

ANGLE LAKE 2021

Lake Stewardship Monitoring Report

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

Summary & Recommendations

Thank you to Bruce & Sandy Goulet, and Diane and Buff Chace, the volunteer monitors for Angle Lake.

The key takeaways from the 2021 monitoring season are:

- Angle Lake continued to have clear water, with low nutrient concentrations and low algal growth.
- Angle Lake continues to be one of the clearest lakes in the Lake Stewardship Program.
- No algal blooms were reported for toxin testing in 2021.

The Lake Stewardship Program recommends:

- 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 Angle Lake through the Lake Stewardship Program.
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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. Many lakes in King County naturally have cold water, so increases in water temperature can favor non-native species.
- **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.

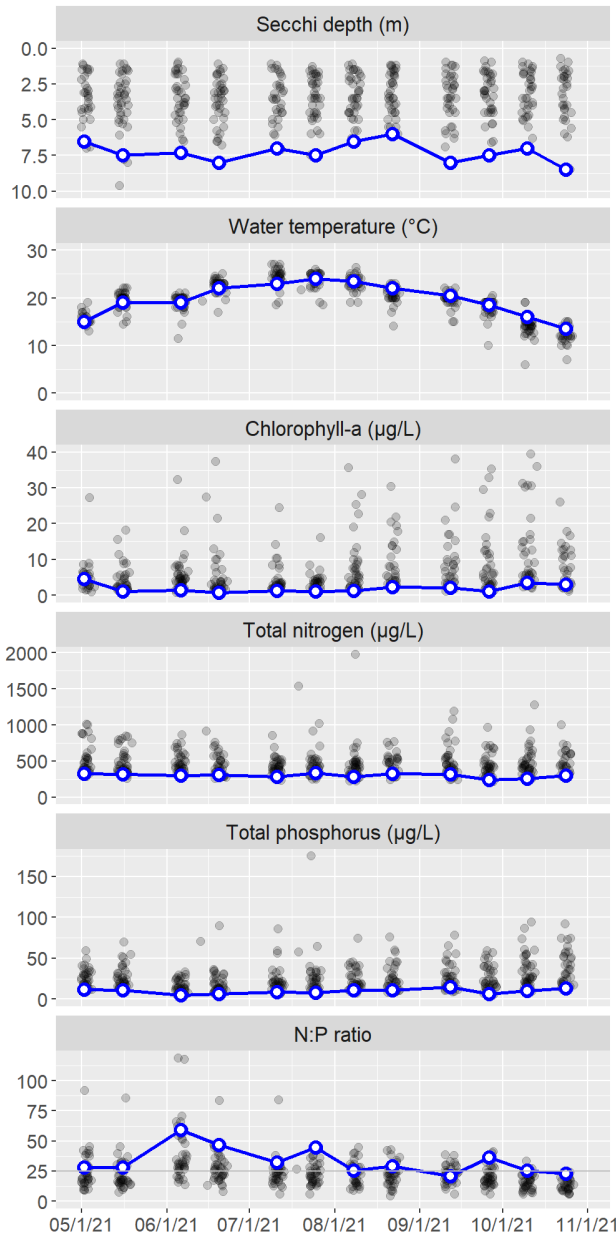
Water Quality Results & Trends

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 2021, and the right column shows average values for each year (May-October averages).

