# PINE 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 Kate Bradley, the volunteer monitor for Pine Lake.*

**The key takeaways from the 2021 monitoring season are:**

- Pine Lake had very clear water, with low to moderate nutrient concentrations and low to moderate algal growth.
- Long-term trends suggest that water quality in Pine Lake has been improving over time, with decreasing nitrogen and chlorophyll concentration sand deeper Secchi (clearer water) depths.
- An algal bloom was sampled for toxin testing in April and September. No algal toxins were detected in this sample.

**The Lake Stewardship Program recommends:**

- Stay alert for toxic algae blooms in Pine 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.
- Monitoring is a key part of good lake stewardship, building a valuable long-term dataset to guide lake management and detect future problems. Continue to monitor Pine Lake through the Lake Stewardship Program.

# 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.

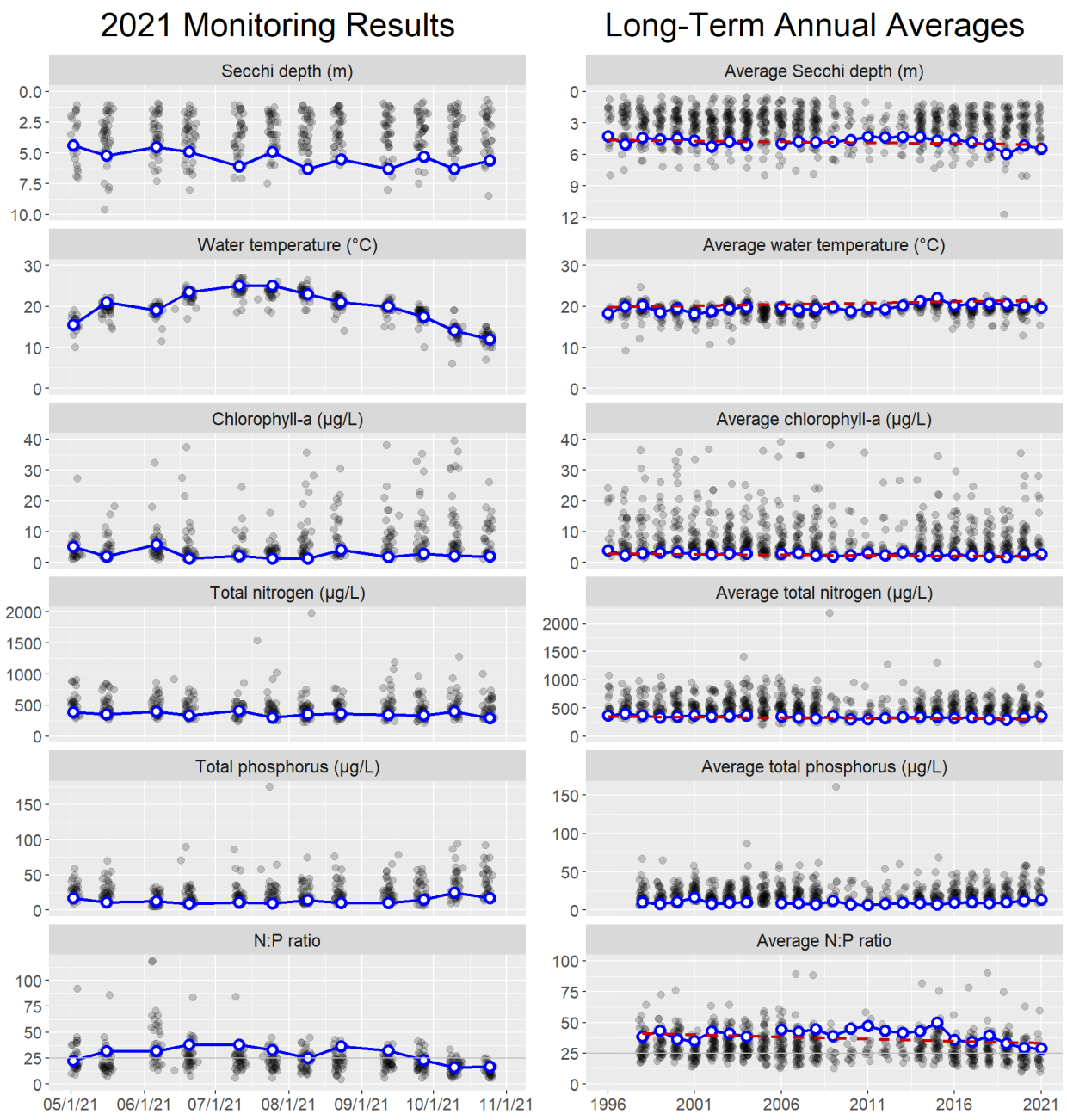
- **Chlorophyll-a** is a measure of the amount of algae in a lake. Chlorophyll-a is a pigment necessary for algae to photosynthesize and store energy.
- **Phosphorus** and **nitrogen** are naturally occurring nutrients necessary for growth and reproduction in both plants and animals. Increases in nutrients (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. Tracking this ratio 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 (May-October) for each year the lake was monitored in the Lake Stewardship Program.

