2021 STATE OF THE LAKES UPDATE

BLACKMANS LAKE

REPORT DESCRIPTION

This report is an update on the health of Blackmans Lake based on water quality data collected from 1989 through 2021 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 Blackmans Lake, please visit www.lakes.surfacewater.info.

LAKE DESCRIPTION

Blackmans Lake is a 63-acre lake located in the City of Snohomish. It is relatively shallow, with a maximum depth of 8.8 meters (29 feet) and an average depth of 4.3 meters (14 feet). The watershed, which is the land area that drains to the lake, is small—less than 7 times the lake size. Both the shoreline and the surrounding watershed have undergone significant development over the past thirty years.

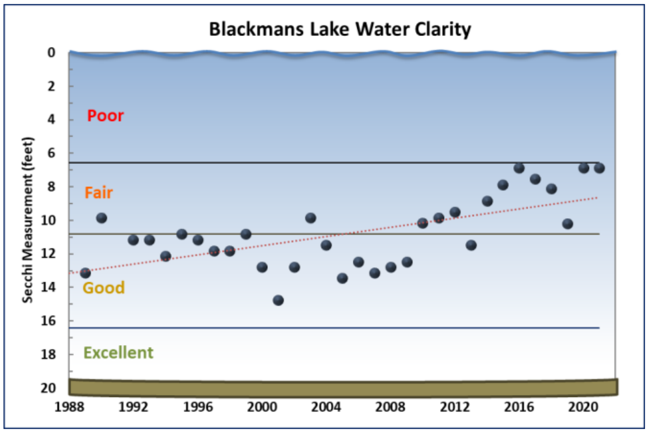
LAKE CONDITIONS

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

The water clarity in Blackmans Lake is fair, with a long-term summer average of 10.8 feet. Between 1999 and 2005, the average water clarity varied considerably from year to year, reaching a high of 14.8 feet in 2001, and a low of 9.8 feet in 2003. From 2005 through 2009, water clarity was stable at close to 13 feet. However, since 2010 the clarity has continued to decline. In 2016 the average was only 6.9 feet. Water clarity improved and even reached an average of 10.2 feet in 2019 but has since declined in 2020 and 2021. Lower water clarity often corresponds with higher levels of algae, so the annual variations are likely caused by changes in the amount of algae in the lake. Overall, between 1992 and 2021 there has been a statistically significant towards declining water quality at Blackmans Lake ($p=0.00$).



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 from the color of algae or sediment suspended in the water.

The water color of Blackmans Lake averaged 16 platinum-cobalt color units in 2010-2011. This indicates a slight to moderate amount of color in the water and is similar to a measurement in 1973. The amount of color in the lake is not enough to have a significant effect on water clarity or algae growth.

Water color data will be taken in the summers of 2021 and 2022. After two years of data collection the results can be compared to previous measurements and assessed for changes. As water color affects clarity, updated information will help explain potential causes of declining 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.

