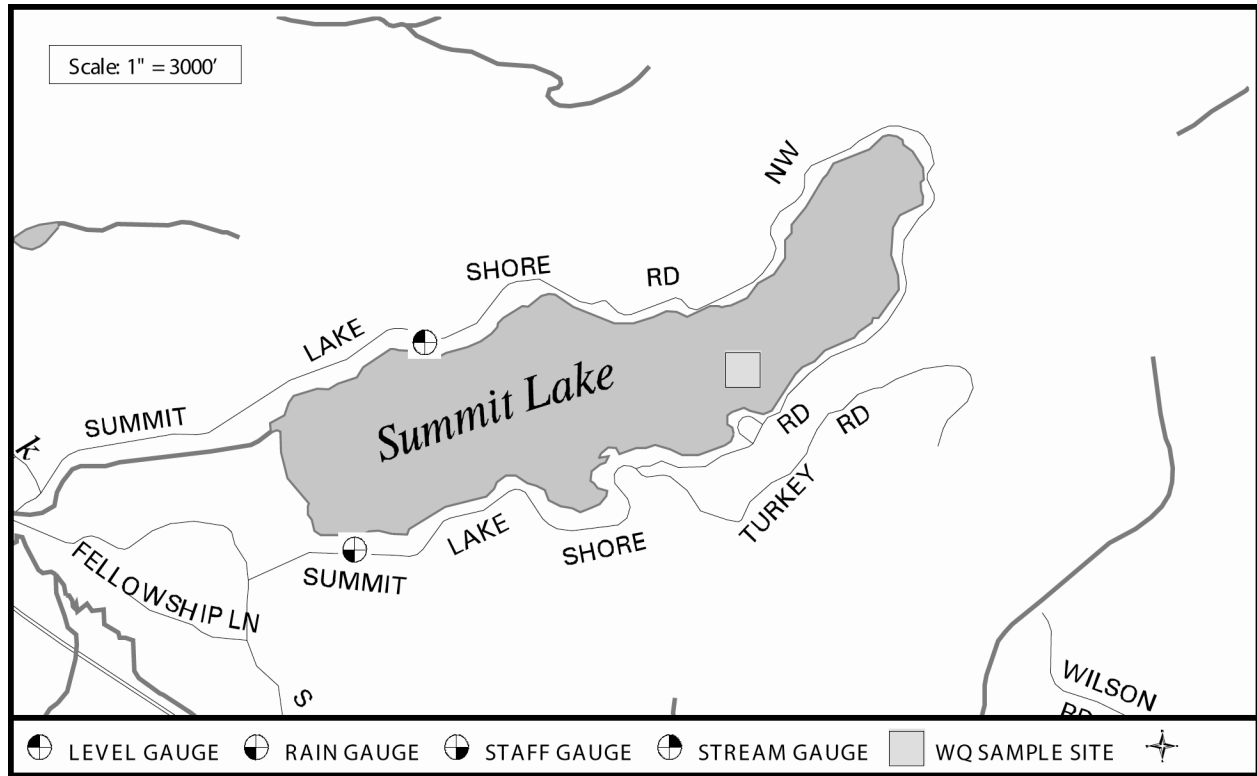


2016 Summit Lake Water Quality Report

Prepared by Thurston County Environmental Health Division



PART OF TOTTEN INLET WATERSHED

LENGTH OF LAKE: 2.2 miles

SHORELINE LENGTH: 5.6 miles

LAKE SIZE: 530 acres

BASIN SIZE: 2.8 square miles

MEAN DEPTH: 53 feet

MAXIMUM DEPTH: 100 feet

VOLUME: 28,000 acre-feet

PRIMARY LAND USES: The majority of the basin is commercial forest with dense development concentrated along the shoreline. There are approximately 400 homes along the shoreline.

PRIMARY LAKE USE:

Domestic water supply, fishing, boating, swimming, and other water sports.

PUBLIC ACCESS:

Washington Department of Fish and Wildlife public boat launch; three small private community accesses; 126-acre boy-scout camp at the west end of the lake.

GENERAL TOPOGRAPHY:

The approximate altitude of the lake is 460 feet. The drainage is steep and rugged with slopes up to 80 percent. There are numerous springs and intermittent streams that flow into the lake. The outlet, at the west end of the lake, is controlled by flash boards and flows into Kennedy Creek.

GENERAL WATER QUALITY: (Excellent, Good, Fair, Poor)

Good to Excellent - The lake has low nutrient and chlorophyll-*a* levels and good water clarity. The lake is used as a drinking water source for most of the lake residents. Uses are not impeded by aquatic weeds or algal growth.

