Minnehonk Lake

WATER QUALITY REPORT

2023

30 Mile River Watershed Association
P.O. Box 132
Mount Vernon, ME
www.30mileriver.org

2023 Minnehonk Lake Water Quality Report

TABLE OF CONTENTS

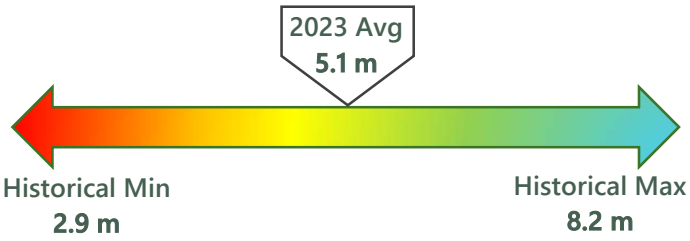
TABLE OF FIGURES

2023 Water Quality Summary[1]

Monitoring occurred on twelve (12) dates between May and November 2023 by Whitney Baker and Silas Mohlar of 30 Mile River Watershed Association (30 Mile) and local volunteers.

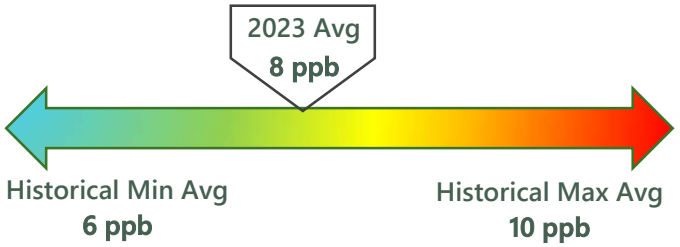
Water clarity readings in 2023 ranged from 4.10 meters (November 2nd) to 5.95 meters (September 5th) with an annual average of 5.1 meters. 15 readings were collected in 2023 in total.

Water Clarity (m)	
2023 Water Clarity Average	5.1
Historical SDT Average	5.6
Maine Lakes SDT Average	4.8



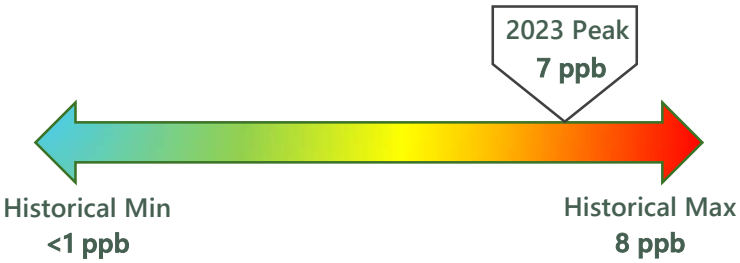
Seven (7) samples were collected and analyzed for **Total Phosphorus**. Laboratory results ranged from 2 ppb (parts per billion) to 13 ppb with an average of 8 ppb.

Total Phosphorus (ppb)	
2023 TP Average	8
Historical TP Average	8
Maine Lakes TP Average	12



Chlorophyll was measured Seven (7) times in 2023. Results ranged from <1 ppb (September 22nd) to 7 ppb (August 21st) with an annual average of 5 ppb.

Chlorophyll-a (ppb)	
2023 Chl-a Average	5
2023 Peak Chl-a	7
Historical Chl-a Average	3
Maine Lakes Chl-a Average	5



Twelve (12) **Dissolved Oxygen (DO)** profiles were collected in 2023. Anoxia (DO <2 mg/L) was first encountered in July in waters 23m and deeper, but this zone of anoxia grew to include all waters 14m and deeper by the end of the monitoring season. Though common in the bottom 2-6m of the lake, in recent years anoxia has been reaching much shallower depths (17m in '18, '20, & '22). The largest anoxic zone documented to date was observed in 2023. A metalimnetic oxygen minima was also observed in 2023 with anoxia encountered between 7-10 m in late summer.

[1] Scale bars illustrate the range of data collected for each parameter over the historical monitoring record for general comparison with the 2022 monitoring results. The blue end represents the historical minimum (best), and the red end represents the historical maximum (worst) of all monitoring data collected.

Overview

Minnehonk Lake is located in the town of Mount Vernon in Kennebec County, Maine and has a direct watershed area of 1.7 square miles. Its indirect upstream watershed is quite large (14 square miles) and includes the upstream drainages of Flying Pond, Boody Pond, Kimball Pond, Mill Pond, and Black Pond. Minnehonk Lake has a single outlet, Hopkins Stream, located at the south end of the lake that flows south to Hopkins Pond and Taylor Pond, also in Mount Vernon.

