PART OF HENDERSON INLET WATERSHED

LENGTH OF LAKE: 1.9 miles

SHORELINE LENGTH: 7.1 miles

LAKE SIZE: 330 acres

BASIN SIZE: 8.25 square miles

MEAN DEPTH: 12 feet

MAXIMUM DEPTH: 21 feet

VOLUME: 3,900 acre-feet

PRIMARILY LAND USES:
Primarily urban and suburban residential use, with a small percentage in agriculture and forest. Dense residential development exists along the lake shore.

PRIMARILY LAKE USES:
Fishing, boating, swimming, and other water sports.

PUBLIC ACCESS:
Washington Department of Fish and Wildlife public boat launch, City of Lacey - Long Lake Park, & 10 small private community accesses.

GENERAL TOPOGRAPHY:
Approximate altitude of the lake is 150 feet above mean sea level (MSL). Long Lake is third in a series of four interconnected lakes beginning with Hicks Lake, then Pattison Lake, Long Lake, and finally Lois Lake. These lakes collectively drain to Woodland Creek, which flows to Henderson Inlet. The watershed is relatively flat with extensive wetlands between the lakes.
**GENERAL WATER QUALITY:**
(Excellent, Good, Fair, Poor)

*Fair* – Long Lake is considered *eutrophic*, with nutrient-rich waters and consequent blue-green algae blooms at times, often impeding water clarity. Many areas of the lake have emergent aquatic plants that interfere with recreational activities. Invasive aquatic plants are present in the lake and are actively controlled through a combination of chemical and non-chemical methods.

**GENERAL DISCUSSION**

Long Lake is third in a chain of lakes which discharge to Woodland Creek and ultimately drain to Henderson Inlet. Long Lake has two major basins, a north and south basin, which are connected by a narrow, shallow channel. The south basin has a maximum depth of about 13 feet, and the maximum depth in the north basin is about 20 feet. A small creek enters the south basin, and an outlet channel is located at the north end of the lake. The lake is also in continuity with regional shallow groundwater, resulting in several underwater springs/groundwater discharge points.

For many years, the Long Lake Management District (LLMD) has supported water quality improvement activities such as aquatic weed harvesting, Eurasian water milfoil surveys, alum treatments, and water quality monitoring. In 2008, the LLMD contracted for an alum treatment in the south basin of the lake to reduce phosphorus, increase water clarity, and subsequently reduce the frequency of nuisance algae blooms. The effectiveness of the 2008 treatment appears to have diminished in both basins, as the annual means of total surface and benthic nitrogen & phosphorus concentrations increased dramatically from 2015 to 2016.

In 2017, per request from the lakes manager, total soluble reactive phosphorus (SRP) was sampled rather than total phosphorus, which are not comparable. However, 2017 nitrogen concentrations followed the increasing trend. The 2017 annual average total nitrogen (TN) concentrations were the highest observed in both basins for the entire sampling history to date.

From May to October 2017, Thurston County conducted monthly ambient monitoring at two monitoring sites located in the deepest areas of the north and south basins. The parameters included temperature, dissolved oxygen, pH, conductivity, color, and secchi disk readings (water clarity). Thurston County also collected surface water samples from just below the surface (*surface*) and 0.5 to 1 meter above the lake bottom (*benthic*) of each basin. Samples were analyzed for soluble reactive phosphorus (SRP) and TN. In addition, Thurston County collected composite samples from the *epilimnion* (warm surface layer) or photic zone. Samples collected from the photic zone were analyzed for chlorophyll-*a* and pheophytin concentrations. SRP, TN, and chlorophyll-*a* samples were analyzed by IEH Analytical Laboratories in Seattle, WA. Tabular and graphical water quality data are located at the end of this report.

**OTHER AVAILABLE DATA:**

Water Quality data - Thurston County Environmental Health Division,
(360) 867-2626
[http://www.co.thurston.wa.us/health/ehrp/waterqualitymonitoring.html](http://www.co.thurston.wa.us/health/ehrp/waterqualitymonitoring.html)

Thurston County Stormwater Program
(360) 754-4681
[http://www.thurstoncountywa.gov/sw/Pages/monitoring.aspx](http://www.thurstoncountywa.gov/sw/Pages/monitoring.aspx)
**Field Parameters**

Graphical water quality data depicting monthly temperature, dissolved oxygen, pH, and conductivity profiles throughout the water column are located at the end of this report.

*Thermal stratification* is when two distinct layers of water form in the lake during the summer, a warm upper layer and a colder lower layer. The 2017 data indicates that both basins were stratified from May through August, and had begun to mix by September. In September and October 2017, the lake water temperatures were generally homogeneous throughout both basin water columns indicating the mixing of stratified lake layers.

In both basins, dissolved oxygen concentrations near the bottom were extremely low during periods of stratification (approaching zero milligrams per liter [mg/L]). Under low oxygen conditions (*anoxic*), phosphorus is released from the sediments into the water column in a form readily used by algae (a process referred to as *internal loading*). Consequently, when the lake mixed in late summer, the nutrient-rich benthic water enabled excessive algae growth.

