2020 Water Quality Committee Report

2020 Summary

The 2020 lake season was an interesting one for many reasons, most notably the COVID-19 pandemic. Despite the resulting anxiety and restrictions, the Watchic Lake Water Quality Committee was able to perform the majority of the planned water quality monitoring. Based on the findings contained in this report, the water quality of Watchic Lake remains good and is substantially unchanged from data collected over the previous 4 years (2016-2019). Specifically, water clarity and total phosphorus levels are consistent with previous years and consistent with other Maine lakes like ours.

2020 had a long ice-free/algae growing period for 2020 (283 days). However, the relatively dry Spring and Summer resulted in less algae growth as measured by trophic state indicators (water clarity and core total phosphorus and chlorophyl-A levels) than observed during wetter years. As in recent years, we experience long periods of low dissolved oxygen levels in 2020. Such conditions can restrict fish populations and increase algae growth.

However, like all lakes, Watchic Lake is in a delicate balance where both nature and human influences could tip the balance against it. Nutrient laden run-off from storms (especially mega-storms) can wash into the watershed and lake causing negative changes in the lake's water quality. This could lead to significant algae blooms. In addition, while to-date no invasive plant or aquatic species have been identified in Watchic Lake, it only takes a little carelessness to create a big problem.

The Watchic Lake Watershed Protection Plan sponsored by the Watchic Lake Association (WLA) was approved by the Environmental Protection Agency last year. It identified areas within the watershed where storm run-off is entering the lake. The WLA applied for, and received, a grant to address some of these problems. The WLA will be working with the state, town and individual landowners on these projects in 2021.

Table of Contents

Scope of Report

This report summarizes data collected on Watchic Lake and its tributaries from 19-Oct-19 to 22-Oct-20. The data is compared to historical data (mostly 2016-2019, but also older data when appropriate) to look for trends or variations which could suggest a shift in lake water quality or health. The data collected and the analysis is used to direct further monitoring efforts and if necessary, specific actions.

Background and Methodology

This report documents the results of water quality monitoring conducted at Watchic Lake by the WLA Water Quality Committee volunteers in 2020. This work builds on volunteer work performed over the last 25+ years and the comprehensive monitoring plan directed by FB Environmental (FBE) from 2016-2018. Since 2019, WLA volunteers have been independently managing water monitoring on the lake in consultation with the Lake Stewards of Maine and/or FBE when required. This year, monitoring was conducted at the Deep Spot of the Lake and Page Brook (see Figure 1).

Figure 1: Watchic Lake Monitoring sites

Weather

In 2020, weather data for Watchic Lake was obtained from a personal weather station installed on the lake (Burnell dock) (https://dashboard.ambientweather.net/devices/public/07ab0e16e084b686213a92cd64264c2e). This station measures outdoor temperature, precipitation, wind direction/speed and other parameters. In addition, air temperature and barometric pressure were collected using an Onset HOBO® barometric pressure logger deployed on the north end of the lake (Watson dock). Data is compared to historical weather data from the Portland Jetport (https://www.wunderground.com/history/monthly/us/me/south-portland/KPWM/date/2019-10). Ice-in and Ice-out dates are taken from the Watchic Lake Dam logbook and from data reported to the Lake Stewards of Maine (resident reported, see https://www.lakestewardsofmaine.org/near-real-time-lake-data/).

Water sampling/monitoring

Water Quality Committee volunteers (Cathy Watson and David and Eileen Burnell) received formal training and certification in the proper techniques for Lake sampling/monitoring from the Lake Stewards of Maine. Due to COVID restrictions this year's re-certification took place virtually.

Table 1 lists the dates monitoring was performed and the procedures carried out on each date.

Table 1: 2020 Monitoring Schedule

Date	Volunteer(s)	Secchi	Temp/DO	Meter	Logger reading	Water Samples	Comments
03-May-20	Eileen and David Burnell	√	√	ProSolo			Winter buoy and weight removed. Summer buoy added to winter buoy configuration. Temp loggers not reordered and DO loggers not added. Logger depth now measured from water surface
17-May-20	Eileen and David Burnell	√	√	ProSolo			
02-Jun-20	Eileen and David Burnell	√	√	ProSolo			
13-Jun-20	Eileen and David Burnell	√	√	ProSolo			
05-Jul-20	Eileen and David Burnell	√	√	ProSolo			
21-Jul-20	Eileen and David Burnell	√	√	ProSolo			
22-Jul-20	Cathy Watson	√	√	ProODO	√		All temperature loggers successfully read. Loggers were very slimy. 3 DO loggers added to buoy and temperature loggers moved to summer configuration.
31-Jul-20	Eileen and David Burnell	√	√	ProSolo			
10-Aug-20	Cathy Watson	√	√	ProODO	√	√	Water samples driven to HETL
19-Aug-20	Eileen and David Burnell	√	√	ProSolo			
03-Sep-20	Cathy Watson	√	√	ProODO	√	√	Water samples driven to HETL
03-Sep-20	Eileen and David Burnell	√	√	ProSolo			
13-Sep-20	Eileen and David Burnell	√	√	ProSolo			
29-Sep-20	Cathy Watson	√	√	ProODO	√	√	2m DO didn't download. Page Brook culvert repair is near completion. Metal barricades used for water diversion were removed just prior to sampling. Bridge to reopen next week. Both lake and stream are low due to lack of rain.

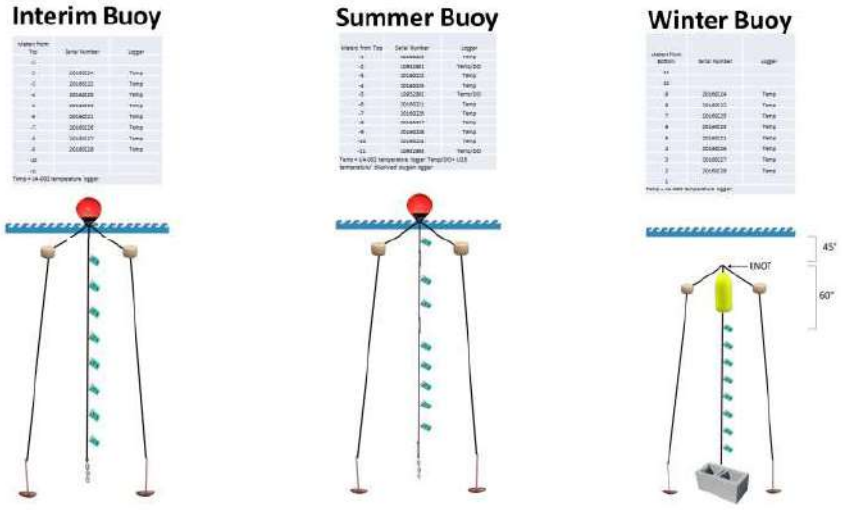
10-Oct-20	Eileen and David Burnell	√	√	ProSolo			
22-Oct-20	Cathy Watson	√	√	ProODO	√		Batteries replaced in Temp loggers. Buoy Reconfigured (all DO loggers removed for winter)

