Elm Creek Watershed Management Commission
Lake Water Quality Summaries
2013

Introduction

Elm Creek Watershed Commission contracted Three Rivers Park District to monitor several lakes in 2013. Three Rivers Park District monitored the water quality in Fish Lake, Weaver Lake, Diamond Lake, French Lake, Mill Pond, and Rice Lake. These lakes were sampled biweekly from late April through late October with the exception of French Lake which was sampled monthly. The seasonal and annual changes in water quality parameters were monitored for total phosphorus, soluble reactive phosphorus, total nitrogen, chlorophyll-a, and secchi depth transparency. To assess changes in water quality trophic conditions, annual growing season averages were calculated for total phosphorus, chlorophyll-a, and secchi depth transparency using data collected from May through September. The annual average for each trophic assessment parameter was compared to the MPCA state nutrient standards used for determination of recreational use impairment (Table 1). The MPCA's assessment for water body impairments are based on a conservative average that is estimated from data collected from June through September. This report is an assessment of overall trophic condition during the time period of primary recreational use (growing season from May through September) and is compared to MPCA state standards as a reference point.

Table 1: Minnesota Pollution Control Agency lake eutrophication standards for aquatic recreational use assessments.

North Central Hardwood Forest Ecoregion			
Classification	TP µg/L	Chl-a µg/L	Secchi m
Aquatic Recreation Use (Class 2b) Deep Lakes	< 40	< 14	> 1.4
Aquatic Recreation Use (Class 2b) Shallow Lakes	< 60	< 20	> 1.0

Note: ***Deep Lakes*** *are enclosed basins filled or partially filled with fresh water that have a maximum depth > 15 feet.*
Shallow Lakes *are enclosed basins filled or partially filled with fresh water that have a maximum depth < 15 feet or a littoral zone (area shallow enough to support emergent and submerged vegetation) that is ≥ 80% of the lake surface area.*

Fish Lake

Fish Lake has consistently had an average phosphorus concentration above the MPCA "deep lake" impaired water eutrophication standard of 40 µg/L. The average phosphorus concentration for Fish Lake in 2013 was 52.7 µg/L with values ranging from 35 µg/L to 125 µg/L (Figure 1 & 2). The average phosphorus concentration increased in comparison to the decreasing trend that has been observed since 2009. The increase in average phosphorus was partially due to spring turnover that occurred in May (Figure 2). Typically, spring turnover for Fish Lake occurs in April and these elevated phosphorus concentrations are not included in the growing season average. However, spring turnover did not occur until early May due to the late ice-off conditions in 2013. The in-lake phosphorus concentrations after spring turnover (from June through September) were slightly above and below the phosphorus state standard of 40 µg/L (Figure 2). Based on concentrations from June through September, the average phosphorus concentration for the summer was 43 µg/L. The Fish Lake phosphorus concentrations can be influenced by sources of internal loading. After the onset of stratification, phosphorus concentrations build up in the hypolimnion during the summer. Fish Lake hypolimnetic phosphorus concentrations near the bottom reached 642 µg/L (Figure 3). The seasonal changes in lake stratification have the potential to entrain some of this hypolimnetic phosphorus to the surface through partial mixing events and complete fall turnover. A significant portion of the hypolimnetic phosphorus is in a soluble form that is readily available for algal uptake (Figure 3).

The excessive amount of phosphorus has been conducive for the development of severe algal blooms during the summer. Typically, the severity of these algal blooms has often been in response to the changes in phosphorus concentration. However, the average chlorophyll-a concentration has increased significantly despite a decreasing trend in phosphorus concentrations since 2009. In 2013, the average chlorophyll-a concentration was 32.6 µg/L (Figure 4) with values ranging from 5 to 66 µg/L (Figure 7). This is the highest average chlorophyll-a concentration observed since 2003. Despite severe algal blooms, the average secchi depth transparency has met the state standard since 2009 (Figure 5). In 2013, the average secchi depth transparency was 1.49 m (Figure 5) with values ranging between 0.51 and 3.91 m (Figure 6). There appears to be clear water phase in June that was most likely attributed to zooplankton feeding on algae (Figure 6). The water clarity decreased substantially after June due to conditions that were more conducive for algal growth (Figure 6). The algal blooms during the summer from mid-July through September were most likely attributed to nitrogen fixing blue-green algae. Eutrophic lakes that are not phosphorus limited have blue-green algae species that have the ability to fix nitrogen. During periods with excessive blue-green algal blooms, the amount of total nitrogen often corresponds to the seasonal changes in chlorophyll-a concentration. Based on the changes in total nitrogen and chlorophyll-a concentration, it appears that Fish Lake had severe blue-green algal blooms from July through September in 2013 (Figure 7).

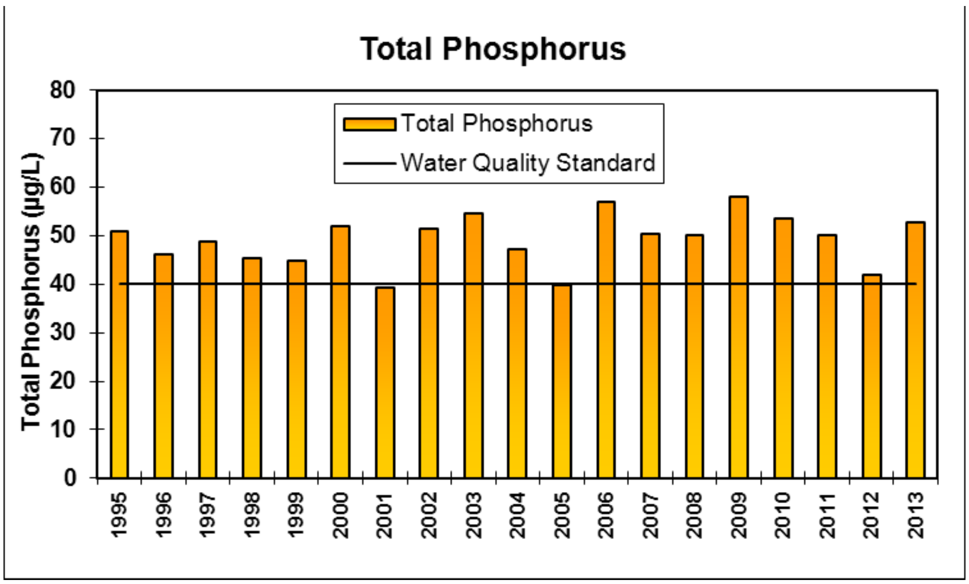

Figure 1. Fish Lake average annual total phosphorus concentrations.

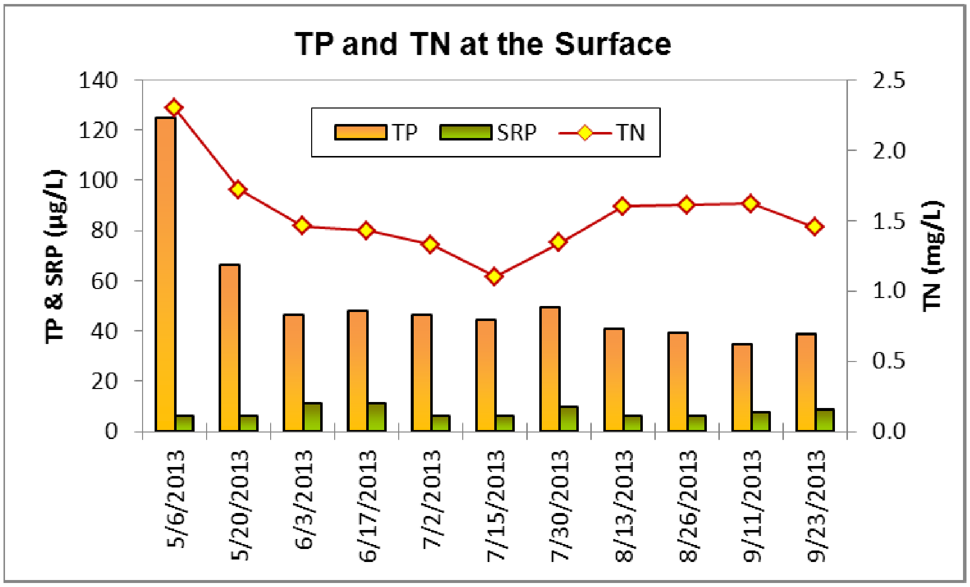

Figure 2. Fish Lake seasonal changes in total phosphorus, soluble reactive phosphorus, and total nitrogen in 2013.

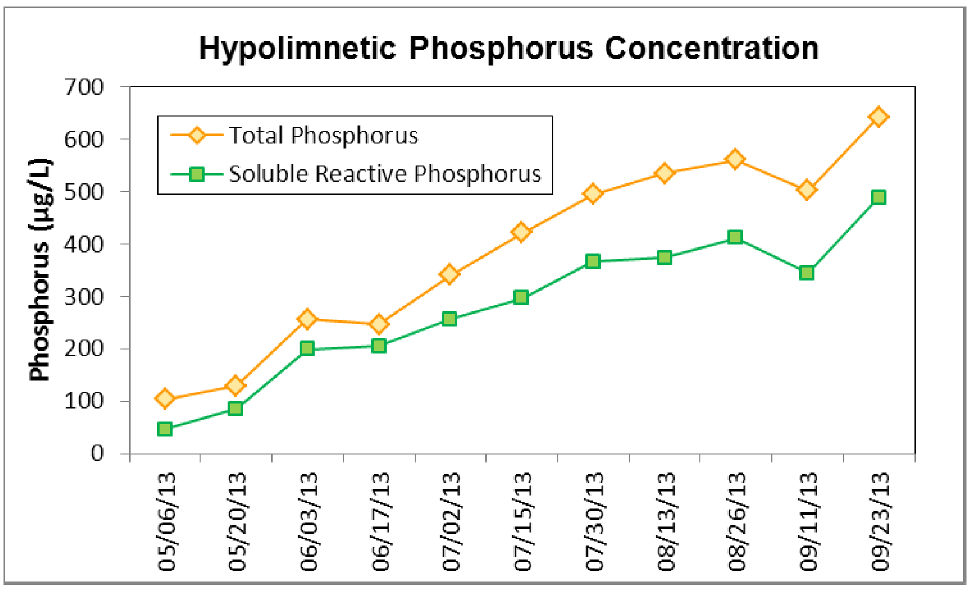

Figure 3. Seasonal changes in hypolimnetic phosphorus concentrations in 2013.

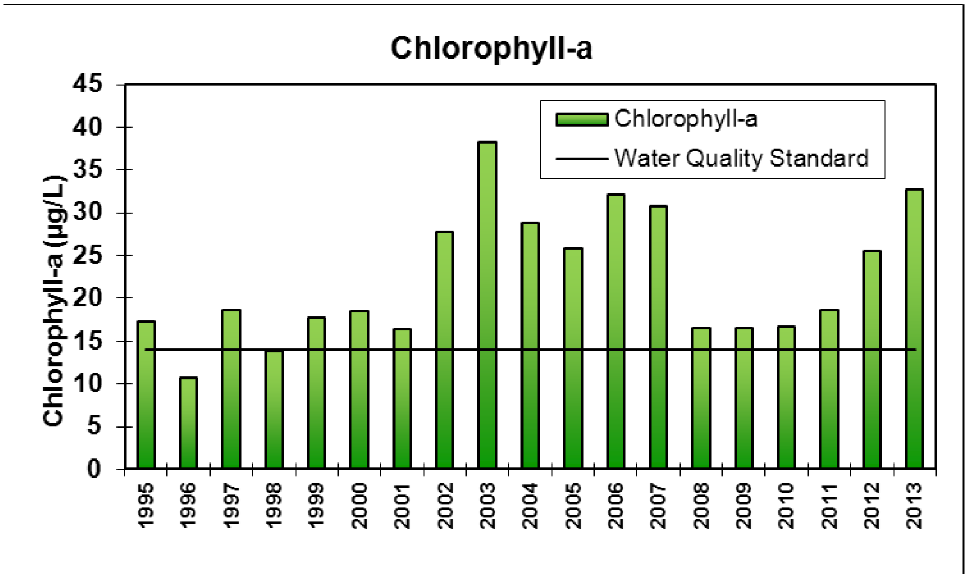

Figure 4. Fish Lake average annual chlorophyll-a concentrations.

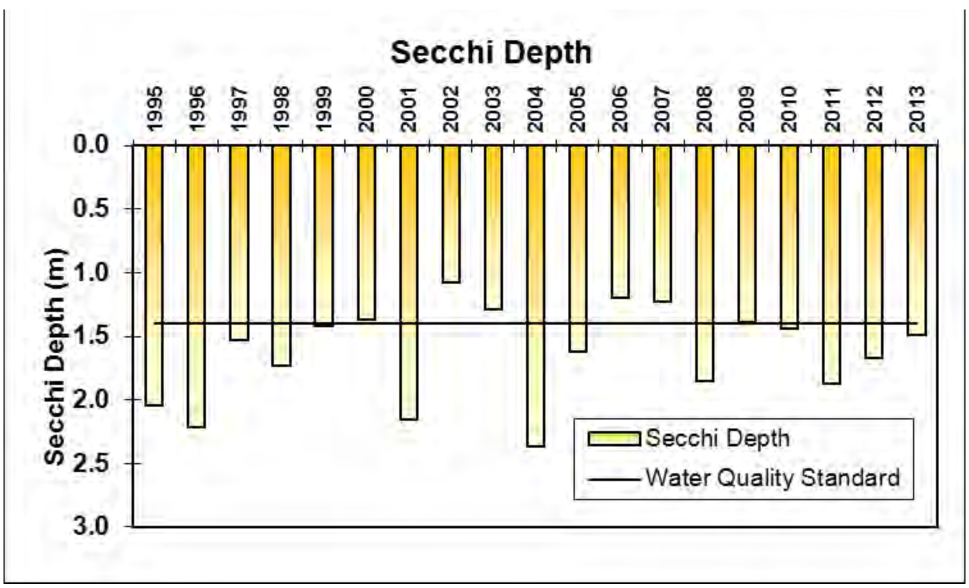

Figure 5. Fish Lake average annual Secchi depth measurements.

