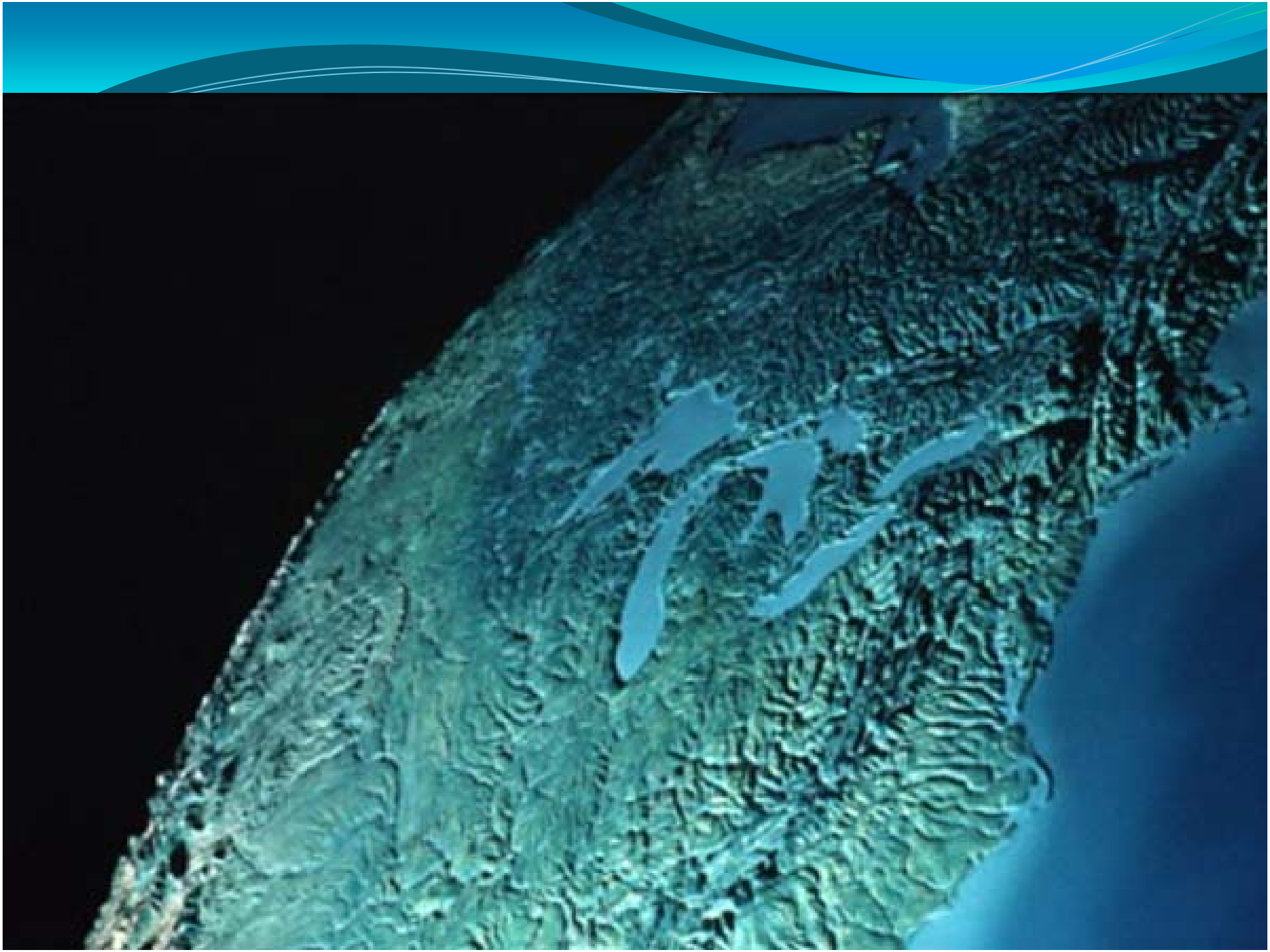
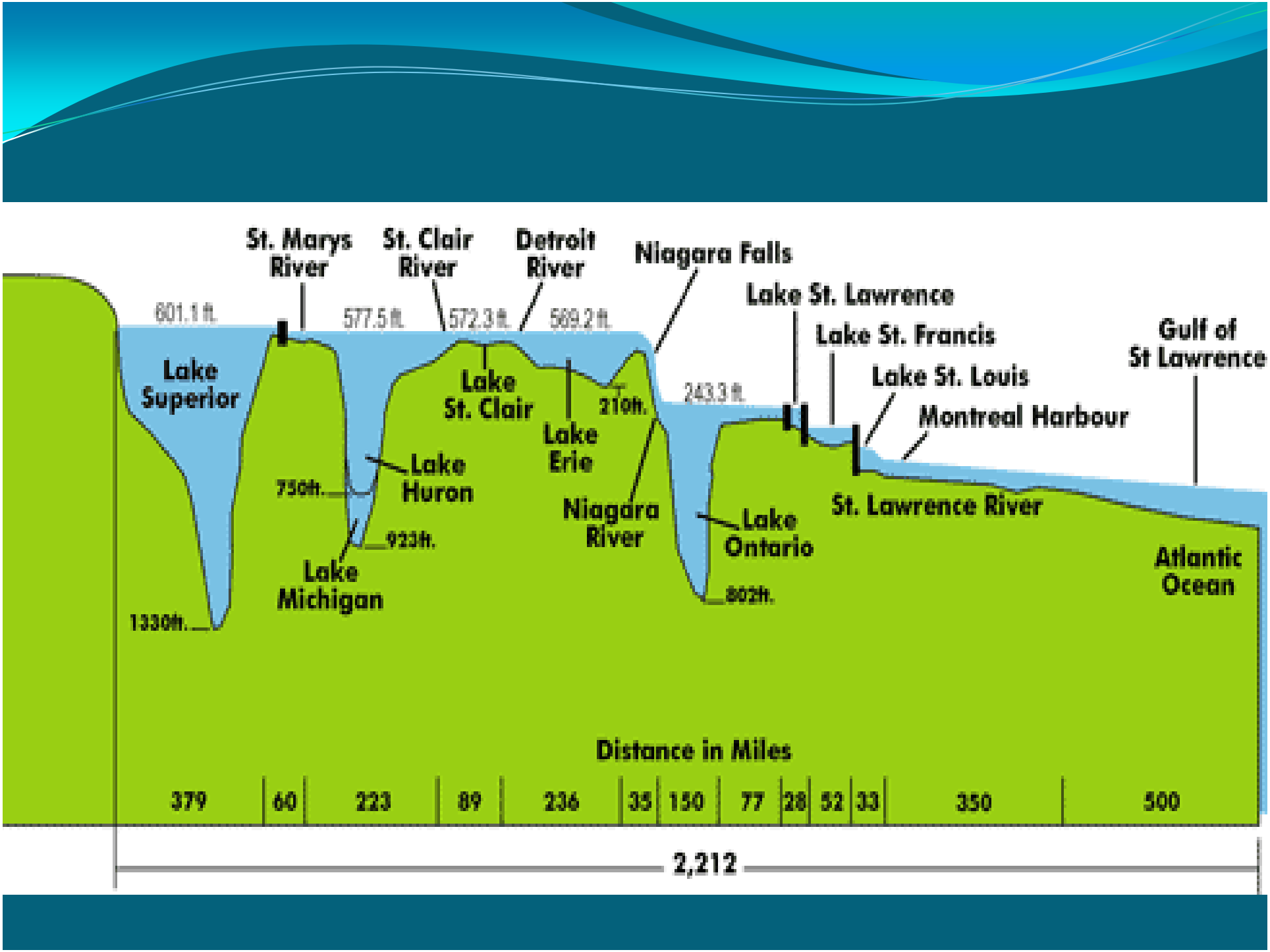
Strategies & Actions for
Responsible Floodplain Management

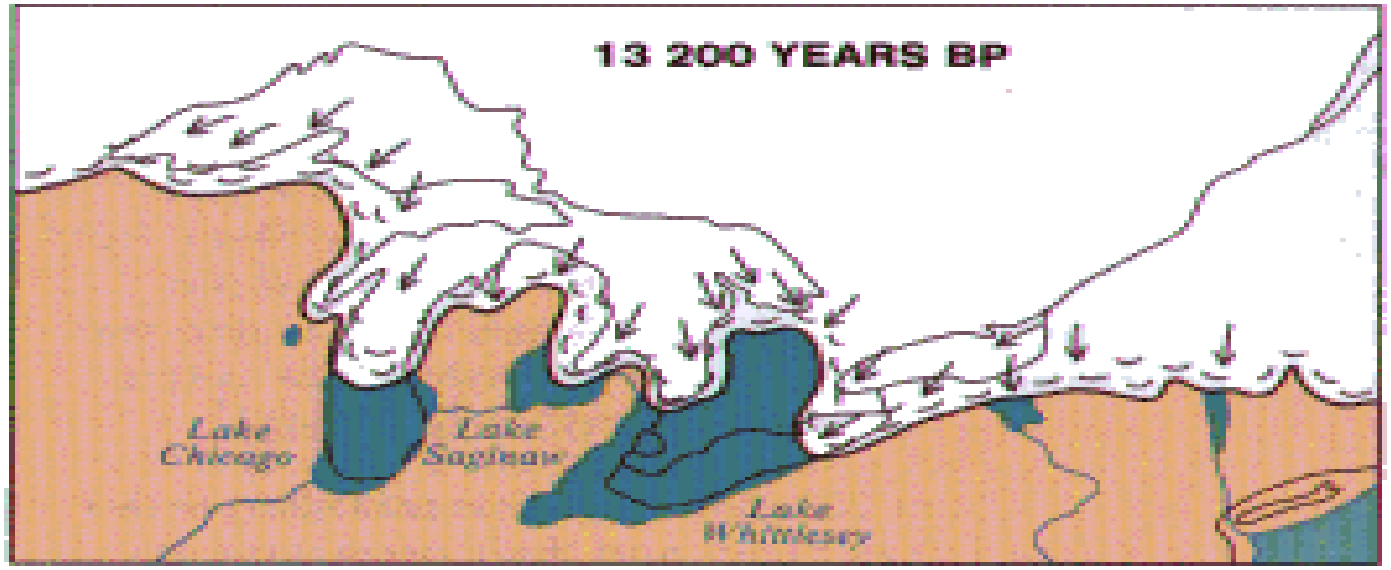
No Adverse Impacts Strategies

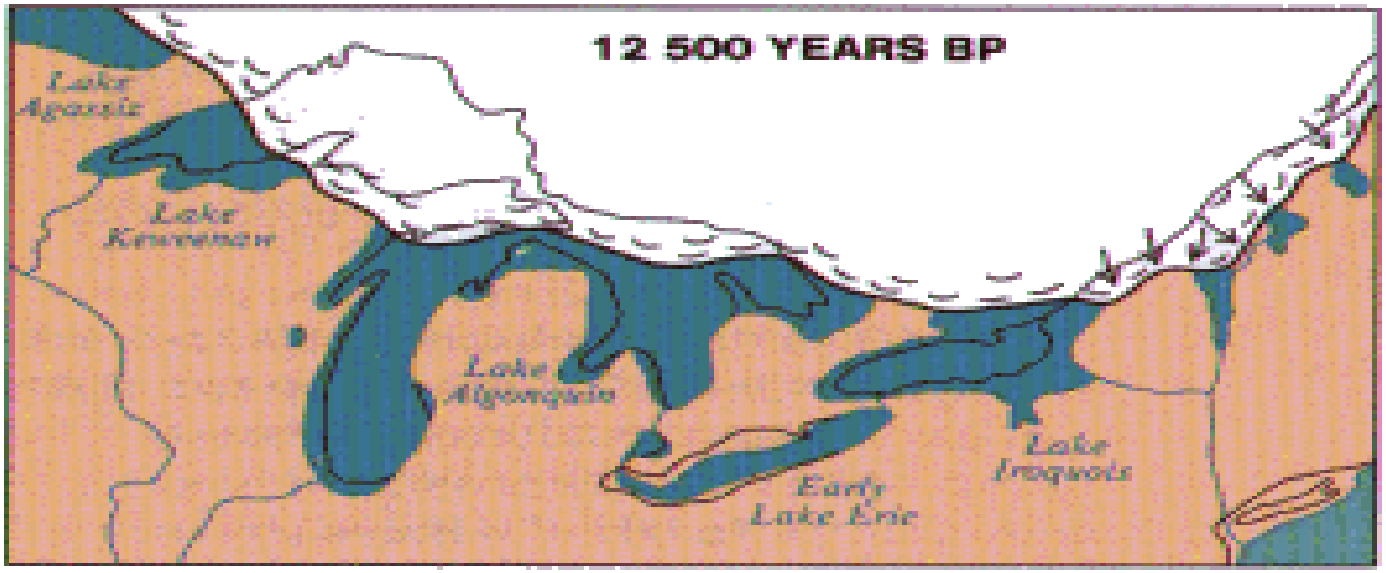


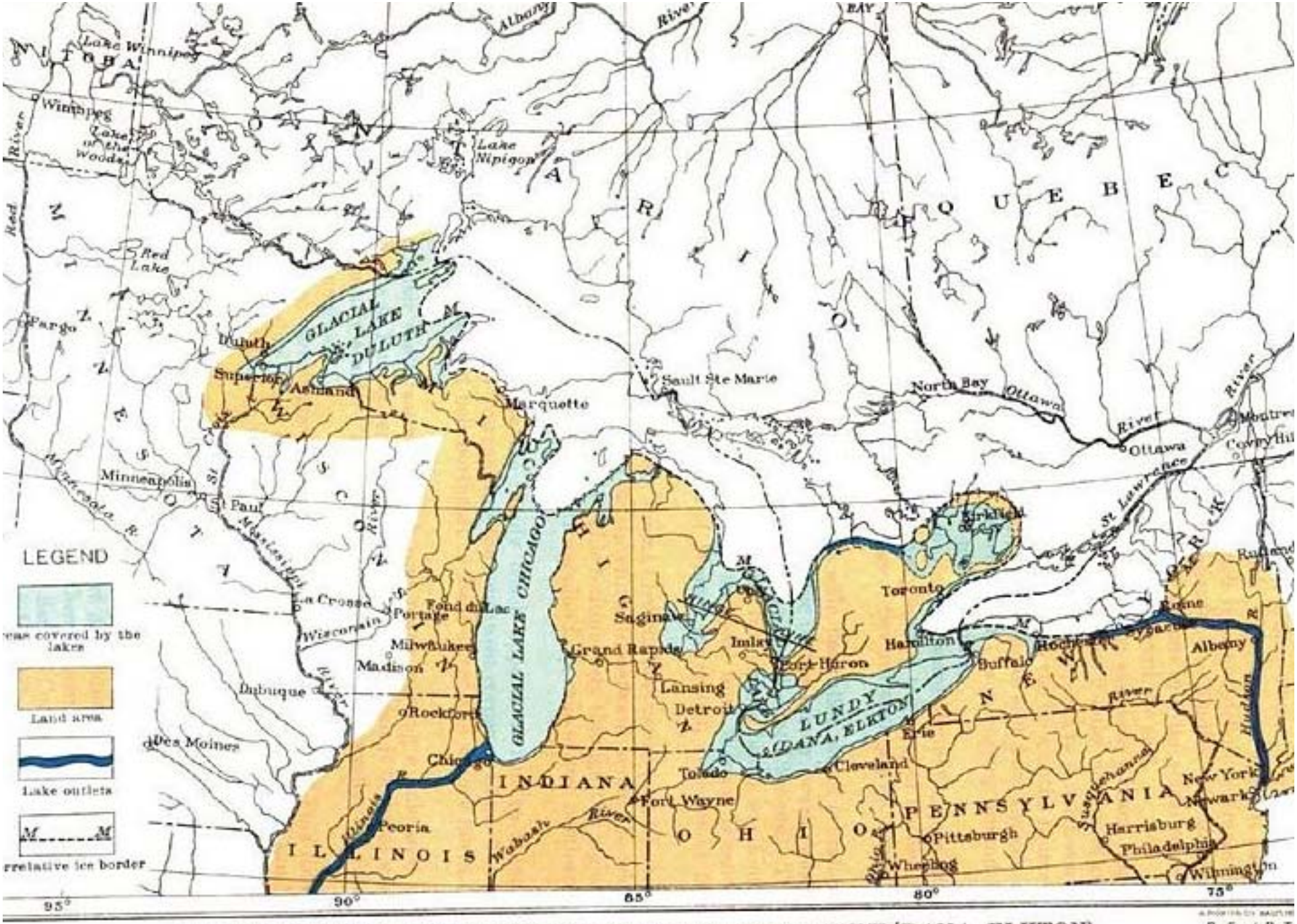

St. Marys River
St. Clair River
Detroit River
Niagara Falls
Lake St. Lawrence
Lake St. Francis
Lake St. Louis
Montreal Harbour
Gulf of St Lawrence
601.1 ft.
577.5 ft.
572.3 ft.
569.2 ft.
243.3 ft.
Lake Superior
Lake St. Clair
Lake Erie
Lake Huron
Lake Michigan
Niagara River
Lake Ontario
St. Lawrence River
Atlantic Ocean
1330ft.
750ft.
923ft.
210ft.
802ft.
Distance in Miles
379
60
223
89
236
35
150
77
28
52
33
350
500
2,212

STAGES IN THE EVOLUTION OF THE GREAT LAKES

SCALE 1: 20 000 000



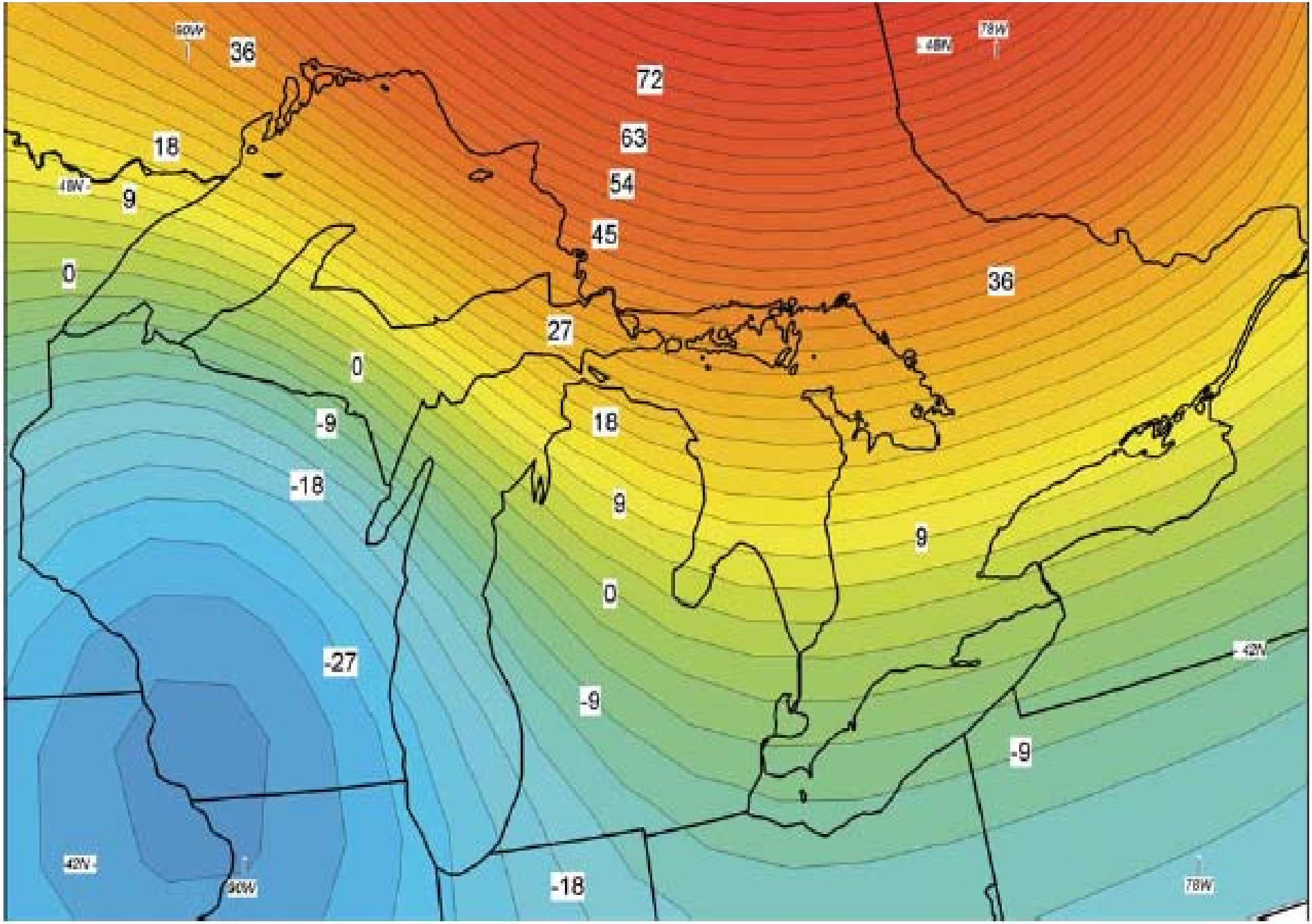




MAP OF GLACIAL LAKES DULUTH, CHICAGO, AND LUNDY (DANA, ELKTON)

By Frank B. T

100 0 100 200 300 Miles



i. Contour map of ICE-3G global postglacial rebound–derived velocities in the Great Lakes area. Contour interval—3 cm

