LAKE BOSWORTH

REPORT DESCRIPTION

This report is an update on the health of Lake Bosworth based on water quality data collected from 1990 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 Bosworth, please visit www.lakes.surfacewater.info or call SWM at 425-388-3464.

LAKE DESCRIPTION

Lake Bosworth is a 103 acre lake located three miles south of Granite Falls. It is a deep lake, with a maximum depth of 24 meters (79 feet) and an average depth of 10.7 meters (35 feet). The watershed, which is the land area that drains to the lake, is mostly undeveloped, except for dense homes located around the lake shore.

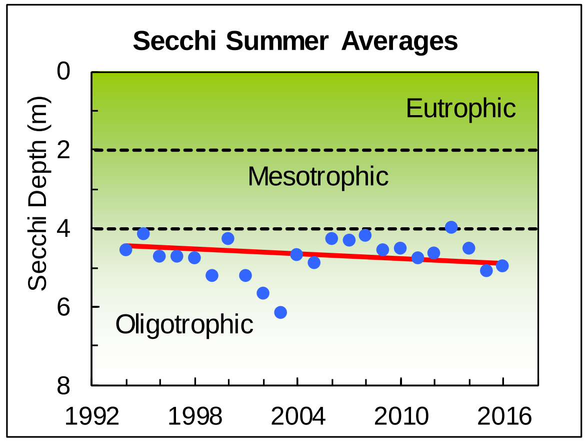
LAKE CONDITIONS

The following graphs illustrate the summer averages and trend lines (shown in red) for water clarity, total phosphorus, and chlorophyll *a* for Lake Bosworth. 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.

The water clarity in Lake Bosworth is high, with a long-term summer average of 4.6 meters (15 feet). In 2002 and 2003, water clarity was much better than the long-term average, peaking at 6.2 meters. Since 2004, the water clarity has been near the long-term average. In 2015, summer average improved at 5.1 meters (16.7 feet), which is closer to the values observed in the early 2000's. Overall, there has been no trend in water clarity in Lake Bosworth between 1990 and 2016, but in general, the water clarity is better than in the early 1990s.



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 Bosworth averaged 12 pcu (platinum-cobalt color units) in 2010 - 2011, which indicates a slight amount of color in the lake water. The average has not changed much from the 1994 – 1995 average of 10 pcu. This amount of color is too small to have a significant effect on water clarity or algae growth.

LAKE BOSWORTH

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 2015 (the most recent data available), temperature measurements were taken at each meter throughout the Lake Bosworth water column (see graph). Temperature profiles for 2015 show that throughout the sampling season the lake was strongly thermally stratified. 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 the upper waters measured about 64˚F (18°C) in temperature, and by July had reached their peak at 77°F (25°C). At the same time, bottom water temperatures changed only a little and remained around 42°F (5.5°C).

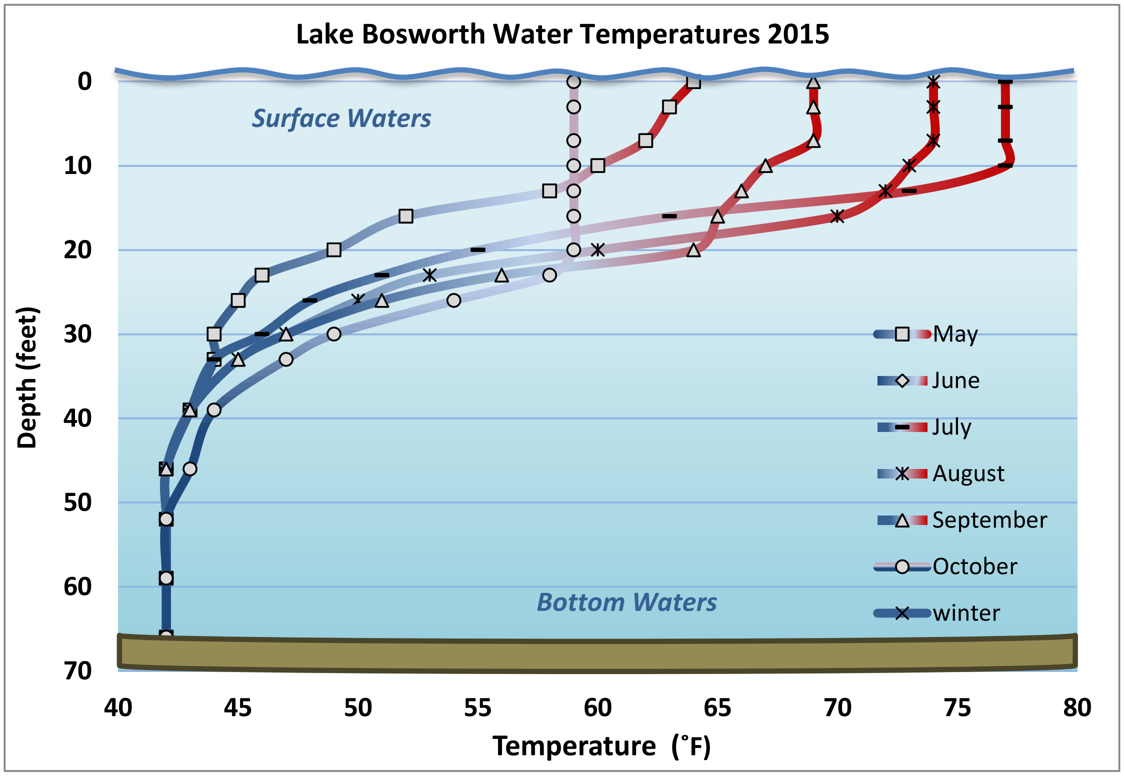
By September, the surface waters began to cool to 69˚F (21°C). Each fall the surface waters will continue to cool until the temperatures are almost equal from top to bottom. As stratification weakens, the lake water will turn over (or mix). The lake will stay mixed during the winter until springtime, when the upper waters began to warm again.

