USGS SWaTH Network Rapidly Deployed Sensor Networks

Integrating Coastal Flood Research, Modeling and Monitoring to Improve Coastal Resiliency in the Mid-Atlantic

September 16, 2015 Clayton Hall, University of Delaware

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Geographer, U.S. Geological Survey

U.S. Department of the Interior
U.S. Geological Survey

History of USGS STS Program

Began by USGS

La WSC after Hurricane Katrina (2005)

- Rita (2005)
- Wilma (2005)
- Ernesto (2006)
- Gustav (2008)
- Ike (2008)
- Earl (2010)
- Irene (2011)
- Isaac (2012)
- Sandy (2012)

USGS

Improving USGS Storm Tide and Wave Monitoring and Response after Hurricane Sandy

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- (703) 648-5916
- hjenter@usgs.gov

USGS

USGS post-Sandy Response

- **Detailed in Circular 1390: Meeting the Science Needs of the Nation in the Wake of Hurricane Sandy—A U.S. Geological Survey Science Plan for Support of Restoration and Recovery**

“The understanding we gain from these studies will provide data and information to guide recovery activities and to set the stage for better models and assessments of future hazards,” said USGS Acting Director, Suzette Kimball. “It will help coastal communities be better prepared to withstand and respond to catastrophic storms.”

