Vol. No. 136 **July 2, 1999**

US Army Corps of Engineers
Detroit District

Great Lakes Update

Anthropogenic Changes to Great Lakes Water Levels

By
Frank H. Quinn, Ph. D.

Most observers of Great Lakes water levels are familiar with the changes in Great Lakes water levels due to natural climate variability. These include the seasonal cycle, with the lakes peaking in the summer and falling to minimums in mid-winter, and the normal interannual variability which results in year-to-year changes including both high and low water level episodes. However, many people are not familiar with the anthropogenic or man-made changes to the system. These changes have resulted in either permanent alteration of water levels or a decreased range of levels. The former include diversions into, out of, or between the lakes, navigational dredging, sand and gravel dredging, filling, and infrastructure placed in the connecting channels. The latter includes the regulation of Lakes Superior and Ontario. While individual impacts may or may not seem significant, cumulative impacts of even small changes may be important.

Diversions

The most well known changes are from the inter- and intra-basin diversions (see Figure 1). Diversions have been a hydraulic feature of the Great Lakes since the early 1800's. At the present time there are two interbasin diversions and two intrabasin diversions in operation. The Lake Michigan diversion at Chicago is perhaps the most well known interbasin diversion taking water from Lake Michigan and diverting it into the Illinois and Mississippi River drainage basins. In

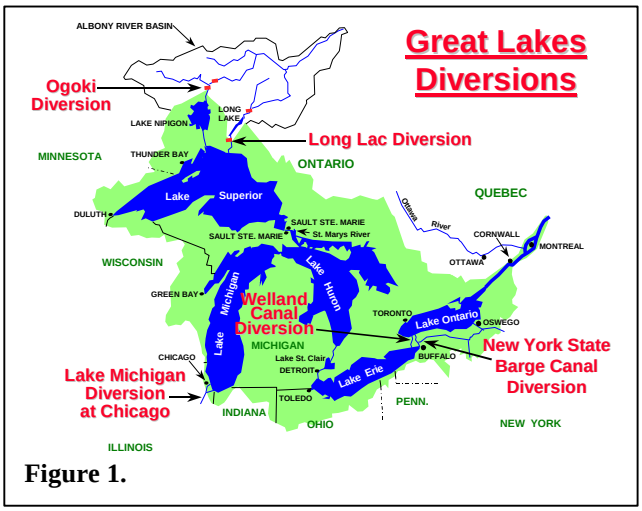

Figure 1.

1848, the Illinois and Michigan Canal was completed allowing muledrawn barges to travel between Lake Michigan and LaSalle, Illinois. The diversion of water to the canal averaged about 500 cubic feet per second (cfs). In 1900, the Chicago Sanitary and Ship Canal was completed. This replaced the upper reaches of the Illinois and Michigan Canal. The primary purpose of the Sanitary and Ship Canal was to divert sewage to the Illinois River system away from the Chicago water intakes in Lake Michigan. This alleviated a major health problem in the Chicago area. The diverted water increased to a maximum of 10,000 cfs in 1928. The diversion has been governed by U.S. Supreme Court decrees since 1930. The present average diversion of 3,200 cfs was established by a U.S. Supreme Court decree in 1967.

The Long Lac and Ogoki Diversions starting in 1941 and 1943, respectively, divert water from the Hudson Bay watershed into Lake Superior. These are entirely separate projects. The original intent of the Long Lac Diversion was to drive logs south to Lake Superior for the logging industry. However both the Long Lac and the Ogoki Diversions are important today for hydropower generation. Electricity is generated as the water arrives at Lake Superior, and at the St. Marys, Niagara, and St. Lawrence River hydropower plants. The combined diversions on an annual basis have ranged from 1,100 cfs in 1941 to a maximum of 8,000 in 1964. At the present time the combined diversions are averaging about 5,000 cfs. These diversions are governed by an exchange of notes between the U.S. and Canada.

The Welland Diversion and New York State Barge Canal are intrabasin diversions, transferring water from the Lake Erie to the Lake Ontario basin. A reconstructed Welland Canal was completed in 1882 which required the diversion of water from Lake Erie. The diversion supported navigation through the canal. In the late 1880's and 1890's, the canal was adapted for hydropower generation which increased the need for diversions of water from Lake Erie. The initial diversion requirements were about 400 cfs. During the intervening years since 1900, additional power generation has been developed leading to the present diversion of about 8,500 cfs.