OTHER DATA:

Thurston County Resource Stewardship Department, Water Resources Program;
(360) 754-4681; www.co.thurston.wa.us/monitoring

Washington Department of Ecology (Ecology), Environmental Assessment Program, (water quality data);
(360) 407-6700

Ecology – Water Quality Assessment for Washington, June 2016. <https://fortress.wa.gov/ecy/wqamapviewer/default.aspx?res=1680x1050>

Water quality data - Thurston County Environmental Health Division;
(360) 867-2626; www.co.thurston.wa.us/health/ehswat/swater.htm

GENERAL DISCUSSION:

Summit Lake is one of the deepest lakes in Thurston County, with a maximum depth of 30 meters (100 feet). In 2016, ambient monitoring consisted of monthly sampling, May through October, at one monitoring site located at deepest area of the lake. Thurston County measured temperature, dissolved oxygen, pH, color, and conductivity at 2-meter increments from the lake surface to the bottom. Water clarity was measured using a standard secchi disk. Thurston County collected water samples near the lake surface (*surficial*) and near the bottom (*benthic*). Samples were analyzed for total phosphorus (TP) and total nitrogen (TN) by IEH Analytical Laboratories, Seattle, WA. Three-point composite samples were collected from the *epilimnion* (warm surface layer), or photic zone, and analyzed for chlorophyll-*a* and algae speciation. Chlorophyll-*a* samples were also analyzed by IEH Analytical Laboratories and algae samples were analyzed by the King County Environmental Laboratory.

Field Parameters

The 2016 monthly temperature, dissolved oxygen, pH, and conductivity profiles are graphically represented in subsequent sections of this report. The term “*thermal stratification*” refers to a condition in the lake when there are two distinct thermal layers of water, a warm upper layer and a cold bottom layer. Summit Lake is typically thermally stratified throughout the sampling season, as depicted in the aforementioned profile graphs.

By May 2016, the lake was stratified with the temperature in the surficial water (immediately below the surface), at 16.80° C. and the benthic water temperature at 8.12° C. The surficial temperature was the warmest in August at 21.90° C. Throughout the sampling season, the benthic (immediately above the lake bottom) temperature ranged between 8.07 ° C and 9.11° C.

During periods when the lake is thermally stratified, there is no exchange of oxygen from the atmosphere into the bottom waters. During that time, bacterial decomposition of organic material in the benthic, *anoxic* lake water and sediment, depletes the available dissolved oxygen in the bottom waters, a process referred to as *eutrophication*.

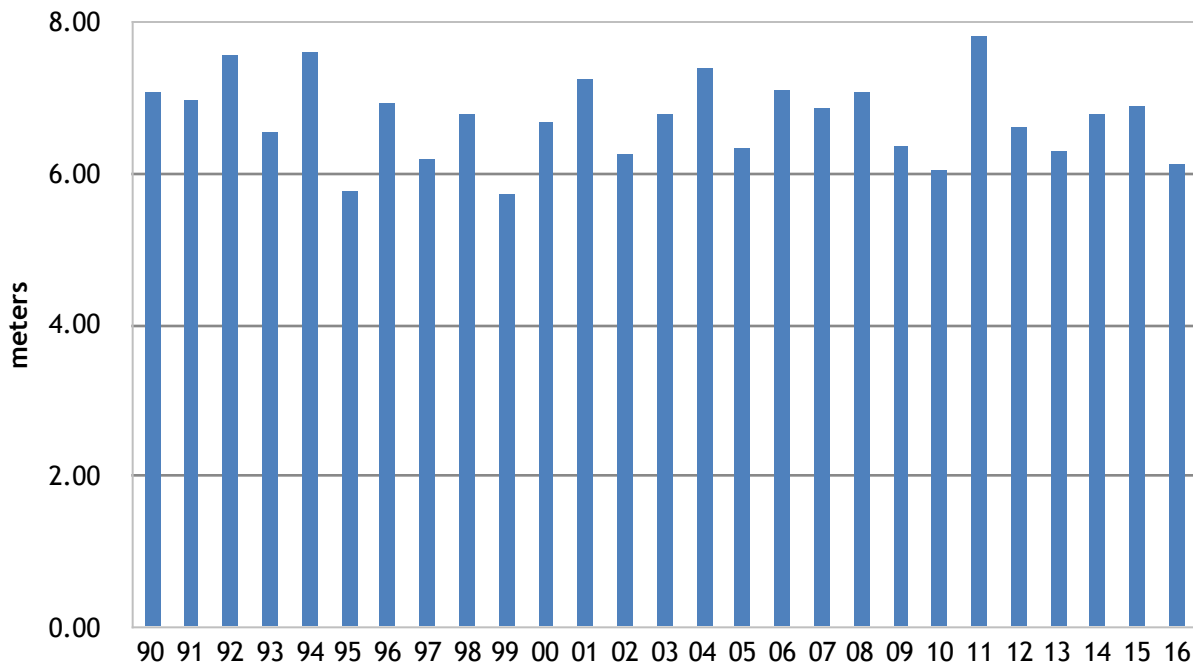
In 2016, benthic oxygen levels were depleted by August with a concentration of 0.82 mg/L. The *anoxic* benthic condition lasted through the remainder of the sampling season, with dissolved oxygen concentrations of 0.47 mg/L & 0.42 mg/L in September and October, respectively.

