FINAL REPORT

North Lake 2025 Water Quality Monitoring Program

Prepared for:

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The photograph was taken by Tyler Bender of Aqua Link at North Lake while performing a lake treatment in early September of 2025.

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1. Introduction

The North Lake Improvement Association Inc. (hereinafter referred to as the Association) hired Aqua Link to continue monitoring the water quality of North Lake in 2025. Similarly to last year, the 2025 water quality program was designed to accurately assess the overall degree of lake eutrophication and the lake's trophic state.

North Lake is a moderately deep, somewhat crescent shaped lake, that is located in Sweet Valley, Luzerne County, Pennsylvania (Figure 1.1). North Lake is approximately 38.5 acres in surface area and has a maximum water depth of around 20 feet. Water discharged from North Lake flows into an unnamed tributary that flows into Hunlock Creek. Hunlock Creek flows in a southeast direction and eventually discharges directly into the Susquehanna River.

Lake eutrophication is the natural "aging" of a lake as it slowly fills in overtime with sediments and nutrients, leading to more aquatic plant and algae growth, poorer water clarity, eventually, shallower water. This process can take centuries to thousands of years, but it can be greatly accelerated by human activities where nutrient (phosphorus and nitrogen) and sediment loadings to lakes are dramatically increased. Some examples of increased nutrient and sediment loadings to lakes by man are fertilizer runoff from lawns, golf courses, and agricultural lands; septic systems; wastewater treatment plants; streambank erosion; and soil erosion from agriculture, silviculture, and urban land uses. These increased nutrient and sediment loadings will negatively impact lakes – more algal blooms, reduced water clarity, shallowness, overabundance of aquatic vegetation, and low-oxygen conditions that stress fish and other aquatic life.

The overall degree of lake eutrophication is often described in terms of trophic state. Trophic state in lakes ranges from oligotrophic (nutrient poor and biologically unproductive) to eutrophic (nutrient enriched and highly, biologically productive) lakes. This process can change significantly if nutrient and sediment loadings are increased as a result of land use changes. Increases in trophic state are often associated with decreases in both water quality and clarity. Trophic status or trophic state of a lake are terms used to quantify the overall biological productivity in lakes. Biological productivity includes the amount or biomass of algae, aquatic plants and other forms of aquatic life including fish. Trophic state is directly influenced by the amount of nutrients (namely phosphorus and to a lesser extent nitrogen).

The purpose of the 2025 water quality monitoring program was to evaluate: 1) the overall ecological health (trophic state) of North Lake and 2) the success of the in-lake management program as performed by Aqua Link. Aqua Link also compared the newly acquired 2025 lake data to the 2024. These data comparisons allow Aqua Link to determine whether lake water quality was improving or degrading over time.

In 2025, Aqua Link was also hired to control noxious blue-green algal blooms that frequently occur during the summer recreational season. Aqua Link implemented a hybrid lake treatment program using low dosing rates of copper sulfate (a copper based algaecide) in combination with moderate dosing rates of concentrated bacteria additives – namely MicroLife Clear Max (Hydro Logic Products, Doylestown PA). MicroLife Clear Max was applied evenly over the entire surface of the lake while copper sulfate was applied along the lake perimeter where problematic mats of filamentous algae tend to grow. The advantage of this hybrid program is to use less copper sulfate, which is safer for aquatic life, while naturally improving water quality and clarity using naturally occurring, proprietary strains of *Bacillus* bacteria. MicroLife Clear Max when used regularly helps promote more balanced algal populations in lakes, thereby reducing the dominance by potentially toxic forms of planktonic blue-green algae.

Figure 1.1 North Lake & NL1 Monitoring Station

Lastly, Aqua Link was also hired in 2025 to upgrade the existing lake aeration system. The original aeration system was installed by CleanFlo (West Chester PA) in 2007. Based upon the 2024 lake report (Aqua Link 2025), it was observed by lake residents and Aqua Link that the original low profile air diffusers were promoting lake bed sediment scouring, thereby allowing for the resuspension of lake sediments and attached phosphorus back into the lake water column.

Based upon the above, the Association hired Aqua Link to remove and replace all of the original CleanFlo air diffusers with new Hydro Logic AirPod XL air diffusers. The Hydro Logic AirPod XL units have large elevated bases that will not disturb lake sediments and contain dual EPDM rubber membrane air diffuses that are extremely durable and clog resistant unlike the CleanFlo air diffusers which apparently are made of air stone like materials.

In 2024, Aqua Link began monitoring the water quality of North Lake while it was being managed by CleanFlo. During this study period, the Association hired CleanFlo to maintain the lake aeration system and aggressively treat the lake using their line of proprietary bioaugmentation products. The goal of the CleanFlo bioaugmentation program was to improve water quality and clarity and breakdown organic sediments. CleanFlo told the Association that water quality and clarity improvements would occur by promoting the growth of beneficial algae, namely diatoms, using their products while aerating the lake. Overall, this proposed increased growth of diatoms were to suppress the growth of more problematic and potentially toxic blue-green algae species. Unfortunately, as determined by Aqua Link, the 2024 summer recreational season at North Lake was plagued by noxious blooms of blue-green algae while the growth of diatoms were considered virtually insignificant (Aqua Link 2024).

Historically, prior to 2007, algal blooms in North Lake were primarily controlled by applying large-scale copper sulfate treatments for the entire lake. These whole lake copper sulfate treatments were used to control both the growth of filamentous algae in shallow, lake shoreline areas (littoral zone) and planktonic algae (algal blooms) throughout the remainder of the lake.

Unfortunately, the sole use of copper sulfate to control lake-wide algal blooms can have some rather significant adverse impacts on lakes. Below are a few of these negative impacts along with some noted limitations of just using copper sulfate for algae control (PALMS 2004):

- Use of chemical algaecides to treat large areas of excessive algae growth can rapidly deplete dissolved oxygen concentrations, which may result in fish kills.

- Over time, copper can accumulate in the sediment, which may adversely affect the health of bottom-dwelling organisms that comprise the lower levels of the aquatic food chain.

- Accumulated copper in lake sediments can increase the cost of dredging projects, since dredged sediments containing copper are considered hazardous materials. Hazardous materials are much more expensive and difficult to dispose of.

- Certain species of blue-green algae can build up a tolerance to copper with prolonged use.

Although many reasons exist why copper sulfate should not be used as a primary control method for routine lake treatments, it often can be a valuable tool when integrated with other lake management techniques. First, copper sulfate can be used to address problematic coves or other locations where heavy algae growth occurs - using copper sulfate as a spot treatment. Secondly, low dose copper sulfate treatments combined with bio-augmentation, aeration, and phosphorus inactivation are a very effective means to control problematic algal blooms – especially when the planktonic algae community is dominated by noxious blue-green algae (cyanobacteria). This is especially true for those lake owners or lake associations where the use of non-copper based algaecides are cost prohibitive.

In this report, the water quality monitoring program for this lake assessment is discussed in Section 2. Section 3 provides a primer on lake ecology and watershed dynamics, and the results of your lake assessment are presented in Section 4. Lastly, our conclusions and recommendations to improve and protect the water quality and aesthetics of the lake are discussed in Section 5.

As part of this report, the newly acquired 2025 lake water quality data were compared to the 2024 data in order to assess whether lake water quality has improved or degraded over time. The comparison of newly acquired data to historical data is referred to as "water quality trend analysis". Water quality trend analysis is a very useful tool for lake associations and professional lake managers to make educated, scientifically based decisions on how to best manage their lake. It is also very important in determining the overall success and effectiveness of any implemented lake or watershed best management practices. Water quality trend analysis for North Lake will become increasingly more powerful as more lake data are acquired and analyzed over time.

2. Lake Water Quality Monitoring Program

2.1. Lake Water Quality Monitoring Program

Aqua Link monitored North Lake for water quality on June 10th, July 10th, and August 7th in 2025. On these study dates, Aqua Link visually inspected the overall appearance and ecological condition of the lake. The lake was monitored at Station NL1, which is located in the upper portion of the lake within the deepest section (Figure 1.1). The maximum water depth during the 2025 study period was approximately 6.0 meters (19.8 feet).

On each study date, *in-situ* water quality data were measured and recorded by Aqua Link. *In-situ* water quality data (pH, dissolved oxygen, temperature, conductivity, specific conductance, total dissolved solids, salinity, and oxidation-reduction potential (ORP), chlorophyll-a and phycocyanins) were measured and recorded simultaneously using a YSI ProDSS Sonde and data logger (Yellow Spring Instruments). *In-situ* data were collected at 1.0 meter intervals throughout the water column at Station NL1. Secchi disk transparency was measured and recorded at Station NL1 using a standard 8-inch (20 cm) freshwater Secchi disk.

Water samples were collected at two different depths on each study date. Surface samples were collected 1.0 meter (3.3 feet) below the lake's surface and bottom samples were collected 1.0 meter (3.3 feet) above the lake bottom sediments. All water samples were collected using a Kemmerer water sampler unit. Once collected, all water samples were transferred into bottles, preserved accordingly in the field, and then shipped to the certified contract laboratory for further analysis.

The collected surface water samples were analyzed for alkalinity, hardness, total phosphorus, dissolved reactive phosphorus (namely orthophosphorus), total suspended solids, chlorophyll-a, and phaeophytin. The bottom water samples were analyzed for all of the above parameters except chlorophyll-a and phaeophytin. Lastly, an additional lake water sample was collected at a depth of 1.0 meter for phytoplankton identification and enumeration on each study date. All phytoplankton samples were preserved in the field and subsequently analyzed by an expert in plankton taxonomy.

2.2. Lake Treatments & Field Observations

This is the first year that the Associaton hired Aqua Link to treat the lake to improve water quality and to control algal blooms for the entire summer season. In 2025, Aqua Link implemented a hybrid treatment program using a combination of a copper based algaecide (copper sulfate at low dosing rates) and a concentrated bioaugmentation product - MicroLife Clear Max by Hydro Logic Products. Copper sulfate was only applied along the shallow lake perimeter (littoral zone) to control nuisance stands and floating mats of filamentous algae.

MicroLife Clear Max was applied over the entire lake surface to improve both water quality and water clarity plus reducing the dominance of problematic blue-green algae (cyanobacteria).

Aqua Link performed five full lake treatments using copper sulfate and MicroLife Clear Max, as described above, during the 2025 growing season. Starting in May, the first lake treatment was performed with MicroLife Clear Max and copper sulfate. The following four treatments were performed monthly from June through September. The same dosage rates of both products were used during each treatment.

MicroLife Clear Max (Hydro Logic Products) contains concentrated selected naturally occurring strains of *Bacillus* bacteria, which improve water quality and water clarity plus breakdown organic sediments. Selected strains of *Bacillus* bacteria excrete enzymes that break down organic matter suspended in the water column and lake sediments. In addition, these bacteria are highly effective in consuming soluble nutrients and micronutrients needed by algae. Aqua Link has successfully used this product by itself or in combination with low doses of algaecides on many lakes over the past 20 years. It should be noted that concentrated bacteria products like MicroLife Clear Max work best when applications start in early May and continue every 3 to 4 weeks through September or October. Copper sulfate is a common algaecide widely used in the lake management field for combatting various algae problems, such as planktonic blooms and filamentous algae mats.

In 2025, some sporadic, but sometimes dense, filamentous algae was observed in a few isolated areas in the lake, typically around docks on the lake perimeter. Due to the increased water clarity, other forms of benthic (lake bottom) filamentous algae and submerged plants were able establish due to increased sunlight penetration and become more prolific. Any filamentous algae observed during a lake treatment was subsequently treated with the algaecide, copper sulfate.

Lastly, Aqua Link observed low to moderate quantities of aquatic vegetation in the lake during the study period. In June, Aqua Link observed a few floating sprigs of common waterweed (*Elodea spp*.) and eel grass (*Vallsineria spp*.), which are rooted, submerged aquatic plants. Aqua Link field staff also observed some floating-leaved aquatic plants during the study period: white water lily (*Nymphaea spp.*), spatterdock (*Nuphar spp.*), duckweed (*Lemna spp.*) and watershield (*Brasenia spp.*). None of these aquatic plants were considered problematic throughout the growing season in 2025.

It should be noted that the lake was previously stocked with triploid grass carp years ago to control the growth of aquatic vegetation. Presently, lakeside residents have told us that only a few grass carp have been observed in the lake in the last several years. Therefore, it is assumed that many of the large carp have died and the few remaining fish are no longer a significant method for controlling rooted aquatic plants.

3. Primer on Lake Ecology and Watershed Dynamics

A glossary of lake and watershed terms is provided in Appendix A (U.S. EPA 1980). This glossary is intended to serve as an aid to understanding this section and contains many of the technical terms used throughout the remainder of this report.

The water quality of a lake is often described as a reflection of its surrounding watershed. The term "lake" collectively refers to both reservoirs (man-made impoundments) and natural lake systems. Water from the surrounding watershed enters a lake as streamflow, surface runoff and groundwater. The water quality of these water sources is greatly influenced by the characteristics of the watershed such as, geology, soils, topography and land use. Of these characteristics, changes in land use (e.g., forested, agriculture, silviculture, residential, commercial, industrial) can greatly alter the water quality of lakes.

Nutrients (e.g., phosphorus, nitrogen, carbon, silicon, calcium, potassium, magnesium, sulfur, sodium, chloride, iron) are primarily transported to lakes via streamflow, surface runoff and groundwater while sediments are mainly conveyed as streamflow and surface runoff. As streamflow and surface runoff enter a lake, their overall velocity decreases, which allows transported sediments to settle to the lake bottom. Many of these incoming nutrients may be bound to sediment particles and subsequently will also settle to the lake bottom. Very small sediment particles, such as clays, may resist sedimentation and subsequently pass through the lake without settling.

Once within the lake, water quality is further modified through a complex set of physical, chemical and biological processes. These processes are significantly affected by the lake's morphological characteristics (morphology). Some of the more important morphological characteristics of lakes are size, shape, depth, volume, and bottom composition. In addition, the hydraulic residence time (i.e., the lake's flushing rate) also greatly affects these processes and is directly related to the lake's volume and the annual volume of water flowing into the lake.

With respect to nutrients, phosphorus and nitrogen are generally considered the most important nutrients in freshwater lakes. Phosphorus and, to a lesser degree, nitrogen typically determines the overall amount of aquatic plants present. Aquatic plants adsorb and convert available nutrients into energy, which is then used for additional growth and reproduction. In lakes, aquatic plants are mainly comprised of phytoplankton (free-floating microscopic plants or algae) and macrophytes (higher vascular plants). The most readily available form of phosphorus is dissolved orthophosphate (analytical determined as dissolved reactive phosphorus), while ammonia (NH_3-N) and nitrate (NO_3-N) are the most readily available forms of nitrogen.

The transfer and flow of energy in lakes is ultimately controlled by complex interactions between various groups of aquatic organisms (both plants and animals). The feeding interactions that exist between all aquatic organisms is called the food web. A simplistic diagram of a food chain for a lake is presented as Figure 3.1. As shown in this figure, algae (phytoplankton) and aquatic macrophytes capture energy from the sun and convert this energy into chemical energy through the process known as photosynthesis. During photosynthesis, carbon dioxide, nutrients, water and captured sunlight energy are used to produce organic compounds (chemical energy), which are then used to support further growth and reproduction.

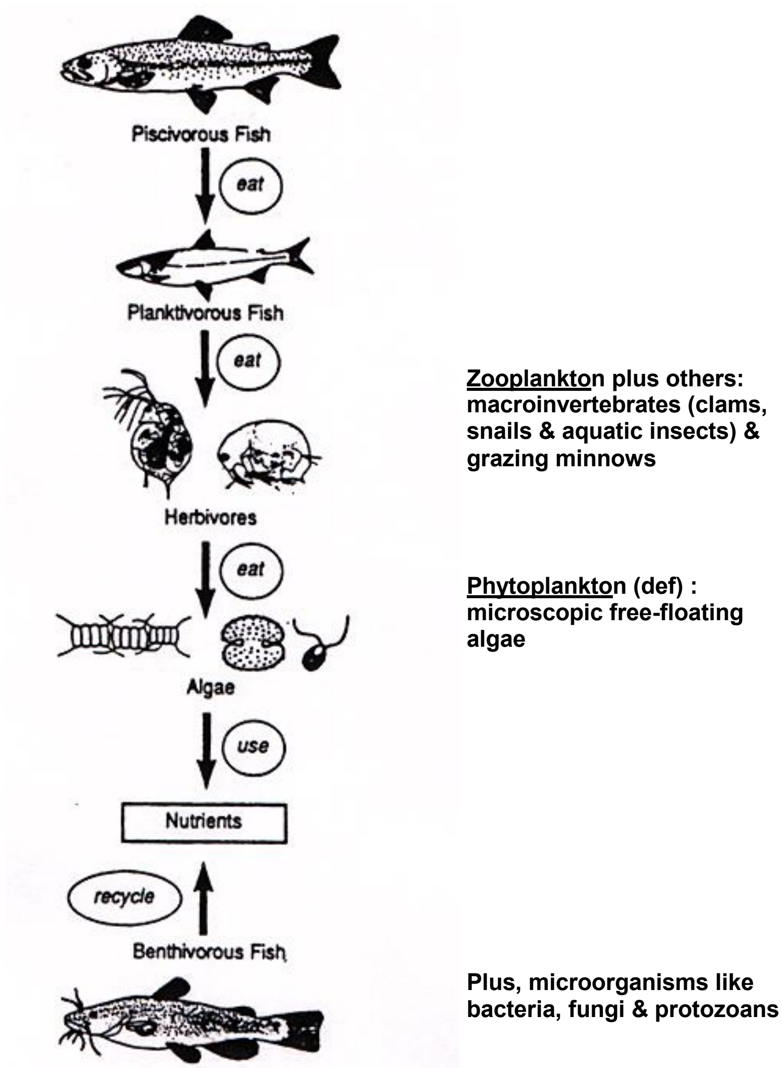

Figure 3.1 Aquatic Food Chain

Energy continues to flow upward through the food chain. Algae are primarily grazed upon by zooplankton. Zooplankton are tiny aquatic animals that are barely visible to the naked eye. Next, zooplankton serve as prey for planktivorous (plankton-eating) fish and larger invertebrates (macroinvertebrates), which then are consumed by larger piscivorous (fish-eating) fish. Overall, these aquatic organisms (zooplankton, macroinvertebrates and fish) derive energy by breaking down organic matter through the process known as respiration. During respiration, organic matter, water and dissolved oxygen are converted into carbon dioxide and nutrients.

At the bottom of the food chain (Figure 3.1), particulate organic waste products (excrement) from aquatic organisms along with dead aquatic organisms settle to the lake bottom and are subsequently feed upon by other organisms. Organisms that live or reside along the lake bottom are referred to as benthivores. After settling to the lake bottom, dead organic materials and organic waste products are now called detritus. Some benthivorous fish (catfish and carp) and microorganisms (bacteria, fungi and protozoans) feed upon detritus. Aquatic organisms that feed upon detritus in lakes are referred to as decomposers. Decomposers obtain energy by breaking down detritus (dead organic matter) via the process of respiration. During decomposition, some of the nutrients are recycled back into lake water and can now once again be used by algae and aquatic plants for growth and reproduction. Any unused detritus will accumulate and eventually become part of the lake sediments, thereby increasing the organic content of these sediments.

