LAKE MARTHA (MARTHA N.)

REPORT DESCRIPTION

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

LAKE DESCRIPTION

Lake Martha is a 63-acre lake located in the Seven Lakes area north of the Tulalip Reservation. It is fed by runoff from Lake Howard and empties into an unnamed stream that discharges to Port Susan near Warm Beach. Lake Martha is one of the deeper lakes in the county, with a maximum depth of 21.3 meters (70 feet) and an average depth of 10.1 meters (33 feet).

The total watershed, which is the land area that drains to the lake, including the drainage area from Lake Howard, is large—about 17 times the size of the lake. There are over 70 homes clustered around the lake shore. Much of the overall watershed is still undeveloped, but more development is anticipated, including the possibility of a large planned development north and east of the lake. Future land use changes could have an impact on the water quality of the lake.

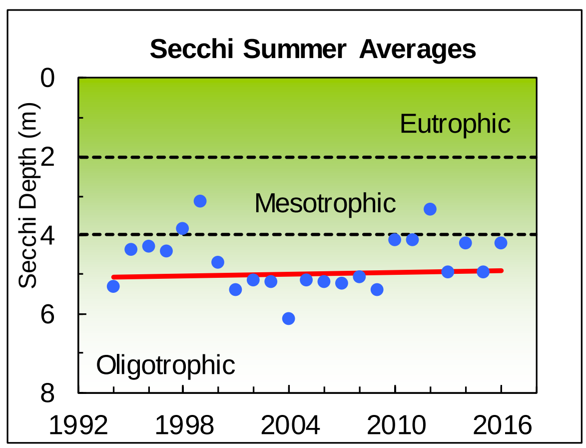
LAKE CONDITIONS

The following graphs illustrate the summer averages and trend lines (shown in red) for water clarity, total phosphorus, and chlorophyll *a* for Lake Martha. 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 Martha is high and variable, with a long-term 1990 - 2016 summer average of 4.7 meters (15.4 feet). There was a sharp decline in water clarity between 1994 and 1999, suggesting that the lake was receiving more nutrients from the watershed and producing more algae. However, the water clarity was better in 2000 through 2009, averaging around 5.3 meters in most years. Since 2009, the water clarity has been quite variable. Although there has been no statistically significant trend in water clarity between 1990 and 2016, the lower water clarity in some years may reflect increased algae levels. Changes in the natural color of the lake water may also be affecting water clarity measurements in some years.



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 Martha averaged 24 pcu (platinum-cobalt color units) in 2010 – 2011, which indicates a slight to moderate amount of color in the lake water. This is an increase in color from the 1994 – 1995 average of 13 pcu. It is possible that changes in water color related to the amount of rainfall in particular years may be one factor affecting the variations in 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 May through October 2011 (the most recent year of available data), temperature was measured at each meter throughout the Lake Martha water column. The temperature data show that the lake was strongly thermally stratified during the entire warm weather period (see graph). This means that there was a strong temperature difference between the warm upper waters and the cool bottom waters, and mixing did not occur between these layers. By May the upper waters were already significantly warmer than the lower waters. The upper waters reached a peak in temperature in August of 71°F (22°C). Over the same time period, bottom water temperatures changed only a little, remaining around 43°F (6°C). In September and October the upper waters began to cool. During the fall, cooling will continue 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.