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Science Themes

- Theme 1: Coastal Topographic and Bathymetric Data to Support Hurricane Impact
- Theme 2: Impacts to Coastal Beaches and Barriers
- Theme 3: Impacts of Storm Surge, Including Disturbed Estuarine and Bay Hydrology
- Theme 4: Impacts on Environmental Quality, Including Exposure to Chemical and Microbial Contaminants
- Theme 5: Impacts to Coastal Ecosystems, Habitats, and Fish and Wildlife

Network Objectives

Surge
Wave
and
Tide
Hydrologic

1. maximize the deployment of temporary storm surge and wave sensors within a network of pre-established locations

2. establish wave-monitoring sensors along pre-selected transects that extend inland through various physical features from shore to built-up environments

3. increase capability to deploy real-time monitoring gages at locations critical to emergency managers, and

4. provide as much hydrologic data as possible to accurately define the scope and timing of storm tide, surge, waves, and inland flooding associated with hurricanes, intense Nor'easters, and any other areally-distributed surge-producing weather phenomena.

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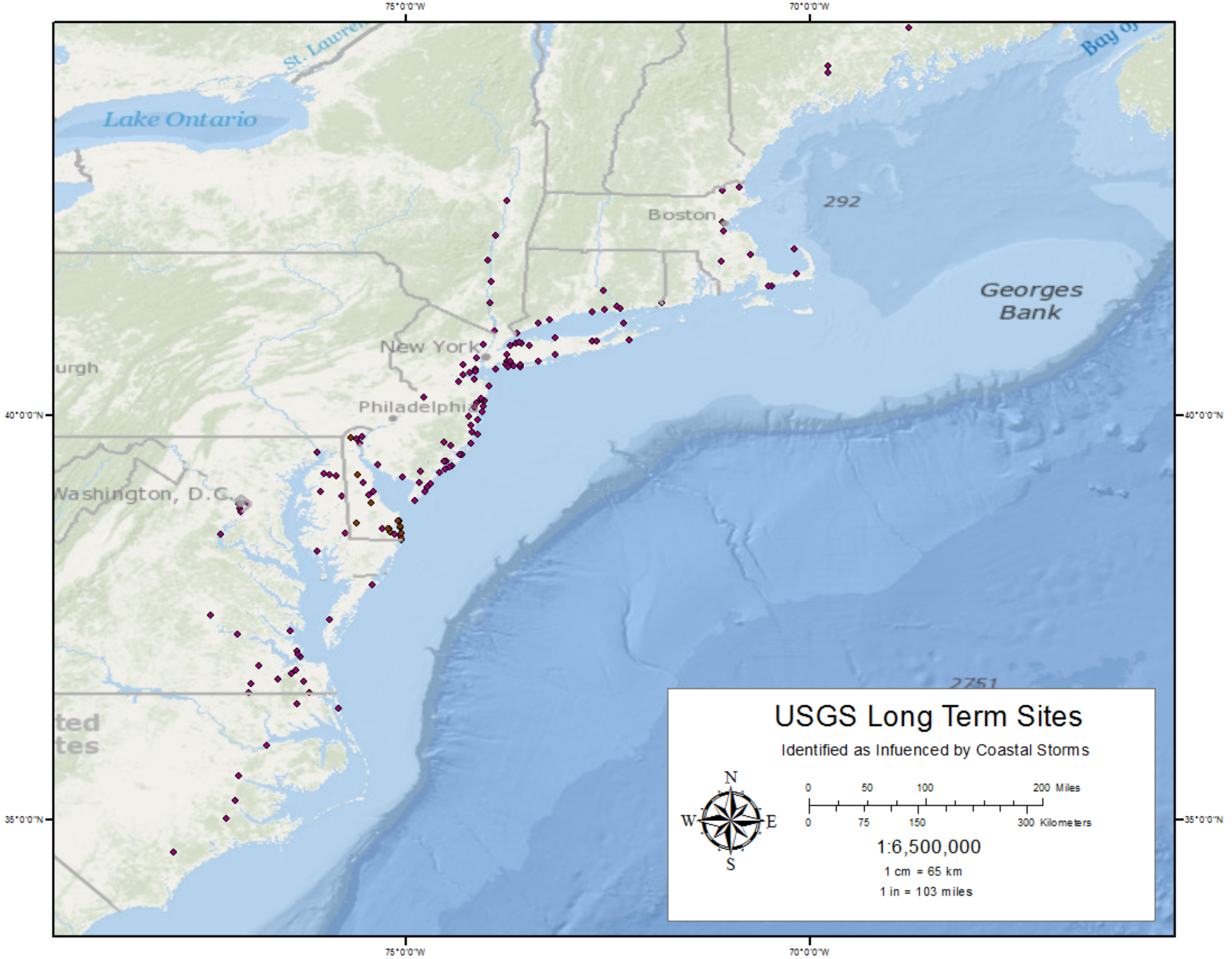
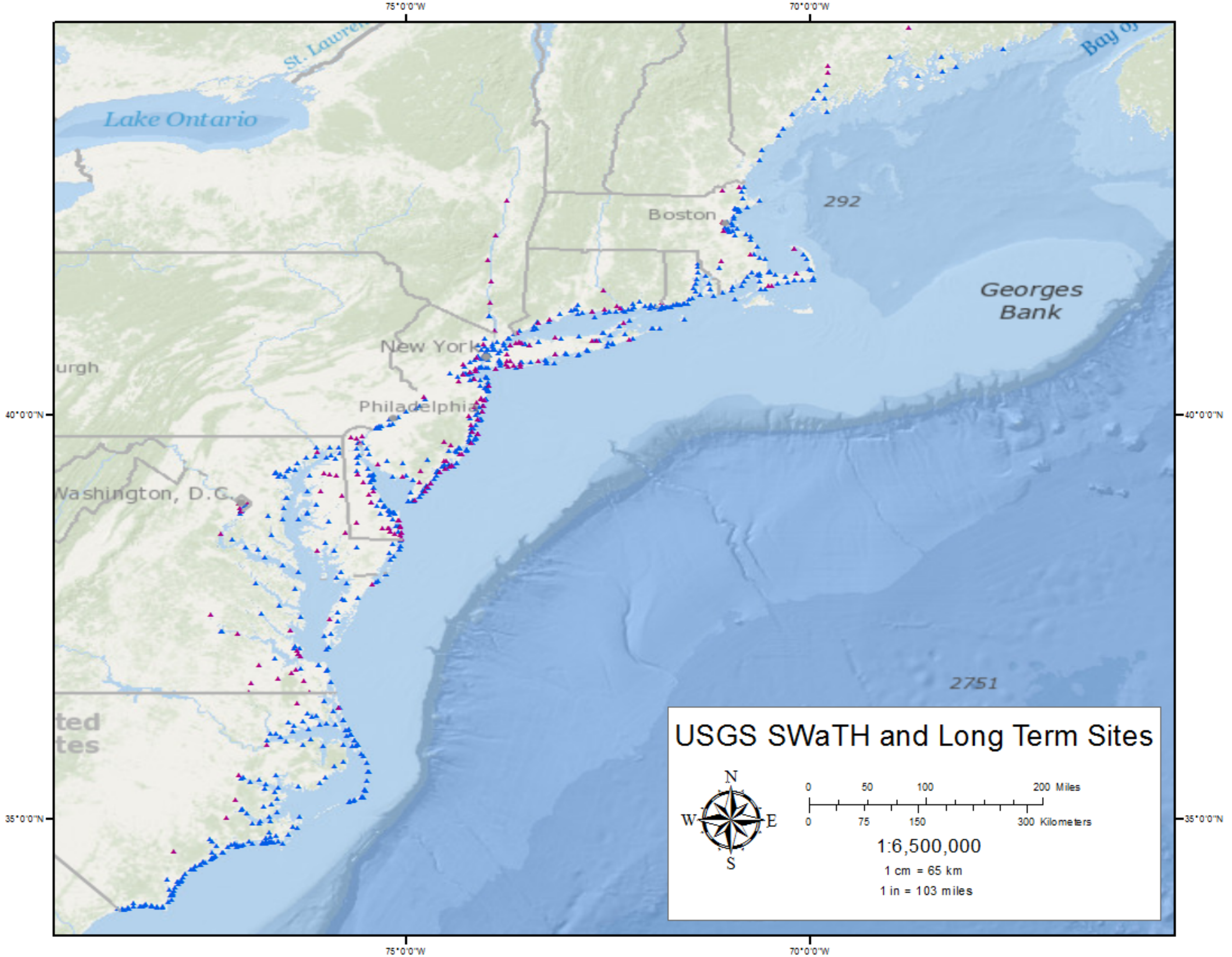

