OFFSHORE PIPELINE STABILITY DURING MAJOR STORM EVENTS

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Minerals Management Service

Government / Industry Pipeline Research and Development Forum

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About the MMS

- Bureau of the Department of the Interior

- Manage the mineral resources located on the Nation's Outer Continental Shelf (OCS)

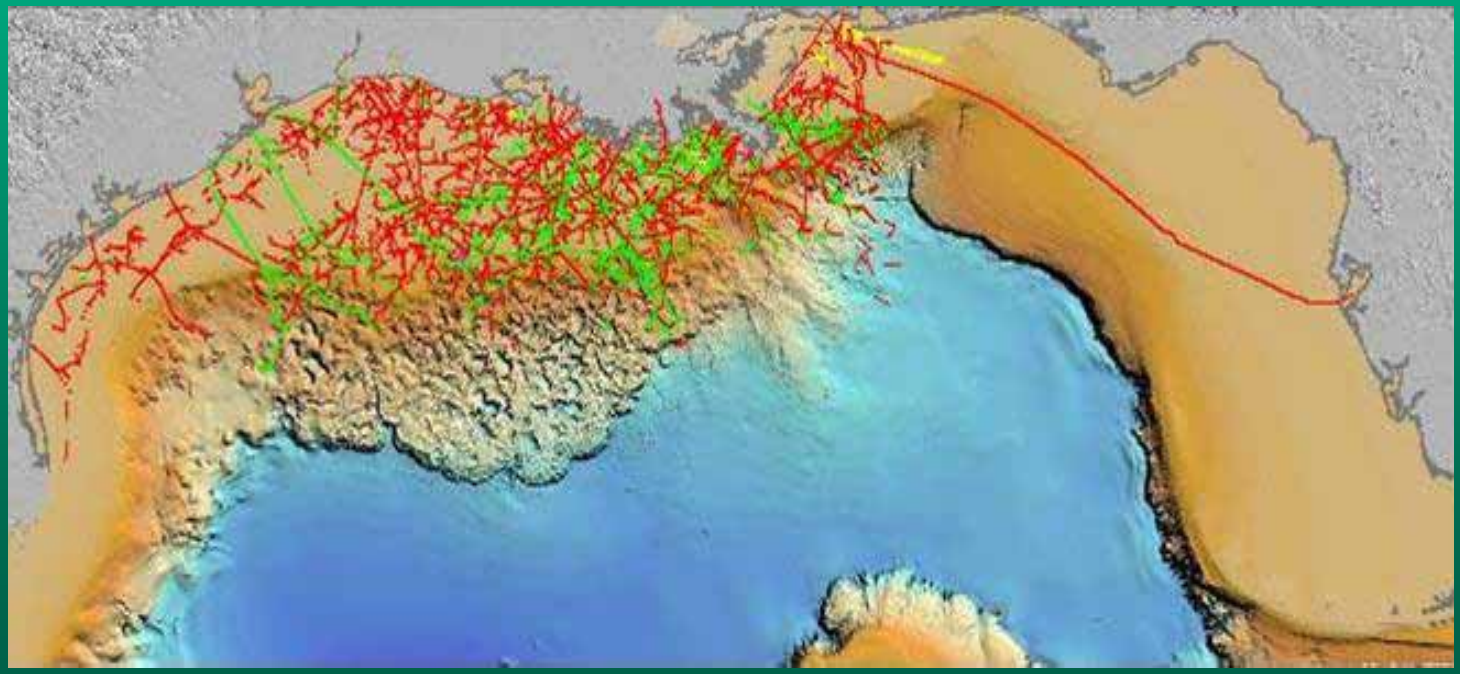
Gulf of Mexico OCS

- 30% of the Nation's oil production (~ 570 million bbls./year)
- 21% of the Nation's natural gas production (~ 5 trillion cu. ft./year)

Gulf of Mexico Infrastructure

Pipelines on the OCS

- 23,313 miles of ACTIVE pipelines
- 12,298 miles of ACTIVE DOT pipelines



Overview

- On-bottom Stability
- Recent events
- Case Studies
- Further Research

Pipeline On-Bottom Stability

Design, Inspection, Maintenance

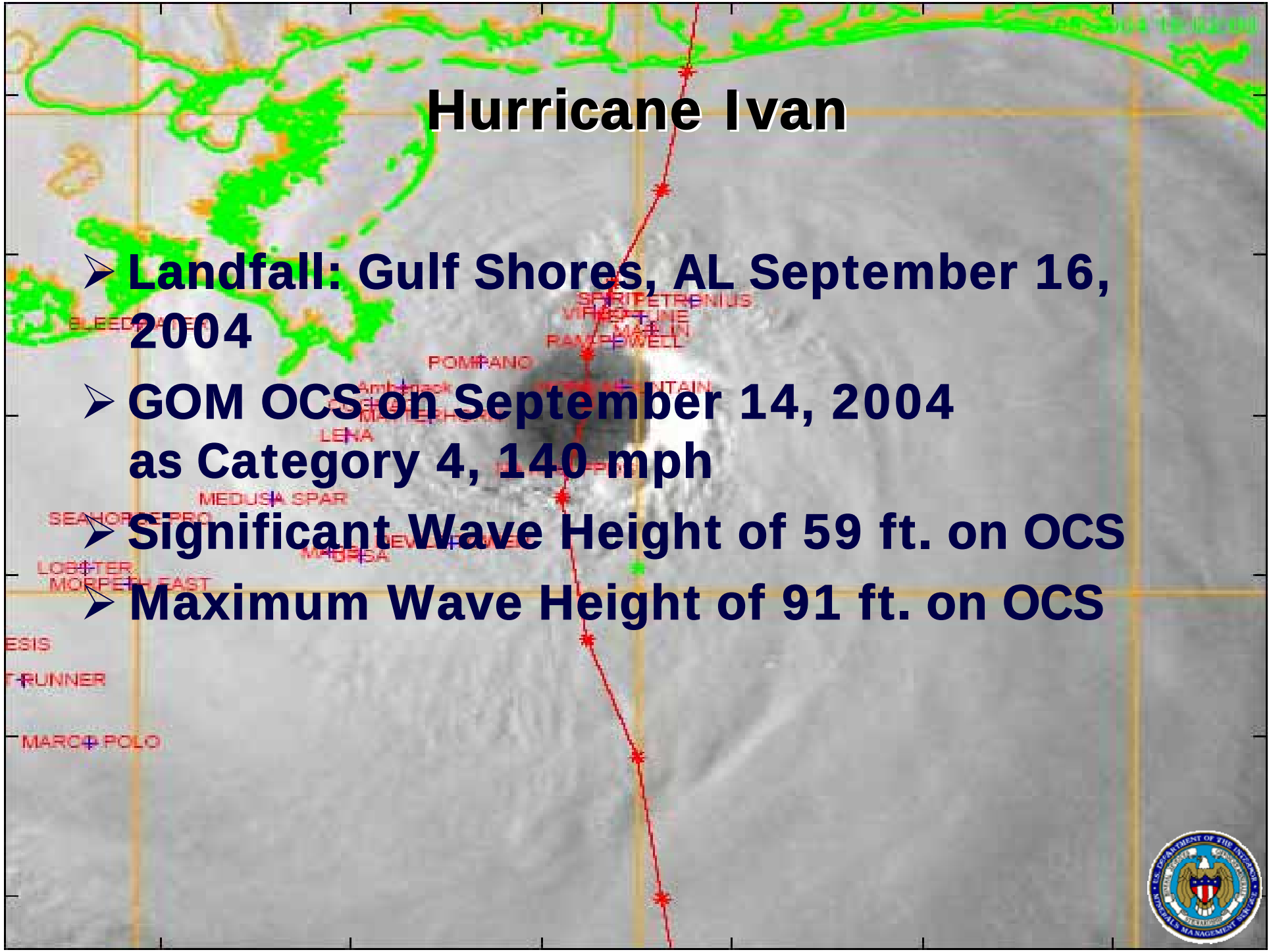
- 100 yr storm or 5x design
- Wave and current forces
- Spanning
- Liquefaction
- Slope failure (mudslide)

