

# ***UNDERSTANDING COASTAL GEOLOGIC HAZARDS, SEA LEVEL RISE and CLIMATE CHANGE in THE NORTHEASTERN US***

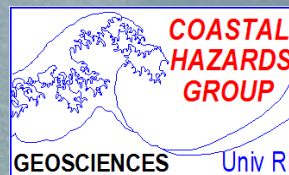
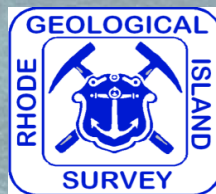
***Congressional Hazards Caucus Briefing – Washington, DC***

***18 November 2009***

**Jon C. Boothroyd**

**Rhode Island Geological Survey**

**Department of Geosciences, University of Rhode Island**



# The Sea Is Rising – But.....

Narragansett Pier, RI Seawall –  
Patriots Day 2007



WPRI.com  
16 apr 2007



An aerial photograph of a coastal city, likely New York City, showing the Hudson River and the city grid. The image is semi-transparent, serving as a background for the text.

# ***When Contemplating Northeastern US Coastal Geologic Hazards***

## **One Must Consider:**

- Extratropical Cyclones (“Nor’easters”)**
- Hurricanes (Tropical Cyclones)**
- and ..... Sea Level Rise**

An aerial photograph of a coastal city, likely New York City, showing the Hudson River and the city grid. The image is used as a background for the text.

# ***When Contemplating Northeastern US Coastal Geologic Hazards***

## **Which Give Rise to these Processes:**

- **Frontal Erosion – from Breaking Waves and Swash**
- **Storm-Surge Overwash**
- **Elevated MHHW into the Future**





# ***When Contemplating Northeastern US Coastal Geologic Hazards***

## **The Scale of Processes are:**

- **Breaking Waves –**  
1 to 3+ meters at shoreline
- **Storm-Surge Overwash –**  
30 cm to 3+ m water depth across shore zone
- **Sea-Level Rise –**  
2.7-3.3 mm/year at present;  
could increase to 1-1.5 cm/yr

# Sediment Transport Pathways Charlestown – Green Hill, RI Barrier and Headland

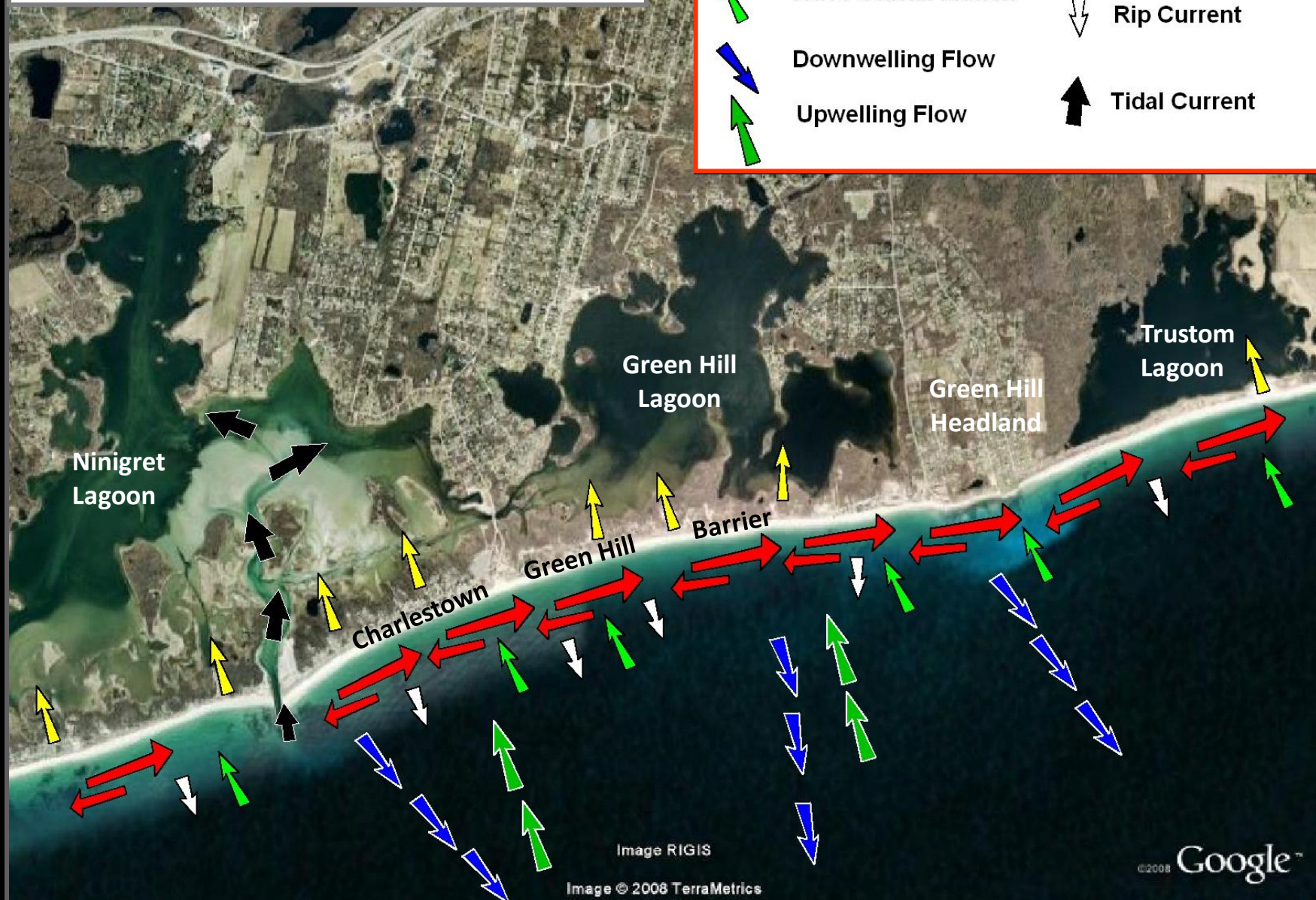
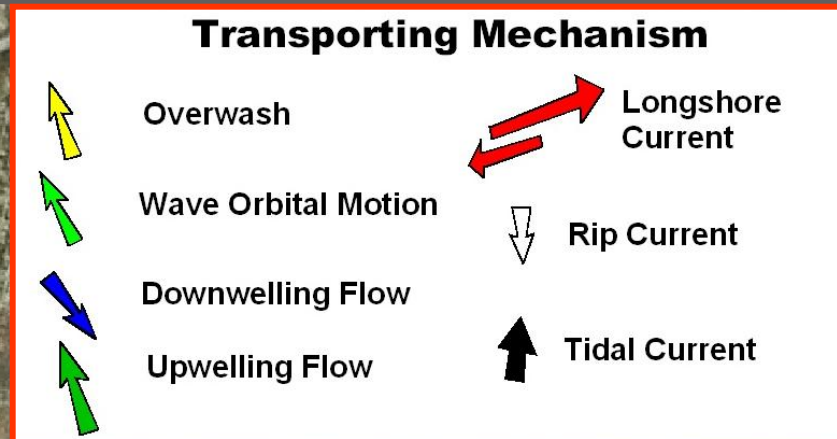


Image RIGIS

Image © 2008 TerraMetrics

©2008 Google™





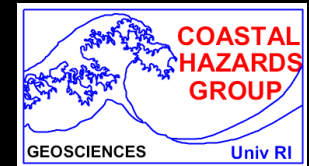
# ***Storms as Modifying Agents in the Coastal Environment***

## **Are Governed By:**

- **Size and Intensity of the Storm**
- **Speed of Storm Passage**
- **Tidal Phase – Spring-Neap, High-Low**
- **Path of Storm with Respect to Orientation of Shoreline**
- **Time Interval between Storms**