Anoxic conditions cause phosphorus from the sediments to be released into the water near the lake bottom. When the lake mixes in late-summer/early-fall, phosphorus-rich benthic water in close contact with sediments is transported towards the surface, which can stimulate algae growth.

Secchi Disk Water Clarity

Water clarity in a lake is measured with a device called a secchi disk. Summit Lake is one of the clearest lakes in Thurston County. The average water clarity for the 2016 season was 6.12 meters (20.08 feet), a slight decrease from the water clarity observed in 2015 (6.92 meters [22.70 feet]). In 2016, the water clarity ranged from 3.52 meters in June to 9.53 meters in August (11.55 to 31.27feet). The graph below shows the annual averages for water clarity since 1990.

Summit Lake Water Clarity Average Secchi Readings

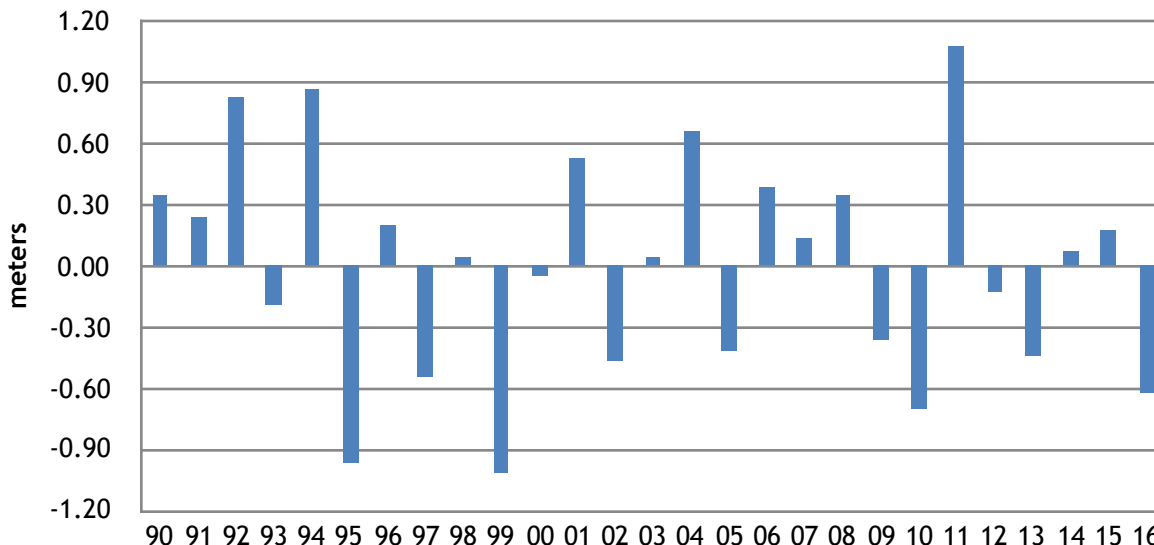


Water clarity trends are depicted on the trend graph below. The graph shows the difference between each average annual secchi reading and the long-term average for the entire period of record (6.74 meters). When the bar is above the “0” line, it indicates that the average water clarity for that year was better than the long-term average. A bar below the “0” line indicates that the water clarity for that year was poorer than the long-term average. Graphing the water clarity data in this way helps to show trends in water quality versus normal annual fluctuations. For Summit Lake, there is no obvious upward or downward trend in water clarity, just variation plus or minus of approximately one meter from the long-term average.

As noted previously, the average water clarity for the 2016 sampling season has decreased to levels recorded in 2010.

