US Army Corps
of Engineers
North Central Division

# GREAT LAKES LEVELS

UPDATE LETTER NO. 73 2 AUGUST 1991

## FORECASTING GREAT LAKES WATER LEVELS

This article focuses on the methods used to produce the 6-month water levels forecasts for the "Monthly Bulletin of Lake Levels for the Great Lakes". The Great Lakes and their connecting channels make up the largest fresh water system in the world. The Great Lakes basin is shown in Figure 1. The five Great Lakes--Superior, Michigan, Huron, Erie, and Ontario--with their connecting channels and Lake St. Clair, have a total water surface area of about 95,000 square miles. They drain a land area over twice as large, which includes all or part of eight U.S. states and portions of two Canadian provinces.

The Great Lakes system has an impact on a large segment of mid-America's population, including riparian, recreation, navigation, and power interests. Following World War II, the economy of the Great Lakes region thrived. Commercial navigation was on an upturn, industries developed and expanded, cities grew and the populace flocked to the shorelines for fun and recreation. As such, the need to have current and near future information on lake levels increased. In 1951 and 1952, at a time of very high water levels, the need to know present conditions not only heightened, but also an additional question surfaced: "will lake levels continue to rise?" To answer this question, it would require someone to predict future water levels. The U.S. Lake Survey District, U.S. Army Corps of Engineers, located in Detroit, took on this challenge and, in 1952, published and distributed the first monthly bulletin of lake levels. These initial bulletins included forecasts of lake levels that were based on judgmental consideration of the factors affecting lake levels. Since then, numerous analyses and studies have been conducted to determine mathematical relationships between these factors and water supplies in order to improve overall forecasts. In 1970, following the reorganization of the U.S. Lake Survey, the Detroit District, U.S. Army Corps of Engineers, was given responsibility for producing and publishing the forecast of Great Lakes water levels. (Update Letter No. 69 describes the history of the Lake Survey from 1841 to 1976.)

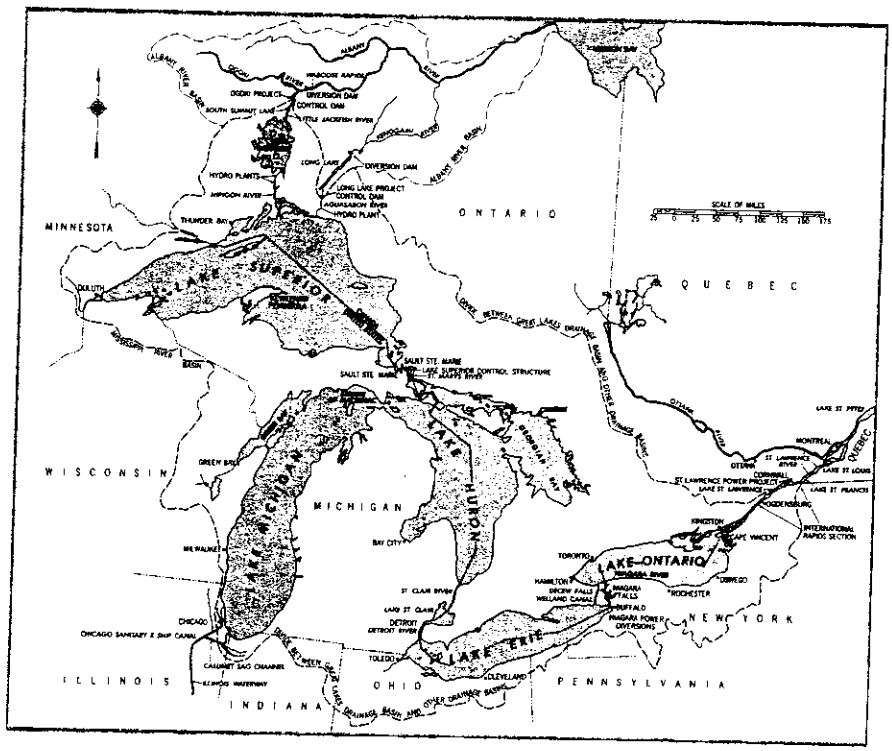


**Figure 1. The Great Lakes - St. Lawrence River Basin.**

To produce the Monthly Bulletin of Lake Levels for the Great Lakes, the U.S. Army Corps of Engineers prepares forecasts of future water sup-

