NIWA
Taihoro Nukurangi

Assessment of three lowland Southland lakes using LakeSPI

Lake George, Lake Vincent, and The Reservoir

Prepared for Environment Southland

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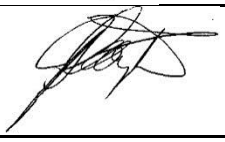
J. Clayton	Approved for release by:	

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Executive summary

NIWA was contracted by Environment Southland to assess the ecological condition of three lowland coastal lakes: George, Vincent and The Reservoir, using LakeSPI (Submerged Plant Indicators).

The LakeSPI method provides a cost-effective bio-assessment tool for monitoring and reporting on the ecological condition of lakes using submerged vegetation characteristics, and compliments other forms of condition monitoring such Trophic Level Index (TLI). Scoring of lake condition using LakeSPI is set by expectations according to the type and depth of the water bodies being assessed. Therefore LakeSPI allows 'lake condition' to be compared between very different waterbodies, rather than directly comparing lake characteristics and values. It allows lake managers to assess and report on the status of lakes at an individual, regional or national level; monitor change in a lake or group of lakes over time and prioritise lake management initiatives accordingly (e.g., protection, monitoring, weed surveillance).

LakeSPI information is already being used by Environment Southland for reporting on the status of six natural lakes in the Fiordland area, which are mostly of glacial origin and are high-scoring in terms of ecological condition.

Of the three lowland coastal lakes surveyed in November 2014, Lake George is categorised as in 'excellent' condition and The Reservoir and Lake Vincent as in 'high' condition.

Lake George had a LakeSPI Index of 96%. This high score is close to the maximum scoring potential for this very shallow lake, reflecting the fact that it has retained a well-developed and diverse native plant community with the absence of any invasive plant species.

The Reservoir and Lake Vincent had LakeSPI indices of 67% and 56% respectively, which reflects lake systems with predominantly native plant communities with little to moderate impact from invasive species. The invasive species elodea (*Elodea canadensis*) was present in both lakes and water buttercup (*Ranunculus trichophyllus*) was also recorded at limited sites.

We recognise that lowland lakes such as those surveyed may be under high pressure from land-use intensification, with impacts evident in the restricted plant depth limits of the two deeper lakes and an absence of some vegetation elements where lake edge has not been retired in The Reservoir. On average LakeSPI surveys are recommended every 5 years but should be undertaken on a more frequent basis (e.g., every two years) if waterbodies are vulnerable to deleterious influences or invasions by invasive species. It is recommended that LakeSPI surveys be repeated for Lakes George, Vincent and The Reservoir in the next two to four years to allow changes in lake ecological condition to be identified.

To gain a further understanding of the overall state of lakes in the Southland Region, it is also suggested that one-off surveys be completed for additional lakes with no or limited information. Knowing their condition will provide a better understanding of the region's diversity of lakes and factors that influence macrophyte presence. Benefits of further longer term monitoring should be considered relative to assessed values and risks.

1 Background

Environment Southland manages Southland's water resources which includes a duty to monitor and report on the overall state of the region's freshwater lakes (Environment Southland, 2011).

Lake Submerged Plant Indicators (LakeSPI) is a bio-assessment survey method widely used for monitoring and reporting on the ecological condition of New Zealand lakes. It is recommended by Ministry for the Environment (MFE) as one of two indicators of water quality (MFE, 2014) and is used by regional councils for State of the Environment (SOE) reporting.

LakeSPI allows lake managers to quickly assess and report on the status of their lakes at an individual regional or national level, monitor changes occurring within a lake or group of lakes over time and prioritise lake management initiatives accordingly (e.g., protection, monitoring, weed surveillance).

LakeSPI information is used by Environment Southland for reporting on the status of six natural state lakes in the Fiordland area. Lakes Te Anau, Manapouri, Hauroko, Mavora North, Mavora South, and Gunn were surveyed using LakeSPI between 2001 and 2007 and results show these lakes to be in 'high' ecological condition (i.e., LakeSPI Indices >50-75%).