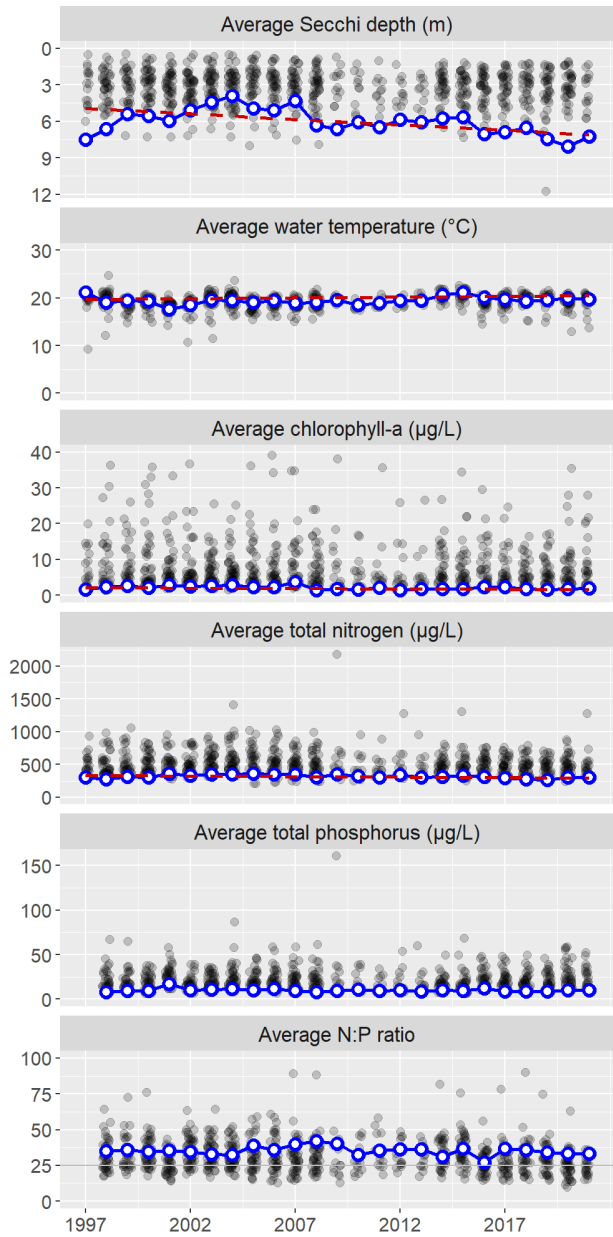
Data for Angle Lake are the blue circles (with white centers) connected by the blue line. Any gaps in the blue line indicate missed samples. To provide some context for these values, the grey points in the background are results for all other lakes in the Lake Stewardship program.

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

2021 Monitoring Results



Long-Term Annual Averages



Nutrient and chlorophyll concentrations remained low and fairly stable throughout the monitoring season.

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 1997, when monitoring started.

Parameter	Change per Decade	(%)
Secchi depth	0.9 m	(18%)
Water temperature	0.33 °C	(1.7%)
Chlorophyll-a	-0.24 µg/L	(-11%)
Total nitrogen	-16 µg/L	(-4.7%)

Chlorophyll and total nitrogen concentrations have decreased over time in Angle Lake, and Secchi depths have gotten deeper, suggesting that water quality has been improving slightly. Although the chlorophyll change per decade of 0.24 µg/L would be insignificant in many lakes, it is several percent of Angle Lake’s average chlorophyll concentration.

