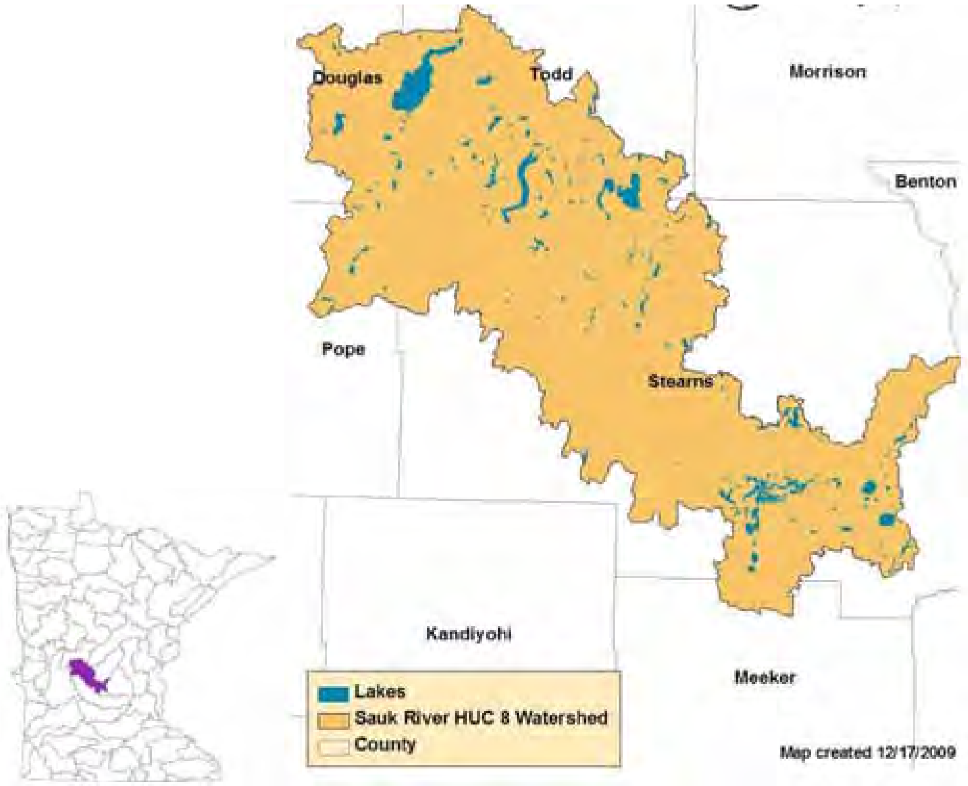
# Assessment Report of Selected Lakes within the Sauk River Watershed

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**Water Monitoring Section**
**Lakes and Streams Monitoring Unit**
**July 2010**


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# Executive Summary

The Sauk River (HUC 8) Watershed is a medium-sized watershed spanning five lake-rich counties in west central Minnesota. Eleven sub-watersheds (HUC 11) comprise the Sauk River HUC 8. A total of 371 established lake basins are in the Sauk River watershed. The report includes a summary of lake water quality related information on the Sauk River Watershed. It also includes detail on each of sub-watershed (HUC 11s) in the Sauk River. Fifty-five lakes in the Sauk River Watershed have some level of assessment. This report includes individual lake summaries on lakes within the watershed that are 200 acres or greater in size and that have assessment data (Table 1).

**Table 1 Lakes assessed in this report**

| HUC 11 Name | Lake Name | Lake ID | County | Area Acres | ARUS |
|---|---|---|---|---|---|
| Adley and Prairie Creeks | Big Birch | 77008400 | TODD | 2095 | |
| Adley and Prairie Creeks | Little Birch | 77008900 | TODD | 829 | Full Support |
| Ashley Creek | Westport | 61002900 | POPE | 199 | Not Support |
| Eden Valley | Eden | 73015000 | STEARNS | 260 | Not Support |
| Getchell Creek | Sand | 73019900 | STEARNS | 210 | Not Support |
| Lower Sauk River | Big Fish | 73010600 | STEARNS | 541 | Full Support |
| Lower Sauk River | Cedar Island (Main Bay) | 73013301 | STEARNS | 420 | Not Support |
| Lower Sauk River | Great Northern | 73008300 | STEARNS | 210 | Not Support |
| Lower Sauk River | Horseshoe | 73015700 | STEARNS | 596 | Not Support |
| Lower Sauk River | Knaus | 73008600 | STEARNS | 309 | Not Support |
| Lower Sauk River | Long | 73013900 | STEARNS | 467 | Not Support |
| Lower Sauk River | North Brown's | 73014700 | STEARNS | 309 | Not Support |
| Lower Sauk River | Pleasant | 73005100 | STEARNS | 219 | Full Support |
| Middle Sauk Rive | Kings | 73023300 | STEARNS | 201 | Full Support |
| Middle Sauk Rive | Uhlenkolts | 73020800 | STEARNS | 240 | Not Support |
| Pearl Lake | Grand | 73005500 | STEARNS | 649 | Full Support |
| Pearl Lake | Pearl | 73003700 | STEARNS | 751 | Not Support |
| Roscoe | Becker | 73015600 | STEARNS | 251 | Full Support |
| Roscoe | Big | 73015900 | STEARNS | 415 | Full Support |
| Upper Sauk River | Fairy | 77015400 | TODD | 324 | Full Support |
| Upper Sauk River | Little Sauk | 77016400 | TODD | 294 | Not Support |
| Upper Sauk River | Maple | 77018100 | TODD | 376 | Not Support |
| Upper Sauk River | Osakis | 77021500 | TODD | 6341 | Not Support |
| Upper Sauk River | SAUK (NORTH BAY) | 77015002 | TODD | 1,701 | Not Support |
| Upper Sauk River | SAUK (SW BAY) | 77015001 | TODD | 430 | Not Support |
| Upper Sauk River | Smith | 21001600 | DOUGLAS | 648 | Not Support |

# Introduction to the Watershed Approach

The Minnesota Pollution Control Agency (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 (8-digit hydrologic unit code). There are 81 major watersheds in Minnesota, and the MPCA has established a schedule for intensively monitoring 6-8 of them annually. With this strategy, we 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 10-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% of the total lake area (greater than 10 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% 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.

Major watersheds are defined by the Minnesota Department of Natural Resources (MDNR) and use a standardized numbering convention called Hydrologic Unit Codes (HUC). HUC is a way of identifying all of drainage basins in the United States in a nested arrangement from largest (basin) to smallest (catchment). A drainage basin is an area or region of land that catches precipitation that falls within that area, and funnels it to a particular creek, stream, river, lake or ocean. MPCA's watershed approach focuses on eight digit HUCs. HUC with fewer digits represent larger HUC systems while HUCs with more digits are smaller components of larger HUCs.

MPCA lake monitoring activities were not yet in line with the watershed approach in 2008, the year MPCA intensively monitored streams in the Sauk River Watershed to assess their condition; however, a great deal of local monitoring has been ongoing for some time in this watershed, so there is still a great deal of information available. This report will describe all available lake data collected by partner agencies, grantees, and citizen volunteers for the Sauk River Watershed to date.

# Sauk River Watershed

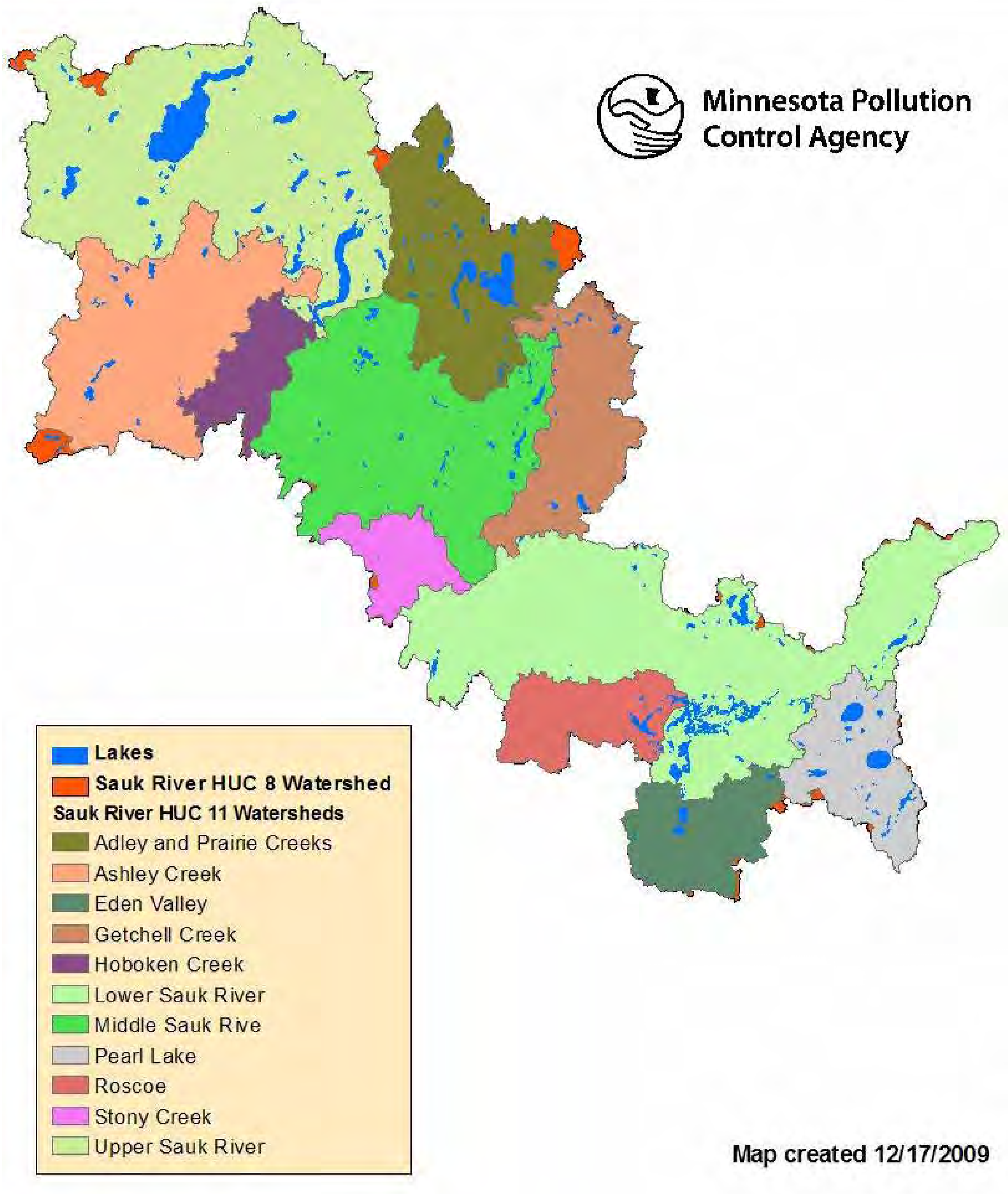
The Sauk River watershed is a part of the Upper Mississippi Basin and is located in the North Central Hardwood Forest (NCHF) ecoregion. This Sauk River watershed eight digit HUC is 07010200. The Sauk River HUC8 has a total area of 270,513 hectares (667,513 acres). . The Sauk River HUC8 The Sauk River is comprised of eleven sub-watersheds classified as 11 digit HUC watersheds shown in Figure 2. The 11 digit HUC's vary in size as well as the amount of lakes located within them (Table 2). The Sauk River flows through the watershed starting in the Upper Sauk moving through the Middle Sauk and draining out of the Lower Sauk into the Mississippi River in St. Cloud.

**Table 2. Sauk River Watershed 11 digit HUC Lake Summary**

| HUC Name | Area /Acres | Total Lakes | Protected Lakes | Lakes >10 Acres | Lake <10 Acres | Full Support | Not Supported | Insufficient Data |
|---|---|---|---|---|---|---|---|---|
| Sauk River HUC 8 | 667,212 | *374 | *168 | *38 | *128 | 13 | 31 | 11 |
| Upper Sauk River | 144,337 | 85 | 40 | 9 | 31 | 1 | 10 | 4 |
| Ashley Creek | 72,152 | 28 | 17 | 7 | 10 | | 1 | |
| Hoboken Creek | 18,155 | 5 | 4 | 1 | 3 | | | |
| Middle Sauk River | 95,181 | 61 | 20 | 3 | 17 | 3 | 3 | 2 |
| Adley and Prairie Creeks | 57,134 | 47 | 22 | 3 | 19 | 2 | | 1 |
| Getchell Creek | 42,616 | 16 | 8 | 8 | 0 | | 1 | 1 |
| Stony Creek | 16,467 | 5 | 4 | 2 | 2 | | | |
| Roscoe | 25,241 | 9 | 4 | 1 | 3 | 2 | | |
| Eden Valley | 27,561 | 8 | 3 | 0 | 3 | | 2 | |
| Pearl Lake | 30,891 | 31 | 12 | 1 | 11 | 3 | 2 | 1 |
| Lower Sauk River | 137,477 | 79 | 34 | 3 | 29 | 2 | 12 | 2 |

*This number includes individually established basins within lakes

**Figure 1 Sauk River 11-digit HUCs**



## Landuse

The Sauk River Watershed is dominated by crop and rangeland with few patches of forest and wetland areas (Figure 2). The eleven digit HUC's have a similar land use composition. Since runoff from cultivated and pastureland is more nutrient-rich than forest or wetland runoff, nutrient loads to rivers and lakes in many of the 11 digit HUCs may be high. A more detailed assessment of land in Sauk River Watershed including: relief, ownership, soil published by the National Resource Conservation Service (NRCS) can be found at http://www.mn.nrcs.usda.gov/technical/rwa/assessments/reports/sauk.pdf.

**Figure 2 Land use the Sauk River HUC 11 watersheds**

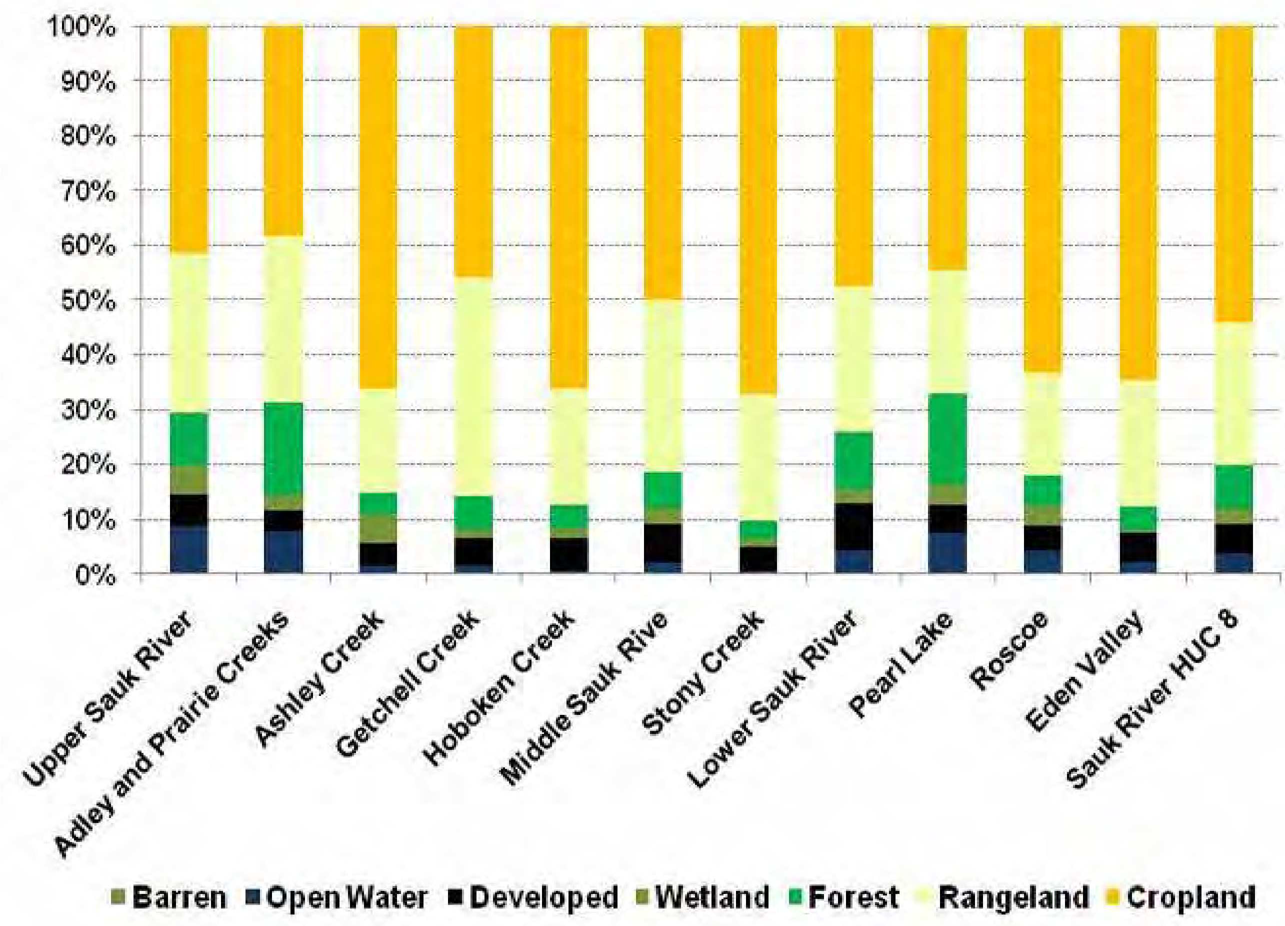
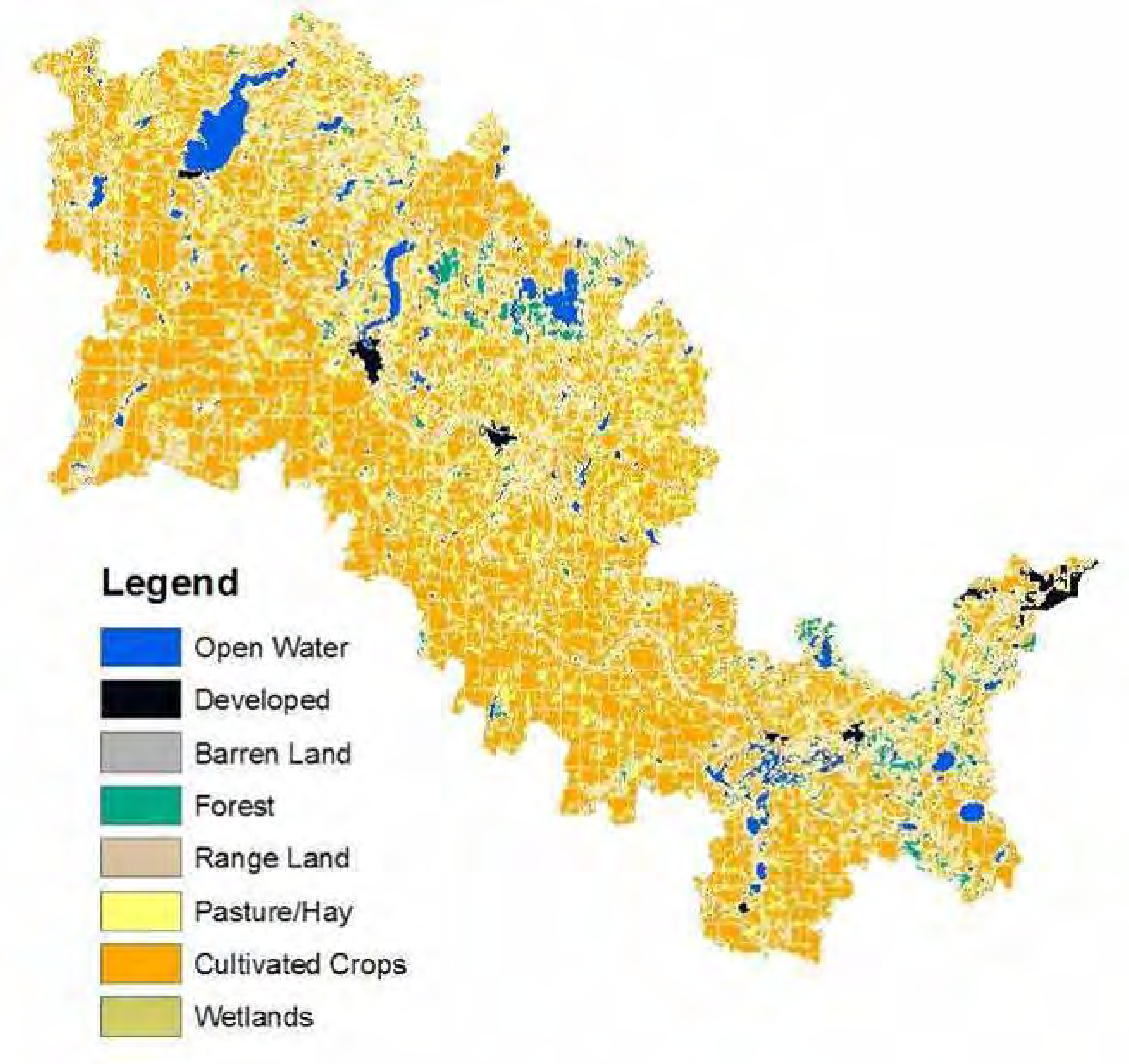


**Figure 3. Land use the Sauk River HUC 11 watersheds**



## Climate

The most recent water year precipitation summary (Oct. 2008- Sept. 2009) shows normal to slightly dryer condition (Figure 2). Water year precipitation ranged from 24 to 32 inches across the Sauk River Watershed (Figure 2). Monthly average temperature and precipitation information was taken from Sauk Centre (station kd39) from 1990 to 2009. Precipitation in the watershed ranges from 25 to 29 inches each year. Evaporation estimates are between 36 to 37 inches annually Minnesota State Climatologists Office, 1999).

**Figure 4. Summary of 2008 climate and hydrological data**

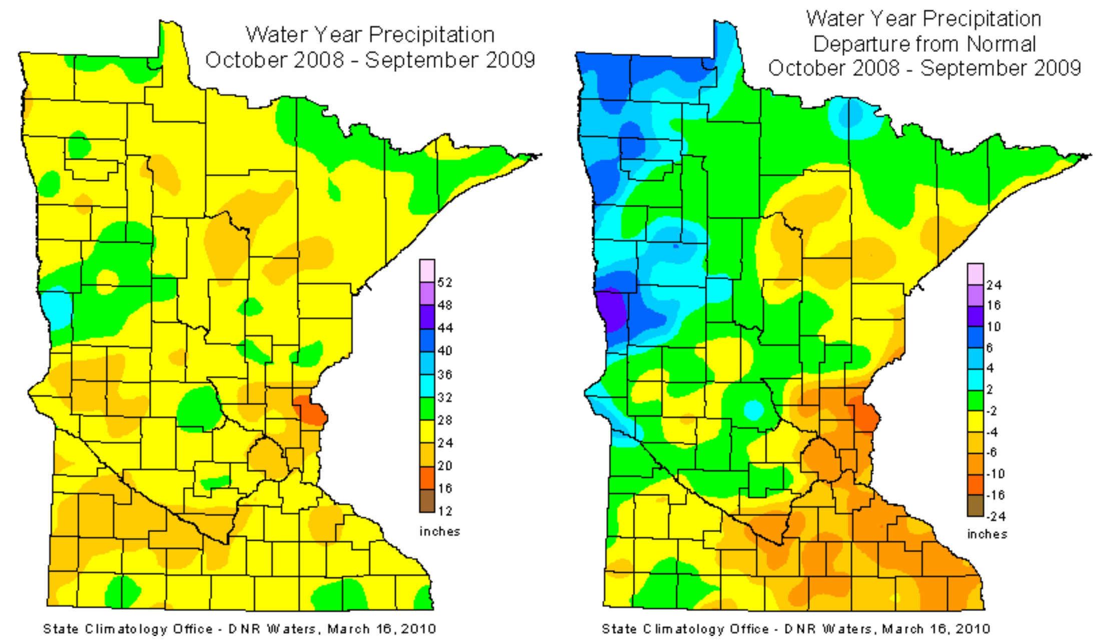
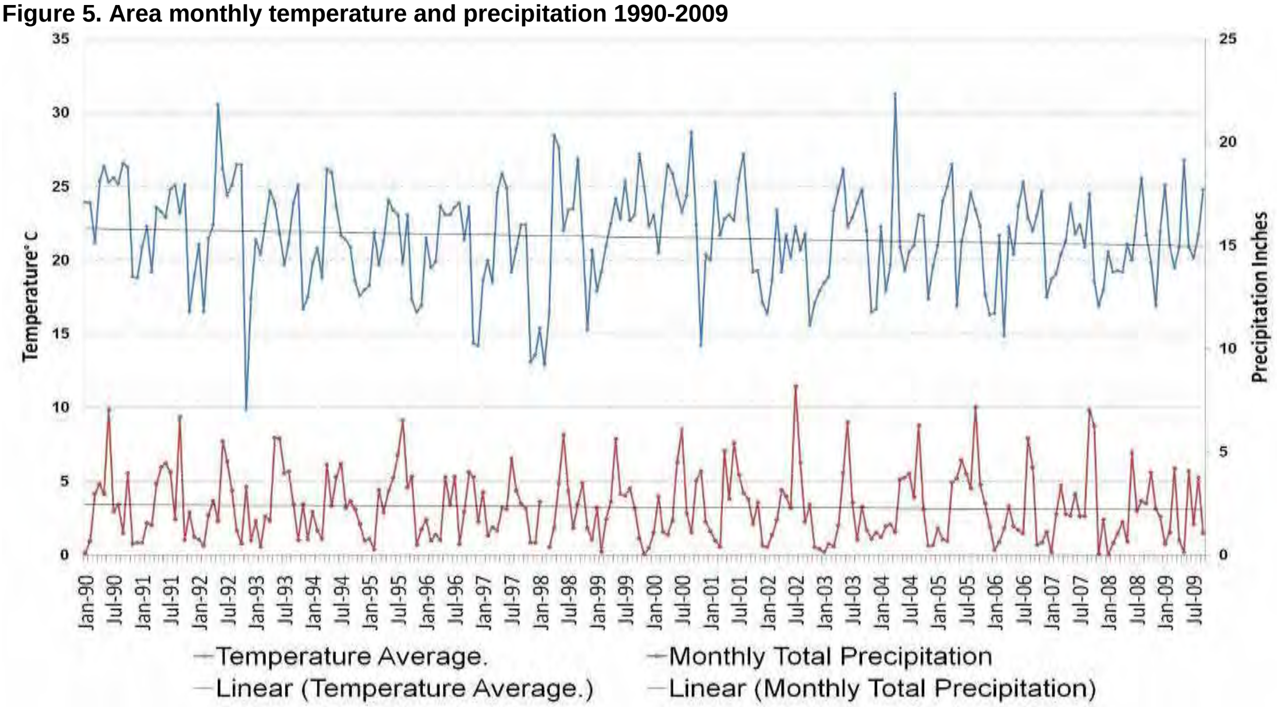


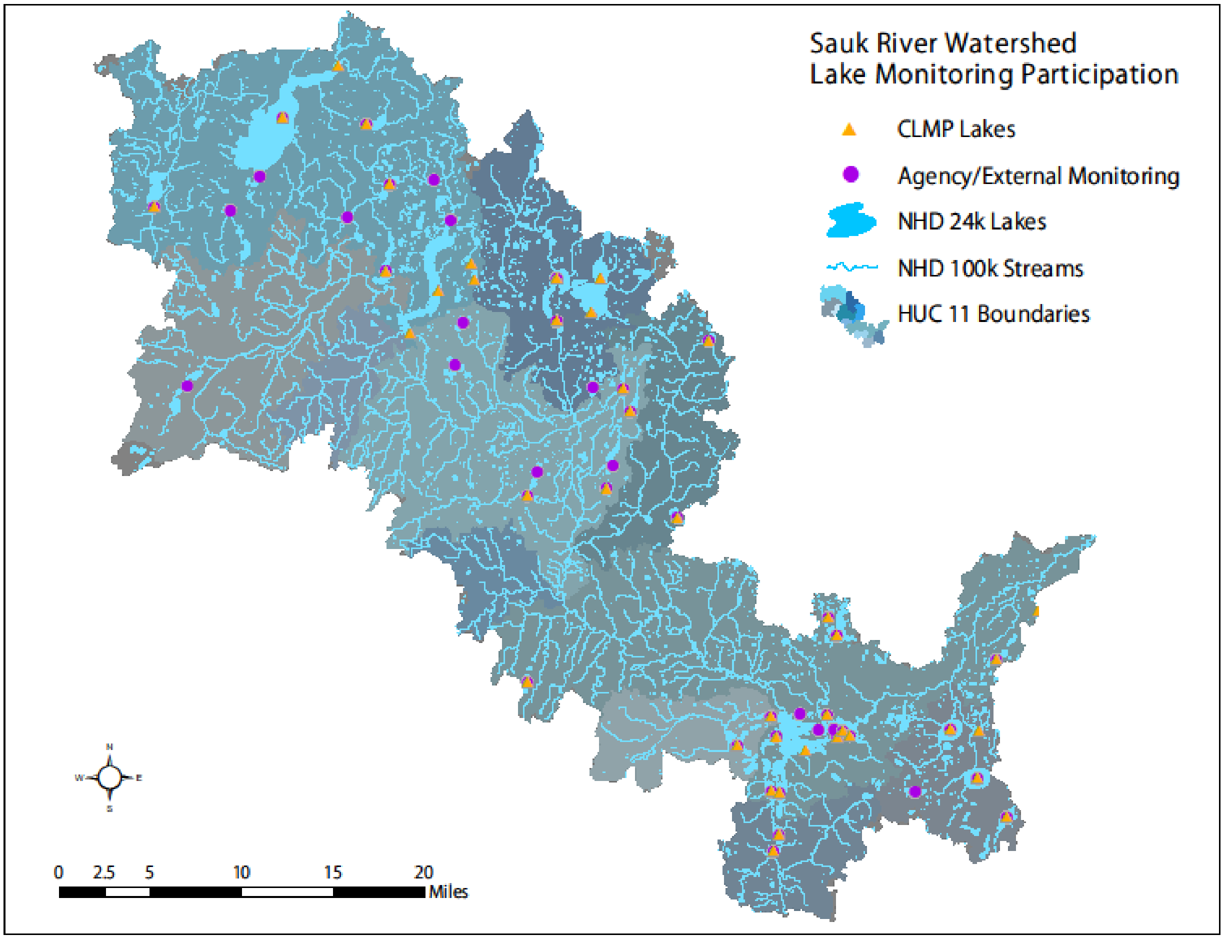

**Figure 5. Area monthly temperature and precipitation 1990-2009**



# Lake Monitoring in the Sauk River Watershed

There has been extensive monitoring of surface waters in the Sauk River HUC 8. Some areas such as the Horseshoe Chain of Lakes (also referred to as the Sauk River Chain of Lakes) have a particularly robust monitoring history. Volunteers enrolled in the MPCA's Citizens Lake Monitoring Program (CLMP) have done the majority of the lake monitoring in the Sauk River HUC. Volunteer efforts are largely focused on taking water clarity readings using a tool called a Secchi disk. This program has been ongoing for over 30 years, and there are many lakes in Minnesota for which we have long periods of Secchi records. These records help us understand water quality trends over time. The MPCA assesses lake condition to determine if it is suitable for aquatic recreation. Heavy loading of nutrients to lake stimulates algal growth, which in turn reduces water clarity. For this reason, we focus lake monitoring efforts and assessments on concentrations of total P and chl-a (measurement of algal) and also pair this data with Secchi readings.

**Figure 6 Sauk River Major (HUC 8) Watershed Description**



# Background to Lake Assessments

## Lake Mixing

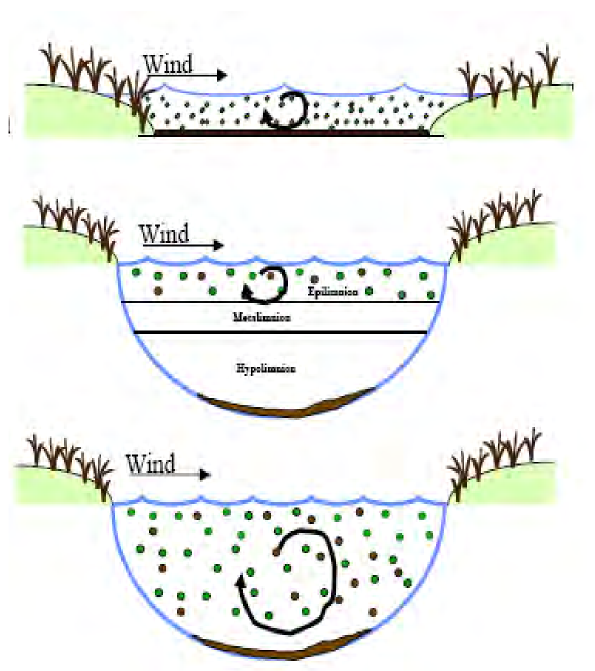
Lake depth can have a significant influence on lake processes and water quality. One such process is thermal stratification (formation of distinct temperature layers), in which deep lakes (maximum depths of 9.1 – 12.1 meters (30 - 40 feet) or more) often stratify (form layers) during the summer months and are referred to as dimictic (Figure 7). These lakes fully mix or turn over twice per year, typically in spring and fall. Shallow lakes (maximum depths of 4.6 meters (15 feet) 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. It can also identify the depth of the thermocline (zone of maximum change in temperature over the depth interval). 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 environment in the hypolimnion is conducive to the release of total phosphorus (TP) from the lake sediments. During stratification, dense colder hypolimnion waters are separated from the nutrient hungry-*a*lgae in the epilimnion. Mixing events allow the nutrient-rich sediments to be re-suspended and available to algae. Most of the fish in the lake are usually found in the epilimnion or near the thermocline.

**Figure 7. Lake stratification**

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

**Dimictic Lake**
**Deep, form layers,**
**Mixes Spring/Fall**

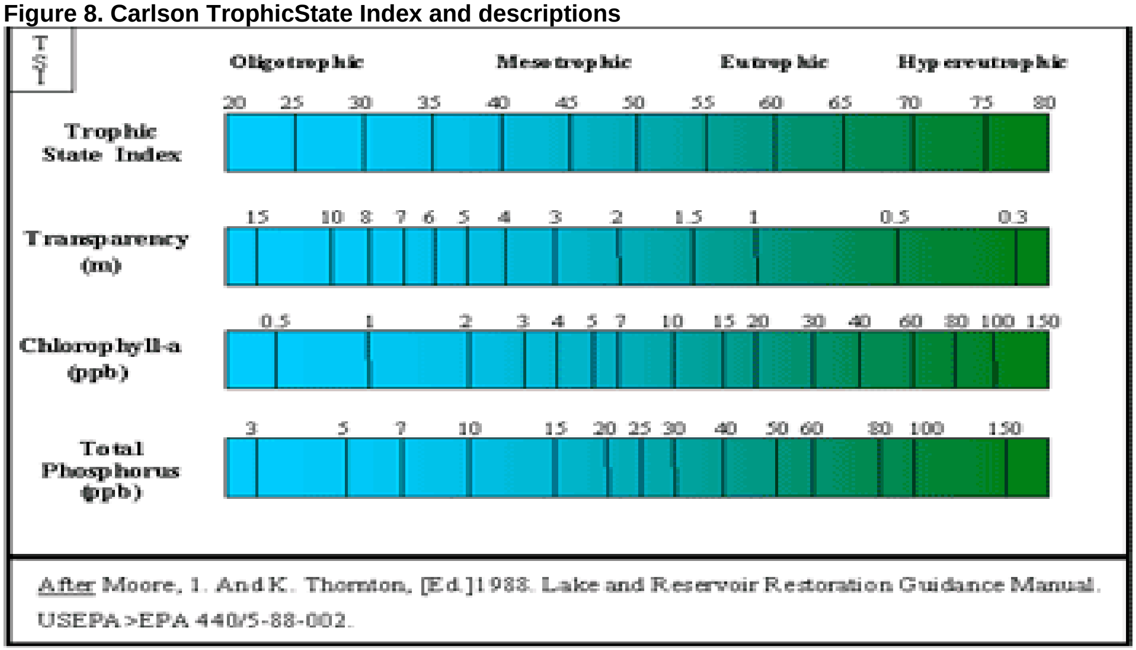
**Intermittently Stratified**
**Moderately deep**
**Mixes during high winds**
**Spring, Summer, & Fall**



## Trophic Status Indicators

Trophic state is defined as the total weight of living biological material (biomass) in a water body at a specific location and time. A frequently used biomass-related index is the Carlson Trophic State Index or TSI (Carlson 1977). It is relatively simple to use, requires a minimum of data, and is generally easy to understand, both in theory and in use. It is numerical, but the traditional nutrient-related trophic state categories fit into the scheme. The range of the index is from approximately zero to 100, although the index theoretically has no lower or upper bounds. The index has the advantage over the use of the raw variables in that it is easier to memorize units of 10 rather than the decimal fractions of raw phosphorus or chlorophyll values.

**Figure 8. Carlson TrophicState Index and descriptions**




| | |
|---|---|
| TSI <30 | Classic oligotrophy; Clear water, oxygen through the year in the hypolimnion, salmonid fisheries in deep lakes. |
| TSI 30-40 | Deeper lakes still exhibit classical oligotrophy, but some shallower lakes will become anoxi in the hypolimnion during the summer. |
| TS 40-50 | Water moderately clear, but increasing probability of anoxia in hypolimnion during summer |
| TS 50-60 | Lower boundary of classical eutrophy: Decreased transparency, anoxic hypolimnion during the summer, macrophyte problems evident, and warm-water fisheries only. |
| TSI 60-70 | Dominance of blue-green algae, algal scums probable, extensive macrophyte problems. |
| TSI 70-80 | Heavy algal blooms possible throughout the summer, dense macrophyte beds, but extent limited by light penetration. Often would be classified as hypereutrophic. |
| TSI > 80 | Algal scums, summer fish kills, few macrophytes, dominance of rough fish. |

## 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.

In the watershed-scale reports, the Minnesota Lake Eutrophication Analysis Procedures (MINLEAP) model (Wilson and Walker, 1989) is used to place the observed condition of the lakes in perspective. 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 Sauk 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 all lakes with assessment-level detail and will be discussed in detail in the individual lake section.

## 303(d) Assessments

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 Aquatic Recreational Use Suitability (ARUS) of Minnesota lakes. Table 3 lists the assessment criteria used for lakes based on ecoregional expectations. Values for the NCHF ecoregion were used for assessing lakes within the Sauk River HUC-8 watershed. Lake-specific results for lakes within this watershed that have been assessed in the appropriate HUC-11 watershed sections later in this report.

**Table 3. Minnesota lake eutrophication standards by ecoregion and lake type (Heiskary and Wilson, 2005) and 2010 303(d) assessment values.**

| Ecoregion | TP ppb | Chl-*a* ppb | Secchi meters |
|---|---|---|---|
| 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 |

# Methods

Water chemistry and Secchi data used in this report was taken for the MPCA's STORET database. The data was collected by a variety of organizations including: Stearns County Soil and Water Conservation District Sauk River Watershed District, MPCA and CLMP volunteers. In most cases lake samples collected at the lake's maximum depth using an integrated sampler (a poly vinyl chloride (PVC) tube 2 meters in length, with an inside diameter of 3.2 centimeters) a surface grab sample. Sampling methods are similar among the groups and are described in MPCA Standard Operating Procedure for Lake Water Quality document, found at http://www.pca.state.mn.us/publications/wq-s1-16.pdf . The Water quality data analysis for each of the addressed lakes generally includes: (where available) most recent temperature and Dissolved Oxygen (DO), TP, chl-*a* and Secchi. The analysis includes long-term summer means and standard error (SE). A large SE implies either high variability among seasonal measures and/or that very few measures were taken. Sample analysis was done at the analysis was performed by the laboratory of the Minnesota Department of Health (MDH), or other certified labs using United States Environmental Protection Agency-*a*pproved methods. The MDH laboratory methods are detailed in table 4.

The CLMP program provides monitoring equipment to over 900 volunteers throughout the state. These volunteers take multiple monthly clarity readings from May to September each year. The volunteer reading are vital in filling in gaps where we do not have chemistry data as well as looking at long term trends. To determine Secchi transparency trend results, all available Secchi data were extracted from STORET, the U.S. EPA's national water quality database. The statistical software package Systat was used to perform the Seasonal Kendall test to determine whether the data for each lake exhibit increasing or decreasing trends, as well as other non-parametric statistical tests.

Remote sensing (RS) data was also used to address lakes with no sampling or Secchi data. RS data consist of satellite imagery calibrated to in lake transparency results. MPCA contracted with the University of Minnesota to estimate water clarity statewide using 2005 Landsat satellite imagery. Methods can be found in Olmanson (2008) and http://www.water.umn.edu/.

Table 4. Minnesota Department of Health laboratory information

| Parameter | Reporting Limit & Units | Method number | Precision: [1] mean difference | Difference as Percent of observed |
|---|---|---|---|---|
| Total Phosphorus | 3.0 µg/L | EPA365.1 | 4.8 µg/L | 2.7 % |
| Chlorophyll-a | | SM10200H | 1.7 µg/L | 7.4 % |
| Pheophytin | | SM10200H | -- | -- |

# 11 Digit HUC discussions

The Sauk River HUC 8 is comprised eleven sub-watersheds (HUC 11). There are similarities and contrasts among the HUC 11's (table 2). This section summarizes each of the HUC 11's, describing the watershed and each lake, detailing the assessment of the larger lakes.

# Upper Sauk River HUC 11

The Upper Sauk watershed drains to the southeast out of Lower Sauk Lake and is the largest of the 11 digit HUCs in the Sauk River watershed. Land use in the Upper Sauk is similar to the other HUC 11s in the Sauk River (Figure 8). The Upper Sauk River has many lakes including some of the larger lakes in the Sauk River HUC 8. Several lakes are better defined as riverine lakes (wide spots on the river) and/or reservoirs (main stem impoundments controlled by a dam), including: Guernsey, Little Sauk, Juergens, and Sauk Lakes. There are fifteen lakes in the Upper Sauk River HUC 11 that have level of Assessment data. Two separate TMDL projects are on in the Upper Sauk, studding the source and solutions to water quality impairments. One project includes Clifford, Smith, Fairy and Osakis Lakes and another includes North and South Sauk Lakes. Both TMDL studies are targeted for completion in 2010. Following are discussions for seven lakes in the Upper Sauk: Little Sauk, Maple, Osakis, Sauk (N Bay) Sauk (SW Bay), Smith, and Fairy.

**Figure 9. Upper Sauk**

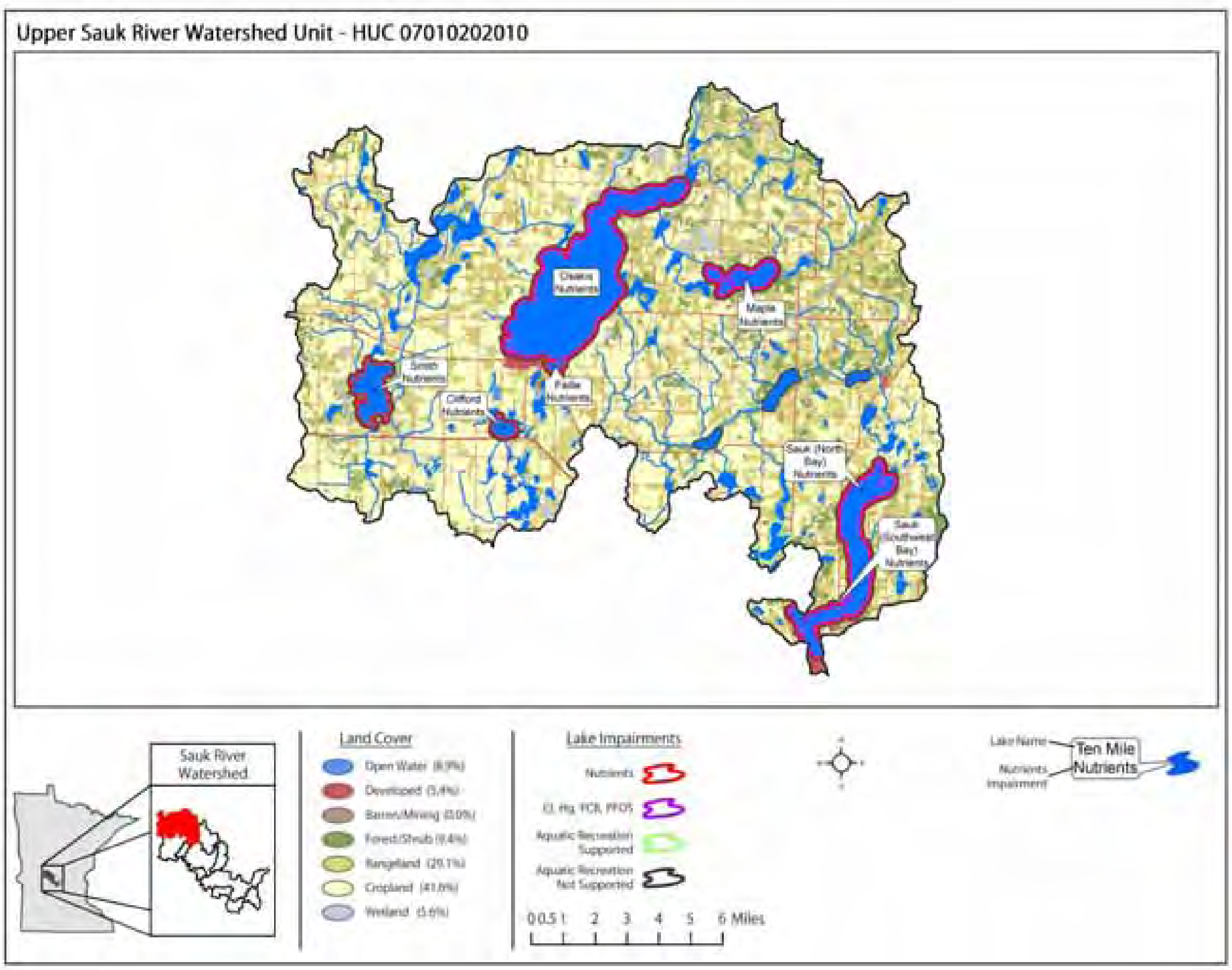


**Table 5. Upper Sauk lakes >10 acres information and status**

| Name | DOW# | County | Area (acres) | % Littoral | Avg. Depth (M) | Max. Depth (M) | ARUS | Trophic Status | Mean TP (µg/L) | Mean chl-*a* (µg/L) | Secchi Mean (M) | CLMP Trend | RS 2005 | RS Trend |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Osakis | 77021500 | TODD | 6341 | 55 | 17 | 67 | NS | E | 54 | 28 | 2 | NT | | |
| Sauk | 77015000 | TODD | 2137 | 13 | | 59 | | | | | | | 1.2 | NT |
| SAUK (N Bay) | 77015002 | TODD | 2137 | | 18 | 61 | NS | E | 54 | 35 | 2 | ↗ | | |
| SAUK (S Bay) | 77015001 | TODD | 2137 | | 7 | 18 | NS | H | 116 | 60 | 1 | ↘ | | |
| Smith | 21001600 | DOUGLAS | 648 | 47 | 14 | 36 | NS | E | 48 | 32 | 2 | NT | | |
| Maple | 77018100 | TODD | 376 | 41 | | 21 | NS | E | 81 | 46 | 2 | NT | | |
| Fairy | 77015400 | TODD | 324 | 47 | | 36 | FS | M | 21 | 8 | 3 | ↗ | | |
| Little Sauk | 77016400 | TODD | 294 | 60 | 11 | 29 | NS | E | 55 | 47 | 1 | | 1.1 | NT |
| Long | 77014900 | TODD | 176 | 45 | 16 | 36 | | | | | | | 2.8 | NT |
| Clifford | 21000300 | DOUGLAS | 164 | | | | NS | H | 308 | 20 | 1 | | 1.0 | NT |
| Herberger | 21000700 | DOUGLAS | 156 | | | | | | | | | | 1.6 | NT |
| LONG | 77014901 | TODD | 141 | | | 36 | ID | M | | | 4 | ↗ | | |
| Cedar | 77016000 | TODD | 137 | 60 | 15 | | | | | | | | 2.8 | NT |
| Guernsey | 77018200 | TODD | 132 | 94 | 7 | 19 | NS | E | 70 | 45 | 1 | | 0.9 | NT |
| Juergens | 77016300 | TODD | 117 | 76 | 9 | | NS | E | 80 | 45 | 1 | | 1.3 | NT |
| Bird | 21001800 | DOUGLAS | 113 | | | | | | | | | | 1.4 | NT |
| Little Osakis | 77020100 | TODD | 112 | 34 | | | ID | M | | | 4 | | 2.5 | NT |
| Long | 77035700 | TODD | 102 | 60 | 10 | | | | | | | | 1.8 | NT |
| Unnamed | 21002500 | DOUGLAS | 98 | | | | | | | | | | 0.9 | NT |
| William | 77018000 | TODD | 78 | | | | | | | | | | 1.5 | NT |
| Lily | 77035800 | TODD | 61 | 50 | 15 | | | | | | | | 3.0 | ↗ |
| Faille | 77019500 | TODD | 58 | 100 | | | NS | H | 173 | 28 | 1 | | 1.8 | NT |
| Unnamed | 21000100 | DOUGLAS | 49 | | | | | | | | | | 2.0 | NT |
| Mud | 77015100 | TODD | 47 | 100 | | | ID | E | 67 | 11 | 2 | | 1.6 | NT |
| Gulden | 21000600 | DOUGLAS | 46 | | | | | | | | | | | |
| South Twin | 73027600 | STEARNS | 46 | | | | | | | | | | 1.7 | ↗ |
| Mud | 77016200 | TODD | 46 | 100 | | | | | | | | | 0.8 | NT |
| Deer | 77009300 | TODD | 38 | 69 | | | | | | | | | 1.8 | ↗ |
| Unnamed | 77018300 | TODD | 37 | | | | | | | | | | 0.5 | NT |
| Beim | 77020000 | TODD | 36 | 100 | | | | | | | | | 1.9 | NT |
| Unnamed | 21003900 | DOUGLAS | 36 | | | | | | | | | | 1.2 | NT |
| LONG (S BAY) | 77014902 | TODD | 35 | | | 20 | ID | M | | | 3 | ↗ | | |
| Unnamed | 77025900 | TODD | 34 | | | | | | | | | | 1.5 | |
| Unnamed | 77019600 | TODD | 33 | | | | | | | | | | 1.8 | NT |
| Unnamed | 77015700 | TODD | 33 | | | | | | | | | | 1.3 | NT |

| Name | DOW# | County | Area (acres) | % Littoral | Avg. Depth (M) | Max. Depth (M) | ARUS | Trophic Status | Mean TP (µg/L) | Mean chl-*a* (µg/L) | Secchi Mean (M) | CLMP Trend | RS 2005 | RS Trend |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Unnamed | 77020200 | TODD | 31 | | | | | | | | | | 1.8 | NT |
| Spier | 77014800 | TODD | 31 | | | | | | | | | | 1.8 | |
| Unnamed | 73027500 | STEARNS | 30 | | | | | | | | | | 1.3 | NT |
| Twin Island | 77016600 | TODD | 29 | | | | | | | | | | 1.8 | NT |
| Stowe | 21002000 | DOUGLAS | 24 | | | | | | | | | | 0.5 | ↘ |
| Stevens | 21002200 | DOUGLAS | 22 | | | | | | | | | | 2.5 | NT |
| North Twin | 77015800 | TODD | 21 | | | | | | | | | | | |
| Unnamed | 77017400 | TODD | 19 | | | | | | | | | | | |
| Unnamed | 77015200 | TODD | 17 | | | | | | | | | | | |
| Unnamed | 77015500 | TODD | 16 | | | | | | | | | | 1.0 | ↗ |
| Platt | 77019000 | TODD | 15 | | | | | | | | | | | |
| Clear | 77015300 | TODD | 14 | | | | | | | | | | | |
| Unnamed | 77016800 | TODD | 14 | | | | | | | | | | | |
| Unnamed | 77035400 | TODD | 13 | | | | | | | | | | | |
| Unnamed | 73050400 | STEARNS | 13 | | | | | | | | | | 1.3 | |
| Plum Marsh | 77016500 | TODD | 12 | | | | | | | | | | | |

↘ decreasing/declining trend ↗ increasing/improving trends NT No Trend ID Insignificant Data
FS Full Support NS none supporting HE hypereutrophic E Eutrophic M Mesotrophic O Oligotrophic

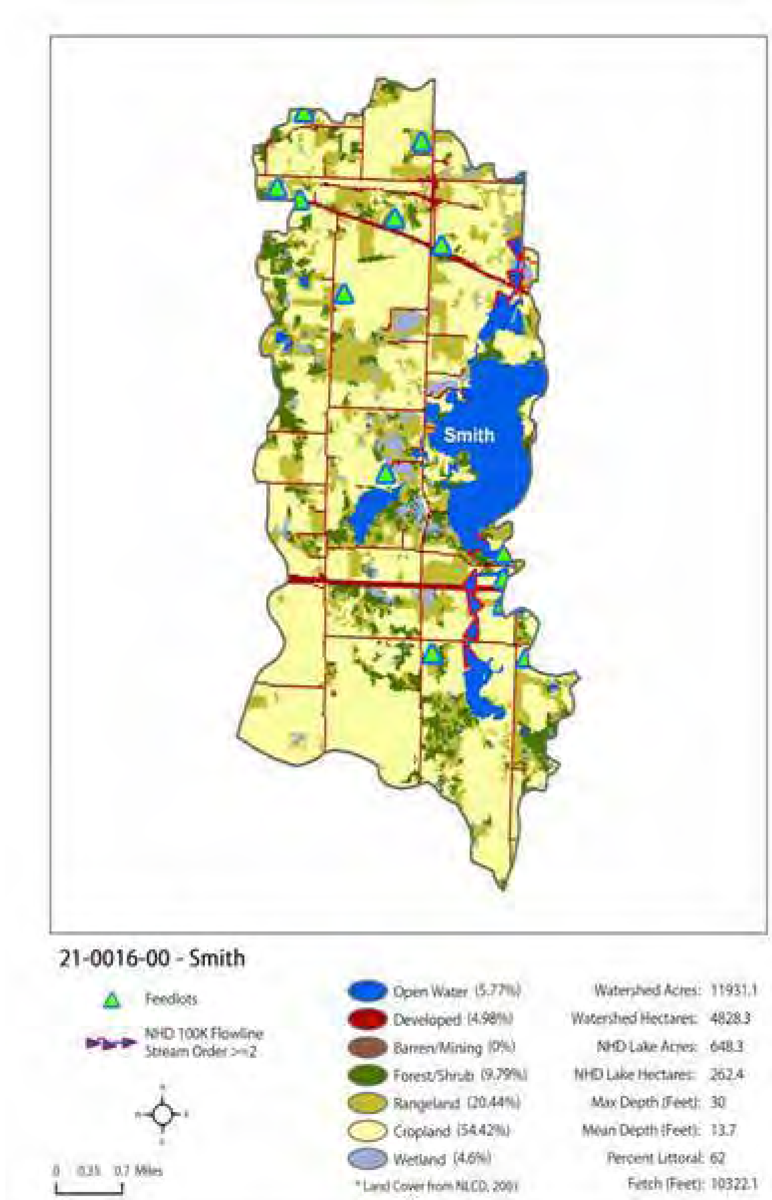
# Smith Lake 21-0016

**Figure 10. Smith Lake bathymetry**

Smith Lake is located just north of I-94 between Alexandria and Osakis. The lake has a long water quality monitoring record going back to 1974. Smith Lake was part of the MPCA's ecoregion reference lake monitoring effort in the mid 1980s. The lake was assessed in a 2000 MPCA report on water quality located on the web at http://www.pca.state.mn.us/water/lakereport.html.