Environment Southland also recognises the importance of the smaller coastal lakes and contracted NIWA to carry out LakeSPI surveys on three lowland coastal lakes: George, Vincent and The Reservoir. In 2013, a modified, LakeSPI 'like' method (Roberson & Stevens, 2013) was applied to these same lakes but the data collected from these surveys could not be used to generate LakeSPI indices of the standard required for SOE reporting.

This report presents the results of LakeSPI surveys for Lakes George, Vincent and The Reservoir, and compares the status of these lakes with those regionally and nationally.

2 Methods

2.1 LakeSPI

LakeSPI is a management tool that uses Submerged Plant Indicators (SPI) for assessing the ecological condition of New Zealand lakes and for monitoring change. Key features of aquatic vegetation structure and composition are used to generate three LakeSPI indices:

- 'Native Condition Index' – This captures the native character of vegetation in a lake based on diversity and extent of indigenous plant communities. A higher score means healthier, deeper, more diverse communities.
- 'Invasive Impact Index' – This captures the invasive character of vegetation in a lake based on the degree of impact by invasive weed species. A higher score reflects greater impact from exotic species, which is usually undesirable.
- 'LakeSPI Index' – This is a synthesis of components from both the native condition and invasive impact condition of a lake and provides an indication of overall lake condition. The higher the score the better the condition.

Key assumptions of the LakeSPI method are that native plant species and high plant diversity represents healthier lakes or better lake condition, while invasive plants are ranked for undesirability based on their displacement potential and degree of measured ecological impact (Clayton & Edwards 2006).

Because lakes have differing physical characteristics that can influence the extent and type of submerged vegetation, each of the LakeSPI indices are expressed in this report as a percentage of a lake's maximum scoring potential. Scoring potential reflects the maximum depth of the lake to normalise the results from very different types of lakes.

LakeSPI results are supported by a web-reporting service found at www.lakespi.niwa.co.nz, where scores for lakes assessed to date can be searched for and displayed. This secure and freely-accessible data repository allows agencies to compare lake scores with other lakes regionally and nationally as required.

2.2 Field surveys

The LakeSPI method (Clayton and Edwards 2006, de Winton et al. 2012) was applied at five baseline sites selected from within each of the three lakes: Lake George, Lake Vincent and The Reservoir, on the 26-27 November 2014. Baseline sites are carefully selected to be representative of maximal vegetation development and situated away from local influences such as streams.

At each site scuba divers scored 11 metrics over a 2 m wide transect from shore to the deepest vegetation limit. Metrics included measures of diversity from the presence of key plant communities, depth of vegetation growth and the extent that invasive weeds were represented. A complete description of measured characters is given in the technical report at http://lakespi.niwa.co.nz.

Metrics were then entered into the NIWA LakeSPI database which is used to calculate LakeSPI indices for individual lakes. Additionally an inventory of all plant species encountered was also made (Appendix A).

2.3 LakeSPI status

For ease of reporting results, five lake condition categories are used to provide a description of a lakes status at the time of a survey. These categories are allocated according to the LakeSPI Index score:

Score =		**LakeSPI Category**
>75%	=	Excellent
>50-75%	=	High
>20-50%	=	Moderate
>0-20%	=	Poor
0%	=	Non-vegetated

3 Results

Table 1 presents LakeSPI results for each lake, with the indices presented as a percentage of the maximum scoring potential.

Table 1: Summary of LakeSPI Indices for Lakes George, Vincent and The Reservoir; in order of their overall lake condition (November 2014).

