



FEMA Risk MAP Program: Great Lakes Coastal Flood Study

Alan R Lulloff , P.E., CFM Association of State Floodplain Managers *alan@floods.org*











Great Lakes Coastal Flood Study



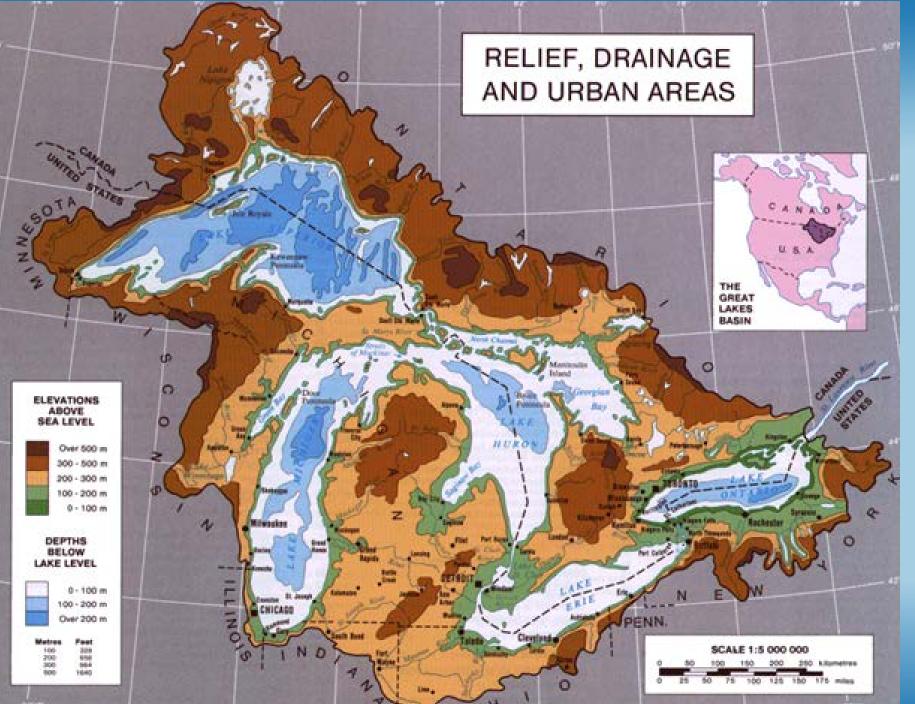
The initiative is a system-wide solution that provides a comprehensive analysis of storm and high water events within the Great Lakes Basin





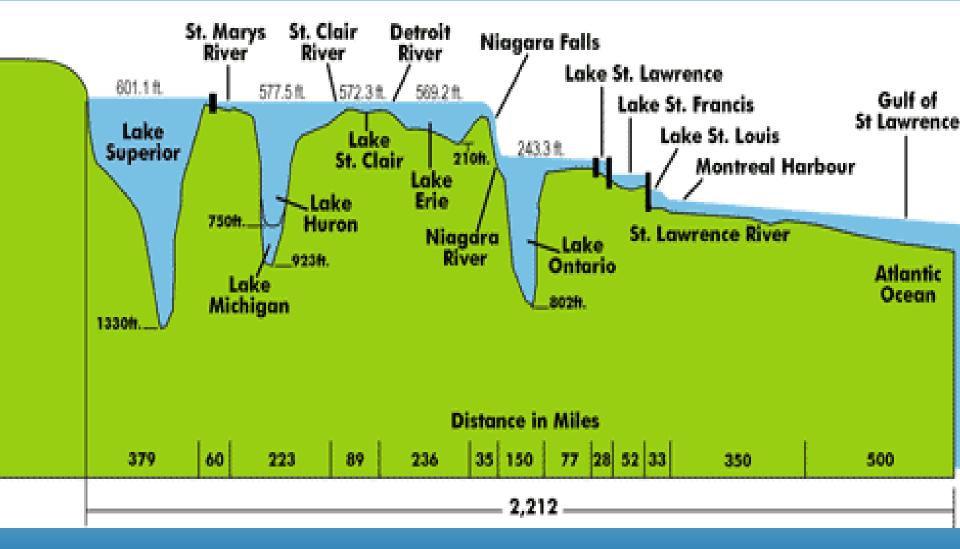
Some Terms

- BFE Base Flood Elevation
- V-Zones Velocity Zones
- LIMWA Limit of Moderate Wave Action



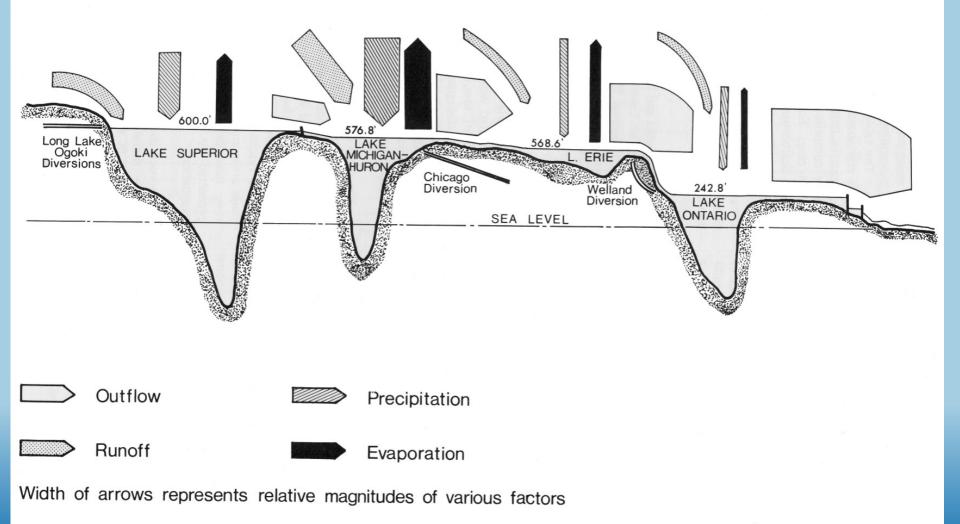
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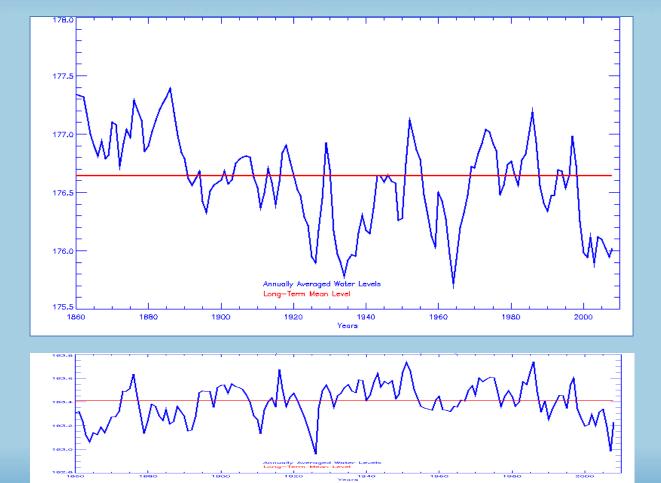




Great Lakes Watershed







Total Change (feet)	Time Span	Annual Rate of Change (ft./yr.)	Period of Change
Lakes Michigan- Huron			
+ 3.5	17 months	+2.5	Feb. 1928 - July 1929
+3.1	18 months	+2.1	Feb. 1951 - Aug. 1952
+3.2	18 months	+2.1	Feb. 1959 - Aug. 1960
+5.6	8.5 years	+0.7	Jan. 1965 – July 1973
-4.8	3.5 years	-1.4	July 1929 – Jan. 1933
-4.0	2.3 years	-1.7	Oct. 1986 – Feb. 1989
-4.7	3.5 years	-1.3	Aug. 1997 – Dec. 2000
Lake Superior			
-3.3	2.5 years	-1.3	April 1926 – Oct. 1928
-2.8	4.5 years	-0.6	Aug. 1926 – Mar. 2001



Great Lakes Coastal Flood Study



Why now?





