5 CEDAR LAKE

HISTORY

Cedar Lake is a dimictic, glacial kettle lake in the Chain of Lakes and was named for the red cedar found along its shoreline. Some evidence exists that the lake may mix in some years during the late summer and then re-stratify (Lee and Jontz, 1997). Dredging occurred between 1911 and 1917, and channels between Lake of the Isles and Brownie Lake were created in 1913 and 1917, respectively. The canal connecting Cedar Lake to Lake of the Isles caused a water elevation drop of six feet in Cedar. The lower water elevation changed the shape of the lake. The most noticeable impact was the land connection of Louis Island; making it a peninsula on the west side of the lake. Figure 5A shows a recent photograph of Cedar Lake.

Cedar Lake, also part of the Clean Water Partnership project, has received a multitude of restoration projects. Both constructed wetlands (1995) and an aluminum sulfate (alum) treatment (1996) were best management practices (BMPs) implemented to improve general water quality in the lake. Figure 5B shows a bathymetric map of Cedar Lake. Table 5A shows the Cedar Lake morphometric data.

Figure 5A. Fishing pier on Cedar Lake.

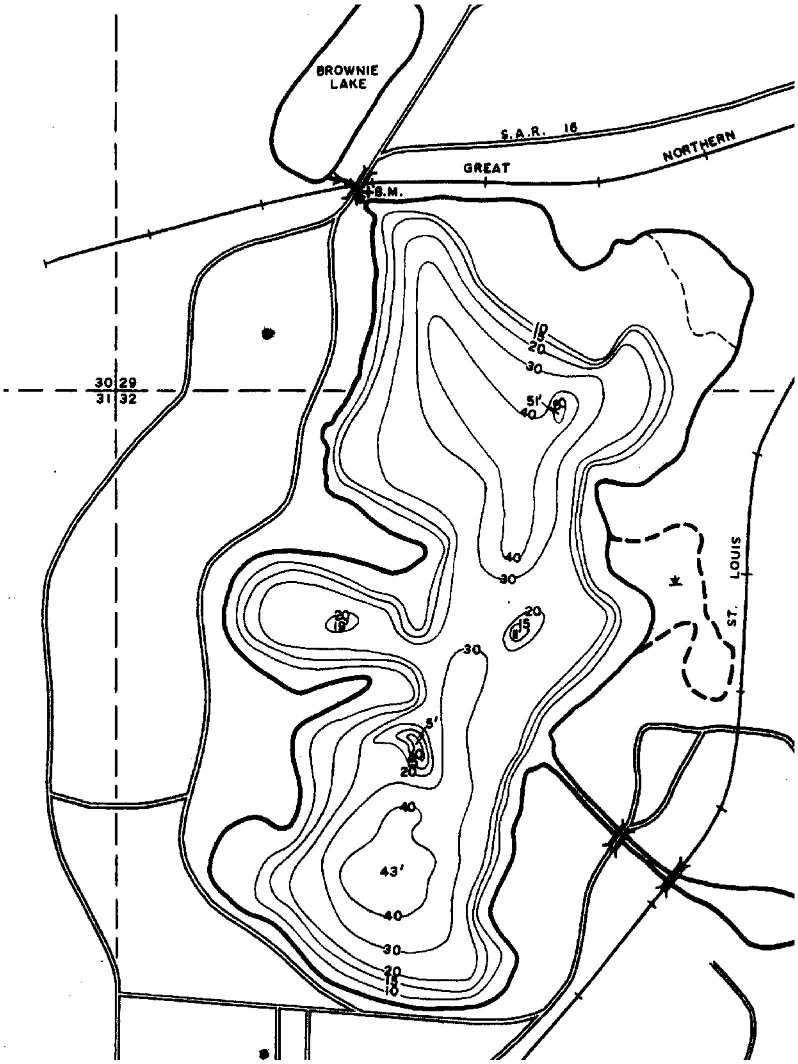


Figure 5B. Bathymetric map of Cedar Lake. Map courtesy of the Minnesota Department of Natural Resources (MDNR).