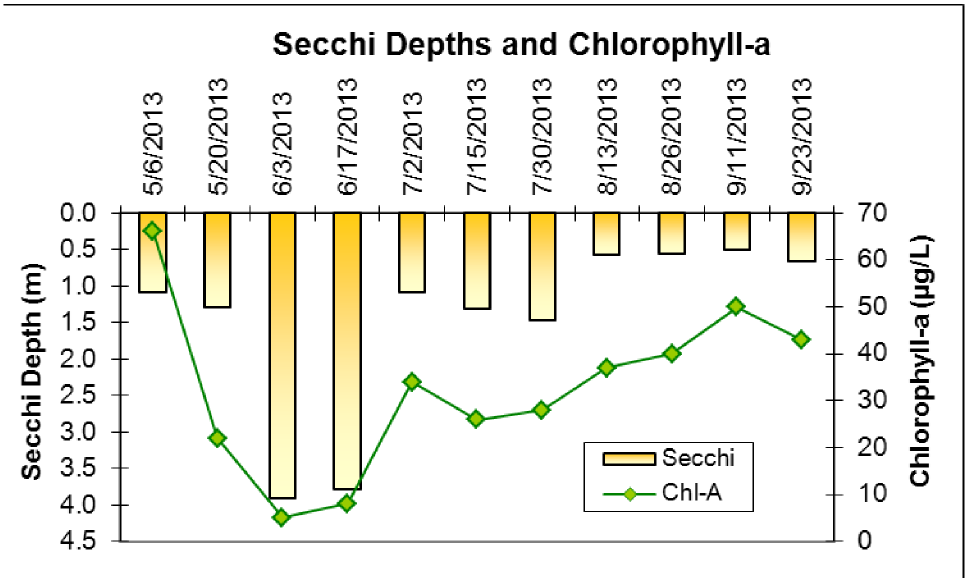

Figure 6. Fish Lake seasonal changes in Secchi depth and chlorophyll-a concentrations in 2013.

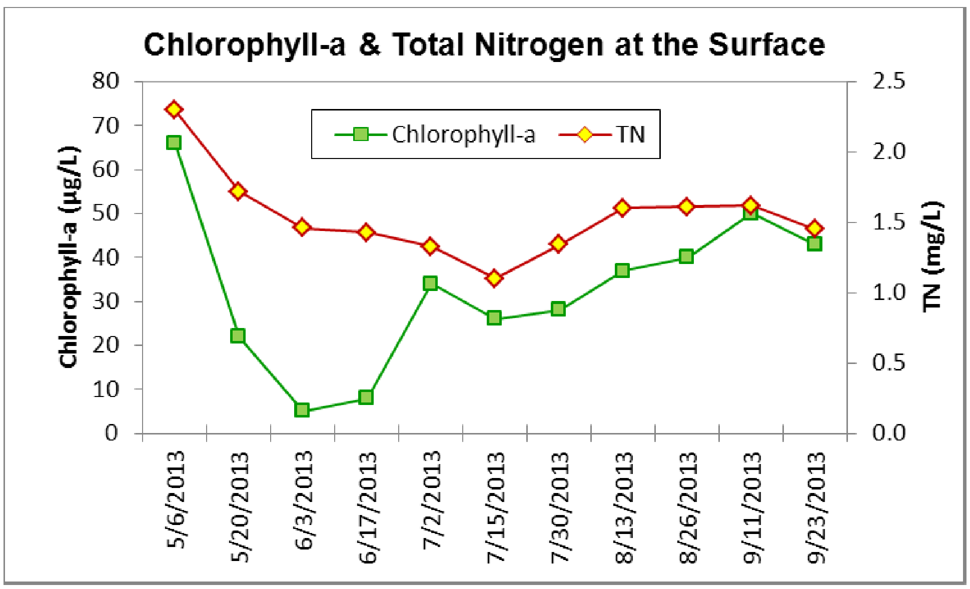

Figure 7: Fish Lake seasonal changes in chlorophyll-a and total nitrogen.

Weaver Lake

Weaver Lake frequently had phosphorus concentrations that were above the MPCA "deep lake" impaired standard from 1995 through 2004. However, Weaver Lake phosphorus concentrations have significantly improved and have met the state standard from 2005 through 2013. The average phosphorus concentrations from 2005 through 2013 have consistently averaged between 22.7 to 36.9 µg/L (Figure 8). The average annual phosphorus concentration in 2013 was 36.9 µg/L (Figure 8) with values ranging from 29.1 to 53.0 µg/L (Figure 9). These concentrations are the highest reported since 2005, but are still below the state phosphorus standard. The highest phosphorus concentration occurred in mid-May during spring turn-over. After spring turn-over, phosphorus concentrations seem to vary considerably throughout the remaining portion of the year. Watershed loading may influence in-lake phosphorus concentrations to a minor extent, but most likely is not considered a significant source of loading to the lake due to the small watershed drainage area. Internal loading has the potential to become a significant source of loading to the lake that can significantly impact in-lake phosphorus concentrations. After the onset of stratification, phosphorus concentrations build up in the hypolimnion during the summer. Weaver Lake hypolimnetic phosphorus concentrations near the bottom reached 527 µg/L (Figure 10). The seasonal changes in lake stratification have the potential to entrain some of this hypolimnetic phosphorus to the surface through partial mixing events and complete turnover. A significant portion of the hypolimnetic phosphorus is in a soluble form that is readily available for algal uptake.

The low phosphorus concentrations have also significantly improved water clarity conditions by reducing the frequency of algal blooms. Chlorophyll-a concentration has met the state standard from 2005 through 2012 (Figure 11). Unfortunately, the chlorophyll-a concentration in 2013 did not meet the state standard for the first time since 2005. In 2013, the average chlorophyll-a concentration was 16.4 µg/L (Figure 11) with values ranging between 5 and 51 µg/L (Figure 13). The average chlorophyll-a concentrations have been gradually increasing since 2009. Despite the recent higher chlorophyll-a concentrations, the secchi depth transparency has continued to meet the state standard since monitoring began in 1995. In 2013, the average secchi depth transparency was 2.2 m (Figure 12) with values ranging between 0.9 and 7.04 m (Figure 13). There was a clear water phase that occurred in May that was most likely due to an increase in zooplankton feeding on phytoplankton. As water temperatures increased in July, there was a decrease in water clarity that persisted throughout the summer due to the development of algal blooms. These algal blooms are not as severe as other lakes within the ecoregion. It does not appear that these algal blooms are due to an increase in nitrogen fixing blue-green algal species. Those lakes that are not phosphorus limited often have blue-green algae that have the ability to fix nitrogen. Lakes that are blue-green algal dominated during the summer often have total nitrogen concentrations that correspond with the seasonal changes in chlorophyll-a concentrations. In 2013, there was no relationship between nitrogen and chlorophyll-a concentrations (Figure 14). Consequently, these algal blooms do not appear to be blue-green algae related species that fix nitrogen. This may further suggest that Weaver Lake is currently phosphorus limited for growth of blue-green algal species. The low chlorophyll-a concentrations and excellent water clarity conditions indicates that Weaver Lake does not appear to have severe algal blooms that inhibit recreational use.

The improvements in water quality conditions for Weaver Lake correspond with a lake-wide effort to control curlyleaf pondweed. Historically, Weaver Lake has had nuisance growth conditions of curlyleaf pondweed that inhibited recreational use and degraded water quality. Weaver Lake typically developed severe algal blooms after the senescence of curlyleaf pondweed. In an attempt to control curlyleaf pondweed, herbicide applications occurred throughout the littoral area of the lake with fluridone from 2005 through 2007 and with endothall from 2008 and 2009. The herbicide treatments were successful in controlling curlyleaf pondweed in Weaver Lake. There were also noticeable improvements in water quality that corresponded with the first year of treatment in 2005. Management efforts to control curlyleaf pondweed may have reduced the amount of internal loading associated with senescence.

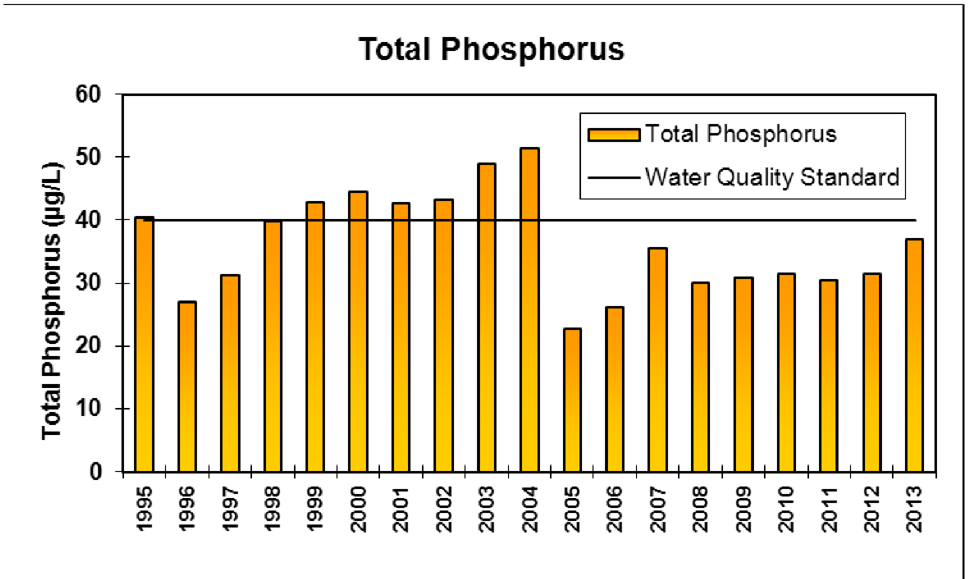

Figure 8. Weaver Lake average annual total phosphorus concentrations.

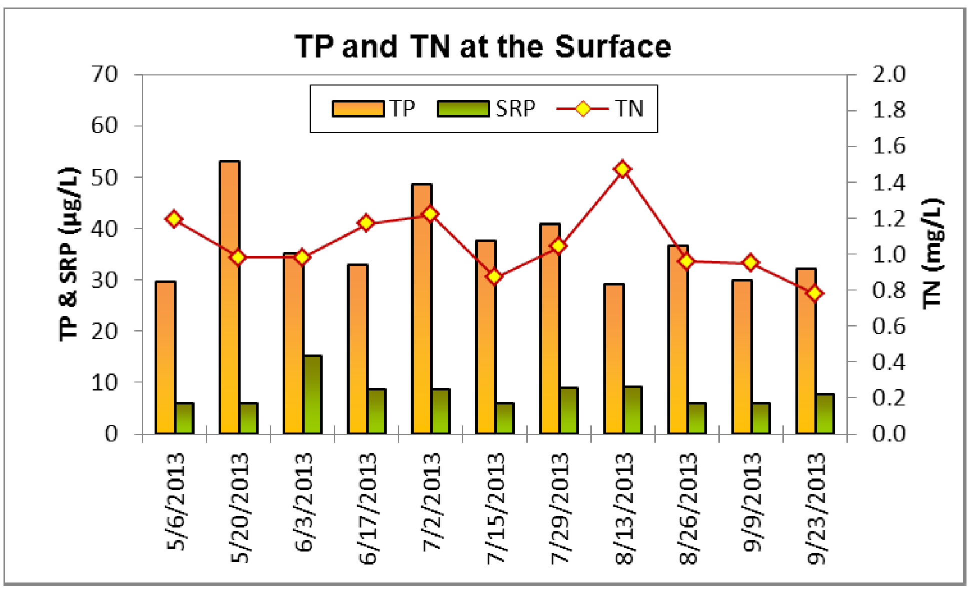

Figure 9. Weaver Lake seasonal changes in total phosphorus, soluble reactive phosphorus, and total nitrogen in 2013.

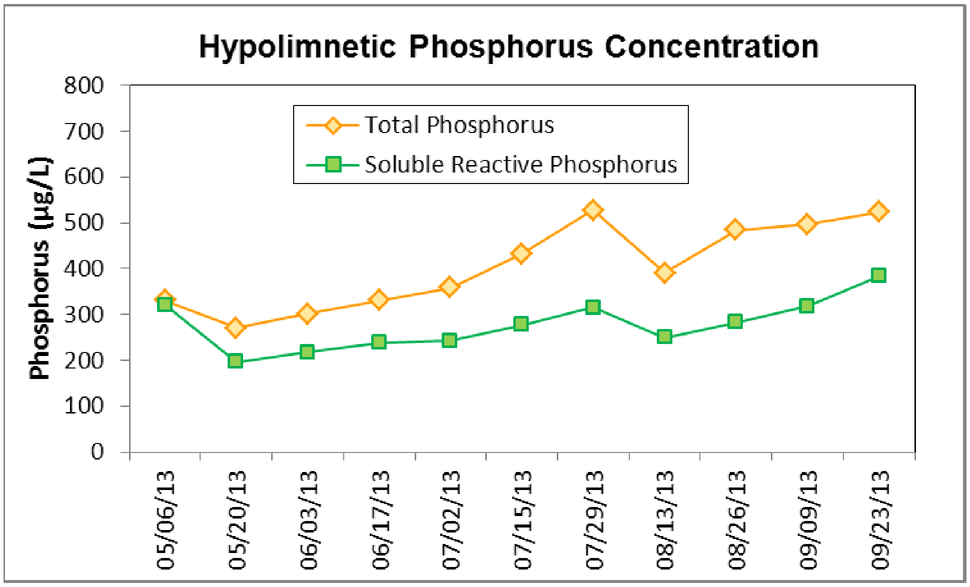

Figure 10. Seasonal changes in hypolimnetic phosphorus concentrations in 2013.

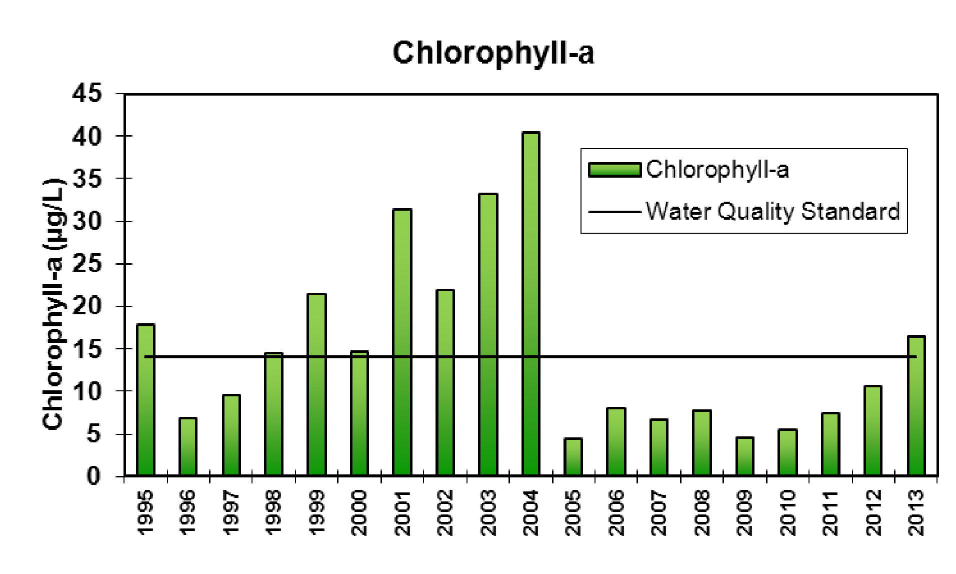

Figure 11. Weaver Lake average annual chlorophyll-a concentrations.

