CRYSTAL LAKE

REPORT DESCRIPTION

This report is an update on the health of Crystal Lake based on water quality data collected from 1994 through 2011 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 Crystal Lake, please visit www.lakes.surfacewater.info or call SWM at 425-388-3464.

LAKE DESCRIPTION

Crystal Lake is a 50-acre lake located south of Maltby adjacent to the King County line. The lake has a maximum depth of over 9 meters (30 feet) and an average depth of about 4 meters (13 feet). The watershed, which is the land area that drains to the lake, surrounding Crystal Lake is large—almost 2100 acres, which is over 40 times the size of the lake. There is a 115-acre wetland immediately north of the lake. This wetland was originally part of a larger Crystal Lake, but has become vegetated over thousands of years. The body of the lake is surrounded by a gated community consisting of approximately 68 homes clustered around the lake shore. The Crystal Lake homeowners' association, incorporated as Crystal Lake, Inc., is active in managing the lake.

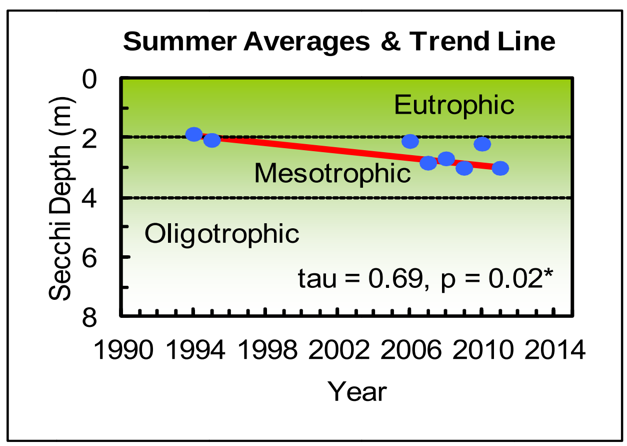
LAKE CONDITIONS

The following graphs illustrate the summer averages (May through October) and trend lines (in red) for water clarity, total phosphorus, and chlorophyll *a* for Crystal 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 Crystal Lake is low to moderate, partly because of the naturally dark color of the lake water. The long-term summer average water clarity is 2.5 meters (8.2 feet). There appears to be a trend towards improving water clarity in Crystal Lake. However, this trend should be viewed cautiously because of the lack of data from 1996 through 2005. Additional years of monitoring will help to understand if the water clarity conditions in Crystal Lake are actually improving.



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 Crystal Lake averaged 46 pcu (platinum-cobalt color units) in 2010-2011. This indicates a moderate amount of color in the lake water and is a slight increase from the 1994 – 1995 average of 40 pcu. Darker water should result in less algae and poorer water clarity. However, this is at odds with the increasing trend in chlorophyll *a* described below and the apparent improvement 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.

Temperature profile data taken during 2011 show that Crystal Lake was strongly thermally stratified from May through October (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. The upper waters reached their peak in temperature in August at 71°F (22°C) and then cooled down through October. At the same time, bottom water temperatures changed only a little and remained around 42 - 45°F (6° - 7°C). In October to December, the surface waters continued to cool until the temperatures were almost equal from top to bottom. As stratification weakened, the lake water turned over (or mixed). 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 2011 largely correspond to the temperature profiles seen during that time period (see graph). By June there was little or no oxygen in the very bottom waters. Then, each month the zone of no oxygen expanded until August and September when there was no dissolved oxygen below 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. When dissolved oxygen levels are near zero, phosphorus is often released from the sediments into the lake. This phosphorus can feed future algae blooms. In the fall and winter when the lake is mixed, dissolved oxygen is replenished throughout the entire lake.

