Impacts on Upper Great Lakes Water Levels:
St. Clair River

Draft Report of the
International Upper Great Lakes Study

Summary Report

Prepared for the
International Joint Commission

May 2009

Impacts on Upper Great Lakes Water Levels: St. Clair River
Preliminary Findings and Recommendations

For the past two years, more than 100 scientists and engineers from Canada and the United States have worked together to address challenging questions about the St. Clair River system flowing from Lake Michigan-Huron to Lake Erie: Has the conveyance or water-carrying capacity of the St. Clair River changed, and if so, why? What effect could an altered flow have on water levels in the upper Great Lakes? What other factors may be affecting the change in the water levels? What actions, if any, should be taken by governments to remedy concerns about low water levels?

The answers are now coming into focus. The draft report, ***Impacts on Upper Great Lakes Water Levels: St. Clair River***, the first of two reports by the bi-national International Upper Great Lakes Study Board, was released on May 1st, 2009 for a 60-day period of public review and comment. Following this review period, the Study Board will finalize the report and submit it to the International Joint Commission in the fall of 2009. The International Joint Commission will review the findings with the United States and Canadian governments and recommend a course of action.

This **Summary Report** provides a less technical overview of the Study's objectives, approach and preliminary findings and recommendations. More information on the Study and the full scientific report are available at the website of the International Upper Great Lakes Study: http://www.iugls.org.

Key *preliminary findings* of the Study's draft report:

1. The difference in water levels between Lake Michigan-Huron and Lake Erie has declined by 23 centimetres (cm) (9 inches) between 1962 (the time of the last major dredging in the St. Clair River) and 2006.

2. Three key factors have contributed to this decline:

- A change in the *conveyance* of the St. Clair River accounts for 10 to 12 cm (3.9 to 4.7 inches); a relatively dramatic and rapid change in conveyance appears to have occurred in the mid-1980s, possibly resulting from a single event, such as a major ice jam.
- Changes in *climatic patterns* account for 9 to 27 cm (3.5 to 10.6 inches); this factor has become even more important in recent years, accounting for an estimated 75 percent of the decline between 1996 and 2005.
- *Glacial isostatic adjustment* (the rebounding of the earth's crust after the melting of the glaciers about 10,000 years ago) accounts in general for 4 cm (about 1.6 inches), but varies greatly throughout the basin

Determining the total decline is not as simple as adding up the estimates of the three contributing factors. These estimates are highly dependent on the choice of the specific time period being analyzed within the 1962-2006 timeframe. However, the lower-bounded numbers provide a good approximation.

3. There has been no ongoing erosion along the length of the St. Clair River bed since at least 2000.

4. Remedial measures on the St. Clair River are not warranted at this time, given the preliminary findings and the Study's mandate. However, climate change has emerged as a critical but uncertain factor in the future of the upper Great Lakes.

The Study Board recommends that:

- *Remedial measures not be undertaken in the St. Clair River at this time.*
- *The need for mitigative measures in the St. Clair River be examined as part of the comprehensive assessment of the future effects of climate change on water supplies in the upper Great Lakes basin in Report 2 of the Study, on Lake Superior regulation.*

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For More Information or to Comment on the Draft Report

If you are interested in reviewing the draft of the Study's full scientific report on the St. Clair River, or want to attend a public meeting on the Study being held in your area, please visit the website of the International Upper Great Lakes Study for more information: www.iugls.org.

If you would like to comment on the Draft Report, comments can be submitted using the form at the website or by email to the Study Board at comments@iugls.org. Comments can also be provided in writing to either of the following addresses:

International Upper Great Lakes Study
234 Laurier Ave. W., 22nd Floor
Ottawa, ON K1P 6K6

International Upper Great Lakes Study
2100 Commonwealth Blvd., Ste. 100
Ann Arbor, MI 48105-1563

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1. Introduction

Water levels in the upper Great Lakes are the focus of a five-year international study.

Impacts on Upper Great Lakes Water Levels: St. Clair River is the first of two major reports of a five-year international study of the upper Great Lakes undertaken at the direction of the International Joint Commission.

The International Joint Commission is an independent bi-national organization created in 1909 to prevent and resolve disputes regarding many of the lakes and rivers along the border between Canada and the United States. This role includes approving the construction and management of works in boundary waters that affect levels and flows on the other side. At the request of both governments, the International Joint Commission also has a role in helping the two countries restore and maintain the chemical, physical, and biological integrity of the waters of the Great Lakes.

In 2007, following extensive consultation with governments, organizations and individuals with an interest in the Great Lakes, the Commission launched the International Upper Great Lakes Study (the Study). The Study has two major objectives:

1. Examine physical processes and possible ongoing changes in the St. Clair River and their impacts on levels of Lake Michigan-Huron and, if applicable, evaluate and recommend potential remedial options (**Report 1**); and

2. Review the regulation of Lake Superior outflows and assess the need for improvements to address both the changing conditions of the upper Great Lakes and the evolving needs of the many interests served by the system (**Report 2** of the Study, to be completed in early 2012).

Figure 1 illustrates the area covered by the Study.

Figure 1
International Upper Great Lakes Study Area

2. Changing Water Levels in the Upper Great Lakes: Key Science Issues

From any perspective – economic, social or environmental – the Great Lakes are of tremendous importance to Canada and the United States.

The Great Lakes region is home to millions of people who depend on the lakes as the largest single source of surface freshwater in the Western Hemisphere. The Great Lakes support rich ecosystems and diverse animal and plant species and are the foundation of major industries such as manufacturing, shipping, tourism, power generation and commercial fishing. Many Native American communities and First Nations rely on the natural resources provided by the Great Lakes to meet their economic, cultural, medicinal and spiritual needs.

The upper Great Lakes basin stretches from the headwaters of Lake Superior all the way downstream to Niagara Falls, an area of about 686,000 square kilometres (265,000 square miles). The upper Great Lakes system encompasses Superior, Michigan, Huron (including Georgian Bay) and Erie, and the connecting channels of the St. Marys River, the Straits of Mackinac, the St. Clair River system (consisting of the St. Clair River, Lake St. Clair and the Detroit River), and the Niagara River. (For the purposes of this Study, Lakes Michigan and Huron are considered a single lake because they have the same surface water elevation due to their shared connection to the broad and deep Straits of Mackinac. In addition, Lake Erie was included in the Study, given its importance in determining the water levels in Lake Michigan-Huron.)

