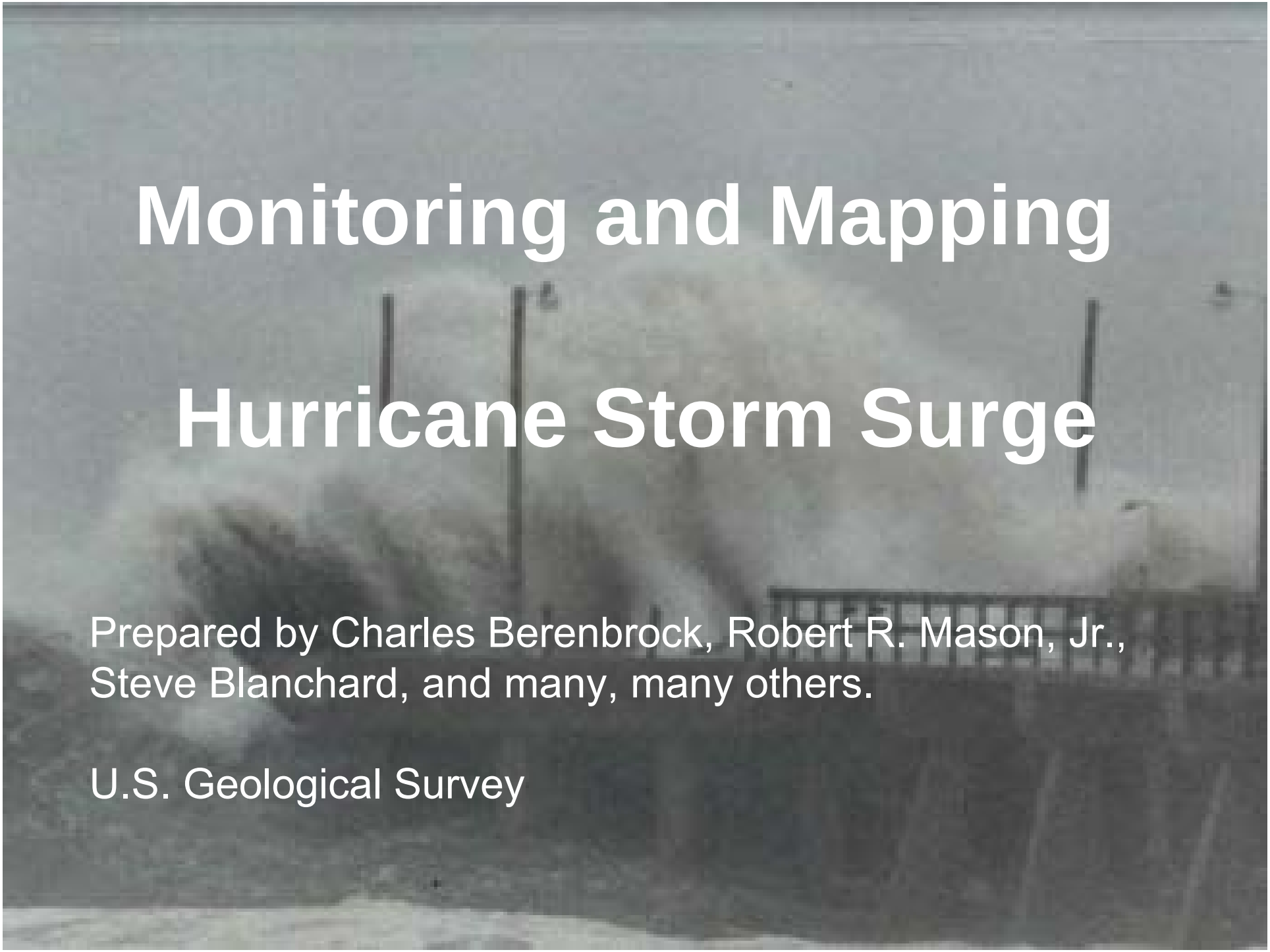


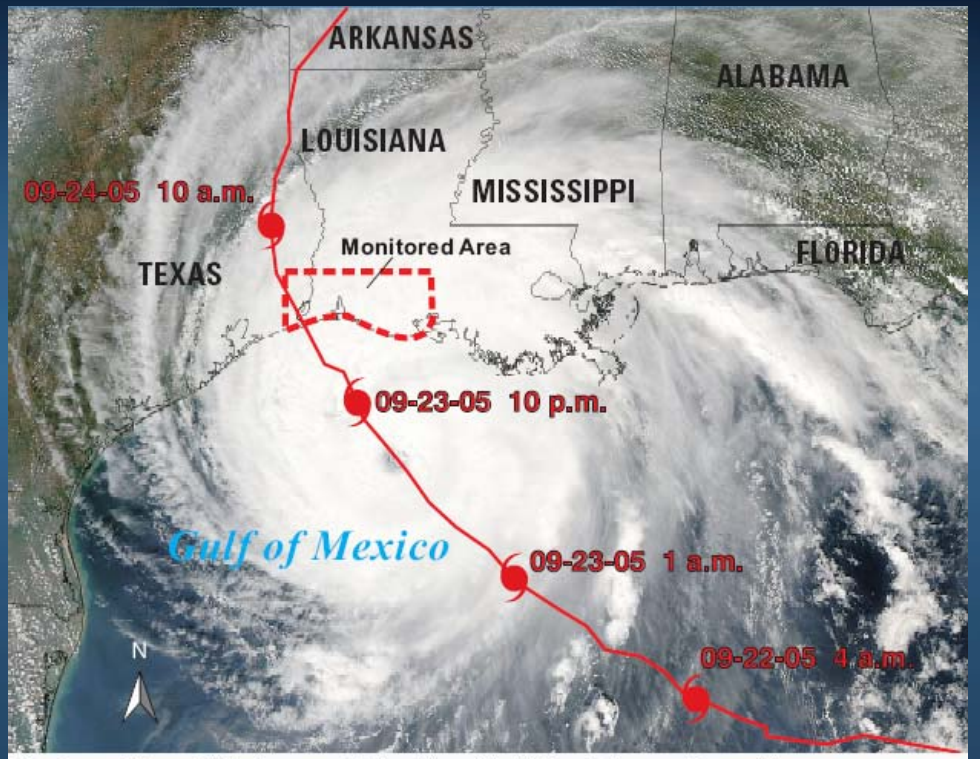
Monitoring and Mapping Hurricane Storm Surge

Prepared by Charles Berenbrock, Robert R. Mason, Jr., Steve Blanchard, and many, many others.

U.S. Geological Survey

Presentation Outline

- Need and motivation
- Monitoring Approach
  - New instruments
  - Mobile network
- Example deployment
- Monitoring Results for Rita
- Mapping Rita storm tide
- Plans for improvement



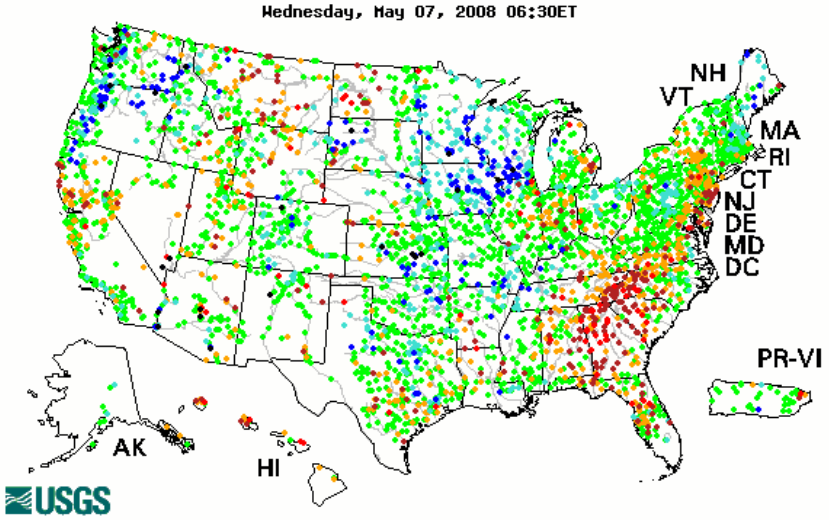
Hurricane Rita satellite imagery obtained from the National Aeronautics and Space Administration (2006).

