# Echo Lake Water Quality:
## Water Quality Monitoring Results for Water Year 2013

February 2014

King County

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**Prepared for:**
The City of Shoreline

**Submitted by:**
King County Lakes and Streams Monitoring Group
King County Water and Land Resources Division
Department of Natural Resources and Parks

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# Acknowledgements

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# OVERVIEW

In 2001, the King County Lakes and Streams Monitoring Group (KCLSM) and its predecessor, the Lake Stewardship Program, began monitoring water quality with volunteers on Echo Lake. The lake was not monitored in 2002, but the project resumed in 2003 and continues to this day.

Echo Lake is monitored at Level II, at which samples are collected bi-monthly from May through October and analyzed for various water quality parameters. Water quality data indicate that the lake is moderately high in primary productivity with fair water quality.

In 2005, City of Shoreline staff members began working with King County to continue the monitoring effort in Echo Lake. The City also participated in the Regional Examination of Harmful Algal Blooms (REHAB), a four year cyanobacteria monitoring project.

The discussion in this report focuses on the 2013 water year. The specific data used to generate the charts in this report can be downloaded from the King County Lakes and Streams Monitoring data website at:

http://your.kingcounty.gov/dnrp/wlr/water-resources/small-lakes/data/default.aspx

Data can also be provided in the form of excel files upon request.

Further introduction and a discussion of the philosophy of the volunteer lake monitoring program and the parameters measured can be found on-line at:

http://your.kingcounty.gov/dnrp/library/archive-documents/wlr/waterres/smlakes/2006_Intro.pdf

# 1.0 WHAT WE MEASURE AND WHY

Measurements that were taken at all of the lakes in the small lakes monitoring program are discussed in this section to introduce the parameters and give context to the discussions of the data that follow.

**Secchi transparency** is a common method used to assess and compare water clarity. It is a measure of the water depth at which a black and white disk disappears from view when lowered from the water surface. Factors in the water that affect Secchi readings include the number and size of particles present, such as algae and silt, as well as water color from dissolved organic molecules. Other factors that affect the readings are the amount of glare, choppiness of the water, shade from tall trees or the boat, and variation in the vision of the observers.

**Water temperature** is usually measured using an alcohol-based thermometer that holds a specific temperature long enough to allow the observer to read the value after retrieving the thermometer from the water.

Phosphorus and nitrogen are naturally occurring elements necessary for growth and reproduction in both plants and animals. However, many activities associated with residential development can increase these nutrients in water beyond natural levels. In lakes of the Puget Sound lowlands, phosphorus is often the nutrient in least supply, meaning that biological productivity is most often limited by the amount of available phosphorus. Increases in phosphorus can lead to more frequent and dense algae blooms – a nuisance to residents and lake users, and a potential safety threat if blooms become dominated by cyanobacteria (bluegreen algae) that can produce toxins.

**Total phosphorus (TP)** and **total nitrogen (TN)** are both measured every time the level II volunteers collect water at the 1m depth. More specific forms of nitrogen and phosphorus are measured twice during the sampling period, when water is collected from 3 depths at the station: 1 m, the middle depth of the water column, and 1 m from the lake bottom. These include nitrate-nitrite, ammonia, and soluble reactive phosphorus, and the data can be used to infer the amount of oxygen present in deep water, as well as the presence of internal loading of nutrients from the sediments back into the lake water.

The **ratio of total nitrogen to total phosphorus (N:P)** can be used to determine if nutrient conditions are favorable for the growth of cyanobacteria (bluegreen algae), which can negatively impact uses of the lake and potentially produce toxins. When N:P ratios are near or below 25, nitrogen is as likely to be the limiting nutrient as phosphorus. Cyanobacteria may then be able to dominate the algal community due to their ability to take up nitrogen from air.

**Chlorophyll-*a*** concentrations indicate the abundance of phytoplankton in the lake. Although different species of algae contain varying amounts of chlorophyll, all algae use it in order to complete the photosynthetic pathway by which they store energy. For example,

some cyanobacteria have other light-catching pigments and thus have relatively little chlorophyll compared to their biovolume.

