

CalMan Lakes Watershed Management Planning Project

Update: May 2016

The Calumet County Land and Water Conservation Department (CCLWCD) is sponsoring an on-going project that aims to assess four lakes on the Calumet/Manitowoc County border, along with their watersheds. CCLWCD staff is working closely with Onterra, LLC, a lake management planning firm, on this project along with other partners including the Wisconsin Department of Natural Resources (WDNR), Manitowoc County Soil and Water Conservation Department, Brillion Conservation Club and Long Lake Advancement Association. The primary focus of this project is to evaluate the water quality of these lakes and examine potential for watershed and water quality restoration. Components of this study include:

- Water quality/quantity monitoring of inlet streams
- Lake bottom sediment analysis
- Precipitation monitoring
- Native aquatic plant inventories
- Aquatic invasive species inventories
- Shoreland development evaluations
- Near shore aquatic habitat assessments
- Fisheries data integration
- Public input and educational initiatives

The CCLWCD has successfully obtained several grants through the WDNR state-wide lake management grant program to fund these efforts. These grants have funded the many lab analyses, survey time, and reporting expenses associated with a comprehensive watershed management project. Additionally, many hours of in-kind, donated labor have been invested by county staff and volunteers on this project. The project, first beginning in 2013, is now in its third year of study. This update intends to discuss activities involved with the watershed management planning project, including 2015 monitoring and survey work, along with providing an update on the projected course of action the CCLWCD and Onterra plan to take in preparing for 2016 studies.

In-Lake Water Quality Monitoring

From 2013-2015, water quality has been monitored at regular intervals in all four of the CalMan project Lakes. Monitoring has been completed by CCLWCD staff, Onterra staff, and volunteers. These data have been compared with historical data that have been collected from other projects, such as the Citizens Lake Monitoring Network and WDNR Long-Term Trends Monitoring (Long Lake), to develop longer-term datasets and have allowed for the examination of trends in water quality. Nutrients, suspended sediment, chlorophyll *a* (a measurement of algae growth), dissolved oxygen, temperature and water clarity are monitored. By examining these samples, project managers are able to calculate the level of impairment on the lakes and attempt to distinguish from where the impairing elements originate. For example, a large component of this project is identifying the relative contributions of nutrients to the lake from within the lake (nutrient recycling) and from the surrounding watershed. Other factors such as inputs from residences (developed properties, septic systems) are important as well. If the major source of nutrients is from internal sources the management plan would be different than if the major source of nutrients was from the watershed.

Figure 1 displays a summary of total phosphorus (blue) and chlorophyll *a* (green) data from the four CalMan Lakes in recent years, along with the Impairment Threshold for the Fish and Aquatic Life Use designation of deep, seepage lakes in Wisconsin. Several of the lakes display wide variances in their water quality parameters. Long Lake exhibits the best water quality while Boot Lake has the

worst. Examining when the changes in water quality occur will be crucial in helping to determine the contributing sources of nutrient pollution to the lakes, and what might be done to mitigate this.

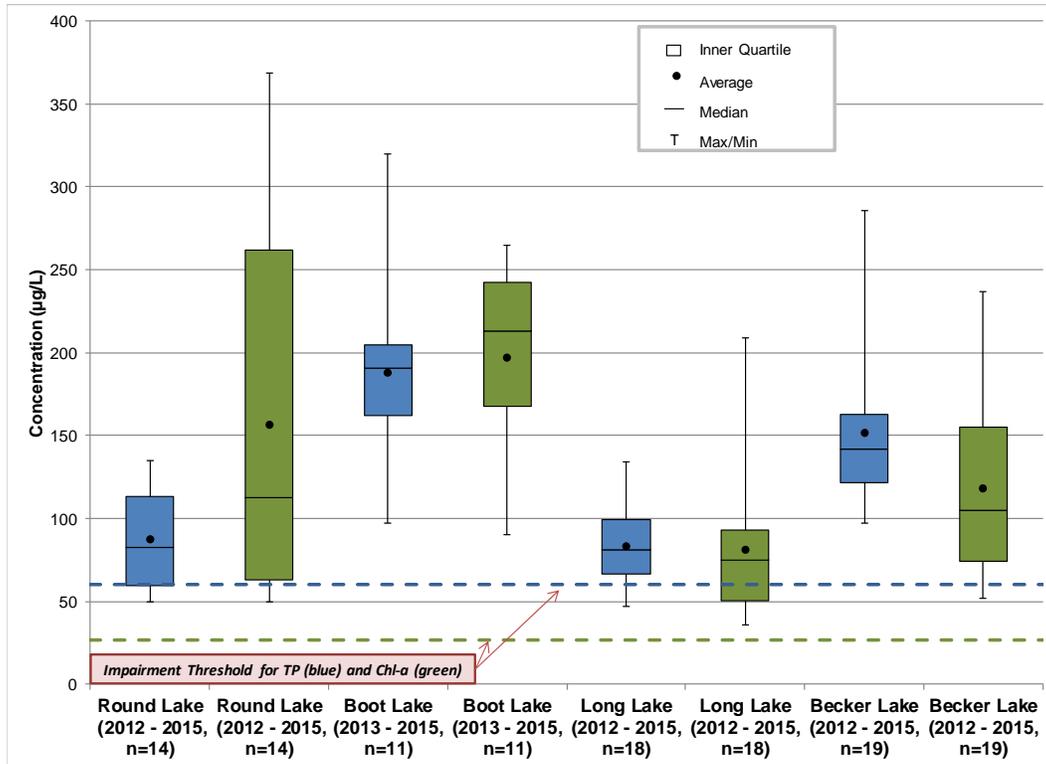


Figure 1. CalMan Lakes total phosphorus and chlorophyll-a concentrations, June 1 to September 15, 2012-2015. All data collected from surface water samples. Total phosphorus concentrations and deep seepage lake impairment threshold depicted in blue, chlorophyll-a depicted in green.

In 2015, steps were taken to collect data to assist in determining the relative contributions of nutrients from the surrounding watershed and from within the lake. The studies are summarized in the “In-Lake Phosphorus Profile Study” and “Tributary Monitoring” sub-sections.

In-Lake Phosphorus Profile Study

During October 2015, Onterra staff visited the CalMan Lakes to collect detailed water column data in an effort to estimate the importance of internal phosphorus loading from the sediments when the bottom waters are devoid of oxygen. When oxygen is absent in the deep waters, phosphorus that is bound with iron in the sediments is released into the overlying waters. In these lakes this release occurs during the entire period of stratification which typically lasts until early October. By measuring the phosphorus mass at the end of stratification managers can estimate the amount of internal phosphorus loading. Dissolved oxygen and total phosphorus samples were collected at numerous intervals through the water column. By multiplying the concentration of phosphorus at each interval across the volume of water for that given interval, the total phosphorus mass may be calculated for each lake. Typically these data may be compared to spring turnover concentrations.