USGS

Earthquakes ★ Floods ★ Hurricanes ★ Landslides ★ Tsunamis ★ Volcanoes ★ Wildfires

WaterWatch -- *Current water resources conditions*

Map of real-time streamflow compared to historical streamflow for the day of the year (United States)

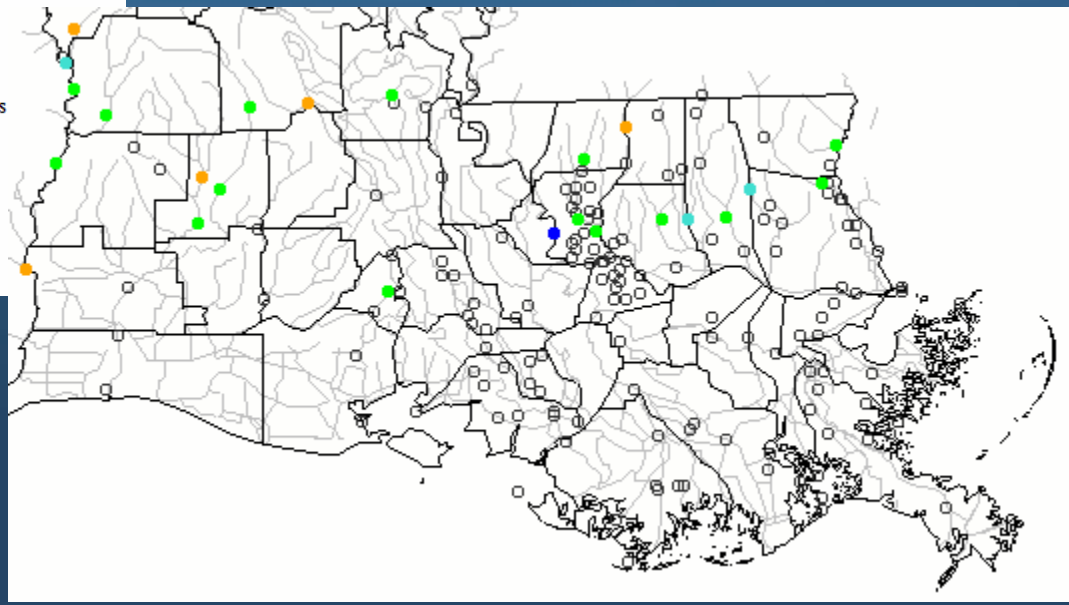


Choose a data retrieval option and select a location on the map

○ List of all stations in state, ◉ State map, or ○ Nearest stations

Explanation - Percentile classes						
●	●	●	●	●	●	●
Low	<10 Much below normal	10-24 Below normal	25-75 Normal	76-90 Above normal	>90 Much above normal	High

