4 LAKE CALHOUN

HISTORY

Lake Calhoun is the largest lake in the Minneapolis Chain of Lakes (Figure 4A). It receives water from the upstream lake, Lake of the Isles, and discharges water to Lake Harriet. The lake has a multitude of recreational opportunities including canoe rentals, sail boat buoy rentals, three public beaches, fishing and picnicking. In fact, the Minneapolis Chain of Lakes Regional Park is the most visited park in the State of Minnesota with over 5.7 million user visits a year (Met Council, 2006).

Figure 4A. View of downtown Minneapolis from Lake Calhoun.

Previously known as Lake of the Loons, the lake was renamed after John Caldwell Calhoun. While Calhoun was Secretary of War under President Monroe he established a military post at Fort Snelling. The lake and adjacent property were acquired by the Minneapolis Park and Recreation Board (MPRB) between 1883 and 1907, at a cost of $130,000. Similar to other lakes in the Minneapolis Chain of Lakes, Lake Calhoun was dredged and surrounding wetland areas were filled (~35 acres) in the early part of the 20^{th} century. Nearly 1.5 million cubic yards of soil were placed on the shoreline between 1911 and 1924.

A substantial push was made to connect Lake of the Isles and Lake Calhoun after a number of wet years in the early 1900s increased interest in water related activities. A water connection between Isles and Calhoun was created in 1911 after the MRPB was bombarded with requests and petitions to join the lakes. A connection between Lake Calhoun and Lake Harriet was pondered but was never implemented due to a five foot elevation difference between the lakes. However, in 1967, a pipeline and pumping station were constructed between Lakes Calhoun and Harriet to help regulate water elevations in the Chain of Lakes. During 1999 to 2001, the outlet was converted to a gravity-flow partially overland connection to Lake Harriet.

Studies have shown that water quality in Lake Calhoun has degraded with human activity. Shapiro and Pfannkuch (1973) found that phosphorus levels in the sediment were about 80% lower than they have been in the past 80 to 90 years. Total phosphorus in the water column also increased to 50-60 µg/L by the 1970s from pre-impact levels of between 16 – 19 µg/L (Brugam and Speziale, 1983). The increases in sediment and water column phosphorus appear to be due to settlement and land clearing for agriculture in the watershed. The construction and connection of storm sewers to Lake Calhoun (1910 to 1940) is also thought to have had a negative impact on water quality. It is difficult to compare phytoplankton studies due to inconsistencies with equipment and sampling techniques. However, in a study by Klak (1933), cyanobacteria were dominant by the early 1930s in Lake Calhoun indicating nutrient enrichment.

Recent restoration techniques, or best management practices (BMPs), have improved water quality in Lake Calhoun in recent years. A detailed Clean Water Partnership diagnostic study conducted in 1991 determined that phosphorus input to the Chain of Lakes should be reduced to increase water quality. BMPs were then implemented for Calhoun and included: public education, increased street sweeping, improved storm-water treatment (i.e. constructed wetlands (1999) and grit chambers (1995, 1998, 1999)) and an aluminum sulfate (alum) treatment to limit internal loading of phosphorus in 2001. Current data analysis confirms that the BMPs are having a positive effect and that water quality in Lake Calhoun is at, or even slightly better than historical, pre-impact conditions (Heiskary et al., 2004).

Lake Calhoun is a deep, dimictic, glacial kettle lake that generally remains stratified until late October. Table 4A contains the morphometric data for Lake Calhoun. Figure 4B shows a bathymetric map of Lake Calhoun.

Table 4A. Lake Calhoun morphometric data. * Littoral area was 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)
421	10.6	27.4	31%	1.80×10^7	2,992	7.1	4.2

