Hurricane Katrina's Impact on Louisiana's Transportation Infrastructure

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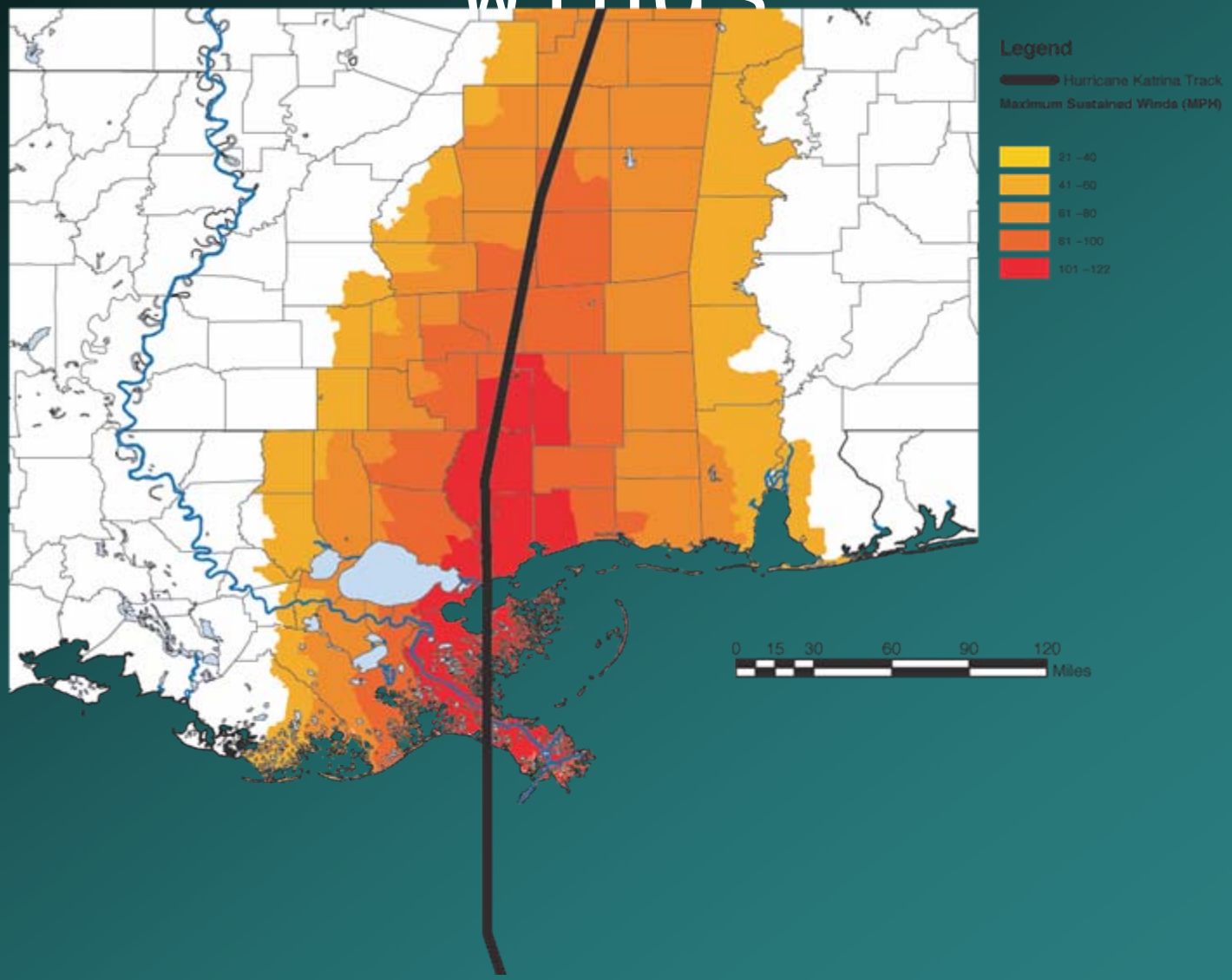
Outline

- Overview of Hurricane Katrina
- Damage to Highway and Rail Bridges and Roads
  - Rerouting of traffic
  - Impact on new design
- Damage to Ports
  - Physical damage
  - Operational impacts
- Related initiatives at Georgia Tech