**Pheophytin** is a product of chlorophyll decomposition and is generally measured along with chlorophyll as an indicator of how fresh or viable the phytoplankton in the sample are. Bottom sediments will contain a large amounts of pheophytin compared to chlorophyll, while actively-growing algae from surface waters will have very little pheophytin present.

A common method of tracking water quality trends in lakes is by calculating the **Trophic State Index (TSI)**, developed and first presented by Robert Carlson in a scientific paper dated 1977. TSI values predict the biological productivity of the lake based on three parameters that are easily measured: water clarity (Secchi), total phosphorus, and chlorophyll-*a.* The values are scaled from 0 to 100, which allow them to be used for comparisons of water quality over time and between lakes. If all of the operating assumptions about a lake ecosystem are met, the 3 TSI values should be very close together for a particular lake. When they are far apart in value, lake conditions and measurements should be examined to understand what special conditions exist at the lake or to evaluate the data for errors.

The Index relates to three commonly used categories of productivity:

- *oligotrophic* (low productivity, below 40 on the TSI scale - low in nutrient concentrations, small amount of algae growth);
- *mesotrophic* (moderate productivity, between 40 and 50 on TSI scale – moderate nutrient concentrations, moderate growth of algae growth); and
- *eutrophic* (high productivity, above 50 – high nutrient concentrations, high level of algae growth).

A lake may fall into any of these categories naturally, depending on the conditions in the watershed, climate characteristics, vegetation, and rock and soil types, as well as the shape and volume characteristics of the lake basin. Activities of people, such as land development, sanitary waste systems, and agricultural practices, can also increase productivity, which is known as “cultural eutrophication.”

# 2.0 PHYSICAL PARAMETERS

City staff collected Secchi transparency and temperature data during the 2013 sample season in Echo Lake. Secchi depth ranged from 0.9 to 3.3 meters (Figure 1). The summer average transparency was 2.2 meters, placing Echo Lake in the lower third for water clarity out of the twelve lakes monitored in 2013. Note that the Y-axis is traditionally reversed on Secchi charts to mimic looking into the water from the lake surface.

There was a notable decline of water clarity in early June, similar to a pattern that occurred last year. Secchi transparency increased for the next two sample dates, and then decreased slightly through early September, after which Secchi depth began to increase again. Average Secchi depth from this year was nearly equal to last year (2.3 meters), though spring Secchi transparency was not as deep (5.0 meters in 2012).

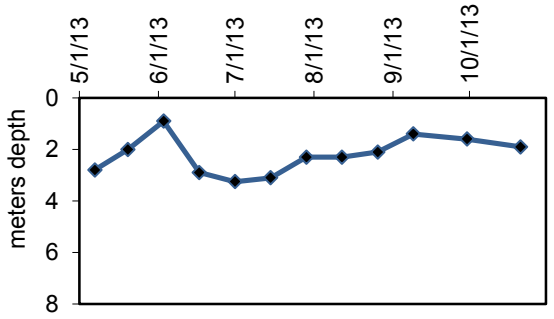


**Figure 1. Echo Lake Secchi transparency, May – October 2013.**

Shallow water temperatures at 1m ranged between 17.5 and 24.0 degrees Celsius, with an average of 19.7°C (Figure 2). Temperatures warmed through July, during which the summer maximum temperature was recorded. Water temperature during the sampling season followed a pattern similar to other lakes in the region. Compared with measurements from 2012, lake temperature warmed earlier and remained warmer for a longer period of time.