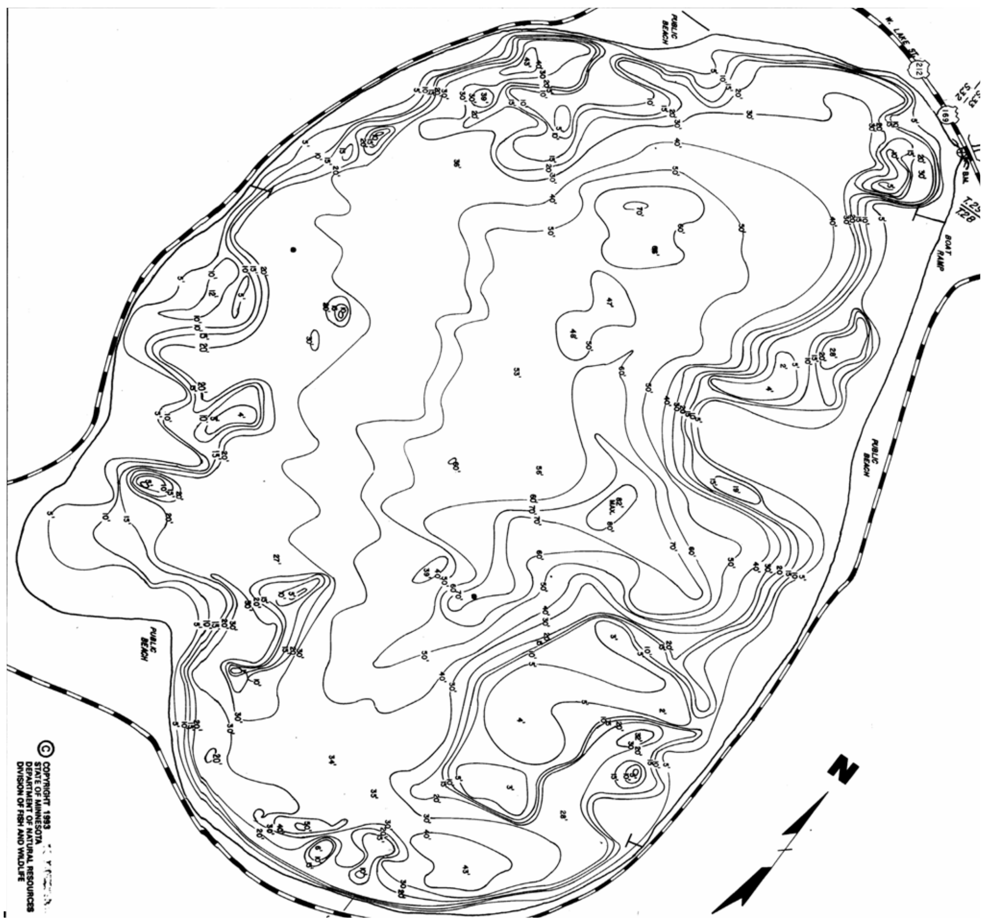


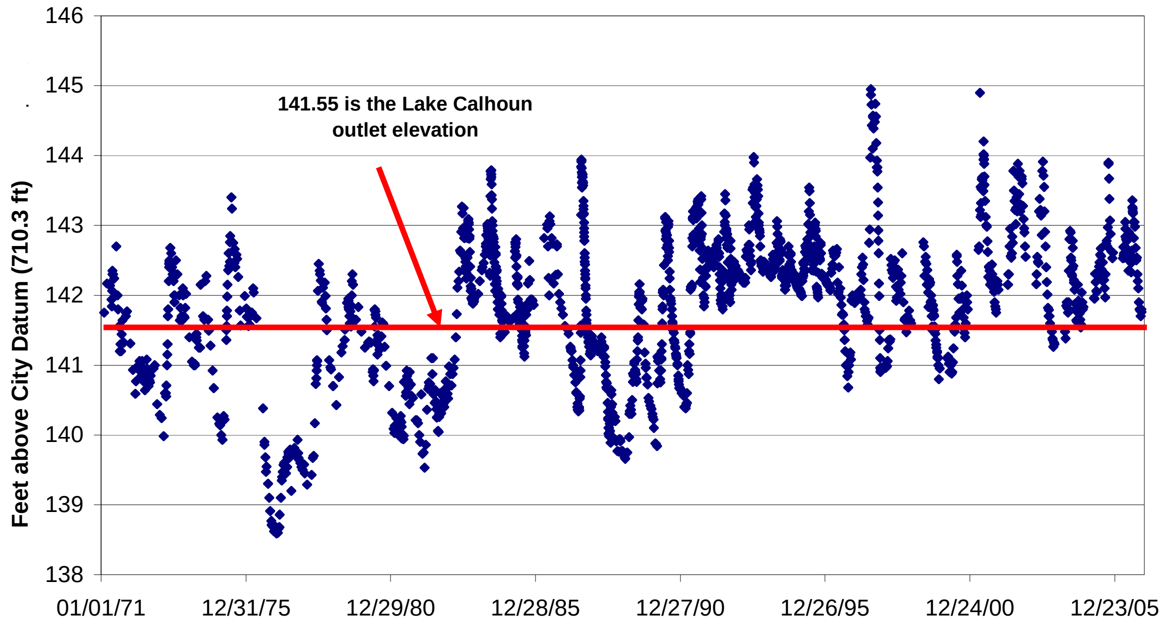
Figure 4B. Bathymetric map of Lake Calhoun. Map courtesy of the Minnesota DNR.

