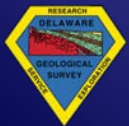


# THE DELAWARE COASTAL FLOOD MONITORING SYSTEM



John Callahan (Delaware Geological Survey)  
Kevin Brinson, Daniel Leathers, Linden Wolf (Delaware  
Environmental Observing System)

[www.deos.udel.edu](http://www.deos.udel.edu)



# Background

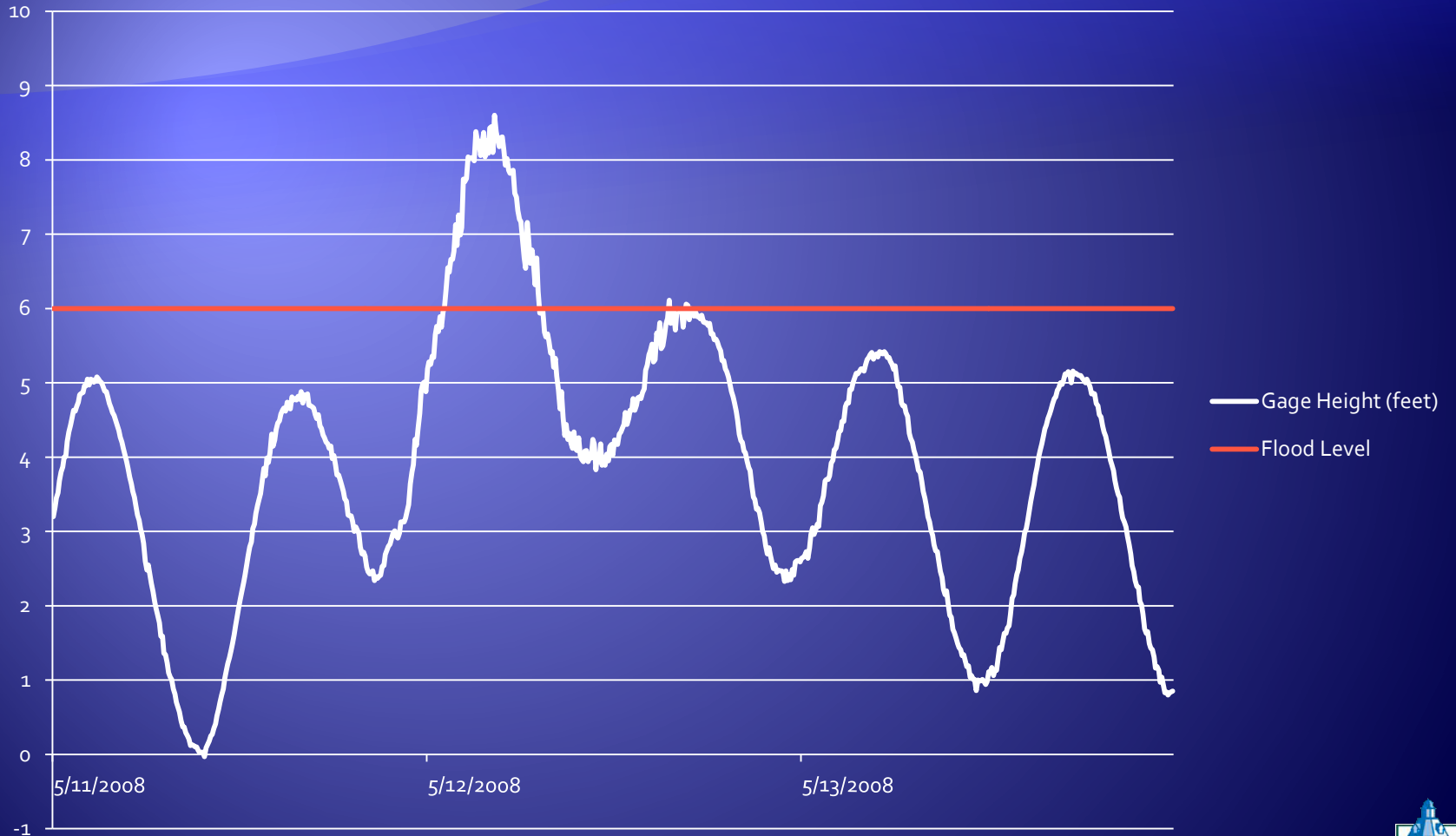
- ◆ Delaware is extremely vulnerable to the impacts of coastal flooding
  - ◆ Tropical systems
  - ◆ Extra-tropical systems
- ◆ Numerous communities built up along the coast
  - ◆ Atlantic Ocean, Delaware Bay, and Delaware River



# Background

- ◆ **Mother's Day Storm** - May 12<sup>th</sup>, 2008 Nor'easter and astronomically high tides caused significant coastal flooding, particularly in Kent County, DE
- ◆ Evacuations at Slaughter Beach, Kitts Hummock, Bowers Beach, and Woodland Beach
- ◆ Rough seas caused research vessel to capsize off Rehoboth Beach, DE – 1 crewman died
- ◆ Estimated up to \$2 million in damage (FEMA)

