LAKE HOPATCONG – 2023 WATER QUALITY REPORT

MORRIS AND SUSSEX COUNTIES, NEW JERSEY

MARCH 2024

PREPARED FOR:

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1.0 INTRODUCTION

Princeton Hydro, LLC conducted general water quality monitoring of Lake Hopatcong during the 2023 growing season (May through September). This monitoring program represents a continuation of the long-term monitoring program of Lake Hopatcong. While the 2010 through 2012 water quality monitoring programs were conducted with funds awarded to the Lake Hopatcong Commission by the New Jersey Department of Environmental Protection (NJDEP) through the Non-Point Source (319(h) of the Clean Water Act) grant program (Project Grant RP10-087), the water quality monitoring program of 2013 was funded through the Lake Hopatcong Foundation as a monetary match toward the grant. Remaining funds in the 319(h) grant were made available for the 2014, 2015, and 2016 water quality monitoring programs. The annual water quality monitoring program was funded by the Lake Hopatcong Commission from 2018 through 2023.

The current water quality monitoring program is a modified version of the program that was originally initiated in the Phase I Diagnostic / Feasibility Study of Lake Hopatcong (PAS, 1983) and continued through the Phase II Implementation Projects. Both the Phase I and Phase II projects were funded by the US EPA Clean Lakes (314) Program. The modified monitoring program also continued through the development, revision, and approval of the Total Maximum Daily Load (TMDL)-based Restoration Plan, as well as through the installation of a series of watershed projects funded through three NJDEP 319 grants and a US EPA Targeted Watershed grant. Some additional monitoring was conducted during each sampling event in 2020, 2021, and 2022 as part of the HAB grant awarded in 2020 as well as a 319 grant (*WQR-2019-LHC00130)* awarded in 2021. The recent 319 grant involved modeling efforts to better quantify the internal phosphorus load on a seasonal and monthly basis under varying hydraulic conditions and will also involve the implementation of various in-lake and watershed-based projects to reduce nutrient loading to the waterbody. Finally, additional *in-situ* monitoring was conducted in July and August of the 2022 and 2023 seasons as part of a Highlands Council funded project to better characterize carryover brown trout (*Salmo trutta*) habitat during the peak summer months. This grant allowed for weekly *in-situ* sampling during the summer months, providing invaluable high-frequency data.

The current water quality monitoring program is valuable in terms of continuing to assess the overall "health" of the lake on a year-to-year basis, identifying long-term trends or changes in water quality, and quantifying and objectively assessing the success and potential impacts of restoration efforts. In addition, the in-lake water quality monitoring program continues to be an important component in the evaluation of the long-term success of the implementation of the phosphorus TMDL-based Restoration Plan, which was approved by NJDEP in April of 2006. The monitoring program also provides the data necessary to support the Foundation's and Commission's requests for grant funding to implement both watershed-based and in-lake projects to improve the water quality of Lake Hopatcong. Also, much of the data collected in 2023 will be used to assess the relative effectiveness of in-lake and watershed-based projects, designed to prevent or minimize the impacts of HABs in Lake Hopatcong. Finally, it should be noted that the 2006 Restoration Plan was recently updated with funds provided by the NJ Highlands Council in 2021 into a Watershed Implementation Plan (WIP) and is being used to select, design and implement additional watershed-based projects.

2.0 MATERIALS AND METHODS

In-lake water quality monitoring was conducted at the following eleven (12) locations in Lake Hopatcong (represented as red circles in Figure 1, Appendix A) during the 2023 study period:

Station Number	Location
1	Woodport Bay
2	Mid-Lake
3	Crescent Cove/River Styx
4	Point Pleasant/King Cove
5	Outlet
6	Henderson Cove
7	Inlet from Lake Shawnee
8*	Great Cove
9*	Byram Cove
10	Northern Woodport Bay
11	Jefferson Canals
12	Landing Channel

* *In-situ* monitoring only

During the 2023 season, standard water quality sampling was conducted on 11 May, 13 June, 24 July, 21 August, and 18 September. Additional *in-situ* monitoring events that were included as part of the trout study were conducted on 5 July, 11 July, 17 July, 1 August, 7 August, and 14 August. An Aqua TROLL 500 multi-probe unit was used to monitor the *in-situ* parameters dissolved oxygen (DO), temperature, pH, specific conductance, phycocyanin, and chlorophyll *a* during each sampling event. Data were recorded at 1.0 m increments starting at 0.1-0.2 m below the water's surface and continued to within 0.5 m of the lake sediments at each station. In addition, water clarity was measured at each sampling station with a Secchi disk.

Discrete water quality samples were collected with a Van Dorn sampling device 0.5 m below the lake surface at each station, with the exception of Stations 8 and 9, as well as mid-depth and 0.5 m above the sediment at the mid-lake sampling site (Station 2). Discrete water samples were appropriately preserved, stored on ice, and transported to a State-certified laboratory for the analysis of the following parameters:

- total suspended solids
- total phosphorus-P
- soluble reactive phosphorus-P
- nitrate-N
- ammonia-N
- chlorophyll *a*

During each sampling event, phytoplankton and zooplankton samples were collected at the surface and mid-depth of the deep sampling station (Station 2). Phytoplankton samples were collected at the surface and mid-depth utilizing a Van Dorn sampling device and quantitatively assessed, while zooplankton samples were collected utilizing a Schindler sampling device and qualitatively assessed. Phytoplankton grab samples were also collected at the surface of Station 3 and Station 10 for the quantitative assessment of cyanobacteria.

3.0 RESULTS AND DISCUSSION

3.1 IN-SITU PARAMETERS

TEMPERATURE

Summer thermal stratification results when increasing solar radiation and air temperatures, aided by a few days of little wind activity, combine to thermally stratify the water column. Thermal stratification consists of a relatively warm upper water layer (epilimnion), a transition zone (metalimnion or thermocline), and a cold, deep water layer (hypolimnion). The density differences imparted through thermal stratification serve to inhibit wind driven mixing of the water column thereby effectively sealing off the hypolimnetic layer from contact with the atmosphere. This phenomenon has important implications in that bottom waters of thermally stratified systems may become devoid of oxygen due to excessive bacterial decomposition of organic matter and a lack of atmospheric replenishment of dissolved oxygen through diffusion. Resultant conditions of hypolimnetic anoxia include internal sediment release of metals and phosphorus, and reduced fish habitat.

In the late summer and early fall, declining air temperatures result in a negative heat income to the lake, and a loss of heat exceeds inputs from solar radiation. Surface waters are thus cooled and induce convection currents which serve to erode the metalimnion of the lake until the water column exhibits a uniform temperature and therefore uniform density. At this point the lake experiences fall turnover. The transition from the final stages of weak summer thermal stratification to fall turnover are often times abrupt, and can occur over a period of a few hours, especially if associated with the high wind velocities of a storm.

Surface water temperatures measured at Station 2 were coolest in May and June, with respective temperatures of 16.81 °C and 19.99 °C. The lake was still in the early stages of the annual growing season thermal stratification pattern on 11 May, with a shallow epilimnion in the upper 2.0 m and a thermocline present throughout the remainder of the water column. By mid-June, surface temperatures at Station 2 had increased by over 3.00 °C relative to the 11 May event. However, water temperatures deeper in the epilimnion (4.0-6.0 m) had increased to a greater degree as this upper layer continued to mix, resulting in a more defined thermal stratification pattern and a larger epilimnion, now present in the upper 6.0 m. Surface temperatures at Station 2 increased to a seasonal maximum of 26.76 °C on 17 July; this data was collected during one of the trout habitat monitoring events. Water temperatures in the upper epilimnion increased as the summer progressed, resulting in a slight shrinking of the epilimnion, present in the upper 4.0 m on 24 July. Temperatures throughout the epilimnion had decreased by the 21 August monitoring event, with a surface temperature of 24.49 °C; this resulted in an expansion of the epilimnion to the upper 6.0 m. Water temperatures cooled significantly by the final monitoring event on 18 September; however, the lake was still stratified with an epilimnion in the upper 6.0 m.

Water temperatures were often higher at the other stations throughout the lake as a result of the shallower depths. It takes less energy from the sun to heat the other stations since the zone of mixing is much shallower. Surface water temperatures often exceeded 27.00 °C at the shallower stations in July. The only other two stations that developed true thermal stratification patterns throughout the season were Stations 8 and 9 which are both approximately 7.5 – 8.5 m deep.

In addition to collecting temperature data over the 2023 growing season, the long-term, surface water temperatures from Station 2 during the month of July have been graphed and are shown below in Figure 1. This analysis was conducted to assess the potential impacts of climate change on Lake Hopatcong. The Station 2, mid-lake data were used because there was no chance of shading from near-shore trees or structures at this location. The July data were used since it is typically the warmest month of the year in the Mid-Atlantic States.

As shown in Figure 1, there has been a statistically significant increase in surface water temperatures at Lake Hopatcong over the past 34 years. Additionally, the July 2022 surface water temperature at Station 2 was the fourth highest recorded at 27.50 °C. It should be noted that each year from 2019 to 2022 were in the top six of the highest recorded July surface water temperatures dating back to 1988. The highest surface water July temperature at Station 2 was recorded in 2005 and was 28.52 °C. These data provide evidence that climatic change is impacting Lake Hopatcong. In turn, increasing water temperatures makes the lake more favorable for larger and more frequent Harmful Algal Blooms (HABs).

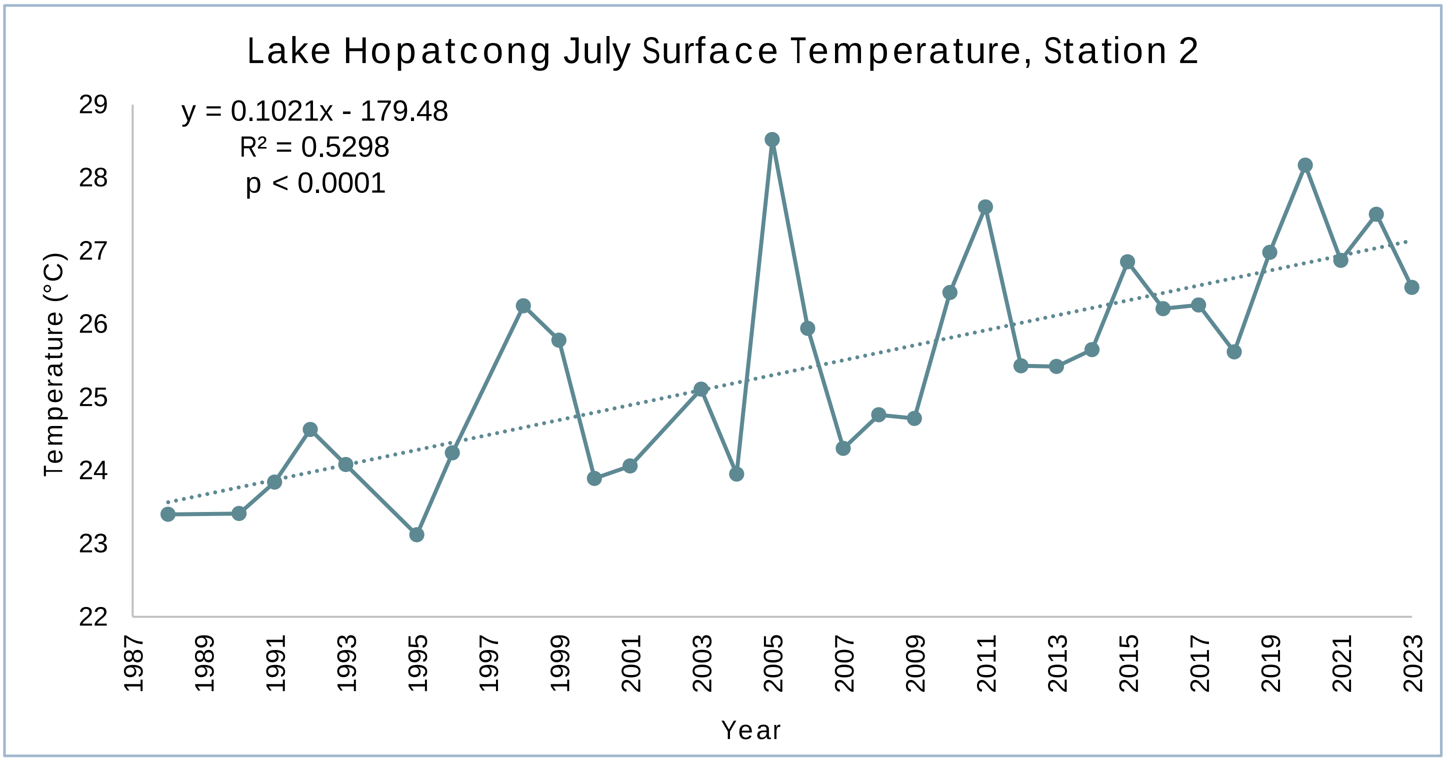


Figure 1: Long-term, July surface water temperatures at the mid-lake sampling station at Lake Hopatcong

DISSOLVED OXYGEN

DO is crucial to almost all biochemical reactions occurring in freshwater ecosystems. The primary sources of DO in a lake are diffusion from the atmosphere and photosynthesis. Biological respiration and bacterial decomposition of organic matter are the primary sources of consumption; these processes are often classified as water oxygen demand (WOD) and sediment oxygen demand (SOD) in limnology. The abundance and distribution of DO in a lake system is predicated on the relative rates of these producers and consumers; producers include aquatic macrophytes and phytoplankton. As the producers photosynthesize, they utilize water, carbon dioxide, and sunlight to create oxygen and glucose. This process increases DO concentrations in the sun-lit zone of a lake; this active area of the lake is known as the photic zone. As such, DO concentrations are generally higher in photic zone and lower in the deeper water, where a lack of photosynthetic activity in conjunction with organism respiration results in a decrease. DO is also influenced by the thermal properties of the water column. This includes both lake stratification and the varying degree of oxygen retention capacity of water at different temperatures; colder water holds more oxygen than warmer water.

When lakes thermally stratify, there is generally a correlated stratification of DO levels. The hypolimnion usually has lower DO concentrations, as this water cannot mix with the epilimnion, whereby DO concentrations would be replenished with atmospheric sources. In highly productive lakes, the hypolimnion may become devoid of oxygen due to bacterial decomposition of excessive inputs of organic material. The source of this material may either be from excessive phytoplankton production in the upper water layers that then sink to the bottom when they die (autochthonous), from excessive watershed derived sediment loading (allochthonous), or more likely a mixture of the two. Also, as DO concentrations are generally measured during the daytime when concentrations are highest, concentrations are lower at night when photosynthesis ceases but respiration continues.

An important consequence of anoxic (DO < 1.00 mg/L) conditions in the hypolimnion includes both reduced fish habitat and the release of metals and phosphorus, a process termed internal loading. Internal loading occurs when tightly bound iron and phosphate sediment complexes are reduced, thereby dissociating phosphorus from iron, and making it available for diffusion into the water column. This process has been documented to contribute to the overall eutrophication of many lakes, as this internal source of phosphorus is pulsed into the photic zone during strong storm events whereby it may serve as fuel for excessive algal growth. A general guideline for DO concentrations in lakes is that a concentration of greater than 1.0 mg/L is needed to preclude internal nutrient and metal release while concentrations of 4.0 mg/L and greater should be kept in order to sustain proper warm-water fisheries habitat.

DO concentrations remained above 5.0 mg/L in the epilimnion at Station 2 throughout the 2023 growing season. DO concentrations remained oxic (DO > 2.0 mg/L) throughout the water column at Station 2 on 11 May and did not drop below 5.0 mg/L until a depth of 11.0 m. As the surface water warmed in June and the lake developed a more defined thermal stratification pattern, DO concentrations began to decline rapidly below the thermocline; this trend continued until the last monitoring event on 18 September. On 13 June, 24 July, and 21 August, DO concentrations fell below the 5.0 mg/L threshold at depths of approximately 6.9 m, 4.3 m, and 5.7 m, respectively. Due to the high oxygen demand in Lake Hopatcong, DO concentrations fell to anoxic concentrations (DO < 1.0 mg/L) shortly below the above-mentioned depths. Essentially, the entire hypolimnion was anoxic in June, July, and August. By 18 September, the hypolimnion remained anoxic below a depth of 7.0 m.

During the 11 May event, DO concentrations at all remaining stations were above 5.0 mg/L throughout the water column. On 13 June, all other sampling stations had DO concentrations that were above 5.0 mg/L, with the exception of the bottom 3.0 m at the deeper (8.0 m) Station 9. DO concentrations began to decrease slightly at the shallower stations as the water temperatures increased in July, though the only station that had a surface concentration below 5.0 mg/L was Station 11, with a concentration of 4.21 mg/L. The bottom 2.0 – 3.0 m of Stations 8 and 9 were anoxic on 24 July. By 21 August, surface concentrations remained above 5.0 mg/L at all stations while the bottom meter of Station 8 and the bottom 2.0 m of Station 9 were anoxic. On 18 September, all other sampling stations had DO concentrations that were above 5.0 mg/L, with the exception of the bottom 2.0 m at Station 9.