Lake Level

The lake level for the Upper Chain of Lakes (Brownie, Calhoun, Cedar and Isles) is taken at Lake Calhoun. Since channels connect the lakes, this gives the level for the four lakes.
The historical lake levels for the Upper Chain of Lakes are shown in Figure 4C for the entire period of record. Mean sea level elevation can be calculated by adding the city datum (710.3 feet) to the elevations shown in Figure 4C.

See Section 18 for a comparison between other MPRB lake levels.

Figure 4C. Historical lake levels for the Minneapolis Upper Chain of Lakes (Brownie, Cedar, Isles and Calhoun).



WATER QUALITY TRENDS (TSI)

The TSI data and linear regression show Lake Calhoun water quality to be improving as the TSI score falls. A detailed explanation of TSI can be found in Section 1. Figure 4D shows Lake Calhoun TSI scores and trend line. Lake Calhoun has a strong water quality improvement trend due to rehabilitation efforts.

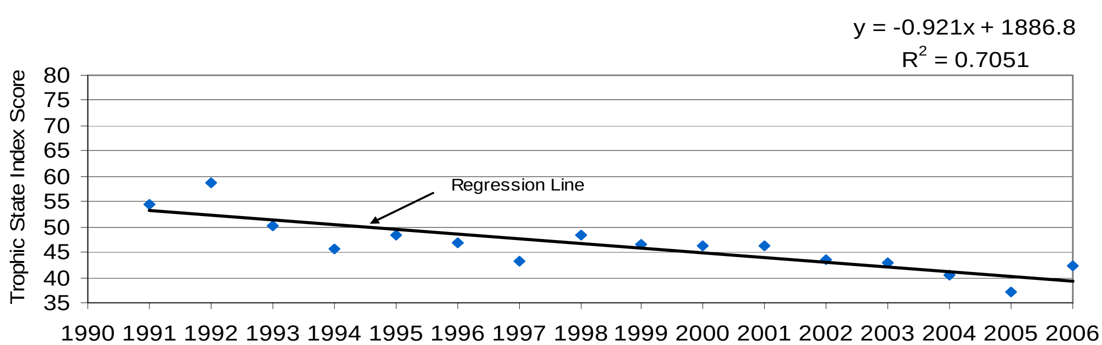


Figure 4D. Lake Calhoun TSI scores and regression analysis.

Lake Calhoun is mesotrophic, with moderately clear water and some algae. In comparison to other lakes in this ecoregion, Calhoun is in the top 5% of TSI scores (based on calculations from the Minnesota Pollution Control Agency using the Minnesota Lake Water Quality Data Base Summary, 2004). Lake Calhoun's observed TP is similar to the TP level from 1750 and 1800, using diatom reconstruction of sediment cores (Heiskary et al., 2004).

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. A detailed explanation of box and whisker plots can be found in Section 1. Figure 4E shows the box and whisker plots of Lake Calhoun TSI data. The influence of the 2001 alum treatment can be clearly seen in the box plots. In most post-treatment years, the shallowest secchi depths are deeper, indicating clearer water during more of the growing season. Chlorophyll-*a* measurements since the treatment are lower, have less scatter, and contain fewer extreme outliers. Phosphorus levels in the past five years have also been consistently lower than in the past.