The Barge Canal is a relatively minor diversion taking approximately 1,000 cfs from the upper Niagara River at Buffalo and discharging it into Lake Ontario at 4 locations along the shoreline. The Barge Canal was originally constructed in the early 1800's and reconstructed in 1918 to its present configuration. Its purpose is navigation and recreational boating between Lake Erie and Lake Ontario and the Erie Canal. The changes in the various diversion rates over time since 1860 is shown below in Figure 2.

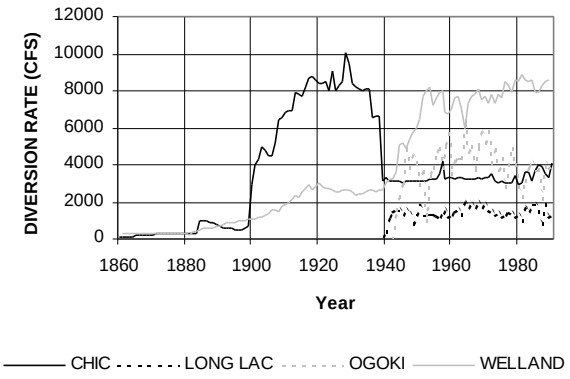

Figure 2. Great Lakes Diversion Rates

The diversions, with the exception of the New York State Barge Canal, have measurable impacts on the water levels, as shown in Table 1 below. The effects on Lakes Superior and Ontario are dependent upon the regulation plans in effect at any given time.

Channel Modifications

A second major source of anthropogenic lake level changes has been channel modifications in

Table 1. Computed Impacts of Existing Diversions on Lake Levels

Diversion	Amount cfs	Superior ft	Michigan-Huron ft	Erie ft	Ontario ft
Long Lac – Ogoki	5,600	+0.21	+0.37	+0.25	+0.22
Chicago	3,200	-0.07	-0.21	-0.14	-0.10
Welland	9,400	-0.06	-0.18	-0.44	0
Combined		+0.07	-0.02	-0.33	+0.08

the St. Clair, Detroit, and Niagara Rivers. Dredging navigation channels and sand or gravel mining from the river beds increase the flow capacity of the rivers. Filling in constricted areas of the rivers and construction of engineering works such as bridges which require large supports in the rivers decreases the flow. It is important to note that projects in the connecting channels have a permanent effect only upon the upstream lakes due to backwater affects. St. Clair River dredging for the 25-foot and 27-foot navigation projects in the mid-1930's and early 1960's, and sand and gravel dredging between 1908 and 1925, have lowered Lake Michigan-Huron by about 0.9 foot. Uncompensated dredging projects were also undertaken between 1860 and 1900, concentrated primarily at the head of the river and in the St. Clair delta with unknown effects.

The Detroit River also underwent navigation dredging between 1907 and 1913 in the lower river and between 1919 and 1921 in the Grosse Pointe Channel at the head of the River. The Detroit River was also dredged for the 25-foot and 27-foot navigation projects. Compensating works were designed and placed in the river to compensate for the water level changes due to the projects. Prior to 1900, dredging projects in the Grosse Pointe Channel and at the Limekiln Crossing were undertaken. These had an undetermined effect on the levels of Lakes St. Clair and Michigan-Huron.

Channel modifications in the upper Niagara River include the Bird Island Pier, piers for the construction of the International Railway and Peace Bridges, and channel filling around Squaw Island and in the vicinity of Fort Erie. The net effect of the modifications has been an increase of about 0.4 foot in the water levels of Lake Erie and an increase of about 0.1 foot in the water levels of Lakes Michigan-Huron. Channel modifications to the St. Marys and St. Lawrence Rivers and their impacts on lake levels are generally tied to the effects of the regulation of Lake Superior and Lake Ontario outflows control works.