Lake	Most Recent LakeSPI Survey	LakeSPI Index (%)	Native Condition Index (%)	Invasive Impact Index (%)	Overall Condition
George	26/11/2014	96	91	0	Excellent
The Reservoir	27/11/2014	67	51	16	High
Vincent	27/11/2014	56	59	40	

3.1 Lake George

Lake condition:	Excellent
Lake depth	1.4 m
Max depth of vegetation	1.4 m

Table 2: LakeSPI results for Lake George. LakeSPI Indices are expressed as a percentage of lake maximum potential.

Survey Date	Status	LakeSPI %	Native Condition %	Invasive Impact %
November 2014	Excellent	96%	91%	0%

Lake George is categorised as being in excellent ecological condition with a LakeSPI Index of 96% (Table 2). This high score, close to its maximum scoring potential of 100%, reflects a lake that while very shallow, has retained a well-developed and relatively diverse native plant community in the absence of any invasive species.

Charophytes (*Chara australis, Nitella claytonii, Nitella tricellularis)* dominated the submerged vegetation of Lake George at all 5 baseline sites extending down to the lake maximum depth of 1.4 m at the time of survey.

Figure 1: Charophytes were the dominant vegetation in Lake George. (Photo: R Wells).

Other vegetation (Appendix A) common at all sites included native milfoils (*Myriophyllum triphyllum*), horse's mane (*Ruppia polycarpa*), and blunt pondweed (*Potamogeton ochreatus).* A low growing turf species *Lilaeopsis ruthiana* was also recorded from two sites.

Figure 2: Divers identifying submerged plants at baseline sites within Lake George (Photo: C. Owen, Southern Waterways).

High total plant covers (51% to 95% at all 5 sites) and relatively high native species diversity characterised this shallow lake. Although water clarity was minimal due to high winds and sediment re-suspension at the time of the survey, the maximum depth of the lake still supported significant covers of submerged vegetation indicating earlier water clarity had been adequate to support plant growth. While Lake George may be susceptible to storm-driven fluctuations in submerged vegetation development, it is also likely to recover quickly from a sediment seed bank, based on the widespread presence of seed producing native species in the lake.

As a shallow waterbody Lake George may also experience water level fluctuations that have the potential to influence the submerged vegetation. Other dune lakes in New Zealand have undergone drainage and water level decrease due to land change such as pine plantation plantings. The ecology of Lake George would be susceptible to such impacts should the lake outlet be deepened or the hydrology modified in other ways In the future.

The lake catchment comprises 50.5% pasture (Freshwater Ecosystems of New Zealand Geo-database) but the extensive wetland around the lake would still be providing some buffering against nutrient and sediment inflows.

Freshwater mussels were also noted as widespread in Lake George. This indicates good oxygenated conditions at the lake bed and the likely enhancement of water clarity by these filter feeders.

3.2 The Reservoir

Lake condition:	High
Lake depth:	5.5 m
Max depth of vegetation	2.5 m

Table 3: LakeSPI results for The Reservoir. LakeSPI Indices are expressed as a percentage of lake maximum potential.

Survey Date	Status	LakeSPI %	Native Condition %	Invasive Impact %
November 2014	High	67%	51%	16%

The Reservoir is categorised as being in high ecological condition with a LakeSPI Index of 67% (Table 3). This score is largely driven by the very limited presence of invasive weed species which is reflected by a very low Invasive Impact Index of 16% (Table 3). Elodea (*Elodea canadensis*) and the water buttercup (*Ranunculus trichophyllus*) were present at only 2 of the 5 baseline sites, forming low covers (average ≤5%) with little impact on the overall vegetation.

The native pondweed (*Potamogeton ochreatus*) dominated the submerged vegetation at all sites forming the deepest vegetation (1.9 to 2.5 m) at variable covers (average 6-95%). In the shallows a mixed community of charophytes, milfoils and turf species (Appendix A) were present.

Overall the submerged vegetation of The Reservoir was comprised of common native plants that are typical of freshwater systems with little evidence of saline influence despite their close proximity to the sea.