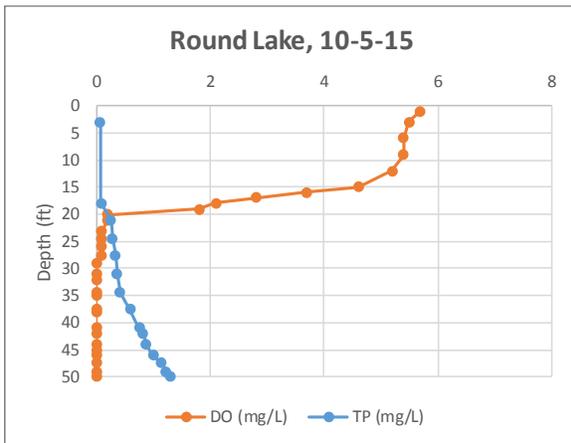
During the spring, the entire water column is oxygenated and sediment nutrient release is minimal. In essence, this is the “starting point” for internal nutrient release for the season.

This analysis was not done in Boot Lake because this lake periodically mixes during the summer as a result of its shallow depth. The bottom waters do become anoxic and sediment phosphorus release does occur. A different technique to estimate internal load will be used in 2016. Sediment cores will be collected from the lake and these cores will be incubated in the laboratory to estimate the sediment phosphorus release rate.

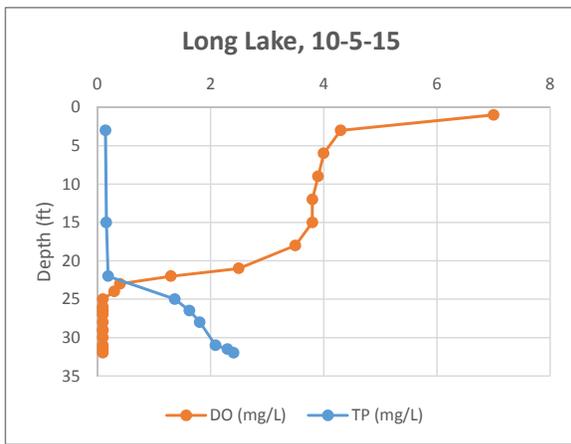
Fall concentrations of phosphorus in the deeper lakes ranged from 163 µg/L to 2,140 µg/L in Becker Lake, 146 µg/L to 2,410 µg/L in Long Lake, and 65.7 µg/L to 1,310 µg/L in Round Lake. Figure 2 displays the dissolved oxygen and total phosphorus profiles for these three lakes in October 2015. It is estimated that the water column in Becker Lake contained 689 lbs of phosphorus in the fall of 2015, while Long Lake contained 627 lbs and Round Lake 132 lbs. Again, these measurements are calculated at a period at the end of stratification when phosphorus mass would be the highest. From data collected earlier that spring (2015), estimates can be made as to what proportion of the fall TP mass values are derived from the sediments of each respective lake (Figure 2). Spring 2015 data was obtained during the month of April, when the lake was experiencing spring turnover. Thus, phosphorus values were largely similar throughout the entire water column. Figure 2 illustrates that over the course of the summer, each lake gained phosphorus, within the hypolimnion. Round Lake gained 42.2 lbs over the course of summer 2015 and Long Lake 278.7 lbs. Becker Lake added 398.1 lbs, from its spring mass. Although the samples collected in 2015 clearly show there is considerable internal loading from the deep water sediments, it is unclear how much this may be. The spring turnover phosphorus concentrations are very high in all of the lakes and the surface concentrations generally decline during the summer (Figures 3 and 4). At this time it is unclear whether the high spring concentrations are the result of internal loading from the previous summer (and winter stratification) or the result of phosphorus runoff from the watershed during spring runoff. It is important to determine whether internal loading or runoff from the watershed is the main source as this will strongly influence the management plan for the lakes. The relative contribution from internal loading and watershed runoff will be estimated in 2016.

Figure 3 displays the surface water phosphorus and chlorophyll *a* values for Round and Long Lakes. In most years, high spring turnover values are followed by gradually decreasing summer values. In years in which a fall turnover sample was collected (and correctly timed) the phosphorus concentration spikes once again while chlorophyll *a* does not increase due to the low water temperatures and sunlight availability at that time. In Round Lake, 2012 data were collected only during August and September so these trends are not evident for that year.

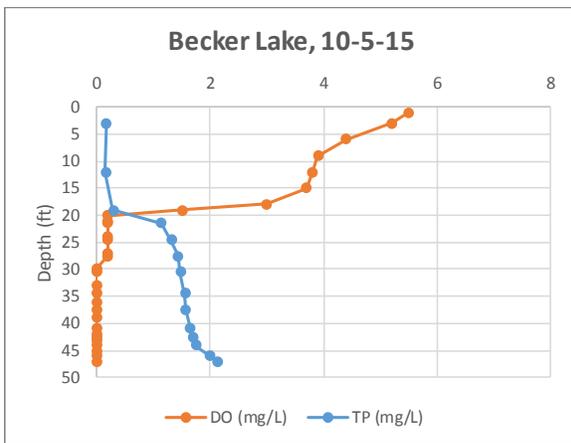
Figure 4 displays the surface water phosphorus and chlorophyll *a* values for Becker and Boot Lakes. In Becker Lake, trends appear similar to what is observed in Round and Long Lakes - high spring turnover values are followed by gradually decreasing summer values, and a high fall turnover phosphorus concentration (when collected and correctly timed). In Boot Lake spring concentrations are also quite high, as are fall turnover samples. In the Boot Lake time series, intermittent pulses of phosphorus during the summer (2013 and 2015) are evident and likely are the result of partial mixing during the summer months. This periodic mixing during the summer means that phosphorus released from the sediments is immediately available for algal growth and likely explains why this lake has the highest chlorophyll *a* and phosphorus concentrations of the four lakes (Figure 1).



Round Lake	
Fall 2015 Total TP (lbs)	174.6
Spring 2015 Total TP (lbs)	132.4
Difference (lbs)	42.2



Long Lake	
Fall 2015 Total TP (lbs)	906.3
Spring 2015 Total TP (lbs)	627.6
Difference (lbs)	278.7



Becker Lake	
Fall 2015 Total TP (lbs)	688.6
Spring 2015 Total TP (lbs)	290.5
Difference (lbs)	398.1

Figure 2. Round, Long and Becker Lake fall 2015 profiles (left) and total phosphorus mass calculations (right). Spring calculations were completed through April 2015 lake turnover samples, where it was assumed the lake was completely mixed. Fall 2015 calculations derived from data shown at left, prior to fall turnover. The difference in phosphorus mass is assumed to largely be derived from anoxic bottom sediments. Please note the X-axis displays total phosphorus in mg/L, whereas it is referenced in $\mu\text{g/L}$ within other charts.

