LAKE KI

REPORT DESCRIPTION

This report is an update on the health of Lake Ki 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 Lake Ki, please visit www.lakes.surfacewater.info or call SWM at 425-388-3464.

LAKE DESCRIPTION

Lake Ki is a 100-acre lake located in the Seven Lakes area north of the Tulalip Reservation. The lake is fed mainly by groundwater. The outlet flows north to Fish Creek and eventually to the Stillaguamish River. Lake Ki is one of the deepest lakes in the county, with a maximum depth of 21 meters (69 feet) and an average depth of 10.1 meters (33 feet). The watershed, which is the land area that drains to the lake, is small, only 5.2 times the size of the lake, so there is less potential for pollution from the watershed compared to a lake with a large watershed. However, dense residential development surrounds the shoreline of Lake Ki, which can affect water quality. Development is also increasing in the watershed.

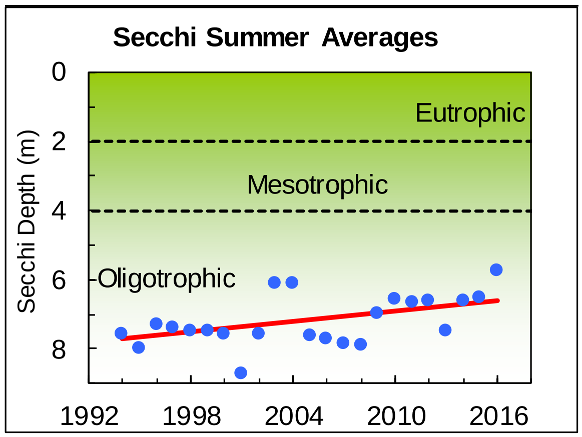
LAKE CONDITIONS

The following graphs illustrate the summer averages and trend lines (in red) for water clarity, total phosphorus, and chlorophyll *a* for Lake Ki. 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 Ki is high (the best in Snohomish County), with a long-term 1992 - 2016 summer average of 7.2 meters (24 feet). Water clarity has been quite variable since 2001. The 2016 summer average of 5.7 meters was the poorest on record. Despite the variability, overall there is a weak, but statistically significant trend in decreasing water clarity between 1992 and 2016 (p=0.03).



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 Ki averaged only 5 pcu (platinum-cobalt color units) in 2010 – 2011, the same as in 1994-95. This value indicates a very slight amount of color in the lake water. This slight color is not enough to have a significant effect on water clarity or algae growth in the lake.

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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 2013 (the most recent available data), temperature measurements were taken at each meter throughout the Lake Ki water column (see graph). Temperature profiles for 2013 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 65˚F (18°C) in temperature, and by August had reached their peak at 75°F (24°C). At the same time, bottom water temperatures changed only a little and remained around 44-46°F (7-8°C). The upper waters cooled down in September and October. Through the 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 Ki water column from May through October 2013 (see graph). Oxygen levels were relatively high in the upper waters from May through October. Through most of the summer, there was also a sharp increase in dissolved oxygen levels between about 20 and 30 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 the bottom waters from early to mid-summer. By June, there was little or no oxygen in the water below about 40 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.

