LAKE CASSIDY

REPORT DESCRIPTION

This report is an update on the health of Lake Cassidy based on water quality data collected from 1992 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 Cassidy, please visit www.lakes.surfacewater.info or call SWM at 425-388-3464.

LAKE DESCRIPTION

Lake Cassidy is a 131-acre lake located north of Lake Stevens and east of Marysville. The lake is relatively shallow, with a maximum depth of 7.5 meters (25 feet) and an average depth of 3.4 meters (11 feet). The lake has a large watershed, which is the land area that drains to the lake. The watershed is almost 20 times the size of the lake, which increases the risk of pollution reaching the lake. There are about two dozen homes around the lake, but most of the shoreline is undeveloped. Snohomish County Parks has an access point on the east shore from the Centennial Trail.

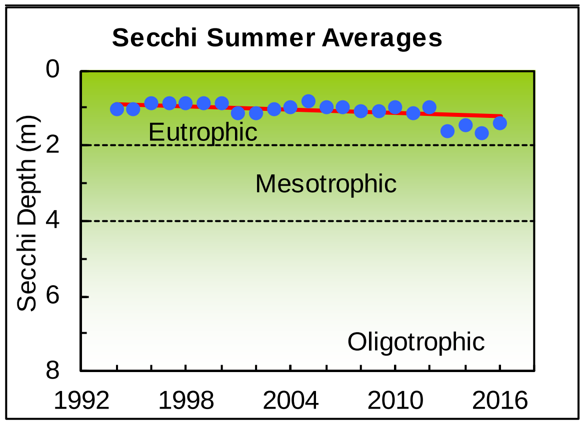
LAKE CONDITIONS

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

Lake Cassidy has low water clarity. The 1992 through 2016 long-term summer average is 1.1 meter (3.3 feet). Lake Cassidy, in fact, has the lowest water clarity of the 38 lakes monitored in Snohomish County. Water clarity in Lake Cassidy is poor because of dense algae and the lake's naturally dark water color. In recent years, water clarity has improved. Overall there is a small, but statistically significant toward improved water clarity in Lake Cassidy (p=0.01).



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 Cassidy averaged 160 pcu (platinum-cobalt color units) in 2010 - 2011. Lake Cassidy has the darkest water color of all the monitored lakes in Snohomish County, and the amount of color has increased from the 1994-1995 average of 133 pcu. Lake Cassidy's naturally dark color is one variable that contributes to very 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 June through September 2015, the most recent available data, temperature data were collected at each meter throughout the Lake Cassidy water column. The temperature data show that the lake was already thermally stratified in June and maintained strong stratification through August (see graph). 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 June the upper waters were already 74°F (21°C) warmer than the lower waters. The surface waters reached a temperature peak in June and July of 74°F (23°C) and then cooled down in September. At the same time, bottom water temperatures changed only a little, remaining around 54-58°F (12-14°C). Beginning in September, surface waters began to cool, and the lake became less thermally stratified. By winter the temperatures were equal from top to bottom. As the stratification weakened, the lake water turned over or mixed. Turnover occurs earlier in shallow lakes like Lake Cassidy. 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 measured in 2015 largely mirrored the temperature profiles seen during that time period (see graph). By June, there was very little oxygen near the lake bottom. Throughout the summer, there was essentially no dissolved oxygen in the lake below about 10 feet deep. During the stratified summer period, oxygen in the lower waters is consumed by the decomposition of organic material within the lake. Since the lake is strongly stratified, the oxygen is not replenished by the overlying oxygen-rich upper waters or by the atmosphere. By winter, the lake was almost fully mixed, and dissolved oxygen levels rose within the bottom waters.

