APPENDIX A

Elk Lake Oxygenation System

2025 Annual Report

Capital Regional District | June 2026

Elk Lake Oxygenation System

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Acronyms and Abbreviations

ACH	Aluminum Chlorohydrate
acfm	actual cubic feet per minute
ASME	American Society of Mechanical Engineers
BEES	Beaver Elk Environmental Stewards
CRD	Capital Regional District
DFO	Fisheries and Oceans Canada
DO	Dissolved Oxygen
Fe	iron
$g/m^2/d$	grams per square metre per day
gal	gallons (US)
HDPE	High-Density Polyethylene
HOS	Hypolimnetic Oxygenation System
HP	horsepower
Hz	Hertz
kg	kilogram
kg_{O2}/d	kilograms of oxygen per day
km	kilometre
km/h	kilometres per hour
kPa	kilo-Pascals
kW	kilo-Watt
kWh	kilo-Watt hours
L	litres
mg/L	milligram per litre
m	metre
mm	millimetre
Mn	manganese

NH_3	ammonia
NHC	Northwest Hydraulic Consultants
NHs	nitrogen hydrides
NO_3	Nitrate
P	Phosphorous
PLAN	PLAN Contracting Ltd
PSA	Pressure Swing Adsorption
RDO	Rugged Dissolved Oxygen
RFP	Request for Proposal
Saanich	District of Saanich
scfm	standard cubic feet per minute
SDR	standard dimension ratio
slpm	standard litres per minute
SOD	Sediment Oxygen Demand
V	Volts
WQO	Water Quality Objectives
°C	degrees Celsius
°C/day	degrees Celsius per day
%vol	percent by volume
µg/L	micrograms per litre

Executive Summary

A direct injection hypolimnetic oxygenation system (HOS) was installed in Elk Lake in late 2023 as one aspect of a multi-pronged approach to address nutrient loading, mainly phosphorus, contributing to cyanobacteria growth (algal blooms). The oxygenation system includes a diffusive porous line along the deepest part of Elk Lake and injects high-purity oxygen into the hypolimnion to prevent anoxic conditions and sequester iron- and manganese-bound phosphorus in the lake-bed sediments, preventing them from being released into the water column. The system is expected to only influence deep-water sediment sources of phosphorus and not sources from shallower water nor from stream and overland sources.

This report summarizes the 2025 operational year of the HOS and evaluates data collected by the Capital Regional District (CRD) against Water Quality Objectives (Table E.1) for the Elk/Beaver Lake Watershed. During 2025, the oxygenation equipment received warranty-related repairs and experienced one significant valve failure that reduced system capacity to 50% during July. However, overall, the system maintained a high operational uptime and positive trends were observed in water quality data. The hypolimnion phosphorus levels at fall turnover were reduced from pre-oxygenation levels by 80%, consistent with 2024 concentrations. Anoxic conditions were present for three months from July to September, compared to five months from May to October pre-oxygenation.

While Elk Lake experienced a large algal bloom in the spring of 2025, environmental factors were likely a contributing cause. Weather data over the past five years showed the spring of 2025 saw favourable algal growth conditions, such as high precipitation in March followed by sunny and stable days in April and May.

Overall, the Elk Lake HOS had a measurable impact on water quality in 2025, building on its first year of operation in 2024 with similar improvements to dissolved oxygen and reductions in hypolimnion phosphorus. Continued water quality improvements are expected with long-term operation, though oxygenation is only one part of the holistic solution for Elk Lake.

Table E.1: Summary of Water Quality Objectives and 2025 Values

Parameter	Objective	2025 Values at ELK02 Sampling Location
Total Phosphorus	Spring Average: 5-15µg/L	32µg/L in February
Hypolimnion Temperature	<15°C	Average: 9.6°C; Maximum: 13.9°C
Dissolved Oxygen	>5mg/L 1m above sediment	Average: 3.64mg/L; Minimum: 0.01mg/L
Secchi Depth	>1.9m	Average: 2.77m; Minimum: 1.1m
Chlorophyll-a	Summer Average 1.5-2.5µg/L	Average: 5.9µg/L

Introduction

In November 2023, the CRD began operating a hypolimnetic oxygenation system (HOS) at Elk Lake in Saanich, BC. The overall objective of the system is to restore lake health and preserve the recreational values by improving dissolved oxygen (DO) levels in the hypolimnion during the summer, reducing internal phosphorus (P) loading and thereby reducing the frequency and duration of cyanobacteria (blue-green algae) blooms in the fall and winter after destratification of the lake. Improved DO levels may also have secondary benefits, such as improving habitat for native fish, but are not specifically tracked as part of this report. It should also be noted that reduction of invasive species, such as Eurasian milfoil, is not an anticipated result of oxygenation.

This 2025 annual report summarizes the project scope, activities completed, and lessons learned during the 2025 operational year. Plans for 2026 and beyond will also be discussed. This report is not meant to be a comprehensive review of lake water quality or watershed health; instead, the focus is on the direct and measurable impacts of the oxygenation in the hypolimnion.

Background

Elk/Beaver Lake Regional Park is located on the Saanich Peninsula, 12 kilometres (km) north of Victoria, BC, immediately west of Highway 17. The park is managed by the CRD which supports the year-round recreational use of the lakes through the provision of park facilities and services. The lakes also serve as critical aquatic habitat for the endangered western painted turtle and as headwaters of the Colquitz River, which supports a range of salmonids.

Elk Lake System

According to Northwest Hydraulic Consultants (NHC) (2021a), Elk and Beaver lakes can be divided into three separate limnological areas: Elk Lake, Beaver Lake and the shallow channel separating the two basins. The maximum depths at Elk and Beaver lakes are 18 metres (m) and 8m, respectively, which are influenced in part by the spillway of a dam constructed at the outlet of Beaver Lake. Maximum water levels generally occur in the winter and spring and may be reduced by 2m over the summer and fall, depending on precipitation levels. The primary input to Elk Lake is O'Donnel Creek at its northwest end, with minor inputs from natural surficial drainage channels around the perimeter of the lake.

Elk Lake is a monomictic lake that is typically thermally stratified from early May to early November. During the summer months, the thermocline is encountered at approximately 5m below the surface, while the top of the hypolimnion is encountered at approximately 8m below surface (Nordin 2015; NHC 2021b).

When thermally stratified, the density gradient between the epilimnion (surface waters) and the hypolimnion (deep waters) prevents the water layers from mixing and inhibits the oxygen transfer from the surface to deeper waters. The oxygen demand of organisms in the hypolimnion, primarily in the nutrient-rich sediments, can deplete the dissolved oxygen levels over the summer months. When the oxygen demand exceeds the available oxygen stored in the hypolimnion, this leads to anoxic conditions, halting the aerobic breakdown of sediments and allowing the release of nutrients, particularly phosphorus, into the water.

Elk Lake Water Quality Issues

Water quality issues at Elk/Beaver Lake were identified in the 1980s. Nutrient loading in the lakes can come from several sources, including external (e.g., creeks and surface runoff) and internal (e.g., lake bottom sediments). The oxygenation system is designed to target internal sources from the hypolimnion of Elk Lake only; more information on the multi-pronged approach for addressing other nutrient sources is presented in the Elk/Beaver Lake Watershed Management Plan (CRD 2020). Previous studies have suggested that hypolimnetic oxygen depletion in the summer months facilitates the internal release of phosphorus from lake bottom sediments, which contributes to cyanobacteria blooms in the fall when the lake de-stratifies and the nutrient-rich water from the hypolimnion mixes with the epilimnion. These effects can negatively impact recreational users of the lake and watershed health.

To support fish and aquatic species, the BC Water Quality Guidelines set a 30-day average dissolved oxygen target of 8 milligrams per litre (mg/L), with an instantaneous minimum of 5mg/L. Prior to the HOS being installed, data collected by Nordin in 2014 and 2015 and by the CRD since 2019 indicated the hypolimnion of Elk Lake was anoxic (DO<2mg/L) during the period when the lake is stratified (approximately early May through end of October). Along with constraining the growth of fish and benthic organisms, the resulting sediment nutrient releases lead to cyanobacteria blooms in the fall and winter. Therefore, the CRD committed to installing the HOS to help manage dissolved oxygen levels in Elk Lake during the summer while it is stratified. More information can be found in the Watershed Management Plan (CRD 2020).

Elk Lake Oxygenation System

In 2015, an interagency group was tasked with assessing the lake ecosystem health and recommending remedial options for Elk/Beaver Lake. In 2018, the CRD examined dredging, biological sequestration, aeration and oxygenation approaches to reduce internal phosphorus loading and increase hypolimnetic oxygen concentrations. A pilot project was originally considered for Beaver Lake in 2018 using down-flow bubble contact oxygenation technology but did not proceed due to budget constraints. From 2018 to 2021, NHC conducted several studies to develop a remediation master plan to address impacts at Elk and Beaver lakes, including possible options for oxygenation of the hypolimnion at Elk Lake and a destratification system appropriate to promote mixing at Beaver Lake.

In 2021, Arcadis and Paul Gantzer completed additional sediment oxygen demand (SOD) studies and recommended two options for remediation of Elk Lake: side-stream saturation technology via a Speece cone or direct oxygenation (Arcadis 2021). It was Arcadis' opinion that direct oxygen injection would be effective, with lower capital and operating costs. Hence, CRD moved forward with the design and installation of a direct oxygenation system in 2023. It was resolved that staff would initiate efforts to first remediate Elk Lake before addressing Beaver Lake.

The design for Elk Lake is based on measured total hypolimnetic oxygen demand, of which about 90 percent (%) is determined by SOD. The SOD was measured to be 0.626 grams per square metre per day (g/m2/d) at 3.3 degrees Celsius (°C) (NHC 2021b). The maximum rate, adjusted to 20°C, is therefore 1.35g/m2/d. For the area under the thermocline, the corresponding maximum hypolimnetic oxygen demand is approximately 1,650 kilograms of oxygen per day (kg_{O2}/d) in Elk Lake. This equates to a maximum volumetric injection flow target of 848 standard litres per minute (slpm) (or 30 standard cubic feet per minute [scfm]) of oxygen at a concentration of 95 percent by volume (%vol).

To meet the oxygen flow rate, two parallel oxygen-generating trains are used. Each train can generate 424 slpm (15 scfm) of 95 $\%O_2$ and can be operated independently or in tandem to meet the target flow rates during different seasons. In the winter and spring, the system operates at approximately 142 slpm (5 scfm), 710 – 848 slpm (25 – 30 scfm) in the summer, and 284 – 425 slpm (10 – 15 scfm) in the fall. Flow adjustments are made depending on the presence and depth of the thermocline (i.e., how stratified the lake is). The goal is to inject as much oxygen as possible without inducing mixing of the hypolimnion with warmer waters above.

Each oxygen generation train is comprised of a 50 HP Ingersoll-Rand RS-37i rotary screw compressor, which feeds an AirSep AS-K pressure swing adsorption unit that removes nitrogen from the compressed air. The concentrated oxygen is stored in a receiver tank and delivered to the lake through an Alicat flow control valve that is adjusted to meet the target flow rate. These units are housed in a small building at the east end of Hamsterly Drive on the northeast shore of Elk Lake by Highway 17.

The in-lake components of the system include a 1400m long delivery line bundle that stretches out across the deepest part of Elk Lake near the north shore. The bundle of lines includes the main oxygen supply header (50mm diameter), a buoyancy line (75mm diameter) for raising the bundle during maintenance, a supplementary dosing line (32mm diameter) for optional amendments, and anchors spaced to hold the lines in place on the lake bottom. Only the last 400m of the oxygen line contains perforated diffuser branches (25mm diameter) where the oxygen enters the water.

Additionally, a remote sensing buoy was placed in the deepest part of the lake, near the middle of the oxygen line, to continuously monitor dissolved oxygen and water temperature at three depths: 8m, 11m, and 15m. These sensors are used in conjunction with periodic manual water sampling to adjust oxygen flow rates and monitor water quality. A simplified map of the in-lake components is presented in Appendix A.

More detailed information on the setup and components of the oxygenation system can be found in the *2024 Arcadis Closure Report* (Arcadis 2024).

Project Summary

This report focuses on operations of the Elk Lake oxygenation system during the 2025 calendar year. Water quality data collected in 2025 is compared against previous years to assess the impact the system has had on the lake.

2025 Scope of Work

Through 2025, the second full year of operating the oxygenation system, the primary goals were to maximize uptime (number of hours of functional operation) and to collect data to assess the efficacy of the system. Steps were also taken to optimize flow rates and cost, with more planned for 2026. This report took the following steps to evaluate the impact of oxygenation on Elk Lake:

1. Data Review and Analysis:
    - Identify and assess any trends and significant water quality changes post-oxygenation to evaluate impacts of the oxygenation system.
    - Measure outcomes against key water quality objectives (WQO):
        - Average spring (pre-stratification) phosphorus reduced to 5-15 micrograms per litre (µg/L).
        - Hypolimnion temperature should not exceed 15°C.
        - DO should not be less than 5mg/L, 1m above sediment during summer.
        - Secchi depth must exceed 1.9m; and
        - Chlorophyll-a shall have a mean summer range of 1.5-2.5 µg/L.
    - Measure outcomes against operational targets of the oxygen generation system:
        - Flow rate targets.

        - Timing of flow rate adjustments with respect to thermocline location.
        - Response of DO to flow adjustments.
        - Downtime and maintenance.
        - Cost of operating the system; and
        - Updates to the Operational and Maintenance Plan (if required).
    - Identify any other key parameters of interest to identify or assess any other unexpected impacts of the system on the water quality (e.g., nitrogen, turbidity, etc.).

2. Review the existing water quality and lake health monitoring plan and provide any recommendations/changes. The objectives are to ensure appropriate data is collected to support assessment of the water quality and lake health against WQO, and the assessment of the efficacy of the oxygenation system.

3. Report on how the continuous dissolved oxygen data is informing the performance of the oxygenation system and describe changes in dissolved oxygenation over time and how those may relate to natural processes versus the oxygenation system.

Project Team

Operation of the oxygenation system in 2025 involved CRD staff, supported by external water quality consultants as identified in Table 1.

