

# SABBATHDAY LAKE

## 2020 WATER QUALITY REPORT

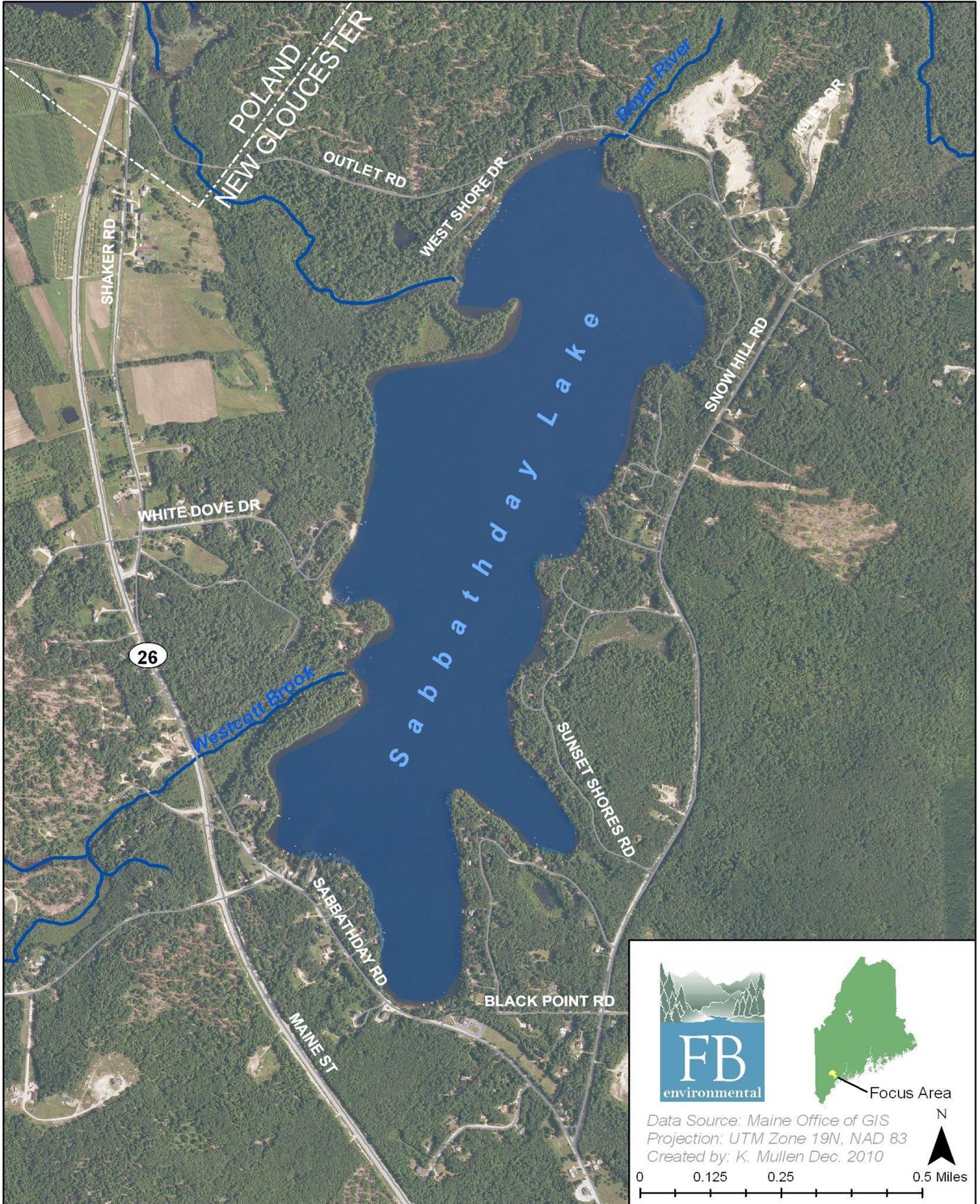
**December 2020**



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**FB**  
environmental

Focus Area

Data Source: Maine Office of GIS  
Projection: UTM Zone 19N, NAD 83  
Created by: K. Mullen Dec. 2010

0 0.125 0.25 0.5 Miles

N

This block contains the logo for "FB environmental" (Forest Biology) on the left, which includes a stylized tree and mountain graphic. To the right is a green map of the state of Maine with a yellow dot indicating the "Focus Area" in the western part of the state. Below the map is a north arrow and a scale bar showing 0, 0.125, 0.25, and 0.5 miles. Text at the bottom provides the data source, projection, and creation date.

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Special thanks to Sabbathday Lake Association (SDLA) volunteers, Rick and Cheryl Fortier, whose ongoing support makes this project possible. Thanks to SDLA members for supporting the long-term collection of water quality data.

*Photo Credit: Whitney Baker of Ecological Instincts*

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# BACKGROUND

## LAKE FACTS

**Watershed:** Royal River  
**Town:** New Gloucester  
**Watershed Area:** 5.33 sq. mi.  
**Mean Depth:** 24 feet  
**Max Depth:** 68 feet  
**Surface Area:** 342 acres  
**Flushing Rate:** 0.88 flushes/year



Sabbathday Lake is a 342-acre, non-colored waterbody located in the Town of New Gloucester, Cumberland County, Maine. The lake is part of the larger Royal River watershed and has a direct **watershed** area of 5.33 square miles, a maximum depth of 68 feet (20.7 meters), a mean depth of 24 feet (7.3 meters), and a flushing rate of 0.88 times per year (see DEP lake depth maps in Appendix A).

Historically, Sabbathday Lake has been an important natural resource for the local Shaker community and the Town of New Gloucester. Today, the lake provides recreational opportunities, such as swimming, boating, and fishing, as well as valuable habitat for fish, birds, and other wildlife.