To better illustrate the relationship between thermal stratification and DO concentrations across the growing season, isopleth figures are presented below (Figures 2 and 3).

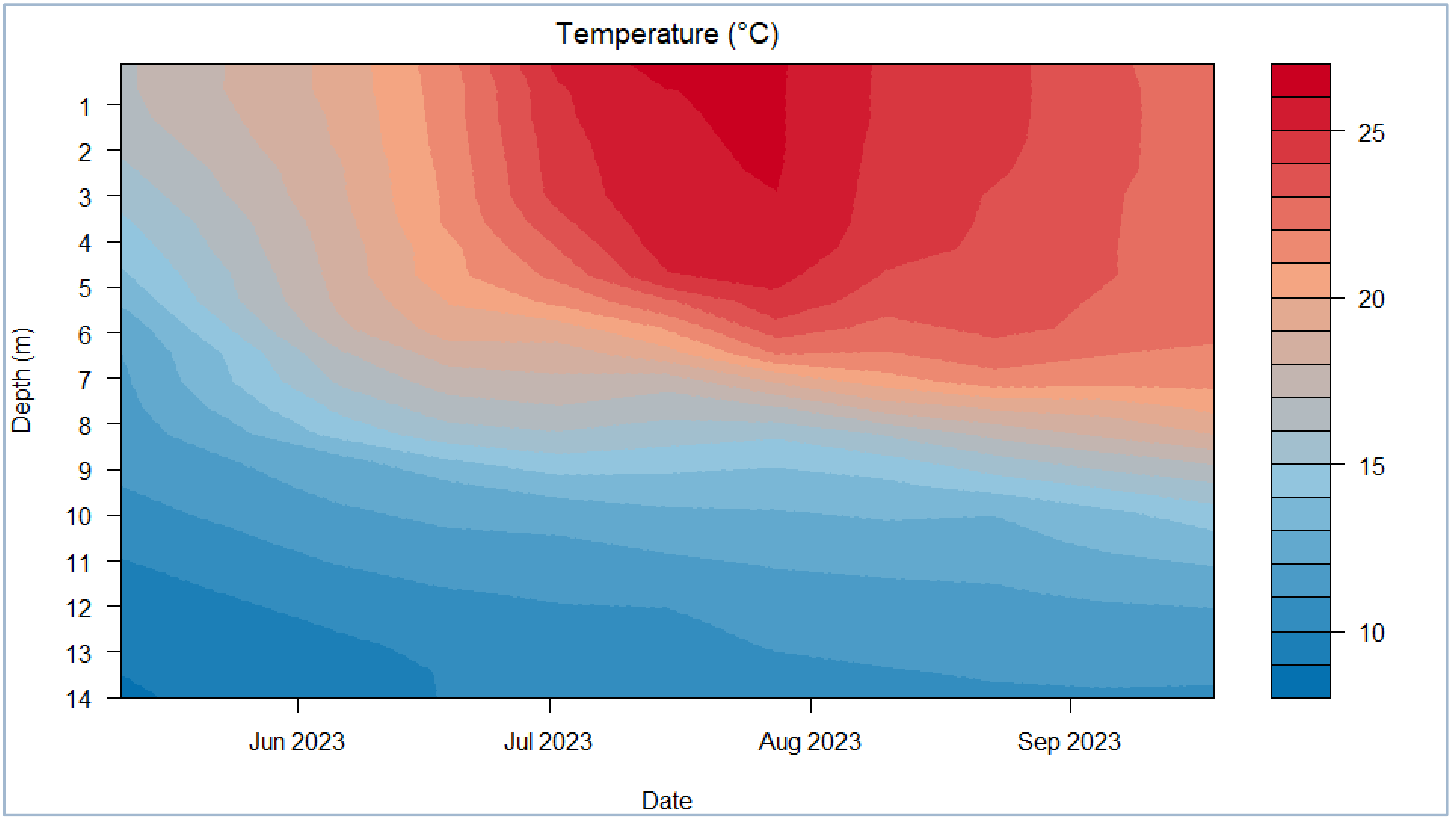


Figure 2: Temperature isopleths at Station 2 throughout the 2023 season

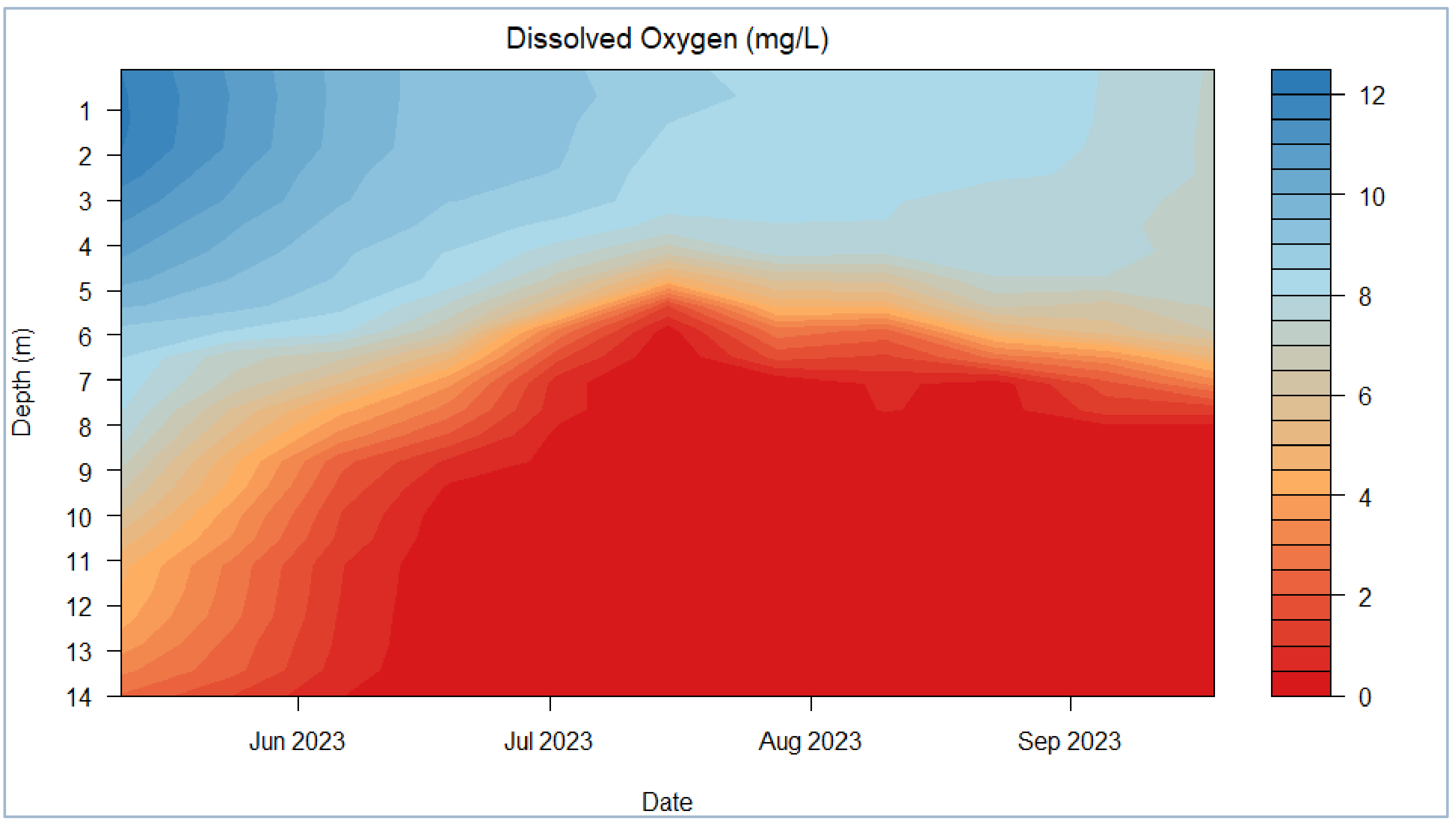


Figure 3: Dissolved oxygen isopleths at Station 2 throughout the 2023 season

PH

pH is a unitless measurement of the hydrogen ion concentration in water. Expressed on a negative logarithmic scale from 0 to 14, every change of 1 pH unit represents a 10-fold change in hydrogen ion concentration. The pH of pure water is 7 and is termed neutral. Any value less than 7 is termed acidic, while any value greater than 7 is termed basic. Baseline pH values in aquatic systems are primarily determined by the ionic constituency of the surrounding geology. Watersheds draining soils of easily erodible anionic constituents are generally well buffered, and as such have runoff waters with basic pH values (pH above 7). Spatial variations in pH throughout the water column are largely due to relative rates of photosynthesis versus respiration. As plants and algae photosynthesize and carbon dioxide is removed from the water, pH values increase. Conversely, respiration releases carbon dioxide into the environment which results in a reduction in pH. Given these relationships, pH values may differ substantially in the epilimnion and hypolimnion. The optimal range of pH for surface waters, as recognized by the NJDEP, is between 6.5 and 8.5.

Surface pH values ranged between 7.5 – 9.6 on 11 May, with nine stations exceeding the NJDEP optimal range. The elevated surface values are likely a result of early season phytoplankton growth; photosynthesis increases the pH of the water. On 13 June, surface pH values ranged between 7.3 – 8.1 throughout the lake. pH values often decrease with depth as a result of decreasing rates of photosynthesis, although pH values at all depths remained above 6.5 during each sampling event. Surface values again remained within the optimal range of 6.5 – 8.5 from July – September.

WATER CLARITY

Transparency in lakes is generally determined through the use of a Secchi disk. The Secchi disk is a contrasting white and black disk that is lowered into the lake until no longer visible then retrieved until visible again. The average of those two lengths is termed the Secchi depth. This depth may be influenced by algal density, suspended inorganic particles, organic acid staining of the water or more commonly a combination of all three. This parameter is often times used to calculate the trophic status (productivity) of a lake and as such is a critical tool in lake evaluation. Secchi depths less than 1.0 m are generally associated with reduced water quality due to high concentrations of algae or suspended inorganic sediments and as such is generally associated with impaired quality.

Water clarity was measured at each in-lake monitoring station throughout the 2023 season. Based on Princeton Hydro's in-house, long-term database of lakes in northern New Jersey, water clarity is considered acceptable for recreational activities when the Secchi depth is equal to or greater than 1.0 m (3.3 ft).

Water clarity was variable throughout the lake during each sampling event. In May, all stations had Secchi depths above the 1.0 m threshold, ranging from 1.1 m at Station 4 up to 1.9 m at Station 6. Clarity decreased throughout the lake on 13 June, ranging from a minimum of 0.7 m at Station 10 up to 1.5 m at Station 7. Water clarity continued to decrease throughout the lake on 24 July, with a minimum of 0.6 m at Stations 3, 10, and 12 and a maximum of 1.1 m at Stations 2 and 9. On 21 August, clarity ranged from 0.6 m at Station 10 up to 1.5 m at Station 2. Water clarity in Lake Hopatcong remained variable by location on 18 September, ranging between 0.7 m at Station 10 and 1.5 at Station 7. Water clarity was consistently poor at Station10 located at the northern end of Woodport Bay.

3.2 DISCRETE PARAMETERS

AMMONIA-NITROGEN (NH_3-N)

In lakes, ammonia is naturally produced and broken down by bacterial processes while also serving as an important nutrient in plant growth. In a process termed ammonification, bacteria break down organically bound nitrogen to form NH_4^+. In aerobic systems bacteria then break down excess ammonia in a process termed nitrification to nitrate (NO_3^-). These processes provide fuel for bacteria and are generally kept in balance as to prevent accumulation of any one nitrogen compound.

Ammonia is generally present in low concentrations in oxygenated epilimnetic layers of lakes due to the rapid conversion of the ammonium ion to nitrate. In addition, most plants and algae prefer the reduced ammonium ion to the oxidized nitrate ion for growth and therefore further contribute to reduced concentrations of ammonia in the upper water layer. In the anoxic hypolimnion of lakes ammonia tends to accumulate due to increased bacterial decomposition of organic material and lack of oxygen which would otherwise serve to oxidize this molecule to nitrate.

Increased surface water concentrations of ammonia may be indicative of excessive non-point source pollution from the associated watershed. The ammonium ion, unlike that of nitrate, may easily bind to soil particles whereby it may be transported to the lake during storm events. Another likely source of excessive ammonia in suburban watersheds is runoff from lawn fertilizer which is often highly rich in nitrogenous species. Increases in ammonia concentrations in the hypolimnion of lakes are generally associated with thermal stratification and subsequent dissolved oxygen depletion. Once stratification breaks down a pulse of ammonia rich water may be mixed throughout the entire water column whereby it will cause undue stress to aquatic organisms, as well as possible toxicity.

Toxicity of ammonia to aquatic species generally increases with increasing pH (>8.5) and decreasing temperature (<5°C). The general guideline issued by the EPA is that ammonia should not exceed a range of 0.02 mg/L to 2.0 mg/L, dependent upon water temperature and pH, to preclude toxicity to aquatic organisms.

Surface ammonia-N concentrations were low throughout Lake Hopatcong in 2023. Surface concentrations never exceeded 0.02 mg/L from May through July, and most samples had concentrations at or below 0.01 mg/L. Surface ammonia-N concentrations remained low in August and September but did increase to 0.03 mg/L at Stations 1, 3, 5, 10, and 12.

Mid-depth samples collected at Station 2 were also low throughout the season, reaching a seasonal maximum of 0.05 mg/L on 18 September. Deep samples at Station 2 were elevated in July and September, with respective concentrations of 0.24 mg/L and 0.50 mg/L. As mentioned above, ammonia often accumulates in the anoxic hypolimnion due to the lack of oxygen which would otherwise oxidize the molecule and convert it to nitrate.

NITRATE-NITROGEN (NO_3-N)

Nitrate is the most abundant form of inorganic nitrogen in freshwater ecosystems. Common sources of nitrate in freshwater ecosystems are derived from bacterial facilitated oxidation of ammonia and through groundwater inputs. The molecular structure of nitrate lends it poor ability to bind to soil particles but excellent mobility in groundwater.

Nitrate is often utilized by algae, although to a lesser extent than ammonia, for growth. Nitrate distribution is highly dependent on algal abundance and the spatial distribution of dissolved oxygen concentrations. In many eutrophic lake systems nitrate concentrations show temporal and spatial variability due to algal productivity and relative concentrations of dissolved oxygen.

Excessively high concentrations of nitrate are primarily attributable to either wastewater inputs or excessive organic matter decomposition in oxygenated hypolimnion. Typically, lakes with concentrations above 0.30 mg/L indicates nitrogen-loading, however, concentrations below 0.50 mg/L are still considered acceptable surface water quality. For comparison purposes, the drinking water standard for nitrate is 10 mg/L.

Surface nitrate-N concentrations were extremely variable in May, ranging between 0.02 mg/L at Station 5 and 0.96 mg/L at Station 10. Surface nitrate-N concentrations exceeded 0.10 mg/L at Stations 3, 7, 10, and 11; Station 3 had an elevated concentration of 0.52 mg/L. Surface nitrate-N concentrations decreased throughout the lake in June, but did remain slightly elevated at Station 10, with a concentration of 0.12 mg/L. Surface concentrations were variable throughout the lake again in July, ranging from 0.03 mg/L at Stations 2, 5, and 6 up to 0.11 mg/L at Station 7. Surface nitrate-N concentrations were low at all stations with the exception of Station 10 in August; Station 10 had a concentration of 0.26 mg/L. Surface concentrations were below the lab detection limit of 0.07 mg/L at all stations in September. Most of the samples with elevated concentrations were collected at shallow stations in proximity to the shoreline and could be influenced by nearshore septic systems.

Mid-depth samples collected at Station 2 were low throughout most of the season and peaked at 0.06 mg/L in May. Deep samples began to increase in July and peaked at a concentration of 0.15 mg/L on 21 August.

In summary, surface nitrate-N concentrations were generally low throughout the season with a few elevated concentrations at near-shore stations including 3, 7, 10 and 11.

TOTAL PHOSPHORUS (TP)

Phosphorus is often the limiting nutrient in lake ecosystems, or the nutrient in which abundance is lowest relative to demand by plants and algae. As a result, phosphorus is often the primary nutrient driving excessive plant and algal growth. Given this nutrient limitation, only relatively small increases in phosphorus concentration can fuel algal blooms and excessive macrophyte production. By monitoring total phosphorus concentrations, the current trophic status of the lake can be determined and future trends in productivity may be predicted. It is important to note that total phosphorus concentrations account for all species of phosphorus, including organic, inorganic, soluble, and insoluble. Therefore, this measure accounts not only for those dissolved, inorganic species of phosphorus that are readily available for algal assimilation, but also for those species of phosphorus either tightly bound to soil particles or contained as cellular constituents of aquatic organisms which are generally unavailable for algal assimilation.