plies to the lakes. "Water supply" is the portion of precipitation, streamflow, and groundwater that eventually makes its way into the lakes. The Great Lakes are comparable to a system of interconnected reservoirs, beginning at Lake Superior and continuing downstream to Lake Ontario and then through the St. Lawrence River to the Atlantic Ocean. The method of tracking the effects of predicted water supplies through the system is known as "routing." The forecast water supplies are routed through the Great Lakes system, using mathematical models, to determine the water levels that would result.

Water supplies and the resulting lake levels vary through the seasons of the year. Basically, the net supply of water to a lake from its own basin, known by the term "net basin supply," is the result of the water that comes into the lake adjusted for the water that evaporates from the lake. Figure 2 depicts the hydrologic factors. As previously mentioned, water enters a lake from its own drainage basin as rain or snow that falls directly to the lake surface, as runoff from the land portion of the basin, or as groundwater inflow. In the winter, water is stored on the land portion of the basin in the form of ice and snow with relatively small amounts reaching the lakes. Ice cover on the lakes in the winter reduces the evaporation from the lakes. The loss in water through evaporation occurs mainly in the fall and early winter, when cool dry air absorbs water from the warm surfaces of the lakes. The seasonal variation in water supply to the lakes is what causes the seasonal fluctuation of the lakes (Figure 3).

Forecasts of net basin supplies are based on what can reasonably be predicted about the factors that affect them. The Corps of Engineers' method of forecasting supplies is heavily dependent on the relatively predictable seasonal cycle of the supplies. Variations from the seasonal patterns are the result of weather variability. Predicting the exact amount of rain and snow that will fall and when and how fast the snow will melt comes under the realm of weather forecasting. The Corps of Engineers incorporates the National Weather Service's 30-day precipitation and temperature outlooks into the determination of the forecast water supplies. Because

