Milton

Volunteer Lake Monitoring Program

Introduction

The City of Milton initiated a volunteer lake monitoring program in 2011 with the goals of promoting lake stewardship through citizen participation in the monitoring program, and to provide water quality data to assist in tracking and better understanding of conditions of Surprise Lake and make 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. Volunteer monitoring this year began a month late due to COVID restrictions. This report summarizes the data collected during the 2020 lake monitoring season (June – October).

Lake Description

Surprise Lake, a 32-acre lake with a maximum depth of 40 feet, is in the Puyallup River watershed within the city limits of Milton. The lake has a drainage area of approximately 0.7 miles^2, and its estimated elevation is 315 feet (MSL). Surprise Lake drains into Surprise Lake Creek which flows in a southwesterly direction to Hylebos Creek. There are no inflowing creeks to the lake.

Monitoring Program

Water chemistry and physical characteristics of lakes vary both seasonally and with depth. Lake volunteers collected physical data (water transparency, weather conditions, other observations), completed measurements of temperature and dissolved oxygen profiles, and collected water samples for chemical analysis (total phosphorus, chlorophyll *a*) on a monthly basis beginning in June and ending in late October.

While lake levels on Surprise Lake are not regularly tracked, depth at the monitoring site is measured each time the lake is monitored. It has been noted that the depth of the monitoring site has decreased over the last several years. A depth meter was added to the equipment to assist in confirming the location of the deepest spot.

Measurements of temperature and dissolved oxygen were made throughout the water column at the deepest point in the lake. The “shallow” samples for total phosphorus analysis were collected one meter below the surface of the lake; the “deep” samples were collected one meter above the lake bottom. Samples for chlorophyll *a* were collected only from the upper, lighted part of the lake, where algae are most typically found. Field data and samples were collected in 2020 by Dan Hull and Linda Pomeroy-Hull; field data and lab results can be found in Table 1. City staff collected samples for bacterial analysis at three sites around the lake three times during the monitoring season; these results can be found in Table 3.

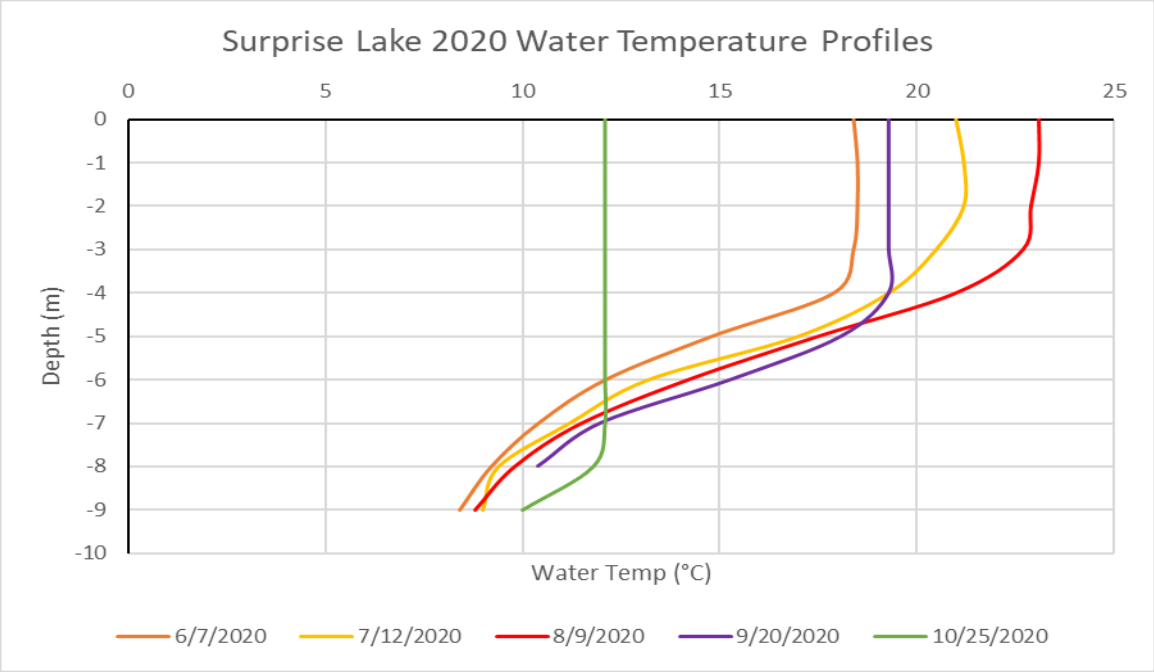
Dissolved Oxygen and Water Temperature Profiles

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. This process is called thermal stratification. Once this condition is fully developed, in summer, there is very little vertical mixing of the upper and lower layers because of their density differences.

The vertical profiles of temperature and dissolved oxygen are similar during stratification (see figure 1); 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 show that stratification of the lake was well underway in early June (orange line). Turnover was almost complete by late October (green line) with the temperature profile nearly uniform from top to bottom.