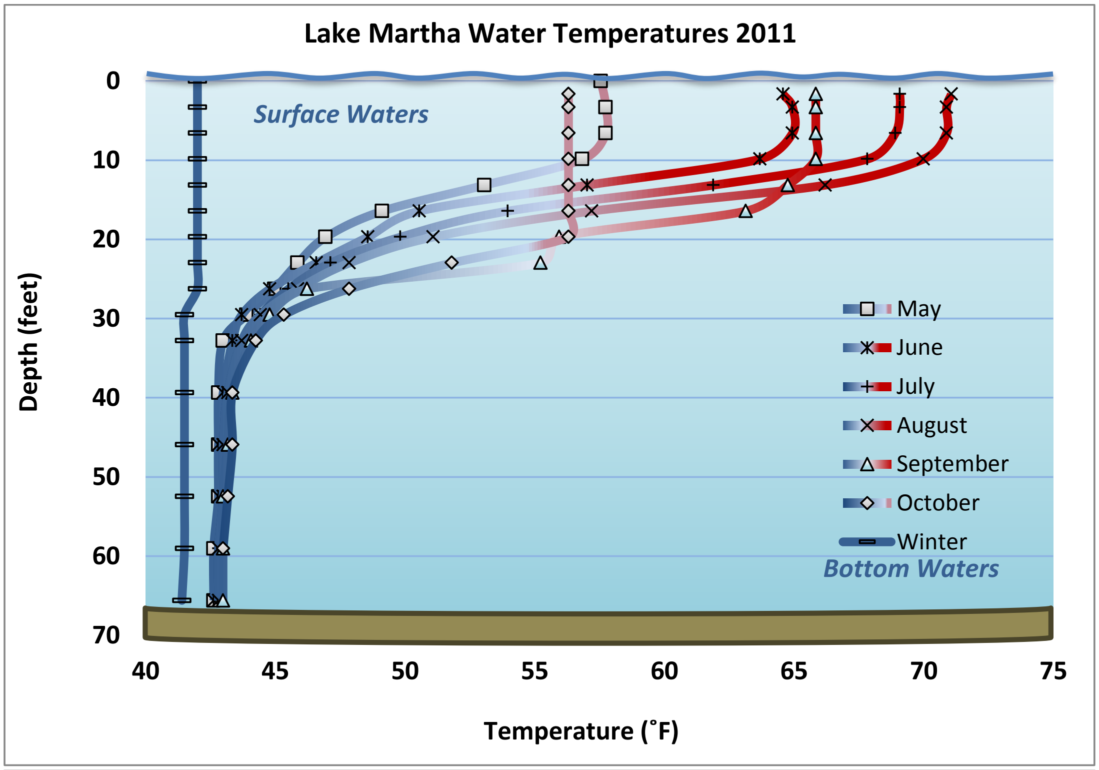
Dissolved Oxygen

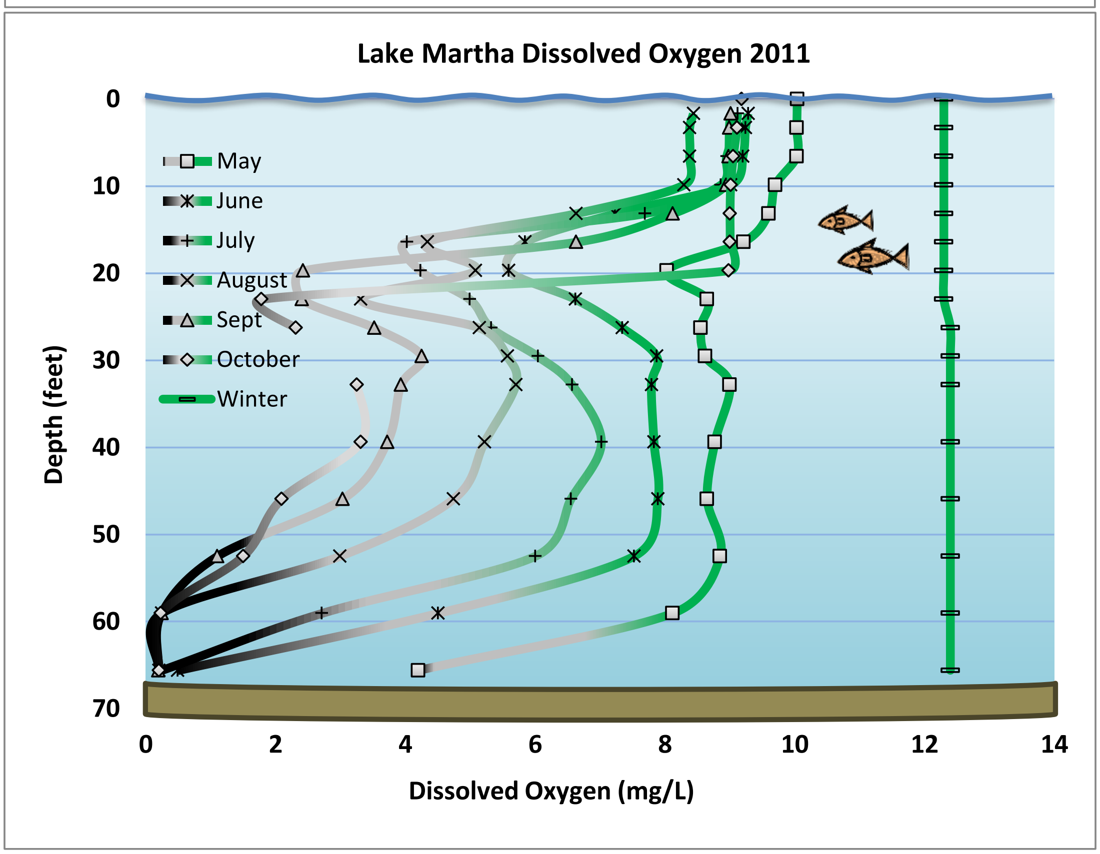
Oxygen dissolved in the water is essential for life in a lake. Most of the dissolved oxygen comes from the atmosphere. Like temperature, dissolved oxygen levels vary over time and with depth. During the warm months, the upper waters receive oxygen from the atmosphere, but the lower waters cannot be replenished 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.

