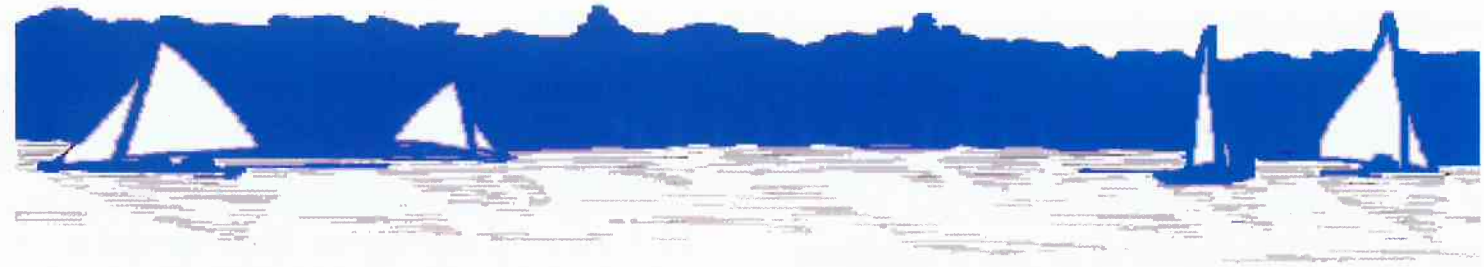

GENEVA LAKE'S BUDGET

INTRODUCTION

Just as we prepare budgets to better understand and manage our financial matters, lakes have similar budgets that help us to better manage them. Lake budgets give us a quantitative knowledge of water or pollutant contributions from various sources, the amount lost, where it goes and the amount that stays in the lake. For understanding Geneva Lake, the two most important budgets are its water budget and *phosphorus budget*. During 1997-1999 extensive studies were conducted on Geneva Lake that allowed for an updating of its budgets.

GENEVA LAKE'S HYDROLOGIC BUDGET

Geneva Lake's level is dependent upon three major factors; water input, water loss and storage capacity (Figure 1). Water input can be from *precipitation* (ppt), *surface water inflow* (SWin) and *groundwater inflow* (GWin). Water loss can be through *evaporation* (Evap), *surface water outflow* (SWout) and *groundwater outflow* (GWout). Storage capacity is the amount of water that stays in the lake basin. It is measured by recording the lake level.

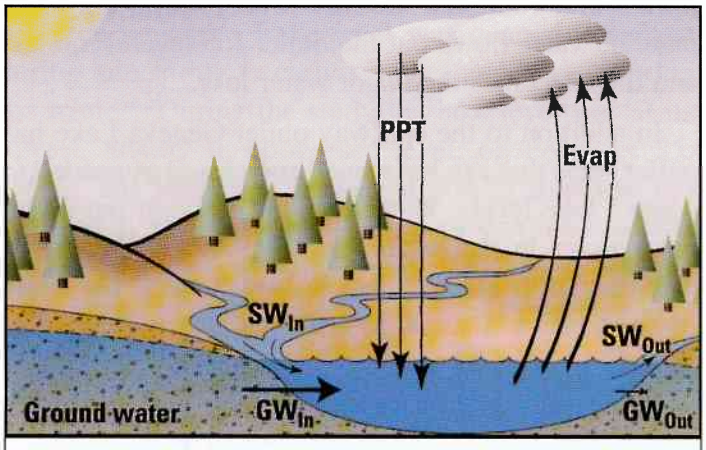

Figure 1. Schematic of a typical lake hydrologic budget

Geneva Lake's water input, water loss and storage all vary throughout the year. Surface water input may play a bigger role in the lake during the spring when *precipitation* and runoff are more likely to happen. *Evaporation* rates may be highest during the warm, windy, sunny summer months than during the winter when the lake has an ice cover. Lake stage as a result of these changes will also vary throughout the year and between years.

