FORBES 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 Caroll Pohl-Ferry, Elena Ferry and Julia Schoemig, the volunteer monitors for Forbes Lake.

The key takeaways from the 2021 monitoring season are:

- Forbes Lake continued to have high nutrient concentrations, with fairly clear water and moderate algal growth.
- While phosphorus concentrations have been increasing since 2018, long-term trends suggest that water quality in Forbes Lake has been improving over time, with decreasing nitrogen and deeper Secchi depths.
- No algal blooms were reported for toxin testing in 2021.

The Lake Stewardship Program recommends:

- Stay alert for toxic algae blooms in Forbes 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 Forbes 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.

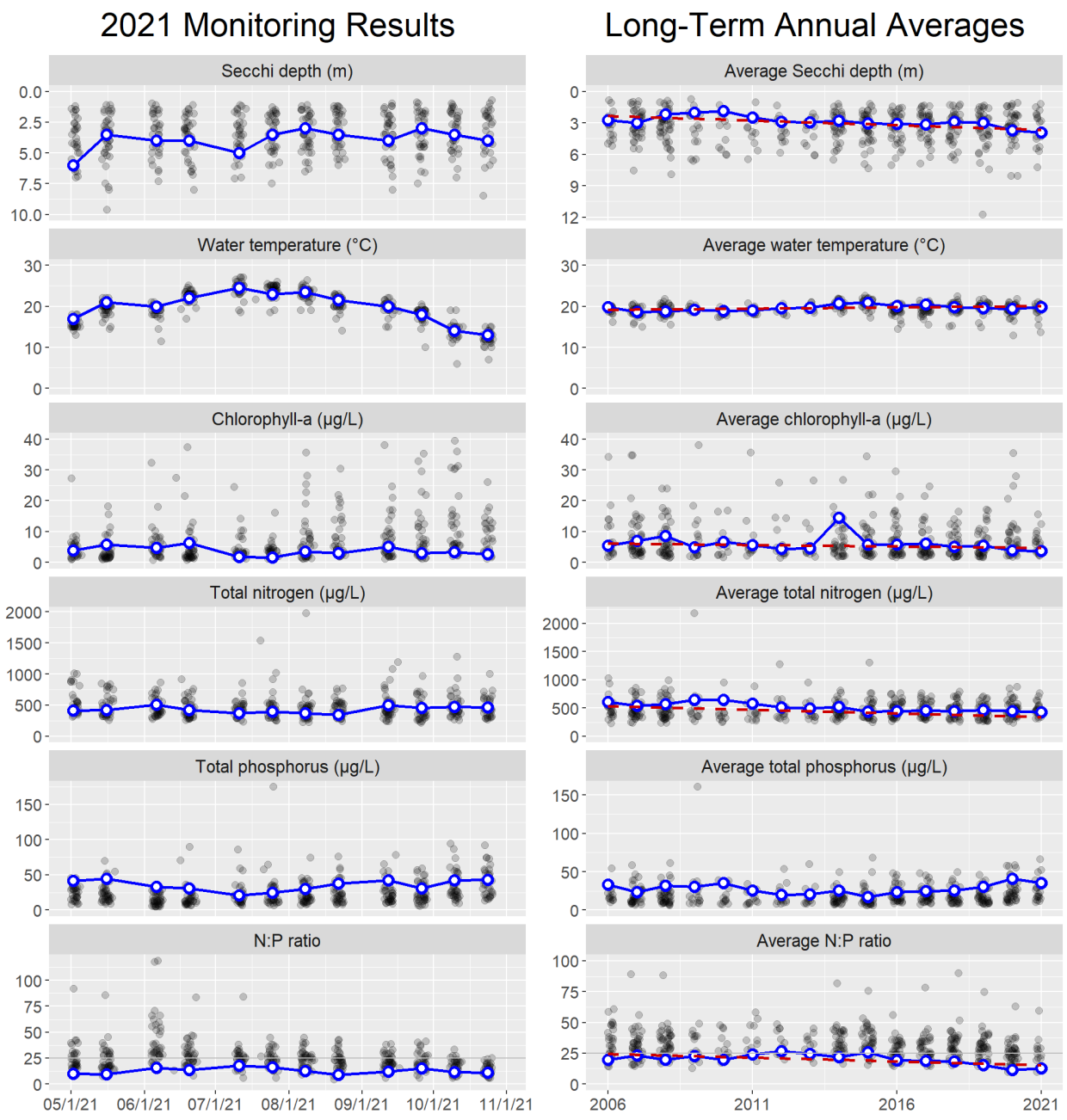
- **Chlorophyll-a** is a measure of the amount of algae in a lake. Chlorophyll-a is a pigment necessary for algae to photosynthesize and store energy.
- **Phosphorus** and **nitrogen** are naturally occurring nutrients necessary for growth and reproduction in both plants and animals. Increases in nutrients (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 Forbes 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 Forbes Lake values.

