Assessment Report of Selected Lakes Within the Le Sueur River Watershed Minnesota River Basin

Minnesota Pollution Control Agency Water Monitoring Section Lakes and Streams Monitoring Unit

Minnesota Pollution Control Agency

June 2010

Authors

Kelly O'Hara

Geographical Information System Mapping

Kris Parson

Editing

Steve Heiskary
Dana Vanderbosch

Assessment Report of Selected Lakes
Within the Le Sueur River Watershed
Minnesota River Basin
Intensive Watershed Monitoring 2009

Minnesota Pollution Control Agency
Water Monitoring Section
Lakes and Streams Monitoring Unit

The MPCA is reducing printing and mailing costs by using the Internet to distribute reports and information to wider audience. Visit our Web site at: www.pca.state.mn.us/water/lakereport.html.

MPCA reports are printed on 100% post-consumer recycled content paper manufactured without chlorine or chlorine derivatives.

Minnesota Pollution Control Agency

520 Lafayette Road North | Saint Paul, MN 55155-4194 | www.pca.state.mn.us | 651-296-6300
Toll free 800-657-3864 | TTY 651-282-5332

This report is available in alternative formats upon request, and online at www.pca.state.mn.us

Document number: wq-ws3-07020011

Contents

List of Tables

List of Figures

Executive Summary

The Minnesota Pollution Control Agency (MPCA) conducts and supports lake monitoring for a variety of objectives. Staff within the MPCA's Lakes and Streams Monitoring Unit sample approximately 100 lakes per year, coordinate citizen volunteer monitoring through the Citizen Lake Monitoring Program, and manage Surface Water Assessment Grants given to local groups to monitor lake and stream water quality. Watershed-based monitoring emphasizes large lakes (500 acres or greater) whenever possible. All water quality data from these activities are compared to state water quality standards to determine if a given lake is fully supporting or not supporting standards set for recreational use (e.g., swimming, wading, etc.). Lakes not supporting aquatic recreational use are termed "impaired" and are placed on a list biennially. This list is formally termed the 303(d) list (referencing the section within the federal Clean Water Act that requires us to assess for condition); it is also commonly called the "Impaired Waters List". A lake placed on the Impaired Waters List is required to be intensively researched through a Total Maximum Daily Load (TMDL) study to determine the source and extent of the pollution problem. The study also requires the development of a restoration plan. For unimpaired waters, a protection plan will be developed following the assessment process. It should be noted that a great deal of lake monitoring is also carried out by various other MPCA staff and local groups who are undertaking TMDL studies or other, special projects.

This report details the assessment of lakes within the Le Sueur River Hydrologic Unit Code (HUC)-8 watershed. The Le Sueur River watershed is made up of eleven HUC-11 intensively monitored watersheds. A general description at the eight-digit HUC level is provided, followed by discussions for each 11-digit HUC that has one or more assessed lakes. A full list of the assessed lakes, including their morphometric characteristics, within the Le Sueur River watershed is located in Appendix A.

Many of the Le Sueur River watershed lakes possessing assessment level data were determined to be non-supporting of recreational use. Of the four lakes (Buffalo, Minnesota, Bass, and Rice) that have insufficient data to complete an assessment, only one (Bass Lake) indicates improving water conditions. Two lakes (St. Olaf and Reeds) within the watershed have been determined to be fully supporting of recreational use.

Intensive Watershed Monitoring Approach Introduction

MPCA conducts and supports lake monitoring for a variety of objectives. One of our key responsibilities per the federal Clean Water Act is to monitor and assess lakes in Minnesota to determine whether or not these lakes support their designated uses. This type of monitoring is commonly referred to as condition monitoring. While the MPCA conducts its own lake monitoring, local partners (SWCDs, watershed districts, etc.) and citizens play a critical role in helping us because their efforts greatly expand our overall capacity to conduct condition monitoring. To this end, the MPCA coordinates citizen volunteer monitoring through the Citizen Lake Monitoring Program (CLMP), and manages Surface Water Assessment Grants given to local groups to monitor lake water quality. All of the data from these activities are combined with our own lake monitoring data to assess the condition of Minnesota lakes. Lake condition monitoring activities are focused on assessing the recreational use-support of lakes and identifying trends over time. The MPCA also assesses lakes for aquatic consumption use-support, based on fish-tissue and water-column concentrations of toxic pollutants.

The primary organizing approach to MPCA's condition monitoring is the "major" watershed (eight-digit hydrologic unit code). There are 81 major watersheds in Minnesota, and the MPCA has established a schedule for intensively monitoring six-eight of them annually. With this strategy, the MPCA and its partners will cycle through all 81 watersheds every ten years. The MPCA began aligning its stream condition monitoring to this watershed approach in 2007. Lake monitoring was brought into this framework in 2009. The year 2017 will mark the final year of the first ten-year cycle. The watershed approach provides a unifying focus on the water resources within a watershed as the starting point for water quality assessment, planning, and results measures. By intensively monitoring lakes and streams within a given watershed at the same time, the lake and stream data can be considered together to provide a comprehensive picture of water quality status and a determination can be made regarding how best to proceed with development of restoration and protection strategies.

Even when pooling MPCA, local group and citizen resources, we are not able to monitor all lakes in Minnesota. The primary focus of MPCA monitoring is lakes $\geq$500 acres in size (“large lakes”). These resources typically have public access points, they generally provide the greatest aquatic recreational opportunity to Minnesota’s citizens, and these lakes collectively represent 72 percent of the total lake area (greater than ten acres) within Minnesota. Though our primary focus is on monitoring larger lakes, we are also committed to directly monitoring, or supporting the monitoring of, at least 25 percent of Minnesota’s lakes between 100-499 acres (“small lakes”). In most years, we monitor a mix of large and small lakes, and provide grant funding to local groups to monitor lakes that fall in the 10-499 acre range. Currently, we are fully meeting the “large” lake goal, and we are greatly exceeding the “small” lake monitoring goal.

MPCA lake monitoring activities were not yet in sync with the watershed approach in 2008; the year MPCA intensively monitored streams in the Le Sueur watershed to assess their condition. MPCA monitoring of large lakes within the Le Sueur watershed were concluded in 2009. This report will describe all available lake data collected within the past ten years by partner agencies, grantees, and citizen volunteers found in STORET for the Le Sueur watershed. Trophic status, thermal stratification, temporal trends, model-predicted phosphorus and assessment status is noted for all lakes with sufficient data. Further detail on concepts and terms in this report can be found in the Guide to Lake Protection and Management: (http://www.pca.state.mn.us/water/lakeprotection.html).

Lake monitoring methods

The MPCA collects water quality data for lakes from May through September for each of the applicable years. Data collected from June through September is used to assess the lake’s condition while May data is collected to observe lake conditions near the spring turn over and compare this with the remaining seasonal data. Lake surface samples were collected with an integrated sampler, a polyvinyl chloride (PVC) tube two meters (6.6 feet) in length with an inside diameter of 3.2 centimeters (1.24 inches). Depth total phosphorous (TP) samples were collected with a Kemmerer sampler. A summary of data follows (Appendix C).

For lakes sampled by the MPCA, sampling procedures were employed as described in the MPCA Standard Operating Procedure for Lake Water Quality document, which can be found at: http://www.pca.state.mn.us/publications/wq-s1-16.pdf. Samples collected by the MPCA were sent to the Minnesota Department of Health using Environmental Protection Agency-approved methods for laboratory analysis. Samples were analyzed for nutrients, color, solids, pH, alkalinity, conductivity, and chlorophyll-*a* (chl-*a*). Temperature and dissolved oxygen (DO) profiles and Secchi disk transparency measurements were also taken. Historical DO and temperature profiles were used for water column analysis in the absence of more recent data.

Lake mixing

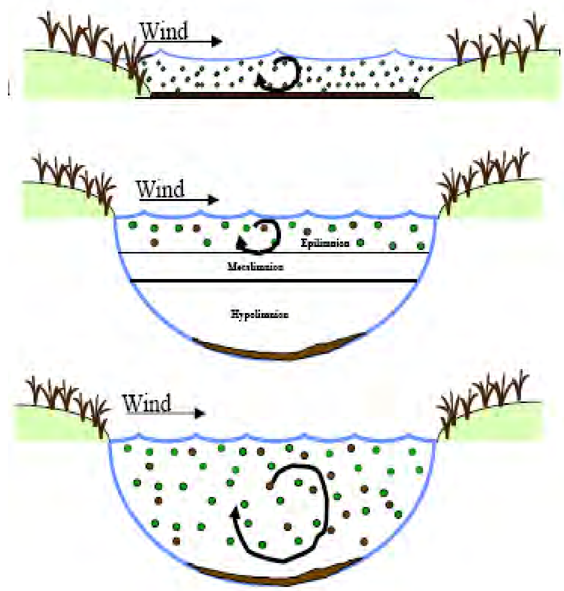
Lake depth and mixing has a significant influence on lake processes and water quality. *Thermal stratification* (formation of distinct temperature layers), in which deep lakes (maximum depths of nine meters or more) often stratify (form layers) during the summer months and are referred to as *dimictic* (Figure 3). These lakes fully mix or turn over twice per year; typically in spring and fall. Shallow lakes (maximum depths of five meters or less) in contrast, typically do not stratify and are often referred to as *polymictic*. Lakes, with moderate depths, may stratify intermittently during calm periods, but mix during heavy winds and during spring and fall. Measurement of temperature throughout the water column (surface to bottom) at selected intervals (e.g. every meter) can be used to determine whether the lake is well-mixed or stratified. The depth of the thermocline (zone of maximum change in temperature over the depth interval) can also be determined. In general, dimictic lakes have an upper, well-mixed layer (epilimnion) that is warm and has high oxygen concentrations. In contrast, the lower layer (hypolimnion) is much cooler and often has little or no oxygen. This low oxygen environments in the hypolimnion are conducive to TP being released from the lake sediments. During stratification, dense colder hypolimnion waters are separated from the nutrient hungry algae in the epilimnion. Intermittently (weakly) stratified polymictic lakes are mixed in high winds and during spring and fall. Mixing events allow the nutrient rich sediments to be re-suspended and are available to algae.

Figure 1: Lake stratification

Polymictic Lake
Shallow, no layers,
Mixes continuously
Spring, Summer & Fall

Dimictic Lake
Deep, form layers,
Mixes Spring/Fall

Intermittently Stratified
Moderately deep
Mixes during high winds
Spring, Summer, & Fall



Modeling

Numerous complex mathematical models are available for estimating nutrient and water budgets for lakes. These models can be used to relate the flow of water and nutrients from a lake's watershed to observed conditions in the lake. Alternatively, they may be used for estimating changes in the quality of the lake as a result of altering nutrient inputs to the lake (e.g., changing land uses in the watershed) or altering the flow or amount of water that enters the lake. To analyze the most recent water quality of lakes within the Le Sueur River watershed, the Minnesota Lake Eutrophication Analysis Procedures (MINLEAP) model (Wilson and Walker, 1989) was used. MINLEAP was developed by MPCA staff based on an analysis of data collected from the ecoregion reference lakes. It is intended to be used as a screening tool for estimating lake conditions with minimal input data and is described in detail in Wilson and Walker (1989). For the analysis of lakes within the Le Sueur River watershed, MINLEAP was applied as a basis for comparing the observed TP, chl-*a*, and Secchi values with those predicted by the model based on the lake depth and size and the size of the watershed. Individual results for each of the assessed lakes will be discussed in the lake summary portion of the HUC-11 watershed sections within this report. Complete MINLEAP results can be found in Appendix B.

303 (d) Assessment

The federal Clean Water Act requires states to adopt water quality standards to protect waters from pollution. These standards define how much of a pollutant can be in the water and still allow it to meet designated uses, such as drinking water, fishing and swimming. The standards are set on a wide range of pollutants, including bacteria, nutrients, turbidity and mercury. A water body is "impaired" if it fails to meet one or more water quality standards.

Under Section 303(d) Impaired Waters List of the Clean Water Act, the state is required to asses all waters of the state to determine if they meet water quality standards. Waters that do not meet standards are added to the 303(d) Impaired Waters List and updated every even-numbered year. If a water resource is listed, an investigative study termed a Total Maximum Daily Load (TMDL) is conducted to determine the sources and magnitude of the pollution problem, and to set pollutant reduction goals needed to restore the waters. The MPCA is responsible for monitoring surface waters, assessing condition of lakes and streams, creating the 303(d) Impaired Waters List, and conducting or overseeing TMDL studies in Minnesota.

TP, chl-*a*, and Secchi transparency standards are used to determine the recreational suitability of Minnesota lakes. Table 1 lists the assessment criteria used for lakes based on ecoregional expectations. Values for the North Central Hardwood Forests (NCHF) and Western Corn Belt Plains (WCBP) and NGP ecoregions were used for assessing lakes within the Le Sueur River HUC-8 watershed. Individual assessment results for each of the lakes will be discussed in the lake summary portion of the HUC-11 watershed sections within this report.

Table 1: Minnesota lake eutrophication standards by ecoregion and lake type (Heiskary and Wilson, 2005) and 2010 303(d) assessment values.

Ecoregion	TP	Chl-*a*	Secchi
	ppb	ppb	meters
NLF – Lake trout (Class 2A)	< 12	< 3	> 4.8
NLF – Stream trout (Class 2A)	< 20	< 6	> 2.5
NLF – Aquatic Rec. Use (Class 2B)	< 30	< 9	> 2.0
NCHF – Stream trout (Class 2a)	< 20	< 6	> 2.5
NCHF – Aquatic Rec. Use (Class 2b)	< 40	< 14	> 1.4
NCHF – Aquatic Rec. Use (Class 2b) Shallow lakes	< 60	< 20	> 1.0
WCBP & NGP – Aquatic Rec. Use (Class 2B)	< 65	< 22	> 0.9
WCBP & NGP – Aquatic Rec. Use (Class 2b) Shallow lakes	< 90	< 30	> 0.7

Background

The major watersheds in Minnesota are classified with the 8-digit HUC system. This is a standardized watershed classification system developed by United States Geological Survey (USGS) in the mid 1970s. Hydrologic units are watershed boundaries organized in a nested hierarchy by size. An eight-digit code uniquely identifies each of the four levels of classification within four two-digit fields. The first two digits identify the water-resources region; the first four digits identify the sub-region; the first six digits identify the accounting unit, and the addition of two more digits for the cataloging unit completes the eight-digit code (Seaber, P.R., Kapinos, F.P., and Knapp, G.L., 1987).

HUC-8 watershed characteristics

The Le Sueur River watershed covers a 287,176 hectare (710,832 acre) area in south central Minnesota within the Minnesota River Basin. A majority of the watershed lies within the WCBP ecoregion with a small portion residing in the NCHF ecoregion (Figure 2). The watershed drains to the northwest into the Blue Earth River (and sub-sequentially into the Minnesota River) via the Le Sueur River approximately two miles southwest of Mankato MN. Agriculture accounts for the majority of land use activities within the watershed (Table 3). Watershed areas were estimated based on data from the University of Minnesota Remote and Geospatial Analysis Lab.

The Le Sueur River watershed is comprised of eleven 11 digit HUC minor watersheds (Figure 3). Six of these HUC-11 watersheds have lakes that have sufficient monitoring data to allow assessment. A majority of the soil types within the watershed are medium- to fine-textured prairie and prairie border soils of south-central Minnesota. Erosion control is commonly a problem as well as drainage. The landscape is a level to gently rolling area (Arneman 1963).

A summary of the morphometric characteristics of the lakes with enough data to allow for assessment within the Le Sueur River watershed is presented in Table 2. Of the 49 total lakes (> 10 acres) within the HUC-8 watershed, only 22 percent have been monitored (Table 4 and Figure 3). Percent littoral area refers to that portion of the lake that is 4.5 meters (15 feet) or less in depth, which often represents the depth to which rooted plants may grow in the lake. Lakes with a high percentage of littoral area often have extensive rooted plant (macrophyte) beds. These plant beds are a natural part of the ecology of these lakes and are important to protect.

Table 2: Monitored lakes within the Le Sueur River Watershed

Lake ID	Lake Name	County	Ecoregion	Area	Max Depth	Mean Depth	Littoral Area	Watershed Area
				Hectares	Meters	Meters	%	Hectares
07-0044	Madison	Blue Earth	NCHF	561	18	3.4	65	4,509
07-0060	Eagle (North)	Blue Earth	NCHF	290	3	2.1	100	3,812
07-0079	Lura	Blue Earth	WCBP	523	2.7	1.5	100	1,073
22-0033	Minnesota	Faribault	WCBP	773	1.5	0.5	100	2,332
22-0074	Bass	Faribault	WCBP	80	6	3	84	197
22-0075	Rice	Faribault	WCBP	395	1.5	0.7	100	5,973
24-0044	Freeborn	Freeborn	WCBP	808	0.9	0.9	100	3,097
81-0003	St. Olaf	Waseca	WCBP	36	10	4.4	60	6,740
81-0055	Reeds	Waseca	NCHF	79	17	4.5	59	216
81-0083	Buffalo	Waseca	WCBP	352	1.5	-	100	1,617
81-0095	Elysian	Waseca	NCHF	900	3	1.8	100	11,696

Table 3: Le Sueur River HUC-11 overall land use comparison for the North Central Hardwood Forest and Western Corn Belt Plains ecoregions

Land Use (%)	Le Sueur River WS[1]	NCHF ecoregion	WCBP ecoregion
Developed	7	2-9	0-16
Cultivated (Ag)	83	22-50	42-75
Pasture & Open	4	11-25	0-7
Forest	1	6-25	0-15
Water & Wetland	5	14-30	3-26

[1]National Land Cover Database www.mrlc.gov/index.php

Figure 2: Minnesota's EPA mapped ecoregions and Le Sueur River watershed location

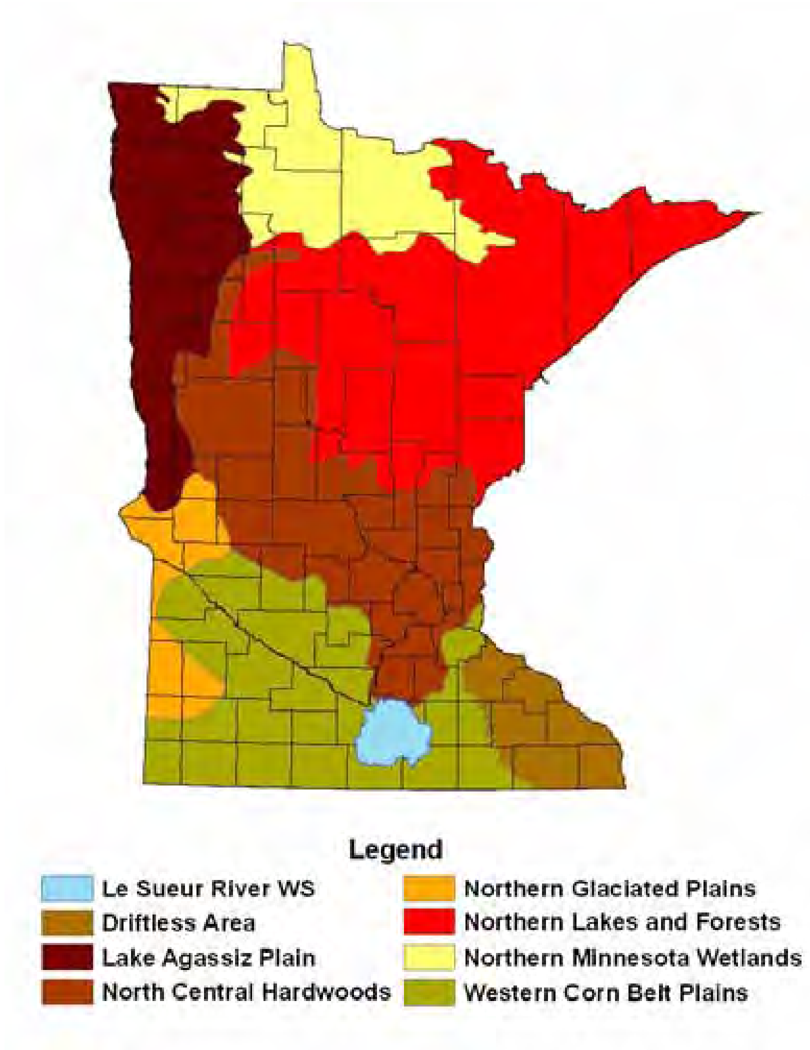
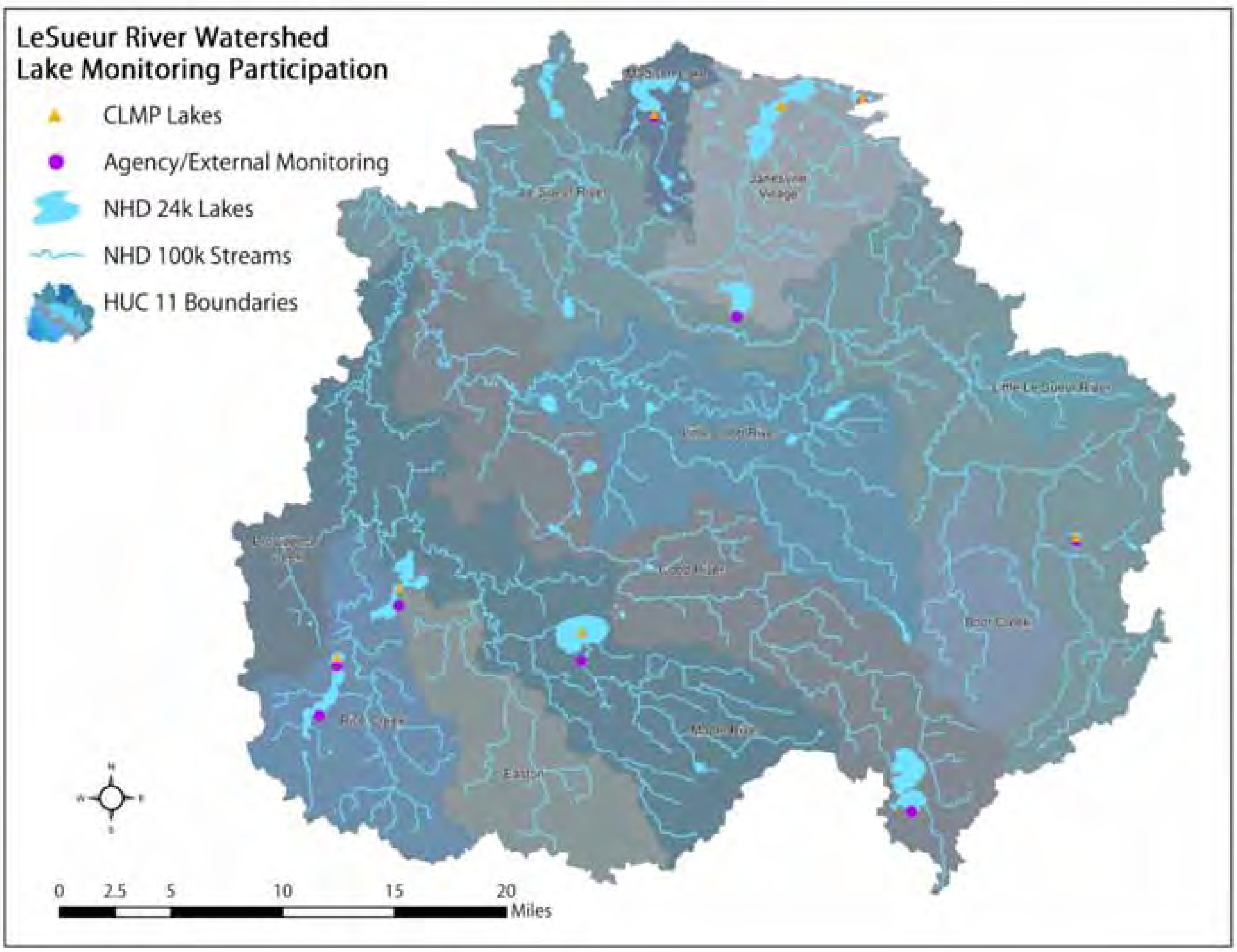


Table 4: Le Sueur River HUC-11 watershed units

HUC-11 Units	Area (Acres)	Percent of HUC-8	Number of monitored lakes
Providence Creek	17,336	2	-
Rice Creek	52,149	7	3
Easton	43,703	6	-
Maple River	105,554	15	1
Cobb River	114,306	16	1
Boot Creek	32,015	5	-
Little Cobb River	84,543	12	-
Le Sueur River	179,164	25	2
Little Le Sueur River	15,508	2	-
Janesville Village	54,352	8	3
Madison Lake	12,202	2	1

Figure 3: Le Sueur River HUC-11 watershed boundaries, surface water and monitoring coverage



Climatic Conditions

Rain gauge records from the watershed's drainage point near Mankato, as well as Wells, Waseca, and Amboy, indicate dry conditions throughout the watershed in water year 2009 (October 2008 through September 2009). The average precipitation (based on rain gauge data collected from May through September) from the four locations was 11.2 inches. This was about six-ten inches below normal (Figure 5) for 2009. Major rain events increase runoff throughout the watershed and may influence in-lake water quality and lake levels. While overall precipitation was below normal, there were several major rain events in 2009 (Figure 4) and these will be referred to later in the report as they pertain to individual lakes.