Smith Lake is a classified as a deep lake based on maximum depth and littoral area. The lake's catchment (area draining to it) is comprised of mostly of crop and rangeland including 13 registered feedlots (Figure 13).

**Figure 11.Smith Lake catchment and landuse map**



**Water Quality Summary**
The most recent profile data (2000) and TSI data (2008-2009) were used in this assessment.

Weak thermal stratification was evident in most 2000 profiles. A thermocline was evident in mid-June at four to six meters (Figure 12). DO values in the upper 6 M remained above 5mg/L. Hypoxic (DO <2.0 mg/L) conditions were present in the lower depth throughout the 2000 monitoring. These periods of low or no-DO near the sediments allow for internal recycling of phosphorus (P) from the sediments, which can contribute to elevate TP in the upper waters upon wind mixing.

TP, chl-*a* and Secchi indicate eutrophic condition varied within each and among the two years. TP was low in May and June of 2008 and then increased markedly in July and September. Chl-*a* responded to the increase resulting in severe nuisance blooms evident in July and August. In 2009, TP was high in May, declined in June but increased steadily thereafter. Secchi responded directly to changes in chl-*a*. The patterns observed in Smith, though variable, are consistent with intermittingly mixing lakes. Intermittent mixing may allow P-rich bottom waters to mix with surface water, which promotes algal growth.

**Figure 12. Smith Lake temperature profiles**

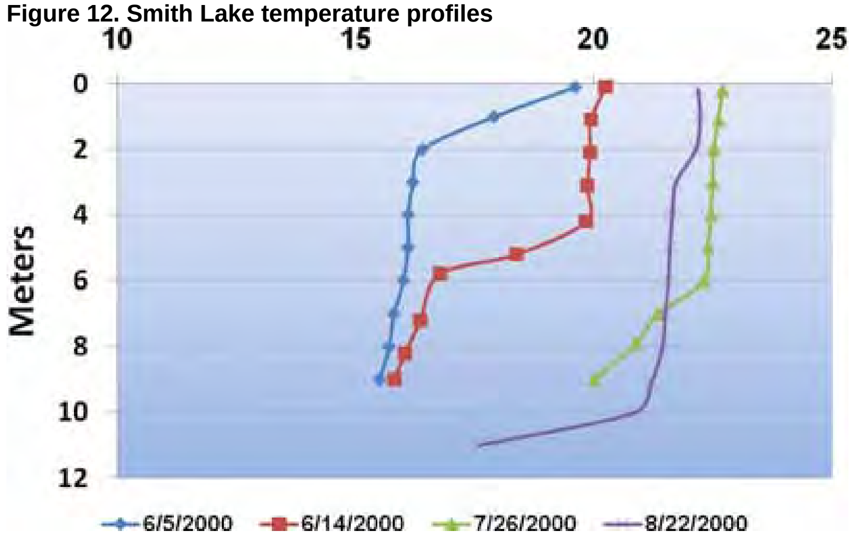



**Figure 13. Smith Lake DO profiles**

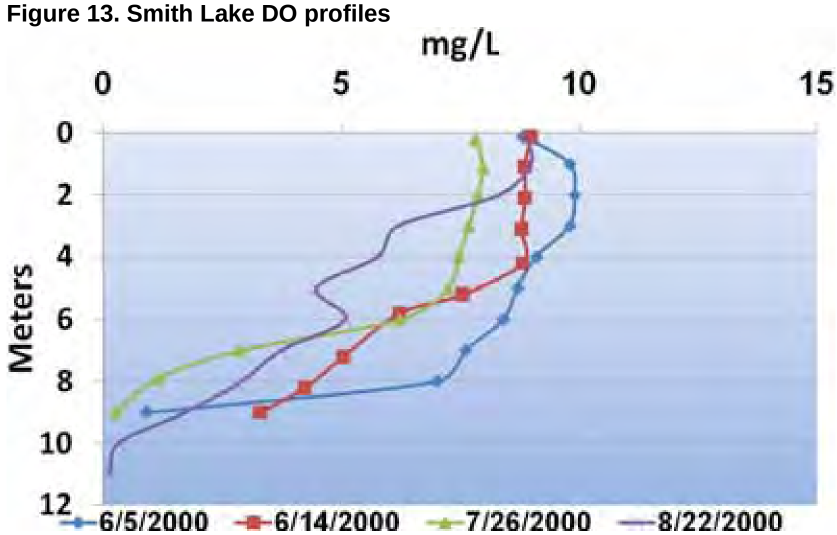
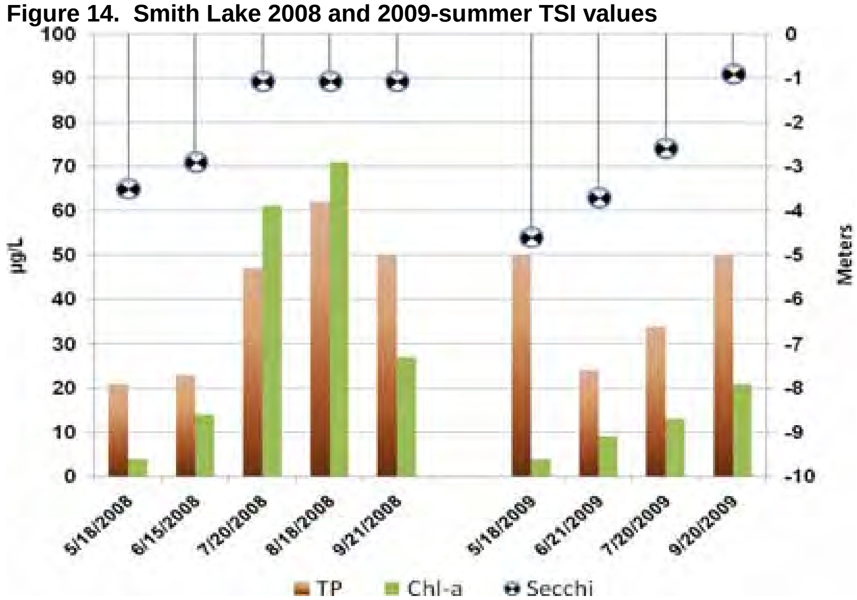



**Figure 14. Smith Lake 2008 and 2009-summer TSI values**



## Water Quality Trends

Smith Lake's data record extends from the 1970s to 2008; though it is a discontinuous record (Figure 15). TP measurements in the 1980s were approximately 60-70 µg/L as compared to 40-55 µg/L in 2000-2009. Over these same years chl-*a* is variable no trend is apparent (Figure 15). Secchi has been in the 1.0-1.5 m range over most years of record and no trend is evident. Remote sensing data concur with this finding and indicate no trend over time.

## Modeling and Assessment Status

Smith Lake was assessed as non-supporting of aquatic recreational uses and was included in the 2004 303(d) "impaired waters" list for aquatic recreation because of nutrient over- enrichment (Figure 16). The final Total Maximum Daily Load (TMDL) study report is scheduled to be completed in 2010. MINLEAP modeling indicates observed TP, chl-*a* and Secchi are in the range of predicted (Figure 16). Estimated background TP is lower than MINLEAP-predicted and observed TP.

**Figure 15. Smith Lake long-term water quality trends**

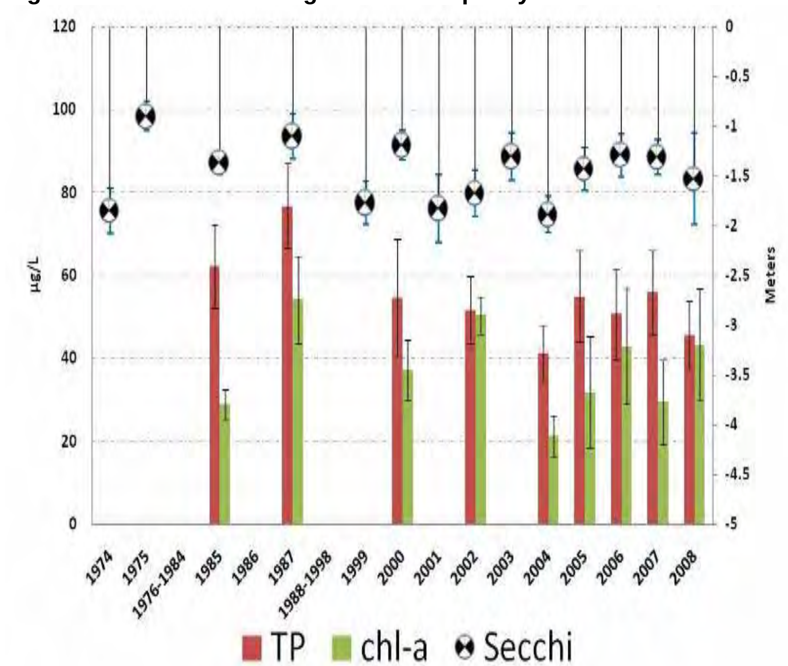
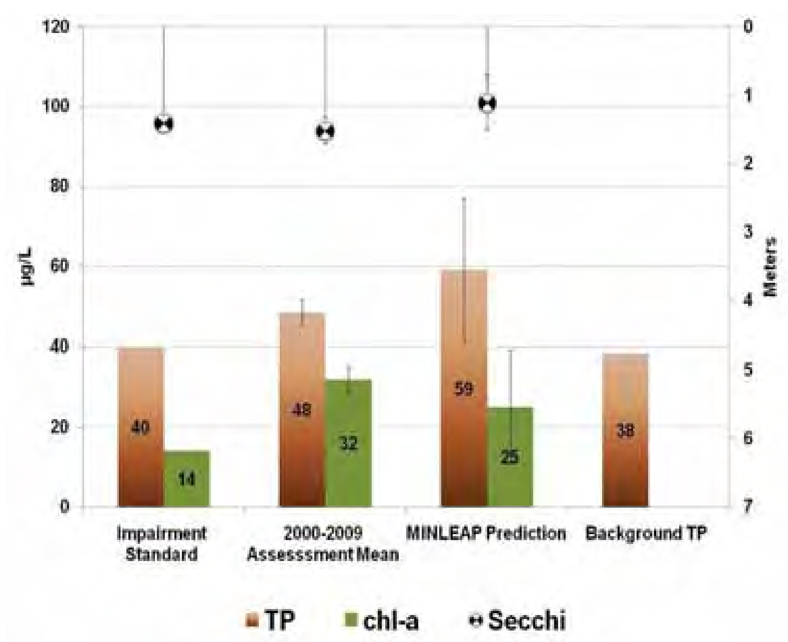



**Figure 16. Smith Lake modeling and assessment information**

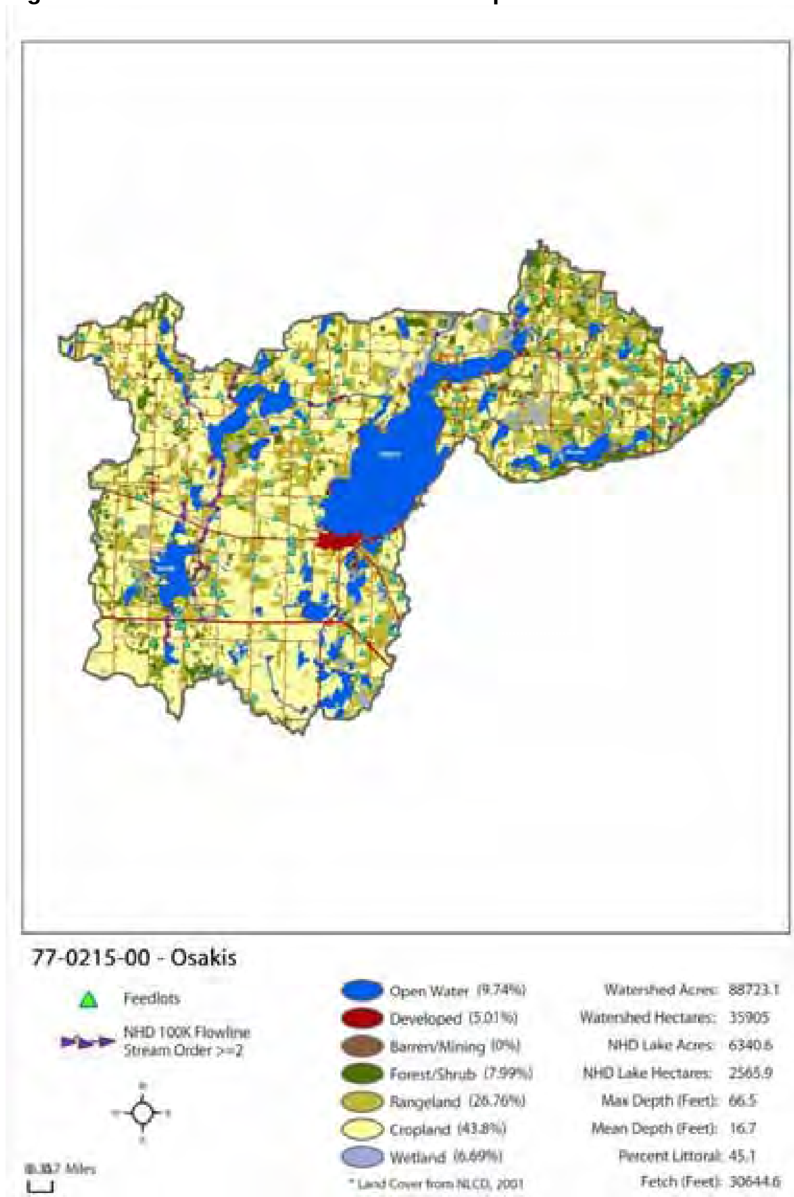


# Osakis 77-0215

Lake Osakis is a very popular lake and has a productive fishery. It has a long history of water quality monitoring and improvement projects.

It is the largest lake in the Sauk River Watershed at 6,341 acres, of which half is littoral. The 82,383-acre lake catchment consists mostly of crop and rangeland as well as numerous small lakes.

**Figure 17 Lake Catchment and landuse map**



## Water Quality Summary

The most recent profile data (2009) and TSI data for 2006 and 2009 from site 102 were used in this assessment.

In 2009 Osakis had a strong thermocline at 7-9 meters on June 17th (Figure 18). Temperature stratification was evident through early August. DO levels were mixed through the water column in early June. Significant declines in DO below the thermocline was observed in mid June and early July (Figure 19).

TP and chl-*a* values were much lower in 2009 as compared to 2006 (Figure 20). In 2009 TP remained stable and lower when the lake was stratified; however, following mixing TP increased (Figure 20). Chl-*a* increased and Secchi decreased in response to the increased TP. Overall TSI values show the lake to be eutrophic.

**Figure 18 Osakis Lake temperature profiles 2009**

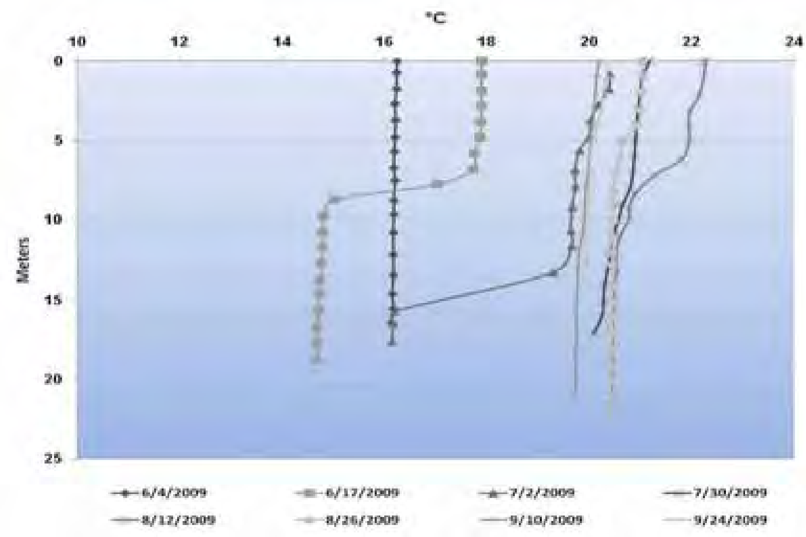



**Figure 19 Osakis Lake DO profiles**

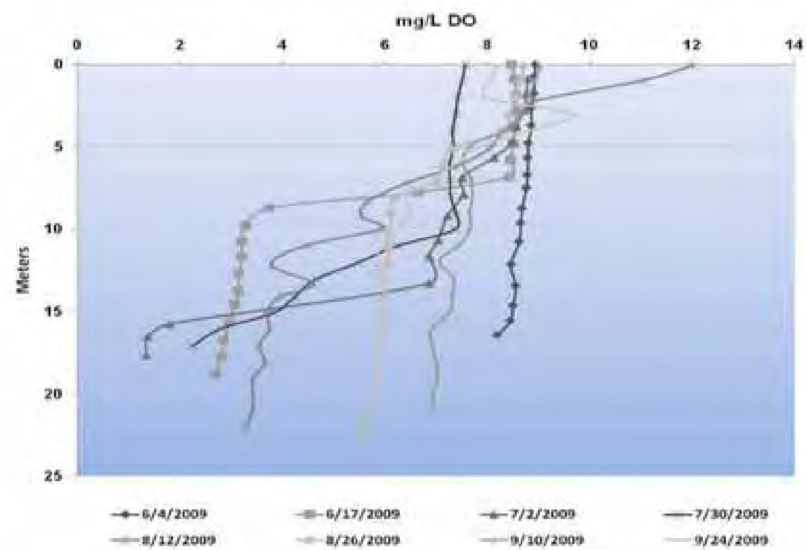
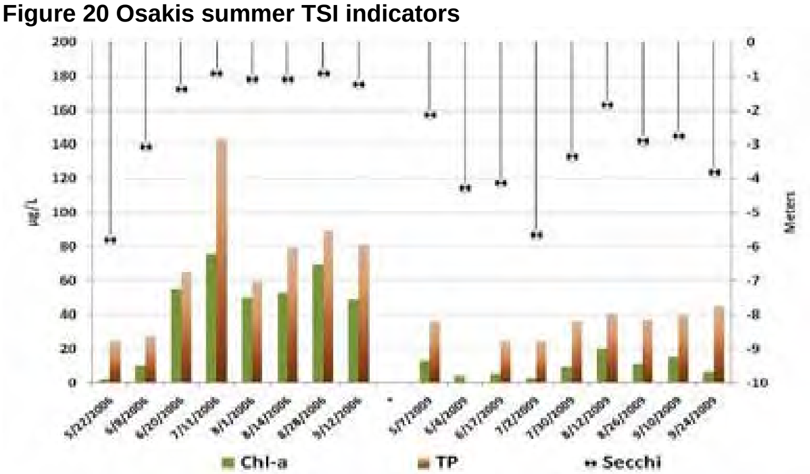



**Figure 20 Osakis summer TSI indicators**




## Water Quality Trends

Long-term records go back to 1950 on Lake Osakis. No overall trend is evident in any of the trophic indicators (Figure 21). Summer-mean TP is quite variable ranging from 30-60 µg/L in most summers. Likewise chl-*a* and Secchi are quite variable as well.

## Modeling and Assessment Status

MINLEAP predictions were very similar to observed Lake Osakis (Figure 22). The Osakis Lake exceeds both the TP and chl-*a* standard for a deep CHF lake. The lake was placed on the impaired waters list in 2004 and the TMDL is scheduled to be finished in 2010.

**Figure 21. Lake long-term water quality trends**

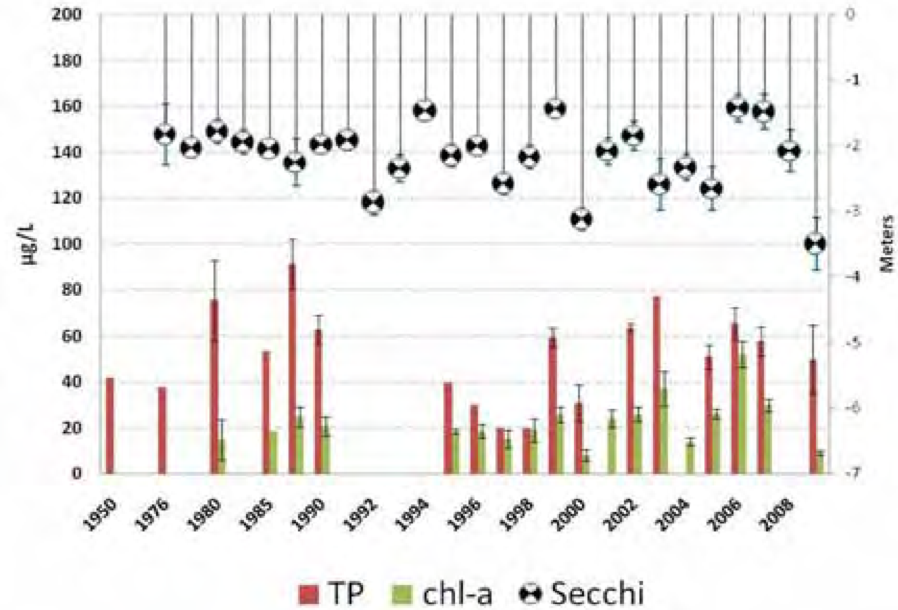
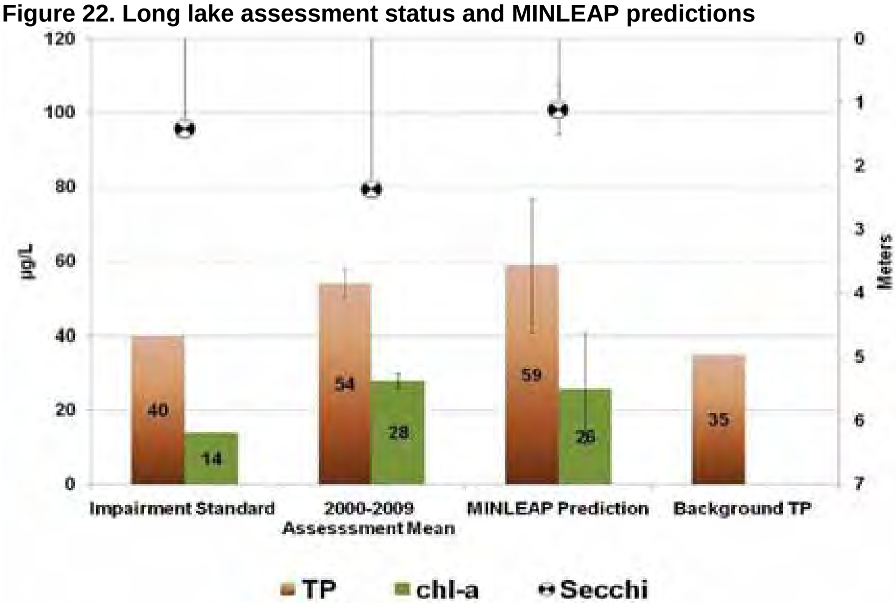


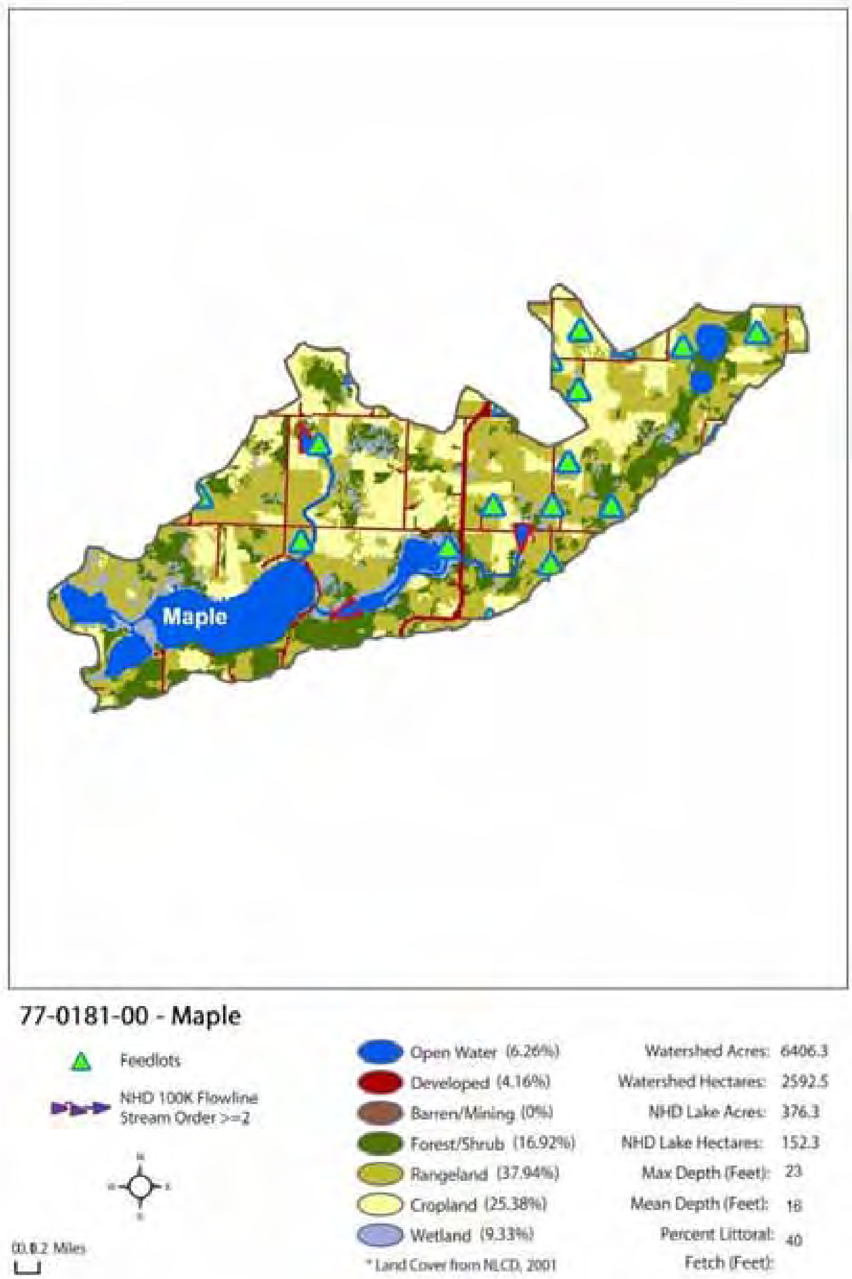

**Figure 22. Long lake assessment status and MINLEAP predictions**



# Maple Lake 77-0181

Maple Lake is moderate-sized lake (376 acres) with typical basin bathymetry. The lake drains to the east eventually reaching Lake Osakis. The majority of the catchment is comprised of crop and range land with a fair amount of forested land (Figure 23).

**Figure 23. Maple Lake catchment and landuse map**



## Water Quality Summary

Temperature profiles from 2007 show a slight thermocline in May and June followed by mixed conditions during the summer (Figure 24). DO levels in July declined dramatically throughout the water column (Figure 25).

TP is variable within and among summers based on the 2006-2009 data (Figure 26). In general, TP increases over the course of the summer, which is consistent with other well-mixed lakes in Minnesota. Chl-*a* and Secchi respond to the changes in TP. Lake water clarity is typically two to three meters in May and June, followed by declines to about a meter in July and August.

**Figure 24 Maple Lake 2007 temperature profiles**

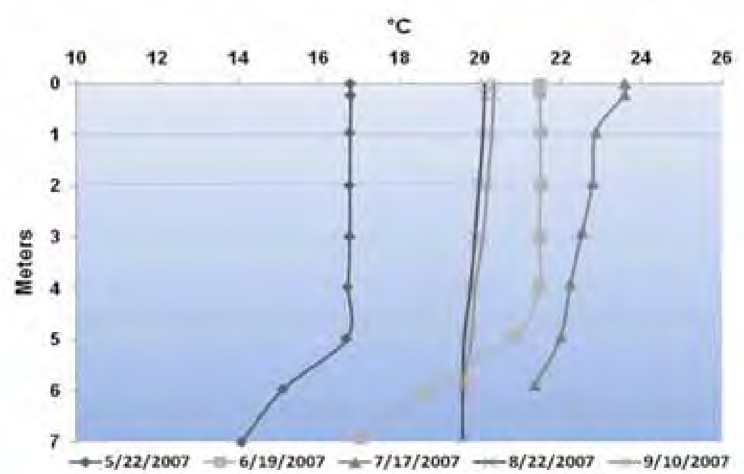



**Figure 25 Maple Lake 2007 DO profiles**

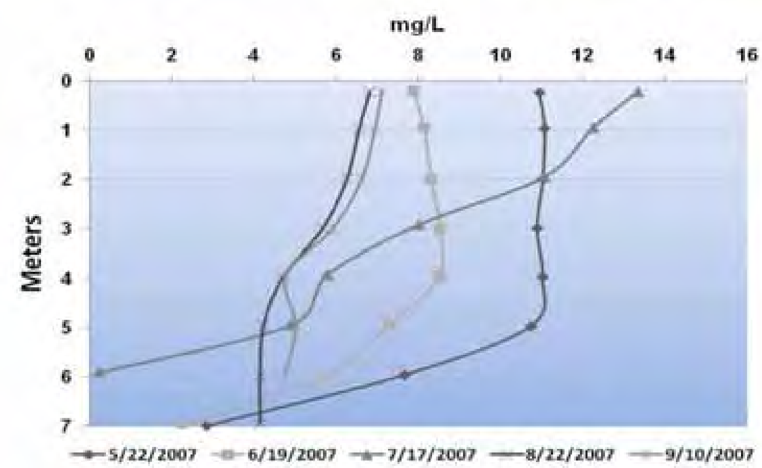
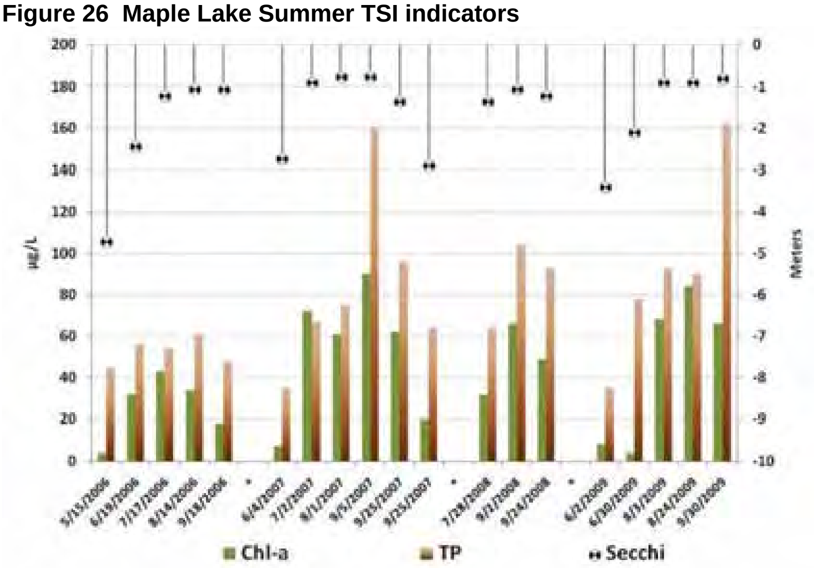



**Figure 26 Maple Lake Summer TSI indicators**



## Water Quality Trends

Water quality records for Maple Lake go back to 1956. Based on the 1980 and 2006-2009 record TP ranges between 50-90 µg/Land chl-*a* from 30-55 µg/L as summer-means. No overall trend was found on the long-term data.

## Modeling and Assessment Status

The MINLEAP model prediction was very similar to the 2000-2009 assessment mean (Figure 28). The estimated background TP concentration is near the impairment standard but much lower than observed TP. The lake was placed on the 2010 303 (d) list. TMDL is scheduled to be completed in 2015.

**Figure 27. Maple Lake long-term water quality trends.**

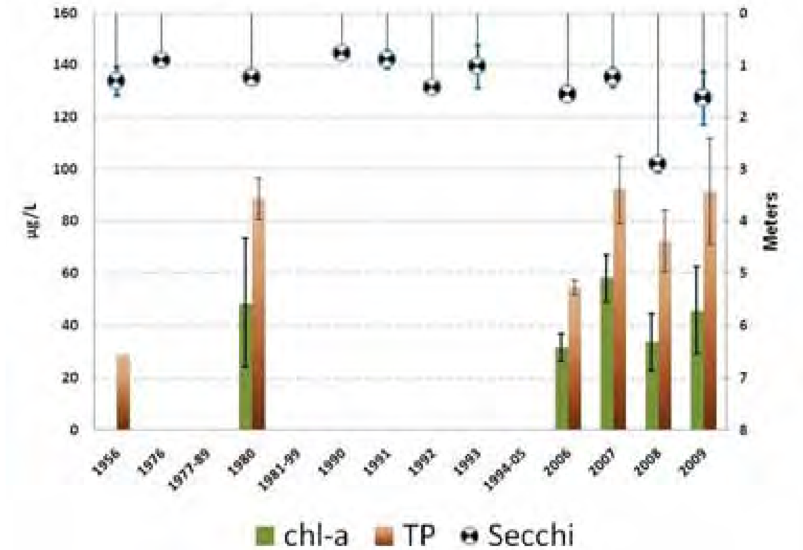
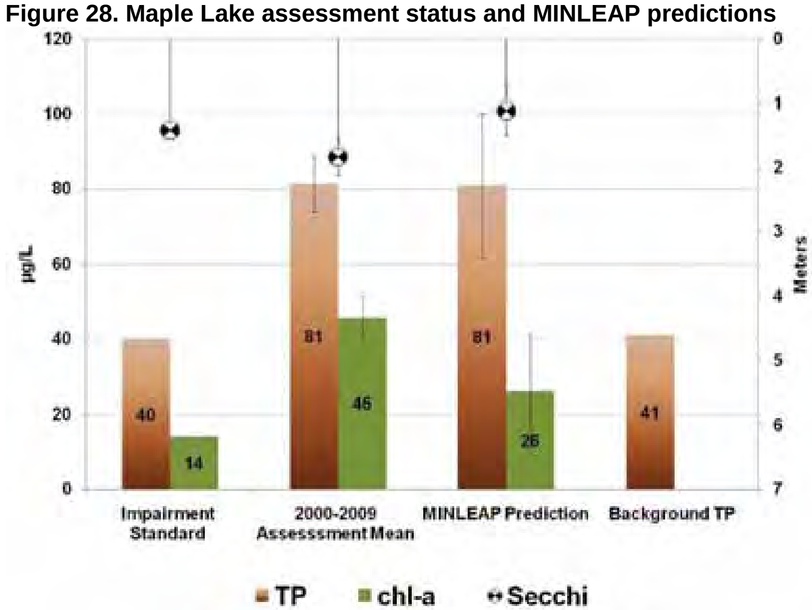


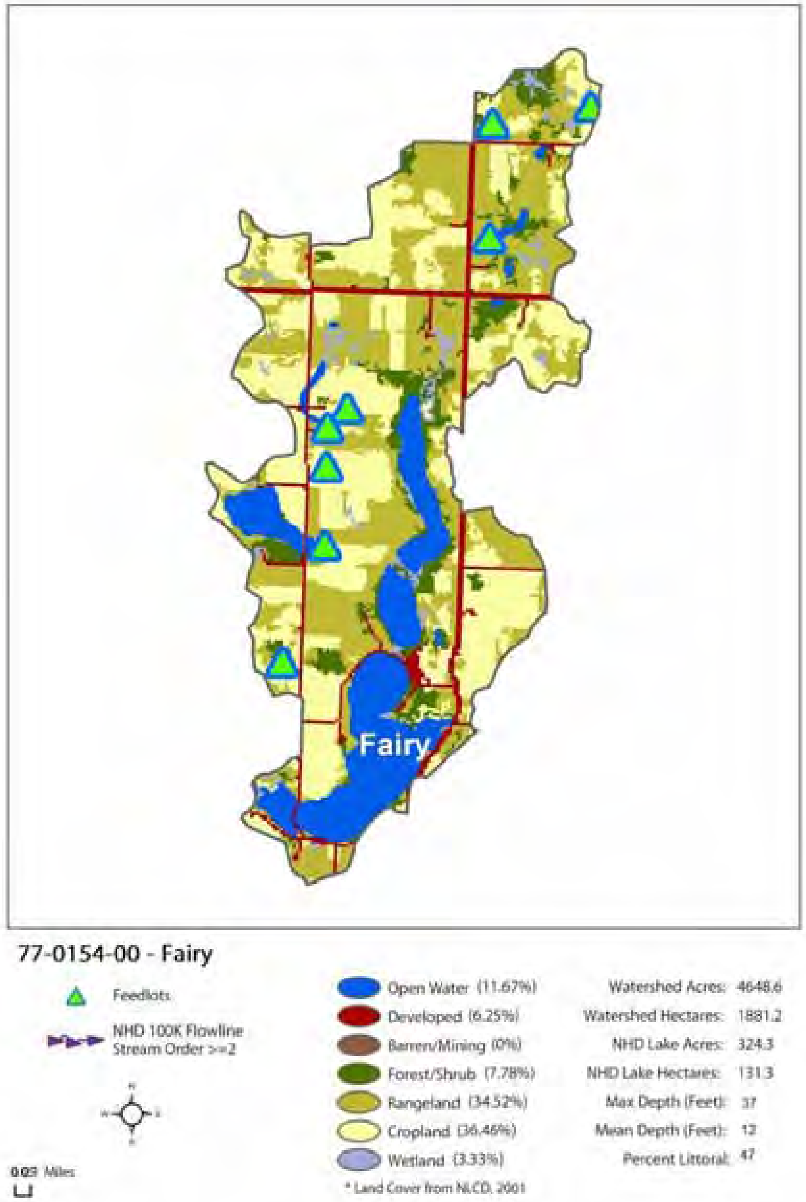

**Figure 28. Maple Lake assessment status and MINLEAP predictions**



# Fairy Lake 77-0154

Fairy Lake is a modest sized lake at 131 hectares (324 acres). Rangeland and cultivated landuse dominate, consistent with most catchments in this HUC 8. Several feedlots are present in this watershed (Figure 29).

**Figure 29. Fairy Lake catchment and landuse map**



## Water Quality Summary

Only one year of profile and TSI exists for Fairy Lake from 2001. Thermoclines were observed in June and remained through the summer (Figure 30). DO stratification had a similar pattern of summer stratification (Figure 31).

TP and chl-*a* remained relatively low through the summer of 2001 (Figure 32), with a slight increase in September as the lake was undergoing fall mixing (Figure 30). This pattern is consistent with other stratified lakes in Minnesota.

**Figure 30 Fairy Lake temperature profiles**

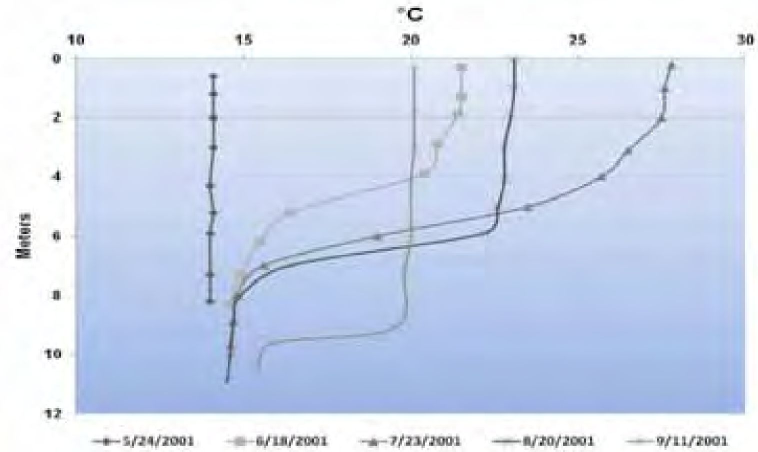



**Figure 31 Fairy Lake DO profiles**

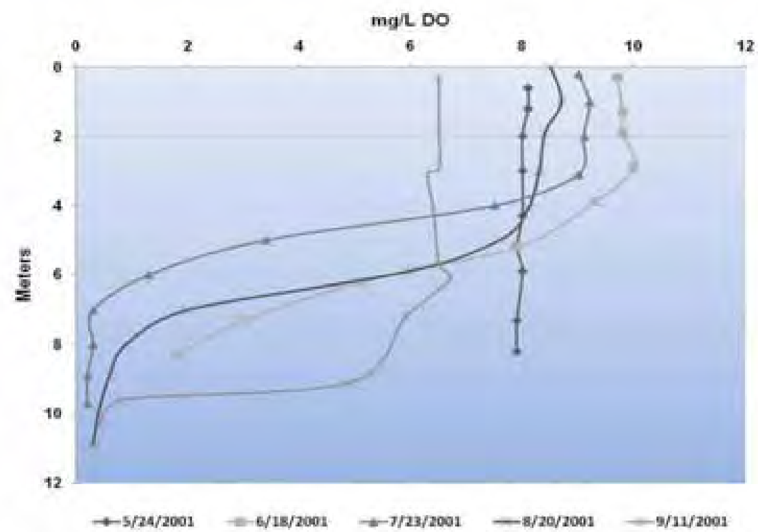
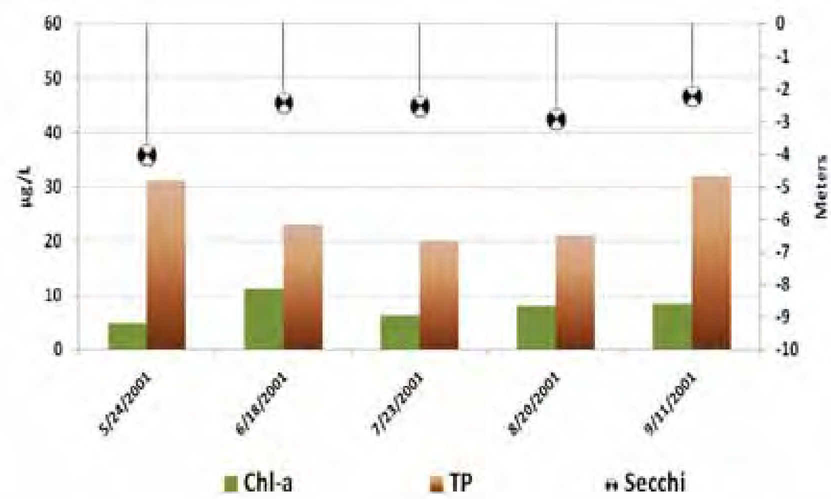



**Figure 32 Fairy Lake TSI indicators**



## Water Quality Trends

Very few chl-*a* and TP records exist on Fairy lake. Summer-mean transparency exhibit a cyclic pattern: improving transparency from 2001-2004 and a declining transparency from 2005-2007. Continued monitoring will allow us to see if this pattern continues in the future.

## Modeling and Assessment Status

Fairy Lake is assessed as fully supporting for ARUS. TSI indicators are well below the CHF standards (Figure 34) MINLEAP prediction higher TP and chl-*a*.

**Figure 33 Fairy Lake long-term water quality trend**

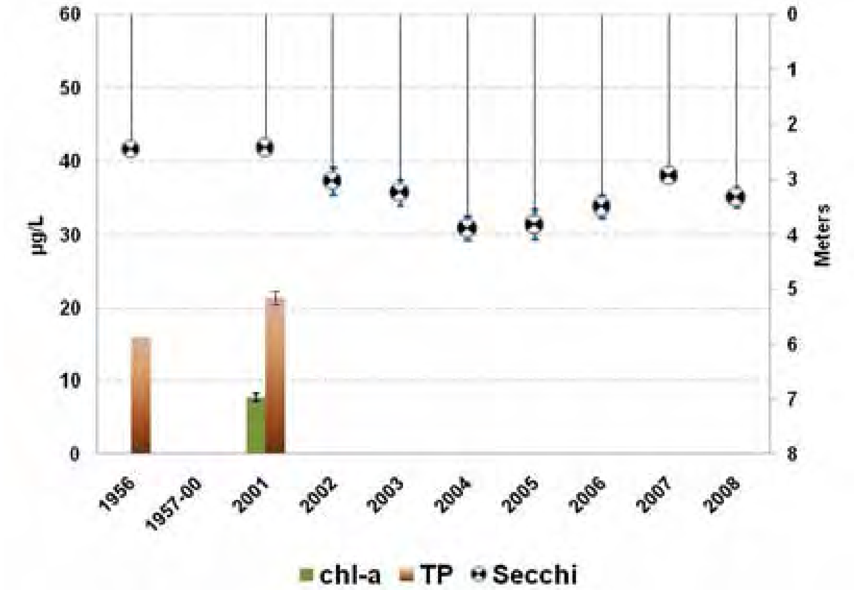
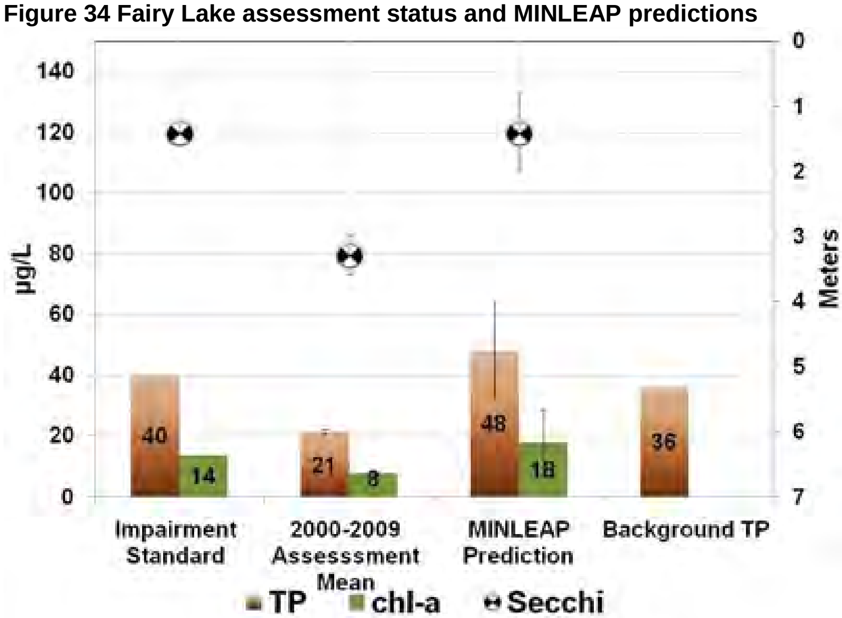


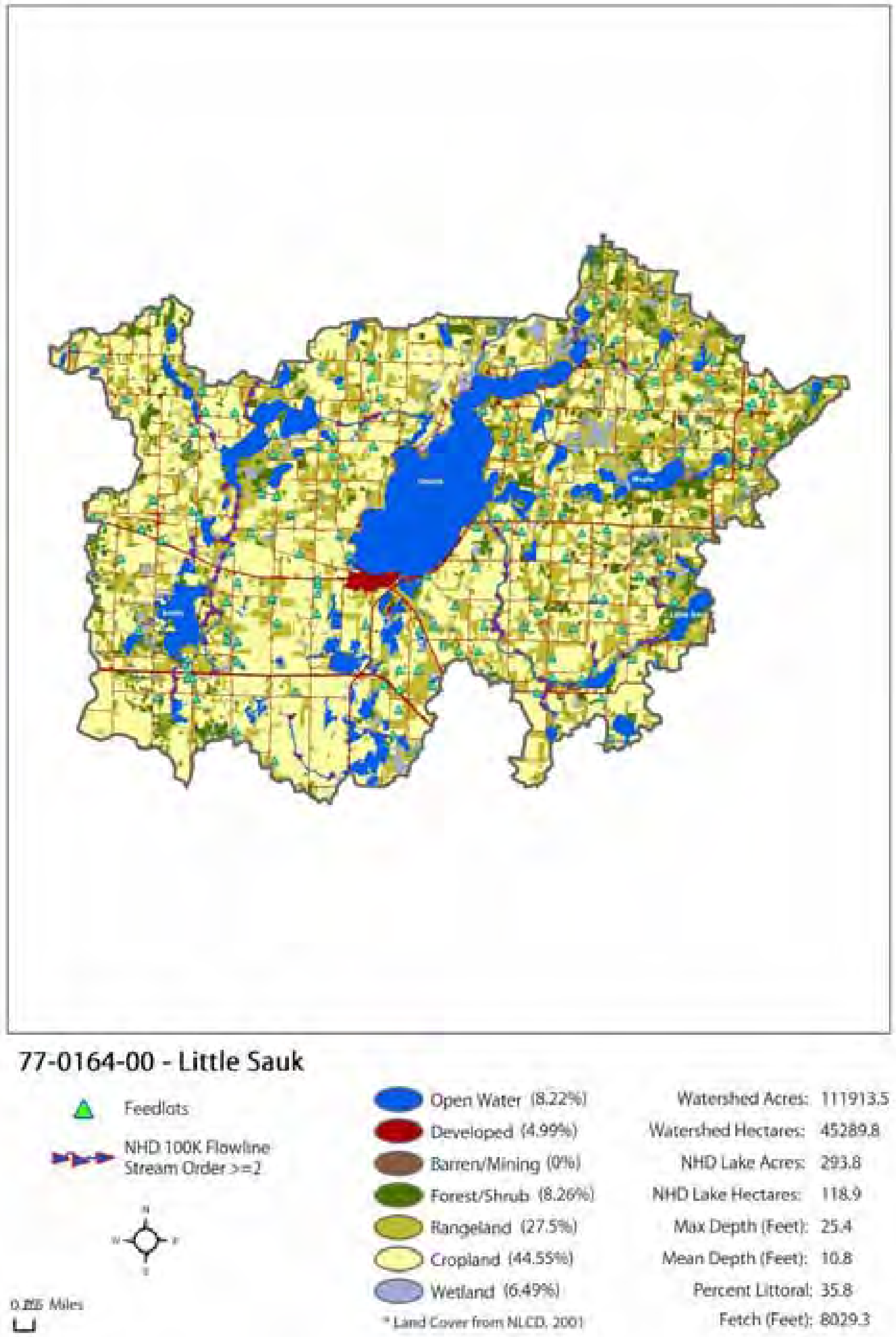

**Figure 34 Fairy Lake assessment status and MINLEAP predictions**



# Little Sauk 77-0164

Little Sauk Lake is a very fertile, riverine lake. The lake is part of the Sauk River system located between Osakis and North Sauk Lake. The lake directly reflects the nutrient-rich condition of the Sauk River. Algae blooms are common in the summer time.