Table 5A. Cedar Lake morphometric data. * Littoral area defined as less than 15 feet deep.

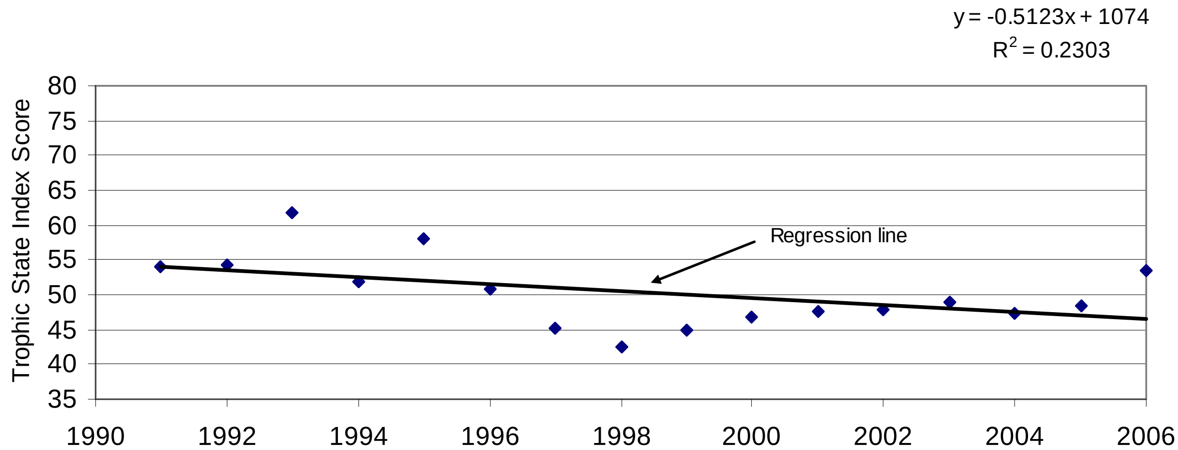
Surface Area (acres)	Mean Depth (m)	Maximum Depth (m)	Littoral Area*	Volume (m^3)	Watershed Area (acres)	Watershed: Lake Area (ratio)	Residence Time (years)
170	6.1	15.5	37%	$4.26x10^6$	1,956	11.5	2.7

LAKE LEVEL

See Lake Calhoun, Section 4.

WATER QUALITY TRENDS (TSI)

The TSI scores for Cedar Lake are shown in the linear regressions in Figure 5C. Restoration efforts begun in 1994 and have helped improve water quality in the lake. Cedar Lake is mesotrophic, with moderately clear water and some algae. In comparison to other lakes in this ecoregion, Cedar is in the top 25% of TSI scores (based on calculations from the Minnesota Pollution Control Agency, using the Minnesota Lake Water Quality Data Base Summary, 2004). A detailed explanation of TSI can be found in Section 1.