USGS Long Term Sites
Identified as Infuenced by Coastal Storms
N
S
E
W
0 50 100 200 Miles
0 75 150 300 Kilometers
1:6,500,000
1 cm = 65 km
1 in = 103 miles
Lake Ontario
St. Lawren
Bay of
Boston
New York
Philadelphia
Washington, D.C.
urgh
ted
tes
Georges
Bank
292
2751
75°0'0"W
70°0'0"W
40°0'0"N
35°0'0"N

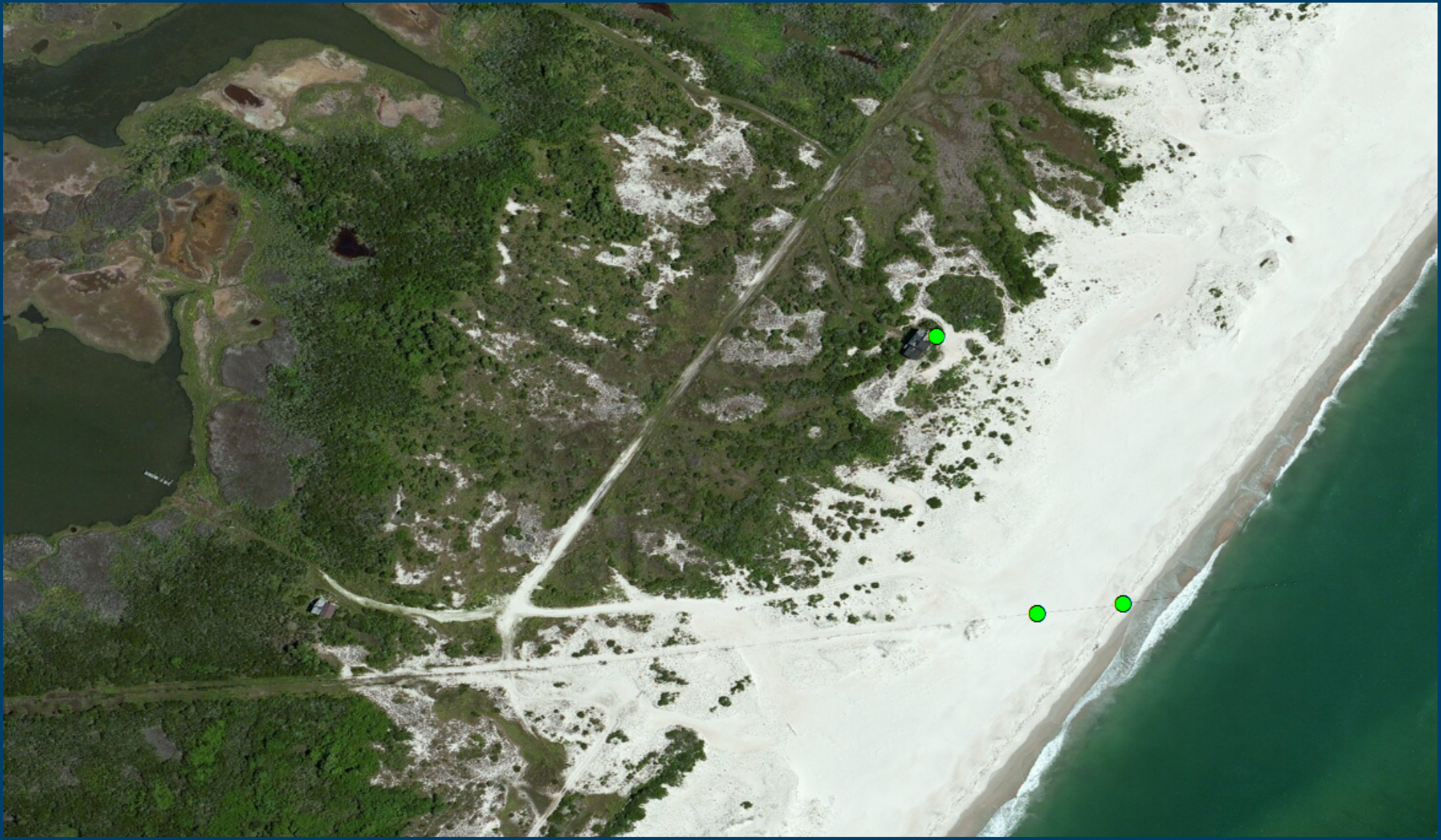


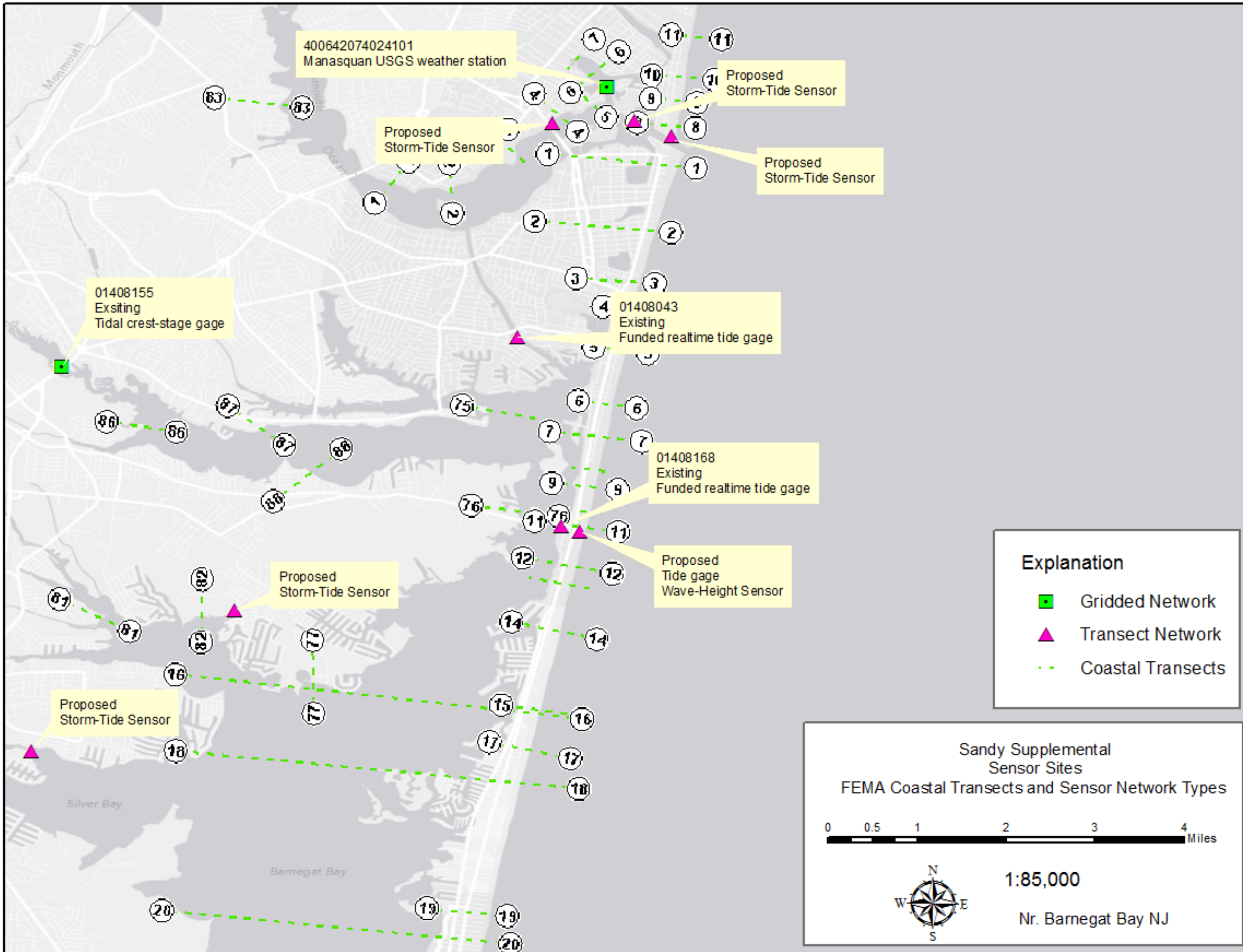
USGS SWaTH and Long Term Sites
75°0'0"W
70°0'0"W
40°0'0"N
35°0'0"N
Lake Ontario
St. Lawren
Boston
New York
Philadelphia
Washington, D.C.
Georges Bank
292
2751
N
S
E
W
0 50 100 200 Miles
0 75 150 300 Kilometers
1:6,500,000
1 cm = 65 km
1 in = 103 miles

Network Sub-Types

- Distributed
  - Water level sensors: pressure transducers
    - Generally 30-second recording intervals (shorter if needed)
    - Supports FEMA and other inundation modeling
  - RDGs
    - Water Level (Radar) and Met data
    - GOES connected
    - Could be important to local emergency operations
- Transect
  - Wave sensors (RBR)
    - 0.25-second recording interval
    - Supports USGS wave run-out, FEMA, and other modeling

