Picture: School Lake near outlet, July 30, 2007

COMFORT LAKE-FOREST LAKE WATERSHED DISTRICT 2013 WATER MONITORING REPORT

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Comfort Lake-Forest Lake Watershed District

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2013 STREAM MONITORING REPORT

I. EXECUTIVE SUMMARY

This portion of the report focuses on the summary and comparison of the stream water quality data collected by the Washington Conservation District (WCD) from January 1 – December 31, 2013, as well as historical data. In 2013, at the request of the Comfort Lake-Forest Lake Watershed District (CLFLWD) the WCD conducted continuous discharge and stream water quality monitoring at the following sites: Tributary to Bone Lake at Bone Lake North Inlet, Tributary to Sunrise River at Bone Lake Outlet, Tributary to Sunrise River at Little Comfort Lake Inlet, Sunrise River at Forest Lake Outlet, Tributary to Sunrise River at Heims Lake Drainage (new site in 2012), Sunrise River at Greenway Avenue, Sunrise River at Comfort Lake Inlet, and Sunrise River at Comfort Lake Outlet (Figure 2). Automated storm composite, manual base and storm grab, and *E. coli* samples were collected at each site, with the exception of Sunrise River at Forest Lake Outlet and Tributary to Sunrise River at Bone Lake Outlet where no samples were collected. For the 2013 monitoring season the decision was made to switch to collecting an automated storm composite sample, taking advantage of the monitoring equipment that was already at the site collecting data. However, manual storm grabs were collected when deemed necessary. Snowmelt grabs were also collected where possible. Site locations and monitoring types can be found in Table 3. This report and the accompanying data will also be provided in an electronic format. Please contact the Washington Conservation District at (651) 275-1136 to obtain historical data.

Each of the stream monitoring sites showed an increase in total discharge in 2013 as compared to 2012. The cause of the overall increase in discharge could be attributed to the above average amount of snow observed in the winter of 2012/2013 and early spring of 2013 and the above average precipitation from April through June of 2013. Average monthly precipitation totals were derived from historic 30-year (1981-2010) averages for this region. The total precipitation for 2013, according to the State Climatology Office, was 35.07 inches while the average annual precipitation is 30.61 inches; it was an above average year for precipitation (Figure 1). Tributary to Bone Lake at Bone Lake North Inlet, Tributary to Sunrise River at Little Comfort Lake Inlet, Sunrise River at Forest Lake Outlet, Tributary to Sunrise River at Heims Lake Drainage, and Sunrise River at Comfort Lake Outlet all showed an increase in total phosphorus (TP) loads in 2013 as compared to 2012. Sunrise River at Greenway Avenue and Sunrise River at Comfort Lake Inlet showed a decrease in TP loads. The total phosphorus load for the Sunrise River and entire Comfort Lake-Forest Lake Watershed District was estimated at 0.087 lbs./ac (2,129 lbs.) as determined by the Sunrise River at Comfort Lake Outlet site (Table 23). Table 1 provides the 2013 discharge, loading, and rainfall summary for each stream monitoring station.

While stream monitoring has been taking place on CLFLWD streams since 2004 it should be noted that the sampling technique has changed at almost all sites. When monitoring began the automated composite sampling technique was used at most sites. This involves multiple water samples collected at various flow points by an automated device, typically during storm events. Composite samples generally capture more of the rising limb and peak of a storm event where most nutrient loading is likely to occur. Between the years of 2005 and 2009 the sampling technique changed at several sites to grab samples, which is a manually collected discrete water sample. The issue with manual grab samples is the timing of the sample collection; it is very easy to miss the rising limb or peak of a storm event. Grab samples capture data at just one point in time during the storm event whereas a composite sample collects many samples during different points in the storm event. Composite samples can produce a more accurate loading number. When comparing loading numbers at sites where the sampling technique has changed it appears as though at some point there is a significant decrease in TP load. This apparent decrease correlates with the year in which the sampling technique was changed from composite to grab samples. When looking at the loading numbers it may lead to an unrealistic conclusion that phosphorus loads are decreasing. The switch in sampling techniques must be taken into consideration when comparing loading numbers. The 2012 monitoring season brought a slight change in sampling technique for all monitored

sites yet again. Grab sampling was still the technique used however; the samples were collected using the automated sampler versus a manual grab. The reasoning was that the timing of the grab sample would be more accurate when automatically collected, during the rising limb or at the peak of the storm event. In 2013 it was decided to go back to collecting automated storm composite samples in order to achieve more accurate loading numbers from sites where samples are collected.

The Sunrise River at Forest Lake Outlet, Sunrise River at Comfort Lake Outlet, and Tributary to Sunrise River at Bone Lake Outlet sites have each utilized three different sampling techniques. All three sites started with the automated composite sampling technique, then switched to manual grab samples, and finally switched to using in-lake TP concentrations to estimate load. At Forest Lake Outlet composite sampling was used for the 2004 and 2005 monitoring seasons and switched to manual grab samples in 2006. Sampling ceased at the site in 2007 and all TP loads since then have been estimated using in-lake sample concentrations collected in the West Basin of Forest Lake. At Comfort Lake Outlet composite sampling was used for the 2004 and 2005 monitoring seasons and switched to manual grab samples in 2006. Grab samples were also collected in 2008 by the Army Corps of Engineers. In-lake TP concentrations were used to estimate load for the 2009 and 2010 monitoring seasons. In 2011 manual grab samples were once again collected at this site and in 2012 automated grab samples were collected. In 2013 automated storm composite samples were once again collected. At Bone Lake Outlet automated composite sampling was used in 2004 and 2005 and switched to manual grab samples in 2006. Monitoring was discontinued at this site from 2007 through 2012. Monitoring resumed in 2013 using in-lake TP concentrations collected in Bone Lake to estimate load. As with grab samples, using in-lake total phosphorus concentrations may lead to artificially low loading numbers. This is due to the difference in sampling technique and location (in-lake versus in-stream). More accurate loading numbers can be estimated by collecting samples at the monitoring site. Once again, the changes in sampling techniques must be taken into consideration when comparing loading numbers.

Table 1. CLFLWD 2013 Stream Discharge, Loading, and Rainfall Summary

Site	Subwatershed (acres)	Yearly Discharge (cf)	Yearly Discharge (ac-ft.)	Peak Discharge (cfs)	Yearly Total Phosphorus Load (lbs.)	Yearly Total Suspended Solids Load (lbs.)	Monitored Rainfall (in.)
Bone Lake North Inlet	2,479	16,205,989	372	5.016	349	14,512	14.96
Bone Lake Outlet	5,495	80,882,661	1,858	13.283	194	NA	NA
Little Comfort Lake Inlet	10,513	60,039,577	1,379	11.686	330	50,187	13.89
Forest Lake Outlet	8,719	311,584,377	8,719	33.004	706	NA	NA
Heims Lake Drainage	667	9,605,584	221	4.128	495	24,224	NA
Greenway Avenue	10,874	326,439,257	7,498	34.651	2,071	129,646	NA
Comfort Lake Inlet	13,732	355,022,452	8,154	33.531	1,519	99,754	15.68
Comfort Lake Outlet	24,558	425,748,209	9,779	55.228	2,129	147,718	16.87

The WCD also conducted monitoring on seven lakes for CLFLWD in 2013. A map of the locations of the monitoring sites can be found in Figure 2 and a table of the locations and monitoring types can be found in Table 3. The monitored lakes were as follows: Bone Lake, Comfort Lake, Forest Lake (West, Middle, and East Basins), Little Comfort Lake, Moody Lake, Shields Lake, and Sylvan/Halfbreed Lake. Lake results are discussed in the Lake Monitoring portion of this report.

II. INTRODUCTION AND METHODS

This portion of the report focuses on the summary and comparison of the stream water quality data collected by the Washington Conservation District (WCD) from January 1 – December 31, 2013, as well as historical data. In 2013, the WCD conducted continuous discharge and stream water quality monitoring at eight sites: Tributary to Bone Lake at Bone Lake North Inlet, Tributary to Sunrise River at Bone Lake Outlet, Tributary to Sunrise River at Little Comfort Lake Inlet, Sunrise River at Forest Lake Outlet, Tributary to Sunrise River at Heims Lake Drainage (new site in 2012), Sunrise River at Greenway Avenue, Sunrise River at Comfort Lake Inlet, and Sunrise River at Comfort Lake Outlet (Figure 2). Automated storm composite, manual base and storm grab, and *E. coli* samples were collected at each site, with the exception of Sunrise River at Forest Lake Outlet and Tributary to Sunrise River at Bone Lake Outlet where no samples were collected. Site locations and monitoring types can be found in Table 3. Multiple water quality parameters were monitored and analyzed at each stream site. The purpose of this monitoring was to assess and document the current water quality conditions of the streams, identify problem resources or areas, and to continue a long-term baseline monitoring program which will enable the Comfort Lake-Forest Lake Watershed District (CLFLWD) to identify trends associated with land use changes in the watershed.

Continuous stage, velocity, and discharge measurements were recorded every 15 minutes at the Tributary to Bone Lake at Bone Lake North Inlet from May 13-November 4, 2013, Tributary to Sunrise River at Bone Lake Outlet from April 24-November 4, 2013, Tributary to Sunrise River at Little Comfort Lake Inlet from May 13-November 4, 2013, Sunrise River at Forest Lake Outlet from April 9-November 3, 2013, Tributary to Sunrise River at Heims Lake Drainage from April 9-November 4, 2013, Sunrise River at Greenway Avenue from May 15-November 4, 2013, Sunrise River at Comfort Lake Inlet from May 13-November 4, 2013, and Sunrise River at Comfort Lake Outlet from April 9-November 4, 2013. Precipitation data was also continuously collected at Tributary to Bone Lake at Bone Lake North Inlet, Tributary to Sunrise River at Little Comfort Lake Inlet, Sunrise River at Comfort Lake Inlet, and Sunrise River at Comfort Lake Outlet.

Staff gages were installed and read at each site. Field stage measurements were taken in the stream channels by measuring the area/velocity sensor (probe) depth. Temperature, dissolved oxygen, specific conductivity, pH, and transparency tube measurements were also taken. Stage-discharge relationships were developed at all stream sites and an area-velocity relationship was used to determine discharge during certain time periods. Automated storm composite and manual storm and base flow grab samples were collected at all continuous stream monitoring sites, with the exception of Sunrise River at Forest Lake Outlet and Tributary to Sunrise River at Bone Lake Outlet where no samples were collected. *E. coli* grab samples were also collected at all sampled monitoring sites. Duplicate base and/or storm samples were collected at most monitored sites per WCD standard operating procedures. The purpose of duplicate samples is to obtain information on the magnitude of errors owing to contamination, random and systematic errors, and any other variabilities that are introduced from the time of sampling until the samples arrive at the lab, therefore the duplicate results are not incorporated into the report. The Metropolitan Council Environmental Services Laboratory in St. Paul analyzed all samples. A complete list of detailed Washington Conservation District water monitoring methods and standard operating procedures can be found at http://www.mnwcd.org/water-quality-water-monitoring/.

CLFLWD streams are considered to be Class 2B Waters, according to the Minnesota Pollution Control Agency (MPCA). These types of streams are described as cool- and warm-water fisheries (not protected for drinking water) and are held to certain water quality standards as set by the MPCA (https://www.revisor.mn.gov/rules/?id=7050.0222). The state standards can be found in Table 2. According to

the MPCA, water quality standards are used to: "define maximum allowable levels of pollutants to protect beneficial uses, ascertain the quality of the state's water resources by comparing the standards to monitoring data, identify waters that are polluted, help establish priorities for the allocation of treatment resources and cleanup efforts, set effluent limits and treatment requirements for dischargers in some situations, and assess risks to surface water from ground water contamination sites and help define cleanup goals." More water quality standard information can be found here: http://www.pca.state.mn.us/index.php/water/water-monitoring-and-reporting/water-quality-and-pollutants/water-quality-standards.html.

It is important to track these water quality standards at each site to determine if the waters are meeting state goals and whether or not they are impaired. The MPCA is working on developing new standards for altered stream systems as part of the Tiered Aquatic Life Uses (TALU) framework (http://www.pca.state.mn.us/index.php/water/water-permits-and-rules/water-rulemaking/tiered-aquatic-life-use-talu-framework.html).

Table 2. MPCA Class 2B Water Quality Standards

Parameter	Water Quality Standard
Chloride (Chronic)	> 230 mg/L
Low DO	< 5 mg/L as daily minimum
pH	< 6.5 or >8.5
Turbidity	> 25 NTU
Turbidity (TSS values)	> 100 mg/L
Turbidity (Transparency values)	< 20 cm
E. coli	> 126 mg/L

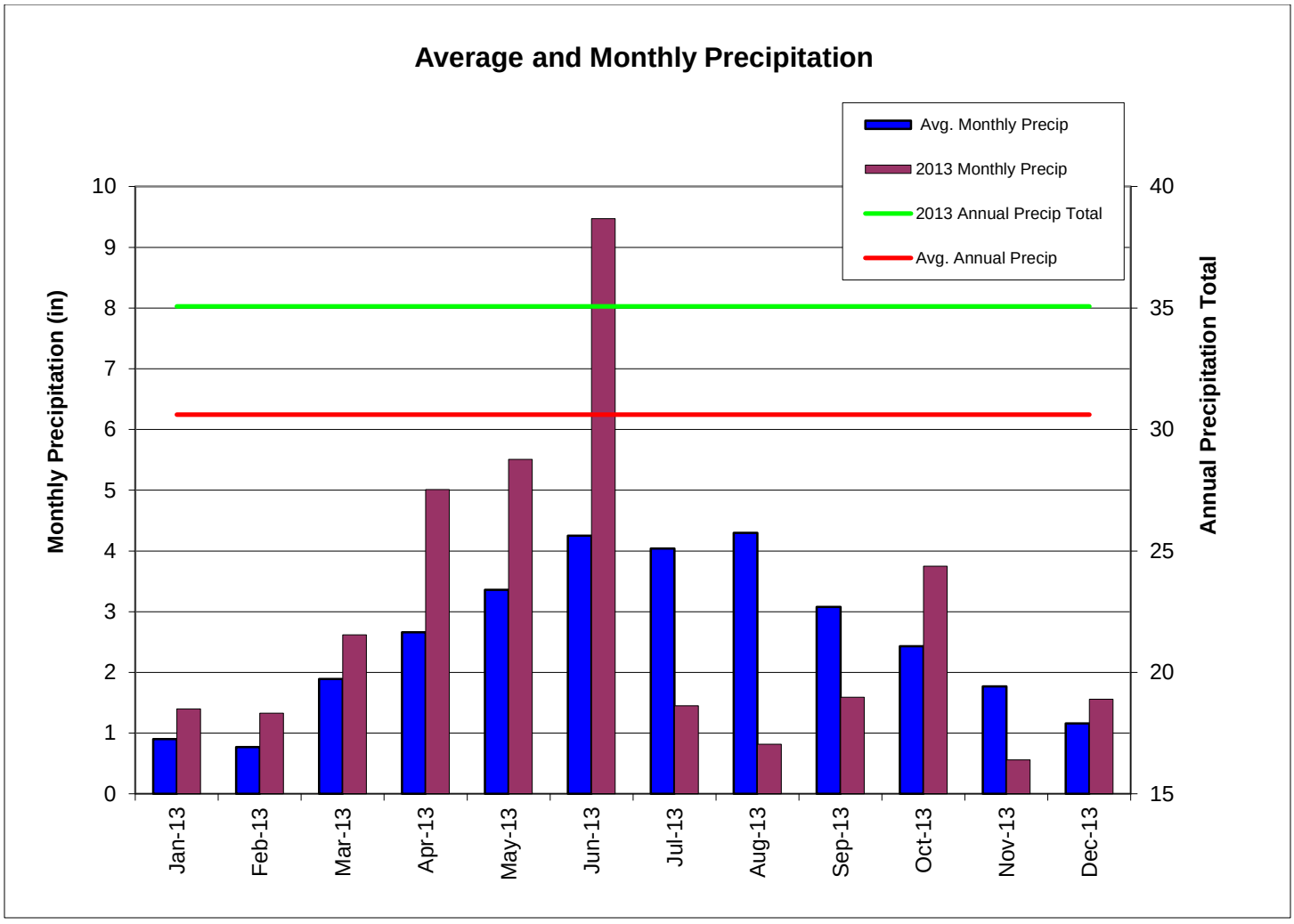


Figure 1. 2013 Monthly Precipitation and Historic 30-Year Average Monthly Precipitation

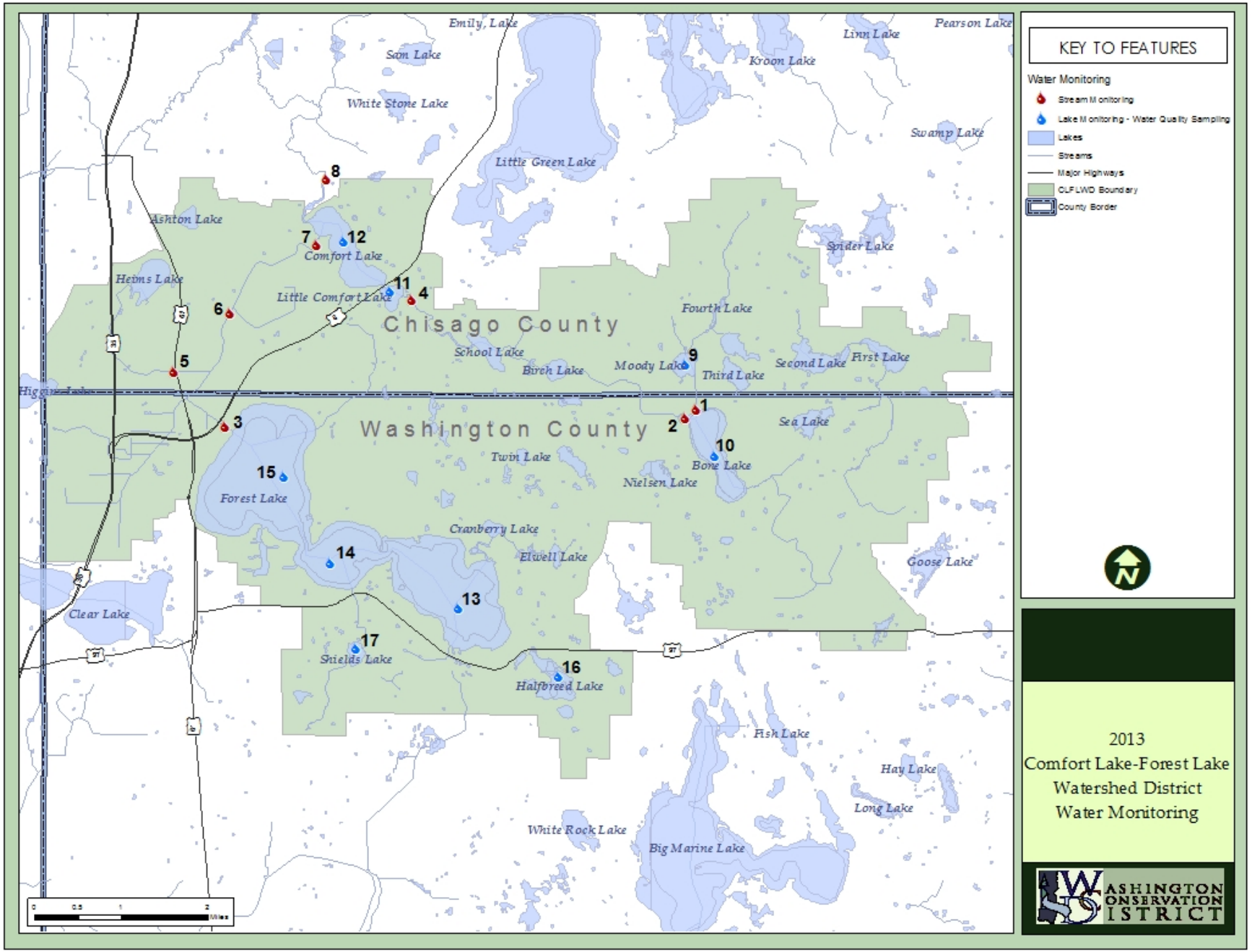


Figure 2. CLFLWD Monitoring Locations

Table 3. Monitoring Site Location and Description Summary

Site Description	Map Site ID#	Full Site Name	Summarized Site Name	General Site Location	Monitoring Site Description	Monitored Parameters
Stream Monitoring	**1**	Tributary to Bone Lake at Bone Lake North Inlet	Bone Lake North	238th Street North	Flow Monitoring Through Culvert	Discharge and Automated Water Quality Grab Samples*
Stream Monitoring	**2**	Tributary to Sunrise River at Bone Lake Outlet	Bone Lake Outlet	Lofton Avenue North	Flow Monitoring Through Culvert	Discharge Only
Stream Monitoring	**3**	Tributary to Sunrise River at Forest Lake Outlet	Forest Lake Outlet	North Shore Drive	Flow Monitoring in Natural Cross-Section	Discharge Only
Stream Monitoring	**4**	Tributary to Sunrise River at Little Comfort Lake Inlet	Little Comfort Lake Inlet	Itasca Avenue	Flow Monitoring Through Culvert	Discharge and Automated Water Quality Grab Samples*
Stream Monitoring	**5**	Tributary to Sunrise River at Heims Lake Drainage	Heims Lake Drainage	Hwy 61	Flow Monitoring in Natural Cross-Section	Discharge and Automated Water Quality Grab Samples*
Stream Monitoring	**6**	Sunrise River at Greenway Avenue	Greenway Ave.	Greenway Avenue	Flow Monitoring Through Culvert	Discharge and Automated Water Quality Grab Samples*
Stream Monitoring	**7**	Sunrise River at Comfort Lake Inlet	Comfort Lake Inlet	West Comfort Drive	Flow Monitoring Through Culvert	Discharge and Automated Water Quality Grab Samples*
Stream Monitoring	**8**	Sunrise River at Comfort Lake Outlet	Comfort Lake Outlet	Wyoming Trail	Flow Monitoring in Natural Cross-Section	Discharge and Automated Water Quality Grab Samples*
Lake Monitoring	**9**	Moody Lake	---	Chisago Lakes Township	---	Surface Water Quality Samples, Elevation**
Lake Monitoring	**10**	Bone Lake	---	City of Scandia	---	Surface Water Quality Samples, Elevation**
Lake Monitoring	**11**	Little Comfort Lake	---	Chisago City	---	Surface Water Quality Samples**
Lake Monitoring	**12**	Comfort Lake	---	City of Wyoming	---	Surface Water Quality Samples, Elevation**
Lake Monitoring	**13**	Forest Lake – East Basin (3)	---	City of Forest Lake	---	Surface Water Quality Samples**
Lake Monitoring	**14**	Forest Lake – Middle Basin (2)	---	City of Forest Lake	---	Surface Water Quality Samples**
Lake Monitoring	**15**	Forest Lake – West Basin (1)	---	City of Forest Lake	---	Surface Water Quality Samples**
Lake Monitoring	**16**	Sylvan/Halfbreed Lake	---	City of Forest Lake	---	Surface Water Quality Samples, Elevation**
Lake Monitoring	**17**	Shields Lake	---	City of Forest Lake	---	Surface Water Quality Samples, Elevation**

*Stream Monitoring Water Quality Sample Parameters Include: Total Phosphorus, Dissolved Phosphorus, Total Kjeldahl Nitrogen, Nitrate, Nitrite, Ammonia Nitrogen, Total Suspended Solids, Volatile Suspended Solids, Total Chlorides, *E. coli* Bacteria

**Lake Monitoring Water Quality Sample Parameters Include: Total Kjeldahl Nitrogen, Total Phosphorus, Chlorophyll-a, Secchi Disk Transparency

II. BONE LAKE SUBWATERSHED

Bone Lake North Inlet

The station at the Bone Lake North Inlet recorded stage, velocity, and rainfall from May 13-November 4, 2013 (Figure 3). This site was removed prior to the end of the 2012 monitoring season in preparation for the Bone Lake fish barrier project construction. As a result of that project the site had to be monitored in a pipe for 2013 instead of a natural stream channel, as it had been done in the past. Total discharge during this period was 16,205,989 cf or 372 acre-ft. Total rainfall recorded during the monitoring season was 14.96 inches. Peak discharge of 5.016 cfs was recorded on June 27th.

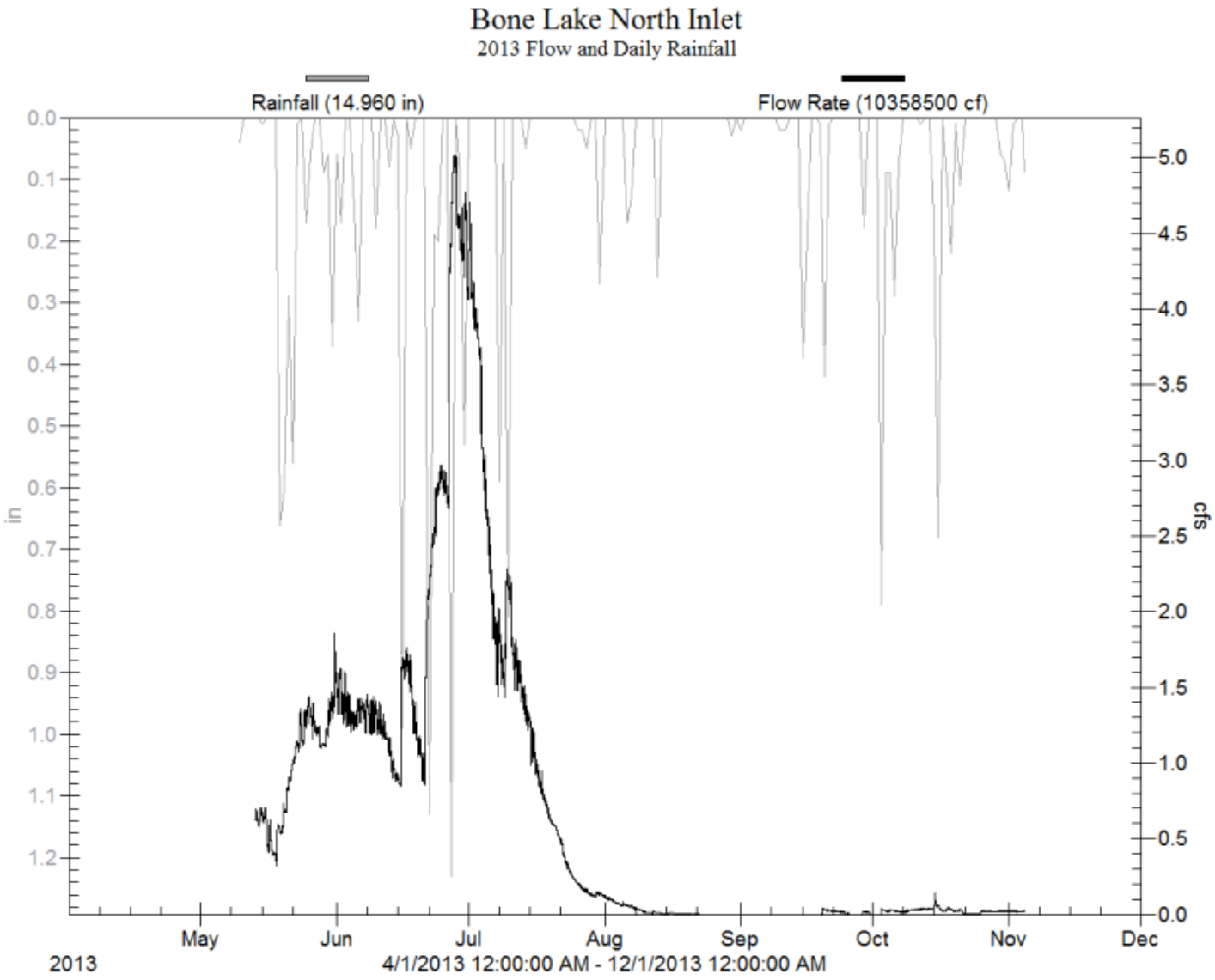


Figure 3. Bone Lake North Inlet 2013 Flow and Daily Rainfall

A limited number of automated storm composite, manual base grab, and snowmelt grab samples were collected at the Bone Lake North Inlet site in 2013. The total suspended solids (TSS), volatile suspended solids (VSS), total Kjeldahl nitrogen (TKN), total phosphorus (TP), dissolved phosphorus, chloride, nitrite, nitrate, ammonia nitrogen, and *E. coli* results from all collected samples are listed in Table 4 and field water quality measurements are listed in Table 5. The highest TKN result of 2.5 mg/L and the highest TP result of 0.528 mg/L both came from a base grab collected on July 17th. The highest TSS result of 27 mg/L also came from the same grab.

Table 4. Bone Lake North Inlet 2013 Sample Chemistry Results

Sample Type	Start	End	TSS (mg/L)	VSS (mg/L)	TKN (mg/L)	TP (mg/L)	Dissolved TP (mg/L)	Chloride (mg/L)	Nitrite (mg/L)	Nitrate (mg/L)	Ammonia Nitrogen (mg/L)	*E. coli* (mpn/100ml)
Snowmelt Grab	4/8/2013 11:07	4/8/2013 11:07	8	~2	1.5	0.213	0.177	7.8	<0.03	0.16	0.26	
Storm Composite	6/23/2013 4:13	6/23/2013 12:28	8	6	1.7	0.293	0.119	13.2	<0.03	0.08	~0.03	
Base Grab	7/17/2013 14:01	7/17/2013 14:01	27	20	2.5	0.528	0.127	12.2	<0.03	<0.05	0.28	
E. coli Grab	6/27/2013 9:38	6/27/2013 9:38										1733

Table 5. Bone Lake North Inlet 2013 Field Water Quality Measurements

Date/Time	Transparency (cm)	Water Temperature (C)	Dissolved Oxygen (mg/L)	Conductivity (umhos/cm)	pH
4/8/2013 11:07		0.4		108	7.8
7/17/2013 14:01	70	24.4	0.09	230	6.8

Exceeds Water Quality Standard

Table 6. Bone Lake North Inlet 2013 Total Suspended Solids and Total Phosphorus Loading

	Sample Collection Time				Loading Interval					
Sample Type	Start	End	TSS (mg/L)	TP (mg/L)	Start	End	Interval Volume (cf)	Interval Volume (ac-ft)	Interval TSS (lb)	Interval TP (lb)
*Base**			*14*	*0.345*	*1/1/13 0:00*	*4/7/13 18:30*	*4,180,500*	*96.02*	*3740.6*	*89.95*
Snowmelt Grab*	4/8/2013 11:07	4/8/2013 11:07	8	0.213	4/7/13 18:30	4/9/13 5:30	88,200	2.03	44.0	1.17
*Base**			*14*	*0.345*	*4/9/13 5:30*	*5/13/13 11:30*	*1,479,600*	*33.98*	*1323.9*	*31.84*
Base			*14*	*0.345*	*5/13/13 11:30*	*5/18/13 6:30*	*227,556*	*5.23*	*203.6*	*4.90*
Storm			*14*	*0.345*	*5/18/13 6:30*	*5/18/13 12:30*	*10,648*	*0.24*	*9.5*	*0.23*
Base			*14*	*0.345*	*5/18/13 12:30*	*5/19/13 17:30*	*58,783*	*1.35*	*52.6*	*1.26*
Storm			*14*	*0.345*	*5/19/13 17:30*	*5/19/13 20:30*	*7,537*	*0.17*	*6.7*	*0.16*
Base			*14*	*0.345*	*5/19/13 20:30*	*5/29/13 22:30*	*977,682*	*22.46*	*874.8*	*21.04*
Storm			*14*	*0.345*	*5/29/13 22:30*	*5/30/13 1:30*	*13,273*	*0.30*	*11.9*	*0.29*
Base			*14*	*0.345*	*5/30/13 1:30*	*6/1/13 12:30*	*299,938*	*6.89*	*268.4*	*6.45*
Storm			*14*	*0.345*	*6/1/13 12:30*	*6/1/13 16:30*	*21,704*	*0.50*	*19.4*	*0.47*
Base			*14*	*0.345*	*6/1/13 16:30*	*6/5/13 9:30*	*434,420*	*9.98*	*388.7*	*9.35*
Storm			*14*	*0.345*	*6/5/13 9:30*	*6/5/13 14:30*	*23,245*	*0.53*	*20.8*	*0.50*
Base			*14*	*0.345*	*6/5/13 14:30*	*6/15/13 12:30*	*1,028,730*	*23.63*	*920.5*	*22.13*
Storm			*14*	*0.345*	*6/15/13 12:30*	*6/15/13 21:30*	*43,931*	*1.01*	*39.3*	*0.95*
Base			*14*	*0.345*	*6/15/13 21:30*	*6/21/13 2:30*	*606,845*	*13.94*	*543.0*	*13.06*
Storm			*14*	*0.345*	*6/21/13 2:30*	*6/21/13 17:30*	*95,136*	*2.19*	*85.1*	*2.05*
Base			*14*	*0.345*	*6/21/13 17:30*	*6/23/13 3:30*	*281,173*	*6.46*	*251.6*	*6.05*
Storm Composite	6/23/2013 4:13	6/23/2013 12:28	8	0.293	6/23/13 3:30	6/23/13 13:30	94,450	2.17	47.2	1.73
Base			*14*	*0.345*	*6/23/13 13:30*	*6/26/13 11:30*	*712,468*	*16.36*	*637.5*	*15.33*
Storm			*14*	*0.345*	*6/26/13 11:30*	*6/26/13 17:30*	*81,797*	*1.88*	*73.2*	*1.76*
Base			*14*	*0.345*	*6/26/13 17:30*	*6/29/13 2:30*	*971,470*	*22.31*	*869.2*	*20.90*
Storm			*14*	*0.345*	*6/29/13 2:30*	*6/29/13 5:30*	*47,957*	*1.10*	*42.9*	*1.03*
Base			*14*	*0.345*	*6/29/13 5:30*	*7/7/13 18:30*	*2,480,890*	*56.98*	*2219.8*	*53.38*
Storm			*14*	*0.345*	*7/7/13 18:30*	*7/7/13 21:30*	*20,134*	*0.46*	*18.0*	*0.43*
Base			*14*	*0.345*	*7/7/13 21:30*	*7/9/13 7:30*	*204,844*	*4.71*	*183.3*	*4.41*
Storm			*14*	*0.345*	*7/9/13 7:30*	*7/9/13 11:30*	*25,295*	*0.58*	*22.6*	*0.54*
Base			*14*	*0.345*	*7/9/13 11:30*	*7/16/13 12:30*	*945,234*	*21.71*	*845.8*	*20.34*
Base Grab	7/17/2013 14:01	7/17/2013 14:01	27	0.528	7/16/13 12:30	7/17/13 21:30	105,552	2.42	177.9	3.48
Base			*14*	*0.345*	*7/17/13 21:30*	*8/12/13 0:30*	*453,699*	*10.42*	*406.0*	*9.76*
Storm			*14*	*0.345*	*8/12/13 0:30*	*8/12/13 3:30*	*140*	*0.00*	*0.1*	*0.00*
Base			*14*	*0.345*	*8/12/13 3:30*	*10/2/13 21:30*	*16,920*	*0.39*	*15.1*	*0.36*
Storm			*14*	*0.345*	*10/2/13 21:30*	*10/3/13 0:30*	*304*	*0.01*	*0.3*	*0.01*
Base			*14*	*0.345*	*10/3/13 0:30*	*10/4/13 22:30*	*3,968*	*0.09*	*3.6*	*0.09*
Storm			*14*	*0.345*	*10/4/13 22:30*	*10/15/13 9:30*	*26,978*	*0.62*	*24.1*	*0.58*
Base			*14*	*0.345*	*10/15/13 9:30*	*11/4/13 14:30*	*35,808*	*0.82*	*32.0*	*0.77*
*Base**			*14*	*0.345*	*11/4/13 14:30*	*1/1/14 0:00*	*99,180*	*2.28*	*88.7*	*2.13*
Base Average			27	0.528						
Storm Average			8	0.293						
Snowmelt Average			8	0.213						
All Average			14	0.345						
Total							**16,205,989**	**372**	**14,512**	**349**
CLFLWD Major Subwatershed Total Acres							2,479			
Total Load										
Total TSS/TP (lbs/ac/yr)									**5.85**	**0.14**

Italics indicate estimated concentrations based on average base and storm flow concentrations. Used All Average TSS and TP numbers to estimate base and storm loads due to the lack of samples collected.

*Interval volumes from 1/1/2013 to 4/7/2013, 4/7/2013 to 4/9/2013, 4/9/2013 to 5/13/2013 and 11/4/2013 to 1/1/2014 were estimated based on average base and storm flow concentrations.

Total phosphorus loading at the Bone Lake North Inlet site for 2013 was estimated at 0.14 lbs/ac or 349 lbs. (Table 6). Due to the limited number of samples collected at this site it was deemed necessary to use the all average numbers for estimating TSS and TP during both base and storm intervals where samples were not collected. The low number of samples collected was due to the unfamiliarity of the flow characteristics of the new pipe, which made it difficult to know how to set the sampler to collect

samples. Provided there is an average amount of precipitation, this issue should be remedied for the 2014 monitoring season. Monitoring should continue at this site in an effort to attain a total phosphorus loading trend entering Bone Lake.

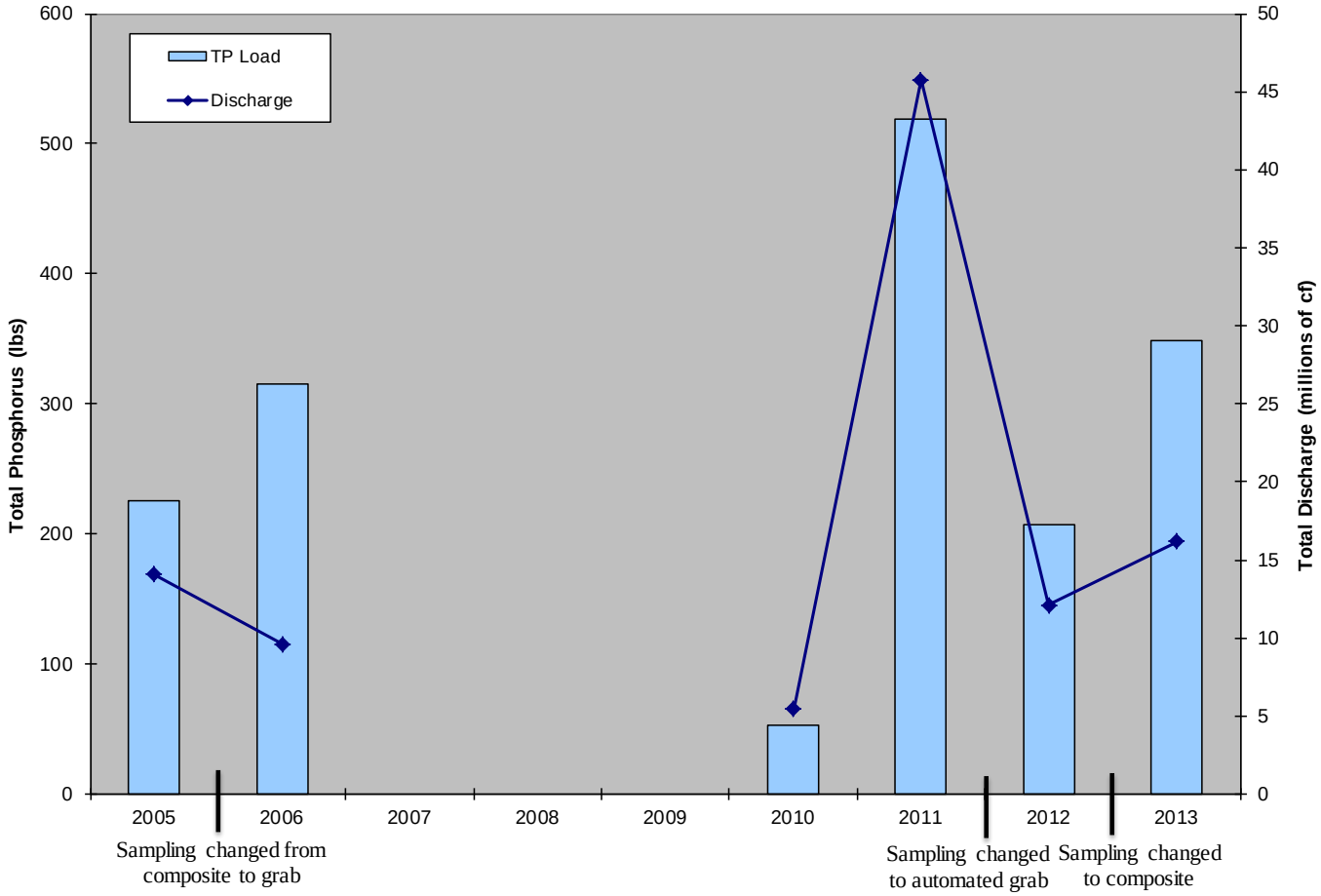


Figure 4. Bone Lake North Inlet Historic Annual Discharge and Total Phosphorus Load

Flow and water chemistry data has been collected at the Bone Lake North Inlet site since 2005, excluding the years 2007-2009. Total estimated annual discharge and phosphorus loads can be found in Figure 4. When comparing year-to-year loading numbers it should be noted that the sampling technique changed between 2005 and 2006, 2011 and 2012, and 2012 and 2013. In 2005, water chemistry data was collected using automated composite samples. Since 2006, excluding the years 2007-2009, this data was collected by manual grab samples. The sampling technique changed again slightly in 2012. Automated storm grabs were collected utilizing the sampling equipment at the site. This allowed for improved timing of the storm grabs, more were collected during the rising limb and near the peak of storm events. For the monitoring season of 2013 the sampling technique changed again and automated storm composite samples were collected once again. Composite samples generally capture more of the rising limb and peak of a storm event, whereas grab samples typically are taken near the peak or on the falling limb of a storm event. This is important to note because typically the majority of the load that is present in an event is concentrated in the rising limb. 2012 saw a dramatic decrease in discharge and TP load from 2011. This decrease could be misleading due to the fact that this site was removed prior to the

end of the monitoring season. It was removed at the beginning of August in preparation for the fish barrier project on Bone Lake. There was an increase in discharge and TP load from 2012 to 2013 which again could be misleading due to the fact that the site was removed early in 2012. In order to make a better comparison for the years 2011 through 2013, similar time periods could be compared: 1/1/2011-8/8/2011, 1/1/2012-8/9/2012, and 1/1/2013-8/12/2013. When comparing the discharge and total phosphorus load estimates for these time periods there is still a decrease for both parameters between the years 2011 and 2012 and an increase for both parameters between the years 2012 and 2013. Due to the installation of the fish barrier, the site will continue to be monitored in a pipe instead of a natural stream channel.

Bone Lake Outlet

The station at the Bone Lake Outlet recorded stage and velocity from April 24-November 4, 2013 (Figure 5). Rainfall was not recorded at this station. Total discharge during this period was 80,882,661 cf or 1,858 acre-ft. Peak discharge of 13.283 cfs was recorded on June 26th. This site was last monitored from 2004 to 2006.