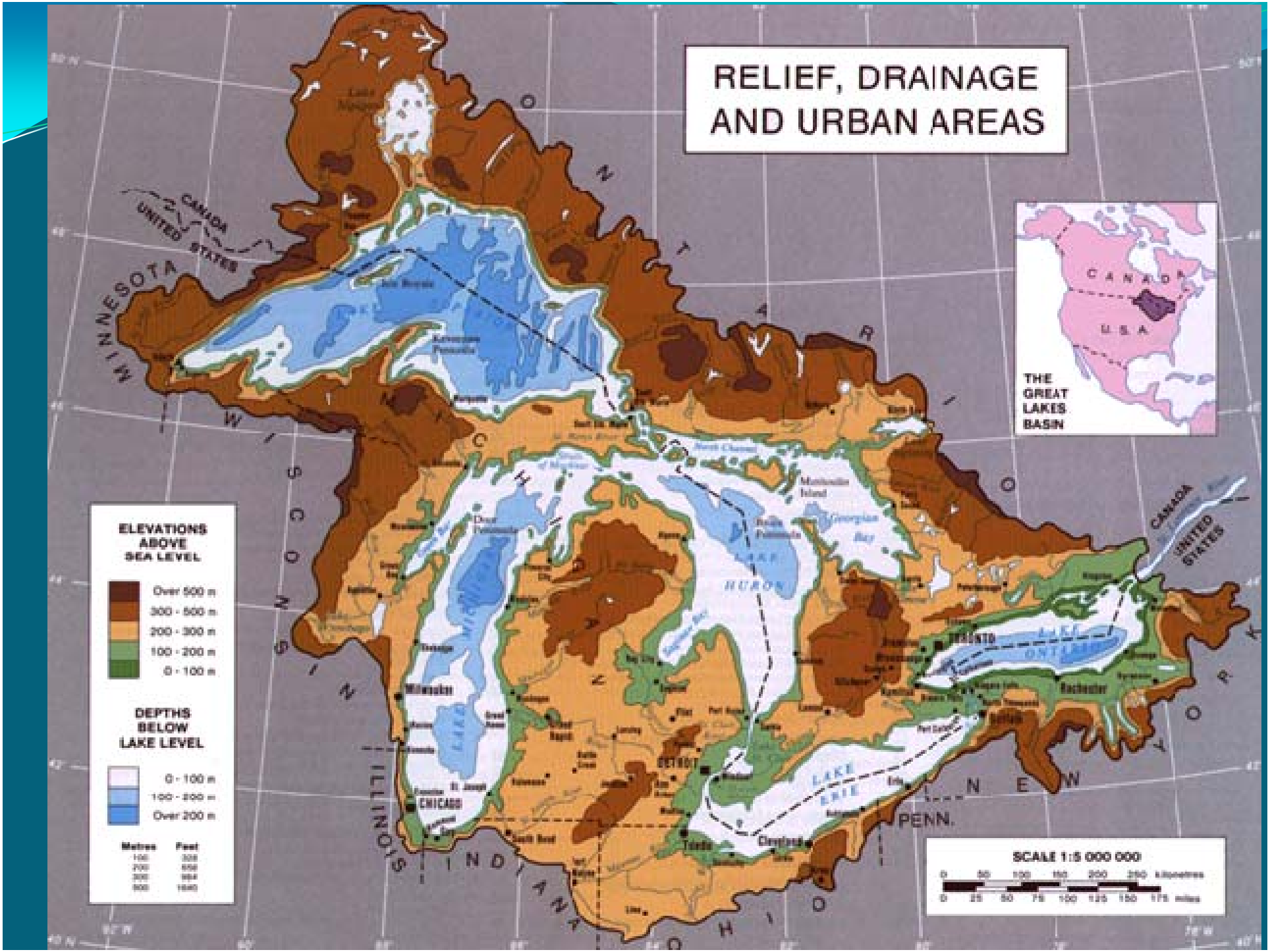
MAP OF NIPISSING GREAT LAKES AND CORRELATIVES

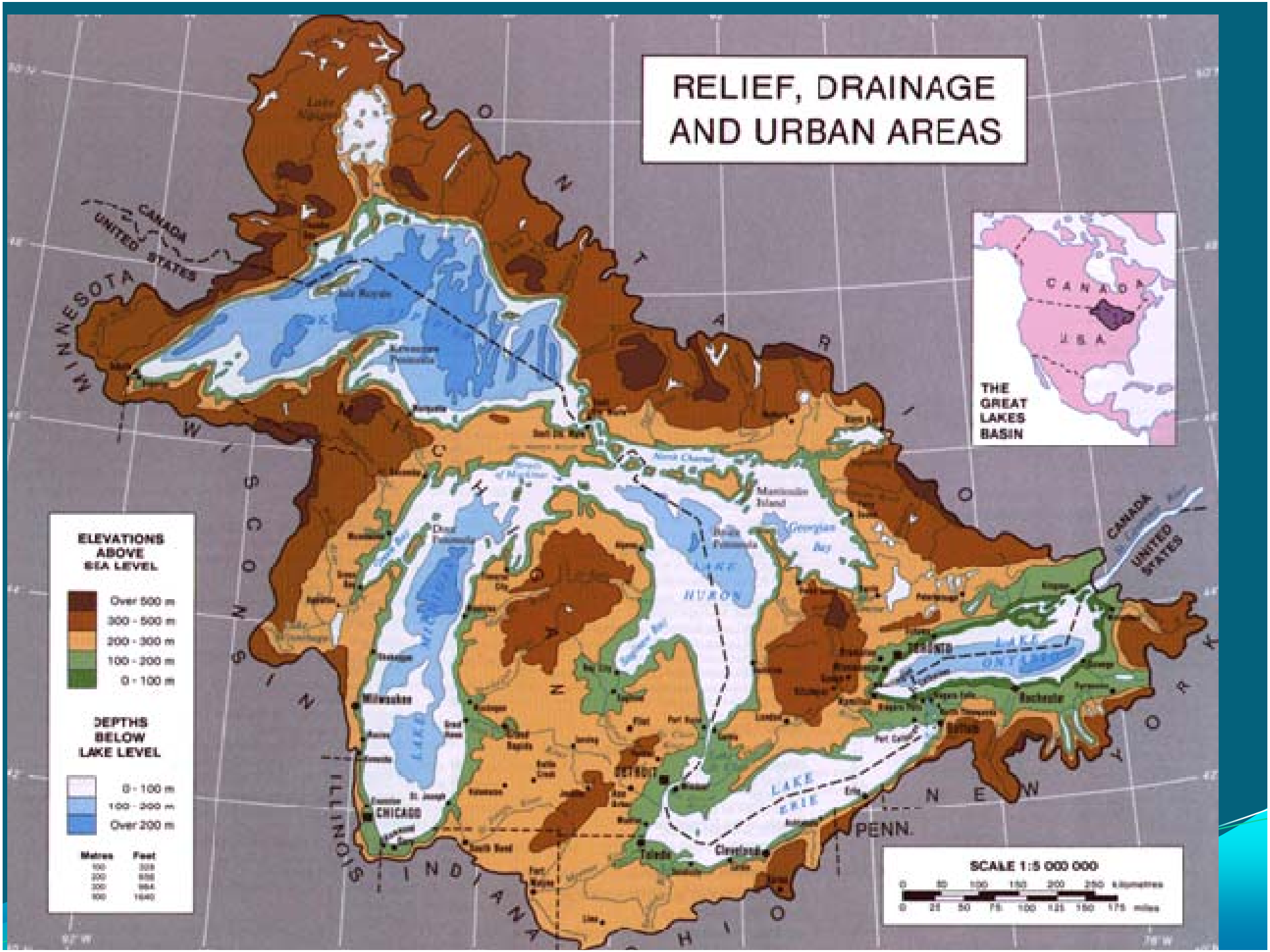
By Frank B. Taylor and Frank Leverett

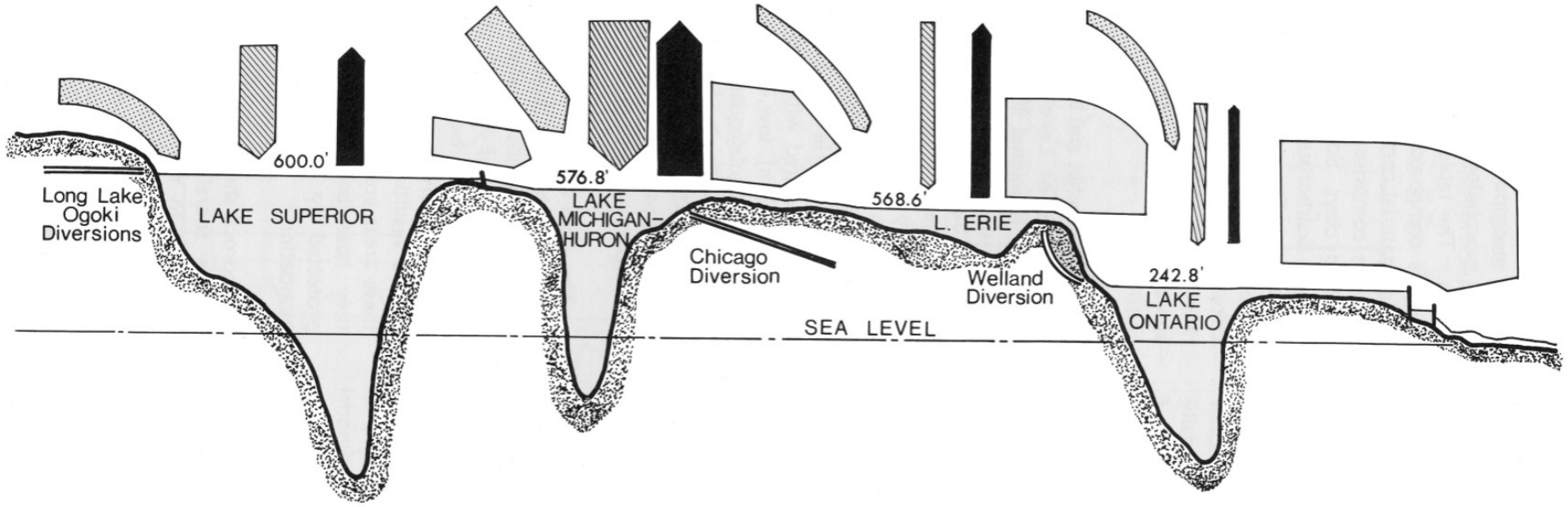
100 0 100 200 300 Miles

House Doc. No. ; 64th Cong., 2d S

1917


RELIEF, DRAINAGE AND URBAN AREAS
CANADA
UNITED STATES
MINNESOTA
WISCONSIN
ILLINOIS
INDIANA
OHIO
PENN.
NEW YORK
LAKE SUPERIOR
LAKE MICHIGAN
LAKE HURON
LAKE ERIE
LAKE ONTARIO
Georgian Bay
Manitoulin Island
Bruce Peninsula
Thunder Bay
Duluth
Minneapolis
Milwaukee
CHICAGO
DETROIT
Toronto
Cleveland
Buffalo
Rochester
THE GREAT LAKES BASIN
CANADA
USA
ELEVATIONS ABOVE SEA LEVEL
Over 500 m
300 - 500 m
200 - 300 m
100 - 200 m
0 - 100 m
DEPTHS BELOW LAKE LEVEL
0 - 100 m
100 - 200 m
Over 200 m
Metres
Feet
SCALE 1:5 000 000
kilometres
miles


RELIEF, DRAINAGE
AND URBAN AREAS
CANADA
UNITED STATES
MINNESOTA
WISCONSIN
ILLINOIS
INDIANA
OHIO
PENN.
NEW YORK
ELEVATIONS
ABOVE
SEA LEVEL
Over 500 m
300 - 500 m
200 - 300 m
100 - 200 m
0 - 100 m
DEPTHS
BELOW
LAKE LEVEL
0 - 100 m
100 - 200 m
Over 200 m
Metres
Feet
THE
GREAT
LAKES
BASIN
CANADA
U.S.A.
LAKE
HURON
LAKE
ERIE
LAKE
ONTARIO
DETROIT
CHICAGO
Milwaukee
Toledo
Cleveland
Buffalo
Rochester
SCALE 1:5 000 000
kilometres
miles



Outflow

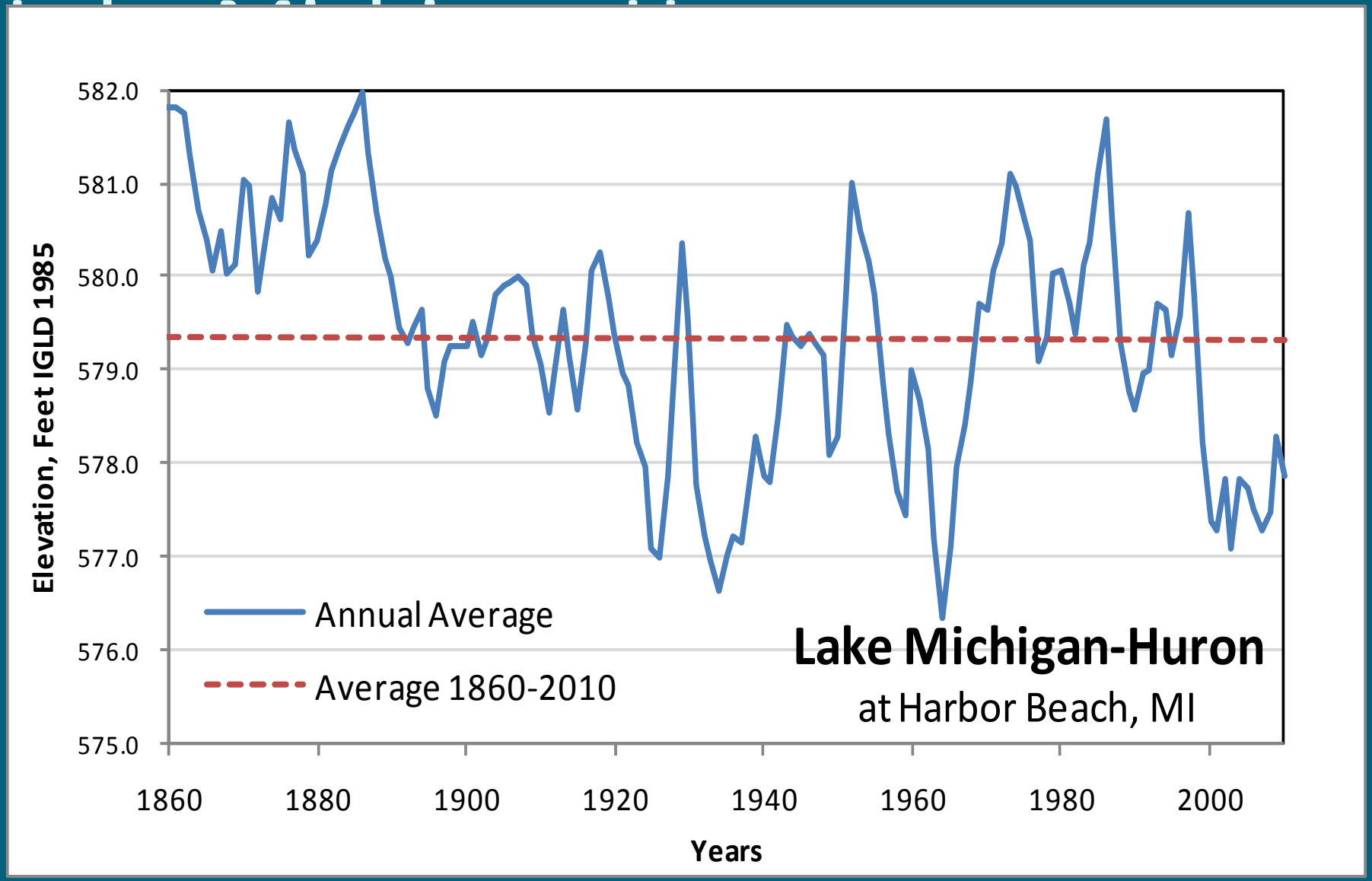
Precipitation

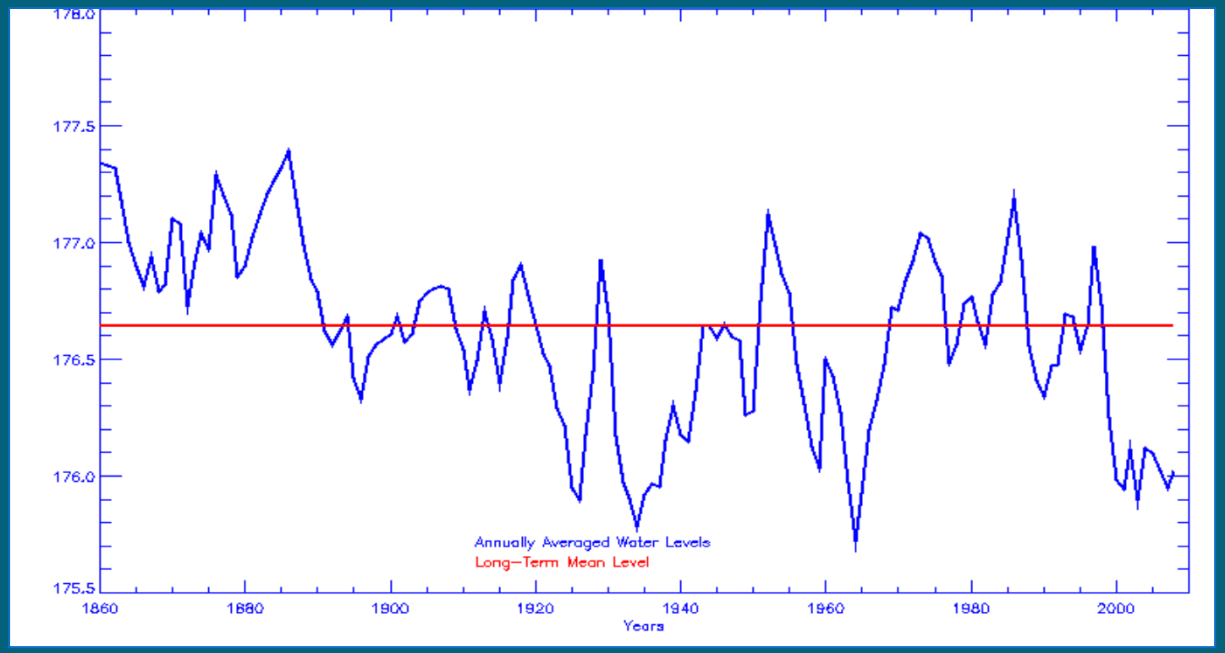
Runoff

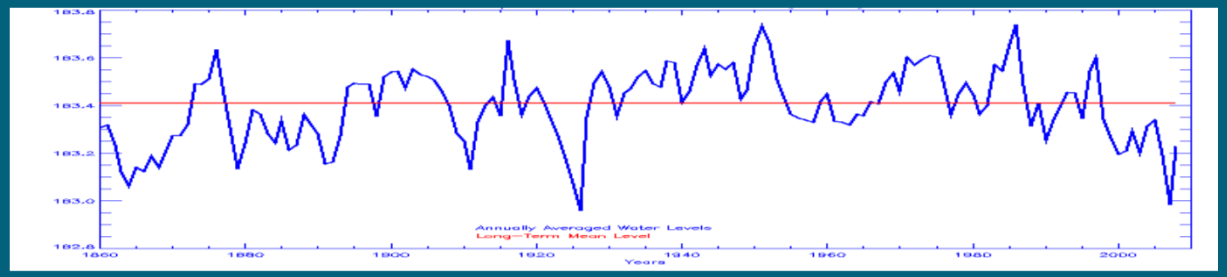
Evaporation

Width of arrows represents relative magnitudes of various factors

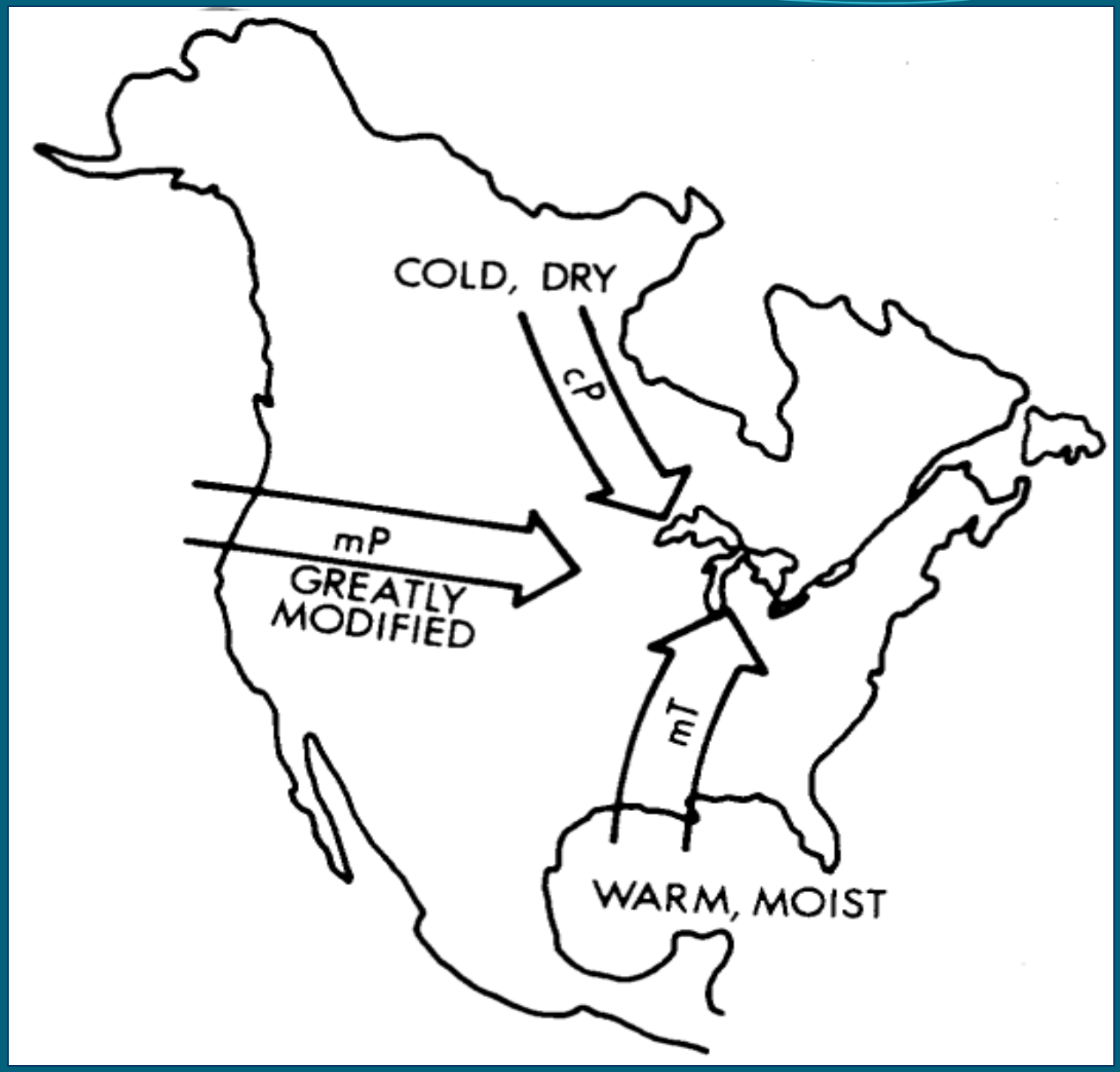

Lake
Superior
St. Marys River
St. Lawrence
River
Lake
Huron
Lake Michigan
Lake Ontario
Niagara River
St. Clair River
Lake St. Clair
Detroit River
Lake Erie
NOAA Gauges
DFO Gauges

