

**Pioneer-Sarah Creek Watershed Management Commission
Lake Monitoring History**

Lake City	Ardmore Loretto	Haften Greenfield	Half Moon Independence	Haughey Independence	Independence/ Independence/ Medina	Little Long Minnetrista	Peter Medina	Rattail Greenfield	Rebecca Greenfield/ Independence	Robina Independence	Sarah Greenfield/ Independence	Schudel Greenfield	Schwauppau Greenfield	Spurzem Medina	Whaletail Minnetrista	Winterhalter Medina
2011			T		T		C	T	T	T			T	T	T	
2010	C	C	T		T	C	C				T			T	T	
2009	C	T			T	C	C				T			T	T	
2008	C				T						T			T		
2007	C				T	C					T			T		
2006		C			T	C			T		T			T		
2005		C			T						T			T	M	
2004		M			T	T					T			T	M	
2003						M								T	T	
2002				C	T	T			T		T					
2001		M				M									M	
2000		M									T				T	
1999						T	T					T				
1998		T				M				T	T				M	
1997																
1996		T					T								T	
1995																
1994					C		T				T					
1993					C	T									T	
1992							T				T					
1991	T					T										
1990							T								T	
1989						T					T			T		
1988					T		T				T					T

T = Monitored by Three Rivers Park District/Hennepin Parks
C = Monitored through the CAMP Program
M = Monitored by Metropolitan Council

Pioneer and Sarah Creek Watershed Management Commission

Lake Water Quality Summaries

2011

Introduction

Pioneer and Sarah Creek Watershed Commission contracted Three Rivers Park District to monitor the trophic condition for several lakes in 2011. Three Rivers Park District monitored the water quality in Lake Independence, Spurzem Lake, Half Moon Lake, Lake Sarah and Whaletail Lake (west and east basins). These lakes were sampled biweekly from late April (4/25/2011) through late October (10/24/2011). The seasonal and annual changes 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). It should be noted that the MPCA's assessment for waterbody 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. Trophic state indices (TSI) were also calculated using growing season means for total phosphorus, chlorophyll-a, and Secchi depth. The trophic state index (TSI values ranging from 0-100) describes the productivity of a lake from oligotrophic to hypereutrophic conditions. An average TSI value is calculated from the estimated TSI values derived for total phosphorus, chlorophyll-a, and Secchi depth.

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.

Lake Independence

Lake Independence has exceeded the MPCA “deep lake” phosphorus standards since 2001. There have been slight improvements in water quality since the completion of the TMDL (2006) and implementation plan (2007). However, the total phosphorous concentrations appeared cyclic with gradual decreases and increases in total phosphorus since 1995 (Figure 1). The mean phosphorus concentration in Lake Independence increased from 44.3 µg/L in 2010 to 55.2 µg/L in 2011. Total phosphorus concentration in 2011 ranged from 22.6 to 82.1µg/L (Figure 2). The fluctuations in phosphorus concentration for Lake Independence have often been attributed to the watershed and internal loading processes.

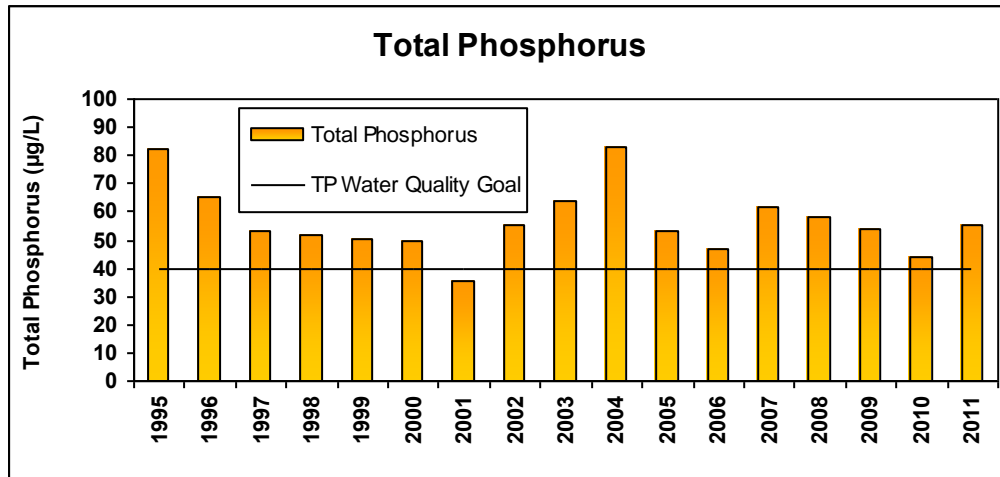


Figure 1. Lake Independence annual changes in average phosphorus concentration from 1995-2011.

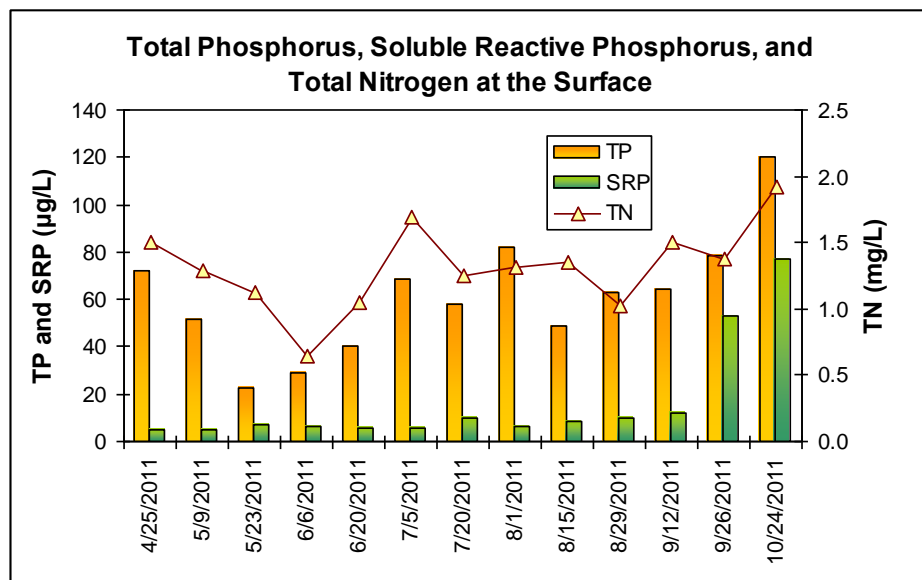


Figure 2. Lake Independence seasonal changes in total phosphorus, soluble reactive phosphorus, and total nitrogen concentrations in 2011.

The increase in total phosphorus concentration resulted in severe algal blooms in 2011. The average chlorophyll-a concentration increased from 16 µg/L in 2010 to 26.7 µg/L in 2011 (Figure 3). This average chlorophyll-a concentration is considerably higher than the MPCA water quality standard for impairment of 14 µg/L. Despite the severe algal blooms, there were variations in Secchi depth transparency that ranged from 0.8 to 7.6 meters in 2011 (Figure 5). The lake typically has a clear water phase in early spring that is followed by severe algal blooms that persist throughout the summer. In 2011, the clear water phase persisted throughout June in which Secchi depth transparency ranged from 3.0 to 7.6 m. Severe algal blooms occurred from July through September contributing to Secchi depth transparencies frequently below 1.0 m. The average Secchi depth transparency for 2011 was 2.3 m (Figure 4). Typically, poor water clarity and high chlorophyll-a concentrations indicate algal production. Algae growth can also be effected by numerous environmental factors including, but not limited to, phosphorus and nitrogen concentrations, oxygen, carbon dioxide, light and temperature.

A trophic status index was calculated for Lake Independence using the total phosphorus, chlorophyll-a, and Secchi depth measurements. The average trophic status index calculated for 2011 was 59.4 indicating that Lake Independence has eutrophic conditions. Eutrophic lakes tend to have an increase in nutrient enrichment, leading to the overgrowth of aquatic plants, oxygen depletion, and algal blooms. These eutrophic conditions are similar to other lakes within the ecoregion.

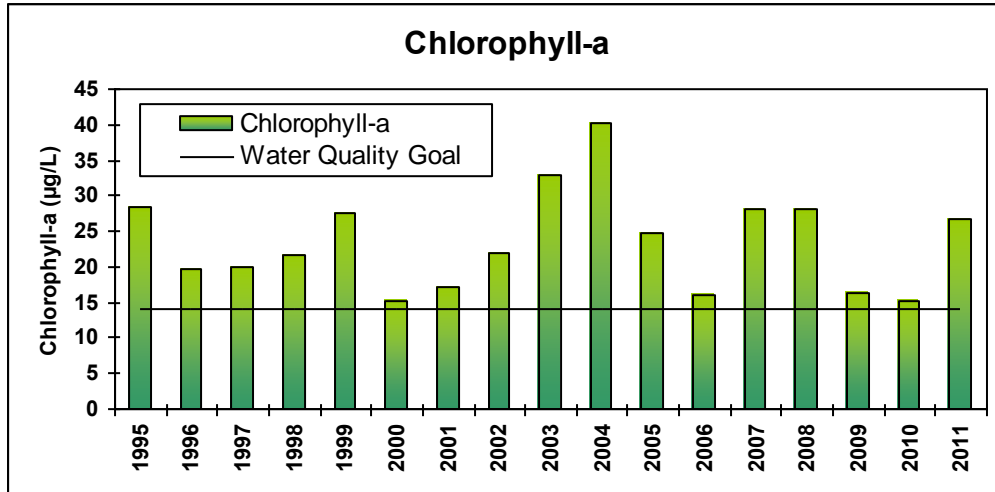


Figure 3. Lake Independence annual changes in average chlorophyll-a concentration from 1995-2011.