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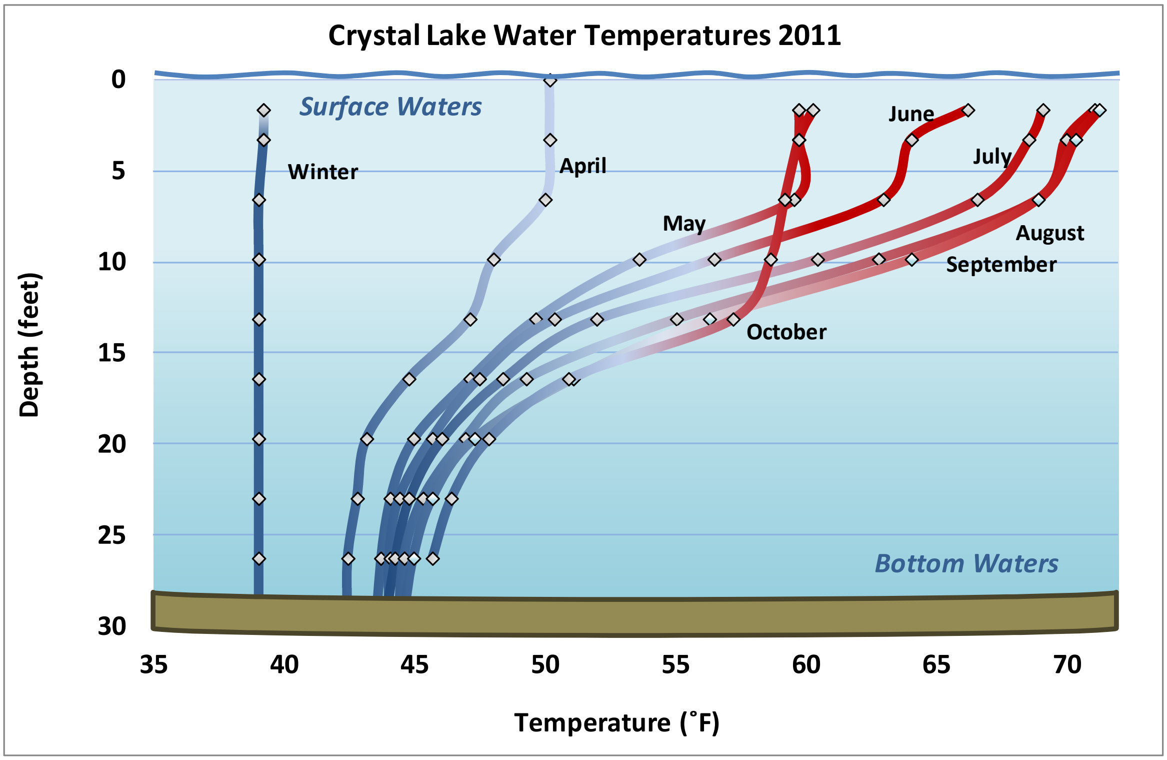