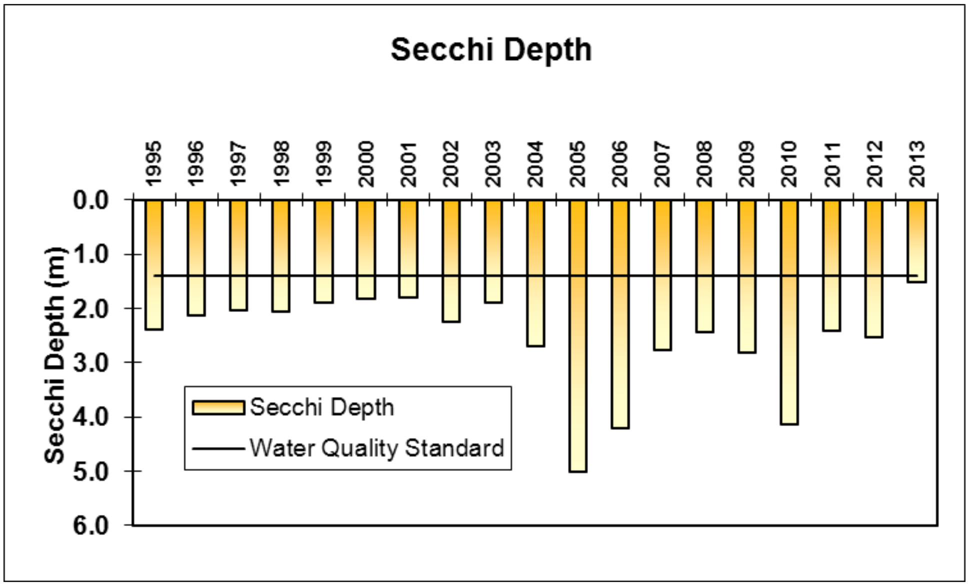

Figure 12. Weaver Lake average annual Secchi depth measurements.

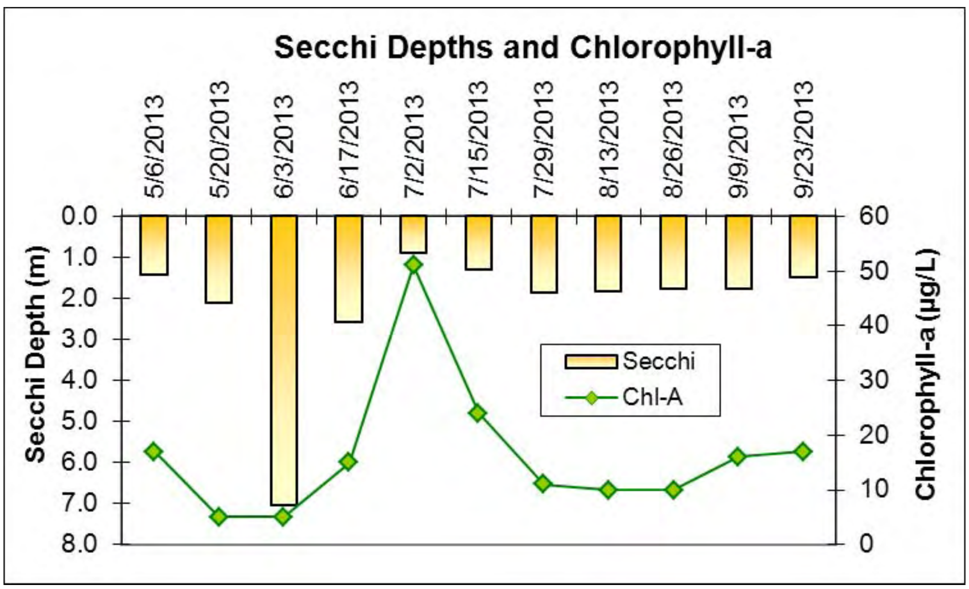

Figure 13. Weaver Lake seasonal changes in Secchi depth and chlorophyll-a concentrations in 2013.

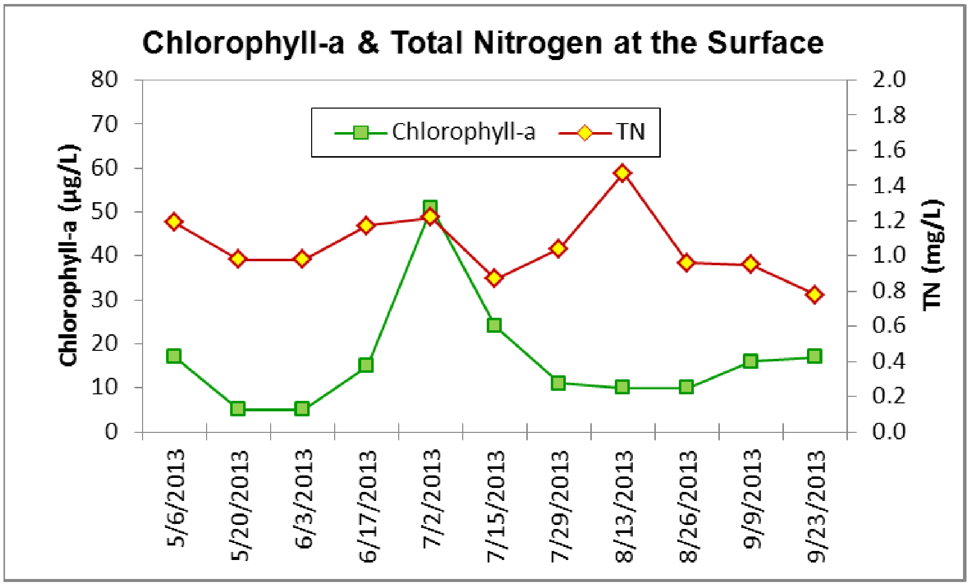

Figure 14: Weaver Lake seasonal changes in chlorophyll-a and total nitrogen.

Diamond Lake

Diamond Lake continues to have impaired water quality conditions for excessive nutrients. Diamond Lake is a "shallow lake" that has a total phosphorus standard of 60 µg/L. The lake has been considered hyper-eutrophic with respect to phosphorus concentration prior to 2008. The average annual phosphorus concentrations frequently ranged between 148.7 µg/L to 255.3 µg/L prior to 2008 (Figure 15). Despite the excessive phosphorus concentrations, the average total phosphorus concentrations significantly decreased from 210 µg/L in 2008 to 96 µg/L in 2011 (Figure 15). Unfortunately, the decreasing trend in phosphorus concentration did not continue in 2012 and 2013. The average phosphorus concentration increased to 119.2 µg/L in 2012 and 126 µg/L in 2013 (Figure 15). In 2013, the seasonal phosphorus concentrations ranged between 45.7 µg/L and 203 µg/L (Figure 16).

The excessive phosphorus concentrations have been conducive for the development of severe algal blooms. The severity of algal blooms in Diamond Lake corresponded with the fluctuations in phosphorus concentrations. Diamond Lake typically had extremely poor water clarity prior to 2008 due to severe algal blooms that resulted in annual average chlorophyll-a concentrations ranging from 46.3 to 87.8 µg/L and average secchi depth measurements ranging from 0.24 to 0.55 m (Figures 17 and 18). Water clarity conditions significantly improved from 2008 to 2011 with secchi depth transparency increasing from 0.78 m in 2008 to 1.7 m in 2011 (Figure 18). The average chlorophyll-a concentration in 2011 met the MPCA "shallow lake" standard of 20 µg/L (Figure 17); and secchi depth transparency has met MPCA standards of 1.0 m since 2009 (Figure 18). Despite these improvements in water clarity, the chlorophyll-a concentration and secchi depth transparency has degraded in 2012 and 2013. The average chlorophyll-a concentration increased to 52.9 µg/L in 2012 and 84.4 µg/L in 2013 (Figure 17); and the secchi depth transparency decreased to 1.13 m in 2012 and 0.40 m in 2013 (Figures 18). The increase in phosphorus in 2012 and 2013 most likely caused severe algae blooms resulting in a reduction in water clarity.

The improvements in water quality in Diamond Lake from 2008 through 2011 may have been attributed to a shift from an algal dominated to a plant dominated condition. Typically, Diamond Lake is dominated by curly-leaf pondweed growth in the spring, and shifts to a more algal dominated condition after curly-leaf pondweed senescence occurs at the end of June and beginning of July. The most recent point-intercept aquatic vegetation surveys for Diamond Lake indicated there has been a substantial increase in nuisance growth of native coontail and elodea in the past several years after curly-leaf pondweed senescence. The establishment of a native aquatic plant community can reduce the potential for nutrient re-suspension by stabilizing in-lake sediments and improving water quality conditions. These conditions may have contributed to the improvements in phosphorus concentration and water clarity from 2008 through 2011. Unfortunately, an increase in curly-leaf pondweed growth in shallow lakes has the potential to off-set any water quality improvements. The absence of snow-cover and poor ice conditions in the winter of 2011 and 2012 were conducive for curly-leaf pondweed growth. Consequently, there was a substantial increase in nuisance growth of curly-leaf pondweed in 2012, which most likely contributed to an increase in internal loading through senescence and resulted in poor water quality conditions. In May of 2013, 60 acres of the lake were treated with herbicide to control curly-leaf pondweed. A point-intercept survey prior to the treatment shows that there was a significant amount of curlyleaf pondweed as well as an abundance of native elodea and coontail. There appears to be an algal bloom that significantly decreased water clarity (Figure 19) in response to an increase in phosphorus that corresponded with the senescence of curlyleaf pondweed at the end of June and beginning of July in 2013 (Figure 16). These algal blooms appear to be due to nitrogen fixing blue-green algae since there is a relationship between total nitrogen and chlorophyll-a concentration (Figure 20). Based on the recent water quality data from 2012 and 2013, it appears that Diamond Lake may be shifting to an algal dominated system that typically has poorer water quality conditions.

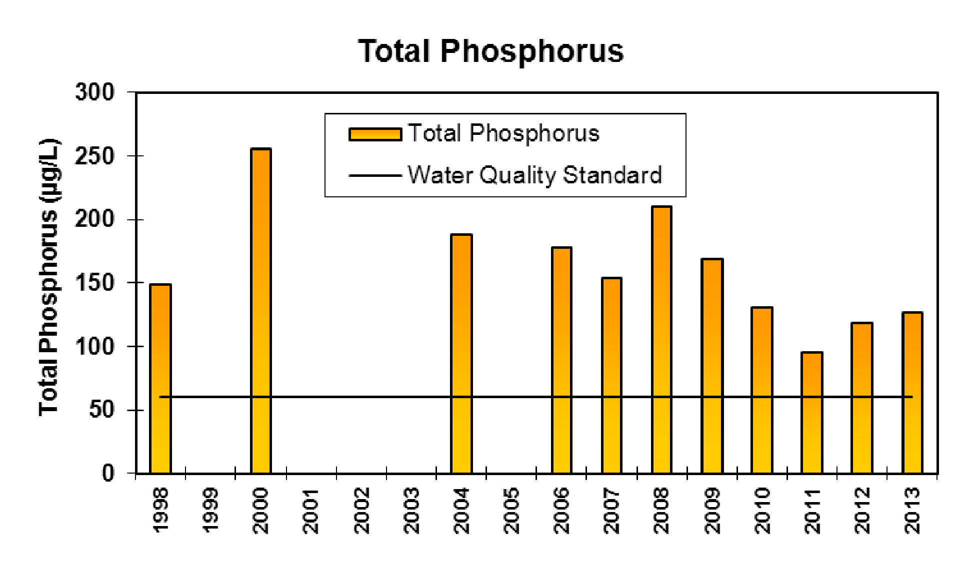

Figure 15. Diamond Lake average annual total phosphorus concentrations.

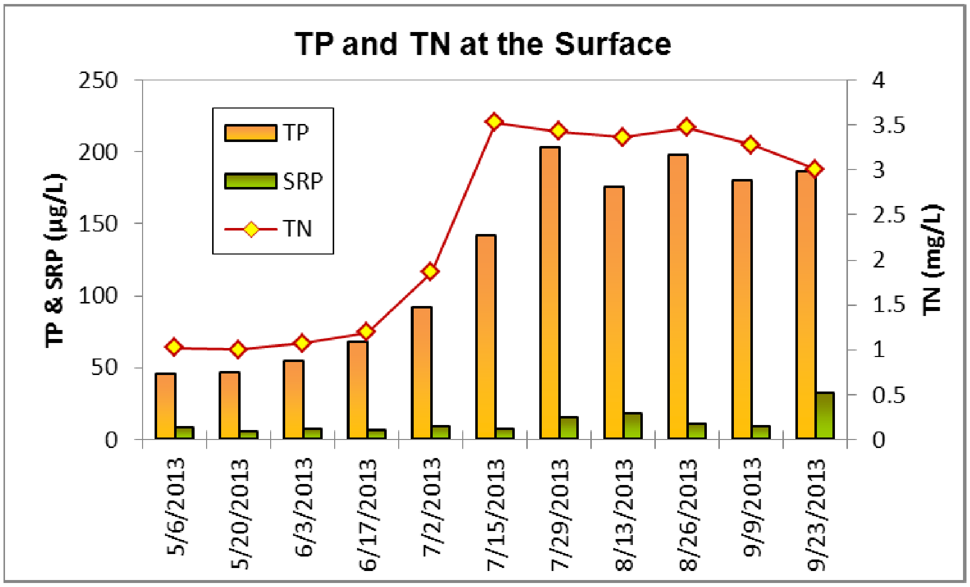

Figure 16. Diamond Lake seasonal changes in total phosphorus, soluble reactive phosphorus, and total nitrogen in 2013.