**Figure 35. Lake Catchment and Landuse map**



## Water Quality Summary

The most recent profile data (2009) indicated a weak thermocline by mid- summer (Figure 36). Under stratified conditions DO fell below 2 mg/L in the hypolimnion (figure 37). TP and chl-*a* were elevated early in each year in response to spring mixing and high spring runoff. June to early July TP was rather low but increased as the summer progressed in each year (figure 38). Chl-*a* responded and attained nuisance bloom levels by mid-late summer. Secchi responded to increases in Chl-*a*.

**Figure 36 Little Sauk temperature profiles**

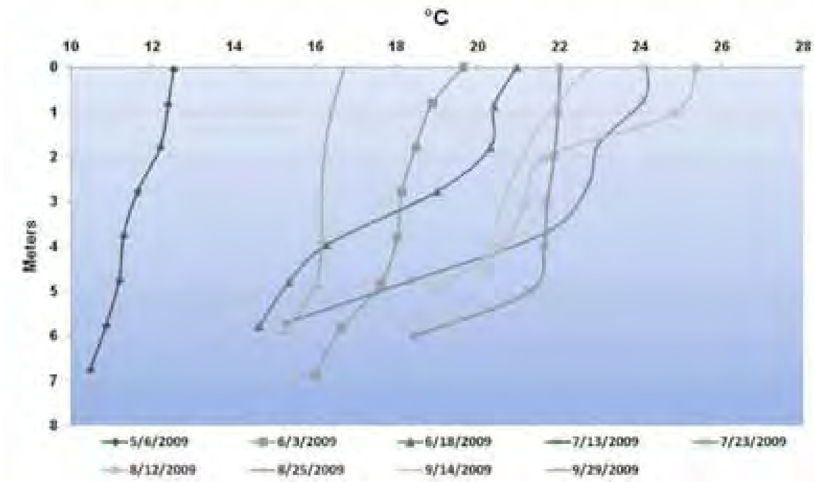



**Figure 37 Little Sauk DO profiles**

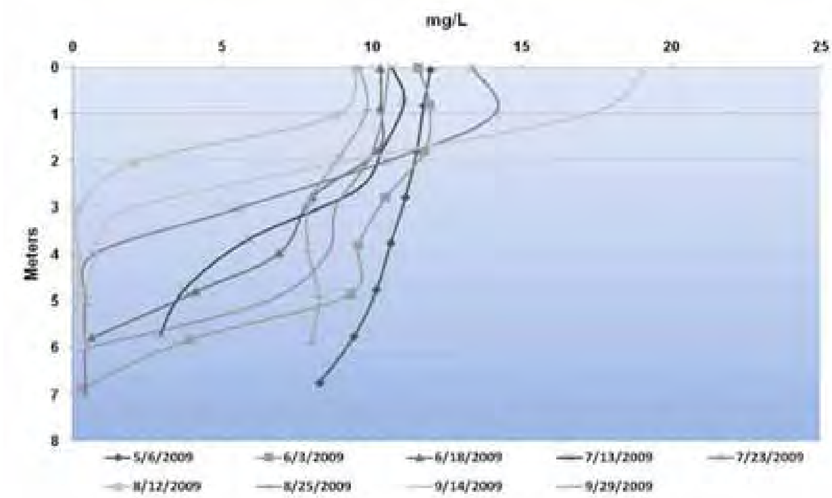
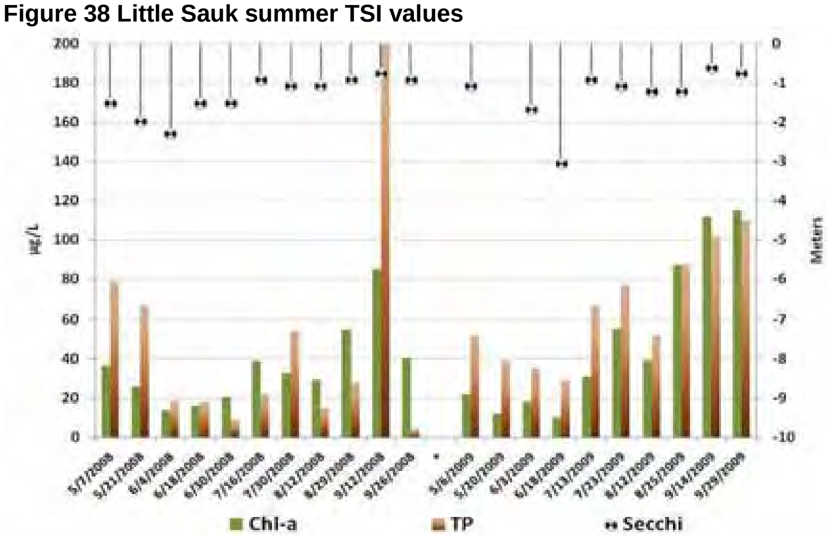



**Figure 38 Little Sauk summer TSI values**



## Water Quality Trends

Secchi records go back to 2004 and no trend is evident. Chl-*a* and TP records were only available for 2008 and 2009 and provide a sense of the year-to-year variability that may occur in Little Sauk.

## Modeling and Assessment Status

MINLEAP predicted-TP was higher than observed. This occurs because the model does not account for the sedimentation of P in upstream lakes, e.g. Osakis. Model-predicted and observed Secchi and Chl-*a* were similar. Estimated background P was lower than observed and similar to the impairment standard. Little Sauk Lake was included on the 2010 303(d) list.

**Figure 39 Long term water quality**

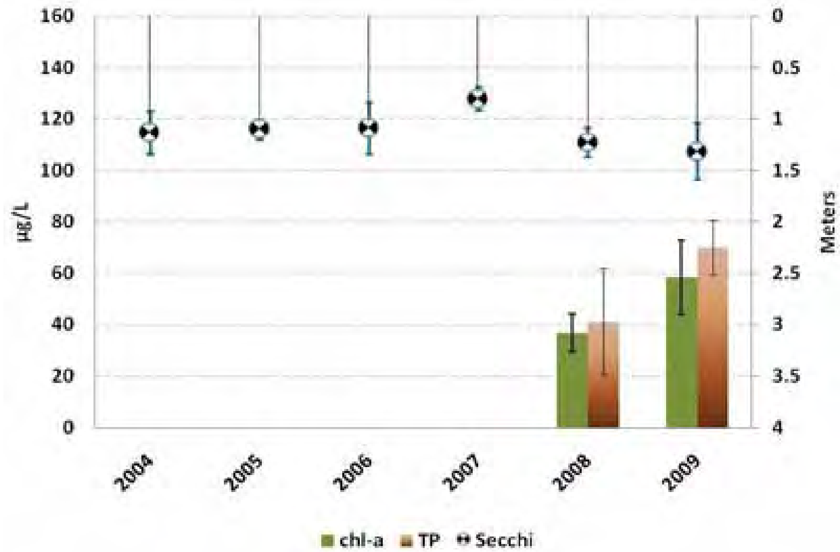
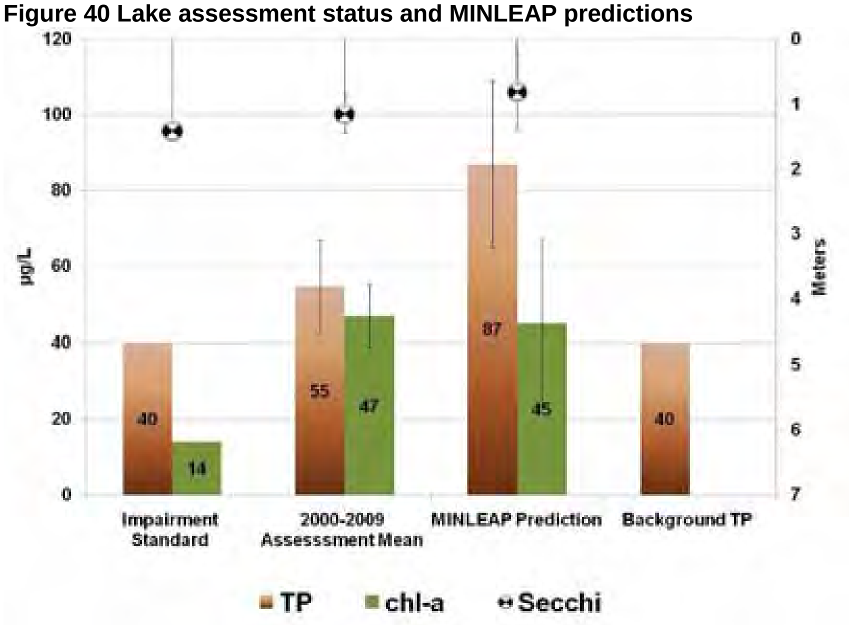



**Figure 40 Lake assessment status and MINLEAP predictions**



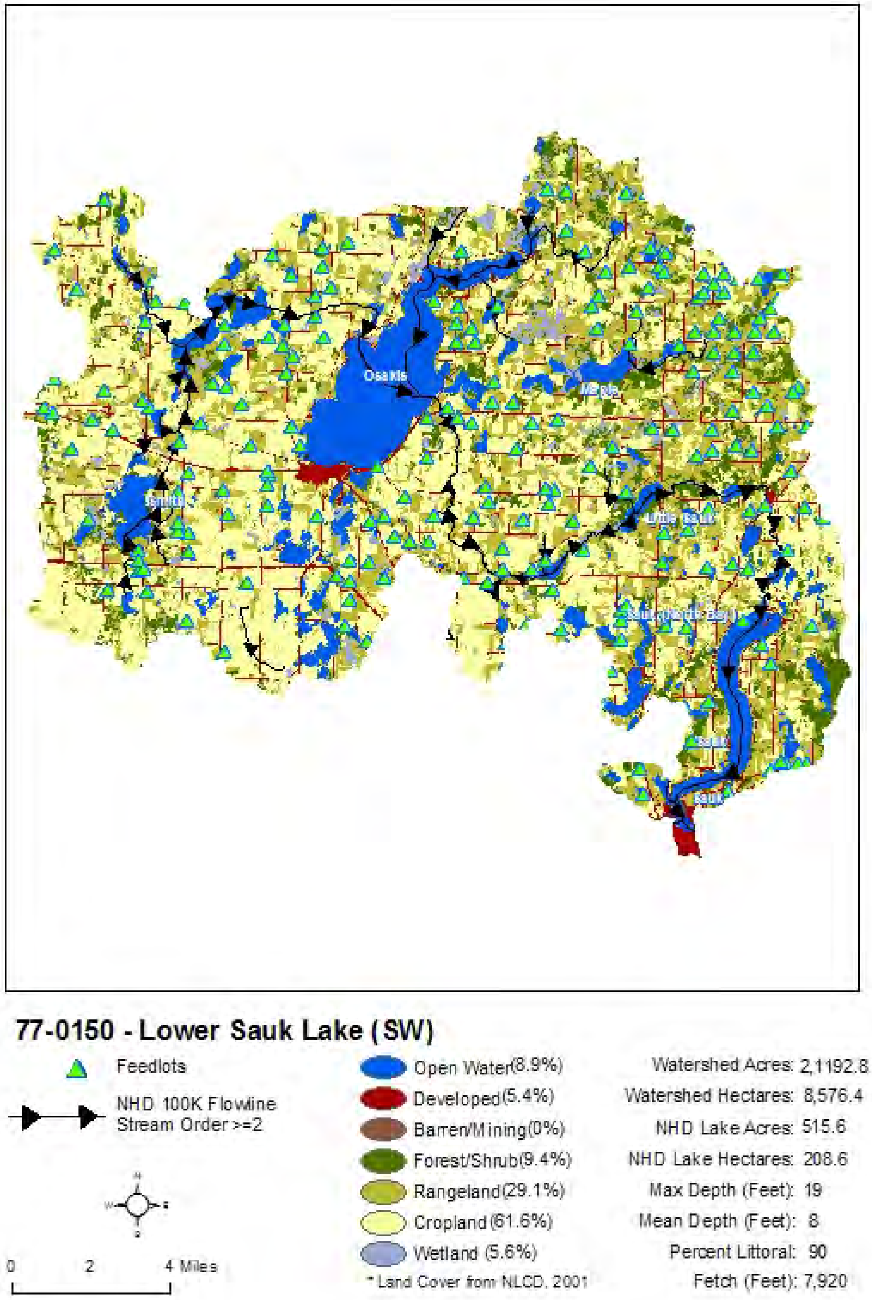
# Sauk Lake 77-0150

Sauk Lake is divided into two basins: South Sauk, which is the outlet of the entire Upper Sauk HUC; and North Sauk. Both portions of Sauk Lake would be best described as reservoirs. A control dam at the South Sauk outlet controls water levels on both lakes. The Sauk River flows out of Lake Osakis and through several small riverine lakes (Guernsey, Little Sauk, Juergens and Mud) before entering North Sauk Lake.

## North Sauk Lake 77-0150-01

North Sauk Lake (77-0150-01) lake is 1,701 acres and has much more depth than South Sauk Lake with a maximum depth of over 50 feet.

**Figure 41. Lake catchment and landuse map**



## Water Quality Summary

A profile measurement from 2008 show a thermocline was present only on July 2nd. It is likely that the reservoir conditions/flow and large fetch in North Sauk keep the lake more fully mixed than a typical lake with 50 feet of depth.

TSI indicators data from 2007 show different patterns between the two seasons. In 2007, TP and chl-*a* concentration increased through the summer, while Secchi depths declined through midsummer then became stable (Figure 44). TP was lower in 2008 compared to 2007. A notable seasonal increase in TP and chl-*a* was observed in 2007.

**Figure 42 North Sauk Lake 2008 temperature profiles (site 207)**

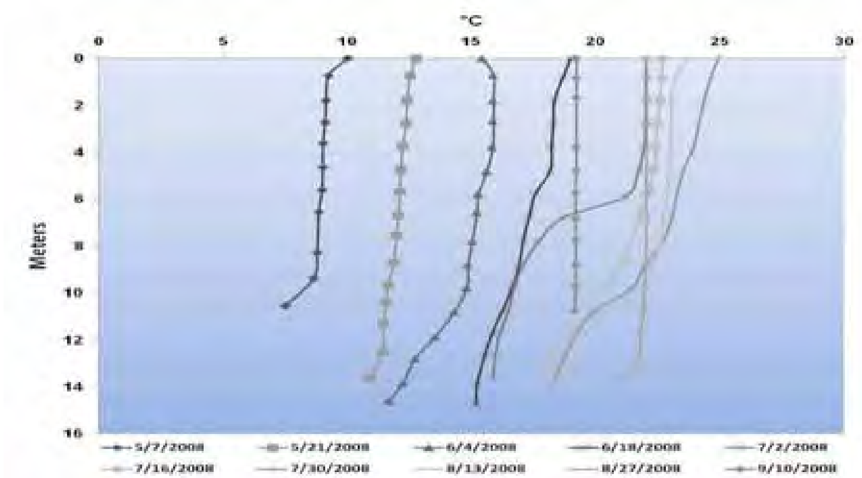



**Figure 43 North Sauk Lake 2008 DO profiles (site 207)**

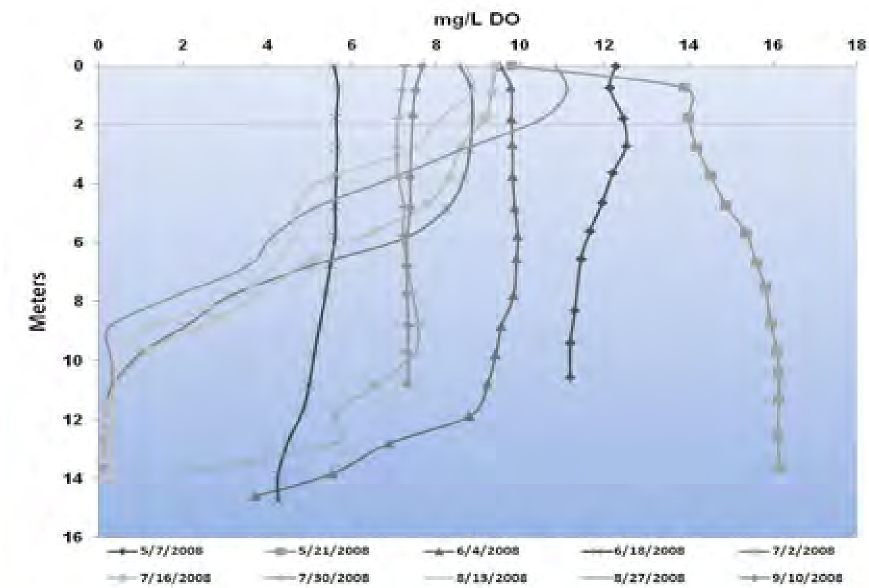
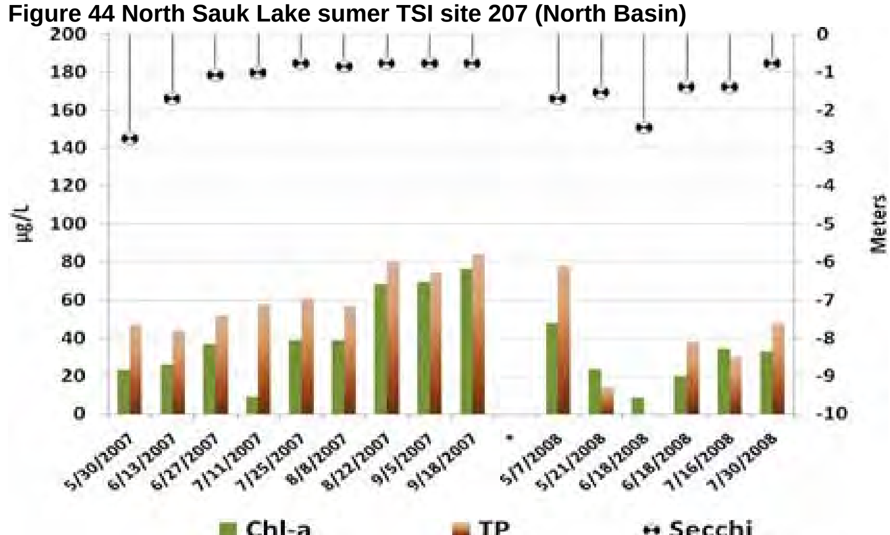



**Figure 44 North Sauk Lake sumer TSI site 207 (North Basin)**




## Water Quality Trends

TSI results for North Sauk go back to 1948. Summer-mean TP and chl-*a* for the 1980s, 1990s and early 2000s are higher than more recent measures (Figure 45). The CLMP Secchi record is quite strong; however, no long-term trend is evident. Over most summers, mean Secchi ranges from 1.5-2.0 m.

## Modeling and Assessment Status

MINLEAP-predicted TP is higher than observed; however Chl-*a* is equal to observed (Figure 46). Estimated background TP is much lower than observed and is well below the water quality standard. North Sauk Lake was placed on the 2004 303(d) and a TMDL is scheduled to be completed in 2010.

**Figure 45 Lake long-term water quality trends**

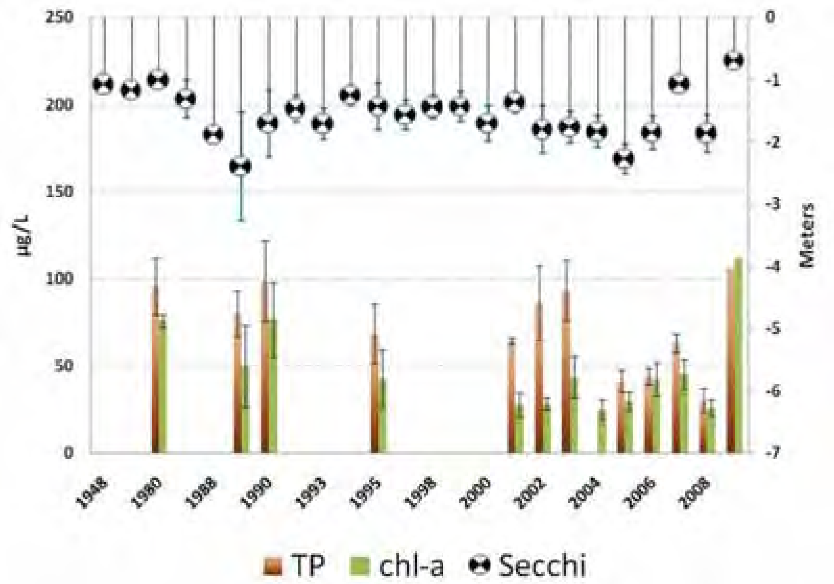
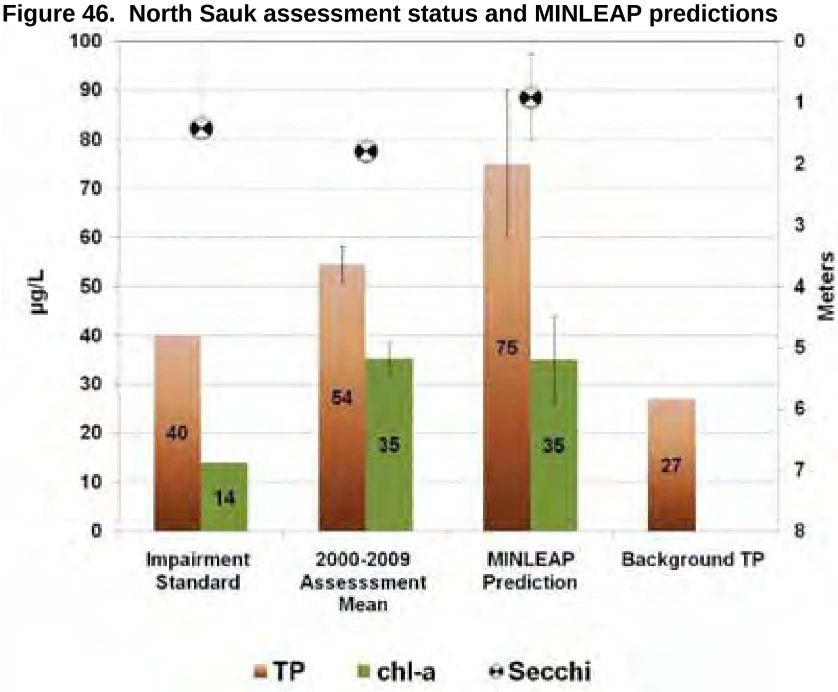



**Figure 46. North Sauk assessment status and MINLEAP predictions**



## Lower Sauk Lake
## 77-0150-02

South Sauk Lake is located on the north end of the City of Sauk Center. It has an area of 430 acres and a mean depth of about 7 feet. The lake is the confluence of Hoboken Creek, Ashley Creek and the Upper Sauk River.

## Water Quality Summary

The most recent profile data is from 2008. The lake was e generally well mixed with only slight stratification seen in mid-summer of 2008. The limited stratification is likely due water flow through the lake combined with the large fetch. DO profiles in 2008 showed significant declines occurring at depth starting in July.

TSI data from 2007-2008 were used in this assessment. TP exhibited a marked seasonal increase in 2007, which likely was related to periodic mixing and internal recycling of P. Chl-*a* responded accordingly with very severe nuisance blooms occurring in July through September. Conditions in 2008 were somewhat better; however, a seasonal increase was still evident (Figure 49).

**Figure 47. Sauk Lake South 2008 temperature profiles**

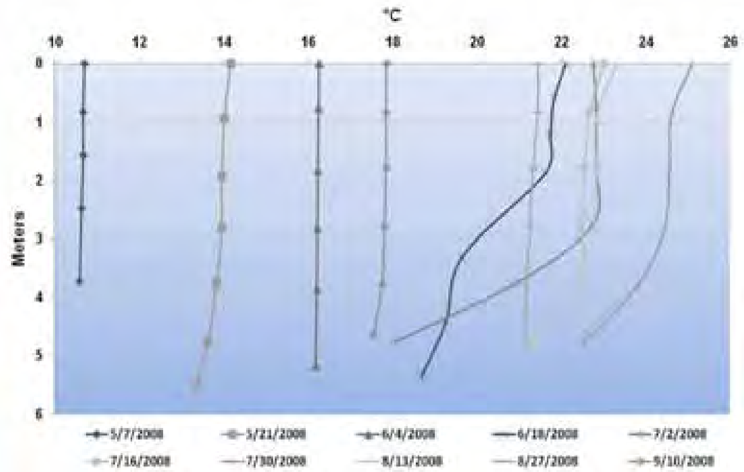



**Figure 48 Sauk Lake (South) 2008 DO profiles**

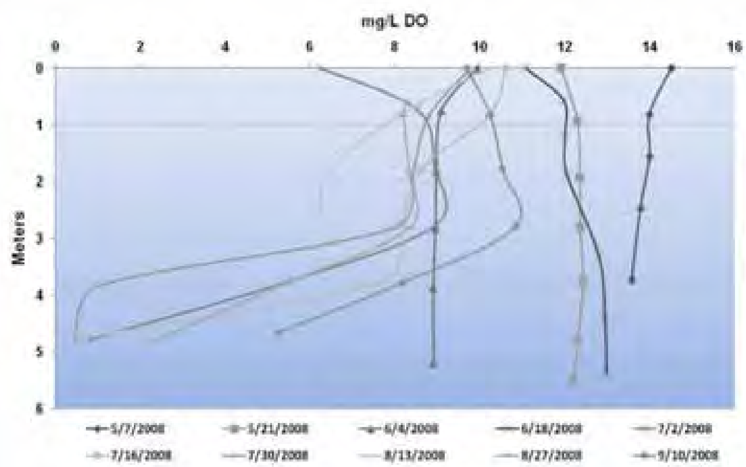
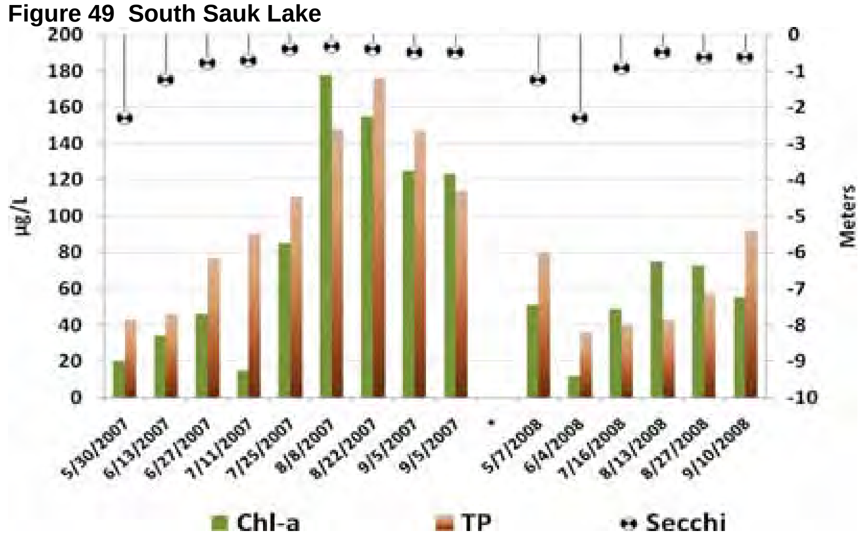



**Figure 49 South Sauk Lake**



## Water Quality Trends

Secchi records extend back to 1980 and no overall trend is evident. TSI indicators vary notably from year to year.

## Modeling and Assessment Status

MINLEAP-predicted P is less than observed in Sauk Lake. Likewise, estimated background P is much lower than observed and lower than the water quality standard, as well (Figure 51).Sauk Lake exceeds the shallow lake water quality standards for the CHF. It was placed on the 2004 303(d). TMDL is scheduled to be completed in 2010.

**Figure 50 Lake long-term water quality trends**

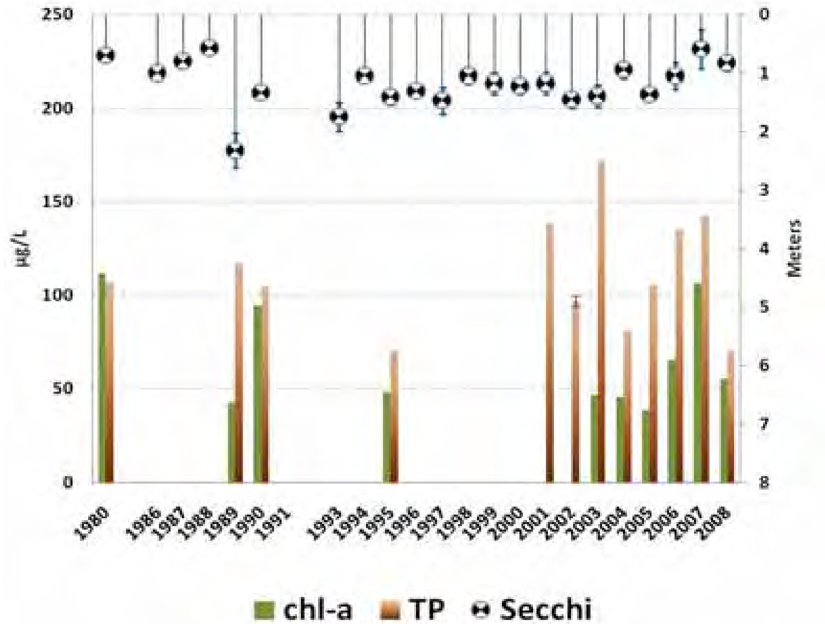
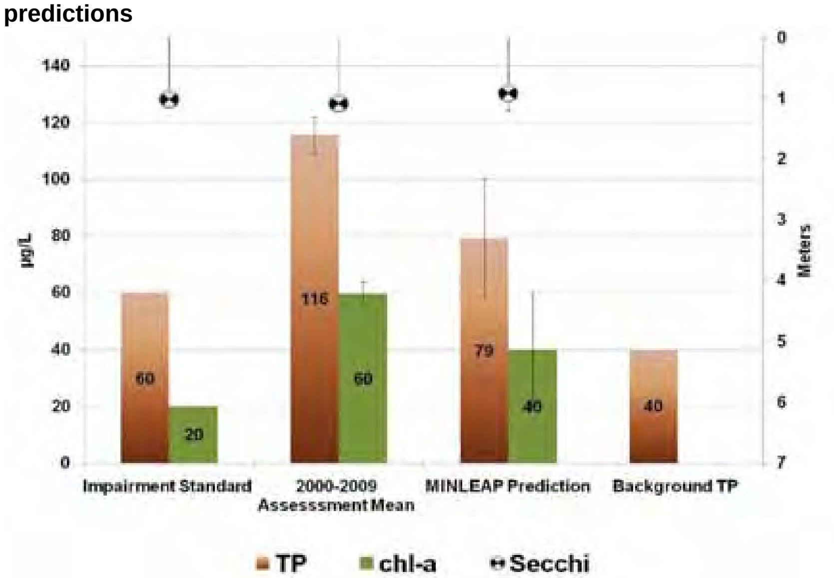



**Figure 51. South Sauk Lake Assessment status and MINLEAP predictions**



# Ashley Creek HUC 11

Ashley Creek is a 72,152 acre HUC 11 that is 2/3rds cropland (Figure 52). The HUC 11 has 28 established lakes of which only 12 lakes are greater than 10 acres (Table 6). Westport Lake is the only lake in the watershed with lake assessment data. Many of the shallow lakes in Ashley Creek are also be classified as wetland. The NRCS 18 category land use mapping show a much higher amount of wetland in Ashley found at http://www.mn.nrcs.usda.gov/technical/rwa/assessments/reports/sauk.pdf.

**Figure 52 Ashley Creek HUC 11 Landuse map**

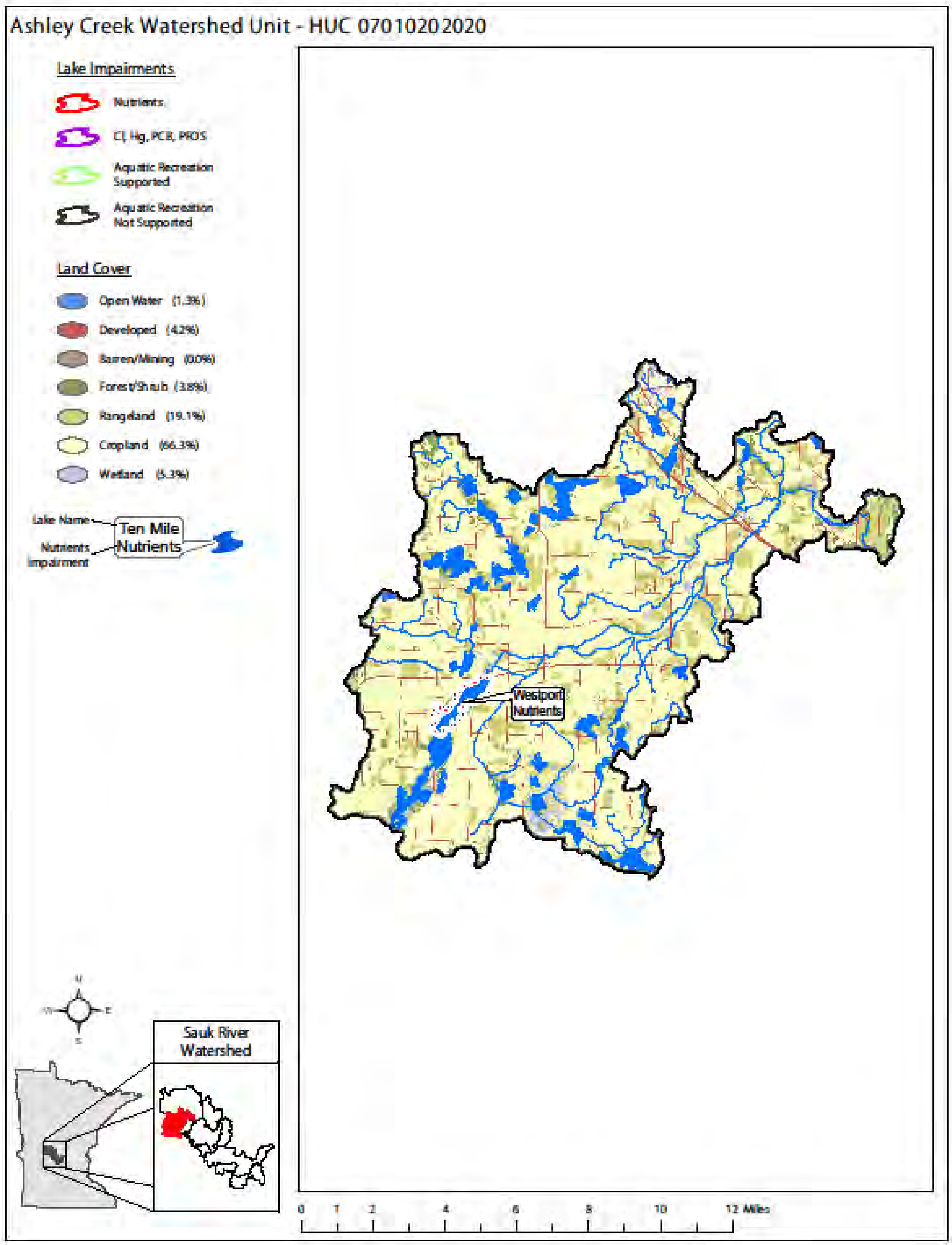


**Table 6 Status and information of Lake in Ashley Creek > 10 Acres**

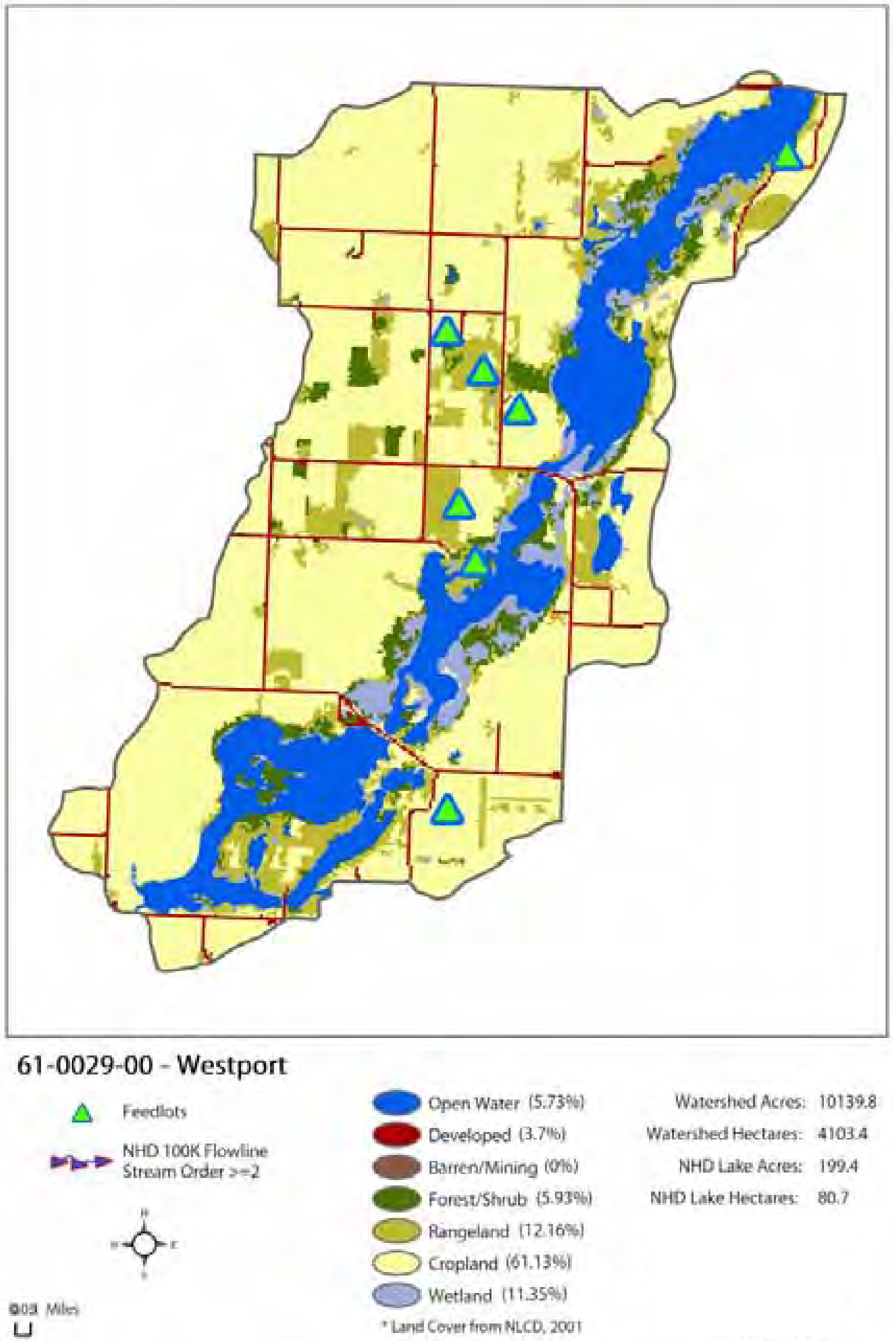
| Name | DOW# | County | Area | % Littoral | Avg. Depth (M) | Max. Depth (M) | ARUS | Trophic Status | Mean TP | Mean chl-a | Secchi Mean | CLMP Trend | RS 2005 | RS Trend |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Westport | 61-0029 | POPE | 199 | | | 13 | NS | E | 78 | 47 | 1 | | 1.1 | NT |
| Swan | 61-0025 | POPE | 186 | | | 4 | | | | | | | 1.0 | NT |
| Kuntz | 21-0011 | DOUGLAS | 143 | | | | | | | | | | 0.6 | NT |
| Burroughs | 61-0030 | POPE | 99 | | | | | | | | | | 1.1 | NT |
| East Ellen | 61-0031 | POPE | 93 | | | | | | | | | | 2.0 | NT |
| West Union | 77-0188 | TODD | 82 | 100 | | | | | | | | | 0.9 | ↗ |
| Shultz | 21-0014 | DOUGLAS | 49 | | | | | | | | | | 1.0 | NT |
| Krantz | 61-0018 | POPE | 39 | | | | | | | | | | 1.9 | NT |
| Selinsky | 77-0184 | TODD | 33 | | | | | | | | | | 0.5 | NT |
| Schultz | 21-0012 | DOUGLAS | 26 | | | | | | | | | | 0.9 | NT |
| Unnamed | 73-0292 | STEARNS | 17 | | | | | | | | | | | |
| Unnamed | 77-0311 | TODD | 11 | | | | | | | | | | | |

↘ decreasing/declining trend ↗ increasing/improving trends NT No Trend ID Insignificant Data
FS Full Support NS none supporting HE hypereutrophic E Eutrophic M Mesotrophic O Oligotrophic

# Westport 61-0029

Westport Lake is located one mile west of city of Westport. It is a shallow, excessively fertile lake, with frequent winter fish kills. Maximum depth of Westport is 12 feet. Draining to the lake includes several shallow lakes/open water wetlands

**Figure 53 Westport lake catchment and landuse map**



## Water Quality Summary

No profile data was found on Westport Lake. TSI data from 2007-2009 show similar trends, of increasing TP and chl-*a* through mid-summers (Figure 54).

## Water Quality Trends

Only a few years of data are available on the lake (Figure 55). Summer mean in the three were similar and show no trend.

## Modeling and Assessment Status

The MINLEAP model predicted similar values to the observed on Westport. (Figure 56). Westport was placed on the 2010 impaired waters list. The TMDL is scheduled to be complete in 2016. The assessment mean values are well over the shallow lake ARUS standards for the CHF.

**Figure 54 Westport Lake long-term TSI indicators for Westport Lake**

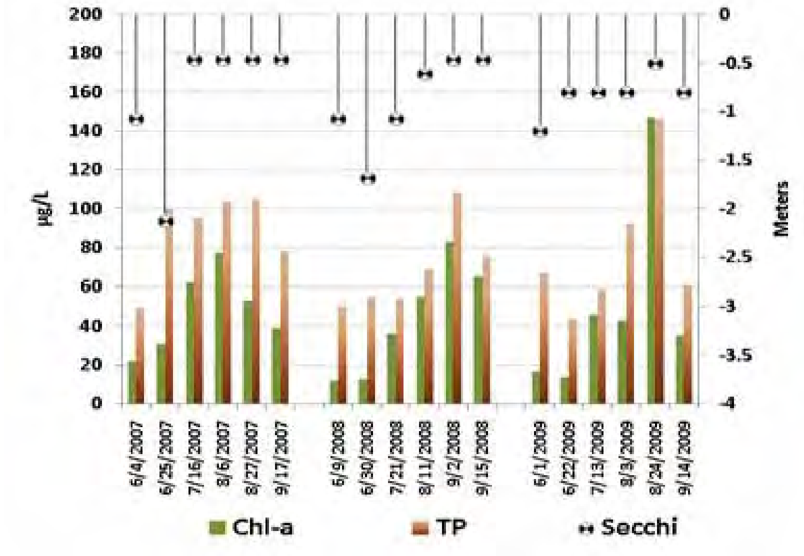



**Figure 55 Westport Lake long-term water quality trends**

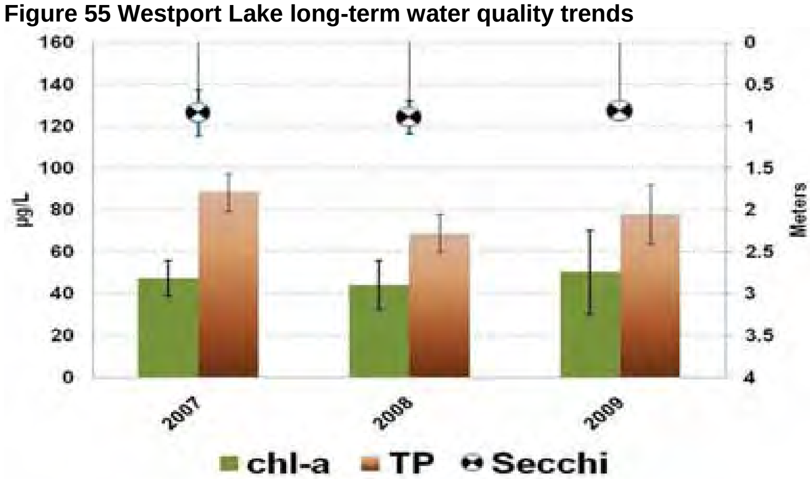
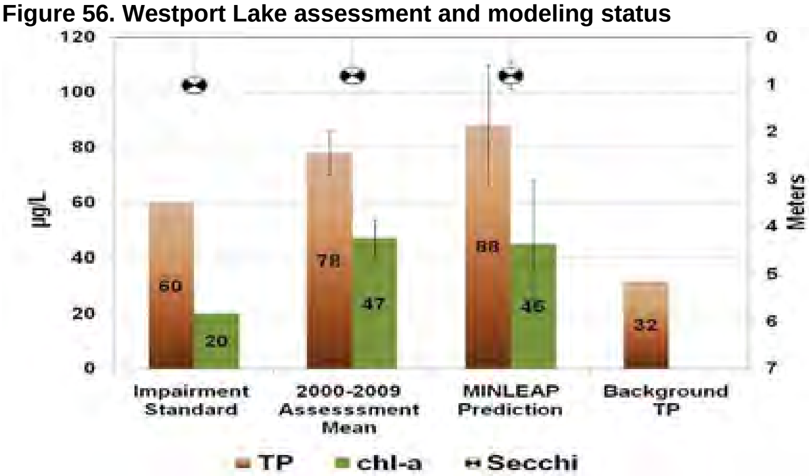



**Figure 56. Westport Lake assessment and modeling status**



# Hoboken Creek   HUC 11

Hoboken Creek in one of the smallest and most crop dominated HUC 11 in the Sauk River HUC 8. This HUC 11 has only five established lakes and none of the lakes in Hoboken Creek has assessment level data (Table 7). Only one lake, Unnamed 23-0271, has remote sensing data

**Figure 57 Hoboken Creek landuse map**

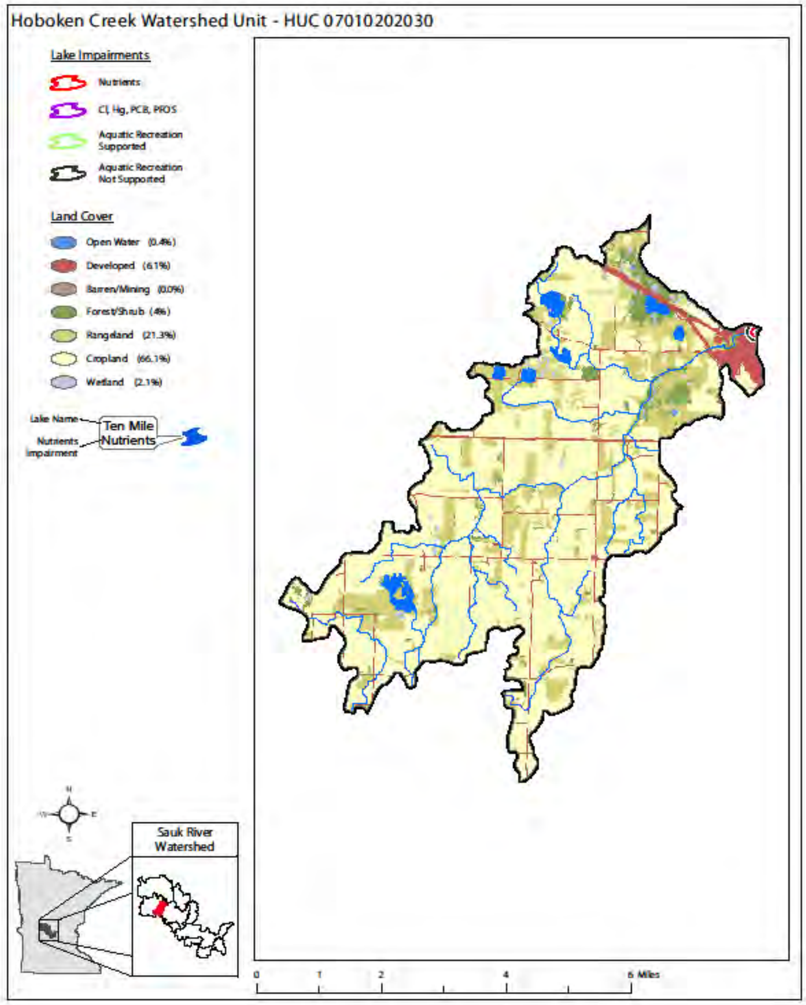



**Table 7. Status and information of Lakes > 10 acres in Ashley Creek**

| Name | DOW# | County | Area (acres) | % Littoral | Avg. Depth (M) | Max. Depth (M) | ARUS | Trophic Status | Mean TP (µg/L) | Mean chl-*a* (µg/L) | Secchi Mean (M) | CLMP Trend | RS 2005 (M) | RS Trend |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Unnamed | 73-0270 | STEARNS | 21 | | | | | | | | | | | |
| Unnamed | 73-0288 | STEARNS | 14 | | | | | | | | | | | |
| Unnamed | 73-02710 | STEARNS | 11 | | | | | | | | | | 1.8 | |
| Unnamed | 73-03460 | STEARNS | 3 | | | | | | | | | | | |
| Unnamed | 73-02870 | STEARNS | 0 | | | | | | | | | | | |

↘ decreasing/declining trend   ↗ increasing/improving trends   NT No Trend   ID Insignificant Data
FS Full Support   NS none supporting   HE hypereutrophic   E Eutrophic   M Mesotrophic   O Oligotrophic

# Middle Sauk River

The Middle Sauk is the third largest HUC 11 in the Sauk River. It has 61 established lakes, of which eight have assessment level data. Only two lakes are greater than 200 acres Kings and Uhlenkolts (Table 8). Numerous protection and improvement projects have occurred in the Middle Sauk including: Middle Sauk River Rehabilitation Project, Restoring Water Resources of the Sauk River Chain of Lakes, and the Middle Sauk River Rehabilitation Project.

