



Fluctuating Great Lakes Water Levels

A SUMMARY OF INFORMATION, PUBLIC PERCEPTIONS, TRENDS, AND TECHNOLOGY

If you live or vacation along the Great Lakes, you have likely become accustomed to shifting sands along the region's coastline. Shifting sands are one of many changing components of the dynamic Great Lakes system. Considering the relationships between components of a complex system may help us understand why changes occur, and allow us to predict what might change over time.

The Great Lakes basin is a complex system of five lakes, the channels that connect them and many tributaries. Water flows from the high point in the Superior basin through the St. Marys River into Lake Huron. Lakes Michigan and Huron, joined at the Straits of Mackinac, have the same water level. Water then flows from Lake Huron through the Huron-Erie corridor (St. Clair River, Lake St. Clair, and Detroit River) to Lake Erie, then over Niagara Falls and into Lake Ontario, the St. Lawrence River, and to the Atlantic Ocean.

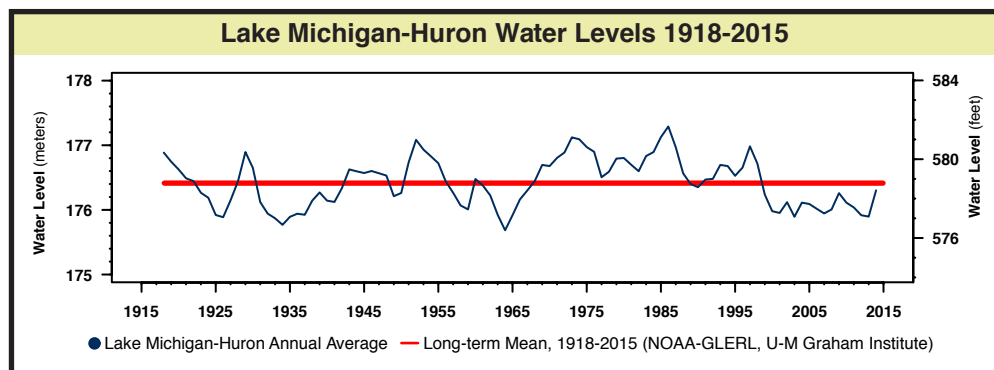


Figure 1. Water level fluctuations for Lake Michigan-Huron are shown over time, from 1918-2015. Note the long period of low water levels, from the late 1990s to 2013. Despite the rapid rise in water levels since 2013, the lakes are still well below the highest level recorded in the mid-1980s. Data is from NOAA CO-OPS, the Canadian Hydrographic Service, USACE, and Environment Canada (courtesy of NOAA GLERL).

HIGHS AND LOWS

Great Lakes water levels fluctuate on different time and space scales. The timing of seasonal high and low lake levels are closely related to the timing of precipitation, snowmelt, and evaporation. In general, water levels peak in the late summer or fall and are lowest in the winter months. The annual rise and fall varies from 12 to 18 inches on average. The primary drivers of the rise and fall in water levels are the main components of the water budget: precipitation, runoff, and evaporation. Water level dynamics also occur at very short-term scales, during wind-driven, localized events, and at much longer time scales. Multi-year periods of high or low water levels are very difficult to predict (See fig. 3).

MONITORING LAKE LEVELS

Great Lakes water levels have been recorded for more than 150 years. The US Army Corps of Engineers (USACE) began monitoring Great Lakes water levels in 1860. Currently, NOAA's Center for Operational Oceanographic Products and Services (CO-OPS) maintains 53 water level stations, and the Canadian Hydrographic Service operates 33 stations. Water levels are precisely measured and recorded every few minutes. The USACE and Environment Canada coordinate water level data and seasonal forecasts through a binational partnership, as part of their operational duties related to Great Lakes water management. These and other agencies, such as NOAA-Great Lakes Environmental Research Laboratory (GLERL), use water level data to conduct research to improve models that help predict water level fluctuations.

PUBLIC PERCEPTIONS

In 2014, more than 1,800 Great Lakes coastal property owners, managers, and other stakeholders from the US and Canada, participated in an online survey about lake levels. Questions focused on key concerns about both high and low levels. Survey participants identified property damage, flooding, and erosion among their key concerns. Businesses were particularly concerned about increased operating expenses due to both high and low water levels.

The majority of respondents perceived that high water levels have negative impacts, approximately half of respondents perceived that low levels have negative impacts, and many respondents indicated that both high and low levels have negative impacts. In addition, survey respondents noted their perception of what factors play the largest role in water level change. Respondents rated ice cover, precipitation and evaporation as the top three factors (See fig. 2).