During the summer months, lake monitors upload real-time Secchi disk readings to the Lake Stewards of Maine website (https://www.lakestewardsofmaine.org/near-real-time-lake-data/)

Lake Monitoring at Deep Spot - WLA Buoy

WLA Water Quality volunteers maintained a series of Onset HOBO® continuous logging devices at the WLA Buoy at the Deep Spot of the lake. The winter buoy consists of 8 Onset HOBO® UA-002 temperature loggers at 1-meter intervals starting at 2 meters from the bottom of the lake (Figure 3). The winter buoy was deployed on 19-Oct-2019 and remained in place over the 2019/2020 winter. Due to COVID restrictions, the winter buoy was not reconfigured to the summer buoy in April/May as usual. Instead, the winter float and weights were removed and the summer float added (Figure 3, interim buoy) on 3-May-2020. The Dissolved Oxygen (DO) loggers were not added at this time. On 22-Jul-2020, the reconfiguration of the buoy system was completed. This included adding the 3 Onset HOBO® U26 temperature/dissolved oxygen loggers at 2, 5 and 11 meters below the water surface (these depths equate to critical layers in the water column, which becomes thermally-stratified in summer) and redistributing the temperature loggers at 1-meter intervals (Figure 3, summer buoy). The logger data from 19-Oct-19 to 22-Jul-20 was successfully retrieved on 22-Jul-2020. The loggers were cleaned and downloaded during each monthly sampling event thereafter. When examining the DO logger data, it was noted that the 2m logger stopped recording on 27/28-Aug-20, and the 5m on 12-Oct-20. These stoppages were due to battery failures. All DO loggers were sent to the manufacturer (Onset) to have the batteries replaced in November 2020. On 22-Oct-2020, the summer buoy was pulled from the water. All U26 temperature/dissolved oxygen loggers were removed from the line and the batteries on the UA-002 temperature loggers were replaced and moved to the winter buoy design (Figure 3). At 3:55pm, the reconfigured line was redeployed for the winter. All loggers are set to read every 15 minutes while deployed.

Figure 3: Buoy and HOBO® Logger configurations



WLA volunteers collected manual temperature and dissolved oxygen profiles (using YSI DO meters) and Secchi disk transparency readings bi-weekly from May – October (Table 1).

In addition to the above measurements, integrated epilimnetic cores (a column of water taken from the surface of the lake, through the epilimnion (biologically active area) to the upper part of the thermocline (where the water temperature changes rapidly) were extracted monthly during the 2020 season (see Table 1 for dates). The thermocline was determined based on the Secchi disk, temperature and dissolved oxygen readings on the day of sampling. These core samples represent an average of lake water quality and were analyzed for trophic state indicators (total phosphorus and chlorophyll-a) and chemical parameters (total alkalinity, pH, and color). In addition to the core sample, grab samples from the bottom of the lake were taken using a Kemmerer Bottle (1.2 L PVC, Silicone) sampler on 3 dates (Table 1 above). Immediately after sampling, all samples were driven to the Health and Environmental Testing Laboratory (HETL) in Augusta, ME for analysis.

Page Brook Monitoring

Page Brook was monitored at the sampling station just downstream from the Route 113 bridge near the Outpost Restaurant. This sampling stations is located far enough upstream from the brook's outlet to the lake in order to minimize the impact of any mixing with lake water. The brook was monitored for dissolved oxygen and temperature and total phosphorus (analyzed at HETL) monthly (Table 1 above).

Metaphyton Monitoring

No formal metaphyton monitoring was conducted this year. Informal visual surveys were conducted at least monthly, but no significant accumulations were found.

Data Gaps

Due to the late deployment of the DO loggers, no DO logger data was recorded from 3-May to 22-Jul-20. In addition, as mentioned above, the batteries on the 2m and 5m DO loggers failed, resulting in a reduction of the DO logger data available for analysis.
The 2m logger failed from 8:15:21 PM 27-Aug-20 2:00:21 PM 28-Aug-20 and from 3:45:21 PM to 4:45:21 PM 28-Aug-20, then completely died at 3:15:21 AM on 29-Aug-20. The 5m logger just died at 8:45:43 PM on 12-Oct-20.
DO data is available from the manual monitoring was performed.

Results

Weather

Weather has a major effect on the water quality of a lake. A summary of the weather conditions from Oct-2019 to Oct-2020 is given below.

Ice-in and Ice-out time can affect water quality by increasing/decreasing the growing season for algae in the lake. Dates for the last 5 years are shown in Table 2. 2020 was another early ice-out year. The earliest ice-out recorded at Watchic Lake in recent years was 09-Mar-2010. The