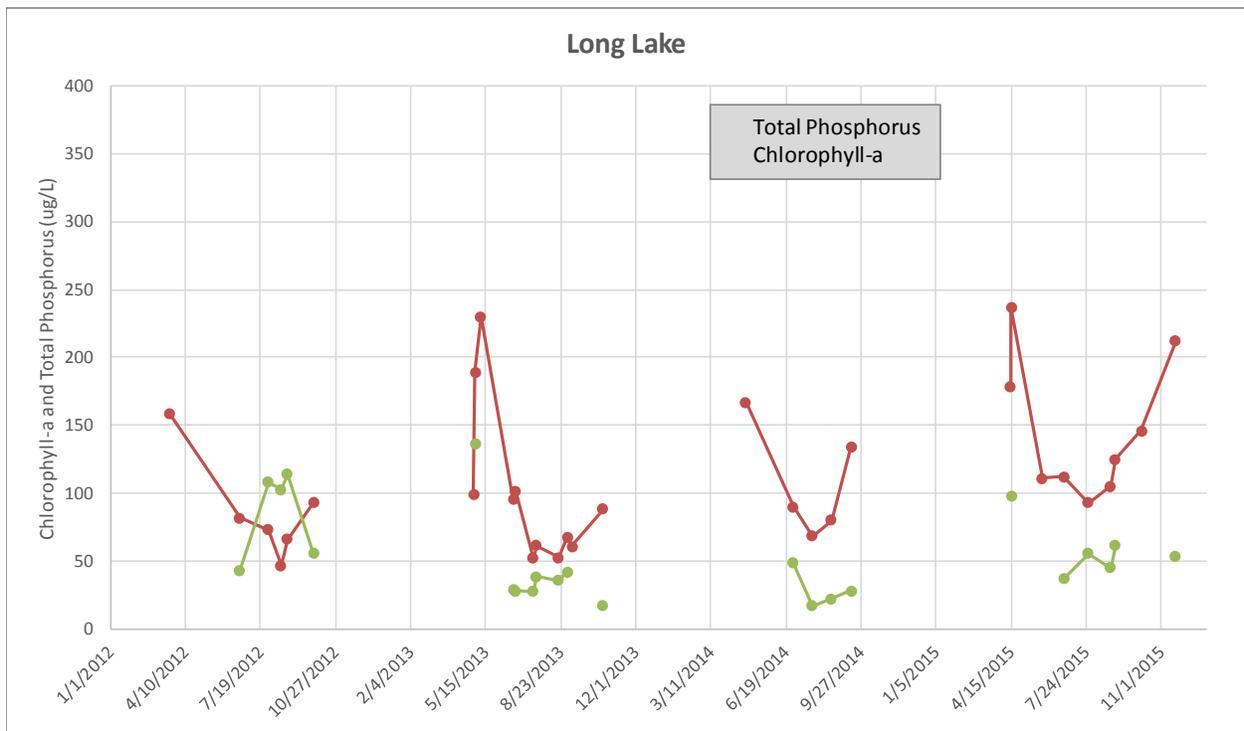
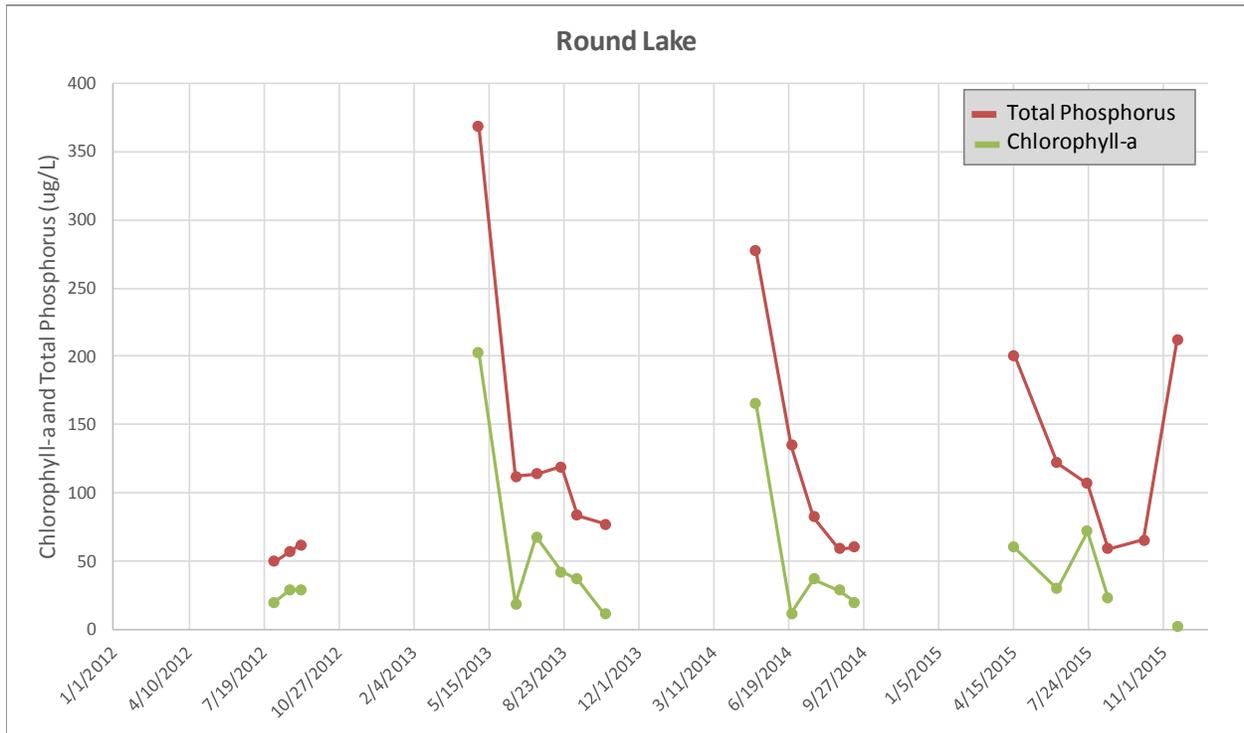


Figure 3. Round and Long Lake total phosphorus and chlorophyll-a time series, 2012-2015. Data depicts surface water samples collected from spring turnover to fall turnover time periods.