**Secchi Disk Water Clarity**

Average monthly 2017 water clarity (secchi) measurements for both the north and south basins are graphed below. Water clarity in the north basin ranged from 1.02 meters (3.35 feet) in October to 2.61 meters (8.56 feet) in July. The seasonal average was 1.89 meters (6.2 feet). The north basin long-term average over the period of record is 2.32 meters (7.6 feet).

Water clarity in the south basin ranged from 0.81 meters (2.6 feet) in September, to 2.32 meters (7.6 feet) in October. The 2016 water clarity average for the south basin was 2.32 meters (7.6 feet). For comparison, the south basin average water clarity over the period of record is 2.19 meters (7.2 feet).
Following is a line graph illustrating the annual average secchi disk readings over the period of record. In 2017, the average water clarity in both basins was lower in comparison to 2016 values.

The clarifying effects of a whole lake alum treatment in 1983 are evident on the graph above, with enhanced water clarity above in both lake basins for several years following 1983. Improved water clarity in the south basin following a 2008 partial alum treatment is also evident.

To better examine trends in water clarity, annual average secchi disk readings were normalized by subtracting the average secchi results for the entire record from each annual average. A positive bar on the graph indicates that water clarity that year was better than the long-term average. A negative bar indicates that water clarity that year was poorer than the overall average.
Soluble Reactive Phosphorus (SRP) Levels

Generally, lakes in the Puget Sound region with summer average surface total phosphorus (TP) concentrations greater than 0.030 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. This water quality standard does not differentiate between the different forms of phosphorus.

In 2017, the lakes manager requested a change in the type of phosphorus sampled, from TP to SRP, or orthophosphate. Phosphates exist in three forms: orthophosphate (SRP), metaphosphate and organically bound phosphate. SRP typically originates from human sources such as septic systems, agricultural runoff and manure based lawn fertilizers. SRP is easily metabolized by algae and vegetation in lakes, and because if this, it is typically found in very low concentrations in unpolluted lake systems.

2017 monthly surface and benthic SRP concentrations for both the north & south basins are depicted in the line graphs below.
Although 2017 monthly surface SRP concentrations are not comparable to past TP concentrations, the surface SRP concentrations in both basins did not exceed the 0.020 mg/L phosphorus water quality standard. The mean 2017 surface SRP concentrations were 0.002 mg/L in the north basin and 0.01 mg/L in the south basin.

The mean 2017 benthic SRP concentrations were 0.019 mg/L in the north basin and 0.020 mg/L in the south. Benthic phosphorus levels are typically higher due to thermal stratification and low dissolved oxygen levels in the hypolimnion. In both basins a spike in benthic SRP concentrations occurred in August, which also coincided with an algal bloom and lower dissolved oxygen levels throughout the water column.

**Total Nitrogen Levels (TN)**

The graphs below illustrate seasonal surface TN fluctuations throughout the 2017 sampling season in both basins. It appears that surface TN concentrations are higher in the south basin in comparison to the north. The 2017 averages were 0.545 mg/L in the north basin and 0.585 mg/L in the south basin. In contrast, the benthic TN concentration in the north basin was higher than the south basin during the 2017 sampling season, with averages of 1.690 mg/L & 0.677 mg/L in the north and south basins, respectively.
The average surface TN concentrations over the period of record are 0.463 mg/L for the north basin, and 0.526 mg/L for the south. The 2017 surface TN concentrations are lower than the above-referenced averages over the period of record.

The average benthic TN concentrations for the north and south basins over the period of record are 0.582 mg/L & 0.583 mg/L, respectively. The 2017 benthic TN concentrations are notably higher than the above-referenced averages.

The two graphs below illustrate the mean annual surface and benthic TN concentrations over the period of record. The average 2017 annual surface and benthic TN in each basin were lower than 2016 averages, however concentrations are notably higher than the long term averages.
Trophic State Indices

Carlson Trophic State Indices (TSI) are unitless, and are used to express the degree of productivity of a lake. Average summer total phosphorus concentrations, chlorophyll-\(a\) concentrations, and secchi disk transparency are each used to calculate a TSI for the lake. In 2017 TP was not sampled in Long Lake, therefore the 2017 TSI includes chlorophyll-\(a\), and secchi disk calculations only.

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. Characteristics of a eutrophic lake include poor water clarity and excessive aquatic plant and algae growth.
North basin 2017 TSIs for chlorophyll-\(a\), and secchi disk are 58 and 51 respectively. South basin TSIs for chlorophyll-\(a\), and secchi disk are 62 and 55 respectively. All 2017 TSIs for Long Lake are well within the eutrophic range (>50), indicating a highly nutrient-rich and productive lake, which impairs lake uses. As such, the average for the north and south basins are 55 and 58, which classifies both basins of Long Lake as eutrophic. The average 2016 TSIs for the north and south basins were 60 & 61, respectively, also within the eutrophic range.