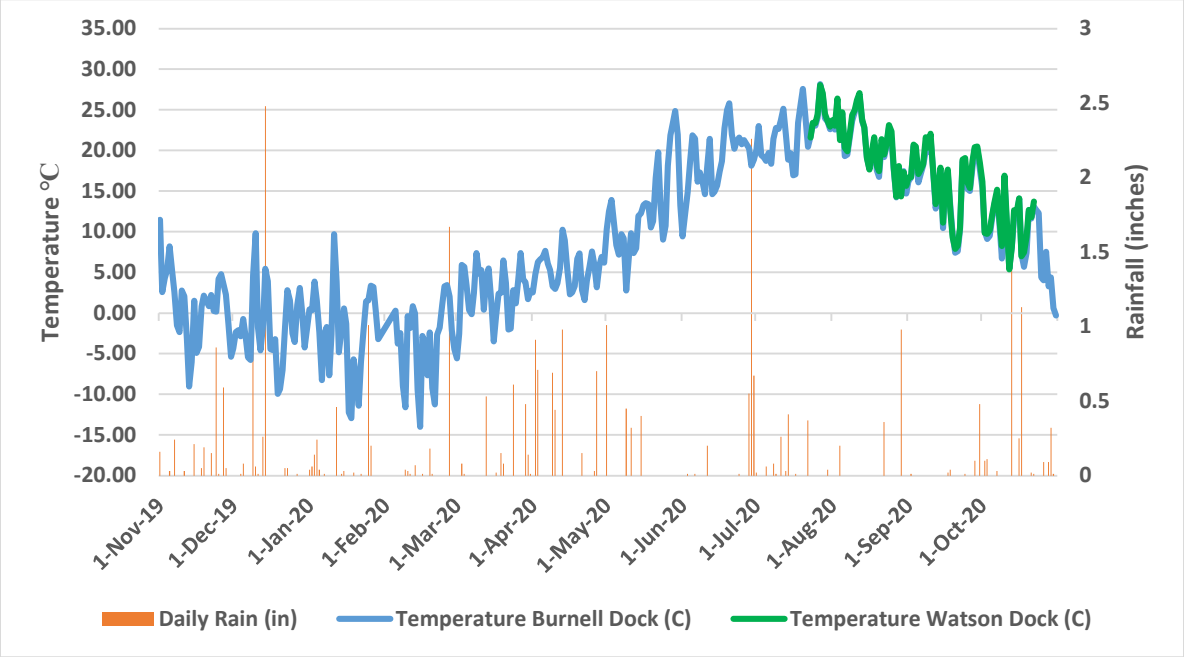
early ice-out teamed with a late ice-in date (31-Dec), made 2020 the longest ice-free year (283 days) recorded recently.

Table 2: Ice-in/Ice-Out Dates

YEAR	ICE-OUT	ICE-IN	Ice-free Days
2016	13-Mar-16	Not Recorded	
2017	15-Apr-17	15-Dec-17	244
2018	22-Apr-18	13-Dec-18	235
2019	16-Apr-19	17-Dec-19	245
2020	23-Mar-20	31-Dec-20	283

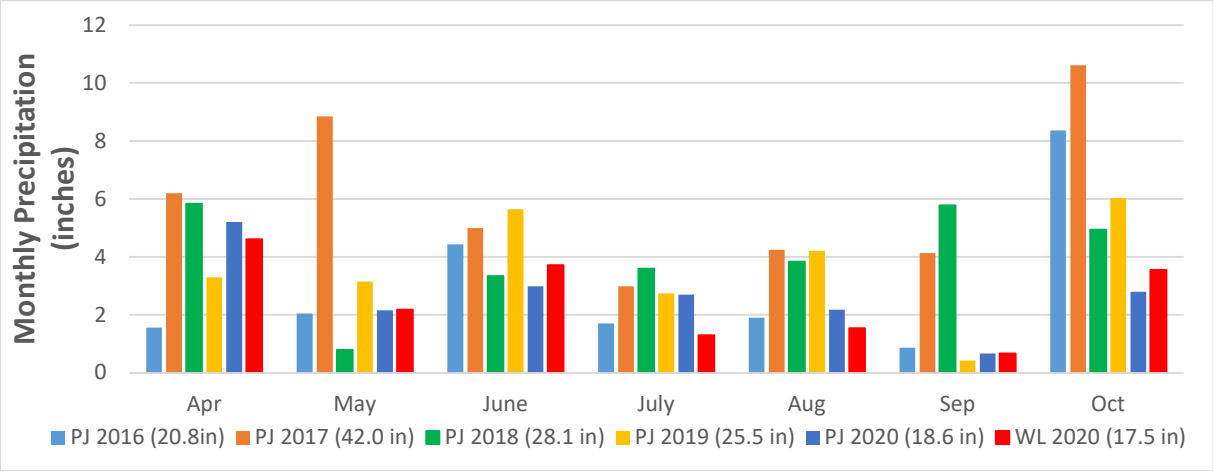
The average daily air temperature and precipitation recorded at the local weather station (Burnell dock) and the temperature from the HOBO logger (Watson dock) are shown in Figure 4. Temperatures in both locations on the lake were similar.

Figure 4: Average Daily Air Temperature and Precipitation



The total monthly precipitation recorded at the Portland Jetport for the last 5 lake seasons (Apr-Oct) are presented in Figure 5. This was the first year complete data was collected at the Burnell's dock. In comparison to the data from the Jetport, 2016-2019, 2020 was the driest in the last 5 years (17.5 and 18.6 in at the lake and Jetport, respectively). July through September were quite dry, with a total of only 3.5 inches being recorded at the lake.

Figure 5: Monthly Precipitation at Portland Jetport (PJ 2016-2020) & Watchic Lake (WL 2020)