The State's Surface Water Quality Standard (SWQS, N.J.A.C. 7:9B – 1.14(c) 5) for TP in the surface waters of a freshwater lake or impoundment is 0.05 mg/L. This established TP concentration is for any freshwater lake or impoundment in New Jersey that does not have an established TMDL. Lake Hopatcong has established a phosphorus TMDL, which was revised and approved by NJDEP in June 2006. Based on its refined phosphorus TMDL, the long-term management goal is to maintain an average growing season TP concentration of 0.03 mg/L or less within the surface waters of Lake Hopatcong. Based on Princeton Hydro's in-house database on northern New Jersey lakes, TP concentrations equal to or greater than 0.03 mg/L increases the likelihood of nuisance algal growth and/or HABs.

Surface TP concentrations were generally low in May, although Station 4 had a concentration of 0.04 mg/L; all other stations had concentrations at or below 0.03 mg/L. Surface TP concentrations did increase around the lake on 13 June and exceeded the 0.03 mg/L recommended threshold at four stations. Stations 4 and 5 had concentrations of 0.04 mg/L, Station 12 yielded concentration of 0.05 mg/L, and Station 10 had a concentration of 0.06 mg/L. Surface TP concentrations continued to increase throughout the lake in July, exceeding 0.03 mg/L at seven stations. Stations 1, 3, 10, and 12 had surface TP concentrations of 0.05 mg/L. Surface TP concentrations remained slightly elevated in August and exceeded 0.03 mg/L at seven stations again. Station 3 had the highest concentration of 0.07 mg/L, and Stations 1, 10, and 12 yielded concentrations of 0.05 mg/L. Surface TP concentrations began to decrease around the lake by 18 September and Stations 3 and 10 were the only two that exceeded the recommended threshold with concentrations of 0.04 mg/L.

Stations 1, 3, and 10 consistently had the highest TP concentrations in 2023, continuing a trend that's been occurring in recent years. Stations 1 and 10 are both located north of Brady Bridge and water in this northern section of the lake was often turbid. The water is much shallower in this section of the lake and it's possible that sediment is being resuspended into the water column.

Mid-depth TP concentrations at Station 2, which were collected from the middle of the thermocline, were low all season and did not exceed 0.03 mg/L. This indicates that little to no TP that was building up in the anoxic hypolimnion throughout the season was mixed with the surface water and likely explains why TP concentrations were generally low at the surface of Station 2 throughout the season. Deep TP concentrations collected from approximately 0.5 m above the sediment increased as the season progressed and anoxic conditions persisted, reaching a maximum of 0.42 mg/L on 18 September.

The mean TP concentration was calculated for each surface water sampling station to determine if they were in compliance with the TMDL threshold concentration of 0.03 mg/L. Of the ten long-term water quality monitoring stations, seven stations were compliant with this TMDL in 2023. Stations 3, 10, and 12 all had seasonal mean concentrations of 0.04 mg/L. There was a significant amount of precipitation in the Lake Hopatcong watershed from June through September which likely influenced TP concentrations in some of the near-shore stations.

SOLUBLE REACTIVE PHOSPHORUS (SRP)

Soluble reactive phosphorus (SRP) represents the dissolved inorganic portion of total phosphorus metrics. This species of phosphorus is readily available for assimilation by all algal forms for growth and is therefore normally present in limited concentrations except in very eutrophic lakes. Princeton Hydro recommends concentrations to not exceed 0.005 mg/L to prevent nuisance algal blooms.

Surface SRP concentrations were low throughout the lake for most of the 2023 growing season. SRP concentrations remained below the lab detection limit of 0.003 mg/L at all stations in May and June. Only one sample from Station 4 exceeded 0.003 mg/L in July and August, with a concentration of 0.004 mg/L on 21 August. Surface SRP concentrations remained low at most stations in September; however, Stations 1 and 2 had respective concentrations of 0.007 mg/L and 0.006 mg/L.

Mid-depth SRP concentrations at Station 2 were below the lab detection limit of 0.003 mg/L from May through August before increasing to 0.004 mg/L in September. Deep SRP concentrations at Station 2 were low from May through July but increased significantly in August and September with a concentration of 0.02 mg/L; this increase was a direct result of internal phosphorus loading from the anoxic hypolimnion.

CHLOROPHYLL *A*

Chlorophyll *a* is a pigment possessed by all algal groups, used in the process of photosynthesis. Its measurement is an excellent means of quantifying algal biomass. In general, an algal bloom is typically perceived as a problem by the layperson when chlorophyll-*a* concentrations are equal to or greater than 25.0 to 30.0 µg/L. In contrast, the <u>targeted</u> average and maximum chlorophyll-*a* concentrations, once Lake Hopatcong is in complete compliance with the TMDL, are predicted to be 8.0 and 14.0 µg/L, respectively.

Chlorophyll *a* concentrations were elevated at two stations in May, with concentrations of 22.0 µg/L and 47.0 µg/L at Stations 2 and 4, respectively. On 13 June, surface chlorophyll *a* concentrations exceeded the 14.0 µg/L threshold at six stations, ranging from 18.0 µg/L at Station 2 up to 31.0 µg/L at Station 5. In July, eight stations had chlorophyll *a* concentrations above 14.0 µg/L, ranging from 15.0 µg/L at Station 5 up to 32.0 µg/L at Station 10. Concentrations remained moderately elevated in August, with five stations exceeding the recommended threshold. During the final monitoring event in September, five stations exceeded the recommended threshold, ranging from 17.0 µg/L at Station 12 up to 27.0 µg/L at Station 10.

Lakewide average surface chlorophyll *a* concentrations were calculated for each month and compared with the targeted goal of 8.0 µg/L. Average surface chlorophyll *a* concentrations exceeded the targeted goal of 8.0 µg/L during each sampling event in 2023, ranging from 13.6 µg/L in May up to 19.4 in July. Station 11 was the only site that had a growing season average below the targeted threshold of 8.0 g/L. All other stations exceeded this threshold, ranging from a seasonal average of 11.5 µg/L at Station 7 up to a maximum of 21.9 µg/L at Station 3. This is the second year in a row that Station 3 had the highest seasonal average chlorophyll *a* concentration. Stations 1 and 10, both located north of Brady Bridge, also had elevated seasonal averages for the second year in a row; Station 1 had a seasonal average of 19.2 µg/L and Station 10 had a seasonal average of 20.3 µg/L.

TOTAL SUSPENDED SOLIDS (TSS)

The concentration of suspended particles in a waterbody that will cause turbid or “muddy” conditions, total suspended solids is often a useful indicator of sediment erosion and stormwater inputs into a waterbody. Because suspended solids within the water column reduce light penetration through reflectance and absorbance of light waves and particles, suspended solids tend to reduce the active photic zone of a lake while contributing a “muddy” appearance at values over 25 mg/L. Total suspended solids measures include suspended inorganic sediment, algal particles, and zooplankton particles.

TSS concentrations were low across the lake in May, with a maximum concentration of 4 mg/L at Station 11. TSS concentrations increased slightly in June but still remained relatively low, ranging from 3 mg/L at Station 6 up to 13 mg/L at Station 3. TSS concentrations remained relatively low throughout the lake on 24 July, with concentrations of 14 mg/L at Stations 1 and 3 and a concentration of 13 mg/L at Station 5; all other stations had concentrations below 12 mg/L. TSS concentrations decreased at all stations in August, and Stations 3 and 10 were the only samples that exceeded 5 mg/L; they both had a concentration of 10 mg/L. TSS concentrations remained relatively low in September, ranging from below the lab detection limit of 2 mg/L at Stations 11 and 12 up to 13 mg/L at Station 1.

3.3 BIOLOGICAL PARAMETERS

PHYTOPLANKTON

Phytoplankton are algae that are freely floating in the open waters of a lake or pond. These algae are vital to supporting a healthy ecosystem since they are the base of the aquatic food web. However, high densities of phytoplankton can produce nuisance conditions. The majority of nuisance algal blooms in freshwater ecosystems are the result of cyanobacteria, also known as blue-green algae. Some of the more common water quality problems created by blue-green algae include bright green surface scums, taste and odor problems, and the generation of cyanotoxins. Phytoplankton samples were collected from the surface and mid-depth of Station 2 during the 2023 season and were quantitatively assessed for comparison with the NJDEP HAB Alert Levels. Surface samples were also collected at Stations 3 and 10 for quantitative analysis during each event. New Jersey implemented advanced harmful algal bloom (HAB) screening and response protocols in 2020, and these HAB standards are provided below in Figure 4.

Surface and mid-depth grab samples collected at Station 2 during the 11 May sampling event yielded a diverse plankton community, with 20 genera identified at the surface and 16 genera identified at mid-depth. The green algae and diatom communities were the most diverse in May, with a total of 13 genera identified at the surface and 10 genera identified at mid-depth. However, the cyanobacteria community was already moderately abundant at this time, with a total cyanobacteria cell count of 20,335 cells /mL at the surface and 23,498 cells/mL at mid-depth; *Aphanizomenon* was the dominant genera. The phytoplankton community remained diverse on 13 June, with 18 genera identified at the surface and 17 genera identified at mid-depth. The green algae community was again the most diverse, yielding 8 genera at the surface and 10 genera at mid-depth. However, the cyanobacteria community increased in abundance, with cyanobacteria densities of 59,697 cells/mL at the surface and 63,254 cells/mL at mid-depth; *Aphanizomenon* was the dominant genus again.

As the season progressed into July, the phytoplankton community became less diverse, with 11 genera identified at the surface of Station 2 and 15 genera at mid-depth. The cyanobacteria community also became more diverse during this event, especially at the surface of Station 2. The cyanobacteria cell count at the surface increased to 69,335 cells/mL while the cell count at mid-depth decreased to 13,654 cells/mL. *Aphanizomenon* was again the dominant genus in July.

Cyanobacteria densities decreased in August but the surface sample from Station 2 remained elevated with a cell count of 50,247 cells/mL. The phytoplankton community was very diverse in August, with 31 genera identified at the surface and 29 genera identified at mid-depth. The green algae community was the most diverse, with 14 genera identified at the surface and 9 genera identified at mid-depth. The phytoplankton community at Station 2 remained diverse in September, with 27 genera identified at the surface and 20 genera identified at mid-depth. The cyanobacteria community remained relatively consistent over the preceding month, with total cyanobacteria counts of 51,874 cells/mL and 18,749 cells/mL at the surface and mid-depth, respectively. *Raphidiopsis raciborskii* (previously named *Cylindrospermopsis raciborskii*) was the dominant genera in September. *Raphidiopsis* is a subtropical cyanobacteria genus that has been blooming in Lake Hopatcong, as well as other temperate waterbodies, in increasing numbers in recent years. Based on the last three years of data, this subtropical cyanobacteria tends to appear at Station 3 at the heigh of the summer season.

Surface grabs were also collected at Station 3 during each sampling event. The sample collected at Station 3 during the 11 May sampling event yielded a diverse plankton community, with 17 different genera identified. The green algae and diatom community was the richest in May, with 13 genera identified between the two groups. The cyanobacteria community only comprised a minor portion of the May plankton community at Station 3, with a total cyanobacteria cell count of 3,159 cells/mL. The plankton community at Station 3 increased considerably in richness and abundance on 13 June, with a total of 28 genera identified, with a very diverse green algae and diatom community. The cyanobacteria community also increased in richness and abundance in June, with a total of 4 genera identified and a cyanobacteria cell count of 37,038 cells/mL; *Aphanizomenon* was the dominant genus. 24 total genera were identified in the sample collected at Station 3 on 24 July; however, the sample was extremely dense with cyanobacteria. The total cyanobacteria count was 114,074 cells/mL and was dominated by *Aphanizomenon and Dolichospermum*. Cyanobacteria densities remained elevated in August, with a total cyanobacteria cell count of 136,301 cells/mL. Overall phytoplankton diversity remained high in August, with 30 genera identified at Station 3. Cyanobacteria densities remained high in September, with a total cell count of 99,549 cells/mL.

Surface samples were also collected at Station 10 for the first time in 2023. Cyanobacteria densities remained low at Station 10 in May and June, with respective cell counts of 733 cells/mL and 101 cells/mL. Cyanobacteria densities increased over the proceeding three months, with respective cell counts of 28,857 cells/mL, 64,096 cells/mL, and 75,540 cells/mL. *Raphidiopsis* was the dominant cyanobacteria genera in August and September.

HAB Alert Level	Criteria	Recommendations
HAB Not Present	**HAB reported and investigated. No HAB present.**	**None**
WATCH *Suspected or confirmed HAB with potential for allergenic or irritative health effects*	Suspected HAB based on field survey **OR** Confirmed cell counts ≥20K - <80K cells/mL **AND** No known toxins above public health thresholds	**Public Bathing Beaches Open** Waterbody Accessible: Use caution during **primary contact (e.g. swimming) and secondary (e.g. non-contact boating)** activities Do not ingest water (people/pets/livestock) Do not consume fish
ADVISORY *Confirmed HAB with moderate risk of adverse health effects and increased potential for toxins above public health thresholds*	Lab testing for toxins Microcystins: ≥2 µg/L Cylindrospermopsin: ≥5 µg/L Anatoxin-a: ≥15 µg/L Saxitoxin: ≥0.6 µg/L **OR** Confirmed cell counts ≥80K cells/mL	**Public Bathing Beaches Closed** Waterbody Remains Accessible: Avoid primary contact recreation Use caution for secondary contact recreation Do not ingest water (people/pets/livestock) Do not consume fish
WARNING *Confirmed HAB with high risk of adverse health effects due to high toxin levels*	Toxin (microcystins) ≥20 - <2000 µg/L	**Public Bathing Beaches Closed** Cautions as above May recommend against secondary contact recreation.
DANGER *Confirmed HAB with very high risk of adverse health effects due to very high toxin levels*	Toxin (microcystins) ≥2000 µg/L	**Public Bathing Beaches Closed** Cautions as above. Possible closure of all or portions of waterbody and possible restrictions access to shoreline.

Figure 4: NJDEP HAB Response Guidelines

The New Jersey Department of Environmental Protection (NJDEP) modified their HAB alert level classifications for 2020 and beyond. Cell counts between 20,000 – 80,000 cells/mL fall under the classification of "Watch." Under this classifications, public health beaches can remain open, depending on local health authority evaluation and assessment, but monitoring under these classifications should increase. As cell counts exceed 80,000 cells/mL, the alert levels progress into "Advisory," "Warning," and "Danger" depending on cyanotoxin concentrations; however, public bathing beaches would be closed under any of these elevated classifications.

Cyanobacteria cell counts at the surface of Station 2 fell under the "Watch" category during each sampling event in 2023. Cyanobacteria cell counts at mid-depth of Station 2 fell under the "Watch" category in May and June. Cyanobacteria cell counts at Station 3 fell under the "Watch" category in June before progressing into the "Advisory" category, based on cell counts only, for the remainder of the season. Cyanobacteria cell counts at Station 10 fell under the "Watch" category from July through September.

In addition to the cyanobacteria cell counts at Station 2, Turner handheld fluorometers were utilized to measure phycocyanin at the surface during these main water quality sampling events. Phycocyanin is a pigment that is produced almost exclusively by cyanobacteria and is currently being assessed by NJDEP in terms of monitoring for HABs. NJDEP has developed correlations between phycocyanin measurements and cyanobacteria cell concentration with three types of water quality meters. It's important to note that the model of meter has different ranges and requires a separate correlation. A correlation was calculated by NJDEP for the Turner handheld meter used by Princeton Hydro, with a value of 12 µg/L correlating with an estimated cyanobacteria cell count of 20,000 cells/mL and a value of 44 µg/L correlating with an estimated cyanobacteria cell count of 80,000 cells/mL.

Phycocyanin measurements were taken at the surface of all stations in 2023. Phycocyanin concentrations remained low in May, ranging from 1 µg/L at Station 11 up to 9 µg/L at Station 4. Concentrations increased at most stations on 13 June, exceeding 12 µg/L at Stations 1, 2, 3, 4, 5, 6, 8, 9, and 12; Stations 5 and 12 had the highest phycocyanin concentrations at 35 µg/L and 42 µg/L, respectively. Phycocyanin concentrations remained moderately elevated in July and exceeded 12 µg/L at stations besides Stations 7 and 11. The only station that had a phycocyanin concentration above 30 µg/L in July was Station 3, with a concentration of 41 µg/L. Phycocyanin concentrations were elevated throughout most of Lake Hopatcong again in August, exceeding 12 µg/L everywhere besides Station 11; concentrations exceeded 40 µg/L at Stations 1, 3, and 10. Phycocyanin concentrations were still elevated in September and exceeded 12 µg/L everywhere besides Station 11; concentrations exceeded 40 µg/L at Stations 1, 3, and 10 for the second consecutive month.

