Water Quality Monitoring Report for Te Roto o Wairewa – Lake Forsyth: January – December 2025

Prepared to meet the requirements of CRC134849

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Report: Water Quality Monitoring Report for Te Roto o Wairewa – Lake Forsyth: January – December 2025

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Executive Summary

This report briefly summarises the surface water quality monitoring of Te Roto o Wairewa – Lake Forsyth for the 2025 calendar year and provides an analysis of long-term trends since 1993.

Conductivity, salinity, turbidity, nitrogen and phosphorus levels, as well as phytoplankton and cyanobacteria unit counts, all recorded statistically significant decreases since monitoring began. Trophic Level Index (TLI) also decreased over time, which is not surprising as this index is calculated from total nitrogen and total phosphorus (as well as chlorophyll a). There was no change in temperature over time. However, a likely increasing trend was noted. This is also supported by the guideline level for temperature (19°C) being exceeded on two consecutive occasions during the 2025 monitoring year.

The cyanobacteria biovolume alert and action levels were exceeded on two and one occasions, respectively. This number of exceedances is within the range recorded since monitoring began in 2008. As a result of these exceedances, health warnings were issued from November 2024 to June 2025). The decrease in salinity is likely partially driving the change in phytoplankton composition from *Nodularia* spp. to *Dolichospermum* spp. and *Aphanizomenon* spp..

These results demonstrate that water quality continues to improve within the lake, most likely attributed to the initiation of the canal opening regime. This is supported by a significant decrease in lake inputs and subsequent interactions of cyanobacteria and phytoplankton. However, the water quality is still poor at times, and additional lake and catchment management practices that improve water quality (e.g., planting) should therefore continue.

Contents Page

Report: Water Quality Monitoring Report for Te Roto o Wairewa – Lake Forsyth: January – December 2025 i

1. Introduction 1

2. Methods 1

3. Results 2

3.1. Conductivity and salinity 2

3.2. Temperature 2

3.3. Turbidity 3

3.4. DIN 3

3.5. DRP 3

3.6. TLI 4

3.7. Phytoplankton and cyanobacteria unit counts 4

3.8. Cyanobacteria biovolume 5

3.9. Lake openings 6

4. Conclusion 6

5. Appendix A: Graphs 8

1. Introduction

In accordance with the requirements of Condition 11c (monitoring and reporting) of consent CRC134849 (to take and divert water from, and dam, Te Roto o Wairewa – Lake Forsyth), this report briefly summarises the surface water quality results of Te Roto o Wairewa – Lake Forsyth covering the 2025 calendar year and provides an analysis of long term trends. The data utilised in this report was provided by Environment Canterbury (ECan).

2. Methods

Samples were collected from the lake at least monthly and analysed for the parameters of conductivity, salinity, temperature, turbidity, Dissolved Inorganic Nitrogen (DIN), Dissolved Reactive Phosphorus (DRP), phytoplankton unit counts, cyanobacteria unit counts and cyanobacteria biovolume. The Trophic Level Index (TLI) was calculated using chlorophyll a, total nitrogen and total phosphorus. Cyanobacteria are a subset of phytoplankton, and both unit counts and biovolumes were assessed for selected species of potentially toxic cyanobacteria.

Water quality parameters were assessed from commencement of monitoring in 1993 until December 2025. Phytoplankton and cyanobacteria unit counts were available from 2004, while cyanobacteria biovolume data was available from 2008. Samples were typically collected from the ECan water level recorder site (henceforth referred to as 'Recorder'). Salinity is recorded at two additional sites (Figure 1). Due to the interplay of conductivity and salinity, these are parameters are presented together in this report.

Long-term data trends were analysed using Time Trends software (NIWA, 2014[1]). The Seasonal Kendall trend test was used to test the significance, magnitude and direction of trends, and to estimate average annual percent change. Water quality parameters were analysed as independent data. Total phytoplankton data, including the subsets of cyanobacteria and potentially toxic cyanobacteria, were analysed as dependent data, due to the potential for species numbers to impact replication between sampling events. Long-term data trends in cyanobacteria biovolume were not analysed, due to the sampling methodology differing between the State of Environment monitoring and samples collected during bloom events to assess human health risk assessment.

[1] NIWA, 2014. Trend and equivalence analysis. Software Version 9.0. NIWA. https://www.jowettconsulting.co.nz/home/time-1.

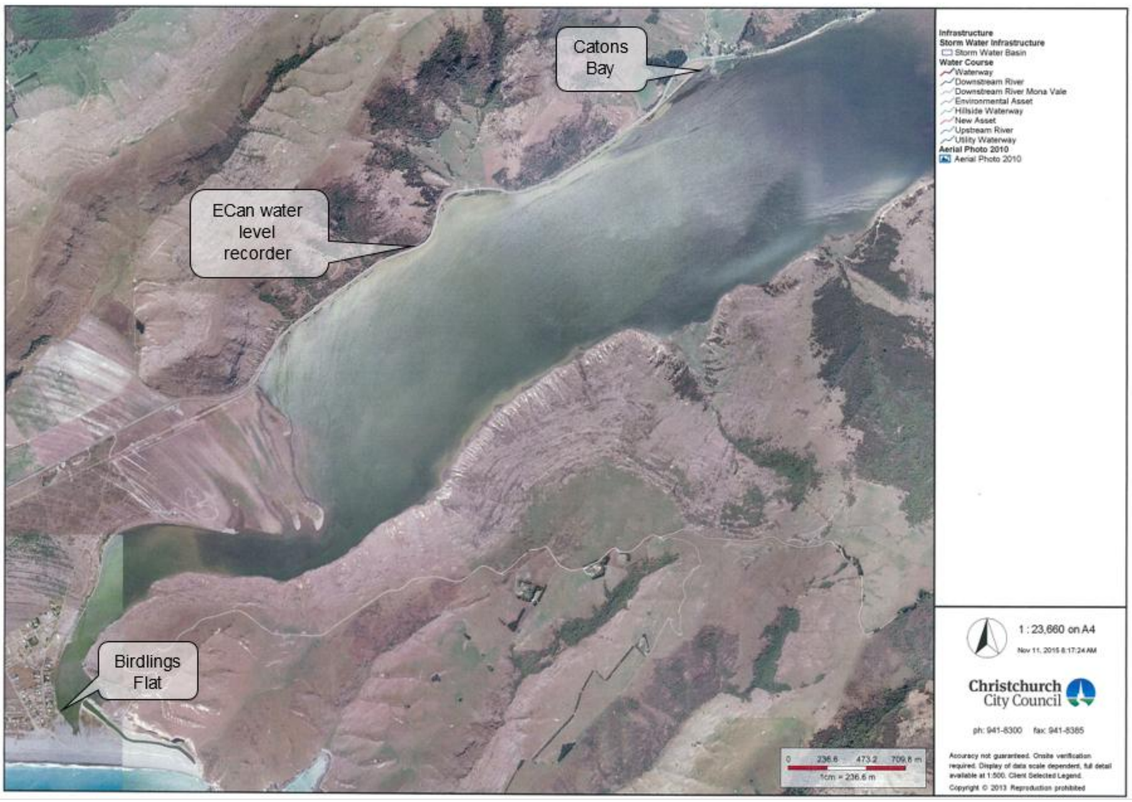

Figure 1. Location of water quality monitoring sites in Te Roto o Wairewa – Lake Forsyth.

3. Results

3.1. Conductivity and salinity

- A general decreasing trend was recorded over the monitoring periods for both parameters (Figures 2 – 3 in Appendix A).
- Following the initiation of the canal opening regime, median conductivity and salinity concentrations have decreased close to 80%, while mean concentrations decreased by over 70% (Table 1).
- There was a significant decrease (5% per annum) in conductivity at the Recorder site since monitoring began in July 1993.
- There was a significant decrease (18% per annum) in salinity at the Recorder site since monitoring began in December 2006. A significant decrease of 12% was recorded at Birdlings Flat and 14% at Catons Bay sites since monitoring began in December 2006.

3.2. Temperature

- Following the initiation of the canal opening regime, median temperature increased by 17% and mean temperatures by 8% (Table 1).
- No significant change over time was recorded for temperature since monitoring began in August 1993, with seasonal variations in levels as expected (Figure 4 in Appendix A).

- Frequent exceedances of the Land and Water Regional Plan guideline (LWRP) level (19°C; Environment Canterbury, 2015[2]) have occurred since the establishment of monitoring. Two of the 13 samples taken during the 2025 monitoring year exceeded this guideline. Overlap of exceedances occurred during the months of January and February for all sites.

3.3. Turbidity

- Following the initiation of the canal opening regime, turbidity decreased by 24% (median) and 36% (mean) (Table 1).
- There was a significant per annum decrease in turbidity of 2% since monitoring began in July 1993, with fewer large peaks in levels over time (Figure 5 in Appendix A).
- Turbidity spikes were recorded on the 30th May, 25th June, 28th August and 27th November, indicating elevated conditions (Figure 5 in Appendix A). No substantive rainfall was recorded within a six-day timeframe of these dates pre sampling (Kaituna Valley Road recorder). In the absence of significant rainfall, elevated turbidity is likely driven by internal lake processes.

3.4. DIN

- Following the initiation of the canal opening regime, DIN decreased by 60% (median) and 38% (mean) (Table 1).
- There was a significant decreasing trend in DIN since monitoring began in July 1993, with an annual percent change of 2% (Figure 6 in Appendix A).
- Compared to the rest of the data for 2025, there were no exceedances in DIN concentrations relative to the LWRP guideline of 0.34 mg/L (Environment Canterbury, 2015). The highest concentration observed was 0.335 mg/L in June, which remained below the guideline threshold.

