2016 STATE OF THE LAKES UPDATE

LAKE RILEY

REPORT DESCRIPTION

This report is an update on the health of Lake Riley based on water quality data collected from 1994 through 2016 by citizen volunteers and Snohomish County Surface Water Management (SWM) staff. For additional background on the information provided here or to find out more about Lake Riley, please visit www.lakes.surfacewater.info or call SWM at 425-388-3464.

LAKE DESCRIPTION

Lake Riley is a 33-acre bog lake located near the Cascade foothills 10 miles northeast of Arlington. The lake is fed mainly by groundwater; there are no visible surface water flows into the lake. The lake drains to Jim Creek and eventually to the south fork of the Stillaguamish River.

Lake Riley has a maximum depth of 13.7 meters (45 feet) and an average depth of 6.7 meters (22 feet). The watershed, which is the land area that drains to the lake, is relatively small—about 9 times the size of the lake. Much of the watershed is forested, but the Normanna Park recreational community is located next to the lake.

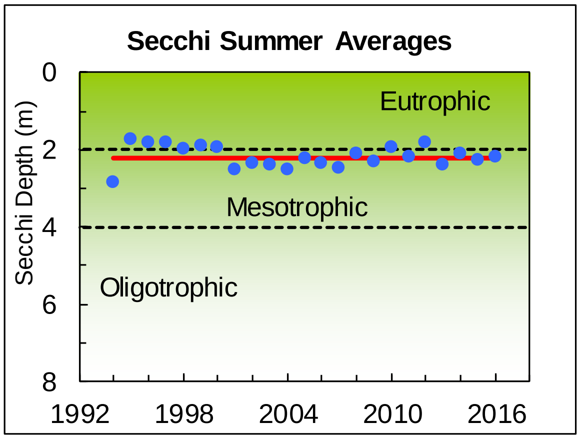
LAKE CONDITIONS

The following graphs illustrate the summer averages and trend lines (shown in red) for water clarity, total phosphorus, and chlorophyll *a* for Lake Riley. 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 Riley is low to moderate, with a 1994 - 2016 long-term summer average of 2.2 meters (7.2 feet). From 2001 through 2009, water clarity was slightly better than it was in the mid to late 1990s. However, in 2010 and 2012, water clarity declined to levels similar to the 1990s. Overall, there has been no statistically significant trend up or down in the water clarity of Lake Riley. It appears that the amount of algae in the water and the naturally dark color of the water are the primary factors affecting water clarity.



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 Lake Riley averaged 54 pcu (platinum-cobalt color units) in 2010 - 2011, which indicates a substantial amount of natural color in the lake. This was somewhat darker than the color in 1994 – 1995, when the average was 47 pcu. The naturally dark color of the water contributes to the lake's low water clarity.

Temperature

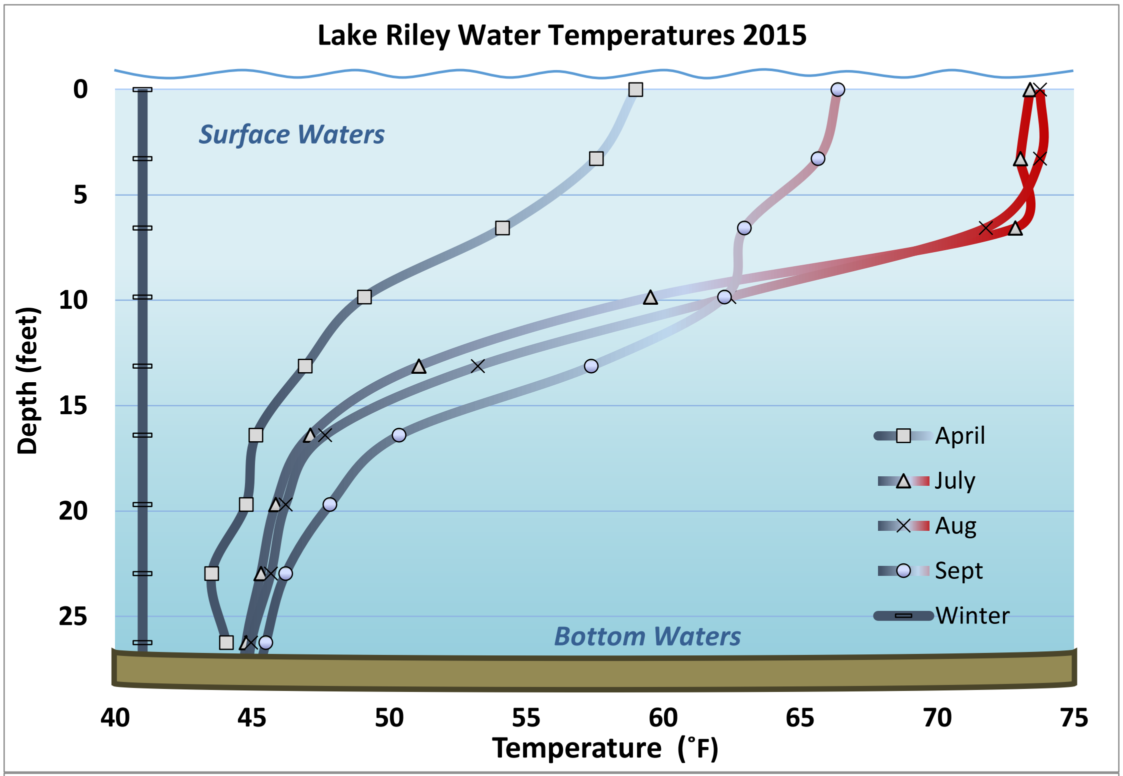
The temperature of lake water changes with the seasons and varies with depth. During spring and summer, the sun warms the upper waters. Because warmer water is less dense, it floats above the cooler, denser water below. The temperature and density differences create distinct layers of water in the lake, 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.