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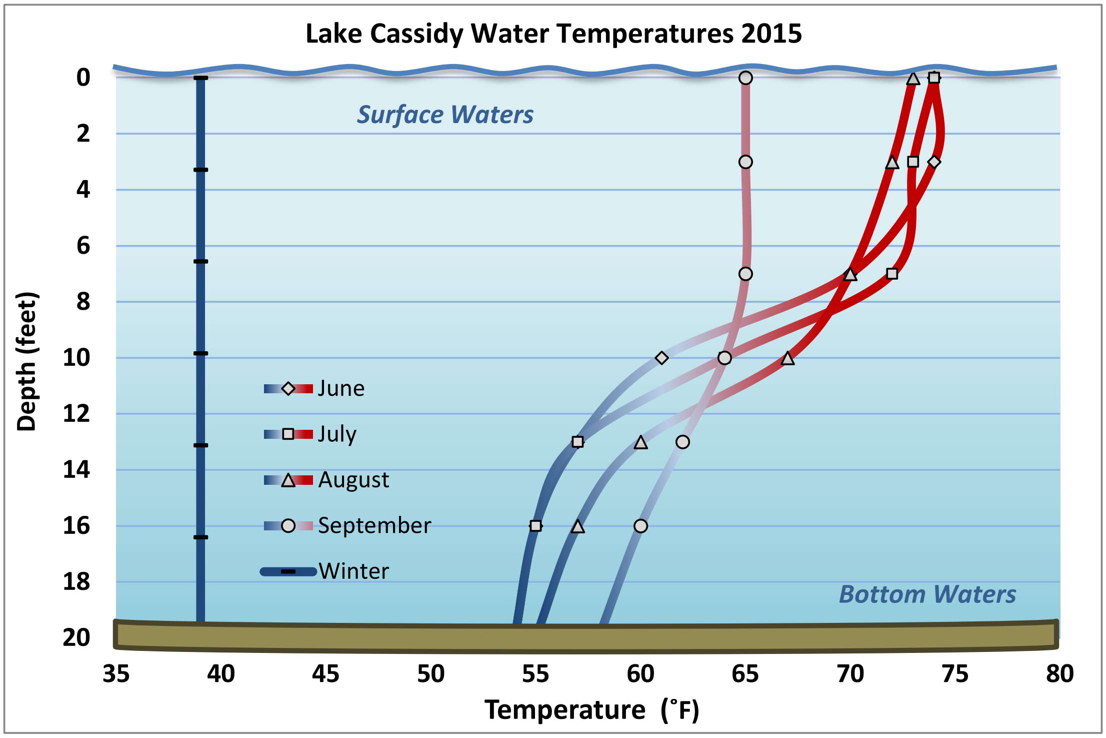