3.5. DRP

- Following the initiation of the canal opening regime, median DRP decreased by 25% after remaining static for several years. However, the mean DRP decreased by 43% (Table 1), which is slightly less than value recorded last year (46%). No significant changes were observed in the concentrations of water quality parameters such as DO, pH, temperature, and conductivity that could explain the reduction in DRP.
- There was a significant decrease in DRP of 2% per annum since monitoring began in July 1993 (Figure 7 in Appendix A).
- The observed trend of fewer peak concentrations approximately after 2010 was still apparent.
- In comparison to the rest of the 2025 data, spikes in DRP were recorded in January (0.068 mg/L), February (0.106 mg/L) and March 2025 (0.036 mg/L) (Figure 5 in Appendix A). These spikes exceeded the LWRP guideline of 0.02 mg/L (Environment Canterbury, 2015[2]). No rain was recorded at the time of sampling at the Kaituna Valley Road recorder. However, rainfall totals in January (115.5mm) and March (154mm) were elevated

[2] Environment Canterbury, 2015. Canterbury Land and Water Regional Plan - Volume 1. February 2017. Environment Canterbury, Christchurch.

relative to what would typically be expected for late summer and early autumn conditions in the area. February exhibited low rainfall (15.5mm) which may suggest elevated concentrations could be attributed to other catchment processes.

3.6. TLI

- Following the initiation of the canal opening regime, median and mean TLI decreased by 7% and 8%, respectively (Table 1).
- A significant decrease in TLI of 0.5% per annum was recorded since monitoring began in September 1999 (Figures 8a - 8c in Appendix A).
- Prior to the canal opening there was an increasing trend (Figure 8b); however, levels have been decreasing since the implementation of the canal opening in 2009 (Figure 8c).

3.7. Phytoplankton and cyanobacteria unit counts

- Total phytoplankton unit counts per annum significantly decreased by 8%, since monitoring began in 2004 (Figure 9 in Appendix A).
- Total cyanobacteria unit counts per annum significantly decreased by 17%, since monitoring began in 2004 (Figure 9 in Appendix A).
- A reduction in large peaks of concentrations for both parameters has been an observed trend since monitoring began. Elevated spike counts of cyanobacteria *Merismopedia spp.* was observed during January and February 2025 along with *Aphanizomenon spp* during September 2025 (Figure 9 in Appendix A).
- Regarding counts of potentially toxic cyanobacteria:
  - Following implementation of the canal opening regime, cyanobacteria count decreased by 99% (median) and 80% (mean).
  - *Merismopedia* spp. counts were elevated when monitoring first commenced in 2004. Since 2011, counts have reduced to occasional spikes, with a significant per annum decrease of 137% since monitoring began (Figure 10 in Appendix A). While a decrease greater than 100% is theoretically impossible, this figure reflects the drop from extremely high counts to substantially low counts or complete absence. This has resulted in a strong decreasing trend, and when averaged over time results in an annual percentage decrease that exceeds realistic bounds. It is anticipated this rate of decrease will lessen over time as the trend slope flattens and is supported by previous annual reports: 362% (2021 report), 329% (2022 report), 282% (2023 report), 231% (2024 report). The decrease in species presence over time appears to be due to an intolerance of freshwater conditions. Like 2024, the spike recorded this year was associated with freshwater conditions. Elevated conductivity in January and DRP (January, February and March) could be attributed to the increase. In addition, heavy January rainfall preceding sampling resulted in increased nutrient inputs that were utilised by cyanobacteria.
  - Elevated counts of *Nodularia* spp. were recorded when monitoring first commenced, but only occasional spikes have occurred since 2010 (Figure 10 in Appendix A). For example, a spike in concentration (20,336 units/ml) was recorded during February 2025. The decline in *Nodularia* spp. is likely due to a decrease in lake salinity, as

optimal growth occurs between 7–18 ppt[3]. Salinities in the lake have not exceeded 5 ppt since 2010. Although a significant decrease was recorded since monitoring began, the percent change was zero, likely attributed to a small number of peaks recorded at the beginning of the dataset and little recordings thereafter.

- *Dolichospermum* spp. and *Aphanizomenon* spp. have generally been present in low numbers since 2010, with occasional and infrequent spikes. This was generally the case this monitoring year; however, *Aphanizomenon* spp. exhibited a spike of 38,614 units/ml was recorded in September (Figure 10 in Appendix A). *Dolichospermum* spp. unit counts also had multiple spikes in February (17,620 units/ml), March (11,548 units/ml) and October (20,570 units/ml). A significant increasing trend was recorded for both cyanobacteria species; however, a zero percent change over time was recorded, due to a high proportion of zero abundance, particularly early in the dataset. It is probable that the increasing abundance of these two cyanobacteria is a result of lower salinity in the lake, as both species can grow in freshwater[4].
- Cyanobacteria exhibited elevated concentrations during January, February and October compared to other months. These results did not correspond to high levels of water quality parameters except for DRP, which recorded 0.068mg/L in January and 0.106 mg/L, in February (both exceeded the LWRP guideline of 0.02 mg/L (Environment Canterbury, 2015[2]). October DRP count of 0.015mg/L was below guideline. Rainfall totals at the Kaituna Valley Road recorder were characterised by high totals during January (115.5mm) and October (93.5mm). February (15.5mm) exhibited a lower monthly rainfall total, however 3.5mm was recorded 4 days prior to sampling. Overall, there was no evident correlation established between water quality parameters and cyanobacteria concentrations.

3.8. Cyanobacteria biovolume

- A comparison of the pre and post canal opening regime is not provided for biovolume, as the metric is impacted due to the low sample numbers collected pre-opening (19 samples).
- With respect to the biovolume of potentially toxic cyanobacteria species (Figure 11 in Appendix A):
  - *Merismopedia* spp. biovolume was occasionally high when monitoring first began, but levels are now generally low year-round, apart from two consecutive spikes in January and February.
  - *Nodularia* spp. biovolume was periodically high when monitoring first began but was particularly high during the 2016 monitoring year. A single small to moderate spike in *Nodularia* spp. has occurred in most years since 2019. January and February presented the highest counts of 2025 before ceasing for the remainder of the year.
  - *Dolichospermum* spp. have generally been present in low volumes. Small spikes were recorded during February and March.

[3] Mazur-Marzec, H., Żeglińska, L. & Pliński, M. 2005. The effect of salinity on the growth, toxin production, and morphology of Nodularia spumigena isolated from the Gulf of Gdańsk, southern Baltic Sea. Journal of Applied Phycology 17, 171–179.
[4] Halinen, K., Jokela, J., Fewer, D., Wahlsten, M., & Sivonen, K. 2007. Direct evidence for production of microcystins by Anabaena strains from the Baltic Sea. Applied Environmental Microbiology, 73(20), 6543–6550.

- Low numbers of *Aphanizomenon* spp. are typically recorded; however, small peaks of biovolume have occurred every spring/summer since December 2016. This was the case in 2025, with the largest spike recorded in October.

- Of the 13 samples collected in 2025, the biovolume alert guideline level for all potentially toxic cyanobacteria (0.5 mm^3/L) was exceeded on five occasions, and the action guideline level (1.8 mm^3/L) was exceeded on four occasions (Ministry for the Environment and Ministry of Health, 2009[5]; Figure 12a in Appendix A). Two exceedances of the alert level were due to *Nodularia* spp. and *Dolichospermum* spp.. The 2025 exceedances were attributed to these two cyanobacteria species and represented the highest exceedance counts since 2020 (Figure 12b in Appendix A).

- In light of the exceedances, a harmful algal bloom health warning was issued in November 2024 and carried into 2025, with lifting of the warning in June 2025. The warning advised the public to avoid contact with the water, eating fish or shellfish from the lake, and recommended to keep livestock and pets away from the lake.

3.9. Lake openings

- The lake was opened on the 21st March , 2nd May, 10th June and 5th August 2025. (Figures 2 and 13 in Appendix A).

4. Conclusion

- Since the canal opening was instigated in 2009, there have been significant improvements in water quality within the lake. Conductivity, salinity, turbidity, nitrogen, phosphorus, phytoplankton, cyanobacteria, and TLI have all demonstrated decreases. The monitoring from 2025 is still showing continual improvements in water quality, however more elevated cyanobacteria unit counts were recorded during 2025. The opening of the lake likely improves water quality by allowing water to flow out to sea and preventing significant flows of salt water to mix with the lake. This formerly occurred during the mid-beach opening regime. The overall regime change has resulted in a decrease in lake salinity.

- The decrease in salinity is probably partially driving the change in phytoplankton composition from *Nodularia spp.*, to *Dolichospermum spp*. and *Aphanizomenon spp.*.

- Water quality results still demonstrate occasional poor outcomes therefore efforts should continue to improve sustainable land management practices within the wider catchment.

[5] Ministry for the Environment and Ministry of Health. 2009. New Zealand Guidelines for Cyanobacteria in Recreational Fresh Waters – Interim Guidelines. Prepared for the Ministry for the Environment and the Ministry of Health by SA Wood, DP Hamilton, WJ Paul, KA Safi and WM Williamson. Wellington: Ministry for the Environment.

Table 1. Percent change of parameters at the Environment Canterbury Recorder Site at Te Roto o Wairewa – Lake Forsyth, before (various dates for each parameter from 1993 – September 2009) and after (October 2009 – December 2025), the implementation of the canal opening regime.