Experience from Katrina

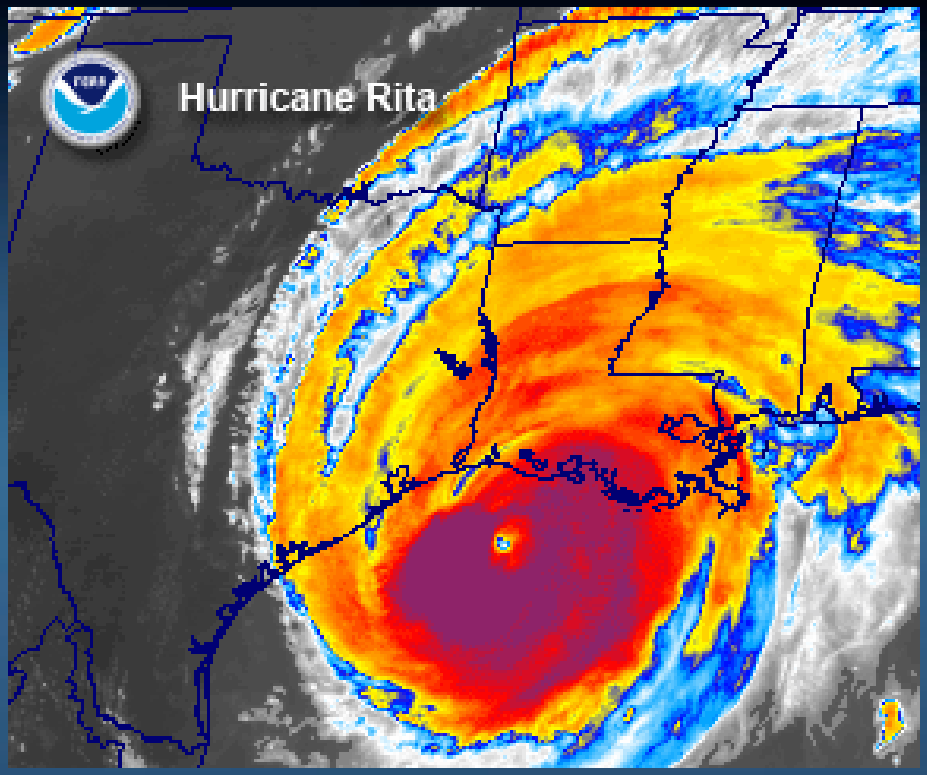


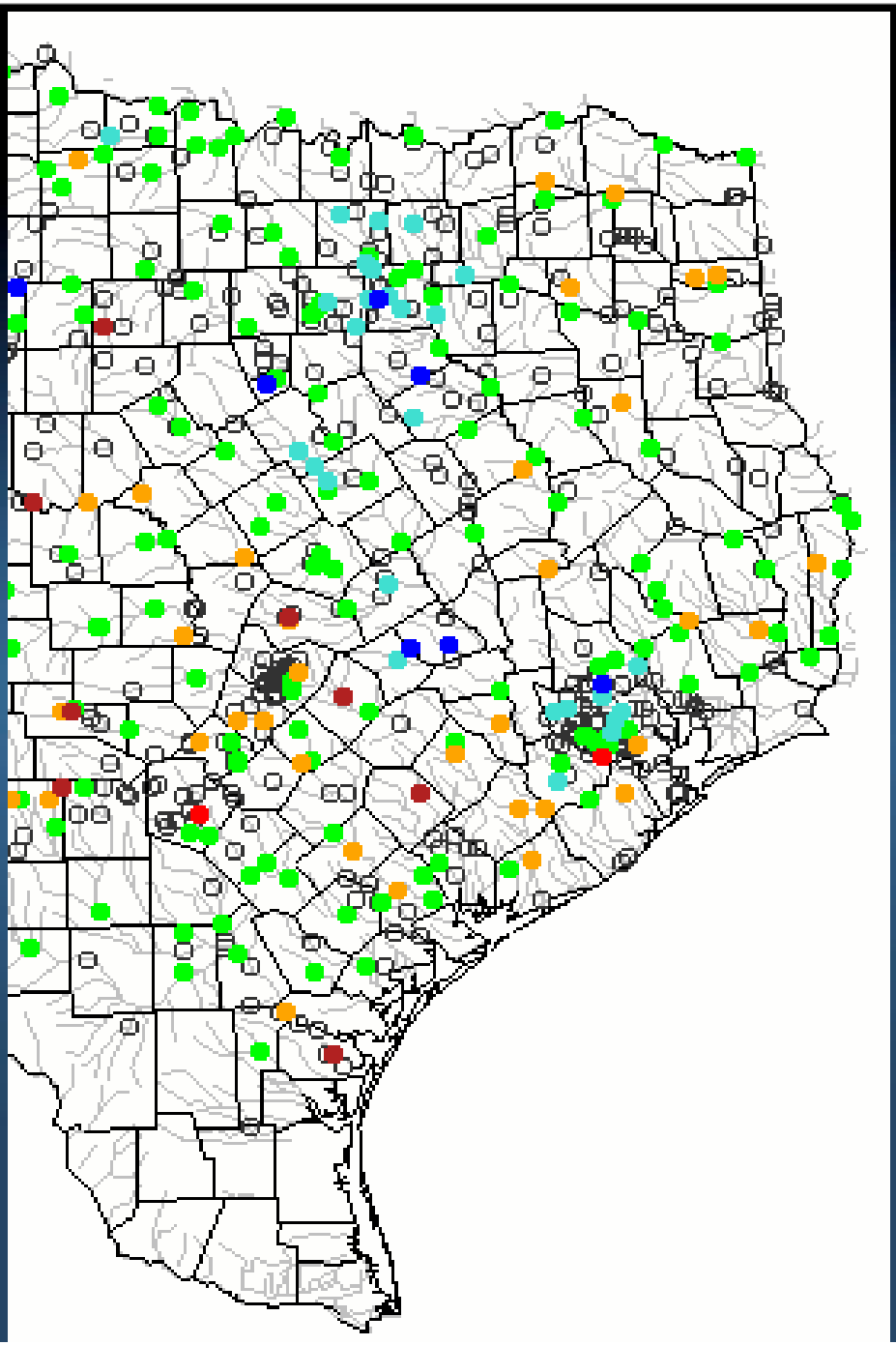
USGS

High Water Marks

USGS

Earthquakes ★ Floods ★ Hurricanes ★ Landslides ★ Tsunamis ★ Volcanoes ★ Wildfires





USGS

Problem: Need Inland Storm-Surge Data

- Coastal gages are scarce and vulnerable (USGS and NOAA lost about 35 gages during Katrina)
- HWMs provide limited information and are difficult to interpret

USGS

Factors Affecting Storm-Surge

- Storm intensity
- Forward speed
- Landfall approach angle
- Inclination of the sea floor - shallower inclines lead to high and more penetrating surge
- Local topography - bays, shore orientation, and offshore islands can funnel and amplify the storm Surge.

USGS Storm-Surge Program Objectives

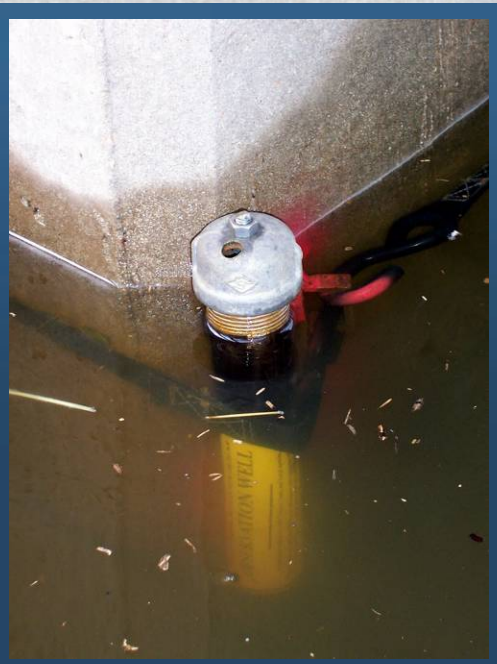
- Provide data for:
  - Development of inundation maps
  - Calibration/verification of storm-surge models
  - Aide development of model parameterization schemes (inland wind-water drag and -wave height relationships)
  - Assess performance of topographical or engineered structures
  - (Eventually) real-time assessments and warnings

USGS

New Technology

- Unvented pressure transducers (40/storm)
  - Record temperature and pressure for 8 days at 30 second intervals
  - Mobile
  - Self-contained
  - Inexpensive
  - Accurate (+/- 0.05)
- Steel-pipe housing units
- **Entire** hydrograph—not just peak

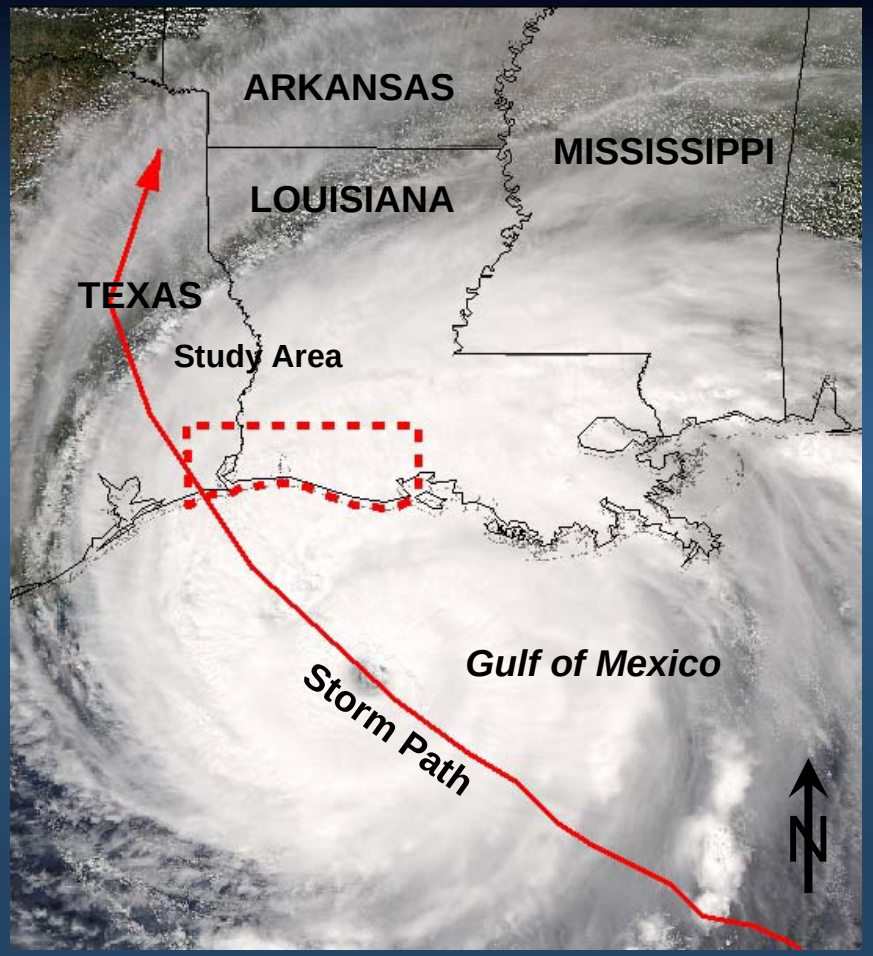
Hobo by Onset



USGS

First Deployment -Hurricane Rita

- Study area positioned east of the hurricane track
- Covered approx. 4,000 square miles
- Extended approx. 30 miles inland and 140 miles along the coast
- Site selection emphasized road access
- Target bridges and piers near waterways
- Supplement with “transects” when possible



