CLMP+ Report for Venus Lake (Douglas County)

Lake ID# 21-0305-00
2015-2016 CLMP+ Data Summary

MINNESOTA POLLUTION CONTROL AGENCY

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Introduction

The Minnesota Pollution Control Agency (MPCA) conducts and supports lake-monitoring activities to determine if water quality is suitable for recreational uses (swimming, wading, boating, etc.) of lakes. This information is also used to measure and compare regional differences and trends in water quality with lakes from all over the state. MPCA staff, local partners (SWCDs, watershed districts, tribal entities, etc.), and citizens all play a role in sampling lake water quality.

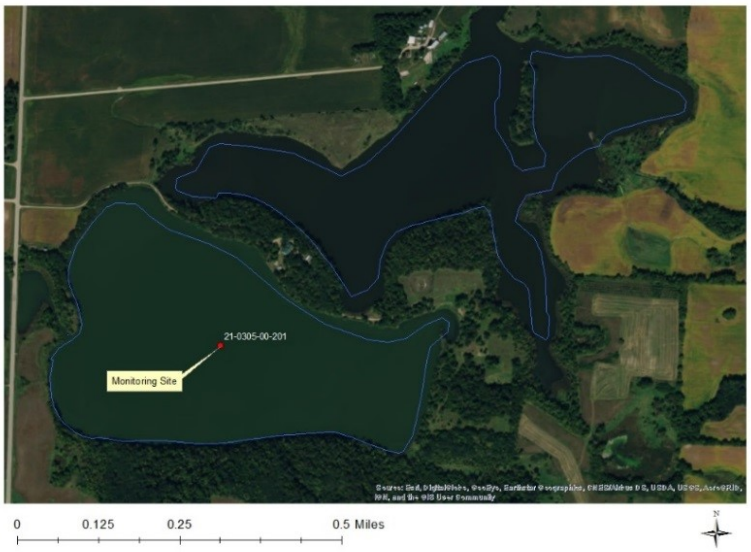

Figure 1. Aerial photo of Venus Lake

As part of the MPCA's Advanced Citizen Lake Monitoring Program (CLMP+), Ed Wons & Julie Cole measured water quality in Venus Lake from May-September in 2015 and 2016. Venus Lake (Figure 1) is located in Douglas County, approximately 6 miles NE of Hoffman, Minnesota. It is 198 acres in size and has a maximum depth of 17 feet (5.18 meters). CLMP+ volunteers measured water transparency, temperature and dissolved oxygen profiles twice monthly, and collected water chemistry samples monthly. This report provides a summary of the water quality data, and of other physical and ecological characteristics, of the lake.

Ecoregion and land use characteristics

When investigating lake water quality, it is important to consider how land within the lake's catchment (the area of land surrounding the lake that drains water directly to it) is used. Certain land uses increase pollutant loading to the lake. For instance, phosphorus in animal waste can runoff from feedlots to surface waters during heavy rain events. Likewise, manure and commercial fertilizers can be washed from cultivated fields over land or through tiling systems to lakes. Additionally, phosphorus binds tightly to soil, so eroded soil from developed lakeshore or stream banks is often a large source of phosphorus to lakes and streams. Conversely, forested areas, undeveloped land, and wetlands are important features that preserve good water quality by serving as a buffer to filter water that flows across the catchment and into the lake.

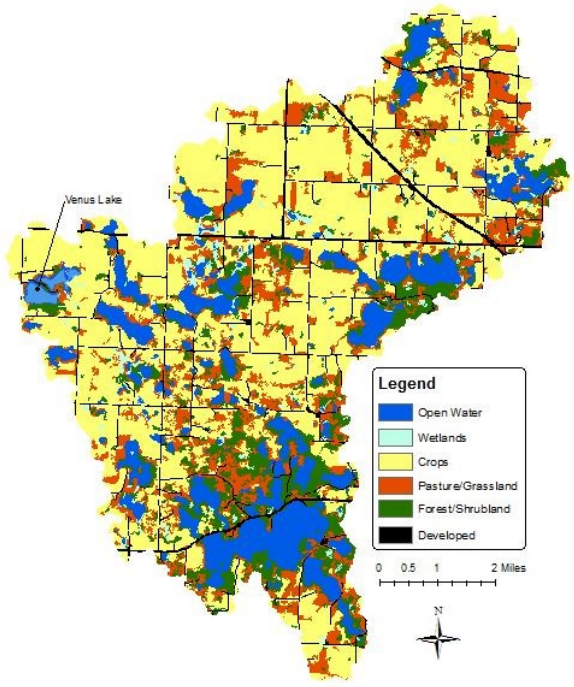

Figure 2. Venus Lake watershed area

Minnesota has seven ecoregions, as defined by soils, land surface form, natural vegetation and current land use. Venus Lake is located in the Northern