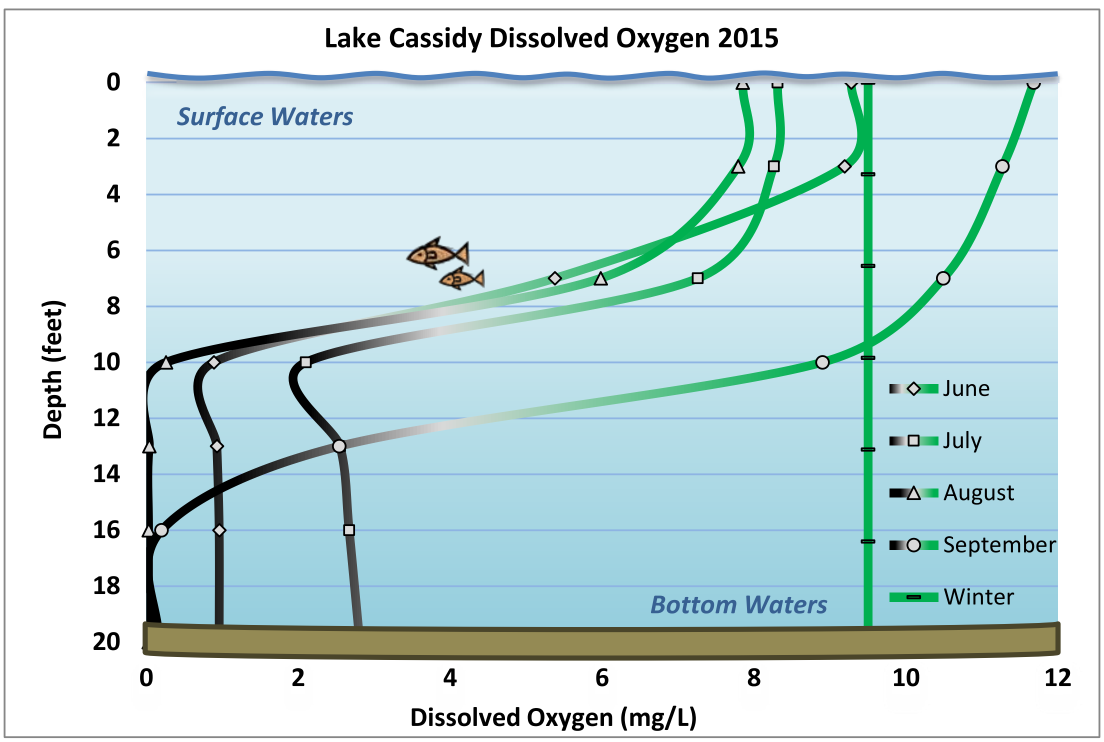

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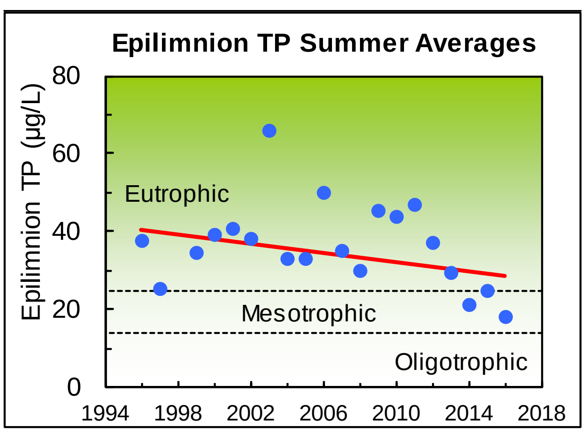
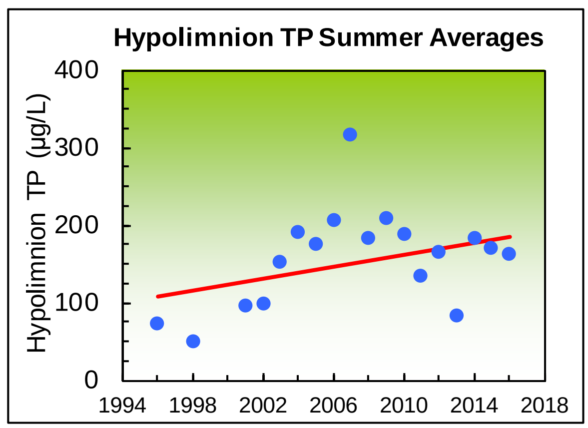
Phosphorus (key nutrient for algae)

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 concentrations in the epilimnion (upper waters) are high and variable, with a long-term 1996 to 2016 summer average of 36 µg/L (micrograms per liter, which is equivalent to parts per billion). There has been no statistically significant trend over the 1996 to 2016 period. The summer averages were especially high in 2003 and 2006 at 66 µg/L and 50 µg/L, respectively. The 2009 through 2011 summer averages were also higher than the long-term average. Since 2013, the summer averages have dropped below 30 µg/L. These high phosphorus levels are the reason that Lake Cassidy is listed as “impaired” in Washington State’s official 2012 water quality assessment.



Phosphorus values in the hypolimnion (bottom waters) are also high, with a long-term summer average of 158 µg/L. From 1998 through 2007, phosphorus levels in the bottom waters appeared to be increasing dramatically. The lake experienced its highest summer average in 2007 at 316 µg/L. However, from 2008 through 2016, summer averages have been lower. Overall, from 1996 through 2016, the increase in phosphorus concentrations is not considered statistically significant. High phosphorus levels in the bottom waters are the result of a build-up of phosphorus in the sediments, which is released during periods of low dissolved oxygen. This released phosphorus may become available for algae growth. Higher phosphorus levels in the bottom waters are also an indication of accelerating eutrophication.