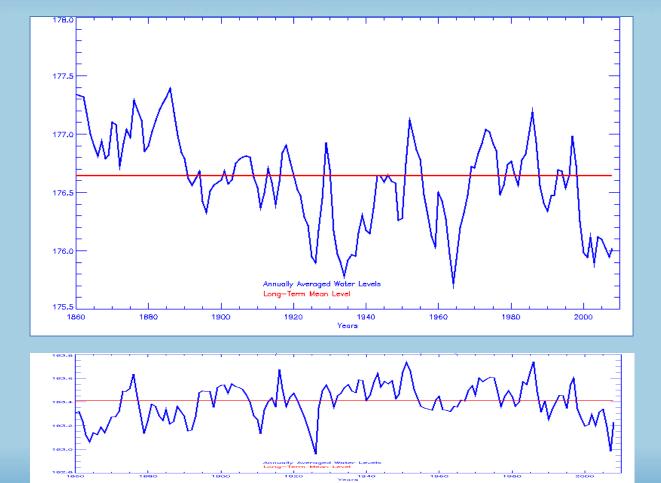
Other Initiatives

- IJC
 - Lake Superior Board of Control
 - Lake Ontario Board of Control
- GLRI
 - NOAA Community Resiliency









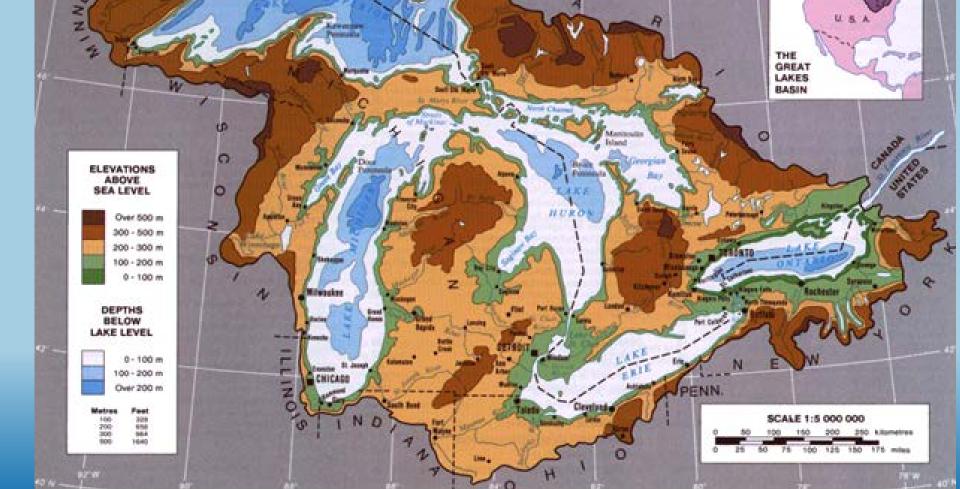




Causes of WL Fluctuations

- Size of watershed
- Anthropogenic
- Climate Change
- Isostatic Adjustment

RELIEF, DRAINAGE AND URBAN AREAS

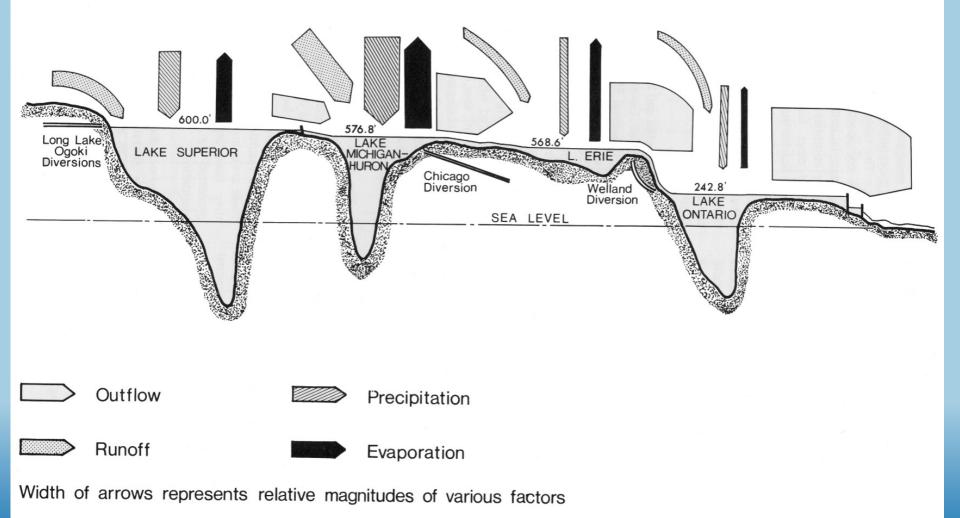


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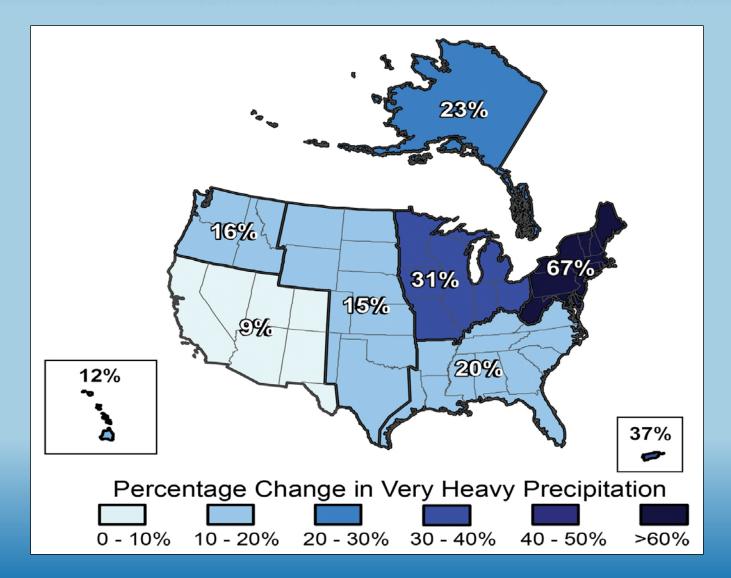
Impact of Climate Change on the Great Lakes



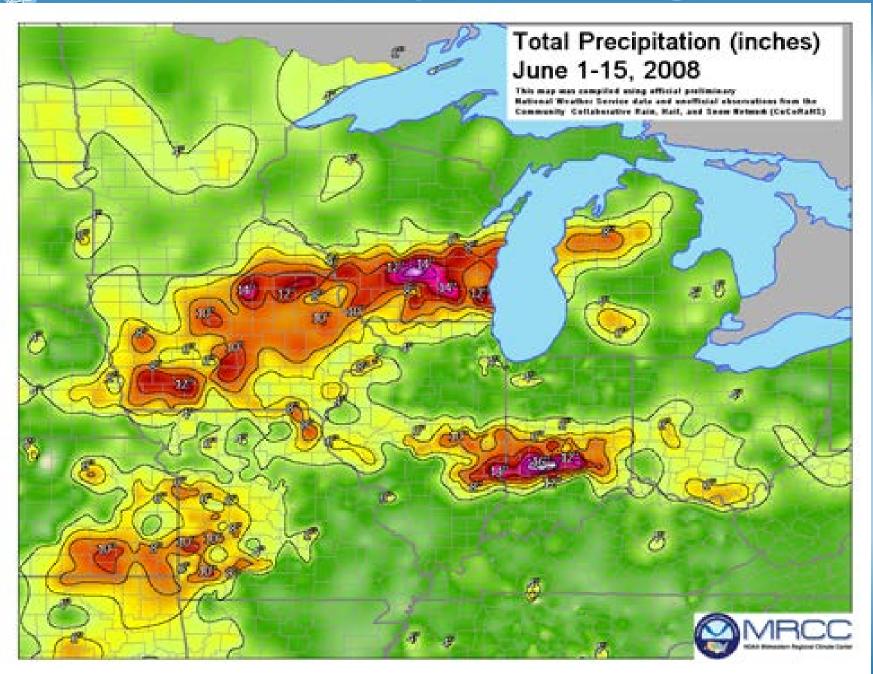




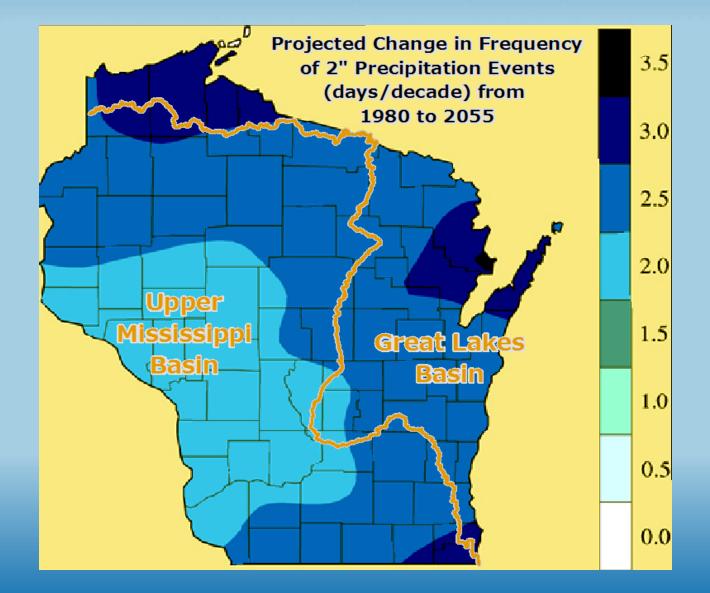
Very Heavy Precipitation Events (1958-2007)