Sabbathday Lake supports a cold- and warm-water fishery, which include largemouth bass, rainbow smelt, brown trout, brook trout, chain pickerel, and black crappie. Maine Inland Fisheries and Wildlife has stocked the lake with brown trout and brook trout since 1989. Cold-water fish, such as trout, need at least 5 parts per million (ppm) of **dissolved oxygen (DO)** in the water to survive and even higher levels to grow. Historically, Sabbathday Lake has experienced critically-low DO concentrations in the deepest areas of the lake in August and September. Low DO in Sabbathday Lake can release **phosphorus** from bottom sediments into the water column where it can fuel algal growth. Thus, DO monitoring is an important part of the annual water quality evaluation.

On their website, the Lake Stewards of Maine provide a [summary of water quality indicators in lakes across Maine](#).

A **watershed** is an area of land that drains water to a single location such as the outlet of a lake.

**Dissolved Oxygen (DO)** is the concentration of oxygen dissolved in water. DO is critical to the healthy metabolism of many organisms that reside in the water. DO concentrations may change dramatically with lake depth due to the natural process of thermal stratification in summer. Oxygen is produced in the top portion of a lake (where sunlight drives photosynthesis), and consumed near the bottom of a lake (where organic matter accumulates and decomposes).

**Phosphorus** is an essential nutrient for plant growth naturally present in small amounts in lake water and sediments. Stormwater runoff, lawn/garden fertilizers, and malfunctioning wastewater systems can supply excess phosphorus can lead to increased plant and algae growth in lakes.

**Water clarity** is a vertical measure of transparency or the ability of light to penetrate water, obtained by lowering a black and white disk into the water until it is no longer visible. Changes in transparency may be due to increased or decreased algal growth or the amount of dissolved or particulate suspended material in a lake, resulting from human disturbance or other impacts.

including a historical analysis of average indicator values since 1975. Based on these historical measures of **water clarity** as measured by Secchi disk transparency (SDT), total phosphorus (TP), and **chlorophyll-a (Chl-a)**, the water quality of Sabbathday Lake is considered above the Maine lakes average. However, Sabbathday Lake is sensitive to pollutants in stormwater runoff from the watershed. Significant amounts of stormwater runoff can temporarily reduce water clarity and, if erosion in the watershed increases, long-term degradation in water clarity can become extremely difficult to reverse.

## METHODS

On three sampling days in 2020 (July 15, August 10, and September 14), subconsultant Ecological Instincts accompanied SDLA volunteers to collect water quality data and grab samples at the deep spot (Station 1) of Sabbathday Lake. Sampling was conducted in accordance with standard methods and procedures for lake monitoring established by the Maine Department of Environmental Protection (Maine DEP), the U.S. Environmental Protection Agency (USEPA), and the Lake Stewards of Maine (LSM). All water samples were analyzed at the Health and Environmental Testing Lab (HETL) in Augusta.

An integrated **epilimnetic core** was collected at the deep spot (Station 1) of Sabbathday Lake during each sampling event. Due to thermal stratification, the depth of the core sample (or upper part of the thermocline) varied throughout the season. Parameters measured included **Trophic State Indicators** (i.e., water clarity, TP, and Chl-a), DO and water temperature profiles, **true color, total alkalinity,** and **pH**.

**Sabbathday Lake is a  
mesotrophic lake and has  
intermediate levels of  
phosphorus and  
chlorophyll-a and water  
clarity at depths between 4  
and 8 meters.**

**Chlorophyll-a (Chl-a):** a measurement of the green pigment found in all plants, including microscopic plants like algae. It is used as an estimate of algal biomass; higher Chl-a equates to greater amounts of algae.

An **epilimnetic core** is a lake water sample taken by lowering a vertical tube down from the surface of the lake to the upper part of the thermocline (the depth at which temperature begins to decrease dramatically during summer stratification). This technique allows lake scientists to capture water from the entire upper layer of the lake where most photosynthetic algae and cyanobacteria reside, including the metalimnetic maximum or “oxygen bubble.”

**Trophic State Indicators** are measures of biological productivity in lake ecosystems, including water clarity, total phosphorus, and chlorophyll-a. The combination of these parameters helps determine lake trophic state and productivity – the amount of growth of algae, cyanobacteria such as **Gloetrichia**, and other photosynthetic organisms – and serves as a signal of changing water quality.

**True Color** measures the influence of suspended and dissolved particles in water from weathered geologic material, vegetation cover, and land use activity. Colored lakes (>25 PCU) can have reduced water clarity and increased phosphorus concentrations.

**Total Alkalinity** is a measure of the capacity of water to neutralize acids (i.e., buffering capacity). Total alkalinity above 20 ppm buffers against drastic changes in pH that could impact aquatic plants and animals.