Water Clarity Trend

Annual Average Minus Long-Term Average



Total Phosphorus and Nitrogen

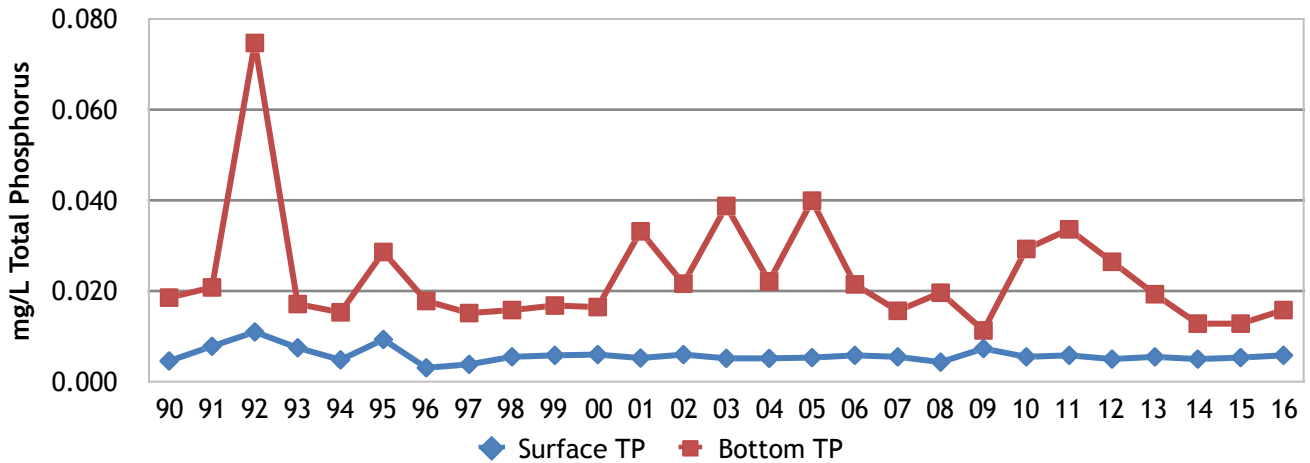
Generally, lakes in the Puget Sound region with summer average surface total phosphorus (TP) concentrations greater than 0.030 milligrams per liter (mg/L) experience undesirable algae growth which interferes with recreational uses of the lake (*USGS Water Supply Paper 2240*). The action level established in WAC 173-201A, “*Water Quality Standards for Surface Water of the State of Washington*” is 0.020 mg/L.

Below are graphs of the annual average TP and total nitrogen (TN) concentrations at the lake surface and bottom for the period of record.

In 2016, the average surface TP concentration was 0.006 mg/L. Monthly 2016 TP concentrations ranged from 0.002 to 0.015 mg/L, below the state action level. In Summit Lake, as with most freshwater lakes, algae production is limited by the amount of available TP. Summit Lake is low in nutrients, and as a result has low algae and aquatic plant production.

The benthic TP concentrations have been declining since 2011, and during 2014, 2015, & 2016 benthic phosphorus concentrations were below the state water quality standard of 0.020 mg/L (albeit not applicable to benthic TP). Benthic TP slightly increased since 2015 from 0.013 mg/L to 0.016 mg/L in 2016.