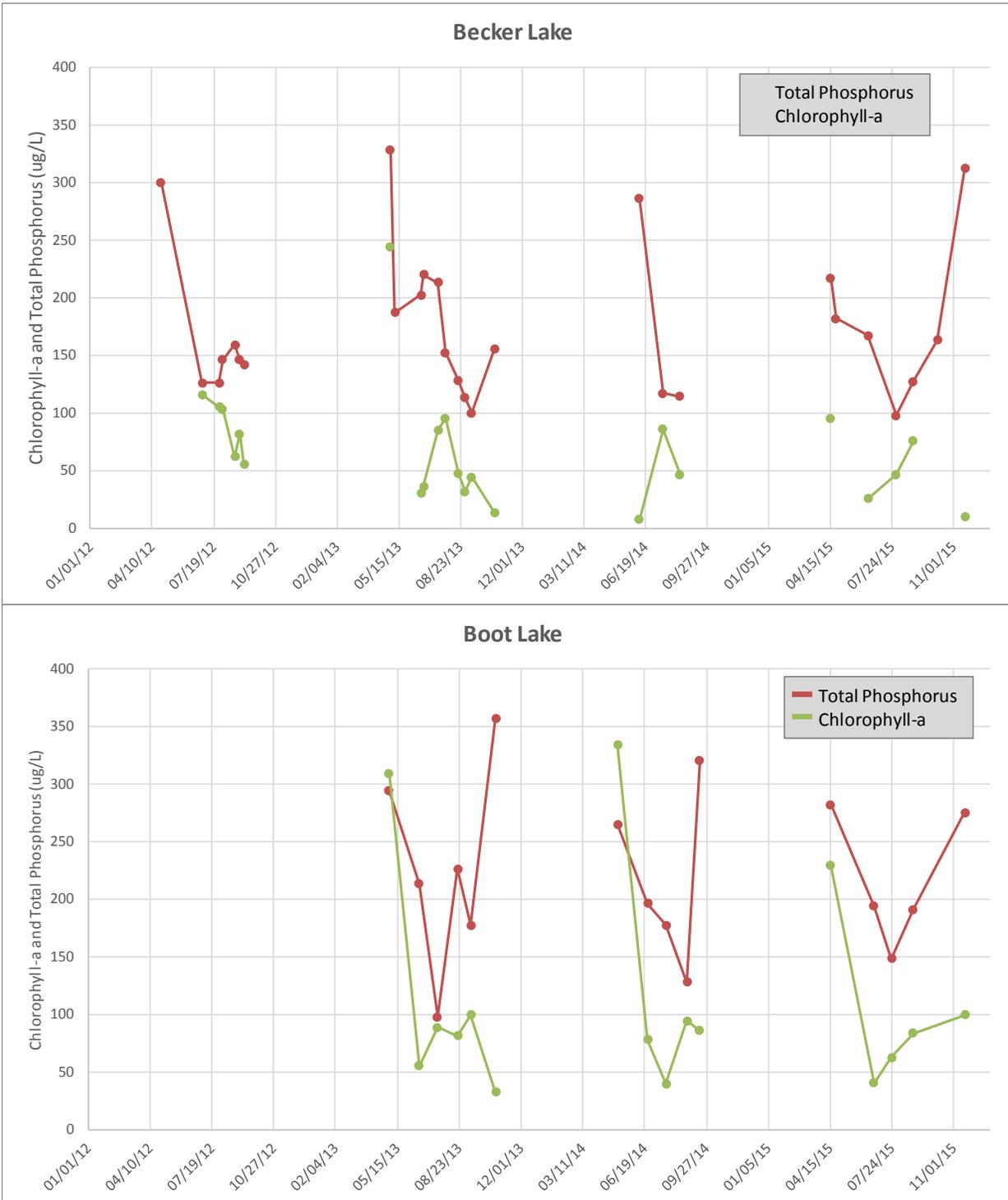


Figure 4. Becker and Boot Lake total phosphorus and chlorophyll-a time series, 2012-2015. Data depicts surface water samples collected from spring turnover to fall turnover time periods.

Tributary Monitoring

The CalMan Lakes drainage basin is relatively small in size and the drainage patterns in the basin are reflective of this, with “flashy” streams that may run for only several hours following a rain event. Three of the lakes have intermittently running tributary streams – Round, Long and Becker lakes. All four of the lakes however receive surface water runoff during spring snow melt and may receive input during large rain events. Tracking this runoff, and the nutrient/sediment content within it, is a complicated endeavor requiring the use of highly sensitive flow monitoring equipment, calibration and recalibration of the equipment based upon various flow regimes, constant monitoring of weather conditions, and finally the flexibility of project personnel to make visits to the area to collect storm runoff samples on a short notice.

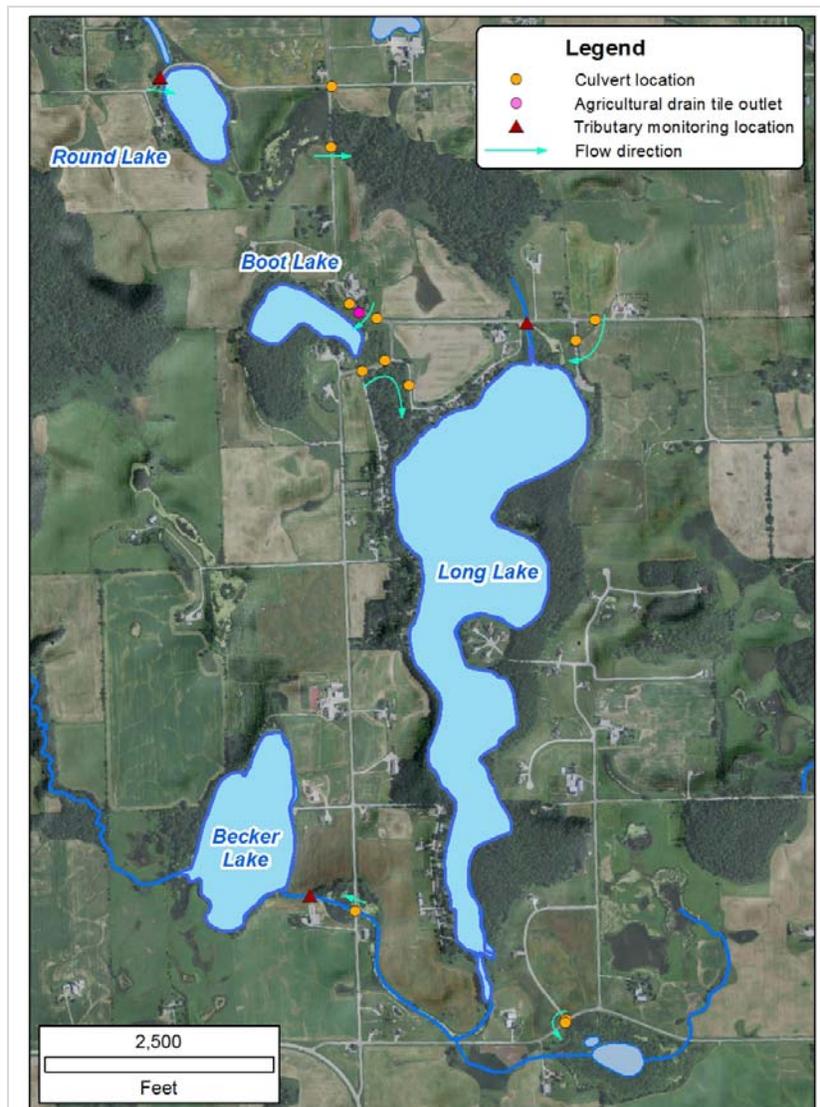


Figure 5. Map showing study lakes and stream monitoring sites. The three triangles are the sites of the continuous recorders. The culvert sites were sampled when flow occurred.

