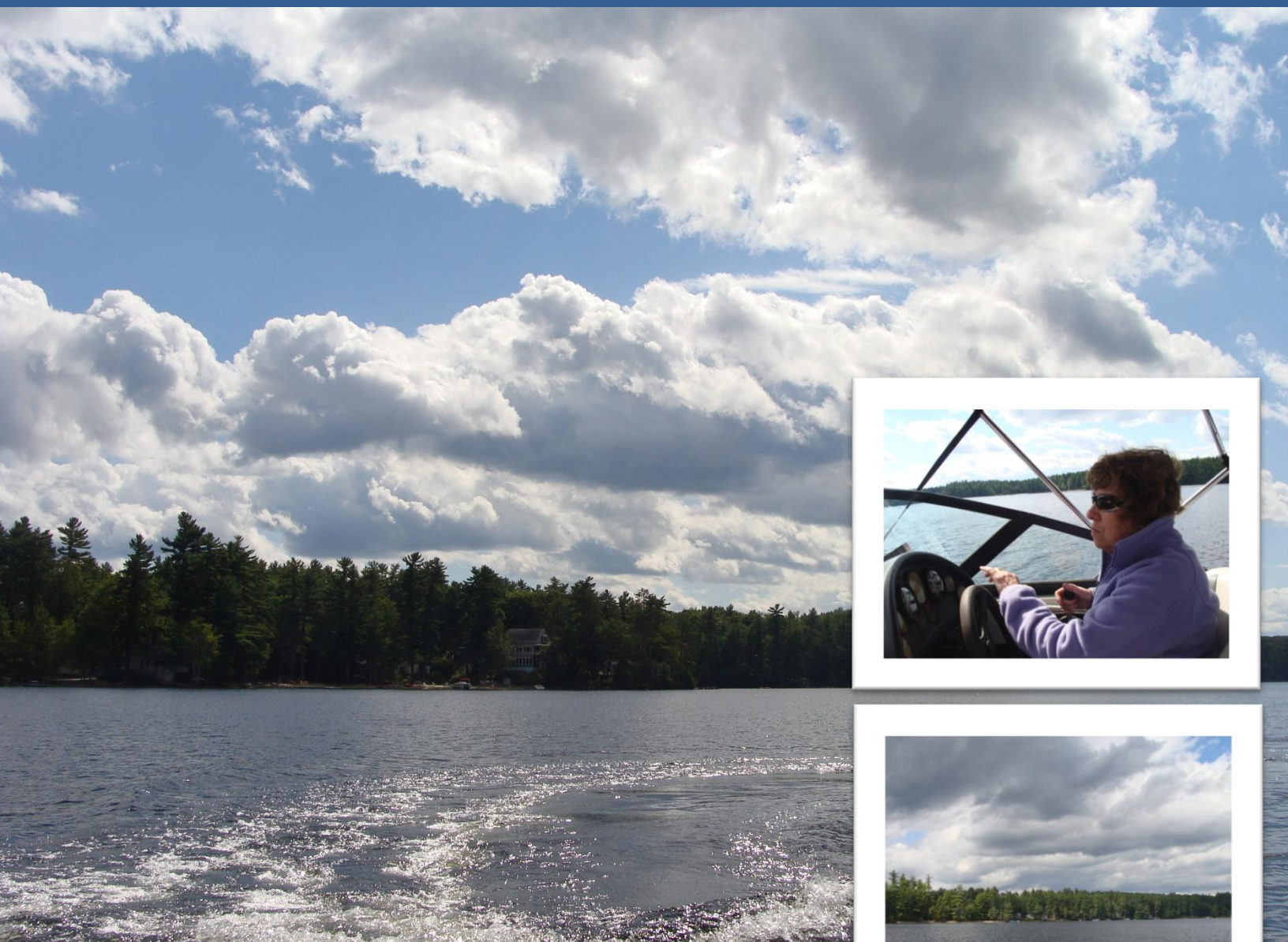


# 2014 Sabbathday Lake Water Quality Report



***January 2015***



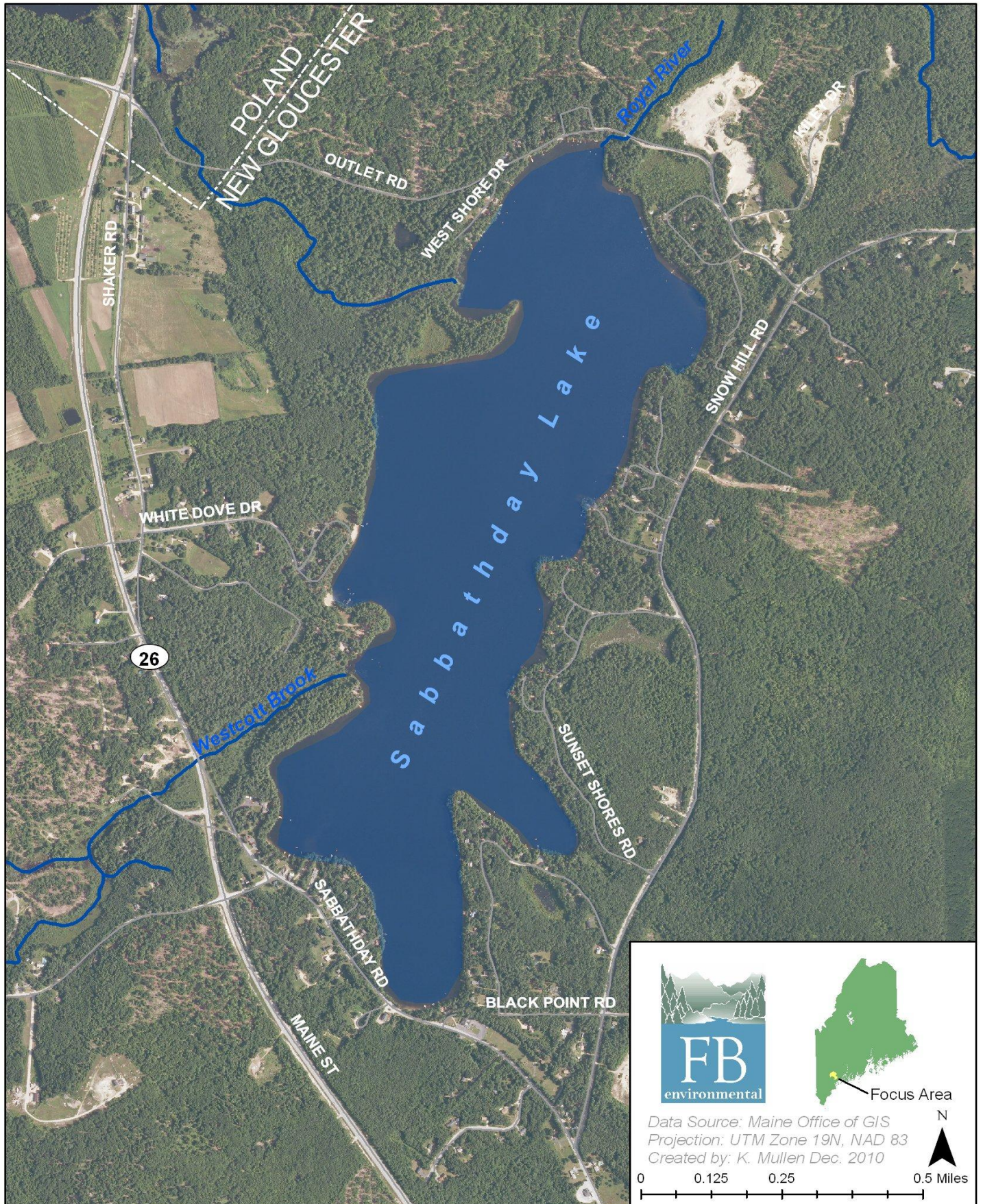
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# 2014 Sabbathday Lake Water Quality Report

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*Special thanks to Sabbathday Lake Association volunteers Cheryl Fortier and Aaron Ricardi for volunteering their time and boats over the course of the 2014 sampling season. Their efforts are greatly appreciated. Thanks to members of the Sabbathday Lake Association for supporting the long-term collection of water quality data.*

*Cover photos: FB Environmental*

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# 2014 SABBATHDAY LAKE WATER QUALITY REPORT

## 1. BACKGROUND AND HISTORICAL INFORMATION

### Sabbathday Lake Facts

**Watershed:** Royal River

**Town:** New Gloucester

**Watershed Area:** 5.33 sq. mi.

**Mean Depth:** 24 feet

**Max Depth:** 58 feet

**Surface Area:** 342 Acres

**Flushing Rate:** 0.88 flushes/year



*Sabbathday Lake, 2009*

Sabbathday Lake is a 342-acre non-colored waterbody located in the Town of New Gloucester in Cumberland County, Maine. The lake is part of the larger Royal River Watershed, and has a direct **watershed** area of approximately 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 new 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-water fishery which includes species of largemouth bass, rainbow smelt, brown trout, brook trout, and chain pickerel, among others. 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 five 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 dissolved oxygen concentrations in the deepest areas of the lake in August and September. According to the Maine Department of Environmental Protection

### KEY TERMS

**Watershed:** A drainage area or basin in which all land and water areas drain or flow toward a control collector such as a stream, river or lake at a lower elevation.

**Dissolved Oxygen (DO)** is the concentration of oxygen that is dissolved in water. DO is critical to the healthy metabolism of many creatures that reside in the water.

**Phosphorus** is one of the major nutrients needed for plant growth. It is naturally present in small amounts and limits the plant growth in lakes. Generally, as phosphorus increases, the amount of algae also increases. Total Phosphorus (TP) refers the total concentration of phosphorus found in the water including organic and inorganic forms.

(Maine DEP), this loss of dissolved oxygen in Sabbathday Lake may be associated with the natural release of **phosphorus** from the bottom sediments.