Long-term trends in Forbes 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 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).

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 2006, when monitoring started.

Parameter	Change per Decade	(%)
Secchi depth	0.89 m	(38%)
Water temperature	0.62 °C	(3.3%)
Chlorophyll-a	-0.92 µg/L	(-15%)
Total nitrogen	-130 µg/L	(-23%)
N:P ratio	-6.1	(-25%)

While phosphorus concentrations have been increasing since 2018, long-term trends suggest that water quality in Forbes Lake has been improving over time, with decreasing nitrogen and deeper Secchi depths.

Trophic State

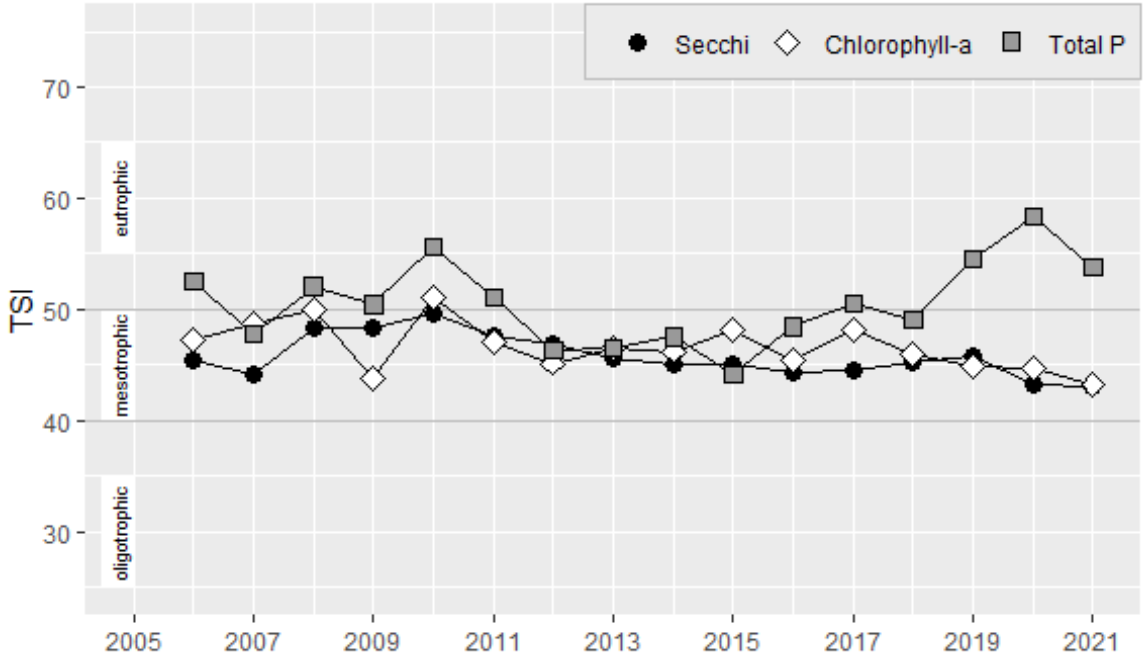
The Trophic State Index (TSI) is a common index of a lake's overall biological productivity. Index values are calculated from Secchi depth, chlorophyll-a concentrations, and total phosphorus concentrations, all scaled between 0 and 100.

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).