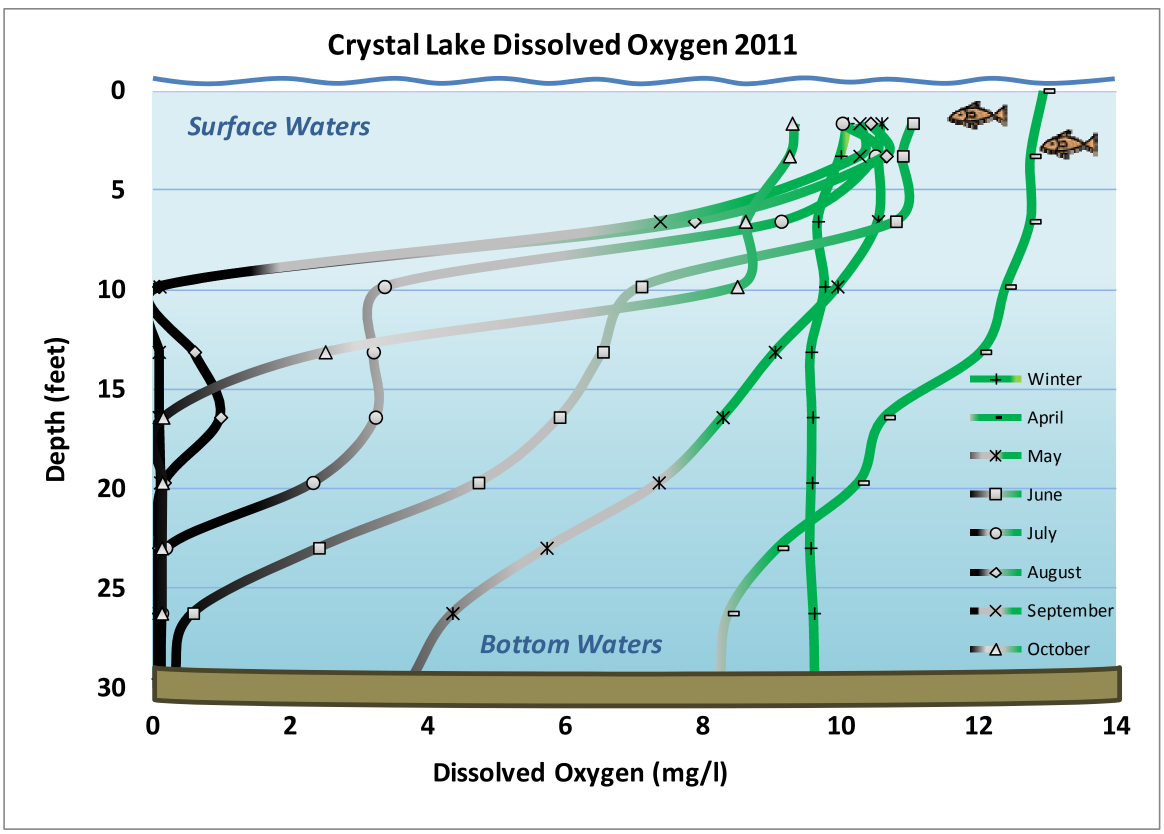

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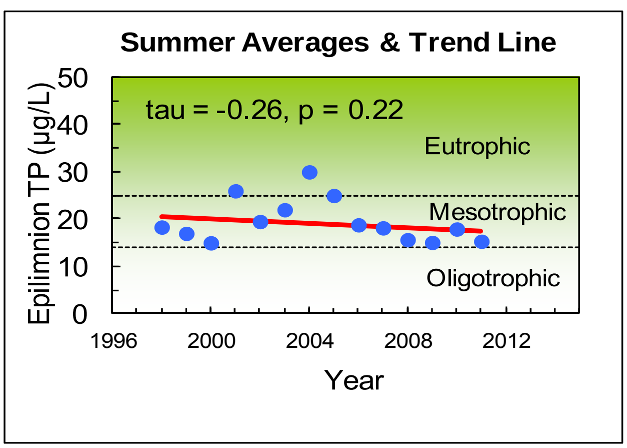
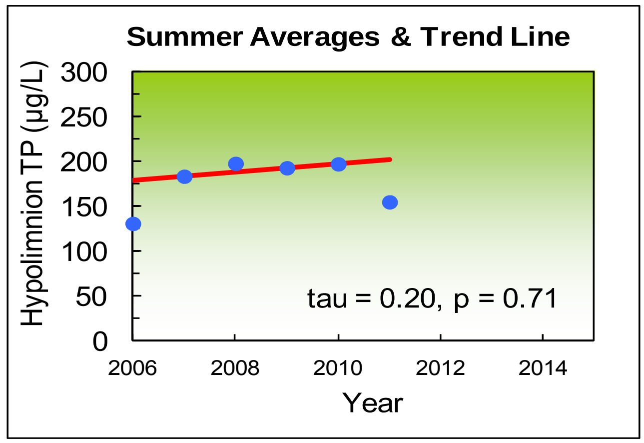
Phosphorus (key nutrient for algae)

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. The principal nutrient of concern in Crystal Lake is phosphorus. Monitoring of phosphorus levels over time helps to identify changes in nutrient pollution.

In the epilimnion (upper waters) of Crystal Lake, the phosphorus levels are moderate, with a 1998 – 2011 long-term summer average of 20 µg/l (micrograms per liter, which is equivalent to parts per billion). The annual averages were higher and more variable from 2001 through 2006, but in recent years have been lower and similar to levels in the late 1990s. One reason for this variability may be that there were only 1 or 2 measurements each summer from 1998 through 2005. Based on the data collected over the entire 1998 through 2011 period, there has been no statistically significant trend indicating changes in total phosphorus levels in the upper waters.



Total phosphorus concentrations in the hypolimnion (or bottom waters) are high. The 2006 – 2011 long-term summer average is 176 µg/l. Although the concentrations appear to be higher in some years, there are too few years of data to determine if there is any trend. High phosphorus in the bottom waters is the result of a build-up of phosphorus released from the bottom sediments and can be a warning sign of accelerating eutrophication.



Examining the pattern of phosphorus concentrations through each month of the year provides clues to the dynamics occurring in the lake. Over the last six years, phosphorus concentrations in the upper waters increased around the time of lake turnover in November (see figure on page 5). Phosphorus was especially high during the winter of 2009-10. The winter spikes in phosphorus occur because phosphorus has been released from the bottom sediments during the summer period of low dissolved oxygen and built up in the bottom waters. The graph of phosphorus concentrations in the bottom waters shows how the levels steadily increase through the summer until lake turnover. Once the lake mixes, this phosphorus spreads throughout the lake and remains to feed algae growth in the spring. The inflow from streams also contributes to higher phosphorus levels in the rainy period beginning in November.