The depth profiles of dissolved oxygen in 2011 largely mirror the temperature profiles seen during that time period (see graph). In May, oxygen levels were high throughout most of the lake. Dissolved oxygen levels near the lake bottom steadily declined through the summer. By August, there was little or no oxygen in the water below 55 feet. During the stratified summer period, oxygen in the lower waters of the lake is consumed by the decomposition of organic material within the lake. Since Lake Martha is strongly stratified, the oxygen is not replenished by the overlying oxygen-rich upper waters or by the atmosphere. Through the summer and fall, dissolved oxygen levels slowly decline in the bottom waters. When the lake cools in the fall and winter, the lake will eventually mix or turnover, and dissolved oxygen will be replenished throughout the lake. 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 after turnover or the next spring.

Between June and October, there was a persistent pattern of lower dissolved oxygen around 15 – 25 feet deep coupled with an increase in dissolved oxygen immediately below that depth. The reasons for this phenomenon (which is seen every year) may be slow settling and decomposition of organic matter, an abundance of zooplankton (tiny animals) at this depth, and/or the shape of the lake which causes much of the lake bottom decomposition to occur at this depth.

LAKE MARTHA (MARTHA N.)





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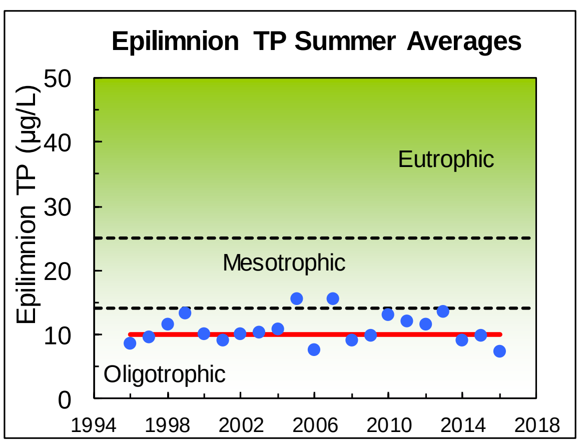
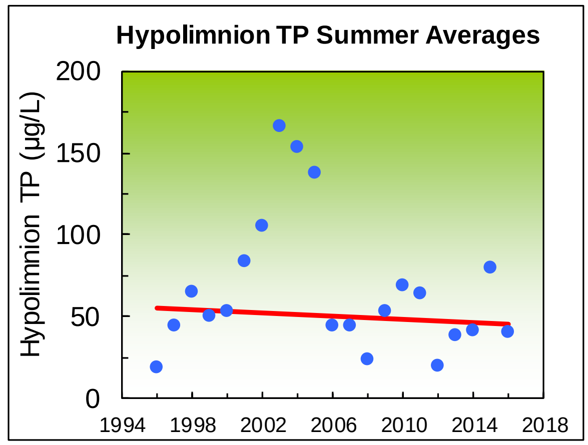
Phosphorus (key nutrient for algae)

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 Martha are relatively low, with a long-term 1996 to 2016 summer average of 11 µg/L (micrograms per liter, which is equivalent to parts per billion). The average phosphorus concentrations in 2005 and 2007 were higher at 16 µg/L. However, during most years, the averages have been close to the long-term average. Overall, there is no evidence of a trend toward higher phosphorus concentrations in the epilimnion between 1996 and 2016.