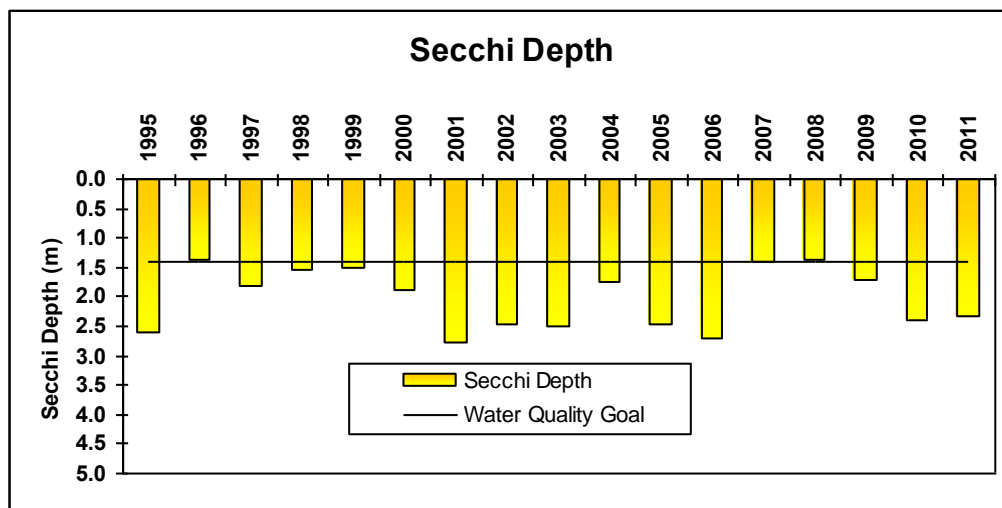


Figure 4. Lake Independence annual changes in average Secchi depth from 1995-2011.

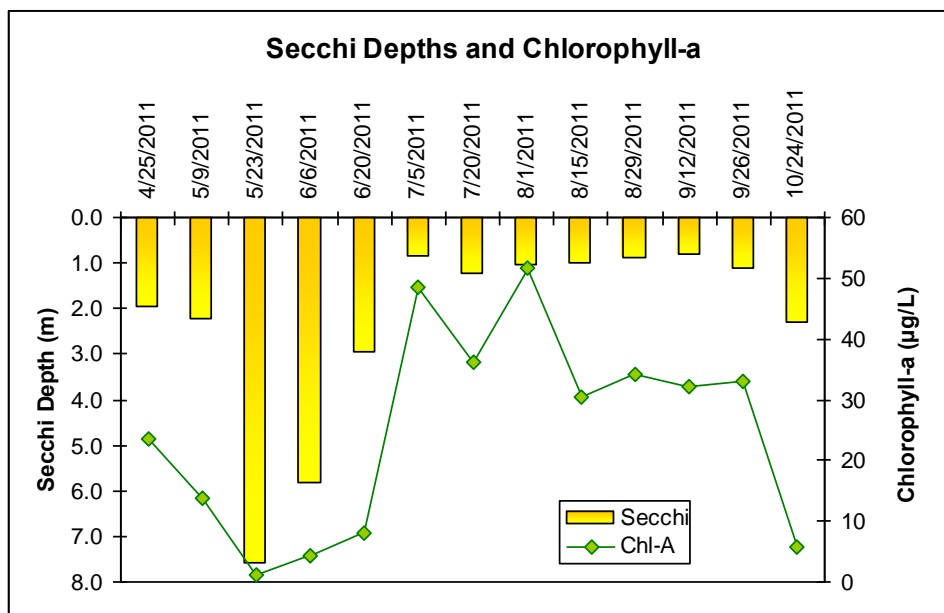


Figure 5. Lake Independence seasonal changes in Secchi depth and chlorophyll-a concentration in 2011.

Spurzem Lake

Spurzem Lake continues to exceed the impaired water criteria for the MPCA “deep lake” eutrophication standards. The total phosphorus concentration standard to support direct contact recreational use for Spurzem Lake is 40 µg/L. The average total phosphorus concentration in 2011 was 140.3 µg/L with values ranging between 63.2 and 244.1 µg/L (Figures 6 & 7). The high phosphorus concentrations are attributed to significant sources of external and internal loading.

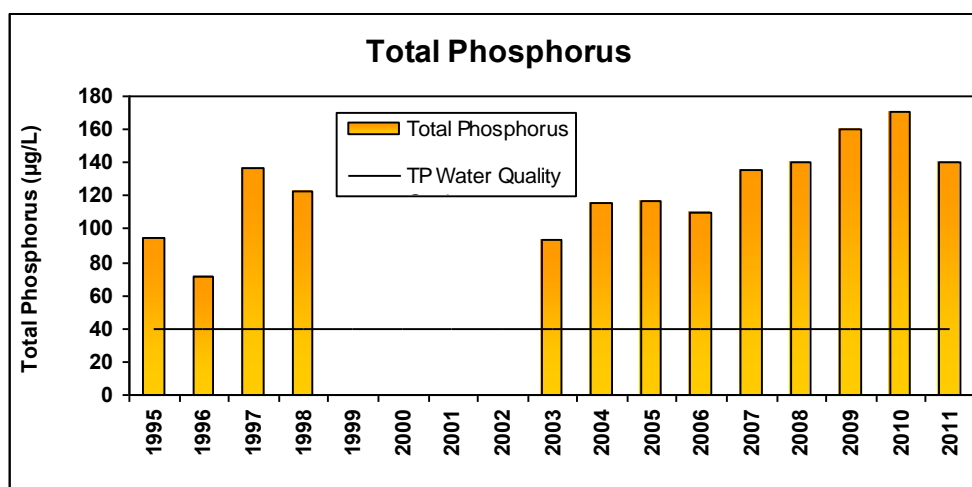


Figure 6. Lake Spurzem annual changes in average total phosphorus concentrations from 1995-2011.

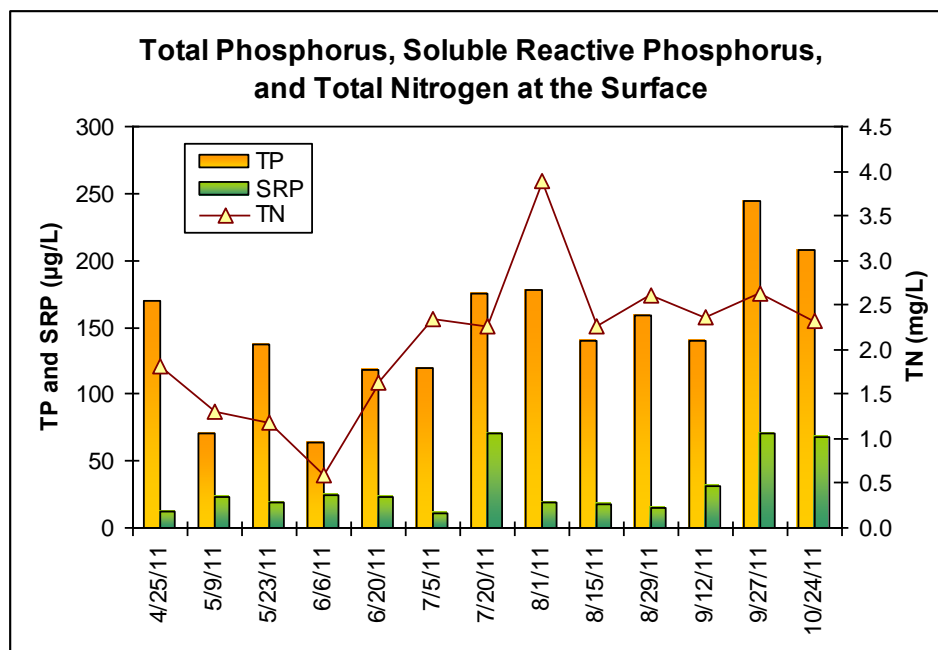


Figure 7. Spurzem Lake seasonal changes in total phosphorus, soluble reactive phosphorus, and total nitrogen concentrations in 2011.

The excess phosphorus concentrations in Spurzem Lake resulted in severe algal blooms with decreased water clarity. The water quality conditions in 2011 are also considerably higher than the MPCA eutrophication standards for impairment of chlorophyll-a (14 µg/L) and Secchi depth (1.4 m). The average chlorophyll-a concentration in 2011 (81.2 µg/L) was the highest reported since monitoring began in 1995 (Figure 8). This high average is partially attributed to a severe algal bloom in August producing a chlorophyll-a concentration of 298 µg/L (Figure 10). The severe algal blooms produced an average Secchi depth transparency of 0.9 m (Figure 9). Despite poor water clarity conditions in 2011, a clear water phase did occur in May and early June with chlorophyll-a concentrations ranging from 9.5 to 15.7 µg/L, and Secchi depth transparencies ranging from 1.2 to 2.11 meters (Figure 10).

A trophic status index was calculated for Spurzem Lake using the total phosphorus, chlorophyll-a, and Secchi depth measurements. Spurzem Lake is classified as a hyper-eutrophic lake with a trophic state index of 71.9. Hyper-eutrophic lakes typically have degraded water quality conditions that typically limit recreational use, create light-limited productivity, and promote dense blue-green algae blooms. These hyper-eutrophic conditions are considered extreme in comparison to the eutrophic conditions that are typically observed within the ecoregion.

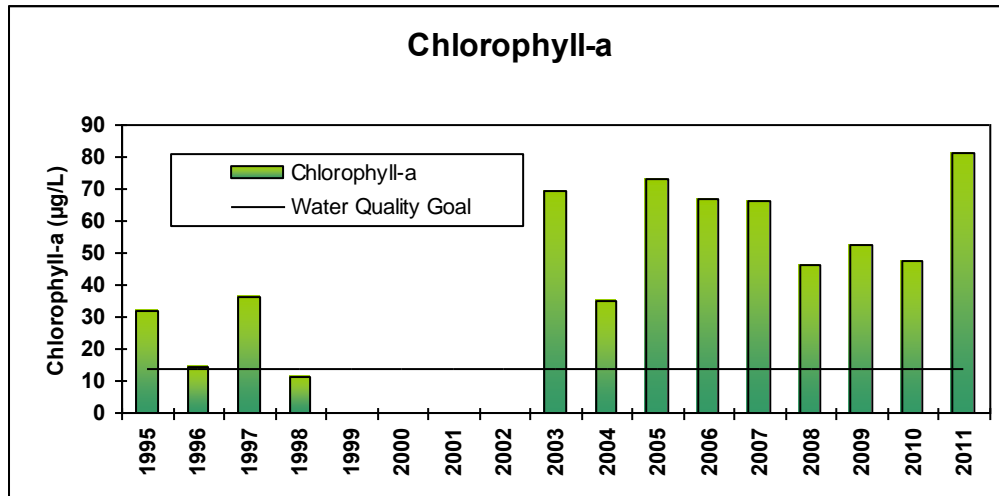


Figure 8. Spurzem Lake annual changes in average chlorophyll-a concentration from 1995-2011.