Figure 4: Summer 2009 rainfall based on records from various stations throughout the Le Sueur River Watershed

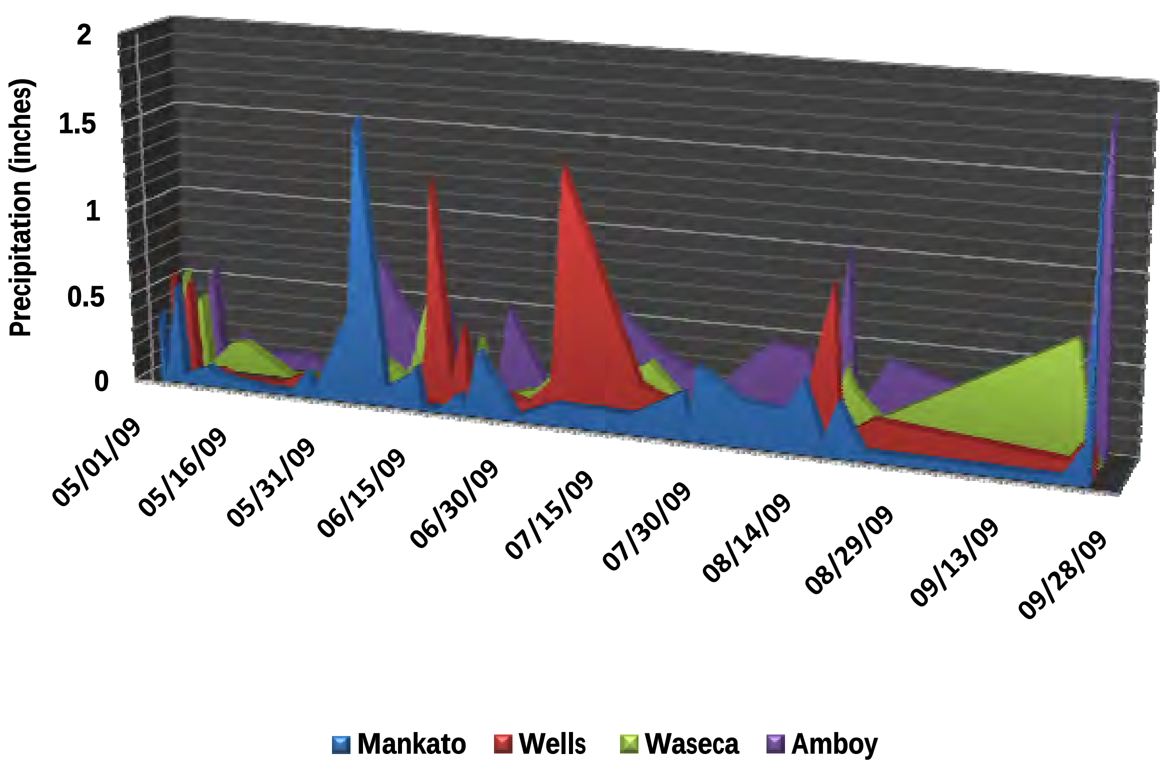
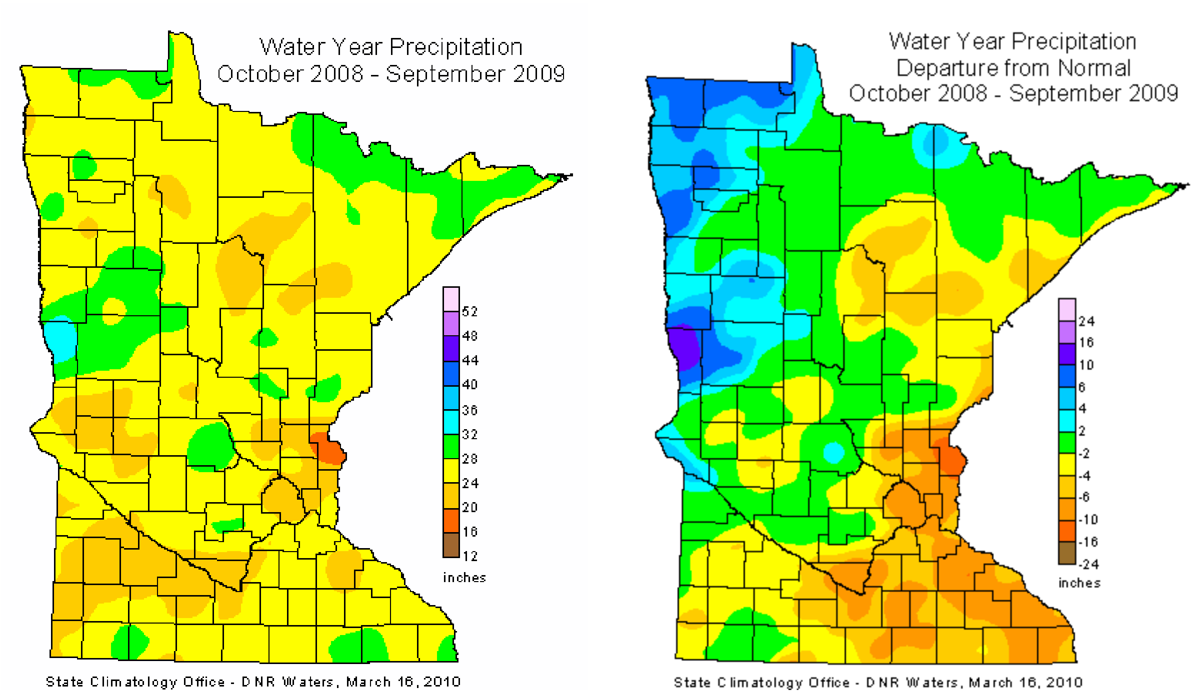


Figure 5: 2009 Minnesota water year precipitation and departure from normal

Prepared by State Climatology Office DNR Waters

Values are in inches



HUC-11 Lake Assessment

The Le Sueur River HUC-8 watershed is comprised of eleven HUC-11 watershed units (Figure 3 & Table 4). Each individual watershed has had varying amounts of surface water monitoring. Lake assessment results are presented for the HUC-11 watershed units within the Le Sueur River watershed where monitoring was conducted. This scale provides a robust assessment of water quality condition in the watershed unit and is a practical size for the development, management, and implementation of effective TMDLs and protection strategies.

Feedlot and permitted discharge sites were mapped to assist with the determination of the land use characteristics within each of the HUC-11 watersheds. Additional information regarding the permitting of feedlots and discharge sites can be found at: http://www.pca.state.mn.us/index.php/regulations/permits-and-rules/permits-and-the-permitting-process.html

Cobb River HUC-11 Watershed

The Cobb River (07020011070) HUC-11 watershed lies roughly within the center of the Le Sueur River watershed. This 46,179 hectare (114,306 acre) watershed represents 16 percent of the Le Sueur River watershed (Figure 3 & Table 4). Cropland is the major land use within this area (Figure 7) and only one lake (Freeborn) has been assessed (Table 5). The Cobb River pours into the Le Sueur River 3.5 miles south of Mankato, MN. Based on 2003 National Pollutant Discharge Elimination System (NPDES)/State Disposal System (SDS) registered feedlot data, there are ten permitted discharge sites and 142 registered feedlots throughout the Cobb River watershed (Figure 6).

Table 5: Assessed lakes within the Cobb River HUC-11 watershed

Lake ID	Lake Name	COUNTY	Lake Area	Max Depth	Mean Depth
			Acres	Meters	Meters
24-0044	Freeborn	Freeborn	2001	2.1	0.9

Figure 6: Cobb River flow network and permitted discharge locations

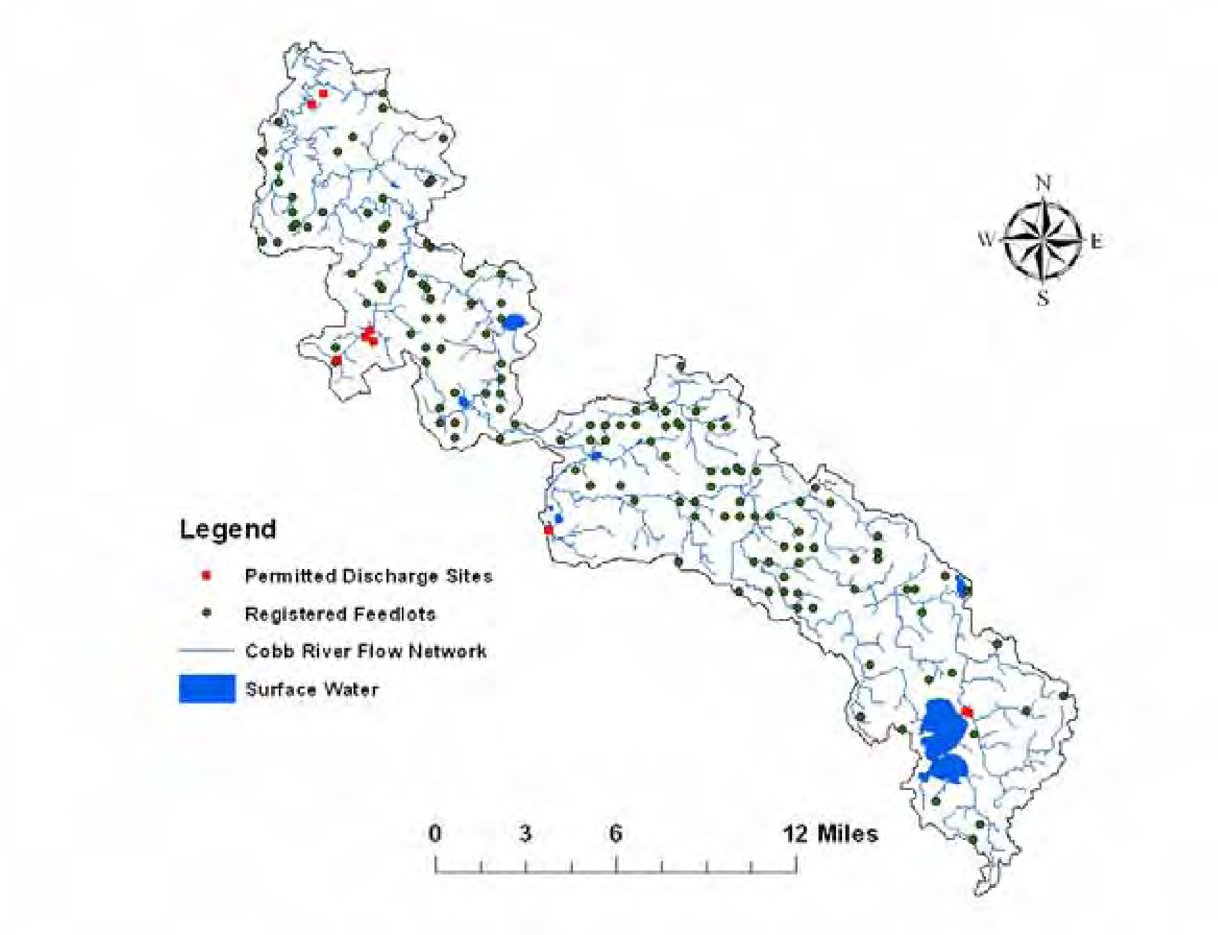
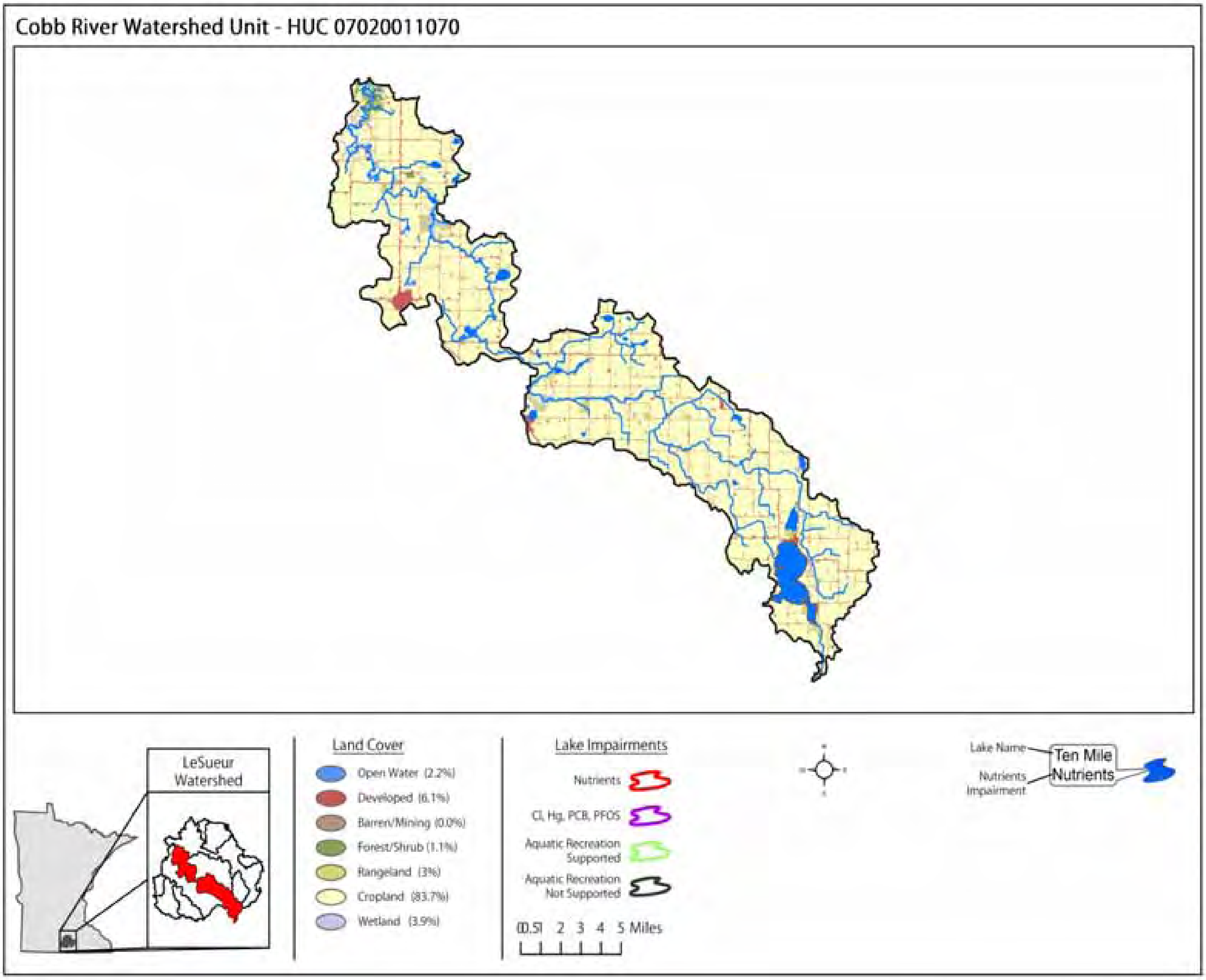


Figure 7: Cobb River HUC-11 watershed land use characteristics and lake impairments



Freeborn Lake

Freeborn Lake is a large, shallow polymictic lake located approximately seven miles northwest of Albert Lea, Minnesota. The town of Freeborn lies on the northern shore. The lake currently sees limited recreational use and has low water clarity and minimal aquatic vegetation. Freeborn Lake's watershed is small relative to its surface area with a watershed to lake ratio of 4:1. Land use is dominated by cultivated agricultural use that is typical for the WCBP ecoregion (Table 7 & Figure 8). Additionally, the lake itself makes up a larger portion of the watershed as indicated by the high percentage of open water land use.

Freeborn Lake was sampled for chemistry from May through September of 2008 and 2009. The average TP for Freeborn Lake from both 2008 and 2009 data was 325 micrograms per liter (µg/L) (Table 6). This is well above the assessment criteria for shallow lakes within the WCBP ecoregion. TP in Freeborn Lake spiked in June at 489 µg/L and steadily declined throughout the summer to its lowest level of 228 µg/L in September (Figure 10).

The average chl-*a* for Freeborn Lake over the two-year period was 120 µg/L (Table 6). This was also well above the assessment criteria for the WCBP ecoregion. Chl-*a* levels spiked in August at 179 µg/L and were at their lowest in the spring (Figure 10). As a result of the high levels of TP and chl-*a*, as well as exceedingly high total suspended inorganic solids, the water clarity of Freeborn Lake is below the range expected for its ecoregion, with an average of just 0.2 meters (0.7 feet).

The lake was well-mixed throughout the 2009 monitoring season, which is to be expected for large, shallow lakes. Water temperature remained nearly constant from the surface to the bottom of the lake. DO remained above five milligrams per liter (mg/L) throughout the entire year with the lowest levels appearing in September at approximately seven mg/L (Figure 9).

Based on the trophic status data, Freeborn Lake was classified as hypereutrophic. Additionally, based on the TP and chl-*a* assessment standards, Freeborn Lake was determined to be non-supporting of aquatic recreational use and will be listed as impaired under the 2012 303(d) Impaired Waters List.

A MINLEAP model was utilized for Freeborn Lake as a basis for comparing the observed (2009) TP, chl-*a*, and Secchi values with those predicted by the model based on the lake depth and size and the size of the watershed. The observed TP for Freeborn Lake was significantly higher than the predicted value. This simply means that the observed TP was much higher than what was predicted for a lake of its size, depth, and watershed area in the WCBP ecoregion. The model predicted TP loading at 2,537 kilograms per year (kg/yr). This result is likely lower than the actual loading rate since the observed TP was higher than predicted. The areal water load to the lake was estimated at 0.6 meters per year (m/yr) and estimated water residence time is approximately 1.6 years. The complete modeling results can be found in Appendix B.

Table 6: Freeborn Lake total phosphorous, chlorophyll-*a*, and Secchi averages compared to Western Corn Belt Plain assessment standards

Ecoregion	TP	Chl-*a*	Secchi
	ug/L	ug/L	meters
WCBP & NGP – Aquatic Rec. Use (Class 2B)	< 65	< 22	> 0.9
WCBP & NGP – Aquatic Rec. Use (Class 2b) Shallow lakes	< 90	< 30	> 0.7
Freeborn Lake 2008 & 2009	325	120	0.2

Table 7: Freeborn Lake watershed land use

Land use	Freeborn Lake land use percentage	WCBP typical land use percentage
Developed	6	0 – 16
Cropland	54	42 - 75
Rangeland	5	0 - 7
Forest/Shrub	< 1	0 - 15
Water & Wetland	35	3 – 26

Figure 8: Freeborn Lake watershed land use and monitoring site location

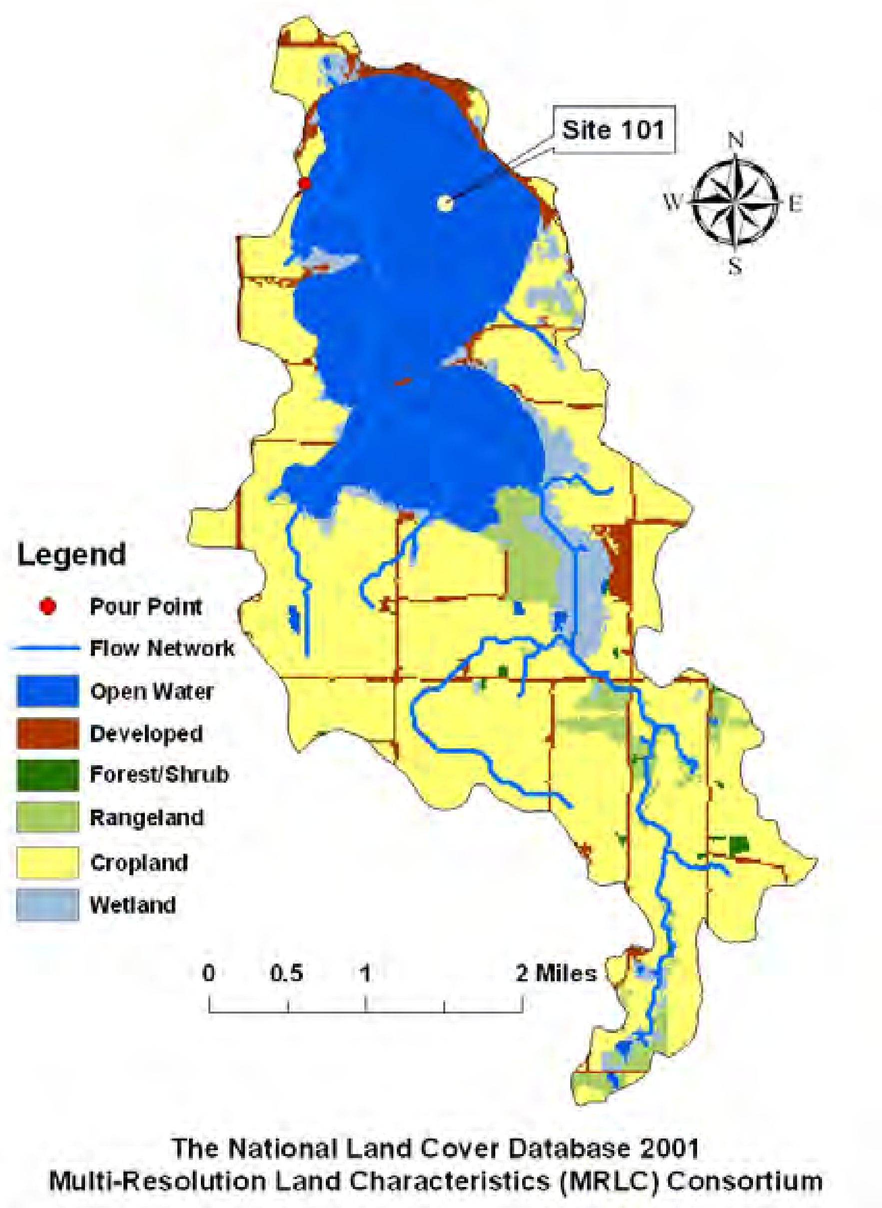
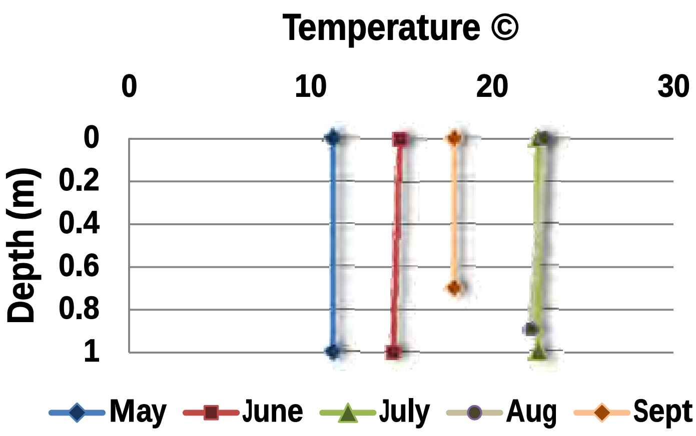


Figure 9: Freeborn Lake 2009 monthly temperature and dissolved oxygen profiles



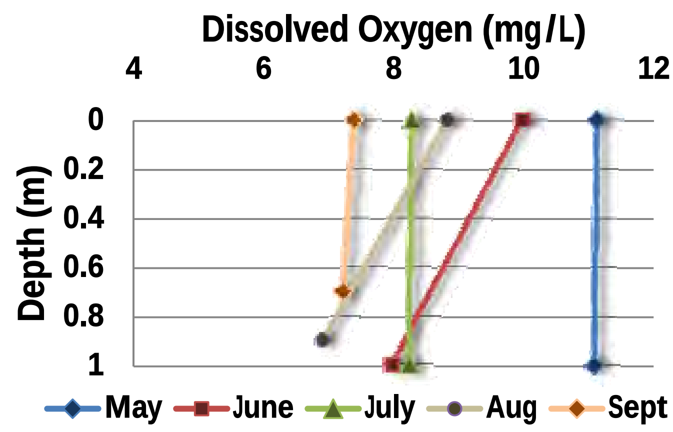
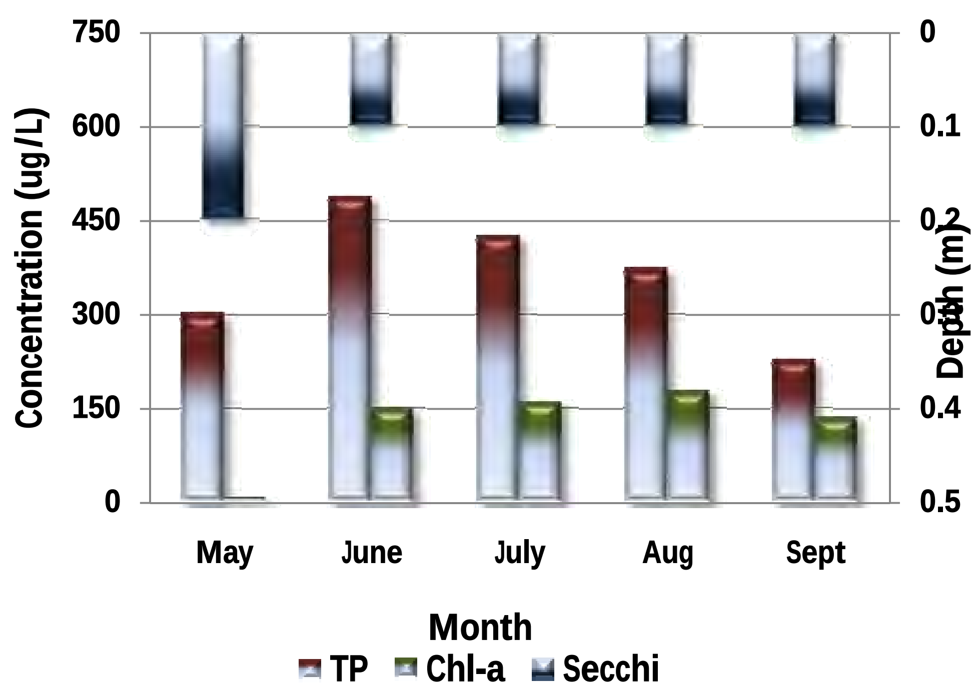


Figure 10: Freeborn Lake 2009 total phosphorous, chlorophyll-a, and Secchi values



Le Sueur HUC-11 Watershed

The Le Sueur River (07020011010) HUC-11 watershed lies in the northern half of the Le Sueur River watershed. This 72,382 hectare (179,164 acre) watershed represents 25 percent of the Le Sueur River HUC-8 watershed (Figure 3 & Table 4). Cropland is the major land use within this watershed (Figure 12). There are two lakes (Eagle Lake North and St. Olaf) that have been assessed (Table 8). The Le Sueur River HUC-11 watershed receives input from the Maple River, Cobb River, Boot Creek, Little Le Sueur River, and various county ditches. The Le Sueur River drains into the Blue Earth River two miles southwest of Mankato, MN. Based on 2003, NPDES/SDS registered feedlot data, there are 193 permitted discharge sites and 162 registered feedlots throughout the Le Sueur River HUC-11 watershed (Figure 11).