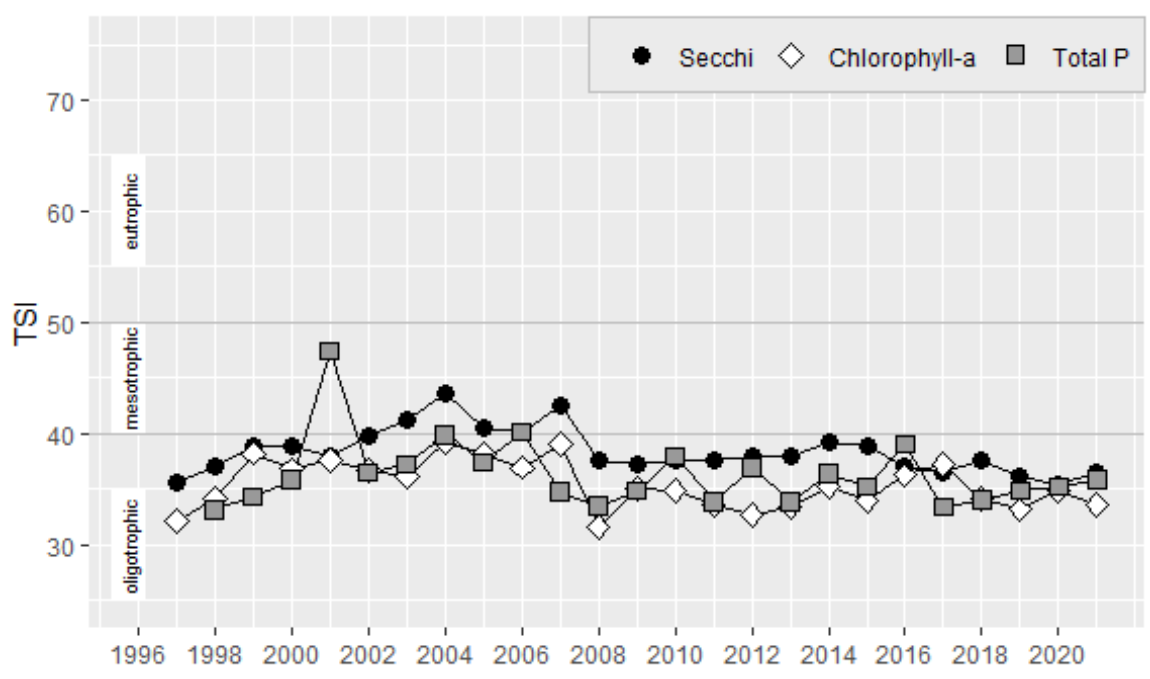
Trophic State

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. This is in contrast with the annual averages shown above, which also include May and October 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).