Ultimately, the amount of nutrients in lakes controls the overall degree of aquatic productivity (Figure 3.1). Lakes with low levels of nutrients and low levels of aquatic productivity are referred to as oligotrophic. Oligotrophic lakes are typically clear and deep with low quantities of phytoplankton and rooted aquatic plants. In these lakes, the deeper, colder waters are generally well-oxygenated and capable of supporting coldwater fish, such as trout. Conversely, lakes with high nutrient levels and high levels of aquatic productivity are referred to as eutrophic. Eutrophic lakes are generally more turbid and shallower due to the deposition of sediments and the accumulation of detritus. If deep enough, the bottom waters of eutrophic lakes are generally less oxygenated. Eutrophic lakes are often capable of supporting warmwater fish, such as bluegill and bass. Mesotrophic lakes lie somewhere in between oligotrophic and eutrophic lakes. These lakes contain moderate levels of nutrients and moderate levels of aquatic productivity.

In some instances, the flow of energy through the food web may be disrupted. In hyper-eutrophic (highly eutrophic) lakes, aquatic productivity is extremely high and is dominated by very large numbers of a few, undesirable species. The phytoplankton community is typically comprised largely by blue-green algae during the summer months. Many species of blue-green algae are not readily grazed upon the zooplankton community. Under these conditions, the blue-green algae community is allowed to flourish due to the lack of predation, while the zooplankton community collapses. Decreases in zooplankton biomass in a lake may in turn adversely affect the lake's fishery. In addition, shallow lake areas may be completely infested with dense stands of aquatic macrophytes and the fishery may be dominated by rough fish such as the common carp and catfish.

4. Water Quality Data Results

Section 4 provides an in-depth discussion of all data gathered and analyzed as part of the 2025 North Lake water quality monitoring program. The 2025 lake data are presented and discussed extensively in Section 4.1. As mentioned previously, Station NL1 was located in the deepest section of the lake (Figure 1.1). The maximum water depth for Station NL1 was approximately 6.0 meters (19.8 feet).

Chemical water quality data for the surface and bottom waters were monitored at Station NL1. Surface water data represent lake water samples collected at approximately 1.0 meter below the lake's surface (NL1-S) and bottom samples were collected approximately 1.0 meter above the lake bottom sediments (NL1-B). Also, for the remainder of this report, this station will be referred to as the lake name as opposed to the station name since only one station was monitored in this lake.

All *in-situ*, chemical, and phytoplankton data for 2025 are included in Appendix B. The calculated Carlson Trophic State Index (TSI) values for Secchi depth, chlorophyll-a, and total phosphorus for 2025 are also presented in Appendix B. Refer to Section 2 for more information about the study design and data acquisition for this project.

In subsequent years, Aqua Link will continue to enter newly acquired data into the North Lake database and these data will be compared to previously collected lake water quality data. This process is commonly referred to as *water quality trend analysis*, which provides a powerful tool in assessing lake water quality improvements or degradation. For water quality trend analysis, lake water quality data will be presented as graphs and many of these graphs will contain linear trend lines indicating whether water quality is improving or degrading over time.

4.1. Lake Water Quality Data

4.1.1. Temperature and Dissolved Oxygen

In late spring to the beginning of summer, many moderately deep to deep temperate lakes develop stratified layers of water. Under stratified conditions, warmer and colder waters are near the lake's surface (epilimnion) and the lake's bottom (hypolimnion), respectively. As the temperature differences become greater between these two water layers, the resistance to mixing increases. During lake stratification, the epilimnion is usually oxygen-rich due to photosynthesis and direct inputs from the atmosphere, while the hypolimnion may become depleted of oxygen due to the respiration of aquatic organisms. As previously discussed, aquatic organisms (e.g., bacteria, fungi, protozoan, zooplankton, macroinvertebrates, & fish) consume dissolved oxygen in order to metabolize prey or detritus (U.S. EPA 1980, U.S. EPA 1990 and U.S. EPA 1993).

Conversely, shallow temperate lakes may only become weakly stratified during the summer months or some lakes may never stratify at all. The overall degree and duration of stratification in weakly stratified lakes are largely dependent upon local wind conditions and the morphological characteristics of the lake itself. During windy days, surface wave action may be sufficient to partially or completely destratify (mix) a lake. Conversely, a shallow lake may become partially stratified on windless days.

Overall, water temperatures and dissolved oxygen concentrations are very important with regards to a lake's fishery. In general, the optimal water temperature for salmonid fish (i.e., trout) is 55 to 60 ^{o}F (12.8 to 15.6 ^{o}C). Trout may withstand water temperatures above 80 ^{o}F (26.7 ^{o}C) for several hours, but if water temperatures exceed 75 ^{o}F (23.9 ^{o}C) for extended periods, high trout mortality is expected (Pennsylvania State University). Conversely, non-salmonid fish such as golden shiners, bass, and bluegills can grow well even when water temperatures exceed 80 ^{o}F (26.7 ^{o}C). In general, safe minimum dissolved oxygen concentrations for adult salmonid and non-salmonid fish are 5.0 and 3.0 mg/L, respectively. When dissolved oxygen concentrations fall below these concentrations, production impairment of the lake's fishery can be expected.

In addition to impacting the lake's fishery, low dissolved oxygen levels in the bottom waters of a lake will often accelerate the release of nutrients such as soluble orthophosphorus (analytically measured as dissolved reactive phosphorus) and ammonia nitrogen, from anoxic (oxygen depleted) in-lake sediments. In particular, the accelerated release rates of nutrients (referred to as internal loading) can represent a substantial portion of all incoming nutrients to a lake. Increased nutrient loadings via in-lake sediments may further degrade lake water quality by increasing the production of both phytoplankton and aquatic macrophytes (vascular plants).

North Lake

The 2025 water temperature and dissolved oxygen profile data for North Lake are graphically presented in Figures 4.1 and 4.2, respectively. The maximum water depth at Station NL1 was approximately 6.0 meters (19.8 feet). North Lake was thermally destratified during the study period due to the diffused aeration system. As a result, dissolved oxygen levels were relatively consistent from the surface waters (epilimnion) to the deeper lake waters (hypolimnion) on all study dates. Typically, the thermocline, which is the point where the temperature change is the greatest, divides the epilimnion (surface waters) and the hypolimnion (bottom waters). Since the lake was mixed (destratified) by the aeration system, there was no defined thermocline on any of the study dates.

During the June - August study period, the surface and bottom water had adequate dissolved oxygen levels to support a warmwater fishery. Higher dissolved oxygen levels in deeper lake waters reduced release rates of phosphorus from in-lake sediments.

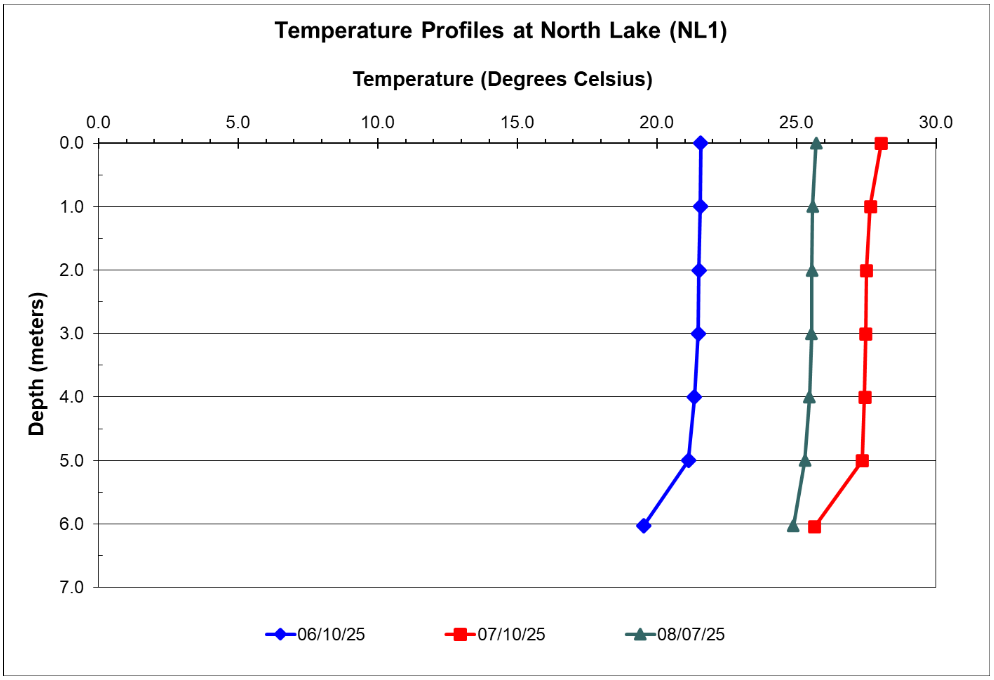

Figure 4.1 Temperature Profiles at North Lake

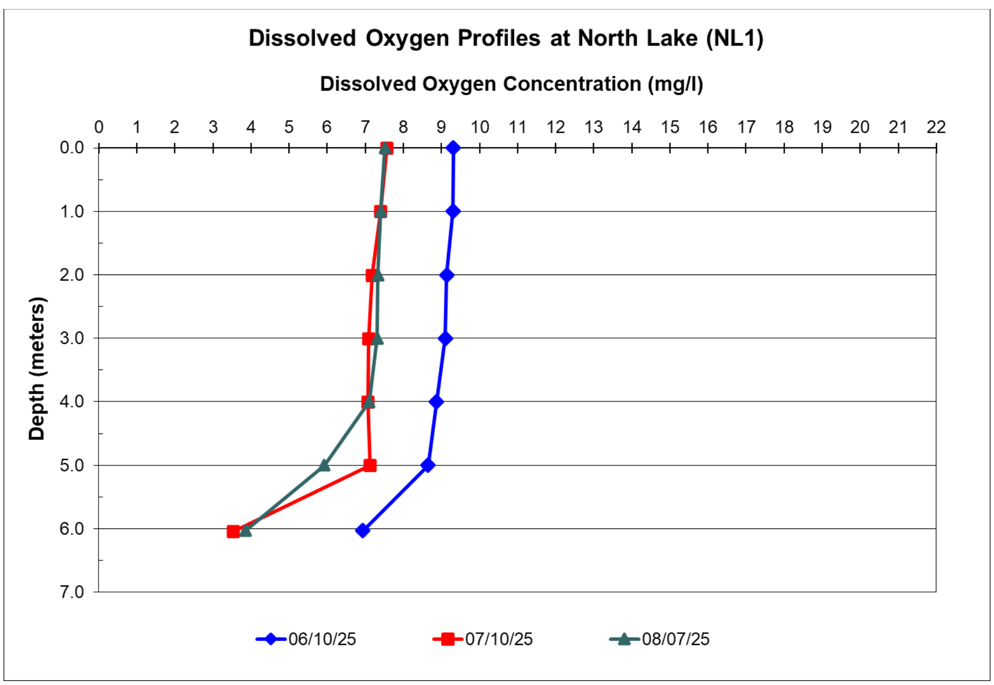

Figure 4.2 Dissolved Oxygen Profiles at North Lake

Based on the above data, North Lake is classified as a moderate depth lake that is best suited as a warmwater fishery. Due to the diffused aeration system, North Lake was thermally destratified during the growing season (May through September) with adequate dissolved oxygen throughout the water column. Even with the aeration system performing well, warmer temperatures throughout the water column during the summer season limit the lake's ability to support a coldwater fishery. Without a diffused aeration system running consistently during the growing season, it is likely that low dissolved oxygen levels in the colder, deeper lake waters would promote the release of nutrients, such as phosphorus, from anoxic in-lake sediments (sediments containing no dissolved oxygen). The lake would also likely be limited by low dissolved oxygen levels in the bottom waters to support aquatic life.

4.1.2. Transparency

The transparency, or clarity, of a lake is most often reported as the Secchi disk depth. This measurement is taken by lowering a circular black-and-white disk, which is 20 cm (8 inches) in diameter, into the water until it is no longer visible. Observed Secchi disk depths range from a few centimeters in very turbid lakes to over 40 meters in the clearest known lakes (Wetzel, 1983). Although somewhat simplistic and subjective, this field monitoring method probably best represents those lake conditions that are most often perceived by lake users and the general public.

Secchi disk transparency is related to the transmission of light in water, and depends on both the absorption and scattering of light. The absorption of light in dark-colored waters reduces light transmission. Light scattering is usually a more important factor than absorption in determining Secchi depths. Scattering can be caused by water discoloration or by the presence of both particulate organic matter (e.g., algal cells) and inorganic materials (e.g., suspended clay particles).

In general, a lake is classified as oligotrophic at values greater than 4.0 meters, mesotrophic between 2.0 and 4.0 meters, eutrophic between 1.0 and 1.9 meters, and hypereutrophic less than 1.0 meter (Nurnberg 2001).

North Lake

The 2025 mean Secchi disk transparency value for North Lake was 2.23 meters (7.3 ft), with values ranging from a low of 2.0 meters in July and August to a high of 2.7 meters during the June study date (Figure 4.3). It should be noted that the 2025 average transparency value was approximately 2.5 times greater than the 2024 average, as can be seen in Figure 4.4. Based upon Nurnberg (2001) and the observed transparency values, the lake would be best classified as highly mesotrophic during the 2025 field season.

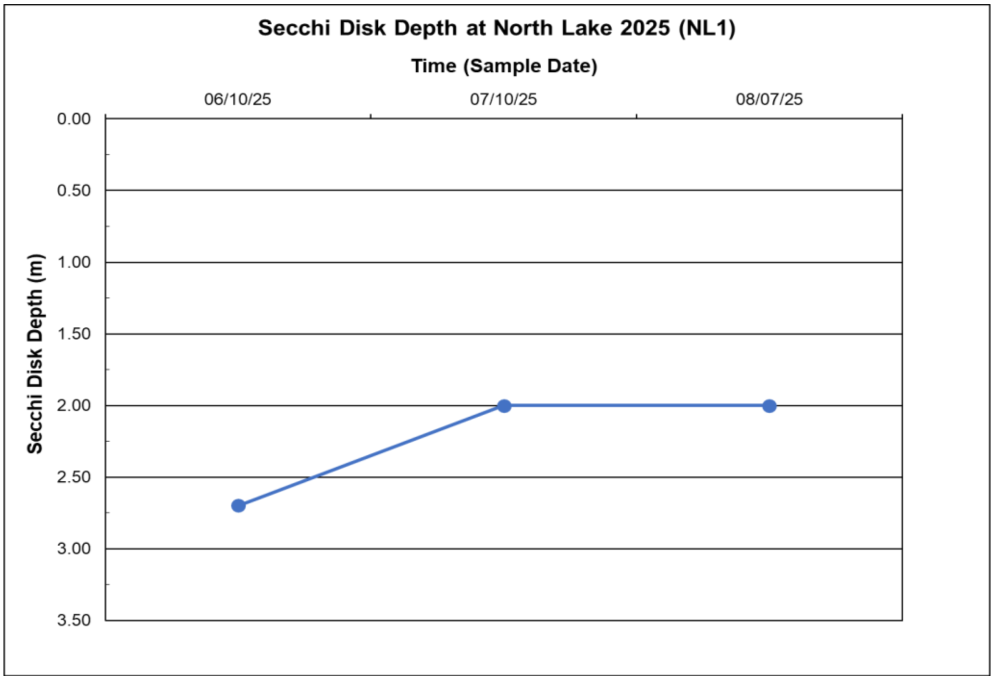

Figure 4.3 Secchi Disk Depths at North Lake

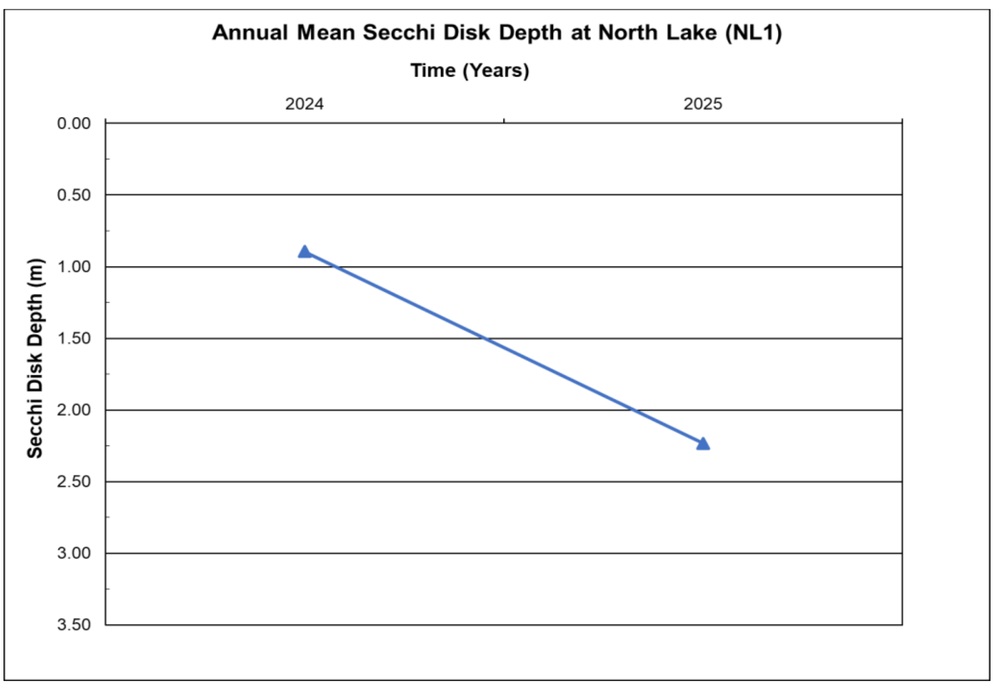

Figure 4.4 Annual Mean Secchi Disk Depth

4.1.3. Nutrient Concentrations

Phosphorus and nitrogen are major nutrients required for the growth of phytoplankton (free floating, microscopic photosynthetic organisms) and macrophytes (aquatic vascular plants) in lakes. Of the two major nutrients, phosphorus is most often the limiting nutrient in freshwater lakes and ponds. The dissolved inorganic nutrients, namely dissolved reactive phosphorus, nitrate, and ammonia nitrogen, are regarded as the forms most readily available to support aquatic plant growth, while the total nutrient amounts provide an indication of the maximum growth potential that could be achieved in lakes. The lake monitoring program for this study included the analysis of lake samples for both total and dissolved inorganic forms of phosphorus only.

4.1.3.1. Phosphorus

Total phosphorus represents the sum of all forms of phosphorus. Total phosphorus includes dissolved and particulate organic phosphates (e.g., algae and other aquatic organisms), inorganic particulate phosphorus as soil particles and other solids, polyphosphates from detergents and dissolved orthophosphates. Soluble (or dissolved) orthophosphate (determined analytically as dissolved reactive phosphorus) is the phosphorus form that is most readily available for algal uptake. Soluble orthophosphate is usually reported as dissolved reactive phosphorus because laboratory analysis takes place under acid conditions and may result in the hydrolysis of some other phosphorus forms. Total phosphorus levels are strongly affected by the daily phosphorus loadings to a lake, while soluble orthophosphate levels are largely affected by algal consumption during the growing season.

Based on criteria established by Nurnberg (2001), a lake is classified as oligotrophic, mesotrophic, eutrophic, and hypereutrophic when surface total phosphorus concentrations are less than 0.010 mg/l as P, 0.010 to 0.030 mg/l as P, 0.031 to 0.100 mg/l as P and greater than 0.100 mg/l as P, respectively.

<u>North Lake</u>

The total phosphorus concentrations for surface and bottom waters on all study dates in 2025 are shown in Figures 4.5 and 4.6, respectively. The mean total phosphorus concentrations for surface and bottom waters were both 0.027 mg/L as P. The same concentrations in both the surface and the bottom waters for each study date indicate the water column is well-mixed as a result of the diffused aeration system.

