3 BROWNIE LAKE

HISTORY

Human activities during the past two centuries have drastically impacted the morphometry of Brownie Lake (previously known as Hillside Harbor). Figure 3A shows the bathymetric map and Table 3A shows the morphometric data for Brownie Lake. Construction of a railroad embankment in 1867 caused a decrease in lake surface area of 34% (Wirth, 1945). During the construction of the inter-lake canal between Cedar and Brownie (completed in 1917), the water level of Brownie Lake dropped approximately 3 m (~10 ft) causing a further decrease in surface area of 56% (Swain, 1984). Swain theorized that these activities caused the lake to become meromictic. The water column in a meromictic lake stays stratified due to density differences caused by minerals dissolved in the water. The sharp density difference in meromictic lakes is called a chemocline. Meromictic lakes do not mix due to the stability of the chemocline

According to detailed analysis of a 117 cm core, Swain (1984) found shifts in the iron/manganese (Fe/Mn) and iron/phosphorus (Fe/P) ratios consistent with constant anoxia at 40 cm sediment depth (corresponding to ca. 1925 determined from lead^{210} and cesium^{137} dating). Sediment records indicated the presence of ragweed pollen at sediment core depths that correspond to 1850-1860, which indicate European-American settlement (Swain, 1984). Watershed changes led to increases in primary productivity, algal biomass and sediment accumulation indicating eutrophication as agriculture based land uses decreased. As water clarity decreased, Benthic diatoms were eventually replaced by planktonic forms and the zooplankton community shifted from large bodied *Daphnia* to the smaller *Bosmina* species (Swain, 1984).

At various times in its history, Brownie Lake has seen manipulations in its water level and source. Groundwater was first used to augment lake levels in the Chain of Lakes (Brownie, Cedar, Isles and Calhoun) in 1933 and continued through 1938. During the 1950s, the Prudential Insurance Building began discharged 1.9 x 10^5 liters of cooling water per day into Brownie Lake and a link was created between Brownie and Bassett's Creek that provided water to the Chain of Lakes during times of low water levels. In 1966, a pumping station was constructed at the Mississippi River, to augment flow in Bassett's Creek, and it was used to regulate water levels in the Chain of Lakes by pumping water from the Mississippi River into Brownie Lake. 1990 was the last year that the pump was used. Stormwater inputs from Highway 394 (old Hwy 12) have added pollutants (e.g. chloride) to Brownie Lake, contributing to the stability of the chemocline.

Figure 3A. Bathymetric map of Brownie Lake. Map courtesy of the MDNR.

Table 3A. Brownie 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)
18	6.8	15.2	67%	$4.98x10^5$	369	20.5	2.0

Lake Level

See Lake Calhoun, Section 4.

Water Quality Trends (TSI)

The Brownie Lake linear regression appears to be stable. A detailed explanation of TSI can be found in Section 1. Figure 3B shows Brownie Lake TSI scores and trend line.

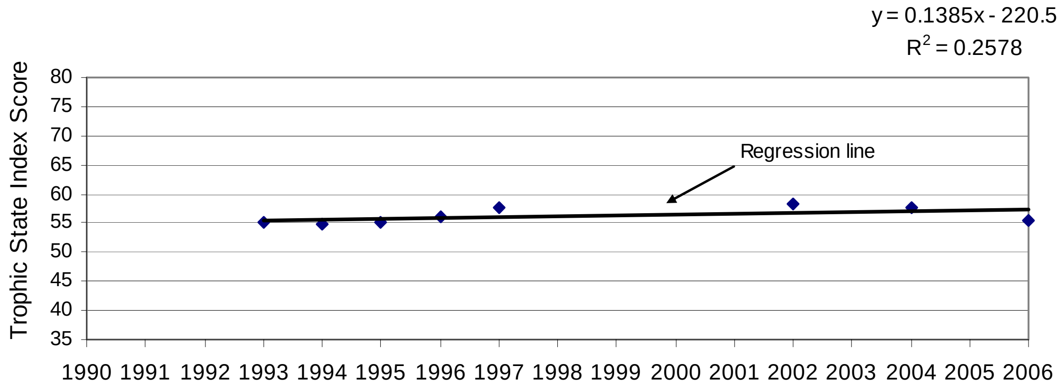
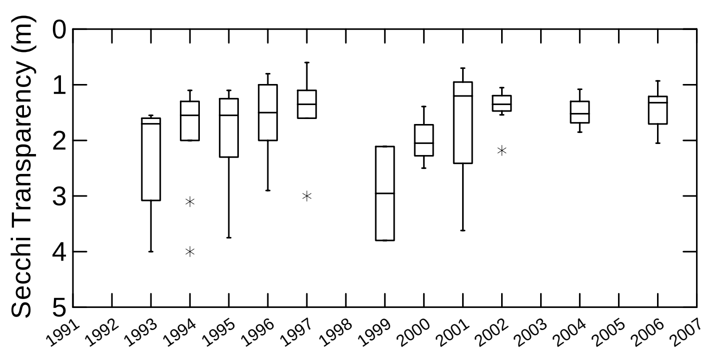