ZOOPLANKTON

Zooplankton are the micro-animals that live in the open waters of a lake or pond. Some large-bodied zooplankton are a source of food for forage and/or young gamefish. In addition, many of these large-bodied zooplankton are also herbivorous (i.e. algae eating) and can function as a natural means of controlling excessive algal biomass. Given the important role zooplankton serve in the aquatic food web of lakes and ponds, samples for these organisms were collected at the surface and mid-depths of Station 2 during each monitoring event.

The Cladoceran genera *Bosmina* and *Chydorus*, as well as a diversity of rotifer genera, were common at Station 2 in May. In total, there were 9 zooplankton genera identified at the surface and 10 genera identified at mid-depth, with representation from the three major groups: Cladocerans, copepods, and rotifers. Zooplankton richness increased slightly at the surface of Station 2 in June, with a total of 11 genera identified at the surface and 10 genera identified at mid-depth. The larger herbivorous Cladocerans increased in diversity as well, with four genera identified at the surface and three genera identified at mid-depth; the Cladoceran genus *Bosmina* was common at both depths. The zooplankton community remained relatively diverse in late July, with a total of 11 genera identified at the surface and 13 genera identified at mid-depth. However, the zooplankton community was dominated by the smaller rotifers, with the genera *Ascomorpha* and *Conochilus* being the most abundant at both depths. At least three Cladoceran genera were identified in each sample as well and *Bosmina* was common at mid-depth. Copepod nauplii were common in both samples.

The zooplankton community increased in genera richness in late August, mainly due to an increase in rotifer diversity; 9 rotifer genera were identified at the surface and 7 rotifer genera at mid-depth. Cladoceran diversity remained consistent with the previous month, but overall abundance of Cladocerans decreased. Rotifers dominated the zooplankton community again in September, but Cladoceran diversity and abundance did increase at the surface and mid-depth. In summary, the zooplankton community remained abundant and diverse throughout the season, but as the summer progressed and cyanobacteria began to dominate the phytoplankton community, the rotifers dominated the zooplankton community.

3.4 RECREATIONAL FISHERY AND POTENTIAL BROWN TROUT HABITAT

Of the recreational gamefish that reside or are stocked in Lake Hopatcong, trout are the most sensitive in terms of water quality. For their sustained management, all species of trout require DO concentrations of at least 4.0 mg/L or greater. However, the State's designated water quality criteria to sustain a healthy, aquatic ecosystem is a DO concentration of at least 5.0 mg/L.

While all trout are designated as cold-water fish, trout species display varying levels of thermal tolerance. Brown trout (*Salmo trutta*) have an <u>optimal</u> summer water temperature range of 18.00 to 24.00 °C (65 to 75 °F) (USEPA, 1994). However, these fish can survive in waters as warm as 26.00 °C (79.00 °F) (Scott and Crossman, 1973), defined here as acceptable habitat. The 2023 temperature and DO data for Lake Hopatcong were examined to identify the presence of optimal and acceptable brown trout habitat. As with previous monitoring reports, this analysis focused primarily on *in-situ* data collected at the mid-lake sampling station (Station 2).

For the sake of this analysis, sections of the lake that had DO concentrations equal to or greater than 5.0 mg/L and water temperatures less than 24.00 °C were considered optimal habitat for brown trout. In contrast, sections of the lake that had DO concentrations equal to or greater than 5.0 mg/L and water temperatures between 24.00 and 26.00 °C were considered acceptable or carry over habitat for brown trout.

A separate brown trout (*Salmo trutta*) study was also conducted over the course of the 2023 season for the second consecutive year. This study involved the stocking of 1,000 tagged trout, larger than the trout stocked by the state, to determine if the increase in mass and fat reserves gives them an advantage in holding over through the hot summer months. The stocking of the tagged trout was funded by the Lake Hopatcong Commission, Foundation, and the Knee-Deep Club. Additionally, the Highlands Council funded a study to collect additional, high-frequency water quality data to better define carryover habitat in the lake. The Highlands Council grant also includes the analysis of trout data garnered from tag data and creel surveys and a report that synthesizes those elements to manage the trout fishery and trout carryover habitat of Lake Hopatcong. A separate report will be submitted in 2024 that includes all of these elements.

Optimal brown trout habitat was present in the upper 10.70 m of the lake on 11 May. By mid-June, optimal brown trout habitat was reduced to the upper 6.95 m of the water column at Station 2 due to anoxic conditions present in the hypolimnion. Carryover habitat was available at these same depth intervals in May and June since the limiting factor was low DO in the hypolimnion rather than elevated temperatures near the surface.

In-situ sampling conducted on 5 July as part of the trout study revealed limited optimal brown trout habitat throughout the lake as a result of increasing temperatures in the epilimnion as well as anoxic conditions creeping upwards in the water column. *In-situ* sampling was conducted at approximately 1 ft intervals through the thermocline during the summer to accurately define trout habitat. As such, there was approximately 1.60 m of optimal trout habitat at Station 2 on 5 July; on the same date in 2022, there was only 0.10 m of optimal brown trout habitat. However, there was carryover trout habitat present in approximately 5.00 m of the water column at Station 2 on the same date in 2023.

Weekly sampling through 7 August revealed that there was no optimal trout habitat present on any of the days that Princeton Hydro monitored the lake. However, carryover habitat was available later into the season and eventually proved to be extremely dynamic on a weekly basis throughout the summer months.

On 11 July, there was carryover habitat present in the upper 4.80 m of Station 2. Carryover habitat was more compressed on 17 July, with approximately 2.00 m of available habitat, between depths of 2.30 m and 4.30 m. Carryover habitat became extremely limited on 24 July, with only 0.25 m of available habitat at Station 2, from approximately 4.05 m to 4.30 m. However, during the next sampling event on 1 August there was carryover habitat present in the upper 5.80 m of Station 2. There was a slight cooling at all stations on 1 August near the surface, and four of the five stations fell back under the 26.0 °C threshold thereby extending the habitat to the surface at those locations. Water temperatures continued to cool over the following week which resulted in a slight shrinking of the epilimnion and carryover trout habitat, present in the upper 4.50 m at Station 2.

As water temperatures in the epilimnion continued to decrease over the following week, optimal trout habitat was present at Station 2 for the first time since 5 July. On 14 August, there was approximately 1.40 m of optimal trout habitat and 6.00 m of carryover trout habitat. Optimal brown trout habitat was present in the upper 2.0 m at Station 2 on 21 August, and carryover brown trout habitat was present in the upper 5.70 m. Temperatures throughout the epilimnion were below 24.0 °C on 18 September, resulting in both optimal and carryover brown trout habitat in the upper 6.45 m at Station 2.

3.5 MECHANICAL WEED HARVESTING PROGRAM

Many of the shallower sections of Lake Hopatcong are susceptible to the proliferation of nuisance densities of rooted aquatic plants. Given the size of Lake Hopatcong, the composition of its aquatic plant community, and its heavy and diverse recreational use, mechanical weed harvesting is the most cost effective and ecologically sound method of controlling nuisance weed densities. Thus, the weed harvesting program has been in operation at Lake Hopatcong since the mid-1980's with varying levels of success. However, one consistent advantage mechanical weed harvesting has over other management techniques, such as the application of aquatic herbicides, is that phosphorus is removed from the lake along with the weed biomass. In fact, based on a plant biomass study conducted at Lake Hopatcong in 2006 and the plant harvesting records from 2006 to 2008, approximately 6-8% of the total phosphorus load targeted for reduction under the established TMDL was removed through the mechanical weed harvesting program.

In sharp contrast to the 2006 – 2008 harvesting years, only 1.2% of the phosphorus load targeted for reduction under the TMDL was removed through mechanical weed harvesting during the 2009 growing season. This substantial reduction in the amount of plant biomass and phosphorus removed in 2009 was due to severe budgetary cuts that resulted in laying off the Commission's full time Operation Staff, as well as initiating the harvesting program later in the growing season. However, the 2010 harvesting season resulted in the estimated removal of approximately 6% of the phosphorus load targeted for reduction under the TMDL, similar to the percentages removed in 2006 – 2008.

In contrast to the 2012 growing season, the mechanical weed harvesting program ran longer from 2013 through 2016. This was primarily due to the fact that the program was initiated earlier in these years relative to 2012. NJDEP has directly overseen the operation of the weed harvesting program for the last seven years and each year displays a higher rate of removal, which was attributed to hired staff becoming more familiar with the operations and lake-specific conditions. In addition, the operations staff has been excellent at maximizing high rates of efficiency during harvesting operations.

Due to an extremely unfortunate accident at the initiation of the 2020 harvesting season, the harvesting of aquatic vegetation at Lake Hopatcong was largely postponed over the 2020 growing season. The removal of only 35 cubic yards (16 tons) of plant biomass from Lake Hopatcong in 2020 resulted in the removal of only 3 kgs (6 lbs) of TP from the lake. This was less than 0.1% of the TP load targeted for removal under the TMDL.

Mechanical weed harvested was not conducted over the 2021 growing season. However, the harvesting program was resumed in 2022, resulting in the removal of 1,178 cubic yards (531 tons) of plant biomass. This resulted in the removal of approximately 86 kgs (189 lbs) of TP, which has the potential to produce approximately 208,200 lbs of wet algae biomass. The 189 lbs of TP accounts for 2.6% of the TP targeted for removal under the lake's TMDL.

Approximately 2,198 cubic yards (990 tons) of plant biomass was removed from Lake Hopatcong in 2023, representing the highest rate of removal in recent years. This resulted in the removal of approximately 160 kgs (353 lbs) of TP, which has the potential to produce approximately 388,479 lbs of wet algae biomass. The 353 lbs of TP accounts for 4.9% of the TP targeted for removal under the lake's TMDL.

3.6 INTERANNUAL ANALYSIS OF WATER QUALITY DATA

Annual mean values of Secchi depth, chlorophyll *a*, and TP concentrations were calculated for the years 1991 through 2023. The annual mean values for Station 2 were graphed, along with the long-term mean for the lake, and can be found in Appendix A.

The 2023 mean Secchi depth at Station 2 was 1.30 m which was a decrease of approximately 0.20 m relative to 2022. While this seasonal average is below the long-term mean of 2.03, it is still above the targeted threshold of 1.00 m.

The mean chlorophyll *a* concentration at Station 2 was 15.8 µg/L, which is higher than the targeted mean value of 8.0 µg/L. However, the two highest chlorophyll *a* concentrations at Station 2 occurred early in the season in May and June, with respective concentrations of 22.0 µg/L and 18.0 µg/L. The average chlorophyll *a* concentration from July through September was 13.0 µg/L. The long-term seasonal chlorophyll *a* average at Station 2 is 10.8 µg/L.

The 2023 mean TP concentration at Station 2 was relatively low, with a concentration of 0.020 mg/L, falling well below the targeted threshold of 0.030 mg/L as per the TMDL. The long-term mean TP concentration at the surface of Station 2 is 0.021 mg/L.

3.7 WATER QUALITY IMPAIRMENTS, ESTABLISHED TMDL CRITERIA AND EVALUATION

As identified in N.J.A.C. 7:9B-1.5(g)2, "Except as due to natural condition, nutrients shall not be allowed in concentrations that cause objectionable algal densities, nuisance aquatic vegetation or otherwise render the waters unsuitable for the designated uses." For Lake Hopatcong, these objectionable conditions specifically include both algal blooms and nuisance densities of aquatic vegetation.

As described in detail in the Lake Hopatcong TMDL Restoration Plan, a targeted mean TP concentration, as well as mean and maximum chlorophyll-*a* ecological endpoint, was established to identify compliance with the TMDL. For the sake of this 2023 analysis, the mid-lake (Station 2), Crescent Cove / River Styx (Station 3) and Northern Woodport Bay (Station 10) monitoring stations were reviewed. To provide guidance for this review, the criteria developed under Lake Hopatcong's TMDL are provided below:

TMDL Criteria for Lake Hopatcong

Targeted mean TP concentration	0.03 mg/L
Targeted mean chlorophyll *a* concentration endpoint	8 µg/L
Targeted maximum chlorophyll *a* concentration endpoint	14 µg/L

Surface TP concentrations remained low throughout the 2023 season at Station 2, with the seasonal mean (0.02 mg/L) and each individual event remaining below the targeted mean concentration of 0.03 mg/L recognized under the TMDL. Surface TP concentrations at Station 2 were 0.02 mg/L during each sampling event. The 2023 seasonal mean chlorophyll *a* concentration at Station 2 was 15.8 µg/L. As such, the 2023 average exceeded the targeted mean chlorophyll *a* concentration of 8.0 µg/L. This was largely due to increased chlorophyll *a* concentrations early in the season. Chlorophyll concentrations ultimately ranged from 12.0 µg/L on 21 August to 22.0 µg/L on 11 May. The May and June sampling events exceeded the targeted maximum chlorophyll *a* concentration endpoint of 14.0 µg/L during the 2023 season, with respective concentrations of 22.0 and 18.0 µg/L.

Elevated chlorophyll *a* and TP concentrations were noted at Station 3 at various times throughout the 2023 season. The 2023 mean TP concentration was 0.04 mg/L, exceeding the targeted mean of 0.03 mg/L. 2023 concentrations ranged between 0.02 mg/L and 0.07 mg/L, exceeding 0.03 mg/L in July, August, and September. The seasonal mean chlorophyll *a* concentration at Station 3 was the highest compared to the other sampling stations for the second consecutive year, with an average of 21.9 µg/L; this mean concentration is significantly higher than the targeted mean concentration of 8.0 µg/L. Overall, chlorophyll concentrations ranged from 8.3 µg/L to 30.0 µg/L.

At Station 10, the seasonal TP average was 0.04 mg/L, exceeding the targeted mean. TP concentrations at Station 10 ranged from 0.02 mg/L in October up to 0.06 mg/L in June. Chlorophyll *a* concentrations were variable throughout the 2023 season, ranging between 8.5 µg/L in May and 32.0 µg/L in July. Concentrations exceeded the maximum target of 14.0 µg/L in July (32.0 µg/L), August (21.0 µg/L) and September (27.0 µg/L). The 2023 seasonal average exceeded the 8.0 µg/L targeted mean, yielding concentrations of 20.3 µg/L.

4.0 SUMMARY

This section provides a summary of the 2023 water quality conditions, as well as recommendations on how to preserve the highly valued aquatic resources of Lake Hopatcong.

1. The water column was thermally stratified to varying degrees throughout the growing season at Station 2. DO declined with depth, ultimately declining below the 5.0 mg/L threshold below the epilimnion during each event. From June through September, DO concentrations dropped below 5.0 mg/L at the top of the thermocline as a result of the high oxygen demand during the summer months. By June, anoxic conditions were present above the sediment and remained this way through the last sampling event in September. Anoxic conditions were present in at least the bottom 6.0 m of the water column.

2. While the previous long-term water quality database had value, the HABs experienced in 2019 identified the need to slightly expand the monitoring program. Specifically, soluble reactive phosphorus (SRP) was added to the monitoring program at each sampling station. The plankton monitoring was adjusted, including phytoplankton counts (in particular with the cyanobacteria) at surface and mid-depth. Finally, additional vertical sampling of discrete parameters at Station 2 to cover surface, mid-depth, and deep-water samples were added to the program in 2020. This increased sampling scope was continued during through the 2023 season which allowed for a more detailed analysis of nutrient concentrations throughout the lake and how they may be affecting cyanobacteria densities. An additional station located in Landing Channel was added in 2023. Sampling this station is important in tracking any future improvements in Landing Channel resulting from potential additional PhosLock applications or any dredging that may occur. This increased scope should be continued for future sampling years to continue to bolster the historic database for Lake Hopatcong.

3. It has been well documented that phosphorus is the primary limiting nutrient in Lake Hopatcong. That is, a slight increase in phosphorus will result in a substantial increase in the amount of algal and/or aquatic plant biomass. TP concentrations in the surface water were variable throughout the lake, ranging between 0.02 mg/L and 0.07 mg/L. Elevated TP concentrations at surface stations were often noted in areas with near-shore septic systems. Surface and mid-depth TP concentrations were low throughout the season at Station 2, with maximum concentrations of 0.03 mg/L. Deep water concentrations were elevated from July through September as anoxic conditions persisted, reaching a maximum of 0.42 mg/L on 18 September. Elevated TP in the deep waters is attributed to extended periods of anoxia which results in the internal loading of phosphorus from the sediment.

4. The 2023 season was wet, particularly from June – September, depositing a total of 32.01” of rain from May - September. This is approximately 9.62” more than normal values. Please note that ‘normal’ refers to the monthly averages from 1991 – 2020. As a result, flushing rates were higher during the 2023 growing season. The increased precipitation from June – September likely also resulted in higher TP concentrations at the nearshore stations.