Results for Pine Lake are the blue circles connected by the blue line. Gaps in the blue line indicate missed samples. The grey points in the background are results for all other lakes in the Lake Stewardship program. These points provide some context for Pine Lake values.

Long-term trends in Pine Lake, if present, are shown with a dashed red line and described below the graphs. Statistical trend analyses use a seasonal (monthly) Kendall test ($p<0.05$).




Nitrogen-to-phosphorus (N:P) ratios were above 25 for most of the monitoring season. This indicates a low likelihood for the algal community to be dominated by cyanobacteria (which have the ability to produce toxins).

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 | 0.17 m | (3.6%) |
| Water temperature | 0.67 °C | (3.4%) |
| Chlorophyll-a | -0.35 µg/L | (-12%) |
| Total nitrogen | -19 µg/L | (-5.3%) |
| N:P ratio | -3.5 | (-8.4%) |

Long-term trends suggest that water quality in Pine Lake has been improving over time, with decreasing nitrogen and chlorophyll concentration sand deeper Secchi (clearer water) depths.

# Trophic State

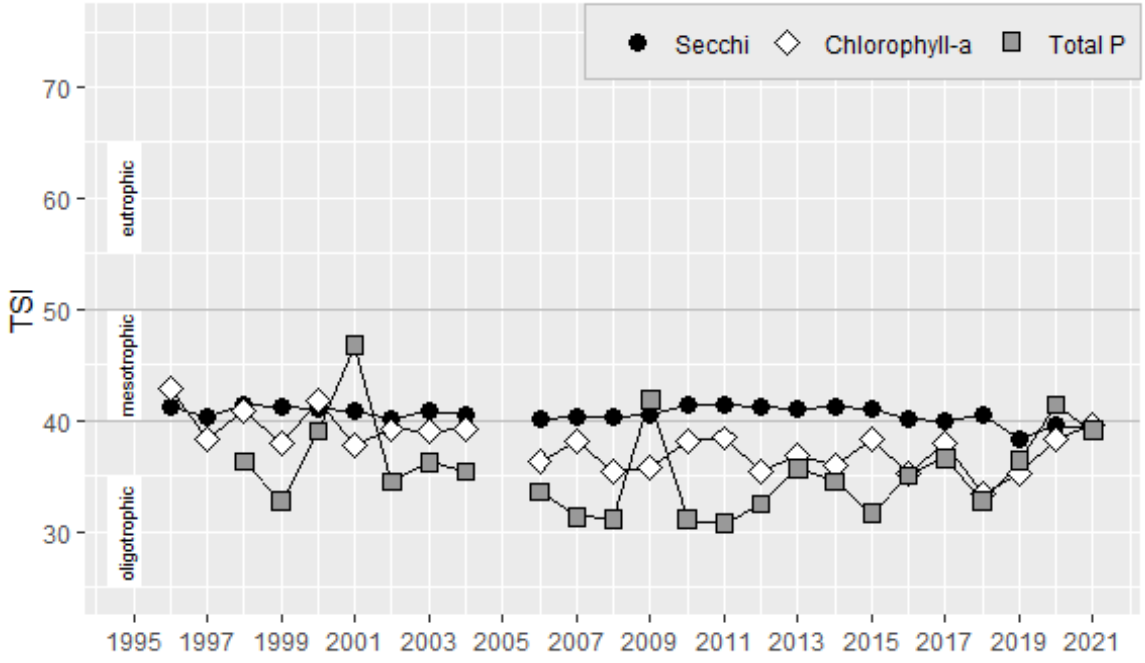
The Trophic State Index (TSI) is a common index of a lake's overall biological productivity. Index values are calculated from Secchi depth, chlorophyll-a concentrations, and total phosphorus concentrations, all scaled between 0 and 100.

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. Based on TSI values, a lake is usually classified as being in one of the three possible classes: oligotrophic, mesotrophic, or eutrophic.