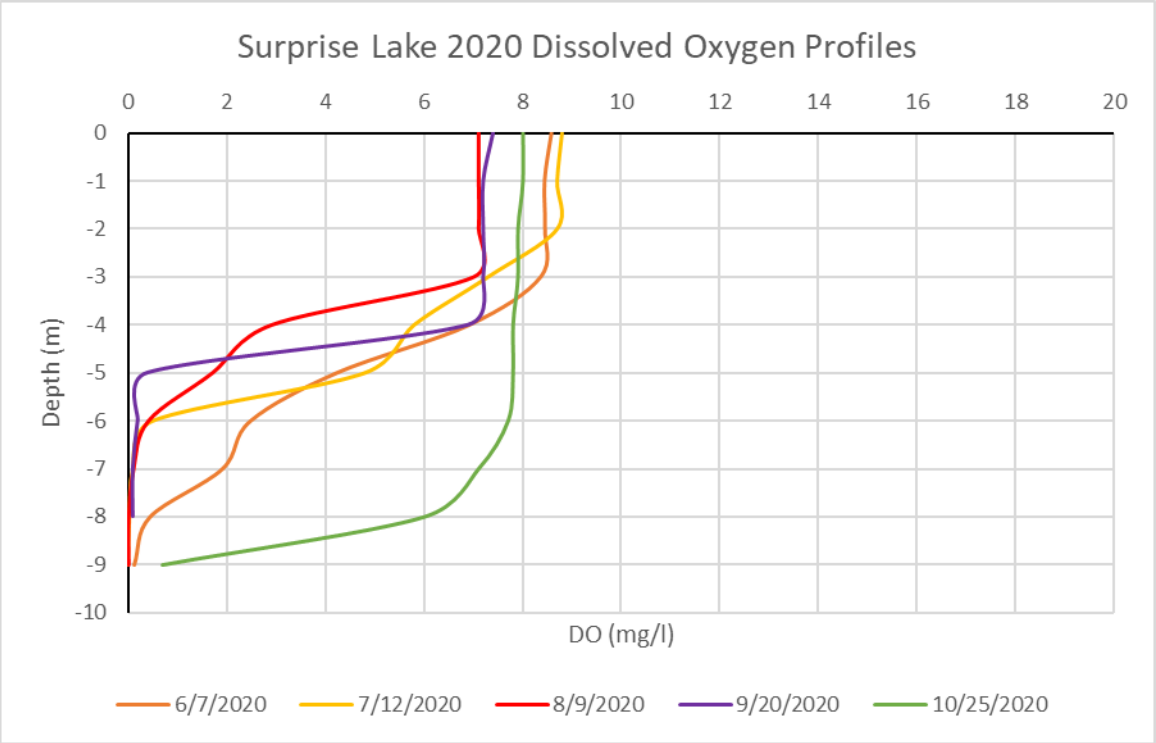


Figure 1.

Transparency

Water clarity is measured using a black-and-white secchi disk and is a measure of how deep one can see into the lake. This measurement is reported as secchi depth. Clarity is affected by the presence of algae, sediment particles, and by water color. Lakes with higher secchi depth readings (clearer water) usually have lower amounts of algae while lakes with lower secchi depth readings (cloudier water) usually have higher levels of algae present.

Secchi depth measurements observed in the 2020 monitoring season ranged from 2.7 to 4.5 meters, with highest transparency occurring early in the monitoring season (June) as in previous years. Secchi depths in 2020 were similar to the previous year (2019). The summer average of secchi depths for all years are shown below in Figure 2.

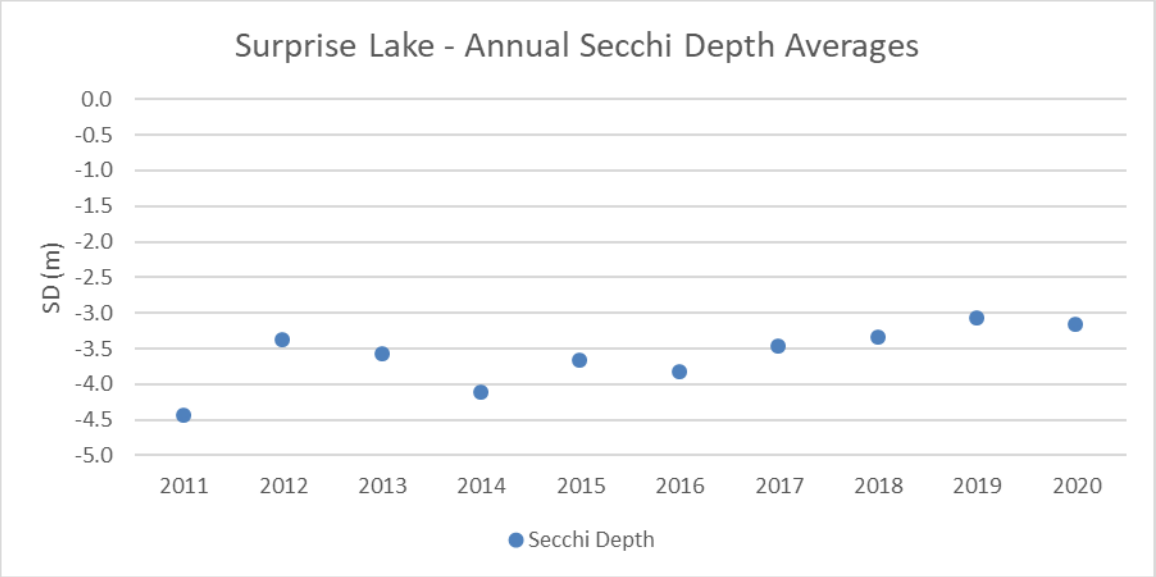


Figure 2.