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.

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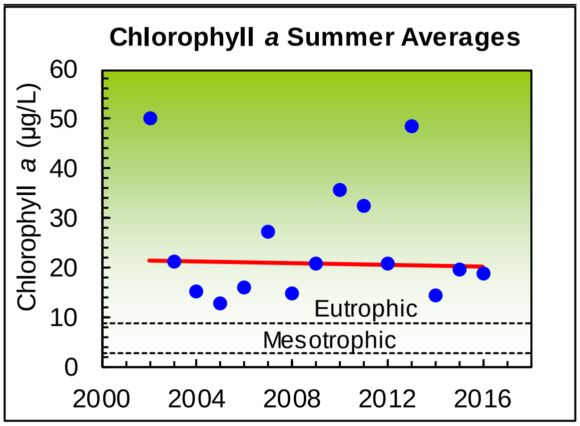
Chlorophyll *a* measurements are one method for tracking the amount of algae in a lake.

Chlorophyll *a* values in Lake Cassidy are high, which means that the lake produces large amounts of algae in response to the readily available phosphorus in the lake. The 2002 - 2016 long-term summer average is 25 µg/L. Because of substantial variability from year to year, there is no evidence of an increasing trend in chlorophyll *a* averages.



Toxic Blue-Green Algae (Cyanobacteria)

Lake Cassidy experiences periods of intense blue-green algae growth called blooms. Blue-green algae, also called cyanobacteria, are a type of algae capable of producing toxins during 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 (see photo). 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 has been identified as toxic, the lake will have postings at public access sites.

Since 2005, volunteers and SWM staff have screened algae at Lake Cassidy for potentially toxic blooms. In 2008 and 2009, SWM staff and citizen volunteers conducted weekly monitoring to better assess the frequency and toxicity of blue-green algae blooms at Lake Cassidy through a grant funded by the Washington State Department of Ecology. Similar bi-weekly monitoring was conducted in 2009 through 2012 as part of a project coordinated by the Washington Department of Health and funded by from the U.S. Centers for Disease Control (CDC). The project involved monitoring of 30 lakes within Snohomish, King, and Pierce counties. Water samples were tested for several types of toxins, in particular microcystin (a liver toxin) and anatoxin-a (a neurotoxin).

LAKE CASSIDY BLUE GREEN ALGAE BLOOM - SUMMER 2015

During every summer from 2005 through 2015 (excluding 2014), Lake Cassidy has experienced toxic blue-green blooms. In 2005 and 2006, microcystin was detected, but at very low levels. However, in 2007, a toxic bloom exceeding the Washington Department of Health recreational guidelines was present from late August through mid-September (see table). In 2011, Microcystin levels reached 18,400 µg/l, the highest value recorded up to that time in Snohomish County and one of the highest on record in the state. Blooms were reported in 2012, 2013, and 2015, with microcystin concentrations ranging from 0-171 µg/L. Through the years, the anatoxin-a toxin has also been detected a few times at Lake Cassidy, but at very low levels. No blooms were reported in 2016.

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Exposure to algae scums in lake water with these levels of toxins presents a high risk to humans and pets. Whenever toxic algae were detected at Lake Cassidy, SWM posted warning signs at public access sites to alert lake users to the risks from toxic algae. Several times when toxins were found to exceed recreational guidelines, SWM also warned lakefront residents through email (if provided by homeowners) and direct mailings.

SWM will continue to screen for potentially toxic algae blooms at Lake Cassidy in 2017. Continued monitoring will help to alert the public to potential health risks, as well as determine the frequency and severity of the blooms at Lake Cassidy.

