



**WEATHERING
CHANGE**



ANTIOCH UNIVERSITY NEW ENGLAND
**Center for Climate Preparedness
and Community Resilience**



Strengthen communities to prepare,
respond and recover in the face of
climate impacts and other disruptions
through collaborative, innovative
solutions.

communityresilience-center.org

Dr. Christa Daniels
Senior Associate, CCPCR

Climate Change Resilience

... a series of online courses focused on the fundamentals of climate change resilience.

- Engage in each course for 4 weeks
- Enroll for graduate credit or audit the course
- Increase your skill set in climate resilience for better outcomes
- Discover solutions to local issues you face on the job or in your community.
- Register for one course or the whole series.



<http://www.communityresilience-center.org/climate-change-resilience-series/>

Climate Change Resilience Certificate

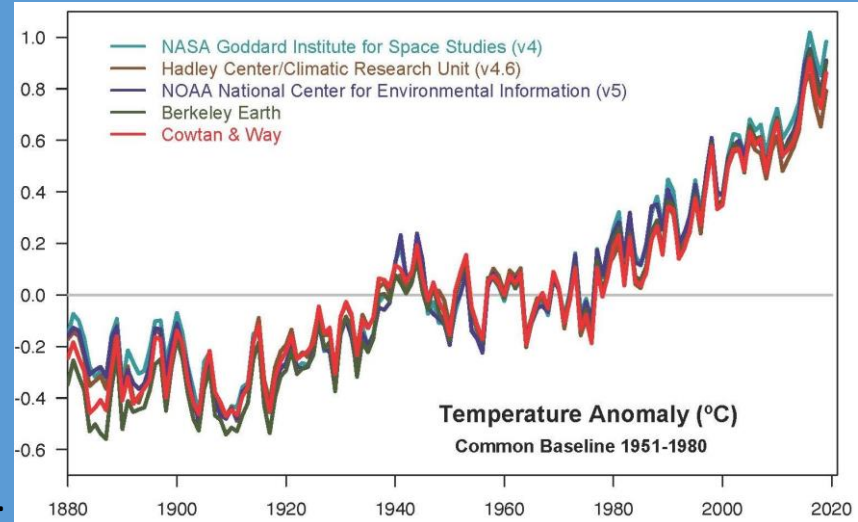
Climate Change: the Science, Uncertainty, and Risk

Online (1-credit) Course Aug 30, 2020 through Sept 6, 2020

Already communities are being impacted by a changing climate. This module focuses on the science of our changing climate and how to ascertain uncertainty and risk in the models and science. System thinking principles and application in this field will be explored in depth.

For more information or to register for this course:

<https://www.communityresilience-center.org/climate-change-science/>



Additional Fall 2020 Climate Change Resilience Professional Certificate Online Courses

Policy Advocacy: Climate

Dates: Sept 10- Nov 19, 2020

Synchronous Online Class:
Thursdays 10:00-11:00 AM ET

<http://www.communityresilience-center.org/climate-change-resilience-series/>

Climate Impacts: Communication, Facilitation, and Stakeholder Capacity Building

Dates: October 4-31, 2020

Asynchronous Online Class

Climate Impacts: Vulnerability and Adaptation Planning

Dates: November 8 – December 12, 2020

Asynchronous Online Class



Meet the challenges of a changing climate by finding information and tools to help you understand and address your climate risks.

toolkit.climate.gov

Dr. Ned Gardiner,
Engagement Manager

Logistics



If you have a question, please write it in the Q&A section (not Chat) and select to All Panelists, so we can see the questions.



If you are having technical difficulty, please use Chat and send to Host, so we can address the issue with you directly.



The presentation will be recorded and posted to the Antioch website within a week www.communityresilience-center.org

Great Lakes Water Levels and Coastal Impacts



Brandon Krumwiede

Great Lakes Regional Geospatial Coordinator

CSS Inc on contract to NOAA Office for Coastal Management

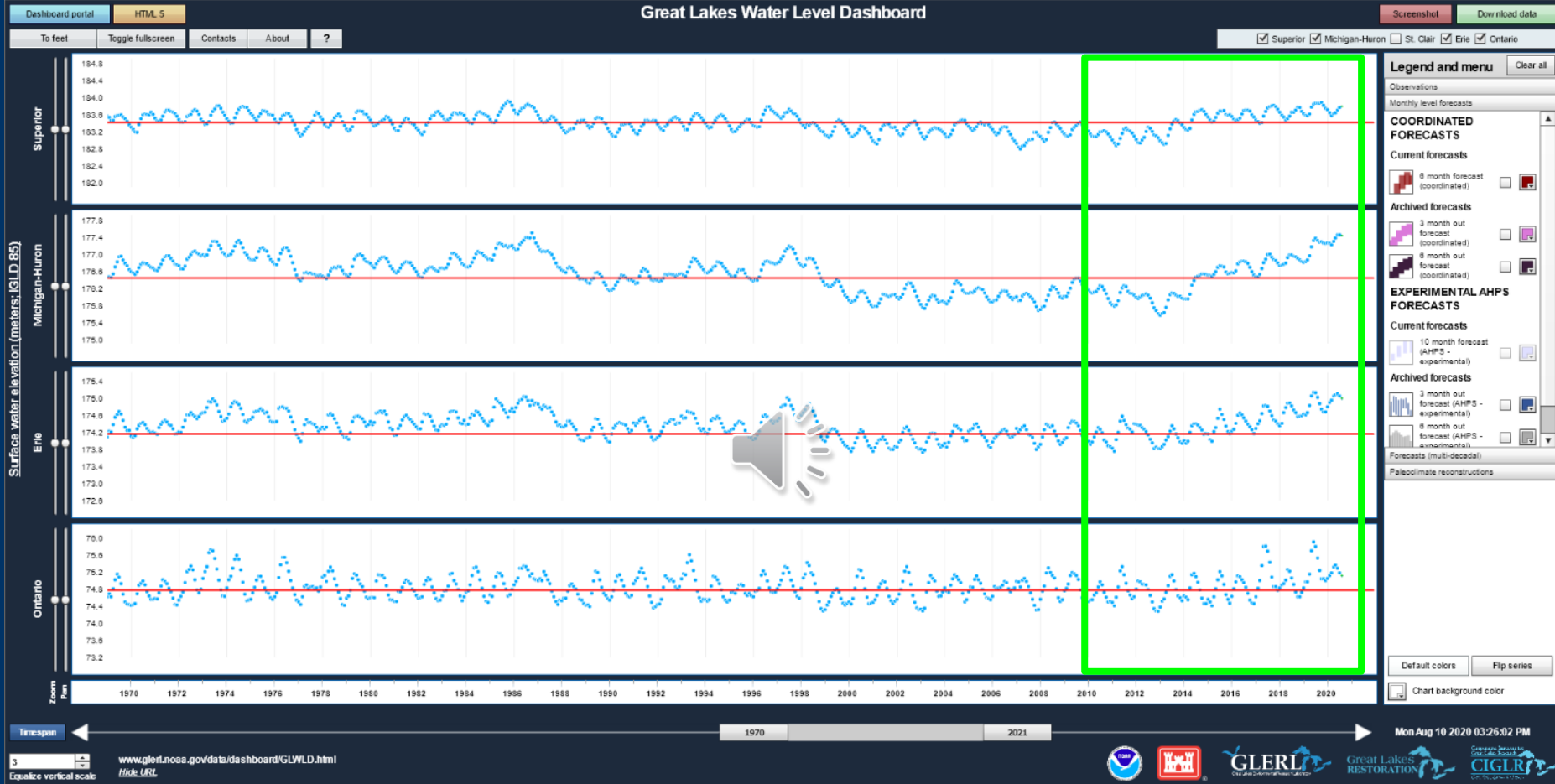


PRE-RECORDED



Presentation Overview

Water Levels
Water and Wind
Coastal Impacts
Data, Tools, and Resources



Office for Coastal Management



Great Lakes Water Levels: Current

JULY 2020

Precipitation just above average for the Great Lakes basin



Lake Superior rose 2 inches in July

Lake Michigan/Huron remained high and 2 inches above past monthly mean July record

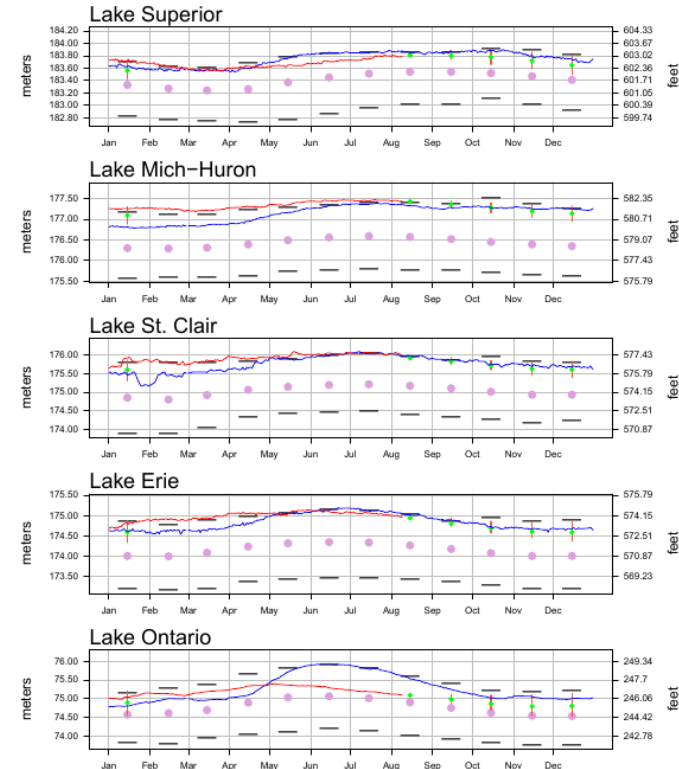
Lake Erie and Lake Ontario declining in water levels

Office for Coastal Management



Daily Great Lakes Water Levels

— 2020
— 2019
● Coordinated Forecast
— LTA Monthly Mean
— Record High/Low Monthly Mean



Lakewide average levels are based on a network of water level gages located around the lakes.
LTA and record levels are computed from a period of record of 1918 to 2019
Elevations are referenced to the International Great Lakes Datum (1985).

Updated 2020-08-10

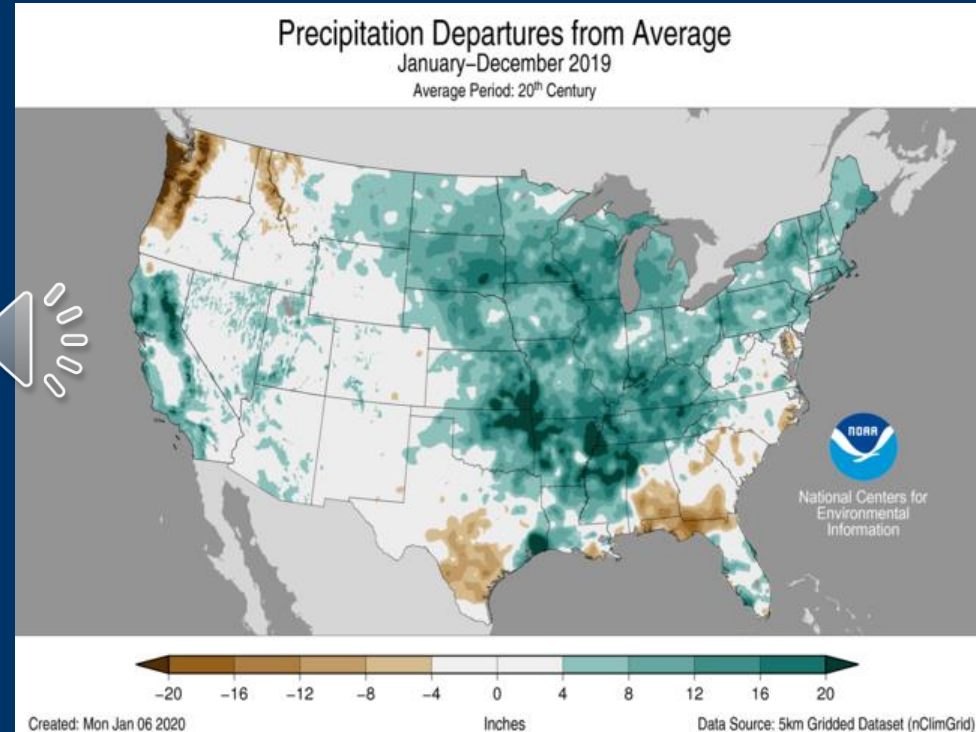


Great Lakes Water Levels: Inputs and Outputs

2019

Wet across much of the Great
Lakes basin in 2019

Year to Date Precipitation
Departure from Average
2019

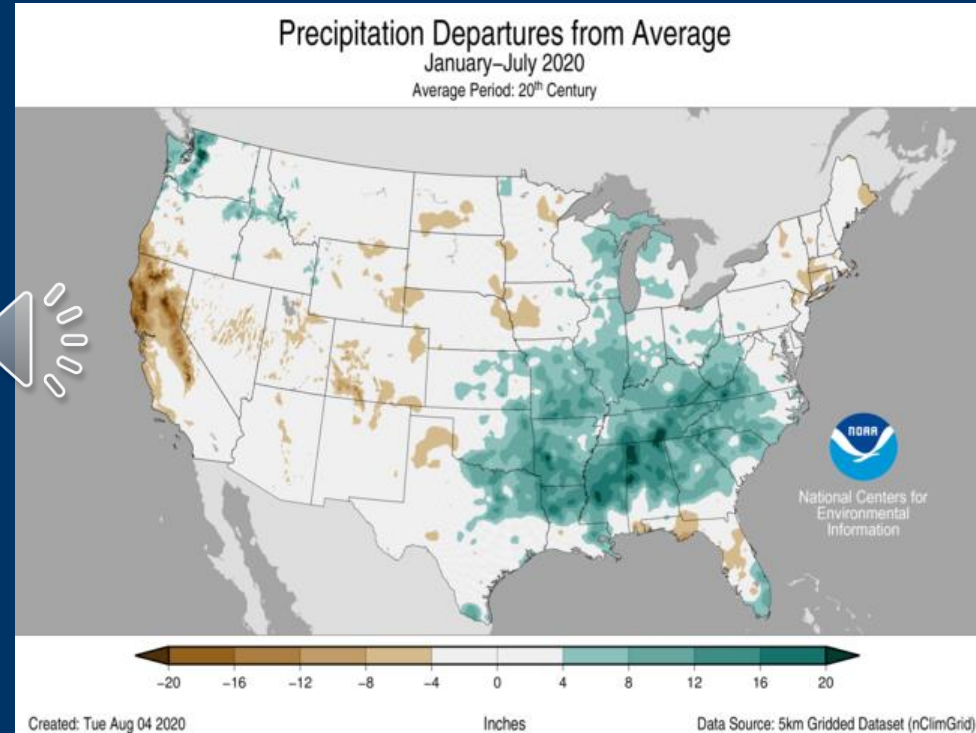


Great Lakes Water Levels: Inputs and Outputs

2020

Wet across central part of the
Great Lakes basin

Year to Date Precipitation
Departure from Average
Last 6 months





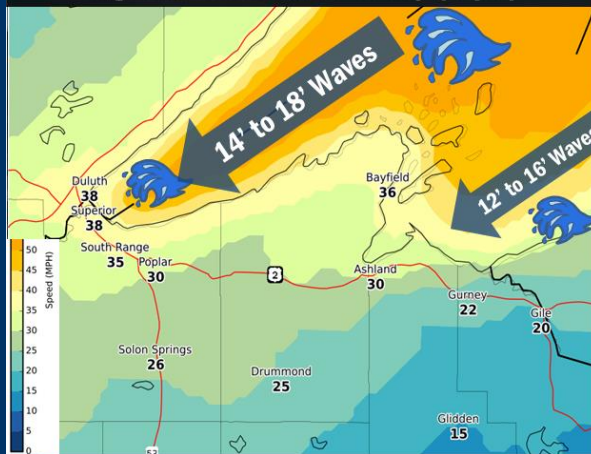
Water Wind

Lake Superior Water Levels: Storm Impacts

AN ANGRY LAKE SUPERIOR

Today through This Evening

Highest Wind Gusts Today (mph)



GALE WARNING

- Gale-force winds and near storm-force gusts today through this evening.

IMPACTS

- Isolated tree damage and power outages near the lake.
- Flooding, erosion, and damage to shoreline.
- Difficult travel for high-profile vehicles on high bridges between Duluth and Superior.

