November 2021 Update on Kalamazoo Lake Levels- Past, Present and Future

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November 2021

Introduction: This is an update to the August 2021 report of water levels in the Saugatuck and Douglas harbor area. Saugatuck and Douglas have continued to experience above-normal Kalamazoo Lake and River water levels through November 2021. However, aside from a short increase following a wet summer, the water levels in Lakes Michigan and Huron continue to decline from the historically high levels experienced in summer 2020. While the mean October water level (580.32 ft. msl) is approximately 24 inches below the summer 2020 peak, it is still approximately 17 inches higher than the long term mean October elevation of Lake Michigan (approximately 578.94 ft. msl). The lake level forecast provided by the US Army Corps of Engineers (USACE) indicates that the water level will continue to decline through the fall and early winter as part of the typical seasonal cycle, but will likely remain above the historic average over the next 12 months. Many stakeholders are again asking what is going on and will the Lake level significantly go down? We will try to address these questions with this discussion, but note the predictions on future lake level are educated guesses by NOAA and USACE scientists and engineers based on modeling Mother Nature.

First point to reemphasize: Kalamazoo Lake and Lake Michigan are hydrostatically connected! This means that as Lake Michigan rises, so does the Kalamazoo Lake and River. Kalamazoo Lake is what is referred to as a drowned river mouth.

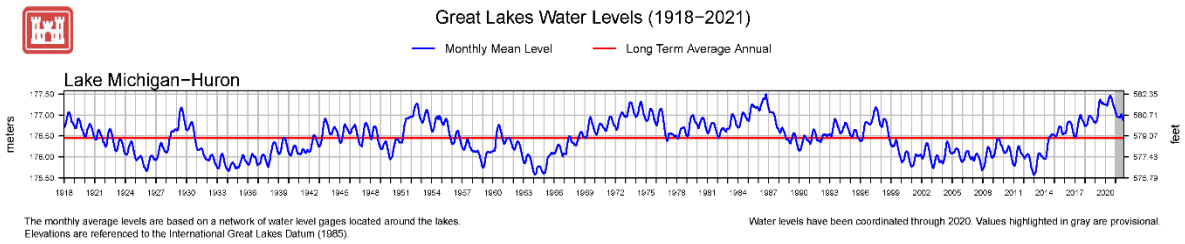


Figure 1: *Historical Lake Michigan water levels*

Historical Lake Levels: Let's again look at the updated historical Lake Michigan water levels going back to the year 1918 (Figure 1). As discussed in prior reports, Lakes Michigan and Huron are also hydrostatically connected by the Straits of Mackinac. The time history in Figure 1 shows at least six periods of high water and five low water level events, with a near record low occurring in 2013 (remember all the dredging concerns). Some modelers see a periodicity in high to low water levels of eight to fifteen years, but suffice to say the water level goes up and it goes down at least each decade. If we examine the length of high water events during the entire record we observe high water events as short as one year and as long as approximately eight years. The average duration of high water events is approximately four years. We are presently seven years into this high water event and the plot shows we are trending downward. Good news.

Figure 2 shows in more detail the mean monthly water levels from 2020 and 2021 relative to the historic maximum, minimum, and mean water levels. After water levels reached a record high in July-August 2020 (~582.4 ft. msl, 7.3 inches higher than the previous maximum), the water has steadily declined to a mean October level of approximately 580.39 ft. msl. This is down approximately 2 feet from the record highs of last summer, and 14 inches from the mean October 2020 levels, but still approximately 17 inches higher than the long term October mean.