	Count (n)		Median		Mean		Percentage change	
Parameter	Pre	Post	Pre	Post	Pre	Post	Median	Mean
Conductivity (µS/cm)	587	230	920	210	987	250	-77%	-75%
Salinity (ppt)	496	295	5.2	1.1	5.1	1.4	-79%	-73%
Temperature °C	694	309	13.0	15.2	13.2	14.4	17%	8%
Turbidity (NTU)	599	195	14.0	10.7	31.2	20.1	-24%	-36%
DIN (mg/L)	512	189	0.043	0.017	0.112	0.070	-60%	-38%
DRP (mg/L)	504	175	0.004	0.004	0.028	0.016	0%	-43%
TLI	121	193	5.99	5.56	6.17	5.67	-7%	-8%
Potentially toxic cyanobacteria - counts (unit/ml)	137	236	47,500	120	171,471	34,218	-99%	-80%

5. Appendix A: Graphs

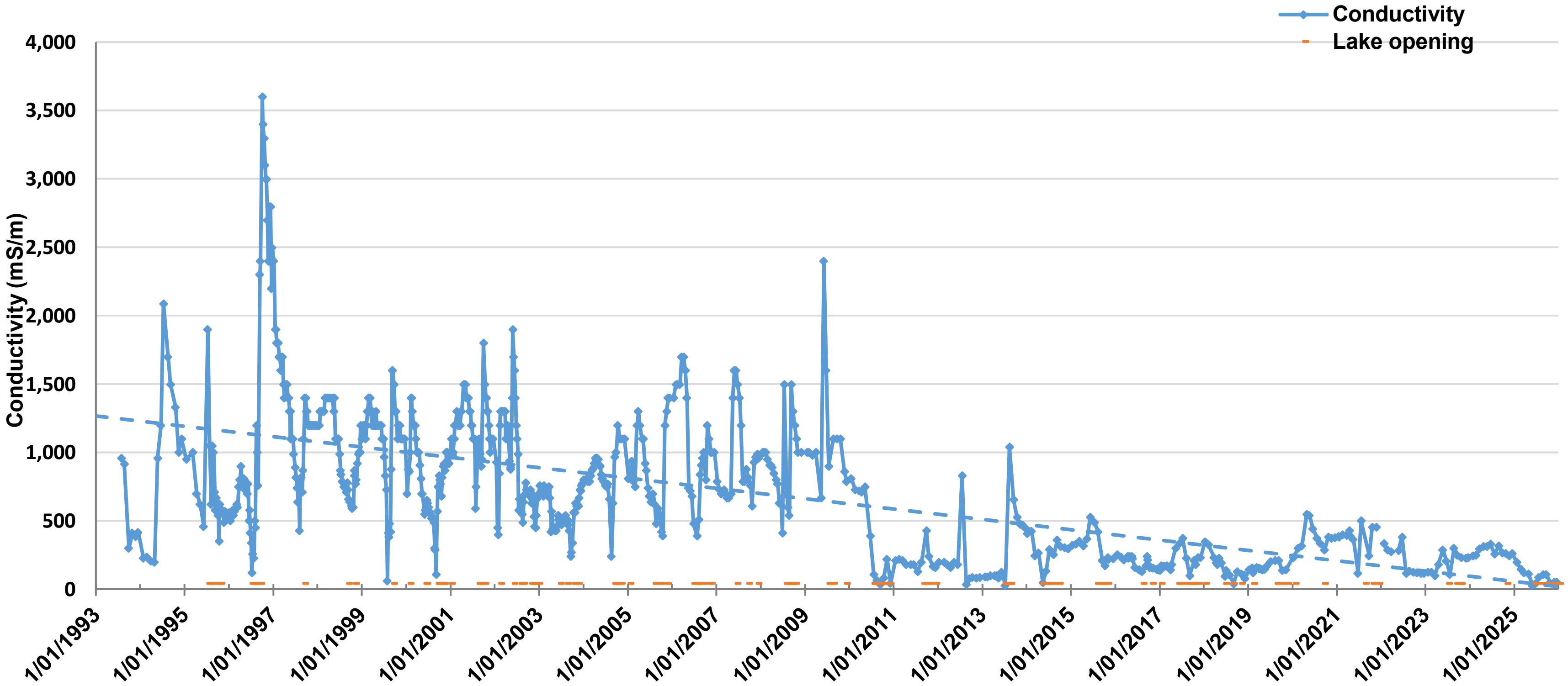

Figure 2. Conductivity of water at Te Roto o Wairewa – Lake Forsyth at the ECan Water Level Recorder site July 1993 - December 2025. The dashed line is a linear trendline.

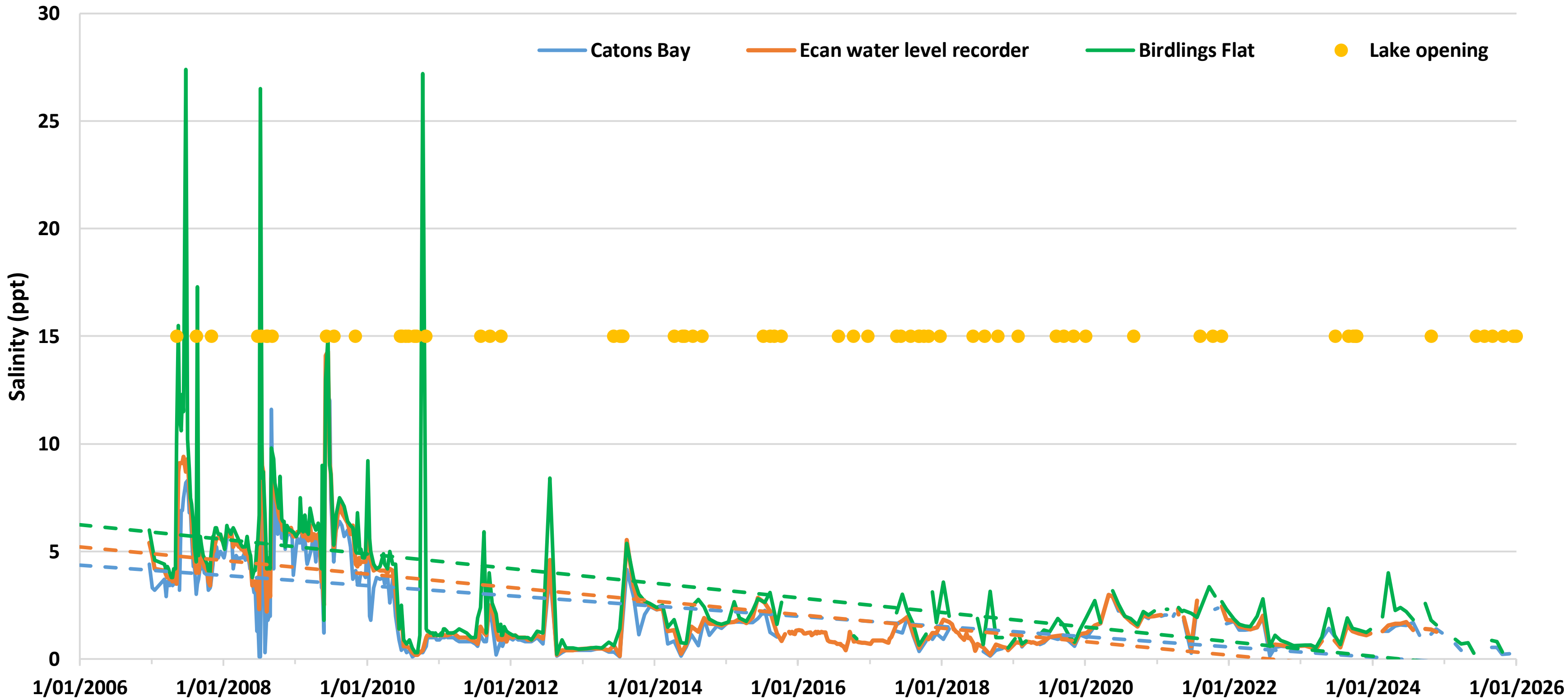

Figure 3. Salinity of water at Te Roto o Wairewa – Lake Forsyth at three sites (ECan Water Level Recorder, Catons Bay and Birdlings Flat) December 2006 - December 2025. The dashed lines are linear trendlines.

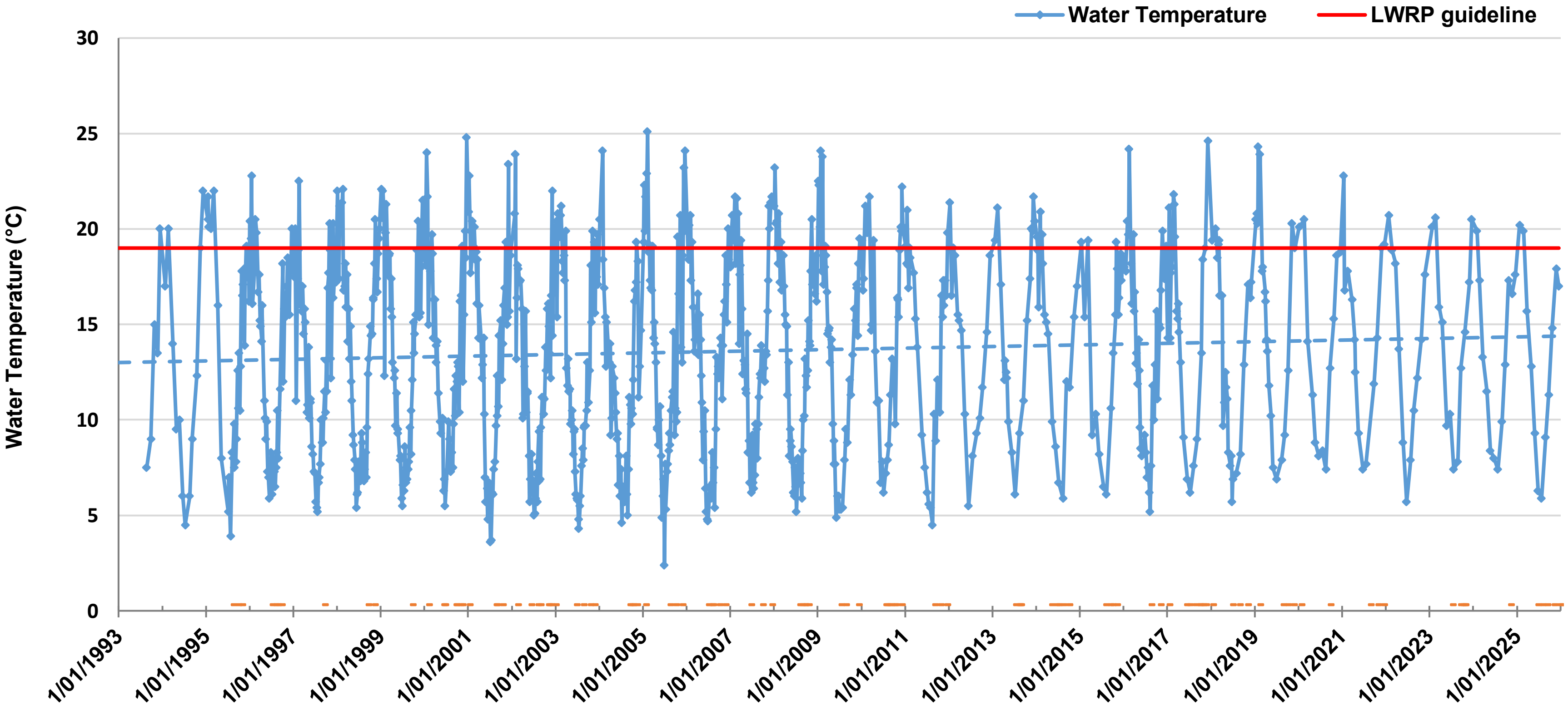

Figure 4. Water Temperature at Te Roto o Wairewa – Lake Forsyth at the ECan Water Level Recorder site August 1993 - December 2025. The dashed line is a linear trendline. Red line = Land and Water Regional Plan (LWRP) guideline for coastal lakes (19°C).

