Milton

Volunteer Lake Monitoring Program

Introduction

The City of Milton's volunteer lake monitoring program began in 2011 with the goal of collecting data to establish long-term trends in lake water quality, provide the citizens and the City with a better understanding of lake processes, and provide information on Surprise Lake that will be helpful in making appropriate management decisions. While conditions may vary from year to year, long-term data collection is the key to tracking trends in water quality over time. This report contains a summary of the data collected during the 2015 lake monitoring season (May – October/November).

Sampling Program

Water chemistry and physical characteristics of lakes vary both seasonally and with depth. The "growing season" for lakes occurs from early spring through the fall. Lake volunteers collect physical data (water transparency, water color, weather conditions), made measurements of temperature and dissolved oxygen, and collected water samples for chemical analysis (total phosphorus, chlorophyll *a*) on a monthly basis beginning in early May and ending in late October or early November.

Measurements of temperature and dissolved oxygen were made throughout the water column at the deepest point in the lake. The samples for total phosphorus analysis were collected one meter below the surface of the lake and one meter above the lake bottom. Samples for chlorophyll *a* were collected from the upper, lighted part of the lake, where algae are most typically found. Additional shallow samples were collected three times during the monitoring season to determine the number and type of algae present. The City of Milton staff also collected water samples for bacterial analysis at two sites around the lake once during the monitoring season.

All analyses for levels of nutrients, chlorophyll *a*, and bacteria, and for the identification and enumeration of algae, were performed by Water Management Labs of Tacoma, Washington.

Field data collected in 2015 is included in the packet and can be found in Table 1.

Dissolved Oxygen and Water Temperature Profiles

With the onset of warmer weather in spring and early summer, deep lakes will begin to separate into a warmer, low-density layer at the surface, known as the epilimnion, and a cooler, high-density layer at the bottom, known as the hypolimnion. Between the epilimnion and the hypolimnion is a layer of rapidly changing temperature called the metalimnion, or thermocline. Thus begins the process of thermal stratification. Once this condition is fully developed, in summer, there is no vertical mixing of the upper and lower layers because of their density differences.

The vertical profiles of dissolved oxygen and temperature are similar during stratification; warmer water with abundant oxygen near the surface, and cooler water with declining or no oxygen at depth. A well-oxygenated epilimnion is usually the result of the diffusion of oxygen from the atmosphere and the presence of algae that generate oxygen as a byproduct of photosynthesis. A hypolimnion with reduced or no oxygen is the result of the decomposition of organic matter that settles into that layer. These conditions occur despite the general rule that, all other factors being equal, cold water can hold more dissolved oxygen than warm water.