Historic On-bottom Stability Cases

Mudslides

Pipeline Stability During Recent Storm Events

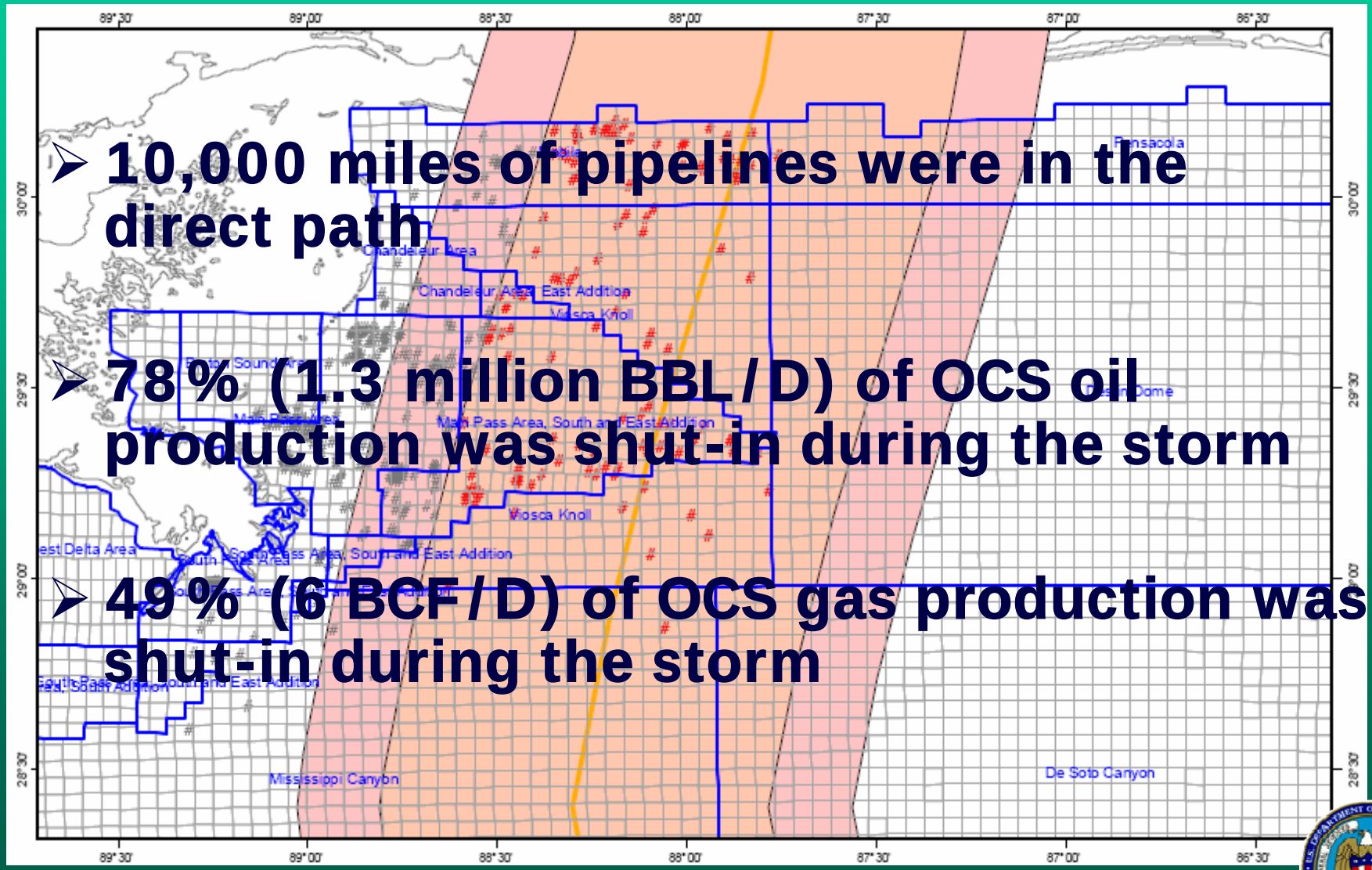
- Large pipe displacements
- Large quantities of pipe affected
- Large pipe diameters
- Non-mudslide events
- High specific gravities



Hurricane Ivan

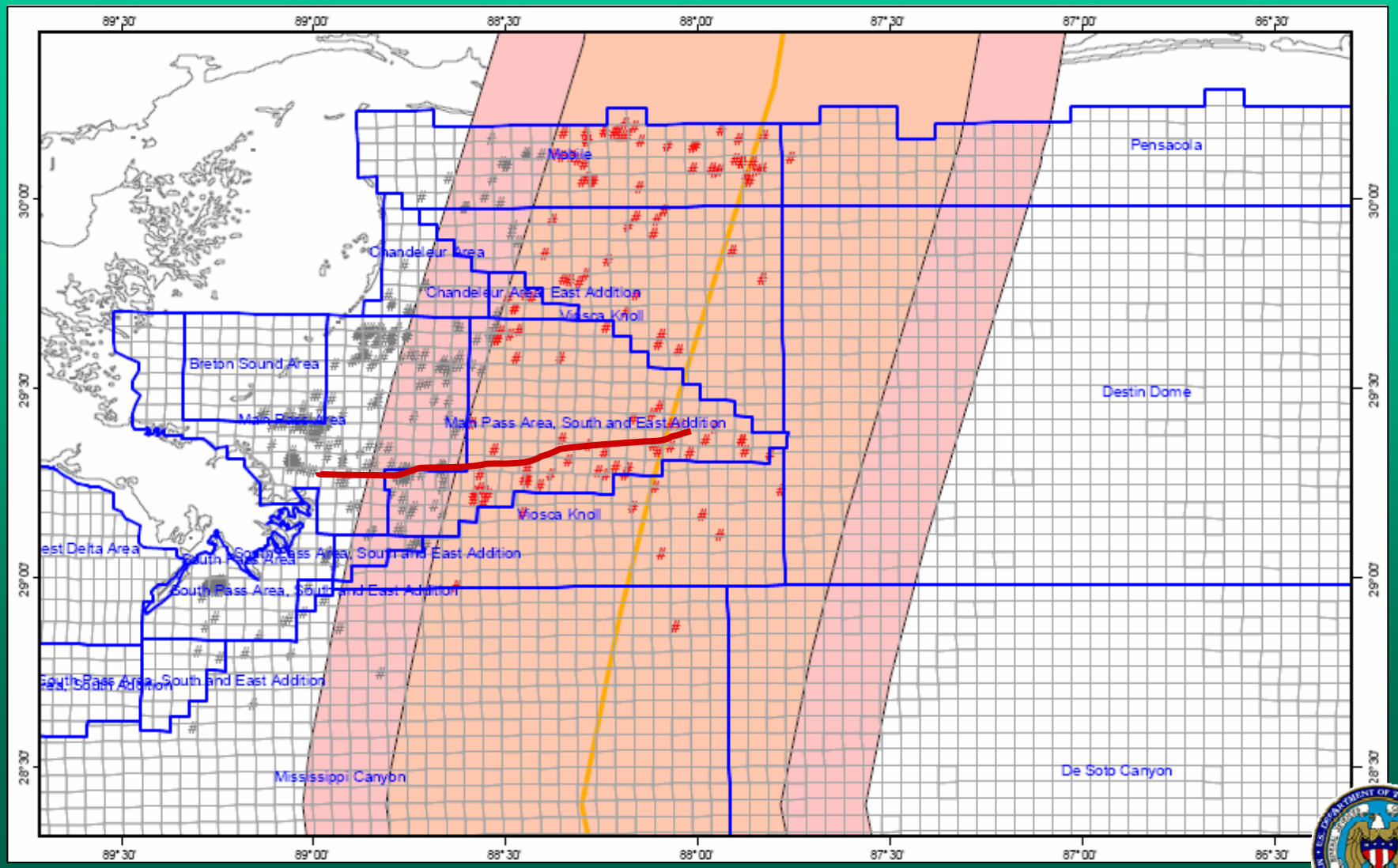
- **Landfall: Gulf Shores, AL September 16, 2004**
- **GOM OCS on September 14, 2004 as Category 4, 140 mph**
- **Significant Wave Height of 59 ft. on OCS**
- **Maximum Wave Height of 91 ft. on OCS**