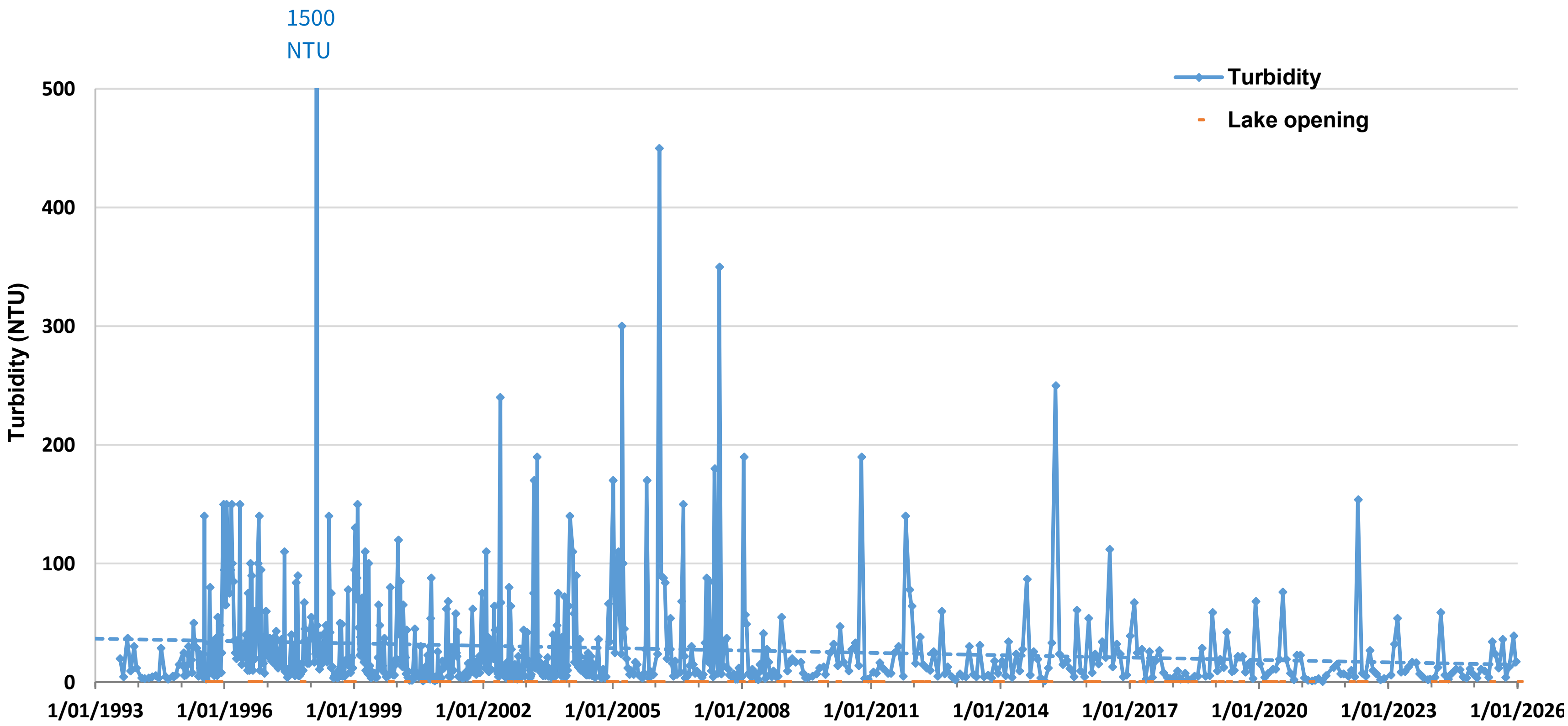

Figure 5. Turbidity of water at Te Roto o Wairewa – Lake Forsyth at the water level recording site July 1993 - December 2025. The dashed line is a linear trendline. One data point is substantially higher than the other data points and is therefore off the scale of the graph – the number above the graph details the concentration.

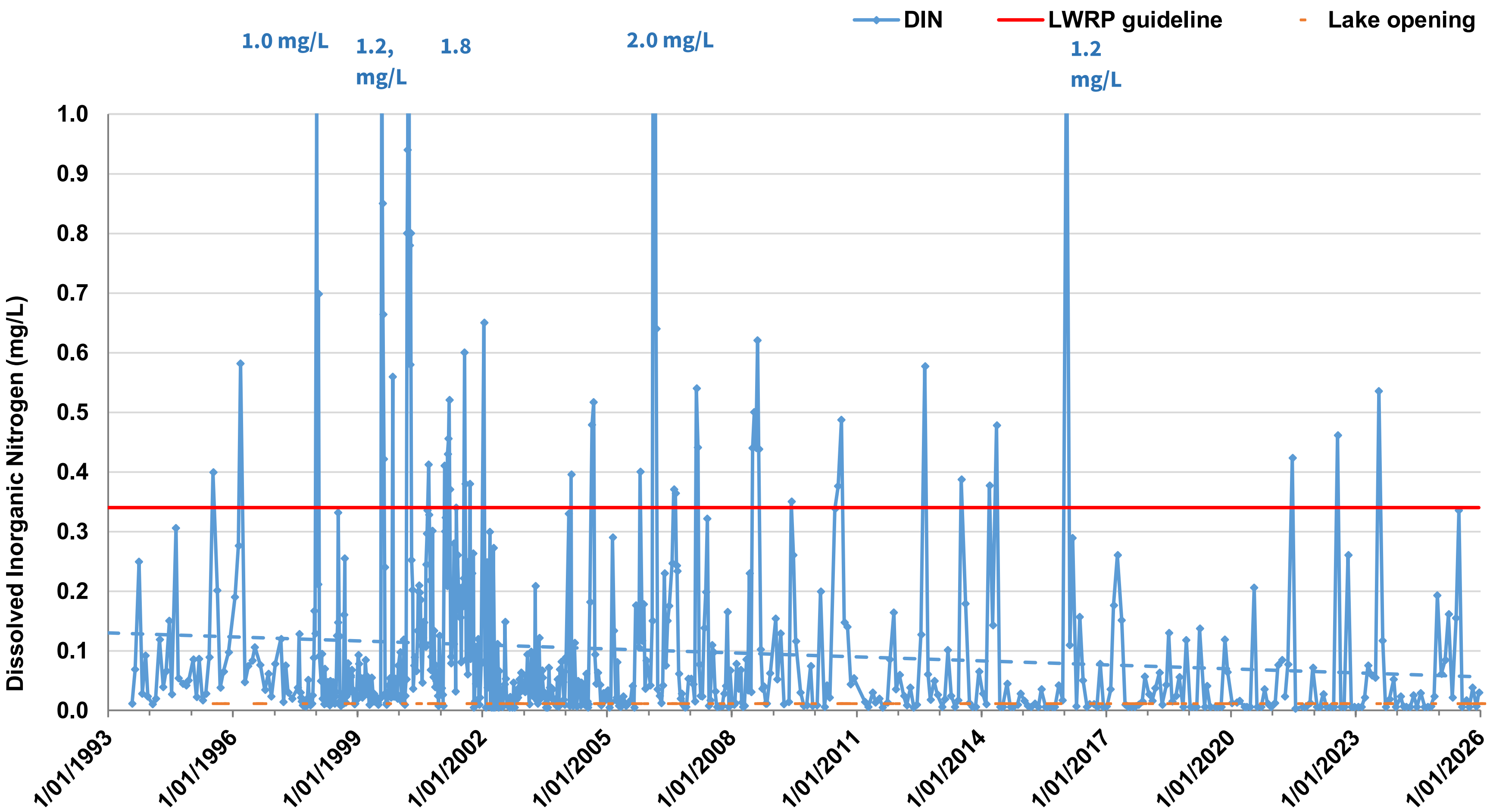

Figure 6. DIN at Te Roto o Wairewa – Lake Forsyth at the ECan Water Level Recorder site, July 1993 – December 2025. The dashed line is a linear trendline. Five data points are substantially higher than the other data points and are therefore off the scale of the graph – the numbers above the graph detail their concentrations.