Great Lakes Coastal Flood Study

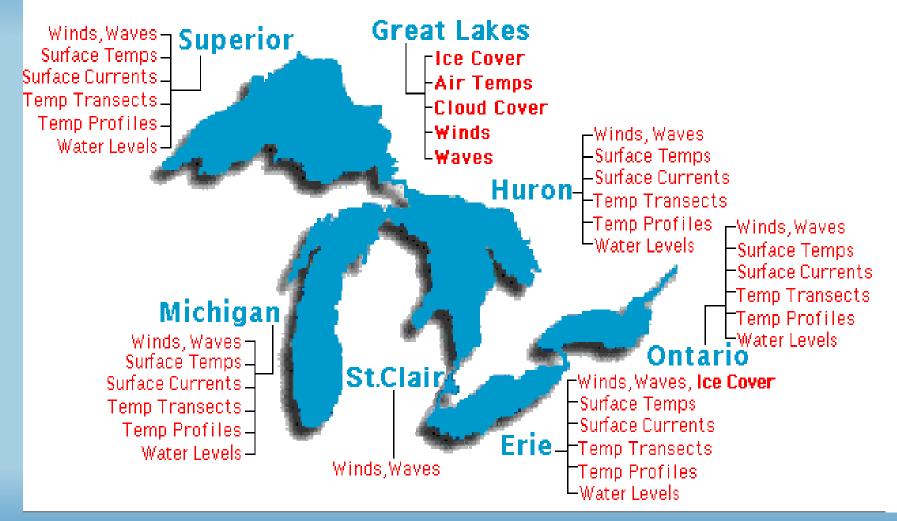






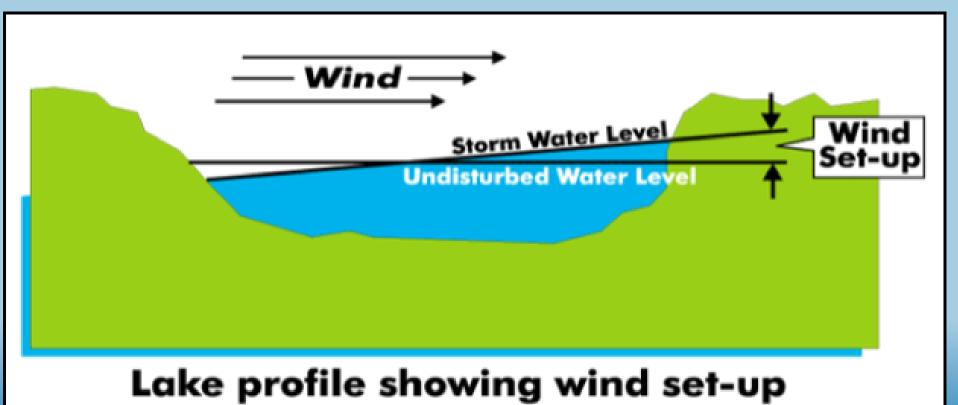


Great Lakes Coastal Forecasting System



http://www.glerl.noaa.gov/res/glcfs/





Courtesy Living with the Lakes, copyright 2000 USACE-Detroit District and Great Lakes Commission







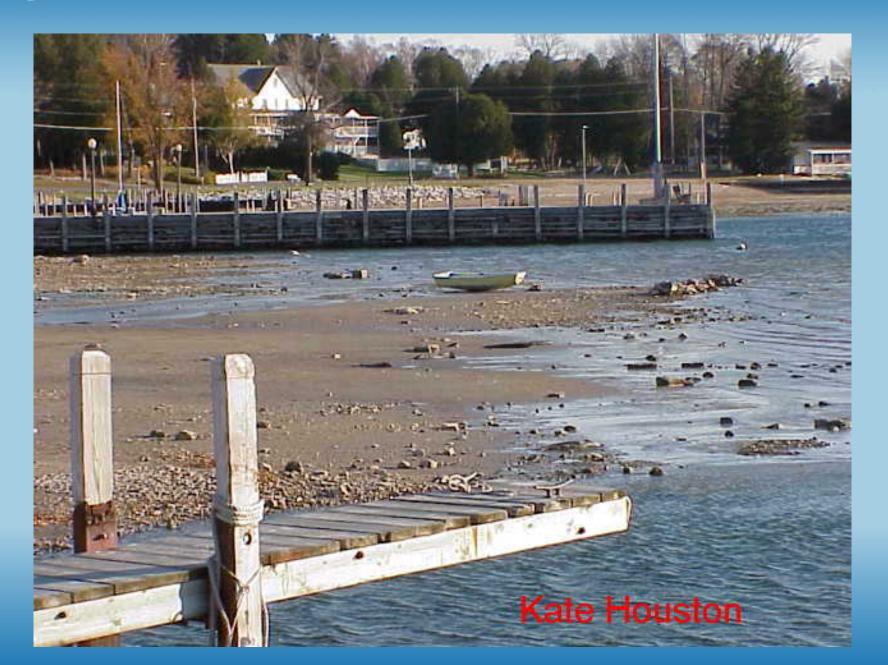
















Vision



Increase Public Awareness of Lake Levels

Improve Communities Resilience to Flood Loss



<u>Great Lakes Flood Hazard Mapping</u> (GLFHM)

Collaborative Project

Between:

FEMA Region 5 (Lead)

FEMA Region 2

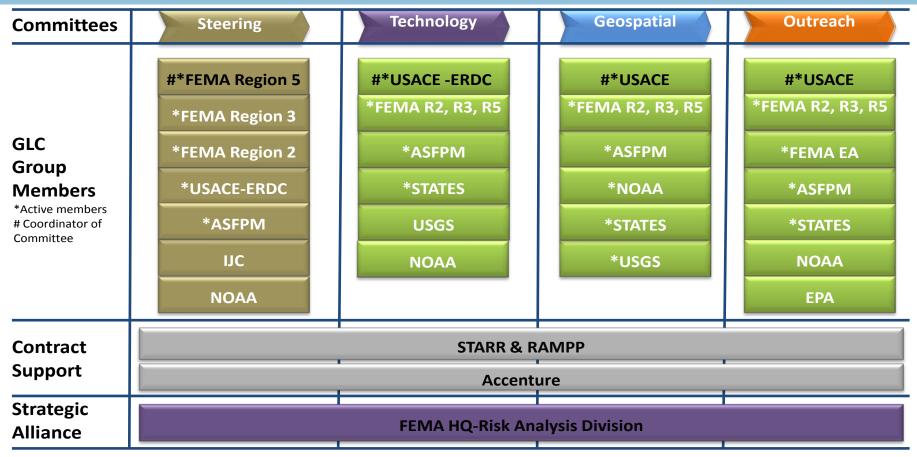
FEMA Region 3

Detroit District USACE





Great Lakes Program Governance



Legend

ASFPM= Association of State Floodplain Managers EA= External Affairs ERDC= Engineer Research and Development Center FEMA= Federal Emergency Management IJC= International Joint Committee Canada & US NOAA= National Oceanic and Atmospheric Administration USACE= US Army Corps of Engineers USGS= U.S. Geological Survey EPA= Environmental Protection Agency

- Execute program decisions
- = Expedite subprojects initiated by the Steering Committee
 - = Observe, provide feasibility assessment as needed, develop work products
- = Maintain strategically the Risk MAP related endeavors and objectives



- 1. Run-up Computations
 - Old method used the 100-year S.W.L. with a 3-year wave height
 - New method uses a response-based analysis approach to run-up computations
 - > 100-year water levels will be updated from the 1988 Open Coast Report.



Photo: Timaru Herala



- 2. New Run-up Methods Available for Structures and Revetments
- Updated methodology provides for the TAW runup method at the structures and revetments
- Mean overtopping rates from Owen & Goda may be used



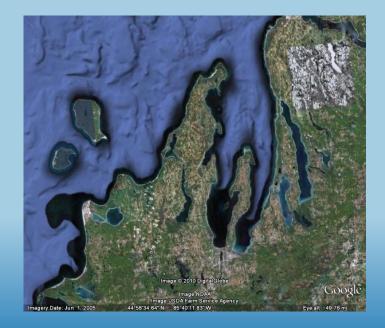
Photo: Timaru Herald



3. New Methods for Overland Wave Propagation

- Available for Embayments and Sheltered Shoreline Areas
- Discarding the use of ACES **\$** Transitioning to CHAMP
- WHAFIS and STWAVE together can be better utilized







4. Ice Cover

Currently examining multiple methods to include ice cover in wave height determination, run-up, and overland wave propagation calculations