Table 8: Assessed lakes within the Le Sueur River HUC-11 watershed

Lake ID	Lake Name	COUNTY	Lake Area	Depth Max	Depth Mean
			Acres	Meters	Meters
07-0060	Eagle	Blue Earth	718	3	2.1
81-0003	St. Olaf	Waseca	89	9.1	4.4

Figure 11: Le Sueur River flow network and permitted discharge locations

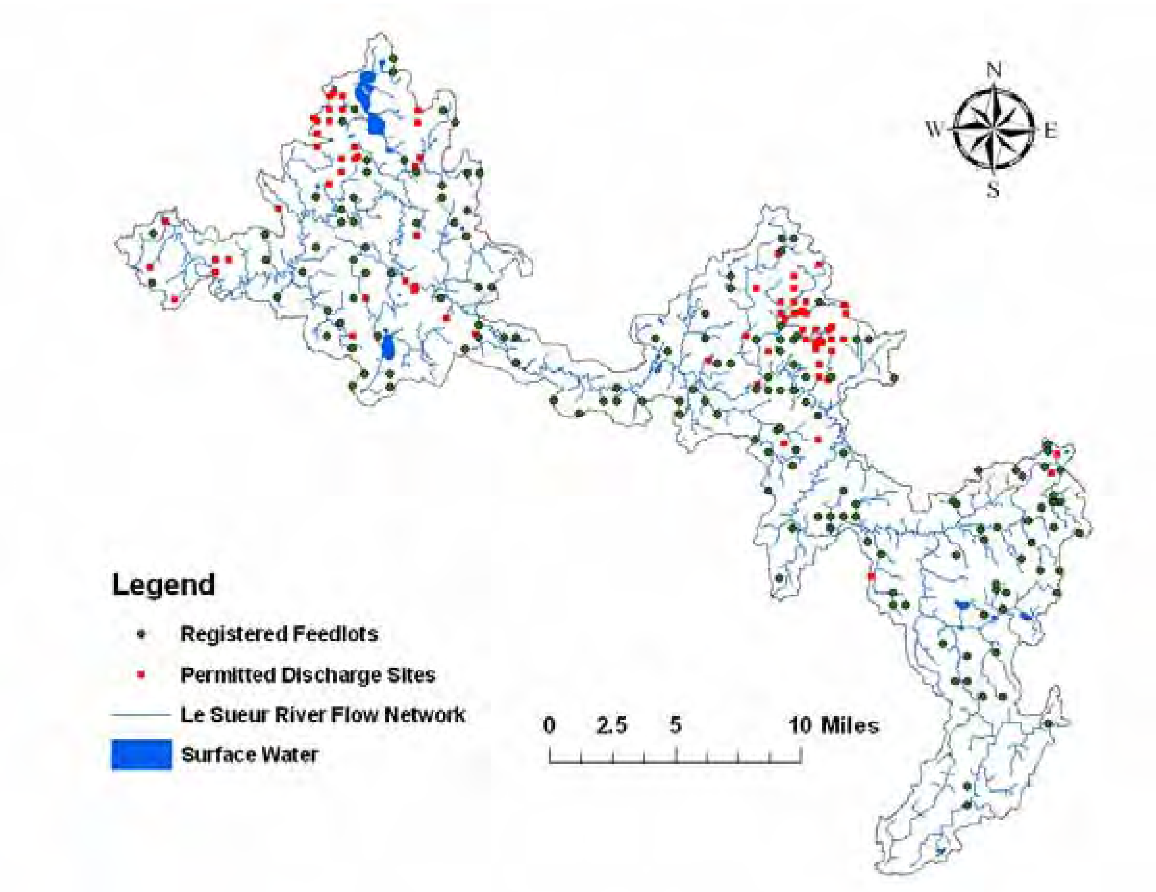
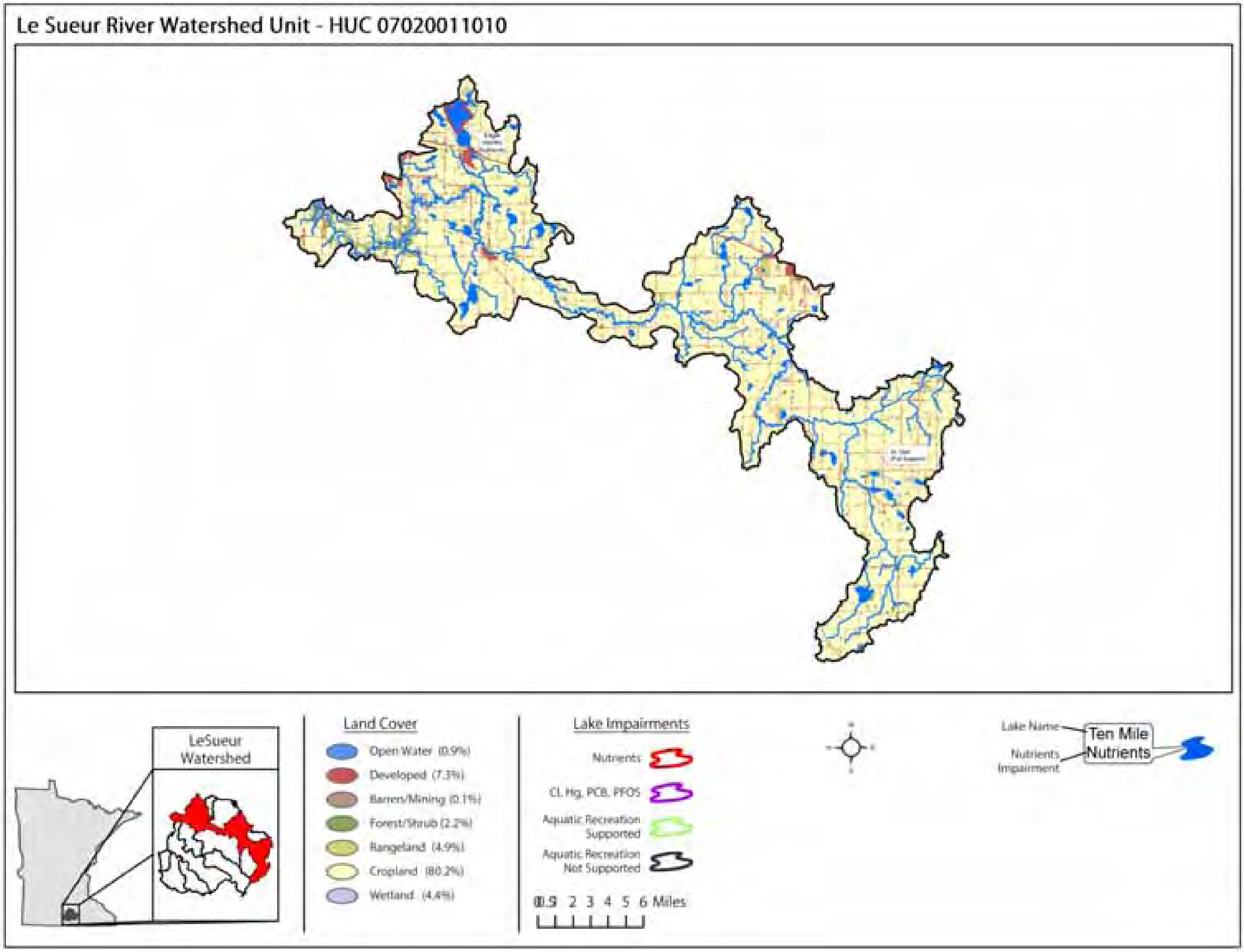


Figure 12: Le Sueur River HUC-11 watershed land use characteristics and lake impairments



Eagle Lake North

Eagle Lake North is the northern basin of Eagle Lake located approximately two miles east of Mankato, Minnesota. Eagle Lake North is a shallow lake that is 189 hectares (467 acres) and represents 65 percent of the whole of Eagle Lake. A public landing is on the northern shore within Eagle Lake County Park. Unlike a majority of the other lakes within the Le Sueur River HUC-8 watershed that are in the WCBP ecoregion, Eagle Lake is located within the NCHF ecoregion. Eagle Lake's watershed is moderate relative to its surface area with a watershed to lake-ratio of 20:1 (Figure 13). Eagle Lake was one of several lakes included in a study of shallow south-central Minnesota lakes and further information may be found in the report at: http://www.pca.state.mn.us/water/lakequality.html.

Land use within the Eagle Lake watershed is relatively typical of the NCHF ecoregion with the exception of a high percentage of open rangeland (Table 10 & Figure 13). In addition, the percentage of forested land is below normal. Given Eagle Lake's close proximity to the border of the NCHF and WCBP ecoregions, it is not uncommon for the watershed land use to be relatively similar to WCBP values.

Eagle Lake North was sampled for chemistry from May through September of 2006 and 2008. The average TP for Eagle Lake from both 2006 and 2008 data was 170 µg/L (Table 9). This is well above the assessment criteria for lakes within the NCHF or WCBP ecoregion. TP in Eagle Lake climbed throughout the season and spiked in August of 2008 at 198 µg/L before declining in September (Figure 18).

The average chl-*a* for Eagle Lake North over the two-year period was 76 µg/L (Table 9). This was also well above the assessment criteria for the NCHF. Chl-*a* levels spiked in August of 2008 at 84 µg/L and were at their lowest in the spring (Figure 16). As a result of the high levels of TP and chl-*a* as well as high total suspended inorganic solids the water clarity of Eagle Lake was well below the range of expected ecoregional values with an average of just 0.3 meters (one foot).

The lake was well-mixed throughout both monitoring seasons (Figure 15). This is typical for large, shallow lakes. Water temperature remained nearly constant from the surface to the bottom of the lake. DO remain above five mg/L throughout the entire year with the lowest levels appearing in July at just above five mg/L.

Based on the trophic status data, Eagle Lake was classified as hypereutrophic. Additionally, based on the TP and chl-*a* assessment standards, Eagle Lake North was determined to be non supporting of aquatic recreational use and was listed as impaired under the 2010 303(d) Impaired Waters List.

A MINLEAP model was utilized for Eagle Lake as a basis for comparing the observed (2008) TP, chl-*a*, and Secchi values with those predicted by the model based on the lake depth and size and the size of the watershed. Observed TP is significantly higher than predicted. This simply means that the observed TP is much higher than what is expected for a lake of its size, depth, and watershed area in the NCHF ecoregion. The model predicted TP loading at 790 kg/yr. This result is likely lower than the actual load rate given that observed TP is higher than predicted. The areal water load to the lake was estimated at 2.6 m/yr and estimated water residence time is approximately 0.8 years. The complete modeling results can be found in Appendix B.

St. Olaf Lake

St. Olaf Lake is located approximately three miles east of New Richland, Minnesota. St. Olaf Lake is a relatively small (36 hectares, 89 acres) with a maximum depth of 9.1 meters (30 feet). A public landing is on the northern shore within St. Olaf Lake County Park. St. Olaf Lake is located within the WCBP ecoregion. St. Olaf Lake's watershed is small relative to its surface area with a watershed to lake-ratio of 2:1 (Figure 14). Land use within the St. Olaf Lake watershed is typical of the WCBP ecoregion with a majority of the land devoted to agricultural cropland use (Table 10 & Figure 14).

Because of its relatively good water quality, St. Olaf was used as a WCBP ecoregion reference lake for in the 1980s (Heiskary and Wilson 2005). St. Olaf Lake is now part of a statewide study, Sustaining Lakes in a Changing Environment (SLICE), which looks at the effects of changing climate and land use on Minnesota lakes. Further monitoring on St. Olaf Lake is scheduled to continue.

St. Olaf Lake was sampled for chemistry from May through September of 2008 and 2009. The average TP for St. Olaf Lake from both 2008 and 2009 data was 37 µg/L (Table 9). This is below the assessment criteria for lakes within the WCBP ecoregion. TP in St. Olaf Lake peaked in May at 73 µg/L during spring turnover and steadily declined throughout the rest of the season (Figure 18).

The average chl-*a* for St. Olaf Lake over the two year period was 20 µg/L (Table 9). This was above the assessment criteria expected for lakes within the WCBP ecoregion. Chl-*a* levels spiked in May at 60 µg/L and were at their lowest in September (Figure 18). Coinciding with low TP and chl-*a*, as well as low total suspended inorganic solids, the water clarity of St. Olaf Lake was above the range of WCBP ecoregional values with an average of 1.5 meters (4.9 feet).

The lake was well-mixed during the spring turnover event with a distinct thermocline forming at approximately four meters from July through September of 2008 and 2009 (Figure 15). DO remained above five mg/L throughout the entire water column in the spring with levels dropping below five mg/L between four and five meters (~16.4 feet) from July through September. The highest level of oxygen consumption occurred in August with DO levels dropping below five mg/L between three and four meters (~13.1 feet).

Based off the chemical monitoring results and poor water clarity, St. Olaf Lake is classified as a eutrophic lake. Additionally, based on the TP, and, chl-*a*, and Secchi transparency assessment standards, St. Olaf Lake was determined to be fully supporting of aquatic recreational use and was not listed in the 2012 303(d) Impaired Waters List. This assessment may change since the chl-*a* average was just above the standard and additional monitoring is scheduled.

The MINLEAP model was utilized for St. Olaf Lake as a basis for comparing the observed (2009) TP, chl-*a*, and Secchi values with those predicted by the model based on the lake depth and size and the size of the watershed. The observed TP, chl-*a*, and Secchi values for St. Olaf Lake are very different from the predicted values. This simply means that the observed TP was much lower than what is expected for a lake of its size, depth, and watershed area in the WCBP ecoregion. The model predicted TP loading at 67 kg/yr. The areal water load to the lake was estimated at 0.3 m/yr and estimated water residence time is approximately 13.2 years. The complete modeling results can be found in Appendix B.

Table 9: Eagle Lake and St. Olaf Lake total phosphorous, chlorophyll-*a*, and Secchi averages compared to North Central Hardwood Forest & Western Corn belt Plains assessment standards

	TP	Chl-*a*	Secchi
	ug/L	ug/L	meters
NCHF – Aquatic Rec. Use (Class 2b)	< 40	< 14	> 1.4
NCHF – Aquatic Rec. Use (Class 2b) Shallow lakes	< 60	< 20	> 1.0
Eagle Lake North 2006 & 2008 Averages	170	76	0.3
WCBP & NGP – Aquatic Rec. Use (Class 2B)	< 65	< 22	> 0.9
WCBP & NGP – Aquatic Rec. Use (Class 2b) Shallow lakes	< 90	< 30	> 0.7
St. Olaf Lake 2008 & 2009 Averages	37	20	1.5

Table 10: Eagle Lake and St. Olaf Lake watershed land use

Land use	Eagle Lake land use percentage	NCHF typical land use percentage	St. Olaf Lake land use percentage	WCBP typical land use percentage
Developed	3	2 - 9	6	0 - 16
Cropland	37	22 - 50	85	42 - 75
Rangeland	41	11 - 25	4	0 - 7
Forest	3	6 -25	1	0 - 15
Water & Wetland	16	14 - 30	4	3 - 26

Figure 13: Eagle Lake watershed land use and monitoring site location

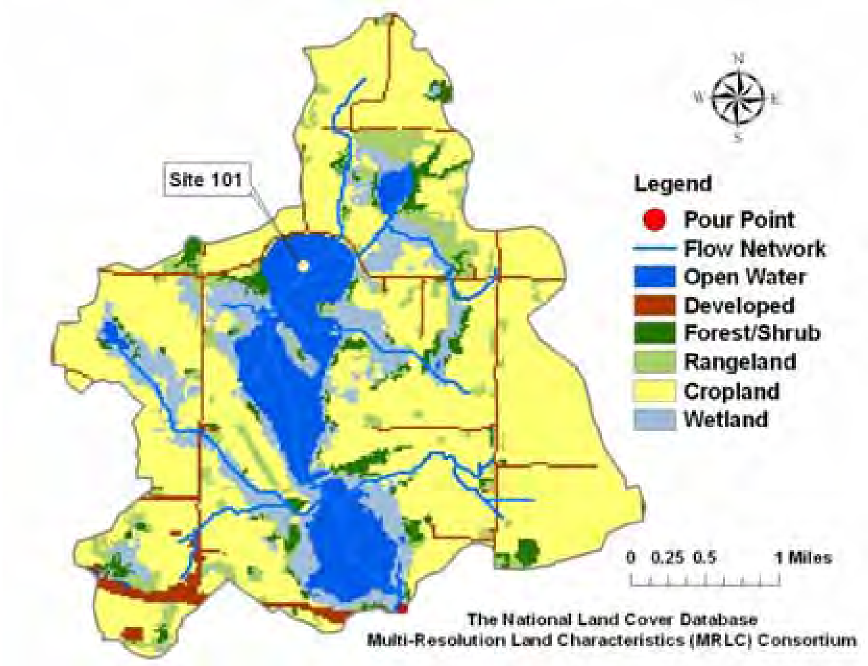


Figure 14: St. Olaf Lake watershed land use

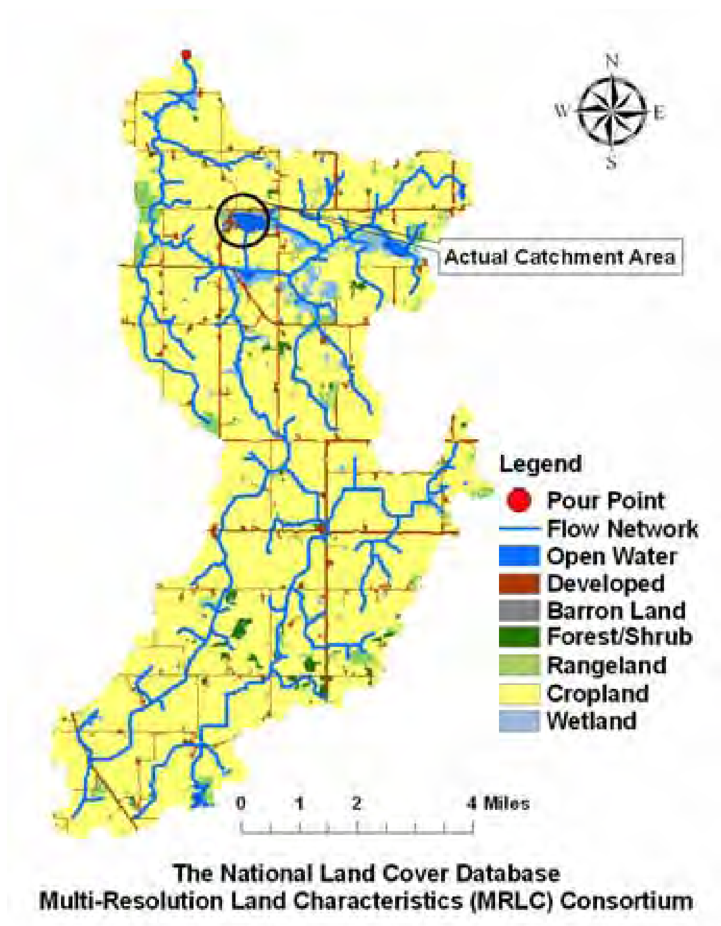


Figure 15: Eagle Lake 2009 monthly temperature and dissolved oxygen profiles

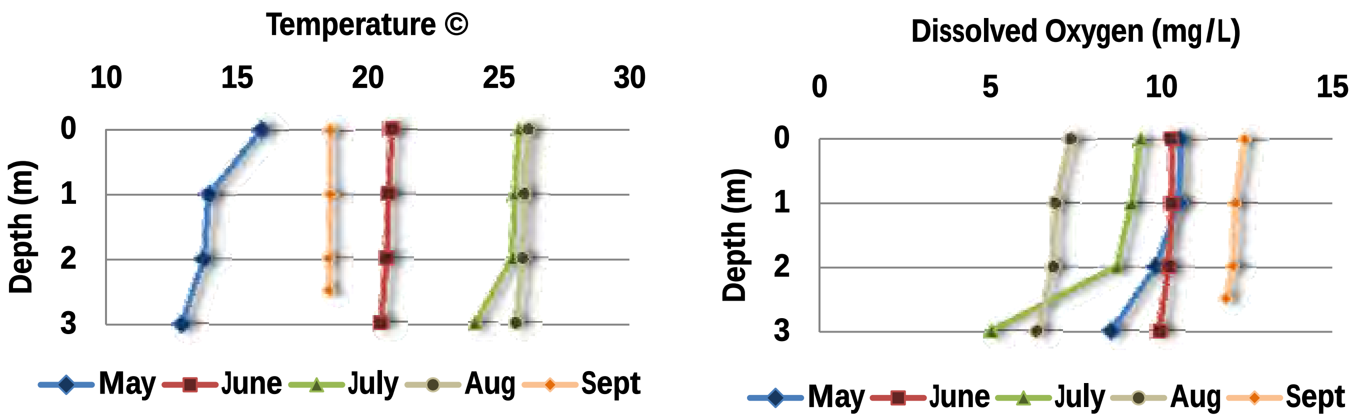


Figure 16: Eagle Lake 2009 total phosphorous, chlorophyll-*a*, and Secchi values

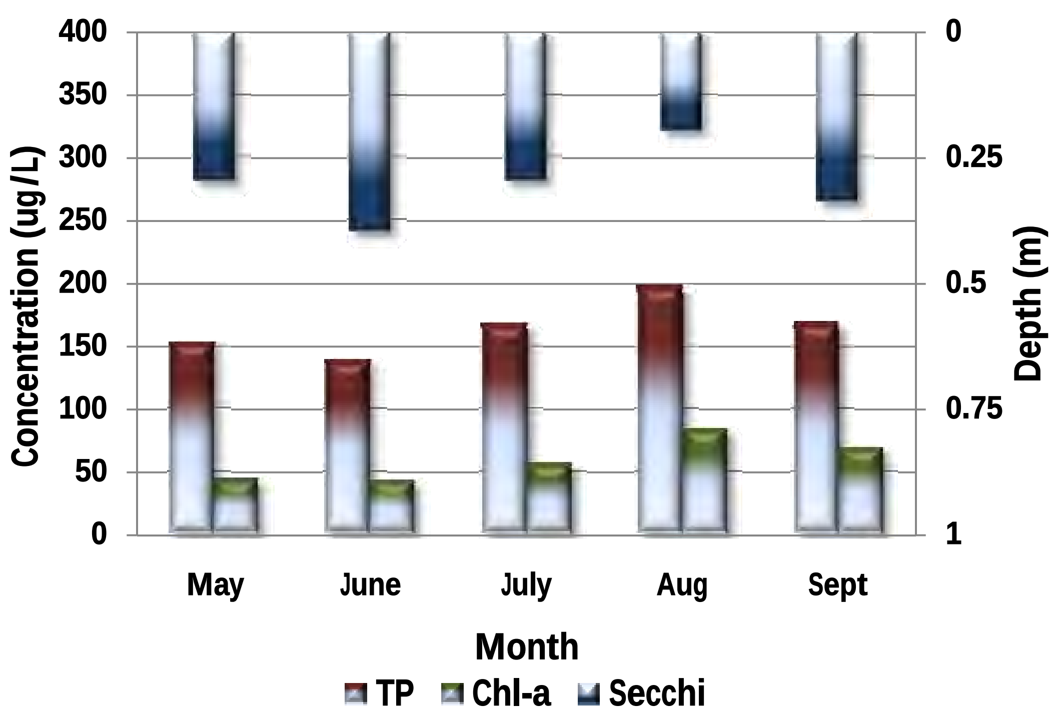


Figure 17: St. Olaf Lake 2009 monthly temperature and dissolved oxygen profiles

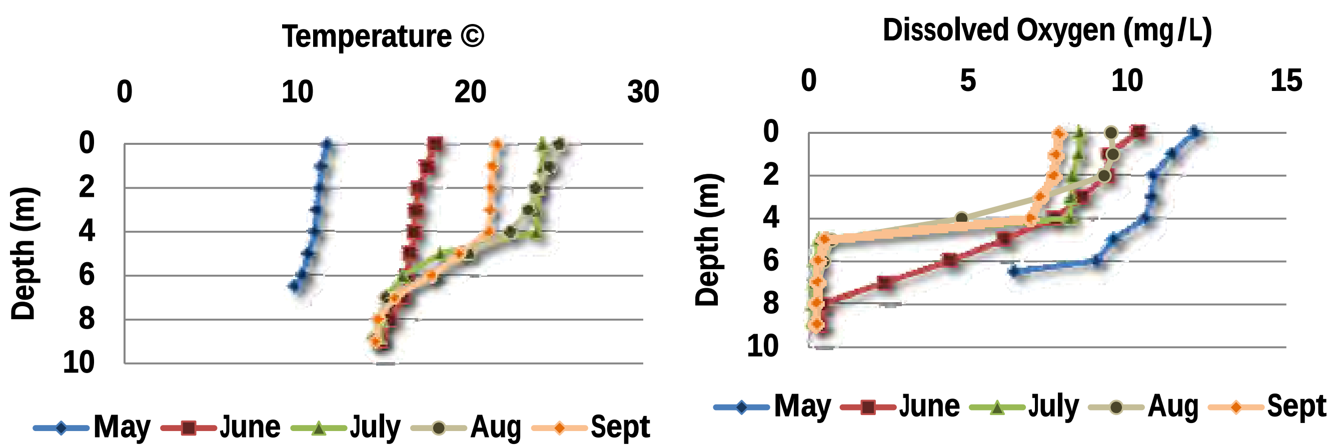
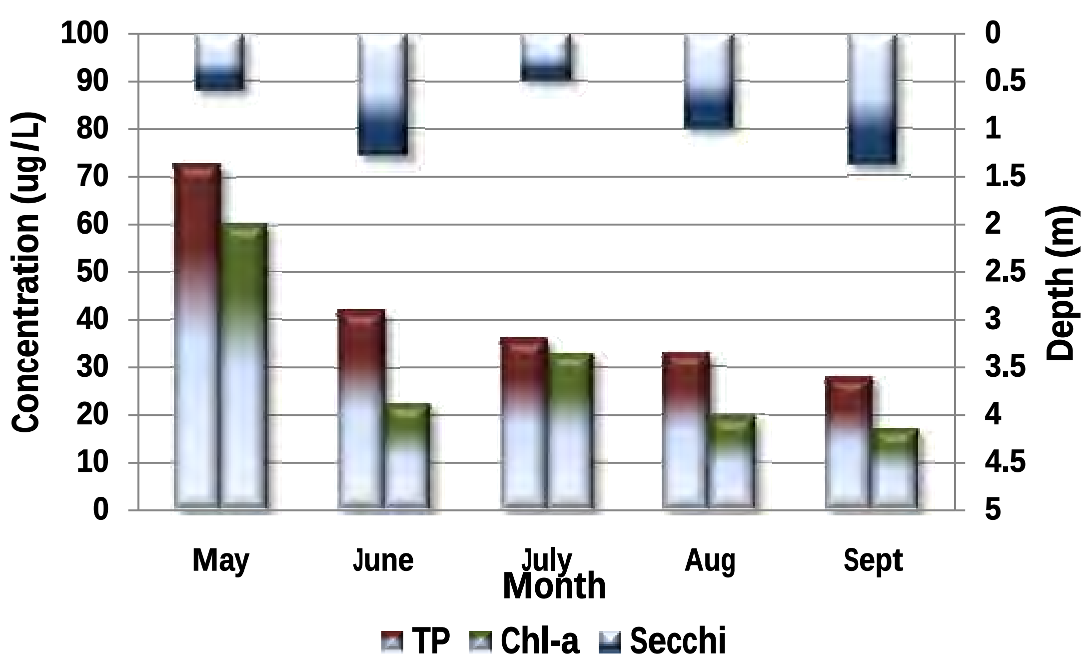