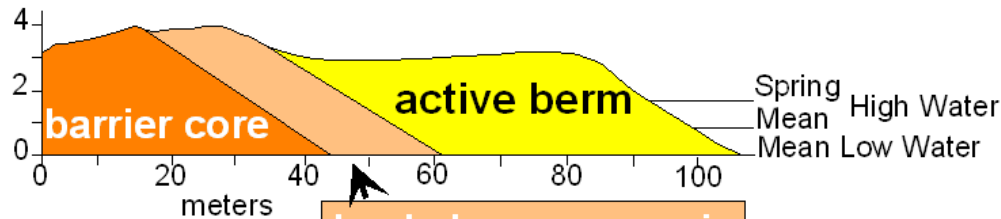
**Hayes and Boothroyd, 1969, 1986**

# Beach Cycles – RI Shore



Boothroyd and Galagan, 1999

## Long-Term Depositional

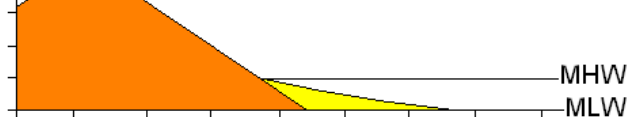


Hrs-10's Hrs

## Moderate Storm

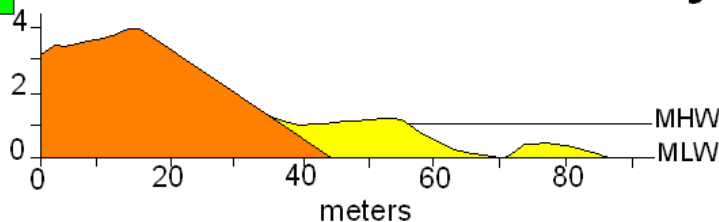


## Severe Storm

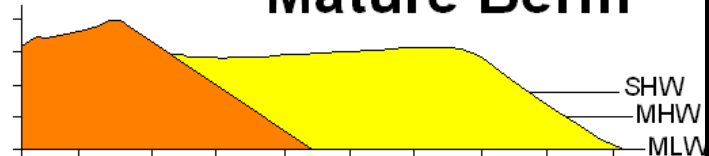


10's Hrs-Days

## Post-Storm Recovery

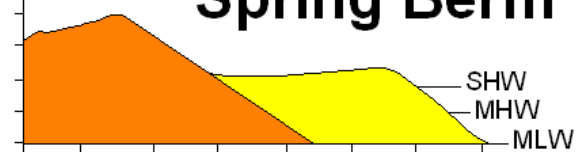


## Mature Berm



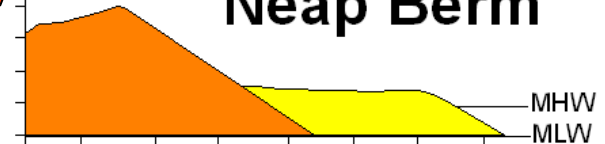
Months

## Spring Berm



2 - 4 Weeks

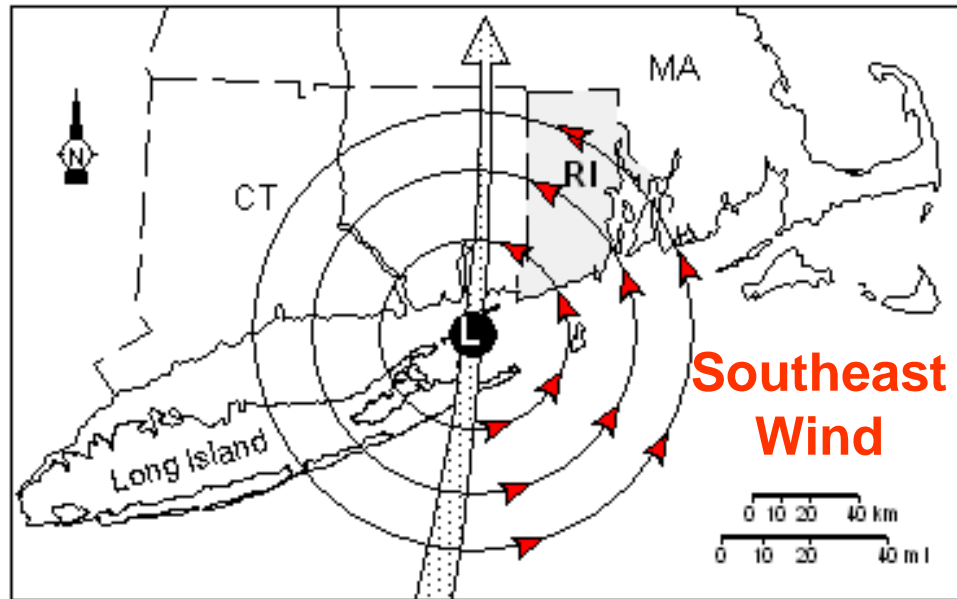
## Neap Berm



4-7 Days



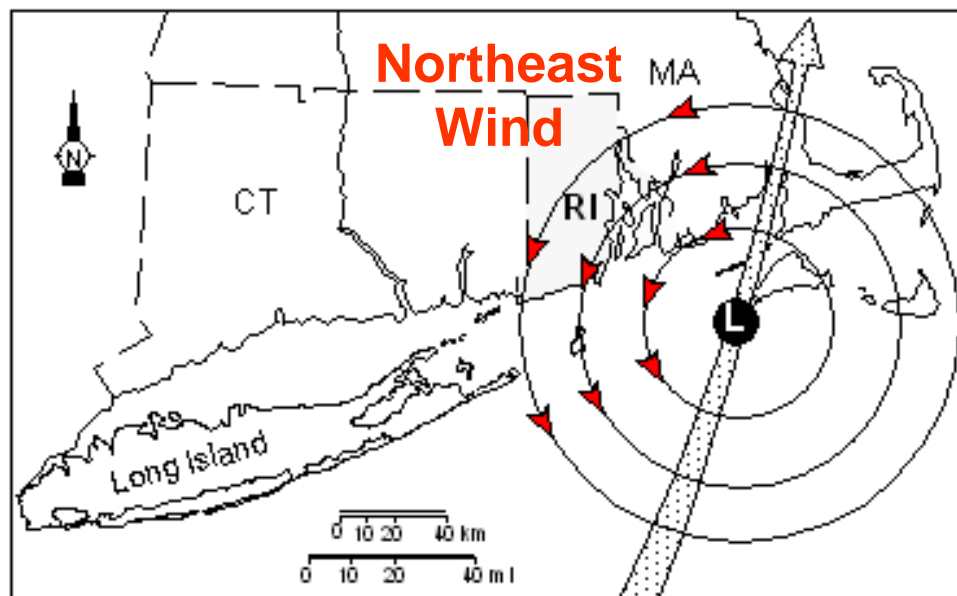
# HURRICANE and EXTRATROPICAL STORM PATHS and ASSOCIATED WIND PATTERNS



## PASSAGE TO THE WEST

- Maximum Onshore Wind
- Severe Storm-Surge Flooding

**Sou'easters**



## PASSAGE TO THE EAST

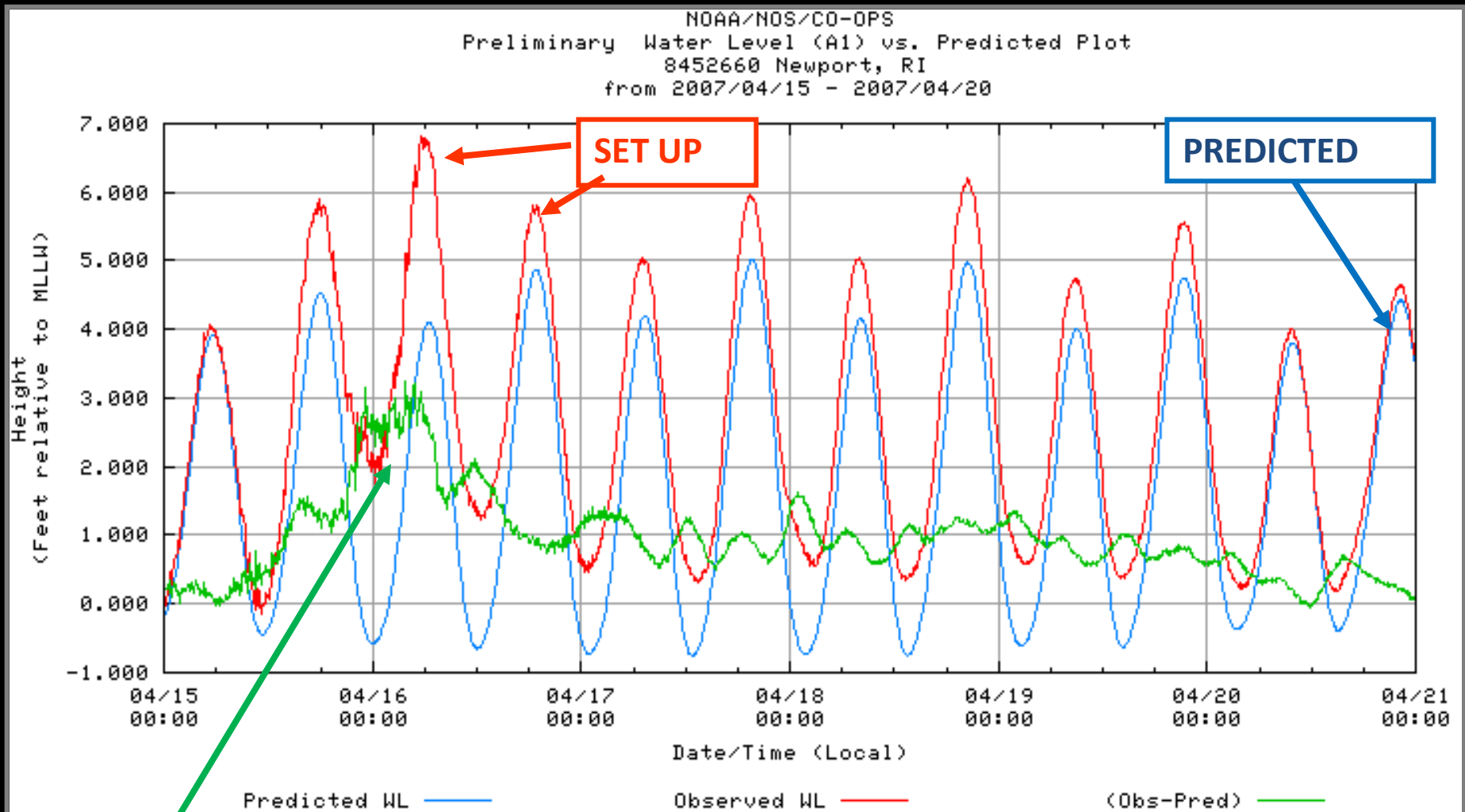
- Offshore Wind
- Minimum Storm-Surge Flooding