Lake Cassidy Toxic Algae Summary

Year	# Weeks Sampled	# Weeks Toxic	Microcystin Range
2007	3	3	12.6 to >100
2008	3	3	>6 to >20.1
2009	6	6	30.7 to 4,600
2010	17	8	0.37 to 116
2011	13	7	0.6 to 18,400
2012	13	3	0 to 155
2013	5	0	0 to 1.8
2015	4	4	21.9 to 171

**number of weeks tested that were above the State recreational standard is 6 µg/L for Microcystin*

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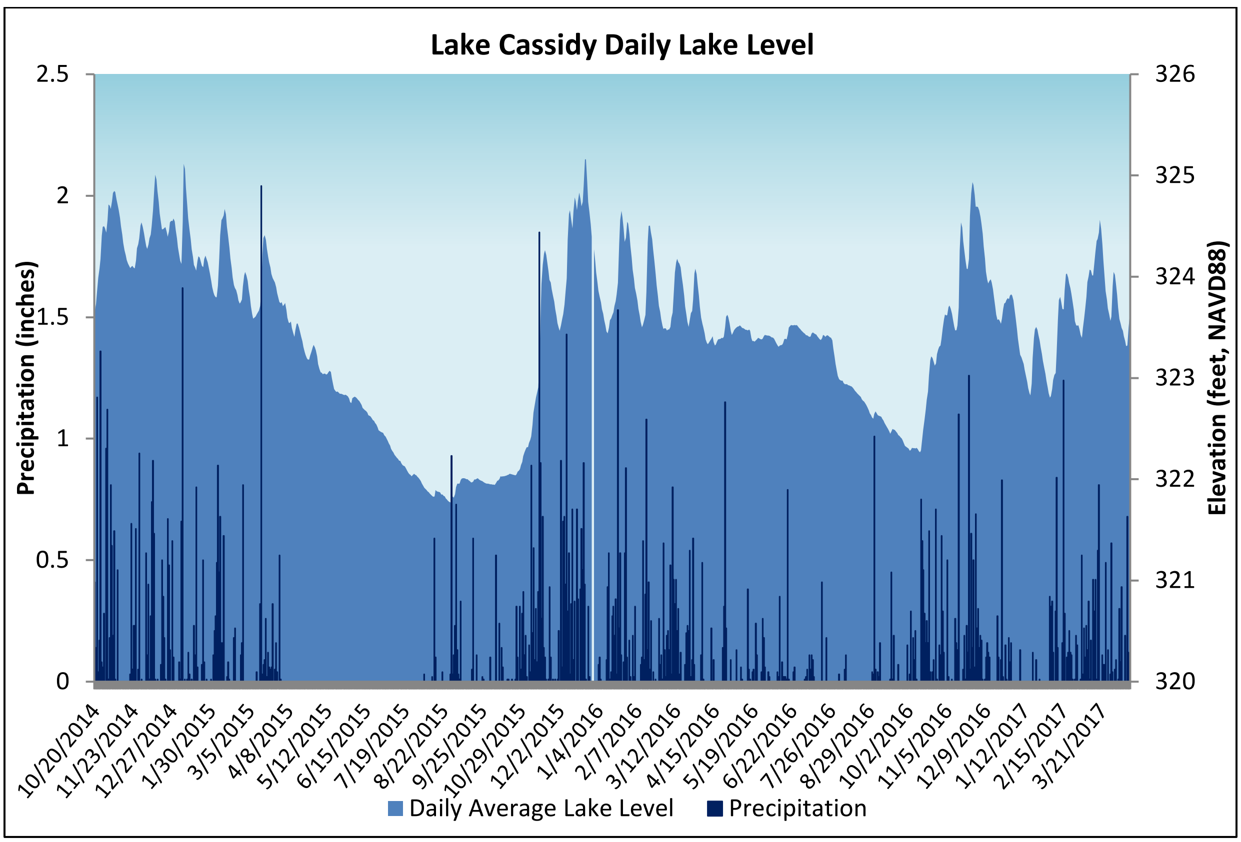
Lake Level

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 Centennial Trail dock in October 2014 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 Blackmans Lake from the time of installation through mid-April 2017. The precipitation data used for graph was recorded at the Sunnyside @ Soper Hill Road rain gage located 3 miles south west of Lake Cassidy. Lake levels fluctuate and average 3 feet each year. The summer of 2016 was fairly dry and the lake level dropped 2.5 feet. Heavy rains in in the fall resulted in large rises in the lake level.



