DETROIT DISTRICT
U.S. ARMY CORPS OF ENGINEERS
BOX 1027
DETROIT, MICHIGAN 48231-1027
August 2007

Record Low Water Levels Expected on Lake Superior

In early June of this year, the Corps of Engineer issued a media advisory to alert everyone to the increased probability of setting new record low water levels on Lake Superior, for each of the fall months. Currently, Lake Superior is very close to setting a new record low monthly average water level for August. This is not the lowest point on record for Lake Superior. The lowest level occurred in April 1926 and was about 1 foot (0.3 metres) lower than now. Our forecast for September shows a definite new record low, likely several inches (centimetres) below the old record set back in 1926.

Since April 1998 Lake Superior has been below its long-term average (1918-2006) and is currently in the longest period of below average water levels in history. Water levels on Lake Superior are highly dependent on the supply of water received by the Lake Superior watershed. The hydrologic cycle has many components that affect the supply of water to the lake such as precipitation, evaporation and runoff. Natural factors contributing to these record low water levels on Lake Superior include:

- Precipitation in 2007 through July is an inch (25 mm) below average.
- Precipitation in 2006 was close to 6 inches (150 mm) below average.
- Precipitation in 2005 was about an inch and a half (37 mm) below average.
- December 2006 was a relatively warm month, leading to slower than normal ice growth. When very cold air temps arrived in mid-January, evaporation rates greatly increased. Evaporation in January and February of 2007 was much above average. In 2007, only the months of May and June saw below average evaporation.
- The amount of water available from the winter 2006/2007 snow pack was 60% below average.
- Portions of the Lake Superior watershed have been classified as moderate drought or drier since May 2006.

The above factors influence the amount of water available to the lake (known as the supply) and largely contribute to water levels. Regulation of Lake Superior outflow also has an effect on water levels but to a much lesser extent. Over the past year, outflows have been reduced to the approximate flow that would have existed prior to any man made changes in the St. Marys River. Diversions into and out of the system can also have minor impacts. Water is diverted into Lake Superior through the Long Lac and Ogoki diversions in a greater amount than water is withdrawn through the Lake Michigan Diversion at Chicago. The major influence on Lake Superior water levels is the hydrologic cycle and the current dry conditions are having a substantial effect on water levels.

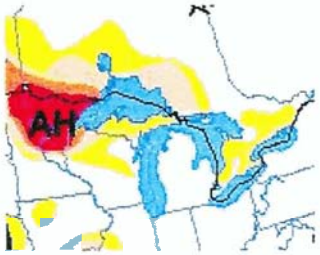
Forecasted water levels are highly dependent on the supply of water Lake Superior is expected to receive over the coming months. The U.S. Army Corps of Engineers and Environment Canada will continue to monitor basin conditions and provide updated information on our websites at http://www.lre.usace.army.mil/glhh and http://www.waterlevels.gc.ca/C&A/tidal_e.html

DROUGHT

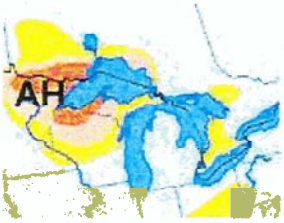
1. ABNORMALLY DRY and MODERATE DROUGHT conditions were first seen in the Lake Superior basin in the April 2006 edition of the North American Drought Monitor (NADM).
2. SEVERE DROUGHT was first seen on the August 2006 edition of the NADM and EXTREME DROUGHT on the Sept 2006 edition.
3. Bottom Line….Portions of the Lake Superior watershed have been classified as MODERATE DROUGHT or worse since April 2006.
4. Currently (Aug 21, 2007) EXTREME DROUGHT affects much of the Superior watershed.

April 2006

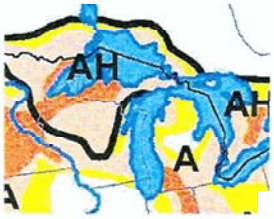
August 2006



Sept 2006



May 2007



Jul 2007

Intensity:

- D0 Abnormally Dry
- D1 Drought - Moderate
- D2 Drought - Severe
- D3 Drought - Extreme
- D4 Drought - Exceptional

CURRENT

U.S. Drought Monitor

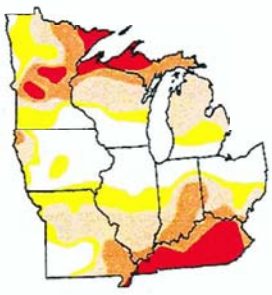
Midwest

August 21, 2007

Valid 7 a.m. EST

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	27.9	72.1	53.2	27.1	10.3	0.0
Last Week (08/14/2007 map)	19.0	81.0	54.9	27.9	4.7	0.0
3 Month Ago (05/29/2007 map)	66.8	33.2	14.8	4.8	0.0	0.0
Start of Calendar Year (01/02/2007 map)	57.8	42.2	18.0	11.1	7.1	0.0
Start of Water Year (10/03/2006 map)	63.5	36.5	21.9	10.3	7.7	0.0
One Year Ago (08/22/2006 map)	47.4	52.6	30.3	13.9	6.3	0.0



Intensity:

D0 Abnormally Dry
D1 Drought - Moderate
D1 Drought - Extreme
D2 Drought - Severe
D3 Drought - Severe
D4 Drought - Exceptional