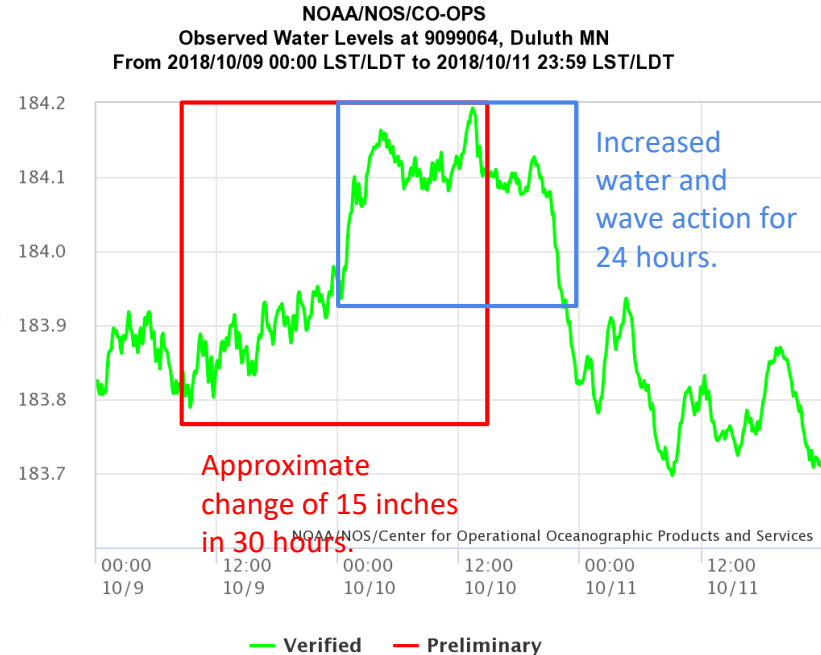
NATIONAL WEATHER SERVICE DULUTH, MN

weather.gov/duluth

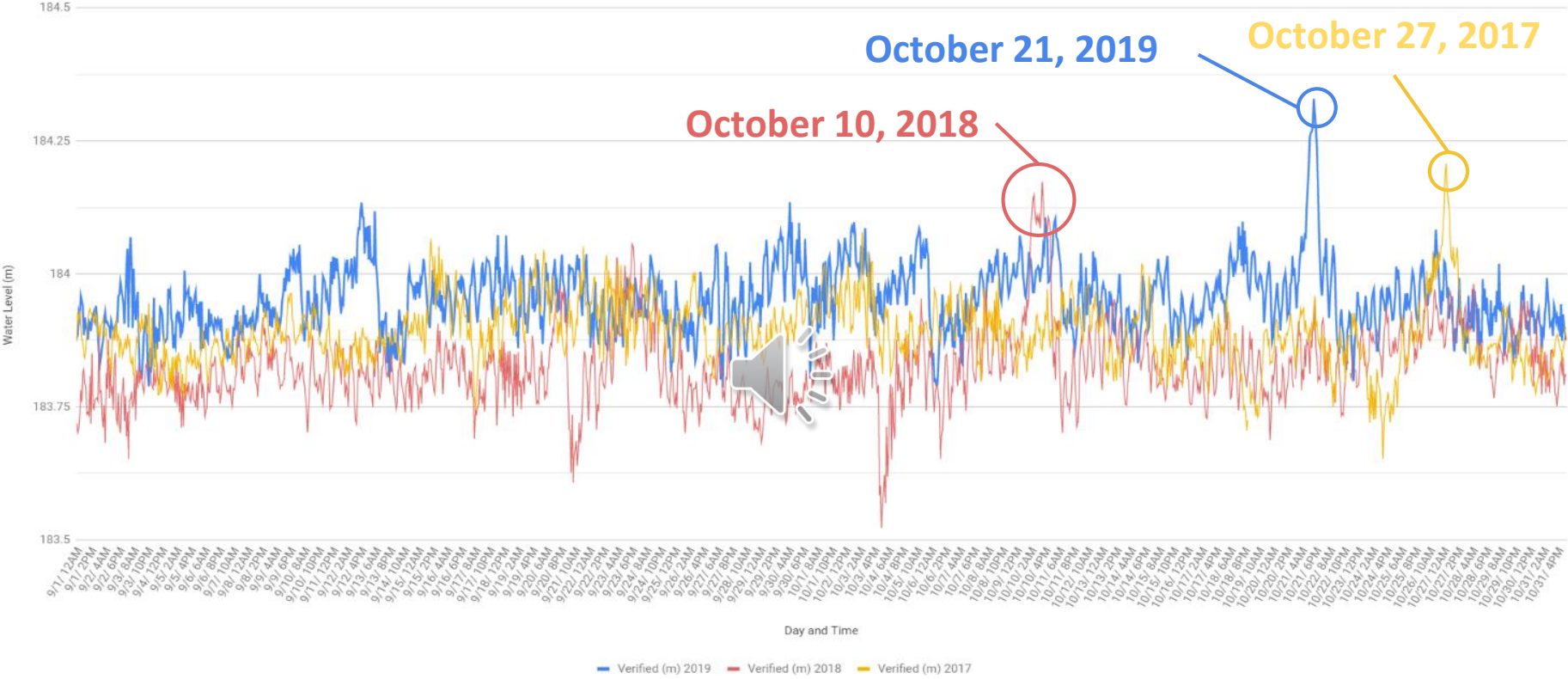


Published on: 10/10/2018 at 6:58AM

Height in meters (IGLD 1985)



Comparison of Water Levels and Storm Events - Duluth, MN 9099064



Great Lakes Water Levels: Coastal Impacts

- Coastal Erosion
- Increased sediment transport in the littoral zone
- Alterations to stream and river mouths
- Damage to coastal infrastructure
- Flooded marinas and docks
- Hazards to navigation
- Loss of coastal terrestrial and wetland habitat
- Shrinking beaches for recreational use
- Increased impacts when storms move through
- Damage and loss of private property



Brighton Beach, Duluth, MN



Illinois Beach State Park

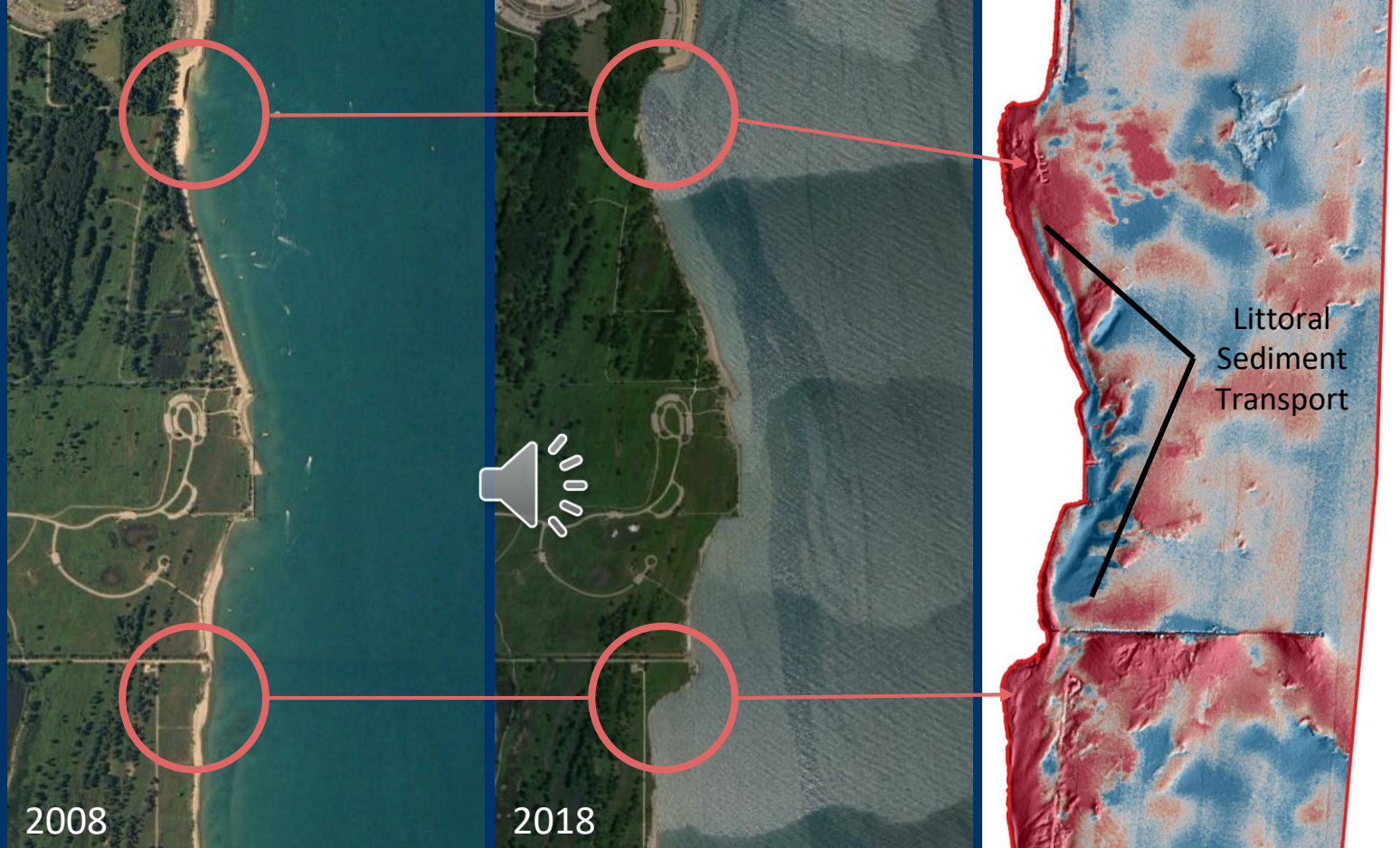
Coastal Erosion

Impact to coastal wetlands

Littoral sediment transport

Red - erosion

Blue - deposition



Coastal Erosion

Lincoln Charter Township, Michigan
AUGUST 2005



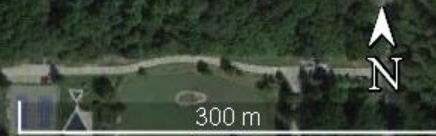
Coastal Erosion

Lincoln Charter Township, Michigan
APRIL 2011



Coastal Erosion

Lincoln Charter Township, Michigan
SEPTEMBER 2015



Coastal Erosion

Lincoln Charter Township, Michigan
MARCH 2019



Ontario Beach Park, Rochester, NY

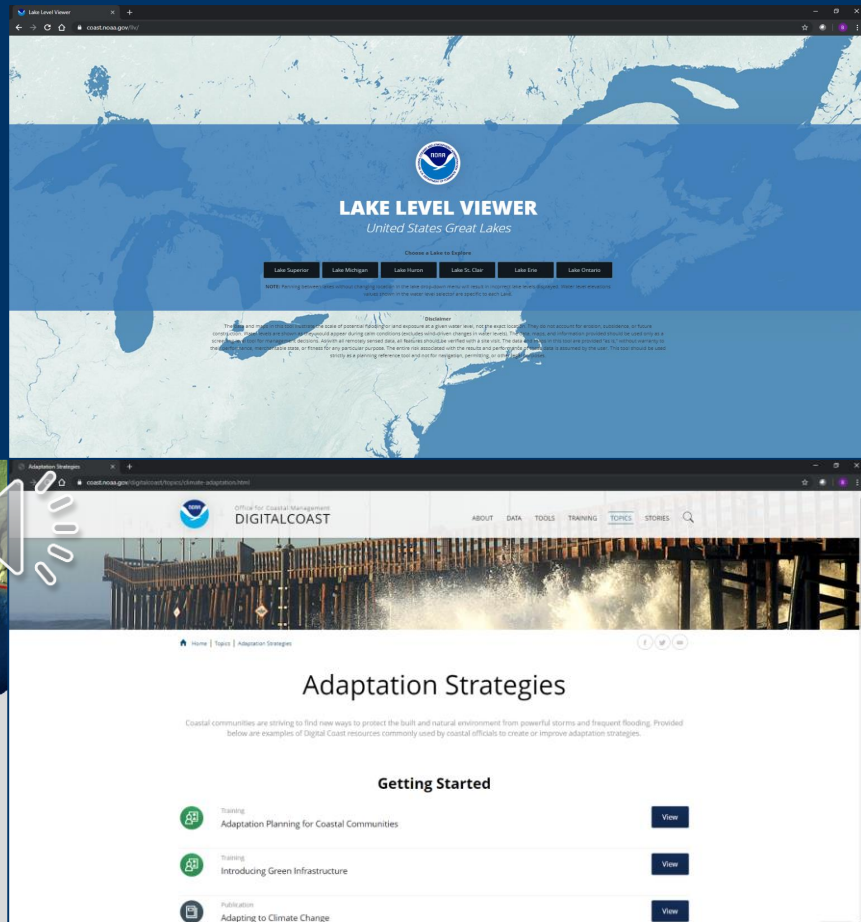
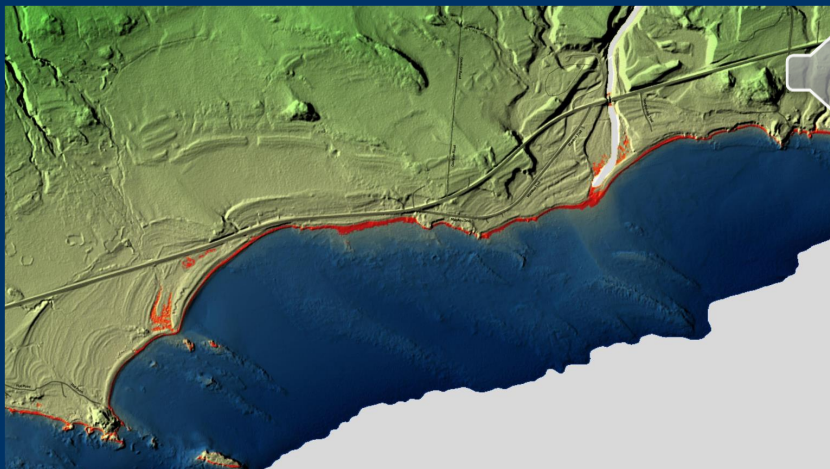


June 14, 2019

Digital Coast

Data, Tools, Trainings, and Resources

<https://coast.noaa.gov/digitalcoast/>



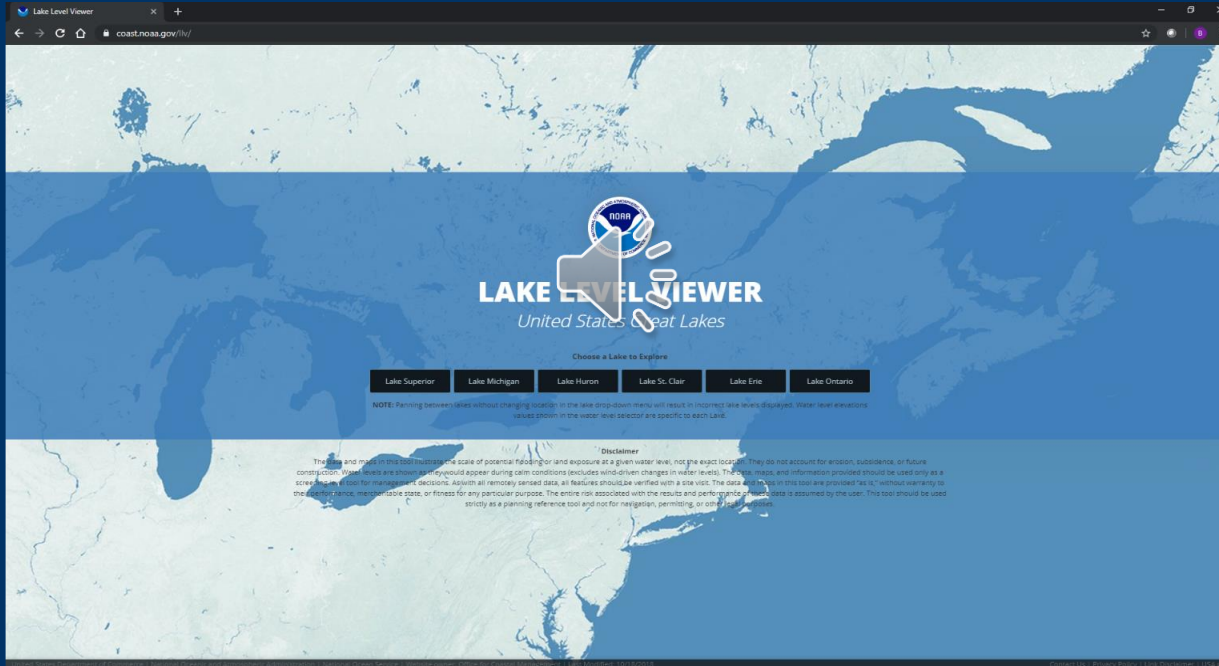
Office for Coastal Management



NOAA's Lake Level Viewer

- Work on the Lake Level Viewer began over 7 years ago
- First official release in November 2014
- Funded by the Great Lakes Restoration Initiative
- Fills a critical information data gap through easy to navigate mapping and visualization
- Digital elevation model data updated in 2016

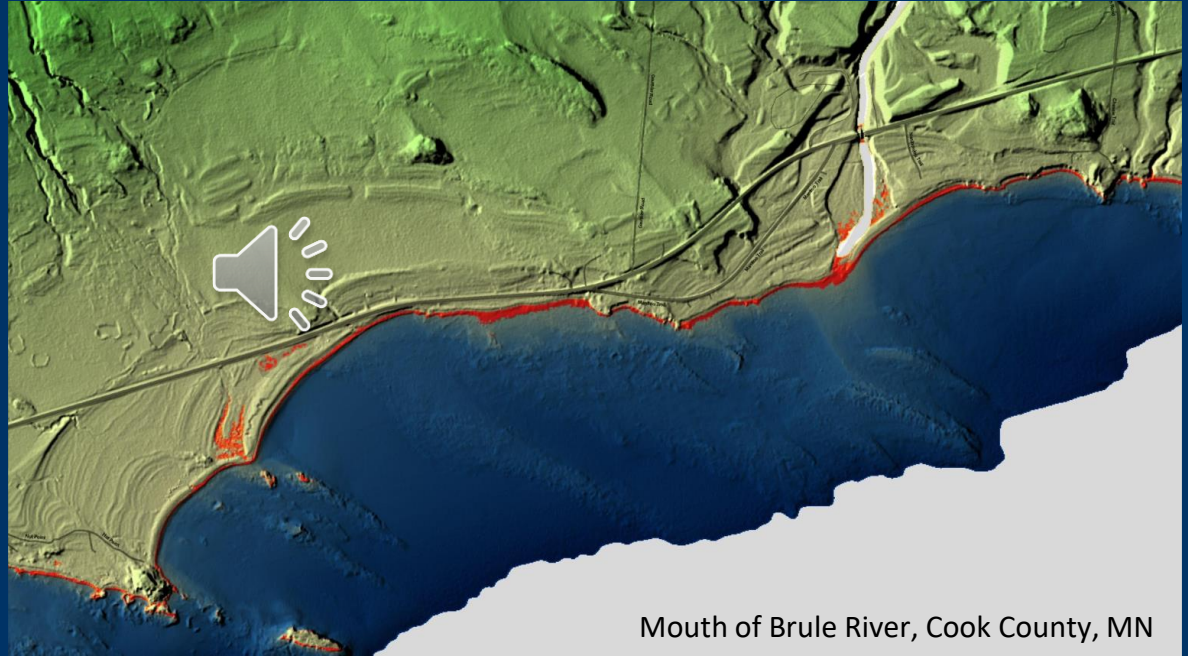
NOAA's Lake Level Viewer: Tool



NOAA's Lake Level Viewer: Data

Digital Elevation Models
(DEMs):

