LOST LAKE

REPORT DESCRIPTION

This report is an update on the health of Lost Lake based on water quality data collected from 1992 through 2016 by local volunteers and Snohomish County Surface Water Management (SWM) staff. For additional background on the information provided here or to find out more about Lost Lake, please visit www.lakes.surfacewater.info or call SWM at 425-388-3464.

LAKE DESCRIPTION

Lost Lake is a small, 13-acre lake located southeast of Maltby. The lake is fed mainly by groundwater and drains south to Ricci Creek and then east to the Snoqualmie River. Lost Lake is relatively deep for its size, with a maximum depth of 13.7 meters (45 feet) and an average depth of 7.0 meters (23 feet). The watershed, which is the land area that drains to the lake, is slowly shifting from rural to suburban residential densities. There is a large wetland downstream of the lake. In recent years, beaver activity in the wetland has dammed the outflow and raised the level of the lake. With Snohomish County SWM assistance, residents have worked to limit the effects of the beaver dams.

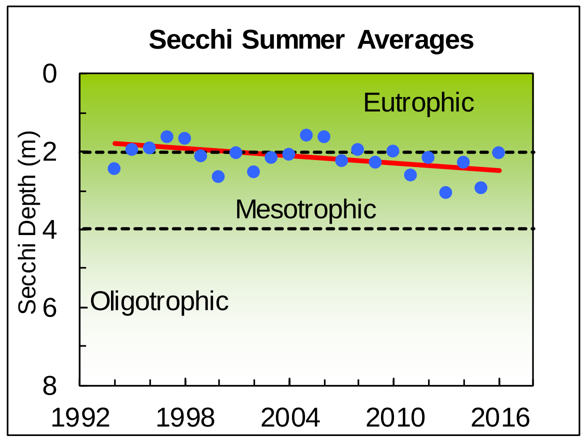
LAKE CONDITIONS

The following graphs illustrate the summer averages and trend lines (shown in red) for water clarity, total phosphorus, and chlorophyll *a* for Lost Lake. Please refer to the table at the end of the report for long-term averages and for averages and ranges for individual years.

Water Clarity

The water clarity of a lake, measured with a Secchi disk, is a reading of how far one can see into the water. Water clarity is affected by the amount of algae and sediment in the lake, as well as by water color. Lakes with high water clarity usually have low amounts of algae, while lakes with poor water clarity often have excessive amounts of algae.

Water clarity in Lost Lake is low to moderate, with a long-term 1992 – 2016 summer average of 2.1 meters (6.9 feet). There has been considerable variability in water clarity averages from year to year. In spite of the variability, between 1992 and 2016, there has been a statistically significant trend toward improving water clarity (p=0.02). The changes in water clarity may be in response to variations in algae growth (see chlorophyll *a* discussion below) and/or changes in natural water color.



Water Color

The color of lake water affects water clarity and the depths at which algae and plants can grow. In many lakes, the water is naturally brown, orange, or yellow. This darker color comes from dissolved humic compounds from surrounding wetlands and does not harm water quality. Measurements of true water color provide clues to changes in water clarity. True water color is only the color from dissolved materials and not of the color of algae or sediment suspended in the water.

The water color of Lost Lake averaged 54 pcu (platinum-cobalt color units) in 2010 – 2011, which indicates a moderate to high amount of color in the lake water. The color is somewhat darker than in 1994-1995 when the average was 42 pcu. The darkness of Lost Lake's water color is one reason that the lake has relatively low water clarity.

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Temperature

The temperature of lake water changes with the seasons and varies with depth. During spring and summer, the sun warms the upper waters. Because warmer water is less dense, it floats above the cooler, denser water below. The temperature and density differences create distinct layers of water in the lake, and these layers do not mix easily. This process is called stratification and occurs during the warm months. The warm, upper water layer is called the epilimnion. The colder, darker bottom zone is called the hypolimnion. These layers will stay separated until the fall when the upper waters cool, the temperature differences decrease, and the entire lake mixes, or turns over.

