MARTHA LAKE (MARTHA S.)

REPORT DESCRIPTION

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

LAKE DESCRIPTION

Martha Lake is a 62-acre lake located just east of I-5 between Lynnwood and Mill Creek. It is fed by two small streams and drains south into Martha Creek and eventually to Swamp Creek. Martha Lake has a maximum depth of 14.6 meters (48 feet) and an average depth of 7.3 meters (24 feet).

The Martha Lake watershed, which is the land area that drains to the lake, is less than 8 times the size of the lake, which should reduce the potential for pollution to impact the lake. However, the watershed is densely developed with urban uses, including the I-5 freeway, and more growth is under way. These land uses may contribute nutrients that adversely affect the health of the lake.

LAKE CONDITIONS

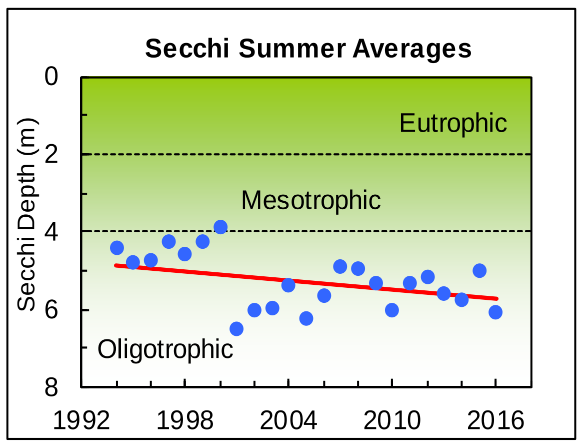
The following graphs illustrate the summer averages and trend lines (shown in red) for water clarity, total phosphorus, and chlorophyll *a* for Martha Lake. Please refer to the table at the end of the report for long-term averages and for averages and ranges for individual years.

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 Martha Lake is moderately high, with a 1990 - 2016 long-term summer average of 5.2 meters (17 feet). Between 1990 and 2000, water clarity was low and declining. Then between 2001 and 2016, the summer averages have been much better and more variable. The reasons for this dramatic improvement are unclear. There was no change in volunteers that may have affected the readings. Also, there is no evidence that algae levels were greater in the 1990s than in the 2000s. One factor that may affect the water clarity is less natural color in the water during recent years.

Between 1990 and 2016, there has been a statistically significant trend toward improving water clarity ($p=0.04$). This trend should be viewed cautiously because within each period (1990-2000 and 2001-2016) water clarity appears to be slowly declining. More years of monitoring are needed to see if a clearer pattern emerges.



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 Martha Lake averaged 9 pcu (platinum-cobalt color units) in 2010 – 2011, which indicates a slight amount of color in the lake water. This amount of color is not significant enough to have a large effect on water clarity or algae growth. However, there was a difference in water color between 2010 and 2011, with a 2010 average of 16.7 pcu and 2011 measurements averaging 3.8 pcu. This suggests that there may be sizeable fluctuations in water color from year to year. Changes in water color could affect the water clarity readings.

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 2016, temperature was measured at several depths throughout the Martha Lake water column. Selected temperature profiles for 2016 (see graph) show that the lake was beginning to stratify by May. 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. The upper waters gradually warmed up throughout the summer. By August, the upper waters had reached their peak at 73°F (23°C). At the same time, bottom water temperatures changed only a little and remained between 48-49°F (8-9°C) during the summer. By October, the upper waters were beginning to cool, and they will continue cooling through the fall. 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.

The depth profiles of dissolved oxygen measured in 2016 are similar to the temperature profiles seen during that time period (see graph). In May, the bottom waters were beginning to lose some of the oxygen. By June, dissolved oxygen was low near the lake bottom, but was very high, super-saturated, near the surface. From May through July, there was a sharp increase in dissolved oxygen levels about 15 feet deep. This indicates vigorous algae growth at that depth which added oxygen to the water.

From June through September, there was virtually no dissolved oxygen in the lake below about 22 feet deep. During the stratified 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 (usually 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 again in the bottom.