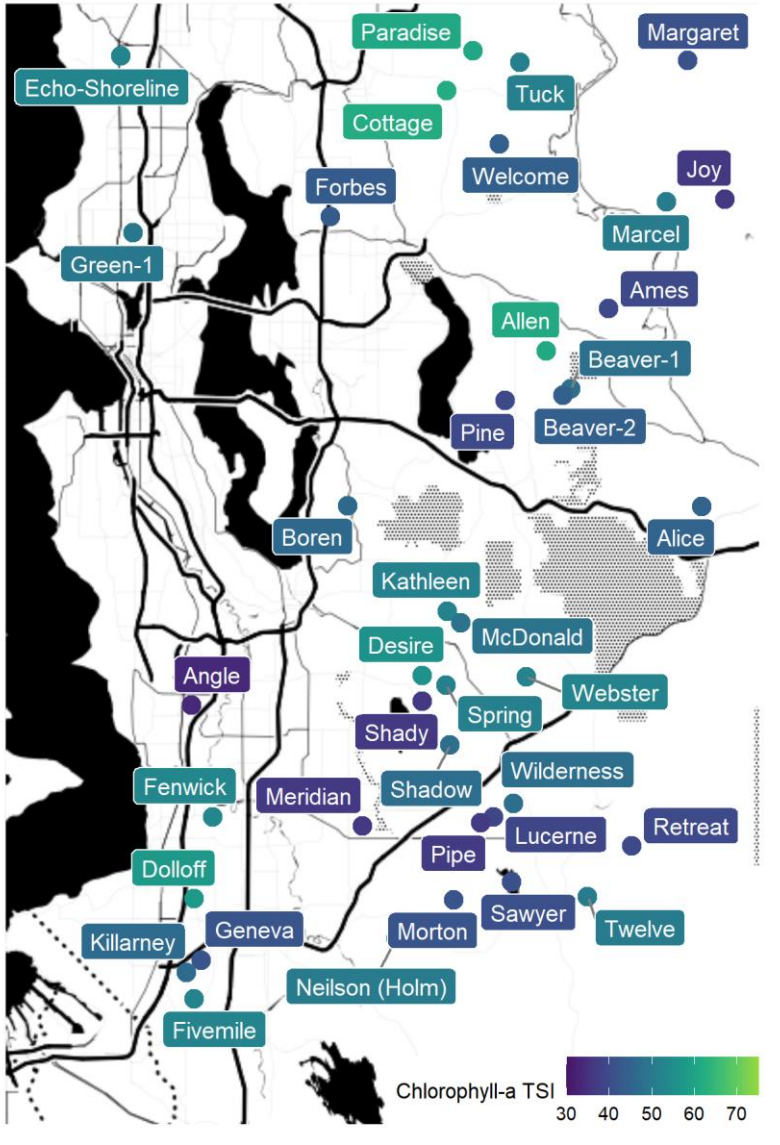
Trophic state indices



In 2021, all three TSI values were in the oligotrophic range. This has been true for Angle Lake since 2008.

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 2021. The color of each circle indicates the lake's average chlorophyll-a TSI value for the year.



Supplemental Data

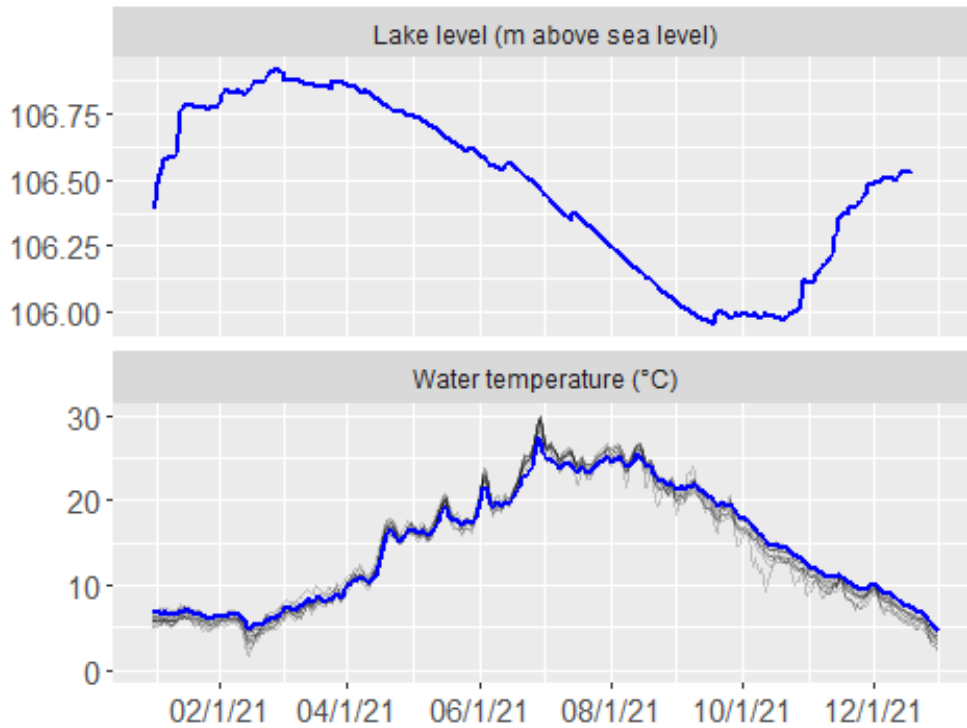
Summary statistics

This table summarizes data from 2021 (1 m depth only), giving the minimum, mean (average), and maximum values for each parameter. This includes summary statistics for the full 2021 calendar year for Secchi and/or temperature, which were measured year-round, and May-October summary statistics for all parameters. 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
Full-year statistics			
Secchi depth (m)	4.0	6.0	8.6
May-October statistics			
Secchi depth (m)	5.0	6.7	8.6
Water temperature (°C)	13.5	19.7	24.0
Chlorophyll-a (µg/L)	0.6	1.9	4.5
Total nitrogen (µg/L)	239.0	299.6	338.0
Total phosphorus (µg/L)	5.0	9.9	15.2
N:P ratio	20.9	33.2	59.2