Central Hardwood Forests (NCHF) ecoregion. Throughout this report, Venus Lake characteristics are compared to the typical range of values from reference lakes within the NCHF ecoregion. Venus Lake has a watershed area of 34,211 acres (Figure 2). This is a very large-sized watershed relative to the size of the lake (173:1 watershed: lake area ratio). Lakes with large watersheds relative to lake area, often receive high water and nutrient loads; in contrast, those with small watersheds often receive low water and nutrient loads.

Land use within the Venus Lake watershed is typical of that found within its ecoregion (Table 1). The area is heavily cultivated with fifty percent of the lake's watershed dominated by agriculture. Watersheds dominated by cultivated land typically deliver high amounts of nutrients to waterbodies from fertilizers, erosion and organic debris compared to lands dominated by forest, pasture or wetland areas, which capture nutrients and sediment before they enter lakes.

Table 1. Land Use composition

Land use	Venus Lake watershed land use percentage	NCHF typical land use percentage
Developed	5	2-9
Cultivated (Ag)	50	22-50
Pasture & Open	16	11-25
Forest	12	6-25
Water & Wetland	17	14-30
Feedlots (#)	35	

Lake mixing and stratification

Lake size, depth and the shape of the basin, affect whether a lake stratifies (forms distinct temperature layers) and how it mixes, which have a significant influence on water quality. Deep lakes that stratify during the summer months fully mix, or turn over, twice per year, typically in spring and fall. Shallow lakes (maximum depth of six meters), in contrast, mix continuously and have uniform temperature throughout the water column during the open water season. Lakes with moderate depths may stratify intermittently during calm periods, but mix during heavy winds and during spring and fall. Mixing events allow nutrient-rich lake sediments to be re-suspended, which, under high temperature, can introduce phosphorus into the water where it may encourage the growth of algae. As a result, lakes that continuously mix are at more risk of developing algal blooms than deeper lakes that stratify. Lakes that strongly stratify often have little or no oxygen near the lake bottom. Low oxygen can allow phosphorus to be released from the lake sediments, which is another way nutrients are introduced to the water and can stimulate the growth of algae after the fall turn over.

To determine if a lake stratifies or not, water temperature and dissolved oxygen profiles are taken every meter throughout the water column (surface to bottom) several times during the open-water season. These profiles show distinct patterns if the lake stratifies and how oxygen levels change with depth. The small size and shallow depth of Venus Lake led to continuous mixing during 2015 and 2016 – typical for a lake of this size and depth. Both 2015 and 2016 temperature profiles (Figures 3 & 4) show consistent readings from surface to bottom, indicating stratification did not occur in either year.

Dissolved oxygen (DO) levels did show variability at different depths in both 2015 & 2016. Most mid-summer readings in both years show high DO at the surface and low near the bottom (Figures 5 & 6). This could indicate a high level of algae productivity in the lake during that time of year. Algae photosynthesizing at the water's surface produce oxygen, while decaying algae at the bottom of the lake deplete oxygen levels.

Because Venus Lake does not stratify, it is considered to be polymictic, meaning that it mixes frequently. Shallow lakes are often polymictic and can be sensitive to excess nutrient levels since nutrients are continually dispersed throughout the water column through mixing rather than settling to the lake bottom.