For all of its vastness and timeless beauty, the Great Lakes region is always changing.

Many features of the Great Lakes region – its lakes, connecting channels, lake beds and river beds, water levels and flows – are continually changing over periods of days, decades and millennia. Sometimes the changes are subtle, other times dramatic.

Behind these changes are complex natural and human-caused forces. Depending on the location, these forces can include:

- changes in the flows of connecting channels (such as the St. Clair River);
- changing patterns of rainfall, snowfall, runoff and evaporation; and
- the rising and falling of the earth's crust from the removal of the weight of the glaciers that covered the Great Lakes region during the last ice age (known as glacial isostatic adjustment).

2.1 Water Level Trends

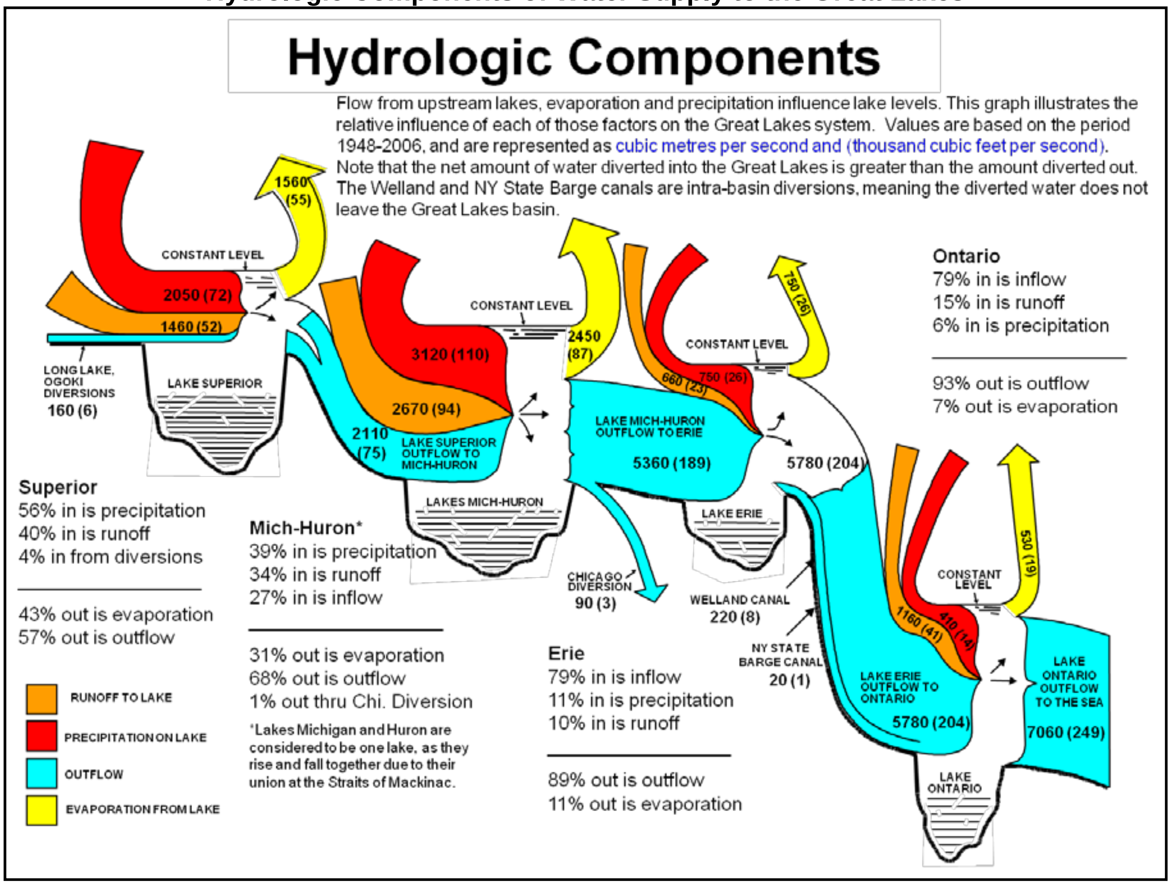
The most obvious sign of continuous change in the Great Lakes is their fluctuating water levels.

In general, Great Lakes water levels depend on the storage capacity of the lakes, the outflow characteristics of the connecting channels, and the water supply received by each lake. Figure 2 illustrates the major components of the hydrologic system. Water enters a lake by way of precipitation, runoff from its drainage basin, diversions, and inflow from the lake or river upstream. Water leaves a lake through evaporation, diversions and outlets to the downstream lake. All of these processes vary over time.

Data for water level measurements prior to about 1860 do not exist, though scientists have suggested that significant changes in water levels have occurred across the region over the past several thousand years. The records of the past century indicate that there were record low water levels during the late 1920s and

1930s and again in the mid-1960s. Record high levels were seen in the early 1950s, in 1973, and again in 1985-1986. In the late 1990s, a nearly 30-year period of above-average water level conditions in the upper Great Lakes ended. Since then, Lake Michigan-Huron and Lake Superior have experienced lower than average lake level conditions, with Lake Superior establishing record lows in August and September of 2007.

Figure 2
Hydrologic Components of Water Supply to the Great Lakes



2.2 The Role of the St. Clair River

Recent concerns about low water levels in the upper Great Lakes have focused in part on the important role that the St. Clair River plays in the basin.

With the immense storage capacities of the lakes, in combination with the relatively small capacity of the outflow channels, the upper Great Lakes system is largely naturally regulated. Large variations in water supplies to the basin can be absorbed relatively easily by the lakes, with the outflows remaining remarkably steady compared to the range of flows in other large river systems in the world. The large size of the lakes also means that extremely high or low levels and flows can persist for a considerable time even after the factors that caused them have changed.