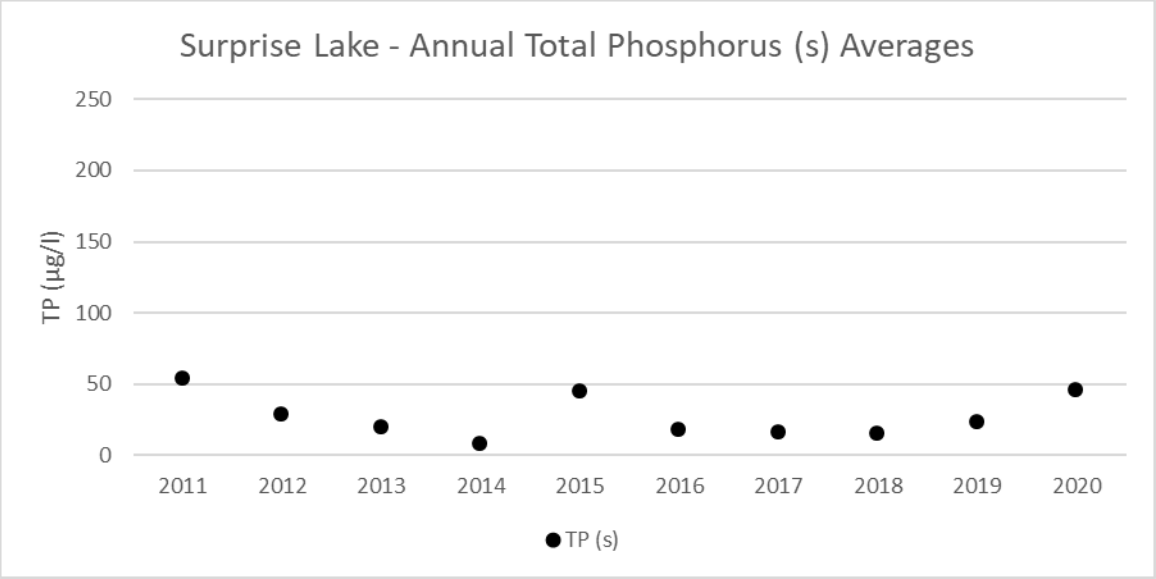
Nutrients

Nutrients are chemicals necessary for growth of fish, 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 algal 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, normally 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, and once oxygen is depleted or very low, phosphorus is released from the bottom sediments. When vertical mixing eventually occurs in the lake, usually in the fall, the high phosphorus load in the hypolimnion is brought to the epilimnion. With this influx of phosphorus, algal populations in that layer can increase to the point of producing an algal bloom.

Total phosphorus concentrations for Surprise Lake in 2020 ranged from 18 µg/l to 101 µg/l in the shallow samples, and from 52 µg/l to 372 µg/l in the deep samples. The nutrient conditions for shallow samples were higher than those observed in the last several years. The deep samples were also higher than the last several years. The average total phosphorus levels this year (2020) for both shallow and deep samples are similar to results reported in 2015.

The summer averages for total phosphorus in both shallow and deep total phosphorus concentrations are found in Figure 3 below.



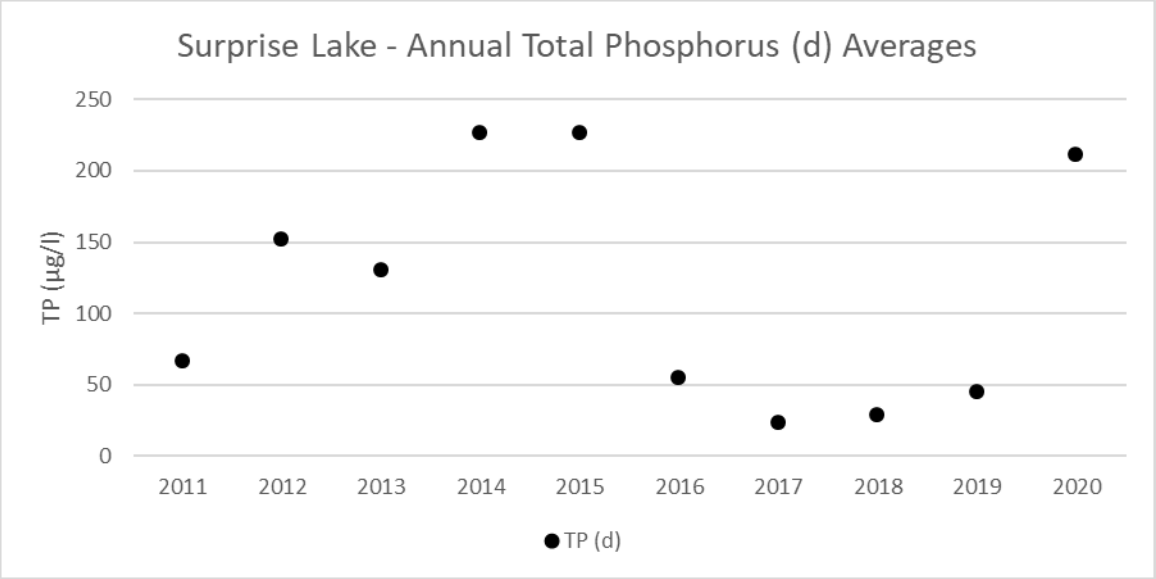


Figure 3.

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 measure the productivity (trophic state – how much life it supports) of the lake. Test results must be interpreted carefully, however, because chlorophyll *a* levels can be variable in time and space. In addition, 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. Also, algae typically concentrate at different levels in the water column in response to preferred light and temperature conditions, thereby escaping collection.