**Figure 58 Middle Sauk HUC 08 landuse map**

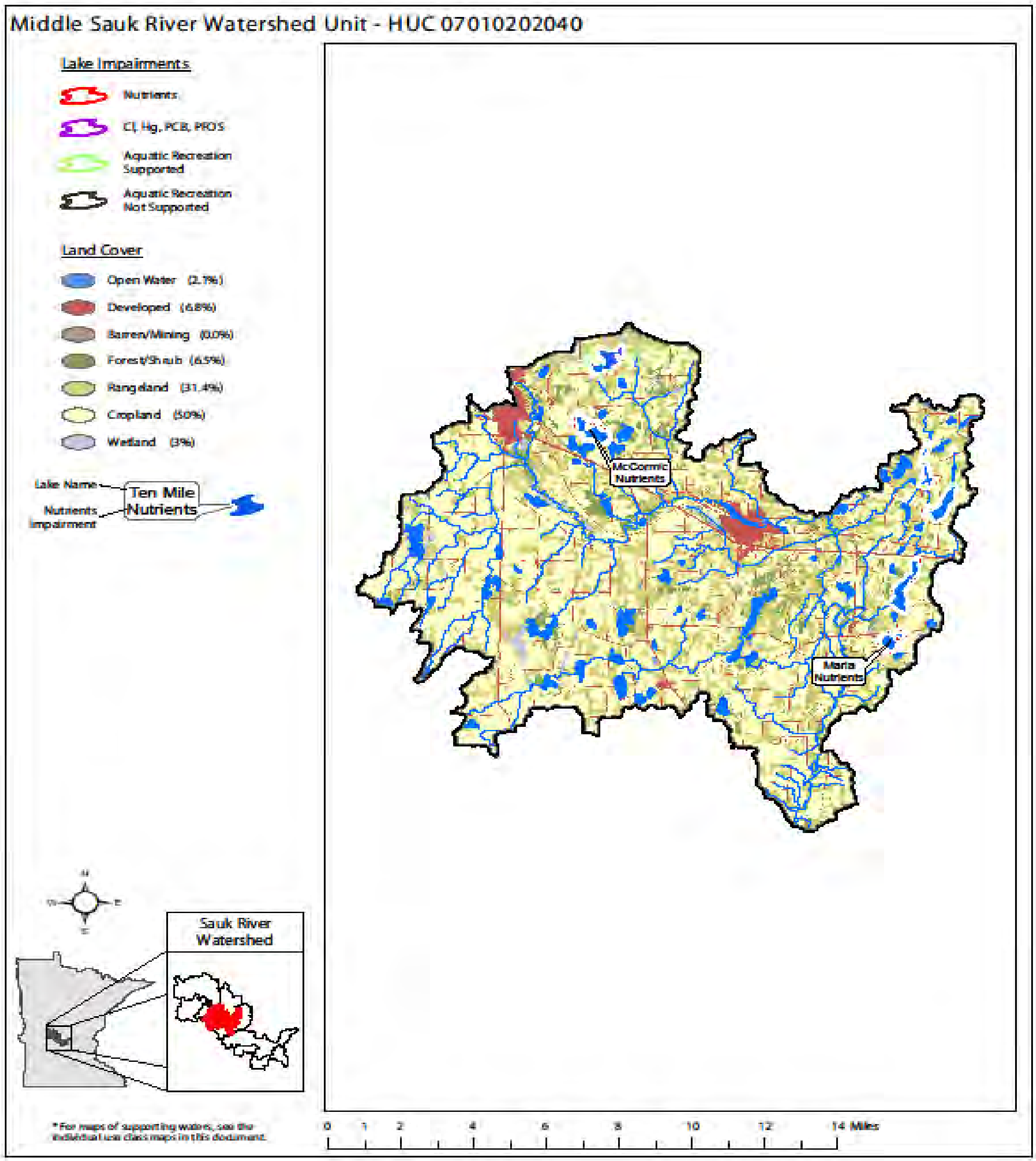
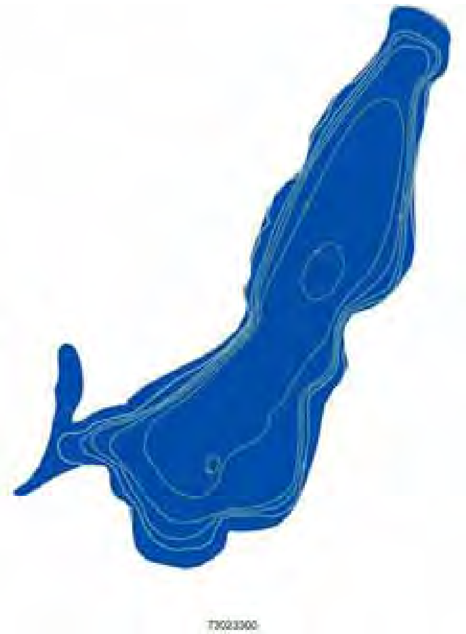


**Table 8 Status and information of Lake in Middle Sauk > 10 Acres**

| Name | DOW# | County | Area | % Littoral | Avg. Depth (M) | Max. Depth (M) | ARUS | Trophic Status | Mean TP | Mean chl-a | Secchi Mean | CLMP Trend | RS 2005 | RS Trend |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Uhlenkolts | 730208 | STEARNS | 240 | | 1 | 3 | NS | H | 244 | 80 | 0 | | 0.3 | NT |
| Kings | 730233 | STEARNS | 201 | 24 | 23 | 44 | FS | E | 33 | 12 | 3 | | 1.7 | NT |
| Cedar | 730255 | STEARNS | 187 | | | 5 | FS | E | 40 | 6 | 1 | | 1.7 | ↗ |
| McCormic | 730273 | STEARNS | 186 | 100 | | 12 | NS | E | 93 | 57 | 2 | | 1.4 | NT |
| Black Oak | 730241 | STEARNS | 100 | 94 | | | ID | H | 101 | 31 | 1 | | 0.8 | NT |
| Maria | 730215 | STEARNS | 99 | 60 | 13 | 45 | NS | H | 114 | 18 | 1 | ↗ | | |
| Long | 730231 | STEARNS | 82 | 39 | 20 | | FS | M | 21 | 8 | 2 | | 1.6 | NT |
| Melrose | 730251 | STEARNS | 77 | 100 | | | | | | | | | 1.3 | NT |
| Frevels | 730210 | STEARNS | 69 | | | | | | | | | | 0.7 | NT |
| Unnamed | 730274 | STEARNS | 65 | | | | | | | | | | 1.7 | NT |
| Isabelle | 730239 | STEARNS | 42 | | | | | | | | | | 2.3 | NT |
| MELROSE (NW ) | 730251 | STEARNS | 42 | | | | | | | | | | | |
| Unnamed | 730256 | STEARNS | 38 | | | | | | | | | | 0.4 | NT |
| Ellering | 730244 | STEARNS | 36 | 49 | | | ID | E | 70 | 29 | 2 | | 0.9 | NT |
| MELROSE (SE BASIN) | 730251 | STEARNS | 35 | | | | | | | | | | | |
| Mud | 730225 | STEARNS | 34 | | | | | | | | | | 0.7 | NT |
| Unnamed | 730332 | STEARNS | 31 | | | | | | | | | | 2.0 | |
| Isabelle | 730265 | STEARNS | 30 | | | | | | | | | | | |
| Unnamed | 730262 | STEARNS | 26 | | | | | | | | | | 1.7 | NT |
| Unnamed | 730264 | STEARNS | 22 | | | | | | | | | | 0.4 | NT |
| Swamp | 730229 | STEARNS | 20 | | | | | | | | | | 1.7 | NT |
| Unnamed | 730236 | STEARNS | 18 | | | | | | | | | | | |
| Unnamed | 730393 | STEARNS | 17 | | | | | | | | | | | |
| Unnamed | 730471 | STEARNS | 17 | | | | | | | | | | | |
| Unnamed | 730333 | STEARNS | 17 | | | | | | | | | | 1.7 | NT |
| Unnamed | 730445 | STEARNS | 17 | | | | | | | | | | | |
| Unnamed | 730214 | STEARNS | 13 | | | | | | | | | | | |
| Unnamed | 730240 | STEARNS | 13 | | | | | | | | | | 2.8 | NT |
| Unnamed | 730586 | STEARNS | 13 | | | | | | | | | | | |
| Unnamed | 730213 | STEARNS | 12 | | | | | | | | | | | |
| Unnamed | 730327 | STEARNS | 12 | | | | | | | | | | | |
| Marie | 730243 | STEARNS | 11 | | | | | | | | | | 2.3 | |
| Unnamed | 730245 | STEARNS | 11 | | | | | | | | | | | |
| Unnamed | 730209 | STEARNS | 11 | | | | | | | | | | | |
| Unnamed | 730247 | STEARNS | 11 | | | | | | | | | | 1.7 | |

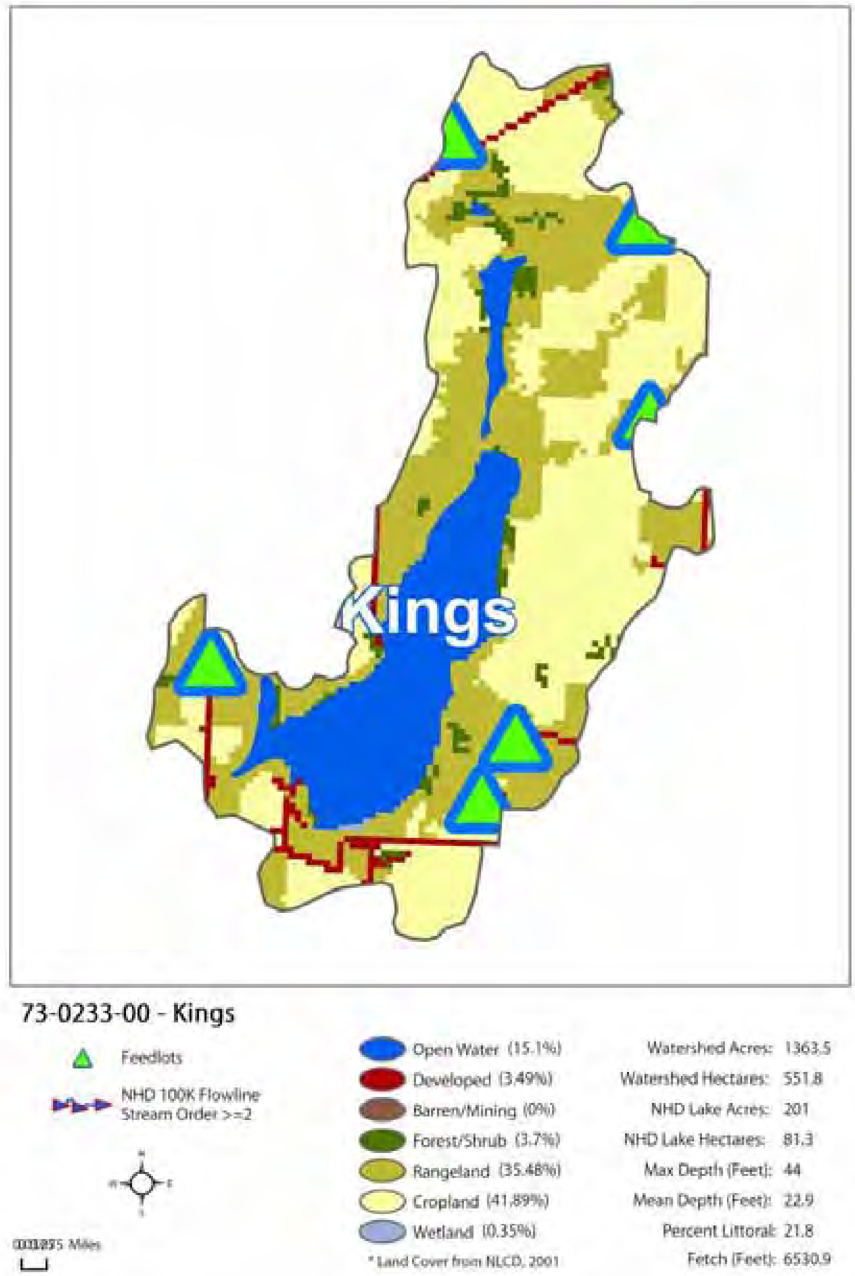
↘ decreasing/declining trend ↗ increasing/improving trends NT No Trend ID Insignificant Data
FS Full Support NS none supporting HE hypereutrophic E Eutrophic M Mesotrophic O Oligotrophic

# Kings 73-0233



Kings Lake is an 81-hectare (200 acres) lake with a mean depth of 7 meters. Much of the lakes shore land undeveloped. The watershed is small dominated by crop and rangeland much of which goes up to the lake shore.

**Figure 59. Lake catchment and landuse map**



## Water Quality Summary

The most recent profile and trophic indicators on Kings Lake are from 2009. No stratification was present early June 2009, but by late June, surface temperatures had risen to 23°C and thermoclines were present through the rest of the summer (Figure 60). Below 8 meters water temperatures remained between 14-15 °C throughout the summer. Significant declines in DO below the thermocline was observed in mid June and August (Figure 19). DO levels reacted hypoxic conditions between six to eight meters mid June and August. TSI indicator data from 2007 and 2009 show similar results and trend between the two summers (Figure 62). Transparency depth decreased through each summer.

**Figure 60 Kings Lake 2009 temperature profiles**

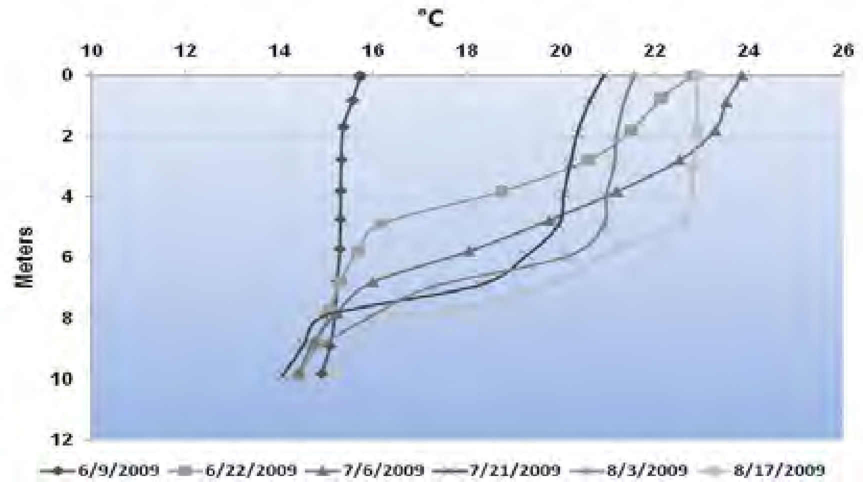



**Figure 61 Kings Lake DO profiles**

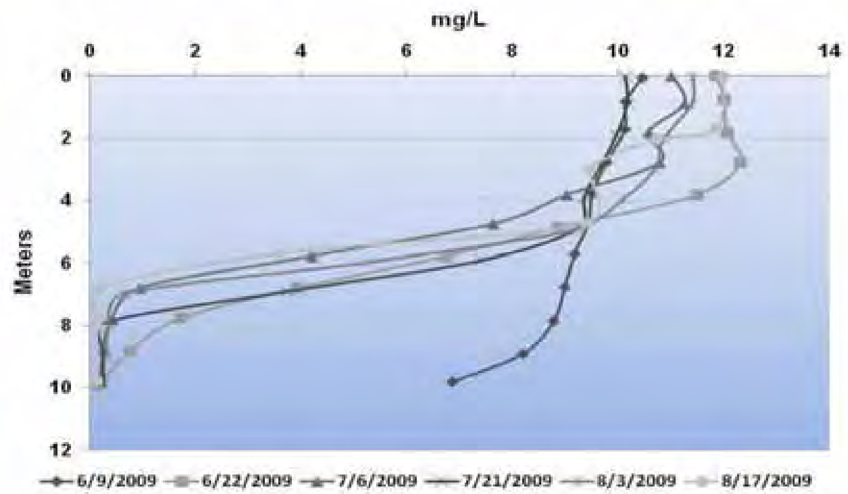
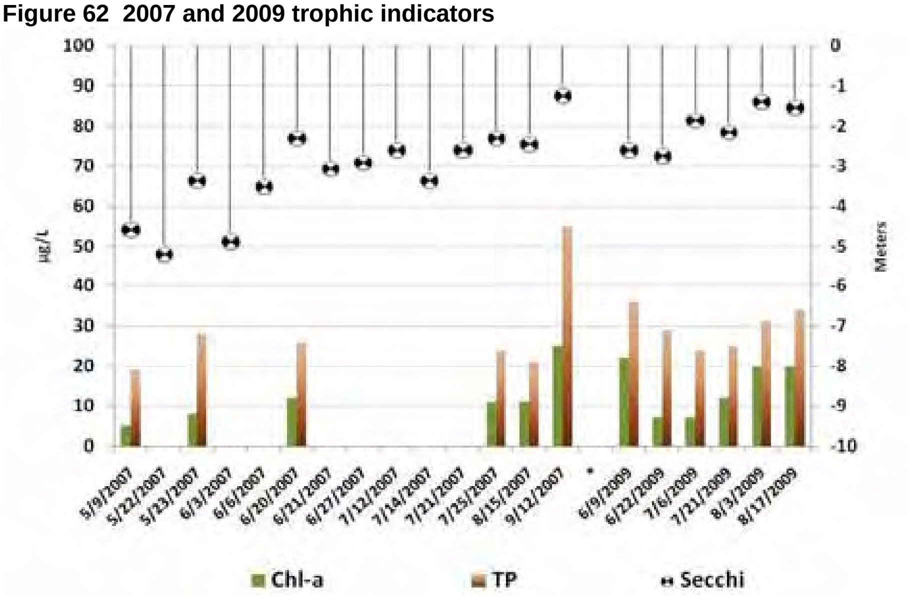



**Figure 62 2007 and 2009 trophic indicators**



## Water Quality Trends

TSI indicators on Kings Lake begin in 1981. Summer averages are similar throughout the record. No overall trend was present in the long-term record.

## Modeling and Assessment Status

The MINLEAP model predicted TSI indicator values similar to the 2000-2009 assessment means. The assessment mean values for all three indicators show Full Support for ARUS.

**Figure 63 Long-term water quality trends**

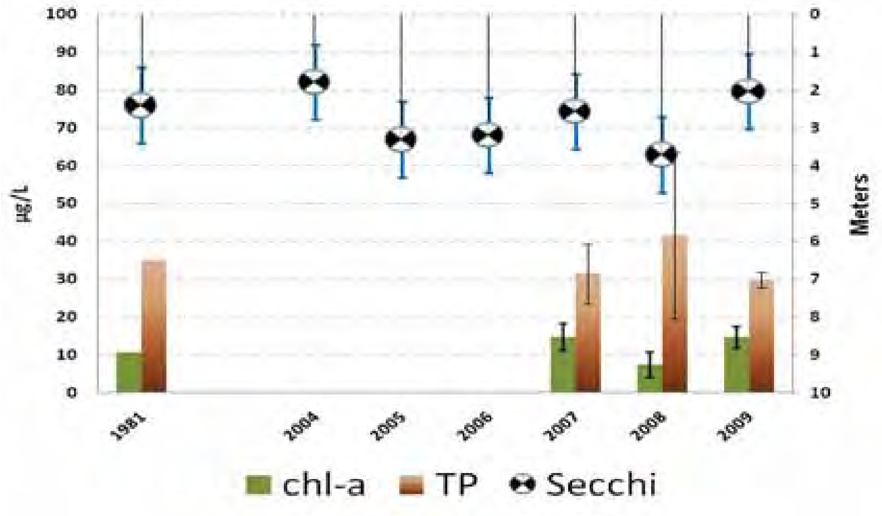
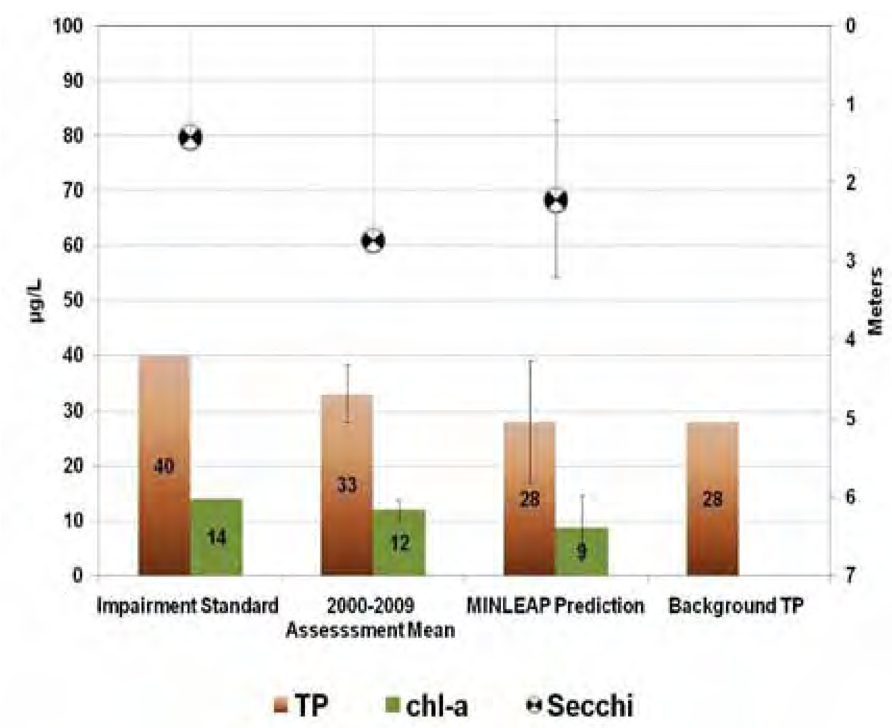


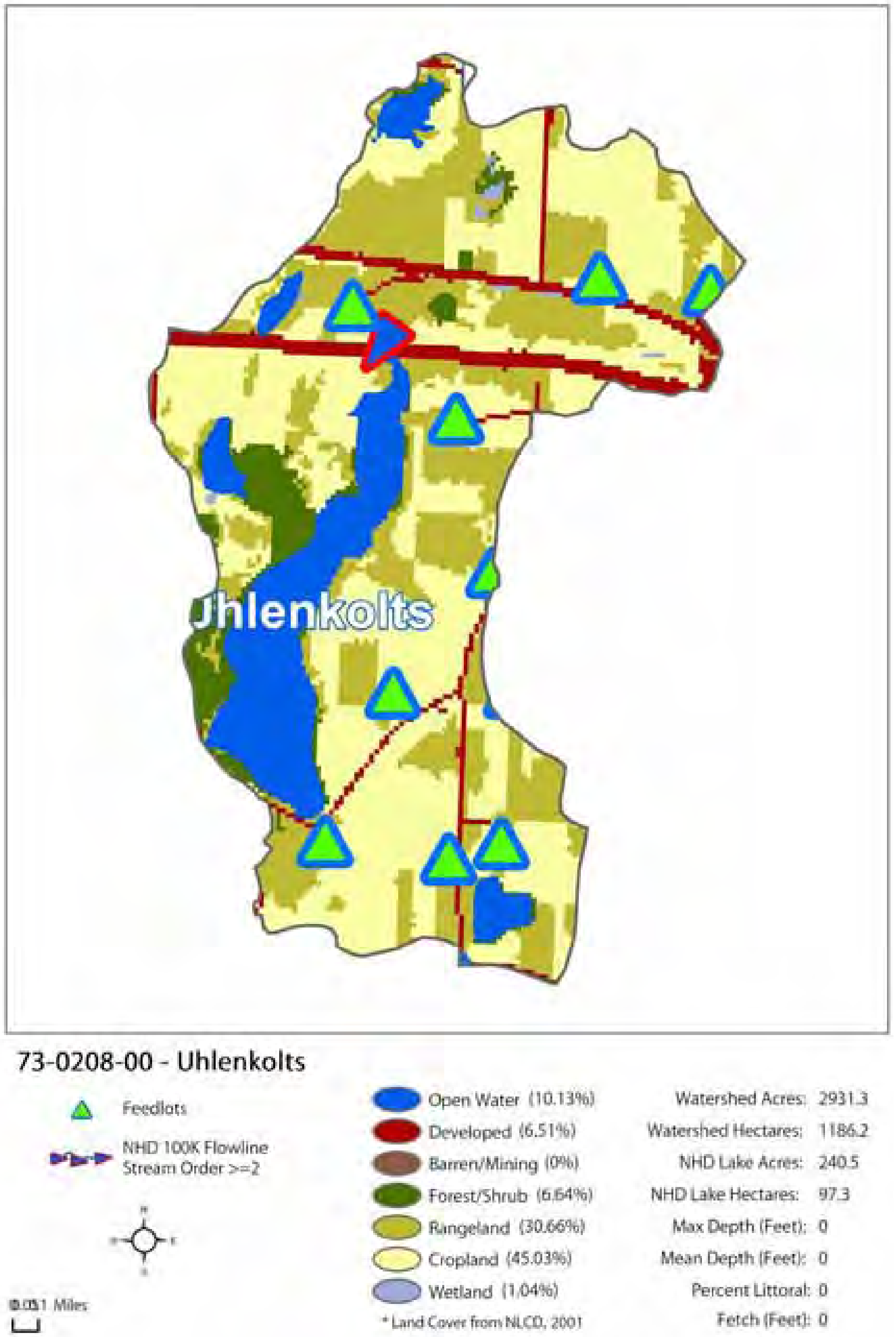

**Figure 64 King Lake assessment status and MINLEAP predictions**



# Uhlenkolts 73-0208

Uhlenkolts is a shallow lake (maximum depth of 18 feet) located near of New Munich just south of HWY 94 Minnesota. The lake has a modest sized watershed consisting of several feedlots and cropland (Figure 65). The west bank of the lake is primarily forested. Recreation use on Uhlenkolts is most likely waterfowl hunting.

**Figure 65. Lake Uhlenkolts catchment and landuse map**



## Water Quality Summary

The most recent profile data (2009) and TSI data (2008-2009) were used in this assessment. Little temperature stratification was observed during the 2009 monitoring. DO level dropped but depth but rarely dropped below hypoxic in the hypoxic in the hypolimnium. Monthly TSI values show a distinct difference between the two years of monitoring.

**Figure 66. Uhlenkolts Lake temperature profiles**

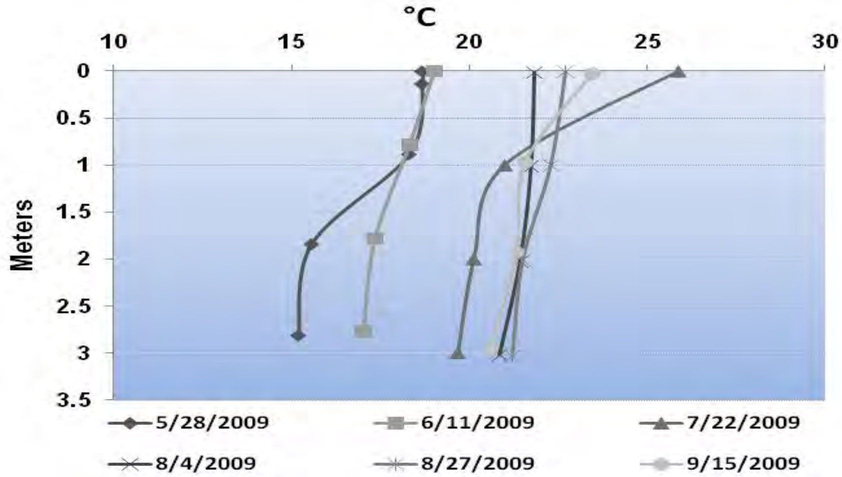



**Figure 67. Uhlenkolts Lake DO profiles**

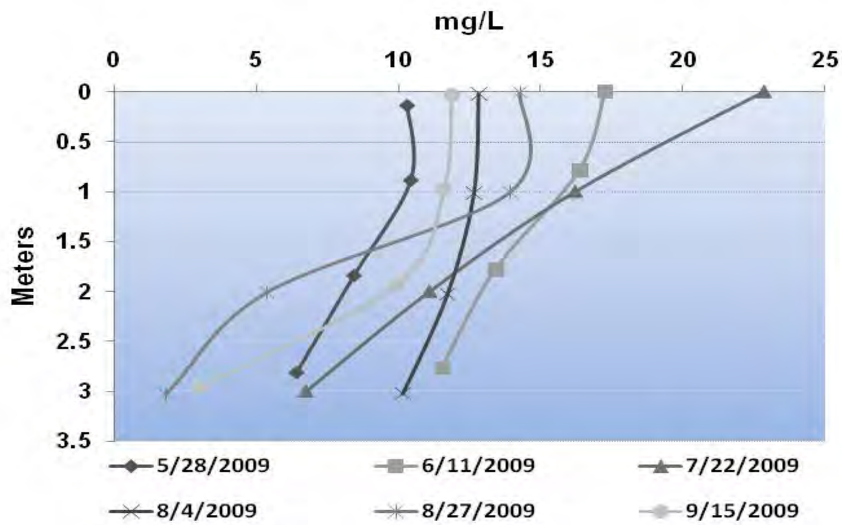
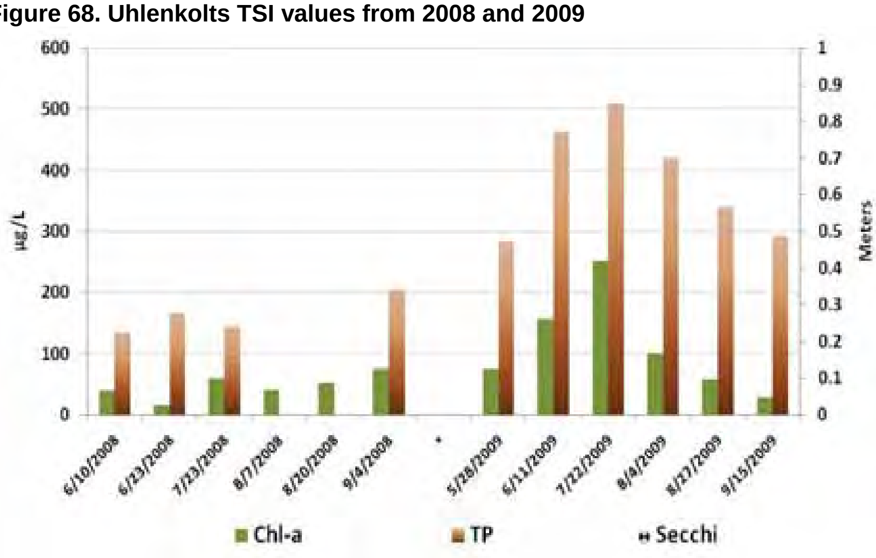



**Figure 68. Uhlenkolts TSI values from 2008 and 2009**



## Water Quality Trends

Only data available for the lake was from 2008 and 2009. The 2009 results were significantly higher than the previous season.

## Modeling and Assessment Status

MINLEAP predicted TSI values are much lower than the Assessment mean and above the impairment standard for shallow lakes. The lake has been assesed as not supporting and was put on the 2009 303(d) impaired waters list.

**Figure 69. Long-term water quality trends**

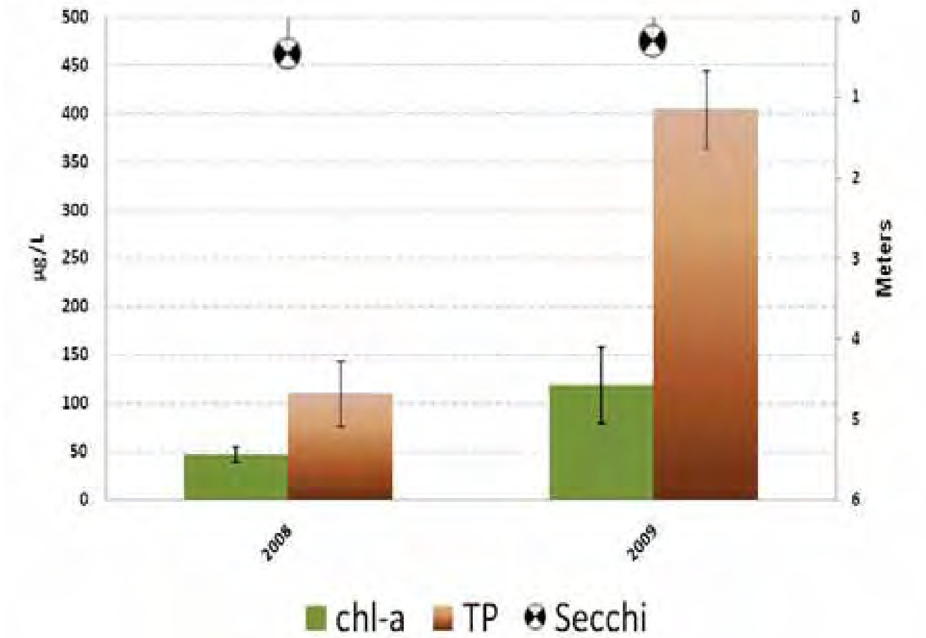
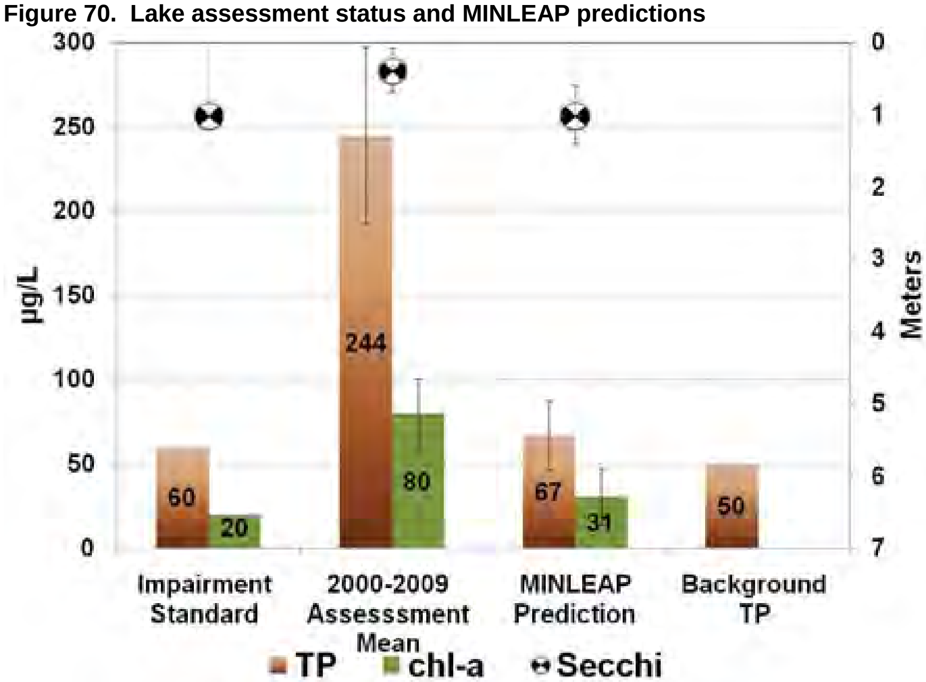



**Figure 70. Lake assessment status and MINLEAP predictions**



# Adley and Prairie Creeks

The Adley and Prairie Creek HUC 11 has 47 lakes of which 28 are greater than 10 acres (Table 9). Only three lakes have assessment level water quality data. Only one lake, Little Birch, has assessment data and is over 200 acres.

**Figure 71. Adley and Prairie HUC 08 landuse map**

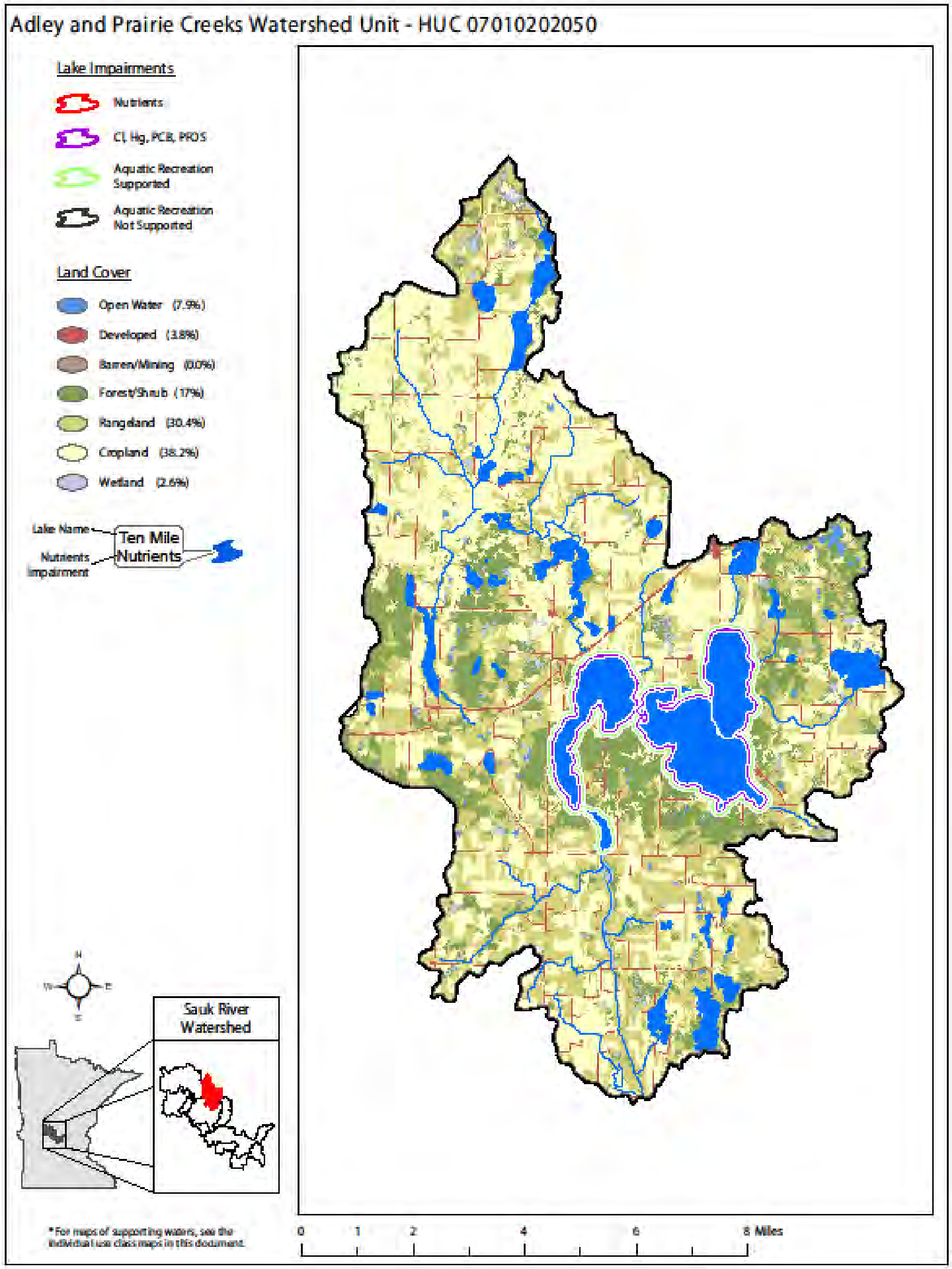
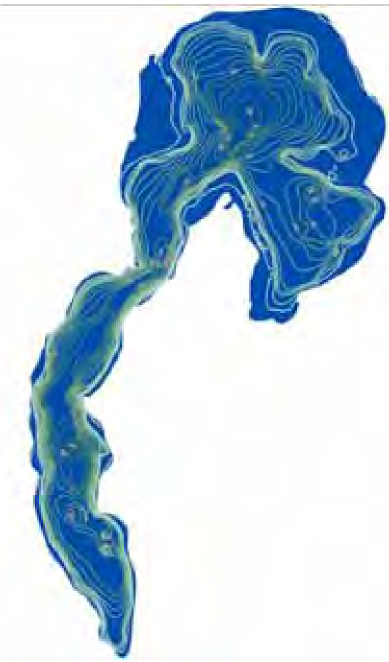


**Table 9. Status and information on Lakes >10 acres in Adley and Prairie Watershed**

| Name | DOW# | County | Area (acres) | % Littoral | Avg. Depth (M) | Max. Depth (M) | ARUS | Trophic Status | Mean TP (µg/L) | Mean chl-*a* (µg/L) | Secchi Mean (M) | CLMP Trend | RS 2005 | RS Trend |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Big Birch | 77008400 | TODD | 2095 | 31 | 25 | 77 | | | | | | | | |
| Little Birch | 77008900 | TODD | 829 | 33 | 29 | 89 | FS | M | 22 | 7 | 3 | ↗ | | |
| Felix | 77011500 | TODD | 134 | | | | | | | | | | 1.6 | NT |
| Goose | 77001800 | TODD | 130 | 100 | | | | | | | | | 2.0 | NT |
| Cedar | 73022600 | STEARNS | 93 | 78 | 7 | 36 | ID | M | 22 | 6 | 2 | | 2.6 | NT |
| Hansman | 77011100 | TODD | 87 | | | | | | | | | | 1.6 | NT |
| Sylvia | 73024900 | STEARNS | 86 | 28 | 26 | 56 | FS | M | 17 | 6 | 3 | NT | | |
| Pauley | 77010300 | TODD | 71 | 100 | | | | | | | | | 0.7 | NT |
| Hennessy | 77009600 | TODD | 65 | 65 | 11 | | | | | | | | 1.4 | NT |
| Stub | 73025200 | STEARNS | 57 | | | | | | | | | | 2.8 | NT |
| Buckhead | 77001100 | TODD | 56 | 94 | | | | | | | | | 2.8 | NT |
| Fuller | 77009500 | TODD | 48 | 52 | 16 | | | | | | | | 1.9 | NT |
| Pixley | 77009700 | TODD | 37 | | | | | | | | | | 1.1 | NT |
| Unnamed | 77010200 | TODD | 36 | | | | | | | | | | | |
| Schafer | 77009000 | TODD | 31 | | | | | | | | | | 2.3 | NT |
| Bunker | 77010100 | TODD | 30 | | | | | | | | | | 2.8 | NT |
| Hartnett | 73025300 | STEARNS | 27 | | | | | | | | | | 1.4 | NT |
| McKenny | 73022100 | STEARNS | 26 | | | | | | | | | | 0.4 | NT |
| North Wolf | 73022800 | STEARNS | 18 | | | | | | | | | | | |
| Wolf | 73032800 | STEARNS | 16 | | | | | | | | | | 1.7 | NT |
| Zager | 77010000 | TODD | 15 | | | | | | | | | | | |
| Unnamed | 73032900 | STEARNS | 12 | | | | | | | | | | | |
| Unnamed | 77009400 | TODD | 12 | | | | | | | | | | | |
| Marty Pond | 77001700 | TODD | 12 | | | | | | | | | | 2.9 | NT |
| Feucht | 77009100 | TODD | 12 | | | | | | | | | | 2.0 | NT |
| Unnamed | 77024900 | TODD | 11 | | | | | | | | | | | |
| Unnamed | 77033400 | TODD | 11 | | | | | | | | | | | |
| Unnamed | 77021800 | TODD | 10 | | | | | | | | | | | |

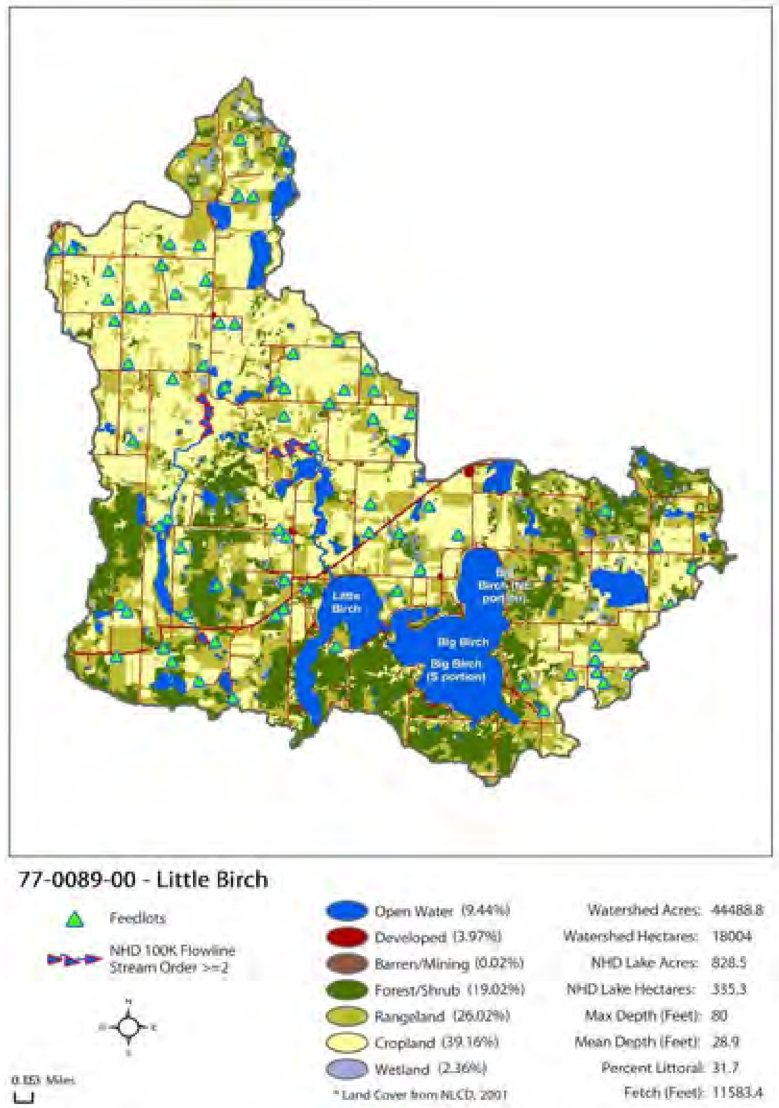
↘ decreasing/declining trend ↗ increasing/improving trends NT No Trend ID Insignificant Data
FS Full Support NS none supporting HE hypereutrophic E Eutrophic M Mesotrophic O Oligotrophic

# Little Birch 77-0089



Little Birch Lake is deep at 27 meters (89 feet) with only 31% littoral depth. The lake has a larger watershed that includes Big Birch Lake as well as a fair amount of forested area and small lakes (Figure 72).

**Figure 72. Lake catchment and landuse map**



## Water Quality Summary

Only one set of profile measurements was found from 2002 for Little Birch Lake. The profiles show stratified condition in early June. A strong thermocline was present between 5 and 8 meters at that time. The most recent TSI results (2005) show higher TP in May. Chl-*a* and TP levels were stable June through September.

**Figure 73. Little Birch temperature and DO profiles**

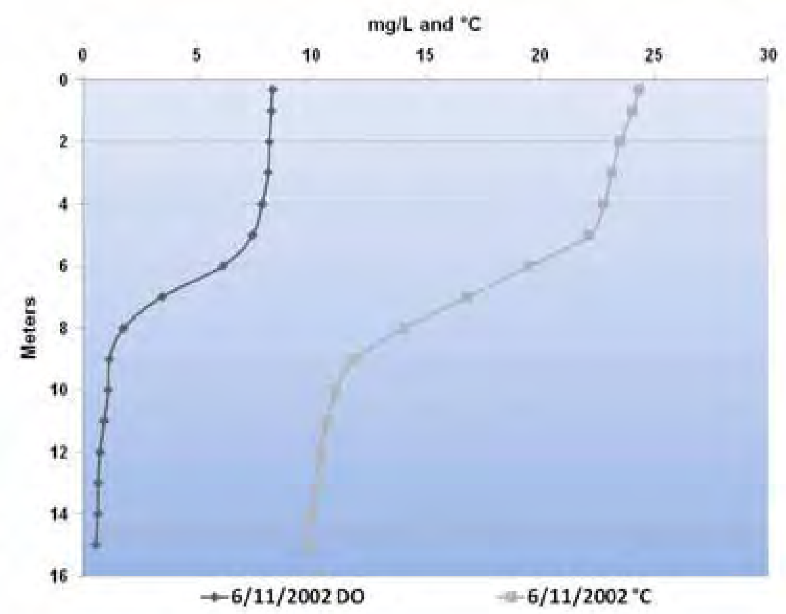
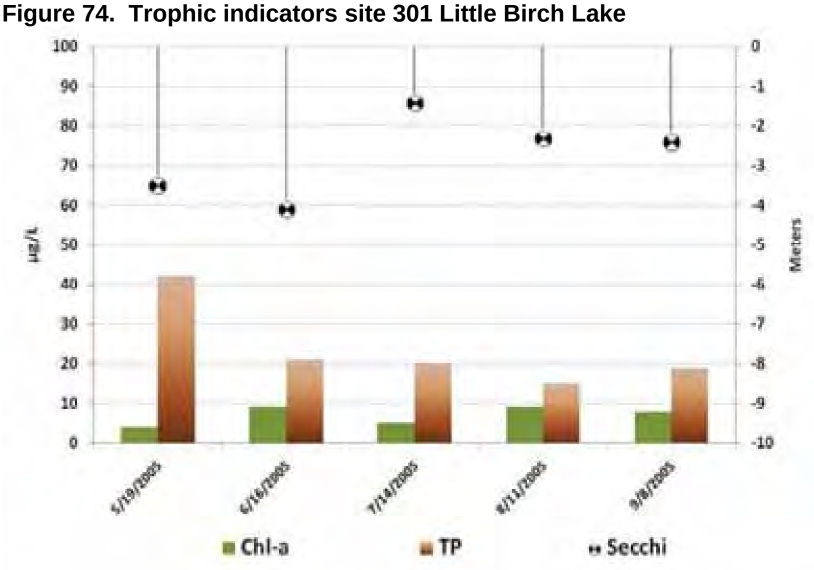



**Figure 74. Trophic indicators site 301 Little Birch Lake**



## Water Quality Trends

Secchi records for Little Birch Lake began in 1948. No overall trend is evident in any of the TSI indicators.