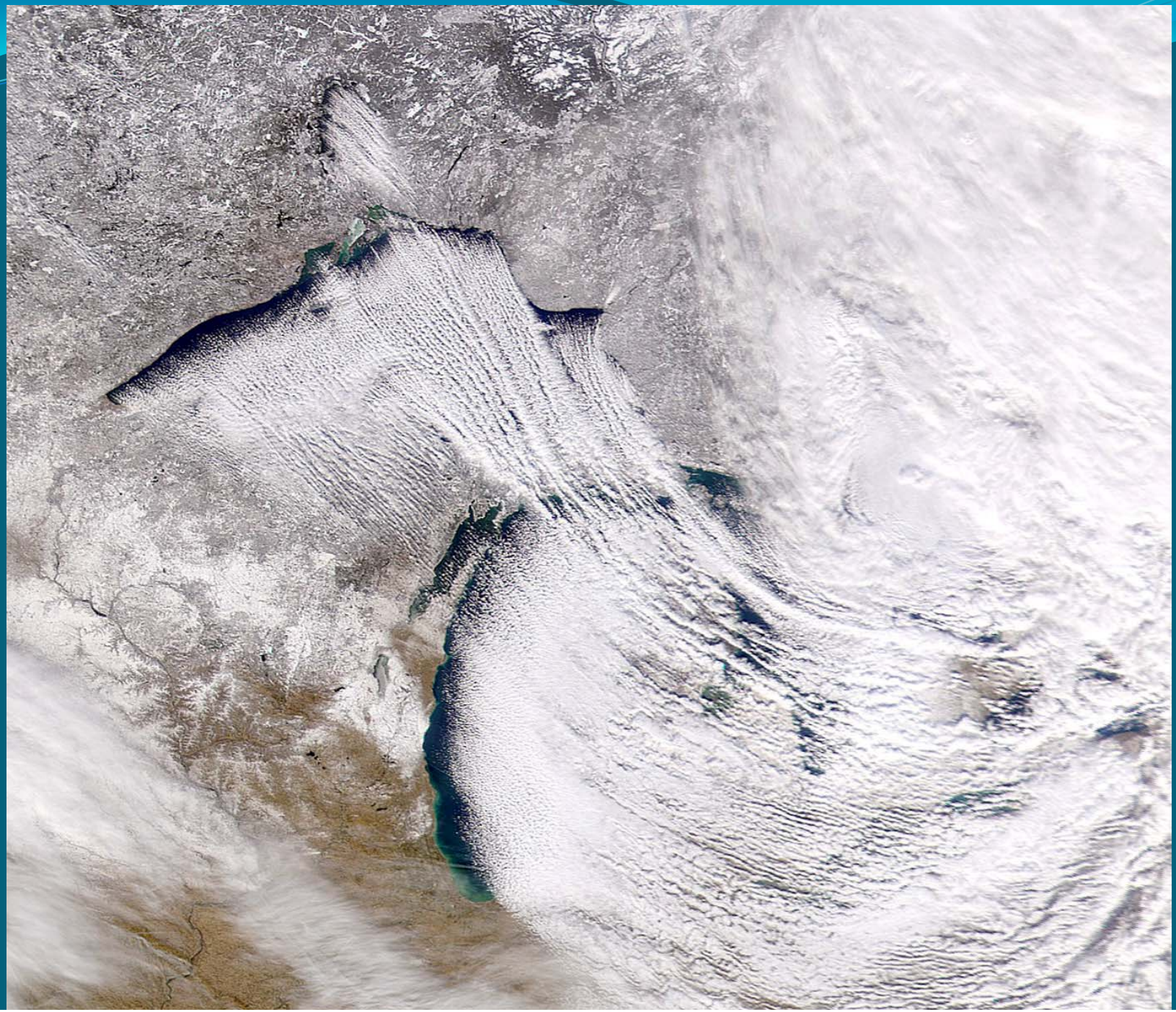

582.0
581.0
580.0
579.0
578.0
577.0
576.0
575.0
Elevation, Feet IGLD 1985
1860
1880
1900
1920
1940
1960
1980
2000
Years
Annual Average
Average 1860-2010
Lake Michigan-Huron
at Harbor Beach, MI

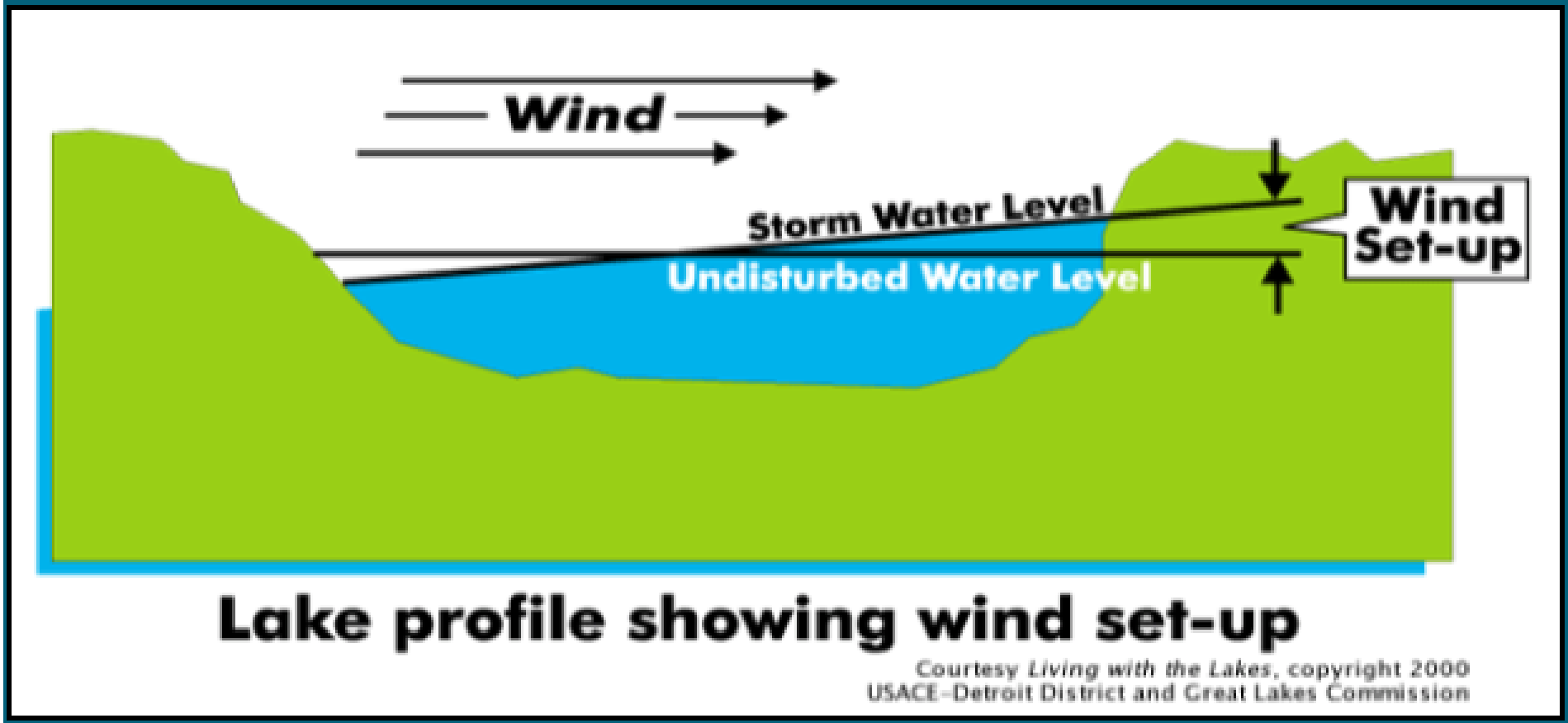

178.0
177.5
177.0
176.5
176.0
175.5
1860
1880
1900
1920
1940
1960
1980
2000
Years
Annually Averaged Water Levels
Long-Term Mean Level


183.8
183.6
183.4
183.2
183.0
182.8
1860
1880
1900
1920
1940
1960
1980
2000
Years
Annually Averaged Water Levels
Long-Term Mean Level

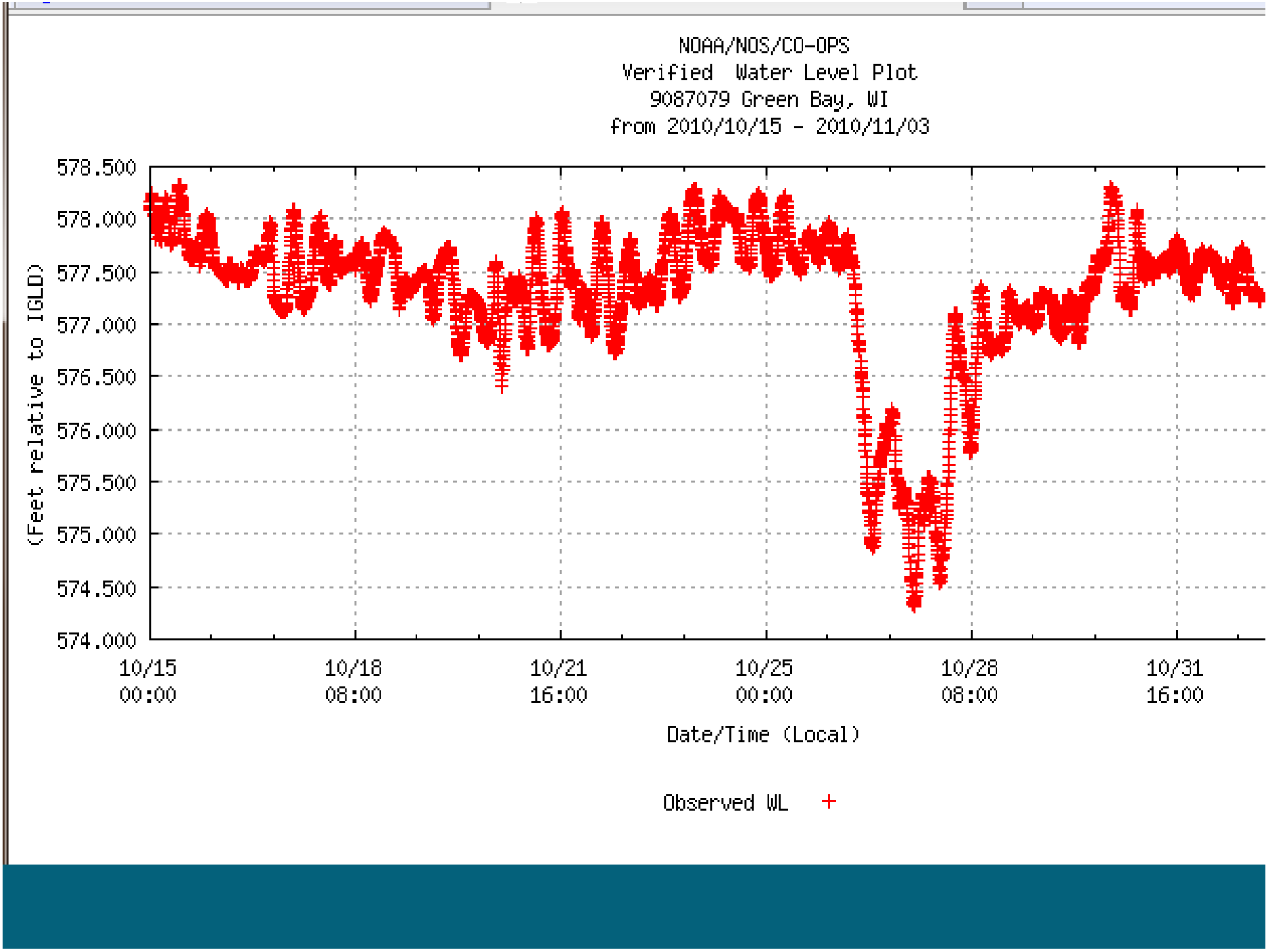
Total Change (feet)	Time Span	Annual Rate of Change (ft./yr.)	Period of Change
Lakes Michigan-Huron			
+1.5	8 months	+2.4	Feb. 2013 – Aug 2013
+ 3.5	17 months	+2.5	**Feb. 1928 - July 1929**
+3.1	18 months	+2.1	**Feb. 1951 - Aug. 1952**
+3.2	18 months	+2.1	**Feb. 1959 - Aug. 1960**
+5.6	8.5 years	+0.7	**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			


COLD, DRY
cP
mP
GREATLY
MODIFIED
mT
WARM, MOIST





Lake profile showing wind set-up


NOAA/NOS/CO-OPS
Verified Water Level Plot
9087079 Green Bay, WI
from 2010/10/15 - 2010/11/03
578.500
578.000
577.500
577.000
576.500
576.000
575.500
575.000
574.500
574.000
(Feet relative to IGLD)
10/15
00:00
10/18
08:00
10/21
16:00
10/25
00:00
10/28
08:00
10/31
16:00
Date/Time (Local)
Observed WL

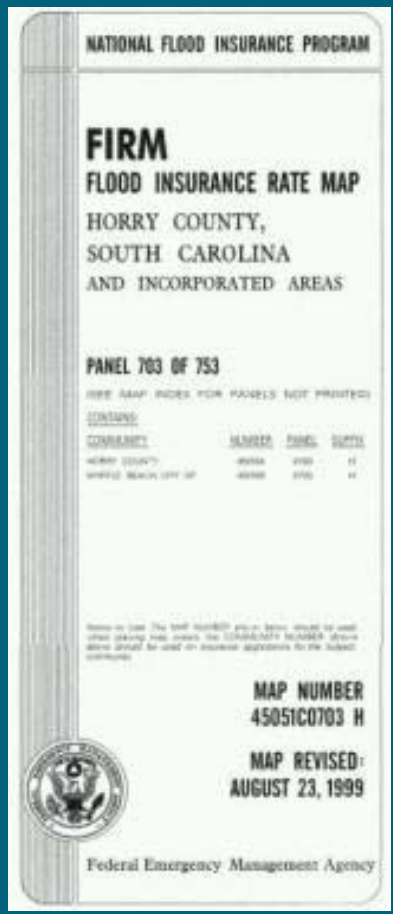
NAI Strategies

- Hazard Identification
- Planning
- Regulations and Standards
- Mitigation Actions
- Infrastructure
- Emergency Services
- Education and Outreach

Hazard Identification

BASIC

The Flood Insurance Rate Map


NATIONAL FLOOD INSURANCE PROGRAM

FIRM

FLOOD INSURANCE RATE MAP

HORRY COUNTY,
SOUTH CAROLINA
AND INCORPORATED AREAS

PANEL 703 OF 753

MAP NUMBER
45051C0703 H

MAP REVISED:
AUGUST 23, 1999

Federal Emergency Management Agency

Welcome to GreatLakesCoast.org

- Great Lakes Coastal Analysis & Mapping
  - Wind Surge Study
  - Coastal Hazard Analysis & Mapping
  - Great Lakes Flood Zones Overview
  - Technical Resources
  - Outreach
    - Fact Sheets
    - Newsletters
    - Presentations
    - Events
    - Discovery Reports
- Additional Resources
  - Contact Information
  - Site Map

Search for:

Search

Home > Great Lakes Coastal Analysis & Mapping > **Technical Resources**

Technical Resources

Project Data Centers

- **C-STORM** [cstormdb.erdc.dren.mil] – Basin wave and storm surge database platform, for access to wind, waves, pressure, ice, and water level data at near-shore "Save Points"
  Note: This site will start with Lake Michigan data, followed by Lake St. Clair and Lake Erie data.
- **U.S. Army Corps of Engineers Great Lakes Oblique Photo Viewer** [greatlakes.usace.army.mil]
- **LiDAR** [csc.noaa.gov] – High-resolution bathymetric and topographic data housed at NOAA's Coastal Service Center
- **Great Lakes Shoreline Geodatabase (.gdb)** [2.4 MB .zip]
- **CSHORE** [sites.google.com] – CSHORE is a one-dimensional time-averaged nearshore profile model for predictions of wave height, water level, wave-induced steady currents, and profile evolution.

Great Lakes Coastal Flood Study, 2012 Federal Inter-Agency Initiative: Guidance Documents and Reports

- ***Statistical Analysis and Storm Sampling for Lakes Michigan and St. Clair*** [3.68 MB .pdf],
  Norberto C. Nadal-Caraballo, Jeffrey A. Melby, and Bruce A. Ebersole, U.S. Army Corps of Engineers
  (Final Published Report, September 2012)
- ***Lake Michigan: Prediction of Sand Beach and Dune Erosion for Flood***