Annual TSIs for both basins are graphed below. Lower TSIs in the 1980s show water quality improvements resulting from a 1983 whole lake alum treatment.
**Algae**

Some species of blue-green algae can produce toxins that can cause illness, or even death, in people, pets, and wildlife if ingested. Pets are particularly vulnerable to poisoning from toxic algae blooms due to their smaller body size, weight and their tendency to ingest higher doses. In recent years there has been an increase in documented toxic blue-green algae blooms occurring in lakes within Washington State. In response, Washington Department of Health established provisional recreational guidance values for several algae toxins, and Washington Department of Ecology funds statewide laboratory services to test for toxins during algae blooms. When algae blooms occur, Thurston County Environmental Health staff send water samples for analysis to determine if, and how much, algae toxin is present.

In 2017, Thurston County Health received citizen complaints regarding algae bloom concerns/observations. Each instance entailed water/algae scum sampling. In the event the toxin(s) are above guidance levels, the water body is posted for toxic algae, recommending use restrictions. The impacted water body is subsequently sampled weekly until toxins are not detected or are below guidance levels for two weeks in a row. At that point, the water use advisory is lifted.

Long Lake experienced two toxic algae blooms in 2017. In August 2017, Thurston County Health sampled surface water/algae scum and submitted samples to the King County Environmental Laboratory for toxin analysis. Laboratory analysis exhibited Microcystin toxin at a concentration of 20.8 micrograms per liter ($\mu$g/L), well above the guidance value of 6 $\mu$g/L. Again, in late September 2017, surface water/algae scum samples sent to King County Environmental Laboratory exhibited Microcystin toxin at a concentration of 39.7 micrograms per liter.

Thurston County subsequently posted an advisory, warning lake users and residents to restrict activities such as swimming and fishing until toxin levels were below the level of concern for two consecutive weeks.

Thurston County Health sent a total of fifteen samples to King County Environmental Laboratories for algae toxin testing (see table at the end of this report for toxin sampling information. Samples were submitted in July, August, September and October 2017. For more information please visit the freshwater algae bloom monitoring program website at: [www.nwtoxicalgae.org/](http://www.nwtoxicalgae.org/).

Lake residents and users should always observe lake conditions and avoid contact with lake water when 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](http://www.co.thurston.wa.us/health/ehadm/swimming/swimming_index.html)

**Major Issues:**

- Abundant nutrients (TP & TN) often cause algae blooms which can become toxic and impair water clarity. Nutrients also stimulate filamentous algae growth, which form floating mats on the surface, impairing recreational uses.
- Blue-green algae blooms interfere with recreational uses of the lake. Lake residents and users should avoid water contact and keep children and pets out of the lake during severe algae blooms and when health advisories are in effect.
- Urban land uses, storm water discharges, and other non-point pollution sources have the potential to degrade water quality if on-going measures are not taken.
- Invasive aquatic species have been identified in Long Lake, specifically Eurasian water-milfoil.
**Recommendations:**

- Monitor and manage any recurrence of milfoil or emergence of other aquatic plants to meet recreational and aesthetic needs, fishery and wildlife habitat requirements, and watershed concerns.
- Conduct water quality monitoring. Expand the current frequency to include the months of April and November.
- Investigate and promote best management practices (BMPs) and shoreline habitat enhancement to decrease external nutrient deposition into the lake.
- Perform phosphorus and nitrogen analysis for specific species (i.e. orthophosphate, kjedahl nitrogen, etc.) in addition to total phosphorus and total nitrogen sampling.
- Educate lake residents on the proper application (agronomic rates) of fertilizers.
- Routinely inspect and maintain on-site septic systems to assure they are operational, and not contributing to the excessive nutrients into the lake.
- Identify up-gradient potential pollution sources.
- 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.
- Maintain a steering committee responsible for directing Long Lake Management District activities, overseeing finances and communicating with property owners.

**Funding Sources:**

2017 water quality monitoring was funded by Thurston County.
## Thurston County Water Resources Annual Report - 2017

### Long Lake @ LO#3 (North Basin)

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Bottom Depth m</th>
<th>Bottom Sample Depth m</th>
<th>Surface SRP mg/L</th>
<th>Bottom SRP mg/L</th>
<th>Surface TN mg/L</th>
<th>Bottom TN mg/L</th>
<th>Secchi (clarity)</th>
<th>Chl a ug/L</th>
<th>Phae a ug/L</th>
<th>Water Color</th>
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**Averages**

- Sur SRP: 0.002
- Secchi: 1.892
- Chl a: 16.833
## Thurston County Water Resources Annual Report - 2017

**Long Lake @ LO#4 (South Basin)**

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<th>Surface SRP mg/L</th>
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<th>Bottom TN mg/L</th>
<th>Secchi (clarity)</th>
<th>Chl a ug/L</th>
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**Averages**
- Sur SRP: 0.002
- Secchi: 1.41
- Chl a: 24.12
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