Table 1. Project Team Members

Name	Key Individuals	Roles and Responsibilities
CRD Staff	• Jill Robinson (Regional Parks) • Cody Murray (Engineering Services) • Dean Lacey (Environmental Protection) • Barri Rudolph (Environmental Protection)	• Project management • Operational management • Water quality sampling • Analysis and reporting
Clarity Resources Group	• Paul Gantzer	• Operational support and guidance • Data analysis and reporting

Oxygenation System Operation

The following subsections describe the HOS as installed at Elk Lake. More history and details about why this system was chosen and how it was designed can be found in the Arcadis and Gantzer Water design and construction reports (Arcadis 2024).

System Overview

The main components used to deliver up to 1,650 kg/d of 95% oxygen to the bottom of Elk Lake are summarized in Table 2.

Table 2. HOS System Components

Component	Brand	Model	Specifications
Air Compressors (2)	Ingersoll-Rand	RS-37i-A118-TAS	- Direct drive, air cooled, rotary screw compressor - 50 HP, 575V/60Hz - 6,230 lpm @ 814 kPa (220 acfm @ 118 psig) - Integrated refrigerant dryer and filter system (TAS)
Compressed Air Receiver Tanks (2)	AirSep	N/A	- 1,098 l (290 gal) vertical steel tank - 940mm (24 inch) diameter by 2,020mm (80 inch) high - maximum pressure rating of 1,138 kPa (165 psig)
Oxygen Generators (2)	AirSep	AS-K900	- Pressure swing absorption unit - Up to 95.5% O_2 at 354-425 lpm (750-900 ft^3/hr), 310-448 kPa (45-65 psig)
Oxygen Receiver Tanks (2)	AirSep	N/A	- ASME oxygen cleaned 1,098 l (290 gal) vertical tanks - 940mm (24 inch) diameter by 2,020mm (80 inch) high - maximum pressure rating of 1,138 kPa (165 psig)

Compressed Air Condensate Separator	Beko	Qwik-Pure 200	- 72L condensate filter for collection, filtration, and discharge of compressor condensate
Mass Flow Controller (2)	Alicat Scientific	MCR-500SLPM-D-DB9M-20X124/10M	- standalone mass flow controller calibrated to 95% O_2 - 50-425 slpm range - +/-0.4% of reading + 0.2% of full scale
In-Lake Line Diffuser (1)	N/A	N/A	- 1400m bundle consisting of 50mm (2 inch) HDPE SDR 11 oxygen supply pipe, 75mm (3 inch) HDPE SDR 17 buoyancy pipe, 32mm (1.25 inch) HDPE SDR 11 coagulant pipe, saddle ties and 19mm (¾ inch) tee assemblies connected to perforated oxygen supply hoses located every 5m along diffuser length - A total of approximately 800m of 25mm (1 inch) extruded rubber porous hose (two lines of porous hose along the 400m length of the diffuser) - Orifice installed in each tee assembly sized to control flow to porous hose based on design flow and reservoir depth - 28kg concrete anchors connected every 5m to diffuser assembly with coated stainlesssteel cables or stainless-steel gear clamps

Remote In-lake DO Sensors (3)	In-Situ	0090930	- 3 RDO Pro-X optical dissolved oxygen sensors, along with Shore Science observation buoy, VuLink datalogger and telemetry, and associated cables and fittings - DO range 0-60mg/L - Accuracy +/-0.1mg/L up to 20mg/L - Powered by 3 D-cell batteries - Programmed to take a reading every 12 hours at noon and midnight each day

System Operation Summary

In 2025, the Elk Lake oxygenation system generally operated at a low rate of 142 slpm (5 scfm) in the winter and spring, 710–848 slpm (25–30 scfm) in the summer, and 284–425 slpm (10–15 scfm) in the fall. Injected oxygen concentrations are kept between 90 and 95% since pure oxygen transfer is more efficient than air. For the same volume of gas, pure oxygen delivers about five times more oxygen to the water than air, which contains only 21% oxygen.

The line diffusers contain very small holes, which create equally small bubbles that allow for a low intensity of gas emission (sparging) that entrain relatively small vertical currents of water. This allows the oxygen to better dissolve in the hypolimnion and reduces the potential for mixing the water column, compared to aeration (a.k.a., destratification). At the depth of the location in Elk Lake, the oxygen transfer efficiency of the linear diffusers is estimated to be over 90% (Arcadis 2024).

Small residual bubbles may be observed at the surface of the lake above the diffuser line, but these predominantly contain nitrogen (Gantzer 2022). As a high-oxygen concentration bubble rises through the water column, the oxygen dissolves into the water, moving from an area of high concentration to low. Similarly, since there is little nitrogen in the bubble, nitrogen from the water column will diffuse into the bubble, although not at the same rate oxygen is transferring to the water column. As bubbles rise, nearly all the oxygen is dissolved into the surrounding water and any residual bubbles reaching the surface are mostly nitrogen.

Schedule of Events

A summary of the schedule of key events that occurred during the 2025 operational season is presented in Table 3.

Table 3. Summary Schedule of Events

Date	Description
January 2025	• Flow remained set at 142 slpm (5 scfm)
February 2025	• Flow remained set at 142 slpm (5 scfm) • Regular compressor service completed by Wiseworth Canada February 4 – CBV876954: 8,606 hrs. • Noted overheating issue on initial ramp; recommended replacing thermal valve – CBV876955: 5,228 hrs. • Unit in good condition
March 2025	• Flow remained set at 142 slpm (5 scfm) • Regular AirSep AS-K service completed by Clarity Resources March 17 • In-lake diffuser line raised and serviced; numerous broken connections, which were repaired, and clogged hoses discovered – System shutdown until issues rectified
April 2025	• Wiseworth Canada replaced thermal valves in both air compressors April 3 • CIMCO Refrigeration serviced CBV876954 air dryer April 3 • System restarted but pressure restricted to 345 kPa (50 psig) to avoid further issues with diffuser line – Maximum flow achieved 170 slpm (6 scfm) • Second Alicat mass-flow controller installed April 9; flow from each AS-K now individually controlled
May 2025	• Maximum allowable pressure increased to 385 kPa (56 psig) – Maximum flow achieved 198 slpm (7 scfm)
June 2025	• Perforated hoses along diffuser line replaced by Clarity Resources June 6 – New hoses are sized for better flow and feature anti-clog construction

Date	Description
	– Repositioning of diffuser line on bottom of lake successful; line is in near-optimal position • Flow set to 566 slpm (20 scfm) – Bubble pattern on surface of lake indicated good flow distribution
July 2025	• Flow set to 610 slpm (21.5 scfm) • Pilot solenoid valve on Equalization Valve of AS-K #2 failure July 3 – AS-K #2 shutdown until valve replaced – AS-K #1 remained functional; total system capacity reduced to 305 slpm (10.8 scfm) with only one oxygen generator operating
August 2025	• AS-K #2 pilot valve replaced August 12; unit restarted • System flow returned to 610 slpm (21.5 scfm)
September 2025	• Flow remained at 610 slpm (21.5 scfm)
October 2025	• Flow remained 610 slpm (21.5 scfm) • Regular service completed on air compressors by Wiseworth Canada October 1 – CBV876954: 11,979 hrs. – CBV876955: 8,694 hrs. • Flow reduced to 225 slpm (8 scfm) October 31; lake has de-stratified
November 2025	• Flow remained at 225 slpm (8 scfm)
December 2025	• Flow remained at 225 slpm (8 scfm)

System Operational Issues and Solutions

As noted in Table 3, there were some equipment and operational issues identified throughout 2025 that are described below along with corrective actions taken or plans to rectify them:

- Compressor thermal valve replacement(s)—thermal valves regulate oil temperature in rotary screw compressors and are particularly important during initial ramp-up when starting or coming out of standby. Heavy cycling can wear these valves and prevent them from opening properly, resulting in compressor overheating. These were identified as a likely wear item in early 2025 due to continuous use throughout the year. Instead of waiting for the valves to show signs of wear, the maintenance plan will incorporate replacing them once per year, typically in the spring.

- Second mass flow controller added—to better balance flow from each of the separate oxygen generators, a second Alicat flow controller was added in April. Each oxygen generator now has its own dedicated flow controller, and flow is combined afterwards as it enters the diffuser line.

- Diffuser line maintenance—the line was floated in March to investigate a suspected broken branch line causing localized increased bubbling. More breaks were discovered along with clogged lines, which was also causing increased back pressure in the system. Clarity Resources elected to replace all the porous hose sections with more robust tubing and fittings. This work was completed under warranty in early June. The bubble patterns and system backpressures have been very good since.

- Equalization valve failure—the pilot valve that controlled the main pneumatic equalization valve of the second oxygen generator failed in early July. This valve enables the pressure in the adsorbers to equalize after product oxygen exits. When it fails, the adsorbers can't cycle properly, so oxygen is not produced. Typically, these valves are readily available but were backordered at the time, so the second generator was offline until early August. Shelf spares are now kept in the oxygenation building.

- Maximum achievable oxygen flow rate below target—the combined oxygen generation trains were designed to achieve 848slpm (30scfm), which corresponded to the target mass of oxygen required to satisfy the hypolimnion demand (1650 kg_{O2}/d). However, over the summer of 2025, each train could only reliably achieve a maximum flow rate of 305slpm (10.8scfm) for a combined maximum of 610slpm (21.5scfm). Above this flow, the oxygen concentration would fall below 90%vol causing the generators to alarm and shut off.

    - Adjustments to some operating settings may improve maximum operating efficiency. For example, it is possible that the refrigerant dryers on the air compressors are cooling the incoming air below the optimal adsorption efficiency temperature for the oxygen generators. For 2026, the discharge temperature of the refrigerant dryers will be raised from 2°C to 4°C, and the impact on maximum flow will be assessed.

- System telemetry and staff response time—there is no telemetry or remote-control capabilities associated with any components of the oxygenation system. While staff make weekly routine visits to the system, if an alarm sounds in the building, staff may not become aware of the situation for days. Plans for upgrading the controls and adding telemetry to the system are being discussed and may be implemented in 2026 when additional funding becomes available.

Water Quality Monitoring

Water sampling events were completed by CRD Environmental Protection staff throughout 2025 at two locations in Elk Lake. The main sampling point (known as ELK02 at approximately 48.53057°N, 123.40314°W) has been the primary location in previous years, but in 2025 a second location (known as ELK04 at approximately 48.52867°N, 123.39474°W) was added to assess dispersion of dissolved oxygen away from the diffuser line. Samples and water quality parameters were taken starting at the surface and at 1m depth increments to the bottom (~16m at ELK02 and ~12m at ELK04). Parameters and analytes are presented in Table 4. Additional environmental monitoring and sampling was completed by the Beaver Elk Environmental Stewards (BEES) at inputs into the lake, including O'Donnell Creek and Haliburton Creek, and in Beaver Lake. The BEES' data is not as frequent nor as directly relevant to the oxygenation system performance and so is therefore not discussed in this report. It may be included in an overall watershed health update report in the future.

Table 4: Elk Lake Sampling Parameters

Parameter	Depth(s)	
	ELK02	ELK04
Field Meters		
Dissolved Oxygen	Profile	Profile
Temperature	Profile	Profile
pH	Profile	Profile
Conductivity	Profile	Profile
Secchi (clarity)	Surface	Surface
Turbidity	Surface/Depth	Surface/Depth
Lab Analyses		
Total Phosphorous	Surface/Depth	None
Nitrogen (Total, NO2, NO3, NH4)	Surface/Depth	None
Dissolved Organic Carbon	Surface/Depth	None
Chlorophyll-a	Surface/Depth	None

The frequency of sampling events changed throughout the year. ELK02 was sampled twice monthly between March and October to better monitor the water quality and thermocline changes throughout the summer. The first sampling event for ELK04 was in June and occurred monthly thereafter. Sampling dates are listed below in Table 5.

Table 5: Water Quality Sampling Dates and Locations

Date	Location(s) Sampled	
February 27, 2025	ELK02	
April 4, 2025	ELK02	
April 22, 2025	ELK02	
May 6, 2025	ELK02	
May 20, 2025	ELK02	
June 3, 2025	ELK02	
June 18, 2025	ELK02	ELK04
July 10, 2025	ELK02	
July 24, 2025	ELK02	ELK04
August 5, 2025	ELK02	
August 19, 2025	ELK02	ELK04
September 2, 2025	ELK02	
September 16, 2025	ELK02	ELK04
October 27, 2025	ELK02	
October 21, 2025	ELK02	ELK04
November 14, 2025	ELK02	ELK04
December 12, 2025	ELK02	ELK04

Lab analyses were completed by Bureau Veritas in Burnaby, except for Chlorophyll-a, which was done at the Calgary location. Field meters used by CRD staff included:

- YSI ProDSS for conductivity, temperature, pH/ORP, optical dissolved oxygen, and total algae-phycocyanin (TAL-PC)
- HACH 2100Q for turbidity
- Fieldmaster Secchi disk for transparency

Overview of Water Quality Targets

The primary goal of the oxygenation system is to help reduce the frequency and duration of cyanobacteria blooms in Elk Lake by reducing the availability of phosphorus in the hypolimnion. This is accomplished by eliminating anoxic conditions in the hypolimnion, which promote the aerobic degradation of sediments. The oxygenation system should also not disrupt the natural thermal stratification of the lake and should maintain suitable cold-water fish (trout) habitat. The water quality objectives that support these goals are:

- Average spring (pre-stratification) phosphorus reduced to 5-15µg/L.
- Hypolimnion temperature should not exceed 15°C.
- DO should not be less than 5mg/L, 1m above sediment.
- Secchi depth must exceed 1.9m; and
- Chlorophyll-a shall have a mean summer range of 1.5-2.5µg/L.

With regard to controlling internal phosphorus loading, it was stated in the August 2018 EBLI technical report (CRD 2018) that “The addition of oxygen at the sediment-water interface will address the release of iron and manganese (Fe/Mn)-bound phosphorus (up to 41%), organic-bound phosphorus (up to 59%)”. However, it is crucial to understand that oxygen maintenance to sequester phosphorus will only address the Fe/Mn-bound fraction but not the organic-bound fraction. This is a commonly misunderstood mechanism for using oxygen to manage phosphorus. As organic compounds are decomposed, having been previously bound with phosphorus, that phosphorus has the potential to be released to the water column. However, the portion of organic bound phosphorus that could be released to the water column has not been determined. Decomposition of organic matter does not necessarily result in release back into the water; it would largely be incorporated into the biomass of microbial decomposers, such as bacteria and fungi, as a consequence of nutrient cycling and then into the higher levels of the food chain, benthos and fish (Nordin 2015). This supports the strategy to monitor hypolimnion phosphorus following oxygenation before implementing any additional binding strategies.