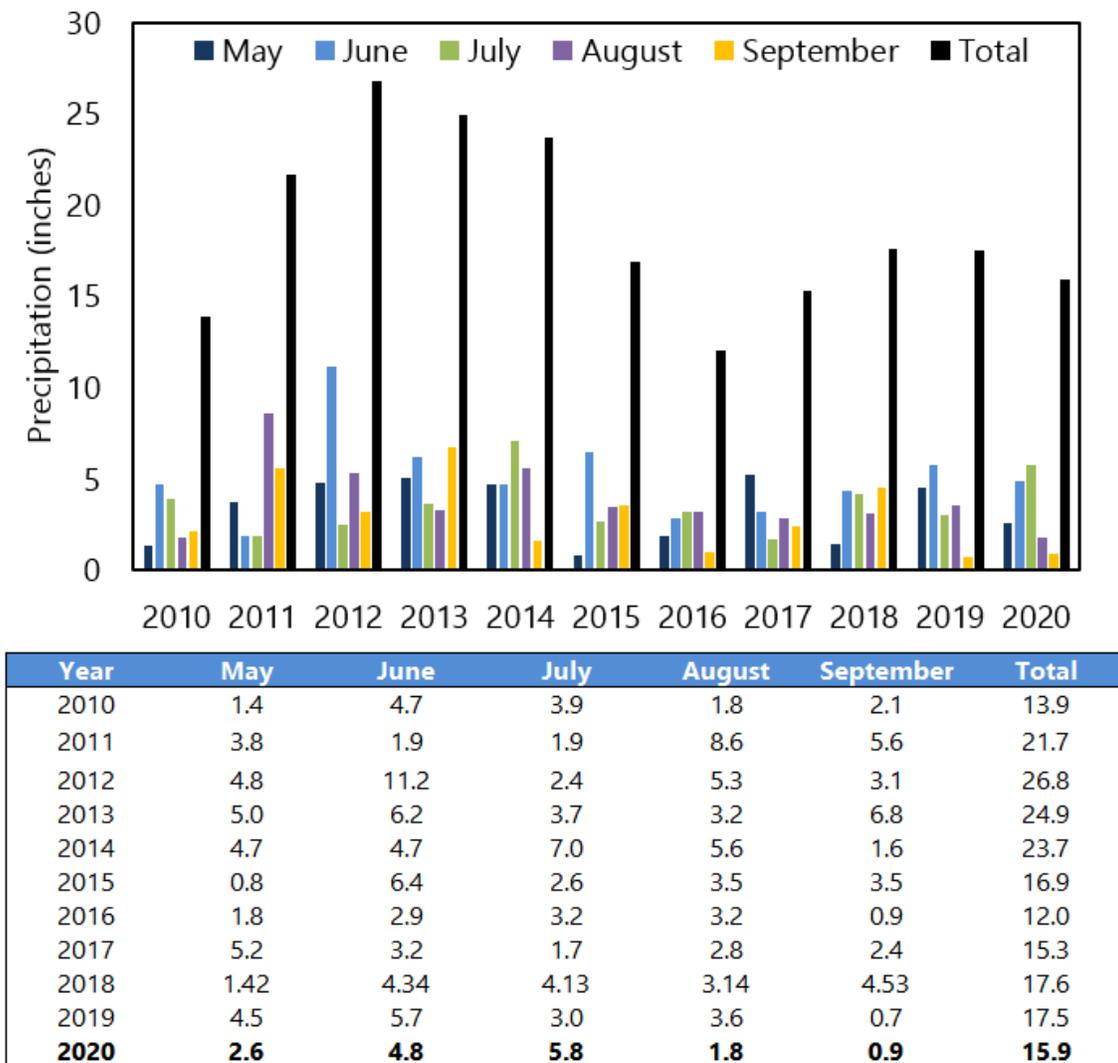
**pH** measures of the acidity of a solution on a scale of 0-14. Most aquatic species require a pH between 6.5 and 8.0.

**Eutrophic, mesotrophic, and oligotrophic lakes** have high, medium, and low productivity, respectively. A eutrophic lake will have high phosphorus, high chlorophyll-a, and low water clarity; an oligotrophic lake will have low phosphorus, low chlorophyll-a, and high water clarity; and a mesotrophic lake will have moderate values for all indicators. Sabbathday Lake is classified as a mesotrophic lake by Maine DEP.

# RESULTS

## WEATHER

Weather is one of the major factors influencing interannual variability in lake water quality. Abnormally dry summer conditions (as experienced in 2010 and 2016) reduce the amount of runoff, containing sediment and nutrients, to the lake, resulting in improved water quality (e.g., higher water clarity, lower phosphorus, and lower chlorophyll-a or algae). Conversely, wetter years transport more material from the landscape to the lake, resulting in degraded water quality. The region experienced the lowest total summer rainfall of the decade in 2016, with only 12 inches in New Gloucester, Maine (Figure 1). With a total of 15.9 inches, 2020 was a slightly below average summer for the current decade (2010-2020). However, 2020 had record low August and September rainfall amounts, receiving only 1.8 inches in August and 0.9 inches in September (Figure 1).



**FIGURE 1.** Monthly precipitation for Sabbathday Lake from May-September (2010-2020). All units are in inches of rainfall. Data are from NOAA NCDC for station GHCND: US1MECM0003 - New Gloucester 3.0, SE, ME, US.

## TROPHIC STATE INDICATORS

### Water Clarity

Measuring water clarity is one of the most useful ways for determining if a lake is changing from year to year. Changes in water clarity may be due to a change in the amount and composition of algal communities or the amount of dissolved or particulate suspended materials in a lake. Such changes are likely the result of human disturbance or other impacts to the lake's watershed. Water clarity varies widely in Maine lakes, ranging from 0.5 to 15.5 meters, with an average of 4.81 meters (Maine VLMP, 2015). Generally, water clarity of 2 meters or less indicates a water quality problem and a higher potential for severe algal blooms. Maine DEP classifies productive or eutrophic lakes as 4 meters or less, moderately productive or mesotrophic lakes as 4-8 meters, and unproductive or oligotrophic lakes as 8 meters or greater.

Since 1975, water clarity in Sabbathday Lake has ranged from 4.0 to 9.2 meters, with an all data average of 6.6 meters (Gulf of Maine Knowledge Base, 2019). Sabbathday Lake is generally clearer than the average water clarity of Maine lakes and has shown a relatively stable trend in water clarity over the sampling record (Figure 2). In 2020, water clarity in Sabbathday Lake ranged from 7.0 to 8.1 meters, with an average of 7.4 meters, which is slightly shallower than the deepest annual average over the entire sampling record (8.1 meters, set in 2016) and is 0.8 meters deeper than the all data average (Table 1). In drier years, there are typically fewer nutrient and sediment inputs that would fuel algal growth or supply suspended sediments. August and September of 2020 were extremely dry with 1.8 and 0.9 inches of precipitation, respectively.

