GENEVA LAKE'S WATER QUALITY

INTRODUCTION

In 1997, a collaborative effort between the Geneva Lake Environmental Agency (GLEA), the United States Geological Survey (USGS), the Wisconsin Department of Natural Resources (WDNR) and Southeastern Wisconsin Regional Planning Commission (SEWRPC) was initiated to conduct an extensive three-year study on Geneva Lake. The goal of the project was to better understand Geneva Lake in order to make sound decisions in its management. One product of this effort will be a new and updated lake management plan.

HYDROLOGIC CHARACTERISTICS

Geneva Lake is a deep, large lake with a relatively small *watershed* (Table 1). With its small *watershed-to-lake ratio* of 2.5:1, atmospheric deposition plays a large role in the lake's water sources (48%).

Table 1. Basic Lake Information, Geneva Lake, Walworth County, WI.

LAKE VOLUME	1.151 x 107 AC/FT
LAKE SIZE	5231.2 AC
WATERSHED SIZE	13,121.2 AC
WATERSHED TO LAKE RATIO	2.5 : 1
SHORELINE LENGTH	20.2 MI
MAXIMUM LENGTH	7.5 MI
MINIMUM WIDTH	0.5 MI
MAXIMUM WIDTH	2.0 MI
MAXIMUM DEPTH	145.2 FT
MEAN DEPTH	61.0 FT

Source: GLEA and USGS.

Groundwater contributes about 5 - 8% of the inflow to the lake. Stream flow represents the majority of the surface water inflow (44 - 47%). Surface water is significant because of its potential for nutrient loading into the lake.

Annually about 60% of the water loss is through the White River with the remaining 40% loss through evaporation. The lake has a 15-year *residency time.*

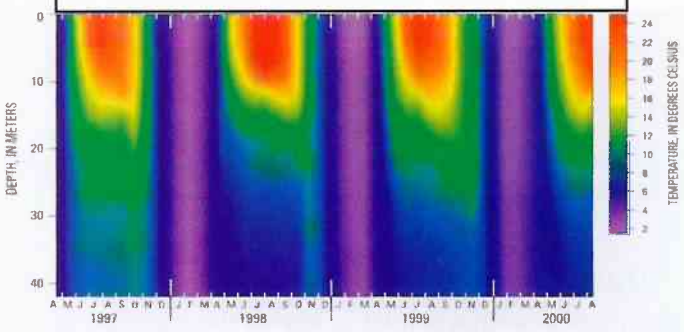
TEMPERATURE

Geneva Lake is a *dimitic* lake. Seasonal changes in temperature and wind cause the lake to mix and stratify twice a year.

During the spring and late autumn mixings the water temperatures and dissolved oxygen levels are relatively uniform from the lake's surface to the bottom. During the summer and winter stratifications the lake becomes layered into two distinctly different zones separated by a third zone of rapid temperature change.

Heated by the warm summer air, the lake's summer stratification begins to form in mid-May and strengthens throughout the summer (Figure 1).

Figure 1. Water Temperature at Deepest Hole, Geneva Lake, Walworth Country, WI. USGS



During summer stratification the lake is separated into three layers. The upper layer, the *epilimnion,* is generally 10 - 15 meters thick and continually mixed by wave and wind action. The middle layer, the *thermocline,* is an area of very rapid temperature decrease and is generally only a few meters thick. The bottom layer, the *hypolimnion,* is cool and stagnant and runs from the bottom of the thermocline to the lake's bottom.

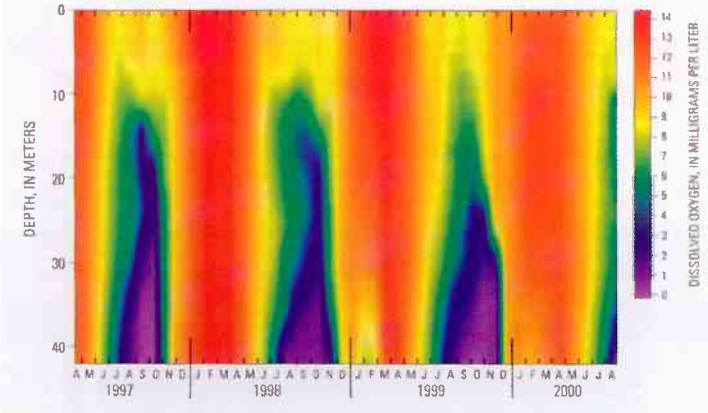
*Italicized, blue colored words are defined in the glossary on the last page of this Summary Information Sheet

During the summer months Geneva Lake's surface temperature averages around 23°C (74°F). The temperature within the *hypolimnion* can get as low as 7°C (44°F). The cooler fall weather breaks down the stratification allowing complete mixing to occur in late November. With the covering of ice in winter the lake stratifies with the bottom water being the warmest at 4°C (39°F). Spring ice out brings complete mixing.