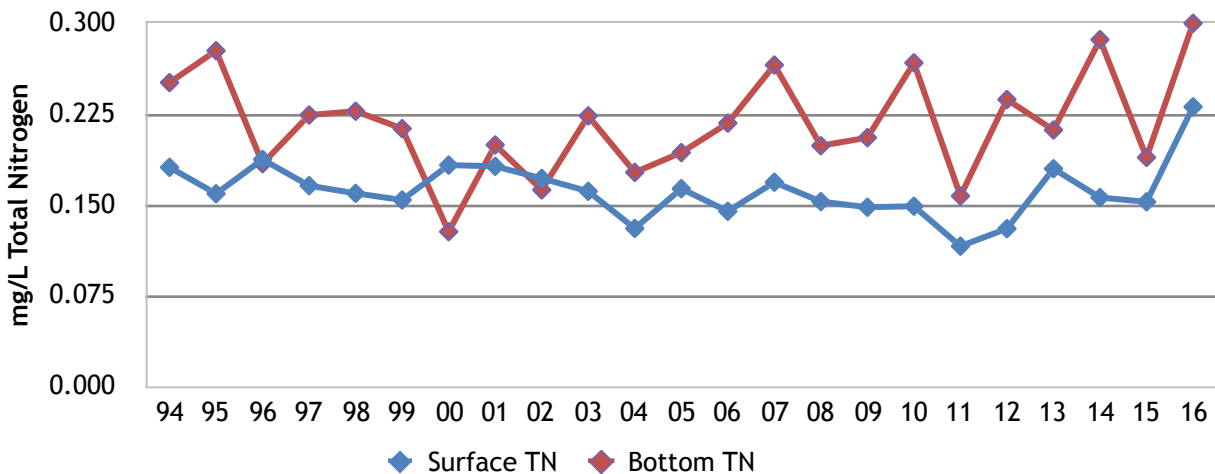
Total Phosphorus Annual Averages



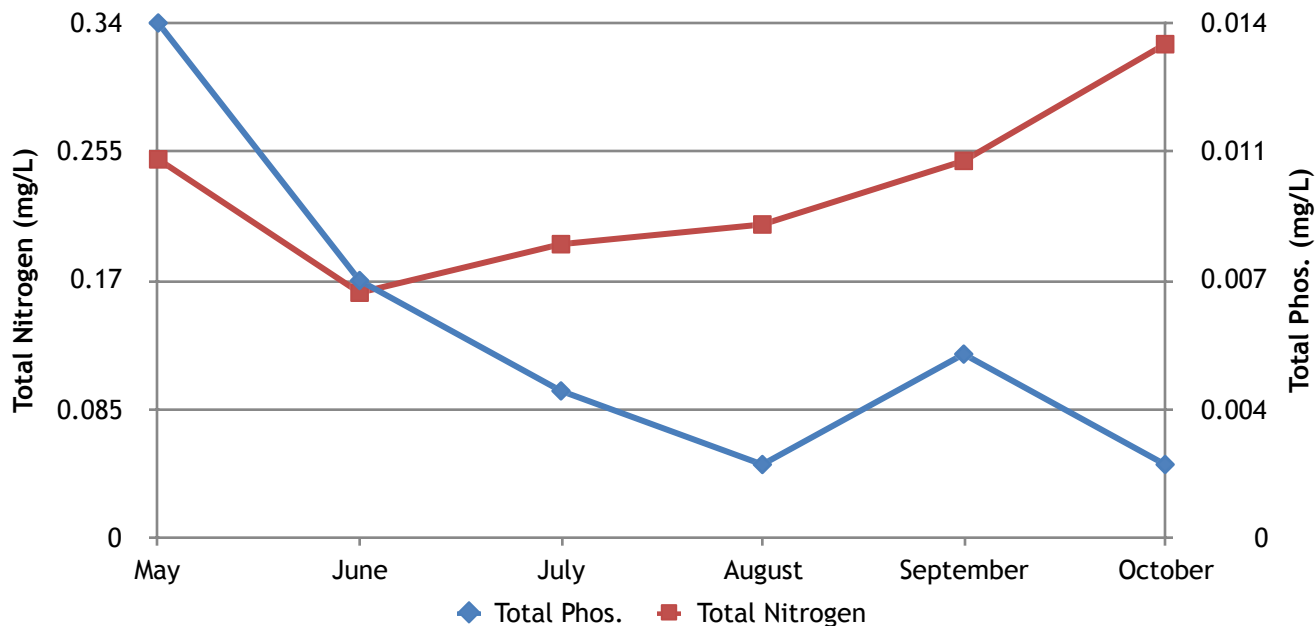
water quality standard

The below graph illustrates the average annual TN over the period of record for both benthic and surficial TN. Surficial and benthic TN concentrations fluctuate over the period of record, with no anomalous spikes. Benthic TN increased since 2015 from 0.189 mg/L to 0.300 mg/L in 2016; and surficial TN increased from 0.153 mg/L to 0.231 mg/L in 2016. No regulatory standard is in place for TN in surface waters.

Total Nitrogen Annual Averages



Summit Lake - 2016 Monthly Total Phosphorus & Total Nitrogen



The graph above depicts the monthly surficial TP & TN over the 2016 sampling season. All months in the 2016 sampling season were in compliance with the aforementioned regulatory TP action level of 0.020 mg/L. Surficial TP decreased throughout the sampling season with concentrations in May 2016 0.014 mg/L to 0.002 mg/L in October 2016.

Surficial TN was elevated in May 2016 at a concentration of 0.25 mg/L, then steadily increased over the remainder of the sampling season (June to October).