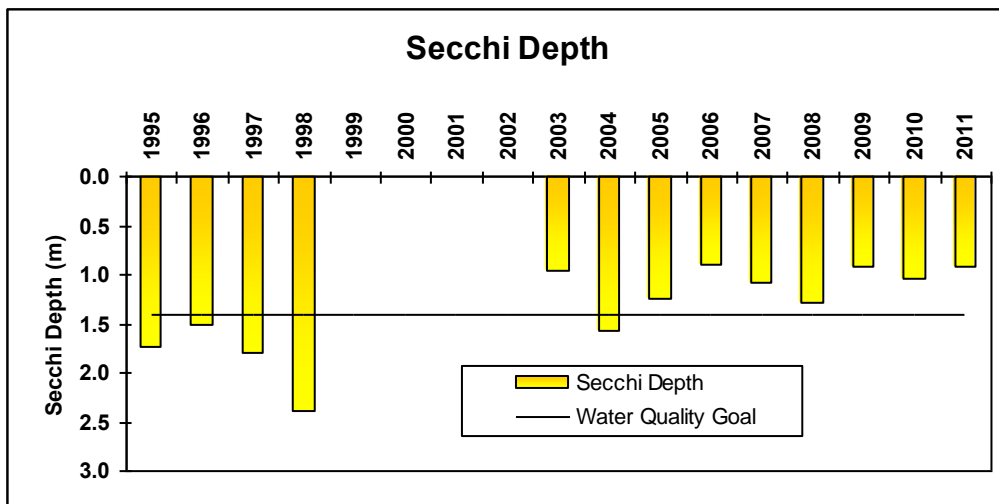


Figure 9. Spurzem Lake annual changes in average Secchi depth from 1995-2011.

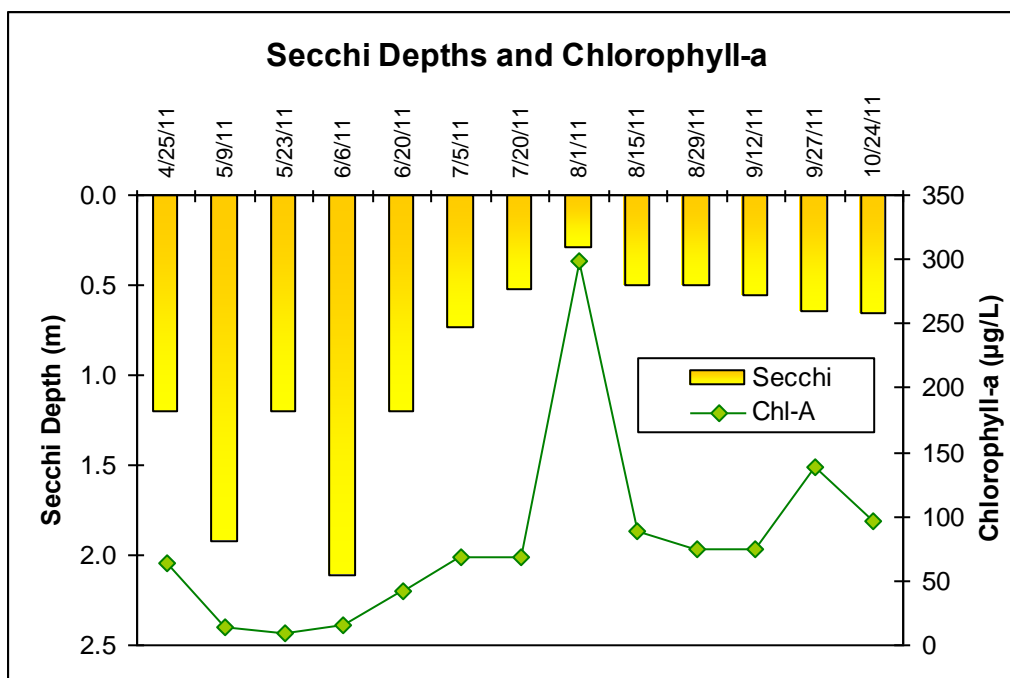


Figure 10. Spurzem Lake seasonal changes in Secchi depth and chlorophyll-a concentration in 2011.

Half Moon Lake

Half Moon Lake continues to exhibit degraded water quality conditions. Half Moon had an average phosphorus concentration of 134.5 µg/L with values ranging from 61.5 to 227.6 µg/L in 2011 (Figures 11 & 12). There has not been any improvement in phosphorus concentrations in comparison to the previous years that have been monitored. The average total phosphorus concentrations have been substantially higher than the MPCA “deep lake” standard of 40 µg/L to support aquatic recreational use.

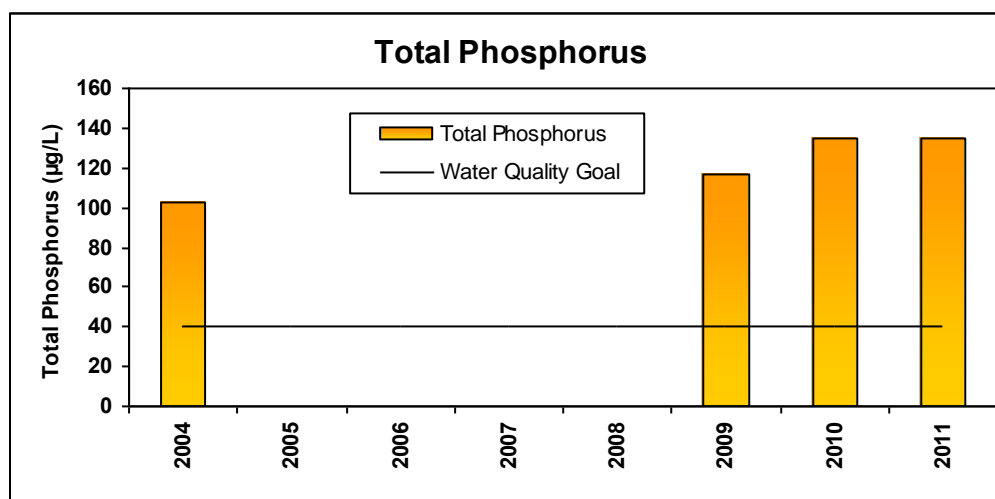


Figure 11. Half Moon Lake annual changes in average total phosphorus concentration from 2004-2011.

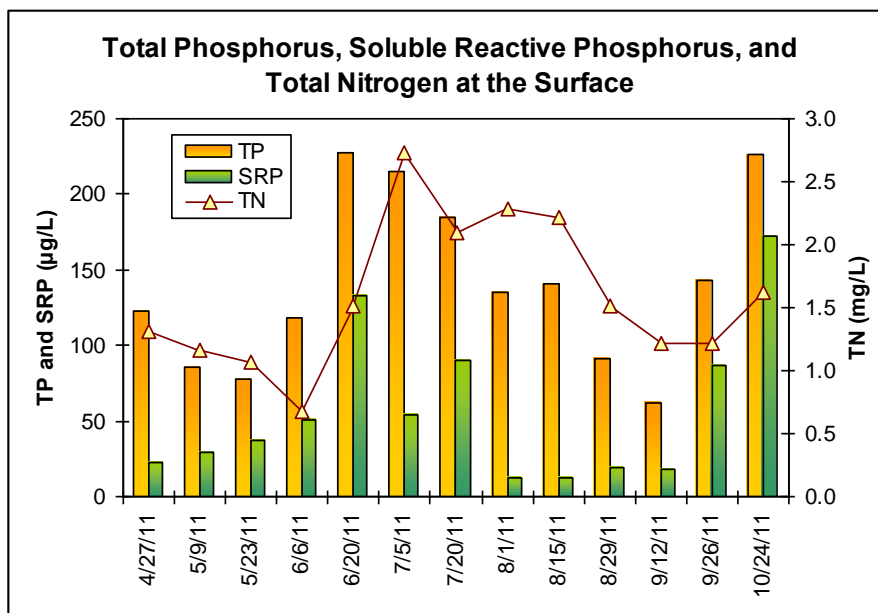


Figure 12. Half Moon Lake seasonal changes in total phosphorus, soluble reactive phosphorus, and total nitrogen concentrations in 2011.

The excessive phosphorus concentrations are conducive for the development of severe algal blooms that occurred numerous times throughout the summer. The average chlorophyll-a concentration in 2011 was 38.5 µg/L with values ranging from 8.8 to 143.3 µg/L (Figure 13). Despite the severe algal blooms, the average Secchi depth of 1.3 m (Figure 14) was an improvement in comparison to 2010. Half Moon Lake had a clear water phase similar to Spurzem Lake throughout May and June. This clear water phase most likely was attributed to an increase in zooplankton abundance. Water clarity gradually decreased in response to the development of algal blooms as water temperatures increased throughout the summer. Secchi depth transparency ranged between 0.5 and 2.3 meters during the summer (Figure 15).

The total phosphorus, chlorophyll-a, and Secchi depth data was used for estimating an average TSI value for Half Moon Lake. The average TSI value of 67.6 for Half Moon Lake is indicative of lakes with eutrophic to hypereutrophic conditions. Lakes with eutrophic to hypereutrophic conditions frequently have a dominance of blue-green algae, few aquatic plants due to limited light penetration, and an anaerobic hypolimnion that can lead to fish kills.

