CLMP+ Report on Lake Bronson
(Kittson County)

Lake ID# 35-0003-00
2013-2014 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 supports recreational uses (swimming, wading, boating, etc.) of lakes, and to measure and compare regional differences and trends in water quality with lakes from all over the state. MPCA staff, local partners (soil and water conservation districts, watershed districts, tribal entities, etc.), and citizens all play a role in sampling lake water quality.

As part of the MPCA's Advanced Citizen Lake Monitoring Program (CLMP+), Fred Wilebski and Matt Feigum measured water quality in Lake Bronson from May-September in 2013 and 2014 from two locations (Site 201 and Site 204). Lake Bronson is located in Kittson County, approximately two miles east of Lake Bronson, Minnesota. It is 320 acres in size, has a maximum depth of 8.84 meters (29 feet) and is approximately 76% littoral (area of the lake that is less than 15 feet deep). CLMP+ volunteers measured water transparency, collected temperature and dissolved oxygen (DO) profiles, and water chemistry samples monthly. This report provides a summary of the water quality data and of other physical and ecological characteristics of the lake (Figures 1 and 2).

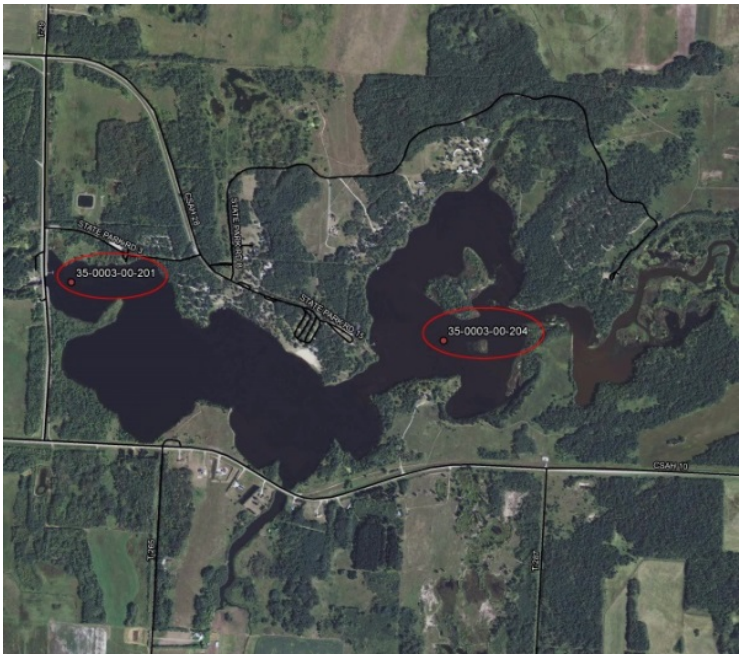

Figure 1. Aerial photo of Lake Bronson

Ecoregion and 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 uses of the land 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.

Minnesota is divided into seven ecoregions, as defined by soils, land surface form, natural vegetation and current land use. Lake Bronson is located in the Red River Valley ecoregion. Because this ecoregion has few lakes, specific lake water quality standards have not been developed for this ecoregion. For the purposes of this report, land use, watershed characteristics and water quality standards of similar ecoregions in the state were reviewed and comparative ecoregions were chosen by which to compare Lake Bronson's water quality. It was determined that Lake Bronson's characteristics are similar to the typical range of values from reference lakes within the Western Cornbelt Plains (WCBP) and Northern Glaciated Plains (NGP) ecoregions because conditions in these ecoregions are similar to those found in this portion of the Red River Valley.