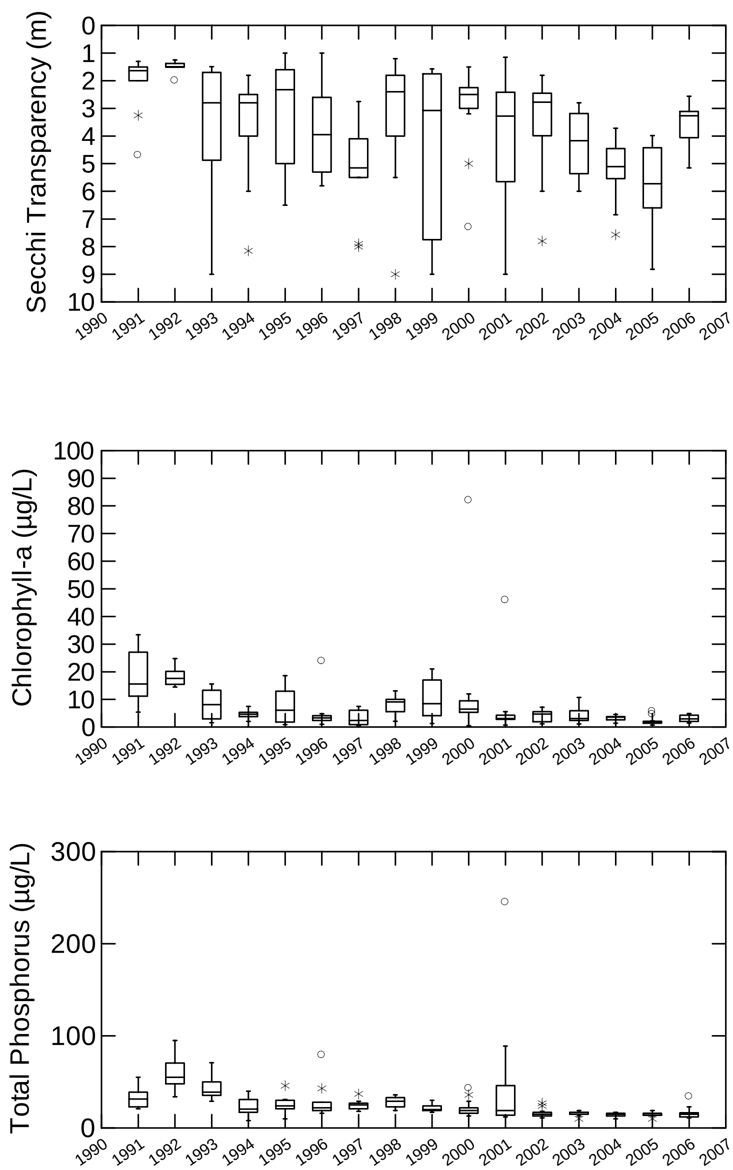


Figure 4E. Lake Calhoun box and whisker plots of TSI data.

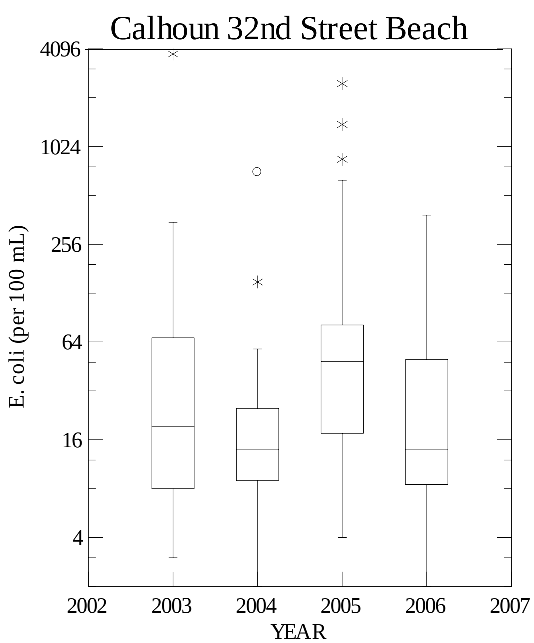
BEACH MONITORING

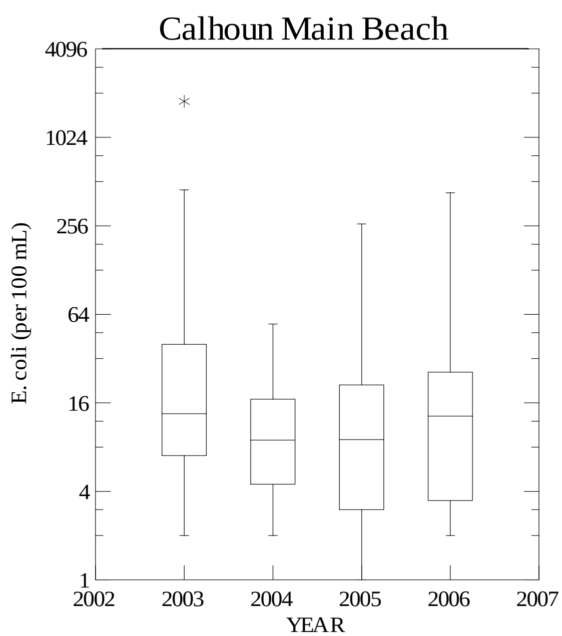
Bacteria levels were monitored at three different locations (Calhoun 32nd Street Beach on the east side, Calhoun Main Beach on the north side, and Calhoun Thomas Beach on the south side) at Lake Calhoun in 2006. As can be seen from Table 4B, the season long geometric means for *E. coli* at all three beaches were low. The geometric mean of Calhoun 32nd Street Beach was the highest of the MPRB public beaches, but was only 19. The median values for *E. coli* were also low for all three beaches. All three Lake Calhoun beaches were open for the entire season. See Section 19 for more information on beach monitoring.

