ALLEN LAKE 2017

Lake Stewardship Monitoring Report

King County Water & Land Resources Division
Science & Technical Support Section
www.kingcounty.gov/EnvironmentalScience

Summary & Recommendations

Thank you to David Burton, the volunteer monitor for Allen Lake

The key takeaways from the 2017 monitoring season are:

- Allen Lake had fairly high nutrient concentrations, moderate algal growth, and less-clear water.
- Long-term trends suggest that water quality in Allen Lake has generally been improving over time, though there has been considerable variation from year to year. Overall, nitrogen, phosphorus, and chlorophyll concentrations have decreased, and Secchi depths have gotten deeper.
- Nitrogen-to-phosphorus (N:P) ratios were below 25 throughout the monitoring season. This indicates the potential for algal blooms to be dominated by cyanobacteria (which have the ability to produce toxins).
- No algal blooms were reported for toxin testing in 2017.

The Lake Stewardship Program recommends:

- Stay alert for toxic algal blooms in Allen Lake – increase people's awareness of toxic algae, and their ability to identify which algae are potentially toxic. Any potentially toxic blooms should be reported to the King County Lake Stewardship Program and sampled for toxin analysis.
- Explore what has helped to decrease nutrient concentrations in Allen Lake – and encourage those trends to continue. Understanding the sources of year-to-year variability may provide some useful insights, as well.
- Monitoring is a key part of good lake stewardship, building a valuable long-term dataset to guide lake management and detect any future problems. Continue to monitor Allen Lake through the Lake Stewardship Program.

In this report:

What We Measure & Why

- **Secchi depth** is a measure of water clarity or transparency. Secchi depth is shallower when there are more suspended particles in the lake, such as sediment or algae. Secchi depth is also affected by water color, often from tannins or other naturally occurring organic molecules.

- **Water temperature** can affect the growth rates of plants and algae. In addition, cooler or warmer water temperatures favor different species of fish and other aquatic organisms.

- **Chlorophyll-a** is a measure of the amount of algae in a lake. Chlorophyll-a is a pigment necessary for algae to photosynthesize and store energy.

- **Phosphorus** and **nitrogen** are naturally occurring nutrients necessary for growth and reproduction in both plants and animals. Increases in nutrients (especially phosphorus) can lead to more frequent and dense algal blooms.