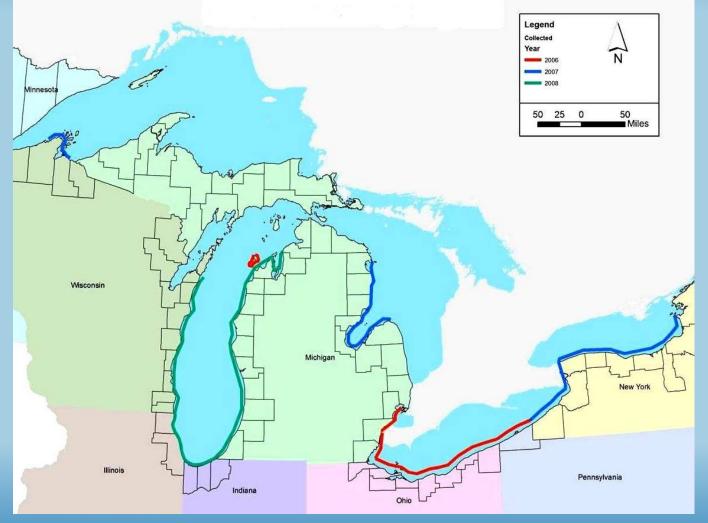


Photo: Lori Niedenfuer

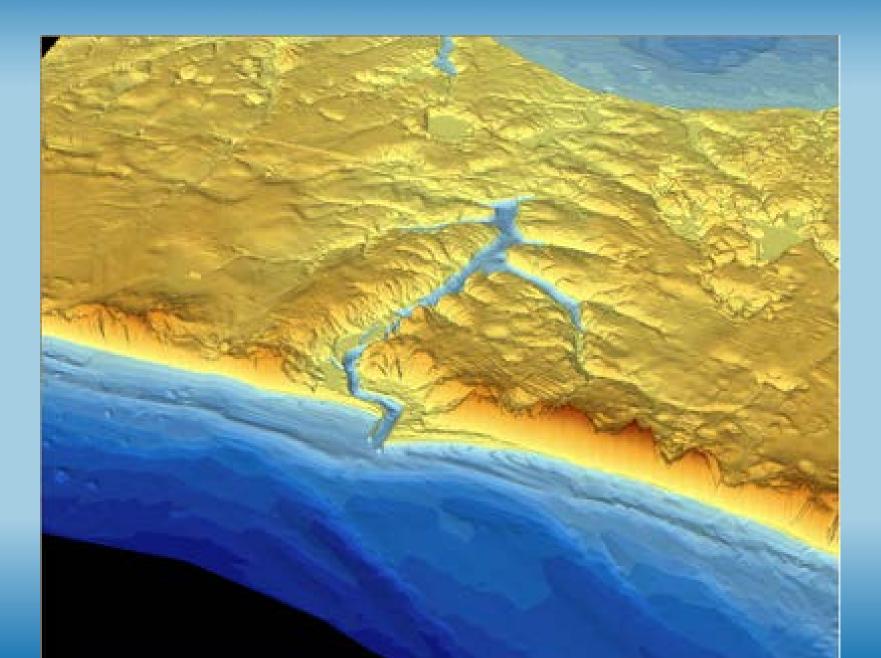
Photo: Michigan Travel Bureau



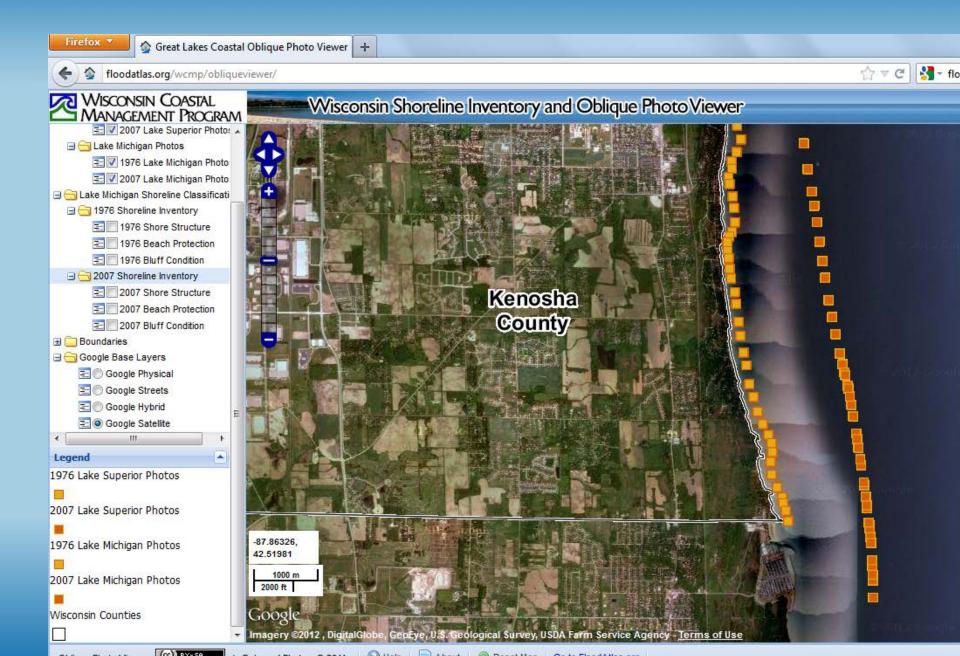
Status of Shoreline Bathymetry







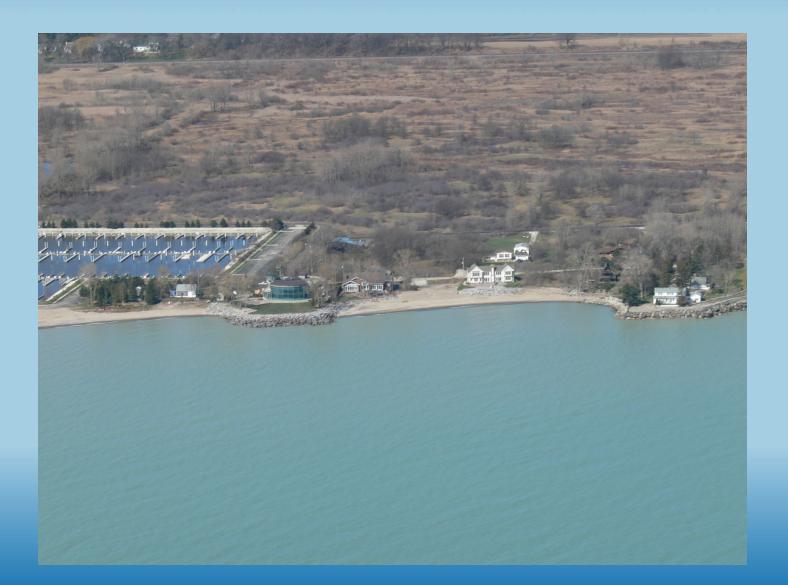




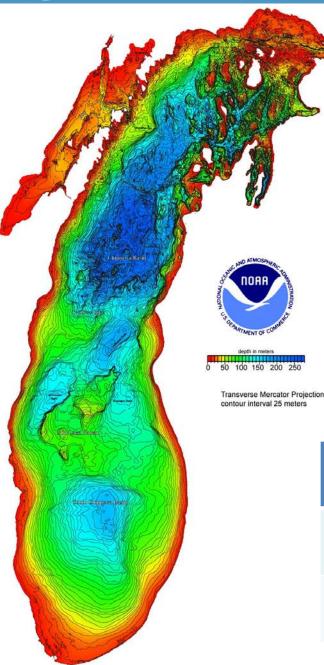












Contributors to BFEs Approximate Magnitudes

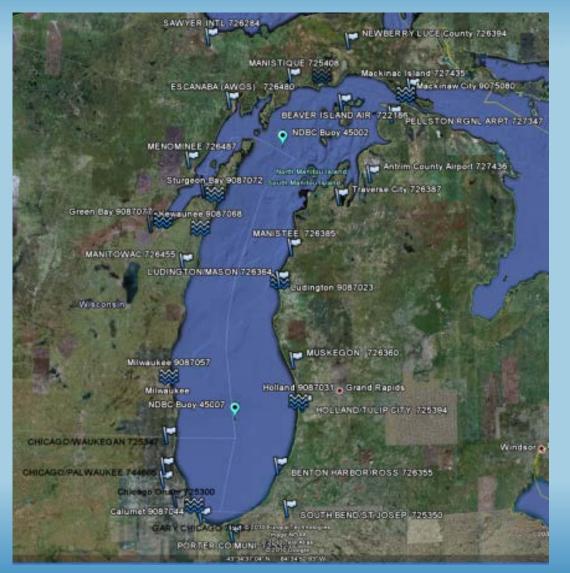
Long-term lake level changes
Seasonal lake level changes
Storm waves and surge

	Lake Level	Storm Surge	Waves	Beach Run-up
Lake Michigan	+/- 3 ft	3 ft	H = 20 ft T= 8 sec	4 to 7 ft
Green Bay	+/- 3 ft	5 ft	H = 9 ft T = 6 sec	2 to 3 ft





Measured Data Sources



NOAA NDBC wave and met buoys (removed in winter)
NOAA NWS land based weather stations
NOAA NOS water level gages

•100+ years of data at some locations to evaluate statistical approach to water levels and storm sampling issues