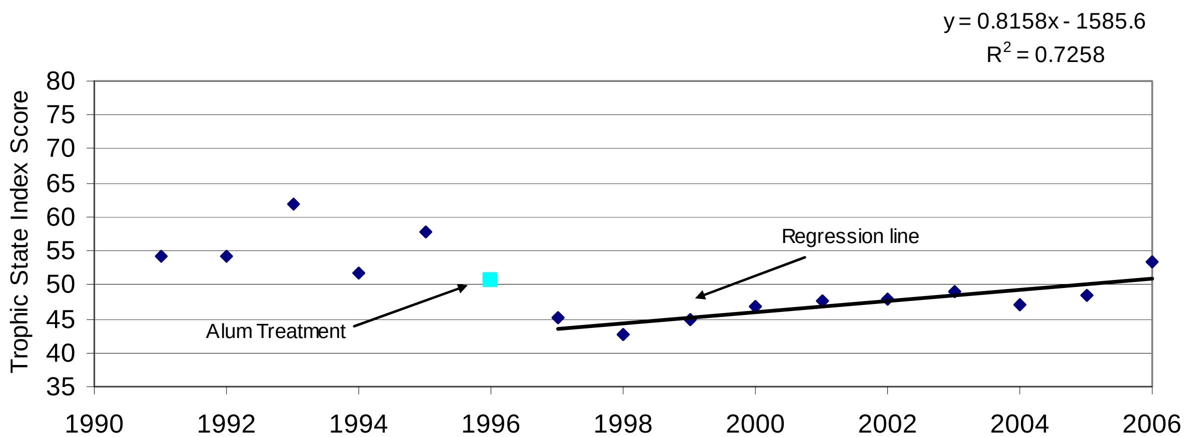


Figure 5C. Cedar Lake TSI scores and regression analysis from 1997-2006. Top graph shows the regression line for the entire period of record. Bottom graph shows the regression for the years after the 1996 alum treatment.

Although the trend through all of the years of TSI data is towards decreasing TSI scores, the trend is weak (r^2=0.23) and a regression through recent data shows that the trend may have reversed. Plotting a regression though the data following the alum treatment (1997- present) shows a stronger trend towards increasing TSI scores (r^2= 0.72) (Figure 5C).

Even though the TSI score for 2006 is the highest since the alum treatment, it does not appear that the alum treatment has become ineffective. The average TSI score for the years preceding the alum treatment is 56, and the average score since the alum treatment is 47. Although the trend in Cedar Lake may be towards increasing TSI scores, the average over the past 5 years

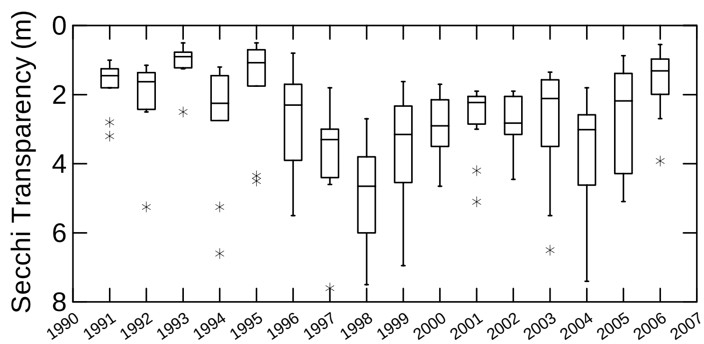
(2002-2006) is a TSI of 49, which remains a significant improvement over the pre-restoration conditions. Table 5D.

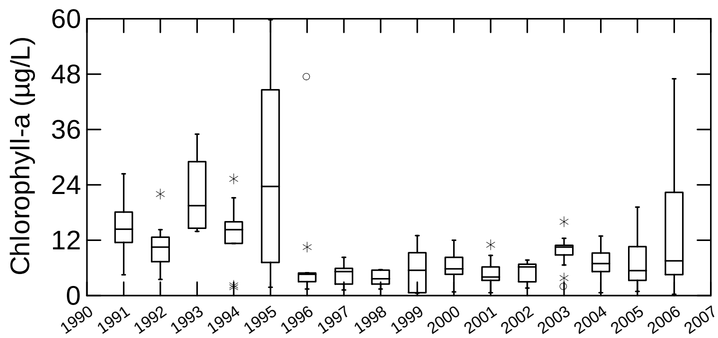
Table 5D. Average TSI scores for Cedar Lake for: all of the years of data preceding the alum treatment (1991-1995), following the alum treatment (1997-2006), the five years following the alum treatment (1997-2001) and the last 5 years of data (2002-2006).

	Pre-Alum Treatment (1991-1995)	Post-Alum Treatment (1997-2006)	5 Years following Alum Treatment	Last 5 Years (2001-2006)
Average TSI Score	56	47	45	49
Standard Deviation	3.9	2.9	1.9	2.6

BOX AND WHISKER PLOTS

The box and whisker plots show the scatter within the years data set for the Secchi, chlorophyll-*a* and total phosphorus in more detail. Long-term lake monitoring is necessary to evaluate the seasonal and year-to-year variations seen in each lake and predict trends. Figure 5E shows box and whisker plots of data from 1991-2006. A detailed explanation of box and whisker plots can be found in Section 1.