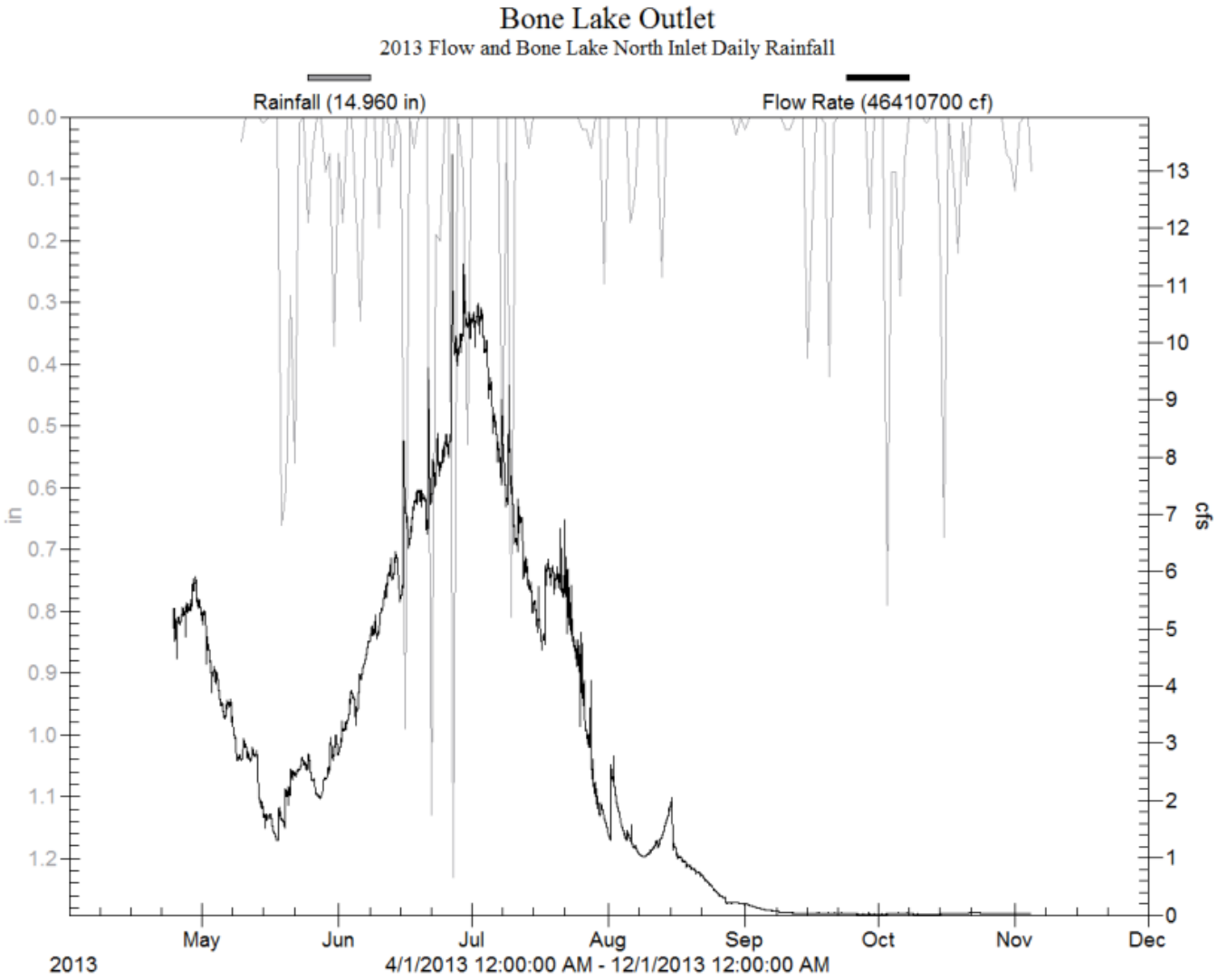


Figure 5. Bone Lake Outlet 2013 Flow and Bone Lake North Inlet Daily Rainfall

Table 7. Bone Lake Outlet 2013 Total Suspended Solids and Total Phosphorus Loading

	Sample Collection Time				Loading Interval					
Sample Type	**Start**	**End**	**TSS (mg/L)**	**TP (mg/L)**	**Start**	**End**	**Interval Volume (cf)**	**Interval Volume (ac-ft)**	**Interval TSS (lb)**	**Interval TP (lb)**
*Base**			*N/A*	*0.038*	*1/1/13 0:00*	*4/24/13 16:00*	*34,372,800*	*789.5*	*N/A*	*81.4*
Base			*N/A*	*0.038*	*4/24/13 16:00*	*4/28/13 22:00*	*1,928,620*	*44.3*	*N/A*	*4.6*
Storm			*N/A*	*0.038*	*4/28/13 22:00*	*4/29/13 0:00*	*42,072*	*1.0*	*N/A*	*0.1*
Base			*N/A*	*0.038*	*4/29/13 0:00*	*5/6/13 11:00*	*2,982,970*	*68.5*	*N/A*	*7.1*
In-Lake Sample	5/7/2013 14:28	5/7/2013 14:28	N/A	0.055	5/6/13 11:00	5/8/13 11:00	610,808	14.0	N/A	2.1
Base			*N/A*	*0.038*	*5/8/13 11:00*	*5/18/13 6:00*	*1,949,270*	*44.8*	*N/A*	*4.6*
Storm			*N/A*	*0.038*	*5/18/13 6:00*	*5/18/13 14:00*	*48,434*	*1.1*	*N/A*	*0.1*
Base			*N/A*	*0.038*	*5/18/13 14:00*	*5/19/13 17:00*	*162,769*	*3.7*	*N/A*	*0.4*
Storm			*N/A*	*0.038*	*5/19/13 17:00*	*5/19/13 20:00*	*22,144*	*0.5*	*N/A*	*0.1*
Base			*N/A*	*0.038*	*5/19/13 20:00*	*5/22/13 11:00*	*522,450*	*12.0*	*N/A*	*1.2*
In-Lake Sample	5/23/2013 13:35	5/23/2013 13:35	N/A	0.057	5/22/13 11:00	5/24/13 11:00	451,006	10.4	N/A	1.6
Base			*N/A*	*0.038*	*5/24/13 11:00*	*6/5/13 11:00*	*2,964,280*	*68.1*	*N/A*	*7.0*
In-Lake Sample	6/6/2013 13:59	6/6/2013 13:59	N/A	0.032	6/5/13 11:00	6/7/13 11:00	743,232	17.1	N/A	1.5
Base			*N/A*	*0.038*	*6/7/13 11:00*	*6/15/13 14:00*	*3,854,360*	*88.5*	*N/A*	*9.1*
Storm			*N/A*	*0.038*	*6/15/13 14:00*	*6/15/13 19:00*	*142,565*	*3.3*	*N/A*	*0.3*
Base			*N/A*	*0.038*	*6/15/13 19:00*	*6/17/13 11:00*	*985,415*	*22.6*	*N/A*	*2.3*
In-Lake Sample	6/18/2013 13:26	6/18/2013 13:26	N/A	0.036	6/17/13 11:00	6/19/13 11:00	1,249,110	28.7	N/A	2.8
Base			*N/A*	*0.038*	*6/19/13 11:00*	*6/21/13 3:00*	*1,034,370*	*23.8*	*N/A*	*2.4*
Storm			*N/A*	*0.038*	*6/21/13 3:00*	*6/21/13 8:00*	*160,862*	*3.7*	*N/A*	*0.4*
Base			*N/A*	*0.038*	*6/21/13 8:00*	*6/26/13 12:00*	*3,551,700*	*81.6*	*N/A*	*8.4*
Storm			*N/A*	*0.038*	*6/26/13 12:00*	*6/26/13 16:00*	*172,223*	*4.0*	*N/A*	*0.4*
Base			*N/A*	*0.038*	*6/26/13 16:00*	*7/1/13 11:00*	*4,250,760*	*97.6*	*N/A*	*10.1*
In-Lake Sample	7/2/2013 13:10	7/2/2013 13:10	N/A	0.053	7/1/13 11:00	7/3/13 11:00	1,802,350	41.4	N/A	6.0
Base			*N/A*	*0.038*	*7/3/13 11:00*	*7/7/13 19:00*	*3,362,930*	*77.2*	*N/A*	*8.0*
Storm			*N/A*	*0.038*	*7/7/13 19:00*	*7/7/13 22:00*	*93,290*	*2.1*	*N/A*	*0.2*
Base			*N/A*	*0.038*	*7/7/13 22:00*	*7/9/13 8:00*	*937,605*	*21.5*	*N/A*	*2.2*
Storm			*N/A*	*0.038*	*7/9/13 8:00*	*7/9/13 13:00*	*155,930*	*3.6*	*N/A*	*0.4*
Base			*N/A*	*0.038*	*7/9/13 13:00*	*7/15/13 11:00*	*3,283,080*	*75.4*	*N/A*	*7.8*
In-Lake Sample	7/16/2013 13:21	7/16/2013 13:21	N/A	0.035	7/15/13 11:00	7/17/13 11:00	867,227	19.9	N/A	1.9
Base			*N/A*	*0.038*	*7/17/13 11:00*	*7/30/13 11:00*	*5,030,370*	*115.5*	*N/A*	*11.9*
In-Lake Sample	7/31/2013 13:26	7/31/2013 13:26	N/A	0.039	7/30/13 11:00	8/1/13 12:00	278,648	6.4	N/A	0.7
Storm			*N/A*	*0.038*	*8/1/13 12:00*	*8/1/13 15:00*	*28,053*	*0.6*	*N/A*	*0.1*
Base			*N/A*	*0.038*	*8/1/13 15:00*	*8/13/13 11:00*	*1,408,850*	*32.4*	*N/A*	*3.3*
In-Lake Sample	8/14/2013 13:25	8/14/2013 13:25	N/A	0.032	8/13/13 11:00	8/15/13 11:00	302,710	7.0	N/A	0.6
Storm			*N/A*	*0.038*	*8/15/13 11:00*	*8/15/13 14:00*	*12,283*	*0.3*	*N/A*	*0.0*
Base			*N/A*	*0.038*	*8/15/13 14:00*	*8/28/13 11:00*	*745,706*	*17.1*	*N/A*	*1.8*
In-Lake Sample	8/29/2013 12:44	8/29/2013 12:44	N/A	0.033	8/28/13 11:00	8/30/13 11:00	37,494	0.9	N/A	0.1
Base			*N/A*	*0.038*	*8/30/13 11:00*	*9/10/13 11:00*	*109,824*	*2.5*	*N/A*	*0.3*
In-Lake Sample	9/11/2013 12:58	9/11/2013 12:58	N/A	0.025	9/10/13 11:00	9/12/13 11:00	7,144	0.2	N/A	0.0
Base			*N/A*	*0.038*	*9/12/13 11:00*	*9/19/13 11:00*	*17,890*	*0.4*	*N/A*	*0.0*
Storm			*N/A*	*0.038*	*9/19/13 11:00*	*9/19/13 16:00*	*651*	*0.0*	*N/A*	*0.0*
Base			*N/A*	*0.038*	*9/19/13 16:00*	*9/23/13 11:00*	*9,500*	*0.2*	*N/A*	*0.0*
In-Lake Sample	9/24/2013 13:35	9/24/2013 13:35	N/A	0.023	9/23/13 11:00	9/25/13 11:00	4,014	0.1	N/A	0.0
Base			*N/A*	*0.038*	*9/25/13 11:00*	*10/8/13 11:00*	*22,016*	*0.5*	*N/A*	*0.1*
In-Lake Sample	10/9/2013 13:36	10/9/2013 13:36	N/A	0.035	10/8/13 11:00	10/10/13 11:00	3,162	0.1	N/A	0.0
Base			*N/A*	*0.038*	*10/10/13 11:00*	*10/21/13 11:00*	*20,740*	*0.5*	*N/A*	*0.0*
Storm			*N/A*	*0.038*	*10/21/13 11:00*	*10/21/13 14:00*	*504*	*0.0*	*N/A*	*0.0*
Base			*N/A*	*0.038*	*10/21/13 14:00*	*11/4/13 15:00*	*39,326*	*0.9*	*N/A*	*0.1*
*Base**			*N/A*	*0.038*	*11/4/13 15:00*	*1/1/14 0:00*	*99,144*	*2.3*	*N/A*	*0.2*
In-Lake/Base Average			N/A	0.038						
Storm Average			N/A	NA						
All Average			N/A	0.038						
Total							**80,882,661**	**1,858**	**N/A**	**194**
CLFLWD Major Subwatershed Total Acres							5,495			
Total Load										
Total TSS/TP (lbs/ac/yr)									**N/A**	**0.035**

Italics indicate estimated concentrations based on average base and storm flow concentrations.

*Interval volumes from 1/1/2013 to 4/24/2013 and 11/4/2013 to 1/1/2014 were estimated based on average base and storm flow concentrations.

Although no samples were collected at the Bone Lake Outlet site in 2013, the WCD used in-lake concentrations from samples collected in Bone Lake to estimate a total phosphorus load at this location. Total phosphorus loading at the Bone Lake Outlet site for 2013 was estimated at 0.035 lbs/ac or 194 lbs. (Table 7).

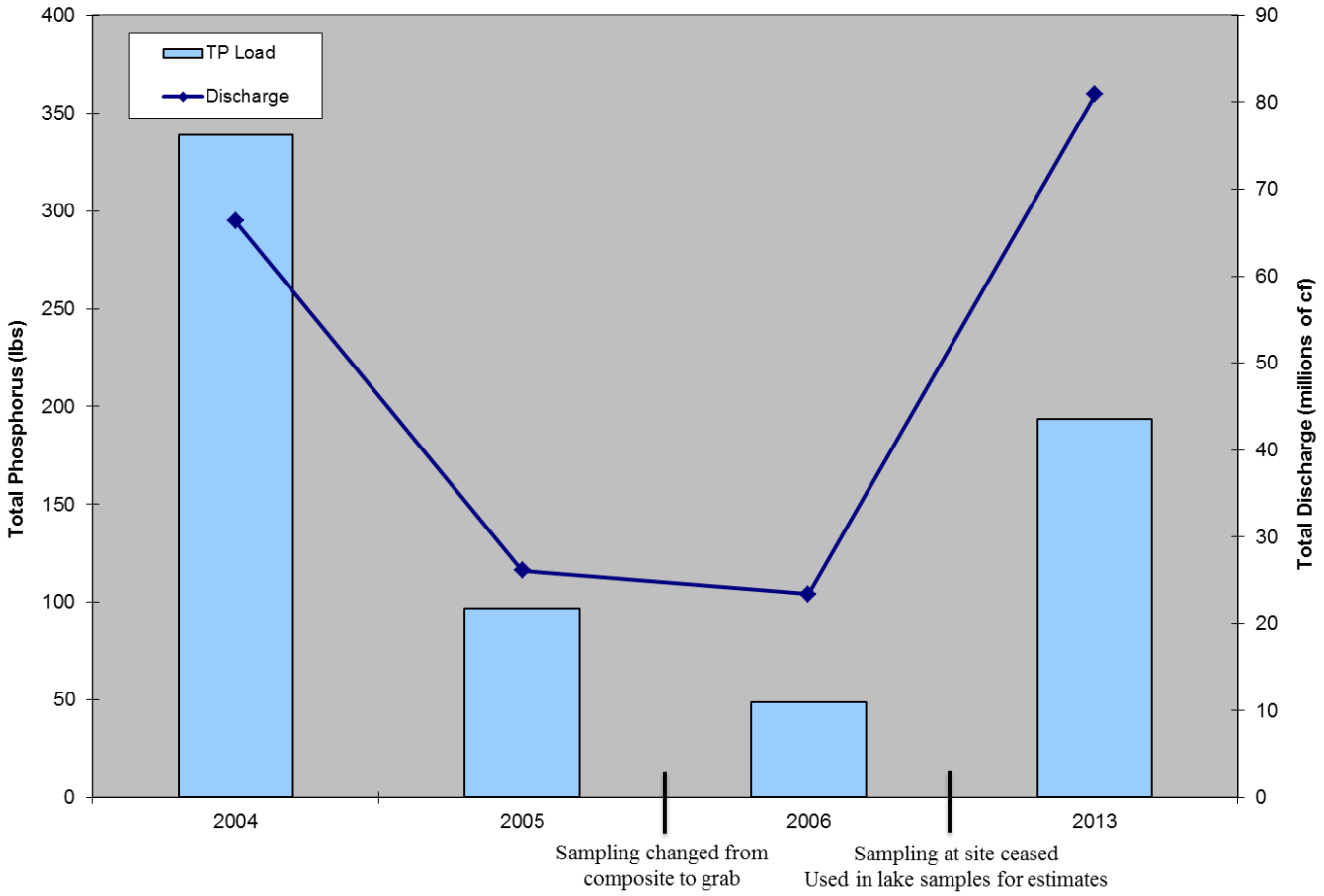


Figure 6. Bone Lake Outlet Historic Annual Discharge and Total Phosphorus Load

Flow and water chemistry data was collected at the Bone Lake Outlet from 2004 through 2006 and not again until 2013. Total estimated annual phosphorus loading and discharge can be found in Figure 6. It should be noted that when comparing year to year loading estimates, the sampling technique utilized at this site has changed. Automated composite sampling was used in the 2004-2005 monitoring seasons, and was switched to manual grab sampling for the 2006 season. Sampling at the site ceased in 2007 but was resumed in 2013 when the sampling technique changed again. Load estimates for 2013 were made using in-lake sample concentrations. Composite sampling typically does the best job of characterizing nutrient levels, as it is able to capture the rising limb and peak of a storm event. Manual grab sampling usually occurs near the peak or falling limb of storm events, where the nutrient concentration is normally much lower. In-lake concentrations are generally much lower than the results of either of the other two sampling methods.

III. LITTLE COMFORT LAKE SUBWATERSHED

Little Comfort Lake Inlet

Stage, velocity, and rainfall were recorded at the Little Comfort Lake Inlet site from May 13-November 4, 2013, with the exception of May 30th-June 5th due to a power failure (Figure 7). Total discharge during this period was 60,039,577 cf or 1,379 acre-ft. Total rainfall recorded during the monitoring season was 13.89 inches. Peak discharge of 11.686 cfs occurred on June 17th.

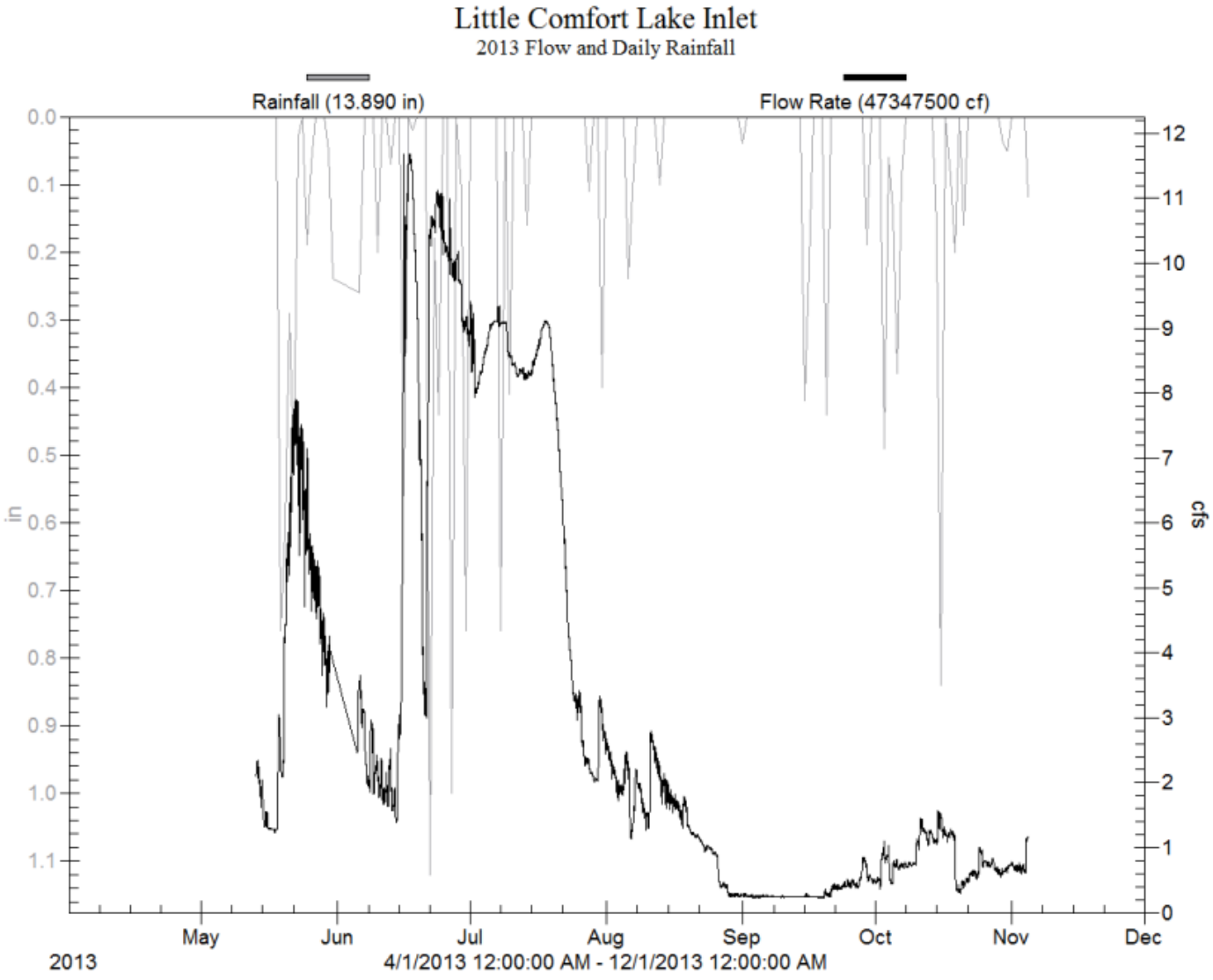


Figure 7. Little Comfort Lake Inlet 2013 Flow and Daily Rainfall

Automated storm composite, manual base and storm grab, and snowmelt grab samples were collected at the Little Comfort Lake Inlet site in 2013. The TSS, VSS, TKN, TP, dissolved phosphorus, chloride, nitrite, nitrate, ammonia nitrogen, and *E. coli* results from all collected samples are listed in Table 8 and field water quality measurements are listed in Table 9. The highest concentrations of TKN and TSS were 2.60 mg/L and 268 mg/L, respectively, from a storm composite collected on June 15th. The TSS result exceeded the turbidity water quality standard of >100 mg/L. The highest TP concentration was 0.298 mg/L from a storm grab collected on June 24th. Unfortunately the TSS and VSS results for this sample are missing due to lab error.

Table 8. Little Comfort Lake Inlet 2013 Sample Chemistry Results

Sample Type	Start	End	TSS (mg/L)	VSS (mg/L)	TKN (mg/L)	TP (mg/L)	Dissolved TP (mg/L)	Chloride (mg/L)	Nitrite (mg/L)	Nitrate (mg/L)	Ammonia Nitrogen (mg/L)	*E. coli* (mpn/100ml)
Snowmelt Grab	4/8/2013 9:49	4/8/2013 9:49	6	~4	1.60	0.211	0.134	11.3	<0.03	0.25	0.39	
Storm Grab	6/24/2013 11:25	6/24/2013 11:25			1.20	0.298	~0.021	14.4	<0.03	<0.05	<0.02	
Storm Composite	5/19/2013 18:21	5/20/2013 10:25	31	15	1.80	0.121	<0.020	15.7	<0.03	0.06	~0.04	
Storm Composite	6/15/2013 21:49	6/16/2013 11:40	268	96	2.60	0.223	~0.031	17.6	0.04	0.07	<0.02	
Base Grab	7/17/2013 13:34	7/17/2013 13:34	3	~2	1.10	0.077	~0.040	14.2	<0.03	<0.05	0.10	
Base Grab	8/15/2013 10:37	8/15/2013 10:37	~2	~1	0.99	~0.048	~0.035	15.0	<0.03	0.07	~0.04	63
Base Grab	9/24/2013 9:45	9/24/2013 9:45	~2	~2	1.00	0.064	~0.034	18.1	<0.03	0.14	0.19	266
Base Grab	10/10/2013 10:21	10/10/2013 10:21	4	3	1.40	0.119	<0.020	17.8	<0.03	0.08	0.06	326
E. coli Grab	6/27/2013 9:24	6/27/2013 9:24										67
E. coli Grab	7/29/2013 10:10	7/29/2013 10:10										45

Exceeds Water Quality Standard

Table 9. Little Comfort Lake Inlet 2013 Field Water Quality Measurements

Date/Time	Transparency (cm)	Water Temperature (C)	Dissolved Oxygen (mg/L)	Conductivity (umhos/cm)	pH
4/8/2013 9:49		1.6		212	8.0
7/17/2013 13:34	>100	29.3	2.10	325	7.5
9/24/2013 9:45	>100	12.9	6.56	343	8.2
10/10/2013 10:21	>100	12.8	8.06	407	7.9

Exceeds Water Quality Standard

Table 10. Little Comfort Lake Inlet 2013 Total Suspended Solids and Total Phosphorus Loading

	Sample Collection Time				Loading Interval					
Sample Type	Start	End	TSS (mg/L)	TP (mg/L)	Start	End	Interval Volume (cf)	Interval Volume (ac-ft)	Interval TSS (lb)	Interval TP (lb)
*Base**			*3*	*0.077*	*1/1/13 0:00*	*4/8/2013 8:15*	*6,728,400*	*154.54*	*1155*	*32.3*
Snowmelt Grab*	4/8/2013 9:49	4/8/2013 9:49	6	0.211	4/8/13 8:15	4/9/2013 18:15	244,800	5.62	92	3.2
*Base**			*3*	*0.077*	*4/9/13 18:15*	*5/13/13 12:15*	*2,916,000*	*66.98*	*501*	*14.0*
Base			*3*	*0.077*	*5/13/13 12:15*	*5/18/13 6:15*	*645,042*	*14.82*	*111*	*3.1*
Storm			*150*	*0.214*	*5/18/13 6:15*	*5/18/13 22:15*	*142,247*	*3.27*	*1329*	*1.9*
Base			*3*	*0.077*	*5/18/13 22:15*	*5/19/13 17:15*	*155,364*	*3.57*	*27*	*0.7*
Storm Composite	5/19/2013 18:21	5/20/2013 10:25	31	0.121	5/19/13 17:15	5/20/13 12:15	300,110	6.89	581	2.3
Base			*3*	*0.077*	*5/20/13 12:15*	*5/30/13 4:45*	*4,801,170*	*110.28*	*824*	*23.1*
*Base**			*3*	*0.077*	*5/30/13 4:45*	*6/5/13 9:30*	*2,142,000*	*49.20*	*368*	*10.3*
Base			*3*	*0.077*	*6/5/13 9:30*	*6/15/13 13:15*	*2,019,610*	*46.39*	*347*	*9.7*
Storm Composite	6/15/2013 21:49	6/16/2013 11:40	268	0.223	6/15/13 13:15	6/16/13 13:15	743,177	17.07	12434	10.3
Base			*3*	*0.077*	*6/16/13 13:15*	*6/21/13 3:15*	*3,376,060*	*77.54*	*580*	*16.2*
Storm			*150*	*0.214*	*6/21/13 3:15*	*6/21/13 12:15*	*205,156*	*4.71*	*1917*	*2.7*
Storm			*150*	*0.214*	*6/21/13 12:15*	*6/22/13 0:15*	*419,068*	*9.63*	*3915*	*5.6*
Base			*3*	*0.077*	*6/22/13 0:15*	*6/23/13 6:15*	*1,146,980*	*26.34*	*197*	*5.5*
Storm Grab**	6/24/2013 11:25	6/24/2013 11:25	150	0.298	6/23/13 6:15	6/24/13 12:15	1,190,480	27.34	11148	22.1
Base			*3*	*0.077*	*6/24/13 12:15*	*6/26/13 11:15*	*1,748,440*	*40.16*	*300*	*8.4*
Storm			*150*	*0.214*	*6/26/13 11:15*	*6/26/13 17:15*	*222,189*	*5.10*	*2076*	*3.0*
Base			*3*	*0.077*	*6/26/13 17:15*	*6/29/13 1:15*	*1,992,250*	*45.76*	*342*	*9.6*
Storm			*150*	*0.214*	*6/29/13 1:15*	*6/29/13 8:15*	*232,040*	*5.33*	*2168*	*3.1*
Base			*3*	*0.077*	*6/29/13 8:15*	*7/7/13 18:15*	*6,392,350*	*146.82*	*1097*	*30.7*
Storm			*150*	*0.214*	*7/7/13 18:15*	*7/7/13 21:15*	*98,626*	*2.27*	*921*	*1.3*
Base			*3*	*0.077*	*7/7/13 21:15*	*7/9/13 8:15*	*1,144,270*	*26.28*	*196*	*5.5*
Storm			*150*	*0.214*	*7/9/13 8:15*	*7/9/13 11:15*	*95,921*	*2.20*	*896*	*1.3*
Base			*3*	*0.077*	*7/9/13 11:15*	*7/15/13 12:15*	*4,375,730*	*100.51*	*751*	*21.0*
Base Grab	7/17/2013 13:34	7/17/2013 13:34	3	0.077	7/15/13 12:15	7/22/13 12:15	4,950,370	113.70	927	23.8
Base			*3*	*0.077*	*7/22/13 12:15*	*7/30/13 2:15*	*1,984,520*	*45.58*	*341*	*9.5*
Storm			*150*	*0.214*	*7/30/13 2:15*	*7/30/13 16:15*	*150,430*	*3.46*	*1405*	*2.0*
Base			*3*	*0.077*	*7/30/13 16:15*	*8/10/13 18:15*	*1,953,890*	*44.88*	*335*	*9.4*
Storm			*150*	*0.214*	*8/10/13 18:15*	*8/11/13 4:15*	*89,759*	*2.06*	*839*	*1.2*
Base Grab	8/15/2013 10:37	8/15/2013 10:37	2	0.048	8/11/13 4:15	8/18/13 12:15	1,231,470	28.29	154	3.7
Base			*3*	*0.077*	*8/18/13 12:15*	*9/22/13 12:15*	*1,415,780*	*32.52*	*243*	*6.8*
Base Grab	9/24/2013 9:45	9/24/2013 9:45	2	0.064	9/22/13 12:15	9/27/13 12:15	182,999	4.20	23	0.7
Base			*3*	*0.077*	*9/27/13 12:15*	*10/2/13 4:15*	*232,780*	*5.35*	*40*	*1.1*
Storm			*150*	*0.214*	*10/2/13 4:15*	*10/3/13 0:15*	*59,802*	*1.37*	*559*	*0.8*
Base Grab	10/10/2013 10:21	10/10/2013 10:21	4	0.119	10/3/13 0:15	10/15/13 0:15	941,977	21.64	235	7.0
Storm			*150*	*0.214*	*10/15/13 0:15*	*10/15/13 5:15*	*25,691*	*0.59*	*240*	*0.3*
Base			*3*	*0.077*	*10/15/13 5:15*	*11/4/13 13:45*	*1,357,950*	*31.19*	*233*	*6.5*
*Base**			*3*	*0.077*	*11/4/13 13:45*	*1/1/14 0:00*	*1,984,680*	*45.59*	*341*	*9.5*
Base Average			3	0.077						
Storm Average			150	0.214						
Snowmelt Average			6	0.211						
All Average			45	0.123						
Total							**60,039,577**	**1,379**	**50,187**	**330**
CLFLWD Major Subwatershed Total Acres							10,513			
Total Load										
Total TSS/TP (lbs/ac/yr)									**4.77**	**0.03**

Italics indicate estimated concentrations based on average base and storm flow concentrations.

*Interval volumes from 1/1/2013 to 4/8/2013, 4/8/2013 to 4/9/2013, 4/9/2013 to 5/13/2013, 5/30/2013 to 6/15/2013 and 11/4/2013 to 1/1/2014 were estimated based on average base and storm flow concentrations.

**TSS result missing for this storm grab, used the storm average number but did not include in storm or all averages.

Total phosphorus loading at Little Comfort Lake Inlet for 2013 was estimated at 0.03 lbs/ac or 330 lbs. (Table 10). Monitoring should continue at this site in an effort to attain a total phosphorus loading trend entering Little Comfort Lake.

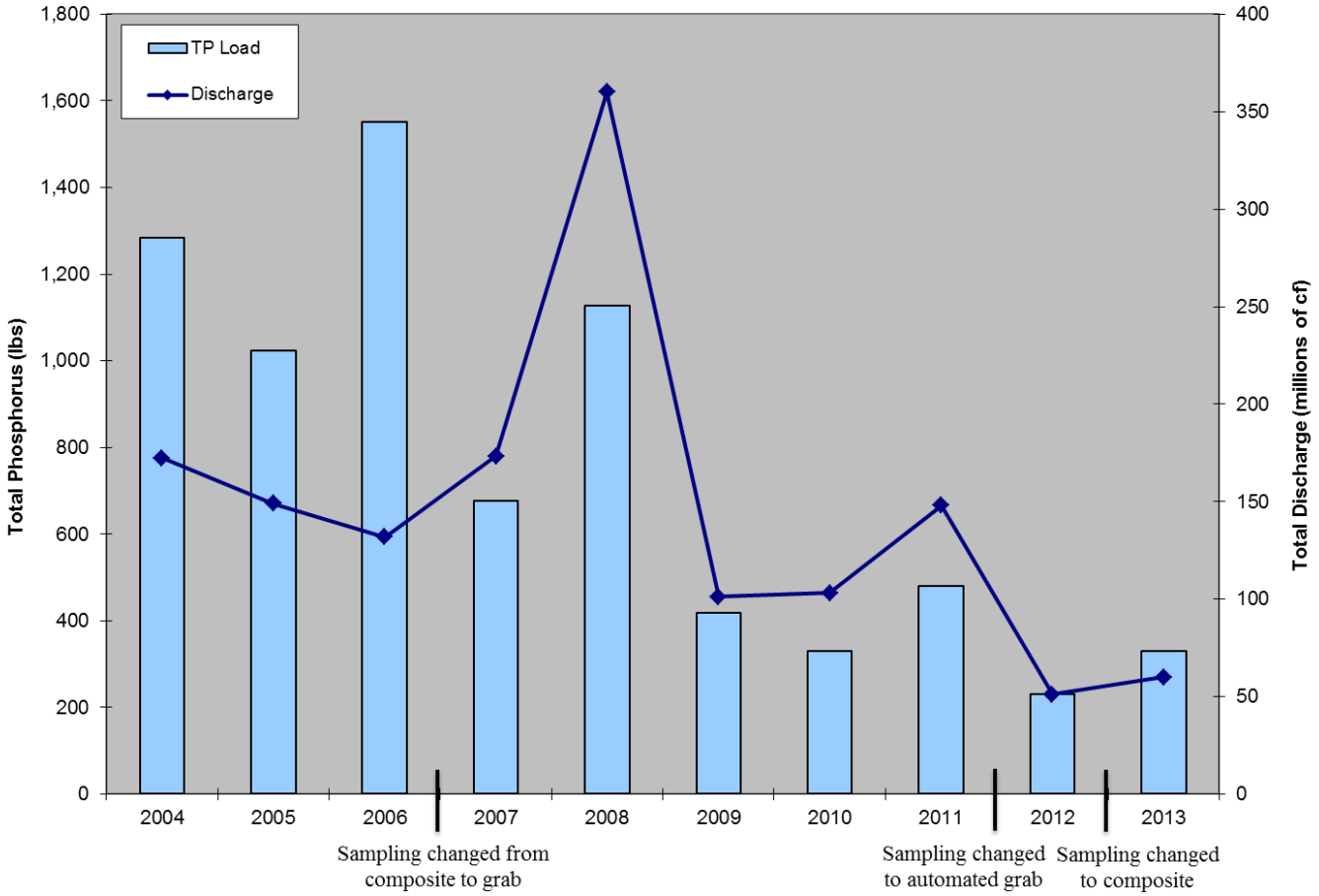


Figure 8. Little Comfort Lake Inlet Historic Annual Discharge and Total Phosphorus Load

Flow and water chemistry data has been collected at the Little Comfort Lake Inlet site since 2004. Total estimated annual discharge and phosphorus loads can be found in Figure 8. When comparing year-to-year loading numbers it should be noted that the sampling technique changed between 2006 and 2007, 2011 and 2012, and 2012 and 2013. From 2004 through 2006 water chemistry data was collected using automated composite samples. Starting in 2007 this data was collected by manual grab samples. The drop in total phosphorus export between 2006 and 2007 may be due to the change in sampling techniques. Composite samples generally capture more of the rising limb and peak of a storm event, whereas grab samples typically are taken near the peak or on the falling limb of a storm event. This is important to note because typically the majority of the nutrient load that is present is concentrated in the rising limb. The sampling technique changed again slightly in 2012. Automated storm grabs were collected utilizing the sampling equipment at the site. This allowed for improved timing of the storm grabs, with more collected during the rising limb and near the peak of storm events. The 2013 monitoring season once again saw a change in sampling technique, back to collecting automated storm composites. There was an increase in both discharge and TP load from 2012 to 2013. This is most likely due to the above average amount of snowfall and subsequent snowmelt in the winter of 2012/2013 and the above average amount of precipitation from April through June 2013.

IV. FOREST LAKE SUBWATERSHED

Forest Lake Outlet

The station at the Forest Lake Outlet site recorded stage and velocity from April 9-November 3, 2013 (Figure 9). Total discharge during the recorded period was 311,584,377 cf or 8,719 acre-ft. No automated rain gage was installed at this site to determine total seasonal rainfall. The highest discharge recorded was 33.004 cfs which occurred on May 21st.

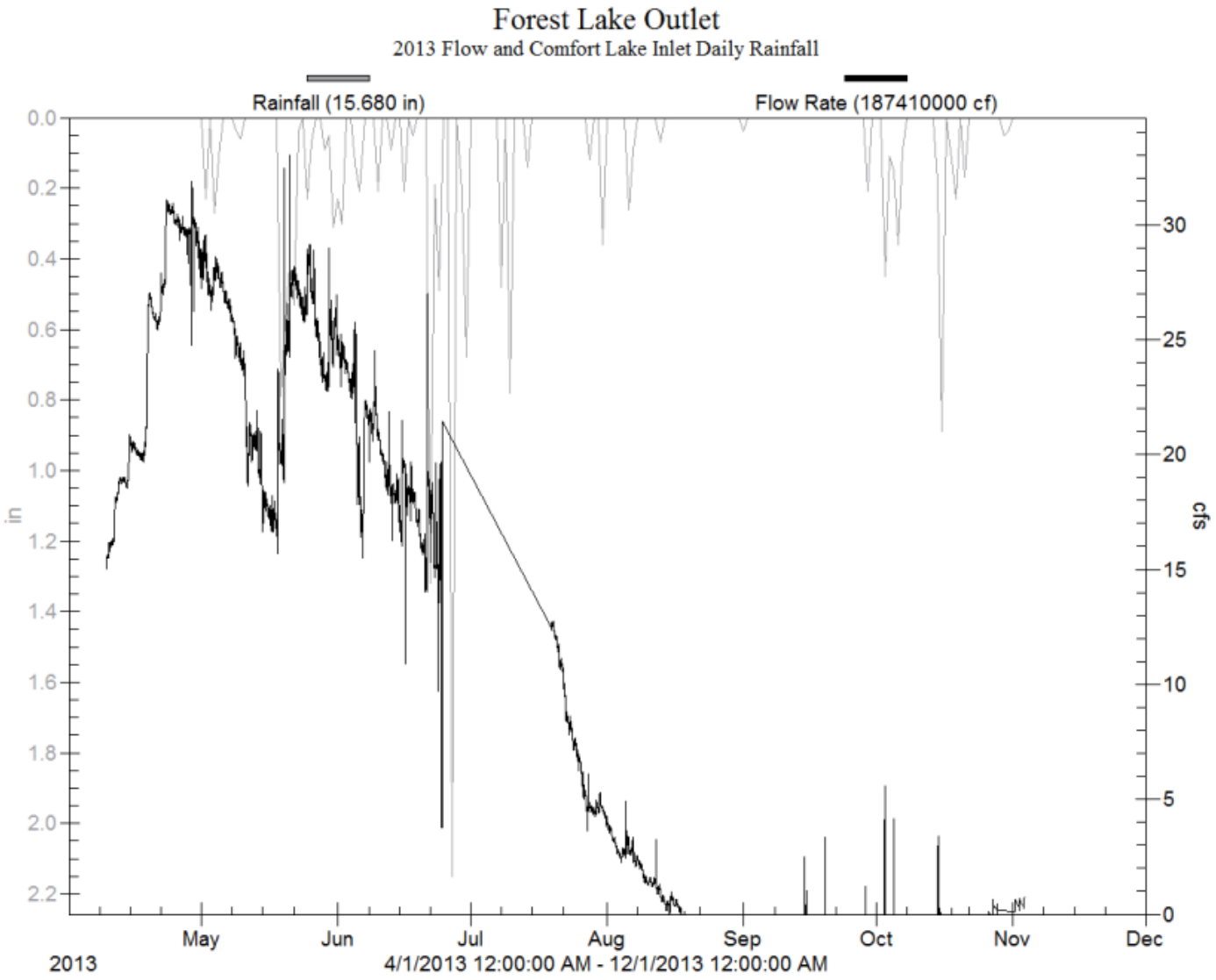


Figure 9. Forest Lake Outlet 2013 Flow and Comfort Lake Inlet Daily Rainfall

Table 11. Forest Lake Outlet 2013 Total Suspended Solids and Total Phosphorus Loading