- *Oligotrophic* lakes (TSI <40) are very clear, with low nutrient concentrations and low algal growth.
- *Mesotrophic* lakes (TSI 40-50) have fairly clear water, and moderate nutrient concentrations and algal growth.
- *Eutrophic* lakes (TSI >50) have less-clear water, with high nutrient concentrations and high algal growth. Eutrophic lakes are also more likely to have frequent algal blooms.

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).

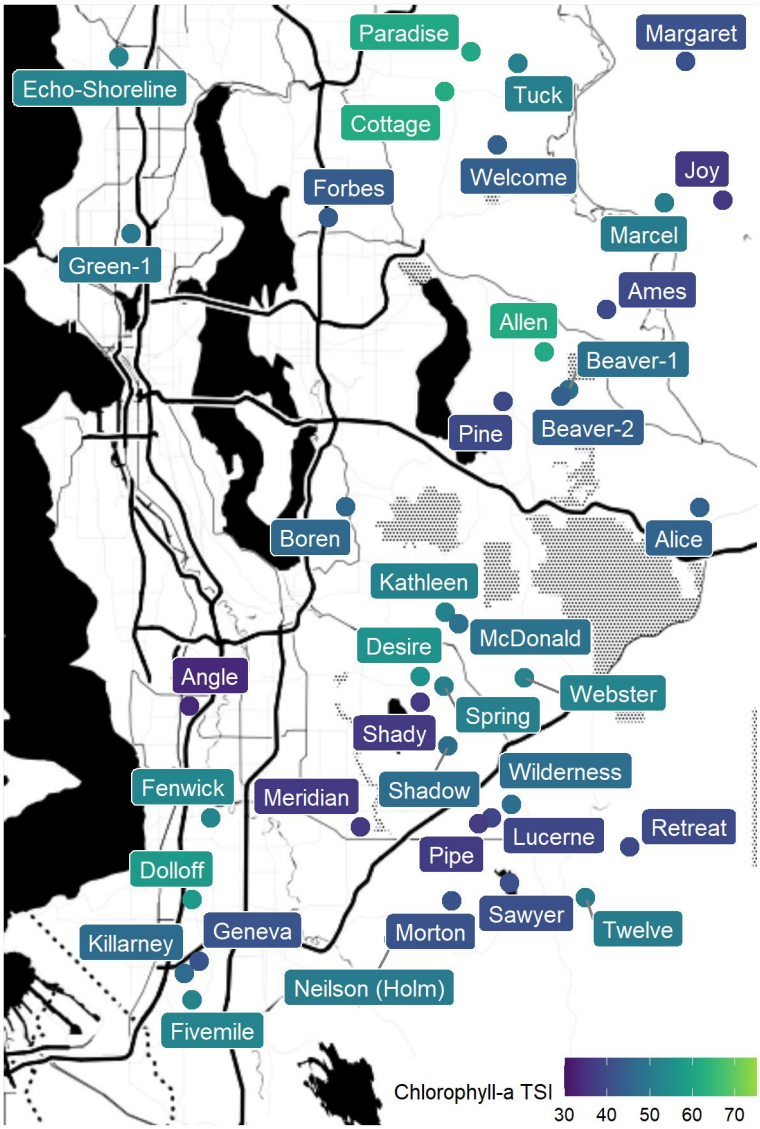
## Trophic state indices




In 2021, the TSI values were around the mesotrophic-oligotrophic boundary.

# Comparison map

For a comparison with other lakes, the following 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