The mean total phosphorus concentrations for surface and bottom waters in 2024 and 2025 are presented in Figures 4.7 and 4.8. Fortunately, the 2025 annual mean total phosphorus concentrations at 0.27 mg/L were considerably less than the annual mean surface and bottom

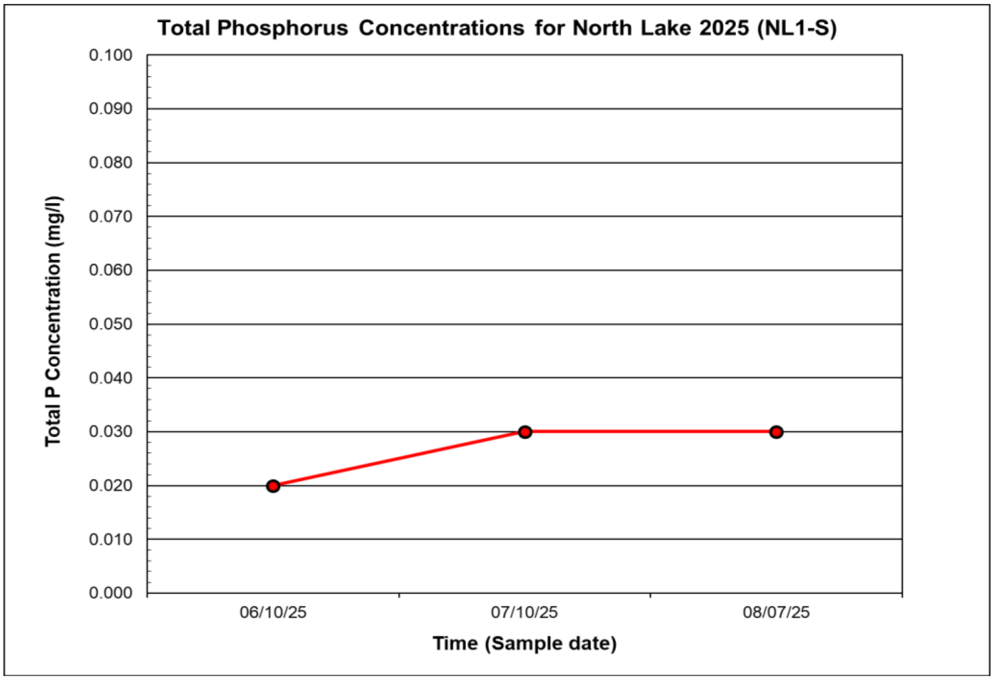

Figure 4.5 Total Phosphorus Concentrations at Surface in North Lake

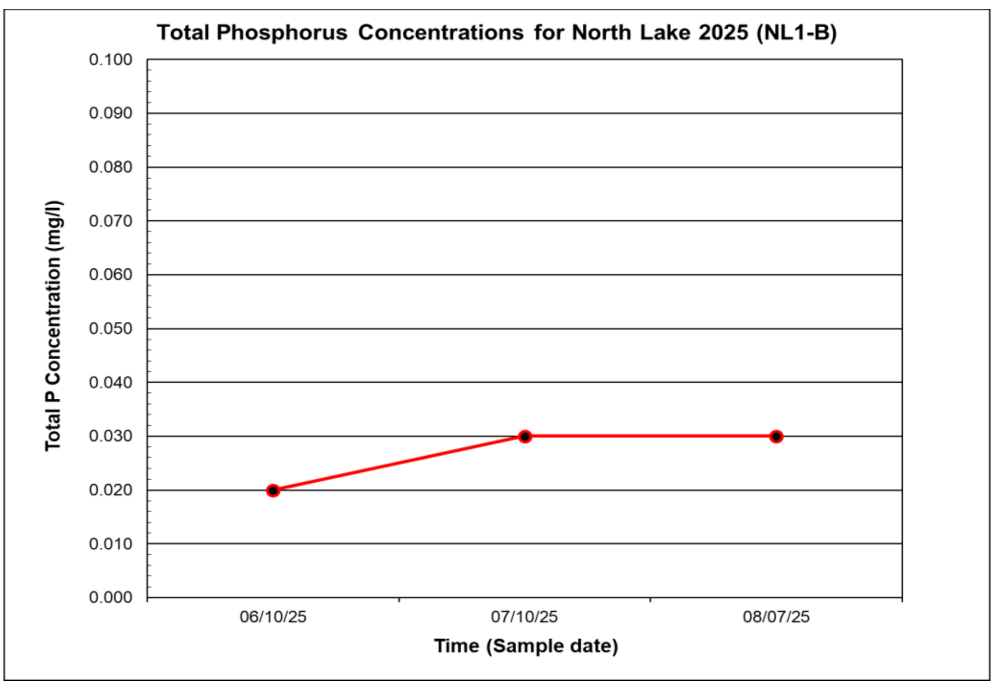

Figure 4.6 Total Phosphorus Concentrations at Bottom in North Lake

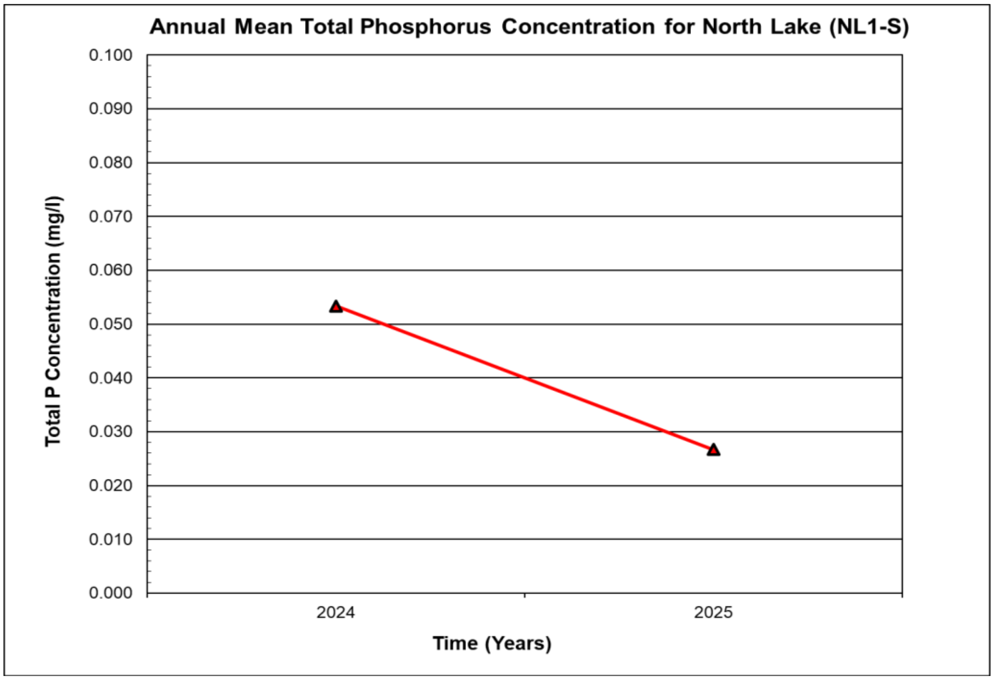

Figure 4.7 Annual Mean Total Phosphorus at Surface in North Lake

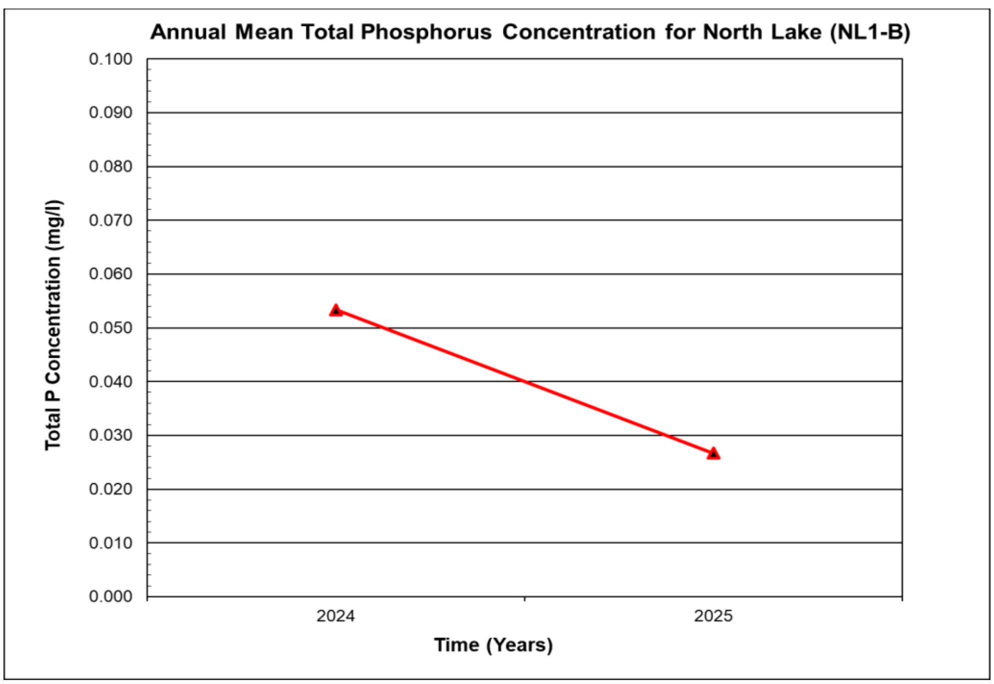

Figure 4.8 Annual Mean Total Phosphorus at Bottom in North Lake

phosphorus concentrations at 0.53 mg/L in 2024. The lower 2025 concentrations will limit how much algal biomass can grow. Based upon the above criteria, the mean total phosphorus concentrations for surface waters suggest that North Lake was classified highly mesotrophic in 2025.

Minor changes in total phosphorus levels are common from season to season, but should be monitored closely every year during the growing season. Increases in total phosphorus concentrations often indicate internal loading of phosphorus and may indicate that the aeration system is not operating properly. When the hypolimnion (bottom waters) become anoxic (void of oxygen), phosphorus is released from the sediment at a higher rate. Continued monitoring in subsequent years will help determine whether these levels are in fact increasing or decreasing.

The dissolved reactive phosphorus concentrations for surface and bottom waters on all study dates in 2025 are shown in Figures 4.9 and 4.10, respectively. In 2025, the mean dissolved reactive phosphorus concentrations for surface waters were 0.002 mg/L and 0.003 mg/L for bottom waters as P. Lower dissolved reactive phosphorus concentrations in the surface waters indicate that this form of phosphorus is rapidly used by phytoplankton as soon as it becomes available. In 2025, annual mean dissolved reactive phosphorus levels increased very slightly by 0.001 mg/L at both the surface and bottom of the lake, when compared to the 2024 data (Figures 4.11 & 4.12). This slight increase of dissolved reactive phosphorus levels in the lake may be due to reduced phytoplankton within North Lake or simply seasonal fluctuation due to environmental changes from year to year.

4.1.4. Plankton and Chlorophyll-a

The quantity of phytoplankton (free floating, microscopic photosynthetic organisms, commonly referred to as algae) and macrophytes (vascular aquatic plants) are primary biological indicators of lake trophic conditions. Small aquatic animals, namely zooplankton and macroinvertebrates, graze upon algae and fragments of aquatic plants. Larger invertebrates and fish then consume the above grazers and to a lesser extent, some aquatic plants.

Information about the plankton community composition and succession is extremely useful when attempting to gain a better understanding about various lake problems. For example, eutrophic lakes often support unbalanced phytoplankton communities characterized by very large numbers of relatively few species. The number of larger zooplankton will tend to decrease during periods when blue-green algae are dominant. Conversely, oligotrophic lakes and acidic lakes often have smaller populations of both phytoplankton and zooplankton, which typically consist of fewer species.

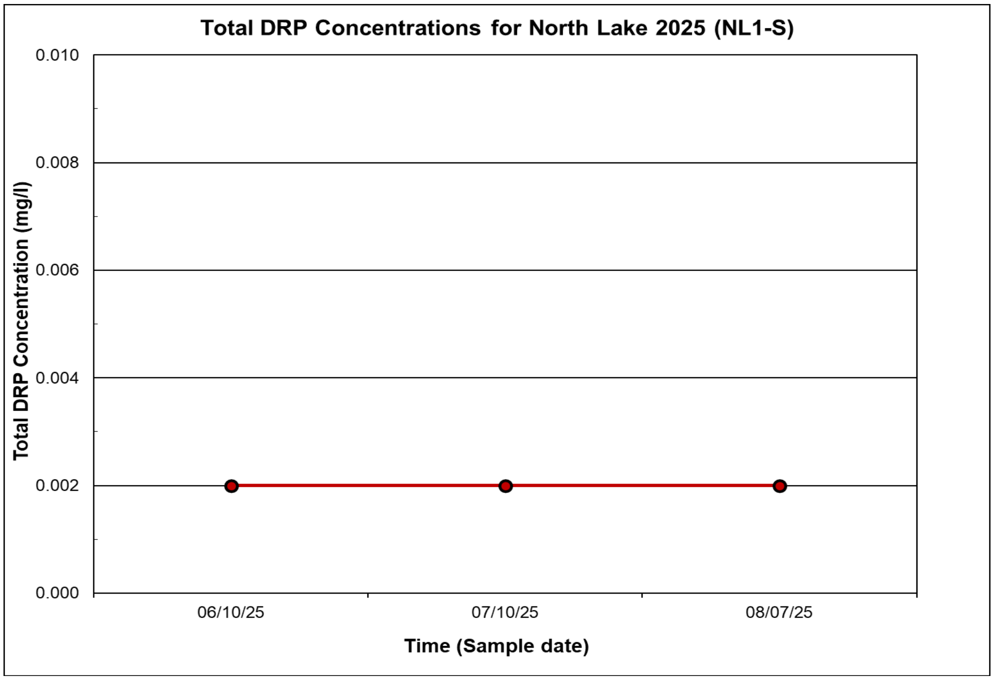

Figure 4.9 DRP Concentrations at Surface in North Lake

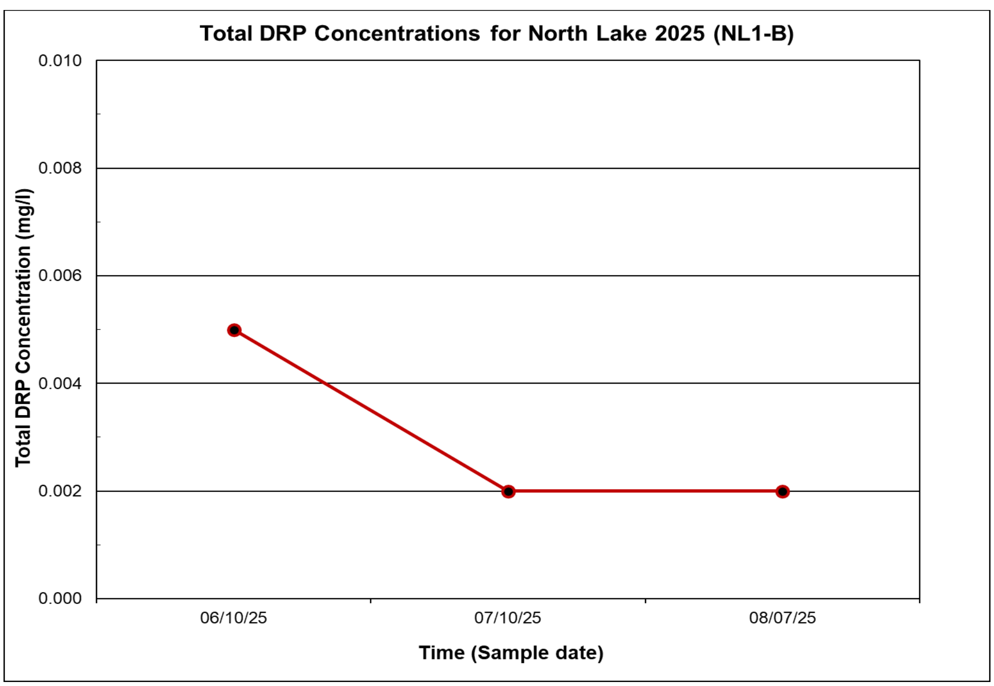

Figure 4.10 DRP Concentrations at Bottom in North Lake

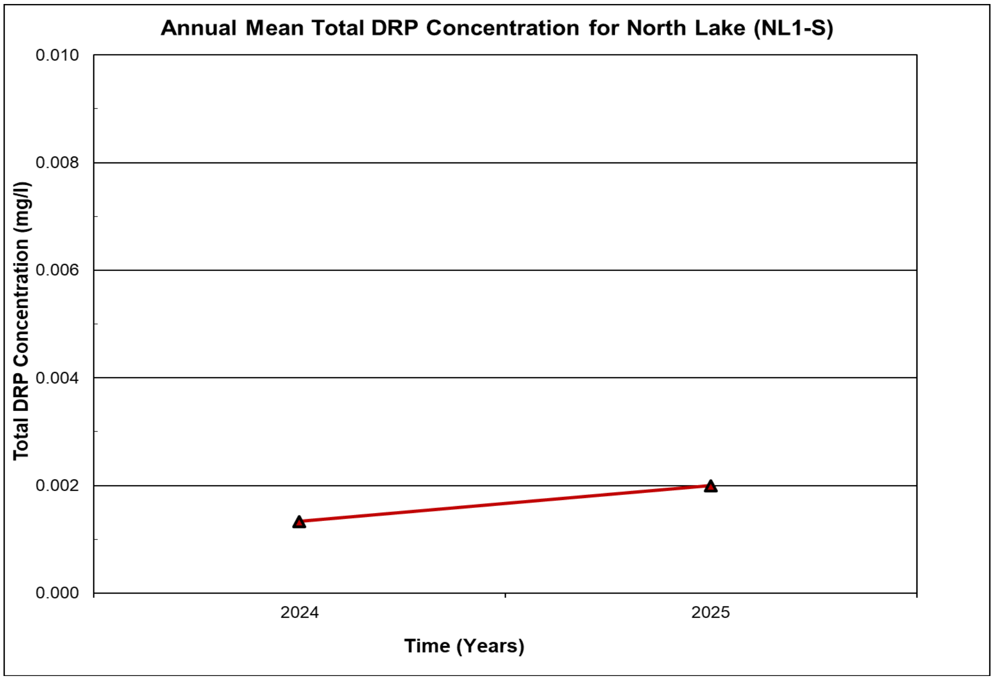

Figure 4.11 Annual Mean DRP at Surface in North Lake

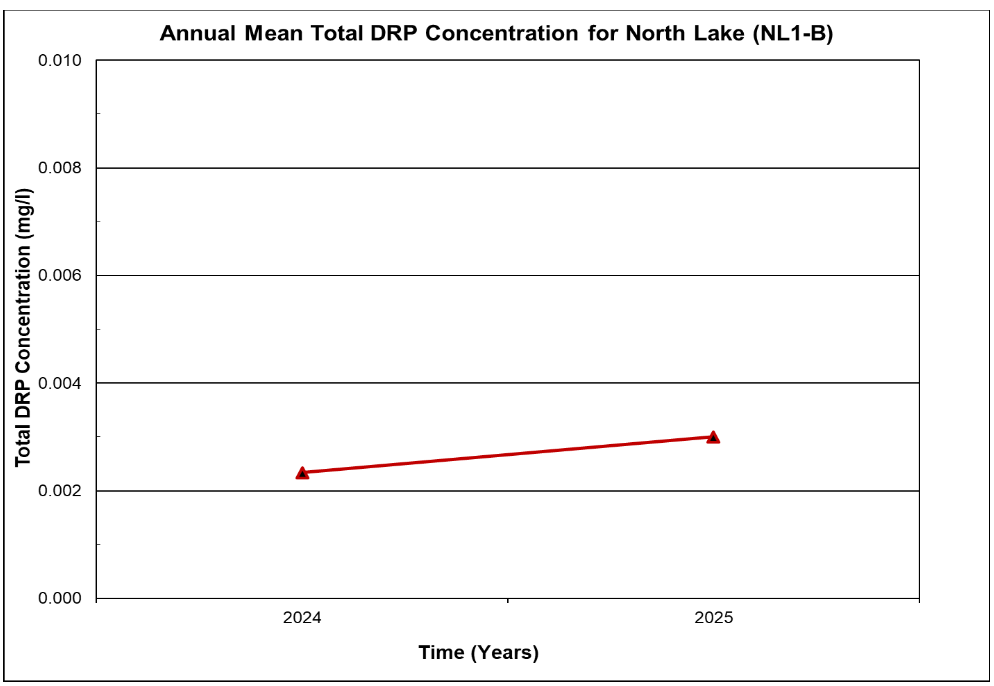

Figure 4.12 Annual Mean DRP at Bottom in North Lake

4.1.4.1. Phytoplankton

Phytoplankton are free floating, microscopic photosynthetic organisms that have little or no resistance to currents and live suspended in open water. Their forms may be unicellular, colonial or filamentous. As photosynthetic organisms (primary producers), phytoplankton form the base of aquatic food chain and are grazed upon by zooplankton and herbivorous fish.