Minnehonk Lake is a relatively deep lake with a maximum depth of 22 m (73 ft) and an average depth of just 9 m (30 ft). The lake has a small surface area covering approximately 99 acres and can be accessed via a public launch located on Route 41 at the north end of the lake in Mount Vernon Village.

Figure 1. Minnehonk Lake Monitoring Stations.

Water Quality Monitoring in 2023

Water quality monitoring on Minnehonk Lake takes place at the deepest spot in the lake (Maine DEP Station 1), also known as the "deep spot", and is just over 22 meters deep (Figure 1). Monitoring in 2023 was completed by Whitney Baker and Silas Mohlar of 30 Mile River Watershed Association (30 Mile) and local volunteers. A special thanks to the 2023 volunteers Greg Cauldwell, Christine Merchant, and Jane & Carl Rogers.

Volunteer, Chrstine Merchant and 30 Mile Staff, Silas Mohlar at the Minnehonk Lake monitoring station in 2023.

Water quality data was collected on twelve (12) dates between May and November. Parameters include Secchi disk transparency, dissolved oxygen and temperature, phosphorus, chlorophyll, and advanced chemistry parameters (pH, Alkalinity, Color, and Conductivity).

Secchi Disk Transparency (Water Clarity)

Secchi disk transparency (SDT) is an indicator of water clarity. To measure water clarity, a black and white disk is lowered into the water and the reading is taken at the depth at which it is no longer visible. Factors that affect water clarity include algal growth, zooplankton densities, natural water color, and suspended silt or sediment particles.

Water Clarity (m)	
2023 Water Clarity Average	5.1
Historical SDT Average	5.6
Maine Lakes SDT Average	4.8

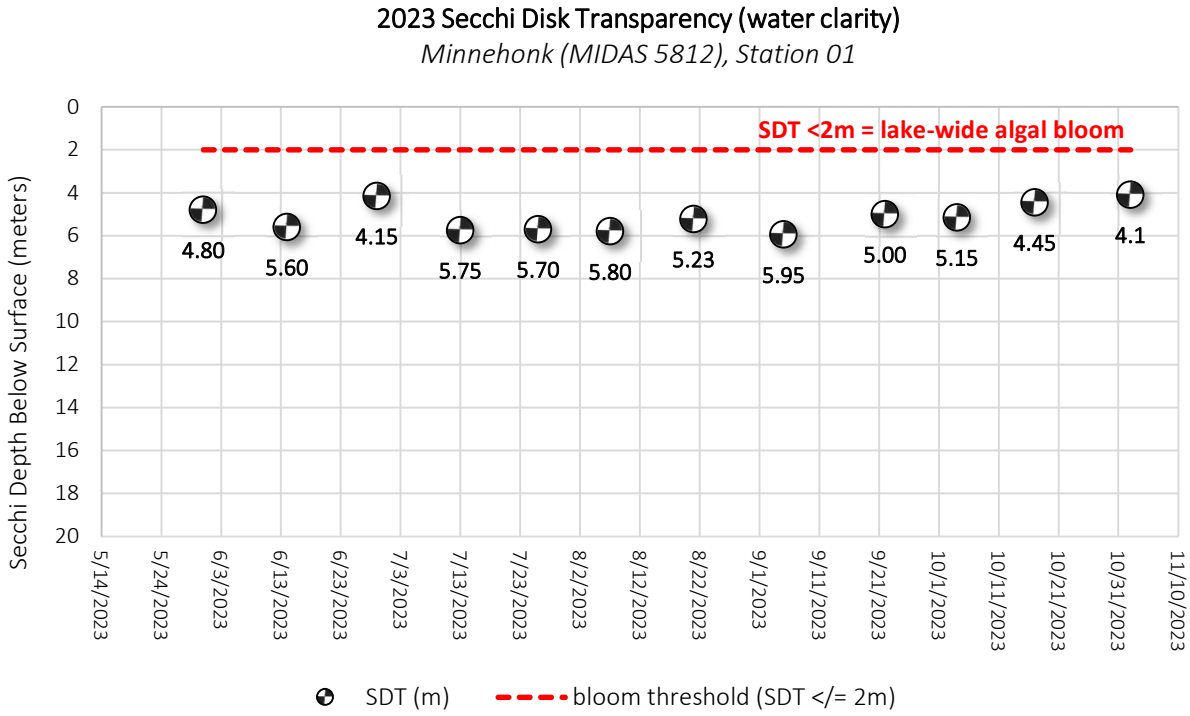


Figure 2. 2023 Secchi Disk Transparency, Station 01

Water clarity readings in 2023 ranged from 4.10 meters (November 2nd) to 5.95 meters (September 5th) with an annual average of 5.1 meters. 15 total readings were collected over 12 monitoring days in 2023 (Figure 2). SDT data has been collected on Minnehonk Lake during 25 years over the historical monitoring period spanning the past 49 years starting in 1974. Over this time Secchi readings have ranged from 2.9 m (1976) to 8.2 m (2017) with an average annual reading 5.7 m (Figure 3).