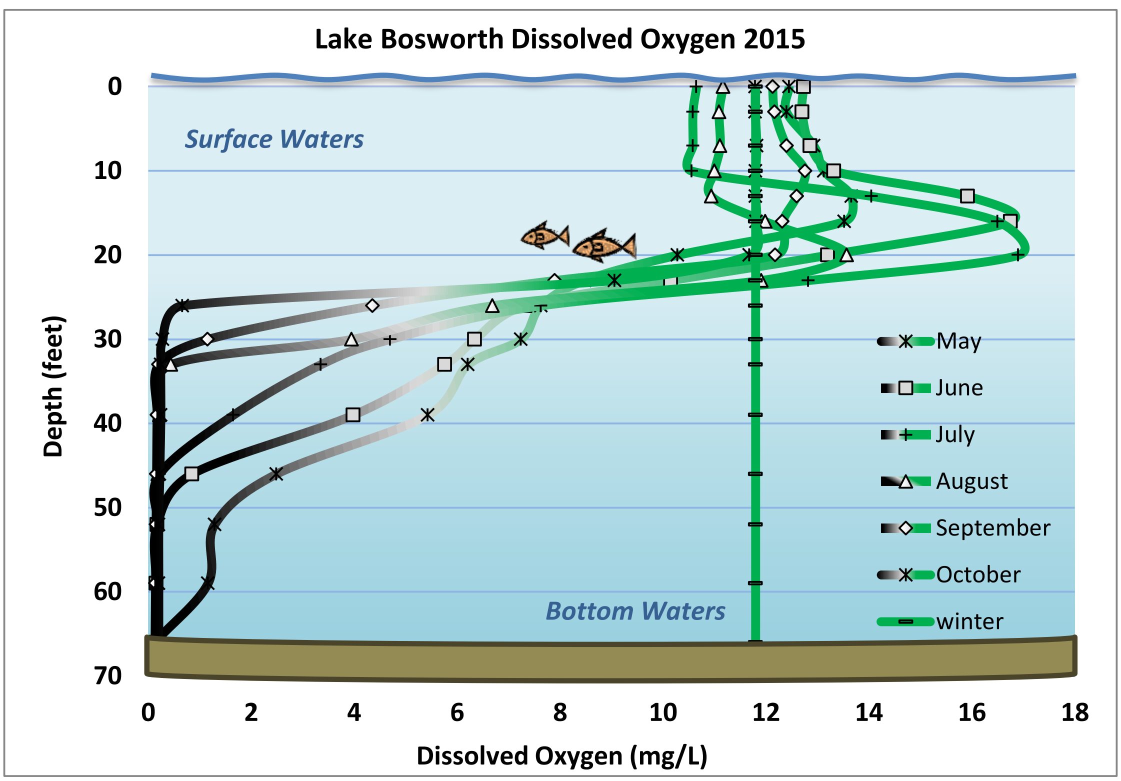
Dissolved Oxygen

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 Bosworth water column from May to October in 2015 (see graph). Oxygen levels were relatively high in the upper waters from May through October. Through much of the summer, there was a sharp increase in dissolved oxygen levels between about 15 and 20 feet deep. This indicates vigorous algae growth at that depth which added oxygen to the water. Meanwhile, the bottom waters contained much less dissolved oxygen, and oxygen levels declined in through the summer. By July, there was little or no oxygen in the water below about 50 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. 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 until springtime when the upper waters begin to warm and dissolved oxygen begins to decline in the bottom.