Red area denotes coastal
areas that fall between
record high and record low
water levels for Lake
Superior



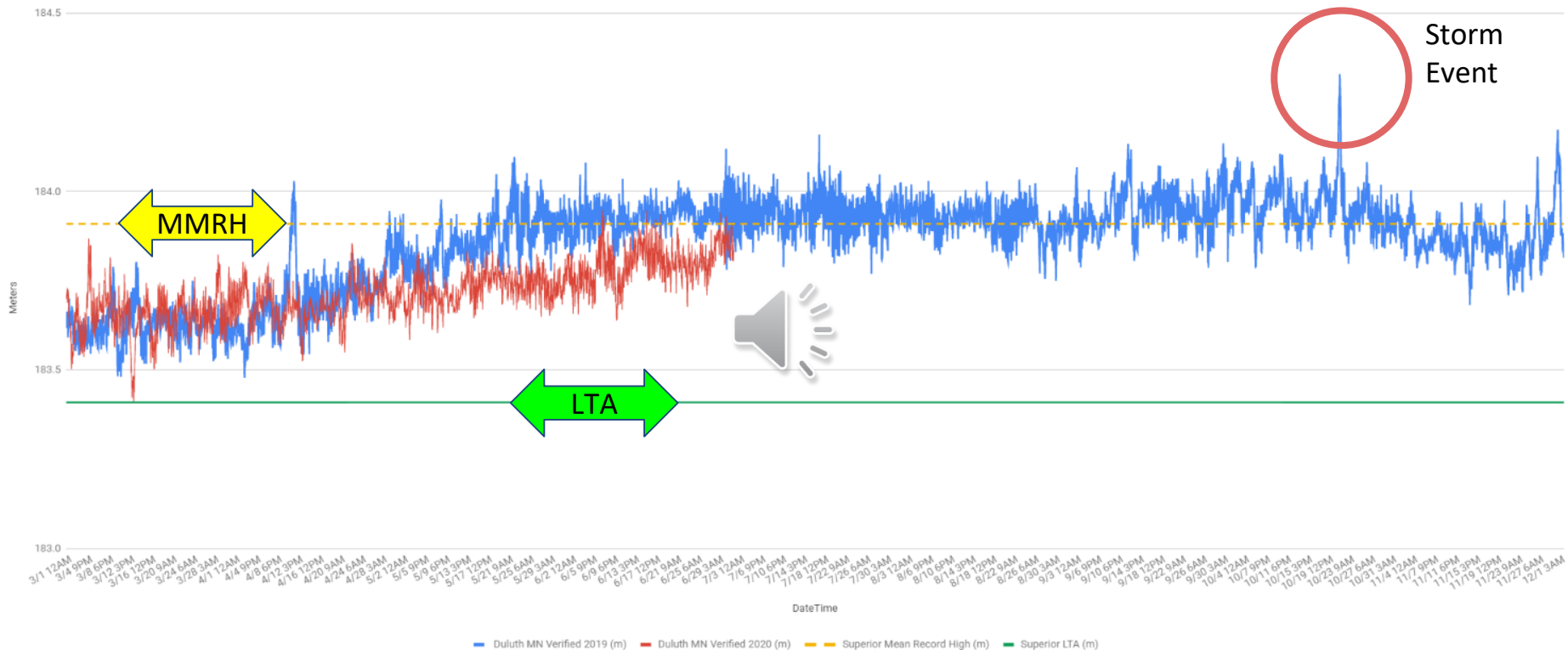
NOAA's Lake Level Viewer

Recent Examples:

Duluth, Minnesota October 21, 2019

Buffalo, New York November, 1, 2019

Large storm event moving west to east across the Great Lakes basin causing lakeshore flooding in multiple locations.



Duluth, MN

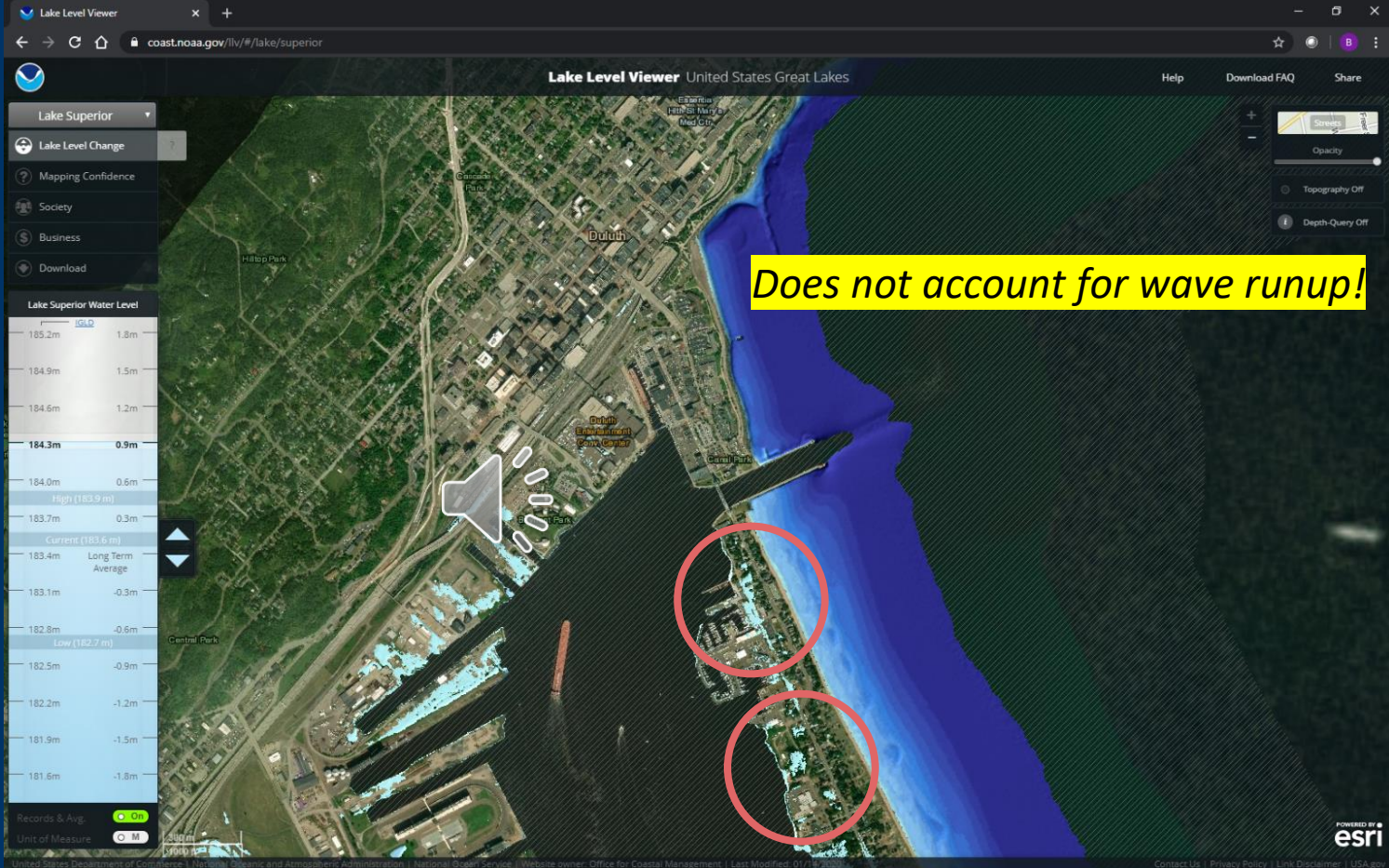
10/21/2019 4PM

184.33 meters
604.75 feet

LTA

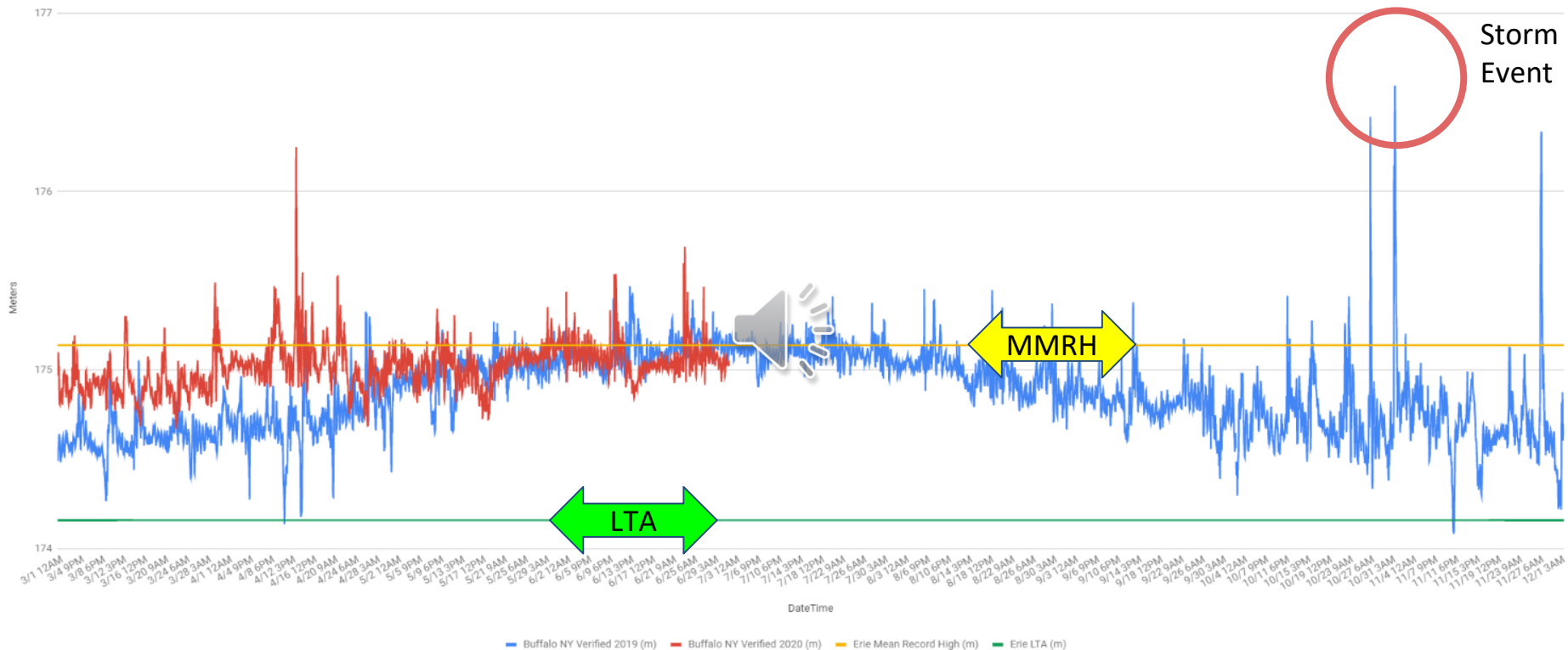
183.41 m
601.74 ft

Difference
+0.92 m
+3.02 ft



Office for Coastal Management





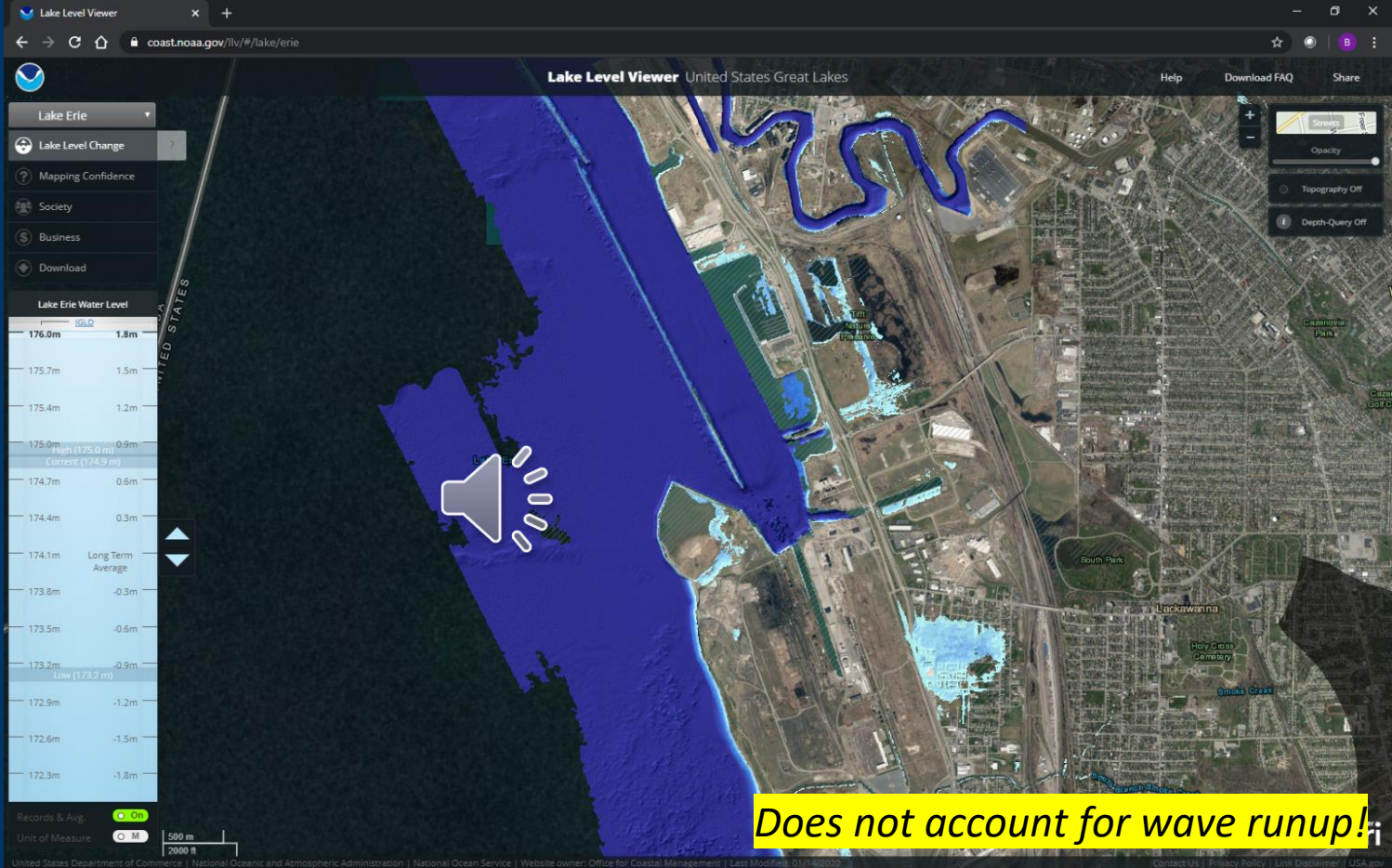
Buffalo, NY

11/1/2019 12AM

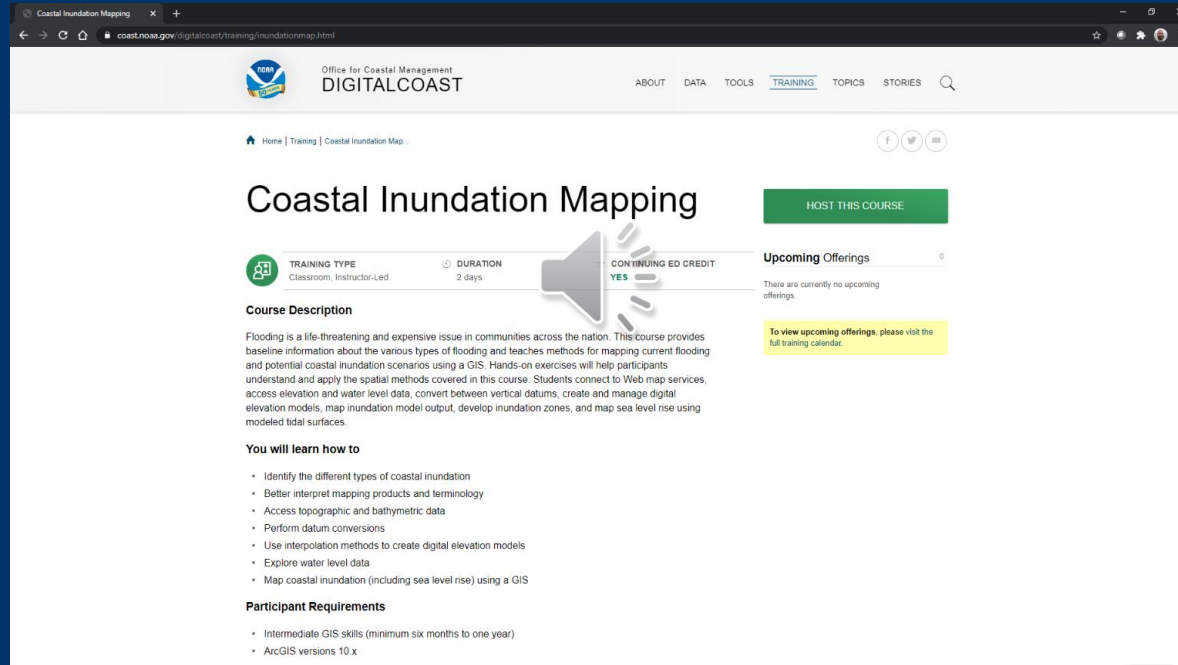
176.59 meters
579.36 feet

LTA
174.16 m
571.4 ft

Difference
+2.43 m
+7.96 ft



Coastal Inundation Mapping Training



The screenshot shows a web browser window displaying the NOAA Digital Coast website. The page is titled "Coastal Inundation Mapping" and features a navigation bar with links for ABOUT, DATA, TOOLS, TRAINING, TOPICS, and STORIES. The main content area includes a large heading "Coastal Inundation Mapping" and a green button labeled "HOST THIS COURSE". Below the heading, there is a section for "TRAINING TYPE" (Classroom, Instructor-Led) and "DURATION" (2 days). A large speaker icon is overlaid on the page. To the right, there is a section for "Upcoming Offerings" which states "There are currently no upcoming offerings." and a yellow box with the text "To view upcoming offerings, please visit the full training calendar." The "Course Description" section explains that flooding is a life-threatening and expensive issue, and the course provides baseline information about various types of flooding and teaches methods for mapping current flooding and potential coastal inundation scenarios using a GIS. The "You will learn how to" section lists several skills, including identifying types of coastal inundation, interpreting mapping products, accessing topographic and bathymetric data, performing datum conversions, using interpolation methods, exploring water level data, and mapping coastal inundation. The "Participant Requirements" section lists intermediate GIS skills and ArcGIS versions 10.x.