Approximately 66% of the lake catchment is pasture (Freshwater Ecosystems of New Zealand Geo-database) and little of the lake margin has been fenced off and retired. This likely contributes to the limited emergent vegetation and turf plant presence noted in the lake shallows. The lakes exposure to predominant winds and a wave-disturbed shallow littoral shelf may also restrict development of these plants on exposed shorelines. Total cover within the vegetated zone ranged from 10% to 90% across the five sites.

The depth extent of submerged vegetation also suggests a strong limitation by low water clarity. Low water clarity noted at the time of the survey (through water visibility of 0.5 to 0.7 m for divers) was suggestive of sediment re-suspension and/or algal productivity although some humic staining was also apparent. The areal extent of vegetation development was also constrained by the steeper lake bathymetry found beyond the shallow littoral shelf. Taller-growing pondweeds that are more tolerant of low water clarity comprised the deepest vegetation, with an absence of deeper charophyte meadows that develop under higher water clarity conditions.

3.3 Lake Vincent

Lake condition:	High
Lake depth:	6 m
Max depth of vegetation	3.8 m

Table 4: LakeSPI results for Lake Vincent. LakeSPI Indices are expressed as a percentage of lake maximum potential.

Survey Date	Status	LakeSPI %	Native Condition %	Invasive Impact %
November 2014	High	56%	59%	40%

Lake Vincent is categorised in high ecological condition with a LakeSPI Index of 56% (Table 4). This score reflects a lake with a well-developed native plant community (Native Condition Index of 59%) with only moderate impact from the invasive weed species elodea.

The native pondweed *Potamogeton ochreatus* (Figure 3) and four charophyte species (Appendix A, Figure 4) dominated the native vegetation forming a complete cover to a maximum depth of 3.8 m. Charophyte meadows (>75% cover) were present at the maximum depth of plant growth at all sites. Native turf species (*Glossostigma elatinoides* and *Lilaeopsis ruthiana*) (Figure 5) and freshwater mussels (*Echyridella menziesi*) were also recorded (Figure 6).

Elodea was the only invasive species recorded from the lake. An Invasive Impact Index of 40% (Table 4) reflects its presence at all five baseline sites where it generally formed low cover clumps in the shallows (<2 m). *Ranunculus trichophyllus* was observed in the lake (Appendix A) but was not common enough to be recorded at the baseline sites.

Despite the very high proportion (91%) of the catchment that has been developed as pasture land (Freshwater Ecosystems of New Zealand Geo-database) submerged vegetation remains abundant and relatively diverse. At the time of the survey water clarity was relatively good (through water visibility of ≥2 m for divers). However water clarity prevents complete plant coverage of the lake, although the lake bathymetry having only a small area of deeper basin, results in a high proportion of the lake bed still being colonised. The margins of Lake Vincent appeared to be predominantly fenced and retired so that emergent buffer zones were well developed.

Figure 3: ***Potamogeton ochreatus*** **in Lake Vincent.** (Photo: R. Wells)