Hurricane Katrina

- August 25, 2005, 6: 30 pm EDT - Landfall near Fort Lauderdale, FL as a Category 1 hurricane with maximum sustained winds of 75 mph.
- August 28, 2005 - Category 5 hurricane with maximum sustained winds of 175 mph and a pressure of 902 mbar (fourth lowest on record).
- August 29, 2005, 7:10 am EDT - Landfall near Buras, LA (Plaquemines Parish) as a Category 4 hurricane with maximum sustained winds of 140 mph.
- August 29, 2005, 11:00 am EDT - Landfall near Louisiana-Mississippi border as a Category 3 hurricane with maximum sustained winds of 125 mph.

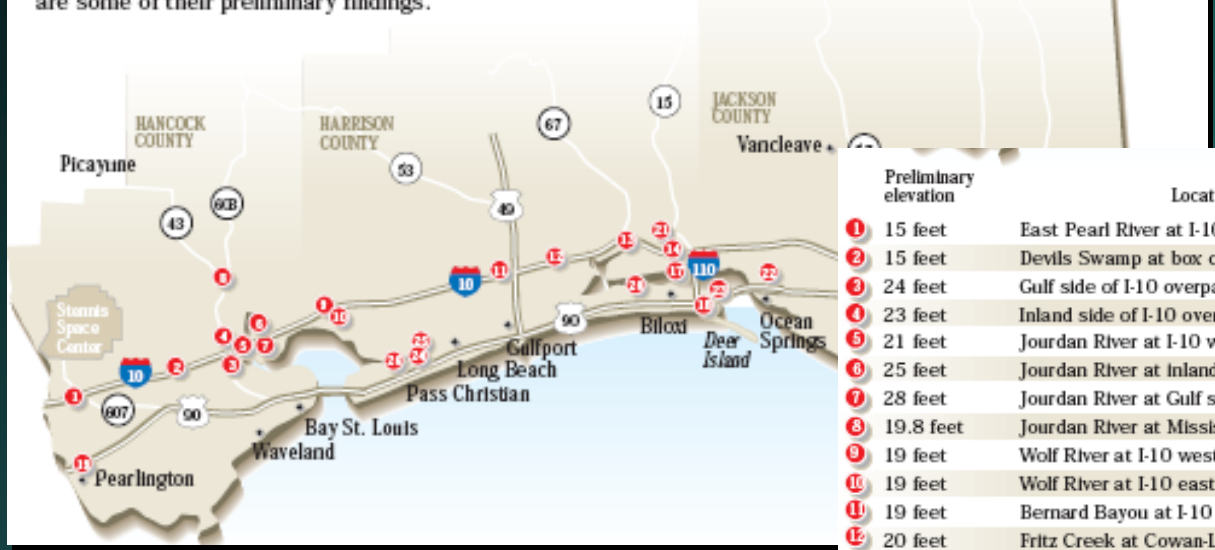
Maximum Sustained Winds



Storm Surge in MS Gulf Coast

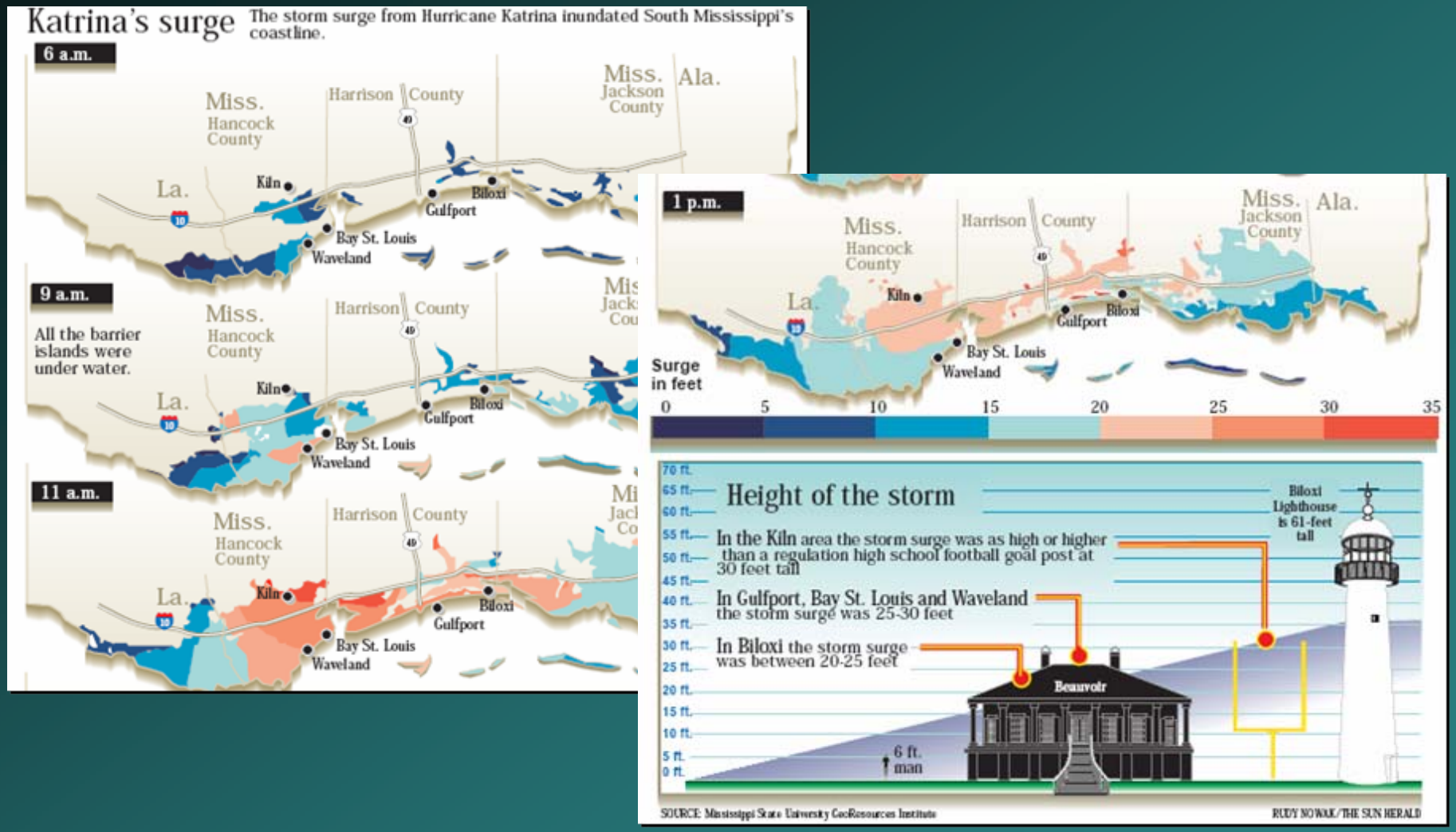
Plotting Katrina's surge

Surveyor's have begun documenting and refining the data from Hurricane Katrina's storm surge. Here are some of their preliminary findings.