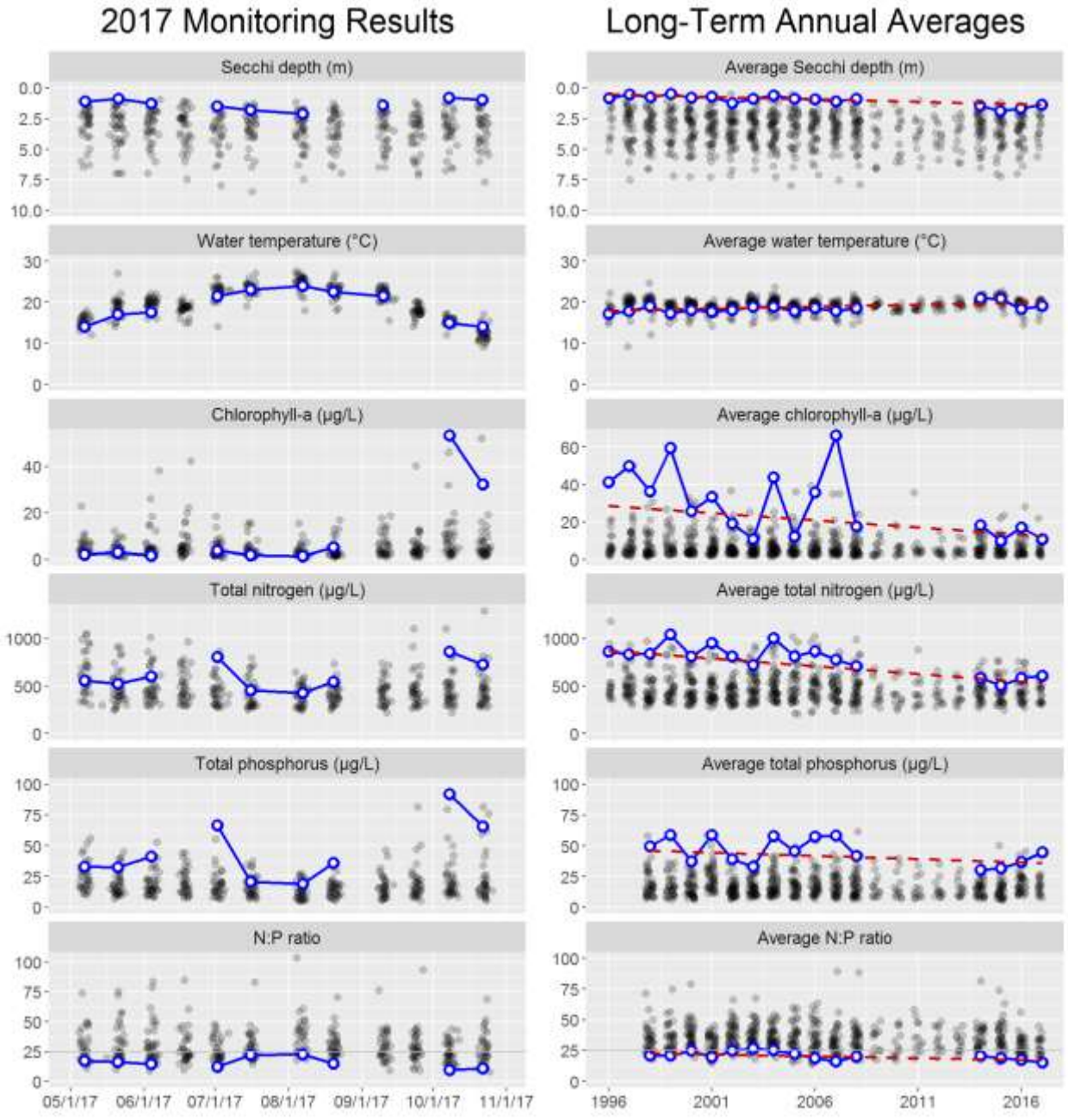
- The **ratio of total nitrogen to total phosphorus (N:P)** indicates whether nutrient conditions favor the growth of cyanobacteria (blue-green algae). When N:P ratios are near or below 25, cyanobacteria can dominate the algal community. This is important because cyanobacteria have the ability to produce toxins.

Water Quality Results & Trends

The following graphs show the water-quality parameters that are sampled from May through October, at 1 m depth (additional depths and parameters are measured on profile days; see *Supplemental Data*). The left column of graphs shows results for each sampling date in 2017, and the right column shows average values for each year (May-October averages).

Data for Allen Lake are the blue circles (with white centers) connected by the blue line. Any gaps in the blue line indicate missed samples. To provide some context for these values, the grey points in the background are results for all other lakes in the Lake Stewardship program.

Any long-term trends in Allen Lake are drawn with a dashed red line and described further after the graphs. Statistical trend analyses used a seasonal (monthly) Kendall test ($p<0.05$).



While no algal blooms were reported for toxin testing in 2017, data from the October 8th sample indicate an algal bloom that was likely to be dominated by cyanobacteria (which have the ability to produce toxins). The algae were dispersed through the upper part of the

water column on that date, rather than concentrated in an obvious surface scum. This highlights that Allen Lake has the potential for toxic algal blooms, which can take multiple forms (flecks, clumps, particulates, scums, etc.). Continue to increase people's awareness of toxic algae in Allen Lake, and encourage them to report potentially toxic blooms.

The table below gives more details about the long-term trends. Results are presented as an average amount and percent of change per decade (the increase or decrease over ten years). Percent change is calculated as the percent of the estimated value in 1996, when monitoring started.

Parameter	Change per Decade	(%)
Secchi depth	0.4 m	(72%)
Water temperature	0.99 °C	(5.5%)
Chlorophyll-a	-7.7 µg/L	(-27%)
Total nitrogen	-160 µg/L	(-19%)
Total phosphorus	-5.3 µg/L	(-11%)
N:P ratio	-3	(-13%)

Long-term trends suggest that water quality in Allen Lake has generally been improving over time, though there has been considerable variation from year to year. Overall, nitrogen, phosphorus, and chlorophyll concentrations have decreased, and Secchi depths have gotten deeper.