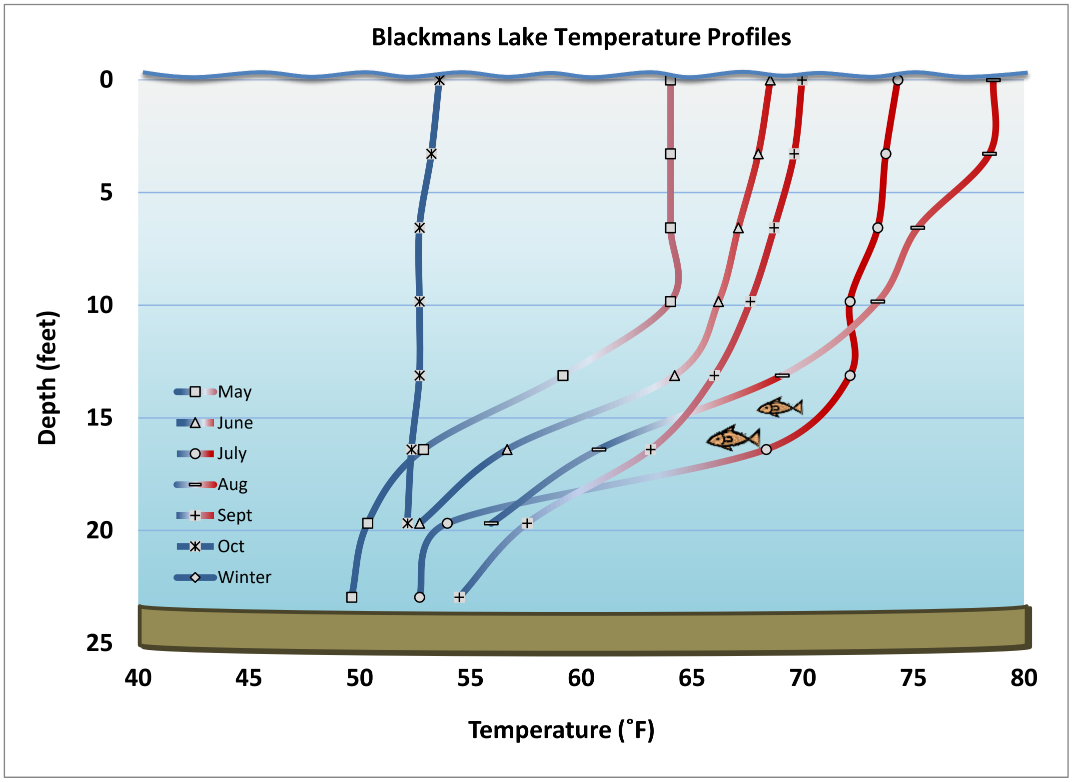
From May through October 2021, temperature was measured monthly at each meter throughout the Blackmans Lake water column. Temperature profiles (see graph on next page) show that the upper waters had warmed up by May, and from then through September the lake was strongly thermally stratified. The upper waters were about 18°F warmer than bottom waters. Because of the difference in temperatures and the fact that warm water is lighter, mixing did not occur between these layers. The upper waters reached their peak temperature in August at 79°F (25.9°C). Bottom water temperatures changed less and warmed from 50-55°F (10-14°C) during the summer. The upper waters had cooled down to about 70°F (21.1°C) in September. By October, the surface waters continued to cool until the temperatures are 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.

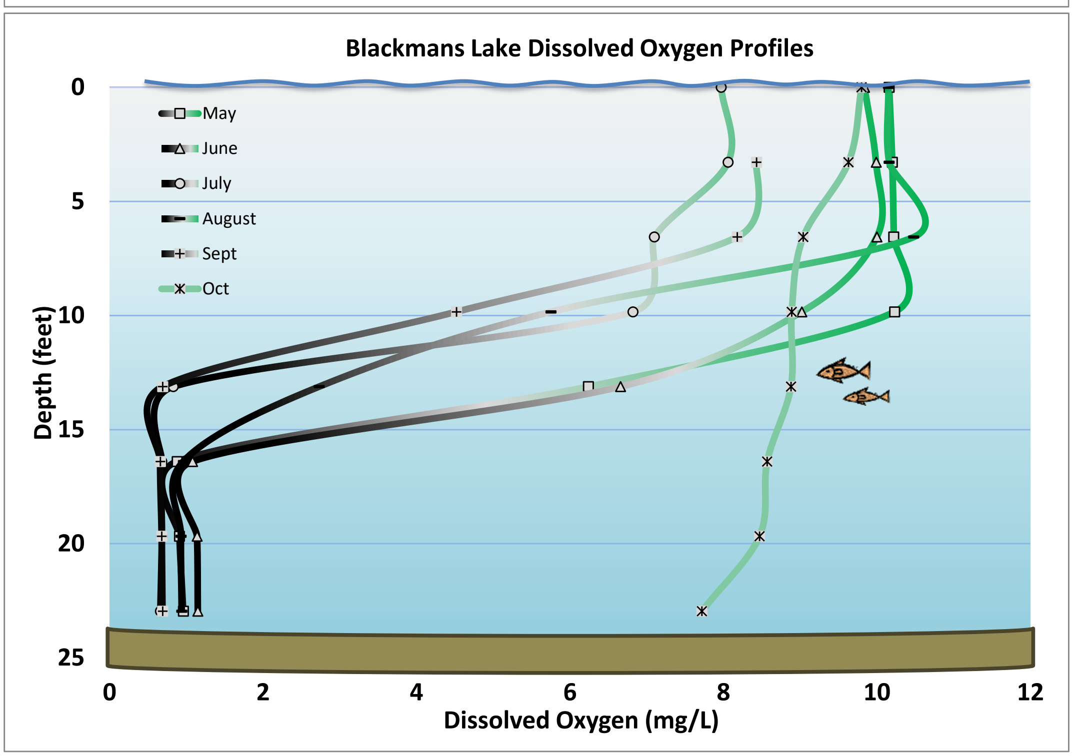
Dissolved Oxygen

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.