Table 4B. Summary of *E. coli* (per 100 mL) results for Lake Calhoun beaches in 2006.

Statistical Calculation	Calhoun 32nd	Calhoun Main	Calhoun Thomas
Minimum Value	2	2	2
Maximum Value	450	650	200
Median Value	12	10	12
Geometric Mean	19	11	11
Standard Deviation	108	133	56
Number of Samples Taken	41	41	41

Figure 4F illustrates the box and whisker plots of *E. coli* sampling results (per 100 mL of lake water) of Lake Calhoun beaches from 2003 to 2006. The box and whisker plots show in more detail the scatter, within the years, of the data set. Calhoun 32nd Street Beach shows the most variability among the years and Thomas Beach shows the least.





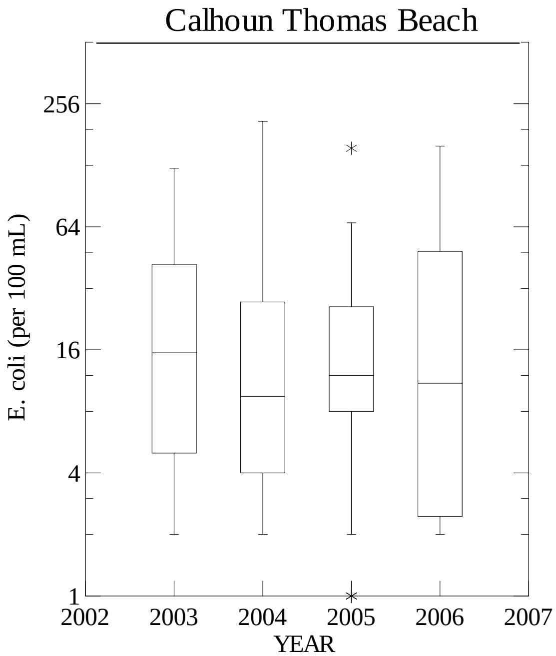


Figure 4F. Box and whisker plots of *E. coli* results (per 100 mL) for Lake Calhoun beaches, 2003 – 2006. Note log scale on Y-axis.

Table 4C illustrates the correlations that existed between *E. coli* and select variables at Lake Calhoun beaches. At Calhoun 32nd Street Beach, very strong positive correlations existed with rainfall amount from the previous 24 hours, and intensity and duration of the rainfall, and strong positive correlations existed with the lake elevation and wind direction. Strong negative correlations existed with dissolved oxygen, percent dissolved oxygen, pH and specific conductivity. At Calhoun Main Beach very strong positive correlations existed with rainfall, rainfall duration and intensity and lake elevation. Strong negative correlations existed with dissolved oxygen, percent dissolved oxygen, pH and specific conductivity. A slight negative correlation also occurred with the air temperature. Calhoun Thomas Beach had positive correlations with air temperature, animals, wind speed and direction, and percent dissolved oxygen. Negative correlations were found with lake elevation, rainfall amount, rainfall duration and intensity.

Table 4C. Selected correlations (r) between *E. coli* results (per 100 mL) and select variables at each beach on Lake Calhoun in 2006.

Variables	Calhoun 32nd	Calhoun Main	Calhoun Thomas
Air Temperature	-0.085	-0.324	0.359
Animals	-0.091	-0.079	0.569
Dissolved Oxygen	-0.510	-0.511	0.256
Lake Elevation	0.515	0.603	-0.468
Percent Dissolved Oxygen	-0.523	-0.481	0.384
pH	-0.545	-0.527	0.165
Rainfall	0.883	0.718	-0.173
Rainfall Duration	0.920	0.764	-0.339
Rainfall Intensity	0.918	0.958	-0.307
Specific Conductivity	-0.654	-0.580	0.109
Wind Direction	0.444	-0.128	0.346
Wind Speed	0.035	0.183	0.364

LAKE AESTHETIC AND USER RECREATION INDEX (LAURI)

Figure 4G shows the LAURI for Lake Calhoun. Lake Calhoun was rated excellent in aesthetics, water clarity and bacteria levels during the growing season in 2006. It received a good rating for recreational interferences due to invasive Eurasian water milfoil *(Myriophyllum spicatum)* in the littoral areas of the lake. Details on LAURI can be found in Section 1, a comparison with other lakes can be found in Section 18.