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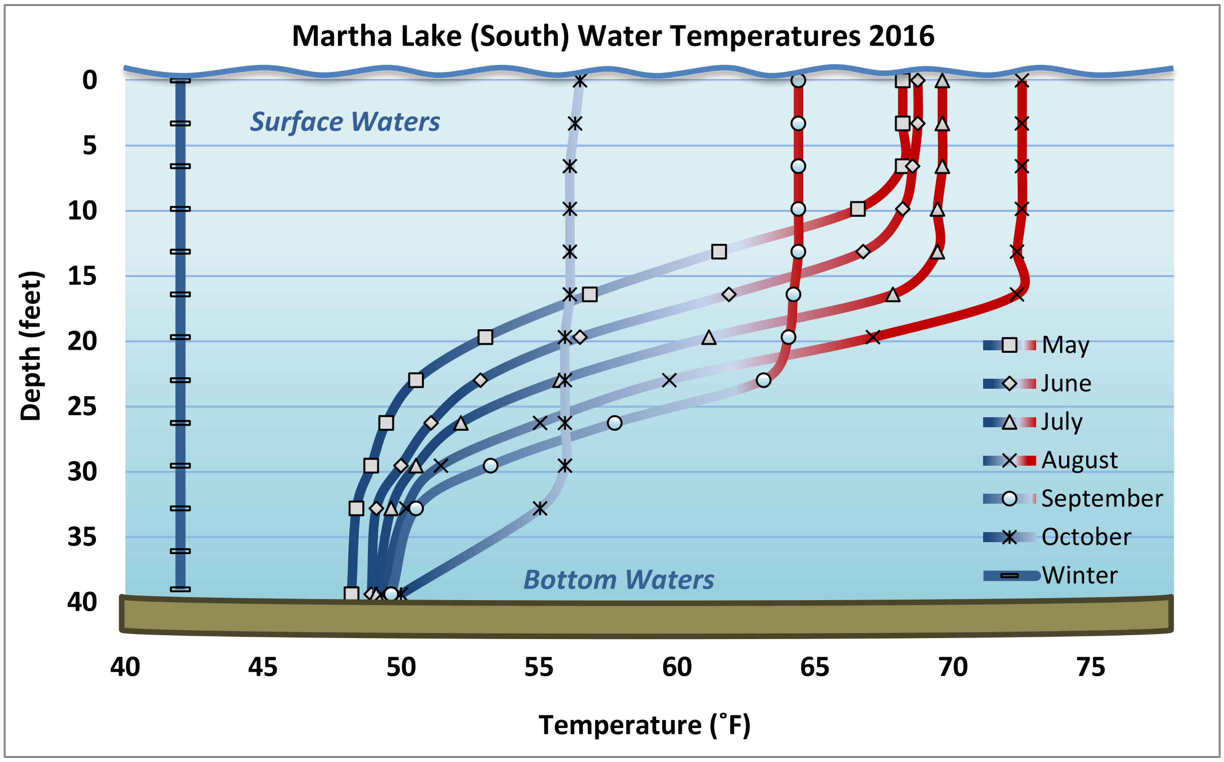