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SHORELINE CONDITION

The condition of the lake shoreline is important to 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.

Lake Cassidy has one of the least developed shorelines in the county. Surveys from the mid-1990s found that there were only 28 homes on the lake – many of which were small cottages. There are also 19 docks present on the lake. The lake shoreline is also relatively pristine, as only 3% of the roughly 2 mile shoreline has been modified. The largest shoreline modification is the State boat launch. Ninety-four percent of the vegetation immediately adjacent to the shoreline is also intact. Much of the northern and eastern shoreline is a large wetland complex, part of which is located in Snohomish County's Lake Cassidy wetlands park. There is also a moderate amount (about 84 pieces) of large wood still remaining in the lake. These old logs and branches are valuable for fish and wildlife habitat. The intact shoreline and abundance of natural vegetation help to protect Lake Cassidy and provide important aquatic habitat 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 Cassidy may be classified as eutrophic, with low water clarity, high phosphorus concentrations, high algae levels, the presence of blue-green algae blooms, oxygen depletion, and dense aquatic plant growth.

Condition and Trends

Lake Cassidy is not meeting the water quality targets of improving water clarity and reducing phosphorus concentrations. There have been no significant trends in phosphorus concentrations between 1992 and 2016. However, the long-term hypolimnetic phosphorus summer average has risen to 158 µg/L, well above the target of 54 µg/L.

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Overall, Lake Cassidy is impaired and in need of restoration to improve water quality, particularly to reduce phosphorus levels and to limit the frequency of algae blooms. Reducing the amount of phosphorus entering the lake from development or human activities is critical for restoration. In particular, pollution from existing septic systems near the lake may be a source of nutrients because the chronically high water table has the potential to transport nutrients from septic system drainfields into the lake. Lake Cassidy's large watershed size also makes the lake vulnerable because there are many sources that can contribute nutrients to the lake.

Careful preservation of the surrounding wetlands is important to protecting the health of the lake because the wetlands serve to buffer the lake from pollution. To find out more about ways to protect lake water quality and information on the causes and problems of elevated lake nutrient levels visit www.lakes.surfacewater.info.

DATA SUMMARY FOR LAKE CASSIDY						
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
Bortleson, et al, 1976	**6/21/74**	1.5	70	36	-	-
Sumioka and Dion, 1985	**7/7/81**	0.6	20	60	-	21
Volunteer	**1992**	0.6 - 1.6 (1.3) *n = 7*	-	-	-	-
Volunteer	**1993**	1.0	-	-	-	-
SWM Staff or Volunteer	**1994**	1.0 - 1.2 (1.1) *n = 5*	-	-	-	10 - 43 (27) *n = 2*
SWM Staff or Volunteer	**1995**	0.8 - 1.3 (1.0) *n = 7*	-	-	-	21
SWM Staff	**1996**	0.8 - 1.0 (0.9) *n = 2*	32 - 43 (38) *n = 2*	37 - 108 (73) *n = 2*	-	-
DD#8	**1997**	0.5 - 1.2 (0.9) *n = 5*	18 - 36 (25) *n = 7*	-	-	3.1 - 31 (15) *n = 8*
DD#8 or WDFW	**1998**	0.8 - 0.9 (0.9) *n = 2*	-	51	-	13
DD#8	**1999**	0.7 - 1.0 (0.9) *n = 2*	24 - 45 (35) *n = 2*	-	-	1.9 - 5.9 (3.9) *n = 2*
DD#8	**2000**	0.8 - 1.0 (0.9) *n = 2*	26 - 52 (39) *n = 2*	-	-	-
SWM Staff or DD#8	**2001**	0.8 - 1.3 (1.1) *n = 6*	33 - 47 (41) *n = 6*	38 - 124 (95) *n = 4*	-	-
SWM Staff or DD#8	**2002**	0.9 - 1.3 (1.1) *n = 6*	30 - 46 (38) *n = 6*	33 - 158 (98) *n = 4*	-	25 - 90 (50) *n = 4*
SWM Staff or DD#8	**2003**	0.9 - 1.2 (1.1) *n = 6*	33 - 187 (66)[a] *n = 6*	111 - 230 (153) *n = 4*	-	10 - 50 (22) *n = 6*
SWM Staff	**2004**	0.8 - 1.3 (1.0) *n = 6*	23 - 52 (33) *n = 6*	91 - 307 (192) *n = 4*	-	4.8 - 20 (15) *n = 6*