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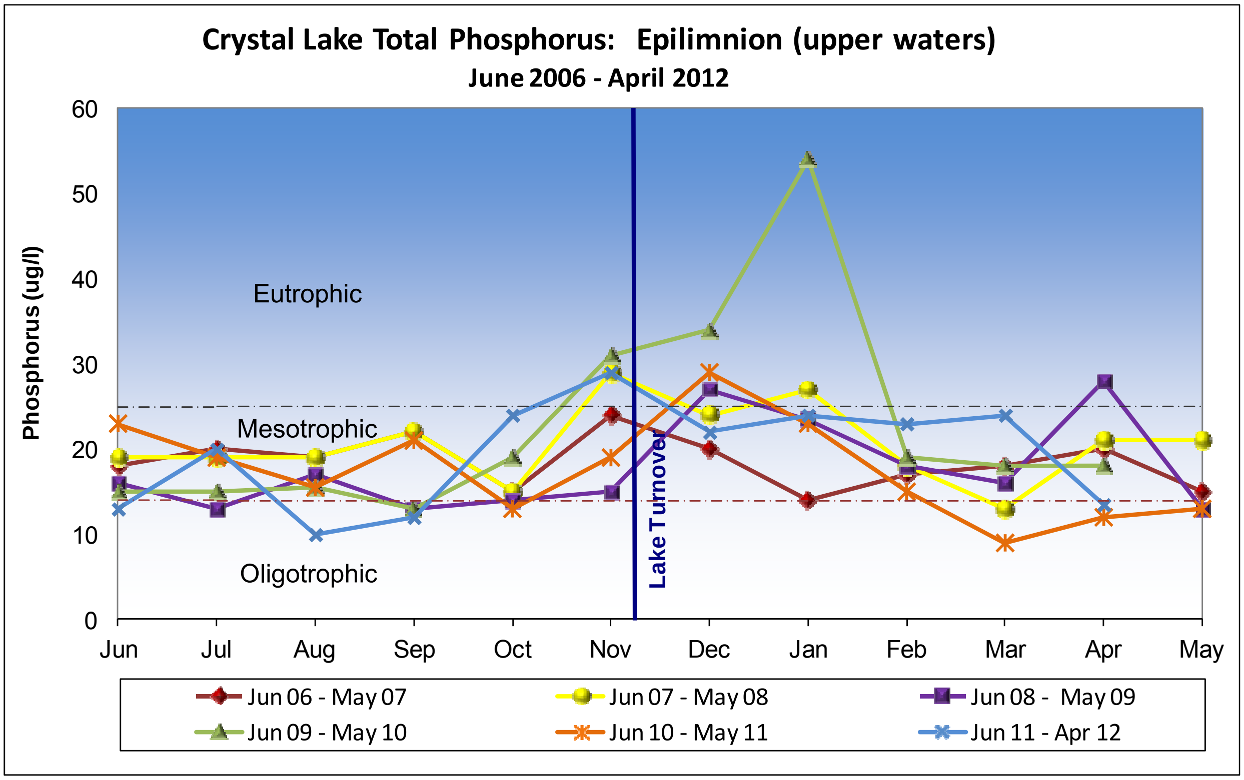