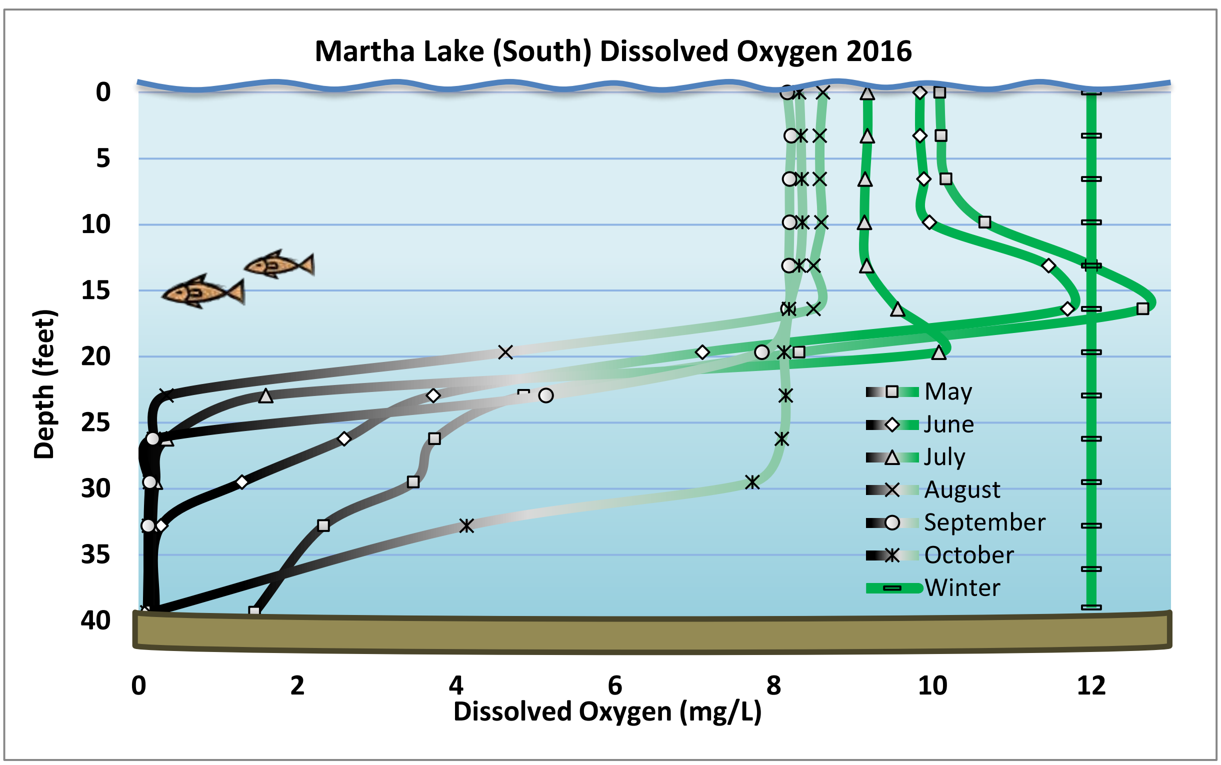

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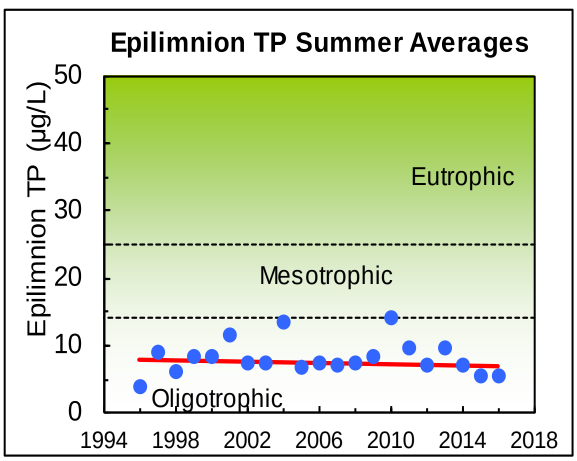
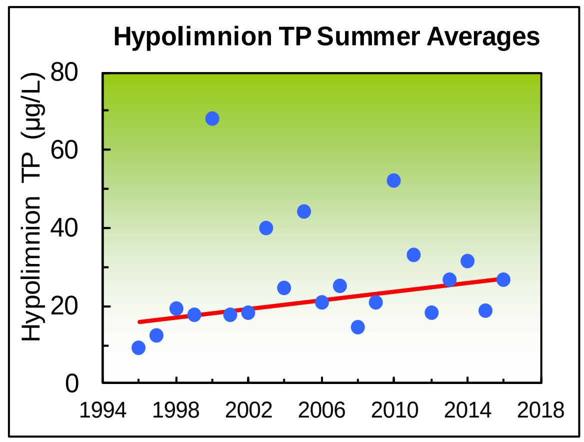
Phosphorus (key nutrient for algae)

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) are low. The long-term 1996 - 2016 summer average is 8 µg/L (micrograms per liter, which is equivalent to parts per billion). Except for 2001, 2004, and 2010, when the averages were somewhat higher, there has been little year-to-year variability in phosphorus levels. Overall, between 1996 and 2016, there has not been any discernible trend in phosphorus concentrations in the upper waters.