The CalMan Lakes are headwaters with the drainage pattern being Round and Boot lakes draining into Long Lake and Long Lake draining into Becker Lake. The stream leaving Becker Lake flows into Grass Lake and becomes Black Creek. Efforts have been undertaken to understand the flow regimes at three sites within the watershed. Numerous culverts that drain towards the CalMan Lakes were also sampled on an infrequent basis. Figure 5 shows the study lakes and the three sites where continuous flows were measured as well as the culverts that were sampled. The continuous monitoring sites are the inlet to Round Lake, near where the stream draining Round Lake enters Long Lake, and near where the stream enters Becker Lake. During 2015, the three streams and these numerous culverts were assessed for flow during storm events by CCLWCD and Onterra staff. Flow monitors were deployed on the Round, Long and Becker Lake tributaries to collect sensitive flow on a 10-minute interval. While it may be beneficial to deploy these flow monitors at the secondary, less-frequently flowing culvert locations, the expense and labor to maintain the monitors prevents widespread distribution. Instead, at the less frequently flowing culvert locations CCLWCD staff collected water depth and other measurements following storm events. Using Manning's Equation, a standard flow calculation for culverts and pipes, an estimate as to the instantaneous water discharge can be calculated. While the flow units on the three intermittent tributaries gave project managers a detailed understanding of the flow conditions at these sites, the secondary culvert monitoring would assist managers in understanding the level of runoff that may be unaccounted for in the tributary monitoring.

Water flow volumes and nutrient loads were collected in 2015 using flow monitoring units from Blue Siren® (www.blue-siren.com). The three tributary flow monitoring locations have proven to be a challenge in monitoring due to the specifics of each watershed and the site characteristics themselves. Continuous flow data was collected in the field and sent through a wireless connection to online servers every 30-60 minutes. Due to the remote locations of these sites, wireless connectivity was limited at times resulting in interruptions in data uploading. When low connectivity occurred, the monitor would attempt uploading again at the next 30-60 minute interval. In mid-June, high oscillations were observed in two of the three sites and were determined to be due to low battery power. Batteries were changed on all three units on June 27. The manufacturer of the flow units believes that the oscillations in depth data will have little impact on the overall flow and load calculations. Despite the challenges encountered, continuous flow data were collected from the three tributary monitoring locations from early May until mid-November in 2015. The monitoring at each site is discussed below:

Round Lake Tributary (Site ID ROT1):

A single culvert runs underneath Round Lake Rd., connecting the western part of Round Lake's 33 acre watershed to Round Lake. On the northwestern side of the culvert, a small wetland complex exists and on the southeastern side is Round Lake. In 2014, CCLWCD used survey-grade GPS to measure the length and slope of the culvert. These data indicate that the culvert is slightly negatively pitched, in other words, sloping from the lake towards the wetland. Very often the surface water elevation is the same on the wetland and lake sides of Round Lake Rd. While the culvert's intention is to drain water from the wetland into Round Lake, it is actually more or less acting as a level conduit between the two basins on either side of the road. Additionally, often during early season rain events flow overtops the road and this is flow and nutrient loading that is difficult to account for.

Monitoring of ROT1 began on March 11, 2015 and continued through November 18, 2015. CCLWCD and Onterra staff collected samples during runoff events as well as during lower flow

periods. Ten total suspended solids (TSS) and total phosphorus (TP) samples were collected in 2015, along with three soluble reactive (dissolved) phosphorus samples (SRP). Samples were collected only when visible flow was occurring (stagnant conditions not sampled). Even following rain events, often times flow was not observed in the culvert. It is believed that the hydrology of this system is such that water backs up for a period of time until proper draining can occur at the lake's outlet, into a nearby wetland. So a "lag time" may exist between when the wetland and lake fill from a rain event, and when the water begins to move out of this watershed. Despite these challenges, several rain events were recorded and sampled during 2015. Figure 6 displays TP and TSS samples collected over the flow monitored timeframe. Diurnal oscillations in the water height can be observed on these charts. The reason for these oscillations is not fully understood at this time. They are possible because the culvert enters directly into Round Lake and is always partially filled. As previously mentioned, the larger oscillations observed during the month in June are exaggerated a bit due to a low power battery, which was replaced on June 27th.

Long Lake Tributary (Site ID LOT1):

Once water leaves Round Lake, it collects with other runoff from Long Lake's watershed in a forested wetland just north of Long Lake. It then flows south, under a Boot Lake Rd. bridge, into Long Lake. As with ROT1, this inlet's water elevation is similar to the lake's water level and has a low slope. As such, water velocity is often minimal and largely derived by rain events. During multiple field visits during smaller rain events, an increase in the water depth was noticed however visible flow was not always observed. This would indicate the stream and lake level could be rising at a consistent rate, the stream fed by northern upstream sources and the lake fed by inputs from the west and eastern shoreline. Three significant rain events were captured at LOT1 during 2015, including during mid-April and early and mid-June (Figure 7). Moderate rain events occurring in the fall were not captured. It is believed that a long period of stagnant water may have "fouled" the instrument sensors and prevented velocity measurement. There is potential that after a long period of dry weather, these moderate rain events may have percolated into the soil and not triggered a substantial flow at this site either. Only a moderate flow was measured the other two sites during this time.