5. There were no significant cyanobacteria blooms or HABS in Lake Hopatcong in 2023 like the bloom that occurred in Crescent Cove in 2022. However, cyanobacteria concentrations in Crescent Cove were consistently elevated during the summer months; cyanobacteria cell counts ranged between 99,549 cells/mL and 136,310 cells/mL from July – September. Crescent Cove continues to be prone to elevated cyanobacteria concentrations during the summer.

6. Based on the *in-situ* conditions, optimal brown trout habitat was present in the upper 10.70 m of Station 2 in May, the upper 6.95 m of the lake in June, 1.60 m on 5 July, 1.40 m on 14 August, 2.00 m on 21 August, and the upper 6.45 m on 18 September. Besides the 1.60 m of optimal brown trout habitat on 5 July, the rest of July and early August was too hot and there was no optimal brown trout habitat available in the lake. However, carryover brown trout habitat was present in varying degrees throughout the entire

season. Brown trout habitat became limited during the peak summer months as a result of low DO concentrations creeping upwards and warm temperatures creeping down. However, unlike the 2022 season in which there were two separate monitoring events with no carryover brown trout habitat present in the lake, carryover habitat never disappeared in 2023.

7. A mechanical weed harvesting program has been in operation at Lake Hopatcong since the early 1980s. Over the 2023 growing season approximately 2,198 cubic yards (990 tons) of plant biomass was removed. This resulted in the removal of approximately 353 lbs of TP, which has the potential to produce approximately 388,479 lbs of wet algae biomass. The 353 lbs of TP accounts for 4.9% of the TP targeted for removal under the lake's TMDL.

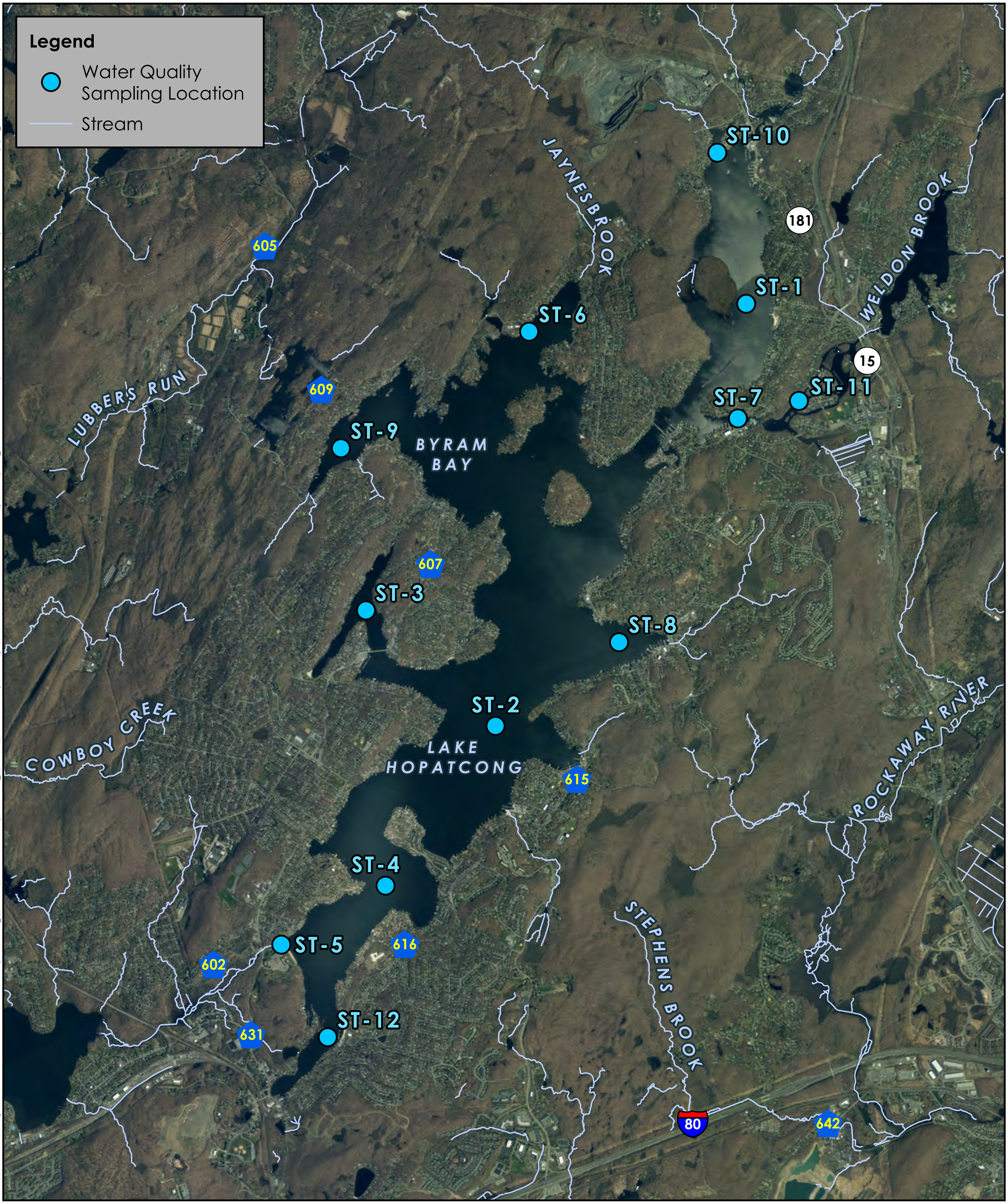
8. While the 2023 mean surface water, mid-lake TP concentration remained in compliance with the targeted concentration under the lake's TMDL, other near-shore stations had higher mean values. In addition, the mean 2023 Secchi depth at the mid-lake station was the lowest recorded (Appendix A). However, as previously noted slightly over 32" of rain fell from May – September, which contributed to these lower water clarity values.

9. While the frequent and large storms contributed to the increased turbidity in 2023, it was not the only factor contributing to the observed conditions. Over the last ten years, the 2023 mean, mid-lake chlorophyll-a value was the third highest, exceeding the mean value from 2019 (Appendix A). While not as high as the mean values from 2014 and 2020, the 2023 mean value does indicate that the cyanobacteria were being sustained in their growth. Since the surface water TP concentrations, particularly in the mid-lake section of the lake were low, more than likely the genera found in the open waters were being fueled by taking advantage of the lake's high internal phosphorus load. Indeed, the dominant genera, *Aphanizomenon* and *Dolichospermum*, have gas vacuoles and can quickly move through the water column, fueling up on phosphorus in the deeper waters. Again, these observations continue to emphasize the need to address the lake's internal phosphorus load through nutrient inactivation (alum) and some type of aeration / oxygenation.

10. Finally, it should be noted that in late August *Raphidiopsis raciborskii* (previously named *Cylindrospermopsis raciborskii*) appeared in the shallower sections of the lake and then was found in the mid-lake, open waters by September (Appendix A). Based on these observations as well as those made over the last few years, this pattern of growth and distribution for *Raphidiopsis* is typical since it was identified in Lake Hopatcong a few years ago. Such observations indicate that this genus typically resides along the sediment / water interface in the shallow sections of the lake where nutrient availability is higher than in the open waters. Thus, if this cyanobacteria increases in dominance in Lake Hopatcong, more proactive, innovative measures may need to be considered in the management of the shallow sections of the lake. Additionally, the LHC may want to consider conducting some over-winter assessments of some select near-shore sediments to determine if indeed the *Raphidiopsis* originates from these benthic habitats.

APPENDIX A

Figures



NOTES:
1. Sampling locations are approximate
2. Streams obtained from the United States Geological Survey's (USGS) National Hydrography Dataset (NHD).
3. 2020 orthoimagery obtained from the NJ Geographic Information Network (NJGIN) Open Data portal: https://njgin.nj.gov/

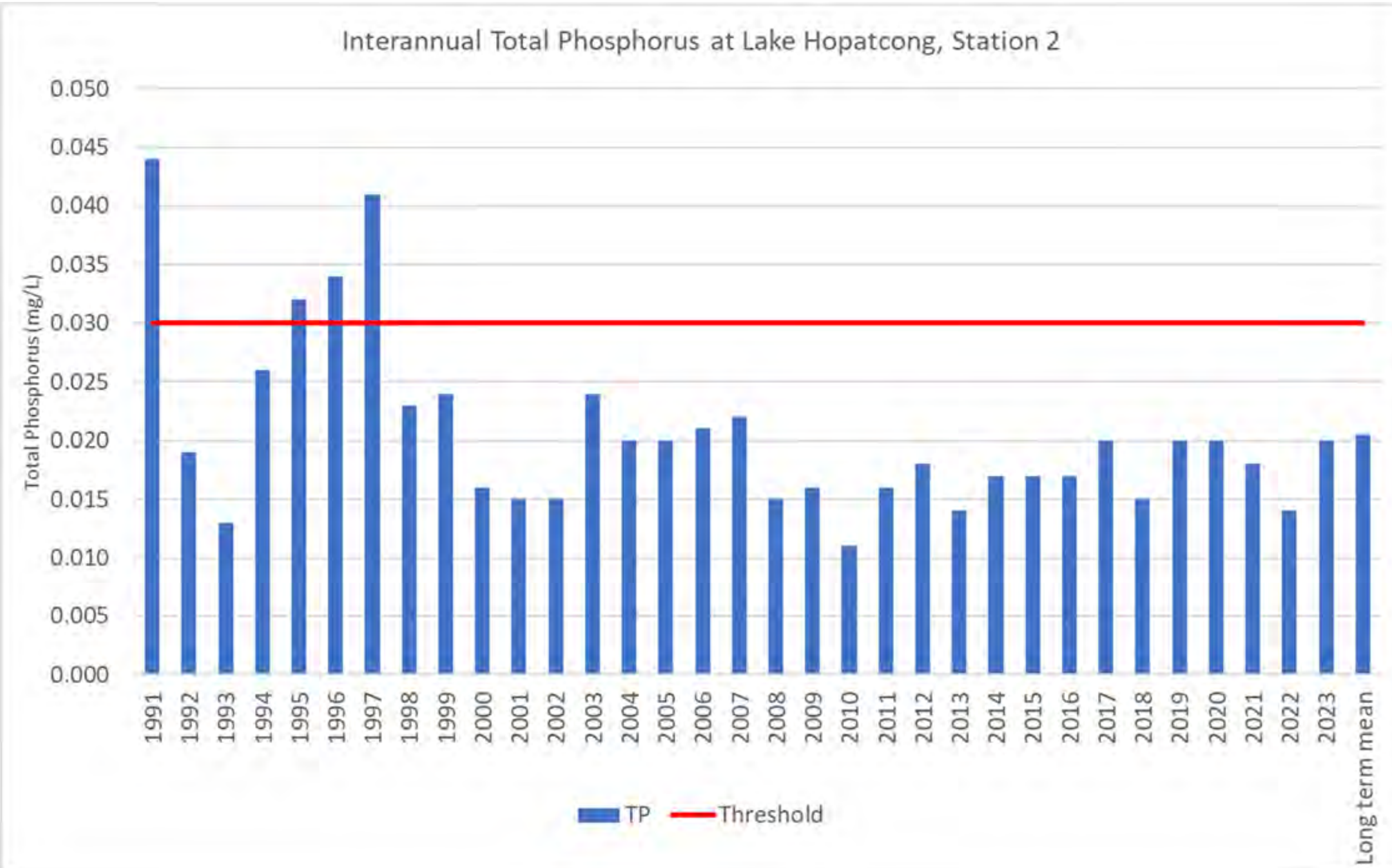
0 2,000 4,000 Feet

Spatial Reference: NAD 1983 StatePlane New Jersey FIPS 2900 Feet

STANDARD WATER QUALITY SAMPLING LOCATIONS

LAKE HOPATCONG
LAKE HOPATCONG COMMISSION
SUSSEX AND MORRIS COUNTIES, NEW JERSEY

PRINCETON HYDRO
SCIENCE DESIGN ENGINEERING
www.PrincetonHydro.com


Interannual Total Phosphorus at Lake Hopatcong, Station 2
Total Phosphorus (mg/L)
0.050
0.045
0.040
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
1991
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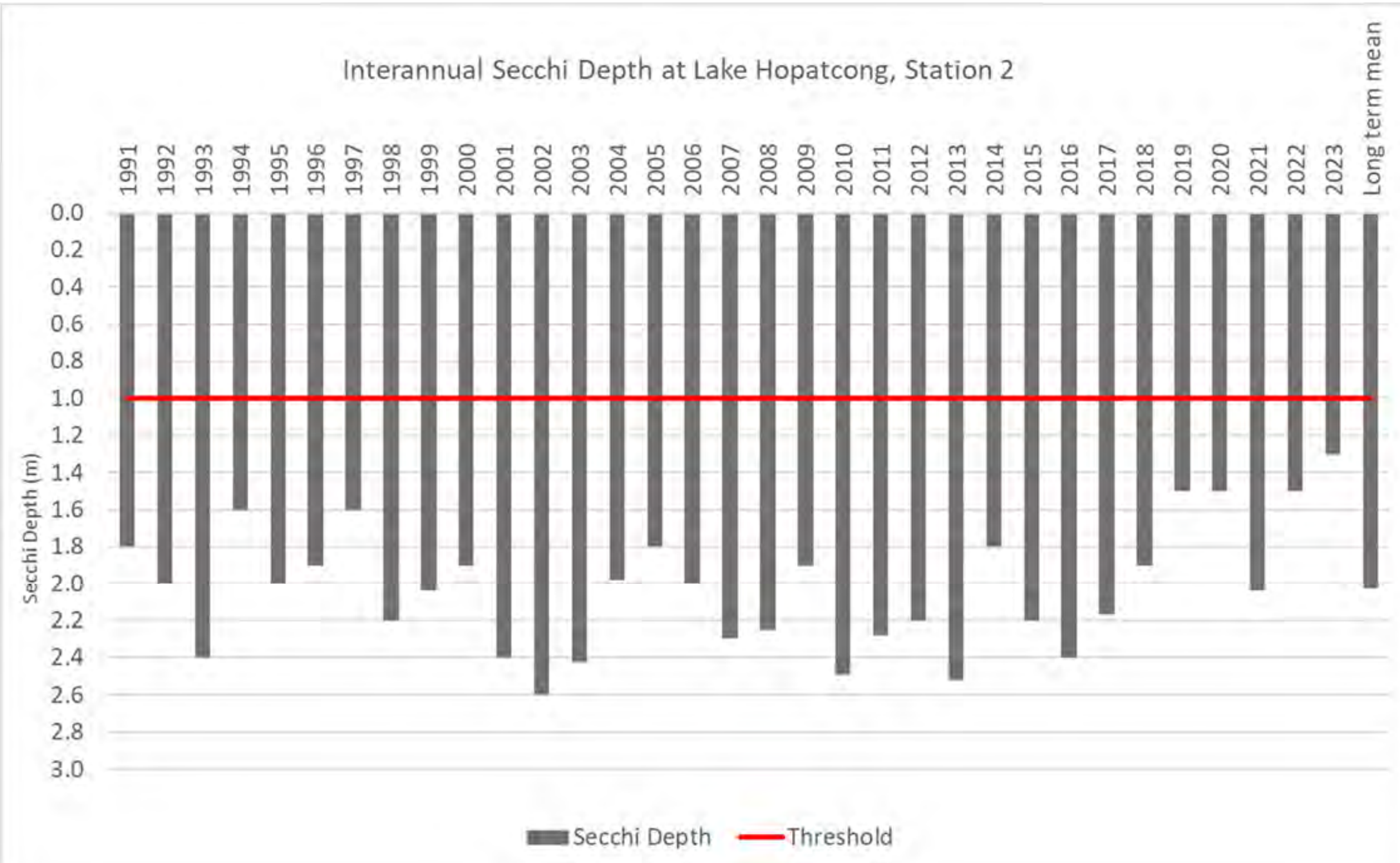
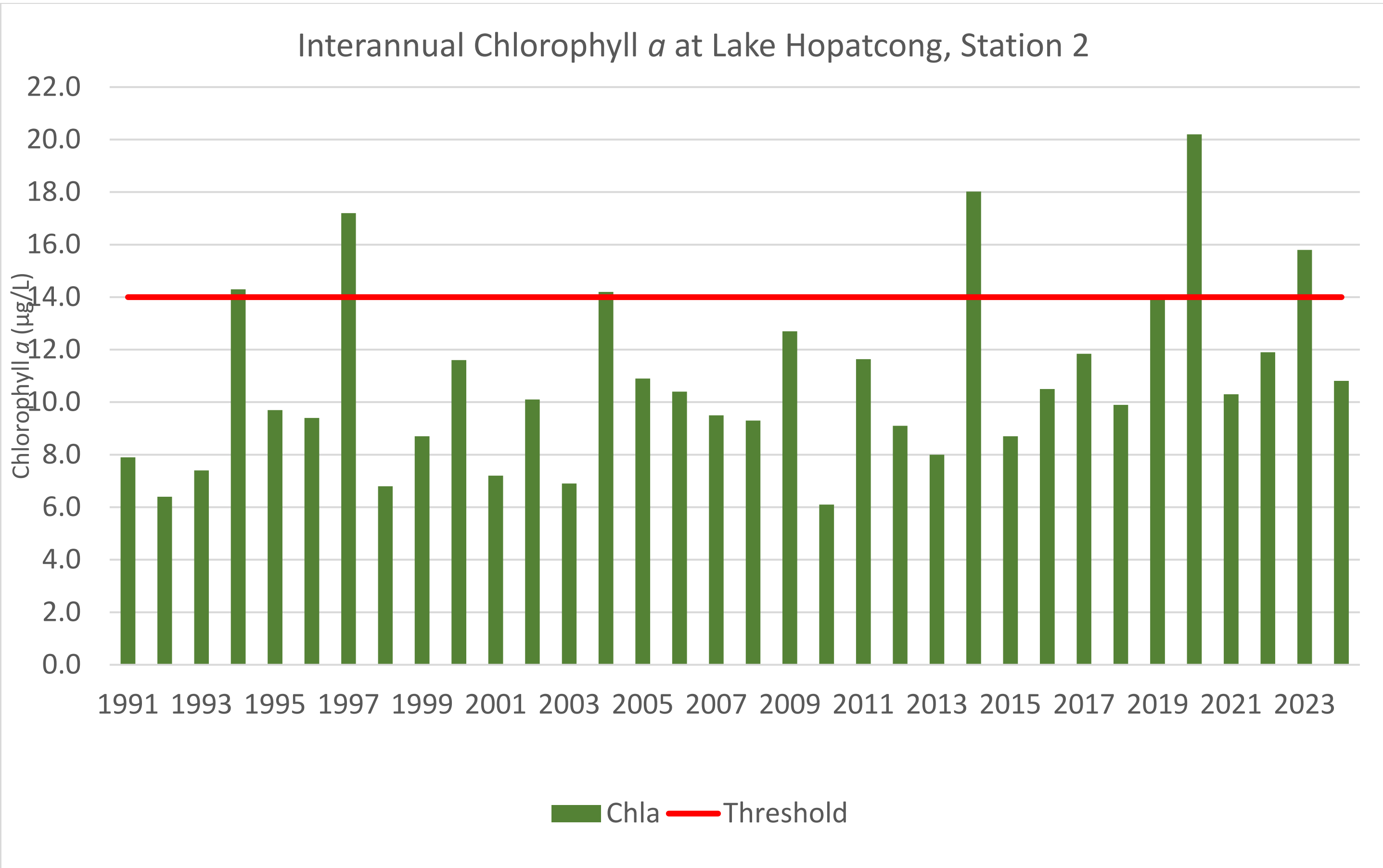
2019
2020
2021
2022
2023
Long term mean
TP
Threshold