	Preliminary elevation	Location	Hurricane Camille	Rough difference
1	15 feet	East Pearl River at I-10 east bridge end	6.9 feet	+8 feet
2	15 feet	Devils Swamp at box culvert at I-10	10.4 feet	+5 feet
3	24 feet	Gulf side of I-10 overpass of Mississippi 43	14.6 feet	+9 feet
4	23 feet	Inland side of I-10 overpass of Mississippi 43	13.8 feet	+9 feet
5	21 feet	Jourdan River at I-10 west bridge end	14.2 feet	+7 feet
6	25 feet	Jourdan River at inland side of I-10 east bridge end	15.1 feet	+10 feet
7	28 feet	Jourdan River at Gulf side of I-10 east bridge end	16.9 feet	+11 feet
8	19.8 feet	Jourdan River at Mississippi 43 gage	12.2 feet	+8 feet
9	19 feet	Wolf River at I-10 west bridge end	13.5 feet	+6 feet
10	19 feet	Wolf River at I-10 east bridge end	13.5 feet	+6 feet
11	19 feet	Bernard Bayou at I-10	14.3 feet	+5 feet
12	20 feet	Fritz Creek at Cowan-Lorraine Road Extension	13.5 feet	+7 feet
13	19 feet	Tchoutacabouffa River at I-10	13.3 feet	+6 feet
14	16 feet	Old Fort Bayou at I-10	11.4 feet	+5 feet
15	18 feet	West Pascagoula River inland side of I-10 west bridge end	9.1 feet	+5 feet
16	10.6 feet	Escatawpa River at I-10 gauge	4.9 feet	+6 feet
17	20 feet	House on Kennedy Lane near Damphman Point,Biloxi	14.2 feet	+6 feet
18	24 feet	Isle of Capri Casino, Biloxi	15.6 feet	+8 feet
19	18.6 feet	Communications building on Whites Bayou, near Pearlington	8.8 feet	+10 feet
20	19 feet	Popp's Ferry Bridge, south abutment	13.9 feet	+5 feet
21	17.7 feet	Tchoutacabouffa River at Mississippi 15 and 67, D'Iberville	12.6 feet	+5 feet
22	20.8 feet	Old Fort Bayou at Mississippi 609	14.8 feet	+6 feet
23	20 feet	Biloxi Bay/Beach Mini Mart near east end of U.S. 90 bridge	15.5 feet	+5 feet
24	27 feet	1310 Scenic Drive, Pass Christian	23.4 feet	+4 feet
25	26 feet	1310 Scenic Drive, Pass Christian	23.4 feet	+3 feet
26	28 feet	1320 Scenic Drive, Pass Christian	23.4 feet	+5 feet
27	12.7 feet	Pascagoula River at I-10 east bridge end	8.6 feet	+4 feet
28	13 feet	Pascagoula River at I-10 west bridge end	8.6 feet	+4 feet