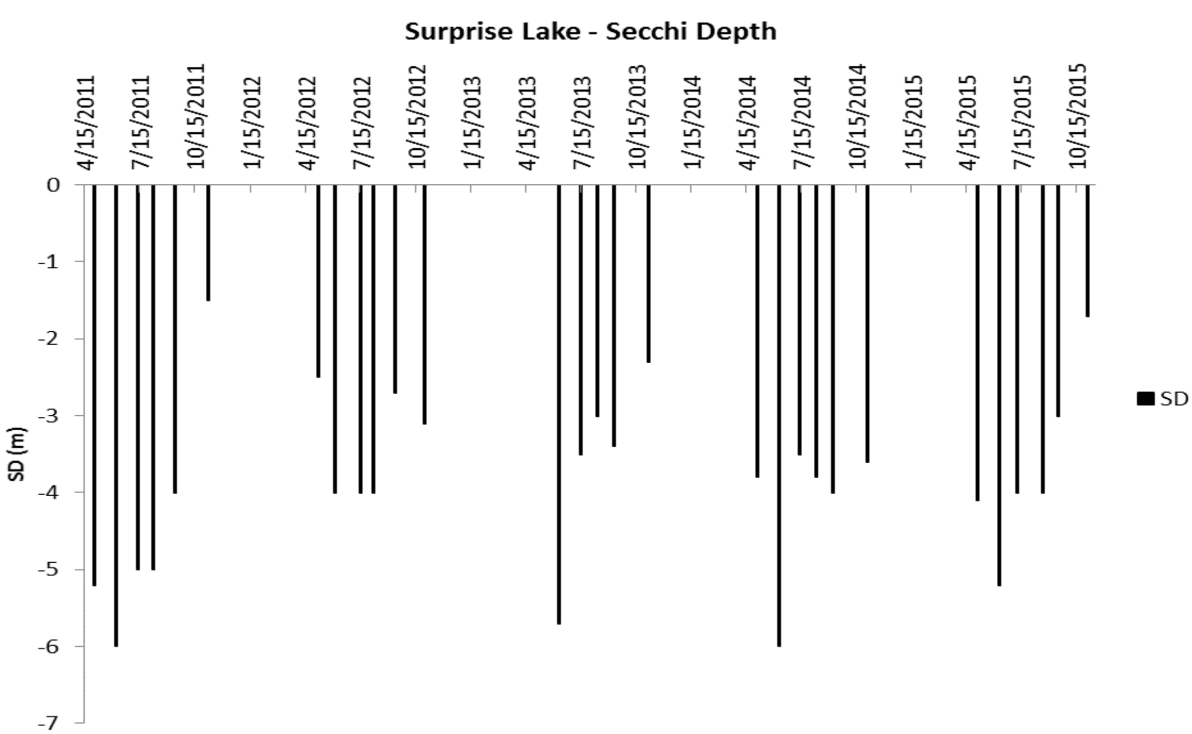
With the onset of cooler weather in the fall, the thermal stratification begins to break down and the shallow and deep layers of water begin to mix vertically once again. This phenomenon is usually called turnover.

This year the temperature and dissolved-oxygen profiles (Figure 1) show that stratification of the lake was well underway in early May, as in previous years. Turnover was complete by early November with the temperature profile uniform top to bottom. The profile graphs for all years of observation are included in Figure 1.

Transparency

Water transparency is measured using a secchi disk and is traditionally reported as secchi depth in meters (1 meter = 3.3 feet). It is influenced by several factors such as dissolved substances, algae, and sediment particles. Transparency readings can also be affected by waves, wind, and glare. Higher secchi depth readings indicate clearer water (more transparent) while lower secchi depth readings indicate more turbid water. Clear water allows more light to penetrate deeper in the lake, allowing photosynthesis in aquatic plants and algae to occur; this leads to higher levels of dissolved oxygen. Conversely, a decrease in transparency is often seen with an increase in algae, or an influx of sediment and detritus due to a major storm event or because of human activities in the watershed. Nonetheless, secchi depth is commonly used as an indicator of algal abundance.

Secchi depth measurements ranged from 1.7 to 5.2 meters during the 2015 monitoring season with an average secchi depth of 3.7 meters. Graphs showing the results for secchi depth for all other years of data collection are shown below. June seems to have either the highest or one of the highest secchi depths (greatest clarity) each year.