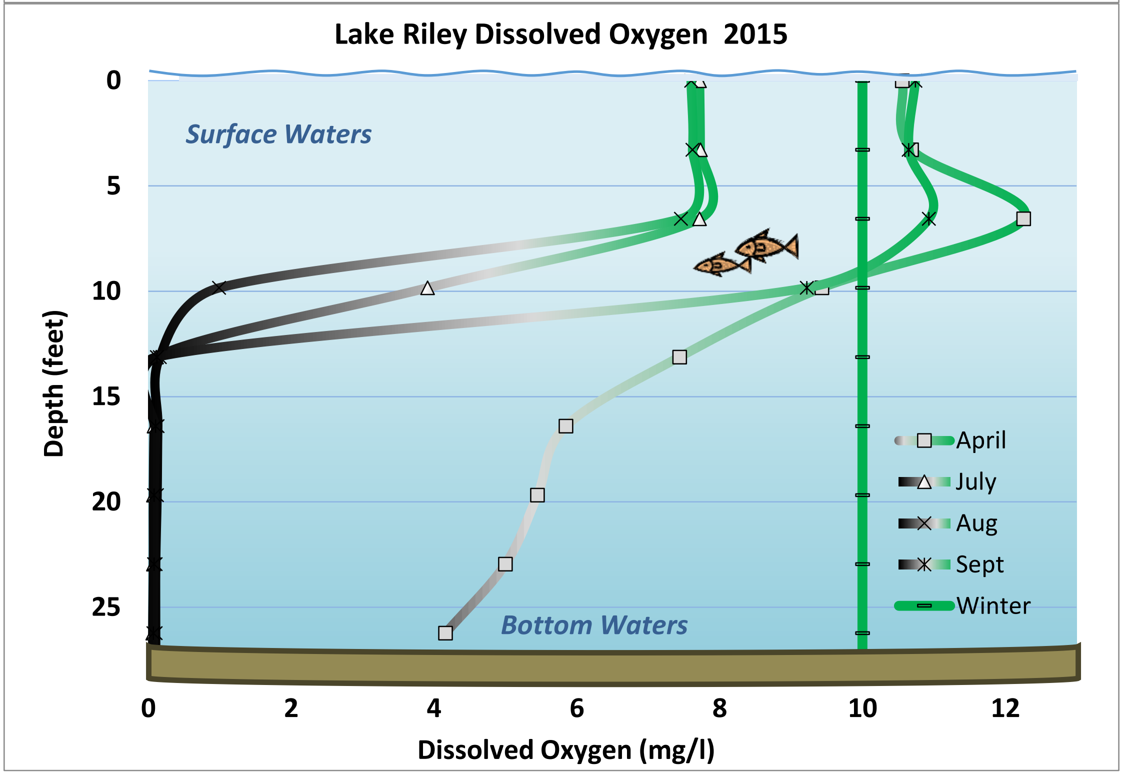
From April through September 2015, the most recent available data, temperature data were collected at each meter throughout the Lake Riley water column (see graph). Data from May and June were not used due to instrument error. Temperature profiles for 2015 show that the lake was beginning to stratify in April. 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. By August, the upper waters had reached their peak at 74°F (23°C). At the same time, throughout the summer the bottom water temperatures remained around 44-45°F (6.8-7.1°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 Lake Riley water column (see graph). Oxygen levels were relatively high in the upper waters from April through September, although the levels were slightly lower in the hottest months because warm water cannot hold as much dissolved oxygen as colder water. Meanwhile, the bottom waters contained little to no dissolved oxygen. By July, there was virtually no dissolved oxygen in the lake below about 10 feet. 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 lake then remains mixed through the winter until springtime when the upper waters begin to warm and dissolved oxygen begins to decline in the bottom.


