2016 STATE OF THE LAKES UPDATE

LAKE STICKNEY

REPORT DESCRIPTION

This report is an update on the health of Lake Stickney based on water quality data collected from 1993 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 Lake Stickney, please visit www.lakes.surfacewater.info or call SWM at 425-388-3464.

LAKE DESCRIPTION

Lake Stickney is a 25-acre lake located between Interstate 5 and Highway 99 south of Everett. The lake has a maximum depth of 10.4 meters (34 feet) and an average depth of 4.6 meters (15 feet). The lake lies in the headwaters of Swamp Creek, which flows through the lake from the north to the west and eventually empties into the Sammamish River and Lake Washington. The watershed, which is the land area that drains to the lake, is very large—over 100 times the size of the lake. This means there is a high potential for pollution impacts from the watershed. About two-thirds of the lake shoreline is developed with single family homes, while the west and northwest shores are bordered by large wetlands. Recent proposed developments near the lake may impact water quality unless measures are taken to control nutrients.

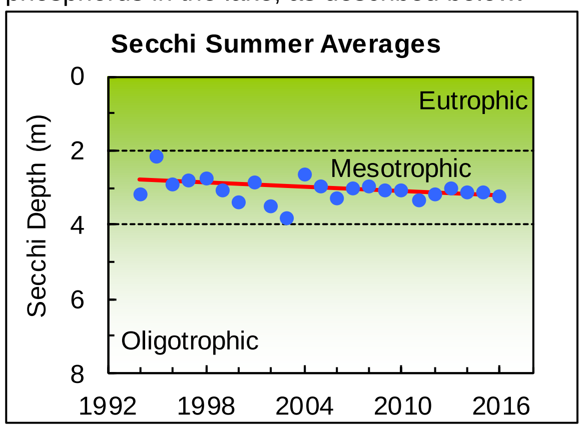
LAKE CONDITIONS

The following graphs illustrate the summer averages and trend lines (shown in red) for water clarity, total phosphorus, and chlorophyll *a* for Lake Stickney. 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 Lake Stickney is moderate, with a long-term summer average of 3.0 meters (9.8 feet). Although water clarity has been fairly consistent since 2005, overall between 1993 and 2016, there has been a small, but statistically significant, trend towards improving water clarity ($p=0.04$). Possible reasons for the improving clarity are less natural color in the water and/or less algae in the lake (although the chlorophyll *a* data do not indicate lower algae levels). In addition, the trend toward improving clarity is at odds with the trends toward more phosphorus in the lake, as described below.



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.

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The water color of Lake Stickney averaged 33 pcu (platinum-cobalt color units) in 2010 - 2011, which indicates a moderate amount of natural color in the lake water. This is a decrease in water color from the 1994 – 1995 average of 45 pcu. Lighter water color is likely a factor in the improving water clarity of the lake over the same time period.

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 2014 (the most recent data available), temperature data were collected at each meter throughout the Lake Stickney water column. Temperature profiles for 2014 show that throughout this period the lake was strongly thermally stratified (see graph). 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. In May and June, the upper waters measured about 66° F (18.9°C) in temperature. By July, surface temperatures had reached 80° F (26.7°C). At the same time, bottom water temperatures changed only a little and remained between 43 and 44° (6.1-6.7°C). In August and September, the upper waters began to cool, and by October the temperature had fallen to 62°F (16.7°C). Through the fall the surface waters will continue cooling until stratification weakens and 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 Lake Stickney water column from May to October 2014 (see graph). Oxygen levels were relatively high in the upper waters from May through October, while there was little or no oxygen in the water below about 16 feet. The lack of oxygen in the lower waters can allow phosphorus in the bottom sediments to be released into the lake water where it can fuel algae growth. In May, June, and July, there were sharp increases in dissolved oxygen between 7 and 13 feet deep. These spikes indicate vigorous algae growth at that depth which added oxygen to the water. The bottom of the lake will remain devoid of oxygen through the summer until the lake mixes (typically in late October/early November). The lake will remain mixed, with high dissolved oxygen levels from top to bottom, until the upper waters begin to warm again in the springtime and oxygen begins to drop in the bottom waters.