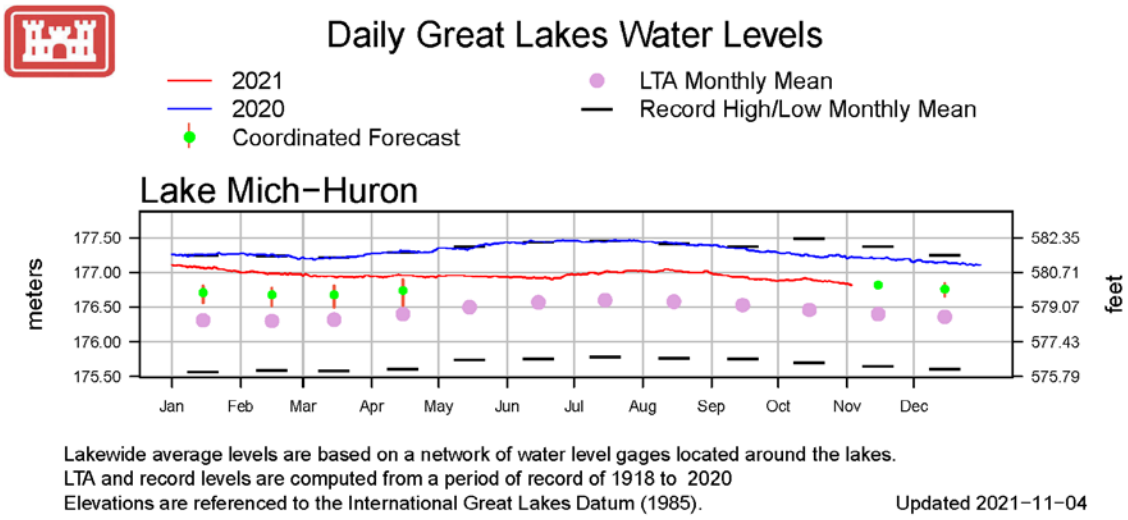


Figure 2: *Mean Daily Lake Michigan water levels for 2020 and the first ten months of 2021 compared to the historic mean (pink dots), minimum and maximum (horizontal black bars).*

The top of the seawall at East Shore Harbor Condos (ESHC) is at approximately 582 ft. msl, thus any Lake Michigan water level above 582 ft results in flooding. The 582 ft. msl is representative of the height of other seawalls in the areas, thus if there is flooding at ESHC flooding will be occurring in other parts of the harbor. The mean daily water level for Lake Michigan exceeded 582 ft every day from May 20, 2020 through early September. After that point, the average monthly water level has not exceeded 581.5 ft. msl, thus no flooding. The Lake Michigan water level gauge at Holland can be easily accessed (see https://tidesandcurrents.noaa.gov/waterlevels.html?id=9087031) to ascertain whether flooding of the shore is occurring. Just remember ~582 ft. msl or lower equals no flooding.

Present Lake Level and Near Term Trends:

Presently Lake Michigan and thus Kalamazoo Lake are at 580.22 ft. msl which is approximately 33.5 inches above the low water datum (LWD) value. Water level is down approximately 16 inches from the mean October 2020 level and 26 inches from the record high set in July 2020. However, the water level today is still approximately 17 inches higher than the long term average. The water level will likely continue to decline through the fall and early winter as air temperatures decline and evaporation increases.

Future Lake Levels:

The US Army Corps of Engineers, NOAA, and various Canadian government organizations all monitor the water level in the Great Lakes and make predictions as to future water levels. Some predictions look a few months into the future while others predict next year or five and ten years out. For this discussion we are presenting the USACE water level forecast for a 12 month period starting from October 2021. Recall, three factors determine lake level; precipitation, evaporation, and runoff which is referred to as the Net Basin Supply (NBS).

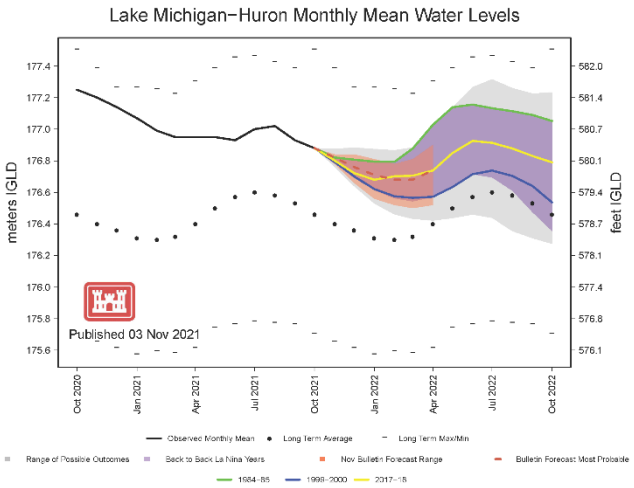


***Figure 3**: Prediction of Lake Level for Lake Michigan*

Figure 3 shows projected water levels based on a range of scenarios. The purple envelope represents the range of likely water levels based on 10 years that also experienced La Niña conditions in back-to-back years, similar to 2021. In this range of scenarios, the water level will continue to decline through January 2022 before peaking again in Summer 2022. However, this range of scenarios indicates that levels should remain below the 582 ft msl flooding threshold. The much wider gray area represents the range of possible modeling scenarios based on historical data from 1900 to 2020.