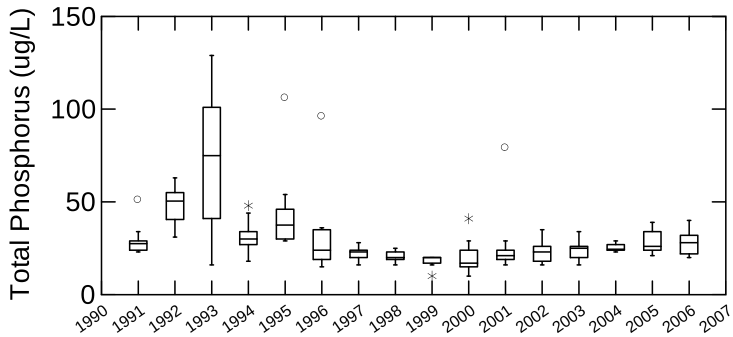


Figure 5E. Box and whisker plots of Cedar Lake 1991-2006.

The restoration efforts, begun in 1994, appear to have caused less variability in the data. The alum treatment, in 1996, improved phosphorus levels at the surface and the hypolimnion, and was predicted to have a treatment life span of at least 7 years (Huser, 2005).

2006 was an unusually bad year for water clarity Cedar Lake, see Figure 5F. Both secchi depths and chl-*a* had results more comparable to Cedar Lake prior to the alum treatment; however, total phosphorus was more comparable to the years post-treatment, see Figure 5E. Several events could be contributing to the worsening water quality trend in Cedar Lake. The Cedar Meadows wetland has not been functioning at maximum efficiency because of trash buildup at the diversion structure. Lack of treatment by Cedar Meadows along with a strong localized April storm could have contributed to the shallower secchi depths during what normally is the “clear water phase”. Additionally, 2006 saw very low levels of milfoil growth in Cedar Lake. The nutrients not used by aquatic plants and associated epiphytic communities were available to sustain increased levels of planktonic algae contributing to decreased clarity.

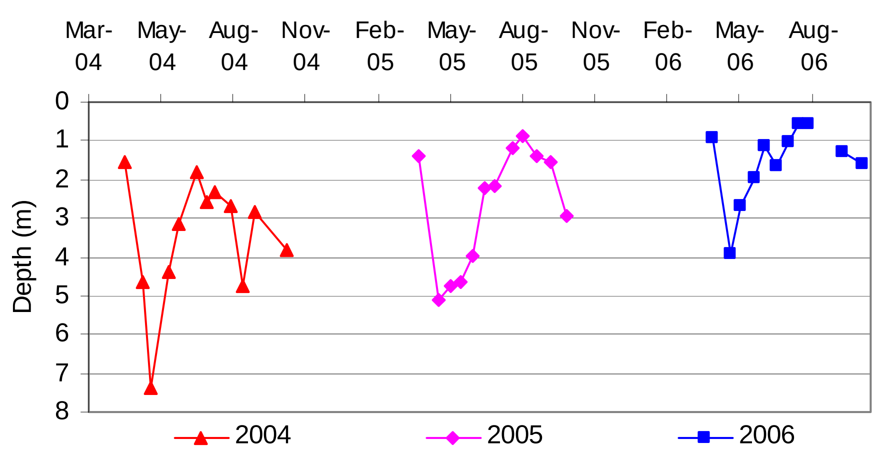


Figure 5F. Secchi transparency in Cedar Lake from 2004 – 2006.

LAKE AESTHETIC AND USER RECREATION INDEX (LAURI)

The LAURI for Cedar Lake is presented in Figure 5F. Cedar Lake scored "excellent" in aesthetics and public health. Lower Secchi depths lead to a "poor" rating for water clarity. The increased amount of algae interfered with the amount of sunlight reaching aquatic plants and lead to a "good" rating for aquatic plants, meaning recreational interferences due to aquatic plants were minimal. See Section 1 for details on the LAURI.