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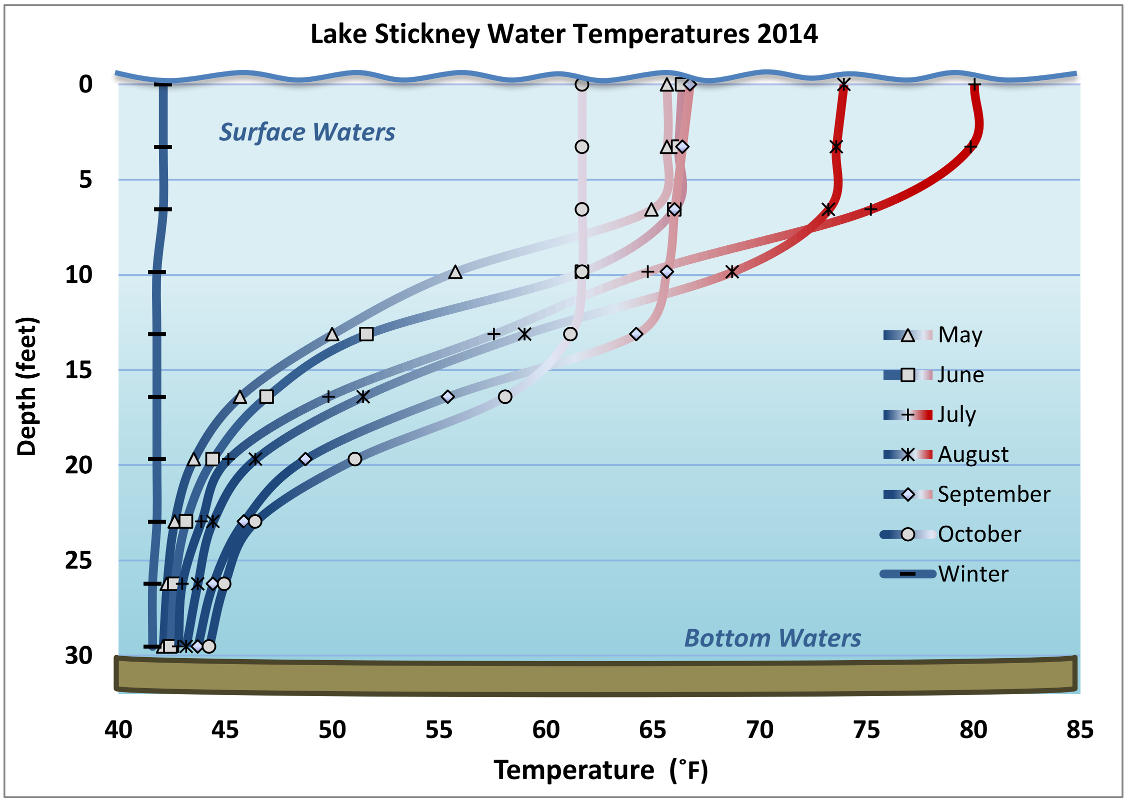

