

# 2017 McWain Pond Report

## Lakes Environmental Association

Prepared by LEA for the McWain Pond Association



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# About LEA

The Lakes Environmental Association (LEA) is a non-profit organization founded in 1970 with the goal of preserving and restoring the high water quality and the traditional character of Maine's lakes, watersheds and related natural resources. Headquartered in Bridgton, Maine, LEA focuses its efforts on 6 towns in the western Maine Lakes Region, although its reach and influence extends across the whole state.

## Invasive Plant Program

LEA's Milfoil Control Team successfully eradicated invasive Variable Leaf Milfoil from Brandy Pond and the Songo River in 2015, after over a decade of hard work. The focus shifted to Sebago Cove in 2016, where a dense infestation threatens nearby waterbodies, and in 2017 they began work on Long Lake after an infestation was found there. LEA's program has been a model for the entire state.

## Environmental Education

LEA offers environmental education programs to local elementary, middle, and high schools, reaching over 1,000 students annually. LEA also hosts educational programs for all ages at the Holt Pond Preserve, Highland Lake Preserve and Pondicherry Park, all of which LEA played a key role in establishing.

## Lake Water Testing

Water testing on over 40 lakes and ponds in the area occurs every year through traditional and advanced testing initiatives. The results are presented in this report.

## Landowner and Municipal Assistance

LEA provides technical assistance to residents

interested in preventing erosion on their property. This service helps educate landowners about simple erosion control techniques and existing land use regulations. LEA also works with municipalities on comprehensive planning, natural resources inventories and ordinance development.

## Courtesy Boat Inspections

Every summer, LEA hires over 30 courtesy boat inspectors to educate boaters at public boat launches about invasive plants and help them perform inspections on their watercraft. This program, begun by LEA, has been adopted across the state.

## Maine Lake Science Center

Opened in 2015, LEA's Maine Lake Science Center is a hub for lake research in the state. The center regularly hosts researcher retreats and other events at its remodeled and renovated energy-efficient headquarters located in Bridgton.

## Please Join LEA!

LEA is a primarily member-funded operation. If you swim, boat, fish or simply believe Maine wouldn't be Maine without clear, clean lakes and ponds, please join the Lakes Environmental Association and protect Maine's lakes now and for future generations.

**You can become an LEA member with a donation of any amount. Just mail a check to LEA, 230 Main St., Bridgton, ME 04009 or join online at [www.minelakes.org](http://www.minelakes.org).**




## Water Quality at a Glance

Please See Key on the Next Page.

Lake	Oxygen Depletion	High P at depth	Clarity Trend	Phos. Trend	Chl-a Trend	Coldwater Fish	Other Issues	Degree of Concern
ADAMS POND							---	HIGH
BACK POND							Low Al:Fe	HIGH
BEAR POND							---	HIGH
BEAVER P. (Bridgton)						N/A	---	MOD
BEAVER P. (Denmark)		N/A	N/A			N/A	---	AVG
BOG POND		N/A	N/A	N/A	N/A	N/A	---	AVG
BRANDY POND							---	MOD
COLD RAIN POND		N/A					---	MOD
CRYSTAL LAKE							Low Al:Fe	MOD
DUCK POND		N/A	N/A	N/A	N/A	N/A	---	AVG
FOSTER POND		N/A				N/A	---	AVG
GRANGER POND		N/A				N/A	Algae	MOD
HANCOCK POND							---	MOD
HIGHLAND LAKE							Algae	HIGH
HOLT POND		N/A				N/A	---	AVG
ISLAND POND		N/A					---	MOD
JEWETT POND						N/A	---	MOD
KEOKA LAKE							Gloeo	HIGH
KEYES POND							---	MOD/HIGH
KEZAR POND		N/A	N/A			N/A	---	AVG
LITTLE POND		N/A	N/A			N/A	---	AVG
LITTLE MOOSE POND						N/A	---	MOD
LITTLE MUD POND		N/A				N/A	---	AVG
LONG LAKE (3 BASINS)							Gloeo/Al:Fe/ Milfoil	HIGH
LONG POND		N/A				N/A	---	AVG
McWAIN POND		N/A				N/A	Gloeo	MOD
MIDDLE POND							---	MOD/HIGH
MOOSE POND (Main)							Gloeo/Al:Fe	HIGH
MOOSE POND (North)						N/A	---	AVG
MOOSE POND (South)			N/A	N/A	N/A	N/A	---	MOD
MUD POND		N/A				N/A	---	AVG
OTTER POND		N/A				N/A	---	AVG
PAPOOSE POND		N/A				N/A	---	AVG
PEABODY POND							Low Al:Fe	MOD/HIGH
PERLEY POND		N/A				N/A	---	AVG
PICKEREL POND		N/A				N/A	---	AVG
PLEASANT POND		N/A				N/A	---	AVG
SAND POND							Algae	HIGH
SEBAGO COVE		N/A	N/A	N/A	N/A	N/A	Milfoil	AVG
STEARNS POND							---	MOD
TRICKEY POND							---	HIGH
WEBBER POND		N/A	N/A	N/A	N/A	N/A	---	AVG
WOODS POND						N/A	---	MOD

## Key to Water Quality at a Glance Table

**Oxygen Depletion:** Did the lake suffer from low oxygen conditions in 2017?

 = severe     = slight     = none

**High P at depth:** Were deep-water phosphorus levels above 12 ppb in 2017?

 = Yes     = No    N/A = not tested


**Clarity, Phosphorus, and Chlorophyll-a trends:**

Data from 1996-2017 was analyzed to determine if these parameters are improving or worsening over time.    N/A = no trend analysis