Cyanobacteria Activity in 2025

Precise cyanobacteria bloom tracking over the entire lake is difficult. Small, isolated blooms may occur in sheltered bays and can drift depending on wind and current activity. The CRD, in coordination with Vancouver Island Health Authority (VIHA), periodically samples the shallow waters at Hamsterly and Eagle beaches for cyanobacteria biovolumes after a visible bloom has receded to confirm the areas are safe. However, these samples are driven by public health risks and are not specific to total lake bloom tracking. The CRD has plans to work with the University of Victoria to use satellite imagery to better assess and track blooms. This project is expected to be completed in late 2027.

In 2025, there was one significant and long-lasting bloom that covered the entire lake from approximately mid-April to mid-June. The bloom was atypical in appearance, being a more muted, dirty green colour compared to the usual vibrant green. This was likely caused by the strain of cyanobacteria dominating the bloom. This bloom was also noteworthy for coinciding with the Ironman triathlon event held on May 25, 2025, and causing the cancellation of the swim portion of the race.

Outside of the large May bloom, there was limited and/or isolated cyanobacteria activity reported in 2025. Other swim events took place without issue in the summer and feedback from the Elk Lake Rowing Club has been positive regarding water quality since oxygenation began.

Measured Environmental Data

Evaluation of trends of water quality and condition data must be done in the context of environmental data, which form external inputs to the lake system. Average climate patterns help establish long-term trends, while specific weather data helps explain acute events, such as the large bloom during the spring of 2025. The following environmental data was gathered from the sources identified in Table 6, with most coming from the Victoria Airport weather station, as it had the most complete data:

- Precipitation
- Wind
- Ambient Air Temperature

Table 6. Summary of Information Sources

Information	Source
Weather Information	Weather Underground https://www.wunderground.com/history/daily/ca/victoria/CYWH
Climate Information	Environment Canada Canadian Climate Normals https://climate.weather.gc.ca/climate_normals/

The information retrieved from these sources is summarized in the following sections and is presented as box plots to show the 1st and 3rd quartile, and median values as the boxes and whiskers representing the maximum and minimums of the data sets.

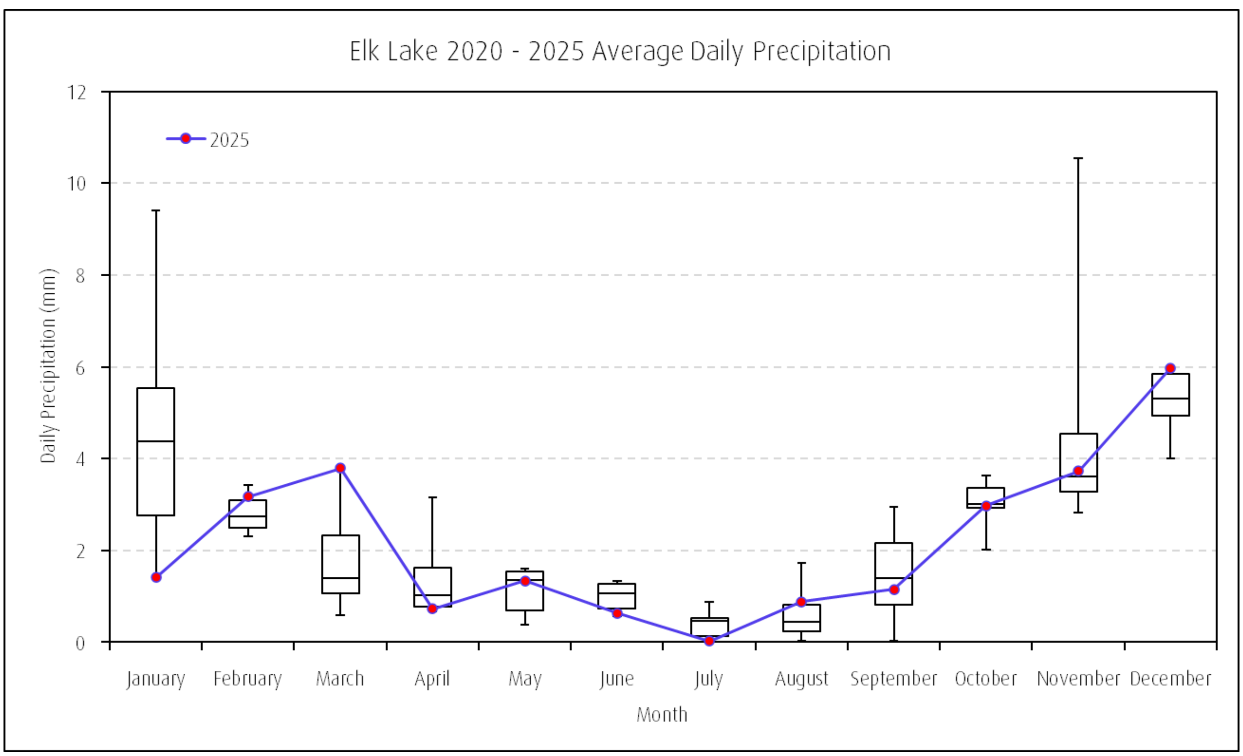
Precipitation

Average precipitation data was compiled for 2020 to 2025 and is presented in Figure 1. Additionally, for comparison, 2025 averages are superimposed as red dots and a blue line to show where the 2025 average precipitation rates fall on the historical trends. The most significant observation from this data is that March 2025 represented the maximum for that month over the past five years, with February also receiving above-average precipitation. Conversely, April 2025 saw the lowest average precipitation and had relatively clear skies.

Cloud Cover 8 can be used to quantify how clear the sky is, with 0 being perfectly sunny and 8 being complete cloud cover; 4 is considered partly cloudy or a mix of sun and clouds. The average score for April 2025 was 4, with only five days being considered mostly cloudy (score of 5 or higher).

High precipitation events increase nutrient runoff and external phosphorous loading in lakes (Province of BC 2022).

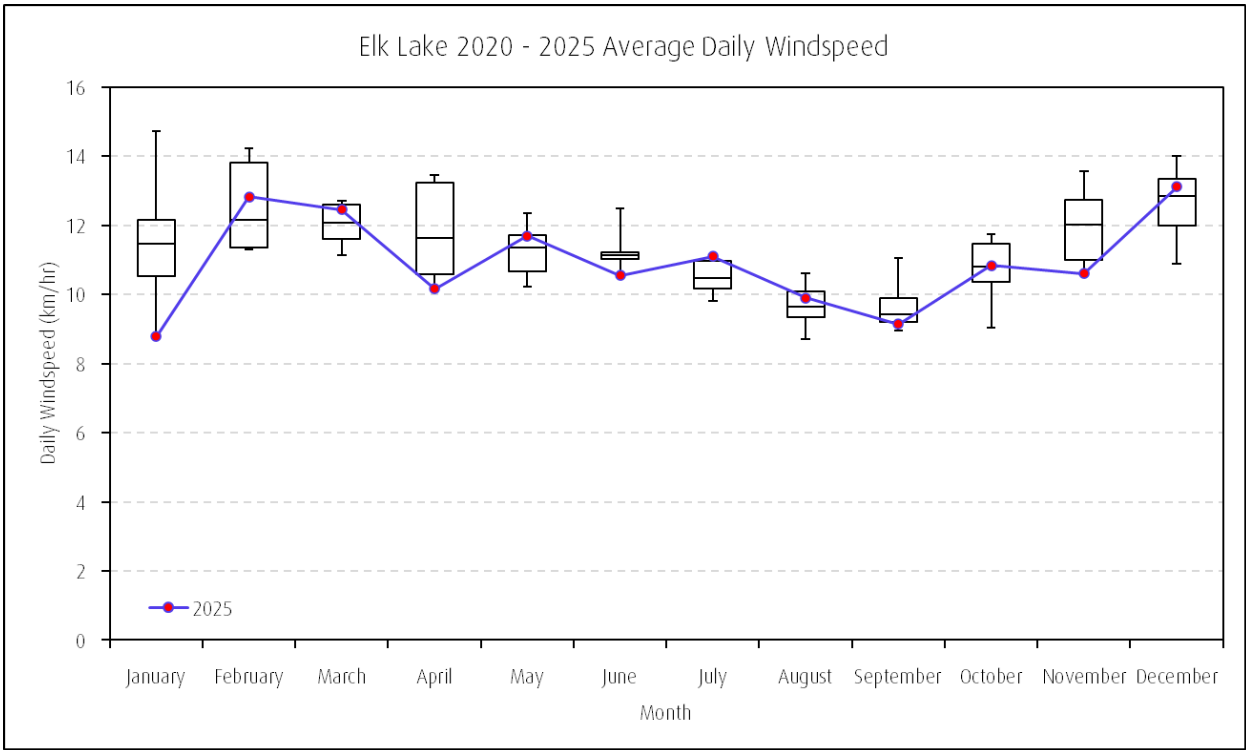
Figure 1. Average Daily Precipitation (2020-2025)



Wind

Average daily wind speed was calculated for the period between 2020 and 2025 and is presented in a box plot in Figure 2. Additionally, for comparison, 2025 wind averages are superimposed as red dots and a blue line to show where the 2025 wind speeds compare to the historical trends. Of note, April 2025 was the calmest (lowest wind speed) in the period analyzed. Calmer conditions generally favour algal bloom development, as the surface water can absorb more solar energy and mixes less with the water column (Province of BC 2022).

Figure 2. Average Daily Wind Speed (2020-2025)

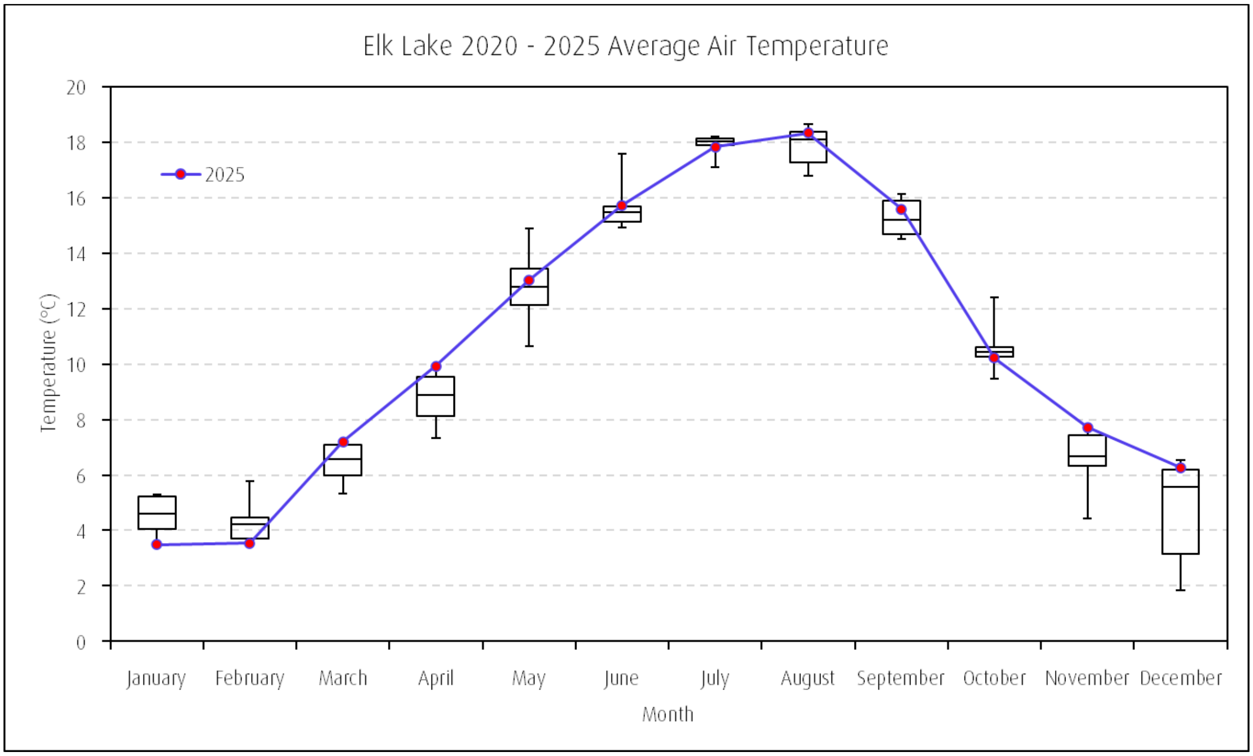


Ambient Air Temperature

Average monthly temperature was calculated for the period between 2020 and 2025 and is presented as a box plot in Figure 3. Monthly 2025 averages are overlaid and indicate that March and April were the warmest in the past five years with average temperatures of 7.2°C and 9.9°C, respectively. Additionally, the average daily high in April 2025 was 14.8°C and the average daily minimum was 5.0°C. Cyanobacteria are known to prefer warmer temperatures and abundant light (Province of BC 2022).

The warmer temperatures, sunny days, and calm conditions in April, combined with assumed increased external nutrient loading from the high amounts of rainfall in March, were likely the primary cause of the spring algae bloom in Elk Lake.

Figure 3: Average Monthly Temperatures (2020-2025)



Measured Lake Water Quality Data

As previously noted, consistent water quality data has been gathered at Elk Lake since 2019, except for 2023, due to funding constraints. Additional data exists before 2019 as well but is less consistent both with timing and locations. Monitoring since 2019 forms a good base of data for evaluation of water quality trends pre-operation of the oxygenation system (prior to 2024) and responses within its first two years of operation. While many parameters are analyzed (e.g., metals and E. coli), the most relevant water quality data to evaluate the efficacy of the system are:

- Dissolved Oxygen
- Temperature
- Nitrogen
- Phosphorous
- Turbidity
- Chlorophyll-a

A summary and evaluation of the data collected on the individual parameters is provided in the following sections. Where applicable, location data between ELK02 and ELK04 is compared to evaluate impacts of the system farther away from the active diffuser line.

