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Climate Change Implications and Adaptation Strategies for Great Lakes Ports, Harbors and Marinas

Nearly all Great Lakes ports, harbors and marinas will need to adapt to the region's changing climate over the next few decades and beyond. Most facilities will have to adapt to potential changes in rainfall amounts and storm intensities as well as water-level changes in lake levels, and wave and erosion impacts on their structures.

We cannot say with any certainty whether lake levels will rise or fall, but either change will carry with it the need for adaptation. In addition, increased storm intensity and frequency could increase structure damage to Great Lakes ports, harbors and marinas.

This fact sheet will focus on facility structure and channel/slip depth issues but not the potential operational changes that may also be very important.

PORT, HARBOR AND MARINA INFRASTRUCTURE AND SEDIMENTATION ISSUES

Ports, harbors and marinas are certainly subject to several potential climate change variables. Lower lake levels can increase the need for dredging to avoid bottoming out of commercial ships and recreational boats. Low water levels may adversely affect boat launches at marinas and public access points as well. Greater wave heights will be associated with higher water levels and could result in damage to port structures, harbor infrastructure and marina docks and boats at their slips. Increased storm intensities can increase the amount of stream and river sediment load that could result in greater port, harbor and marina sedimentation volumes. The high channel

Above: Low water conditions may make docks unusable without dredging. Right: Small launch ramps with concrete ramps may become completely unusable during periods of very low water.

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The degrees of susceptibility to these impacts will vary, whether we are talking about ports and harbors (normally large-scale commercial maritime operations with fixed-height structures) or marinas (smaller recreational facilities with smaller docks, either fixed or floating). Unfortunately, the typical lifespan of the associated infrastructure is on the order of 40-50 years for marinas and somewhat longer for most port and harbor structures. Because of the long-term projections and those observations for the potential climate-change impacts may not been seen for several years, the majority of Great Lakes facilities rarely plan now for future events. Often, infrastructure, management and operational changes are made only when the facilities are actually being threatened or damaged.

The three major climate change impacts that are most relevant to ports, harbors and marinas are water level, storm, and precipitation, and temperature changes. Water level changes (either higher or lower) that are different than the normal ranges typically observed on the Great Lakes affect facilities in several different ways. Lower water levels create situations in ports and harbors where ships cannot be fully loaded, may need to carry less cargo per trip, damage vessels by hitting the channel or slip bottom, require the need for additional dredging (which can create further problems with where to dispose of the additional material), can undermine the existing structure, could require modifying the dock to accommodate the change in elevation between the vessel and cargo area, may require rock scour protection at the base of the dock wall or necessitate the relocation of the entire facility. For marinas, the potential issues with lower water levels include the need for increased dredging, the potential for boat bottoms to be damaged by the shallow depths and potential safety concerns if the dockage is at a fixed height and the vertical distance from the water level to the dock is too great.

Higher water levels can impact port, harbor and marina infrastructure stability and overall strength. In addition to the structure issues, higher water levels can create a greater potential for flooding of critical land areas and operational structures. A climatic change resulting in the increase in storms (both severity and frequency) and increased precipitation can also have detrimental effects on ports, harbors and marinas. The increased storms can create larger waves, higher seiches and greater storm surges that can damage port and harbor infrastructure to the point of requiring rehabilitation or replacement. In addition, the storms can affect the vessel maneuverability, vessel speeds and mooring problems. In marinas, storms can damage dockage and boats while moored to those docks. In addition to the infrastructure issues, increased storms can increase channel sedimentation or the re-suspension of existing material that may be contaminated, which would require additional dredging problems analogous to the lower water level scenarios. Storm winds may also impact vessel and boat mooring requirements and could affect some facility operations.

Lower water levels in Great Lakes commercial harbors and recreational marinas may require additional dredging to accommodate navigation. Site characterization and dredging are both costly endeavors and the process often takes years to complete. Marinas and harbors may contain contaminated sediments once considered “safe” because they were too deep to be disturbed from navigation traffic.