Coastal Inundation Mapping

Office for Coastal Management
DIGITALCOAST

ABOUT DATA TOOLS TRAINING TOPICS STORIES

Home | Training | Coastal Inundation Map...

HOST THIS COURSE

TRAINING TYPE: Classroom, Instructor-Led

DURATION: 2 days

CONTINUING EDUCATION CREDIT: YES

Upcoming Offerings: 0

There are currently no upcoming offerings.

To view upcoming offerings, please visit the full training calendar.

Course Description

Flooding is a life-threatening and expensive issue in communities across the nation. This course provides baseline information about the various types of flooding and teaches methods for mapping current flooding and potential coastal inundation scenarios using a GIS. Hands-on exercises will help participants understand and apply the spatial methods covered in this course. Students connect to Web map services, access elevation and water level data, convert between vertical datums, create and manage digital elevation models, map inundation model output, develop inundation zones, and map sea level rise using modeled tidal surfaces.

You will learn how to

- Identify the different types of coastal inundation
- Better interpret mapping products and terminology
- Access topographic and bathymetric data
- Perform datum conversions
- Use interpolation methods to create digital elevation models
- Explore water level data
- Map coastal inundation (including sea level rise) using a GIS

Participant Requirements

- Intermediate GIS skills (minimum six months to one year)
- ArcGIS versions 10.x

Great Lakes Coastal Zone Management Programs



Resources

Digital Coast

coast.noaa.gov/digitalcoast/

Lake Level Viewer

coast.noaa.gov/llv/

Water Level Dashboard

 www.glerl.noaa.gov/data/dashboard/GLWLD.html

NOAA CO-OPS Water Levels

tidesandcurrents.noaa.gov/stations.html?type=Water+Levels

US Interagency Elevation Inventory

coast.noaa.gov/inventory/

Coastal Inundation Mapping Training

coast.noaa.gov/digitalcoast/training/inundationmap.html

USACE Great Lakes Information

www.lre.usace.army.mil/Missions/Great-Lakes-Information/

Contact Information

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Wisconsin Sea Grant

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Vulnerability to Heightened Lake Levels on Wisconsin's Great Lakes



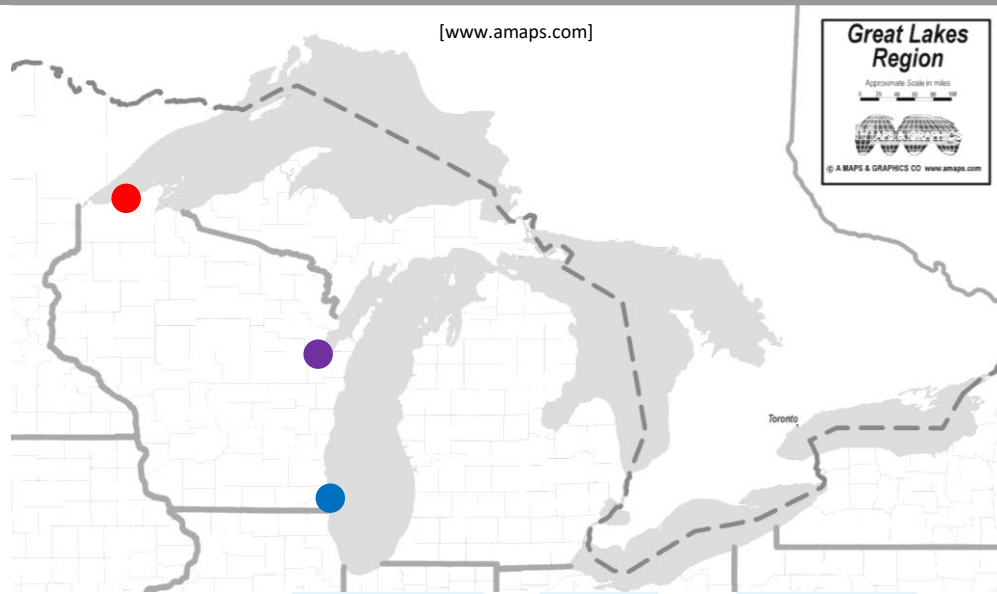
[Wisconsin Shoreline Inventory and Oblique Photo Viewer]



[Julia Noordyk]



[Wisconsin Shoreline Inventory and Oblique Photo Viewer]



[Wisconsin Shoreline Inventory and Oblique Photo Viewer]

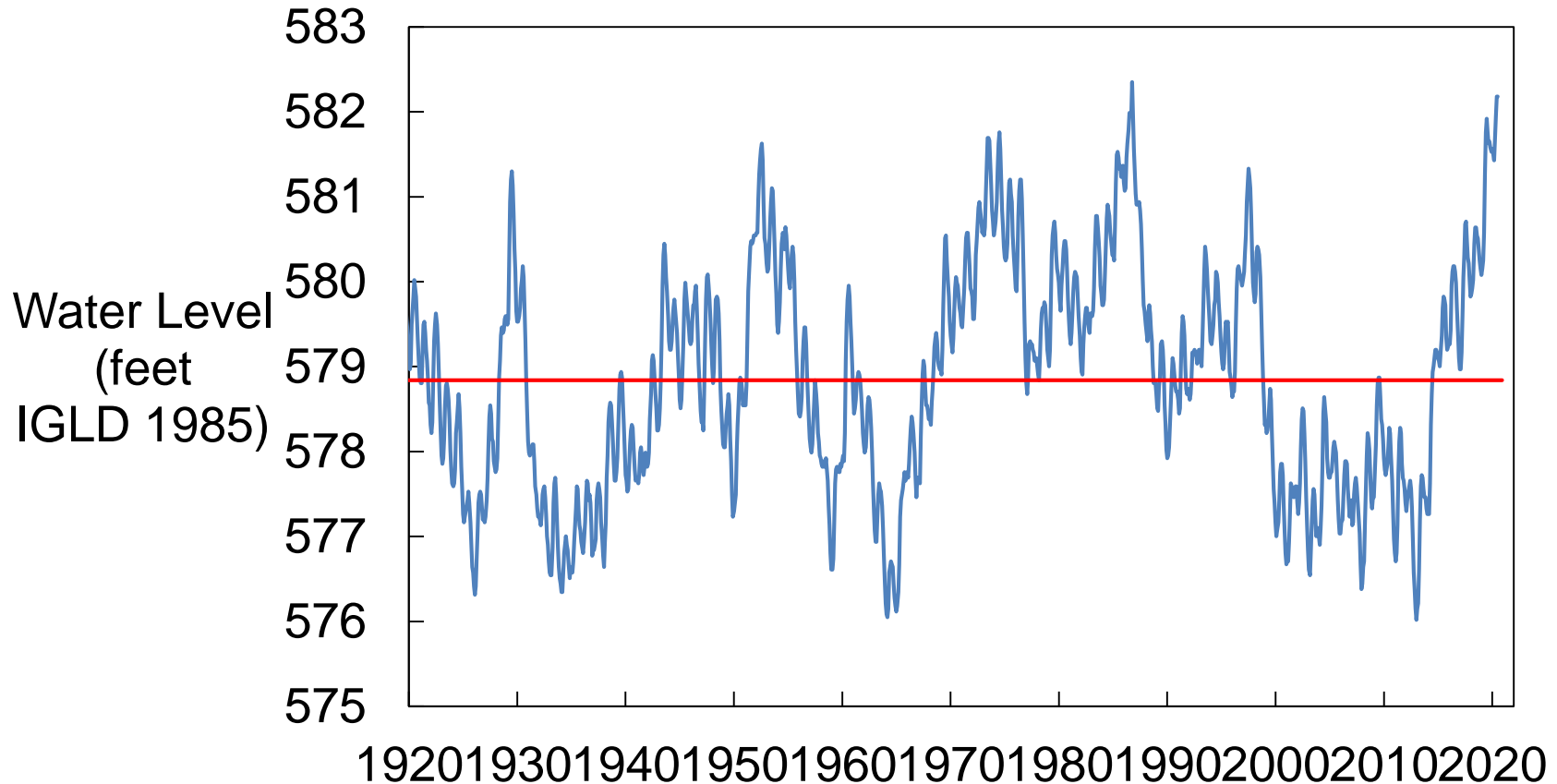


[Julia Noordyk]



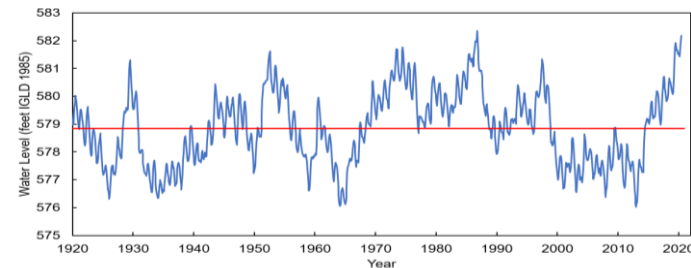
[Wisconsin Shoreline Inventory and Oblique Photo Viewer]

Lake Michigan Water Levels (1918-2020)

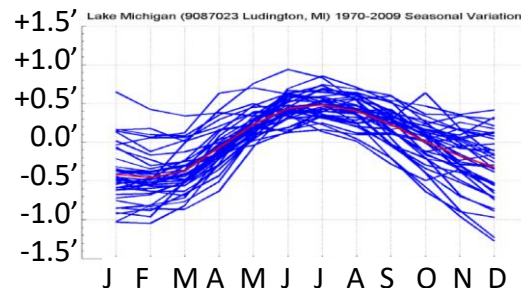


Time Scale of Water Level Changes

- Inter-annual



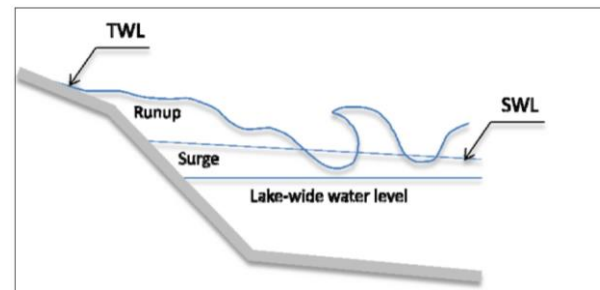
- Seasonal



[modified from
Melby et al., 2012]

- Short-term

- Seconds – wind waves
- Minutes/hours – storm surge



[Nadal-Carabello et al.,
2012]

Figure 2. Still water and total water levels sketch.

Green Bay Coastal Flooding 2019-2020



[Julia Noordyk]



[Jeff DuMez – Brown County]



Historic Green Bay Coastal Flooding

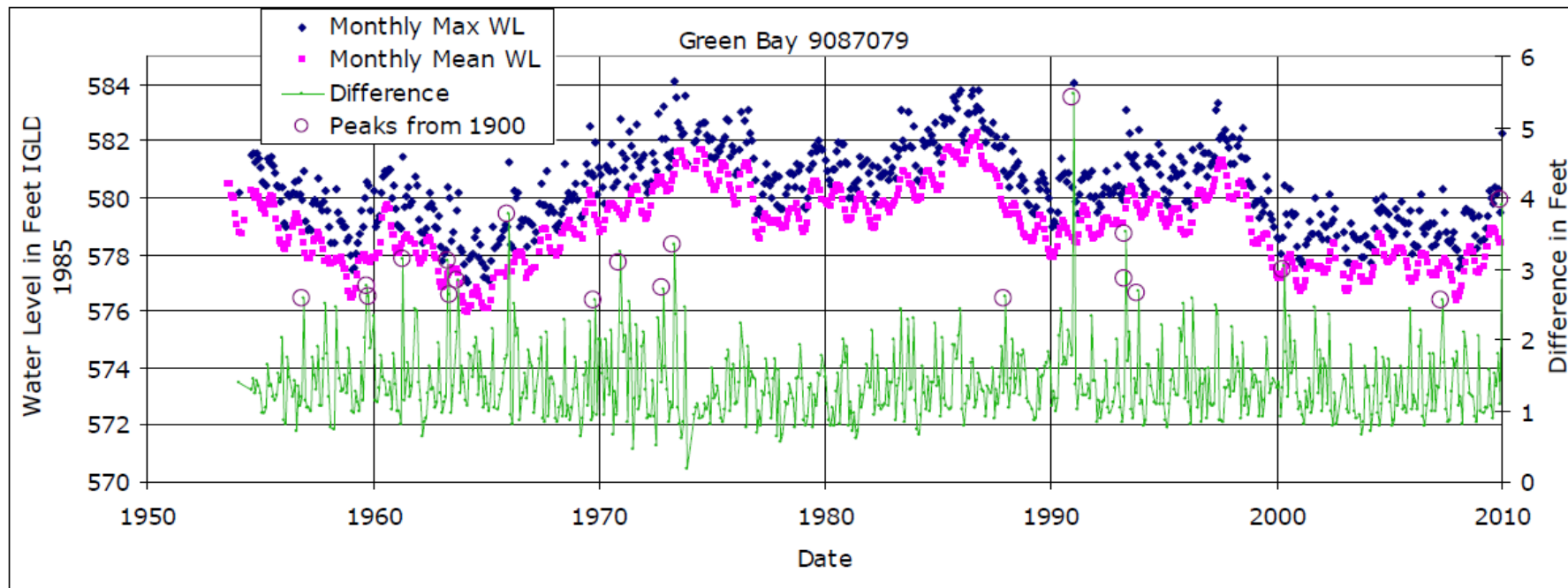


Figure 12. Green Bay 9087078 and 9087079 measured water levels 1954 – 2010.

Melby , J. A., Nadal-Caraballo, N. C., Pagan-Albelo, Y. and Ebersole, B. A. (2012),
“Wave Height and Water Level Variability on Lakes Michigan and St. Clair,” U.S. Army Corps of Engineers, TR-12-23

April 8, 1973

GREEN BAY PRESS-GAZETTE

VOLUME LVI, No. 283

48 PAGES

1973

GREEN BAY, WISCONSIN, TUESDAY, APR. 10, 1973

15 CENTS

Floods Force 800 From Homes

The flooding waters of Green Bay, which had been rising to breach the walls of a 15-acre earthen levee, began receding today in the wake of a backwash stormy that dumped five inches of rain in the area.

As many as 800 persons left 1,811 homes, many in flooded areas along the bay shore, and the Fox and East rivers.

The storm, which by noon had peaked up to 18 miles in heat, dropped steady, and high winds, blowing traffic the

big most of the afternoon and early evening.

It was one of the worst spring rain long-time residents could remember.

Officials reported a low rise for this morning, noting that people who had power

failure and had to heat in their homes.

Police crews were maintaining a constant check on the flooded area today to determine if it was safe for residents to return to their homes.

At the peak of the flooding, Monday police evacuated an area located by the Fox and East rivers, which officers, along with the police and the Fire Department, had to clear.

Police Chief Elmer Hildman estimated that between 200 and 400 persons were rescued from the flooded area and

rescuees left on their own. Underwater, there is still water. The water is receding on Lake Michigan, but some residents are not leaving until they have a good look at the water.

Two full pages of flood and storm pictures on B and C-8.

"It's a tragedy," the publisher of the Green Bay Press-Gazette, Hildman, said, "but we are doing our best to get the news to you as fast as we can."

"We're having trouble with our printers," Hildman said, "but we are doing our best to get the news to you as fast as we can."

and police are entering this area of the area and if they don't leave, they will be arrested.

The report of flooding at a bay shore house was reported by police that Hildman said.

He said police were called by a person who saw a person carrying something out of the house.

He reported the person was carrying something out of the house.

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To the Rescue — These young men with a four-wheel drive vehicle spent much of Monday evening living in a flooded area in Green Bay.

Never Been So Bad, Flood Victims Say

"I never saw anything like this," Ray Shultz, who lives in a flooded area in Green Bay, said, "I never saw anything like this."

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didn't have water in it yet when he left.

"I don't know," Shultz said, "I don't know."