Nutrients

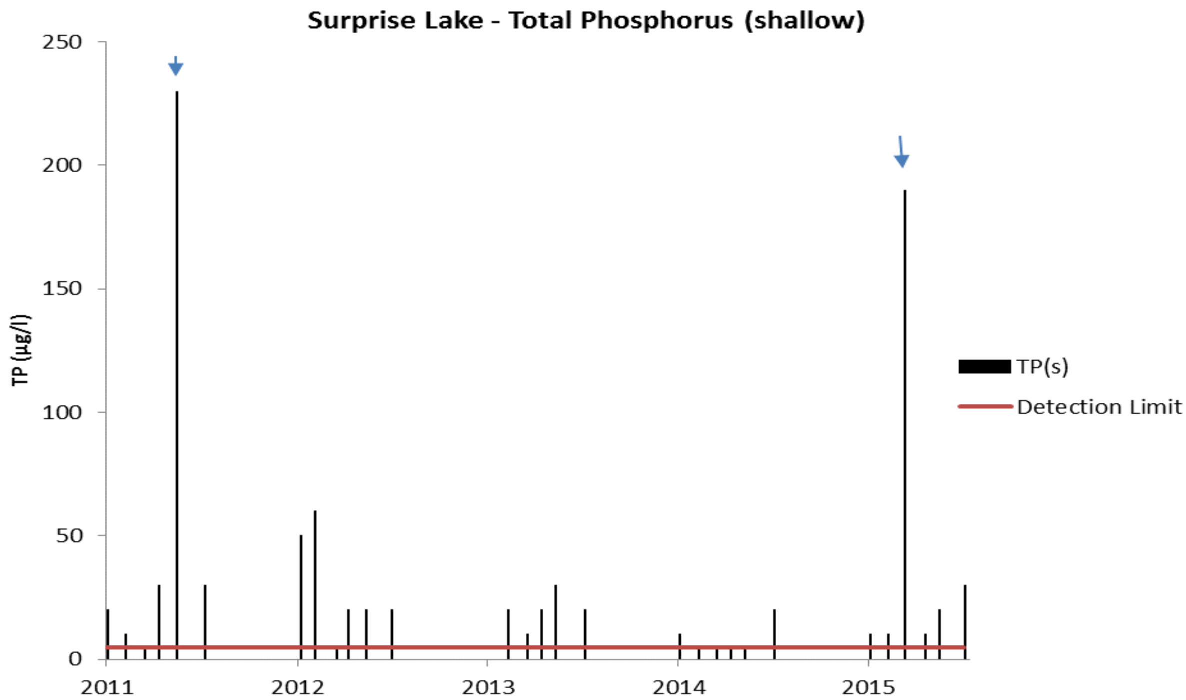
Nutrients are chemicals necessary for growth of algae and aquatic plants. Phosphorus and nitrogen are the main nutrients of concern in a lake system. In many lakes, phosphorus is the limiting nutrient in the system, which means it is only available to plants and algae in very limited quantities. Once the limited supply of phosphorus is exhausted, the algae population will stop expanding.

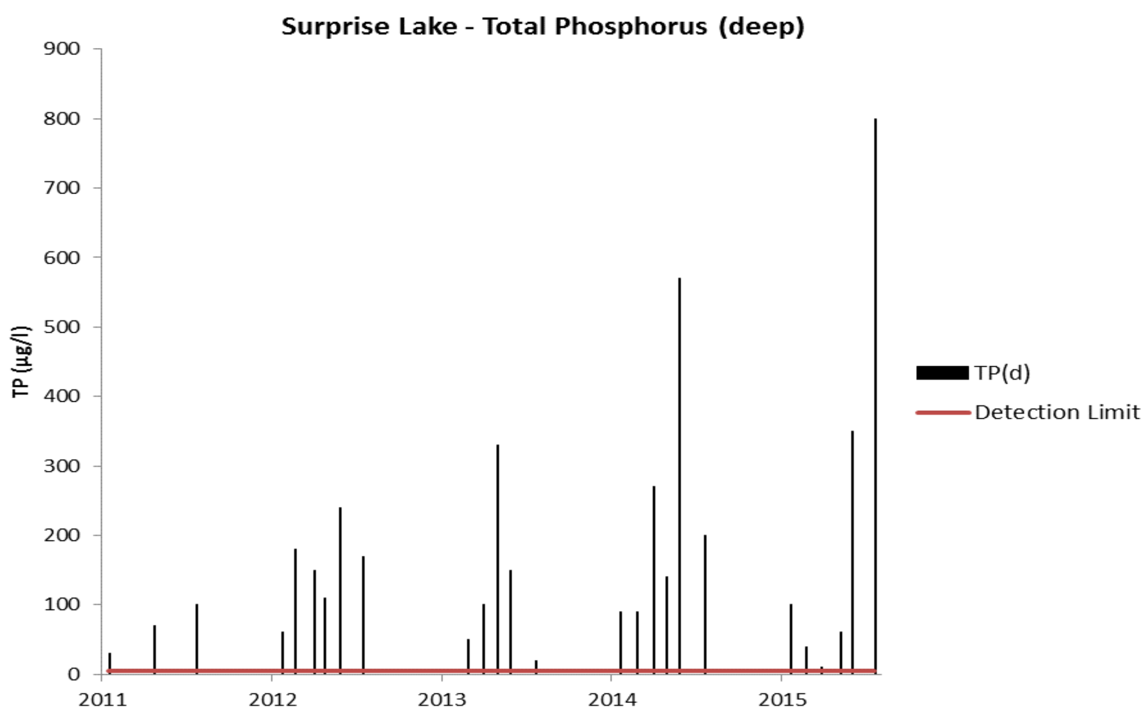
In lakes that are deep enough to stratify, typically in summer, total phosphorus concentrations in the hypolimnion increase and remain higher than in the epilimnion until the time of turnover, typically in the fall. This increase in phosphorus in the hypolimnion is caused in large part by the decomposition of phosphorus-rich organic matter at depth, a process that also consumes any oxygen present. Once oxygen is depleted or very low, phosphorus is also released from the bottom sediments. When vertical mixing eventually occurs in the lake, the high phosphorus load in the hypolimnion is brought to the epilimnion. With this influx of phosphorus, algae populations in that layer can increase to the point of producing an algal bloom in the fall.