	Sample Collection Time				Loading Interval					
Sample Type	Start	End	TSS (mg/L)	TP (mg/L)	Start	End	Interval Volume (cf)	Interval Volume (ac-ft)	Interval TSS (lb)	Interval TP (lb)
*Base**			*N/A*	*0.037*	*1/1/13 0:00*	*4/9/13 10:15*	*127,561,500*	*2929.9*	*N/A*	*291.3*
Base			*N/A*	*0.037*	*4/9/13 10:15*	*4/18/13 12:15*	*14,710,300*	*337.9*	*N/A*	*33.6*
Storm			*N/A*	*0.037*	*4/18/13 12:15*	*4/19/13 12:15*	*2,181,810*	*50.1*	*N/A*	*5.0*
Base			*N/A*	*0.037*	*4/19/13 12:15*	*4/22/13 18:15*	*7,407,750*	*170.1*	*N/A*	*16.9*
Storm			*N/A*	*0.037*	*4/22/13 18:15*	*4/23/13 6:15*	*1,289,340*	*29.6*	*N/A*	*2.9*
Base			*N/A*	*0.037*	*4/23/13 6:15*	*5/6/13 12:15*	*33,145,900*	*761.3*	*N/A*	*75.7*
In-Lake Sample	5/7/2013 11:43	5/7/2013 11:43	N/A	0.026	5/6/13 12:15	5/8/13 12:15	4,540,290	104.3	N/A	7.4
Base			*N/A*	*0.037*	*5/8/13 12:15*	*5/18/13 6:15*	*17,131,000*	*393.5*	*N/A*	*39.1*
Storm			*N/A*	*0.037*	*5/18/13 6:15*	*5/18/13 10:15*	*278,457*	*6.4*	*N/A*	*0.6*
Storm			*N/A*	*0.037*	*5/18/13 10:15*	*5/18/13 12:15*	*159,463*	*3.7*	*N/A*	*0.4*
Base			*N/A*	*0.037*	*5/18/13 12:15*	*5/19/13 17:15*	*2,108,520*	*48.4*	*N/A*	*4.8*
Storm			*N/A*	*0.037*	*5/19/13 17:15*	*5/19/13 19:15*	*185,885*	*4.3*	*N/A*	*0.4*
Base			*N/A*	*0.037*	*5/19/13 19:15*	*5/20/13 23:15*	*2,500,150*	*57.4*	*N/A*	*5.7*
Storm			*N/A*	*0.037*	*5/20/13 23:15*	*5/21/13 2:15*	*300,771*	*6.9*	*N/A*	*0.7*
Base			*N/A*	*0.037*	*5/21/13 2:15*	*5/22/13 12:15*	*3,376,360*	*77.6*	*N/A*	*7.7*
In-Lake Sample	5/23/2013 11:00	5/23/2013 11:00	N/A	0.037	5/22/13 12:15	5/24/13 12:15	4,608,760	105.9	N/A	10.6
Base			*N/A*	*0.037*	*5/24/13 12:15*	*5/29/13 23:15*	*12,040,300*	*276.6*	*N/A*	*27.5*
Storm			*N/A*	*0.037*	*5/29/13 23:15*	*5/30/13 2:15*	*279,932*	*6.4*	*N/A*	*0.6*
Base			*N/A*	*0.037*	*5/30/13 2:15*	*6/1/13 14:15*	*5,417,860*	*124.4*	*N/A*	*12.4*
Storm			*N/A*	*0.037*	*6/1/13 14:15*	*6/1/13 17:15*	*261,630*	*6.0*	*N/A*	*0.6*
Base			*N/A*	*0.037*	*6/1/13 17:15*	*6/5/13 12:15*	*7,631,720*	*175.3*	*N/A*	*17.4*
In-Lake Sample	6/6/2013 11:38	6/6/2013 11:38	N/A	0.045	6/5/13 12:15	6/7/13 12:15	3,287,210	75.5	N/A	9.2
Base			*N/A*	*0.037*	*6/7/13 12:15*	*6/17/13 12:15*	*16,824,200*	*386.4*	*N/A*	*38.4*
In-Lake Sample	6/18/2013 10:42	6/18/2013 10:42	N/A	0.021	6/17/13 12:15	6/19/13 12:15	3,072,580	70.6	N/A	4.0
Base			*N/A*	*0.037*	*6/19/13 12:15*	*6/21/13 3:15*	*2,195,260*	*50.4*	*N/A*	*5.0*
Storm			*N/A*	*0.037*	*6/21/13 3:15*	*6/21/13 5:15*	*150,116*	*3.4*	*N/A*	*0.3*
Base			*N/A*	*0.037*	*6/21/13 5:15*	*6/23/13 6:15*	*3,025,850*	*69.5*	*N/A*	*6.9*
Storm			*N/A*	*0.037*	*6/23/13 6:15*	*6/23/13 7:15*	*64,235*	*1.5*	*N/A*	*0.1*
Base			*N/A*	*0.037*	*6/23/13 7:15*	*6/24/13 13:45*	*1,744,770*	*40.1*	*N/A*	*4.0*
*Base**			*N/A*	*0.037*	*6/24/13 13:45*	*6/26/13 11:15*	*2,457,000*	*56.4*	*N/A*	*5.6*
*Storm**			*N/A*	*0.037*	*6/26/13 11:15*	*6/26/13 14:15*	*205,200*	*4.7*	*N/A*	*0.5*
*Base**			*N/A*	*0.037*	*6/26/13 14:15*	*7/1/13 12:15*	*5,522,400*	*126.8*	*N/A*	*12.6*
In-Lake Sample*	7/2/2013 10:40	7/2/2013 10:40	N/A	0.026	7/1/13 12:15	7/3/13 12:15	2,160,000	49.6	N/A	3.5
*Base**			*N/A*	*0.037*	*7/3/13 12:15*	*7/9/13 8:15*	*5,544,000*	*127.3*	*N/A*	*12.7*
*Storm**			*N/A*	*0.037*	*7/9/13 8:15*	*7/9/13 11:15*	*151,200*	*3.5*	*N/A*	*0.3*
*Base**			*N/A*	*0.037*	*7/9/13 11:15*	*7/15/13 12:15*	*4,698,000*	*107.9*	*N/A*	*10.7*
In-Lake Sample*	7/16/2013 10:40	7/16/2013 10:40	N/A	0.039	7/15/13 12:15	7/17/13 12:15	1,382,400	31.8	N/A	3.4
*Base**			*N/A*	*0.037*	*7/17/13 12:15*	*7/19/13 10:15*	*1,159,200*	*26.6*	*N/A*	*2.6*
Base			*N/A*	*0.037*	*7/19/13 10:15*	*7/30/13 12:15*	*7,275,980*	*167.1*	*N/A*	*16.6*
In-Lake Sample	7/31/2013 11:09	7/31/2013 11:09	N/A	0.041	7/30/13 12:15	8/1/13 12:15	740,730	17.0	N/A	1.9
Base			*N/A*	*0.037*	*8/1/13 12:15*	*8/5/13 2:15*	*916,916*	*21.1*	*N/A*	*2.1*
Storm			*N/A*	*0.037*	*8/5/13 2:15*	*8/5/13 6:15*	*45,096*	*1.0*	*N/A*	*0.1*
Base			*N/A*	*0.037*	*8/5/13 6:15*	*8/12/13 1:15*	*1,212,180*	*27.8*	*N/A*	*2.8*
Storm			*N/A*	*0.037*	*8/12/13 1:15*	*8/12/13 3:15*	*12,432*	*0.3*	*N/A*	*0.0*
Base			*N/A*	*0.037*	*8/12/13 3:15*	*8/13/13 12:15*	*113,072*	*2.6*	*N/A*	*0.3*
In-Lake Sample	8/14/2013 10:36	8/14/2013 10:36	N/A	0.032	8/13/13 12:15	8/15/13 12:15	81,349	1.9	N/A	0.2
Base			*N/A*	*0.037*	*8/15/13 12:15*	*8/28/13 12:15*	*91,048*	*2.1*	*N/A*	*0.2*
In-Lake Sample	8/29/2013 10:17	8/29/2013 10:17	N/A	0.035	8/28/13 12:15	8/30/13 12:15	0	0.0	N/A	0.0
Base			*N/A*	*0.037*	*8/30/13 12:15*	*9/10/13 12:15*	*0*	*0.0*	*N/A*	*0.0*
In-Lake Sample	9/11/2013 10:33	9/11/2013 10:33	N/A	0.045	9/10/13 12:15	9/12/13 12:15	0	0.0	N/A	0.0
Base			*N/A*	*0.037*	*9/12/13 12:15*	*9/14/13 17:15*	*0*	*0.0*	*N/A*	*0.0*
Storm			*N/A*	*0.037*	*9/14/13 17:15*	*9/14/13 23:15*	*11,126*	*0.3*	*N/A*	*0.0*
Storm			*N/A*	*0.037*	*9/14/13 23:15*	*9/15/13 7:15*	*2,261*	*0.1*	*N/A*	*0.0*
Base			*N/A*	*0.037*	*9/15/13 7:15*	*9/19/13 10:15*	*0*	*0.0*	*N/A*	*0.0*
Storm			*N/A*	*0.037*	*9/19/13 10:15*	*9/19/13 14:15*	*11,509*	*0.3*	*N/A*	*0.0*
Base			*N/A*	*0.037*	*9/19/13 14:15*	*9/23/13 12:15*	*0*	*0.0*	*N/A*	*0.0*
In-Lake Sample	9/24/2013 11:02	9/24/2013 11:02	N/A	0.046	9/23/13 12:15	9/25/13 12:15	0	0.0	N/A	0.0
Base			*N/A*	*0.037*	*9/25/13 12:15*	*9/28/13 11:15*	*0*	*0.0*	*N/A*	*0.0*
Storm			*N/A*	*0.037*	*9/28/13 11:15*	*9/28/13 18:15*	*7,573*	*0.2*	*N/A*	*0.0*
Base			*N/A*	*0.037*	*9/28/13 18:15*	*10/2/13 20:15*	*0*	*0.0*	*N/A*	*0.0*
Storm			*N/A*	*0.037*	*10/2/13 20:15*	*10/3/13 1:15*	*24,915*	*0.6*	*N/A*	*0.1*
Base			*N/A*	*0.037*	*10/3/13 1:15*	*10/4/13 23:15*	*0*	*0.0*	*N/A*	*0.0*
Storm			*N/A*	*0.037*	*10/4/13 23:15*	*10/5/13 3:15*	*14,504*	*0.3*	*N/A*	*0.0*
Base			*N/A*	*0.037*	*10/5/13 3:15*	*10/8/13 12:15*	*0*	*0.0*	*N/A*	*0.0*
In-Lake Sample	10/9/2013 11:07	10/9/2013 11:07	N/A	0.046	10/8/13 12:15	10/10/13 12:15	0	0.0	N/A	0.0
Base			*N/A*	*0.037*	*10/10/13 12:15*	*10/14/13 23:15*	*0*	*0.0*	*N/A*	*0.0*
Storm			*N/A*	*0.037*	*10/14/13 23:15*	*10/15/13 12:15*	*38,589*	*0.9*	*N/A*	*0.1*
Storm			*N/A*	*0.037*	*10/15/13 12:15*	*10/15/13 20:15*	*71*	*0.0*	*N/A*	*0.0*
Base			*N/A*	*0.037*	*10/15/13 20:15*	*10/17/13 22:15*	*0*	*0.0*	*N/A*	*0.0*
Storm			*N/A*	*0.037*	*10/17/13 22:15*	*10/18/13 7:15*	*984*	*0.0*	*N/A*	*0.0*
Base			*N/A*	*0.037*	*10/18/13 7:15*	*10/20/13 11:15*	*0*	*0.0*	*N/A*	*0.0*
Storm			*N/A*	*0.037*	*10/20/13 11:15*	*10/20/13 21:15*	*0*	*0.0*	*N/A*	*0.0*
Base			*N/A*	*0.037*	*10/20/13 21:15*	*11/3/13 14:15*	*121,799*	*2.8*	*N/A*	*0.3*
*Base**			*N/A*	*0.037*	*11/3/13 14:15*	*1/1/14 0:00*	*100,926*	*2.3*	*N/A*	*0.2*
In-Lake/Base Average			N/A	0.037						
Storm Average			N/A	N/A						
All Average			N/A	0.037						
Total							**311,584,377**	**7,157**	**N/A**	**706**
CLFLWD Major Subwatershed Total Acres							8,719			
Total Load										
Total TSS/TP (lbs/ac/yr)									**N/A**	**0.081**

Italics indicate estimated concentrations based on average base and storm flow concentrations.

*Interval volumes from 1/1/2013 to 4/9/2013, 6/24/2013 to 7/19/2013 and 11/3/2013 to 1/1/2014 were estimated based on average base and storm flow concentrations.

Although no samples were collected at the Forest Lake Outlet site in 2013, the WCD used in-lake concentrations from samples collected in the West Basin of Forest Lake to estimate a total phosphorus load at this location. Total phosphorus loading at the Forest Lake Outlet site for 2013 was estimated at 0.081 lbs./ac or 706 lbs. (Table 11). There was an increase in discharge and TP load from 2012 to 2013. This is likely due to the above average amount of snowfall and subsequent snowmelt in the winter of 2012/2013 and above average amount of precipitation from April through June of 2013.

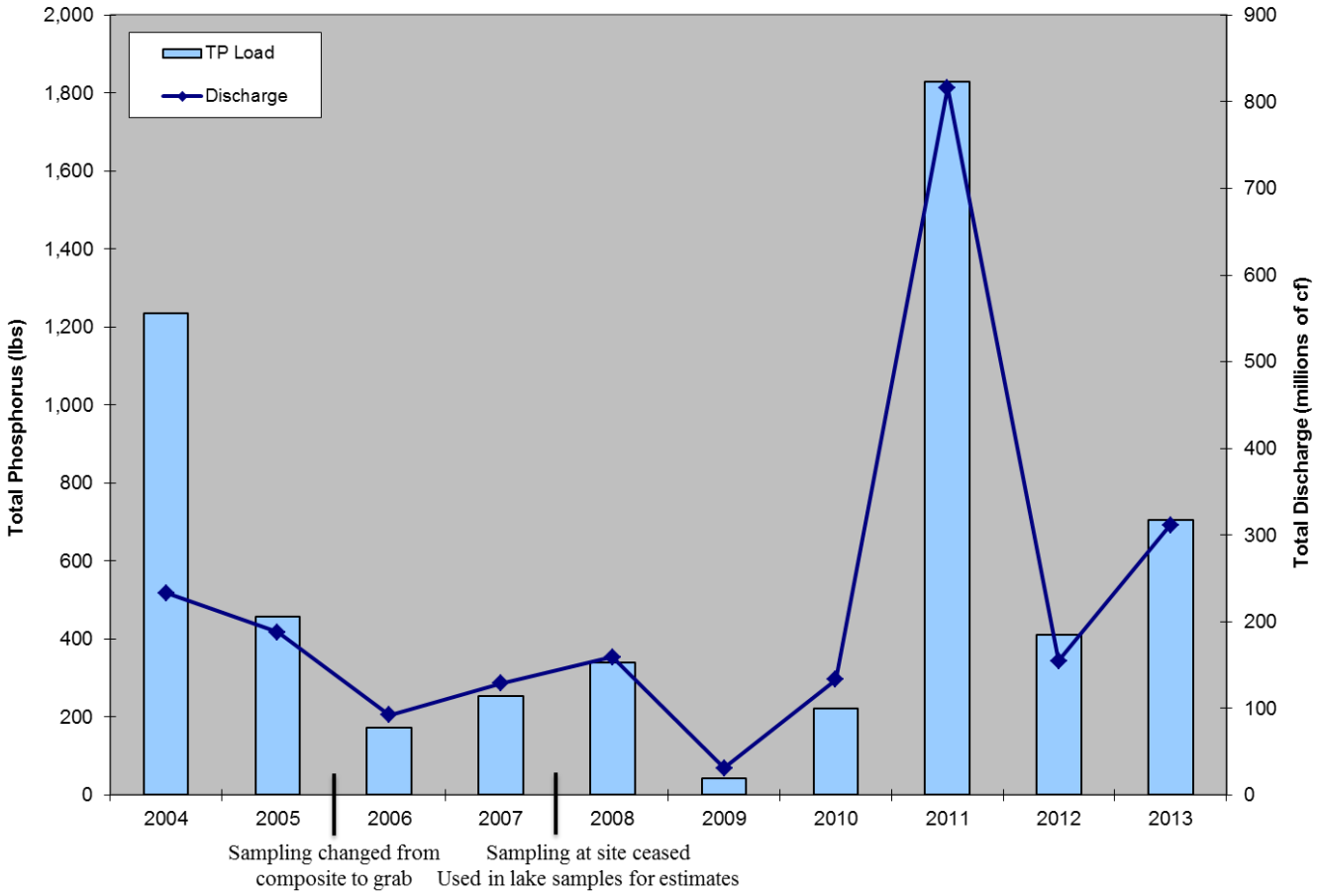


Figure 10. Forest Lake Outlet Historic Annual Discharge and Total Phosphorus Load

Flow and water chemistry data has been collected at the Forest Lake Outlet site since 2004. Total estimated annual phosphorus loading and discharge can be found in Figure 10. It should be noted that when comparing year to year loading estimates, the sampling technique utilized at this site has changed a number of times. Automated composite sampling was used in the 2004-2005 monitoring seasons and was switched to manual grab sampling for the 2006 season. Sampling at the site ceased in 2007, and all loading estimates since then have been made using in-lake sample concentrations. These changes partially explain the reduction in load versus discharge, due to the refinement level of each technique. Composite sampling typically does the best job of characterizing nutrient levels, as it is able to capture the rising limb and peak of a storm event. Manual grab sampling usually occurs near the peak or falling limb of storm events, where the nutrient concentration is normally much lower. In-lake concentrations are generally much lower than the results of either of the other two sampling methods.

V. COMFORT LAKE SUBWATERSHED

Heims Lake Drainage

The Heims Lake Drainage site recorded stage and velocity from April 9-November 4, 2013 (Figure 11). 2013 is the second year that monitoring has taken place at this location. The primary purpose of this site is to quantify the discharge and load contributions coming from Heims Lake and other small tributaries. This drainage eventually discharges into the Sunrise River upstream of the Greenway Avenue monitoring site. Total discharge for the monitoring season was 9,605,584 cf, or 221 acre-feet. No automated rain gage was installed at this site to record daily rainfall. A peak discharge of 4.128 cfs occurred on June 21st.

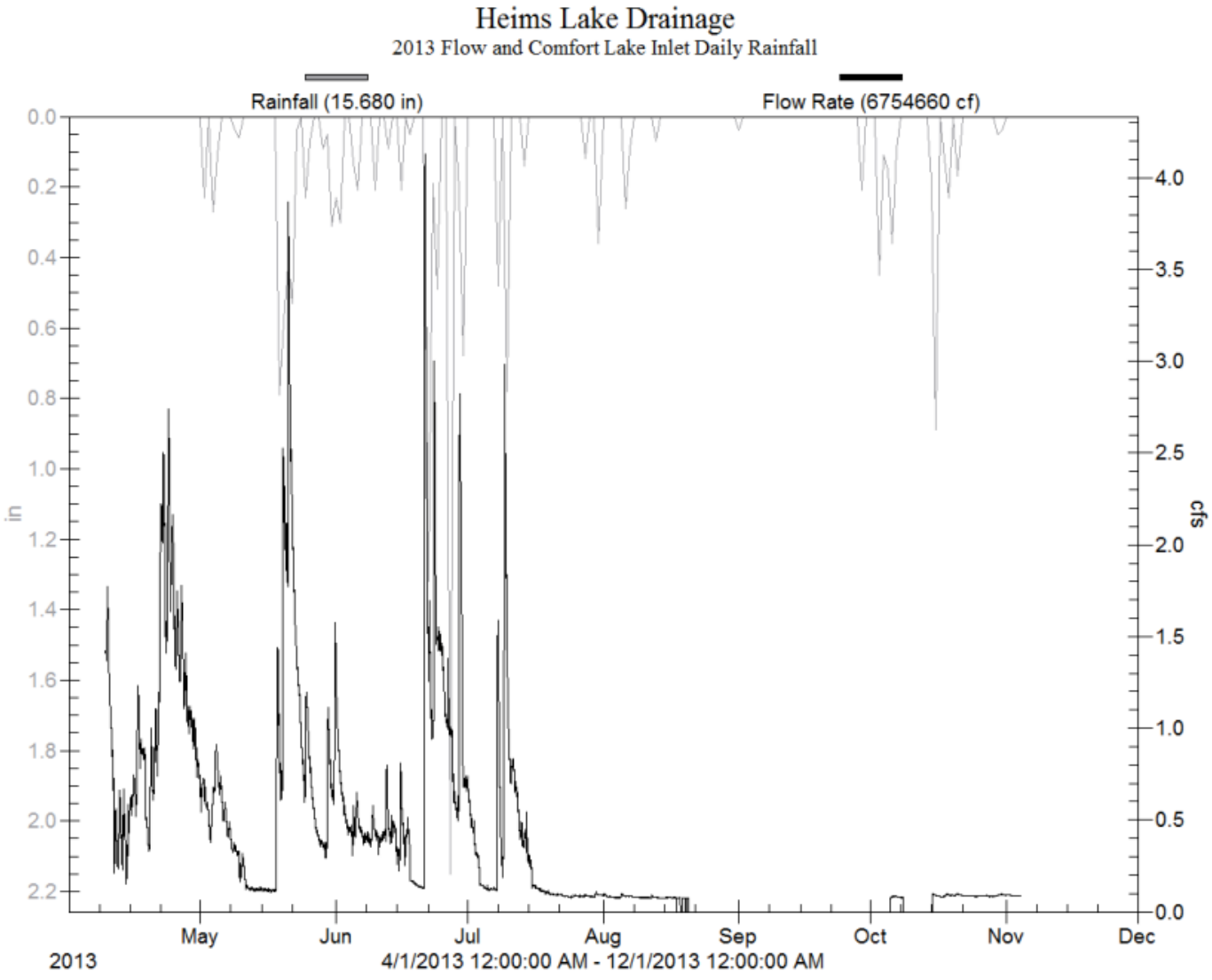


Figure 11. Heims Lake Drainage 2013 Flow and Comfort Lake Inlet Daily Rainfall

Automated storm composite, manual base grab, and snowmelt grab samples were collected at the Heims Lake site in 2013. The TSS, VSS, TKN, TP, dissolved phosphorus, chloride, nitrite, nitrate, ammonia nitrogen, and *E. coli* results from all collected samples are listed in Table 12 and field water quality measurements are listed in Table 13. The highest TSS and TKN concentrations of 492 mg/L and 6.6 mg/L, respectively, were observed on June 21st from a storm composite sample. The highest TP concentration of 1.410 mg/L was collected on July 7th from a storm composite sample. The dissolved phosphorus, chloride, nitrite, nitrate, and ammonia nitrogen results were not requested from this sample due to the low volume of sample water. All five of the TSS results exceeded the turbidity water quality standard of >100 mg/L.

Table 12. Heims Lake Drainage 2013 Sample Chemistry Results

Sample Type	Start	End	TSS (mg/L)	VSS (mg/L)	TKN (mg/L)	TP (mg/L)	Dissolved TP (mg/L)	Chloride (mg/L)	Nitrite (mg/L)	Nitrate (mg/L)	Ammonia Nitrogen (mg/L)	*E. coli* (mpn/100ml)
Snowmelt Grab	4/8/2013 10:37	4/8/2013 10:37	6	3	1.5	0.128	0.081	12.4	<0.03	1.16	0.19	
Storm Composite	5/19/2013 21:55	5/20/2013 11:28	211	121	3.6	0.363	~0.045	24.2	<0.03	0.10	~0.04	
Storm Composite	6/21/2013 4:27	6/21/2013 10:06	492	320	6.6	1.220	0.129	11.8	<0.03	0.11	0.18	
Storm Composite	6/23/2013 8:16	6/23/2013 15:21	203	126	2.9	0.408	0.159	18.0	<0.03	0.13	0.07	
Storm Composite	7/7/2013 21:21	7/7/2013 23:23	140	~96	3.8	1.410						
Storm Composite	7/9/2013 9:56	7/9/2013 19:37	249	166	3.4	0.892	0.180	12.4	<0.03	0.08	~0.04	
Base Grab	5/28/2013 9:26	5/28/2013 9:26	19	12	2.2	0.431	0.199	34.7	<0.03	<0.05	0.09	
Base Grab	7/17/2013 10:35	7/17/2013 10:35	10	~5	2.5	1.260	>1.00	38.3	<0.03	<0.05	0.34	
E. coli Grab	6/27/2013 8:41	6/27/2013 8:41										135

Exceeds Water Quality Standard

Table 13. Heims Lake Drainage 2013 Field Water Quality Measurements

Date/Time	Transparency (cm)	Water Temperature (C)	Dissolved Oxygen (mg/L)	Conductivity (umhos/cm)	pH
4/8/2013 10:37		0.6		181	7.6
5/28/2013 9:26	>100	12	6.13	329	7.2
7/17/2013 10:35	20	22.2	2.69	380	7.1

Exceeds Water Quality Standard

Table 14. Heims Lake Drainage 2013 Total Suspended Solids and Total Phosphorus Loading

	Sample Collection Time				Loading Interval					
Sample Type	**Start**	**End**	**TSS (mg/L)**	**TP (mg/L)**	**Start**	**End**	**Interval Volume (cf)**	**Interval Volume (ac-ft)**	**Interval TSS (lb)**	**Interval TP (lb)**
*Base**			*15*	*0.846*	*1/1/13 0:00*	*4/7/13 23:45*	*2,513,970*	*57.74*	*2275.6*	*132.69*
Snowmelt Grab*	4/8/2013 10:37	4/8/2013 10:37	6	0.128	4/7/13 23:45	4/9/13 10:45	88,200	2.03	33.0	0.70
Base			*15*	*0.846*	*4/9/13 10:45*	*4/16/13 10:45*	*400,058*	*9.19*	*362.1*	*21.12*
Storm			*259*	*0.859*	*4/16/13 10:45*	*4/16/13 21:45*	*39,009*	*0.90*	*630.7*	*2.09*
Base			*15*	*0.846*	*4/16/13 21:45*	*4/21/13 13:45*	*309,808*	*7.12*	*280.4*	*16.35*
Storm			*259*	*0.859*	*4/21/13 13:45*	*4/22/13 3:45*	*90,373*	*2.08*	*1461.2*	*4.84*
Base			*15*	*0.846*	*4/22/13 3:45*	*4/22/13 10:45*	*52,449*	*1.20*	*47.5*	*2.77*
Storm			*259*	*0.859*	*4/22/13 10:45*	*4/22/13 16:45*	*51,079*	*1.17*	*825.9*	*2.74*
Base			*15*	*0.846*	*4/22/13 16:45*	*4/23/13 12:45*	*127,826*	*2.94*	*115.7*	*6.75*
Storm			*259*	*0.859*	*4/23/13 12:45*	*4/23/13 19:45*	*61,826*	*1.42*	*999.6*	*3.31*
Base			*15*	*0.846*	*4/23/13 19:45*	*5/18/13 6:45*	*1,344,840*	*30.89*	*1217.3*	*70.98*
Storm			*259*	*0.859*	*5/18/13 6:45*	*5/18/13 18:45*	*42,192*	*0.97*	*682.2*	*2.26*
Base			*15*	*0.846*	*5/18/13 18:45*	*5/19/13 16:45*	*67,982*	*1.56*	*61.5*	*3.59*
Storm Composite	5/19/2013 21:55	5/20/2013 11:28	211	0.363	5/19/13 16:45	5/20/13 12:45	152,050	3.49	2002.8	3.45
Base			*15*	*0.846*	*5/20/13 12:45*	*5/20/13 23:45*	*77,596*	*1.78*	*70.2*	*4.10*
Storm			*259*	*0.859*	*5/20/13 23:45*	*5/21/13 4:45*	*60,617*	*1.39*	*980.1*	*3.25*
Base			*15*	*0.846*	*5/21/13 4:45*	*5/24/13 21:45*	*501,355*	*11.52*	*453.8*	*26.46*
Storm			*259*	*0.859*	*5/24/13 21:45*	*5/25/13 6:45*	*32,512*	*0.75*	*525.7*	*1.74*
Base Grab	5/28/2013 9:26	5/28/2013 9:26	19	0.431	5/25/13 6:45	5/29/13 23:45	221,206	5.08	262.4	5.95
Storm			*259*	*0.859*	*5/29/13 23:45*	*5/30/13 6:45*	*22,931*	*0.53*	*370.8*	*1.23*
Base			*15*	*0.846*	*5/30/13 6:45*	*5/31/13 13:45*	*82,104*	*1.89*	*74.3*	*4.33*
Storm			*259*	*0.859*	*5/31/13 13:45*	*5/31/13 19:45*	*26,818*	*0.62*	*433.6*	*1.44*
Base			*15*	*0.846*	*5/31/13 19:45*	*6/12/13 11:45*	*519,101*	*11.92*	*469.9*	*27.40*
Storm			*259*	*0.859*	*6/12/13 11:45*	*6/12/13 15:45*	*10,346*	*0.24*	*167.3*	*0.55*
Base			*15*	*0.846*	*6/12/13 15:45*	*6/15/13 13:45*	*105,554*	*2.42*	*95.5*	*5.57*
Storm			*259*	*0.859*	*6/15/13 13:45*	*6/15/13 18:45*	*12,152*	*0.28*	*196.5*	*0.65*
Base			*15*	*0.846*	*6/15/13 18:45*	*6/21/13 2:45*	*119,821*	*2.75*	*108.5*	*6.32*
Storm Composite	6/21/2013 4:27	6/21/2013 10:06	492	1.220	6/21/13 2:45	6/21/13 11:45	97,476	2.24	2993.9	7.42
Base			*15*	*0.846*	*6/21/13 11:45*	*6/23/13 5:45*	*232,780*	*5.35*	*210.7*	*12.29*
Storm Composite	6/23/2013 8:16	6/23/2013 15:21	203	0.408	6/23/13 5:45	6/23/13 15:45	88,043	2.02	1115.7	2.24
Base			*15*	*0.846*	*6/23/13 15:45*	*6/29/13 1:45*	*509,801*	*11.71*	*461.5*	*26.91*
Storm			*259*	*0.859*	*6/29/13 1:45*	*6/29/13 9:45*	*66,830*	*1.53*	*1080.5*	*3.58*
Base			*15*	*0.846*	*6/29/13 9:45*	*7/7/13 18:45*	*290,659*	*6.68*	*263.1*	*15.34*
Storm Composite	7/7/2013 21:21	7/7/2013 23:23	140	1.410	7/7/13 18:45	7/8/13 0:45	28,948	0.66	253.0	2.55
Base			*15*	*0.846*	*7/8/13 0:45*	*7/9/13 8:45*	*61,117*	*1.40*	*55.3*	*3.23*
Storm Composite	7/9/2013 9:56	7/9/2013 19:37	249	0.892	7/9/13 8:45	7/9/13 20:45	102,594	2.36	1594.7	5.71
Base			*15*	*0.846*	*7/9/13 20:45*	*7/16/13 12:45*	*314,468*	*7.22*	*284.6*	*16.60*
Base Grab	7/17/2013 10:35	7/17/2013 10:35	10	1.260	7/16/13 12:45	7/18/13 0:45	16,237	0.37	10.1	1.28
Base			*15*	*0.846*	*7/18/13 0:45*	*8/27/13 12:45*	*238,265*	*5.47*	*215.7*	*12.58*
Base			*15*	*0.846*	*8/27/13 12:45*	*10/4/13 22:45*	*0*	*0.00*	*0.0*	*0.00*
Storm			*259*	*0.859*	*10/4/13 22:45*	*10/6/13 4:45*	*4,374*	*0.10*	*70.7*	*0.23*
Base			*15*	*0.846*	*10/6/13 4:45*	*10/14/13 23:45*	*16,388*	*0.38*	*14.8*	*0.86*
Storm			*259*	*0.859*	*10/14/13 23:45*	*10/15/13 7:45*	*1,941*	*0.04*	*31.4*	*0.10*
Base			*15*	*0.846*	*10/15/13 7:45*	*11/4/13 10:00*	*153,130*	*3.52*	*138.6*	*8.08*
*Base**			*15*	*0.846*	*11/4/13 10:00*	*1/1/14 0:00*	*248,760*	*5.71*	*225.2*	*13.13*
Base Average			15	0.846						
Storm Average			259	0.859						
Snowmelt Average			6	0.128						
All Average			166	0.764						
Total							**9,605,584**	**221**	**24,224**	**495**
CLFLWD Major Subwatershed Total Acres							667			
Total Load										
Total TSS/TP (lbs/ac/yr)									**36.32**	**0.742**

Italics indicate estimated concentrations based on average base and storm flow concentrations.

*Interval volumes from 1/1/2013 to 4/7/2013, 4/7/2013 to 4/9/2013 and 11/4/2013 to 1/1/2014 were estimated based on average base and storm flow concentrations.

Total phosphorus loading at the Heims Lake Drainage site for 2013 was estimated at 0.742 lbs/ac or 495 lbs. (Table 14). Monitoring at this location will help quantify discharge and loads coming from Heims Lake, which eventually discharges into the Sunrise River upstream of the Greenway Avenue site.

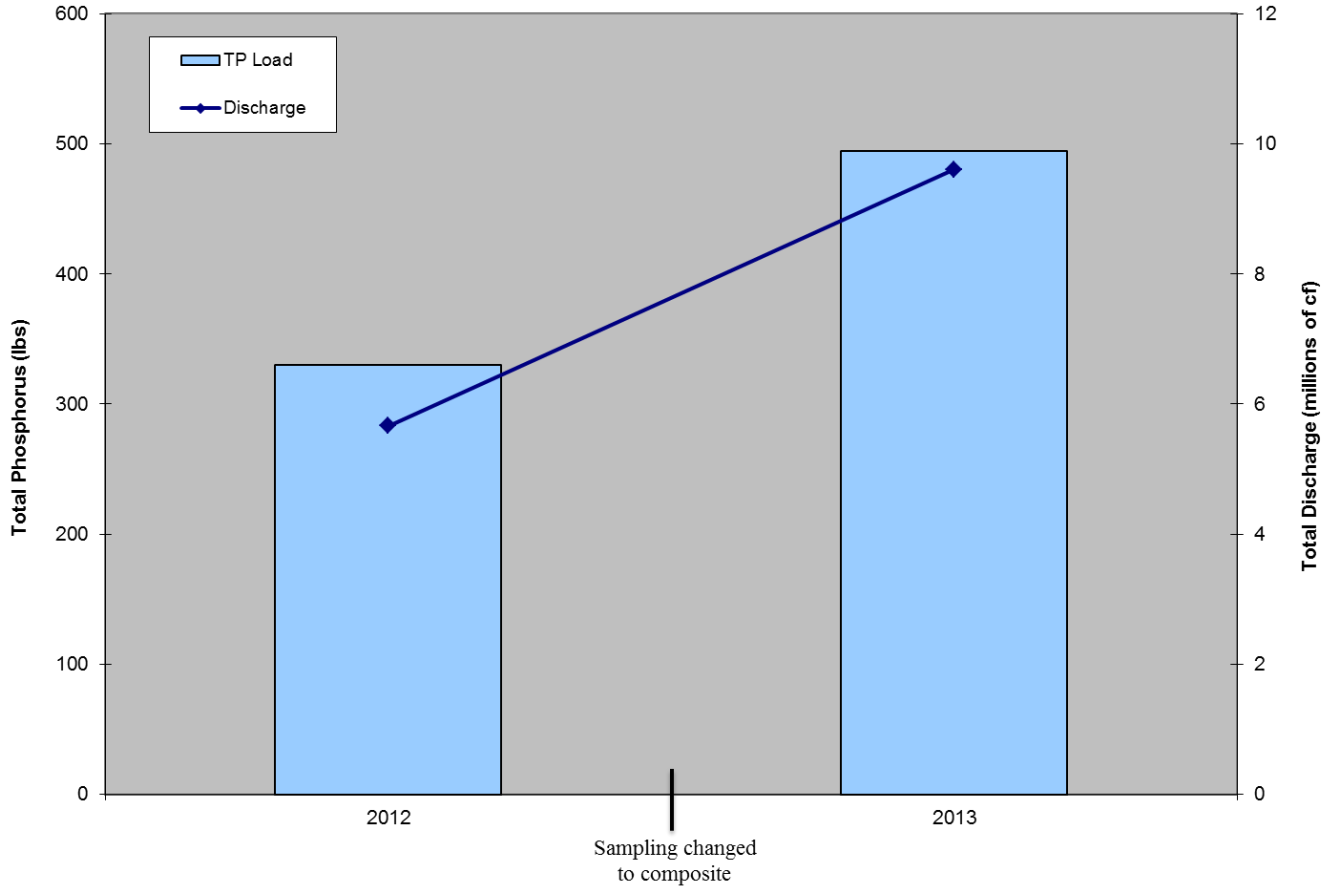


Figure 12. Heims Lake Drainage Historic Annual Discharge and Total Phosphorus Load

2013 is the second year that flow and water chemistry data has been collected at the Heims Lake Drainage site. Estimated annual total discharge and phosphorus export can be seen in Figure 12. There was an increase in discharge and TP load from 2012 to 2013. This could be due to the fact that the winter of 2012/2013 had above average amounts of snowfall and subsequent snowmelt and above average precipitation from April through June of 2013. Another factor to consider is the change in sampling technique from 2012 (automated grab samples) to 2013 (automated composite samples). Composite sampling typically does the best job of characterizing nutrient levels, as it is able to capture the rising limb and peak of a storm event. Manual grab sampling usually occurs near the peak or falling limb of storm events, where the nutrient concentration is normally much lower. Further monitoring is needed to assess and understand the loading trend present at this site and its effects downstream.

Greenway Avenue

The Greenway Avenue site recorded stage and velocity from May 15-November 4, 2013 (Figure 13). 2013 was the third consecutive year that monitoring has taken place at this site; the first year of monitoring was 2008. The primary purpose of this site is to quantify the loads previous to discharging to the Shallow Pond, a wetland complex, for determination of phosphorus release or capture between this location and Comfort Lake. Total discharge for the monitoring season was 326,439,257 cf, or 7,498 acre-feet. No automated rain gage was installed at this site to record rainfall. A peak discharge of 34.651 cfs occurred on May 23rd.

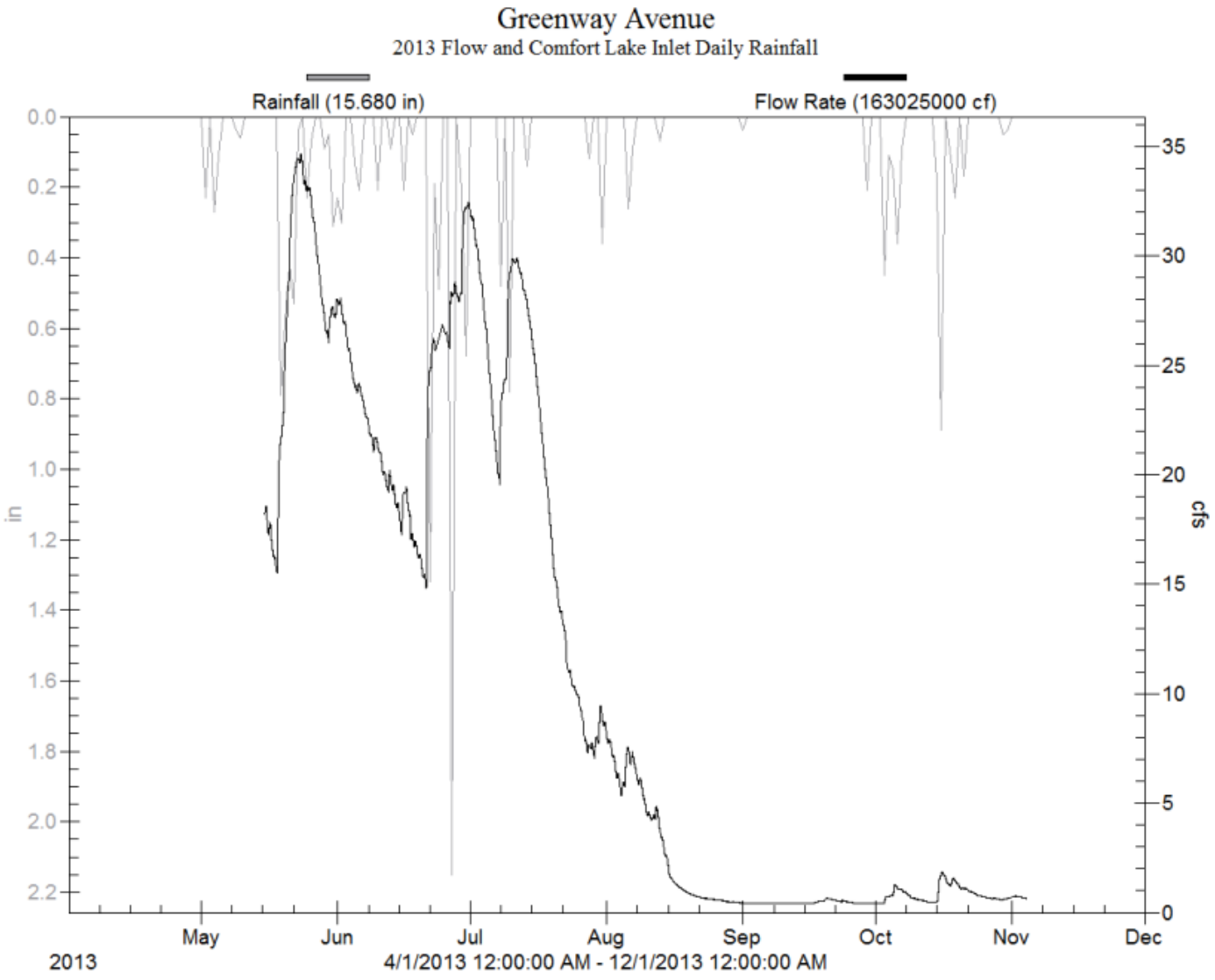


Figure 13. Greenway Avenue 2013 Flow and Comfort Lake Inlet Daily Rainfall

Automated storm composite, manual base grab, and snowmelt grab samples were collected at the Greenway Avenue site in 2013. The TSS, VSS, TKN, TP, dissolved phosphorus, chloride, nitrite, nitrate, ammonia nitrogen, and *E. coli* results from all collected samples are listed in Table 15 and field water quality measurements are listed in Table 16. The highest TSS concentration of 25 mg/L was collected from a June 21st-22nd storm composite, the highest TKN concentration of 2.2 mg/L was collected from an April 8th snowmelt grab, and the highest TP concentration of 0.148 mg/L was from a base grab collected on July 17th.