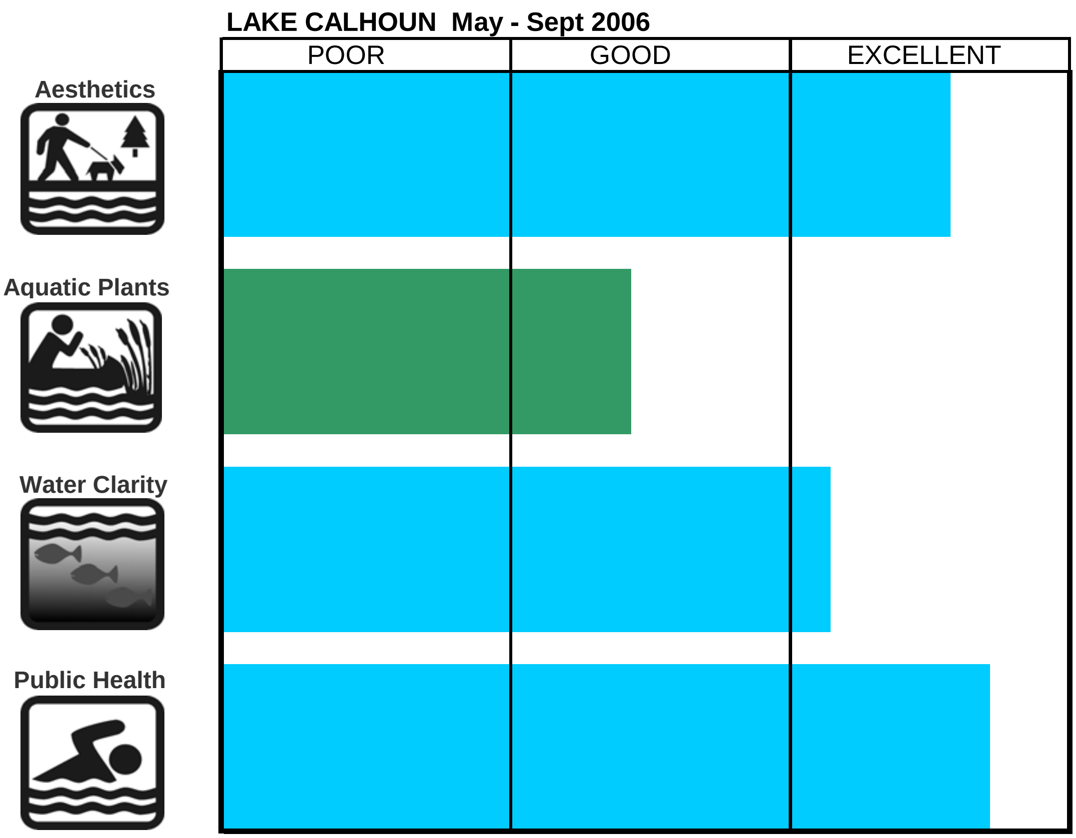


Figure 4G. The 2006 LAURI for Lake Calhoun.

WINTER ICE COVER

Ice came off Lake Calhoun on April 7, 2006, a few days earlier than average. Ice was on the lake on January 16, 2007. This is 16 days later than the latest date of ice-off ever recorded (see Figure 4I below).

For ice out dates, Lake Calhoun has 55 years of records. While there is a lot of scatter in the data, the general trend over the last 60 years is towards sooner ice off (Figure 4H). This could be an indication of climate change and point to a warming trend. This may have implications for lakes in this region such as an extended growing season and warmer water temperatures, which may allow for more vigorous plant and algal growth. Climate change may also cause a shift in plant and animal species. New invasive species may find a warmer climate more tolerable.