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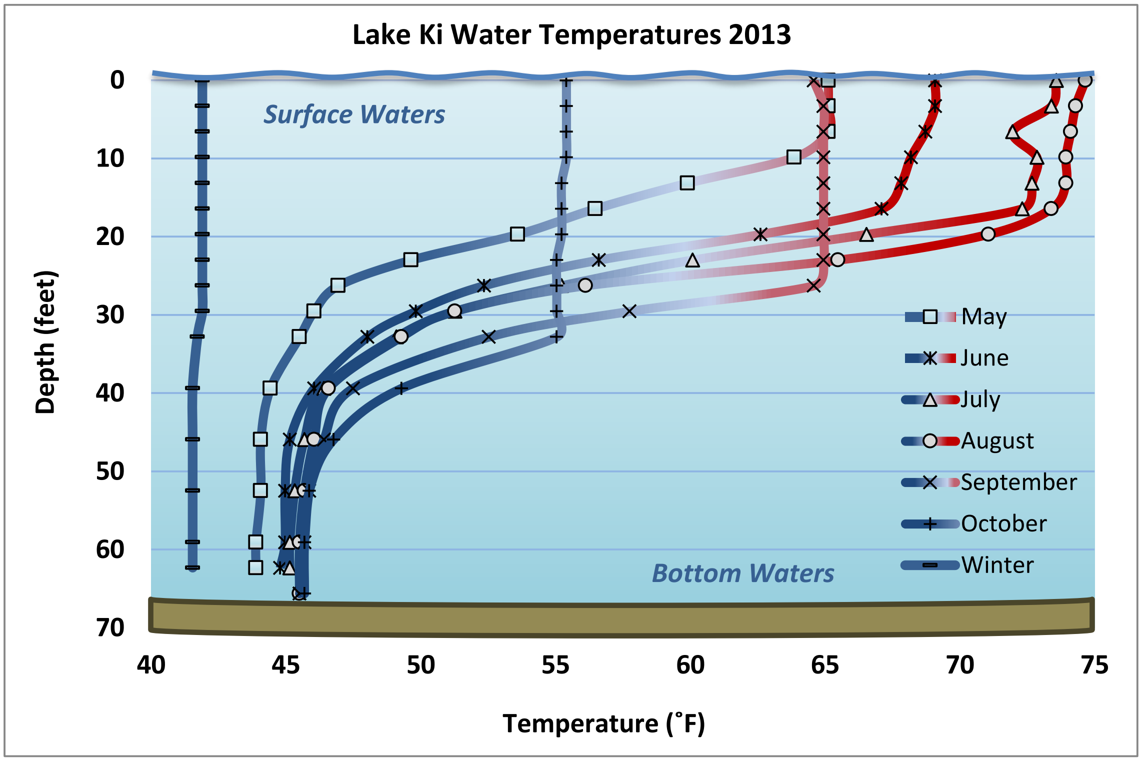
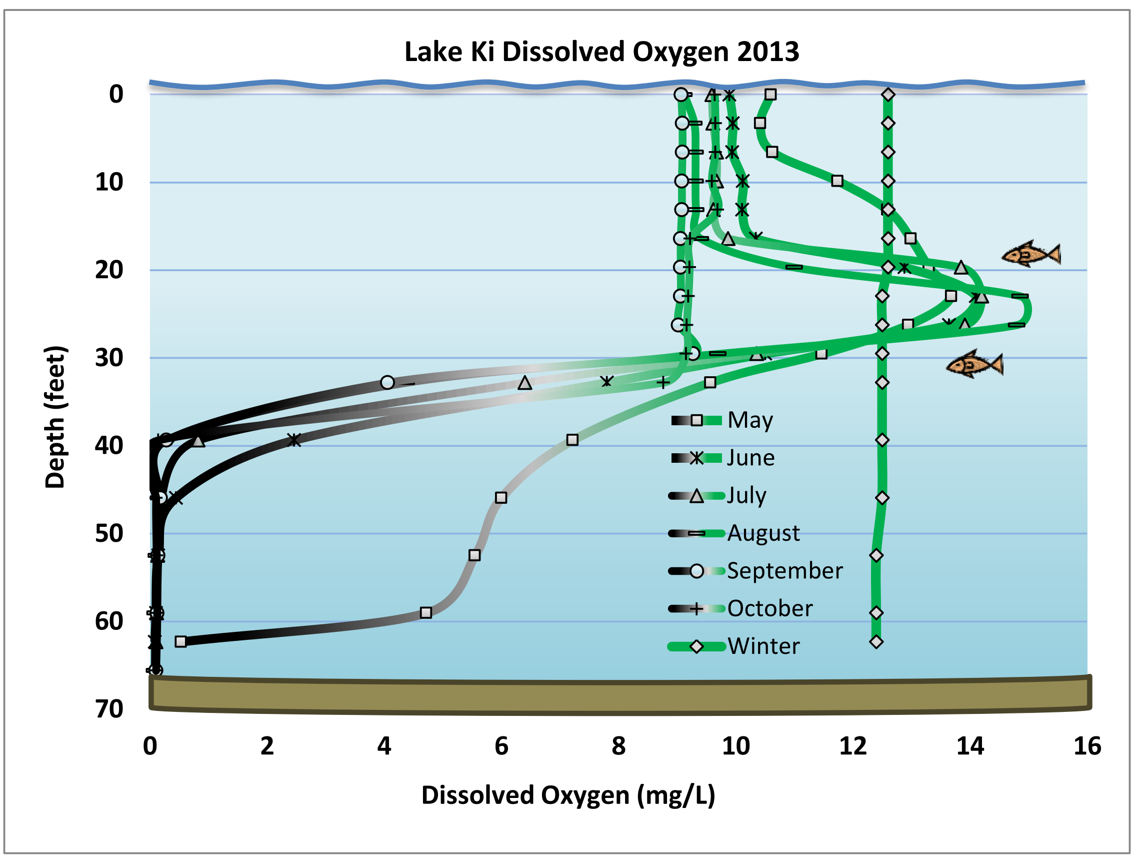