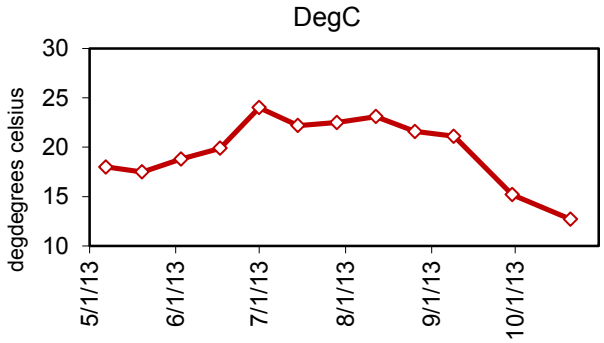


**Figure 2. Echo Lake temperature, May – October 2013.**

The average May – October temperature in 2013 was notably warmer than the 2012 summer average and was the highest average temperature recorded since 2006 (Figure 3). This increase reflects the much warmer, drier summer weather experienced in 2013. While there is no directional trend occurring in summer water temperatures over time, temperatures do seem to reflect annual weather patterns over the sample period.

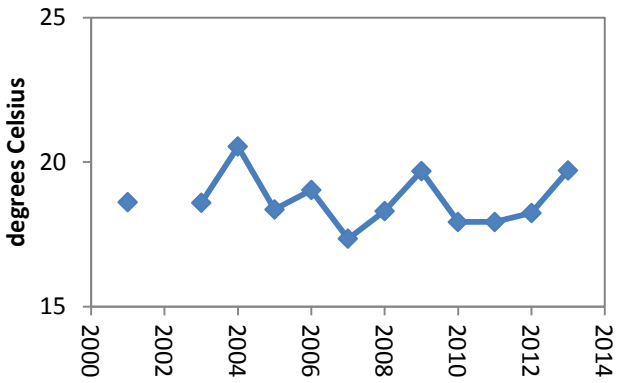


**Figure 3. Average summer temperature for Echo Lake, 2006-2013.**

# 3.0 NUTRIENT AND CHLOROPHYLL ANALYSIS

Samples for total phosphorus (TP) and total nitrogen (TN) analyses were collected by city staff at a depth of one meter during the months of May through October. Samples from additional depths were collected on two dates: one in mid-May and another in late August.

Phosphorus and nitrogen exhibited similar patterns during the 2013 sample season (Figure 4). Both nutrients exhibited large peaks in June and smaller peaks in July and September. The maximum values in nitrogen and phosphorus correspond to the decrease in Secchi transparency.

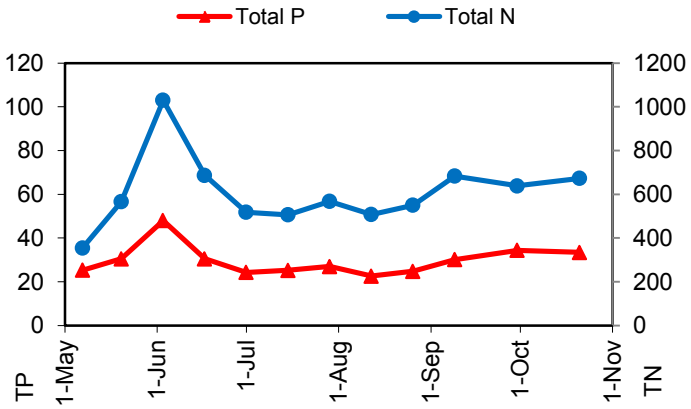


**Figure 4. Echo Lake Total P (TP) and Total N (TN) in µg/L, summer 2013. Note that the TP axis is 10x smaller than the TN axis.**

During the 2013 sampling season, N:P ratios in Echo Lake ranged from 14.0 – 22.7, with an average of 20.4 (Figure 5), all below a value of 25, which has been proposed as a threshold below which some cyanobacterial species have an advantage because of their ability to fix nitrogen from the atmosphere. Echo Lake exhibited the lowest N:P average of the twelve lakes sampled in 2013. Ratios remained steady throughout the summer, possibly allowing cyanobacteria to out-compete other algal species.