Water quality data for Sabbathday Lake has been collected since 1975. Based on measures of Secchi disk transparency (SDT), total phosphorus (TP), and chlorophyll-a (Chl-a), the water quality has generally been considered above average since monitoring began (Lakes of Maine, 2015). Historically, Sabbathday Lake has an average TP concentration of 7.0 ppb and an average Chl-a concentration of 4.0 ppb. These numbers fall within the average range for most lakes in Maine. Similarly, the historical average SDT for the lake is 6.6 meters, compared to an average of 4.8 meters for Maine lakes. Although many of the water quality measurements in for Sabbathday Lake have historically been better than the Maine average, Sabbathday Lake is still sensitive to pollutants in stormwater runoff from stemming from the surrounding watershed. Significant amounts of stormwater runoff can temporarily reduce transparency, and if erosion in the watershed increases, the long-term reductions in transparency could become permanent.

## 2. WATER QUALITY MONITORING – METHODS AND PARAMETERS

In 2014, FB Environmental collected water quality data for Sabbathday Lake over a period of three sampling events (July 8, August 19, and September 18). 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 (EPA), and the Maine Volunteer Lake Monitoring Program (VLMP). All water samples were analyzed at the Health and Environmental Testing Lab (HETL) in Augusta. The following parameters were measured in 2014:

***Trophic State Indicators (TSI):*** “Trophic state” indicators, or indicators of biological productivity in the lake ecosystem, help to determine the extent of and effects of eutrophication in lakes. Eutrophication is the process by which lakes are enriched with nutrients, increasing the production of rooted aquatic plants and algae. Sabbathday Lake is a mesotrophic lake. This type of lake has intermediate levels of phosphorus and chlorophyll, and Secchi disk transparencies of 4m to 8m (13.3 to 26.5 ft.). The “trophic state” indicators measured in Sabbathday Lake include:

- **Secchi disk transparency** (water clarity)
- **Total Phosphorus (TP)**
- **Chlorophyll-a (Chl-a)**

***Dissolved oxygen:*** In addition to the above parameters, the concentration of oxygen dissolved in the water and the water temperature were also



**Figure 1. Sabbathday Lake 2014 sampling location.**

measured. Dissolved oxygen (DO) levels in lake water are influenced by a number of factors, including water temperature, the concentration of algae and other plants in the water, and the amount of nutrients and organic matter that flow into the water body from the watershed. Oxygen is needed by virtually all fish, algae and macrophytes, and for many chemical reactions that are important to lake functioning.

Dissolved oxygen concentrations may change dramatically with lake depth. Oxygen is produced in the top portion of a lake (where sunlight drives photosynthesis), and oxygen consumption is greatest near the bottom of a lake (where organic matter accumulates and decomposes). In deeper, stratified lakes, such as Sabbathday, this difference may be dramatic - with high oxygen near the top and minimal amounts near the bottom. As mentioned earlier, some species of fish are particularly sensitive to any loss of oxygen, particularly coldwater varieties like trout and salmon.

**Additional parameters:** Indicators of lake water quality measured in addition to trophic state and dissolved oxygen data include:

- **True Color**
- **Total Alkalinity**
- **pH**

An “integrated epilimnetic core” method was used to collect samples at the “deep hole” (Station 1) of Sabbathday Lake. With this method, a core of water is collected from the water surface to the upper part of the thermocline. Sampling results reflect the “average” concentration for each of the measured parameters. Due to thermal stratification, the depth of the core sample varies throughout the season.

#### **KEY TERMS**

**Secchi Disk Transparency (SDT):** a vertical measure of the transparency of water (ability of light to penetrate water) obtained by lowering a black and white disk into the water until it is no longer visible.

**Chlorophyll-a (Chl-a):** a measurement of the green pigment found in all plants including microscopic plants such as algae. It is used as an estimate of algal biomass; the higher the Chl-a number, the higher the amount of algae in the lake.

**True Color** is influenced by both suspended and dissolved particles in the water. Natural dissolved organic acids such as tannins can give water a tea color. Suspended material can be from both natural causes and human activity. Weathered geologic material, vegetation cover within the watershed, and land-use activity will influence the types and amount of dissolved and suspended material found in a lake or stream. Lake color can have a strong bearing on other water quality indicators.