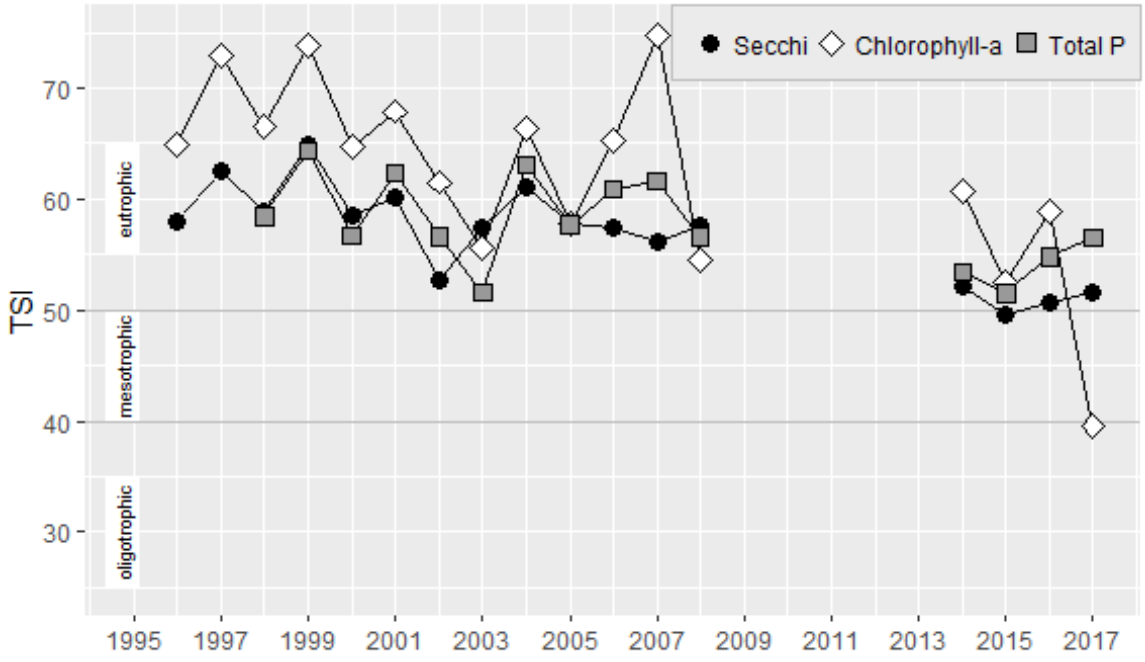
Trophic State

The Trophic State Index (TSI) is a common index of a lake's overall biological productivity. TSI values are calculated from Secchi depth, chlorophyll-a concentrations, and total phosphorus concentrations. These three TSI estimates are all scaled between 0 and 100.

TSI calculations use average values from June-September, focusing on fairly consistent "summer" conditions. Note that previous Lake Stewardship reports (through 2016) included May and October data as well. The TSI values presented below, for all years, have been recalculated using only June-September data.

Oligotrophic lakes (TSI <40) are very clear, with low nutrient concentrations and low algal growth. *Eutrophic* lakes (TSI >50) have less-clear water, with high nutrient concentrations and high algal growth. Eutrophic lakes are more likely to have frequent algal blooms. *Mesotrophic* lakes (TSI 40-50) are in the middle, with fairly clear water, and moderate nutrient concentrations and algal growth. Lakes in lowland King County have a range of different natural trophic states, and human activities may also alter a lake's trophic state (usually by changing nutrient inputs).