Summertime phosphorus concentrations in the hypolimnion (bottom waters) are higher and more variable than in the epilimnion. However, the phosphorus levels are still relatively low compared to many other lakes in Snohomish County. The long-term average is 27 µg/L for the 1996 - 2016 period. Averages in 2000, 2003, 2005, and 2010 were considerably higher than in other years. Even though there has been high variability, between 1996 and 2016 there is a statistically significant increasing trend in phosphorus levels in bottom waters ($p=0.07$). Higher phosphorus levels reflect a possible release of phosphorus from the bottom sediments during periods of low dissolved oxygen. The build-up of phosphorus in the bottom waters through time may be a sign of accelerating eutrophication and could lead to future increases in algae growth.



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* measurements show low to moderate levels of algae in Martha Lake. The long-term average for the summers of 2002 through 2016 is 2.5 µg/L. Occasional algae blooms have been observed in Martha Lake, but do not appear to cause substantial impacts to the use of the lake. There is no evidence of a long-term trend in chlorophyll *a* levels.

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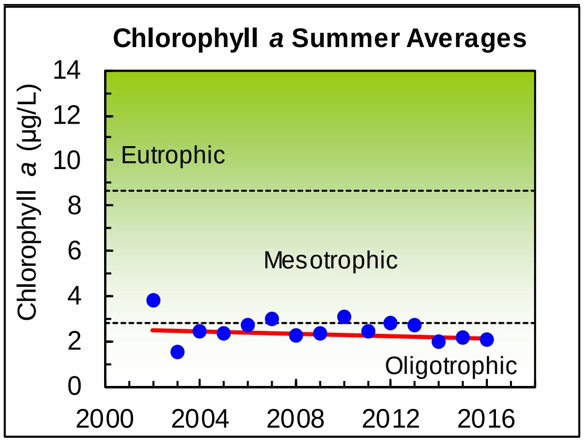

Nitrogen (another essential nutrient for algae)

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, Martha Lake had moderately low levels of total nitrogen (summer average of 350 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. Martha Lake had a high average N:P ratio of 55, and blue green algae blooms were not observed in 2016.