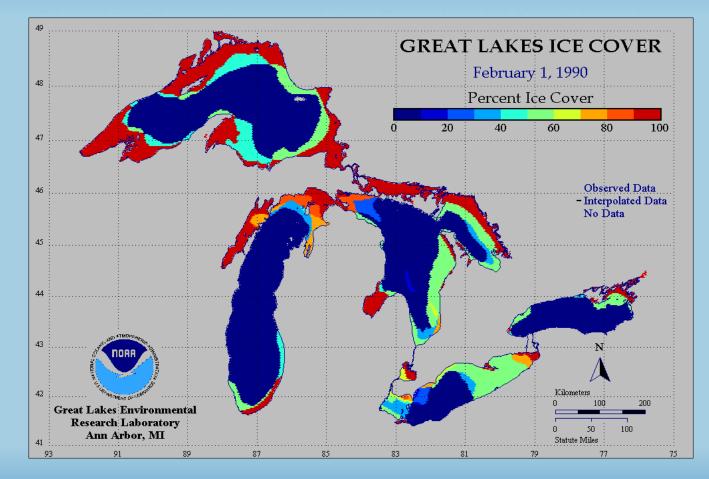
NOAA GLERL Ice Cover Data

•lce Concentration Data Base (1960-1979)

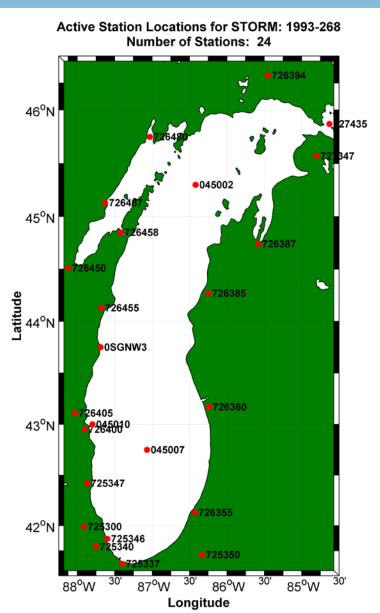
•Digital Ice Atlas (1973-2002)

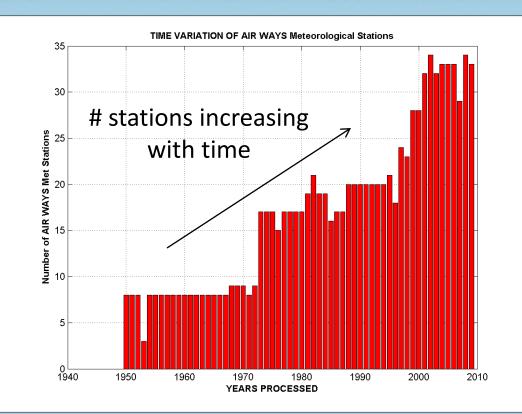
•Recent Digital Data (2003-2009)

•Data only available since 1960



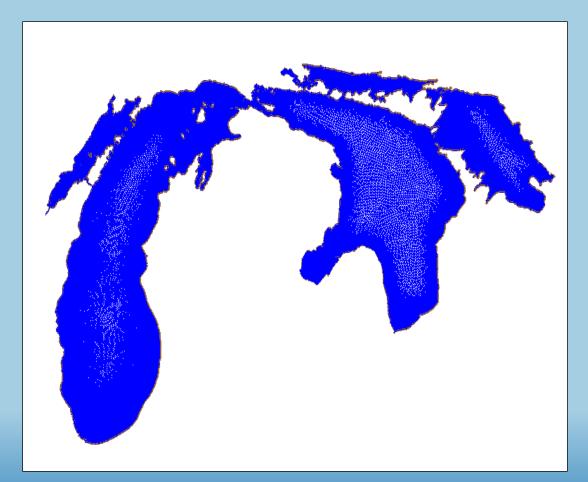






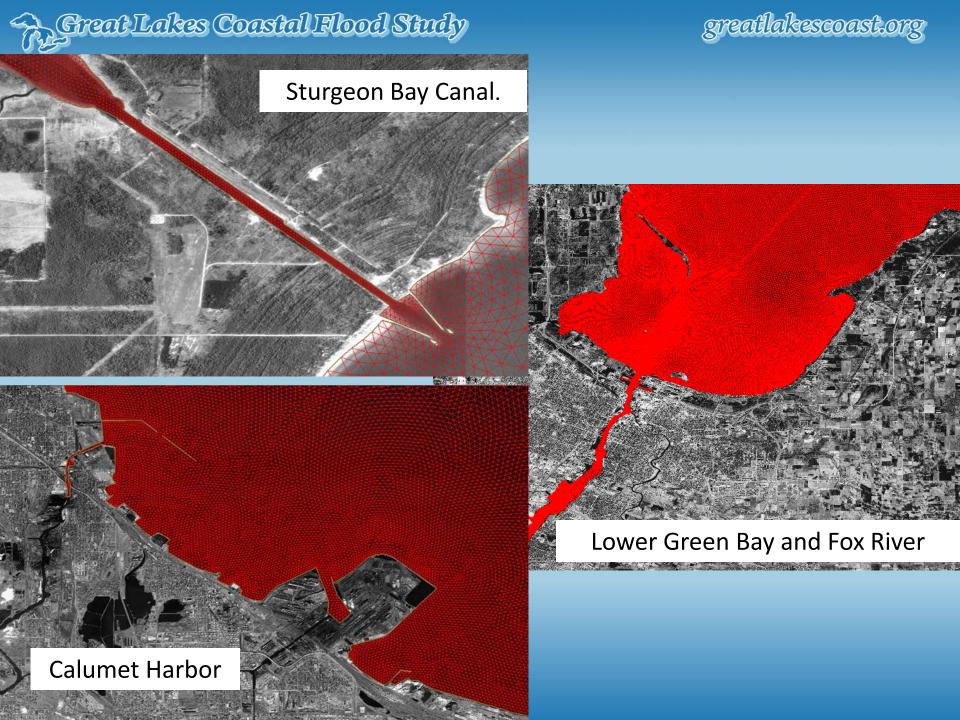


Storm Surge Modeling with ADCIRC



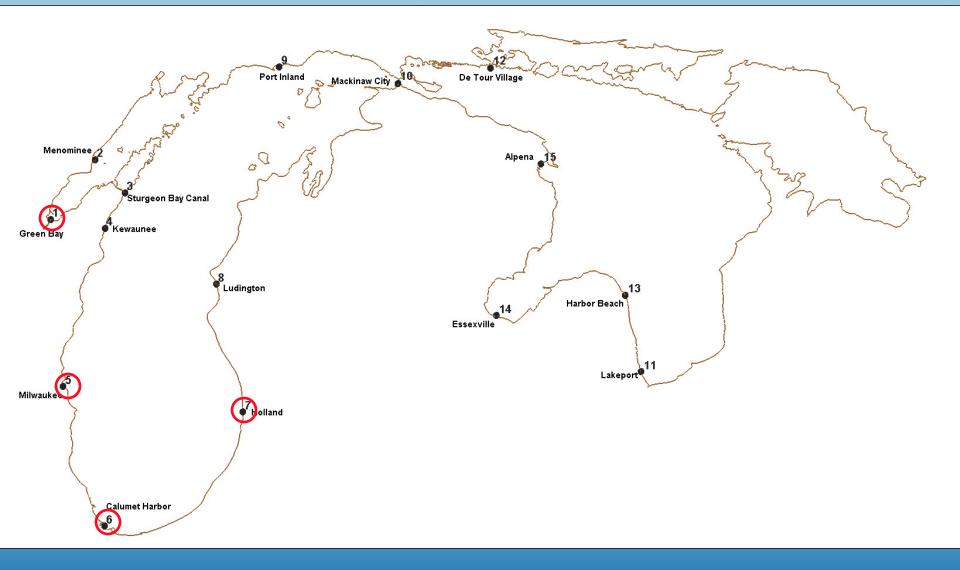
•Coupling of lakes required to accurately model water exchange between lakes associated with moving low pressure systems

•Can increase water level throughout Lake Michigan and Green Bay by as much as 1.5 ft

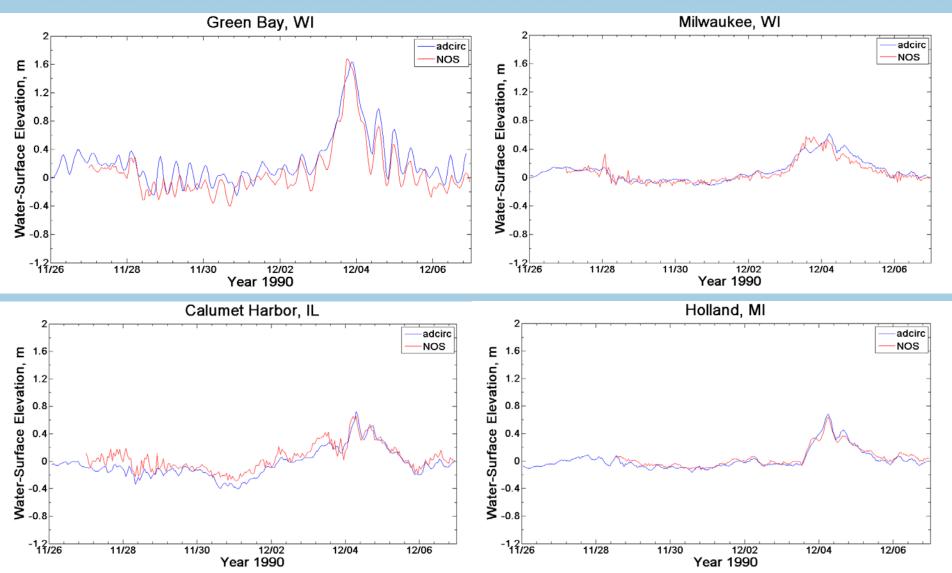




Water Level Measurement Locations



Great Lakes Coastal Flood Study greatlakescoast.org ADCIRC Model Comparisons to Measurements (Dec 1990 Storm)