# Bowers Beach Tide Gage

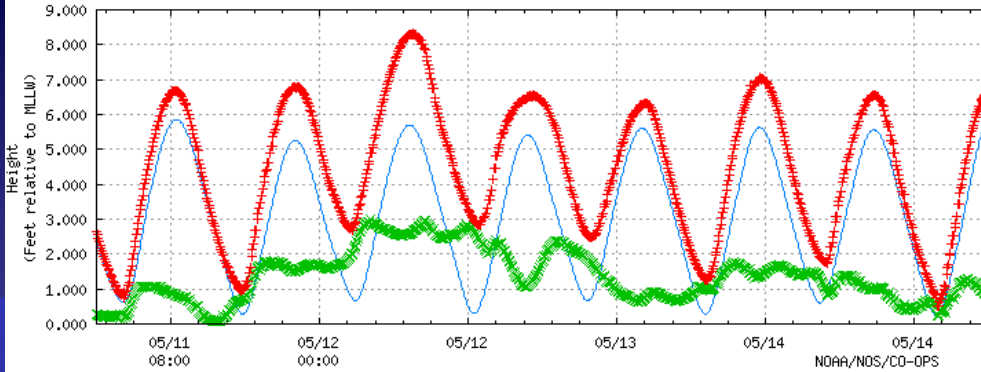


United States Geological Survey



# Reedy Point

NOAA/NOS/CO-OPS  
 Verified Water Level vs. Predicted Plot  
 8551910 Reedy Point, DE  
 from 2008/05/11 - 2008/05/14

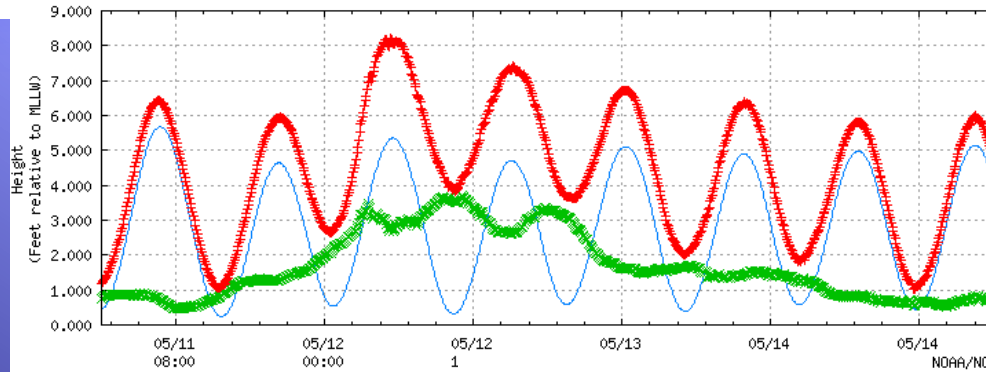


# Mother's Day Storm NOS Stations

2 – 3 ft above MHHW  
 in Delaware Bay

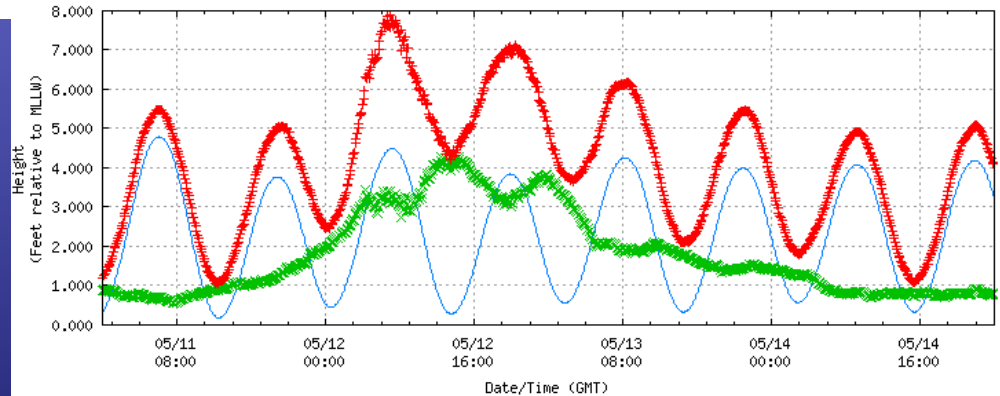
# Brandywine Shoal

NOAA/NOS/CO-OPS  
 Verified Water Level vs. Predicted Plot  
 8555889 Brandywine Shoal Light, DE  
 from 2008/05/11 - 2008/05/14



# Lewes

NOAA/NOS/CO-OPS  
 Verified Water Level vs. Predicted Plot  
 8557380 Lewes, DE  
 from 2008/05/11 - 2008/05/14



Hurricane Sandy  
 was even worse...  
 3 – 4 ft above MHHW

Predicted Tide — (Obs-Pred) x Observed WL +

# We need a system that...

1. Alerts emergency personnel in advance of potential flooding events
2. Includes some measure of the extent and timing of the event
3. Online (web-based) portal to visualize predicted and current conditions
4. Provides documentation and training
5. Focused on Delaware coastal communities

# Funding Partners

- ◆ DNREC Coastal Programs
- ◆ Delaware EPSCoR  
(initial development)



