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On Behalf of the
Great Lakes Commission

Field Hearing on *Lake Levels in the Great Lakes*
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Introduction

Madame Chairwoman Johnson, Congressman Kagen and members of the Subcommittee on Water Resources and Environment, I appreciate this opportunity to share the perspectives of the Great Lakes Commission on issues related to current low water levels on the upper Great Lakes and regional challenges related to prospective climate change. My name is Roger Gauthier and I am a Program Manager with the Great Lakes Commission and for the last two years have served as the Interim Executive Director of the Great Lakes Observing System (GLOS). I am also a retired hydrologist from the U.S. Army Corps of Engineers. In my current capacity, I oversee projects dealing with the collection, management and distribution of social, economic and environmental data for the Great Lakes – St. Lawrence River watershed.

The Great Lakes Commission is a public agency established by the Great Lakes Basin Compact in 1955 to help its members – the Great Lakes states and provinces – to speak with a unified voice and collectively fulfill their vision for a healthy, vibrant Great Lakes - St. Lawrence River region. To fulfill the mission of the Commission, a multi-jurisdictional approach is taken in the development of regional strategies to protect and maintain the ecological and economic health of the Great Lakes.

Water levels on the upper Great Lakes (Superior, Michigan and Huron), have been significantly lower than average over the last eight years. Water levels fell nearly four feet on lakes Michigan and Huron over a two-year period as a result of the record warm La Niña winter of 1999-2000. Water levels have remained in the lower third of each lake's historic range since then, with more incidences of severely low levels than the last major low water epoch, which occurred during the Dust Bowl era of the 1930s. The lakes have been retaining more heat energy over the last eight years than any period since records have been collected. This has caused below average ice cover, which in turn has increased evaporation rates from the lake surface, causing more water to be lost to the atmosphere.

Water levels on Lake Superior set a new record low in 2007 for the month of September. Similar new record lows on lakes Michigan and Huron were forecasted as distinct possibilities for this spring and summer. These forecasts have changed due to heavier than average snowfall across the region over the last 100 days. It is important to maintain a long-term perspective when considering fluctuations in Great Lakes water levels regardless of a seasonal shift of a few months or climatic variability over a few years. Short-term hydrologic changes need to be viewed in the context of longer term water level cycles and the potential of climate shifts caused by global warming.

Although the upper Great Lakes are currently undergoing protracted low water conditions adversely affecting the economic and environmental viability of the region, it is critically important to also remember that extreme high water level conditions persisted over the region for nearly 35 years starting in the early 1960s, causing a different set of economic and environmental losses. Adaptive approaches to water level change should focus on the resiliency of our coastal communities to withstand extreme high and low water level conditions alike.

Causative Factors

There are several factors that influence the water levels of the Great Lakes, including natural phenomena and human modifications to the hydrologic/hydraulic system. Natural phenomena are driven by movement of moisture entering the system as precipitation directly on the lake, runoff from surrounding land, direct and indirect groundwater recharge and inflow from the upstream lakes. Water leaves the system through evaporation from the land and water surface, transpiration from vegetation, consumptive uses (manufacturing, water supply, etc), diversions out of the basin, and outflows to downstream lakes, eventually out to the Atlantic Ocean.

Natural Factors

It needs to be made clear at the outset that the largest determinant factor in water level fluctuations is nature, not human activities. It has been said: “Man influences lake levels in a matter of inches and Mother Nature influences them in a matter of feet.” By far the largest natural factor effecting change in water levels are longer-term climatic factors including temperatures, precipitation and evaporation.

Over most of the last eight years, spring and summer rainfall has been substantially below average for most of the upper Great Lakes and near average over the Erie and Ontario watersheds. Snowfall over the northern latitudes, measured by airborne surveys on an annual basis, has been particularly below average, during periods when peak accumulation is expected. Substantially above-average surface water temperatures, measured from satellite observations for the last eight years, have caused significantly increased evaporation from the lake surface. One manifestation of these conditions is frequent “lake effect” snowfalls on the leeward side of the lakes.

Water level fluctuations on the Great Lakes are: a) short-term (hourly or daily) affected by winds and barometric pressure; b) seasonal (low in fall/winter, high in spring/summer); and c) long-term (occurring over decades). Recent paleo-geologic evidence indicates that extreme high water levels on the Great Lakes are cyclical with high water periods occurring every 30-35 years and extreme highs every 150-160 years. This evidence indicates that the Great Lakes region is an excellent indicator of changes that occur in global climate patterns over thousands of years.