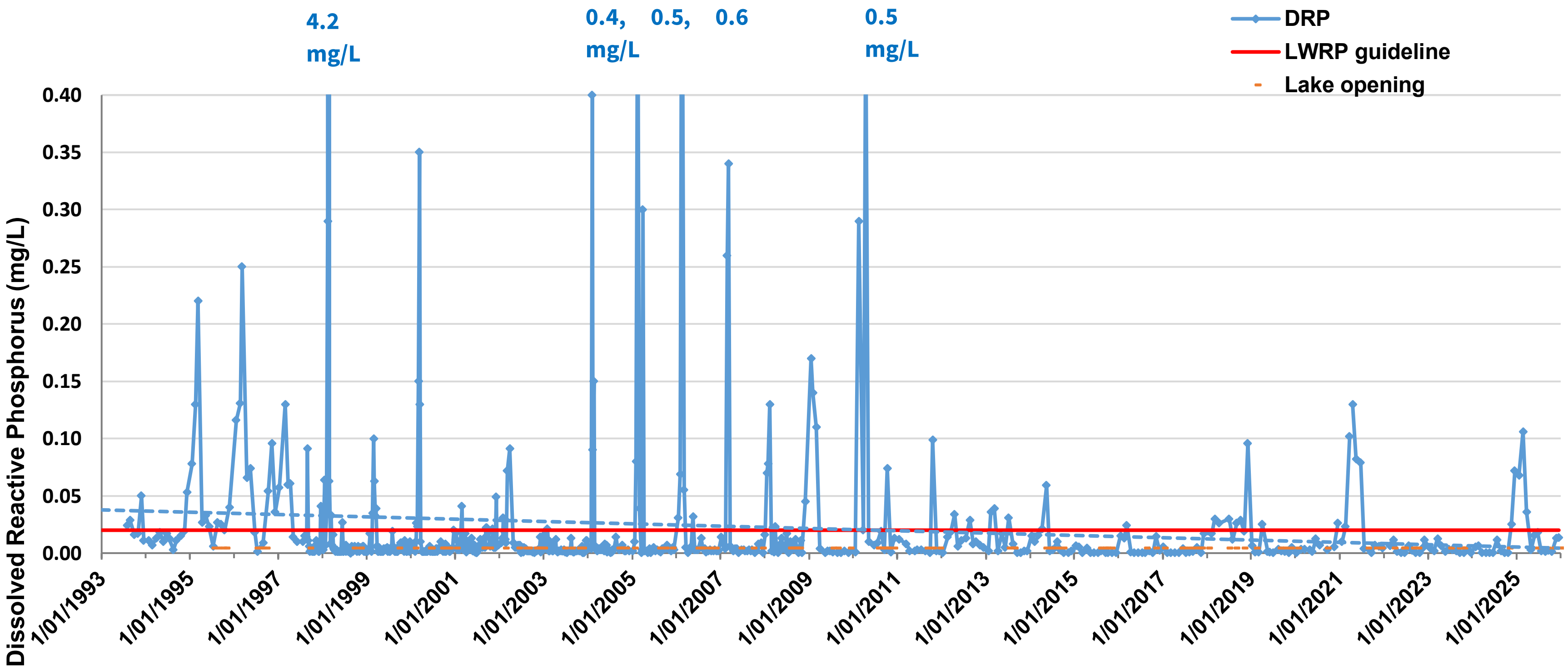

Figure 7. DRP at Te Roto o Wairewa – Lake Forsyth at the ECan Water Level Recorder site, July 1993 – December 2025. The dashed line is a linear trendline. Five data points are substantially higher than the other data points and are therefore off the scale of the graph – the numbers above the graph detail their concentrations.

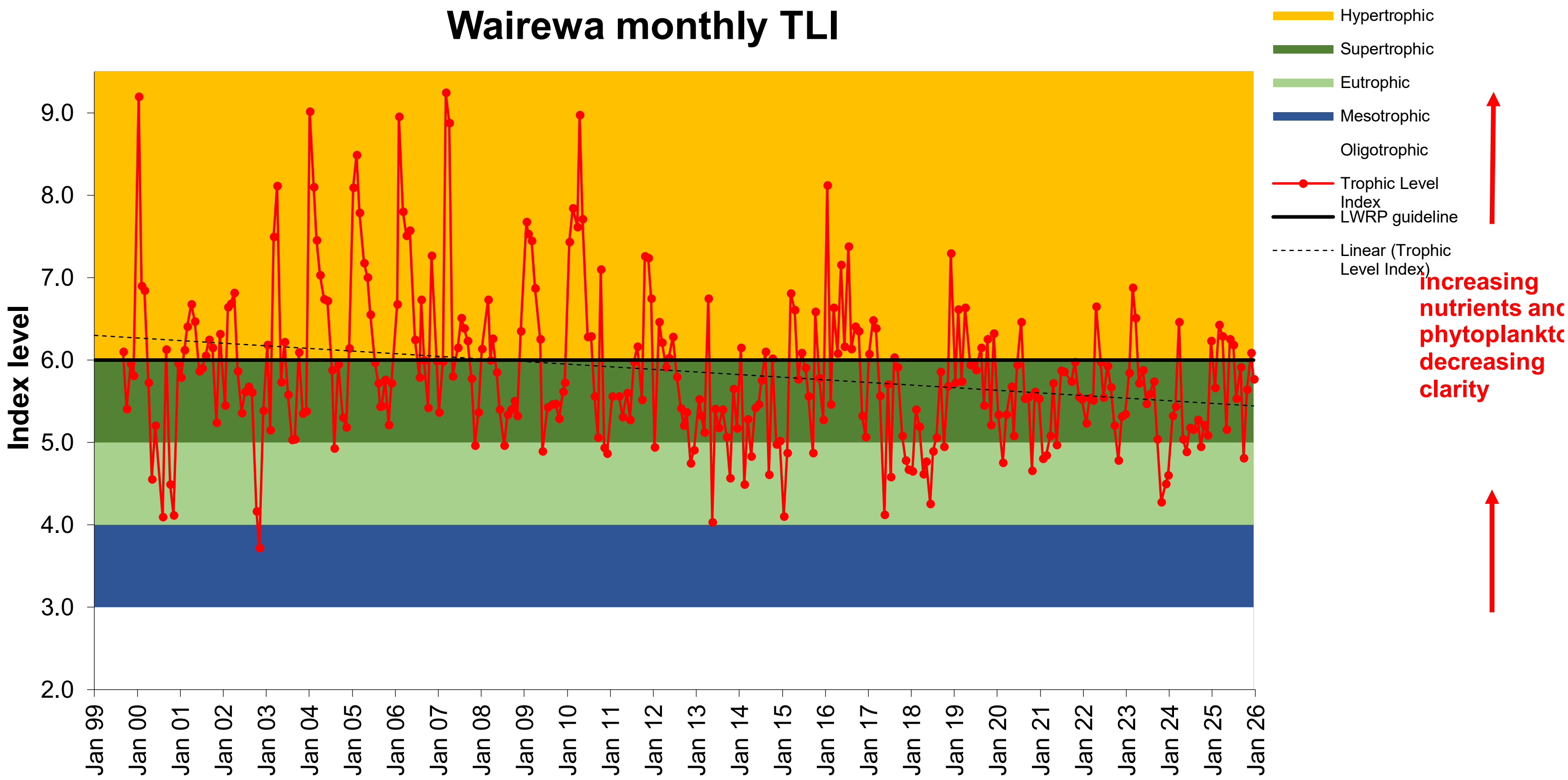

Figure 8a. Trophic Level Index (TLI) at Te Roto o Wairewa – Lake Forsyth at the ECan Water Level Recorder site for the entire dataset (September 1999- December 2025). The dashed line is a linear trendline. Solid black line = Land and Water Regional Plan (LWRP) guideline for coastal lakes (6 TLI). Graph modified from ECan versions.

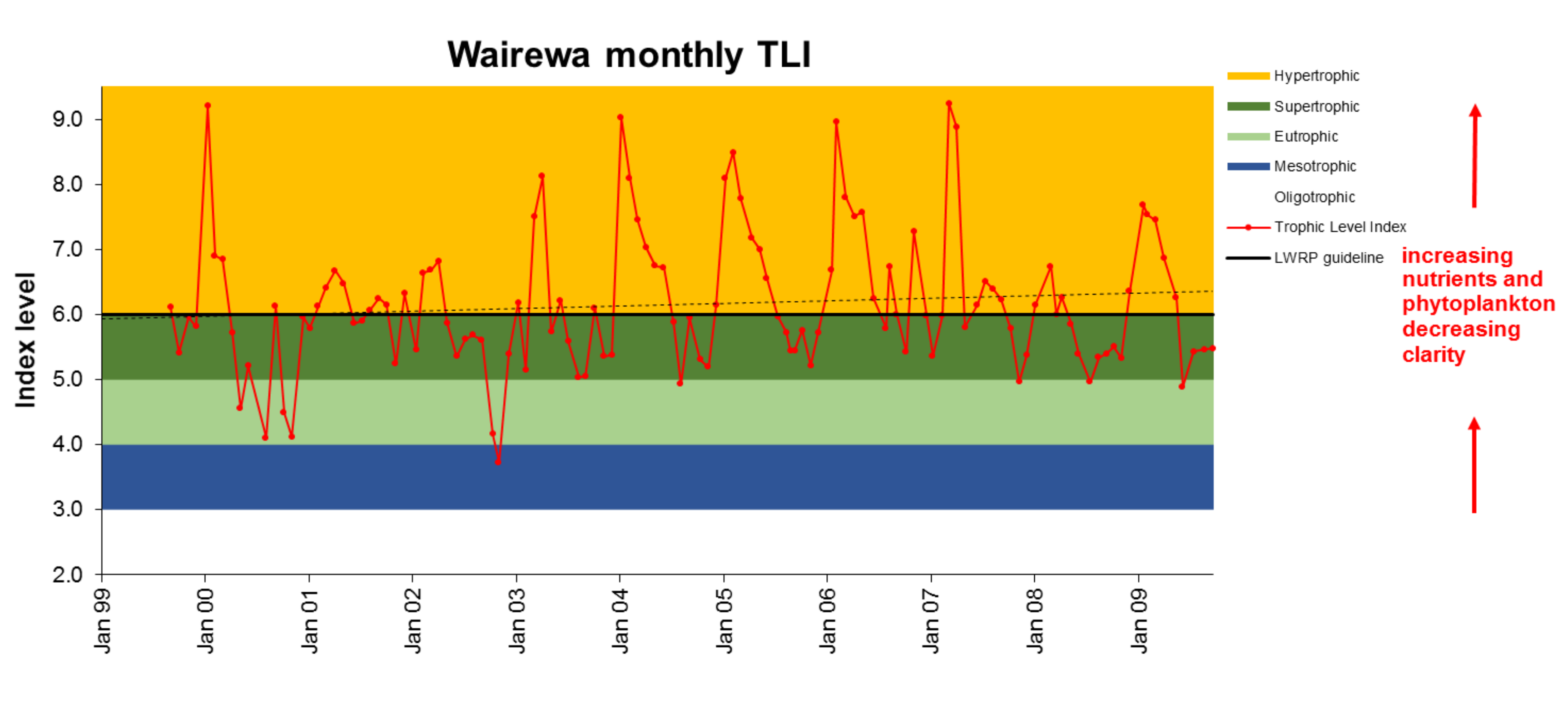

Figure 8b. Trophic Level Index (TLI) at Te Roto o Wairewa – Lake Forsyth at the ECan Water Level Recorder site prior to the construction of the canal opening (September 1999 –September 2009). The dashed line is a linear trendline. Solid black line = Land and Water Regional Plan (LWRP) guideline for coastal lakes (6 TLI). Graph modified from ECan versions.