Hurricane Ivan

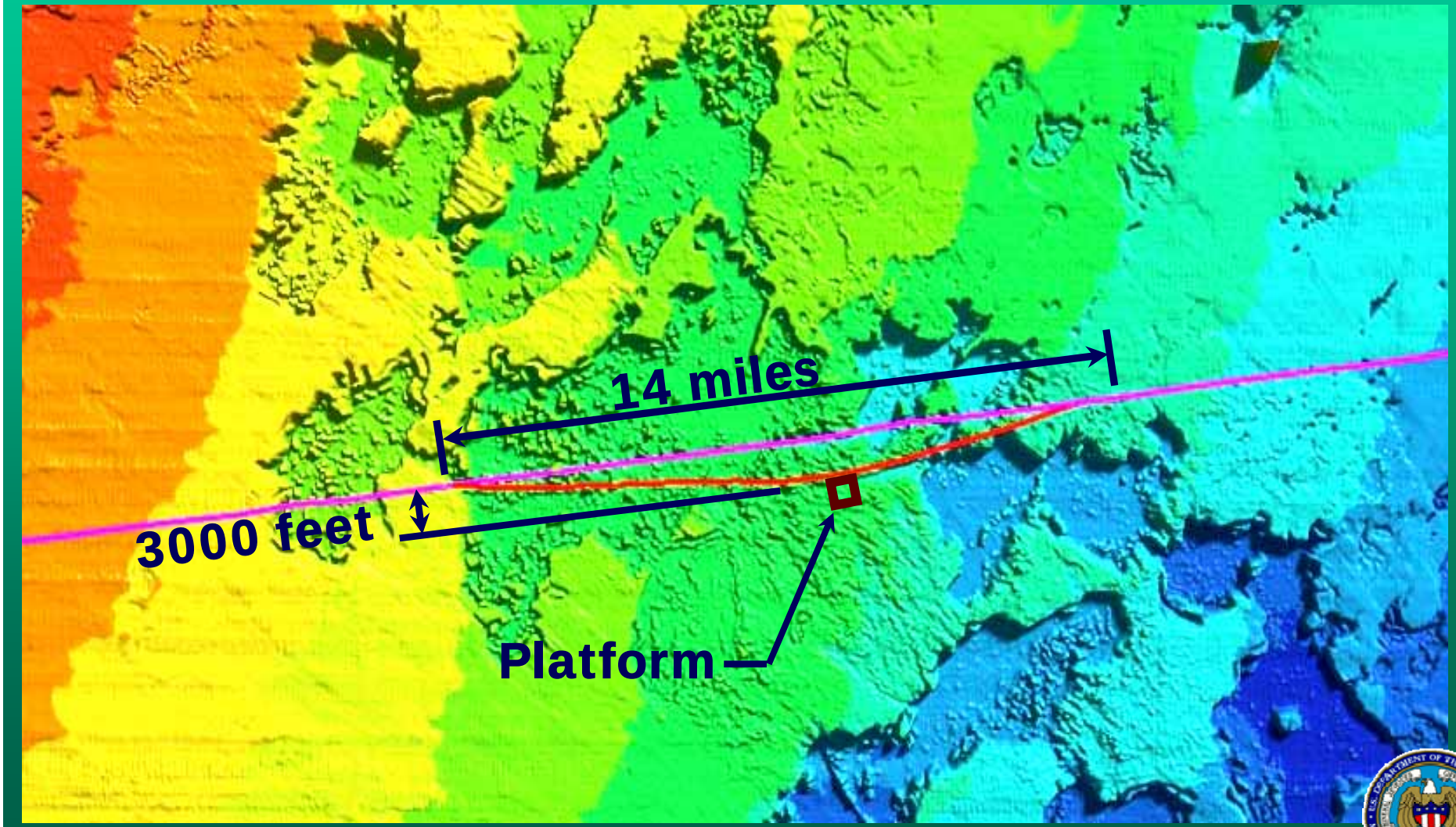


- 10,000 miles of pipelines were in the direct path
- 78% (1.3 million BBL/D) of OCS oil production was shut-in during the storm
- 49% (6 BCF/D) of OCS gas production was shut-in during the storm

Hurricane Ivan
18-inch Oil Pipeline



Hurricane Ivan
18-inch Oil Pipeline



Hurricane Ivan
18-inch Oil Pipeline

Observations

- Pipeline is un-buried
- Relatively deep water
- Pipe Specific Gravity: >1.6
- S.G. is product dependent
- Southward movement