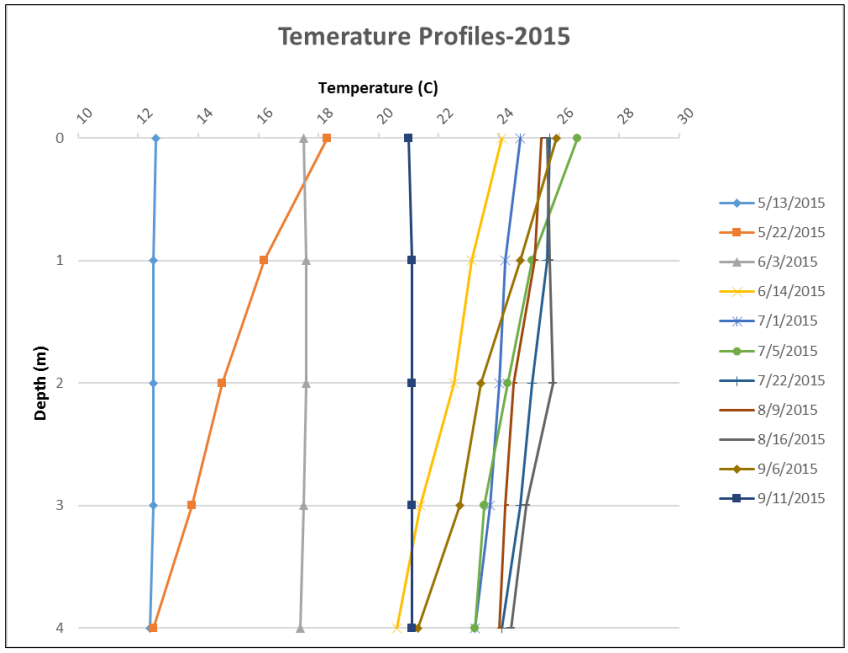

Figure 3. Venus Lake Temperature Profiles, 2015

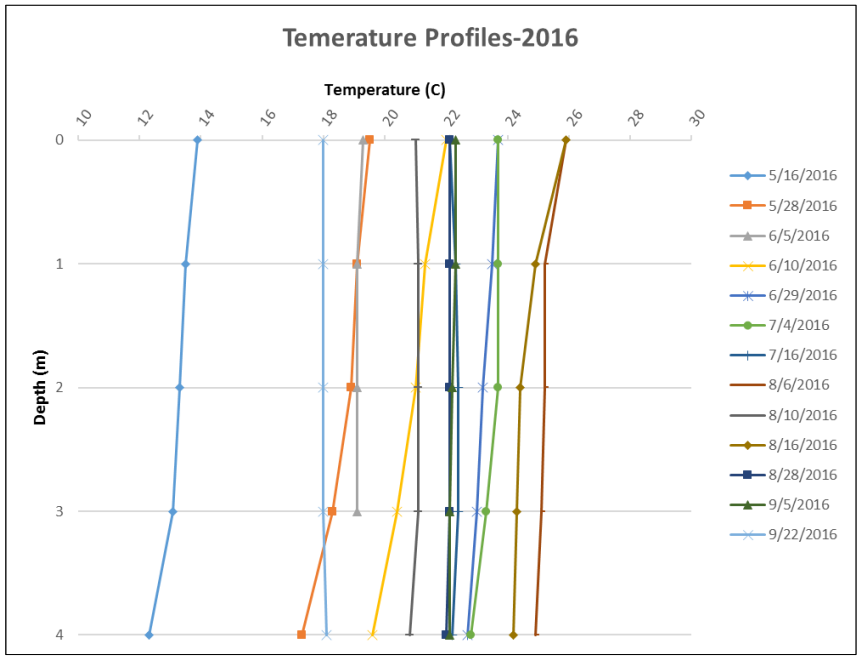

Figure 4. Venus Lake Temperature Profiles, 2016

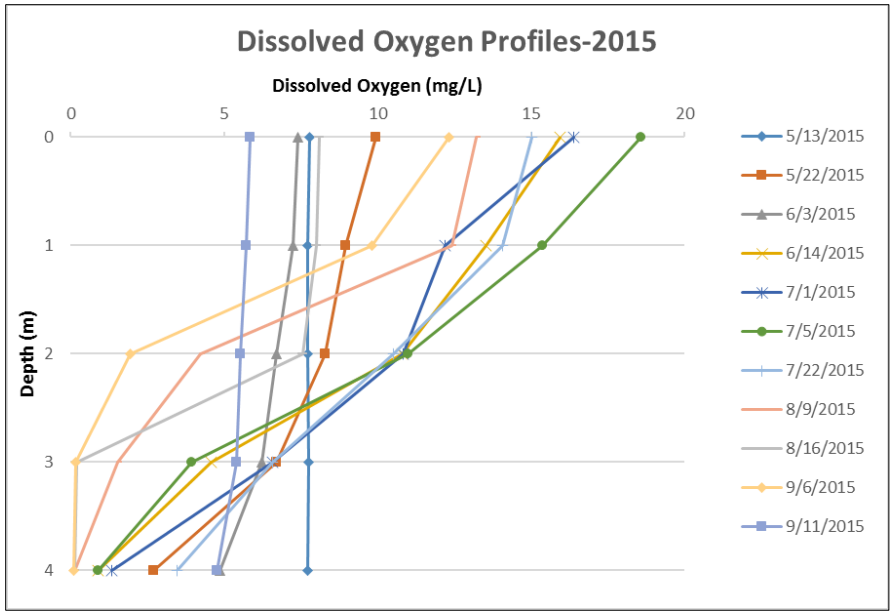

Figure 5. Venus Lake Dissolved Oxygen Profiles, 2015

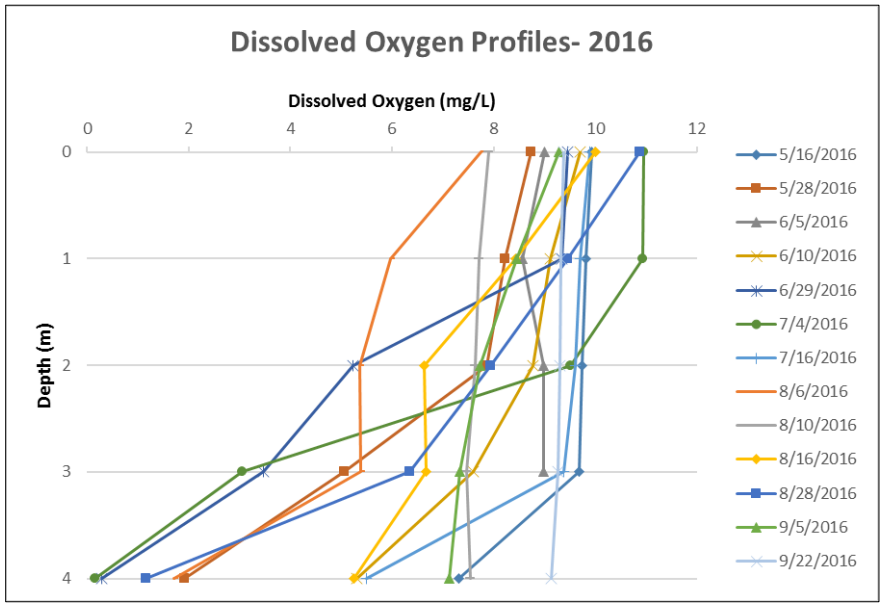

Figure 6. Venus Lake Dissolved Oxygen Profiles, 2016

Water quality data

Phosphorus and nitrogen are the primary nutrients that promote algal growth in lakes. When lakes receive an overabundance of these nutrients, there is an increase in the likelihood of nuisance algal blooms and that lakes will not support aquatic recreational uses; however, there are other factors that also should be considered. For this reason, it's important to collect information on water color, suspended solids, temperature, dissolved oxygen, and a number of other parameters. All June-September water chemistry data for Venus Lake gathered in 2015 and 2016 were averaged (referred to as "summer mean" values) and compared to reference lakes in the NCHF ecoregion (Table 2). Reference

lakes include those selected to be typical of the ecoregion and minimally impacted, and allow for comparison to Venus Lake.

Table 2. Venus Lake data compared to typical range for NCHF ecoregion reference lakes

Parameter	Venus Lake 2015[1]	Venus Lake 2016[1]	Venus Lake 2-year summer mean[1]	Typical range for reference lakes in NCHF
Number of reference lakes				43
Total phosphorus (µg/L)	62	115	89	23 – 50
Total Kjeldahl Nitrogen (mg/L)	2.3	2.3	2.3	<0.60 – 1.2
Chlorophyll mean (µg/L)	66.3	53.3	60	5 – 22
Transparency				
(Feet)	1.6	2.0	1.8	4.9 – 10.5
(meters)	0.5	0.6	0.55	1.5 – 3.2
TN:TP ratio	37:1	20:1	26:1	25:1 – 35:1
Chloride (mg/L)	13.15	15.53	14.34	4 – 10
Total Suspended Solids (mg/L)	20.3	26.8	23.5	2 – 6