Table 15. Greenway Avenue 2013 Sample Chemistry Results

Sample Type	Start	End	TSS (mg/L)	VSS (mg/L)	TKN (mg/L)	TP (mg/L)	Dissolved TP (mg/L)	Chloride (mg/L)	Nitrite (mg/L)	Nitrate (mg/L)	Ammonia Nitrogen (mg/L)	*E. coli* (mpn/100ml)
Snowmelt Grab	4/8/2013 10:18	4/8/2013 10:18	9	4	2.2	0.107	0.059	106.6	0.04	1.99	0.33	
Storm Composite	5/19/2013 17:37	5/20/2013 5:27	16	~6	1.8	0.066	<0.020	93.7	<0.03	0.19	0.08	
Storm Composite	6/21/2013 9:44	6/22/2013 8:27	25	~12	1.7	0.114	~0.036	53.1	0.05	0.12	0.10	
Storm Composite	7/9/2013 17:53	7/10/2013 13:12	22	10	1.5	0.096	~0.024	49.8	<0.03	0.06	<0.02	
Storm Composite	10/15/2013 8:51	10/16/2013 15:55	6	~4	1.1	0.107	~0.038	126.4	<0.03	0.33	0.08	
Base Grab	7/17/2013 11:10	7/17/2013 11:10	9	6	1.2	0.148	~0.040	43.5	<0.03	<0.05	<0.02	
Base Grab	10/10/2013 9:36	10/10/2013 9:36	~2	~2	1.4	0.055	<0.020	148.2	<0.03	<0.05	0.09	207
E. coli Grab	6/27/2013 8:52	6/27/2013 8:52										132
E. coli Grab	7/29/2013 9:20	7/29/2013 9:20										127

Table 16. Greenway Avenue 2013 Field Water Quality Measurements

Date/Time	Transparency (cm)	Water Temperature (C)	Dissolved Oxygen (mg/L)	Conductivity (umhos/cm)	pH
4/8/2013 10:18		1.6		678	7.9
5/28/2013 9:42	34	13.9	7.20	452	7.9
7/17/2013 11:10	56	27.6	4.74	407	7.8
10/10/2013 9:36	>100	14.1	4.33	849	7.8
	Exceeds Water Quality Standard				

Table 17. Greenway Avenue 2013 Total Suspended Solids and Total Phosphorus Loading

	Sample Collection Time				Loading Interval					
Sample Type	**Start**	**End**	**TSS (mg/L)**	**TP (mg/L)**	**Start**	**End**	**Interval Volume (cf)**	**Interval Volume (ac-ft)**	**Interval TSS (lb)**	**Interval TP (lb)**
*Base**			*6*	*0.102*	*1/1/13 0:00*	*4/7/13 13:15*	*108,447,300*	*2490.91*	*37234.7*	*687.15*
Snowmelt Grab*	4/8/2013 10:18	4/8/2013 10:18	9	0.107	4/7/13 13:15	4/8/13 21:15	2,073,600	47.63	1165.0	13.85
*Base**			*6*	*0.102*	*4/8/13 21:15*	*5/15/13 10:15*	*50,515,200*	*1160.28*	*17344.1*	*320.08*
Base			*6*	*0.102*	*5/15/13 10:15*	*5/18/13 6:15*	*4,184,410*	*96.11*	*1436.7*	*26.51*
Storm			*17*	*0.096*	*5/18/13 6:15*	*5/18/13 21:15*	*1,026,500*	*23.58*	*1105.4*	*6.14*
Base			*6*	*0.102*	*5/18/13 21:15*	*5/19/13 17:15*	*1,584,140*	*36.39*	*543.9*	*10.04*
Storm Composite	5/19/2013 17:37	5/20/2013 5:27	16	0.066	5/19/13 17:15	5/20/13 14:15	1,950,960	44.81	1948.7	8.04
Base			*6*	*0.102*	*5/20/13 14:15*	*5/21/13 0:15*	*1,029,570*	*23.65*	*353.5*	*6.52*
Storm			*17*	*0.096*	*5/21/13 0:15*	*5/21/13 15:15*	*1,695,350*	*38.94*	*1825.6*	*10.13*
Base			*6*	*0.102*	*5/21/13 15:15*	*5/30/13 0:15*	*22,732,600*	*522.14*	*7805.1*	*144.04*
Storm			*17*	*0.096*	*5/30/13 0:15*	*5/30/13 6:15*	*578,939*	*13.30*	*623.4*	*3.46*
Base			*6*	*0.102*	*5/30/13 6:15*	*5/31/13 14:15*	*3,157,700*	*72.53*	*1084.2*	*20.01*
Storm			*17*	*0.096*	*5/31/13 14:15*	*5/31/13 20:15*	*601,636*	*13.82*	*647.9*	*3.60*
Base			*6*	*0.102*	*5/31/13 20:15*	*6/1/13 14:15*	*1,805,810*	*41.48*	*620.0*	*11.44*
Storm			*17*	*0.096*	*6/1/13 14:15*	*6/1/13 16:15*	*201,863*	*4.64*	*217.4*	*1.21*
Base			*6*	*0.102*	*6/1/13 16:15*	*6/15/13 14:15*	*26,681,700*	*612.85*	*9161.0*	*169.06*
Storm			*17*	*0.096*	*6/15/13 14:15*	*6/16/13 4:15*	*949,713*	*21.81*	*1022.7*	*5.68*
Base			*6*	*0.102*	*6/16/13 4:15*	*6/21/13 3:15*	*7,256,050*	*166.66*	*2491.3*	*45.98*
Storm Composite	6/21/2013 9:44	6/22/2013 8:27	25	0.114	6/21/13 3:15	6/22/13 22:15	3,777,970	86.78	5896.1	26.89
Base			*6*	*0.102*	*6/22/13 22:15*	*6/23/13 3:00*	*440,989*	*10.13*	*151.4*	*2.79*
*Base**			*6*	*0.102*	*6/23/13 3:00*	*6/24/13 14:00*	*2,898,000*	*66.56*	*995.0*	*18.36*
Base			*6*	*0.102*	*6/24/13 14:00*	*6/24/13 20:15*	*602,562*	*13.84*	*206.9*	*3.82*
*Base**			*6*	*0.102*	*6/24/13 20:15*	*6/25/13 10:45*	*1,252,800*	*28.78*	*430.1*	*7.94*
Base			*6*	*0.102*	*6/25/13 10:45*	*6/26/13 11:15*	*2,307,000*	*52.99*	*792.1*	*14.62*
Storm			*17*	*0.096*	*6/26/13 11:15*	*6/26/13 18:15*	*704,849*	*16.19*	*759.0*	*4.21*
Base			*6*	*0.102*	*6/26/13 18:15*	*6/29/13 1:15*	*5,600,070*	*128.63*	*1922.7*	*35.48*
Storm			*17*	*0.096*	*6/29/13 1:15*	*6/29/13 20:15*	*2,120,720*	*48.71*	*2283.7*	*12.68*
Base			*6*	*0.102*	*6/29/13 20:15*	*7/7/13 18:15*	*18,749,500*	*430.65*	*6437.5*	*118.80*
Storm			*17*	*0.096*	*7/7/13 18:15*	*7/8/13 9:15*	*1,230,340*	*28.26*	*1324.9*	*7.35*
Base			*6*	*0.102*	*7/8/13 9:15*	*7/9/13 8:15*	*2,007,660*	*46.11*	*689.3*	*12.72*
Storm Composite	7/9/2013 17:53	7/10/2013 13:12	22	0.096	7/9/13 8:15	7/10/13 20:15	3,740,800	85.92	5137.5	22.42
Base			*6*	*0.102*	*7/10/13 20:15*	*7/16/13 18:15*	*14,047,800*	*322.66*	*4823.2*	*89.01*
Base Grab	7/17/2013 11:10	7/17/2013 11:10	9	0.148	7/16/13 18:15	7/18/13 6:15	2,776,530	63.77	1560.0	25.65
Base			*6*	*0.102*	*7/18/13 6:15*	*10/2/13 23:15*	*22,334,000*	*512.99*	*7668.2*	*141.51*
Storm			*17*	*0.096*	*10/2/13 23:15*	*10/3/13 9:15*	*22,037*	*0.51*	*23.7*	*0.13*
Base			*6*	*0.102*	*10/3/13 9:15*	*10/5/13 1:15*	*108,478*	*2.49*	*37.2*	*0.69*
Storm			*17*	*0.096*	*10/5/13 1:15*	*10/5/13 13:15*	*48,550*	*1.12*	*52.3*	*0.29*
Base			*6*	*0.102*	*10/5/13 13:15*	*10/9/13 7:15*	*307,390*	*7.06*	*105.5*	*1.95*
Base Grab	10/10/2013 9:36	10/10/2013 9:36	2	0.055	10/9/13 7:15	10/10/13 18:15	79,521	1.83	9.9	0.27
Base			*6*	*0.102*	*10/10/13 18:15*	*10/14/13 23:15*	*186,168*	*4.28*	*63.9*	*1.18*
Storm Composite	10/15/2013 8:51	10/16/2013 15:55	6	0.107	10/14/13 23:15	10/16/13 16:15	217,713	5.00	81.5	1.45
Base			*6*	*0.102*	*10/16/13 16:15*	*10/18/13 5:15*	*185,447*	*4.26*	*63.7*	*1.18*
Storm			*17*	*0.096*	*10/18/13 5:15*	*10/18/13 18:15*	*69,252*	*1.59*	*74.6*	*0.41*
Base			*6*	*0.102*	*10/18/13 18:15*	*11/4/13 11:30*	*1,168,190*	*26.83*	*401.1*	*7.40*
*Base**			*6*	*0.102*	*11/4/13 11:30*	*1/1/14 0:00*	*2,981,880*	*68.49*	*1023.8*	*18.89*
Base Average			6	0.102						
Storm Average			17	0.096						
Snowmelt Average			9	0.107						
All Average			13	0.099						
Total							**326,439,257**	**7,498**	**129,646**	**2,071**
CLFLWD Major Subwatershed Total Acres							10,874			
Total Load										
Total TSS/TP (lbs/ac/yr)									**11.92**	**0.190**

Italics indicate estimated concentrations based on average base and storm flow concentrations.

*Interval volumes from 1/1/2013 to 4/7/2013, 4/7/2013 to 4/8/2013, 4/8/2013 to 5/15/2013, 6/23/2013 to 6/24/2013, 6/24/2013 to 6/25/2013 and 11/4/2013 to 1/1/2014 were estimated based on average base and storm flow concentrations.

Total phosphorus loading at the Greenway Avenue Site for 2013 was estimated at 0.190 lbs/ac or 2,071 lbs. (Table 17). Of the eight sites monitored in CLFLWD, this site has one of the highest loading rates.

One possibility for the higher load and discharge rates that occur at this site could be the contribution from Heims Lake. The discharge from Heims Lake eventually flows into the Sunrise River upstream of the Greenway Avenue site. A monitoring station was installed at the Heims Lake Drainage site in 2012 which will confirm or deny the discharge and load contributions from that lake. Another reason for the higher load concentrations and discharge rates is due to the large size of the subwatershed that drains to this site, which includes the City of Forest Lake.

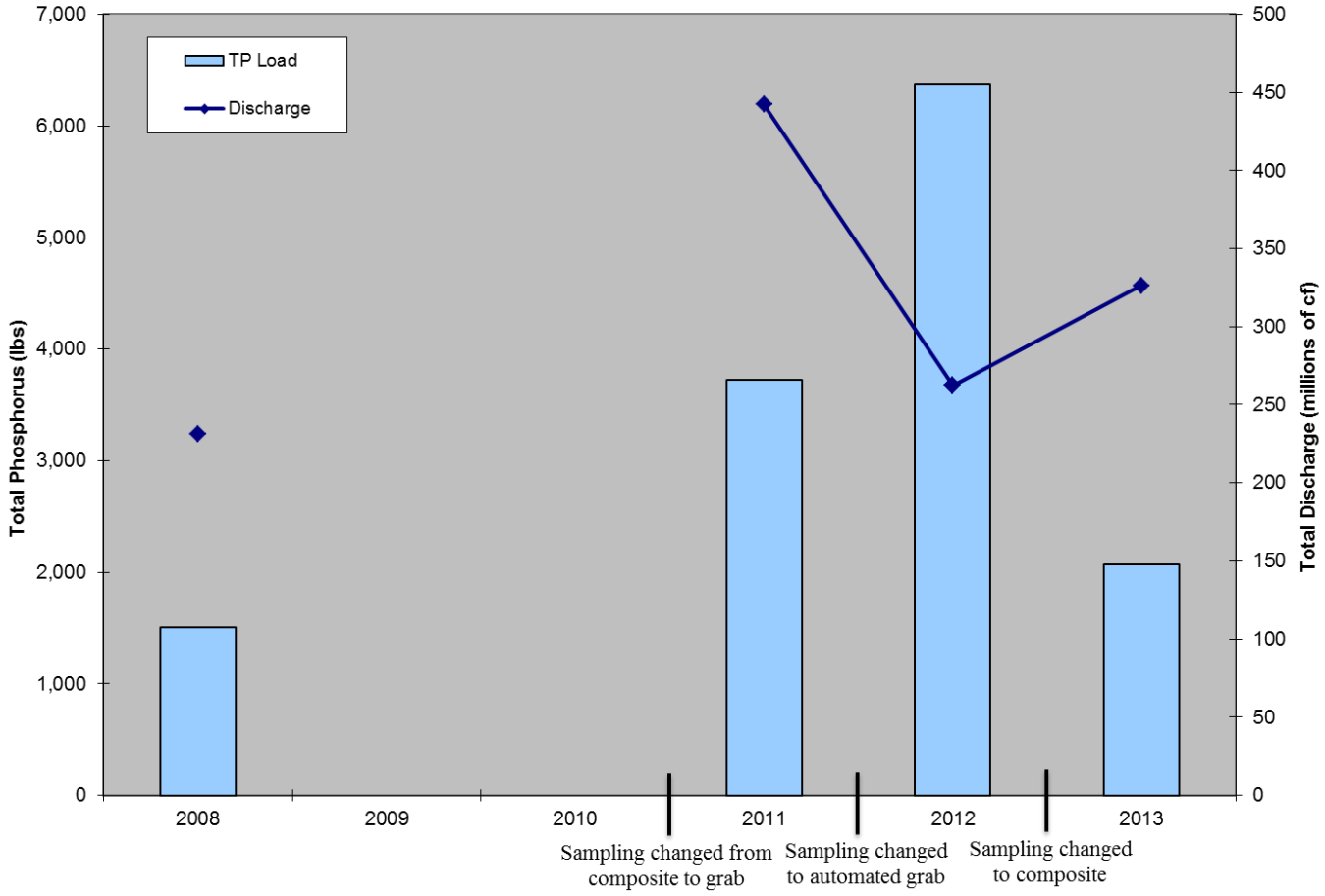


Figure 14. Greenway Avenue Historic Annual Discharge and Total Phosphorus Load

Flow and water chemistry data was first collected at the Greenway Avenue site in 2008, and again from 2011-2013. Estimated annual total discharge and phosphorus export can be seen in Figure 14. When comparing year-to-year load estimations, the change in the sampling techniques used at this site should be noted. In 2008 an automated composite sampling technique was used, whereas only manual grab samples were collected in 2011. Composite samples typically lead to higher load estimations due to the nature of the sampling technique; although this did not hold true for the 2013 monitoring season. Composite sampling typically catches the rising limb and peak of a storm event which typically carries more nutrients. Manual grab sampling typically catches the peak or falling limb of a storm event where fewer nutrients are present. There was an increase in discharge at this site from 2012 to 2013 which could be attributed to above average amounts of snowfall for the winter of 2012/2013 and above average

amounts of precipitation from April through June 2013. The TP load however, significantly decreased from 2012. This is due to the difference in sample results from 2012; all samples collected were significantly lower in 2013. In particular TSS, seven of the nine storm samples collected in 2012 exceeded the water quality standard; along with those results were higher TP results also. The TP load for 2012 was 0.586 lbs/year (6,370 lbs.) while in 2013 it was 0.190 lbs/year (2,071 lbs.). The significant difference in loads could in part be due to the change in sampling techniques used from 2011-2013. 2013 samples were collected by using the automated storm composite technique. In 2012 grab samples were collected automatically, utilizing the sampling equipment at the site. This allowed for better timing of the grab sample collection, most were collected during the rising limb or near the peak of the storm event. It is not clear if the difference in sampling techniques has anything to do with the differences in load estimations at this site since there are not enough years of data to compare. Further monitoring is needed to assess the loading trend present at this site.

Comfort Lake Inlet

The station at Comfort Lake Inlet recorded stage, velocity, and rainfall from May 13-November 4, 2013 (Figure 15). Total discharge for the monitoring season was 355,022,452 cf or 8,154 acre-ft. Total rainfall for the monitoring season was 15.68 inches. A peak flow of 33.531 cfs occurred on May 22nd.

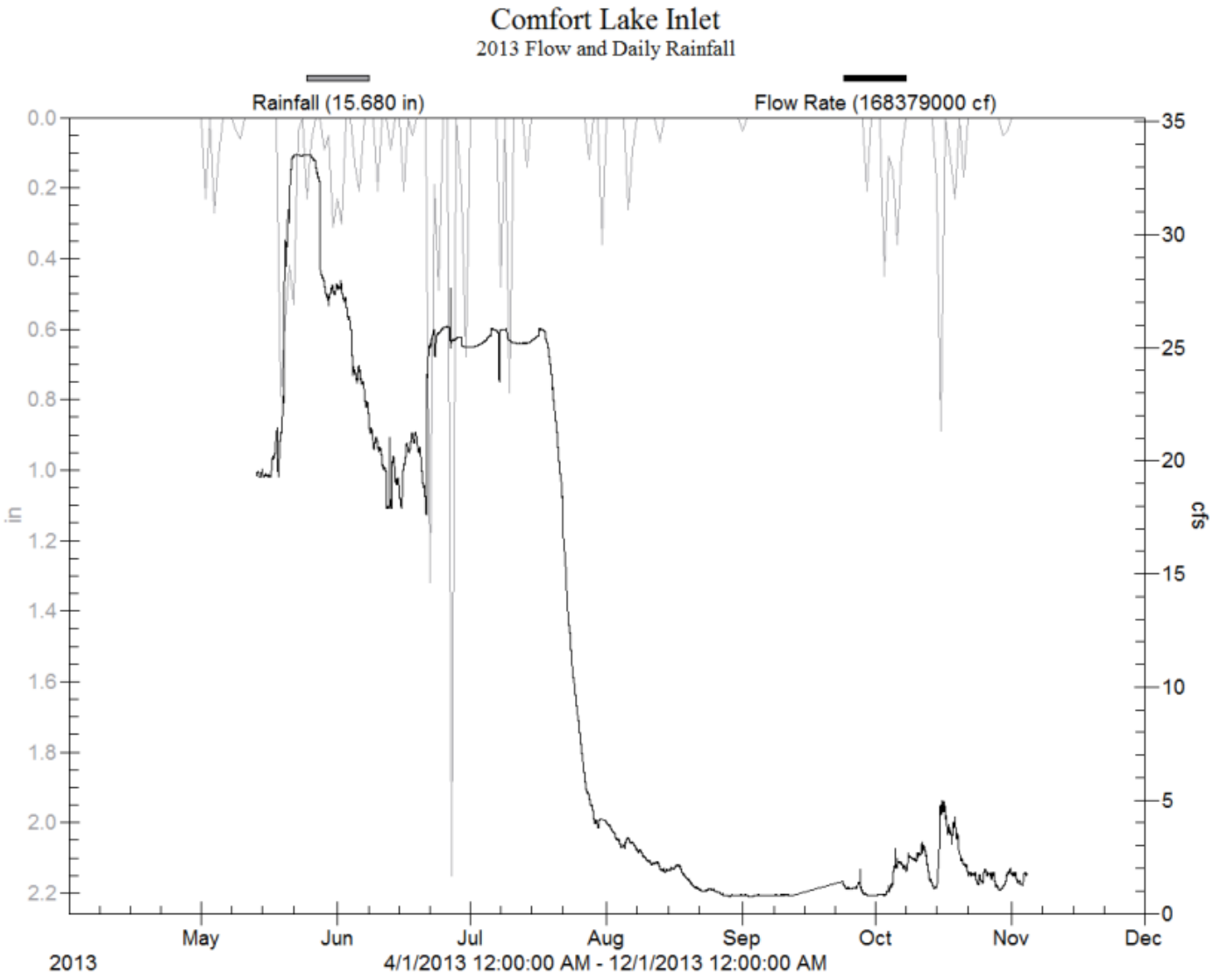


Figure 15. Comfort Lake Inlet 2013 Flow and Daily Rainfall

Automated storm composite, manual base, and snowmelt grab samples were collected at the Comfort Lake Inlet site in 2013. The TSS, VSS, TKN, TP, dissolved phosphorus, chloride, nitrite, nitrate, ammonia nitrogen, and *E. coli* results from all collected samples are listed in Table 18 and field water quality measurements are listed in Table 19. The highest TSS concentration observed was 20 mg/L from a June 23rd storm composite. The highest TKN and TP concentrations observed were 2.2 mg/L and 0.126 mg/L, respectively, both from an April 8th snowmelt grab.

Table 18. Comfort Lake Inlet 2013 Sample Chemistry Results

Sample Type	Start	End	TSS (mg/L)	VSS (mg/L)	TKN (mg/L)	TP (mg/L)	Dissolved TP (mg/L)	Chloride (mg/L)	Nitrite (mg/L)	Nitrate (mg/L)	Ammonia Nitrogen (mg/L)	*E. coli* (mpn/100ml)
Snowmelt Grab	4/8/2013 10:07	4/8/2013 10:07	5	3	2.2	0.126	~0.045	119.4	0.05	1.82	0.39	
Storm Composite	5/20/2013 9:57	5/20/2013 19:16	6	~3	1.6	0.058	<0.020	81.1	<0.03	0.21	~0.05	
Storm Composite	6/23/2013 8:10	6/23/2013 16:36	20	~11	1.8	0.105	~0.025	63.7	<0.03	0.15	~0.04	
Base Grab	7/17/2013 12:59	7/17/2013 12:59	9	~5	1.4	0.106	0.054	44.3	<0.03	0.06	~0.03	
Base Grab	9/24/2013 10:11	9/24/2013 10:11	~2	~1	0.9	~0.044	<0.020	99.4	0.03	1.45	0.07	461
Base Grab	10/10/2013 10:02	10/10/2013 10:02	~2	~2	1.1	0.053	<0.020	109.3	0.06	0.46	~0.04	179
E. coli Grab	6/27/2013 9:04	6/27/2013 9:04										407
E. coli Grab	7/29/2013 9:50	7/29/2013 9:50										53

Table 19. Comfort Lake Inlet 2013 Field Water Quality Measurements

Date/Time	Transparency (cm)	Water Temperature (C)	Dissolved Oxygen (mg/L)	Conductivity (umhos/cm)	pH
4/8/2013 10:07		1.0		698	7.8
7/17/2013 12:59	59	26.2	2.68	418	7.4
9/24/2013 10:11	>100	13.4	3.87	701	7.9
10/10/2013 10:02	>100	12.7	1.34	828	7.7

Exceeds Water Quality Standard

Table 20. Comfort Lake Inlet 2013 Total Suspended Solids and Total Phosphorus Loading

	Sample Collection Time				Loading Interval					
Sample Type	**Start**	**End**	**TSS (mg/L)**	**TP (mg/L)**	**Start**	**End**	**Interval Volume (cf)**	**Interval Volume (ac-ft)**	**Interval TSS (lb)**	**Interval TP (lb)**
*Base**			*4*	*0.068*	*1/1/13 0:00*	*4/7/13 10:15*	*124,969,500*	*2870.4*	*33,806*	*527.9*
Snowmelt Grab*	4/8/2013 10:07	4/8/2013 10:07	5	0.126	4/7/13 10:15	4/8/13 20:15	2,080,800	47.8	649	16.4
*Base**			*4*	*0.068*	*4/8/13 20:15*	*5/13/13 15:15*	*48,096,000*	*1104.7*	*13,011*	*203.2*
Base			*4*	*0.068*	*5/13/13 15:15*	*5/18/13 6:15*	*7,855,110*	*180.4*	*2,125*	*33.2*
Storm			*13*	*0.082*	*5/18/13 6:15*	*5/18/13 22:15*	*1,160,830*	*26.7*	*942*	*5.9*
Base			*4*	*0.068*	*5/18/13 22:15*	*5/19/13 17:15*	*1,483,280*	*34.1*	*401*	*6.3*
Storm			*13*	*0.082*	*5/19/13 17:15*	*5/19/13 19:15*	*170,995*	*3.9*	*139*	*0.9*
Base			*4*	*0.068*	*5/19/13 19:15*	*5/20/13 4:15*	*903,727*	*20.8*	*244*	*3.8*
Storm Composite	5/20/2013 9:57	5/20/2013 19:16	6	0.058	5/20/13 4:15	5/20/13 20:15	1,724,050	39.6	646	6.2
Base			*4*	*0.068*	*5/20/13 20:15*	*5/21/13 0:15*	*445,839*	*10.2*	*121*	*1.9*
Storm			*13*	*0.082*	*5/21/13 0:15*	*5/21/13 2:15*	*226,652*	*5.2*	*184*	*1.2*
Base			*4*	*0.068*	*5/21/13 2:15*	*5/30/13 0:15*	*24,676,200*	*566.8*	*6,675*	*104.2*
Storm			*13*	*0.082*	*5/30/13 0:15*	*5/30/13 2:15*	*195,518*	*4.5*	*159*	*1.0*
Base			*4*	*0.068*	*5/30/13 2:15*	*6/1/13 14:15*	*5,955,940*	*136.8*	*1,611*	*25.2*
Storm			*13*	*0.082*	*6/1/13 14:15*	*6/1/13 15:15*	*100,411*	*2.3*	*81*	*0.5*
Base			*4*	*0.068*	*6/1/13 15:15*	*6/21/13 3:15*	*36,191,500*	*831.3*	*9,790*	*152.9*
Storm			*13*	*0.082*	*6/21/13 3:15*	*6/21/13 7:15*	*322,013*	*7.4*	*261*	*1.6*
Base			*4*	*0.068*	*6/21/13 7:15*	*6/23/13 6:15*	*4,232,120*	*97.2*	*1,145*	*17.9*
Storm Composite	6/23/2013 8:10	6/23/2013 16:36	20	0.105	6/23/13 6:15	6/23/13 17:15	1,008,270	23.2	1,259	6.6
Base			*4*	*0.068*	*6/23/13 17:15*	*6/26/13 11:15*	*6,136,170*	*140.9*	*1,660*	*25.9*
Storm			*13*	*0.082*	*6/26/13 11:15*	*6/26/13 14:15*	*282,216*	*6.5*	*229*	*1.4*
Base			*4*	*0.068*	*6/26/13 14:15*	*7/9/13 8:15*	*27,894,800*	*640.7*	*7,546*	*117.8*
Storm			*13*	*0.082*	*7/9/13 8:15*	*7/9/13 11:15*	*275,833*	*6.3*	*224*	*1.4*
Base			*4*	*0.068*	*7/9/13 11:15*	*7/16/13 12:15*	*15,370,100*	*353.0*	*4,158*	*64.9*
Base Grab	7/17/2013 12:59	7/17/2013 12:59	9	0.106	7/16/13 12:15	7/18/13 3:15	3,614,710	83.0	2,031	23.9
Base			*4*	*0.068*	*7/18/13 3:15*	*9/12/13 9:30*	*20,135,400*	*462.5*	*5,447*	*85.1*
*Base**			*4*	*0.068*	*9/12/13 9:30*	*9/23/13 15:00*	*2,910,600*	*66.9*	*787*	*12.3*
Base Grab	9/24/2013 10:11	9/24/2013 10:11	2	0.044	9/23/13 15:00	9/25/13 3:15	150,950	3.5	19	0.4
Base			*4*	*0.068*	*9/25/13 3:15*	*10/9/13 7:15*	*1,652,710*	*38.0*	*447*	*7.0*
Base Grab	10/10/2013 10:02	10/10/2013 10:02	2	0.053	10/9/13 7:15	10/10/13 20:15	324,078	7.4	40	1.1
Base			*4*	*0.068*	*10/10/13 20:15*	*11/4/13 10:30*	*4,529,330*	*104.0*	*1,225*	*19.1*
*Base**			*4*	*0.068*	*11/4/13 10:30*	*1/1/14 0:00*	*9,946,800*	*228.5*	*2,691*	*42.0*
Base Average			4	0.068						
Storm Average			13	0.082						
Snowmelt Average			5	0.126						
All Average			7	0.082						
Total							**355,022,452**	**8,154**	**99,754**	**1,519**
CLFLWD Major Subwatershed Total Acres							13,732			
Total Load										
Total TSS/TP (lbs/ac/yr)									**7.26**	**0.111**

Italics indicate estimated concentrations based on average base and storm flow concentrations.

*Interval volumes from 1/1/2013 to 4/7/2013, 4/7/2013 to 4/8/2013, 4/8/2013 to 5/13/2013, 9/12/2013 to 9/23/2013 and 11/4/2013 to 1/1/2014 were estimated based on average base and storm flow concentrations.

Total phosphorus loading at Comfort Lake Inlet for 2013 was estimated at 0.111 lbs/ac or 1,519 lbs. (Table 20). In 2011 a site at Greenway Avenue was installed and monitored to further help understand where the majority of load entering Comfort Lake was coming from. In 2011 Greenway Avenue showed a greater TP load estimate than at Comfort Lake Inlet. This also held true when looking at the 2012 and 2013 loading data. This could lead to the conclusion that the Shallow Pond, a wetland complex between the Greenway Avenue and Comfort Lake Inlet sites, is acting as a sink for nutrients before they reach Comfort Lake Inlet. This was also the case in 2008 when the Greenway Avenue site was first monitored.

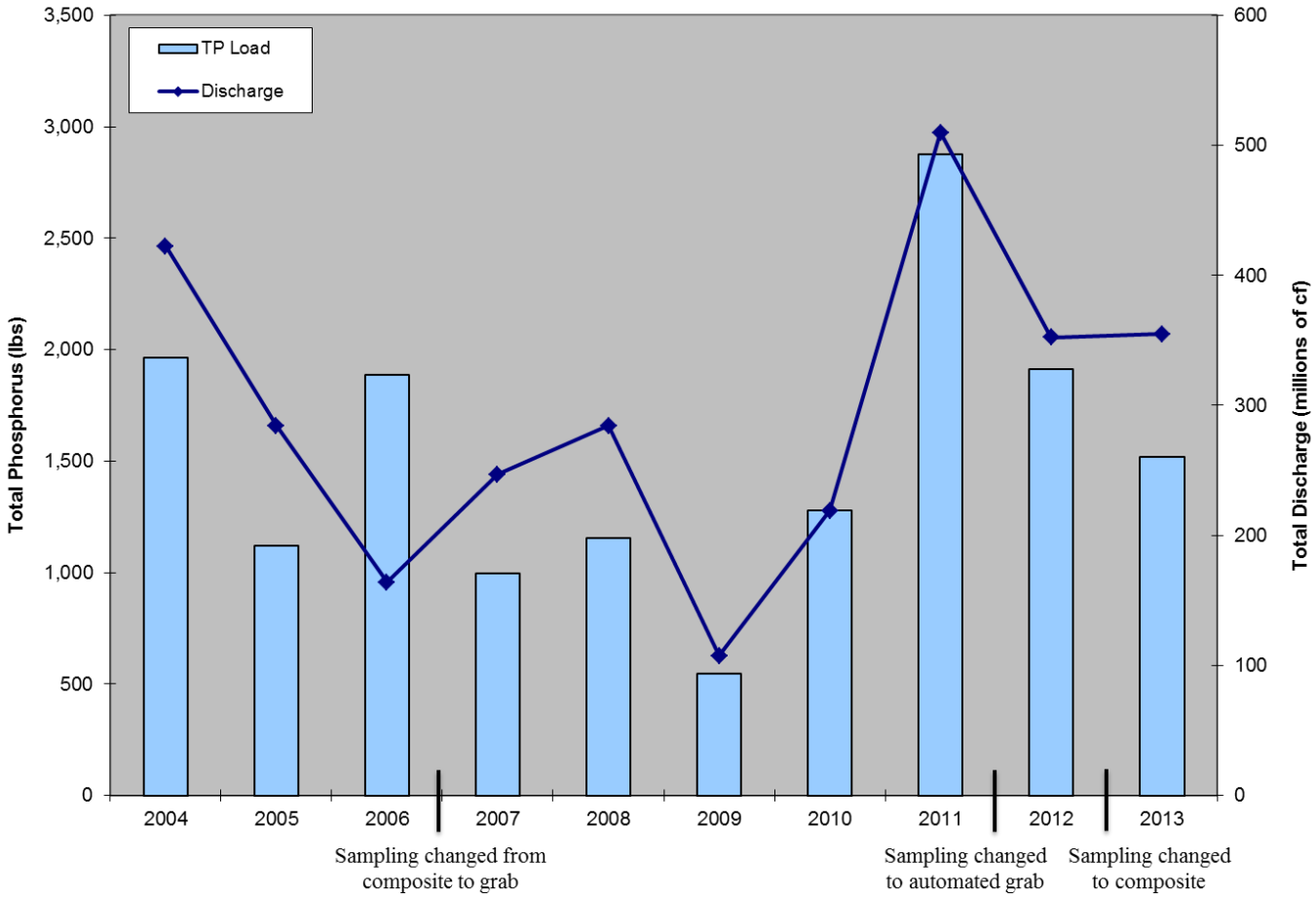


Figure 16. Comfort Lake Inlet Historic Annual Discharge and Total Phosphorus Load

Flow and water chemistry data has been collected at the Comfort Lake Inlet site since 2004. Estimated total annual phosphorus export and discharge can be seen in Figure 16. When making year-to-year comparisons of load estimates, it should be noted that the sampling technique changed from automated composite sampling to manual grab sampling in 2007. 2012 brought a slight change to the sampling technique again. Grab samples were collected using the automatic sampler that was already at the site collecting data. This allowed for better timing of the grab sample collection, most of the grabs occurred during the rising limb or near the peak of a storm event, which is where most of the nutrient load during an event occurs. There was another sampling technique change for the 2013 monitoring season back to composite sampling. Unlike the other sites with historic information available, there does not seem to be as great of an impact on the overall load estimation when switching between the two sampling methods. One potential cause of this could be that the Shallow Pond wetland complex upstream of the site may be acting as a sink for nutrients, and settling them out before they reach this site. The estimated TP load decreased from 2012 to 2013, while the discharge increased only slightly.

It should be noted that the Comfort Inlet culvert was replaced in early spring of 2011. The previous culvert was a corrugated round pipe that was 8 feet in diameter. The current culvert is a concrete box culvert that measures 7 feet by 7 feet. Discharge numbers for the years prior to 2011 may have been

slightly altered due to the condition of the previous culvert. The bottom and sides of the culvert were rusted and deteriorating in areas which could have possibly caused some of the discharge to be missed. Discharge will be more accurately measured within this new culvert.

Comfort Lake Outlet

The station at the Comfort Lake Outlet site recorded stage, velocity, and rainfall from April 9-November 4, 2013 (Figure 17). Total flow for this period was 425,748,209 cf or 9,779 acre-ft. Total rainfall for the monitoring season was 16.87 inches. The highest flow was recorded at 55.228 cfs on July 13th.

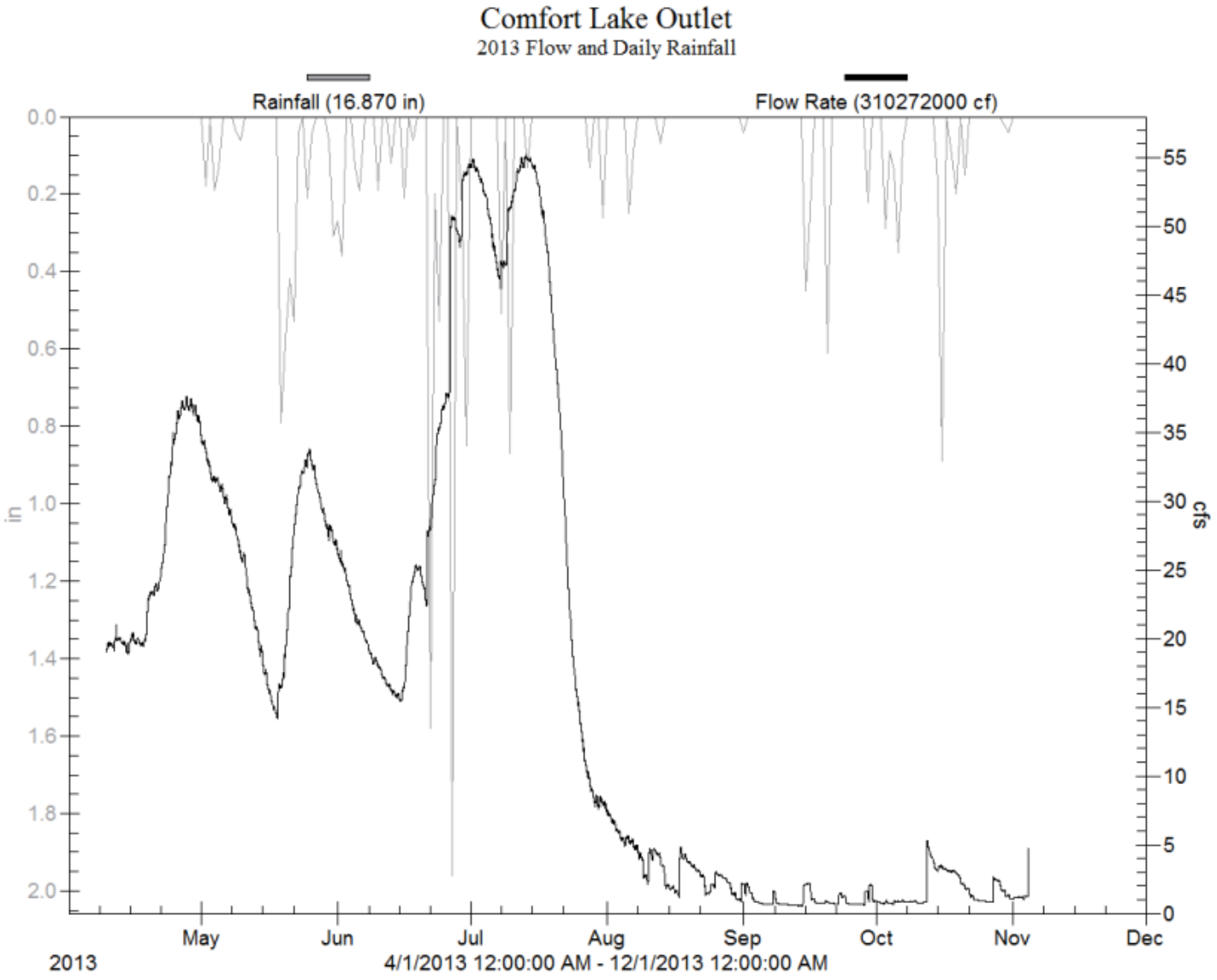


Figure 17. Comfort Lake Outlet 2013 Flow and Daily Rainfall

2013 is the third year since 2006 that samples were collected by the WCD at the Comfort Lake Outlet site. Grab samples were collected by the Army Corps of Engineers in 2008. Automated storm composite, manual base, and snowmelt grab samples were collected in 2013. The TSS, VSS, TKN, TP, dissolved phosphorus, chloride, nitrite, nitrate, ammonia nitrogen, and *E. coli* results from all collected samples are listed in Table 21 and field water quality measurements are listed in Table 22. The highest TSS and TKN concentrations were 75 mg/L and 2.7 mg/L, respectively, from a storm composite collected on May 20th-21st. A July 17th base grab had the highest TP concentration of 0.162 mg/L.

Table 21. Comfort Lake Outlet 2013 Sample Chemistry Results

Sample Type	Start	End	TSS (mg/L)	VSS (mg/L)	TKN (mg/L)	TP (mg/L)	Dissolved TP (mg/L)	Chloride (mg/L)	Nitrite (mg/L)	Nitrate (mg/L)	Ammonia Nitrogen (mg/L)	*E. coli* (mpn/100ml)
Snowmelt Grab	4/8/2013 9:58	4/8/2013 9:58	3	~2	1.6	0.052	~0.031	55.7	<0.03	0.39	0.41	
Storm Composite	5/20/2013 14:17	5/21/2013 8:42	75	40	2.7	0.127	~0.037	51.0	0.04	0.27	<0.02	
Storm Composite	6/17/2013 23:25	6/19/2013 10:14	21	11	1.3	0.050	<0.020	49.3	<0.03	0.10	<0.02	
Storm Composite	6/23/2013 6:27	6/24/2013 11:36	22	~11	1.2	~0.038	<0.020	47.8	<0.03	0.08	<0.02	
Base Grab	7/17/2013 12:10	7/17/2013 12:10	5	4	1.2	0.162	~0.037	40.9	<0.03	<0.05	<0.02	
Base Grab	8/15/2013 10:08	8/15/2013 10:08	~1	~1	1.1	~0.034	~0.024	42.1	<0.03	<0.05	0.10	10
Base Grab	9/24/2013 9:55	9/24/2013 9:55	~2	~2	1.1	0.064	<0.020	41.6	<0.03	<0.05	0.06	99
Base Grab	10/10/2013 9:43	10/10/2013 9:43	8	~4	1.4	0.060	<0.020	46.5	0.04	0.14	0.24	76
E. coli Grab	6/27/2013 9:13	6/27/2013 9:13										435
E. coli Grab	7/29/2013 9:35	7/29/2013 9:35										28

Table 22. Comfort Lake Outlet 2013 Field Water Quality Measurements

Date/Time	Transparency (cm)	Water Temperature (C)	Dissolved Oxygen (mg/L)	Conductivity (umhos/cm)	pH
4/8/2013 9:58		2.6		536	8.3
7/17/2013 12:10	>100	28.8	5.50	421	7.8
9/24/2013 9:55	>100	14.8	4.80	393	7.9
10/10/2013 9:43	>100	13.1	4.81	495	7.8

Exceeds Water Quality Standard

Table 23. Comfort Lake Outlet 2013 Total Suspended Solids and Total Phosphorus Loading

	Sample Collection Time				Loading Interval					
Sample Type	**Start**	**End**	**TSS (mg/L)**	**TP (mg/L)**	**Start**	**End**	**Interval Volume (cf)**	**Interval Volume (ac-ft)**	**Interval TSS (lb)**	**Interval TP (lb)**
*Base**			*4*	*0.080*	*1/1/13 0:00*	*4/7/13 15:45*	*108,564,300*	*2493.60*	*27109.0*	*542.18*
Snowmelt Grab*	4/8/2013 9:58	4/8/2013 9:58	3	0.052	4/7/13 15:45	4/9/13 3:45	1,944,000	44.65	364.1	6.31
Base			*4*	*0.080*	*4/9/13 3:45*	*4/18/13 10:45*	*15,237,500*	*349.99*	*3804.9*	*76.10*
Storm			*39*	*0.072*	*4/18/13 10:45*	*4/19/13 2:45*	*1,247,400*	*28.65*	*3062.9*	*5.58*
Base			*4*	*0.080*	*4/19/13 2:45*	*4/21/13 9:45*	*4,639,530*	*106.56*	*1158.5*	*23.17*
Storm			*39*	*0.072*	*4/21/13 9:45*	*4/23/13 20:45*	*5,791,500*	*133.02*	*14220.6*	*25.91*
Base			*4*	*0.080*	*4/23/13 20:45*	*5/18/13 6:45*	*60,175,900*	*1382.17*	*15026.2*	*300.52*
Storm			*39*	*0.072*	*5/18/13 6:45*	*5/18/13 16:45*	*574,934*	*13.21*	*1411.7*	*2.57*
Base			*4*	*0.080*	*5/18/13 16:45*	*5/19/13 16:45*	*1,446,500*	*33.22*	*361.2*	*7.22*
Storm			*39*	*0.072*	*5/19/13 16:45*	*5/19/13 18:45*	*130,164*	*2.99*	*319.6*	*0.58*
Base			*4*	*0.080*	*5/19/13 18:45*	*5/20/13 13:45*	*1,337,840*	*30.73*	*334.1*	*6.68*
Storm Composite	5/20/2013 14:17	5/21/2013 8:42	75	0.127	5/20/13 13:45	5/21/13 10:45	1,763,060	40.50	8254.6	13.98
Base			*4*	*0.080*	*5/21/13 10:45*	*6/16/13 0:45*	*52,790,600*	*1212.54*	*13182.1*	*263.64*
Storm Composite	6/17/2013 23:25	6/19/2013 10:14	21	0.050	6/16/13 0:45	6/19/13 15:45	7,139,690	163.99	9359.8	22.29
Base			*4*	*0.080*	*6/19/13 15:45*	*6/21/13 2:45*	*2,987,190*	*68.61*	*745.9*	*14.92*
Storm			*39*	*0.072*	*6/21/13 2:45*	*6/21/13 5:45*	*278,870*	*6.41*	*684.7*	*1.25*
Base			*4*	*0.080*	*6/21/13 5:45*	*6/23/13 5:45*	*5,100,410*	*117.15*	*1273.6*	*25.47*
Storm Composite	6/23/2013 6:27	6/24/2013 11:36	22	0.038	6/23/13 5:45	6/24/13 13:45	4,063,210	93.33	5580.3	9.64
Base			*4*	*0.080*	*6/24/13 13:45*	*6/26/13 11:45*	*6,194,850*	*142.29*	*1546.9*	*30.94*
Storm			*39*	*0.072*	*6/26/13 11:45*	*6/26/13 14:45*	*529,074*	*12.15*	*1299.1*	*2.37*
Base			*4*	*0.080*	*6/26/13 14:45*	*7/7/13 18:45*	*49,649,700*	*1140.40*	*12397.8*	*247.96*
Storm			*39*	*0.072*	*7/7/13 18:45*	*7/7/13 21:45*	*507,167*	*11.65*	*1245.3*	*2.27*
Base			*4*	*0.080*	*7/7/13 21:45*	*7/9/13 8:45*	*5,953,060*	*136.73*	*1486.5*	*29.73*
Storm			*39*	*0.072*	*7/9/13 8:45*	*7/9/13 11:45*	*549,575*	*12.62*	*1349.4*	*2.46*
Base			*4*	*0.080*	*7/9/13 11:45*	*7/16/13 9:45*	*32,097,200*	*737.24*	*8014.8*	*160.30*
Base Grab	7/17/2013 12:10	7/17/2013 12:10	5	0.162	7/16/13 9:45	7/17/13 18:45	6,122,330	140.62	1911.0	61.92
Base			*4*	*0.080*	*7/17/13 18:45*	*8/14/13 15:45*	*32,900,900*	*755.70*	*8215.5*	*164.31*
Base Grab	8/15/2013 10:08	8/15/2013 10:08	1	0.034	8/14/13 15:45	8/16/13 2:45	238,800	5.48	14.9	0.51
Base			*4*	*0.080*	*8/16/13 2:45*	*9/19/13 10:45*	*4,970,690*	*114.17*	*1241.2*	*24.82*
Storm			*39*	*0.072*	*9/19/13 10:45*	*9/19/13 14:45*	*12,569*	*0.29*	*30.9*	*0.06*
Base			*4*	*0.080*	*9/19/13 14:45*	*9/23/13 10:45*	*298,580*	*6.86*	*74.6*	*1.49*
Base Grab	9/24/2013 9:55	9/24/2013 9:55	2	0.064	9/23/13 10:45	9/24/13 20:45	116,465	2.68	14.5	0.47
Base			*4*	*0.080*	*9/24/13 20:45*	*10/9/13 8:45*	*1,103,050*	*25.34*	*275.4*	*5.51*
Base Grab	10/10/2013 9:43	10/10/2013 9:43	8	0.060	10/9/13 8:45	10/10/13 19:45	104,081	2.39	52.0	0.39
Base			*4*	*0.080*	*10/10/13 19:45*	*11/4/13 12:00*	*4,219,520*	*96.92*	*1053.6*	*21.07*
*Base**			*4*	*0.080*	*11/4/13 12:00*	*1/1/14 0:00*	*4,968,000*	*114.11*	*1240.5*	*24.81*
Base Average			4	0.080						
Storm Average			39	0.072						
Snowmelt Average			3	0.052						
All Average			17	0.073						
Total							**425,748,209**	**9,779**	**147,718**	**2,129**
CLFLWD Major Subwatershed Total Acres							24,558			
Total Load										
Total TSS/TP (lbs/ac/yr)									**6.02**	**0.087**

Italics indicate estimated concentrations based on average base and storm flow concentrations.