Hurricane Ivan
18-inch Oil Pipeline

Possible Causes

- Storm surge recession (post storm)
- Soil liquefaction

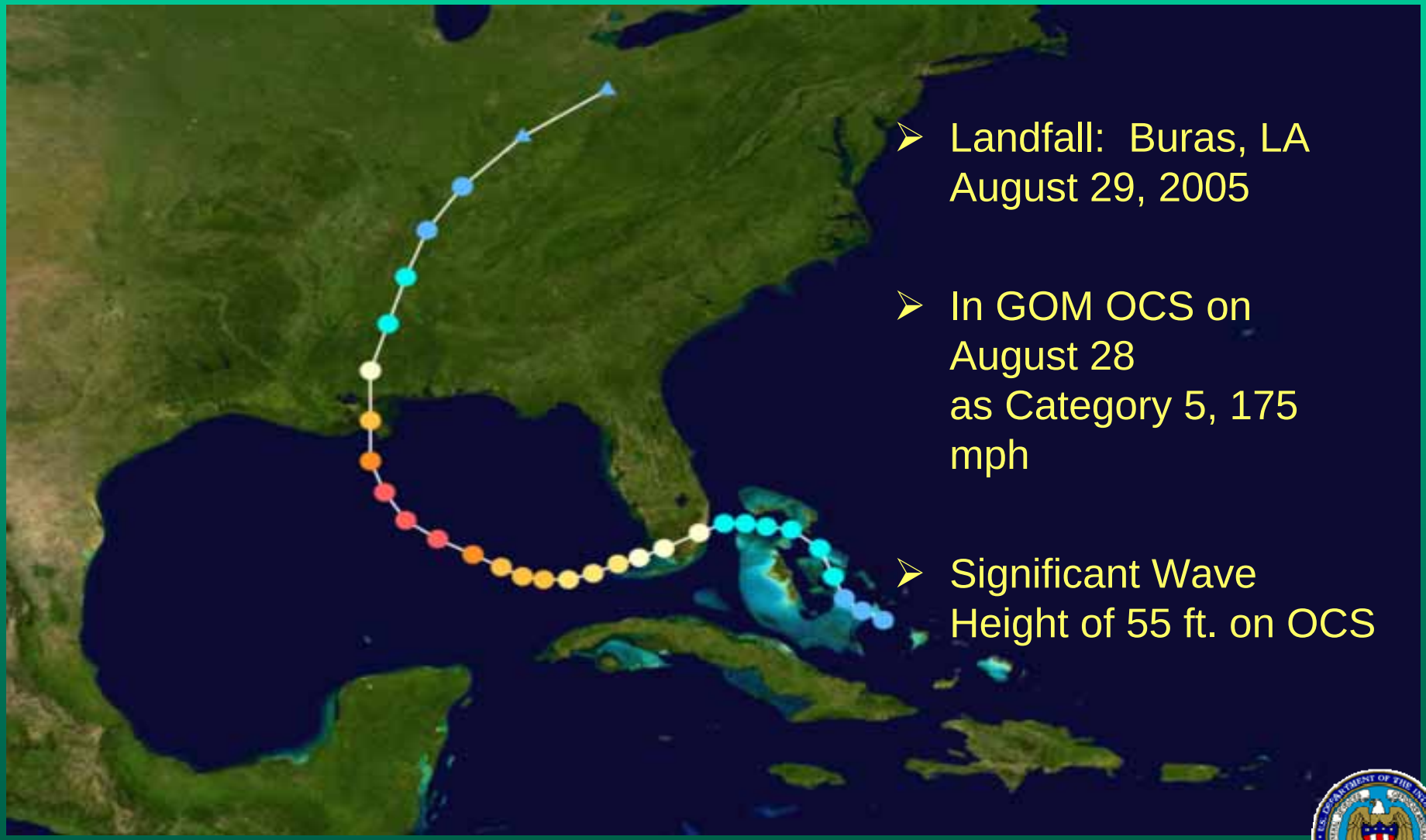
Hurricane Ivan
18-inch Oil Pipeline

Repairs / Remediation

- Post-inspection revealed
  - No leaks
  - Integrity maintained

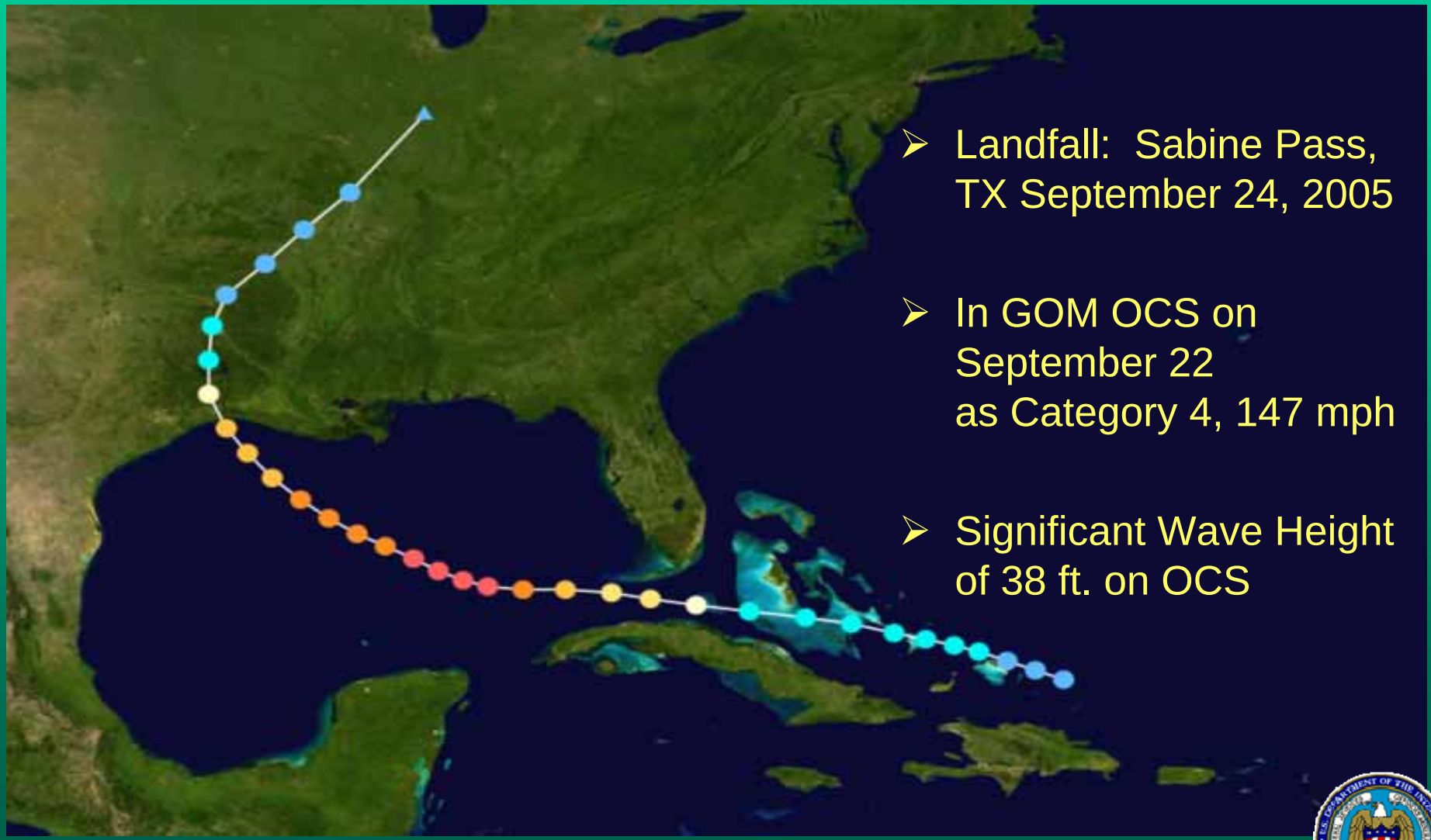
- Minor cover damage at pipeline crossings