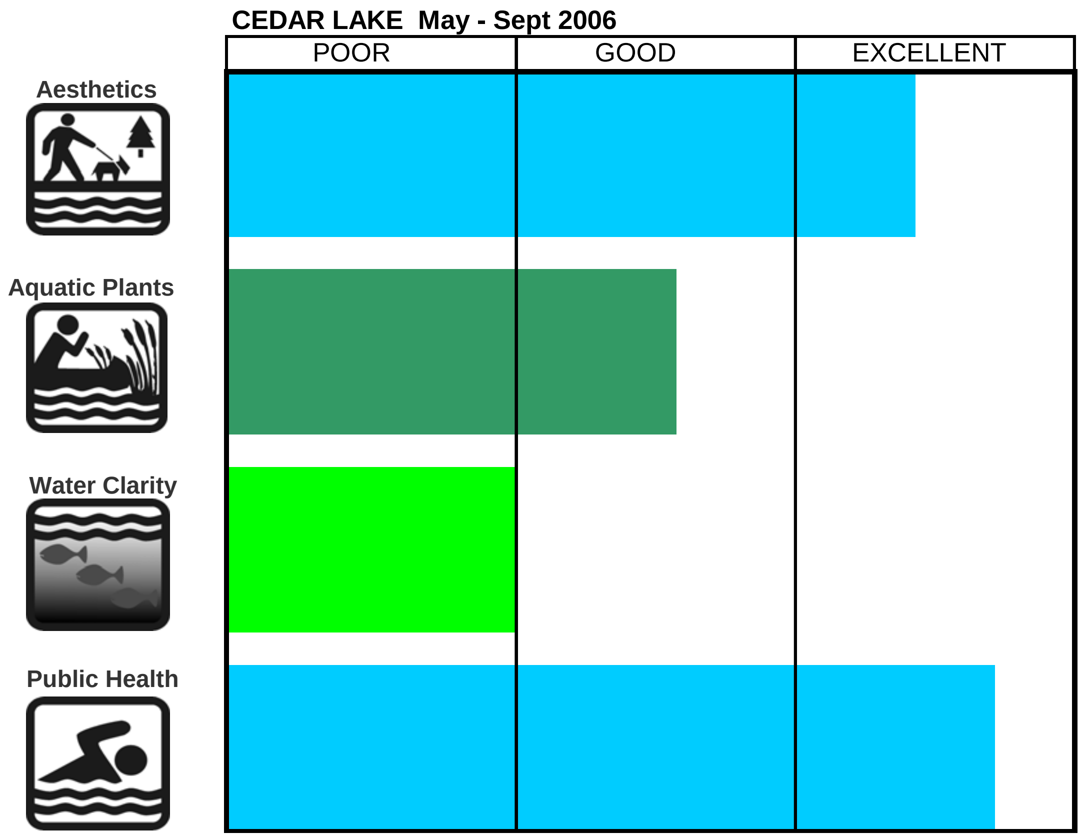


Figure 5F. The 2006 LAURI for Cedar Lake.

WINTER ICE COVER

Ice came off Cedar Lake on April 7, 2006, which is one day earlier than the average. Ice was on the lake by December 5, 2006, which is two weeks earlier than the average. See Section 1 for details on winter ice cover records and Section 18 for a comparison with other lakes.

EXOTIC AQUATIC PLANT MANAGEMENT

The MDNR requires a permit to remove or control Eurasian watermilfoil. These permits limit the area from which milfoil can be harvested to protect fish habitat. The permits issued to the MPRB allowed for harvesting primarily in swimming areas, boat launches and shallow areas where recreational access was necessary. The permitted area on Cedar Lake is 30 acres, which is 18% of the total lake area. Eurasian watermilfoil growth was quite limited on Cedar Lake in 2006; therefore, the lake was not harvested during the 2006 season. See Section 1 for details on aquatic plants.