The depth profiles of dissolved oxygen measured in 2021 are similar to the temperature profiles seen during that time period (see graph on next page). Oxygen levels were relatively high in the upper waters from, while the bottom waters contained much less oxygen. In fact, there was little or no oxygen in the water at 12 feet and below for much of the summer which affects the amount of suitable fish habitat. During this 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 in October. The lake then remains mixed until springtime when the upper waters begin to warm and dissolved oxygen begins to decline again in the bottom.

BLACKMANS LAKE



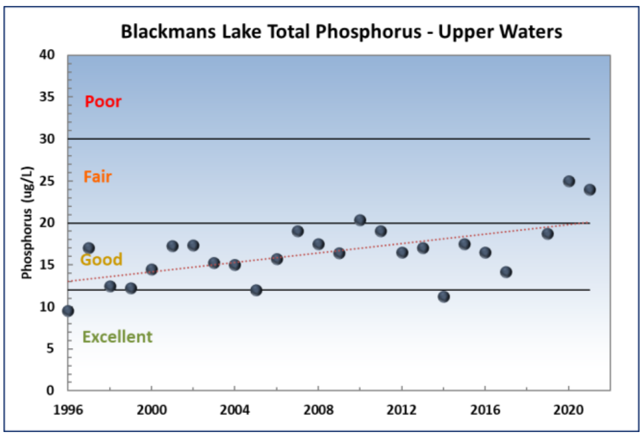


BLACKMANS LAKE

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. Monitoring of phosphorus levels over time helps to identify changes in nutrient pollution.

Phosphorus pollution comes from the homes and development around the lake. When it rains, the phosphorus washes into ditches and streams and ends up in the lake. Sources of phosphorus include fertilizers, pet and animal wastes, poorly maintained septic systems and dirt from driveways, roads and eroding soils.



Total phosphorus values in the epilimnion (upper waters) are good, with a long-term 1996 - 2021 average of 16 µg/L (micrograms per liter, which is equivalent to parts per billion). Although still at moderate levels, the phosphorus concentrations have been increasing. Higher phosphorus levels can lead to increased algae growth which is occurring at Blackmans Lake as described below.

Higher phosphorus concentrations in the epilimnion can be a result of more nutrients running into the lake from the watershed areas surrounding the lake. To investigate this possibility, SWM collected water samples from storm drains that empty into the northeast corner of Blackmans Lake at Park Avenue, 19th Street, and at Hill Park on several occasions during the winter months of 2011 through 2019.

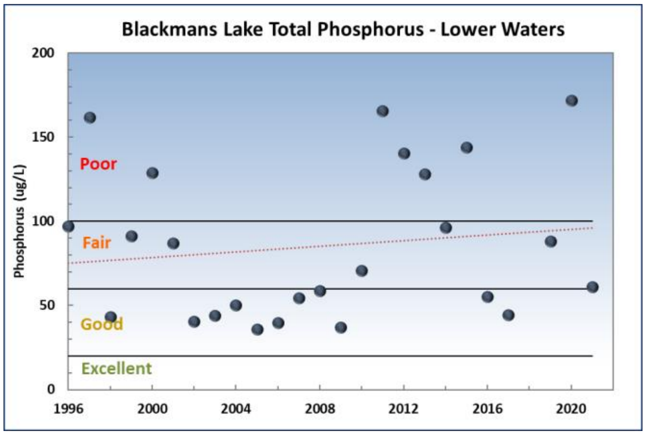
The table below shows the seasonal averages for total phosphorus collected at these sampling locations. The total phosphorus averages are moderate values and similar to those at streams or storm drain outfalls near other lakes. However, there are increases during rainstorms as shown by data from February 2012 when the concentrations were 132 µg/L and 85 µg/L at Park Avenue and 19th Street, respectively. There was only one sampling date in 2014-2015 and values were higher than at any time other than February 2012. These higher values indicate that Blackmans Lake can receive heavy doses of phosphorus during rain storms, which is likely contributing, in part, to the increasing phosphorus levels.