Water Sampling - Lake

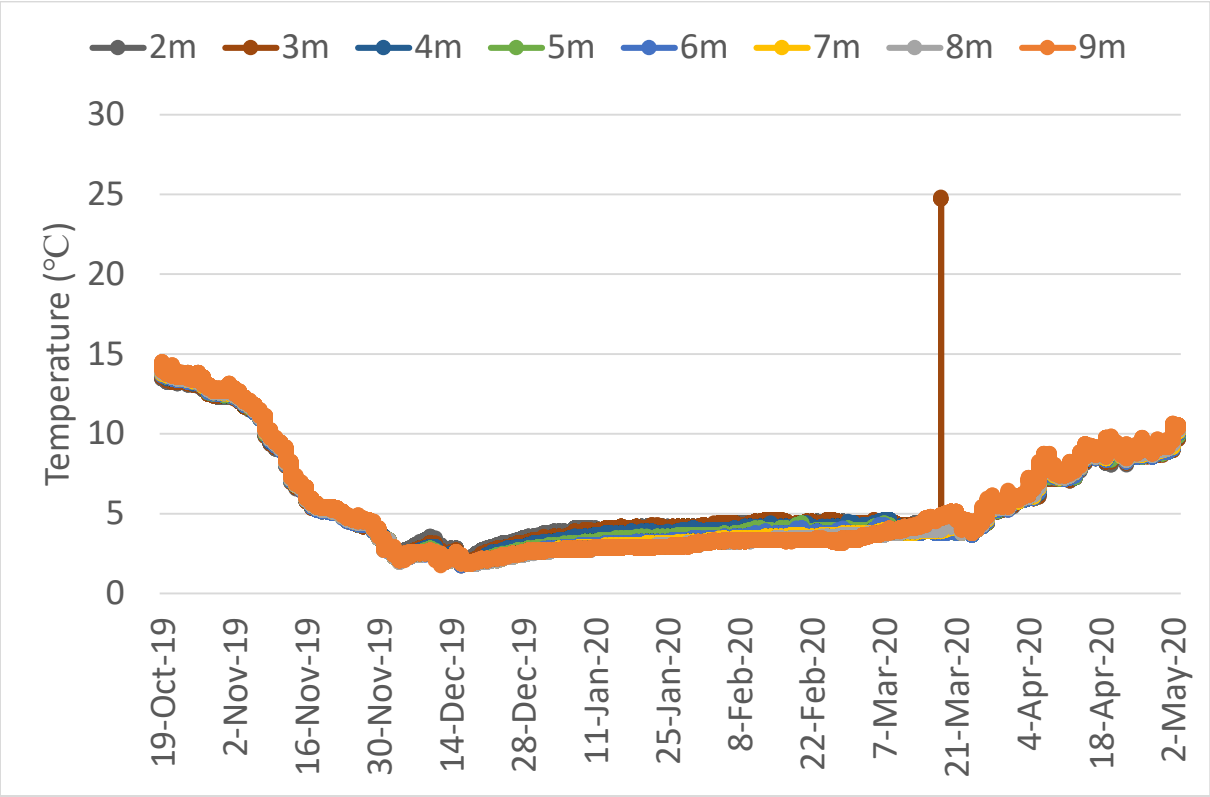
Temperature and Dissolved Oxygen

At the Deep Spot of the lake, temperature and Dissolved Oxygen (Temp/DO) were measured using continuous Onset HOBO® loggers attached to the WLA buoy (see Figure 3), and bi-weekly during the summer using DO/Temp YSI meters. Figure 6A shows the water temperature at 1-meter intervals during the Winter buoy configuration from 19-Oct-2019 to 3-May-2020. In this configuration, depths are measured from the bottom of the lake upwards, with higher numbers representing locations closer to the surface of the lake (*e.g*. 8m). Fall turnover, when the lake mixes top to bottom, occurred on ~19-Oct-19, eliminating the lakes temperature and DO stratification. The temperature of the lake was relatively uniform from this point and throughout the winter period, starting at ~14℃ in the fall and dropping to less than 2℃ in December, then settling in at 2-5℃ until March. Ice-out was 18-Mar-20 and the lake started to warm up through April. Interestingly, the 8m logger (deployed 3m from the bottom of the lake) had 4 unexplained readings of 24℃ between 3-4:00:00 PM on 18-Mar-20. The temperature before and after these readings was ~4.5℃

Despite the early ice-out, spring turnover appears to have occurred slowly this year with temperature and DO stratification beginning around 15-May. Figure 6, Panel B show the water temperature at 1-meter intervals during the Interim and Summer buoy configurations from 3-May-2020 to 22-Oct-2020. In this configuration, depths are measured from the top of the lake downward, with larger negative numbers representing locations closer to the bottom of the lake (e.g. -11m). Consistent with past years, the temperature at the bottom of the lake remained constant at ~10℃ while the top warmed up during the season, reaching a maximum of 29.9℃ at the surface on July 31st. Lower depths continued to warm into September. Fall turnover appears to have occurred between 9-12 October. Upon completion the entire lake was ~15.5℃ and had a DO of ~8.3mg/L.

Data collected bi-weekly using the YSI meters (Figures 7 and 8) are consistent with those from the continuous loggers (Figures 6B and 9).

Figure 6: Water Temperature from HOBO® Loggers
A: Winter - 19-Oct-2019 to 3-May-2020



B: Summer – 3-May-2020 to 22-Oct-2020

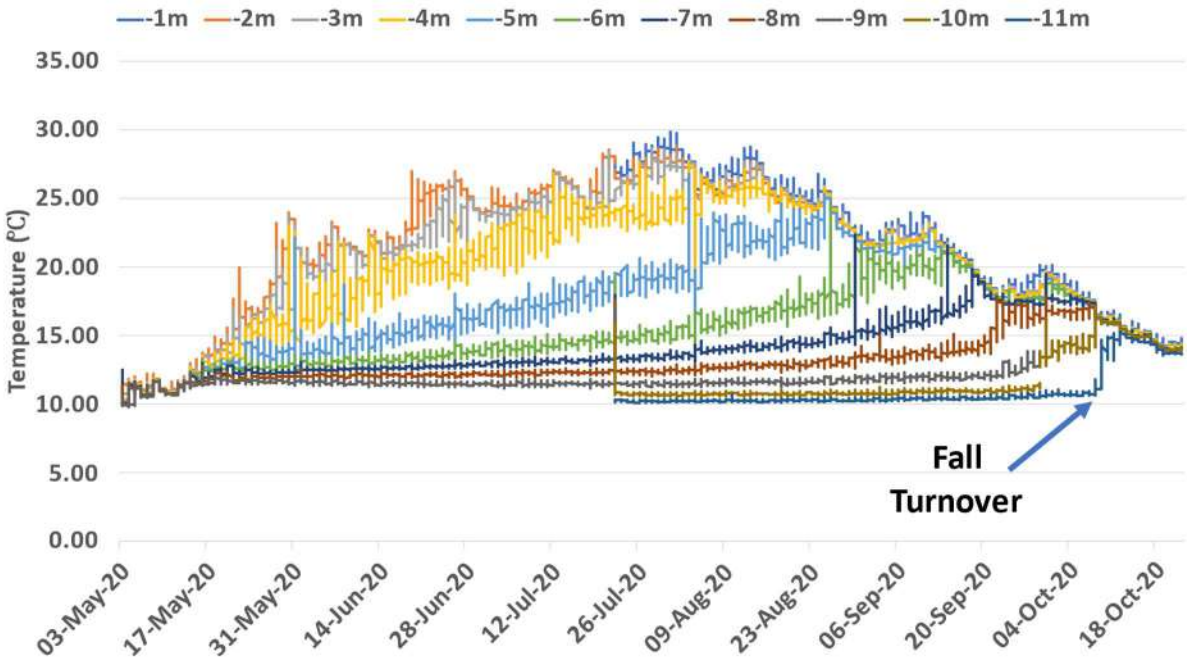
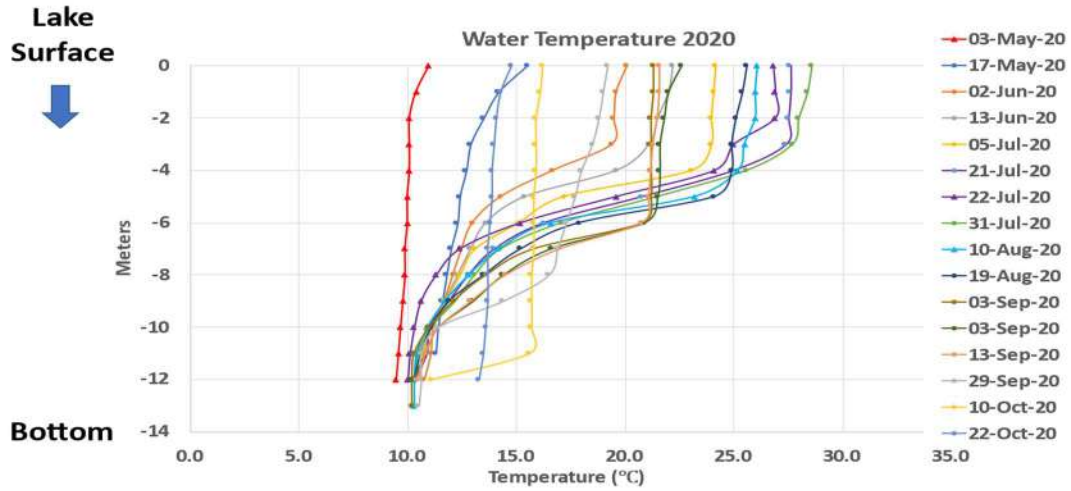