**Total Alkalinity:** a measure of the capacity of water to neutralize acids (buffering capacity).

**pH:** a measure of relative acid-base status of lake water.



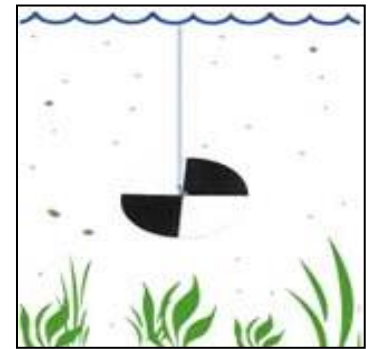
### 3. SABBATHDAY LAKE WATER QUALITY MONITORING RESULTS

#### 3.1 WATER CLARITY

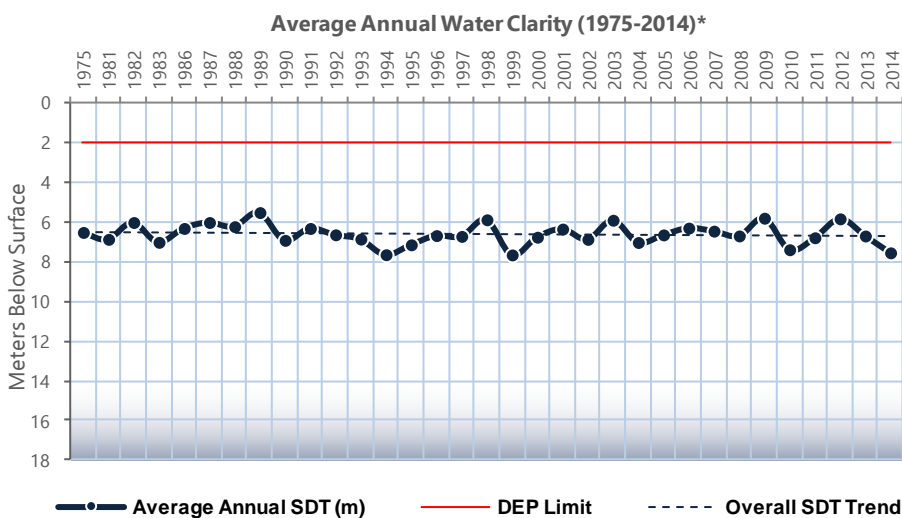
Measuring Secchi disk transparency (SDT) is one of the most useful ways of determining if a lake is changing from year to year. Changes in transparency may be due to increased or decreased algal growth, or the amount of dissolved or particulate materials in a lake. Such changes could be the result of human disturbance or other impacts to the lake watershed area. Factors that affect transparency include algae, water color, and sediment. Transparency can be used to indirectly measure the algal population, because algae typically have the greatest effect on transparency. Lake color affects light penetration and therefore depth at which plants can grow. Relatively clear lakes (above) let the light through the water reaching greater depths and allowing increased plants growth at the lake bottom.



Photo: Maine VLMP



Transparency values vary widely in Maine lakes, ranging from 0.5 m to 15.5 m, with an average of 4.8 m (VLMP, 2013). Generally, a transparency reading of 2 meters or less indicates a water quality problem and the potential for severe algal blooms. Transparency readings have been collected in Sabbathday Lake since 1975 by trained volunteers, Maine DEP and consulting water quality experts. All of this data can be used to assess how water quality has changed over time. Since 1975, Secchi disk readings in Sabbathday Lake have ranged from 4.0 m to 9.2 m with an annual average over this time period of 6.6 m. This is higher (clearer) than the average transparency for lakes throughout Maine. While there is expected variability in Secchi disk transparency from year to year, the overall trend in Sabbathday Lake is stable, and may even be improving slightly (Figure 2). A clear lake with small algal populations results in deep Secchi disk readings and low levels of chlorophyll-a and TP.



**Figure 2.** Sabbathday Lake average annual water clarity.

*\*Note: The 2014 average includes only FBE SDT readings and does not include any data collected by Maine DEP or VLMP.*



In Maine, average Secchi disk readings are related to algal productivity using the following guidelines (Maine VLMP):

- ☐ 4m or less = *Productive*
- ☐ 4-7m = *Moderately Productive*
- ☐ 7m or greater = *Unproductive*

In 2014, transparency in Sabbathday Lake ranged from 7.1 m to 8.3 m with an average of 7.5 m, slightly deeper (more clear) than the 2013 average. Based on the productivity guidelines above, Sabbathday Lake is in the range of an unproductive lake for the year, but based on the historical average (6.6 m) is still considered moderately productive.

The 2014 average is the highest average since 1999 (7.6m), and 1.0 m deeper than the historical average (6.5 m). Weather and other local land-use changes can result in annual variability of transparency readings. In 2014, the rainfall total for New Gloucester, Maine was 23.7" between May and September 2014. With the exception of 2013 (which had record low rainfall), the 2014 total is more in line with rainfall totals during this time period (Table 1). As described above, rainfall is one of several variables that can influence water clarity. Rainfall delivers sediments and other pollutants directly into the lake as overland flow (stormwater). In years with low rainfall, less runoff occurs, thereby resulting in better water clarity.