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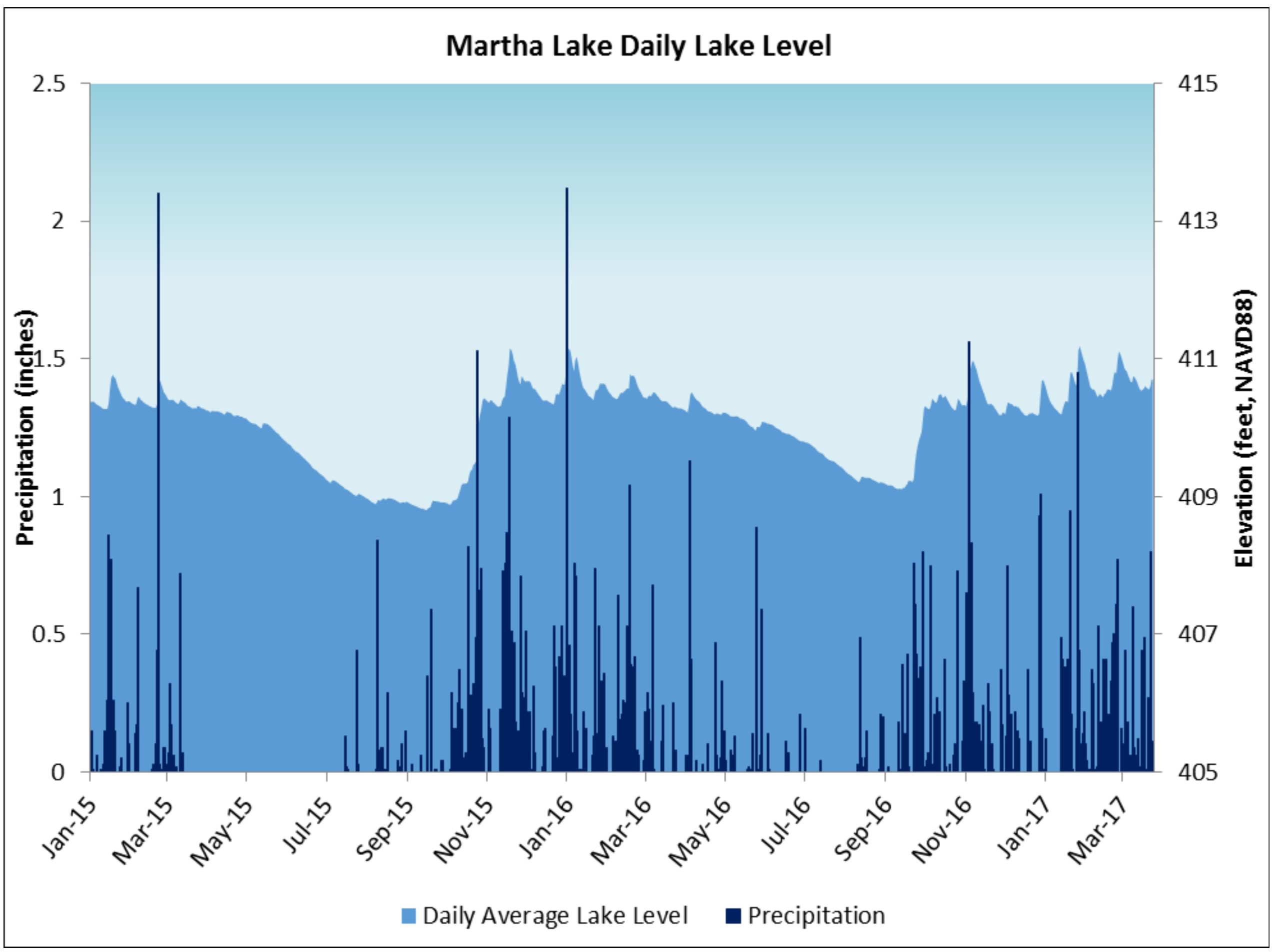
Lake Level

Lake level data tracks the amount of water in the lake and the balance between water coming in by streams, precipitation, groundwater and water leaving by evaporation or outflow. Lake levels in our region are highest in early spring and lowest in late summer and fall. The importance of lake level is to indicate the seasonal effects of the water balance in the lake. In addition to rainfall, lake levels can be affected by sedimentation, surrounding topography, beaver activity, plugged outlets, and the ratio of developed to undeveloped land in the watershed. Paved or impervious surfaces will create faster runoff and quickly rising lake levels during large rain events, while forests, wetlands, and pastures will slow down runoff and limit large rises in lake level

SWM installed a continuous gage at the fishing dock at the Martha Lake County Park in January 2015 to monitor lake levels year round. Lake data is recorded hourly as elevation in feet. The graph below shows the daily average lake level and daily total rainfall for Martha Lake from the time of installation through December 2015. The precipitation data used for graph was recorded at the Alderwood Water District Office located about 2 miles northwest of Martha Lake. The lake level fluctuated 2.1 feet in 2016. The summer was fairly dry and the lake level dropped. Heavy rains in in the fall resulted in large rises in the lake level.



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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.

Martha Lake has one of the most densely developed shorelines in the county. The number of homes along the shoreline increased from 85 in 1973 to 97 by the mid-90s. There are also 90 docks present, covering 0.8 acres of the lake. The lake shoreline also has the second highest level of shoreline modifications in the County—72% of the 1.6 miles of shoreline are armored. The armoring primarily consists of wood or stone revetments (50% of the armoring) and bulkheads (48%).