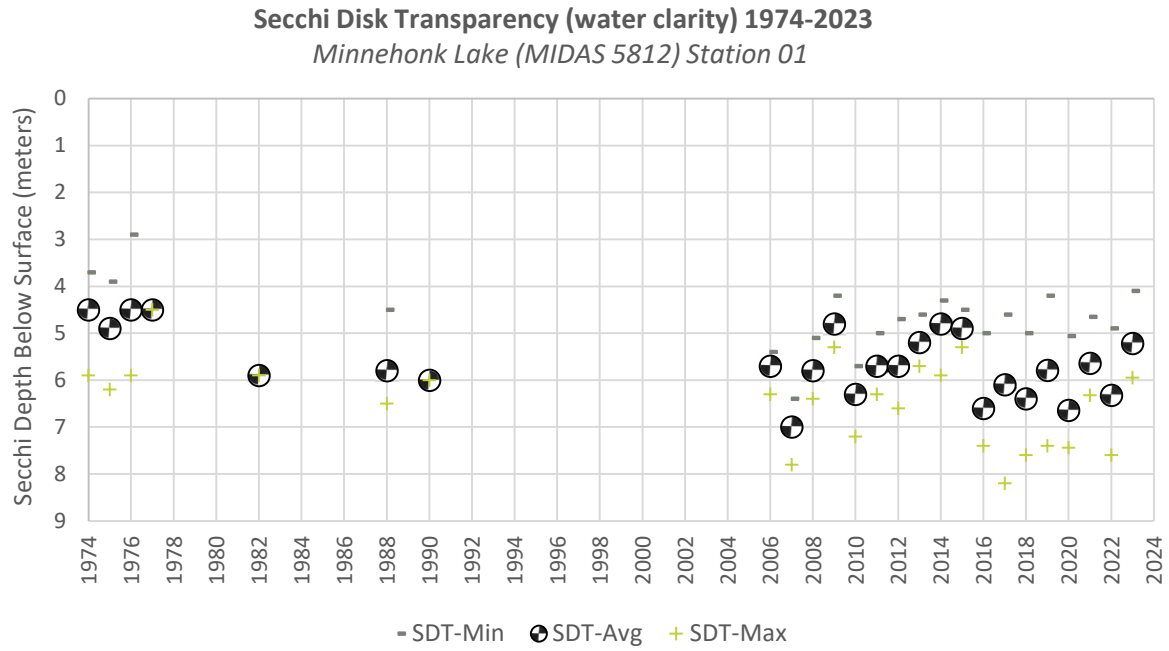


Figure 3. Average annual Secchi disk transparency (water clarity), Station 01, 1976-2023

Dissolved Oxygen and Temperature

Dissolved oxygen (DO) is a critical indicator of the health of the lake system. DO is produced through photosynthesis, consumed during respiration and decomposition, and is influenced by wind, wave action, weather events, and lake productivity. A good supply of oxygen is essential for fish and other aquatic species, with most fish species requiring a DO concentration of 5 mg/L or more. *Anoxia* can occur when DO drops below 2 mg/L. As lake water is warmed during the summer, deep lakes will form three distinct temperature layers. There is a warm layer at the surface (epilimnion), a thin transitional layer (metalimnion or thermocline), and a deep cold layer (hypolimnion). The change in water temperature and density at the metalimnion acts as a physical barrier that prevents mixing of the upper and lower layers for several months during summer and early fall.

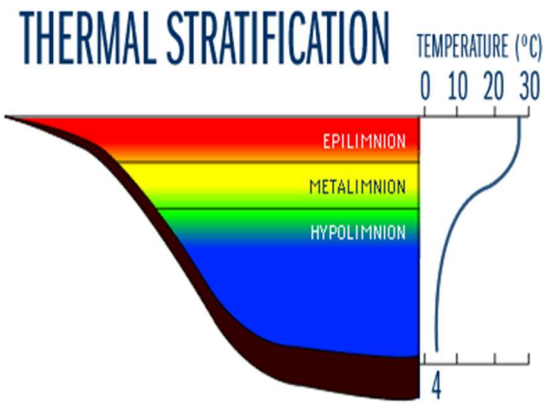


Figure 4. Thermal Stratification in a deep lake. Image source: www.watertheweb.org.