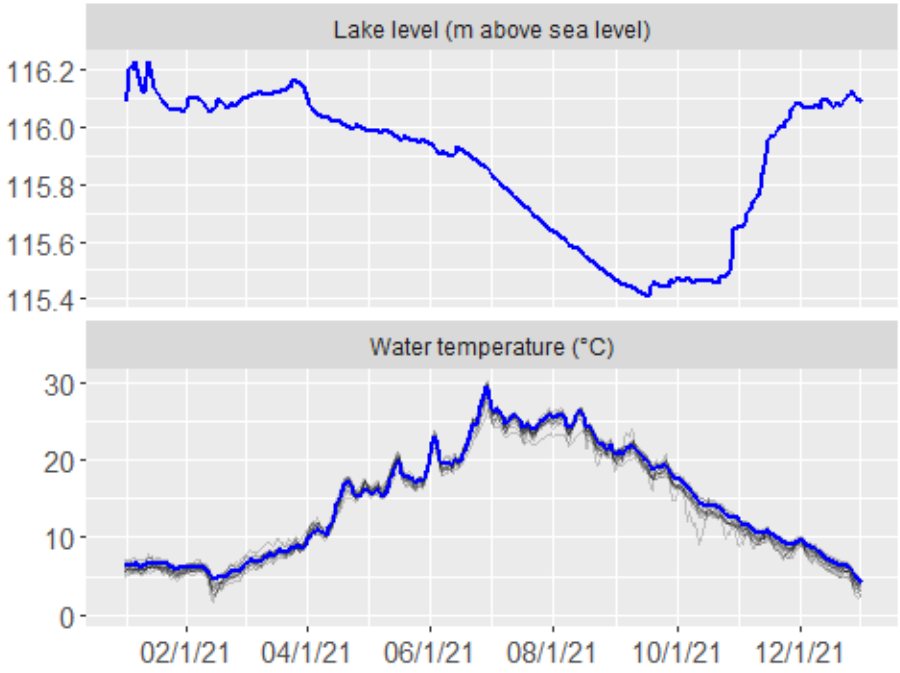
## Summary statistics

The following 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) | 3.3 | 4.8 | 7.0 |
| **May-October statistics** | | | |
| Secchi depth (m) | 4.3 | 5.4 | 7.0 |
| Water temperature (°C) | 12.0 | 19.7 | 25.0 |
| Chlorophyll-a (µg/L) | 1.2 | 2.6 | 5.8 |
| Total nitrogen (µg/L) | 294.0 | 355.3 | 412.0 |
| Total phosphorus (µg/L) | 8.8 | 13.4 | 24.7 |
| N:P ratio | 16.2 | 28.7 | 38.1 |

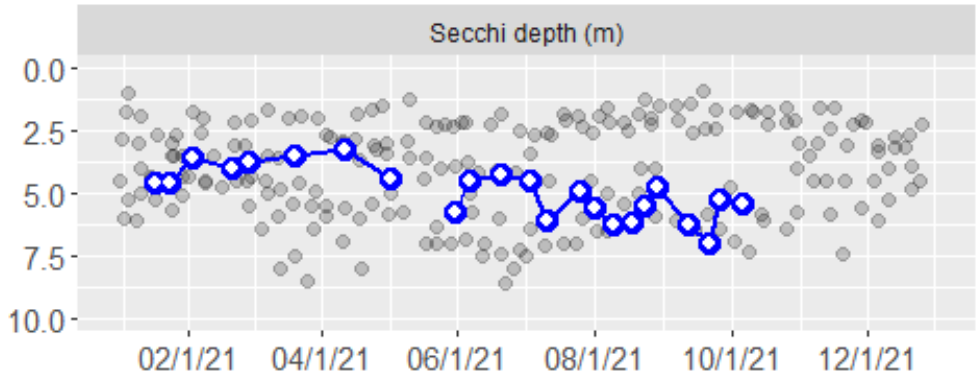
## Continuous lake level and temperature

Lake level and water temperature were recorded continuously by an automated logger. The blue line shows daily averages for Pine 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 Pine 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

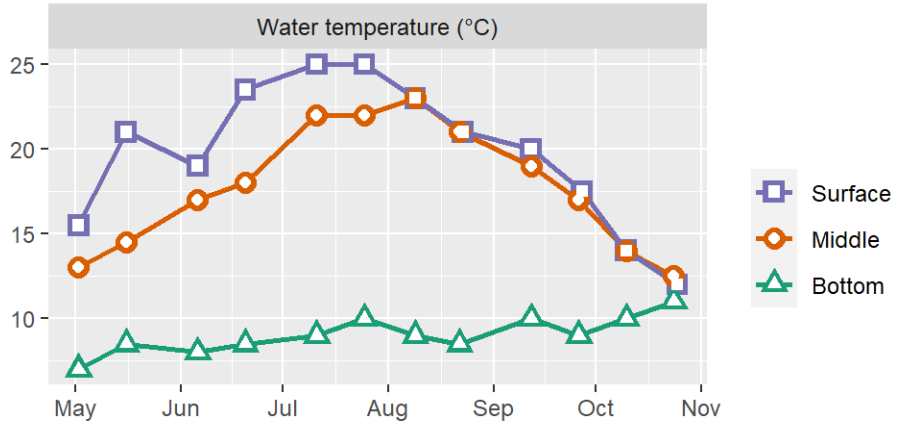
In May and August, water was collected at the mid-lake sampling station from three depths in a water column profile: 1 m, the middle depth of the water column, and 1 m from the lake bottom.