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Rescue Crews Resort to Waders

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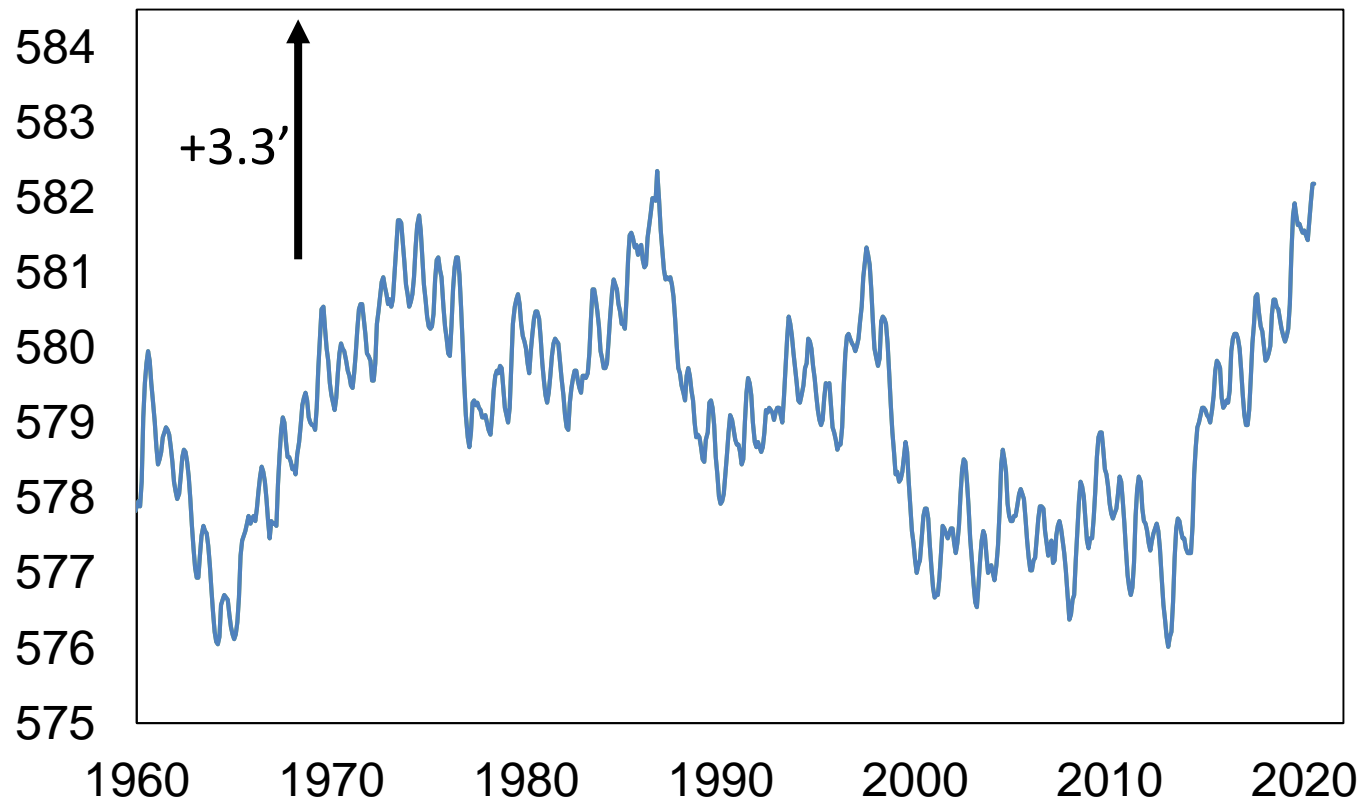


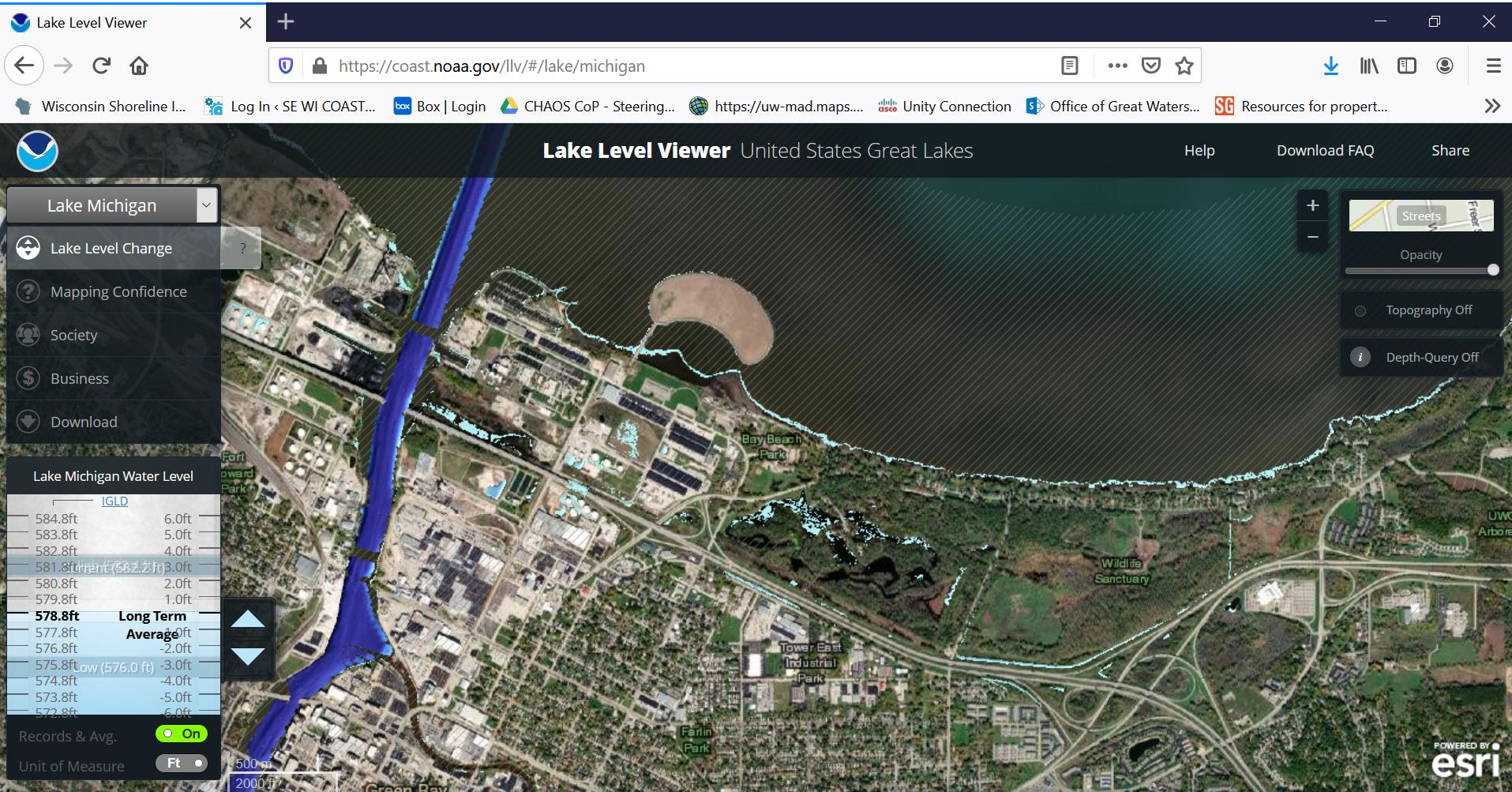
[Green Bay Press-Gazette]

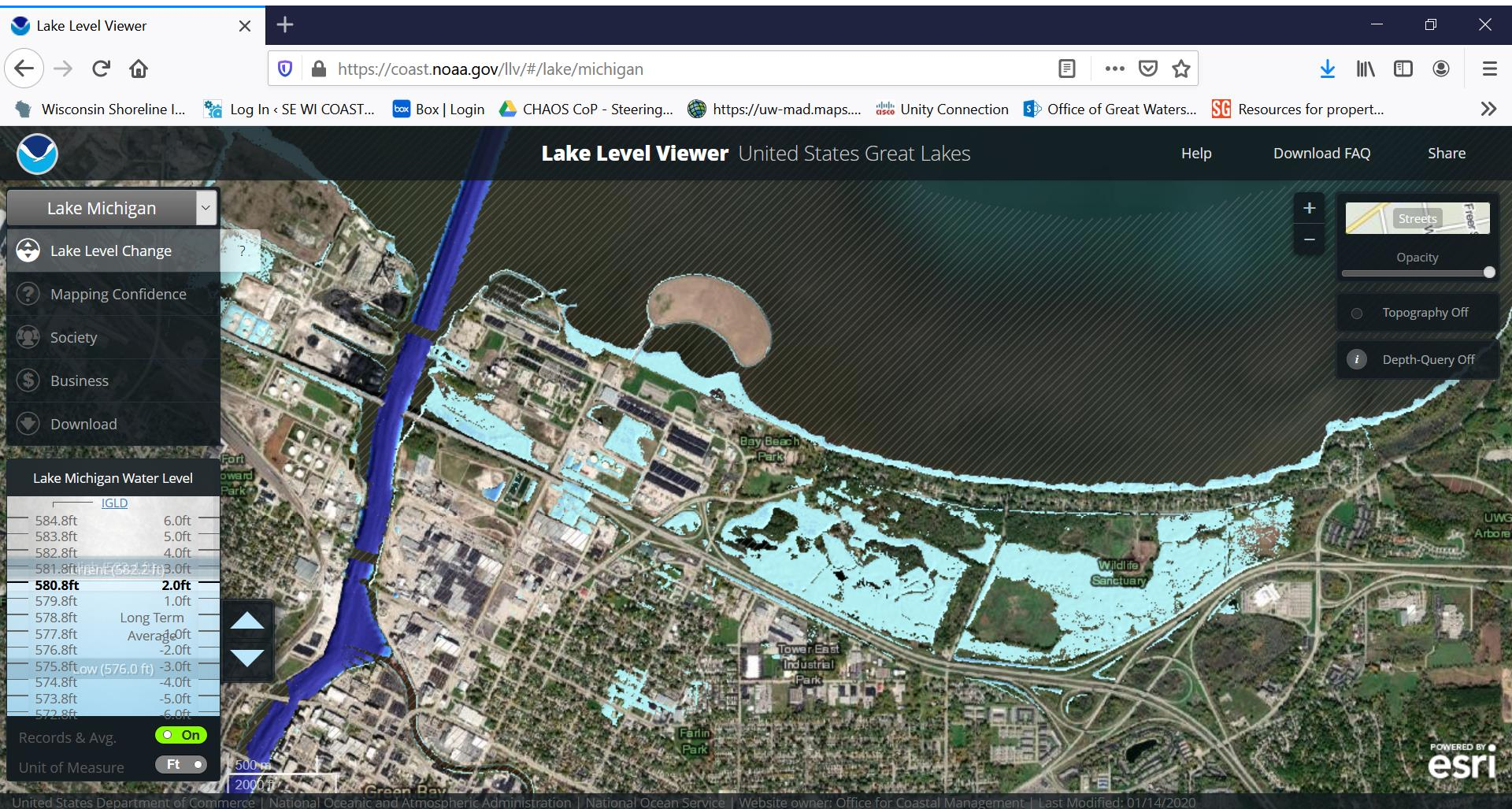
[Green Bay Press-Gazette]

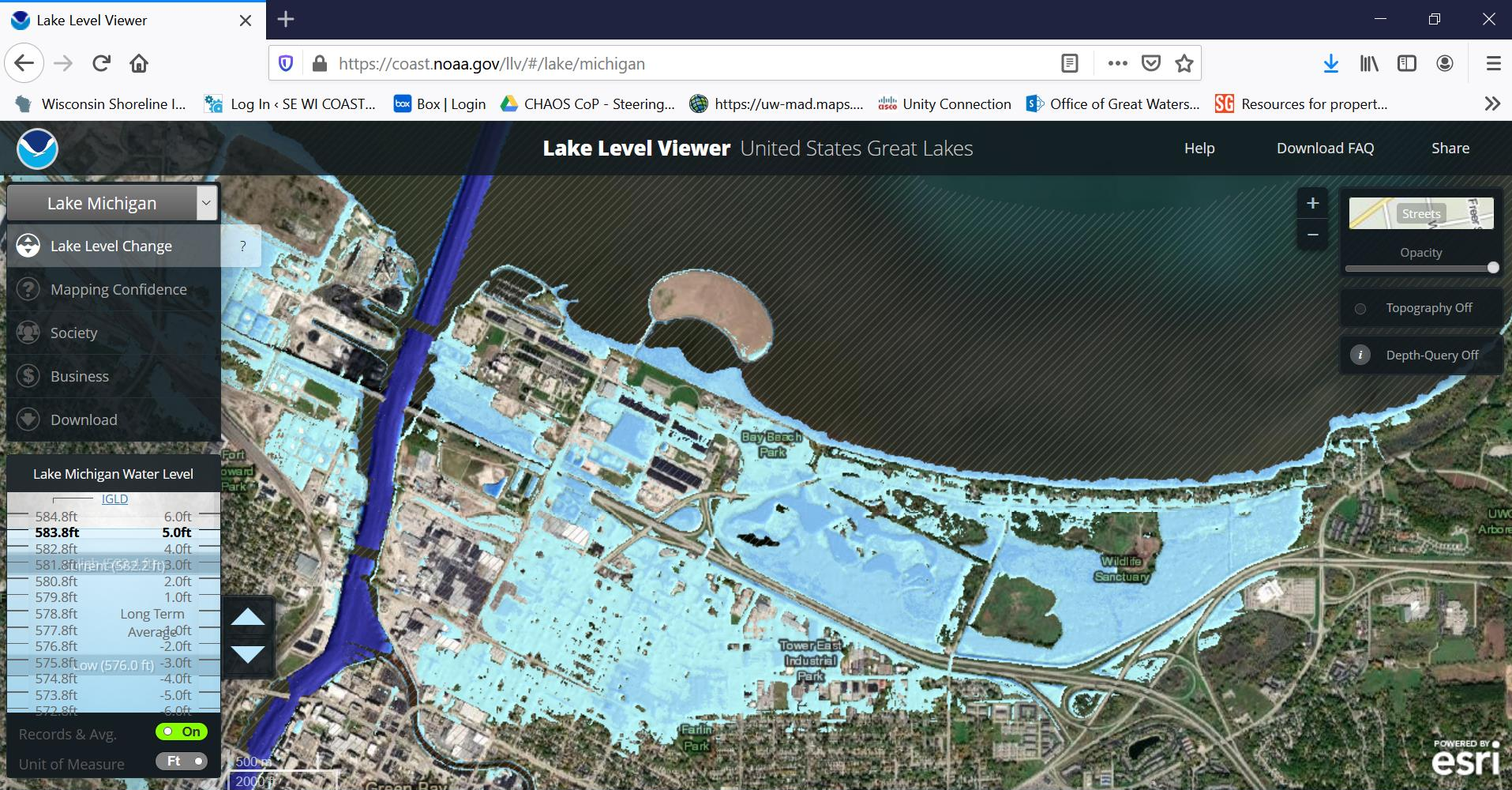
April 8, 1973

Water Level
(feet
IGLD 1985)









May 12,
1973



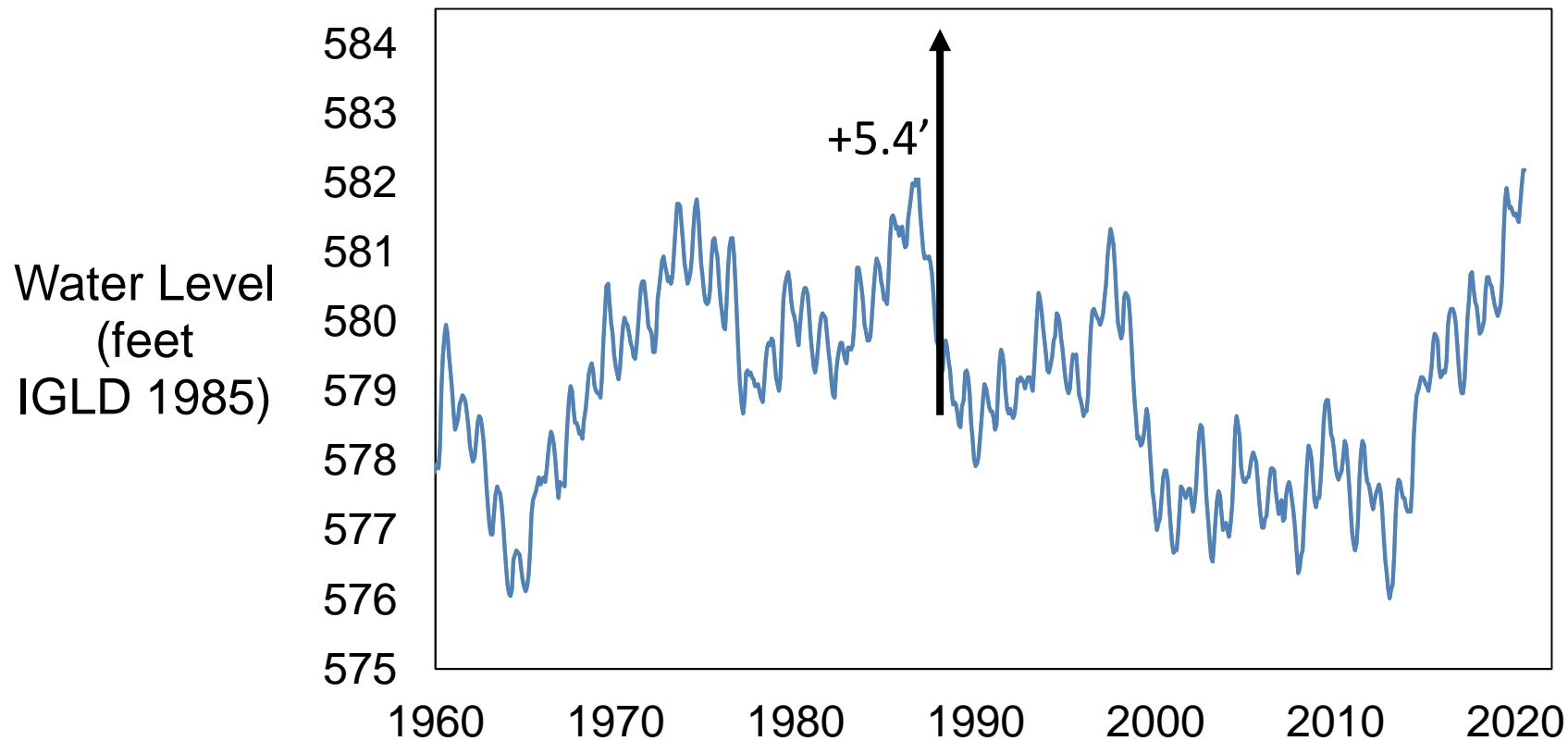
Dike Work Started — Heavy equipment was brought in this week to move sand and clay for the state of the \$1 million east shore dike. The Boulanger Construction Co. of Casco is building the dike which will run from near the mouth

of the Fox River to Mahon Avenue. It is hoped the dike will prevent flooding, such as that which occurred last month which caused widespread damage to homes and businesses on the Northeast Side.