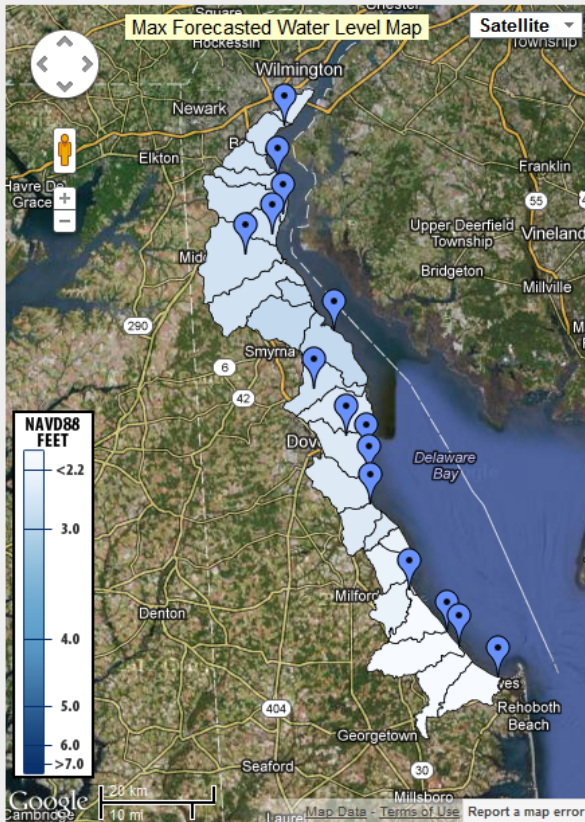
# Delaware Coastal Flood Monitoring System (CFMS)

- ◆ Ingest NOAA operation model forecasts for water levels along Delaware Bay.
- ◆ Send out alerts for each community if water levels are predicted to reach a critical level.
- ◆ Assume a constant level throughout each community (bathtub model.)
- ◆ Develop website with maps, tidal graphs, road elevation profiles, and other information for each community.

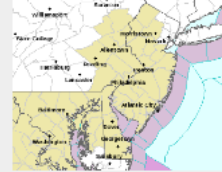


# Delaware Coastal Flood Monitoring System

Home | Community Flood Maps | Current Conditions | Tide Models | Weather Forecast | Educational Resources | FAQ



## January 26, 2013 - 48hr Coastal Conditions



NWS Alert Map



0 active NWS warning(s)

### DE Bay Maximum Forecasted Water Level



MHHW 3.02  
MAX 2.83

near [Woodland Beach Community](#)

on **01/27/2013 10:00 am**

Show more details for:

### Moon Phase



Full Moon

### Upcoming High Tides

<a href="#">Reedy Point</a>	<a href="#">Lewes</a>
01/26 10:56 PM	01/26 08:18 PM
01/27 11:08 AM	01/27 08:37 AM
01/27 11:32 PM	01/27 08:56 PM
01/28 11:42 AM	01/28 09:13 AM



### About the Delaware Coastal Flood Monitoring System

The Delaware Coastal Flood Monitoring System (CFMS) is a web-based tool and alert system designed to provide emergency managers, planners, and others the information needed regarding upcoming coastal flood events. The CFMS covers the Delaware Bay coastline from New Castle to Lewes and serves three primary functions: to send out warning alerts up to 48 hrs in advance of potential flood conditions, to provide access to current meteorological and hydrologic conditions, and to provide local tidal predictions and map their areas of impact.

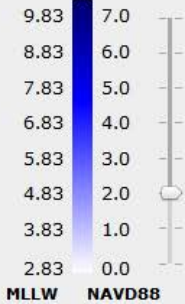


# Delaware Coastal Flood Monitoring System

Home Community Flood Maps Current Conditions Tide Models Weather Forecast Educational Resources FAQ

Bowers Beach

## Flood Map Water Depth (Feet)



Reset Map to:

Current Max

### Current model data:

**-3.1 ft\*** ▼  
Today, 3:00 pm

### Maximum forecasted water level:

**2.46 ft\***  
01/27/2013 09:00 am

MHHW: 2.75 ft  
MSL: 0.248 ft  
MLLW: -2.83 ft

\*All data relative to NAVD88

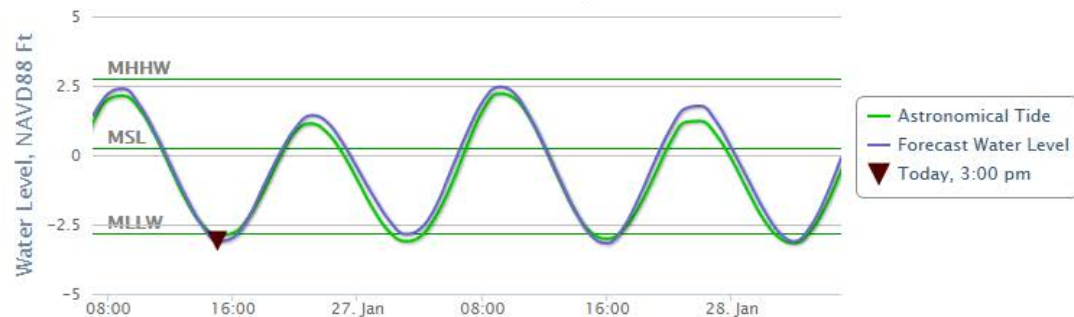
▼ = Current time



Tidal Graph Tidal Data Bowers Beach Rd South Bowers Rd

## Bowers Beach - Forecast Water Level

Forecast for 2013-01-26 07:00 through 2013-01-28 07:00 EDT



Highcharts.com

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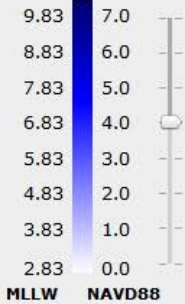
Copyright 2011-2012 Delaware Geological Survey and Delaware Environmental Observing System