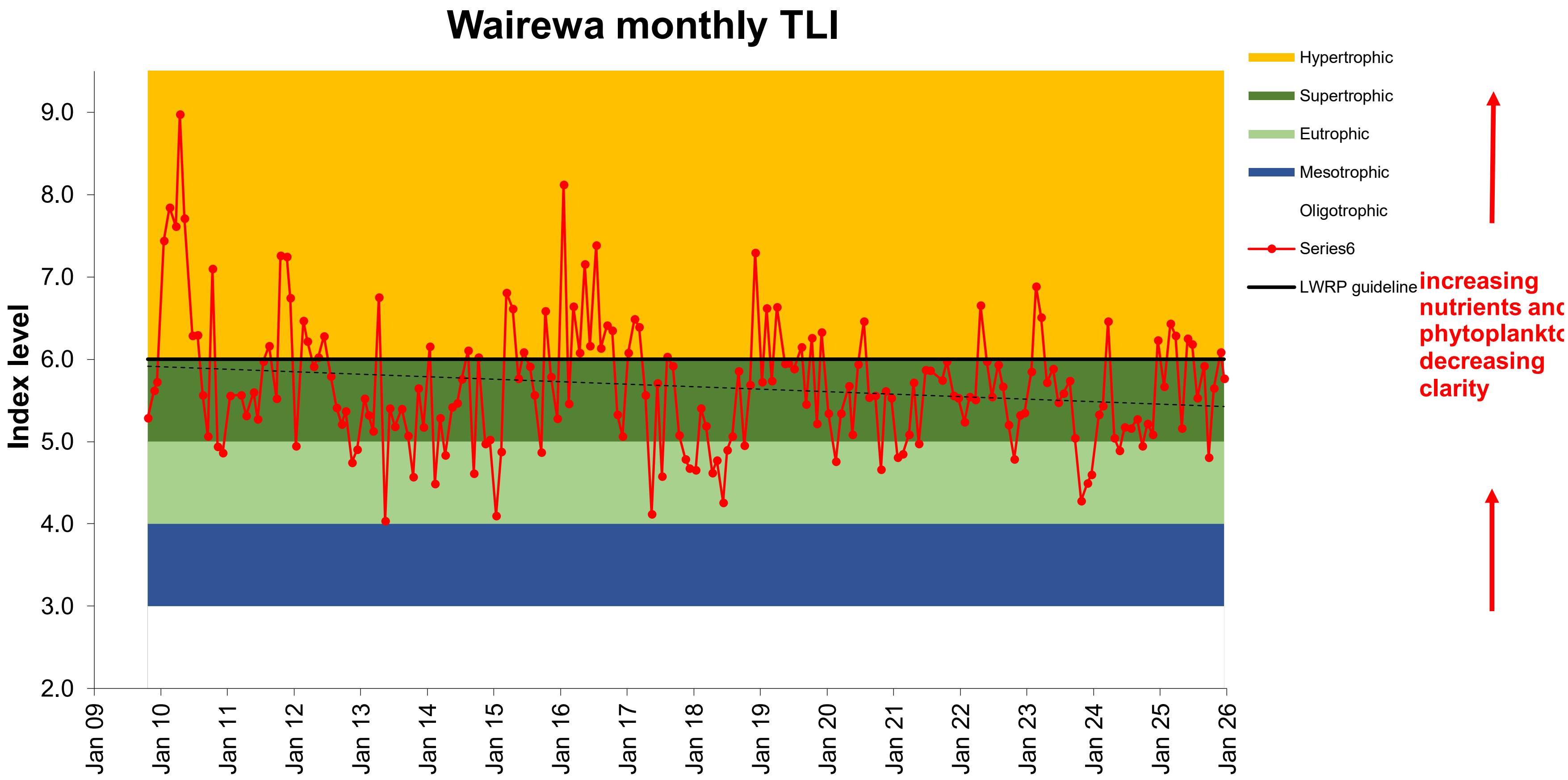

Figure 8c. Trophic Level Index (TLI) at Te Roto o Wairewa – Lake Forsyth at the ECan Water Level Recorder site after the construction of the canal opening (October 2009– December 2025). The dashed line is a linear trendline. Solid black line = Land and Water Regional Plan (LWRP) guideline for coastal lakes (6 TLI). Graph modified from ECan versions.

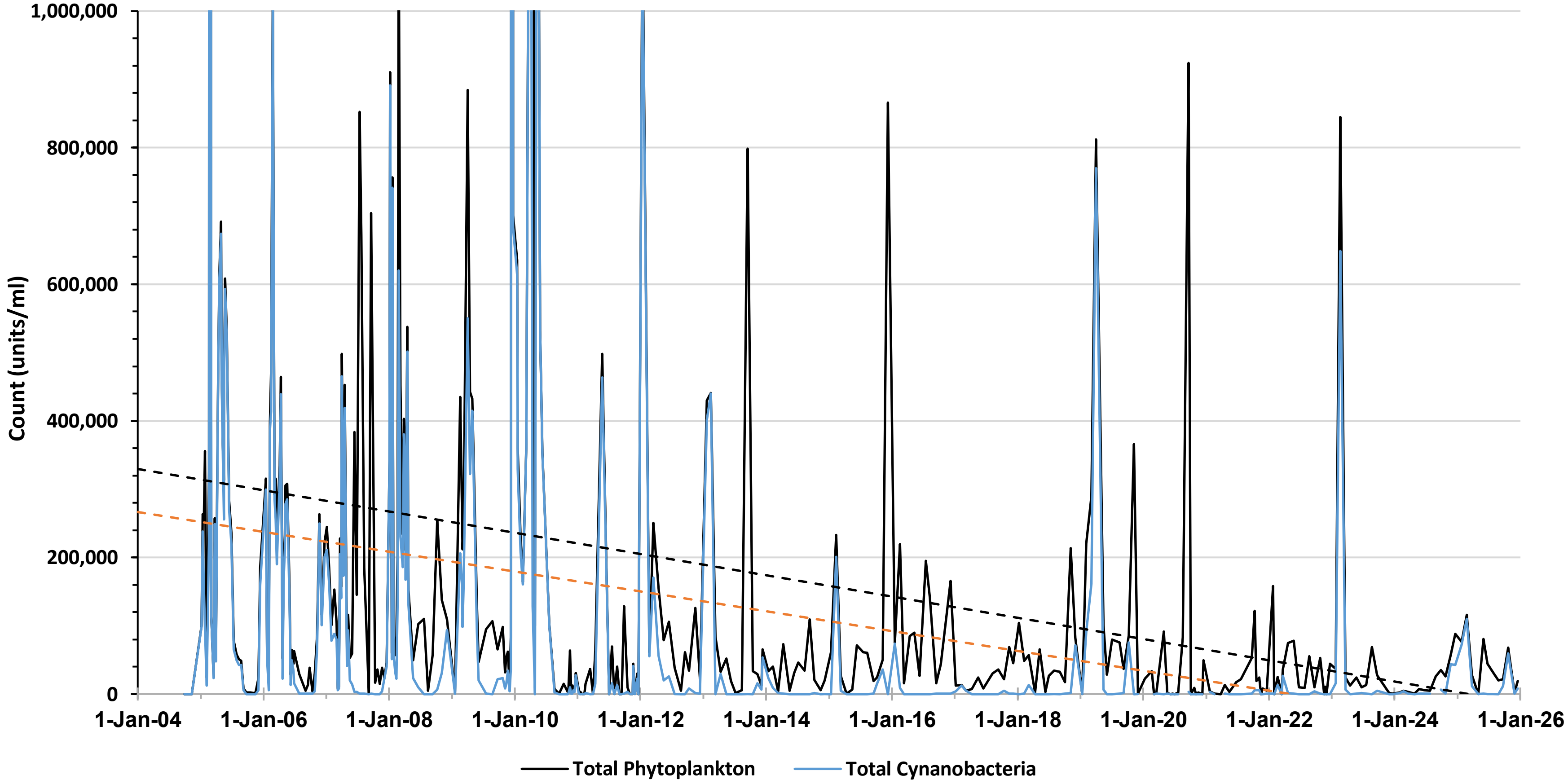

Figure 9. Total phytoplankton and cyanobacteria unit counts at Te Roto o Wairewa – Lake Forsyth at the ECan Water Level Recorder site from September 2004 to December 2025. The dashed lines are linear trendlines. Due to the large number of records above the y-axis cut-off, concentrations above this value have not been provided.