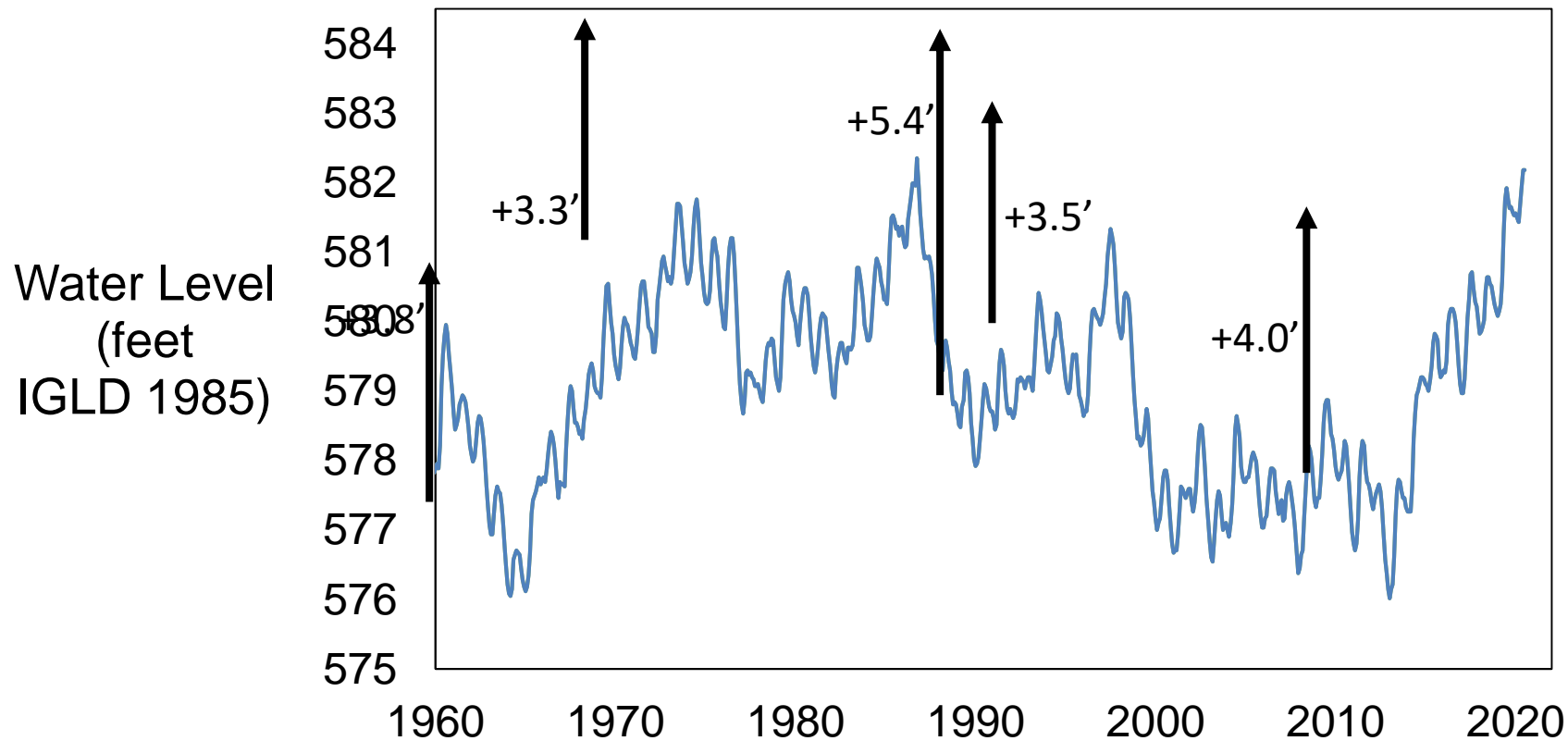
(Press-Gazette Photo)

[Green Bay Press-Gazette]

December 3, 1990



Timing of Water Levels + Storm Surge



December 1, 2019

+2.4 foot storm surge
(~average annual storm surge height)



[Julia Noordyk]

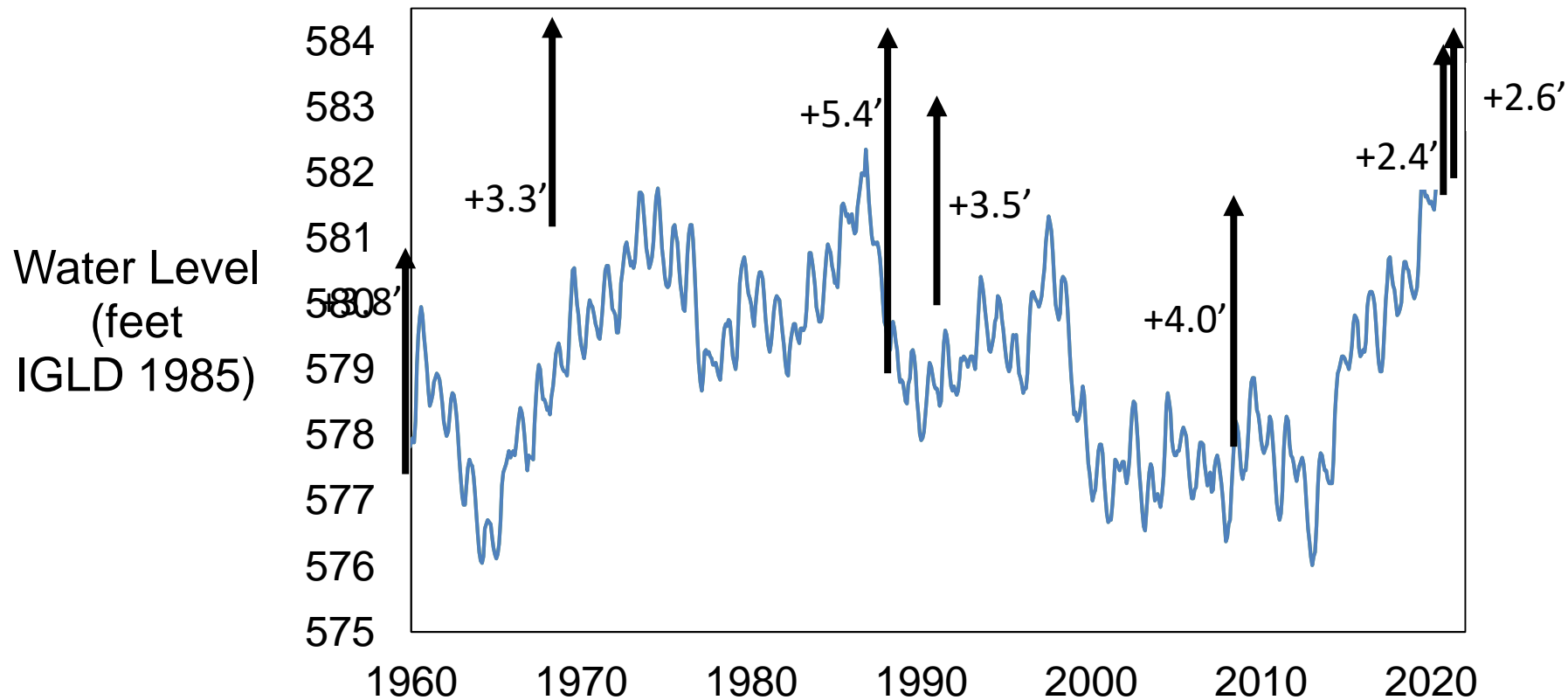
April 28, 2020

+2.6 foot storm surge (~2 to 3 year return interval storm surge height)



[Jeff DuMez, Brown County]

Timing of Water Levels + Storm Surge



January 11th 2020 Southeastern Wisconsin Coastal Storm



[Michael Sears – Milwaukee Journal Sentinel]



[Stephanie Jones – Racine Journal Times]



[Mike De Stisi – Milwaukee Journal Sentinel]

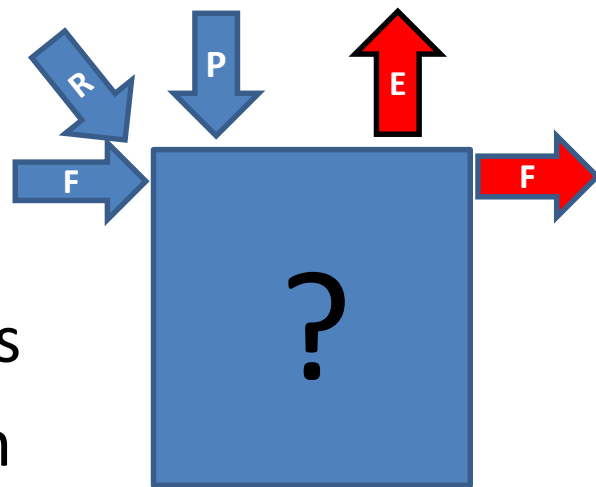


Summary

- Multiple Time Scales of Coastal Risk in the Great Lakes
 - Inter-annual - Lake Levels
 - Seasonal - Lake Levels
 - Short-Term - Storm Surge and Waves

Climate Change Impact on Great Lakes Water Levels

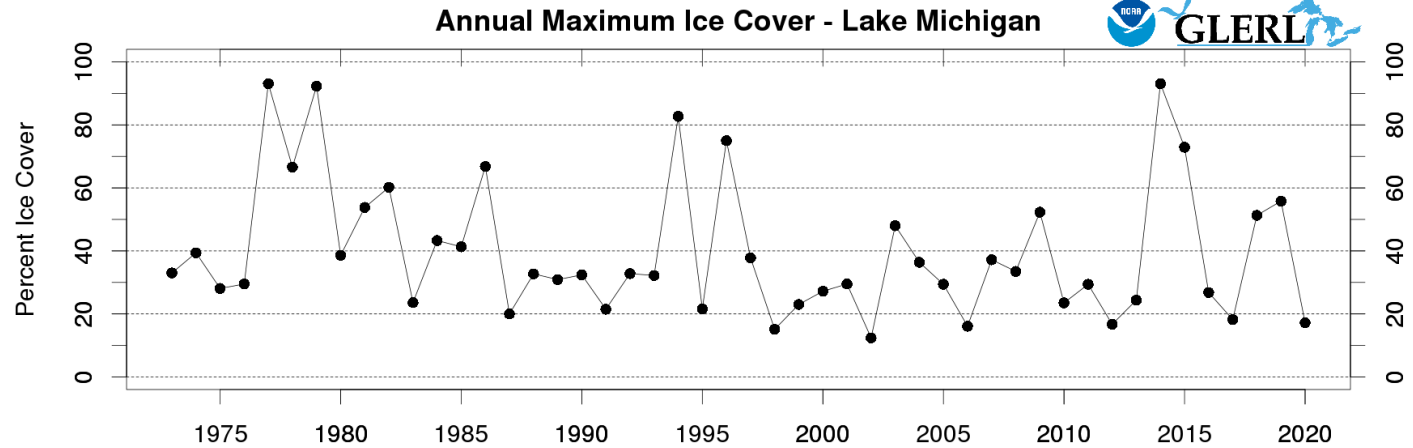
- ↑ • **Precipitation** onto a lake surface
- ↑ • **Runoff** into a lake
- ↑ • **Evaporation** from lake surface
- **Flow** through connecting channels
- **Diversions** into/out of lake system



Climate Change Impacts on Ice Cover



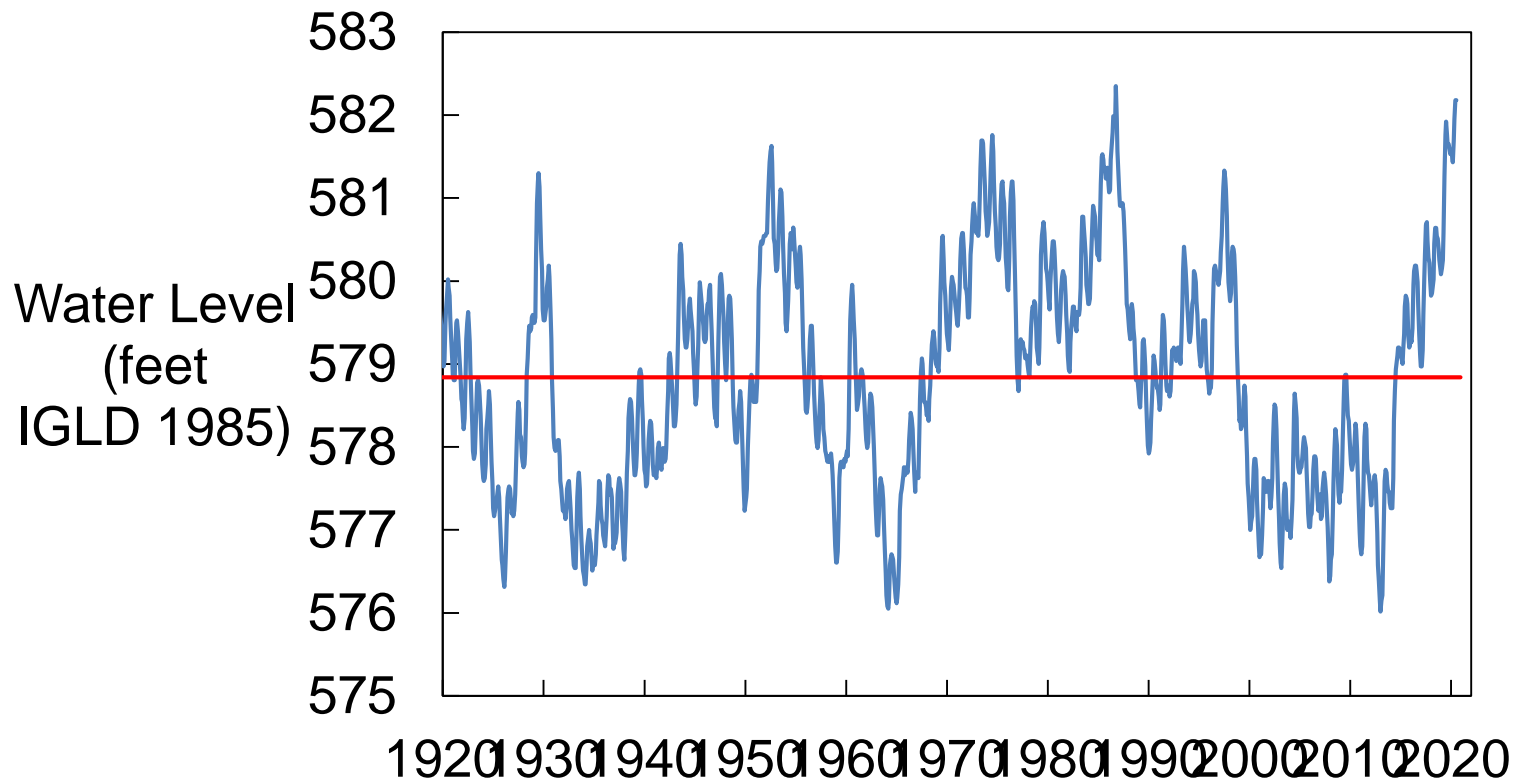
[MODIS Satellite Image]



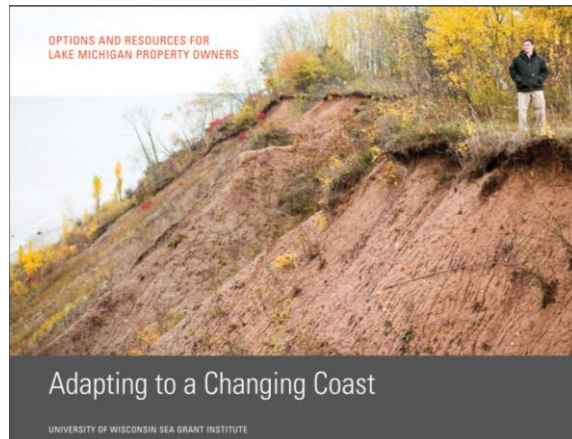
Summary

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 - Seasonal - Lake Levels
 - Short-Term - Storm Surge and Waves
 - Climate Change - Lake Levels, Ice, and Storms

Awareness of Coastal Hazard Risks \propto Great Lakes Water Levels?