**Table 1.** Monthly precipitation for Sabbathday Lake from May to September (2010-2014).

Year	May	June	July	August	September	Total
<b>2014</b>	4.7	4.7	7.1	5.6	1.6	23.7
<b>2013</b>	0	0.02	3.59	3.65	1.17	8.43
<b>2012</b>	5.2	11.1	2.5	5.9	3.86	28.6
<b>2011</b>	3.6	2.1	2.2	8.2	5.1	21.2
<b>2010</b>	1.5	5.5	4.3	2	5.1	18.4

*\*Note: The 2014 data is from NOAA NCDC online for station GHCND: US1MECM0003- New Gloucester 3.0, SE, ME US. (<http://www.ncdc.noaa.gov/cdo-web/datatools/findstation>). This station is closer to Sabbathday Lake than the Gray weather station (2013 - 2010 data presented above).*

### 3.2 DISSOLVED OXYGEN

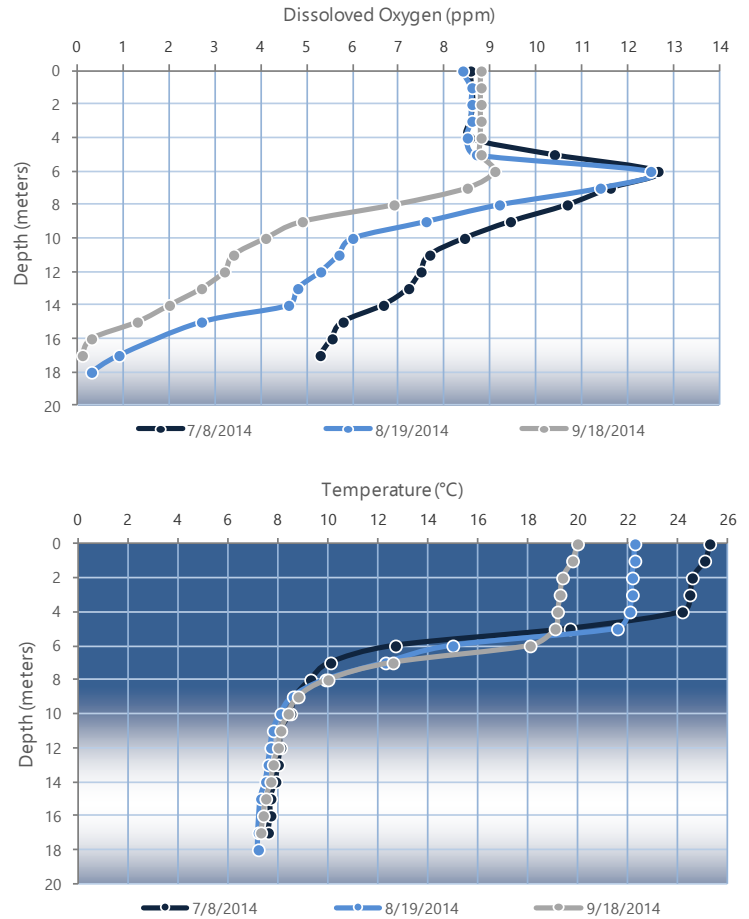
Dissolved oxygen (DO) is a measure of the amount of oxygen dissolved in the water. All living organisms, except for anaerobic bacteria, need oxygen to survive. Too little oxygen severely reduces the diversity and population of aquatic communities. DO levels below 5 ppm can stress some species of cold water fish, and over time reduce habitat for sensitive cold water species. During the summer, thermal stratification can prevent oxygenated water from mixing with water deep in the lake. As a result, oxygen levels in deeper areas can become depleted. Another result of oxygen depletion is the potential release of biologically-available phosphorus from bottom sediments, a natural process that can occur under low oxygen conditions. This phosphorus provides food for algae.

Sabbathday Lake has a history of DO depletion in deep, cold areas of the lake (below 8 meters) in late summer. In 2014, DO levels dropped below 5 ppm, at 9 m in September, 13 m in August (Figure 3). As in previous years, the most significant oxygen loss occurred in mid-September, when dissolved oxygen levels declined to less than 3 ppm beginning at 12 m and below. The sharp increase in DO between 4 m and 6 m, as well as a drop in temperature, is indicative of the thermocline. It is at this depth that algae are most productive, and is also the lower limit that light reaches as measured by SDT readings. This means that the lower half of the lake, below the thermocline, has less oxygen available for plants and animals, thus decreasing the habitat available for fish and other animals. Ongoing monitoring of DO trends is needed to characterize oxygen depletion over time, and phosphorus samples collected near the bottom of the lake may provide information about internal phosphorus recycling from bottom sediments as a result of the oxygen loss. Loss of oxygen at the bottom of the lake has been linked to release of phosphorus laden sediments into the water column, adding to the phosphorus inputs from the watershed. These combined inputs provide food for algae, and can make the lake more productive over time and lead to algal blooms.

### 3.3 TOTAL PHOSPHORUS

Total phosphorus (TP) refers to the total concentration of phosphorus found in the water, including organic and inorganic forms. TP is one of the major nutrients needed for plant growth. TP is generally present in small amounts and limits plant growth in lakes. As phosphorus increases, the amount of algae usually increases as well. If the amount of algae increases enough, an algal bloom may occur. Humans can unintentionally add phosphorus to a lake through stormwater runoff, lawn or garden fertilizers, and leaky or unmaintained septic tanks.