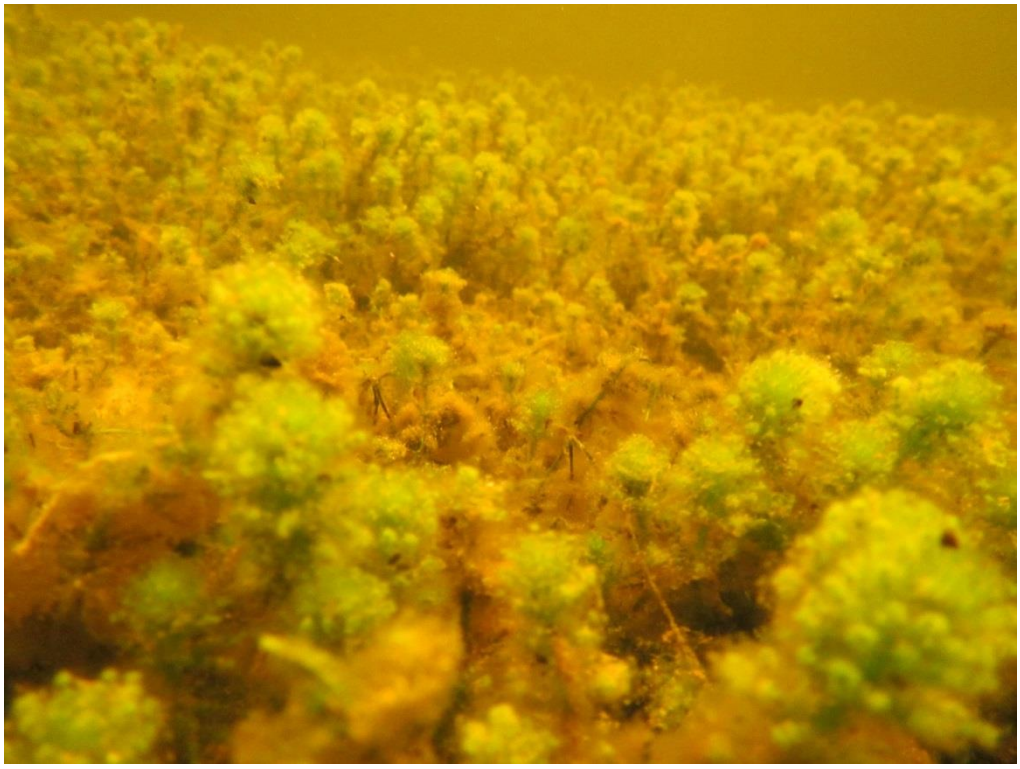

Figure 4: ***Chara fibrosa*** **meadow in Lake Vincent.** (Photo: R. Wells)

Figure 5: Turf species growing along the margin of Lake Vincent. (Photo: R. Wells)

Figure 6: Freshwater mussels and charophytes in Lake Vincent. (Photo: R. Wells)

4 Discussion

LakeSPI results for all lakes are expressed as a percentage of a lakes maximum scoring potential, with the maximum depth of each lake used in setting the scoring potential. This is important as there should be different expectations for shallow coastal water bodies compared to, for example, deep glacial waterbodies. LakeSPI allows 'lake condition' to be compared between very different waterbodies, rather than directly comparing lake characteristics and values.

Of the three lowland coastal lakes surveyed in November 2014, Lake George is categorised as in 'excellent' condition for a lake of its type, and The Reservoir and Lake Vincent as in 'high' condition (Figure 7). These results show that while each of the lakes are very shallow in nature (maximum lake depths ranging from only 1.4 - 6m) each lake retained a well-developed aquatic plant community.

Impacts from invasive weed species were absent (Lake George) to moderate (Lake Vincent). The only weeds present were the relatively benign *Ranunculus trichophyllus*, which is a seed-spread species that tends to be encountered intermittently in cooler waterbodies, and the vegetatively-spread *Elodea canadensis*. The reason for the limited influence of elodea in Lake Vincent and The Reservoir was not apparent, but as coastal waterbodies they may experience fluctuations in salinity that does not favour this species. Elodea has been widely distributed within New Zealand lakes with early releases of trout, and possibly also with perch.

Threats from additional weed species appear minimal on account of lack of public access to these waterbodies, however w would advise that land owners exercise discretion in allowing access to the water bodies to reduce the risk of a new weed incursions. Aquatic weeds are known to be spread in agricultural landscapes by contaminated drainage machinery and by eel fishing nets and the invasive weed *Lagarosiphon major* is known from waterways around Invercargill. The lakes also remain under continued threat from invasive fish (e.g., perch) and nutrient enrichment. The shallow nature of Lake George, Vincent and The Reservoir mean that they are especially vulnerable to change and seemingly small impacts have the potential to have big ecological consequences over a short time period.