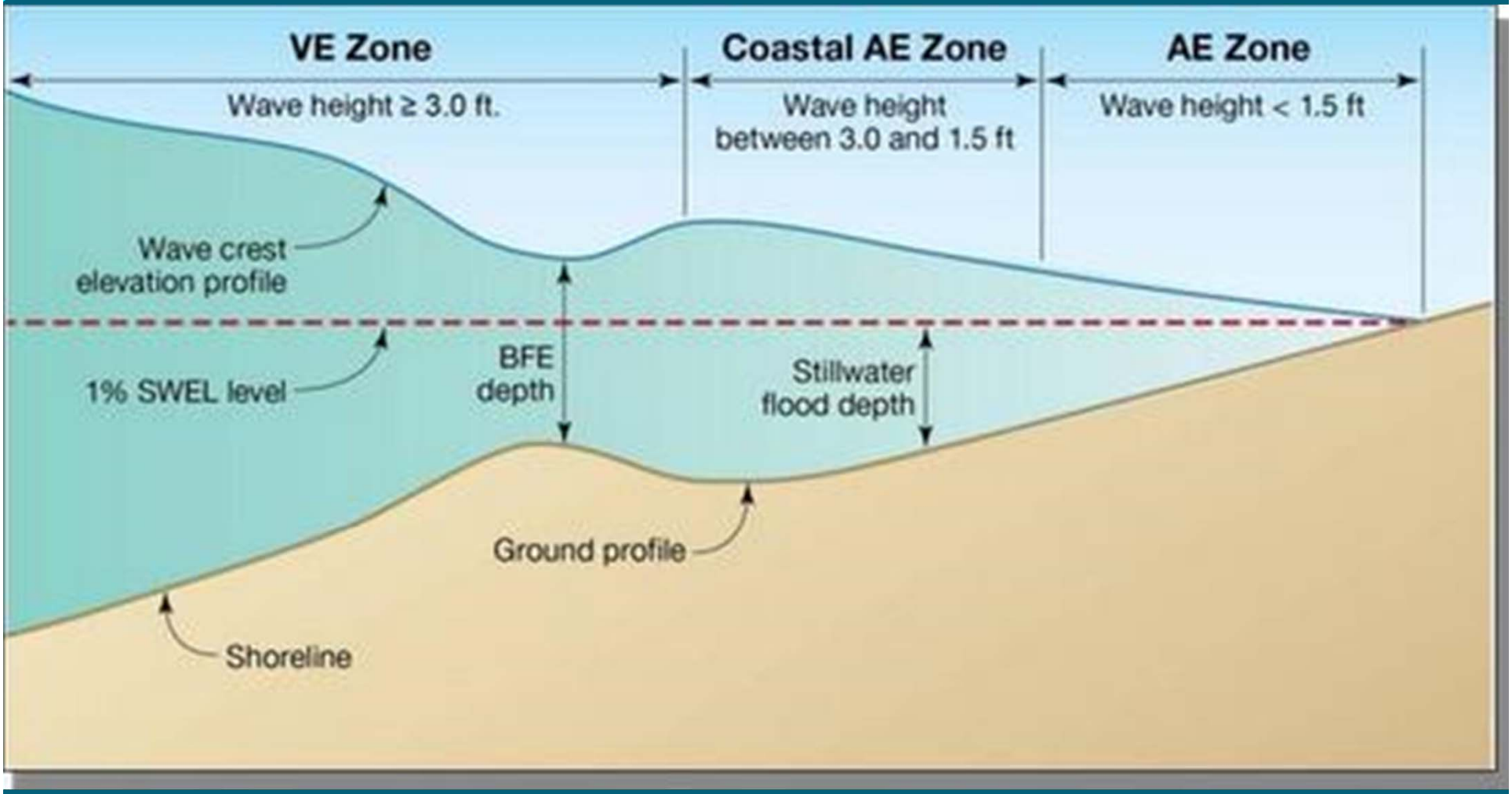
RSS Feed

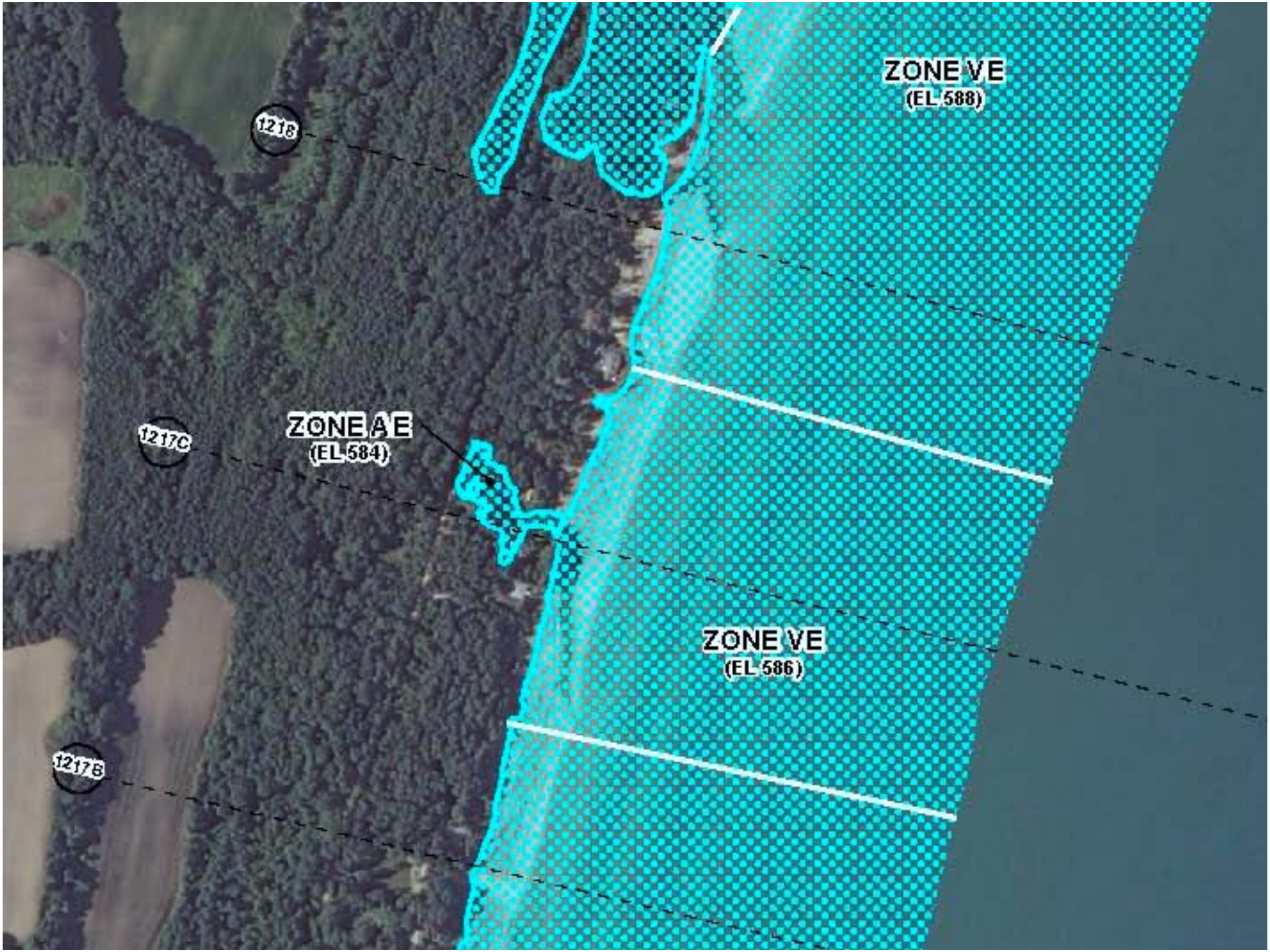
- Great Lakes Coast RSS

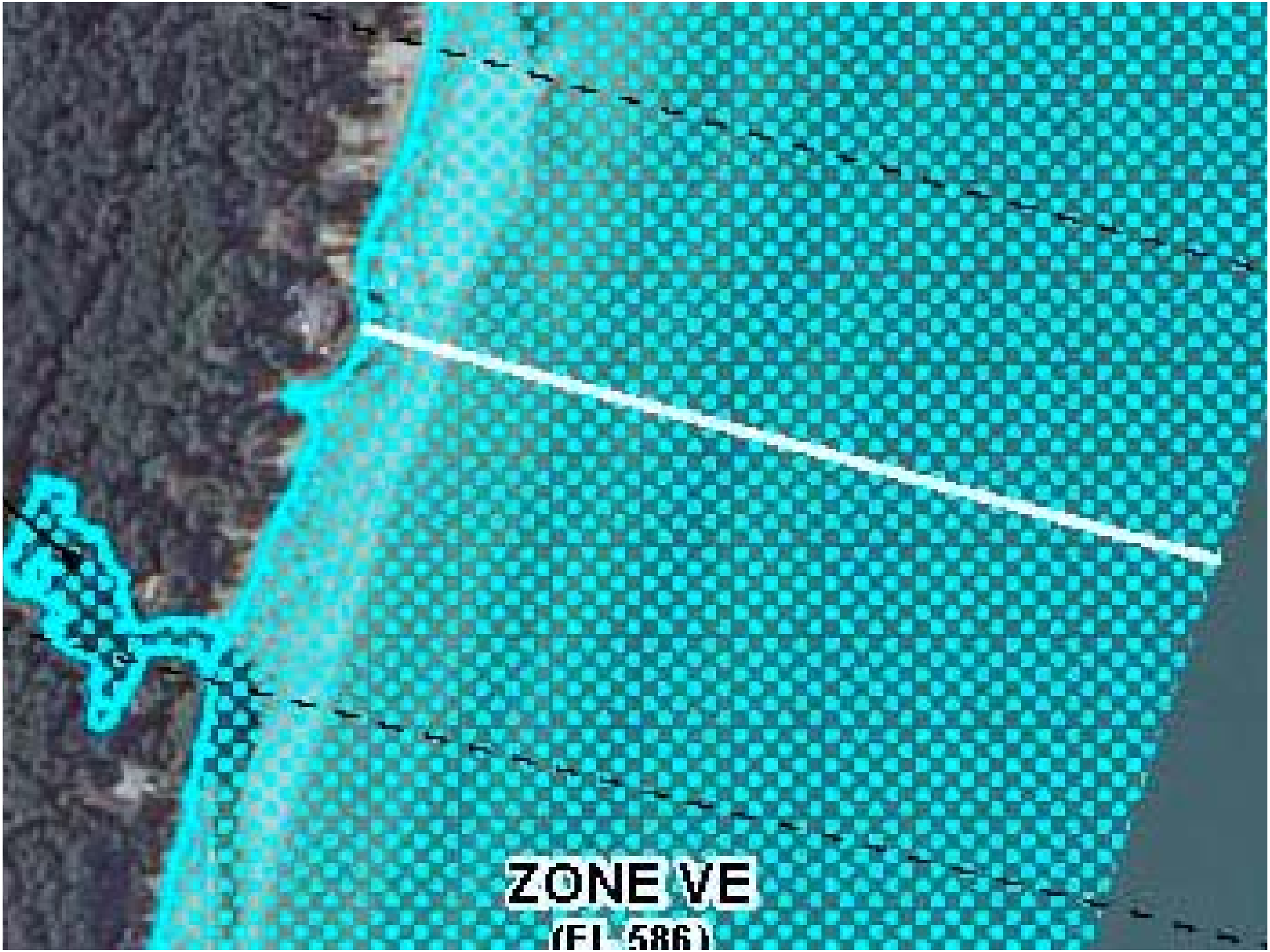
Archives

- October 2012 (1)
- August 2012 (1)
- July 2012 (1)
- June 2012 (1)
- May 2012 (2)
- April 2012 (3)

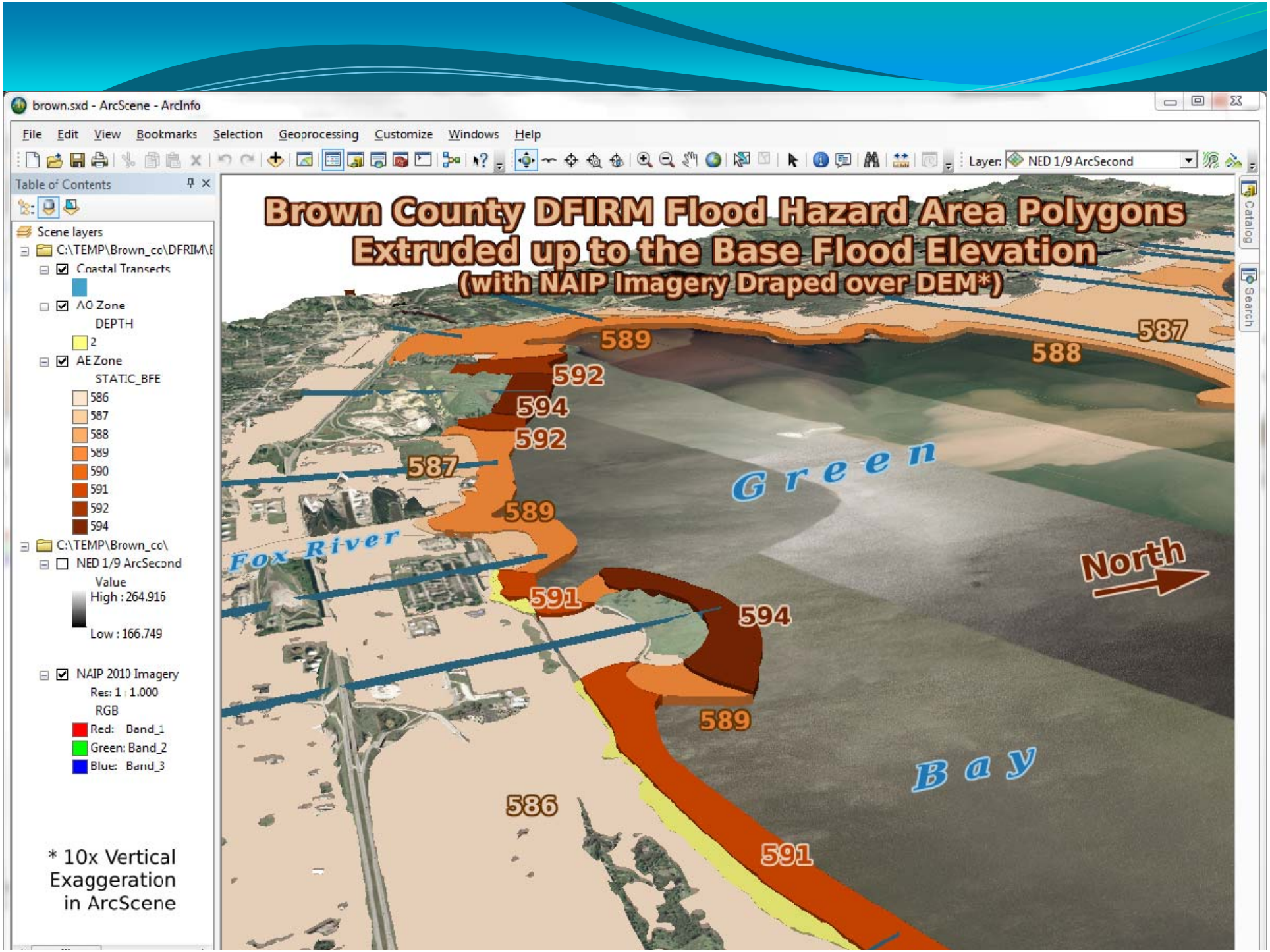
Generalized Coastal Zone Schematic


VE Zone
Wave height ≥ 3.0 ft.
Coastal AE Zone
Wave height
between 3.0 and 1.5 ft
AE Zone
Wave height < 1.5 ft
Wave crest
elevation profile
1% SWEL level
BFE
depth
Stillwater
flood depth
Ground profile
Shoreline


ZONE VE
(EL 588)
1218
1217C
ZONE A E
(EL 584)
ZONE VE
(EL 586)
1217B


ZONE VE


586
588


brown.sxd - ArcScene - ArcInfo
File Edit View Bookmarks Selection Geoprocessing Customize Windows Help
Layer: NED 1/9 ArcSecond
Table of Contents
Scene layers
C:\TEMP\Brown_cc\DFRIM\E
Coastal Transects
AO Zone
DEPTH
2
AE Zone
STATIC_BFE
586
587
588
589
590
591
592
594
C:\TEMP\Brown_cc\
NED 1/9 ArcSecond
Value
High : 264.916
Low : 166.749
NAIP 2010 Imagery
Res: 1 : 1.000
RGB
Red: Band_1
Green: Band_2
Blue: Band_3
* 10x Vertical Exaggeration in ArcScene
Brown County DFIRM Flood Hazard Area Polygons
Extruded up to the Base Flood Elevation
(with NAIP Imagery Draped over DEM*)
589
587
588
592
594
592
587
589
Green
Fox River
North
591
594
589
Bay
586
591
Catalog
Search

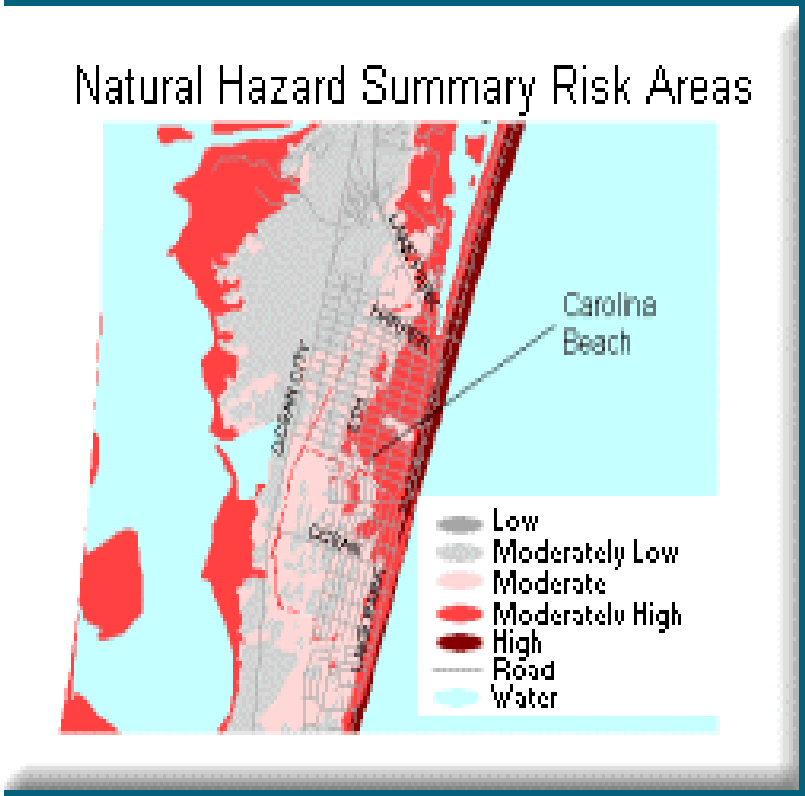
Hazard Identification

BETTER

Fill in the Gaps

- Overlay other jurisdictional lines, wetlands and other protected areas over the FIRM
- Map other flood-related hazards (coastal erosion hazard area, areas with local flood history; stream erosion; dam failure inundation; mudflow hazard)
- Document High Water Marks from significant storms to aid in FIS/FIRM updates

Hazard Identification



NAI Strategies

- **Higher Mapping Standards**
- **Natural & Beneficial Functions**
- **Information Sharing**

Hazard Identification

NAI

Higher Mapping Standards

- Use future conditions hydrology (flood discharges based on build-out scenarios for current zoning)
- Map hazards not shown on FIRM (unstable bluffs and coastal recession)

Hazard Identification

Identify Sensitive Resources - NAI

Natural & Beneficial Functions
Environmentally Sensitive Areas

- **Wetlands**
- **Beaches**
- **Critical Habitat for Threatened & Endangered Species**

Hazard Identification

Information Sharing

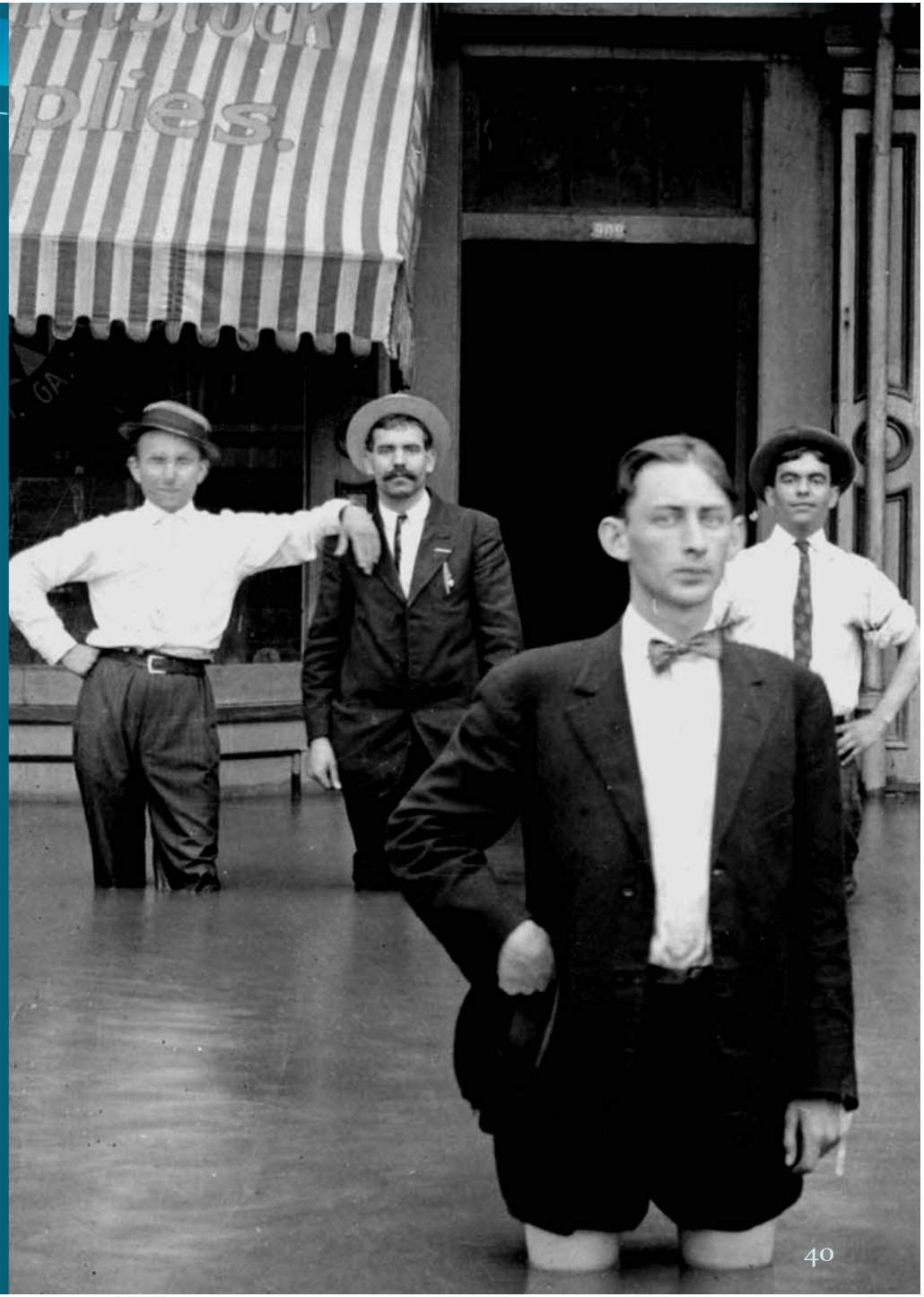
- Make Community Data Available
- Limit Fee and/or Licensing Requirements
- Host Website for Downloading Data
- Develop Disaster Contingency for Data Access

Hazard Identification

Think big and small, current & future…

Explore hazards history & impacts…

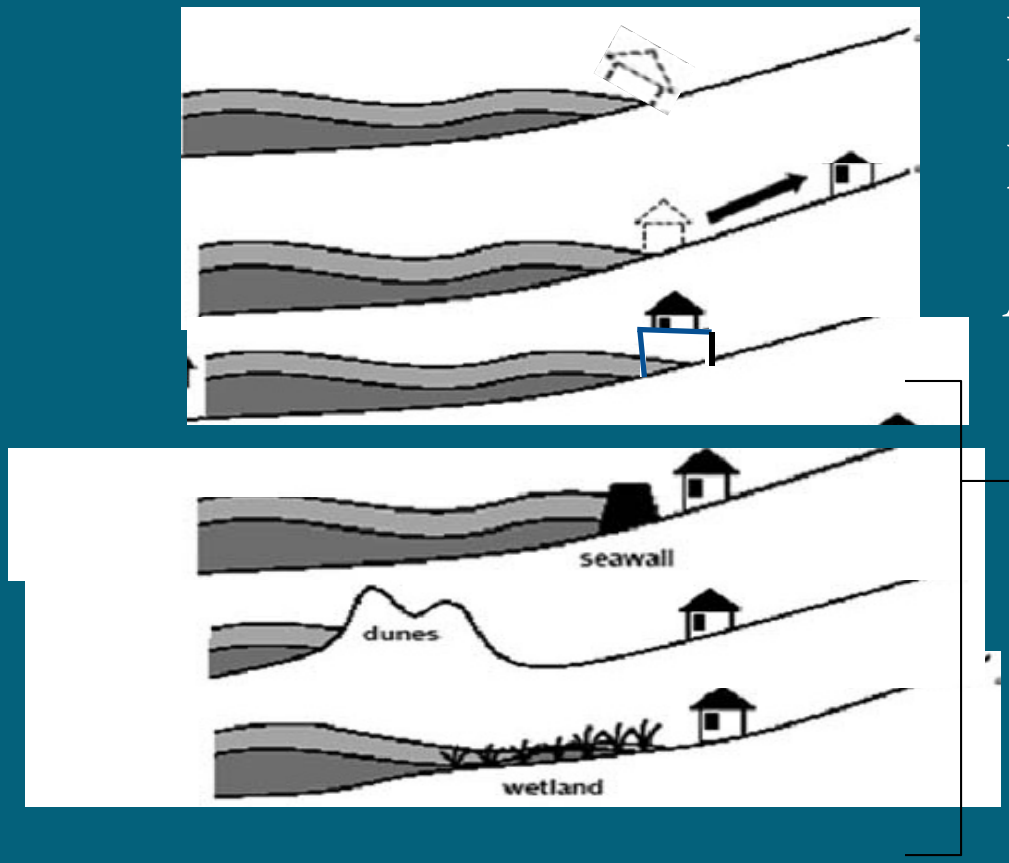
Find stories (examples, anecdotes and photos) to supplement other data sources…



NAI Strategies

- Hazard Identification
- Planning
- Regulations and Standards
- Mitigation Actions
- Infrastructure
- Emergency Services
- Education and Outreach

Adaptation Strategies



Do nothing

Retreat

Accommodate

Protect

Planning

BASIC *Planning & Implementation*

- Prepare comprehensive land use plans
  - Identify hazard areas
  - Identify appropriate land uses
- Develop special subject plans to supplement comprehensive plans
  - Economic development plans
  - Habitat protection plans
  - Watershed management plans
- Adopt zoning or other ordinances to enforce plans

Planning

BETTER *Risk Analysis and Strategy*

- Identify flood-risk areas on plans and restrict development
- Adopt low-density zoning in floodplains
- Use specialized tools (ex: GIS, HAZUS, etc.)
- Prepare FPM, storm water management plans to supplement comprehensive plans
- Prepare multi-hazard mitigation plans

Planning

NAI *Sustainability*

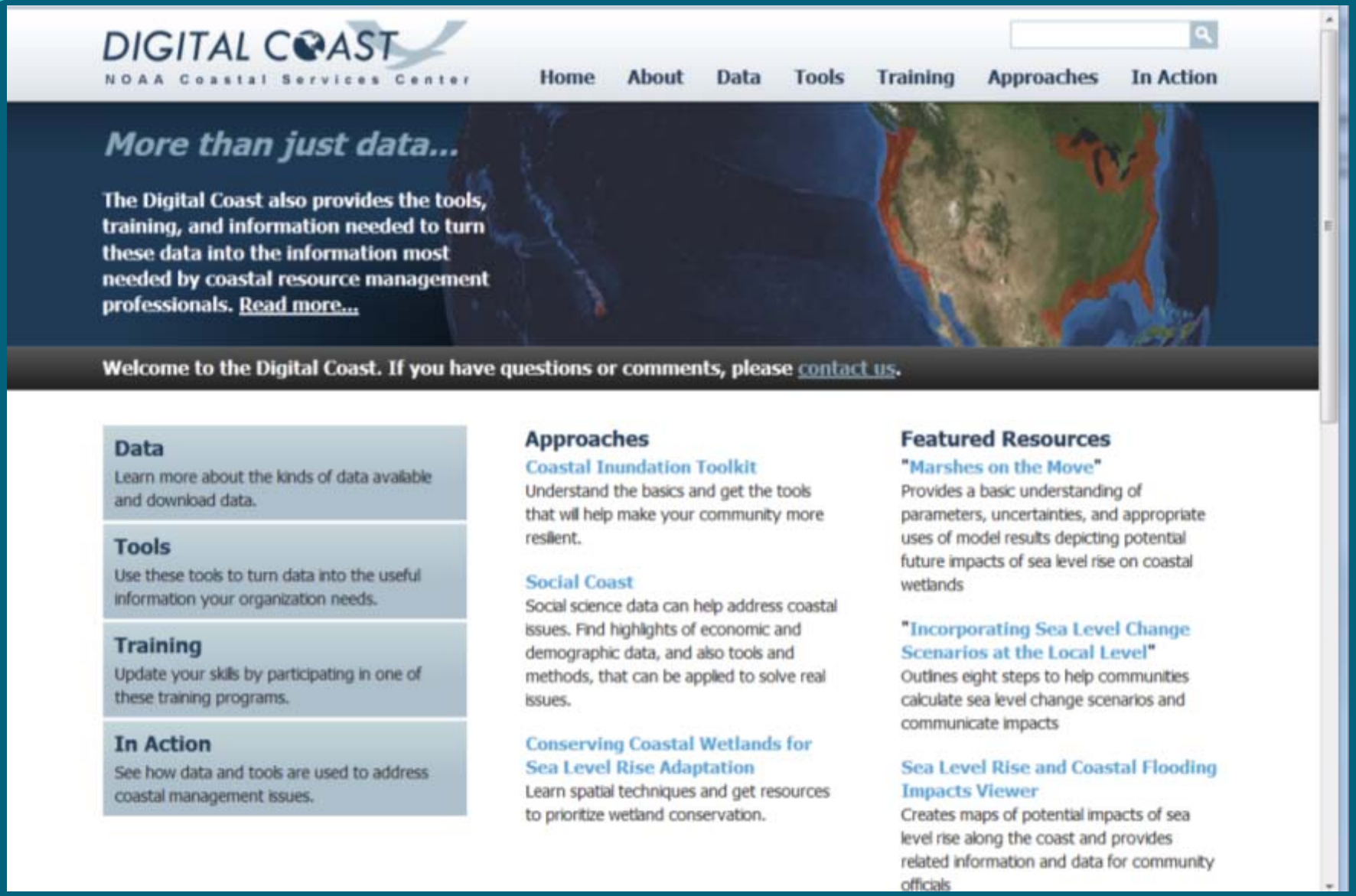
Include watershed, MOM and sustainable development principles in land use planning