LAKE BOSWORTH



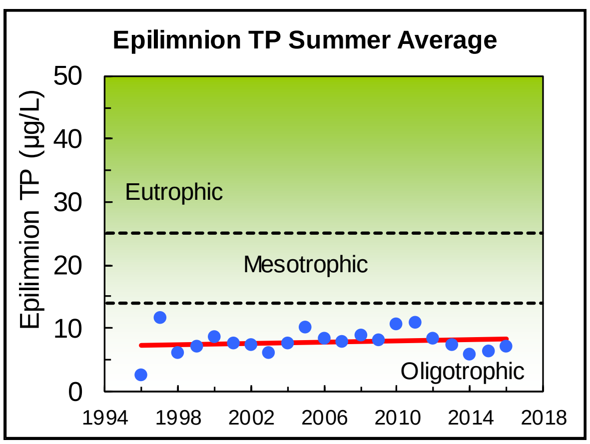


LAKE BOSWORTH

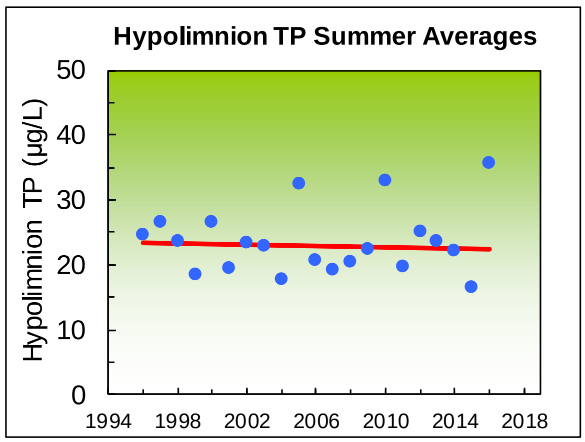
Phosphorus (key nutrient for algae)

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 Lake Bosworth are low, with a long-term summer average of 8 µg/L (micrograms per liter - which is equivalent to parts per billion) in the epilimnion (upper waters). Between 1998 and 2011, it appeared that phosphorus levels were slightly increasing in the upper waters. The phosphorus levels decreased in 2012 – 2014 but began to rise in 2015. Overall, between 1996 and 2016, there has been no statistically significant trend in phosphorus in the upper waters. Any increases in phosphorus concentrations can lead to greater production of algae and reduced water clarity in the lake.



Phosphorus values in the hypolimnion (bottom waters) are also low but variable, with a long-term summer average of 24 µg/L. There have been a few isolated increases in the summer average values, when the average rose to 33 µg/L in both 2005 and 2010, and 36 µg/L in 2016. These higher phosphorus levels could indicate a build-up of nutrients in the bottom waters that may contribute to more algae growth over time. In spite of the higher averages in these few years, there is no statistical evidence of long-term changes in phosphorus levels in the bottom waters of Lake Bosworth.

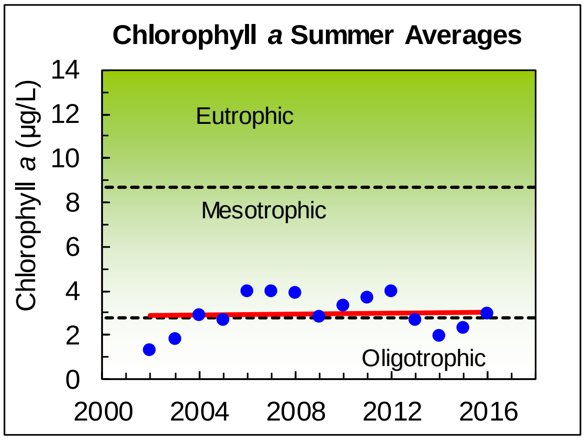


LAKE BOSWORTH

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* samples showed low to moderate algae levels in the summers of 2002 to 2016. The long-term summer average is 3.0 µg/L. Chlorophyll *a* averages were somewhat higher from 2006 through 2012, perhaps in response to a similar pattern of higher phosphorus levels in the upper waters. Chlorophyll *a* summer averages have increased over the last three years, although there has been no statistically significant trend in chlorophyll *a* between 2002 and 2016. While there have been occasional observations of dense algae in Lake Bosworth, algae blooms are not currently a persistent problem in the lake. The main concern is that any increase in phosphorus concentrations can lead to more algae growth.



