

Minnesota Lake ID: 41-0089
Area: 995 acres
Watershed Area: 9,046 acres
Ecoregion: Northern Glaciated Plains (NGP)

Shaokotan Lake

Lincoln County

Sentinel Lakes

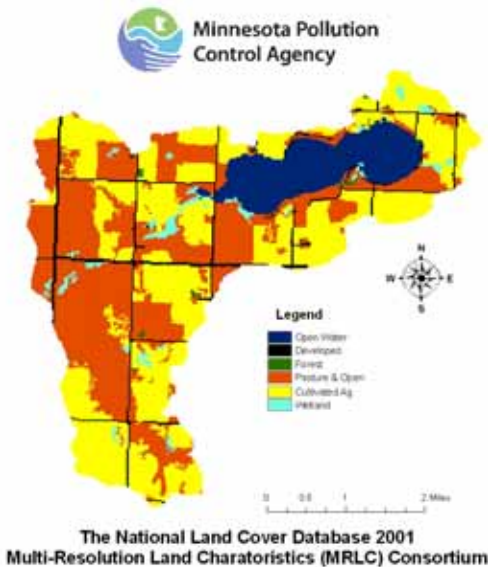
Trophic State: Hypereutrophic
Maximum Depth: 10 feet
Mean Depth: 7.9 feet
Mixing Status: Well-Mixed (Polymictic)

Figure 1. Shaokotan Lake 3D depth contour



DNR Ecological Service and Fisheries Divisions 2002
Lake Bathymetric DEM Shaded Relief Image

Figure 2. Lake Watershed land use



The National Land Cover Database 2001
Multi-Resolution Land Characteristics (MRLC) Consortium

Table 1. Land use compositions

Land use	Shaokotan Lake land use percentage	NGP typical land use percentage
Developed	5	0-2
Cultivated (Ag)	45	60-82
Pasture & Open	43	5-15
Forest	-	0-1
Water & Wetland	7	8-26
Feedlots (#)	6	

**Table 2. Shaokotan Lake summer-mean as compared to typical range for NGP ecoregion reference lakes
MPCA data based on 2008 sample collections**

Parameter	Shaokotan Lake	NGP
Number of reference lakes		13
Total Phosphorus ($\mu\text{g/L}$)	132	122-160
Chlorophyll mean ($\mu\text{g/L}$)	69	36-61
Secchi Disk (feet)	2.6	1.3-2.6
(meters)	0.8	(0.4-0.8)
Total Kjeldahl Nitrogen (mg/L)	2.38	1.8-2.3
Alkalinity (mg/L)	160	160-260
Color (Pt-Co U)	12.5	20-30
pH (SU)	8.4	8.3-8.6
Chloride (mg/L)	10	11-18
Total Suspended Solids (mg/L)	15	10-30
Total Suspended Inorganic Solids (mg/L)	6.9	5-15
Conductivity (umhos/cm)	683	640-900
TN:TP ratio		13:1-17:1

$\mu\text{g/L}$ = micrograms per liter
 mg/L = milligrams per liter
 umhos/cm = micromhos per centimeter