 = Worsening     = Improving     = No change

**Coldwater Fish:** Did coldwater fish have 2 m of suitable habitat at all times of the year in 2017?

 = No     = Yes    N/A = no coldwater fishery

**Other Issues:** Additional risks that factor into the level of concern. Each issue = 

Low Al/Fe: Lake is at a greater risk of phosphorus release from sediments

Algae: An algae bloom has occurred in the past

Gloeo: Lake has a history of elevated *Gloeotrichia echinulata* levels





Milfoil: Invasive milfoil has been found in this lake

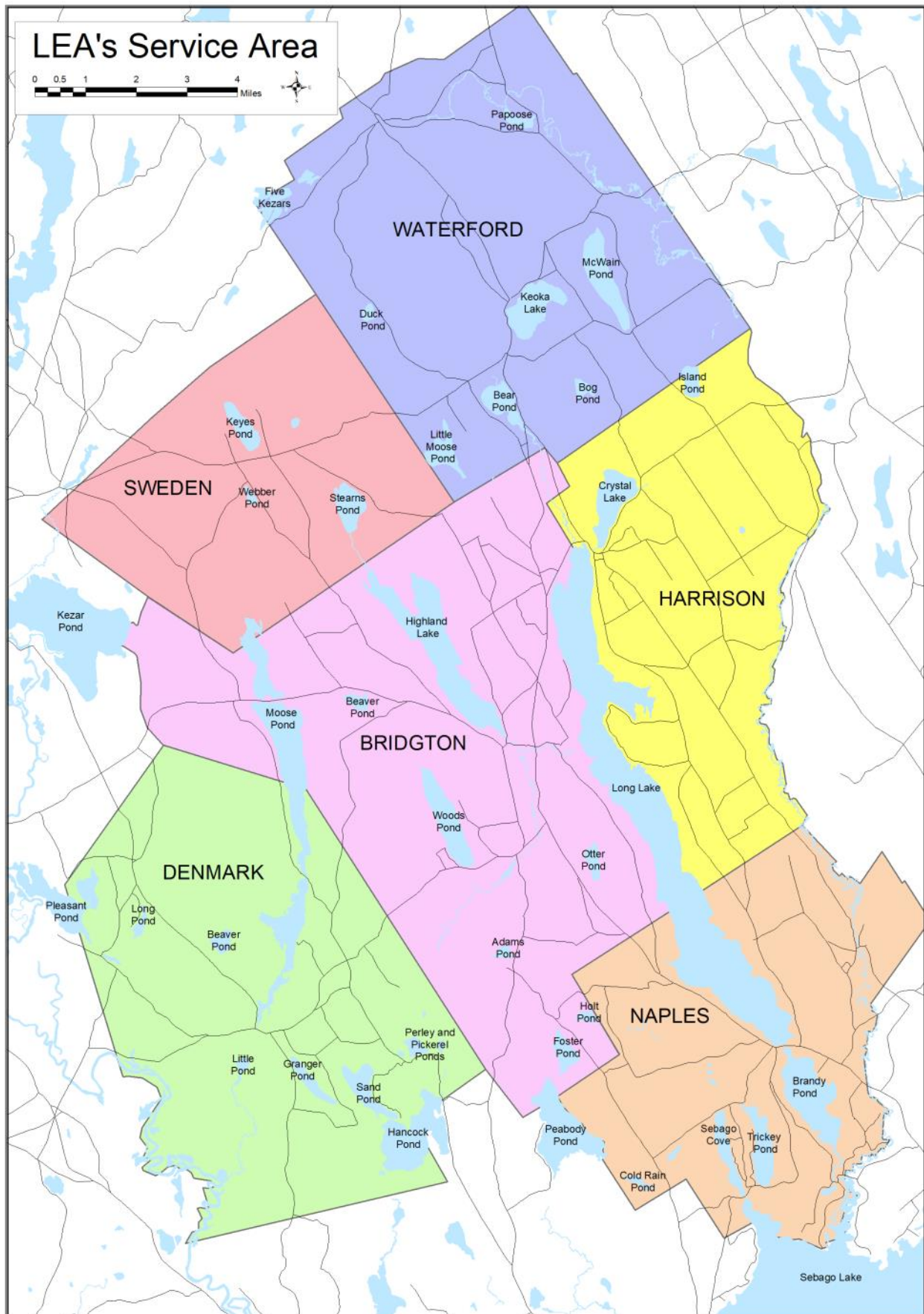
**Degree of Concern:** LEA's risk assessment for future lake water quality

Average: none or 1 

Moderate:  

Moderate/High:   

High:     or a worsening chl-a trend



LEA would not be able to test the 41 lakes and ponds of this area without strong support from our surrounding community. Every year, we rely on volunteer monitors, lakefront landowners, summer interns and financial support from Lake Associations and the Towns of Bridgton, Denmark, Harrison, Naples, Sweden, and Waterford to continue to monitor and analyze lake water quality. **Thank you for all your help!**

### 2017 Volunteer Monitors and Lake Partners

Paul America	Kokosing	Jane Seeds
Bill Ames and Paulina Knibbe	Lydia Landesberg	Linda and Orrin Shane
Richard and Andy Buck	Amy March	Foster and Marcella Shibles
Steve Cavicchi	Julie and Dan McQueen	Bob Simmons
Jeff and Susan Chormann	Dorothy Mayberry	Barry Smith
Janet Coulter	Bob Mahanor	Paul Stander
David Ehrman	Bob Mercier	Carolyn Stanhope
Jane Forde	Bill Muir	Tom Stockwell
Joe and Carolee Garcia	Papoose Pond Campground	Tom Straub
Carol Gestwicki	Barry and Donna Patrie	Don and Pat Sutherland
Shelly Hall	Nancy Pike	Charlie Tarbell
Carl and JoAnne Harbourt	Jean Preis	David Thomae
Aiden Ireland	Don Rung	Chip and Rhona Wendler
Jim Kelly	Stephanie Searce	Camp Wigwam
	Arthur and Jean Schilling	

### 2017 Water Testing Crew

Isabella Davis	Grace Kimzey	Jacob Moulton
Kayla Gray	Erin Levasseur	Chloe Wendler



### Lake Association Partners Who Contribute to Advanced Testing Initiatives

Five Kezar Ponds Watershed Assoc.	Keyes Pond Env. Prot. Assoc.	Trickey Pond Env. Prot. Assoc.
Hancock and Sand Ponds Association	McWain Pond Association	Woods Pond Water Quality Comm.
Island Pond Association	Moose Pond Association	
Keoka Lake Association	Peabody Pond Protective Assoc.	

# Lake Stratification 101

To understand much of LEA's water quality data, you must understand the concept of lake stratification.

Lake stratification is the separation of water in a lake or pond into distinct layers. This is caused by density differences in water at different temperatures. However, wind also plays a key role in maintaining and breaking down stratification. This layering happens in both the summer and winter and breaks down in the spring and fall, allowing for "turnover" — full mixing throughout the water column.

In Maine, three layers often form; the epilimnion, metalimnion (also called the thermocline), and the hypolimnion.

The epilimnion is the warm surface layer of the lake and the hypolimnion is the cold bottom layer. The thermocline is a narrow zone in between these layers where temperature and oxygen levels change rapidly. The exact depths of each layer change over the course of the summer and from lake to lake and year to year.

Due to the nature of stratification, which does not allow for exchange between the top and bottom layers, oxygen and nutrient concentrations often differ significantly between the upper and lower portions of a stratified lake. This is especially true in late summer.

This has several consequences for the lake. Light penetration is greatest near the top of the lake, meaning that algae growth primarily occurs in the epilimnion. Algae growth will sometimes peak near the thermocline, often in lakes with deep light penetration and higher hypolimnetic phosphorus levels.

Oxygen levels in the epilimnion are constantly replenished through wind mixing, but the hypolimnion is cut off from the atmosphere, leaving it with a fixed volume of oxygen which is slowly used up over the summer. This can affect coldwater fish species in some lakes.

Phosphorus, the limiting element controlling algae growth in our lakes, is often more abundant in the hypolimnion because it is stored in sediments.

When oxygen levels are low at the bottom of the lake, as often happens later in the summer, a chemical reaction occurs that releases stored phosphorus from sediments. However, due to the density barrier at the metalimnion, these nutrients do not move easily into the epilimnion. This often causes a buildup of phosphorus in the hypolimnion.



Smallmouth Bass

## Epilimnion

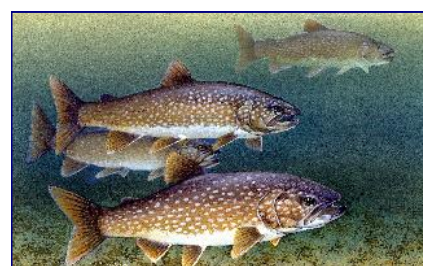
The warm upper waters are sunlit, wind-mixed and oxygen rich.



Landlocked salmon

## Metalimnion

This layer in the water column, also known as the thermocline, acts as a thermal barrier that prevents the interchange of nutrients between the warm upper waters and the cold bottom waters.



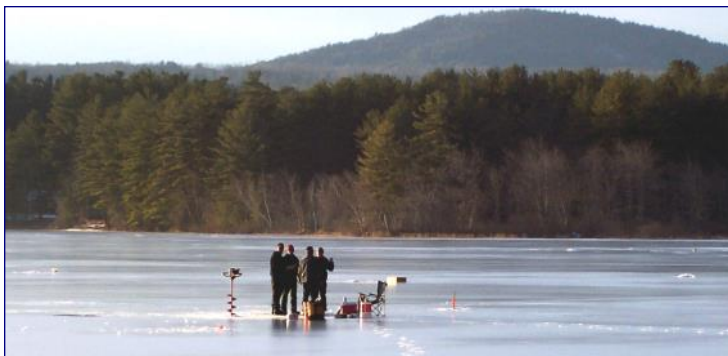
Lake trout, also known as togue

## Hypolimnion

In the cold water at the bottom of lakes, food for most creatures is in short supply, and the reduced temperatures and light penetration prevent plants from growing.