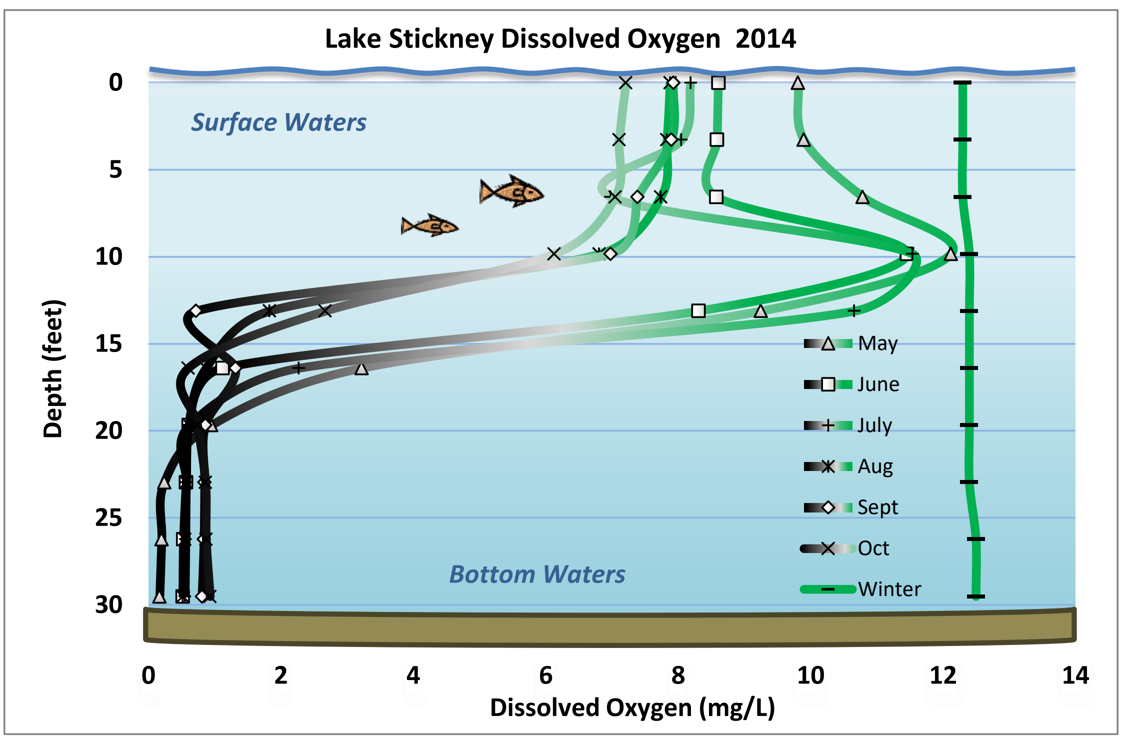

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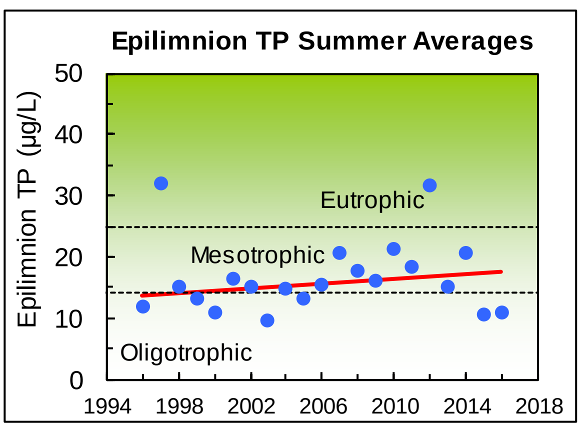
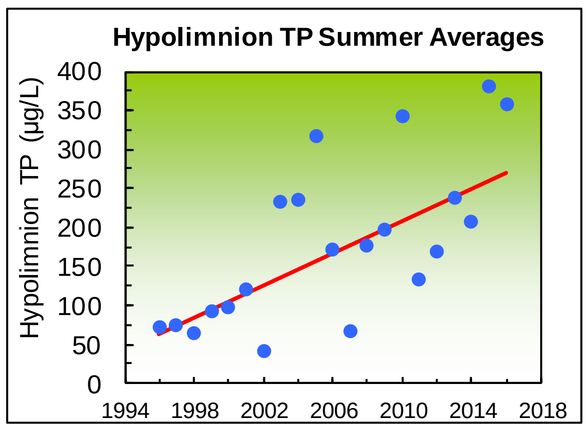
Phosphorus (key nutrient for algae)

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 Lake Stickney are moderate. The 1996 – 2016 long-term summer average for the epilimnion is 17 µg/L (micrograms per liter, which is equivalent to parts per billion). Between 1996 and 2014, there was a statistically significant trend towards increasing phosphorous concentrations in the upper waters. This increasing trend disappeared in 2015. More phosphorus in the lake can lead to increased algae and can be a sign of accelerating eutrophication.



The summertime phosphorus averages in the hypolimnion (bottom waters) of Lake Stickney are high and increasing. The long-term 1996 to 2016 summer average is 180 µg/L. 2015 and 2016 yearly averages are the highest on record, with averages of 382 µg/L and 357 µg/L respectively. Overall, there has been a statistically significant trend toward increasing phosphorus in the hypolimnion (p=0.00). The increase in phosphorus in the bottom waters is likely a sign of on-going pollution coming from the large watershed. Phosphorus builds up in the bottom sediments and is released during the summer period of low dissolved oxygen. Increased phosphorus levels may lead to increased algae growth and are another sign of accelerating lake eutrophication.



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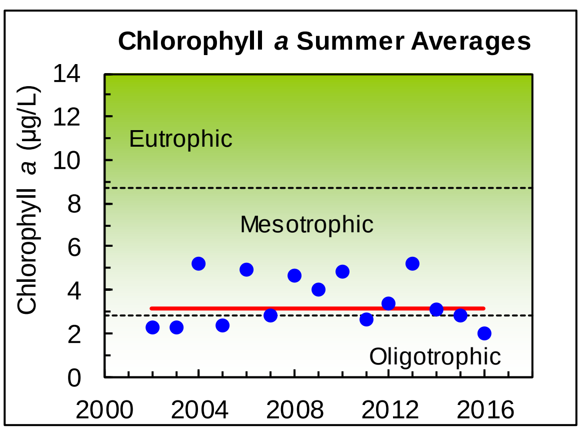
Chlorophyll a (Algae)

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* levels in Lake Stickney from 2002 to 2016 were moderate, with a long term summer average of 3.5 µg/L. The naturally dark color of the water partly inhibits the growth of algae. The chlorophyll *a* averages are variable from year to year, likely in response to more substantial algae blooms in some years. Overall, there has been no statistically significant trend in chlorophyll *a* levels. However, if phosphorus levels in the upper waters and the bottom waters continue to increase, more algae growth can be expected in future years.