A healthy lake should support a diverse assemblage of phytoplankton, in which many algal species are represented. Excessive growth of a few species is usually undesirable. Such growth can result in dissolved oxygen depletion during the night, when the algae are respiring rather than photosynthesizing. Dissolved oxygen depletion also can occur shortly after a massive "algal bloom" due to increased levels of respiration by bacteria and other microorganisms that are metabolizing dead algal cells. Excessive growth of some species of algae, particularly members of the blue-green group, may cause taste and odor problems, release toxic substances to the water, or give the water an unattractive green soupy or scummy appearance.

Planktonic productivity is commonly expressed in terms of density and biomass. Phytoplankton densities are most frequently expressed as cells per milliliter (cells/ml). Biomass is commonly expressed on a mass per volume basis as micrograms per liter (µg/l). Of the two, biomass provides a better estimate of the actual standing crop of phytoplankton in lake systems.

In general, phytoplankton biomasses below 2,500 ug/l are considered low, ranging from 2,500 to 7,500 ug/l are moderately low to moderately high, ranging from 7,500 to 10,000 ug/l are high, and above 10,000 are considered very high. Biomasses often exceeding 5,000 ug/l are often perceived by many as "algal bloom" conditions.

<u>North Lake</u>

The phytoplankton community in 2025 was represented by genera from seven different taxa: Bacillariophyta (diatoms), Chlorophyta (green algae), Chrysophyta (golden-brown algae), Cryptophyta (cryptomonads), Cyanophyta (blue-green algae), Euglenophyta (euglenoids), and Pyrrhophyta (fire algae) as shown in Figures 4.13 and 4.14. The phytoplankton biomasses in North Lake ranged from a low of 1,399 ug/L (micrograms per liter) in July to a high of 2,861 ug/L in August as shown in Figure 4.13.

In June, total phytoplankton biomass was at a low level and was solely dominated by flagellated classic golden chrysophytes (Chrysophyta). In July, a further decrease in total biomass was observed to a very low level when *Ceratium* (Pyrrhophyta) became dominant, followed by *Aulacoseira* (Bacillariophyta), *Cryptomonas* (Cryptophyta), and *Pseudostaurastrum* (Chrysophyta). An increase in total biomass to a moderately low level occurred in August as

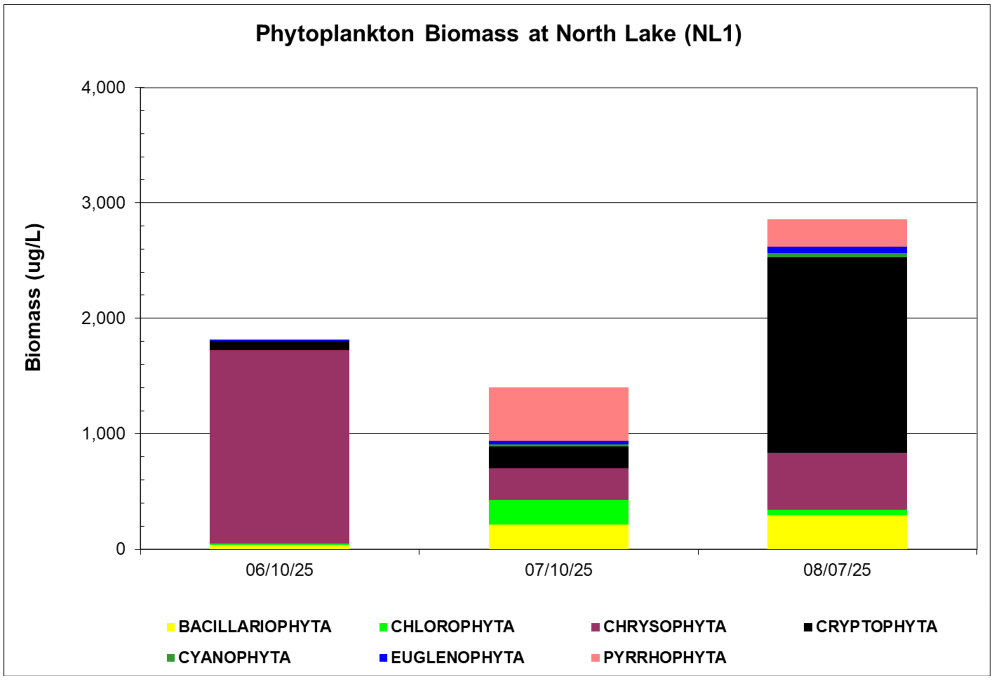

Figure 4.13 Phytoplankton Biomass in North Lake

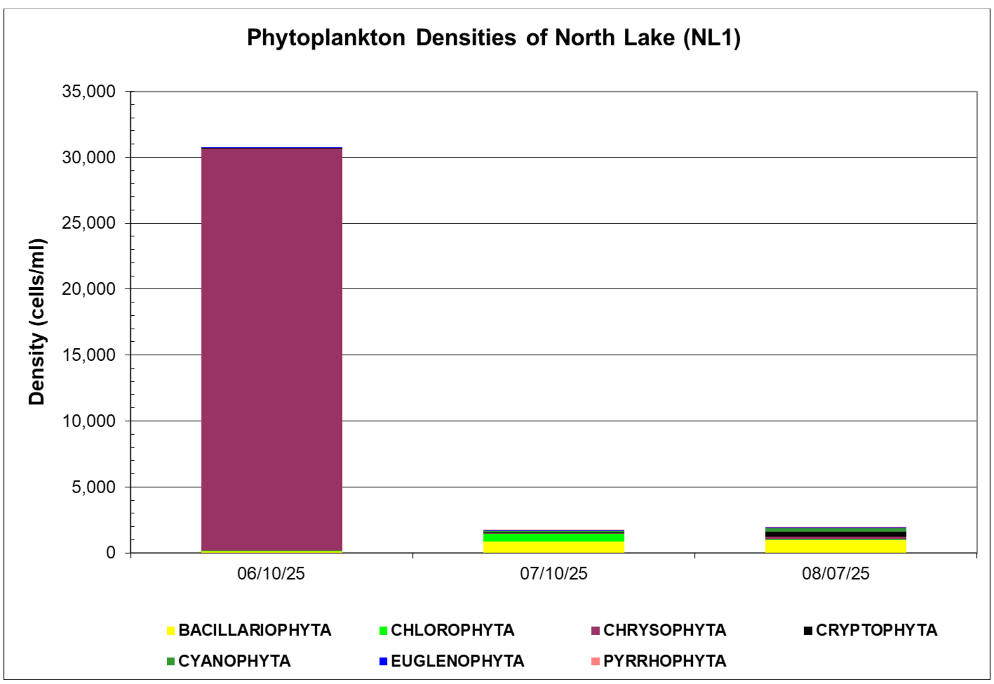

Figure 4.14 Phytoplankton Densities in North Lake

Cryptomonas (Cryptophyta) became highly dominant followed distantly by *Dinobryon* (Chrysophyta), further by *Aulacoseira* and further yet by *Ceratium* (Pyrrhophyta).

The phytoplankton biomass values, broken down by phyla and sampling dates for 2025 at Station NL1, are illustrated in Figure 4.13. During the 2025 study period, the phylum Chrysophyta heavily dominated the month of June with other phytoplankton taxa having minimal biomass. July was the most evenly distributed and diverse of the sampling months, in terms of biomass. Although the phylum Pyrrhophyta was slightly dominant in July, each of the remaining phyla contained similar proportions of biomass, without any taxa being highly dominant. In August, the phylum Cryptophyta consisted of over half of the total phytoplankton biomass collected during that month. Although Cryptophyta were dominant in August, all other phyla were present at healthy levels, creating a more diverse collection of taxa than the month of June. The overall taxa diversity and biomass observed in 2025 indicate a healthy and diverse assemblage.

An additional important note for 2025 is the low Cyanophyta (blue-green algae) biomass collected over the three-month period. No Cyanophyta were detected in June while July and August had minimal biomass. This is a significant improvement over the 2024 season when Cyanophyta dominated the overall phytoplankton assemblage throughout the year. The 2025 phytoplankton data show a much improved and more diverse phytoplankton community with minimal amounts of potentially harmful blue-green algae species. This is important as phytoplankton make up the base of aquatic food chains and a diverse assemblage of phytoplankton helps ensure the health of aquatic ecosystems.

Blue-green algae have the ability to rapidly propagate, dominating all other taxa (i.e. groups) of algae, reducing planktonic diversity, potentially causing many negative effects. Blue-green algae can produce massive blooms that discolor the water, and produce substantial surface scum that can persist for months. Cyanobacteria are also responsible for most HABs (harmful algae blooms), which cause public health concerns through the production of cyanotoxins. HABs can also reduce the recreational value of a waterbody, due to unpleasant appearances and odors. Due to the concerns surrounding blue-green algae, the lake should continue to be monitored closely for its presence.

Phytoplankton densities ranged from a low of 1,742 cells per mL (cells per milliliter) in July to a high of 30,734 cells per mL in June as shown in Figure 4.14. The highest phytoplankton density occurred in June and was solely dominated by flagellated classic golden chrysophytes. The lowest overall phytoplankton density was in July with a sharp decline and was dominated by *Aulacoseira* followed by *Cyclotella*, both from phylum Bacillariophyta, further followed by *Oocystis* and *Eudorina*, both from phylum Chlorophyta. In August, total density increased very slightly from July, with *Aulacoseira* once again remaining the dominant taxa followed distantly by *Cryptomonas* (Cryptophyta) and further yet by *Aphanizomenon* (Cyanophyta). In terms of density, the phylum Chrysophyta was the most dominant during the month of June, while the phylum Bacillariophyta was most dominant in July and August.

Depending on dominant genera, the difference between biomass and density graphs is largely due to the cell size of certain phytoplankton in relation to other phytoplankton. For example, in the case of North Lake in June, the genera within the phylum Chrysophyta happened to be smaller in size, but more numerous, compared to the majority of other phytoplankton. This caused the month of June to look somewhat different between the two graphs. In contrast, the densities during July and August for other taxa are very low, meaning these taxa were generally larger and with higher biomass, but less numerous (Figures 4.13 & 4.14).

When blue-green algae are the dominant taxa of algae, the algal bloom is often referred to as a harmful algal bloom (HAB). This is because many blue-green algae (cyanobacteria) potentially have the capability of producing toxins that can impact both aquatic and terrestrial life. If produced at high enough levels, blue-green algal toxins can affect the liver, the skin, and the nervous system of livestock, pets, and humans. It should be noted that not all blue-green algal blooms produce toxins, but may have the potential to produce toxins. More research is presently occurring to determine when and why blue-green algal blooms produce and release toxins to lake waters.

During the 2025 field season, Cyanophyta also known as cyanobacteria, were significantly reduced from the previous year. Cyanobacteria were not recorded in June and very low levels were recorded in July and August. For this study, in terms of both biomass and density, *Aphanizomenon* was the only taxa of blue-green algae found in North Lake. This genus is commonly found in many other nutrient rich freshwater lakes. *Aphanizomenon* is a filamentous nitrogen fixer and has the potential to produce toxins as well as foul odors.

The annual mean biomass of cyanobacteria (Cyanophyta) compared to the annual mean total biomass of all phytoplankton from 2024 and 2025 is presented in Figure 4.15. This figure shows that the biomass of cyanobacteria in relation to other phytoplankton was extremely low for the 2025 season. Figure 4.15 compares the annual mean of total phytoplankton biomass versus the mean of cyanobacteria biomass over the past two seasons when Aqua Link started monitoring North Lake's water quality in June 2024. The graph shows a sharp decline in overall phytoplankton biomass as well as an even more significant decline in cyanobacteria biomass from 2024 to 2025.

In general, cyanobacteria (blue-green algae) are considered far less palatable for zooplankton when compared to algae from other taxa (groups) like green algae and diatoms. Blue-green algae often occur as long strands or in colonies that are sometimes covered in a mucous layer. Larger size and the presence of mucous further makes blue-green algae even more difficult for zooplankton to graze upon. In turn, zooplankton numbers will often sharply decline in lakes that are dominated by blue-green algae. A decline in zooplankton will inevitably have negative impacts throughout the remainder of the aquatic food web (refer to Section 3.0).

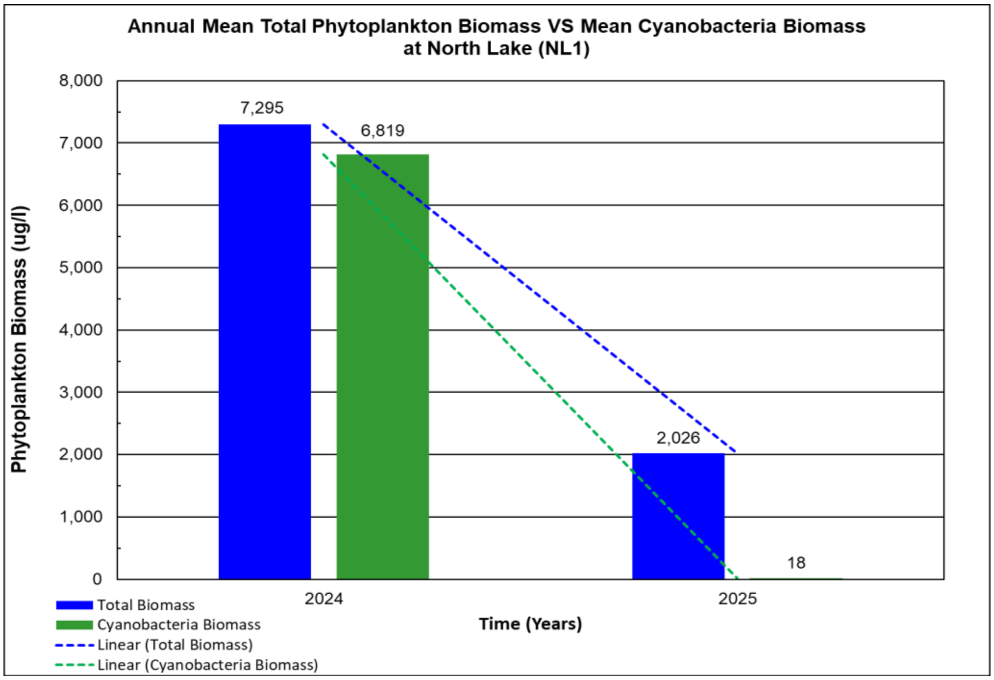

Figure 4.15 Annual Mean Total Phytoplankton Biomass vs Mean Cyanobacteria Biomass

4.1.4.2. Chlorophyll-a

Chlorophyll-a is a pigment that gives all plants their green color. The function of chlorophyll-a is to convert sunlight to chemical energy in the process known as photosynthesis. Because chlorophyll-a constitutes about 1 to 2 percent of the dry weight of planktonic algae, the amount of chlorophyll-a in a water sample is an indicator of phytoplankton biomass. According to Nurnberg (2001), a lake is generally classified oligotrophic, mesotrophic, eutrophic and hypereutrophic when chlorophyll-a concentrations are less than 3.5 ug/l, 3.5 to 9.0 ug/l, 9.1 to 25.0 ug/l, and greater than 25.0 ug/l (micrograms per liter), respectively.

<u>**North Lake**</u>

The 2025 mean chlorophyll-a concentration in North Lake was 6.4 ug/L and concentrations ranged from a low of 1.0 ug/L observed in July to a high of 11.0 ug/L in June during the study period (Figure 4.16). According to the Nurnberg criteria, the mean chlorophyll-a concentration indicates mesotrophic conditions. The highest chlorophyll-a concentration was in June and the lowest was recorded in July. Based upon the 2025 data, the range of chlorophyll-a values for all study dates suggests oligotrophic to slightly eutrophic lake conditions.

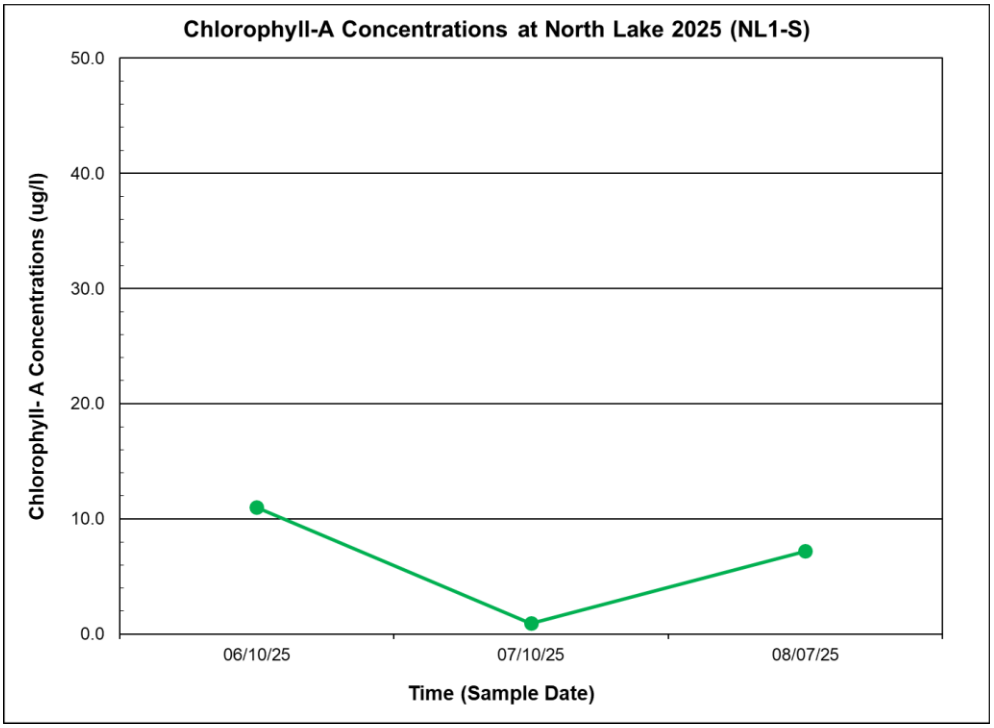

Figure 4.16 Chlorophyll-a Concentrations in North Lake

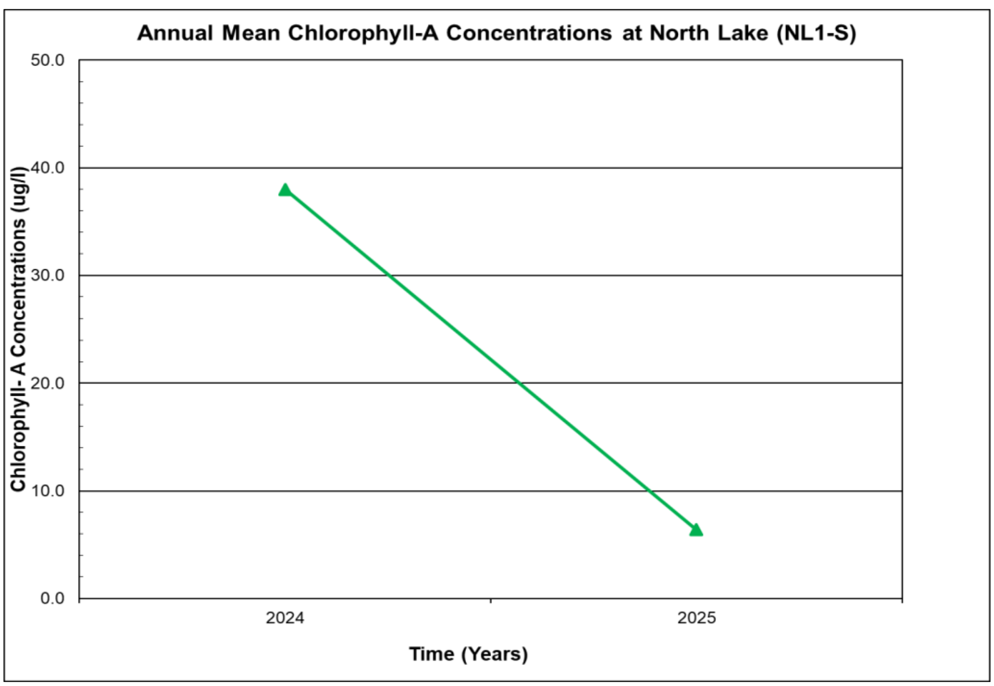

Figure 4.17 Annual Mean Chlorophyll-A Concentrations at North Lake Surface

Figure 4.17 represents the trend of annual mean chlorophyll-a concentrations on North Lake during the past two years. Chlorophyll-a concentrations sharply declined from 2024 to 2025, which can be attributed to a number of factors. Two of these factors likely include modifications to the lake treatment program to incorporate the use of copper sulfate in addition to concentrated bacteria additives throughout the growing season in 2025 as well as improvements to the aeration system when Hydrologic AirLift diffusers were installed in early 2025.