BEACH MONITORING

E. coli levels were sampled at two different locations around Cedar Lake, Cedar Main Beach and Cedar Point Beach. As can be seen from Table 5B, the season long geometric means for *E. coli* were extremely low. Cedar Point Beach had one of the lowest values and Cedar Main Beach was amongst some of the lowest values for all MPRB beaches. Both beaches also had very low median *E. coli* values for the season. Cedar Main and Cedar Point beaches remained open for the entire beach season. Figure 5G illustrates box and whisker plots of *E. coli* sampling results (per 100 mL) for 2003-2006. Box and whisker plots show in more detail the scatter, within the years, of the data set. Additional information on beach monitoring can be found in Section 19.

Table 5B. Summary of *E. coli* results (per 100 mL) for Cedar Lake beaches in 2006.

Statistical Calculation	Cedar Main Beach	Cedar Point Beach
Minimum Value	2	2
Maximum Value	280	98
Median value	10	3
Geometric Mean	14	7
Standard Deviation	82	22
Number of Samples Taken	41	42

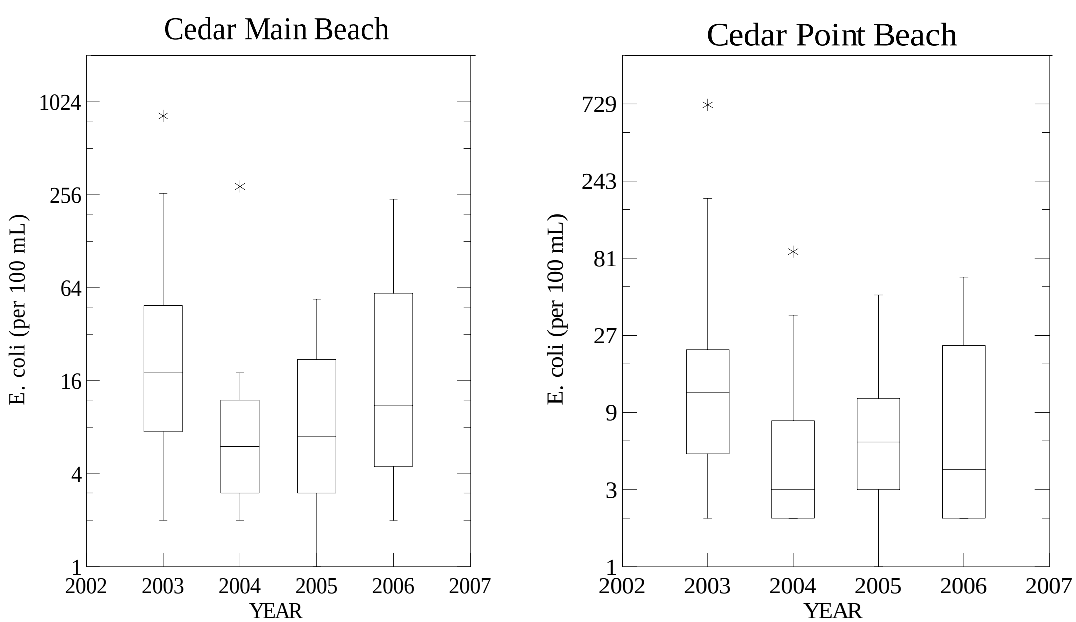


Figure 5G. Box and whisker plots of *E. coli* results (per 100 mL) for Cedar Lake beaches, 2003-2006. Note that the log scales differ on each y-axis.

Table 5C shows correlations between *E. coli* and select variables at Cedar Lake beaches. At Cedar Main Beach there were very strong positive correlations with *E. coli* and rainfall amount from previous 24 hours and rainfall intensity and duration. Moderately strong negative correlations existed with dissolved oxygen, percent dissolved oxygen and specific conductivity. There was also a positive correlation with wind speed. At Cedar point beach there were strong positive correlations with animals and wind speed and negative correlations with pH and rainfall intensity.

Table 5C. Selected correlations (r) between *E. coli* results (per 100 mL) and select variables at each beach on Cedar Lake in 2006.