Dissolved Oxygen

A summary contour plot of DO collected in Elk Lake from 2019 to the end of 2025, excluding 2023, is presented in Figure 4. The 2025 DO trends from the remote sensors are presented in Figure 5, along with key operational adjustments. In 2025, DO was observed to be low (<2mg/L) during early-July to mid-October. This can be primarily attributed to the equalization valve failure on one of the oxygen generators, which reduced the overall system capacity by half during July. The impact on hypolimnion phosphorus levels is discussed in detail in the phosphorus section of this report.

The target DO levels may not have been achieved for several possible reasons:

- the HOS was operating at 50% capacity during July due to an equalization valve failure on one of the oxygen generators.
- the maximum achievable flow rate from both oxygen generation trains was only 710slpm (25scfm), compared to the full design capacity of 848slpm (30scfm).

To address the reduced operating capacity, Clarity Resources performed several warranty upgrades during the spring 2025 service. Work included replacing all porous hose in the lake, shortening the piping between the air receivers and the oxygen generators, and by measuring the flow profile of the oxygen generators using one compressor and one air receiver, one compressor and two air receivers, and two compressors and two air receivers to identify any variation in the feed air profile to the oxygen generators. Ongoing testing of each compressor will be conducted to identify the actual delivery capacity to ensure they are achieving manufacturer specifications. Adjustments will be made to the oxygen generators to ensure maximum flow is achieved or to be able to identify the root cause of the current limited output capacity.

Figure 4. Dissolved Oxygen Depth Profiling (ELK02) (2019-2025)

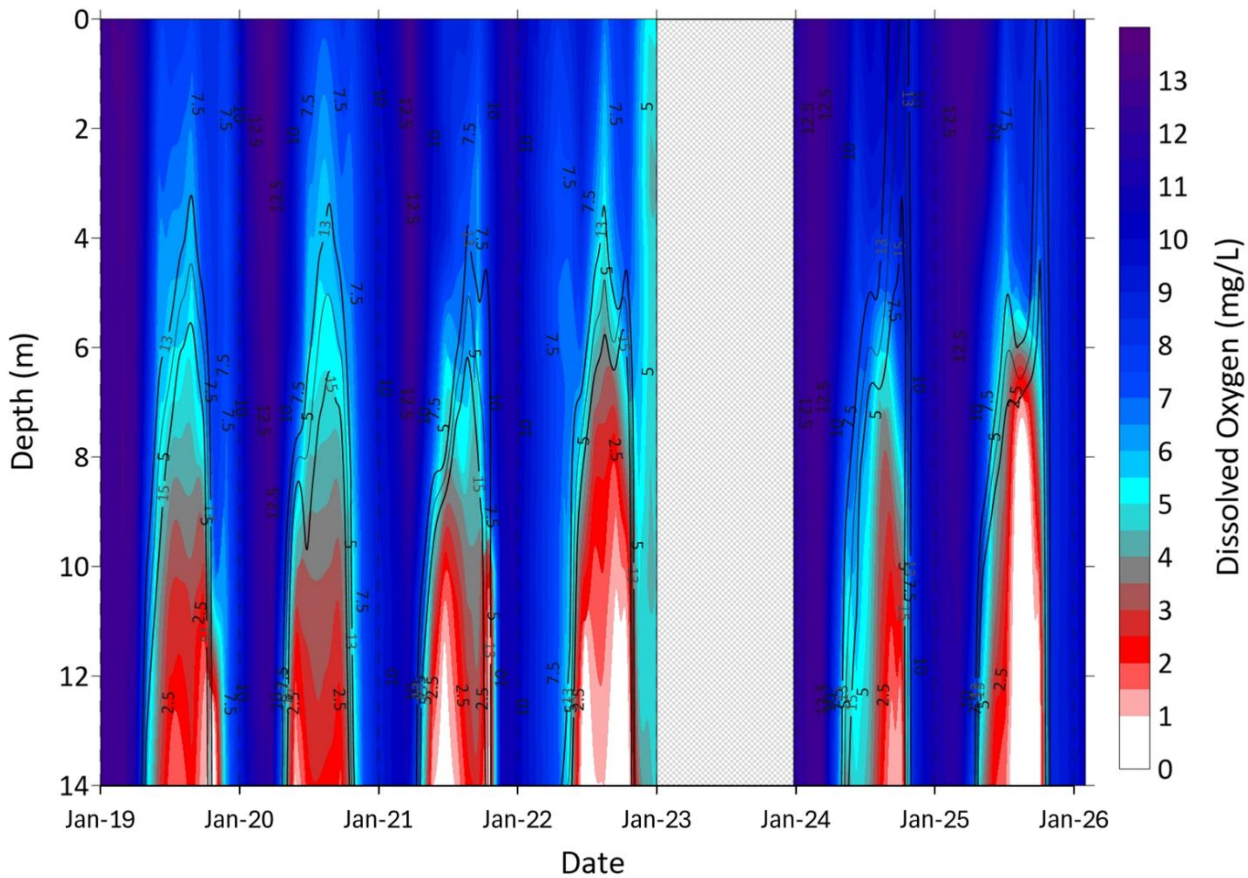
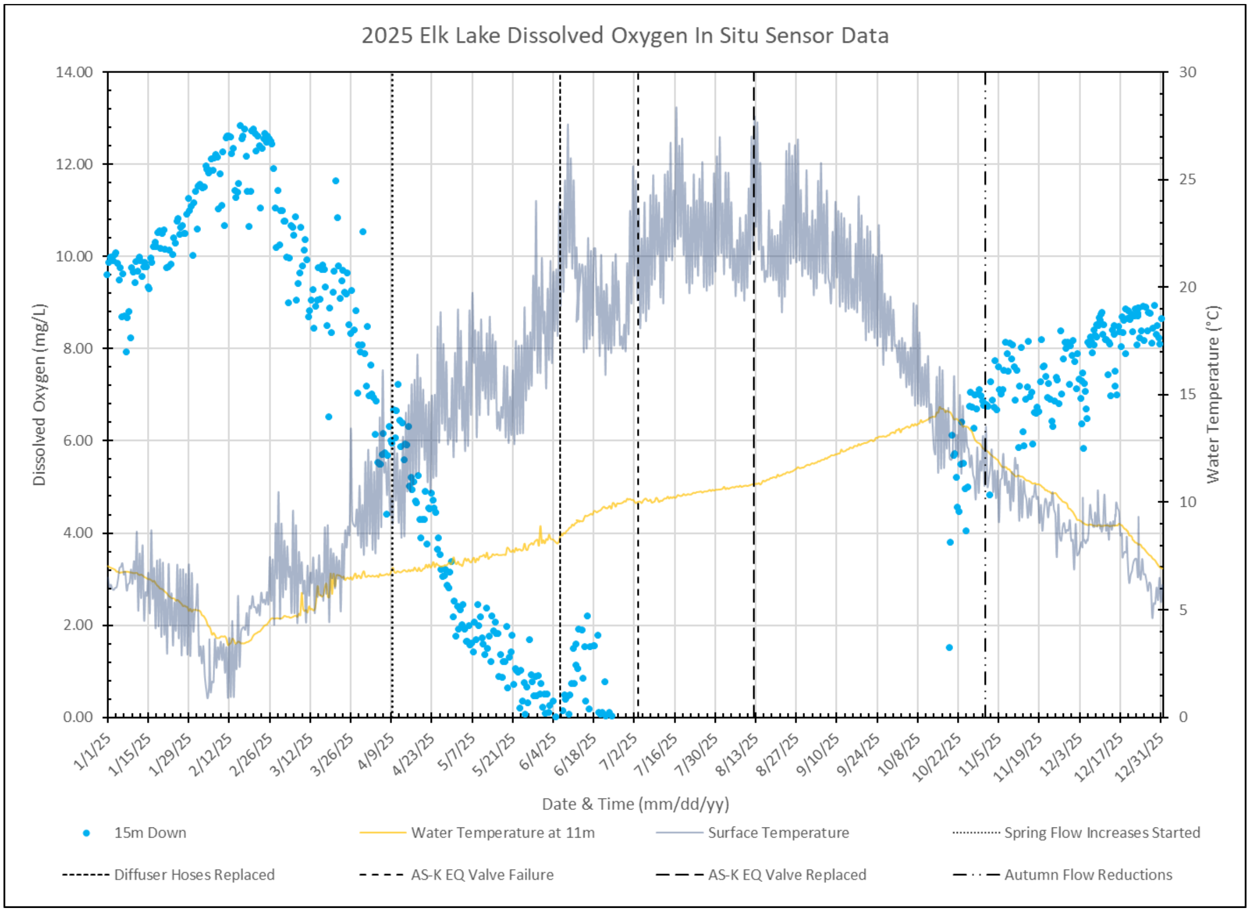
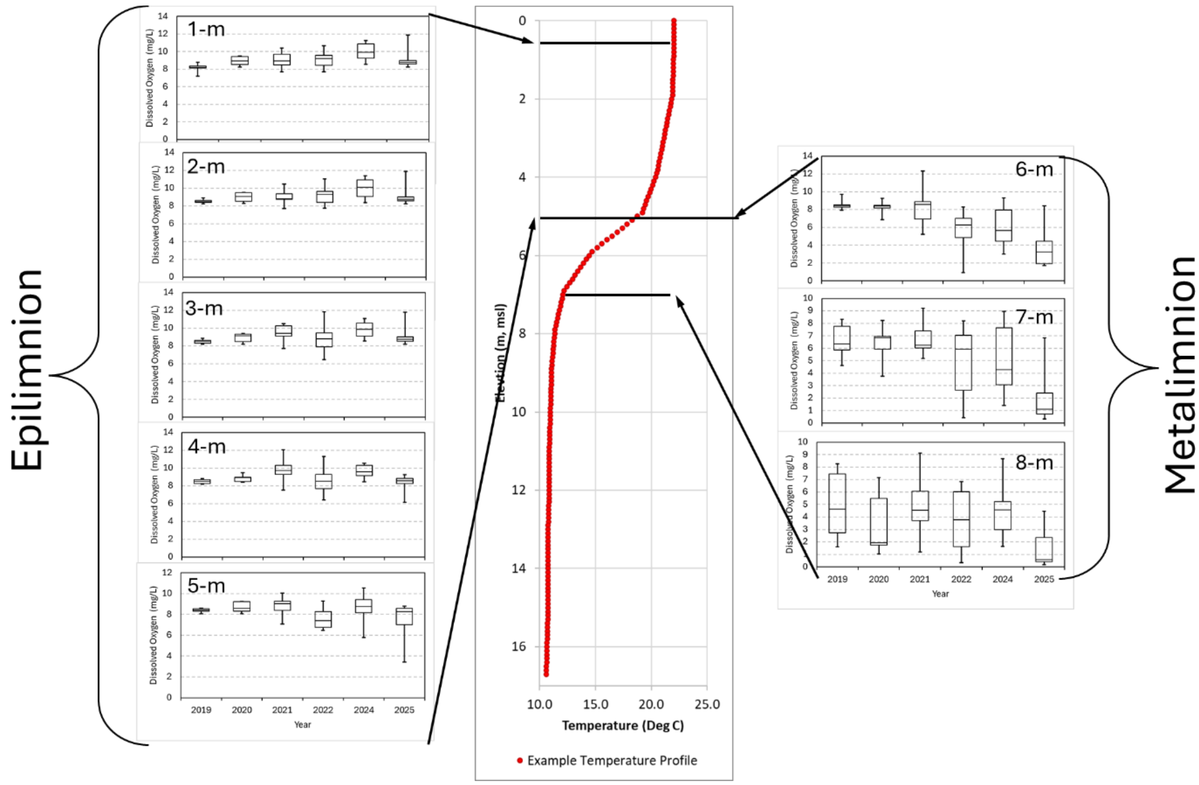


Figure 5: 2025 In Situ Sensor Dissolved Oxygen Data



As an alternate way to represent a summary of oxygen conditions, all DO data were summarized using box plots for each metre of data collected between June and October for the years data were available. This date range was chosen to eliminate bias between years when data were not available during earlier and later months. A 'generic' temperature data set was used to show the different regions of the water column: epilimnion, metalimnion (thermocline) and hypolimnion. Epilimnion and metalimnion data show very little difference between each year where data was collected. There does appear to be increasing variability in data from 2019 to 2025, which is evident in the increased box sizes. The 2025 hypolimnion data does not show as much improvement as observed in 2024, on account of oxygen delivery capacity during July 2025; however, the whisker portion of the plot shows improvement over years before HOS operation. There appears to be a slight downward trend in DO condition in the metalimnion; however, it is difficult to identify the cause of this observation. This could be due to environmental factors such as the onset of stratification early or the progression of the thermocline deeper in the water column.