Total phosphorus concentrations for Surprise Lake in 2015 ranged from 10 µg/l to 30 µg/l in the shallow samples, and from 40 µg/l to 800 µg/l in the deep samples. In general, nutrient conditions were similar to those observed in previous years.

There is some question, however, as to whether the shallow and deep total-phosphorus samples collected on July 8 were accidentally switched (mislabeled) in the field at the time of sampling, or in the laboratory at the time of analysis. For reasons described previously, it is unusual for concentrations of total phosphorus in summer tend to be higher in the epilimnion than in the hypolimnion. In addition, the same question of mislabeling applies to the September 11, 2011, sampling results.

Graphs showing both shallow and deep total phosphorus levels for all years are shown below. These graphs were drawn using the original data provided by the laboratory; that is, the possible switching of samples (blue arrows) was ignored.



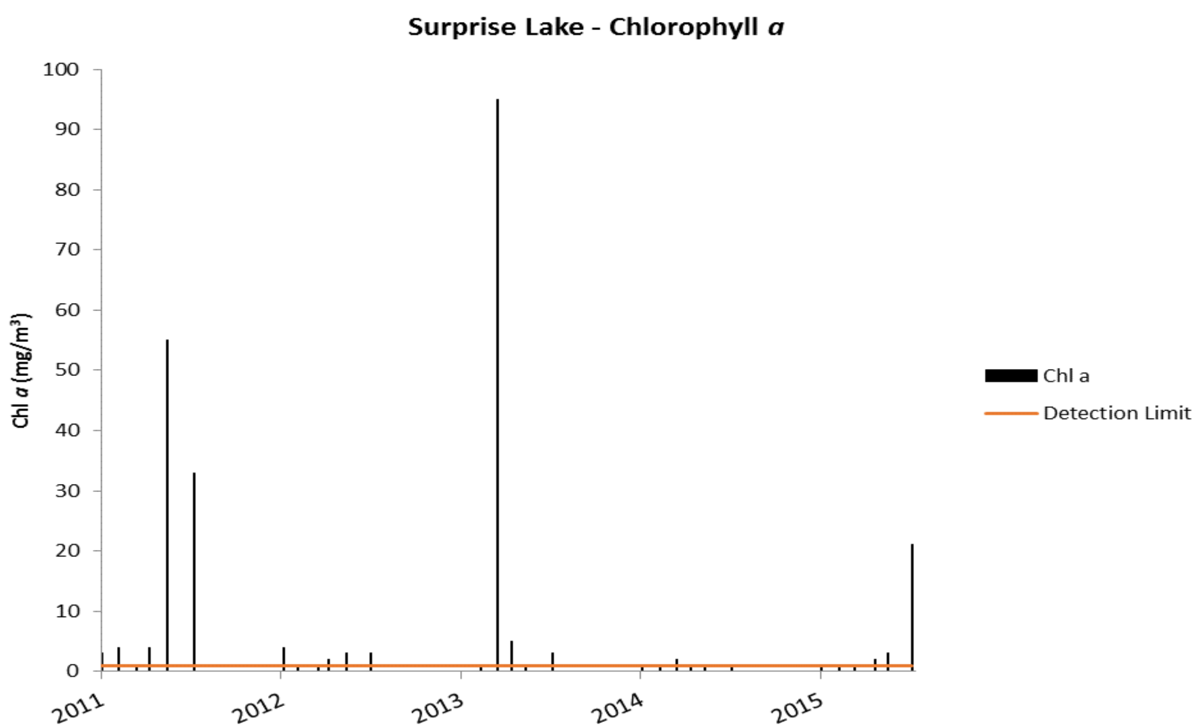