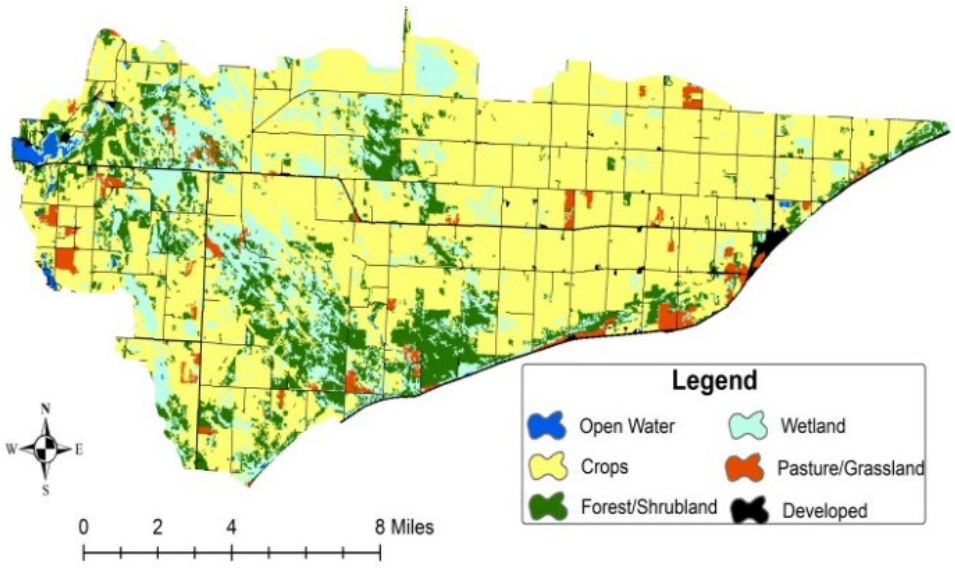

Figure 2. Lake Bronson catchment area

Lake Bronson has a catchment area of 94,823 acres. This is a very large-sized watershed relative to the size of the lake (296:1 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. The amount of nutrients present within the water load for any size lake depends greatly upon land use in the larger watershed.

In general, land use in the Lake Bronson catchment is very similar to the typical land uses found in the WCBP ecoregion (Table 1). The watershed is relatively flat and heavily cultivated with two-thirds of the lake's catchment area being dominated by agriculture (Figure 2). Watersheds dominated by cultivated land typically deliver high amounts of nutrients to lakes.

Table 1. Land use composition

Land use	Bronson Lake catchment land use (%)	Western Cornbelt Plains typical land use (%)	Northern Glaciated Plains typical land use (%)
Developed	4	0 – 16	0-2
Cultivated (Ag)	64	42 – 75	60-82
Pasture & Open	2	0 – 7	5-15
Forest	14	0 – 15	0-1
Water & Wetland	16	3 – 26	8-26
Feedlots (#)	7		

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 depths of six meters or less), in contrast, typically do not stratify and mix continuously. 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 introduces phosphorus into the water where it may encourage the growth of algae, so lakes that continuously mix are at more risk of developing algal blooms than deeper lakes that stratify. That said, 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. To determine if a lake stratifies or not, water temperature and DO are measured throughout the water column (surface to bottom) at selected intervals (e.g. every meter) several times during the open-water season. These measurements, called "profiles", will reveal specific patterns if the lake stratifies and will also show how oxygen changes with depth.

Lakes with a large open basin and large fetch (longest unbroken stretch of open water on a lake which the wind can blow unobstructed) are often well mixed throughout the summer and are called polymictic lakes. This is the case with Lake Bronson. Temperature data indicates that the lake has a uniform temperature column throughout the summer. It was well mixed on almost all sampling events (Figures 3-6). The sampling event on June 15, 2013, (Figure 3) indicates slight stratification. This could occur from prolonged warm weather with little to no wind.

Dissolved oxygen concentrations in Lake Bronson depict a mixed lake with fairly consistent oxygen levels. At one point in both 2013 and 2014, at both sites, DO levels sharply dropped off, with some nearing 0 mg/L (Figures 7-10). Low DO at lake bottom is typical in stratified lakes. In Lake Bronson's case, since it is a mixed lake, the low DO readings may be attributed to either the bacterial breakdown of decaying algae (a typical occurrence in most lakes) or the possibility of the measuring device resting in sediment, which can lower the device's ability to properly read oxygen levels. In either case, the low DO readings aren't a concern and are to be expected so close to the bottom of the lake.