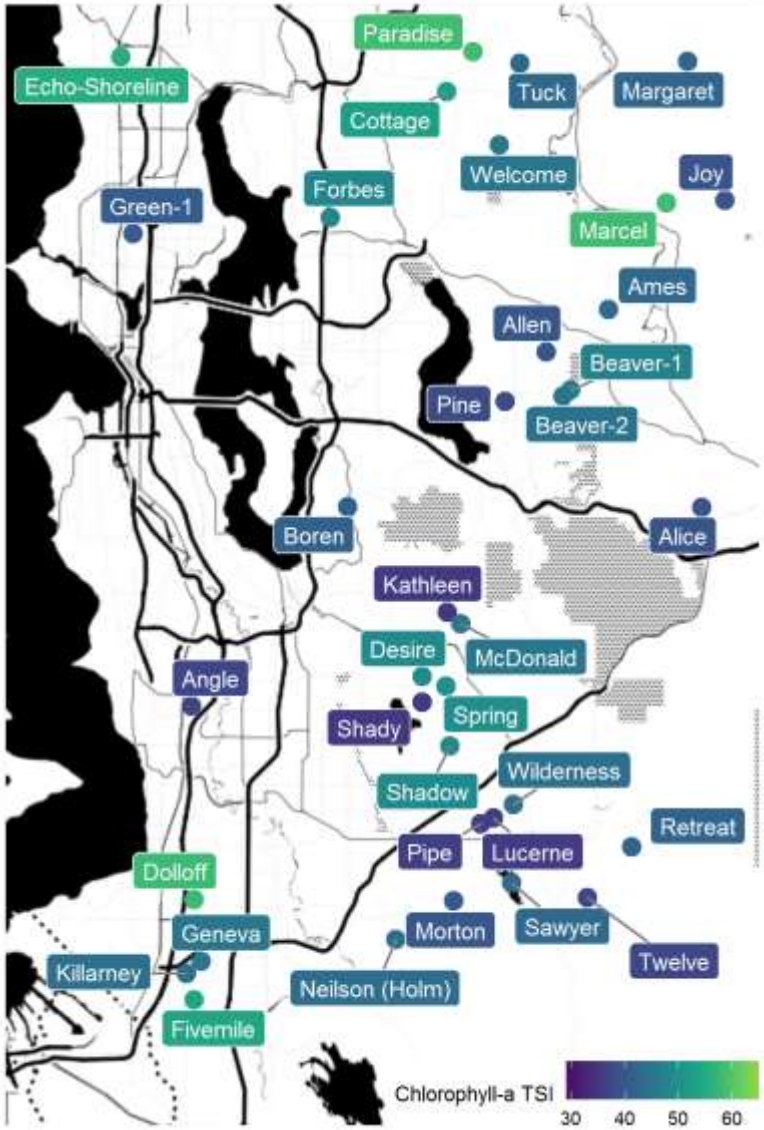
Trophic state indices



Looking at the TSI values over time highlights that water quality in Allen Lake has varied considerably from year to year. In 2017, the chlorophyll TSI value was unusually low. No samples were collected in September 2017, so it is difficult to say whether this low TSI reflects actual June-September conditions, or whether chlorophyll concentrations were higher in September (as has been the case in some past years).

Comparison map

For a comparison with other lakes, this map shows the trophic state for each lake in the King County Lake Stewardship program in 2017. The color of each circle indicates the lake's average chlorophyll-a TSI value for the year.



Supplemental Data

Summary statistics

This table summarizes data from May-October 2017 (1 m depth only), giving the minimum, mean (average), and maximum values for each parameter. To reduce biases from missing data or changes in sampling frequency, monthly means were calculated and then averaged to give an overall mean.

Parameter	Minimum	Mean	Maximum
Secchi depth (m)	0.8	1.4	2.1
Water temperature (°C)	14.0	19.1	24.0
Chlorophyll-a (µg/L)	1.4	10.5	53.3
Total nitrogen (µg/L)	428.0	610.0	861.0
Total phosphorus (µg/L)	18.9	44.8	91.9
N:P ratio	9.4	15.4	22.6

Water column profile

In May and August, water was collected at the mid-lake sampling station from three depths in a water-column profile: 1 m, the middle depth of the water column, and 1 m from the lake bottom.