# Delaware Coastal Flood Monitoring System

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Bowers Beach

### Flood Map Water Depth (Feet)



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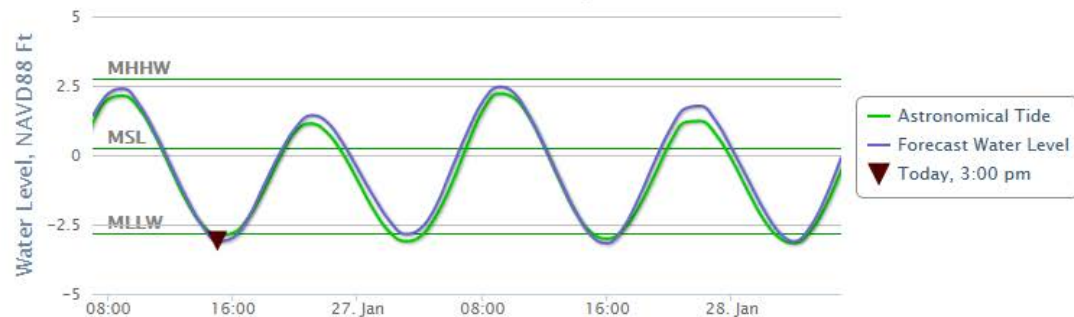
▼ = Current time



Tidal Graph Tidal Data Bowers Beach Rd South Bowers Rd

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Highcharts.com

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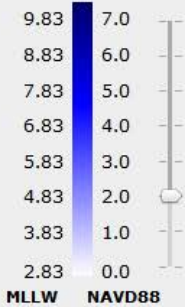
Copyright 2011-2012 Delaware Geological Survey and Delaware Environmental Observing System

# Delaware Coastal Flood Monitoring System

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Bowers Beach

Flood Map  
Water Depth (Feet)



Reset Map to:

Current Max

Current model data:

**-3.1 ft\*** ▼  
Today, 3:00 pm

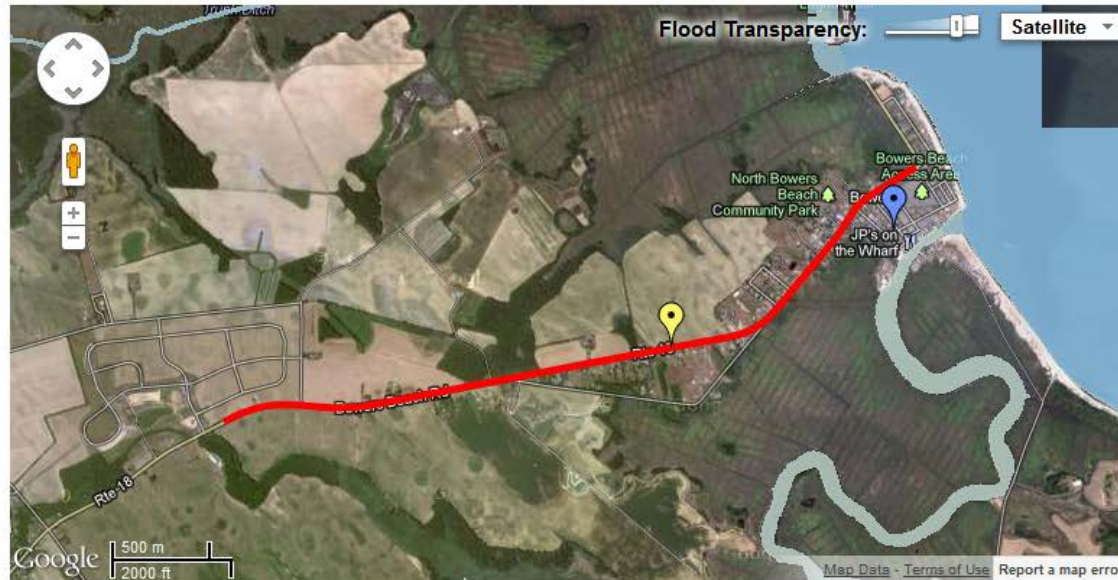
Maximum forecasted  
water level:

**2.46 ft\***  
01/27/2013 09:00 am

MHHW: 2.75 ft  
MSL: 0.248 ft  
MLLW: -2.83 ft

\*All data relative to  
NAVD88

▼ = Current time



Tidal Graph

Tidal Data

Bowers Beach Rd

South Bowers Rd

Bowers Beach Rd, Bowers Beach – Road Elevation



Highcharts.com

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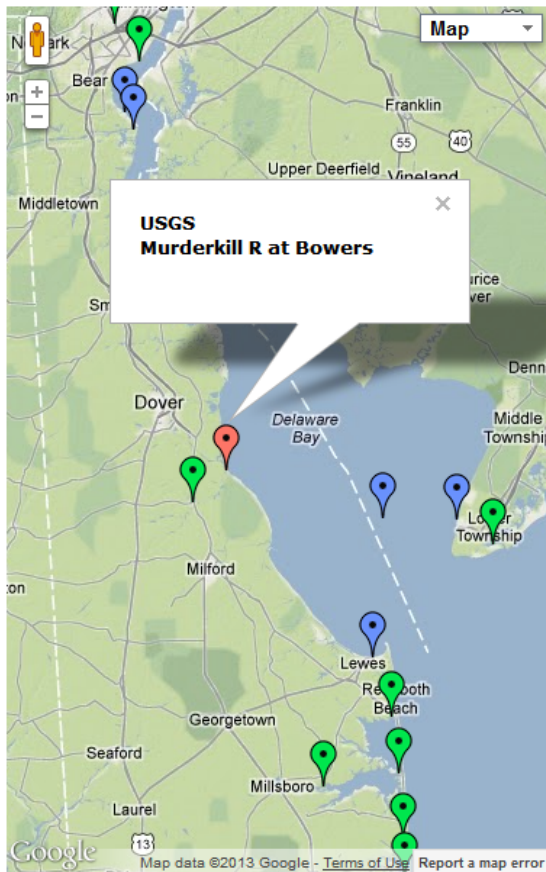
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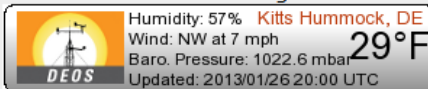
## Current Meteorological and Tidal Conditions

There are two primary networks for real-time monitoring of tides: United States Geological Survey (USGS) and NOAA's National Ocean Service (NOS). Both networks are displayed on the map below. Click on a map marker to display data.