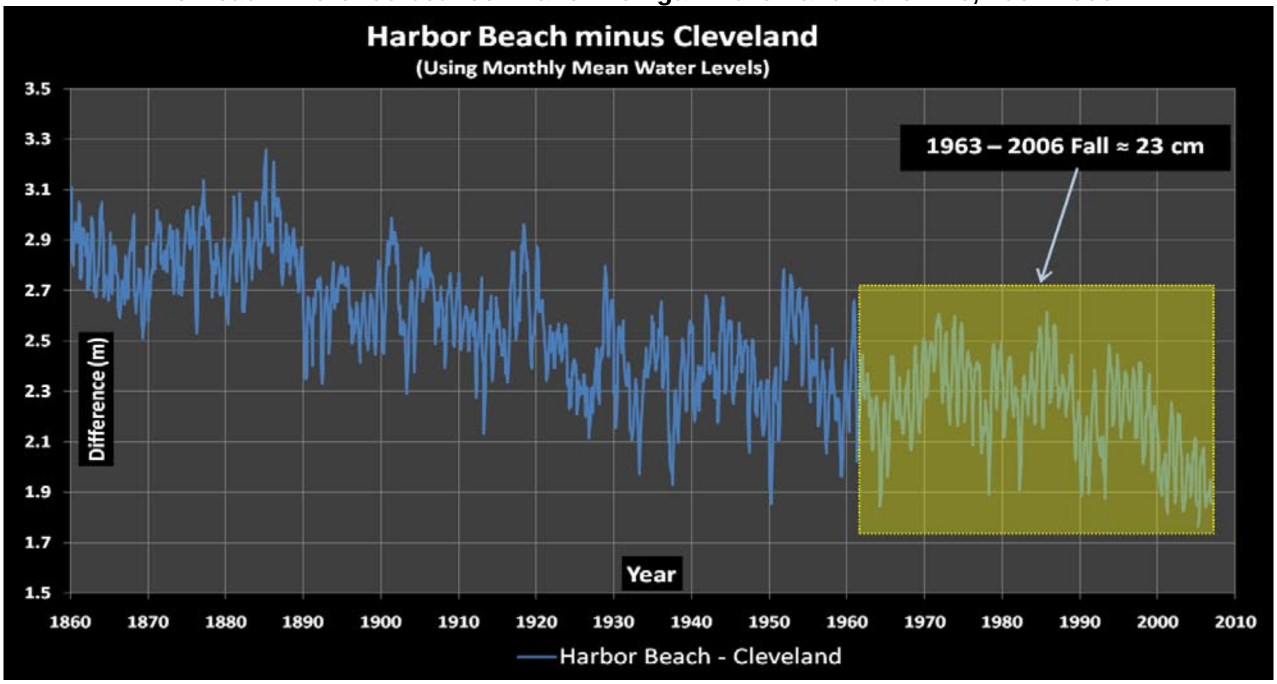
Canada and the United States have only a very limited ability to regulate lake levels in the upper Great Lakes – on the St. Marys River, where the International Joint Commission has regulated Lake Superior outflows within certain ranges since 1921, when authorized control works were completed.

This limited capacity to regulate flows in such a huge basin means that the natural flow from Lake Michigan-Huron to Lake Erie through the St. Clair River, Lake St. Clair and the Detroit River is a key factor in determining water levels of the upper Great Lakes.

What drives the flow of the St. Clair River is the difference in the levels of Lake Michigan-Huron and Lake Erie (known as the ***head difference***).

Figure 3 illustrates this difference from 1860 to the present day. This head difference has changed considerably over time and fluctuates significantly from year to year. Records of annual mean water levels (recorded at Harbor Beach, Michigan on Lake Huron and Cleveland, Ohio on Lake Erie) show that the head difference between the two lakes was about 2.9 metres (9.5 feet) between 1860 and 1880. The difference then decreased sharply through the turn of the century and generally continued to decline for more than 100 years. In 2008, the head difference was about 1.9 metres (6.2 feet). From 1963 to 2006, there was a 23 cm (9 inches) decrease.

Figure 3
The Head Difference between Lake Michigan-Huron and Lake Erie, 1962-2006



2.3 Concerns about Low Lake Level Conditions

For the past decade, low lake level conditions have been a serious concern for commercial shippers, property owners, recreational boaters, Native Americans, First Nations and others across the upper Great Lakes basin.

Persistently low water levels in the basin can:

- reduce a ship's capacity to transport the maximum cargo the vessel was built for, requiring more voyages and increasing operating costs, which are ultimately passed on to the consumer in the form of higher prices;
- increase the risk of a ship going aground and being damaged, which translates into increased costs and delays while the ship is being repaired;

- affect wetlands by damaging habitats and reducing the diversity in plants and animals supported by these habitats;
- lead to increased pumping and water treatment costs for municipalities along the lakes;
- affect shore-wells, a primary source of water outside of urban areas;
- expose shore protection infrastructure;
- expose the shoreline to muddy bottom lands, rocks, or shoreline sedimentation;
- limit access to lakefront property by owners and emergency boats; and
- impede accessibility to marinas, docks and boat ramps, thus restricting recreational boating and other tourism activities.

In 2005, a study investigating the causes of low water levels in Lake Michigan-Huron, commissioned by the GBA Foundation (a charity that carries out research and education projects related to Georgian Bay), was released. Commonly known as the Baird Report, this study identified three possible causes for what it called the "ongoing and significant drop" in the difference in water levels between Lake Michigan-Huron and Lake Erie:

> "The possible causes included: glacial rebound; a shift in the relative net basin supplies (NBS) making the E (Erie) basin wetter than and MH (Michigan-Huron) basin; and erosion of the St. Clair River bed. Based on the review, glacial rebound was found to be negligible compared to the total drop, the NBS shift was found to be unsubstantiated, and the primary cause of the drop in MH lake levels is due to river bed erosion, particularly across a relatively short section, between the Fort Gratiot and the Mouth of the Black River water level gauges, at the upstream end of the river."[1]

The findings of the Baird Report prompted the International Joint Commission to revise its original Plan of Study of Lake Superior outflow regulation to include an examination of possible ongoing physical changes in the St. Clair River from natural and man-made causes, and their effects on lake levels.