From May through October 2016 temperature measurements were taken at each meter throughout the Lost Lake water column (see graph). Temperature profiles for 2016 show that the lake was strongly thermally stratified during the summer. This means that there was a large temperature difference between the warm upper waters and the cool bottom waters, and mixing did not occur between these layers. Throughout the summer months, the upper waters gradually warmed up until the temperature reached about 75°F (24°C) in June. Meanwhile, the bottom water October, the upper waters began to cool, dropping to about 56°F (13°C).

Each fall the surface waters will continue to cool until the temperatures are almost equal from top to bottom. As stratification weakens, the lake water will turn over (or mix). The lake will stay mixed during the winter until springtime, when the upper waters begin to warm again.

Dissolved Oxygen

Oxygen dissolved in the water is essential for life in a lake. Most of the dissolved oxygen comes from the atmosphere. Like temperature, dissolved oxygen levels vary over time and with depth. During the warm months, the upper waters receive oxygen from the atmosphere, but the lower waters cannot be replenished with oxygen because of the separation between water layers. Meanwhile, bacteria in the lake bottom are consuming oxygen as they decompose organic matter. Eventually oxygen is depleted in the bottom waters. Low dissolved oxygen in the bottom waters can lead to a release of nutrients from the lake sediments.

Dissolved oxygen was also measured at every meter throughout the Lost Lake water column from May through October in 2016 (see graph). Oxygen levels were relatively high in the upper waters during this period. Meanwhile, the dissolved oxygen in the bottom waters gradually declined. There was virtually no dissolved oxygen in the lake below about 12 feet deep in late summer. During the summer period, oxygen in the lower waters is consumed by the decomposition of organic material within the lake. When the lake is stratified, the oxygen is not replenished by the overlying oxygen-rich upper waters or the atmosphere. Very low dissolved oxygen levels in the bottom waters can lead to a release of phosphorus from the lake sediments that can result in increased algae growth in late summer and fall or the next spring. The bottom of the lake will remain devoid of oxygen until the lake mixes (typically in late October/early November). The entire lake contains high dissolved oxygen levels during the winter. The lake remains mixed until springtime when the upper waters begin to warm and dissolved oxygen begins to decline in the bottom.