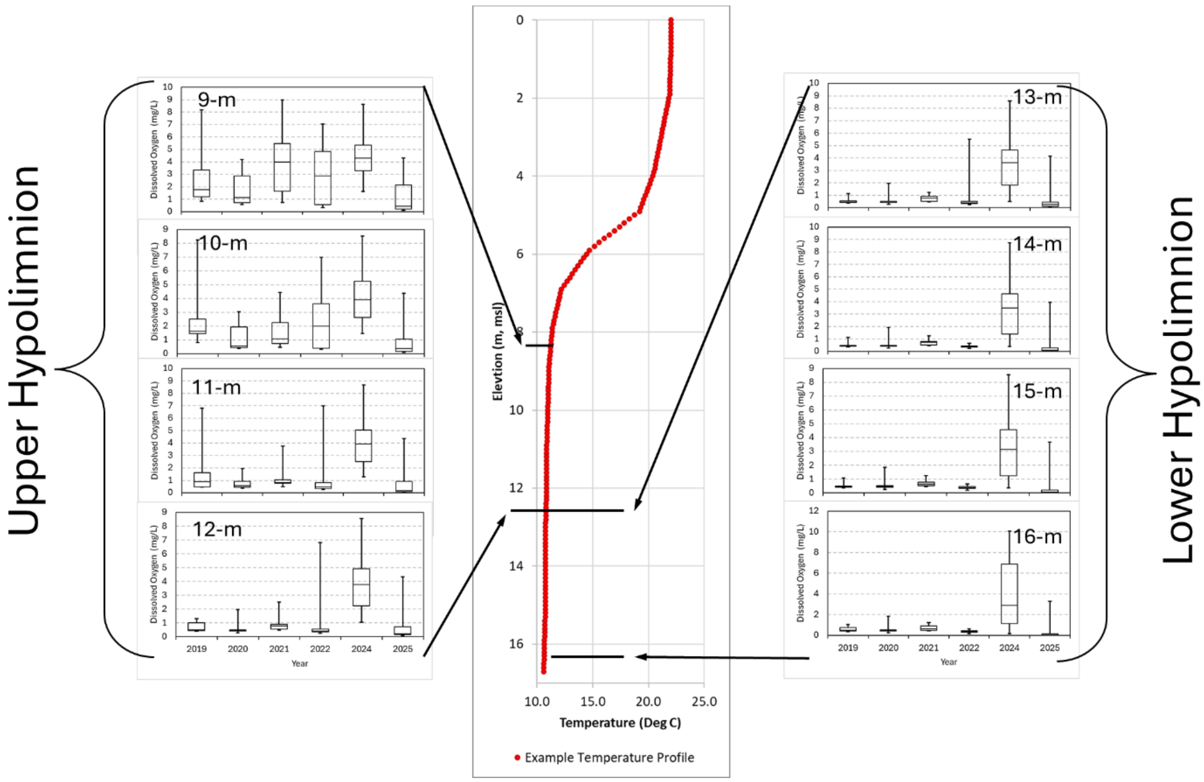
Figure 6. Dissolved Oxygen Annual Trends in Epi and Metalimnion (2019-2025)



The hypolimnion DO data were separated into upper and lower hypolimnion, each region representing a 4-metre depth range. All DO data measured in 2025 were observed to not be as high as 2024, which demonstrates the true impact of HOS operation not operating at capacity during July and trying to recover low DO once it occurs.

In 2025, anoxic conditions (average DO < 2mg/L) were not reached until mid-July and recovered by mid-October (approximately 3 months' duration). Historically, anoxia in the hypolimnion occurred in mid-May and lasted until late October (over a five-month duration). This suggests that the oxygenation system is achieving impactful gains in DO levels within the hypolimnion, even with some operational limitations in 2025.

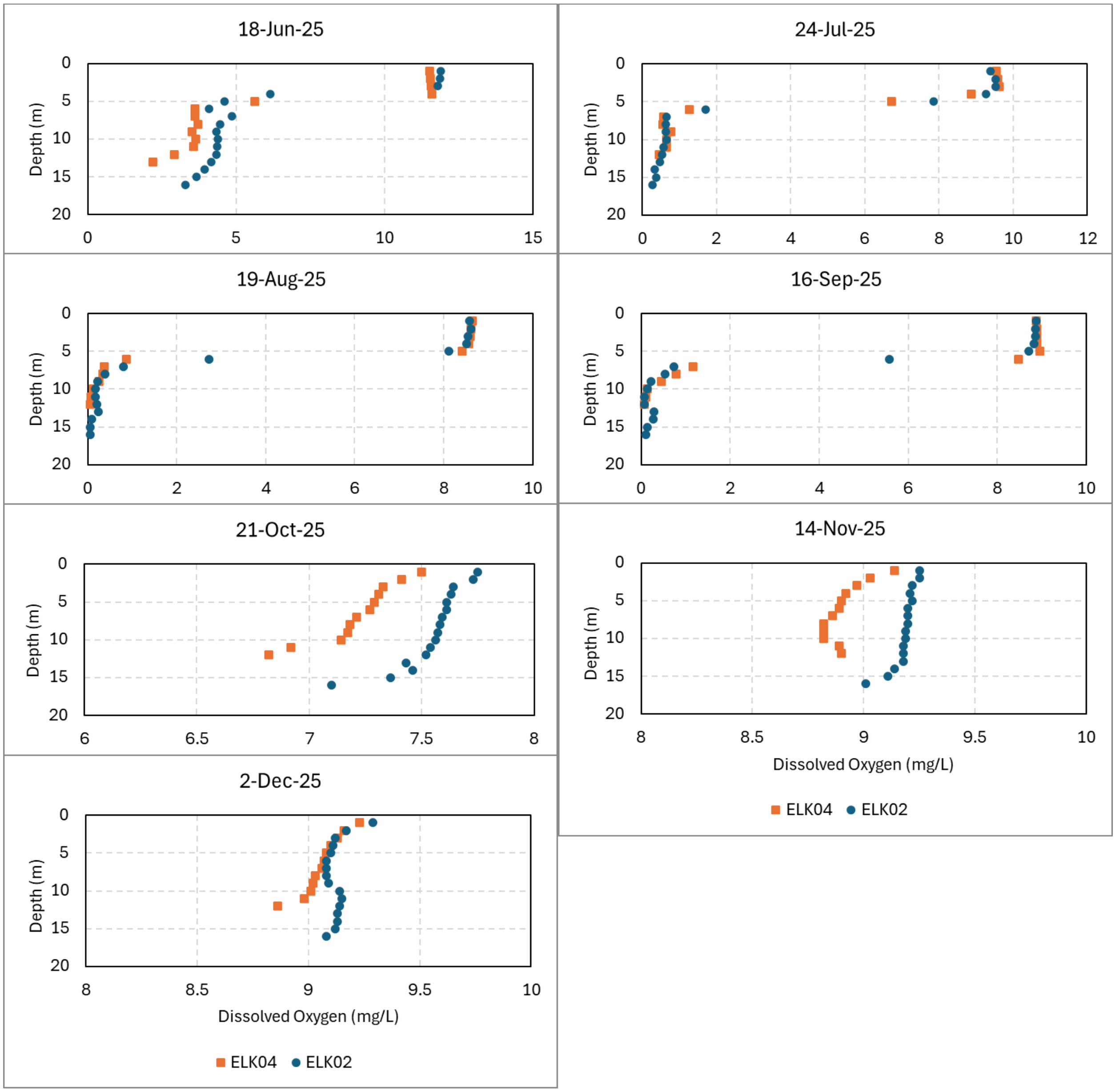
Figure 7. Dissolved Oxygen Annual Trends in Hypolimnion (2019-2025)



ELK02 vs. ELK04 Dissolved Oxygen Comparison

During 2025, a second monitoring site (ELK04) was added to identify oxygen distribution characteristics; a map of the locations is available in Appendix A. There are insignificant differences between the two sampling locations from June to September, while the lake was stratified, as shown in Figure 8. This demonstrates strong dispersion of dissolved oxygen throughout the hypolimnion during stratification, in response to oxygenation. There was a slight average difference of 0.3-0.5mg/L observed during late-season operation, evident in the October and November data. During late season, the lake was well mixed; however, the HOS was still operating. Overall, applied oxygen appears to be dispersing well throughout the hypolimnion and DO concentrations at both sampling locations are consistently above historical levels pre-oxygenation. The second location (ELK04) will continue to be monitored monthly in 2026 but will likely be removed in 2027.

Figure 8. Comparison of ELK02 and ELK04 Profile DO Measurements



Temperature

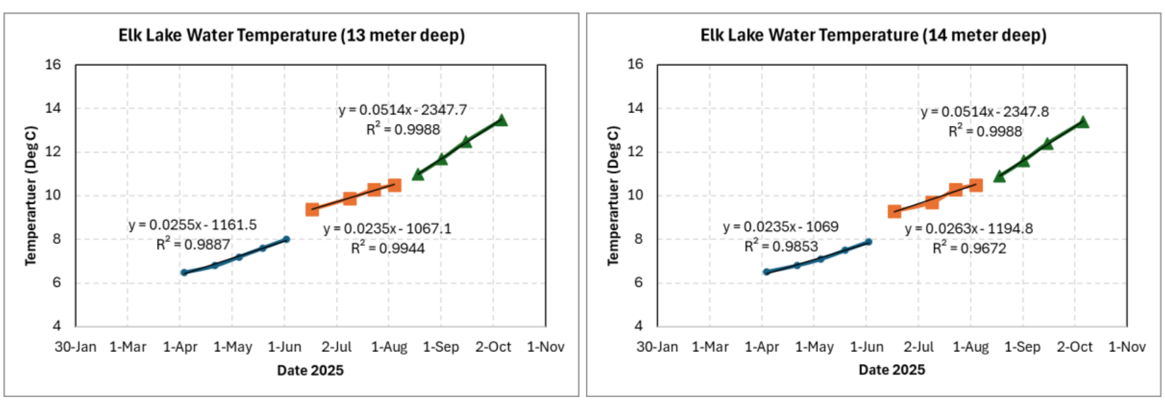
The hypolimnion water quality objective to maintain temperature below 15°C is driven by the optimum temperature ranges for salmonids (specifically cutthroat trout in Elk Lake) from the BC Water Quality Guidelines, as discussed in the Watershed Management Plan. During the design phase of the oxygenation system, there was concern regarding potential warming of the hypolimnion to greater than 15°C, which is discussed in the 2018 EBLI report. One misunderstanding is that the oxygen bubbles are adding heat to the hypolimnion because they are being injected at ambient atmospheric temperatures, which is typically much warmer than observed hypolimnion temperatures. The mass of an air bubble and relative thermal heat capacity compared to that of water is insignificant. However, hypolimnetic warming may be caused by cooler hypolimnion water being carried upward in the water column and mixing with warmer water at the base of the thermocline. The amount of hypolimnetic warming is therefore a function of applied gas flow rate, with higher flow rates resulting in more mixing, thus more warming.

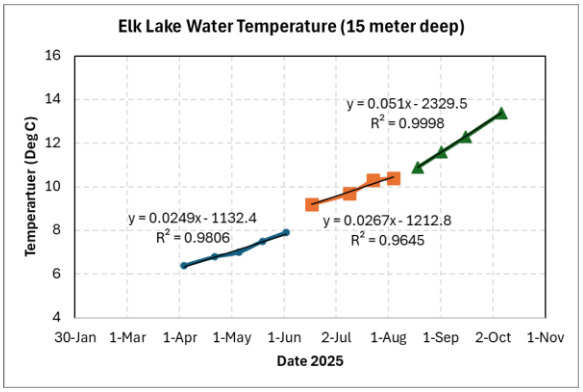
The oxygenation system operates on a continuous protocol, with the goal of never allowing DO in the hypolimnion to be depressed. The injection flow rates are modified according to DO and water column temperature data. Therefore, it is not expected to significantly influence higher warming rates of the hypolimnion. Additionally, since anaerobic decomposition is less efficient, it can contribute to deep water lake warming over time, while higher DO would facilitate aerobic decomposition and a cooling effect long-term.

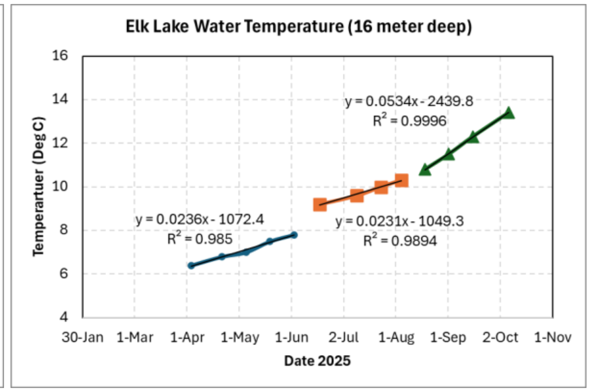
Data collected during initial stratification in 2021 (Jan–Jun) on Elk Lake by NHC and the CRD were analyzed for temperature below 7m depth. Initial warming in the hypolimnion was calculated to be 0.022 degrees Celsius per day (°C/day) between January and April, decreasing to 0.0079°C/day between April and June.

During the second year of operating the oxygenation system (2025), warming rates in the hypolimnion, presented in Figure 9, are separated into three time periods: Apr-May (blue data points), Jul (orange data points), and Aug–Oct (green data points). These time periods apply to different applied gas flow rates to the lake, with the latter part of the year being nearly double. Initial warming rates were observed to be approximately 0.025 °C/day during early spring (Apr–May and Jul) when injection flows were lower, which are on par with historically observed rates, and then increased to 0.05 °C/day when the applied flow was increased.

Figure 9. Temperature Profile Measurements







A summary of the average and highest hypolimnion temperatures, 10m depth and below, from 2020 to 2022 and 2024 to 2025 is presented in Table 7. The warmest temperatures typically occurred in October, just before turnover. The highest observed hypolimnion temperature before fall turnover in 2025 was 13.9°C. While this is higher than pre-oxygenation observed maximums, it is slightly lower than 2024 values and still below the water quality objective. Operational monitoring of water temperature will be emphasized moving forward to prevent mixing of the hypolimnion induced by oxygen injection.

Table 7: Average and Maximum Temperatures of the Hypolimnion

	Average Hypolimnion Temperature (°C, below 10m)	Maximum Hypolimnion Temperature (°C, below 10m)
May - October 2020	7.5	10.9
May – October 2021	7.8	11.4
June – October 2022[1]	8.9	10.5
May – October 2024	11.5	14.6
May – October 2025	10.5	13.9

1 – No data available from May 2023

Nitrogen

Total nitrogen, ammonia (NH_3), and nitrate (NO_3) were analyzed from samples collected at 1m and 16m depths between 2019 and 2025 and presented in Figure 10 and Figure 11, respectively. Total nitrogen appeared to be slightly higher at 1m in 2024 and 2025 than in previous years; however, not at 16m. The 2025 surface nitrogen levels were elevated in the first half of the year and may have been influenced by weather related to more heavy rain events observed in March and May, as discussed in the Environmental

Data section and evident in the 2025 1-m turbidity data. The higher nitrogen levels at the surface in 2025 do not appear to be influenced by hypolimnion levels because hypolimnion levels in 2025 were lower than prior years and wind speeds were not observed to be significantly different in 2025 than prior years, ruling out possible increased mixing.