Figure 18: St. Olaf Lake 2009 total phosphorous, chlorophyll-a, and Secchi values



Jaynesville Village HUC-11 Watershed

The Jaynesville Village (07020011040) HUC-11 watershed lies along the northern boundary of the Le Sueur River watershed. This 21,958 hectare (54,352 acre) watershed represents eight percent of the Le Sueur River watershed (Figure 3 & Table 4). Cropland is the major land use within this area (Figure 20). Two lakes (Upper Elysian & Reeds) have been fully assessed and one (Lily) with remote sensing data. Buffalo Lake is currently in a drawdown for waterfowl management (Table 11) and thus has insufficient data to complete an assessment. The Jaynesville Village watershed drains into the Le Sueur River near St. Clair, MN through County Ditch No. 6. Based on 2003 National Pollutant Discharge Elimination System NPDES/SDS there are seven permitted discharge sites and 75 registered feedlots throughout the Jaynesville Village watershed (Figure 19).

Table 11: Lakes monitored or assessed within the Jaynesville Village HUC-11 watershed

Lake ID	Lake Name	County	Lake Area	Depth max	Depth Mean
			Acres	Meters	Meters
81-0083	Buffalo	Waseca	872	1.5	-
81-0095-01	Elysian (Upper - u/s dam)	Waseca	2,228	4	1.8
81-0055	Reeds	Waseca	195	17.1	4.5
81-0067	Lily	Waseca	111	7	-

Figure 19: Jaynesville Village flow network and permitted discharge locations

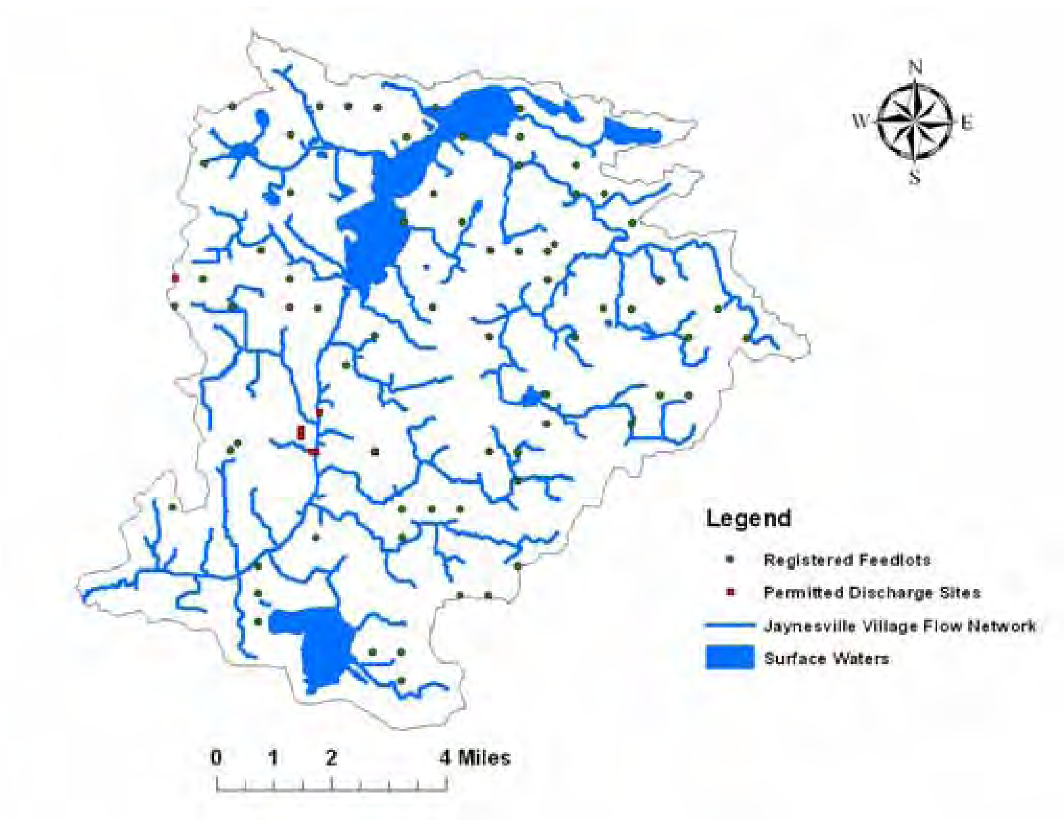
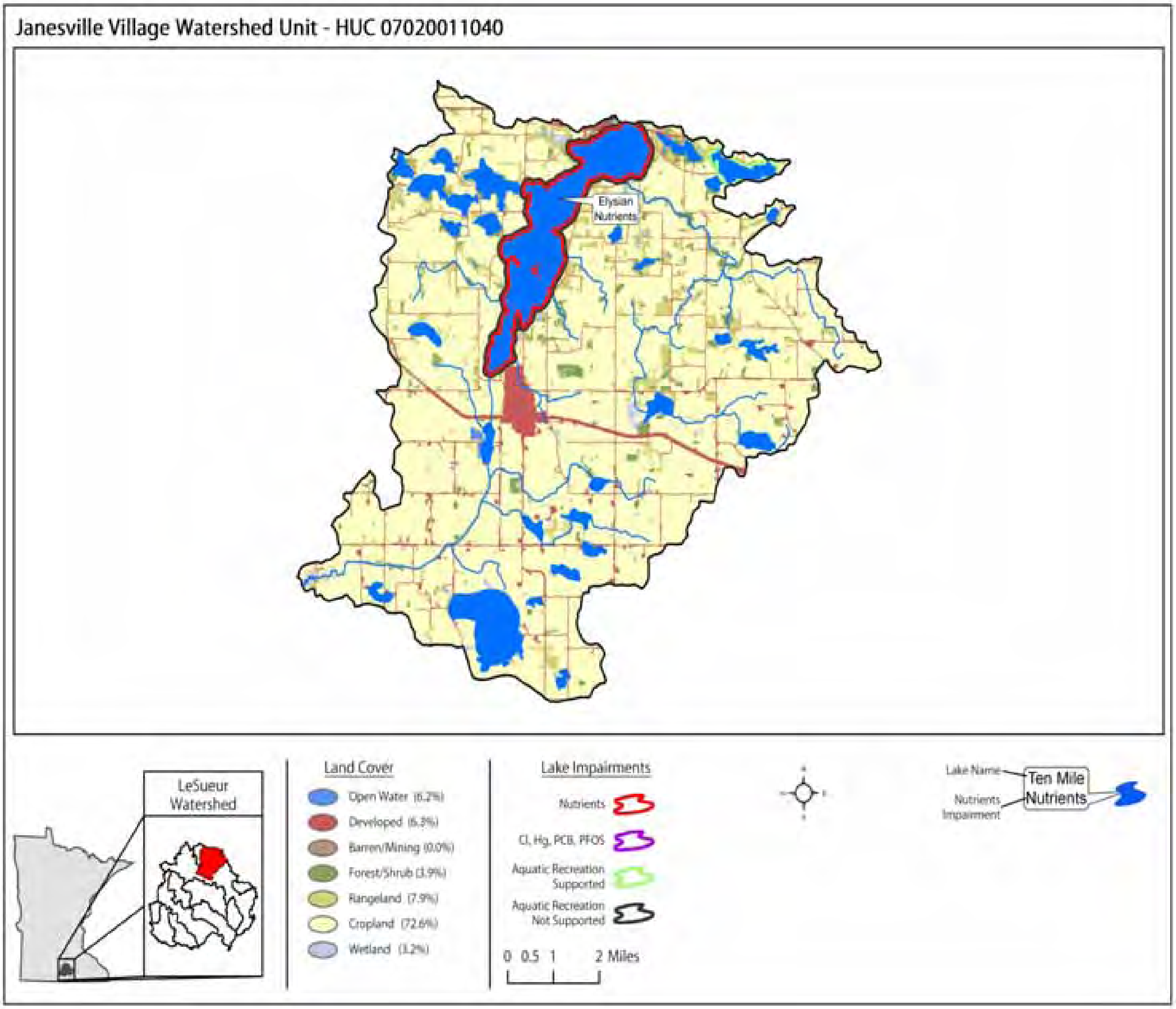


Figure 20: Jaynesville Village HUC-11 watershed land use characteristics and lake impairments



Upper Elysian Lake

Upper Elysian Lake is a large, shallow polymictic lake located approximately one mile north of Jaynesville, Minnesota. Upper Elysian Lake's watershed is moderate relative to its surface water area with an area of 11,696 hectares (28,951 acres) and a watershed to lake ratio of 13:1. Land use is dominated by cropland use with the percentage being closer to use found in the WCBP but exceeding the expected range for the NCHF (Table 13 & Figure 21). An MPCA Lake Assessment Program (LAP) report was completed for Upper Elysian Lake in 1998. Further information can be obtained at: http://www.pca.state.mn.us/index.php/water/water-types-and-programs/surface-water/lakes/lake-water-quality/lake-water-quality-assessment-reports.html.

Upper Elysian Lake was sampled for chemistry from May through September of 2006, 2007, and 2009. The average TP for Upper Elysian Lake from all the sampling years was 169 µg/L (Table 12). This is well above the assessment criteria for shallow lakes within the NCHF ecoregion. Over the course of the three sampling years, TP spiked in July of 2006 at 289 µg/L and was at its lowest in September of 2009 at 60 µg/L (Figure 24).

The average chl-*a* value for Upper Elysian Lake was 73 µg/L (Table 12). This was also well above the assessment criteria for the NCHF ecoregion. Chl-*a* levels spiked in May of 2007 at 187 µg/L and were at their lowest in June of 2007 at 8 µg/L (Figure 24). As a result of the high levels of TP and chl-*a*, as well as high total suspended inorganic solids (13 mg/L), the water clarity of Upper Elysian Lake is below the range of the assessment standard with an average of just 0.5 meters (1.6 feet).

Figure 24 illustrates the pattern of Upper Elysian Lakes water chemistry and transparency from the summer of 2009. TP concentrations were high during the spring, dropped in June, and increased over the summer peaking in August. The pattern of increasing TP from June through August in Upper Elysian Lake is consistent with other shallow lakes in Minnesota. When compared to historic profile data (Figure 23) the absence of a thermocline suggests that Upper Elysian Lake is subject to continuous mixing throughout the season resulting in nutrients being stirred up from the sediment and released into the lake water.

Minimal profile data exists however, when historic temperature and DO profiles, collected in 1998, are used as a reference the lake likely remains well-mixed throughout the season (Figure 24). Water temperature remained nearly constant from the surface to the bottom of the lake. DO remain above five mg/L through most of the year with hypoxic conditions developing at approximately two meters in July and August.

Based on the chemical monitoring results and poor water clarity, Upper Elysian Lake was classified as a hypereutrophic lake. Additionally, based on the TP and chl-*a* standards for the support of aquatic recreation, Upper Elysian Lake was determined to be non supporting of aquatic recreational use and was listed as an impaired water under the 2008 303(d) Impaired Waters List.

The MINLEAP model was utilized for Upper Elysian Lake as a basis for comparing the observed (2009) TP, chl-*a*, and Secchi values with those predicted by the model based on the lake depth and size and the size of the watershed. The observed TP, chl-*a*, and Secchi values for Upper Elysian Lake are very different from the predicted values. This simply means that the observed TP was much higher than what is expected for a lake of its size, depth, and watershed area in the NCHF ecoregion. The model predicted TP loading at 2,520 kg/yr. This result is likely lower than the actual load rate given that the observed TP is higher than the predicted values. The areal water load to the lake was estimated at 1.7 m/yr and estimated water residence time is approximately one year. The complete modeling results can be found in Appendix B.

Reeds Lake

Reeds Lake is a small, deep dimictic lake located approximately four miles northeast of Jaynesville, Minnesota. Reeds Lake's watershed is small relative to its surface water area with an area of 216 hectares (534 acres) and a watershed to lake ratio of nearly 3:1. As a result of its small watershed, land use is dominated by open water with a percentage that exceeds the expected range for the NCHF (Table 13 & Figure 22).

Reeds Lake was sampled for chemistry from May through September of 2001 and 2008. The average total TP for Reeds Lake was 29 µg/L (Table 12). This is well below the assessment criteria for shallow lakes within the NCHF ecoregion.

The average chl-*a* value for Reeds Lake was 12 µg/L (Table 12). This was also below the assessment criteria for the NCHF ecoregion. As a result of the low levels of TP and chl-*a*, as well as low total suspended inorganic solids (3 mg/L), the water clarity of Reeds Lake is greater than the assessment standard with an average of 1.8 meters (5.9 feet).

Figure 26 illustrates the pattern of water chemistry and transparency from the summer of 2008 for Reeds Lake. TP concentrations remained low high during a majority of the year until September when they climbed to 47 µg/L during the fall turn over. When compared to historic profile data the presence of a thermocline at four meters indicates that Reeds Lake is subject to the development of two limnetic layers. The upper, warmer layer is well mixed with higher DO while the lower layer remains cooler with lower DO concentrations. During the spring and fall turnovers, nutrients are subject to release within the water column mixing throughout the season resulting in nutrients being stirred up from the sediment and released into the lake water as is evident in the September TP spike.

Minimal profile data exists however, when historic temperature and DO profiles, collected in 2001, are used as a reference the lake likely mixes in the spring and fall and forms a distinct thermocline during the summer months (Figure 25). The thermocline developed around nine meters (29.5 feet) during the spring and was present between three and four meters (~13 feet) during the summer months. DO remained above five mg/L to a depth of nine meters (29.5 feet) in the spring but dropped below 5 mg/L around 4 meters (13 feet) through the summer with anoxic conditions below 6 meters (19.7 feet).

Based on the chemical monitoring results and high water clarity, Reeds Lake was classified as a eutrophic lake. Additionally, based on the TP and chl-*a* standards for the support of aquatic recreation, Reeds Lake was determined to be fully supporting of aquatic recreational use and was not listed as an impaired water under the 2010 303(d) Impaired Waters List.

The MINLEAP model was utilized for Reeds Lake as a basis for comparing the observed (2008) TP, chl-*a*, and Secchi values with those predicted by the model based on the lake depth and size and the size of the watershed. The observed TP, chl-*a*, and Secchi values for Reeds Lake are similar to the predicted values. This simply means that the observed TP was at expected levels for a lake of its size, depth, and watershed area in the NCHF ecoregion. The model predicted TP loading at 65 kg/yr. This result is likely an accurate representation of the actual load rate given that the observed TP is similar to the predicted values. The areal water load to the lake was estimated at 0.4 m/yr and estimated water residence time is approximately 11.4 years. Complete modeling results can be found in Appendix B.

Buffalo Lake

Buffalo Lake is a large (352 hectares (872 acres)), shallow polymictic lake located approximately three miles south of Jaynesville, Minnesota. Buffalo Lake's watershed is 1,617 hectares (4,003 acres) and is small relative to its surface water area with a watershed to lake ratio of nearly 6:1. Watershed land use is dominated by cropland. Water quality monitoring for Buffalo Lake began in the spring of 2008 but was canceled following the drawdown of the lake for waterfowl management. The average for the three TP, chl-*a*, and Secchi samples collected were 222 µg/L, 111 µg/L, and 0.6 meters (two feet) respectively. Based on these limited results, Buffalo Lake would likely have been listed as impaired. However, more data is required to conclude this assessment.

Table 12: Upper Elysian Lake & Reeds Lake total phosphorous, chlorophyll-*a*, and Secchi averages compared to North Central Hardwood Forest assessment standards

Ecoregion	TP	Chl-*a*	Secchi
	ug/L	ug/L	meters
NCHF – Aquatic Rec. Use (Class 2b)	< 40	< 14	> 1.4
NCHF – Aquatic Rec. Use (Class 2b) Shallow lakes	< 60	< 20	> 1.0
Upper Elysian Lake Averages 2007 & 2009	162	73	0.5
Reeds Lake Averages 2001 & 2008	29	12	1.8

Table 13: Upper Elysian Lake and Reeds Lake watershed land use

Land use	Upper Elysian Lake land use percentage	Reeds Lake Land Use Percentage	NCHF typical land use percentage
Developed	5	3	2 - 9
Cropland	66	32	22 - 50
Rangeland	11	12	11 - 25
Forest/Shrub	6	9	6 - 25
Water & Wetland	12	44	14 - 30

Figure 21: Upper Elysian Lake watershed land use and monitoring site locations

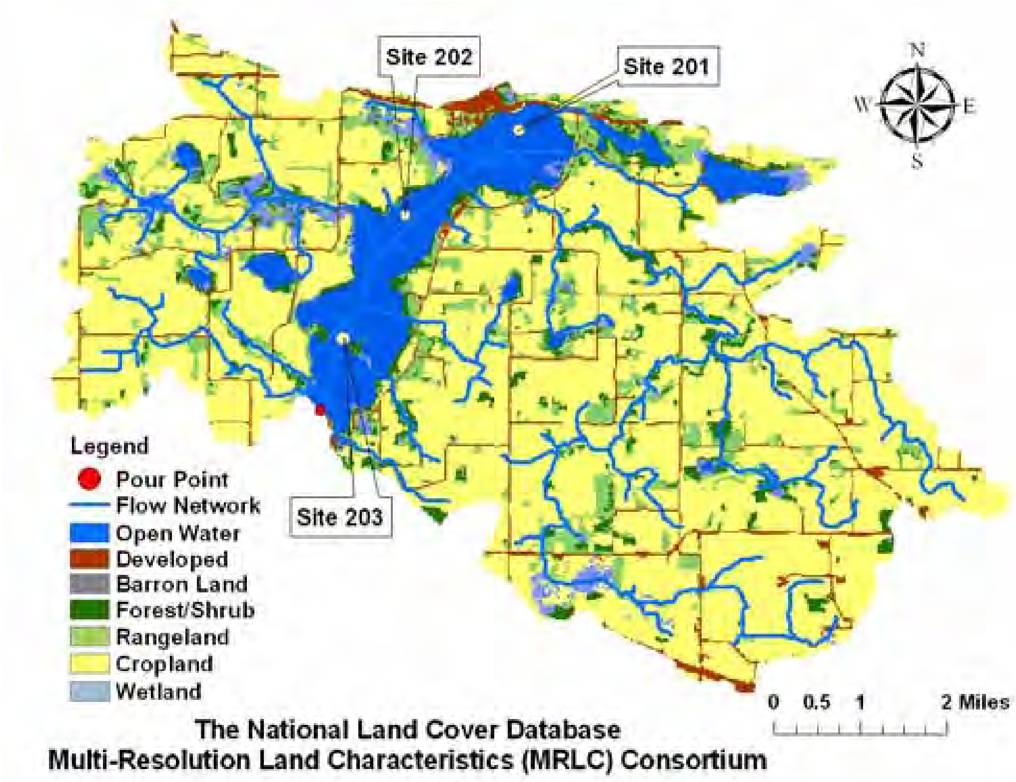


Figure 22: Reeds Lake watershed land use and monitoring site locations

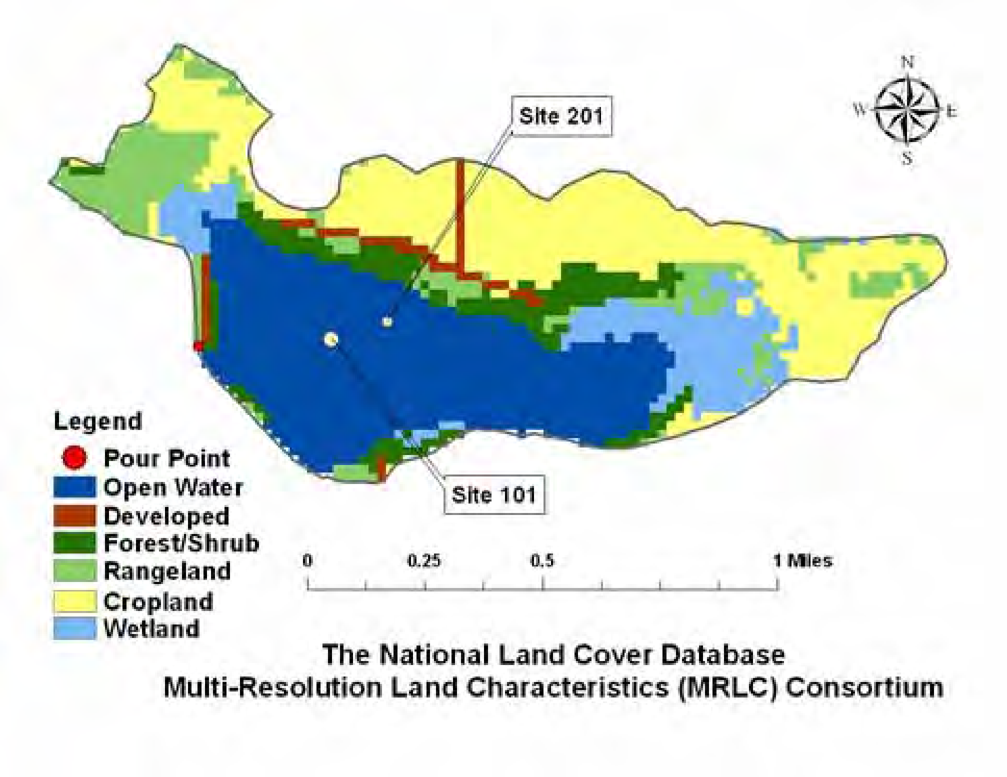
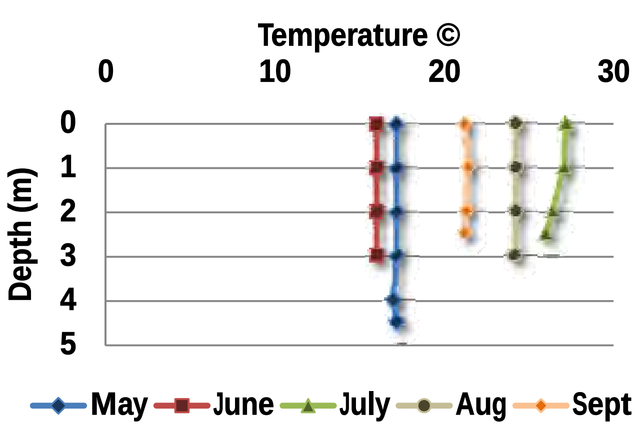