### Total Phosphorus

Since 1982, total phosphorus in Sabbathday Lake has ranged from 3.0 to 15.0 parts per billion (ppb), with an all data average of 6.6 ppb (Gulf of Maine Knowledge Base, 2019). Sabbathday Lake has low phosphorus compared to average phosphorus levels in Maine lakes and has shown a relatively stable trend in phosphorus over the sampling record (Figure 2). In 2020, total phosphorus in Sabbathday Lake ranged from 4.0 to 7.0 ppb, with an average of 5.2 ppb, which is the third lowest annual average on record. The lowest annual average on record is 4.0 ppb from 2018. The 2020 average of 5.2 ppb is 1.4 ppb lower than the all data average of 6.6 ppb (Table 1).

Maine DEP also collected bottom grab samples in summer (June-September) for total phosphorus at Sabbathday Lake from 1982 to 2011. Phosphorus at the bottom of the lake ranged from 6.0 to 22.0 ppb, with an all data average of 11.9 ppb (almost double the all data average for epilimnetic phosphorus). High levels of phosphorus in bottom waters of the lake indicate that phosphorus from the lake bottom sediment is entering the water column in a process known as internal phosphorus cycling. Briefly, conditions of low summer DO enable phosphorus to be chemically released from bonds with iron oxides in the sediment, which would otherwise be an effective storage mechanism. A profile sample collected shortly after both spring and fall turnover would provide more information about potential internal phosphorus cycling.

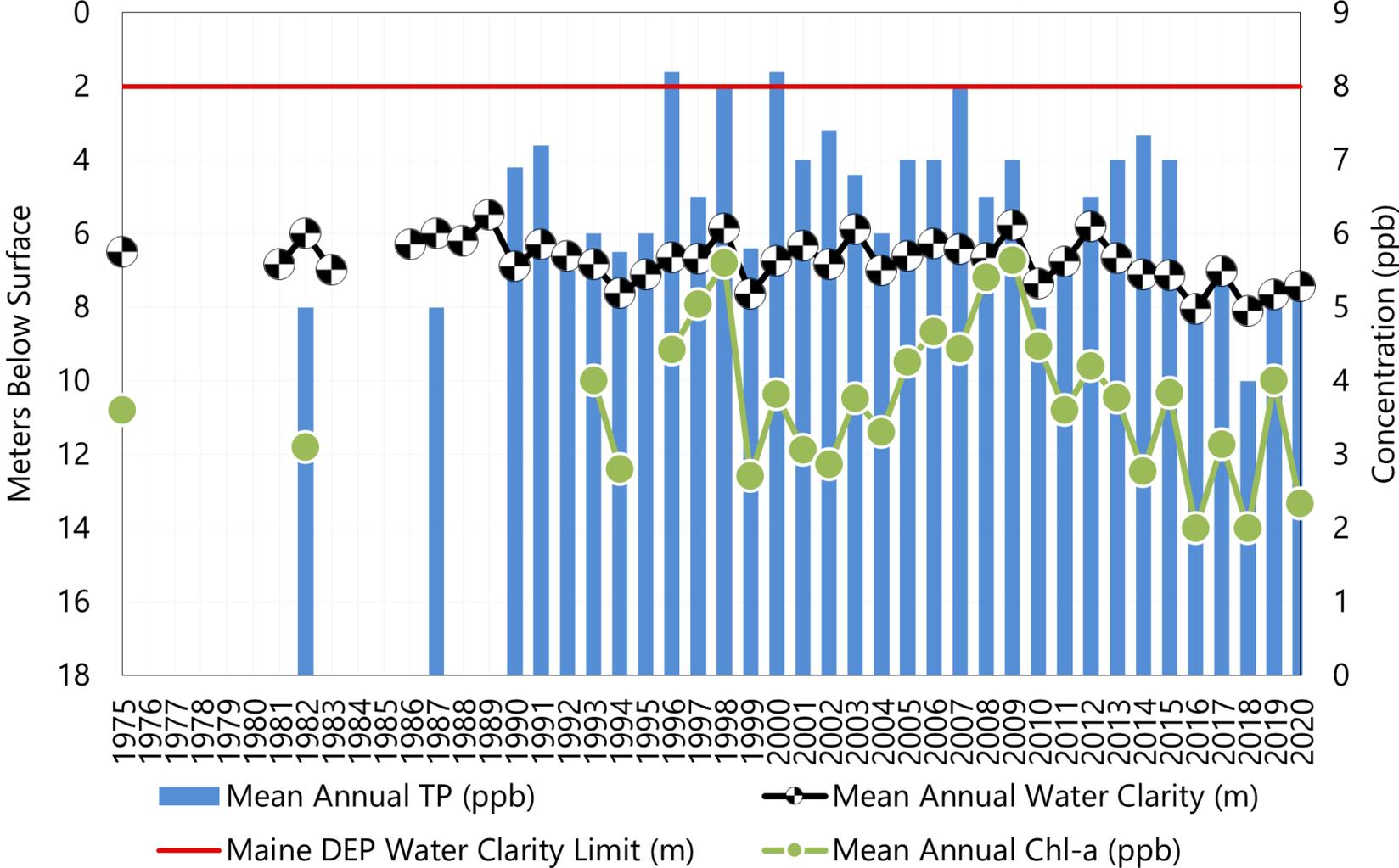
### Chlorophyll-a

Since 1975, chl-a in Sabbathday Lake has ranged from 1.6 to 10.6 ppb, with an all data average of 3.8 ppb (Gulf of Maine Knowledge Base, 2019). Sabbathday Lake has low chlorophyll-a (algae) compared to average chlorophyll-a levels in Maine lakes and has shown a relatively stable trend in chlorophyll-a over the sampling record (Figure 2). In 2020, chlorophyll-a in Sabbathday Lake ranged from 2.0 to 3.0 ppb and averaged 2.3 ppb, which is 1.5 ppb lower than the all data average of 3.8 ppb, and is the second lowest annual average on record (average of 2.0 ppb was recorded in 2016 and 2018) (Table 1).