[1] The Baird Report is available at: http://bit.ly/J7f45

2.4 Understanding Changing Water Levels: Contributing Factors

To understand what is affecting the upper Great Lakes water levels, three important factors need to be understood:

- Has the St. Clair River changed as a result of natural forces or human actions, resulting in lower water levels on the upper Great Lakes?
- What is the effect of climate variability and climate change?
- What is the effect of glacial isostatic adjustment?

2.4.1 Understanding the Changing St. Clair River

Natural and human activities can change the conveyance of the St. Clair River.

The St. Clair River system connecting Lake Michigan-Huron to Lake Erie is 156 kilometres (97 miles) long. No single section of the river plays a dominant role in determining the system's flow. Rather, the flow depends primarily on the force of gravity – driven by the water level of Lake Michigan-Huron at its southern end where the St. Clair River begins and the head difference between Lake Michigan-Huron and Lake Erie.

Historically, the St. Clair River monthly mean flows during the open-water season have varied within 20 to 30 percent of the average discharge of 5,150 cubic metres/second (181,900 cubic feet/second). The river is subject to a range of physical forces, both natural and human-caused, that can contribute to changes in its conveyance.

Natural forces can include: sedimentation and bed erosion (the ongoing movement of sediment in rivers and lakes); aquatic vegetation growth or decline; and seasonal ice cover and ice jams.

The St. Clair River channel has been changed by human activities many times since the mid-1800s. More than 100 years ago, there was dredging for navigation and sand and gravel mining. While sand and gravel mining ended in 1926, the last major deepening of the navigation channel was completed in 1962. Maintenance dredging has been carried out periodically since 1962 to maintain sufficient depths for navigation. Other human activities that can affect the river's natural flow include the construction of bridges, piers and shoreline protection works.

Key science questions:

Has the "morphology" (the shape and composition of the river bed) of the St. Clair River been altered since the 1962 dredging? Specifically,

- *Is the St. Clair River bed stable or eroding?*
- *If the bed of the St. Clair River is eroding, what initiated it, and when?*

What is causing the declining head difference between Lake Michigan-Huron and Lake Erie? Specifically,

- *Has the "conveyance" of the St. Clair River changed since the 1962 dredging?*
- *If the conveyance has changed what were the causes?*

2.4.2 Understanding the Effects of Climate

Climate directly affects water levels in the upper Great Lakes.

Contributing climatic factors include the amount of: precipitation the lakes receive and when; water the lakes receive through runoff from their drainage basins; water lost through evaporation; and the extent and timing of ice cover on the lakes and connecting channels.

Over the long-term, regional climatic patterns affect the amount of water that can be stored in or released from a lake. In the past, water supplies to the upper Great Lakes basin have varied considerably, over periods of years, centuries and longer. Periods of higher and lower water supplies can be expected in the future due to climatic variations.

Beyond these variations in climatic patterns are the still-uncertain implications of global climate change, particularly the effects of a changing climate at the regional level.

Key science question:
- *How has climate affected the change in lake level relationship between Lake Michigan-Huron and Lake Erie?*

2.4.3 Understanding the Effects of Glacial Isostatic Adjustment

The uneven shifts in the earth's crust as it rebounds from the last period of continental glaciation affect levels and flow of water throughout the Great Lakes basin.

During periods of continental glaciation, the last of which ended in North America only 10,000 years ago, the weight of the glaciers depressed the earth's crust. During the last glacial era, the ice in some areas north of the Great Lakes in Canada was as much as three kilometres (1.9 miles) thick. When the glaciers retreated and melted, the earth's crust, relieved of this weight, began to rebound.

This process, called glacial isostatic adjustment, continues today, though at different rates across the Great Lakes basin. Glaciers were thicker and remained longer over the areas that later became the northern and eastern portions of the Great Lakes basin. As a result, the basin's northeasterly area (including Georgian Bay) is rising. In the southern portion of the basin, the unconsolidated material left by the glaciers is compacting over time and the land is sinking.

These uneven shifts in the earth's crust, in turn, affect levels and flow of water in the Great Lakes basin. For example, water levels on the northern and eastern shores of Lake Michigan-Huron appear to have receded or declined over time, while water levels on the southern and western shores appear to have risen. Table 1 lists the effect of glacial isostatic adjustment at selected locations in the Great Lakes basin since 1962, and illustrates how the effect can vary widely across the basin.

Key science questions:
- *What portion of the change in head difference is attributable to glacial isostatic adjustment?*
- *What role, if any, does this adjustment have with respect to changing relative water levels in the upper Great Lakes?*

Table 1
Effects of Glacial Isostatic Adjustment at
Selected Locations in the Great Lakes Basin, 1962-2006

Location	Change in Earth's Crust as a Result of Glacial Isostatic Adjustment
Georgian Bay area (Parry Sound)	+ 11 cm (4.3 inches)
Lake Michigan-Huron outlet	0
Milwaukee, WI	- 6 cm (2.4 inches)

3. The St. Clair River Study

3.1 Study Approach

Canada and the United States established the St. Clair River Study to answer these key science questions.

The International Joint Commission appointed a 10-member bi-national Study Board to be responsible for the Study's overall planning and management. Members were drawn from the two federal governments, state and provincial governments, and universities.

The St. Clair River Study accounted for about 25 percent of the Upper Great Lakes Study's total five-year budget of $17.5 million (CDN) or $14.6 million (US). The costs are shared equally by the United States and Canadian governments.

Over the past two years, more than 100 scientists and engineers from governments and academia in both countries have worked together to plan and undertake the necessary investigations, analyze the results, and prepare the Study's findings and recommendations. Their work drew on many disciplines, including engineering, hydrology, hydraulics, geology, sedimentology, physics and climatology.

The Study's investigators addressed the science questions from three distinct but inter-related perspectives:

- ***sediment (morphology)***, examining the sediment processes in the St. Clair River to determine whether the river bed is eroding or stable;
- ***hydraulic***, focusing on understanding the relationships between levels and flows of the St. Clair River, and how changes in the river bed have affected the river's conveyance and ultimately water levels in the upper Great Lakes; and
- ***hydroclimatic***, examining the components in the water balance – precipitation, evaporation, runoff and other factors – to determine what portion of the observed changes in water levels is due to changes in basin water supplies.