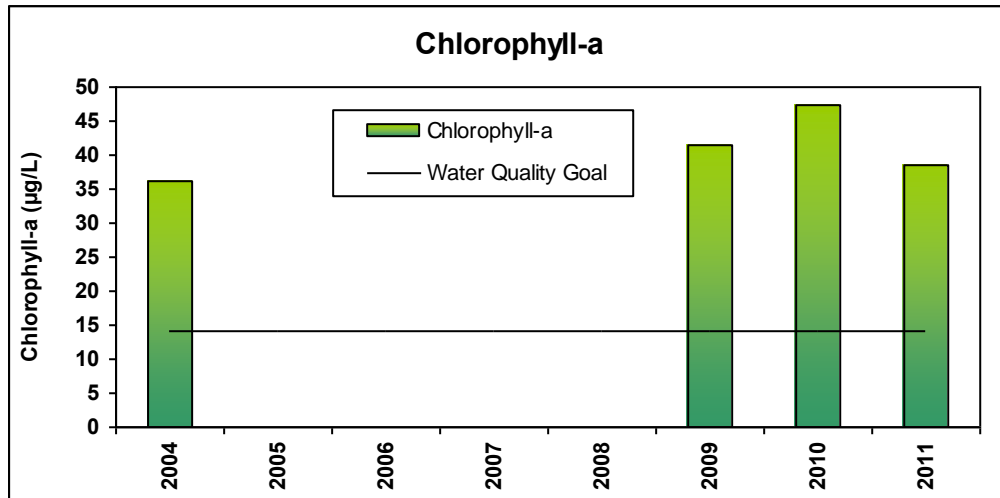


Figure 13. Half Moon Lake annual changes in average chlorophyll-a concentration from 2004-2011.

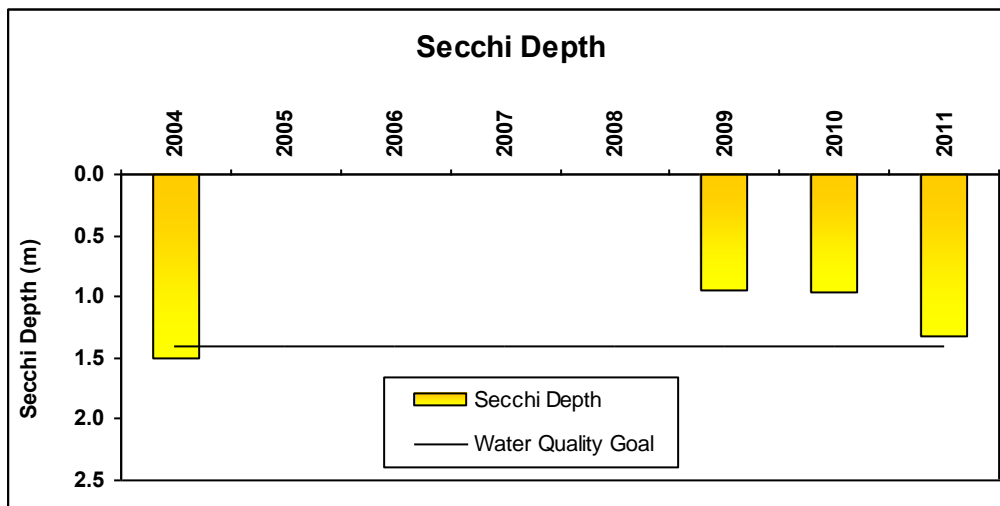


Figure 14. Half Moon Lake annual changes in average Secchi depth from 2004-2011.

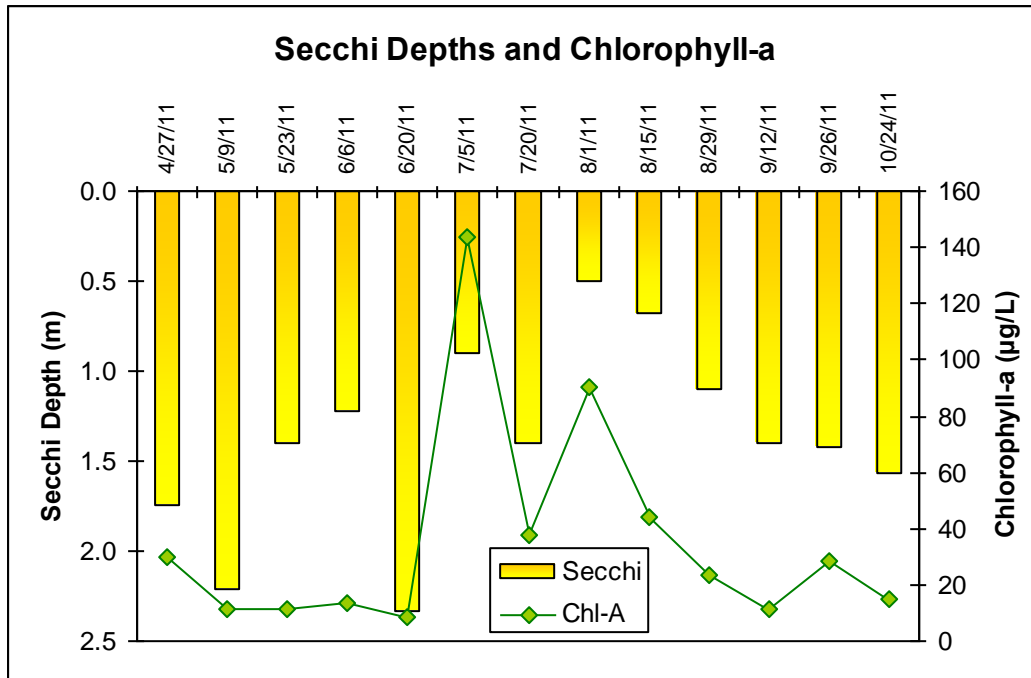


Figure 15. Half Moon Lake seasonal changes in Secchi depth and chlorophyll-a concentration in 2011.

Lake Sarah

Lake Sarah has exceeded MPCA “deep lake” standards for total phosphorus since 1996 (Figure 16). During the past summer (2011), the average annual total phosphorus concentration was 88.0 µg/L. These phosphorus concentrations are an improvement from 2010 (113.4 µg/L). The high phosphorus concentrations are partially due to the senescence of curly-leaf pondweed and nutrient loading from the watershed. The highest total phosphorus concentrations in 2011 occurred during the fall lake turn-over cycle. These processes re-suspended nutrients throughout the water column and accounted for the high total phosphorus concentrations that reached 158.0 µg/L after fall turnover (Figure 17).

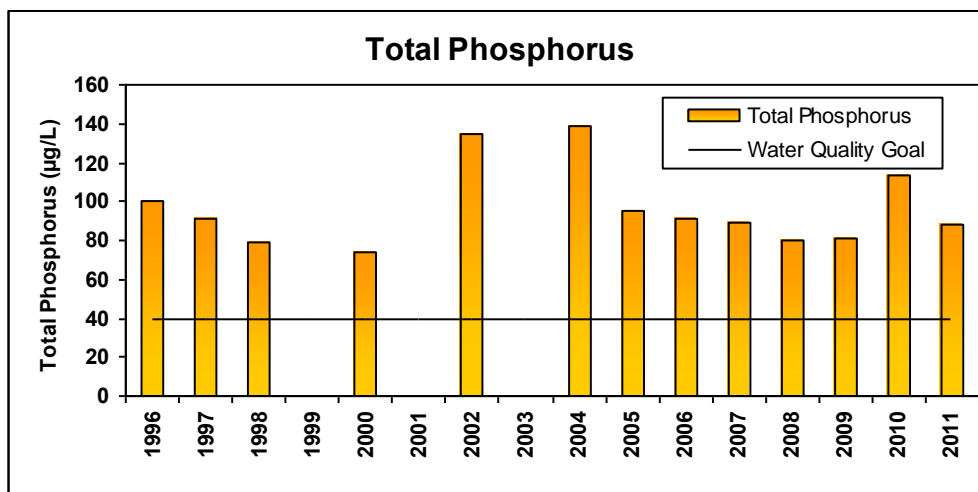


Figure 16. Lake Sarah annual changes in average total phosphorus concentration from 1996-2011.

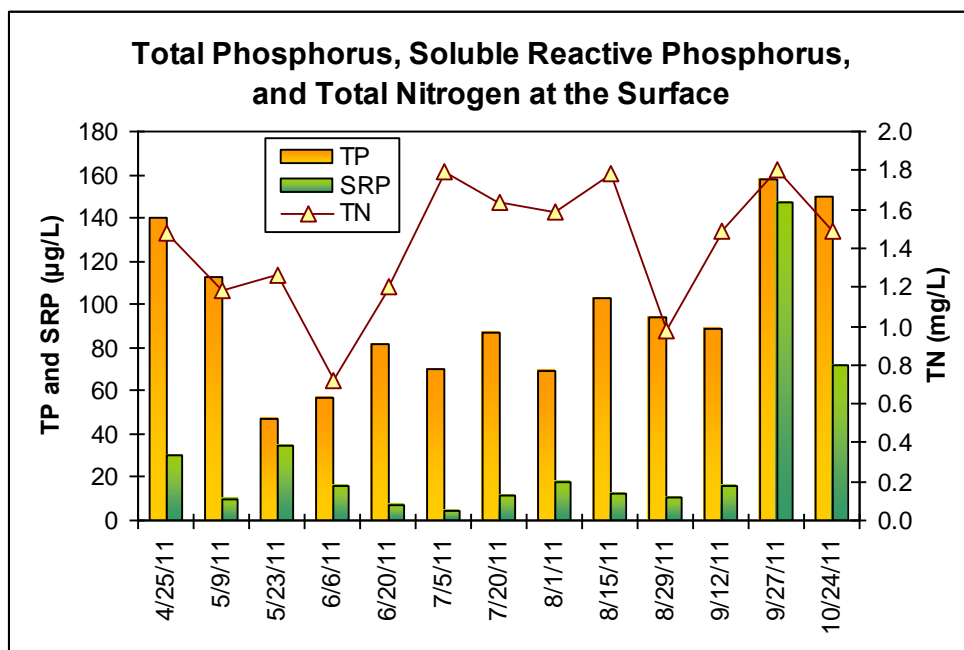


Figure 17. Lake Sarah seasonal changes in total phosphorus, soluble reactive phosphorus, and total nitrogen concentrations in 2011.