HYDROLOGIC BUDGET - GENEVA LAKE, WI
1998 - 1999

Budget Component	1998	1999	Total
INPUTS			
Precipitation	4729	6155	10910
Surface Water	4394	5970	10355
Base Flow	2056	1852	3910
Storm Runoff	2338	4121	6446
Groundwater	777	700	1474
Total Input	**9906**	**12839**	**22719**
OUTPUTS			
Evaporation	4280	4729	9008
Surface Water	5653	8136	13790
Groundwater[1]	0	0	0
Total Output	**9933**	**12865**	**22798**

All values in million of gallons
[1] No net loss to groundwater. Source: GLEA/USGS

Table 1. Hydrologic Budget for Geneva Lake WI

During the study period, Geneva Lake lost slightly more water than it gained (Table 1). This resulted in a minimal drop in lake level. *Precipitation* for 1998 was near normal, 33 inches. 1999 was a wet year receiving 43 inches resulting in *precipitation* and storm water runoff playing a larger role in the lake's water input. The lake level was above the spillway crest more often, which allowed more water to leave the lake over the spillway.

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

WATER INPUT

Precipitation (ppt.)

When discussing *precipitation's* role in a lake's hydrological budget, only the amount of water that falls directly on the surface of the lake is considered. During the study years Geneva Lake received an average annual rainfall of 38 inches. The average annual *precipitation* for the Geneva Lake area over the last 18 years is 33 inches. During the study period *precipitation* represented about 48% of the lake's annual hydrologic load (Figure 2).

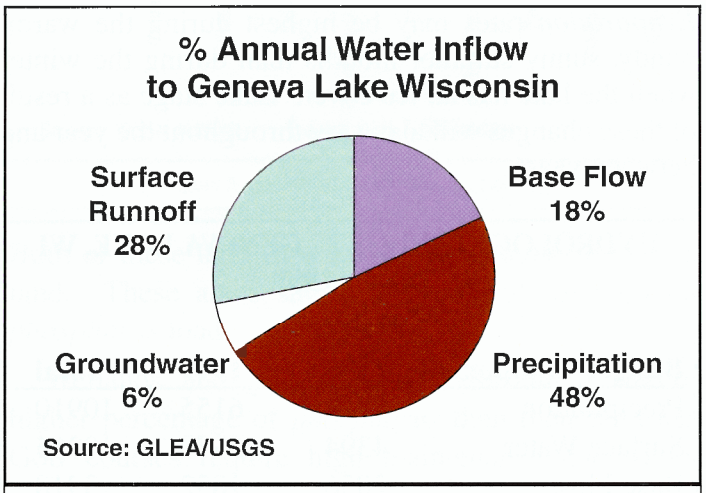

Figure 2. Percentages of Annual Water Inputs to Geneva Lake WI

Surface Water Input (SWin)

Surface water is delivered to Geneva Lake by two means, *base flow* and *surface runoff*. *Base flow* is the contribution of groundwater to the streams and channels that flow into the lake. *Surface runoff* is the water that does not soak into the ground during *precipitation* events and ends up running off into the streams or channels that flow to the lake.

Base flow is responsible for stream flow during the dry seasons. Base flow contributes approximately 18% of the annual water load to Geneva Lake. Surface runoff is often responsible for the large, fast increase in stream flow and flooding during or shortly after precipitation events. *Surface runoff* contributes approximately 28% to the annual water load to Geneva Lake.

Surface water plays a smaller role in Geneva Lake's hydrological budget, 46%, than it would on a lake with a large *watershed*. Approximately 13,121 ac. of land drain into the 5,213 ac. Geneva Lake resulting in a 2.5:1 *watershed-to-lake ratio*. For every acre of lake only about 2.5 acres of land drain into it. As a comparison, Delavan Lake, located just to the northwest of Geneva Lake has a 13:1 *watershed-to-lake ratio*. Surface water represents about 52% of Delavan Lake's annual hydrologic loading.

Groundwater Input (GWin)

Groundwater monitoring to establish a lake water budget can be difficult and expensive. Groundwater contributions can be calculated by knowing all the other sources and losses, and knowing the change in lake level. Having all the other variables identified, groundwater, the only unknown, can be determined by solving for that unknown. Groundwater can be either a water contributor or a loss to a lake. During the study period Geneva Lake had a net gain from groundwater that represented 6% of the lake's total annual input.

WATER LOSS

With *precipitation* playing such a major role in Geneva Lake's hydrologic budget, a dry year can have a significant impact in the annual budget. If *precipitation* is down, it not only can change the balance of water inputs but it can also change the balance of water loss. If the lake level stays below the outlet spillway for an abnormal portion of the year, *surface outflow* will not play a large role. *Evaporation* may then become the major water loss. If *precipitation* is normal and the lake level follows a normal pattern, water flows out the outlet for several months and thus becomes the major water loss.