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

http://drought.unl.edu/dm

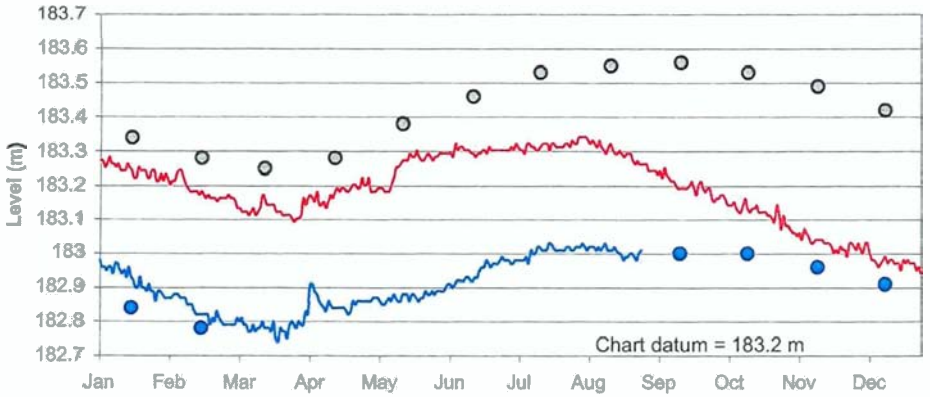
USDA

Released Thursday, August 23, 2007

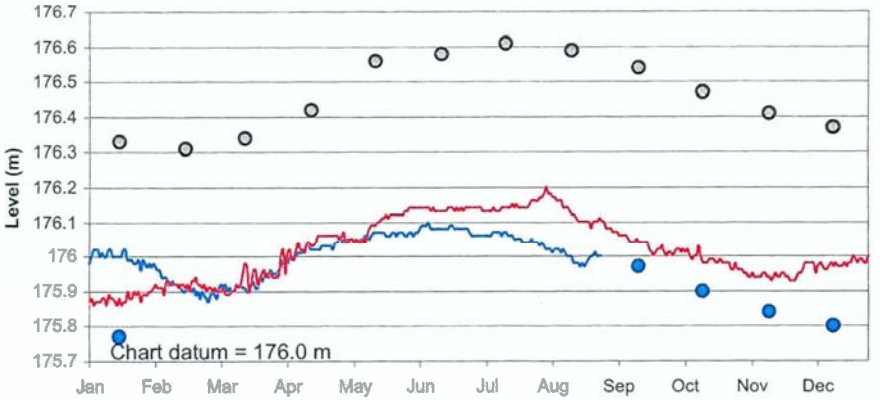
Author: Richard Heim/J. Lawrimore/L. Love-Brotak, NOAA/NESDIS/NCDC

All graphics and data are from the North American Drought Monitor and the United States Drought Monitor.