- Consider current and future development
- Coordinate floodplain planning with other planning activities (economic development, housing, recreation, ecosystem restoration, water quality, etc.)
- Identify long-term implications of alternative land uses
- Promote “sustainable” development

Planning

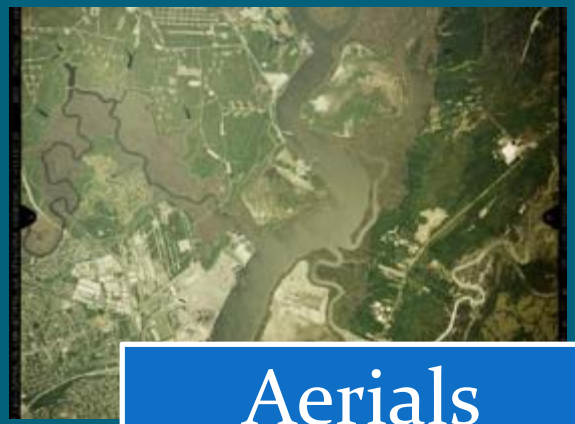
Some great planning tools:

Digital Coast

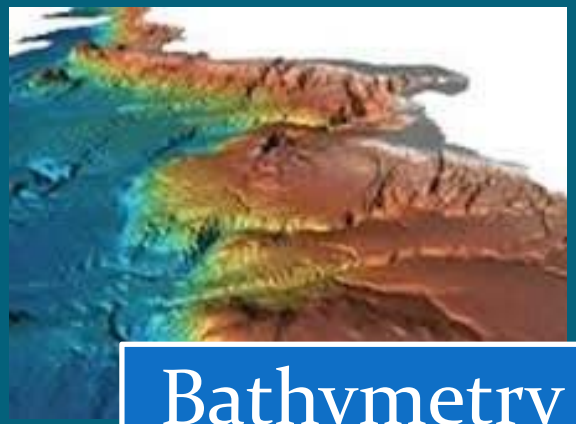


www.csc.noaa.gov/digitalcoast/

Digital Coast Data



Aerials

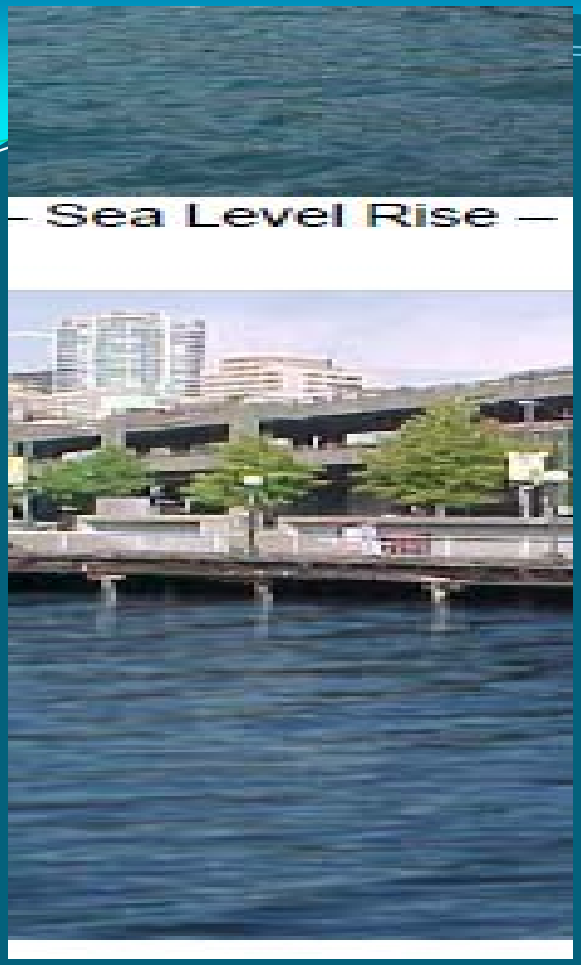


Bathymetry

LiDAR

LandCover

CanVis Tool



Visualization

Alternatives

Charleston Customs House – 1.5m SLR - Before

Charleston Customs House – 1.5m SLR - After

Communication

Coastal Resilience Guidebook

Who are you?
Coastal Manager
Floodplain Manager
Planner
Emergency Manager

Where are you?
Lake: Michigan
State: Wisconsin
County: Ozaukee
Municipality: None
Address: None

Find Location (Map)

Great Lakes Coastal Resilience Guidebook

This guidebook allows state and local officials engaged in coastal management, planning, mitigation and development issues to explore the primary coastal and shoreline hazards facing Great Lakes communities by allowing them to:

- examine how recent and ongoing trends in short-term and long-term climate conditions affect hazards and their impacts on land, water and resources
- investigate how different hazards management alternatives respond to and affect changing conditions

1. **Hazards Management and Planning**

2. **Coastal Erosion & Bluff Recession**

3. **Coastal Infrastructure Planning**

4. **Habitat Conservation & Restoration**

Learn:
Great Lakes
Lake Levels
Climate Change
Geology
History

NAI Strategies

- Hazard Identification
- Planning
- Regulations and Standards
- Mitigation Actions
- Infrastructure
- Emergency Services
- Education and Outreach

Regulation & Development Standards

BASIC *Core Regulations*

Adopt floodplain management ordinance recognizing:

- Flood damage can still occur with minimum standards
- BFEs subject to change, particularly as development occurs in watershed

Regulation & Development Standards

BETTER *Higher Regulations*

- Prevent a loss of storage and/or an increase in velocity
- Restrict development in Coastal High Hazard Areas
- Adopt higher health/safety regs
- Utilize “green infrastructure”
- Adopt storm water regulations

Regulation & Development Standards

NAI

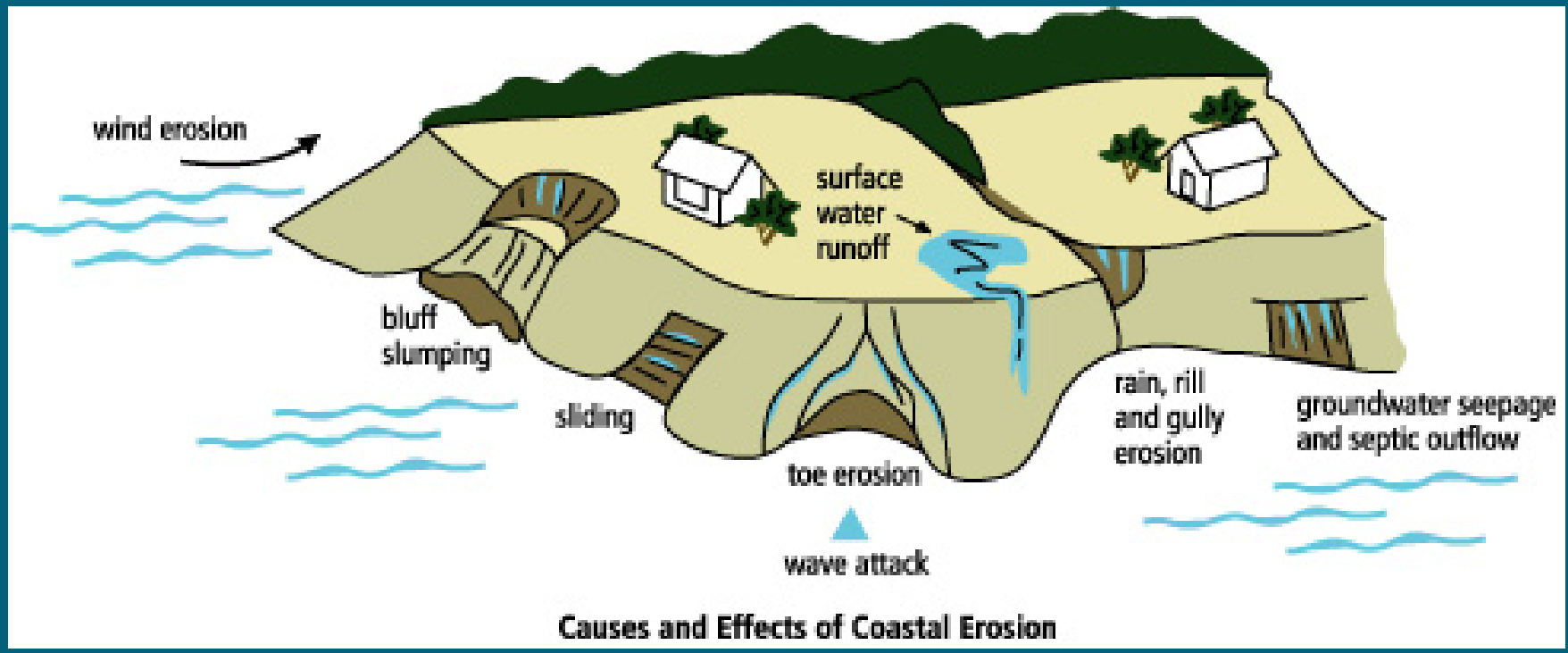
Ensure Neighbors are not adversely impacted

Require community permits for shore protection structures:

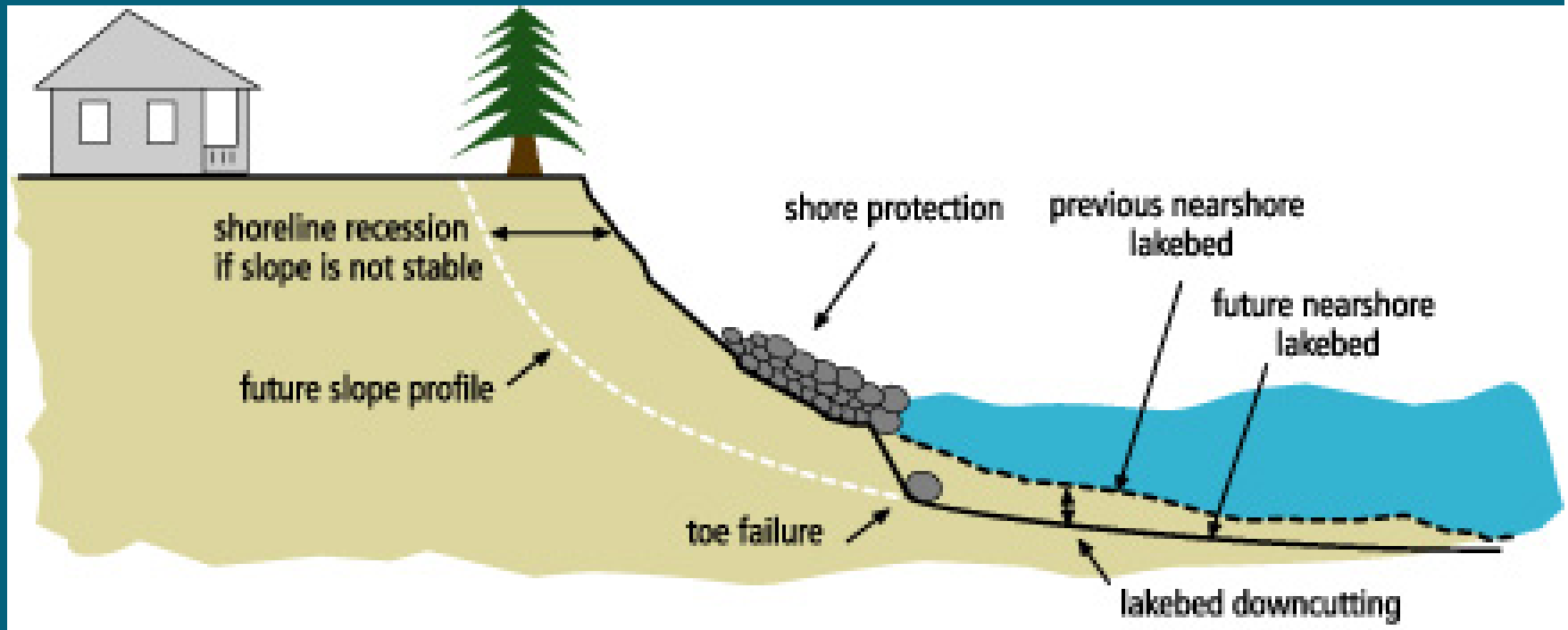
- Include a requirement that structures do not adversely impact neighboring property

Adopt setback regulations in areas with unstable bluffs

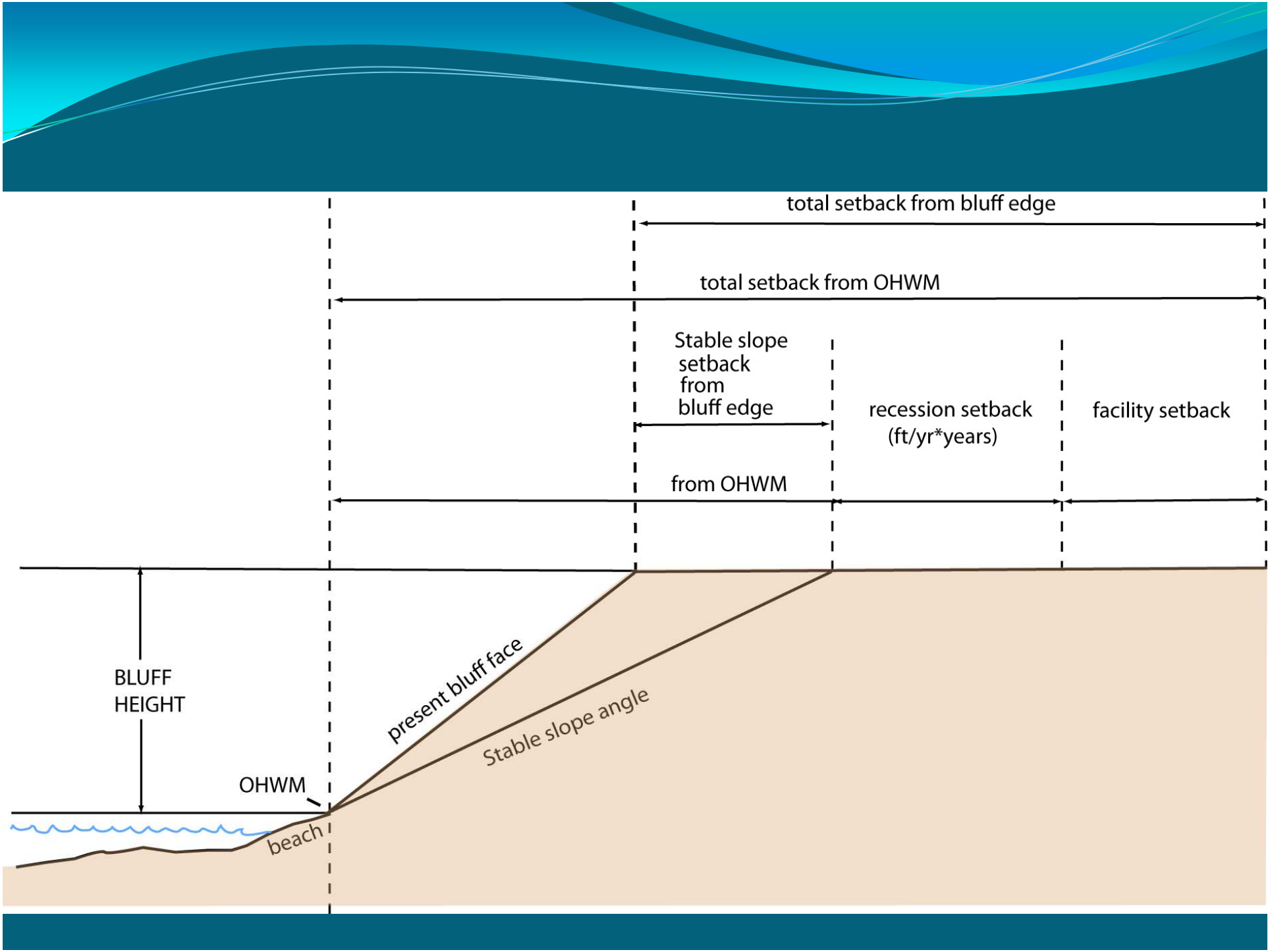
CAUSES OF COASTAL EROSION



Causes and Effects of Coastal Erosion



Lakebed Erosion with Slope Recession and
Failure of Shore Protection Structure

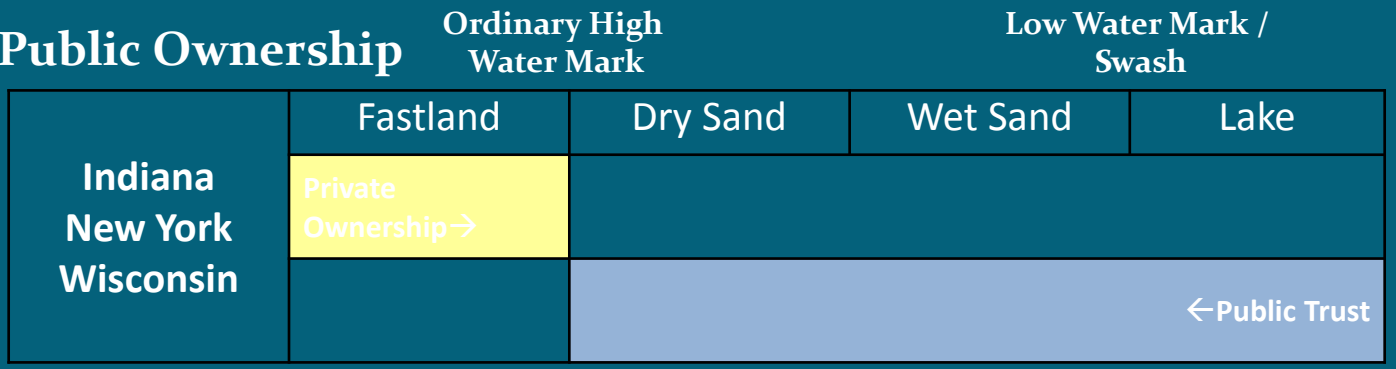

total setback from bluff edge
total setback from OHWM
Stable slope setback from bluff edge
recession setback (ft/yr*years)
facility setback
from OHWM
BLUFF HEIGHT
present bluff face
Stable slope angle
OHWM
beach

GL States with Coastal Setbacks

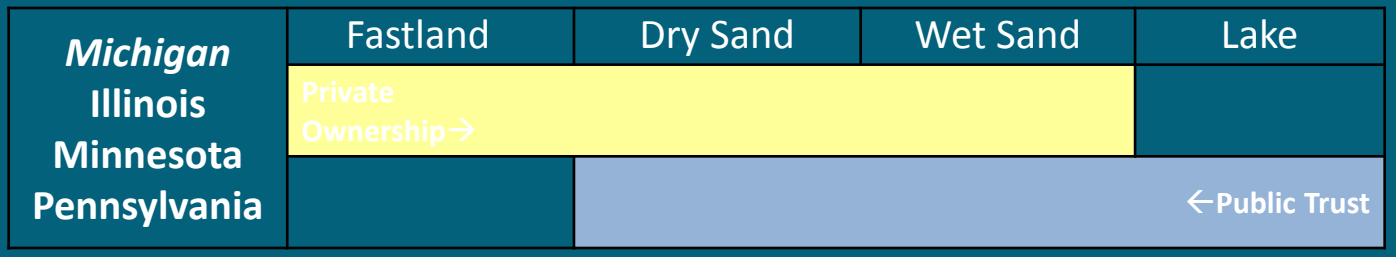
- Michigan
- Pennsylvania
- Ohio
- New York
- Wisconsin (some counties)