Figure 23: Upper Elysian Lake historic monthly temperature and dissolved oxygen profiles



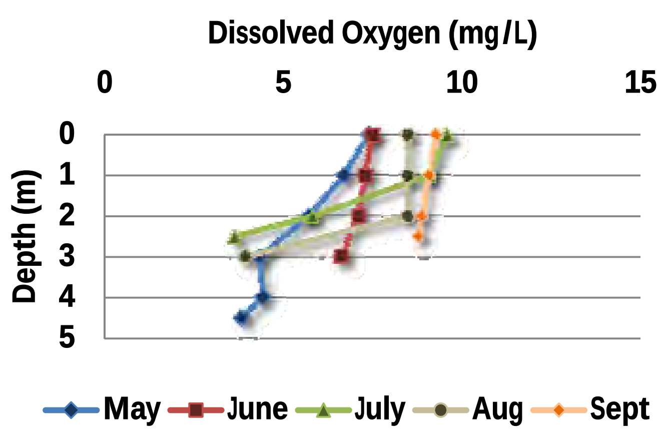


Figure 24: Upper Elysian Lake 2009 total phosphorous, chlorophyll-*a*, and Secchi values

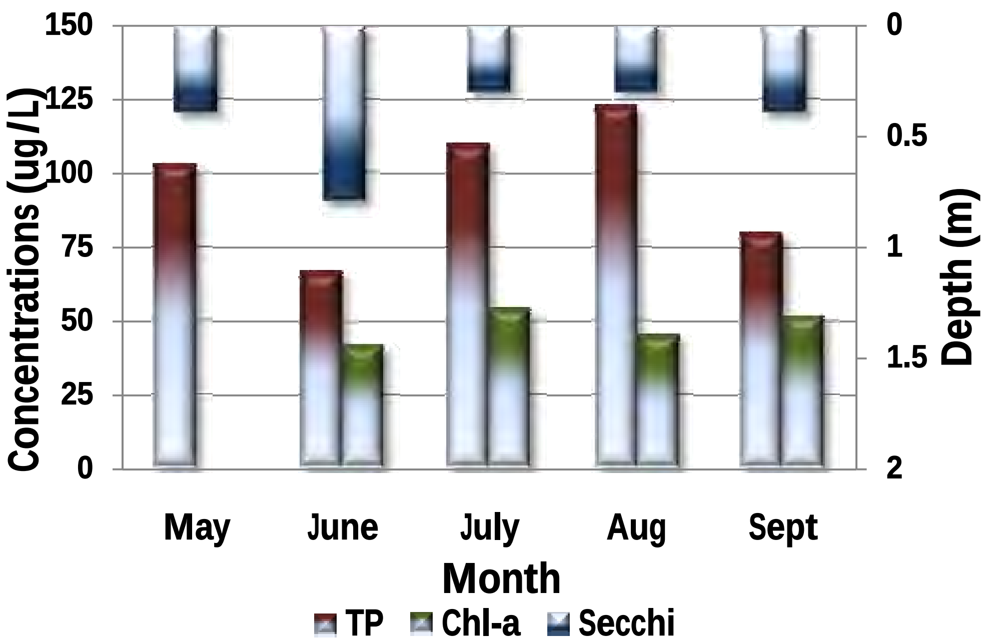


Figure 25: Reeds Lake historic monthly temperature and dissolved oxygen profiles

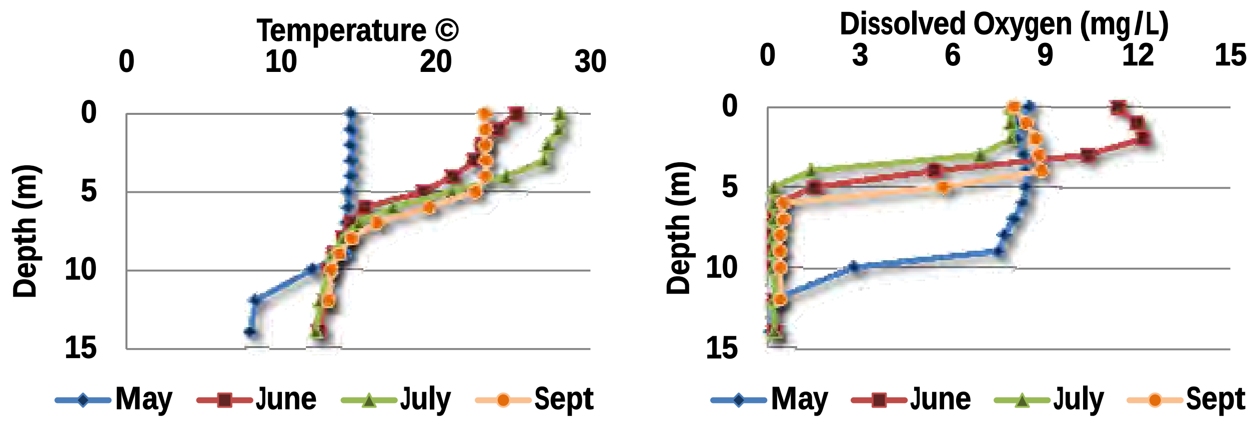
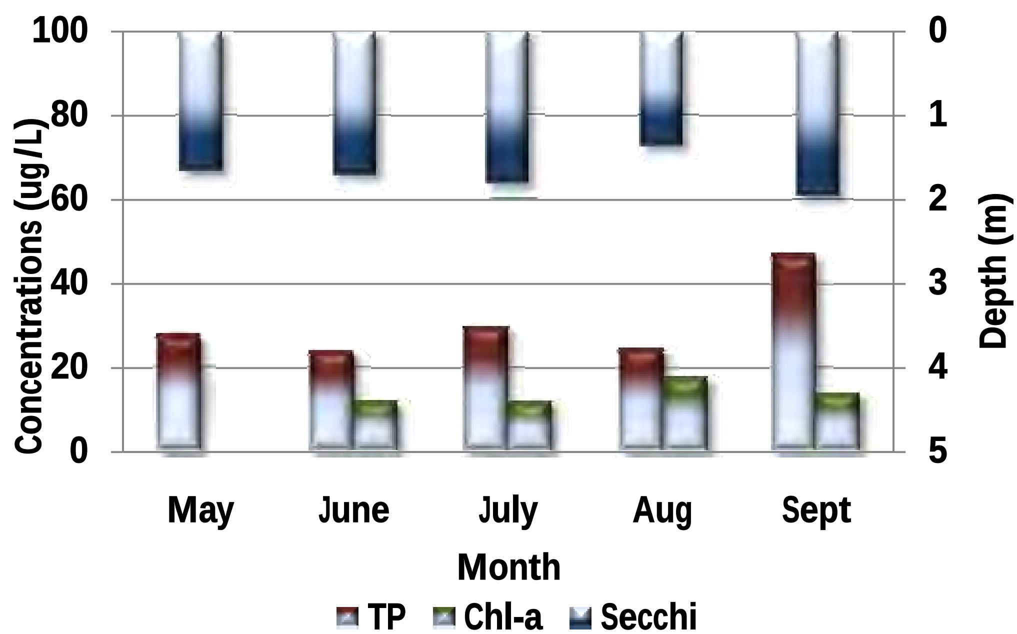


Figure 26: Reeds Lake 2008 total phosphorous, chlorophyll-*a*, and Secchi values



Madison Lake HUC-11 Watershed

The Madison Lake (07020011050) HUC-11 watershed lies along the northern boundary of the Le Sueur River watershed. This 4,930 hectare (12,202 acre) watershed represents two percent of the Le Sueur River watershed (Figure 3 & Table 4). Cropland is the major land use within this area (Figure 28) and there are eight lakes of which one (Madison (07-0044)) has been assessed (Table 14). The Madison Lake watershed drains into an unnamed tributary that eventually flows into the Le Sueur River near Eagle Lake, MN through an outlet south of Mud Lake. Based on 2003 NPDES/SDS there are five permitted discharge sites and 12 registered feedlots throughout the Madison Lake watershed (Figure 27).

Table 14: Assessed lakes within the Madison Lake HUC-11 watershed

Lake ID	Lake Name	County	Lake Area	Depth Max	Depth Mean
			Acres	Meters	Meters
07-0044	Madison	Blue Earth	1389	17.9	3.4

Figure 27: Madison Lake flow network and permitted discharge locations

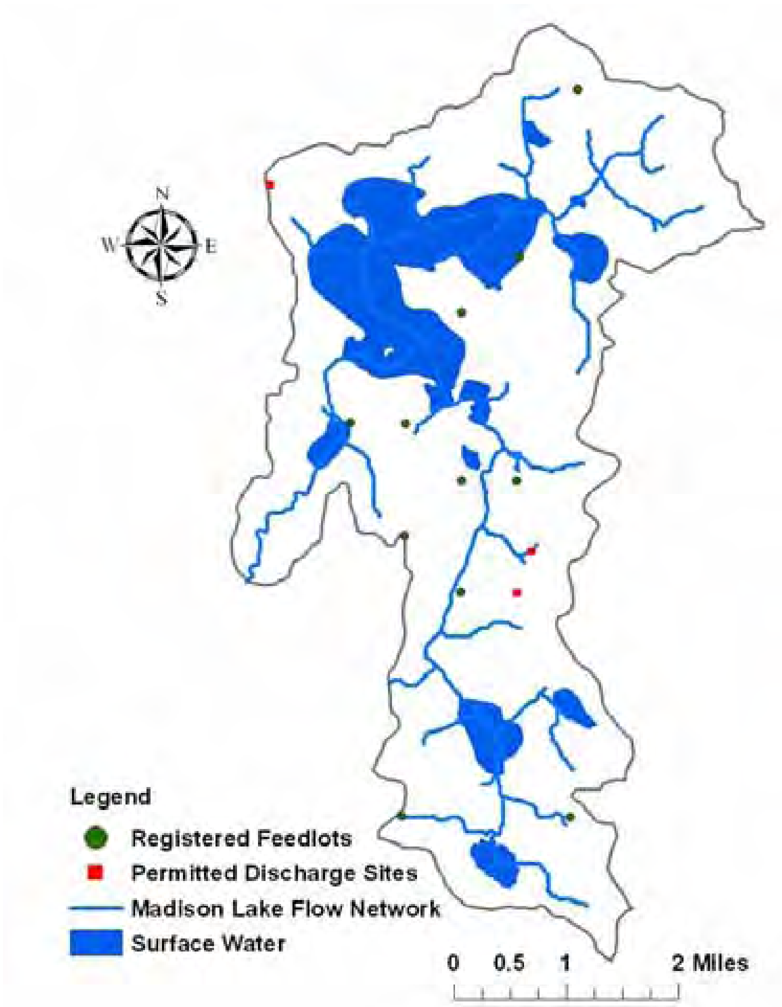
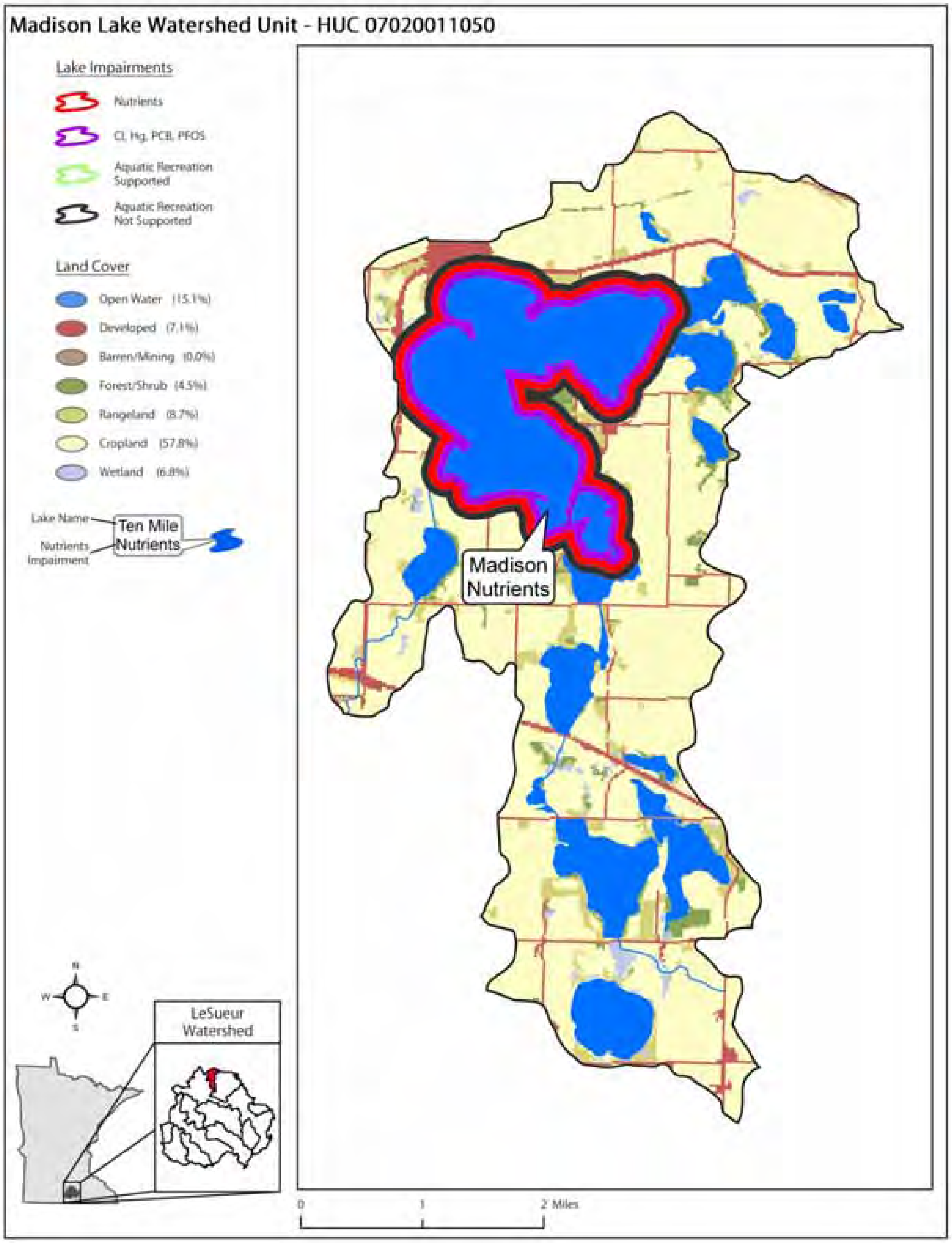


Figure 28: Madison Lake HUC-11 watershed land use characteristics and lake impairments



Madison Lake

Madison Lake is a large, deep intermittently stratifying lake located approximately six miles east of Mankato, Minnesota. Madison Lake's watershed is moderate relative to its surface water area with an area of 4,509 hectares (11,161 acres) and a watershed to lake ratio of 8:1. Land use is dominated by cropland with the percentage being closer to what is found in the WCBP and exceeding the expected range for the NCHF (Table 16 & Figure 29). Madison Lake was previously monitored as a part of a study on blue-green algal toxins. Results from that study may be found at: http://www.pca.state.mn.us/water/lakereport.html (see Blue Earth County). Madison Lake is also part of the SLICE program with further monitoring scheduled to continue.

Madison Lake was sampled for chemistry from May through October of 2008 and 2009. The average TP for Madison Lake was 78 µg/L (Table 15). This was above the assessment criteria for lakes within the NCHF ecoregion. Samples were collected at two locations on Madison Lake with higher values occurring at site 101 (Figures 31 & 34). Additionally, depth TP samples were collected with high values being recorded in late summer as nutrients are released into the lake water as decomposition occurs within the lake sediment (Figure 32). This coincides with the sharp drop in DO within the hypolimnium as oxygen is consumed during the decomposition.

The average chl-*a* value for Madison Lake was 44 µg/L (Table 15). This was also well above the assessment criteria for the NCHF ecoregion. Chl-*a* levels spiked in Sept at 52 µg/L at site 101 and were at their lowest in June at 7 µg/L at site 201 (Figures 31 & 34). As a result of the high levels of TP and chl-*a* the water clarity of Madison Lake is below the range of the assessment standard with an average of just one meter (3.3 feet).

Figures 31 and 34 illustrate the pattern of Madison Lake's water chemistry and transparency for both sampling sites from the summer of 2008. TP concentrations were low during the spring and steadily increased over the summer peaking in September. The pattern of increasing TP in Madison Lake is consistent with other lakes in Minnesota.

Profile data from 2008 for both sites indicates (Figures 30 & 33) that a weak thermocline forms at a depth of eight-nine meters (~29.5 feet) in July and August but remains well mixed during the rest of the season. This indicates that Madison Lake is subject to continuous mixing during the spring and fall but a thermocline will develop during periods of low winds and water movement. As a result, nutrients are likely being stirred up from the sediment and released into the lake water during much of the year. DO remained above five mg/L through most of the year with hypoxic conditions developing at approximately four-six meters (~19.7) in July and August and anoxic conditions below six meters (19.7 feet) in July.

Based on the chemical monitoring results and poor water clarity, Madison Lake was classified as a eutrophic lake. Additionally, based on the TP and chl-*a* standards for the support of aquatic recreation, Madison Lake was determined to be non-supporting of aquatic recreational use and was listed as an impaired water under the 2010 303(d) Impaired Waters List.

The MINLEAP model was utilized for Madison Lake as a basis for comparing the observed (2008 & 2009) TP, chl-*a,* and Secchi values with those predicted by the model based on the lake depth and size and the size of the watershed. The results indicated that the observed TP, chl-*a,* and Secchi values for Madison Lake are different from the predicted values. This simply means that the observed TP was much higher than what is expected for a lake of its size, depth, and watershed area in the NCHF ecoregion. The model predicted TP loading at 1,036 kg/yr. This result is likely lower than the actual load rate given that the observed TP is higher than the predicted values. The areal water load to the lake was estimated at 1.1 m/yr and estimated water residence time is approximately one year. The complete modeling results can be found in Appendix B.

Table 15: Madison Lake total phosphorous, chlorophyll-a, and Secchi averages compared to North Central Hardwood Forest assessment standards

Ecoregion	TP	Chl-a	Secchi
	ug/L	ug/L	meters
NCHF – Aquatic Rec. Use (Class 2b)	< 40	< 14	> 1.4
NCHF – Aquatic Rec. Use (Class 2b) Shallow lakes	< 60	< 20	> 1.0
Madison Lake Averages 2006, 2008, & 2009	78	44	1.0

Table 16: Madison Lake watershed land use

Land use	Madison Lake land use percentage	NCHF typical land use percentage
Developed	7	2 - 9
Cropland	56	22 - 50
Rangeland	9	11 - 25
Forest/Shrub	5	6 - 25
Water & Wetland	23	14 - 30

Figure 29: Madison Lake watershed land use and monitoring site locations

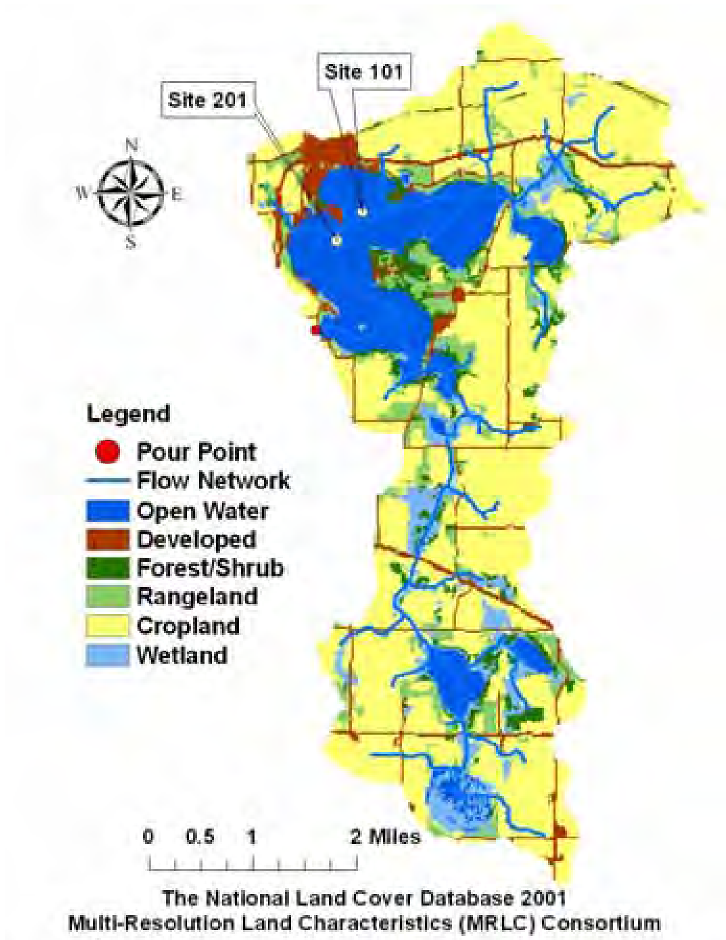


Figure 30: Madison Lake 2008 Site 101 monthly temperature and dissolved oxygen profiles

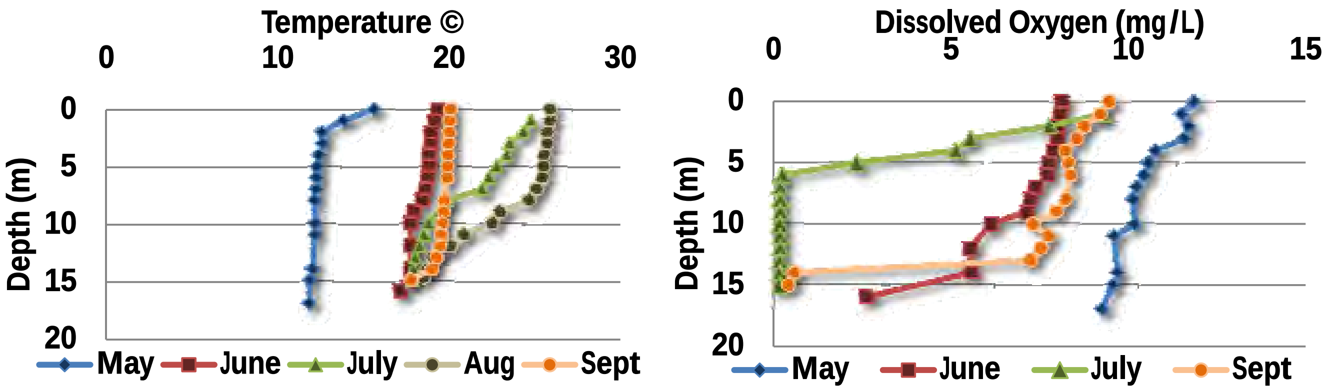


Figure 31: Madison Lake 2008 Site 101 total phosphorous, chlorophyll-a, and Secchi values

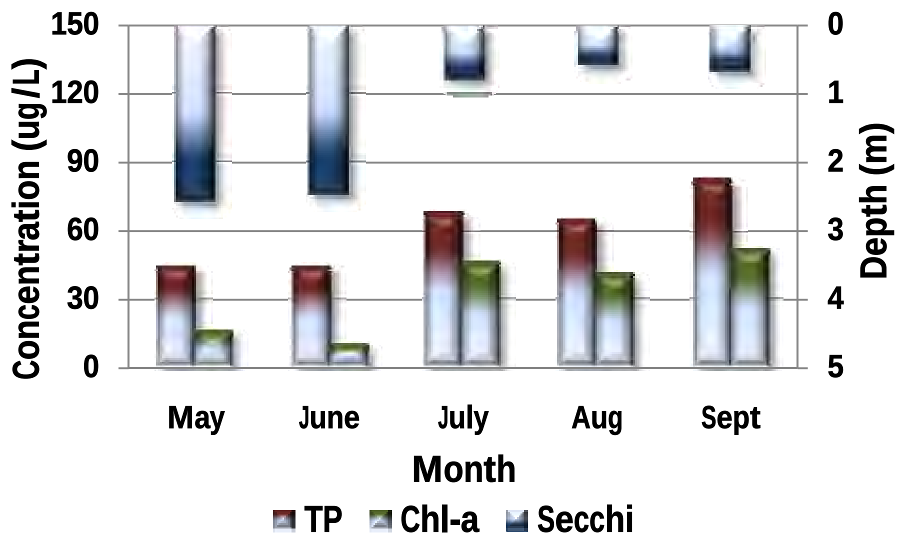


Figure 32: Madison Lake Site 101 surface and depth total phosphorous comparison

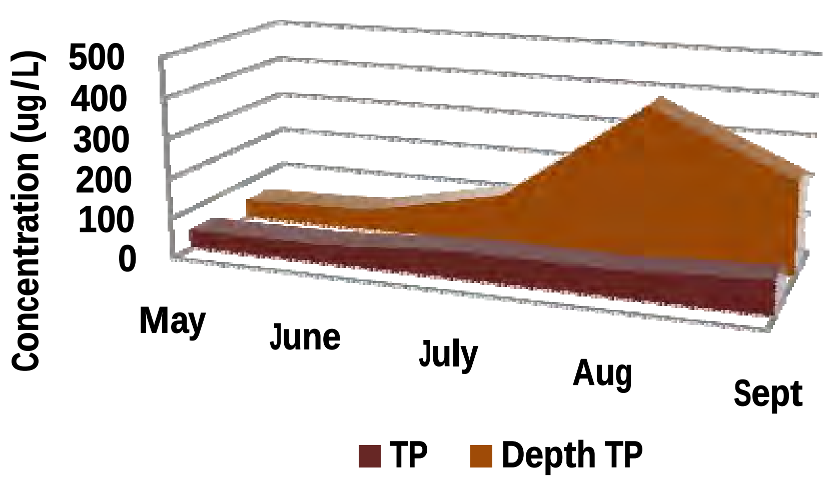
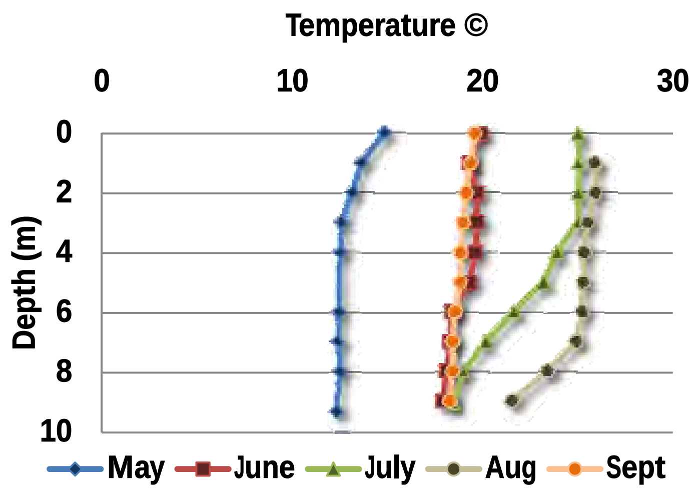


