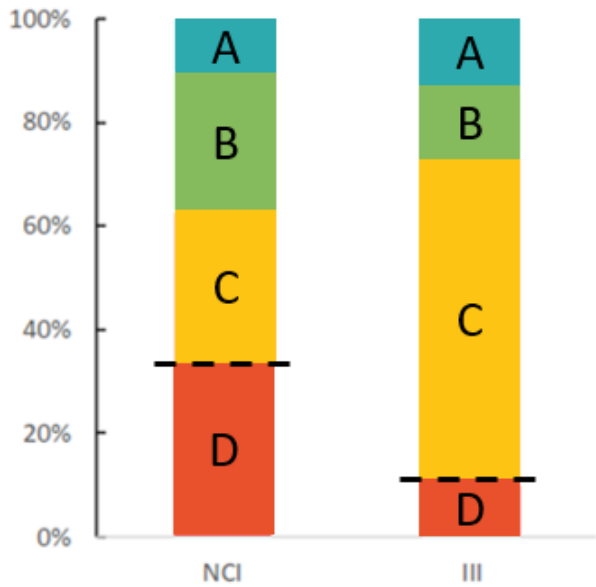
The results of the LakeSPI surveys are presented in Table 4 and were assessed against the NOF attribute tables (Table 1 and Table 2, de Winton *et al.*, 2022). Under the NPS-FM, Lake Kaikura achieved band B for both the Native Condition Index and the Invasive Impact Index, reflecting the lake's moderate level of native plant cover and low level of invasive plant impact. Both lakes Mangawhio and Rotokare fell within band C for both NOF attributes.

- Lake Kaikura had a LakeSPI Index of 66%, falling into the 'High' category for lake ecological condition. This result reflected the dominance of native submerged plants but of relatively limited biodiversity, and minimal impact by non-native weeds. Lake Kaikura ranked 70th nationally for ecological condition (for 257 rank positions over 323 surveyed lakes). Under the NPS-FM, a Native Condition Index of 52% and low Invasive Impact Index of 19% placed Lake Kaikura within band B for both attributes.
- A LakeSPI Index of 21% placed Lake Mangawhio into the 'Moderate' category of ecological condition. The depth development of submerged vegetation was restricted and the invasive weeds *Lagarosiphon major*, and to a lesser extent *Ceratophyllum demersum*, had a large influence on the structure and diversity of the lake vegetation. Lake Mangawhio ranked 212th for ecological condition nationally. A Native Condition Index of 28% and an Invasive Impact Index of 79% placed Lake Mangawhio in band C for both attributes.
- Lake Rotokare recorded a LakeSPI Index of 33%, or 'Moderate' category for lake ecological condition. This result reflected the areas of native submerged vegetation that have persisted despite the widespread presence of the invasive alien weed *Lagarosiphon major*. The lake ranked 176th for ecological condition nationally. The Native Condition Index of 37% and Invasive Impact Index of 64% placed Lake Rotokare in band C.

At Rotokare, neither LakeSPI Indices approached the national bottom line, with the Native Condition Index nearly double the bottom line of 20% and a 26% buffer between the Invasive Impact Index and the bottom line for acceptable weed impact of 90%. The Native Condition Index at Lake Mangawhio exceeded the national bottom line of 20% by 8% and the Invasive Impact Index shows an 11% buffer below the acceptable score of 90%. Therefore all lakes scored above the national bottom line.

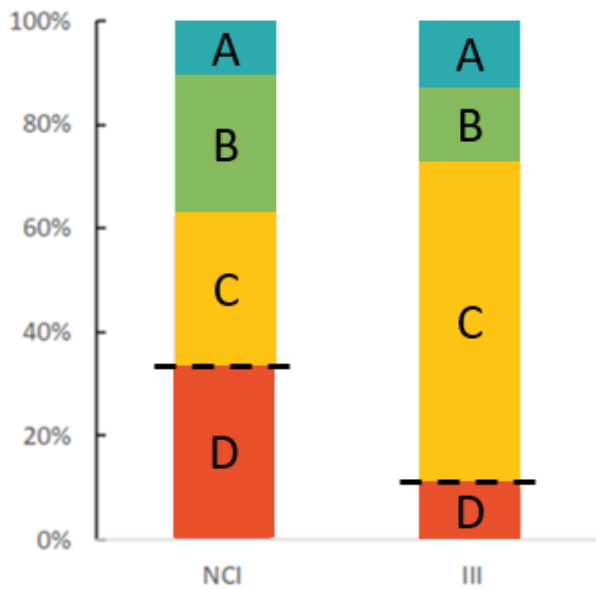
Table 4: Summary of the Native Condition Index and Invasive Impact Index and the associated bands of the three lakes, ranked in order of their condition (NIWA, 2022a).