The three solid lines represent water level projections if NBS and hydrologic conditions (i.e. air temperature, winds, precipitation) are similar to those observed in three of the 10 back-to-back La Niña years: 1984-85, 1999-2000, and 2017-18. All three scenarios resulted in a continued decline in water levels through spring 2022 while remaining above the long term historic mean and below the historic maximum.

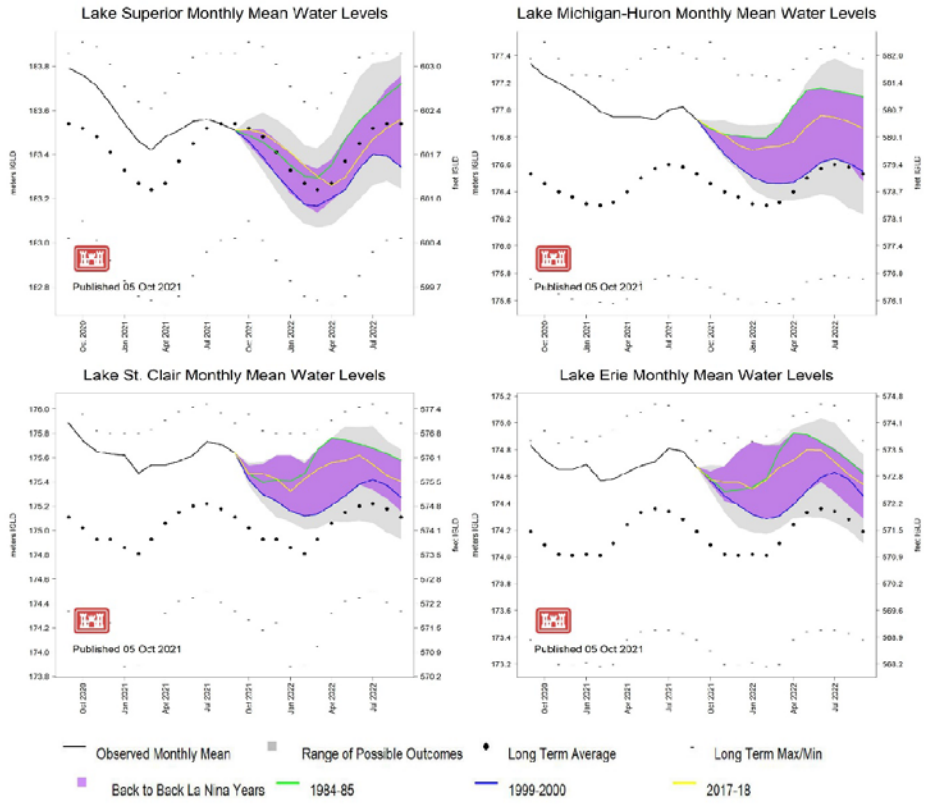
Summary: The high water levels of 2020 created problems and large expenses for the harbor stakeholders. The big question that we do not have a reliable answer for is, when if ever will the water return to normal (i.e. is near average value). It really is mostly about the precipitation and evaporation. The average annual precipitation in the Michigan watershed basin is approximately 32 inches, with a high value of 40 inches occurring in 1985 and a low of 21.6 inches in the year 2016. Last year (2020) the annual precipitation in the Saugatuck area was 39.2 inches, near the high. However, a dry winter and spring in 2021 has resulted in a continued reduction in water levels. Current forecasts suggest a likelihood of above normal temperatures over Lake Michigan and equal chances of above-average, normal, and below-average precipitation for the next few months. The takeaways are:

1) Kalamazoo Lake and Lake Michigan are hydrostatically connected, if Lake Michigan rises so does Kalamazoo Lake and River.
2) **Remember the number 582 ft. msl.** When the gauge at Holland reads 582 or higher we are going to get flooding.
3) Storm surge and seiche events on Lake Michigan will still occur and result in local flooding due to the high water, in normal times we barely notice these occurrences.
4) The future lake level is all about NBS, really it translates into rain and snow fall. Above average precipitation in the Great Lakes Basin spells trouble.

US Army Corps of Engineers ®
Detroit District

Great Lakes Water Level Future Scenarios

Volume 25 October 2021: Back-to-Back La Niña Years



*At this time, water level outlooks for Lake Ontario are still under development due to complexities of its weekly regulation process. For the official 6-month forecast of all lakes, including Lake Ontario, see the Monthly Bulletin of Great Lakes Water Levels.