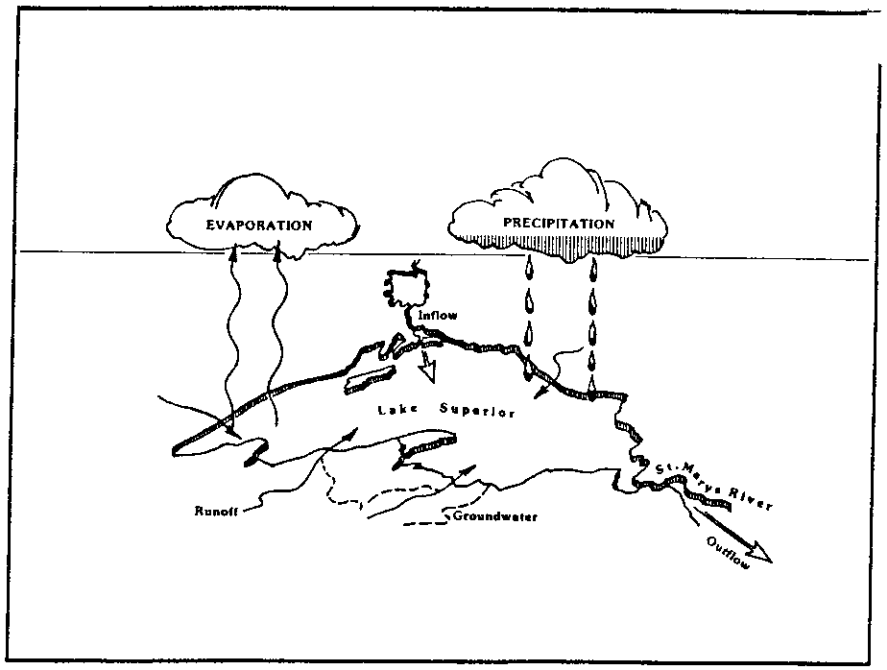


**Figure 2. Hydrologic Factors.**

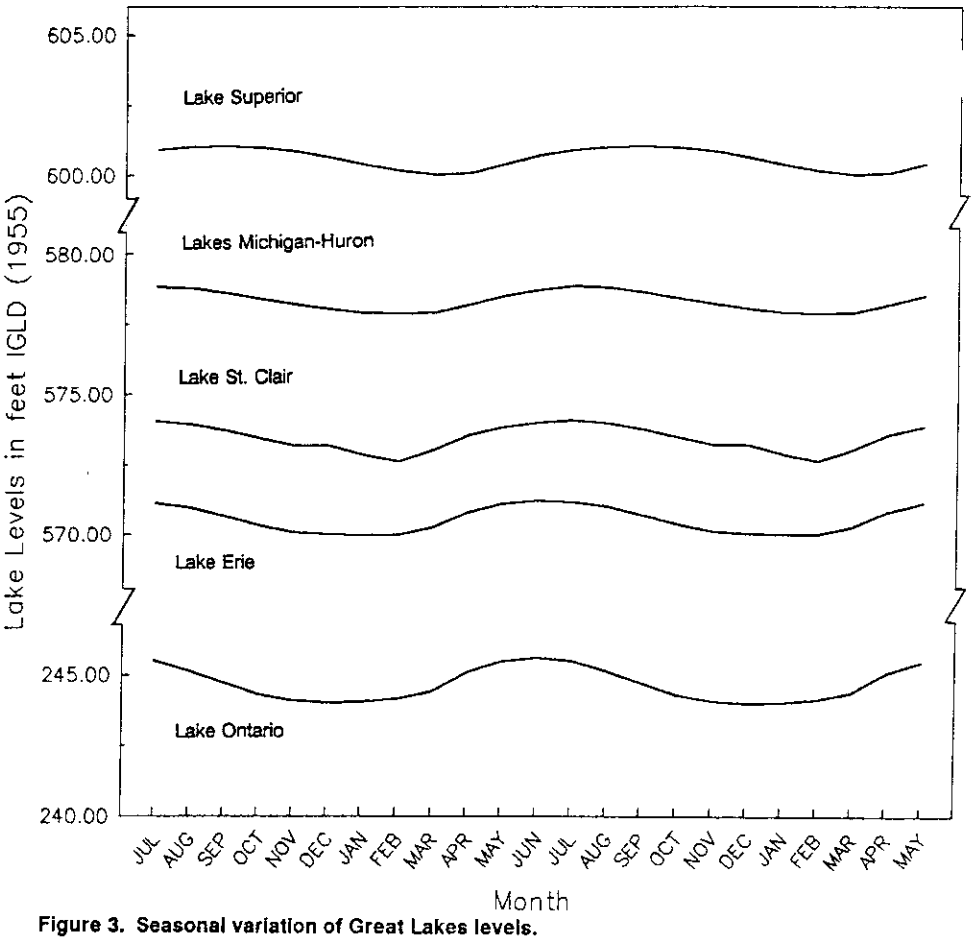


**Figure 3. Seasonal variation of Great Lakes levels.**

weather is such a determining factor in the amount of water available to a lake, any unforeseen deviation from the expected can have a major impact on the accuracy of water supply predictions. Extreme weather events cannot be predicted far enough in advance to be accounted for in a water supply forecast. The Corps of Engineers' method also looks at the trend of supplies for the last few months and the last few years. There is, however, no long-term (more than a year) cycle of water supplies or water levels on which to base predictions. The lack of long-range weather forecasts and the lack of a long-term cycle in supplies limits the Corps of Engineers forecasts to 6 months.

After a set of forecasted net basin supplies has been determined, it is put into a mathematical model to determine how the lake levels are affected. The level of a lake and the amount of water coming into it affects how much water flows out. Taken together they determine how the lake level will change (Figure 4). If more water comes into a lake than goes out, the lake level rises. Conversely, if more water flows out of a lake than comes in, the lake level goes down.