Chlorophyll *a* levels for shallow samples in 2020 varied from below detection levels to 6.9 mg/m^3 with the highest levels occurring in fall. Chlorophyll *a* results for 2020 were very similar to 2019 results. Summer averages for all years of data collection are shown below in Figure 4.

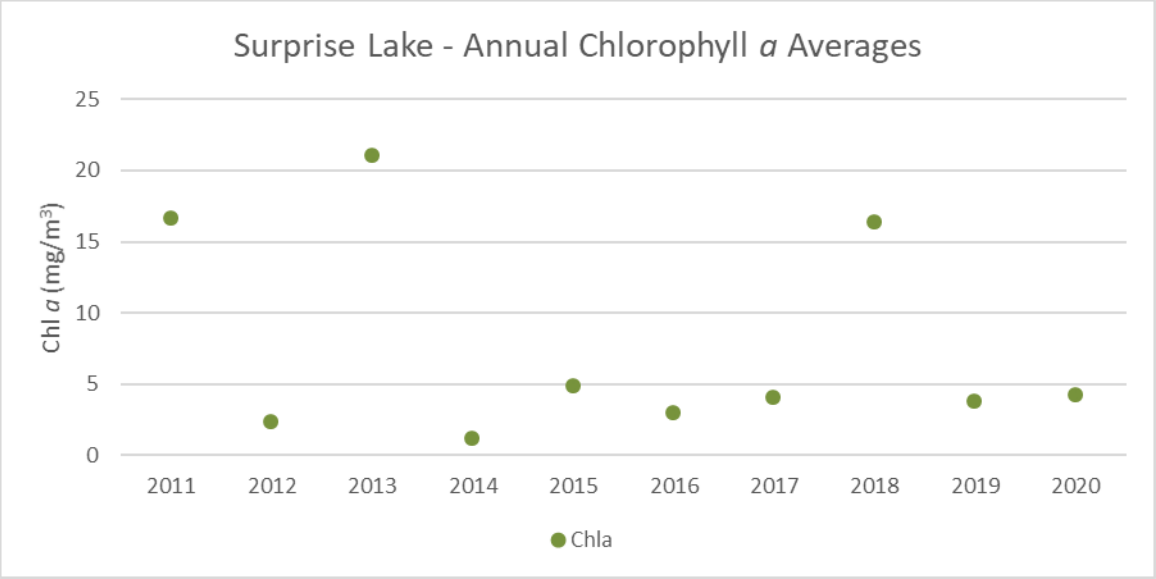


Figure 4.

Trophic State Index

All lakes go through a natural process of aging as a result of enrichment by nutrients and sediment from the surrounding watershed. This process is called eutrophication and as more nutrients and sediment flow into lakes there is increased growth of aquatic plants and algae. Lakes will gradually fill up with organic material over thousands of years.

Lakes can be classified by their degree of eutrophication, also referred to as the trophic state. Lakes are usually classified as being in one of three possible trophic states - oligotrophic, mesotrophic, or eutrophic. Oligotrophic lakes have very clear water, low levels of nutrients, and few aquatic plants and animals. Mesotrophic lakes have more nutrients and tend to support more aquatic plants, and algae, and have lower water clarity. Eutrophic lakes are quite biologically productive and support an abundance of aquatic plants and animals, tend to have frequent algae blooms, lower water clarity, and lower dissolved oxygen in bottom waters.

Trophic state of a lake does not necessarily indicate good or poor water quality because eutrophication is a natural process. However, the natural aging process is accelerated by human activities that add sediment and nutrients to a lake and can result in declining water quality. Stormwater runoff from agricultural areas, fertilized lawns, failing septic systems, logging, urban development, and construction areas all contribute to accelerated enrichment (aging) of our lakes.

The Trophic State Index (TSI), a rating system, is used to determine the trophic state of a lake. The index ranges from 1 to 100 (see Table 2) with low TSI values indicating low biological productivity (oligotrophic) and high TSI (eutrophic) values indicating high biological productivity. TSI values are calculated each year for Surprise Lake based on averaging three (July, August, September) results for secchi depth, total phosphorus, and chlorophyll *a.* Because there are only 3 results used in calculating the TSI, one very different (high or low) result can skew the averages.

Table 2. Comparison of Trophic State Index to Water Quality Parameters and Lake Productivity				
Trophic State	TSI	Secchi Disk (m)	Total Phosphorus (µg/l)	Chlorophyll *a* (µg/l)
Oligotrophic	0	64	0.75	0.04
	10	32	1.5	0.12
	20	16	3	0.34
	30	8	6	0.94
Mesotrophic	40	4	12	2.60
	50	2	24	6.40
Eutrophic	60	1	48	20
	70	0.5	96	56
	80	0.25	192	154
	90	0.12	38	427
	100	0.062	768	1,183
(NOTE: The original source of this table and the equations is Carlson, R.E., 1977. A Trophic State Index for Lakes. Limnology and Oceanography, 22:361-369.)				

The TSI average values for the all years are shown below in Figure 5. This year's results indicate that Surprise Lake remains a mesotrophic lake as in previous years. Mesotrophic lakes generally have moderate nutrient concentrations, moderate algae and aquatic plant growth, and water clear enough for swimming.