Close inspection of the graph for total phosphorous in the hypolimnion (above) shows what might be construed as an upward trend over the years. If this were the case a corresponding upward trend in chlorophyll *a* and trophic status (TSI) might be expected. Such trends are not evident, however, possibly because trophic state is determined largely by summer nutrient conditions in the epilimnion, not the hypolimnion.

Chlorophyll *a*

Chlorophyll *a* is one of the green pigments found in nearly all algae. The concentration of chlorophyll *a* is commonly used to estimate algal biomass and to assess the productivity (trophic state) of the lake. Test results must be interpreted carefully, however, because chlorophyll *a* levels can be fairly variable. For example, various species of algae contain differing amounts of chlorophyll per cell. The amount of chlorophyll can also vary with the health and age of the algal population, as well as with weather conditions. Additionally, algae can concentrate at different levels in the water column and thereby escape collection.

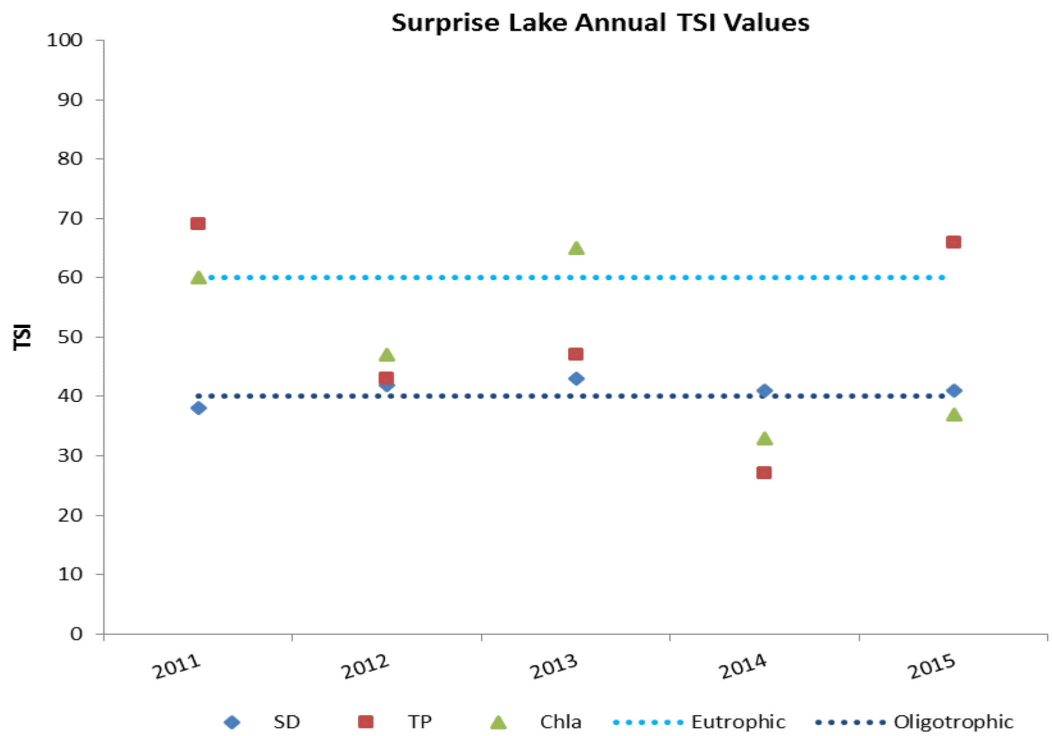
Chlorophyll *a* levels at the one-meter depth in 2015 ranged from below detection to 21 mg/m^3. Levels for all five years are shown in the graph below.