In contrast, summertime phosphorus levels in the hypolimnion (bottom waters) are much higher and quite variable, with a long-term 1996 - 2016 summer average of 67 µg/L. Between 1996 and 2005, there appeared to be a strong trend toward increasing phosphorus in the bottom waters. However, lower values in 2006 through 2016 have eliminated evidence of an overall trend. Higher phosphorus levels in the bottom waters can indicate a build-up of phosphorus being released from the bottom sediments during periods of low dissolved oxygen. If this occurs, it would point to accelerated eutrophication and could lead to future algae problems. The recent lower levels may be an indication of stabilizing lake conditions and reductions in nutrients coming from the watershed.



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 to moderate levels of algae in Lake Martha during the summers of 2002 through 2016, with a long-term average concentration of 3.1 µg/L. However, dense blue-green algae blooms are sometimes reported in the lake, and the levels of chlorophyll *a* were higher from 2010 through 2012. Overall, there is no statistically significant trend toward increasing chlorophyll *a* concentrations in Lake Martha.

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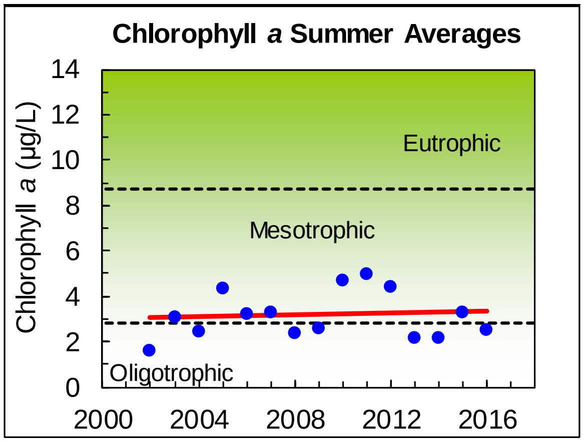

Toxic Blue-Green Algae (Cyanobacteria)

Blue-green algae, also called cyanobacteria, are a group of algae capable of producing toxins during periods of high growth, known as algae blooms. The toxins can cause serious illness in people and pets that come into contact with affected water. Blooms often look like blue or green paint floating on the 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 is identified as toxic, the lake will be posted with signs at the public access site.

Since 2005, volunteers and SWM staff have screened algae at Lake Martha for potentially toxic blooms. From 2009 -2011, routine toxin testing at Lake Martha also occurred 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 microcystis (a liver toxin) and anatoxin-a (a neurotoxin). Tests for saxitoxin (a neurotoxin) and cylindrospermopsin (a liver toxin) were also conducted in 2010 and 2011. From 2009 through 2011, Martha Lake did have a few blooms of blue-green algae. However, sample concentrations were well below the recreational guidelines, 6 µg/L for microcystins and 1 µg/L for anatoxin, set by the Washington State Department of Health.

No significant blue-green algae blooms were reported in 2012 through 2016. Continued screening in 2017 will help to alert the public to potential health risks as well as determine the frequency and severity of the toxic algae blooms at Lake Martha.

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 Martha had moderate levels of total nitrogen (summer average of 399 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 Martha had a relatively moderate average N:P ratio of 46, and blue green algae blooms were not a problem in 2016.

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SHORELINE CONDITION

The condition of the lake shoreline is important to understanding overall lake health. As development on a lake increases, lake shorelines typically are modified through removal of natural vegetation, the installation of bulkheads or other hardening structures, and/or the removal of large 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.