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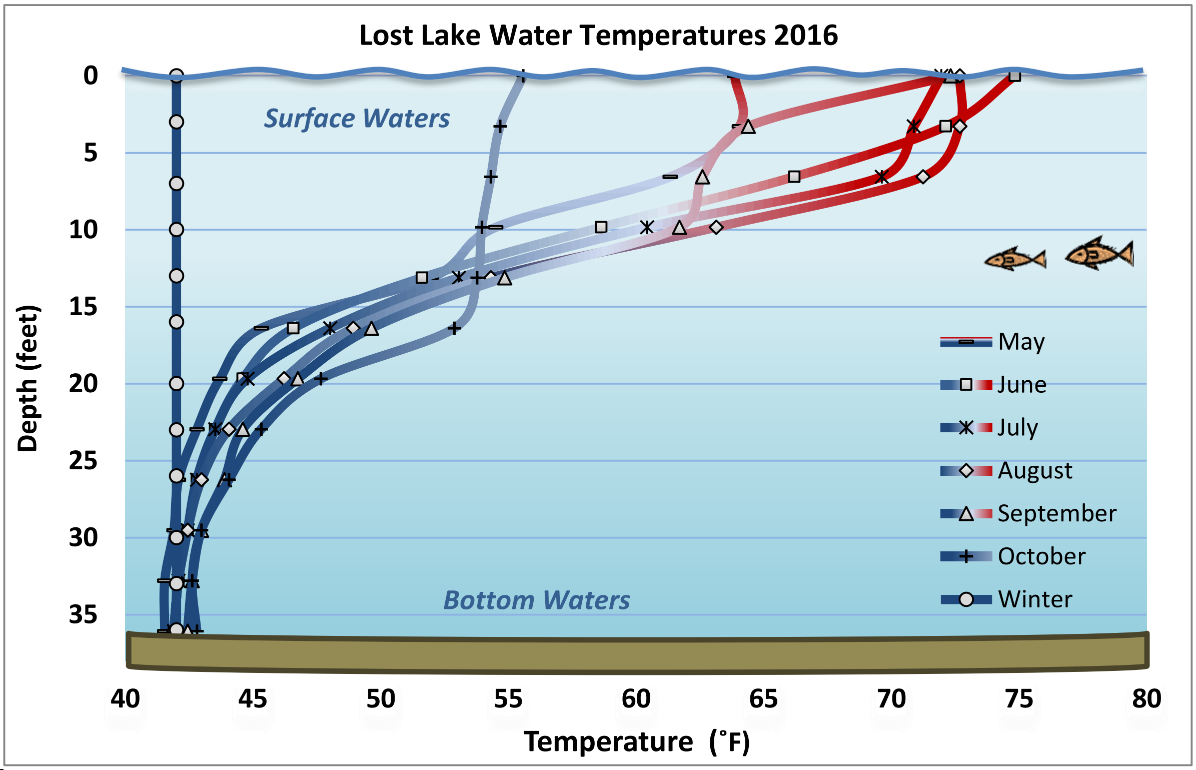
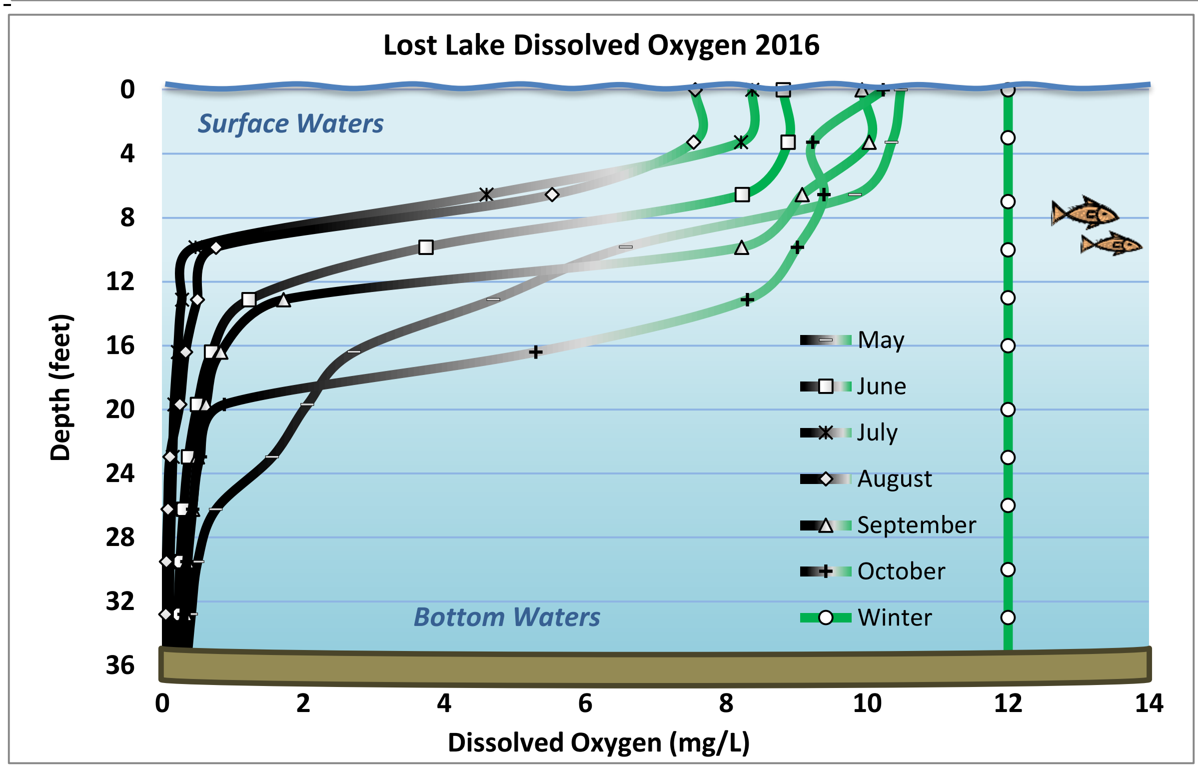