Marking OHW on the Great Lakes

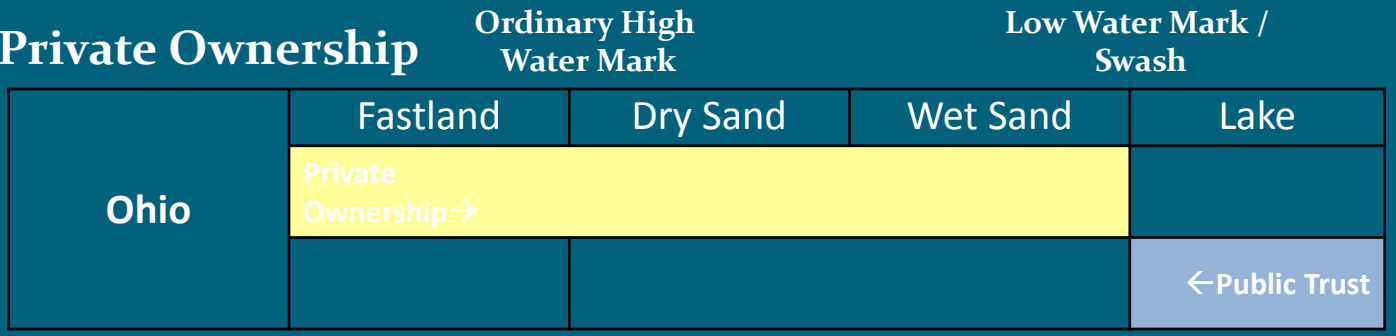
Strong Public Ownership

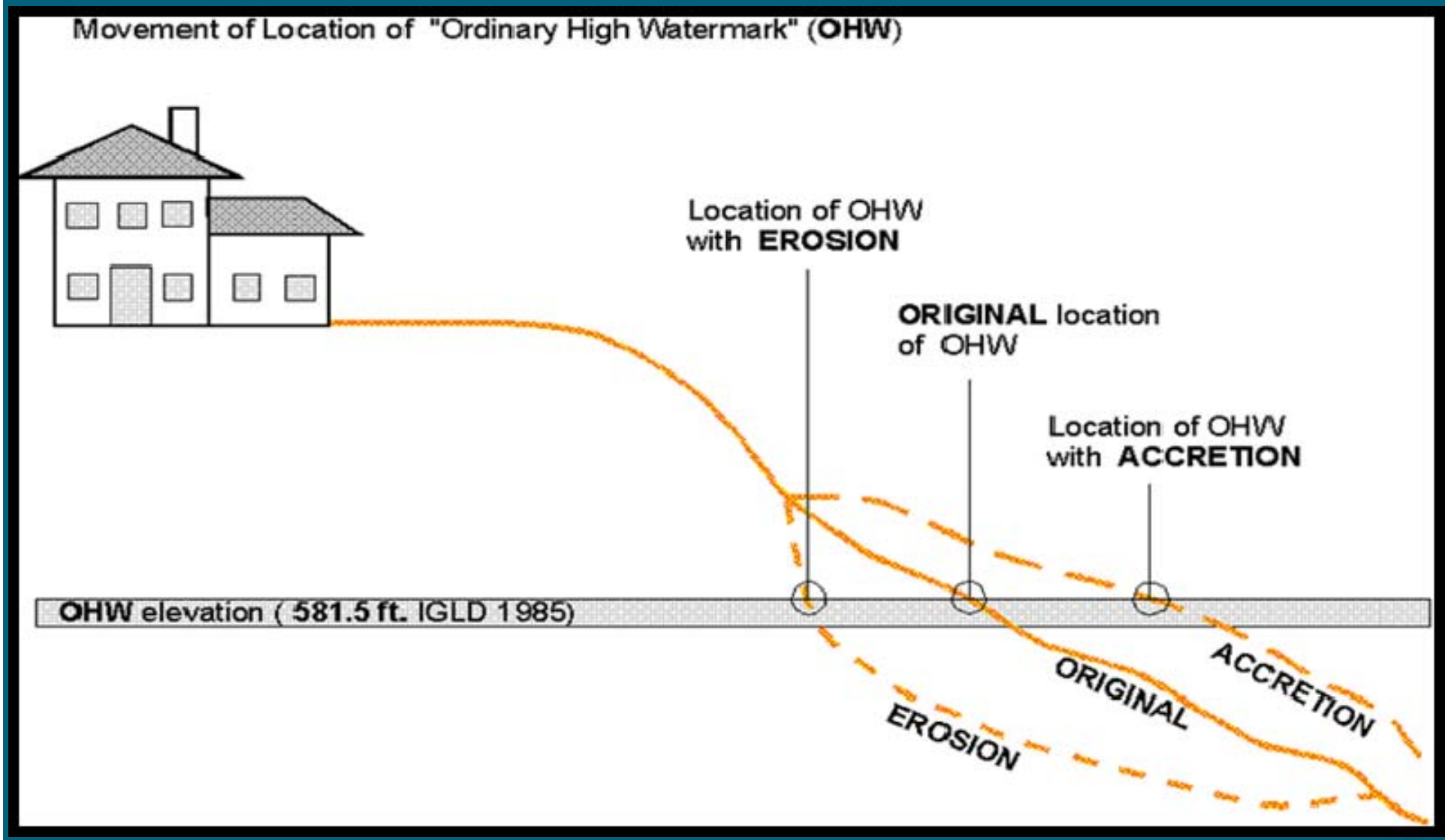


Overlapping Ownership



Strong Private Ownership



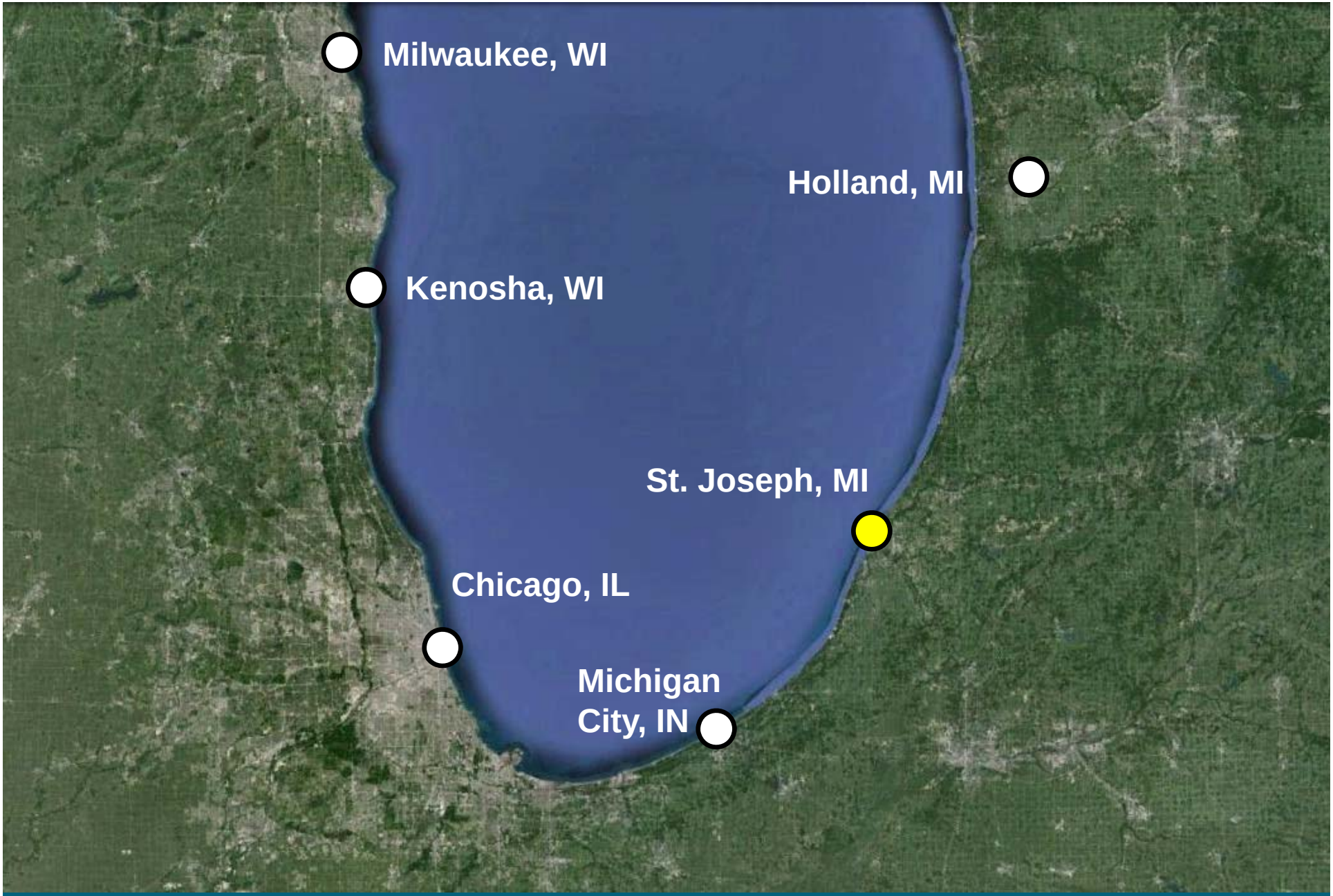

Movement of Location of "Ordinary High Watermark" (OHW)
Location of OHW with EROSION
ORIGINAL location of OHW
Location of OHW with ACCRETION
OHW elevation (581.5 ft. IGLD 1985)
ORIGINAL
ACCRETION
EROSION

Regulation & Development Standards

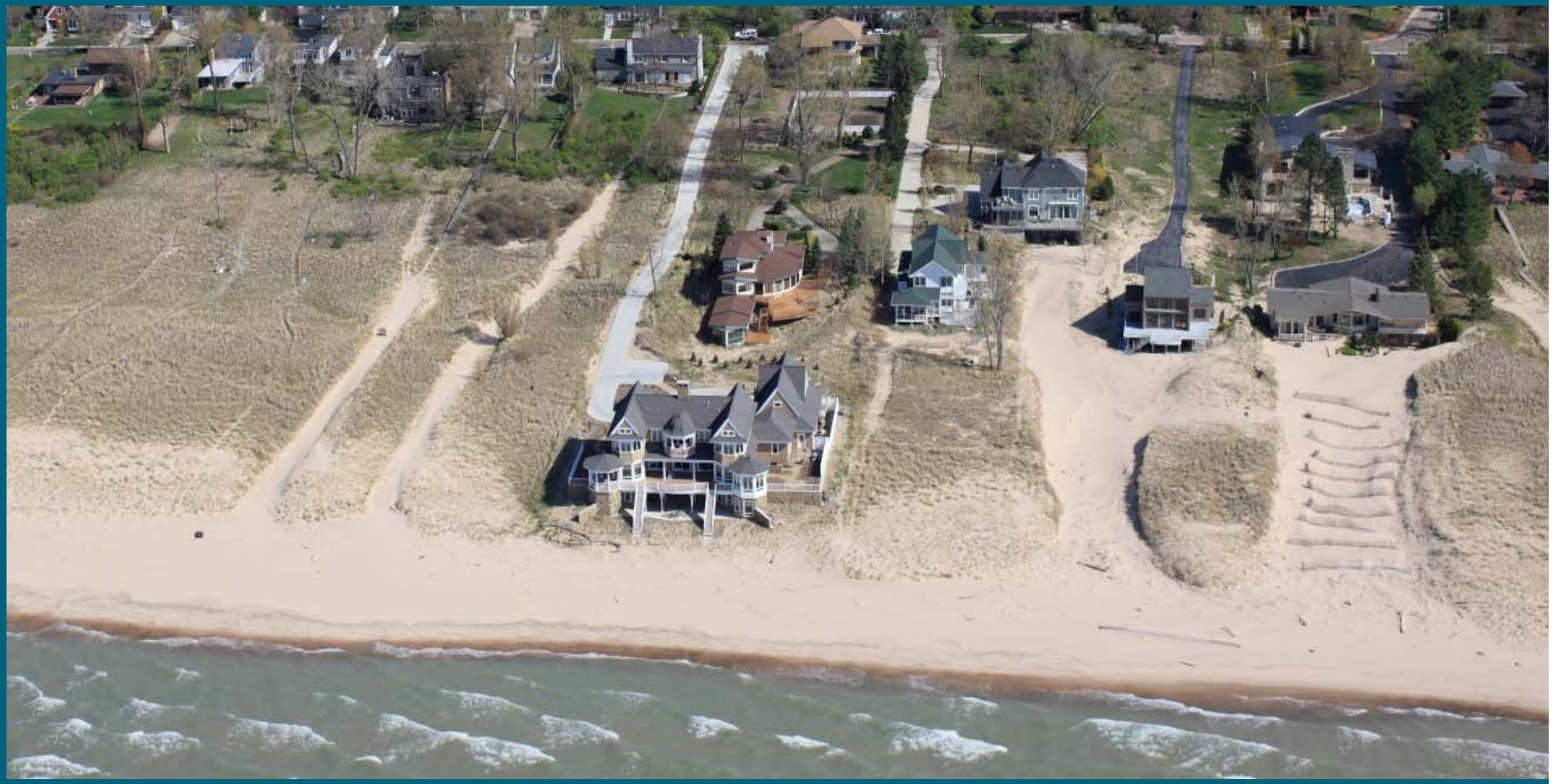
NAI *Natural Floodplain Functions*

Preserve beneficial natural floodplain functions

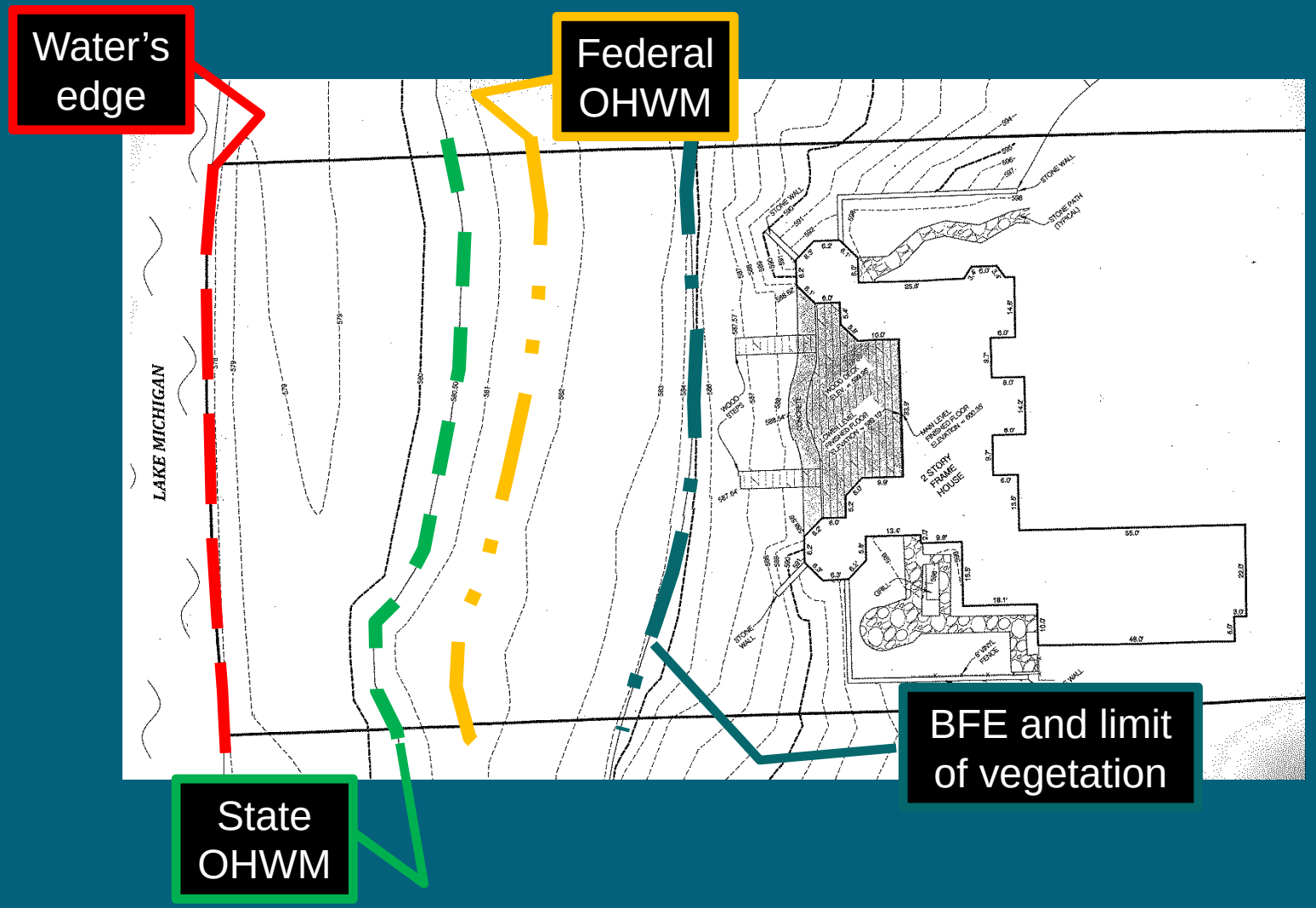
- Adopt setback standards to establish minimum distances from river channels or shorelines
- Adopt buffer zone requirements between sensitive and developed areas
- Implement stream restoration programs



Developing a No-Build Zone Ordinance – St. Joseph, MI



2008 – A new home



Base Flood Elevation (BFE)

FLOOD INSURANCE STUDY

The flood profiles for Tanner Creek and William & Esseg Drain were started with a boundary condition of 581.3 feet, NGVD 1929, the mean lake level of Lake Michigan.

Tanner Creek and William & Esseg Drain, the Bridgman City Drain, and Bedortha Drain all experience peak flows at similar times. The starting water surface elevation for Bedortha Drain has been taken to be the corresponding flood elevation for Tanner Creek and William & Esseg at the confluence with Bedortha Drain.

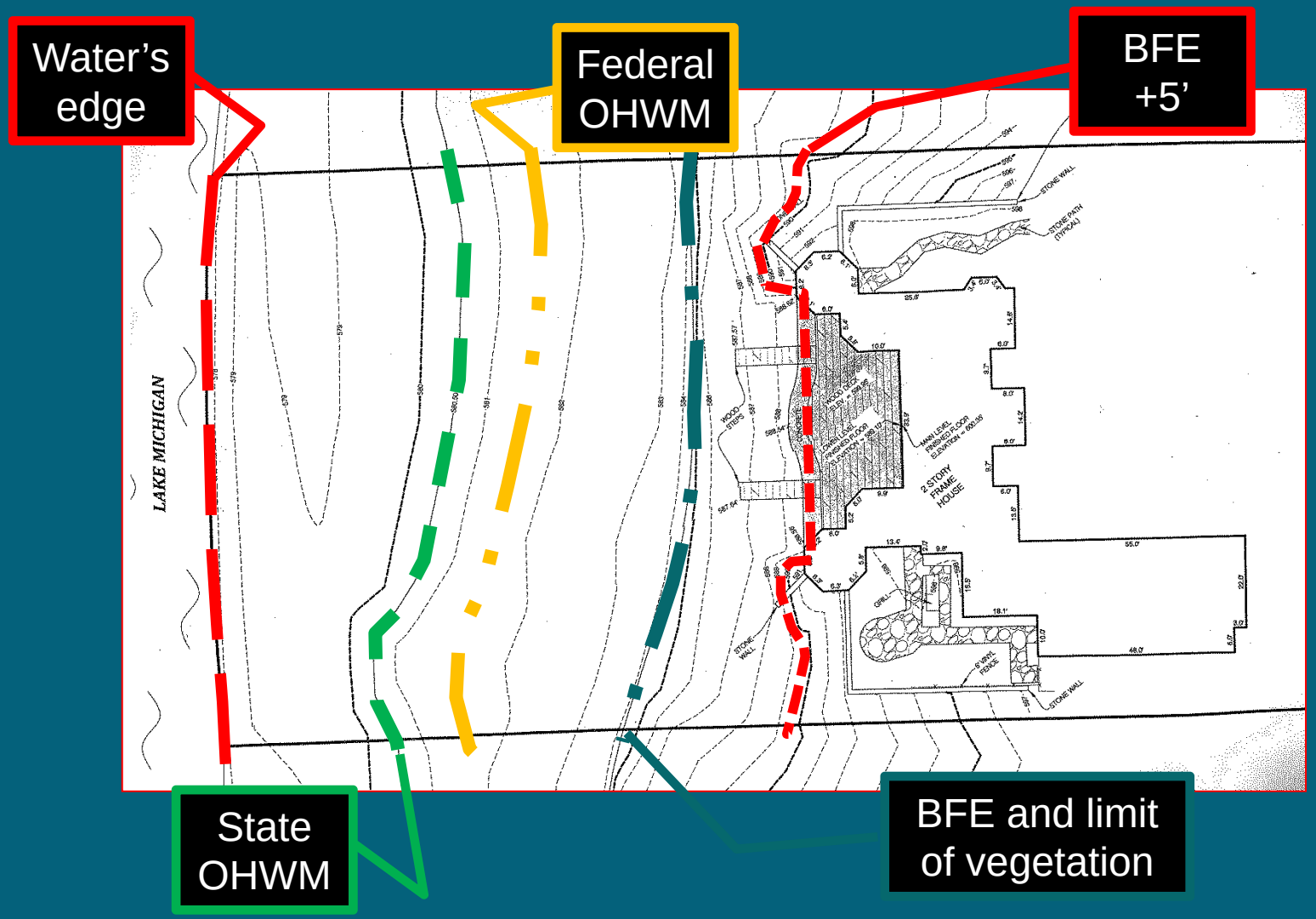
Lake from the Township of Watervliet 1983 FIS and Township of Coloma 1983 FIS are shown in the table. However, a 1983 USACE report for Paw Paw Lake supersedes the 1-percent-annual-chance flood level (Reference 48).

Approximately five feet may be added to Lake Michigan flood levels to account for wave runup. This value assumes uniformly sloped beaches subject to direct wave attach from the west. Factors such as location and shoreline configuration could alter this estimated wave runup and value. When methodology on wave runup determination is resolved, additional shoreline flood hazard areas may be delineated by FEMA.