Hypolimnion nitrogen concentrations were observed to increase each year between 2019 and 2022 and appeared to be dominated by ammonia (nitrogen hydrides [NH_5]). Additionally, there appeared to be an upward trend in end-of-summer ammonia levels between 2019 and 2022. Ammonia levels in 2025 were observed to be lower than in previous years and remained below the BC Water Quality Guideline concentrations. Hypolimnion ammonia did increase slightly over the summer, which is expected given the low DO observed later in the summer. Nitrate was observed to be present during early summer and then decrease as DO levels were observed to be low. This is characteristic of the de-nitrification process under low DO conditions.

Figure 10. Shallow (1m) Nitrogen Concentrations

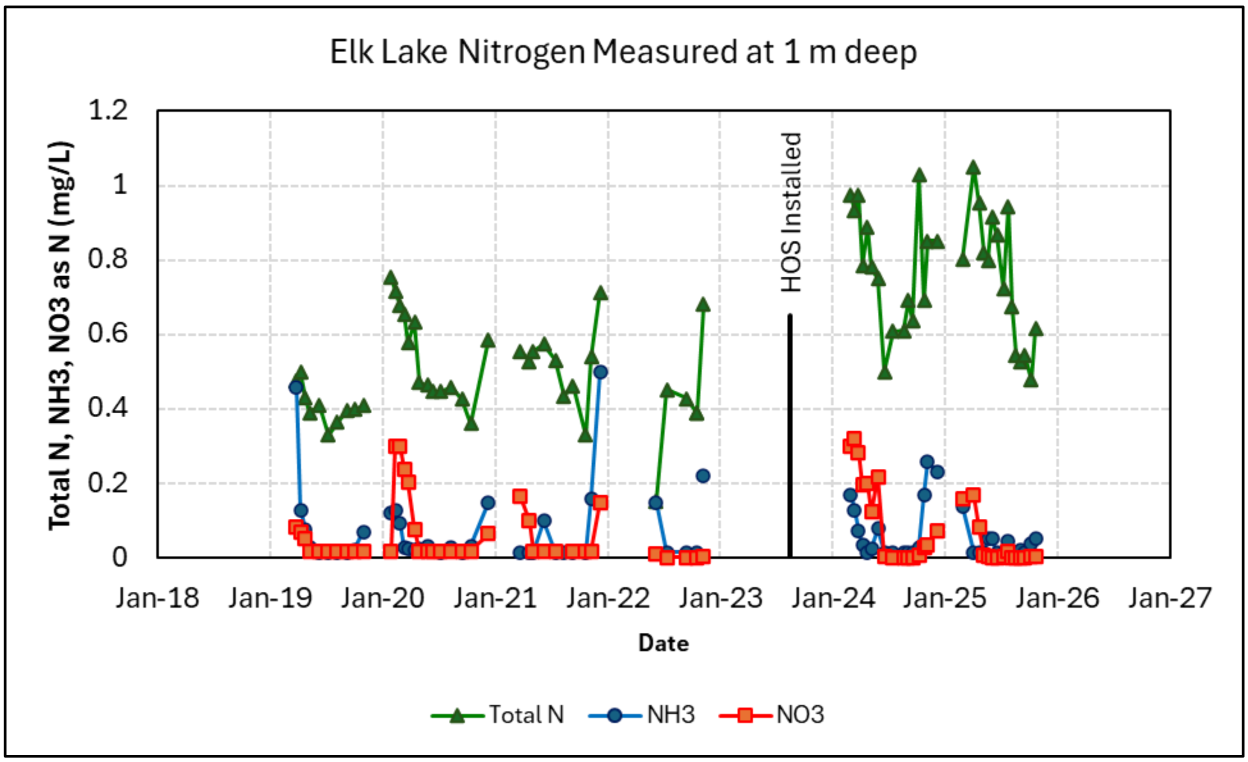
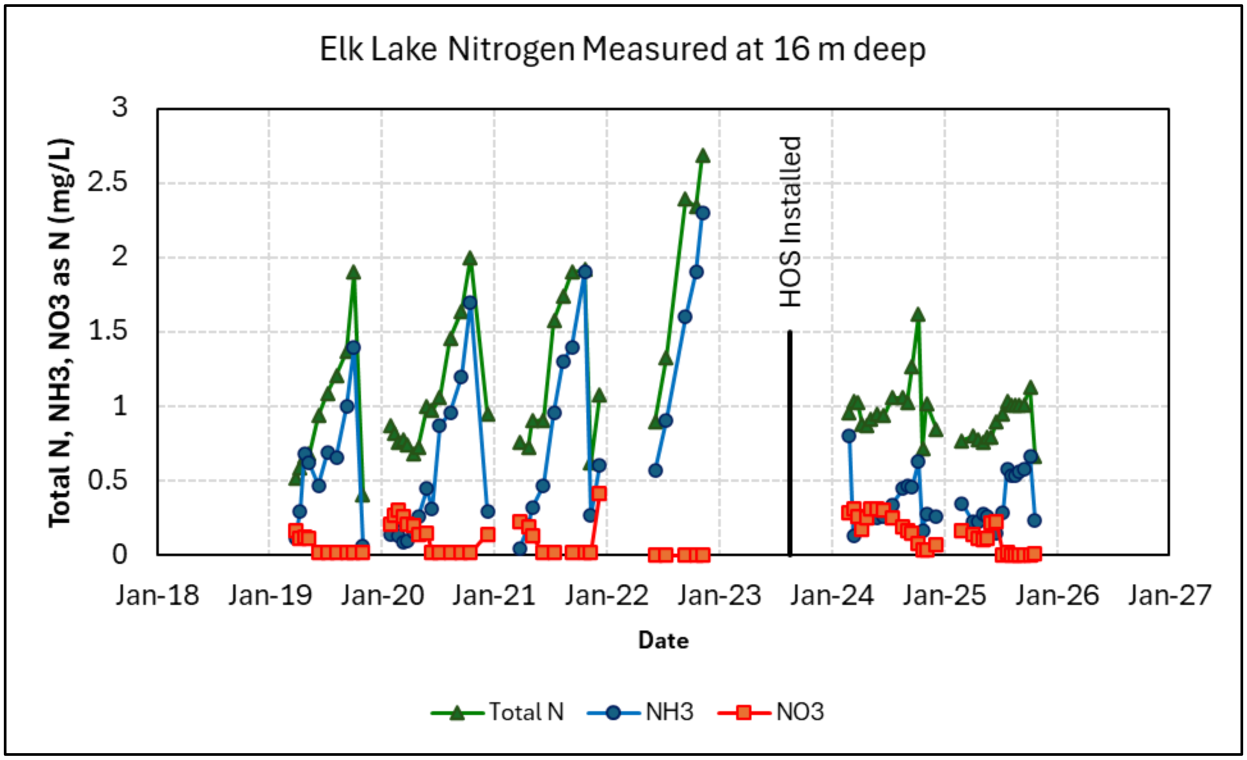


Figure 11. Deep (16m) Nitrogen Concentrations



Phosphorus

Total phosphorus data are presented in Figure 12 and Figure 13 for samples collected at 1m and 16m depths, respectively, between 2019 and 2025, excluding 2023. The hypolimnion data (Figure 13) has a green dotted line at 400 µg/L that represents the predicted total phosphorus levels following HOS operation (Gantzer 2022).

In general, surface phosphorus data increases following fall turnover as the nutrient-rich hypolimnion water mixes with the epilimnion. The October data point in both surface and deep data sets are coloured red to show the same point in time for each year. Hypolimnion phosphorus data shows rapid decline following fall turnover for each year. Additionally, hypolimnion phosphorous data showed an increasing trend from 2019 to 2022. In 2024, values were observed to increase over the summer but only to a maximum concentration of 290 µg/L compared to 1,800 µg/L observed in 2022, which is >80% reduction in hypolimnion phosphorous observed at the 16m depth. In 2025, hypolimnion phosphorus concentrations showed a similar trend until July when the equalization valve failure occurred, limiting the oxygenation system to half capacity. As DO levels declined below 2mg/L, more phosphorus was released into the hypolimnion in July and August. However, with the oxygenation system back at full capacity in August, DO slowly recovered, and phosphorus was re-sequestered. By the end of September, phosphorus concentrations were below the predicted 400 µg/L, with an observed concentration of 290 µg/L at the end of October when the lake destratified. While the valve failure impacted operations during the height of summer, this data supports the principle that phosphorus can be re-sequestered with elevated DO concentrations. The oxygenation system was able to recover DO levels well enough to sequester enough phosphorus to achieve the target at fall turnover.

Surface phosphorus levels are driven by external loading, while bottom levels are driven by oxygen concentration. The phosphorus levels in the upper water column are shown to be higher in spring 2025 and decrease over the summer, which corresponds to the extreme rain event(s) that occurred in March followed by below-average rain during the following months.

Figure 12. Shallow (1m) Phosphorus Measurements

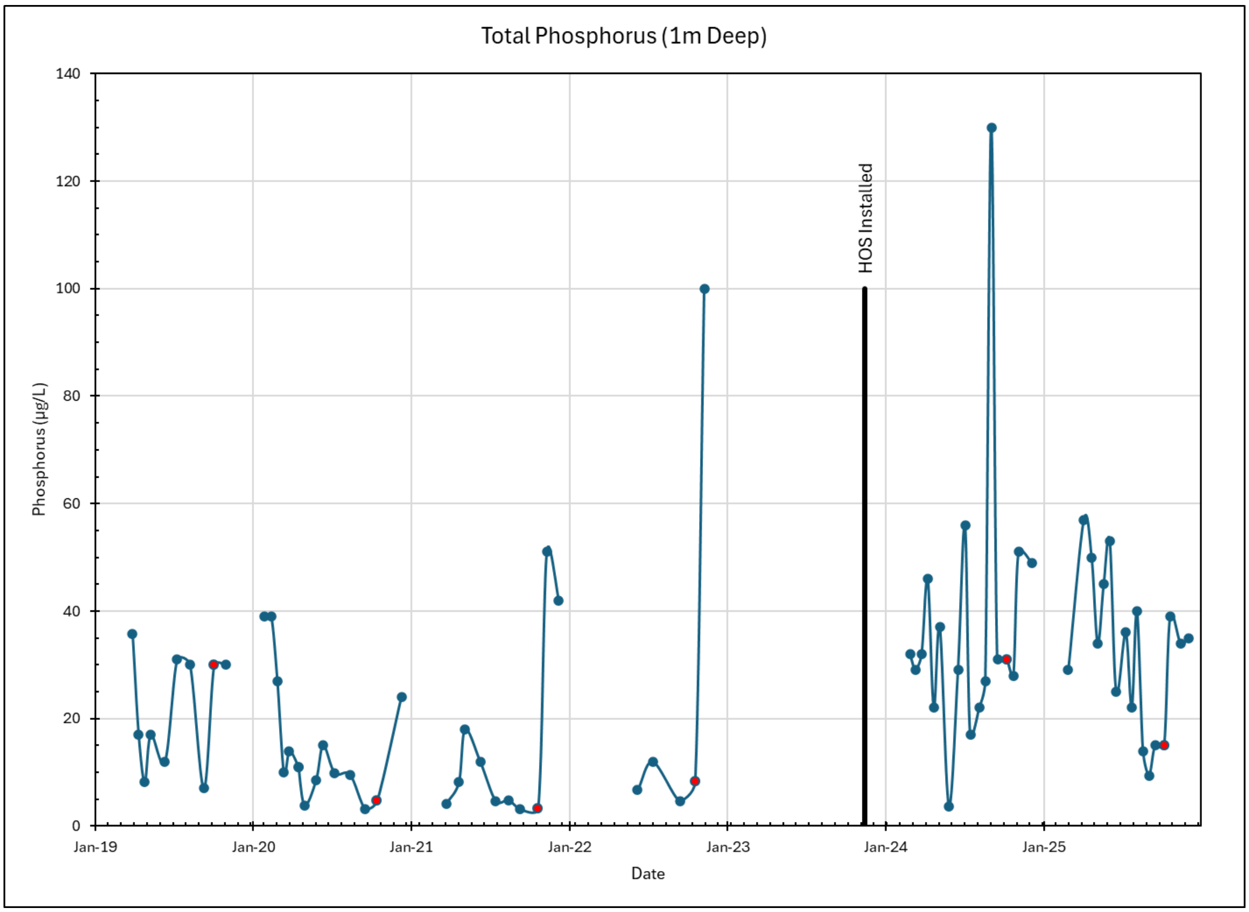
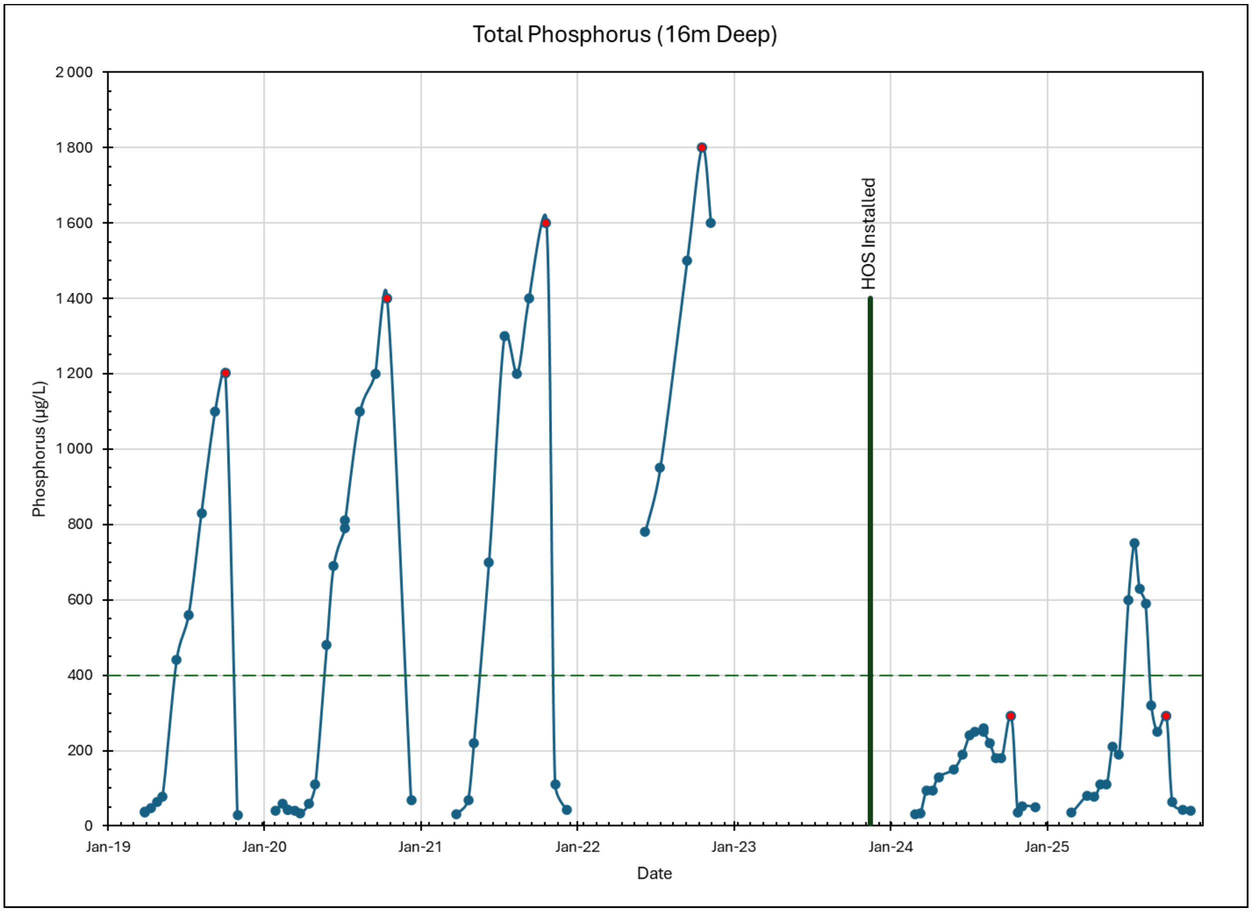


Figure 13. Deep (16m) Phosphorus Measurements



Note: May 7, 2024, hypolimnion data are included due to an erroneous high value that could not be validated with any other data.