Study teams took care in assessing the quality of historical data and undertook additional field data collection programs using the latest available technology. They also carried out extensive modelling work using state-of-the-art models. For example, several one-dimensional (1-D) and two-dimensional (2-D) hydraulic models were used to provide a high level of confidence in determining whether the St. Clair River's conveyance has changed. The Study determined that the application of a three-dimensional model was not required, because 1-D and 2-D models adequately addressed the Study's primary question regarding conveyance change.

3.2 Public Information and Engagement

The Study includes a comprehensive public information and engagement program.

The International Joint Commission is committed to ensuring that Study's management board and teams of investigators understand the concerns of the various interests in the region, and that people and organizations affected by changes in water levels in the upper Great Lakes are well informed and provided opportunities to make their views known.

As part of this effort, the Commission established a bi-national Public Interest Advisory Group, with members drawn from a wide range of public groups with an interest in the Great Lakes. The co-chairs of the group, one Canadian and one American, serve as members of the Study Board.

This Advisory Group assists the Study in organizing and conducting public meetings and workshops, and in preparing newsletters and related public information documents. Members also serve as liaisons to technical work groups.[2]

3.3 Independent Peer Review

The International Joint Commission recognized the need to ensure that the Study was scientifically credible and accountable at all stages.

Scientific credibility and accountability are essential to the Study's success, given the diverse public and private interests concerned about Great Lakes water levels, the complexity of many of the scientific and

[2] Information on the members and activities of the Public Interest Advisory Group is available at website of the International Upper Great Lakes Study: www.iugls.org

engineering studies required, and the uncertainty and debate around some of the scientific issues.

As a result, the International Joint Commission contracted with the Environmental and Water Resources Institute of the American Society of Civil Engineers and the Canadian Water Resources Association to review the work plans and products of the Study. Over the duration of the St. Clair River Study, these national organizations have provided independent experts to review methodological reports, scientific studies and synthesis documents. The peer review groups operate independently of the Study and provide their views directly to the International Joint Commission.[3]

4. Preliminary Findings and Recommendations

The Study has greatly advanced the understanding of how the St. Clair River works and the forces that have changed it.

The Study has identified preliminary findings and recommendations based on the analyses and integration of extensive data collection and modelling work in the three focus areas of sediment transport, hydraulics and climate. The results represent a significantly improved level of understanding of the St. Clair River – its geology, its sediment transport, its flow, and its effect on water levels in the upper Great Lakes. The Study has brought into focus how various natural forces and human activities have changed the St. Clair River since 1962.

4.1 Accounting for the Changes in Water Levels

Three key factors have contributed to the 23 cm (9 inch) decline in head difference between Lake Michigan-Huron and Lake Erie between 1963 and 2006.

The Study estimates that there was a decline in the head difference of 23 cm (9 in) between 1963 and 2006. The Study also concludes that the decline in the head difference is not the result of any single factor. Rather, several physical forces have combined to lead to the decline:

- a *change in the conveyance* of the St. Clair River – and particularly a relatively sudden change possibly caused by a major event or series of events in the mid-1980s – accounts for 10 to 12 cm (3.9 to 4.7 inches) of the decline in the head difference;
- *changes in climatic patterns* account for another 9 to 27 cm (3.5 to 10.6 inches); and
- *glacial isostatic adjustment* in the upper Great Lakes basin is responsible for 4 cm (1.6 inches) of the change.

Determining the total decline in head difference is not as simple as adding up the estimates of the three contributing factors. Estimates of the relative contributions of each of the three factors, and thus of the overall decline, are highly dependent on the choice of the time period being analyzed. Within the 1963-2006 timeframe, for example, there are several periods during which the decline was actually higher than 23 cm. However, the lower-bounded numbers provide a good approximation.

[3]Information on the peer review process and peer reviewers is available at the ASCE-Environmental and Water Resources Institute website: http://content.ewrinstitute.org/committees/IUGLS.cfm

4.1.1 Changes in St. Clair River Conveyance

There was a change in the St. Clair River's conveyance – notably in the mid-1980s.

The Study's data and analyses confirm that there was a change in the bathymetry (the depth and width) of the bed of the St. Clair River. Using bathymetric data collected in 1971 and 2000, the Study concludes that the river bed changed sometime during this period, resulting in an enlarged channel and an increased conveyance of the river.

Overall, the modelling results indicate that an increase in the St. Clair River's conveyance accounts for about 10 to 12 cm (3.9 to 4.7 inches) of the decline in the head difference between Lake Michigan-Huron and Lake Erie between 1963 and 2006.

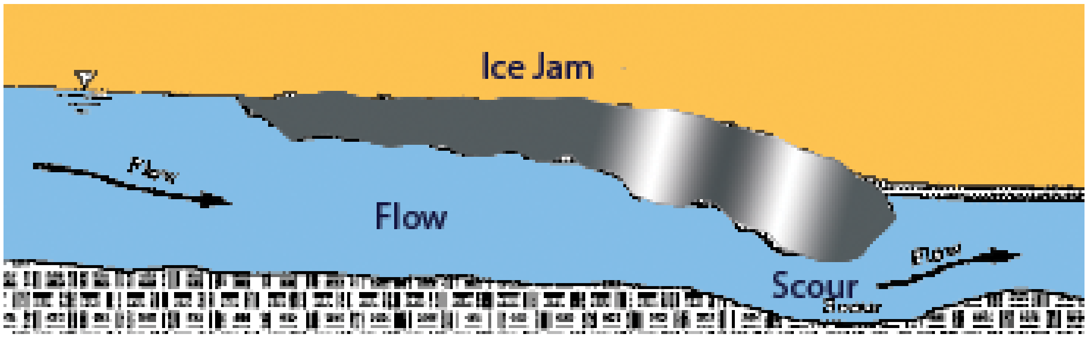
The changes in the river bed were not confined to a particular section of the river. Rather, analysis and modelling using data collected at water level stations along the St. Clair River indicate that there was a change in conveyance in several reaches in the river. In some of these reaches, conveyance increased over time, while in others conveyance decreased.