Figure 3B. Brownie Lake TSI scores and regression analysis.

Brownie Lake's 2006 TSI score is 56. It falls near the 50th percentile category for lakes in this ecoregion, based on calculations from the Minnesota Lake Water Quality Assessment Data Base Summary (MPCA, 2004).

Box and Whisker Plots

The box and whisker plots show, in more detail, the scatter within the years' data set for the Secchi, chlorophyll-*a* and total phosphorus. Long-term lake monitoring is necessary to evaluate the seasonal and year-to-year variations seen in each lake and predict trends. A further detailed explanation of box and whisker plots can be found in Section 1. Figure 3C shows the box and whisker plots of Brownie Lake TSI data. Figure 3C should be viewed in context as Brownie Lake is monitored one a month, whereas, most of the other lakes monitored by the MPRB are monitored twice a month (May – September). Brownie Lake is unusual because it is meromictic (permanently stratified). The only other meromictic lake in Minneapolis is Spring Lake. Brownie Lake should ideally be compared to other meromictic lakes in the region of similar size and watershed characteristics.



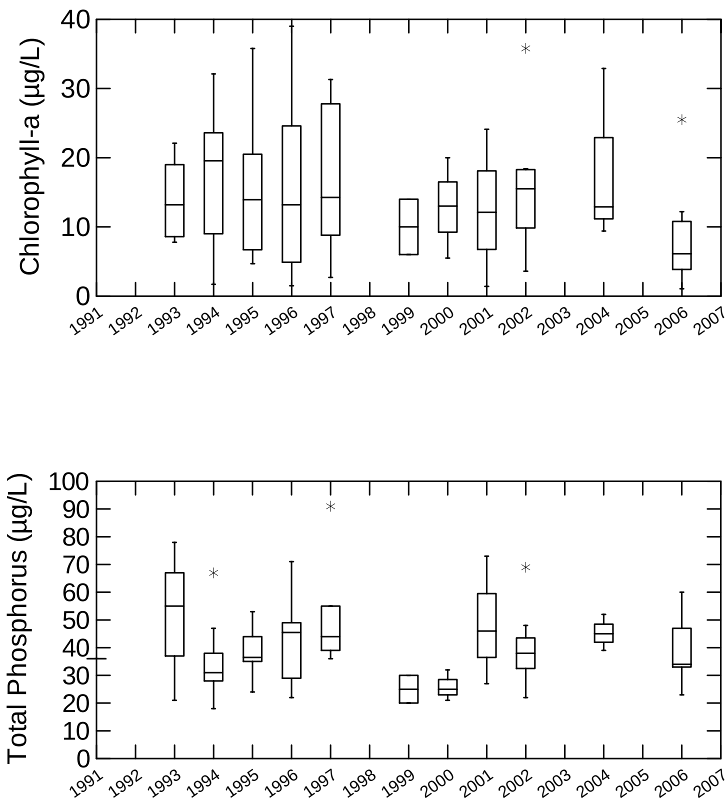


Figure 3C. Brownie Lake Box and Whisker plots of TSI data.