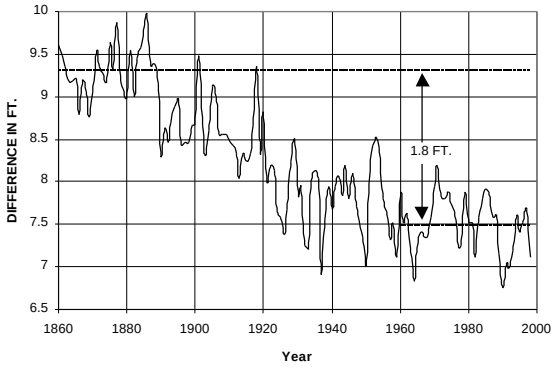

Figure 3. Difference in water levels between Lakes Michigan-Huron and Lake Erie

An excellent way of assessing cumulative impacts in the connecting channels is to examine the differences in elevation between Lakes Michigan-Huron and Erie. These differences, as shown in Figure 3, integrate all the impacts in the St. Clair, Detroit, and Niagara Rivers. The combined effect of diversions and changes in the Niagara River on Lake Erie approach +0.1 foot, leading to a negligible rise in Lakes Michigan-Huron. Figure 3 then represents the cumulative impacts on Lake Michigan-Huron due to all anthropogenic changes in the Detroit and St. Clair Rivers. Thus the net lowering of Lake Michigan-Huron is observed to be about 1.8 feet since the 1860-1880 time period and about 1.0 foot since 1900.

Regulation

With the completion of the Lake Superior compensating works in 1921, total control of the outflow became possible. The desired goal of Lake Superior regulation was to reduce the natural range of levels on that lake. Prior to implementation of Plan 1977 in 1979 and its successor, Plan 1977-A (the current regulation plan) in 1990, Lake Superior regulation was based solely upon the water levels of Lake Superior. Plan 1977-A provides for the relative balancing of Lake Superior with Lakes Michigan-Huron. The impact of Lake Superior regulation during the

period 1921-1975 was an average increase of about 0.4 foot in Lake Superior water levels with no apparent bias on the water levels of the lower lakes.

Lake Ontario has been regulated since 1960 with the construction of the St. Lawrence Seaway and Power Project. The primary regulatory structure is the Moses-Saunders Power Dam between Massena, New York and Cornwall, Ontario. The basic regulation plan in use is Plan 1958-D. The primary emphasis are hydropower, navigation, and limiting upstream and downstream flooding. The regulation has been extremely effective during the high water periods in the early 1970's and mid 1980's.

About the Author

Frank H. Quinn is a Senior Research Hydrologist with the Great lakes Environmental Research Laboratory of the National Oceanic and Atmospheric Administration. He has a Ph.D. in Civil Engineering from the Unversity of Michigan. His research interests include hydrology and hydraulics of the Great Lakes, hydrologic modeling, and climate change studies. He has worked on Great Lakes water resource issues since 1962 and in 1987 was awarded the U.S. Department of Commerce Silver Medal for outstanding contributions towards the management of natural resources. Dr. Quinn may be reached via e-mail at:

quinn@glerl.noaa.gov

Current Basin Condition Update

Through June 1999 the Great Lakes region is somewhat dryer than it was at this time year. Cumulative precipitation through June is about 14.9 inches. This is about 1.1 inches, or 7% less than for the same period last year.

Lake levels are all lower than they were in June 1998. Lake Superior is only about 3 inches lower, while lakes Michigan-Huron, St. Clair, Erie and Ontario are substantially lower at about 23, 19, 20 and 16 inches below their respective June 1998 monthly mean levels. Refer to the current *"Monthly Bulletin of Lake Levels for the Great Lakes"* for June 1999 hydrologic data.

Public Meetings

The **International Lake Superior Board of Control** (ILSBC) annual meeting is being held from 7:00 p.m. – 9:00 p.m. Tuesday, July 6, 1999 in Sault Ste. Marie, Ontario. The meeting will be held in the Algoma Board Room, Civic Centre, 99 Foster Drive, Sault Ste. Marie, Ontario. The regulation of Lake Superior outflows and water levels of Lakes Superior, Michigan and Huron will be discussed. For additional details check the ILSBC Internet Home Page at:

http://www.lre.usace.army.mil/ijc/superior.html

The International St. Lawrence River Board of Control (ISLRBC) met in Cornwall, Ontario on June 2, 1999 to discuss the regulation of outflows and water levels of Lake Ontario and the St. Lawrence River. More than 160 people attended. The ISLRBC Web Page can be accessed at the following internet address:

http://www.islrbc.org