Dissolved oxygen concentration of five milligrams per liter (mg/L) or more is required to maintain a healthy game fish population and concentrations in Lake Bronson are generally high enough to support a healthy fish population. The Minnesota Department of Natural Resources conducted a Fisheries Lake Survey on Bronson on April 1, 2013. The survey suggests healthy populations of desirable game species. More information on the survey can be found at http://www.dnr.state.mn.us/lakefind/showreport.html?downum=35000300.

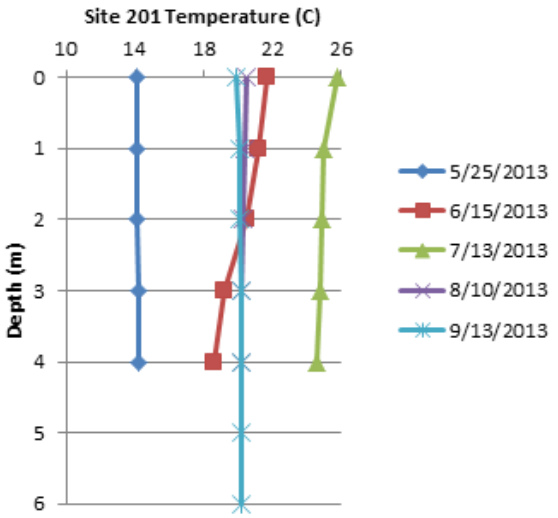

Figure 3. 2013 temperature profiles for Site 201

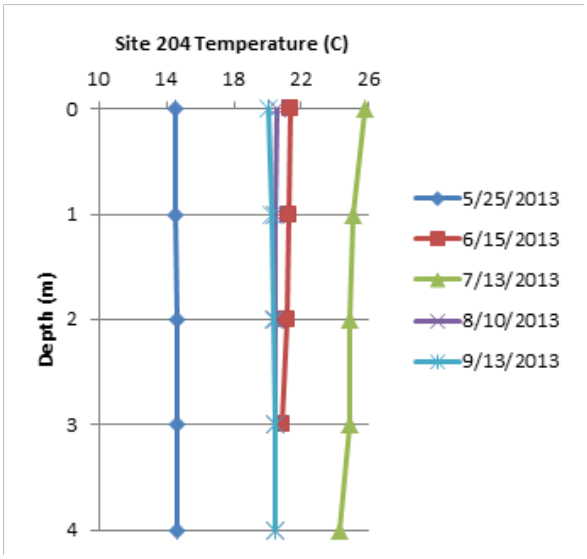

Figure 4. 2013 temperature profiles for Site 204

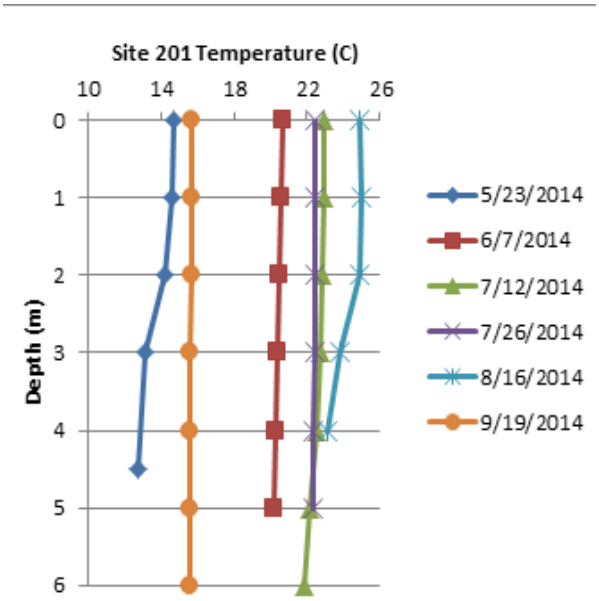

Figure 5. 2014 temperature profiles for Site 201

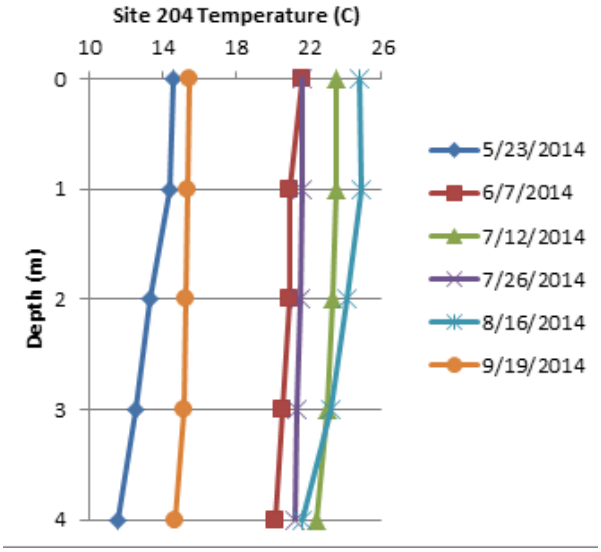

Figure 6. 2014 temperature profiles for Site 204

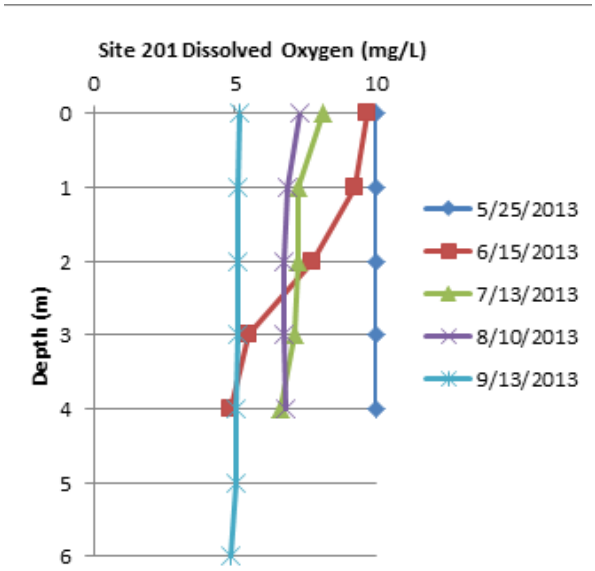

Figure 7. 2013 dissolved oxygen profiles for Site 201

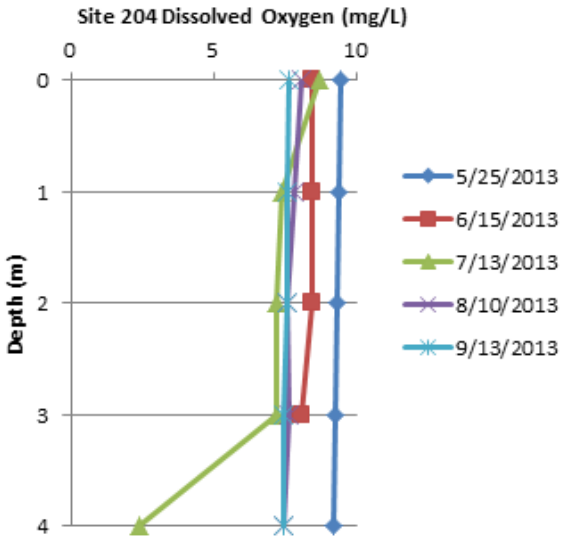

Figure 8. 2013 dissolved oxygen profiles for Site 204

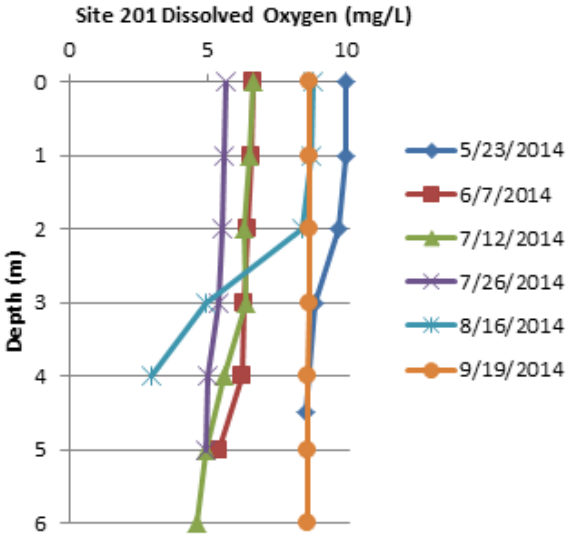

Figure 9. 2014 dissolved oxygen profiles for Site 201