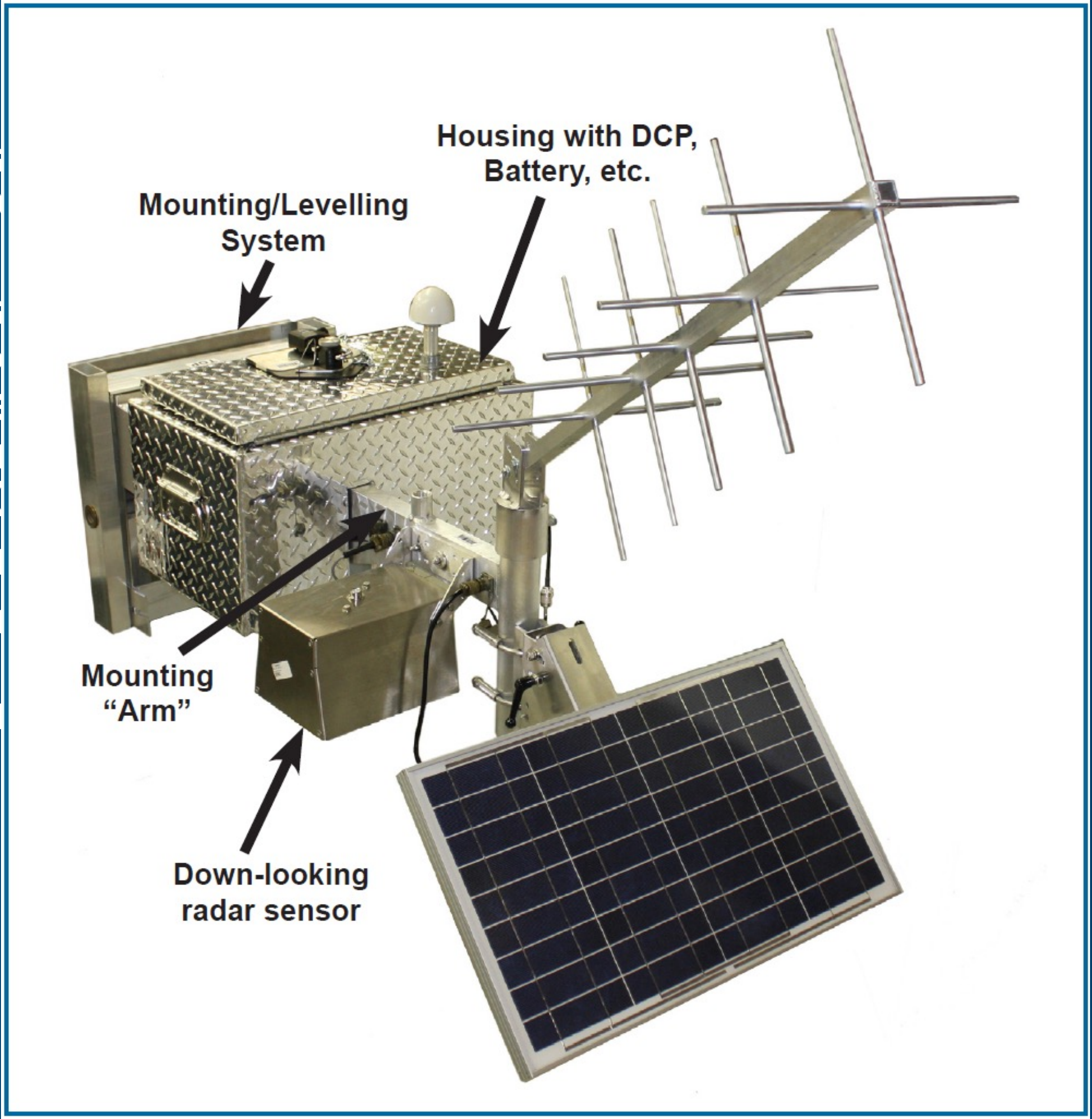
USGS




400642074024101
Manasquan USGS weather station
Proposed
Storm-Tide Sensor
Proposed
Storm-Tide Sensor
Proposed
Storm-Tide Sensor
01408155
Exsiting
Tidal crest-stage gage
01408043
Existing
Funded realtime tide gage
01408168
Existing
Funded realtime tide gage
Proposed
Tide gage
Wave-Height Sensor
Proposed
Storm-Tide Sensor
Proposed
Storm-Tide Sensor
Silver Bay
Barnegat Bay
Explanation
Gridded Network
Transect Network
Coastal Transects
Sandy Supplemental
Sensor Sites
FEMA Coastal Transects and Sensor Network Types
0 0.5 1 2 3 4 Miles
1:85,000
Nr. Barnegat Bay NJ

Rapid Deployment Gages (RDGs)

- Records
  water lev
  sensor)
- Records
  meteoro
  pressure
  wind sp
  WXT-52
- GOES a
- Dramati
  focused
  manage



Rapid Deployment Gage Version 3 (RDG-3)

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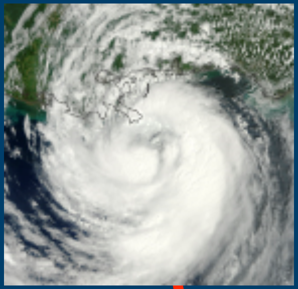
Protective Housing for the Built Environment

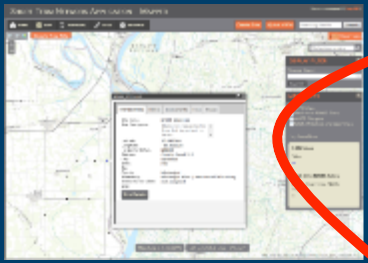
- 2”-diameter aluminum pipe, custom length
- Open at the bottom
- Vented near the bottom
- Locked cap at the top
- Instrument deployed on pinned rod inside housing with transducer very near the open bottom
- Bottom of housing ≤ 18” from sea bed
- Housing may be pre-installed or installed at instrument deployment (fouling, vandalism, ease of install etc…)
- Pre-surveyed reference point

Data flow during an event

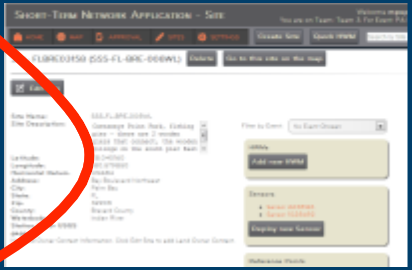


- Event declared and started in STN

- Data Collected by field crews
  - Deployments, retrievals, etc.
- Entered into STN
  - In field or office/hotel



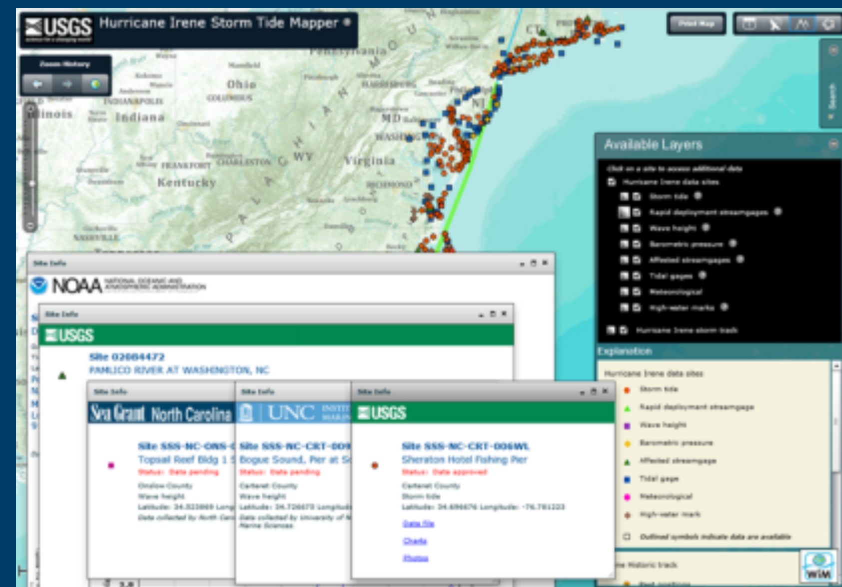
- QA processing
  - In any office



- Immediate Provisional Data release
  - Mapper
  - Data Services

Using a Mapper to Communicate data

- Before storm
  - Locate sensor networks
  - Plan with partners
- During storm
  - Monitor real-time gaging locations
- After storm
  - Coordinate and communicate retrieval process and HWMs
  - Coordinate data processing and approval
  - Data dissemination