As lakes become more biologically productive in the summer, oxygen can decline as decomposition occurs in deep areas of the lake. While oxygen loss at the bottom of a deep lake is common in the summer months, excessive loss of oxygen may indicate a stressed and changing ecosystem. Monitoring the pattern and extent of oxygen loss in deep areas of Minnehonk Lake is important to understanding changes

between the years and throughout a single season and is particularly important for Echo Lake because may be more vulnerable for internal phosphorus loading due to unique lake sediment chemistry.[2]

Twelve (12) DO and temperature profiles were collected in 2023. DO <5 mg/L was first observed in the deepest waters of the lake in June at 23 meters, but this zone of low DO grew to include all waters 6 meters and deeper by September. DO <2 mg/L (anoxia) was first observed in the deepest waters of the lake at a depth of 23 meters in July, but this anoxic zone grew to include all waters 14 meters and deeper by the end of the monitoring season (Figure 4).

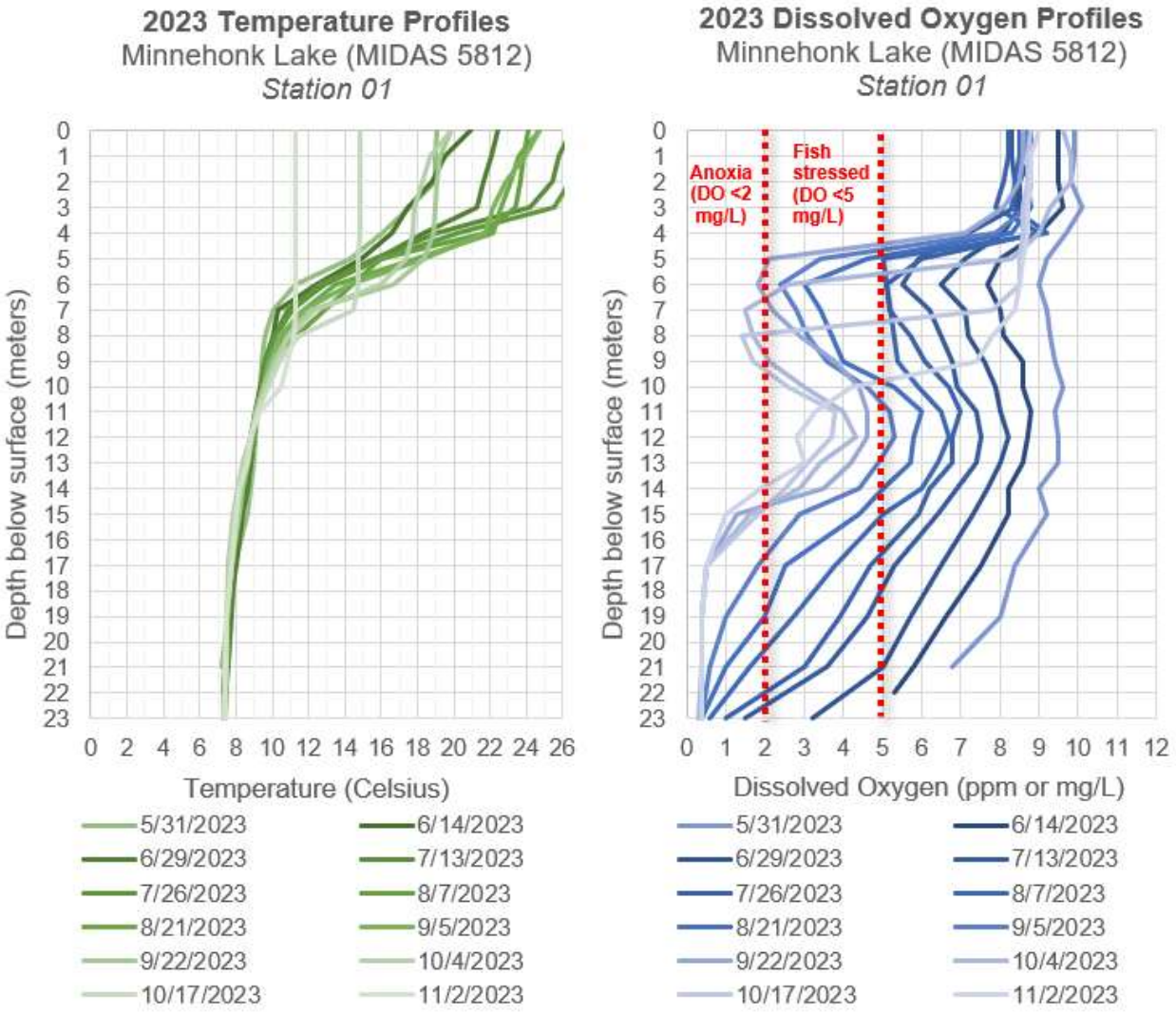


Figure 5. 2023 Dissolved Oxygen and Temperature Profiles, Station 01

[2]Some lakes in Maine may be more vulnerable than others to internal phosphorus loading, a phenomenon that can occur when deep waters become anoxic (DO loss <2 ppm) resulting in phosphorus release from the bottom sediments exposed to anoxic waters.

Oxygen depletion in deep areas of the hypolimnion is not uncommon during late summer and early fall in Minnehonk Lake. Historically, DO and temperature profiles have been collected during 13 years (1976, 1982, 1990, 2007, 2012, and 2016-2023) throughout the historical monitoring period spanning the past 47 years. However, deep-water anoxia has been observed only somewhat recently starting in 2012 when the anoxic zone at the lake's bottom included all waters 17 meters and deeper. Anoxia has also been observed in every year since 2016 when 30 Mile began monitoring water quality in Minnehonk Lake. Between 2016 and 2022 the depth of the observed anoxic zone ranged between 17 and 21 meters and deeper, the largest anoxic zone ever documented in Minnehonk Lake observed in 2023 that included all waters 14 meters and deeper.