Lost Lake Water Temperatures 2016
Surface Waters
Bottom Waters
Depth (feet)
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
Temperature (˚F)
May
June
July
August
September
October
Winter


Lost Lake Dissolved Oxygen 2016
Surface Waters
Bottom Waters
Depth (feet)
0
4
8
12
16
20
24
28
32
36
0
2
4
6
8
10
12
14
Dissolved Oxygen (mg/L)
May
June
July
August
September
October
Winter

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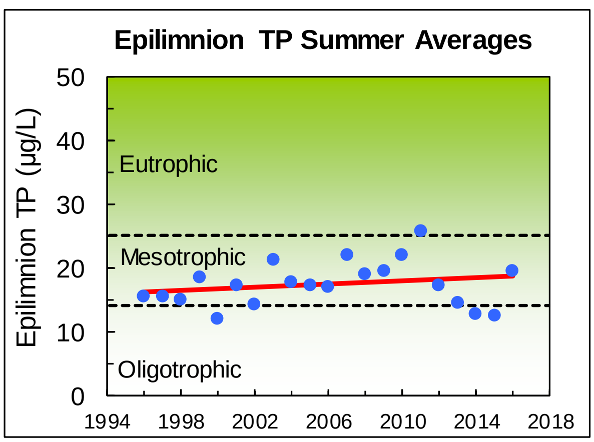
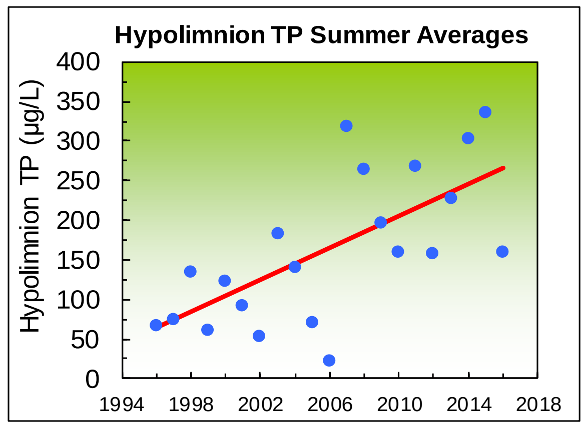
Phosphorus (key nutrient for algae)

Nutrients are essential for the growth of algae, fish, and aquatic plants in a lake. However, too many nutrients, especially phosphorus, can pollute a lake and lead to unpleasant algae growth. Nutrients enter the lake through stormwater runoff or from streams flowing into the lake. Sources of nutrients include fertilizers, pet and animal wastes, poorly-maintained septic systems and erosion from land clearing and construction. Monitoring of phosphorus levels over time helps to identify changes in nutrient pollution.

Total phosphorus (TP) concentrations in the epilimnion (upper waters) of Lost Lake are moderate. The long-term 1996 - 2016 summer average is 17 µg/L (micrograms per liter, which is equivalent to parts per billion). Until 2012, there had been a statistically significant increasing trend in phosphorus levels. Since 2013, the summer averages have dropped below the long term average. Overall, there is now no increasing trend. Any increases in phosphorus can lead to more algae and higher chlorophyll *a* values.



Phosphorus concentrations in the hypolimnion (bottom waters) are much higher. The long-term 1996 - 2016 summer phosphorus average is 162 µg/L, and the averages are increasing. The phosphorus levels in the hypolimnion are also extremely variable, with summer averages ranging between the record low of 21 µg/L in 2006 to a high of 335 µg/L in 2015. In spite of the variability, between 1996 and 2016 there has been a statistically significant trend toward increasing phosphorus in the bottom waters of Lost Lake (p=0.00). The high averages in recent years may be a warning sign of accelerating eutrophication. Higher phosphorus levels are the result of more nutrients washing into the lake, as well as phosphorus being released from the bottom sediments during periods of low dissolved oxygen.