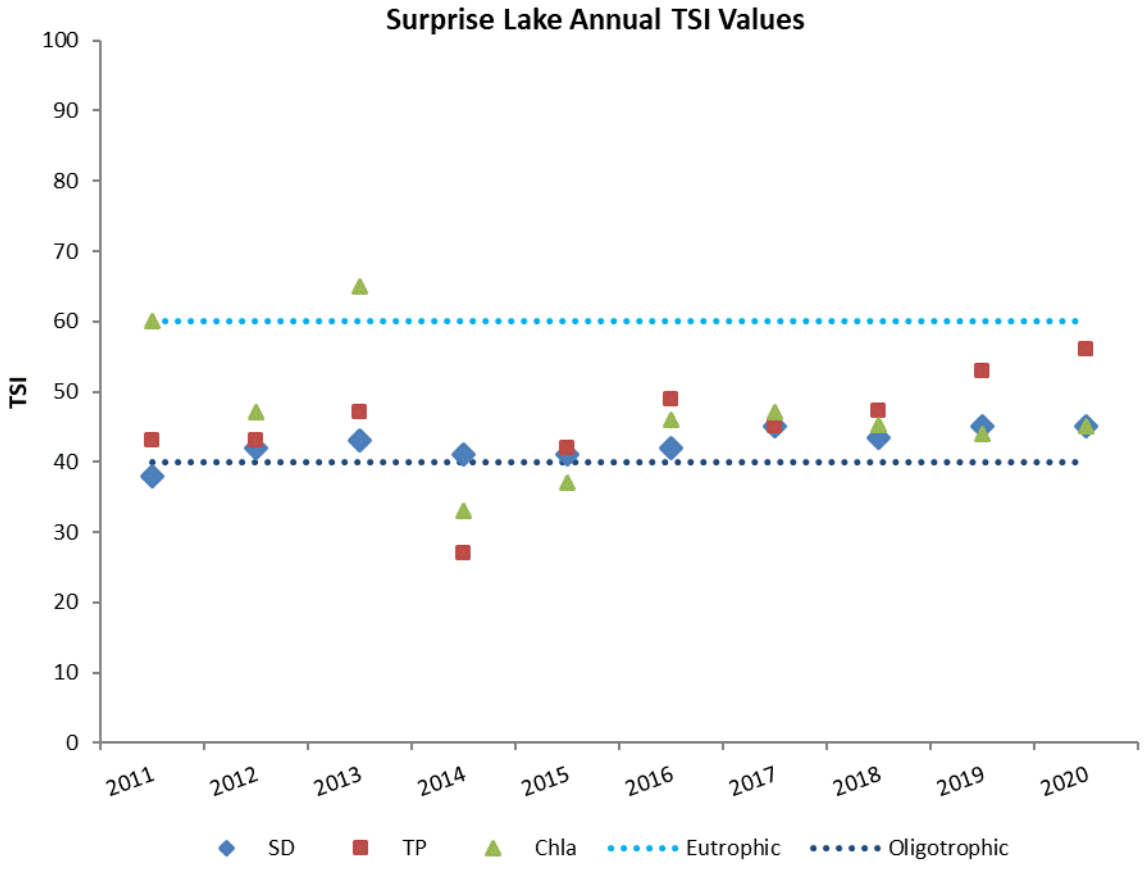


Figure 5.

Fecal Coliform Bacteria

Fecal coliform bacteria concentrations are indicators of contamination from sewage and pose a potential human health risk. Although high fecal coliform counts indicate sewage is present in the water, it does not necessarily indicate that humans are the source of that contamination. Many other animals such as dogs, cats, waterfowl, livestock, and other wildlife are common sources of fecal contamination in lakes. Unless there is evidence that human sewage is being discharged into a lake, either through failing septic systems or a sanitary sewer overflow, the major source of fecal coliform bacteria is typically assumed to be of nonhuman origin. Discouraging waterfowl use of adjacent lawns and docks by planting vegetation along the shoreline will minimize bacteria from waterfowl. Shoreline vegetation has the added benefit of filtering storm water runoff, another source of bacterial contamination, before it enters the lake.

The current Washington State standard for bacteria states "Fecal coliform organism levels within an averaging period must not exceed a geometric mean value of 100 CFU or MPN per 100 mL, with not more than 10 percent of all samples (or any single sample when less than ten sample points exist) obtained within an averaging period exceeding 200 CFU or MPN per 100 ml." **Starting Dec. 31, 2020**, the bacterial standard for fecal coliform will expire and E. coli will be the only applicable indicator for compliance with water contact recreational bacterial criteria in fresh water.

The aerial photograph (Figure 6) below shows the sampling locations (yellow markers) around Surprise Lake from this year. Fecal coliform sampling was conducted at three sites on Surprise Lake in July, August and September; however due to a sampling error results were obtained for only two sites in September. Table 3 below shows the results of bacterial sampling. The fecal coliform results met the water quality standard for all sampling sessions this year.

Figure 6.