*Interval volumes from 1/1/2013 to 4/7/2013, 4/7/2013 to 4/9/2013 and 11/4/2013 to 1/1/2014 were estimated based on average base and storm flow concentrations.

Total phosphorus loading at the Comfort Lake Outlet site and the entire Comfort Lake-Forest Lake Watershed was estimated at 0.087 lbs/ac or 2,129 lbs. (Table 23). This increase from 2012 could in part be due to the change in sampling technique. In 2012 automated grab samples were collected utilizing the sampler that was already at the site collecting data, whereas in 2013 composite samples were collected. Composite samples typically lead to higher load estimations due to the nature of the sampling technique; it catches the rising limb and peak of a storm event which typically carries more nutrients.

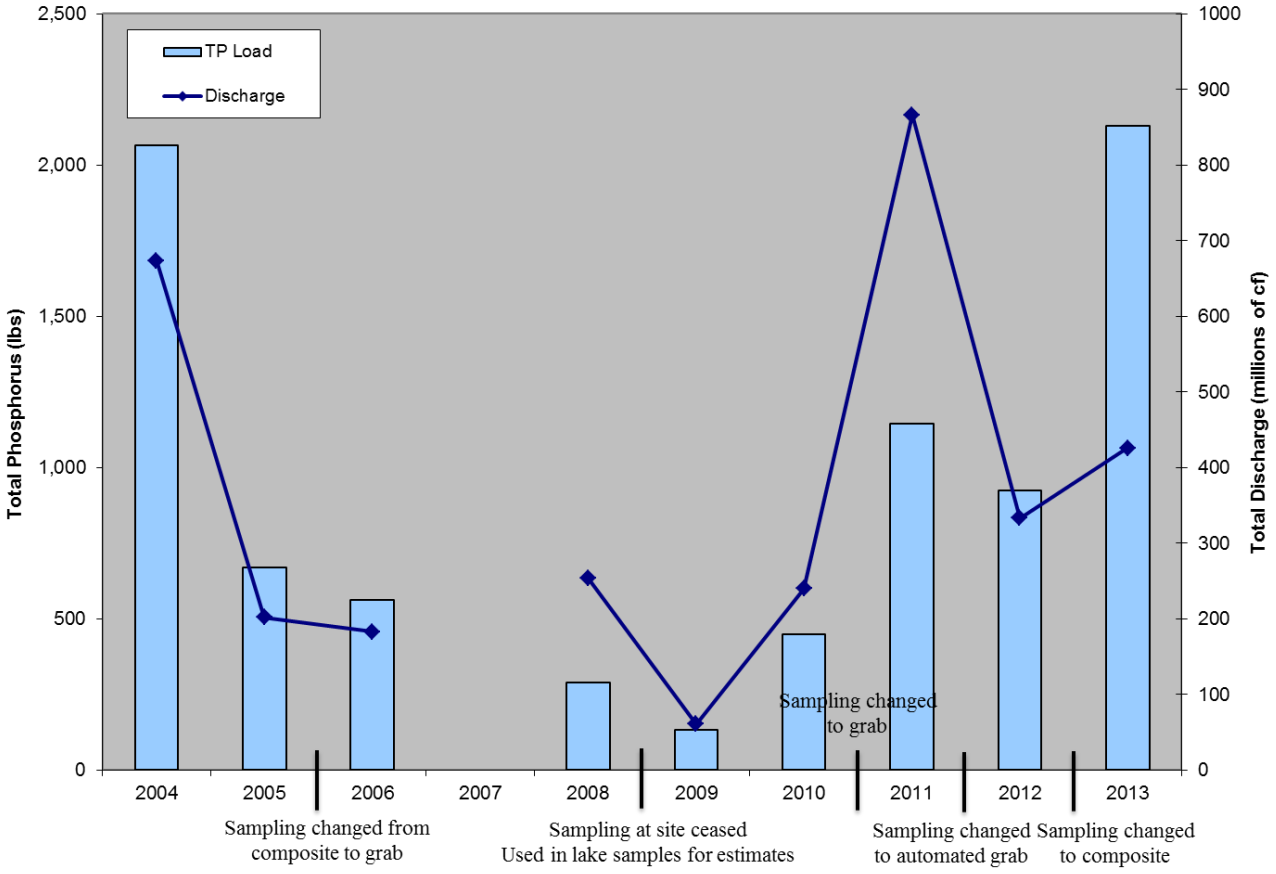


Figure 18. Comfort Lake Outlet Historic Annual Discharge and Total Phosphorus Load

Flow and water chemistry data has been collected at the Comfort Lake Outlet site since 2004. The equipment was installed but damaged in 2007, making load and discharge data unavailable from that year. Estimated total annual phosphorus load and discharge can be seen in Figure 18. When making year-to-year load comparisons, it should be noted that three different sampling methods have been employed at this site. Automated composite sampling was used in 2004-2005, and manual grab sampling occurred in 2006. Grab samples were taken in 2008 by the Army Corps of Engineers, where sampling was on a set schedule and was not event based. In-lake nutrient concentrations were used to develop an estimate of total phosphorus loads in 2009-2010. The sampling methods used in 2008-2010 do not necessarily characterize the full export accurately, as they do not represent the concentrations present during storm flow conditions. In 2011 and 2012 event grab samples were collected at the monitoring site and in 2013 the sampling technique was switched back to composite. It is recommended that event based sampling continue at this site to better understand the load that is leaving the Comfort Lake-Forest Lake Watershed.

VI. WATERSHED PHOSPHORUS FLOW CHART

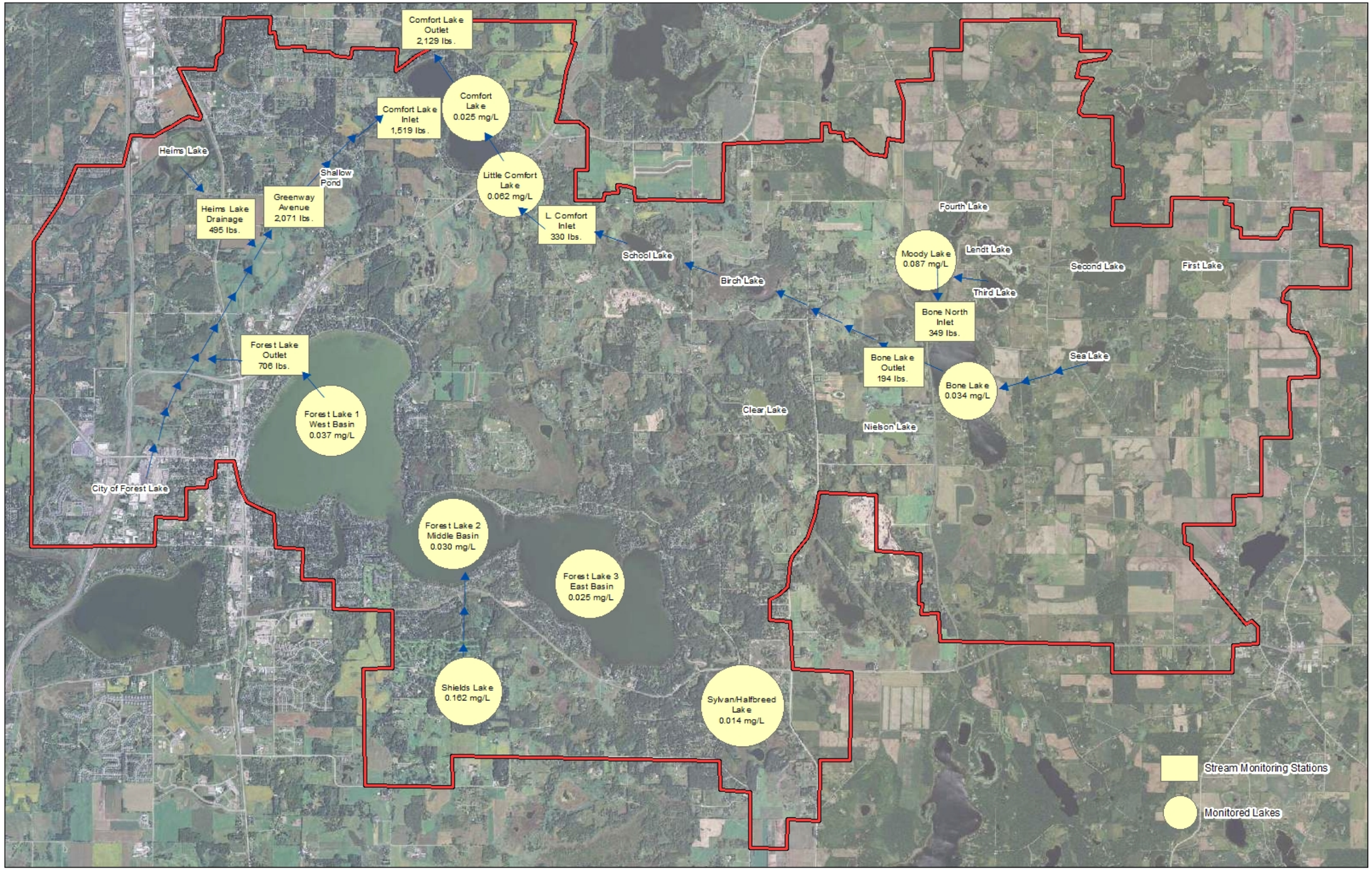


Figure 19. 2013 Watershed Summer Average Lake Phosphorus Concentrations and Total Phosphorus Load Water Quality Flow Chart

Table 24. CLFLWD Historical Stream Loading, Discharge, and Rainfall Summary

			Growing Season (June 1-Sept 30) Discharge*		Yearly Estimated Discharge		Growing Season (June 1-Sept 30) Load*		Total Yearly Estimated Load		
Site	Year	Monitoring Season	Cubic Feet	Acre Feet	Cubic Feet	Acre Feet	TP (lbs.)	TSS (lbs.)	TP (lbs.)	TSS (lbs.)	Monitored Rainfall (inches)
Tributary to Sunrise River at Bone Lake North Inlet	2003	5/27/03-10/30/03	23,012,779	528	NA	NA	654	129,443	NA	NA	12.73
Tributary to Sunrise River at Bone Lake North Inlet	2005	3/29/05-11/1/05	3,370,684	77	14,075,577	323	89	14,745	226	24,817	20.73
Tributary to Sunrise River at Bone Lake North Inlet	2006	5/1/06-10/25/06	1,892,891	43	9,625,678	221	74	1,085	315	5,225	15.67
Tributary to Sunrise River at Bone Lake North Inlet	2007										
Tributary to Sunrise River at Bone Lake North Inlet	2008										
Tributary to Sunrise River at Bone Lake North Inlet	2009										
Tributary to Sunrise River at Bone Lake North Inlet	2010	4/5/10-11/1/10	1,519,181	35	5,475,569	126	17	742	53	2,588	19.33
Tributary to Sunrise River at Bone Lake North Inlet	2011	4/7/11-10/31/11	9,840,224	226	45,744,150	1,051	106	2,048	519	9,390	14.87
Tributary to Sunrise River at Bone Lake North Inlet	2012	3/23/12-8/9/12	NA	NA	12,133,284	279	NA	NA	207	17,310	19.13
Tributary to Sunrise River at Bone Lake North Inlet	2013	5/13/13-11/4/13	8,995,972	207	16,205,989	372	194	8,096	349	14,512	14.96
Tributary to Sunrise River at Bone Lake Outlet	2003	5/27/03-10/30/03	45,627,921	1,047	NA	NA	297	66,763	NA	NA	12.35
Tributary to Sunrise River at Bone Lake Outlet	2004	3/24/04-11/2/04	27,081,226	622	66,316,511	1,522	146	14,138	339	35,283	18.03
Tributary to Sunrise River at Bone Lake Outlet	2005	3/29/05-11/1/05	7,753,089	178	26,115,815	600	36	30,343	97	38,776	18.27
Tributary to Sunrise River at Bone Lake Outlet	2006	5/1/06-10/30/06	6,821,497	157	23,460,532	539	14	1,018	49	3,158	14.08
Tributary to Sunrise River at Bone Lake Outlet	2013	4/24/13-11/4/13	37,604,427	864	80,882,661	1,858	90	NA	194	NA	No Data Available at Site
Tributary to Sunrise River at Bone Lake South Inlet	2005	4/5/05-11/1/05	4,581,651	105	23,004,776	528	117	34,695	231	41,383	No Data Available at Site
Tributary to Sunrise River at Bone Lake South Inlet	2006	5/1/06-10/30/06	2,278,834	52	15,794,923	363	71	4,734	229	14,324	No Data Available at Site
Tributary to Sunrise River at Shields Outlet/Forest Inlet	2005	4/20/05-11/1/05	11,446,896	263	27,638,328	634	237	19,188	420	79,186	19.63
Tributary to Sunrise River at Shields Outlet/Forest Inlet	2006	5/2/06-10/30/06	4,119,142	95	17,784,049	408	92	3,372	332	8,620	13.18
Tributary to Sunrise River at Forest Lake Outlet	2003	5/29/03-10/11/03	134,712,756	3,093	NA	NA	551	209,614	NA	NA	No Data Available at Site
Tributary to Sunrise River at Forest Lake Outlet	2004	3/31/04-11/2/04	93,716,849	2,151	233,100,967	5,351	598	107,761	1,235	167,533	No Data Available at Site
Tributary to Sunrise River at Forest Lake Outlet	2005	3/24/05-11/2/05	59,097,451	1,357	187,748,294	4,310	141	27,981	457	83,383	No Data Available at Site
Tributary to Sunrise River at Forest Lake Outlet	2006	5/2/06-10/25/06	21,006,901	482	92,349,949	2,120	41	5,738	173	24,263	No Data Available at Site
Tributary to Sunrise River at Forest Lake Outlet	2007	3/26/07-10/29/07	5,378,189	123	128,950,817	2,960	8	NA	253	NA	No Data Available at Site
Tributary to Sunrise River at Forest Lake Outlet	2008	4/3/08-11/3/08	41,809,187	960	159,233,702	3,656	81	NA	341	NA	No Data Available at Site
Tributary to Sunrise River at Forest Lake Outlet	2009	4/9/09-11/2/09	373,155	9	31,187,212	716	1	NA	43	NA	No Data Available at Site
Tributary to Sunrise River at Forest Lake Outlet	2010	3/30/10-11/2/10	65,644,741	1,507	133,406,543	3,063	117	NA	221	NA	No Data Available at Site
Tributary to Sunrise River at Forest Lake Outlet	2011	4/5/11-10/31/11	106,740,354	2,452	816,052,697	18,744	234	NA	1,828	NA	No Data Available at Site
Tributary to Sunrise River at Forest Lake Outlet	2012	3/23/12-11/5/12	77,082,238	1,770	155,054,646	3,561	204	NA	411	NA	No Data Available at Site
Tributary to Sunrise River at Forest Lake Outlet	2013	4/9/13-11/3/13	77,476,102	1,780	311,584,377	7,157	175	NA	706	NA	No Data Available at Site
Tributary to Sunrise River at Bixby Park	2009	5/7/09-10/20/09	11,602,336	266	22,103,528	507	103	5,212	179	9,317	No Data Available at Site
Tributary to Sunrise River at Bixby Park	2010	3/30/10-11/1/10	15,997,632	367	21,072,618	484	121	7,639	158	9,737	No Data Available at Site
Tributary to Sunrise River at Bixby Park	2011	4/13/11-10/31/11	15,314,122	352	30,679,839	705	148	11,821	285	22,316	No Data Available at Site
Tributary to Sunrise River at Bixby Park	2012	3/30/12-11/5/12	23,932,555	550	50,118,632	1,151	293	123,763	973	1,152,008	No Data Available at Site
Sunrise River at County Line Ditch	2007	3/27/07-10/29/07	13,265,950	305	168,125,270	3,860	420	35,317	1,212	109,981	20.65
Sunrise River at County Line Ditch	2008	4/3/08-11/4/08	46,128,347	1,059	167,318,507	3,841	216	67,304	650	144,481	16.85
Sunrise River at County Line Ditch	2009	4/3/09-11/3/09	15,225,062	350	71,188,173	1,634	45	2,364	85	5,403	17.52
Sunrise River at County Line Ditch	2010	3/31/10-11/1/10	104,422,088	2,397	182,196,709	4,183	524	41,009	811	69,760	23.86
Sunrise River at County Line Ditch	2011	5/16/11-10/31/11	174,130,314	4,000	376,243,391	8,642	858	90,682	1,792	193,402	12.28
Sunrise River at County Line Ditch	2012	3/30/12-11/5/12	72,141,600	1,657	158,144,746	3,632	344	163,389	930	609,889	22.07
Tributary to Sunrise River at Heims Lake Drainage/Hwy 61	2012	4/2/12-11/5/12	1,309,476	30	5,667,458	130	40	2,172	330	51,715	No Data Available at Site
Tributary to Sunrise River at Heims Lake Drainage/Hwy 61	2013	4/9/13-11/4/13	2,814,191	65	9,605,584	221	150	9,577	495	24,224	No Data Available at Site
Sunrise River at Greenway Avenue	2008	4/14/08-11/4/08	64,476,470	1,480	231,516,014	5,315	499	233,541	1,505	696,004	No Data Available at Site
Sunrise River at Greenway Avenue	2009										
Sunrise River at Greenway Avenue	2010										
Sunrise River at Greenway Avenue	2011	5/26/11-10/31/11	155,958,904	3,582	442,205,000	10,157	1,358	76,702	3,722	218,922	No Data Available at Site
Sunrise River at Greenway Avenue	2012	4/2/12-11/5/12	87,412,116	2,008	262,400,771	6,027	888	750,188	6,370	7,183,660	No Data Available at Site
Sunrise River at Greenway Avenue	2013	5/15/13-11/4/13	121,486,726	2,790	326,439,257	7,498	778	54,590	2,071	129,646	No Data Available at Site
Tributary to Sunrise River at Manning Trail	2008	4/21/08-11/3/08	7,613,182	175	63,196,487	1,451	41	1,232	508	7,421	No Data Available at Site
Tributary to Sunrise River at Manning Trail	2009	4/2/09-11/2/09	759,696	17	11,231,268	258	7	265	104	3,718	No Data Available at Site
Tributary to Sunrise River at July Avenue	2008	4/17/08-11/3/08	22,886,998	525	80,937,662	1,858	146	5,316	431	14,137	17.25
Tributary to Sunrise River at July Avenue	2009	4/2/09-11/2/09	3,759,027	86	27,127,126	623	23	1,295	151	9,112	17.92
Tributary to Sunrise River at Little Comfort Lake Inlet	2004	5/4/04-11/2/04	79,549,516	1,826	172,272,256	3,955	584	474,947	1,283	1,220,397	19.59
Tributary to Sunrise River at Little Comfort Lake Inlet	2005	3/29/05-11/2/05	56,782,372	1,304	149,011,733	3,421	461	211,373	1,023	697,890	21.99
Tributary to Sunrise River at Little Comfort Lake Inlet	2006	5/4/06-10/30/06	42,677,774	980	131,946,491	3,029	834	411,398	1,551	643,540	16.89
Tributary to Sunrise River at Little Comfort Lake Inlet	2007	4/26/07-10/30/07	54,709,030	1,256	173,218,653	3,977	202	13,620	676	43,113	23.65
Tributary to Sunrise River at Little Comfort Lake Inlet	2008	4/22/08-11/3/08	93,791,250	2,153	360,171,837	8,268	256	23,369	1,127	94,344	16.35
Tributary to Sunrise River at Little Comfort Lake Inlet	2009	4/9/09-11/2/09	26,119,773	600	101,219,564	2,324	119	12,439	418	34,444	17.34
Tributary to Sunrise River at Little Comfort Lake Inlet	2010	3/30/10-10/15/10	56,666,594	1,301	103,234,147	2,370	188	9,260	331	18,146	23.58
Tributary to Sunrise River at Little Comfort Lake Inlet	2011	4/21/11-10/31/11	65,595,117	1,507	148,136,193	3,403	223	12,635	481	29,758	19.14
Tributary to Sunrise River at Little Comfort Lake Inlet	2012	3/30/12-10/30/12	20,666,292	475	51,169,672	1,175	78	5,065	230	37,392	23.20
Tributary to Sunrise River at Little Comfort Lake Inlet	2013	5/13/13-11/4/13	39,736,345	913	60,039,577	1,379	225	43,960	330	50,187	13.89
Sunrise River at Comfort Lake Inlet	2004	4/5/04-11/2/04	147,834,005	3,394	422,272,825	9,694	899	255,626	1,963	403,759	20.97
Sunrise River at Comfort Lake Inlet	2005	3/29/05-11/2/05	93,498,873	2,146	284,332,944	6,527	392	33,117	1,119	125,039	22.48
Sunrise River at Comfort Lake Inlet	2006	5/2/06-10/30/06	40,363,884	927	163,858,477	3,762	913	52,781	1,887	175,089	18.27
Sunrise River at Comfort Lake Inlet	2007	3/26/07-10/30/07	39,591,680	909	247,038,494	5,671	242	15,064	997	63,755	22.42
Sunrise River at Comfort Lake Inlet	2008	4/3/08-9/24/08	109,097,724	2,505	284,321,095	6,527	482	85,171	1,153	196,267	18.24
Sunrise River at Comfort Lake Inlet	2009	4/3/09-11/2/09	33,167,079	761	107,548,295	2,469	155	7,325	547	21,691	17.80
Sunrise River at Comfort Lake Inlet	2010	3/30/10-10/30/10	113,660,642	2,609	218,947,013	5,026	874	39,921	1,278	60,721	22.68
Sunrise River at Comfort Lake Inlet	2011	5/4/11-11/2/11	245,003,912	5,628	509,788,473	11,709	1,506	111,184	2,876	215,478	13.93
Sunrise River at Comfort Lake Inlet	2012	4/5/12-11/7/12	126,038,503	2,895	352,448,988	8,095	717	46,916	1,914	150,817	21.14
Sunrise River at Comfort Lake Inlet	2013	5/13/13-11/4/13	126,233,743	2,899	355,022,452	8,154	545	36,696	1,519	99,754	15.68
Sunrise River at Comfort Lake Outlet	2003	5/29/03-11/3/03	361,495,072	8,299	NA	NA	1,308	285,063	NA	NA	13.09
Sunrise River at Comfort Lake Outlet	2004	3/22/04-11/2/04	249,741,973	5,733	673,985,011	15,473	1,076	401,584	2,065	566,195	21.68
Sunrise River at Comfort Lake Outlet	2005	3/24/05-11/2/05	85,981,864	1,974	201,840,954	4,634	326	153,936	670	251,622	22.32
Sunrise River at Comfort Lake Outlet	2006	5/2/06-10/30/06	51,812,383	1,189	183,293,248	4,208	122	16,097	563	60,519	18.32
Sunrise River at Comfort Lake Outlet	2007	3/26/07-7/12/07	NA	NA	NA	NA	NA	NA	NA	NA	21.42
Sunrise River at Comfort Lake Outlet	2008	5/1/08-11/3/08	73,273,609	1,682	254,442,469	5,841	99	21,762	291	62,469	16.53
Sunrise River at Comfort Lake Outlet	2009	4/22/09-11/2/09	17,619,711	404	61,039,355	1,401	34	NA	134	NA	No Data Available at Site
Sunrise River at Comfort Lake Outlet	2010	4/5/10-11/2/10	144,901,319	3,326	240,198,442	5,514	273	NA	450	NA	22.97
Sunrise River at Comfort Lake Outlet	2011	4/18/11-10/31/11	433,531,324	9,958	866,127,458	19,894	566	136,863	1,146	267,379	18.57
Sunrise River at Comfort Lake Outlet	2012	3/30/12-11/5/12	181,016,017	4,158	333,317,104	7,656	487	74,168	924	175,609	22.91
Sunrise River at Comfort Lake Outlet	2013	4/9/13-11/4/13	213,603,980	4,906	425,748,209	9,779	1,072	69,944	2,129	147,718	16.87

*Growing season discharge and loads include quantities estimated from just previous to and including June 1, and just post and including September 30.

E. coli

The Minnesota Pollution Control Agency has set water quality standards for Class 2 Waters of the State for aquatic life and recreation (https://www.revisor.mn.gov/rules/?id=7050.0222). The following is the description for the *Escherichia (E.) coli* standard:

> "Not to exceed 126 organisms per 100 milliliters as a geometric mean of not less than five samples representative of conditions within any calendar month, nor shall more than ten percent of all samples taken during any calendar month individually exceed 1,260 organisms per 100 milliliters. The standard applies only between April 1 and October 31."

Monthly Geometric Means for *E. coli* (#/100 mL)

Site	April	May	June	July	August	September	October
Bone Lake North Inlet	Insufficient Data	Insufficient Data	110	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data
Bone Lake South Inlet	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data
Bone Lake Outlet	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data
Shields Outlet/Forest Inlet	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data
Forest Lake Outlet	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data
Bixby Park	Insufficient Data	Insufficient Data	Insufficient Data	815	Insufficient Data	Insufficient Data	Insufficient Data
County Line Ditch	Insufficient Data	Insufficient Data	88	161	187	Insufficient Data	Insufficient Data
Heims Lake	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data
Greenway Avenue	Insufficient Data	Insufficient Data	121	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data
Manning Trail	Insufficient Data	Insufficient Data	99	152	415	Insufficient Data	Insufficient Data
July Avenue	Insufficient Data	Insufficient Data	21	56	208	Insufficient Data	Insufficient Data
Little Comfort Inlet	Insufficient Data	Insufficient Data	67	138	168	210	147
Comfort Lake Inlet	Insufficient Data	63	140	146	206	151	Insufficient Data
Comfort Lake Outlet	Insufficient Data	Insufficient Data	36	16	Insufficient Data	35	19

Exceeds geometric mean of 126 #/100mL from not less than 5 samples in a calendar month

10% of samples taken in the last 10 years exceed 1,260 #/100mL (Doesn't necessarily exceed geometric mean standard)

Site	Date	*E. coli* (#/100ml)
Greenway Avenue	6/5/2008 9:50	31
	6/26/2008 10:00	126
	7/17/2008 7:38	147
	8/7/2008 8:45	326
	8/27/2008 9:40	104
	6/9/2011 9:30	156
	7/7/2011 9:18	66
	8/11/2011 9:59	50
	5/31/2012 10:23	30
	6/26/2012 10:00	326
	7/24/2012 12:27	182
	6/27/2013 8:52	132
	7/29/2013 9:20	127
	10/10/2013 9:36	207
Shields Outlet/Forest Inlet	5/5/2005 8:15	27
	7/13/2005 9:15	120
	10/19/2005 9:30	14
	6/14/2006 9:15	66
	10/10/2006 9:00	59
Forest Lake Outlet	7/22/2003 10:25	13
	6/8/2004 8:45	3
	7/15/2004 8:45	18
	5/5/2005 8:30	59
	7/13/2005 9:30	126
	10/19/2005 9:45	19
	6/14/2006 9:30	10
	8/10/2006 9:15	44
	9/6/2006 9:30	13
Bone Lake South Inlet	5/5/2005 8:30	13
	7/13/2005 10:45	567
	10/19/2005 10:45	95
	6/14/2006 10:30	345
	8/10/2006 8:30	96
	9/6/2006 8:15	250
	10/10/2006 10:00	115

Site	Date	*E. coli* (#/100ml)
Bone Lake North Inlet	7/22/2003 9:40	69
	9/11/2003 8:45	1,638
	10/7/2003 10:15	44
	10/28/2003 8:25	28
	5/5/2005 8:15	26
	7/13/2005 10:30	384
	10/19/2005 11:00	38
	6/14/2006 10:20	32
	8/10/2006 8:45	411
	9/6/2006 8:45	238
	5/25/2010 9:26	17
	6/24/2010 9:35	74
	6/9/2011 8:40	28
	7/7/2011 8:50	32
	8/11/2011 9:20	1,553
	5/31/2012 9:12	19
	6/26/2012 9:10	142
	7/24/2012 12:45	921
	6/27/2013 9:38	1,733
Bone Lake Outlet	7/22/2003 9:20	<1
	9/11/2003 8:55	265
	6/8/2004 10:00	3
	7/15/2004 10:00	2
	8/12/2004 9:15	139
	5/5/2005 8:15	1
	7/13/2005 10:30	<1
	10/19/2005 11:00	2
	6/14/2006 10:25	1
	7/24/2006 10:30	727
	8/10/2006 8:50	26
	9/6/2006 8:30	33

Site	Date	*E. coli* (#/100ml)
Comfort Lake Inlet	6/8/2004 9:00	19
	7/15/2004 9:15	50
	8/12/2004 8:30	176
	9/27/2004 9:30	22
	5/5/2005 8:45	302
	7/13/2005 9:45	158
	8/25/2005 8:45	435
	10/19/2005 10:00	32
	6/14/2006 9:45	128
	7/24/2006 9:45	387
	8/10/2006 9:00	291
	9/6/2006 10:00	261
	5/2/2007 11:00	31
	6/13/2007 9:43	115
	7/16/2007 10:23	127
	10/18/2007 9:48	649
	6/5/2008 10:35	86
	6/12/2008 9:07	365
	6/19/2008 9:00	150
	6/26/2008 9:45	249
	6/30/2008 9:28	206
	7/7/2009 9:30	115
	7/14/2008 10:00	160
	7/17/2008 7:50	238
	7/24/2008 8:40	172
	7/31/2008 9:30	167
	8/7/2008 9:00	649
	8/11/2008 9:30	179
	8/14/2008 9:08	387
	8/21/2008 9:10	150
	8/27/2008 9:25	326
	5/28/2009 9:15	41
	6/25/2009 9:00	>2,420
	7/29/2009 8:54	118
	8/27/2009 10:25	84
	9/30/2009 9:13	152
	5/25/2010 8:45	84
	6/24/2010 8:55	206
	7/28/2010 10:43	261
	8/26/2010 8:43	161
	9/30/2010 8:51	77
	6/9/2011 9:20	54
	7/7/2011 9:29	118
	8/11/2011 10:10	46
	9/8/2011 9:04	387
	5/31/2012 10:06	30
	6/26/2012 9:45	192
	7/24/2012 12:18	214
	8/30/2012 8:52	192
	6/27/2013 9:04	407
	7/29/2013 9:50	53
	9/24/2013 10:11	461
	10/10/2013 10:02	179
Comfort Lake Outlet	7/22/2003 10:00	3
	9/11/2003 8:25	34
	10/7/2003 10:00	13
	10/28/2003 8:10	3
	6/8/2004 9:15	6
	7/15/2004 9:30	6
	8/12/2004 8:45	32
	9/27/2004 9:45	14
	5/5/2005 8:45	3
	7/13/2005 10:00	14
	10/19/2005 10:15	6
	6/14/2006 9:55	42
	7/24/2006 10:00	111
	8/10/2006 9:00	17
	9/6/2006 9:15	18
	10/10/2006 9:20	10
	6/9/2011 9:10	26
	7/7/2011 9:39	16
	8/11/2011 10:23	18
	9/8/2011 9:16	64
	10/5/2011 9:58	276
	5/31/2012 9:50	19
	6/26/2012 9:35	19
	7/24/2012 12:11	22
	6/27/2013 9:13	435
	7/29/2013 9:35	28
	8/15/2013 10:08	10
	9/24/2013 9:55	99
	10/10/2013 9:43	76

Site	Date	*E. coli* (#/100ml)
County Line Ditch	5/2/2007 10:45	22
	6/13/2007 10:02	186
	7/16/2007 10:37	>2,420
	10/18/2007 10:23	328
	6/5/2008 9:55	20
	6/12/2008 8:46	1,300
	6/19/2008 8:50	28
	6/26/2008 10:15	18
	6/30/2008 9:07	34
	7/7/2008 9:45	66
	7/14/2008 9:45	45
	7/17/2008 7:22	162
	7/24/2008 8:25	140
	7/31/2008 10:00	129
	8/4/2008 9:20	131
	8/7/2008 8:30	142
	8/14/2008 8:43	218
	8/21/2008 9:25	210
	8/27/2008 9:50	>2,420
	5/28/2009 9:30	1120
	6/25/2009 8:30	>2,420
	7/29/2009 8:37	29
	8/27/2009 10:15	68
	9/30/2009 8:56	44
	5/25/2010 8:32	93
	6/24/2010 8:41	31
	7/28/2010 10:18	461
	8/26/2010 9:00	135
	9/30/2010 8:34	64
	6/9/2011 9:45	44
	7/7/2011 9:09	185
	8/11/2011 9:47	79
	9/8/2011 8:40	201
	10/5/2011 9:20	111
	5/31/2012 10:49	16
	6/26/2012 10:15	105
	7/24/2012 12:38	219
Manning Trail	6/5/2008 9:15	249
	6/12/2008 9:52	417
	6/19/2008 9:35	71
	6/26/2008 9:15	41
	6/30/2008 10:08	26
	7/7/2008 8:50	102
	7/14/2008 10:03	118
	7/17/2008 8:21	214
	7/24/2008 9:16	115
	7/31/2008 8:30	272
	8/4/2008 8:30	88
	8/7/2008 9:30	195
	8/14/2008 9:47	205
	8/21/2008 8:30	248
	8/27/2008 8:50	>2,420
	5/28/2009 8:45	58
	6/10/2009 8:10	119
	8/26/2009 8:00	>2,420
July Avenue	6/5/2008 9:18	23
	6/12/2008 9:37	52
	6/19/2008 9:25	10
	6/26/2008 9:20	15
	6/30/2008 9:56	12
	7/7/2008 9:05	11
	7/14/2008 9:10	19
	7/17/2008 8:12	125
	7/24/2008 9:04	56
	7/31/2008 9:00	38
	8/4/2008 8:45	46
	8/7/2008 9:20	88
	8/14/2008 9:36	144
	8/21/2008 8:45	411
	8/27/2008 9:00	980
	5/28/2009 9:00	126
	6/10/2009 8:20	37
	7/28/2009 8:00	579
	8/26/2009 8:11	345

Site	Date	*E. coli* (#/100ml)
Little Comfort Inlet	6/8/2004 9:45	16
	7/15/2004 9:45	16
	8/12/2004 9:00	195
	9/27/2004 10:00	126
	5/5/2005 9:00	4
	7/13/2005 10:00	69
	10/19/2005 10:30	21
	6/14/2006 10:05	108
	7/24/2006 10:15	214
	8/10/2006 8:45	461
	9/6/2006 9:00	166
	10/10/2006 9:40	101
	5/2/2007 11:10	30
	6/13/2007 9:28	109
	7/16/2007 10:10	147
	10/18/2007 9:32	41
	6/5/2008 9:30	38
	6/12/2008 9:27	148
	6/19/2008 9:15	31
	6/26/2008 9:35	63
	6/30/2008 9:45	23
	7/7/2008 9:20	72
	7/14/2008 9:20	225
	7/17/2008 8:01	1,733
	7/24/2008 8:53	365
	7/31/2008 9:15	145
	8/4/2008 9:00	261
	8/7/2008 9:10	687
	8/14/2008 9:22	172
	8/21/2008 9:00	56
	8/27/2008 9:15	261
	6/10/2009 8:30	548
	7/28/2009 8:10	201
	5/25/2010 8:59	866
	6/24/2010 9:08	121
	7/28/2010 11:01	210
	8/26/2010 8:30	91
	9/30/2010 9:05	201
	6/9/2011 9:00	20
	7/7/2011 9:52	83
	8/11/2011 10:39	37
	9/8/2011 9:28	365
	10/5/2011 10:07	2,420
	5/31/2012 9:34	61
	6/26/2012 9:25	135
	7/24/2012 11:59	111
	8/30/2012 8:38	345
	6/27/2013 9:24	67
	7/29/2013 10:10	45
	8/15/2013 10:37	63
	9/24/2013 9:45	266
	10/10/2013 10:21	326

Site	Date	*E. coli* (#/100ml)
Bixy Park	6/16/2009 9:15	7
	6/23/2009 8:15	30
	6/30/2009 9:09	63
	7/15/2009 8:54	>2,420
	7/21/2009 8:45	>2,420
	7/28/2009 8:00	579
	8/11/2009 8:30	43
	8/18/2009 8:30	41
	8/26/2009 8:34	192
	5/25/2010 8:17	125
	7/28/2010 10:04	1,300
	7/7/2011 8:57	68
	8/11/2011 9:29	91
	7/24/2012 12:49	980
Heims Lake	5/31/2012 10:36	91
	6/26/2012 10:30	82
	7/24/2012 12:40	222
	6/27/2013 8:41	135

Note: When fecal coliform samples were collected, results were converted to equivalent *E. coli* values.

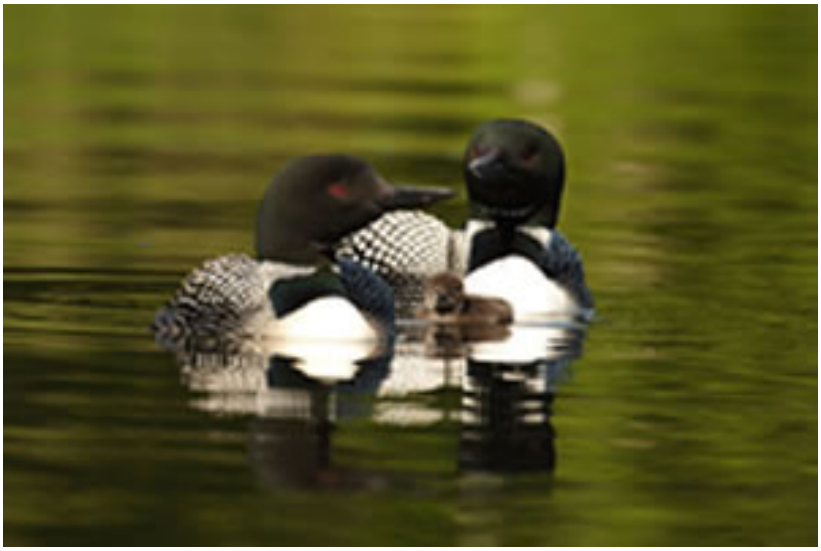
2013 LAKE MONITORING REPORT

I. EXECUTIVE SUMMARY

Monitoring of resources within the Comfort Lake-Forest Lake Watershed District has been a priority since the District was formed in 1999. However, some level of water quality monitoring has been conducted in the District going back to the late 1970's. Starting in the 1990's a more comprehensive approach to the monitoring of its lakes was adopted and in 2013 a total of seven lakes (Bone, Comfort, Forest (3 basins), Little Comfort, Moody, Shields, and Sylvan/Halfbreed) were monitored by the Washington Conservation District. These data are being used to monitor long-term water quality trends, calibrate water quality models, prioritize management actions, and assess past improvement projects.

The data tell different stories on each lake. Sylvan Lake continues to earn top marks with its very low phosphorus and chlorophyll concentration and excellent water clarity and in 2013 even showed a statistically significant improving trend for both Secchi disk transparency and total phosphorus concentrations. Other lakes like Forest Lake, Comfort Lake, and Bone Lake can be described as having good water quality but during the months of June, July, and August can exhibit algae blooms and reduced water clarity that exceed state water quality standards for phosphorus and clarity. Some lakes like Moody Lake and Shields Lake continue to have very poor water quality and greatly exceed state water quality standards. The data for most of our lakes indicate a neutral trend, neither improving nor declining over the period of time that monitoring has been conducted. Only two lakes, Shields Lake and Comfort Lake, showed a statistically significant declining trend for 2013, both for Secchi disk transparency. Lake grades and trends can be found in Figure 22 and Table 26.

The purpose of this document is to summarize water quality trends and current conditions in the Districts' main recreational lakes. The information provided here is used regularly by the Comfort Lake-Forest Lake Watershed District to guide water resource management decisions. We also hope that the information will be useful to our member cities and citizens alike.



II. INTRODUCTION AND METHODS

There are 19 named lakes in the Comfort Lake Forest-Lake Watershed. These lakes have significant aesthetic and recreational value. They also serve as a home to a wide variety of plants, fish, mammals, reptiles, and migratory waterfowl. The quality of water in these lakes is a key variable in how the lake is used, both by humans and animals. Poor water quality can result in decreased use for recreation and loss of habitat for plants and animals. More specifically, poor water quality can lead to nuisance algae blooms, odor problems, fish kills, and shifts in fish populations toward less desirable species such as carp and bullhead. Improving and protecting lake water quality is a high priority for the Comfort Lake-Forest Lake Watershed District.

The culprit for poor water quality is often high nutrient levels, specifically phosphorus. Phosphorus is a nutrient that is required by algae to grow. In Minnesota lakes, phosphorus is often the "limiting" nutrient, meaning that the main factor limiting algae growth would be not enough phosphorus. Therefore, the addition of phosphorus translates directly into more algae. Although phosphorus is found naturally in all lakes, the addition of phosphorus through human activities is common in urban and agricultural areas. Among other sources, phosphorus is added to lakes by urban stormwater, agricultural runoff, lakeshore erosion, and non-native plants and fish.

Regularly assessing water quality allows resource managers to compare lakes to one another, measure change over time, and prioritize management actions. Monitoring of lake water quality has been conducted in the Comfort Lake-Forest Lake Watershed District as far back as the 1970's. Water quality data over the years has been collected by a number of organizations including the Comfort Lake Forest-Lake Watershed District, the Washington Conservation District, Metropolitan Council, the MN Department of Natural Resources, the MN Pollution Control Agency, and citizen volunteers.

LAKE CLASSIFICATION AND GOALS

The Comfort Lake-Forest Lake Watershed District's *Watershed Management Plan* (2011) assigns numerical water quality goals for in lake phosphorous for each of its ten major recreational lakes; Moody, Bone, Birch, School, Little Comfort, Shields, Sylvan/Halfbreed, Forest, Heims, and Comfort. These standards correspond to current state water quality standards adopted in Minnesota by the MN Pollution Control Agency. The numeric goals for phosphorus are listed in Table 25.

Table 25. In-lake Water Quality Goals for Summer Average Total Phosphorus Concentrations

Lake	10-year In-Lake Total Phosphorus Goal (μg/L)	20-year In-Lake Total Phosphorus Goal (μg/L)	Long Term In-Lake Total Phosphorus Goal (μg/L)
Moody	60	40	40
Bone	40	40	30
Birch	60	60	60
School	50	40	40
Little Comfort	40	40	30
Shields	100	60	60
Sylvan/Halfbreed	20	20	20
Forest	<40	<40	30
Heims	40	40	40
Comfort	40	40	30

WATER QUALITY PARAMETERS

This report presents data for three key water quality parameters: phosphorus (measured as total phosphorus, TP), Chlorophyll-*a* (Chl-*a*), and Secchi depth. Phosphorus is a plant nutrient that is the primary driver for algal growth. Chlorophyll-*a* is found in all photosynthesizing plant cells, including algae. By measuring the amount of chlorophyll-*a* in a lake, you are measuring the amount of algae. Secchi depth is a measure of water clarity and is measured by lowering a Secchi disk over the side of a boat. The deepest depth at which the Secchi disk is visible is the Secchi depth. Since phosphorus drives algae growth, and algae affects water clarity, these parameters are often coupled – i.e. more phosphorus = more algae (chl-*a*) = reduced water clarity. This relationship is illustrated in Figure 20. Secchi depth data is not always available for all lakes. In very shallow lakes, or in lakes with dense plant growth, a Secchi disk is not a practical tool for evaluating water clarity but at this time is the best tool available.