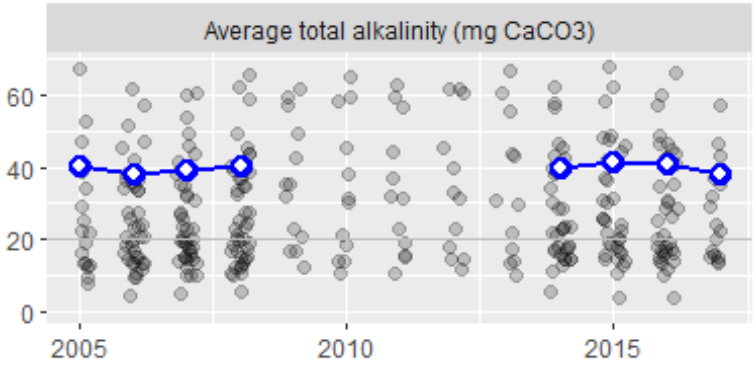
Date	Depth	Temp	Chlor	Pheo	TN	NH3	NO2/3	TP	OPO4
5/21/2017	1.0	17.0	2.8	1.1	524	25.9	46.4	32.4	7.1
	2.0	12.5	0.9	(1.1)	511	–	–	34.7	–
	3.5	10.5	(0.5)	(1.1)	663	226.0	44.6	93.0	50.1
8/20/2017	1.0	22.5	5.1	(1.4)	547	6.6	(10.0)	36.2	1.2
	2.0	16.2	118.0	(9.2)	743	–	–	55.9	–
	3.5	14.9	37.9	–	697	3.8	(10.0)	89.3	6.6

* Parameter abbreviations are: chlorophyll-a (Chlor), pheophytin (Pheo), total nitrogen (TN), ammonia (NH3), nitrate/nitrite (NO2/3), total phosphorus (TP), orthophosphate (OPO4). Depth is in m, temperature is in °C, and all other parameters are in µg/L. Dashes indicate parameters that were not analyzed for a given sample. Values below the method detection limit (MDL) are enclosed in parentheses and have the value of the MDL substituted.

Total alkalinity

A lake's ability to resist acidification, also called its buffering capacity, is measured as "total alkalinity." Lakes with total alkalinity less than 20 mg $CaCO_3$ are considered sensitive to acidification. We measured total alkalinity in May and August (on profile-sampling days) at 1 m depth. In 2017, the average total alkalinity of these two samples was 37.9 mg $CaCO_3$.

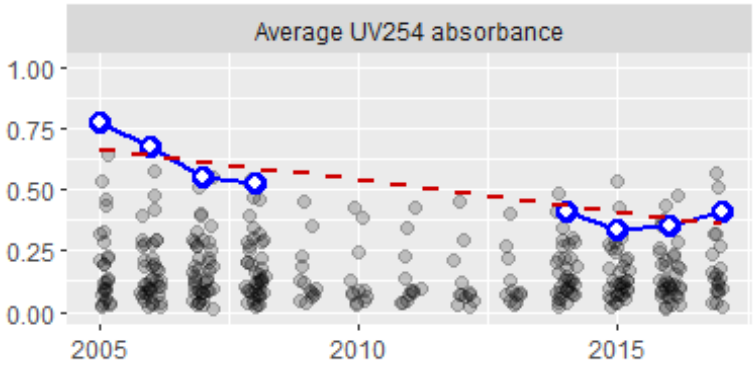
The blue circles (with white centers) and blue line are annual average alkalinity values for Allen Lake. Grey points in the background are results for all other lakes in the Lake Stewardship program.



Water color

Water color affects a lake's water clarity (and Secchi depth). Water color is measured by shining a specific wavelength of ultraviolet light (254 nm) through a filtered water sample and measuring the percent that was absorbed. We measured UV254 absorbance in May and August (on profile-sampling days) at 1 m depth. In 2017, the average UV254 absorbance of these two samples was 0.41, on a scale where 0 is no absorbance (perfectly clear) and 1 is complete absorbance (perfectly opaque).

The blue circles (with white centers) and blue line are annual average UV absorbance values for Allen Lake. Grey points in the background are results for all other lakes in the Lake Stewardship program. The dashed red line shows the long-term trend in UV absorbance, with an average change of -0.25 absorbance units per decade.



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