Pt-Co-U = Platinum Cobalt Units
 SU = Standard Units

Figure 3. Lake Shaokotan 2008 temperature and dissolved oxygen (DO) profiles

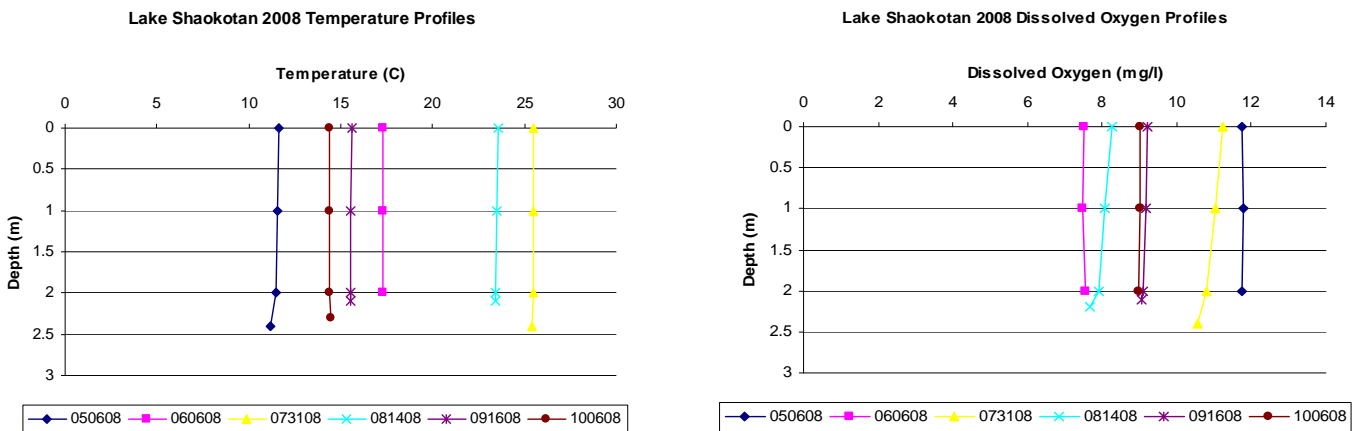
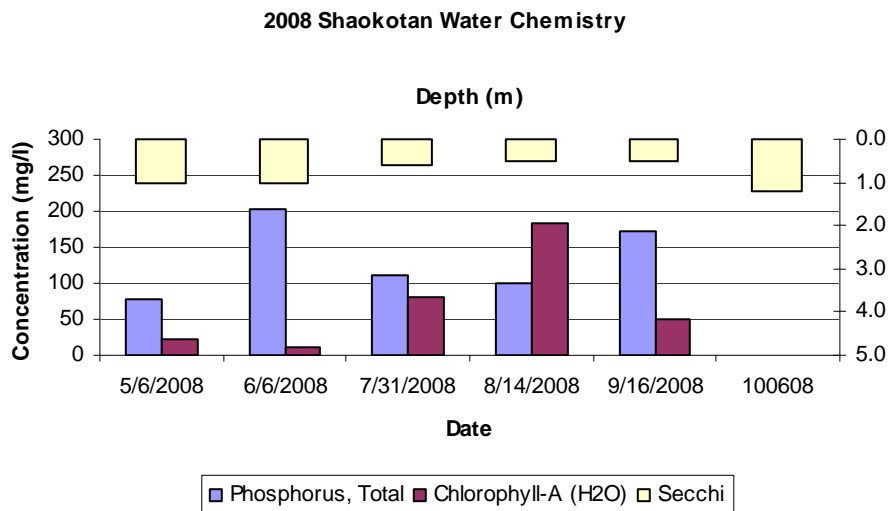


Figure 4. Summer 2008 trophic status measurements



Watershed, water quality, and fishery summary

Lake Shaokatan is a shallow Northern Glaciated Plains (NGP) ecoregion lake located west of Marshall and just east of the South Dakota boarder. It has a modest sized (9:1 ratio) watershed relative to its surface area that is dominated by agricultural uses (Figure 2). The lake has a history of water quality problems, including severe nuisance blue-green blooms, summer and winter anoxia, and periodic fish kills. These problems are the result of excessive external nutrient loading to the lake combined with internal recycling through various processes.

Based on dissolved oxygen (DO) and temperature profiles for 2008, the lake is well mixed and DO was present down to the bottom of the lake (Figure 3). Total Phosphorus (TP) and chlorophyll-a were quite variable in 2008 and severe nuisance algal blooms were common from July through September. Secchi was correspondingly low throughout the summer. Most water quality measurements for Shaokatan are comparable to the typical range for NGP reference lakes.