Hurricane Katrina



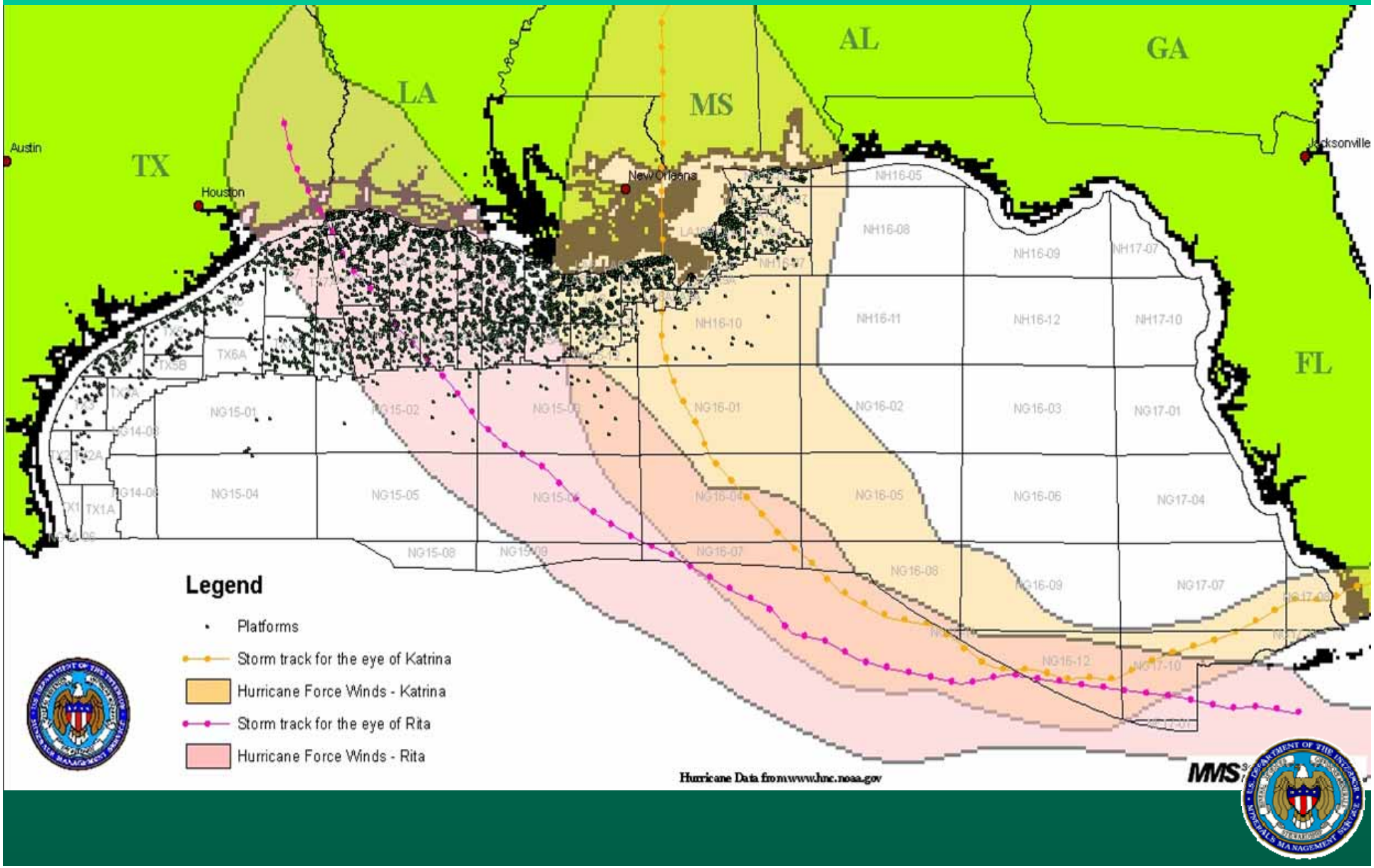
- Landfall: Buras, LA
  August 29, 2005
- In GOM OCS on
  August 28
  as Category 5, 175
  mph
- Significant Wave
  Height of 55 ft. on OCS

Hurricane Rita

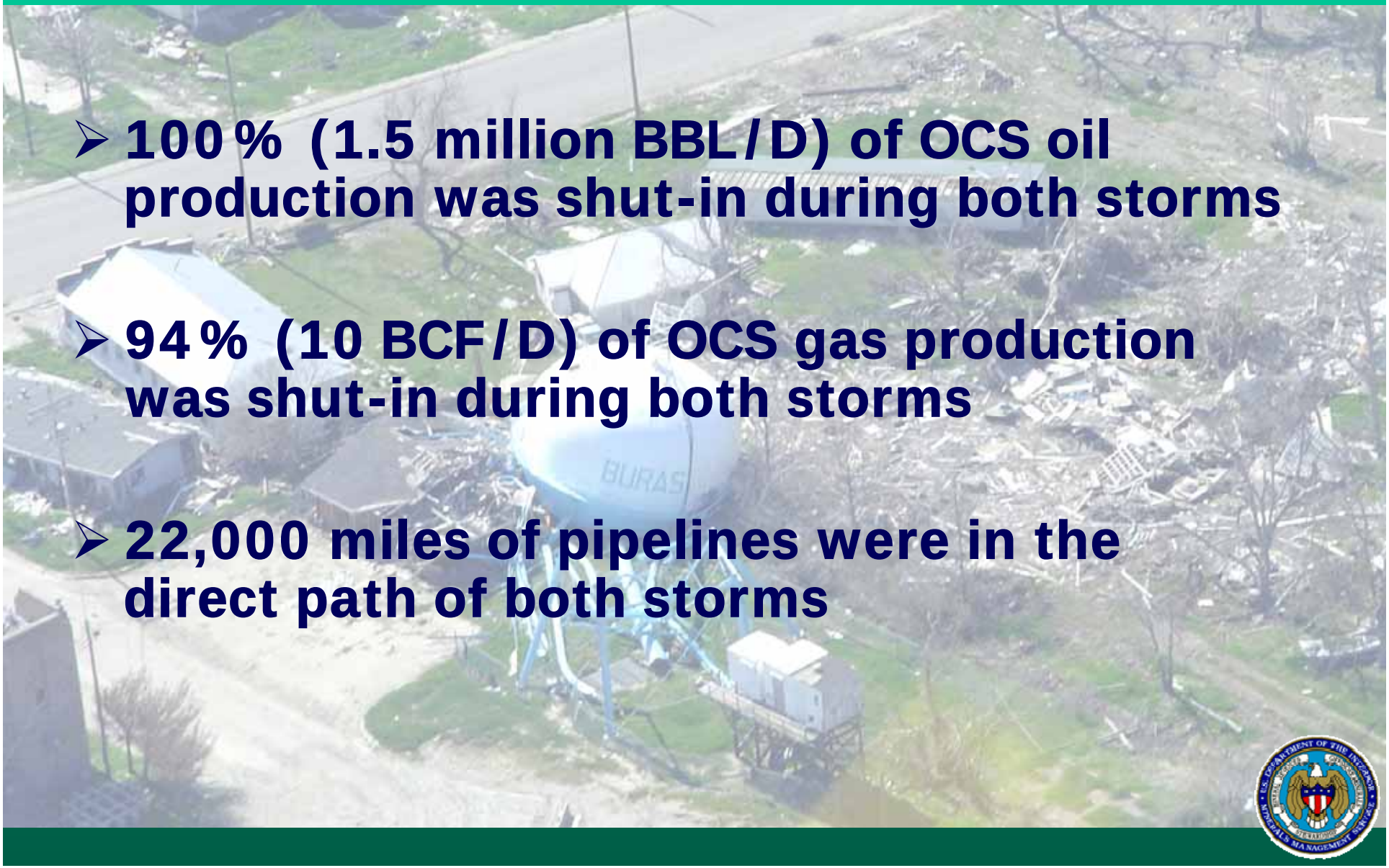


- Landfall: Sabine Pass, TX September 24, 2005
- In GOM OCS on September 22 as Category 4, 147 mph
- Significant Wave Height of 38 ft. on OCS

Hurricanes Katrina and Rita



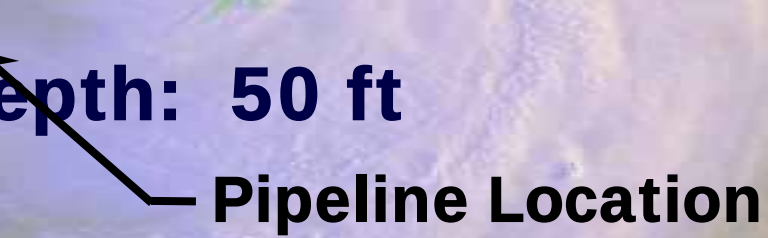
Hurricanes Katrina and Rita



- 100% (1.5 million BBL/D) of OCS oil production was shut-in during both storms
- 94% (10 BCF/D) of OCS gas production was shut-in during both storms
- 22,000 miles of pipelines were in the direct path of both storms