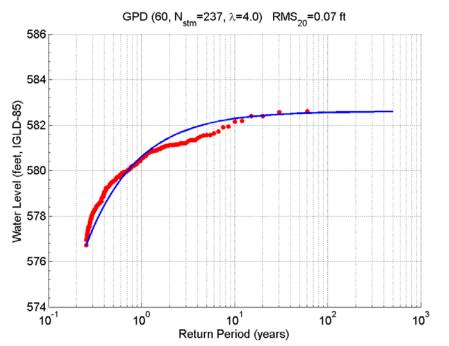


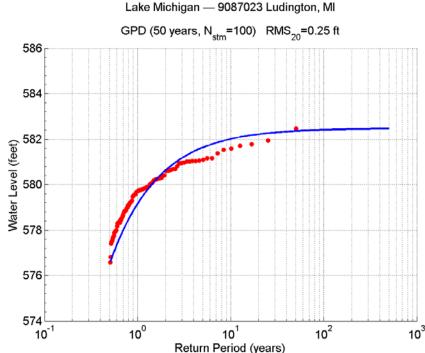




Storm Sample Size

- Challenge Produce reliable statistics in the extreme tail of distribution, with minimum number of storms
- Verification of Statistical Approach
 - Full set vs. 100-storms Composite set Water Level
 - 100 storms minimum will simulate 150 Lake Michigan – 9087023 Ludington, MI









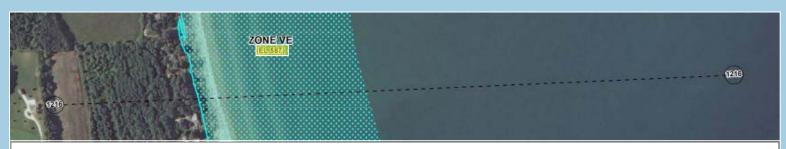
Data for Lake Michigan

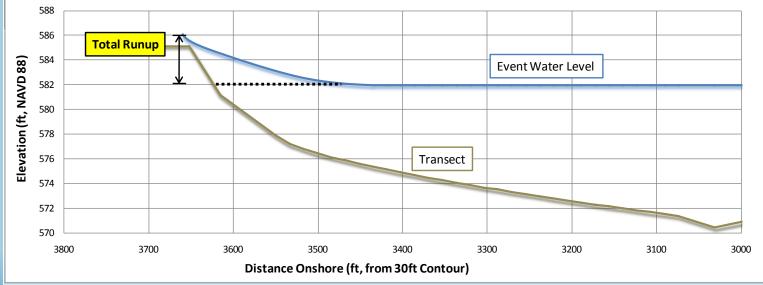
- Ice cover, wind fields, grids, bathymetry, Input files, metadata
- Historical measurements from water level, meteorological, wave gages
- Processed results such as lake level, statistics, etc





I – Event vs. Response for Runup









Event Based (G&S, 2003)

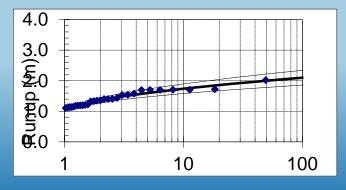
- 1% SWEL and 3-yr wave height
 - Extreme value analysis (EVA) required for hourly wave data
- <u>Single</u> run-up calculation per transect
- R_{2%} defines spatial extent of floodplain
- VE/AE transition based on where runup profile is less than 3 ft above terrain





Modified Response (2010)

- Runup calculated for actual storms and hourly lake levels
- One event per year selected that produced the highest runup elevation
- Annual maximum to determine the 1% Flood Elevation (BFE)





Sample Response Calculation

Combined waves (from hindcast) & WLs (NOAA) to create stormlisting

Year	Duration	Hs (m)	Tp (s)	Dir	Surge (m)
1998	15	2.92	8.61	22	0.22
1998	13	3.27	8.24	22	0.17
1998	23	3.65	9.44	22	0.16
1998	37	3.92	8.88	22	0.53
1998	23	2.96	7.07	112	0.25
1998	14	3.01	8.87	22	0.2
1998	49	4.24	9.74	22	0.35
1997	21	2.95	7.67	45	0.28
1997	7	2.55	7.16	22	0.33
1997	14	2.64	7.78	45	0.25
1997	3	2.5	7.82	135	0.21
1997	8	2.4	7.53	90	0.15
1996	2	2.47	7.23	158	0.1
1996	1	2.35	6.8	112	0.11
1996	5	2.68	7.67	135	0.15

Calculate R_{2%}

R _{2%} (m)
0.914
0.875
1.002
0.943
0.751
0.942
1.034
0.814
0.760
0.826
0.830
0.799
0.768
0.722
0.814

Add R_{2%} to TWL from each storm





Event vs Modified Response

- Old Event
 - = SWEL_{1%} + R_{2%} = Transect 1224 BFE = 587 ft

Modified Response

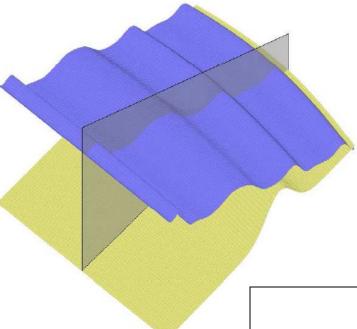
 TWL (actual storms) + R_{2%}
 Fit probability distribution to all runups
 Transect 1224 BFE = 588 ft



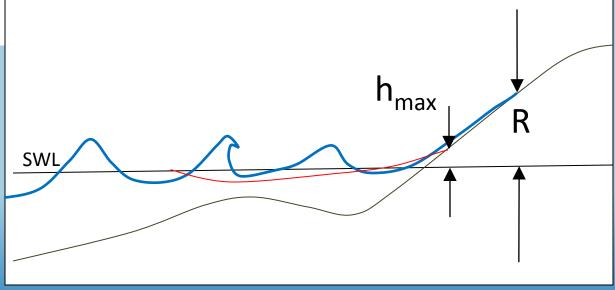
Summary

- Technically superior methodology
- Detailed wave and surge modeling under way for ~150 storms per lake
- Results will be used for the Modified Response approach



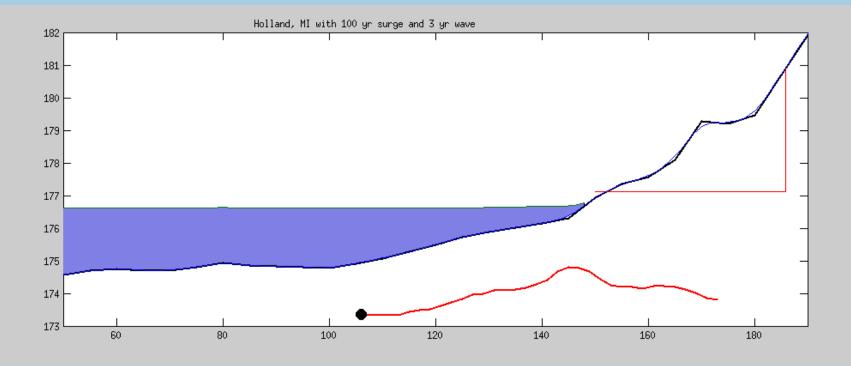


Nearshore Dynamics and Wave Run-up Modeling with CSHORE





Beach Erosion Simulations



Holland, MI morphology change using CSHORE



Bathy/Topo Resolution

- High Resolution
- $R_{2\%} = 589 \text{ ft}$



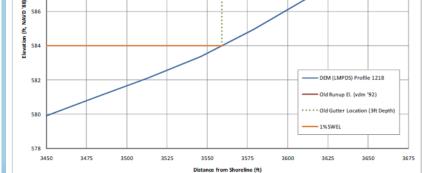


Figure 3.2 DEM/LMPDS Coarse Resolution Transect for 1218 in Sheboygan County with Runup

Combined LIDAR Profile 1218 592 590 588 (ft, NAVD '88) 586 Elevation 58/ Combined LIDAR Profile 1218 582 Old Runup El. (vdm '92) • • • • Old Gutter Location (3ft Depth) 580 1%SWE 578 3450 3475 3500 3525 3550 3575 3600 3625 3650 3675 Distance from Shoreline (ft Figure 3.1 Combined High Resolution LIDAR Transect for 1218 in Sheboygan County with Runup