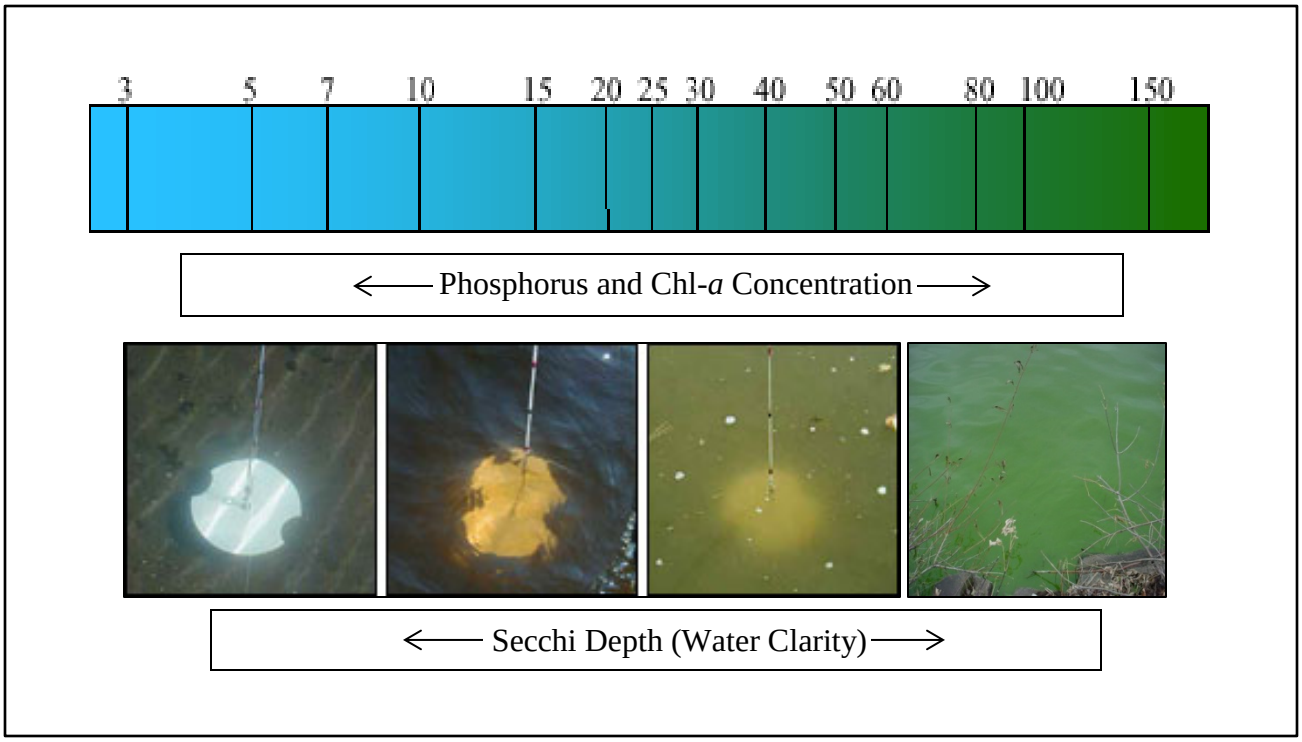


Figure 20. Relationship Between Phosphorus, Chlorophyll-*a*, and Secchi Depth

Although these parameters are usually coupled, complex biological processes can lead to a decoupling of phosphorus, chlorophyll-*a*, and clarity. When this occurs more detailed analysis is often needed to understand why the relationship has broken down.

Water quality presented in this report is compiled from several sources, including CLFLWD databases, the state water quality database 'EQuIS', Washington Conservation District, DNR's Lake Finder, and the Metropolitan Council's lake database. The values presented are summer averages; summer months of June through September. This is the same seasonal period used by the Metropolitan Council to establish lake grades as part of its regional Citizen-Assisted Monitoring Program (CAMP).

INTERPRETING WATER QUALITY GRAPHS – EXAMPLES

The example set of graphs can be used as a guide for interpreting the water quality graphs presented in this report (Figure 21).

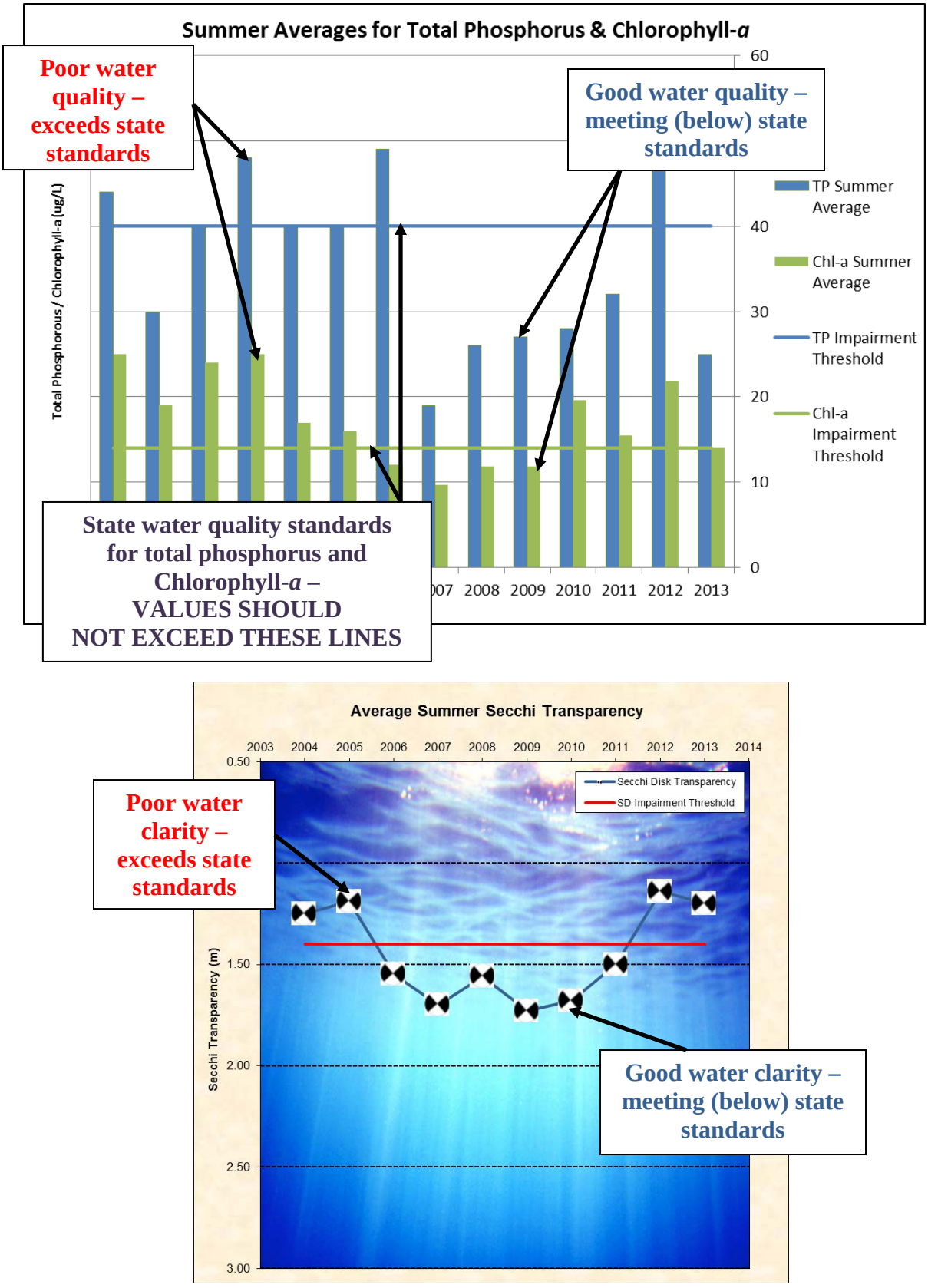


Figure 21. Example Water Quality Graphs

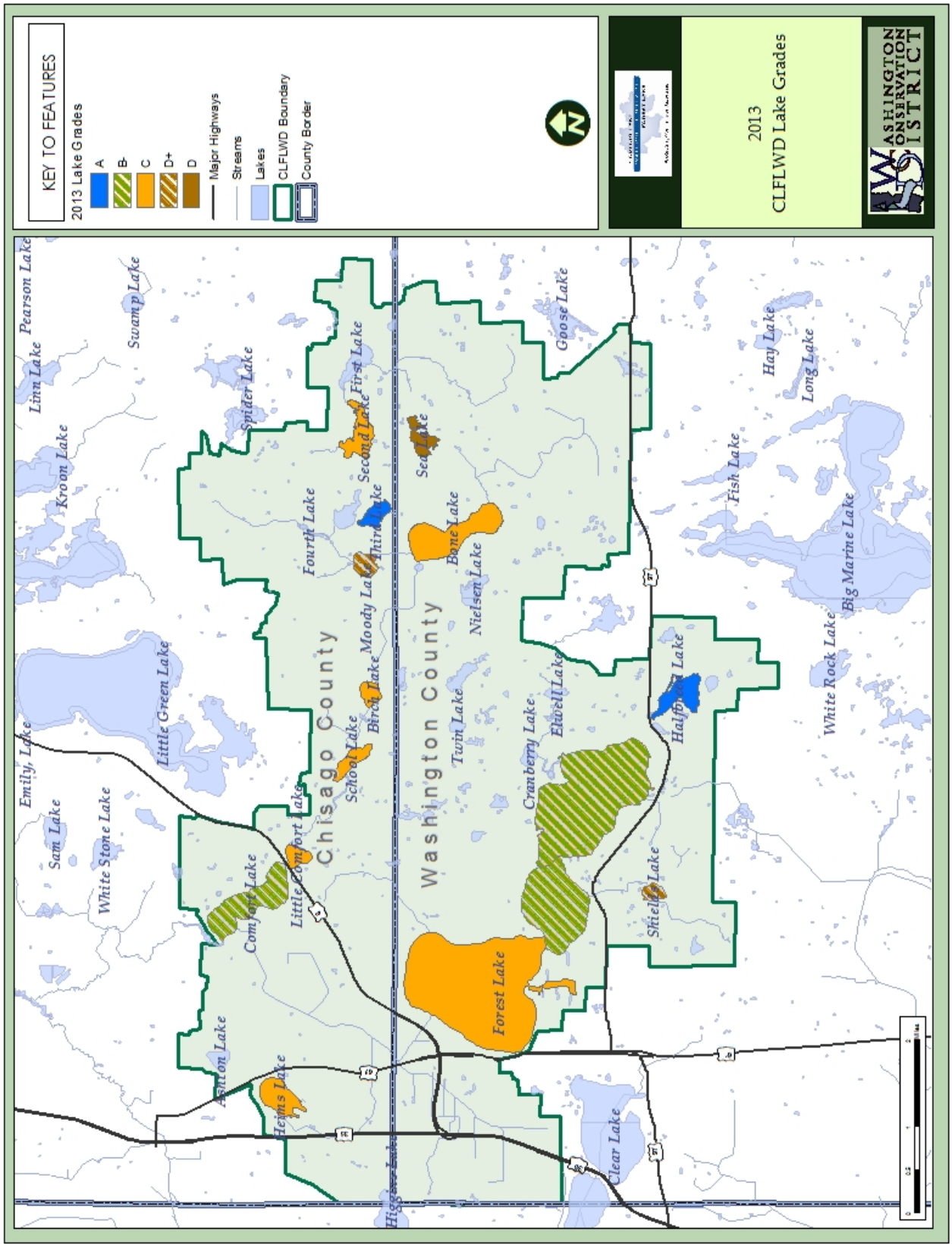


Figure 22. Lake Water Quality Grades

Table 26. Comfort Lake-Forest Lake Watershed District Lake Water Quality Summary

Lake	Acres	DNR ID	Most Recent Phosphorous Average (ug/L)	Year	Grade	Listed by MPCA as Impaired for Phosphorous	Secchi Disk Water Quality Trend	Total Phosphorus Water Quality Trend
Bone	221	82005400	34	2013	C	X	No Trend	No Trend
Birch	33	13004200	60	2007	C		NA	NA
Comfort	218	13005300	25	2013	B-	X	Declining	No Trend
Forest (West)	1086	82015600	37	2013	C		No Trend	No Trend
Forest (Middle)	364	82015600	30	2013	B-		No Trend	NA
Forest (East)	790	82015600	25	2013	B-		No Trend	NA
Heims	90	13005600	37	2009	C		NA	NA
Little Comfort	36	13005400	62	2013	C	X	No Trend	No Trend
Moody	45	13002300	87	2013	D+	X	NA	NA
Second	75	13002500	54	2008	C	X	NA	NA
School	47	13005700	47	2009	C	X	NA	NA
Sea	50	82005300	122	2009	D		NA	NA
Shields	30	82016200	162	2013	D+	X	Declining	No Trend
Sylvan/Halfbreed	75	82008000	14	2013	A		Improving	Improving
Third Lake	42	13002400	14	2008	A		NA	NA

Grade

Grade is determined by the most recent summer average for phosphorus. The scale used to assign grades is the same used by Metropolitan Council.

A<23 B 23-32
C32-68 D68-152
F>152

Impaired for Phosphorus

X'ed lakes are listed as impaired by the State of Minnesota for exceeding phosphorous standards. TMDL studies are required on these lakes.

Water Quality Trend

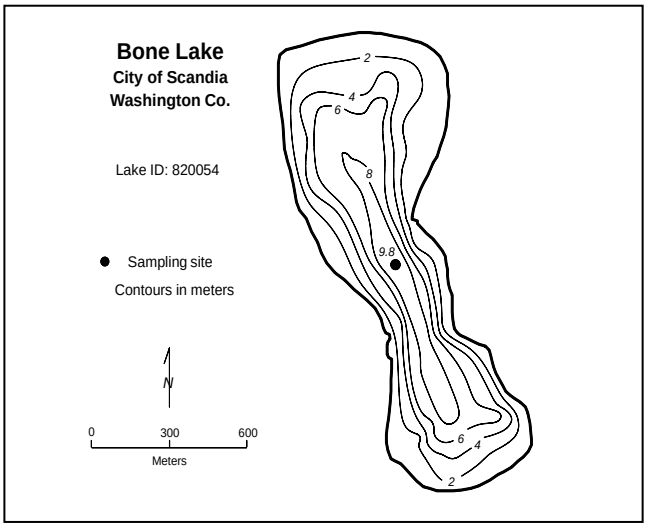
Trend was assigned by reviewing phosphorus averages where a 10 year record of monitoring exists.

III. INDIVIDUAL LAKE WATER QUALITY SUMMARIES

Bone Lake

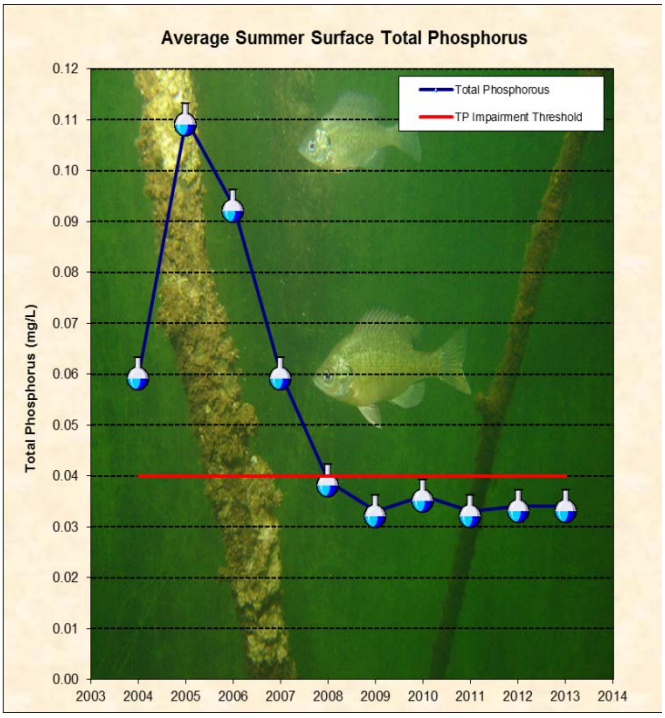
2013 Lake Grade: C

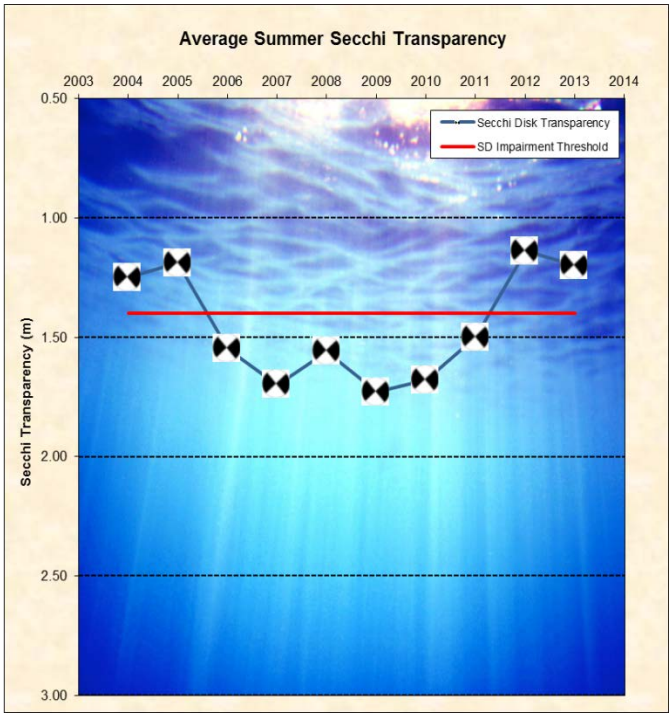
- DNR ID #: 82005400
- Municipality: City of Scandia
- Location: Section 5 T32N-R20W
- Lake Size: 221.45 acres
- Maximum Depth (2013): 32 ft.
- Ordinary High Water Mark: 909.1 ft.
- 56% Littoral
  Note: Littoral area is the portion of the lake <15 ft. and dominated by aquatic vegetation.



Summary Points

- Bone Lake was considered a eutrophic lake in 2013, based on the Carlson Trophic State Index.
- At this time no statistically significant trend is present for water quality.
- The major land use is rural/agricultural.
- The lake stratified in 2013 with the thermocline varying between 4 and 5 meters.
- Bone Lake is listed as impaired for nutrients on the Minnesota Pollution Control Agency's Impaired Waters List.
- Eurasian watermilfoil and Curly-leaf pondweed (invasive aquatic plants) are extensive in this lake.
- Carp removal was performed in the winter of 2010.
- Low velocity fish barriers were installed at Bone Lake north inlet and Bone Lake outlet in the fall of 2012.





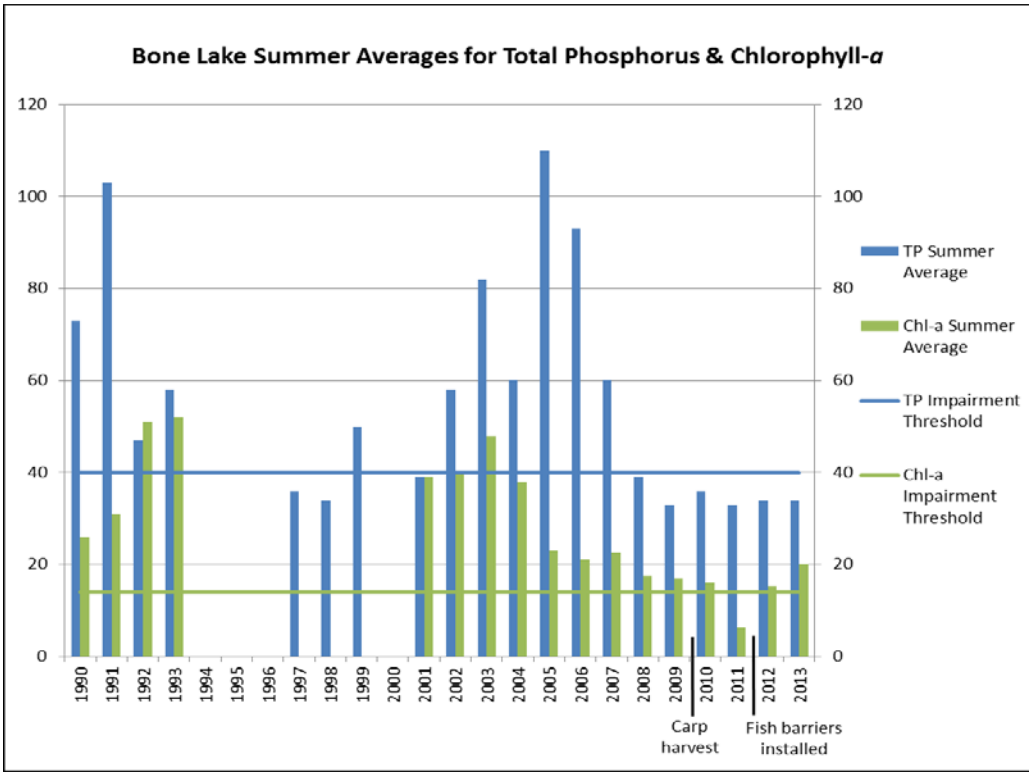
Date	Total Phosphorus (mg/L)	Chlorophyll-*a* (ug/L)	Total Kjeldahl Nitrogen (mg/L)	Secchi Disk Depths (m)	Surface Temperature Levels (Celsius)	Surface Dissolved Oxygen Levels (mg/L)
5/7/2013	0.055	11.0	2.00	1.68	11.5	11.62
5/23/2013	0.057	25.0	1.80	1.68	15.2	11.10
6/6/2013	0.032	31.0	1.20	1.37	16.5	9.51
6/18/2013	0.036	18.0	1.20	1.37	22.9	9.88
7/2/2013	0.053	15.0	1.80	1.07	25.9	11.10
7/16/2013	0.035	18.0	1.50	1.37	28.2	7.85
7/31/2013	0.039	33.0	1.50	0.91	22.4	7.59
8/14/2013	0.032	18.0	1.20	1.52	24.6	7.34
8/29/2013	0.033	20.0	1.40	1.37	27.7	8.03
9/11/2013	0.025	15.0	1.30	0.91	23.8	8.27
9/24/2013	0.023	14.0	1.40	0.91	18.7	5.45
10/9/2013	0.035	23.0	1.90	1.83	15.9	8.91
2013 Average	0.038	20.1	1.52	1.33	21.1	8.89
2013 Summer Average	0.034	20.2	1.39	1.20	23.4	8.34

Water quality thresholds are 0.04 mg/L TP, 14 µg/L CL-a, 1.4 m Secchi depth*

Shallow lake water quality thresholds are 0.06 mg/L TP, 20 µg/L CL-a, 1.0 m Secchi depth*

	High	High Date	Low	Low Date	Average
2013 Elevation (ft)	909.88	7/1/2013	907.66	9/24/2013	908.85

*MPCA description of Impaired Lake's Listing criteria: "At a minimum, a decision that a given lake is impaired for the 303(d) list due to excessive nutrients will be supported by data for both causal and response factors. Data requirements for 303(d) listing consist of 12 or more TP measurements collected from June through September over the most recent 10-year period. Ideally this should represent 12 separate visits to the lake over the course of two summers; however it might also reflect four monthly samples over the course of three years (a typical sampling regimen for many lake monitoring programs). In addition to exceeding the TP guideline thresholds, lakes to be considered for 303(d) listing should have at least 12 Secchi measurements and 12 chlorophyll-a measurements. This amount of data will allow for at least one season (preferably more) for paired TP, chlorophyll-a, and Secchi disk data and provide a basis for evaluating their interrelationships and hence the trophic status of the lake."



Lake Water Quality Summary											
	Trophic Status	Lake Grades									
	2013	2013	2012	2011	2010	2009	2008	2007	2006	2005	2004
Total Phosphorus (mg/L)	Eutrophic	C	C	C	C	C	C	C	C	C	C
Chlorophyll-*a* (ug/L)	Eutrophic	C	B	A	B	B	B	B	B	C+	C
Secchi disk (ft)	Eutrophic	C	D	C	C	C	C	C	C	C	C
Overall	Eutrophic	C	C	C+	C+	C+	C+	C+	C+	C	C

Bone Lake
Water Surface Elevation Statistics

Outlet Elevation (culvert): 907.3 ft.

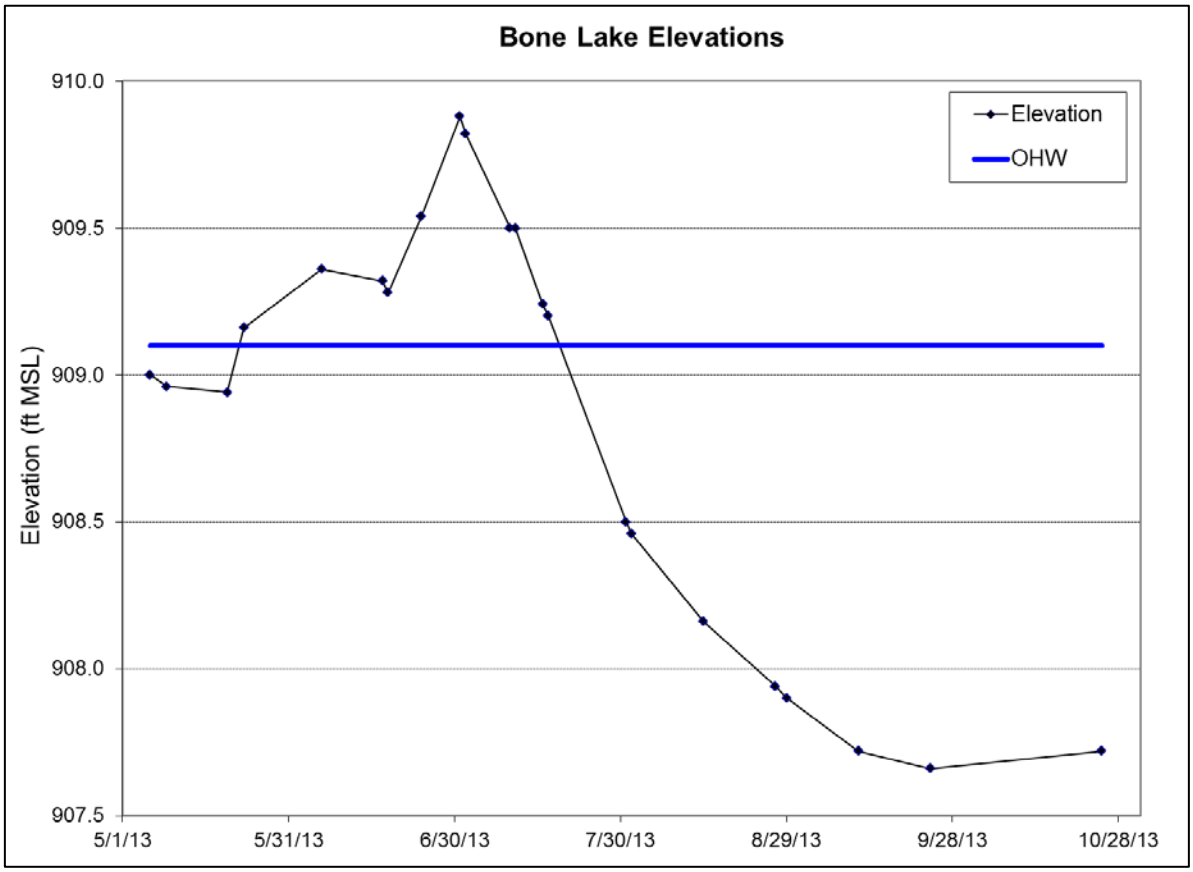
Ordinary High Water Level (OHW) Elevation: 909.1 ft.

100 Year Flood Elevation (CLFLWD): 910.6 ft.

Highest Recorded Elevation: 910.97 ft. (07/07/1975)

Lowest Recorded Elevation: 906.7 ft. (11/07/1966)

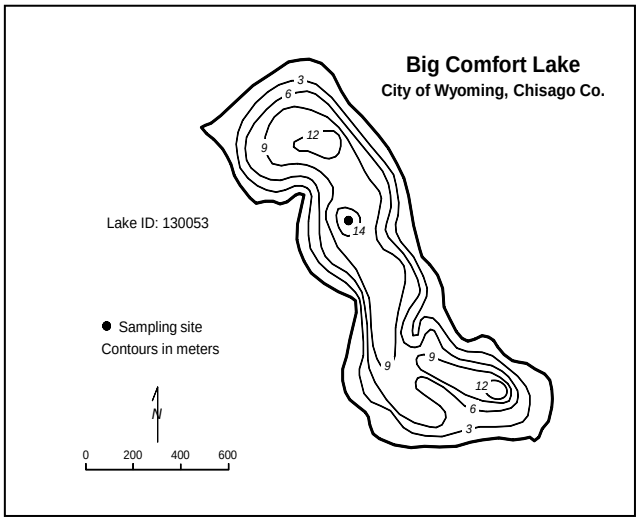
Datum: NGVD 29 (ft.)



Comfort Lake

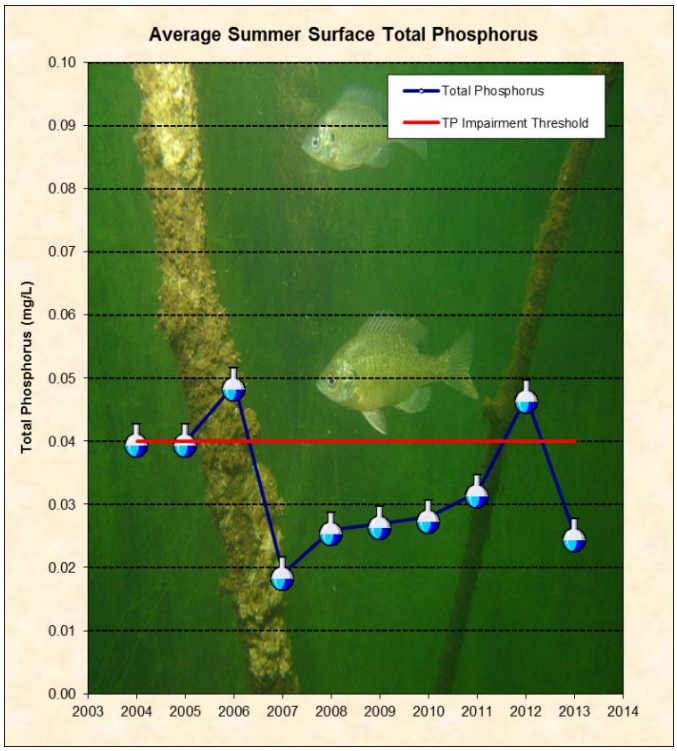
2013 Lake Grade: B-

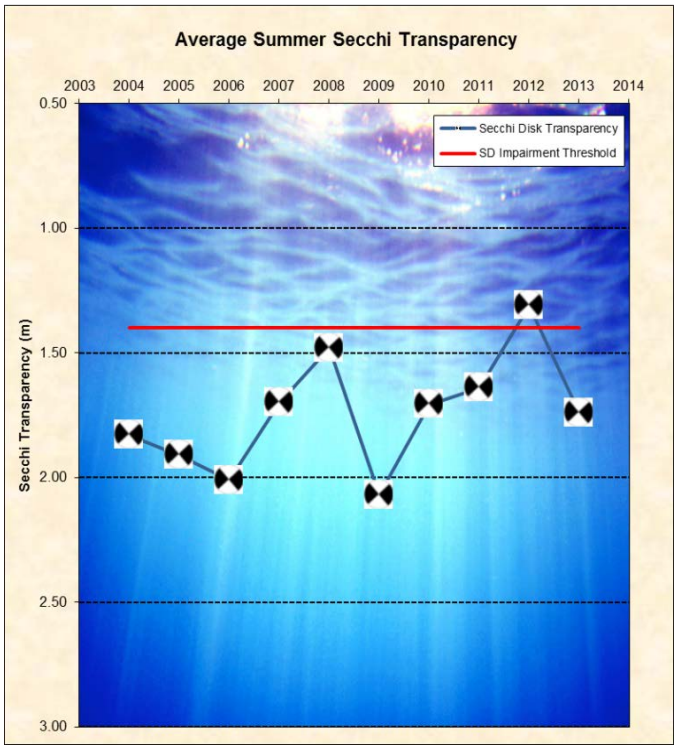
- DNR ID #: 13005300
- Municipality: City of Wyoming
- Location: Section 27 T33N-R21W
- Lake Size: 217.82 acres
- Maximum Depth (2013): 46 ft.
- Ordinary High Water Mark: 887.2 ft.
- 41% Littoral
  Note: Littoral area is the portion of the lake <15 ft. and dominated by aquatic vegetation.



Summary Points

- Comfort Lake was considered a eutrophic lake in 2013, based on the Carlson Trophic State Index.
- There is a statistically significant **declining trend** for average Secchi transparency and no trend is present for average total phosphorus.
- The major land use is a mix of semi-urban, rural, and agricultural.
- The lake stratified in 2013 with the thermocline varying between 5 and 7 meters.
- Comfort Lake is listed as impaired for nutrients on the Minnesota Pollution Control Agency's Impaired Waters List.
- Curly-leaf pondweed (an invasive aquatic plant) is extensive in this lake.





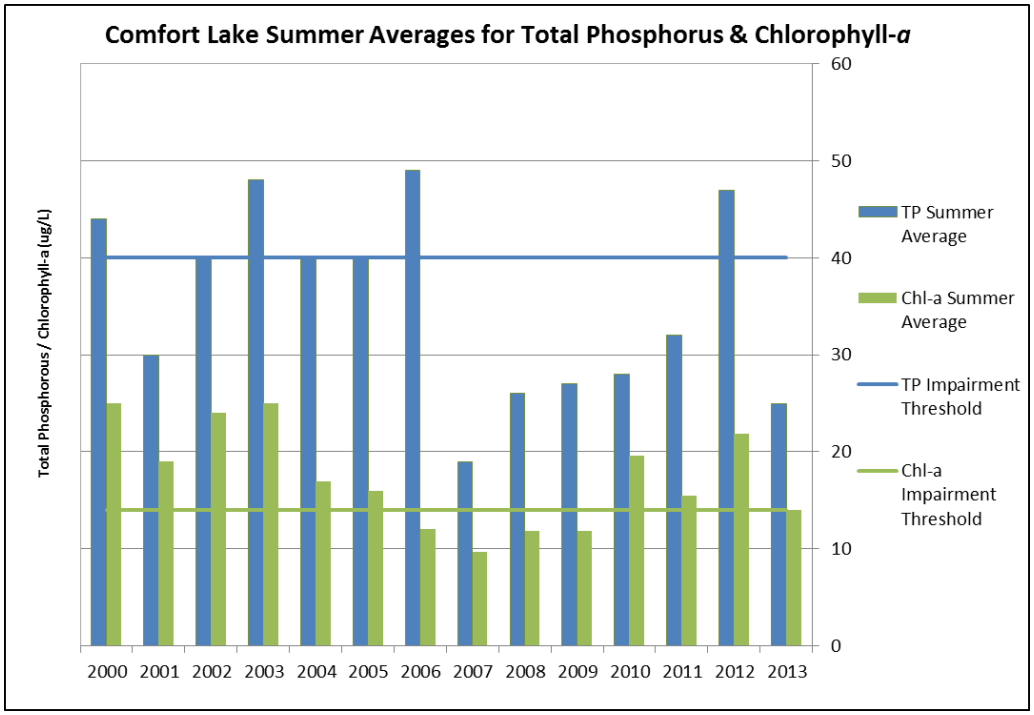
Date	Total Phosphorus (mg/L)	Chlorophyll-*a* (ug/L)	Total Kjeldahl Nitrogen (mg/L)	Secchi Disk Depths (m)	Surface Temperature Levels (Celsius)	Surface Dissolved Oxygen Levels (mg/L)
5/7/2013	0.039	8.4	1.50	1.83	12.9	10.65
5/23/2013	0.045	20.0	1.20	2.29	14.8	11.59
6/6/2013	0.018	16.0	1.10	1.98	16.3	9.24
6/18/2013	0.021	6.5	1.30	2.74	22.1	8.87
7/2/2013	0.038	14.0	1.90	1.37	25.6	9.66
7/16/2013	0.040	18.0	1.90	1.22	27.5	7.81
7/31/2013	0.024	16.0	1.30	1.07	22.4	7.20
8/14/2013	0.020	15.0	1.10	1.52	23.9	7.72
8/29/2013	0.021	7.1	1.20	1.98	27.7	7.34
9/11/2013	0.020	21.0	1.00	2.13	24.0	7.40
9/24/2013	0.019	12.0	1.00	1.68	18.4	7.54
10/9/2013	0.022	11.0	1.10	1.83	15.9	7.93
2013 Average	0.027	13.8	1.30	1.80	21.0	8.58
2013 Summer Average	0.025	14.0	1.31	1.74	23.1	8.09

Water quality thresholds are 0.04 mg/L TP, 14 µg/L CL-a, 1.4 m Secchi depth*

Shallow lake water quality thresholds are 0.06 mg/L TP, 20 µg/L CL-a, 1.0 m Secchi depth*

	High	High Date	Low	Low Date	Average
2013 Elevation (ft)	887.31	7/1/2013	885.69	9/11/2013	886.51

*MPCA description of Impaired Lake's Listing criteria: "At a minimum, a decision that a given lake is impaired for the 303(d) list due to excessive nutrients will be supported by data for both causal and response factors. Data requirements for 303(d) listing consist of 12 or more TP measurements collected from June through September over the most recent 10-year period. Ideally this should represent 12 separate visits to the lake over the course of two summers; however it might also reflect four monthly samples over the course of three years (a typical sampling regimen for many lake monitoring programs). In addition to exceeding the TP guideline thresholds, lakes to be considered for 303(d) listing should have at least 12 Secchi measurements and 12 chlorophyll-a measurements. This amount of data will allow for at least one season (preferably more) for paired TP, chlorophyll-a, and Secchi disk data and provide a basis for evaluating their interrelationships and hence the trophic status of the lake."



Lake Water Quality Summary											
	Trophic Status	**Lake Grades**									
	2013	2013	2012	2011	2010	2009	2008	2007	2006	2005	2004
Total Phosphorus (mg/L)	Mesotrophic	B	C	B	B	B	B	A	C	C	C
Chlorophyll-*a* (ug/L)	Eutrophic	B	C	B	B-	B	A	A	B	B	B
Secchi disk (ft)	Eutrophic	C	C	C	C	C	C	C	C	C	C
Overall	Eutrophic	B-	C	B-	B-	B	B	B+	C+	C+	C+

Comfort Lake
Water Surface Elevation Statistics

Outlet Elevation (rock weir): 885.4 ft.

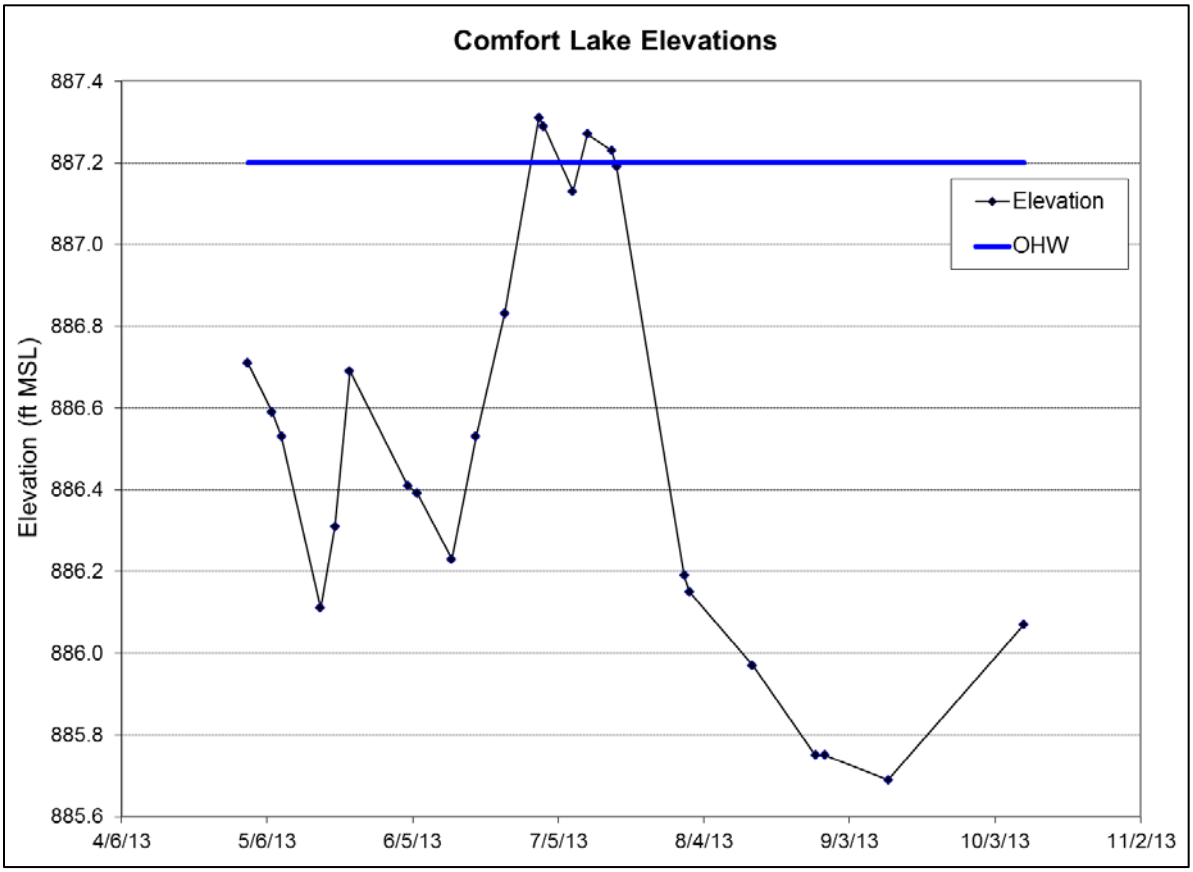
Ordinary High Water Level (OHW) Elevation: 887.2 ft.

100 Year Flood Elevation (CLFLWD): 889.5 ft.

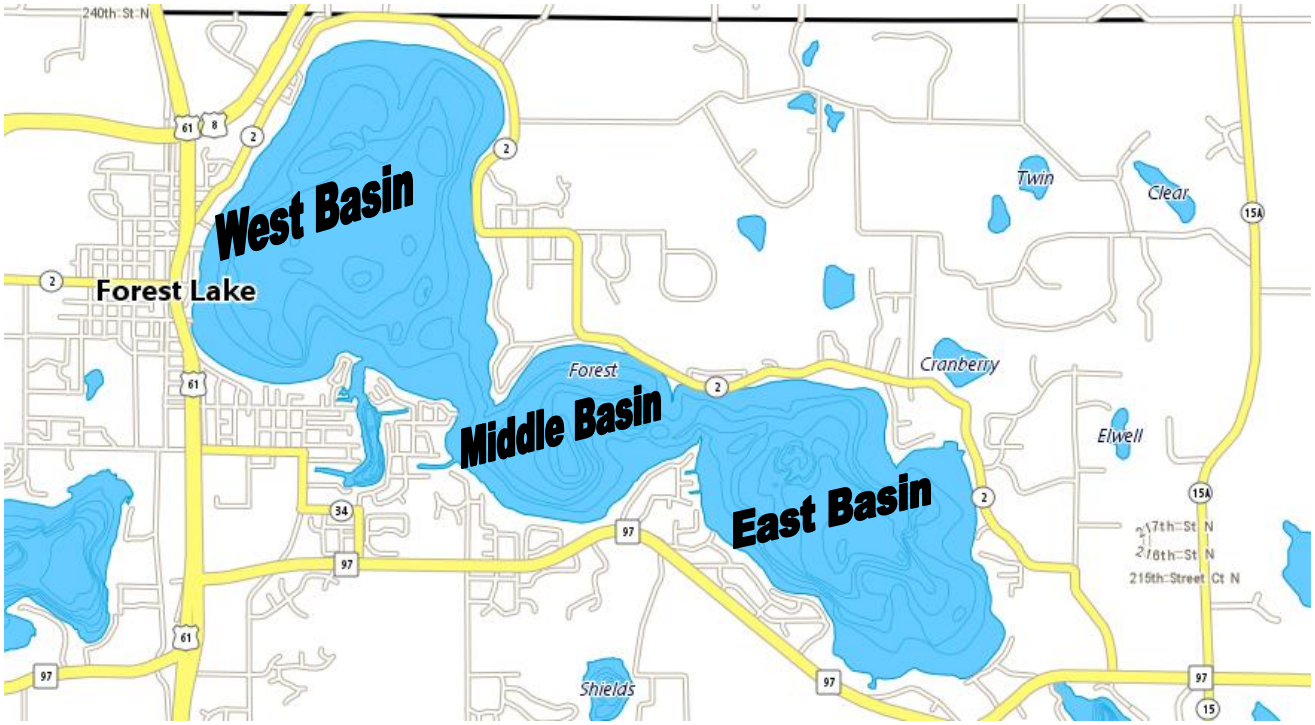
Highest Recorded Elevation: 888.32 ft. (07/02/1975)

Lowest Recorded Elevation: 884.8 ft. (10/08/1969)

Datum: NGVD 29 (ft.)