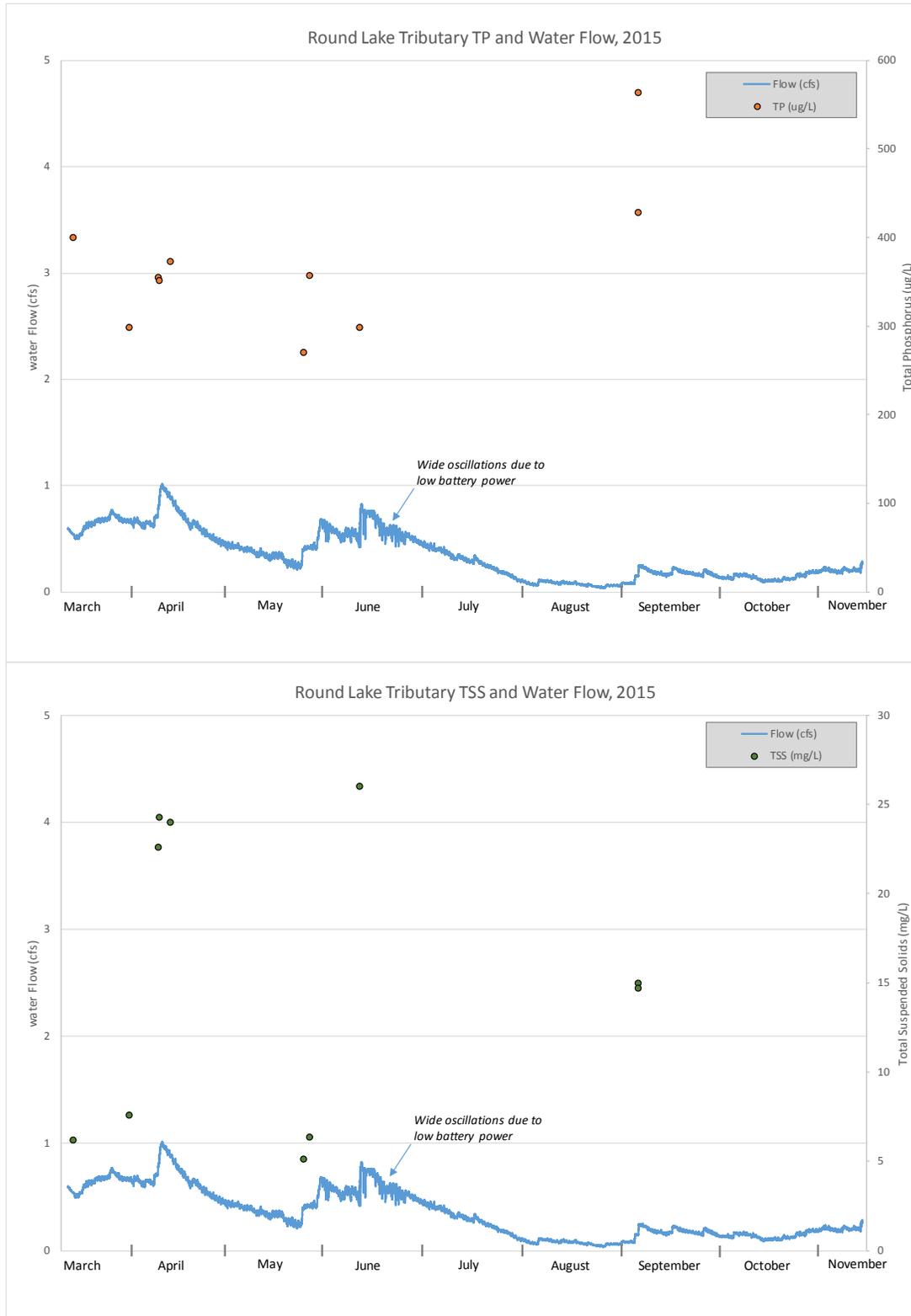


Figure 6. Round Lake total phosphorus and total suspended solids concentrations paired over 2015 water flow. Data depicts surface water grab samples collected during anticipated rain event and low flow conditions. Note that flows at this site were much less than at inlets of Long and Becker lakes.

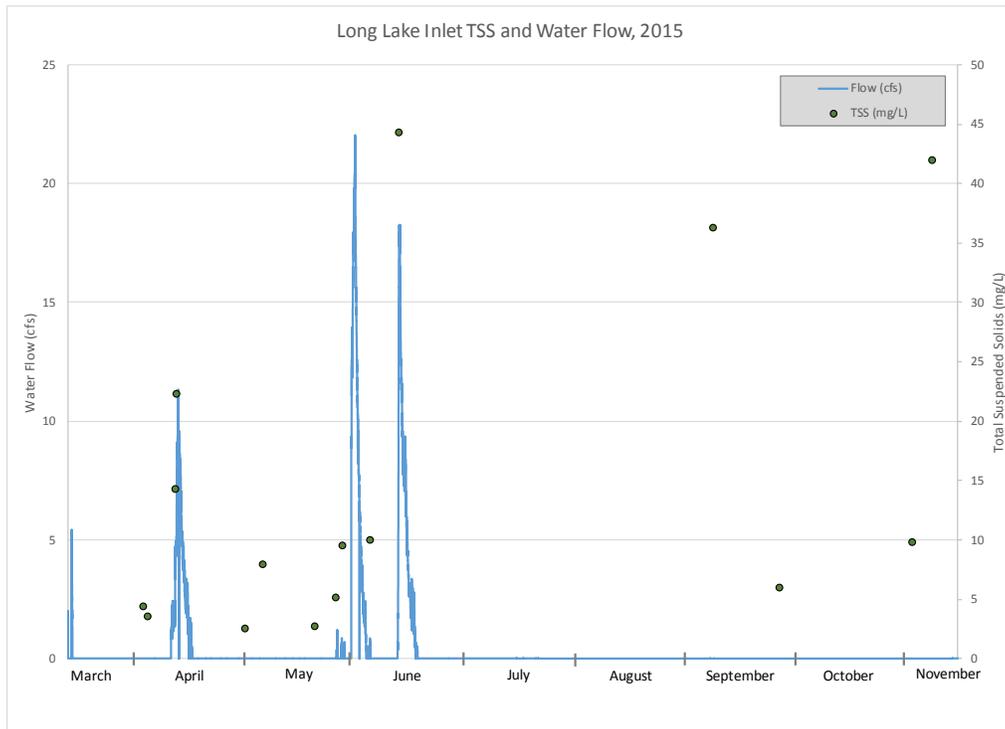
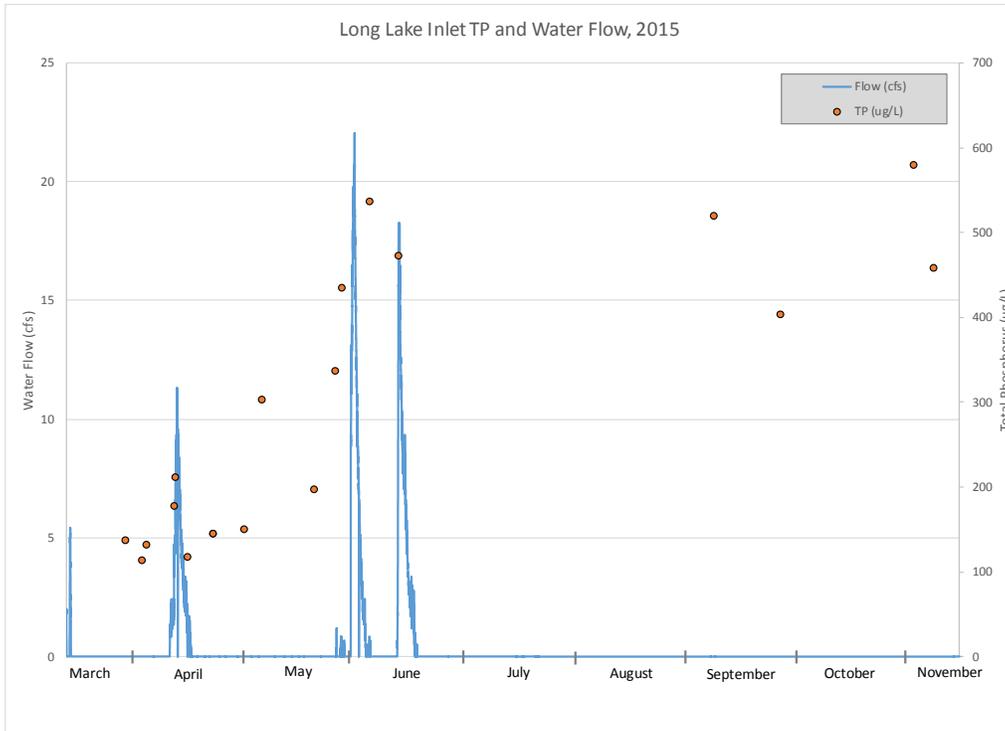