The Great Lakes have experienced extreme high and low water levels over the last 135 years since water levels were first measured. Lake Superior’s historic water level range from extreme high to extreme low is nearly 4 feet, while the other lakes have historic ranges between extremes of 6 to 7 feet. Over the last 40-50 years, at the same time that a great deal of coastal community development has occurred across the system, these historic ranges were modified due to human activities.

Human Factors

Lake Superior outflows have been regulated since 1921 under increasingly more complex regulation plans. It should be stressed that levels on Lake Superior are controlled only to a minor extent; again the largest determinant being climate. Regulation has allowed a moderation of the levels on Lake

Superior, within limits that are dictated by nature, due primarily to the lakes' vast storage capacity. The regulation of Lake Superior outflows are authorized under the International Joint Commission's (IJC) 1914 Orders of Approval and supplemental orders of 1979. These Orders direct that the natural range of levels on Lake Superior be reduced from 3.9 feet to less than 3.0 feet, with compression eliminating the frequency of occurrences of extreme low water conditions. It is unknown what these changes have caused to nearshore processes and habitat characteristics across the lake.

Control of outflows from Lake Ontario is managed by the hydropower project in the St. Lawrence River near Cornwall, Ontario and Massena, New York. The IJC approved this project in 1952, with subsequent amendments, to provide dependable flow for hydropower, adequate navigation depths and protection for shoreline interests on Lake Ontario and downstream areas in Québec. Lake Ontario's natural range of 6.4 feet was reduced to less than 5 feet as a result of outflow regulation.

Existing diversions into, out of, and within the basin include: a) flow into Lake Superior through the Long Lac and Ogoki channels; b) flow out of Lake Michigan through the Chicago Diversion; and c) intrabasin flow between lakes Erie and Ontario through the Welland Canal. There are also some minor diversions that exist between lakes as a by-product of drinking water/wastewater systems. Flows within these diversions have been nearly constant over the last eight years without adversely affecting water levels on the upper lakes.

Channel Changes in the St. Clair – Detroit Rivers

The St. Clair River flows from the outlet of Lake Huron to a multi-channeled delta area at the upper end of Lake St. Clair, which in turn feeds into the Detroit River and subsequently into Lake Erie. Over the last few years, more evidence has been collected that changes at the head of the St. Clair River, acting as the outlet from the combined lakes Michigan and Huron, likely have caused major permanent changes in water levels on these lakes, and in turn on Lake Superior as a consequence of the current outflow regulation plan which "balances" levels between these lake systems.

There have been numerous alterations made to the St. Clair River – Lake St. Clair - Detroit River system since the mid-1800s, mainly to improve economic efficiencies of commercial navigation, but also for sand and gravel mining prior to 1930. These changes in the river affect its conveyance or capacity to carry water. Studies completed in the early 1960s for the IJC determined that all dredging, sand mining and other structural modifications in the St. Clair River since the mid-1800s have caused a permanent lowering of water levels on lakes Michigan and Huron water levels of between 13 -18 inches. The uncertainty within these estimates reflects imprecise estimates for dredging that occurred between 1855 and 1906 and sand mining through 1930.

The last major dredging project was completed in 1962 to deepen selected reaches of the St. Clair River from a 25-foot to a 27-foot navigation depth. This dredging occurred in the Lake Huron approach to the St. Clair River and further downstream (not in the river mouth near the Blue Water Bridge, connecting Port Huron, Michigan to Sarnia, Ontario). Prior to this dredging, it was determined that lakes Michigan and Huron would be permanently lowered by 5 inches (included in the 13-18 inch estimate above) as a consequence of the artificial channel modifications unless some form of remediation structures were placed on the bottom of the St. Clair River mouth immediately downstream of the Blue Water Bridge. This remediation was not constructed due in large part to high water levels that occurred on the upper Great Lakes for the next 35 years. It was also concluded that downstream levels on lakes St. Clair, Erie and Ontario would reach a new equilibrium within a few years and that these lakes would not see any permanent impact from the dredging project.

Recent questions dealing with erosion in the upper St. Clair River center on the difference in water levels between lakes Michigan-Huron and Lake Erie becoming smaller over time. This difference between elevations is referred to as “head difference.” The head difference is getting smaller since the mid-19th century, but there is considerable disagreement over why this is happening, which is the major emphasis of the current IJC International Upper Great Lakes Study (IUGLS). This study is expected to produce preliminary findings in spring 2009.