# *A year in the life of a lake*

**Winter** is a quiet time. Ice blocks out the sunlight and also prevents oxygen from being replenished in lake waters because there is no wind mixing. With little light below the ice and gradually diminishing oxygen levels, plants stop growing. Most animals greatly slow their metabolism or go into hibernation.



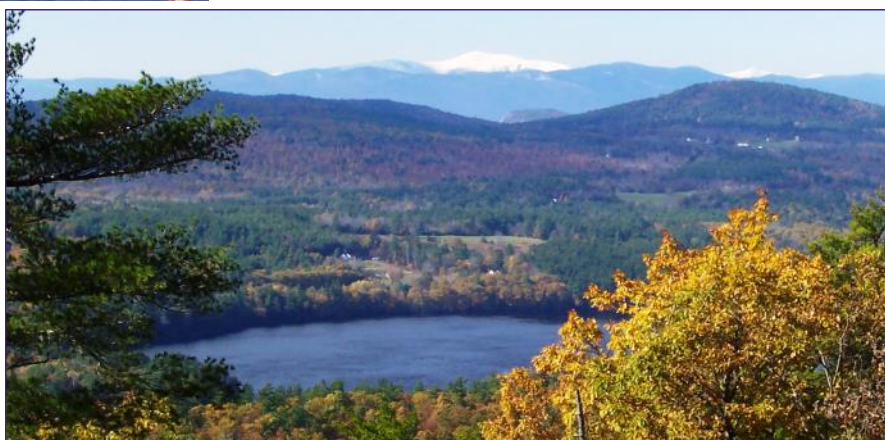
**Spring** is a period of rejuvenation for the lake. After the ice melts, all of the water is nearly the same temperature from top to bottom. During this period, strong winds can thoroughly mix the water column allowing for oxygen to be replenished throughout the entire lake.

This period is called spring turnover. Heavy rains, combined with snow melt and saturated soils are a big concern in the spring. Water-logged soils are very prone to erosion and can contribute a significant amount of phosphorus to the lake. Almost all soil particles that reach the lake have attached phosphorus.



**Summer** arrives and deeper lakes will gradually stratify into a warm top layer and a cold bottom layer, separated by a thermocline zone where temperature and oxygen levels change rapidly. The upper, warm layers are constantly mixed by winds, which “blend in” oxygen. The cold, bottom waters are essentially cut off from oxygen at the onset of stratification. Coldwater fish, such as trout and landlocked salmon, need this thermal layering to survive in the warm summer months and they also need a healthy supply of oxygen in these deep waters to grow and reproduce.

**Fall** comes and so do the cooler winds that chill the warm upper waters until the temperature differential weakens and stratification breaks down. As in Spring, strong winds cause the lake to turn over, which allows oxygen to be replenished throughout the water column.



## Water Quality Testing Parameters

LEA's testing program is based on parameters that provide a comprehensive indication of overall lake health. Tests are done for transparency, temperature, oxygen, phosphorus, chlorophyll, color, conductivity, pH, and alkalinity.

**Clarity** is a measure of water transparency. It is determined with a Secchi disk and measured in meters. Clarity is affected by water color and the presence of algae and suspended particles.

**Chlorophyll-a** is a pigment found in all algae. Chlorophyll (the -a is dropped for simplicity) sampling in a lake is used to estimate the amount of algae present in the water column. Chlorophyll concentrations are measured in parts per billion (ppb). Samples are a composite of the top layer of water in a lake.

**Phosphorus** is a nutrient needed by algae to grow and reproduce. It is used to determine the potential for algae growth in a lake. Phosphorus is measured in parts per billion (ppb). Upper layer phosphorus samples are a composite (blended sample) of the top few meters of the water column, while deep-water phosphorus samples are taken at individual depths using a grab sampler.

**Dissolved oxygen** is measured at one-meter intervals from the surface to the bottom of the lake. It is measured in parts per million (ppm). Over the course of the summer, oxygen in the bottom waters is consumed through organic matter decomposition. If dissolved oxygen concentrations reach zero at the bottom of the lake, phosphorus can be released into the water column from bottom sediments, which can cause increased algal growth that fuels further lake oxygen depletion. Phosphorus release is inhibited in lakes with high sediment aluminum levels. Oxygen depletion can be a natural occurrence in some lakes due to the lake's shape. It is a special concern in lakes that support coldwater fish. In this report, "oxygen depletion" refers to dissolved oxygen levels below 4 ppm. During the fall, cooler temperatures and winds cause the lake to de-stratify and oxygen is replenished in the deep waters as the lake mixes.

**Temperature** is measured at one-meter intervals from the surface to the bottom of the lake. This data is used to assess thermal stratification. Lakes deep enough to stratify will divide into three distinct layers: the epilimnion, metalimnion and hypolimnion. The epilimnion (upper layer) is comprised of the warm surface waters. The hypolimnion is made up of the deep, colder waters. The metalimnion, also known as the thermocline, is a thin transition zone of rapidly decreasing temperature between the upper and lower layers. Temperature is recorded in degrees Celsius.

*Other Measurements:* We collect data on these parameters, but they tend to remain stable over long periods time. They are not reported on unless unusual conditions were observed.

**Conductivity** measures the ability of water to carry electrical current. Pollutants and minerals in the water will generally increase lake conductivity.

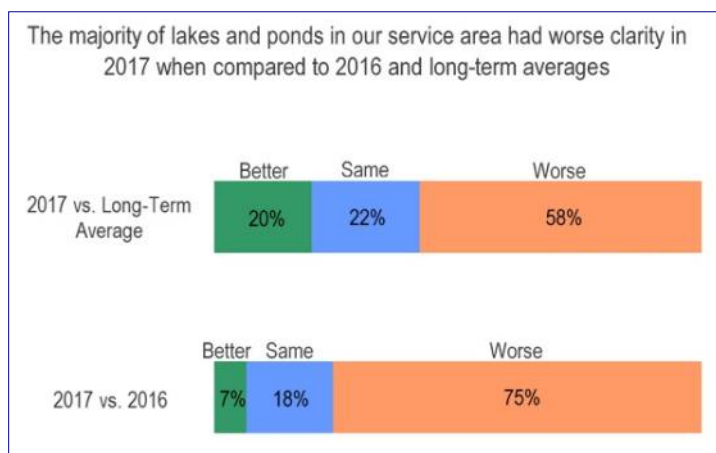
**Color** is a measure of tannic or humic acids in the water.

**pH** is important in determining the plant and animal species living in a lake. pH is used to measure the acidity of lake water.

**Alkalinity** is a measure of the amount of calcium carbonate in the water and it reflects the ability of the water to buffer pH changes.

## 2017 as a Year

The water quality results for 2017 show a mediocre year for water quality in the lakes region. Several factors influenced the results seen in 2017. The winter of 2016-2017 deposited a larger than average amount of snow in the region, leading to higher water flows in the spring. There was also a significant amount of rainfall in the spring and early summer. More water running off into lakes meant more erosion bringing particulates and pollution, as well as higher water levels. Tornadoes in the Long Lake and Moose Pond watersheds in early July also caused severe erosion and extensive damage to shorefront property and vegetation. Relatively cold temperatures in the spring delayed stratification and meant that ice-out occurred around its average date, despite a trend of increasingly earlier ice-out over the last few decades. While rainfall was high early in the season, later in the summer the region experienced mild drought conditions. The lack of rain increased clarity in many lakes toward the end of the season, but because of low readings early in the season, the majority of lakes saw worse than average clarity in 2017.