In 2014, TP levels in Sabbathday Lake ranged from 5 ppb to 11 ppb, with an average of 7.0 ppb (Table 2). The average TP concentration in Sabbathday Lake is much lower than the Maine average of 12 ppb. In



**Figure 3.** Sabbathday Lake 2014 dissolved oxygen (top), and temperature (bottom) profiles.

**Table 2.** Sabbathday Lake total phosphorus.

TP (ppb)	
7/8/2014	11
8/19/2014	6
9/18/2014	5
2014 Average (SDL)	7
Historical Avg. (SDL)	7
Average (Maine Lakes)	12



addition epilimnetic TP samples, Maine DEP has collected bottom grab samples for Sabbathday Lake over the course of 11 years between 1982 and 2011. Phosphorus concentrations at the bottom of the lake have ranged from 6 ppb (1995) to 19 ppb (1994). Since 2004, TP in bottom grab samples have ranged from 10 to 12 ppb. Higher concentrations of phosphorus in water at the bottom of the lake compared to the surface may indicate release of phosphorus from the bottom sediments as a result of low dissolved oxygen concentrations at the bottom of the lake. A profile sample collected shortly after ice out in the spring would provide more information about potential internal recycling in Sabbathday Lake.

### 3.4 COLOR

Color is the influence of suspended and dissolved particles in the water, and is measured by comparing a sample of the lake water to Platinum-Cobalt Units (PCU). A variety of sources contribute to the types and amount of suspended material in lake water, including weathered geologic material, vegetation cover, and land use activity. Colored lakes (>25 PCU) can have reduced transparency readings and increased phosphorus values, however, this does not necessarily mean such lakes are more productive. Color can interfere with test results, so Chlorophyll-a (Chl-a) is the best indicator of productivity in colored lakes. The average water color in Maine lakes is 28 PCU (VLMP, 2013). In 2014, color in Sabbathday Lake ranged from 12 to 15 PCU with an average of 13 PCU (Table 3). While this range is greater than the range of color in 2013 (11-12 PCU), it is still lower than the historical average for Sabbathday Lake, and half the average color of Maine Lakes as a whole. Sabbathday Lake is considered a non-colored lake.

**Table 3. Sabbathday Lake true color.**

Color (PCU)	
7/8/2014	12
8/19/2014	15
9/18/2014	12
2014 Average (SDL)	13
Historical Avg. (SDL)	14
Average (Maine Lakes)	28

### 3.5 CHLOROPHYLL-A

Chlorophyll-a (Chl-a) is a measurement of the green pigment found in all plants including microscopic plants such as algae. It is used as an estimate of algal biomass, where high Chl-a values reflect a high amount of algae in the lake. In 2014, Chl-a measurements in Sabbathday Lake ranged from 2.2 ppb in July, to 3.4 ppb in August, with an average of 2.8 ppb. This is the second lowest average annual Chl-a on record at Sabbathday Lake behind, and the lowest since 1999 (2.7 ppb). The 2014 average is lower than the lake's historical average of 4.0 ppb (Table 4), and considerably lower than average Chl-a in Maine lakes of 5.4 ppb.

### 3.6 ALKALINITY

Alkalinity is a measure of the buffering capacity of a lake, or the capacity of water to neutralize acids. It is primarily a measure of naturally available bicarbonate, carbonate, and hydroxide ions in the water, which is largely influenced by the local geology of the soils and rocks in the watershed. Alkalinity is important to aquatic life because it buffers against changes in pH that could have drastic effects on animals and plants. Sabbathday Lake has a historical average alkalinity of 10.6 ppm, lower than the Maine

**Table 1: U.S. E.P.A. Classification<sup>1</sup> of lakes and ponds based on alkalinity as measured in concentration of calcium carbonate (CaCO<sub>3</sub>).**

U.S. E.P.A. category	Concentration of CaCO <sub>3</sub> (mg/L)
Acidified	< 1 and pH < 5
Critical	< 2
Endangered	2 – 5
Highly Sensitive	5 – 10
Sensitive	10 – 20
Not Sensitive	> 20

average of 11.8 ppm (Table 5). In 2014, the average alkalinity was 11.7 ppm, slightly below the state average. Like most lakes in Maine, Sabbathday is sensitive to changes in pH.

### 3.7 pH

pH is the standard measure of the acidity or alkalinity of a solution on a scale of 0-14, where 7 is neutral. Most aquatic species require a pH between 6.5 and 8. As the pH of a lake declines, particularly below 6, the reproductive capacity of fish populations can be greatly impacted as the availability of nutrients and metals changes. pH is influenced by bedrock, acid rain deposition, wastewater discharge, and natural carbon dioxide fluctuations. Average pH in Maine lakes ranges from 4.2 to 9.5 with an average of 6.8 (VLMP, 2013). In 2014, the pH of water collected from Sabbathday Lake ranged between 6.7 and 7.3 with an average of 7.0. Sabbathday Lake's pH is higher (less acidic) than the Maine lakes average. The 2014 average is the same as Sabbathday Lake's historical average for pH (Table 6).