*Gloeotrichia* is a genus of planktonic freshwater cyanobacteria. In an effort to further understand why blooms of *Gloeotrichia* are occurring on some lakes throughout New England and to assess which lakes may be or become vulnerable to these blooms, Maine DEP has included a presence or absence box on the lake profile sampling form. Here, lake monitors can record the presence of *Gloeotrichia* if applicable and the density of the colony. The presence of *Gloeotrichia* in the water column was not noted on any of the 2020 sampling dates.



*Photo: Very calm waters on a nearly windless, sunny sampling day, August 10, 2020. Four adult loons were observed during the sampling efforts.*



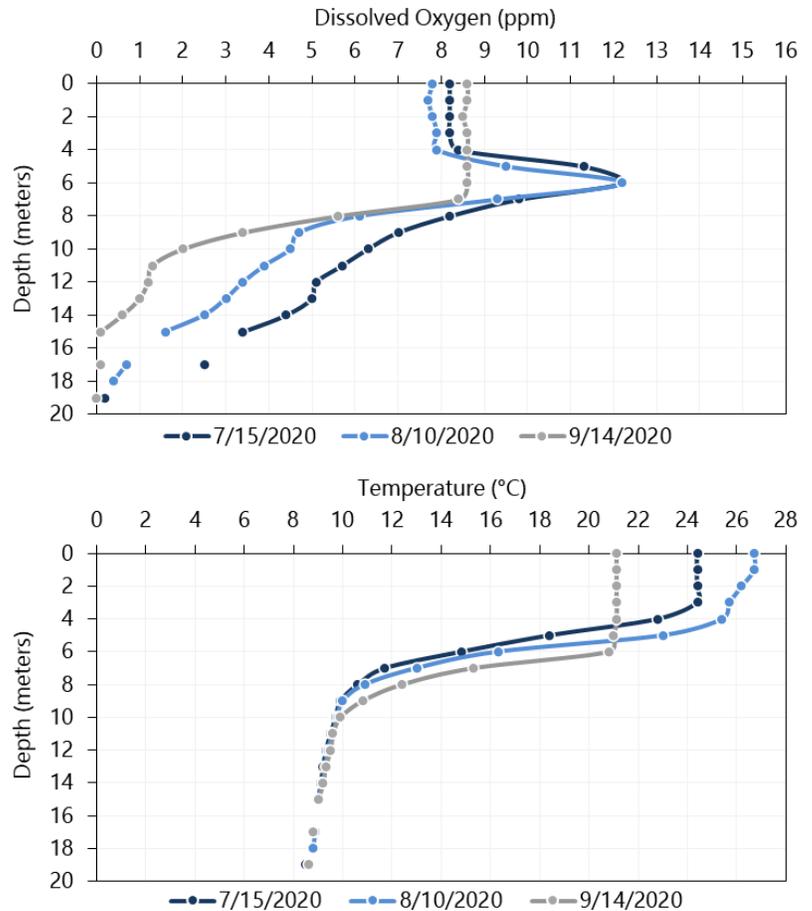
**FIGURE 2.** Average annual water quality data for trophic state indicators (water clarity, total phosphorus (TP), and chlorophyll-a (Chl-a)) for Sabbathday Lake. 2015-2020 annual averages include only data collected by FB Environmental and Ecological Instincts on behalf of SDLA.

## DISSOLVED OXYGEN & TEMPERATURE

Sabbathday Lake has a history of DO depletion in deep, cold areas of the lake (below 8 meters) in late summer. In 2020, DO levels dropped below 5 ppm at approximately 14 meters in July, at 9 meters in August, and at 9 meters in September (Figure 3). The volume of the lake affected by DO concentrations less than 5 ppm was approximately 6% in July, 24% in August, and 24% in September. As in previous years, the most significant DO depletion occurred in September when DO levels dropped below 2 ppm beginning at 10 meters. On this date DO levels fell below 1 ppm at 14 meters below the surface.

A DO **metalimnetic maximum** (commonly referred to as an “oxygen bubble”) occurred between 4 and 8 meters, accompanied by a marked decrease in water temperature, is indicative of the thermocline and persists all season. The upper part of the thermocline is where algae are most productive; below this, decreasing light penetration limits algal growth. In addition, cold-water fish prefer waters of 18°C and can tolerate waters up to 24°C. In summer of 2020, the upper 0-6 meters (43% of the lake volume) were warmer than 18°C, while deeper waters were oxygen-depleted. The suitable habitat of cooler, oxygenated waters was thus restricted to a layer at depths of 6 to 8 meters, comprising 13% of the total lake volume.

Continued monitoring of DO is needed to characterize oxygen depletion over time in Sabbathday Lake. Collecting regular phosphorus samples near the bottom of the lake could also provide information on internal phosphorus cycling. Internal phosphorus loading is the process whereby phosphorus bound to lake bottom sediments is released back into the water column during periods of anoxia. The phosphorus can be used as fuel for algae growth, creating a positive feedback to eutrophication and low DO concentrations.



**FIGURE 3.** Dissolved oxygen (top) and temperature (bottom) profiles collected in 2020 at Sabbathday Lake.

## CHEMICAL PARAMETERS

### Color

Since 1982, color in Sabbathday Lake has ranged from 5 to 32 platinum-cobalt units (PCU), with an all data average of 12.9 PCU (Gulf of Maine Knowledge Base, 2019). Sabbathday Lake has low color compared to average color in Maine lakes and has shown a relatively stable trend in color over the sampling record (Figure 4). In 2020, color in Sabbathday Lake measured between 10 and 13 PCU (for an average of 11.3 PCU) – 1.7 PCU better than the all data average (Table 1). The lowest annual average over the entire sampling record was recorded at 7 PCU in 2016.