Interannual Secchi Depth at Lake Hopatcong, Station 2
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
Long term mean
Secchi Depth (m)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
2.6
2.8
3.0
Secchi Depth
Threshold


Interannual Chlorophyll *a* at Lake Hopatcong, Station 2
Chlorophyll *a* (µg/L)
22.0
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
1991 1993 1995 1997 1999 2001 2003 2005 2007 2009 2011 2013 2015 2017 2019 2021 2023
Chla
Threshold

APPENDIX B

In-Situ Data

***In-Situ* Monitoring for Lake Hopatcong 5/11/2023**										
Station	**Depth (meters)**			**Temperature**	**Specific Conductance**	**Dissolved Oxygen**		**pH**	**Phycocyanin**	**Chlorophyll *a***
	Total	**Secchi**	**Sample**	**°C**	**mS/cm**	**mg/L**	**% Sat.**	**S.U.**	**RFU**	**RFU**
STA-1	2.30	1.80	0.1	18.49	0.426	11.27	123.8	8.58		
			1.0	18.33	0.428	11.55	126.1	8.51		
			2.0	17.31	0.429	10.87	115.5	7.99		
STA-2	14.20	1.50	0.1	16.81	0.441	11.99	126.7	8.79	0.044	0.677
			1.0	16.83	0.441	12.10	127.8	8.78	0.486	1.539
			2.0	16.16	0.437	12.00	124.4	8.72	0.378	1.742
			3.0	15.29	0.440	11.30	115.5	8.39	0.393	1.583
			4.0	14.47	0.449	10.68	107.0	8.12	0.352	2.108
			5.0	13.58	0.446	9.97	98.1	7.87	0.359	2.361
			6.0	12.13	0.455	8.72	82.8	7.56	0.332	2.114
			7.0	11.83	0.458	8.29	78.5	7.36	0.431	1.404
			8.0	11.58	0.459	7.86	74.0	7.23	0.404	1.197
			9.0	11.20	0.458	6.94	64.5	7.10	0.418	0.987
			10.0	10.61	0.460	5.91	54.4	6.98	0.377	0.953
			11.0	9.94	0.462	4.66	42.2	6.85	0.557	0.447
			12.0	9.45	0.462	4.36	39.0	6.80	0.542	0.557
			13.0	9.14	0.464	3.65	32.4	6.74	0.519	0.424
			14.0	8.84	0.467	2.41	20.9	6.65	0.127	1.953
STA-3	2.30	1.70	0.1	17.89	0.761	13.81	149.6	9.13		
			1.0	17.24	0.740	13.81	147.4	9.06		
			2.0	16.80	0.755	13.54	143.0	8.98		
STA-4	3.20	1.10	0.1	17.72	0.448	13.32	143.4	9.32		
			1.0	17.70	0.447	13.39	144.1	9.33		
			2.0	16.26	0.444	12.67	132.2	9.04		
			3.0	13.05	0.467	3.36	32.7	7.66		
STA-5	2.60	1.50	0.1	17.72	0.450	13.92	140.6	9.61		
			1.0	17.27	0.447	14.44	153.9	9.67		
			2.0	13.89	0.458	10.31	102.3	8.29		
STA-6	3.00	1.90	0.1	16.47	0.438	11.35	119.3	8.35		
			1.0	15.72	0.440	11.44	117.8	8.09		
			2.0	15.30	0.442	11.44	117.3	8.02		
			2.5	14.86	0.445	10.75	109.2	7.81		
STA-7	1.80	1.60	0.1	18.69	0.151	8.83	97.1	7.81		
			1.0	18.23	0.184	8.69	94.4	7.61		
			1.5	17.73	0.183	8.49	91.3	7.47		
STA-8	5.50	1.50	0.1	16.89	0.431	11.38	120.7	8.60		
			1.0	16.56	0.433	11.54	121.2	8.54		
			2.0	16.31	0.431	11.56	120.9	8.53		
			3.0	16.24	0.432	11.51	120.0	8.43		
			4.0	15.97	0.433	11.25	116.8	8.25		
			5.0	15.18	0.437	10.68	109.0	8.00		
STA-9	8.00	1.40	0.1	16.84	0.447	11.39	120.5	8.95		
			1.0	15.55	0.447	11.67	120.1	8.08		
			2.0	14.83	0.447	11.49	116.3	7.93		
			3.0	14.41	0.448	11.27	113.9	7.74		
			4.0	14.05	0.448	10.85	108.2	7.58		
			5.0	13.81	0.451	10.43	103.2	7.45		
			6.0	13.54	0.454	10.04	99.0	7.35		
			7.0	12.44	0.453	8.67	83.3	7.13		
			7.5	11.64	0.461	5.00	47.4	6.96		
STA-10	1.30	1.30	0.1	18.11	0.475	14.51	158.6	8.88		
			1.0	17.39	0.477	18.88	201.6	9.14		
STA-11	1.20	1.20	0.1	18.22	0.147	8.88	96.5	7.51		
			1.0	17.42	0.152	8.67	92.8	7.38		
STA-12	2.00	1.40	0.1	18.67	0.469	11.76	129.2	9.36		
			1.0	18.53	0.469	11.58	126.7	9.34		
			1.5	18.41	0.469	11.44	125.0	9.34		

In-Situ Monitoring for Lake Hopatcong 6/13/2023										
Station	Depth (meters)			Temperature	Specific Conductance	Dissolved Oxygen		pH	Phycocyanin	Chlorophyll *a*
	Total	Secchi	Sample	°C	mS/cm	mg/L	% Sat.	S.U.	RFU	RFU
STA-1	2.30	1.10	0.1	21.02	0.440	8.78	102.4	7.58		
			1.0	20.86	0.441	8.69	101.2	7.65		
			1.5	20.72	0.442	8.58	99.6	7.88		
STA-2	14.20	1.20	0.1	19.99	0.464	9.25	105.9	8.01	1.097	0.043
			1.0	19.97	0.463	9.24	105.8	8.04	1.800	0.088
			2.0	19.90	0.464	9.21	105.1	8.03	1.029	0.157
			3.0	19.77	0.465	9.07	103.8	7.96	1.100	0.335
			4.0	19.69	0.465	8.80	99.9	7.89	0.924	0.131
			5.0	19.65	0.465	8.62	98.0	7.82	0.971	0.354
			6.0	19.11	0.465	7.79	87.6	7.66	0.836	0.189
			7.0	17.40	0.459	4.93	53.6	7.36	0.000	0.033
			8.0	15.85	0.453	2.63	27.0	7.18	0.454	0.022
			9.0	12.97	0.457	0.63	6.2	7.03	0.764	0.020
			10.0	12.14	0.459	0.24	2.2	6.85	0.762	0.013
			11.0	11.38	0.464	0.06	0.5	6.68	0.881	0.016
			12.0	10.55	0.472	0.01	0.0	6.61	1.005	0.019
			13.0	9.95	0.480	0.00	0.0	6.55	0.886	0.009
			13.5	9.94	0.488	0.00	0.0	6.84	0.920	0.013
STA-3	2.30	1.00	0.1	21.80	0.714	8.46	99.2	7.52		
			1.0	21.20	0.714	8.10	95.0	7.61		
			2.0	20.98	0.672	7.71	90.0	7.60		
STA-4	3.20	0.80	0.1	20.32	0.477	8.16	94.0	7.36		
			1.0	20.40	0.475	7.92	91.4	7.40		
			2.0	30.36	0.475	7.78	89.7	7.44		
			2.5	20.30	0.476	7.32	84.3	7.37		
STA-5	3.20	0.75	0.1	21.53	0.497	8.65	101.2	7.28		
			1.0	21.30	0.496	8.25	96.1	7.38		
			2.0	21.12	0.496	7.50	87.7	7.41		
			3.0	20.85	0.499	6.03	70.1	7.32		
STA-6	3.20	1.20	0.1	20.96	0.463	8.89	103.7	7.47		
			1.0	20.70	0.461	8.92	103.5	7.60		
			2.0	20.26	0.462	8.44	97.1	7.63		
			3.0	18.98	0.460	7.15	79.5	7.51		
STA-7	1.80	1.50	0.1	21.48	0.397	7.50	88.4	7.49		
			1.0	21.47	0.396	6.91	81.2	7.42		
			1.5	21.31	0.396	6.52	76.6	7.39		
STA-8	5.50	1.30	0.1	19.93	0.463	9.25	105.6	8.00		
			1.0	19.92	0.463	9.24	105.5	8.02		
			2.0	19.90	0.463	9.21	105.1	8.04		
			3.0	19.89	0.463	9.17	104.7	8.04		
			4.0	19.89	0.463	9.15	104.4	8.04		
			5.0	19.78	0.463	9.10	103.7	8.01		
STA-9	8.00	1.30	0.1	20.44	0.464	9.75	112.7	8.12		
			1.0	20.44	0.464	9.81	113.4	8.21		
			2.0	20.40	0.463	9.79	112.9	8.19		
			3.0	20.20	0.462	9.28	106.1	8.03		
			4.0	18.50	0.458	6.89	76.4	7.76		
			5.0	16.38	0.457	2.79	29.6	7.35		
			6.0	14.25	0.459	0.85	8.6	7.14		
			7.0	13.16	0.464	0.33	3.0	7.01		
			7.5	12.30	0.471	0.13	1.2	6.85		
STA-10	1.30	0.70	0.1	21.46	0.509	7.45	87.2	7.60		
			1.0	21.17	0.499	7.90	92.5	7.85		
STA-11	1.20	1.10	0.1	20.83	0.318	7.41	84.9	7.50		
			1.0	20.37	0.331	6.68	76.6	7.31		
STA-12	2.00	0.75	0.1	20.52	0.502	6.93	80.2	7.30		
			1.0	20.47	0.498	6.93	80.2	7.32		
			1.5	20.50	0.500	6.67	77.1	7.30		

In-Situ Monitoring for Lake Hopatcong 7/24/2023										
Station	Depth (meters)			Temperature	Specific Conductance	Dissolved Oxygen		pH	Phycocyanin	Chlorophyll *a*
	Total	Secchi	Sample	°C	mS/cm	mg/L	% Sat.	S.U.	RFU	RFU
STA-1	2.30	0.70	0.1	26.64	0.316	7.96	101.8	7.47		
			1.0	26.64	0.351	7.91	101.2	7.45		
			1.5	26.51	0.352	7.31	93.3	7.38		
STA-2	14.20	1.10	0.1	26.50	0.432	8.82	112.7	8.30	1.026	0.426
			1.0	26.51	0.431	8.82	112.7	8.31	0.225	0.550
			2.0	26.46	0.432	8.76	111.7	8.25	0.301	0.495
			3.0	26.30	0.430	8.45	107.6	8.11	0.199	0.748
			4.0	26.06	0.430	7.83	99.0	7.86	0.366	0.894
			4.3	25.25	0.435	5.06	63.9	7.45	0.401	0.788
			4.6	24.95	0.443	4.55	56.5	7.36	0.577	0.301
			5.0	23.94	0.445	1.95	23.2	7.14	1.471	0.044
			6.0	22.08	0.456	0.00	0.0	6.98	2.286	0.036
			7.0	19.06	0.469	0.00	0.0	6.93	2.246	0.112
			8.0	15.31	0.469	0.00	0.0	6.88	2.434	0.018
			9.0	13.84	0.472	0.00	0.0	6.90	2.336	0.015
			10.0	12.90	0.470	0.00	0.0	6.90	2.310	0.009
			11.0	12.09	0.475	0.00	0.0	6.89	2.325	0.011
			12.0	11.48	0.477	0.00	0.0	6.89	2.199	0.011
			13.0	10.85	0.484	0.00	0.0	6.84	2.058	0.015
			14.0	10.51	0.488	0.00	0.0	6.89	2.018	0.013
STA-3	2.30	0.60	0.1	27.14	0.576	10.45	135.1	8.49		
			1.0	27.07	0.578	10.40	134.1	8.51		
			2.0	26.39	0.601	9.00	114.6	8.12		
STA-4	2.80	1.00	0.1	26.93	0.376	8.60	110.8	8.03		
			1.0	26.74	0.418	8.51	109.3	8.00		
			2.0	25.86	0.411	6.80	86.0	7.67		
			2.5	25.50	0.411	5.54	69.1	7.49		
STA-5	2.80	0.80	0.1	27.55	0.500	9.15	118.8	8.13		
			1.0	26.86	0.417	9.24	118.5	8.18		
			2.0	26.32	0.426	7.42	92.5	7.76		
			2.5	26.22	0.427	6.35	80.5	7.54		
STA-6	2.90	1.00	0.1	26.94	0.361	8.10	104.2	7.22		
			1.0	26.77	0.373	8.00	102.6	7.37		
			2.0	26.56	0.378	7.39	94.7	7.38		
			2.7	26.29	0.381	6.48	81.0	7.27		
STA-7	1.80	0.90	0.1	26.26	0.132	7.04	89.5	7.22		
			1.0	25.84	0.190	6.24	77.8	7.09		
			1.5	24.74	0.159	4.85	59.9	6.90		
STA-8	7.30	1.00	0.1	27.07	0.382	9.05	116.5	8.29		
			1.0	27.01	0.414	9.04	116.5	8.31		
			2.0	26.93	0.415	9.01	116.0	8.29		
			3.0	26.85	0.416	8.82	113.1	8.19		
			4.0	26.64	0.420	8.03	102.8	7.90		
			5.0	26.01	0.421	6.41	80.8	7.54		
			5.3	24.77	0.425	3.86	47.8	7.33		
			6.0	22.18	0.448	0.00	0.0	7.11		
			7.0	19.10	0.463	0.00	0.0	7.01		
STA-9	8.20	1.10	0.1	26.78	0.427	8.88	113.9	7.92		
			1.0	26.72	0.424	8.89	114.0	7.97		
			2.0	26.26	0.427	8.49	107.9	7.86		
			3.0	26.04	0.427	7.43	94.6	7.64		
			4.0	25.74	0.432	6.41	80.7	7.47		
			5.0	25.33	0.439	4.64	57.9	7.26		
			6.0	21.67	0.462	0.00	0.0	7.08		
			7.0	17.83	0.470	0.00	0.0	6.89		
			8.0	15.92	0.474	0.00	0.0	6.85		
STA-10	1.30	0.60	0.1	26.53	0.363	9.27	118.4	7.78		
			1.0	24.88	0.402	8.66	107.3	7.74		
STA-11	1.30	1.30+	0.1	24.79	0.132	4.21	52.1	6.72		
			1.0	24.13	0.177	3.62	43.7	6.63		
STA-12	2.00	0.60	0.1	27.69	0.412	9.08	118.4	7.93		
			1.0	27.29	0.421	8.84	114.1	7.85		
			1.8	26.74	0.423	7.24	92.2	7.65		