Coastal Resilience Outreach



Coastal Resilience Self-Assessment



Part 1: Identifying Coastal Hazard Risks

COASTAL HAZARD ISSUE	PROBABILITY	IMPACT			PREPAREDNESS	RISK SCORE
	<i>Likelihood this issue will occur</i>	<i>HUMAN</i> <i>Possibility of death or injury</i>	<i>PROPERTY</i> <i>Physical losses and damages</i>	<i>BUSINESS/ AGENCY</i> <i>Interruption of services</i>	<i>Level of planning done for this issue</i>	<i>Relative threat *calculated by Coastal Resilience team</i>
Shoreline Recession & Bluff Failure	High ▾	Low ▾	High ▾	Moderate ▾	Low ▾	75
Coastal Flooding	▾	▾	▾	▾	▾	0
Shore Protection Damage	▾	▾	▾	▾	▾	0
Beach Loss	▾	▾	▾	▾	▾	0
Beach Impairment	▾	▾	▾	▾	▾	0
Port, Harbor, & Marina Damage	▾	▾	▾	▾	▾	0
Port, Harbor, & Marina Navigation Impairment	▾	▾	▾	▾	▾	0

Coastal Resilience Self-Assessment



Part 2: Resilient Practices Questionnaire

- Understanding Coastal Hazard Impacts
- Hazard Mitigation Planning
- Community Planning
- Local Ordinances
- Public Education and Engagement
- Shore Protection
- Managing Water on Coastal Lands
- Beaches
- Ports Harbors and Marinas

Coastal Resilience Self-Assessment



CITY OF RACINE, WISCONSIN

- | | Yes | No | ? |
|--|-----------------------|----------------------------------|----------------------------------|
| 2) Do updated maps or spatial data exist that identify areas at risk to coastal hazards? | <input type="radio"/> | <input checked="" type="radio"/> | <input type="radio"/> |
| 19) Are ordinances pertaining to coastal hazards consistent with those of surrounding jurisdictions in both policy and language? | <input type="radio"/> | <input type="radio"/> | <input checked="" type="radio"/> |
| 35) Do beach management plans exist that detail strategies for addressing beach loss due to erosion or high lake level conditions? | <input type="radio"/> | <input checked="" type="radio"/> | <input type="radio"/> |

Coastal Resilience Self-Assessment



Ports, Harbors and Marinas (if applicable)	Yes	No	?
37) Does your facility conduct a regular assessment of critical infrastructure to identify maintenance issues requiring corrective action?	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
38) Does your facility have an assessment of costs to maintain, repair and replace its assets?	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>

Summary

- Multiple Time Scales of Coastal Risk in the Great Lakes
 - Inter-annual - Lake Levels
 - Seasonal - Lake Levels
 - Short-Term - Storm Surge and Waves
 - Climate Change - Lake Levels, Ice, Storms
- Coastal Resilience Outreach
 - Build and maintain institutional knowledge
 - Self-Assessment to start conversation about holistic approaches to resilience



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<https://seawatercoastalresilience.org/>

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References

Images

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- NOAA Lake Level Viewer - <https://coast.noaa.gov/llv/>

Water Level Data

NOAA GLERL - <https://www.glerl.noaa.gov/data/dashboard/data/>

Ice Data

NOAA GLERL - <https://www.glerl.noaa.gov/data/ice/#historical>

Surge Data

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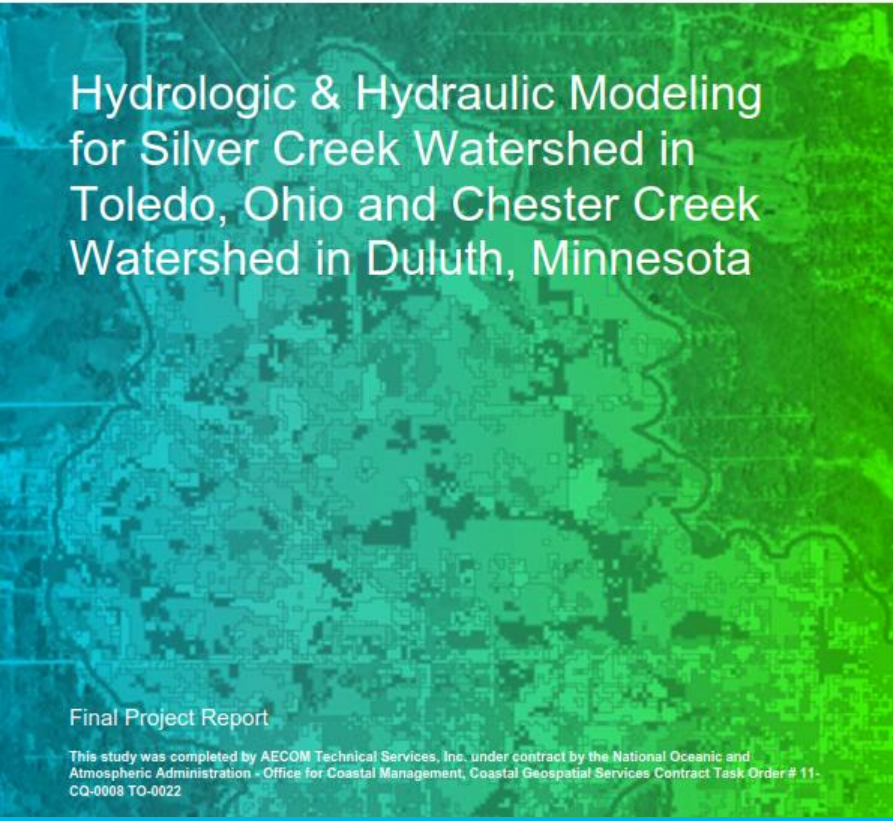
Nadal-Caraballo, N. C., Melby, J.A. and Ebersole, B.A. (2012), “Lake Michigan: Statistical Analysis and Storm Sampling Approach” U.S. Army Corps of Engineers, TR 12-18

2D Modeling Applications for Watershed Modeling Studies in Toledo, OH and Duluth, MN

Joe Chapman, PE
Vice President



August 13, 2020

The background of the left half of the slide is an aerial map of the Silver Creek Watershed. The map is overlaid with a green and blue color scheme, highlighting the watershed's boundaries and surrounding areas. The text "Hydrologic & Hydraulic Modeling for Silver Creek Watershed in Toledo, Ohio and Chester Creek Watershed in Duluth, Minnesota" is written in white over the map.

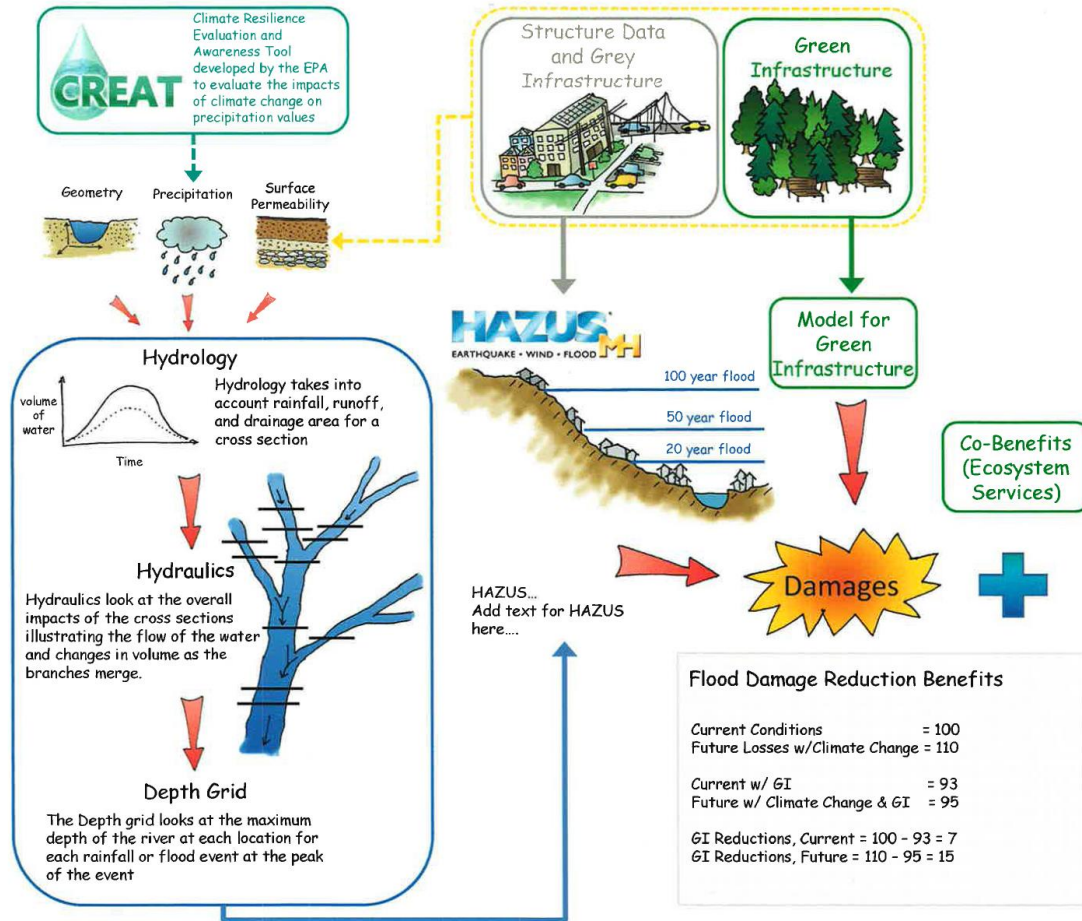
Hydrologic & Hydraulic Modeling for Silver Creek Watershed in Toledo, Ohio and Chester Creek Watershed in Duluth, Minnesota

Final Project Report

This study was completed by AECOM Technical Services, Inc. under contract by the National Oceanic and Atmospheric Administration - Office for Coastal Management, Coastal Geospatial Services Contract Task Order # 11-CQ-0008 TO-0022

Study Overview

Framework for Original Pilot



Old Pilot vs New Pilot

Final Report

Economic Assessment of Green Infrastructure Strategies for Climate Change Adaptation: Pilot Studies in The Great Lakes Region

May 2014

Eastern Research Group, Inc.

Written under contract for the
National Oceanic and Atmospheric Administration
Coastal Services Center

NOAA Coastal Services Center
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AECOM

Submitted to
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Submitted by
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North Charleston, SC 29405
April 22, 2016

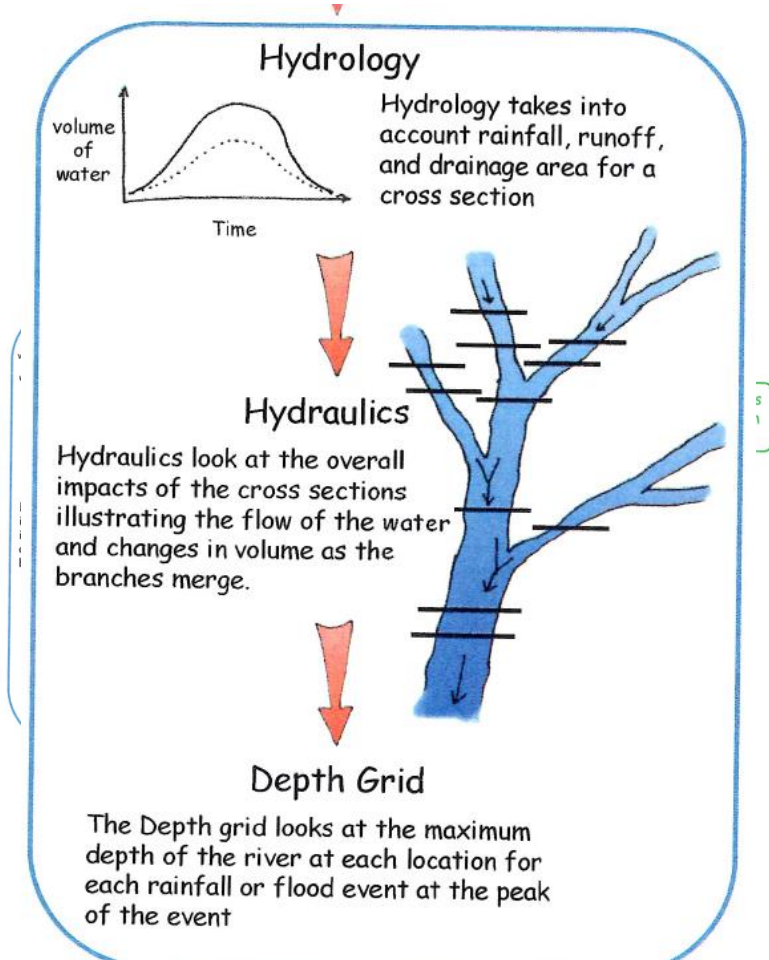
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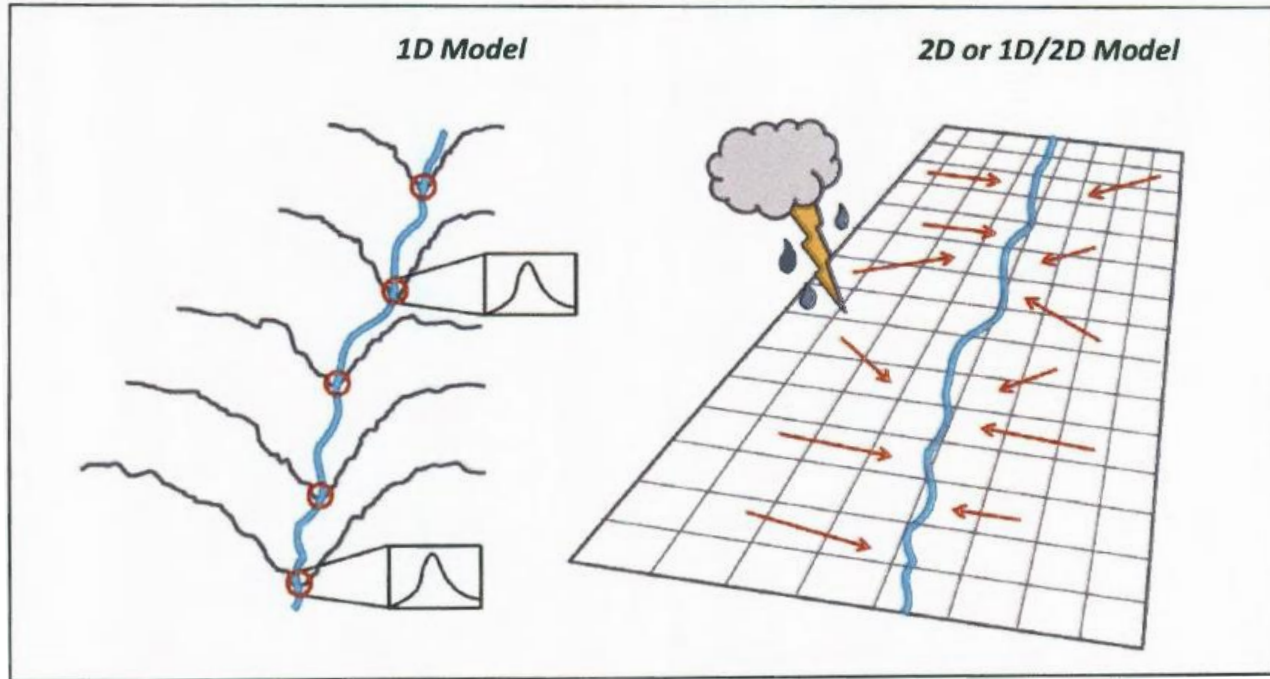
AECOM

New Project Objectives

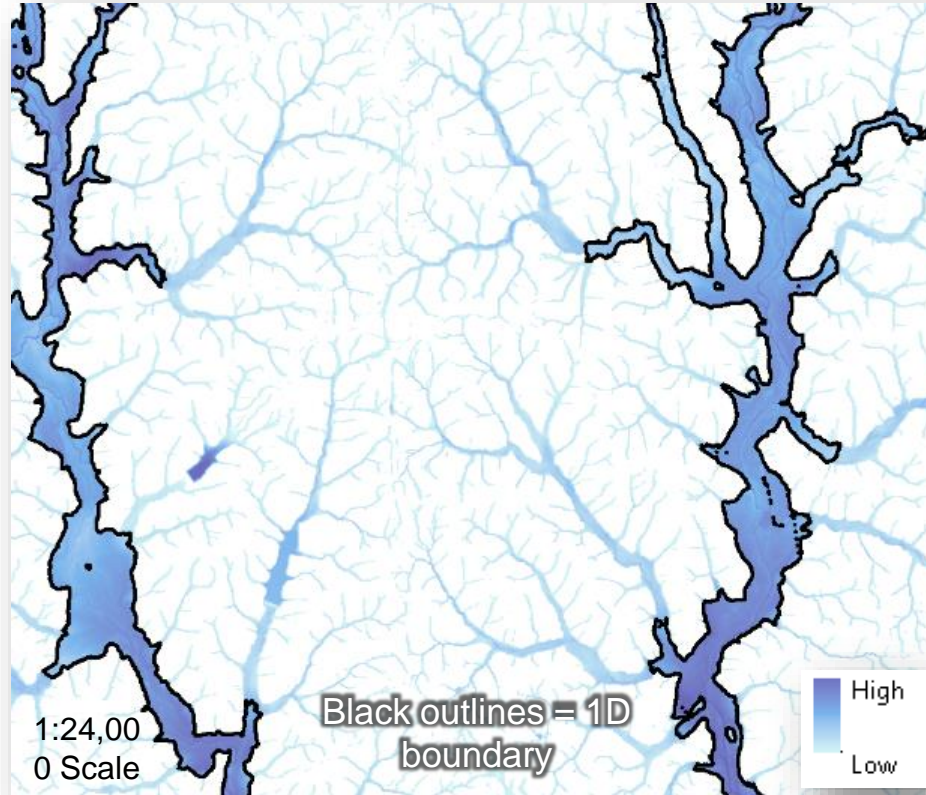


- Evaluate application of 2D modeling approach to previous pilot study areas
- Assess existing and future (with and w/out GI) scenarios
- Prepare summary findings and recommendations