### Alkalinity

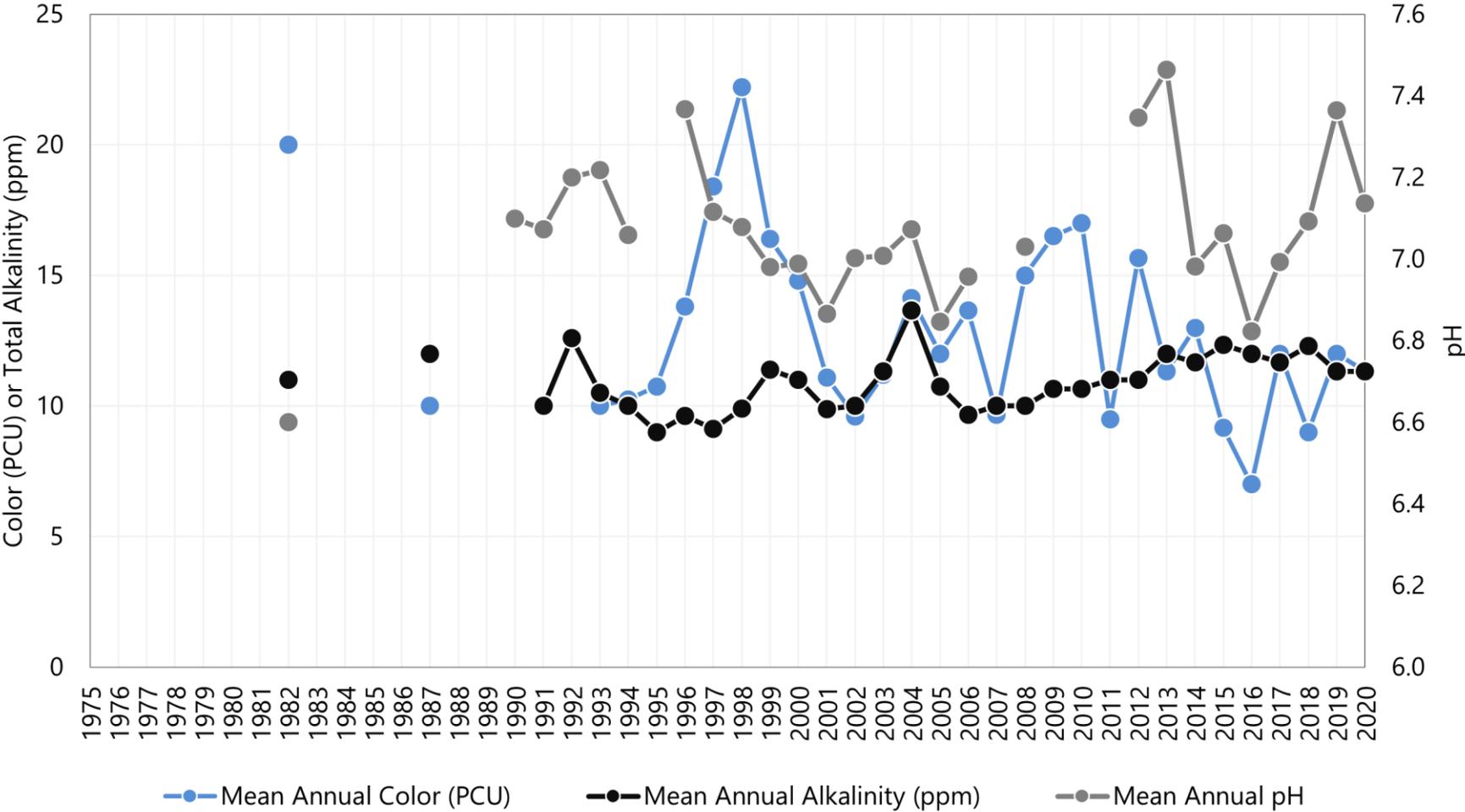
Since 1982, total alkalinity in Sabbathday Lake has ranged from 7.1 to 17.5 ppm, with an all data average of 10.9 ppm (Gulf of Maine Knowledge Base, 2019). Sabbathday Lake has slightly lower alkalinity compared to average alkalinity in Maine lakes and has shown stability over the sampling record (Figure 4). In 2020, total alkalinity in Sabbathday Lake ranged from 11.0 to 12.0 ppm for an average of 11.3 ppm, which is 0.4 ppm higher than the all data average (Table 1). Per the USEPA, these average total alkalinity levels in Sabbathday Lake fall in the “sensitive” category of 10 ppm to 20 ppm. A lake is well-buffered against changes in pH if total alkalinity is greater than 20 ppm, which average alkalinity in Maine lakes falls well below.

### pH

Since 1982, pH in Sabbathday Lake has ranged from 6.6 to 7.5, with an all data average of 7.0 (Gulf of Maine Knowledge Base, 2019). Sabbathday Lake has slightly higher pH compared to average pH in Maine lakes and has shown a relatively stable trend in pH over the sampling record (Figure 4). In 2020, pH in Sabbathday Lake ranged from 7.0 to 7.3, with an average of 7.1, which is 0.1 above the all data average (Table 1).

**TABLE 1.** Summary of 2020 data and historical averages for water clarity, total phosphorus (TP), chlorophyll-a (Chl-a), color, alkalinity, and pH at Sabbathday Lake (SDL). Average Maine lake values were obtained from VLMP (2018).