Overview

During the summer months, most of the Great Lakes basin experienced wetter conditions, besides the Lake Superior basin, which experienced persistent dry conditions. Several heavy rainfall events occurred, which led to water level rises into July. In recent months, the lakes have begun their seasonal decline in water levels, which is typical for this time of year. Water levels follow a seasonal cycle where during the fall and early winter, the lakes generally decline due to an increase in evaporation as temperatures decline and cold air moves over the relatively warm lake waters. In the spring, water levels typically rise due to increased precipitation and enhanced runoff from snowmelt. We refer to the combined effect of precipitation over the lake, evaporation from the lake, and runoff to the lake as Net Basin Supply (NBS).

In 2021, predominantly dry conditions existed over the first half of the year, with the summer becoming much wetter for most of the Great Lakes region, excluding the Lake Superior basin, which has remained generally dry. The last few months of 2021 and beginning of 2022 are forecast to be impacted by a La Niña. A La Niña occurs when sea surface temperatures in the eastern and central Pacific Ocean are cooler than normal, which can impact the weather patterns across North America. An example of how a La Niña can impact North American during the winter months is shown in Figure 1.

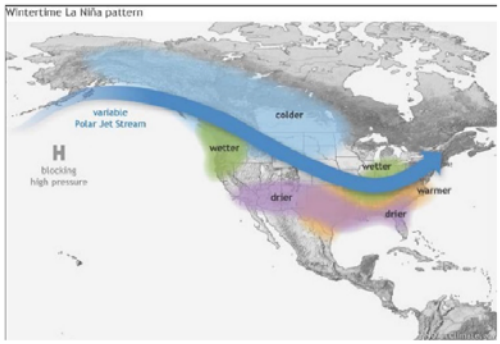
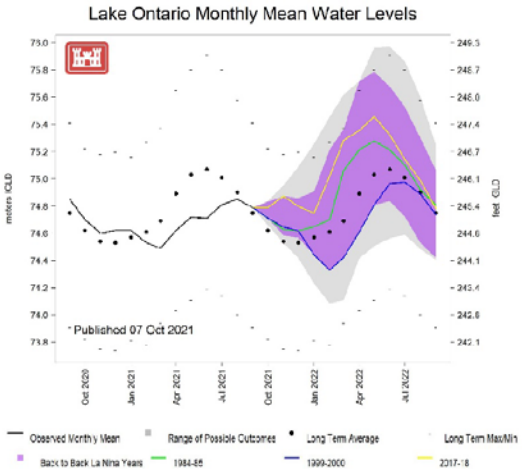


Figure 1: An example of the weather conditions across North America during a typical La Niña winter. (NOAA)

Figure 1 shows generally that with La Niña conditions during the winter, there is a chance for colder air to move into the western portions of the Great Lakes basin and wetter conditions are likely in the southern and eastern portions of the basin. Also, if a La Niña develops for the winter months this would be the second winter in a row that La Niña conditions have occurred.

This edition of the Water Level Future Scenarios showcases a purple plume that represents ten years where La Niña conditions occurred during the previous winter and developed again the following winter. Since a La Niña occurred in the winter 2020-21 and is expected to develop for the winter 2021-22, the years included in the plume would represent the second year of La Niña conditions. Three of the years within the plume have been called out to show the difference in hydroclimate conditions that could occur over the next 12 months. These three scenario years are 1984-85, 1999-2000, and 2017-18. Also, the gray shaded area on the plot represents the full range of possible outcomes using historical sequences of NBS from 1900 through 2020. This version also incorporates an experimental version of a Lake Ontario graphic. For Lake Ontario, the range of possible outcomes (gray shaded area) is based on historical NBS from 1900-2017.



Purple Plume: Back-to-Back La Niña Years

The purple plume represents ten years that experienced a La Niña in the year prior and in the current year, which led to back-to-back winters of La Niña conditions. Three years within the plume, 1984-85, 1999-2000, and 2017-18 have been called out and represented by the green, blue, and yellow lines. The 1984-85 scenario is shown by the green line and represents water levels that would occur if NBS was similar to the rest of 1984 through September of 1985. The 1999-2000 scenario is represented by the blue line and indicates water levels that would occur if the NBS sequence for the rest of 1999 and the first 9 months of 2000. The 2017-18 scenario is represented by the yellow line and shows water levels that would occur is NBS was similar to the rest of 2017 through September of 2018.