Winter Season	TP Seasonal Average in Stormwater		
	Park Ave (µg/L)	19th St (µg/L)	Hill Park (µg/L)
2011-2012	78	52	24
2012-2013	33	22	15
2013-2014	38	15	-
2014-2015	74	44	-
2015-2016	-	-	-
2016-2017	46.5	28	-
2017-2018*	-	-	-
2018-2019	25	20	-

**TP data rejected in Winter 2017- 2018*

BLACKMANS LAKE

Phosphorus levels in the hypolimnion (bottom waters) are higher than in the upper waters, with a long-term average of 85 µg/L. Between 2002 and 2021, summer average phosphorus concentrations in the hypolimnion had been relatively stable. However, phosphorus levels were much higher and more variable in the last ten years. Summer averages have ranged from 172 µg/L in 2020 to 45 µg/L in 2017. These averages are similar to 1996-1997 values and to samples during a 1992 study of the lake.



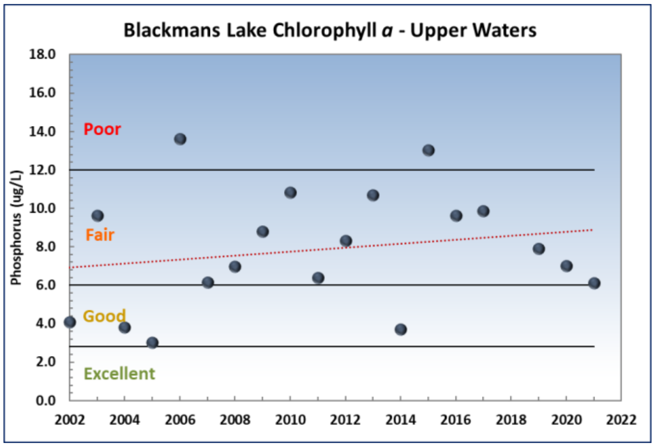
In spite of the high phosphorus levels in recent years, there has been no statistically significant trend in phosphorus levels in the bottom waters. However, the lake should be watched to see if these higher levels persist.

High phosphorus concentrations in the bottom waters are usually the result of phosphorus being released from the lake bottom sediments during the period of low dissolved oxygen in the summer months. The high phosphorus levels show that the lake sediments are also likely a source of phosphorus pollution to the lake contributing to the increasing trends of phosphorus observed in the upper waters.

<u>Chlorophyll a (Algae)</u>

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 can be used to track the amount of algae in a lake.

Chlorophyll *a* values in Blackmans Lake are fair, with a long-term summer average of 7.5 µg/L between 2002 and 2021. There has been a high degree of variability from year to year with peaks as high as 13 ug/L in 2015. Overall, there has been no statistically significant long-term trend in chlorophyll *a* levels. Whenever chlorophyll *a* is higher, it suggests that algae are obtaining needed nutrients from runoff into the lake or pollution recycled back into the lake from the lake sediments.



BLACKMANS LAKE

Toxic Blue-Green Algae (Cyanobacteria)

Blackmans Lake experiences periods of intense blue-green algae growth known as blooms. Blue-green algae, also called cyanobacteria, are a group of algae capable of producing toxins. 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 blue-green algae bloom has been identified at Blackmans Lake, this information will be posted at public access sites and the City of Snohomish website.

Since 2005, volunteers and SWM staff have screened algae at Blackmans Lake for potentially toxic blooms. From 2009 through 2011, routine toxin testing was conducted 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 identified algae blooms that could pose a potential health threat and alerted the public about toxic algae. During 2009 - 2011, water samples were tested every two weeks from June through October for several types of toxins, primarily microcystin (a liver toxin) and anatoxin-a (a neurotoxin).

Toxin tests on Blackmans Lake from 2008 through 2021 occasionally detected low to moderate levels of microcystin. Tests in 2017 and 2020 showed toxin levels that exceeded the Washington State Department of Health's recreational guidelines. In recent years scums have been observed near the fishing docks at Hill Park and at the boat launch in the late summer, fall, and winter. Most notably the lake was posted for toxic algae from September 2020 through May 2021 for an intermittent bloom that persistent through the winter. The state's toxin testing program does not accept samples after funds have been exhausted which is typically from November through April. This is the period when blooms are common at Blackmans Lake which helps explain why few samples were taken when the lake was posted for an extended period. Given that blue-green algae species have the potential to produce toxins, residents should assume that toxins are present where there is scum in the absence of testing.