Clarity, a measure of how transparent the water is, was the same or better on 42% of lakes and worse on 58% when compared to long-term averages. Chlorophyll-a, a measurement of the algae concentration in a lake, was stable or improved over the long-term average in 62% of lakes and worse than average on 38% of lakes. Phosphorus, the limiting nutrient that controls algae growth, was also the same or better in the upper layer of the water column on 62% of lakes and worse on 38%. Phosphorus levels at depth appeared to be lower overall in 2017 compared to previous years. This may be explained by the delay in the set up of stratification in the spring, which resulted in less severe oxygen depletion and meant there was less phosphorus release from lake sediments. Weather is often the driving force behind water quality in any given year. The weather in 2017 affected water quality in both positive and negative ways. Fortunately, no major water quality declines or algae blooms were reported in 2017.

On a longer timescale, water quality trends are impacted by climate, changes in land use, non-point source pollution, and best management practices. This means that any changes we make to protect our lakes — such as installing water bars, pumping septic systems, or planting a vegetated buffer on a shoreline — do not often result in visible benefits for several years, but are extremely important to the long-term health of our lakes. With strong support and investment in the future of our lakes, we can keep the Lakes Region resilient and protected for years to come.

## Interpreting Water Testing Data

### Water Quality Classification

The pond's clarity, chlorophyll, and phosphorus readings are the basis for determining water quality classification. Most lakes in LEA's service area are in the moderate range for all three parameters. The following table shows the range of values in each category (low, moderate, etc.) for each parameter.

<u>Clarity in meters (m)</u>		<u>Phosphorus in parts per billion (ppb)</u>		<u>Chlorophyll-a in parts per billion (ppb)</u>	
10.0 +	excellent	less than 5.0	low	less than 2.0	low
7.1 – 10.0	good	5.1 – 12.0	moderate	2.1 – 7.0	moderate
3.1 – 7.0	moderate	12.1 – 20.0	high	7.1 – 12.0	high
less than 3.0	poor	20.1 +	very high	12.1 +	very high

### Trends and Long-Term Averages

The data summary starts with an explanation of clarity, chlorophyll, and phosphorus trends. These trends are a regression analysis of all the data LEA has collected on the pond since 1996 (1997 in the case of phosphorus data). If the p-value of the regression is less than 0.05, it is a worsening or improving trend (depending on the direction of the trend). If the p-value is above 0.05, there is no detectable trend. These trends show water quality changes over time.

The long-term average is a simple mean of all the data we have on record for each parameter (clarity, chlorophyll, and phosphorus). The long-term average doesn't tell us specifically how each parameter changes over time like the trend analysis does; it is instead used to see how the current year's data compares to historical values. The long-term average uses all the data available, rather than just data collected in or after 1996.

This means that the trend and the long-term average can be at odds. For example, the overall clarity trend might be improving over time, but if the current year had particularly bad water clarity, the yearly average may be worse than the long-term average. The trend shows how the parameter has changed over time, while the long-term average is used as a benchmark to assess the current year's data.

### Coldwater Fish Habitat

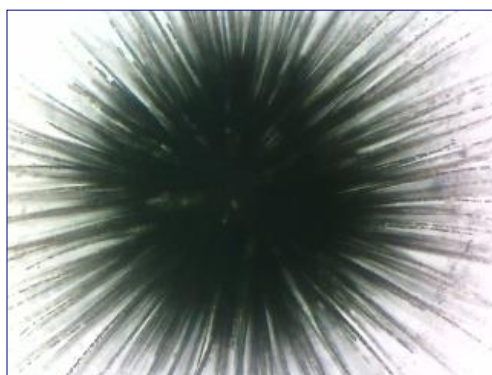
Suitable habitat is defined as being below 15.5 °C and above 5 ppm dissolved oxygen. Marginal habitat is between 15.5 and 20 °C and above 5 ppm oxygen. Coldwater fish habitat is considered a water quality issue in lakes with coldwater fisheries that do not have at least 2 meters' worth of suitable habitat at all times during the testing season.

### Degree of Concern

The pond is also given a degree of concern category ranking. The average, moderate, moderate/high, and high degree of concern categories are based on the number of water quality issues the pond faces. An increasing chlorophyll trend automatically results in a high level of concern. Recent algae blooms raise the degree of concern by one level. You can see more about these rankings in the "Water Quality at a Glance" table and key on pages 2 and 3.

## *Gloeotrichia echinulata* Monitoring

*Gloeotrichia echinulata* (also known as “Gloeotrichia” or simply “Gloeo”) is a colonial cyanobacteria species. Each colony is made up of numerous hair-like filaments that radiate outward, creating the characteristic “fuzzy ball” appearance of this species. The colonies are approximately 1-3 mm in diameter and tend to be free-floating in the water column, only forming surface scums at extremely high concentrations.



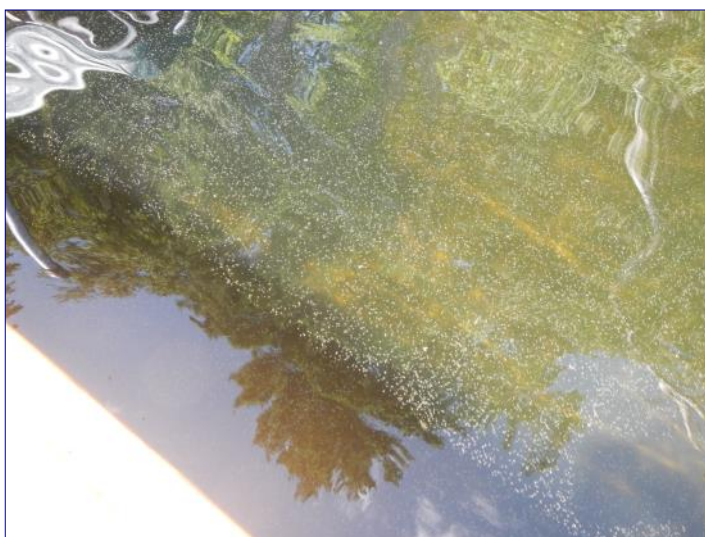
A Gloeo colony under the microscope

Cyanobacteria (also known as blue-green algae) such as Gloeo are not actually algae, but photosynthetic bacteria. There are several cyanobacterial species that are notorious for causing toxic blooms in high-nutrient lakes. Gloeo do not form sludgy, green “pea soup” blooms like other cyanobacteria, but they can produce toxins under certain conditions. Rather than pea soup, Gloeo tend to look like small yellow spheres floating throughout the water column, and their large size makes them very noticeable even at low concentrations.

While algae blooms are typically associated with high nutrient lakes, Gloeo is known for its proliferation in low nutrient lakes, such as those in the Lakes Region. One concern with Gloeo is that it may be enriching these lakes by moving phosphorus from the sediments into the water column.

Gloeotrichia is a fairly common sight in late summer throughout New England, and can be found in high concentrations in several lakes in Maine each summer. They are not an invasive species or particularly new to our waters. Evidence of Gloeo is present in sediment cores from various lakes, and a report on Waterford Lakes from 1973 shows that Gloeo was common in McWain Pond and Keoka Lake 45 years ago.

While Gloeo can be seen in the water column from June through September, the highest levels of Gloeo are typically seen within a two week span in late July and early August. The amount of Gloeo present in a lake depends primarily on light, temperature, and nutrient levels, as well as several smaller contributing factors. Temperature in particular can be used to explain the timing of peak Gloeo concentrations.



High density of Gloeo colonies seen near the shore of Moose Pond, August 2017.

## *Gloeotrichia* in the Lakes Region

LEA began sampling for Gloeo in 2013. Samples are collected in shallow areas of lakes and ponds using a plankton tow net made of fine mesh, which strains the algae from the water. Sites of sample collection have remained consistent since sampling began, but not all sites were visited in all years. Abundance is measured in a unit called “colonies per liter” (abbreviated col/L), which is the number of Gloeo that would be seen in an average liter of lake water (it helps to imagine the size of a 1 liter soda bottle).