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 , Lake Stickney had moderately high levels of total nitrogen (summer average of 500 µg/L). This is consistent with the moderate 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. Lake Stickney had a moderate average N:P ratio of 37, and blue green algae blooms were not a problem in 2016.

SHORELINE CONDITION

The condition of the lake shoreline is important to understanding overall lake health. Frequently, lake shorelines are modified through removal of natural vegetation and the installation of bulkheads or other hardening structures. These types of alterations can be harmful to the lake ecosystem because natural shorelines protect the lake from harmful pollution, prevent bank erosion, and provide important habitat for fish and wildlife.

The Lake Stickney shoreline is moderately developed, with more development proposed. There were 33 homes or cabins around the lake shore in 1973. By the mid-90s, there were 45 homes bordering the lake. There are also 33 docks present on the lake.

Compared to many other suburban lakes, the shoreline of Lake Stickney has limited structural modifications. Only 4% of the shoreline has been altered with bulkheads and earthen fill. In addition, the zone of native vegetation immediately adjacent to the shoreline is still mostly intact, with 78% supporting native grasses, shrubs, and trees. As more homes are built or enlarged around the lake shore, the potential for converting the valuable native vegetation to bulkheads and lawns will increase. Limiting shoreline modifications is important for the health of the lake. Shoreline changes 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. The loss of native vegetation along the shoreline can also lead to shoreline erosion.

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, Lake Stickney may be classified as mesotrophic, with moderate water clarity, phosphorus, and productivity of plants and algae. This is likely the natural state for this relatively shallow lake, but it is important to prevent any further enrichment.

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Condition and Trends

The water quality targets for Lake Stickney are to maintain stable water clarity and reduce phosphorus levels. The lake is currently meeting the target for water clarity. There has been a small, but statistically significant, improvement in water clarity since 1993.

In contrast, phosphorus levels are increasing. There has been a statistically significant trend toward higher phosphorus concentrations between 1996 and 2016 in bottom waters. These changes are likely signs of increasing eutrophication that may lead to impaired water quality in the future.

Overall, Lake Stickney is in fair condition. However, the lake is at risk of future water quality declines as indicated by the increasing phosphorus levels. The primary threat to lake water quality is an increase of nutrients entering the lake through new development and from human activities around the lake shore and 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 the causes and problems of elevated lake phosphorus levels and tips to protect lake water quality please visit www.lakes.surfacewater.info

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DATA SUMMARY FOR LAKE STICKNEY						
		Water Clarity (Secchi depth	**Total Phosphorus (µg/L)**		**Total Nitrogen (µg/L)**	**Chlorophyll *a* (µg/L)**
Source	**Date**	**in meters)**	**Surface**	**Bottom**	**Surface**	**Surface**
Bortleson, et al, 1976	**7/25/73**	2.1	16	22	-	-
Sumioka and Dion, 1985	**7/1/81**	2.1	20	40	-	2.1
Volunteer	**1993**	1.9 - 2.6 (2.1) *n = 3*	-	-	-	-
SWM Staff	**1994**	2.4 - 4.1 (3.2) *n = 2*	-	-	-	3.7 - 5.3 (4.5) *n = 2*
SWM Staff or Volunteer	**1995**	1.7 - 2.8 (2.2) *n = 11*	-	-	-	12
SWM Staff or Volunteer	**1996**	2.6 - 3.2 (2.9) *n = 8*	7 - 17 (12) *n = 2*	58 - 86 (72) *n = 2*	-	-
SWM Staff or Volunteer	**1997**	2.3 - 3.4 (2.8) *n = 8*	31 - 33 (32) *n = 2*	43 - 105 (74) *n = 2*	-	-
Volunteer	**1998**	2.3 - 3.4 (2.7) *n = 7*	12 - 19 (15) *n = 4*	34 - 121 (65) *n = 4*	-	-
Volunteer	**1999**	2.6 - 3.4 (3.1) *n = 7*	11 - 16 (13) *n = 4*	29 - 136 (93) *n = 4*	-	-
Volunteer	**2000**	2.9 - 4.0 (3.4) *n = 7*	6 - 15 (11) *n = 4*	17 - 146 (97) *n = 4*	-	-
Volunteer	**2001**	2.2 - 3.5 (2.9) *n = 7*	13 - 19 (17) *n = 4*	79 - 235 (120) *n = 4*	-	-
Volunteer	**2002**	2.5 - 3.9 (3.5) *n = 5*	12 - 19 (15) *n = 4*	23 - 60 (41) *n = 4*	-	0.1 - 4.8 (2.3) *n = 4*
Volunteer	**2003**	3.0 - 4.4 (3.8) *n = 10*	8 - 11 (10) *n = 4*	85 - 344 (233) *n = 4*	-	0.8 - 3.3 (2.3) *n = 4*
Volunteer	**2004**	1.6 - 4.0 (2.6) *n = 12*	13 - 16 (15) *n = 4*	170 - 269 (236) *n = 4*	-	1.6 - 14 (5.2) *n = 4*
Volunteer	**2005**	2.5 - 3.5 (3.0) *n = 7*	11 - 16 (13) *n = 4*	132 - 556 (317) *n = 4*	-	1.6 - 3.2 (2.4) *n = 4*
Volunteer	**2006**	2.6 - 4.1 (3.3) *n = 9*	12 - 22 (16) *n = 4*	95 - 285 (170) *n = 4*	-	1.6 - 8.0 (5.0) *n = 4*