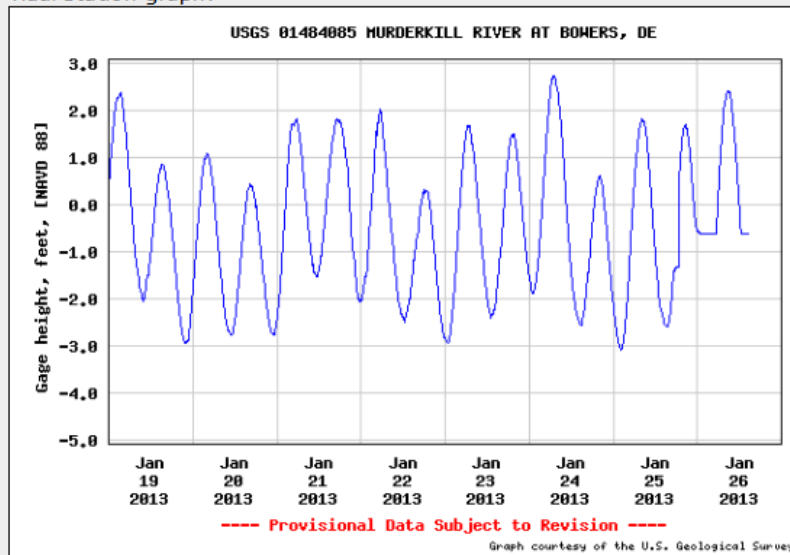


### USGS: Murderkill R at Bowers

Nearest DEOS meteorological station:



Tidal station graph:

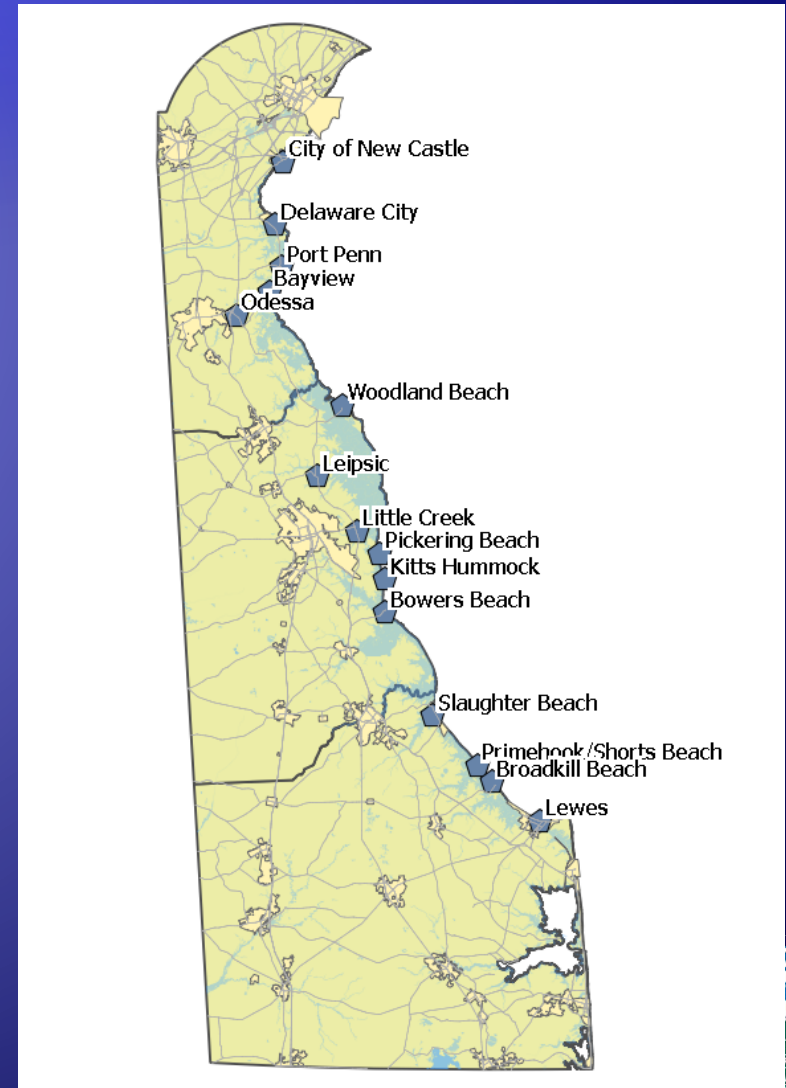


Source: <http://waterdata.usgs.gov/usa/nwis/uv?01484085>

All tidal data graphs are MLLW feet, except for the USGS Bowers Beach gage, which is NAVD88 feet.