The findings also suggest that the St. Clair River's conveyance likely increased relatively rapidly in the mid-1980s, possibly as a result of an episodic event or series of events. Study investigators identified a possible cause of this change: a major ice jam on the St. Clair River in 1984. Ice jams can temporarily increase the force of the water's flow over a river bed by forcing the same volume of water to flow through a much smaller, constricted channel. Upstream of an ice jam, the flow discharge is significantly reduced and water tends to back upstream. Under the ice jam itself, the more rapidly moving water can trigger river bed scouring and subsequently deposition of sediment downstream. Further erosion occurs when the ice jam breaks up, as the sudden surge of released water erodes sediment from the river bed (Figure 4).

The St. Clair River ice jam of 1984 started in April and lasted for a month, trapping a number of large vessels. It remains the worst ice jam ever recorded on the river. The ice increased the water level on the river north of Port Lambton for more than 34 kilometres (21.3 miles), causing local flooding and backing up water into Lake Michigan-Huron, and reducing the river's month-to-month flow by 45 percent. Hydraulic modelling done as part of the Study suggests that the surge resulting from the breakup of the 1984 ice jam along the St. Clair River could have resulted in increased shear stress (the force of the water on the river bed) , leading to considerable transport of sediment along that reach of the river.

Extreme highs and lows in upper Great Lakes water levels in the mid-1980s could have played a role in the relatively rapid change in the river's conveyance, as well.

Figure 4
Ice Jam Effects



4.1.2 Changes in Climatic Patterns

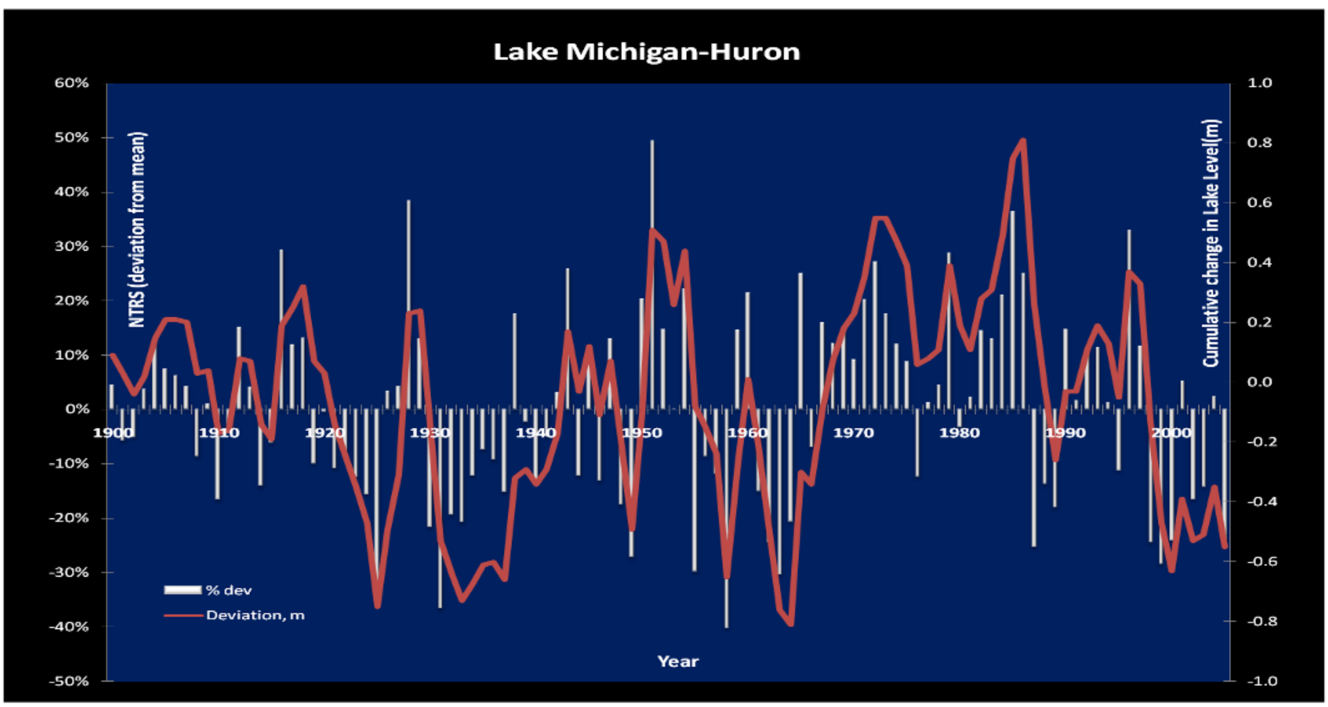
Climate has been the single most important factor in the decline in head difference between Lake Michigan-Huron and Lake Erie since 1996.

The Study's extensive hydroclimatic measurement and modelling indicate that declining supplies of water reaching the lakes – primarily as a result of reduced rainfall and snowfall in the basins of Lake Superior and Lake Michigan-Huron – account for 9 to 27 cm (3.5 to 10.6 inches) of the decline in the head difference between Lake Michigan-Huron and Lake Erie since 1962. The effects of climate vary depending on the time intervals used within the 1962-present timeframe, and thus the wide range in estimates.

Figure 5 illustrates the deviation each year from annual mean net total water supplies to Lake Michigan-Huron and the corresponding cumulative change in lake levels. Since 1996, this decline in water supplies has greatly contributed to the lowering of the water levels.

From 1962 to the mid-1980s, the Study concludes that it is likely that conveyance changes and climatic shifts were relatively comparable contributing factors in the declining head difference. In the late 1990s, however, a 30-year period of generally higher than average water supplies ended, and the influence of climatic patterns on the head difference increased dramatically. The Study estimates that declines in water supplies likely account for 75 percent of the lake-to-lake fall between 1996 and 2005.