The zone of vegetation immediately adjacent to the shoreline has also been greatly altered, with only 16% being classified as intact native vegetation. In most 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. Fortunately, there is still a moderate amount of large wood (about 101 pieces) still remaining in the lake. These old logs and branches are valuable for fish and wildlife habitat.

The large amount of shoreline modification at Martha Lake 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.

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, Martha Lake may be classified as oligo-mesotrophic, with high water clarity and low to moderate phosphorus and chlorophyll *a* levels. This means the lake has low to moderate productivity of algae and aquatic plants.

Condition and Trends

The water quality targets for Martha Lake are to maintain stable water clarity and total phosphorus levels in the lake. With a trend toward improving water clarity, Martha Lake is exceeding the water clarity target.

Phosphorus levels in the epilimnion (upper waters) appear to be stable despite higher values in some years. However, the lake is not meeting the goal for phosphorus concentrations in the hypolimnion (bottom waters). The long-term summer average has increased from 23 µg/L to 27 µg/L in recent years; and there has been a long-term statistically significant trend toward increasing phosphorus concentrations in the bottom waters. This indicates that nutrients are building up from the release of phosphorus from the bottom sediments during periods of low dissolved oxygen.

Overall, Martha Lake is in good condition. But, the lake is at risk of future water quality declines. The increasing phosphorus levels in the hypolimnion raise concerns about accelerated eutrophication that may lead to more algae growth and reduced water clarity in the future.

The primary threat to lake water quality is an increase of nutrients entering the lake through new development and human activities in the watershed, particularly given the high amount of shoreline modification. 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.

MARTHA LAKE (MARTHA S.)

DATA SUMMARY FOR MARTHA LAKE (S.)						
		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**	4.0	3	9	-	-
Entranco, 1991 or DOE	**1990**	3.3 - 6.3 (5.0) *n = 22*	3 - 12 (7) *n = 11*	3 - 28 (17) *n = 11*	-	2.3 - 7.5 (4.3) *n = 11*
DOE	**1991**	4.3 - 5.5 (4.8) *n = 12*	-	-	-	-
Volunteer or DOE	**1992**	4.3 - 5.8 (4.9) *n = 11*	-	-	-	0.4 - 1.1 (0.8) *n = 2*
Volunteer or DOE	**1993**	3.4 - 7.3 (5.1) *n = 12*	-	-	-	1.1 (1.1) *n = 2*
Volunteer or DOE	**1994**	2.9 - 6.0 (4.4) *n = 10*	-	-	-	1.8 - 2.5 (2.2) *n = 2*
Volunteer or DOE	**1995**	3.9 - 6.0 (4.8) *n = 12*	-	-	-	1.9 - 2.8 2.4 *n = 2*
Volunteer or DOE	**1996**	3.7 - 5.8 (4.7) *n = 14*	3 - 5 (4) *n = 2*	6 - 12 (9) *n = 2*	-	2.1 - 3.9 (3.0) *n = 2*
SWM Staff, Volunteer or DOE	**1997**	3.1 - 5.6 (4.2) *n = 11*	5 - 13 (9) *n = 2*	10 - 15 (13) *n = 2*	-	2.0
SWM Staff, Volunteer or DOE	**1998**	3.8 - 6.0 (4.5) *n = 10*	5 - 8 (6) *n = 4*	15 - 22 (20) *n = 4*	-	-
SWM Staff or Volunteer	**1999**	3.3 - 5.7 (4.3) *n = 11*	7 - 10 (9) *n = 4*	12 - 21 (18) *n = 4*	-	-
SWM Staff or Volunteer	**2000**	3.1 - 4.4 (3.9) *n = 8*	7 - 10 (8) *n = 4*	16 - 199 (68)[a] *n = 4*	-	-
Volunteer	**2001**	5.5 - 6.9 (6.5) *n = 5*	7 - 22 (12) *n = 4*	14 - 20 (18) *n = 4*	-	-
SWM Staff	**2002**	4.2 - 7.5 (6.0) *n = 4*	6 - 10 (7) *n = 4*	12 - 30 (18) *n = 4*	-	0.9 - 12 (3.8) *n = 4*
Volunteer	**2003**	4.0 - 10.1 (5.9) *n = 9*	6 - 11 (8) *n = 4*	19 - 77 (40) *n = 4*	-	1.1 - 2.4 (1.5) *n = 4*
Volunteer	**2004**	3.2 - 7.1 (5.4) *n = 5*	8 - 24 (14) *n = 4*	18 - 29 (24) *n = 3*	-	1.1 - 4.8 (2.4) *n = 4*