The causes of head difference are likely: 1) an increase in the size of the outlet; 2) decreased cumulative water supply to lakes Michigan, Huron and Superior; 3) increased cumulative supply to Lake Erie; 4) differential isostatic (post glacial) rebound upstream of Port Huron / Sarnia; 5) encroachment of the outlet of Lake Erie (construction into the Niagara River); and 6) isostatic rise of the Lake Erie outlet.

An analysis of the likely factors affecting the change in head difference was conducted in 2004 by W.F. Baird and Associates, a geocoastal engineering firm funded by the GBA Foundation, a Canadian charitable organization which funds environmental research and education. This initial report concluded that lakes Michigan-Huron have permanently dropped another 9 inches (beyond the historic 13-18 inches drop) from 1971 through 2000 as a consequence of various factors, with river bed erosion being the predominant driver. The "Baird Report" has been the subject of much controversy, warranting more scientific investigation. To that end, we support the efforts being undertaken by the IUGLS study team to examine the role of physical changes in the St. Clair River as one factor that might be affecting water levels and flows throughout the system.

Hydrographic surveys of the upper two to three miles of the St. Clair River were conducted in 1971 and 2000 by NOAA using conventional single beam surveys. The U.S. Army Corps of Engineers (USACE) conducted additional bathymetric surveys in 2002, 2005 and 2007, using a multibeam survey system, which provides greater density of observations to detect subtle bottom characteristics. All surveys have inherent sampling errors, but multidate comparisons reduce cumulative errors. Comparison of the 1970 and 2000 NOAA surveys show that significant erosion of the river bottom (9-12 feet) has occurred immediately downstream of the Blue Water Bridge, with a cumulative increase in channel volume over time. The USACE surveys from 2002 through 2005 show that increases in channel volume were still occurring in the upper St. Clair River for this period.

Historic surveys conducted in 1859 show that depths at the mouth of the river were only 5-10 feet. The river near the Blue Water Bridge is now over 30 feet deep with significant sections that are over 60 feet deep. The historic surveys indicate that the river mouth has been naturally enlarging over the last 150 years as a consequence of extremely high flow velocities and erosive bed characteristics. This is an important insight as conventional wisdom had considered the outlet to be "stable." The outlet from Lake Huron has been enlarging by natural forces for over 4,000 years, an extremely short geologic period. The river is still evolving. Studies on the detailed stratigraphy (bottom composition) at the outlet have never been conducted, although seismic surveys of the river bed are planned to be conducted this summer under the IUGLS, which should provide invaluable insight on the complexity of the problem. More detailed geophysical surveys at the Lake Huron outlet are still critically needed.

Changes in water supplies to the lakes Michigan-Huron and Lake Erie watersheds could account for some of the decline in head differences between these lakes. The upper lakes (Michigan-Huron) could have been disproportionally drier over the last four decades than over the Lake Erie watershed. The magnitude of this factor is debatable, however, due to substantial uncertainties in the computation of water supplies to these lake basins.

Isostatic rebound is the continual imperceptible slow rise of the Earth's crust after the removal of the weight of the nearly two-mile high glaciers that left the region between 14,000 and 7,000 years ago. Isostatic rebound differs over time and space across the region, with the southernmost parts of the basin now encountering negligible rises and the northeastern portions of the Lake Superior watershed rising nearly 17-inches per century. Changes in the outlet from Lake Erie into the Niagara River also could affect the head difference between lakes Michigan-Huron and Erie. Prior IJC studies have identified that the head of the Niagara River has been "encroached" by the construction of structures (Peace Bridge, Railroad Bridge, etc) and infilling along the Canadian shoreline. Isostatic rebound at the Lake Erie outlet could also hold more water back on Lake Erie. Cumulatively these impacts were considered in the Baird report to be a minor fraction of the measured head difference.