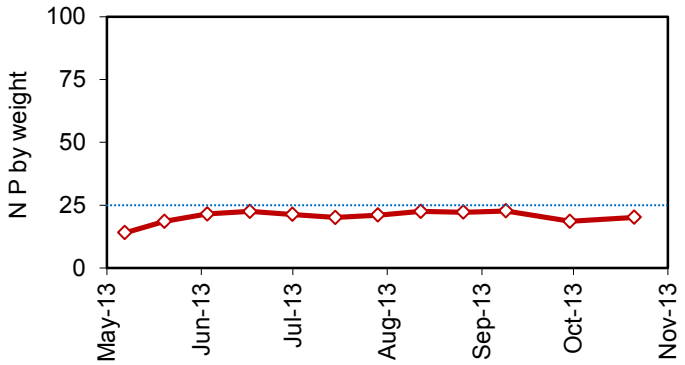


**Figure 5. Echo Lake N:P ratios. Values below the blue line indicate a potential nutrient advantage for cyanobacteria.**

Chlorophyll-a concentrations in Echo Lake ranged from 0.56 – 21.7 µg/L, with an average of 8.84 µg/L (Figure 6). Chlorophyll concentrations varied throughout the sample season, with a large peak occurring in September, and a smaller peak in June. The June peak in chlorophyll levels may correspond to the increase of nutrients and the decrease in Secchi transparency. The large fall peak is likely the result of a cyanobacteria bloom and is a commonly found pattern exhibited by local lakes. Pheophytin, a degradation product of chlorophyll, was generally at low levels throughout the season, with the exception of a peak in June. This peak may indicate that the sample had degraded, and chlorophyll concentrations indicating algal abundance were higher than what was actually measured. It could also have been caused by a disturbance in lake sediments, but no field notes suggested this had occurred.

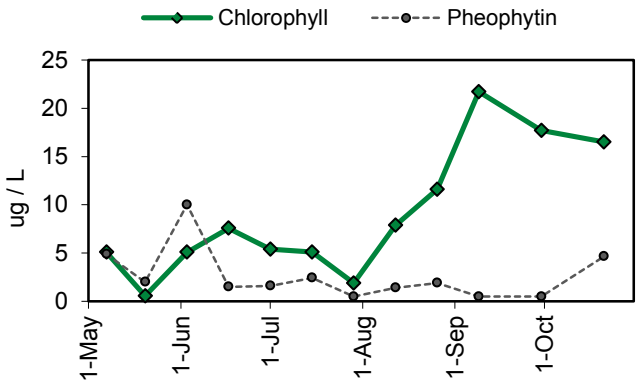


**Figure 6. Chlorophyll and pheophytin concentrations for Echo Lake, May-October 2013.**

# 4.0 WATER COLUMN PROFILES

Samples were collected at multiple lake depths twice during the sample season (Table 1).

Profile temperature data collected in Echo Lake indicate that thermal stratification (temperature layering) was present by early summer and continued through late August. The deeper water also exhibited elevated nutrient levels on both dates, with the exception of total nitrogen in May, which was very slightly elevated compared to the 1m and mid-depth samples. Higher nutrient levels in the hypolimnion (deep lake water below the temperature change) are often indicative of anoxia (lack of oxygen). Anoxia in water facilitates the release of phosphorus from sediments, resulting in higher total phosphorus and orthophosphate (OPO4) values. Higher ammonia (NH3) concentrations in the deep water samples also indicate deep water anoxia.

**Table 1. Echo Lake profile results.Secchi and Depth in meters.Temperature in degrees Celsius. Chlorophyll and Pheophytin in ug/L. Nitrogen, phosphorus, and alkalinity in mg /L. UV254 is in absorption units. Sample values below minimum detection level (MDL) are marked in bold, red font with the MDL value.**

| Lake name | Date | Secchi | Depth | DegC | Chlor-a | Pheo | Total N | NH3 | Total P | OPO4 | UV254 | Total Alk |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Echo | 5/20/13 | 2.0 | 1 | 17.5 | 0.6 | **2** | 0.566 | **0.005** | 0.0305 | 0.0020 | 0.0873 | 17.4 |
| Echo | | | 3 | 17.0 | 9.9 | 3.79 | 0.587 | | 0.0350 | | | |
| Echo | | | 7 | 9.0 | 2.9 | 1 | 0.764 | 0.342 | 0.1610 | 0.0831 | | |
| Echo | 8/26/13 | 2.1 | 1 | 21.6 | 11.6 | 1.9 | 0.550 | **0.005** | 0.0248 | **0.0008** | 0.088 | 17.6 |
| Echo | | | 3 | 21.6 | 20.0 | **0.5** | 0.598 | | 0.0333 | | | |
| Echo | | | 7 | 10.0 | 74.0 | | 1.570 | 0.871 | 0.4910 | 0.1060 | | |