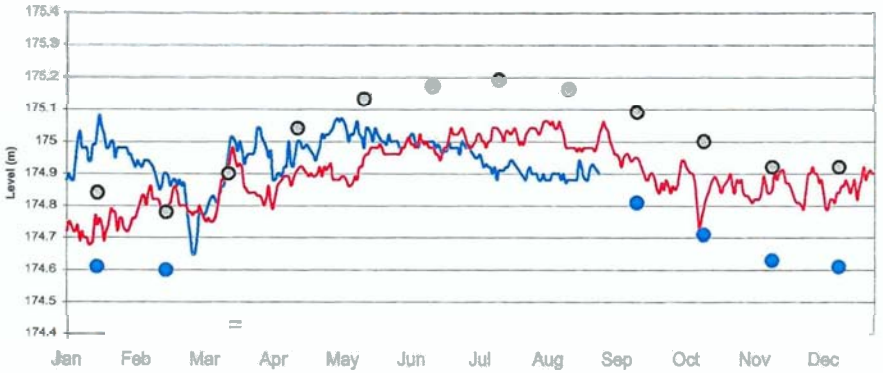
Lake Superior



Lake Michigan-Huron

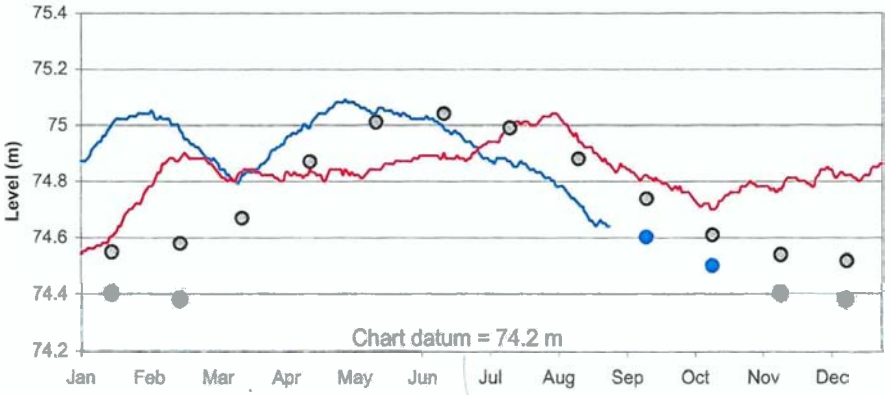


Lake St. Clair



Lake Erie

Lake Ontario



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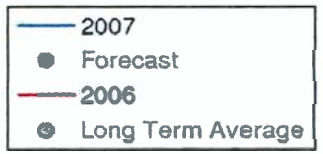
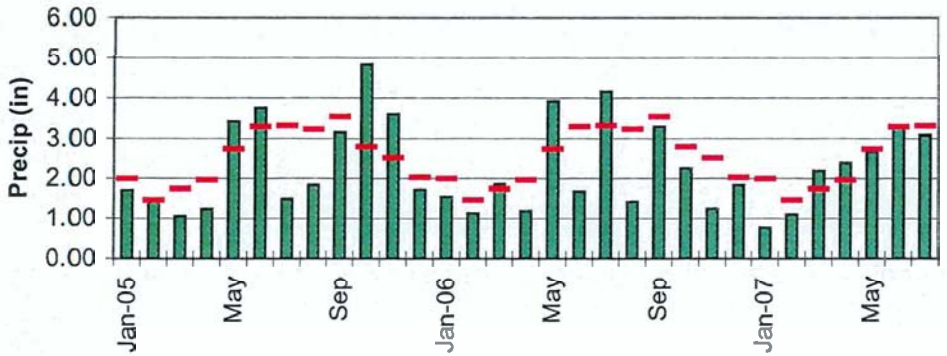
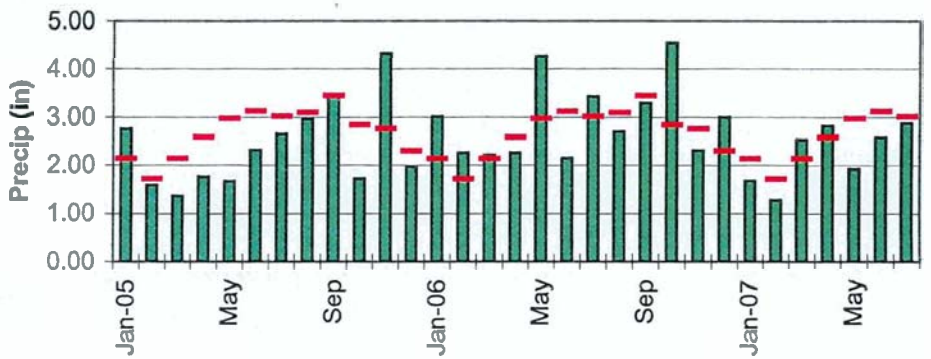


08/31/2007

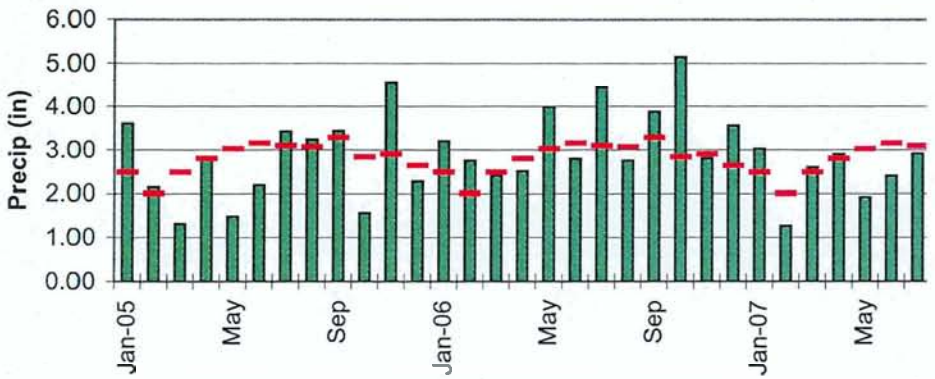
Lake Superior Precip (05-07)



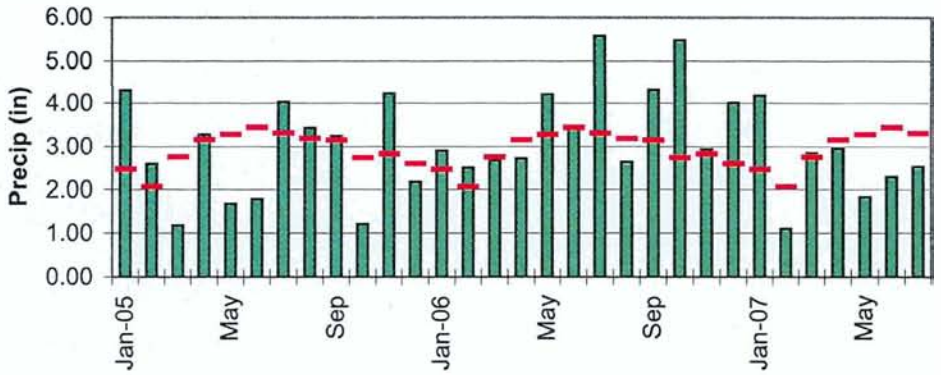
Lake Mich-Hur Precip (05-07)



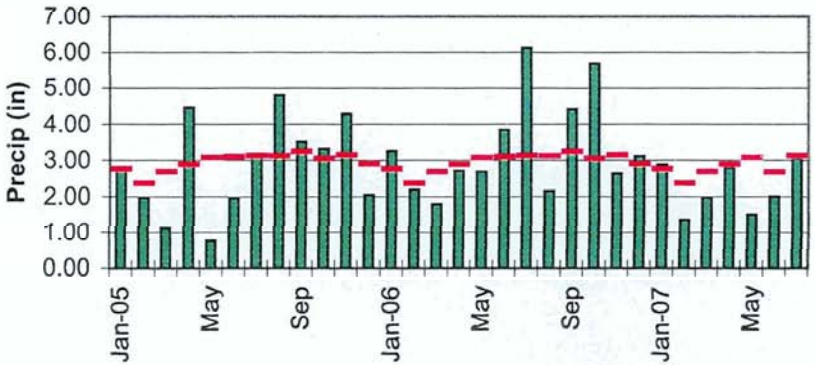
Lake St. Clair Precip (05-07)



Lake Erie Precip (05-07)



Lake Ontario Precip (05-07)