Caution should be taken by lake users anytime a visible scum of algae is present. Regular algae screening will continue in 2022 as part of the normal lake monitoring program, and it will be a priority to take samples to the lab when possible. Continued monitoring will help to alert the public to potential health risks, as well as determine the frequency and severity of the toxic algae blooms at Blackmans Lake.

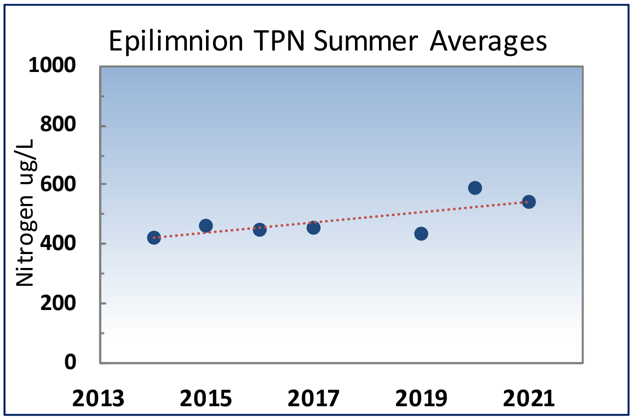
Blackmans Lake Toxic Algae Testing Results

Year	Weeks Posted CAUTION	Weeks Posted WARNING	# Weeks Sampled	# Weeks Toxic*	Microcystin Range (µg/L)	Anatoxin Range (µg/L)
2008	-	-	1	1	greater than 6	-
2009	-	-	1	0	0.05	-
2010	-	-	6	0	0-2.77	-
2011	-	-	7	0	0-0.06	-
2015	-	-	1	0	less than 1	-
2016	10	-	5	0	0.2-0.4	0.01-0.04
2017	2	2	2	1	0-10.1	0
2018	4	-	1	0	0.31	0
2019	4	-	2	0	0-2.23	0-0.03
2020	-	18	4	1	0-21.6	0-0.01
2021	-	24	1	0	0-6.26	0

**Number of weeks above the State recreational guideline of 6 µg/L for Microcystin and 1 µg/L for Anatoxin (2008-2020) or 8 µg/L for Microcystin and 1 µg/L for Anatoxin (2021-present). Only WARNING signs used from 2020-present.*

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. Blackmans Lake has moderate levels of total nitrogen, with a 2014 – 2021 summer average of 492 µg/L. This is consistent with the high 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.

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. From the time nitrogen data was taken (2014-2021), Blackmans Lake had a moderate N:P ratio of 26. This ratio is higher than expected given that blue-green algae blooms happen regularly.

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 Hill Park in June 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 September 2021. The precipitation data used for graph was recorded at the Snohomish County Native Plant Nursery located 6 miles north of Blackmans Lake.

The City of Snohomish completed the Blackmans Lake Outlet Improvement project in the summer of 2016. An earthen berm was constructed downstream of the outlet to alleviate lake flooding during the winter months. From 2014-2016 lake levels fluctuated about 2.5 feet annually and 1.0 feet during the winter. From July 2016 to present, the lake fluctuated about 2.0 feet annually with 0.75 feet of fluctuation during the winter. This data suggests that the outlet improvement has been effective at reducing flooding in the winter months.