In addition to the spillway outlet Geneva Lake has outlet gates that can be opened and closed as needed to control lake level. Water released through the outlet gates flows in the same channel as water that flows over the spillway and thus is measured at the same place and time. During the study period the gates were closed for 17 of 24 months.

Groundwater (Gwout), Surface water (SWout), and Evaporation (Evap.) Losses

The major loss of water from Geneva Lake during the study period was the outflow to the White River, accounting for 60% of the annual water loss (Figure 3). *Evaporation* represented the remaining 40%. Although there may have been some water loss to the groundwater, overall more water was contributed than lost by groundwater. During the study period groundwater did not play a role in the loss portion of the budget.

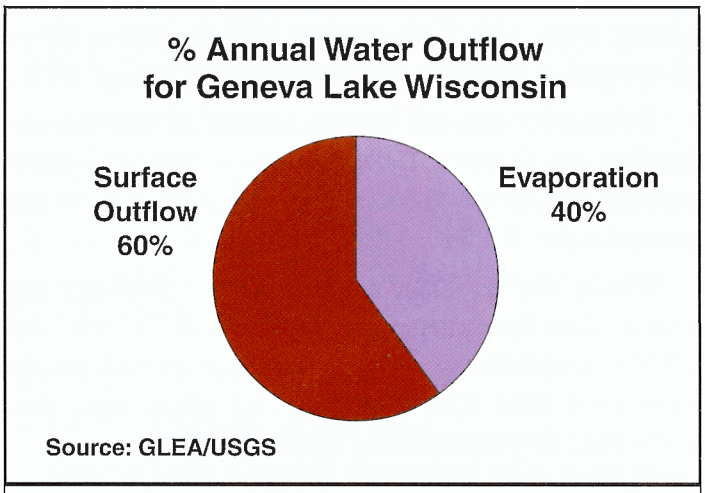

Figure 3. Percentages of Annual Water Loss to Geneva Lake WI

Change in Storage

Change in storage as measured by lake level changes during the study period was minimal. Lake level at the end of the study period was similar to that at the beginning (a drop of approximately 0.75 of an inch). Throughout the study period lake level varied with the seasons. Lake level was generally highest during late spring to early summer and lowest during the winter. During the study the lake level was at its lowest, 864.09 ft. above sea level, on February 25, 1998. The lake level peaked at 865.23 ft. above sea level on June 14, 1999. A drop of one inch in lake level is equal to 150 million gallons.

PHOSPHORUS BUDGET

Because of the importance of *phosphorus* to Geneva Lake's overall health, a *phosphorus budget* was developed for Geneva Lake (Figure 4). Major sources of *phosphorus* to Geneva Lake are the tributaries (84.4%), *precipitation* (7.0%), and waterfowl (6.6%). Groundwater (0.4%) and septic systems (1.6%) contribute to a lesser extent. A tributary loading was calculated by continuous stream monitoring and modeling. Waterfowl and septic systems were calculated based upon counts and values found in the literature. Groundwater contribution represents a net contribution over loss.

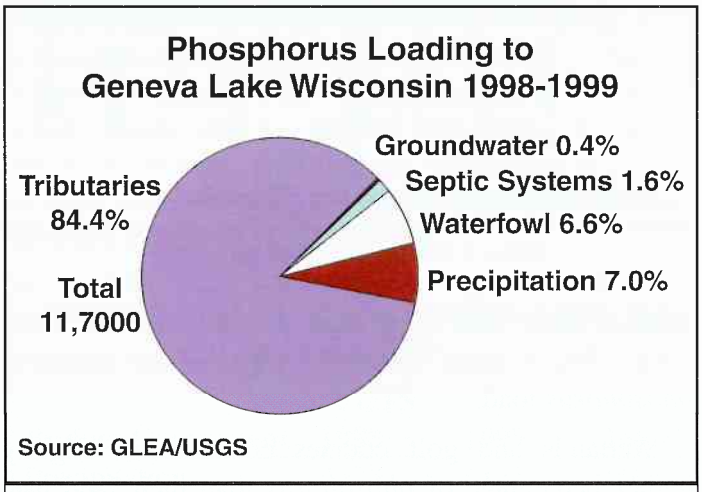

Figure 4. Phosphorus Loading to Geneva Lake WI

LAND USE AND LOADING

When looking at the *phosphorus* loading from the different tributary sources it is important to look at the land use within the *watershed*. Comparing the percent of land use with the percent of *phosphorus* contributed is a good way to identify which land uses are most responsible for *phosphorus* loading (Figure 5). Any loading source that is out of proportion to its composition of land use within the *watershed* is a loading source that should be considered for further investigation and possible loading reduction.