Figure 7. Long Lake total phosphorus and total suspended solids concentrations paired over 2015 water flow. Data depicts surface water grab samples collected during anticipated rain event and low flow conditions.

Becker Lake Tributary (Site ID BET1):

The primary tributary to Becker Lake is outflow from Long Lake and meanders to the west, under Long Lake Rd, and into the southeastern corner of Becker Lake. The Becker Lake tributary monitoring site is located on private property; permission was graciously given for this project by the property owner. At this location, water runs through a cattail wetland and through 5-ft diameter culvert that lies under a farm equipment passageway (two-track trail). The culvert would be an ideal location for flow monitoring except that a mound of cement, put in place to hold the culvert and surrounding structure in place during high water periods, partially covers the opening of the culvert and creates an uneven and oddly shaped weir. The velocity sensors could not be placed at the top of this weir, so they were placed inside the culvert and the weir accounted for by creating a “spill depth” in which to gauge water depth and flow from. Essentially, at this location water pools inside the culvert until it reaches the spill depth, at which it tips over the weir. During low flow periods, water may sit in the culvert and a depth measurement may be registered, however the water is not flowing downstream. There was little flow at all three sites including the Becker Lake Tributary (Figure 8). This was confirmed with field observations made during this time.

In Figures 8-9, total phosphorus data (n=19) as well as dissolved phosphorus data (n=10) is displayed. At this site as well as the inlet to Long Lake, there poor correlation between TSS and phosphorus concentrations implying that most of the phosphorus at these sites is not attached to soil particles. At LOT1 a large percentage of the total phosphorus is in the dissolved form. In the fall samples the total phosphorus was largely in the particulate form. At BET1 the opposite was true with the fall samples having the highest amount of total phosphorus being in the dissolved form.

At the BET1 site, during the late season, TSS samples were of lower concentration than during the spring sampling (Figure 9). It is likely that the TSS is lower in the spring samples as water flow was higher, thus diluting some of the particles. At the Long and Becker lakes sites, phosphorus concentrations are much higher than surface phosphorus concentrations in the upstream lakes. This indicates that considerable phosphorus in the streams is being derived from the wetlands and the stream channels. This is also implied by the relatively high percentage of phosphorus in the dissolved form in many of the samples. It is hypothesized that there are complex processes occurring in the upstream wetlands, such as the decay of organic material and anoxic sediment release, that contributes dissolved phosphorus to the stream water before it enters the lakes. Management plans will need to take these potential sources of phosphorus into consideration.

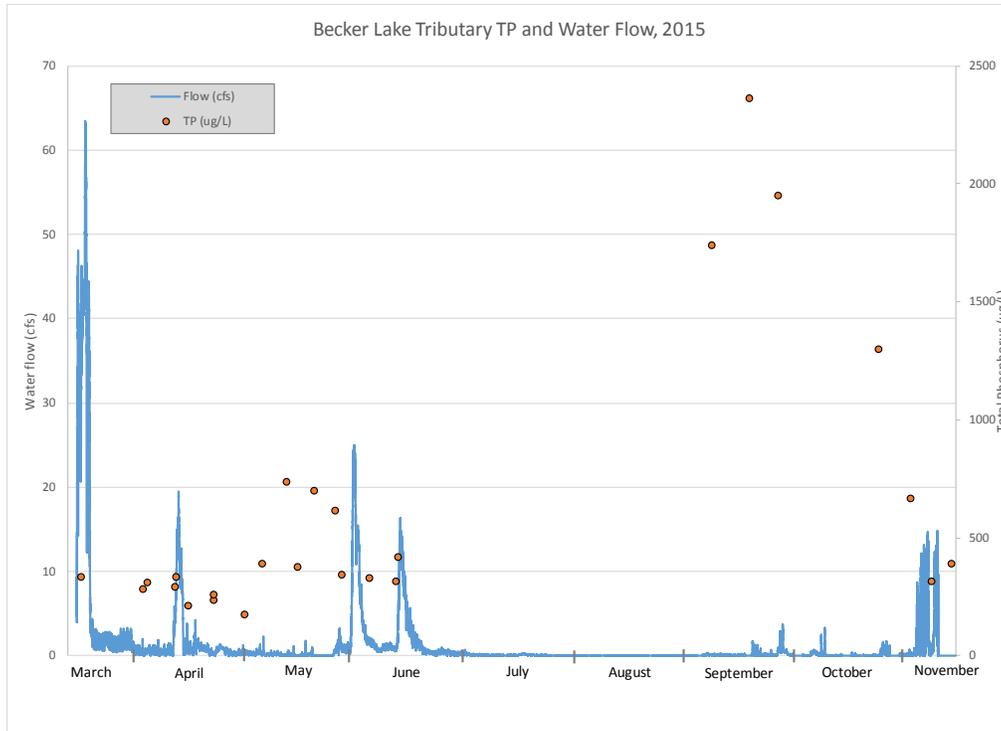


Figure 8. Becker Lake total phosphorus concentrations paired over 2015 water flow. Data depicts surface water grab samples collected during anticipated rain event and low flow conditions.