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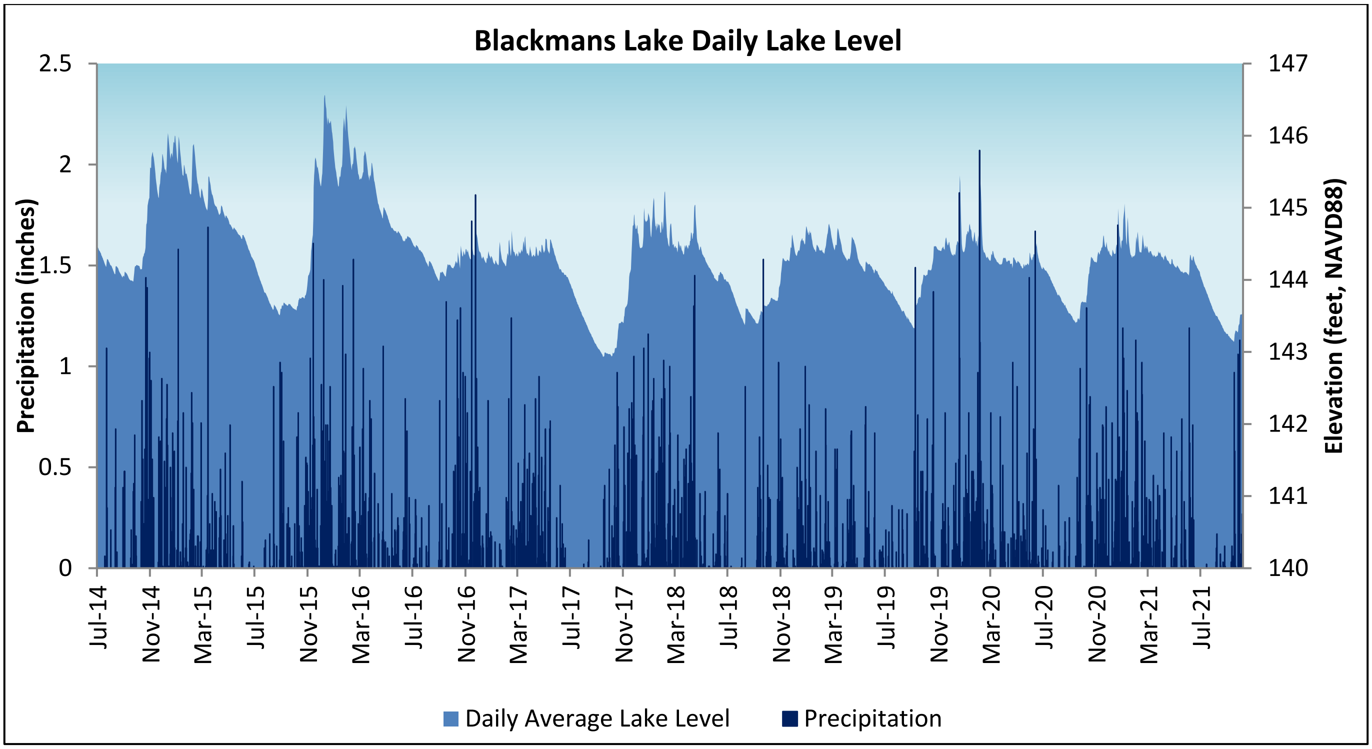

Aquatic Plants

Aquatic plants are important in a lake ecosystem. Plants provide food and shelter for fish and other aquatic animals, stabilize the shoreline and bottom sediments, and in some cases increase water clarity by out-competing algae for nutrients. Some plants grow entirely submersed under the water (like elodea), some have leaves that float on the surface (like lilies), and others have roots under the water with most of the plant standing above the water (like cattails).

It is important to prevent the introduction of non-native, invasive species, such as Eurasian watermilfoil, in Blackmans Lake because they have the potential to take over much of the shallow water areas and interfere with swimming, fishing, and boating. However, a healthy community of native aquatic plants is important. Native plants provide valuable food and shelter for fish, aquatic insects, and other wildlife. Aquatic plants also trap pollutants, stabilize sediments, and utilize nutrients that otherwise might feed the growth of nuisance algae.

Surveys of aquatic plants growing in Blackmans Lake conducted each year from 2009 - 2021 show a robust and diverse plant community. There are large patches of native yellow waterlily (*Nuphar*) near the shore. The submersed (underwater) plants are dominated by *Nitella* and *Chara* (actually macro-algae), as well as water nymph (*Najas flexilis*), common elodea (*Elodea canadensis)*, and several species of native pondweed (*Potamogeton*).

Two invasive plant species have been identified at Blackmans Lake. Over the past 20 years large patches of invasive fragrant waterlily (*Nymphaea odorata*) have expanded and threaten native species. In 2021 SWM staff identified the invasive plant curly leaf pondweed (*Potamogeton crispus*) near the boat launch. There were sparse plants in a small area. The City was notified and is looking into early management actions to eradicate this plant.

BLACKMANS LAKE

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, Blackmans Lake may be classified as mesotrophic, with good phosphorus levels, fair water clarity, and high levels of plants and algae growth.