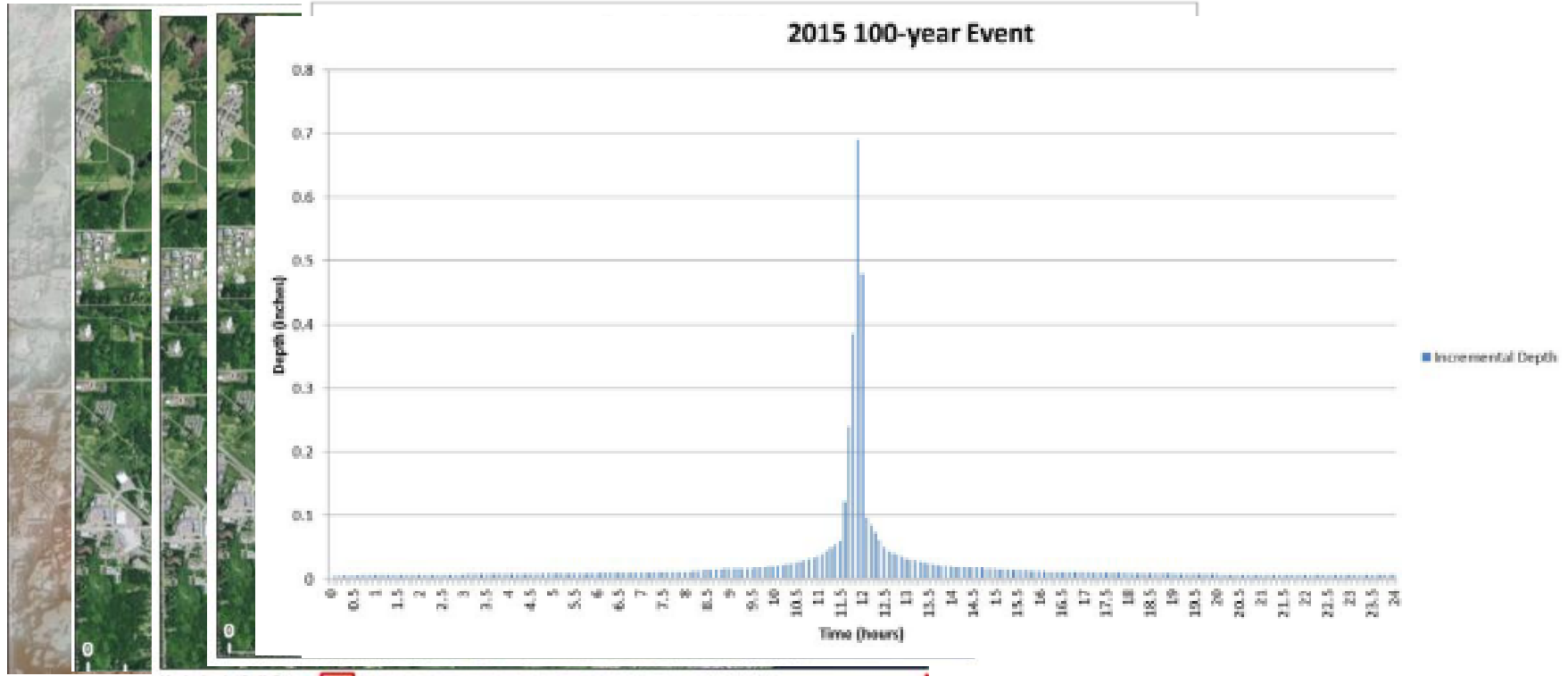
1-D Modeling vs 2-D Modeling



1-D Modeling vs 2-D Direct Rainfall Modeling



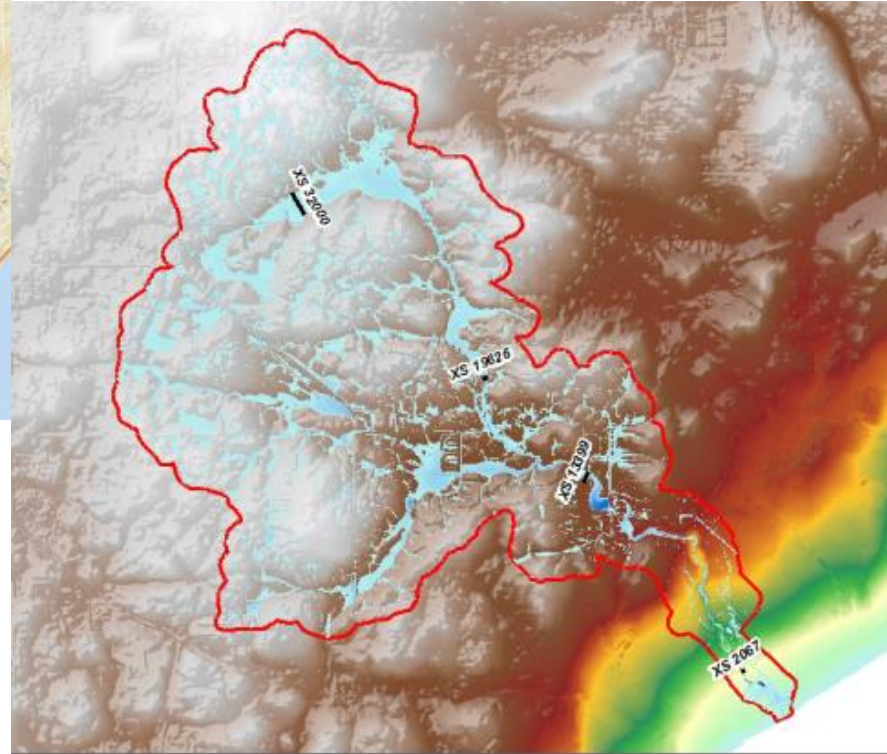
Modeling Input Parameters



1-D Modeling vs 2-D Modeling – Silver Creek



1-D Modeling vs 2-D Modeling – Chester Creek



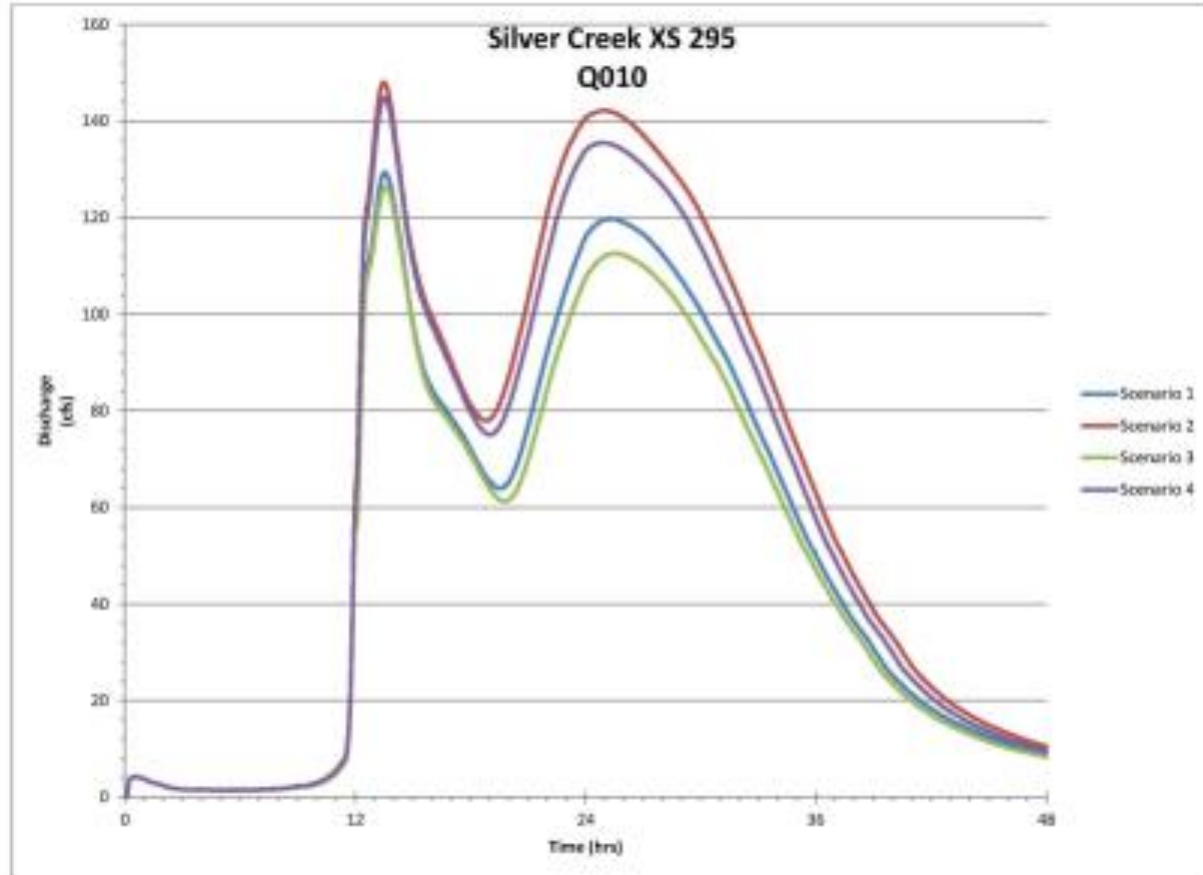
Modeling Scenarios

- TUFLOW GPU
- 2015 – rainfall, landuse, landcover
 - Without Green Infrastructure
 - With Green Infrastructure
- 2035 – projected rainfall, landuse, landcover
 - Without Green Infrastructure
 - With Green Infrastructure

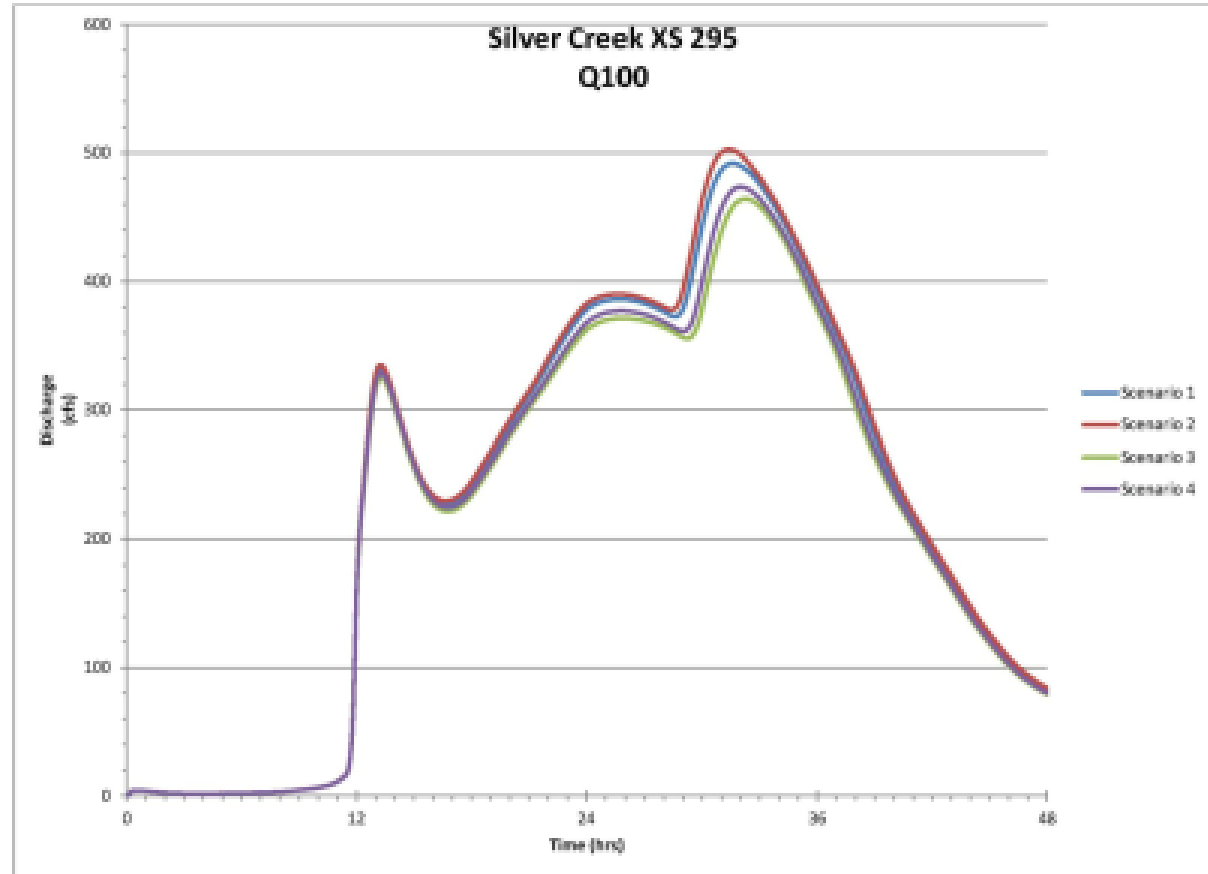
Simulating Impacts of Green Infrastructure

- Green Infrastructure impacts modeled through changes to surface roughness and percent impervious
 - Estimate of percentage of area to be impacted by GI
 - Modify surface roughness and percent impervious for impacted area of watershed

Modeling Results



Modeling Results



Modeling Results – Average Peak Discharge Reductions

Average Chester Creek Peak Discharge Reductions						
	Q2	Q5	Q10	Q25	Q50	Q100
Existing Conditions	0.5%	0.4%	0.4%	0.3%	0.3%	0.3%
Future Conditions	2.7%	1.9%	1.9%	1.6%	1.6%	1.7%
Average Silver Creek Peak Discharge Reductions						
	Q2	Q5	Q10	Q25	Q50	Q100
Existing Conditions	4.7%	5.0%	6.0%	5.3%	4.0%	4.4%
Future Conditions	5.1%	4.5%	4.9%	4.5%	3.9%	4.3%

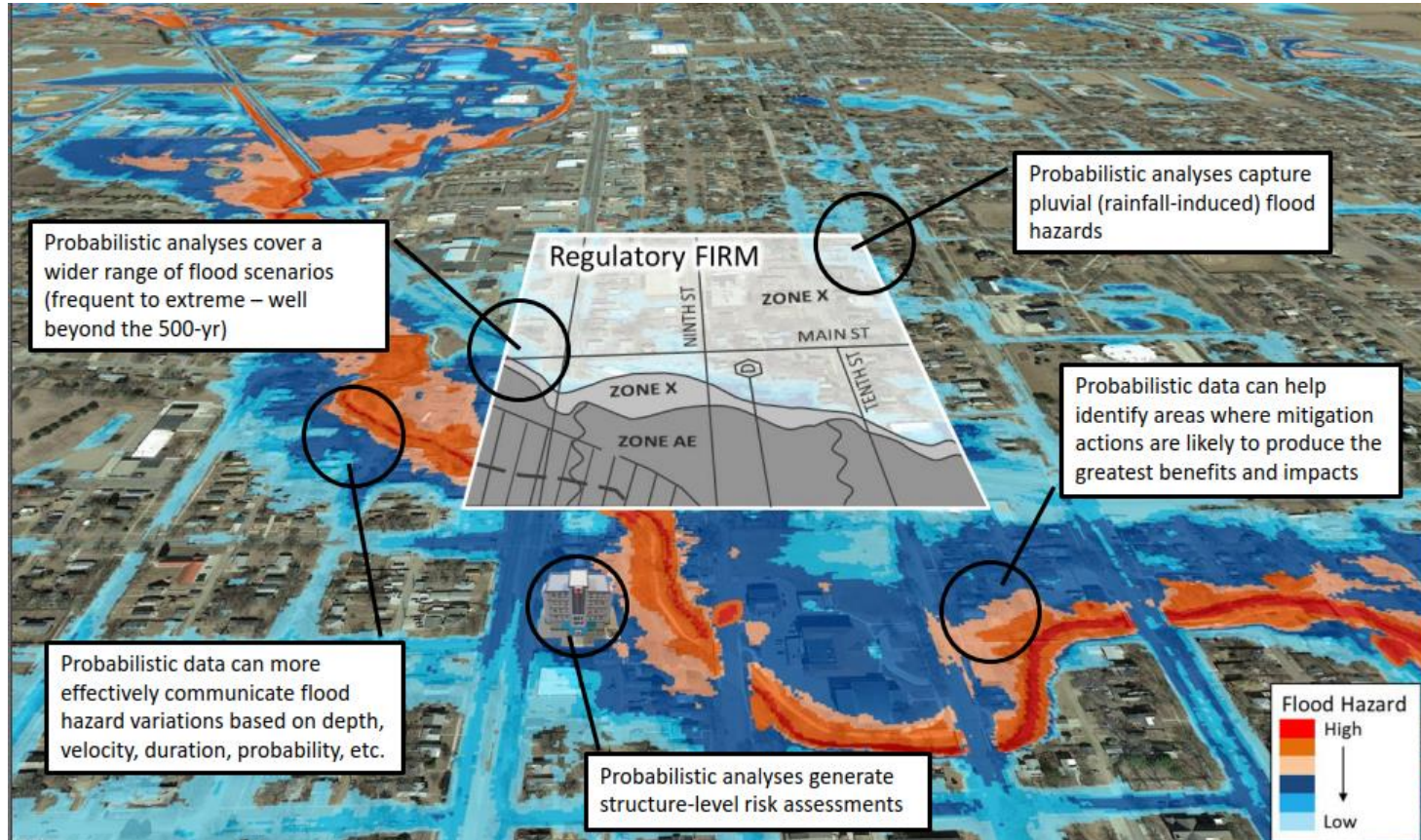
Modeling Results – Average Inundation Area Reduction

	Average Chester Creek Inundation Area Reductions (% acres)					
	Q2	Q5	Q10	Q25	Q50	Q100
Existing Conditions	-0.1% -0.56	-0.1% -0.98	-0.1% -1.09	-0.2% -1.48	-0.2% -1.65	-0.2% -1.86
Future Conditions	-0.5% -3.08	-0.7% -5.55	-0.8% -7.04	-0.8% -7.84	-0.8% -8.65	-0.9% -9.55
	Average Silver Creek Inundation Area Reductions (% acres)					
	Q2	Q5	Q10	Q25	Q50	Q100
Existing Conditions	1.7% 22.65	1.1% 20.37	0.9% 20.52	0.7% 18.30	0.5% 15.72	0.4% 13.58
Future Conditions	1.5% 22.18	1.1% 21.85	0.8% 19.30	0.6% 16.94	0.5% 14.65	0.4% 13.45

Takeaways

- GI can be a cost effective tool for reducing impacts of more frequent flood events
- GI measures can reduce impact of climate induced rainfall increases and extend design life of stormwater infrastructure
- Results vary depending size and shape of watershed, topography, urbanization, etc.
- 2D modeling provides a cost effective method to quickly perform comprehensive watershed wide assessments
- The future of 2D modeling continues to evolve rapidly

2D Modeling – Probabilistic Flood Risk Assessment



The background is a solid blue color. On the right side, there are several thin, white, straight lines that intersect to form a series of overlapping triangles and other geometric shapes, creating a modern, abstract design.

Thank You

Joe Chapman
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Environmental Advocacy Webinar Series

Research as Climate Advocacy: Using Scholarship for Social Change

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- Sept. 17, 2020 Enhancing Opportunities for Socially Vulnerable Populations to Have “a Seat at the Table” in Climate Resilience Planning
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