Lake Ki Water Temperatures 2013
Surface Waters
Bottom Waters
Depth (feet)
0
10
20
30
40
50
60
70
40
45
50
55
60
65
70
75
Temperature (˚F)
May
June
July
August
September
October
Winter


Lake Ki Dissolved Oxygen 2013
Depth (feet)
0
10
20
30
40
50
60
70
0
2
4
6
8
10
12
14
16
Dissolved Oxygen (mg/L)
May
June
July
August
September
October
Winter

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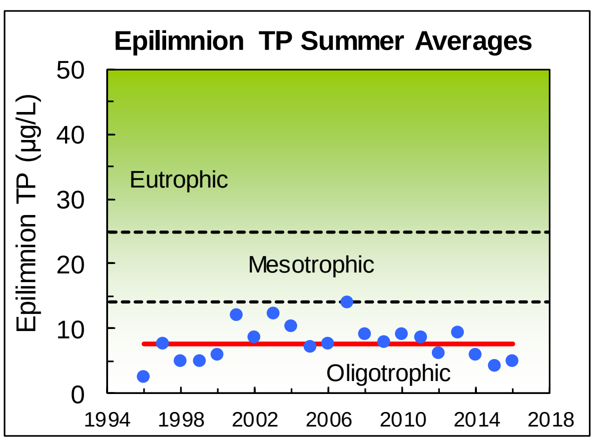
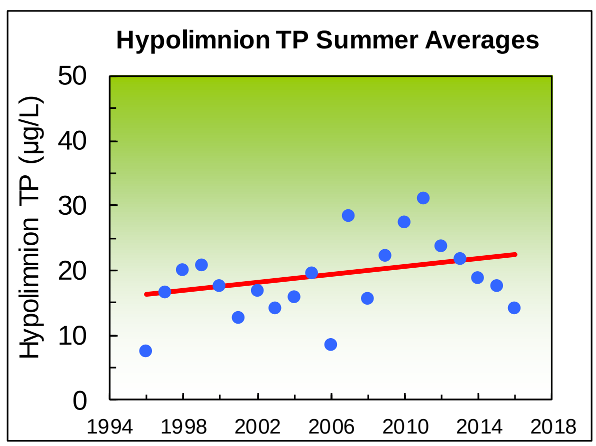
Phosphorus (key nutrient for algae)

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 Lake Ki are quite low compared to most lakes, with a long-term 1996 to 2016 summer average of only 8 µg/L (micrograms per liter, which is equivalent to parts per billion). There has been no statistically significant trend in phosphorus levels in the upper waters between 1996 and 2016. However, phosphorus levels were higher in some years. More phosphorus can lead to excess algae growth in the lake and lower the water clarity.

Summertime phosphorus averages in the hypolimnion (bottom waters) are higher than in the epilimnion, but still lower than in most lakes. The 1996 - 2016 long-term summer average for the hypolimnion is 19 µg/L. Although the summer averages are quite variable from year to year, between 1996 and 2015 there was a statistically significant trend toward increasing phosphorus concentrations in the hypolimnion ($p=0.07$). This trend is no longer apparent, and hypolimnion averages have been decreasing since 2012. In 2011, average summertime phosphorus concentrations reached the highest levels on record, 31 µg/L. Even though the concentrations of phosphorus are low, an increasing trend of phosphorus in the bottom waters suggests that the lake sediments may be releasing phosphorus into the water during the summer when dissolved oxygen levels drop in the bottom waters. More phosphorus in the bottom waters can contribute to excess algae growth in future years.

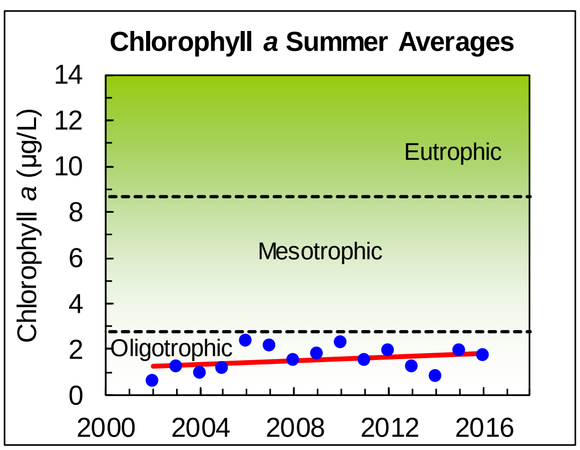




Chlorophyll a (Algae)