Lakes that were sampled for Gloeo in 2017 are listed to the right. Several lake associations provided funding for the collection of samples on their lakes. Of the 28 sites tested, only seven have had elevated levels of Gloeo (>5 col/L) over the 5 years of testing. These are Keoka Lake, Long Lake (which has 4 sample sites), McWain Pond, and Moose Pond’s Main Basin. These sites were sampled five times over the course of 5 weeks in 2017. Several sites have had low levels of Gloeo present in late summer each year (below 5 col/L). The remaining sites, about 75% of the total sites sampled, have had virtually no Gloeo in any samples.

The lakes with and without significant levels of Gloeo have stayed consistent since LEA began sampling. It is likely that some lakes don’t have the ability to support higher concentrations of this species. However, the lake characteristics and conditions needed for Gloeo blooms to occur are not well understood.

The following pages present data from the four lakes with elevated late-summer Gloeo concentrations. Each lake’s results are graphed on plots with the same scale on the x-axis and y-axis to facilitate comparison.

Concentrations of Gloeo discussed in the summaries should be interpreted with the knowledge that LEA sampling provides a “snapshot” of the Gloeo present at a particular spot at a particular point in time, which may not be representative for the lake as a whole. Gloeo populations

can vary across a single lake due to factors like prevailing winds and substrate quality. Long Lake data is a good example of this: sampling from four sites shows the northern part of the lake consistently has the highest Gloeo concentrations. However, on most other lakes, only one site is sampled. This means we potentially miss “hot spots” of elevated Gloeo on some lakes. That being said, after sampling for 5 years and visiting each lake on the above list twice per month every summer for routine water quality monitoring, we can be reasonably sure in our assessment of the relative Gloeo concentrations on these lakes.

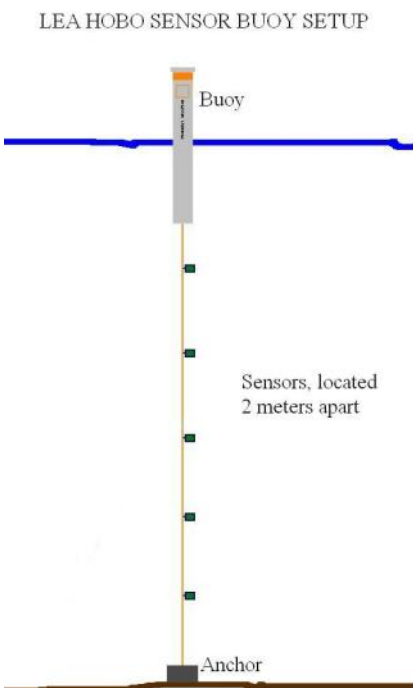
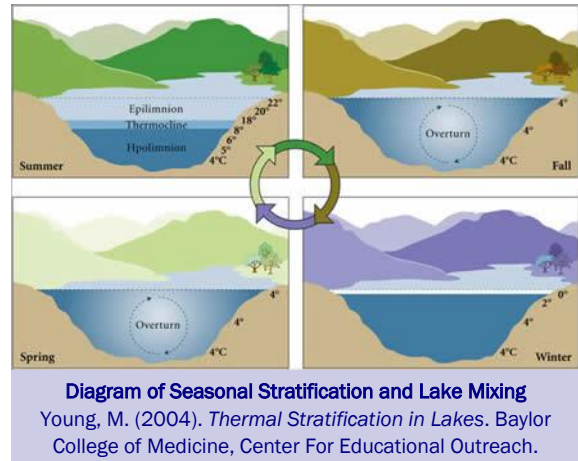
Lakes Sampled for <i>Gloeotrichia</i> in 2017:	
ADAMS POND	●
BACK POND	●
BEAR POND	●
BRANDY POND	●
CRYSTAL LAKE	●
FOSTER POND	●
GRANGER POND	●
HANCOCK POND	●
HIGHLAND LAKE (2 sites)	●
ISLAND POND	●
KEOKA LAKE	●
KEYES POND	●
LITTLE MOOSE POND	●
LONG LAKE (4 sites)	●
MCWAIN POND	●
MIDDLE POND	●
MOOSE POND (Main Basin)	●
MOOSE POND (North Basin)	●
MOOSE POND (South Basin)	●
PEABODY POND	●
SAND POND	●
STEARNS POND	●
TRICKEY POND	●
WOODS POND	●
<div>● NONE</div> <div>● LOW (&lt;5 col/L)</div> <div>● HIGH (&gt;5 col/L)</div>	

## Introduction to High-Resolution Temperature Monitoring

LEA began using in-lake data loggers to acquire high resolution temperature measurements in 2013. The loggers, which are also interchangeably referred to as **HOBO** sensors, temperature sensors, or thermistors, are used to provide a detailed record of temperature fluctuations within lakes and ponds in our service area. This information allows for a better understanding of the thermal structure, water quality, and extent and impact of climate change on the waterbody tested.

Each year, we attempt to capture the entire stratified period within the temperature record, from when stratification begins to form in the spring to when the lake mixes in the fall. Stratification refers to the separation of lake waters into distinct layers, and is a phenomenon that has important consequences for water quality and lake ecology. See page 6 for more information about stratification.

Water temperature is critical to the biological function of lakes as well as the regulation of chemical processes. Lake temperature and stratification are greatly influenced by the weather. Air temperature, precipitation, and wind speed and direction can all affect water temperature and stratification patterns from year to year. Lake size, depth, and shape also greatly impact stratification timing and strength. The larger the difference in temperature between the top and bottom layers of the lake, the stronger the stratification is.



With funding and support from local lake associations, LEA has deployed temperature sensors at sixteen sites on twelve lakes and ponds. Sensors are attached to floating line held in place by a regulatory-style buoy and an anchor. The sensors are attached at 2 meter intervals, beginning 1 meter from the bottom and ending approximately 1 meter from the top. Each buoy apparatus is deployed at the deepest point of the basin it monitors. The setup results in the sensors being located at odd numbered depths throughout the water column (the shallowest sensor is approximately 1 meter deep, the next is 3 meters, etc.).

Temperature sensors are programmed to record temperature readings every 15 minutes. LEA has for many years used a handheld YSI meter to collect water temperature data. However, this method is time consuming, resulting in only 8 temperature

profiles per year. While temperature sensors require an initial time investment, once deployed, the sensors record over 15,000 profiles before they are removed in the fall. This wealth of data provides much greater detail and clarity than the traditional method ever could. Daily temperature fluctuations, brief mixing events caused by storms, the date and time of stratification set up and breakdown, and the timing of seasonal high temperatures are all valuable and informative events that traditional sampling can't accurately measure.



## 2017 Monitoring Season

Several weather events in 2017 impacted the thermal structure of the lakes and ponds in the area. The large snow pack coupled with cooler weather in the spring led to relatively late ice-out and high water levels in the spring. Temperature buoys were deployed in late April and early May. Stratification began to set up in mid-to-late May on most lakes, after being impeded by cold temperatures throughout spring and strong winds that caused mixing around May 15th.

Heavy storms at the end of June and beginning of July (including several tornadoes in the Bridgton area) affected stratification on most lakes and some temperature fluctuations at depth can be seen due to these events. Mixing caused by other storms, such as a thunderstorm on August 2nd, can also be seen in some of the graphs.

Many lakes saw temperatures peak on or around July 22nd. Compared to 2016, the timing of the peak was 6 days earlier and the maximum temperatures were slightly lower in most cases. Temperatures gradually cooled from then on, with a steeper decline toward the end of August. High winds on September 1st accelerated mixing in many lakes, although full mixing was delayed by unusually warm temperatures in the fall, particularly at the end of September. The timing of full mixing was later than usual on many basins. Storms between October 29th–31st brought very high winds, but despite this most lakes that were still partially stratified at that time did not fully mix.