# Coastal Communities

- ◆ 15 communities between cities of New Castle and Lewes
- ◆ Each community has:
  - ◆ Configurable alerts
  - ◆ Inundation maps
  - ◆ Road profiles
  - ◆ Tidal parameters



# CFMS Forecast Alerts

- ◆ Each subscriber sets a critical level to be notified
- ◆ If that level is reached, **at any time within the 48 hour forecast (adjustable)**, an alert is sent via text and email

This is a DEOS Forecast Alert Inbox | X

☆ DEOS Alert System to me

[show details](#) Aug 29 ↩ Reply ▼

This is a DEOS Alert: Predicted Water Level will be 4.56 ft at 2010/08/29 13:00:00 EDT at Lewes, DE. Go to <http://www.deos.udel.edu/> for more information. [2548655]

↩ Reply → Forward

- ◆ Intended use: Let emergency managers know they need to begin keeping an eye on tide gages and possibly begin preparations for any potential flooding.



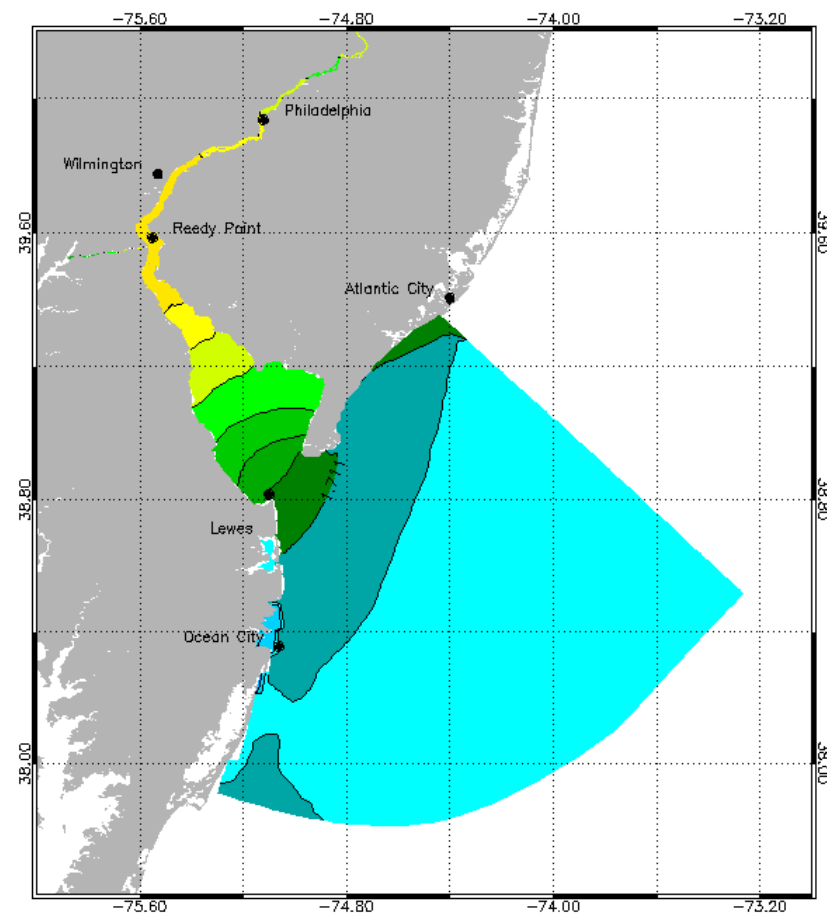
# Input Data

- ◆ Water Level Forecast - Delaware Bay Operational Forecast System (DBOFS)
- ◆ Digital Elevation Model – Delaware Lidar



# DBOFS Forecast

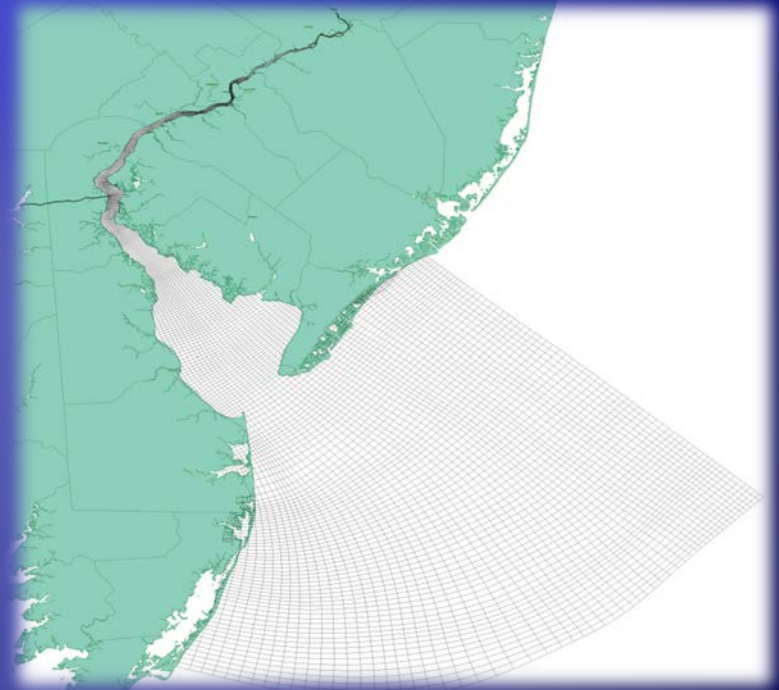
- ◆ NOAA Delaware Bay Operational Forecast System
- ◆ 48-hr prediction
- ◆ Water levels, temp, winds, salinity, currents
- ◆ Updated every 6 hours