Figure 7: Water Temperature from YSI Meters



The dissolved oxygen (DO) pattern observed this season is similar to what has been seen in recent years (Figure 10). Oxygen levels are high, and fairly uniform throughout the water column in May (Figures 8-10), but the deeper water becomes oxygen depleted as the season progresses. By 8-Jul, depths of ≥10m are below 2mg/L of oxygen. This depletion extends to ≥9m by the end of July and to ≥7m by the end of September. The lack of oxygen at the bottom of the lake is known to restrict fish species that require colder water to survive, but may also cause phosphorus bound at the bottom of the lake to be released into the water column. This phosphorus can fuel further algae growth.

Figure 8: Dissolved Oxygen from YSI Meters

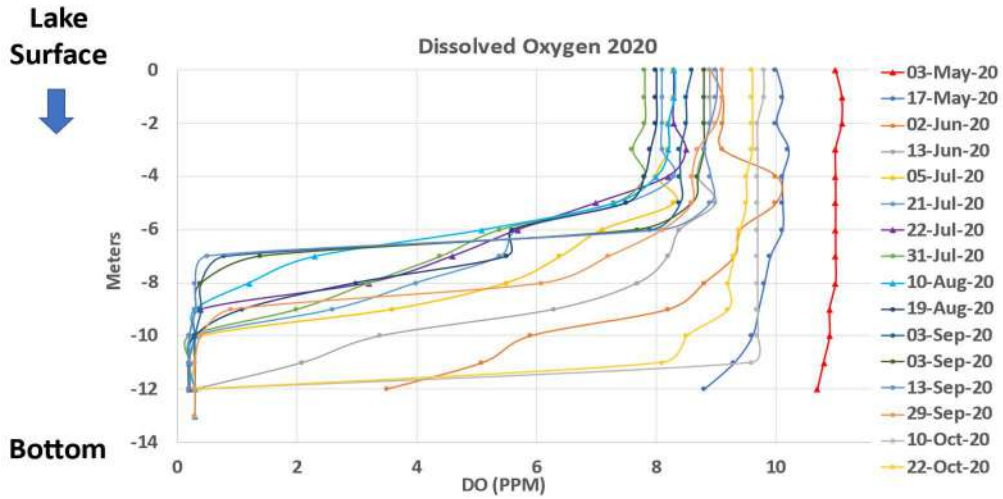


Figure 9: Dissolved Oxygen Levels from HOBO® Loggers

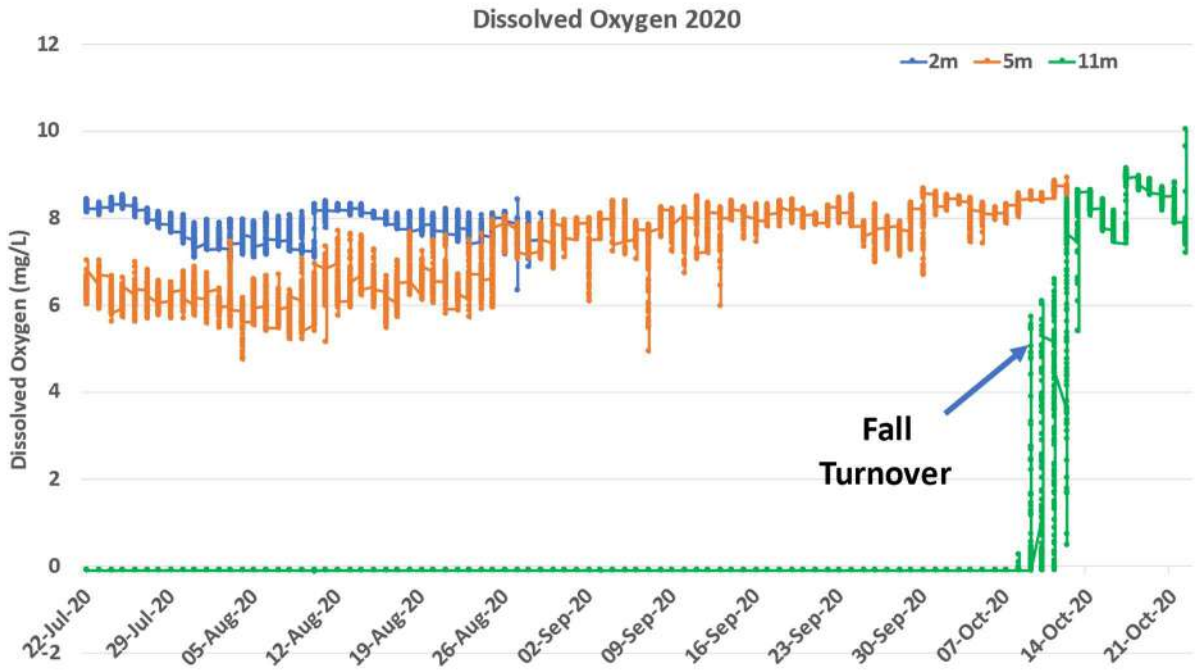
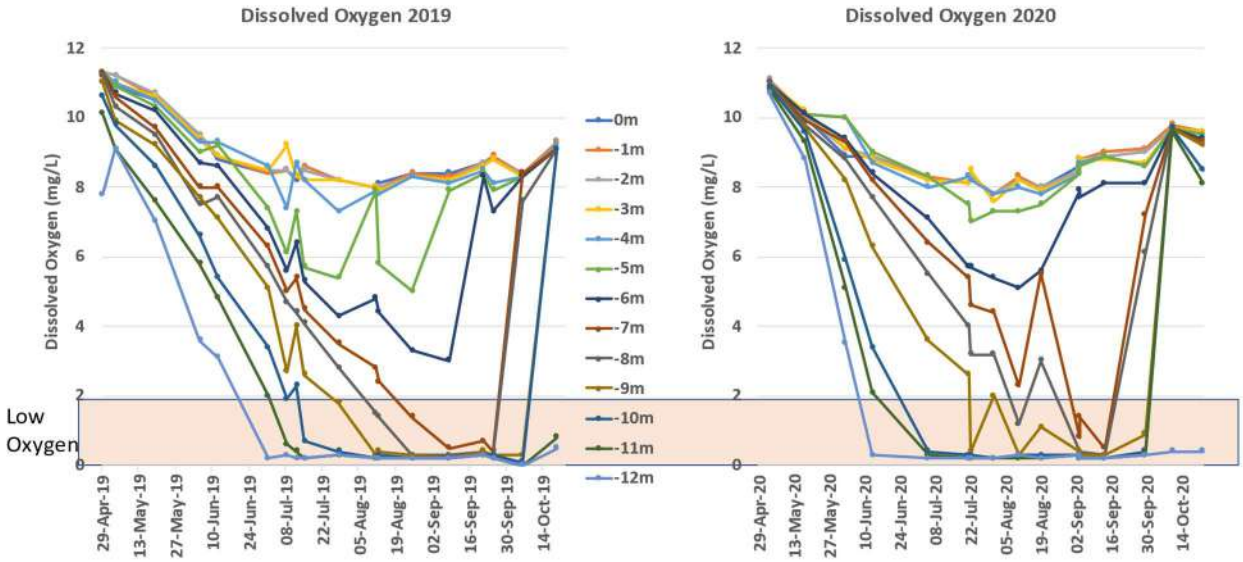