**Nor'easters**

From Wright and Sullivan, 1982

# Patriots Day Extratropical Storm – April 2007

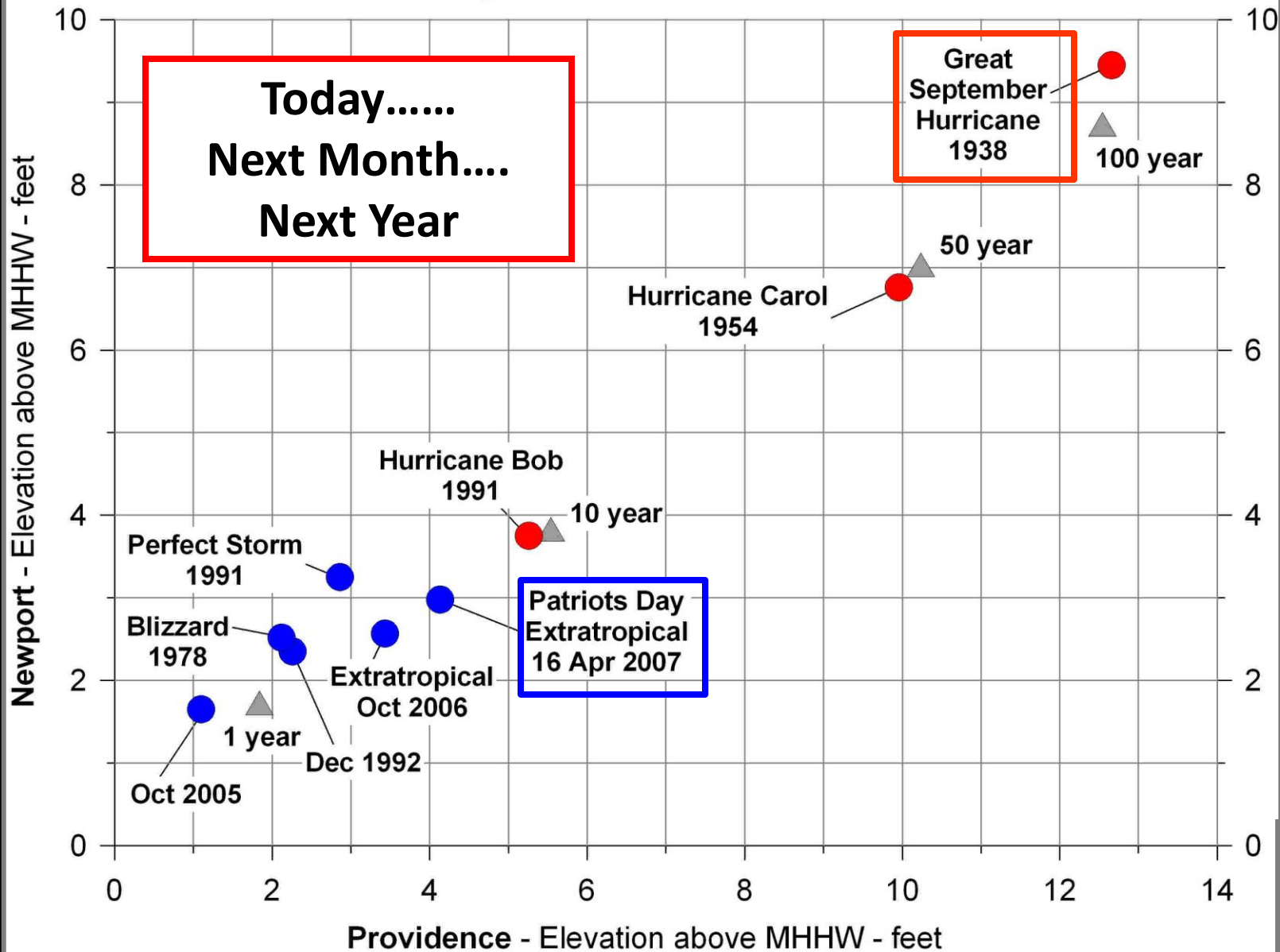
## Newport, RI Tide Gauge



[http://tidesandcurrents.noaa.gov/  
data\\_menu.shtml?stn=8452660%20Newport,%20RI&type=Tide+Data](http://tidesandcurrents.noaa.gov/data_menu.shtml?stn=8452660%20Newport,%20RI&type=Tide+Data)