Date	Water Clarity (m)	TP (ppb)	Chl-a (ppb)	Color (PCU)	Alkalinity (ppm)	pH
7/15/2020	7.2	7.0	3.0	13.0	11.0	7.0
8/10/2020	7.0	4.0	2.0	11.0	11.0	7.2
9/14/2020	8.1	4.5	2.0	10.0	12.0	7.3
2020 Average (SDL)	7.4	5.2	2.3	11.3	11.3	7.1
Historical Avg. (SDL)	6.6	6.6	3.8	13.0	10.9	7.0
Average (Maine Lakes)	5.5	11.2	5.6	20.5	11.6	6.9



**FIGURE 4.** Average annual water quality data for chemical parameters (color, total alkalinity, and pH) for Sabbathday Lake. 2015-2020 annual averages include only data collected by FB Environmental and Ecological Instincts on behalf of SDLA.

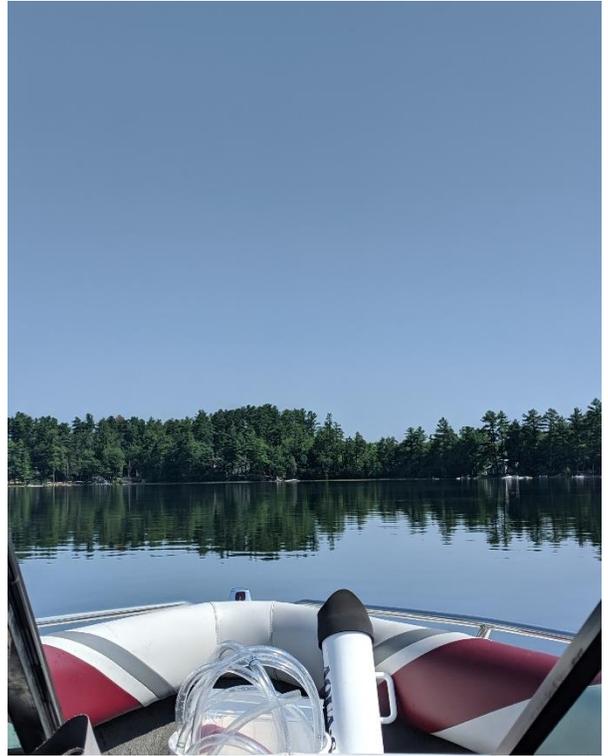
# SUMMARY

Sabbathday Lake continues to have above-average water quality compared to the average for Maine lakes (Table 1).

All water quality parameters measured at Sabbathday Lake show no discernable trends of increase or decrease in annual averages over the entire sampling record.

The 2020 monitoring season received a below average amount of precipitation, with water quality results reflecting the dry sampling season.

- Water clarity, total phosphorus, chlorophyll-a, color, alkalinity, and pH annual averages for 2020 show an improvement from the historical average.
- Water clarity in 2020 was high, surpassed only by the 2016, 2018, and 2019 yearly averages in the historical record.
- Average total phosphorus in 2020 was only 1.2 ppb higher than the lowest yearly average, which was recorded in 2018.
- pH was slightly higher than average in 2020, only 0.4 lower than the highest yearly average which was recorded in 2013.
- Chlorophyll-a was below the historical average by 1.5 ppb and is the third lowest value in the historical record.



The slightly below average rainfall amount received during the 2020 summer, with record low August and September months, likely played a role in the above average water quality observed. Further studies would be necessary to determine if these or other factors were at play.

DO profiles at the Sabbathday Lake deep spot continue to show that depletion is a persistent issue, with depths as shallow as 8-9 meters showing DO levels at or below 5 ppm in 2020. Desirable habitat of cool, oxygenated water for cold-water fish was restricted to between 6 and 8 meters below the water surface in 2020. This low DO may also be releasing biologically available phosphorus from bottom sediments, though phosphorus remains low overall in Sabbathday Lake.

# RECOMMENDATIONS

- Continue the baseline annual water quality monitoring program at Sabbathday Lake.
- Consider adding hypolimnion (bottom) grab samples for phosphorus to the three sampling events.
- Consider collecting water quality data (especially DO and temperature profiles and epilimnion and/or hypolimnion grab samples for phosphorus and chlorophyll-a) immediately after spring and fall turnover to better characterize internal phosphorus cycling in Sabbathday Lake. Low oxygen in late summer when thermal stratification sets in (creating a barrier to lake mixing, so oxygen-rich surface

waters cannot replenish bottom waters) causes a chemical reaction with iron-bound phosphorus in bottom sediments that can re-release phosphorus into the water column and fuel algal growth.

- In addition to collecting water quality data after spring and fall turnover, consider collecting water quality data (DO and temperature profiles and epilimnion and hypolimnion grab samples for phosphorus) during winter stratification if ice conditions are safe. Biological and ecological processes persist during the winter months and little is known about the limnological chemistry during this time within Sabbathday Lake. Shedding light on this data gap can help assess the quality and extent of aquatic habitats within the water column during winter stratification.
- Consider adding a water quality monitoring buoy that continuously measures DO and temperature throughout the ice-free season (can also measure temperature during the winter months). This will help pinpoint spring and fall turnover and the extent and duration of low DO in Sabbathday Lake.
- Consider collecting benthic sediment core samples for phosphorus analysis at the two deep spots in the lake.