## Modeling and Assessment Status

The assessment mean value was much lower than MINNLEAP model predicted the TP, chl-*a* higher but within the margin of error. The 2000-2009 assessment average is well below the impairment standards for deep lakes classifying it as fully supporting for ARUS.

**Figure 75 Long-term water quality trends**

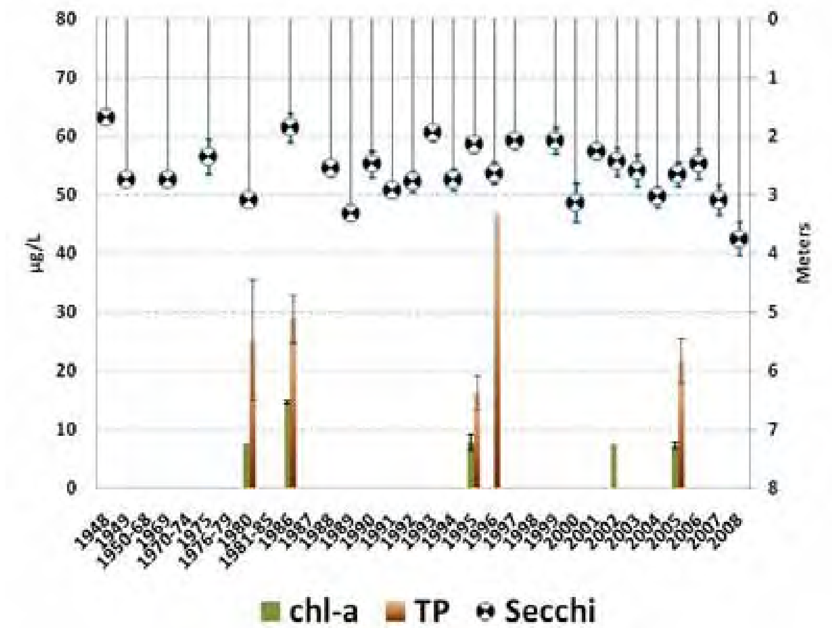
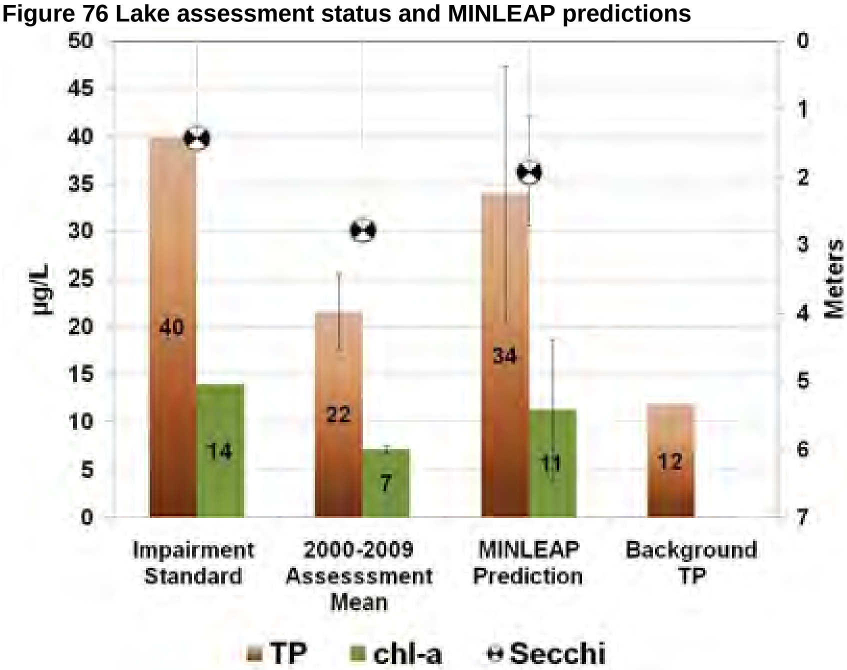



**Figure 76 Lake assessment status and MINLEAP predictions**



# Getchell Creek

Getchell Creek HUC 11 is 42,616 acres of mostly Crop and Rangeland (Figure 77). The HUC 11 has 16 lakes of which eight are over10 acres (Table 10). The only lake in the Getchell HUC 11 has been assessed (Sand Lake 73-0199).

**Figure 77 Getchell HUC 08 Landuse map**

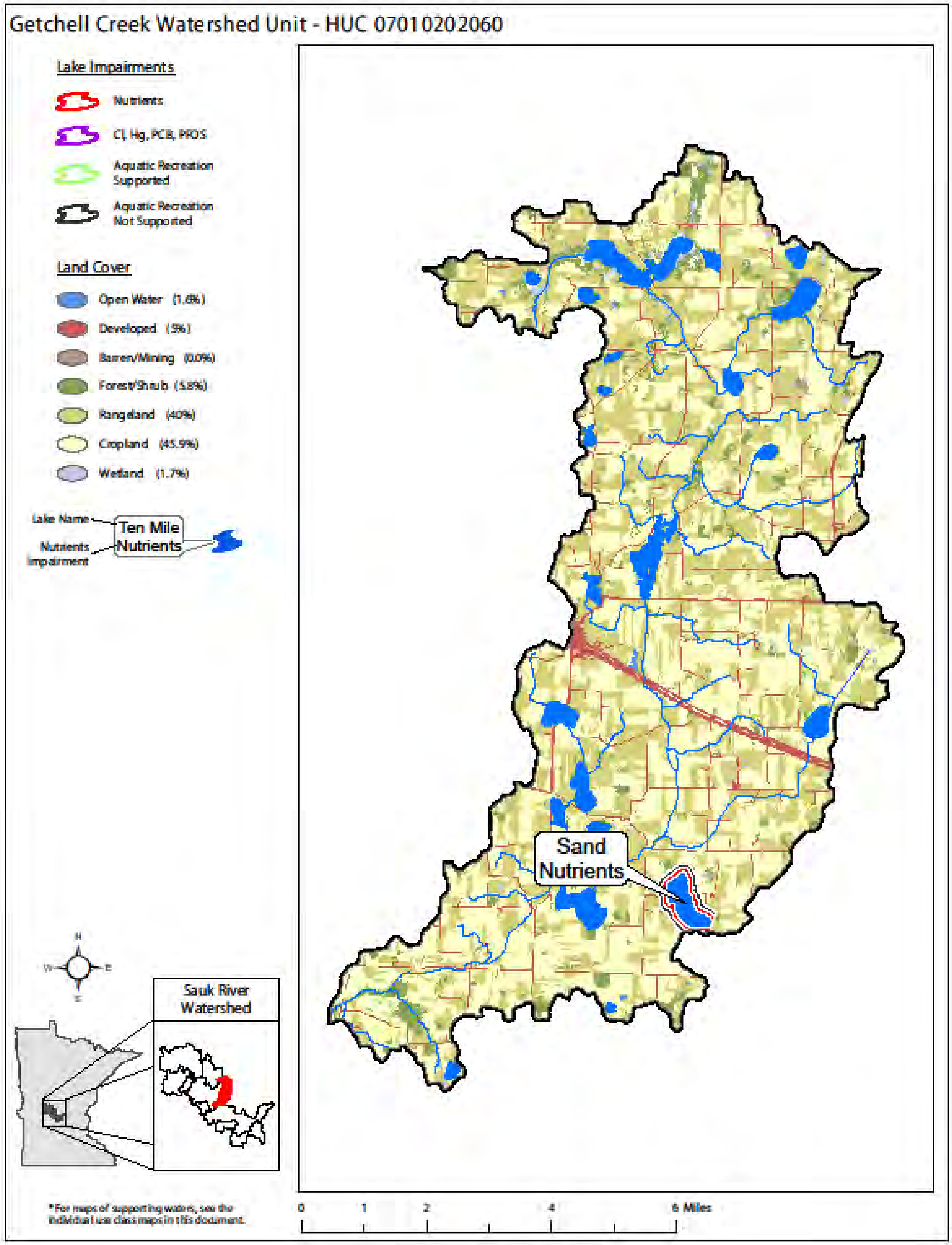


**Table 10 Status and information on Lakes >10 acres in Adley and Prairie Watershed**

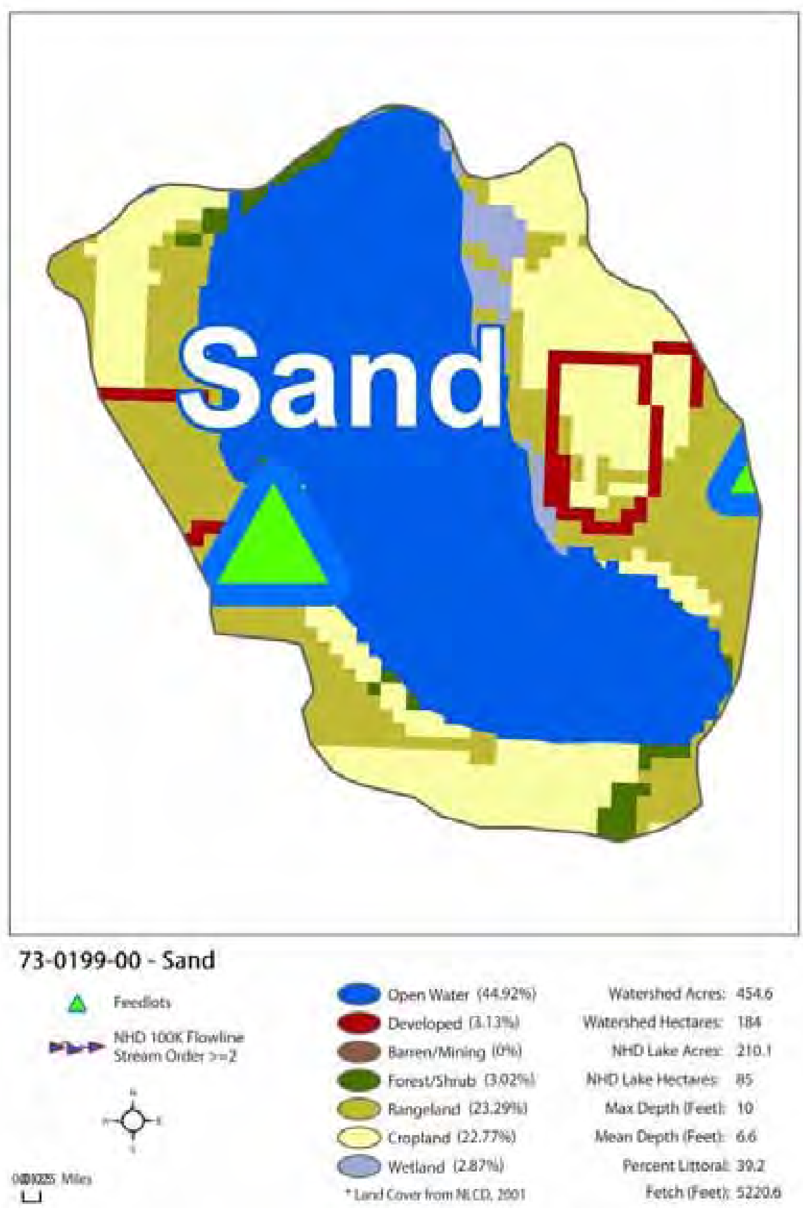
| Name | DOW# | County | Area (acres) | % Littoral | Avg. Depth (M) | Max. Depth (M) | ARUS | Trophic Status | Mean TP (µg/L) | Mean chl-*a* (µg/L) | Secchi Mean (M) | CLMP Trend | RS 2005 | RS Trend |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sand | 73019900 | STEARNS | 210 | 100 | 7 | 12 | NS | H | 153 | 78 | 1 | ↗ | | |
| St. Anna | 73018300 | STEARNS | 118 | 26 | | 105 | ID | E | 81 | 15 | 2 | NT | | |
| Lovell | 73021900 | STEARNS | 72 | | | | | | | | | | 0.5 | NT |
| Getchell | 73021700 | STEARNS | 71 | | | | | | | | | | 1.0 | NT |
| Mud | 73022000 | STEARNS | 39 | | | | | | | | | | 1.1 | NT |
| Freeport | 73021800 | STEARNS | 28 | | | | | | | | | | 1.8 | NT |
| Unnamed | 73022200 | STEARNS | 26 | | | | | | | | | | 2.0 | |
| Unnamed | 73018200 | STEARNS | 18 | | | | | | | | | | | NT |
| Rolling | 73023200 | STEARNS | 18 | | | | | | | | | | 1.6 | NT |
| Unnamed | 73056900 | STEARNS | 17 | | | | | | | | | | 1.6 | NT |
| Unnamed | 73022400 | STEARNS | 11 | | | | | | | | | | | |

↘ decreasing/declining trend ↗ increasing/improving trends NT No Trend ID Insignificant Data
FS Full Support NS none supporting HE hypereutrophic E Eutrophic M Mesotrophic O Oligotrophic

# Sand Lake 73-0199

Sand Lake is a small (210 acres) shallow (100% littoral) lake located three miles southwest of Albany. The lake has a very small closed basin watershed. A feedlot facility is located on the west edge of the lake.

**Figure 78.Sand Lake catchment and landuse map**



## Water Quality Summary

The most recent profile data (2009) and TSI data (2008-2009) were used in this assessment. Temperatures were mixed through the water column (Figure 79) during most observation in 2009. 2008 and 2009 TSI values show the lake is subject to drastic increases in TP and chl-*a* between monthly monitoring (August.4th 2008, June 10th 2009, and July 20th 2009). Considering the lack of any stratification, the shallowness, and spikes in TP and chl-*a*, this lake appears to be significantly affected by wind mixing.

**Figure 79 Sand Lake 2009 temperature profiles**

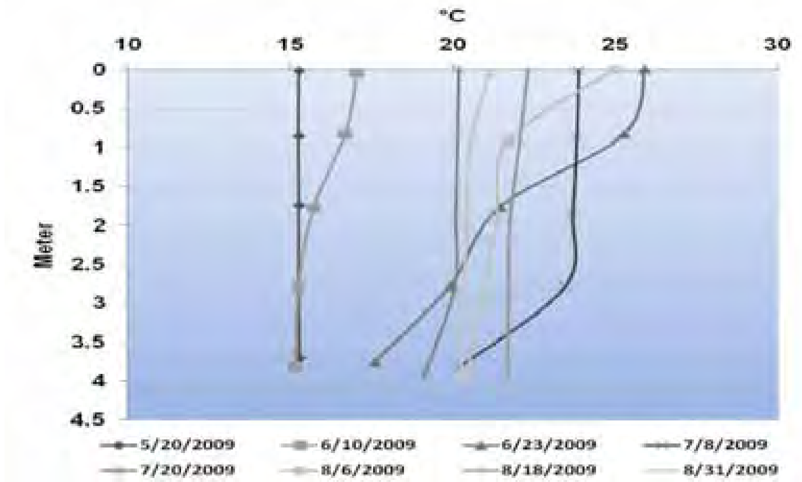



**Figure 80. Sand Lake 2009 DO profiles**

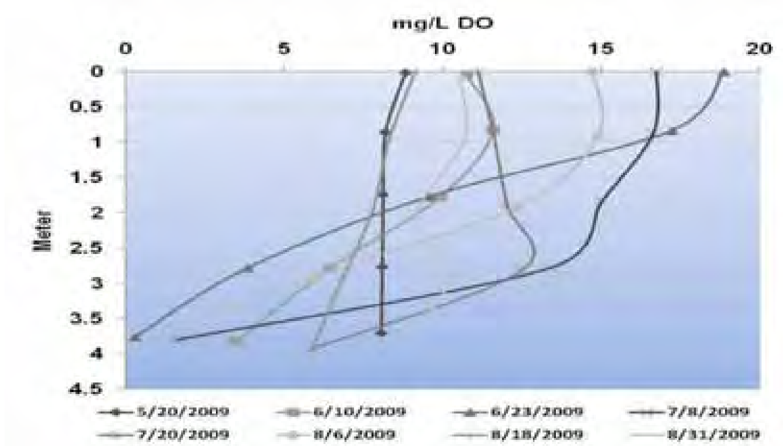
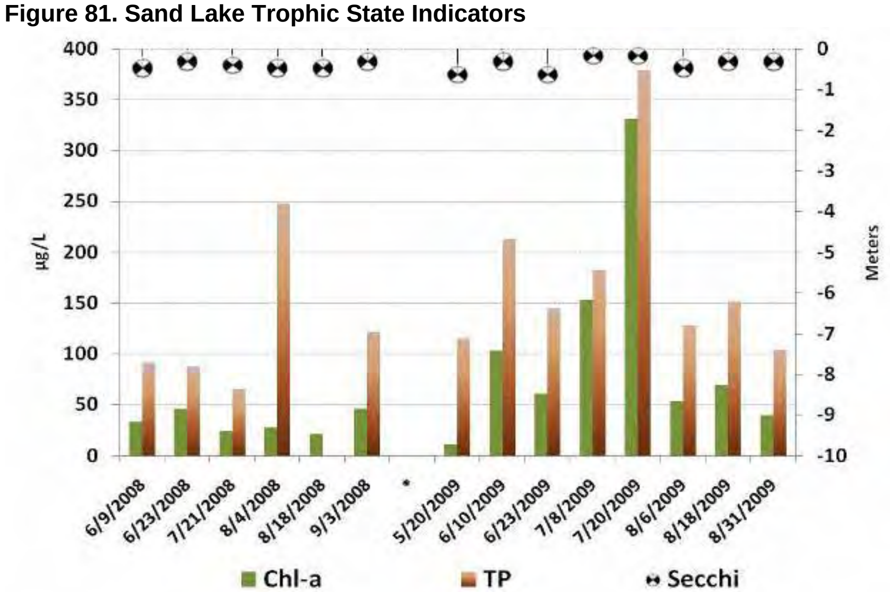



**Figure 81. Sand Lake Trophic State Indicators**



## Water Quality Trends

Water quality records on the lake go back to 1981. The lake has had consistent CLMP monitoring beginning in 1999. TP summer mean values are consistently high and show an increasing trend.

## Modeling and Assessment Status

The MINLEAP model predicted much lower TP and chl-*a* than observed (Figure 83). The lake well exceeds the ARUS standards and was put in the 303(d) impaired waters list.

**Figure 82. Long-term summer mean water quality trends**

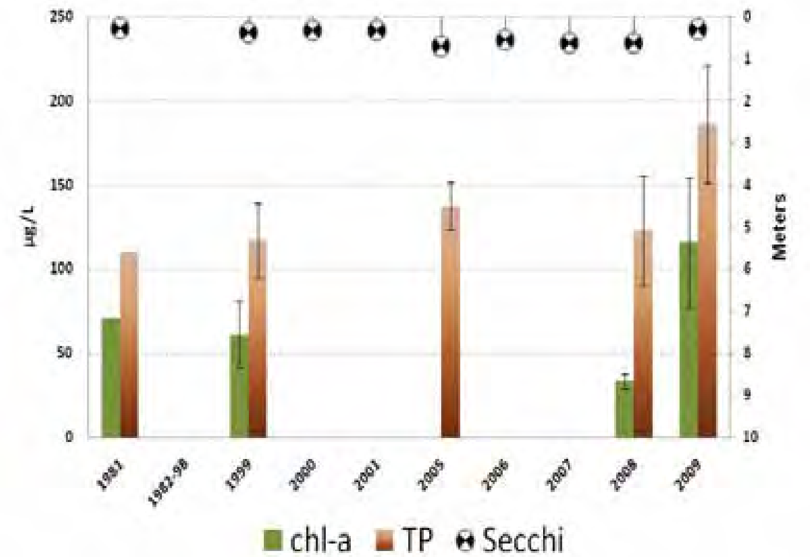
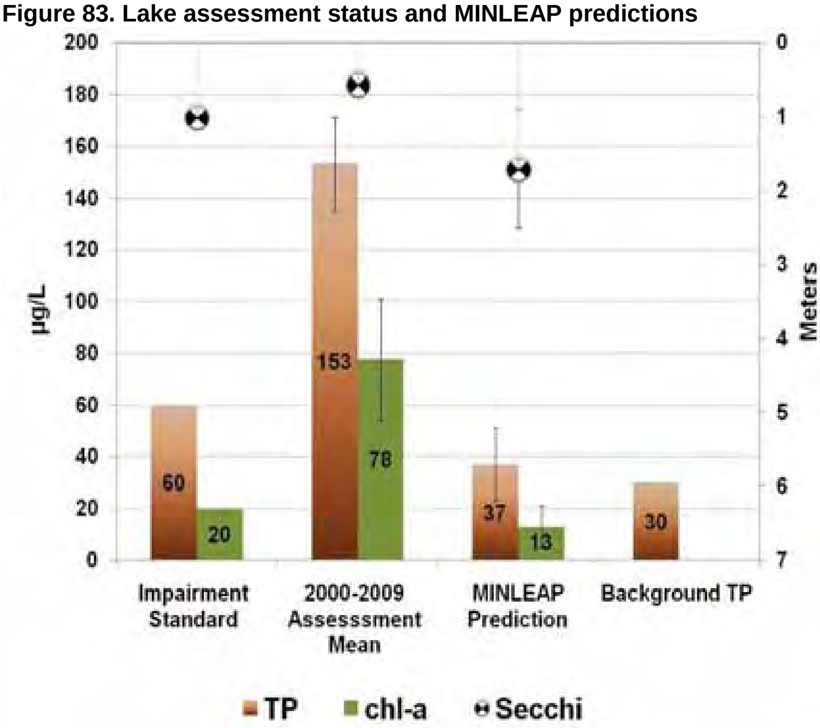



**Figure 83. Lake assessment status and MINLEAP predictions**



# Stony Creek HUC 11

This is the smallest HUC 11 in the Sauk River watershed. Only five established lakes are located in the Stone Creek watershed, of which only two are greater than 10 acres (Table 11). The only water quality information found on lakes in the Stony Creek was satellite. No lakes in the Stony Creek watershed have water quality assessment data. Over two thirds of the watershed is cropland.

**Figure 84 Stony Creek HUC 08 Landuse map**

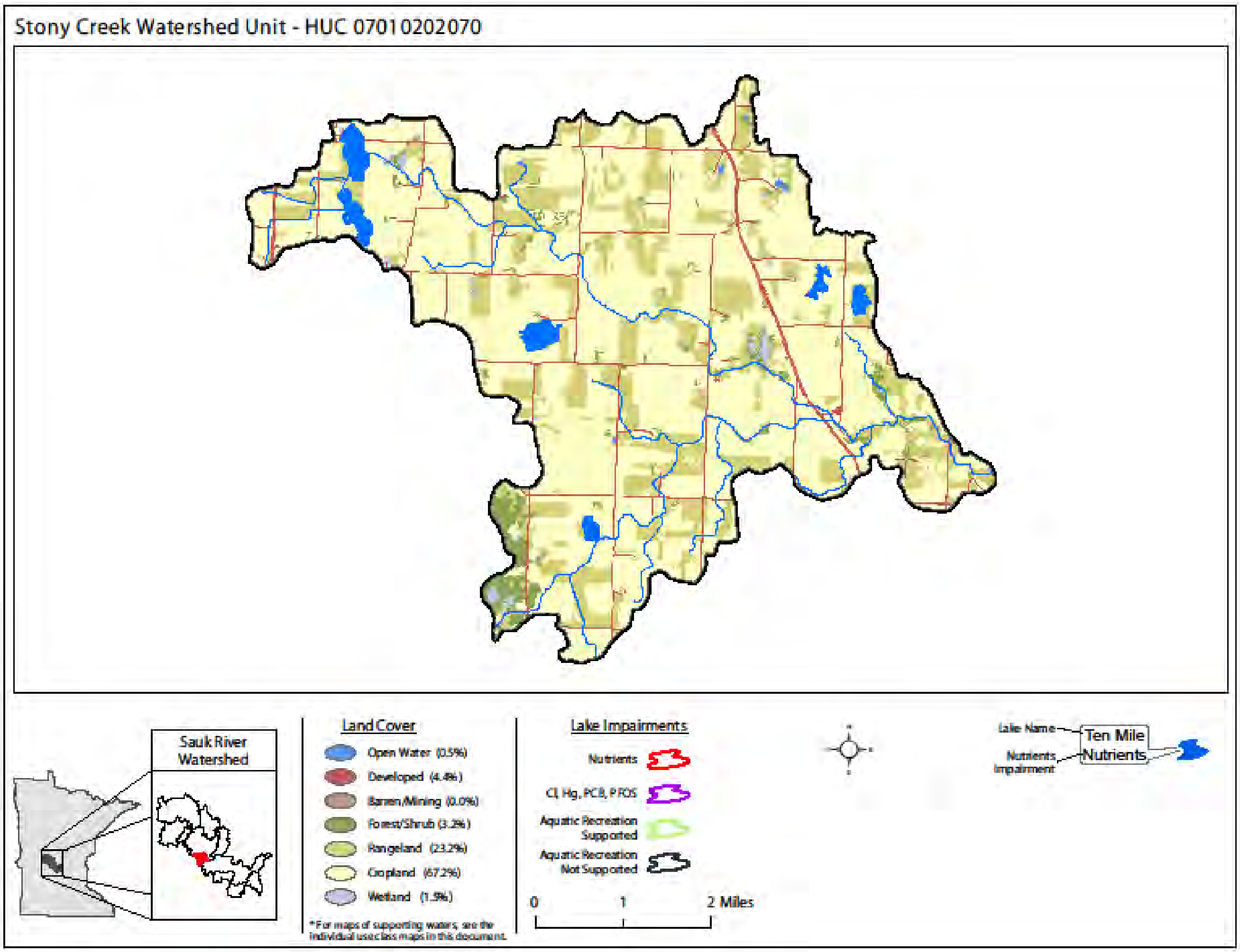



**Table 11. Status and information on Lakes in Stony Creek HUC 8**

| Name | DOW# | County | Area (acres) | % Littoral | Avg. Depth (M) | Max. Depth (M) | ARUS | Trophic Status | Mean TP (µg/L) | Mean chl-*a* (µg/L) | Secchi Mean (M) | CLMP Trend | RS 2005 | RS Trend |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Unnamed | 73-0254 | STEARN | 4 | | | | | | | | | | 1.8 | |

↘ decreasing/declining trend ↗ increasing/improving trends NT No Trend ID Insignificant Data
FS Full Support NS none supporting HE hypereutrophic E Eutrophic M Mesotrophic O Oligotrophic

# Lower Sauk River

Lower Sauk is the second largest HUC 11 in the Sauk River. It is lake rich watershed with 79 established lakes (Table 12). Water quality of the Lower Sauk Lake is generally poor with many eutrophic and hypereutrophic lakes. The western portion of the Lower Sauk HUC 11 consists of the main-stem Sauk River and a few small lakes (Figure 85). The eastern portion of the watershed has numerous lakes including the zigzagging Horseshoe chain of lakes. The horseshoe chain includes several riverine lakes including: Cedar Island, Horseshoe, Long, Knaus, Zumwalde and Schneider. The Sauk River flows through the Horseshoe Lake Chain of lakes and is controlled mechanically by a dam in Cold Springs. The Lower Sauk is a very well monitored area with several ongoing projects. Sixteen lakes in the basins have assessment data: twelve none support, two fully supporting and two with insufficient data. Although non-point sources (agricultural run-off) continue to be a concern, some major contributors or nutrients (such as municipal wastewater discharge) were greatly reduced in the 1980's and 1990's. Efforts to address existing sources include a TMDL study including: Thein, Schneider, Kraus, Zumwalde, Bolfin, Long, Cedar Island, Henry, Great Northern, Pleasant, North Brown's, Knaus, Long, Big Fish and Horseshoe lakes (Table 12). Water quality in most of the lakes remains in the hypereutrophic range (very nutrient-rich).

**Figure 85 Lower Sauk HUC 11 landuse map**

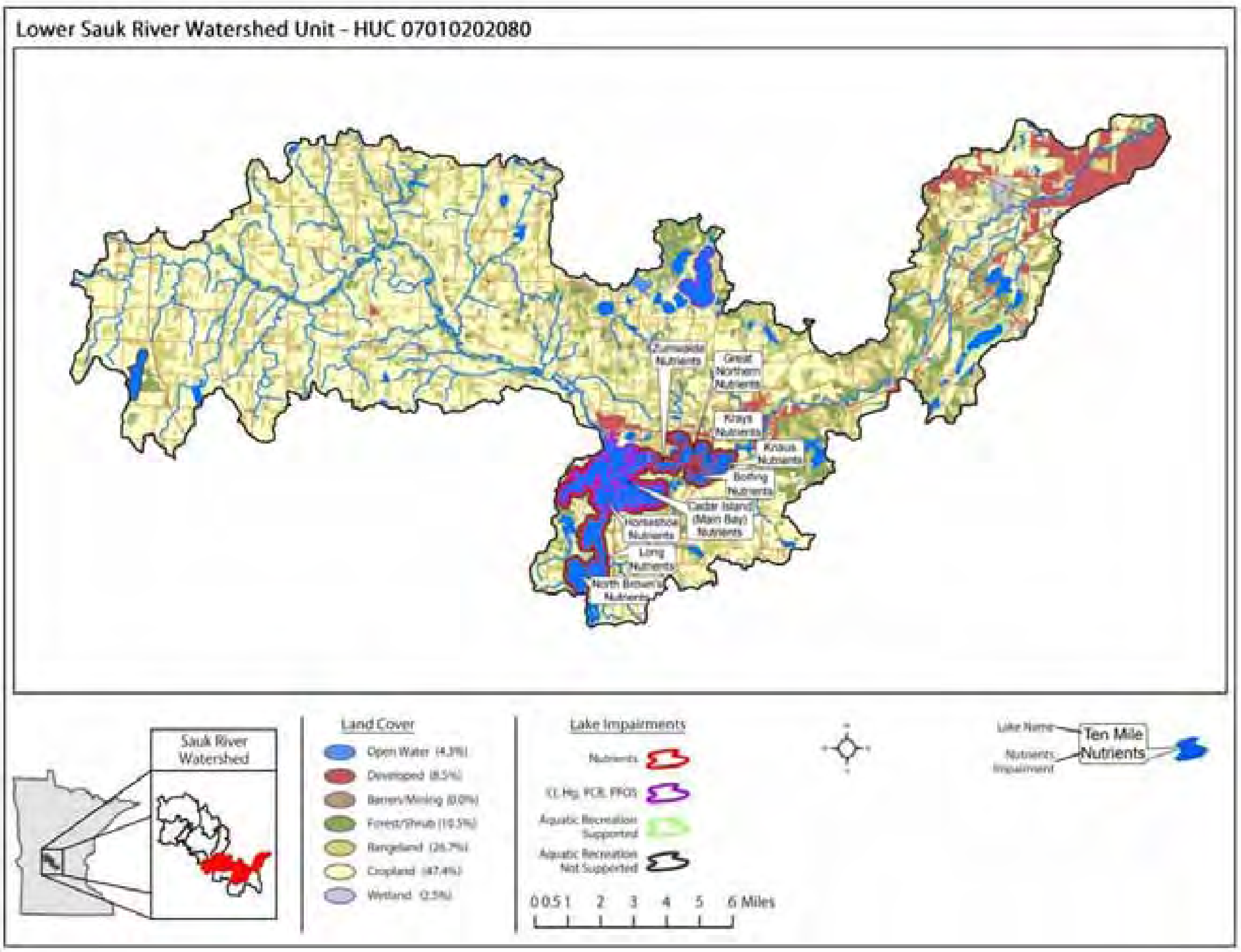


**Table 12 Lower Sauk HUC 11 lake information and status**

| Name | DOW# | County | Area (acres) | % Littoral | Avg. Depth (M) | Max. Depth (M) | ARUS | Trophic Status | Mean TP (µg/L) | Mean chl-*a* (µg/L) | Secchi Mean (M) | CLMP Trend | RS 2005 | RS Trend |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Cedar Island | 73013300 | STEARNS | 959 | 62 | | 75 | | | | | | | | |
| Horseshoe | 73015700 | STEARNS | 596 | 50 | 14 | 57 | NS | H | 103 | 62 | 1 | NT | | |
| Big Fish | 73010600 | STEARNS | 541 | 36 | 26 | 70 | FS | E | 47 | | 5 | ↗ | | |
| Long | 73013900 | STEARNS | 467 | 66 | 10 | 34 | NS | H | 97 | 62 | 1 | ↗ | | |
| Cedar Island (Main Bay) | 73013301 | STEARNS | 420 | | 15 | 18 | NS | E | 82 | 46 | 1 | ↗ | | |
| Knaus | 73008600 | STEARNS | 309 | | 6 | 23 | NS | H | 165 | 74 | 1 | NT | | |
| North Brown's | 73014700 | STEARNS | 309 | 67 | 18 | 34 | NS | H | 121 | 41 | 2 | ↘ | | |
| Cedar Island (East) | 73013304 | STEARNS | 258 | | 2 | 5 | | | | | | NT | | |
| Pleasant | 73005100 | STEARNS | 219 | 49 | 13 | 33 | FS | E | 30 | 7 | 3 | | 2.4 | NT |
| Great Northern | 73008300 | STEARNS | 210 | | 6 | 14 | NS | H | 155 | 77 | 1 | NT | | |
| Byer | 73008500 | STEARNS | 164 | 97 | | | | | | | | | 3.1 | NT |
| Henry | 73023700 | STEARNS | 160 | | | 5 | NS | H | 671 | 41 | 1 | | 0.5 | NT |
| Cedar Island (Koetter Lk | 73013303 | STEARNS | 160 | 66 | 4 | 75 | NS | H | 157 | 79 | 1 | ↗ | | |
| Long | 73010700 | STEARNS | 150 | 56 | | 46 | ID | M | | | 3 | ↗ | | |
| Sand | 73013400 | STEARNS | 124 | | | | | | | | | | 1.0 | NT |
| Bolfing | 73008800 | STEARNS | 110 | | 13 | 30 | NS | H | 128 | 56 | 1 | ↗ | | |
| Zumwalde | 73008900 | STEARNS | 100 | 91 | 6 | 18 | NS | H | 156 | 65 | 1 | ↗ | | |
| Mud | 73014000 | STEARNS | 84 | | | | | | | | | | 2.3 | NT |
| Krays | 73008700 | STEARNS | 81 | | 7 | 31 | NS | H | 163 | 76 | 1 | NT | | |
| Cedar Island (Mud Lk) | 73013302 | STEARNS | 72 | 91 | 10 | 36 | | | | | | | 1.0 | NT |
| School | 73017300 | STEARNS | 69 | | | | | | | | | | 1.6 | NT |
| Schneider | 73008200 | STEARNS | 59 | | 20 | 52 | NS | E | 68 | 35 | 2 | NT | | |
| Shackman | 73007900 | STEARNS | 56 | | | | | | | | | | 2.2 | ↗ |
| Cedar Island (Little) | 73013305 | STEARNS | 50 | | | | | | | | | | | |
| South Brown's | 73014800 | STEARNS | 44 | | | | | | | | | | 1.6 | NT |
| Mud | 73008100 | STEARNS | 42 | | | | | | | | | | 1.0 | NT |
| Kranz | 73016900 | STEARNS | 41 | | | | | | | | | | 1.1 | NT |
| Unnamed | 73008400 | STEARNS | 36 | | | | | | | | | | | |
| Thein | 73013200 | STEARNS | 36 | | | | ID | M | 18 | 9 | 4 | | 2.9 | NT |
| Mud | 73006800 | STEARNS | 32 | | | | | | | | | | 1.3 | NT |

↘ decreasing/declining trend  ↗ increasing/improving trends  NT No Trend  ID Insignificant Data
FS Full Support  NS none supporting  HE hypereutrophic  E Eutrophic  M Mesotrophic  O Oligotrophic

**Table 12 continued**

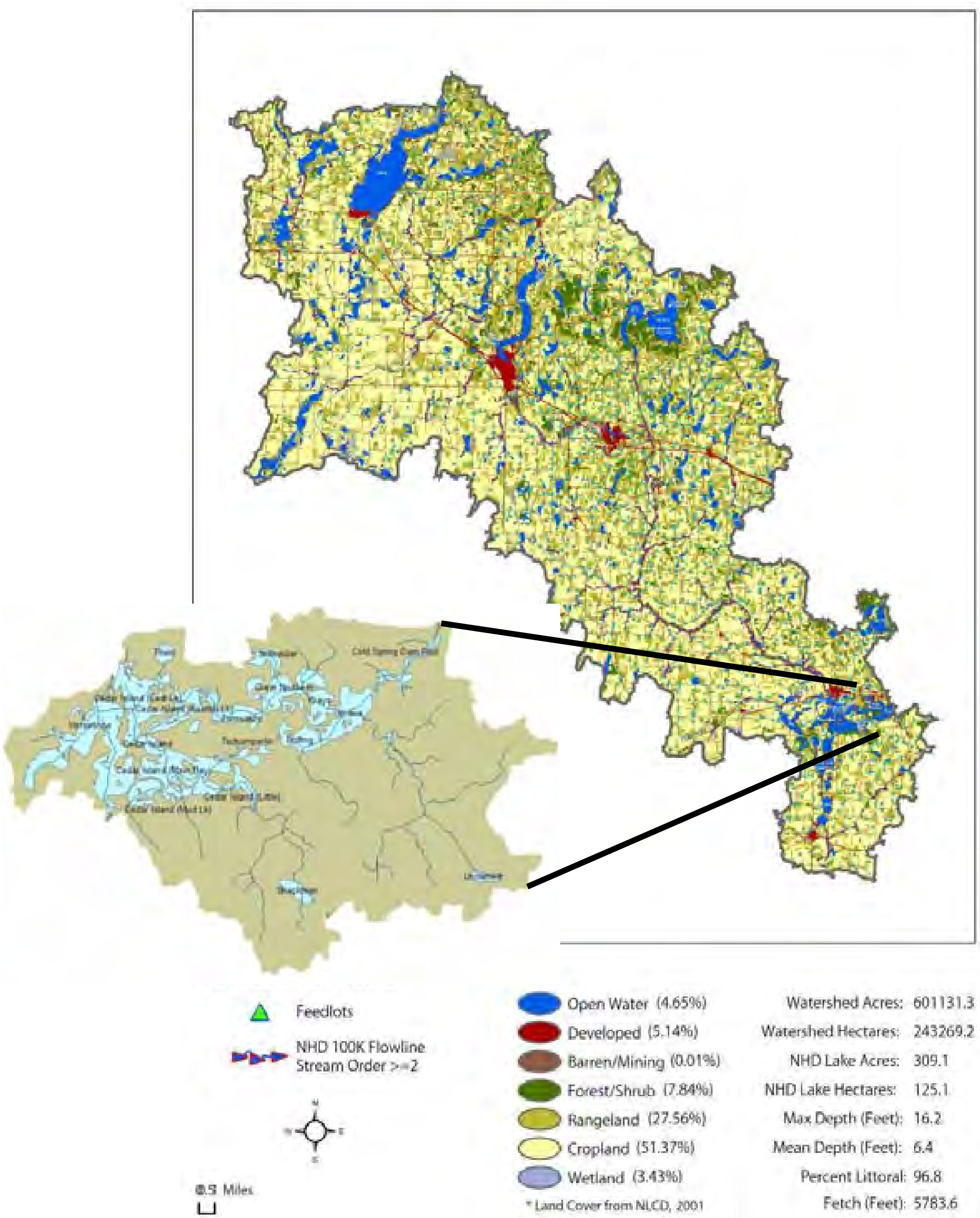
| Name | DOW# | County | Area | % Littoral | Avg. Depth (M) | Max. Depth (M) | ARUS | Trophic Status | Mean TP | Mean chl-a | Secchi Mean | CLMP Trend | RS 2005 | RS Trend |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Unnamed | 73005400 | STEARNS | 32 | | | | | | | | | | 2.3 | NT |
| Mud | 73011000 | STEARNS | 29 | | | | | | | | | | 0.6 | |
| Tschumperlin | 73009000 | STEARNS | 29 | | | | | | | | | | 1.7 | NT |
| Unnamed | 73016400 | STEARNS | 28 | | | | | | | | | | | |
| Unnamed (Hermit) | 73036900 | STEARNS | 26 | | | | | | | | | | 0.8 | ↘ |
| Eagle | 73011200 | STEARNS | 25 | | | | | | | | | | | |
| Unnamed | 73020500 | STEARNS | 24 | | | | | | | | | | 1.4 | NT |
| Rockville | 73005200 | STEARNS | 22 | | | | | | | | | | | |
| Unnamed | 73017400 | STEARNS | 19 | | | | | | | | | | | |
| Eggert | 73016200 | STEARNS | 19 | | | | | | | | | | 0.8 | NT |
| Backes | 73017000 | STEARNS | 17 | | | | | | | | | | 0.9 | NT |
| Lauer | 73016300 | STEARNS | 17 | | | | | | | | | | | |
| Unnamed | 73059000 | STEARNS | 16 | | | | | | | | | | 2.3 | NT |
| Unnamed | 73010800 | STEARNS | 15 | | | | | | | | | | | |
| Unnamed | 73054600 | STEARNS | 14 | | | | | | | | | | | |
| Roman Marsh | 73020300 | STEARNS | 14 | | | | | | | | | | | |
| Lueken | 73013100 | STEARNS | 13 | | | | | | | | | | 1.4 | NT |
| Unnamed | 73031700 | STEARNS | 13 | | | | | | | | | | | |
| Unnamed | 73051200 | STEARNS | 13 | | | | | | | | | | | |
| Unnamed | 73055600 | STEARNS | 10 | | | | | | | | | | | |
| Unnamed | 73011300 | STEARNS | 10 | | | | | | | | | | | |
| Unnamed | 73054000 | STEARNS | 10 | | | | | | | | | | | |
| Unnamed | 73041300 | STEARNS | 10 | | | | | | | | | | | |

↘ decreasing/declining trend ↗ increasing/improving trends NT No Trend ID Insignificant Data
FS Full Support NS none supporting HE hypereutrophic E Eutrophic M Mesotrophic O Oligotrophic

# Horseshoe Chain of Lakes

Sauk River widens near Cold Springs forming a zigzag series riverine lakes (a lake like widening of the river) called the Horseshoe chain of lakes (Figure 86). The Sauk Rivers flows through Horseshoe Cedar Island, Zumwaide, Great Northern, Krays and Knaus Lakes. The majority of the Sauk River HUC 8 watershed drains into the Horseshoe chain. The flow throw and water level in the Horseshoe chain is controlled by a dam structures located the near Cold Spring. Secchi measurements may not be as good of a trophic indicator in these lakes, because of the amount of water moving throw the system in a short time. Overall, the water quality of these lakes is poor, but has improved significantly over recent years.

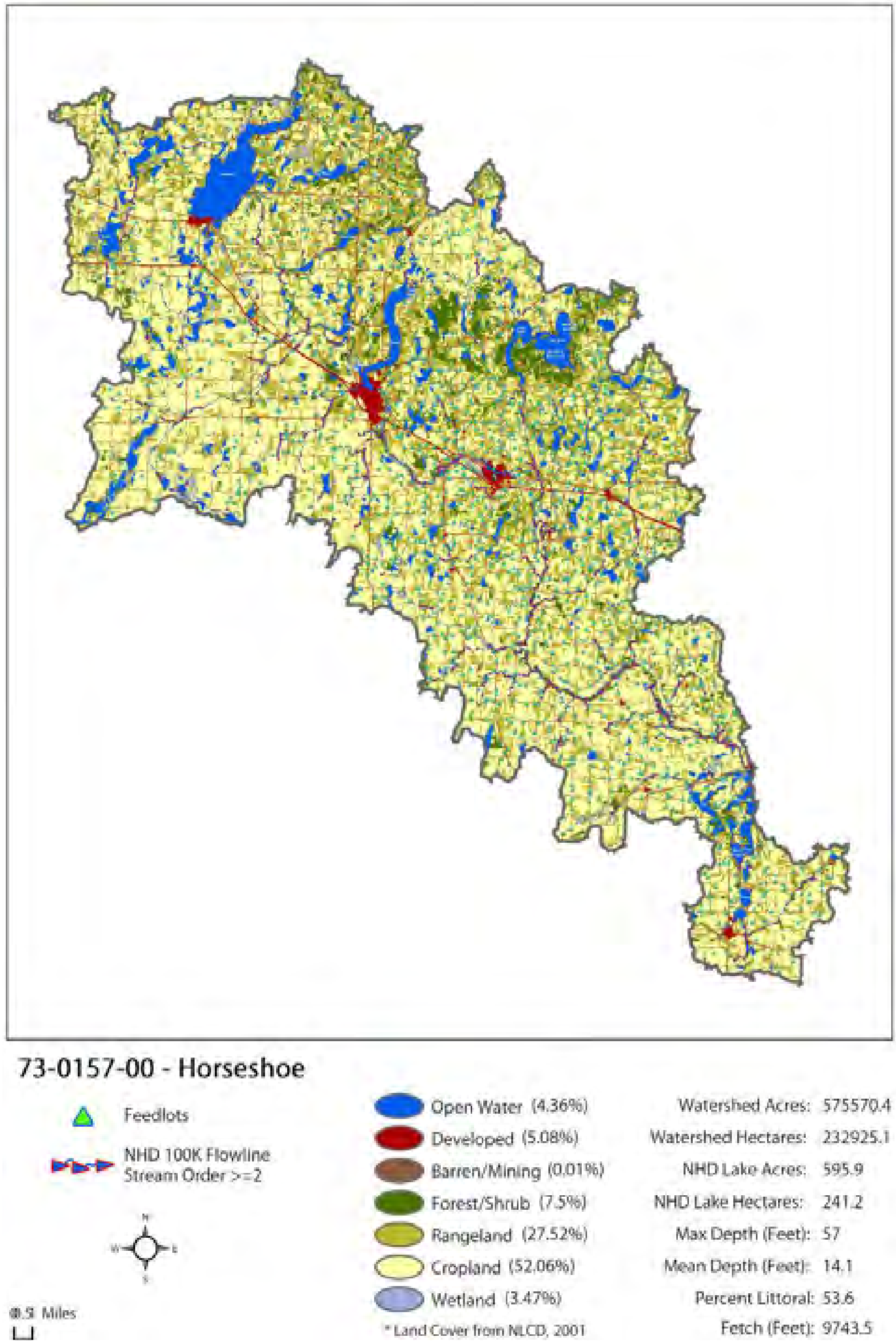
**Figure 86. Horseshoe Lake chain and catchment landuse map**



# Horseshoe 73-0157

Horseshoe is a 241 Hectare lake with a maximum depth of 17.3 (87 feet) located near Richmond Minnesota. The Eden Valley HUC 11 as well as Sauk River drains into Horseshoe lake Water quality reports written by them MPCA with local partners were published in 1985 and 1995. These reports can be found at http://www.pca.state.mn.us/water/lakereport.html

**Figure 87. Horseshoe Lake catchment and landuse map**



## Water Quality Summary

The most recent profile data form 2009 show some temperature stratification present each profiles, with the exception of late September (Figure 88). DO profiles in 2009 show significant oxygen depletion in the hypolimnium from June through August (Figure 89). TSI data from 2008-2009 shows improving chl-*a* and Secchi in the early summer, followed by increases in TP and chl-*a* during both seasons (Figure 90).

**Figure 88 Temperature profiles at the 211 site**

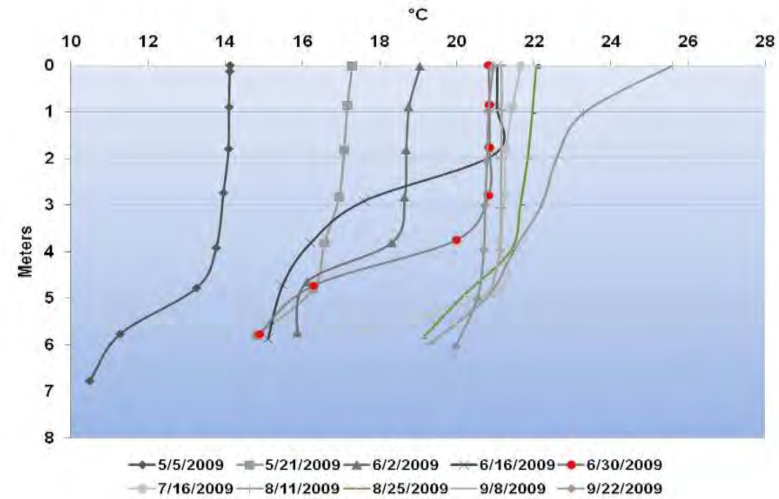



**Figure 89 Trophic State Indicators Horseshoe at the 211 site**

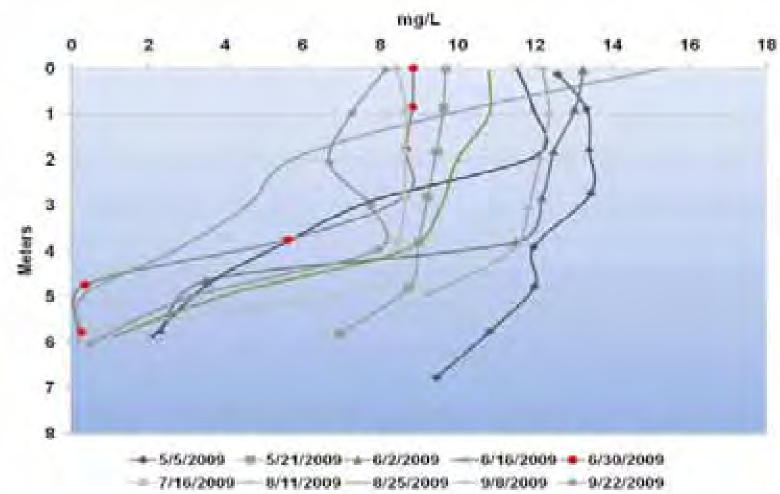
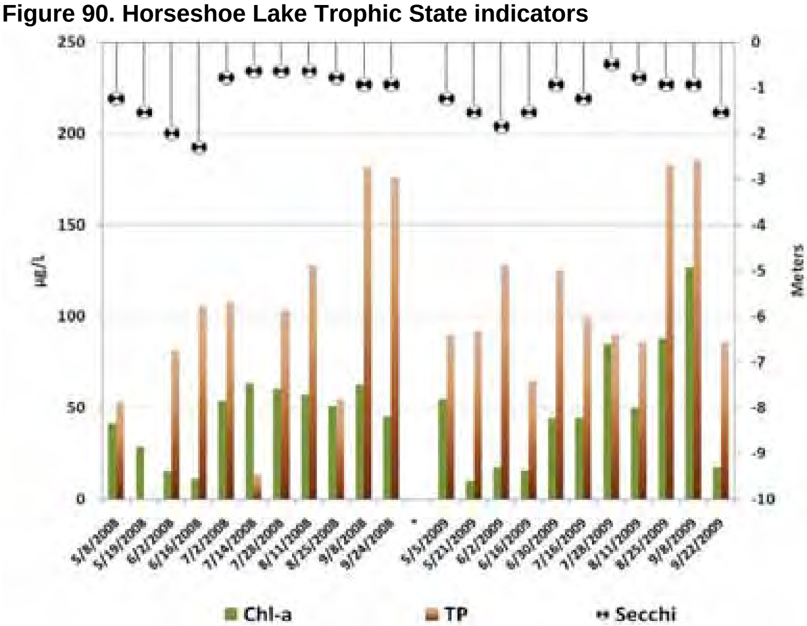



**Figure 90. Horseshoe Lake Trophic State indicators**



## Water Quality Trends

Water quality records on Horseshoe Lake go back to 1978 (Figure 91). Secchi and chl-*a* summer means do not show any long-term trends. TP levels have improved over the monitoring history. It is not likely that Secchi and chl-*a* values will improve unless TP continue to improve.