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DATA SUMMARY FOR LAKE STICKNEY						
		Water Clarity (Secchi depth in meters)	Total Phosphorus (µg/L)		Total Nitrogen (µg/L)	Chlorophyll *a* (µg/L)
Source	**Date**		**Surface**	**Bottom**	**Surface**	**Surface**
Volunteer	**2007**	2.7 - 3.7 (3.0) *n = 11*	9 - 43 (21) *n = 4*	21 - 116 (67) *n = 4*	-	2.1 - 4.3 (2.8) *n = 4*
Volunteer	**2008**	2.4 - 3.9 (3.0) *n = 12*	11 - 27 (18) *n = 3*	59 - 338 (178) *n = 3*	-	3.7 - 6.4 (4.7) *n = 4*
Volunteer	**2009**	2.4 - 4.1 (3.1) *n = 9*	8 - 22 (16) *n = 4*	107 - 354 (198) *n = 4*	-	2.4 - 5.3 (4.1) *n = 4*
Volunteer	**2010**	2.4 - 4.2 (3.1) *n = 11*	15 - 35 (21) *n = 4*	233 - 445 (342) *n = 4*	-	3.2 - 6.4 (4.8) *n = 4*
Volunteer	**2011**	2.8 - 4.0 (3.4) *n = 10*	12 - 23 (19) *n = 4*	46 - 298 (133) *n = 4*	-	1.7 - 4.3 (2.7) *n = 4*
Volunteer	**2012**	2.8 - 3.9 (3.2) *n = 10*	15 - 77 (32) *n = 4*	112 - 194 (170) *n = 4*	-	1.9 - 4.3 (3.4) *n = 4*
Volunteer	**2013**	2.3 - 3.9 (3.0) *n = 10*	12 - 18 (15) *n = 4*	134 - 452 (239) *n = 4*	-	1.1 - 13 (5.2) *n = 4*
Volunteer	**2014**	2.5 - 4.0 (3.1) *n = 11*	13 - 39 (21) *n = 4*	84 - 297 (207) *n = 4*	445 - 724 (600) *n = 4*	1.1 - 13 (5.2) *n = 4*
Volunteer	**2015**	*2.7 - 4.0* *(3.1)* *n = 11*	*7 - 13* *(11)* *n = 4*	*278 - 564* *(382)* *n = 4*	*396 - 439* *(418)* *n = 4*	*2.1 - 3.2* *(2.8)* *n = 4*
Volunteer	**2016**	2.5 - 3.7 (3.2) *n = 10*	7 - 17 (11) *n = 4*	180 - 605 (357) *n = 4*	361 - 544 (482) *n = 4*	1.1 - 2.7 (2.0) *n = 4*
Long Term Avg		**3.0** **(1993-2016)**	**12** **(1996-2016)**	**180** **(1996-2016)**	**500** **(2014-2016)**	**3.5** **(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.
- "Surface" samples are from 1 meter depth and "bottom" samples are from 1-2 meters above the bottom.