Figure 33: Madison Lake 2008 Site 201 monthly temperature and dissolved oxygen profiles



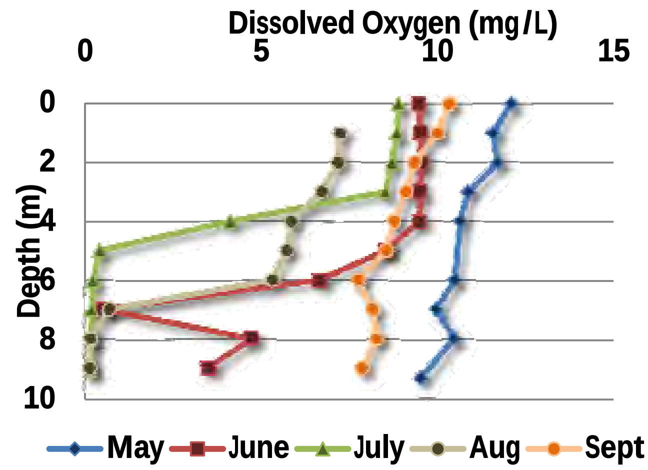
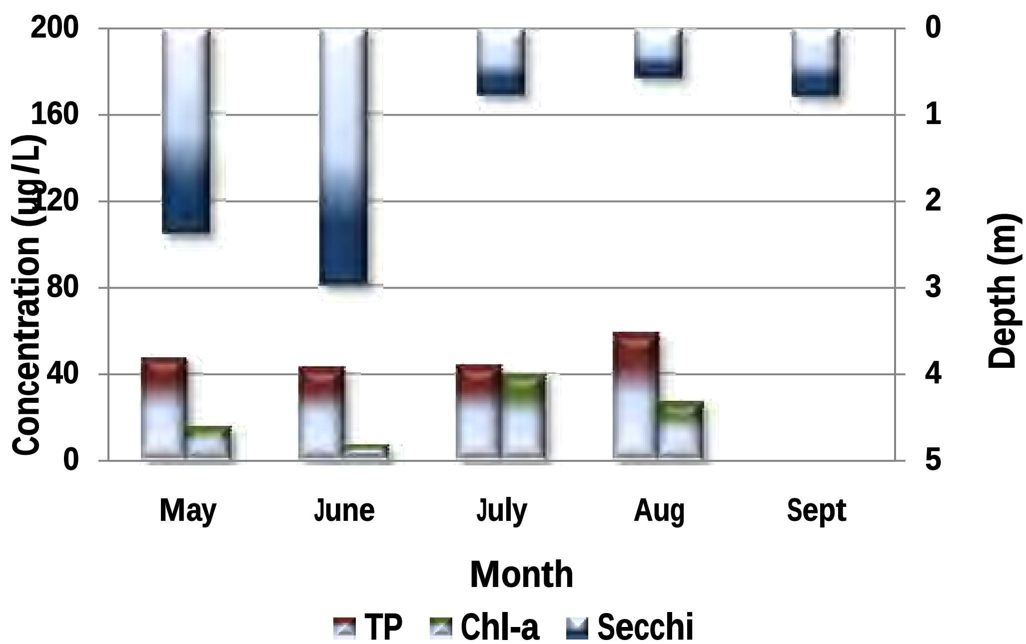


Figure 34: Madison Lake 2008 Site 201 total phosphorous, chlorophyll-*a*, and Secchi values



Maple River HUC-11 Watershed

The Maple River (07020011110) HUC-11 watershed lies within the southern half of the Le Sueur River watershed. This 42,644 hectare (105,554 acre) watershed represents 15 percent of the Le Sueur River watershed (Figure 3 & Table 4). Cropland is the major land use within this area (Figure 36) and Minnesota Lake is the only lake that has been assessed (Table 17). The Maple River watershed drains into the Le Sueur River approximately three miles south of Mankato, MN. Based on 2003 NPDES/SDS there are 30 permitted discharge sites and 139 registered feedlots throughout the Maple River watershed (Figure 35).

Table 17: Assessed lakes within the Maple River HUC-11 watershed

Lake ID	Lake Name	County	Lake Area	Depth Max	Depth Mean
			Acres	Meters	Meters
22-0033	Minnesota	Faribault	1914	1.5	0.5

Figure 35: Maple River flow network and permitted discharge locations

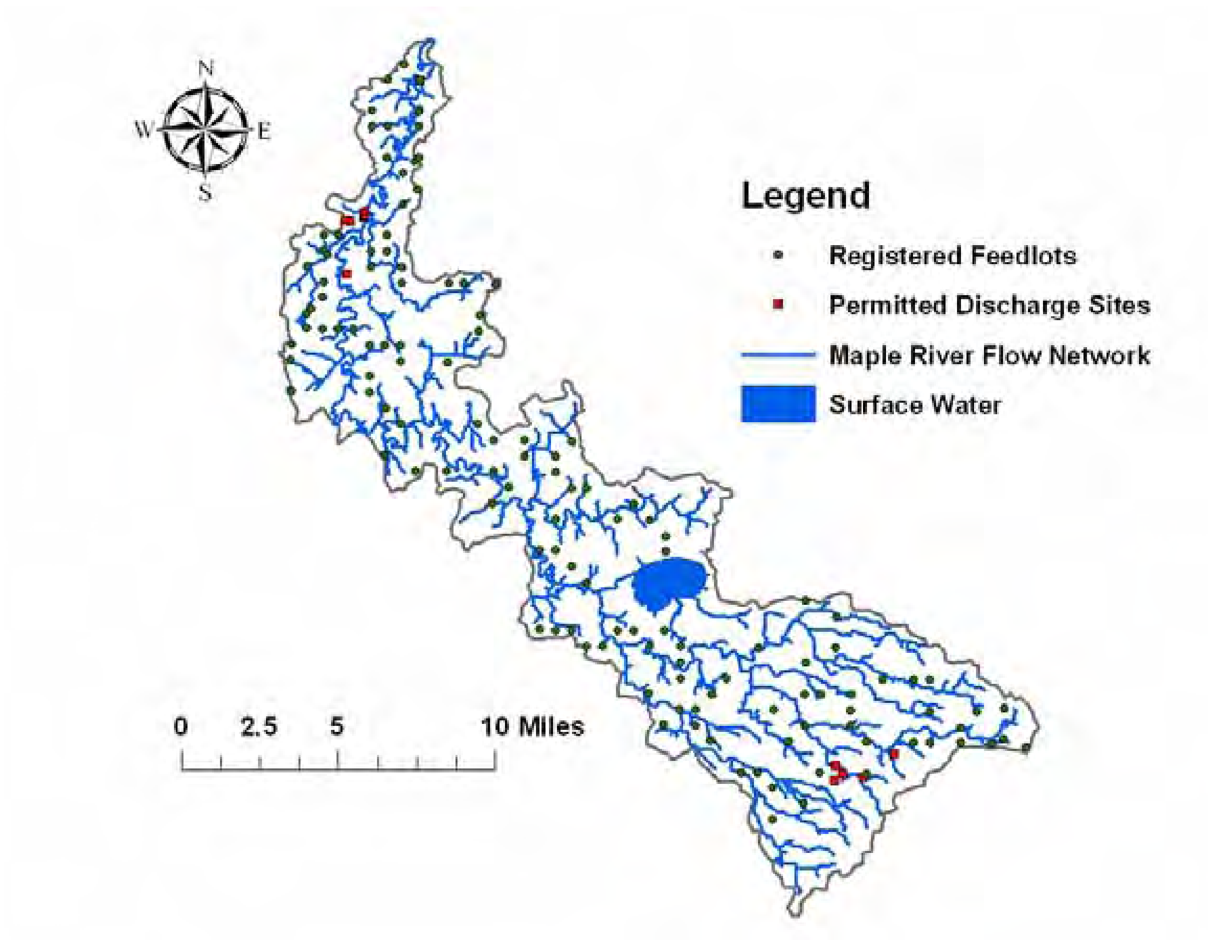
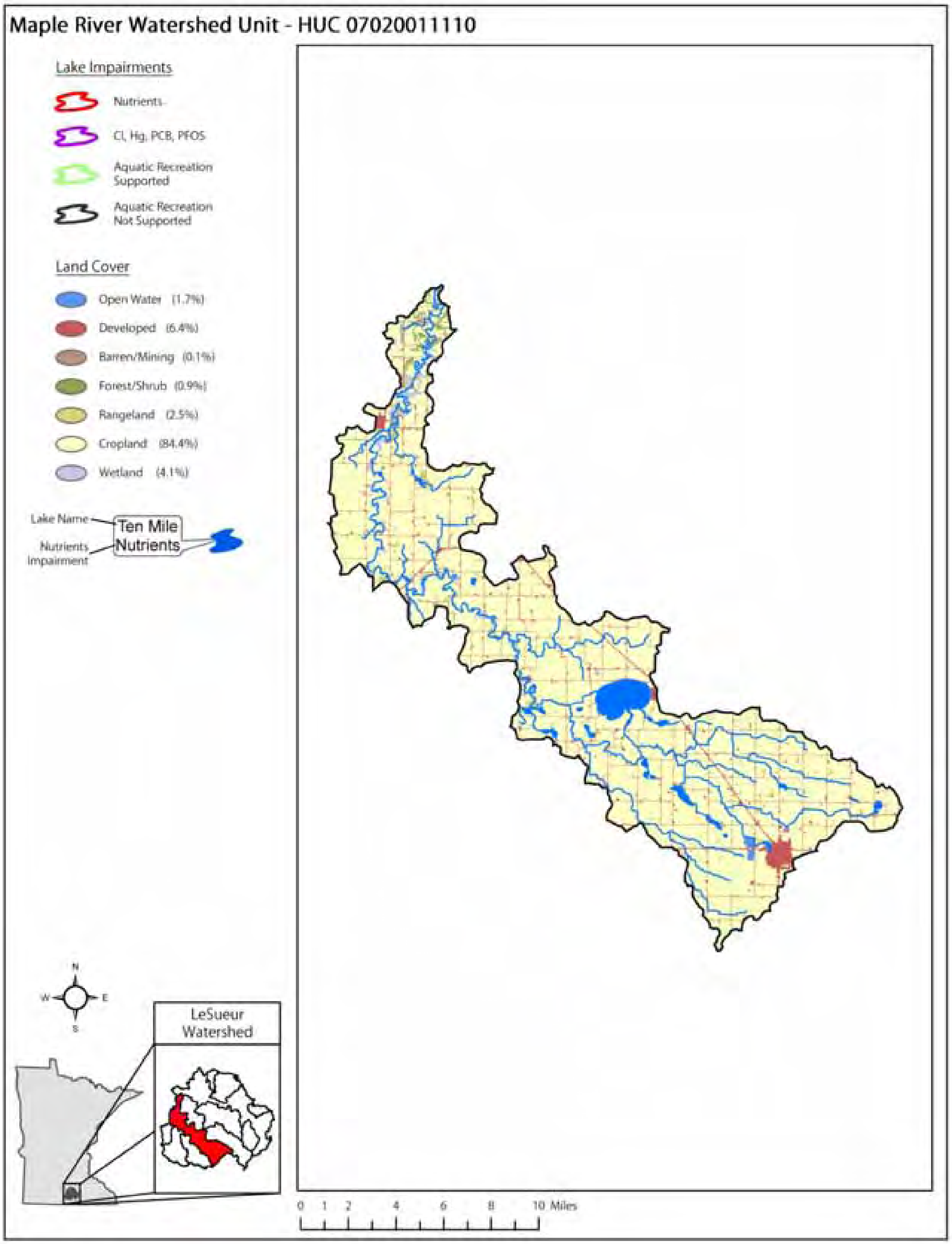


Figure 36: Maple River HUC-11 watershed land use characteristics and lake impairments



Minnesota Lake

Minnesota Lake is a large, shallow polymictic lake located within the town of Minnesota Lake, Minnesota. Minnesota Lake's watershed is small relative to its surface water area with an area of 2,332 hectares (5,772 acres) and a watershed to lake ratio of 3:1. Land use is dominated by cropland use with the percentage falling into the range of values expected for the WCBP (Table 19 & Figure 37). Additionally, water and wetland land use is higher than the typical watershed in the WCBP due to the size of the lake.

Minnesota Lake was sampled for chemistry in 2008 and 2009. The average TP for Minnesota Lake was 145 µg/L (Table 18). This was well above the assessment criteria for lakes within the WCBP ecoregion. Over the course of the two sampling years TP spiked in July of 2009 at 222 µg/L while the lowest value was 115 µg/L in September of 2009.

The average chl-*a* value for Minnesota Lake was 40 µg/L (Table 18). This was also well above the assessment criteria for the WCBP ecoregion. Chl-*a* levels spiked in August of 2009 at 96 µg/L and were at their lowest in July of 2008 at 4 µg/L. As a result of the high levels of TP and chl-*a*, as well as exceedingly high Total Inorganic Solids levels (48 mg/L), the water clarity of Minnesota Lake is below the range of the assessment standard with an average of just 0.3 meters (one foot).

Figure 38 illustrates the pattern of Minnesota Lake's water chemistry and transparency from the summer of 2009. TP concentrations peaked in July and steadily decreased into September. The chl-*a* values for Minnesota lake closely mirror the rise and fall of available nutrients. The pattern of TP levels peaking during mid-summer in Minnesota Lake is consistent with other shallow lakes in Minnesota.

Due to Minnesota Lake's shallow depth, profile data is limited to surface measurements of DO and temperature. DO remained above five mg/L throughout the year while the water temperature spiked at 23.9© in August. The lake's shallow depth, large fetch, and high levels of suspended solids all indicate that Minnesota Lake is subject to continuous mixing throughout the season. As a result, nutrients are continuously being stirred up from the sediment and released into the lake water. Additionally, it is likely that a majority of the nutrient loading for Minnesota Lake occurs internally due to constant mixing and a relatively small watershed.

Based on the chemical monitoring results and poor water clarity, Minnesota Lake was classified as a hypereutrophic lake. Additionally, based on the limited chemical monitoring results and water clarity, Minnesota Lake has not been fully assessed. Due to the limited recreational use and access issues and further monitoring is not recommended. However, based on the TP and chl-*standards* for the support of aquatic recreation, Minnesota Lake would likely be determined to be non-supporting of aquatic recreational use.

The MINLEAP model was utilized for Minnesota Lake as a basis for comparing the observed (2008 & 2009) TP, chl-*a*, and Secchi values with those predicted by the model based on the lake depth and size and the size of the watershed. The results indicated that the observed TP and Secchi values for Minnesota Lake are relatively similar to the predicted values. In contrast, the observed and predicted chl-*a* were not similar. High amounts of suspended sediment throughout the lake would likely inhibit algal growth resulting in lower than expected chl-*a* results. This simply means that the observed TP was similar to what is expected for a lake of its size, depth, and watershed area in the WCBP ecoregion. The model predicted TP loading at 1,960 kg/yr. This is likely the actual load rate given that the observed TP is similar to the predicted values. The areal water load to the lake was estimated at 0.5 m/yr and estimated water residence time is approximately 1.1 years. The complete modeling results can be found in Appendix B

Table 18: Minnesota Lake total phosphorous, chlorophyll-*a*, and Secchi averages compared to Western Corn belt Plains assessment standards

Ecoregion	TP	Chl-*a*	Secchi
	ug/L	ug/L	meters
WCBP & NGP – Aquatic Rec. Use (Class 2B)	< 65	< 22	> 0.9
WCBP & NGP – Aquatic Rec. Use (Class 2b) Shallow lakes	< 90	< 30	> 0.7
Minnesota Lake 2008 & 2009 Averages	145	40	0.3

Table 19: Minnesota Lake watershed land use

Land use	Minnesota Lake land use percentage	WCBP typical land use percentage
Developed	7	0-16
Cropland	57	42-75
Rangeland	1	0-7
Forest/Shrub	<1	0-15
Water & Wetland	34	3-26

Figure 37: Minnesota Lake watershed land use and monitoring site location

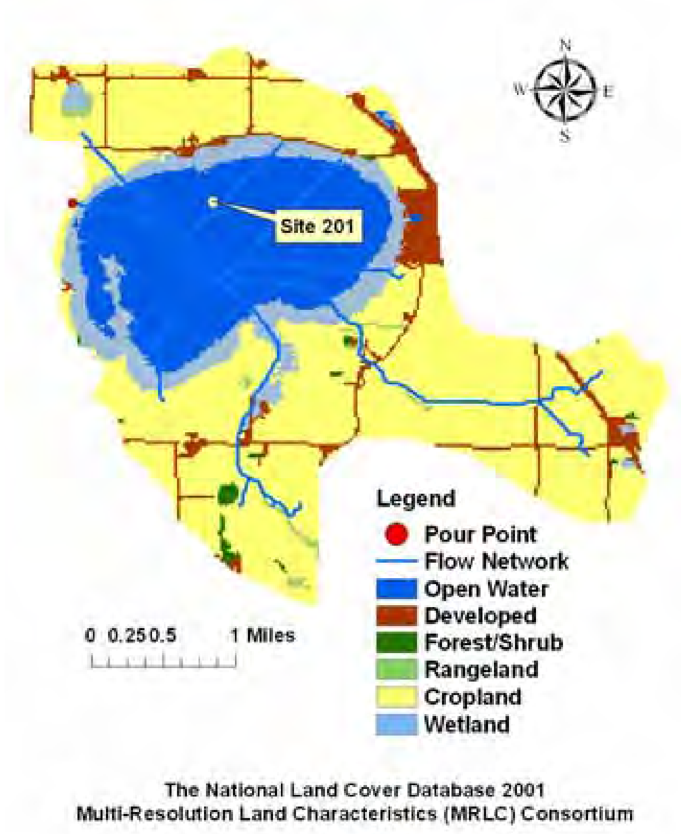
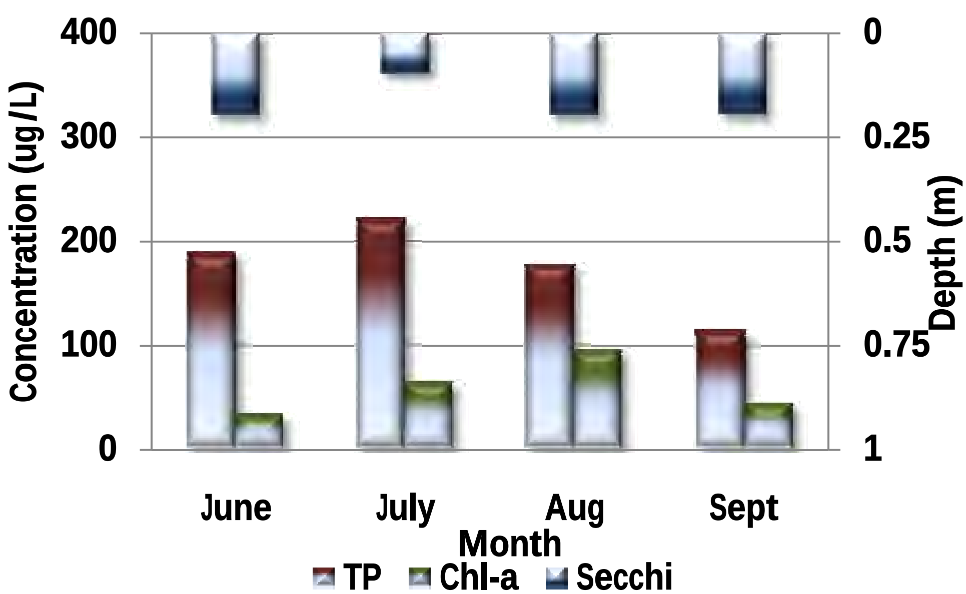


Figure 38: Minnesota Lake 2008 Site 101 total phosphorous, chlorophyll-*a*, and Secchi values



Rice Creek HUC-11 Watershed

The Rice Creek (07020011090) HUC-11 watershed lies within the southwestern portion of the Le Sueur River watershed. This 21,068 hectare (52,149 acre) watershed represents 18 percent of the Le Sueur River watershed (Figure 3 & Table 4). Cropland is the major land use within this area (Figure 40) and there are three lakes with assessment data (Table 20). The Rice Creek watershed drains into the Maple River through Rice Creek near Mapleton, MN. Based on 2003 NPDES/SDS there are 29 permitted discharge sites and 50 registered feedlots throughout the Rice Creek watershed (Figure 39).

Table 20: Monitored or assessed lakes within the Rice Creek HUC-11 watershed

Lake ID	Lake Name	COUNTY	Lake Area	Depth
			Acres	Meters
07-0079	Lura	Blue Earth	1,295	2.7
22-0074	Bass	Faribault	199	6
22-0075	Rice	Faribault	978	1.5

Figure 39: Rice Creek flow network and permitted discharge locations

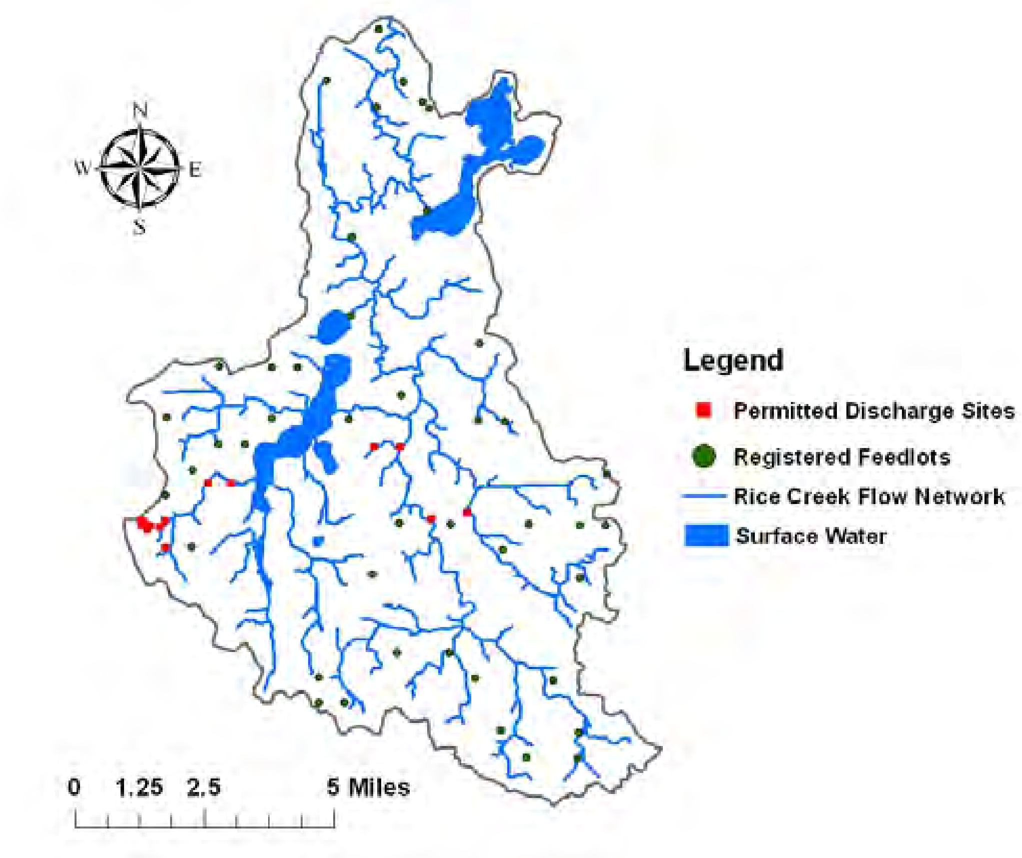
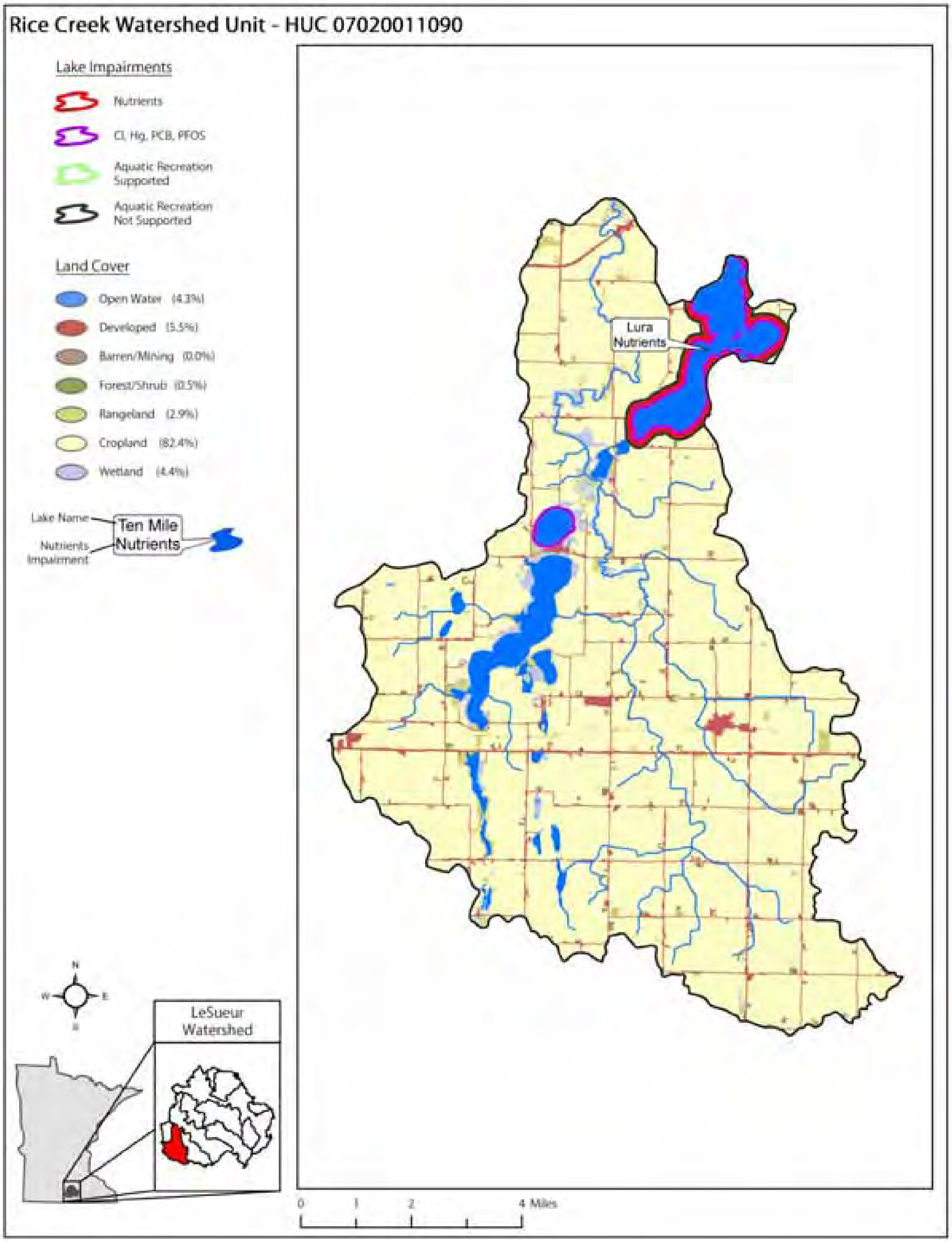


Figure 40: Rice Creek HUC-11 watershed land use characteristics and lake impairments



Lura Lake

Lura Lake is a large, shallow polymictic lake located approximately three miles southwest of Mapleton, Minnesota. Lura Lake's watershed is small relative to its surface water area with an area of 1,073 hectares (2,657 acres) and a watershed to lake ratio of 2:1. Land use is dominated by the lake and surrounding wetlands with the percentage being well above the range of values expected for the WCBP (Table 22 & Figure 41). Additionally, land use devoted to cropland is lower than the typical watershed in the WCBP.