Figure 5
Net Total Supplies of Water to Lake Michigan-Huron and Lake Levels
1900-2008



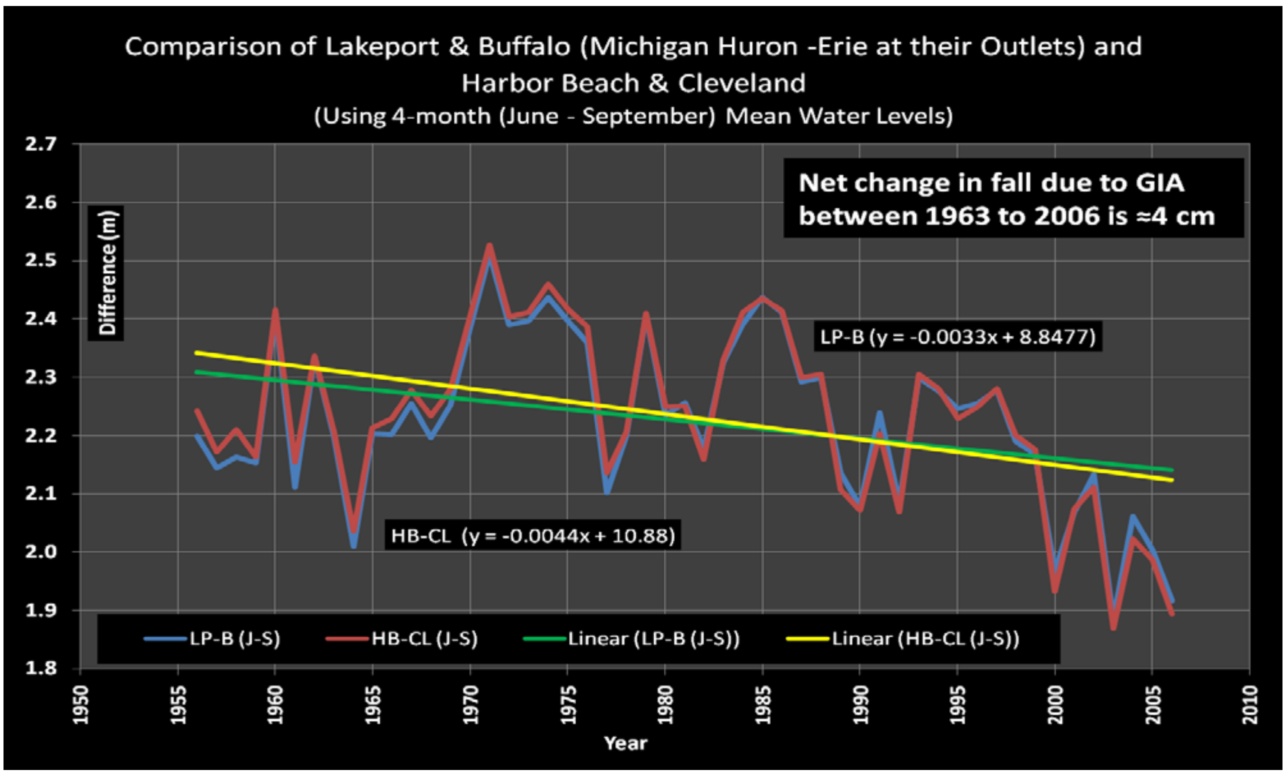
4.1.3 Glacial Isostatic Adjustment

Glacial isostatic adjustment is another factor contributing to the changes in head difference between Lake Michigan-Huron and Lake Erie since 1962.

The Study investigated whether the St. Clair River bed may be steepening as a result of glacial isostatic adjustment, thus tending to increase its discharge over time.

By comparing water level gauge information from stable gauges with those on Lake Michigan-Huron and Lake Erie, it was possible to determine the effect of glacial isostatic adjustment (Figure 6). The preliminary findings indicate that this adjustment is responsible for 4 cm (1.6 inches) of the 23cm (9 inches) fall between Lake Michigan-Huron and Lake Erie since 1962.

Figure 6
Effect of Glacial Isostatic Adjustment, 1963-2006



Note: The slopes of regression lines between the two pairs of gauges, Harbor Beach-Cleveland and Lakeport-Buffalo, were used to calculate the effect of glacial isostatic adjustment on the overall drop in the head difference since 1963, which is about 4 cm (1.6 in).