*Working on process to display partner data

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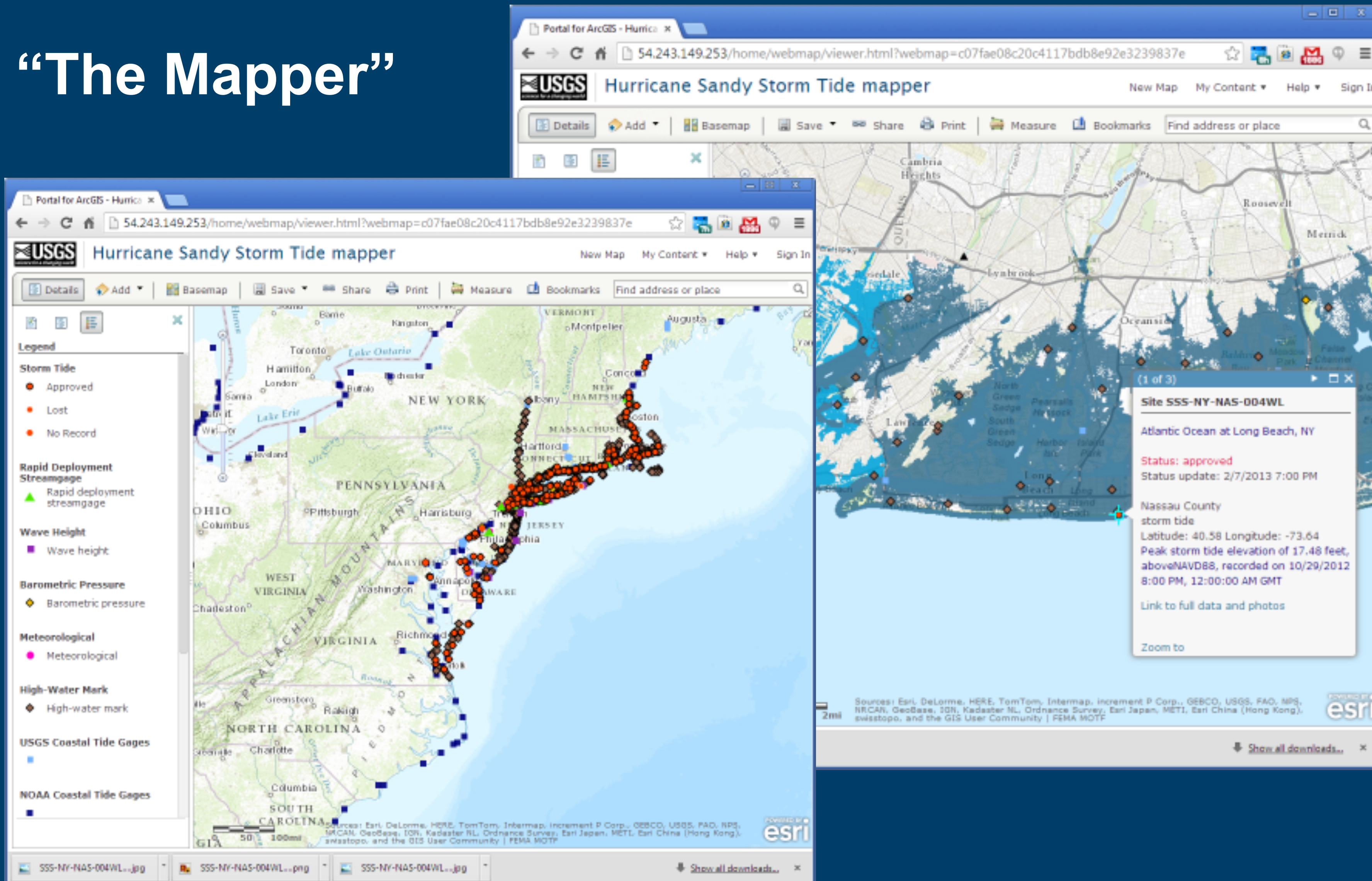
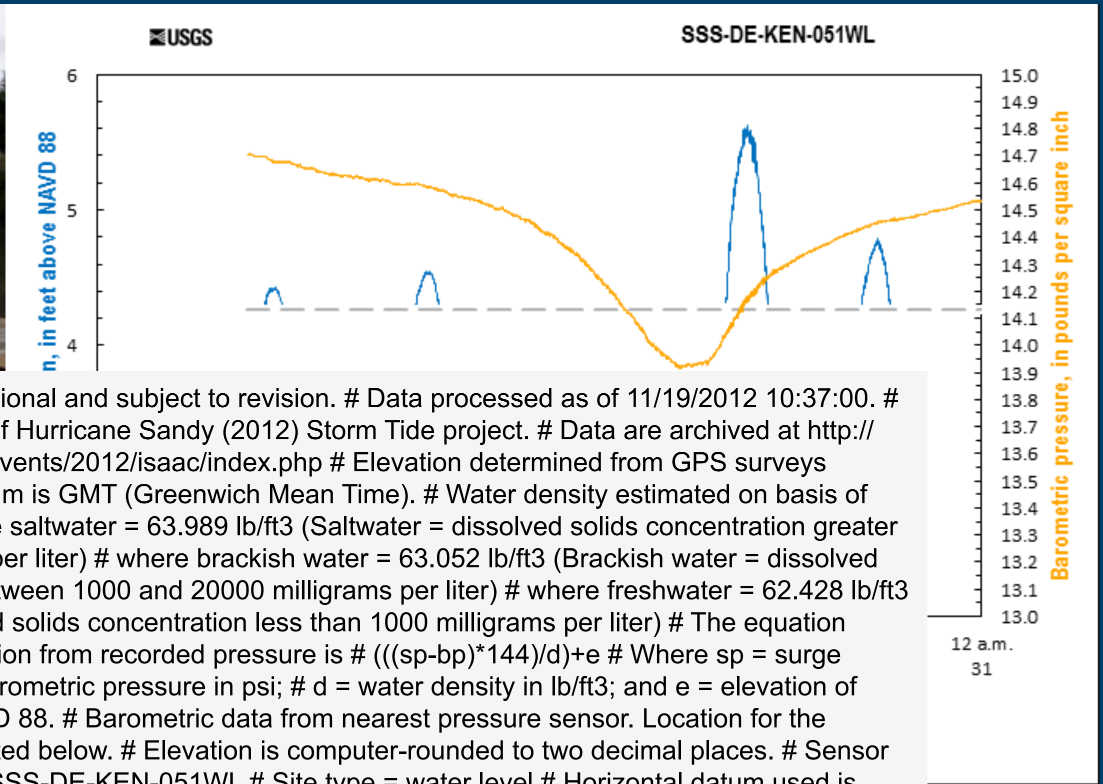
Data Handling - Dissemination

“The Mapper”