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DATA SUMMARY FOR LAKE CASSIDY						
Source	**Date**	**Water Clarity (Secchi depth in meters)**	**Total Phosphorus (µg/L)**		**Total Nitrogen (µg/L)**	**Chlorophyll *a* (µg/L)**
			Surface	**Bottom**	**Surface**	**Surface**
SWM Staff	**2005**	0.6 - 1.0 (0.8) *n = 5*	25 - 39 (33) *n = 6*	59 - 272 (177) *n = 4*	-	1.0 - 35 (13) *n = 6*
SWM Staff	**2006**	0.6 - 1.3 (1.0) *n = 4*	33 - 64 (50) *n = 4*	69 - 325 (207) *n = 4*	-	8.3 - 38 (16) *n = 4*
SWM Staff	**2007**	0.8 - 1.1 (1.0) *n = 4*	28 - 49 (35) *n = 4*	116 - 475 (316) *n = 4*	-	13 - 60 (27) *n = 4*
SWM Staff or Volunteer	**2008**	0.8 - 1.6 (1.1) *n = 17*	28 - 33 (30) *n = 4*	49 - 318 (183) *n = 4*	-	7.7 - 27 (15) *n = 4*
SWM Staff or Volunteer	**2009**	0.6 - 1.4 (1.1) *n = 23*	32 - 79 (46) *n = 4*	52 - 362 (209) *n = 4*	-	12 - 31 (21) *n = 4*
SWM Staff or Volunteer	**2010**	0.8 - 1.1 (1.0) *n = 12*	34 - 51 (44) *n = 4*	54 - 321 (188) *n = 4*	-	17 - 45 (36) *n = 4*
SWM Staff	**2011**	0.6 - 1.4 (1.1) *n = 10*	33 - 63 (47) *n = 10*	41 - 285 (134) *n = 10*	-	6.7 - 121 (33) *n = 10*
SWM Staff	**2012**	0.8 - 1.4 (1.0) *n = 10*	27 - 75 (37) *n = 9*	47 - 338 (165) *n = 10*	*672 - 1500* *(887)* *n = 4*	3.3 - 47 (21) *n = 7*
SWM Staff	**2013**	1.0 - 2.2 (1.6) *n = 4*	23 - 36 (29) *n = 4*	51 - 146 (84) *n = 4*	-	1.1 - 67 (39) *n = 5*
SWM Staff	**2014**	*1.2 - 1.8* *(1.5)* *n = 4*	*20 - 23* *(21)* *n = 3*	*85 - 277* *(183)* *n = 4*	*586 - 732* *(655)* *n = 4*	*8.0 - 19* *(14)* *n = 4*
SWM Staff	**2015**	*1 - 2.7* *(1.7)* *n = 4*	*21 - 31* *(25)* *n = 3*	*116 - 201* *(171)* *n = 4*	*639 - 857* *(741)* *n = 4*	*14 - 29* *(20)* *n = 4*
SWM Staff	**2016**	0.9 - 1.8 (1.4) *n = 7*	6 - 26 (18) *n = 4*	85 - 211 (162) *n = 4*	564 - 875 (744) *n = 4*	8.7 - 37 (19) *n = 4*
Long Term Avg		**1.1** **(1992-2016)**	**36** **(1996-2016)**	**158** **(1996-2016)**	**811** **(2012-2016)**	**25** **(2002-2016)**
TRENDS		**Increasing**	**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 2-3 meters above the bottom.

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