USGS

Sensor Deployment

- USGS Storm-Tide Response Centers (Ruston, LA., Atlanta, and Orlando) and storm-affected USGS offices
- Involve 8-15 people
  Rita 6, Wilma 8
  Ernesto 11
- 30 to 70 sites per storm
  Rita 47, Wilma 35,
  Ernesto 70
- 2-person crews
- Deploy 24-36 hours prior to landfall

USGS

Sensor Deployment –Con't

- Strap-on sensors, mark Ref Pts, take pictures, get GPS coordinates
- Check-in each hour
- "Clear out" at 12 hours to landfall

USGS

Time in field: Rita 11 hours, Wilma 15, and Ernesto 15

Sensor Recovery

- Retrieve sensors, flag HWMs, tape-down to H_2O, run local levels Download, adjust data for barometric pressure, salinity, and upload to web
- Follow-on GPS crews run levels and determine local datum

USGS

Earthquakes ★ Floods ★ Hurricanes ★ Landslides ★ Tsunamis ★ Volcanoes ★ Wildfires

THE SUN NEWS MyrtleBeachOnline.com

Posted on Sat, Sep. 02, 2006

Pipe bomb look-alike blown up at Pier 14

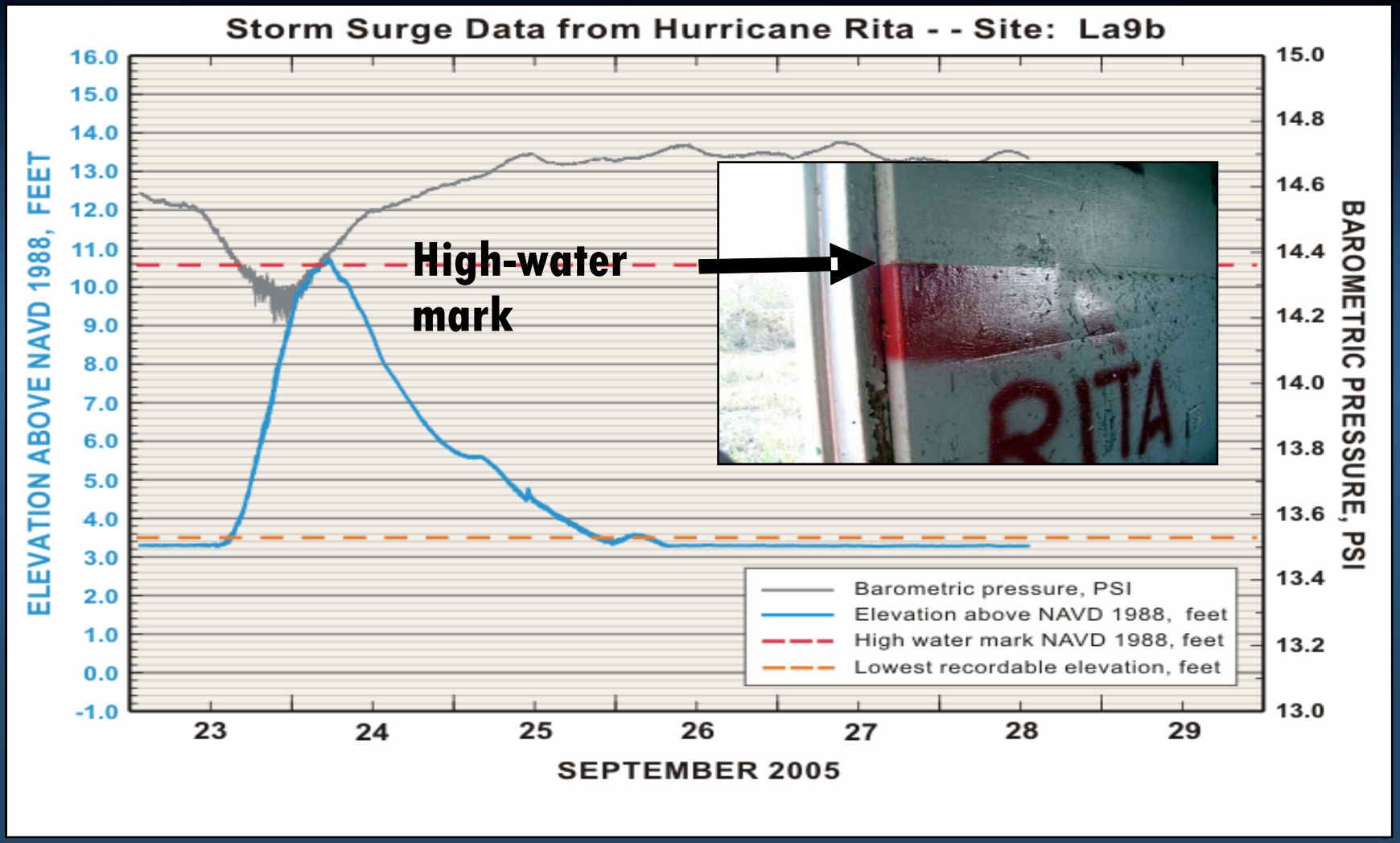
Device placed to gauge storm surge of Ernesto

By Janelle Frost and Tonya Root
The Sun News

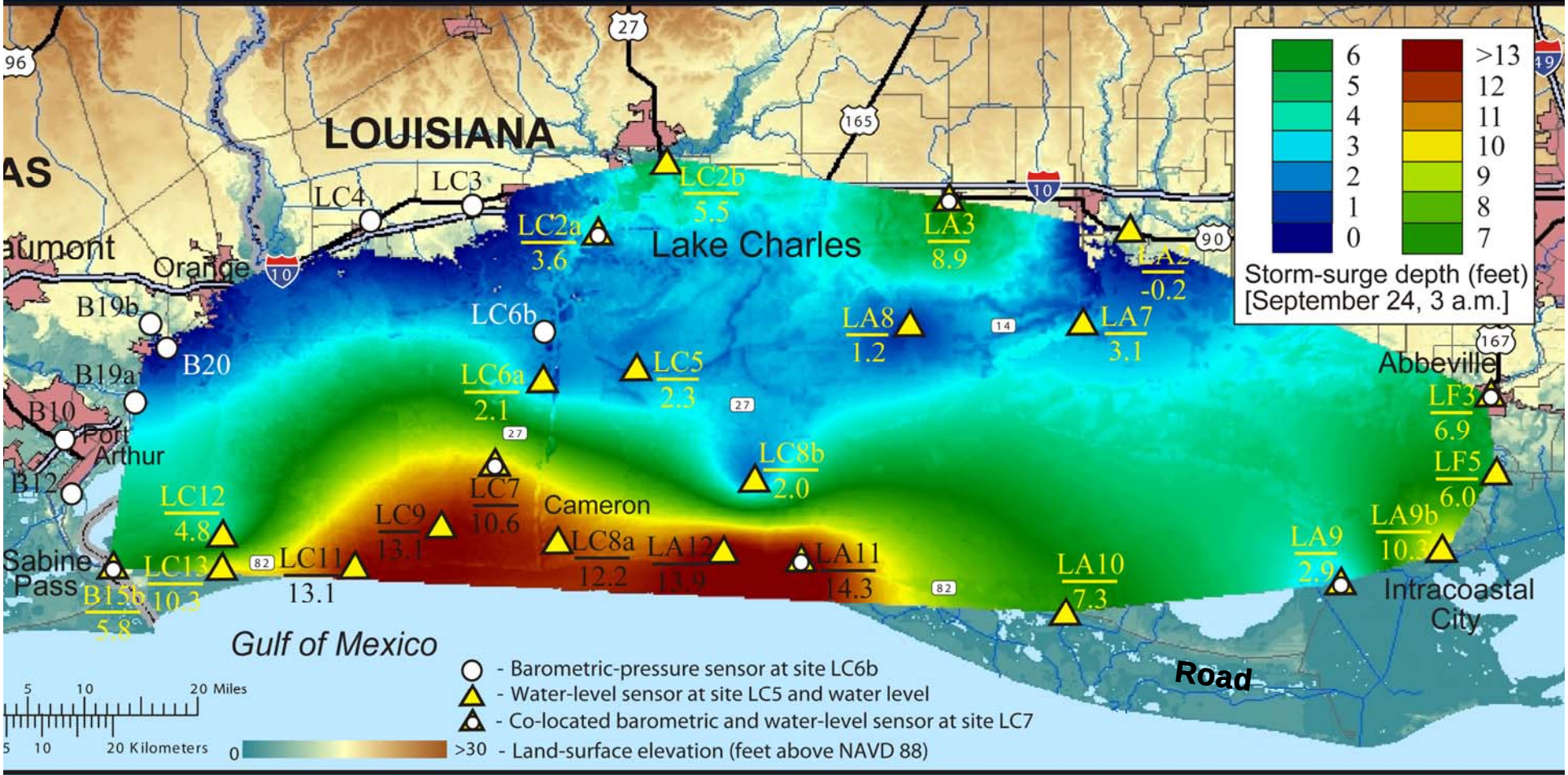
A device meant to measure Tropical Storm Ernesto's impact caused an evacuation at Myrtle Beach's Pier 14 restaurant and drew a crowd of onlookers Friday after it was thought to be a pipe bomb.