Lake Riley Water Temperatures 2015
Surface Waters
Bottom Waters
Depth (feet)
0
5
10
15
20
25
40
45
50
55
60
65
70
75
Temperature (˚F)
April
July
Aug
Sept
Winter

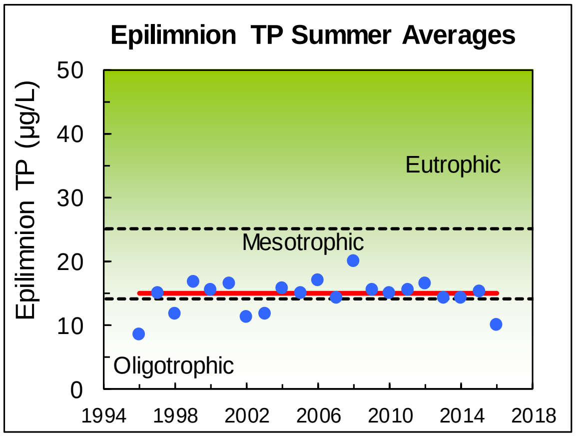

Lake Riley Dissolved Oxygen 2015
Surface Waters
Bottom Waters
Depth (feet)
0
5
10
15
20
25
0
2
4
6
8
10
12
Dissolved Oxygen (mg/l)
April
July
Aug
Sept
Winter

LAKE RILEY

Phosphorus (key nutrient for algae)

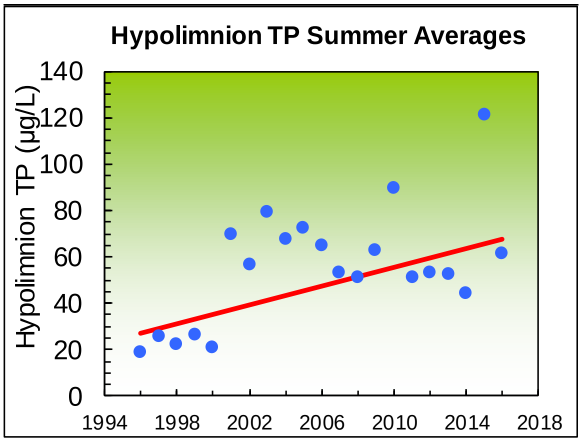
Nutrients are essential for the growth of algae, fish, and aquatic plants in a lake. However, too many nutrients, especially phosphorus, can pollute a lake and lead to unpleasant algae growth. Nutrients enter the lake through stormwater runoff or from streams flowing into the lake. Sources of nutrients 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 concentrations in the epilimnion (upper waters) are low to moderate. The long-term summer average between 1996 and 2016 is 15 µg/L (micrograms per liter, which is equivalent to parts per billion). The 2016 summer average was slightly below the long term average (10 µg/L). Although there has been no statistically significant trend toward increasing phosphorus concentrations, it does appear that phosphorus levels have been higher in some recent years.



Summertime phosphorus averages in the hypolimnion (bottom waters) are much higher, with a long-term 1996 – 2016 summer average of 56 µg/L. Although there has been no statistically significant trend toward increasing phosphorus levels in the bottom waters, the summer averages since 2001 have been higher than in the 1990s. In 2010, the phosphorus average increased to of 90 µg/L. Summer averages dropped below the long term average from 2012 to 2014. In 2015, the summer average reached a record high of 122 µg/L. 2016 summer averages decreased to slightly above the long term average (62 µg/L).