The high phosphorus concentrations have been conducive for the development of algal blooms. Lake Sarah annual average chlorophyll-a concentration was 43.3 µg/L in 2011 (Figure 18) which exceeds the MPCA “deep lake” standard for impairment of 14 µg/L. During the early summer, Lake Sarah exhibited a clear-water phase with relatively low chlorophyll-a concentrations that produced a maximum Secchi depth of 2.7 meters (Figure 20). As the water temperatures increased by mid-summer, there was an increase in chlorophyll-a concentrations (algal blooms) that contributed to poor water clarity. The average Secchi depth transparency for Lake Sarah was 1.5 meters in 2011 (Figure 19). The average Secchi depth transparency has been similar to the previous years monitored (Figure 20).

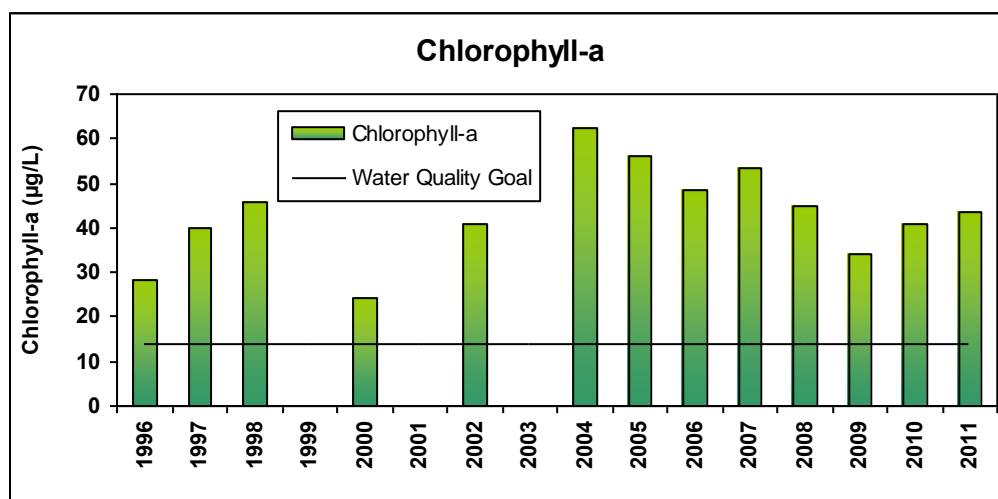


Figure 18. Lake Sarah annual changes in average chlorophyll-a concentration from 1996-2011.

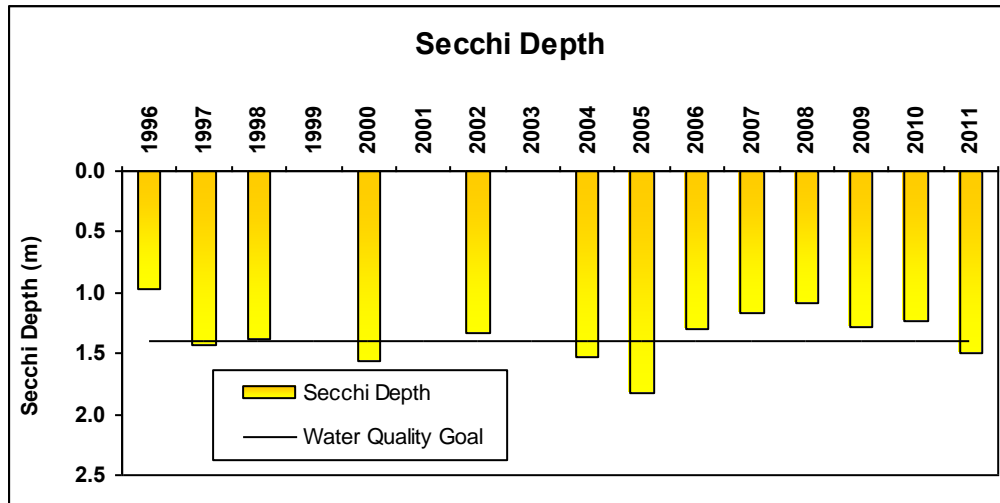


Figure 19. Lake Sarah annual changes in average Secchi depth from 1996-2011.

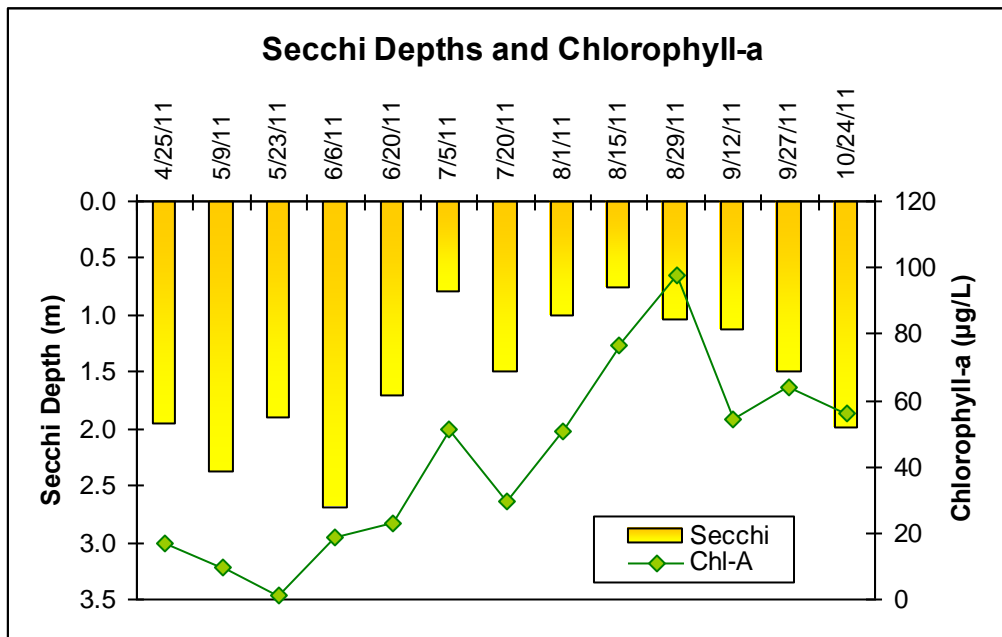


Figure 20. Lake Sarah seasonal changes in Secchi depth and chlorophyll-a concentration in 2011.

A trophic status index was calculated for Lake Sarah using the total phosphorus, chlorophyll-a, and Secchi depth measurements. In 2011, the average trophic status index of 65.3 is representative of a lake with eutrophic conditions. Eutrophic lakes tend to have an increase in nutrient enrichment, leading to the overgrowth of aquatic plants, oxygen depletion, and algal blooms. The trophic conditions for Lake Sarah are similar to other lakes within the ecoregion.

Whaletail Lake

Whaletail Lake has two distinct basins that have been monitored to assess water quality conditions. The west basin of Whaletail Lake has characteristics that are similar to a shallow lake, and the east basin has characteristics that are similar to a deep lake. The distinct differences in morphology have contributed to variations in water quality trophic conditions between the two basins. The water quality conditions were compared to the shallow lake and deep lake water nutrient criteria that are representative for each basin.

The west basin typically has had high phosphorus concentrations that exceed 90 µg/L. Due to excessive phosphorus, the west basin typically has algal blooms that result in chlorophyll-a concentrations exceeding 30 µg/L. These concentrations are significantly higher than the state standards to support recreational use for shallow lakes. Despite these impaired conditions, phosphorus and chlorophyll-a concentrations significantly decreased in 2010 and 2011 in comparison to previous years that were monitored. The west basin had an average annual total phosphorus concentration of 53.9 µg/L and a chlorophyll-a concentration of 19.2 µg/L in 2011. These concentrations currently meet the state standard to fully support recreational use for shallow lakes. Although there have been significant improvements in phosphorus and chlorophyll-a concentrations, the average annual secchi depth of 0.8 m indicates that there has not been significant improvements in water clarity conditions. The secchi depth transparency may not be algal dependent, but may be attributed to turbid conditions from re-suspension of sediment material.

It is speculated that winter fish kills in 2010 and 2011 may have resulted in an improvement in water quality. The past two winters have had significant amount of snow fall accumulation resulting in a shading effect that has reduced oxygen production from photosynthetic activity. Decomposition of organic material has further contributed to the oxygen depleted conditions. These anoxic conditions most likely resulted in partial fish kills the past two winters within the west basin. There were several dead sport-game fish and rough fish (including common carp) found along the west basin shoreline in the spring of the year after ice-out conditions. Common carp have the potential to disrupt rooted aquatic plants and re-suspend sediments creating an increase in phosphorus concentrations as well as turbid water clarity conditions. A reduction in the carp population may have contributed to an improvement in water quality conditions. There have been several shallow lakes within the ecoregion that have experienced similar winter fish kills and have simultaneously transitioned from an algal dominated to a plant dominated condition with improved water quality.

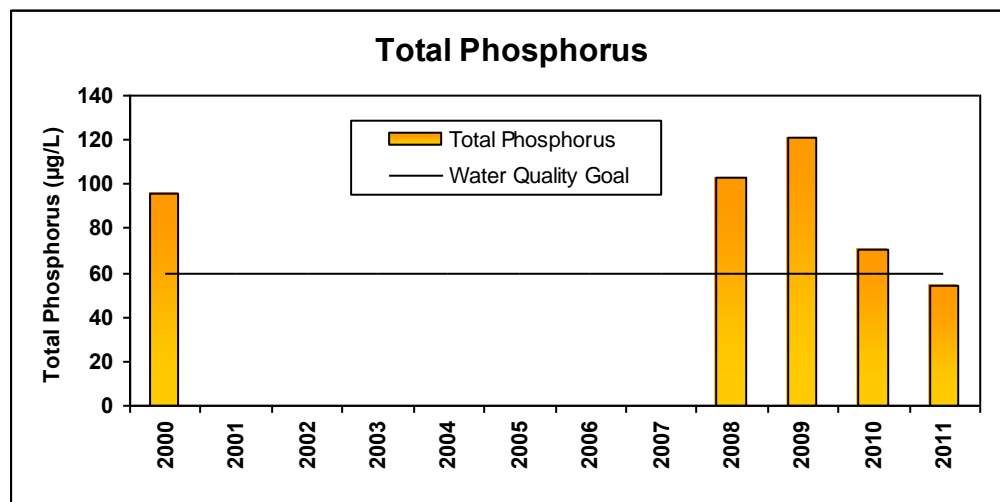


Figure 21. Whaletail West annual changes in average total phosphorus concentration from 2000-2011.