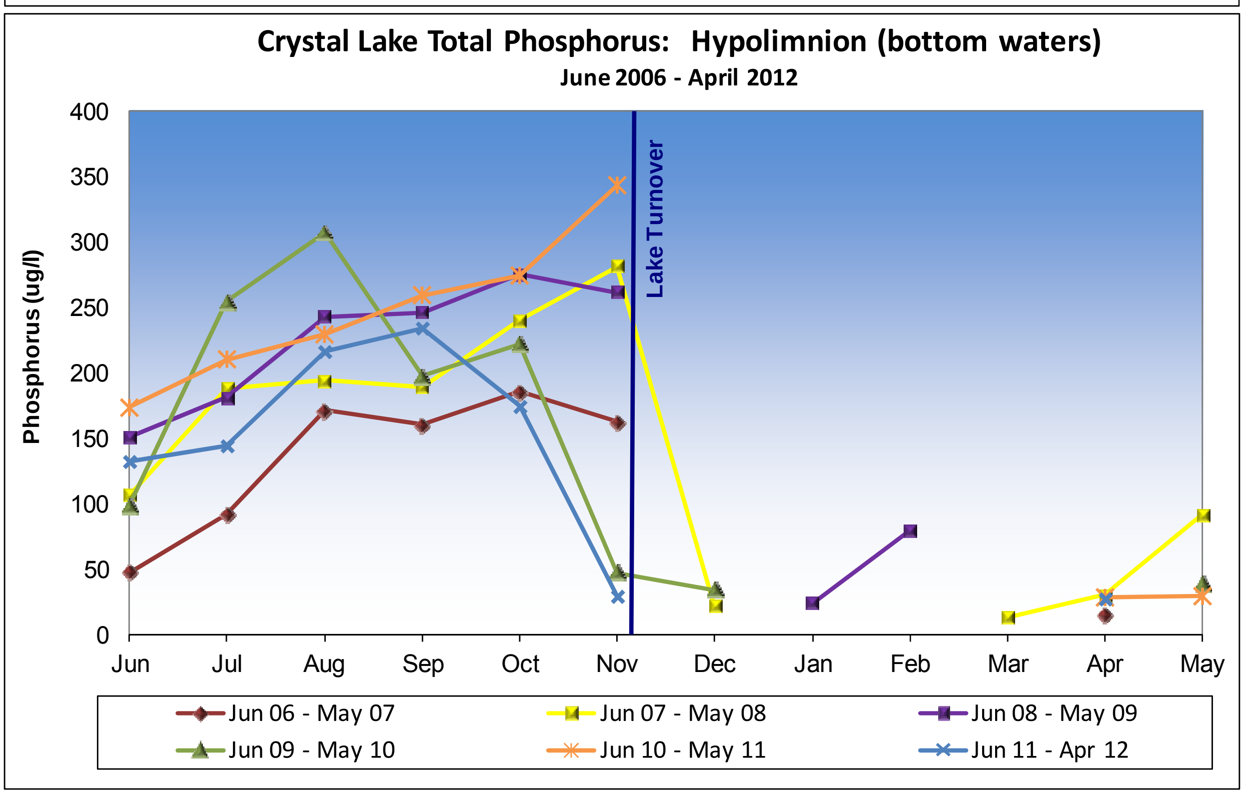

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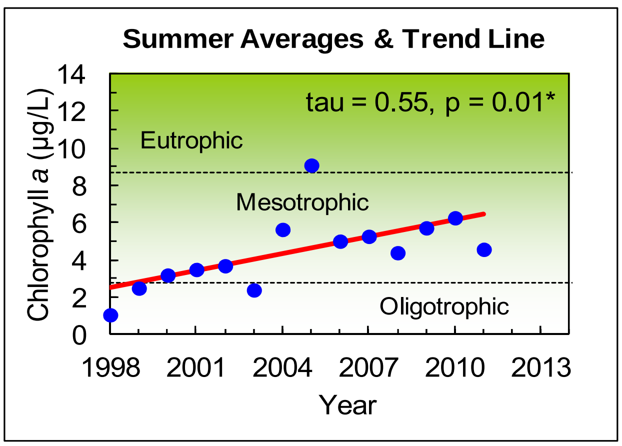
Chlorophyll a (Algae)

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

Chlorophyll *a* is a pigment found in algae and indicates the density of algae in the lake. Chlorophyll *a* levels in Crystal Lake are moderate, with a long-term summer average of 4.5 µg/l. Between 1998 to 2011 there has been a statistically significant increase in summer concentrations of chlorophyll *a*. However, this trend should be viewed cautiously because there were only one or two measurements per year until 2006. The high average of 9.1 µg/l in 2005 was derived from only one June sample. Increasing chlorophyll *a* concentrations may be the result of a build-up of phosphorus that is leading to more algae blooms.