Lura Lake was sampled for chemistry in 2004 and 2009. The average TP for Lura Lake was 193 µg/L (Table 21). This was well above the assessment criteria for lakes within the WCBP ecoregion. Over the course of the two sampling years TP spiked in August of 2009 at 276 µg/L while the lowest value was 53 µg/L in September of 2009.

The average chl-*a* value for Lura Lake was 44 µg/L (Table 21). This was also above the assessment criteria for the WCBP ecoregion. Chl-*a* levels spiked in August of 2009 at 101 µg/L and were at their lowest in June of 2009 at 1.2 µg/L. Despite the high levels of TP and chl-*a*, the water clarity for Lura Lake is above the assessment standard with an average of just 1.1 meters (3.6 feet).

Figure 44 illustrates the pattern of Lura Lake's water chemistry and transparency from the summer of 2009. These values are the averages estimated from samples collected at sites 101, 102, and 103. TP concentrations climbed through the spring until finally peaking in July and then steadily decreasing into September. The chl-*a* values and Secchi transparency for Lura Lake closely mirror the rise and fall of available nutrients. The pattern of TP levels peaking during mid-summer in Lura Lake is consistent with other shallow lakes in Minnesota.

Profile data was collected sporadically throughout Lura Lake for DO and temperature measurements. DO briefly dropped just below five mg/L in early July of 2009 but remained above five mg/L throughout the remainder of the year. The surface water temperature spiked at 25.6© in August and a thermocline did not develop. This indicates that Lura Lake is continuously mixing throughout the season. As a result, nutrients are continuously being stirred up from the sediment and released into the lake water. It is likely that a majority of the nutrient loading for Lura Lake occurs internally due to constant mixing and a relatively small watershed.

Based on the chemical monitoring results and water clarity, Lura Lake was classified as a eutrophic lake. Additionally, based on the TP and chl-*a* standards for the support of aquatic recreation, Lura Lake was determined to be non supporting of aquatic recreational use and was listed as an impaired water under the 2008 303(d) Impaired Waters List.

The MINLEAP model was utilized for Lura Lake as a basis for comparing the observed (2004 & 2009) TP, chl-*a*, and Secchi values with those predicted by the model based on the lake depth and size and the size of the watershed. The results indicated that the observed chl-*a* and Secchi values for Lura Lake are relatively similar to the predicted values. However, the observed and predicted TP for Lura Lake were not similar. The lake's continuous mixing likely resulted in higher than expected TP results despite the relatively small watershed contribution. The model predicted TP loading at 952 kg/yr. This is likely close to the actual load rate given the small watershed ratio. The areal water load to the lake was estimated at 0.3 m/yr and estimated water residence time is approximately 4.6 years. The complete modeling results can be found in Appendix B

Bass Lake

Bass Lake is a small, deep intermittently mixing lake located approximately three miles northeast of Winnebago, Minnesota. Bass Lake's watershed is small relative to its surface water area with an area of 197 hectares (487 acres) and a watershed to lake ratio of 2:1. Land use is dominated by the lake and surrounding wetlands with the percentage being well above the range of values expected for the WCBP (Table 22 & Figure 42). Additionally, land use devoted to cropland is lower than the typical watershed in the WCBP.

Bass Lake was last sampled for chemistry in 2004 by local volunteers. The average TP for Bass Lake was 57 µg/L (Table 21). This was below the assessment criteria for lakes within the WCBP ecoregion. In 2004, TP was at its highest in June at 65 µg/L while the lowest value of 47 µg/L occurred in June.

The average chl-*a* value for Bass Lake was 32 µg/L (Table 21). This was above the assessment criteria for the WCBP ecoregion. In 2004, chl-*a* levels spiked in August at 42 µg/L and were at their lowest in May at 24 µg/L. Coinciding with the relatively low levels of TP and chl-*a*, the water clarity for Bass Lake was below (better than) the assessment standard with an average of 1 meter (3.3 feet).

Figure 47 illustrates the pattern of Bass Lake's water chemistry and transparency from the summer of 2004. TP concentrations fluctuated throughout the season with chl-*a* values and Secchi transparency following a similar pattern as the amount of available nutrients rose and fell. This pattern of fluctuating TP levels during the season is likely a result of varying patterns of nutrient release from the sediment during periods of mixing as well as varying levels of contribution from the watershed.

Historic data from 2004 was used to evaluate Bass Lake's DO and temperature profiles. DO dropped below 5 mg/L in June and July at approximately 3.5 meters (11.5 feet) but remained above 5 mg/L throughout the entire water column in August and September (Figure 46). Temperature profiles indicate weak thermoclines developing from the surface to the bottom of Bass Lake. This is further indication that Bass Lake is continuously mixing throughout the season. It is likely that a majority of the nutrient loading for Bass Lake occurs internally due to constant mixing and the limited external loading due to the small watershed.

Based on the limited chemical monitoring results and water clarity, Bass Lake has not been fully assessed and further monitoring is recommended. However, with the existing data, Bass Lake has been determined to be eutrophic. Additionally, the Citizen Lake Monitoring Program (CLMP) has monitored the lake for several years. Data collected through this program has shown a trend of improving water clarity. Bass Lake has insufficient data to determine whether it will be listed as impaired water or not.

The MINLEAP model was utilized for Bass Lake as a basis for comparing the observed (2004) TP, chl-*a*, and Secchi values with those predicted by the model based on the lake depth and size and the size of the watershed. The results indicated that the observed TP, chl-*a*, and Secchi values for Bass Lake are very similar to the predicted values. The model predicted TP loading at 170 kg/yr. This is likely close to the actual load rate given the small watershed ratio. The areal water load to the lake was estimated at 0.4 m/yr and estimated water residence time is approximately 26 years. The complete modeling results can be found in Appendix B.

Rice Lake

Rice Lake is a large, shallow polymictic lake located approximately two miles east of Winnebago, Minnesota. Rice Lake's watershed is moderate relative to its surface water area with an area of 5,973 hectares (14,787 acres) and a watershed to lake ratio of 15:1. Land use is dominated by cropland with the percentage being above the range of values expected for the WCBP (Table 22 & Figure 43).

Rice Lake was last sampled for chemistry in 2008. The average TP for Rice Lake was 218 µg/L (Table 21). This was well above the assessment criteria for lakes within the WCBP ecoregion. In 2008, TP was at its highest in July at 376 µg/L while the lowest value of 72 µg/L occurred in May.

The average chl-*a* value for Rice Lake was 46 µg/L (Table 21). This was above the assessment criteria for the WCBP ecoregion. In 2008, chl-*a* levels coincided with a nutrient spike in July at 123 µg/L and were at their lowest in August at 2 µg/L. Coinciding with the high levels of TP and chl-*a*, the water clarity for Rice Lake was below the assessment standard with an average of 0.5 meters (1.6 feet).

Figure 45 illustrates the pattern of Rice Lake's water chemistry and transparency from the summer of 2008. TP concentrations were low in the spring before increasing to their peak in July followed by a steady decline into September. Chl-*a* values and Secchi transparency results closely mirrored the amounts of nutrients throughout the season. The pattern of TP levels peaking during mid-summer in Rice Lake is consistent with other shallow lakes in Minnesota.

Due to accessibility issues, consistent profile data was not collected on Rice Lake in 2008. Given the lake's large fetch, shallow depth, and high TSS and TSIS (20 mg/L & 9 mg/L) it is assumed that Rice Lake is continuously mixing. Additionally, only one year of data exists for this basin. The lake is highly managed for waterfowl production and was in drawdown for much of 2008/2009. During these periods Rice Lake was extremely difficult to navigate with little open water and high emergent vegetation.

Based on the limited chemical monitoring results and water clarity, Rice Lake has not been fully assessed. However, with the existing data, Rice Lake has been determined to be hypereutrophic. Due to the high level of waterfowl management and issues with accessing open water further monitoring was not recommended. Rice Lake has insufficient data to determine whether it will be listed as impaired water or not.

The MINLEAP model was utilized for Rice Lake as a basis for comparing the observed (2008) TP, chl-*a*, and Secchi values with those predicted by the model based on the lake depth and size and the size of the watershed. The results indicated that the observed TP, chl-*a*, and Secchi values for Bass Lake are almost similar to the predicted values. The lake's continuous mixing and high TSS and TSIS values likely inhibited algal growth resulting in a higher predicted value for chl-*a* than what was observed. The model predicted TP loading at 4,544 kg/yr. This is likely close to the actual load rate given the size of the watershed and the high observed TP levels. The areal water load to the lake was estimated at two m/yr and estimated water residence time is approximately 0.3 years. The complete modeling results can be found in Appendix B.

Table 21: Lura Lake, Bass Lake, and Rice Lake total phosphorous, chlorophyll-*a*, and Secchi averages compared to Western Corn belt Plains assessment standards

Ecoregion	TP	Chl-*a*	Secchi
	ug/L	ug/L	meters
WCBP & NGP – Aquatic Rec. Use (Class 2B)	< 65	< 22	> 0.9
WCBP & NGP – Aquatic Rec. Use (Class 2b) Shallow lakes	< 90	< 30	> 0.7
Lura Lake 2004 & 2009 Averages	193	44	1.1
Bass Lake 2004 Averages	57	32	1
Rice Lake 2008 Averages	218	46	0.5

Table 22: Lura Lake, Bass Lake, and Rice Lake watershed land use

Land use	Lura Lake land use percentage	Bass Lake land use percentage	Rice Lake land use percentage	WCBP typical land use percentage
Developed	3	9	6	0-16
Cropland	37	37	78	42-75
Rangeland	2	1	4	0-7
Forest/Shrub	<1	0	<1	0-15
Water & Wetland	58	53	12	3-26