Valid at 0100 (EST) 02/24/12

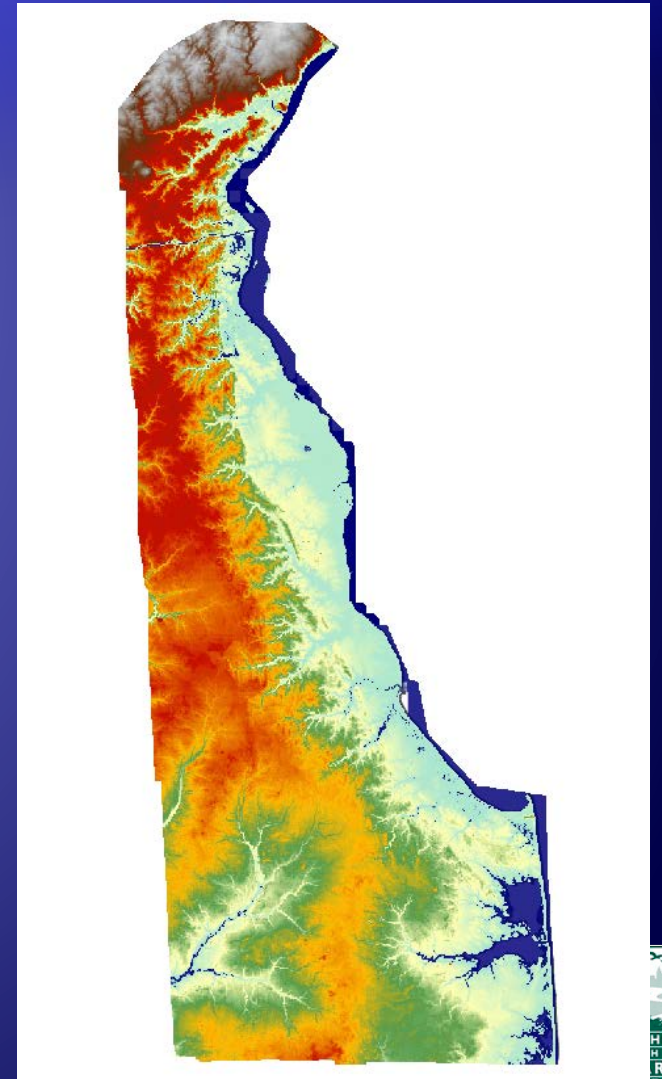
# DBOFS Forecast

- ◆ 48-hour forecast
- ◆ 4xdaily, hourly output
- ◆ 100m – 3km grid cell
- ◆ 119 x 732 x 10
- ◆ ROMS hydro model
- ◆ Winds: NAM-12, then GFS
- ◆ Nowcast mode: CO-OPS and USGS obs
- ◆ Forecast mode: ET-Surge and Nowcast output for boundary/initial conditions



# Lidar Elevation Data

- ◆ Kent and New Castle Counties – 2007
- ◆ Sussex County – 2005
- ◆ Bare earth point observations reprocessed at NOAA CSC
  - ◆ state-wide, seamless, 2-meter
- ◆ RMSE: +/- 18.5 cm (37.5 for heavily veg areas)



# Current Status

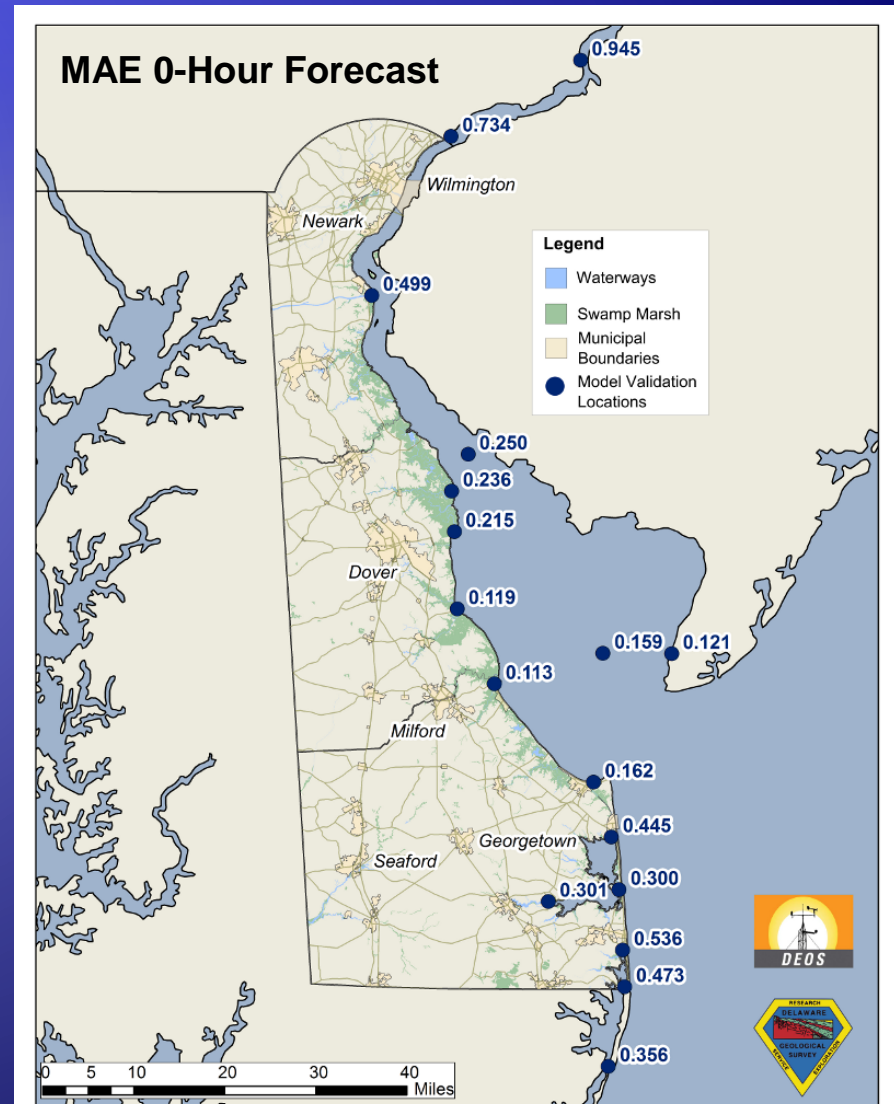
- ◆ Prototype developed in Summer 2011 for Kent County communities only. Current version in beta testing.
- ◆ Scheduled for release in early 2013 (Feb?)
- ◆ Overall, very positive response; forecasts seem to do well with magnitude.
- ◆ User Guide and training workshops in the works.