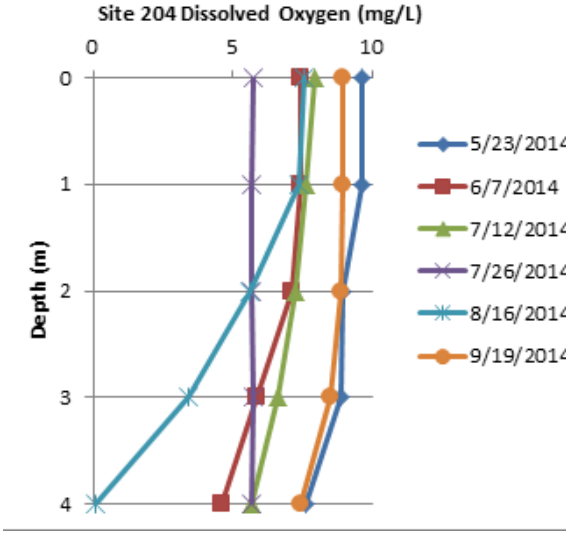

Figure 10. 2014 dissolved oxygen profiles for Site 204

Water quality

Nutrients, typically phosphorus and nitrogen, are the primary drivers of algal productivity in lakes. In general, high nutrient levels increase the likelihood that nuisance algal blooms will grow and that lakes will not support aquatic recreational uses; however, there are sometimes other factors at play that also must be considered. For this reason, it's important to collect information on water color, suspended solids, temperature, DO, and a number of other parameters. June-September water chemistry data for Lake Bronson gathered in 2013 and 2014 were averaged (referred to as "summer mean" values) and compared to minimally impacted reference lakes in the WCBP and NGP ecoregions (Table 2). Reference lakes included in the last two columns in Table 2 include those selected to be typical of the ecoregions and minimally impacted, and allow for comparison to Lake Bronson.

Table 2. Lake Bronson 2013-2014 as compared to typical range for WCBP and NGP ecoregion reference lakes[1]