## Modeling and Assessment Status

The MINLEAP model predicted similar TP and chl-*a* to the 2000-2009 assessment mean (Figure 92). The predicted residence time for the lake is 0.3 years, confirming that water moves through the system quickly. The TMDL is scheduled to be completed in 2010, but maybe delayed due to complications in the chain of lakes reduction calculations.

**Figure 91. Long-term water quality trends**

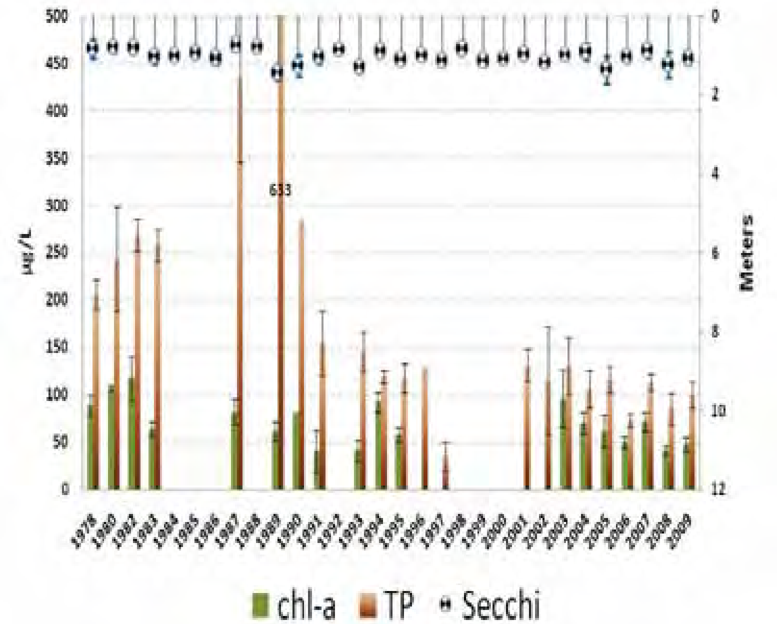
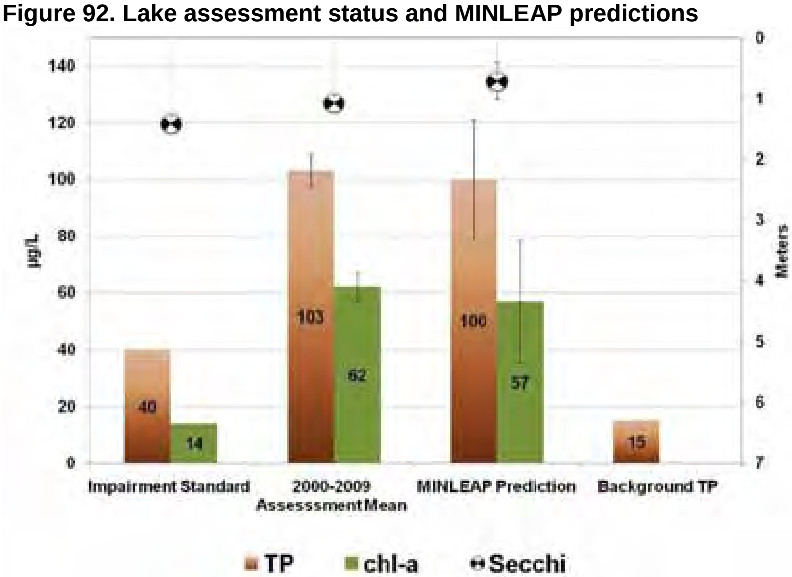



**Figure 92. Lake assessment status and MINLEAP predictions**



# Cedar Island (main bay) 73-0133-01

## Water Quality Summary

Profile data from 2009 shows temperature stratification throughout the summer with thermocline observed in midsummer (Figure 93). DO profiles in the same year show hypoxic condition developed in the hypolimnium in early June (Figure 94). The Hypoxic zone increased to 4.5 meters in early July. The DO conditions were conducive to phosphorus being released from the sediments TSI data from 2008 and 2009 were similar during both years (Figure 95). In 2008, TP levels increased significantly from May through late August. The big swing in TP is likely do the internal loading occurring from the sediments.

**Figure 93. Cedar Island temperature profiles**

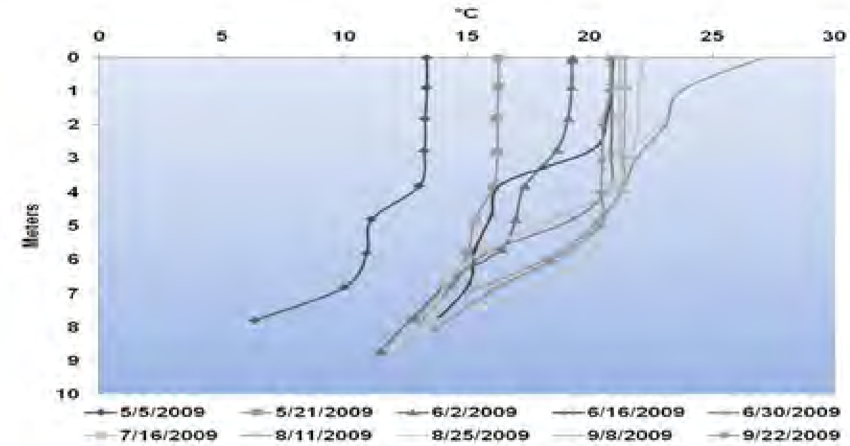



**Figure 94. Cedar Island DO profiles**

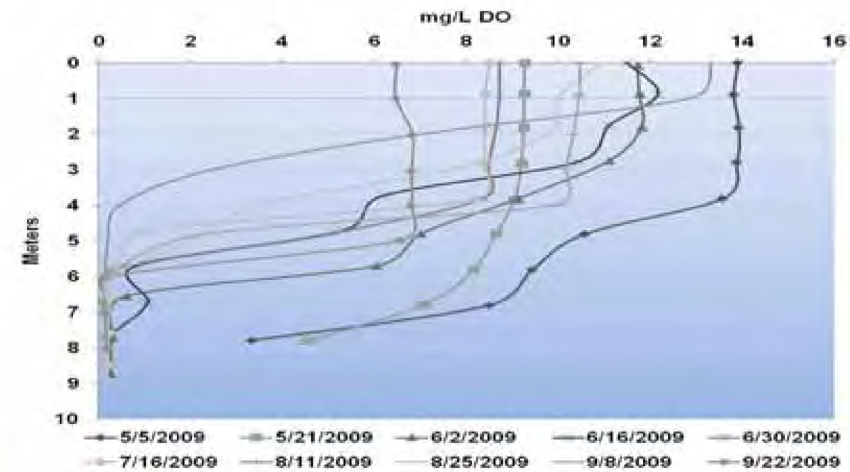
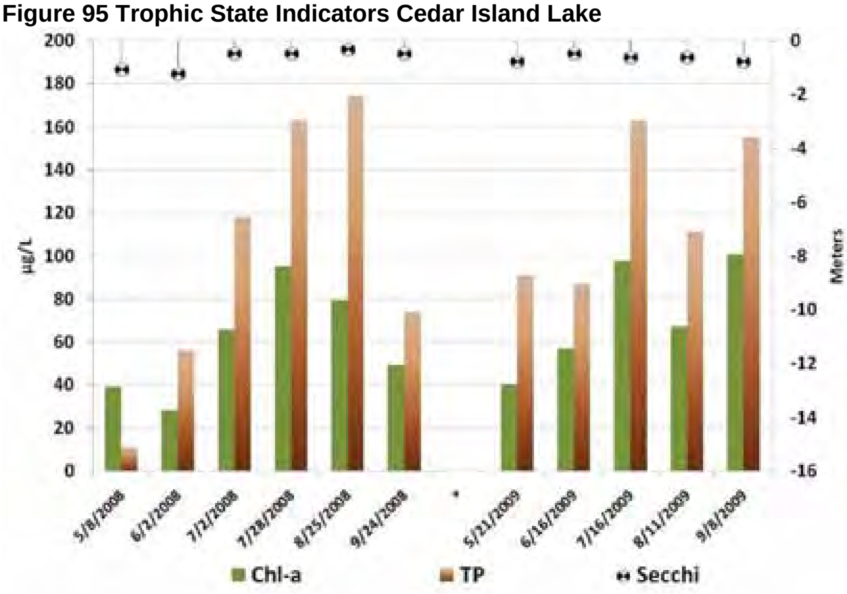



**Figure 95 Trophic State Indicators Cedar Island Lake**



## Water Quality Trends

TSI indicator records go back to 1978 (Figure 96). Secchi and chl-*a* summer means do not show any long-term trends. Summer mean TP has improved (declined).

## Modeling and Assessment Status

The MINLEAP prediction for chl-*a* and TP was similar to the 2000-2009 assessment mean (Figure 97). Assessment TP and chl-*a* was well over the CHF ARUS standards. The lake was put on the 303(d) impaired waters list in 2004. The TMDL study is scheduled to be completed in 2010, but maybe delayed due to complications in the chain of lakes reduction calculations.

**Figure 96. Cedar Island (Main) Long-term TSI indicators**

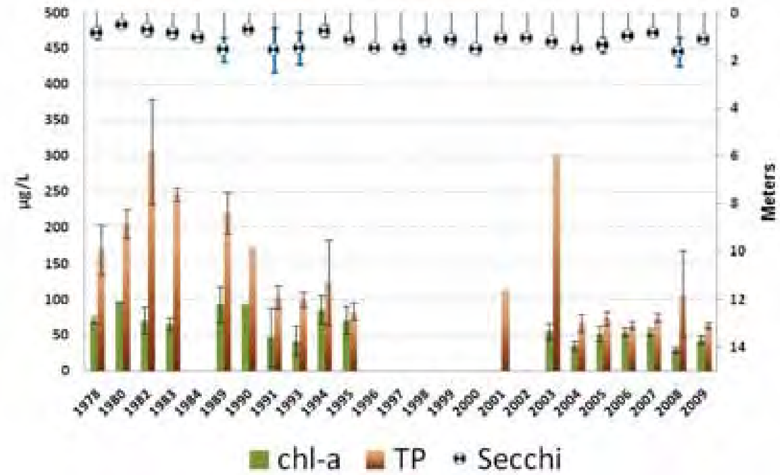
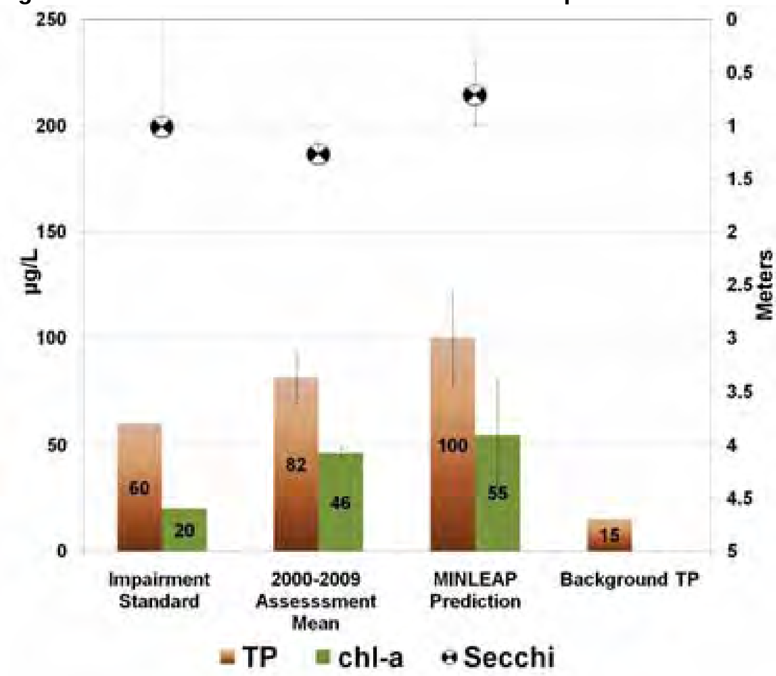


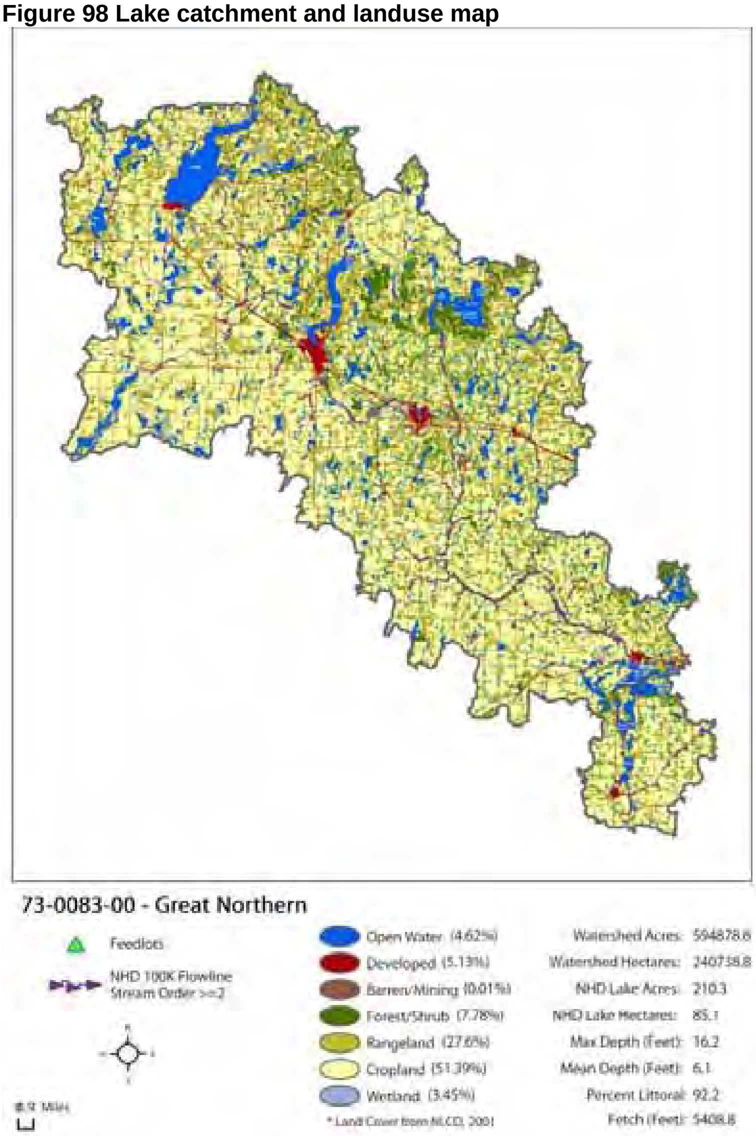

**Figure 97. Lake assessment status and MINLEAP predictions**



# Great Northern 73-0083

Great northern is part of the Horseshoe Chain of Lakes. Great Northern is located near the city of Richmond. The lake is small (210 acres) and shallow (maximum depth of 19 Feet). The lake has a very large drainage area of over 240,739 Hectares (Figure 98).

**Figure 98 Lake catchment and landuse map**



## Water Quality Summary

Profile measurements from 2009 and TSI data form 2006-2009 were used in this assessment (Figure 99 and 100). Temperatures were mixed through the water column from May through September. No notable DO stratification was observed in any of the five 2009 monitoring events. Monthly TSI results were very similar from 2006 – 2009, with increasing TP and chl-*a* through mid-summer (Figure 101).

**Figure 99 Great Northern Lake temperature profiles**

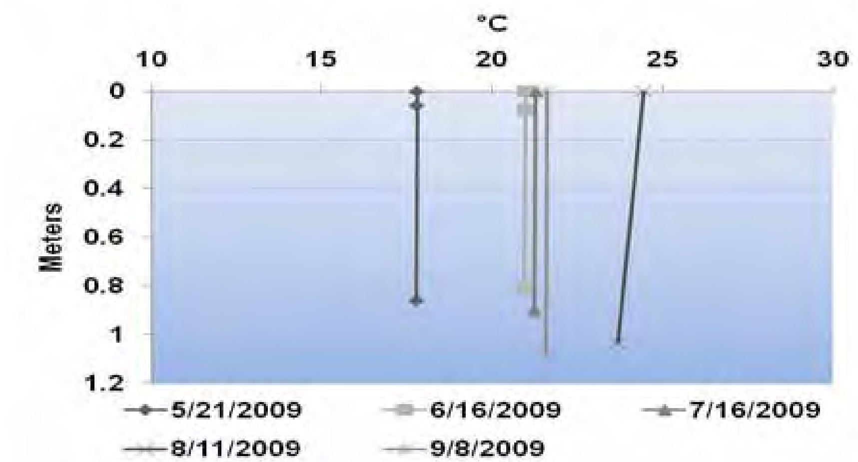



**Figure 100 Great Northern DO profiles**

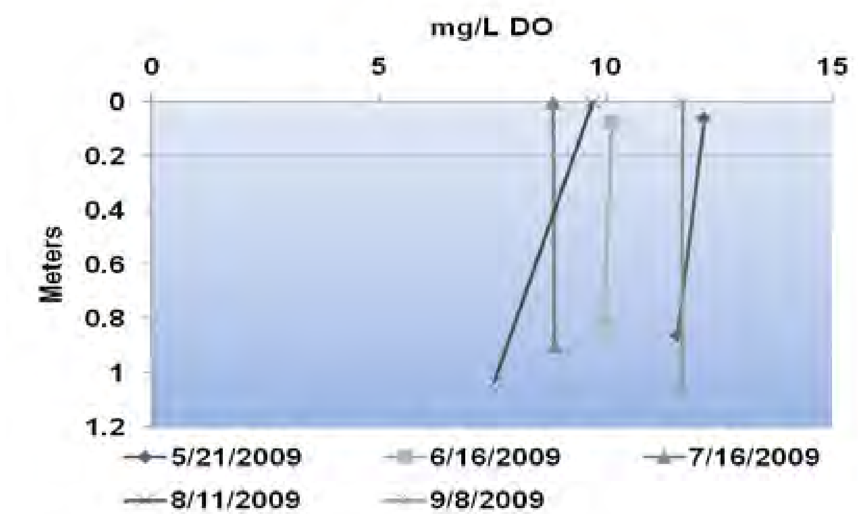
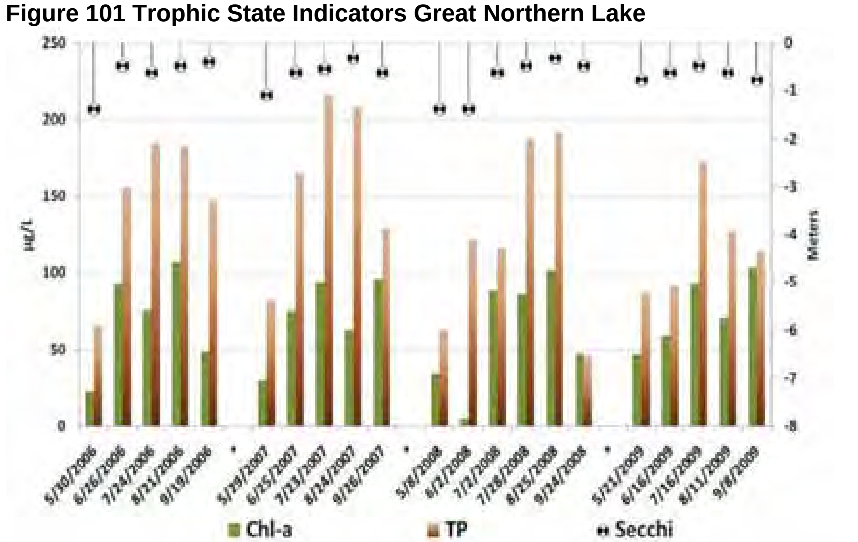



**Figure 101 Trophic State Indicators Great Northern Lake**



## Water Quality Trends

Water quality records go back to 1978 (Figure 102). Long-term TP levels show an improving trend while chl-*a* and Secchi do not show a trend. Improvements in TP not will likely affect Secchi and chl-*a* until summer means drop below 100µg/L.

## Modeling and Assessment Status

Great Northern Lake is well over the shallow lakes standards for the CHF ecoregion (Figure 103). The TMDL is scheduled to be completed in 2010, but maybe delayed due to complications in the chain of lakes reduction calculations. If the delay in TMDL assessment occurs, the project maybe delayed two additional years. MINLEAP predictions were similar to the assessment means.

**Figure 102 Long-term summer mean water quality trends**

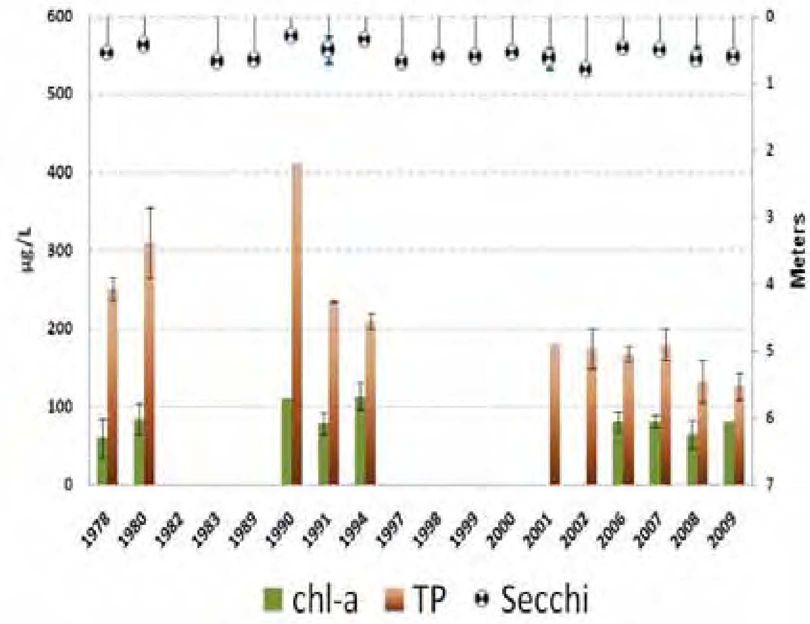
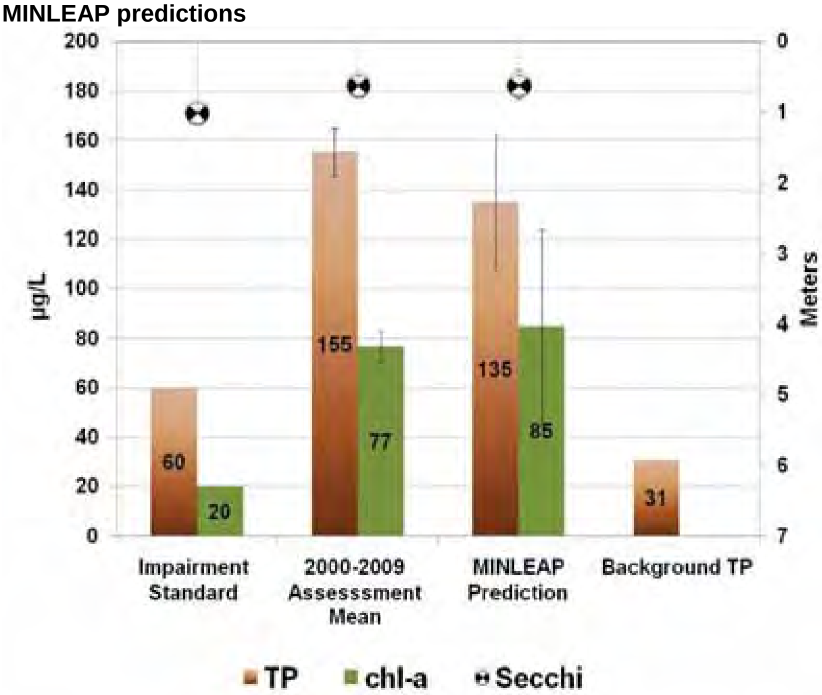



**Figure 103 Great Northern Lake assessment status and MINLEAP predictions**



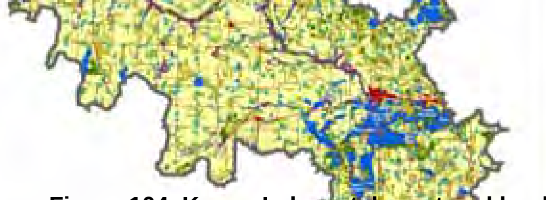
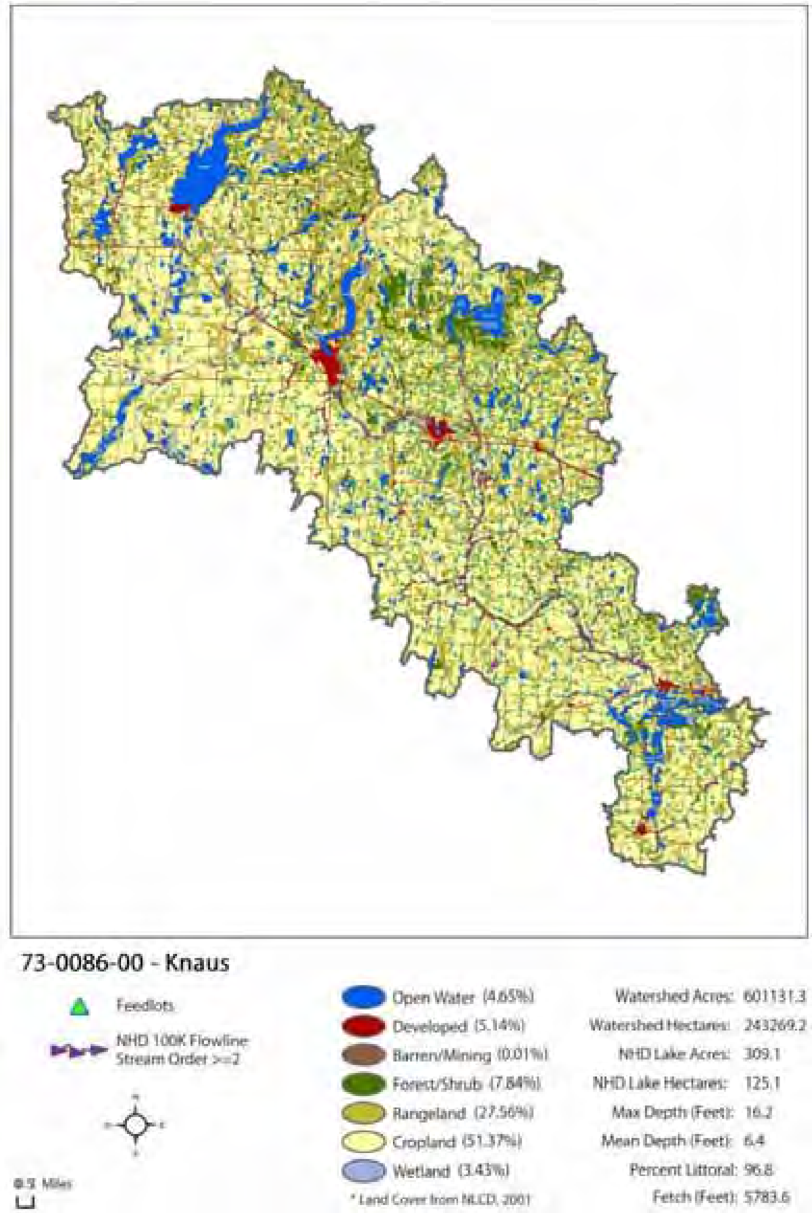


**Figure 104. Knaus Lake catchment and landuse map**




Knaus Lake is located on the east on of the Horseshow chain of lakes, (just east of Great Northern Lake). The lake is a riverine lake with a maximum depth of five meters (Figure 104). The lake has very large watershed, consisting of many upstream HUC 11's.

## Water Quality Summary

Profile measurements from 2009, show now stratification at the sampling point from May through September (Figure 105 and 106). TSI indicator results from 2008-2009 were similar in both years.

**Figure 105 Knaus Lake 2009 temperatures profiles**

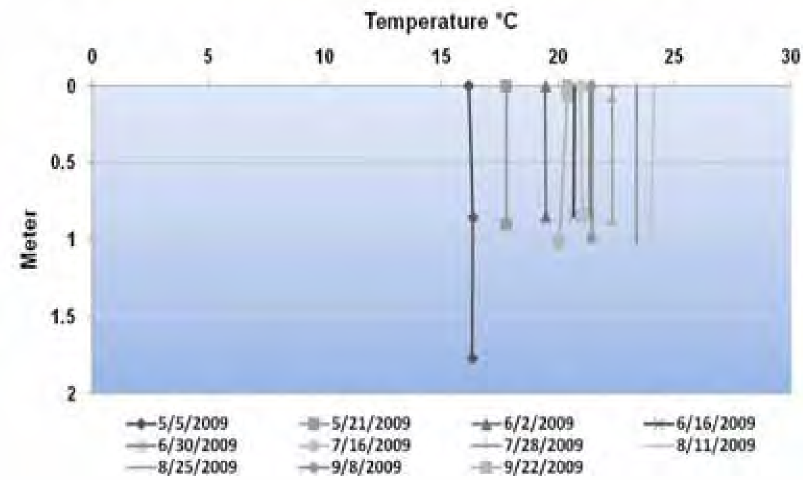



**Figure 106 Knaus Lake 2009 DO profiles**

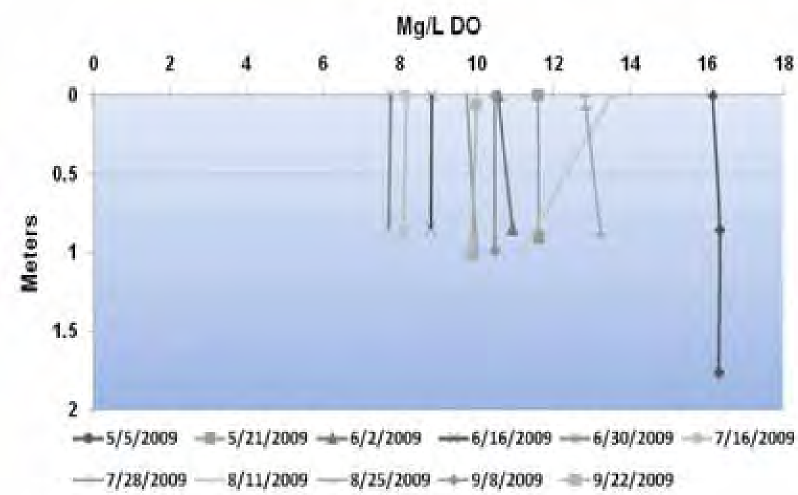
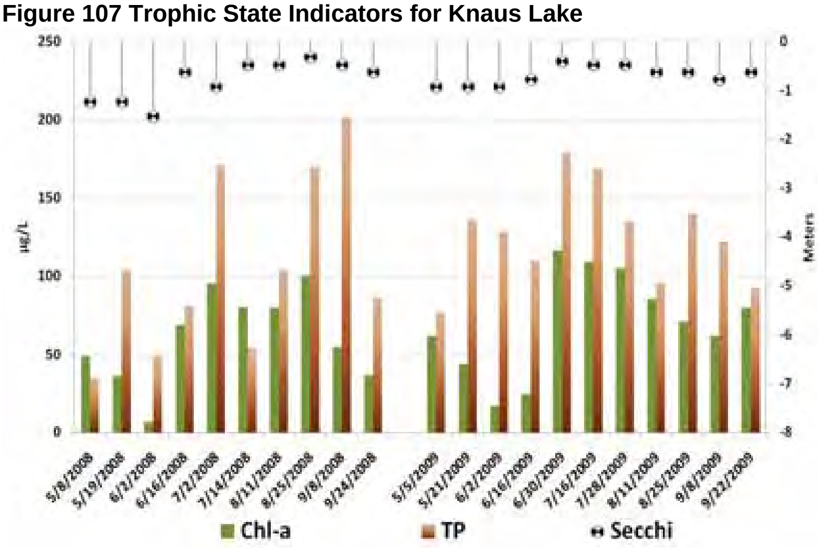



**Figure 107 Trophic State Indicators for Knaus Lake**



## Water Quality Trends

Water quality records on Knaus Lake go back to 1974 Figure 108). Summer mean Secchi values show no long trend. Summer mean TP values have improved with time. Improvements in TP not will likely affect Secchi and chl-*a* until summer means drop below 100µg/L.

## Modeling and Assessment Status

The assessment mean TP value from 2000-2009 is higher than the MINLEAP model predicted (109). The calculated residence time for the lake was less than 30 days. Knaus Lake was put on the 303(d) impaired waters list for ARUS in 2004. The TMDL study is scheduled to be completed in 2010, but maybe delayed due to complications in the chain of lakes reduction calculations.

**Figure 108 Knaus Lake long-term water quality trends**

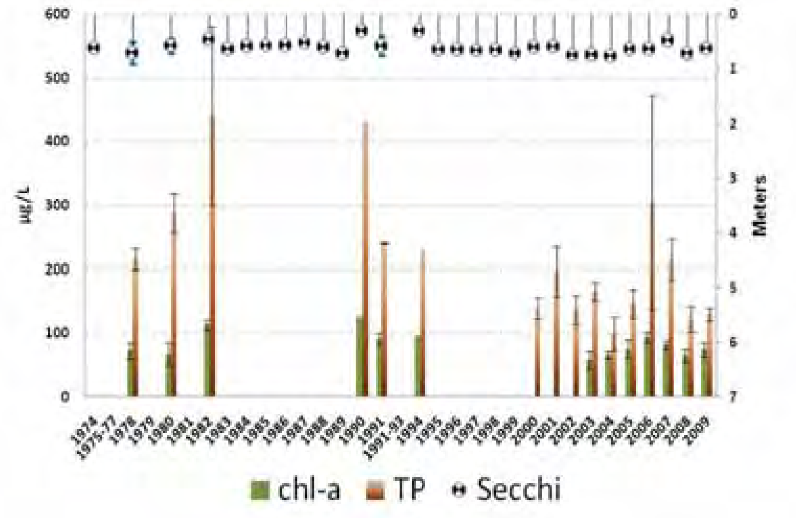
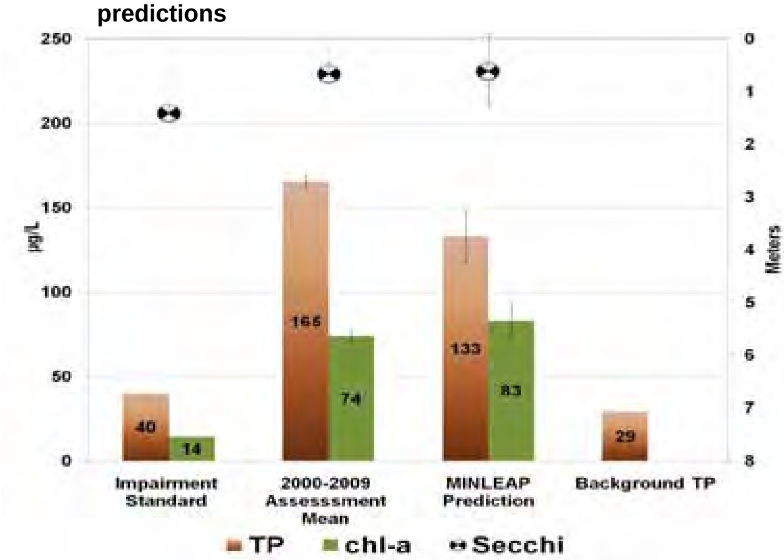


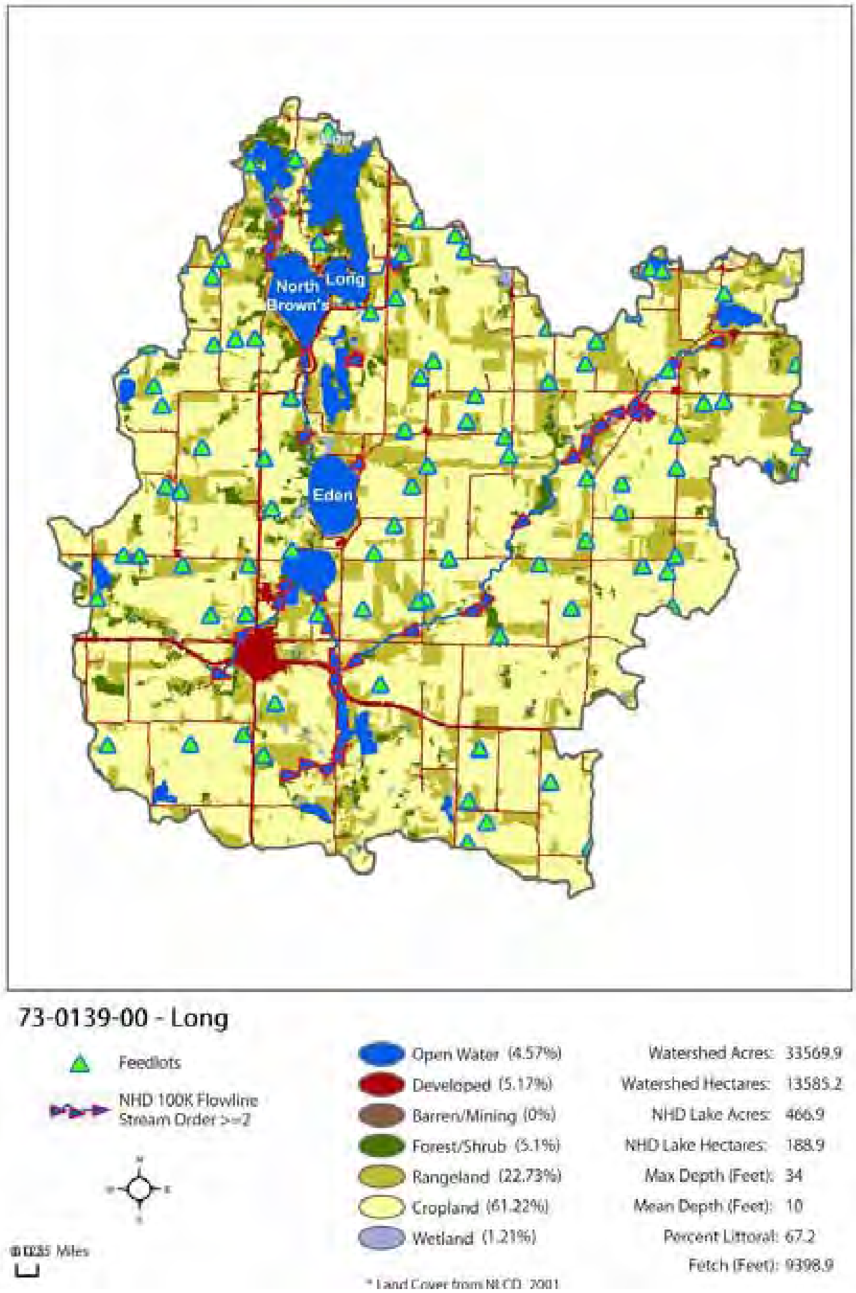

**Figure 109 Knaus Lake assessment status and MINLEAP predictions**



# Long Lake 73-0139

Long lake is a moderate sized lake with a maximum depth of 10.3 m located central Stearns County. The lake a large crop dominated watershed that includes North Browns, Eden and Vails Lakes. Long Lake drains north into Cedar Island.

**Figure 110. Long Lake catchment and landuse map**



## Water Quality Summary

Profile data from 2009 show no Temperature or DO stratification during that summer (Figure 111 and 112). TP values from 2009 were higher compared to 2008 (Figure 113) used in this assessment.

**Figure 111. Long Lake temperature profiles**

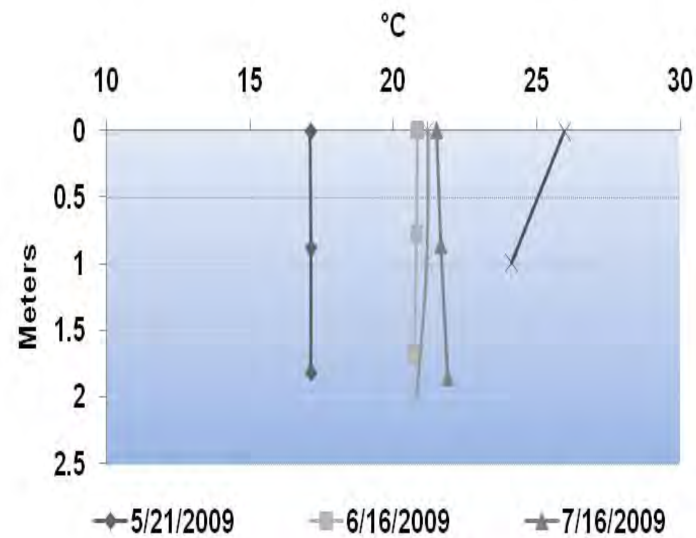



**Figure 112 Long Lake DO profiles**

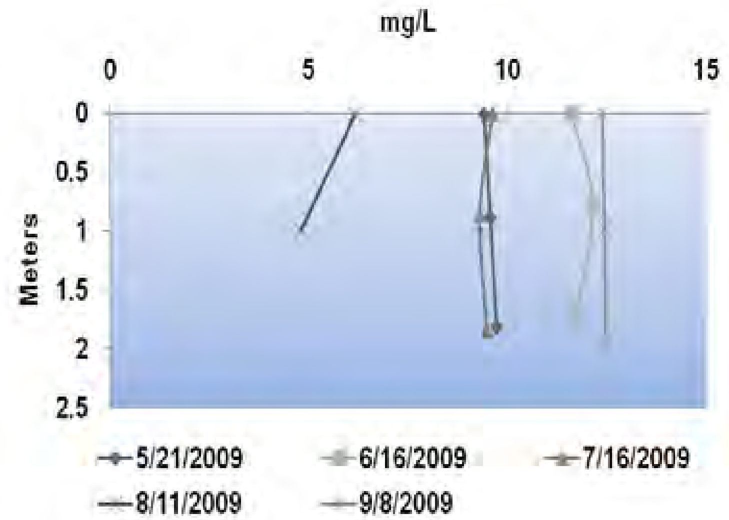
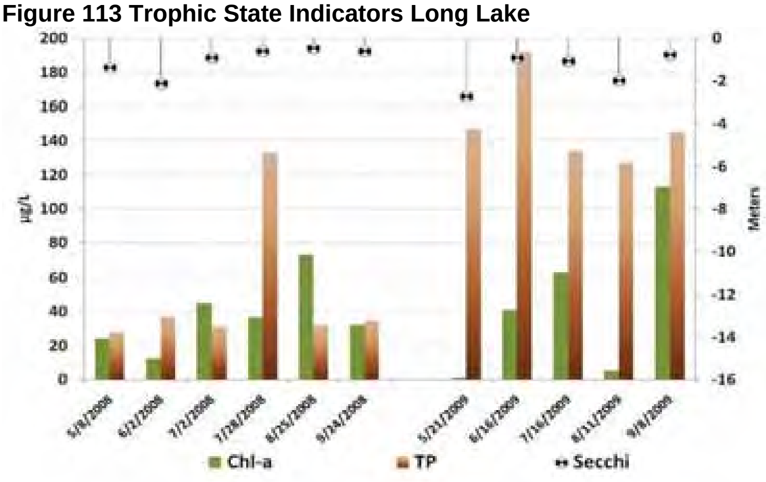



**Figure 113 Trophic State Indicators Long Lake**



## Water Quality Trends Modeling and

TSI indicator records for Long Lake go back 1981 (Figure 114). No overall trend is evident in TP chl-*a* or Secchi.

## Assessment Status

The MINLEAP prediction for chl-*a* and TP is slightly lower than the 2000 – 2009 assessment mean. Long Lake was put on the 2004 303(d) impaired water list. The TMDL study is scheduled to be completed in 2010, but maybe delayed due to complications in the chain of lakes reduction calculations.

**Figure 114 Long-term water quality trends**

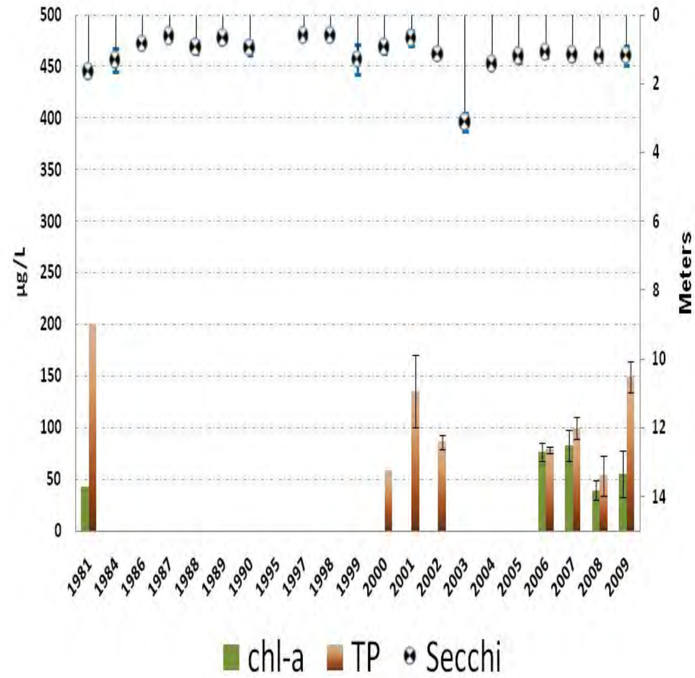
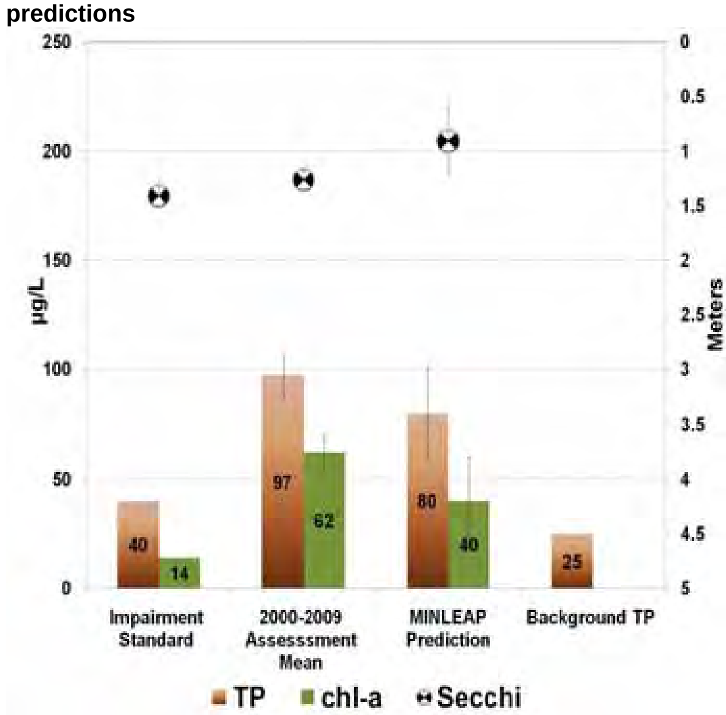
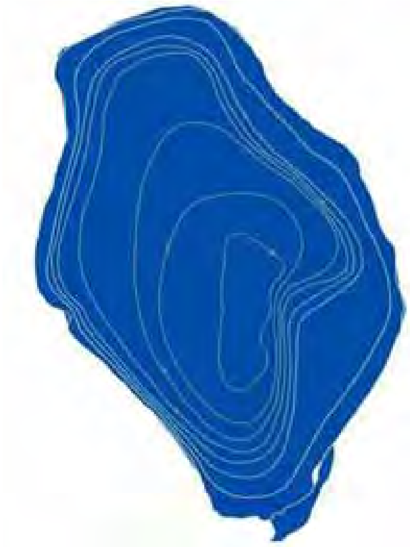



**Figure 115 Long Lake assessment status and MINLEAP predictions**

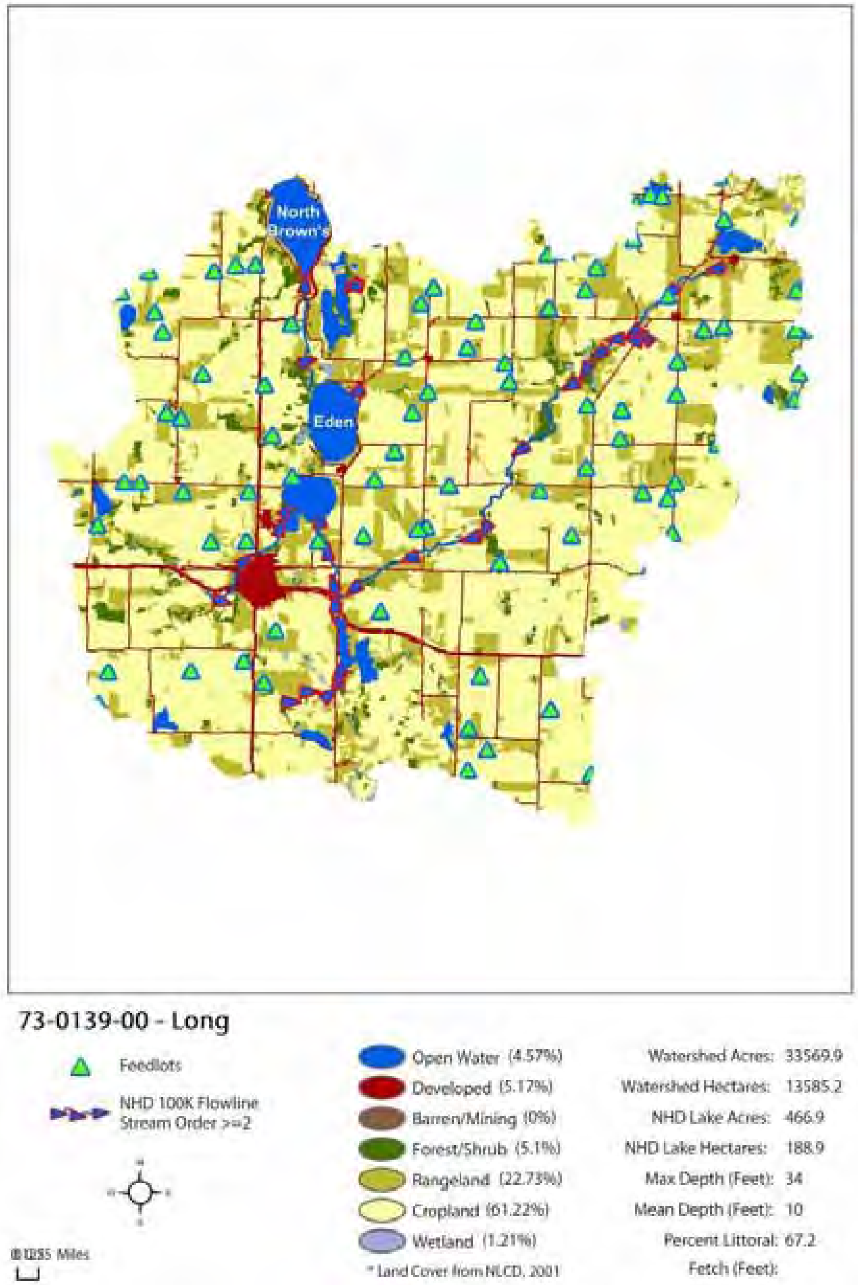


# North Browns Lake
# 73-0147



North Browns Lake is a 125 Hectare (309 acre) lake located northeast of the city Eden Valley. The lake classified as a deep lake with a max depth of 10.5 meters (34 feet) and 62% Littoral area. The lake has a large watershed consisting of mostly cropland and numerous feedlots.