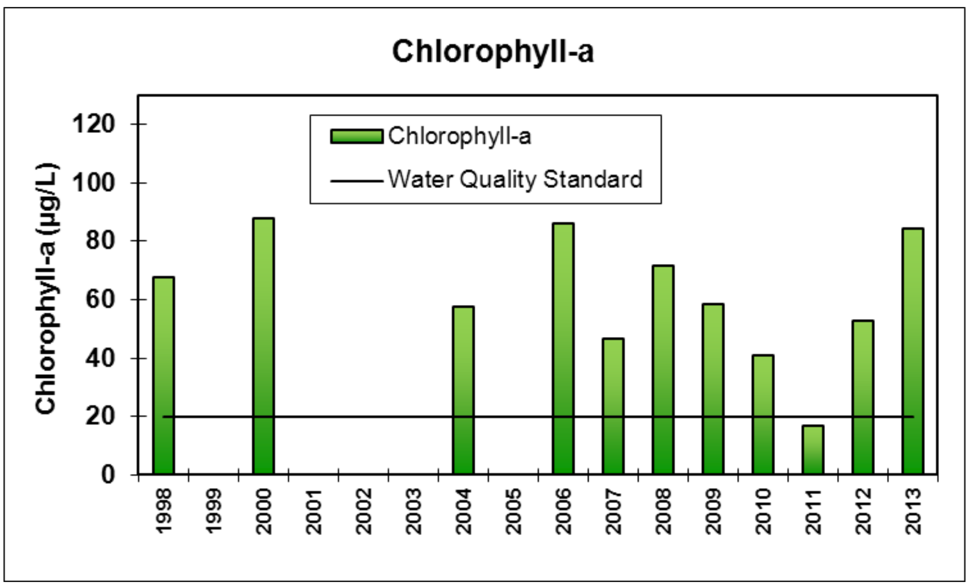

Figure 17. Diamond Lake average annual chlorophyll-a concentrations.

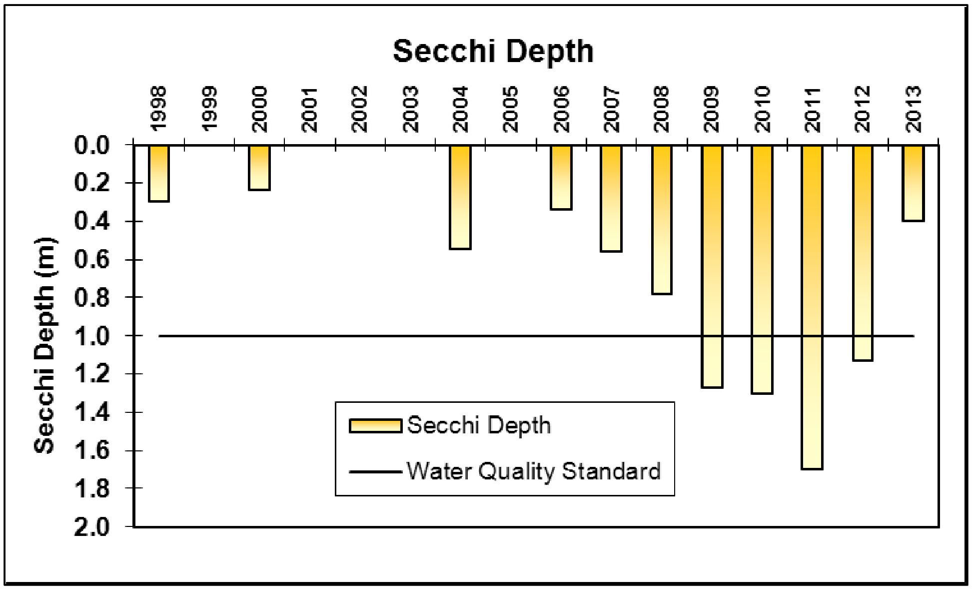

Figure 18. Diamond Lake average annual Secchi depth measurements.

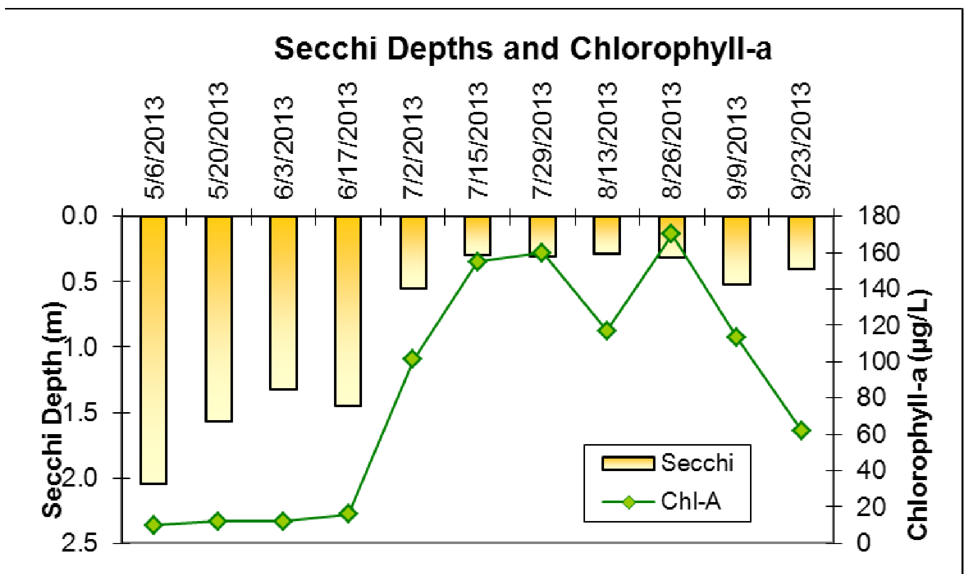

Figure 19. Diamond Lake seasonal changes in Secchi depth and chlorophyll-a concentrations in 2013.

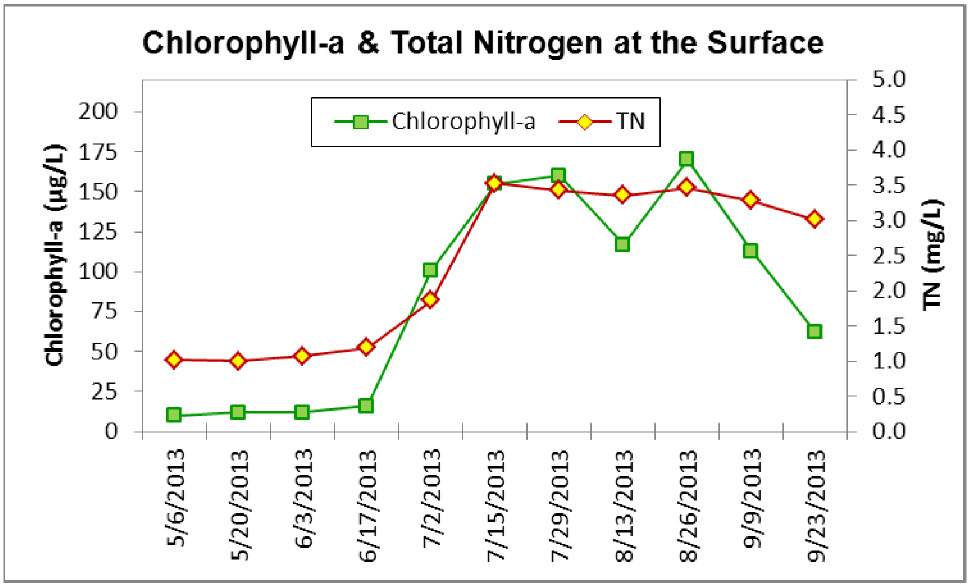

Figure 20: Diamond Lake seasonal changes in chlorophyll-a and total nitrogen.

French Lake

The re-classification of French Lake was reviewed by the MPCA in 2013. French Lake was initially defined as a "shallow lake" that has impaired water quality conditions. However, the lake has morphological characteristics that are similar to a Type 3 and Type 4 wetland that has a maximum depth of 3.8 feet with a cattail marsh perimeter. The lake has poor water quality conditions that are similar to an open water wetland with a significant source of internal loading. Based on the morphology, the water body was re-classified as a wetland by the MPCA in 2013. Unfortunately, the wetland state water quality standards have not been defined by the MPCA, and the current water quality conditions of the water body was not compared to any state water quality standards.

The water body is considered to be hyper-eutrophic based on the high historic phosphorus concentrations. The average phosphorus concentrations have ranged from 154.8 µg/L and 347.2 µg/L from 2005 through 2012 (Figure 21). In 2013, the average phosphorous concentration is lower than it has been in past years. The average phosphorus concentration in 2013 was 117.0 µg/L (Figure 21) with values ranging between 58.3 µg/L and 177.0 µg/L (Figure 22). Although these phosphorus concentrations in 2013 are the lowest reported since monitoring began, these concentrations are still extremely high and are conducive for the develop of severe algal blooms.

French Lake has severe algal blooms that reduced water clarity conditions during the summer. Typically, French Lake has chlorophyll-a concentrations ranging from 44.7 µg/L and 260.4 µg/L (Figure 23); and secchi depth measurements ranging from 0.22 m to 0.77 m (Figures 24). Despite the history of severe algal blooms, the chlorophyll-a concentrations have been the lowest reported since 2009. In 2013, the average chlorophyll-a concentration was 49.0 µg/L (Figure 23) with values ranging from 11.0 µg/L to 110.0 µg/L (Figures 25). The average Secchi depth transparency in 2013 was 0.72 m (Figure 24) with values ranging from 0.36 to 1.09 (Figure 25). It does not appear that these algal blooms were nitrogen fixing blue-green algae in 2013. There was no relationship between the chlorophyll-a and nitrogen concentrations in 2013 (Figure 26).

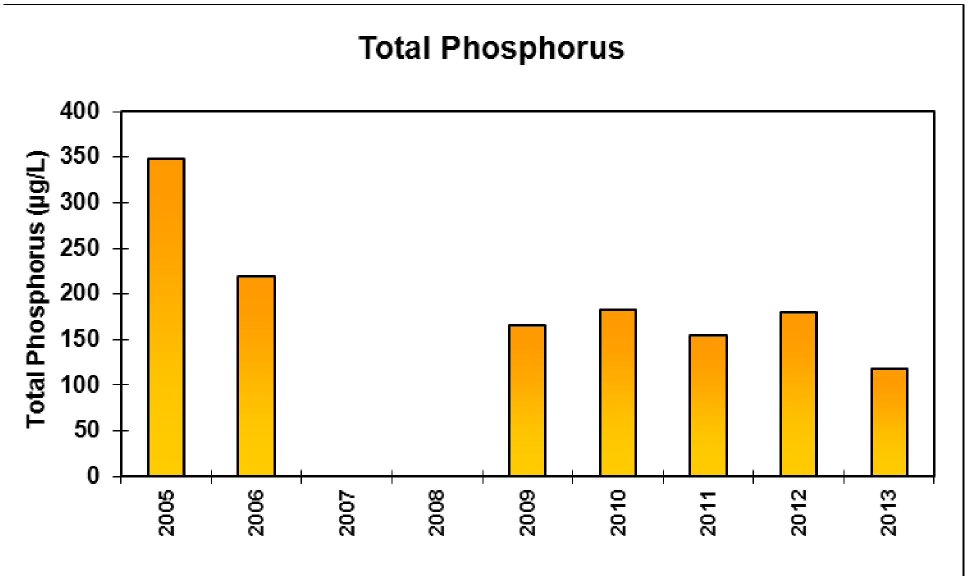

Figure 21. French Lake average annual total phosphorus concentrations.

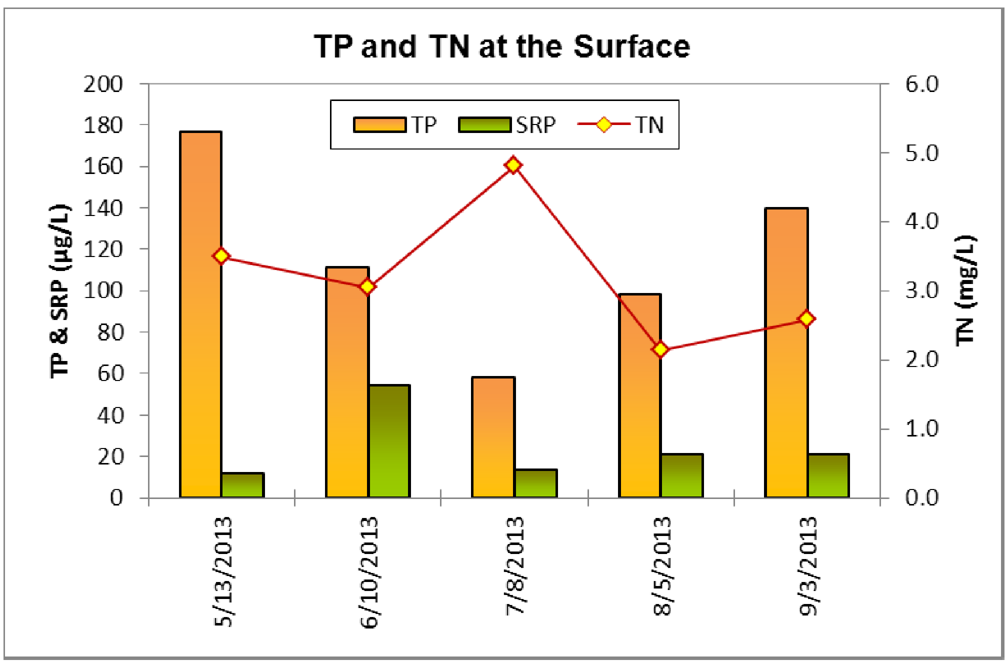

Figure 22. French Lake seasonal changes in total phosphorus, soluble reactive phosphorus, and total nitrogen in 2013.

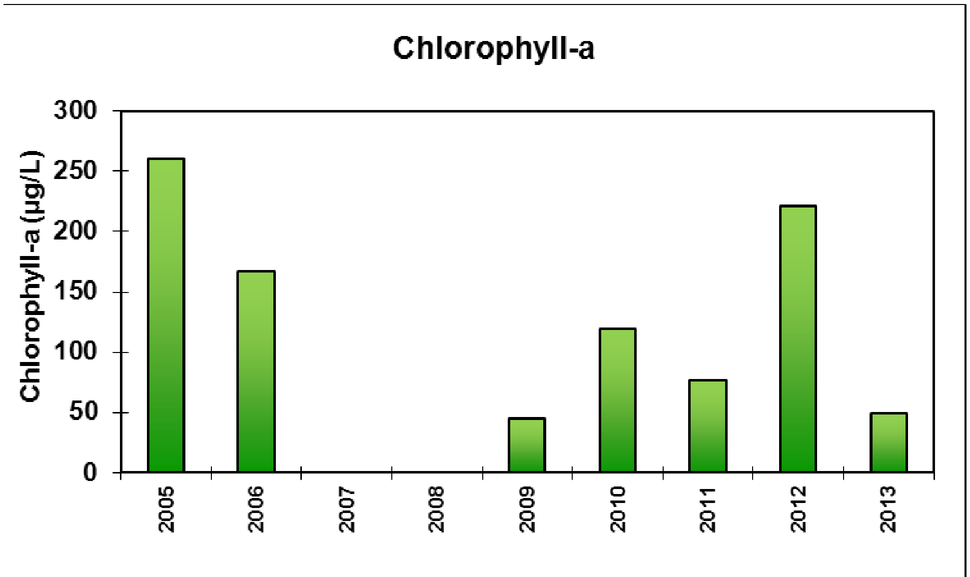

Figure 23. French Lake average annual chlorophyll-a concentrations.