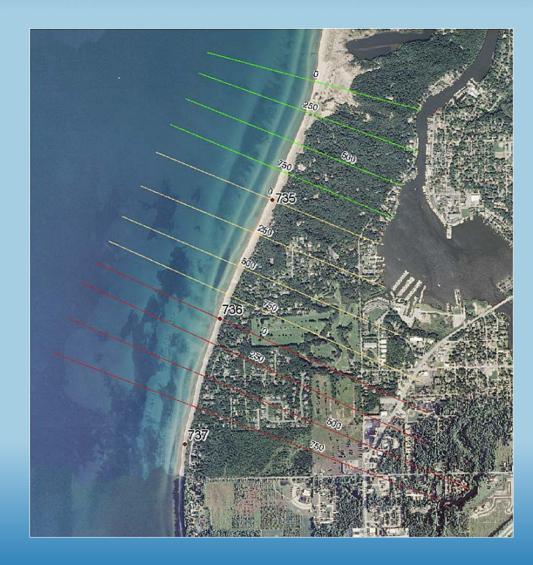
Impact of Lake Level Trends on Beaches

- New LIDAR collected during low phase
- Flood events happen during high wls





Spacing Resolution (Allegan)



Great Lakes Coastal Flood Study

greatlakescoast.org

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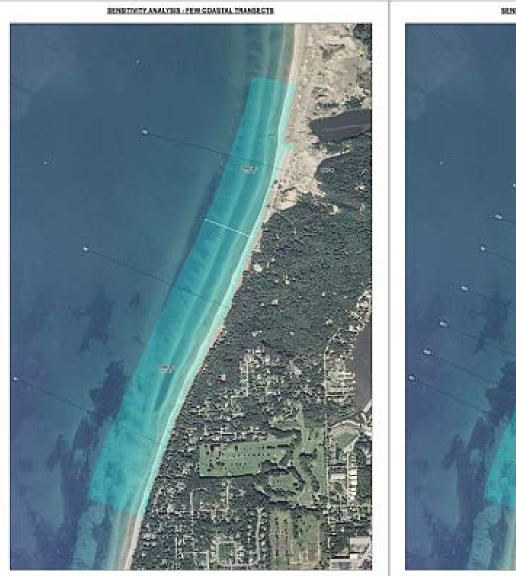
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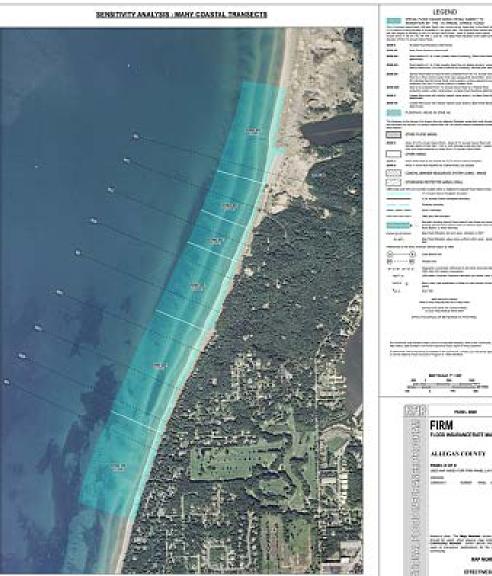
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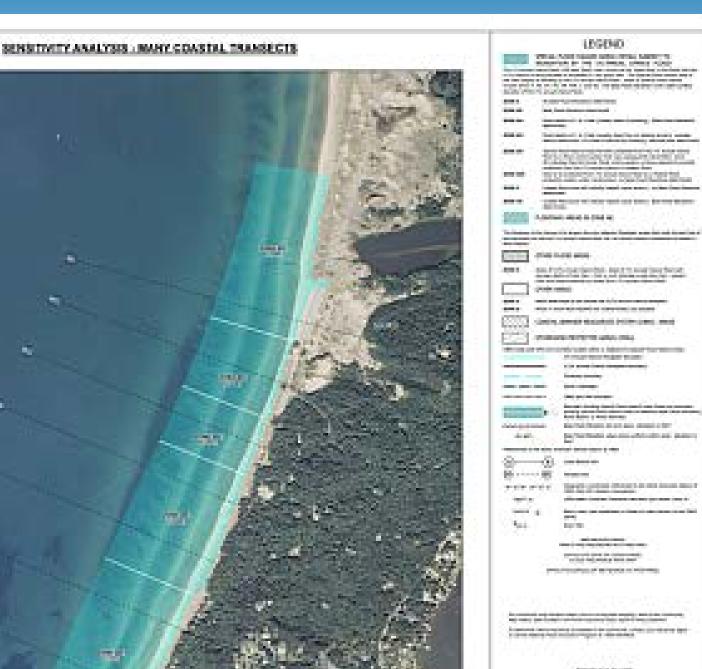




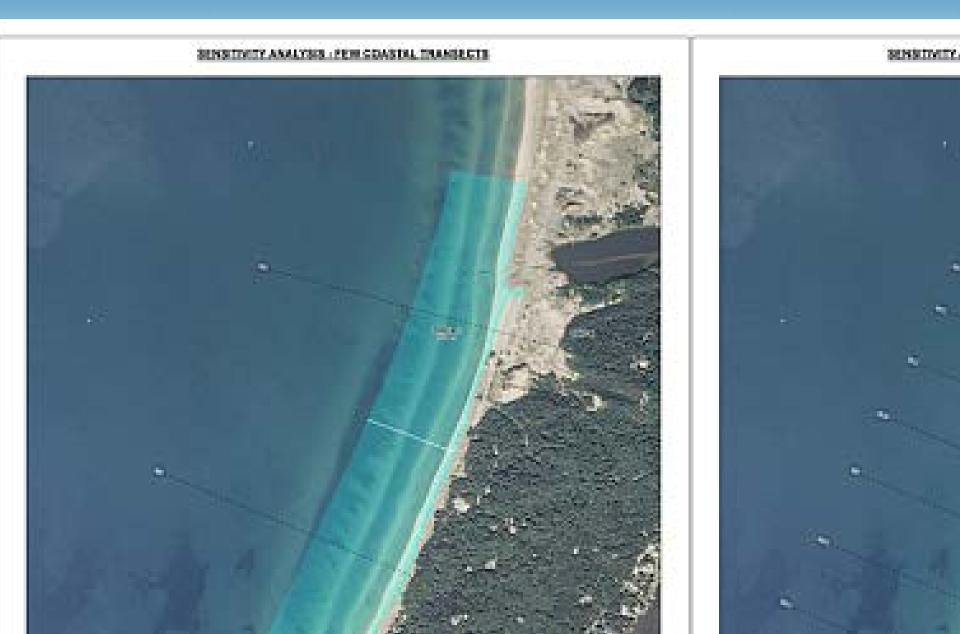




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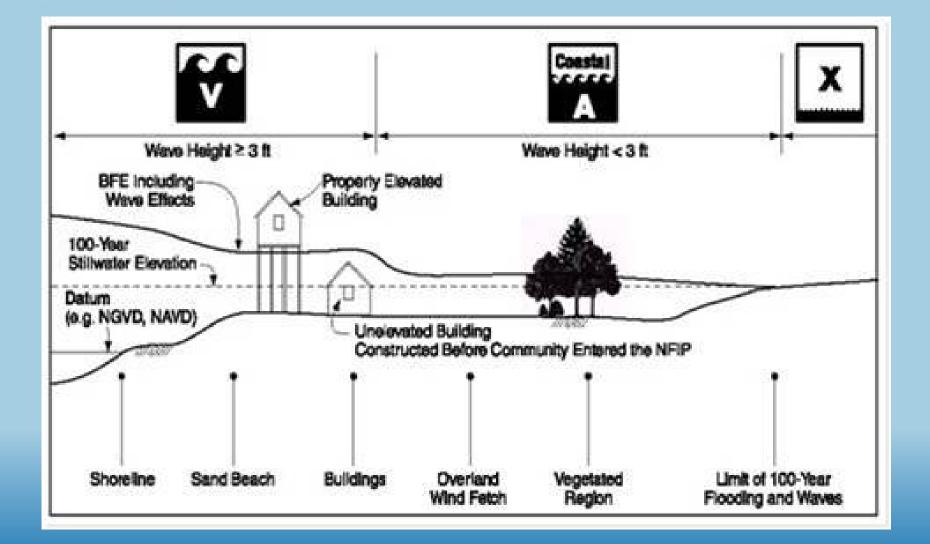