A metalimnetic oxygen minima (MOM) was also observed in 2023. A MOM is an isolated area of oxygen depletion within the lake's metalimnion or thermocline. This can be a result of algae die-off in the upper waters of the lake with decomposition consuming oxygen, or an increase in zooplankton productivity with respiration consuming oxygen, or both of these two things occurring simultaneously. DO <5 mg/L was first documented on August 21st in waters between 5 and 9 meters deep (within the metalimnion or thermocline). This was the onset of a metalimnetic oxygen minima that persisted throughout the entire monitoring season, eventually becoming anoxic (DO <2 mg/L) in late September.

A slight metalimnetic oxygen minima has been observed in recent years in Minnehonk Lake. Low DO (<5 mg/L) was documented in the metalimnion of the lake in 2017, 2019, 2020, and 2021. However in 2023, a strong anoxic oxygen minima was observed for a majority of the season.

Water surface temperatures through the monitoring season ranged from 11.3 C (52.3 F) to 27.3 C (81.1 F) with an average surface water temperature of 21.3 C (70.3 F) between May and November. Continued collection of bi-weekly DO and temperature profiles will identify trends and changes occurring in Minnehonk Lake in order to better understand variations in thermal stratification and the extent and severity of the low DO and anoxic zones throughout the monitoring season.

Total Phosphorus

Total Phosphorus (ppb)	
2023 TP Average	8
Historical TP Average	8
Maine Lakes TP Average	12

Phosphorus is the nutrient that most influences the growth of algae in lakes. Because its natural occurrence in lakes is very small, phosphorus "limits" the growth of algae in lake ecosystems. Small increases in phosphorus in lake water can cause substantial increases in algal growth, hindering lake health as well as the economic, recreational, and aesthetic value of the lake. Tracking in-lake phosphorus levels over time is another way of monitoring change in lake water quality trends.

Twelve (12) samples were collected by 30 Mile staff this year and analyzed for Total Phosphorus (TP). Samples were collected monthly between May and November. Seven (7) of the phosphorus samples were collected from the surface of the lake using an integrated core sampler and are referred to as "epilimnetic core samples". Laboratory results for epilimnetic core samples collected in 2023 ranged from 2 ppb to 13 ppb with an annual average of 8 ppb (Figures 5 and 6).