Myrtle Beach police were called about 10:30 a.m. by someone v
box strapped to a pylon under the pier at 14th Avenue North, My
He said police checked to see whether the device was registere

Results …Water-Level Hydrographs



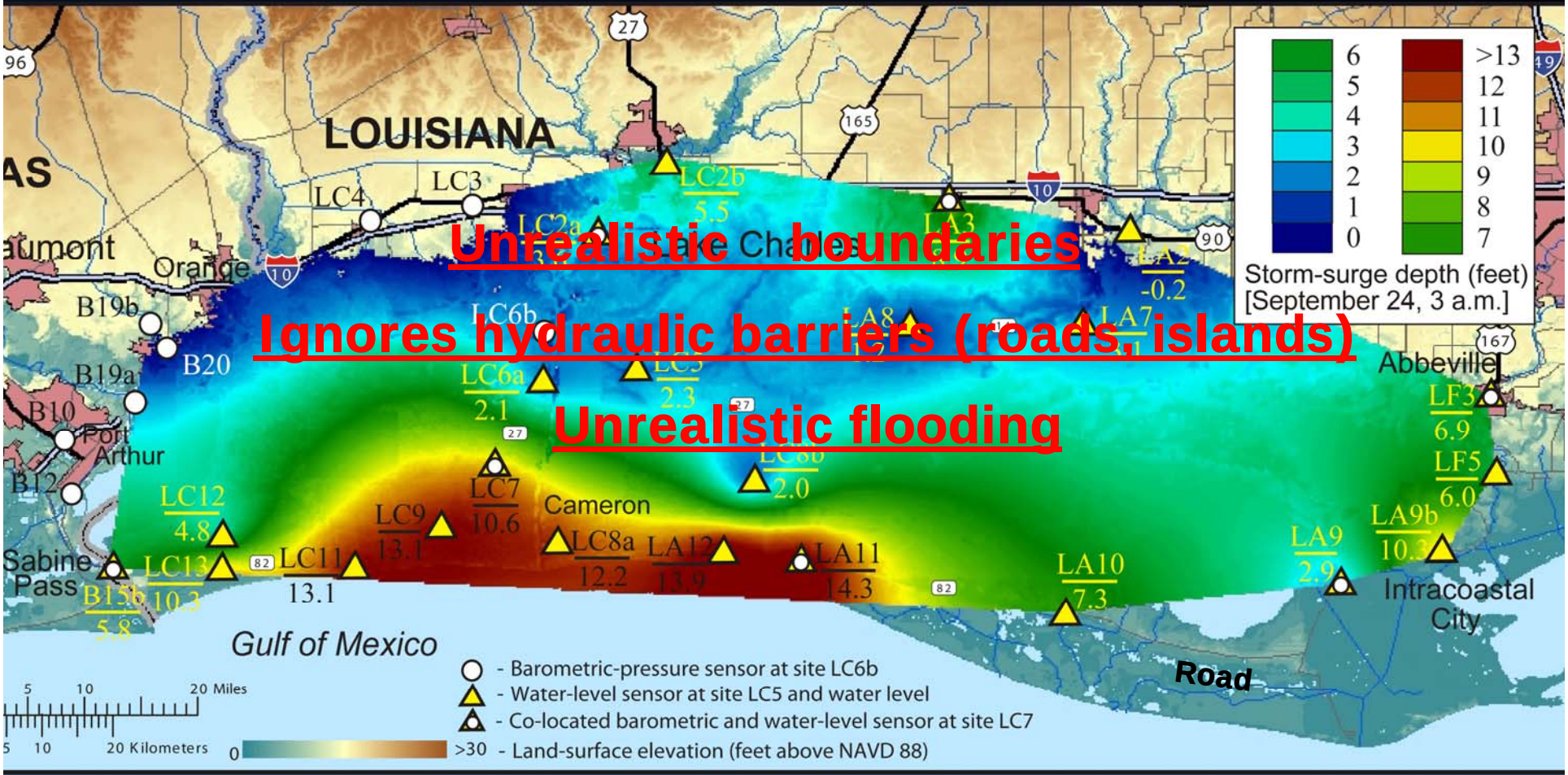
Initial process yielded unrealistic map



USGS

(Modified from figure 8 of McGee and others, 2006b)

Initial process yielded unrealistic map



USGS

(Modified from figure 8 of McGee and others, 2006b)