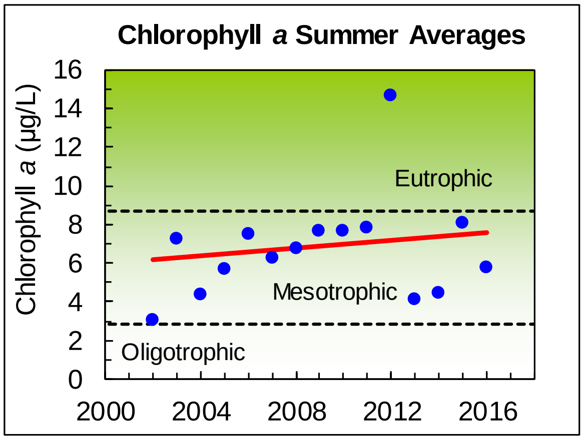
Any increase in phosphorus in the hypolimnion is likely caused by a release of nutrients from bottom sediments during times of low dissolved oxygen. This may be a sign of accelerated eutrophication that could lead to future water quality problems.



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, 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 during the summers of 2002 through 2016, with a long-term average of 6.7 µg/L. The 2012 summer average was the highest on record at 15 µg/L. Between 2002 and 2015, there was a strong and statistically significant trend towards increasing chlorophyll *a* averages in Lake Riley (p=0.04). It appears that there is still a trend towards increasing levels, but it is not statistically significant. While there has been more algae growth in recent years, there have been only a few observations of nuisance algae blooms that produce surface scums. The increasing chlorophyll *a* values suggest that additional phosphorus in the upper waters and the build-up of phosphorus in the bottom waters may be leading to more algae growth. Fortunately, the dark color of the water limits the amount of light available for algae growth.



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, 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 because natural shorelines protect the lake from harmful pollution, prevent bank erosion, and provide important habitat for fish and wildlife.

Lake Riley has low development around the shoreline. There are about 18 homes near the lake shore and 14 docks on the lake. Lake Riley is unique in that it has a large wetland surrounding much of the lake shoreline. The wetland protects the lake because it forces homes around the lake to be set back a significant distance from the lake shore. Therefore, the shoreline is completely unarmored except for the fill material put in place for the two boat launches on the lake. Similarly, 97% of the vegetation along the shoreline remains intact. Furthermore, Lake Riley still has a high level of large wood present. Although the dark water color made surveying difficult, it was estimated that about 207 pieces of old logs and branches remain, which are extremely valuable for fish and wildlife habitat.

The natural state of the shoreline plays an important role in protecting the lake. The natural shoreline reduces the sources of pollution, provides a buffer of native vegetation to filter out nutrients before they can reach the lake, and provides high quality aquatic habitat for fish and wildlife.

LAKE RILEY

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 Riley may be classified as mesotrophic, with low to moderate water clarity and moderate levels of phosphorus and chlorophyll *a*. The lake is moderately productive of plants and algae.

Condition and Trends

One water quality target for Lake Riley is to maintain stable water clarity readings. The lake is meeting this target because the long-term summer average has been stable over the years.

Lake Riley is not meeting its target of maintaining stable phosphorus levels in the epilimnion or hypolimnion. Although there have been no statistically significant trends toward higher phosphorus levels in the upper or lower waters, since 2002, the long-term averages have increased slightly from 14 to 15 µg/L in the upper waters and risen dramatically from 34 to 56 µg/L in the bottom waters. Any increases in phosphorus can contribute to nuisance algae growth.

Chlorophyll *a* levels do show a significant trend toward increasing levels. This is likely the result of more phosphorus available for algae growth.

Overall, Lake Riley is in satisfactory condition for a relatively shallow bog lake. The lake provides high value for lake users and good quality habitat for fish and wildlife. However, the lake is at risk of future water quality declines as indicated by the increases in phosphorus in the hypolimnion and the trend toward higher chlorophyll *a* concentrations.

The primary threat to lake water quality is any increase of nutrients entering the lake through new development and 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, please visit www.lakes.surfacewater.info.