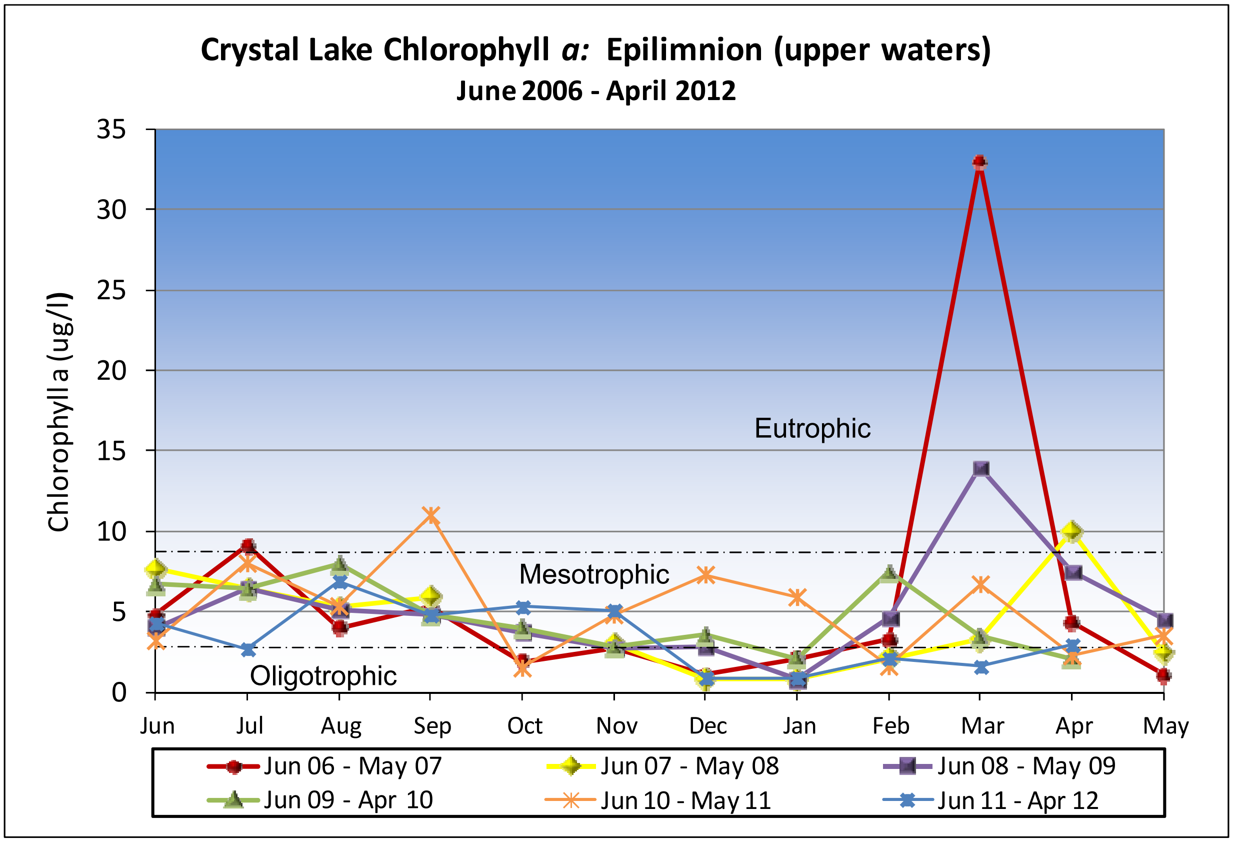


Wintertime chlorophyll *a* concentrations are typically low, around 1 to 3 µg/l, because of lower algae growth in winter (see figure on page 7). However, during the past six years of sampling, there have been several springtime spikes in chlorophyll *a* concentrations indicating algae blooms. The early blooms are likely a result of the high wintertime phosphorus concentrations that result from lake mixing that brings phosphorus from the bottom waters. Also, inflowing water coming from the watershed during rain storms adds more phosphorus. Certain species of algae, including diatoms, are also more likely to bloom in the spring.

Observations at Crystal Lake do indicate that the lake experiences occasional algae blooms that correspond to the higher levels of chlorophyll *a*. A bloom of blue-green algae or cyanobacteria was observed in 2005. Blooms of cyanobacteria are of concern because certain types have the potential to produce toxins. Only minor blooms of blue-green algae have been observed in recent years. However, in some years there have been significant accumulations of stringy filamentous algae growing on the lake bottom that eventually rise to the surface (see photo).

FILAMENTOUS GREEN ALGAE BLOOM - CRYSTAL LAKE 2009

PHOTO COURTESY OF J. NORMAN



<u>In-Flowing Streams</u>

Phosphorus is carried into the lake by rain running off from the land in the surrounding watershed. Phosphorus enters the lake either directly from the shore or runs into a stream that feeds the lake. In November 2006, SWM staff collected one set of samples for total phosphorus from multiple locations in the watershed to determine the primary sources of phosphorus inputs. Samples were taken at the north end of the wetland, at 222nd Street, and at three locations along Bostian Road to characterize flow from the Maltby urban area. The results of these samples showed low to moderate levels of phosphorus from all the northern inflows (5 to 26 µg/l).

Since December 2006, inflowing stream samples have been collected only at 222nd Street and at the west inlet of the lake. The 222nd Street location should represent the entire developed area draining into the north end of the wetland, and the west inlet represents the runoff from the mostly forested area to the west of Crystal Lake. The 222nd St inlet phosphorus concentrations averaged 38 µg/l from 2006 - 2012 (see figures on page 8). The west inlet levels are lower, with an average concentration of 27 µg/l over the same time period. Both inlets had low values in 2011-12.

Although the phosphorus levels in water coming from both the developed and undeveloped areas are low to moderate for most of the wet season, it should be noted that the total amount of phosphorus reaching the wetland and lake may not be low. During periods of high rainfall, it appears that phosphorus concentrations increase as nutrients are flushed from the landscape, as evidence by the high peaks in the 222nd street concentrations during most years. This means that the