DISSOLVED OXYGEN

An important consequence of the mixing and stratification sequences in Geneva Lake is its impact on aquatic life. Stratification is so strong that it results in different isolated layers with different amounts of nutrients and dissolved gases in each of the three layers (Figure 2).

Figure 2. Dissolved Oxygen Distribution at Deepest Hole, Geneva Lake, Walworth County, WI. USGS



Dissolved oxygen is vital to all living animals. Its distribution within a lake is key to the location of fish and other organisms. The colder the water the more dissolved oxygen it can hold.

During mixing, dissolved oxygen levels are near saturation throughout the lake. After lake stratification in May, dissolved oxygen in the *epilimnion* is still near saturation but the warming of the water results in less oxygen being dissolved. Wind and wave action, plus plant *photosynthesis* within the *epilimnion* assures that oxygen is usually present in a sufficient amount to support animal life (5.0 mg/l or greater).

The *hypolimnion* starts the summer with good oxygen levels. As oxygen is used by decomposition and respiration in the deeper waters, combined with the lack of mixing and re-supply, oxygen levels in this area decrease throughout the summer stratification

In late summer dissolved oxygen concentration in the deeper parts of the lake can get so low that many fish and other aquatic animals can not survive in this area of the lake (less than 2.0 mg/l). The stratification breakdown during the fall mixing allows for a re-supply of oxygen to these deep-water areas.

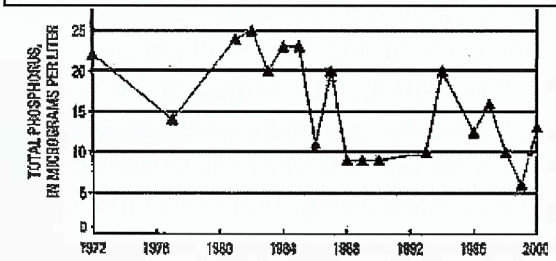
LAKE NUTRIENTS

An important concept in understanding the physical and chemical aspects of lakes is the role nutrients play within the lake. A lake's ability to support a variety of recreational activities and a healthy and balanced aquatic ecosystem is associated with the nutrient status of the lake. The nutrients of concern due to their importance in plant growth are *phosphorous* and *nitrogen.*

These nutrients can be found in several different forms but for general lake assessment total *phosphorus* and total *nitrogen* are useful. Concentrations of *phosphorus* and *nitrogen* can vary with depth and from season to season. It is best to look at the concentration of these nutrients in the spring when the lake is mixing and concentrations are uniform from top to bottom.

The mean total *phosphorus* concentration found in Geneva Lake during the three-year study was 0.086 mg/l (milligrams per liter or parts per million) (Figure 3). The mean total *nitrogen* concentration during the same study period was 5.51 mg/l. These values are relatively low for lakes in southeastern Wisconsin.

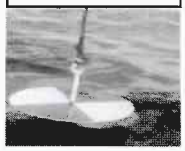
Figure 3. Surface Spring Total Phosphorus Concentrations, Geneva Lake, WI. USGS



Studies on Geneva Lake have shown that *phosphorus* is the more important of these two major nutrients. Any increase in *phosphorous* in the lake will result in an increase in plant growth.

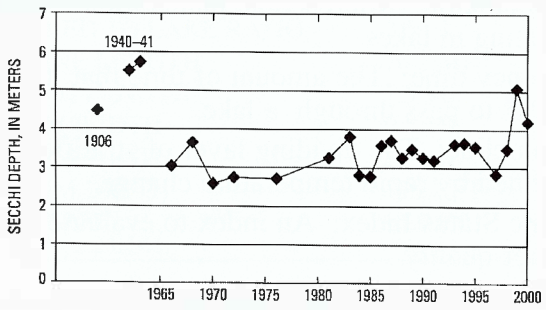
WATER CLARITY

Figure 4. A Secchi Disk



Geneva Lake's water clarity, as measured with a device known as a secchi disk (Figure 4), has been and still is relatively good. A secchi disk reading is the depth at which the secchi disk disappears as it is lowered into the water. The clearer the water the deeper the disk can be seen. Geneva Lake's mean secchi disk reading is 4.8 m (Figure 5).

Figure 5. Average Summer Secchi Depth, Geneva Lake, WI. USGS

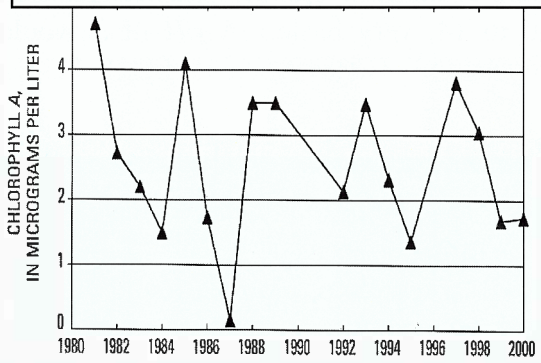


Geneva Lake's water clarity is variable on both a daily and seasonal basis. Many factors can influence it including weather, water color and the viewer. Geneva Lake has a history of good water clarity with an apparent improvement over the last couple of years.