Trophic State Index

The Trophic State Index (TSI) is a rating system that describes biological productivity - the capacity of a lake to produce and support aquatic life including algae, plants, and animals. The index is a scale that ranges from 1 to 100 with low TSI values indicating low biological productivity and high TSI values indicating high biological productivity. Lakes have traditionally been classified into four different groups based on their level of productivity. The groups from the lowest to highest productivity level are oligotrophic, mesotrophic, eutrophic, and hypereutrophic. Generally, lakes with TSI values between 0 and 40 are considered to be oligotrophic, those between 40 and 60 are mesotrophic, and those between 60 and 100 are eutrophic. Hypereutrophic lakes are those whose TSI values are greater than 70. Once the TSI value has been calculated for a lake, the result can be compared to other lakes or the value can be recalculated each year to determine whether there is an upward or downward trend for the lake.

For purposes of this report, TSI values were calculated using average summer values (mid-June through mid- September) of chlorophyll *a*, shallow total phosphorus, and secchi depth. It is important to remember that one dramatically different result in a small number of samples can significantly impact the TSI value. The suspiciously high total phosphorus result for July negatively impacts the TSI for 2015 if it is indeed the correct value. If the total phosphorus result for July is actually 10µg/l, as opposed to 190 µg/l, the TSI value based on total phosphorus would shift from 66 to 42, thereby changing its trophic classification from eutrophic to mesotrophic. The TSI average values for the last four years are shown below. TSI for secchi depth has been fairly consistent, hovering around 40 for all years of sampling. The 2015 TSI value for chlorophyll *a* is similar to that of 2014, while the total phosphorus TSI value is higher, regardless of the possible switching/mislabeling of samples.



Surprise			
	TSI (SD)	TSI (TP)	TSI (Chl-a)
2011	38	69	60
2012	42	43	47
2013	43	47	65
2014	41	27	33
2015	41	66 (42)	37

Algae

Algae are a vital part of a lake's ecosystem; they provide food and oxygen necessary for most aquatic life. However, when algae concentrations become excessive, a condition usually called a bloom results and can lead to fish kills, unpleasant odors, and even health problems if the algae involved contain toxins.

The algae observed in Surprise Lake over the years are a diverse group of organisms and come from all the major groups of algae that have been identified by scientists, including green, cyanobacteria (blue green), diatoms, and flagellates.

Green algae can occur year round in lakes, but prefer the warm water temperatures and high light levels of summer. There were no green algae identified in the samples this year (see below).

Cyanobacteria (formerly referred to as blue green algae) are actually bacteria that contain chlorophyll. They are able to grow quickly in phosphorus rich waters, and can be the source of toxic blooms. Generally they grow well in warm water with high levels of light, and although considered to be summer algae, some species can have significant blooms in the spring and fall. Some members of this group are able to absorb nitrogen from sources, such as the atmosphere, not available to other algae; this allows them to dominate in nitrogen limited lakes. The types of cyanobacteria identified in Surprise Lake this season were *Aphanizomenon* and *Microcystis*. The numbers of cyanobacteria identified in 2015 were larger than those observed in previous years.

Diatoms are most commonly found during winter, spring and early summer as they grow well in cool temperatures and low light. Diatoms have hard siliceous coverings for their cells, and their growth can be limited by the amount of silica present in the water. The type of diatom present in Surprise Lake this year is *Asterionella*.