Table 3. Fecal Counts (cfu/100mls)							
Date	SLW	SLW2	SLE	SLE2	SLS	SLS2	Daily Average
7/14/2020	28	17	23	22	3	8	18.6
8/14/2020	48	160	23	30	10	5	54.2
9/22/2020	82	100	120	170	*	*	118
*sampling error						**Geomean**	**49**

Summary

Volunteer data was collected on Surprise Lake in 2020 beginning in June and ending in late October. The monitoring season this year was shorter than previous years due to COVID restrictions. The data are summarized as follows:

- Temperature and dissolved oxygen stratification in Surprise Lake was well underway at the first sampling date in June, and turnover was almost complete by the last sampling date in late October. Both temperature and dissolved oxygen profiles are very similar to previous years.
- Secchi depth (water clarity) in Surprise Lake ranged from 2.7 to 4.5 meters with an average of 3.2 meters. Secchi depths in 2020 were similar to results in 2019 with the deepest secchi depth occurring early in the monitoring season.
- Concentrations of total phosphorus in shallow samples were higher than results in previous years; and total phosphorus concentrations in deep samples were much higher than previous years. Concentrations of chlorophyll *a* were similar to results in 2019.
- TSI calculations for 2020 classify Surprise Lake as a mesotrophic lake.
- Bacterial levels met the state standard for the 2020 season.

Lake conditions vary from year to year with the change in seasons, weather patterns, and climate conditions. Long-term lake monitoring helps us to understand how our lakes are doing and if they are degrading over time. Graphs displaying the data collected for Surprise Lake since the program began can be found in Appendix 1.

Recommendations

Lakes are a reflection of their watershed. They receive water, dissolved substances carried in water, and sediment from its watershed. Lakes also receive particulates and gases from the atmosphere; and energy from the sun and wind. The condition of a lake at any one time is determined by what is already in the lake, and by what is coming into the lake – attesting to the fact that lakes are complex ecosystems.

Lake management is a complicated job that takes the combined efforts of local government, community groups, individuals, and landowners. To be effective lake management is a long-term commitment and investment.

Many lakes suffer from too many nutrients (phosphorus and nitrogen), entering a lake with stormwater or soil erosion from the surrounding watershed. When it rains nutrients wash into ditches and down storm drains eventually ending up in the lake. This can lead to problems such as excessive aquatic plant growth, nuisance and/or toxic algae blooms, lower water clarity, stressed fish and wildlife, and lower property values.

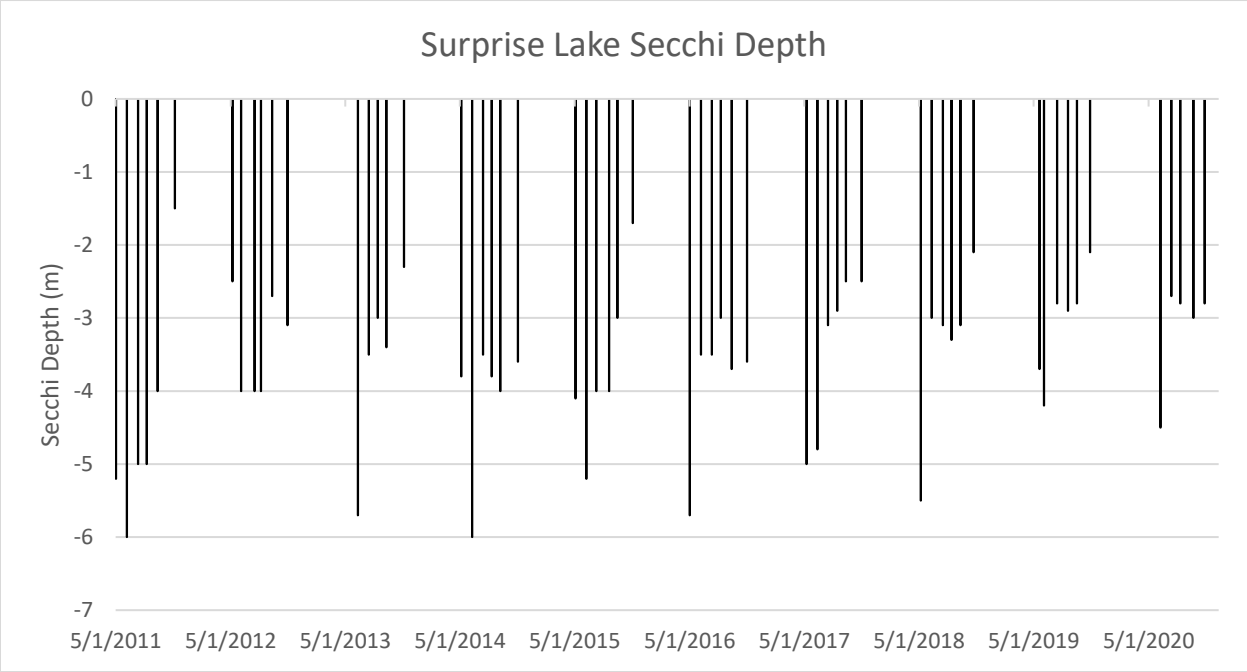
Here are some voluntary actions that can be taken to protect the health of the lake:

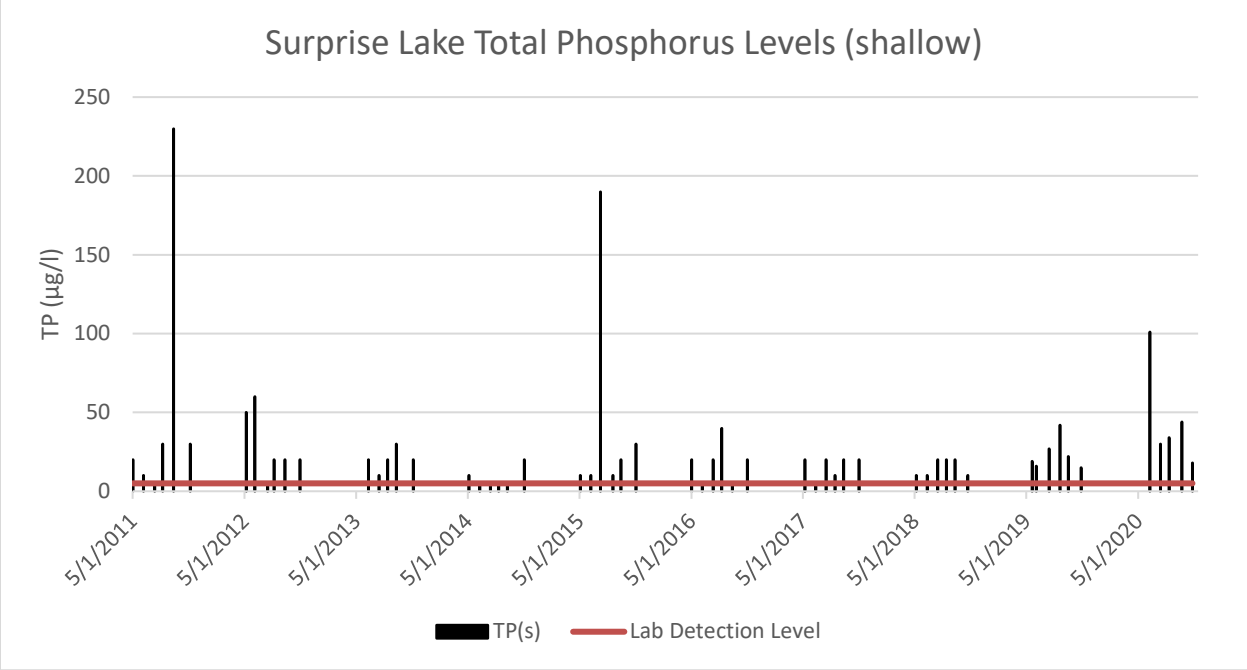
- Avoid fertilizer. If you do fertilize choose phosphorus-free products.
- Scoop pet waste, bag it and toss it in the trash.
- Divert runoff from roofs and driveways into stable vegetated areas.
- If you have a septic system, schedule routine inspections.
- Cover bare soil area with mulch or plants.
- Fix eroding areas in the yard, driveway, and parking areas.
- Don’t dump aquarium contents into the lake.
- Maintain existing natural shorelines – these areas provide additional wildlife benefits for birds, turtles, frogs and other aquatic life.
- Re-establish shoreline vegetation by replacing some lawn with other plants such as shrubs, trees, and perennials. The deeper roots of native trees and shrubs can trap and filter more phosphorus.
- Check boats and trailers for weeds and other invasive species.
- Be active in your lake homeowners’ association.