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During high water conditions and/or periods of greater storm intensities, structures may become completely unusable

If no previous sampling has been conducted to characterize the extent and nature of the pollutants, this would need to be completed before dredging occurs. Additionally, lowered or increased fluctuation of Great Lakes water levels will lead to increased potential for erosion in streams where the lower reaches are influenced by estuarial-type hydrodynamics. This will lead to increased deposition sediments in Great Lakes bays and harbors. Streams with contaminated sediments are another potential risk. Wetter conditions and more intense rainfall could result in higher rates of streambank erosion placing downstream locations at risk of new exposure to pollutants.

ADAPTATION STRATEGIES

This section describes the types of adaptation strategies that could be implemented in the near and long term to adapt to climate change for Great Lakes ports, harbors and marinas.

Ports and harbors can adapt to extreme water level changes by anticipating and planning for greater dredging and the potential need for additional bottom scour protection at the base of their dock walls for lower water levels. They can also anticipate potential dock-top elevation modifications and/or modified loading/unloading procedures. For higher water levels, ports, harbors and marinas can increase the working dock heights, modify loading/unloading operational methods or relocate important facility features to higher land to provide for flooding protection. Ports and harbors can adapt to greater waves, seiches and storm surges by rehabilitating, modifying or replacing weaker portions of their infrastructure to withstand the greater wave forces. Marinas can adapt to changing water level extremes by the conversion of fixed dockage to floating dockage. They can also modify slip layout schemes to position shallower draft boats in the shallow areas and restrict the larger craft to the deeper portions of the marina. However, marinas still may have to dredge periodically if sedimentation increases. Marinas can adapt to higher waves, higher seiches and greater storm surges by utilizing stronger dock designs, especially where docks join one to another (connection points are often the weakest link of a marina dock system). Ports, harbors and marinas can anticipate and adapt to many of the potential climate change issues by using cost effective facility components that allow for both greater flexibility and structural strength. In addition, port, harbor and marina high-risk areas can be identified and wherever possible, avoided to minimize the future effects of extreme water level changes, greater storm impacts, greater channel and slip sedimentation rates and flooding potential. Adaptation strategies for conditions when lake levels may continue to drop, falling well below historic low-lake-level records, may cause increased problems for wood structures. Wood structures should be inspected frequently for signs of increased deterioration, especially in regions where the wood was underwater the majority of the previous time. Due to lower lake levels, the wood will experience a greater number of wet/dry cycles that greatly increase the damage to the wood due to rot. Lower lake levels can also allow rock to deteriorate faster due to greater freeze/thaw exposure. Greater freeze/thaw cycles may cause the rock to crack and become less protective (smaller stone sizes).

It is possible that lake levels will not continue to decline indefinitely and that the region's coasts may experience more frequent and more intense storm precipitation and storm-wave events. It's also possible that lake levels will rise again, even to previous record-high elevations. Adaptation strategies for existing structures under these conditions are harder to implement (or at least are more costly). Structure heights will need to be increased to protect the land or slope behind the structure from wave overtopping and scour. In addition, the structure integrity itself may be at risk as it may have not been originally designed for

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the greater wave energy and may fail. Greater wave energy at the structure will also produce scour at the base of the structure and if not protected could cause a complete collapse of the structure. To mitigate against this potential failure, additional scour protection would need to be placed at the base of the structure. This issue is especially important to vertical structures such as those built with vertical faces.

In summary, adaptation strategies for Great Lakes ports, harbors and marinas to potential climate change must be considered and implemented if applicable. Otherwise, structure failures are only a matter of time. Structures must be designed with potential climate change impacts in mind. A detailed risk assessment can be completed to compare the economic, social and natural resource risks of such structures with the potential impacts and timing of the climate change variables.

At-risk and high-risk port, harbor and marina facilities can be identified with respect to potential dredging problems. Facility owners and managers should develop strategies to adapt to changing lake levels and identify alternatives to dredging such as relocation of critical facilities or exploring new options for additional dredged material disposal or beneficial use.

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July 2012 WISCU-G-12-005