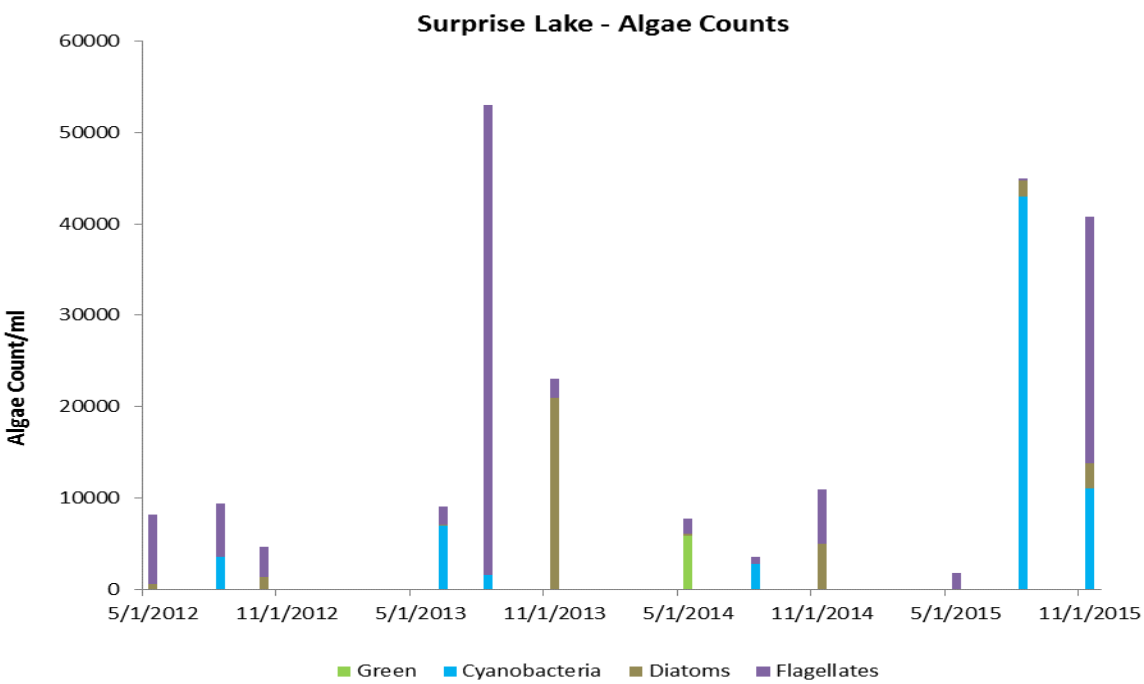
The flagellates have flagella (as their name suggests) which they use to propel themselves. They share both animal- and plant-like characteristics, and are generally considered to be a summer algae. Four types of flagellates were identified in 2015 including *Euglena*, *Dinobryon, Gonium*, and *Chrysococcus*.

Changing conditions in lakes allow different groups of algae to become dominant as the seasons progress. However, a lake typically has a characteristic set of algal populations that do well in its waters year after year. Although the relationship between algae and other components of the lake ecosystem are too complex to make major conclusions based on the limited sampling results to date, the presence of certain indicator species of algae can be indicative of certain conditions within that lake. The composition of a lake's algal populations, however, is simply another tool that provides information on the status of a lake.

Surprise Lake Algae Data

Date	5/6/2012	8/5/2012	10/28/2012	6/9/2013	8/11/2013	11/3/2013	5/4/2014	8/8/2014	11/1/2014
Algae count/ml	8200	9400	4600	9100	53000	23000	7700	3500	10900
Green	0	0	0	0	0	0	5900	0	0
Cyanobacteria	0	3572	0	6916	1590	0	0	2800	0
Diatoms	574	0	1380	182	0	20930	200	0	5000
Flagellates	7626	5828	3220	2002	51410	2070	1600	700	5900

Date	5/3/2015	8/18/2015	11/1/2015
Algae count/ml	1800	45000	40800
Green	0	0	0
Cyanobacteria	0	43000	11000
Diatoms	0	1800	2800
Flagellates	1800	200	27000