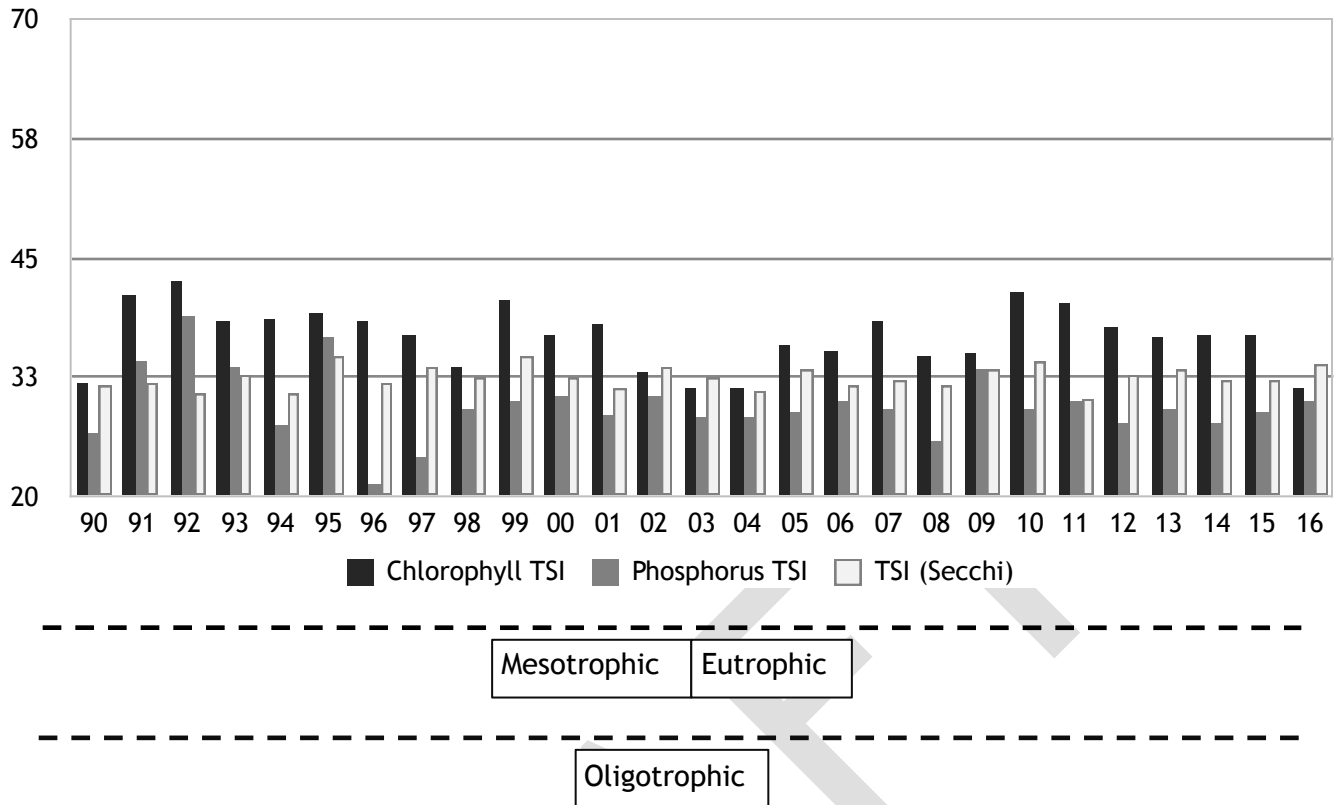
Trophic State Indices

Carlson Trophic State Indices (TSIs) are used to express the degree of productivity in a lake. Average summer TP, chlorophyll-*a*, and secchi disk readings are each used to calculate TSIs. A TSI of 0 to 40 indicates an *oligotrophic*, or low productivity, lake. A TSI of 41 to 50 indicates a *mesotrophic*, or moderately productive, lake. A TSI of greater than 50 indicates a *eutrophic*, or highly productive lake, which are typically characterized by poor water clarity and high algae growth.

Summit Lake is an *oligotrophic*, or low productivity, lake. The Summit Lake 2016 TSIs for TP, chlorophyll-*a*, and secchi disk were 30, 31, and 34, respectively. Summit Lake TSIs are predominantly within the *oligotrophic* range for all three parameters, over the period of record. An *oligotrophic* lake is characterized by low nutrient levels, low algae growth, and good water clarity. Because of this Summit Lake is clear and low in algae and aquatic plant growth, it is popular with recreational users. It is also used as a domestic water source for many residences around the lakeshore, due to the absence of an adequate groundwater supply.