4.1.5. Trophic State Index

The Trophic State Index (TSI) developed by Carlson (1977) is among the most commonly used indicators of lake trophic state. This index is actually composed of three separate indices based on measurements of Secchi disk depths, chlorophyll-a concentrations, and total phosphorus concentrations for many lakes. Total phosphorus was chosen for the index because phosphorus is often the nutrient limiting for phytoplanktonic growth in lakes. Chlorophyll-a is a plant pigment present in all algae and is used to provide an indication of the biomass of phytoplankton and Secchi disk depth is a common measure of lake transparency.

As part of this study, TSI values were determined for Secchi depth, chlorophyll-a, and total phosphorus data for each of the study dates. Secchi disk depths, chlorophyll-a concentrations, and total phosphorus concentrations were logarithmically converted to a trophic state scale ranging from 1 to 100. Increasing values for the Trophic State Index are indicative of increasing lake trophic states.

In general, index values 35 to 40 are indicative of oligotrophic conditions, while index values greater than 50 to 65 are indicative of eutrophic lake conditions. The Pennsylvania Department of Environmental Protection (PA DEP) classifies lakes according to the following: oligotrophic (less than 40), mesotrophic (40 to 50), eutrophic (50 to 65), and hypereutrophic (greater than 65) as noted in its 2002 PA Water Quality Assessment 305(b) Report.

North Lake

The calculated 2025 annual mean TSI values for Secchi depth, chlorophyll-a, and total phosphorus are presented in Table 4.1. In addition, annual mean TSI values for 2024 through 2025 and the individual TSI values for all study dates in the 2025 study period are graphically presented in Figure 4.18 and 4.19, respectively. Figure 4.18 represents the annual mean TSI values comparing results from the past two years. As can be seen in the graph, all three TSI values significantly improved from 2024 to 2025. North Lake went from highly eutrophic levels to a much-improved highly mesotrophic to slightly eutrophic state, which is representative of a healthier lake ecosystem.

The average mean TSI values for Secchi disk transparency and chlorophyll-a concentrations suggest highly mesotrophic conditions and the average mean TSI value for total phosphorus suggest slightly eutrophic conditions. Based on the above, North Lake was best described overall as boarder-line highly mesotrophic to slightly eutrophic in 2025.

Table 4.1 Mean Carlson's TSI Values in North Lake in 2025

Station	Trophic State Index (TSI) Values		
	Secchi Depth	Chl-a	Total P
NL1	48.4	48.8	51.5

Note: Mean TSI values determined by averaging the individual TSI values for each parameter during the 2025 study period.

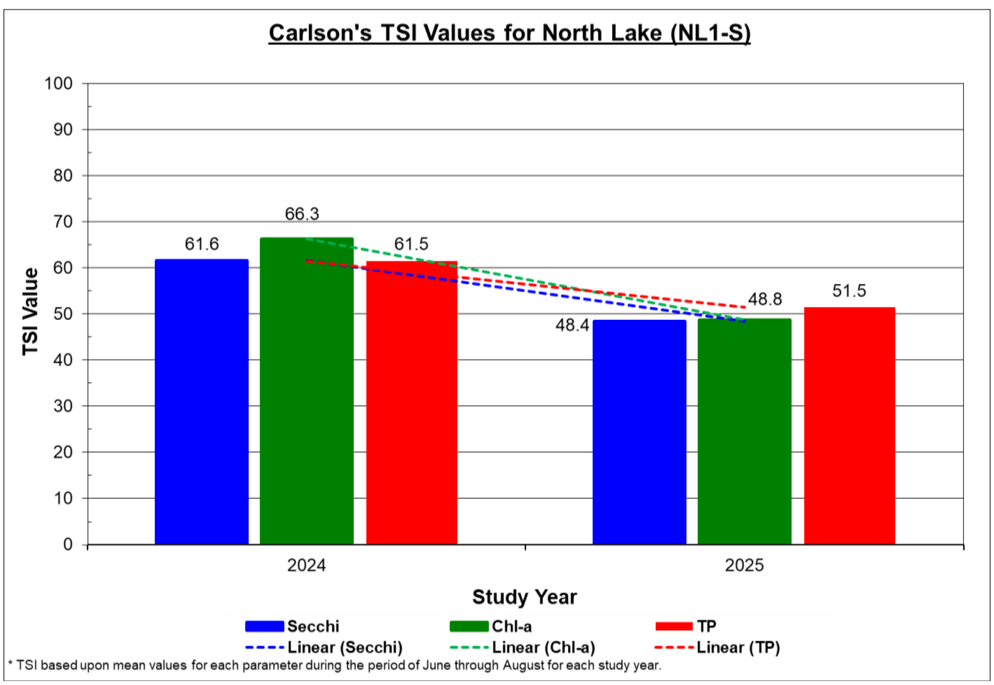

Figure 4.18 Annual Carlson's TSI Values for North Lake Surface

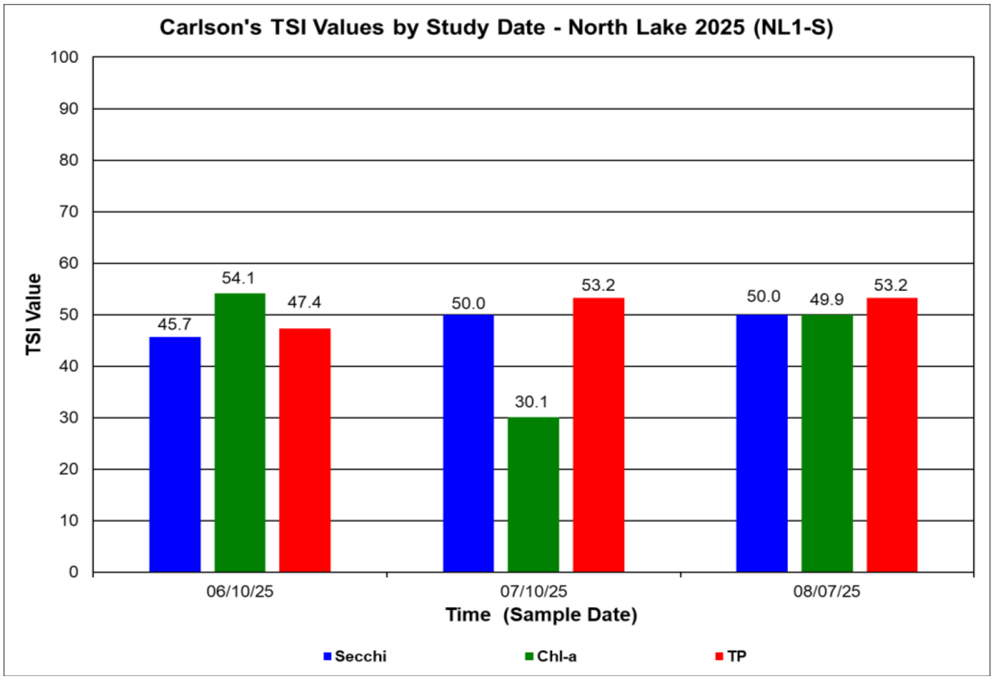

Figure 4.19 Carlson's TSI Values for Each Study Date at North Lake

Individual TSI values are illustrated in Figure 4.19 for all study dates in 2025. Generally, all values were relatively consistent throughout the study period with some exception of a very low chlorophyll-a TSI value in July. This indicates an extraordinarily low phytoplankton level was present at that sampling date, further indicating that the lake treatment program worked exceptionally well in July.

5. Conclusions and Recommendations

In 2025, the water quality and clarity of North Lake was considered healthy and greatly improved since 2024. Overall, water quality data suggests the lake was classified as boarder-line highly mesotrophic to slightly eutrophic from June through August 2025. The mean Carlson TSI values for Secchi disk transparency, chlorophyll-a, and total phosphorus were 48.4, 48.8, and 51.5, respectively. Lakes classified as boarder-line highly mesotrophic to slightly eutrophic typically have moderate to good water clarity, a moderate to moderately high concentration of nutrients, and usually moderate to moderately high biological production of macrophytes and phytoplankton.

North Lake was thermally destratified during the study period due as a result of the installed diffused-air lake aeration system. As a result, dissolved oxygen levels were relatively consistent from the surface waters to the deeper lake waters on all study dates. Since the lake was mixed (destratified) by the aeration system, there was no defined thermocline on any of the study dates.

Based on the above data, North Lake is classified as a moderate depth lake that is best suited as a warmwater fishery. Due to the diffused aeration system, North Lake was thermally destratified during the growing season (May through September) with good concentrations of dissolved oxygen throughout the water column. Even with the aeration system performing well, warmer temperatures throughout the water column during the summer season limit the lake's ability to support a coldwater fishery. Without a diffused aeration system running consistently during the growing season, it is likely that low dissolved oxygen levels in the colder, deeper lake waters would promote the release of nutrients, such as phosphorus, from anoxic in-lake sediments (sediments containing no dissolved oxygen). The lake would also likely be limited by low dissolved oxygen levels in the bottom waters to support aquatic life.

The phytoplankton biomasses in North Lake ranged from a low of 1,399 ug/L (micrograms per liter) in July to a high of 2,861 ug/L in August. In June, total phytoplankton biomass was at a low level and was solely dominated by flagellated classic golden chrysophytes (Chrysophyta). In July, a further decrease in total biomass was observed to a very low level when *Ceratium* (Pyrrhophyta) became dominant, followed by *Aulacoseira* (Bacillariophyta), *Cryptomonas* (Cryptophyta), and *Pseudostaurastrum* (Chrysophyta). An increase in total biomass to a moderately low level occurred in August as *Cryptomonas* (Cryptophyta) became highly dominant followed distantly by *Dinobryon* (Chrysophyta), further by *Aulacoseira* and further yet by *Ceratium* (Pyrrhophyta).

During the 2025 study period, the phylum Chrysophyta heavily dominated the month of June with other phytoplankton taxa having minimal biomass. July was the most evenly distributed and diverse of the sampling months, in terms of biomass. Although the phylum Pyrrhophyta was slightly dominant in July, each of the remaining phyla contained similar proportions of biomass, without any taxa being highly dominant. In August, the phylum Cryptophyta consisted of over half of the total phytoplankton biomass collected during that month. Although Cryptophyta were dominant in August, all other phyla were present at healthy levels, creating a more diverse collection of taxa than the month of June. The overall taxa diversity and biomass observed in 2025 indicate a healthy and diverse assemblage.

An additional important note for 2025 is the low Cyanophyta (blue-green algae) biomass collected over the three-month period. No Cyanophyta were detected in June while July and August had minimal biomass. This is a significant improvement over the 2024 season when Cyanophyta dominated the overall phytoplankton assemblage throughout the year. The 2025 phytoplankton data show a much improved and more diverse phytoplankton community with minimal amounts of potentially harmful blue-green algae species. This is important as phytoplankton make up the base of aquatic food chains and a diverse assemblage of phytoplankton helps ensure the health of aquatic ecosystems.

In 2025, the dramatic decrease of blue-green algae (cyanobacteria) in North Lake is attributed to the combination of an improved aeration system (new Hydro Logic AirPod XL air diffusers) and regularly scheduled lake treatments using a combination of beneficial bacteria (MicroLife Clear Max) and an algaecide (copper sulfate). MicroLife Clear Max was applied as whole lake treatments while copper sulfate was only applied to shallow waters along the lake perimeter. Copper sulfate was applied primarily to control the growth of surface mats of filamentous algae at lake front properties and their docks. This significant decrease in blue-green algae is even more impressive considering that the months of May and June were impacted by heavy amounts of rainfall. Under such conditions, one would expect that external nutrient and sediment loadings to the lake were also higher and this would inevitably impact lake water quality and clarity.

When blue-green algae are the dominant taxa of algae, the algal bloom is often referred to as a harmful algal bloom (HAB). This is because many blue-green algae (cyanobacteria) potentially have the capability of producing toxins that can impact both aquatic and terrestrial life. If produced at high enough levels, blue-green algal toxins can affect the liver, the skin, and the nervous system of livestock, pets, and humans. It should be noted that not all blue-green algal blooms produce toxins but may have the potential to produce toxins. Based upon 2025 phytoplankton biomass data, blue-green algae were not the dominant taxa or group of algae in North Lake, but instead one of the least represented taxa of algae. This is a positive reversal of phytoplankton data when compared to the results of 2024, showing that the phytoplankton assemblage and overall lake health improved significantly in 2025.

Lastly, biomass of aquatic plants or macrophytes ranged from low levels early in the season to moderate levels later in the growing season. Submerged plants were observed more frequently in 2025, with common waterweed and eel grass being among the identified submerged plants. The increase of submerged plants can be attributed to the increase of water clarity in 2025, allowing the plants to further spread and grow due to the increased sunlight penetration. Aqua Link staff also noted various floating leaved aquatic plants including water lily, spatterdock, watershield, and duckweed. No plants were considered problematic during the 2025 season, although the spread of water lily, especially, should be monitored and possibly managed in the future to avoid nuisance levels of the plants.

Based upon the above conclusions of this study, Aqua Link offers the following recommendations to properly manage North Lake:

1. MicroLife Clear Max should continue to be applied as whole lake treatments from May through September. Ideally, these treatments should be applied every three to four weeks during this period. The first treatment should be applied early in order to establish populations of beneficial bacteria before noxious blue-green bacteria (Cyanophyta) populations have an opportunity to become established. MicroLife Clear bacteria additives have shown to dramatically decrease blue-green algae dominance when applied regularly during the growing season (May through September).

2. Algaecide treatments (copper sulfate) should continue to be applied in shallow lake areas to control nuisance stands and surface mats of filamentous algae. These treatments will improve the useability and aesthetics of lakeside properties and their docks. These algaecide treatments likely provided some additional control to planktonic algae in open lake waters (pelagic zone) too.

3. Concentrated bacteria additives (MicroLife Muck Out by Hydro Logic Products) may be purchased and applied directly by lakeside residents to breakdown accumulated organic sediments along their lakeside properties. This product will also help in improving water quality and clarity in these shallow lake areas. MicroLife Muck Out is a time released bio-puck that sinks into the bottom lake sediments. This product can be applied year-round or applied during the growing season from April through October.

4. Baseline water quality data should continue to be collected in 2026. Newly acquired water quality data should be analyzed and compared to those data in the existing 2024 - 2025 database. The overall importance of collecting baseline lake water quality data on an annual basis cannot be over emphasized. Without these data, lake associations become severely limited in their capacity of determining whether lake water quality is actually improving, degrading, or remaining unchanged. In addition, annual baseline data allows lake managers the ability to critically evaluate whether implemented in-lake or watershed restoration techniques are actually improving lake water quality.

5. In-lake best management practices to reduce phosphorus concentrations throughout the lake water column plus to control the release of phosphorus from anoxic in-lake sediments should be evaluated for future implementation. Aquatic products to be evaluated should include the use of alum, PAC (poly- aluminum chloride), Phoslock, and Eutrosorb. The above products can be used with or without lake aeration and the use of algaecides like copper sulfate.

6. A bathymetric (water contour) map of the lake should be developed by Aqua Link. This map should show water depth contours throughout the entire lake basin. Bathymetric maps are very useful tools for both lake managers and lake users. A bathymetric map provides critical information to lake managers such as lake volume, mean (average) water depth, maximum water depth, and aquatic habitats (e.g. shallow spawning areas, nurseries for young and juvenile fish, rock piles, sunken timber, submerged islands, points). This information is necessary to calculate the flushing rates and hydraulic residence times of lakes, which are important when developing nutrient and hydrologic budgets for lakes and phosphorus modeling.

   Lake mapping is very useful and often crucial when evaluating in-lake management practices such as lake water level drawdowns, lake aeration, alum treatments, Phoslock or Eutrosorb treatments, fisheries management including the installation of fish habitat structures, and aquatic plant management strategies including triploid grass carp stockings. These maps are also very useful to lake managers when installing artificial fish habitat structures or reefs for fisheries improvement projects. In addition, these maps can be reproduced and provided to lake users as an aid for fishing and navigation purposes.

7. An aquatic macrophyte (aquatic vascular plant) survey should be performed to identify what species of aquatic plants are present along with their overall abundance. This survey should also accurately delineate the location and relative abundance of any non-native, invasive aquatic plants that are found for later control and/or eradication. Many of these plants tend to be very aggressive and spread quickly by out-competing other native plant species. Controlling the spread of these aquatic plants can be very costly if not detected early.

   Based upon this survey, an aquatic macrophytes map should be developed showing the locations and relative abundances of all major plant species found throughout the entire lake basin. This map should also include the locations where any non-native, invasive aquatic plants were found.

8. A fishery survey should be performed to assess the overall health of the ecosystem, as well as improve the fishery. Fishery surveys provide important data on the current condition of the fishery. These surveys have become increasingly popular among lake associations and other lake owners. Increasing the number of fish in a lake, as well as the quality of game fish for anglers to catch, greatly improves the public's perception of the lake. By continuing to perform fishery surveys, a more accurate management plan can then be implemented to enhance the fishing in North Lake.

   Aside from the game fish, the health of the entire aquatic ecosystem can be monitored through a fishery survey. Invasive species that have the ability to destroy an entire fish population can be discovered in a lake and, in turn, removed from the water body. Also, diseases in the fish population can be exposed, often avoiding mass mortality of thousands of fish. Fishery assessments can be performed during the spring or fall seasons and fishery management strategies can be determined from the findings of the survey.