<u>Climate Change</u>

There is growing evidence that regional climate variability is already altering the Great Lakes, most noticeably since 2000. Whether this climatic shift is a direct consequence of global warming is still debatable. Ice cover since 2000 has diminished conspicuously as a consequence of increases in heat retention within the lakes. According to a recent study from the University of Minnesota - Duluth, summer water temperatures in Lake Superior are warming faster than air temperatures across the region. In contrast to rising sea levels on ocean coasts, water levels along Great Lakes coasts are expect to decline below historic low levels, while climate change impacts will likely occur quicker over the lakes than on the ocean coasts. The majority of global climate models indicate that the Great Lakes region will be warmer and dryer due to global warming. Since the Great Lakes – St. Lawrence River drainage basin covers a vast portion of the mid-latitudes of the continent, changes in water storage can act as the "canary in the coal-mine" to detect larger and more global shifts in climate.

Changes in heat retention of the lakes are not adequately measured. Observations are limited to those collected in nearshore waters at municipal water intakes or through intermittent shipboard surveys. Regional-scale climate models, driven by systematic observations of heat retention, are of critical importance. This information would help the region identify and adapt to climate shifts affecting: public health (quality of drinking water supplies, swimmability of public bathing beaches); integrity of coastal wetlands; sustainability of the $4 billion per annum sport and commercial fishery; hydropower production; and recreational boating opportunities for a $16 billion per annum industry.

Ecological and Economic Impacts of Extreme Levels

The economic and environmental consequences of the current eight years of low water are vast and not well understood. Current funding to support this type of research is inadequate. A combination of biological, chemical and physical factors has degraded the ecologic balance of the Great Lakes system, with the current low water conditions amplifying some of these problems. Several leading regional scientists have reported that the lakes have reached a dangerous "tipping point," with massive irreconcilable losses expected in the near future if nutrient and contaminant loadings and invasive species introductions cannot be controlled. Recently fundamental shifts have occurred in cycling of nutrients in some of the lakes, including declines in phosphorus concentrations, plankton abundance and numbers of forage fish, all of which could be adversely affected by low levels.

The Great Lakes - St. Lawrence River system has long been the primary route of efficient transport of goods and raw materials into the heart of the North American Continent. Nearly a quarter of the U.S. top 150 commercial harbors are located within the system, serving a region that supports 40 percent of the nation's manufacturing industry and 25 percent of the national economy. Lower water levels increase the costs of shipping on the lakes requiring "light loading," potentially forcing a modal shift to rail or other means, increasing energy costs and reducing the economic competitiveness of the region. Improved short-term forecasts of conveyance in the interconnecting waterways are becoming more crucial under the current low lake level period.

Low levels have decreased hydropower production across the region which can reverberate throughout the U.S. and Canadian economies driving up energy costs and raising the specter of local "brown-outs." Lower levels also cause deterioration of wooden shore structures such as pilings and supporting structures now exposed to air, posing additional economic challenges for coastal communities. Regional climate change scenarios predict warmer winters and more extreme precipitation events, which can increase slope failure and bluff retreat, causing losses to residential riparian properties. The costs to remediate these impacts are currently unknown but could be staggering. These anticipated impacts make observations and modeling of changes in thermal structure, lake circulation and physical processes all the more critical.

Policy Responses

The Great Lakes Commission in its Legislative Priorities for FY 2009, released at Great Lakes Day on Capitol Hill in February 2008, called for several strategic investments from Congress to help adapt to current conditions on the Great Lakes. I would like to elaborate on some of these priorities which would help to protect the hydrologic integrity of the Great Lakes – St. Lawrence River system.

A fundamental mandate of the Great Lakes Commission is to foster informed use, management and protection of Great Lakes water resources. Foremost at the moment are concerns about water withdrawal, consumption, diversion, and export of our vulnerable water resources. The effective use, management and protection of Great Lakes basin water resources is a shared responsibility of jurisdictions at all levels of government, with states and provinces as primary stewards. The Commission supports full and open consultation and communication among all affected jurisdictions.

The Great Lakes Commission has consistently supported implementation of the provisions of the 1985 Great Lakes Charter and adoption of its successor, the Great Lakes-St. Lawrence River Basin Water Resources Compact. Once this Compact has been adopted by the eight Great Lakes states, we urge Congress to ratify the accord. The Compact is the best means available to assure that water quantity is managed for the long-term benefit of the region’s economy and ecology. Regardless of the causes and consequences of current low water levels, the Compact will protect the resource from deleterious diversions outside the basin. It will usher in a new era of decision-making based on the best science available for large scale water withdrawal and consumptive uses within the basin. It will position the Great Lakes region as a leader in fresh water conservation and multi-jurisdictional policy and management to assure adequate supply for future generations.