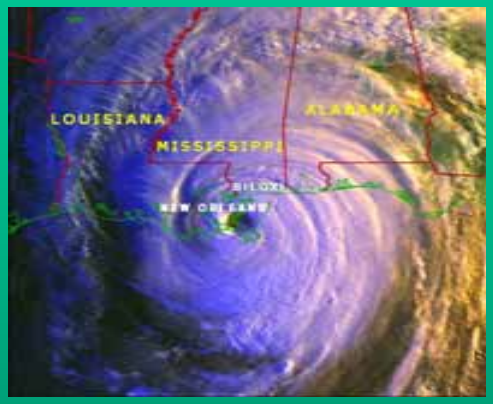
Hurricane Katrina
26-inch Gas Pipeline

- Ship Shoal Area
- Length: 22 miles (Federal OCS)
- Water Depth: 50 ft



Hurricane Katrina
26-inch Gas Pipeline

Damage

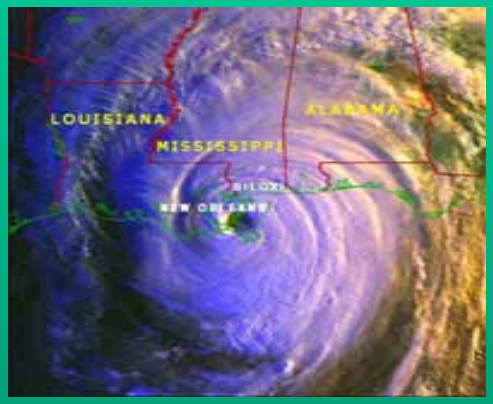


- Over 9 miles of pipe displaced

- Maximum Displacement: 4000 ft out of right of way (north)

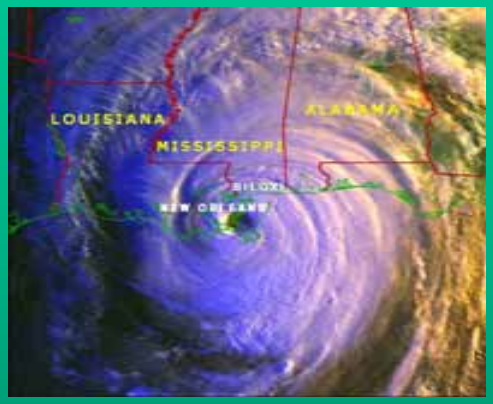
Hurricane Katrina
26-inch Gas Pipeline

Observations



- Buried
  - Relatively shallow water
    - Pipe Specific Gravity 1.4
  - 20-inch SSTI did restrain movement
- Small SSTIs allowed unimpeded movement