Parameter	Site 201, 2013	Site 204, 2013	Site 201, 2014	Site 204, 2014	2-year summer mean values	Typical range for minimally impacted lakes in WCBP	Typical range for minimally impacted lakes in NGP
Number of reference lakes						16	13
Total phosphorus[2] (µg/L)	76	52	116	133	94	65 – 150	122 – 160
Chlorophyll mean (µg/L)	10	19	12	10	13	30 – 80	36 – 61
Transparency (meters) (feet)	1.7 5.6	1.4 4.6	1.7 5.6	1.5 4.9	1.6 5.3	0.5 – 1.0 1.6 – 3.3	0.4 – 0.8 1.3 – 2.6
Total Kjeldahl Nitrogen (mg/L)	1.5	-	1.3	-	1.4	1.3 – 2.7	1.8 – 2.3
Alkalinity (mg/L)	208	-	175	-	191	125 – 165	160 – 260
Chloride (mg/L)	7.1	-	6.3	-	6.7	13 – 22	11 – 18
Total Suspended Solids (mg/L)	4.7	-	3.2	-	3.95	7 – 18	10 – 30
Total Suspended Inorganic Solids (mg/L)	1.1	-	0.6	-	0.85	3 – 9	5 – 15
TN:TP ratio*	22:1	-	13:1	-	16:1	17:1 – 27:1	13:1 – 17:1

1. Concentrations shown are the mean of samples taken June-September (i.e., summer means)

2. The phosphorus detection method used by the Minnesota Department of Health changed in 2012 and 2013, and phosphorus taken up by chlorophyll-*a* was not being included in final lab results, thereby potentially skewing readings slightly lower than they may actually be.