The Lake Martha shoreline is moderate to highly developed. Surveys conducted in the mid-90s identified 74 homes bordering the lake, with an average of 7.5 homes per 1000 feet of shoreline. There are also 79 docks present on the lake. Approximately 38% of the 1.9 miles of shoreline has been modified with bulkheads, rock or log revetments, or fill. Much of the native vegetation immediately adjacent to the shoreline has also been significantly altered, with only 34% now being classified as intact. There is still a moderate amount (about 129 pieces) of large wood 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 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. The loss of native vegetation along the shoreline could 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 Martha may be classified as mesotrophic, with high water clarity, low phosphorus levels in the epilimnion, higher phosphorus in the hypolimnion, low to moderate algae concentrations, and moderate oxygen depletion.

LAKE MARTHA (MARTHA N.)

Condition and Trends

Water clarity in Lake Martha is good. Although water clarity has been lower in some years, there is no evidence of a statistical trend. The lake is currently exceeding the long-term water clarity target of 4.6 meters.

The lake is also meeting the target of maintaining stable phosphorus levels in the upper waters. The phosphorus levels in the epilimnion have remained low with no evident trends.

The target of maintaining stable total phosphorus levels in the hypolimnion is not being fully met because phosphorus concentrations in the bottom waters have been quite variable. Also, the long-term average concentration of phosphorus has been slowly increasing. Although phosphorus levels in the hypolimnion have been lower since 2006, and there is no evidence of a statistical trend toward higher phosphorus in the hypolimnion, it is too early to know if lake conditions will be stable over the long term. Higher phosphorus levels in the bottom waters may be an indication of accelerating eutrophication, which could be an early warning sign of future increases in algae growth in the lake.

Overall, Lake Martha is in good condition. However, the lake is at risk of future water quality declines as indicated by high phosphorus levels in the hypolimnion and higher chlorophyll *a* levels in some years. Lake Martha is susceptible to an increase of nutrients in stormwater runoff from new development and from other human activities in the watershed. Measures to control nutrients in the watershed should be taken now and as new development occurs 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 SWM's web site at www.lakes.surfacewater.info.

LAKE MARTHA (MARTHA N.)

DATA SUMMARY FOR LAKE MARTHA (N.)						
		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**	2.7	17	29	-	-
Sumioka and Dion, 1985	**6/30/81**	3.0	10	80	-	6
Entranco, 1986	**1983**	3.8 - 5.0 (4.4) *n = 5*	<5 - 7 (5.4) *n = 5*	<5 - 39 (18) *n = 5*	-	1.8 - 6.2 (3.1) *n = 5*
DOE	**1990**	3.1 - 5.2 (4.1) *n = 11*	-	-	-	-
DOE	**1991**	3.6 - 5.5 (4.5) *n = 9*	-	-	-	-
DOE	**1992**	3.6 - 6.1 (5.2) *n = 9*	-	-	-	0.6 - 1.9 (1.3) *n = 2*
DOE	**1993**	3.8 - 6.3 (5.4) *n = 11*	-	-	-	3.1 - 5.0 (4.1) *n = 2*
SWM Staff or DOE	**1994**	3.7 - 6.6 (5.3) *n = 12*	-	-	-	0.1 - 4.0 (2.3) *n = 4*
SWM Staff or DOE	**1995**	3.7 - 5.5 (4.4) *n = 12*	-	-	-	3.6 - 9.9 (6.6) *n = 3*
SWM Staff or DOE	**1996**	3.0 - 5.6 (4.3) *n = 12*	4 - 13 (9) *n = 2*	18 - 20 (19) *n = 2*	-	2.6 - 3.0 (2.8) *n = 2*
SWM Staff or DOE	**1997**	3.2 - 5.0 (4.4) *n = 13*	8 - 11 (10) *n = 2*	28 - 61 (45) *n = 2*	-	3.0
SWM Staff or DOE	**1998**	3.2 - 4.7 (3.8) *n = 12*	9 - 15 (12) *n = 4*	29 - 104 (65) *n = 4*	-	-
SWM Staff or DOE	**1999**	1.9 - 5.0 (3.1) *n = 18*	10 - 18 (13) *n = 4*	37 - 65 (51) *n =4*	-	3.2 - 11 (8.3) *n = 4*
SWM Staff or DOE	**2000**	4.0 - 5.3 (4.7) *n = 14*	8 - 14 (10) *n = 4*	28 - 75 (53) *n = 4*	-	-
Volunteer	**2001**	4.9 - 5.9 (5.4) *n = 10*	7 - 11 (9) *n = 4*	32 - 148 (84) *n = 4*	-	-
Volunteer	**2002**	4.3 - 6.2 (5.2) *n = 9*	8 - 12 (10) *n = 4*	24 - 204 (105) *n = 4*	-	0.5 - 3.5 (1.6) *n = 4*
Volunteer	**2003**	4.2 - 6.3 (5.2) *n = 10*	10 - 11 (10) *n = 4*	38 - 389 (166) *n = 4*	-	2.1 - 5.3 (3.1) *n = 4*