LAKE AESTHETIC AND USER RECREATION INDEX (LAURI)

Figure 3E shows the LAURI for Brownie Lake. Brownie Lake was rated excellent in aesthetics, and aquatic plants during the growing season in 2006. It received a poor rating for water clarity due to shallow secchi depths caused by algae growth. Details on LAURI can be found in Section 1, a comparison with other lakes can be found in Section 18.

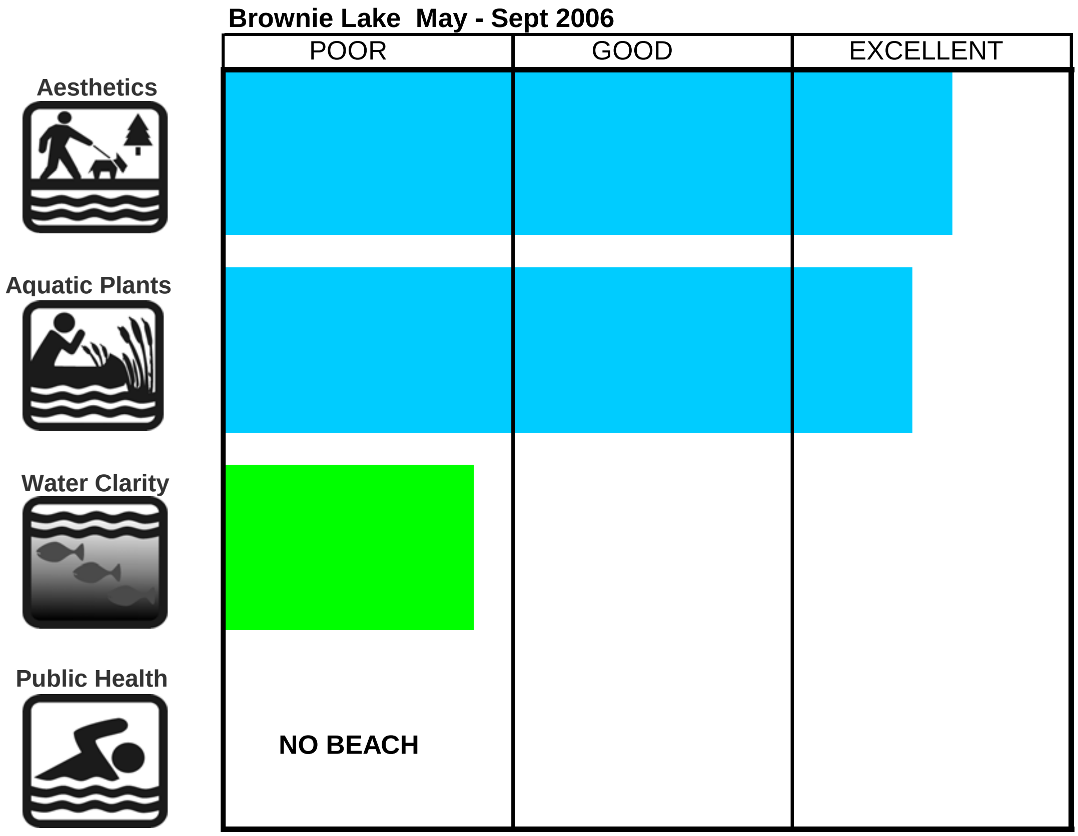


Figure 3E. The 2006 LAURI for Brownie Lake.

WINTER ICE COVER

Ice came off Brownie Lake on April 6, 2006, a few days later than average. Ice came on the lake November 30, 2006, which is also a few days later than average. See Section 1 for details on winter ice cover records and Section 18 for a comparison with other MPRB lakes.

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 3D and 3E show the relative abundance of phytoplankton species and chl-*a* concentrations throughout the 2006 sampling season. During the 2006 sampling season in Brownie Lake, diatoms (bacillariophyta) and cryptomonads (chryptophyta) dominated in early spring. Dominant species shifted to green algae (chlorophyta) in early summer and then to blue-green algae (cyanophyta).