Lake	Survey Date	Native Condition Index (%)	NOF Band	Invasive Impact index (%)	NOF Band
Lake Kaikura	01/12/2021	52	B	19	B
Lake Rotokare	31/11/2021	37	C	64	C
Lake Mangawhio	02/12/2021	28	C	79	C



Band A - Excellent ecological condition
 Band B - High ecological condition
 Band C - Moderate ecological condition
 Band D - Poor ecological condition (below the national bottom line)

Figure 2 shows the attribute band distribution of NZ lakes for each attribute (i.e. Native Condition Index (NCI) and Invasive Impact Index (III)), as of January 2022. Notably, Lake Kaikura is one of a small group of lakes included in the B band for the Invasive Impact Index, reflecting its low impacts of invasive weeds. Regarding the Native Condition Index, the Taranaki lakes fall into bands B and C. These bands include a large proportion of lakes nationally.



Band A - Excellent ecological condition
 Band B - High ecological condition
 Band C - Moderate ecological condition
 Band D - Poor ecological condition (below the national bottom line)

Figure 2: Proportion of NZ lakes in each attribute band (A-D) in relation to the Native Condition Index (NCI) and Invasive Impact Index (III). Retrieved from 'LakeSPI assessment of three Taranaki Lakes' (NIWA, 2022a).

Baseline period and temporal state variability

To date, three lakes have been surveyed on one occasion during 2021. The Council has not previously set freshwater objectives under the NPS-FM 2014 (amended 2017) nor identified the state of submerged plants on 7 September 2017, so the state of these attributes under 1.4 (b) and (c) could not be calculated, and was excluded from identification of baseline states. Hence, Clause 1.4 (a) was used to identify baseline states for native and submerged plants.

An assessment of temporal state variability will be possible in future as surveys are repeated at these sites.

Freshwater Management Unit (FMU) coverage and representativeness

The TRC's regional state of the environment lakes monitoring programme was informed by a review of all lakes throughout the region, which identified 17 potential candidate lakes for inclusion. The following criteria were used to exclude lakes as suitable candidates for monitoring:

- Natural and unmodified. Artificial lakes were excluded on the basis that these lakes are less likely to be considered representative of the natural environment.
- Open water area ≥ 1 ha. Although there are many smaller lakes in the region, in most cases these are not particularly deep and may more reasonably be classed as wetlands.
- Suitable boat access to allow monitoring. Boat access is necessary as boats are required to enable sample collection from the deepest point of the lake.

Of these 17 lakes, eight were located in the Coastal Terrace (CT) FMU, five were located in the Southern Hill Country (SHC), three in the Volcanic Ring Plain (VRP) and one in the Northern Hill Country (NHC). No suitable lakes were identified in the Waitara or Pātea FMUs. The final six lakes included in the monitoring programme were:

- Lake Rotokawau (NHC);
- Barrett Lagoon (VRP);
- Lake Rotokare (SHC);
- Lake Waikare (SHC);
- Lake Herengawe (CT), and;
- Lake Kaikura (CT).

Lake Mangawhio was originally included in the programme, which is why a LakeSPI survey was carried out at this lake. However, this lake has since been substituted for Lake Waikare, due to ongoing issues with lake access (including a road wash out), meaning it had become unsafe to access Lake Mangawhio. The final set of lakes included in the SoE programme, (which in addition to the LakeSPI surveys, involves monthly monitoring of a range of water quality parameters), are considered to be suitably representative of each applicable FMU within the Taranaki region. However, NIWA has recommended to increase the number of lakes surveyed by LakeSPI to 10-12 lakes, to improve regional representation of lake ecological condition (NIWA, 2022a). Additional LakeSPI surveys will be considered as the monitoring programme develops. Further background on the SoE lake selection process is provided by de Winton et al. (2022a).

FMU-based baseline states

There are no spatial models available to estimate the state of submerged plant indicators for lakes throughout the Taranaki region. Site-based assessments are currently the only option available to identify baseline state for these submerged plant attributes. Lake SPI surveys will be completed for additional Taranaki lakes in coming years, which will enable the Council to establish a data set for submerged plants and track changes over time.

Recommendations

Baseline states have been calculated for monitoring sites, to provide the best known state for lake submerged plant attributes as an indicator of ecosystem health.

Target attribute states will need to be set at a level that (at a minimum) achieves the best baseline state identified for each monitoring site, or exceeds the baseline state where this is necessary to achieve improvement. Consideration should be given as to whether target states could be set at broader spatial scales (e.g. at catchment or FMU scale) as well as at additional sites as further Lake SPI surveys are completed.

The next step is to identify and assess the impact of possible actions and mitigations that are available to support the maintenance and improvement of freshwater in relation to Lake SPI indices and more broadly, ecosystem health.

References

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