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 low levels of algae in the summers of 2002 through 2016, with a long-term average of only 1.6 µg/L. This is lower than nearly all other lakes in Snohomish County. Although the chlorophyll *a* averages have been higher in some years, overall between 2002 and 2016, there has not been a statistically significant increase in chlorophyll *a* levels. More algae growth may be a response to higher phosphorus levels in the lake. Fortunately, there have been only a few observations of algae blooms, or dense growths of algae, in the lake through the years. However, in April 2014, there was a dense bloom of blue-green algae concentrated along the northwest shore of the lake. The algae bloom may have been in response to heavy rains washing in pollution from the surrounding area.



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 Ki had relatively low levels of total nitrogen (summer averaged of 322 µg/L). This is consistent with the low 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, Lake Ki had a high average N:P ratio of 64, and blue green algae blooms are not common in the lake.

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. 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 Ki shoreline is highly developed. There were 82 homes or cabins around the lake in 1974. By the mid-90s, there were 90 homes bordering the lake. There are also 93 docks present on the lake. Accompanying the high development, there were significant structural modifications to the shoreline.

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Fifty percent of the 2.0 mile shoreline has been armored with either bulkheads (48% of the armoring), wood or rock revetments (25%), or fill material and boat ramps (26%). The vegetation zone immediately adjacent to the shoreline has also been significantly altered, with only 32% of the native vegetation remaining intact. 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 only a small amount of large wood (about 41 pieces) remaining in the lake. These old logs and branches are valuable for fish and wildlife habitat.

The overall amount of shoreline modification leaves the lake more susceptible to pollution from the watershed, eliminates the buffer of native vegetation that can filter out pollution, and limits the amount of habitat available for fish and wildlife.

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 Ki may be classified as oligotrophic with high water clarity and low phosphorus and chlorophyll *a* concentrations. The lake produces low amounts of algae and aquatic plants.

Condition and Trends

Overall, Lake Ki is in excellent condition, although there is some evidence of water quality changes. The long-term water clarity average has fallen below the water quality target of 7.7 meters and has a statistically significant declining trend. In addition, the long-term average summer phosphorus levels have been slowly creeping up. Even though these levels are still quite low, until 2015 there was a statistically significant trend toward increasing phosphorus concentrations in the bottom waters. Moreover, chlorophyll *a* averages have been higher in some years. These changes in phosphorus and chlorophyll *a* levels may be signs of accelerating eutrophication that could fuel the growth of more algae and plants and endanger this naturally clear lake. For these reasons, Lake Ki is at risk of future water quality problems unless improvements are made.

In order to protect and improve the quality of Lake Ki, actions should be taken to prevent any future negative impacts to the lake. Increased levels of nutrients in the lake can be caused by development and other human activities. To find out more about the causes and problems of elevated lake nutrient levels and tips to improve lake water quality visit www.lakes.surfacewater.info.

DATA SUMMARY FOR LAKE KI						
		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	**6/20/74**	3.7	7	19	-	-
Sumioka and Dion, 1985	**7/6/81**	4.3	10	90	-	2.2 -
Entranco, 1986	**1983**	4.8 - 6.5 (5.8) *n = 5*	<5 (<5) *n = 5*	7 - 14 (10) *n = 5*	-	0.4 - 2.9 (1.8) *n = 5*
Volunteer	**1992**	7.0 - 9.8 (8.1) *n = 6*	-	-	-	-
Volunteer or DOE	**1993**	6.1 - 9.3 (7.1) *n = 13*	-	-	-	1.7 - 3.0 (2.4) *n = 2*
SWM Staff or DOE	**1994**	7.0 - 8.9 (7.6) *n = 14*	-	-	-	1.9 - 10 (4.9) *n = 3*
SWM Staff or DOE	**1995**	7.0 - 9.4 (8.0) *n = 12*	-	-	-	1.3 - 2.0 (1.7) *n = 3*
SWM Staff or DOE	**1996**	6.7 - 8.1 (7.3) *n = 11*	<2 - 3 (2) *n = 2*	7 - 8 (8) *n = 2*	-	1.8 - 2.1 (2.0) *n = 2*
SWM Staff or DOE	**1997**	4.2 - 8.8 (7.4) *n = 9*	4 - 11 (8) *n = 2*	16 - 17 (17) *n = 2*	-	-
SWM Staff	**1998**	6.8 - 8.2 (7.5) *n = 4*	3 - 10 (5) *n = 4*	15 - 26 (20) *n = 4*	-	-
SWM Staff	**1999**	6.0 - 8.6 (7.5) *n = 4*	4 - 6 (5) *n = 4*	15 - 30 (21) *n = 4*	-	-
SWM Staff	**2000**	7.1 - 7.9 (7.6) *n = 4*	4 - 10 (6) *n = 4*	15 - 21 (18) *n = 4*	-	-
Volunteer	**2001**	8.0 - 9.5 (8.7) *n = 7*	8 - 18 (12) *n = 4*	6 - 26 (13) *n = 4*	-	-
Volunteer	**2002**	6.3 - 9.2 (7.6) *n = 5*	5 - 10 (9) *n = 4*	8 - 27 (17) *n = 4*	-	0.1 - 1.6 (0.6) *n = 4*
Volunteer	**2003**	4.6 - 7.3 (6.1) *n = 5*	10 - 15 (12) *n = 4*	10 - 18 (14) *n = 3*	-	0.8 - 2.1 (1.3) *n = 4*
Volunteer	**2004**	2.0 - 8.5 (6.1) *n = 5*	6 - 13 (10) *n = 4*	7 - 22 (16) *n = 4*	-	0.5 - 1.6 (1.0) *n = 4*