Chlorophyll a (Algae)

Algae are tiny plant-like organisms that are essential for a healthy lake. Fish and other lake life depend on algae as the basis for their food supply. However, excessive growths of algae, called algae blooms, can cloud the water, form unsightly scums, and sometimes release toxins. Excess nutrients, such as phosphorus and nitrogen, are the main cause of nuisance algae growth in a lake. Chlorophyll *a* measurements are one method for tracking the amount of algae in a lake.

Chlorophyll *a* values showed moderate to high levels of algae in the summers of 2002 – 2016, with a long-term average of 9.3 µg/L. Chlorophyll *a* averages have also been highly variable, ranging from 3.5 µg/L in 2009 to 19 µg/L in 2011. The 2016 summer average was the same as the long-term average at 9.3 µg/L. Because of this variability, there has been no overall statistically significant trend toward

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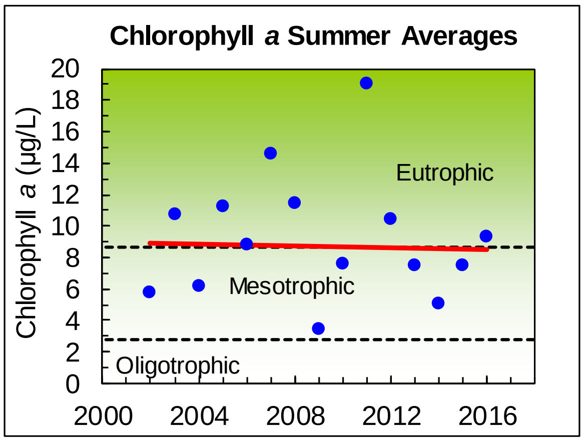
increasing chlorophyll *a* values. The years with higher chlorophyll *a* averages and greater algae growth seem to be associated with years of higher phosphorus levels in the upper and lower waters. More frequent nuisance algae growth may become a problem if phosphorus levels continue to rise in Lost Lake.



Toxic Blue-Green Algae (Cyanobacteria)

Blue-green algae, also called cyanobacteria, are a group of algae capable of producing toxins during periods of high growth, known as blooms. Toxic algae can cause serious illness in people and pets that come into contact with affected water. Algae blooms often look like blue or green paint floating on the water surface. Lake users should avoid contact with the water and keep pets away from the lake when it is experiencing a blue-green algae bloom. If a bloom has been identified, the lake will have notices posted at the public access site.

Since 2005, volunteers and SWM staff have screened algae at Lost Lake for potentially toxic blooms. In 2009, bi-weekly toxin testing was also done as part of a larger project coordinated by the Washington State Department of Health. The project was funded by a grant from the U.S. Centers for Disease Control (CDC) and included monitoring of thirty lakes in Snohomish, King, and Pierce Counties. The CDC project was conducted to identify algae blooms that could pose a potential health threat and to alert the public about toxic algae. Water samples were tested for several types of toxins, in particular microcystin (a liver toxin) and anatoxin-a (a neurotoxin).

Lost Lake did not have noticeable surface accumulations or scums of blue-green algae from 2009 through 2012. However, one water sample taken in October 2009 did test positive for microcystin. The concentration was very low and did not exceed the Washington State Department of Health recreational guideline of 6 µg/L. In June 2011, Lost Lake tested positive for anatoxin-a, although the concentration was below the State Department of Health guideline of 1 µg/L. No algae blooms were observed or samples tested in 2012 or 2013. In the fall of 2014, there was a widespread blue-green algae bloom that tested positive for low levels of microcystin. There were no algae blooms reported in 2015 or 2016.

Screening will continue in 2017 as part of the regular lake monitoring program. Continued monitoring will help alert the public to potential health risks as well as determine the frequency and severity of toxic algae blooms at Lost Lake.