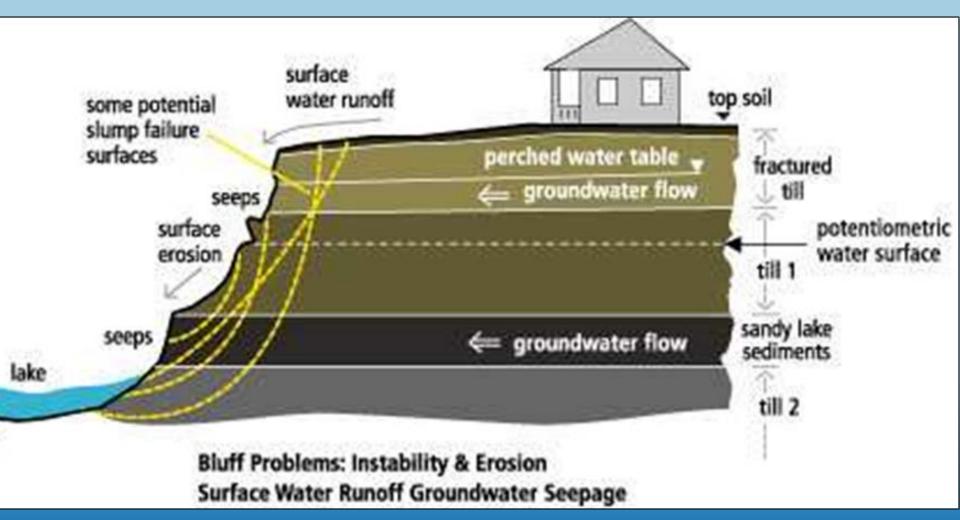




GL States with Coastal Setbacks

- Michigan
- Pennsylvania
- Ohio
- New York
- Wisconsin (some counties)









- Upton Jones
 - Amendment to NFIA
 - -1988 1994
 - 30 year & 60 year erosion hazard areas



Public Trust Doctrine

By the law of nature these things are common to all mankind, the air, running water, the sea and consequently the shores of the sea... The seashore extends as far as the greatest winter flood runs up. - Institutes of Justinian 535 CE





Federal, State and Local Roles

- The Constitution of the United States of America
- <u>Amendment X (1791)</u>:

The powers not delegated to the United States by the Constitution, nor prohibited by it to the States, are reserved to the States Respectively, or to the people





Legal Origins

US Constitution

- States retain ownership of the lands beneath navigable waters
- Federal government retains supreme, but not exclusive, control over navigation



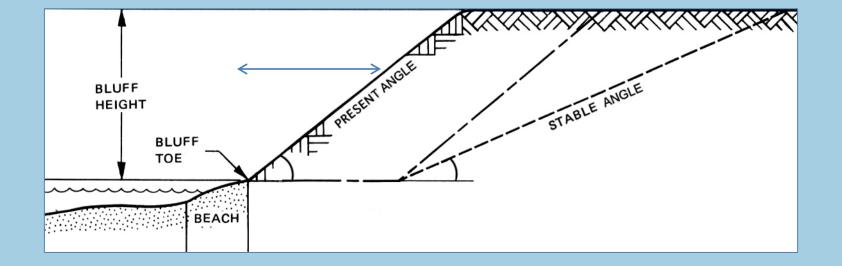
Illinois Central

Illinois Central RR v. Illinois (1892)

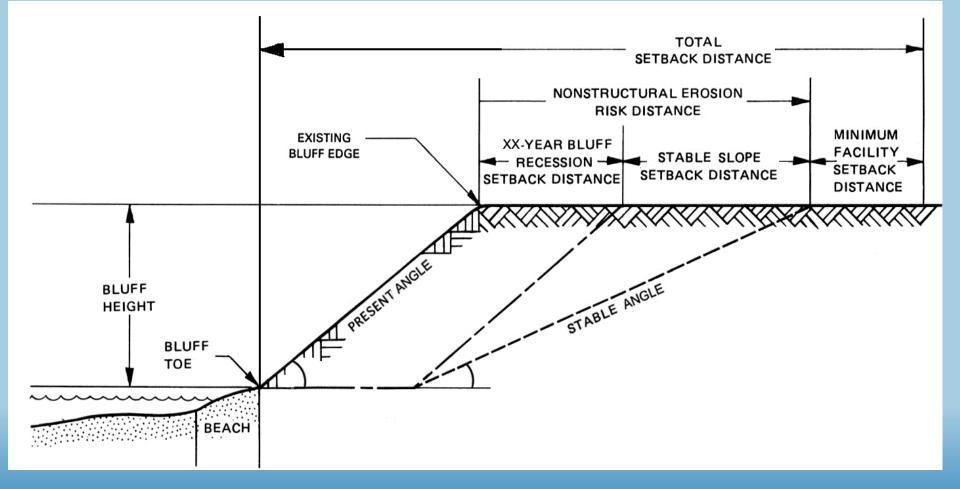
 State had abdicated its responsibility to preserve the waters for public use









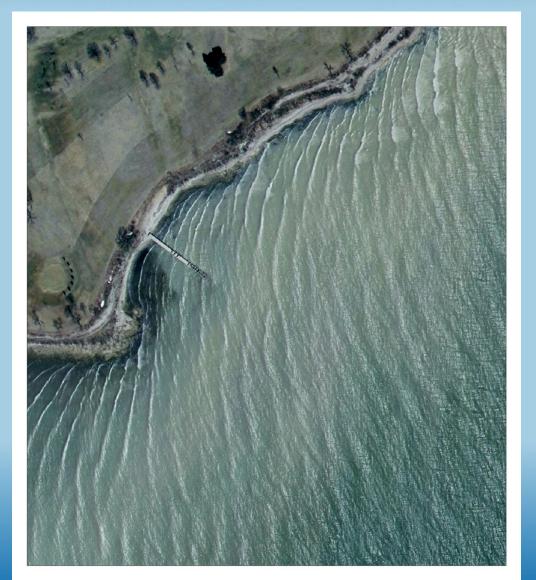






Non-structural vs. Structural







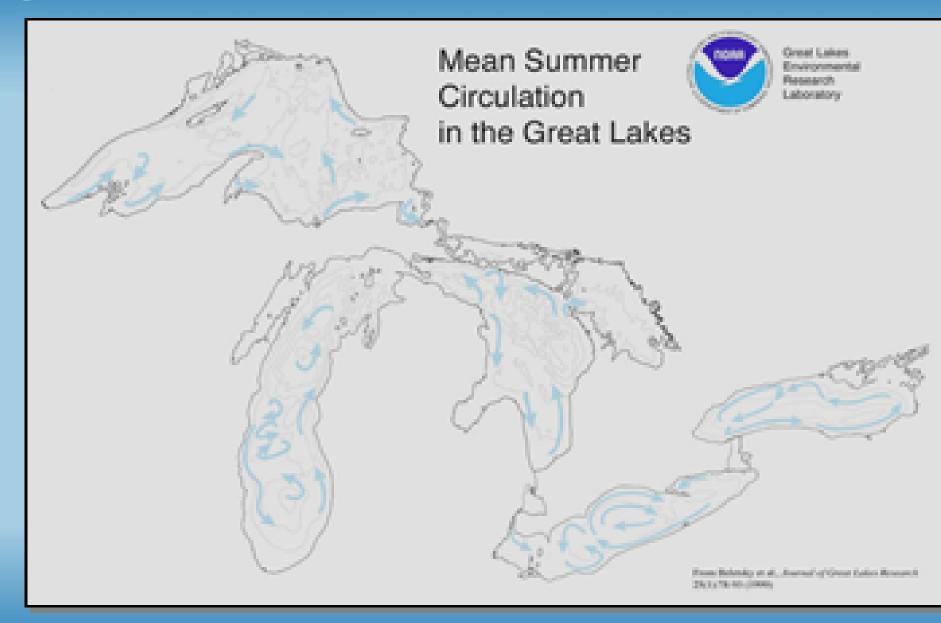


Figure 1 – Circulation Patterns in the Great Lakes

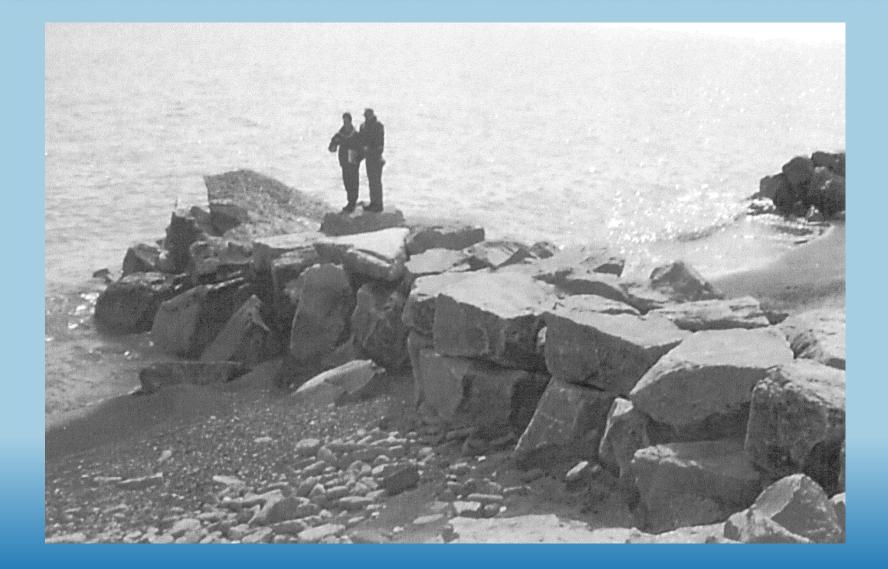
















Thank you for your time! Questions???





Visit *greatlakescoast.org* for more information

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