The amount of flow out of Lake Superior and Lake Ontario, which are regulated lakes, is computed using the regulation plans for those lakes. (Update Letters 59 and 63 discussed the regulation of these two lakes, respectively.) The flows out of Lakes Michigan-Huron through the St. Clair River, Lake St. Clair, through the Detroit River and out of Lake Erie through the Niagara River, are computed using equations that simulate the natural conditions of these channels. A number of streamflow measurements over a range of water level conditions have been used to develop equations relating lake levels to outflows. This way the only data required to determine the outflows are lake levels. During the winter, there are minor effects due to ice retarding the flows. During the late summer, weed growth will also slightly retard the flows out of Lakes Huron and Erie. Thus, the flows out of Lake Huron depend primarily on the levels of Lakes Erie and Huron. The flow in the Niagara River depends on Lake Erie's level. Diversions of water into, out of, and between

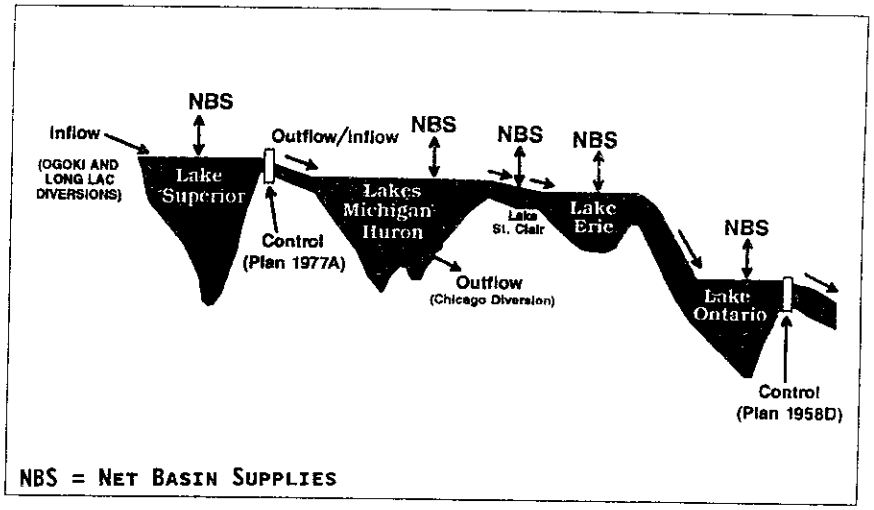


**Figure 4. Conceptual sketch of Great Lakes System.**

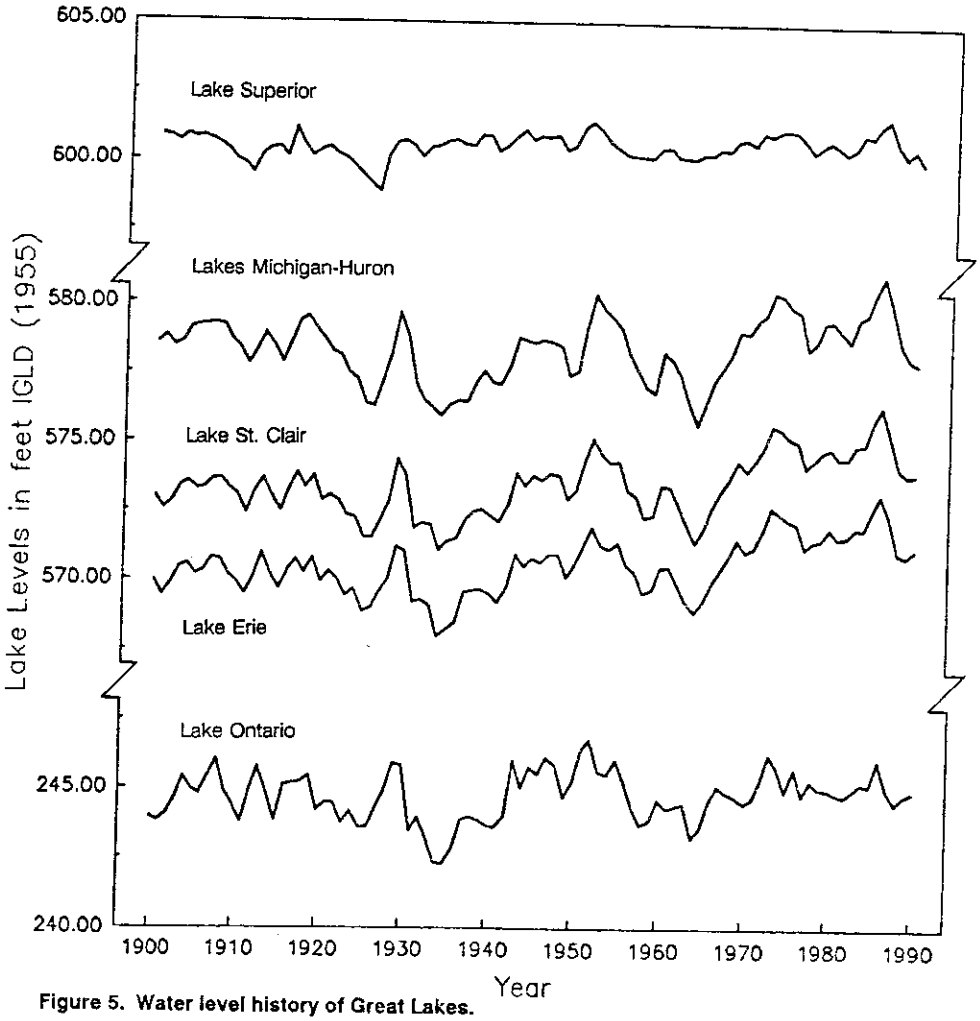


**Figure 5. Water level history of Great Lakes.**

Table 1
Great Lakes Hydrology

| PRECIPITATION | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | JULY | | | | YEAR-TO-DATE | | | |
| BASIN | 1991* | AVERAGE** | DIFF. | % OF AVERAGE | 1991* | AVERAGE** | DIFF. | % OF AVERAGE |
| Superior | 4.2 | 3.2 | 1.0 | 131 | 18.0 | 16.3 | 2.3 | 110 |