Storm Surge in MS Gulf Coast

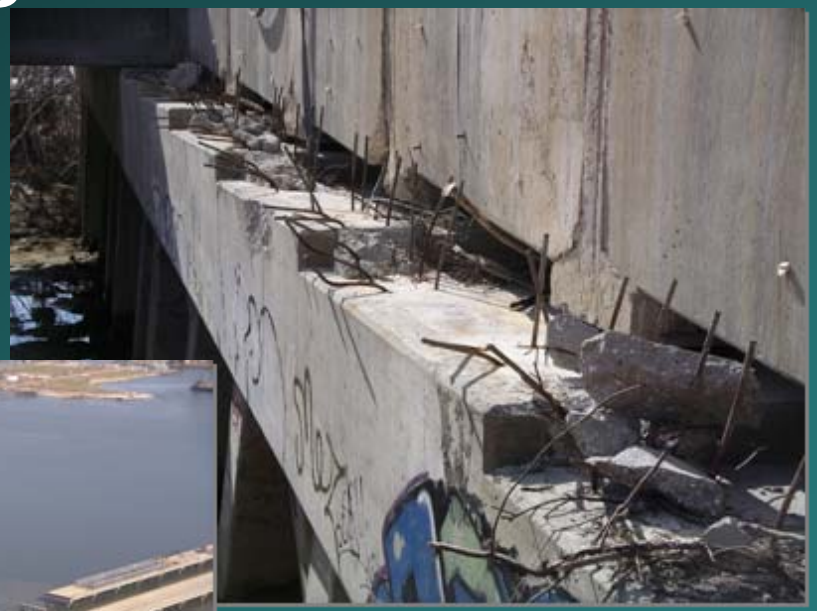


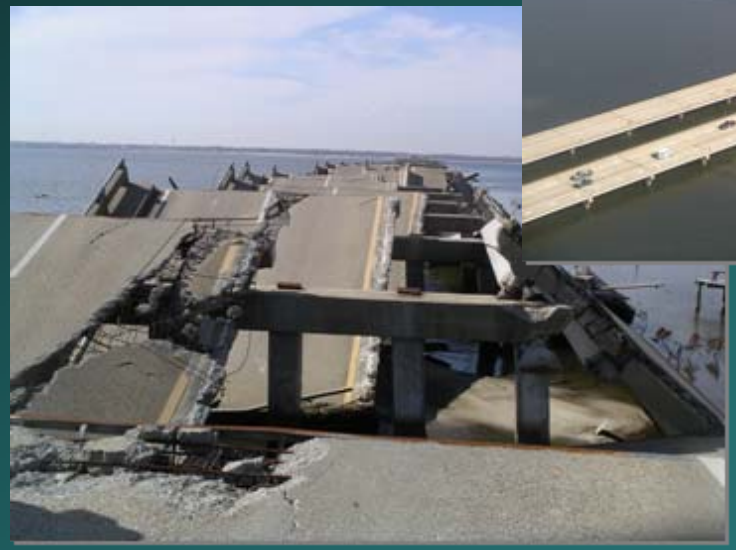
Storm Surge in MS Gulf Coast

Overview of Damage

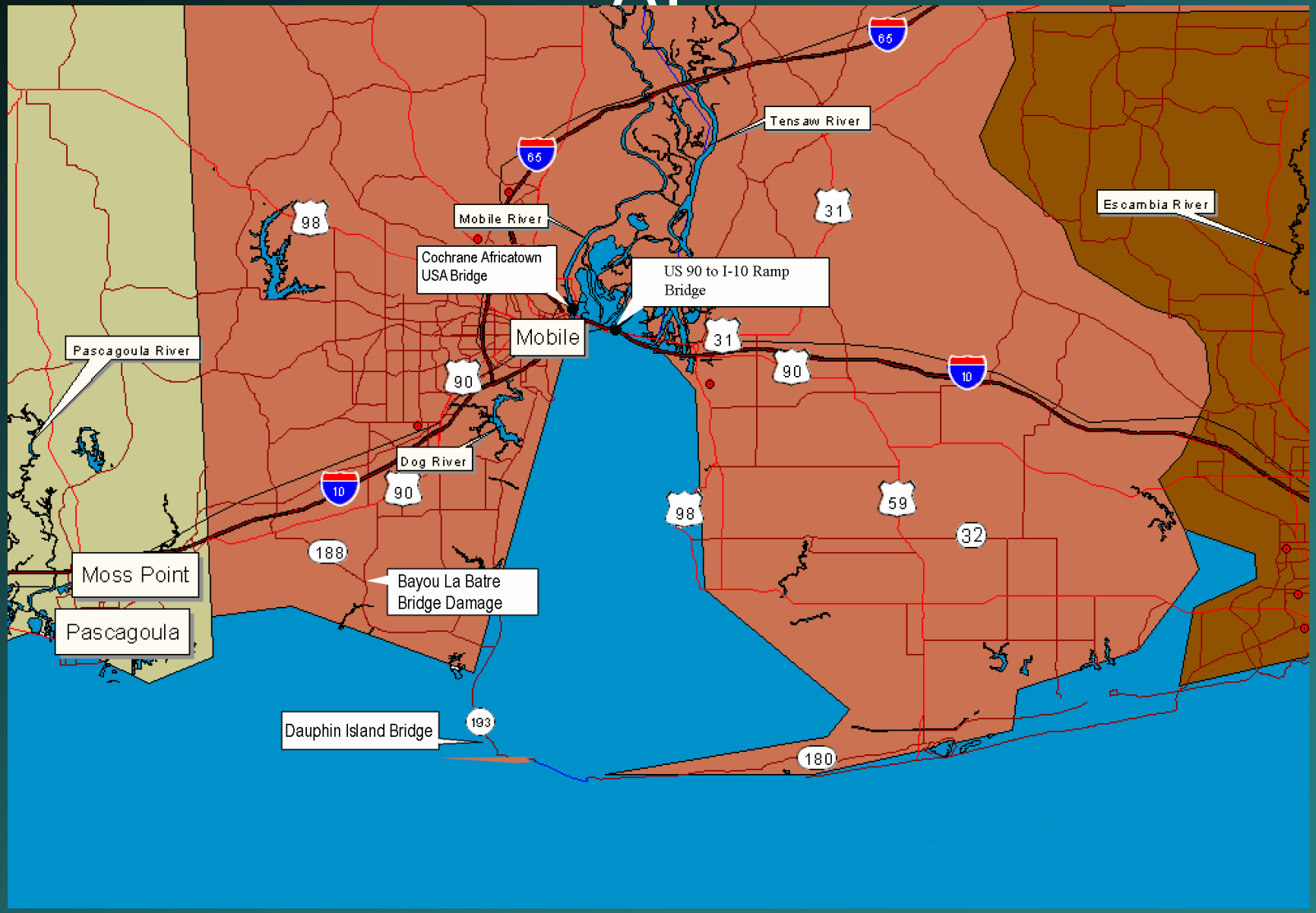
- Over 45 bridges sustained damage in AL, LA, and MS.
- Most damaged bridges were adjacent to water.
- Substructures were rarely damaged.
- Damage on superstructure typically consisted of unseating of decks and damage to guardrails.
- Significant damage to bridges due to loose barges and boats.
- Significant damage to roads in storm surge areas
- Debris on roads and bridges caused major disruption
- Damage depended on the connection between decks and bents