MARTHA LAKE (MARTHA S.)

DATA SUMMARY FOR MARTHA LAKE (S.)						
		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	**2005**	4.2 - 8.2 (6.2) *n = 12*	5 - 9 (7) *n = 4*	15 - 79 (44) *n = 4*	-	1.9 - 2.9 (2.3) *n = 3*
Volunteer	**2006**	3.7 - 7.3 (5.7) *n = 15*	5 - 9 (7) *n = 4*	9 - 36 (21) *n = 4*	-	1.6 - 3.7 (2.7) *n = 4*
Volunteer	**2007**	3.4 - 6.6 (4.9) *n = 9*	5 - 10 (7) *n = 4*	21 - 27 (25) *n = 3*	-	2.1 - 4.3 (3.0) *n = 4*
Volunteer	**2008**	3.2 - 6.2 (5.0) *n = 12*	6 - 9 (7) *n = 4*	11 - 19 (14) *n = 4*	-	1.6 - 3.2 (2.2) *n = 4*
Volunteer	**2009**	4.2 - 6.4 (5.3) *n = 6*	6 - 11 (8) *n = 4*	13 - 29 (21) *n = 4*	-	1.4 - 4.3 (2.3) *n = 4*
Volunteer	**2010**	5.0 - 7.6 (6.0) *n = 9*	6 - 32 (14) *n = 4*	34 - 74 (52) *n = 4*	-	2.1 - 3.7 (3.1) *n = 4*
Volunteer	**2011**	4.0 - 6.1 (5.3) *n = 7*	8 - 11 (10) *n = 4*	12 - 48 (33) *n = 4*	-	0.7 - 3.8 (2.5) *n = 4*
Volunteer	**2012**	2.5 - 6.9 (5.1) *n = 4*	4 - 10 (7) *n = 4*	8 - 27 (18) *n = 4*	-	1.1 - 4.8 (2.8) *n = 4*
Volunteer	**2013**	5.1 - 6.2 (5.6) *n = 5*	7 - 11 (10) *n = 4*	18 - 33 (27) *n = 4*	-	1.6 - 3.9 (2.7) *n = 4*
Volunteer	**2014**	4.0 - 7.3 (5.8) *n = 10*	6 - 8 (7) *n = 4*	25 - 38 (32) *n = 4*	317 - 447 (388) *n = 4*	1.1 - 2.7 (2.0) *n = 4*
Volunteer	**2015**	*3.8 - 5.9* *(5.0)* *n = 12*	*3 - 7* *(6)* *n = 4*	*15 - 22* *(19)* *n = 4*	*242 - 397* *(307)* *n = 4*	*1.3 - 3.5* *(2.1)* *n = 4*
Volunteer	**2016**	4.6 - 8.4 (6.1) *n = 12*	4 - 9 (6) *n = 4*	12 - 40 (27) *n = 4*	234 - 577 (355) *n = 4*	1.2 - 3.5 (2.1) *n = 4*
Long Term Avg		**5.2** **(1990-2016)**	**8** **(1996-2016)**	**27** **(1996-2016)**	**350** **(1996-2016)**	**2.5** **(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.
- DOE = Washington Department of Ecology
- "Surface" samples are from 1 meter depth and "bottom" samples are from 1-2 meters above the bottom.

[a] Average is influenced by one high TP value.