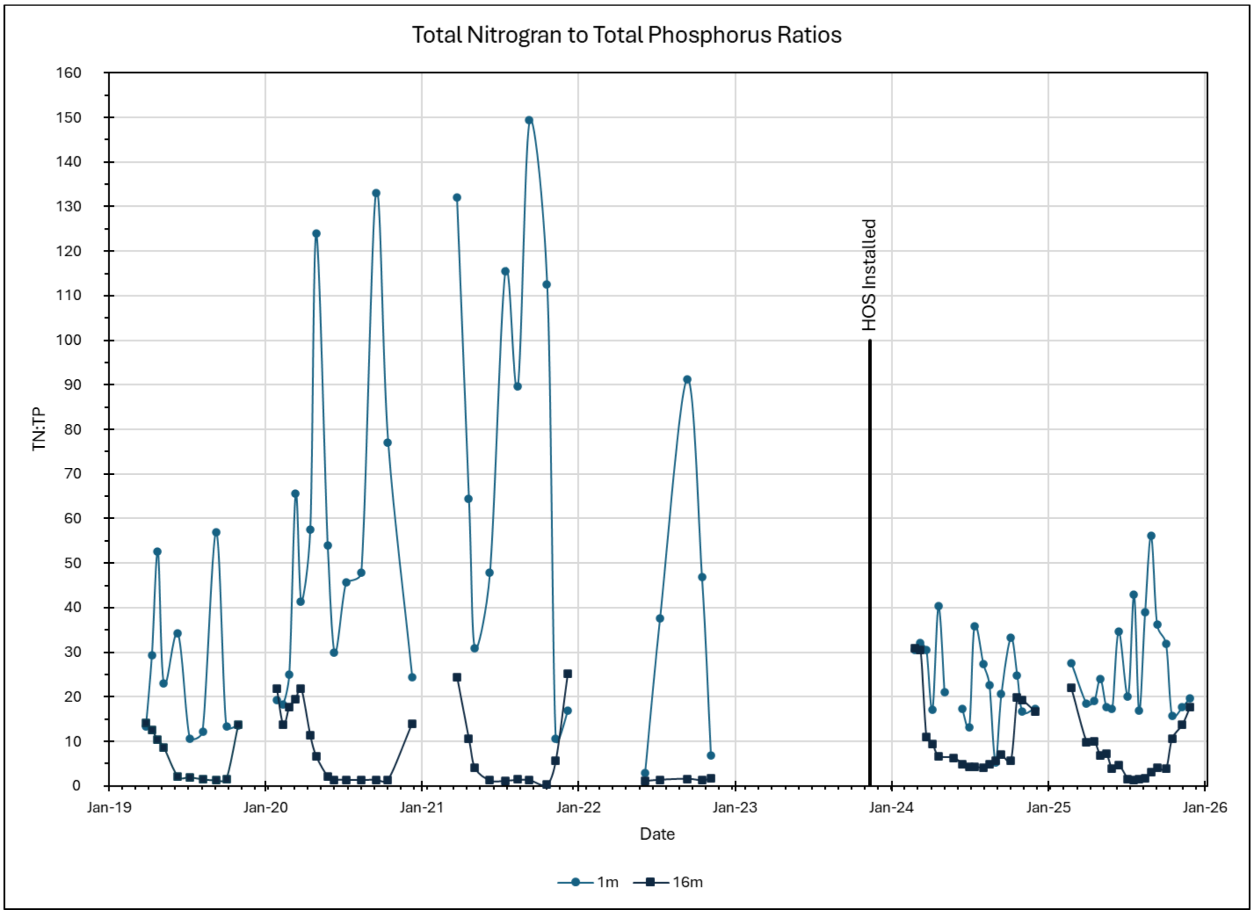
Phosphorus Pre-Stratification

Spring phosphorus concentrations, when the lake is well mixed and homogeneous from surface to bottom, are what the WQO of 15µg/L is based on. Timing of the measurement can vary and must take an average of the surface and bottom concentrations before stratification. From 1980 through 2015, spring total phosphorus concentrations were observed to be increasing, with 2015 having a recorded high of 44µg/L (Nordin 2015). More recently, spring phosphorus concentrations were 36µg/L in March 2019 and 40µg/L in January 2020. Spring pre-stratification data is not available from 2021 through 2023. Post-oxygenation spring phosphorus concentrations have been 32µg/L in both February 2024 and 2025, suggesting some modest improvement though still well above the 15µg/L WQO.

Total Nitrogen to Total Phosphorus Ratios

Total nitrogen to total phosphorus mass ratios (TN:TP) can be used to understand relative limitations between the two nutrients and their effects on algal growth. While the exact threshold ratios can vary for each specific water body, generally, TN:TP mass values less than 7 indicate that the aquatic system is nitrogen limited. This restricts growth in most algal species. However, because cyanobacteria can fix their own nitrogen from the atmosphere, low TN:TP values favour these bacteria and can lead to blue-green algal blooms in high phosphorus conditions. Co-limitation occurs up to TN:TP values of 30, where both nutrients influence algal activity. Above TN:TP values of 30, the aquatic system is phosphorus limited. The TN:TP ratios for both 1m and 16m samples from 2019 to 2025, excluding 2023, are presented in Figure *14*.

Figure 14. TN:TP Ratios at 1m and 16m



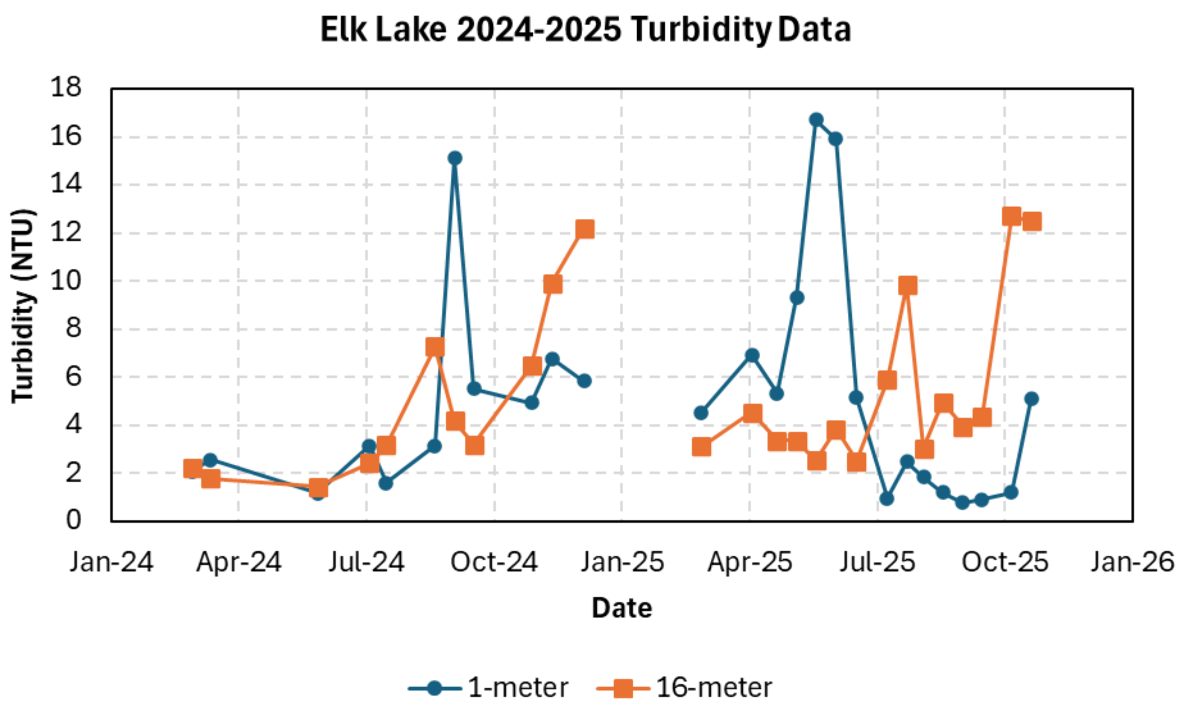
Results generally indicate that TN:TP ratios are shifting post-oxygenation. Shallow (1m) ratios have declined from being very phosphorus limited to fluctuating in the 10 to 40 range. Deep water (16m) summer ratios have also shifted post-oxygenation, increasing from very low (<2) to an average of 4 from

May to October. This suggests that oxygenation is making the hypolimnion less nitrogen limited, though it is still below the threshold of 7, where cyanobacteria are expected to dominate.

Turbidity

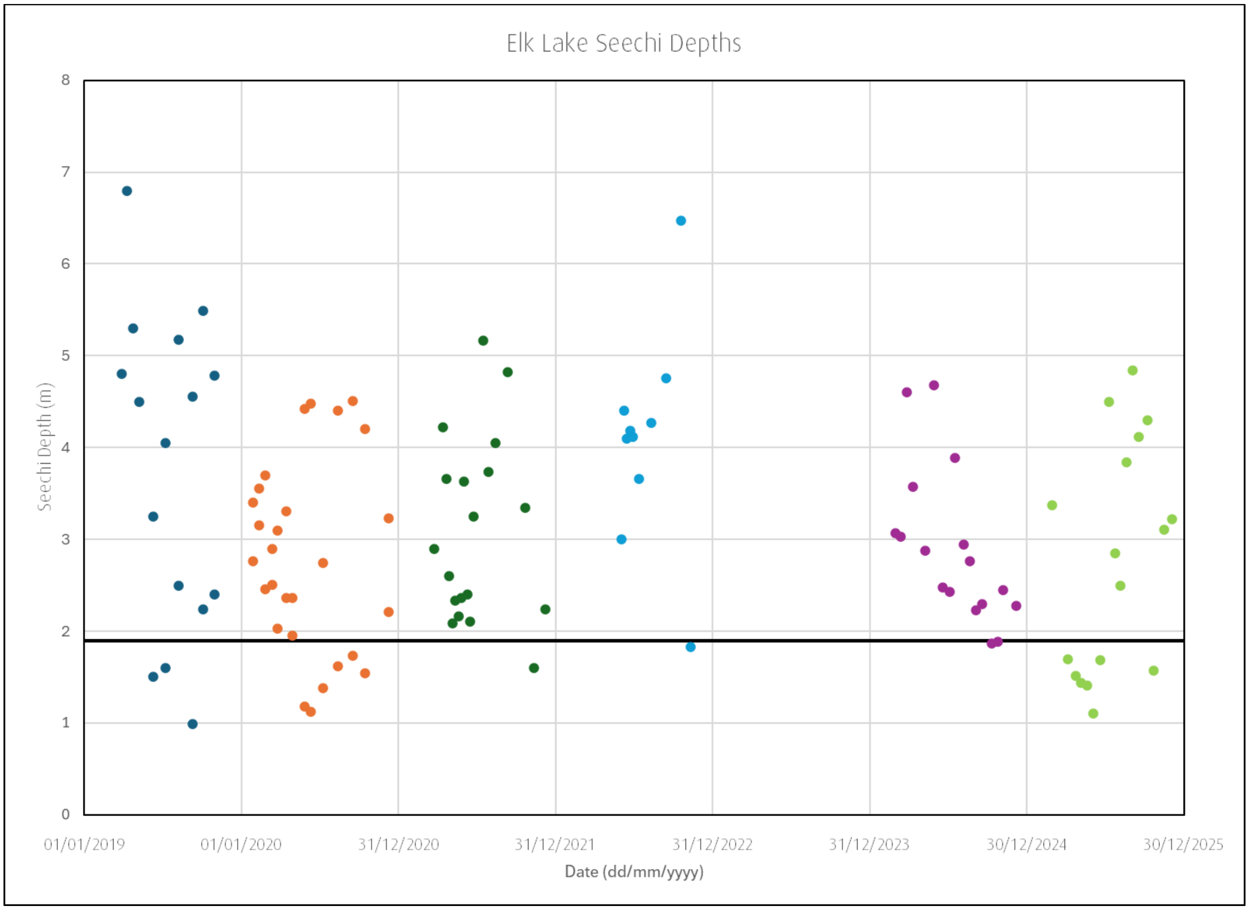
Turbidity is a measure of the amount of suspended particles, such as silt, algae, and other organic matter. Turbidity data from 2024 and 2025 are presented in Figure 15 and generally indicate that deep water (16m) readings were the same as or less than those observed at the surface (1m). This implies that injecting oxygen at the lakebed is not disturbing sediments to an impactful level. Shallow values were observed to be very high in the spring, correlating well with the May bloom, after which they remained low until the lake mixed in the fall. Deep values were observed slightly higher later in the year that correlate to when the lake mixed.