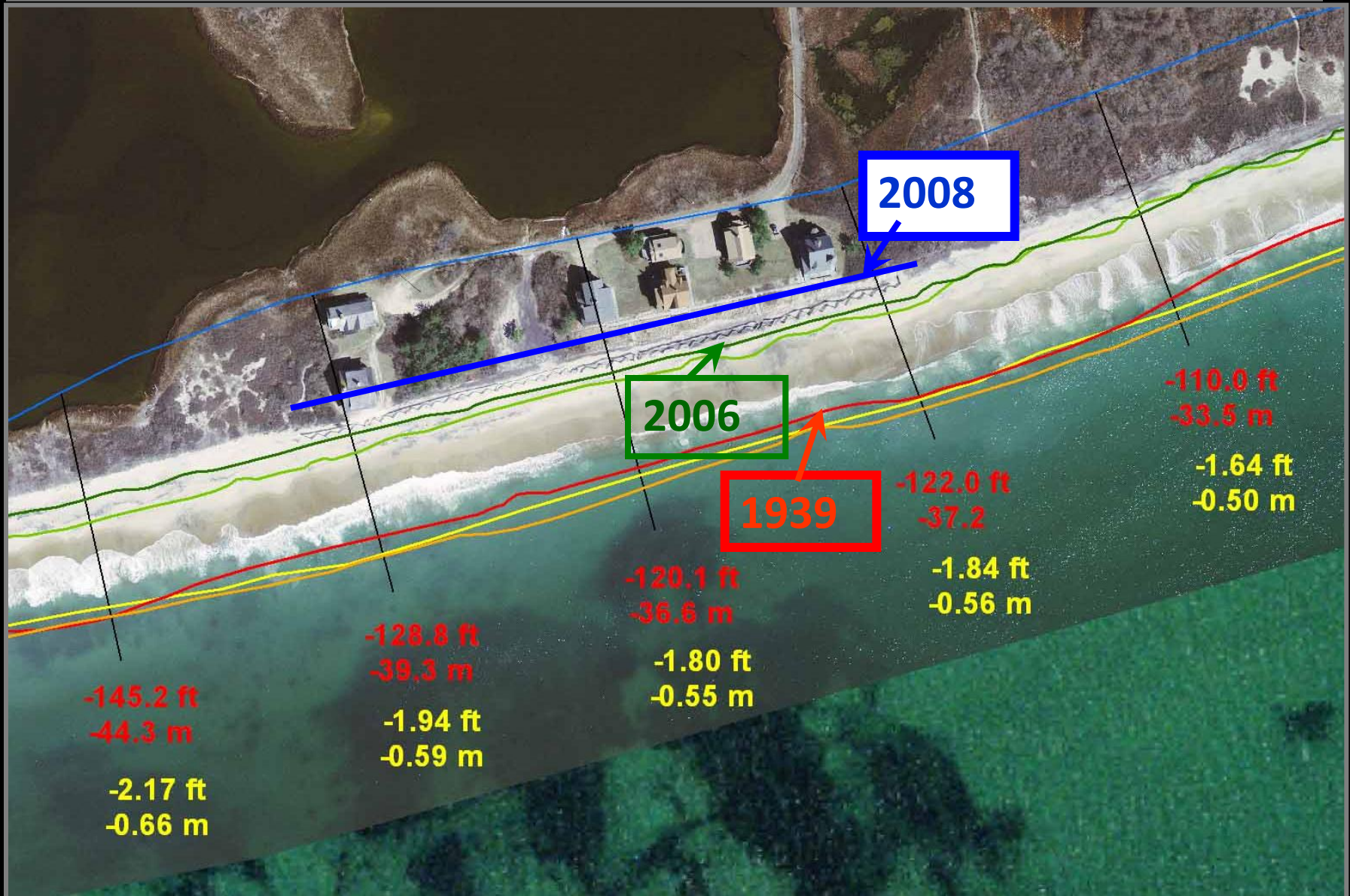


# STORM-SURGE ELEVATION Newport - Providence, RI



Adapted from  
NOAA; USACE  
1988; Hehre  
2007

# Frontal Erosion 1939-2008 - Browning Cottages, Moonstone Barrier, RI





# Frontal Erosion - Browning Cottages, Moonstone Barrier, RI - 1972

Senator John Chafee Family  
Summer Home





# Frontal Erosion - Browning Cottages, Moonstone Barrier, RI – March 2002



3/5/2002

BA Oakley



# Frontal Erosion - Browning Cottages, Moonstone Barrier, RI – Dec 2002



14 12 2002

BA Oakley



# Frontal Erosion - Browning Cottages, Moonstone Barrier, RI - 2007



BA Oakley

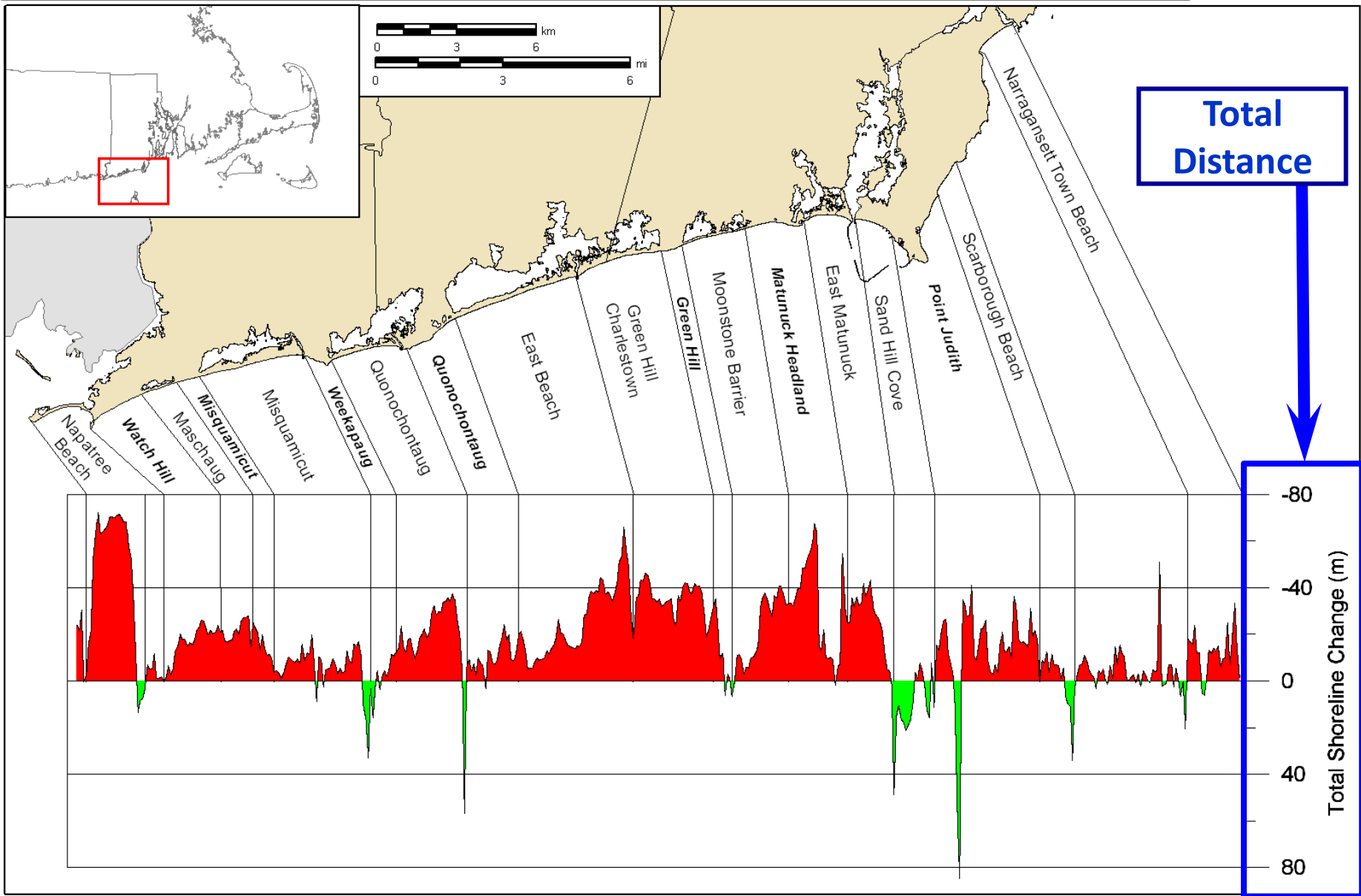
FEB 20 2007



# Frontal Erosion - Browning Cottages, Moonstone Barrier, RI - 2007



# Total Shoreline Change – Southern RI 1939-2004





# Charlestown Beach, RI – Overwash Processes



11 Dec 1992

# Charlestown Barrier, RI – Hurricane Bob 1991 Washover Fans



**Removal is a Bad Idea**

**Aug 1991**

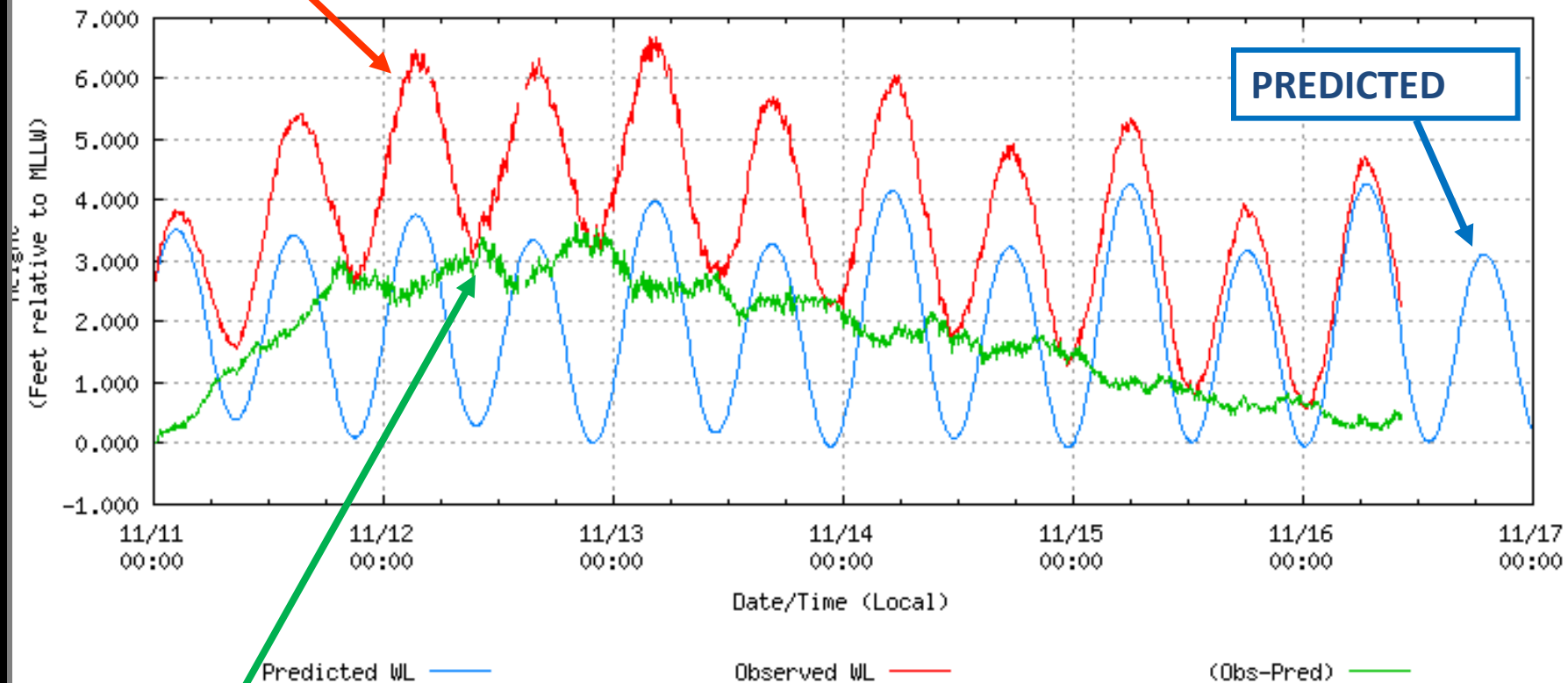


# November 2009 Extratropical Storm Duck, NC Tide Gauge

**SET UP**

NOAA/NOS/CO-OPS  
Preliminary Water Level (A1) vs. Predicted Plot  
8651370 Duck, NC  
from 2009/11/11 - 2009/11/16

**PREDICTED**



**STORM SURGE**

[http://tidesandcurrents.noaa.gov/  
data\\_menu.shtml?stn=8651370%20Duck,%20NC&type=Tide+Data](http://tidesandcurrents.noaa.gov/data_menu.shtml?stn=8651370%20Duck,%20NC&type=Tide+Data)



# Kitty Hawk, NC – Overwash - Nov 2009



NOV 12 2009

# South Nags Head, NC – Overwash - Nov 2009

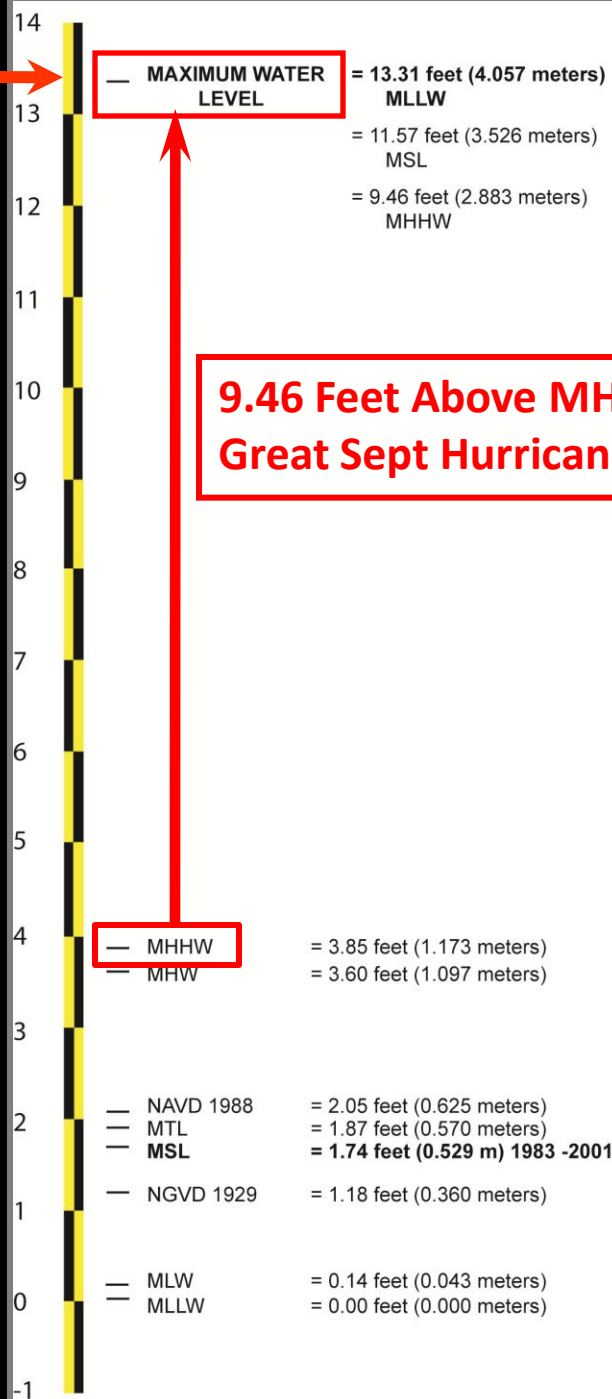


**The Problem of  
Built Infrastructure**

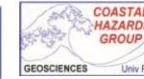
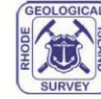
NOV 13 2009

How High  
will the  
Water Be?