Figure 10: Low Oxygen at Lake Bottom 2019-2020



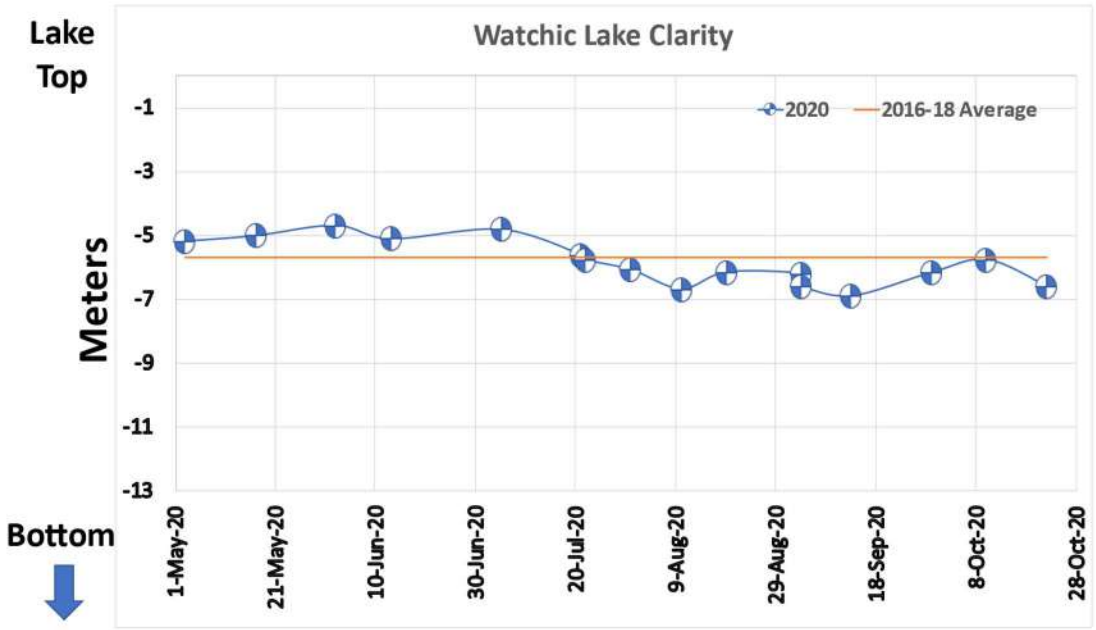
Trophic State indicators

Trophic state indicators (water clarity, total phosphorus, and chlorophyll-a) reflect the biological productivity (e.g. algae growth) of lakes.

Water Clarity

Water clarity (how far you can see down into the water) is measured using a Secchi disk. Figure 11 shows the readings this year and the historical average for 2016-18. In 2020, the Secchi disk readings ranged from -4.68m on 2-Jun to -6.9m on 13-Sep. These values are within the DEP Mesotrophic Water Clarity Acceptable Range of 4-8m. The average of all Secchi disk reading for 2019 was -5.83m, which is slightly higher than the 2016-2018 average (-5.7m). While this may be due to a number of reasons, one big influencer could be the relatively lack of rain this summer, which may have resulted in a decrease in nutrients (especially phosphorus) washing into the lake.

Figure 11: Watchic Lake Secchi Disk Readings



Phosphorus and Chlorophyll-A

Phosphorus in the key nutrient for algae growth in lakes, while chlorophyll-A is a direct measurement of the amount of plant material, mostly algae, in the water.

To sample the most productive part of the lake (relative to algae growth), an epicore sample (a column of water collected from the surface through the epilimnion (usually about 5-6m down in Watchic Lake) was obtained each month at the deepest spot of the lake (WLA buoy). The results represent the average biological and chemical conditions in Watchic Lake.

The 2020 total phosphorus (TP) and chlorophyll-A (Chl-A) results are presented in Table 4. Unfortunately, in 2020, the sample usually taken in mid-late June were not obtained due the Covid-19 restrictions. In previous years a consistent pattern shows values tend to be higher in the Spring/early-Summer (likely due to Spring run-off and increased nutrients delivered to the lake) and decrease in late summer. The missing sample for 2020 makes data interpretation

more difficult. Average TP and Chl-A values for 2020 are similar to those obtained in 2016-19 (Table 5) and individual values are within the min/max values recorded between 2016-2018.