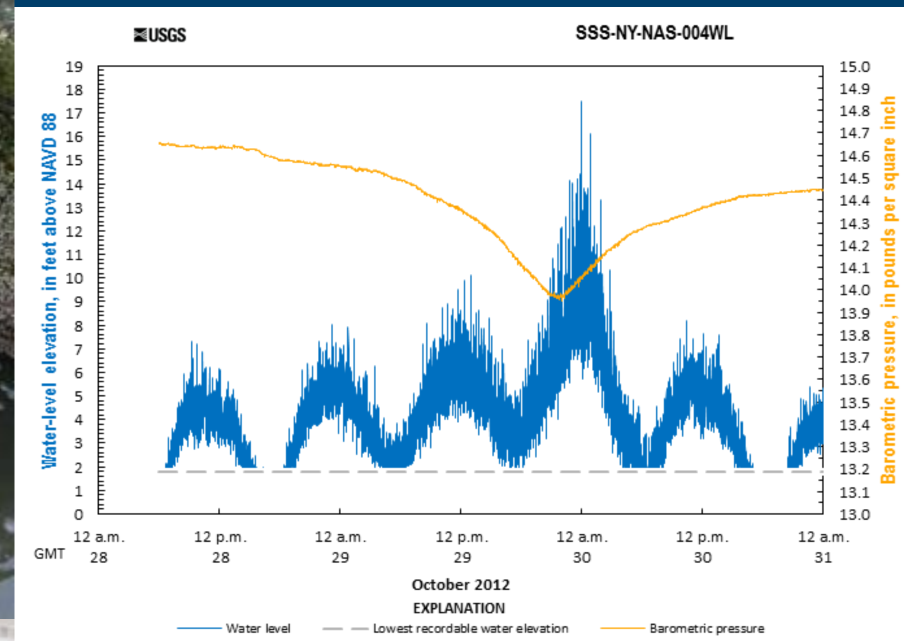


Water Level Sensor Data – DE Sandy



These data are provisional and subject to revision. # Data processed as of 11/19/2012 10:37:00. # Data collected as part of Hurricane Sandy (2012) Storm Tide project. # Data are archived at http://water.usgs.gov/floods/events/2012/isaac/index.php # Elevation determined from GPS surveys (NAVD 88). # Time datum is GMT (Greenwich Mean Time). # Water density estimated on basis of sensor location # where saltwater = 63.989 lb/ft3 (Saltwater = dissolved solids concentration greater than 20000 milligrams per liter) # where brackish water = 63.052 lb/ft3 (Brackish water = dissolved solids concentration between 1000 and 20000 milligrams per liter) # where freshwater = 62.428 lb/ft3 (Freshwater = dissolved solids concentration less than 1000 milligrams per liter) # The equation used to compute elevation from recorded pressure is # (((sp-bp)*144)/d)+e # Where sp = surge pressure in psi; bp = barometric pressure in psi; # d = water density in lb/ft3; and e = elevation of sensor in ft above NAVD 88. # Barometric data from nearest pressure sensor. Location for the barometric sensor is listed below. # Elevation is computer-rounded to two decimal places. # Sensor information # Site id = SSS-DE-KEN-051WL # Site type = water level # Horizontal datum used is NAD 83 # Sensor location latitude 39.325833 # Sensor location longitude -75.474972 # Sensor elevation above NAVD 88 = 4.19 ft # Lowest recordable water elevation is 4.26 ft # Water density value used = 63.052 lb/ft3 # Barometric sensor site (source of bp) = SSS-DE-KEN-051BP # Barometric sensor location latitude 39.325833 # Barometric sensor location longitude -75.474972 date_time_GMT elevation nearest_barometric_sensor_psi 10-28-2012 12:15:00 4.11 14.7023 10-28-2012 12:15:30 4.10 14.7023 10-28-2012 12:16:00 4.10 14.7047 10-28-2012 12:16:30 4.10 14.7047 10-28-2012 12:17:00 4.11 14.7023 10-28-2012 12:17:30 4.10 14.7047 10-28-2012 12:18:00 4.11 14.7023 10-28-2012 12:18:30 4.10 14.7047 10-28-2012 12:19:00 4.10 14.7047 10-28-2012 12:19:30 4.10 14.7047 10-28-2012 12:20:00 4.10 14.7047 10-28-2012 12:20:30 4.10 14.7047 10-28-2012 12:21:00 4.11 14.7023 10-28-2012 12:21:30 4.13 14.7023 10-28-2012 12:22:00 4.13 14.7023 10-28-2012 12:22:30 4.12 14.7023 10-28-2012 12:23:00 4.11 14.7047 10-28-2012 12:23:30 4.09 14.7070 10-28-2012 12:24:00 4.09 14.7047

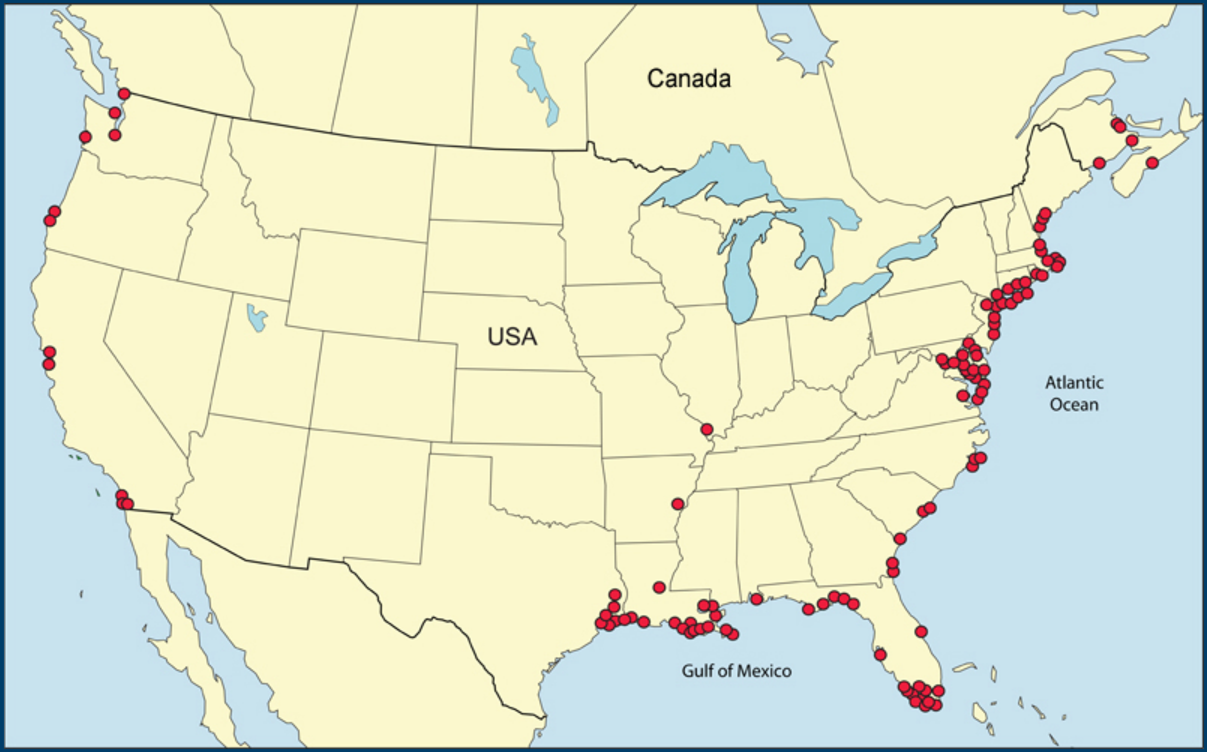
Water Level Sensor Data – NY Sandy



Spin Offs

- Upgrade selected USGS tide gages to comply with NOAA NWLON Standards
  - 9 in the SWaTH study area (DE, MD, NJ, VA)
  - 2 in Delaware, 1 on Eastern Shore of Maryland
- Cooperative work between DelDOT and USGS
  - 6 stage gages, 1 discharge, 5 data integration (stage only)
  - Real time, setup to be directly accessible (raw data) by DelDOT
- TAA for sensor installs with Risk Management Solutions

Spin Offs (Contd.)



The Surface Elevation Table (SET) is a portable mechanical leveling device for measuring the relative elevation change of wetland sediments.

USGS http://www.pwrc.usgs.gov/set/

Forecasting Vulnerability to Extreme Beach Erosion during Storms

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hstockdon@usgs.gov

- Basics about our models
- Coastal erosion hazards for generalized scenarios
- Real-time forecasts of potential erosion
- Operational total water levels

USGS
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Probabilities of coastal change

What is the likelihood that hurricane induced water levels will exceed the elevation of the base and crest of protective sand dunes?