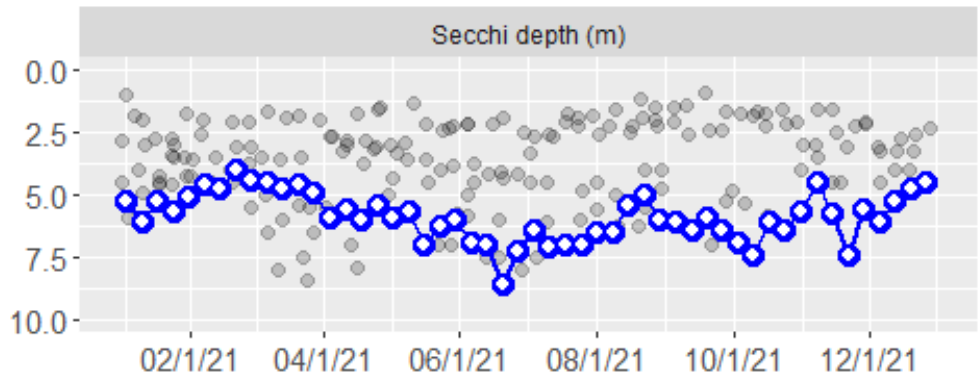
Continuous lake level and temperature

Lake level and water temperature were recorded continuously by an automated logger. The blue line shows daily averages for Angle Lake. Grey lines in the background are temperatures for all other lakes with loggers.



Year-round Secchi depth

Secchi depth was measured weekly in 2021. The blue circles (with white centers) and blue line are data for Angle Lake. Gaps in the line indicate missed sampling dates. Grey points in the background are results for all other lakes in the Lake Stewardship program.



Water column profile

In June 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.

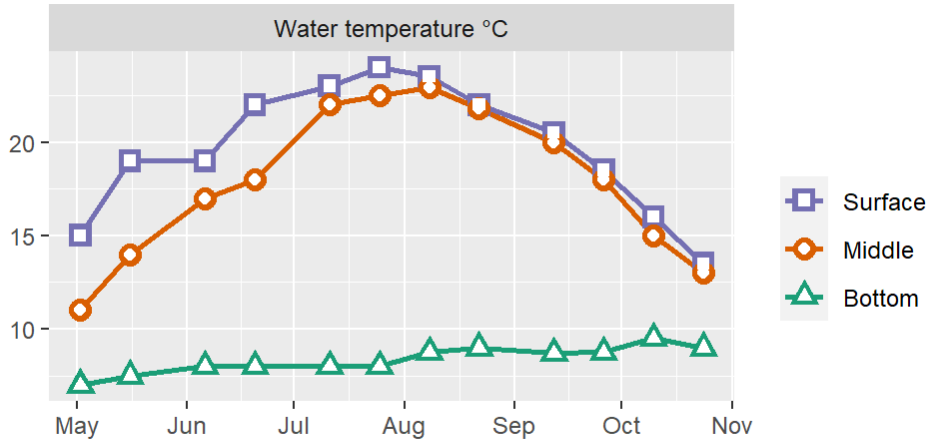
Date	Depth	Temp	Chlor	Pheo	TN	NH3	NO2/3	TP	OPO4
5/16/2021	1	19.0	1.1	(1.3)	317	7.0	(10.0)	11.2	(0.5)
	7	14.0	2.5	(2.0)	342	–	–	23.5	–
	14	7.5	–	–	743	422.0	(10.0)	123.0	9.3
8/8/2021	1	23.5	1.2	(1.0)	286	2.7	(10.0)	11.2	0.7
	7	22.9	1.8	(1.3)	298	–	–	9.5	–
	14	8.8	–	–	1230	320.0	(10.0)	204.0	3.3

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.

Water column temperatures

Temperature was measured at all depths for every event in 2021. A lake experiences thermal stratification when surface and bottom depth temperatures are different. This is typically seen in the summer when surface temperatures are warmer than bottom temperatures. In the fall as the weather conditions cool down, surface temperatures decrease and the lake mixes as the bottom water and surface water are closer in temperatures.