A review of the land use make up for Geneva Lake's *watershed* and the source of *phosphorus* loading as shown in Figure 5, reveals that cropland and urban land contribute a disproportionate amount of the total *phosphorus* loading to Geneva Lake. Cropland makes up only 27.3% of the land use within the *watershed* yet contributes 37.3% of the *phosphorus* loading from the *watershed*. Urban land use makes up 6.1% of the land use yet contributes 13.2% of the tributary *phosphorus*.

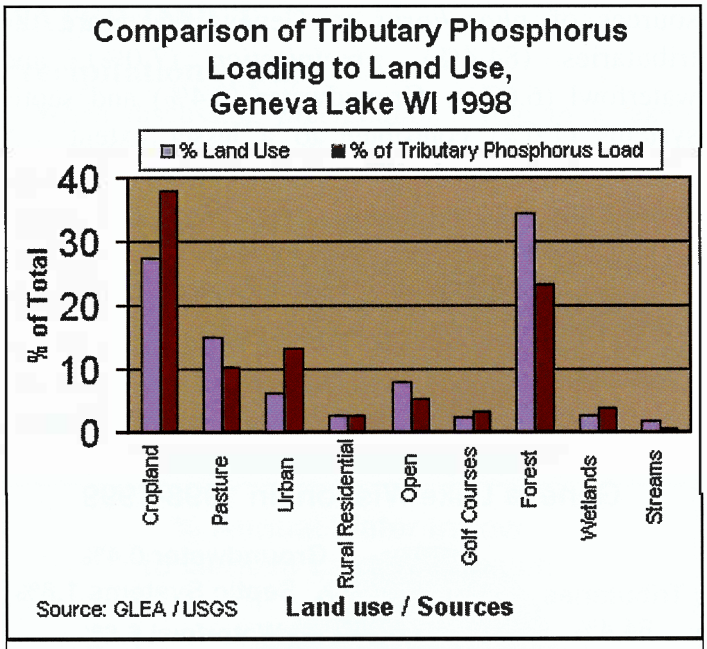

Figure 5. Land Use vs. Phosphorus Loading

Both of these land uses make very intense use of the land. These areas should be targeted for reducing *phosphorus* load.

Wetlands and golf courses contribute a slightly higher percentage of *phosphorus* than their land use. Golf courses require high maintenance due to the *homogeneous* nature of the vegetative community. Wetlands have been found to both trap and release *phosphorus* depending upon the nature of the wetland and time of year. All other land uses either contributed *phosphorus* similar to or less than their role in land use.

SUMMARY

Geneva Lake receives approximately 48% of its annual water load from *precipitation*. *Surface runoff* accounts for the second largest single source at 28%. *Base flow* or groundwater flow into the streams represents 18%. Groundwater discharged directly into the lake contributes 6%. Geneva Lake loses 60% of its annual water loss from outflow into the White River. *Evaporation* accounts for the remaining loss of 40%.

Tributaries are the largest source of *phosphorus* loading to Geneva Lake, 84.4%. Other sources include waterfowl, 6.6%, septic systems, 1.6 % and groundwater, 0.4%.

Within the tributary's contribution cropland and forest contribute the greatest fraction, 37.8% and 23.3% respectively. Yet when compared to the *watershed* land use, cropland and urban land uses contribute disproportionate amounts.

GLOSSARY

Base-flow: That portion of stream flow that is contributed by groundwater.

Evaporation: Water loss directly from the lake surface as water vapor.

Groundwater inflow: The contribution of water to a lake by groundwater.

Groundwater outflow: The loss of water from a lake to groundwater.

Homogeneous: All the same.

Phosphorus: A major nutrient needed for plant growth.

Phosphorus budget: An evaluation of phosphorus sources, losses and retention in relation to a lake.

Precipitation: Water falling directly on the lake surface.

Surface runoff: Rainwater that does not soak into the ground and moves across the land.

Surface water inflow: Water entering a lake through streams or channels.

Surface water outflow: Water leaving a lake through streams or channels.

Tributaries: Streams, creeks, or channels that drain to a lake.

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.

This information sheet is the fifth 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 #5 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 #5.