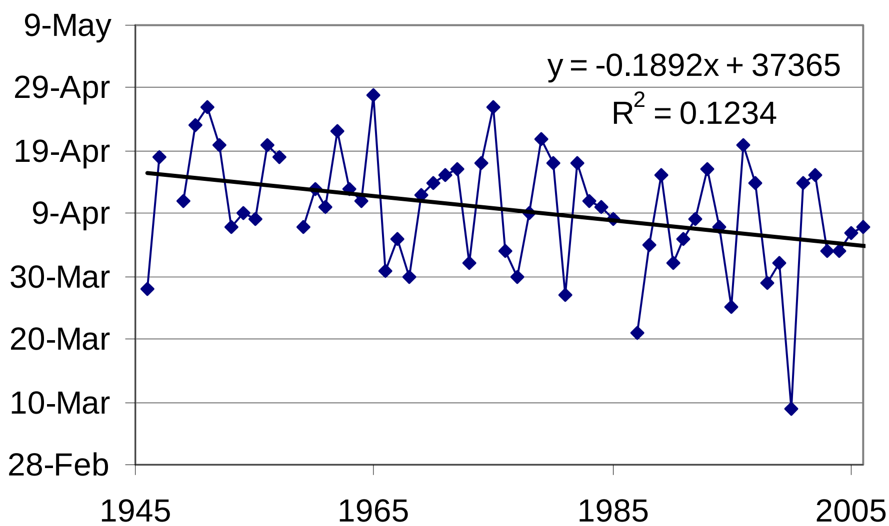


Figure 4H. Lake Calhoun ice off dates for all the years of record.

The same trend is not visible for ice on at Lake Calhoun (Figure 4I) over the last 40 years. Only 37 years of record exist. While there is still scatter in the data, there appears to be either no trend or an extremely weak trend. See Section 1 for details on winter ice cover records and Section 18 for a comparison with other lakes.

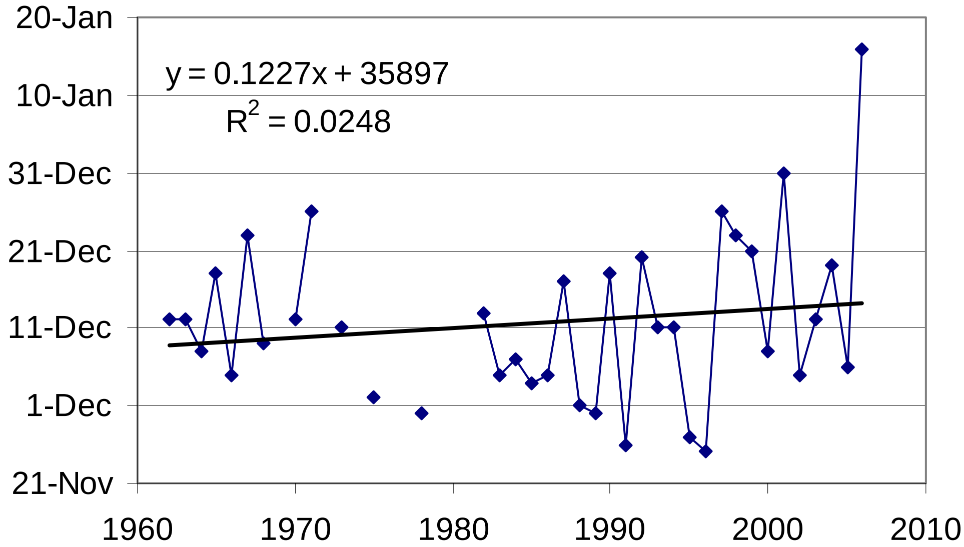


Figure 4I. Lake Calhoun ice on dates for all the years of record.

EXOTIC AQUATIC PLANT MANAGEMENT

The Minnesota Department of Natural Resources (DNR) 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 in areas where recreational access is needed. The permitted area on Lake Calhoun was 50 acres, which is 12% of the total lake area. For more information on aquatic plants see Section 1.

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 4J and 4K show the relative abundance of the various divisions of phytoplankton and chlorophyll-*a* concentrations over the 2006 sampling period. Blue-green algae (cyanophyta) dominated throughout the year except for the spring “clear water phase”, where diatoms (bacillariophyta), golden algae (chrysophyta), and dinoflagellates (pyrrhophyta) were more abundant. Peaks in chl-*a* occurred in April and August, both times when blue-green algae were dominant.