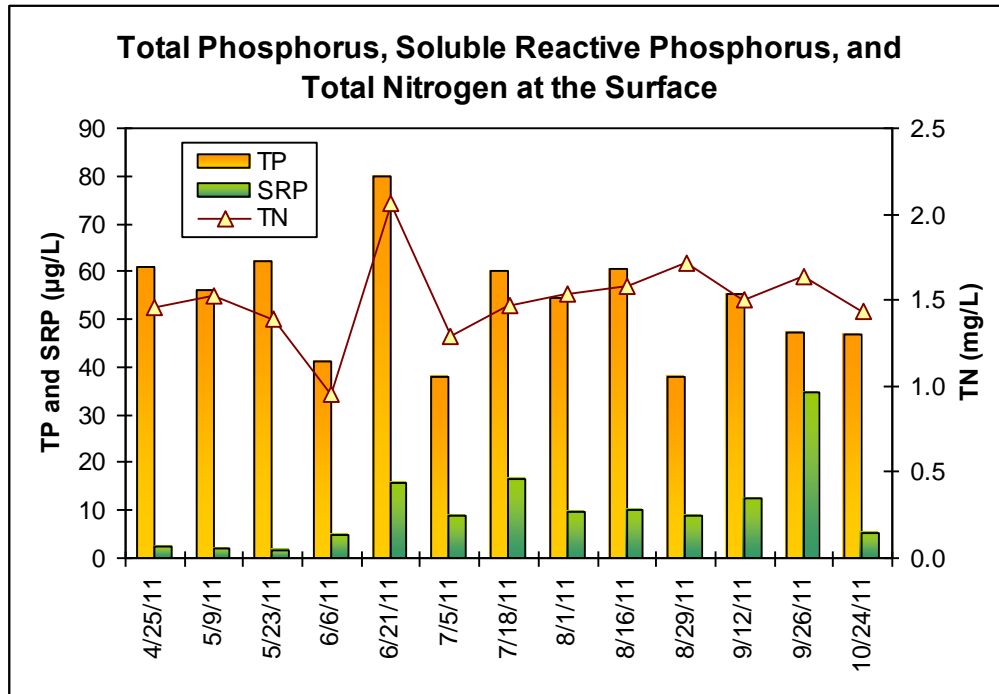


Figure 22. Whaletail West seasonal changes in total phosphorus, soluble reactive phosphorus, and total nitrogen concentrations in 2011.

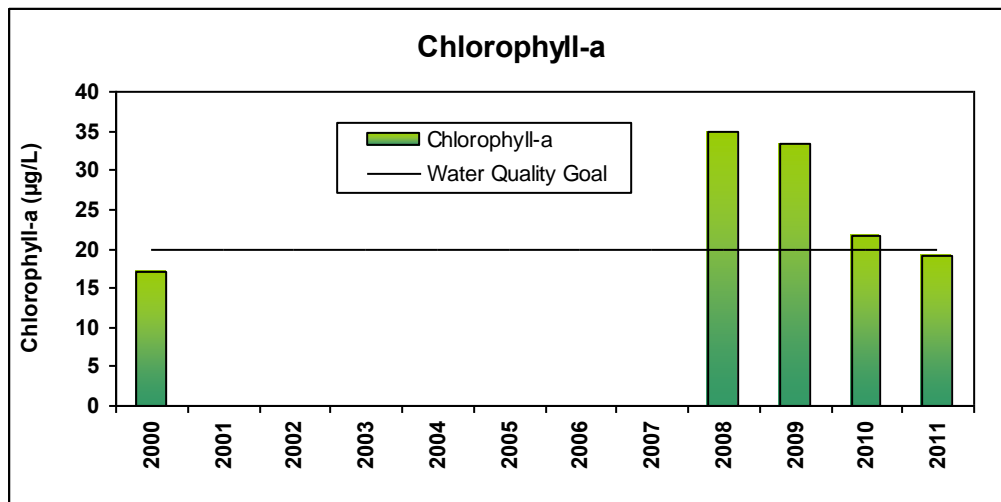


Figure 23. Whaletail West annual changes in average chlorophyll-a concentration from 2000-2011.

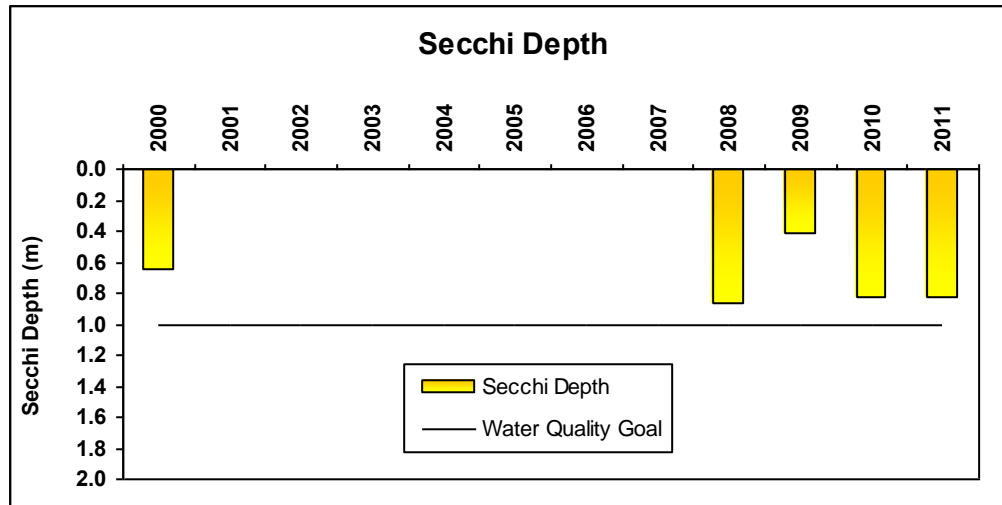


Figure 24. Whaletail West annual changes in average Secchi depth from 2000-2011.

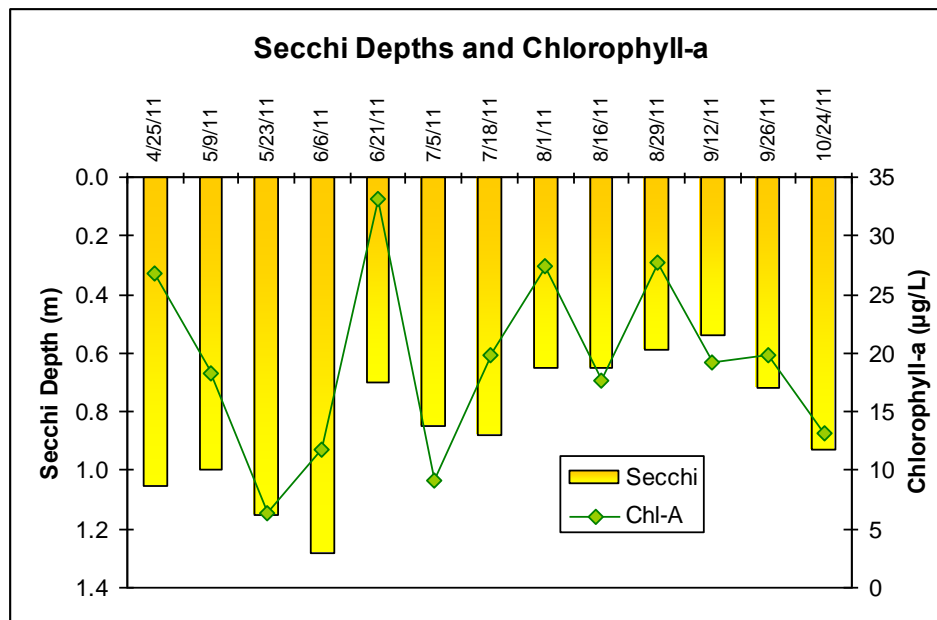


Figure 25. Whaletail West seasonal changes in Secchi depth and chlorophyll-a concentration in 2011.

The east basin of Whaletail Lake typically has had better water quality in comparison to the west basin. However, the water quality conditions in the east basin for 2011 are similar to those observed in the west basin. The east basin had an average annual total phosphorus concentration of 50.7 µg/L with values ranging from 35.5 to 65.9 µg/L (Figures 26 and 27), and an average annual chlorophyll-a concentration of 19.6 µg/L with values ranging from 1.0 to 3.7 µg/L (Figure 28). Although these concentrations exceed MPCA “deep lake” eutrophication standards, these concentrations are not significantly different in comparison to the concentrations observed in the west basin. The water quality in the east basin has not necessarily degraded, but appears to have slightly improved. Consequently, the similarities in water quality conditions are more likely attributed to improvements in water quality in the west basin.

Despite similar phosphorus and chlorophyll-a concentration between basins in 2011, the west basin has better water clarity transparency. In 2011, the average Secchi depth transparency in the east basin was 1.6 m with values ranging from 0.95 to 3.66 (Figures 29 & 30). The improved water clarity may be attributed to the differences in basin morphology. The east basin has a maximum depth of 8 m that allows for the development of in-lake stratification during the summer. Stratification within the east basin typically persists throughout the summer (June – September) which confines the nutrients from sediment release within the hypolimnion. The west basin shallow morphology is more conducive for re-suspension of sediments due to wind mixing. Based on the east basin water quality, the re-suspension of nutrients and sediments does not appear to occur as frequently as the west basin. Currently, the secchi depth transparency for the east basin does meet MPCA “deep lake” standards.