Tidal  
Heights  
Newport, RI



NEWPORT  
TIDE  
GAUGE



Boothroyd and  
Hehre 2008

9.46 Feet Above MHHW  
Great Sept Hurricane 1938



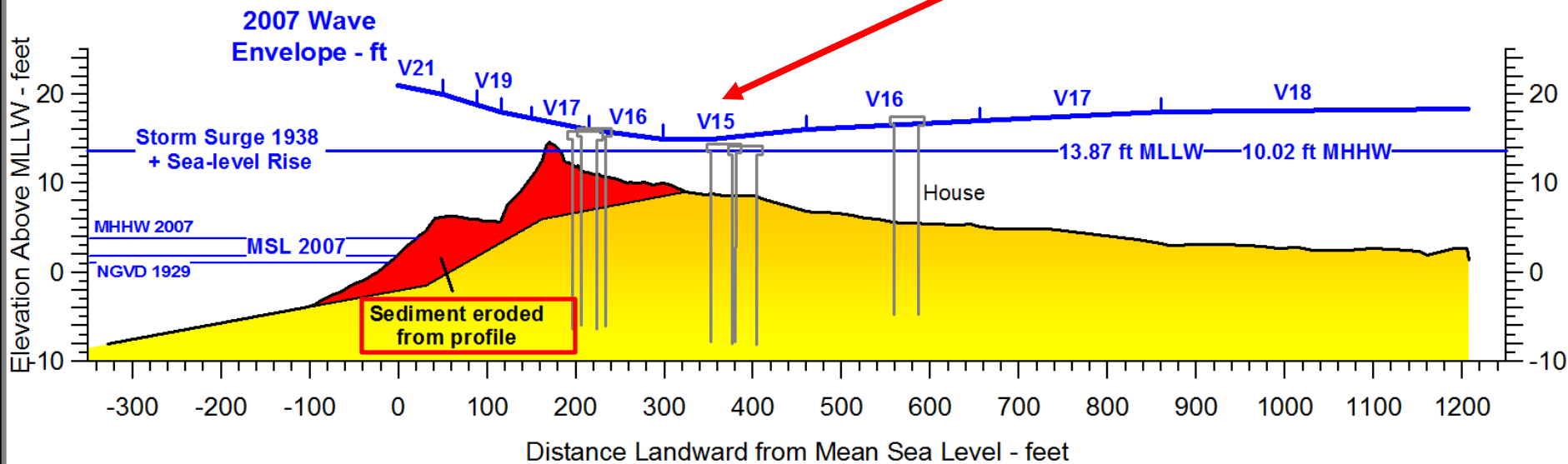
# Erosion Configuration – Charlestown Barrier, RI