Variables	Cedar Main	Cedar Point
Animals	-0.153	0.488
Dissolved Oxygen	-0.391	0.034
Percent Dissolved Oxygen	-0.282	0.038
pH	-0.193	-0.238
Rainfall	0.727	0.121
Rainfall Duration	0.816	-0.078
Rainfall Intensity	0.742	-0.153
Specific Conductivity	-0.325	0.004
Wind Speed	0.232	0.351

Phytoplankton and Zooplankton

Phytoplankton and zooplankton are the microscopic plant and animal life that form the basic food web of lake ecology. The greenness of a lake is measured by chlorophyll-*a* (chl-*a*) as an expression of the phytoplankton present. Figures 5H, 5I, and 5J show the distribution of phytoplankton over the 2006 sampling season and the corresponding chl-*a* and secchi data, respectively. Cyanophyta (blue-green algae) dominated during most of the sampling period, except in April, when bacillariophyta (diatoms), chrysophyta (golden algae), and cryptophyta (cryptomonads) together made up the majority of the algal biomass. The clearest water in Cedar Lake occurred in early May before cyanobacteria dominated and during the time of the lowest chl-*a* concentration. Cedar Lake's clearest water also corresponded to the highest zooplankton numbers (see Figure 5J). In 2006, rotifers were more abundant than arthropods, except in the October sample. Protozoans occurred at levels that were lower than 0.5% of the sample.

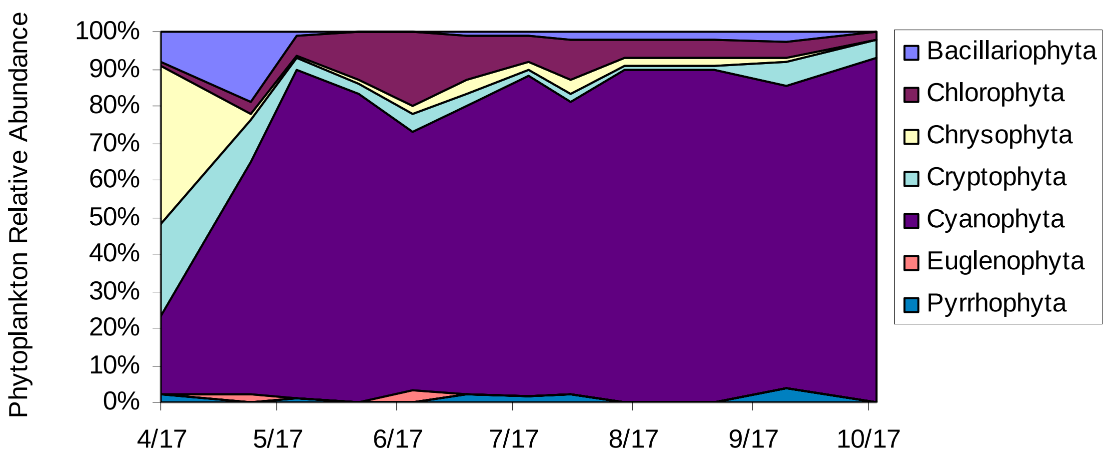


Figure 5H. Distribution of the relative abundance of phytoplankton over the 2006 field season. Cyanophyta (blue-green algae) dominated in all samples except April.