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DATA SUMMARY FOR LAKE KI

Source	Date	Water Clarity (Secchi depth in meters)	Total Phosphorus (µg/L) Surface	Total Phosphorus (µg/L) Bottom	Total Nitrogen (µg/L) Surface	Chlorophyll *a* (µg/L) Surface
Volunteer	**2005**	7.2 - 8.3 (7.6) *n = 5*	4 - 10 (7) *n = 4*	4 - 44 (20) *n = 4*	-	1.0 - 1.3 (1.2) *n = 4*
Volunteer	**2006**	6.9 - 8.2 (7.7) *n = 5*	7 - 9 (8) *n = 4*	5 - 14 (9) *n = 4*	-	1.3 - 4.3 (2.4) *n = 4*
Volunteer	**2007**	7.7 - 8.0 (7.9) *n = 5*	10 - 26 (14) *n = 4*	14 - 42 (28) *n = 4*	-	0.8 - 4 (2.2) *n = 4*
Volunteer	**2008**	6.0 - 9.9 (7.9) *n = 5*	6 - 11 (9) *n = 4*	9 - 26 (16) *n = 4*	-	1.1 - 2.1 (1.5) *n = 4*
Volunteer	**2009**	5.1 - 8.3 (7.0) *n = 11*	6 - 10 (8) *n = 4*	19 - 25 (22) *n = 4*	-	1.3 - 3.2 (1.9) *n = 4*
Volunteer	**2010**	6.2 - 8.0 (6.6) *n = 12*	6 - 14 (9) *n = 4*	24 - 30 (27) *n = 4*	-	1.1 - 3.7 (2.3) *n = 3*
Volunteer	**2011**	4.6 - 8.9 (6.6) *n = 12*	7 - 10 (9) *n = 4*	21 - 46 (31) *n = 4*	-	1.1 - 2.1 (1.5) *n = 4*
Volunteer	**2012**	4.3 - 8.4 (6.6) *n = 9*	5 - 7 (6) *n = 4*	18 - 31 (24) *n = 4*	-	0.4 - 4.8 (2.0) *n = 4*
Volunteer	**2013**	4.2 - 9.5 (7.7) *n = 13*	6 - 13 (9) *n = 4*	16 - 27 (22) *n = 4*	-	0.5 - 2.1 (1.3) *n = 4*
Volunteer	**2014**	4.6 - 8.1 (6.6) *n = 10*	4 - 8 (6) *n = 4*	14 - 21 (19) *n = 4*	224 - 448 (344) *n = 4*	0.50 - 1.6 (0.80) *n = 4*
Volunteer	**2015**	*5.8 - 7.5* *(6.5)* *n = 9*	*2 - 7* *(4)* *n = 4*	*13 - 22* *(18)* *n = 4*	*184 - 361* *(263)* *n = 4*	*0.80 - 3.2* *(1.9)* *n = 4*
Volunteer	**2016**	4.1 - 9.0 (5.7) *n = 10*	4 - 7 (5) *n = 4*	12 - 16 (14) *n = 4*	286 - 476 (361) *n = 4*	0.50 - 3.1 (1.8) *n = 4*
Long Term Avg		**7.2** **(1992-2016)**	**8** **(1996-2016)**	**19** **(1996-2016)**	**322** **(2014-2016)**	**1.6** **(2002-2016)**
TRENDS		**Decreasing**	**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.