## High-Resolution Temperature Monitoring: How to Read the Graphs

The temperature monitoring data summary includes a graph displaying all the data collected in the 2017 season. These graphs can be tricky to understand, so here are a few pointers:

- Each colored line represents the temperature over time at a specific depth in the water. The topmost lines represent water near the top of the lake (red = 1 meter below the surface, etc.), with a difference of 2 meters (approx. 6 feet) in depth between each line.
- The graph shows temperature change over time – The horizontal axis (left to right) shows the date, while the vertical axis (up and down) shows the temperature (in degrees Celsius).
- Generally, the lines are close together on the left side of the graph (late April/early May), then widen out (June-August), then come back together on the right side of the graph (September-November). The top few lines may stay close to each other when the graph widens out, indicating these depths are within the epilimnion, or top stratified layer. Then, there is often a gap in the middle, indicating the rough position of the thermocline. Most of the time, the bottom lines stay relatively flat, indicating that they are within the hypolimnion, the deep, cold layer that makes up the lower portion of the lake.
- Large gaps between lines means there is a large temperature difference between one depth and another.
- The pattern in temperature displayed by the top line (the sensor nearest to the lake's surface) is strongly influenced by air temperature.
- During stratification, the epilimnion does not easily mix with the hypolimnion (hence, these lines do not touch each other). It is only when the temperature of the upper water cools down that the lake can fully mix. You can see this process happening on each graph: the temperatures near the surface get cooler and the deeper waters get warmer as the barrier between the two layers weakens and the waters begin to mix. The lines converge one by one until the temperature is the same at each depth. This is known as lake turnover or destratification.



A HOBO temperature sensor

## LEA's Algae Monitoring Program

Studies of algae populations are a good way for lake managers to glean information about lakes: their nutrient levels, stratification, and a host of complex details are all made more clear through the study of phytoplankton (the technical term for free-floating algae). Algae are the foundation of lake food webs, meaning that they are the food source that directly or indirectly supports much of the animal life existing in a lake. Of course, algae are also the source of algal blooms, which usually result from an over-abundance of nutrients and can cause a host of problems within a lake system. Algal blooms are often a sign of a water quality issue, and are generally bad for people (impacting recreation, fishing, and aesthetics) and for the lakes themselves.

The goal of LEA's algae testing program is to identify the kinds of algae present in our lakes, quantify them, and study how they change over time. The focus is on planktonic algae, which are free-floating in the water, rather than attached to rocks or other material. In 2017, algae samples were collected from twelve lakes once per month for five months (May–September). Samples consisted of lake water from the top layer (ranging from 3-10 meters deep) of the water column. The depth of the sample differed depending on the location of the thermocline in each lake. Collection and analysis of algae samples was made possible by support from local lake associations.

Samples were preserved using Lugol's Iodine at the time of collection. Samples were settled within 3 weeks of collection using an Utermöhl chamber, which consists of a 100 mL tube set over a modified microscope slide. Slides were examined with an inverted microscope at 600x total magnification. Algae were identified to genus level (the level above species) where possible. Random fields were counted until a total of 400 natural algae units was reached. The number of cells per milliliter (cells/mL) was calculated for each sample.

Algae are incredibly diverse, but in general 5-6 algae species will make up about 90% of the biomass in a lake at any given time. The dominant algae change over the course of the summer due to several factors including temperature, nutrient levels, and predation by zooplankton. Samples are taken on a monthly basis to monitor how populations shift throughout the summer.

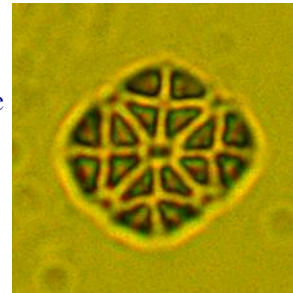
One important water quality indicator that we can determine through collecting algae samples is the amount of cyanobacteria in a lake. Cyanobacteria are not technically algae, but rather photosynthetic bacteria. Nevertheless, they are treated as a type of algae because they have many of the same characteristics. High levels of cyanobacteria are often correlated with high phosphorus levels, and cyanobacteria such as *Aphanizomenon*, *Dolichospermum* (formerly *Anabaena*), and *Microcystis* are the most common causes of harmful cyanobacterial blooms that can be toxic to both people and animals. Cyanobacteria tend to be most common in the later part of the summer, when temperatures are warmest. Colonial cyanobacterial genera such as *Aphanocapsa*, *Aphanothece*, and *Merismopedia* are common in low-nutrient lakes such as those in the Lakes Region and do not contribute to toxic blooms, although they do contribute to relatively high cell counts in some lakes.

Sample Sites
Back Pond
Hancock Pond
Keoka Lake
McWain Pond
Middle Pond
Moose Pond (Main Basin)
Moose Pond (North Basin)
Moose Pond (South Basin)
Peabody Pond
Sand Pond
Trickey Pond
Woods Pond

It is important to note that although LEA continues to measure chlorophyll-a concentrations in water as a proxy for algae abundance, lab-based chlorophyll-a measurements are not comparable to cells/mL concentrations found in these summaries because of differences in the amount of chlorophyll-a in algae cells of varying types and conditions.

### The Difference Between Natural Units and Cell Counts

The summaries on the following pages discuss results in terms of both natural units and cell counts. One natural unit can be one cell or one colony. Natural units treat all algae equally, no matter how many cells they are made up of. Cell counts are simply a count of all cells. A single-celled algae would be counted as one natural unit and one cell, whereas a colony of cells will be counted as one natural unit and, say, 16 cells (or however many cells are present within the colony). There are several cyanobacterial genera that are large colonies made up of many tiny cells, or long, filamentous chains of cells. Because of this, cyanobacteria dominate cell counts in many algae samples. Colonial cyanobacteria such as *Aphanocapsa* and *Aphanothece* are common in our lakes and can lead to high cell counts, but because they are colonies of picoplankton (tiny cells around 1  $\mu\text{m}$  wide), they contribute little biomass to the algae assemblage and do not often cause water quality issues.



This *Crucigenia* would be counted as one natural unit made up of 16 cells.

Natural units give a clearer picture of which algae are present, regardless of whether they are colonies or individual cells. Most samples were dominated by flagellated algae, which are single-celled algae with a “tail” called a flagella that they use to swim. Their populations are better represented when looking at natural unit counts, since they are single-celled. Cell counts allow for a better understanding of colonial algae presence and are necessary to calculate cells/mL accurately, which allows for better comparisons of results between lakes and over time. Colonies, even of the same genera, often vary greatly in the number of cells they contain - one natural unit of *Dinobryon* could be two cells or one hundred, and knowing this information is important in lake assessment.

### Why we Monitor Algae

One reason for the algae testing program is to collect baseline data. Baseline sampling is important because it provides a record of conditions to which future data can be compared. This data will help in assessing changes over time and determining what a typical algae population looks like in each lake. Because these lakes currently have good water quality, knowing which algae are present, and in what concentrations, is especially important. Any water quality changes in the future will be easier to assess if current water quality conditions are understood.

The other reason for algae sampling is to gain more information about water quality. Certain types of algae are only present when specific water quality conditions exist, which makes them good environmental indicators. For example, algae such as *Dolichospermum* and *Aphanizomenon*, two cyanobacterial genera which form algae blooms, are good indicators of eutrophication. Additionally, the dominant algae in a sample can be very informative, since different algae will dominate under varying water quality conditions. Collecting samples at different times throughout the summer enables us to record which algae are present under different conditions for a more complete account of each lake’s algae population.

## The 6 Main Types of Algae

Note: Algae appear brown with a yellow background in photos because they are preserved with iodine.