Figure 15. Shallow (1m) and Deep (16m) Turbidity Measurements



No turbidity data is available prior to 2024, but it will be an important metric to track moving forward. However, Secchi depth data is available for 2019 to 2022 and 2024 and 2025 and is presented in Figure 16. The WQO for Secchi depth is a minimum of 1.9m, represented by a black line in the figure, and was generally met in 2025, with exceptions through April to early June when the lake was experiencing the large bloom. There was also a shallow Secchi depth at the end of October 2025 of 1.57m, which likely corresponded with lake mixing (destratification). Secchi depths in 2025 appear consistent compared to historical values, suggesting no appreciable influence from the oxygenation system.

Figure 16: Secchi depths between 2019-2022 and 2024-2025

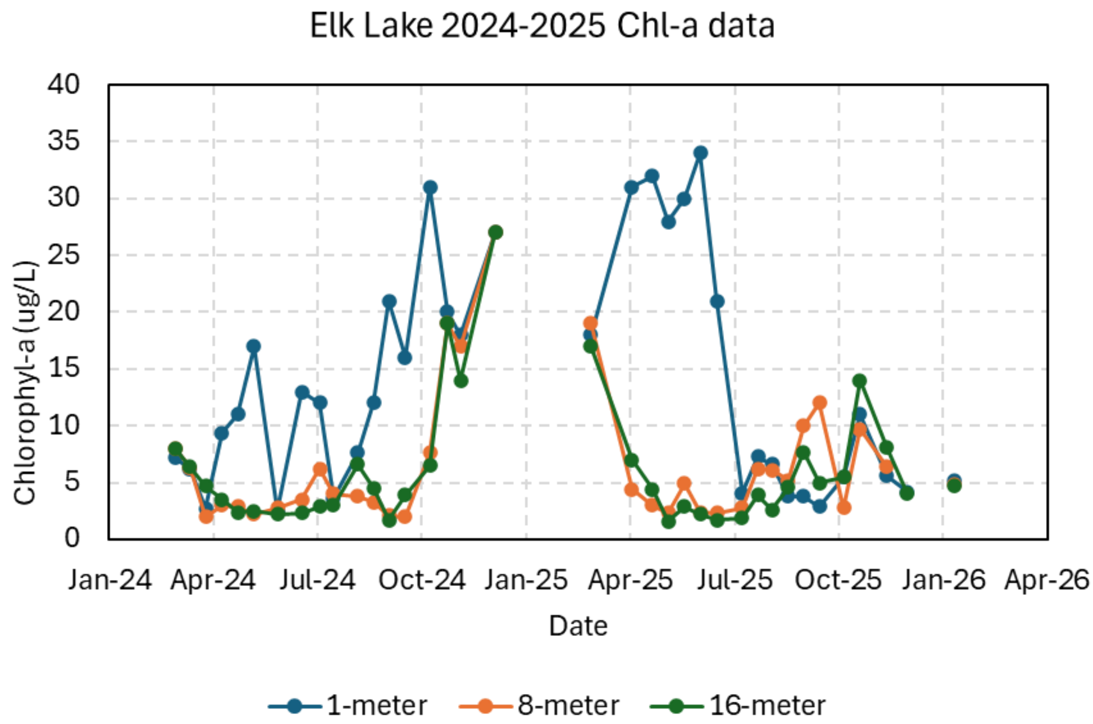


Chlorophyll-a

Chlorophyll-a concentrations can be used as an indicator of the number of photosynthetic organisms, such as cyanobacteria, growing in a waterbody (USEPA 2025). The Elk Lake WQO for chlorophyll-a is to have a mean summer range of 1.5-2.5µg/L. To compare against historical data discussed in the Water Quality Monitoring report, samples collected from 0m – 6m depths in July, August, and September are considered (CCS 2023). The average summer chlorophyll-a concentration for 2025 was 5.9 µg/L, using the available 1m and 8m data. This is almost half of the 2024 summer average (10.4 µg/L), but still above the WQO and historical averages.

The full profile data, presented in Figure 17, indicates lower chlorophyll-a readings at depth compared to the surface during the first half of the summer, with increasing readings throughout the water column following fall turnover. The elevated surface concentrations at the beginning of the year correspond to the heavy rains observed in early spring and the subsequent bloom observed. Figure 17 suggests that the oxygenation system is not impacting chlorophyll-a levels.

Figure 17. 2024-2025 Chlorophyll-a 1, 8, and 16-meter Measurements (ELK02)



Operating Costs

The operational budget for 2025 was conservatively estimated to accommodate some unknowns with warranty services and additional staff time, along with increased water quality monitoring to better assess responses in the lake (e.g., addition of second sampling location). The major expenses are listed in Table *8* along with their estimated budgets, actual costs, and recommended budgets for 2026. The 2026 budget estimates attempt to account for increased global economic uncertainties that may affect maintenance services.

Equipment maintenance costs were less than anticipated due to the warranty work involved with the diffuser line. The 2026 estimate should align with normal maintenance requirements. Consultant support in 2025 was limited to recommendations on flow rate adjustments, which will continue moving forward along with support for annual reporting and data analysis.

Table 8: Oxygenation System Operating Expenses

Operating Expense	Main Supplier	2025 Budget (CAD)	2025 Actual (CAD)	2026 Recommended Budget (CAD)
Electricity	BC Hydro	$ 60,000	$ 60,216.28	$ 65,000
Equipment Maintenance	Wiseworth, CIMCO	$ 40,000	$ 32,689.22	$ 35,000
Consultant Support	Clarity Resources	$ 15,000	$ 14,372	$ 13,500
Water Quality Monitoring	CRD Environmental Protection	$ 30,000	$ 25,040	$ 30,000
Operator Time	CRD Staff	$ 30,000	$ 27,791.50	$ 30,000
Total		**$ 175,000**	**$160,109**	**$ 173,500**

Electricity consumption is dominated by the air compressors and varied throughout 2025 depending on the target oxygen flow rates. During the summer months, with both oxygenation trains operating at full capacity, the system consumed a maximum of 62,214 kilowatt hours (kWh) per month with a peak demand of 86 kilowatts (kW). During the winter months, when only one oxygen generator was operating at reduced flows, energy consumption was as low as 5,109 kWh per month with a peak demand of 67 kW.

2025 Program Conclusions

The second full operational year of the Elk Lake hypolimnetic oxygenation system was generally consistent with expectations. There were some equipment issues associated with the warranty work on the diffuser line and the equalization valve failure in July. These issues have been rectified and operations since have been smooth. Lessons learned regarding flow adjustments and modifications to control structures will be implemented in 2026.

While Elk Lake still experienced algae blooms in 2025, including a major one during April and May, and the WQOs for DO and phosphorus were not achieved (see Table 9), improvements were observed compared to years before the system was installed. Environmental factors were likely a contributing cause of the spring algae bloom in Elk Lake. The equalization valve failure led to reduced hypolimnion DO levels in July and August, resulting in increased lake bottom phosphorous concentrations, but the data showed that phosphorus was sequestered again before fall turnover, after the system was repaired.

The hypolimnion phosphorous levels were reduced by 80% compared to pre-oxygenation years. Anoxic conditions were only present for three months in July through September, compared to five months from

May to October in previous years. The equalization valve issue reduced oxygen flow rates during July, which contributed to lower hypolimnion DO levels. No detrimental effects to temperature or turbidity were observed as a direct result of oxygenation. Overall, 2025 was considered a successful year of operation, and continued improvements are expected in 2026 and beyond.

Table 9: Summary of Water Quality Objectives and 2025 Values

Parameter	Objective	2025 Values at ELK02 Sampling Location	Pre-Oxygenation Values (2019-2022)
Total Phosphorus	Spring Average (Pre-Stratification) 5-15µg/L	32µg/L in February	>35µg/L
Hypolimnion Temperature	<15°C	Average: 9.6°C; Maximum: 13.9°C	Average: 8°C; Maximum: 11.4°C
Dissolved Oxygen	>5mg/L 1m above sediment	Average: 3.64mg/L; Minimum: 0.01mg/L	Average: 3.1mg/L Minimum: 0.16mg/L
Secchi Depth	>1.9m	Average: 2.77m; Minimum: 1.1m	Average: 3.25m; Minimum: 0.99m
Chlorophyll-a	Summer Average 1.5-2.5µg/L	Average: 5.9µg/L	Average: 5.28µg/L

2026 Program Modifications

Based on the HOS operation in 2025, the following modifications to system operations were identified for the 2026 operational season:

- Earlier flow rate ramp-up – After review of the 2025 start-up data, it is possible and advantageous to start the seasonal increase in oxygen flow rates earlier in the year. This will increase the duration and, thereby, the overall volume of oxygen supplied to the lake system over the year. Care will need to be taken to not interrupt the development and stability of the thermocline.
- Oxygen flow rate predictor program – Clarity Resources will develop a program for operations staff to input regular monitoring data and that will advise on target oxygen flow rates based on lake conditions.
- Remote monitoring and control of the onshore equipment – Clarity Resources will design and install upgraded control infrastructure for the oxygen generators and flow control devices. These will allow for remote monitoring, alarm callouts, and remote flow adjustments. This should result in more consistent operations and reduced staff effort.

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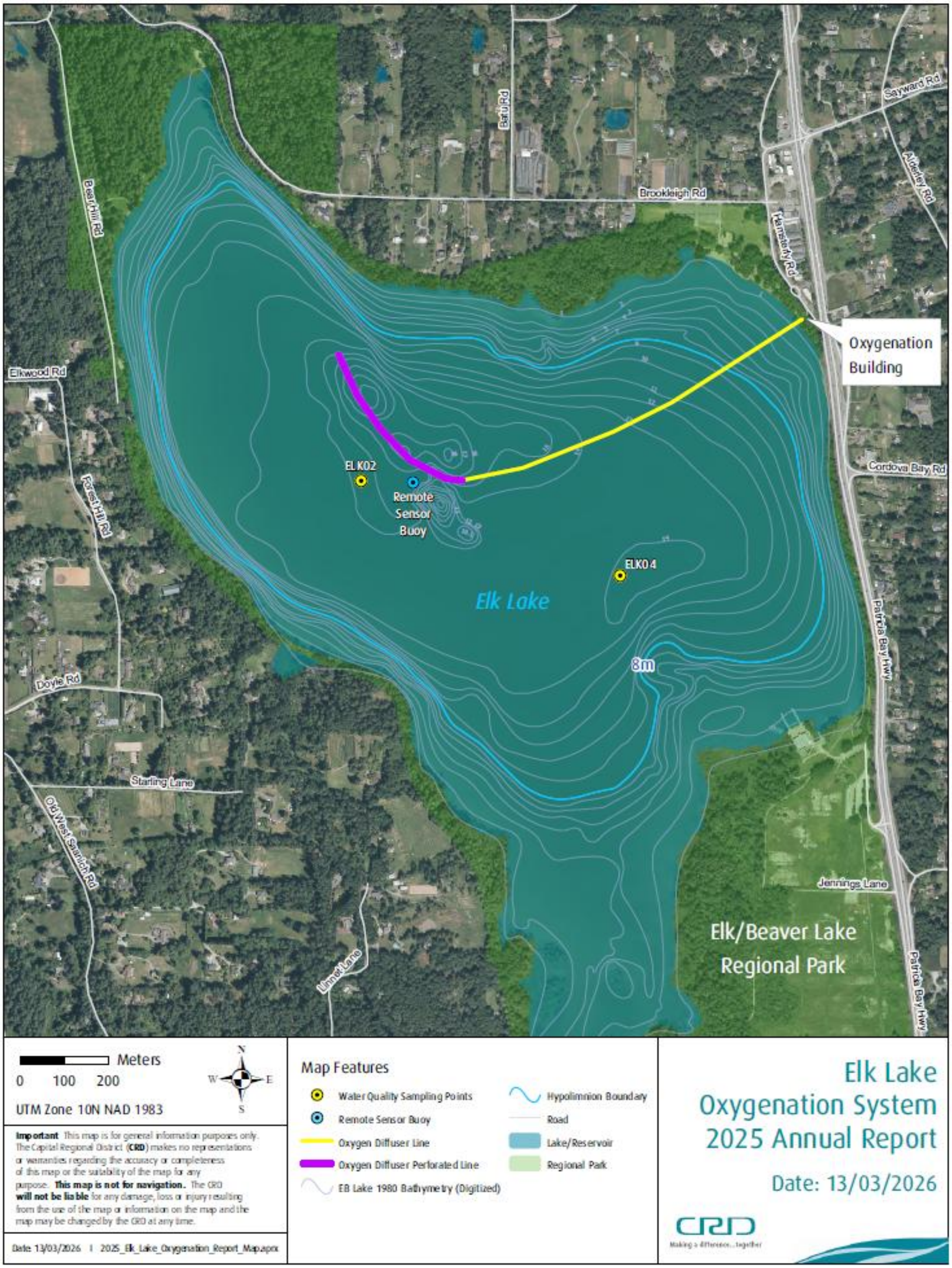
Bear Hill Rd
Brookleigh Rd
Barrow Rd
Sayward Rd
Alderley Rd
Hamsterly Rd
Elkwood Rd
Forest Hill Rd
Cordova Bay Rd
Oxygenation Building
ELK02
Remote Sensor Buoy
ELK04
Elk Lake
8m
Doyle Rd
Starling Lane
Old West Saanich Rd
Patricia Bay Hwy
Jennings Lane
Linnet Lane
Elk/Beaver Lake Regional Park
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Date: 13/03/2026 | 2025_Elk_Lake_Oxygenation_Report_Map.aprx
Map Features
Water Quality Sampling Points
Remote Sensor Buoy
Oxygen Diffuser Line
Oxygen Diffuser Perforated Line
EB Lake 1980 Bathymetry (Digitized)
Hypolimnion Boundary
Road
Lake/Reservoir
Regional Park
Elk Lake Oxygenation System 2025 Annual Report
Date: 13/03/2026
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