* Several Inorganic nitrogen readings were below detectable lab limits (used for calculating TN). For the purposes of summarizing data, all non-detect samples were rounded up to the lowest detectable limit which is 0.05 mg/L.

ug/L = micrograms per liter; mg/L = milligrams per liter

Total phosphorus (TP) is often considered the nutrient that "limits" algal growth in lakes. This is because it is essential to algal growth and it is typically in the shortest supply. Lake Bronson summer-mean TP is within the typical range for WCBP lakes (Table 2). TP concentrations peaked in August 2013 and July 2014 (Figures 11 and 12). TP samples collected at the bottom of the lake in September 2013 and 2014 had similar concentrations of phosphorus to the surface readings, 61 ug/L and 113 ug/L, respectively. Bottom sample results were not included when calculating the summer mean results for Lake Bronson,

rather they were gathered to help gauge lake turnover (when the lake mixes, bottom and surface phosphorus readings are near equal) and determine the amount of phosphorus diffusing out of the sediment during anoxic conditions at the lake bottom during stratification.

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) levels in the lake. 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 often considered "nitrogen-limited" when the TN:TP ratio falls below about 10:1. In the case of Lake Bronson, the two-year averaged ratio is 16:1, which indicates that phosphorus is the nutrient controlling algal growth in this lake.

Chlorophyll-*a* (Chl-*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 Chl-*a* two-year summer mean concentrations for Lake Bronson was 13 ug/L which is lower 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. There was one occurrence when the concentration of Chl-*a* was between 10-20 ug/L (September 2013) and four when the concentration was greater than 20 ug/L (July and August 2013, August and September 2014) indicating that moderate algal blooms did occur on the lake (Figures 11 and 12).

Secchi transparency measures the depth of water clarity. Lake Bronson's transparency readings were better than the typical range for WCBP lakes (Table 2) in both 2013 and 2014. The amount of algae in a lake will have a direct influence on the transparency of the lake. Because of the low Chl-*a* concentration, the Secchi transparency in Lake Bronson is relatively high (Table 2). In some lakes, high total suspended sediment or high color may also limit transparency. High total suspended sediment may arise from suspended sediments (e.g. from runoff or wind mixing). 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 Lake Bronson, the total suspended sediment and color values are low and this is not an issue.