Table 4: 2020 Water sampling results

Station	Date Sampled	Core Depth (m)	Bottom (ft)	pH	Color (PCU)	Chl-a (ppb)	Alk. (ppm)	TP (ppb)
WATC-5040-01	10-Aug-20	6	39	6.9	16	3	7	3
WATC-5040-01	03-Sep-20	6		7.0	11	3	7	5
WATC-5040-01*	03-Sep-20	6		6.9	11	4	7	7
***Duplicate avg.**		6.0		7.0	11.0	3.5	7.0	6.0
WATC-5040-01	29-Sep-20	6	39	7.0	11	2	8	8
Annual Mean		6		7.0	12.7	2.8	7.3	5.7
Annual Median		6		6.9	11.0	3.0	7.0	5.0

Table 5: Average Water sampling results for 2016-2020

Year	Core Depth (m)	pH*	Color (PCU)	Chl-A (ppb)	Alk (ppm)	Total Phos (ppb)
2016	6.8	6.5	12.8	2.9	7.3	7.9
2017	5.8	6.5	22.1	4.1	6.8	8.1
2018	5.3	6.8	14.6	3.3	7	7.3
2019	5.3	7	21	3.8	6.5	7.4
2020#	6	6.9	12.7	2.8	7.3	5.7
Average 2016-19	5.8	6.7	17.6	3.5	6.9	7.7
Max 2016-19	8	7.1	26.5	6.2	8	11
Min 2016-19	5	5.9	10	1.8	6	5

***Median values are reported, # no Jun/Jul sample, Aug-Sep only**
ppb-parts per billion, ppm-parts per million, PCU-platinum-cobalt units

In addition to the epicore samples, a sample was obtained from the bottom of the lake and analyzed for TP (Table 6). Results suggest that there is considerably more total phosphorus at the bottom of the lake than at the top (thermocline). There are historical bottom grab TP results dating back to 1978, with the most comprehensive data coming between 1998-2001. From 1998-2001, most sample were obtained from a 10m depth and had an average TP value of 18.3ppb and a range of 7-31ppb. For 2019 through 2020, samples were taken from 11-13m and values ranged from 26-94ppb. In consultation with Scott Williams from LSM, sampling at depths very close to the bottom of the lake may result in aberrant readings resulting from disturbing the bottom of the lake. Given this, subsequent samples were and will be taken no lower than 12m. This additional phosphorus at the bottom of the lake could be coming from decaying organic material at the bottom of the lake or from bound phosphorus that is released due to the oxygen depletion observed (see Figures 8 and 9 above).

Table 6: 2020 Bottom Grab Total Phosphorus Samples

Station	Date Sampled	Depth (m)	TP (ppb)
WATC-5040-01	12-Aug-19	13	63
WATC-5040-01	25-Sep-19*	12.5	30
WATC-5040-01	25-Sep-19*	12.5	30
WATC-5040-01	10-Aug-20	12.5	94
WATC-5040-01	3-Sep-20*	11	26
WATC-5040-01	3-Sep-20*	11	33
WATC-5040-01	29-Sep-20	12	45

*** duplicates**
ppb-parts per billion

Chemical Parameters

In addition to TP and Chl-A, pH, alkalinity and color were measured in the monthly core water samples (Table 5 above). All 3 parameters were fairly constant throughout the sampling time period (Aug-Sep).

Metaphyton

Metaphyton is cotton candy-like algae that usually floats near the top of the shallow water, but can get stuck in lake vegetation and accumulate. Although no formal surveys were performed this year, the areas were visually examined at least monthly. Small accumulations of Metaphyton were reported by residents just north of the Kiwanis Beach again this year. Homeowners were able to disrupt and clear out most of the clouds by summer.

Water Sampling - Tributaries

Temperature, dissolved oxygen and total phosphorus were measured in Page Brook in August and September. The results are shown in Table 7. The bridge just upstream from the sample site was replaced in September this year. The repairs involved stopping/diverting the Brook water. The sample taken on 3-Sep and 29-Sep were taken before and immediately after, respectively.

Table 7: 2020 Monitoring of Page Brook

Station	Date Sampled	Temp (°C)	DO (ppm)	DO Sat. (%)	TP (ppb)
Page Brook-01	10-Aug-20	21.1	3.9	39	25
Page Brook-01	03-Sep-20*	18.0	5.5	55	50
Page Brook-01	03-Sep-20*	18.0	5.5	55	47
Page Brook-01	29-Sep-20	18.0	3.8	38	100#
Yearly Averages	2016	16.9	5.6	58.0	32.0
	2017	17.0	6.0	61.0	29.1
	2018	17.0	5.5	57.4	26.3
	2019	16.0	4.7	48.1	36.5

Station	Date Sampled	Temp (°C)	DO (ppm)	DO Sat. (%)	TP (ppb)
	2020	19.0	4.4	44.0	57.8

* duplicates, # sample take just after metal plates holding water back for bridge repair was removed
ppb-parts per billion, ppm-parts per million

Conclusions and Recommendations

Based on monitoring performed by the Watchic Lake Water Quality Volunteers in 2020, the water quality of Watchic Lake remains good and is substantially unchanged from data collected over the previous 4 years (2016-2019).

Despite a long ice-free period for 2020 (283 days), the relatively dry Spring and Summer resulted in less algae growth as measured by trophic state indicators (water clarity and core total phosphorus and chlorophyl-A levels) in the lake than may have been expected.

While water quality is good today, Watchic Lake remains at risk over the long term. For example, low oxygen levels were observed in the lower depths of the lake again this summer, and total phosphorus levels from the bottom of that lake were high. The biggest risks to the lake are nutrients from storm run-off and invasive plants. Homeowners must continue to be diligent to protect the lake by stopping storm run-off entering the lake through their property and always remove plant and other organic material from boats and fishing gear.