CHLOROPHYLL "A"

Chlorophyll "a" is a color pigment found in plants. *Chlorophyll "a"* measurements are commonly used to indicate the density of free-floating plants *(phytoplankton)* in a lake. *Chlorophyll "a"* measurements in Geneva Lake are extremely variable seasonally and annually. No long-term trend has yet been identified (Figure 6). Over time the presence of zebra mussels will no doubt impact *Chlorophyll "a"* concentrations. The mean summer concentration during the study period was 2.6 ug/l (micrograms/litre or parts per billion).

Figure 6. Chlorophyll "a" Trends on Geneva Lake WI. USGS



TROPHIC STATUS INDEX

The *Trophic Status Index* (TSI) is a means of evaluating a lake based upon three criteria, *phosphorus* concentrations, free floating algae as measured by *Chlorophyll "a"* and the water clarity as measured by secchi disk readings. Developed specifically for lakes within the state of Wisconsin, TSI relies on the premise that the more *phosphorus* in a lake the more algae (higher *Chlorophyll "a"*), and the more algae, the less clear the water will be as measured by a secchi disk.

Values are assigned to the readings. The higher the values, the lower the water quality. Total TSI values are used to determine whether a lake is eutrophic (many nutrients), mesotrophic (middle or average nutrients) or oligotrophic (few nutrients).

Geneva Lake has generally fluctuated between being mesotrophic and oligotrophic. Although phosphorous levels have generally been constant over the last five years and indicated the lake as being mesotrophic, the secchi depth and *Chlorophyll "a"* concentrations have improved to oligotrophic levels. The introduction and increase in the filter-feeding zebra mussel population in the lake may have some impact on why these values are changing.

pH AND ALKALINITY

The *pH* of the water is the measurement of how acid or basic the water is. This is important in a lake's biology and chemistry. The *pH* scale ranges from 0, very acid to 14, very basic. A *pH* of 7 would be considered neutral. Geneva Lake is slightly basic with values ranging from around 7.5 to 9.3. Depth and time of year can impact *pH* values.

A lake's *alkalinity* is important in moderating drastic changes in the lake's chemistry. A well-buffered lake will not be impacted by acid rain as much as a lake that is not buffered as well. Geneva Lake has a very high *alkalinity* or buffering capability (180 mg/L). Most of its buffering comes from the sedimentary rocks that underlie the lake and is the parent material of much of the glacial soils in the lake's watershed.

WATER QUALITY SUMMARY

Geneva Lake has good water quality (Table 2). Water quality throughout Geneva Lake is relatively uniform. Slight differences may exist in some of the bays and close to shore due to depth and proximity to pollution sources. The lake stratifies in late April and breaks down during November. The bottom water is *anoxic* from late July to November.

Table 2. Geneva Lake's Water Quality.

Mean Secchi – 4.8 m
Mean surface P – 9 ugm/L
Mean surface N – 550 ugm/ L
Mean chlorophyll "a" – 3 ugm/L
Phosphorus is limiting nutrient
Lake is Mesotrophic - Oligotrophic

Source: GLEA and USGS.

GLOSSARY

Alkalinity: The ability to buffer pH changes.
Anoxic: Without oxygen.
Chlorophyll "a": A color pigment found in plants.
Dimitic: A lake with two periods of mixing.
Epilimnion: The warmer upper layer of a stratified lake.
Hypolimnion: The cold stagnant deeper layer of a stratified lake.
Nitrogen: A major nutrient for plant growth.
pH: A value used to evaluate acidity.
Phosphorous: A major nutrient for plant growth.
Photosynthesis: The process of converting radiant energy into chemical compounds.
Phytoplankton: Microscopic plants found free floating in lakes.
Residency time: The amount of time that it takes for water to pass through a lake.
Thermocline: The dividing layer of stratified lakes defined by rapid temperature change.
Trophic Status Index: An index to evaluate lake water quality.
Watershed: A lake's drainage basin.
Watershed-to-lake ratio: A ratio of acres of land in a lake's drainage basin to the surface acres of water in the lake.

Photo Sources - GLEA & Robert Korth

This information sheet is the fourth in a series of information flyers about Geneva Lake and its management. Summary Sheets are educational publications that summarize larger more detailed reports on Geneva Lake. These summaries are prepared by the Geneva Lake Environmental Agency with the assistance of the original authors. SIS #4 is financially made possible by the generosity of the LAKE GENEVA GARDEN CLUB. Additional copies are available at the Geneva Lake Environmental Agency, 262-248-5253 or email at glea@genevaonline.com. Ask for SIS #4.