## WAYS TO PROTECT THE LAKE

There are many ways that individual landowners can help reduce sediment and nutrient input to Sabbathday Lake to protect and even improve water quality, including:

- Join the Sabbathday Lake Association (SDLA)
- Participate in a watershed survey every 10 years
- Pump your septic system every 2-3 years, participate in a septic survey, and inspect your septic system if older than 20 years
- Help form a road association
- Participate in volunteer surveys, including water quality and aquatic plants surveys
- Use phosphorus-free fertilizers and household products
- Plant a vegetated buffer (100-250 feet wide is ideal) along your shorefront area
- Vegetate and mulch bare soils using native materials
- Terrace and vegetate steep slopes
- Create meandering footpaths to slow storm flow to the lake
- Repair eroding driveways to prevent erosion
- Line eroding ditches with rock
- Educate neighbors about lake science
- Become LakeSmart by contacting SDLA and the Maine Lakes Society (207-495-2301 or email [info@mainelakessociety.org](mailto:info@mainelakessociety.org)) for a free LakeSmart evaluation; or become a certified LakeSmart evaluator



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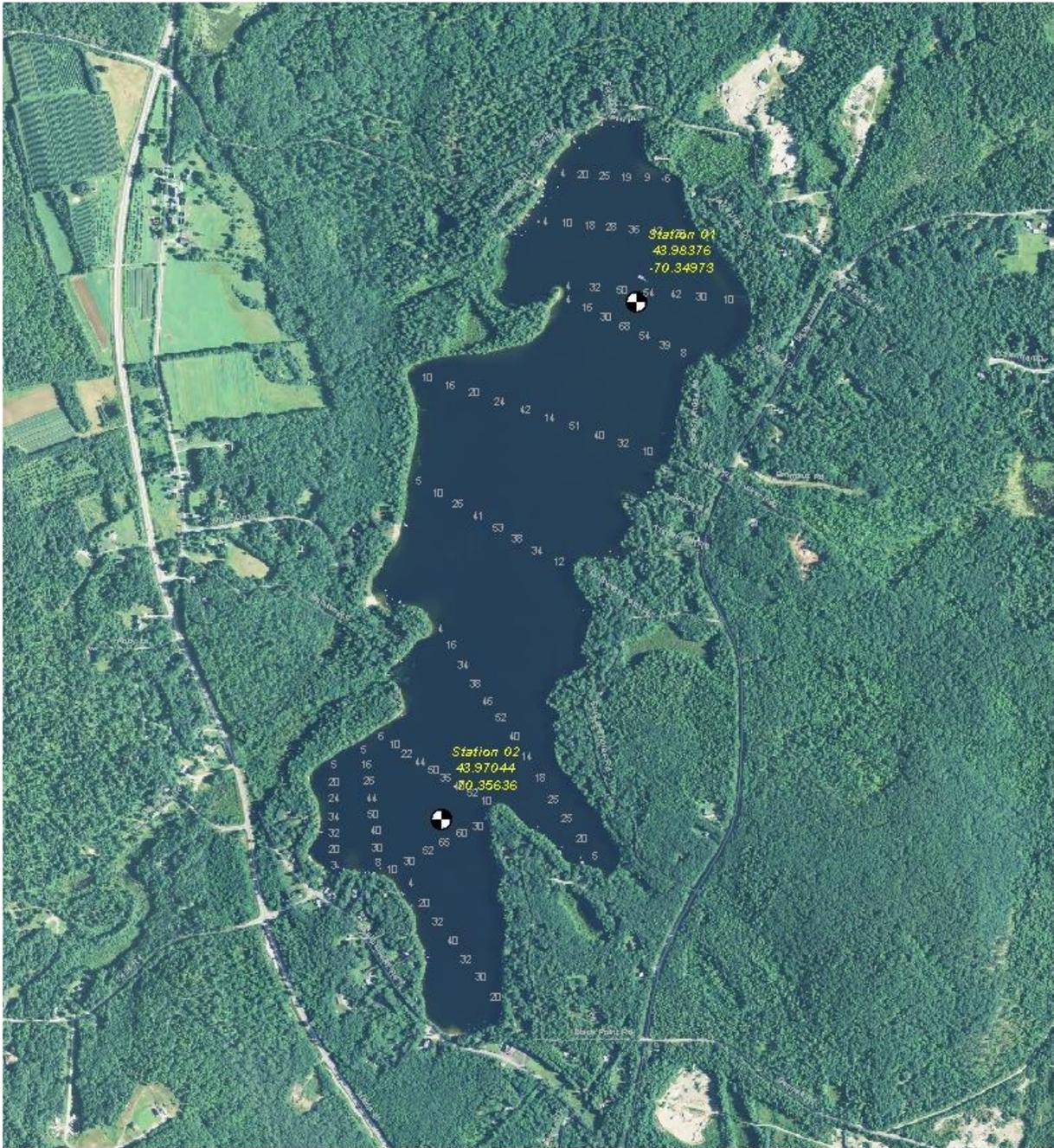
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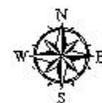
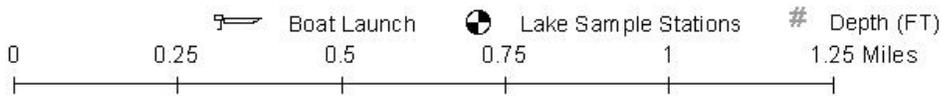
# APPENDIX A | DEPTH MAPS



**Sabbathday Lake**

**MIDAS # 3700**

New Gloucester, Cumberland Co. - Delorme Page 5 - 342 acres



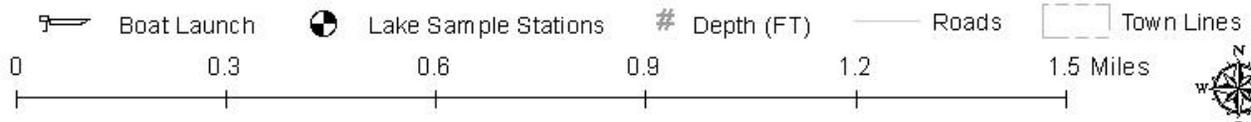
Source: Lakes of Maine, Online: <http://www.lakesofmaine.org/lake-overview.html?m=3700>



# Sabbathday Lake

MIDAS # 3700

New Gloucester, Cumberland Co. - Delorme Page 5 - 342 acres



Source: Lakes of Maine, Online: <http://www.lakesofmaine.org/lake-overview.html?m=3700>