The Commission has also pushed for comprehensive and integrated monitoring and analysis tools to assess cumulative effects of water uses and their impacts on regional ecosystem viability and economic sustainability. The Commission is committed to managing and maintaining the Great Lakes Regional Water Use Database – established under the 1985 Charter – and has offered its expertise and resources to serve the states and provinces to meet the evolving needs of the region in the area of water use, information management, science, conservation and efficiency.

The Great Lakes Commission has passed resolutions calling on Congress to fund investigations related to reducing economic and environmental damages occurring as a consequence of current low water level conditions on the upper Great Lakes. These resolutions specifically address the need for both U.S. and Canadian federal governments to fully investigate whether outflows from Lake Huron through the St. Clair River have increased as a direct consequence of man-made and natural channel enlargements, to initiate investigations of potential remedial measures to compensate for historic conveyance increases, and to complete comprehensive three-dimensional modeling of the interconnecting waterways between the lakes.

The Great Lakes Commission has also consistently championed maintenance of the Great Lakes water level gauging stations, managed by the National Oceanic and Atmospheric Administration (NOAA). This network is essential for supporting regional information needs on lake level changes. The Commission has also coordinated development of GLOS, the regional component of the U.S. Integrated Ocean Observing System, which will improve monitoring of Great Lakes conditions including climate change.

Further information on the policy considerations highlighted above can be found at http://www.glc.org/restore/ and at http://www.glc.org/about/resolutions/. In addition, we provide the following specific and general options for Congressional involvement to better understand and address the economic and ecological consequences of changes in the hydrologic and hydraulic regimes across the Great Lakes – St. Lawrence River system.

Specific options

1. Enact ocean observing authorizing legislation and fund regional initiatives and assure proportional funding to the Great Lakes

Background:

The U.S. House of Representatives passed the National Integrated Coastal and Ocean Observing Act (H.R. 2342) on March 31, 2008. The Act would create the U.S. Integrated Ocean Observing System (IOOS) that will monitor and forecast ocean, coastal and Great Lakes conditions, and provide that information in forms that are accessible and understandable by the people who depend on that information for their livelihood, security and enjoyment. Companion legislation (S. 950) has been introduced in the Senate, which is similar to legislation passed in the 109th and 108th Congresses.

This important authorizing legislation has three purposes: 1) development of IOOS to ensure that societal goals dealing with economic development and ecological sustainability are addressed; 2) implementation of regional associations representing non-federal collaborators and end users (states, academic institutions, non-governmental organizations and trade organizations) to densify observations and generate products that meet user requirements; and 3) implementation of a data, information management and modeling system to develop an early warning system to more effectively predict and mitigate impacts of natural hazards, including climate change effects. These bills require that the system provide for long-term, continuous and quality controlled observations of the coasts, oceans and Great Lakes. The bills also establish NOAA as the lead federal agency for implementation and administration of IOOS and allows for certification and indemnification of regional association to extend functionalities beyond those already provided by federal agencies.

Funding for the IOOS program over the last three fiscal years has been modest for this national program ($30 million or less), with funding for regional associations only occurring last year at $18.3 million. The Great Lakes component of IOOS is represented by GLOS which has been chronically underfunded in this start-up endeavor. Congressional direction is needed to insure that geographic proportionality in funding occurs under the IOOS program and that the Great Lakes receives its proportional share of investment dollars.

The GLOS Regional Association has established a 10-year plan for improving monitoring systems across the region, with a high emphasis on improving climate predictions and adaptability, research on food web dynamics, protection of public water supplies and bathing beaches and improvements in safety and efficiency of commercial navigation and recreational boating. A key component of this plan is establishment of nearshore and offshore buoys to measure changes in heat storage of the lakes, as well as three-dimensional modeling for each of the interconnecting waterways.

- Promote passage of IOOS authorizing legislation (H.R. 2342 / S. 950) in conference with endorsement for long-term operations of regional associations including GLOS.

- Appropriate $95 million for the IOOS program in FY 2009, with at least $3.5 million directed toward implementation of GLOS regional observation/modeling components.