## WAVE ENVELOPE and STORM SURGE for 100 YEAR EVENT

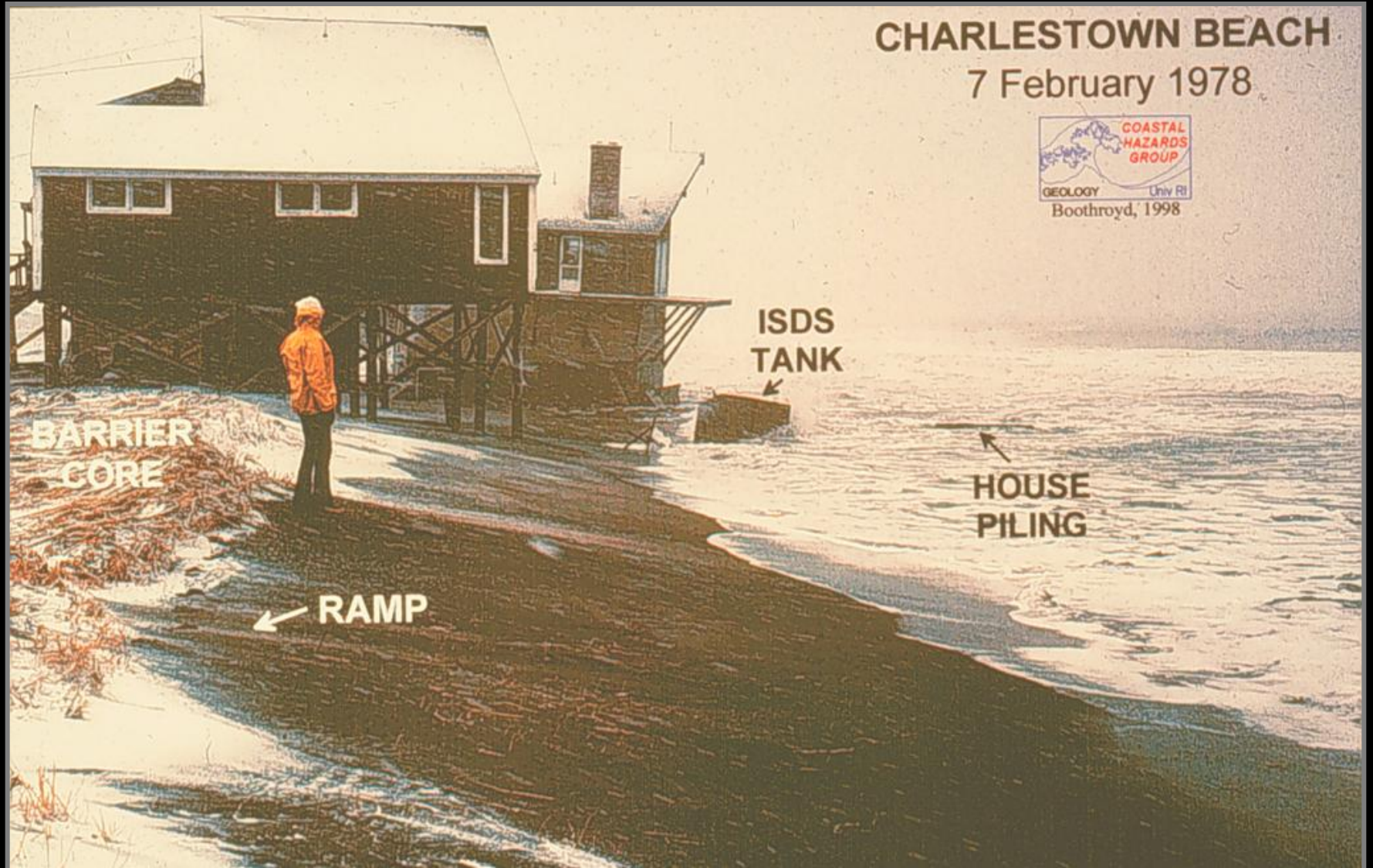
Charlestown Beach - CHA-EZ

Jon C Boothroyd, Bryan A Oakley, GEO 577 Class - 2007

**Sediment Eroded  
from Profile**



# Charlestown Beach, RI – Blizzard 1978 – Erosion Configuration – No Berm





# Charlestown Barrier, RI – 100 Year Storm Surge

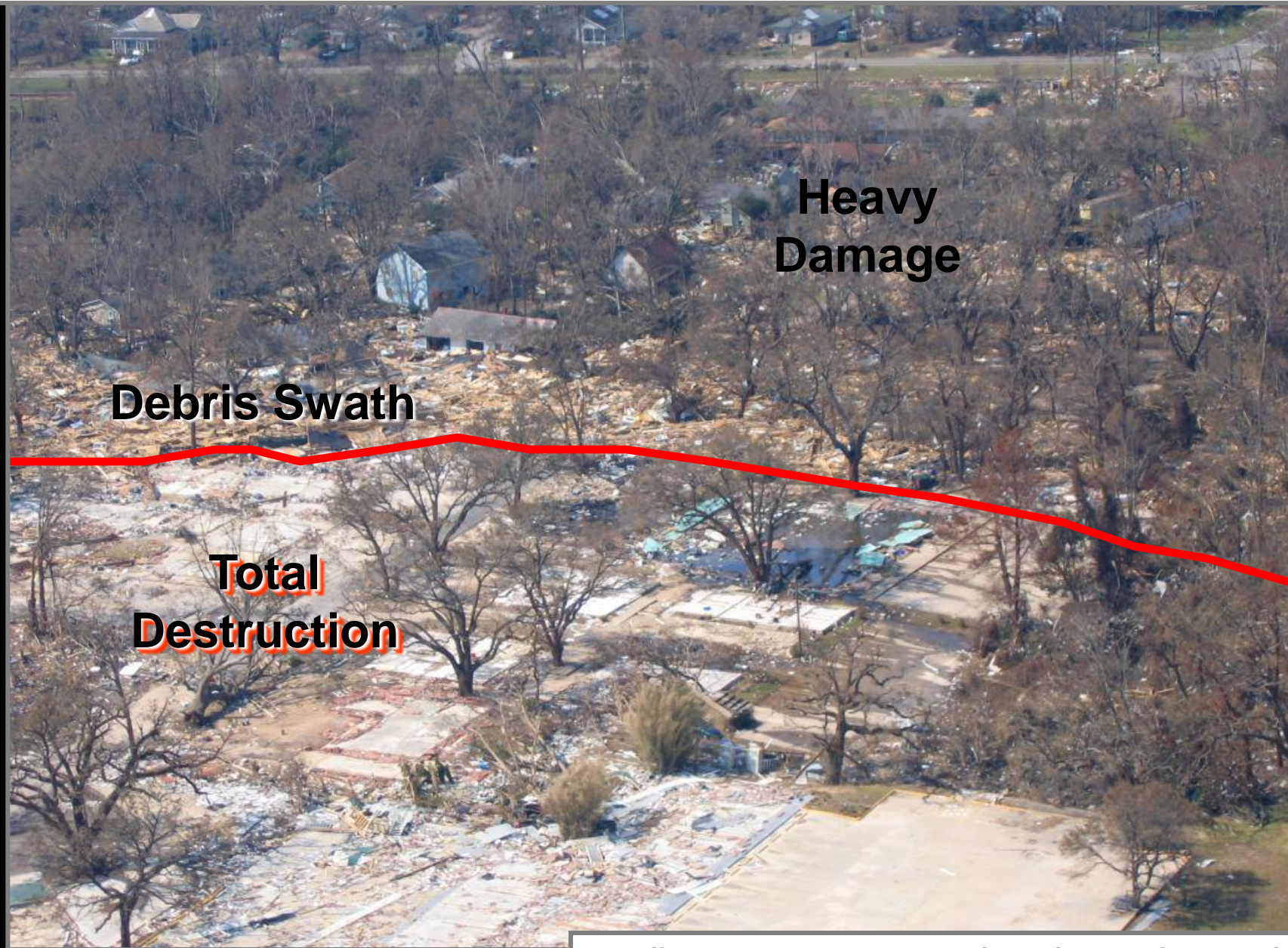


**100 year Storm Surge plus Waves**

04/17/2007 15:15



# Gulfport, MS – Katrina - 2 Sept 2005 – Debris Swaths



**Heavy  
Damage**

**Debris Swath**

**Total  
Destruction**

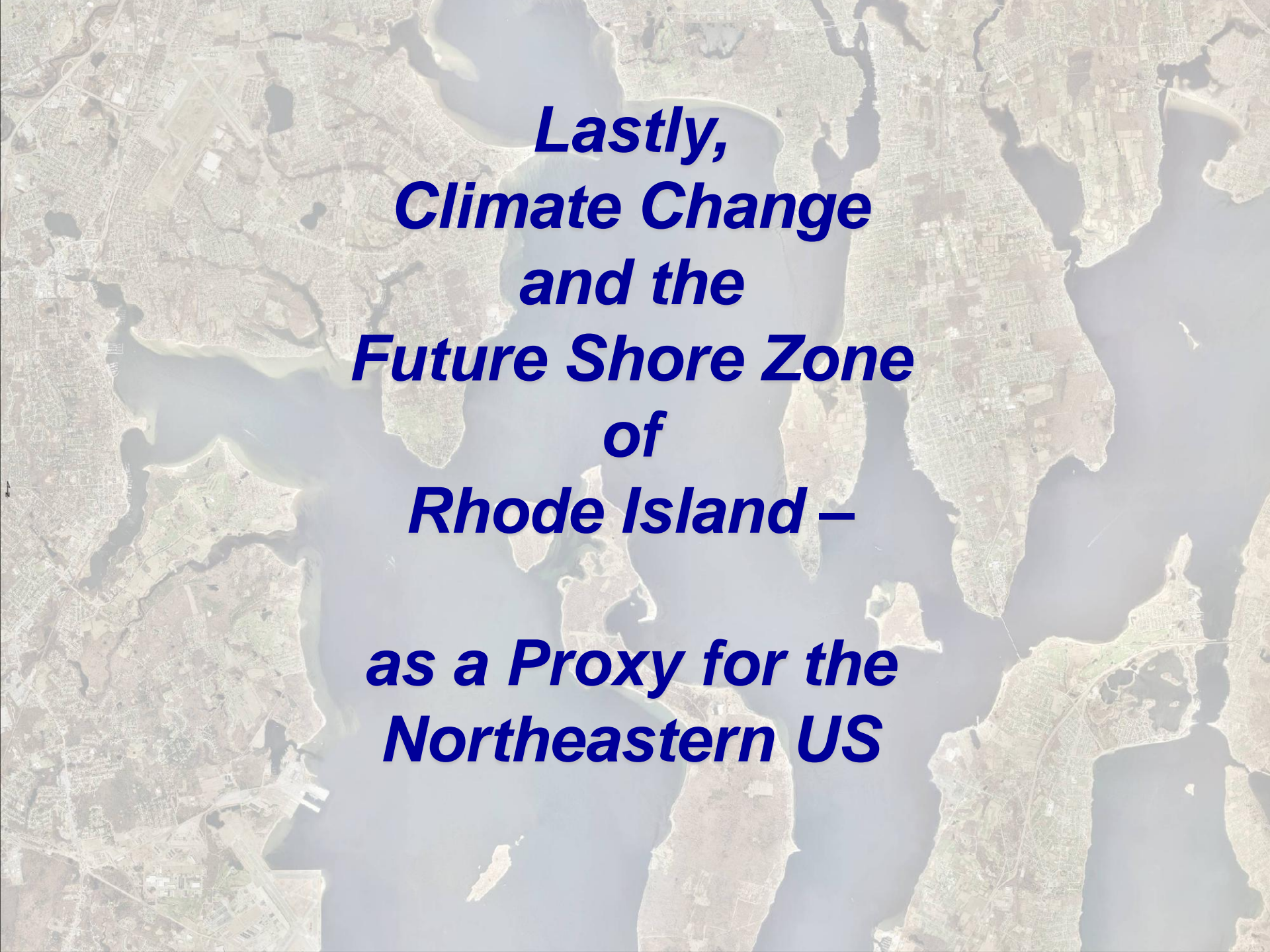


# Misquamicut Barrier – Westerly, RI Upland Debris Swath – Great Sept Hurricane 1938



**Increased Storm Frequency and Intensity??**



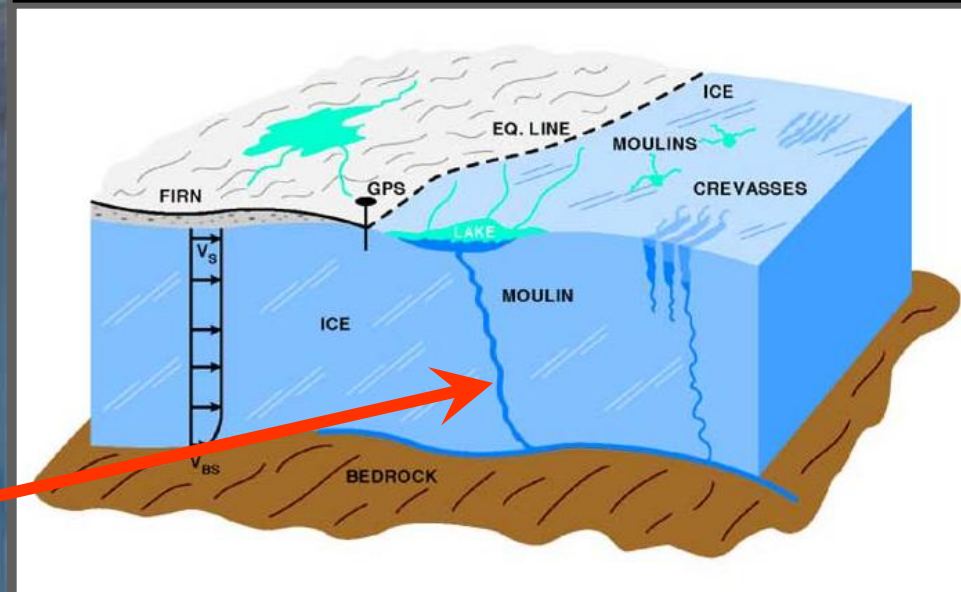
An aerial photograph of Rhode Island, showing its coastline, major cities like Providence and Pawtucket, and surrounding water bodies. A semi-transparent blue rectangular area is overlaid on the center of the image, containing the text.

***Lastly,  
Climate Change  
and the  
Future Shore Zone  
of  
Rhode Island –  
as a Proxy for the  
Northeastern US***