Concentrations shown are the summer means of samples taken June-September. ug/L = micrograms per liter; mg/L = milligrams per liter

Total phosphorus (TP) is generally the limiting nutrient for algal growth in Minnesota lakes. This is because it is essential to algal growth and it is typically in the shortest supply. Venus Lake 2-year summer-mean TP was 88.5, which is much higher the typical range for NCHF lakes. It is important to note that the average TP level in 2016 of 115 ug/L was significantly higher than the 2015 average of 61 ug/L, which made an impact on the overall 2-year average. 2016 was a particularly wet year and Venus Lake was likely impacted by increased runoff from the surrounding watershed - comprised largely of crop and pasture land, which can flush additional nutrients and organic material into the lake and cause an increase in total phosphorus levels.

Nitrogen, while also an essential nutrient for algal growth is typically not the "limiting nutrient" in most Minnesota lakes. Total Kjeldahl nitrogen is a measure of organic nitrogen (i.e., nitrogen found in algae) and ammonia- nitrogen. When combined with inorganic nitrogen, this represents total nitrogen (TN). The ratio of TN to TP is used as a simple basis for discerning which nutrient, TN or TP, is the limiting nutrient. Lakes are considered "nitrogen-limited" when the TN:TP ration falls below 10:1. In the case of Venus Lake, the ratio is 26:1, which indicates that phosphorus is the nutrient controlling algal growth in this lake.

Chlorophyll-*a* (a pigment found in algae) is used to estimate the amount of algal production in a lake and, therefore, the lake's response to nutrients. The chlorophyll-*a* 2-year summer mean concentrations for Venus Lake was 59.8 ug/L, which is much higher than the ecoregional expectations. Concentrations from 10-20 ug/L indicate a mild algal bloom and concentrations greater than 30 ug/L indicate severe nuisance conditions. All but two sampling events from 2015 and 2016 had concentrations greater than 30 ug/L (Figure 8) indicating that the lake was frequently in full bloom, decreasing the overall water quality.

Secchi transparency provides an indirect measure of the amount of suspended material in the water, which in many Minnesota lakes – is the amount of algae in the water. The amount of algae in a lake has a direct influence on the transparency of the lake. Venus Lake's transparency readings were much lower than the typical range for NCHF lakes in both 2015 and 2016 (Figure 7), likely because of the high chlorophyll-*a* concentration. High total suspended solids or color can also limit transparency. High total suspended solids may arise from suspended sediments (from runoff or wind mixing) or from the presence of dead algae in the water. Elevated color, also referred to as bog-stain, may occur when high amounts of runoff from wetland and forest areas enter a lake. This runoff brings in natural organic matter that lends a coffee coloration in to the water. In the case of Venus Lake, the total suspended solids is high (2-year mean of 23.5 mg/L) indicting that it can also limit transparency.