Condition and Trends

Overall, Blackmans Lake is in fair condition, but remains at risk of water quality declines because of phosphorus pollution from the watershed. The lake shows increasing phosphorus concentrations in the upper waters. These higher levels suggest that more phosphorus is washing into the lake from the surrounding watershed. Higher chlorophyll *a* concentrations along with lower water clarity in some recent years are an indication of more algae growth from the increasing phosphorus. Additionally, sustained toxic algae blooms indicate that the lake is suffering from too much phosphorus.

Phosphorus levels in the hypolimnion (bottom waters) have been high in recent years. This means that the lake is not meeting the target for stable phosphorus levels and may indicate that release of phosphorus from the bottom sediments is becoming more of a concern.

Efforts to control nutrient inputs from the watershed should be pursued to head off the increase of phosphorus in the epilimnion and prevent increases in phosphorus levels in the hypolimnion. The large number of ducks and geese that come to Blackmans Lake, and in some cases remain for long periods, also are a source of nutrients to the lake.

Measures to control nutrients in the watershed and around the lake shore should be taken now to prevent any future negative impacts to the lake, such as excessive growth of algae and aquatic plants. In particular, restoring and maintaining a buffer of native vegetation along the shoreline on private properties and on park properties can filter out pollution and reduce problems with excess waterfowl. In addition, actions to neutralize the phosphorus in the lake sediments will likely be needed to improve lake conditions and reduce potentially toxic algal blooms. 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 BLACKMANS LAKE						
		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	**8/13/73**	4.6	8	59	-	-
Sumioka and Dion, 1985	**7/7/1981**	4.3	0	10	-	3.8
DOE	**1989**	2.9 - 4.7 (4.0) *n = 7*	-	-	-	-
DOE	**1990**	3.0	-	-	-	-
KCM, 1994a	**1992**	2.2 - 4.6 (3.4) *n = 12*	16 - 24 (19) *n = 12*	18 - 579 (198) *n = 12*	-	1.6-34 (13) *n = 12*
DOE	**1993**	1.5 - 5.2 (3.4) *n = 9*	-	-	-	2.9
DOE	**1994**	2.9 - 4.6 (3.7) *n = 4*	-	-	-	5.7
Volunteer	**1995**	2.1 - 4.6 (3.3) *n = 8*	-	-	-	-
SWM Staff or Volunteer	**1996**	2.8 - 4.3 (3.4) *n = 9*	8 - 11 (10) *n = 2*	63 - 131 (97) *n = 2*	-	-
SWM Staff or Volunteer	**1997**	2.4 - 7.0 (3.6) *n = 6*	12 - 22 (17) *n = 2*	107 - 216 (162) *n = 2*	-	-
SWM Staff or Volunteer	**1998**	2.8 - 4.3 (3.6) *n = 12*	11 - 14 (13) *n = 4*	26 - 71 (43) *n = 4*	-	-
Volunteer	**1999**	3.0 - 3.7 (3.3) *n = 9*	10 - 15 (12) *n = 4*	23 - 204 (91) *n = 4*	-	-
Volunteer	**2000**	2.3 - 5.4 (3.9) *n = 9*	10 - 19 (15) *n = 4*	22 - 362 (129) *n = 4*	-	-
Volunteer	**2001**	4.0 - 5.1 (4.5) *n = 4*	9 - 30 (17) *n = 4*	35 - 173 (87) *n = 4*	-	-
SWM Staff or Volunteer	**2002**	2.8 - 4.5 (3.9) *n = 5*	11 - 25 (17) *n = 3*	25 - 71 (41) *n = 3*	-	0.8 - 11 (4.1) *n = 4*
Volunteer	**2003**	1.5 - 4.3 (3.0) *n = 6*	12 - 20 (15) *n = 4*	31 - 55 (44) *n = 4*	-	5.9 - 15 (9.6) *n = 3*