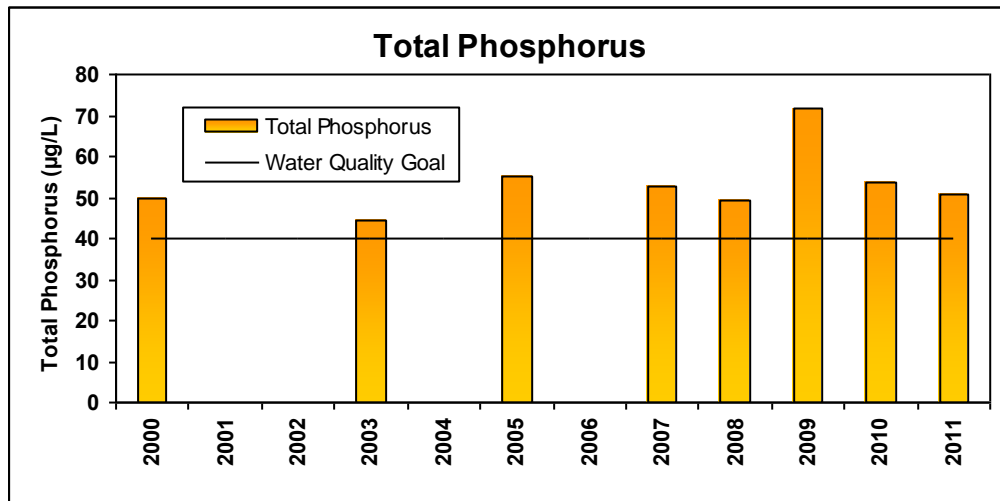


Figure 26. Whaletail East annual changes in total phosphorus concentration from 2000-2011.

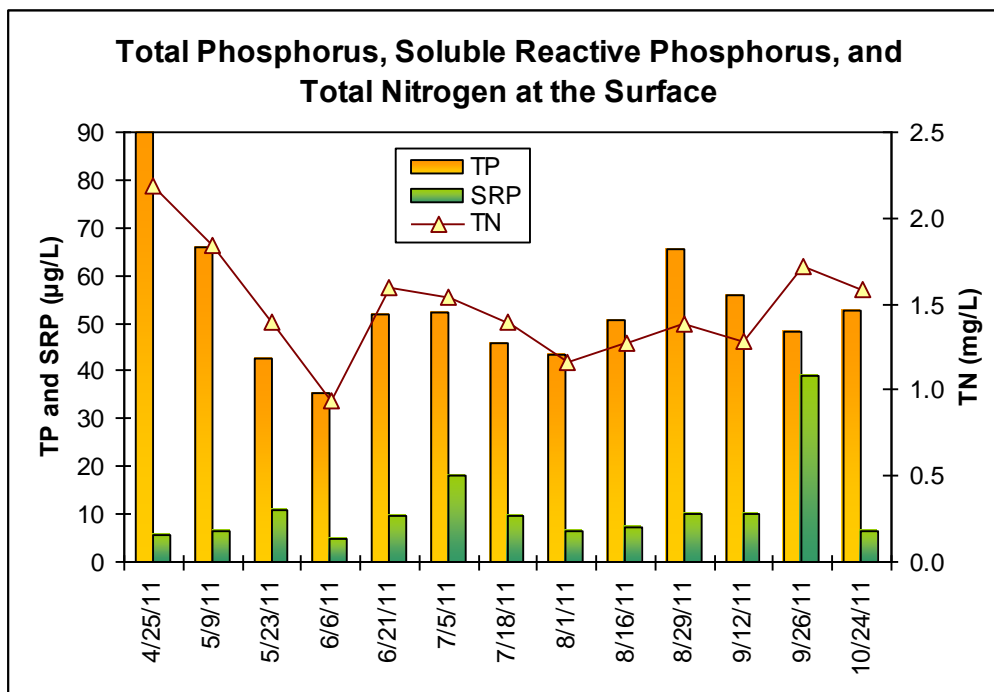


Figure 27. Whaletail East seasonal changes in total phosphorus, soluble reactive phosphorus, and total nitrogen concentrations in 2011.

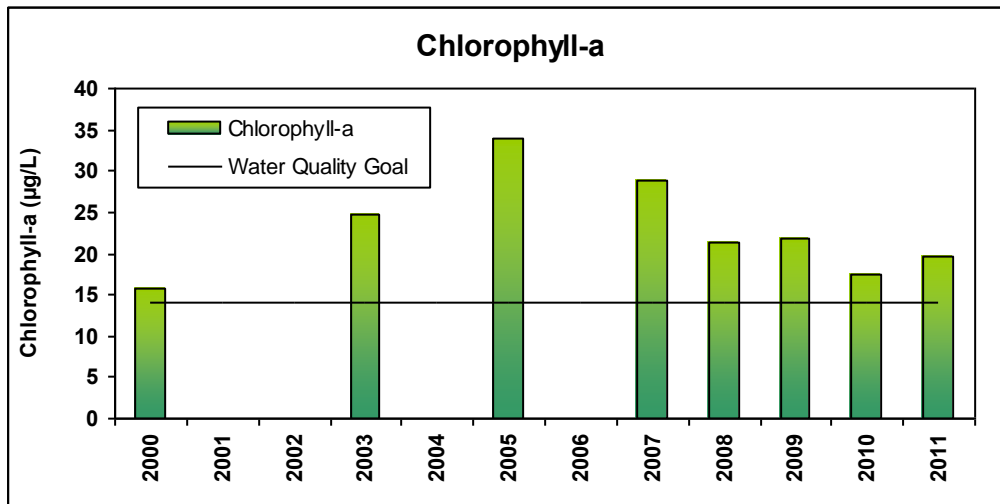


Figure 28. Whaletail East annual changes in chlorophyll-a concentration from 2000-2011.

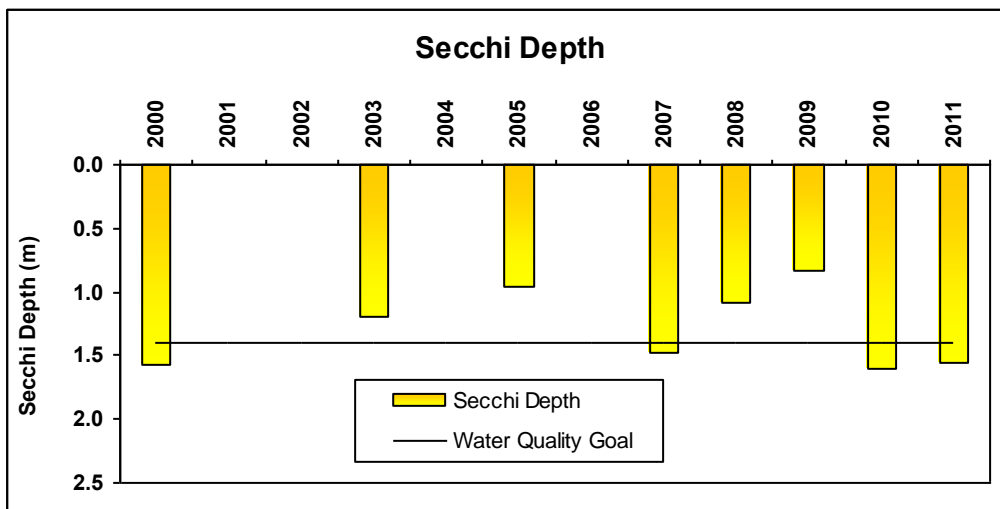


Figure 29. Whaletail East annual changes in average Secchi depth from 2000-2011.

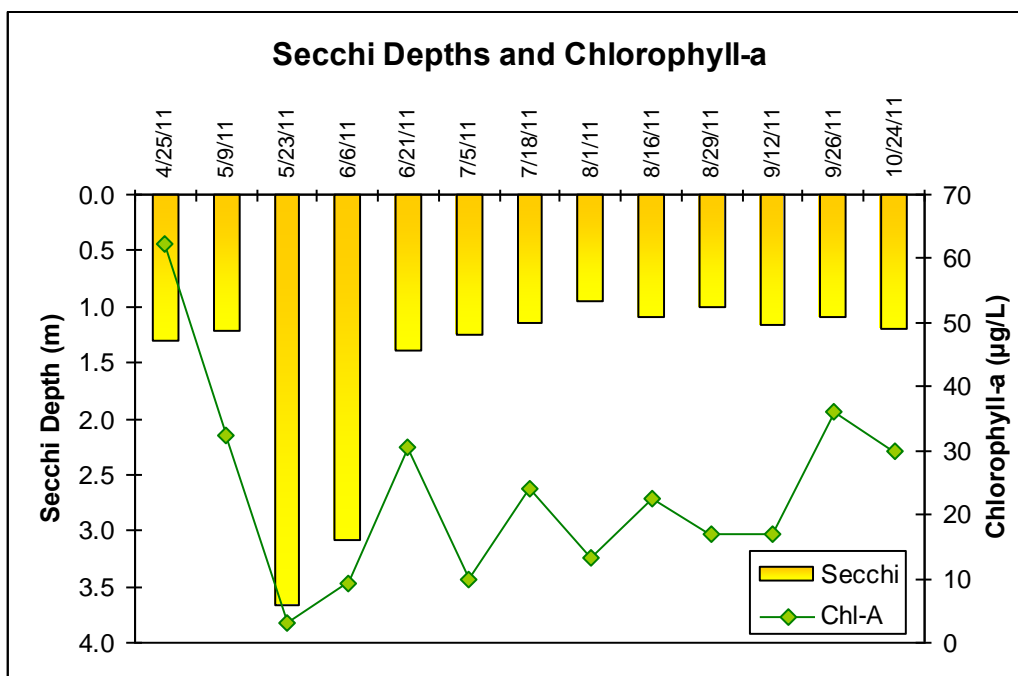


Figure 30. Whaletail East seasonal changes in Secchi depth and chlorophyll-a concentration in 2011.