**Table 4. Sabbathday Lake Chlorophyll-a.**

Chlorophyll-a (ug/L)	
7/8/2014	2.2
8/19/2014	3.4
9/18/2014	2.7
2014 Average (SDL)	2.8
Historical Avg. (SDL)	4.0
Average (Maine Lakes)	5.4

**Table 5. Sabbathday Lake Alkalinity.**

Alkalinity (mg/L)	
7/8/2014	12.0
8/19/2014	11.0
9/18/2014	12.0
2014 Average (SDL)	11.7
Historical Avg. (SDL)	10.6
Average (Maine Lakes)	11.8

**Table 6. Sabbathday Lake pH.**

pH	
7/8/2014	7.3
8/19/2014	7.2
9/18/2014	6.7
2014 Average (SDL)	7.0
Historical Avg. (SDL)	7.0
Average (Maine Lakes)	6.8

## 4. SUMMARY

Sabbathday Lake has above average water quality and clarity, compared to the average for lakes monitored in Maine. With the exception of total phosphorus, the 2014 Sabbathday Lake's water quality results were better than the historical average for the lake, and better than the average water quality for all Maine lakes for all parameters (Table 7). Average water clarity (SDT) was the best it has been in the last 15 years. Not surprisingly, the average Chl-a for 2014 was also the lowest it's been in 15 years. The higher than expected average color was due to an elevated color reading in August. Low amounts of rainfall in September (1.6 inches) may have contributed to the lower average clarity in 2014.

Dissolved oxygen depletion at the “deep hole” of the lake is an on-going trend that has been documented over the last several years, with severe oxygen depletion (< 5 ppm) in the deepest area of the lake during late summer, especially below 9 m in August and early September 2014. The loss of dissolved oxygen in the deepest areas of Sabbathday Lake during late summer suggests that fish habitat may be threatened during this part of the year.

One possible result of oxygen depletion is the potential release of biologically-available phosphorus from bottom sediments. It is important to minimize any additional sediment inputs to Sabbathday Lake to prevent algal blooms, and continue to closely monitoring water quality in Sabbathday Lake to determine long-term



trends in total phosphorus, alkalinity, and chlorophyll-a. Collecting bottom grab samples and collecting a sample in the lake shortly after ice out, and every 6 weeks until fall turnover could help characterize TP concentrations and TP release from bottom sediments over time.

**Table 7. Summary of Sabbathday Lake water quality data from 2010 - 2014.**

	<b>SDT</b>	<b>TP</b>	<b>Chl-a</b>	<b>Color</b>	<b>pH</b>	<b>Alkalinity</b>
	<i>(meters)</i>	<i>(ppb)</i>	<i>(ppb)</i>	<i>(PCU)</i>		<i>(ppm)</i>
2014 Average*	7.5	7.3	2.8	13	7.0	11.7
2013 Average	6.7	7.0	3.8	11	7.5	12.0
2012 Average	5.8	6.5	4.2	16	7.3	11.0
2011 Average	6.8	5.6	3.6	10	-	11.0
2010 Average	7.4	5.0	4.5	17	-	10.7
Historical Average**	6.5	7.0	4.0	14	7.0	10.6
<b>Average for Maine Lakes</b>	<b>4.8</b>	<b>12.0</b>	<b>5.4</b>	<b>28</b>	<b>6.8</b>	<b>11.8</b>

\* 2014 averages do not include data from Maine DEP or VLMP.

\*\* The historical average refers to all data collected before 2014.

There are many ways that individual landowners can help to reduce phosphorus and sediment input into Sabbathday Lake to protect and improve the water quality. Below is a list of ways that landowners can help:

- Join the Sabbathday Lake Association.
- Become LakeSmart! Contact the Maine Lake Society for a LakeSmart evaluation, or become a certified LakeSmart evaluator.
- Participate in a watershed survey every 10 years.
- Pump your septic every 2-3 years & participate in a septic survey.
- Help form a road association.
- Participate in volunteer surveys including water quality and aquatic plants surveys.
- Use phosphorus-free fertilizer.
- Plant a 250 ft. wide buffer on the shorefront.
- Vegetate and mulch bare soil using native materials.
- Terrace and vegetate steep slopes.
- Create meandering foot paths to slow flow.
- Reshape & resurface eroding driveways.
- Line eroding ditches with rock.
- Educate neighbors about lake science.