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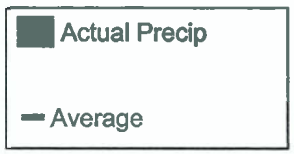
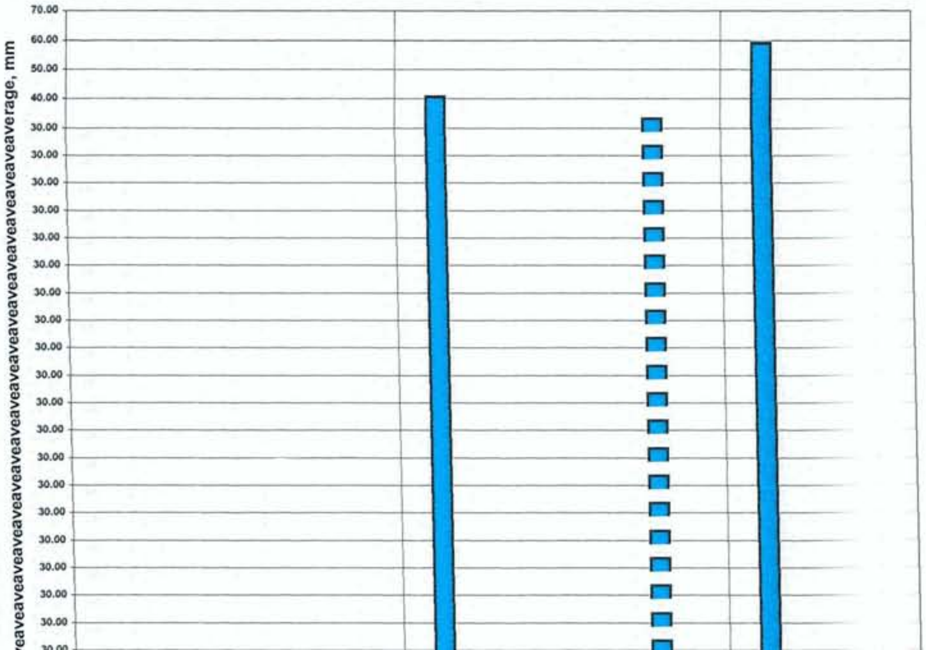
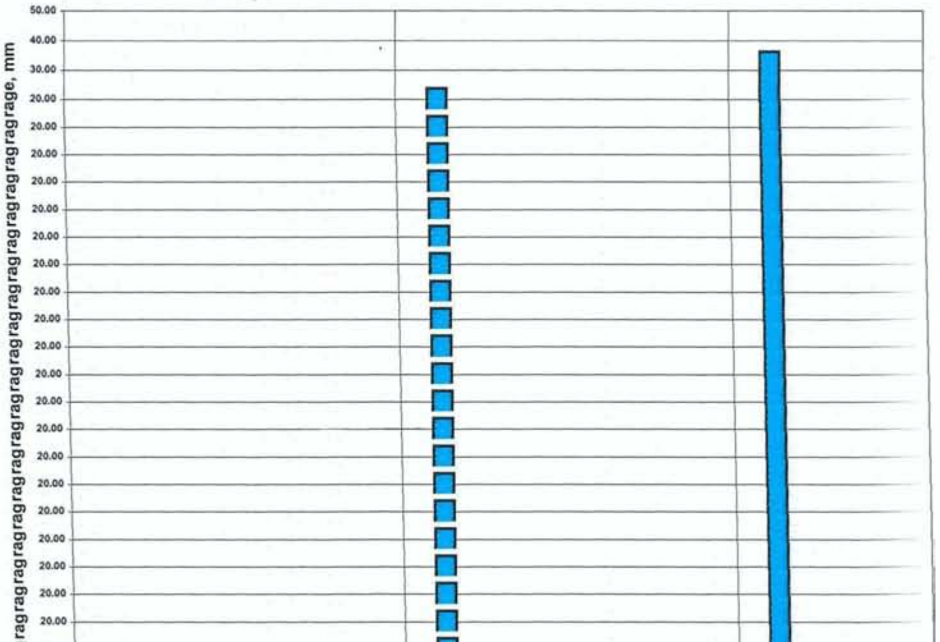


28-Aug-07

Evaporation on Lake Superior



Evaporation on Michigan-Huron



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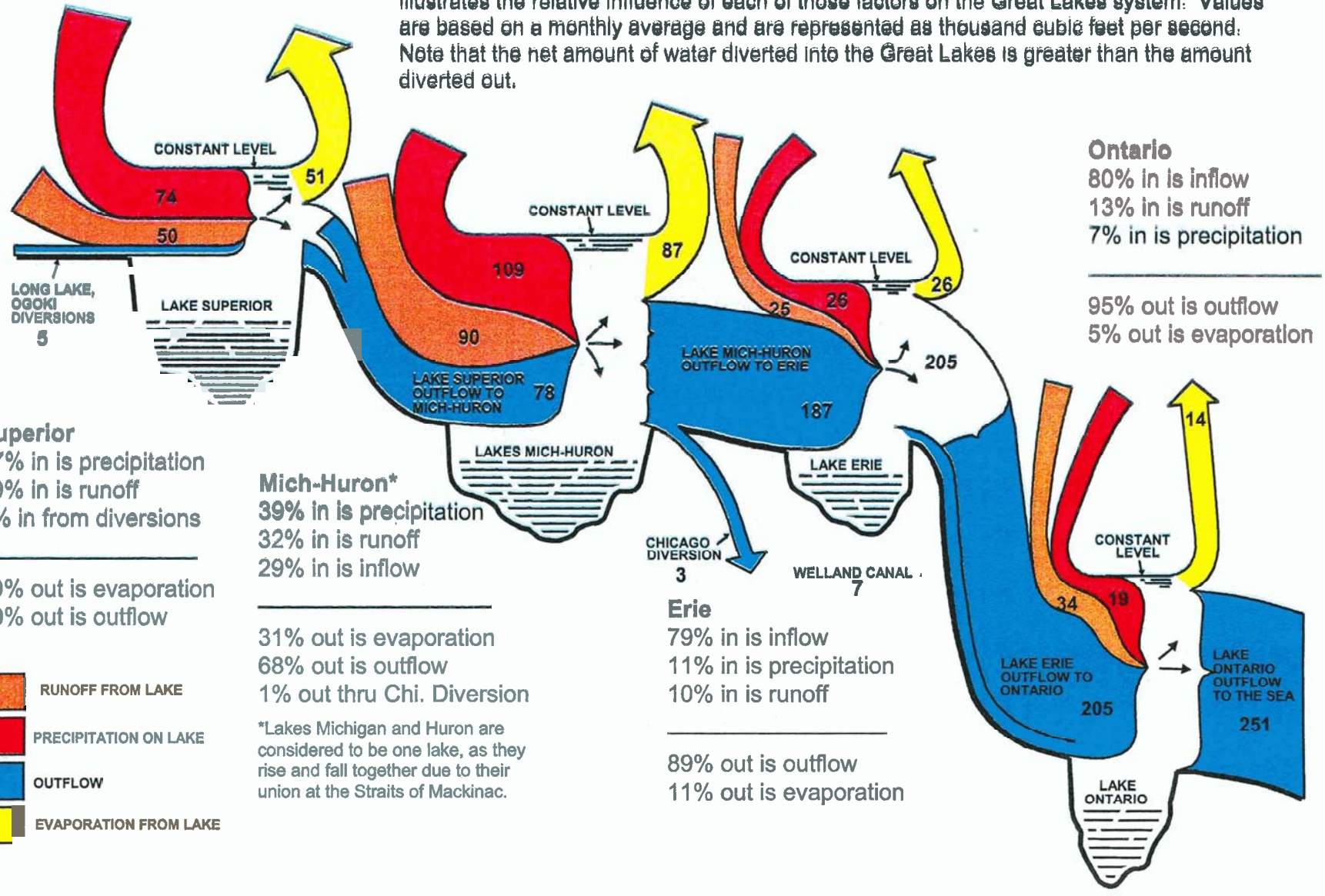
Hydrologic Components