TABLE 10 – Summary of Base Flood Elevations (NGVD)

	10%	2%	1%	0.2%
Paw Paw Lake	626.9	628.6	623.6	631.0

2008 - A new home



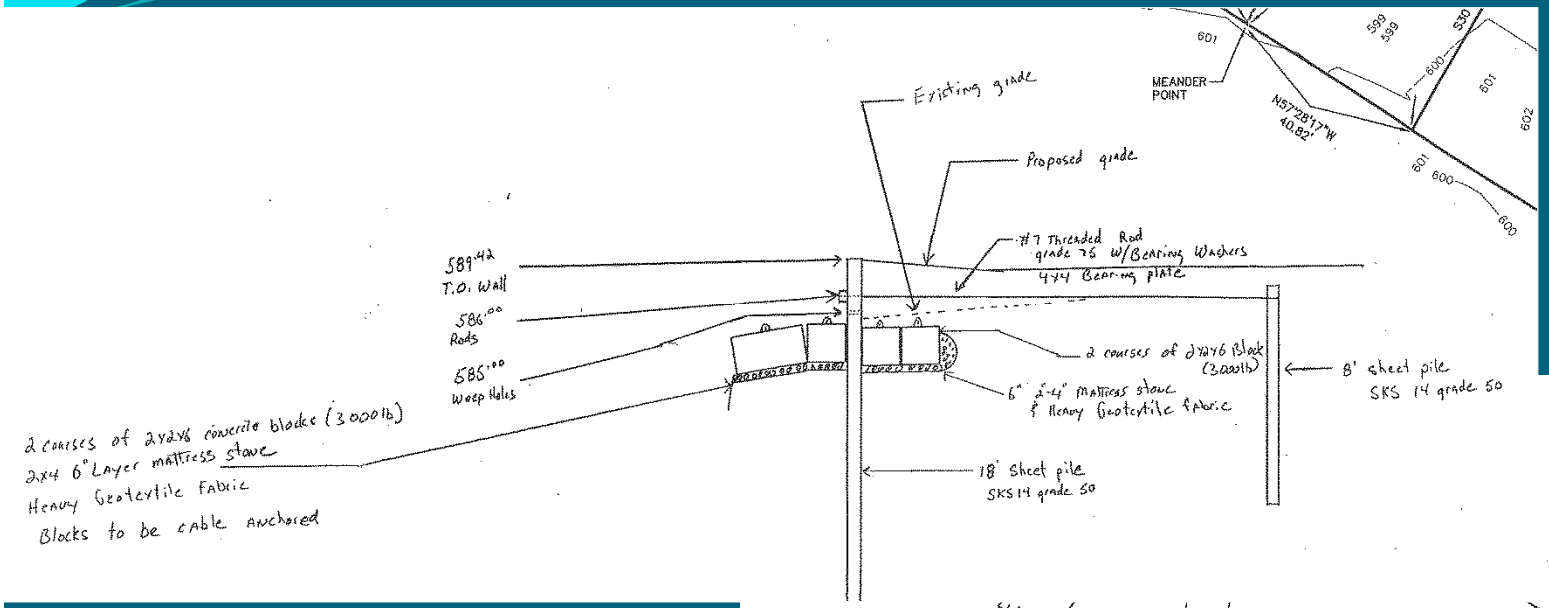
Developing a No-Build Zone Ordinance – St. Joseph, MI

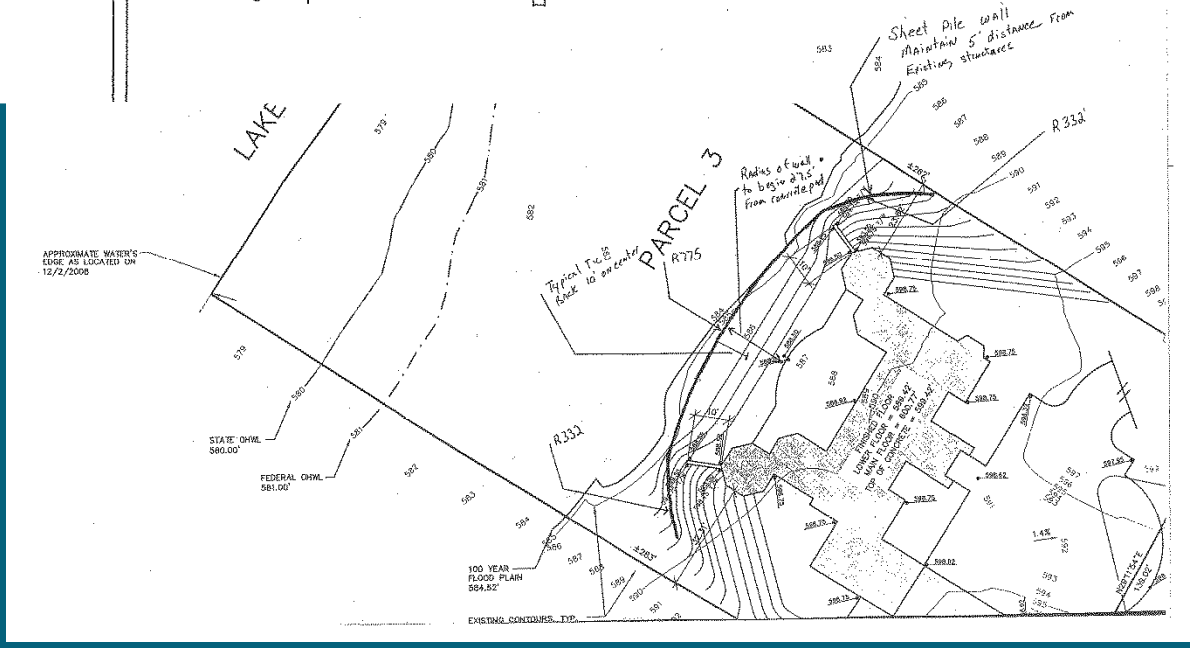
Developing a No-Build Zone Ordinance – St. Joseph, MI

During the 1970's sand-bags were used to protect these four homes from wave damage

Developing a No-Build Zone Ordinance – St. Joseph, MI

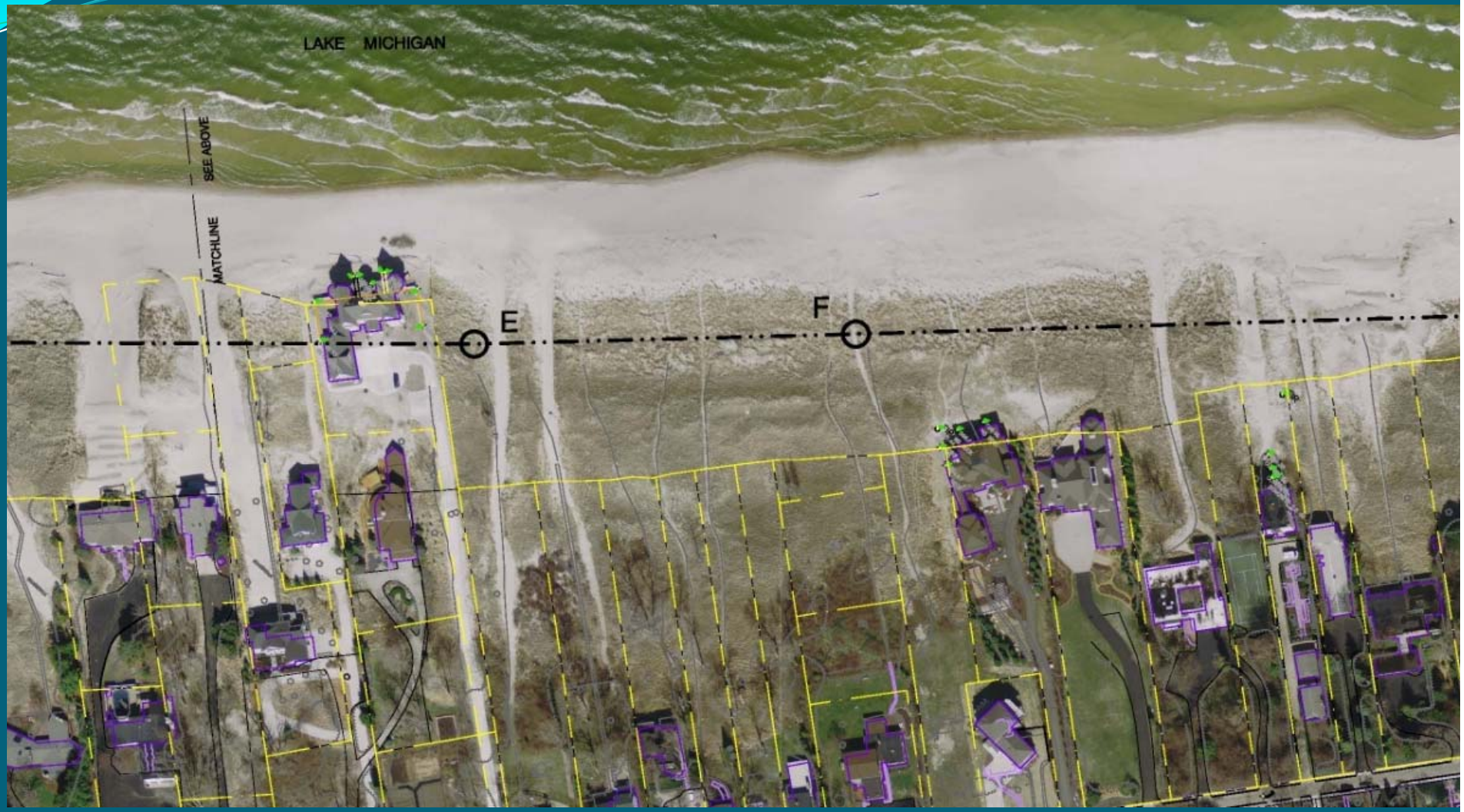
2011 - Seawall Application





Developing a No-Build Zone Ordinance – St. Joseph, MI

Setback Line



Developing a No-Build Zone Ordinance – St. Joseph, MI

NAI Strategies

- Hazard Identification
- Planning
- Regulations and Standards
- Mitigation Actions
- Infrastructure
- Emergency Services
- Education and Outreach

Mitigation

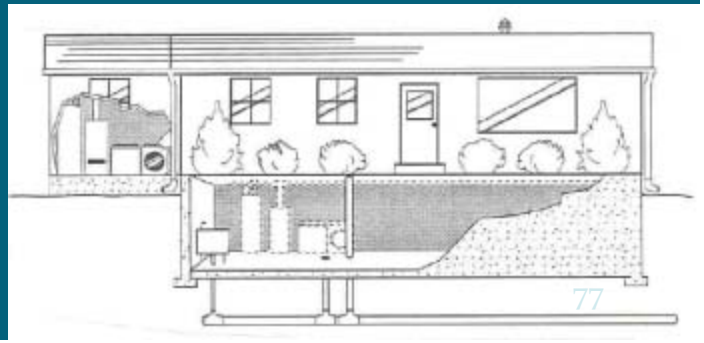
BASIC *Structural Controls, Insurance*

- Structures used to control flooding
  - Levees, floodwalls, seawalls
  - Groins
  - Channel modification
  - Dredging
- Flood Insurance

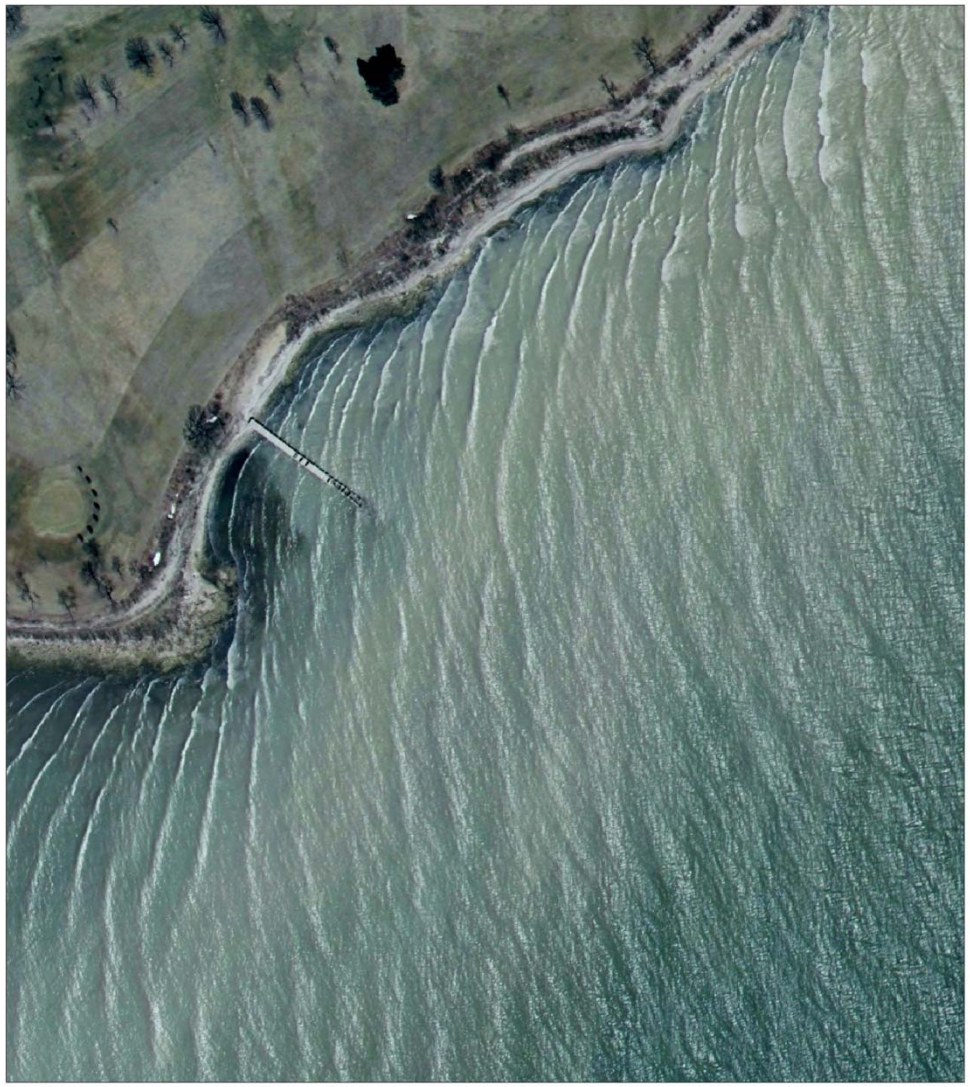
Mitigation

BETTER *Human Adjustment to Flooding*

- Enforcing the rules you *do* have
- Elevating structures
- Building barriers around a structure
- Wet and dry floodproofing



- Non-structural vs. Structural



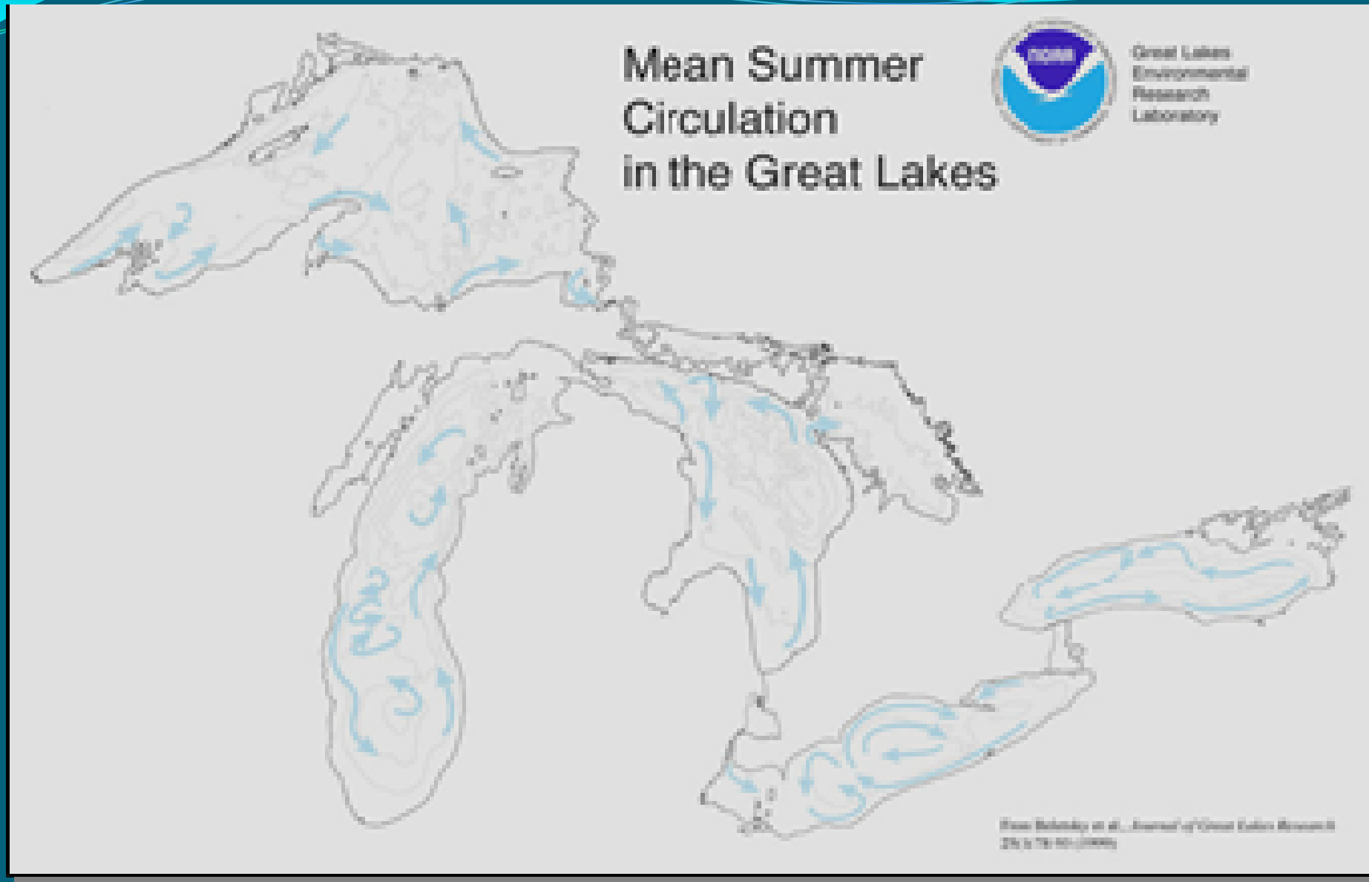


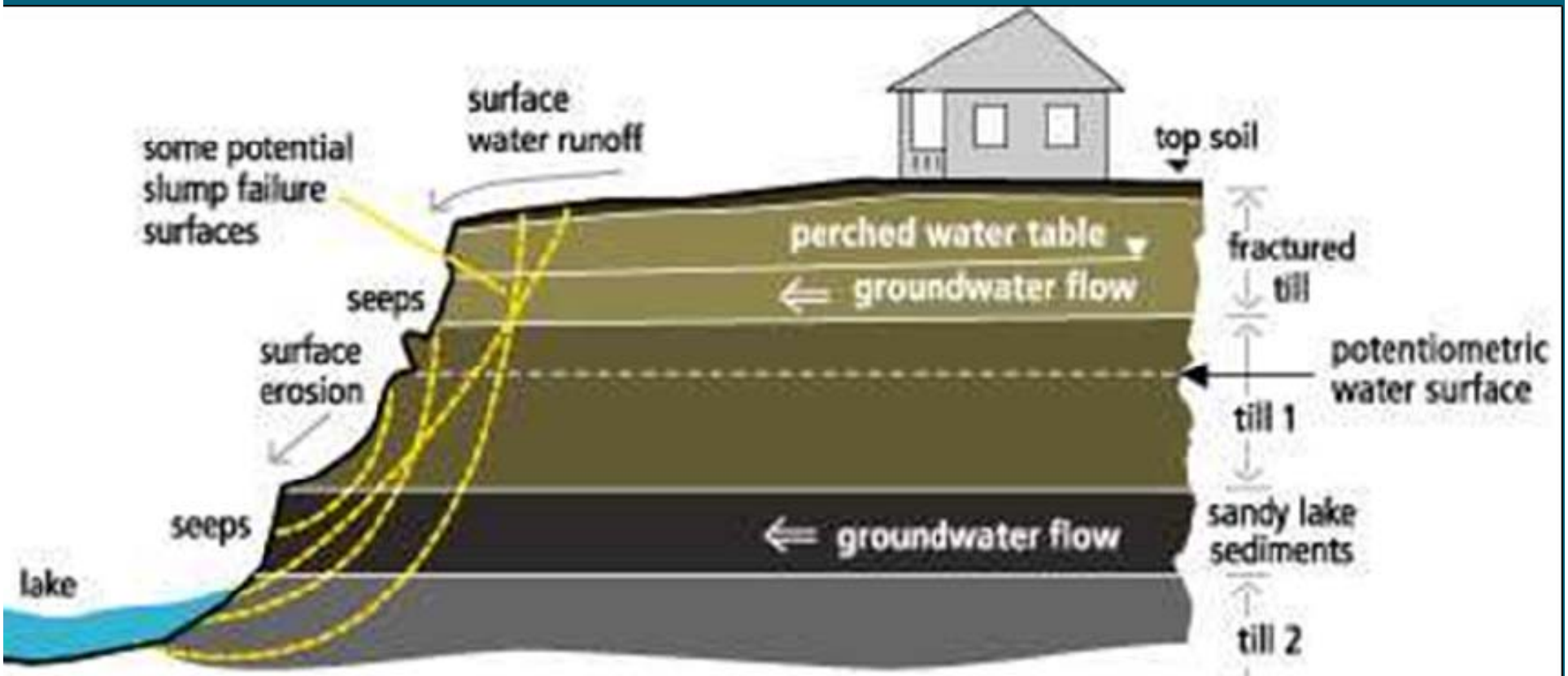
Figure 1 – Circulation Patterns in the Great Lakes


Lake Superior dm
N 46° 47.655' W 091° 23.096'
952 ft
04/18/2007 9:43:56 AM

Mitigation

NAI *Human Adjustment to Flooding*

- Include Ecosystem Services in BCA
- Relocate structures out of the floodplain
- Acquire properties in the floodplain