In-Situ Monitoring for Lake Hopatcong 8/21/2023										
Station	Depth (meters)			Temperature	Specific Conductance	Dissolved Oxygen		pH	Phycocyanin	Chlorophyll *a*
	Total	Secchi	Sample	°C	mS/cm	mg/L	% Sat.	S.U.	RFU	RFU
STA-1	2.30	0.70	0.1	25.79	0.343	8.94	112.9	7.56		
			1.0	25.34	0.347	8.54	107.2	7.53		
			1.5	24.80	0.348	7.46	92.1	7.44		
STA-2	14.20	1.50	0.1	24.49	0.427	8.57	105.9	7.79	0.349	0.650
			1.0	24.48	0.427	8.55	105.4	7.74	0.108	1.226
			2.0	24.39	0.427	8.44	103.9	7.71	0.110	1.442
			3.0	24.03	0.427	7.70	94.1	7.60	0.173	1.765
			4.0	23.96	0.428	7.80	95.1	7.63	0.008	1.994
			5.0	23.90	0.427	7.34	89.5	7.63	0.153	1.900
			5.3	23.82	0.427	6.80	82.8	7.45	0.082	1.711
			5.6	23.44	0.425	5.13	61.9	7.29	0.270	1.672
			6.0	23.33	0.426	4.77	57.6	7.22	0.318	1.519
			7.0	21.79	0.417	0.00	0.0	6.80	0.675	0.371
			8.0	17.69	0.486	0.00	0.0	7.16	0.962	0.028
			9.0	15.06	0.475	0.00	0.0	7.24	1.045	0.017
			10.0	12.80	0.473	0.00	0.0	7.19	1.115	0.011
			11.0	12.20	0.477	0.00	0.0	7.17	0.935	0.014
			12.0	11.65	0.479	0.00	0.0	7.21	0.845	0.015
			13.0	11.14	0.483	0.00	0.0	7.21	0.896	0.012
			14.0	10.91	0.486	0.00	0.0	7.21	0.768	0.018
STA-3	2.30	0.70	0.1	24.80	0.532	8.37	103.2	7.92		
			1.0	24.58	0.533	7.90	98.1	7.74		
			2.0	24.42	0.531	7.36	90.4	7.66		
STA-4	2.80	1.00	0.1	24.39	0.433	8.39	103.3	7.74		
			1.0	24.35	0.433	8.37	102.9	7.69		
			2.0	24.15	0.433	7.54	92.2	7.58		
			2.7	24.06	0.432	6.48	79.8	7.44		
STA-5	2.80	0.90	0.1	24.58	0.434	8.56	105.7	7.88		
			1.0	24.25	0.434	7.91	96.9	7.78		
			2.0	24.09	0.434	7.67	93.9	7.59		
			2.5	24.02	0.434	7.28	88.7	7.54		
STA-6	2.90	1.20	0.1	25.60	0.419	8.40	112.9	7.84		
			1.0	25.17	0.419	8.77	109.8	7.73		
			2.0	24.42	0.420	8.15	100.5	7.60		
			2.7	24.25	0.421	6.59	80.4	7.49		
STA-7	2.00	0.90	0.1	25.10	0.252	7.75	96.6	7.31		
			1.0	24.38	0.257	6.82	82.8	7.17		
			1.8	23.62	0.249	6.04	73.1	7.64		
STA-8	7.30	1.40	0.1	24.91	0.421	8.80	109.1	7.95		
			1.0	24.59	0.422	8.87	109.5	7.90		
			2.0	24.38	0.424	8.56	105.3	7.74		
			3.0	24.31	0.424	8.05	98.8	7.69		
			4.0	24.24	0.423	8.02	98.4	7.68		
			5.0	23.98	0.433	7.35	89.7	7.66		
			6.0	23.29	0.423	5.00	60.2	7.45		
			7.0	22.00	0.413	0.00	0.0	7.04		
STA-9	8.20	1.30	0.1	25.17	0.426	9.03	112.7	7.97		
			1.0	24.52	0.425	9.02	111.0	7.97		
			2.0	24.30	0.425	8.80	108.3	7.92		
			3.0	24.16	0.426	7.99	98.0	7.77		
			4.0	24.05	0.426	7.63	93.0	7.71		
			5.0	23.76	0.431	6.72	81.5	7.64		
			6.0	22.96	0.427	2.66	31.9	7.32		
			7.0	20.49	0.441	0.00	0.0	7.17		
			8.0	17.27	0.491	0.00	0.0	7.31		
STA-10	1.30	0.60	0.1	25.84	0.361	9.59	120.7	8.04		
			1.0	24.83	0.368	9.26	114.9	7.89		
STA-11	1.30	1.30+	0.1	24.61	0.191	5.48	67.9	6.99		
			1.0	23.52	0.189	4.95	59.8	6.76		
STA-12	1.80	0.90	0.1	24.66	0.438	8.09	99.9	7.70		
			1.0	24.65	0.438	7.97	98.5	7.66		
			1.5	24.44	0.442	6.85	84.3	7.49		

In-Situ Monitoring for Lake Hopatcong 9/18/2023										
Station	Depth (meters)			Temperature	Specific Conductance	Dissolved Oxygen		pH	Phycocyanin	Chlorophyll *a*
	Total	Secchi	Sample	°C	mS/cm	mg/L	% Sat.	S.U.	RFU	RFU
STA-1	2.80	0.80	0.1	21.37	0.348	8.40	99.6	7.44		
			1.0	21.48	0.348	8.45	99.3	7.50		
			2.0	21.42	0.346	8.39	98.5	7.54		
			2.5	21.32	0.343	7.92	92.4	7.54		
STA-2	14.20	1.20	0.1	22.21	0.428	7.44	88.9	7.58	0.340	1.352
			1.0	22.34	0.427	7.42	88.8	7.50	0.188	1.002
			2.0	22.35	0.427	7.40	88.5	7.51	0.172	1.151
			3.0	22.35	0.427	7.44	89.0	7.52	0.071	1.250
			4.0	22.32	0.427	7.40	88.4	7.55	0.109	1.543
			5.0	22.35	0.427	7.39	88.3	7.59	0.082	1.342
			6.0	22.21	0.429	6.43	76.6	7.55	0.225	1.126
			7.0	21.41	0.434	3.31	38.9	7.30	0.384	0.780
			8.0	19.63	0.468	0.00	0.0	7.27	0.883	0.035
			9.0	16.60	0.503	0.00	0.0	7.51	0.963	0.020
			10.0	14.40	0.496	0.00	0.0	7.50	0.899	0.030
			11.0	13..1	0.490	0.00	0.0	7.33	0.898	0.021
			12.0	11.92	0.487	0.00	0.0	7.22	0.962	0.014
			13.0	11.47	0.491	0.00	0.0	7.17	0.435	0.016
			14.0	10.82	0.496	0.00	0.0	7.09	0.710	0.021
STA-3	2.30	0.60	0.1	21.42	0.486	7.69	90.3	7.64		
			1.0	21.43	0.485	7.68	90.3	7.60		
			1.9	21.46	0.482	7.61	89.5	7.57		
STA-4	3.10	1.20	0.1	21.94	0.436	8.27	98.2	7.73		
			1.0	22.02	0.427	8.24	97.9	7.65		
			2.0	21.87	0.430	8.13	96.3	7.66		
			2.9	21.70	0.433	6.80	80.4	7.54		
STA-5	3.20	0.90	0.1	21.40	0.430	8.22	96.5	7.83		
			1.0	21.37	0.431	7.85	92.0	7.73		
			2.0	21.37	0.431	7.68	90.1	7.60		
			3.0	21.37	0.431	7.57	88.8	7.57		
STA-6	3.20	1.30	0.1	21.64	0.420	6.55	77.3	7.31		
			1.0	21.77	0.419	6.48	76.6	7.20		
			2.0	21.80	0.419	6.47	78.7	7.19		
			2.9	21.68	0.418	6.39	75.8	7.17		
STA-7	1.80	1.50	0.1	20.33	0.248	7.38	84.9	7.35		
			1.0	20.44	0.246	7.26	83.4	7.14		
			1.5	20.13	0.223	6.40	73.2	7.10		
STA-8	7.30	1.20	0.1	22.28	0.425	7.64	91.4	7.56		
			1.0	22.30	0.426	7.64	91.3	7.51		
			2.0	22.30	0.426	7.62	91.0	7.51		
			3.0	22.35	0.425	7.59	90.8	7.52		
			4.0	22.32	0.425	7.56	90.4	7.54		
			5.0	22.29	0.425	7.53	89.9	7.56		
			6.0	22.27	0.424	7.33	87.4	7.59		
			7.0	22.21	0.425	7.12	84.4	7.61		
STA-9	8.20	1.10	0.1	21.45	0.422	6.53	77.6	7.22		
			1.0	22.03	0.422	6.47	76.7	7.13		
			2.0	22.01	0.422	6.49	77.3	7.13		
			3.0	22.02	0.422	6.48	77.2	7.15		
			4.0	22.02	0.422	6.23	73.9	7.17		
			5.0	21.99	0.422	6.19	73.5	7.20		
			6.0	21.98	0.422	6.01	71.3	7.24		
			7.0	21.90	0.423	4.49	52.3	7.22		
			8.0	21.70	0.432	3.54	41.2	7.15		
STA-10	1.30	0.70	0.1	20.96	0.355	8.41	98.2	7.68		
			1.0	20.94	0.367	8.25	96.0	7.61		
STA-11	1.30	1.30+	0.1	19.91	0.222	5.90	67.3	7.00		
			1.0	19.96	0.202	5.89	66.7	6.79		
STA-12	1.80	0.80	0.1	21.07	0.433	7.97	92.9	7.72		
			1.0	21.12	0.433	7.84	91.5	7.60		
			1.5	21.09	0.440	7.53	87.7	7.52		

APPENDIX C

Discrete Data

Discrete Data 5/11/2023						
STATION	**Chlorophyll a (ug/L)**	**NH3-N (mg/L)**	**NO3-N (mg/L)**	**SRP (mg/L)**	**TP (mg/L)**	**TSS (mg/L)**
ST-1	10.0	0.01	0.04	ND <0.003	0.02	ND<2
ST-2 SURFACE	22.0	ND<0.01	0.04	ND <0.003	0.02	ND<2
ST-2 MID	11.0	0.01	0.06	ND <0.003	0.02	2
ST-2 DEEP		0.01	0.08	ND <0.003	0.02	3
ST-3	8.3	ND<0.01	0.52	ND <0.003	0.02	2
ST-4	47.0	ND<0.01	0.05	ND <0.003	0.04	ND<2
ST-5	3.6	0.02	0.02	ND <0.003	0.01	ND<2
ST-6	7.6	ND<0.01	0.05	ND <0.003	0.01	2
ST-7	9.7	ND<0.01	0.15	ND <0.003	0.02	ND<2
ST-10	8.5	ND<0.01	0.96	ND <0.003	0.02	2
ST-11	5.1	ND<0.01	0.15	ND <0.003	0.02	4
ST-12	14.0	ND<0.01	0.03	ND <0.003	0.03	2
Surface Mean	**13.6**	**0.01**	**0.20**	**0.002**	**0.02**	**1.7**

Discrete Data 6/13/2023						
STATION	**Chlorophyll a (ug/L)**	**NH3-N (mg/L)**	**NO3-N (mg/L)**	**SRP (mg/L)**	**TP (mg/L)**	**TSS (mg/L)**
ST-1	13.0	0.01	0.03	ND <0.003	0.02	4
ST-2 SURFACE	18.0	ND <0.01	ND <0.03	ND <0.003	0.02	4
ST-2 MID	17.0	ND <0.01	ND <0.03	ND <0.003	0.02	5
ST-2 DEEP		0.01	0.04	ND <0.003	0.04	8
ST-3	23.0	ND <0.01	0.07	ND <0.003	0.03	13
ST-4	22.0	ND <0.01	ND <0.03	ND <0.003	0.04	6
ST-5	31.0	ND <0.01	ND <0.03	ND <0.003	0.04	6
ST-6	22.0	ND <0.01	ND <0.03	ND <0.003	0.02	3
ST-7	7.6	ND <0.01	0.05	ND <0.003	0.03	8
ST-10	13.0	ND <0.01	0.12	ND <0.003	0.06	9
ST-11	7.2	ND <0.01	0.08	ND <0.003	0.03	5
ST-12	28.0	ND <0.01	0.03	ND <0.003	0.05	6
Surface Mean	**18.5**	**0.01**	**0.04**	**0.002**	**0.03**	**6.4**

Discrete Data 7/24/2023						
STATION	**Chlorophyll a (ug/L)**	**NH3-N (mg/L)**	**NO3-N (mg/L)**	**SRP (mg/L)**	**TP (mg/L)**	**TSS (mg/L)**
ST-1	23.0	0.01	0.06	ND <0.003	0.05	14
ST-2 SURFACE	13.0	0.01	0.03	ND <0.003	0.02	3
ST-2 MID	9.3	0.01	ND <0.03	ND <0.003	0.03	5
ST-2 DEEP		0.24	0.14	0.004	0.23	6
ST-3	23.0	0.02	0.10	ND <0.003	0.05	14
ST-4	15.0	0.01	ND <0.03	ND <0.003	0.03	6
ST-5	24.0	0.01	0.03	ND <0.003	0.04	13
ST-6	16.0	0.01	0.03	ND <0.003	0.03	7
ST-7	18.0	0.01	0.11	0.003	0.04	8
ST-10	32.0	0.01	0.07	ND <0.003	0.05	7
ST-11	2.6	0.01	0.10	ND <0.003	0.04	4
ST-12	27.0	0.01	0.05	ND <0.003	0.05	11
Surface Mean	**19.4**	**0.01**	**0.06**	**0.002**	**0.04**	**8.7**

Discrete Data 8/21/2023						
STATION	**Chlorophyll a (ug/L)**	**NH3-N (mg/L)**	**NO3-N (mg/L)**	**SRP (mg/L)**	**TP (mg/L)**	**TSS (mg/L)**
ST-1	24.0	0.01	0.03	ND<0.003	0.05	4
ST-2 SURFACE	12.0	0.02	ND<0.03	ND<0.003	0.02	ND<2
ST-2 MID	8.5	0.02	0.03	ND<0.003	0.02	ND<2
ST-2 DEEP		0.03	0.15	0.020	0.20	ND<2
ST-3	30.0	0.03	ND<0.03	ND<0.003	0.07	10
ST-4	12.0	0.01	0.04	0.004	0.04	4
ST-5	18.0	0.01	ND<0.03	ND<0.003	0.04	4
ST-6	12.0	0.01	ND<0.03	ND<0.003	0.03	ND<2
ST-7	12.0	ND<0.01	0.03	ND<0.003	0.04	ND<2
ST-10	21.0	0.01	0.26	ND<0.003	0.05	10
ST-11	4.6	0.01	0.04	0.003	0.03	ND<2
ST-12	22.0	0.01	0.06	ND<0.003	0.05	5
Surface Mean	**16.8**	**0.01**	**0.05**	**0.002**	**0.04**	**4.1**

Discrete Data 9/18/2023						
STATION	**Chlorophyll a (ug/L)**	**NH3-N (mg/L)**	**NO3-N (mg/L)**	**SRP (mg/L)**	**TP (mg/L)**	**TSS (mg/L)**
ST-1	26.0	0.03	ND<0.07	0.007	0.03	13
ST-2 SURFACE	14.0	0.02	ND<0.07	0.006	0.02	6
ST-2 MID	6.5	0.05	ND<0.07	0.004	0.02	6
ST-2 DEEP		0.50	0.13	0.020	0.42	9
ST-3	25.0	0.02	ND<0.07	0.001	0.04	6
ST-4	13.0	0.02	ND<0.07	0.002	0.02	6
ST-5	18.0	0.03	ND<0.07	0.002	0.03	7
ST-6	10.0	0.02	ND<0.07	0.001	0.02	4
ST-7	10.0	0.02	ND<0.07	0.003	0.03	2
ST-10	27.0	0.03	ND<0.07	0.001	0.04	11
ST-11	3.8	0.02	ND<0.07	0.002	0.02	ND<2
ST-12	17.0	0.03	ND<0.07	0.001	0.03	ND<2
Surface Mean	**16.4**	**0.02**	**0.04**	**0.003**	**0.03**	**5.7**