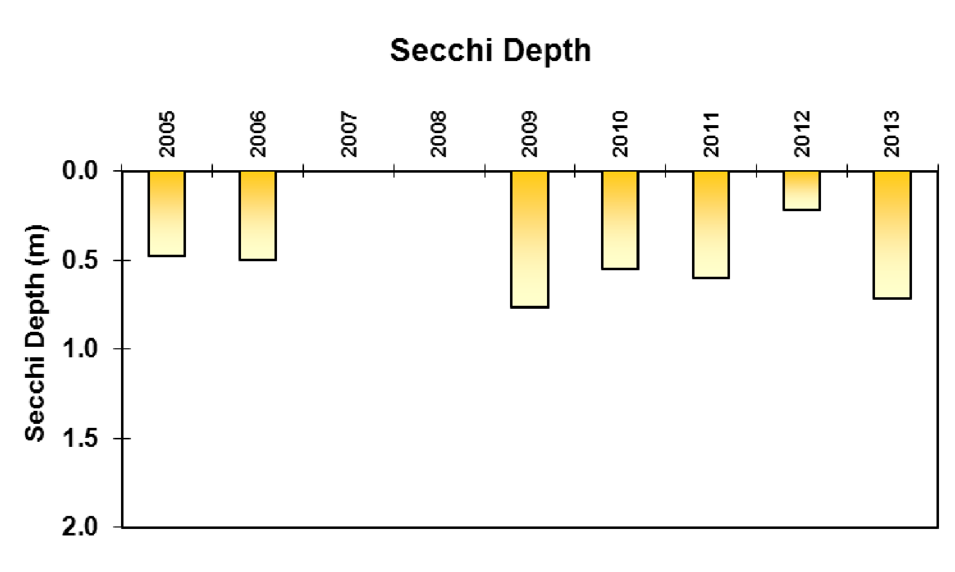

Figure 24. French Lake average annual Secchi depth measurements.

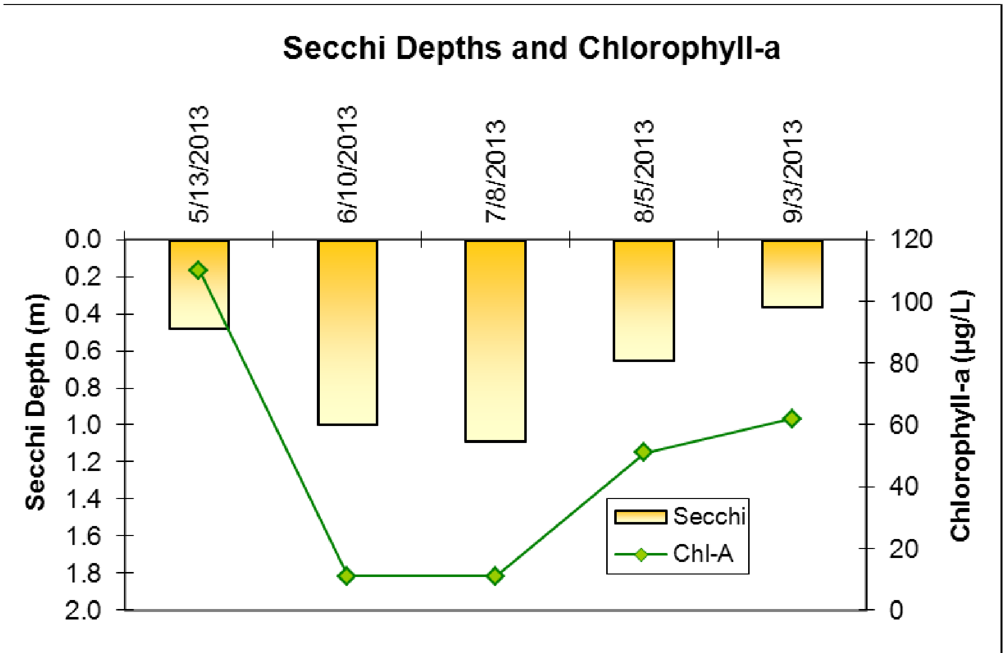

Figure 25. French Lake seasonal changes in Secchi depth and chlorophyll-a concentrations in 2013.

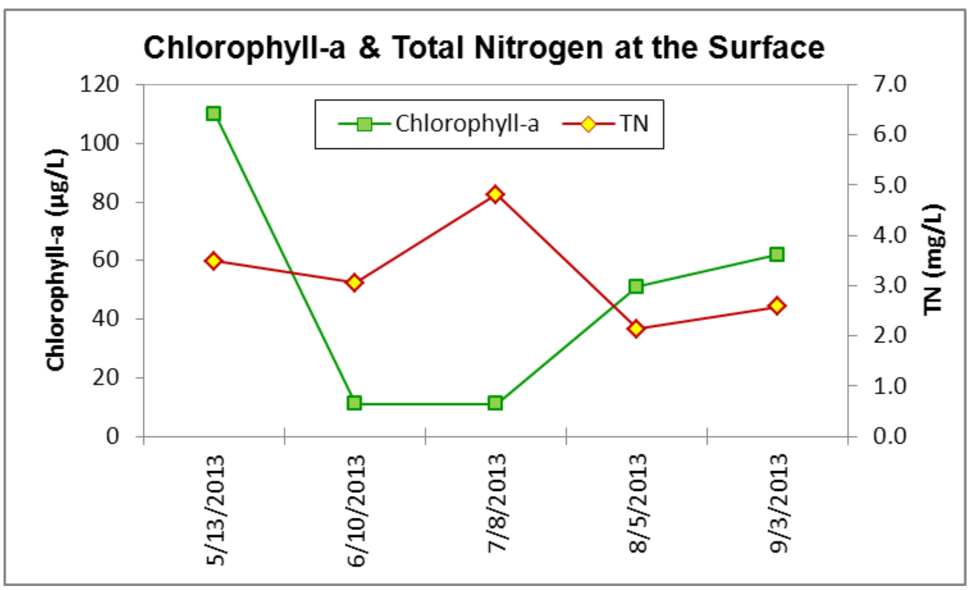

Figure 26: French Lake seasonal changes in chlorophyll-a and total nitrogen.

Mill Pond

Mill Pond is part of the Elm Creek flowage prior to draining to the Mississippi River. It is now considered to be a wide portion of Elm Creek; therefore, the shallow lake water quality standards will no longer apply. Currently, the water quality conditions of Mill Pond are similar to that of Elm Creek, and water quality parameters were not compared to the shallow lake standards.

The average annual phosphorus concentration for Mill Pond has ranged from 184.3 µg/L to 379 µg/L (Figure 27). In 2013, the average annual phosphorus concentration was 218.1 µg/L (Figure 27) with values ranging from 104.0 µg/L to 388.0 µg/L (Figures 28). The soluble reactive phosphorus portion represents approximately 70% of the total phosphorus concentration. These concentrations in Mill Pond are highly indicative of the phosphorus loading exhibited by Elm Creek. Consequently, seasonal changes in phosphorus concentration become dependent upon storm-event run-off volume and loading from Elm Creek.

The average annual chlorophyll-a concentration has ranged from 4.8 µg/L to 10.4 µg/L (Figure 29). In 2013, the average annual chlorophyll-a concentration was 8.91 µg/L (Figure 29) with values ranging from 5.0 µg/L to 27.0 µg/L (Figure 30). Secchi depth transparency was not measured throughout the summer, but water transparency was frequently on the bottom. The residence time within Mill Pond is relatively short since the impounded area is part of the Elm Creek flowage. Consequently, Mill Pond has chlorophyll-a concentrations that are more indicative of Elm Creek. Despite high phosphorus concentrations, Mill Pond does not appear to have severe algal blooms because the reduced residence time is not conducive for the development of algal blooms.

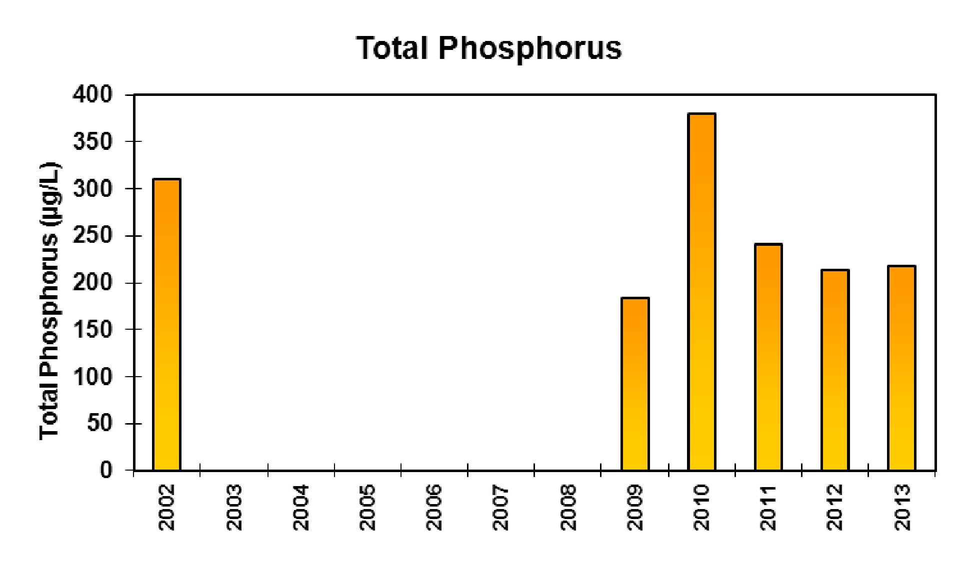

Figure 27. Mill Pond average annual total phosphorus concentrations.

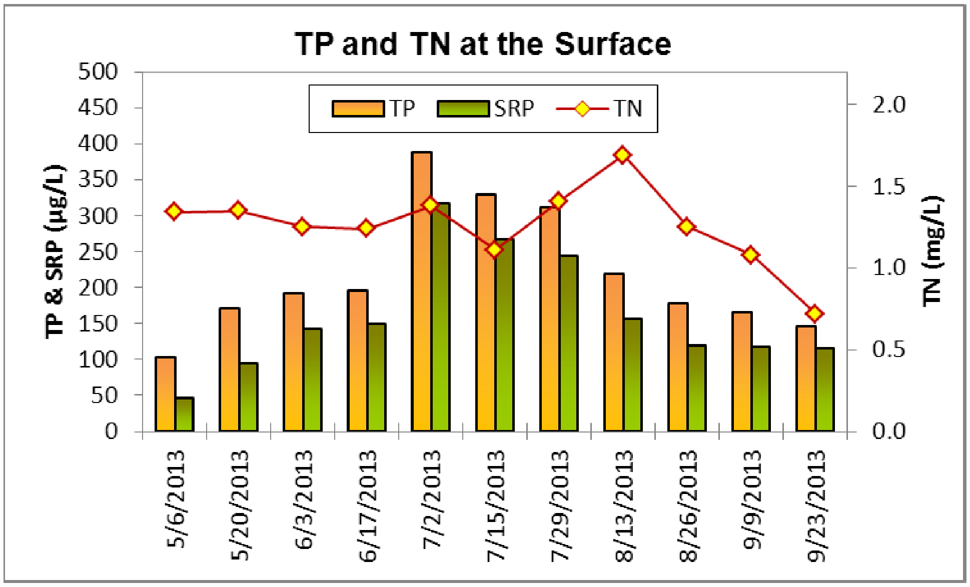

Figure 28. Mill Pond seasonal changes in total phosphorus, soluble reactive phosphorus, and total nitrogen in 2013.

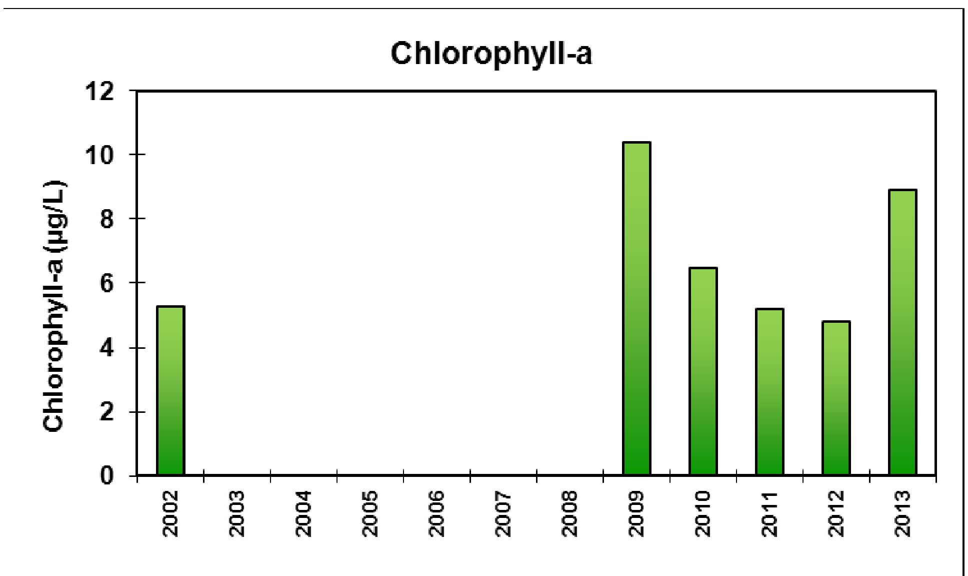

Figure 29. Mill Pond average annual chlorophyll-a concentrations.

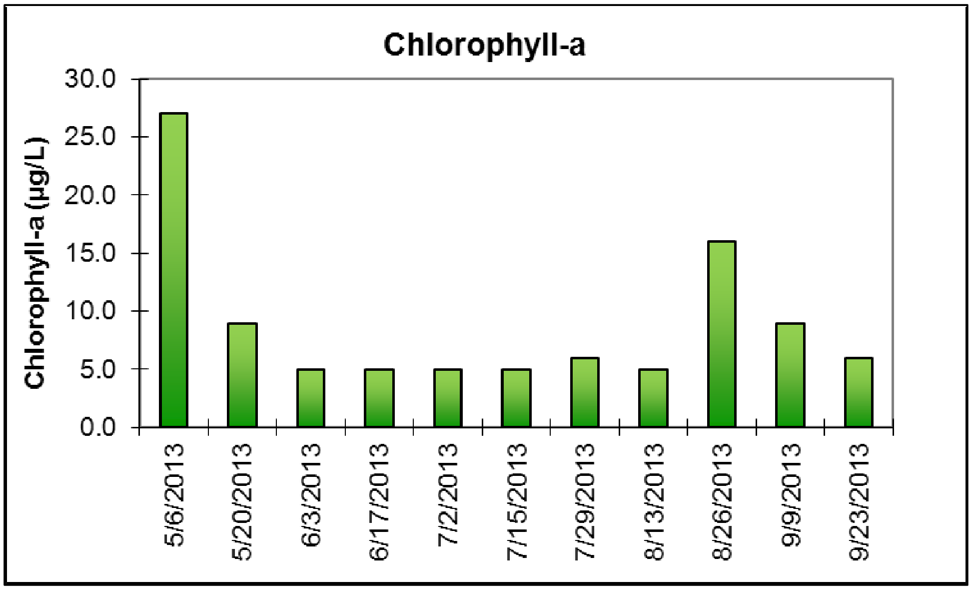

Figure 30. Mill Pond seasonal changes in chlorophyll-a concentrations in 2013.