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Source	**Date**	**in meters)**	**Surface**	**Bottom**	**Surface**	**Surface**
Volunteer	**2004**	3.1 - 4.0 (3.5) *n = 11*	12 - 18 (15) *n = 4*	31 - 64 (50) *n = 4*	-	2.4 - 6.4 (3.8) *n = 4*
Volunteer	**2005**	2.9 - 5.1 (4.1) *n = 8*	9 - 16 (12) *n = 4*	29 - 53 (36) *n = 4*	-	1.9 - 5.1 (3.0) *n = 4*
Volunteer	**2006**	3.0 - 5.7 (3.8) *n = 16*	10 - 21 (16) *n = 4*	25 - 47 (40) *n = 4*	-	2.1 - 26 (14) *n = 4*
Volunteer	**2007**	2.9 - 4.7 (4.0) *n = 11*	11 - 36 (19) *n = 4*	45 - 63 (55) *n = 4*	-	4 - 11 (6.2) *n = 4*
Volunteer	**2008**	2.3 - 5.1 (3.9) *n = 12*	8 - 30 (18) *n = 4*	16 - 117 (59) *n = 4*	-	2.9 - 16 (7.0) *n = 4*
Volunteer	**2009**	1.2 - 5.2 (3.8) *n = 12*	12 - 23 (16) *n = 4*	19 - 68 (37) *n = 4*	-	2.1 - 26 (8.8) *n = 4*
Volunteer	**2010**	2.5 - 4.3 (3.1) *n = 9*	17 - 22 (20) *n = 3*	63 - 76 (71) *n = 4*	-	6.7 - 16 (11) *n = 4*
Volunteer	**2011**	2.0 - 4.1 (3.0) *n = 11*	17 - 21 (19) *n = 4*	56 - 336 (166) *n = 4*	-	3.2 - 8.0 (6.4) *n = 4*
Volunteer	**2012**	2.4 - 3.8 (2.9) *n = 12*	12 - 21 (17) *n = 4*	97 - 207 (141) *n = 4*	-	5.3 - 12 (8.3) *n = 4*
SWM Staff	**2013**	2.7 - 4.1 (3.5) *n = 4*	13 - 21 (17) *n = 4*	41 - 251 (128) *n = 4*	-	5.3 - 18 (11) *n = 4*
Volunteer	**2014**	1.5 - 3.3 (2.7) *n = 11*	10 - 15 (11) *n = 4*	26 - 186 (96) *n = 4*	380 - 454 (423 *n = 3*	1.1 - 5.2 (3.7) *n = 4*
Volunteer	**2015**	1.3 - 3.7 (2.4) *n = 12*	10 - 23 (18) *n = 4*	82 - 202 (144) *n = 4*	364 - 580 (464) *n = 4*	3.7 - 30 (13) *n = 5*
Volunteer	**2016**	1.5 - 3.0 (2.1) *n = 12*	15 - 18 (17) *n = 4*	21 - 69 (55) *n = 4*	379 - 569 (450) *n = 4*	5.9 - 13 (9.6) *n = 3*
Volunteer	**2017**	1.4 - 3.5 (2.3) *n = 8*	12 - 14 (13) *n = 2*	38 - 51 (45) *n = 2*	369 - 547 (458) *n = 2*	2.6 - 3.2 (2.9) *n = 2*
Volunteer	**2018**	1.9 - 3.3 (2.5) *n = 6*	-	-	-	-

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Source	**Date**	**in meters)**	**Surface**	**Bottom**	**Surface**	**Surface**
Volunteer	**2019**	2.2 - 4.8 (3.1) *n = 8*	11 - 25 (19) *n = 4*	35 - 134 (88) *n = 4*	367 - 524 (438) *n = 4*	3.2 - 12 (7.9) *n = 4*
Volunteer	**2020**	2.1 - 3.0 (2.5) *n = 9*	19 - 30 (25) *n = 4*	98 - 340 (172) *n = 4*	502 - 631 (589) *n = 4*	4.0 - 12 (7.0) *n = 3*
Volunteer	**2021**	2.1 - 3.0 (2.5) *n = 9*	20 - 29 (24) *n = 4*	40 - 88 (61) *n = 4*	462 - 671 (542) *n = 4*	4.8 - 8.4 (6.1) *n = 4*
Long Term Avg		**3.3** **(1990-2021)**	**16** **(1996-2021)**	**86** **(1996-2021)**	**481** **(2014-2021)**	**7.5** **(2002-2021)**
TRENDS		**Decreasing**	**Increasing**	**None**	**None**	**None**

NOTES

- Table includes summer data only, Secchi (May-Oct) and TP, TPN and CHLa (Jun-Sep)
- 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.
- TP, TPN, Chla data rejected in 2018