Collision

Waves/surge higher than base of dune lead to erosion

Overwash

Waves/surge overtop dune crest, moving sand landward

Inundation

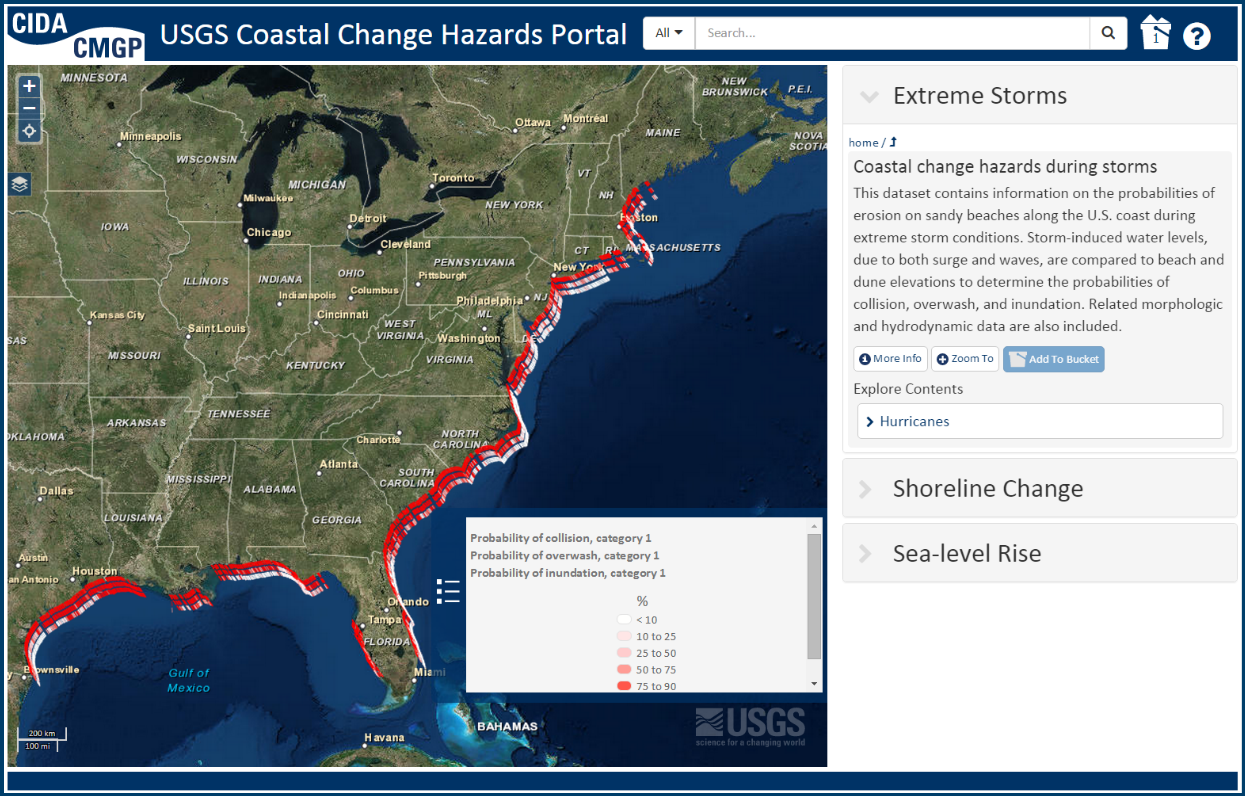
Mean water levels are higher than dune crest, submerging beach system

USGS

1) Scenario-based approach for generalized storms
2) Real-time mode for approaching storms

Scenario based assessment of hurricane-induced coastal erosion hazards

- USGS models that combine lidar-based shorelines and dunes with modeled storm surge and wave conditions are used to determine the probability of dune erosion, overwash, and inundation for beaches along U.S. Gulf of Mexico and Atlantic coasts during category 1-5 hurricane landfall.



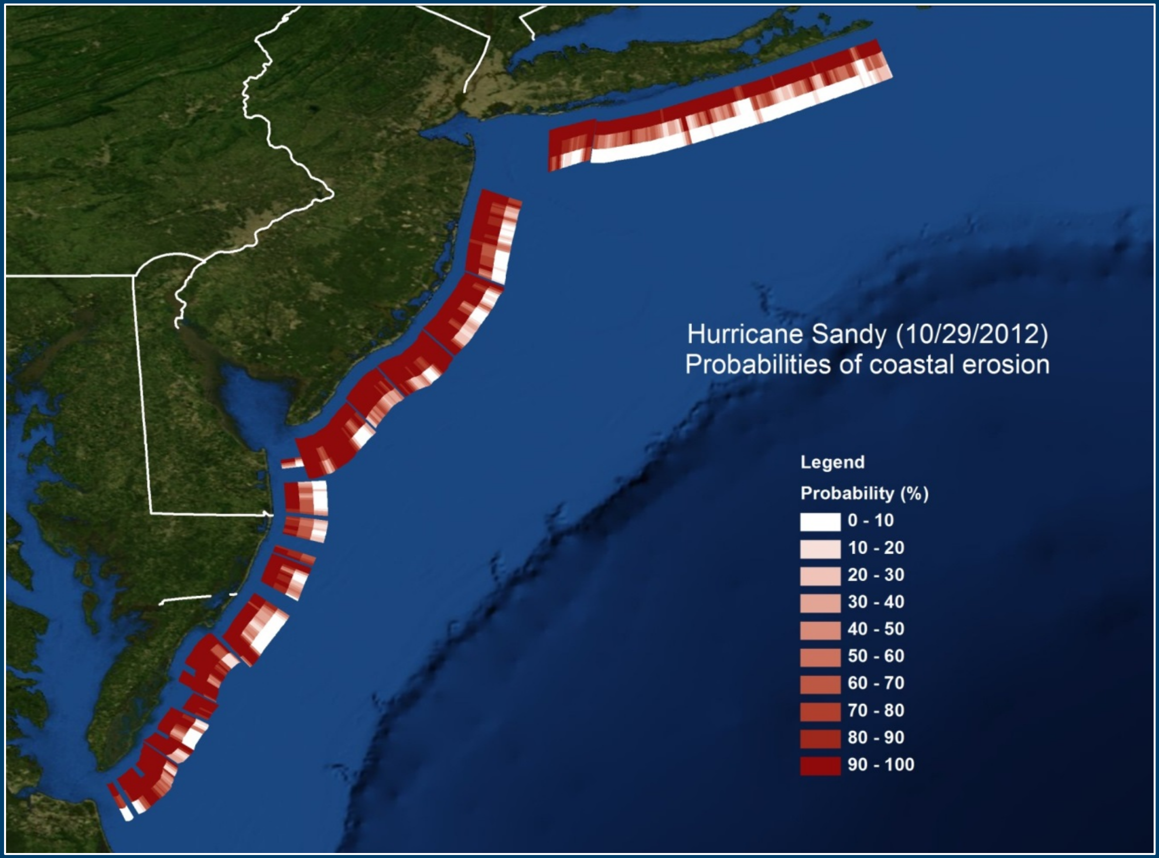
Vulnerability assessments, supporting data, and interactive mapping tools are available online at the USGS Coastal Change Hazards Portal