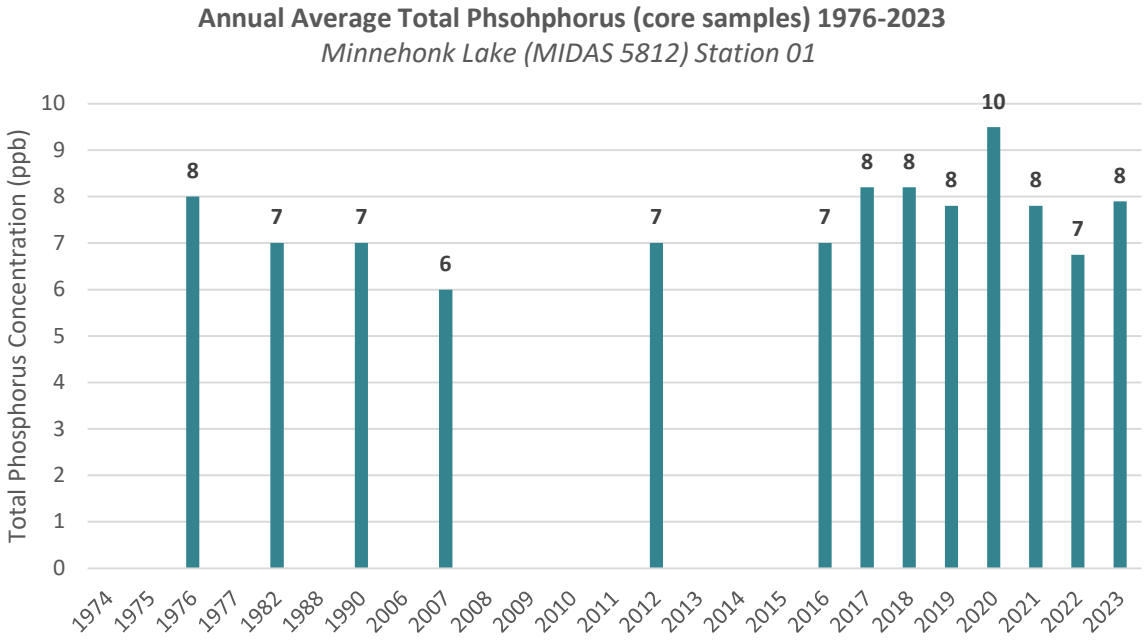


Figure 6. Annual Average Total Phosphorus data (epilimnetic core samples) collected 1976-2023, Station 01.

Generally speaking, in-lake phosphorus concentrations (epilimnetic samples) less than 10 ppb are ideal. Lakes with in-lake phosphorus concentrations of ~13 ppb or more are able to sustain algal blooms, and blooms become frequent as in-lake average concentrations approach 20 ppb. Historically, the annual average in-lake phosphorus concentration in Minnehonk Lake ranges from 6 ppb (2007) to 10 ppb (2020) with a historical average of 8 ppb (Figure 5).

In 2023, five (5) samples were collected from the bottom of Minnehonk Lake using a Kemmerer grab sampler; this type of sample is known as a "bottom grab". Bottom grabs are collected when anoxia is encountered anywhere in the dissolved oxygen profile, and help us determine if there is active phosphorus release from bottom sediments exposed to anoxic conditions. Laboratory results for bottom grab samples collected in 2023 ranged from 18 ppb (July 26th) to 32 ppb (October 17th) for an annual average of 25 ppb.

Historically, bottom grab samples have been collected during 11 years throughout the 49-year monitoring record, with annual average results ranging from 7 ppb (1977) to 34 ppb (2018 and 2022) and a historical annual average of 21 ppb.