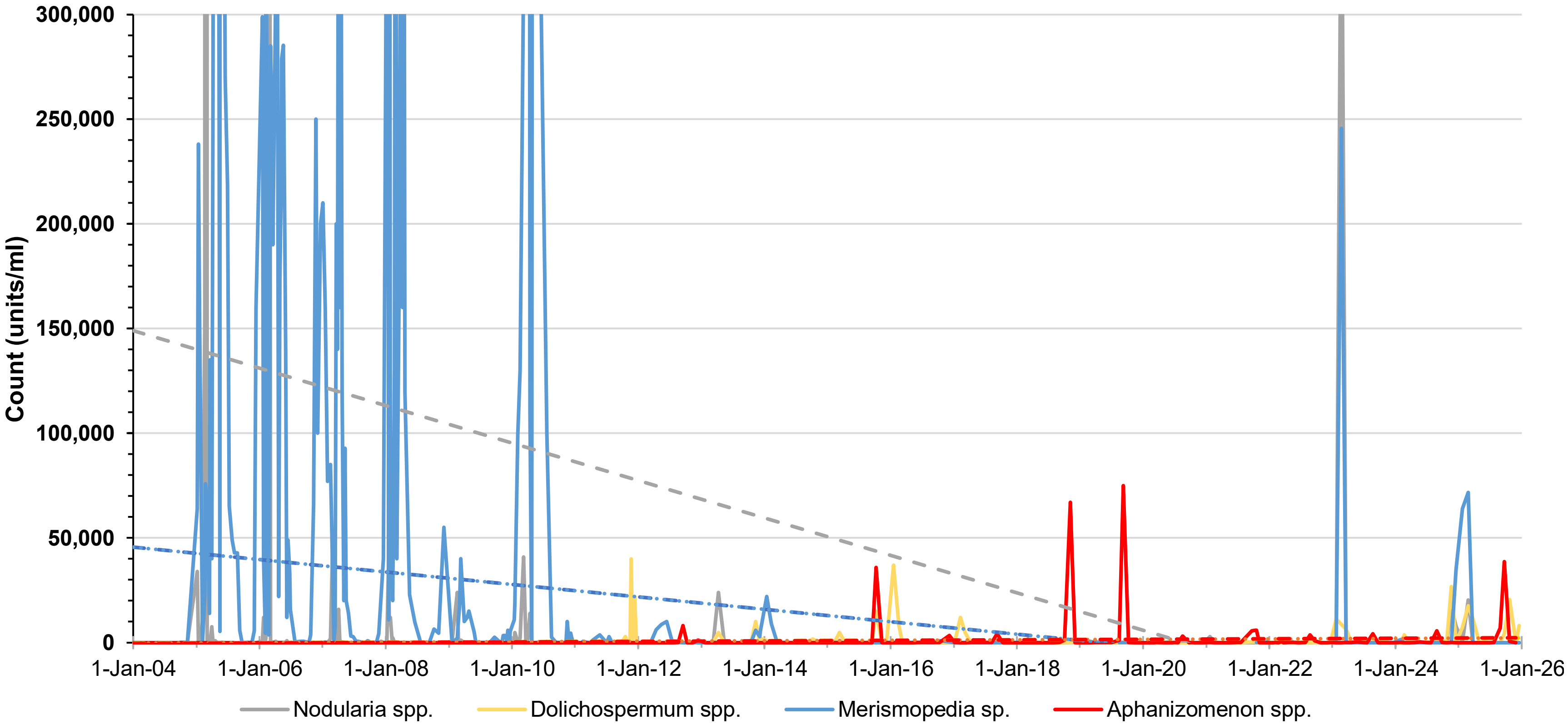

Figure 10. Unit counts at Te Roto o Wairewa – Lake Forsyth at the ECan Water Level Recorder site for the potentially toxic cyanobacteria *Nodularia* spp., *Dolichospermum* spp., *Merismopedia* spp. and *Aphanizomenon* spp. from September 2004 to December 2025. The dashed lines are linear trendlines. Due to the number of records above the y-axis cut-off, concentrations above this value have not been provided.

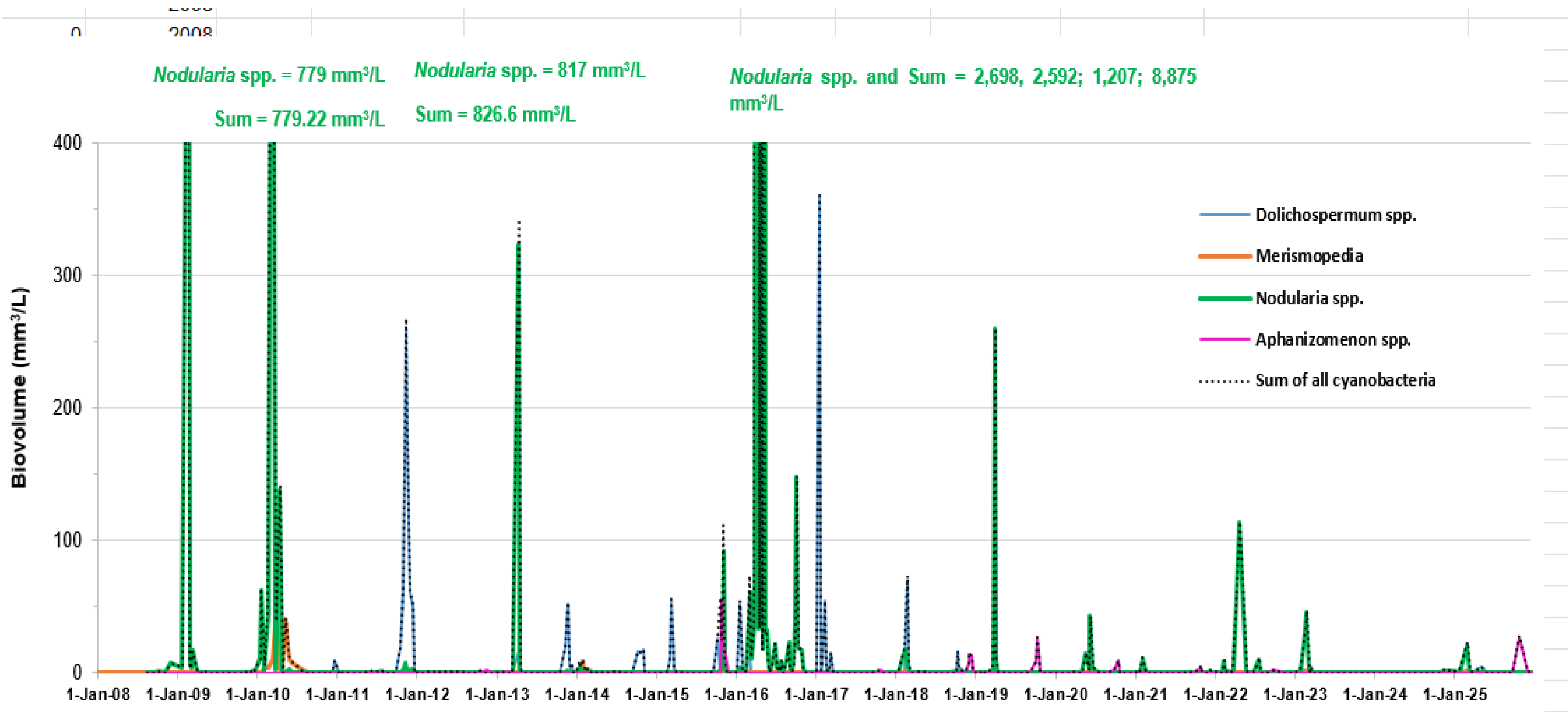

Figure 11. Biovolumes of potentially toxic cyanobacteria *Nodularia* spp., *Dolichospermum* spp., *Merismopedia* spp., *Aphanizomenon* spp. and the sum of all cyanobacteria at Te Roto o Wairewa – Lake Forsyth at the ECan Water Level Recorder site from August 2008 – December 2025. Several data points are significantly higher than the other data points and are therefore off the scale of the graph – the numbers above the graph detail their concentrations.