| Date | Depth | Temp | Chlor | Pheo | TN | NH3 | NO2/3 | TP | OPO4 |
|---|---|---|---|---|---|---|---|---|---|
| **5/16/2021** | 1.0 | 21.0 | 2.0 | (2.0) | 356 | 19.3 | (10.0) | 11.2 | (0.5) |
| | 4.5 | 14.5 | 2.4 | (1.1) | 405 | – | – | 26.4 | – |
| | 9.0 | 8.5 | – | – | 385 | 3.5 | 24.0 | 28.4 | 0.5 |
| **8/9/2021** | 1.0 | 23.0 | 1.2 | (1.0) | 352 | 12.4 | (10.0) | 14.0 | (0.5) |
| | 4.5 | 23.0 | 1.4 | (1.0) | 340 | – | – | 10.3 | – |
| | 9.0 | 9.0 | – | – | 552 | 4.0 | (10.0) | 94.7 | 1.1 |

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.

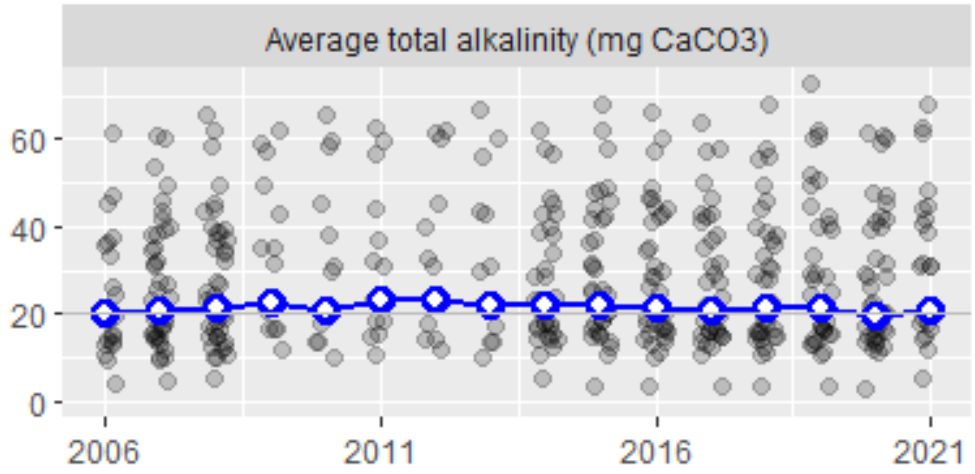



In 2021, Pine Lake was thermally stratified for most of the monitoring season, while mixing is seen at the end of October. Pine Lake's surface (1 m) and middle (4.5 m) temperatures are very similar throughout the monitoring season.

# 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 $CaCO_3$ 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 21 mg $CaCO_3$.

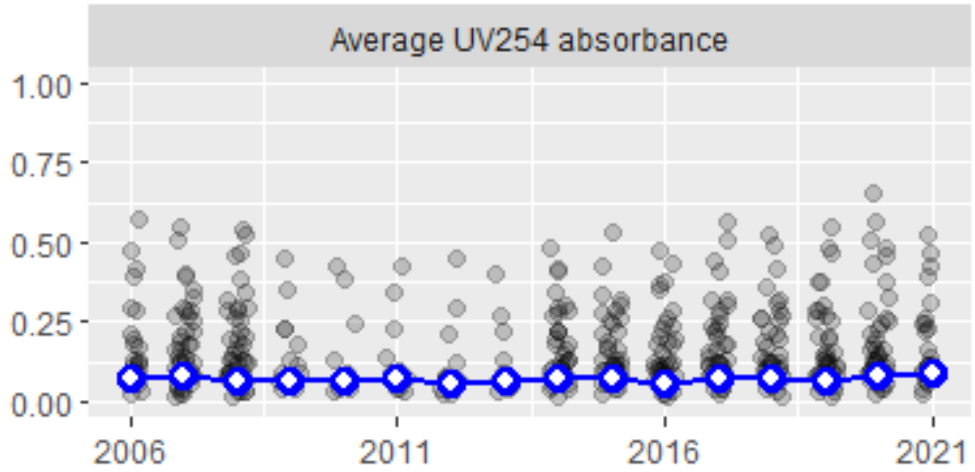
The blue circles and blue line are annual average alkalinity values for Pine Lake. Grey points in the background are results for all other lakes in the Lake Stewardship program.



# 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 2021, the average UV254 absorbance of these two samples was 0.09, 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 Pine 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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