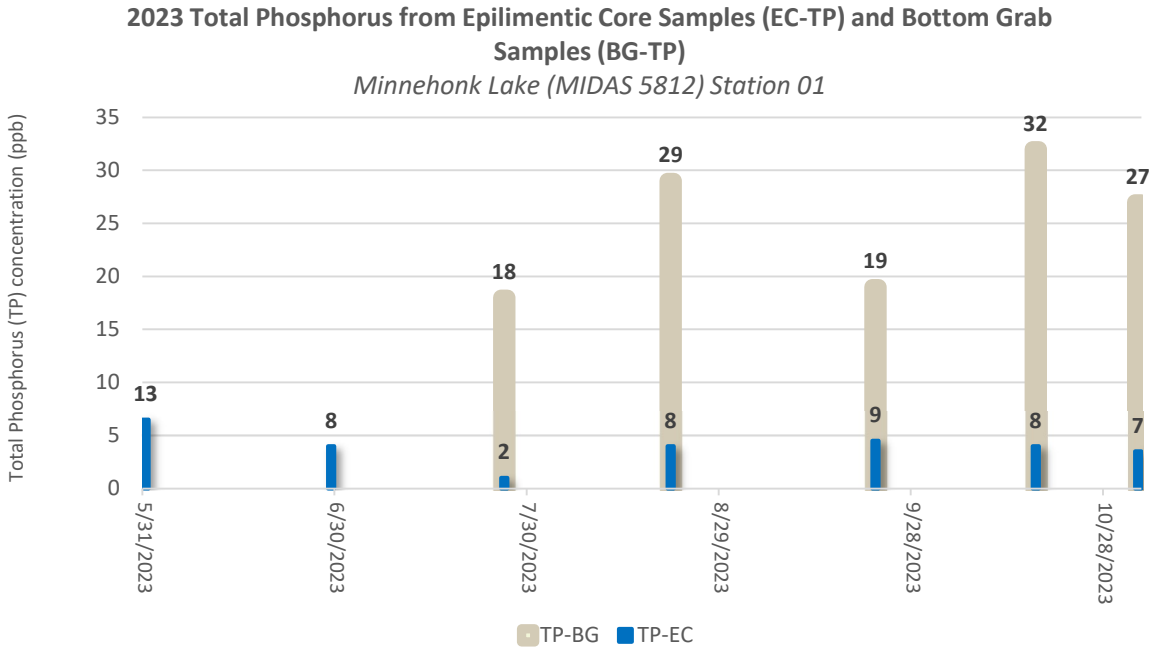


Figure 7. 2023 TP core sample and bottom grab sample results from Minnehonk Lake.

Chlorophyll (Chl-a)

Chlorophyll is found in plants (including algae) and is used to convert sunlight into energy. Measuring the concentration of Chlorophyll in lake water helps us estimate the algae population in the lake. The higher the Chl-a value, the higher the amount of algae in the lake.

Chl-a (ppb)	
2023 Chl-a Average	5
2023 Peak Chl-a	7
Historical Chl-a Average	3.0
Maine Lakes Chl-a Average	5.4

Chlorophyll was measured seven (7) times in 2023. Results ranged from <1 ppb (9/22/23) to 7 ppb (8/21/2023), with an annual average of 5 ppb. Prior to 2023, annual chl-a averages from Minnehonk Lake have ranged from 1.3 ppb (2007) to 8 ppb (2019) with a historical annual average of 3.2 ppb.

pH

pH helps determine which plant and animal species can live in the lake, and it governs biochemical processes that take place. The pH scale ranges from 0-14, with 7 being neutral. Water is increasingly acidic

pH	
2023 pH	7.3
Historical pH Average	7.2
Maine Lakes Average	6.4

below 7, and increasingly alkaline above 7. A one unit change in pH represents a tenfold change in acidity or alkalinity. The pH scale is the inverse log of the hydrogen ion concentration.

pH was measured one time during the 2023 season on August 21st with a result of 7.3. Historically, pH has been analyzed eight (8) years, ranging between 6.6 (2022) and 7.5 (2017) with a historical annual average of 7.2.

True Color

Color (PCU)	
2023 Color	22
Historical Color Average	13
Maine Lakes Color Average	21

Water color refers to the concentration of natural dissolved organic acids. This includes natural tannins and lignins dissolved in the water, often resulting in "tea" or "root beer" colored water. “True Color” is measured in Platinum Cobalt Units (PCU) after all particulates (including algae cells) have been filtered out of the sample. Colored lakes (>25 PCU) can naturally have reduced transparency readings and increased phosphorus values. However, this does not mean the lakes produce more algae. The color simply reduces the transparency such that the reading is not a good measure of algal biomass. Chlorophyll-a (Chl-a) is the best indicator of algal productivity in colored lakes and should be used if possible.

One sample taken on August 21st was analyzed for true color and had a result of 22 PCU. Historically, true color samples have been collected during just six (6) years and results range between 10 PCU (2007, 2017, and 2022) and 22 (2023) with a historical annual average of 13 PCU.

Conductivity

Conductivity (µMHOS/cm)	
2023 Conductivity	71
Historical Conductivity Average	65
Maine Lakes Conductivity Average	51

Conductivity measures the ability of water to carry electrical current and is directly related to the dissolved ions (charged particles) present in the water. Fishery biologists can use conductivity values to calculate fish yield estimates because conductivity will generally increase if there is an increase of pollutants entering the lake or pond. Stormwater runoff from developed areas and roadways is the most common pollutant in Maine lakes that can raise conductivity values. Conductivity is measured in micro-siemens per centimeter (µMHOS/cm).

One sample taken on August 21st was analyzed for conductivity and had a result of 71 µMHOS/cm. Historically, conductivity samples have been collected during nine (9) years and results range between 55 µMHOS/cm (1990) and 82 µMHOS/cm (2022) with a historical annual average of 65 µMHOS/cm.