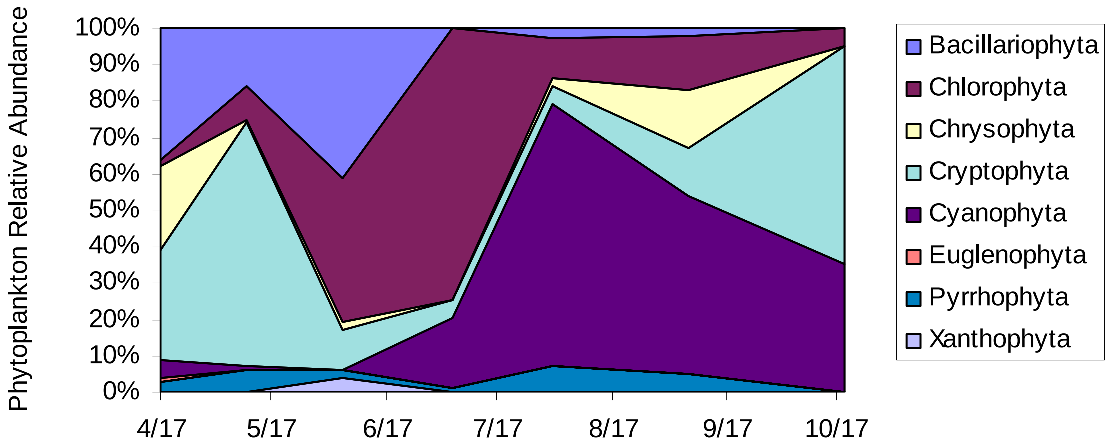


Figure 3D. Relative abundance of phytoplankton during the 2006 Brownie Lake sampling season. Diatoms (bacillariophyta) and cryptomonads (cryptophyta) dominate in early spring. Dominant species shift to green algae (chlorophyta) in summer and to blue-green algae (cyanophyta) during late summer and fall.

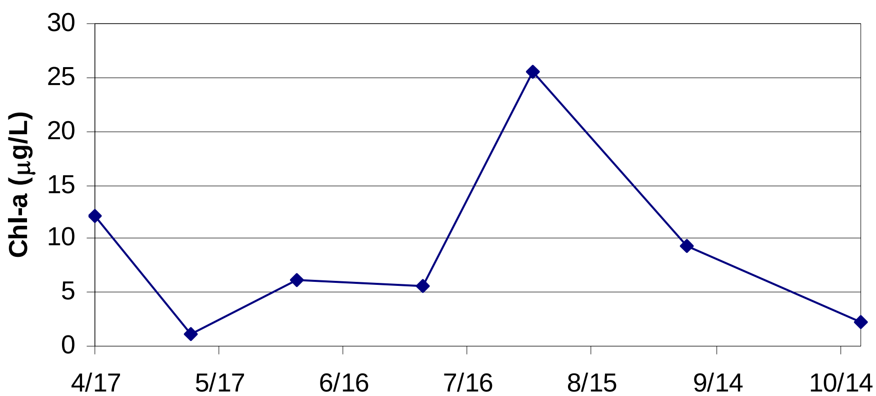


Figure 3E. Chlorophyll-*a* concentration during the 2006 Brownie Lake sampling season. High concentrations of chl-*a* correspond to the largest algae blooms. This season the highest concentration of chl-*a* was during a bloom of cyanobacteria (blue-green algae).

It appears that blue-green algae (cyanobacteria) were not prevalent, historically, in Brownie Lake. Swain (1984) determined that iron limits cyanobacteria growth in Brownie Lake. Cyanobacteria require high amounts of iron in order to grow. In addition, limited diffusion of iron from the sediment to the surface water, occurs due to the strong salinity gradient, which prevents complete mixing. Recent MPRB phytoplankton data indicate that the cyanobacteria may have become more abundant than in the past. The highest chl-*a* readings in 2006 correlate to the late summer cyanobacteria bloom; however, chl-*a* is not a direct measure of algal biomass, macrophyte die-off may also contribute to the chl-*a* content of the lake.