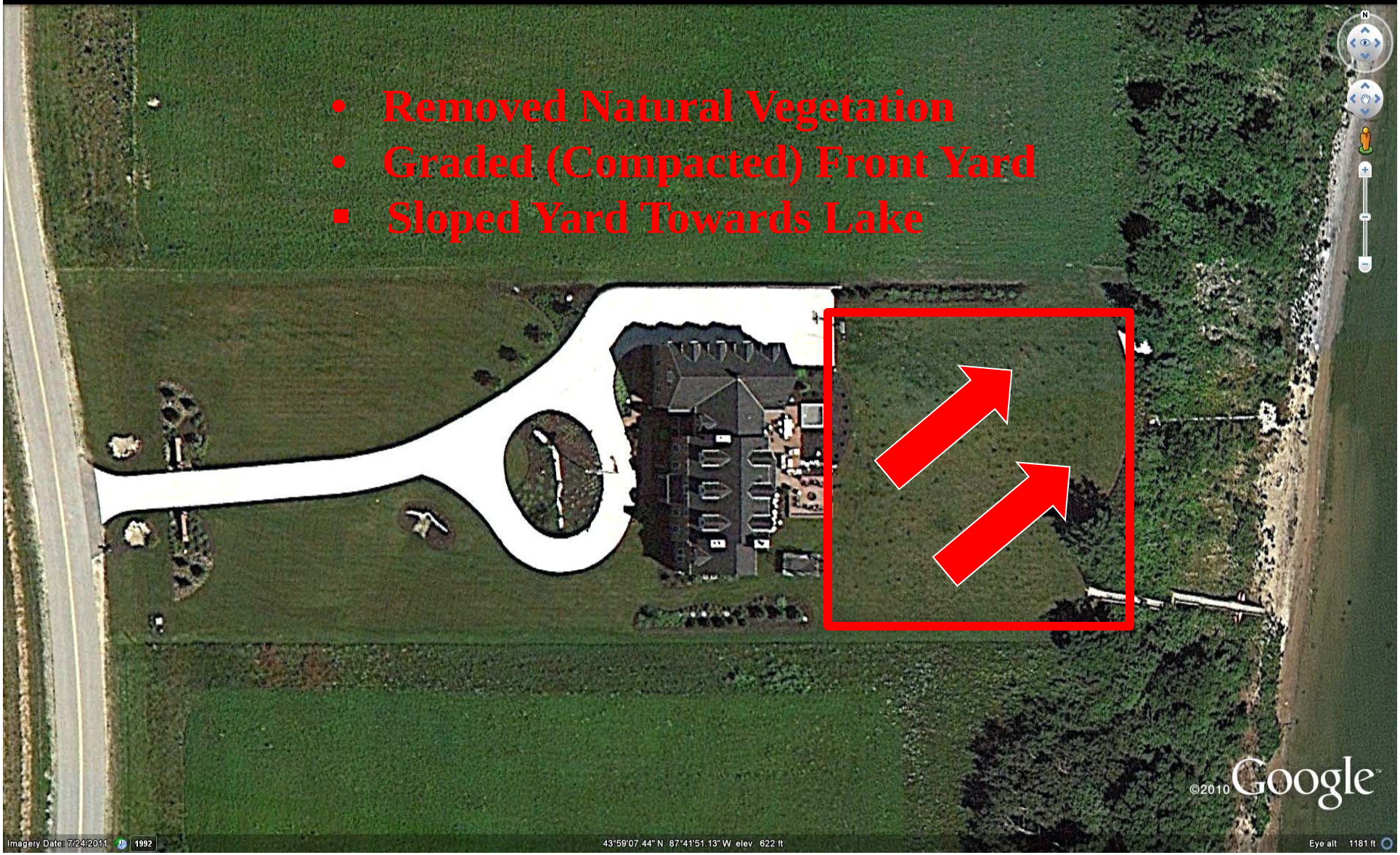
Bluff Problems: Instability & Erosion

Surface Water Runoff Groundwater Seepage

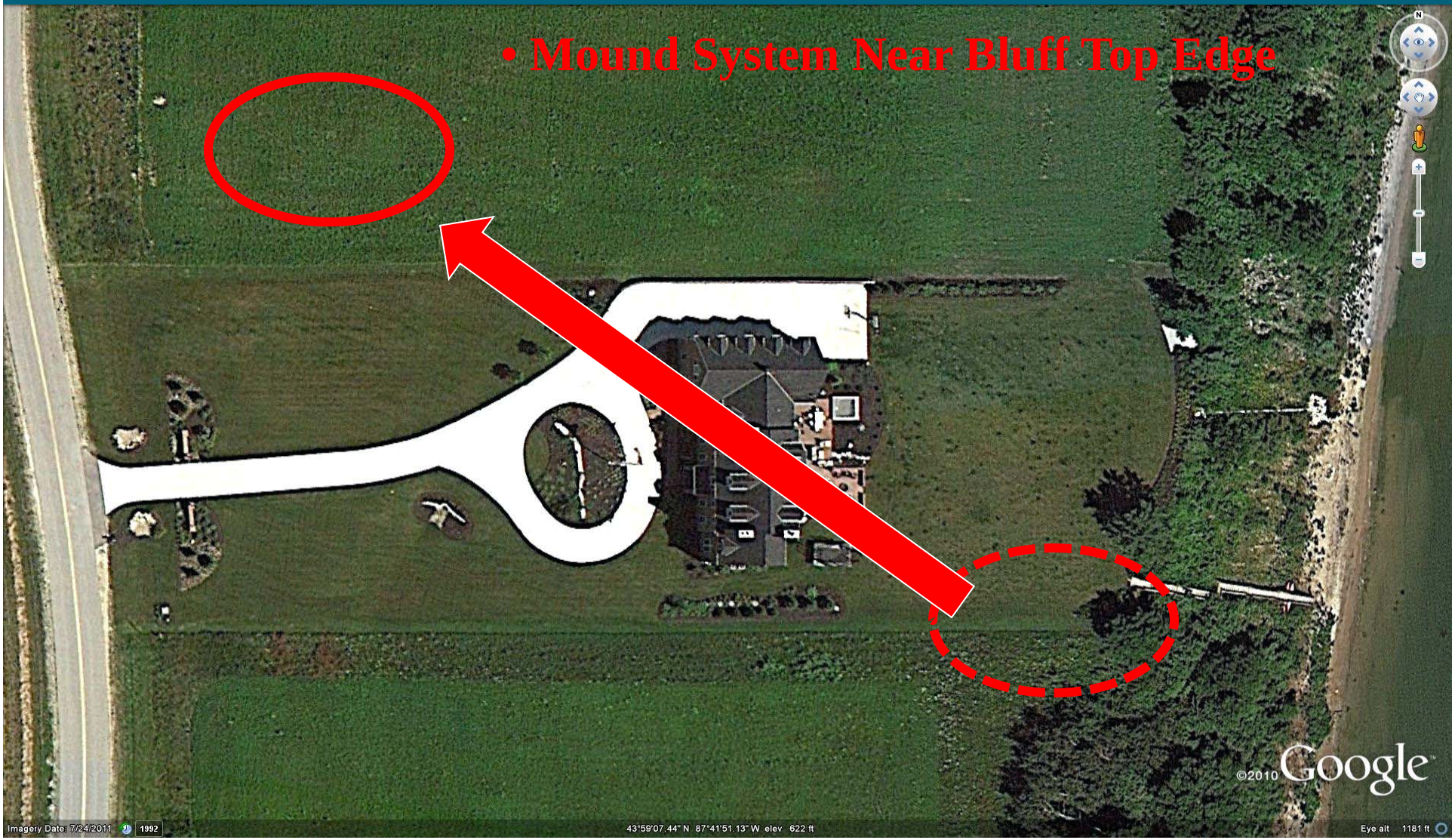
Case Study

Case Study

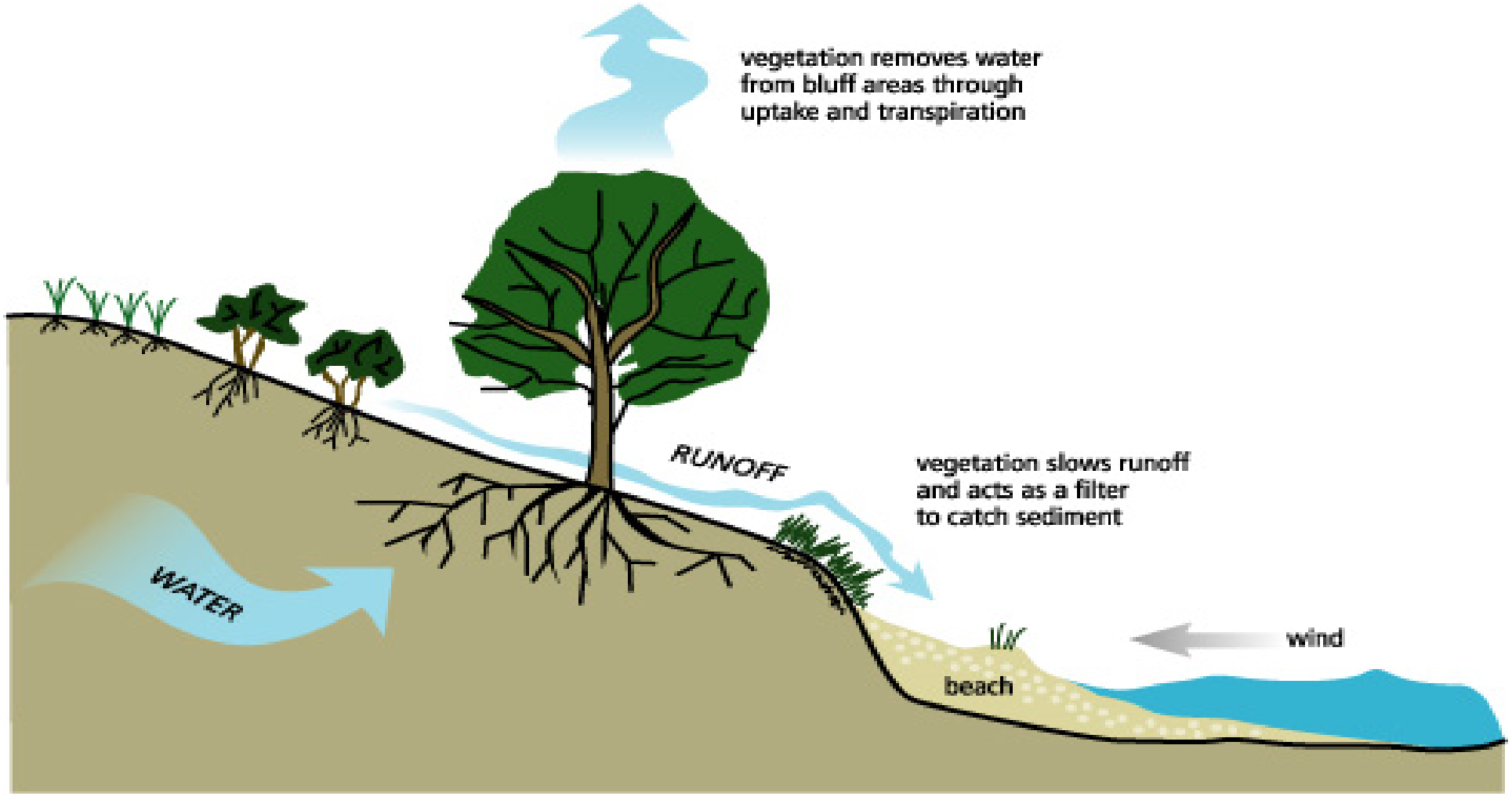
Case Study


• Removed Natural Vegetation
• Graded (Compacted) Front Yard
▪ Sloped Yard Towards Lake
©2010 Google
Imagery Date: 7/24/2011
1992
43°58'07.44" N 87°41'51.13" W elev 622 ft
Eye alt 1181 ft

Case Study


• Mound System Near Bluff Top Edge
©2010 Google
Imagery Date: 7/24/2011
1992
43°58'07.44" N 87°41'51.13" W elev 622 ft
Eye alt 1181 ft

BLUFF STABILITY BMPs
Vegetation Restoration



Revegetated Coastal Slope

- Bluff Stability BMPs
- Courtesy of Gene Clark – WI SeaGrant

BLUFF STABILITY BMPs

Vegetation Restoration – 3 Month Growth

BLUFF STABILITY BMPs

Surface Water Management: Rain Barrels

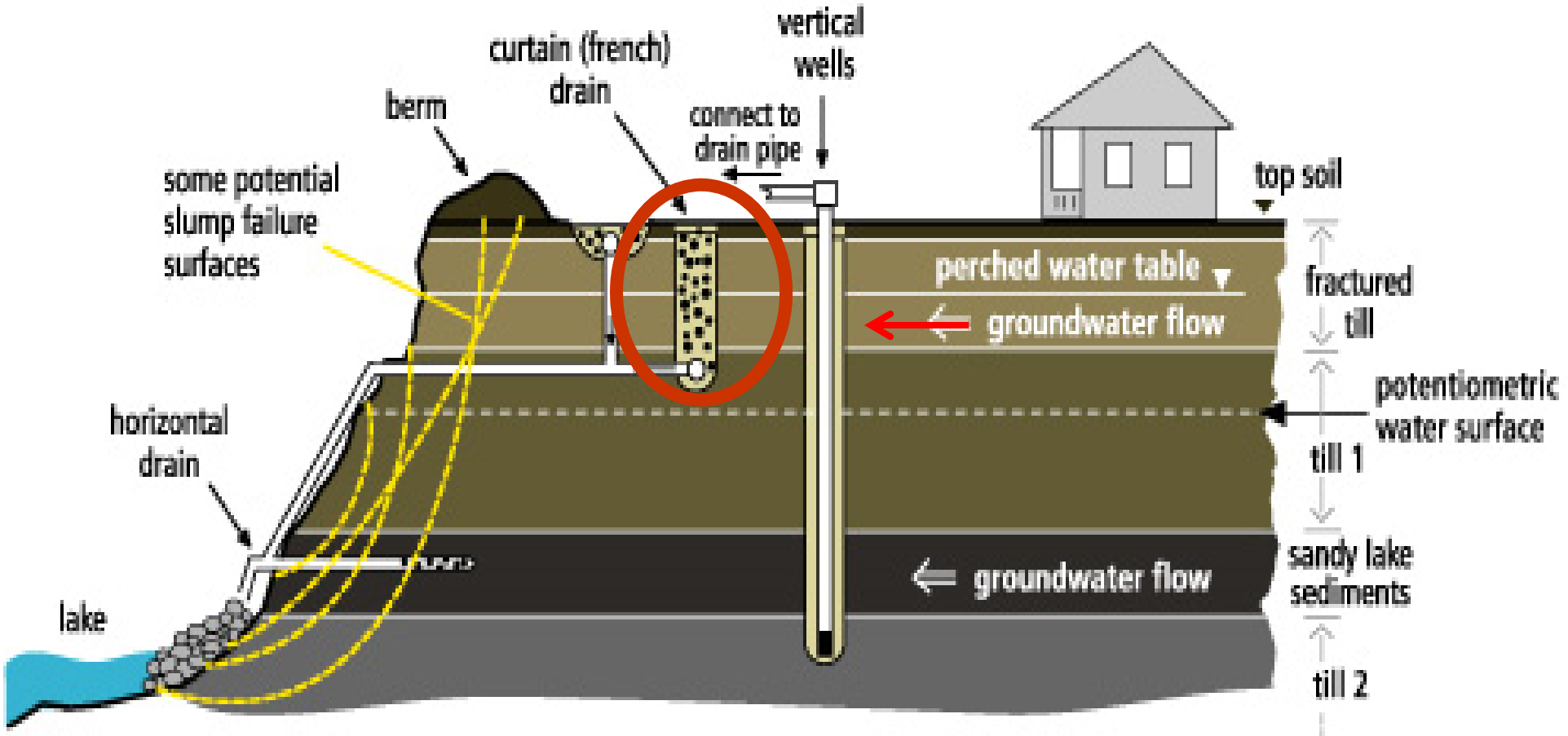
Source: greenculture.com

BLUFF STABILITY BMPs

Surface Water Management: Rain Gardens

BLUFF STABILITY BMPs

Ground Water Management: French Drains



Managing Surface Water and Groundwater

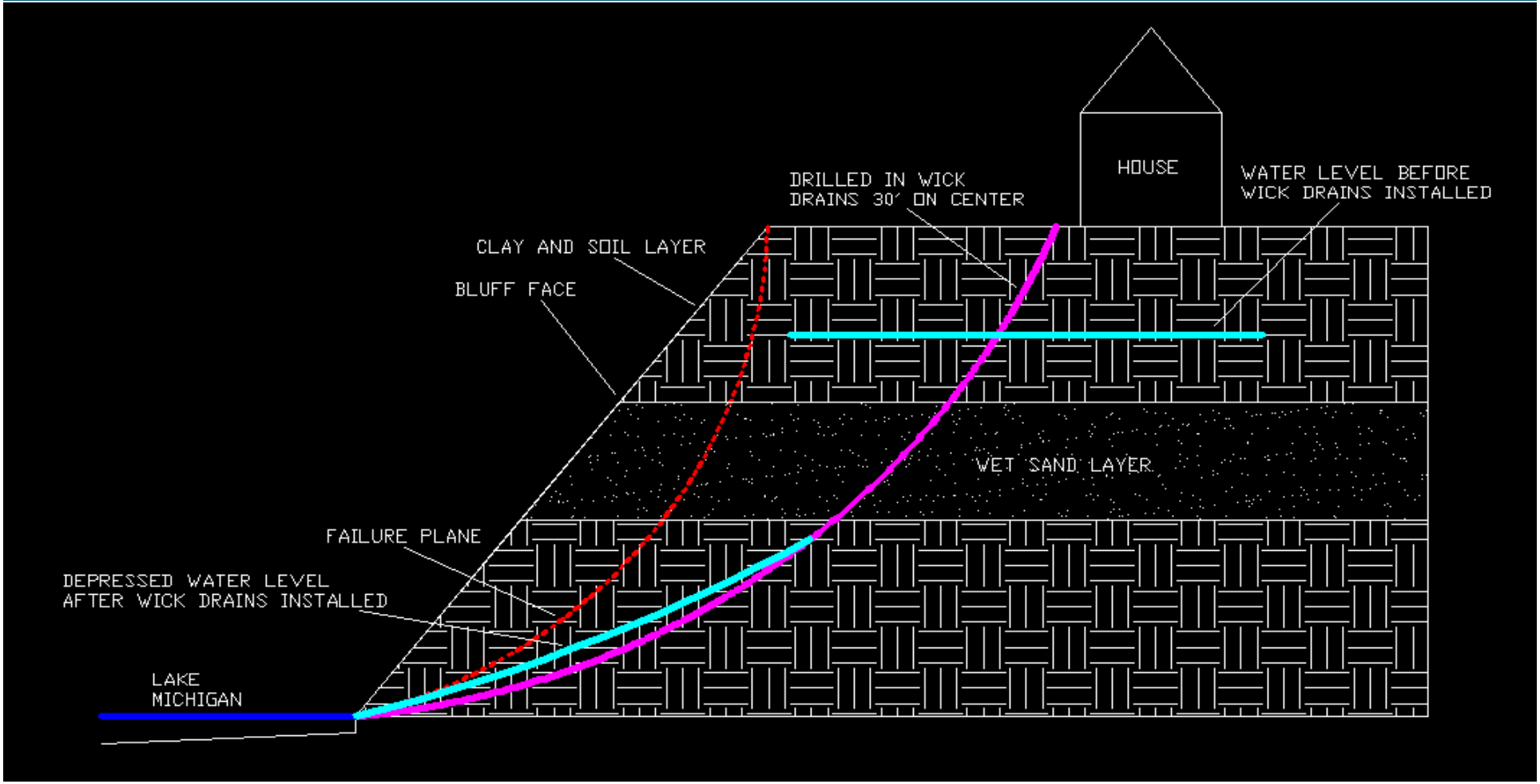
BLUFF STABILITY BMPs

Ground Water Management: French Drains

BLUFF STABILITY BMPs

Ground Water Management: Wick Drains

Source: Edward E. Gillen Co.



BLUFF STABILITY BMPs

Ground Water Management: Wick Drains

Source: Edward E. Gillen Co.

Mitigation

NAI *Master Planning and Monitoring*

- Take a "master plan" approach to flood protection

Involve all levels of services…

- Utilities (water, sewer, power)
- Stormwater
- Streets
- Building services
- Planning
- Parks
- Budget/Finance

Involve the public…

- "Town Hall" meetings
- Workshops with Planning Commission
- Owners of properties affected
- Other interested parties

MITIGATION

How-To Guide for No Adverse Impact

July 2013

Relocation

NAI Strategies

- Hazard Identification
- Planning
- Regulations and Standards
- Mitigation Actions
- Infrastructure
- Emergency Services
- Education and Outreach

Infrastructure

BASIC *Response and Replacement*

- Doing the minimum to maintain the infrastructure and repair it after a flood or other disaster
- Includes roads, bridges, utilities, parks, drainage systems

Infrastructure

BETTER *Protection Measures, Procedures*

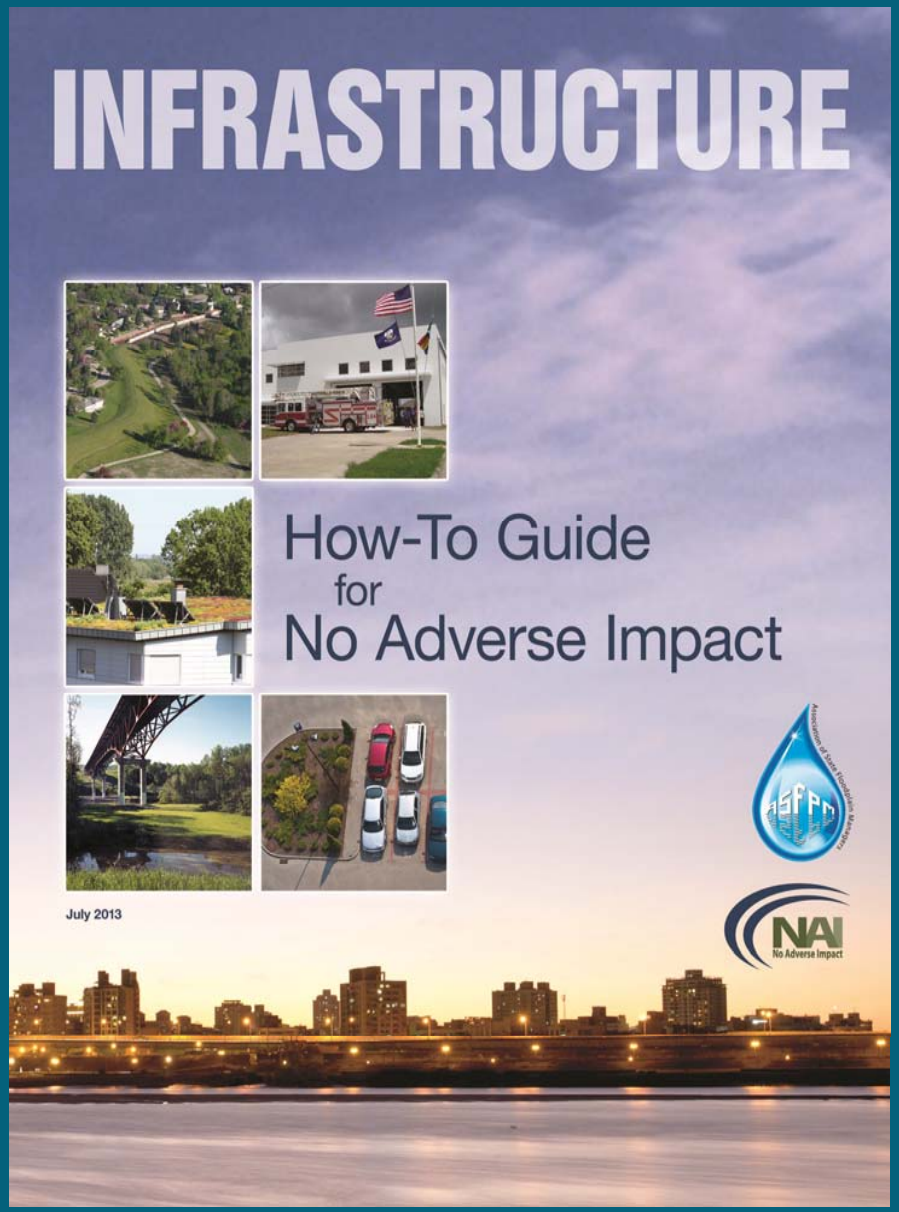
- Routine inspections of bridges, culverts, etc. after a flood event, with resulting corrective measures
- Do a “flood audit” of all public buildings in relation to the floodplain
- Participate in the development of emergency action plans

Infrastructure

NAI *Plans and Alternatives*

- Use a capital improvement plan (CIP) to acquire land for public uses – parks in the floodplain, channels and drainage structures, etc.
- Restrict road development through flood-prone areas (wetlands, marshes, floodplains, etc)
- Create a master greenway plan to link open spaces
- Stream restoration
- Regulate critical facilities out of flood zones

Case Study – County LS



How-To Guide for
No Adverse Impact

INFRASTRUCTURE

July 2013

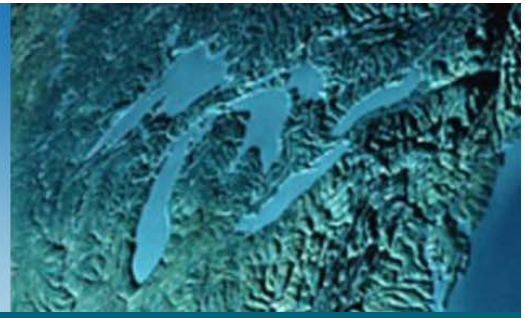
NAI No Adverse Impact

URS


Thank you for your time!
Questions???

Great Lakes Coastal Flood Mapping Program

greatlakescoast.org



Visit *greatlakescoast.org* for more information on the Great Lakes Coastal Flood Study

US ARMY CORP OF ENGINEERS DETROIT DISTRICT

ERDC

FEMA

RiskMAP

Increasing Resilience Together