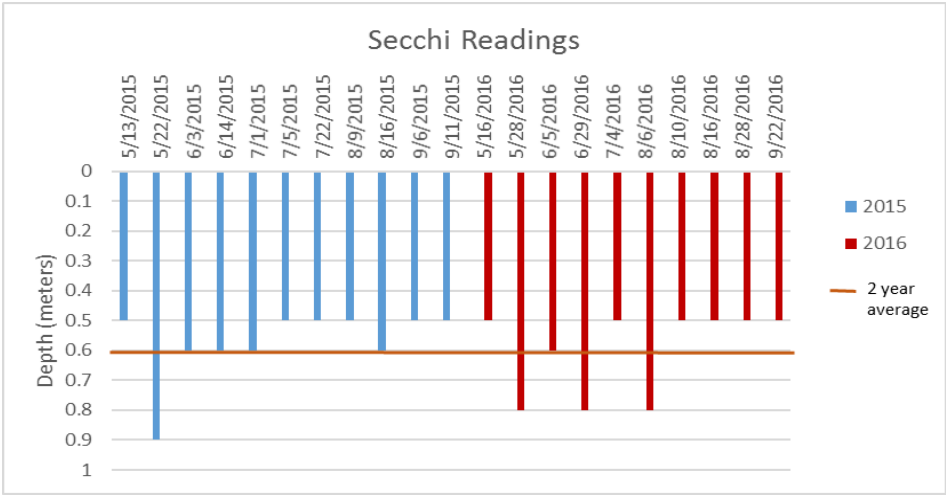

Figure 7. 2015 & 2016 Secchi Readings

CLMP+ data collected for Venus Lake show that in terms of total phosphorus, chlorophyll-*a* and Secchi disk transparency, the water quality of the lake is poor compared to the reference lakes in the NCHF ecoregion (Figure 8). Based on the data collected, Venus Lake is hypereutrophic, meaning that a high level of nutrients are present to support the potential excessive growth of aquatic plants such as algae. Decreased transparency and depleted oxygen levels are also typical of a eutrophic lake.

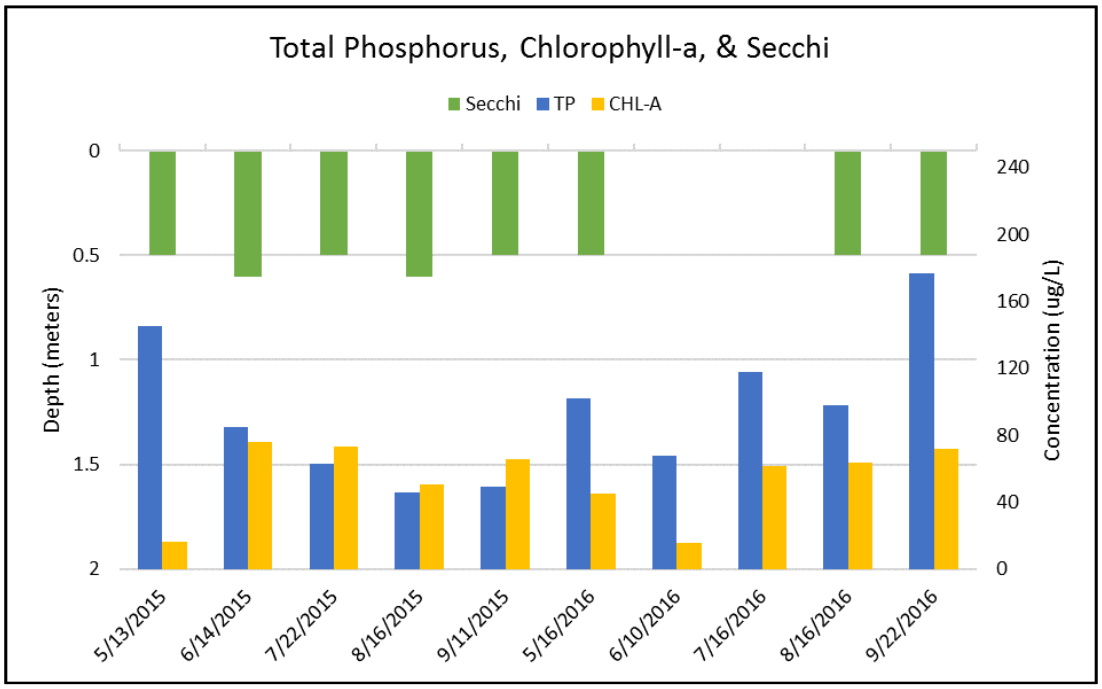

Figure 8. Venus Lake chemistry data

Water quality standards

Through the federal Clean Water Act, water standards are used to determine the quality of the state's water resources. For a lake's water quality to be considered impaired, total phosphorus AND either Secchi or chlorophyll-*a* levels need to exceed state water quality standards. Based on collected data through the CLMP+ in 2015 and 2016, Venus Lake has total phosphorus, chlorophyll-*a* and Secchi levels that are not meeting the state standard established for the NCHF Ecoregion (Table 3). Venus Lake is located in the Chippewa River Watershed. The MPCA and local partners will be monitoring select lakes and streams within this watershed in 2019 and 2020. The data collected during these two years, in addition to recent data collected on lakes such as Venus, will be formally assessed and water quality impairments will be identified. Given the data collected in 2015 and 2016, Venus Lake will be added to the impaired waters list and submitted to the federal Environmental Protection Agency for review and approval. From there, the MPCA will work with local partners to initiate a Total Daily Maximum Load (TMDL) study to identify the source of pollutants impairing Venus Lake's water quality. Once the TMDL is complete, a restoration plan will be developed to reduce the level of nutrients entering the lake.