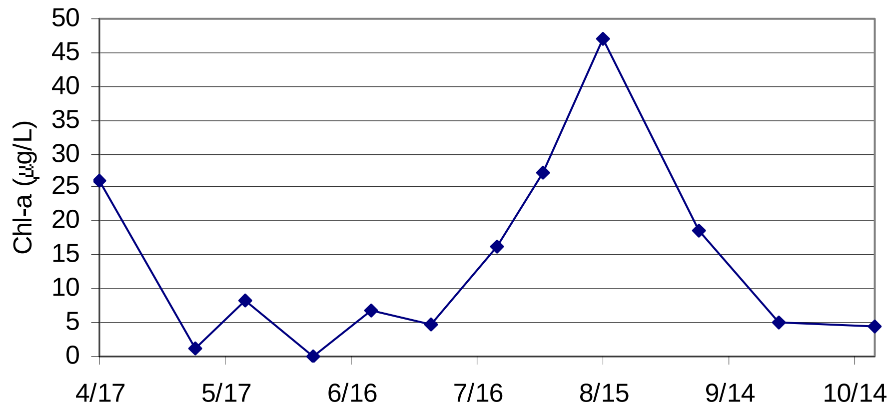


Figure 5I. Cedar Lake 2006 chlorophyll-*a* data. The largest blooms in Cedar Lake were in April, when chrysophytes, cryptophytes, and bacilliarophytes dominated, and between mid-July and mid-September when cyanophyta dominated the plankton assemblage.

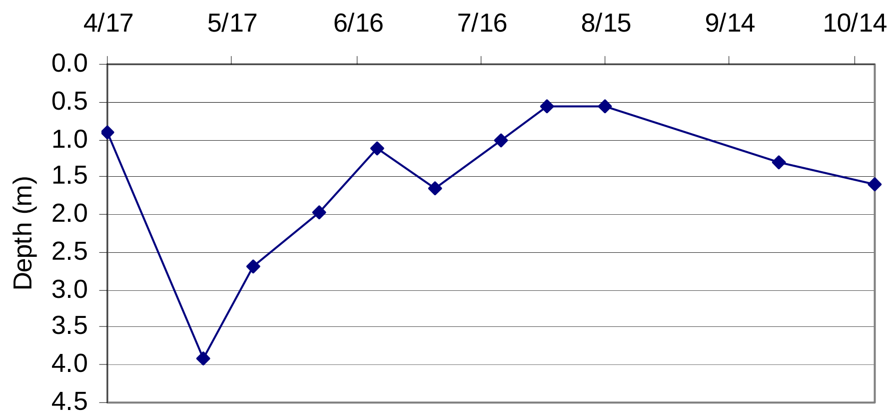


Figure 5J. Cedar Lake 2006 Secchi disk data. The clearest water in Cedar Lake occurred in early May.

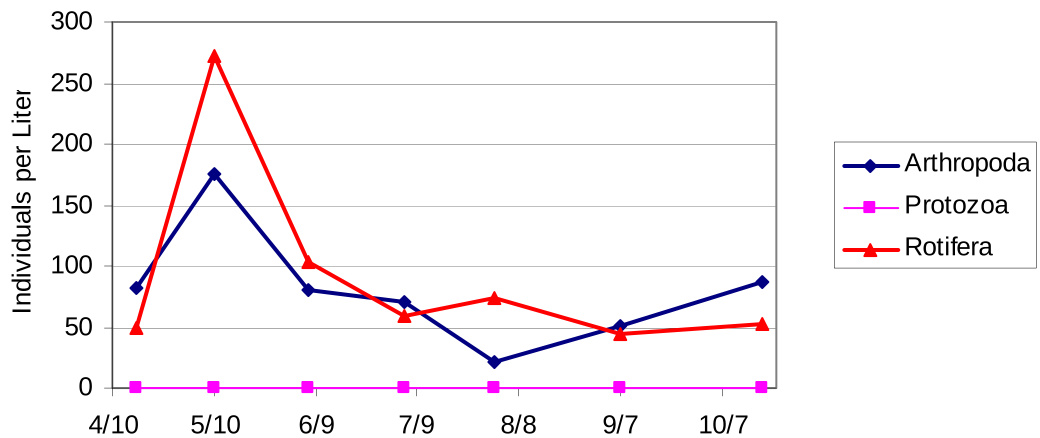


Figure 5K. 2006 Cedar Lake zooplankton distribution.

Fish Stocking

Additional information and a definition of fry, fingerling, yearling, and adult fish sizes can be found in Section 1.

Cedar Lake was stocked by MDNR in:
1998 with 299 fingerling Muskellunge
2001 with 200 fingerling Tiger Muskellunge
2004 with 200 fingerling Tiger Muskellunge
2005 with 1,168 fingerling Walleye