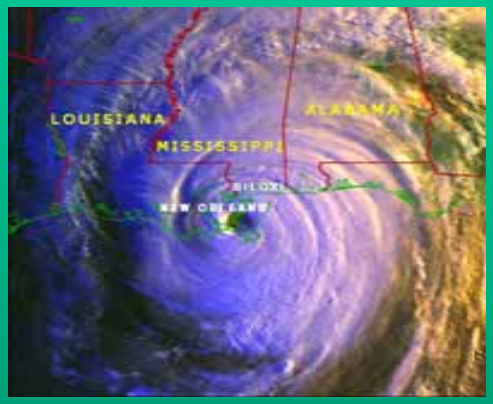
Hurricane Katrina
26-inch Gas Pipeline



Possible Causes

- Long period storm waves
- "Un-zipping" effect
- Hydrodynamic Lift

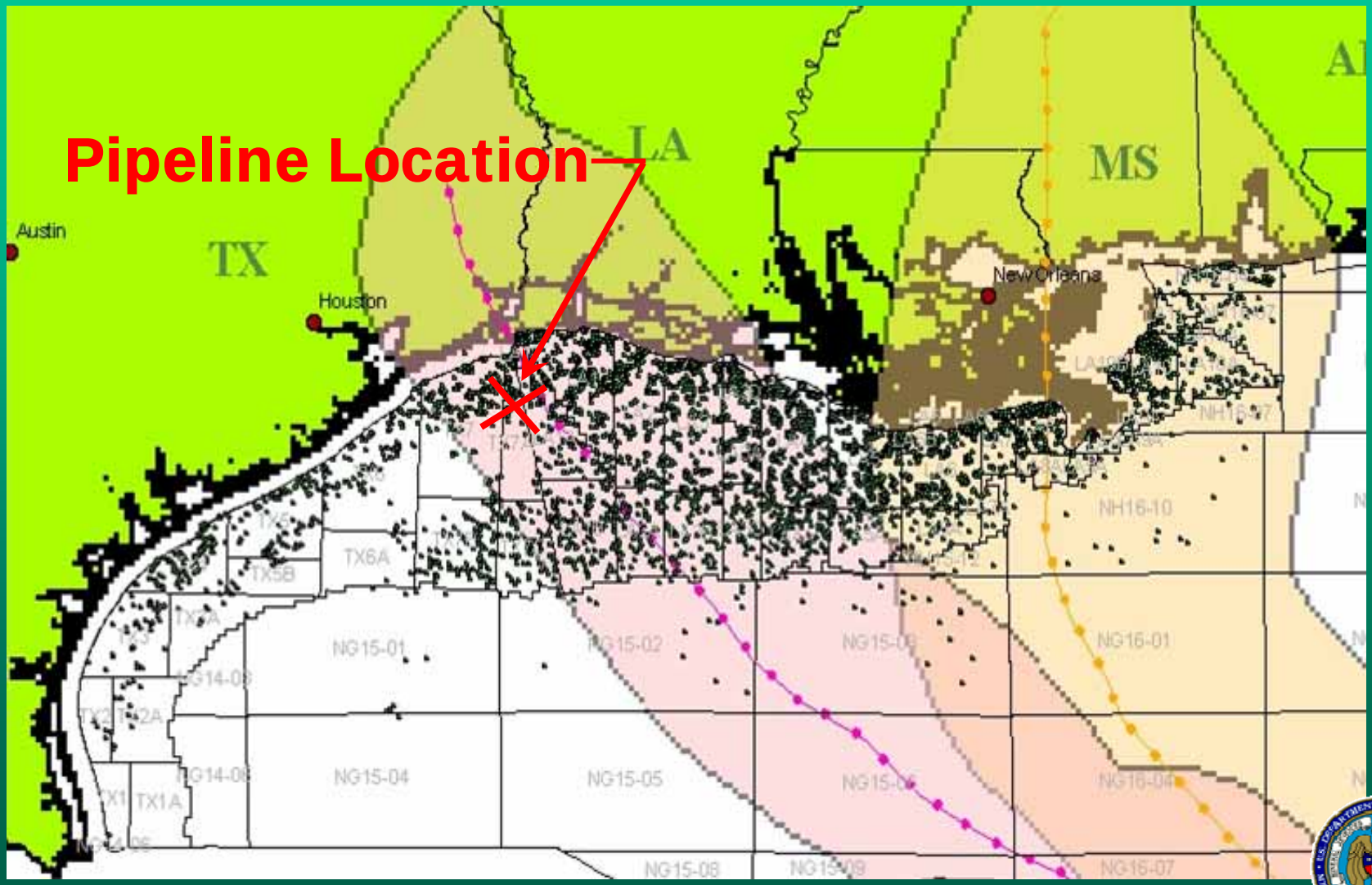
Hurricane Katrina
26-inch Gas Pipeline



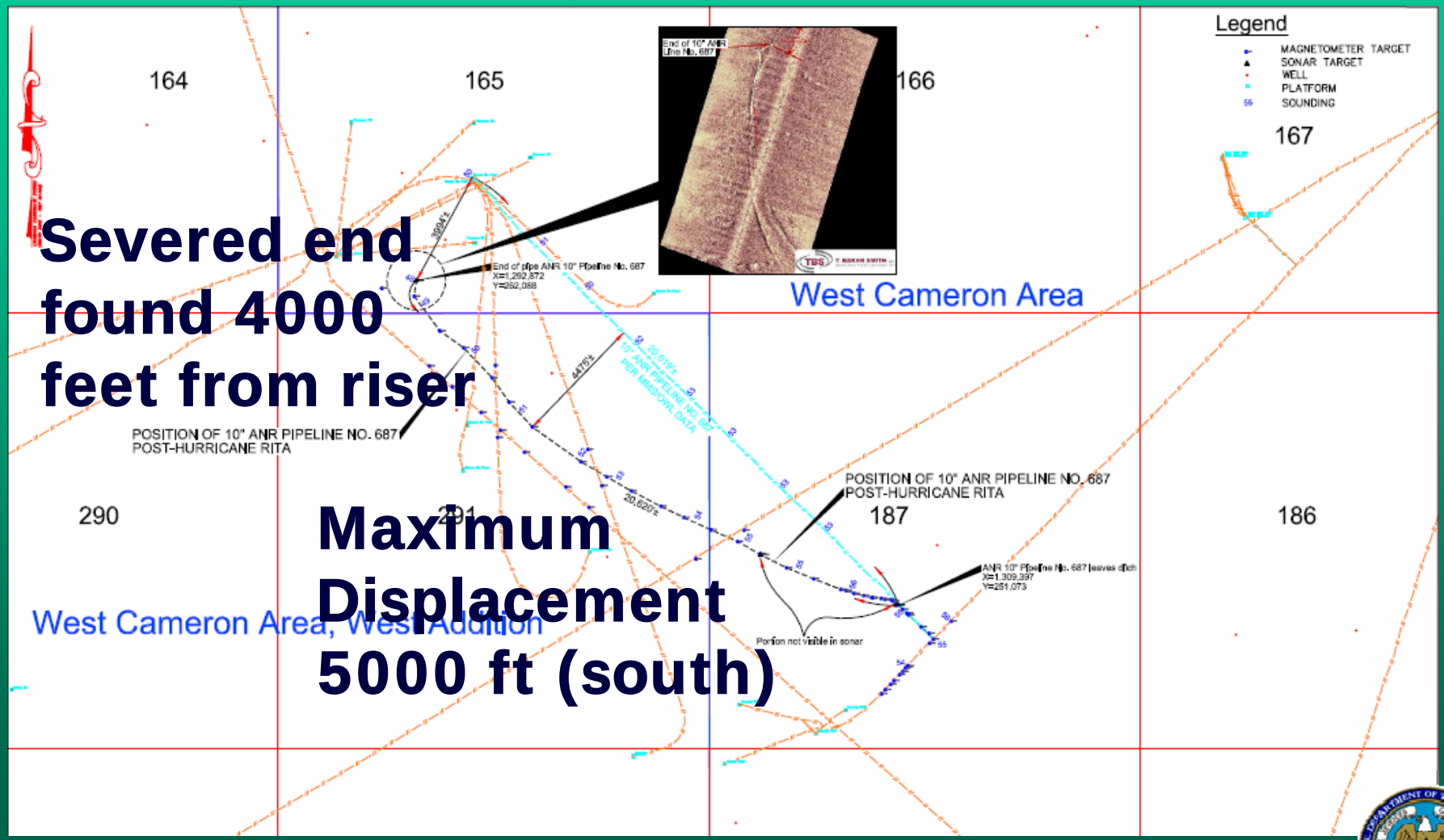
Repair / Remediation

- Decommissioned by removal
  - Replacement of entire pipeline scheduled for Summer 2007