9. The Associaton should consider all available options to reduce nutrient loadings from nearby on-lot septic systems. At a minimum, this should include working with your local municipality's Sewage Enforcement Officer (SEO) to provide information to association members on how to properly maintain their on-lot septic systems. The SEO can also be useful in identifying any severely malfunctioning on-lot systems that are impacting the lake. On a larger scale, the Association should also investigate the option to install public sewers to transport wastewater from lakeside properties to a centralized wastewater treatment facility.

All of our recommendations, as discussed above, will require a high level of expertise in the field of lake management. Some of our recommendations will also require obtaining state permits prior to implementation. Aqua Link is a nationally recognized consulting firm specializing in pond and lake management and we are fully capable of implementing all of the recommendations offered in this report.

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APPENDIX A

Glossary of Lake & Watershed Management Terms

Glossary

Algae - Mostly aquatic, non-vascular plants that float in the water or attach to larger plants, rocks, and other substrates. Also called phytoplankton, these individuals are usually visible only with a microscope. They are a normal and necessary component of aquatic life, but excessive numbers can make the water appear cloudy and colored.

Alkalinity - The acid-neutralizing capacity of water. It is primarily a function of the carbonate, bicarbonate, and hydroxide content in water. The lower the alkalinity, the less capacity the water has to absorb acids without becoming more acidic.

Ammonia (NH3) - A nitrogen-containing substance which may indicate recently decomposed plant or animal material.

Benthos - The communities of aquatic life which dwell in or on the bottom sediments of a water body.

Chlorophyll - Pigments (mostly green) in plants, including algae, that play an important part in the chemical reactions of photosynthesis. A measurement of chlorophyll-a (one type of chlorophyll) is commonly used as a measure of the algae content of water.

Conductivity (Cond) - A measure of water's capacity to convey an electric current. It is related to the total amount of dissolved charged substances in the water. Therefore, it can be used as a general indicator of the quality of the water and can also suggest presence of unidentified material in the water. It is often used as a surrogate for salinity measurements.

Combined Sewer Overflow (CSO) -Discharges of combined sewage and stormwater into water bodies during very wet or storm weather. These discharges occur to relieve the sewer system as it becomes overloaded with normal sewer flow and increased storm run-off. The term is also used to denote a pipe that discharges those overflows.

Dissolved oxygen (DO) - Oxygen that is dissolved in the water. Certain amounts are necessary for life processes of aquatic animals. The oxygen is supplied by the photosynthesis of plants, including algae, and by aeration. Oxygen is consumed by animals and plants at night, and bacterial decomposition of dead organic matter (plant matter and animal waste).

Effluent - Liquids discharged from sewage treatment plants, septic systems, or industrial sources to surface waters.

Epilimnion - The warmer, well-lit surface waters of a lake that are thermally separated from the colder (hence denser), water at the bottom of the lake when a lake is stratified.

Eutrophication - The acceleration of the loading of nutrients to a lake by natural or human-induced causes. The increased rate of delivery of nutrients results in increased production of algae and consequently, poor water transparency. Human-induced (cultural) eutrophication may be caused by input of treated sewage to a lake, deforestation of a watershed, or the urbanization of a watershed.

Fecal Coliform Bacteria - Bacteria from the intestines of warm-blooded animals. Most of the bacteria are not in themselves harmful, so they are measured or counted as an indicator of the possible presence of harmful bacteria.

Groundwater - Water stored beneath the surface of the earth. The water in the ground is supplied by the seepage of rainwater, snowmelt, and other surface water into the soil. Some groundwater may be found far beneath the earth surface, while other groundwater may be only a few inches from the surface. Groundwater discharges into lowland streams to maintain their baseflow.

Hydrology -The science dealing with the properties, distribution and circulation of water. The term usually refers to the flow of water on or below the land surface before reaching a stream or man-made structure.

Hypolimnion - The dark, cold, bottom waters of a lake that are thermally separated from the warmer (hence less dense) surface waters when a lake is stratified.

Invertebrates - Animals without internal skeletons. Some require magnification to be seen well, while others such as worms, insects, and crayfish are relatively large. Invertebrates living in stream and lake sediments are collected as samples to be identified and counted. In general, more varied invertebrate communities indicate healthier water bodies.

Limiting nutrient - The nutrient that is in lowest supply relative to the demand. The limiting nutrient will be exhausted first by algae which require many nutrients and light to grow. Inputs of the limiting nutrient will result in increased algal production, but as soon as the limiting nutrient is exhausted, growth stops. Phytoplankton growth in lake waters of temperate lowland areas is generally phosphorus limited.

Limnology - Scientific study of inland waters.

Littoral zone - portion of a water body extending from the shoreline lakeward to the greatest depth occupied by rooted plants.

Loading rate - Addition of a substance to a water body; or the rate at which the addition occurs. For example, streams load nutrients to lakes at various rates as in "500 kilograms per year (500 kg/yr)" or "227 pounds per year (227 lb/yr)."

Macrophytes - rooted and floating aquatic plants, larger (macro-) than the phytoplankton.

Mesotrophic - A condition of lakes that is characterized by moderate concentrations of nutrients, algae, and water transparency. A mesotrophic lake is not as rich in nutrients as a eutrophic lake, but richer in nutrients than an oligotrophic lake.

Monomictic - A lake which has one mixing and one stratification event per year. If a lake does not freeze over in the winter, the winter winds will mix the waters of the lake. In summer, the lake resists mixing and becomes stratified because the surface waters are warm (light) and the bottom waters are cold (dense). Deep lakes in the Puget lowlands are monomictic lakes.

Nitrate, nitrite (NO3, NO2) - Two types of nitrogen compounds. These nutrients are forms of nitrogen that algae may use for growth.

Nitrogen - One of the elements essential as a nutrient for growth of organisms.

Non-point source pollution - Pollution that originates from diffuse areas and unidentifiable sources, such as agriculture, the atmosphere, or ground water.

Nutrients - Elements or compounds essential for growth of organisms.

Oligotrophic - A condition of lakes characterized by low concentrations of nutrients and algae and resulting good water transparency. An oligotrophic lake has less nutrients than a mesotrophic or eutrophic lake.

Pathogens -Microorganisms that can cause disease in other organisms or humans, animals, and plants. Pathogens include bacteria, viruses, fungi, or parasites found in sewage, in runoff from farms or city streets, and in water used for swimming. Pathogens can be present in municipal, industrial, and nonpoint source discharges.

Pelagic Zone - Deep, open water area of a lake away from the edge of the littoral zone towards the center of the lake.

pH - Measure of the acidity of water on a scale of 0 to 14, with 7 representing neutral water. A pH less than 7 is considered acidic and above 7 is basic.

Phosphorus - One of the elements essential as a nutrient for the growth of organisms. In western Washington lakes, it is usually the algae nutrient in shortest supply relative to the needs of the algae. Phosphorus occurs naturally in soils, as well as in organic material. Various measures of phosphorus in water samples are made, including total-phosphorus (TP) and the dissolved portion of the phosphorus (orthophosphorus).

Photic zone - The lighted region of a lake where photosynthesis occurs.

Phytoplankton - Floating, mostly microscopic algae (plants) that live in water.

Point-source Polution - An input of pollutants into a water body from discrete sources, such as municipal or industrial outfalls.

Primary Treatment - The first stage of wastewater treatment involving removal of debris and solids by screening and settling.

Pump Station -A structure used to move wastewater uphill, against gravity.

Regulator -A structure that controls the flow of wastewater from two or more input pipes to a single output. Regulators can be used to restrict or halt flow, thus causing wastewater to be stored in the conveyance system until it can be handled by the treatemnt plant.

Salmonids - Salmon, trout, char and whitefish species of fish.

Secchi depth - Measure of transparency of water obtained by lowering a 10 cm black and white disk into water until it is no longer visible.

Secondary Treatment - Following primary treatment, bacteria are used to consume organic wastes. Wastewater is then disinfected and discharged through an outfall.

Separation -A method for controlling combined sewer overflow whereby the combined sewer is separated into both a sanitary sewer and a storm drain, as is the practice in new development.

Sewage -That portion of wastewater that is composed of human and industrial wastes from homes, businesses, and industries.

Standard - A legally established allowable limit for a substance or characteristic in the water, based on criteria. Enforcement actions by the appropriate agencies can be taken against parties who cause violations.

Stratification of lakes - A layering effect produced by the warming of the surface waters in many lakes during summer. Upper waters are progressively warmed by the sun and the deeper waters remain cold. Because of the difference in density (warmer water is lighter), the two layers remain separate from each other: upper waters "float" on deeper waters and wind induced mixing occurs only in the upper waters. Oxygen in the bottom waters may become depleted. In autumn as the upper waters cool, the whole lake mixes again and remains mixed throughout the winter, or until it freezes over.

Stormwater -Water that is generated by rainfall and is often routed into drain systems.

Thermocline - Depth in a stratified lake where the greatest change in temperature occurs. Separates the epilimnion from the hypolimnion

Total suspended solids (TSS) - Particles, both mineral (clay and sand) and organic (algae and small pieces of decomposed plant and animal material), that are suspended in water.

Toxic -Causing death, disease, cancer, genetic mutations, or physical deformations in any organism or its offspring upon exposure, ingestion, inhalation, or assimilation.

Transparency - A measure of the clarity of water in a lake, which is measured by lowering a standard black and white Secchi disk into the water and recording the depth at which it is no longer visible. Transparency of lakes is determined by the color of the water and the amount of material suspended in it. Generally in colorless waters of the Puget lowland, the transparency of the water in summer is determined by the amount of algae present in the water. Suspended silt particles may also have an effect, particularly in wet weather.

Trophic status - Rating of the condition of a lake on the scale of oligotrophic-mesotrophic-eutrophic (see definition of these terms).

Turbidity - Cloudiness of water caused by the suspension of minute particles, usually algae, silt, or clay.

Wastewater -Total flow within the sewage system. In combined systems, it includes sewage and stormwater.

Water Column - Water in a lake between the surface and sediments. Used in vertical measurements used to characterize lake water.

Watershed - The areas that drain to surface water bodies, including lakes, rivers, estuaries, wetlands, streams, and the surrounding landscape.

Water of Statewide Significance - Legal term from the state Shoreline Management act, which recognizes particular bodies of water and sets criteria and standards for their protection.

Zooplankton - Small, free swimming or floating animals in water, many are microscopic.

Source: King County, Washington (http://dnr.metrokc.gov/wlr/waterres/lakes/glossary)

APPENDIX B

Lake Water Quality Data

North Lake **Prepared by Aqua-Link, Inc.**
ALI Project No. 1838-04
Lake Water Quality Data

Parameter:	**Units of Measure:**
pH (pH)	Expressed in Standard Units (s.u.)
Alkalinity (Alk)	Expressed in milligrams per liter as calcium carbonate(mg/l as CaCO3)
Hardness	Expressed in milligrams per liter as calcium carbonate(mg/l as CaCO3)
Conductivity (Cond)	Expressed in micromhos per cm (umhos/cm)
Conductivity (Cond)	Expressed in microsiemens per cm (uS/cm)
Specific Conductance (Sp Cond)	Expressed in micromhos per cm (umhos/cm) @ 25.0 degrees Celsius
Total Phosphorus (TP)	Expressed as milligrams per liter as phosphorus (mg/l as P)
Dissolved Reactive Phosphorus (DRP)	Expressed in milligrams per liter as phosphorus (mg/l as P)
Nitrate (NO3)	Expressed in milligrams per liter as nitrogen (mg/l as N)
Nitrite (NO2)	Expressed in milligrams per liter as nitrogen (mg/l as N)
Ammonia nitrogen (NH3)	Expressed in milligrams per liter as nitrogen (mg/l as N)
Total Kjeldahl Nitrogen (TKN)	Expressed in milligrams per liter as nitrogen (mg/l as N)
Total Suspended Solids (TSS)	Expressed in milligrams per liter (mg/l)
Turbidity	Epresssed in ntu's (nephelometric turbidity units)
Color	Expressed in Pt/Co Units
Oil & Grease	Expressed in milligrams per liter (mg/l)
Iron (Fe) total/dissolved	Expressed in milligrams per liter (mg/l)
Manganese (Mn) total/dissolved	Expressed in milligrams per liter (mg/l)
Dissolved Oxygen (Dissol Oxy)	Expressed in milligrams per liter (mg/l)
Temperature (Temp)	Expressed in degress Celsius (degrees C)
Secchi Disk Depth	Expressed in meters (m)
Chlorophyll-a	Expressed in micrograms per liter (ug/l)
Fecal coliform bacteria (FC)	Expressed as number of organisms per one hundred milliliters (No./100 ml)
Fecal streptococcus bacteria (FS)	Expressed as number of organisms per one hundred milliliters (No./100 ml)
Phytoplankton	Expressed as number of organisms per liter (No.per ml)
Phytoplankton	Expressed as biomass in micrograms per liter (ug/l)
Zooplankton	Expressed as number of organisms per liter (No.per liter)
Zooplankton	Expressed as biomass in micrograms per liter (ug/l)

Note(s):
TIN denotes total inorganic nitrogen and is the sum of nitrite, nitrate, and ammonia nitrogen
TN denotes total nitrogen and is the sum of total Kjeldahl nitrogen and nitrite and nitrate nitrogen
TN:TP denotes the ratio ot total nitrogen and total phosphorus
TIN:DRP denotes the ratio of total inorganic nitrogen and dissolved reactive phosphorus
(b) denotes below detection limit, therefore data reported as the detection limit
(*) indicates calculated value
(**) indicates *in-situ* field data collected on the study date (also refer to *in-situ* data)
(^^) indicates inconsistent values outside of typical ranges

North Lake
ALI Project No. 1838-04
Insitu Water Quality Data
Station No. NL1 (upper-lake)

Prepared by Aqua-Link, Inc.

Date mm/dd/yy	Time hh:mm:ss	Site	Depth m	Temp °C	DO % sat	DO mg/L	Cond us/cm	Sp Cond us/cm	pH s.u.	TDS mg/L	Salinity ppt	ORP mV	Chl-a RFU	PC RFU	Conversions Depth ft	Temp °F	Chg Temp °C
06/10/25	10:29:12	NL1	0.0	21.6	105.6	9.31	76.7	82.1	7.87	53.0	0.04	78.9	2.2	0.3	0.0	70.8	0.0
06/10/25	10:29:33	NL1	1.0	21.6	105.5	9.30	76.4	81.8	7.78	53.0	0.04	81.7	3.2	0.3	3.3	70.8	0.1
06/10/25	10:29:58	NL1	2.0	21.5	103.5	9.14	76.3	81.8	7.62	53.0	0.04	87.8	1.6	0.1	6.6	70.7	0.0
06/10/25	10:30:17	NL1	3.0	21.5	103.1	9.10	76.2	81.7	7.57	53.0	0.04	89.8	1.7	0.3	9.8	70.7	0.1
06/10/25	10:30:38	NL1	4.0	21.3	100.1	8.87	76.2	82.0	7.48	53.0	0.04	93.5	0.3	0.0	13.1	70.4	0.2
06/10/25	10:30:54	NL1	5.0	21.1	97.3	8.65	76.0	82.1	7.39	53.0	0.04	95.8	0.1	0.0	16.4	70.0	1.6
06/10/25	10:31:24	NL1	6.0	19.5	75.7	6.94	75.2	83.9	7.09	55.0	0.04	107.6	0.3	0.0	19.8	67.1	
<<insert>>																	
	Min		0.0	19.5	75.7	6.94	75.2	81.7	7.09	53.0	0.04	78.9	0.1	0.0	0.0	67.1	
	Max		6.0	21.6	105.6	9.31	76.7	83.9	7.87	55.0	0.04	107.6	3.2	0.3	19.8	70.8	
	Max - Min		6.0	2.0	29.9	2.37	1.5	2.2	0.78	2.0	0.00	28.7	3.1	0.3	19.8	3.7	
	Count		7	7	7	7	7	7	7	7	7	7	7	7	7	7	

Date mm/dd/yy	Time hh:mm:ss	Site	Depth m	Temp °C	DO % sat	DO mg/L	Cond us/cm	Sp Cond us/cm	pH s.u.	TDS mg/L	Salinity ppt	ORP mV	Chl-a RFU	PC RFU	Conversions Depth ft	Temp °F	Chg Temp °C
07/10/25	10:30:16	NL1	0.0	28.0	96.6	7.56	88.6	83.8	7.15	54.0	0.04	164.6	1.2	0.0	0.0	82.4	0.4
07/10/25	10:30:37	NL1	1.0	27.6	94.0	7.40	88.0	83.8	7.12	54.0	0.04	164.6	1.4	0.0	3.3	81.7	0.1
07/10/25	10:30:58	NL1	2.0	27.5	91.0	7.18	87.8	83.8	7.07	54.0	0.04	165.2	1.7	0.1	6.6	81.5	0.0
07/10/25	10:31:25	NL1	3.0	27.5	89.7	7.08	87.7	83.7	7.02	54.0	0.04	165.9	1.4	0.0	9.8	81.5	0.0
07/10/25	10:31:45	NL1	4.0	27.4	89.4	7.07	87.6	83.7	6.98	54.0	0.04	167.2	1.3	0.0	13.1	81.4	0.1
07/10/25	10:32:07	NL1	5.0	27.3	90.0	7.12	87.4	83.7	6.78	54.0	0.04	177.6	1.5	0.0	16.4	81.2	1.7
07/10/25	10:32:30	NL1	6.0	25.6	43.3	3.53	94.7	93.5	6.25	61.0	0.04	126.4	1.6	0.2	19.8	78.2	
<<insert>>																	
	Min		0.0	25.6	43.3	3.53	87.4	83.7	6.25	54.0	0.04	126.4	1.2	0.0	0.0	78.2	
	Max		6.0	28.0	96.6	7.56	94.7	93.5	7.15	61.0	0.04	177.6	1.7	0.2	19.8	82.4	
	Max - Min		6.0	2.4	53.3	4.03	7.3	9.8	0.90	7.0	0.00	51.2	0.5	0.2	19.8	4.3	
	Count		7	7	7	7	7	7	7	7	7	7	7	7	7	7	

Date mm/dd/yy	Time hh:mm:ss	Site	Depth m	Temp °C	DO % sat	DO mg/L	Cond us/cm	Sp Cond us/cm	pH s.u.	TDS mg/L	Salinity ppt	ORP mV	Chl-a RFU	PC RFU	Conversions Depth ft	Temp °F	Chg Temp °C
08/07/25	10:09:18	NL1	0.0	25.7	92.2	7.52	84.3	83.2	7.29	54.0	0.04	150.9	2.5	0.2	0.0	78.3	0.1
08/07/25	10:09:39	NL1	1.0	25.6	90.7	7.41	84.1	83.2	7.28	54.0	0.04	151.1	2.5	0.1	3.3	78.0	0.0
08/07/25	10:09:59	NL1	2.0	25.6	89.6	7.33	84.1	83.2	7.26	54.0	0.04	151.9	2.5	0.3	6.6	78.0	0.0
08/07/25	10:10:17	NL1	3.0	25.5	89.3	7.31	84.1	83.2	7.23	54.0	0.04	153.2	2.6	0.1	9.8	78.0	0.1
08/07/25	10:10:53	NL1	4.0	25.5	86.7	7.10	84.0	83.3	7.22	54.0	0.04	153.4	3.6	0.2	13.1	77.8	0.2
08/07/25	10:11:19	NL1	5.0	25.3	72.0	5.92	83.9	83.4	7.09	54.0	0.04	157.6	2.4	0.2	16.4	77.5	0.4
08/07/25	10:11:39	NL1	6.0	24.9	46.5	3.85	86.5	86.7	6.86	56.0	0.04	165.9	2.5	0.2	19.8	76.8	
<<insert>>																	
	Min		0.0	24.9	46.5	3.9	83.9	83.2	6.86	54.0	0.04	150.9	2.4	0.1	0.0	76.8	
	Max		6.0	25.7	92.2	7.5	86.5	86.7	7.29	56.0	0.04	165.9	3.6	0.3	19.8	78.3	
	Max - Min		6.0	0.8	45.7	3.7	2.6	3.5	0.43	2.0	0.00	15.0	1.3	0.2	19.8	1.5	
	Count		7	7	7	7	7	7	7	7	7	7	7	7	7	7	

North Lake **Prepared by Aqua-Link, Inc.**

ALI Project No. 1838-04

Analytical Lake Water Quality Data

Station No. NL1 (upper-lake)

Station	Depth	Date	Sp Cond** (uS/cm)	pH** (std units)	Alk (mg/l as CaCO3)	Hardness (mg/l as CaCO3)	DRP (mg/l as P)		TP (mg/l as P)		Ammonia (mg/l as N)
NL1S	Surface	06/10/25	81.8	7.78	25.0	26.0	0.002		0.020		
		07/10/25	83.8	7.12	30.0	16.0	0.002		0.030		
		08/07/25	83.2	7.28	34.0	20.0	0.002		0.030		
<<insert>>											
		Min	81.8	7.12	25.0	16.0	0.002		0.020		
		Max	83.8	7.78	34.0	26.0	0.002	0	0.030	0	
		Mean	82.9	7.39	29.7	20.7	0.002		0.027		
		Median	83.2	7.28	30.0	20.0	0.002		0.030		
		Stds	1.0	0.34	4.5	5.0	0.000		0.006		
		Std	0.8	0.28	3.7	4.1	0.000		0.005		
		Count	3	3	3	3	3		3		

North Lake
ALI Project No. 1838-04
Analytical Lake Water Quality Data
Station No. NL1 (upper-lake)

Prepared by Aqua-Link, Inc.