| Michigan-Huron | 4.2 | 3.0 | 1.2 | 140 | 18.8 | 17.5 | 1.3 | 107 |
| Erie | 2.3 | 3.3 | -1.0 | 70 | 18.7 | 20.4 | -1.7 | 92 |
| Ontario | 2.7 | 3.1 | -0.4 | 87 | 19.8 | 19.8 | 0.0 | 100 |
| Great Lakes | 3.8 | 3.1 | 0.7 | 123 | 18.7 | 17.8 | 0.9 | 105 |

| LAKE | JULY WATER SUPPLIES*** | | JULY OUTFLOW[2] | |
|---|---|---|---|---|
| | CFS[1] | AVERAGE[3] | CFS[1] | AVERAGE[3] |
| Superior | 127,000 | 130,000 | 78,000 | 81,000 |
| Michigan-Huron | 103,000 | 127,000 | 192,000 | 195,000 |
| Erie | -30,000*** | 4,000 | 212,000 | 211,000 |
| Ontario | 9,000 | 24,000 | 268,000 | 259,000 |

* Estimated (inches) ** 1900-89 Average (inches)
*** Negative water supply denotes evaporation from lake exceeded runoff from local basin.

1 Cubic Feet Per Second 2 Does not include diversions 3 1900-89 Average (cfs)

For Great Lakes basin technical assistance or information, please contact one of the following Corps of Engineers District Offices:


**For NY, PA , and OH:**
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U.S. Army Corps
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Buffalo, NY 14207-3199
(716) 879-4200

**For IL and IN:**
LTC Randall R. Inouye
Cdr, Chicago District
U.S. Army Corps
of Engineers
River City Bldg. (6th Flr)
111 N. Canal Street
Chicago, IL 60606
(312) 353-6400

**For MI, MN, and WI:**
Colonel Richard Kanda
Cdr, Detroit District
U.S. Army Corps
of Engineers
P.O. Box 1027
Detroit, MI 48231-1027
(313) 226-6440 or 6441

lakes are also accounted for in the model.