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. Lake Bosworth has relatively low levels of total nitrogen (2014-2016 summer average of 332 µg/L). This is consistent with the low to 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 Bosworth had a high average N:P ratio of 52, and no blue green algae blooms were reported in 2016.

LAKE BOSWORTH

SHORELINE CONDITION

The lake shoreline condition is important in understanding the 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. 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 has one of the most densely developed shorelines in the County. Surveys conducted in the mid-90s indicated 116 homes border the lake. There are also 116 docks present on the lake, covering 1.1 acres in area. For the high level of the development, the shoreline still has relatively moderate shoreline armoring at 26%. Bulkheads comprised the majority of the modification (74%), with some rock revetments (23%). The vegetation immediately adjacent to the shoreline, however, has been greatly altered, with only 15% being classified as intact native vegetation. In many cases, the native vegetation has been replaced by lawns down to the water. Lawns can be a source of nutrients and do not protect the lake as well as a buffer of native vegetation. There is a moderate amount (about 118 pieces) of large wood still remaining in the lake. These old logs and branches are valuable for fish and wildlife habitat.

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 Bosworth may be classified as oligo-mesotrophic, with high water clarity, low phosphorus levels, and low productivity of plants and algae.

LAKE BOSWORTH

Condition and Trends

Overall, Lake Bosworth is in good condition. The target for the lake is to maintain stable water quality. Since the 1990s, there have been no significant changes in water quality. However, phosphorus levels in the upper waters and chlorophyll *a* concentrations have been higher in some recent years. Overall, water quality is still good; but the lake may be at risk of future declines in water quality. If phosphorus and algae levels begin to increase, this may be a sign of accelerated eutrophication that will eventually affect lake users' perceptions of the lake.

The primary threat to Lake Bosworth's water quality is the possibility of an increase in nutrients which come from new development or other human activities in the watershed. Lake Bosworth may be particularly susceptible to changes in the watershed since the shoreline vegetation has been significantly altered. In order to protect the healthy condition of the lake, measures should be taken to control nutrients in the watershed. To find out more about the causes and problems of elevated lake nutrient levels and to obtain tips to improve lake water quality visit www.lakes.surfacewater.info.

DATA SUMMARY FOR LAKE BOSWORTH						
		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	**8/2/73**	4.0	4	11	-	-
DOE	**1990**	3.0 - 4.0 (3.5) *n = 10*	-	-	-	-
DOE	**1991**	2.8 - 5.1 (3.5) *n = 10*	-	-	-	-
DOE	**1992**	3.0 - 5.2 (3.8) *n = 12*	-	-	-	1.5 - 2.2 (1.9) *n = 2*
DOE	**1993**	3.4 - 6.7 (5.0) *n = 10*	-	-	-	2.4 - 5.7 (4.1) *n = 2*
SWM Staff or DOE	**1994**	3.4 - 6.0 (4.5) *n = 15*	-	-	-	1.5 - 3.5 (2.8) *n = 4*
SWM Staff or DOE	**1995**	2.4 - 5.8 (4.1) *n = 13*	-	-	-	2.0 - 2.7 (2.4) *n = 2*
SWM Staff or DOE	**1996**	3.7 - 5.8 (4.7) *n = 14*	2 - 3 (3) *n = 2*	23 - 26 (25) *n = 2*	-	2.7 - 5.3 (4.0) *n = 2*
SWM Staff or DOE	**1997**	3.4 - 6.1 (4.7) *n = 12*	10 - 13 (12) *n = 2*	25 - 28 (27) *n = 2*	-	4.8
SWM Staff or DOE	**1998**	3.7 - 6.0 (4.8) *n = 14*	5 - 7 (6) *n = 4*	18 - 31 (24) *n = 4*	-	-
SWM Staff or DOE	**1999**	4.0 - 6.2 (5.2) *n = 13*	6 - 8 (7) *n = 4*	11 - 22 (19) *n = 4*	-	-
SWM Staff or DOE	**2000**	1.7 - 5.8 (4.3) *n = 11*	7 - 10 (9) *n = 4*	22 - 31 (27) *n = 4*	-	-
SWM Staff	**2001**	3.7 - 6.3 (5.2) *n = 4*	5 - 9 (8) *n = 4*	13 - 23 (20) *n = 4*	-	
SWM Staff	**2002**	5.0 - 6.5 (5.7) *n = 4*	5 - 9 (7) *n = 4*	19 - 28 (24) *n = 4*	-	0.5 - 2.1 (1.3) *n = 4*
SWM Staff	**2003**	5.7 - 7.4 (6.2) *n = 4*	5 - 7 (6) *n = 4*	20 - 29 (23) *n = 4*	-	1.0 - 2.1 (1.8) *n = 4*
Volunteer	**2004**	3.3 - 6.0 (4.7) *n = 10*	6 - 10 (8) *n = 4*	11 - 23 (18) *n = 4*	-	0.5 - 6.4 (2.9) *n = 4*