APPENDIX D

Plankton Data

Phytoplankton and Zooplankton Community Composition Analysis																				
Sampling Location: Lake Hopatcong							**Sampling Date: 5/11/23**							**Examination Date: 5/25/22**						
Site 1: ST-2 Surface Phyto			**Site 2: ST-2 Mid Phyto**				**Site 3: ST-3 Surface Phyto**		**Site 4: ST-10 Surface Phyto**					**Site 5: ST-2 Surface Zoop**			**Site 6: ST-2 Deep Zoop**			
Phytoplankton																				
Bacillariphyta (Diatoms)	**1**	**2**	**3**	**4**	**5**	**6**	**Chlorophyta (Green Algae)**	**1**	**2**	**3**	**4**	**5**	**6**	**Cyanophyta (Blue-Green Algae)**	**1**	**2**	**3**	**4**	**5**	**6**
Asterionella	C	C	C	P			*Akinstrodesmus*	P	P	P				*Aphanizomenon*	15,639	18,522	3,819	302		
Cyclotella			P				*Beachiomonas*				P			*Dolichospermum*	294					
Diatoma			R	R			*Chlamydomonas*	A	P	P				*Microcystis*				431		
Fragilaria	C	C	P	P			*Chlorella*	P	P	P	P			*Planktothrix*	2,516	4,976				
Melosira		P	P	P			*Chlorogonium*				P			*Pseudanabaena*	1,887					
Navicula	P						*Coelastrum*				R									
Nitzschia	P	P					*Koliella*			P				**Euglenophyta (Euglenoids)**						
Stephanodiscus							*Nephrocytium*				P			*Trachelomonas*		P	P			
Synedra	C	C	C	C			*Pediastrum*			R	R									
Tabellaria	C	C					*Scenedesmus*	P		P	P									
							Staurastrum	P												
							Tetradesmus	P	P	P	P									
							Tetraspora				P									
Chrysophyta (Golden Algae)							*Westella*	P						**Dinoflagellates**						
Dinobryon	P	R					**Cryptomonads**							*Gymnodium*	P	P	P	P		
							Cryptomonas	P	P	P	C			*Peridinium*				P		
							Chroomonas				P									
Zooplankton																				
Cladocera (Water Fleas)	**1**	**2**	**3**	**4**	**5**	**6**	**Copecoda (Copepods)**	**1**	**2**	**3**	**4**	**5**	**6**	**Rotifera (Rotifers)**	**1**	**2**	**3**	**4**	**5**	**6**
Bosmina					R	C	*Microcyclops*					P	P	*Anuraeopsis*					R	
Chydorus					P	C	*Nauplii*					P	P	*Ascomorpha*						C
														Asplanchna					R	C
														Brachionus					P	P
														Keratella					C	C
														Polyartha					C	C
														Trichocerca						P
Sites:	**1**	**2**	**3**	**4**	**5**	**6**	**Comments:**													
Total Phytoplankton Genera	20	16	17	20																
Total Cyanobacteria (cells/mL)	20,335	23,498	3,819	733																
Total Zooplankton Genera					9	10														
							Phytoplankton Key: Abundant (A), Common (C), Present (P), and Rare (R)													
							Zooplankton Key: Abundant (A), Common (C), Present (P), and Rare (R)													

Phytoplankton and Zooplankton Community Composition Analysis																				
Sampling Location: Lake Hopatcong							Sampling Date: 6/13/23							Examination Date: 6/19/23 and 6/21/23						
Site 1: ST-2 Surface Phyto				Site 2: ST-2 Mid Phyto			Site 3: ST-3 Surface Phyto				Site 4: ST-10 Surface Phyto			Site 5: ST-2 Surface Zoop				Site 6: ST-2 Deep Zoop		
Phytoplankton																				
Bacillariphyta (Diatoms)	**1**	**2**	**3**	**4**	**5**	**6**	**Chlorophyta (Green Algae)**	**1**	**2**	**3**	**4**	**5**	**6**	**Cyanophyta (Blue-Green Algae)**	**1**	**2**	**3**	**4**	**5**	**6**
Cocconeis			P	C			*Ankinstrodesmus*		P	P				*Aphanizomenon*	57,431	52,880	33,832			
Fragilaria	P		P				*Brachiomonas*							*Dolichospermum*			574			
Frustulia			P	P			*Chlamydomonas*			P				*Planktothrix*	2,266	10,374	1,196			
Melosira	P	R	C	P			*Chlorella*	P	P	P	P			*Pseudanabaena*			1,436			
Navicula			P	C			*Coelastrum*	P		P	P			*Raphidiopsis*				101		
Nitzschia							*Crucigenia*				P									
Synedra	P	P	P	P			*Elakatothrix*		R					**Euglenophyta (Euglenoids)**						
Tabellaria	P	P	P				*Franceia*	P	P					*Euglena sp.*			P	P		
							Gloeomonas	P						*Phacus*			R			
							Golenkinia			P				*Trachelomonas*	C	C				
							Haematococcus			R										
							Koliella		P		R									
							Oocystis		P	P	P									
							Pediastrum	R	P	P	P									
							Scenedesmus	P		C	C									
							Staurastrum	P	P	P	P									
							Teilingia			P										
							Tetradesmus		P											
							Tetrastrum			R										
Chrysophyta (Golden Algae)							*Westella*	P	P		P			**Dinoflagellates**						
Dinobryon			P	R			**Cryptomonads**							*Gymnodium*	P		P			
							Chroomonas				C			*Ceratium*	P					
							Cryptomonas	C	P	C	A									
Zooplankton																				
Cladocera (Water Fleas)	**1**	**2**	**3**	**4**	**5**	**6**	**Copecoda (Copepods)**	**1**	**2**	**3**	**4**	**5**	**6**	**Rotifera (Rotifers)**	**1**	**2**	**3**	**4**	**5**	**6**
Bosmina					C	C	*Microcyclops*					P	P	*Hexartha*					R	
Chydorus					R		*Nauplii*					P	P	*Asplanchna*						R
Ceriodaphnia					P	P								*Conochilus*					C	C
Diaphanosoma					R	R								*Keratella*					C	C
														Polyartha					C	C
														Trichocerca					R	R
Sites:	**1**	**2**	**3**	**4**	**5**	**6**	**Comments:**													
Total Phytoplankton Genera	18	17	28	19																
Total Cyanobacteria (cells/mL)	59,697	63,254	37,038	101																
Total Zooplankton Genera					11	10														
							Phytoplankton Key: Abundant (A), Common (C), Present (P), and Rare (R)													
							Zooplankton Key: Abundant (A), Common (C), Present (P), and Rare (R)													

Phytoplankton and Zooplankton Community Composition Analysis

Sampling Location: Lake Hopatcong | **Sampling Date: 7/24/23** | **Examination Date: 7/28/23 and 7/31/23**

Site 1: ST-2 Surface Phyto | **Site 2: ST-2 Mid Phyto** | **Site 3: ST-3 Surface Phyto** | **Site 4: ST-10 Surface Phyto** | **Site 5: ST-2 Surface Zoop** | **Site 6: ST-2 Deep Zoop**

Phytoplankton

illariphyta (Diatoms)	1	2	3	4	5	6
Asterionella				P		
Cyclotella			P	C		
Fragilaria			C	P		
Melosira		P	C	C		
Nitzschia			P	P		
Pinnularia				P		
Synedra		P	P	P		
Tabellaria	P	P	P	P		
Chrysophyta (Golden Algae)						

Chlorophyta (Green Algae)	1	2	3	4	5	6
Ankinstrodesmus	P	C	P	P		
Atractomorpha				P		
Brachiomonas		P		P		
Chlorella		P	P	C		
Coelastrum			P	P		
Crucigenia		P		P		
Gloeocystis			P			
Gloeomonas						
Golenkinia				P		
Kirchneriella			P			
Koliella				P		
Pediastrum	P	P	A	C		
Scenedesmus	P	P	A	C		
Sphaerocystis						
Staurastrum	P	P	C	P		
Teilingia				P		
Tetradesmus				P		
Tetrastrum			P	P		
Treubaria			P			
Cryptomonads						
Chroomonas		P		P		
Cryptomonas	P	C	A	A		

Cyanophyta (Blue-Green Algae)	1	2	3	4	5	6
Aphanizomenon	45,338	11,172	67,787	3,931		
Aphanocapsa			3,209			
Chroococcus	221		160	740		
Coelosphaerium	2,765					
Dolichospermum	18,246	2,483	30,885	8,787		
Lyngbya	2,765					
Merismopedia				9,619		
Microcystis			12,033	5,781		
Euglenophyta (Euglenoids)						
Euglena sp.				P		
Trachelomonas		P	P	C		
Dinoflagellates						
Gymnodium						
Ceratium			R			

Zooplankton

docera (Water Fleas)	1	2	3	4	5	6
Bosmina					P	C
Ceriodaphnia					P	P
Chydorus					R	P
Daphnia						R

Copecoda (Copepods)	1	2	3	4	5	6
Microcyclops					P	P
Nauplii					C	C

Rotifera (Rotifers)	1	2	3	4	5	6
Ascomorpha					A	A
Asplanchna					R	P
Brachionus						R
Conochilus					A	A
Keratella					P	P
Polyartha					C	C
Trichocerca					R	P

Sites:	1	2	3	4	5	6
Total Phytoplankton Genera	11	15	24	31		
Total Cyanobacteria (cells/mL)	69,335	13,654	114,074	28,857		
al Zooplankton nera					11	13

Comments:

Phytoplankton Key: Abundant (A), Common (C), Present (P), and Rare (R)
Zooplankton Key: Abundant (A), Common (C), Present (P), and Rare (R)

Phytoplankton and Zooplankton Community Composition Analysis																				
Sampling Location: Lake Hopatcong							Sampling Date: 8/21/23							Examination Date: 8/28/23						
Site 1: ST-2 Surface Phyto			Site 2: ST-2 Mid Phyto				Site 3: ST-3 Surface Phyto		Site 4: ST-10 Surface Phyto					Site 5: ST-2 Surface Zoop		Site 6: ST-2 Deep Zoop				
Phytoplankton																				
Bacillariphyta (Diatoms)	**1**	**2**	**3**	**4**	**5**	**6**	**Chlorophyta (Green Algae)**	**1**	**2**	**3**	**4**	**5**	**6**	**Cyanophyta (Blue-Green Algae)**	**1**	**2**	**3**	**4**	**5**	**6**
Asterionella			P	P			*Ankinstrodesmus*		P	P	P			*Aphanizomenon*	33,813	5,080	64,743	12,033		
Cocconeis		R		P			*Brachiomonas*			P	P			*Chroococcus*	271	581		321		
Cyclotella	P	P	A	C			*Chlamydomonas*		P					*Coelosphaerium*	338					
Fragilaria	R	R	P	R			*Chlorella*	C		C	C			*Dolichospermum*	4,869	242	1,460	3,209		
Frustulia				P			*Coelastrum*	P		P	R			*Lyngbya*	203					
Melosira	P	P	A	C			*Cosmarium*	R		P				*Merismopedia*	4,328	2,709				
Navicula				P			*Crucigenia*		R	P	P			*Microcystis*				3,209		
Nitzschia		P					*Gloeocystis*	P						*Planktothrix*		1,451	3,894			
Rhizosolenia		R	R	R			*Gloeotila*	P	P					*Pseudanabaena*	6,425		17,524	18,451		
Stephanodiscus		P		R			*Golenkinia*			C	R			*Raphidiopsis*			48,679	26,874		
Synedra	P	P	P	C			*Golenkinia*	R						*Synechococcus*		1,548				
Tabellaria	C	P	C	C			*Koliella*	P		P				**Euglenophyta (Euglenoids)**						
							Nanochloris	C	C	C	C			*Euglena sp.*			P	P		
							Oocystis				P			*Phacus*		R		P		
							Pediastrum	P	P	C	C			*Trachelomonas*	P	P	C	C		
							Quadrigula	P												
							Scenedesmus	P	P	P	C									
							Selenastrum				P									
							Staurastrum	P	P	C	C									
							Tetradesmus	R												
							Tetraspora		P											
							Treubaria	R												
							Westella			P										
Chrysophyta (Golden Algae)														**Dinoflagellates**						
Dinobryon	R			R			**Cryptomonads**							*Gymnodium*	C	R	P	P		
							Chroomonas							*Ceratium*	R	P	R	P		
							Cryptomonas	P	C	A	A									
Zooplankton																				
Cladocera (Water Fleas)	**1**	**2**	**3**	**4**	**5**	**6**	**Copecoda (Copepods)**	**1**	**2**	**3**	**4**	**5**	**6**	**Rotifera (Rotifers)**	**1**	**2**	**3**	**4**	**5**	**6**
Bosmina					R	C	*Microcyclops*					P	C	*Anuraeopsis*					P	
Ceriodaphnia					R	P	*Nauplii*					P	P	*Ascomorpha*					R	P
Chydorus					R	P								*Asplanchna*					R	C
Daphnia						R								*Brachionus*					R	
														Conochilus					P	P
														Gastropus					R	R
														Keratella					C	C
														Polyartha					A	A
														Trichocerca					P	P
Sites:	**1**	**2**	**3**	**4**	**5**	**6**	**Comments:**													
Total Phytoplankton Genera	31	29	30	36																
Total Cyanobacteria (cells/mL)	50,247	11,611	136,301	64,096																
Total Zooplankton Genera					14	13														
							Phytoplankton Key: Abundant (A), Common (C), Present (P), and Rare (R)													
							Zooplankton Key: Abundant (A), Common (C), Present (P), and Rare (R)													

Phytoplankton and Zooplankton Community Composition Analysis

Sampling Location: Lake Hopatcong		Sampling Date: 9/18/23		Examination Date: 9/20/23	
Site 1: ST-2 Surface Phyto	Site 2: ST-2 Mid Phyto	Site 3: ST-3 Surface Phyto	Site 4: ST-10 Surface Phyto	Site 5: ST-2 Surface Zoop	Site 6: ST-2 Deep Zoop

Phytoplankton

Bacillariphyta (Diatoms)	1	2	3	4	5	6
Asterionella		P	P	C		
Caloneis				P		
Cocconeis	P	P				
Cyclotella			P	P		
Diatoma			R			
Fragilaria						
Frustulia	R		R			
Melosira	P	P	P	C		
Navicula						
Nitzschia	P	P	P	C		
Synedra	P			A		
Tabellaria	C	A	C			

Chlorophyta (Green Algae)	1	2	3	4	5	6
Ankinstrodesmus	P	C		P		
Chlamydomonas	P			P		
Chlorella	P	P	P	C		
Coelastrum	R	P	P	P		
Crucigenia		P	P			
Eudorina	P	R				
Gloeomonas	P			C		
Golenkinia			P			
Koliella			P	P		
Nanochloris						
Pediastrum	R	P	C	C		
Quadrigula	R					
Scenedesmus	P	P	P	C		
Staurastrum	P	P	P	P		
Tetradesmus				R		
Tetrastrum				R		

Cyanophyta (Blue-Green Algae)	1	2	3	4	5	6
Aphanizomenon	14,088	6,171	11,117	11,622		
Aphanocapsa	10,063					
Chroococcus	302					
Dolichospermum	4,528		2,033	4,444		
Merismopedia						
Microcystis			5,718			
Planktothrix	503	475	19,059			
Pseudanabaena		949	635	1,367		
Raphidiopsis	22,390	11,155	60,987	58,108		

Euglenophyta (Euglenoids)	1	2	3	4	5	6
Euglena sp.						
Phacus	P		P	P		
Trachelomonas	C	C	C	P		

Chrysophyta (Golden Algae)	1	2	3	4	5	6
Dinobryon						

Cryptomonads	1	2	3	4	5	6
Chroomonas	P	P				
Cryptomonas	A	C	C	C		

Dinoflagellates	1	2	3	4	5	6
Gymnodium				P		
Ceratium	P			R		

Zooplankton

Cladocera (Water Fleas)	1	2	3	4	5	6
Bosmina					P	C
Ceriodaphnia					P	P
Chydorus					R	R
Daphnia					R	P

Copecoda (Copepods)	1	2	3	4	5	6
Diaptomus					P	
Microcyclops					P	P
Nauplii					P	

Rotifera (Rotifers)	1	2	3	4	5	6
Ascomorpha					C	C
Asplanchna					P	
Brachionus					P	
Conochilus					C	C
Keratella					C	C
Polyartha					P	
Trichocerca						R

Sites:	1	2	3	4	5	6
Total Phytoplankton Genera	27	20	24	26		
Total Cyanobacteria (cells/mL)	51,874	18,749	99,549	75,540		
Total Zooplankton Genera					13	9

Comments:

Phytoplankton Key: Abundant (A), Common (C), Present (P), and Rare (R)
Zooplankton Key: Abundant (A), Common (C), Present (P), and Rare (R)