In comparison to 2015, TSIs fluctuated slightly, but remain well within the *oligotrophic* range. The Summit Lake 2015 TSIs for TP, chlorophyll-*a*, and secchi disk were 29, 37, and 32, respectively. TP & Secchi TSIs slightly decreased in 2016, and the chlorophyll-*a* TSI increased.

Summit Lake Trophic State Indices



Algae

The monitoring program includes identification of algae species present in the lake. The 2016 data can be found at the end of this chapter. There are a variety of algae types present in Summit Lake including diatoms, green, yellow, and blue-green. Blue-green algae species are most common in nutrient-rich lakes and are known to cause visible algae blooms. Blue-green algae species are present in this lake, but are rarely dominant. To date, only relatively minor and localized blue-green algae blooms have been observed.

Some species of blue-green algae can produce toxins that can cause illness, in people, pets, and wildlife if ingested. Pets are particularly vulnerable to poisoning from toxic algae blooms due to their smaller body weight and their tendency to ingest higher doses of water. In recent years, an increase in documented toxic blue-green algae blooms in Washington lakes was noted.

In response to this pattern, Washington Department of Health established state recreational guidance limits for several algae toxins, and Washington Department of Ecology funds statewide laboratory services to test for toxins during algae blooms. When severe algae blooms do occur, Thurston County Environmental Health staff send samples for analysis to determine if, and how much, algae toxin is present. Although toxin testing is now possible, lake residents and users should always observe lake conditions and avoid contact with lake water where an algae bloom is occurring.

More information about blue-green algae and swimming safety information is available through the Thurston County website: www.co.thurston.wa.us/health/ehadm/swimming/swimming_index.html

Major Issues:

- Steep slopes, shallow soils, and generally small lots sizes make siting and functioning of on-site sewage systems around the lake difficult. A 1992-1997 sanitary survey of 330 on-site sewage systems around the lake perimeter found 58 systems were failing (18%). Nearly all of the 58 failing systems were repaired. However, a systematic evaluation of the septic systems surrounding the lake has not been done in nearly twenty years.
- The majority of lakeshore residents use lake water as their domestic water supply, and many do not disinfect it prior to use. Surface waters cannot be adequately protected from contamination to be safely used as a domestic water supply without treatment. A public health advisory issued in 1987 advises against consumption of untreated lake water at Summit Lake.
- The high density residential activities along the shoreline and forestry activities in the upper watershed pose a concern for water quality.

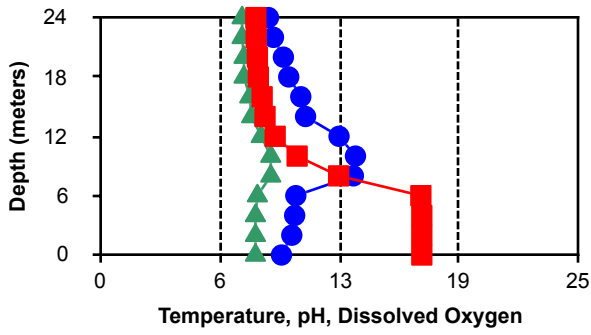
Recommendations:

- Educate lake residents on the proper application (agronomic rates) of fertilizers.
- Conduct and inspect on-site septic systems to assure they are operational, and not contributing to the excessive nutrients into the lake.
- Identify all outfalls and stormwater conveyances discharging to the lake. Conduct dry weather outfall screening and identification. Sample outfalls that are actively discharging to the lake for nutrients.

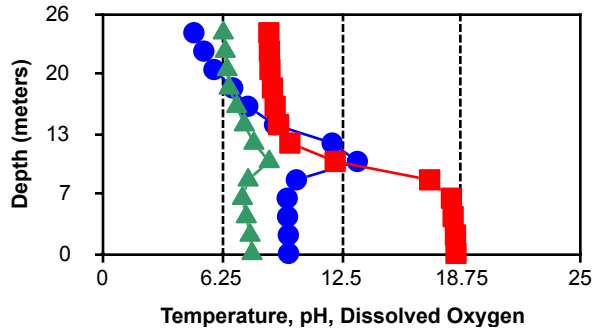
Funding Sources:

Thurston County stormwater program funds will continue to support monitoring in 2017.