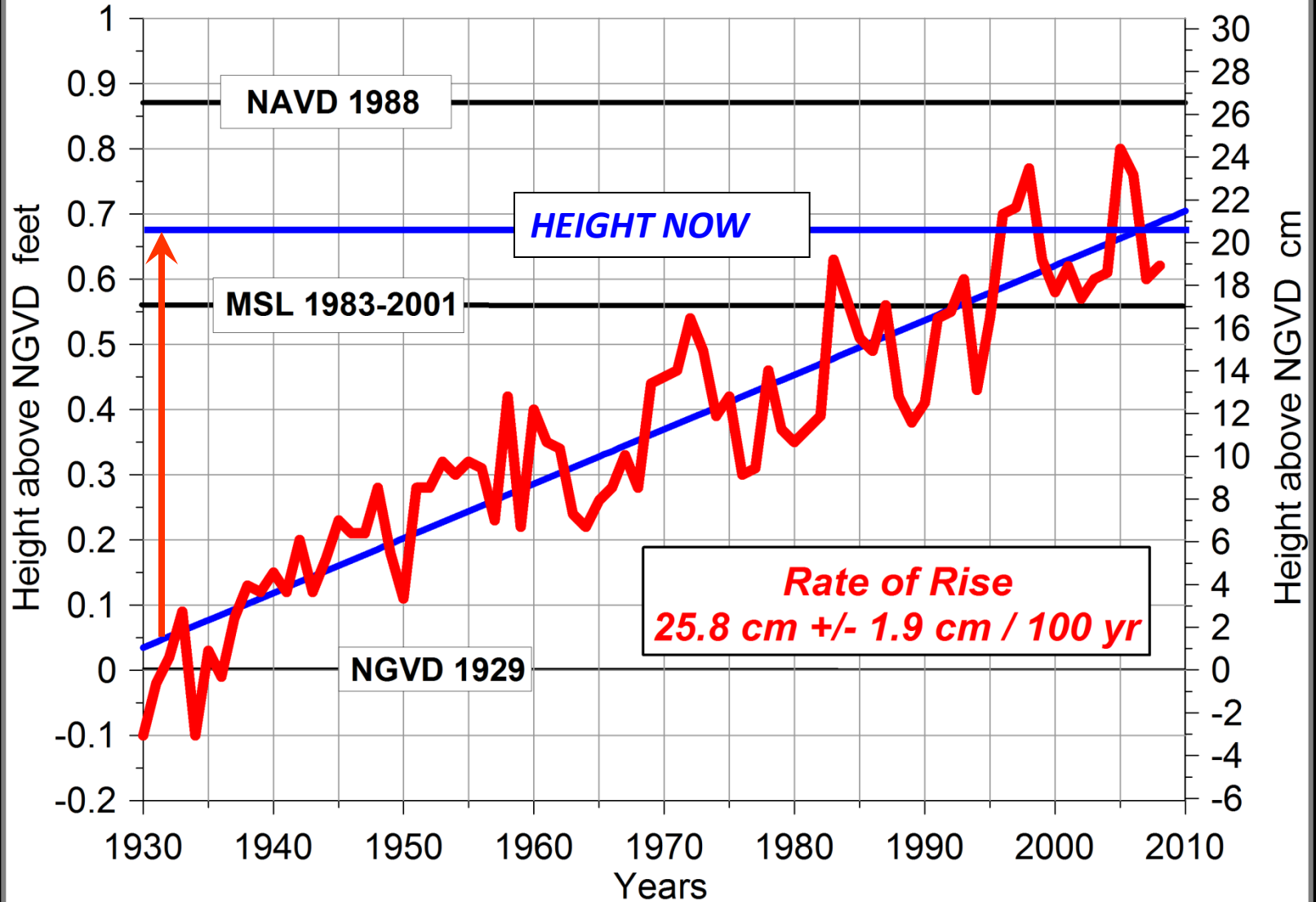


# Greenland Outlet Glaciers - Change from Polythermal to Warm Based

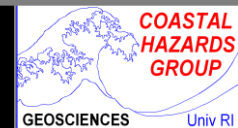
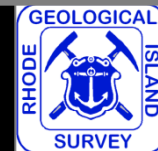
## A Key to Future Sea-Level Rise



# HISTORIC SEA-LEVEL RISE - Newport, RI

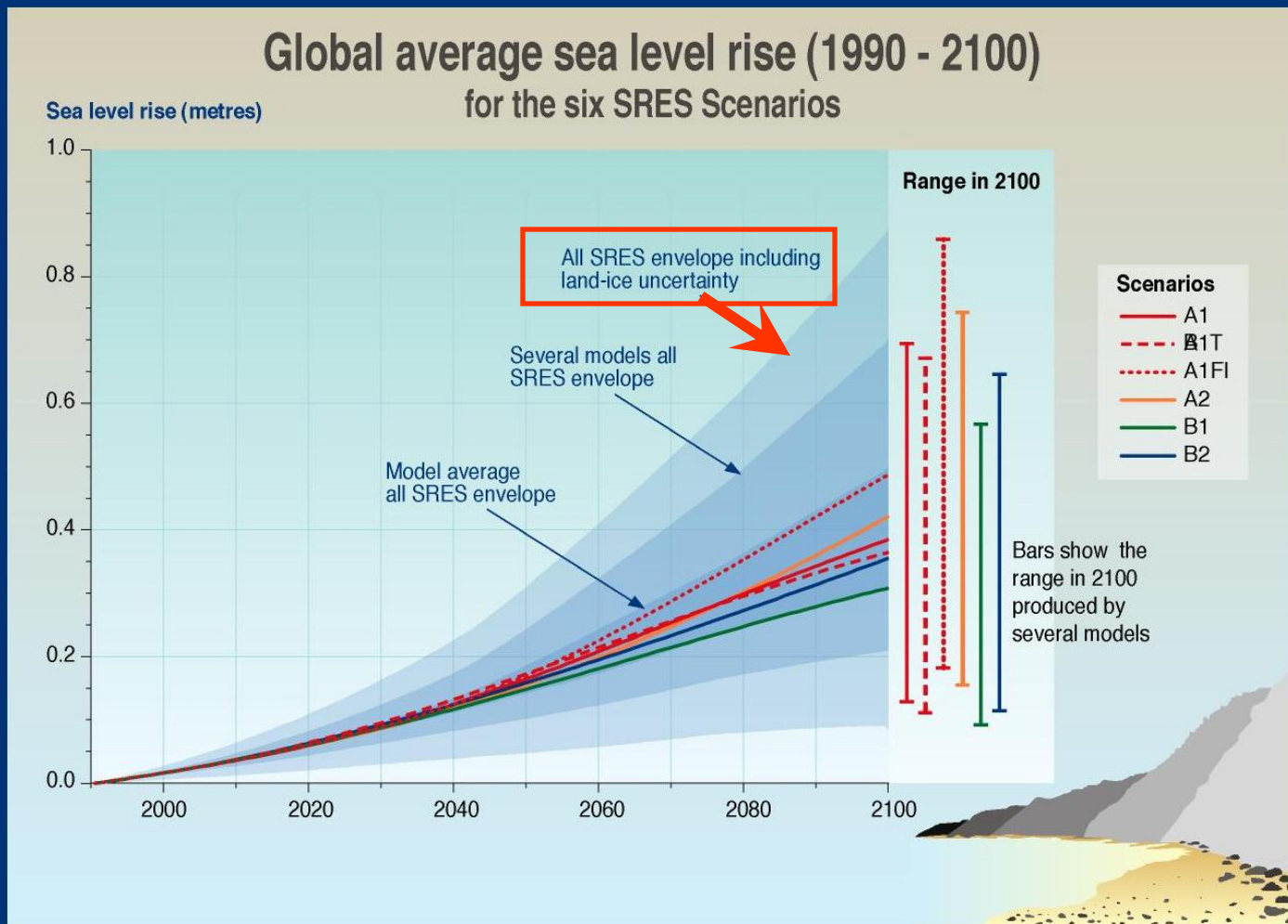


Adapted from: [http://tidesandcurrents.noaa.gov/sltrends/sltrends\\_station.shtml?stnid=8452660%20Newport,%20RI](http://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?stnid=8452660%20Newport,%20RI)



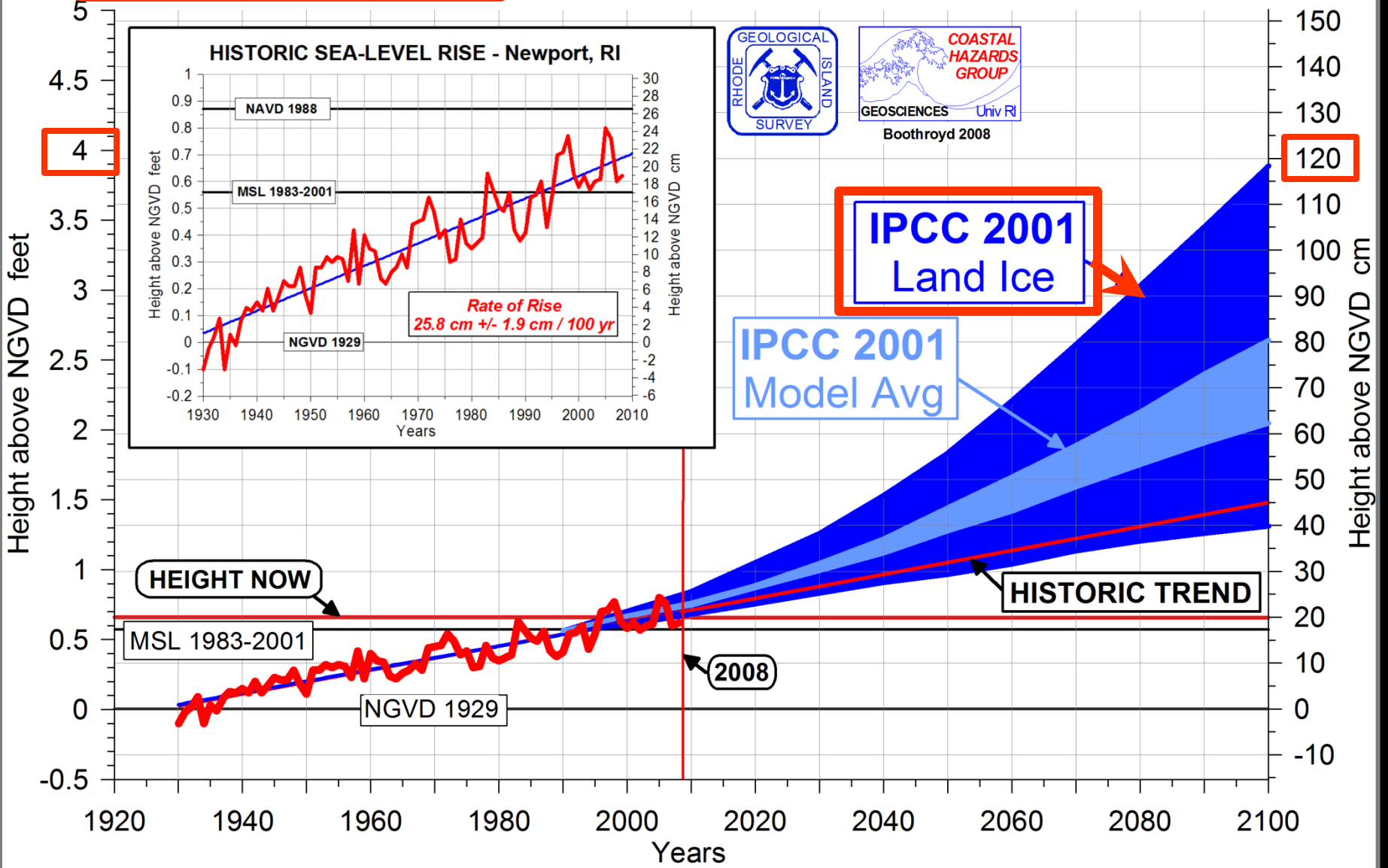
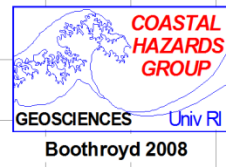
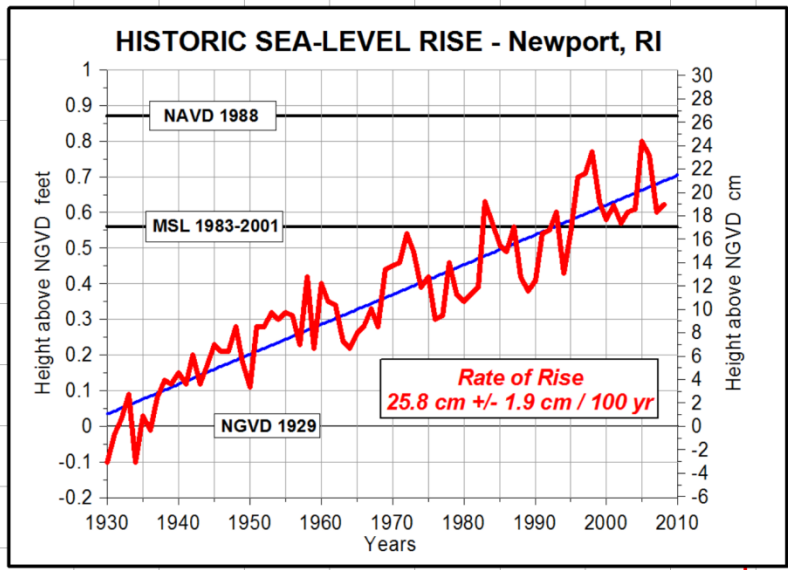