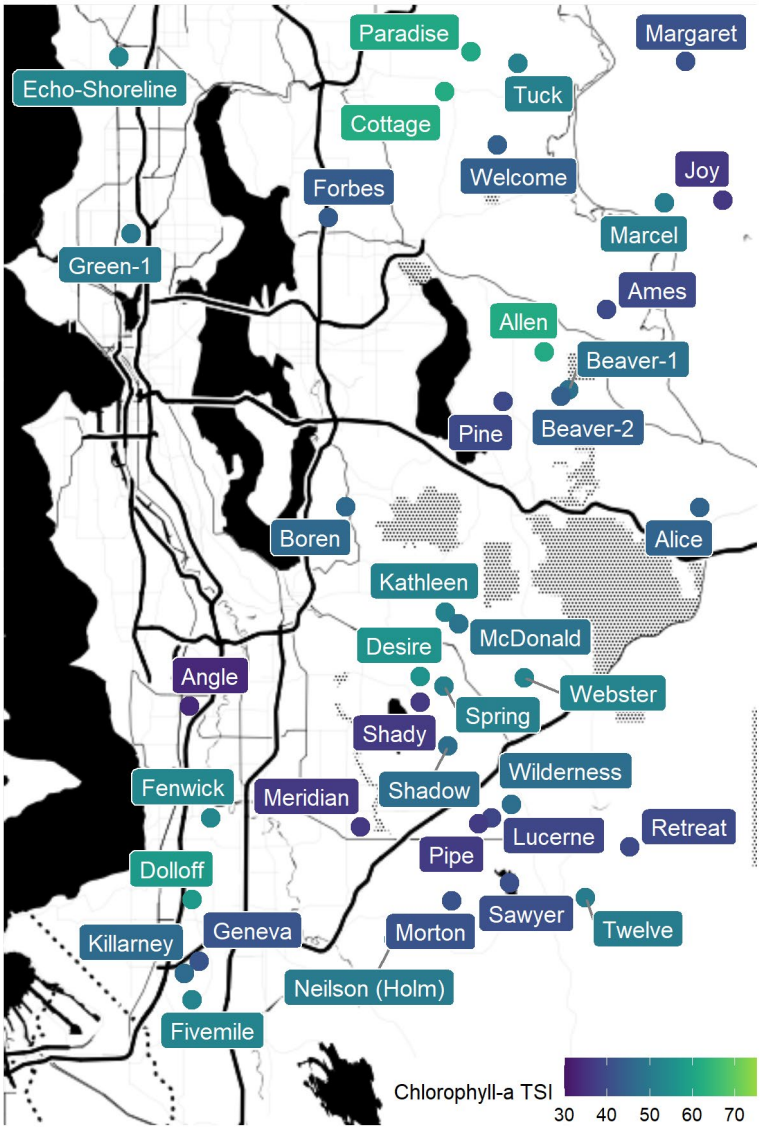
Trophic state indices



In 2021, the chlorophyll and Secchi TSI values were in the mesotrophic range, while the total-phosphorus TSI value was in the eutrophic range.

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 May-October 2021 (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)	3.0	3.9	6.0
Water temperature (°C)	13.0	19.8	24.5
Chlorophyll-a (µg/L)	1.6	3.7	6.3
Total nitrogen (µg/L)	341.0	427.8	509.0
Total phosphorus (µg/L)	21.0	35.1	44.7
N:P ratio	9.0	12.7	17.5

Water column profile

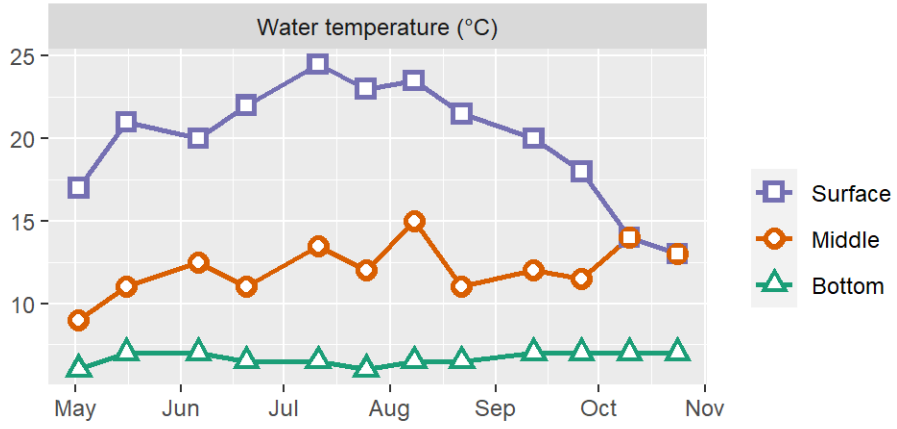
In May and August, water was collected at the mid-lake sampling station from three depths in a water column profile: 1 m, the middle depth of the water column, and 1 m from the lake bottom.