LAKE MARTHA (MARTHA N.)

DATA SUMMARY FOR LAKE MARTHA (N.)						
		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	**2004**	5.2 - 7.2 (6.2) *n = 9*	6 - 13 (11) *n = 4*	40 - 334 (154) *n = 3*	-	1.1 - 4.8 (2.4) *n = 4*
Volunteer	**2005**	3.9 - 6.1 (5.2) *n = 13*	8 - 30 (16) *n = 4*	51 - 254 (138) *n = 4*	-	1.6 - 12 (4.3) *n = 4*
Volunteer	**2006**	4.6 - 6.5 (5.2) *n = 12*	2 - 11 (8) *n = 4*	37 - 57 (45) *n = 3*	-	2.4 - 3.7 (3.2) *n = 4*
Volunteer	**2007**	3.2 - 6.4 (5.2) *n = 12*	12 - 23 (16) *n = 4*	26 - 62 (44) *n = 4*	-	1.6 - 5.3 (3.3) *n = 4*
Volunteer	**2008**	4.5 - 5.9 (5.1) *n = 11*	7 - 11 (9) *n = 3*	19 - 31 (23) *n = 3*	-	1.6 - 2.7 (2.3) *n = 3*
Volunteer	**2009**	4.0 - 6.3 (5.4) *n = 11*	7 - 15 (10) *n = 4*	37 - 66 (53) *n = 3*	-	1.9 - 4.0 (2.6) *n = 4*
Volunteer	**2010**	3.7 - 4.8 (4.1) *n = 8*	11 - 17 (13) *n = 4*	21 - 132 (69) *n = 4*	-	2.1 - 6.7 (4.7) *n = 4*
Volunteer	**2011**	3.3 - 5.6 (4.1) *n = 12*	10 - 15 (12) *n = 4*	48 - 85 (64) *n = 4*	-	3.4 - 9.0 (4.9) *n = 4*
Volunteer	**2012**	2.7 - 4.2 (3.4) *n = 12*	10 - 14 (12) *n = 4*	11 - 26 (19) *n = 4*	-	2.1 - 7.1 (4.4) *n = 4*
Volunteer	**2013**	3.9 - 6.1 (5.0) *n = 12*	11 - 18 (14) *n = 4*	27 - 61 (38) *n = 4*	-	1.6 - 3.2 (2.2) *n = 3*
Volunteer	**2014**	3.2 - 6.6 (4.2) *n = 10*	7 - 12 (9) *n = 4*	33 - 60 (42) *n = 4*	382 - 484 (443) *n = 4*	1.1 - 4.8 (2.2) *n = 4*
Volunteer	**2015**	*4.1 - 5.6* *(4.9)* *n = 12*	*8 - 13* *(10)* *n = 4*	*20 - 190* *(80)* *n = 4*	*309 - 343* *(329)* *n = 4*	*2.1 - 5.3* *(3.3)* *n = 4*
Volunteer	**2016**	3.4 - 4.7 (4.2) *n = 12*	6 - 9 (7) *n = 4*	26 - 58 (41) *n = 4*	303 - 545 (424) *n = 4*	1.6 - 3.8 (2.5) *n = 4*
Long Term Avg		**4.7** **(1990-2016)**	**11** **(1996-2016)**	**67** **(1996-2016)**	**399** **(2014-2016)**	**3.1** **(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.