With these considerations in mind, the water committee has the following recommendations:

Recommendations for Continued Water Monitoring

Based on observations this year and 2016-2020, the following efforts should be continued and/or intensified:

Observation	Recommendation
Loss of oxygen in the lower depths	Expand bottom grab TP sampling to 4 monthly samples
	Consider TP grab samples at various depths
	Collaborate with researchers to look at composition of soil at bottom of lake for potential of phosphorus recycling

General Recommendations for Lake Users to maintain and improve Water Quality

- Become LakeSmart by controlling phosphorus-laden sediment in runoff with best management practices (BMPs).
- Avoid using fertilizers, herbicides, and pesticides within 150 feet of lake, ponds, and streams.
- Leave duff and grass clippings; minimize lawn area and cut grass to 3 inches.
- Pump septic system every 3-5 years and keep leach field clear of trees. Inspect systems more than 20 years old.

- Reduce household chemical and Phosphorus-based product use.
- Wash car and boat in area where runoff is absorbed into the ground.
- Use oil-absorbing pillow or 'bilge snakes' to prevent pollutants from entering the lake via inboard motors.
- Store gas and oil in approved secondary containers and dispose at local repair shops. Clean fluid leaks with cat litter.
- Remove fishing line from water and use lead-free lures.
- Dispose of pet waste in trash or toilet.

Recommendations for Lake Users to avoid the spread of Invasive Plants and other Species

Follow the CLEAN, DRAIN, DRY procedures to prevent the spread of Invasive Species

- **Clean** off visible aquatic plants, animals, and mud from all equipment before leaving a body of water.
- Rinse equipment, boat hulls (with high pressure, when possible), interior compartments and flush motor. Use hot water (120F) when possible.
- **Drain** motor, bilge, livewell, and other water containing devices before leaving water access.
- **Dry** everything for at least 5 days OR wipe with a towel to dry before reuse.
- **Dispose** of any unwanted bait, worms and fish parts in the TRASH.
- If CLEAN, DRAIN, DRY was not done prior to leaving a body of water, ensure that it is done BEFORE entering a new body of water. Be sure to perform the CLEAN and DRAIN activities well away from any body of water.

GLOSSARY OF KEY TERMS

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

Color: A measure of the influence of suspended and dissolved particles in water from weathered geologic material, vegetation cover, and land use activity. Colored lakes (>25 platinum-cobalt units -PCU) can have reduced water clarity and increased phosphorus concentrations.

Dissolved Oxygen (DO): The concentration of oxygen dissolved in water. Adequate oxygen is critical to the healthy metabolism of many creatures that reside in the water. DO levels in lake water are influenced by a number of factors, including water temperature, amount of algae and other plants in the water, and the amount of nutrients and organic matter that flow into the waterbody from the watershed. DO concentrations may change dramatically with lake depth. Oxygen is produced in the top portion of a lake (where sunlight drives photosynthesis), and oxygen is consumed near the bottom of a lake (where organic matter accumulates and decomposes).

Epilimnion: The top layer of lake water that is directly affected by seasonal air temperature and wind. This layer is well oxygenated by wind and wave action during summer. It extends to 5-7 meters below the surface in Watchic Lake.

Escherichia coli (E. coli): An indicator of harmful pathogens from fecal contamination that can derive from a number of mammalian sources, including human, canine, and wildlife.

Eutrophication: Process by which lakes become more productive over time. Lakes with high productivity have high levels of phosphorus and chlorophyll-a, low water clarity, and abundant biomass with significant accumulation of organic matter on lake bottom. Eutrophic lakes are susceptible to algae blooms and severe oxygen depletion in the hypolimnion. Lakes naturally become more productive or "age" over thousands of years. In recent geologic time, however, humans have enhanced the rate of enrichment and lake productivity, speeding up this natural process to tens or hundreds of years.

Fall Turnover: the process of complete lake mixing when cooling surface waters become denser and sink, forcing lighter, less-dense water to the surface. This process is critical for the natural exchange of oxygen and nutrients between surface and bottom layers in the lake.

Hypolimnion: the bottom-most layer of the lake. It experiences periods of low oxygen during stratification and is devoid of sunlight for photosynthesis. Watchic Lake experiences low oxygen in summer from 7 meters to the bottom at 12 meters.

Integrated Epilimnetic Core: A water sample that is taken with a long tube to determine average nutrient concentration from the lake surface to the top of the thermocline.

pH: The standard measure of the acidity or alkalinity of a solution on a scale of 0-14. 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 or snow deposition, wastewater discharge, and natural carbon dioxide fluctuations.

Secchi Disk Transparency (SDT) or Water Clarity: A vertical measure of water transparency (ability of light to penetrate water) obtained by lowering a black and white disk into the water until it is no longer visible. Measuring water clarity is one of the most useful ways to show whether a lake is changing from year to year. Changes in water clarity may be due to increased or decreased algae growth or the amount of dissolved or particulate materials in a lake, resulting from human disturbance or other impacts.

Spring Turnover: the process of complete lake mixing following ice-out when surface waters are exposed to wind action, bringing oxygen to the bottom and nutrients to the top of the water column.

Summer Stratification: the development of a thermal barrier that separates warm surface waters from dense, cool bottom waters. Without oxygen replenishment from the surface, bottom-dwelling organisms rapidly consume oxygen throughout the summer and early fall.

Thermocline: the markedly cooler, dynamic middle layer of rapidly changing water temperature. The top of this layer is distinguished by at least a degree Celsius drop per meter of depth.

Total Alkalinity: A measure of the buffering capacity of a lake (i.e., the capacity of water to neutralize acids). The buffering capacity or the concentration of bicarbonate, carbonate, and hydroxide ions in water, is largely determined by the geology of soils and rocks surrounding the lake. Total alkalinity above 20 ppm buffers against drastic changes in pH that could impact aquatic plants and animals.

Total Phosphorus (TP): The total concentration of phosphorus found in water, including organic and inorganic forms. Phosphorus is one of the limiting nutrients needed for plant growth; as phosphorus increases, the amount of algae generally increases. Humans can add excess phosphorus to a lake through stormwater runoff, lawn or garden fertilizers, and leaky or poorly-maintained septic systems.

Trophic State Indicators: Are indicators of biological productivity in lake ecosystems, including water clarity, total phosphorus, and chlorophyll-a. The combination of these parameters helps determine the extent and effect of eutrophication in lakes, and helps signal changes in lake water quality over time.

Watershed: An area of land that drains water to the outlet of a stream, river, or lake.

Winter Stratification: the development of a physical ice barrier and snowpack layer that limit the exchange of oxygen and nutrients between surface and bottom waters. A layer of ice forms at the lake surface, protecting waters below from frigid temperatures and wind storms. Cold winters with significant snowpack can block sunlight and limit photosynthesis that would otherwise replenish the lake