Date	Depth	Temp	Chlor	Pheo	TN	NH3	NO2/3	TP	OPO4
5/16/2021	1	21.0	5.8	(1.0)	420	4.1	(10.0)	44.7	2.1
	4	11.0	4.2	1.8	482	–	–	56.3	–
	9	7.0	5.2	–	1470	1120.0	(10.0)	495.0	134.0
8/8/2021	1	23.5	3.5	(2.0)	368	10.1	(10.0)	29.8	0.9
	4	15.0	16.3	3.5	639	–	–	93.6	–
	9	6.5	18.8	–	2410	2070.0	(10.0)	1020.0	90.4

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.

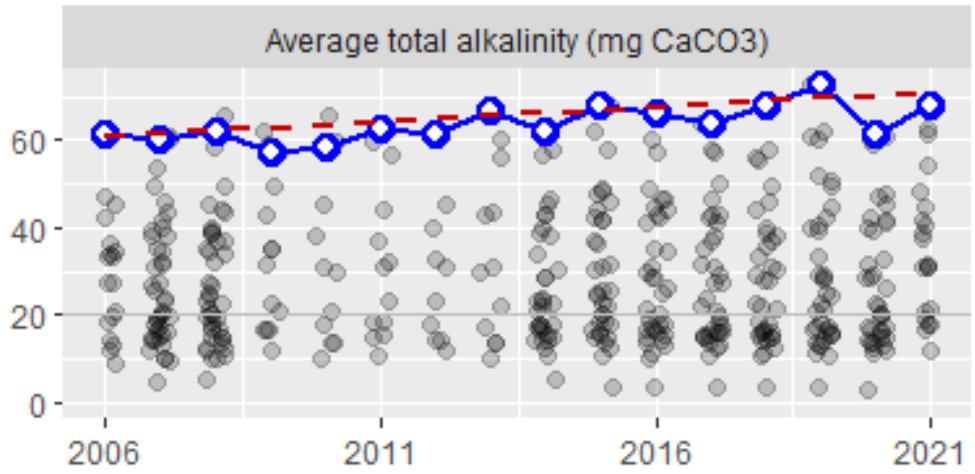


In 2021, Forbes Lake was thermally stratified for most of the monitoring season, while mixing is seen in October.

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 68.2 mg $CaCO_3$.

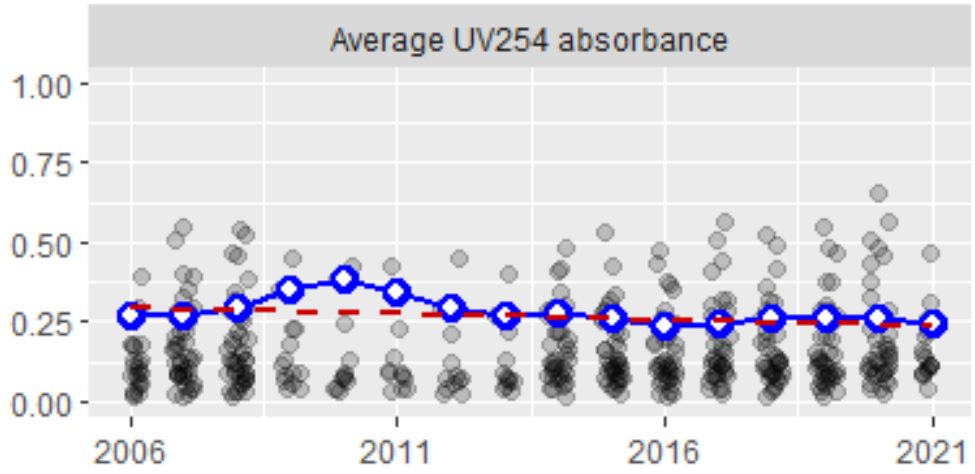
The blue circles and blue line are annual average alkalinity values for Forbes Lake. Grey points in the background are results for all other lakes in the Lake Stewardship program. The dashed red line shows the long-term trend in alkalinity, with an average change of 7 mg $CaCO_3$ (12%) per decade.



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 0.24, 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 Forbes 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 -0.042 absorbance units (-14%) per decade.



Visit the King County Lake Stewardship website for more data and information.

King County

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