LAKE BOSWORTH

DATA SUMMARY FOR LAKE BOSWORTH						
		Water Clarity (Secchi depth	**Total Phosphorus (µg/L)**		**Total Nitrogen (µg/L)**	**Chlorophyll *a* (µg/L)**
Source	**Date**	**in meters)**	**Surface**	**Bottom**	**Surface**	**Surface**
Volunteer	**2005**	4.3 - 5.8 (4.9) *n = 12*	7 - 13 (10) *n = 4*	24 - 40 (33) *n = 4*	-	1.9 - 4.0 (2.7) *n = 4*
Volunteer	**2006**	3.4 - 5.7 (4.3) *n = 13*	6 - 10 (8) *n = 4*	12 - 28 (21) *n = 4*	-	2.1 - 7.5 (4.0) *n = 4*
Volunteer	**2007**	3.4 - 5.5 (4.3) *n=14*	7 - 9 (8) *n=4*	8 - 29 (19) *n=4*	-	3.5 - 4.3 (4.0) *n=4*
Volunteer	**2008**	2.9 - 6.1 (4.2) *n=10*	6 - 12 (9) *n=4*	14 - 28 (20) *n=4*	-	2.4 - 5.9 (3.9) *n=4*
Volunteer	**2009**	3.6 - 6.0 (4.5) *n = 11*	6 - 10 (8) *n = 4*	18 - 27 (23) *n = 4*	-	1.3 - 4.8 (2.8) *n = 4*
Volunteer	**2010**	3.1 - 5.5 (4.5) *n = 10*	7 - 16 (11) *n = 4*	15 - 65 (33) *n = 4*	-	1.1 - 4.8 (3.4) *n = 4*
Volunteer	**2011**	4.1 - 5.5 (4.8) *n = 12*	9 - 13 (11) *n = 4*	12 - 28 (20) *n = 4*	-	2.6 - 4.8 (3.7) *n = 4*
Volunteer	**2012**	3.8 - 6.0 (4.7) *n = 13*	7 - 11 (8) *n = 4*	10 - 37 (25) *n = 4*	-	1.6 - 8.5 (4.0) *n = 4*
Volunteer	**2013**	3.2 - 5.2 (4.0) *n = 11*	5 - 9 (7) *n = 4*	12 - 42 (24) *n = 4*	-	2.1 - 3.2 (2.7) *n = 4*
Volunteer	**2014**	*3.8 - 5.3* *(4.5)* *n = 12*	*5 - 7* *(6)* *n = 4*	*8 - 33* *(22)* *n = 4*	*299 - 423* *(321)* *n = 4*	*1.3 - 2.7* *(1.9)* *n = 4*
Volunteer	**2015**	*4.0 - 6.2* *(5.1)* *n = 11*	*5 - 8* *(6)* *n = 4*	*10 - 24* *(17)* *n = 4*	*209 - 382* *(299)* *n = 4*	*1.1 - 3.7* *(2.3)* *n = 4*
Volunteer	**2016**	4.2 - 5.9 (5.0) *n = 12*	5 - 9 (7) *n = 4*	16 - 71 (36) *n = 4*	265 - 644 (376) *n = 4*	1.5 - 5.0 (3.0) *n = 4*
Long Term Avg		**4.6** **(1990-2016)**	**8** **(1996-2016)**	**24** **(1996-2016)**	**332** **(2014-2016)**	**3.0** **(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.
- DOE = Washington Department of Ecology
- "Surface" samples are from 1 meter depth and "bottom" samples are from 1-2 meters above the bottom.