**Green algae** (Chlorophyta) are the most diverse group of algae present in freshwater habitats. They come in a variety of sizes and shapes: round or filamentous, single-celled or colonial, and flagellated or unflagellated. Green algae can be identified by their deep green grassy color and rigid cell walls.



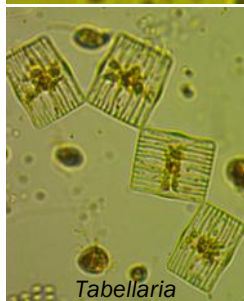
**Cryptomonads** (Cryptophyta) are one-celled algae with two flagella (tails) that allow them to move through water. In this report, Haptophytes (of which only the genus *Chrysochromulina* was identified) and Euglenoids (rare in samples) are counted among the cryptomonads.



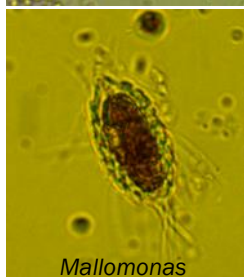
**Cyanobacteria** (Cyanophyta/blue-green algae) are not algae but prokaryotic bacteria that can photosynthesize. Most forms are colonial, and are usually either round or filamentous. While Cyanobacteria are present in all waters and many of them are harmless, there are several species that can produce toxins and will form blooms when nutrient levels are high.



**Dinoflagellates** (Dinophyta) are a group made up of large, motile algae. Large numbers of Dinoflagellates indicate high nitrate and phosphate levels. Most Dinoflagellates are covered in armor-like plates that serve as a protective shell.



**Diatoms** (Bacillariophyta) are easily identified by their hard silica-based outer shells. Diatoms are either centric (round) or pennate (long, thin rectangles or canoe-like shapes). Because their shells make them heavy, diatoms often settle out of the water column during the calm summer months. Most diatoms are single-celled, but a few of the common genera are colonial.



**Golden algae** (Chrysophyta) are common in lakes with low to moderate nutrient levels, low conductivity and alkalinity, moderate color and slightly acidic pH. Golden algae can be identified by their brown to yellow color and the delicate nature of their cells. They are often colonial and a few of the common genera are relatively large in size.

## McWain Pond

### McWain Pond Quick Statistics 2017 Average Versus the Long-term Average:

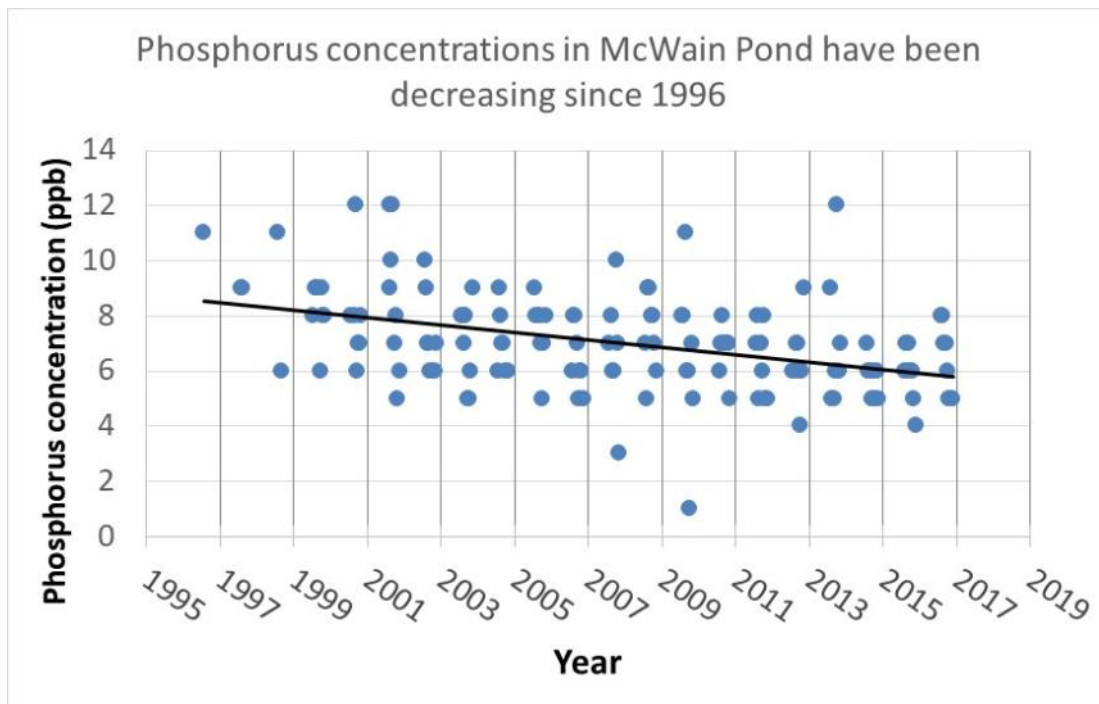
Clarity: Worse at 5.9 meters  
Chlorophyll: Worse at 3.2 ppb  
Phosphorus: Better at 6.4 ppb

<b>Surface Area:</b>	445 acres
<b>Maximum Depth:</b>	42 feet
<b>Mean Depth:</b>	23 feet
<b>Volume:</b>	9,756 acre-feet
<b>Watershed Area:</b>	2,505 acres
<b>Flushing Rate:</b>	0.5 flushes per year
<b>Elevation:</b>	533 feet

### *Water Quality Summary:*

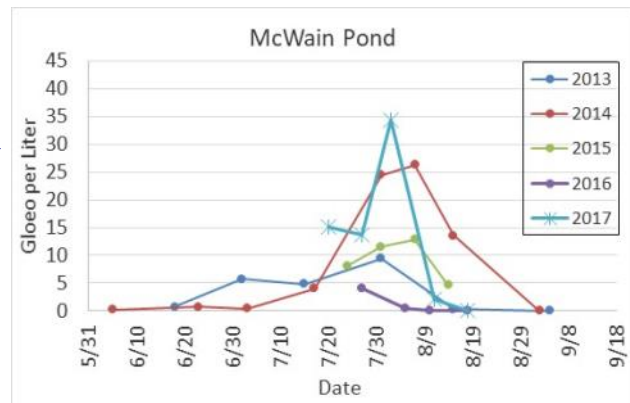
Trend analysis indicates that clarity and chlorophyll are stable on McWain Pond while phosphorus has improved over time. The average phosphorus level in 2017 was a significant improvement over the long-term average, whereas clarity and chlorophyll averages were slightly worse than their long-term average values. All three parameters were within the moderate range in 2017.

The main water quality concerns on McWain Pond are oxygen depletion and *Gloeotrichia echinulata*, a cyanobacterial species that causes blooms and can produce toxins. In previous years, the pond has occasionally had elevated deep-water phosphorus levels. Deep-water phosphorus levels could not be measured on McWain Pond in 2017, so they were not included in the pond's degree of concern assessment. Because of this, McWain Pond has been downgraded to LEA's MODERATE degree of concern category.