Flow from upstream lakes, evaporation and precipitation influence lake levels. This graph illustrates the relative influence of each of those factors on the Great Lakes system. Values are based on a monthly average and are represented as thousand cubic feet per second. Note that the net amount of water diverted into the Great Lakes is greater than the amount diverted out.



Superior
57% in is precipitation
39% in is runoff
4% in from diversions

40% out is evaporation
60% out is outflow

Mich-Huron*
39% in is precipitation
32% in is runoff
29% in is inflow

31% out is evaporation
68% out is outflow
1% out thru Chi. Diversion

*Lakes Michigan and Huron are considered to be one lake, as they rise and fall together due to their union at the Straits of Mackinac.

Erie
79% in is inflow
11% in is precipitation
10% in is runoff

89% out is outflow
11% out is evaporation

Ontario
80% in is inflow
13% in is runoff
7% in is precipitation

95% out is outflow
5% out is evaporation

RUNOFF FROM LAKE
PRECIPITATION ON LAKE
OUTFLOW
EVAPORATION FROM LAKE

The Earth Moves—slowly, but surely—in the Great Lakes Region

During the last ice age, which ended some 12 000 years ago, the tremendous weight of the glacier that covered most of the Great Lakes region depressed the earth's crust underneath it and caused the crust to bulge upwards (forebulge) beyond the edge of the ice sheet. When the glacier melted, the crust, relieved of the excess weight began to recover. The earth's crust in the Great Lakes region continues to move today, affecting water depths along the shoreline around each lake.

The glacier was thicker and remained longer over area that became the north and east portions of the Great Lakes basin. As a result, the land rises more rapidly there than it does in the south and west portions. In absolute terms, Rossport, ON, on the north shore of Lake Superior, is thought to be rising about 47 centimetres per century (cm/century) relative to the centre of the earth as the crust there uplifts. On the other hand, Calumet Harbor, IL, at the southern end of Lake Michigan near Chicago, is subsiding about 11 cm/century as the forebulge collapses. This differential crustal movement and its impact on Great Lakes water levels have been recognized and studied for well over a century.

On an individual lake, how water depths change over time along the shoreline due to differential crustal movement depends on the direction and rate that a particular shoreline location moves relative to the lake's outlet. Recent estimates, determined at water level gauging stations around each of the lakes, are shown in the figure on the back page. A positive vertical velocity value indicates that the location is rising relative to the outlet, and the lake's surface, over time. A negative value indicates that the site is either falling or not rising as fast as the outlet is. Rossport, for example, is rising about 28 cm/century relative to Lake Superior's outlet and the lake's water surface.

To help visualize the effects of differential crustal movement on the location of the water's edge and its depth along the shoreline, take a bowl and partially fill it with water. Next, tilt the bowl by slowly raising its upper right hand edge. As you do this, you should be able to notice that although the average level of the water in the bowl doesn't change, the water becomes shallower as it moves further away from the edge being lifted. At the same time, the water becomes deeper as it moves closer to the opposite side of the bowl.

What does this mean for people living around and boating on Lake Superior with it setting a new record low lake-wide average monthly mean water level for the month of August this year? Lake Superior's August 2007 water level was 1 cm lower than its previous period-of-record low for the month, which was set in 1926. If we could have drawn a line all the way around the lake on a calm day at that time, and went to look for it under similar conditions this August, we would have found it just above the lake's surface at the eastern end of the lake near it's outlet and between Thunder Bay, ON and the Canada/U.S. border at its western end. Elsewhere along the Canadian shoreline we'd have found it a few to several centimetres above the surface, while along the U.S. shoreline it would have been located a few to several centimetres below it. How much above or below depends on how much the location where we were looking has risen or fallen relative to the lake's outlet over the 81 years that have passed since 1926. At Michipicoten, ON, for example, the line would have been about 20 cm above the lake's surface, while at Duluth, MN it would have been about 20 cm below it.