## The LakeSmart Path to Lake Protection



LakeSmart, the flagship program of the Maine Lakes Society, is one of the most effective lake protection programs available today. It recognizes waterfront homeowners who use natural landscaping strategies to protect the health of their lake. LakeSmart's now-familiar blue and white Award signs get posted at shorefront and roadside and say, **"A friend of the lake lives here."**

**Call the Maine Lakes Society Today!**

Phone: (207) 495-2301 Email: [msshannon@mainelakessociety.org](mailto:msshannon@mainelakessociety.org)

## REFERENCES

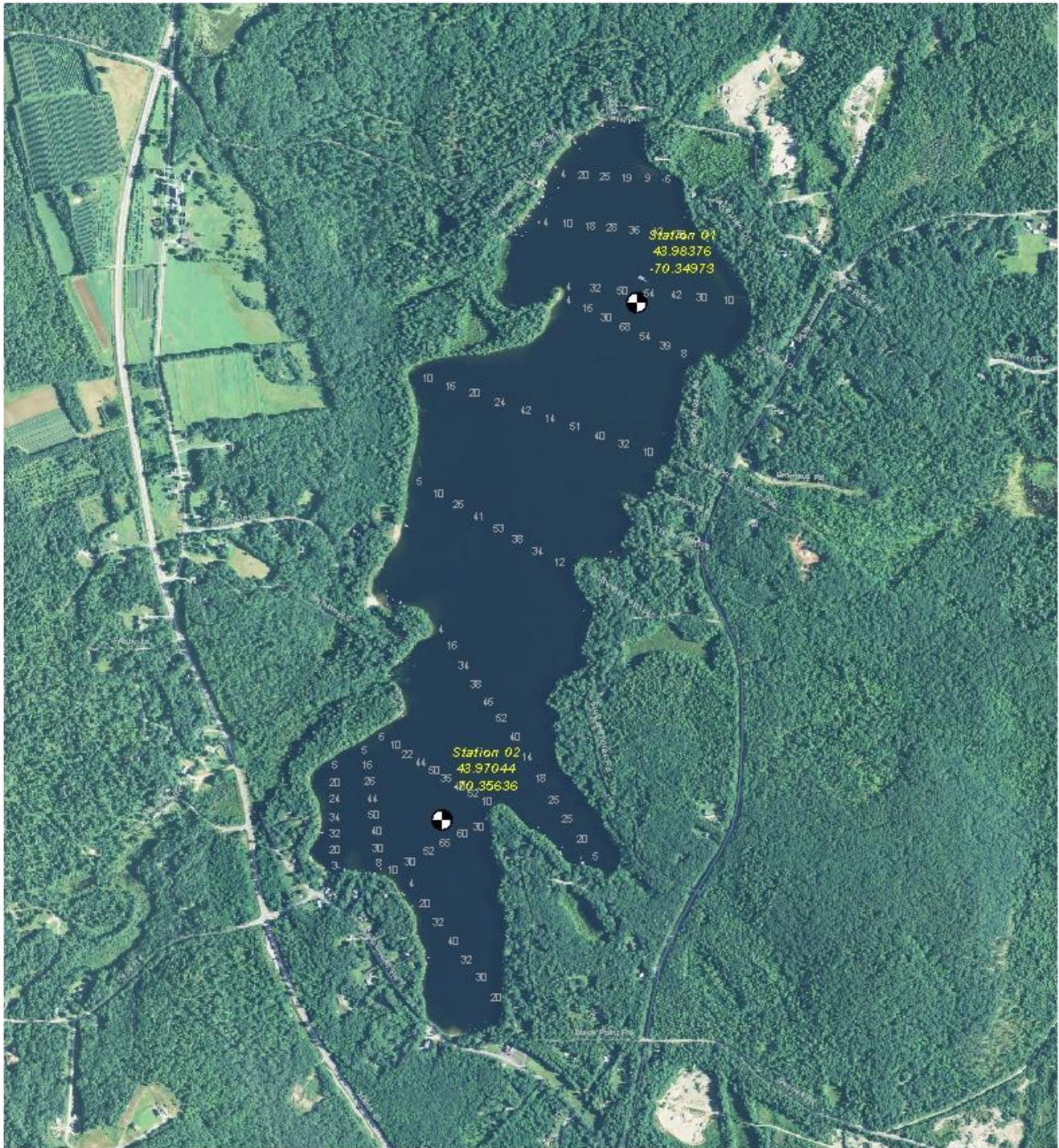
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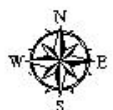
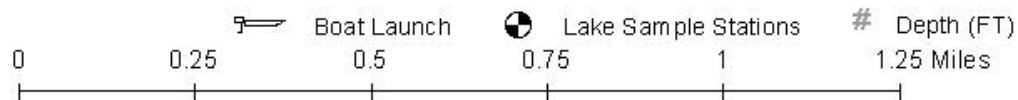
## **APPENDIX A -DEPTH MAPS**



# 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>

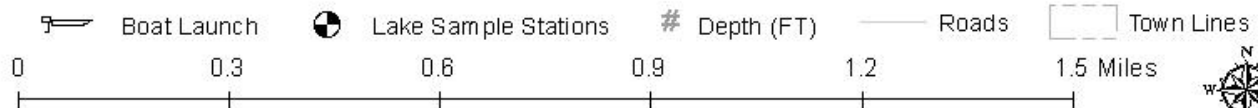




# Sabbathday Lake

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



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