DIVERSION, VS. EVAPORATION AND PRECIPITATION

Survey respondents ranked their impressions of how humans impact water level changes, with diversions, structural controls, and dredging identified as the top three factors. However, the amount of water leaving the system through diversions is actually quite small compared to the amount of water lost through evaporation. For instance, consider Lakes Michigan-Huron. For the years 1953-2010, their average combined evaporation rate is 2,200 cubic meters per second (CMS). The Illinois diversion (near Chicago) averages 90 CMS. The average rate of water entering Lake Michigan-Huron, via precipitation and runoff, over the same period, is 5,800 CMS. Also, at the most northwest edge of the Great Lakes system the average rate of water entering Lake Superior, from the Ogoki and Long Lac diversions, is 160 CMS.

A NEW TREND, MORE EXTREMES

Climate experts have noted that the frequency and intensity of severe storms has increased (Synthesis of the Third National Climate Assessment for the Great Lakes Region, 2014, GLISA). Potential impacts from severe storms include the disruption of business and transportation, and poor water quality. Climate modelers are improving their knowledge about the interaction between regional climate and water levels. However, accurate multiple year forecasts are more difficult to achieve than seasonal forecasts. The USACE and Environment Canada produce seasonal Great Lakes water level forecasts monthly. NOAA is working alongside the USACE and Environment Canada to improve the accuracy of weather prediction models for the nation. A significant challenge remains in monitoring and predicting Great Lakes evaporation, primarily driven by a large temperature difference between warm water and cold air, low specific humidity, and high wind speeds.

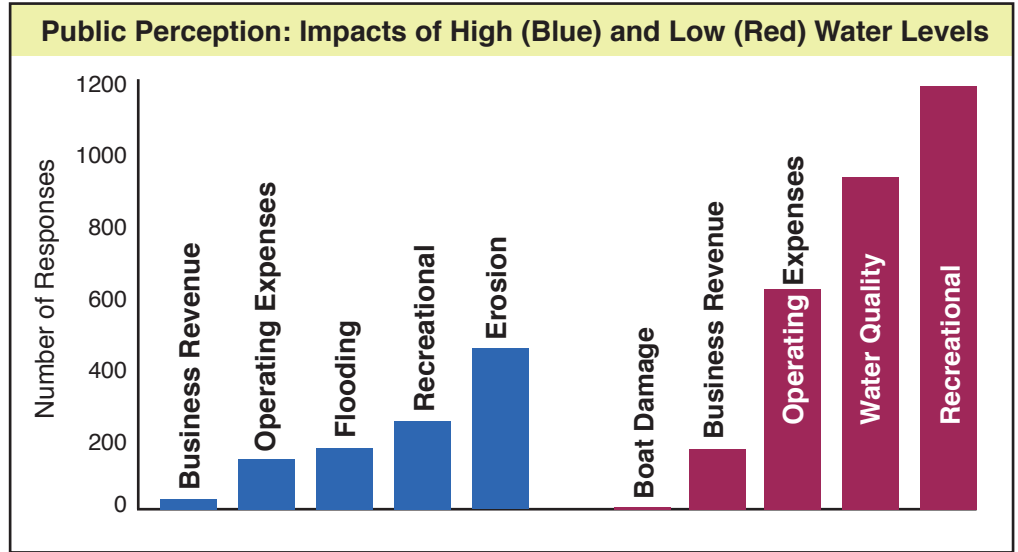


Figure 2. Survey participants identified impacts, such as property damage (high water levels, shown in blue); and a decrease in recreational opportunities (low water levels, shown in red), indicated in this figure. Graham Sustainability Institute, adapted with permission from Jacobson (2014).