Hurricane Rita
10-inch Gas Pipeline



Hurricane Rita
10-inch Gas Pipeline



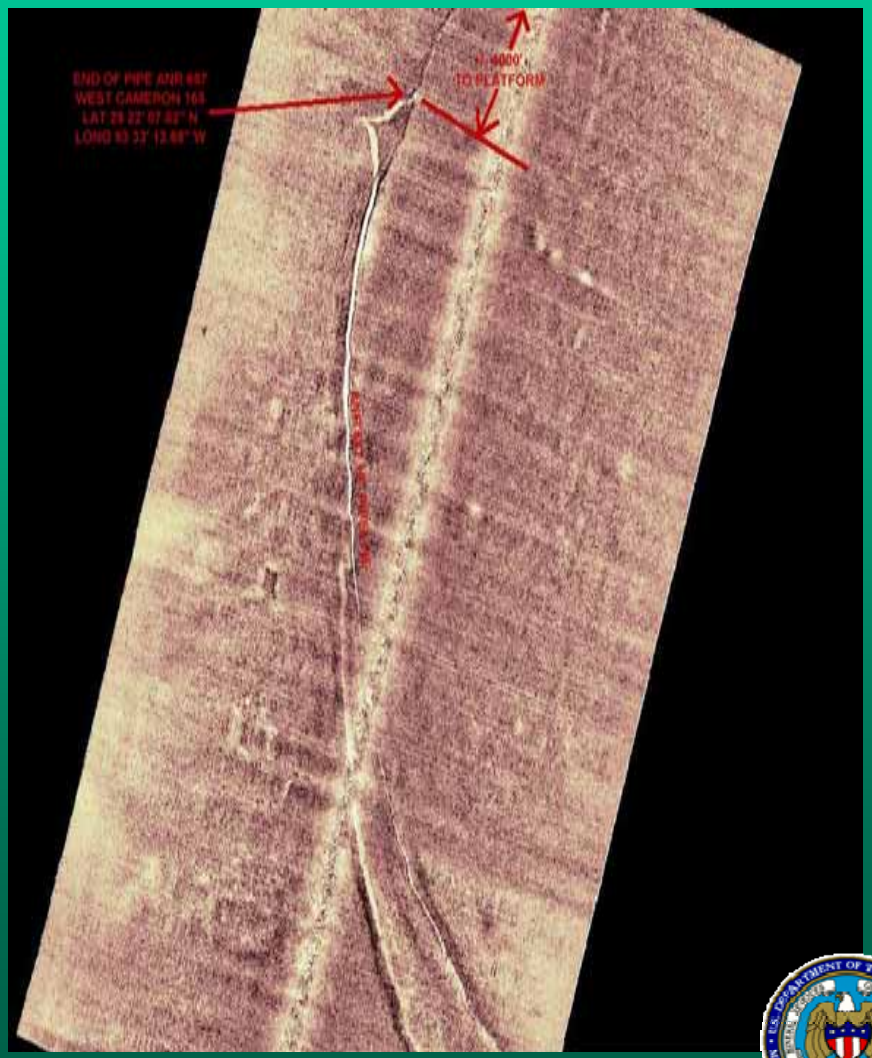
Severed end found 4000 feet from riser

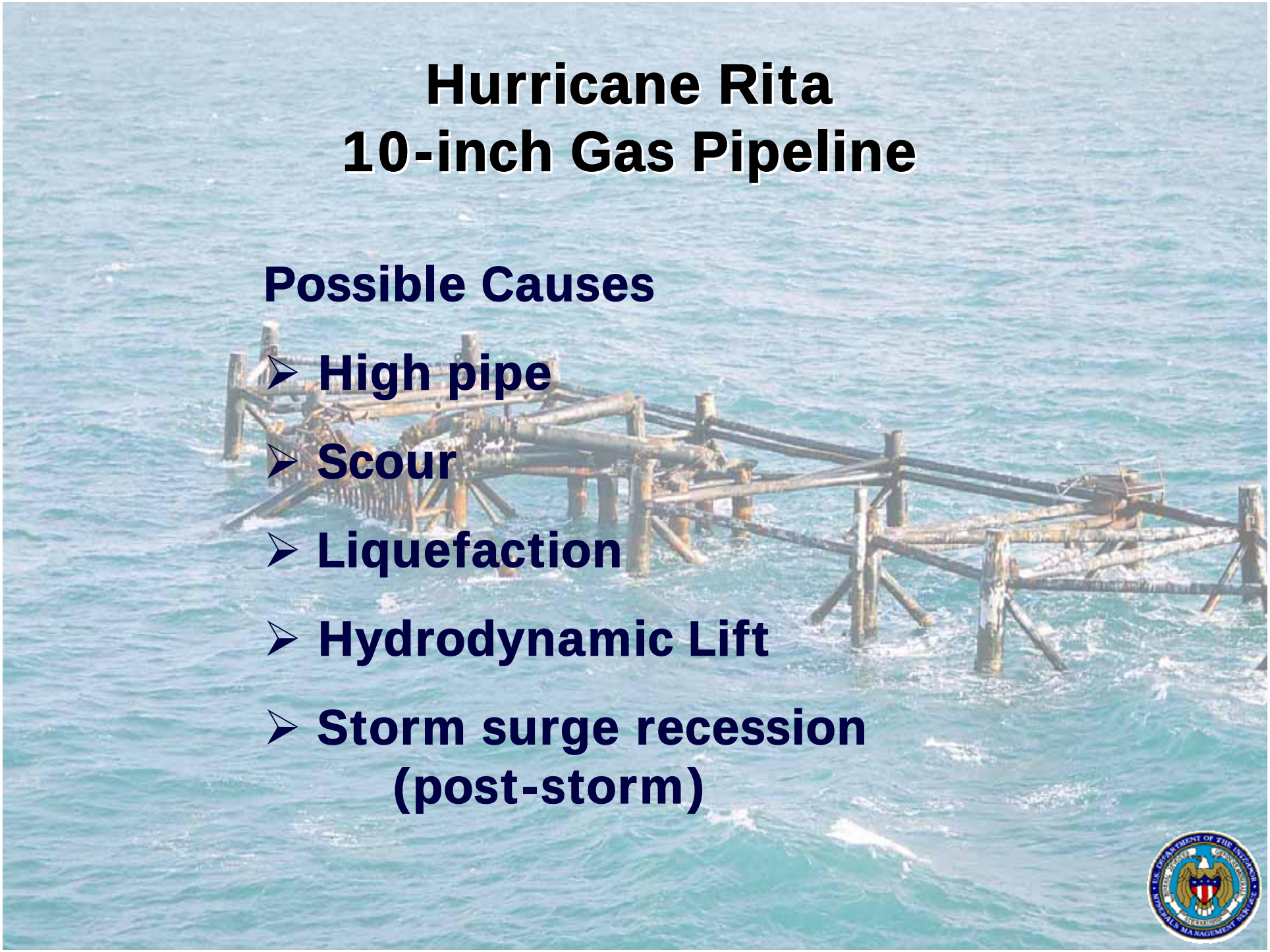
Maximum Displacement 5000 ft (south)

Hurricane Rita
10-inch Gas Pipeline

Observations

- **Buried**
- **Failed pipeline, riser, and riser clamps at platform**
- **Pipeline crossings provided minimal to no impedance to movement**
- **Pipeline displaced neutral to slightly upslope**





Hurricane Rita
10-inch Gas Pipeline

Possible Causes

- High pipe
- Scour
- Liquefaction
- Hydrodynamic Lift
- Storm surge recession (post-storm)

Hurricane Rita
10-inch Gas Pipeline

Repair / Remediation

- Decommissioned by removal
- Entire pipeline has been replaced

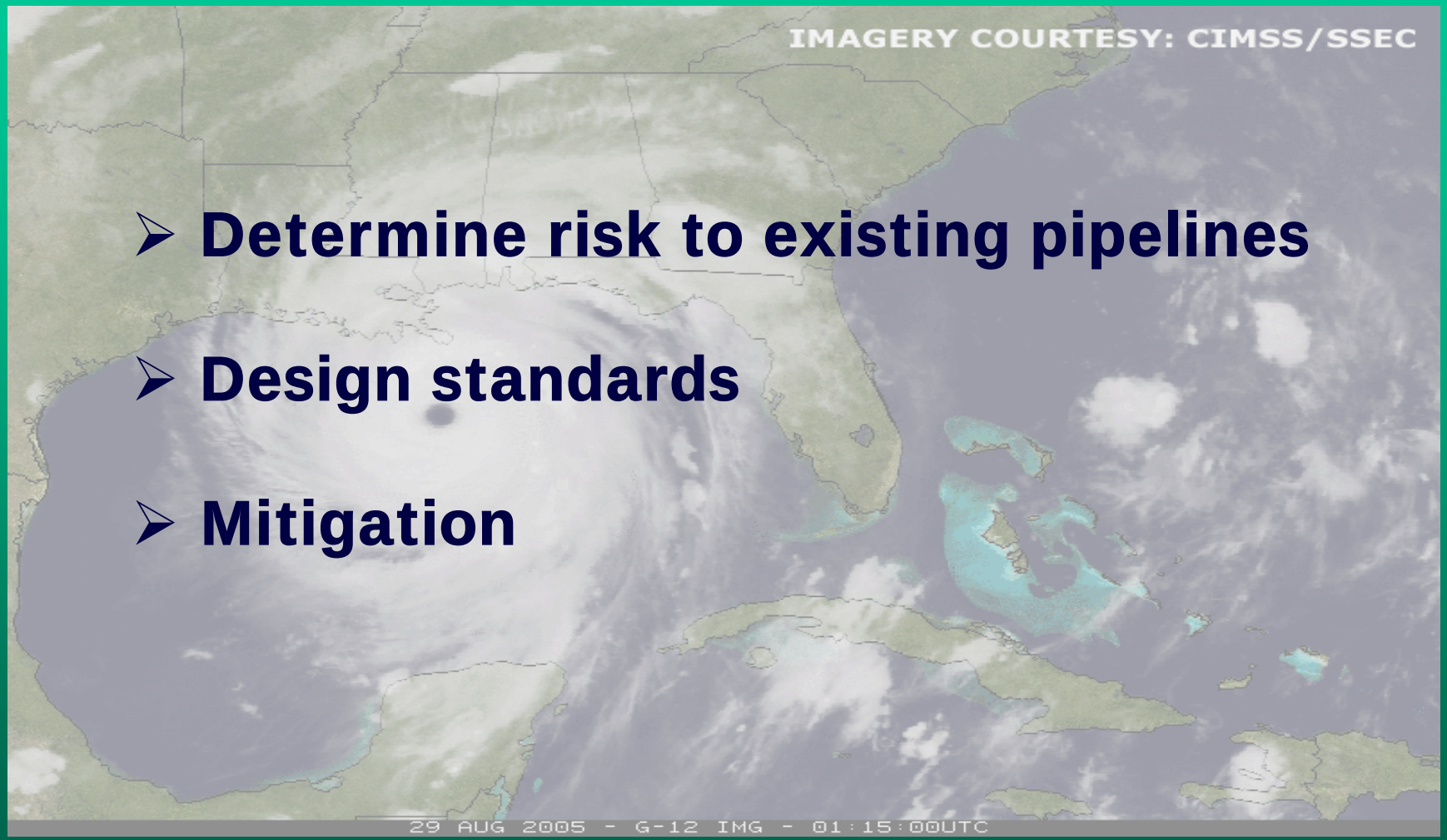
Further Research

- Why these pipelines?
- Storm trajectories
- Geotechnical / Geophysical
  - Soil conditions
  - Seafloor topography
  - Man-made features
  - Water Depth
  - Pipeline orientation

Further Research

- Design assumptions
- Inspection
- Maintenance
- Operation

Further Research



- Determine risk to existing pipelines
- Design standards
- Mitigation


MMS
25th Anniversary