# What's Next? (In Development)

# 1. Forecast Tweaks

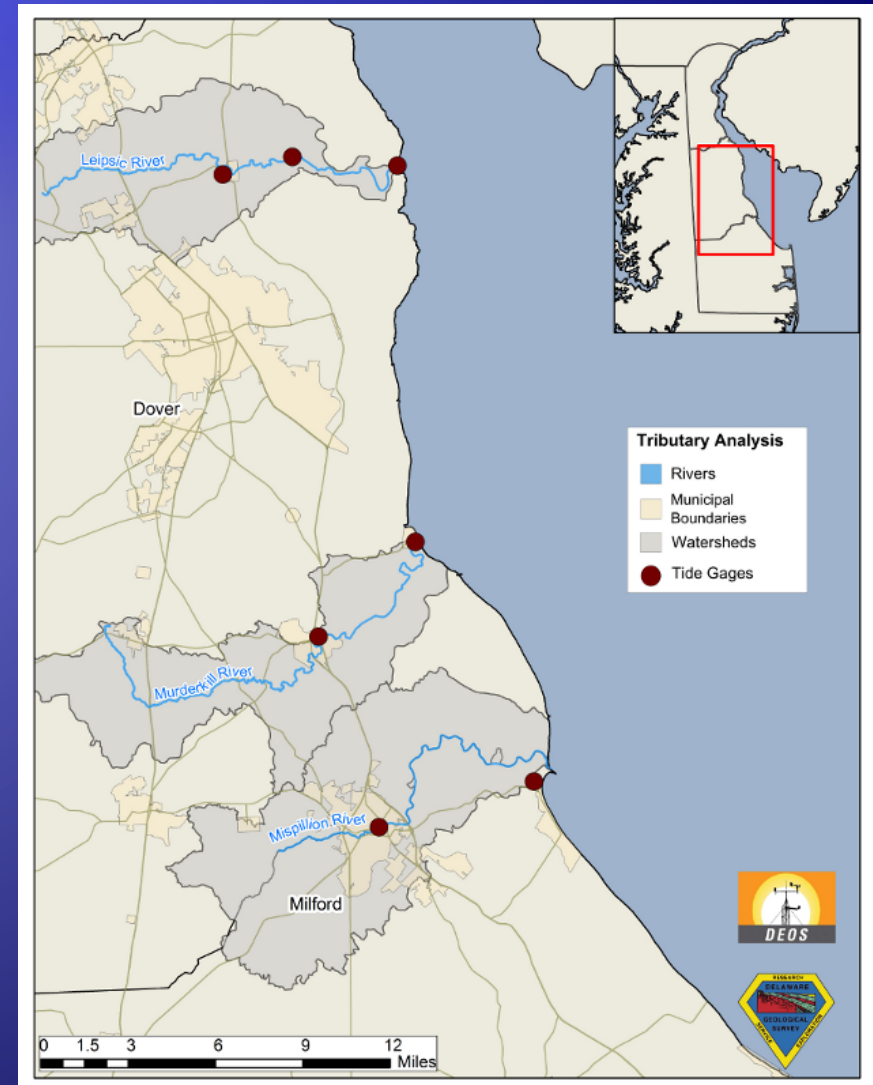
- ◆ Compare DBOFS model coastal predictions to observation data
- ◆ Incorporate bias into predictions
  - ◆ Based on time, location, tidal cycle, meteorological conditions

(Poster on model evaluation analysis)



# 2. Tributary Analysis

- ◆ Analyze observational data along major tributaries
  - ◆ Based on met. conditions, tidal cycle, location
- ◆ Integrate into CFMS; more accurate flood maps for inland communities
  - ◆ move away from bathtub model?



# 3. More Coverage

- ◆ Delaware Inland Bays
  - ◆ DBOFS does not work well here; different hydro model or statistical model
- ◆ Piedmont Region
  - ◆ Need to incorporate precipitation run-off
- ◆ Data Collection
  - ◆ Installed 6 new sensors in Summer 2012
  - ◆ Need more in a few locations





# Thank You!



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Kevin Brinson  
Delaware Environmental  
Observing System  
[kbrinson@UDel.Edu](mailto:kbrinson@UDel.Edu)

DNREC Coastal Programs