Figure 41: Lura Lake watershed land use and monitoring site locations

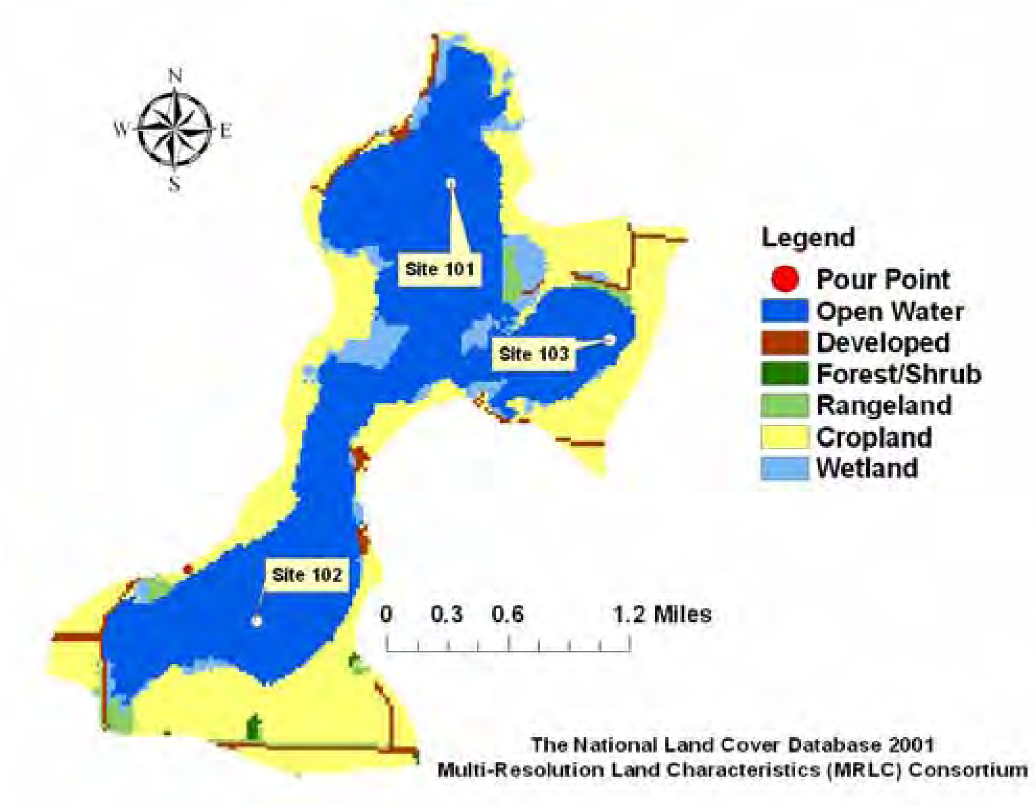


Figure 42: Bass Lake watershed land use and monitoring site location

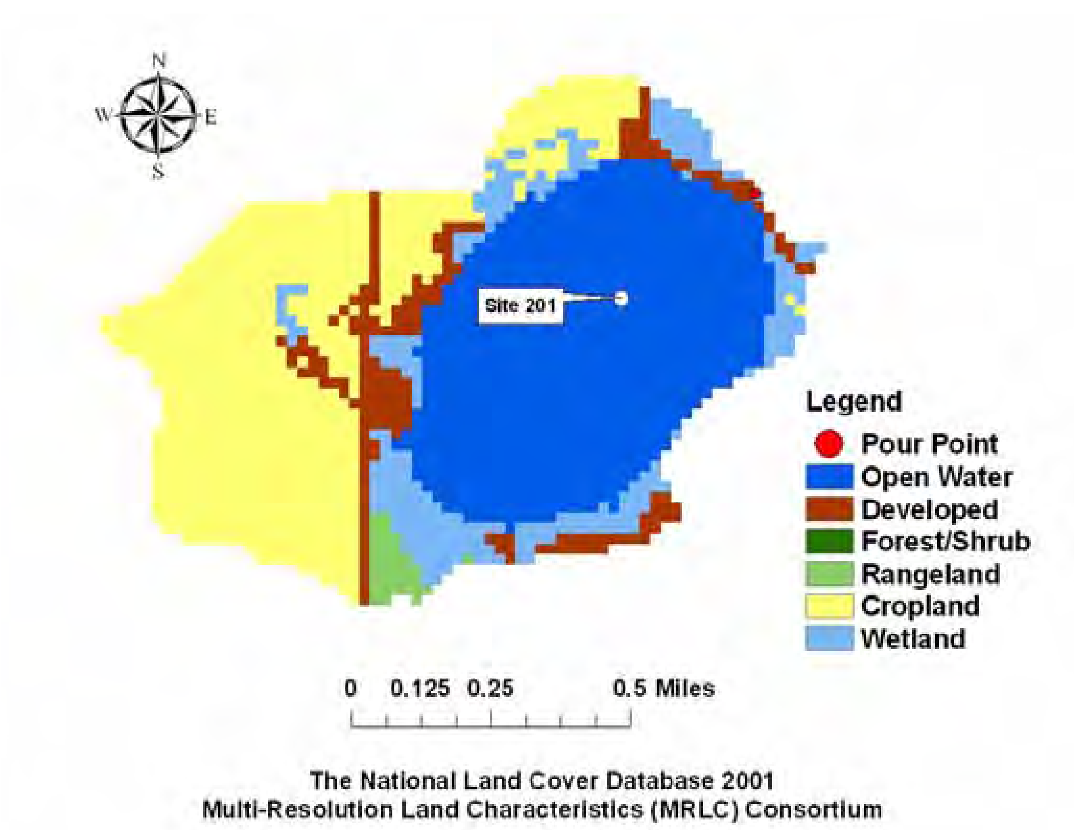


Figure 43: Rice Lake watershed land use and monitoring site location

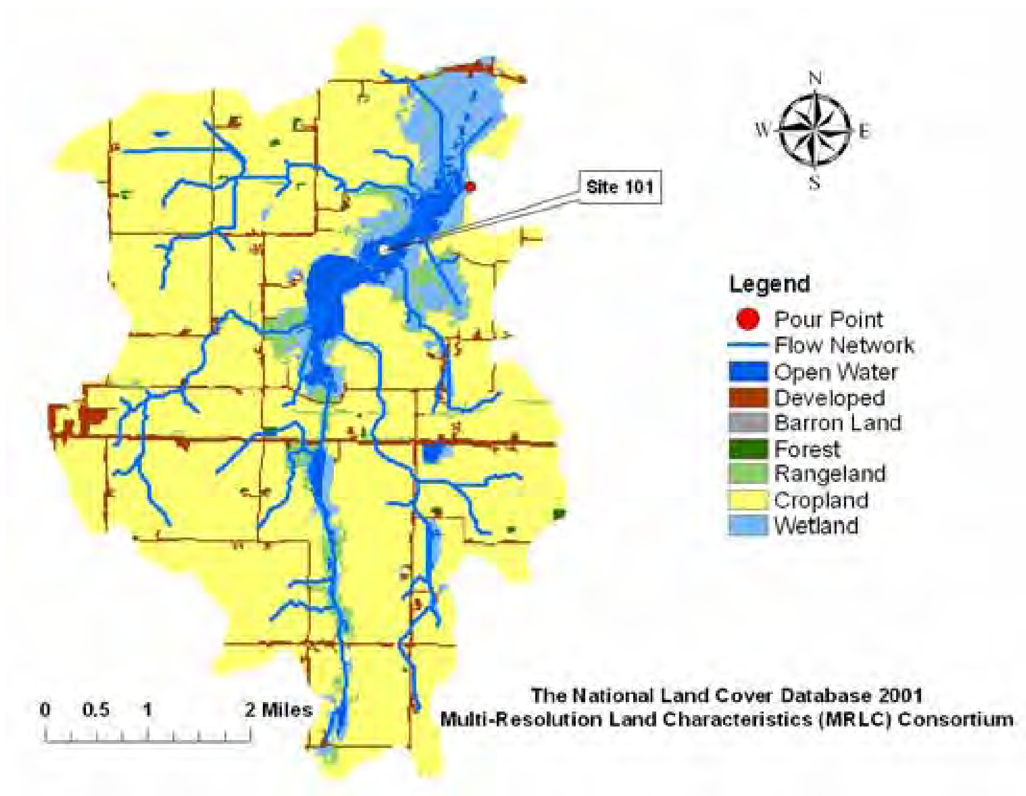


Figure 44: Lura Lake 2009 total phosphorous, chlorophyll-a, and Secchi values

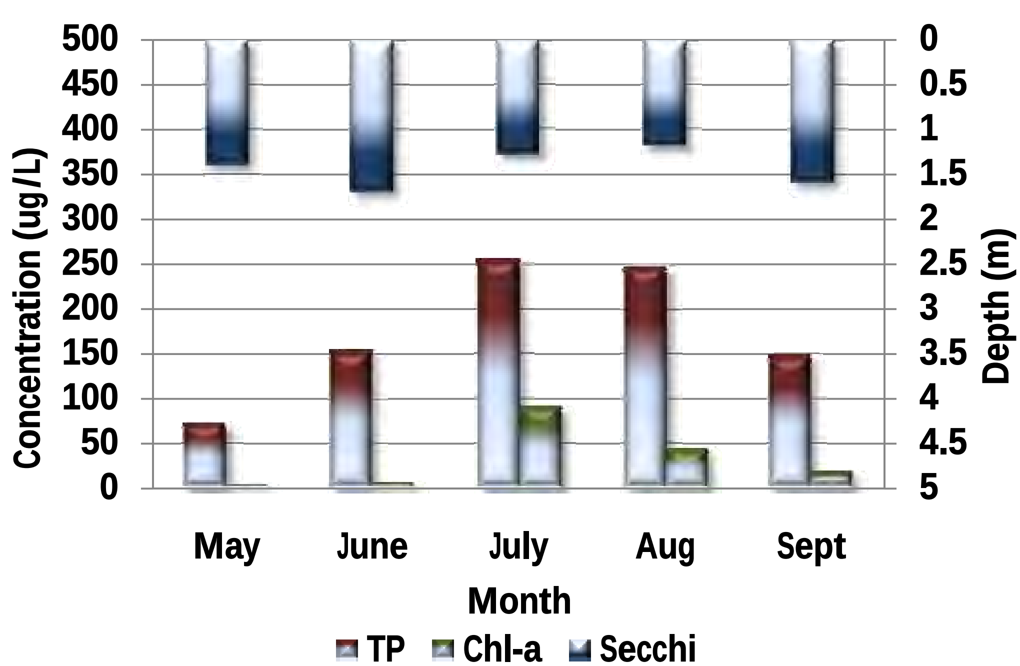


Figure 45: Rice Lake 2008 total phosphorous, chlorophyll-*a*, and Secchi values

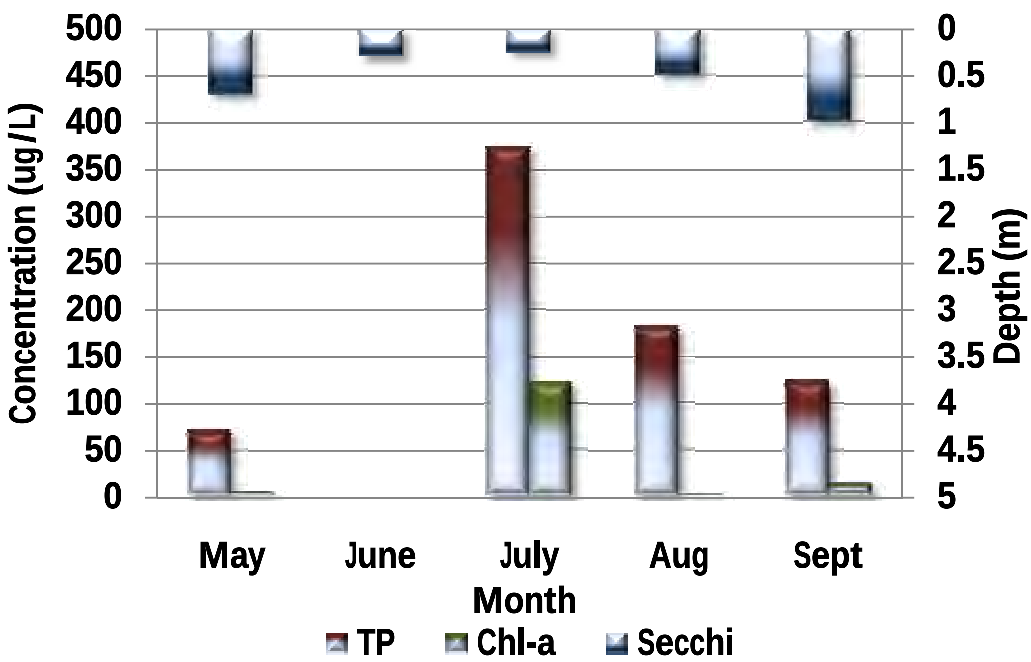


Figure 46: Bass Lake 2004 monthly temperature and dissolved oxygen profiles

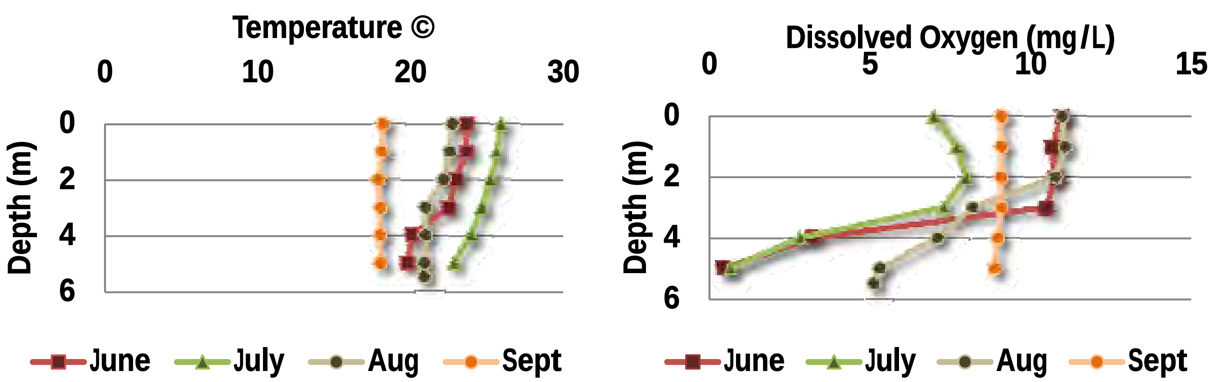


Figure 47: Bass Lake 2004 total phosphorous, chlorophyll-a, and Secchi values

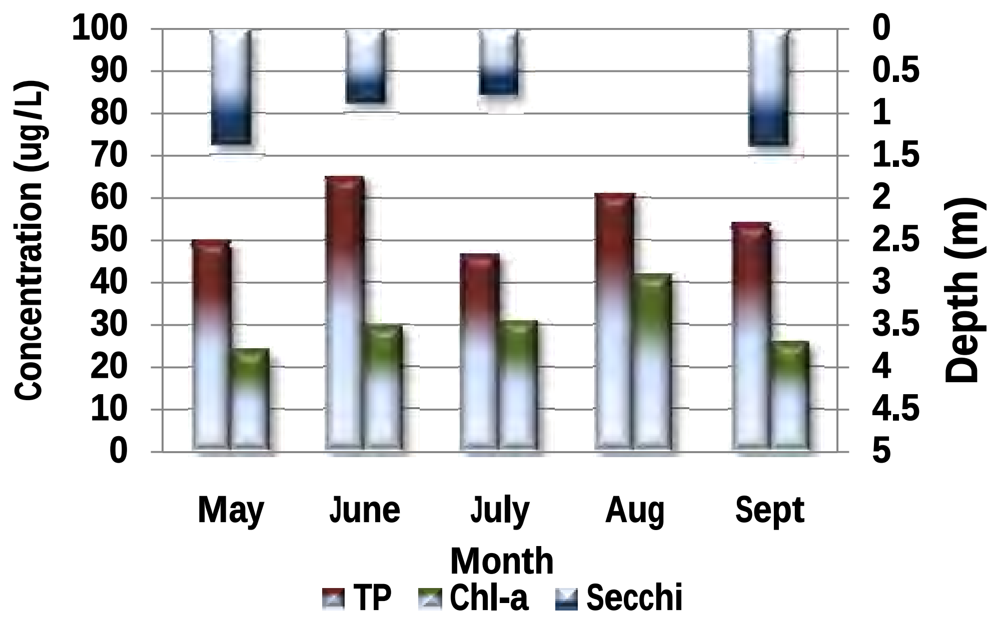
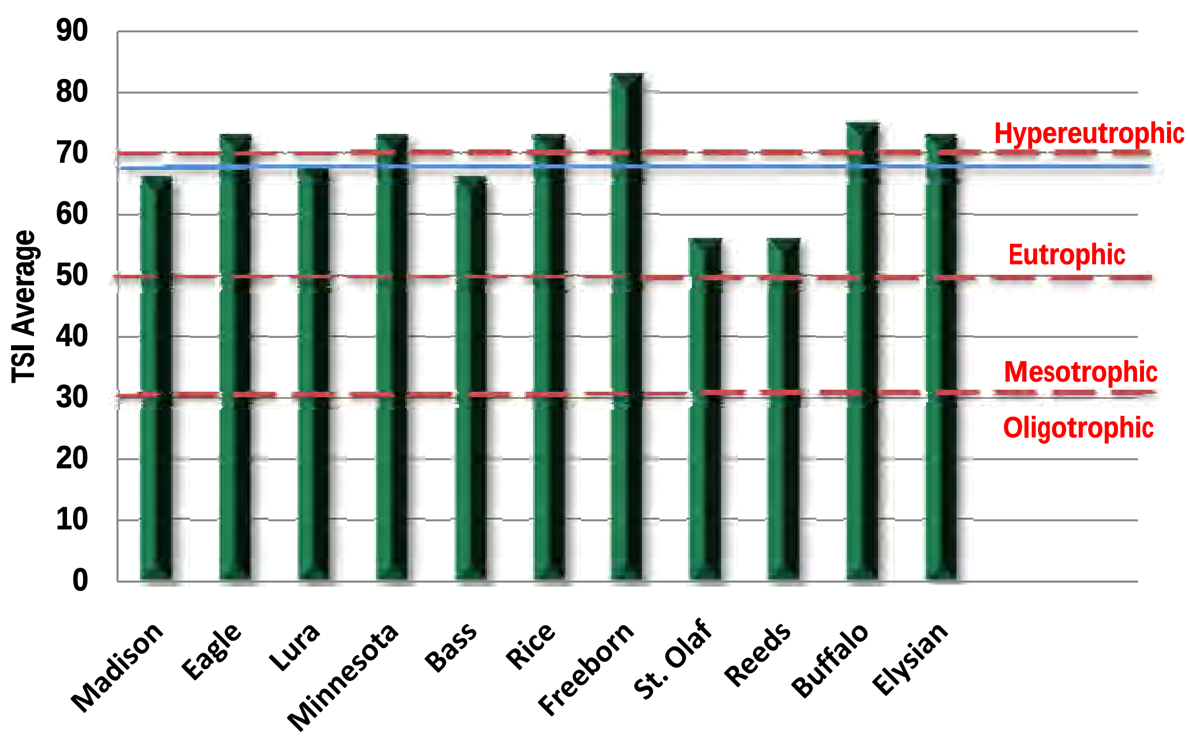


Figure 48: Trophic: State Index values for lakes monitored within the Le Sueur River watershed



Trophic Status Trends

One aspect of lake monitoring is to assess trends in the condition of the lakes. This analysis is based on data gathered through the MPCA's CLMP or data collected by local groups and then stored in STORET. A review of data in STORET indicates there is a fair amount of transparency data for St. Olaf, Elysian, Reeds, Madison and Bass Lake to describe annual variability and to assess trends. It should be noted that there are intermittent gaps in the data for each of these lakes. Trend lines are expressed in each graph as a blue dashed line for transparency and a red dashed line for nutrients. Sufficient data is unavailable for a trend analysis of Freeborn, Eagle, Minnesota, Lura, and Rice Lake.

In general, for trend assessment a minimum of eight years of consistent data is sought. Figures 49 through 53 show a trend of decreasing water clarity for St. Olaf and Elysian Lake and a trend of increasing water clarity for Reeds, Madison, and Bass Lake. Additionally, limited historical chemistry data has also been graphed indicating decreasing nutrient levels for Elysian, Reeds, and Bass Lake. St. Olaf Lake displays an increasing nutrient level trend while Madison Lake shows little change.

Figure 49: St. Olaf Lake long-term total phosphorous, chlorophyll-*a*, and Secchi depth trends

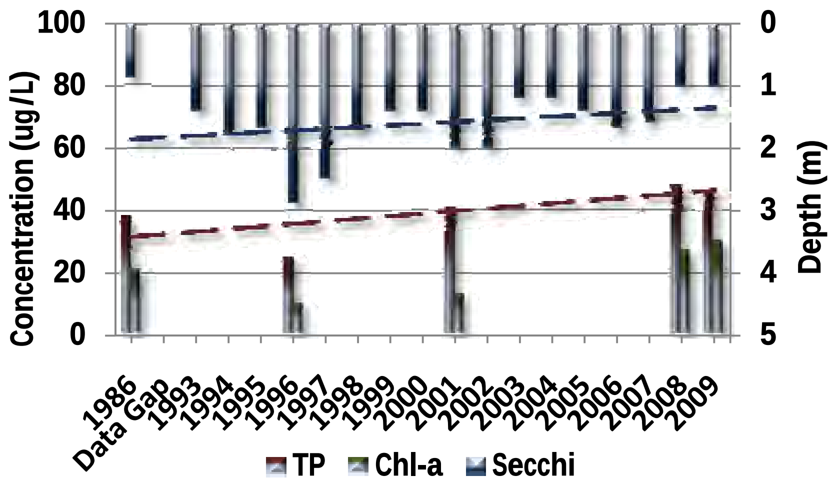


Figure 50: Elysian Lake long-term total phosphorous, chlorophyll-*a*, and Secchi depth trends

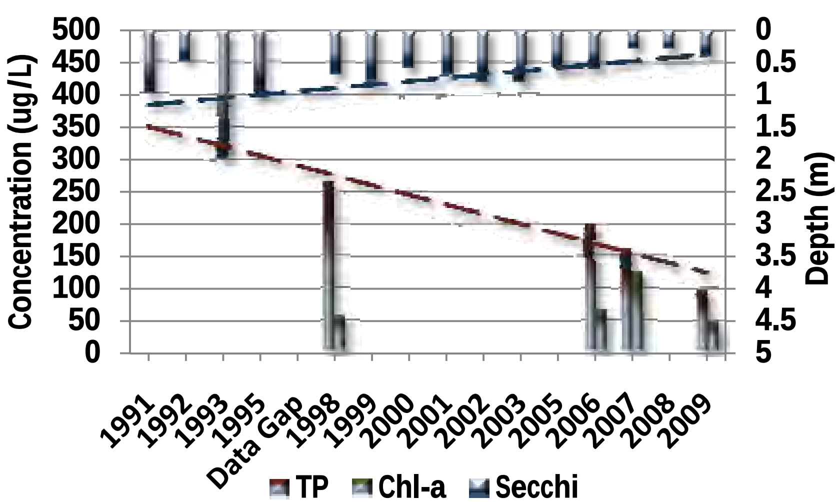


Figure 51: Reeds Lake long-term total phosphorous, chlorophyll-*a*, and Secchi depth trends

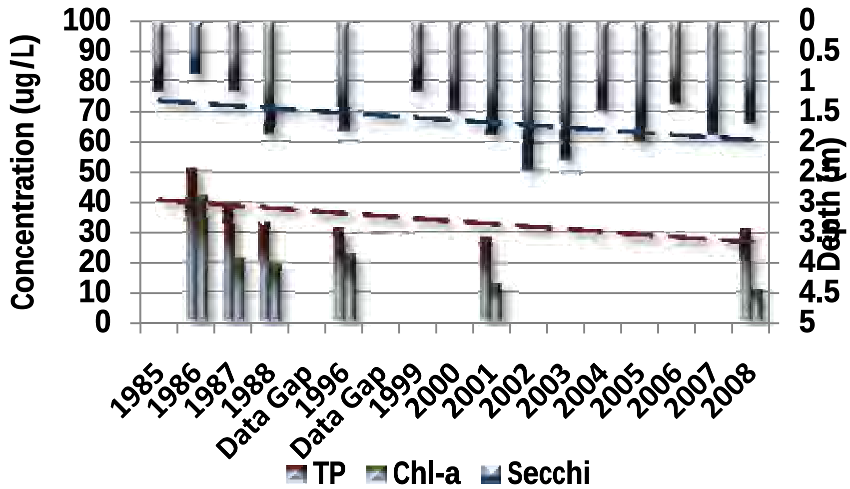


Figure 52: Madison Lake long-term total phosphorous, chlorophyll-*a*, and Secchi depth trends

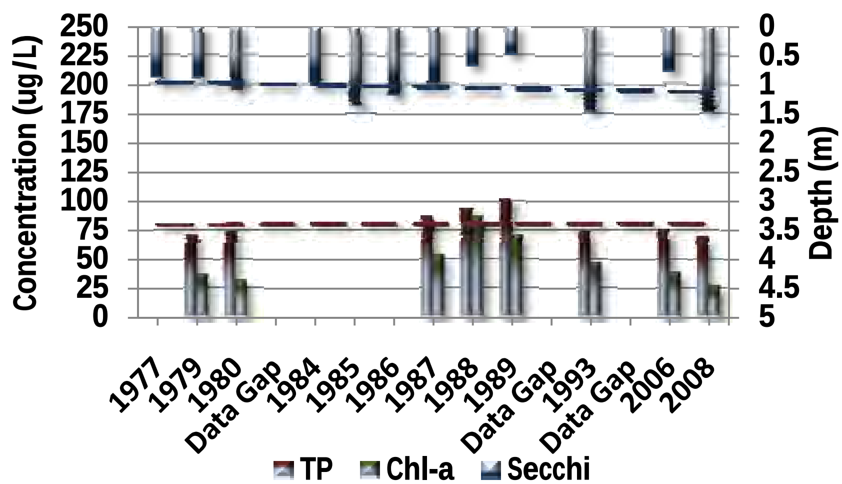
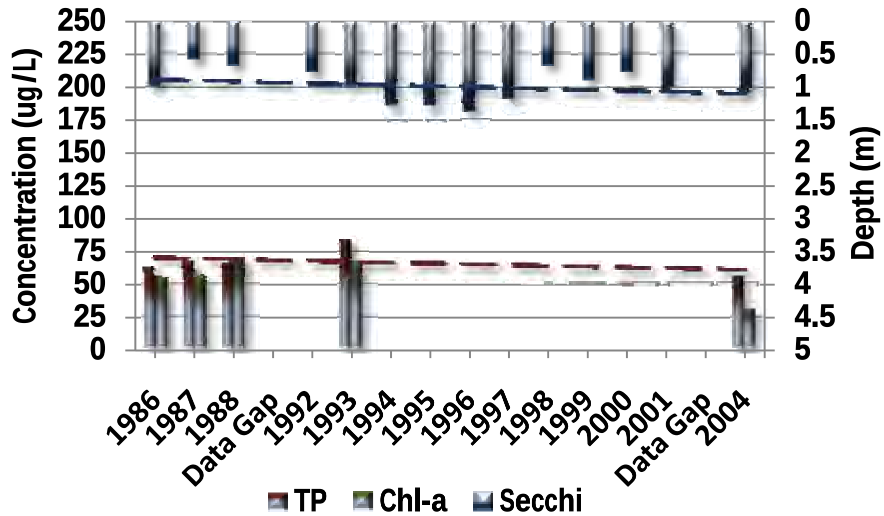


Figure 53: Bass Lake long-term total phosphorous, chlorophyll-*a*, and Secchi depth trends

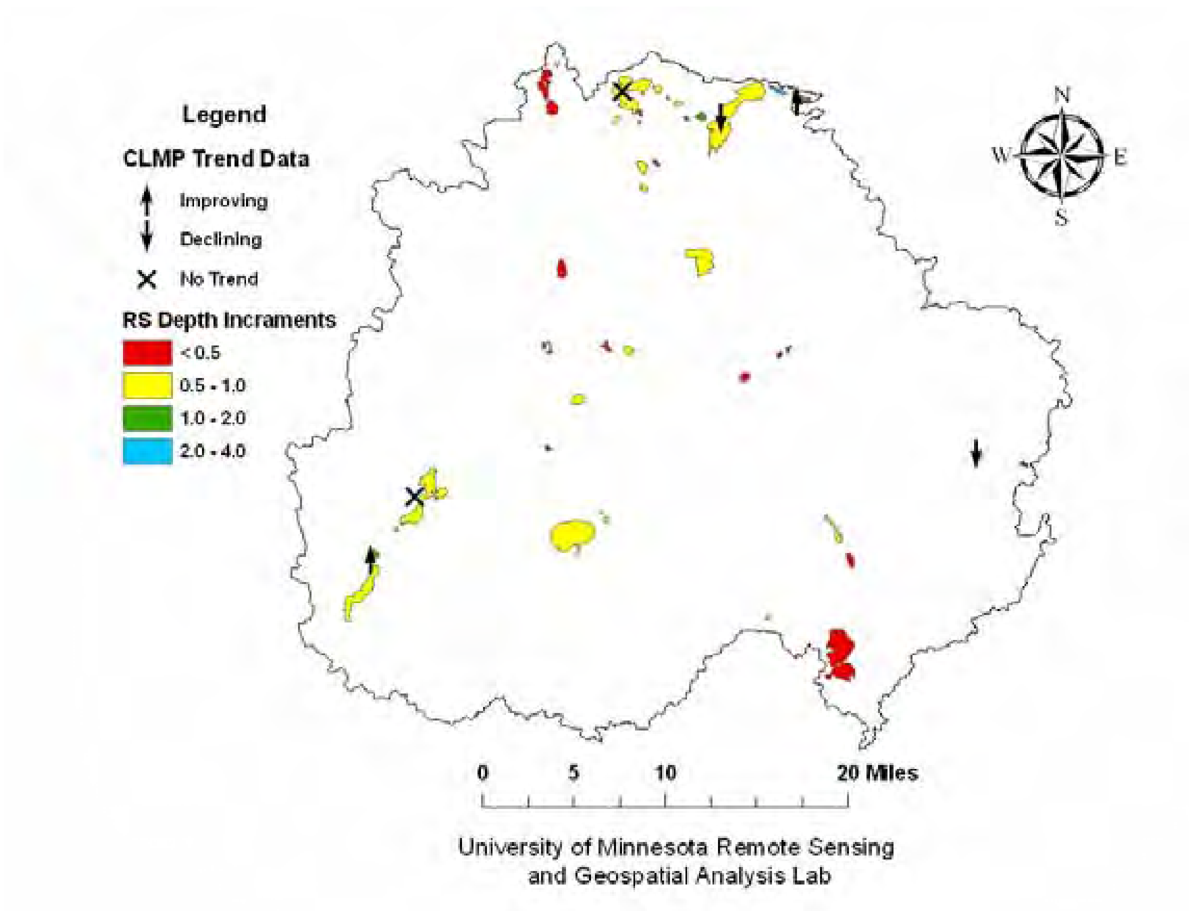


Remote sensing and CLMP trends

Remote Sensing (RS) data has been collected since the early 1970s. The data was provided by the University of Minnesota Remote Sensing and Geospatial Analysis Laboratory. Satellite inferred transparency values have been summarized in five year increments covering 1985-2005 totaling five inferred Secchi results.

Based on available RS data, presented in Figure 54, a majority of the lakes within the watershed have water clarity values below one meter in depth. Only five lakes have clarity greater than one meter and only one lake (Lily) has water clarity greater than two meters. CLMP coverage within the watershed is limited to only six lakes. Of those lakes, only two (Bass and Reeds) indicate a trend of improving water clarity. Upper Elysian and St. Olaf show a trend of declining water clarity. Finally, Lura and Madison Lakes do not indicate a trend of improvement or decline.

Figure 54: Le Sueur River Watershed Remote Sensing water Citizen Lake Monitoring Program trends clarity results and Watershed Summary



Watershed Summary

Lakes within the Le Sueur River watershed display a variety of recreational use conditions. Overall, the majority of these lakes possessing assessment level data have been determined to be non-supporting of recreational use. Of the four lakes (Buffalo, Minnesota, Bass, and Rice) that have insufficient data to complete an assessment, only one (Bass Lake) indicates improving water conditions. However, two lakes within the watershed have been determined to be fully supporting of recreational use.

According to Table 1, the TP and chl-*a* standards for the support of aquatic recreation in lakes within the NCHF ecoregion are less than 40 µg/L and 14 µg/L respectively for deep lakes and less than 60 µg/L and 20 µg/L respectively for shallow lakes. The TP and chl-*a* standards for the support of aquatic recreation in lakes within the WCBP ecoregion are less than 65 µg/L and 22 µg/L respectively for deep lakes and less than 90 µg/L and 30 µg/L respectively for shallow lakes. For chl-*a* levels at or below 30 µg/L, “nuisance algal blooms” (chl-*a* > 20 µg/L) should occur less than ten percent of the summer and transparency should remain at or above three meters (9.8 feet) over 85 percent of the summer.

Reducing levels of TP will be required in order to reduce the occurrence of algal blooms for lakes within the Le Sueur River watershed. Alternatively, should in-lake TP concentrations increase, the potential for nuisance algal blooms will also increase. It is important to limit as much external (watershed) phosphorus loading to the lakes as possible to improve or maintain the current concentrations. Additionally, the watersheds for each of these lakes will need to be addressed through a TMDL study to determine the source and extent of pollution problems.

References

Arneman, H.F. 1963. Soils of Minnesota. University of Minnesota, Agricultural Extension Service and U.S. Department of Agriculture.

Carlson, R.E. 1977. A Trophic State Index for Lakes. Limnology and Oceanography 22:361-369.

'Closest Station' Climate Data Retrieval, October 2008 – September 2009. State Climatology Office, Minnesota Department of Natural Resources. 2010.

Heiskary, S.A. and C.B. Wilson. 2005. "Minnesota Lake Water Quality Assessment Report: Developing Nutrient Criteria." 3rd Ed." MPCA. St. Paul MN 150 pp.

Seaber, P.R., Kapinos, F.P., and Knapp, G.L., 1987, Hydrologic units maps: U.S. Geological Survey Water-Supply Paper 2294, 63 p.

Water Year Precipitation Departure from Normal, October 2008 – September 2009. Map. State Climatology Office, Minnesota Department of Natural Resources. 2010.

Wilson, C.B. and W.W. Walker 1989. Development of lake assessment methods based upon the aquatic ecoregion concept. Lake and Reserve. Manage. 5(2):11-22.

Appendix A

Morphometric Lake characteristics

Lake ID	Lake Name	COUNTY	HUC-11	Ecoregion	Lake Area	Max Depth	Watershed Area	Littoral Area	Littoral %
					acres	Feet	Acres	Acres	
07-0044	Madison	BLUE EARTH	07020011050	NCHF	1,389	59	11,142	722	65
07-0060-01	Eagle (North)	BLUE EARTH	07020011010	NCHF	467	10	9,419	467	100
07-0079	Lura	BLUE EARTH	07020011090	WCBP	1,295	9	2,651	1,295	100
22-0033	Minnesota	FARIBAULT	07020011110	WCBP	1,914	5	5,762	1,914	100
22-0074	Bass	FARIBAULT	07020011090	WCBP	199	20	487	169	84
22-0075	Rice	FARIBAULT	07020011090	WCBP	978	5	14,759	978	100
24-0044	Freeborn	FREEBORN	07020011070	WCBP	2,001	7	7,666	2,001	100
81-0003	St. Olaf	WASECA	07020011010	WCBP	89	30	16,655	61	60
81-0055	Reeds	WASECA	07020011040	NCHF	195	56	534	110	59
81-0083	Buffalo	WASECA	07020011040	WCBP	872	5	-	872	100
81-0095-01	Elysian (Upper - u/s dam)	WASECA	07020011040	NCHF	2,228	13	28,901	100	100

Appendix B

Recent 10 year assessment Lake Chemistry and MINLEAP model-predicted results

	Lake Name	Observed TP Mean	MINLEAP TP	Observed Chl–*a* Mean	MINLEAP Chl-*a*	Secchi Mean	MINLEAP Secchi	Average TP Inflow	TP Load	Background Phos.	Phos. Retention	Outflow	Residence Time	Areal Load
		ug/L	ug/L	ug/L	ug/L	meters	meters	ug/L	kg/yr	ug/L	%	hm3/yr	years	m/yr
07-0044	Madison	78	41	44	15	1	1.6	170	1,036	26	76	6.1	3.1	1.1
07-0060-01	Eagle (North)	170	64	76	29	0.3	1.1	157	790	30	59	5	0.8	2.7
07-0079	Lura	193	72	44	34	1.1	1	557	952	36	87	1.7	4.6	0.3
22-0033	Minnesota	145	137	40	87	0.3	0.6	561	1,960	52	76	3.5	1.1	0.5
22-0074	Bass	57	56	32	24	1	1.2	559	170	28	90	0.3	8	0.4
22-0075	Rice	218	213	46	166	0.5	0.4	568	4,544	50	62	8	0.3	2
24-0044	Freeborn	325	117	120	69	0.2	0.6	562	2,537	37	79	4.5	1.6	0.6
81-0003	St. Olaf	37	43	20	16	1.5	1.5	557	67	24	92	0.1	13.2	0.3
81-0055	Reeds	29	26	12	8	1.8	2.3	209	65	23	87	0.3	11.4	0.4
81-0083	Buffalo	222	-	111	-	0.6	-	-	-	-	-	-	-	-
81-0095-01	Elysian (Upper - u/s dam)	162	60	73	26	0.5	1.1	162	2,520	35	63	15.6	1	1.7