2. Fund development and application of three-dimensional hydrodynamic models for the interconnecting waterways, with initial emphasis on the St. Clair River

Background:

Stakeholders and modeling experts convened in 2005 at a meeting in Port Huron, Michigan arrived at a consensus that high resolution three-dimensional modeling is needed for the St. Clair and Detroit rivers and is applicable for the other interconnecting waterways (St. Marys, Niagara and St. Lawrence rivers). These models need to simulate and forecast plume tracking; (spill response and clean-up), riverbed movement (contaminated sediment transport/erosion studies), ice movement and corresponding flow dynamics and pathogen movement (adjacent to swimming beaches). The development of sediment transport / moving bed model functionality for the upper St. Clair River has been of particular concern. These tasks can be accomplished by providing consistent funding for GLOS for the next 4-5 years.

- Appropriate $95 million for the IOOS program in FY 2009, with at least $3.5 million directed toward implementation of GLOS regional observation/modeling components.

3. Initiate engineering studies to identify appropriate structural measures to retain water in the upper Great Lakes

Background:

Michigan Governor Granholm has requested that the USACE evaluate the potential effectiveness of structural measures previously proposed for the St. Clair River. The Great Lakes Commission has requested that the IJC, USACE and Environment Canada begin investigating mitigation measures to address permanent upstream lowering caused by historic dredging and other channel modifications prior to 1970. This permanent lowering of upstream levels has been acknowledged by both U.S. and Canadian governments. Preliminary design studies were completed in the early 1960s to install a series of submerged sills immediately downstream of the Blue Water Bridge. These measures were not implemented due to high water levels starting in 1965 which lasted for nearly 35 years.

The USACE has identified that it has the capacity to conduct engineering studies to design such mitigation structures but lacks appropriations to conduct this work. The USACE has stated that actual construction of mitigation works would require agreement by the federal governments of the U.S. and Canada, likely under the auspices of the IJC. The essential issue is that these engineering studies should be conducted concurrent with scientific and policy investigations already underway.

Design of underwater mitigation measures should include a series of options depending upon the degree of channel constriction needed and long-term flexibility required. Long-term flexibility is warranted to guarantee that these structures could be removed or disabled when future high water supply occur upstream. Design of such structures would require that three-dimensional flow models be constructed and validated for moving bed dynamics for the head of the St. Clair River addressed in an earlier recommendation. The decision to implement any of the engineering solutions should be made only after bi-national consultation with the affected states and provinces, likely under the auspices of the IJC.

- Appropriate $3.0 million in FY 2009 under Energy and Water appropriations to the USACE to identify engineering design options.

<u>General options</u>

Current water levels on lakes Michigan and Huron are eight inches lower than the "low crisis threshold level" identified in the 1993 Great Lakes Levels Reference Study Report to the IJC. This earlier study called for initiation of control measures to reduce St. Clair and Detroit River channel capacities through construction of underwater sills near the head of each river course. In fact, water levels on these lakes have been below the crisis threshold more than fifty percent of the time over the last eight years. The current IJC study does not include any investigations on implementing crisis response measures identified by the prior study team.

Construction of any structural measure to retain waters on the upper Great Lakes will require binational consensus on acceptable environmental consequences and socio-economic impacts of limited outflow control from Lake Huron, including potential consequences downstream on lakes St. Clair and Erie. These activities are within the mandate of the IJC. Congress should request that the

Administration consult with Canadian counterparts to assure that the IJC has the authority and resources to address economic, environmental and social consequences of implementing partial control of Lake Huron outflows as a crisis response measure.

In addition, research on the economic implications of low water conditions on the Great Lakes has been exceedingly limited. This is an essential first step in defining benefits that could be achieved or losses mitigated by adaptive management policies that could be applied across the region to a changing climate. Comprehensive economic impacts need to be ascertained for the following broad sectors:

- Hydropower production
- Maritime commerce
- Recreation (boating and beach use)
- Coastal infrastructure
- Fishery (sport and commercial)
- Coastal wetlands functions

Conclusion

Action on Great Lakes low water conditions is timely. It will take years to ascertain whether further human intervention is plausible and desired by the states and provinces. Given the costly and likely irreversible economic and environmental impacts that have already occurred, and that long term forecasts indicate that climate change will create favorable conditions for even lower levels over the long term, it is important to get started now. Federal responses and financial resources have been inadequate to date to respond to a rapidly changing climate affecting the region. We urge you to consider implementing the strategic federal legislation activities identified in this testimony. These investments will foster improvements in the knowledge of a rapidly changing Great Lakes region, which would support economic prosperity for the region and guarantee ecological sustainability for generations to come.