DATA SUMMARY FOR LAKE RILEY

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	**8/18/73**	1.8	6	14	-	-
SWM Staff	**1994**	2.6 - 3.2 (2.9) *n = 2*	-	-	-	2.6 - 5.5 (4.1) *n = 2*
SWM Staff or Volunteer	**1995**	1.3 - 2.2 (1.7) *n = 7*	-	-	-	9.8
SWM Staff or Volunteer	**1996**	1.5 - 2.5 (1.8) *n = 12*	8 - 9 (9) *n = 2*	18 - 19 (19) *n = 2*	-	-
SWM Staff or Volunteer	**1997**	1.4 - 2.5 (1.8) *n = 7*	12 - 18 (15) *n = 2*	25 - 27 (26) *n = 2*	-	-
SWM Staff or Volunteer	**1998**	1.5 - 2.9 (1.9) *n = 12*	9 - 14 (12) *n = 4*	19 - 23 (22) *n = 4*	-	-
SWM Staff	**1999**	1.6 - 2.1 (1.9) *n = 4*	14 - 19 (17) *n = 4*	17 - 35 (27) *n = 4*	-	-
SWM Staff or Volunteer	**2000**	1.5 - 2.2 (1.9) *n = 13*	5 - 20 (16) *n = 4*	6 - 30 (21) *n = 4*	-	-
SWM Staff or Volunteer	**2001**	2.2 - 3.0 (2.5) *n = 5*	12 - 25 (17) *n = 4*	47 - 99 (70) *n = 4*	-	-
Volunteer	**2002**	2.2 - 2.6 (2.4) *n = 5*	11 - 12 (11) *n = 4*	23 - 139 (57) *n = 4*	-	2.1 - 4.8 (3.1) *n = 4*
Volunteer	**2003**	1.9 - 2.7 (2.4) *n = 4*	9 - 14 (12) *n = 4*	24 - 137 (80) *n = 4*	-	3.2 - 12 (7.3) *n = 4*
Volunteer	**2004**	2.2 - 3.0 (2.5) *n = 5*	11 - 26 (16) *n = 4*	38 - 110 (68) *n = 4*	-	2.4 - 5.9 (4.4) *n = 4*
Volunteer	**2005**	2.1 - 2.5 (2.2) *n = 5*	13 - 19 (15) *n = 4*	38 - 104 (72) *n = 4*	-	3.2 - 9.6 (5.7) *n = 4*
Volunteer	**2006**	1.9 - 2.8 (2.4) *n = 4*	12 - 22 (17) *n = 4*	30 - 117 (65) *n = 4*	-	2.4 - 12 (7.5) *n = 4*
Volunteer	**2007**	2.2 - 2.7 (2.4) *n = 5*	11 - 17 (14) *n = 4*	42 - 71 (53) *n = 4*	-	4.3 - 7.5 (6.2) *n = 4*
Volunteer	**2008**	1.8 - 2.7 (2.1) *n = 4*	19 - 21 (20) *n = 3*	34 - 74 (51) *n = 3*	-	4.3 - 9.1 (6.8) *n = 3*
Volunteer	**2009**	2.0 - 2.6 (2.3) *n = 4*	12 - 20 (16) *n = 4*	34 - 119 (63) *n = 4*	-	5.9 - 11 (7.6) *n = 4*

LAKE RILEY

DATA SUMMARY FOR LAKE RILEY

Source	Date	Water Clarity (Secchi depth in meters)	Total Phosphorus (µg/L)		Total Nitrogen (µg/L)	Chlorophyll *a* (µg/L)
			Surface	Bottom	Surface	Surface
Volunteer	**2010**	1.5 - 2.4 (1.9) *n = 5*	13 - 18 (15) *n = 4*	37 - 124 (90) *n = 4*	-	2.7 - 19 (7.7) *n = 4*
Volunteer	**2011**	2.0 - 2.6 (2.2) *n = 4*	14 - 18 (16) *n = 4*	30 - 74 (51) *n = 4*	-	4.0 - 11 (7.8) *n = 3*
Volunteer	**2012**	1.4 - 2.3 (1.8) *n = 4*	10 - 26 (16) *n = 4*	32 - 84 (53) *n = 4*	-	5.2 - 25 (15) *n = 4*
Volunteer	**2013**	2.1 - 2.8 (2.4) *n = 5*	11 - 21 (14) *n = 4*	29 - 69 (52) *n = 4*	-	2.7 - 5.9 (4.1) *n = 3*
Volunteer	**2014**	1.9 - 2.2 (2.1) *n = 5*	10 - 19 (14) *n = 4*	22 - 67 (44) *n = 4*	261 - 412 (338) *n = 4*	2.7 - 6.4 (4.4) *n = 4*
Volunteer	**2015**	*1.9 - 2.7* *(2.2)* *n = 4*	*6 - 28* *(15)* *n = 4*	*51 - 260* *(122)* *n = 4*	*285 - 569* *(404)* *n = 4*	*4.3 - 13* *(8.1)* *n = 3*
Volunteer	**2016**	1.8 - 3.1 (2.2) *n = 5*	7 - 14 (10) *n = 4*	31 - 81 (62) *n = 4*	238 - 379 (281) *n = 4*	2.7 - 8.3 (5.8) *n = 4*
Long Term Avg		**2.2** **(1994-2016)**	**15** **(1996-2016)**	**56** **(1996-2016)**	**341** **(2014-2016)**	**6.7** **(2002-2016)**
TRENDS		**None**	**None**	**None**	**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.