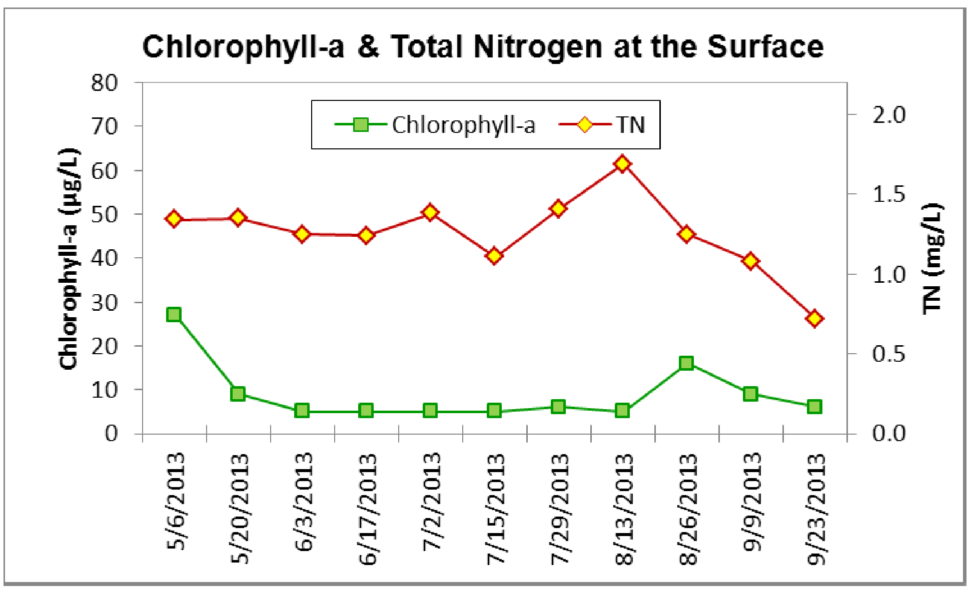

Figure 31. Mill Pond seasonal changes in chlorophyll-a and total nitrogen.

Elm Creek at Hayden Outlet

In 2013, flow and nutrient data were collected at one site in Elm Creek. Elm Creek at Hayden Outlet (ECHO) is located upstream of the Mill Pond sampling site in Elm Creek Park Reserve. Nutrient data was compared between the two sites to determine that Mill Pond is in fact a wide portion of the stream, instead of a shallow lake.

Flow was present throughout the entire monitoring period at the ECHO monitoring station. The highest flow for the monitoring site occurred on June 28th with a daily average flow of 266 cfs (Figure 32). These flows corresponded with a 3.7 rain event that occurred between June 21st and June 23rd. There is a lag between the peak flow and the rain event because Hayden Lake is directly upstream of the monitoring station.

In 2013, the average phosphorus concentration at the ECHO site was 282 µg/L with values ranging from 473.4 µg/L to 106.5 µg/L (Figure 33). Mill Pond had similar phosphorus concentrations that ranged from 104 µg/L to 308 µg/L with an average of 218 µg/L (Figure 34). The average soluble reactive phosphorus was 184.5 µg/L (about 65% of the average total phosphorus concentration) with values ranging from 58.3 µg/L to 328.9 µg/L (Figure 33). Similarly, the soluble reactive phosphorus concentration in Mill Pond makes up approximately 70% of the average total phosphorus. The average total nitrogen was 1.5 mg/L with values ranging from 1.14 mg/L to 1.99 mg/L (Figure 33). The average total suspended solids concentration was 3.15 mg/L with values ranging from 0.75 mg/L to 6.2 mg/L (Figure 35). The average volatile suspended solids concentration was 1.59 mg/L with values ranging from 0.75 mg/L to 2.25 mg/L (Figure 35).

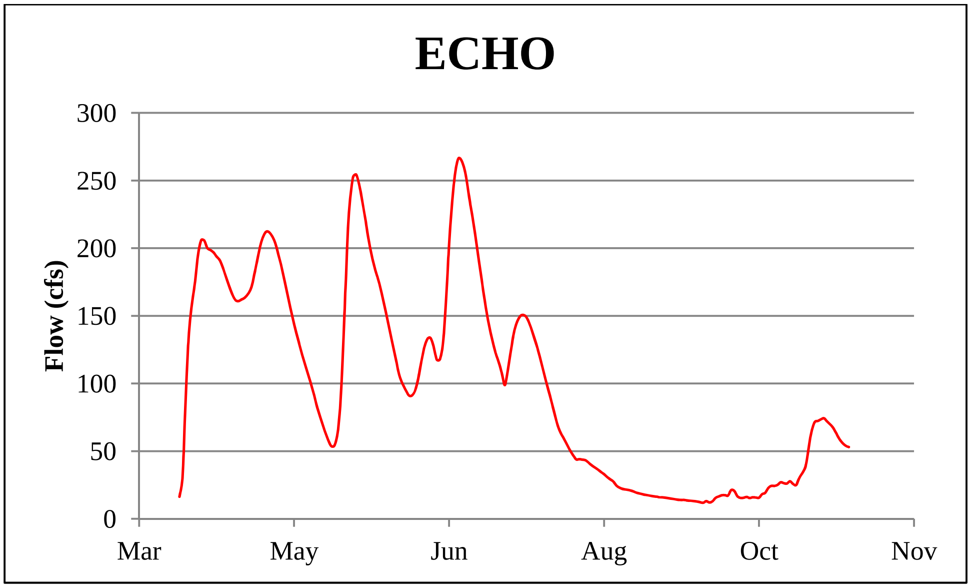

Figure 32. Elm Creek at Hayden Outlet daily average flow.

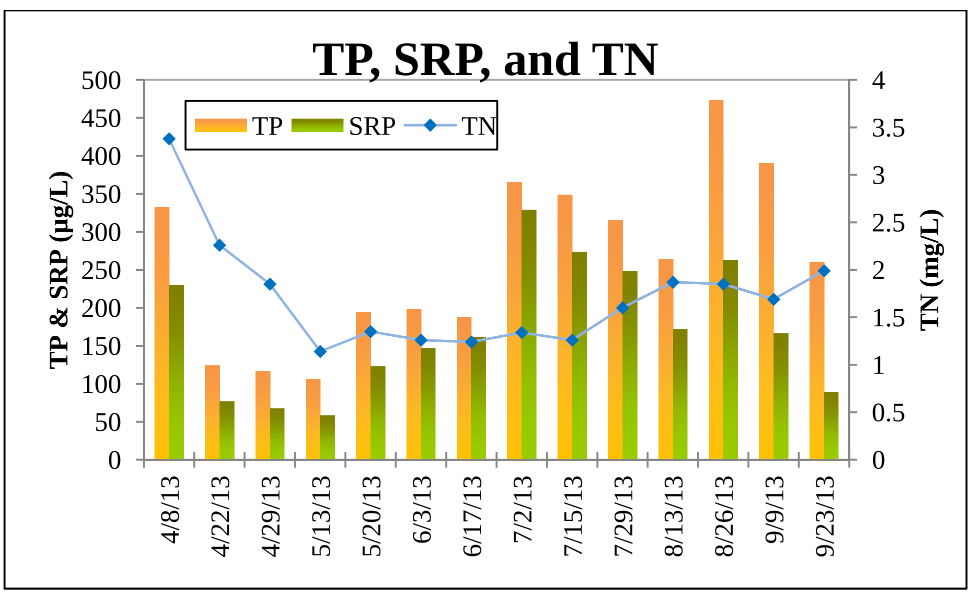

Figure 33. Elm Creek at Hayden Outlet seasonal changes
in total phosphorus, soluble reactive phosphorus, and total nitrogen in 2013.

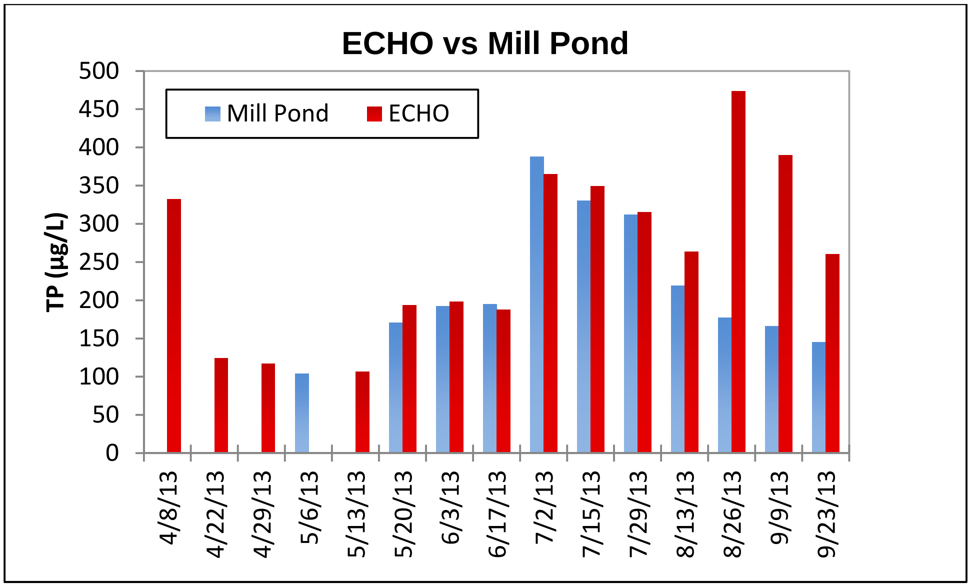

Figure 34. Total phosphorus comparison between the ECHO monitoring Station and Mill Pond.

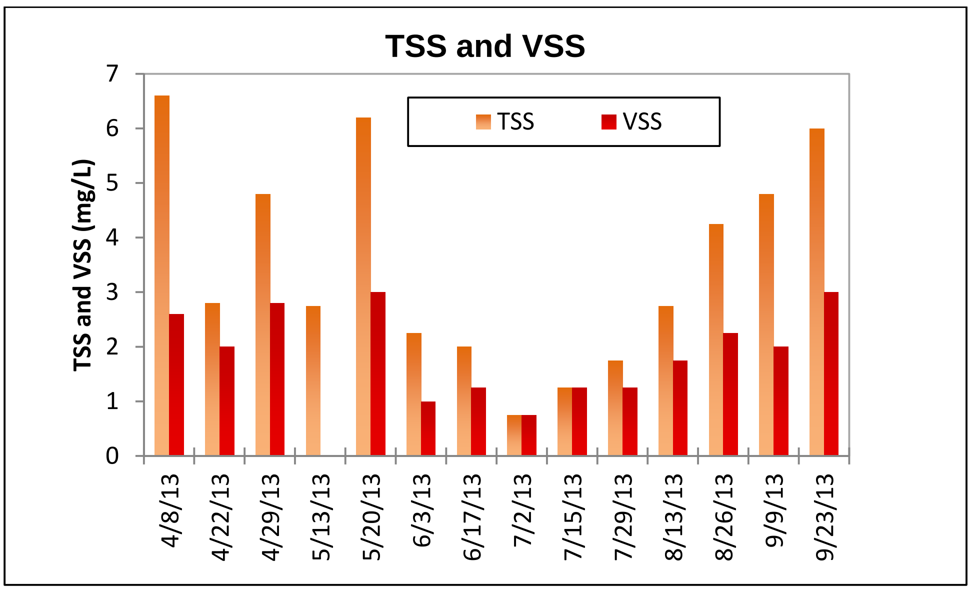

Figure 35. Elm Creek at Hayden Outlet seasonal changes in Total Suspended Solids and Volatile Suspended Solids.

Rice Lake

Rice Lake has two distinct basins that have been monitored to assess water quality conditions. Rice Lake receives drainage from approximately 16,092 acres of the Elm Creek watershed. There is approximately 86% of the entire Elm Creek watershed area that drains into the Rice Lake-West Basin. The Rice Lake–West is approximately 31.7 acre basin that is part of the Elm Creek flowage prior to draining to the 307 acre Rice Lake-Main Basin. The MPCA has reviewed the water quality data for each basin and has been compared to the "shallow lake" water quality state standards for impairment assessment determination. Both basins have been designated as impaired for excessive nutrients. However, the Rice Lake-West Basin doesn't appear to meet the 14-day minimum hydraulic residence time required to be considered a lake or reservoir water body. The MPCA will be reviewing the residence time criteria in 2014 to determine whether the Rice Lake-West Basin should be considered a shallow lake and subsequently having to meet the state "shallow lake" standards.

Rice Lake-West Basin

The Rice Lake-West Basin has phosphorus concentrations that are considered hyper-eutrophic and currently does not meet the shallow lake state standards. The annual average phosphorus concentrations ranged from 173 µg/L to 238.6 µg/L (Figure 36). The highest phosphorus concentrations occurred in 2013 with values ranging between 140.7 µg/L to 353.1 µg/L (Figure 37). These phosphorus concentrations are very similar to those concentrations observed in Elm Creek. Since the west basin has such a short residence time, these in-lake phosphorus concentrations are significantly influenced by the phosphorus load from Elm Creek. These phosphorus concentrations are extremely high and are conducive for the development of severe algal blooms.

The Rice Lake-West Basin does not appear to have severe algal blooms despite the extremely high phosphorus concentrations. The water clarity seems excellent in comparison to other lakes with similar phosphorus concentrations. The average annual chlorophyll-a concentrations ranged from 19 µg/L to 30 µg/L (Figure 38), and secchi depth transparency measurements ranged from 1.2 m to 1.62 m (Figure 39). The water clarity response variables met and slightly exceed the state standards for chlorophyll-a concentration and secchi depth measurements. The short hydraulic residence time for the west basin was not conducive for the development of algal blooms. In 2013, excellent water clarity transparency and relatively low chlorophyll-a concentrations were observed early season (May through mid-July) (Figure 40) during periods that had higher flow conditions from Elm Creek. There appeared to be more algal growth during lower flow conditions from mid-July through September (Figure 40). Based on chlorophyll-a and nitrogen concentrations (Figure 41), these late season algal blooms appear to be partially from nitrogen fixing blue-green algae. It appears that these algal blooms are significantly influenced by the flow conditions from Elm Creek and become dependent upon the hydrologic residence time.