Lost Lake Toxic Algae Testing Results

Date	Microcystin (µg/L)*	Anatoxin (µg/L)*
10/19/2009	0.05	0.00
6/6/2011	0.00	0.03
10/6/2014	0.72	NA

**The state recreational guidelines are 6 µg/L for Microcystin and 1 µg/L for Anatoxin-a*

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Nitrogen (another essential nutrient for algae)

Nitrogen is another important nutrient for plant and algae growth. Similar to phosphorus, lakes with high levels of nitrogen typically have more aquatic plants and algae. From 2014 to 2016, Lost Lake had moderately high levels of total nitrogen (summer average of 477 µg/L). This is consistent with the moderate to high chlorophyll *a* concentrations measured in the lake.

The relative abundance of nitrogen and phosphorus can also be a useful indicator of lake conditions. This is referred to as the nitrogen to phosphorus ratio or N:P ratio. When lakes have low N:P ratios (typically less than 20), algae growth is often high and harmful blue-green algae blooms may be a problem. Low N:P ratios may also indicate that fertilizers, septic systems, polluted runoff from developed areas, and release of phosphorus from the lake bottom sediments are contributing most of the nutrients to the lake.

In contrast, when lakes have higher N:P ratios (greater than 20), algae growth will be limited by the amount of phosphorus available, and blue-green algae are usually less of a problem. In 2016, Lost Lake had a high average N:P ratio of 33, and no algae blooms were reported.

SHORELINE CONDITION

The lake shoreline condition is important in understanding overall lake health. Frequently, lake shorelines are modified through removal of natural vegetation, the installation of bulkheads or other hardening structures, and/or removal of partially submerged logs and branches. This type of alteration can be harmful to the lake ecosystem as natural shorelines protect the lake from harmful pollution, prevent bank erosion, and provide important habitat for fish and wildlife.

The shoreline of Lost Lake is 3/4 of a mile long and mostly developed with residential uses. There were 19 homes or cabins around the shore in 1973, and by the mid-90s, there were 42. There are also 43 docks present on the lake. The shoreline is not highly armored—10% has bulkheads, rock revetments, or fill. However, 33% of the shoreline no longer has a buffer of native vegetation immediately adjacent to the lake shore. Also, the amount of large wood remaining in the lake is relatively low (about 22 pieces). These old logs and branches are valuable for fish and wildlife habitat. Shoreline changes, such as armoring and loss of vegetation, leave the lake susceptible to pollution from the watershed, eliminate the buffer of native vegetation that can filter out pollution, and limit the amount of habitat available for fish and wildlife.

LAKE WATER LEVELS

Lost Lake has experienced episodes of very high water levels that flood docks and the lower portions of residential lots around the lake. The primary reason for high water is beaver activity along the outlet stream of the lake.

In response to high water levels in 2005 and 2006, lake residents worked with the downstream property owners to install a bypass pipe around a large beaver dam. The pipe allowed water to flow through the dam without the beavers being able to block it.

The bypass pipe has seemed to work fairly well for a number of years. However, high water returned in 2015 and 2016. Newer beaver dams are blocking some of the flow out of the lake. The wetland just downstream of Lost Lake is desirable beaver habitat, and beaver activity is likely to continue in the future. SWM will continue to provide technical assistance to the local residents.

LOST LAKE

SUMMARY

Trophic State

All lakes go through a process of enrichment by nutrients and sediment. In this process, known as eutrophication, nutrients and sediment contribute to the ever-increasing growth of algae and aquatic plants. Over thousands of years, lakes will gradually fill up with organic matter and sediments.

Lakes can be classified by their degree of eutrophication, also known as their trophic state. There are three primary trophic states for lakes—oligotrophic, mesotrophic, and eutrophic—as well as intermediate states. Oligotrophic lakes are usually deep, with clear water, low nutrient concentrations, and few aquatic plants and algae. Mesotrophic lakes are richer in nutrients and produce more algae and aquatic plants. Eutrophic lakes are often shallow and characterized by abundant algae and plants, high nutrient concentrations, limited water clarity, and low dissolved oxygen in the bottom waters.