Table 3. A comparison of water quality data from Venus Lake to the lake eutrophication standards for NCHF ecoregion.

	TP (µg/L)	Chl-*a* (µg/L)	Secchi (m)
Thresholds set to protect shallow lakes in the NCHF ecoregion for aquatic recreation use	<60	<20	>1.0
Venus Lake 2-year summer mean values	89	60	0.55

Trends

As part of the CLMP, citizens have monitored Venus Lake for seven years. The primary purpose of CLMP monitoring is to gather water transparency data over a long period of time to determine if the transparency trend for the lake is increasing, decreasing or remaining stable over time. At a minimum, 20 data points over eight years are required for a basic trend analysis. Although short one year of data to make any conclusion about a long-term trend, the seven years of data collected thus far, show no evidence of a long-term trend in either direction (Figure 9). CLMP volunteers are strongly encouraged to continue taking Secchi readings to increase the data on this lake and help determine whether water quality conditions are improving or worsening, and identify how management actions are improving the State's waters overall.

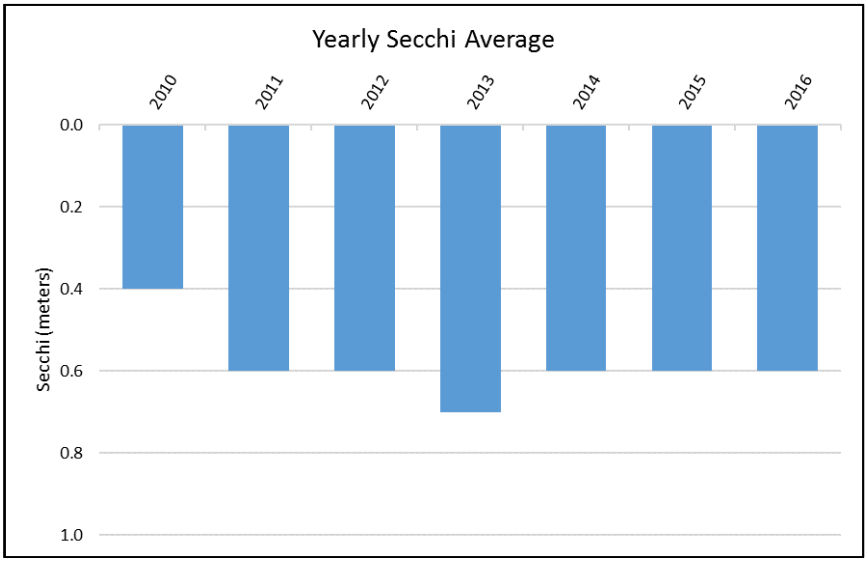

Figure 9 . Long-term Secchi trend

Summary

Venus Lake is a small shallow lake in the Northern Central Hardwood Forest Ecoregion. With a very large watershed, it has a significant amount of nutrients that flow into the lake. Total phosphorus, chlorophyll-*a* and Secchi transparency data show the lake is not meeting water quality standards for aquatic recreation.

Recommendations

- Continue to participate in the CLMP and regularly collect transparency data to provide the continuous water quality records needed for trend assessment.
- Continue to minimize as much as possible the potential for phosphorus to be routed, or loaded, to the lake. This entails limiting lakeshore development and retaining as much undeveloped land in the lake catchment as possible.
- Engage with city and county officials to ensure protection of wetlands in the surrounding watershed. Wetlands trap and filter sediments and nutrients, limiting their eventual run-off into Venus Lake.
- Maintain native aquatic plant beds to support fishery habitat and the quality and balance of the fish community. Native aquatic plants also provide natural wave breaks and results in decreased shoreline erosion. Increased wave action stirs lake sediments, clouding the water, making it difficult for new plants to grow. A healthy rooted aquatic plant community also utilizes available phosphorus, reducing phosphorus available for algal growth.
- Maintain remaining shoreline emergent aquatic vegetation – potentially important habitat for invertebrates and juvenile fish in addition to being a natural trap for washed in sediments and nutrients. Educate shoreland homeowners on the benefits of this habitat. The Minnesota Shoreland Management Guide (http://shorelandmanagement.org) provides useful information on this and other issues relevant to conserving the lake's beneficial uses.