Fecal Coliform Bacteria

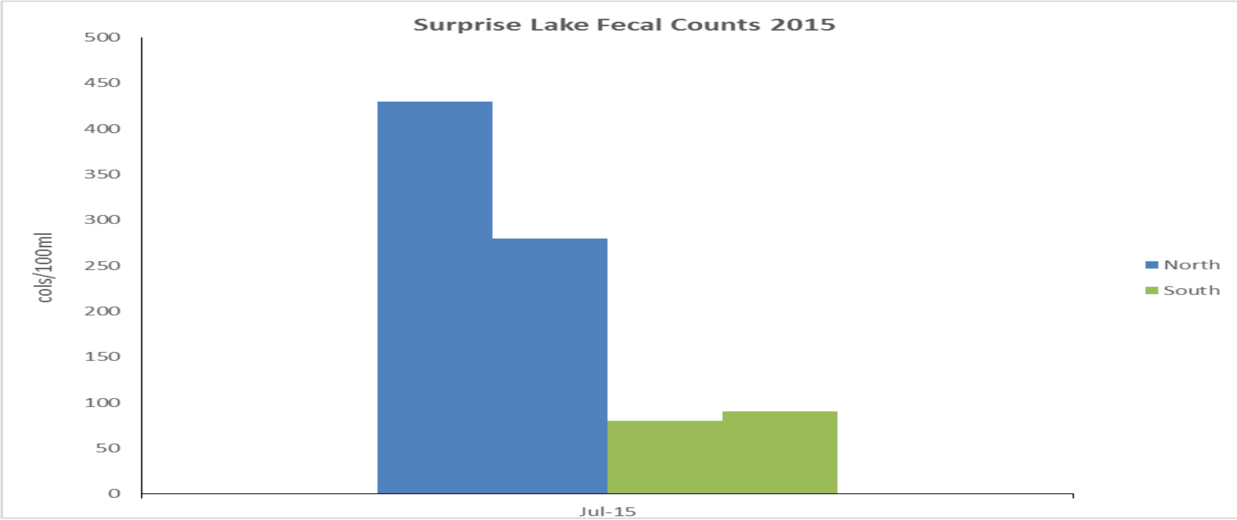
The presence of fecal coliform bacteria in water is an indication of contamination from sewage, and poses a potential human health risk. Their presence, however, does not necessarily indicate that humans are the source of that contamination. Many other animals such as dogs, cats, waterfowl, or livestock are common sources of fecal contamination in lakes. Unless there is evidence that human sewage is being discharged into a lake, through failing septic systems or a sanitary sewer overflow, for instance, the major source of fecal coliform bacteria is typically assumed to be of nonhuman origin.

The state of Washington has set a two-part standard for levels of fecal coliform bacteria in lakes. The regulation states that fecal coliform levels must not exceed a geometric mean value of 50 colonies/100mls, with not more than 10% of the samples exceeding 100 colonies/100mls.

The aerial photograph below shows the sampling locations around Surprise Lake for 2015 and previous years. Fecal coliform sampling was conducted at the north (blue dot) and south (green dot) ends of the lake in July. The dock at Surprise Lake Village (SLV--red dot) was still undergoing repairs at that time so there was no access to sample there this year.

The results of sampling for bacteria in 2015 are shown below. Fecal coliform concentrations exceeded state standards in July at the site (blue) located at the north end of the lake. The table below shows the exceedances in yellow. High bacterial counts can often be attributed to the presence of waterfowl, and in previous years the City staff did indeed note the presence of large numbers of waterfowl while sampling at the north end of the lake, but not at the south end. There were no accompanying notes regarding waterfowl numbers from sampling in 2015.

Encouraging those shoreline residents with septic systems to keep them in proper working order would reduce the seepage of nutrients and bacteria into the lake. Discouraging access to shoreline lawns and docks by waterfowl by planting vegetation would have the same effect. Shoreline vegetation has the added benefit of filtering storm water runoff, another source of bacterial contamination, before it enters the lake.



Date	North	North-2	SLV	SLV-2	South	South-2	Mean
Jul-15	430	280			80	90	220
						Geometric mean	**172**

Summary

Data collected on Surprise Lake in 2015 by volunteers and municipal employees are summarized as follows:

- Thermal stratification in Surprise Lake was well underway by early May and turnover was complete by early November;
- Transparency, as measured by secchi disc, averaged 3.7 meters (about 12 feet);
- Levels of total phosphorus, chlorophyll *a*, and algae were similar to those observed in previous years;
- A switch or mislabeling of samples for phosphorus analysis may have occurred in July;
- An apparent long-term upward trend in total phosphorus at depth did not translate into a similar trend for trophic state;
- Data for all years of sampling show Surprise Lake can be classified as mesotrophic;
- The dominant forms of algae observed in 2015 were cyanobacteria and flagellates;
- Levels of fecal coliform bacteria exceeded State standards in July at the north end of the lake.