FOR MORE INFORMATION:

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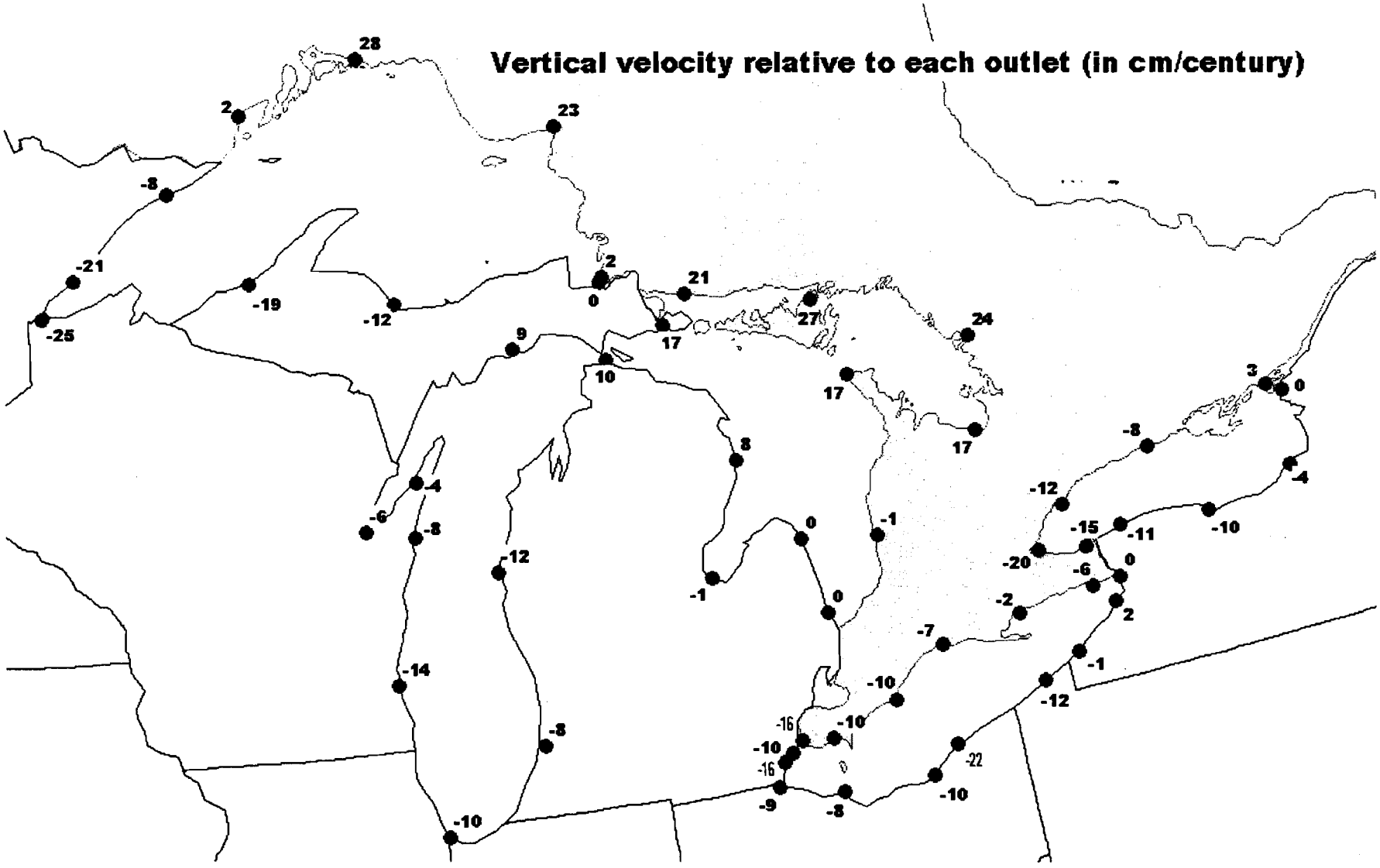

Vertical velocity (in cm/century) at points around each lake relative the lake's outlet

Source: Figure 5 in *Apparent Vertical Movement Over the Great Lakes – Revisited.*
A report prepared by the Coordinating Committee on Great Lakes Basic Hydraulic and Hydrologic Data, November 2001.
Report URL: http://www.geod.nrcan.gc.ca/index_e/pgr_e/PGRgreatLakes_e.html

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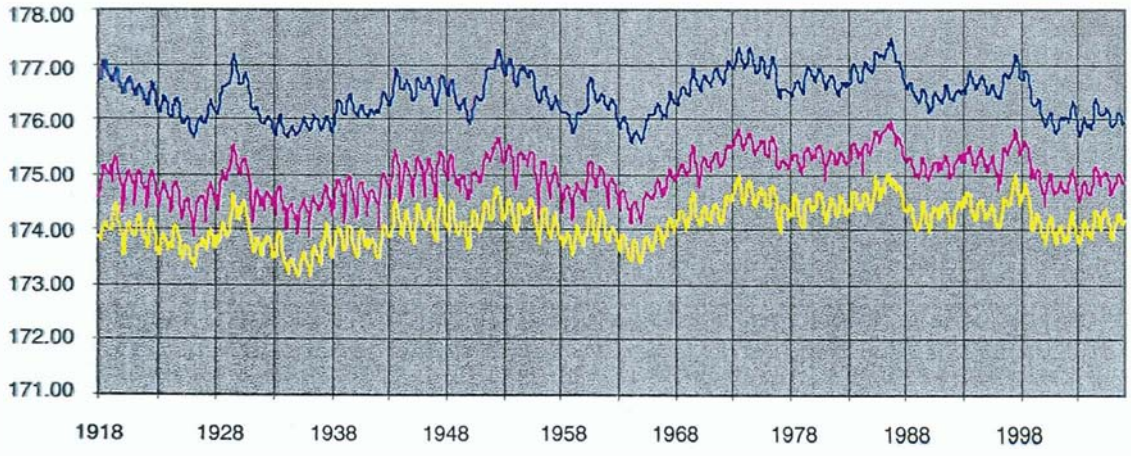
August 2007

St. Clair River Background and Current Issues

The St. Clair River flows from the outlet of Lake Huron, a distance of about 39 miles, through a multi-channeled delta area at the northern end of Lake St. Clair. There are many factors that influence the water levels in the lakes and rivers of the Great Lakes. As weather systems move through our area, they deposit moisture in the form of rain and snow. Water enters the system as precipitation directly on the lake, runoff from surrounding land, groundwater and inflow from the upstream lakes. Water leaves the system through evaporation from the land and water surface or through transpiration from the plants. Water also leaves through consumptive uses (manufacturing, water supply, etc), diversions and outflows to downstream lakes. Changes in this hydrologic cycle will affect how lake and river levels rise and fall over time.