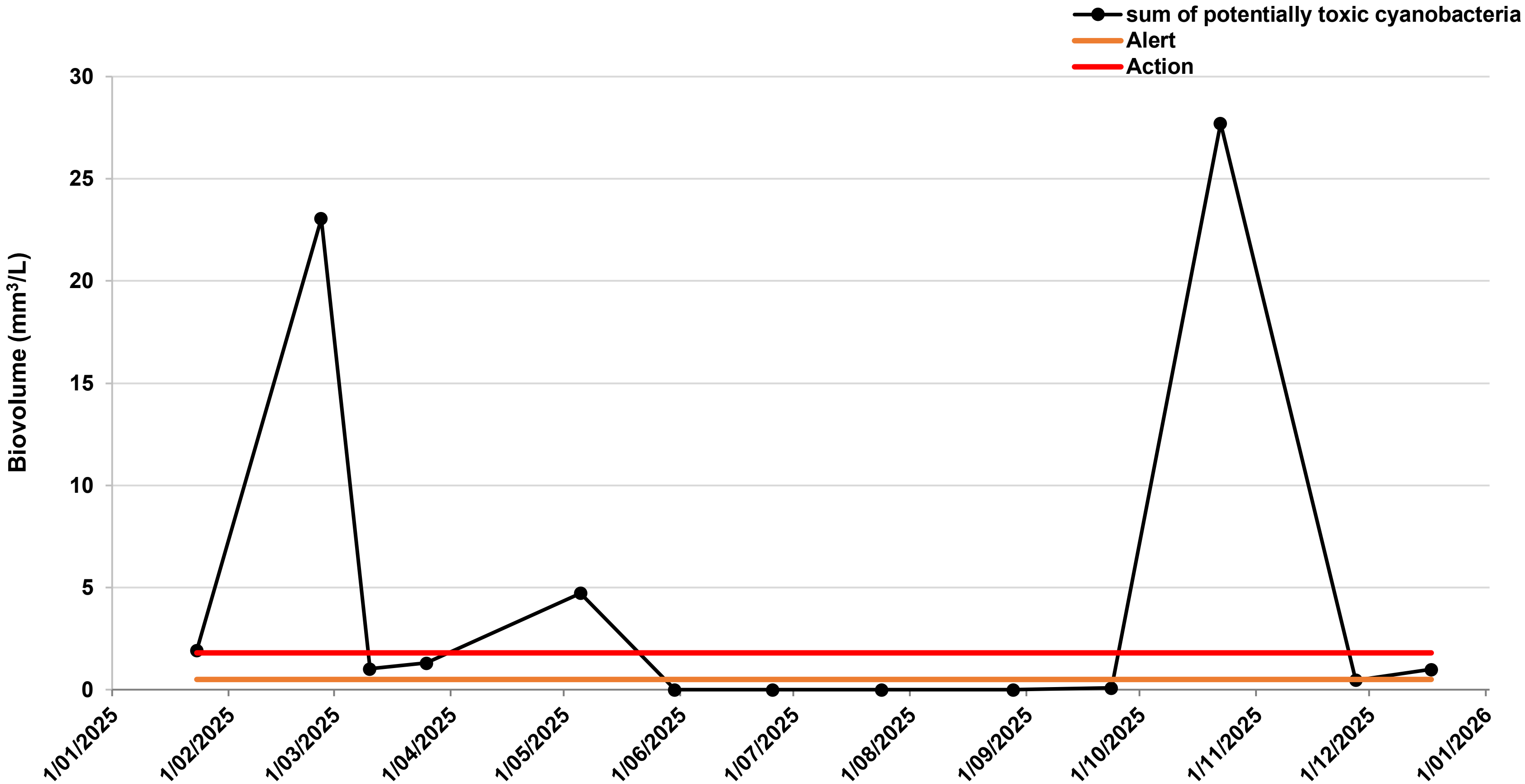

Figure 12a. Biovolume of the sum of all potentially toxic cyanobacteria (*Nodularia* spp., *Dolichospermum* spp., *Merismopedia* spp., and *Aphanizomenon* spp.) at the ECan Water Level Recorder monitoring site in Te Roto o Wairewa – Lake Forsyth in 2025. Orange line = alert guideline level of 0.5 mm^3/L; red line = action guideline level of 1.8 mm^3/L (Ministry for the Environment and Ministry of Health, 2009).

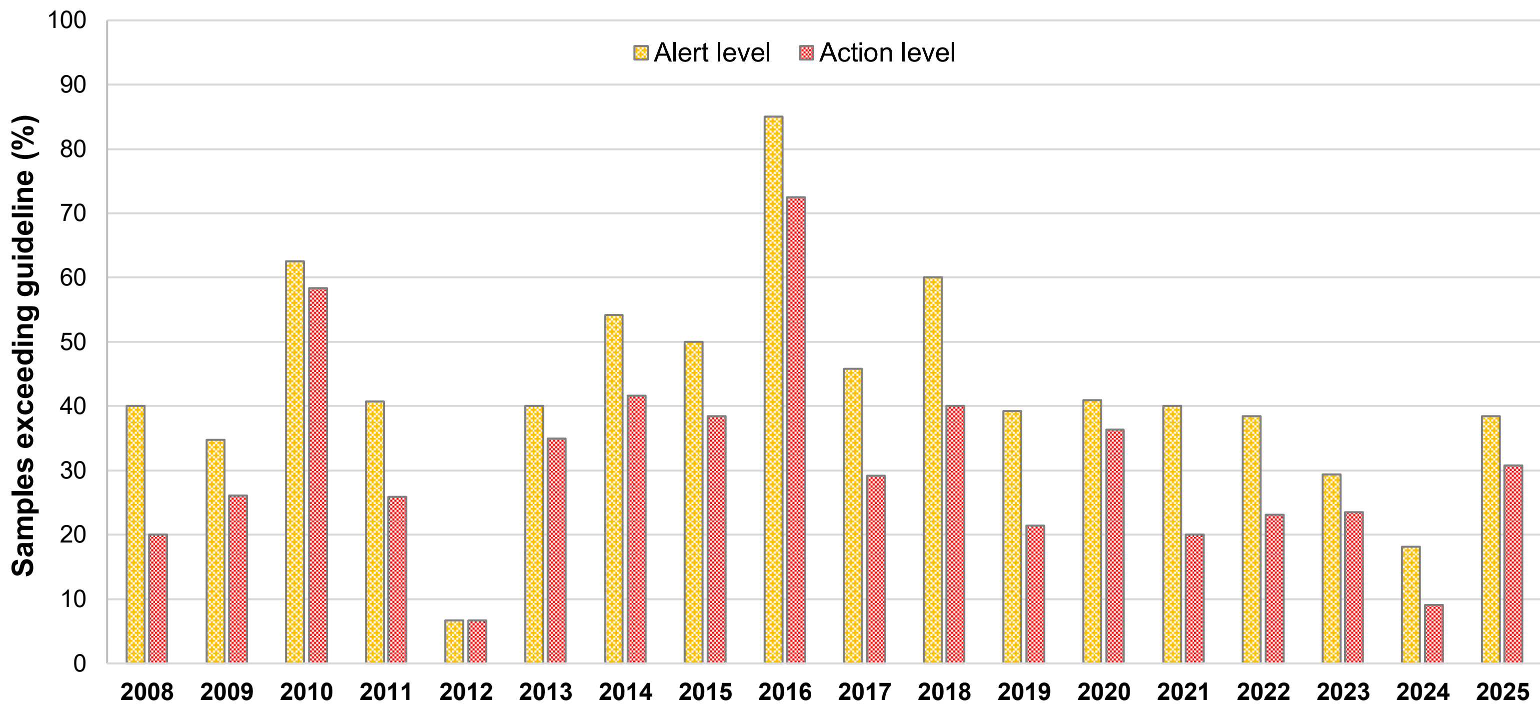

Figure 12b. Number of samples of potentially toxic cyanobacteria (*Nodularia* spp., *Dolichospermum* spp., *Merismopedia* spp., and *Aphanizomenon* spp.) that exceeded either the alert (0.5 mm^3/L) or action (1.8 mm^3/L) level at the ECan Water Level Recorder site in Te Roto o Wairewa – Lake Forsyth from 2008 – 2025 (Ministry for the Environment and Ministry of Health, 2009).

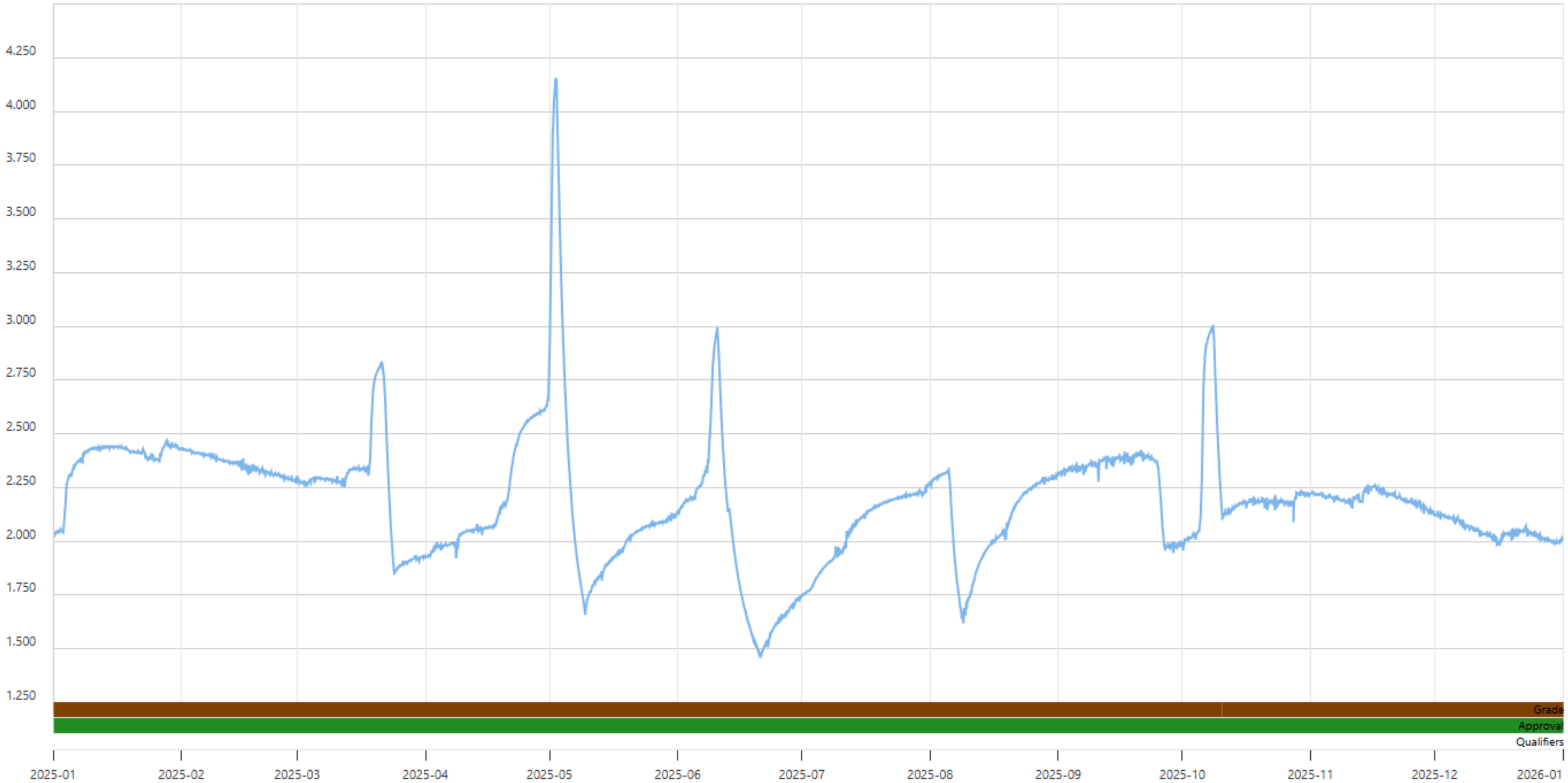

Figure 13. Water level in Te Roto o Wairewa – Lake Forsyth January – December 2025. The sharp drops in water levels indicate when the lake was opened.