**Figure 116. Lake catchment and landuse map**



## Water Quality Summary

The most recent profile data (2009) and TSI data (2008-2009) were used in this assessment. Water temperatures were mixed in May, than showed thermoclines through the remainder of the summer (Figure 117). DO levels dropped significantly with depth from June through September in 2009 (Figure 118). Near Anoxic (near 0) condition were seen from late June and increased September. These low DO conditions are conducive to TP being released from the sediments. Chl-*a* and Secchi values were similar in 2008 and 2009 (Figure 119). Secchi transparency drop several meters through each summer. TP levels differ between the two seasons, which may be due to periods of internal loading.

**Figure 117. North Browns temperature profiles**

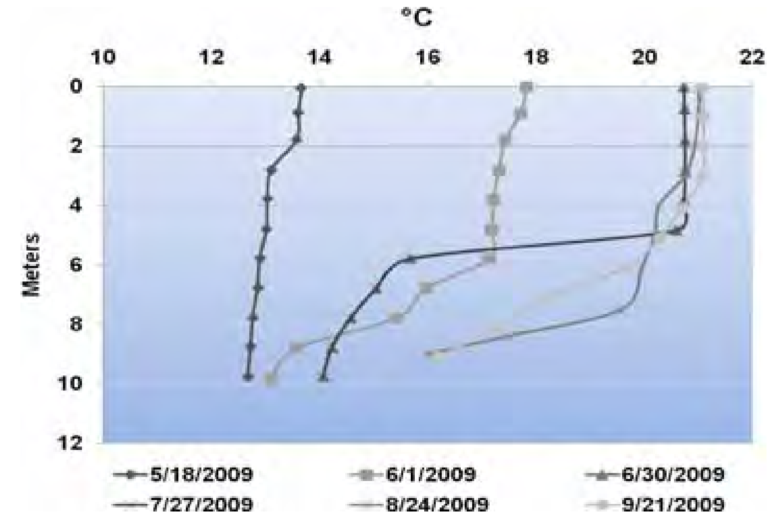



**Figure 118. North Browns Lake DO profiles**

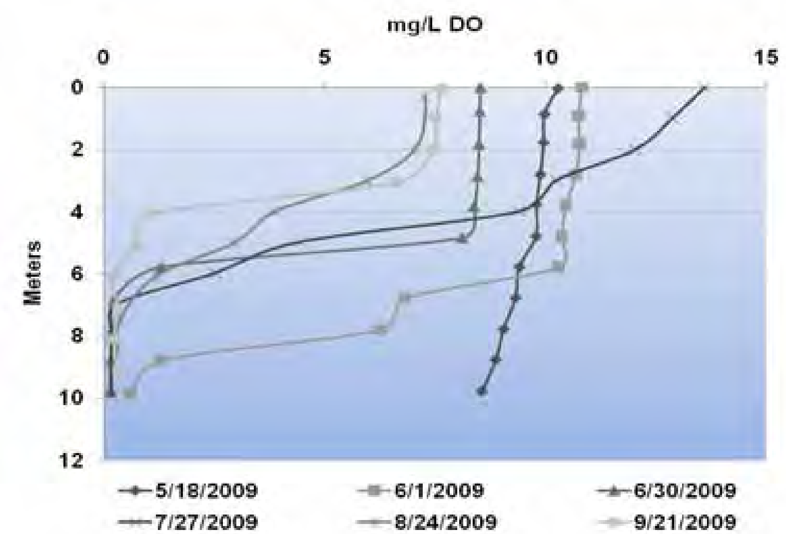
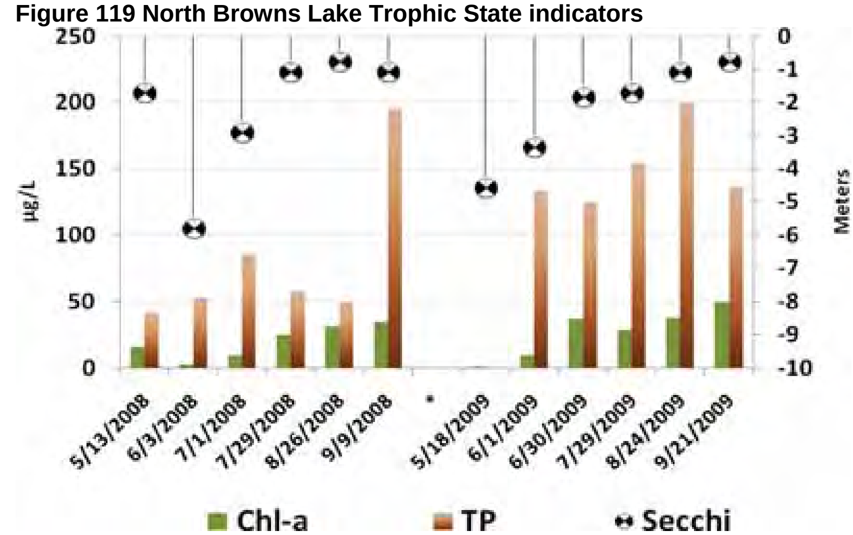



**Figure 119 North Browns Lake Trophic State indicators**



## Water Quality Trends

Water quality records for North Browns Lake go back to 1973 (Figure 120). Secchi records show a declining long-term trend. Chl-*a* and TP records do not show a long-term trend.

## Modeling and Assessment Status

MINLEAP predicted TP and chl-*a* is below 2000-2009 assessment mean and above the impairment standards (Figure 103). North Browns Lake was put the 2008 303d impaired waters list for ARUS. The TP and chl-*a* assessment mean values are will of the deep lake standards for the CHF ecoregion. The TMDL is scheduled to be completed in 2010, but maybe delayed due to complications in the chain of lakes reduction calculations.

**Figure 120 North Browns Lake long-term water quality trends**

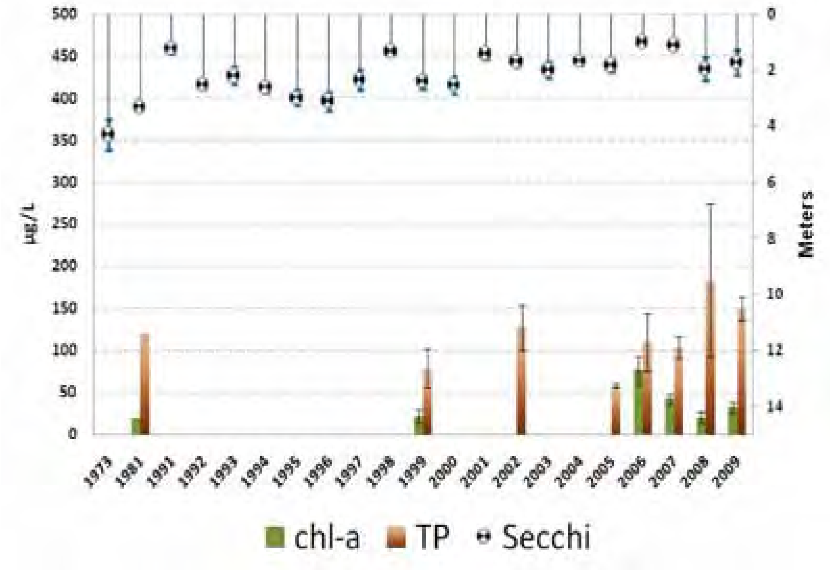
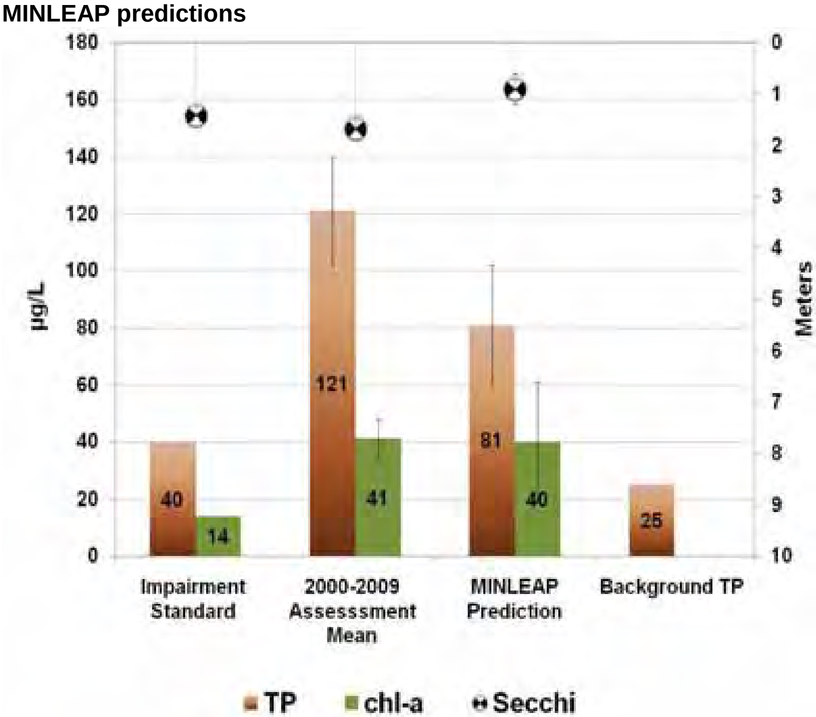


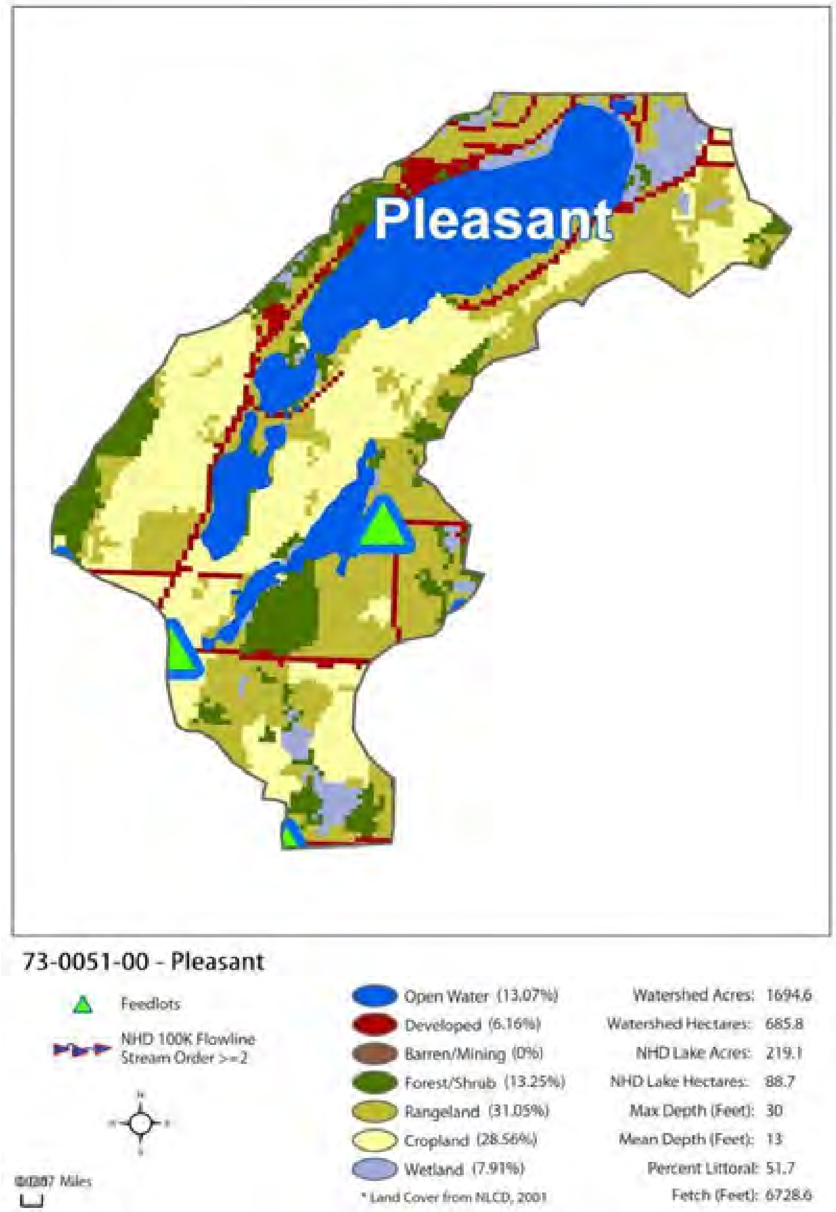

**Figure 121 North Browns Lake lake assessment status and MINLEAP predictions**



# Pleasant Lake 73-0051

Pleasant Lake is a small (222 acres) lake located three miles southwest of St. Cloud (Figure 122). The lake has a maximum depth 33 and is 49% littoral (Figure 122). The lake has a small lake catchment area (685 Hectares).

**Figure 122 Pleasant Lake catchment and landuse map**



## Water Quality Summary

The most recent profile data (2009) and TSI data (2008-2009) were used in this assessment. Temperature measurements show a strong thermocline was present in late June (Figure 123). DO levels dropped significantly below the thermocline (Figure 124). TP and chl-*a* values form 2007 -2009 show a slight variation between years, but each year shows improved condition in the mid-summer (Figure 125).

**Figure 123. Pleasant Lake temperature profiles**

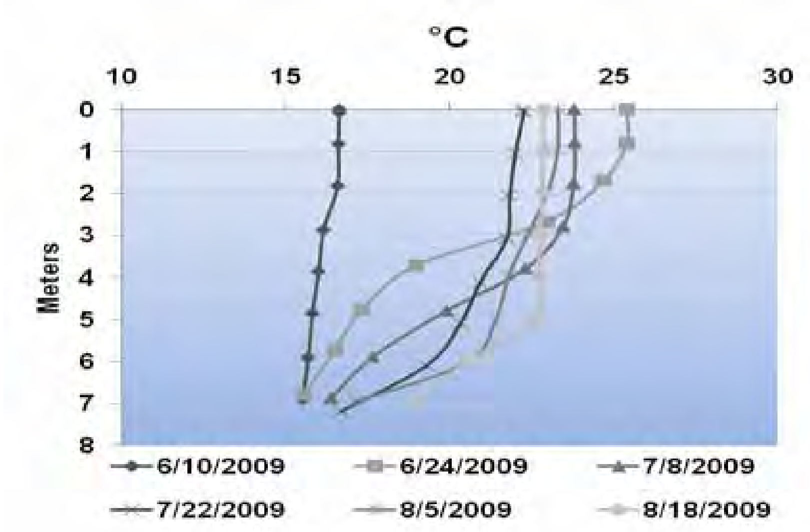



**Figure 124. Pleasant Lake DO profiles**

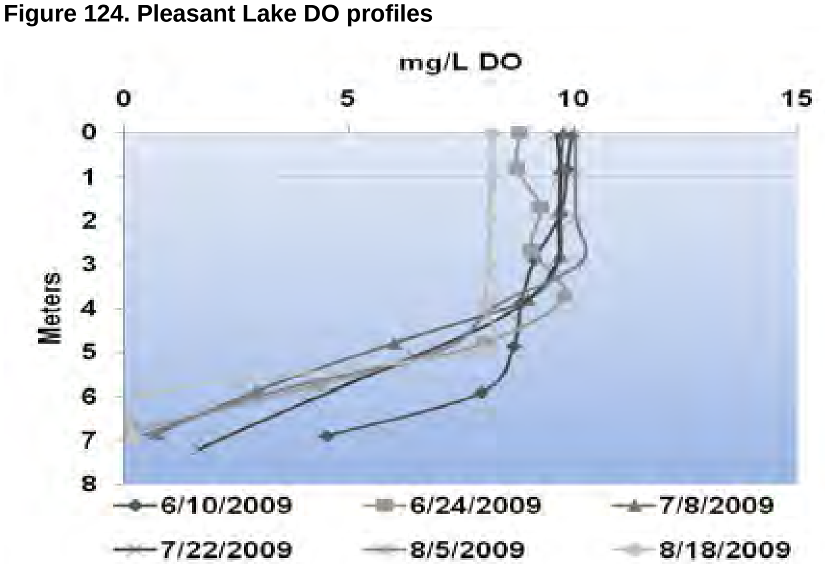
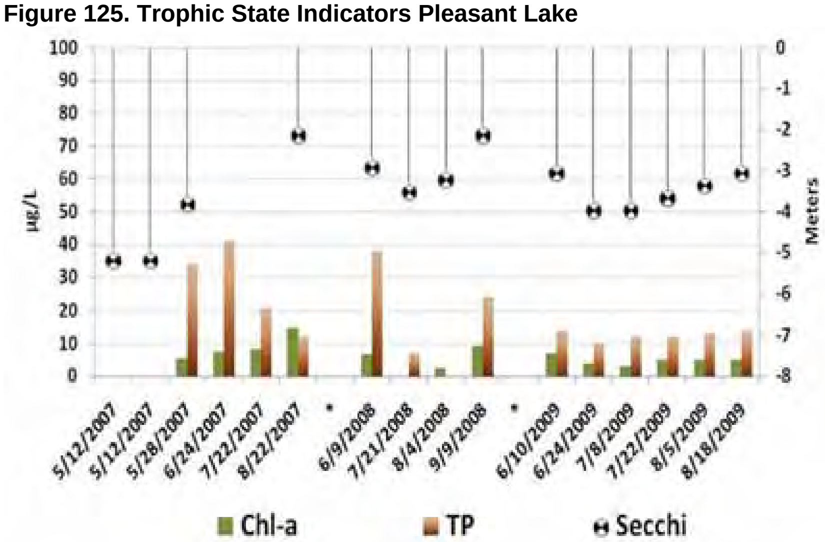



**Figure 125. Trophic State Indicators Pleasant Lake**



## Water Quality Trends

Water quality records on Pleasant Lake go back to 1976 (Figure 126). Long-term Secchi records showed an improving trend. Summer mean TP values levels range significantly from year to year on Pleasant Lake.

## Modeling and Assessment Status

MINLEAP's TP prediction for Pleasant Lake was lower than the 2000-2009 assessment mean. The current assessment classified the lake as full support for ARUS.

**Figure 126 Pleasant Lake summer mean water quality trends**

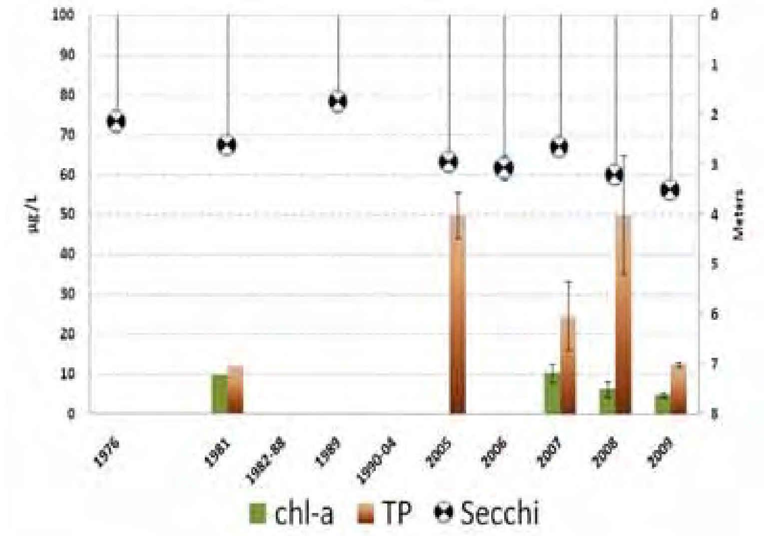
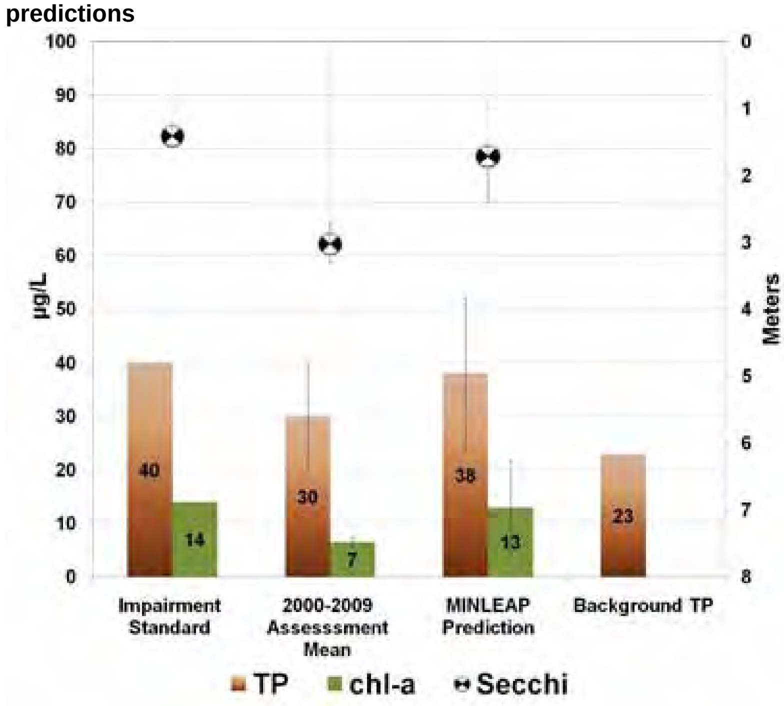


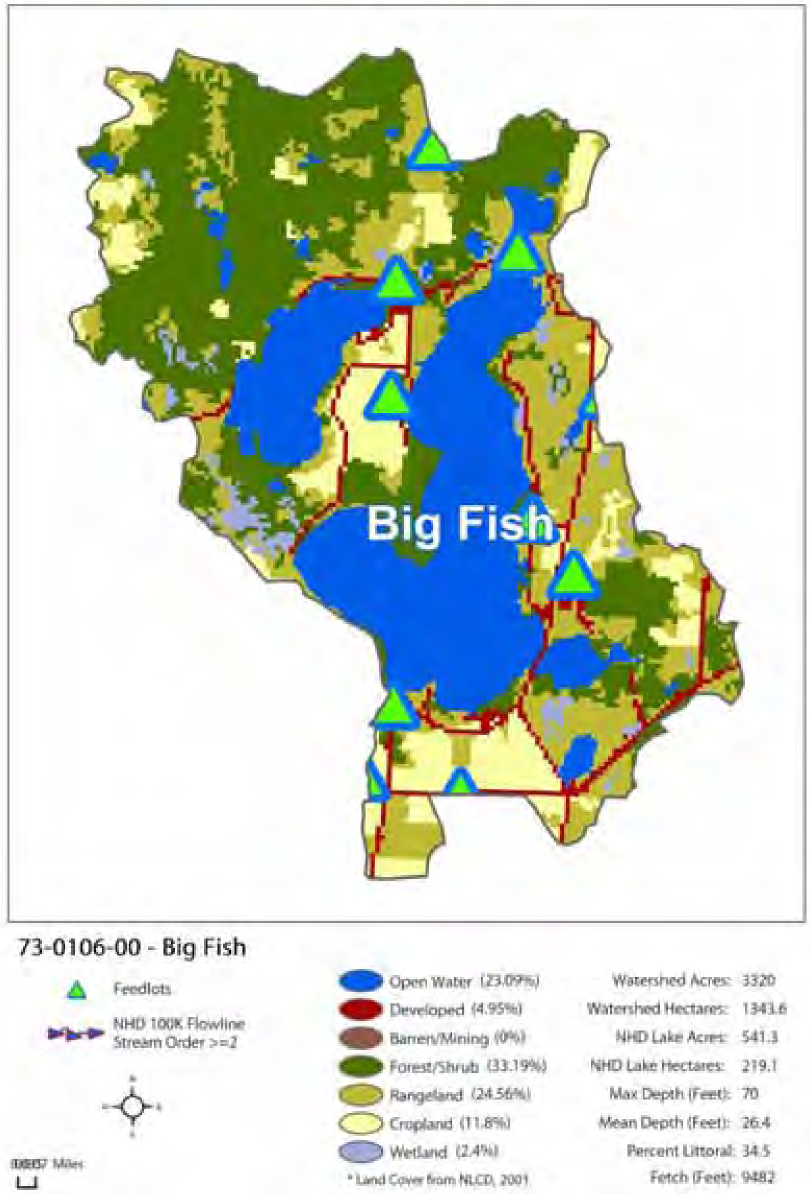

**Figure 127 Pleasant Lake assessment status and MINLEAP predictions**



# Big Fish 73-0106

Big Fish is 219 hectare lake located five miles north of Cold Springs in Stearns County. This lake is one of the deeper lakes in the Sauk River HUC 8 at 21 Meters. The lake has a modest sized watershed with dominated by forested land use (Figure 134).

**Figure 128. Lake catchment and landuse map**



## Water Quality Summary

No profile data were found on the lake. TSI data from 2001-2005 were used in this assessment (Figure 129). Summer Secchi and TP summer trends differed between the two years.

## Water Quality Trends

TSI indicator records go back to 1981(Figure 130). Long-term Secchi depth has improved

## Modeling and Assessment Status

MINLEAP's TP prediction was similar to the 2000-2009 assessment mean values (Figure 131). Big Fish Lake assessed as full support for ARUS.

**Figure 129 Trophic State Indicators Big Fish Lake**

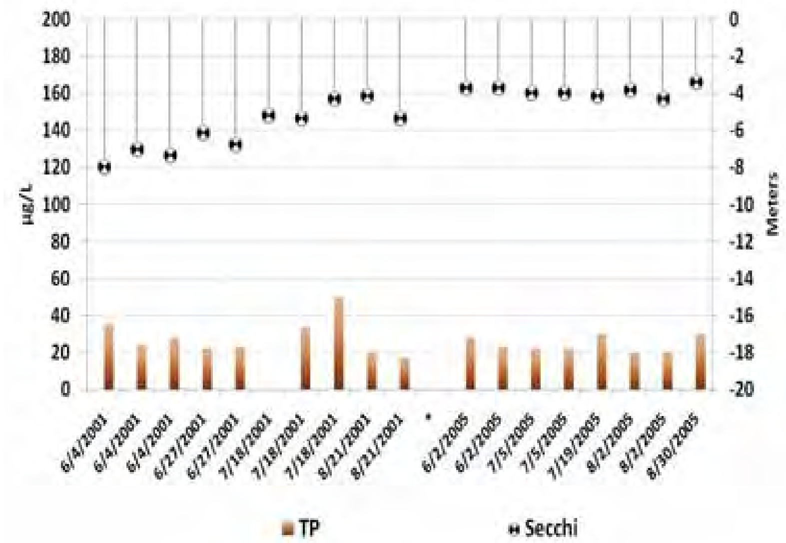



**Figure 130 Summer mean water quality trend**

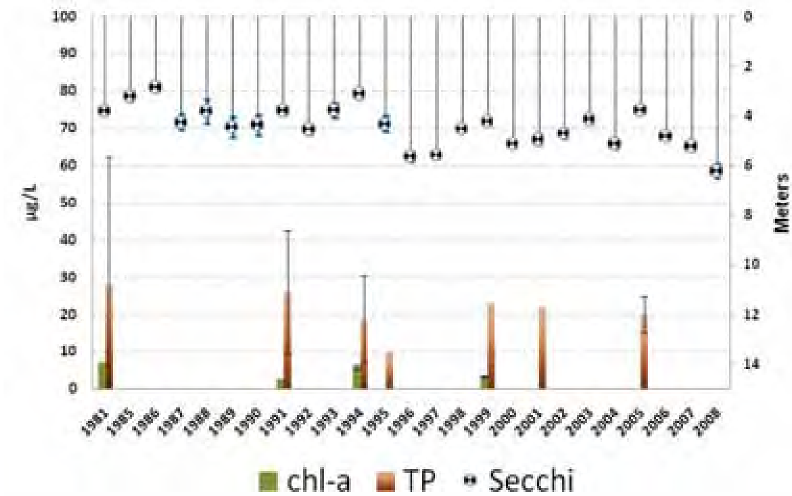
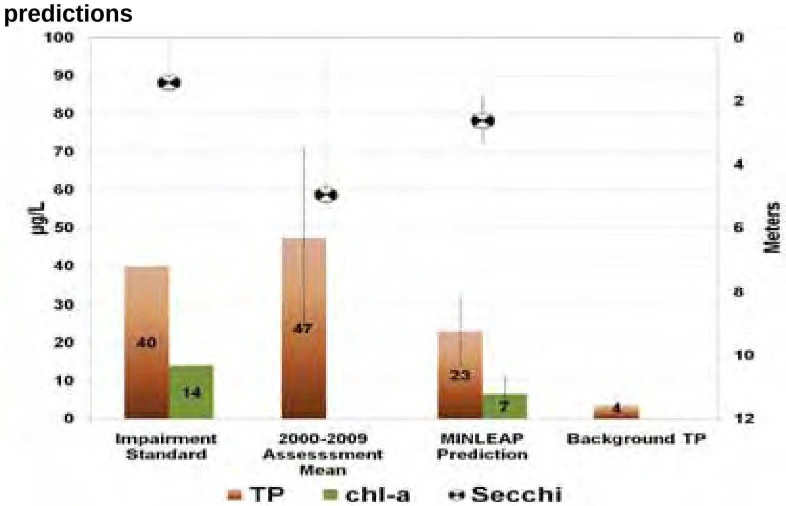



**Figure 131 Big Fish Lake assessment status and MINLEAP predictions**



# Roscoe HUC 11

The Roscoe is the smallest HUC 11 in the Sauk River HUC 8 (Table 2). The Roscoe Watershed has nine lakes of which only tow are greater than 200 acres (Table 13). These two lakes, Big and Becker were assessed as fully supporting in 2009. The Roscoe HUC 11 watershed is dominated by cropland (132).

**Figure 132. Roscoe HUC 11 landuse map**

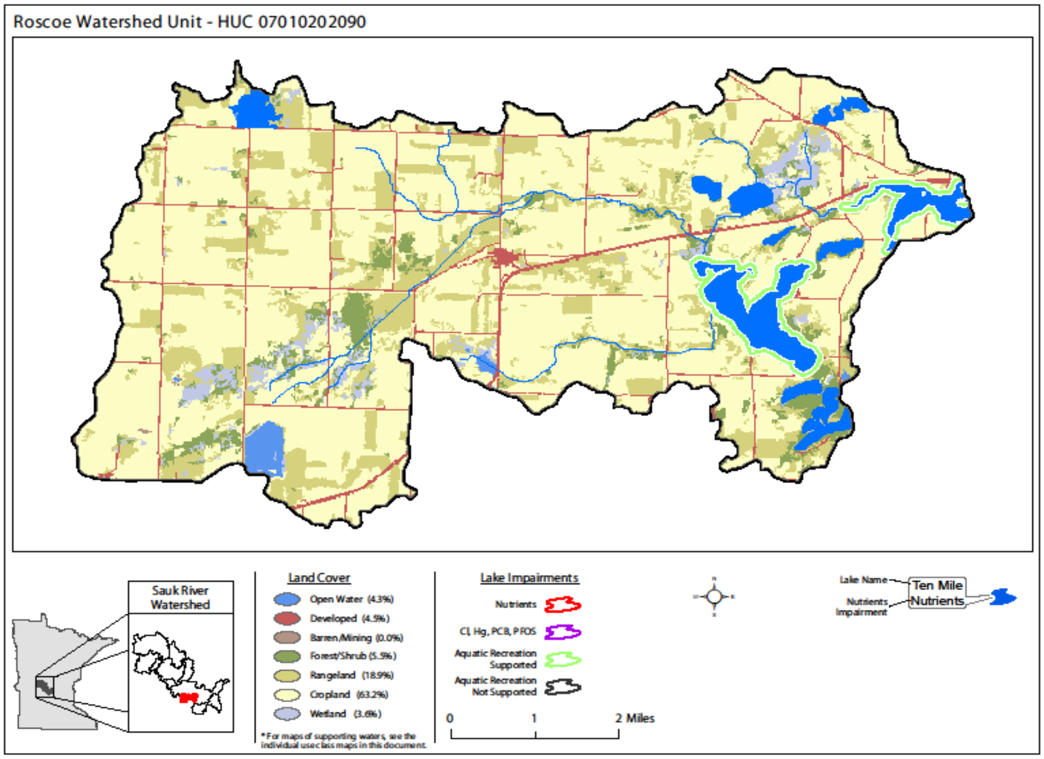



**Table 13. Roscoe HUC lake information and status**

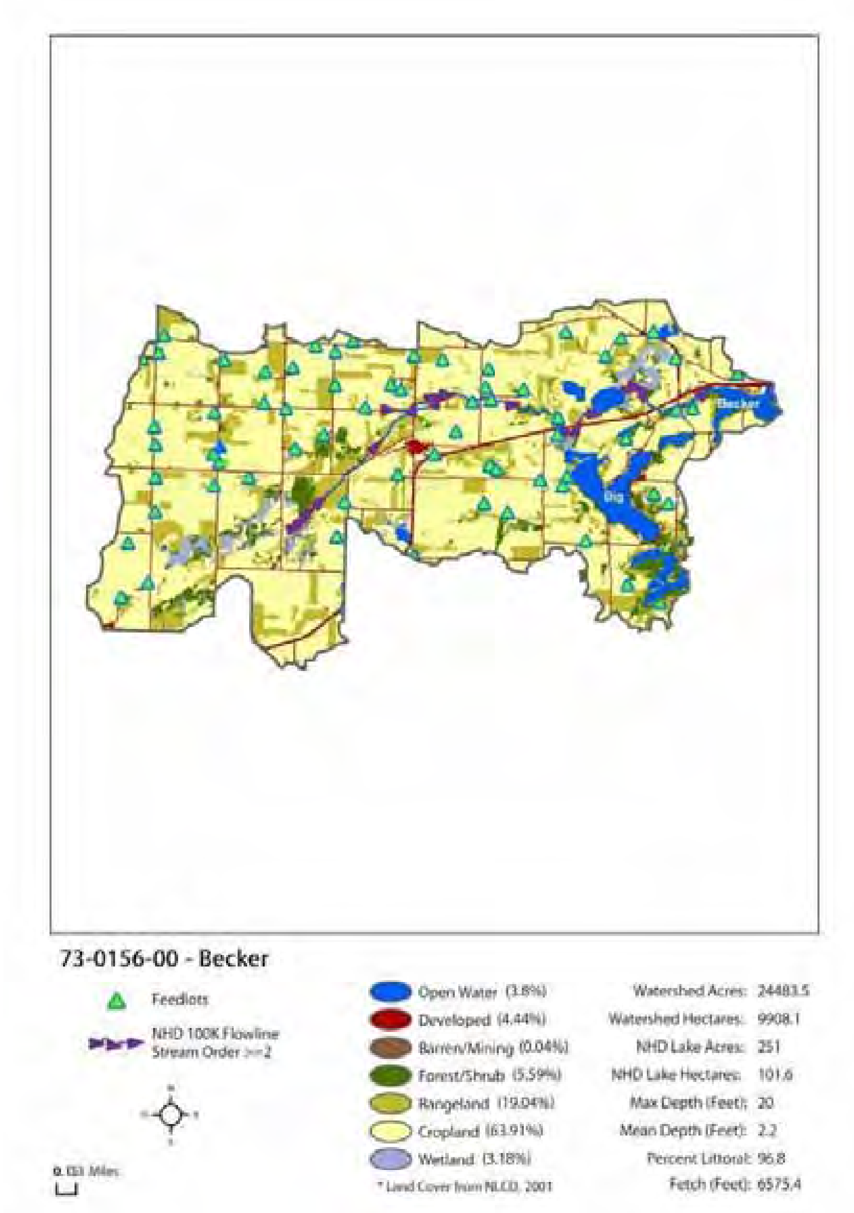
| Name | DOW# | County | Area | % Littoral | Avg. Depth (M) | Max. Depth (M) | ARUS | Trophic Status | Mean TP | Mean chl-a | Secchi Mean | CLMP Trend | RS 2005 | RS Trend |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Big | 73015900 | STEARNS | 415 | 56 | 13 | 42 | FS | E | 29 | 13 | 2 | ↗ | | |
| Becker | 73015600 | STEARNS | 251 | 97 | 2 | 20 | FS | E | 57 | 8 | 1 | ↘ | | |
| Deep | 73014100 | STEARNS | 47 | 24 | | | | | | | | | 3.9 | NT |
| Roschien | 73015500 | STEARNS | 41 | | | | | | | | | | 2.2 | ↗ |
| Ganzer | 73014200 | STEARNS | 32 | | | | | | | | | | 3.9 | NT |
| Schroeder | 73015800 | STEARNS | 32 | | | | | | | | | | 3.9 | NT |
| Meyers | 73014300 | STEARNS | 28 | | | | | | | | | | 2.7 | NT |
| Unnamed | 73044800 | STEARNS | 8 | | | | | | | | | | | |
| Unnamed | 73054400 | STEARNS | 0 | | | | | | | | | | | |

↘ decreasing/declining trend ↗ increasing/improving trends NT No Trend ID Insignificant Data
FS Full Support NS none supporting HE hypereutrophic E Eutrophic M Mesotrophic O Oligotrophic

# Becker Lake 73-0156

Becker is a shallow plant dominated lake located near Richmond, in south-central Stearns County. This 251-*a*cre lake is considered part of the Horseshoe Chain of lakes, but the Sauk River does not flow directly in Becker Lake. This is reflected in the greater water clarity and more abundant submersed plants.
The lake

**Figure 133. Becker Lake catchment and landuse map**



## Water Quality Summary

No useful profiles measurements were found on Becker Lake. TSI data (2008-2009) were used in this assessment.

## Water Quality Trends

Water Quality records for Becker Lake go back 1981. Long-term records show a declining transparency.

## Modeling and Assessment Status

The lake is considered fully supporting for aquatic recreation, with a mean TP just under the standard of 60 µg/L. The TMDL is scheduled to be completed in 2010, but maybe delayed due to complications in the chain of lakes reduction calculations as much as 2 years.

**Figure 134. Trophic indicators**

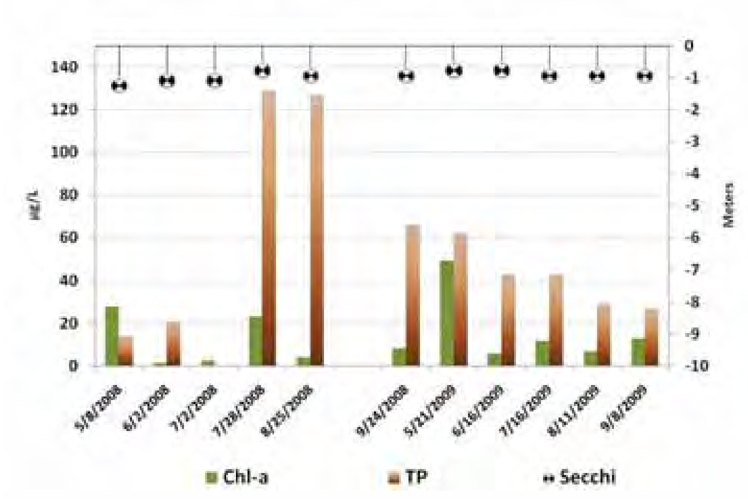



**Figure 135. Long-term water quality trends**

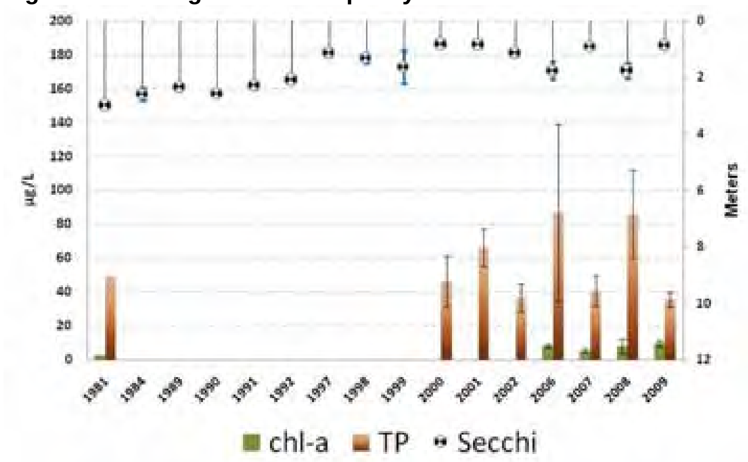
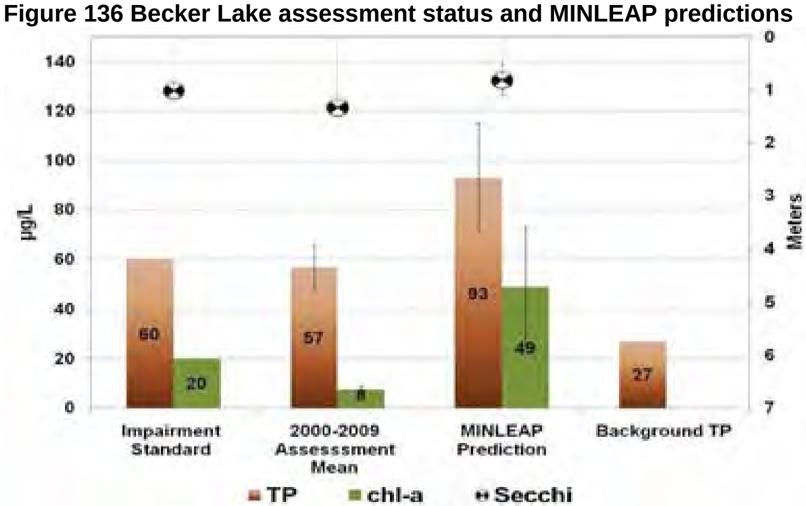



**Figure 136 Becker Lake assessment status and MINLEAP predictions**

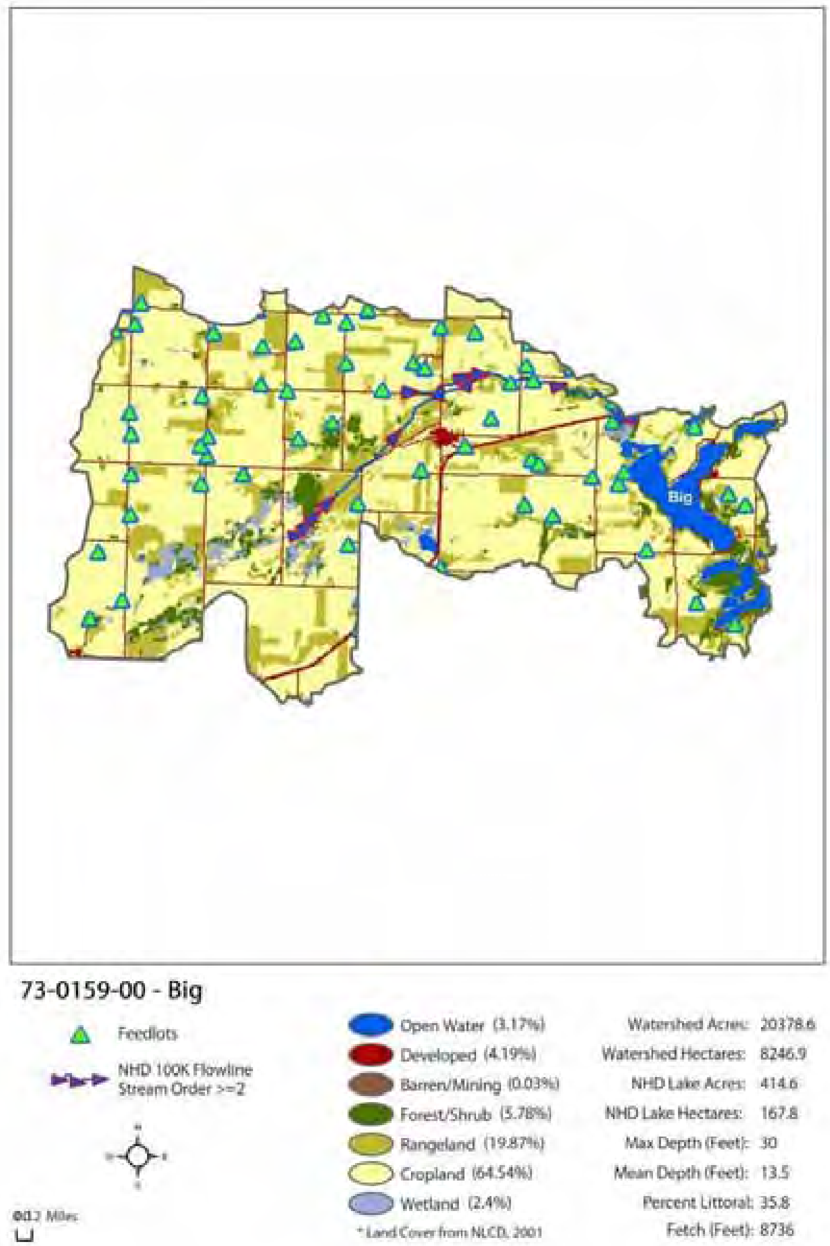


# Big Lake 73-0159

Big Lake is located in south central Stearns County, three miles southwest of Richmond. The lake has a moderate depth and a medium sized watershed with many feedlots (Figure 137).

Lake assessment was complete in 2001 and can be found at http://www.pca.state.mn.us/water/lakereport.html.

**Figure 137. Lake catchment and landuse map**



## Water Quality Summary

The most recent profile data from 2009 show thermoclines were present May through August (Figure 138). DO profiles from 2009 indicate anoxic conditions June through September (Figure 139). TSI data from 2008 and 2009 show similar results (Figure 140). TP and chl-*a* improve during the midsummer this is likely due to stronger stratification.

**Figure 138. Big Lake temperature profiles**

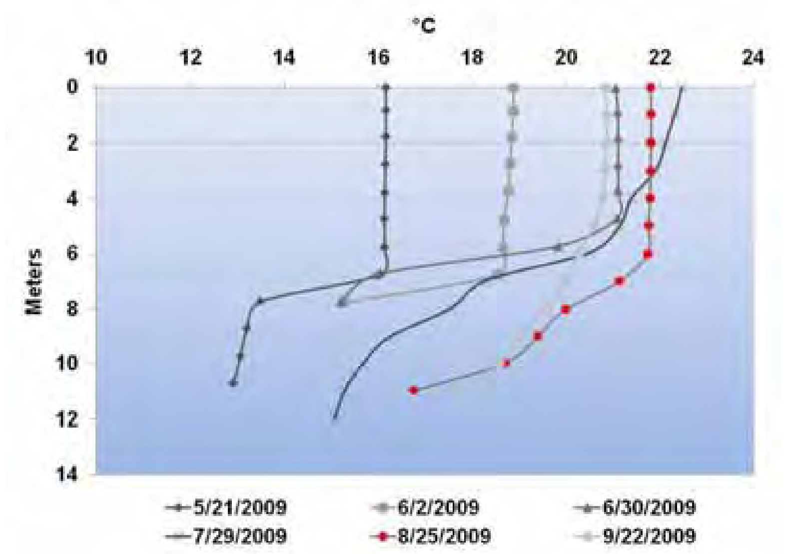



**Figure 139. Big Lake DO profiles**

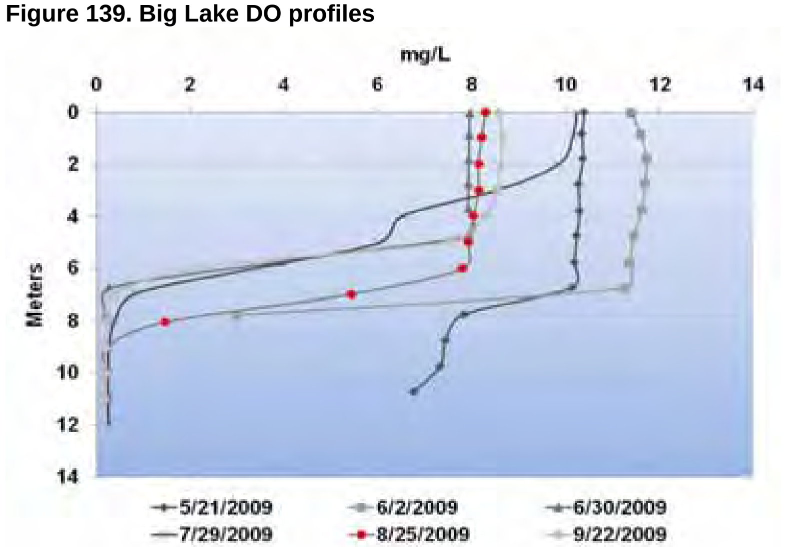
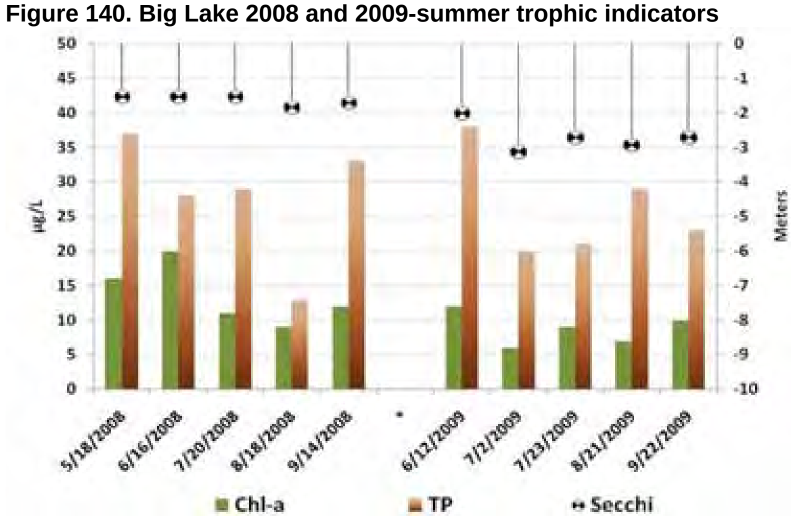



**Figure 140. Big Lake 2008 and 2009-summer trophic indicators**



## Water Quality Trends

TSI data from Big Lake goes back to 1976. All three trophic indicators show an improving trend over that period.

## Modeling and Assessment Status

MINLEAP predicted worse TSI vales than observed (10 year assessment mean) TSI values from 2000 – 2009 averaged less than the standards. Big lake is currently listed as full support.