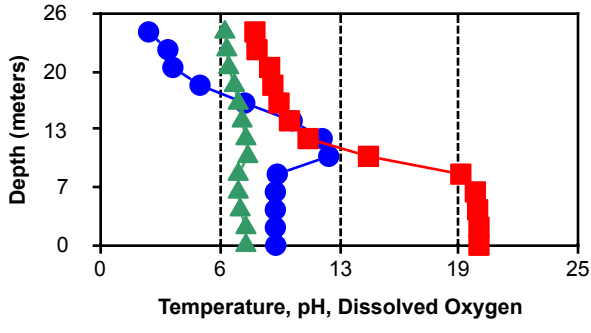
May 18, 2016



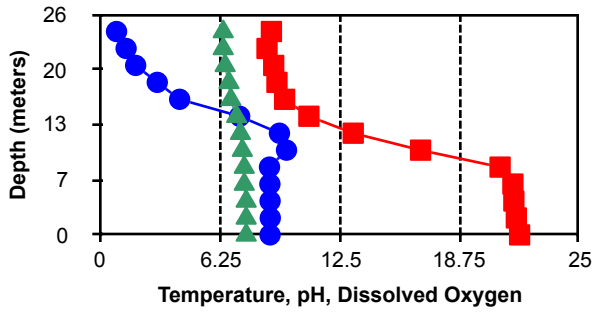
June 21, 2016



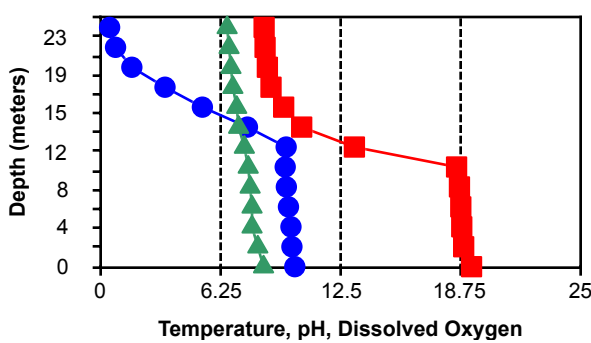
July 19, 2016



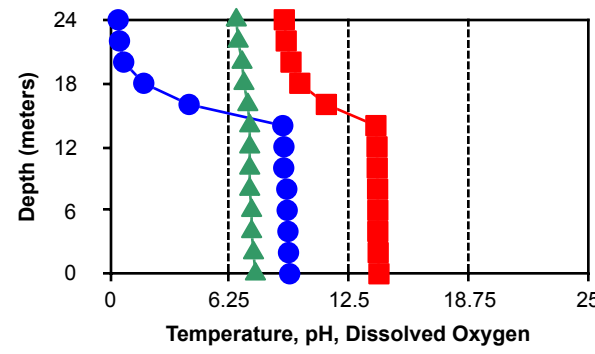
August 23, 2016



September 13, 2016



October 24, 2016



Thurston County Water Resources Annual Report - 2016

Summit Lake, Main (North) Basin

Site ID# TOTSUL010

Date Notes	Time	Bottom	Bottom	Surface	Bottom	Surface	Bottom	Secchi	Chl a	Phae a	Water	Lake
		Depth m	Sample Depth m	TP mg/L	TP mg/L	TN mg/L	TN mg/L	m	ug/L	ug/L		
5/18/20 16	13:00	25.8	24.5	0.014	0.014	0.25	0.28 8	4.11	2.1	0.1	#2 lt. green	Chl a & algae composite @2, 6 & 10m.
6/21/20 16	15:00	25.0	24.5	0.007	0.007	0.162	0.14 1	3.52	1.1	0.1	#2 lt. green	Chl a & algae composite @ 2, 6, & 10m.
7/19/20 16	13:00	24.2	23.5	0.004	0.008	0.194	0.34 3	4.5	0.7	0.1	#2 lt. green	Chl a & algae composite @ 2, 6, & 10m.
8/23/20 16	12:50	24.5	23.5	0.002	0.015	0.207	0.34 2	9.53	0.7	0.5	#2 lt. green	Chl a & algae composite @ 2, 6, & 10m.
9/13/20 16	14:00	25.6	24.5	0.005	0.047	0.249	0.44 2	7.42	0.7	0.1	#2 lt. green	Chl a & algae composite @ 4, 6, & 10m
10/24/2 016	12:00	25.4	24.5	0.002	0.004	0.326	0.24 6	7.61	1.1	0.1	#2 lt. green	Chl a & algae composite @ 2, 4, & 8m.
Averages:		Surface Total Phosphorus				<i>0.006 mg/L</i>						
		Secchi				<i>6.12 meters</i>						
		Chl a				<i>1.07 µg</i>						