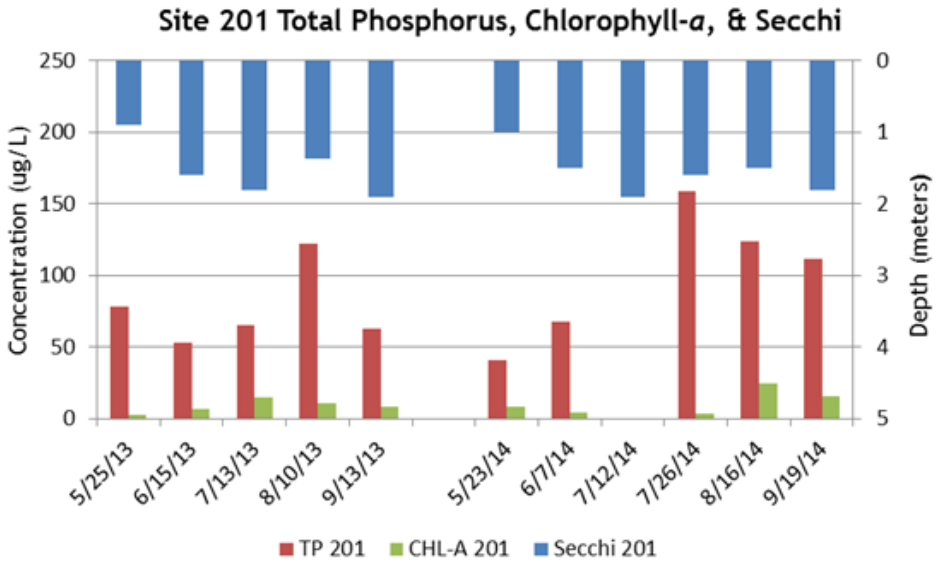

Figure 11. Phosphorus, chlorophyll-a and Secchi for Site 201

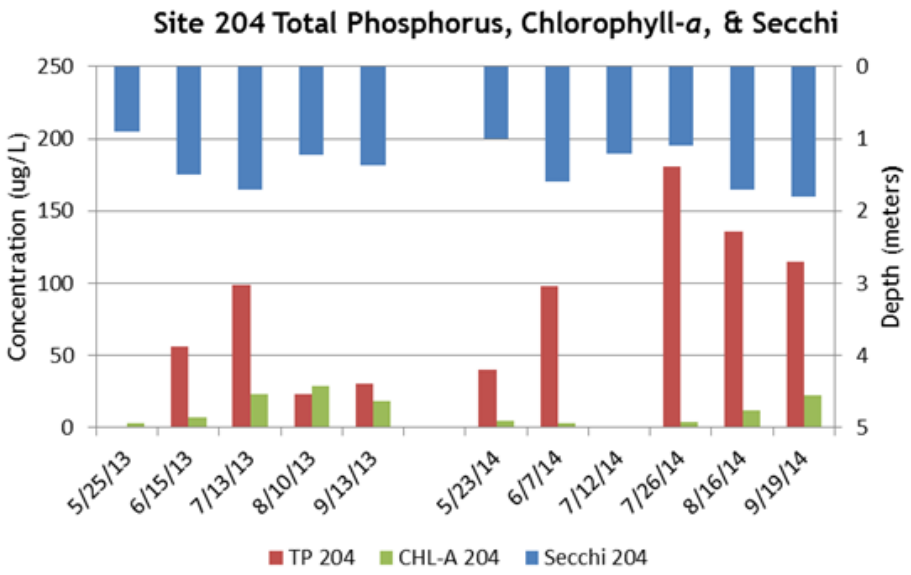

Figure 12. Phosphorus, chlorophyll-a and Secchi for Site 204

CLMP+ data collected for Lake Bronson show that in terms of TP, chlorophyll and Secchi disk transparency, the water quality of the lake is similar to minimally impacted (reference) lakes in the WCBP ecoregion. Based on the data collected, Lake Bronson is on the lower boundary of classic eutrophy, 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 can also be characteristics of a eutrophic lake.

Summary

Based on collected data as part of CLMP+ in 2013-2014, Lake Bronson has TP levels that are worse than the state standard established for the NGP ecoregion, however, Chl-*a* levels and water transparency readings are better than the state standards. This means the lake has considerable phosphorus available to produce algae; however, other factors are preventing blooms from occurring. Examples could include a zooplankton community grazing on algae, cool water temperatures or light limitations by sediment in the water. For a lake to be considered impaired, TP levels must exceed allowable levels **and** either the Secchi or Chl-*a* averages would also need to exceed standards. Since only phosphorus levels exceeded acceptable levels, Lake Bronson would not be considered an impaired water at this time. However, engagement at the local level will be needed to maintain Lake Bronson's current water quality.

Table 3. A comparison of water quality data from Lake Bronson to the lake eutrophication standards for the WCBP & NGP ecoregions

	TP (µg/L)	Chl-a(µg/L)	Secchi (m)
Thresholds set to protect lakes in the WCBP & NGP ecoregions for aquatic recreation use	<65	<22	>0.9
Lake Bronson 2-year summer mean values	94	13	1.6

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 Lake Bronson.
- 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.
- 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.

All of the water quality data from the MPCA's monitoring activities, those of its citizen volunteers, and of other state and local partners, are gathered together and used to assess the condition of Minnesota lakes by determining if thresholds set to protect a lake's recreational uses (swimming, wading, boating, etc.) are being met. Annual assessments of lake and stream data are conducted on a rotating watershed basis. Lake Bronson is located within the Two Rivers major watershed and monitoring of a selection of streams and lakes within this watershed were conducted in 2013 and 2014. A report detailing the results will be completed in 2016. Based on the findings, specific segments of the watershed will be recommended for either restoration or protection activities. Involvement by citizens, counties, cities, and local organizations are highly encouraged by the MPCA during the restoration and protection development process. Please continue to check the Two Rivers watershed page for additional information: http://www.pca.state.mn.us/index.php/water/water-types-and-programs/watersheds/two-rivers.html.