Chlorophyll profile data indicate that algae are present throughout the water column, but at higher concentrations in deeper waters than at the surface, particularly in August. The highest concentrations of algae occurred at the 5 meter depth in May and the 7 meter depth in August. This suggests that enough light was reaching deep water to support algal growth or that algal species able to adapt to lower light levels were able to take advantage of higher nutrient concentrations. Pheophytin could not be evaluated for the deep water in the August chlorophyll sample because of chlorophyll-*b* interference in the sample.

UV254 is the wavelength at which most organic compounds absorb light, and is used to measure the amount of organic compounds coloring lake water. The low values for UV254 indicate that the water of the lake is relatively clear, with a very small amount of coloration from dissolved organic substances. Total alkalinity values show that the water in Echo Lake is soft, with little buffering capacity against pH change.

# 5.0 TROPHIC STATE INDEX RATINGS

In 2013 all three Trophic State Indicators (TSI) values remained near the threshold between mesotrophy and eutrophy (Figure 7). Both the total phosphorus TSI and the chlorophyll TSI value decreased from last year and was at the lowest value since monitoring began, while the Secchi TSI increased slightly.

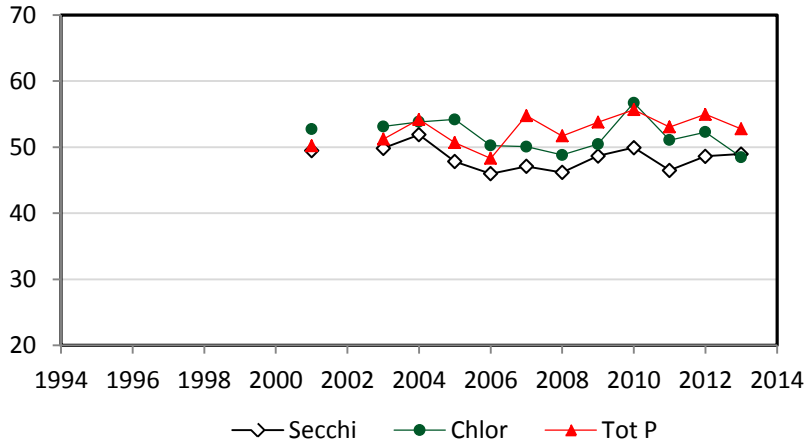


**Figure 7. Echo Lake Trophic State Indicators over time. Chlor = Chlorophyll-*a* and Tot P = total phosphorus.**

When the three TSI values are averaged and plotted over time, no distinct increasing or decreasing trend emerges (Figure 8).