Station	Depth	Date	Nitrate (mg/l as N)	Nitrite (mg/l as N)	TKN (mg/l as N)	TIN* (mg/l as N)	TN* (mg/l as N)	TN:TP*	TIN:DRP*	TSS (mg/l)	Chlorophyll-a (ug/l)		Pheophytin-a (ug/l)
NL1S	Surface	06/10/25								2.0	11.0		2.9
		07/10/25								3.0	1.0	b	0.6
		08/07/25								3.0	7.2		9.9
<<insert>>													
		Min								2.0	1.0	b	0.6
		Max								3.0	11.0		9.9
		Mean								2.7	6.4		4.5
		Median								3.0	7.2		2.9
		Stds								0.6	5.1		4.8
		Std								0.5	4.1		4.0
		Count								3	3		3

North Lake **Prepared by Aqua-Link, Inc.**
ALI Project No. 1838-04
Analytical Lake Water Quality Data
Station No. NL1 (upper-lake)

Station	Depth	Date	Sp Cond** (uS/cm)	pH** (std units)	Alk (mg/l as CaCO3)	Hardness (mg/l as CaCO3)	DRP (mg/l as P)	TP (mg/l as P)	Ammonia (mg/l as N)
NL1B	Bottom	06/10/25	82.1	7.39	26.0	24.0	0.005	0.020	
		07/10/25	83.7	6.78	30.0	16.0	0.002	0.030	
		08/07/25	83.4	7.09	34.0	20.0	0.002	0.030	
<<insert>>									
		Min	82.1	6.78	26.0	16.0	0.002	0.020	
		Max	83.7	7.39	34.0	24.0	0.005	0.030	
		Mean	83.1	7.09	30.0	20.0	0.003	0.027	
		Median	83.4	7.09	30.0	20.0	0.002	0.030	
		Stds	0.9	0.31	4.0	4.0	0.002	0.006	
		Std	0.7	0.25	3.3	3.3	0.001	0.005	
		Count	3	3	3	3	3	3	

North Lake
ALI Project No. 1838-04
Analytical Lake Water Quality Data
Station No. NL1 (upper-lake)

Prepared by Aqua-Link, Inc.

Station	Depth	Date	Nitrate (mg/l as N)	Nitrite (mg/l as N)	TKN (mg/l as N)	TIN* (mg/l as N)	TN* (mg/l as N)	TN:TP*	TIN:DRP*	TSS (mg/l)	Chlorophyll-a (ug/l)	Pheophytin-a (ug/l)
NL1B	Bottom	06/10/25								3.0		
		07/10/25								3.0		
		08/07/25								6.0		
<<insert>>												
		Min								3.0		
		Max								6.0		
		Mean								4.0		
		Median								3.0		
		Stds								1.7		
		Std								1.4		
		Count								3		

TN:TP denotes the ratio ot total nitrogen and total phosphorus
TIN:DRP denotes the ratio of total inorganic nitrogen and dissolved reactive phosphorus
(b) denotes below detection limit, therefore data reported as the detection limit
(*) indicates calculated value
(**) indicates *in-situ* field data collected on the study date (also refer to *in-situ* data)
(^^) indicates inconsistent values outside of typical ranges

North Lake
ALI Project No. 1838-04
Lake Water Quality Trend Analysis
Station No. NL1 (upper-lake)

Prepared by Aqua-Link, Inc.

Station	Depth	Date	Sp Cond** (uS/cm)	pH** (std units)	Alkalinity (mg/l as CaCO3)	Hardness (mg/l as CaCO3)	DRP (mg/l as P)	TP (mg/l as P)	Ammonia (mg/l as N)
NL1S	Surface	06/27/24	85.9	7.34			0.001	0.040	
		07/25/24	77.6	7.27			0.001	0.070	
		08/20/24	75.7	7.06			0.002	0.050	
		06/10/25	81.8	7.78	25.0	26.0	0.002	0.020	
		07/10/25	83.8	7.12	30.0	16.0	0.002	0.030	
		08/07/25	83.2	7.28	34.0	20.0	0.002	0.030	
	Mean	**2024**	79.7	7.22			0.001	0.053	
		2025	82.9	7.39	29.7	20.7	0.002	0.027	

North Lake
ALI Project No. 1838-04
Lake Water Quality Trend Analysis
Station No. NL1 (upper-lake)

Prepared by Aqua-Link, Inc.

Station	Depth	Date	Nitrate (mg/l as N)	Nitrite (mg/l as N)	TKN (mg/l as N)	TIN* (mg/l as N)	TN* (mg/l as N)	TN:TP*	TIN:DRP*	TSS (mg/l)	Chlorophyll-a (ug/l)		Pheophytin-a (ug/l)
NL1S	Surface	06/27/24								12.0	25.0		3.3
		07/25/24								12.0	25.0		7.0
		08/20/24								14.0	64.0	b	1.5
		06/10/25								2.0	11.0		2.9
		07/10/25								3.0	1.0	b	0.6
		08/07/25								3.0	7.2		9.9
	Mean	**2024**								12.7	38.0		3.9
		2025								2.7	6.4		4.5

North Lake
ALI Project No. 1838-04
Lake Water Quality Trend Analysis
Station No. NL1 (upper-lake)

Prepared by Aqua-Link, Inc.

Station	Depth	Date	Sp Cond** (uS/cm)	pH** (std units)	Alk (mg/l as CaCO3)	Hardness (mg/l as CaCO3)	DRP (mg/l as P)	TP (mg/l as P)	Ammonia (mg/l as N)
NL1B	Bottom	06/27/24	85.8	7.17			0.002	0.040	
		07/25/24	77.6	7.25			0.002	0.070	
		08/20/24	75.9	6.74			0.003	0.050	
		06/10/25	82.1	7.39	26.0	24.0	0.005	0.020	
		07/10/25	83.7	6.78	30.0	16.0	0.002	0.030	
		08/07/25	83.4	7.09	34.0	20.0	0.002	0.030	
	Mean	**2024**	79.8	7.05			0.002	0.053	
		2025	83.1	7.09	30.0	20.0	0.003	0.027	

North Lake **Prepared by Aqua-Link, Inc.**
ALI Project No. 1838-04
Lake Water Quality Trend Analysis
Station No. NL1 (upper-lake)

Station	Depth	Date	Nitrate (mg/l as N)	Nitrite (mg/l as N)	TKN (mg/l as N)	TIN* (mg/l as N)	TN* (mg/l as N)	TN:TP*	TIN:DRP*	TSS (mg/l)	Chlorophyll-a (ug/l)	Pheophytin-a (ug/l)
NL1B	Bottom	06/27/24								14.0		
		07/25/24								14.0		
		08/20/24								17.0		
		06/10/25								3.0		
		07/10/25								3.0		
		08/07/25								6.0		
	Mean	**2024**								15.0		
		2025								4.0		

Note(s):
TIN denotes total inorganic nitrogen and is the sum of nitrite, nitrate, and ammonia nitrogen
TN denotes total nitrogen and is the sum of total Kjeldahl nitrogen and nitrite and nitrate nitrogen
TN:TP denotes the ratio ot total nitrogen and total phosphorus
TIN:DRP denotes the ratio of total inorganic nitrogen and dissolved reactive phosphorus
(b) denotes below detection limit, therefore data reported as the detection limit
(*) indicates calculated value
(**) indicates *in-situ* field data collected on the study date (also refer to *in-situ* data)
(^^) indicates inconsistent values outside of typical ranges

North Lake **Prepared by Aqua-Link, Inc.**
ALI Project No. 1838-04
Secchi Disk Depth & General Observations
Station No. NL1 (upper-lake)

Station	Date	Secchi Depth (meters)	Secchi Depth (feet)	
NL1	06/10/25	2.70	8.85	Slightly turbid with dark green tint, relatively clear
	07/10/25	2.00	6.56	Slight green/brown tint, relatively clear
	08/07/25	2.00	6.56	Moderately turbid with dull brownish green tint
<<insert>>				
	Min	2.00	6.56	
	Max	2.70	8.85	
	Mean	2.23	7.32	
	Median	2.00	6.56	
	Stds	0.40	1.32	
	Std	0.33	1.08	
	Count	3	3	

North Lake **Prepared by Aqua-Link, Inc.**

ALI Project No. 1838-04

Secchi Disk Transparency Trend Analysis

Station No. NL1 (upper-lake)

Station	Date	Secchi Depth (meters)	Secchi Depth (feet)
NL1	06/27/24	1.07	3.50
NL1	07/25/24	1.07	3.50
NL1	08/20/24	0.55	1.80
NL1	06/10/25	2.70	8.85
NL1	07/10/25	2.00	6.56
NL1	08/07/25	2.00	6.56

Station NL1 Yearly Mean from June through August

NL1	**2024**	**0.89**	**2.93**
NL1	**2025**	**2.23**	**7.32**

North Lake
ALI Project No. 1838-04
Carlson's Trophic State Index
Station No. NL1 (upper-lake)

Prepared by Aqua Link, Inc.

Station	Date	Secchi (meters)	Chl-a* (ug/l)	TP* (mg/l as P)	TSI Values Secchi	TSI Values Chl-a	TSI Values TP	Mean TSI Values Secchi	Mean TSI Values Chl-a	Mean TSI Values TP
NL1	06/10/25	2.70	11.0	0.020	45.7	54.1	47.4	48.4	48.8	51.5
	07/10/25	2.00	1.0	0.030	50.0	30.1	53.2			
	08/07/25	2.00	7.2	0.030	50.0	49.9	53.2			
	Min	2.00	0.95	0.02	45.7	30.1	47.4			
	Max	2.70	11.00	0.03	50.0	54.1	53.2			
	Mean	2.23	6.38	0.03	------	------	------			
	Median	2.00	7.20	0.03	------	------	------			
	Stds	0.40	5.07	0.01	------	------	------			
	Std	0.33	4.14	0.00	------	------	------			
	Count	3	3	3	3	3	3			

* values reported at 1.0 meter

Note(s):

Station	Year	Mean TSI Values Secchi	Mean TSI Values Chl-a	Mean TSI Values TP
NL1	2024	61.6	66.3	61.5
NL1	2025	48.4	48.8	51.5

Plankton Identification & Enumeration

Kenneth Wagener, Ph.D.

Algae – Phytoplankton

Sample Collection

Samples are normally received by mail or courier. If collected by K. Wagner, samples are either grab samples collected about 1 ft below the surface or are composite samples from a flexible tube lowered to a depth equal to twice the Secchi transparency or the depth of the thermocline, whichever is least. Samples are collected in straight sided plastic containers with a volume of 125 to 1000 ml. Sample bottles are filled to the shoulder of the bottle (straight sided part is filled, air space left by not filling the neck). Samples are preserved in either gluteraldehyde (0.3 to 0.5% by volume) or Lugol's solution (1 to 2% by volume), depending upon client preference. With the use of gluteraldehyde, samples should froth slightly when shaken. For Lugol's solution, the sample should have a weak tea color. If algae appear dense, a little more preservative (up to about double) may be warranted. Samples are labeled with waterbody name, station, date and type of preservative.

Sample Processing

Preserved samples are allowed to stand undisturbed for at least 3 days and normally for 1 week. Each sample is viewed for visual signs of algal density (amount of material accumulated on the container bottom or floating at the surface). Unless the sample obviously contains visually large amounts of algae, the supernatant is decanted or siphoned from the middle to concentrate the sample by a factor of 2 to 6, depending upon how easy it is to remove supernatant without disturbing settled particles (this is a function of container geometry). The remaining sample is then vigorously shaken for 1 minute and 50 mL of sample is poured into a 50 mL graduated test tube.

Test tubes are clear cylinders with a height to diameter ratio of 5:1, with a conical bottom containing approximately 5 mL. Tubes are labeled to match the original sample bottles. Samples in the tubes are allowed to stand undisturbed for at least 3 days and normally for 1 week, after which the concentration process described for the original sample is repeated. Final concentrate volume is typically about 10 mL, concentrating the sample in the tube by a factor of approximately 5. Final concentration factors are therefore typically on the order of 10 to 30, although samples with high algal density may not be concentrated at all and samples with very low density may be concentrated by factors up to 100.

Sample Examination

The concentrated sample is shaken vigorously for about 1 minute to homogenize the contents, then 0.1 mL is pipetted into a Palmer-Maloney style counting chamber. This circular chamber has a depth of 0.04 cm and a diameter of 1.75 cm. The slide is allowed to stand for 5-15 minutes. The slide is then scanned at 200X power (20X objective and 10X oculars) under phase contrast optics and a list of all encountered algal taxa is constructed. Viewing at 400X is conducted if necessary to identify taxa. Using a standard microscope slide and a separate sample aliquot, it is also possible to view specimens at 1000X under oil immersion if necessary. Identifications are made from a variety of reference books as needed, relying mainly on Wehr and Sheath 2003. Actual counting (see below) is performed at 400X.

Sample Enumeration

Counts of algal cells are made along complete transects across the slide; these transects are called strips. A strip count involves recording the cells of each taxon (usually genus) encountered along the transect. To avoid overcounting, cells partially visible on the left side are counted, while those partially visible along the right side are ignored. If appropriate to the project, natural units, colonies, filaments, or other cell groupings may be counted, but in all cases an average number of cells per algal grouping is obtained to allow calculation of density as cells/mL. Based on cell measurements, cells of each taxon are recorded as small, medium or large specimens of the corresponding taxon. The size categories are genus-specific; a large specimen of one taxon with typically smaller cells may be smaller than a small specimen of another taxon with typically larger cells. At least two strips are counted, after which results from each strip are compared. If the increase in taxa is more than 10% of the total or the abundance of any two possible dominants (genera comprising more than 20% of the total count) differs by more than 10%, additional strips are counted until the "10% rule" is satisfied.

Calculations

All counts are recorded in a spreadsheet file. A multiplication factor is established as the inverse of the product of the fraction of 1 mL viewed and the sample concentration factor. For example, if one tenth of the slide was viewed, with that slide representing one tenth of a mL, and the sample had been concentrated by a factor of 10, the multiplication factor would be 1/(0.1X0.1X10), or 10. Multiplication factors are typically between 6 and 30. The cell count for each taxon is multiplied by this factor and recorded in a separate portion of the spreadsheet for easy printing, as cells/mL. Cell counts are tallied by genus, ecologically significant groupings within algal divisions (e.g., flagellated greens, filamentous blue-greens), algal division (e.g., blue-greens, greens, diatoms) and as a grand total.

Based on the number of cells of each taxon in each corresponding size category, a biomass estimate is calculated. Each size category for each taxon is assigned a biomass per cell, based on the average cell dimensions for that category and a specific gravity of 1.0. Multiplication of the genus and size specific factor by the number of cells in that taxon and size category yields both a biovolume and biomass estimate. The sum for each genus (three possible size categories) is reported as ug/L. The sum for each ecologically significant grouping, algal division and the grand total are reported as well.

If requested, a conversion to algal standard units (ASU) is also made. The average area (two dimensional) of each cell for each genus and size category is multiplied by the corresponding number of cells and divided by 400 square microns to derive an ASU value for each taxon. The ASUs are summed for each ecologically significant grouping, algal division and as a grand total as well.

The total number of taxa per ecologically significant grouping, algal division and per sample is also reported, simply as a summation of the taxa observed. Shannon-Weiner Diversity (S) is calculated by the appropriate formula based on the number of cells recorded for each taxon and for the biomass of each taxon. Pielou's Evenness (J) is also calculated, based on S divided by the maximum possible S value for the number of taxa observed, yielding a value between 0 and 1. Additional indices can be calculated as warranted.

Quality Control

Approximately one sample in every ten is subjected to re-analysis. Samples for QC checks are chosen randomly from samples available at the time of analysis. Differences of 10-20% are typical for phytoplankton samples counted by the same analyst and considered acceptable for use in evaluating aquatic conditions.

Algae – Periphyton

Sample Collection

Samples are normally received by mail or courier. If collected by K. Wagner, samples are collected by scraping a defined area of natural or artificial substrate. Enough distilled water is added to create a mixture of appropriate density for microscopic analysis of an aliquot of well-mixed sample. Samples are preserved in either gluteraldehyde or Lugol's solution, depending upon client preference, but as algal density is likely to be high, double the amount of preservative used for phytoplankton samples (1% gluteraldehyde, 2-4% Lugols). Container shape is not critical, but small size (125-250 ml) plastic bottles are preferred, as periphyton samples tend to be very concentrated to begin with. Samples are labeled with waterbody name, station, date and type of preservative, plus the area that was sampled in square centimeters.

Sample Processing, Examination and Enumeration

Samples should not require any concentration, but may be diluted by addition of distilled water. If necessary, concentration by settling is performed as described for phytoplankton analysis above. Examination and enumeration follow the phytoplankton analysis protocols above.

Calculations

All counts are recorded in a spreadsheet file. A multiplication factor is established in the same manner as for phytoplankton, except that the factor for converting cell count to cells/mL is then multiplied by the number of mL of sample and divided by the square centimeters of substrate sampled to yield a measure of cells/cm^2. All other calculations follow the phytoplankton analysis procedures.

Zooplankton

Sample Collection

Samples are normally received by mail or courier. If collected by K. Wagner, samples are concentrates obtained by towing a plankton net with a 53 um mesh size through at least 30 m of water (multiple shorter tows as needed). The net is typically retrieved at an oblique angle after allowing it to settle to within 1 m of the bottom of the lake. Care is taken to avoid tows long enough to cause net clogging. Samples are preserved in either formalin (2%) or gluteraldehyde (2%) or Lugol's solution (strong tea color, usually about 4%), depending upon client preference. Container shape is not critical, but small size (125-250 ml) plastic bottles are preferred, as zooplankton tow samples tend to be very concentrated to begin with. Samples are labeled with waterbody name, station, date and type of preservative, plus the length of the tow and the diameter of the net used.