Shaokatan has a long history of data collection that includes MPCA monitoring, sediment core collections by the Science Museum of Minnesota, and Clean Water Partnership (CWP) and Total Maximum Daily Load (TMDL) monitoring conducted by the Yellow Medicine River Watershed. A detailed CWP Phase I diagnostic study was initiated in 1989 and restoration efforts were underway by 1991. Phase II implementation included rehabilitation of three animal feedlots, four wetland areas, and shoreline septic systems. By 1994, significant reductions in in-lake P were realized with concentrations approaching the ecoregion-based P standard of 90 µg/L, in contrast to the 200 to 350 µg/L noted in previous summers (Figure 5). As a result, the frequency and severity of nuisance algal blooms decreased, and transparency increased. By 1999, anecdotal evidence suggested macrophyte populations were increasing; however, plant surveys in 2000 and 2002 found essentially no rooted plants and the 2008 survey found relatively little plant coverage (Table 3). Water chemistry data indicated an increase in TP and chlorophyll-a in 1999 – 2001, largely attributable to an abandoned feedlot operation in the near- shore area of the lake. Subsequent efforts by the Yellow Medicine Watershed District, Lincoln County and the local sportsman’s group sought to address the problem. TP and chlorophyll-a remained above the trophic status thresholds for the NGP ecoregion and the lake was included on the 2002 303(d) list. A TMDL study is underway and will hopefully complete the work initiated in the CWP and result in reduced (and more stable)TP and chlorophyll-a, which should lead to a reduction in the frequency of severe nuisance blue-green blooms that have characterized recent summers. Such a reduction, combined with improved water transparency, may allow the return of macrophytes to the lake. At this point, the eutrophication criteria (for secondary uses) appear to be very reasonable, given the response to reduced external loads and historical in-lake TP (as based on sediment diatom reconstruction; Figure 5).

Figure 5. Shaokatan summer-mean observed and sediment diatom reconstructed TP

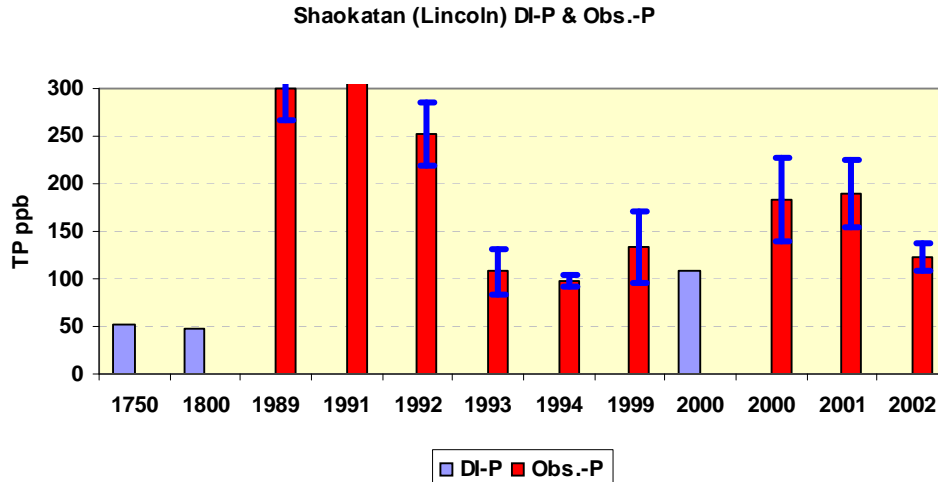


Table 3. Focal species captured during recent surveys and their size and abundance compared with other lakes in its lake class. The “biotic integrity” score for Shaokotan in 2008 was 46, which was average compared with other lakes of similar productivity.

Species	Stocked	Abundance	Size	Trend
Walleye*	Y	High	Average	Increasing
Northern Pike	Y	Low	N too small	Increasing
Bluegill	N	Low	N too small	Variable
Black bullhead	N	Low	Large	Decreasing
Yellow perch (Not Stocked Since 1985)	N	High	Large	Stable

*Management emphasis on this species

Table 4. Aquatic plant summary

Percent cover of aquatic plants \leq 15 ft deep	17%
Number of common species (i.e., \geq 10% cover)	1
Lake depth beyond which most vegetation disappeared	4.4ft
Non-native plant infestation	NA
Frequency of <i>Chara</i>	1%

Narrative

Shaokotan is a shallow, productive lake with a very simple fish community dominated by walleye and more recently, quality-sized yellow perch. In the past, winter aeration and stocking has been required to sustain most game fish populations; however, significant natural reproduction by walleye has been documented in recent years. DNR Fisheries’ management prefers policies that reduce bullheads in favor of game fish that are more desirable to Minnesota residents. Establishing self-sustaining populations of game fish, not to mention waterfowl habitat, will require a resurgence of macrophytes (i.e., aquatic plants) and clear water. Strong enforcement and evaluation of the Shaokotan Lake TMDL implementation plan, which outlines the appropriate best management practices, must be carried out.