Three Rivers Park District
Lake Restoration Project – Lake Rebecca
Monitoring Summary

Background

Table 1 summarizes key features of Lake Rebecca (DNR ID #27-0192) and its watershed.

Table 1 - Key Characteristics of Lake Rebecca

Lake ID #	27-0192
Lake area (acres)	254 ac.
Ecoregion ¹	NCHF
Maximum depth in ft. (meters)	30 ft. (9.3 m)
% of lake area ≤ 15 ft.	54%
Lake depth classification	Deep
Watershed area (ac.)	1,230
Watershed/Lake area ratio	5.5:1

¹North Central Hardwood Forest Ecoregion

The lake has been the subject of a lake restoration effort over the last several years. These efforts have included the following:

1. Improvements to the Shriner Horse Farm to decrease nutrient loadings to reduce nutrient loading to the lake from one of its main tributaries (completed in 2008).
2. Construction of several stormwater BMP's within Lake Rebecca Park Preserve to decrease phosphorus loadings from developed areas of the Park to the lake (on-going)
3. Initiation of multi-year low dose, early season aquatic herbicide treatments to decrease the abundance of curly leaf pondweed and enhance the native aquatic plant community (initiated in 2009).
4. Completion of a batch alum treatment to reduce internal loading from enriched sediments in the lake (completed in spring 2011).

The project is being undertaken by Three Rivers Park District (TRPD). Park staff received assistance from Hennepin County Environmental Services staff in executing the improvements to the Shriner horse farm. The project has also been supported with grants from the Lessard Outdoor Heritage Fund and Hennepin County.

Monitoring Summary

Because less than 80% of Lake Rebecca's area is less than 15 feet deep, the lake is classified as a deep lake with regard to Minnesota's lake eutrophication standards. Table 2 presents Minnesota's eutrophication water quality standards for deep lakes in the north central hardwood forest (NCHF) ecoregion, which is where Lake Rebecca is located. Meeting these standards is considered necessary to adequately protect aquatic recreation.

**Table 2 - Minnesota Eutrophication Water Quality Standards
for Deep Lakes in North Central Hardwood Forest Ecoregion**

Parameter	Standard ¹
Total Phosphorus	≤ 40 ug/l
Chlorophyll a	≤ 14 ug/l
Secchi Depth (Water clarity)	≥ 1.4 meter

¹Values expressed mean values for the June-September period

TRPD staff collected water quality data for Lake Rebecca every two weeks during the open water season in 2011. Samples were taken by boat in the deepest part of the lake and were analyzed by TRPD staff in their certified water quality lab to determine concentrations for phosphorus and chlorophyll a. Data collected for the 2011 growing season show that Rebecca Lake had exceptional water quality that easily met the Minnesota eutrophication water quality standards. A comparison of the state eutrophication standards with 2011 data for Lake Rebecca is shown in Table 3.

Table 3 - Comparison of 2011 Eutrophication Data for Lake Rebecca with Minnesota Water Quality Standards

Parameter	Standard ¹	2011 Data for Lake Rebecca ¹
Total Phosphorus	≤40 ug/l	28.2ug/l
Chlorophyll a	≤14ug/l	10.2ug/l
Secchi Depth (Water clarity)	≥1.4 meter	2.2 meters

¹Values expressed mean values for the June-September period

To aid in a visual assessment of trends, Figures 1 - 3 show plots of historical water quality data (including data from 2011) for total phosphorus, chlorophyll a, and Secchi depth (water clarity) for Lake Rebecca. For reference, horizontal lines are included in each graph that show the state standard for that parameter. These data show that 2011 is the first year since the early 1990's that the growing season mean values for all parameters have been as good or better than their respective standard. The improvements are attributable to the watershed and in-lake projects that have been undertaken since 2008. Monitoring will continue to be done by TRPD staff in future years to determine the longevity of the water quality improvements and/or to help gage the need for additional management measures to improve the resiliency of the system.

Figure 1 – Historical Total Phosphorus Values for Lake Rebecca

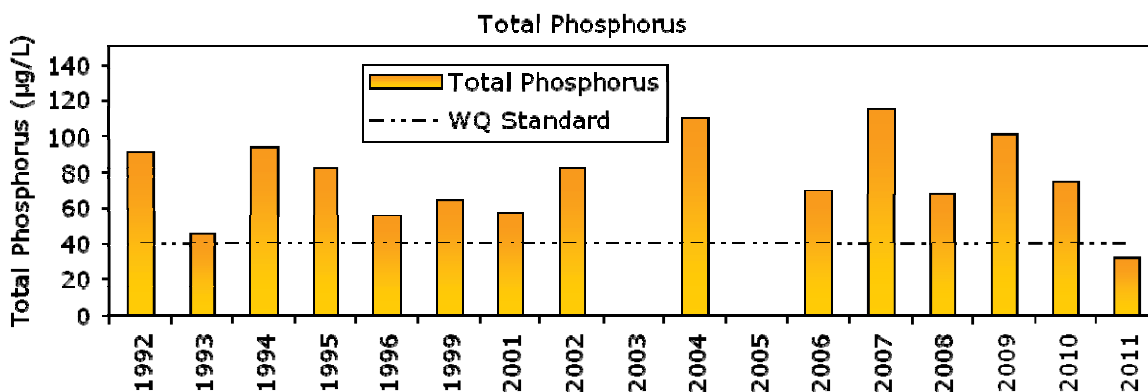


Figure 2 – Historical Chlorophyll a Values for Lake Rebecca

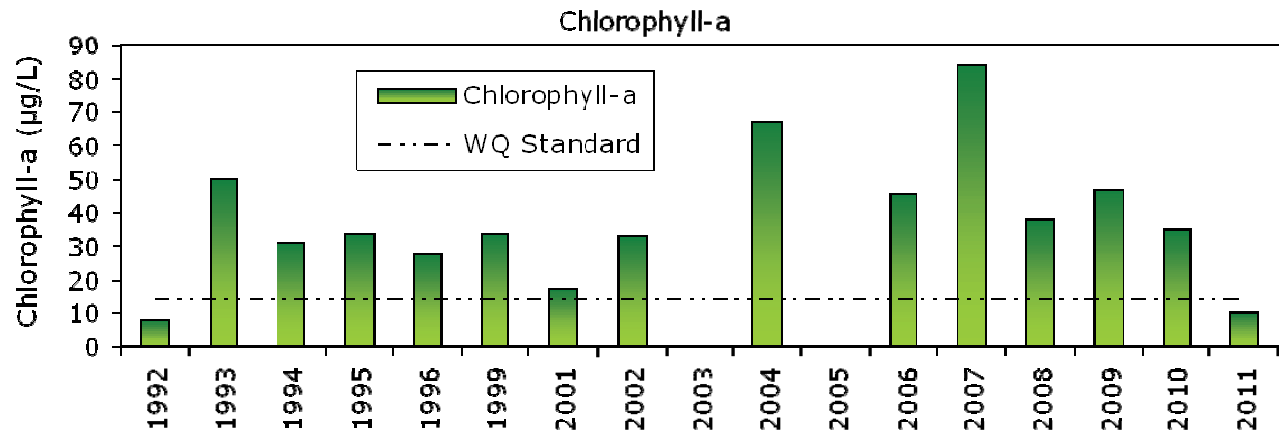
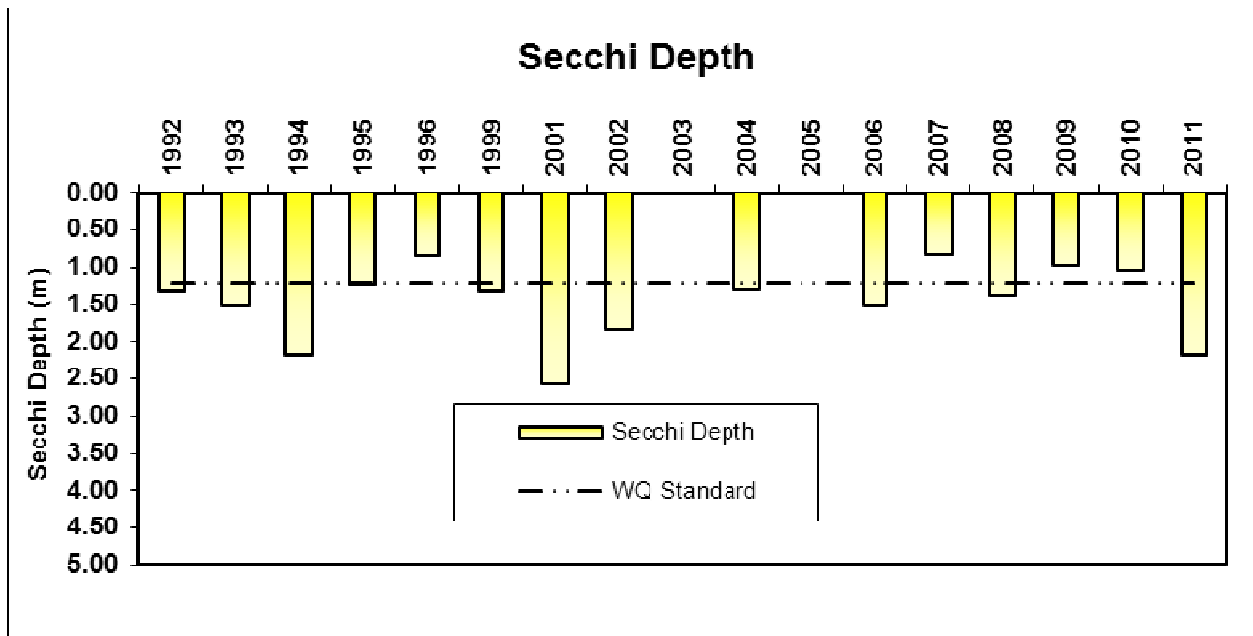


Figure 3 – Historical Water Clarity Values for Lake Rebecca



Picture 1 – Alum Barge on Lake Rebecca



Picture 2 – Beachfront Improvements to Reduce Stormwater Runoff to Lake