Sample Processing

Samples are allowed to stand undisturbed for at least 10 minutes and normally for several hours. Each sample is viewed for visual signs of zooplankton density (amount of apparent zooplankton and other particles accumulated on the container bottom). The supernatant is decanted or siphoned until the concentrated sample will fit into a 50 mL graduated test tube. This may require multiple episodes of settling and transfer, depending upon container geometry and the quantity of algae present, to get a zooplankton sample that can be properly viewed at an appropriate concentration. Where considerable algae are present, siphoning is timed to remove as much algae as possible without losing zooplankton; zooplankton settle faster than most algae. Multiple refills with distilled water, with repeat of the settling/siphoning process, are used to clear the sample of algae to the extent necessary to facilitate unobstructed viewing of zooplankton.

Test tubes are clear cylinders with a height to diameter ratio of 5:1, with a conical bottom containing approximately 5 mL. Tubes are labeled to match the original sample bottles. Final concentrate volume is typically 20 to 50 mL, representing 500 to 1000 L of filtered lake water, depending upon net diameter. Final concentration factors are therefore typically on the order of 20,000 to 30,000.

Sample Examination

The concentrated sample is shaken vigorously for about 30 seconds to homogenize the contents, then 1 mL is pipetted into a Sedgewick-Rafter style counting chamber. This rectangular chamber has a depth of 0.1 cm, a length of 5 cm and a width of 2 cm. The slide is then scanned at 40X power (4X objective and 10X oculars) under brightfield optics and a list of all encountered zooplankton taxa is constructed. Viewing at 100X or higher power is conducted as necessary to identify taxa. Identifications are made from a variety of reference books as needed.

Sample Enumeration

Counts of zooplankton individuals are made along complete transects across the slide; these transects are called strips. A strip count involves recording the individuals of each taxon (usually genus) encountered along the transect. To avoid overcounting, individuals partially visible on the top side are counted, while those partially visible along the bottom side are ignored. Based on body length measurements, individuals of each taxon are recorded as small, medium or large specimens of the corresponding taxon. The size categories are genus-specific; a large specimen of a small-bodied taxon may be smaller than a small specimen of a large-bodied taxon. At least two strips are counted, after which results from each strip are compared. If the increase in taxa is more than 10% of the total or the ratio of any two possible dominants (genera comprising more than 20% of the total count) is greater than 10%, additional strips are counted until the "10% rule" is satisfied. The slide is refilled with fresh sample if more than 3 strips are needed.

Calculations

All counts are recorded in a spreadsheet file as individuals/L. A multiplication factor is established by dividing the sample volume in mL by the product of the fraction of 1 mL viewed and the number of liters of water filtered. For example, if half of the slide was viewed, with that slide representing 40 mL of concentrated sample, and the concentrated sample represented 800 liters, the multiplication factor would be 40/(0.5X800), or 0.1. The specimen count for each taxon is multiplied by this factor and recorded in a separate portion of the spreadsheet for easy printing, as individuals/L. Counts are tallied by genus and zooplankton group (e.g., rotifers, copepods, cladocerans, etc.), and as a grand total.

Based on the number of individuals of each taxon in each corresponding size category, a biomass estimate is calculated. Each size category for each taxon is assigned a biomass per individual, based on the average body length for that category and standard regressions for body weight as a function of length. Multiplication of the genus and size specific factor by the number of individuals in that taxon and size category yields a biomass estimate. The sum for each genus (three possible size categories) is reported as ug/L. The sum for each zooplankton group and the grand total are reported as well.

The total number of taxa per zooplankton group and per sample is also reported, simply as a summation of the taxa observed. Shannon-Weiner Diversity (S) is calculated by the appropriate formula based on the number of individuals recorded for each taxon. Pielou’s Evenness (J) is also calculated, based on S divided by the maximum possible S value for the number of taxa observed, yielding a value between 0 and 1.

A size distribution is also generated, based on the observed body lengths. Average body length for all zooplankton is reported in mm, as well as the average body length for crustacean zooplankton (primarily copepods and cladocerans).

Quality Control

Approximately one sample in every ten is subjected to re-analysis. Samples for QC checks are chosen randomly from samples available at the time of analysis. Differences of 10-20% are typical for zooplankton samples counted by the same analyst and considered acceptable for use in evaluating aquatic conditions.

North Lake **Prepared by Aqua Link, Inc.**
ALI Project No. 1838-04

PHYTOPLANKTON DENSITY (CELLS/ML)

*** = potentially toxic**
**** = likely toxic**
 # = taste and odor producer

TAXON	**North 06/10/25**	**North 07/10/25**	**North 08/07/25**
BACILLARIOPHYTA			
Centric Diatoms			
Aulacoseira #	127.0	633.6	986.4
Cyclotella/related taxa #	0.0	237.6	0.0
Araphid Pennate Diatoms			
Asterionella #	0.0	0.0	0.0
Colonial Fragilaria/related taxa #	0.0	0.0	0.0
Single Fragilaria/Synedra	0.0	0.0	0.0
Tabellaria #	0.0	0.0	0.0
Monoraphid Pennate Diatoms			
Biraphid Pennate Diatoms			
Navicula/related taxa	0.0	0.0	0.0
Nitzschia #	0.0	0.0	0.0
CHLOROPHYTA			
Flagellated Chlorophytes			
Eudorina	0.0	184.8	0.0
Coccoid/Colonial Chlorophytes			
Actinastrum	0.0	0.0	0.0
Ankistrodesmus	0.0	0.0	0.0
Coelastrum	0.0	0.0	0.0
Crucigenia	0.0	0.0	0.0
Dictyosphaerium #	0.0	0.0	0.0
Elakatothrix	0.0	0.0	0.0
Kirchneriella	0.0	52.8	0.0
Monoraphidium	0.0	0.0	0.0
Oocystis	0.0	211.2	0.0
Paulschulzia	0.0	0.0	0.0
Pediastrum #	0.0	0.0	0.0
Quadrigula	0.0	0.0	0.0
Scenedesmus #	0.0	52.8	0.0
Schroederia/Ankyra	0.0	0.0	0.0
Sphaerocystis	0.0	0.0	0.0
Tetraedron	0.0	0.0	0.0
Filamentous Chlorophytes			
Ulothrix	0.0	0.0	0.0
Desmids			
Closterium #	0.0	0.0	0.0
Cosmarium #	0.0	39.6	41.1
Euastrum	0.0	0.0	0.0
Mougeotia/Debarya	0.0	0.0	0.0
Octacanthium	0.0	0.0	0.0
Spirogyra #	0.0	0.0	0.0
Staurastrum #	12.7	13.2	13.7
Staurodesmus	0.0	0.0	0.0

PHYTOPLANKTON DENSITY (CELLS/ML)

*** = potentially toxic**
**** = likely toxic**
 # = taste and odor producer

CHRYSOPHYTA			
Flagellated Classic Chrysophytes			
Dinobryon #	50.8	39.6	164.4
Mallomonas #	0.0	0.0	0.0
Synura #	0.0	0.0	0.0
Other Flagellated Goldens	30480.0	0.0	0.0
Non-Motile Classic Chrysophytes			
Haptophytes			
Tribophytes/Eustigmatophytes			
Centritractus	0.0	0.0	0.0
Pseudostaurastrum	0.0	13.2	0.0
Raphidophytes			
CRYPTOPHYTA			
Cryptomonas #	50.8	66.0	411.0
CYANOPHYTA			
Unicellular and Colonial Forms			
*Aphanocapsa * #*	0.0	0.0	0.0
Chroococcus	0.0	0.0	0.0
Dactylococcopsis	0.0	0.0	0.0
*Microcystis ** #*	0.0	0.0	0.0
*Woronichinia * #*	0.0	0.0	0.0
Filamentous Nitrogen Fixers			
*Aphanizomenon ** #*	0.0	132.0	274.0
Calothrix/Rivularia	0.0	0.0	0.0
*Cylindrospermum **	0.0	0.0	0.0
*Dolichospermum ** #*	0.0	0.0	0.0
*Raphidiopsis **	0.0	0.0	0.0
Filamentous Non-Nitrogen Fixers			
*Limnothrix **	0.0	0.0	0.0
Planktolyngbya	0.0	0.0	0.0
*Pseudanabaena/Komvophoron * #*	0.0	0.0	0.0
EUGLENOPHYTA			
Euglena	0.0	13.2	0.0
Phacus	0.0	0.0	0.0
Trachelomonas	12.7	26.4	54.8
PYRRHOPHYTA			
Ceratium #	0.0	26.4	13.7
Gymnodinium	0.0	0.0	0.0
Peridinium #	0.0	0.0	0.0

PHYTOPLANKTON DENSITY (CELLS/ML)

* = potentially toxic
** = likely toxic
\# = taste and odor producer

DENSITY (CELLS/ML) SUMMARY			
BACILLARIOPHYTA	**127.0**	**871.2**	**986.4**
Centric Diatoms	127.0	871.2	986.4
Araphid Pennate Diatoms	0.0	0.0	0.0
Monoraphid Pennate Diatoms	0.0	0.0	0.0
Biraphid Pennate Diatoms	0.0	0.0	0.0
CHLOROPHYTA	**12.7**	**554.4**	**54.8**
Flagellated Chlorophytes	0.0	184.8	0.0
Coccoid/Colonial Chlorophytes	0.0	316.8	0.0
Filamentous Chlorophytes	0.0	0.0	0.0
Desmids	12.7	52.8	54.8
CHRYSOPHYTA	**30530.8**	**52.8**	**164.4**
Flagellated Classic Chrysophytes	30530.8	39.6	164.4
Non-Motile Classic Chrysophytes	0.0	0.0	0.0
Haptophytes	0.0	0.0	0.0
Tribophytes/Eustigmatophytes	0.0	13.2	0.0
Raphidophytes	0.0	0.0	0.0
CRYPTOPHYTA	**50.8**	**66.0**	**411.0**
CYANOPHYTA	**0.0**	**132.0**	**274.0**
Unicellular and Colonial Forms	0.0	0.0	0.0
Filamentous Nitrogen Fixers	0.0	132.0	274.0
Filamentous Non-Nitrogen Fixers	0.0	0.0	0.0
EUGLENOPHYTA	**12.7**	**39.6**	**54.8**
PYRRHOPHYTA	**0.0**	**26.4**	**13.7**
TOTAL	**30734.0**	**1742.4**	**1959.1**
CELL DIVERSITY	**0.03**	**0.90**	**0.61**
CELL EVENNESS	**0.03**	**0.77**	**0.68**
NUMBER OF TAXA			
BACILLARIOPHYTA	**1**	**2**	**1**
Centric Diatoms	1	2	1
Araphid Pennate Diatoms	0	0	0
Monoraphid Pennate Diatoms	0	0	0
Biraphid Pennate Diatoms	0	0	0
CHLOROPHYTA	**1**	**6**	**2**
Flagellated Chlorophytes	0	1	0
Coccoid/Colonial Chlorophytes	0	3	0
Filamentous Chlorophytes	0	0	0
Desmids	1	2	2
CHRYSOPHYTA	**2**	**2**	**1**
Flagellated Classic Chrysophytes	2	1	1
Non-Motile Classic Chrysophytes	0	0	0
Haptophytes	0	0	0
Tribophytes/Eustigmatophytes	0	1	0
Raphidophytes	0	0	0
CRYPTOPHYTA	**1**	**1**	**1**
CYANOPHYTA	**0**	**1**	**1**
Unicellular and Colonial Forms	0	0	0
Filamentous Nitrogen Fixers	0	1	1
Filamentous Non-Nitrogen Fixers	0	0	0
EUGLENOPHYTA	**1**	**2**	**1**
PYRRHOPHYTA	**0**	**1**	**1**
TOTAL	**6**	**15**	**8**

PHYTOPLANKTON BIOMASS (UG/L)

*** = potentially toxic**
**** = likely toxic**
 # = taste and odor producer

TAXON	**North 06/10/25**	**North 07/10/25**	**North 08/07/25**
BACILLARIOPHYTA			
Centric Diatoms			
Aulacoseira #	38.1	190.1	295.9
Cyclotella/related taxa #	0.0	23.8	0.0
Araphid Pennate Diatoms			
Asterionella #	0.0	0.0	0.0
Colonial Fragilaria/related taxa #	0.0	0.0	0.0
Single Fragilaria/Synedra	0.0	0.0	0.0
Tabellaria #	0.0	0.0	0.0
Monoraphid Pennate Diatoms			
Biraphid Pennate Diatoms			
Navicula/related taxa	0.0	0.0	0.0
Nitzschia #	0.0	0.0	0.0
CHLOROPHYTA			
Flagellated Chlorophytes			
Eudorina	0.0	73.9	0.0
Coccoid/Colonial Chlorophytes			
Actinastrum	0.0	0.0	0.0
Ankistrodesmus	0.0	0.0	0.0
Coelastrum	0.0	0.0	0.0
Crucigenia	0.0	0.0	0.0
Dictyosphaerium #	0.0	0.0	0.0
Elakatothrix	0.0	0.0	0.0
Kirchneriella	0.0	5.3	0.0
Monoraphidium	0.0	0.0	0.0
Oocystis	0.0	84.5	0.0
Paulschulzia	0.0	0.0	0.0
Pediastrum #	0.0	0.0	0.0
Quadrigula	0.0	0.0	0.0
Scenedesmus #	0.0	5.3	0.0
Schroederia/Ankyra	0.0	0.0	0.0
Sphaerocystis	0.0	0.0	0.0
Tetraedron	0.0	0.0	0.0
Filamentous Chlorophytes			
Ulothrix	0.0	0.0	0.0
Desmids			
Closterium #	0.0	0.0	0.0
Cosmarium #	0.0	31.7	32.9
Euastrum	0.0	0.0	0.0
Mougeotia/Debarya	0.0	0.0	0.0
Octacanthium	0.0	0.0	0.0
Spirogyra #	0.0	0.0	0.0
Staurastrum #	10.2	10.6	11.0
Staurodesmus	0.0	0.0	0.0

PHYTOPLANKTON BIOMASS (UG/L)

*** = potentially toxic**
**** = likely toxic**
 # = taste and odor producer

CHRYSOPHYTA			
Flagellated Classic Chrysophytes			
Dinobryon #	152.4	118.8	493.2
Mallomonas #	0.0	0.0	0.0
Synura #	0.0	0.0	0.0
Other Flagellated Goldens	1524.0	0.0	0.0
Non-Motile Classic Chrysophytes			
Haptophytes			
Tribophytes/Eustigmatophytes			
Centritractus	0.0	0.0	0.0
Pseudostaurastrum	0.0	158.4	0.0
Raphidophytes			
CRYPTOPHYTA			
Cryptomonas #	81.3	187.4	1698.8
CYANOPHYTA			
Unicellular and Colonial Forms			
*Aphanocapsa * #*	0.0	0.0	0.0
Chroococcus	0.0	0.0	0.0
Dactylococcopsis	0.0	0.0	0.0
*Microcystis ** #*	0.0	0.0	0.0
*Woronichinia * #*	0.0	0.0	0.0
Filamentous Nitrogen Fixers			
*Aphanizomenon ** #*	0.0	17.2	35.6
Calothrix/Rivularia	0.0	0.0	0.0
*Cylindrospermum **	0.0	0.0	0.0
*Dolichospermum ** #*	0.0	0.0	0.0
*Raphidiopsis **	0.0	0.0	0.0
Filamentous Non-Nitrogen Fixers			
*Limnothrix **	0.0	0.0	0.0
Planktolyngbya	0.0	0.0	0.0
*Pseudanabaena/Komvophoron * #*	0.0	0.0	0.0
EUGLENOPHYTA			
Euglena	0.0	6.6	0.0
Phacus	0.0	0.0	0.0
Trachelomonas	12.7	26.4	54.8
PYRRHOPHYTA			
Ceratium #	0.0	459.4	238.4
Gymnodinium	0.0	0.0	0.0
Peridinium #	0.0	0.0	0.0

PHYTOPLANKTON BIOMASS (UG/L)

*** = potentially toxic**
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 # = taste and odor producer

BIOMASS (UG/L) SUMMARY			
BACILLARIOPHYTA	**38.1**	**213.8**	**295.9**
Centric Diatoms	38.1	213.8	295.9
Araphid Pennate Diatoms	0.0	0.0	0.0
Monoraphid Pennate Diatoms	0.0	0.0	0.0
Biraphid Pennate Diatoms	0.0	0.0	0.0
CHLOROPHYTA	**10.2**	**211.2**	**43.8**
Flagellated Chlorophytes	0.0	73.9	0.0
Coccoid/Colonial Chlorophytes	0.0	95.0	0.0
Filamentous Chlorophytes	0.0	0.0	0.0
Desmids	10.2	42.2	43.8
CHRYSOPHYTA	**1676.4**	**277.2**	**493.2**
Flagellated Classic Chrysophytes	1676.4	118.8	493.2
Non-Motile Classic Chrysophytes	0.0	0.0	0.0
Haptophytes	0.0	0.0	0.0
Tribophytes/Eustigmatophytes	0.0	158.4	0.0
Raphidophytes	0.0	0.0	0.0
CRYPTOPHYTA	**81.3**	**187.4**	**1698.8**
CYANOPHYTA	**0.0**	**17.2**	**35.6**
Unicellular and Colonial Forms	0.0	0.0	0.0
Filamentous Nitrogen Fixers	0.0	17.2	35.6
Filamentous Non-Nitrogen Fixers	0.0	0.0	0.0
EUGLENOPHYTA	**12.7**	**33.0**	**54.8**
PYRRHOPHYTA	**0.0**	**459.4**	**238.4**
TOTAL	**1818.6**	**1399.2**	**2860.6**
BIOMASS DIVERSITY	**0.28**	**0.90**	**0.55**
BIOMASS EVENNESS	**0.36**	**0.77**	**0.60**

	06/10/25	**07/10/25**	**08/07/25**
BIOMASS (UG/L) SUMMARY			
BACILLARIOPHYTA	38.1	213.8	295.9
CHLOROPHYTA	10.2	211.2	43.8
CHRYSOPHYTA	1676.4	277.2	493.2
CRYPTOPHYTA	81.3	187.4	1698.8
CYANOPHYTA	0.0	17.2	35.6
EUGLENOPHYTA	12.7	33.0	54.8
PYRRHOPHYTA	0.0	459.4	238.4

North Lake **Prepared by Aqua Link, Inc.**
ALI Project No. 1838-04
Phytoplankton Data
Station No. NL1 (upper-lake)

Station	**Date**	**Total Density (cells/ml)**	**Total Biomass (ug/L)**	**Cyanobacteria Density (cells/ml)**	**Cyanobacteria Biomass (ug/L)**
NL1	06/27/24	45759.6	3401.1	43821.6	2719.4
NL1	07/25/24	151560.0	8739.9	151110.0	8259.3
NL1	08/20/24	145591.3	9744.6	145297.0	9477.6
NL1	06/10/25	30734.0	1818.6	0.0	0.0
NL1	07/10/25	1742.4	1399.2	132.0	17.2
NL1	08/07/25	1959.1	2860.6	274.0	35.6
<<insert>>					
2024	**Min**	45759.6	3401.1	43821.6	2719.4
	Max	151560.0	9744.6	151110.0	9477.6
	Mean	114303.6	7295.2	113409.5	6818.7
	Median	145591.3	8739.9	145297.0	8259.3
	Count	3	3	3	3
2025	**Min**	1742.4	1399.2	0.0	0.0
	Max	30734.0	2860.6	274.0	35.6
	Mean	11478.5	2026.1	135.3	17.6
	Median	1959.1	1818.6	132.0	17.2
	Count	3	3	3	3
Annual Mean					
NL1	**2024**	**114303.6**	**7295.2**	**113409.5**	**6818.7**
NL1	**2025**	**11478.5**	**2026.1**	**135.3**	**17.6**