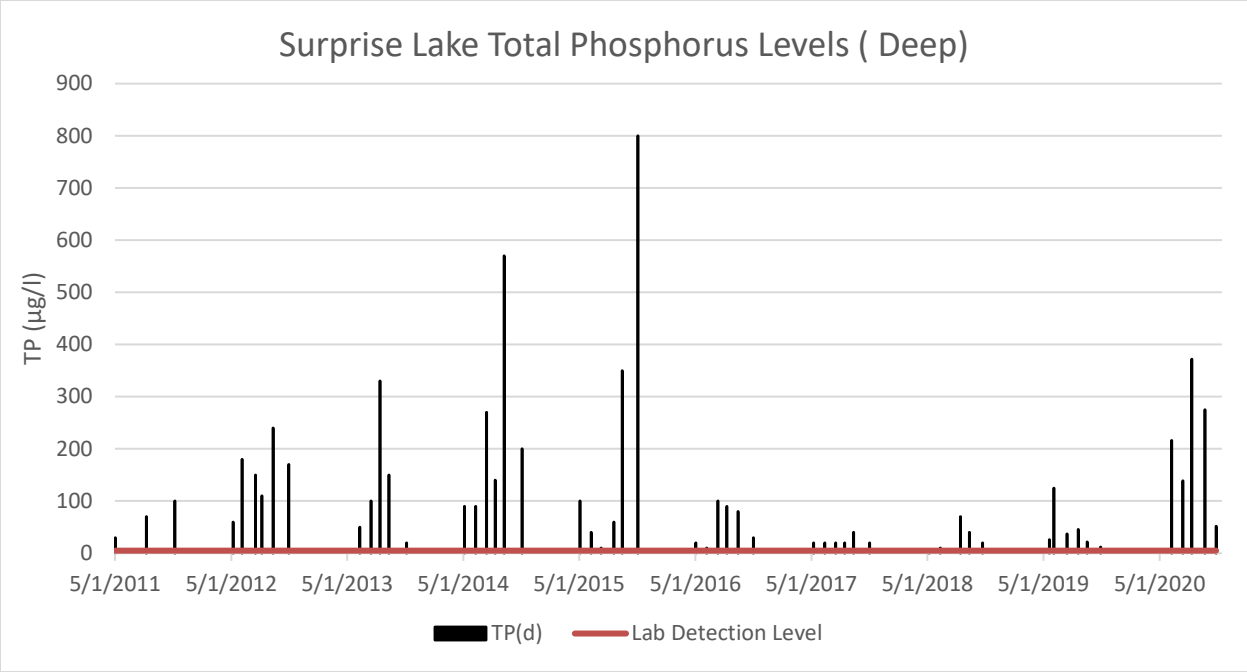
Table 1. Surprise Lake Summer 2020 Data

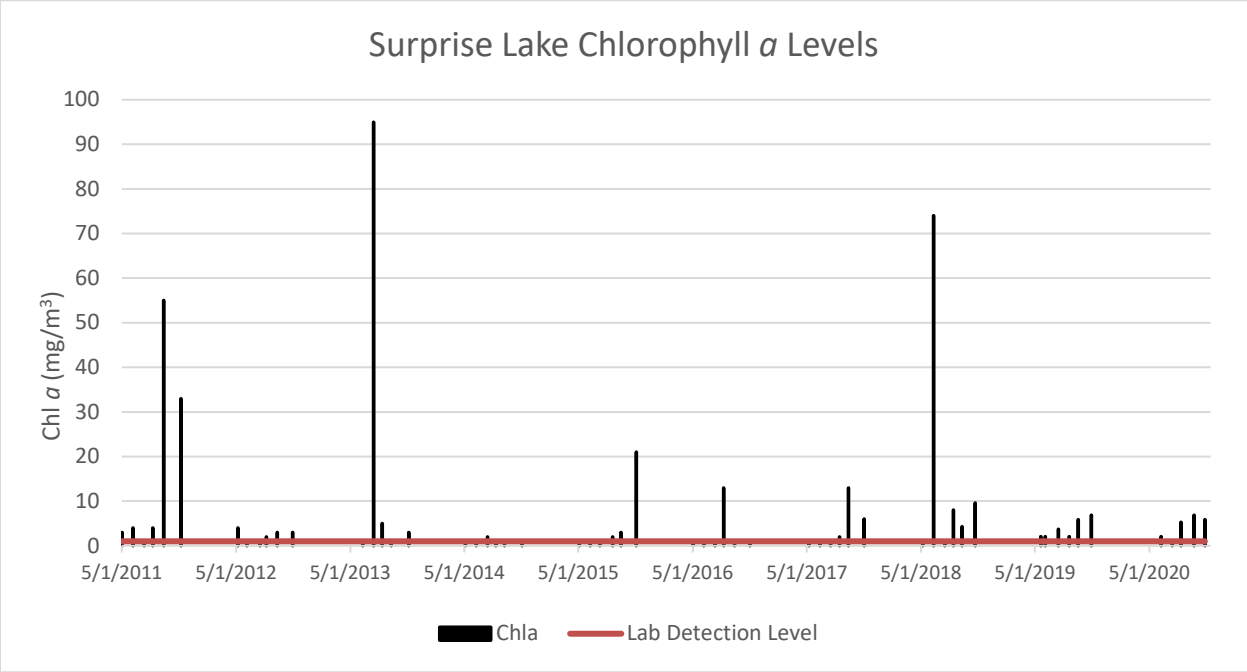
Date	Time	Site Depth (m)	Secchi Depth (m)	Air Temp (°C)	Water Temp (°C) Top	Dissolved Oxygen (mg/l) Top	Water Temp (°C) Bottom	Dissolved Oxygen (mg/l) Bottom	Suspended Algae	Chlorophyll *a* (mg/m^3)	Total Phosphorus (µg/l) shallow	Total Phosphorus (µg/l) deep	Comments
6/7/2020	1:00pm	10	4.5	28	18.4	8.6	8.4	0.1	None	2.1	101	216	Wind - light, SW; overcast; ripples; no odor. 25 waterfowl - geese and ducks; 2 boats, 5 people fishing, 4 swimmers/waders
7/12/2020	12:15PM	9.6	2.7	21	21	8.8	9	0	None	<2.0*	30	139	Wind - breezy, N; weather - partly cloudy; surface - small waves; hazy sunlight. No water odor. 30 geese, ducks. 4 boats, 3 people fishing, 10 swimmers/waders. ***Below detection levels**
8/9/2020	11:30am	10.4	2.8	25.5	23.1	7.1	8.8	0	none	5.3	34	372	Breezy; clear weather; water surface - ripples; strong sunlight, no water odor; about 75 geese and ducks, coots. 3 boats, 3 people fishing, 8 swimmers/waders.
9/20/2020	10:00am	9.5	3	19	19.3	7.4	10.4	0.1	None	6.9	44	275	Wind cond: calm, SW; current weather: overcast; water surface cond: calm; light conditions: overcast. No water odor. 75 geese and ducks. 3 boats, 3 people fishing, 5 swimmers/waders. **B samples**: TP = 52ug/l; Chla 6.9mg/m3
10/25/2020	11:00am	10	2.8	5.5	12.1	8	10	0.69	none	5.9	18	52	Wind cond: breezy, NE; current weather: clear; water surface cond: small waves; light conditions: strong sunlight: no odor. 50 waterfowl - geese, ducks. 2 boats, 1-person fishing, no swimmers/waders.

Appendix 1. Surprise Lake Data






Surprise Lake Total Phosphorus Levels (Deep)
TP (µg/l)
900
800
700
600
500
400
300
200
100
0
5/1/2011
5/1/2012
5/1/2013
5/1/2014
5/1/2015
5/1/2016
5/1/2017
5/1/2018
5/1/2019
5/1/2020
TP(d)
Lab Detection Level


Surprise Lake Chlorophyll a Levels
Chl a (mg/m3)
100
90
80
70
60
50
40
30
20
10
0
5/1/2011
5/1/2012
5/1/2013
5/1/2014
5/1/2015
5/1/2016
5/1/2017
5/1/2018
5/1/2019
5/1/2020
Chla
Lab Detection Level