Alkalinity

Alkalinity (mg/L)	
2023 Alkalinity	16
Historical Alkalinity Average	14
Maine Lakes Alkalinity Average	12

Alkalinity is also referred to as "buffering capacity." It is a measure primarily of naturally available bicarbonate, carbonate, and hydroxide ions in the water and is measured in milligrams per liter (mg/L). Measuring alkalinity is important to determining a lake's ability to neutralize acidic pollution from rainfall or snowmelt. Lakes with alkalinity values >20 mg/L are considered well buffered against pH changes over time. Lakes with low or zero alkalinity may have more variation in pH levels that can sometimes result in damage to aquatic life.

One sample taken on August 21st was analyzed for alkalinity and had a result of 16 mg/L. Historically, alkalinity samples have been collected during just eight (8) years starting in 1976, and annual average results range between 12 mg/L (1982) and 16 mg/L (2017, 2022, and 2023) with a historical annual average of 14 mg/L.

Discussion

2023 was 30 Mile's eighth year of monitoring Minnehonk Lake. Historical data presented in this report includes all monitoring data collected on Minnehonk Lake through 2022, submitted by 30 Mile, volunteer monitors, and state agencies, that has undergone a thorough QA/QC process at Maine DEP. 2023 data presented here is from 30 Mile only.

In 2023, water clarity ranged from 4.1 meters (11/2/23) to 6.0 meters (9/5/23) with an annual average of 5.1 meters. For comparison, Secchi readings collected in 2022 ranged from 4.9 meters (6/6/22 and 6/21/22) to 7.6 meters (9/2/22) with an annual average of 6.4 meters. Though we saw noticeably reduced water clarity in 2023, this year's readings are still within the expected range of historical data collected in Minnehonk Lake since 1976 that ranges from 2.9 meters (1976) to 8.2 meters (2017). However, looking at the previous 5 years of Secchi data, this year's readings are below average in comparison.

The largest anoxic zone (shallowest depth to anoxia) was documented in 2023; observed in waters 14 meters and deeper. Prior to 2023, the shallowest depth of anoxia observed in the deep waters of the lake was 17 meters. We will continue to closely monitor the seasonal anoxic area of the lake through annual baseline monitoring.

A slight metalimnetic oxygen minima (MOM), with low DO (DO <5 mg/L) has been documented only recently in Minnehonk Lake, during most years starting in 2017. However, severe oxygen loss, or anoxia (DO <2 mg/L), in the metalimnion has been documented during only two years in the historical monitoring record starting in 1976 (2012 and 2023). A single DO profile was collected on 9/17/12 documenting anoxic conditions in both the metalimnion and the hypolimnion. However,

the MOM observed in 2023 was much stronger, compared to years prior, with anoxic conditions persisting throughout much of the monitoring season. This phenomenon was observed in a few of the lakes in the 30 Mile River Watershed this season, and it is important that we continue to monitor and track the frequency and extent of anoxic zones in the lake.

Minnehonk lake has a watershed to lake surface area ratio of 101:1 - a significantly high value. Lakes with ratios greater than 10:1 more often experience water quality problems. As watershed area increases in relation to the size of the lake, the potential volume of polluted surface runoff entering the lake is much greater. For this reason, Minnehonk Lake may be more sensitive to inputs of stormwater runoff from intense rain events like those we experienced this spring . This could explain the below average clarity we documented throughout the 2023 season. This also could explain the increase in oxygen depletion we documented throughout the water column in 2023 as increased runoff likely also increased the mass of algae in the lake this year (above average chlorophyll results in 2023), which caused an increase in biological productivity (respiration) and resulting decomposition – two processes that consume oxygen in the water.

Five years of consecutive data collection for any given parameter will provide the baseline condition of the Pond. 10 years of consecutive data collection is needed to meet the minimum data thresholds for determining trends over time. 30 Mile's monitoring program will continue to develop a robust dataset that can help our community identify and address water quality concerns in Minnehonk Lake.

Near real-time data for Minnehonk Lake's clarity (Secchi depth), and dissolved oxygen and temperature profiles can be found online at https://30mileriver.org/minnehonk-lake/, along with a link to the historical dataset and depth map.

Next Steps

1. Continue bi-weekly baseline monitoring between May and October each year to monitor seasonal and annual variability across all parameters, and better document changes and trends over time.

2. Develop a LakeSmart team on Minnehonk Lake, providing education to shorefront property owners about polluted stormwater runoff, phosphorus, and the effects that watershed development can have on lake water quality.

3. Work with 30 Mile to review the list of priority sites identified during the 2013 watershed survey and determine next steps to address remaining sites through LakeSmart and 30 Mile's Technical Assistance Programs.