The trophic state classification of a lake does not necessarily indicate good or bad water quality because eutrophication is a natural process. However, human activities that contribute sediment and excess nutrients to a lake can dramatically accelerate the eutrophication process and result in declining water quality.

Based on the long-term monitoring data, Lost Lake may be classified as meso-eutrophic, with low to moderate water clarity, moderately high phosphorus and chlorophyll *a* concentrations, and moderate production of aquatic plants and algae.

Condition and Trends

The water quality targets for Lost Lake are to maintain stable long-term water clarity and to reduce phosphorus levels. The lake is meeting the target of maintaining stable water clarity. In fact, water clarity has shown a statistically significant trend toward improving conditions.

In contrast, there have been no improvements in phosphorus concentrations. Instead, there have been widely fluctuating phosphorus levels in both the upper and lower waters, and a statistically significant increase in summer phosphorus averages in the bottom waters. Increased phosphorus in the hypolimnion indicates a release of nutrients from lake sediments during times of low dissolved oxygen. Excess phosphorus in the lake is a likely sign of accelerated eutrophication that may begin showing up as nuisance algae growth and reduced water clarity.

Overall, Lost Lake is in fair condition. However, the lake is at risk of future water quality declines if phosphorus levels continue to rise. The primary threat to lake water quality is an increase of nutrients entering the lake through new development and from human activities in the watershed. Measures to control nutrients in the watershed should be taken now to prevent any future negative impacts to the lake. To find out more about ways to protect lake water quality and information on the causes and problems of elevated lake nutrient levels visit www.lakes.surfacewater.info.

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DATA SUMMARY FOR LOST LAKE						
Source	**Date**	**Water Clarity (Secchi depth in meters)**	**Total Phosphorus (µg/L)**		**Total Nitrogen (µg/L)**	**Chlorophyll *a* (µg/L)**
			Surface	**Bottom**	**Surface**	**Surface**
Bortleson, et al, 1976	**8/3/73**	2.1	11	49	-	-
Volunteer	**1992**	1.2 - 2.7 (1.7) *n = 8*	-	-	-	-
Volunteer	**1993**	0.4 - 1.4 (0.9) *n = 14*	-	-	-	-
SWM Staff or Volunteer	**1994**	1.8 - 3.2 (2.5) *n = 10*	-	-	-	4.3 - 8.8 (6.6) *n = 2*
SWM Staff or Volunteer	**1995**	1.6 - 2.3 (1.9) *n = 6*	-	-	-	10
SWM Staff, Volunteer or DOE	**1996**	1.5 - 2.2 (1.9) *n = 12*	10 - 21 (16) *n = 2*	43 - 89 (66) *n = 2*	-	5.4 - 8.3 (6.9) *n = 2*
SWM Staff or Volunteer	**1997**	1.1 - 2.3 (1.6) *n = 9*	11 - 20 (16) *n = 2*	38 - 112 (75) *n = 2*	-	-
SWM Staff or Volunteer	**1998**	1.2 - 2.2 (1.7) *n = 11*	10 - 20 (15) *n = 4*	105 - 159 (134) *n = 4*	-	-
SWM Staff or Volunteer	**1999**	1.7 - 2.5 (2.1) *n = 11*	10 - 26 (19) *n = 4*	31- 107 (61) *n = 4*	-	-
SWM Staff or Volunteer	**2000**	2.1 - 3.8 (2.7) *n = 8*	6 - 17 (12) *n = 4*	58 -200 (123) *n = 4*	-	-
SWM Staff or Volunteer	**2001**	1.7 - 2.4 (2.0) *n = 6*	12 - 23 (17) *n = 4*	44 - 133 (92) *n = 4*	-	-
SWM Staff	**2002**	2.2 - 2.9 (2.5) *n = 4*	10 - 16 (14) *n = 4*	11 - 99 (53) *n = 4*	-	3.2 - 8.5 (5.8) *n = 4*
SWM Staff	**2003**	1.4 - 2.7 (2.2) *n = 4*	10 - 42 (21) *n = 4*	110 - 243 (183) *n = 4*	-	3.5 - 30 (11) *n = 4*
Volunteer	**2004**	1.8 - 2.4 (2.1) *n = 5*	13 - 23 (18) *n = 4*	16 - 282 (141) *n = 4*	-	3.7 - 7.7 (6.2) *n = 4*
Volunteer	**2005**	1.3 - 2.2 (1.6) *n = 4*	11 - 23 (17) *n = 4*	31 - 140 (70) *n = 4*	-	3.5 - 18 (11) *n = 4*
Volunteer	**2006**	1.6 - 1.8 (1.6) *n = 4*	15 - 19 (17) *n = 4*	16 - 27 (21) *n = 4*	-	5.9 - 13 (8.8) *n = 4*