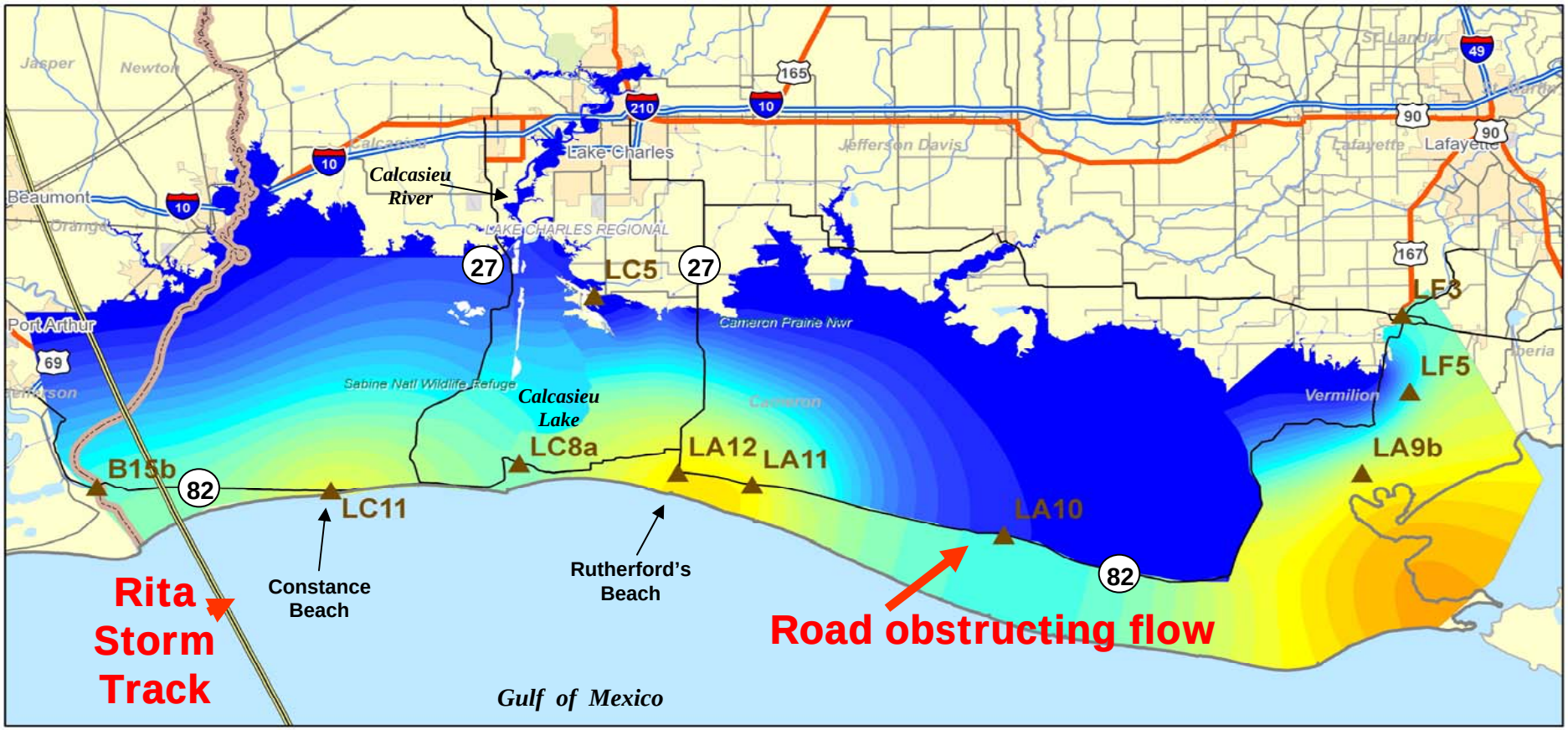
Improved map — Barrier Mapping Process

- Identify/remove data affected by riverine runoff
- Create initial spline-fit of water surface (WS)
- Identify/digitize hydraulic barriers and flow connections
  - Elevated roads, levees, islands
  - Roadway sags, dune breaches, levees break, culverts
- Contour zero depth (where DEM meets WS)
- "Seed" control points on zero contour
- Refit data with "high-tension spline"

(New spline will optimize around barriers and through hydraulic connections.)

USGS

Storm Surge at 12:00 am (midnight)