Forest Lake
2013 Water Quality Summaries

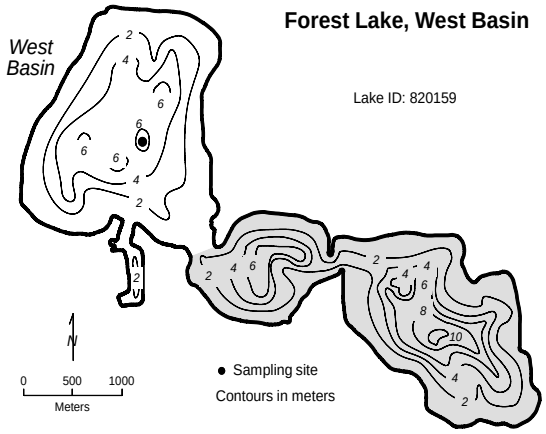


Water quality sampling for Forest Lake is done for each of three basins shown above. The following pages include a summary for each of the three basins and one page on lake level statistics.

Forest Lake (West Basin)

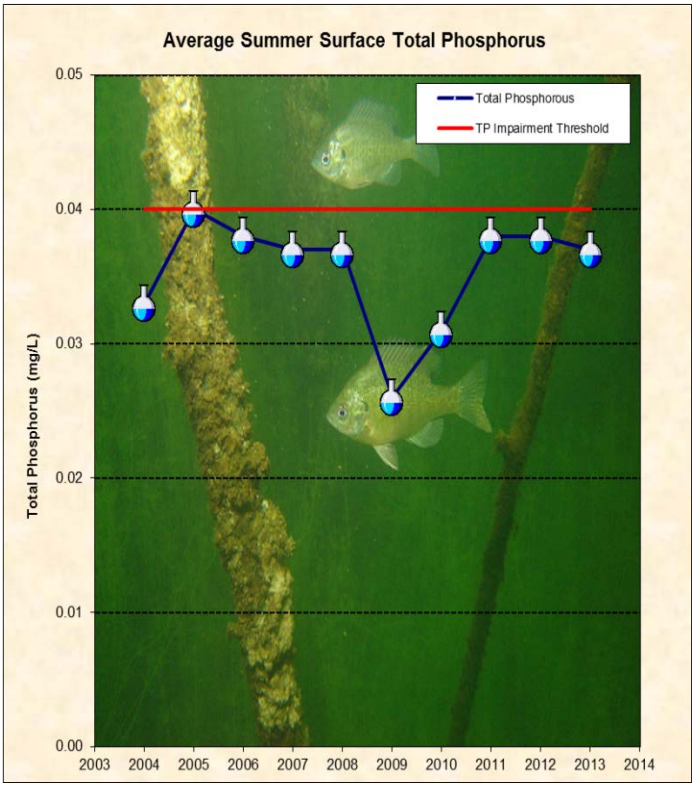
2013 Lake Grade: C

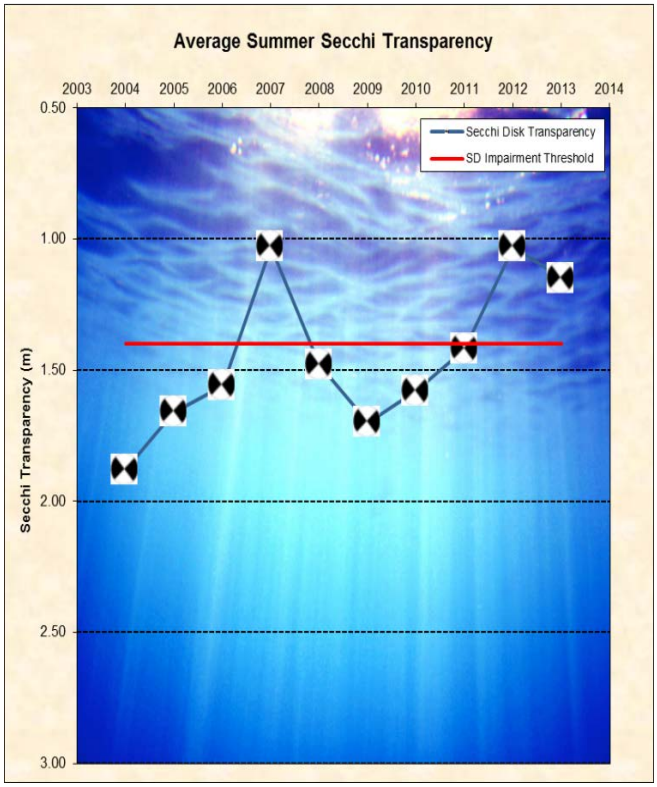
- DNR ID #: 82015900
- Municipality: City of Forest Lake
- Location: Section 9 T32N-R21W
- Lake Size: 1,086.08 acres
- Maximum Depth (2013): 20 ft.
- Ordinary High Water Mark: 901.8 ft.
- 67% Littoral
  Note: Littoral area is the portion of the lake <15 ft. and dominated by aquatic vegetation.



Summary Points

- Forest Lake (West Basin) was considered a eutrophic lake in 2013, based on the Carlson Trophic State Index.
- At this time no statistically significant trend is present for water quality.
- The major land use is urban.
- The lake did not stratify in 2013.
- Flowering rush and Curly-leaf pondweed (invasive aquatic plants) are present in this lake.





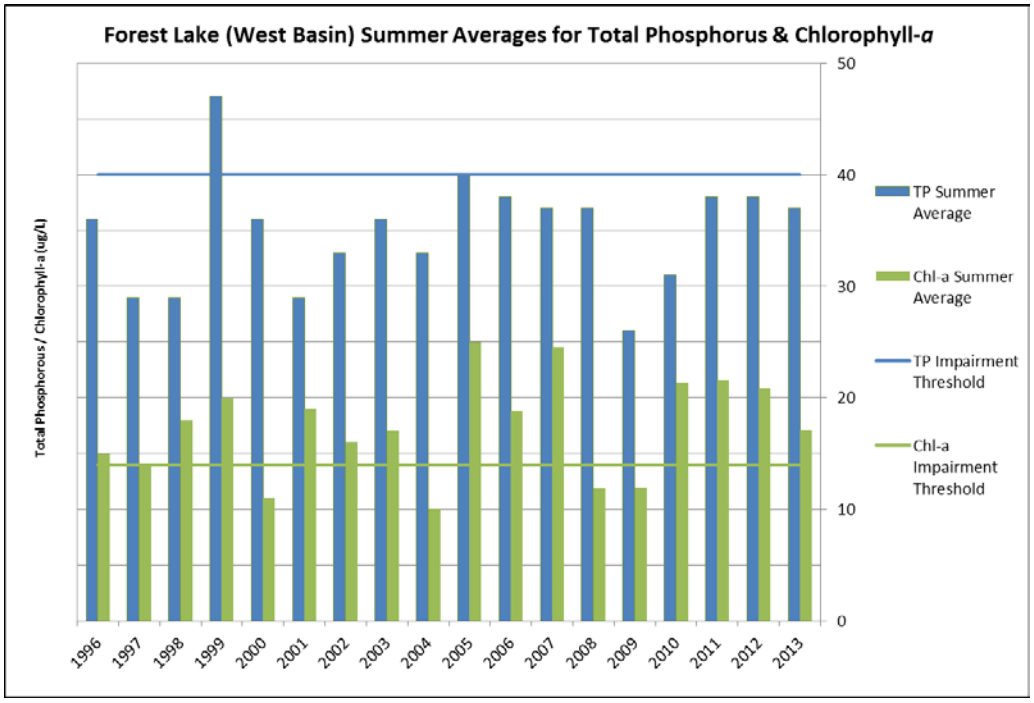
Date	Total Phosphorus (mg/L)	Chlorophyll-*a* (ug/L)	Total Kjeldahl Nitrogen (mg/L)	Secchi Disk Depths (m)	Surface Temperature Levels (Celsius)	Surface Dissolved Oxygen Levels (mg/L)
5/7/2013	0.026	3.8	1.10	2.29	14.9	10.30
5/23/2013	0.037	6.6	1.10	2.13	14.7	8.92
6/6/2013	0.045	15.0	1.10	1.37	16.5	8.20
6/18/2013	0.021	6.7	0.90	1.98	21.0	9.33
7/2/2013	0.026	12.0	1.30	1.37	24.4	8.29
7/16/2013	0.039	17.0	1.20	1.07	26.2	8.28
7/31/2013	0.041	23.0	0.89	0.61	21.9	8.32
8/14/2013	0.032	17.0	1.10	0.91	23.0	8.01
8/29/2013	0.035	18.0	1.20	1.22	26.7	8.76
9/11/2013	0.045	23.0	1.20	0.91	23.2	7.63
9/24/2013	0.046	22.0	1.30	0.91	17.7	9.17
10/9/2013	0.046	20.0	1.30	0.91	15.0	9.35
2013 Average	0.037	15.3	1.14	1.31	20.4	8.71
2013 Summer Average	0.037	17.1	1.13	1.15	22.3	8.44

Water quality thresholds are 0.04 mg/L TP, 14 µg/L CL-a, 1.4 m Secchi depth*

Shallow lake water quality thresholds are 0.06 mg/L TP, 20 µg/L CL-a, 1.0 m Secchi depth*

	High	High Date	Low	Low Date	Average	
2013 Elevation (ft)	NA	NA	NA	NA	NA	

*MPCA description of Impaired Lake's Listing criteria: "At a minimum, a decision that a given lake is impaired for the 303(d) list due to excessive nutrients will be supported by data for both causal and response factors. Data requirements for 303(d) listing consist of 12 or more TP measurements collected from June through September over the most recent 10-year period. Ideally this should represent 12 separate visits to the lake over the course of two summers; however it might also reflect four monthly samples over the course of three years (a typical sampling regimen for many lake monitoring programs). In addition to exceeding the TP guideline thresholds, lakes to be considered for 303(d) listing should have at least 12 Secchi measurements and 12 chlorophyll-a measurements. This amount of data will allow for at least one season (preferably more) for paired TP, chlorophyll-a, and Secchi disk data and provide a basis for evaluating their interrelationships and hence the trophic status of the lake."

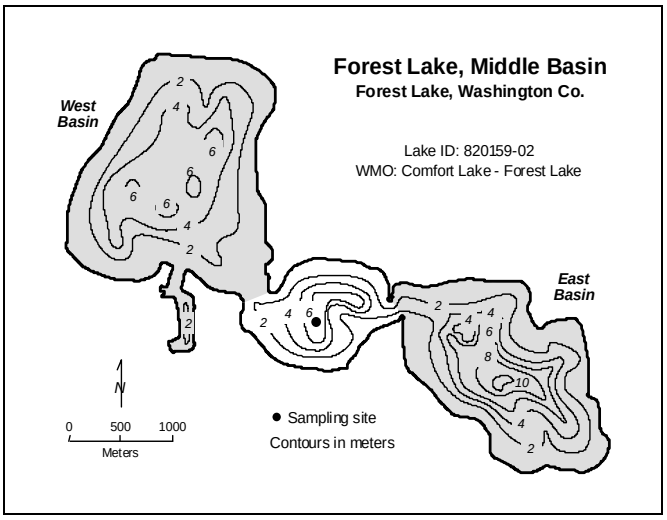


Lake Water Quality Summary											
	Trophic Status	**Lake Grades**									
	2013	2013	2012	2011	2010	2009	2008	2007	2006	2005	2004
Total Phosphorus (mg/L)	Eutrophic	C	C	C	B-	B	C	C	C	C	C+
Chlorophyll-*a* (ug/L)	Eutrophic	B	C	C	C+	B+	B	C	B	C+	A-
Secchi disk (ft)	Eutrophic	D	D	B	C	C	C	C	C	C	B
Overall	Eutrophic	C	C-	C	C+	B	C+	C	C+	C	B

Forest Lake (Middle Basin)

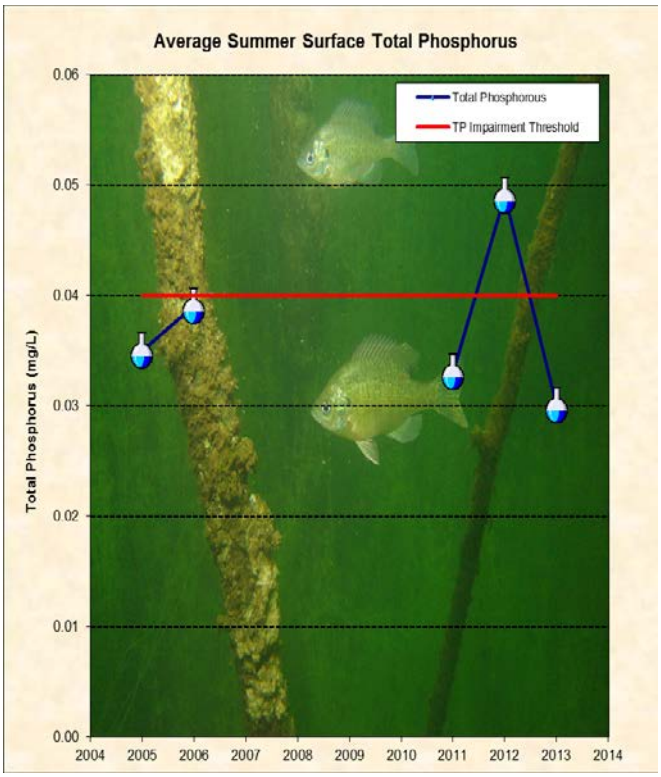
2013 Lake Grade: B-

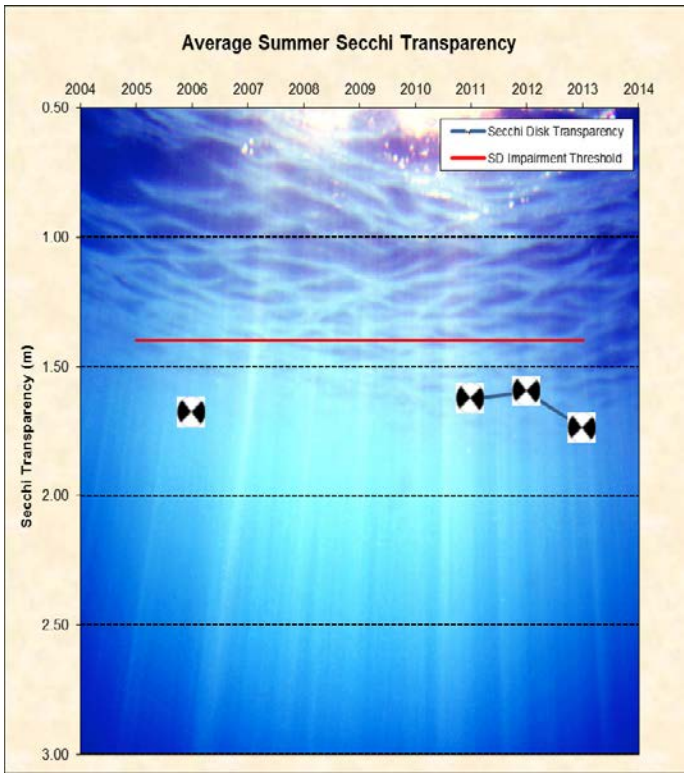
- DNR ID #: 82015900
- Municipality: City of Forest Lake
- Location: Section 9 T32N-R21W
- Lake Size: 363.80 acres
- Maximum Depth (2013): 36 ft.
- Ordinary High Water Mark: 901.8 ft.
- 67% Littoral
  Note: Littoral area is the portion of the lake <15 ft. and dominated by aquatic vegetation.



Summary Points

- Forest Lake (Middle Basin) was considered a eutrophic lake in 2013, based on the Carlson Trophic State Index.
- At this time no statistically significant trend is present for Secchi transparency and there is not enough data to determine a trend for total phosphorus.
- The major land use is urban and rural/agricultural.
- The lake stratified in 2013 with the thermocline varying between 5 and 7 meters.
- Flowering rush and Curly-leaf pondweed (invasive aquatic plants) are present in this lake.





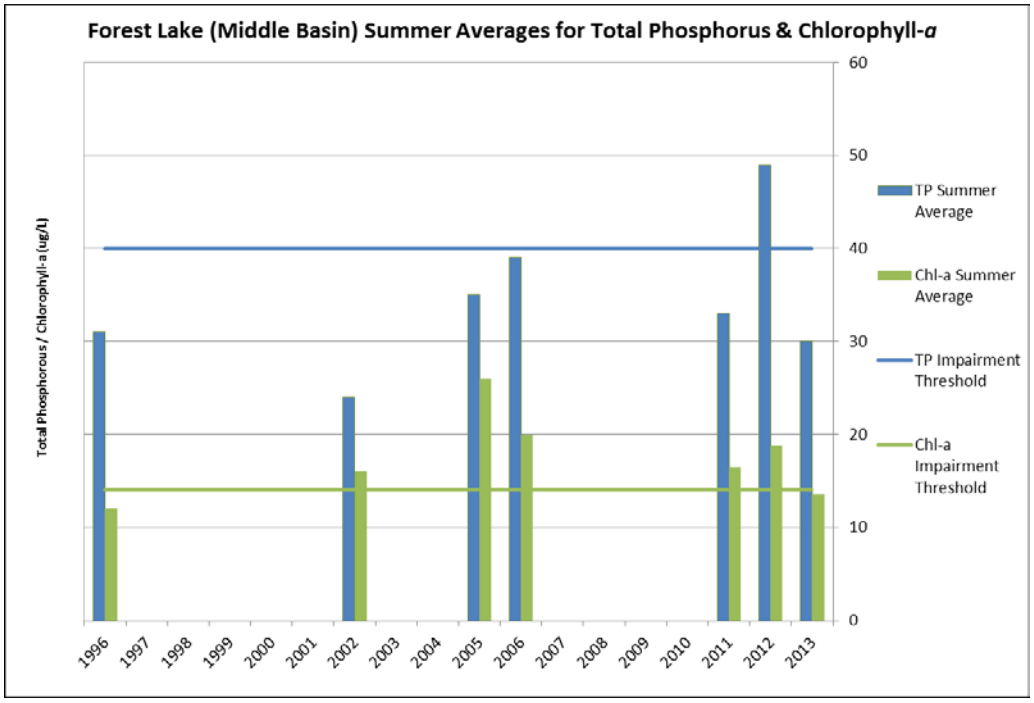
Date	Total Phosphorus (mg/L)	Chlorophyll-*a* (ug/L)	Total Kjeldahl Nitrogen (mg/L)	Secchi Disk Depths (m)	Surface Temperature Levels (Celsius)	Surface Dissolved Oxygen Levels (mg/L)
5/7/2013	0.033	4.9	1.00	2.59	12.3	10.63
5/23/2013	0.056	7.6	1.20	2.13	14.6	8.68
6/6/2013	0.019	8.4	0.90	1.98	16.5	7.82
6/18/2013	0.019	5.1	0.81	3.05	21.6	8.92
7/2/2013	0.026	11.0	1.00	2.29	24.7	9.02
7/16/2013	0.029	11.0	1.10	1.68	26.6	8.18
7/31/2013	0.032	23.0	1.10	1.07	21.6	8.16
8/14/2013	0.030	20.0	1.10	1.22	23.5	8.81
8/29/2013	0.044	10.0	1.30	1.52	27.3	8.51
9/11/2013	0.026	11.0	1.10	1.68	23.1	7.54
9/24/2013	0.044	23.0	1.00	1.22	17.9	8.37
10/9/2013	0.041	24.0	1.10	1.37	15.4	9.31
2013 Average	0.033	13.3	1.06	1.82	20.4	8.66
2013 Summer Average	0.030	13.6	1.05	1.74	22.5	8.37

Water quality thresholds are 0.04 mg/L TP, 14 µg/L CL-a, 1.4 m Secchi depth*

Shallow lake water quality thresholds are 0.06 mg/L TP, 20 µg/L CL-a, 1.0 m Secchi depth*

	High	High Date	Low	Low Date	Average
2013 Elevation (ft)	NA	NA	NA	NA	NA

*MPCA description of Impaired Lake's Listing criteria: "At a minimum, a decision that a given lake is impaired for the 303(d) list due to excessive nutrients will be supported by data for both causal and response factors. Data requirements for 303(d) listing consist of 12 or more TP measurements collected from June through September over the most recent 10-year period. Ideally this should represent 12 separate visits to the lake over the course of two summers; however it might also reflect four monthly samples over the course of three years (a typical sampling regimen for many lake monitoring programs). In addition to exceeding the TP guideline thresholds, lakes to be considered for 303(d) listing should have at least 12 Secchi measurements and 12 chlorophyll-a measurements. This amount of data will allow for at least one season (preferably more) for paired TP, chlorophyll-a, and Secchi disk data and provide a basis for evaluating their interrelationships and hence the trophic status of the lake."

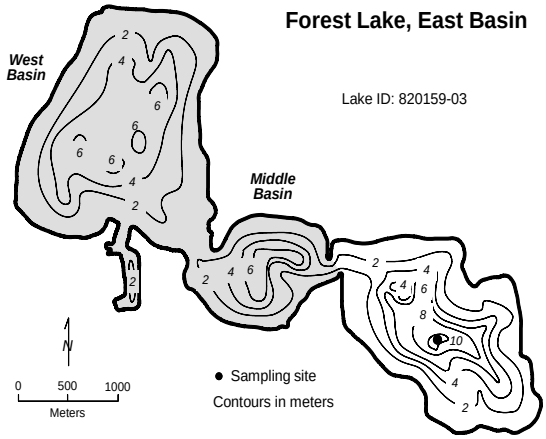


Lake Water Quality Summary											
	Trophic Status	Lake Grades									
	2013	2013	2012	2011	2010	2009	2008	2007	2006	2005	2004
Total Phosphorus (mg/L)	Mesotrophic	B	C	C	NA	NA	NA	NA	C	C	NA
Chlorophyll-*a* (ug/L)	Eutrophic	B	B	B	NA	NA	NA	NA	B	C	NA
Secchi disk (ft)	Eutrophic	C	C	C	NA	NA	NA	NA	C	NA	NA
Overall	Eutrophic	B-	C+	C+	NA	NA	NA	NA	C+	NA	NA

Forest Lake (East Basin)

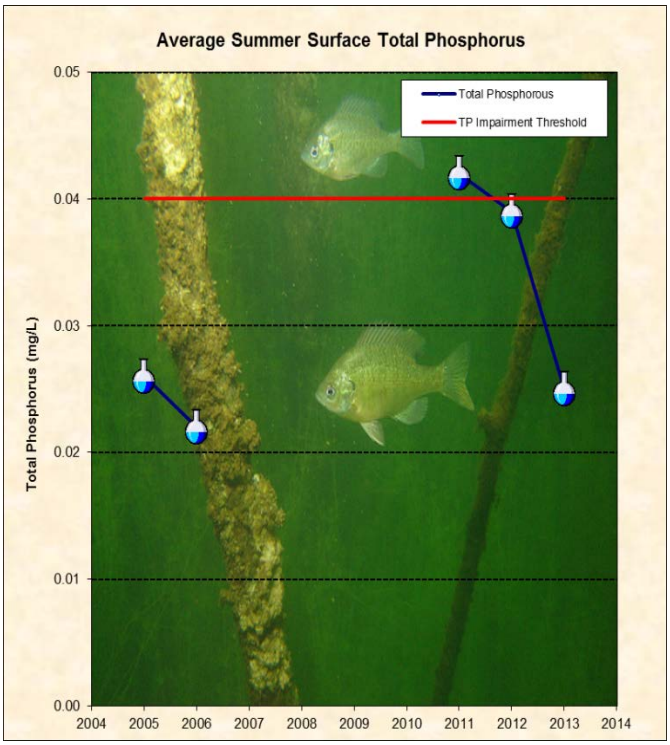
2013 Lake Grade: B-

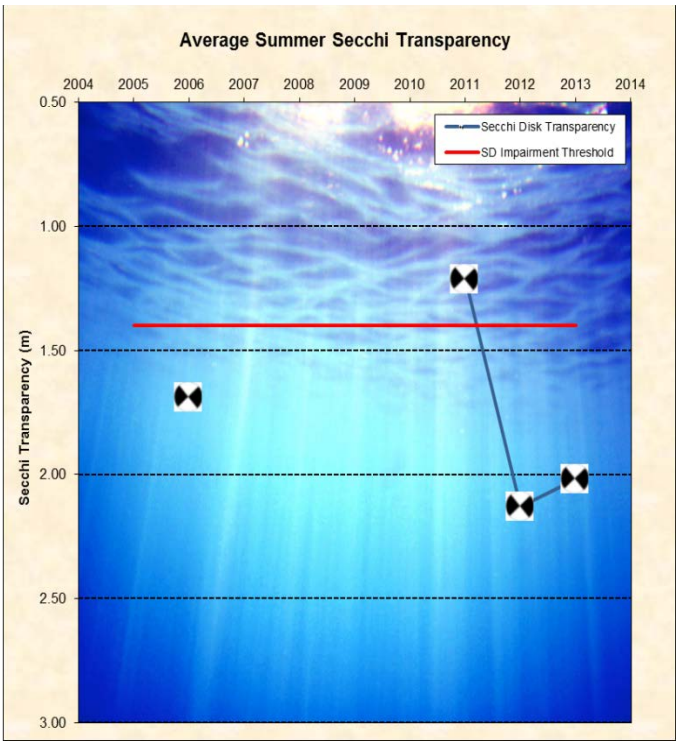
- DNR ID #: 82015900
- Municipality: City of Forest Lake
- Location: Section 9 T32N-R21W
- Lake Size: 789.58 acres
- Maximum Depth (2013): 37 ft.
- Ordinary High Water Mark: 901.8 ft.
- 67% Littoral
  Note: Littoral area is the portion of the lake <15 ft. and dominated by aquatic vegetation.



Summary Points

- Forest Lake (Middle Basin) was considered a mesotrophic lake in 2013, based on the Carlson Trophic State Index.
- At this time no statistically significant trend is present for Secchi transparency and there is not enough data to determine a trend for total phosphorus.
- The major land use is semi-urban and rural/agricultural.
- The lake stratified in 2013 with the thermocline varying between 6 and 9 meters.
- Flowering rush and Curly-leaf pondweed (invasive aquatic plants) are present in this lake.





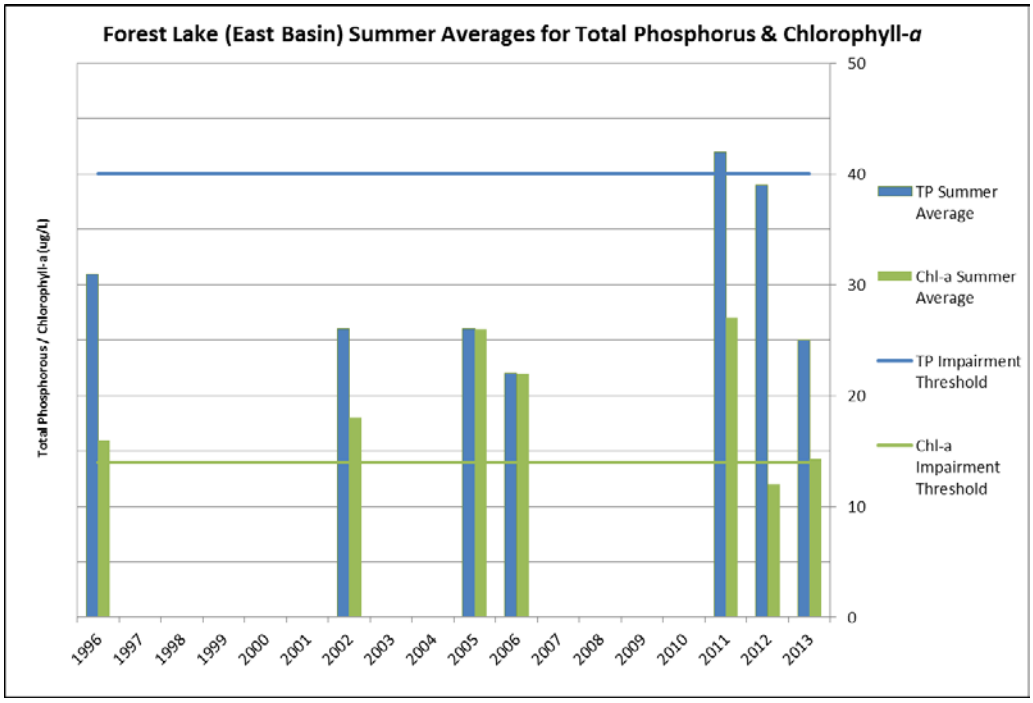
Date	Total Phosphorus (mg/L)	Chlorophyll-*a* (ug/L)	Total Kjeldahl Nitrogen (mg/L)	Secchi Disk Depths (m)	Surface Temperature Levels (Celsius)	Surface Dissolved Oxygen Levels (mg/L)
5/7/2013	0.029	4.9	0.89	2.74	11.3	10.69
5/23/2013	0.045	11.0	1.10	2.13	14.4	9.30
6/6/2013	0.019	6.3	1.40	2.90	16.4	7.67
6/18/2013	0.023	5.6	0.74	3.05	21.5	9.52
7/2/2013	0.018	5.8	0.97	2.74	24.5	8.76
7/16/2013	0.021	7.8	0.98	2.29	26.3	7.98
7/31/2013	0.029	14.0	1.00	1.37	21.7	7.59
8/14/2013	0.033	19.0	0.96	1.68	23.2	8.86
8/29/2013	0.029	16.0	1.10	1.22	27.1	8.71
9/11/2013	0.028	44.0	1.10	1.52	23.2	7.46
9/24/2013	0.029	9.9	0.88	1.37	17.8	8.10
10/9/2013	0.034	22.0	0.94	1.68	15.5	9.08
2013 Average	0.028	13.9	1.01	2.06	20.2	8.64
2013 Summer Average	0.025	14.3	1.01	2.02	22.4	8.29

Water quality thresholds are 0.04 mg/L TP, 14 µg/L CL-a, 1.4 m Secchi depth*

Shallow lake water quality thresholds are 0.06 mg/L TP, 20 µg/L CL-a, 1.0 m Secchi depth*

	High	High Date	Low	Low Date	Average
2013 Elevation (ft)	NA	NA	NA	NA	NA

*MPCA description of Impaired Lake's Listing criteria: "At a minimum, a decision that a given lake is impaired for the 303(d) list due to excessive nutrients will be supported by data for both causal and response factors. Data requirements for 303(d) listing consist of 12 or more TP measurements collected from June through September over the most recent 10-year period. Ideally this should represent 12 separate visits to the lake over the course of two summers; however it might also reflect four monthly samples over the course of three years (a typical sampling regimen for many lake monitoring programs). In addition to exceeding the TP guideline thresholds, lakes to be considered for 303(d) listing should have at least 12 Secchi measurements and 12 chlorophyll-a measurements. This amount of data will allow for at least one season (preferably more) for paired TP, chlorophyll-a, and Secchi disk data and provide a basis for evaluating their interrelationships and hence the trophic status of the lake."



Lake Water Quality Summary											
	Trophic Status	Lake Grades									
	2013	2013	2012	2011	2010	2009	2008	2007	2006	2005	2004
Total Phosphorus (mg/L)	Mesotrophic	B	C	C	NA	NA	NA	NA	A	B	NA
Chlorophyll-*a* (ug/L)	Eutrophic	B	B	C	NA	NA	NA	NA	C	C	NA
Secchi disk (ft)	Mesotrophic	C	C	C	NA	NA	NA	NA	C	NA	NA
Overall	Mesotrophic	B-	C+	C	NA	NA	NA	NA	B-	NA	NA

Forest Lake
Water Surface Elevation Statistics

Outlet Elevation (dam): 901.4 ft.

Ordinary High Water Level (OHW) Elevation: 901.8 ft.

100 Year Flood Elevation (CLFLWD): 902.4 ft.

Highest Recorded Elevation: 902.23 ft. (06/24/1993)

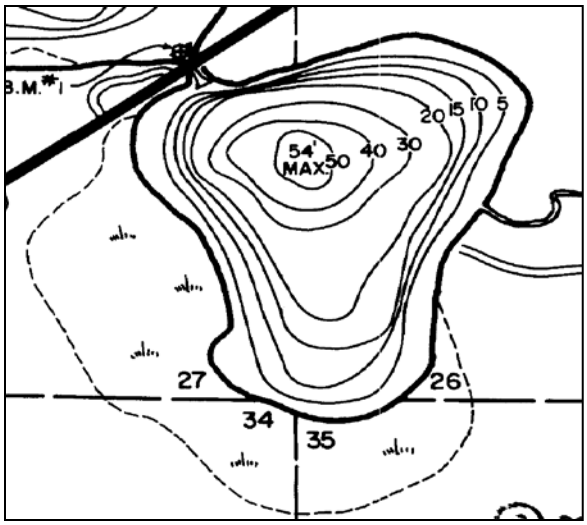
Lowest Recorded Elevation: 899.45 ft. (10/07/1969)

Datum: NGVD 29 (ft.)

Little Comfort Lake

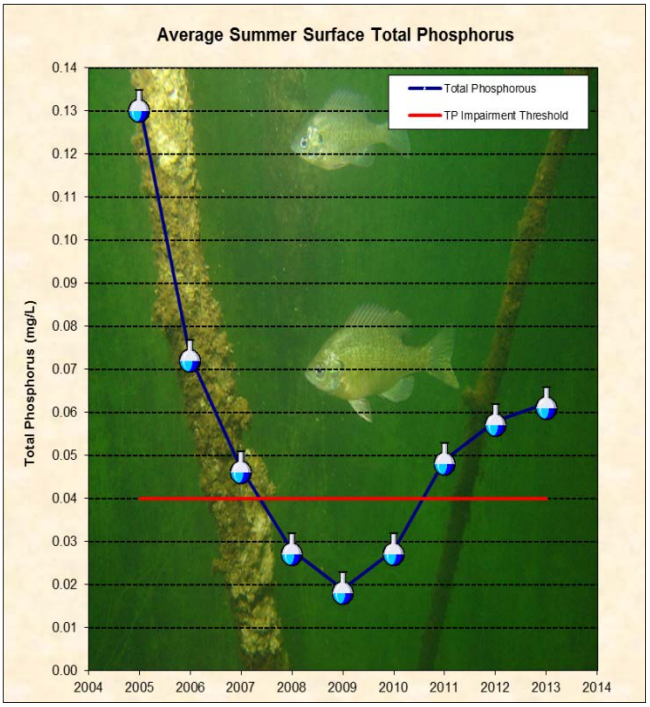
2013 Lake Grade: C

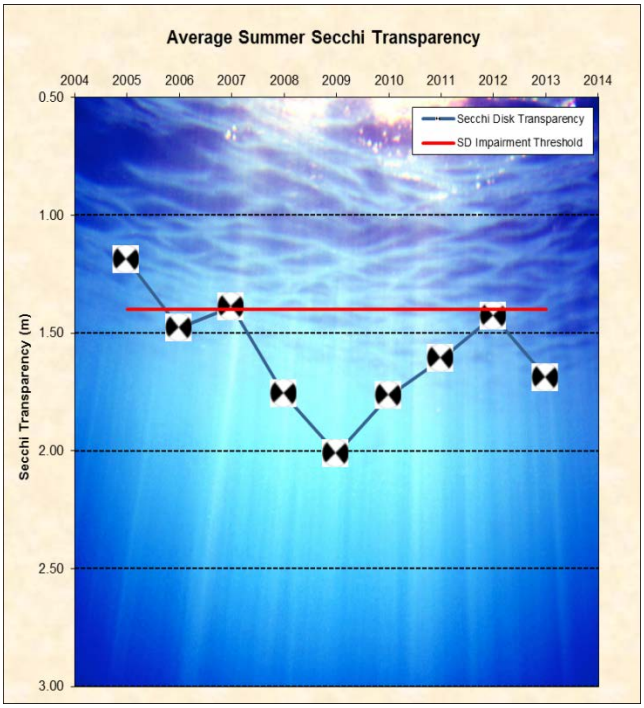
- DNR ID #: 13005400
- Municipality: Chisago City
- Location: Section 27 T33N-R21W
- Lake Size: 36 acres
- Maximum Depth (2013): 53 ft.
- Ordinary High Water Mark: 887.2 ft.
- 44% Littoral
  Note: Littoral area is the portion of the lake <15 ft. and dominated by aquatic vegetation.



Summary Points

- Little Comfort Lake was considered a eutrophic lake in 2013, based on the Carlson Trophic State Index.
- At this time no statistically significant trend is present for water quality.
- The major land use is rural/agricultural.
- The lake stratified in 2013 with the thermocline varying between 4 and 5 meters.
- Little Comfort Lake is listed as impaired for nutrients on the Minnesota Pollution Control Agency's Impaired Waters List.
- Curly-leaf pondweed (invasive aquatic plant) is extensive in this lake.





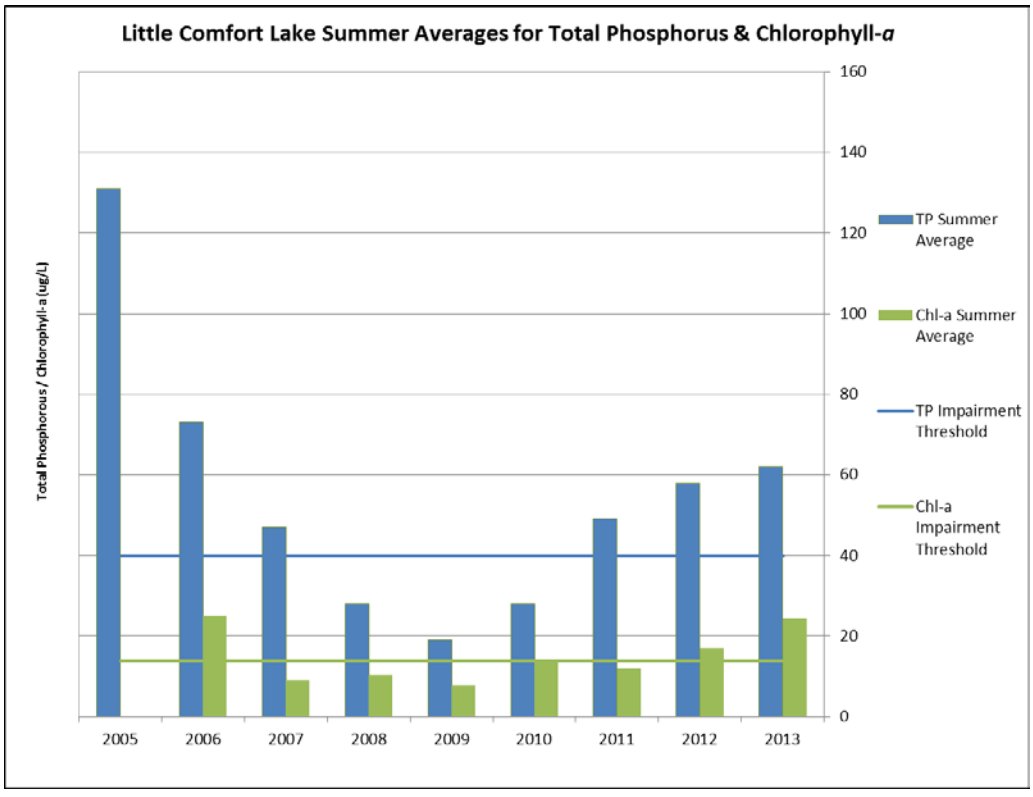
Date	Total Phosphorus (mg/L)	Chlorophyll-*a* (ug/L)	Total Kjeldahl Nitrogen (mg/L)	Secchi Disk Depths (m)	Surface Temperature Levels (Celsius)	Surface Dissolved Oxygen Levels (mg/L)
5/9/2013	0.079	43.0	1.40	1.07	14.3	12.50
5/21/2013	0.059	16.0	1.10	1.22	18.0	9.00
6/5/2013	0.032	9.7	1.10	2.29	17.4	7.35
6/17/2013	0.064	22.0	1.40	1.83	22.0	6.31
7/1/2013	0.065	30.0	1.50	0.91	24.3	7.74
7/17/2013	0.062	18.0	1.40	1.52	27.9	6.55
7/29/2013	0.064	25.0	1.70	1.68	20.7	6.69
8/13/2013	0.037	13.0	1.30	2.29	22.5	5.66
8/27/2013	0.047	13.0	1.30	1.83	27.6	7.26
9/10/2013	0.080	61.0	1.80	1.07	23.1	6.85
9/23/2013	0.106	29.0	1.40	1.83	17.3	7.12
10/10/2013	0.041	12.0	1.30	1.68	15.3	6.91
2013 Average	0.061	24.3	1.39	1.60	20.9	7.50
2013 Summer Average	0.062	24.5	1.43	1.69	22.5	6.84

Water quality thresholds are 0.04 mg/L TP, 14 µg/L CL-a, 1.4 m Secchi depth*

Shallow lake water quality thresholds are 0.06 mg/L TP, 20 µg/L CL-a, 1.0 m Secchi depth*

	High	High Date	Low	Low Date	Average
2013 Elevation (ft)	NA	NA	NA	NA	NA

*MPCA description of Impaired Lake's Listing criteria: "At a minimum, a decision that a given lake is impaired for the 303(d) list due to excessive nutrients will be supported by data for both causal and response factors. Data requirements for 303(d) listing consist of 12 or more TP measurements collected from June through September over the most recent 10-year period. Ideally this should represent 12 separate visits to the lake over the course of two summers; however it might also reflect four monthly samples over the course of three years (a typical sampling regimen for many lake monitoring programs). In addition to exceeding the TP guideline thresholds, lakes to be considered for 303(d) listing should have at least 12 Secchi measurements and 12 chlorophyll-a measurements. This amount of data will allow for at least one season (preferably more) for paired TP, chlorophyll-a, and Secchi disk data and provide a basis for evaluating their interrelationships and hence the trophic status of the lake."



Lake Water Quality Summary											
	Trophic Status	Lake Grades									
	2013	2013	2012	2011	2010	2009	2008	2007	2006	2005	2004
Total Phosphorus (mg/L)	Hypereutrophic	C	C	C	B	A	B	C	D	D	NA
Chlorophyll-*a* (ug/L)	Eutrophic	C	B	B	B	A	C	A	C	NA	NA
Secchi disk (ft)	Eutrophic	C	C	C	C	C	C	C	C	D	NA
Overall	Eutrophic	C	C+	C+	B-	B+	B-	B-	C	NA	NA

Little Comfort Lake
Water Surface Elevation Statistics

Outlet Elevation: 885.7 ft.

Ordinary High Water Level (OHW) Elevation: 887.2 ft.