There are three kinds of water level fluctuations; short-term, seasonal and long-term. Short-term fluctuations are generally due to winds or changes in barometric pressure. They last from a couple hours to a few days and can be very dramatic. Seasonal fluctuations result from changes in the hydrology of the basins throughout the year. In fall and early winter, evaporation is the greatest and water levels fall. As the snow melts in spring and evaporation is low, water levels rise. The range of seasonal fluctuations on the Great Lakes averages about 12-18 inches from winter lows to summer highs. Long-term fluctuations occur over periods of years and have varied dramatically since we have been recording water levels. Continuous wet and cold years cause water levels to rise while dry and warm years cause levels to drop. The Great Lakes basin experienced extremely low levels in the late 1920s, mid-1930s, mid-1960s and again from the late 1990s to present on the upper lakes. Extremely high levels were experienced in the early 1950s, early 1970s, the mid-1980s and the mid-1990s. The figure below shows the fluctuations in water levels (in meters) for Lake Michigan (blue), Lake St. Clair (purple) and Lake Erie (yellow) from 1918 – 2006.



There have been numerous alterations made to the St. Clair River since the mid 1800s, mainly for the support of commercial navigation, but also for commercial sand and gravel mining in the early 1900s. These changes in the river affect its capacity to carry water, and therefore affect the water levels in the upstream lakes (Michigan and Huron) and the downstream lakes (St. Clair and Erie). The last major dredging, for the 27 foot navigation project in the St. Clair River, was completed in 1962. Studies completed at that time determined that all the dredging in the St. Clair River since the mid-1800s would have a lowering impact on Lakes Michigan-Huron water levels of about 14 inches. It was also concluded that the system would reach a new equilibrium balance in time, and the lowering impact would not be continuous.

Recent questions center on the difference in water levels between Lakes Michigan-Huron and the lower lakes becoming smaller over time. This difference is getting smaller, but there is some disagreement on why this is happening. A change in the "fall", or difference between these lakes, could be due to the levels of Lake Michigan-Huron falling or the levels of Lake Erie rising over time. Studies are needed to determine why this is changing. It could be due to changes in the river bottom and therefore the amount of water leaving Lakes Michigan-Huron. It could be due to crustal movement and the rising of the earth's crust from the removed weight of the glaciers. It could be due to changing patterns of water supply such as drier conditions on the upstream lakes and wetter conditions on the downstream lakes.

Recent surveys of the bottom of the St. Clair River show that there are areas at the head of the river that are over 60 feet deep. Historic survey information shows that areas of the upper river were around that depth in the past and are natural river depths. This area of the river has never been dredged for navigation. Comparisons of recent river bottom data show some areas where the river is getting shallower and some areas where it is getting deeper over time. The possibility of the river bottom continuing to erode has not been sufficiently documented at this point, nor can it be linked to dredging operations.

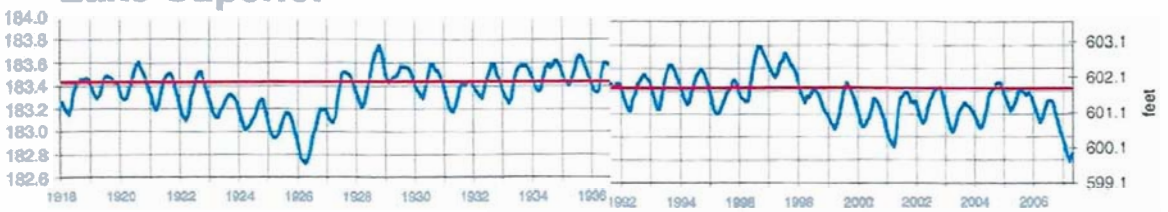
An important factor to consider is the issue of crustal movement. The earth's crust in some parts of the Great Lakes basin is still rebounding from the weight of the glaciers. The northeastern portion of the basin has one of the highest rebound rates, when compared to the southwestern portion of the basin. One theory is that this movement may be making the St. Clair River steeper and therefore faster flowing. Another theory is that it may make Lake Erie's outlet rise and effectively hold back more water in the lake. The impact of this phenomenon on measured water levels throughout the lakes and the differing rate of rebound across the basin need detailed technical analyses.

Investigations need to be made into the role of changes in the water supply (precipitation and evaporation) to the upper and lower lakes over time as well. Initial thoughts have been that the Lake Erie basin is becoming wetter over time in relation to the Lakes Michigan-Huron basin. This change in the supply of water to the lakes can also have an impact on the relative difference between their water levels.

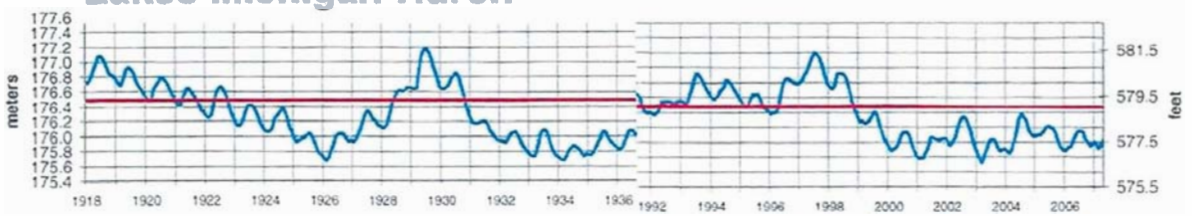
In order to answer the many questions about changes in the St. Clair River over time, and their impact on the rest of the system, the International Joint Commission is beginning its International Upper Great Lakes Study. This study is to review the regulation of Lake Superior and the issues involving the St. Clair River. It will look at impacts on the various interest groups in the basin and suggest possible changes to benefit the Great Lakes basin. The study will include multiple agencies, universities and contractors. Public involvement and independent technical review are also key aspects of the study. The entire study is expected to be completed in 5 years. The St. Clair River issues will be addressed early in the study with reports being completed by the end of the 3rd year.