KEY POINTS:

- Lake levels affect coastal properties, infrastructure, industry, recreation, and plant and wildlife habitat
- Over-lake precipitation, evaporation, and runoff are the primary drivers of seasonal Great Lakes water level fluctuation
- Over-lake monitoring is critical to learning more about the impact of evaporation on the Great Lakes water budget
- More than 150 years of lake level data provides an important context for future infrastructure and water management planning

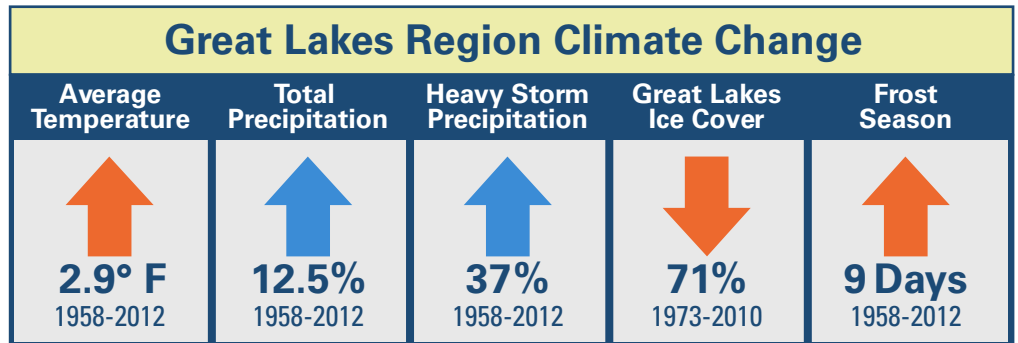


Figure 3. Shown here are key factors that impact water levels. Note: Ice Cover data is not available prior to 1973 or after 2010. Figure adapted by the Graham Sustainability Institute, with permission from the UM Climate Center.

REGIONAL CLIMATE IMPACTS

The Great Lakes basin has an unusually high water-to-land ratio, with five lakes encompassing approximately 33 percent of the basin area. As a result, there are many consequences for the region, such as lake effect snow. Global factors also impact the Great Lakes water budget. For example, the strong El Niño event in 1997 may be related to the recent 15-year period (1998-2013) when the upper Great Lakes water levels remained well below their monthly averages. Significantly warmer water temperatures led to higher evaporation from the lakes, causing economic hardship for coastal businesses, and resulting in a new low water level record for Lake Michigan-Huron in January 2013.

The rapid increase in water levels in 2013 and 2014 was a dramatic change. This was due, in part, to increased precipitation and lower evaporation rates, and the increased amount and duration of ice cover. Researchers are exploring other factors that led to this change, and have identified that more monitoring equipment in open lake areas would be extremely useful for both short and long-term predictions of lake level changes. They will continue to monitor how climate change impacts the Great Lakes, and many other regions of the nation and world (See fig. 3).

PREPARING FOR THE FUTURE

It is important to consider how we may better prepare for the extremes of high and low water levels.

Currently, a multi-disciplinary group of university-based research teams supported by the University of Michigan Graham Sustainability Institute, and the Michigan Office of the Great Lakes are focusing on Lakes Michigan-Huron and Erie. They are evaluating environmentally, politically, socially, and economically feasible adaptive actions and policy options. Strategies will address how coastal homeowners and businesses may better adapt to Great Lakes water level variability through sound planning efforts that consider variable water levels as part of anticipating vulnerabilities, preparing for extremes and adapting accordingly.

The Great Lakes region is an important focal point of NOAA's nation-wide effort to better prepare for more frequent and severe storms and encourage coastal communities to consider how they may be more resilient. The NOAA Coastal Resiliency program is focused on reducing current and potential future risks for coastal communities. A key priority is to implement actions that promote adaptation to changing environmental conditions, and address disaster preparedness.

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LEARN MORE:

- Great Lakes Water Budget, A Summary of the Amount and Flow of Water in the Great Lakes Basin, (Graham Sustainability Institute)
- Great Lakes Water Levels Website (NOAA-GLERL)
- Great Lakes Water Levels Factsheet (NOAA-GLERL)
- Great Lakes Hydro-Climate Dashboard (NOAA-GLERL)
- Advanced Hydrologic Prediction System (NOAA-GLERL)
- Lake Level Viewer Website (NOAA-GLERL)
- Water Levels Integrated Assessment Website (Graham Sustainability Institute)

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- NOAA Center for Operational Oceanographic Products and Services, <http://tidesandcurrents.noaa.gov/>
- NOAA Great Lakes Environmental Research Laboratory, Great Lakes Hydro-climate Dashboard Project, <http://www.glerl.noaa.gov/data/dashboard/GLHCD.html>
- NOAA-GLERL, Great Lakes Water Level Observations, Fluctuations On Different Time Scales, 2015, <http://www.glerl.noaa.gov/data/now/wlevels/levels.html>
- U.S. Army Corps of Engineers Detroit District Water Level Forecast, <http://www.lre.usace.army.mil/Missions/GreatLakesInformation/GreatLakesWaterLevels/WaterLevelForecast.aspx>

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