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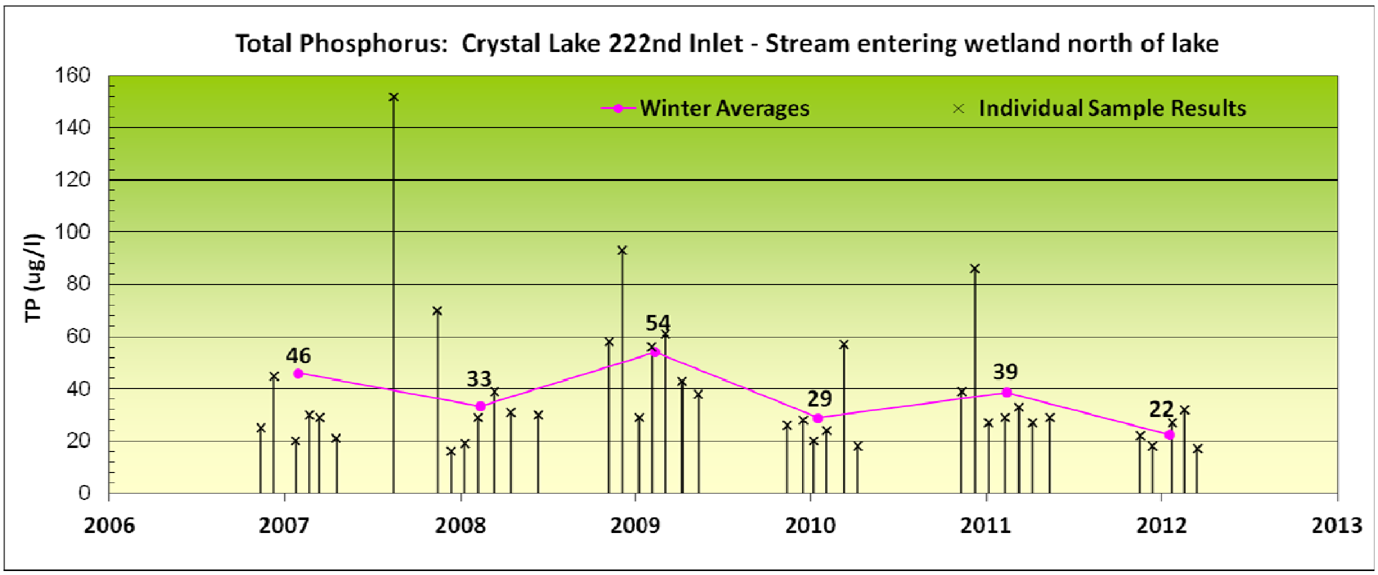
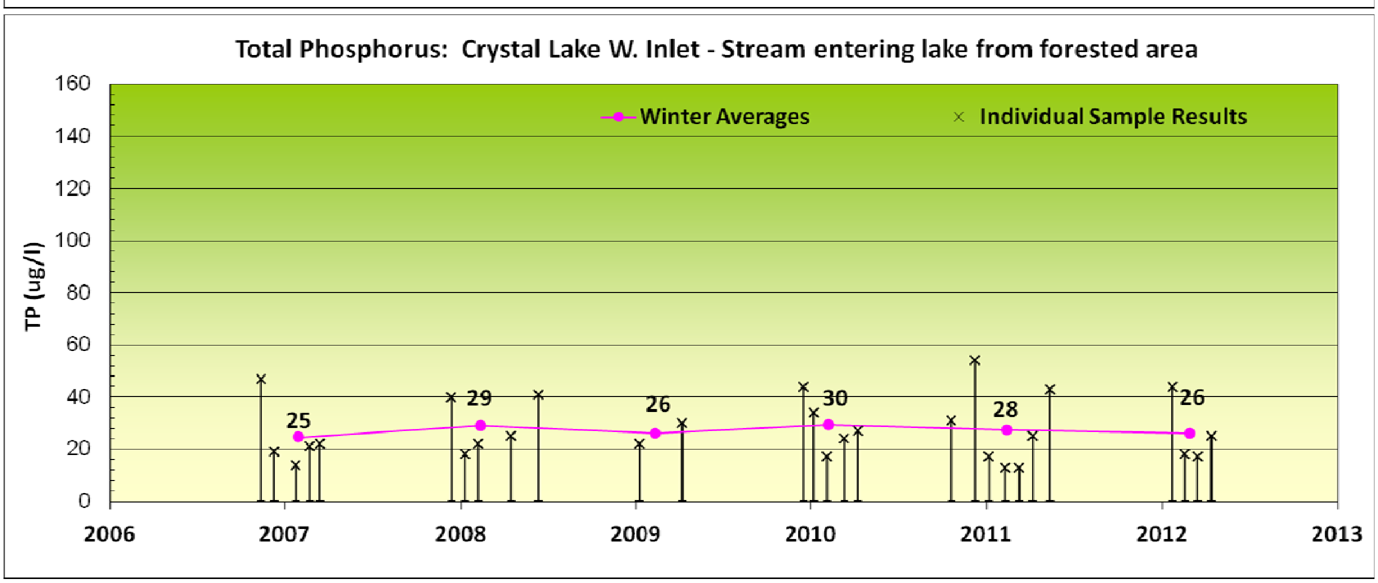
total amount of phosphorus headed toward the lake at those times is high. Even with lower concentrations at other times in the wet season, the total amount of nutrients carried by continuing flows of water is significant. And, because the amount of water coming into the wetland from the developed areas is much larger than the amount flowing into the lake through the west inlet, the total amount of phosphorus from developed areas is higher. However, without actual flow measurements, it is difficult to estimate the total contributions of phosphorus from each area to the lake.

The phosphorus carried by winter flows can take several paths. Some of the phosphorus may be trapped and bound up in the wetland, not immediately reaching the lake. Some may reach the lake and cause immediate effects, such as the algae bloom in March 2007 and the high phosphorus measurement in January 2010. Some may remain in the lake water column to contribute to algae and aquatic plant production during the summer; some may settle to the lake bottom; and some may pass through the lake and be flushed downstream.





CRYSTAL 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, Crystal Lake can be classified as a meso-eutrophic lake. This means that the lake produces moderate to high levels of plants and algae. The levels of phosphorus (the main nutrient of concern) in Crystal Lake are moderate, while the levels of phosphorus entering the lake/wetland from the principal streams range from low to high depending on rainfall patterns.