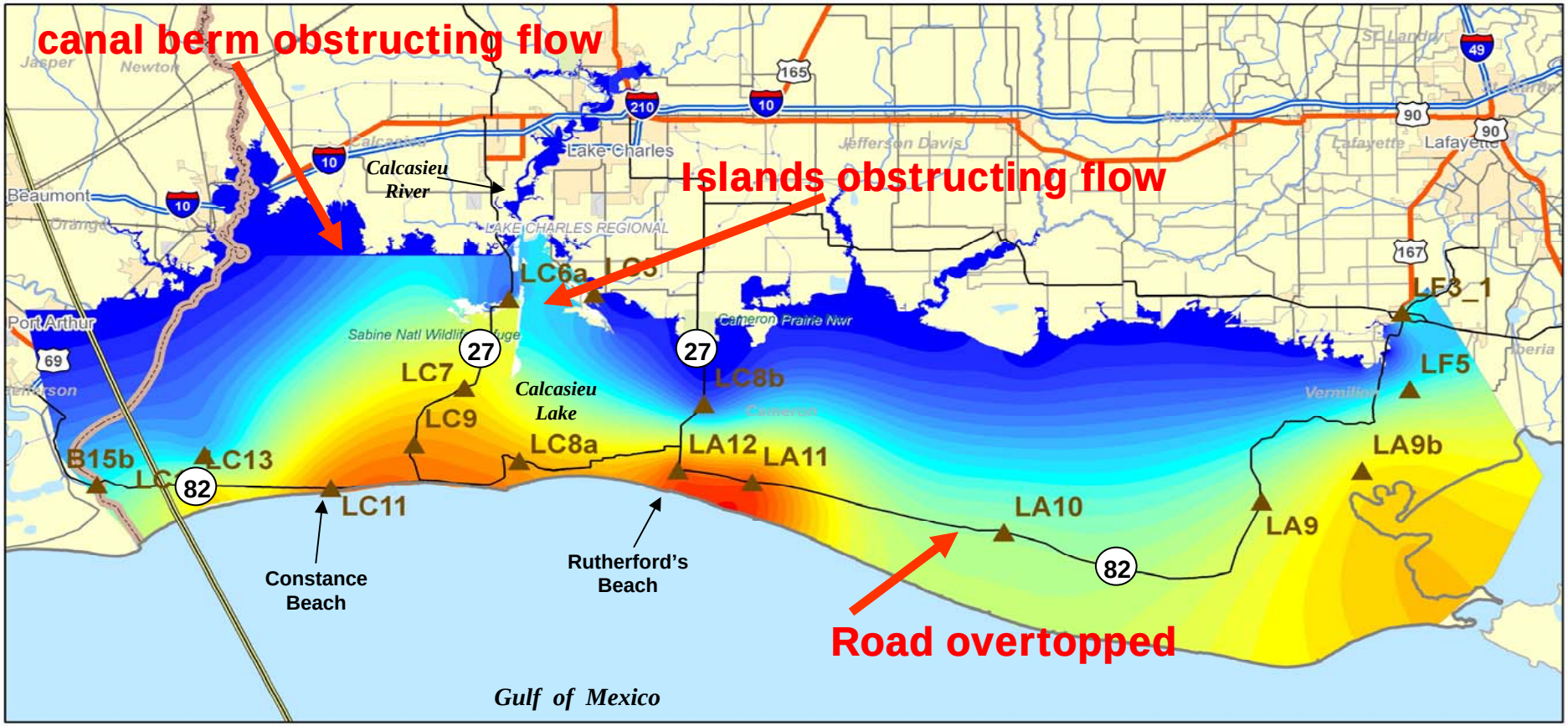
Explanation

▲ LC11 — USGS Storm surge sensor

Storm-tide elevation, in feet above NAVD88

0 - 2	6 - 8	12 - 14
2 - 4	8 - 10	14 - 16
4 - 6	10 - 12	

Storm Surge at 3:00 am



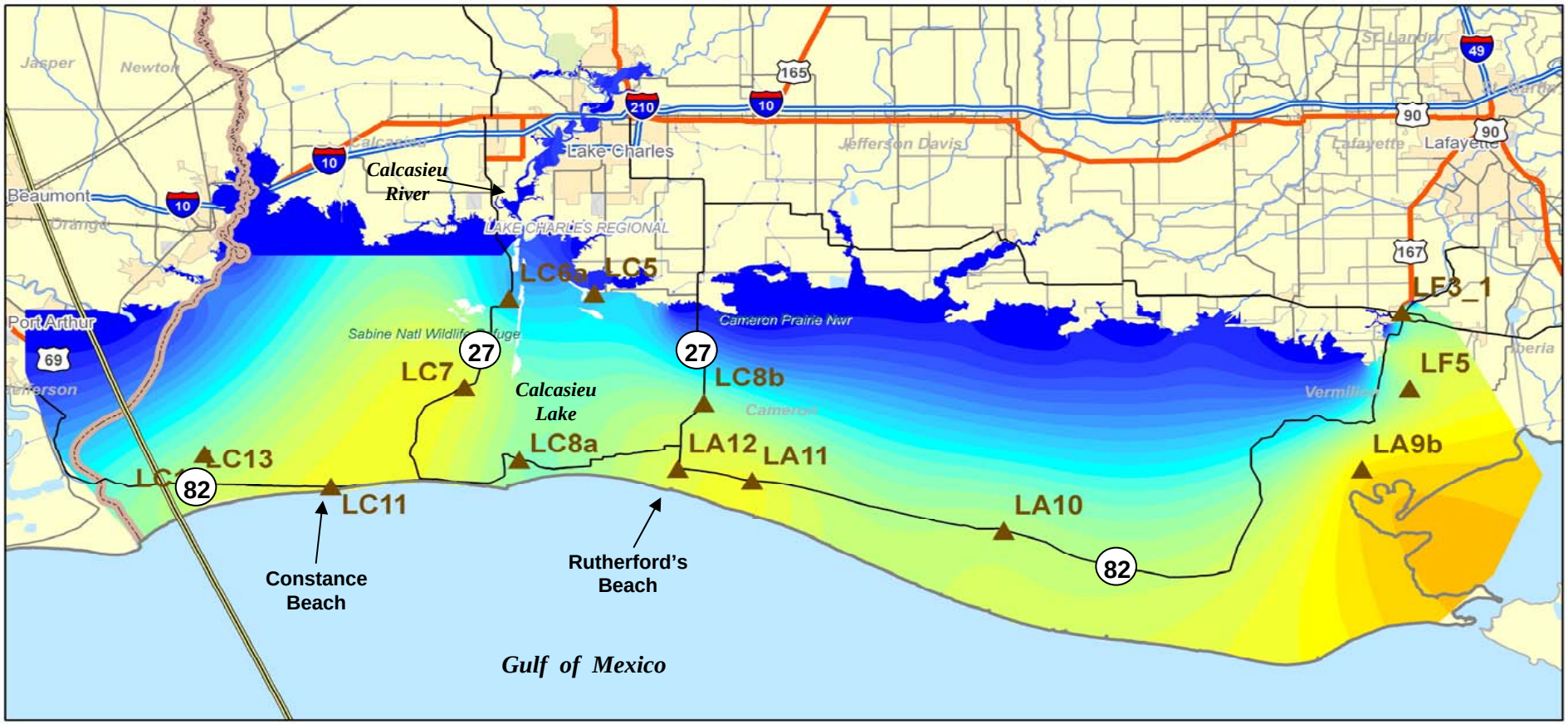
Explanation

▲ **USGS Storm surge sensor**
LC11

Storm-tide elevation, in feet above NAVD88

0 - 2	6 - 8	12 - 14
2 - 4	8 - 10	14 - 16
4 - 6	10 - 12	

Storm Surge at 6:00 am



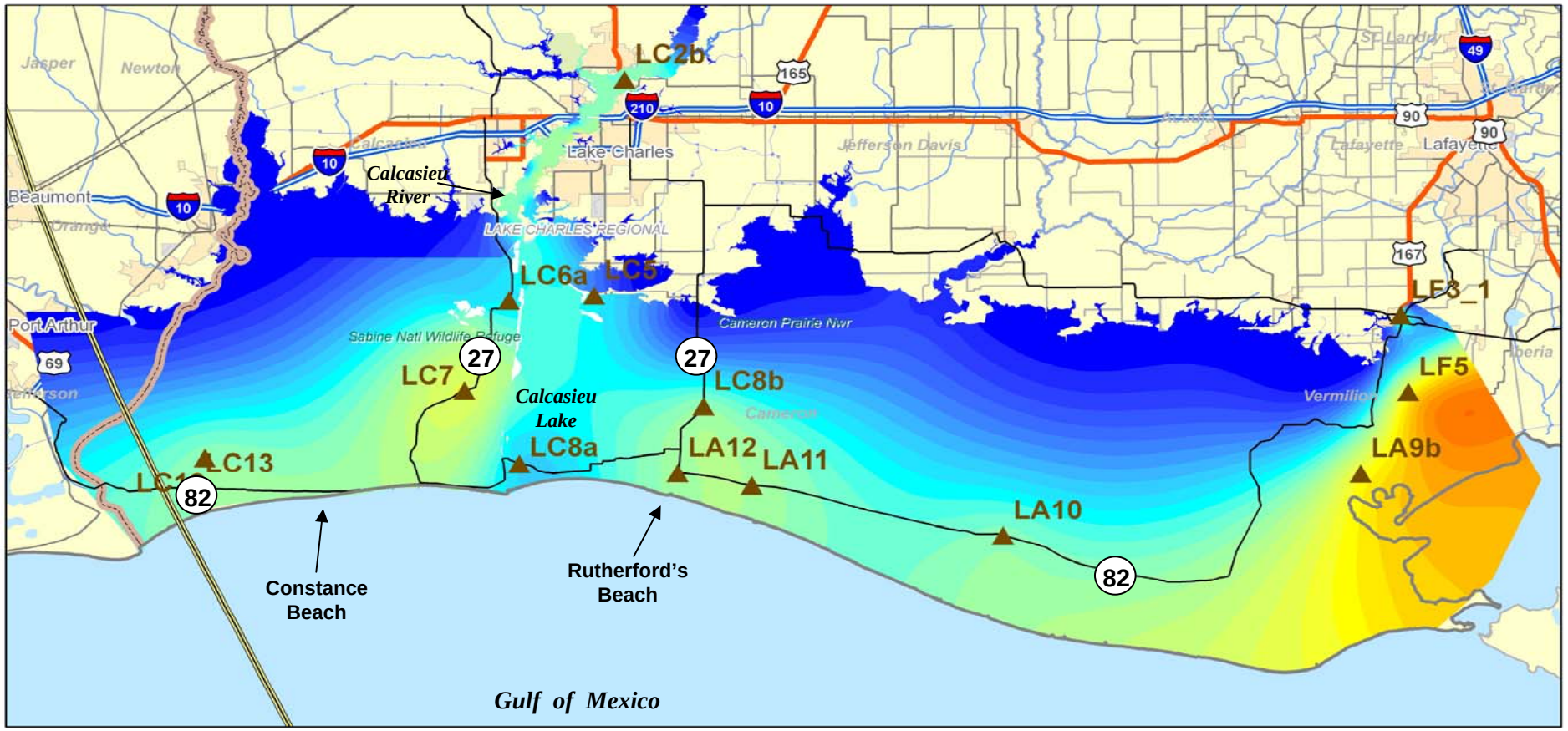
Explanation

▲ **USGS Storm surge sensor**
LC11

Storm-tide elevation, in feet above NAVD88

0 - 2	6 - 8	12 - 14
2 - 4	8 - 10	14 - 16
4 - 6	10 - 12	

Storm Surge at 9:00 am



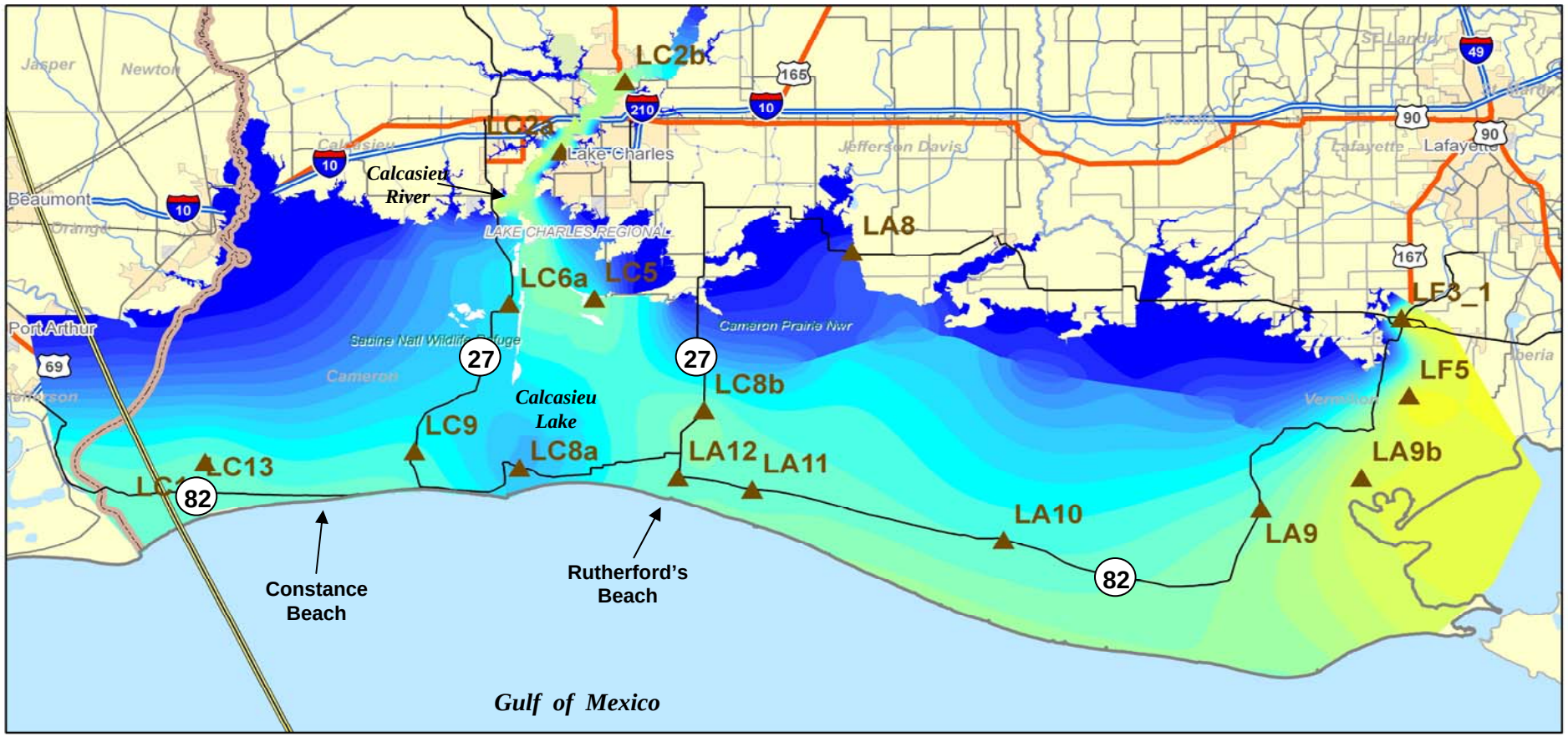
Explanation

▲ USGS Storm surge sensor
LC11

Storm-tide elevation, in feet above NAVD88

0 - 2	6 - 8	12 - 14
2 - 4	8 - 10	14 - 16
4 - 6	10 - 12	

Storm Surge at 12:00 pm (noon)



Explanation

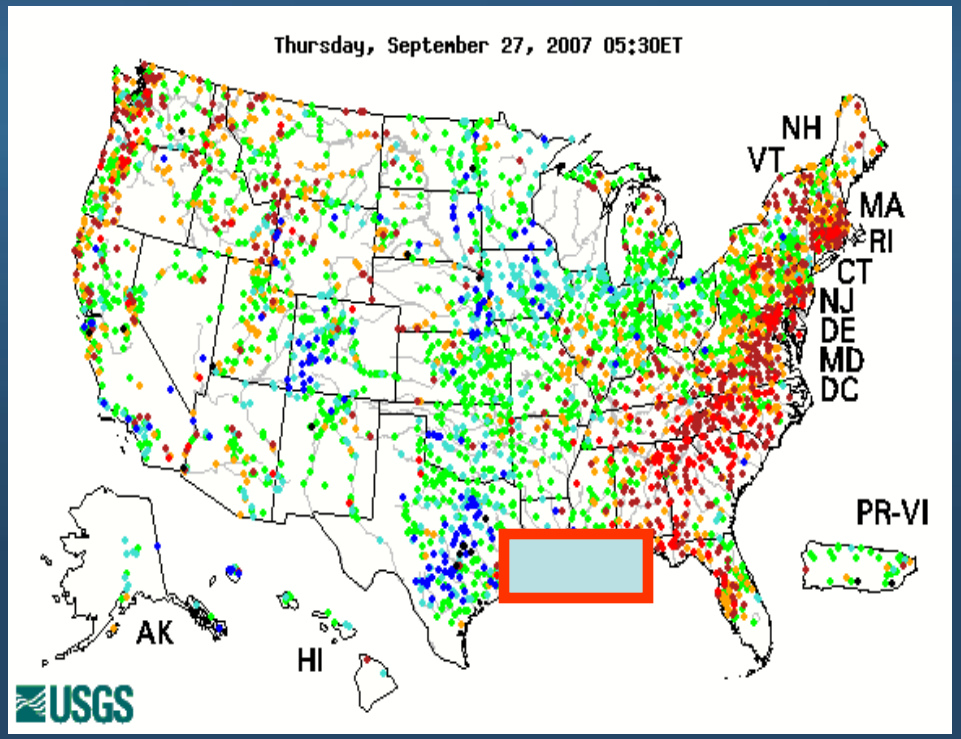
▲ USGS Storm surge sensor
LC11

Storm-tide elevation, in feet above NAVD88

0 - 2	6 - 8	12 - 14
2 - 4	8 - 10	14 - 16
4 - 6	10 - 12	

Planned 2008 Improvements

- Collect continuous salinity at select sites
- Automate pressure and salinity adjustment
- Real-time reporting at select sites (10 test units purchased)
- Improve real-time dissemination



Summary

- Non-vented pressure transducers (sensors) are accurate, reliable, and inexpensive tool to document storm surge and coastal flooding.
- Data collected from sensors can be utilized for a variety of purposes, both long-term and real-time.
- Sensor data and HWMs compliment one another. Sensor data are more consistent, but HWMs cover larger area and greater extremes.
- High Tension Spline mapping including physical structures/barriers provided more realistic inundation maps.

USGS

Questions?

- Robert Mason
  rrmason@usgs.gov
- Charles Berebbrock
  ceberenb@usgs.gov
- Steve Blanchard
  sfblanch@usgs.gov

USGS

Reports and Data

USGS Rita Data Report
http://pubs.usgs.gov/ds/2006/220

USGS Rita Factsheet
http://pubs.usgs.gov/fs/2006/3136/pdf/fs2006-3136.pdf

Current Hydrologic Hazards Map
http://water.usgs.gov/waterwatch/hazards

Inundation-Depth
http://gisdata.usgs.gov/website/gulf

USGS