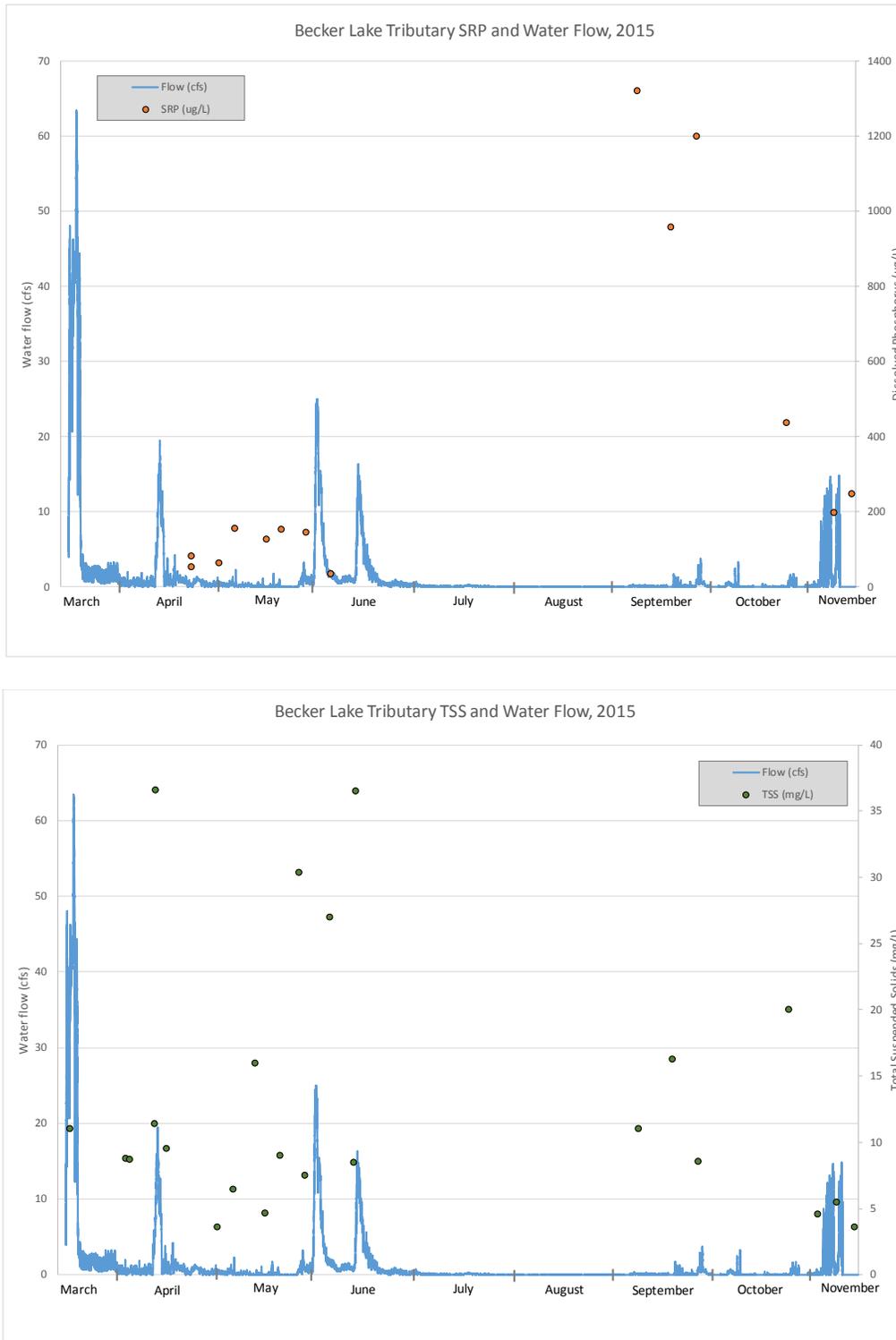


Figure 9. Becker Lake dissolved phosphorus and total suspended solids concentrations paired over 2015 water flow. Data depicts surface water grab samples collected during anticipated rain event and low flow conditions.

Lake Sediment Cores

A lake's sediment profile is a valuable tool to lake managers because it provides a historical record of change. Aquatic organisms within the sediment, deposited over 1,000's of years, can be examined from one period and compared to more recent times. With knowledge about the species present in each era, inferences can be made on the conditions of the lake between the time periods. Diatoms are a type of algae most often used for this analysis. Diatoms have silica-rich cell walls, which enable them to persist in the sediments in a well-preserved state. They are an ecologically diverse group – certain species are found only in pristine conditions, some in poor water quality conditions, some only grow on plants or rocks, some float in the open water. Their study will identify changes in nutrient concentrations, water clarity, pH and even alterations in the aquatic plant community.

Onterra staff had planned to collect sediment cores from all four of the CalMan Lakes during winter 2016, when a visit was already scheduled

to collect winter water chemistry samples and dissolved oxygen readings. During the visit, the cold conditions resulted in freezing of the sediment corer and other sampling equipment. As a result, Onterra staff had to forgo collecting the sediment samples after the collection at Round Lake (Photograph 1). Additional cores will be collected from Boot, Long and Becker Lakes during spring 2016. The diatom community will be examined in the surface section and a section near the bottom of the cores. The top section represents present day conditions and the bottom section represents the conditions in the lake prior to the arrival of European settlers in the early to mid-1800s.

A preliminary examination of the diatom community from the core collected from Round Lake indicates that the condition of the lake at the present time is significantly different from pre-settlement conditions. The diatom community confirms that at the present time the lake is hypereutrophic. Historically the lake was a bog type lake with much lower nutrient levels and lower pH levels. The lake may have been noticeably stained with tannic acids which give the water a brown color.

Stakeholder Participation

The involvement of stakeholders in this project will be crucial to its success. While the project includes several forums for public discussion, there was a perceived desire to include anonymous input from watershed stakeholders and detailed discussion with agricultural land operators and property owners in the watershed. In order to assess the opinions and concerns of these stakeholders, an interview questionnaire and stakeholder survey were drafted in winter of 2015/2016. Beginning in February 2016, CCLWCD staff have been interviewing agricultural land producers and owners on their opinions regarding land use, conservation practices and perceived needs in the watershed. Later



Photograph 1. Onterra staff with an intact sediment core from Round Lake.

Sediment from the top of the core (recent time) will be compared with the bottom of the core (pre-settlement time) to determine changes in the lake's water quality and aquatic plant community.

this spring, an anonymous stakeholder survey will be distributed to lake property owners, watershed residents and Brillion Conservation Club members. Recipients will have an option to take the survey online or request a hard copy version to complete and return. The data collected through the interviews and surveys will shed light upon how these stakeholders view land use practices, water quality and recreational and ecological value in the CalMan Lake's watershed.

Next Steps

In the coming weeks, Onterra and CCLWCD staff will be compiling information on the above-mentioned tasks. Additionally, the team will continue to examine watershed characteristics and practices. One way in which this will be approached is through a relatively new WDNR watershed model called EVAAL (Erosion Vulnerability Assessment for Agricultural Lands). EVAAL was designed to identify areas that are vulnerable to erosion of soil, and thus also likely to release nutrients to surface water runoff. The model uses numerous data layers in a geographic information system (GIS) to complete this analysis. These areas, along with others identified during this planning project, may be prioritized for restoration if reductions in nutrient export to the CalMan Lakes is to be achieved.