100 Year Flood Elevation (CLFLWD): 892.1 ft.

Highest Recorded Elevation: 887.81 ft. (05/08/2001)

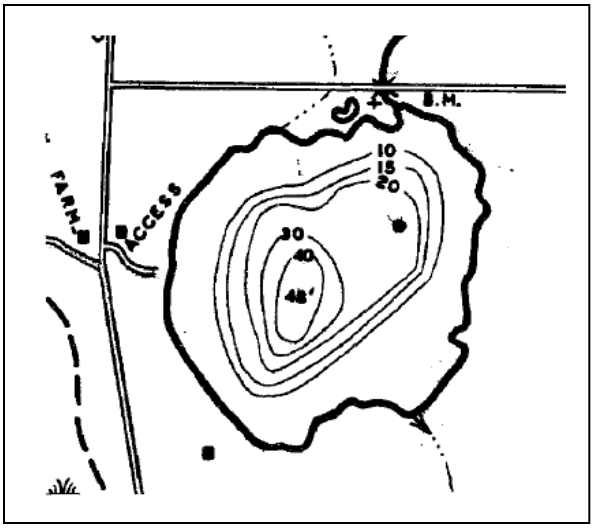
Lowest Recorded Elevation: 885.41 ft. (09/05/2003)

Datum: NGVD 29 (ft.)

Moody Lake

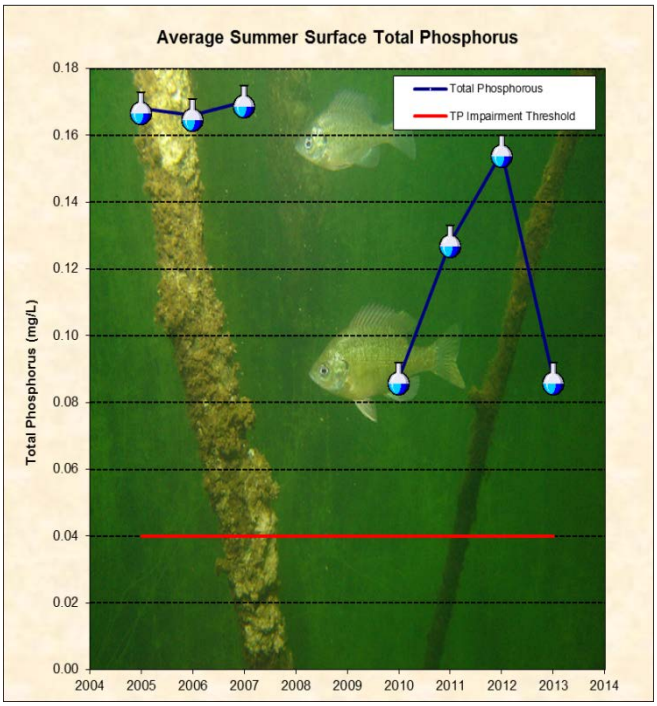
2013 Lake Grade: D+

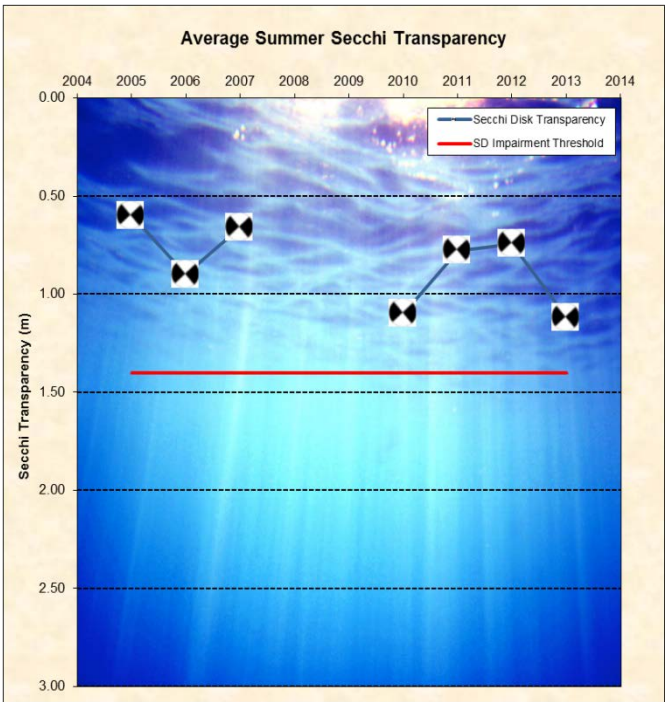
- DNR ID #: 13002300
- Municipality: Chisago Lakes Township
- Location: SW$^{1/4}$ Section 32 T33N-R20W
- Lake Size: 45.33 acres
- Maximum Depth (2013): 47 ft.
- Ordinary High Water Mark: N/A
- 49% Littoral
  Note: Littoral area is the portion of the lake <15 ft. and dominated by aquatic vegetation.



Summary Points

- Moody Lake was considered a hypereutrophic lake in 2013, based on the Carlson Trophic State Index.
- At this time there is not enough data to determine a statistically significant trend for water quality.
- The major land use is rural/agricultural.
- The lake stratified in 2013 with the thermocline varying between 3 and 5 meters.
- Moody Lake is listed as impaired for nutrients on the Minnesota Pollution Control Agency's Impaired Waters List.
- Curly-leaf pondweed (an invasive aquatic plant) is present in this lake.





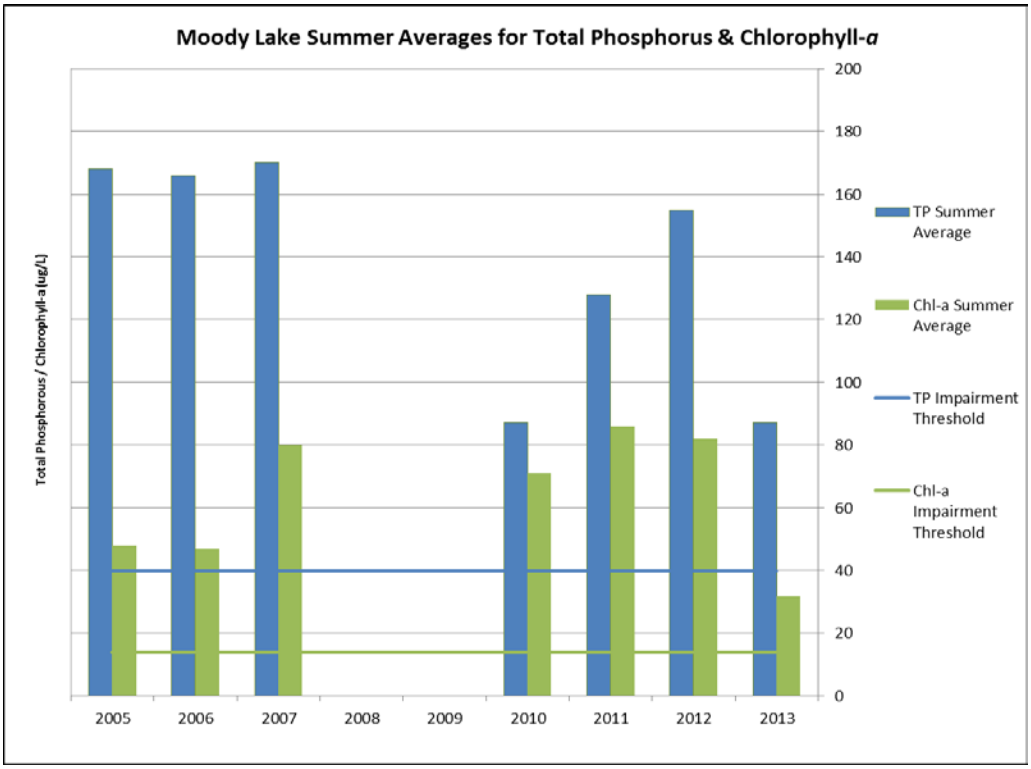
Date	Total Phosphorus (mg/L)	Chlorophyll-*a* (ug/L)	Total Kjeldahl Nitrogen (mg/L)	Secchi Disk Depths (m)	Surface Temperature Levels (Celsius)	Surface Dissolved Oxygen Levels (mg/L)
5/9/2013	0.141	100.0	2.60	0.91	14.9	13.80
5/21/2013	0.062	14.0	1.30	1.83	18.0	9.06
6/5/2013	0.049	12.0	1.30	2.29	17.3	7.67
6/17/2013	0.080	25.0	1.50	1.98	22.1	8.85
7/1/2013	0.178	33.0	2.30	0.76	24.6	7.87
7/17/2013	0.144	49.0	2.30	0.61	29.0	8.59
7/29/2013	0.105	54.0	2.10	1.07	21.4	7.64
8/13/2013	0.065	30.0	1.80	0.76	23.8	7.46
8/27/2013	0.060	33.0	1.70	0.91	28.7	7.88
9/10/2013	0.062	31.0	1.70	0.76	23.5	6.83
9/23/2013	0.041	19.0	1.30	0.91	17.4	7.88
10/10/2013	0.042	17.0	1.50	1.37	15.2	8.37
2013 Average	0.086	34.8	1.78	1.18	21.3	8.49
2013 Summer Average	0.087	31.8	1.78	1.12	23.1	7.85

Water quality thresholds are 0.04 mg/L TP, 14 µg/L CL-a, 1.4 m Secchi depth*

Shallow lake water quality thresholds are 0.06 mg/L TP, 20 µg/L CL-a, 1.0 m Secchi depth*

	High	High Date	Low	Low Date	Average
2013 Elevation (ft)	99.45	7/1/2013	98.37	10/10/2013	98.96

*MPCA description of Impaired Lake's Listing criteria: "At a minimum, a decision that a given lake is impaired for the 303(d) list due to excessive nutrients will be supported by data for both causal and response factors. Data requirements for 303(d) listing consist of 12 or more TP measurements collected from June through September over the most recent 10-year period. Ideally this should represent 12 separate visits to the lake over the course of two summers; however it might also reflect four monthly samples over the course of three years (a typical sampling regimen for many lake monitoring programs). In addition to exceeding the TP guideline thresholds, lakes to be considered for 303(d) listing should have at least 12 Secchi measurements and 12 chlorophyll-a measurements. This amount of data will allow for at least one season (preferably more) for paired TP, chlorophyll-a, and Secchi disk data and provide a basis for evaluating their interrelationships and hence the trophic status of the lake."



Lake Water Quality Summary											
	Trophic Status	**Lake Grades**									
	2013	2013	2012	2011	2010	2009	2008	2007	2006	2005	2004
Total Phosphorus (mg/L)	Hypereutrophic	D	F	D	D	NA	NA	F	F	F	NA
Chlorophyll-*a* (ug/L)	Hypereutrophic	C	F	F	D	NA	NA	F	D	D	NA
Secchi disk (ft)	Eutrophic	D	D	D	D	NA	NA	F	D	F	NA
Overall	Hypereutrophic	D+	F+	D-	D	NA	NA	F	D-	F	NA

Moody Lake
Water Surface Elevation Statistics

Ordinary High Water Level (OHW) Elevation: N/A

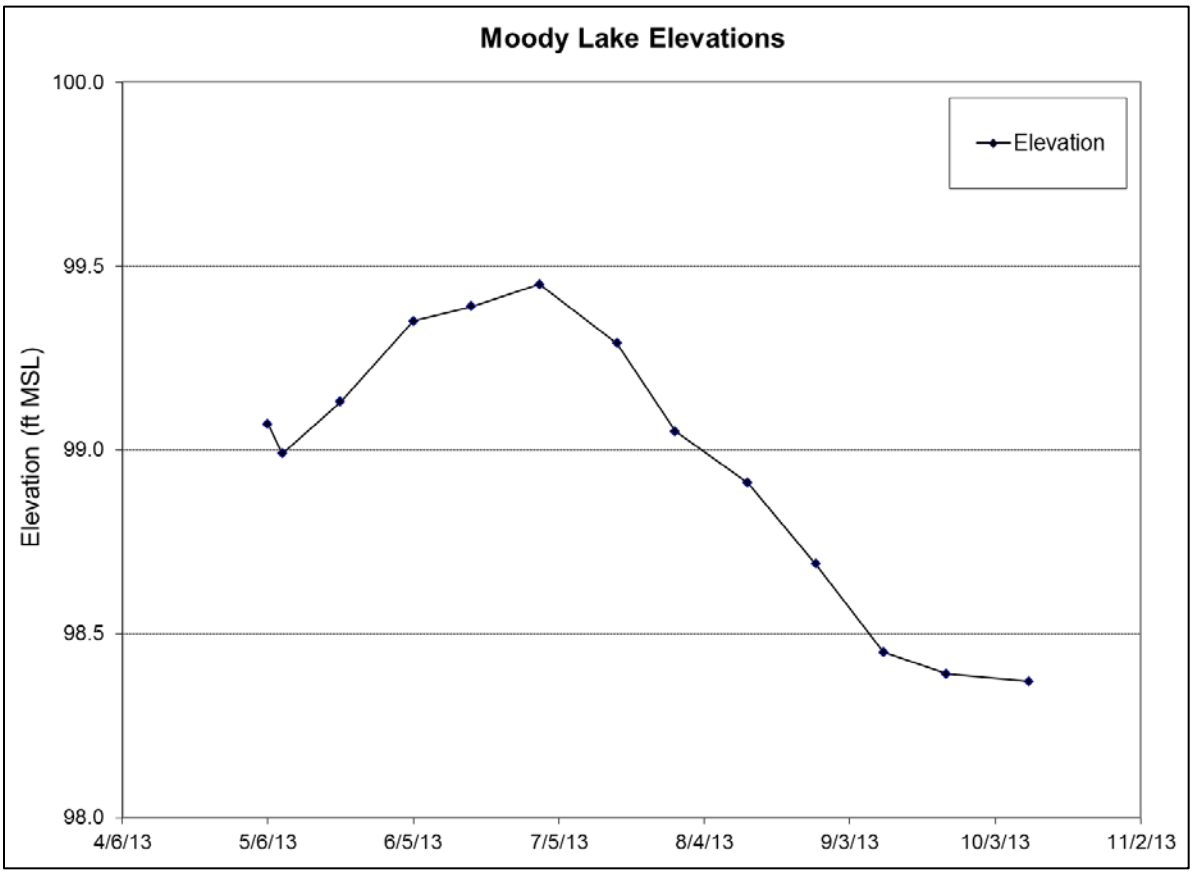
100 Year Flood Elevation (CLFLWD): 892.1 ft.

Highest Recorded Elevation: 99.45 ft. (07/01/2013)*

Lowest Recorded Elevation: 98.37 ft. (10/10/2013)*

Datum: NGVD 29 (ft.)

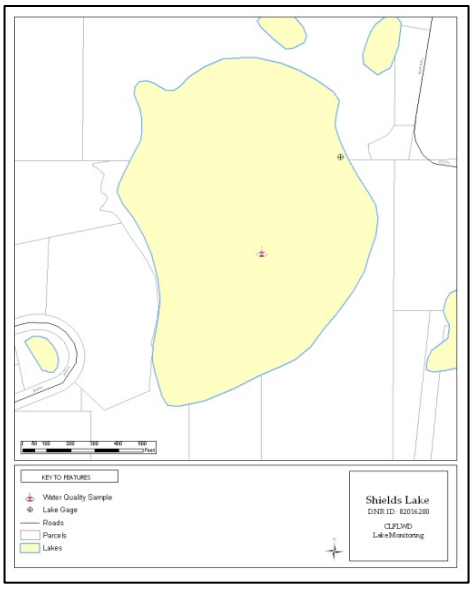
*No benchmark information is available therefore an assumed elevation of 100.00 ft. is used to calculate lake levels.



Shields Lake

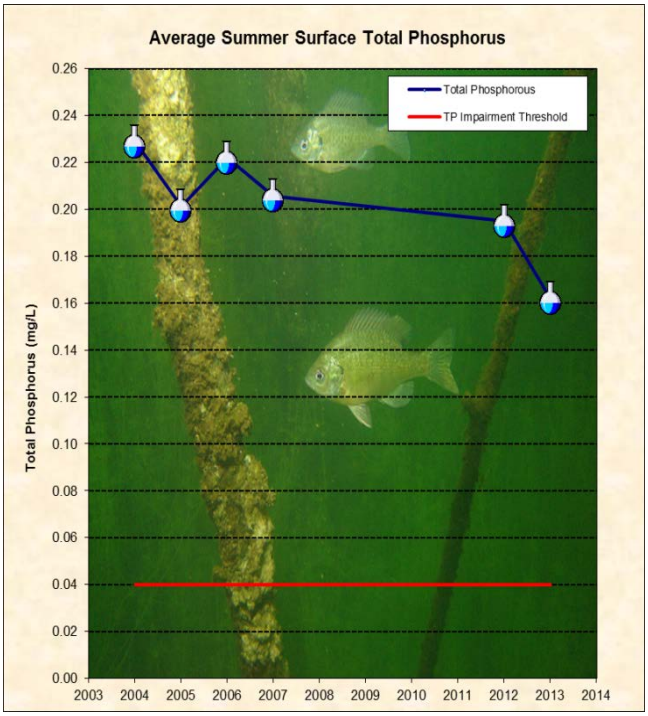
2013 Lake Grade: D+

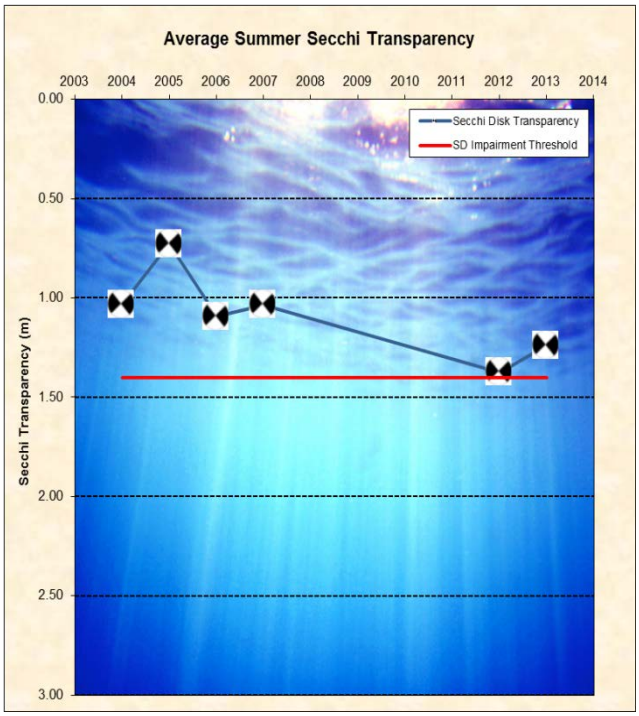
- DNR ID #: 82016200
- Municipality: City of Forest Lake
- Location: NE$^{1/4}$ Section 22 T32N-R21W
- Lake Size: 29.58 Acres
- Maximum Depth (2013): 25 ft.
- Ordinary High Water Mark: 902.5 ft.
- 74% Littoral
  Note: Littoral area is the portion of the lake <15 ft. and dominated by aquatic vegetation.



Summary Points

- Shields Lake was considered a hypereutrophic lake in 2013, based on the Carlson Trophic State Index.
- There is a statistically significant **declining trend** for average Secchi transparency and no trend is present for average total phosphorus.
- The major land use is a mix of semi-urban and rural/agricultural.
- The lake stratified in 2013 with the thermocline varying between 2 and 3 meters.
- Shields Lake is listed as impaired for nutrients on the Minnesota Pollution Control Agency's Impaired Waters List.
- Curly-leaf pondweed (an invasive aquatic plant) is extensive in this lake.





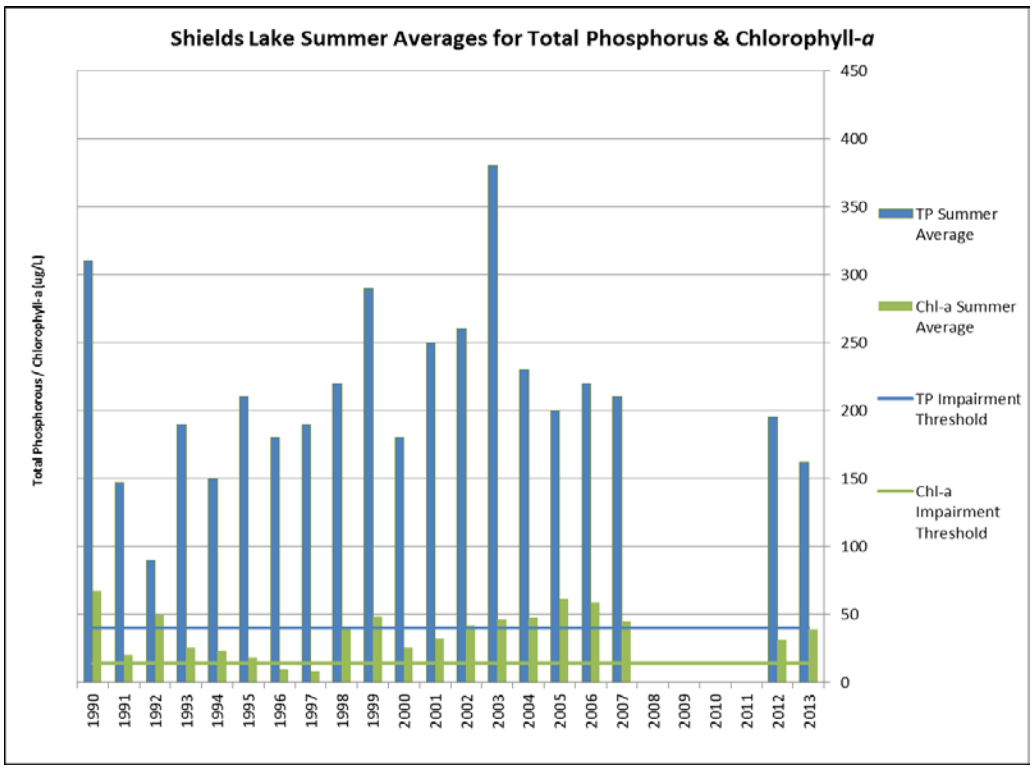
Date	Total Phosphorus (mg/L)	Chlorophyll-*a* (ug/L)	Total Kjeldahl Nitrogen (mg/L)	Secchi Disk Depths (m)	Surface Temperature Levels (Celsius)	Surface Dissolved Oxygen Levels (mg/L)
5/9/2013	0.288	180.0	3.20	0.61	15.5	20.44
5/21/2013	0.112	20.0	1.80	1.22	18.6	9.60
6/5/2013	0.098	8.9	1.50	2.13	17.1	7.83
6/17/2013	0.128	15.0	1.80	2.44	22.3	7.33
7/1/2013	0.358	18.0	2.90	1.22	25.3	5.05
7/17/2013	0.275	52.0	2.90	0.61	29.3	12.63
7/29/2013	0.190	69.0	2.60	1.07	21.2	8.56
8/13/2013	0.081	60.0	2.20	0.91	23.8	7.34
8/27/2013	0.083	39.0	2.50	0.61	29.5	12.16
9/10/2013	0.090	70.0	2.60	0.61	23.9	8.27
9/23/2013	0.151	19.0	3.00	1.52	17.3	4.70
10/10/2013	0.150	20.0	3.50	1.68	15.2	5.87
2013 Average	0.167	47.6	2.54	1.22	21.6	9.15
2013 Summer Average	0.162	39.0	2.44	1.24	23.3	8.21

Water quality thresholds are 0.04 mg/L TP, 14 µg/L CL-a, 1.4 m Secchi depth*

Shallow lake water quality thresholds are 0.06 mg/L TP, 20 µg/L CL-a, 1.0 m Secchi depth*

	High	High Date	Low	Low Date	Average
2013 Elevation (ft)	902.02	7/1/2013	900.48	9/23/2013	901.19

*MPCA description of Impaired Lake's Listing criteria: "At a minimum, a decision that a given lake is impaired for the 303(d) list due to excessive nutrients will be supported by data for both causal and response factors. Data requirements for 303(d) listing consist of 12 or more TP measurements collected from June through September over the most recent 10-year period. Ideally this should represent 12 separate visits to the lake over the course of two summers; however it might also reflect four monthly samples over the course of three years (a typical sampling regimen for many lake monitoring programs). In addition to exceeding the TP guideline thresholds, lakes to be considered for 303(d) listing should have at least 12 Secchi measurements and 12 chlorophyll-a measurements. This amount of data will allow for at least one season (preferably more) for paired TP, chlorophyll-a, and Secchi disk data and provide a basis for evaluating their interrelationships and hence the trophic status of the lake."



Lake Water Quality Summary											
	Trophic Status	**Lake Grades**									
	2013	2013	2012	2011	2010	2009	2008	2007	2006	2005	2004
Total Phosphorus (mg/L)	Hypereutrophic	F	F	NA	NA	NA	NA	F	F	F	F
Chlorophyll-*a* (ug/L)	Hypereutrophic	C	C	NA	NA	NA	NA	C	D	D+	C
Secchi disk (ft)	Eutrophic	C	C	NA	NA	NA	NA	D	D	D+	C
Overall	Hypereutrophic	D+	D+	NA	NA	NA	NA	D	D-	D-	D+

Shields Lake
Water Surface Elevation Statistics

Outlet Elevation (culvert): 900.0 ft.

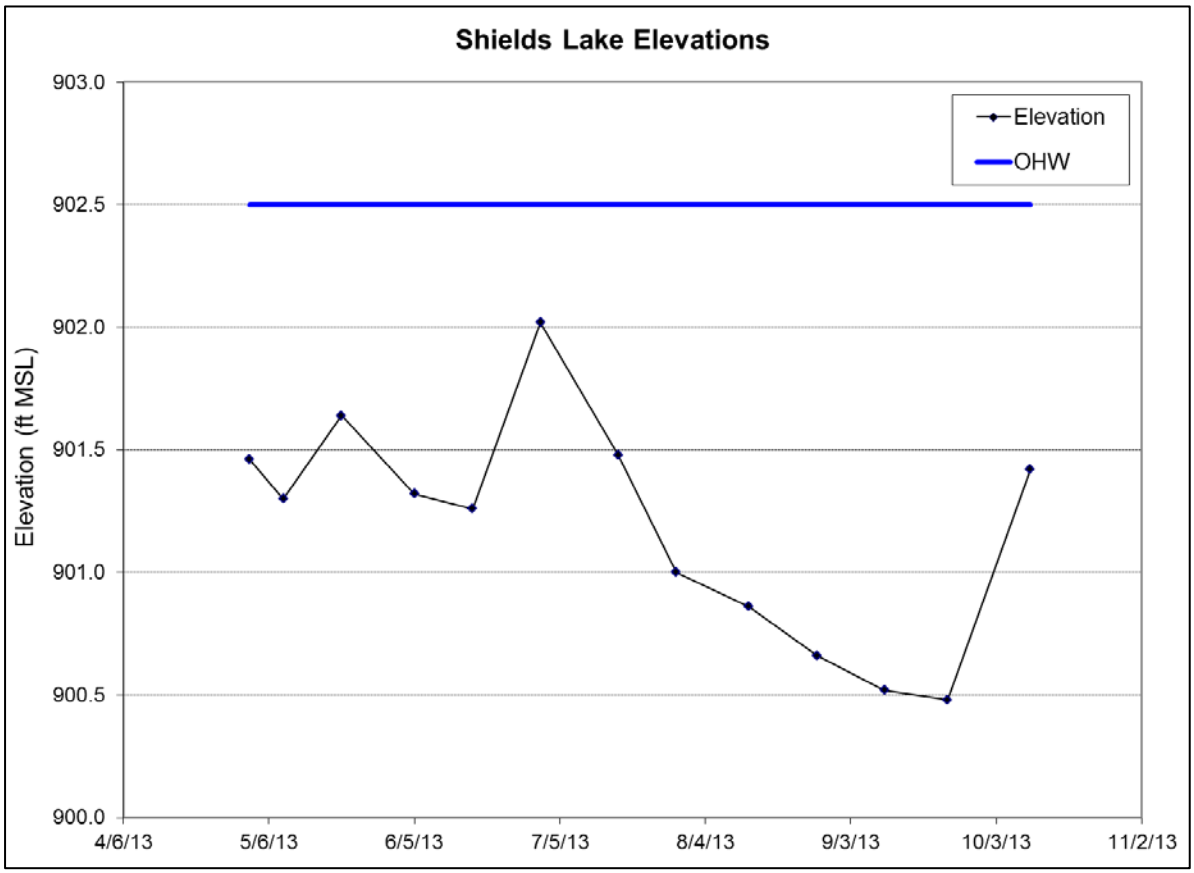
Ordinary High Water Level (OHW) Elevation: 902.5 ft.

100 Year Flood Elevation (FEMA): 904.5 ft.

Highest Recorded Elevation: 903.99 ft. (06/27/2003)

Lowest Recorded Elevation: 899.77 ft. (10/02/2006)

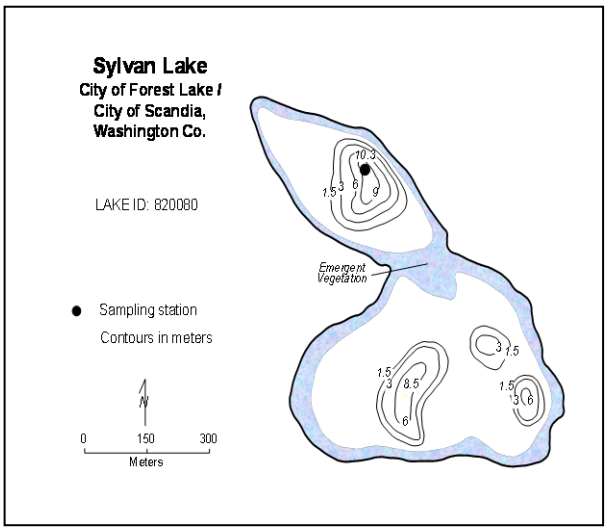
Datum: NGVD 29 (ft.)



Sylvan/Halfbreed Lake

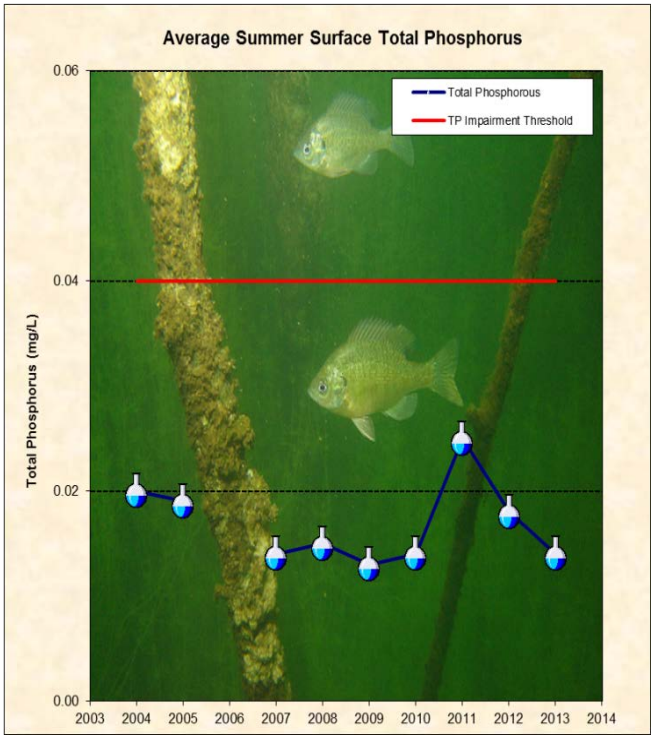
2013 Lake Grade: A

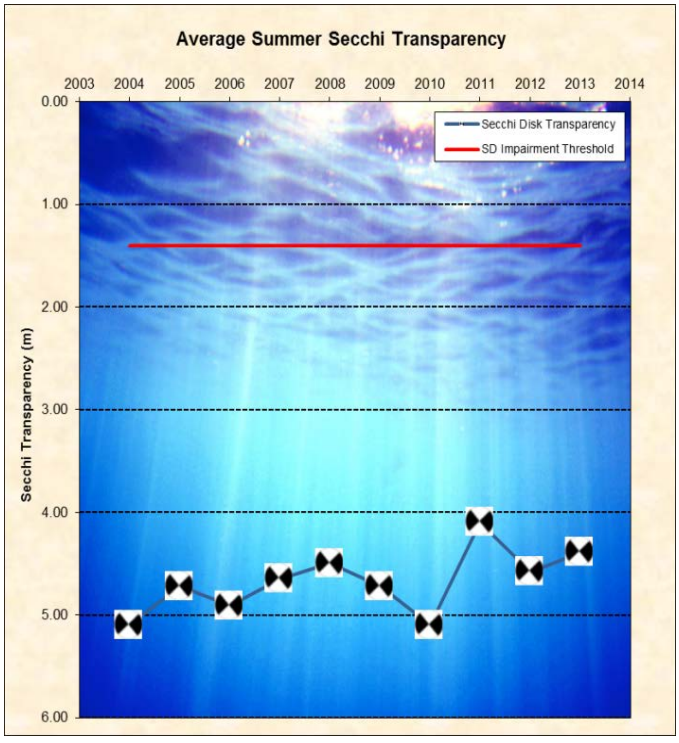
- DNR ID #: 82008000
- Municipality: City of Forest Lake
- Location: Section 24 T32N-R21W
- Lake Size: 74.50 acres
- Maximum Depth (2013): 38 ft.
- Ordinary High Water Mark: 937.1 ft.
- 90% Littoral
  Note: Littoral area is the portion of the lake <15 ft. and dominated by aquatic vegetation.



Summary Points

- Sylvan/Halfbreed Lake was considered a mesotrophic lake in 2013, based on the Carlson Trophic State Index.
- There is a statistically significant **improving trend** for average Secchi transparency and a statistically significant **improving trend** for average total phosphorus.
- The major land use is semi-urban and rural/agricultural.
- The lake stratified in 2013 with the thermocline varying between 5 and 7 meters.
- Curly-leaf pondweed (an invasive aquatic plant) is present in this lake.
- During the August 27th sampling event freshwater jellyfish were observed in this lake.





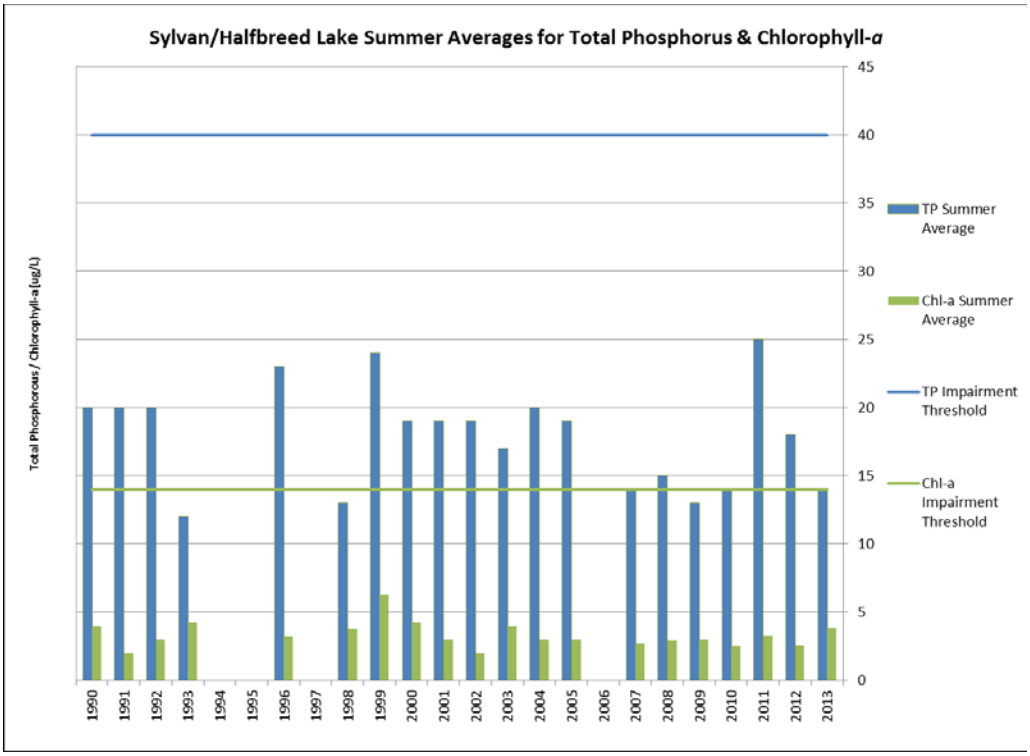
Date	Total Phosphorus (mg/L)	Chlorophyll-*a* (ug/L)	Total Kjeldahl Nitrogen (mg/L)	Secchi Disk Depths (m)	Surface Temperature Levels (Celsius)	Surface Dissolved Oxygen Levels (mg/L)
5/9/2013	0.021	3.0	0.67	2.29	14.3	9.47
5/21/2013	0.024	7.3	0.63	2.59	18.4	8.10
6/5/2013	0.012	4.7	0.63	4.11	17.4	7.08
6/17/2013	0.025	3.6	0.66	4.27	22.3	8.28
7/1/2013	0.015	5.8	0.72	2.59	25.3	7.70
7/17/2013	0.012	3.4	0.69	4.27	28.4	8.25
7/29/2013	0.007	4.1	0.66	5.03	21.5	7.46
8/13/2013	0.011	2.5	0.68	5.33	23.6	7.87
8/27/2013	0.021	1.6	1.00	5.18	28.4	7.54
9/10/2013	0.012	3.0	0.68	4.57	23.5	6.76
9/23/2013	0.010	5.3	0.67	4.11	17.4	8.28
10/10/2013	0.009	2.6	0.64	6.25	15.2	8.13
2013 Average	0.015	3.9	0.69	4.22	21.3	7.91
2013 Summer Average	0.014	3.8	0.71	4.39	23.1	7.69

Water quality thresholds are 0.04 mg/L TP, 14 µg/L CL-a, 1.4 m Secchi depth*

Shallow lake water quality thresholds are 0.06 mg/L TP, 20 µg/L CL-a, 1.0 m Secchi depth*

	High	High Date	Low	Low Date	Average
2013 Elevation (ft)	937.31	6/28/2013	936.15	9/25 & 10/8	936.71

*MPCA description of Impaired Lake's Listing criteria: "At a minimum, a decision that a given lake is impaired for the 303(d) list due to excessive nutrients will be supported by data for both causal and response factors. Data requirements for 303(d) listing consist of 12 or more TP measurements collected from June through September over the most recent 10-year period. Ideally this should represent 12 separate visits to the lake over the course of two summers; however it might also reflect four monthly samples over the course of three years (a typical sampling regimen for many lake monitoring programs). In addition to exceeding the TP guideline thresholds, lakes to be considered for 303(d) listing should have at least 12 Secchi measurements and 12 chlorophyll-a measurements. This amount of data will allow for at least one season (preferably more) for paired TP, chlorophyll-a, and Secchi disk data and provide a basis for evaluating their interrelationships and hence the trophic status of the lake."



Lake Water Quality Summary											
	Trophic Status	**Lake Grades**									
	2013	2013	2012	2011	2010	2009	2008	2007	2006	2005	2004
Total Phosphorus (mg/L)	Mesotrophic	A	A	B	A	A	A	A	A	A	A
Chlorophyll-*a* (ug/L)	Oligotrophic	A	A	A	A	A	A	A	A	A	A
Secchi disk (ft)	Mesotrophic	A	A	A	A	A	A	A	A	A	A
Overall	Mesotrophic	A	A	A-	A	A	A	A	A	A	A

Sylvan/Halfbreed Lake
Water Surface Elevation Statistics

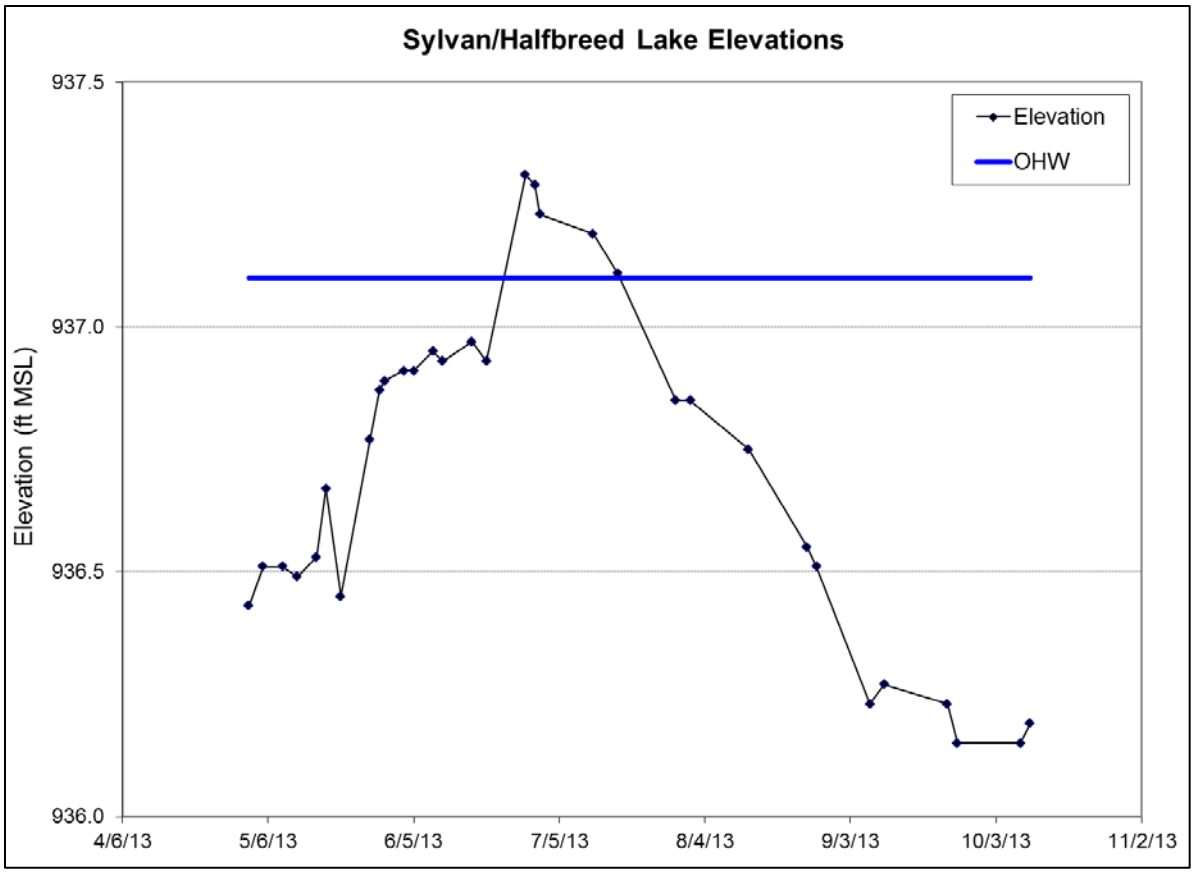
Outlet Elevation: N/A (landlocked)

Ordinary High Water Level (OHW) Elevation: 937.1 ft.

Highest Recorded Elevation: 938.00 ft. (07/03/2003)

Lowest Recorded Elevation: 934.52 ft. (11/22/1990)

Datum: NGVD 29 (ft.)



APPENDIX A

ABBREVIATIONS, ACRONYMS, AND SYMBOLS

BMP	Best Management Practice
CAMP	Citizen-Assisted Monitoring Program
cfs	cubic feet per second
cf	cubic feet
Chl-*a*	Chlorophyll-*a*
CLFLWD	Comfort Lake-Forest Lake Watershed District
Composite Sample	Multiple water samples collected at various flow points by automated device
DO	Dissolved Oxygen
EQuIS	Environmental Quality Information System
Grab Sample	Manually collected discrete water sample
E. coli	*Escherichia coli*
mg/L	milligrams per liter
MPCA	Minnesota Pollution Control Agency
MPN	Most Probable Number
OHW	Ordinary High Water level
TALU	Tiered Aquatic Life Uses
TKN	Total Kjeldahl Nitrogen
TP	Total Phosphorus
TSS	Total Suspended Solids
µg/L	micrograms per liter
VSS	Volatile Suspended Solids
WCD	Washington Conservation District