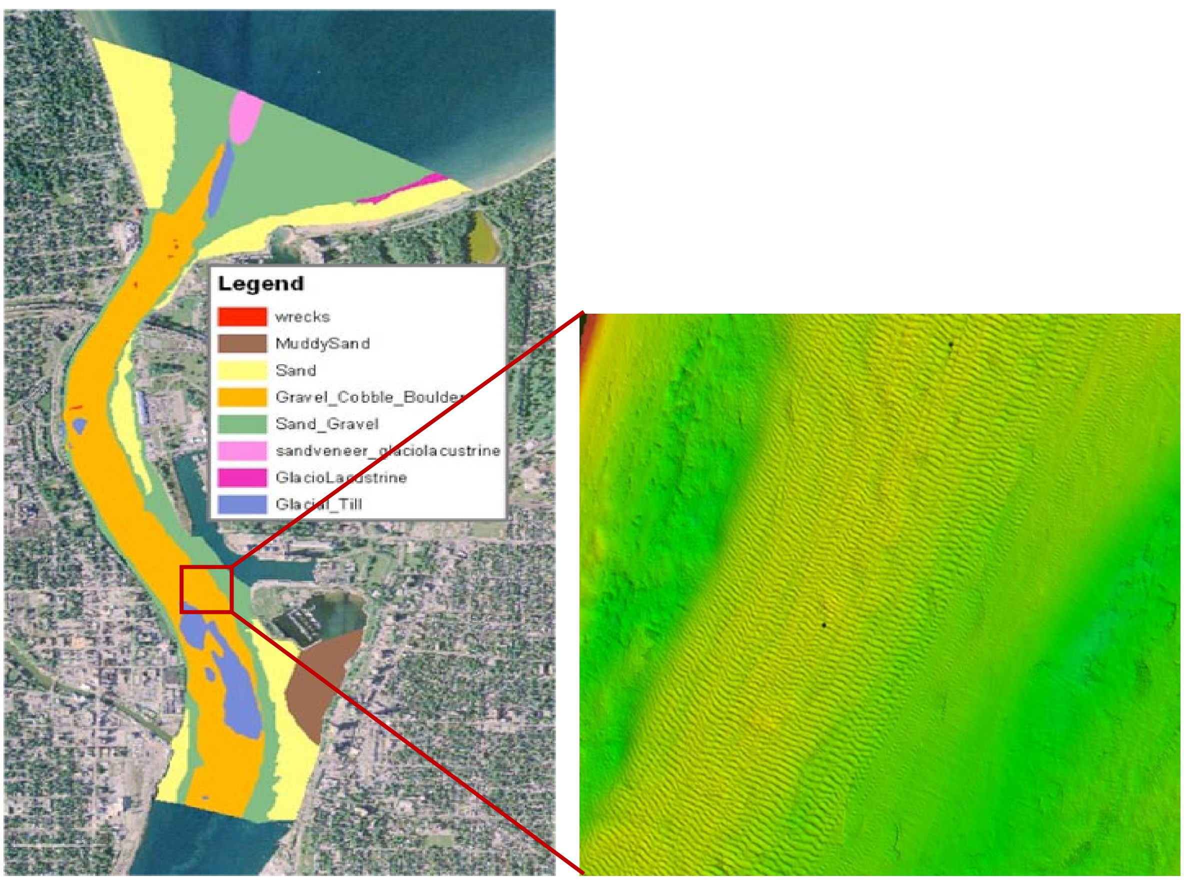
4.2 River Bed Erosion

There has been no ongoing erosion along the length of the St. Clair River bed since at least 2000.

A key finding from the range of studies of the sediment and hydrology of the St. Clair River is that the river bed has not experienced any ongoing erosion since 2000. Rather, the river bed appears to have been stable since at least 2000. In fact, the river bed may well have stabilized prior to 2000, but there is no way to tell for sure, given the lack of measurements between 1971 and 2000.

Using data collected with high resolution multi-beam technology, the Study's investigators were able to confirm that a majority of the upper river bottom consists of gravel-sized material (Figure 7). The investigators also confirmed that the capacity of the river to move gravel-sized material is extremely limited. Isolated instances of short-term scouring or deposition may occur in some spots along the river because of site-specific circumstances (e.g., sunken vessels and the propeller "wash" of large vessels). But this is not the same as erosion over an entire river reach, which would be needed to significantly affect the river's conveyance.

Figure 7
St Clair River Bed Material, and Mobile Bedforms, 2008



4.3 Remedial Measures

In accordance with its directive from the International Joint Commission, the Study analyzed options for remedial measures for the St. Clair River.

Where it has jurisdiction, the International Joint Commission can recommend that the United States and Canadian governments build remedial measures to address *past damages or adverse actions,* and mitigative measures to address *future actions* that might result in adverse effects.

As part of its mandate, the Study was directed to evaluate and recommend potential remedial options, depending on the nature and extent of changes and impacts in the St. Clair River. The Study reviewed past proposed remedial works and new innovative approaches to modifying flows in the St. Clair River. With this information, the Study identified a range of options that might be employed if remediation were deemed necessary. In addition, preliminary work was undertaken to determine the institutional, legal and environmental requirements that would have to be considered in implementing any of these options.

However, the Study's preliminary findings indicate that the change in the river's conveyance since 1962 is relatively small, given the scientific uncertainty associated with the various analyses and measurements. Furthermore, this change is not ongoing and past changes are likely attributable to natural forces and not human actions it. These findings suggest that remedial measures in the St. Clair River are not warranted at this time.

4.4 Effects of Long-Term Climate Change

Climate change has emerged as a critical but uncertain factor in the future of the upper Great Lakes.

Preliminary hydroclimatic modelling undertaken as part of the Study concludes that the effect of shifting climatic patterns is a significant factor in the changes in the head difference between Lake Michigan-Huron and Lake Erie.

Beyond the question of changing climatic patterns is the prospect of long-term climate change. There is general world-wide consensus among scientists that climate change, driven by increasing concentrations of greenhouse gases in the atmosphere, is occurring and will continue. In addition, the regional effects of climate change are expected to differ from one region to another. Understanding these regional effects is essential to the water management of the Great Lakes and to government and community efforts to reduce and adapt to climate change.

The second part of the Study, now underway, is examining current and emerging issues related to the regulation of Lake Superior. Its scope of work includes undertaking a comprehensive assessment of the implications of a changing climate on water supplies over the entire upper Great Lakes basin.[4]

[4] More information on the Lake Superior Regulation part of the International Upper Great Lakes Study is available at the Study's website: www.iugls.org

4.5 Study Board Recommendations

On the basis of the preliminary findings and the Study's mandate from the International Joint Commission, the Study Board recommends that**:**

1. ***Remedial measures not be undertaken in the St. Clair River at this time.***

2. ***The need for mitigative measures in the St. Clair River be examined as part of the comprehensive assessment of the future effects of climate change on water supplies in the upper Great Lakes basin in Report 2 of the Study, on Lake Superior regulation.***

5. Looking Ahead

The Study is seeking comments from individuals and organizations with an interest in the upper Great Lakes.

The release of the draft report, **Impacts on Upper Great Lakes Water Levels: St. Clair River**, is an important milestone in the International Upper Great Lakes Study. But there is considerably more work to be done:

- The draft report will be available for a 60-day period of public review and comment, to July 1, 2009. During this time, members of the Study Board and the Public Interest Advisory Group will host more than a dozen public meetings throughout the upper Great Lakes basin to explain the Study and its preliminary findings and to obtain feedback on the draft report from individuals and organizations with an interest in water level issues in the region.

- The Study Board and the Public Interest Advisory Group will review and consider all the public comments received.

- Over the summer, several Study project teams will be working to complete their final data collection and analysis, taking advantage, in some cases, of an additional season of field work to address specific issues. This work will include further investigations of the effects on the St. Clair River's conveyance of ice jams, navigation and shipping, and maintenance dredging.

- In the fall, the Study Board will finalize the report, incorporating comments from the public review and the independent peer review, and the results of the final modelling and analysis work. The final report on the St. Clair River then will be submitted to the International Joint Commission.

- The International Joint Commission will review the findings of the final report with the United States and Canadian governments and recommend a course of action.