Once the Corps of Engineers has determined its forecasted levels, it coordinates these values with Environment Canada's office in Cornwall, Ontario which also produces a 6-month forecast of Great Lakes levels. This work is done under the auspices of the Coordinating Committee on Great Lakes Basic Hydraulic and Hydrologic Data. The Canadian water level forecast is made in much the same way as the forecast made by the Corps of Engineers with one major difference. While the Corps' attempts to predict future water supplies based on present conditions and weather forecasts, the Canadian forecasted water supplies are approximately the monthly long-term average water supplies each month. A coordinated U.S. and Canadian forecast is what appears as a dashed red line on the U.S. Bulletin as the "most probable" lake levels. Basically, the U.S. and Canadian values are averaged together. The "most probable" forecast is shrouded with a band to reflect the range of levels most likely to occur should weather conditions deviate appreciably from the expected. Figure 5 shows the water level history of the Great Lakes during the period 1900-1990.

In conclusion, the accuracy of the forecasted water levels shown in the bulletin is very dependent on the reliability of climatic forecasts. "Mother Nature" prevails in many cases over the final results. In an effort to improve the accuracy of forecasted water levels, the Corps of Engineers is continually reviewing and testing new methodologies for forecasting water supplies to the Great Lakes.

## IJC Boards' Public Meetings

The International Niagara Board of Control will meet with the public on September 12, 1991, at 7:30 p.m., in the Quality Inn, Central at Garrison Road, Fort Erie, Ontario. The board is responsible for the implementation of the 1950 Niagara Treaty between the U.S. and Canada.

The International Lake Superior Board of Control, which is responsible for administering the regulation of outflows from Lake Superior, will conduct an open house meeting with the public on September 17, 1991 at 7:00 p.m., in the Riverside Holiday Inn, Sault Ste. Marie, Ontario.

Individuals interested in the environment, shoreline properties, recreational boating, ice hydraulics, hydropower, and navigation are cordially invited to these meetings. Questions on regulation and related matters may be addressed to board members and associates.

Several brochures on Great Lakes and the connecting channels will be distributed free of charge. Your participation in these meetings is of interest to the IJC and its boards.

## IJC Levels Reference Study Board and Biennial Water Quality Conference

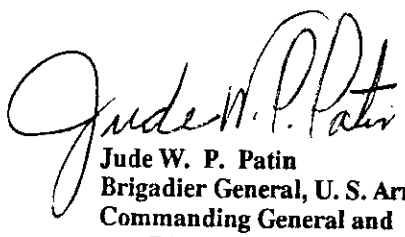
The Levels Reference Study Board, in charge of conducting the study on fluctutating water levels in the Great Lakes-St. Lawrence River basin, has met twice in recent months. On May 21-22, the board met in Alexandria Bay, N.Y., and approved a Goal Statement for the conduct of Phase II of the Reference Study. A site visit was made via tour boat to observe problems associated with fluctuating water levels in the Thousand Islands area of the St. Lawrence River. A public meeting on the study was also conducted at Alexandria Bay on the evening of May 21.

The board also met in Port Rowan and Toronto, Ontario, during June 26-28. During this period, a joint meeting with the Citizens Advisory Committee was held; a tour of shoreline area prone to erosion and flooding was conducted at Long Point, Ontario; and a public meeting on the study was held at Port Rowan June 27. The study board approved a strategy for evaluating measures and agreed on the baseline water level and flow conditions to be applied in the analysis of water-level regulation alternatives. Future study activities include a workshop on the study planning objectives, scheduled for Duluth, Minnesota, on September 5. The next meetings of the Citizens Advisory Committee and the Study Board will be held in conjunction with the IJC's Biennial Water Quality Conference, described below.

The IJC Biennial Water Quality Conference will be held at the Grand Traverse Resort in Traverse City, Michigan from September 29 through October 2, 1991. Those interested are cordially invited to attend. To register please contact the following:

Ms. Rita Kerner
International Joint Commission
2001 S. Street, N.W.
Washington, D.C. 20440
(203) 673-6222

The conference provides a forum for public, elected and agency officials, scientists, policy makers, and special interest groups to discuss the health of the Great Lakes.



**Jude W. P. Patin**
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**Commanding General and**
**Division Engineer**