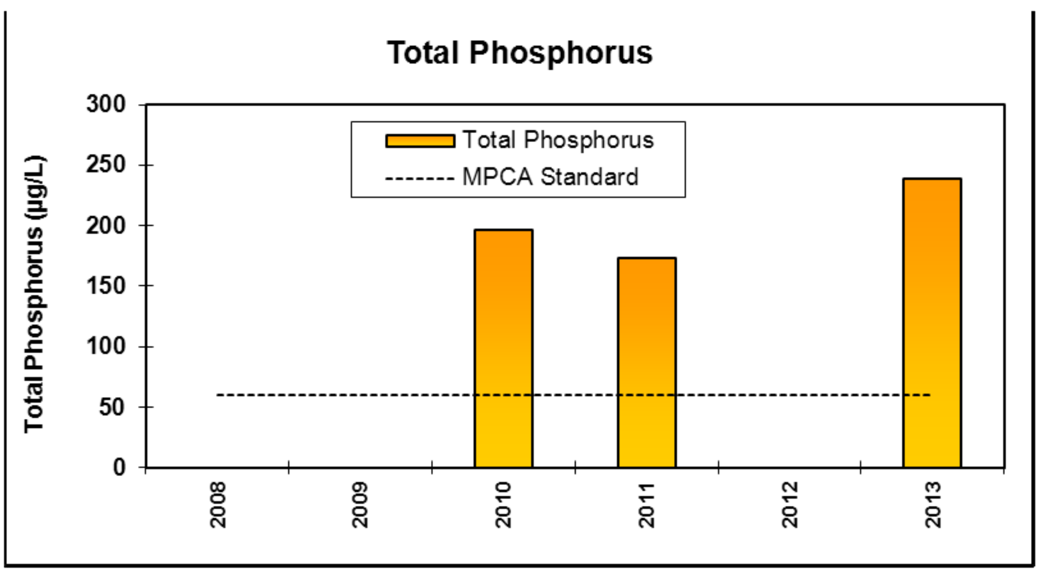

Figure 36. Rice Lake-West Basin average annual total phosphorus concentrations.

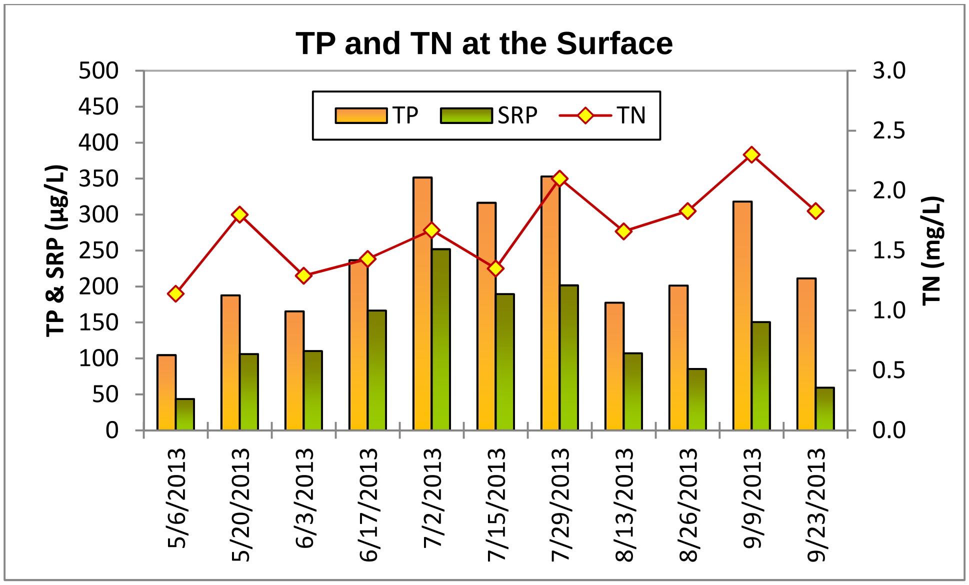

Figure 37. Rice Lake-West Basin seasonal changes in total phosphorus, soluble reactive phosphorus, and total nitrogen in 2013.

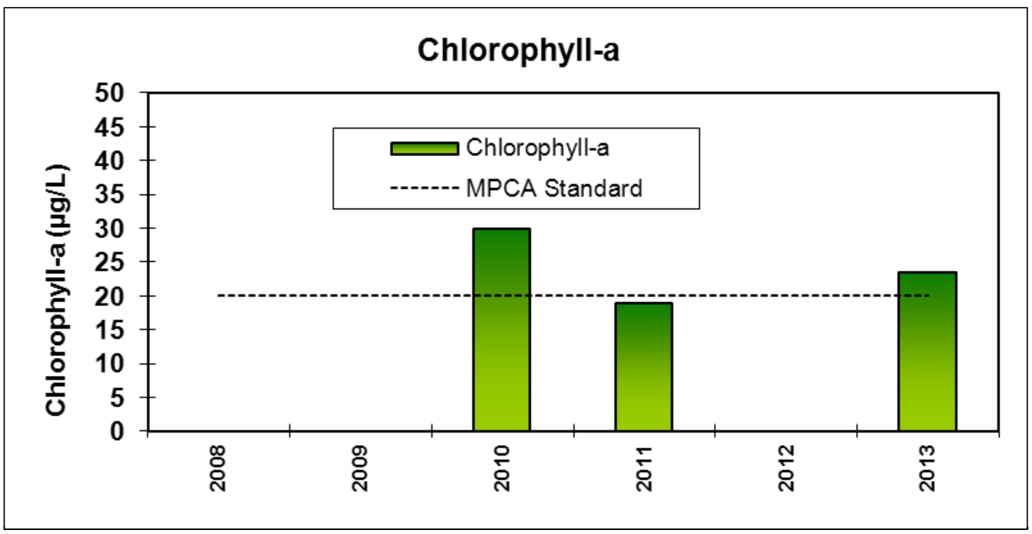

Figure 38. Rice Lake-West Basin average annual chlorophyll-a concentrations.

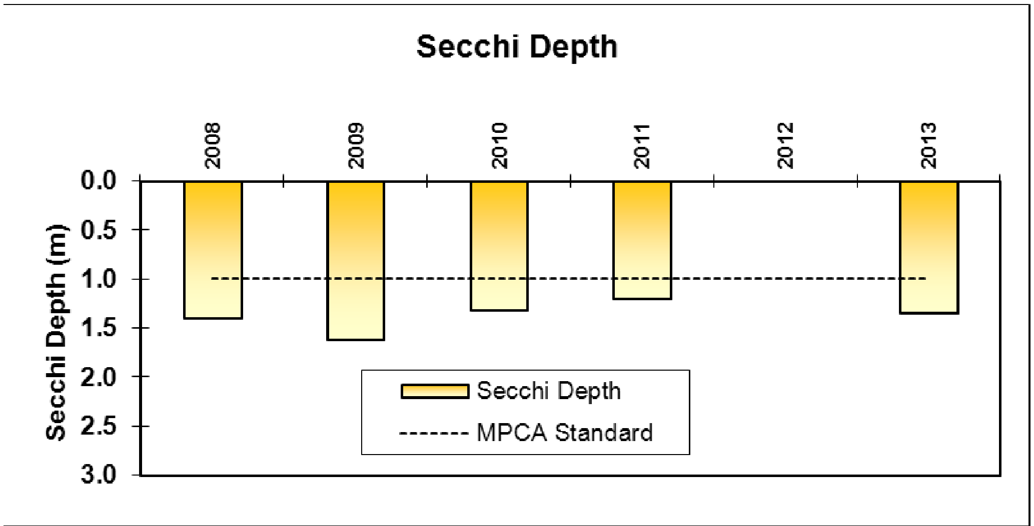

Figure 39. Rice Lake-West Basin average annual Secchi depth measurements.

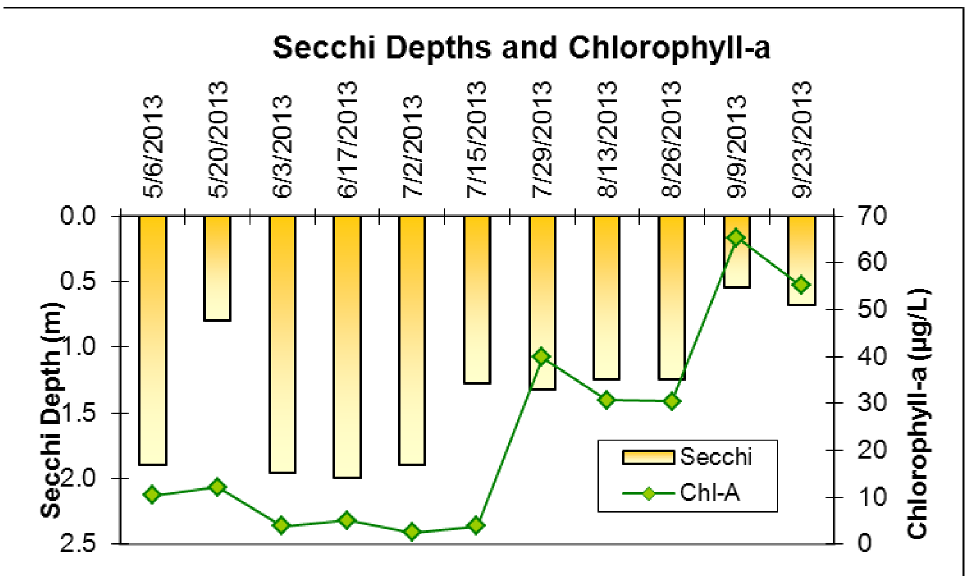

Figure 40. Rice Lake-West Basin seasonal changes in Secchi depth and chlorophyll-a concentrations in 2013.

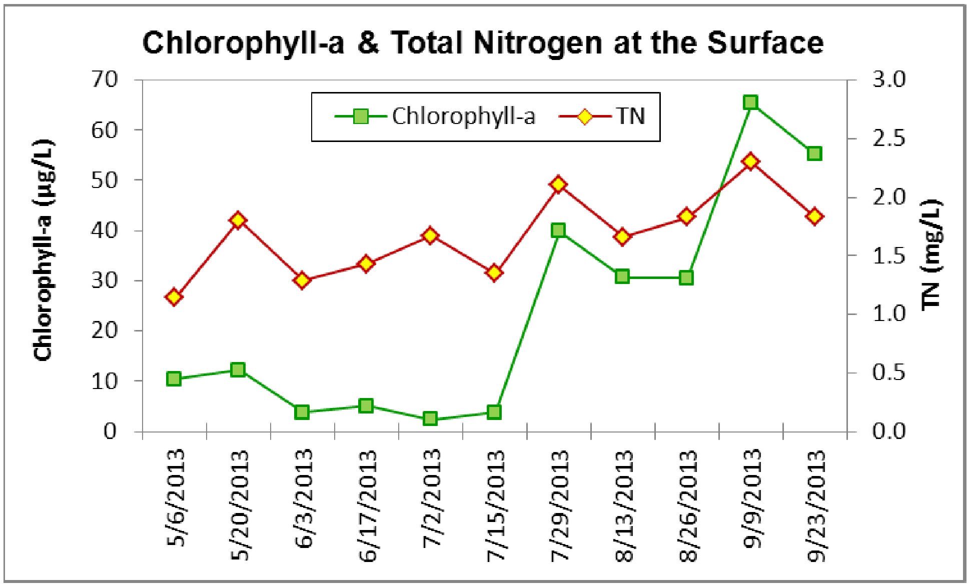

Figure 41. Rice Lake-West Basin seasonal changes in chlorophyll-a and total nitrogen concentrations.

Rice Lake-Main Basin

The in-lake phosphorus concentrations for the Rice Lake-Main Basin are typically higher in comparison to the West Basin. The average annual phosphorus concentrations ranged from 152 µg/L to 468.8 µg/L (Figure 42). In 2013, the average annual phosphorus concentration was 325.8 µg/L (Figure 42) with values ranging from 73.2 µg/L to 584.0 µg/L (Figure 43). These concentrations exceed the “shallow lake” phosphorus state standard. These high concentrations are due to watershed and internal loading. The Rice Lake-Main Basin receives Elm Creek watershed loading from the West Basin channel as well as loading from the direct watershed drainage. In addition, the residence time of the main basin is long enough for the onset of temporary hypolimnetic anoxic conditions due to lake stratification that provides a significant source of internal loading due to sediment phosphorus release. The lake also has a significant amount of internal loading from the senescence of curlyleaf pondweed at the end of June and beginning of July. In 2013, the main basin had a phosphorus spike that corresponded with curlyleaf pondweed senescence at the beginning of July (Figure 44). These concentrations are considered hyper-eutrophic and are conducive for the development of severe algal blooms.

The Rice Lake-Main Basin can potentially have severe algal blooms that decrease water clarity conditions during the summer. The average annual chlorophyll-a concentrations ranged from 16 µg/L to 134 µg/L (Figure 44), and average annual secchi depth transparency ranged from 0.35 m to 1.80 m (Figure 45). It appears that average annual chlorophyll-a concentrations and secchi depth transparency was consistently lower from 1997 through 2004 (Figure 44 & 45). There were two years (2001 & 2002) that actually met the chlorophyll-a shallow lake state standard during this time period (Figure 44); and there were seven years (1998-2002 & 2004-2005) that met the secchi depth transparency shallow lake state standard (Figure 45). Those years that had improved water clarity conditions occurred during periods that had curlyleaf pondweed management control efforts. The lake was drawn down several times (1996-1997, 1997-1998, 2002-2003, and 2004-2005); and there were several years in which there were herbicide treatments for control of curlyleaf pondweed (2000-2002). There have not been any curlyleaf pondweed management control efforts since 2005. The average annual chlorophyll-a concentration in Rice Lake-Main Basin have gradually increased from 2005 through 2013 (Figure 44). The seasonal changes in water clarity during 2013 further supports the impact curlyleaf pondweed senescence may have on water quality conditions. The in-lake water clarity degraded at the beginning of July following curlyleaf pondweed senescence (Figure 46). It appears that the source of algal blooms in Rice Lake-Main Basin were due to nitrogen fixing blue-green algae. In 2013, the seasonal changes in total nitrogen relative to chlorophyll-a concentrations (Figure 47) suggests that nitrogen fixing blue-green algal species were a primary influence on reducing water clarity conditions.