DATA SUMMARY FOR LOST LAKE						
		Water Clarity (Secchi depth in meters)	**Total Phosphorus (µg/L)**		**Total Nitrogen (µg/L)**	**Chlorophyll *a* (µg/L)**
Source	**Date**		**Surface**	**Bottom**	**Surface**	**Surface**
SWM Staff	**2007**	1.9 - 2.8 (2.3) *n = 4*	13 - 29 (22) *n = 4*	138 - 455 (318) *n = 4*	-	6.9 - 28 (15) *n = 4*
SWM Staff	**2008**	1.7 - 2.3 (2.0) *n = 3*	16 - 23 (19) *n = 3*	85 - 474 (265) *n = 3*	-	7.4 - 17 (11) *n = 3*
Volunteer	**2009**	1.5 - 3.2 (2.3) *n = 9*	16 - 22 (20) *n = 4*	49 - 420 (197) *n = 4*	-	2.1 - 4.8 (3.5) *n = 4*
Volunteer	**2010**	1.4 - 2.5 (2.0) *n = 9*	16 - 31 (22) *n = 4*	72 - 235 (160) *n = 4*	-	4.8 - 12 (7.6) *n = 4*
SWM Staff	**2011**	1.7 - 3.4 (2.6) *n = 13*	18 - 35 (26) *n = 4*	88 - 415 (269) *n = 4*	-	4.3 - 40 (19) *n = 4*
SWM Staff	**2012**	1.5 - 3.1 (2.2) *n = 6*	15 - 18 (17) *n = 4*	36 - 280 (158) *n = 4*	-	3.5 - 16 (10) *n = 4*
SWM Staff	**2013**	2.5 - 3.6 (3.1) *n = 4*	10 - 18 (15) *n = 4*	180 - 277 (227) *n = 3*	-	3.5 - 16 (7.5) *n = 4*
Volunteer	**2014**	1.9 - 2.7 (2.3) *n = 12*	9 - 16 (13) *n = 4*	16 - 607 (302) *n = 4*	418 - 757 (567) *n = 4*	1.6 - 11 (5.0) *n = 4*
Volunteer	**2015**	*2.2 - 5.5* *(2.9)* *n = 11*	*7 - 18* *(12)* *n = 6*	*145 - 485* *(335)* *n = 4*	*351 - 730* *(457)* *n = 5*	*2.4 - 14* *(7.5)* *n = 6*
Volunteer	**2016**	1.5 - 2.5 (2.0) *n = 12*	10 - 44 (19) *n = 4*	16 - 227 (160) *n = 4*	341 - 456 (417) *n = 4*	5.0 - 15 (9.3) *n = 4*
Long Term Avg		**2.1** **(1992-2016)**	**17** **(1996-2016)**	**162** **(1996-2016)**	**477** **(2014-2016)**	**9.3** **(2002-2016)**
TRENDS		**Increasing**	**None**	**Increasing**	**NA**	**None**

NOTES

- Table includes summer (May-Oct) data only.
- Each box shows the range on top, followed by summer average in ( ) and number of samples (*n*).
- Total phosphorus data are from samples taken at discrete depths only.
- DOE = Washington Department of Ecology
- "Surface" samples are from 1 meter depth and "bottom" samples are from 1-2 meters above the bottom.