A relationship between macrophyte depth limits and Lake Trophic Level Index (TLI) for 77 LakeSPI surveyed lakes (de Winton et al. 2012) suggests that Lake Vincent falls on the mesotrophic to eutrophic boundary (TLI of 3.8 to 4.1 based on site values), while The Reservoir was eutrophic (TLI 4.5 to 4.9). We are unable to suggest a TLI status for Lake George as a water clarity-based plant depth limit could not be established. Nevertheless, we recognise there is considerable scope for abundant macrophytes to improve measured TLI status in Lakes George and Vincent due to their recognised influences on phytoplankton abundance and water clarity.

Compared nationally, the Southland Region has a high proportion of lakes classified as 'excellent' and in 'high' condition, while none of the lakes were classified as 'moderate', 'poor' or 'non-vegetated' condition (Figure 8). We note, however, that a limited number of waterbodies have been assessed for the Southland Region.

Of the nine lakes surveyed using LakeSPI in the Southland Region, one is classified as being in 'excellent' condition (representing those close to their maximum potential ecological condition) and the other eight are classified in 'high' condition (Figure 7).

Figure 7: LakeSPI scores for Southland lakes (red lines) are plotted with scores for a total of 249 New Zealand lakes. The LakeSPI Index is plotted on the y-axis (points), Native Condition Index as lines to the right and Invasive Impact Index lines to the left of the x-axis. Five categories of the LakeSPI condition are indicated by labelled colour bands.

Figure 8: Proportion of lakes in each of five categories of LakeSPI Index for the region (9) and nationally (249), with the number of lakes assessed shown in parenthesis.

5 Recommendations

It is recommended that LakeSPI surveys be repeated for Lakes George, Vincent and The Reservoir in the next two to four years to allow any changes in lake ecological condition to be identified. On average LakeSPI surveys are recommended to be undertaken every 5 years but if changes are noticed in the lakes condition, or the lake is under high pressure from land-use intensification or from a new invasive species, then surveys should be undertaken on a more frequent basis (e.g., every two years). Also because the shallow nature of these lakes makes them particularly vulnerable to change over a shorter time frame, further work should be continued on the lakes to understand and mitigate any threats to their long term ecological condition.

To gain a further understanding of the overall state of lakes in the Southland Region, it is suggested that one-off surveys be completed for additional lakes with no or limited information. Knowing their condition will provide a better understanding of the region's diversity of lakes and factors that influence macrophyte presence. Benefits of any further longer term monitoring should be considered relative to assessed values and risks.

6 Acknowledgements

Many thanks to Chris Owen (Southern Waterways) for providing boating expertise and local knowledge. Also thanks to the relevant land owners for access permission.

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8 Appendix A – Species list based on 2014 LakeSPI survey.

Table 5: Submerged aquatic plant species recorded for Lake George, The Reservoir and Lake Vincent; based on 2014 LakeSPI survey at five baseline sites.

Species	Lake George	The Reservoir	Lake Vincent
Bryophytes (unidentified moss species)		✓	
Emergents			
Apodasmia similis (*Leptocarpus similis*)	✓		
Carex secta		✓	✓
Phormium tenax			✓
Typha orientalis			✓
Turf plants			
Glossostigma elatinoides		✓	✓
Lilaeopsis ruthiana	✓	✓	✓
Triglochin striata		✓	
Tall native vascular plants			
Myriophyllum triphyllum (*M. elatinoides*)	✓	✓	
Potamogeton cheesemanii		✓	
Potamogeton ochreatus	✓	✓	✓
Ruppia polycarpa (*R. spiralis*)	✓	✓	
Charophytes			
Chara australis (*C. corallina*)	✓	✓	✓
Chara globularis			✓
Chara fibrosa	✓	✓	✓
Nitella hookeri	✓		
Nitella claytonii	✓		
Nitella cristata			✓
Nitella tricellularis	✓		
Invasive species			
Elodea canadensis		✓	✓
Ranunculus trichophyllus		✓	✓