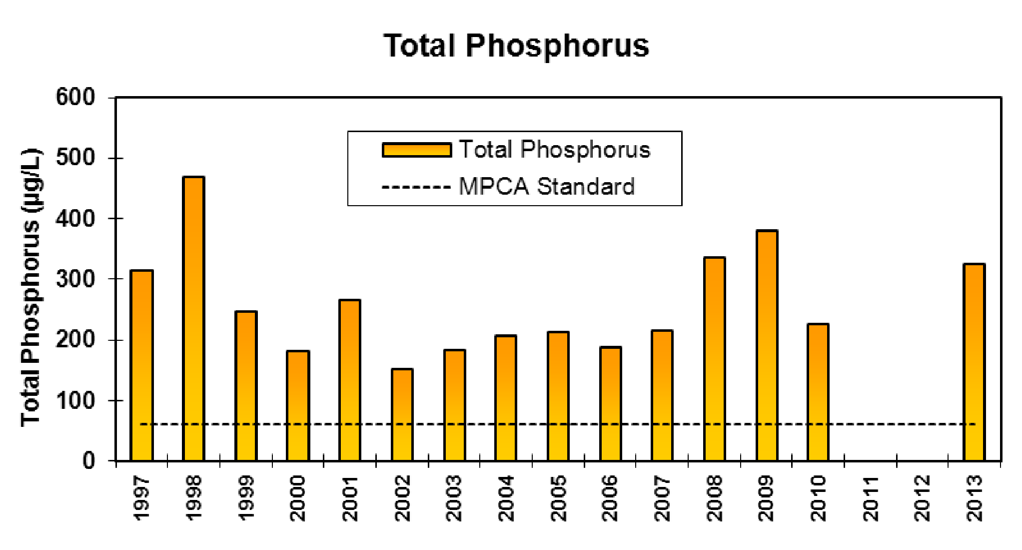

Figure 42. Rice Lake-Main Basin average annual total phosphorus concentrations.

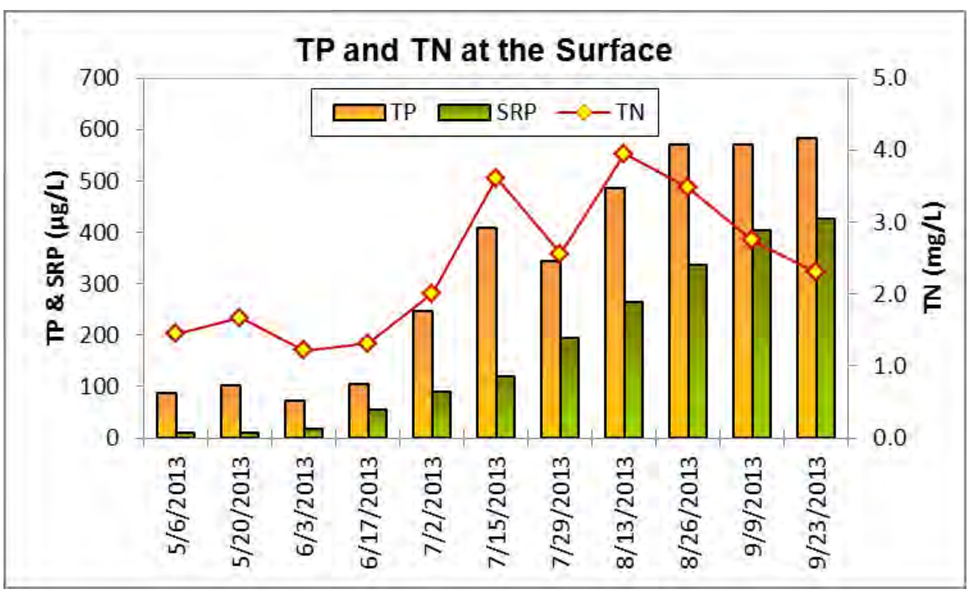

Figure 43. Rice Lake-Main Basin seasonal changes in total phosphorus, soluble reactive phosphorus, and total nitrogen in 2013.

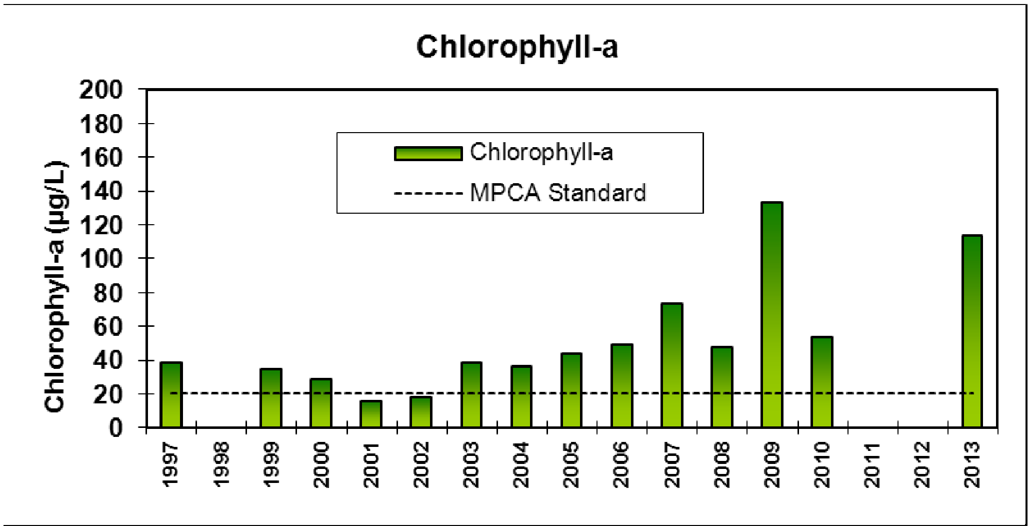

Figure 44. Rice Lake-Main Basin average annual chlorophyll-a concentrations.

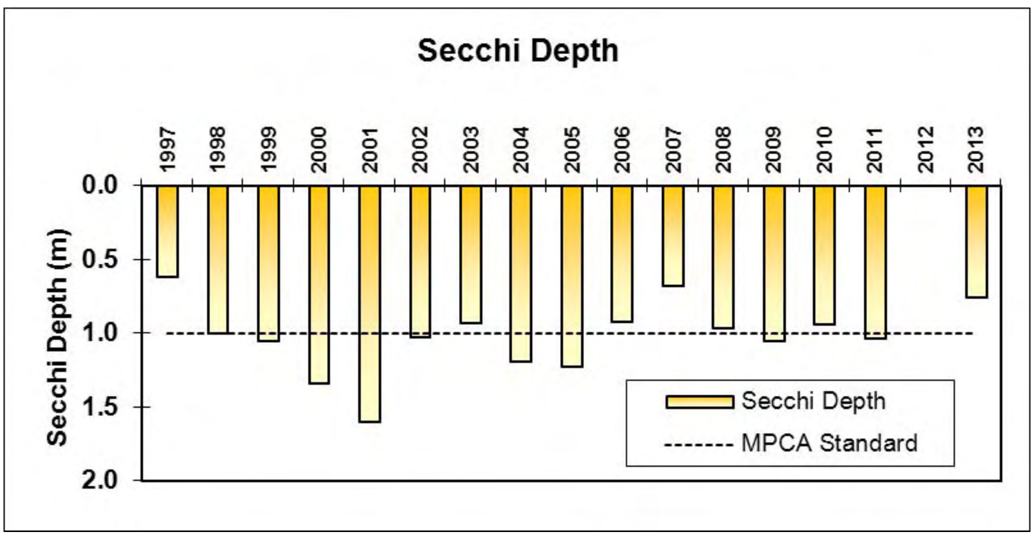

Figure 45. Rice Lake-Main Basin average annual Secchi depth measurements.

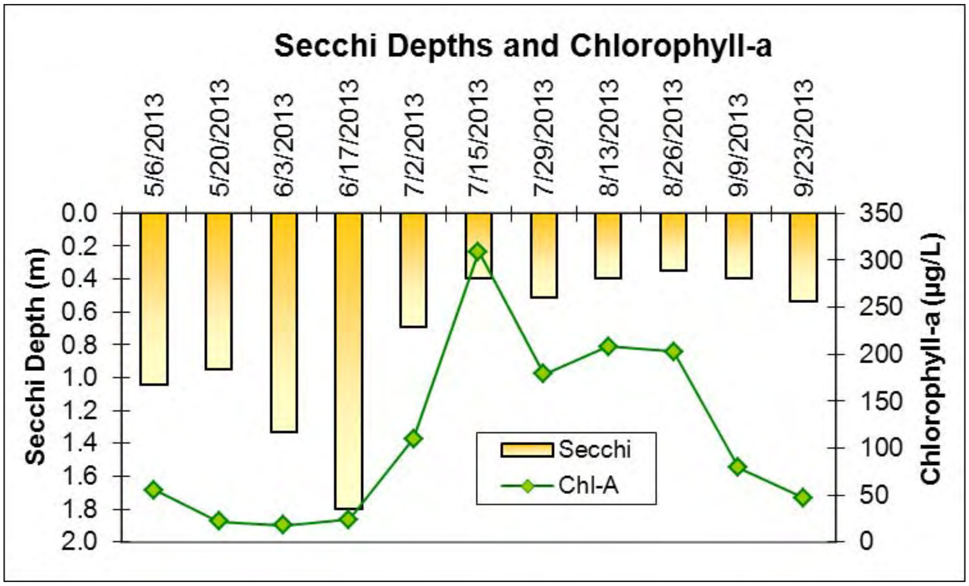

Figure 46. Rice Lake-Main Basin seasonal changes in Secchi depth and chlorophyll-a concentrations in 2013.

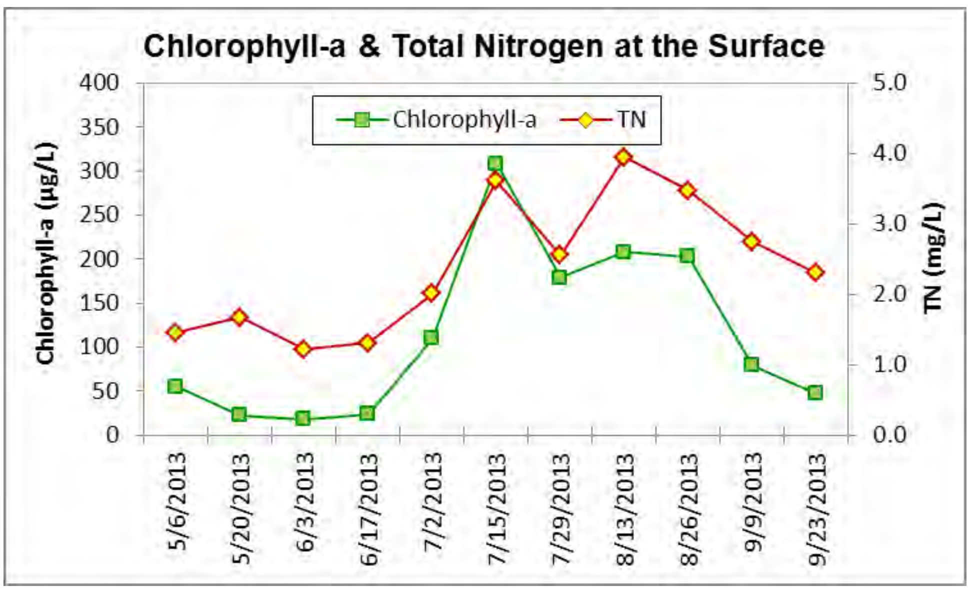

Figure 47. Rice Lake-Main Basin seasonal changes in chlorophyll-a and total nitrogen concentrations.

2013 Lake Monitoring - CAMP

Lakes Dubay, Laura and Sylvan were monitored through the 2013 Citizens Assisted Monitoring Program (CAMP). The 2013 annual CAMP report will be available in summer 2014.

CAMP was initiated by the Metropolitan Council to supplement the water quality monitoring performed by Met Council staff and to increase the knowledge of water quality of area lakes. Volunteers monitor the lakes semi-monthly from mid-April to mid-October. They note natural and cultural observations and general perceptions of the lakes' condition and suitability for recreation. They take a water transparency reading using a Secchi disk, measure surface water temperature, and collect surface water samples that are analyzed for total phosphorous, total Kjeldahl nitrogen, and chlorophyll-a.

Data from each lake's sampling forms and lab analyses are entered into a data management and statistical analysis program called Statistical Analysis System (SAS). Various quality control methods are used throughout the program to ensure that proper sampling and data analysis techniques were used. Suspect data are excluded from the databases or conclusions.

After some delay, Met Council's **2012 Annual Lake Report** is now available. The report is a product of a project to convert the Annual Lake report to an electronic and automated process, which delayed its publication. The report is in a similar format as before, except that the individual lake reports now have room for expanding data sets. The report is located on Met Council's EIMS document repository: http://es.metc.state.mn.us/eimsrelated_documents/view_documents.asp.

Lake Monitoring History

	Cook	*Cowley*	*Diamond*	*Dubay*	*Fish*	*French*	*Henry*	*Jubert*	*Laura*	*Medina*	*Mill Pond*	*Mud*	*Rice*	*Sylvan*	*Weaver*
2013			**T**	**C**		**T**			**C**		**T**		**T**	**C**	**T**
2012			**T**	**C**	**T**	**T**				**C**	**T**			**C**	**T**
2011			**T**	**C**	**T**	**T**	**C**				**T**		**C**		**T**
2010		**C**	**T**		**T**	**T**	**C**				**T**	**T**	**C/T**		**T**
2009		**C**	**T**		**T**	**T**	**C**				**T**		**C**		**T**
2008			**T**		**T**		**C**						**C**	**C**	**T**
2007		**C**	**T**		**T**		**C**						**C**		**T**
2006		**C**			**T**	**T**	**C**								**T**
2005					**T**	**T**	**C**								**T**
2004			**T**		**T**	**T**									**T**
2003															
2002					**T**	**C**					**T**				**T**
2001	**T**				**T**	**C**									**T**
2000					**T**			**C**							**T**
1999					**T**						**T**				**T**
1998			**T**		**T**										**T**
1997					**T**									**T**	**T**
1996					**T**										**T**
1995					**T**		**C**								**T**
1994			**C**		**T**										**T**
1993					**T**										**T**
1992	**T**		**T**		**T**										**T**
1991					**T**			**T**			**T**				**T**
1990	**T**				**T**	**T**									**T**
1989			**T**	**T**	**T**			**T**							**T**
1988	**T**				**T**						**T**				**T**
1987					**T**			**T**							**T**
1986	**T**		**T**	**T**	**T**							**T**			**T**

T = monitored by Three Rivers Park District **C** = monitored through CAMP program