1984-85 Scenario

The 1984-85 scenario shown by the green line depicts water levels if NBS and hydrologic conditions for the next 12 months are like what occurred during the rest of 1984 and the first 9 months of 1985. This scenario is one of the wetter scenarios and is towards the top of the purple plume on all the lakes, besides Lake Ontario. This is especially true, in months further into the future. The 1984-85 scenario on Lake Ontario was near the middle of the purple plume. In this scenario, the rest of the calendar year would be characterized by generally near to above average NBS with an especially wet end to the year in December across the Great Lakes. The beginning of the following year would continue to be wet with precipitation near to above average in January, but well above average in February and March. This would also lead to increased runoff during the early spring, which likely resulted in the large seasonal rises in water levels on the lakes seen in this scenario. In April, conditions would remain wetter in the Lake Superior, Michigan-Huron, and St. Clair basins, but drier conditions would occur in the Lake Erie and Ontario basins. These drier conditions for the eastern portions of the Great Lakes region would continue through the summer months, which would lead to an earlier and steeper seasonal decline on Lake Erie and Ontario. NBS was slightly above average on the upper lakes from July to September, which led to water levels experiencing less of a decline on Lakes Michigan-Huron and St. Clair. On Lake Superior, the peak level by the end of the outlook period was towards the higher range of possible outcomes because of the wetter conditions. The generally wetter conditions in the beginning of the period would keep water levels above average on Lakes Michigan-Huron, St. Clair, Erie, and Ontario. Lake Superior would also eventually go back above average in this scenario.

1999-2000 Scenario

The blue line represents water levels if NBS and hydrologic conditions over the next 12 months are similar to what occurred during the next three months of 1999 and first nine months of 2000. Contrary to the 1984-85 scenario, the 1999-2000 scenario, represented by the blue line is toward the bottom of the purple plume, indicating drier conditions in this scenario. From October to March, precipitation would generally be near to below average across the Great Lakes region. Also, evaporation was well above average in December and January. This would lead to larger seasonal declines through the fall and winter. From April to June, precipitation was generally above average across the Great Lakes, with wetter conditions occurring in the Lake St. Clair, Erie, and Ontario basins. However, runoff would be near to below average through much of the spring due to the antecedent dry conditions in the fall and winter. This would lead to marginal seasonal rises across the lakes. In this scenario, water levels on Lake Superior would remain below average and Lake Michigan-Huron would be close to average by the end of the period. Lake St. Clair and Erie would remain above average, while Lake Ontario would begin above average and transition to below average.

2017-18 Scenario

The yellow line represents water levels if NBS and hydrologic conditions over the next 12 months are similar to what occurred during the next three months of 2017 and first nine months of 2018. This scenario falls almost in the middle of the

purple plume and the total range of possible outcomes (gray shaded area). The period would begin with near to above average precipitation and NBS in October and November before a transition to drier conditions to finish out the year in December. The start of the new year would bring conditions back to above average NBS in January and February before another transition in March when precipitation would be well below average. Overall, in the first six months of this scenario water levels on Lakes Michigan-Huron, St. Clair, Erie, and Ontario would see lesser seasonal declines, due to the generally wetter conditions. However, Lake Superior would experience a steeper seasonal decline throughout winter and early spring due to exceptionally dry conditions in March and April. On the other lakes, NBS would be near to above average in April and May, which would aid in the seasonal rises on those lakes. Generally, over the summer months of June, July, and August NBS would be near average across the Great Lakes region. Under this scenario, water levels would remain near average on Lake Superior and above average on Lakes Michigan-Huron, St. Clair, Erie, and Ontario.

Summary & Climatic Outlook

After analyzing back-to-back La Niña years, there doesn't appear to be an obvious trend towards higher or lower water levels. Each of the scenario years provides insight into the variability of conditions that can be experienced when a La Niña occurs. The purple plume on the plots shows that Lake Superior's water levels will likely remain near average, while water levels on Lakes Michigan-Huron, St. Clair, and Erie will remain above average over the next 12 months. Lake Ontario's purple plume indicates a wider range of potential future water levels and its possible water levels could be above or below average.

The Climate Prediction Center's seasonal forecasts for temperatures for the fall and early winter (October, November, December) show a likelihood of above normal temperatures for all lake basins, besides Lake Superior, which shows equal chances for above, below, or near normal temperatures. The precipitation outlook for the same three-month period shows mostly the central and eastern portions of the Great Lakes basin leaning toward above normal precipitation, while the western portions of the basin show equal chances for above, below, or near normal precipitation.