Monthly Mean Level
Long Term Annual Average

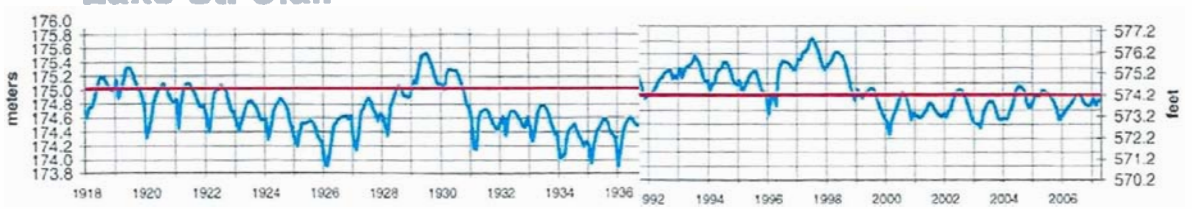
Lake Superior



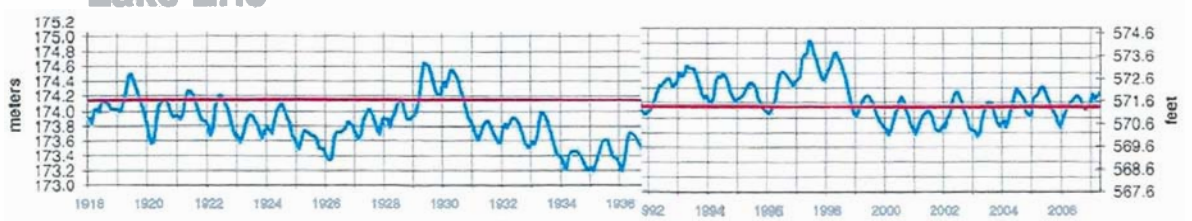
Lakes Michigan-Huron



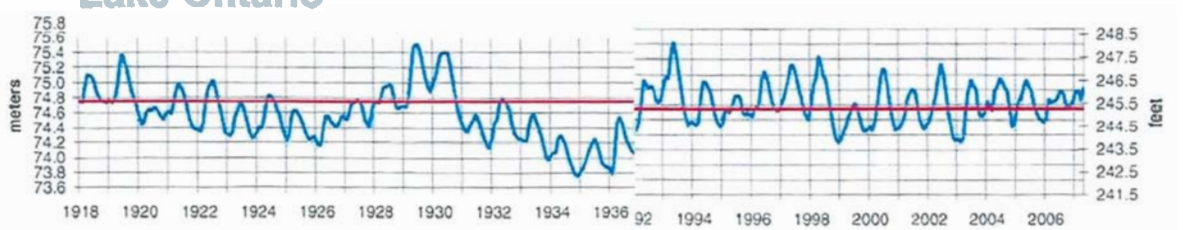
Lake St. Clair



Lake Erie



Lake Ontario



The monthly average levels are based on a network of water level gages located

Elevations are referenced to the International Great Lakes Datum (1985).

Useful Great Lakes Web Addresses 2007

International Lake Superior Board of Control:	http://www.lre.usace.army.mil/IJC/Superior/index.shtml
International Joint Commission:	http://www.ijc.org/
International Upper Great Lakes Plan of Study	http://www.iugls.org/en/home_accueil.htm
USACE Detroit District Web Page:	http://www.lre.usace.army.mil/
Detroit District Water Level Bulletin:	http://www.lre.usace.army.mil/greatlakes/hh/ (Click on 'Forecasts' under "Water Levels")
Canadian Water Level Bulletin:	http://www.waterlevels.gc.ca/C&A/bulletin_e.html
Level News Site:	http://www.on.ec.gc.ca/water/level-news/intro-e.html
Environment Canada Water Levels Page (with links):	http://www.on.ec.gc.ca/water/levels/intro.html
Great Lakes Information Network:	http://www.great-lakes.net/
Canadian Hydrographic Service (CHS):	http://www.waterlevels.gc.ca/C&A/gs_selection_e.html
Great Lakes Nautical Charts (U.S.)	http://www.noaa.gov/charts.html
CHS - Nautical Charts (Canadian):	http://www.chs-shc.gc.ca/pub/en/
National Oceanograpic and Atmospheric Administration:	http://co-ops.nos.noaa.gov/
CHS Hourly Water Levels:	http://www.waterlevels.gc.ca/C&A/gs_selection_e.html
Environment Canada Weather Radar - Ontario:	http://weatheroffice.ec.gc.ca/radar/index_e.html?id=ont
Environment Canada Marine Weather Forecasts:	http://weatheroffice.ec.gc.ca/marine/region_08_e.html
National Weather Service	http://www.nws.noaa.gov
Environment Canada 5-Day Weather Outlooks - Ontario:	http://weatheroffice.ec.gc.ca/forecast/canada/on_e.html
NOAA Climatological Outlooks	http://www.cpc.ncep.noaa.gov/products/predictions/
Environment Canada Climatological Outlooks:	http://weatheroffice.ec.gc.ca/saisons/index_e.html
U.S. Real-Time Streamflows (U.S.G.S.)	http://waterdata.usgs.gov/nwis/rt
Canadian Real-Time Streamflows:	http://scitech.pyr.ec.gc.ca/waterweb/formnav.asp?lang=0
Crustal Movement Report:	http://www.geod.nrcan.gc.ca/pdf/pgrreportnov2001.pdf
Seaway:	http://www.greatlakes-seaway.com/en/home.html