Condition and Trends

Overall, Crystal Lake appears to be in satisfactory condition. Water clarity shows possible signs of improvement. Phosphorus levels in the upper and bottom waters do not show any significant trends. Chlorophyll *a* values, however, do show a statistically significant trend toward higher algae levels over the monitoring time period. In addition, the dense growth of aquatic plants remains a concern for lake users. For these reasons, Crystal Lake appears to be at risk of future water quality declines if increases in chlorophyll *a* levels continue and if higher phosphorus levels occur, especially in the hypolimnion.

The primary threat to lake water quality is a continuing inflow of nutrients entering the lake or the wetland from new development and human activities in the watershed. Measures to control nutrients in the upper watershed and around the lake shore should be taken to prevent any future negative impacts to the lake. Preservation of the large wetland north of the lake is vital for filtering runoff and protecting the lake from the impacts of upstream urban activities. To find out more about ways to protect lake water quality and information on the causes and problems of increased nutrient levels visit www.lakes.surfacewater.info.

DATA SUMMARY FOR CRYSTAL LAKE					
		Water Clarity (Secchi depth	Total Phosphorus (*ug*/l)		Chlorophyll *a* (*ug*/l)
Source	**Date**	**in meters)**	**Surface**	**Bottom**	**Epilimnion**
Bortleson, et al, 1976	**8/2/1974**	1.8	19	18	-
Crystal Lake, Inc.	**6/11/1983**		22		2.3
Crystal Lake, Inc.	**1984**		17 - 17 (17) *n = 2*		0.8 - 2.6 (1.7) *n = 2*
Crystal Lake, Inc.	**9/9/1986**		10		4.7
Crystal Lake, Inc.	**10/6/1987**		14		5.4
Crystal Lake, Inc.	**1998**		14 - 23 (18) *n = 3*		1.0 - 1.6 (1.2) *n = 3*
Crystal Lake, Inc.	**10/15/1990**		17		4
Crystal Lake, Inc.	**8/14/1991**		22		2.5
Crystal Lake, Inc.	**5/15/1992**		21		0.8
Crystal Lake, Inc.	**8/9/93**		22		5.3
SWM Staff	**1994**	1.6 - 2.2 (1.9) *n = 2*			
SWM Staff	**3/5/1995**	2.1			
Crystal Lake, Inc.	**1998**		16 - 17 (17) *n = 2*		1.1 - 1.1 (1.1) *n = 2*
Crystal Lake, Inc.	**1999**		12 - 22 (17) *n = 2*		0.8 - 4.2 (2.5) *n = 2*
Crystal Lake, Inc.	**9/17/2000**		15		3.2
Crystal Lake, Inc.	**8/8/2001**		26		3.5

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DATA SUMMARY FOR CRYSTAL LAKE					
		Water Clarity (Secchi depth	**Total Phosphorus (*ug*/l)**		**Chlorophyll *a* (*ug*/l)**
Source	**Date**	**in meters)**	**Surface**	**Bottom**	**Epilimnion**
Crystal Lake, Inc.	**2002**		16 - 23 (20) *n = 2*		2.1 -5.3 (3.7) *n = 2*
Crystal Lake, Inc.	**5/20/2003**		22		2.4
Crystal Lake, Inc.	**2004**		15 - 45 (30) *n=2*		3.6-7.7 (5.7) *n=2*
Crystal Lake, Inc.	**6/3/2005**		25		9.1
SWM Staff or Volunteer	**2006**	1.6 - 3.0 (2.1) *n = 11*	15 - 22 (19) *n = 5*	47 - 185 (131) *n = 5*	1.9 - 9.1 (5.0) *n = 5*
SWM Staff or Volunteer	**2007**	2.2 - 3.6 (2.8) *n = 11*	15 - 22 (18) *n = 6*	106 - 240 (184) *n = 5*	1.1 - 7.7 (5.3) *n = 5*
SWM Staff or Volunteer	**2008**	2.1 - 3.2 (2.7) *n = 12*	13 - 21 (16) *n = 6*	91 - 275 (198) *n = 6*	2.4 - 6.4 (4.4) *n = 6*
SWM Staff or Volunteer	**2009**	2.2 - 4.0 (3.0) *n = 10*	13 - 19 (15) *n = 6*	79 - 307 (193) *n = 6*	4.0 - 8.0 (5.7) *n = 6*
SWM Staff or Volunteer	**2010**	1.7 - 2.6 (2.2) *n = 12*	13 - 23 (18) *n = 6*	38 - 274 (197) *n = 6*	1.5 - 11 (6.3) *n = 6*
SWM Staff or Volunteer	**2011**	2.2 - 3.9 (3.0) *n = 9*	10 - 24 (15) *n = 6*	29 - 234 (155) *n = 6*	2.7 - 6.9 (4.6) *n = 6*
Long Term Avg		**2.5** **(1994-2011)**	**20** **(1998-2011)**	**176** **(2006-2011)**	**4.5** **(1998-2011)**
TRENDS		**Increasing**	**None**	**None**	**Increasing**

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 1-2 meters above the bottom.