USGS

http://marine.usgs.gov/coastalchangehazardsportal/

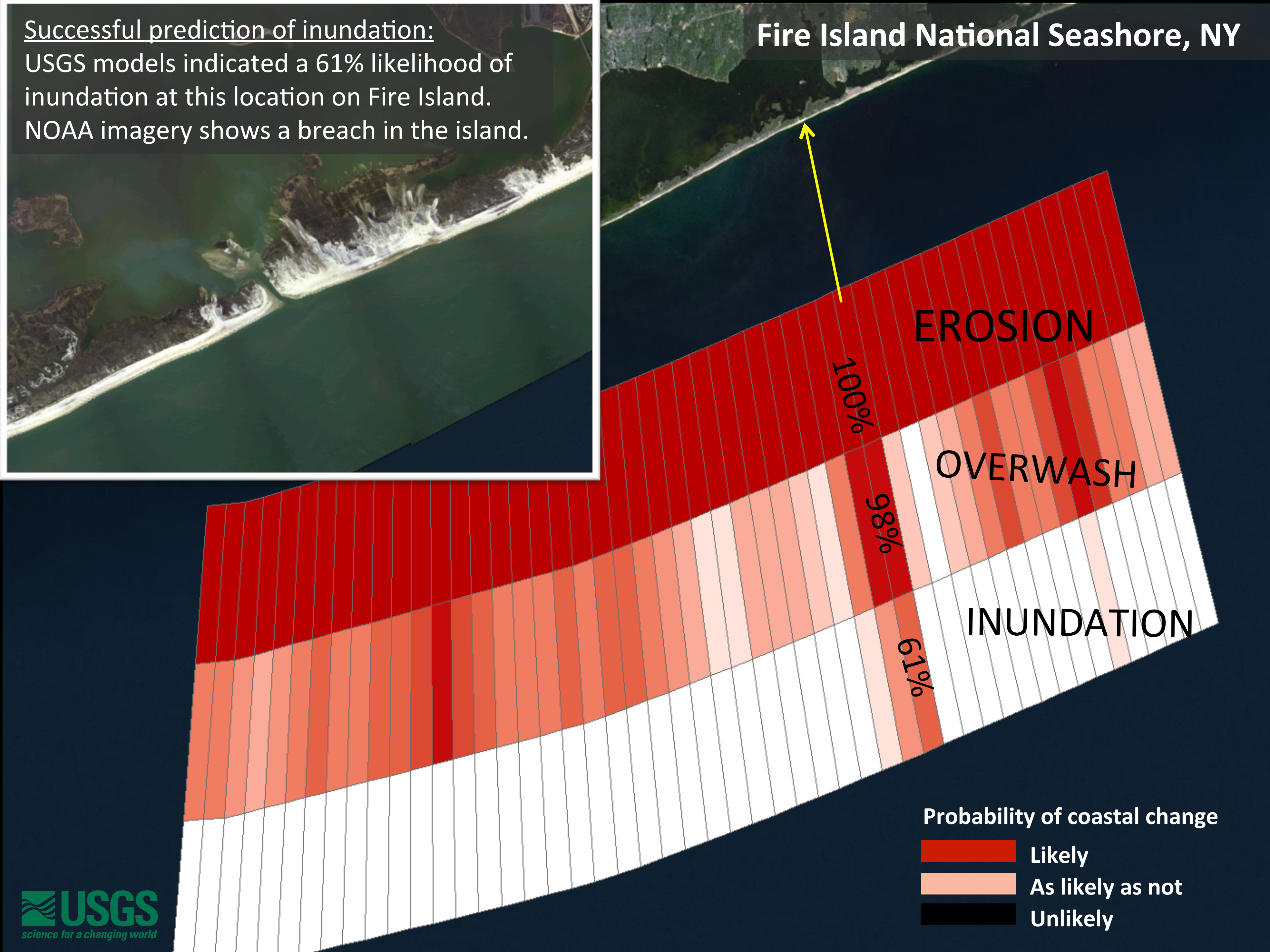
Real-time forecast of coastal erosion – Hurricane Sandy

- Inputs:
  - Lidar-based shorelines, dunes (USGS, USACE)
  - Storm surge (NOAA)
  - Wave conditions (NOAA)
  - Wave runup (USGS)
- Output: Probabilities of
  - Dune erosion
  - Overwash
  - Inundation
- Assessments are posted online and updated with current NHC meteorology as the storm approaches landfall.



% of coast very likely to experience coastal change :			
	Dune erosion (inner)	**Overwash (middle)**	**Inundation (outer)**
Long Island, NY	93	12	4
New Jersey	98	54	21
Delmarva	91	55	22

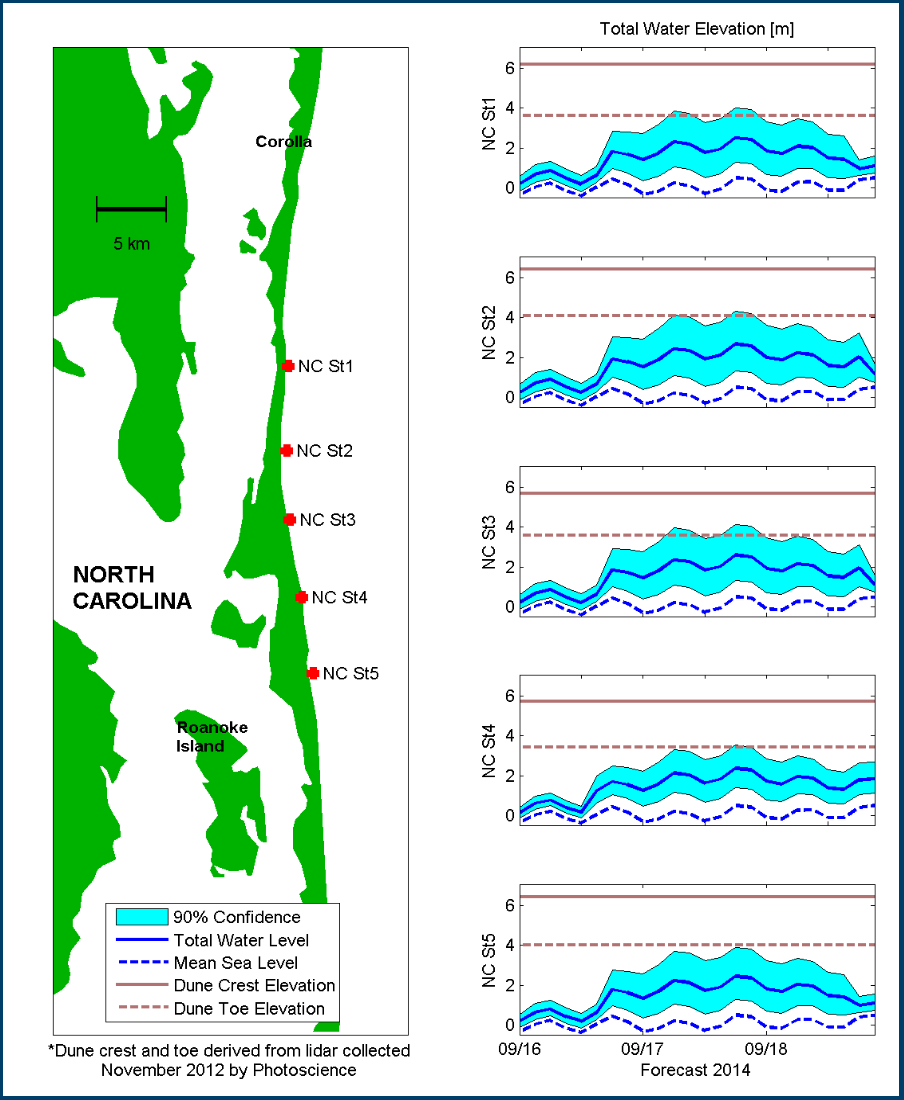
USGS



Successful prediction of inundation:
USGS models indicated a 61% likelihood of inundation at this location on Fire Island. NOAA imagery shows a breach in the island.
Fire Island National Seashore, NY
EROSION
100%
OVERWASH
98%
INUNDATION
61%
Probability of coastal change
Likely
As likely as not
Unlikely
USGS
science for a changing world

Automate Coastal Change Probability Forecasts

- Operational forecasts of total water levels , including tide, surge and wave runup done in collaboration with NOAA NCEP
- Wave components based on USGS measurements of beach slope and models for runup
- Used in conjunction with USGS observations of beach and dune morphology to predict resulting coastal change.
- Operational in Tampa Bay and Outer Banks, NC. Miami and Boston this summer.



Next Steps

- Coastal Action – Timing as important as levels
  - Expand use of web viewer to show time and depths
- Enhance and extend real-time capability
- Better integrate water level with wind data
- Seek opportunities for observations of near-field water and winds effects on veg, terrain, and built structures
- Opportunities to use SSSs as base line for remotely sensed data and model validation
- TAA's with private sector

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Questions?

USGS

Hurricane Gustav, Louisiana 2008
http://pubs.usgs.gov/of/2008/1373/