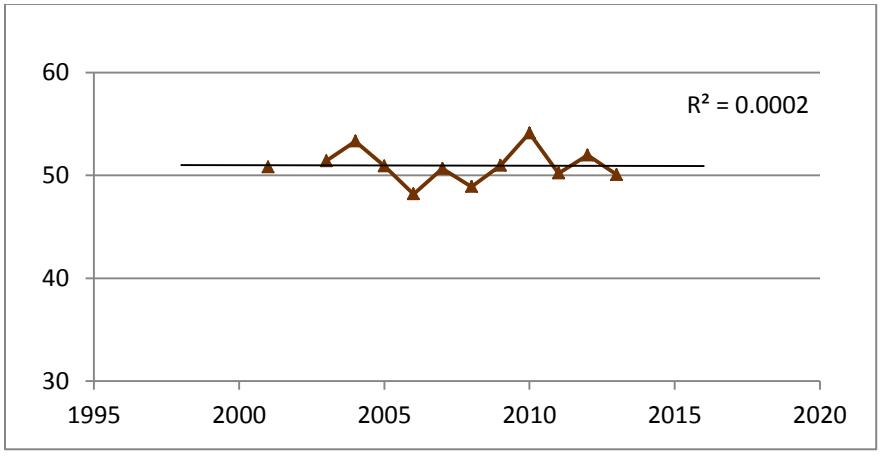


**Figure 8. Average of TSI values for phosphorus, Secchi transparency, and chlorophyll-*a* over time for Echo Lake.**

# 6.0 CYANOBACTERIAL TOXICITY

Both routine monitoring and bloom samples were submitted to the King County Environmental Laboratory in 2013 for microcystin and anatoxin-a evaluation (Table 2). The routine samples were taken from the middle of the lake where water quality sampling was done until August when the location was switched to the swimming beach. The bloom samples submitted were taken along the western shoreline at sites with cyanobacterial accumulations.

**Table 2. Echo Lake 2013 cyanobacterial toxicity testing. Both microcystin and anatoxin-a values are expressed in ug/L. Minimum detection level for microcystin was 0.160 ug/L and for anatoxin-a was 0.01 ug/L.**

| Date | Location | Routine/Bloom | microcystin | Anatoxin |
|---|---|---|---|---|
| 3/27/13 | park beach | Bloom | <MDL | <MDL |
| 5/7/13 | mid-lake | Routine | <MDL | <MDL |
| 5/20/13 | mid-lake | Routine | <MDL | <MDL |
| 6/3/13 | mid-lake | Routine | <MDL | <MDL |
| 6/17/13 | mid-lake | Routine | <MDL | <MDL |
| 7/1/13 | mid-lake | Routine | <MDL | <MDL |
| 7/15/13 | mid-lake | Routine | <MDL | <MDL |
| 7/25/13 | | Bloom | 9.13 | 0.0116 |
| 7/29/13 | mid-lake | Routine | <MDL | <MDL |
| 8/5/13 | west shoreline | Bloom | 1.44 | <MDL |
| 8/12/13 | A764A | Routine | <MDL | <MDL |
| 8/26/13 | park beach | Routine | <MDL | <MDL |
| 9/9/13 | park beach | Routine | <MDL | <MDL |
| 9/30/13 | park beach | Routine | <MDL | <MDL |
| 10/21/13 | park beach | Routine | <MDL | <MDL |

Algal identification from several samples showed that up until late July, the cyanobacteria most commonly found included *Anabaena*, *Aphanizomenon*, and *Woronichinia*. The July 25 sample with significant microcystin contained all three of these genera, but also had *Microcystis* present. After July *Microcystis* disappeared, while *Woronichinia*, *Anabaena, and Aphanizomenon* continued to dominate the phytoplankton.

# 7.0 CONCLUSIONS AND RECOMMENDATIONS

Based on the monitoring data, water quality in Echo Lake has fluctuated over the sampling years of 2001-2013, similar to the behavior of most aquatic systems in responding to multiple and dynamic environmental factors. Measurements of both physical and chemical parameters have shown both upward and downward variations from year to year, but no directional trends have validated to-date.

Certain potential trends, such as those pertaining to temperature and nutrient concentrations, could have negative impacts on Echo Lake. Increasing temperatures in the lake might have adverse effects on plants and animals, as well as on water chemistry. Continued monitoring of Echo Lake will allow for statistically robust determination of long term trends, as well as providing opportunities to identify potentially detrimental changes occurring in the lake.

Low N:P ratios in the shallow water over the season indicate nutrient conditions favorable for nuisance bluegreen algae growth, particularly in the spring and late summer. Peaks in chlorophyll data indicate algal blooms, and correspond to decreases in Secchi transparency.

One mid-season bloom sample submitted for cyanotoxin testing contained microcystin at 9.13 µg/L, above the recreational guideline of 6 µg/L. However, the routine sampling mid-lake and at the park beach was consistently below the minimum detection level. While fewer bloom samples were submitted this year compared to last year, continued sampling of Echo Lake for cyanotoxins is recommended, as high concentrations are potentially hazardous to both people and pets, especially as levels above recreational guidelines have continued to be observed in the lake