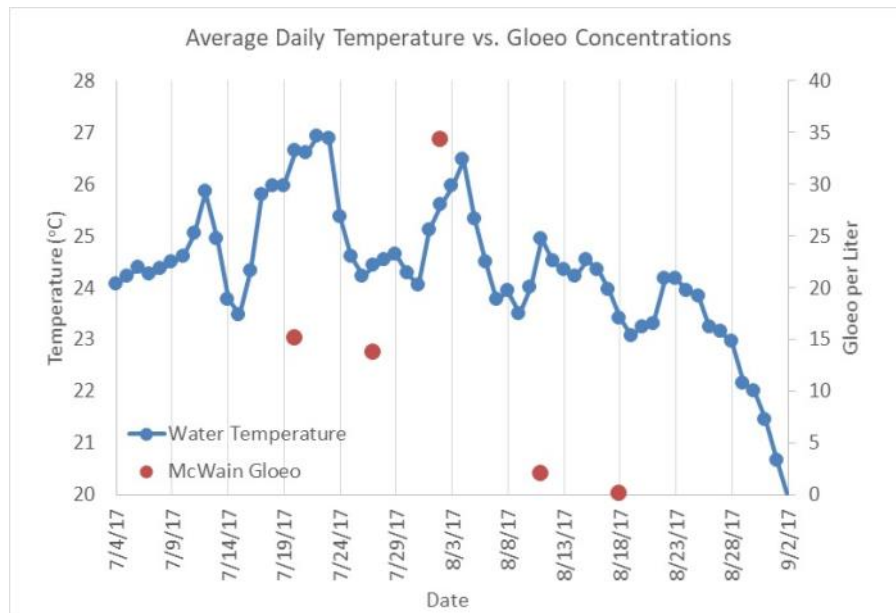
## McWain Pond

Elevated levels of Gloeo in McWain Pond have been documented as far back as the 1970s, although they have likely been present in the pond much longer than that. LEA has been sampling for Gloeo on McWain Pond since 2013, at a site near the middle of the western shore. In 2017, samples were collected approximately once per week between July 20th and August 18th.



The above graph shows concentrations of Gloeo at one site on McWain Pond over the past 5 years.

The peak in Gloeo concentration occurred on August 2nd, and at 34.3 col/L, it was the highest level recorded on the pond in five years of testing. This is in contrast to 2016 results that showed Gloeo concentrations were consistently low (below 5 col/L) each time the pond was sampled. The graph below shows Gloeo levels recorded on McWain Pond in relation to average daily shallow-water temperatures in 2017. It shows that the peak in Gloeo concentration occurred about 11 days after the temperature peak, which matches well with previous demonstrations of the correlation between temperature and Gloeo peaks.



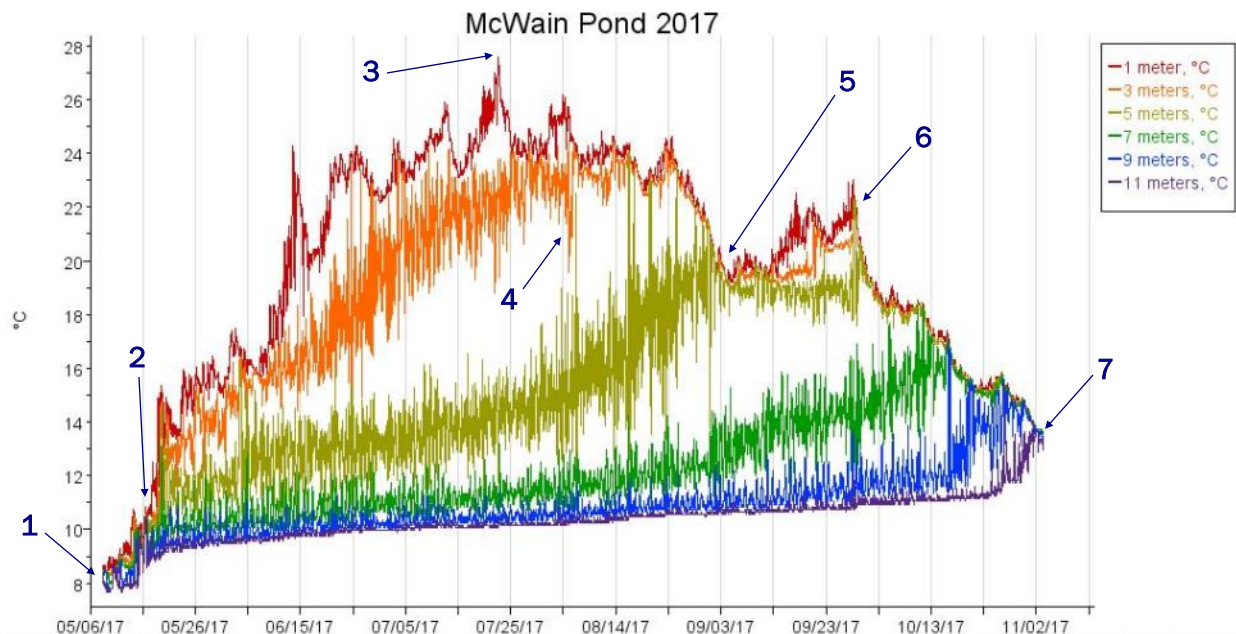
The above graph shows daily average water temperature (taken from Keoka Lake, but representative of the region), with the peak in temperature for the season being between July 20-23. Concentrations of Gloeo from McWain Pond are shown as red dots. The peak in Gloeo concentration occurred about 11 days after the peak in temperature.

## McWain Pond

The temperature record from McWain Pond encompasses the entire stratified period. As seen in the graph below, the 1 meter (red line) sensor data shows distinct, sharp temperature fluctuations, indicating that it is strongly affected by air temperatures. The three meter (orange line) data shows a steady temperature increase across the first part of the graph, then it begins to follow the one meter line closely. The gap between the 3 and 5 meter lines indicates a large temperature disparity between one depth and the next. This indicates the approximate location of the thermocline. At the height of the stratified period, the temperature at one meter deep reached 27.4 °C (81.7 °F) and the thermocline was located at about 4 meters deep.

*The following events can be seen in the graph below:*

- 1) The pond was still well mixed when sensors were deployed May 8th
- 2) Cooler spring temperatures meant surface water temperatures stayed cold until mid-May
- 3) The peak in temperature occurred on July 22nd
- 4) Rain and thunderstorms August 2nd affected temperatures deep into the water column
- 5) High winds on September 1st caused mixing in of deeper water
- 6) Warm temperatures in the fall kept the pond stratified and raised surface water temperatures
- 7) Full mixing occurred on November 2nd

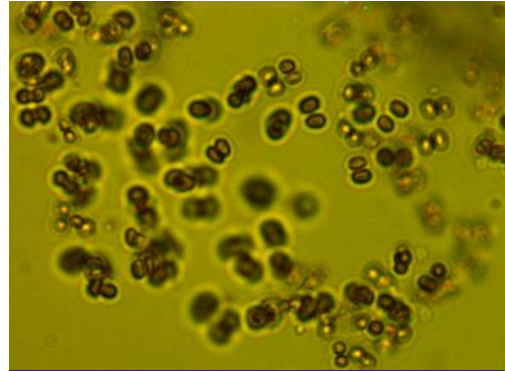


Peak Temperature	Full Mixing
7/22	11/2

## McWain Pond

Algae samples were collected from McWain Pond once per month between May and September, 2017. Algae abundance was relatively high in these samples compared to other lakes sampled. Cell counts were highest in July, although they remained fairly consistent from June through September.

McWain Pond had the highest average percentage of Cyanobacteria based on cell counts, but not based on natural units (although the percentage by natural units was also high at 16%). This means that many of the colonies of cyanobacteria had large numbers of cells. Cyanobacteria that contributed to the high cell count include *Aphanocapsa*, *Aphanothece*, *Chroococcus* (pictured), *Coelophaerium*, *Merismopedia*, and *Rhabdoderma*, none of which cause harmful blooms. There were few nuisance or problem cyanobacteria noted in samples beyond a small amount of *Dolichospermum*, although McWain Pond does have elevated levels of *Gloeotrichia* in most years.



The cyanobacteria *Chroococcus*.

Flagellated algae (one-celled algae with flagella, or “tails”) were common in each sample, especially the cryptomonad *Rhodomonas* (all cryptomonads are flagellates). Small flagellated algae also make up much of the “unknown/other” category in the pie charts below, which means, when assessing by natural units, that flagellates made up a majority of the algae assemblage in the lake. Flagellates are good quality food and constitute a solid basis for the lake food web that supports fish and other wildlife.