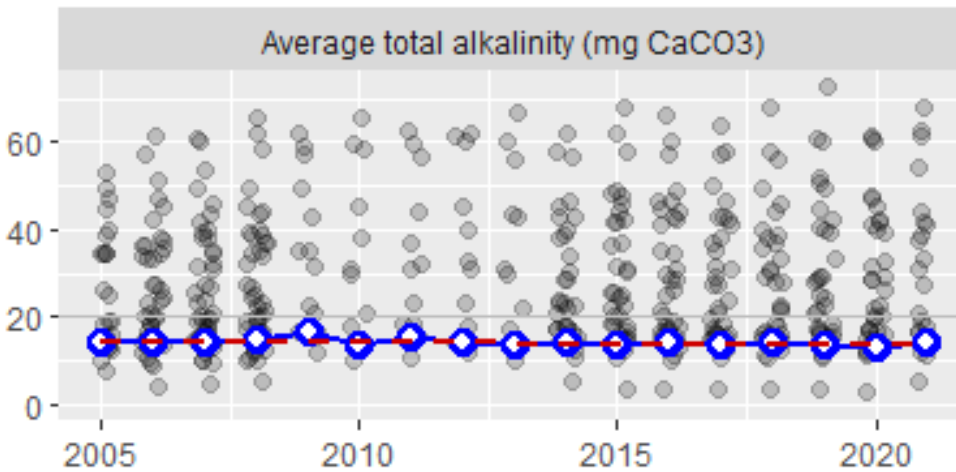
In 2021, Angle Lake was thermally stratified during the summer, while mixing is seen in the beginning and end of the monitoring season.



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 CaCO₃ are considered sensitive to acidification. We measured total alkalinity in May and August (on profile-sampling days) at 1 m depth. In 2021, the average total alkalinity of these two samples was 14.4 mg CaCO₃.

The blue circles (with white centers) and blue line are annual average alkalinity values for Angle 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 alkalinity, with an average change of -0.74 mg CaCO₃ (-5%) per decade.

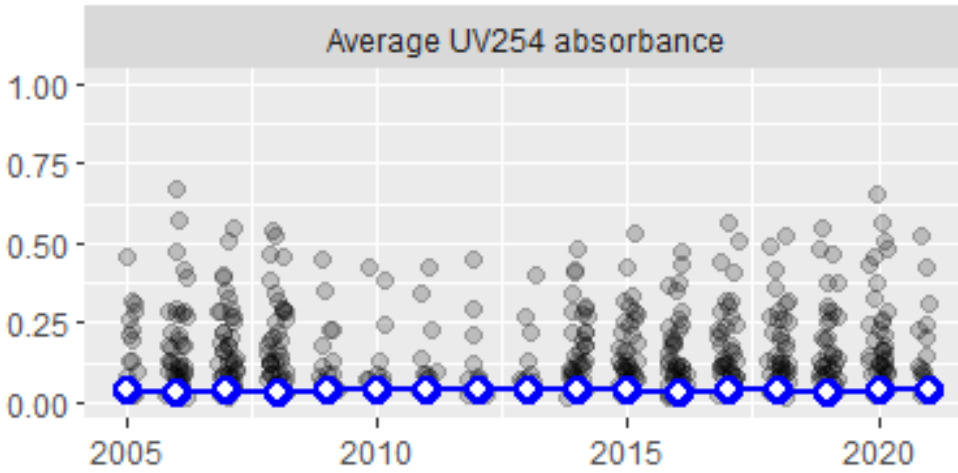


Water color

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 2021, the average UV254

absorbance of these two samples was 0.04, 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 Angle Lake. Grey points in the background are results for all other lakes in the Lake Stewardship program.



Visit the [King County Lake Stewardship](#) website for more data and information. Data from automated loggers is on the [King County Hydrologic Information Center](#) website.



King County

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