**Figure 141 Big Lake long-term water quality**

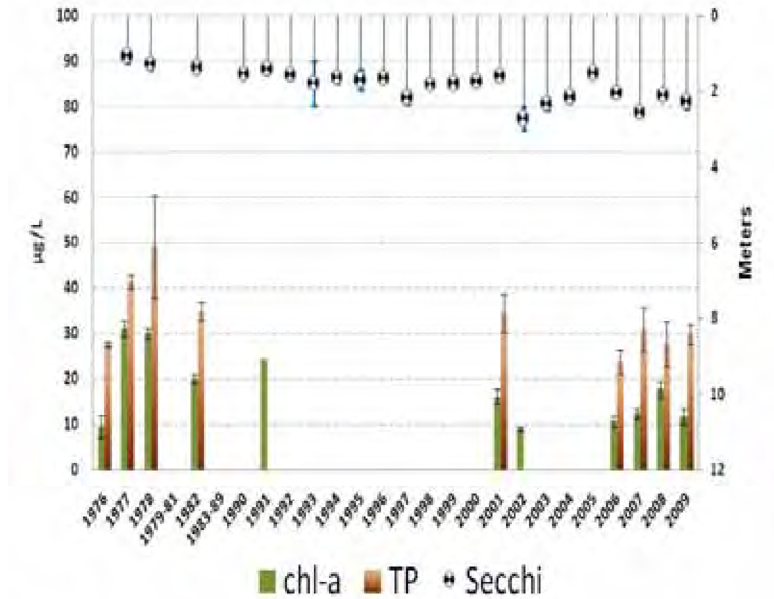
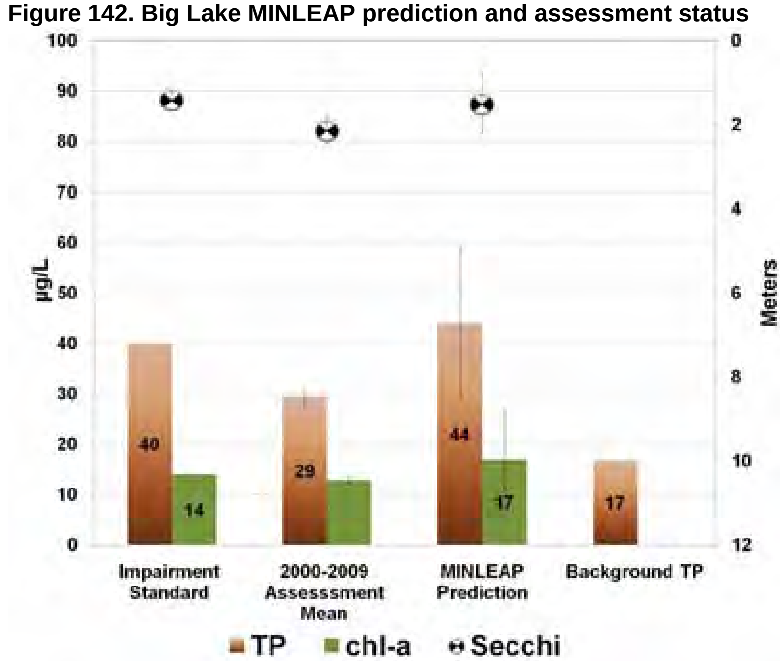



**Figure 142. Big Lake MINLEAP prediction and assessment status**



# Eden Valley HUC 11

The watershed consists of many streams and ditches, but few lakes and wetlands (Figure 145). The Eden Valley HUC 11 has two lakes (Eden and Vails) with assessment data (Table 14). Vails Lake drains to Eden Lake, which drains north to Browns Lake, a part of the Sauk River chain of lakes.

**Figure 143. Lake Catchment and Landuse map**

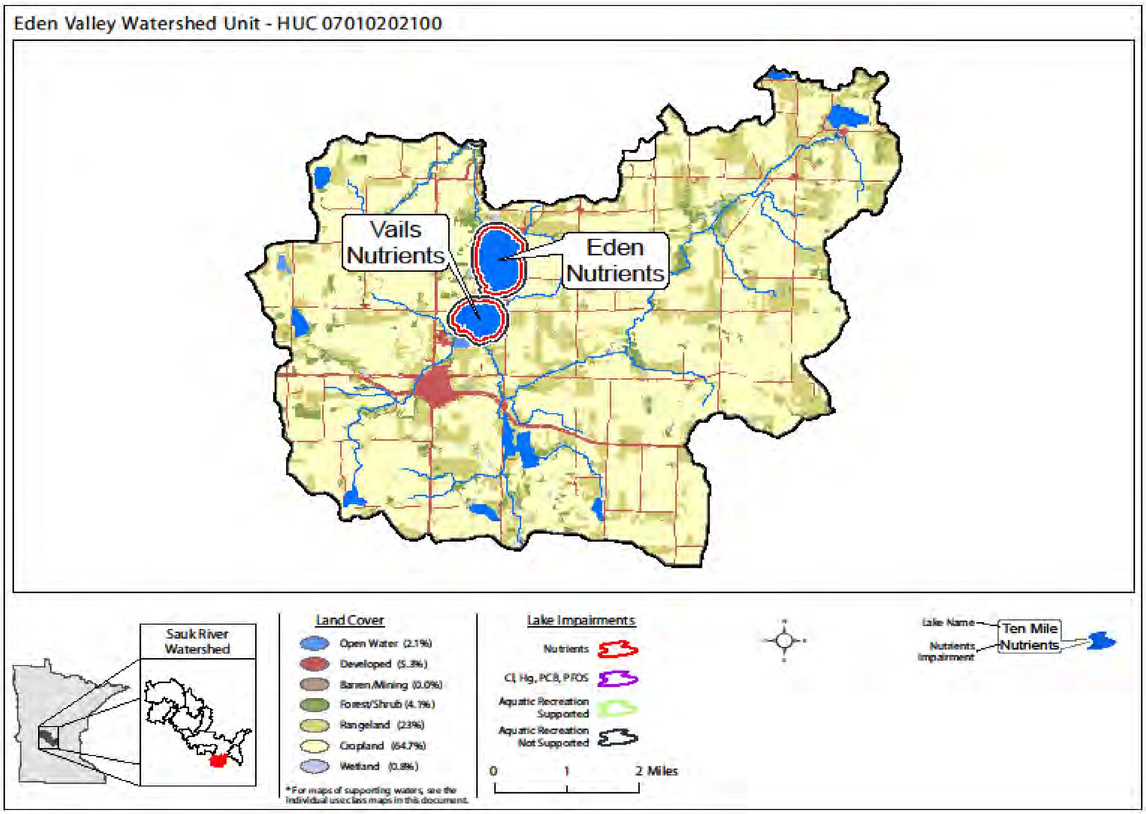



**Table 14 Eden Valley HUC11 lake information and status**

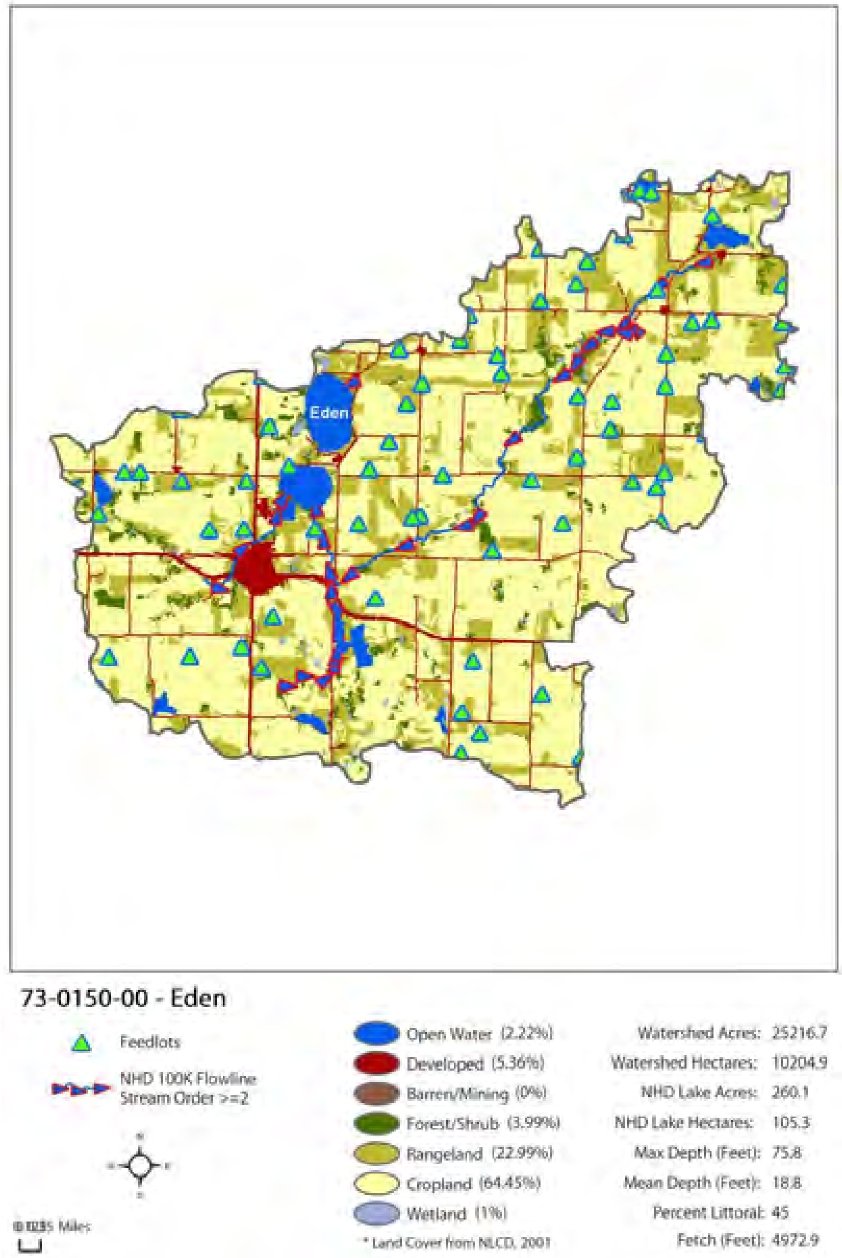
| Name | DOW# | County | Area | % Littoral | Avg. Depth (M) | Max. Depth (M) | ARUS | Trophic Status | Mean TP | Mean chl-a | Secchi Mean | CLMP Trend | RS 2005 | RS Trend |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Eden | 73015000 | STEARNS | 260 | 47 | 19 | 77 | NS | H | 98 | 36 | 2 | NT | | |
| Vails | 73015100 | STEARNS | 150 | 84 | 9 | 129 | NS | H | 192 | 63 | 1 | NT | | |
| School | 73008000 | STEARNS | 56 | | | | | | | | | | 0.8 | NT |
| Unnamed | 73015400 | STEARNS | 23 | | | | | | | | | | 1.4 | NT |
| Unnamed | 73015200 | STEARNS | 17 | | | | | | | | | | | |
| Unnamed | 47030600 | MEEKER | 16 | | | | | | | | | | | |
| Unnamed | 73033500 | STEARNS | 10 | | | | | | | | | | | |
| Unnamed | 47030800 | MEEKER | 4 | | | | | | | | | | | |

# Eden Lake 73-0150

A detailed lake assessment was completed for Eden and Vails Lakes was completed in 2005 and is available at http://www.pca.state.mn.us/water/lakereport.html

Eden Lake is a moderate to small sized lake with depth (76 feet). The lake is located just south of the city of Eden Valley. It has a large agriculture dominated watershed with a watershed to lake ratio of 91:1 (Figure 144).

**Figure 144. Eden lake catchment and landuse map**



## Water Quality Summary

The most recent profile data (2009) show distinct stratification from May through September. Thermoclines were distinct throughout the summer (Figure 145). DO profiles show hypoxic conditions were present throughout the water column in September. DO levels dropped of significantly with depth each monitoring event in 2009 (Figure 146).

TSI data from 2008 and 2009 show TSI indicators vary through the summer. Transparencies reading were significantly better in June and early July during both seasons. A spring diatom bloom is likely the cause to high chl-*a* and low Secchi observed on May 4th 2009. High TP on May 4th 2009 is likely due to recent spring mixing.

**Figure 145 Temperature profiles**

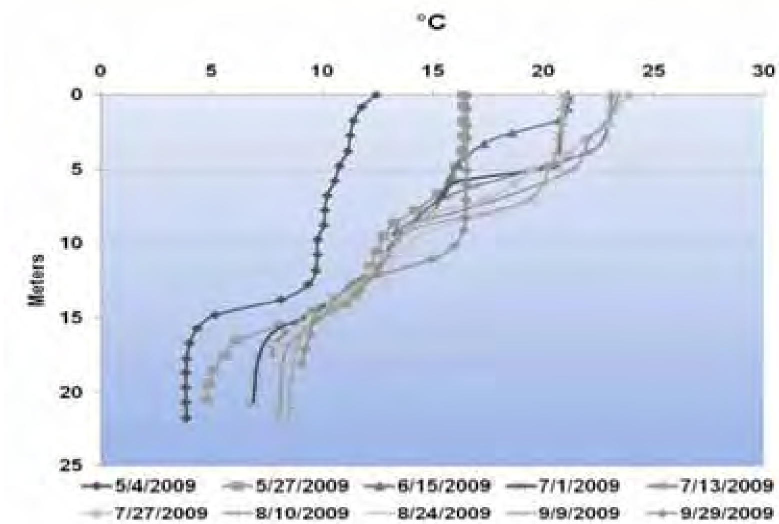



**Figure 146 DO Profiles**

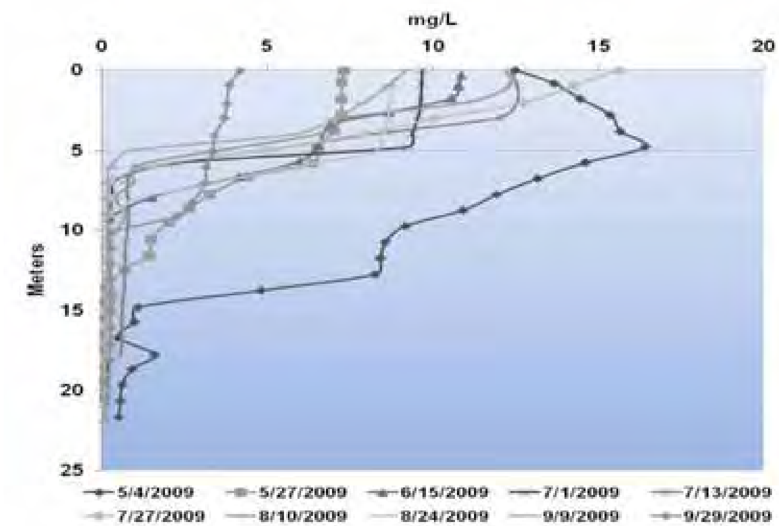
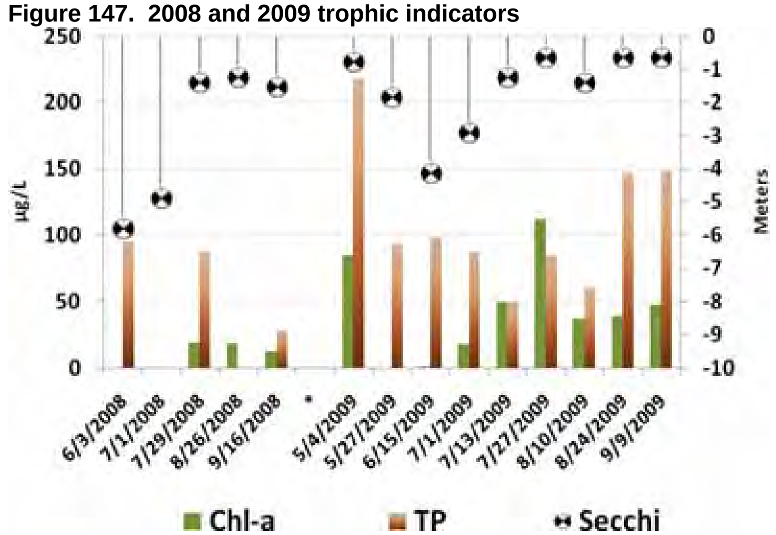



**Figure 147. 2008 and 2009 trophic indicators**



## Water Quality Trends

Water quality records go back to 1979 (Figure 148). TSI indicators show no overall trend. Summer mean TP values have been consistently over the ARUS standard.

## Modeling and Assessment Status

The MINLEAP model predicted lower TP then seen in the 2000-2009 assessment mean value (Figure 149). The model is likely is underestimating TP contribution from the watershed or internal loading. The lake was placed on the impairment list in 2010. The TMDL began in 2010 and it is scheduled to be completed in 2015.

**Figure 148 Eden Lake long-term trends**

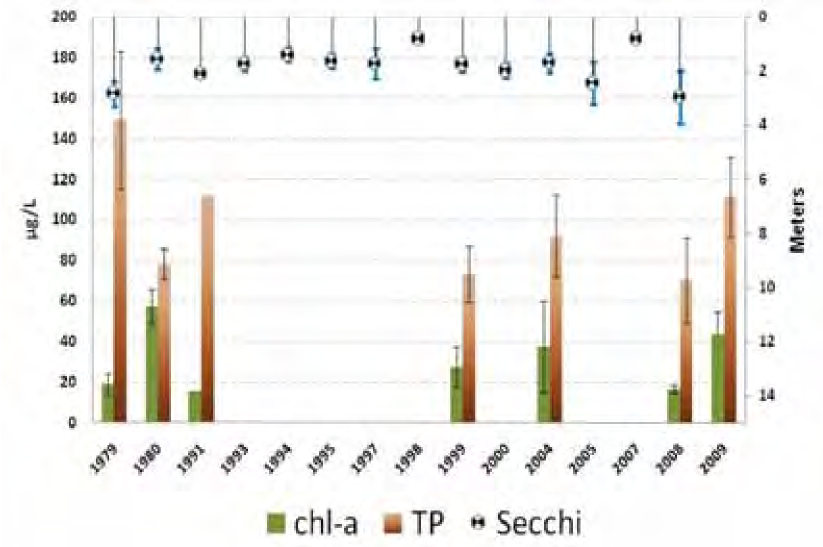
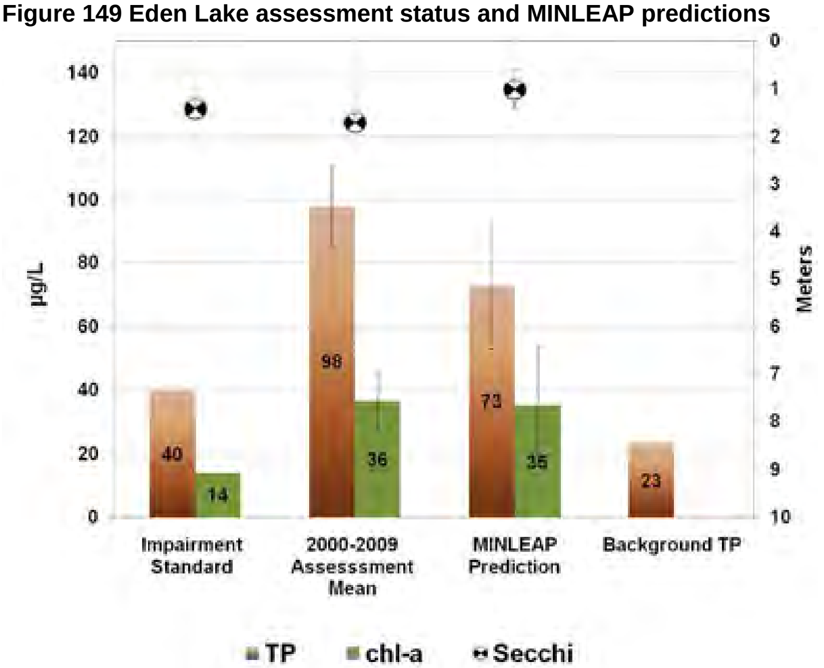



**Figure 149 Eden Lake assessment status and MINLEAP predictions**



# Pearl Lake Watershed

The Pearl HUC 11 drains north into the Lower Sauk. The watershed has more forested area than most of the Sauk River HUC 11's. The watershed has fair amount of lake (31) considering its size (Table 15). Six lakes in the Pearl HUC 11 have assessment level data of which three are full support.

**Figure 150 Pearl HUC 11 watershed and landuse map**

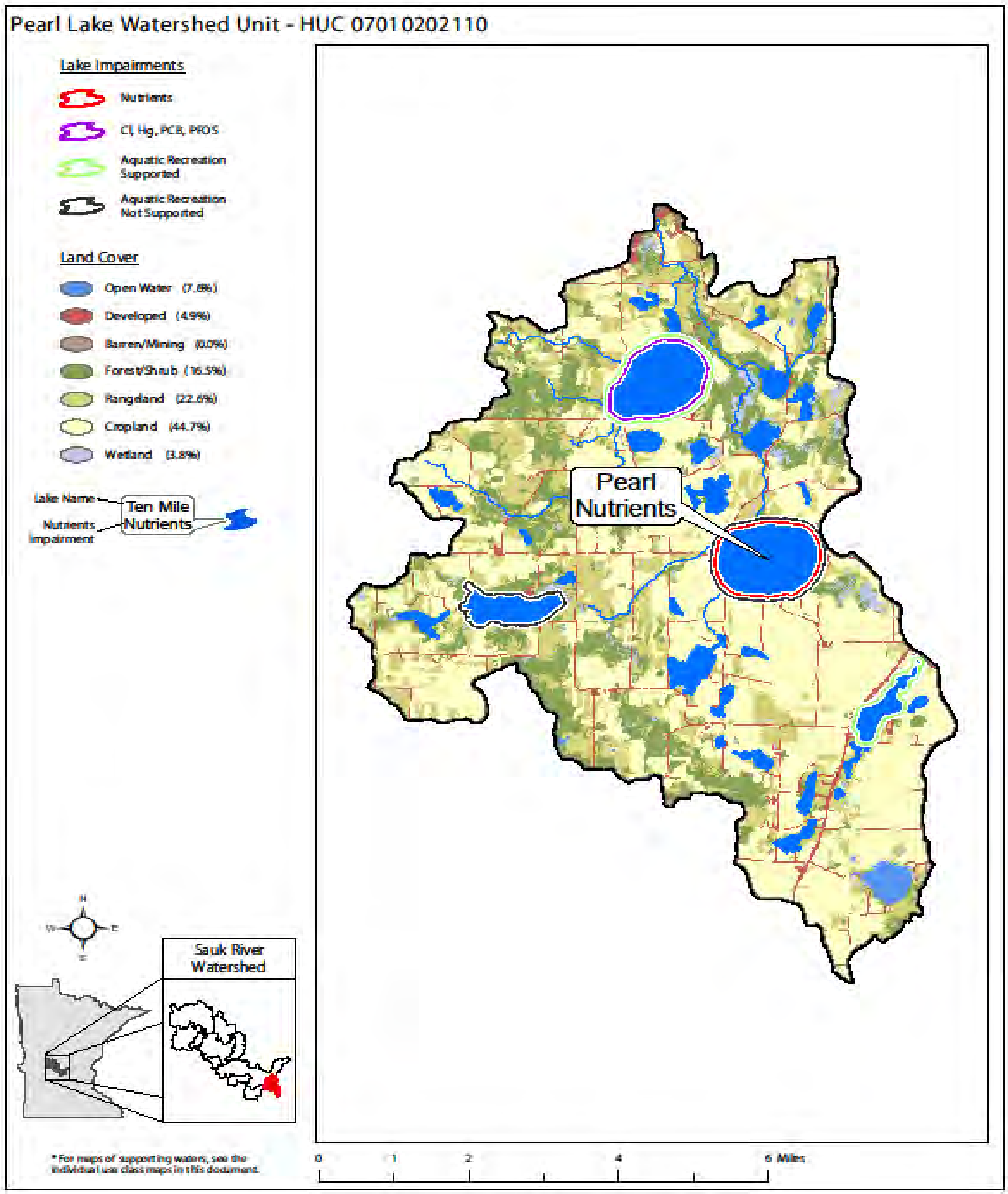


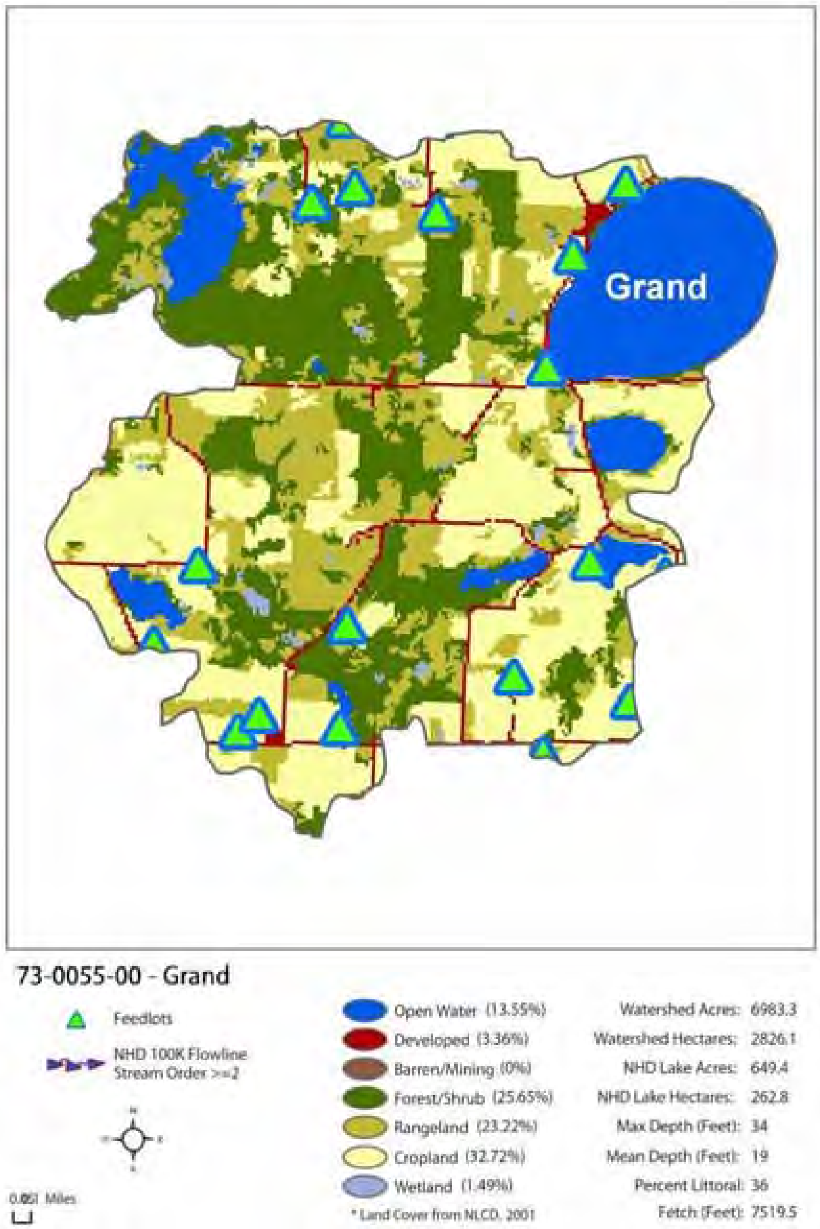
**Table 15. Pearl HUC 11 lake information and status**

| Name | DOW# | County | Area | % Littoral | Avg. Depth (M) | Max. Depth (M) | ARUS | Trophic Status | Mean TP | Mean chl-a | Secchi Mean | CLMP Trend | RS 2005 | RS Trend |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pearl | 730037 | STEARNS | 751 | 70 | 10 | 17 | NS | E | 40 | 16 | 2 | NT | | |
| Grand | 730055 | STEARNS | 649 | 36 | 19 | 30 | FS | E | 48 | 11 | 2 | ↗ | | |
| School Sectio | 730035 | STEARNS | 193 | 100 | 8 | 12 | FS | E | 37 | 9 | 3 | NT | | |
| Goodners | 730076 | STEARNS | 190 | 65 | 8 | 23 | NS | E | 70 | 21 | 2 | | 0.9 | NT |
| Carnelian | 730038 | STEARNS | 186 | 39 | 14 | 32 | FS | M | 15 | 5 | 5 | | 2.9 | NT |
| Rausch | 730057 | STEARNS | 71 | | | | ID | H | | | 0 | | 2.0 | ↗ |
| Mud | 730059 | STEARNS | 68 | | | | | | | | | | 1.5 | ↗ |
| Murray | 730044 | STEARNS | 47 | 65 | | | | | | | | | 1.9 | NT |
| Fink | 730078 | STEARNS | 38 | | | | | | | | | | 1.1 | NT |
| Days | 730043 | STEARNS | 38 | 63 | | | | | | | | | 0.7 | NT |
| Unnamed | 730050 | STEARNS | 35 | | | | | | | | | | | |
| Unnamed | 730045 | STEARNS | 33 | | | | | | | | | | 1.8 | NT |
| Unnamed | 730040 | STEARNS | 33 | | | | | | | | | | | |
| Haus Marsh | 730060 | STEARNS | 28 | | | | | | | | | | 0.6 | |
| Unnamed | 730315 | STEARNS | 23 | | | | | | | | | | 0.7 | NT |
| Unnamed | 730056 | STEARNS | 22 | | | | | | | | | | | |
| Unnamed | 730296 | STEARNS | 22 | | | | | | | | | | | |
| Unnamed | 730039 | STEARNS | 18 | | | | | | | | | | | |
| Unnamed | 730297 | STEARNS | 15 | | | | | | | | | | | |
| Unnamed | 730538 | STEARNS | 11 | | | | | | | | | | | |
| Unnamed | 730491 | STEARNS | 11 | | | | | | | | | | | |
| Unnamed | 730489 | STEARNS | 9 | | | | | | | | | | | |
| Unnamed | 730430 | STEARNS | 9 | | | | | | | | | | | |
| Unnamed | 730299 | STEARNS | 8 | | | | | | | | | | | |
| Unnamed | 730490 | STEARNS | 7 | | | | | | | | | | | |
| Unnamed | 730532 | STEARNS | 7 | | | | | | | | | | | |
| Unnamed | 730298 | STEARNS | 7 | | | | | | | | | | | |
| Unnamed | 730415 | STEARNS | 1 | | | | | | | | | | | |
| Marty | 730049 | STEARNS | 0 | | | | | | | | | | | |
| Unnamed | 730479 | STEARNS | 0 | | | | | | | | | | | |
| Unnamed | 730539 | STEARNS | 0 | | | | | | | | | | | |

# Grand Lake 73-0055

Grand Lake is a modest sized lake located two miles south of Rockville Minnesota. The lake catchment area has a high percentage of forested area (Figure 151) compared to other areas of the Sauk River watershed.

**Figure 151. Lake catchment and landuse map**



## Water Quality Summary

The most recent profile data (2009) show a thermocline had developed by late-June and were present through mid-August (Figure 152). DO profiles show significant declines from late June through August. Hypoxic conditions were only evident below 6 meters (Figure 153). TSI data from 2008-2009 show similar summer condition among the two years (Figure 154).

**Figure 152. Grand Lake temperature profiles**

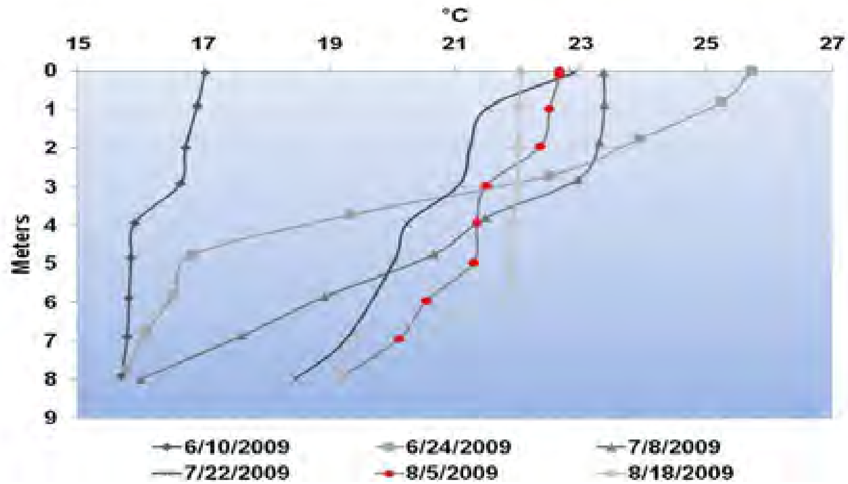



**Figure 153. Grand Lake DO profiles**

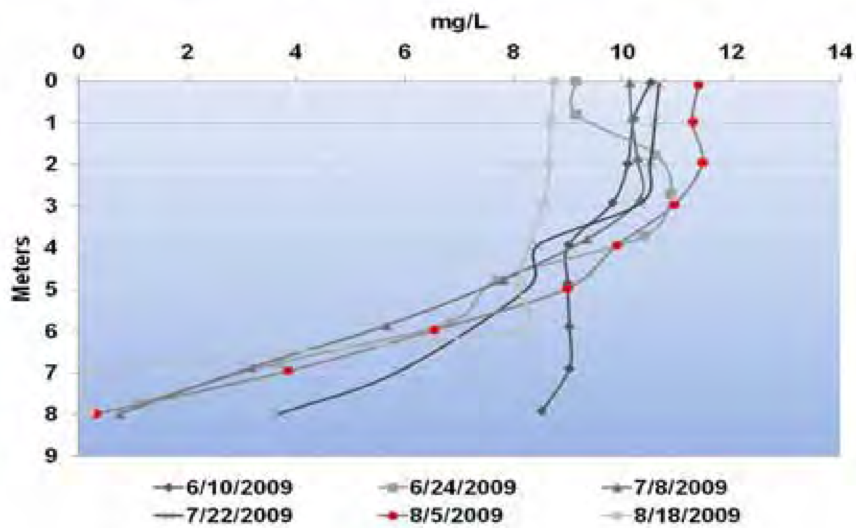
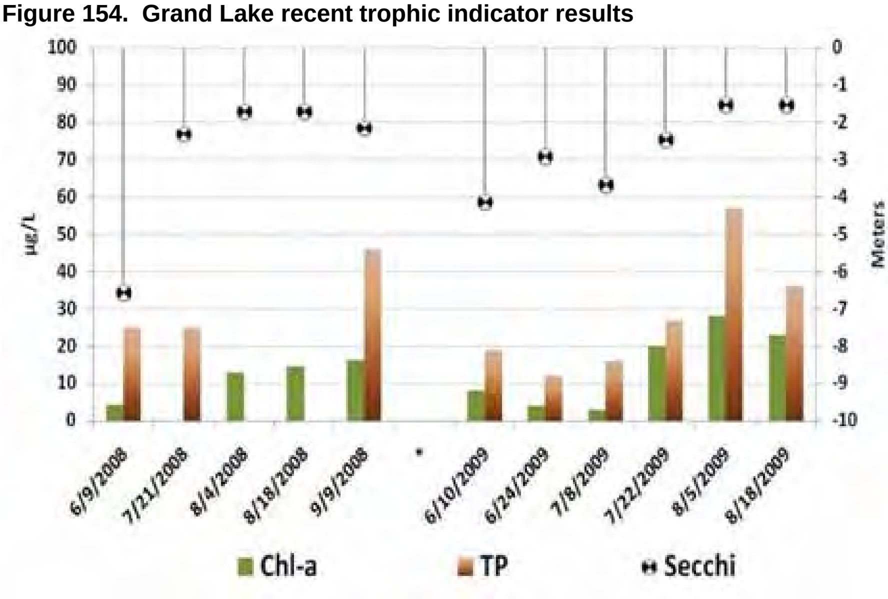



**Figure 154. Grand Lake recent trophic indicator results**



## Water Quality Trends

Water quality records from Grand Lake go back to 1977 (Figure 1977). The lake had an improving trend in transparency from 1977 - 1997. Summer mean transparency depth from 1999-2009 were similar.

## Modeling and Assessment Status

The MINLEAP predicted more eutrophic condition than the 2000-2009 assessment mean. Grand lake was assessed in 2010 and found to be fully supporting for ARUS by a reasonable margin (Figure 162). The MINLEAP model water quality predictions were similar to the 2000 – 2009 assessment water quality means. Grand Lake was placed on the 2002 303d impaired waters list based on ARUS.

**Figure 155. Grand Lake summer mean water quality trends**

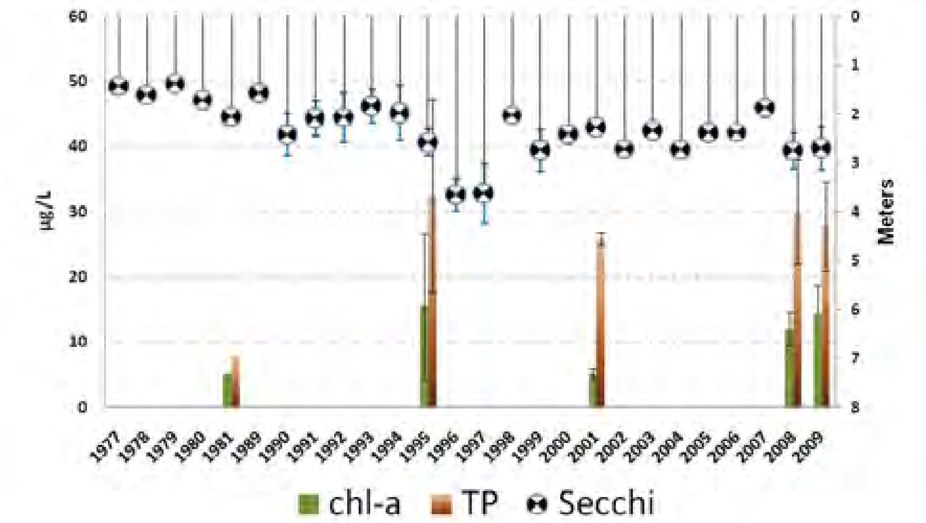
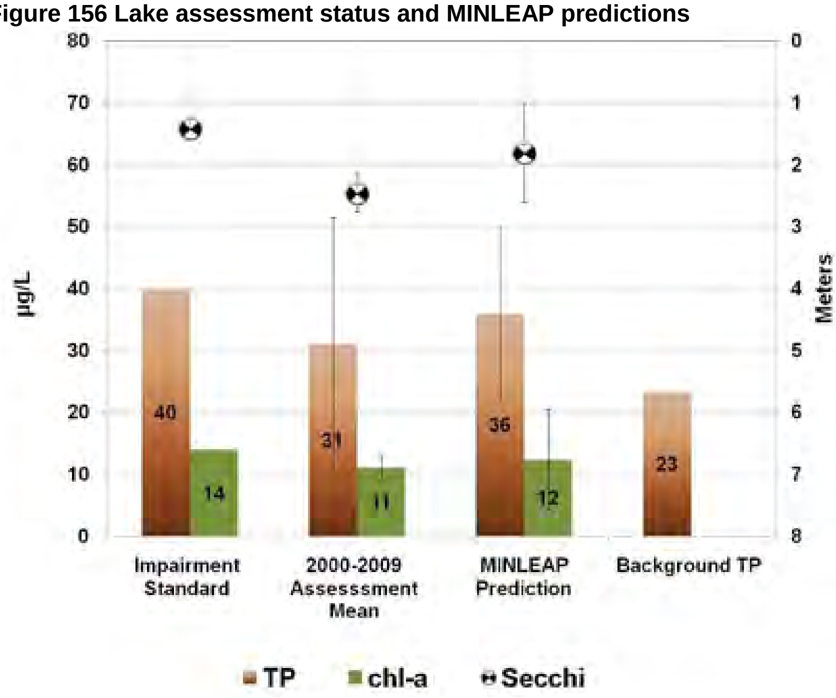



**Figure 156 Lake assessment status and MINLEAP predictions**

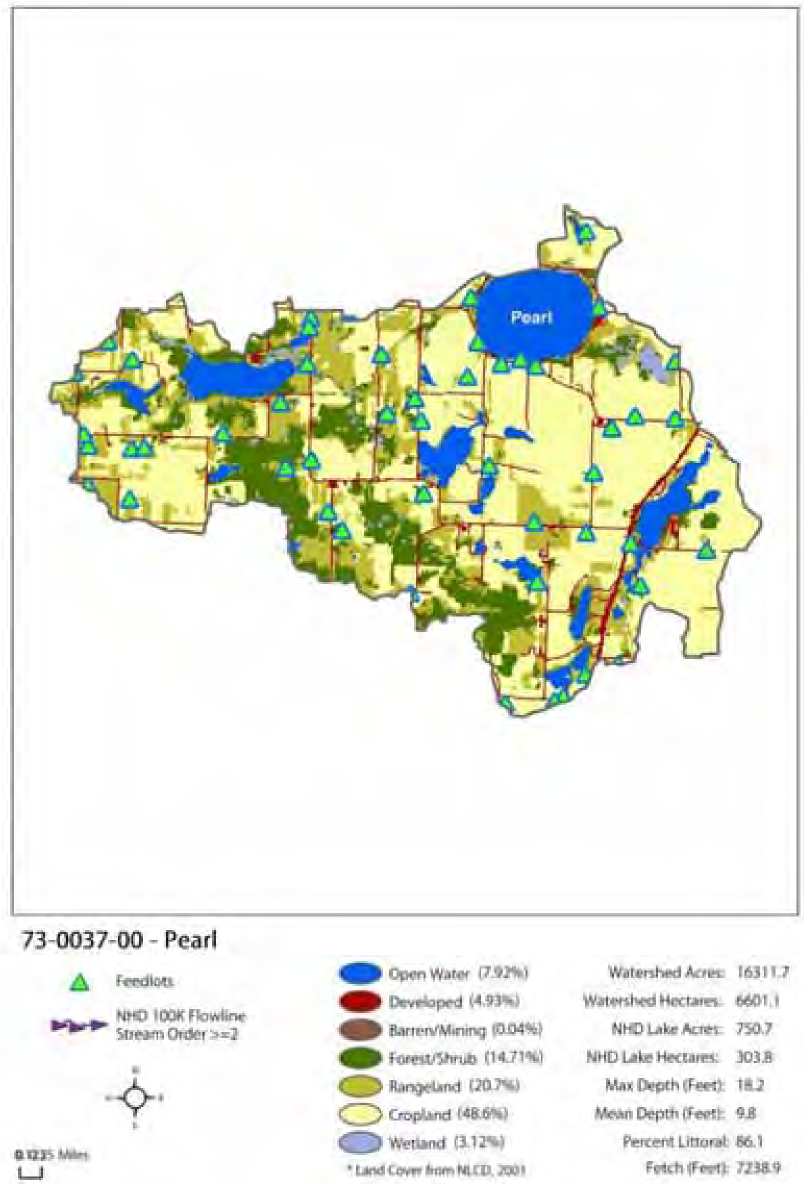


# Pearl Lake 73-0037

Pearl Lake is a 303 hectare (751 acre) lake that is 70% littoral. The lake is located five miles north of the City of Kimball. Pearl Lake is a very popular lake for angling in both summer and winter.

The MPCA published a water quality report on Pearl Lake in 1997. These reports can be found at http://www.pca.state.mn.us/water/lakereport.html

**Figure 157 Lake catchment and landuse map**



## Water Quality Summary

The most recent 2009 profiles show Pearl Lake show generally well mixed condition throughout the summer, with only a very slight temperature gradient observed in late July (Figure 158). Summer DO profiles show generally mixed condition with no hypoxic conditions in 2009 (Figure 159). TSI data show higher TP results in 2008 compared to 2009 (Figure 160).

**Figure 158. Pear Lake temperature profiles**

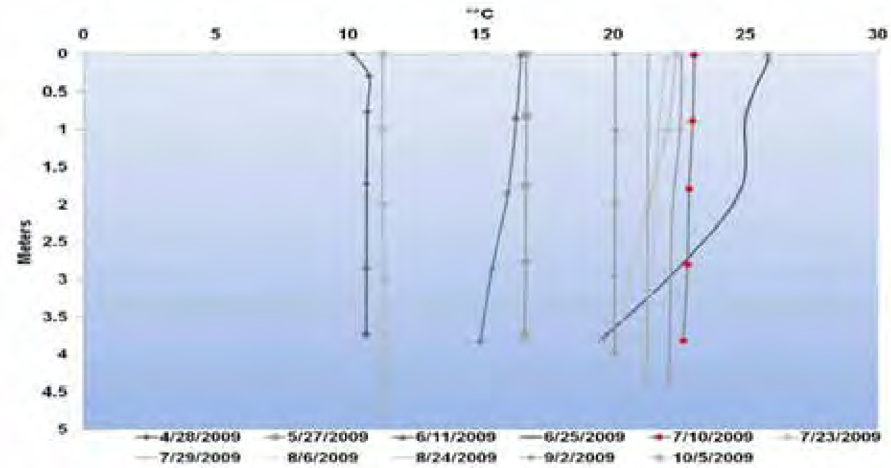



**Figure 159. Pearl Lake DO profiles**

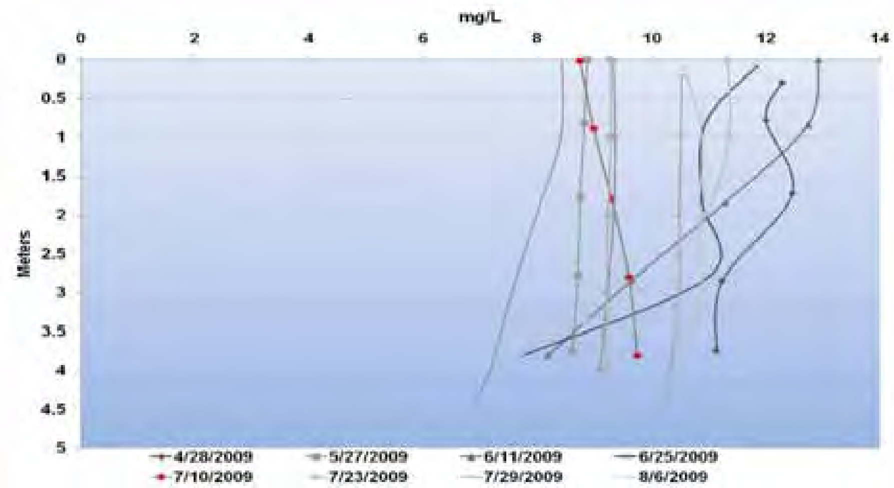
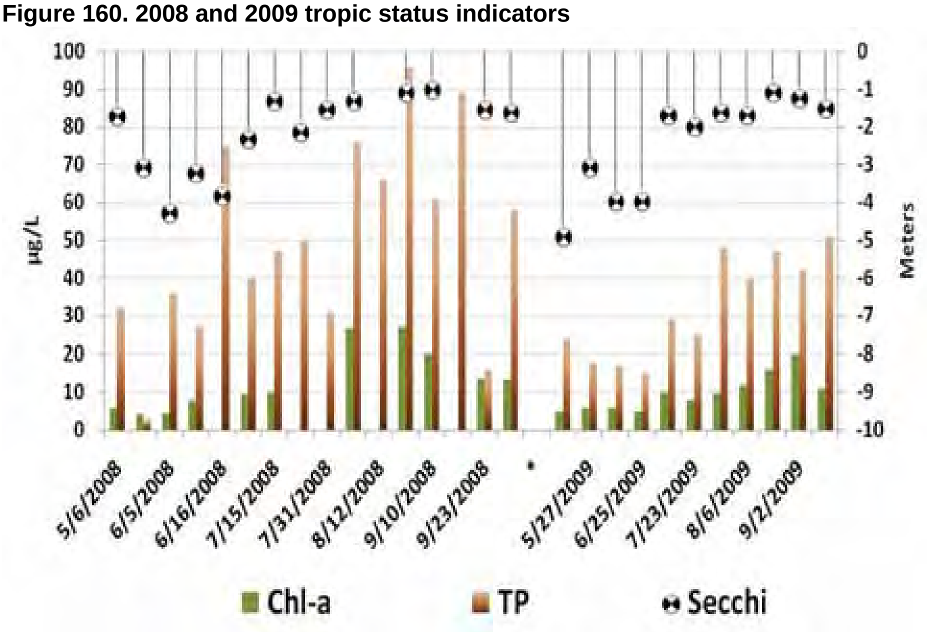



**Figure 160. 2008 and 2009 tropic status indicators**



## Water Quality Trends

Water quality records on Pearl Lake began in 1981. Conditions declined through 2006, but recent summer mean results show and improvement (Figure 161).

## Modeling and Assessment Status

The MINLEAP predicted more eutrophic condition than the 2000-2009 assessment mean.

Pearl Lake was placed on the 303d impaired waters list in 2008. The current assessment means for Pearl were very close to the impairment standards. The TMDL is scheduled to be complete d in 2010.

**Figure 161.Pear Lake water quality trends**

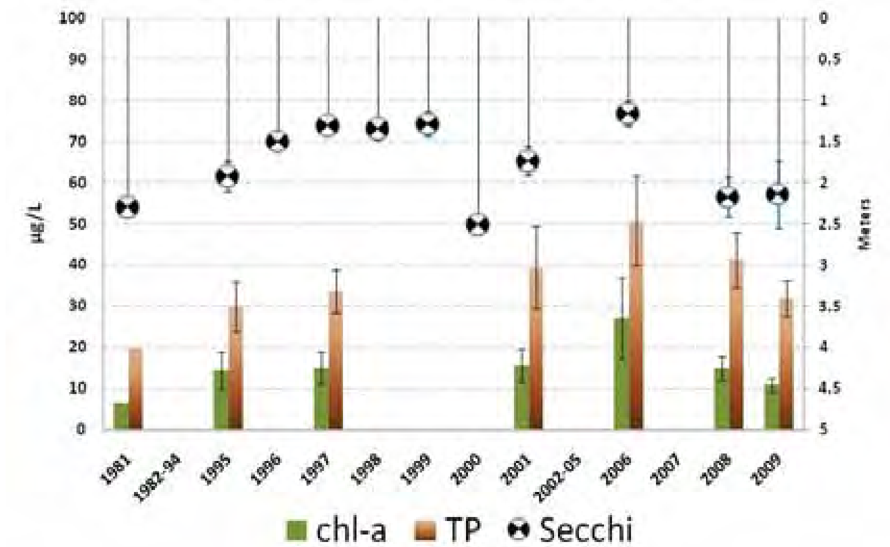
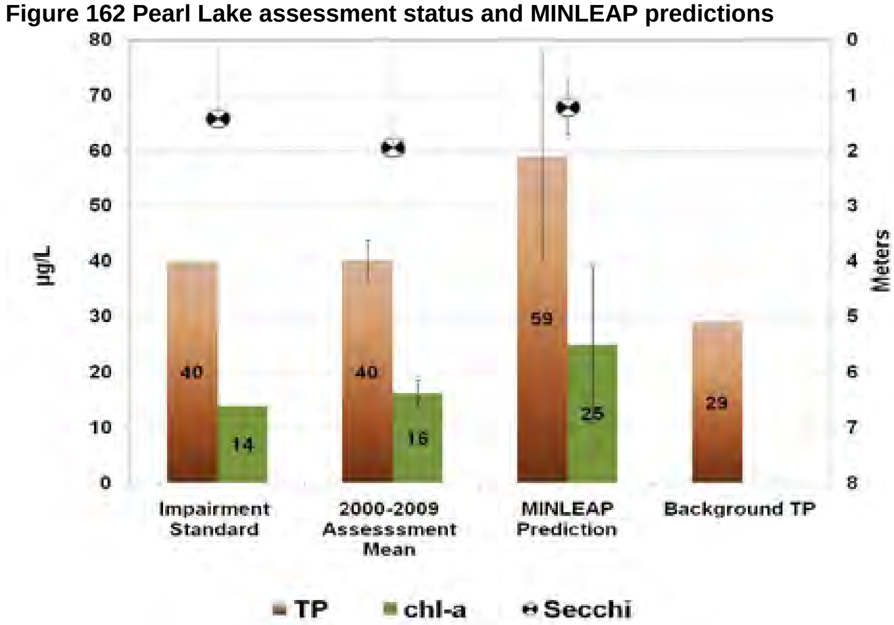



**Figure 162 Pearl Lake assessment status and MINLEAP predictions**



# Summary

The Sauk River watershed is a lake-rich watershed with 370 established lakes. Lakes within the watershed display a variety of recreational use conditions. Forty-four lakes within the Sauk River HUC 8 have been assessed for ARUS. The majority of assessed lakes (31) are categorized as non-supporting because of excess nutrients and algae, which is resulting in declining water clarity. CLMP water quality trends analysis indicate that water quality is improving on 16 lakes, declining on three lakes, and indicate that 15 lakes show no trend in water clarity. Numerous monitoring, assessment and improvement projects are underway in the Sauk River watershed, including efforts from the Sauk River SWCD MPCA and other local partners. The focus will be reducing phosphorus contribution from nonpoint sources within the watershed. Bringing the watersheds lakes into full support is an immense task, considering the scale and complexity of the problem.

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