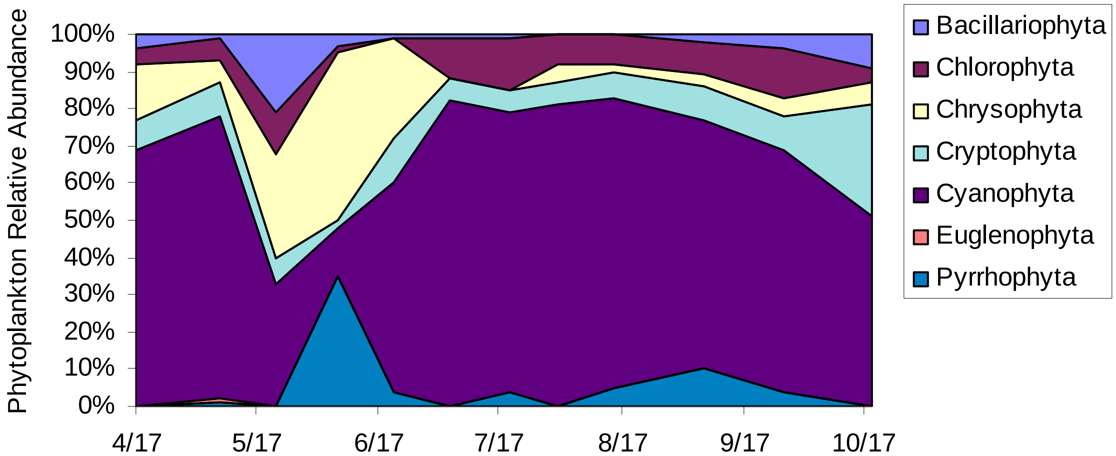


Figure 4J. Lake Calhoun 2006 phytoplankton relative abundance.

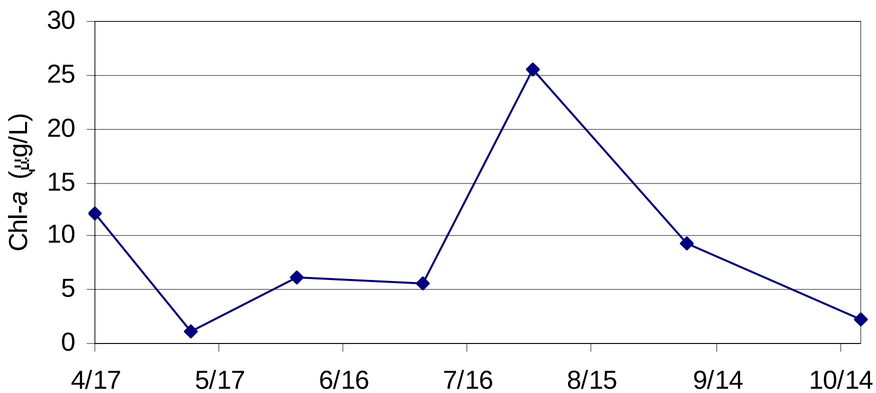


Figure 4K. Lake Calhoun 2006 chlorophyll-*a* concentrations.

Figure 4L shows the zooplankton distribution throughout 2006. Zooplankton abundance was highest in spring, during the clear-water phase, when both arthropods and rotifers were abundant. In Lake Calhoun, protozoa were only abundant in the June and July samples. Arthropods peaked a second time in fall.

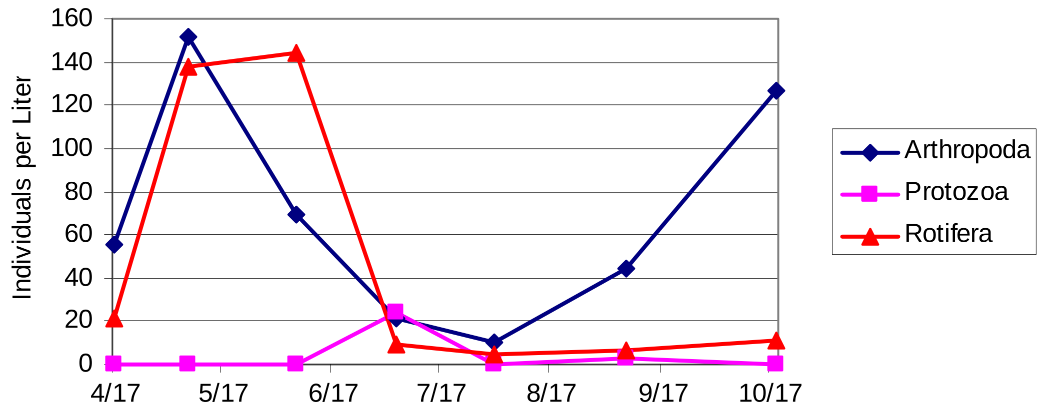


Figure 4L. Lake Calhoun 2006 zooplankton distribution.

Fish Stocking

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

Lake Calhoun was stocked by the DNR in:
1999 with 71 adult Muskellunge, 125 fingerling Muskellunge
2000 with 107 adult Muskellunge, 1,590 yearling Walleye
2001 with 12,654 fingerling Walleye
2002 with 500 fingerling Tiger Muskellunge
2003 with 5,545 fingerling Walleye
2005 with 500 fingerling Tiger Muskellunge
2006 with 2,356 fingerling Walleye