# IPCC Scenarios 2001



WG1 TS FIGURE 24

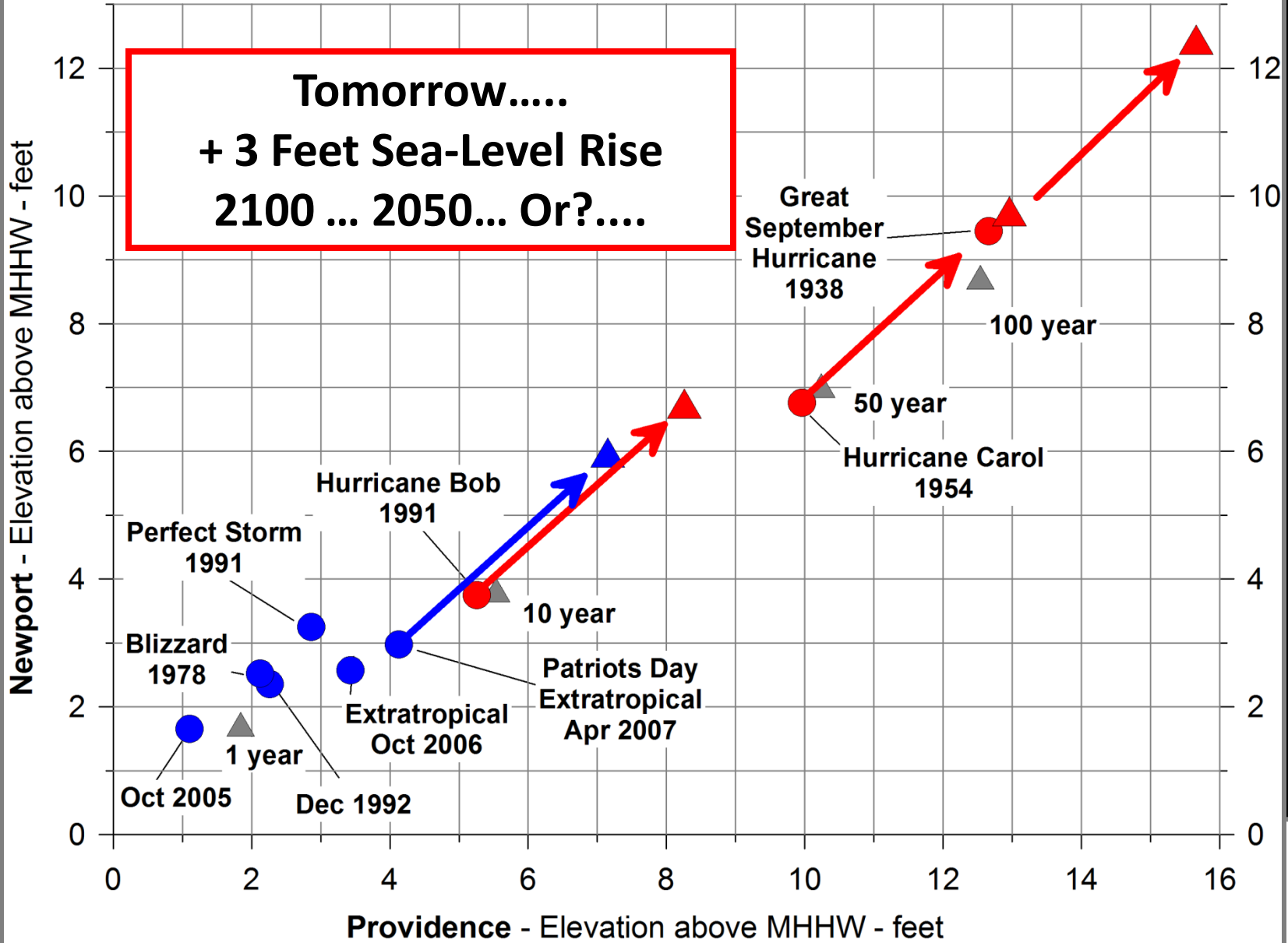
# ACCELERATED SEA-LEVEL RISE - Newport, RI





# PROJECTED STORM-SURGE ELEVATIONS

## Newport - Providence, RI



Adapted from  
NOAA; USACE  
1988; Hehre  
2007

# Ninigret Lagoon, RI - 2004



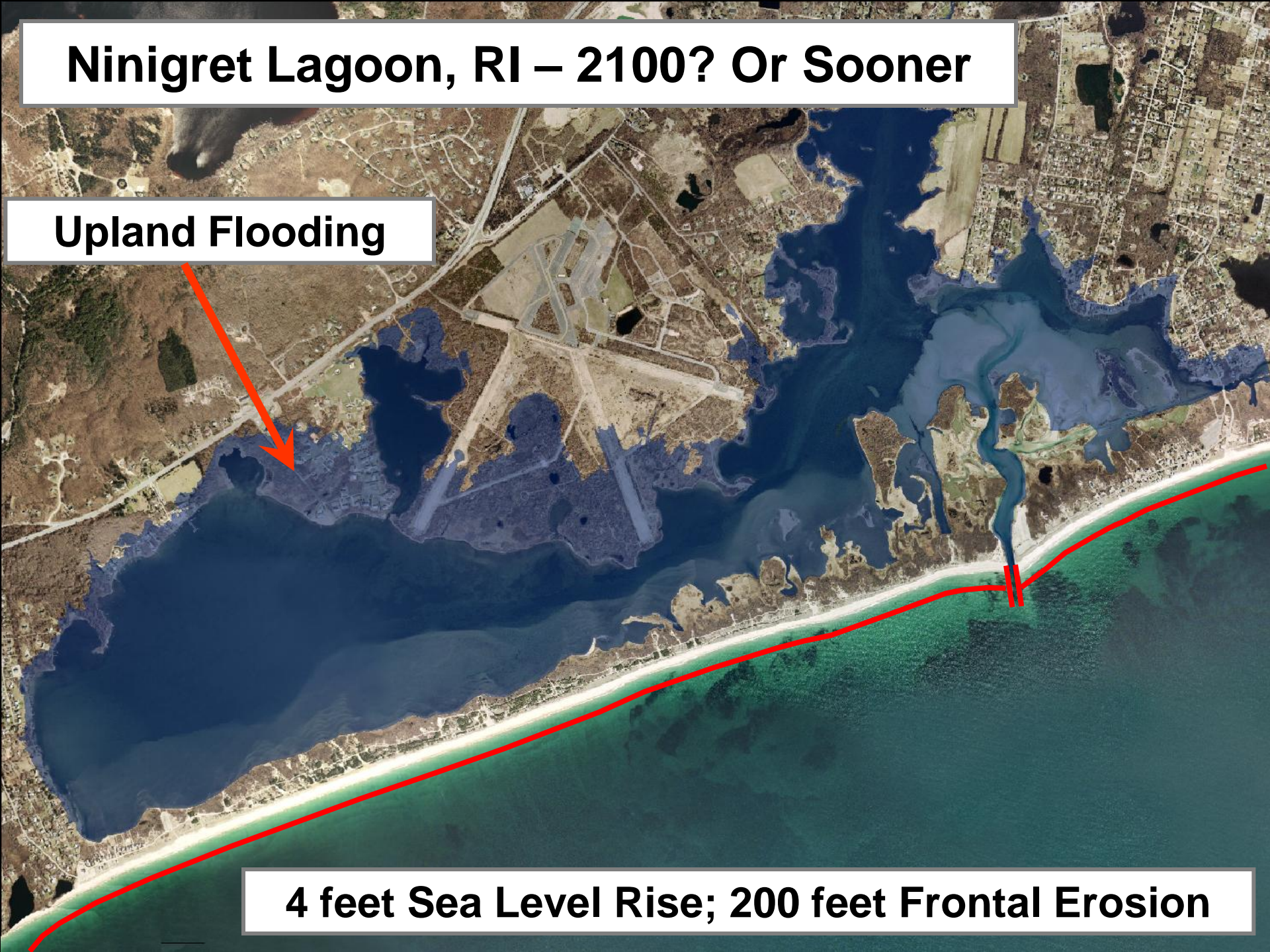


# Ninigret Lagoon, RI – 2100? Or Sooner

**Upland Flooding**



**4 feet Sea Level Rise; 200 feet Frontal Erosion**





# Pettaquamscutt Coastal Lagoon, RI: A Common View of the Future





**End of Presentation**