Performance and Repair of Bridges





Overview of Bridge Damage in AL



Overview of Damage - AL

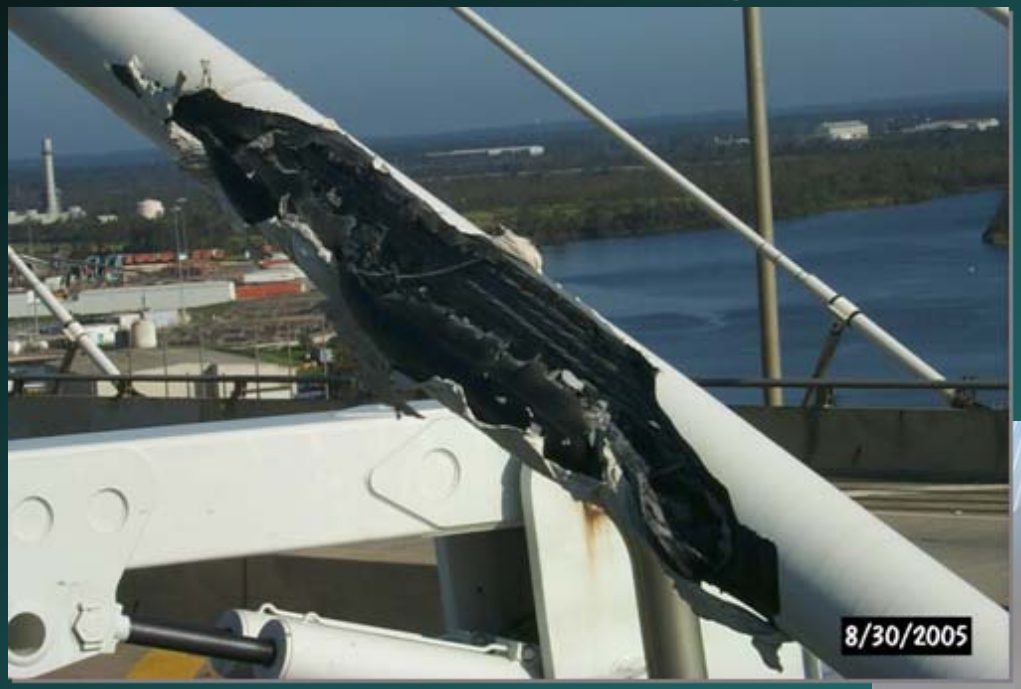
- In Alabama, 2 bridges received moderate to major damage, and two bridges received minor damage.

Bridge name	Carrier	Status as of 7 Nov	Repair cost	Expected downtime
Cochrane Africatown USA Bridge	Alabama DOT	Currently being repaired	$1.75 million	none
I-10 On-Ramp at Mid-Bay Crossing of US-90/98	Alabama DOT	Repairs begin in January 2006	$1 million	6 months
Bayou La Batre	Alabama DOT	Repairs completed	<$100,000	none
Dauphin Island Bridge	Alabama DOT	Repairs completed	<$100,000	none

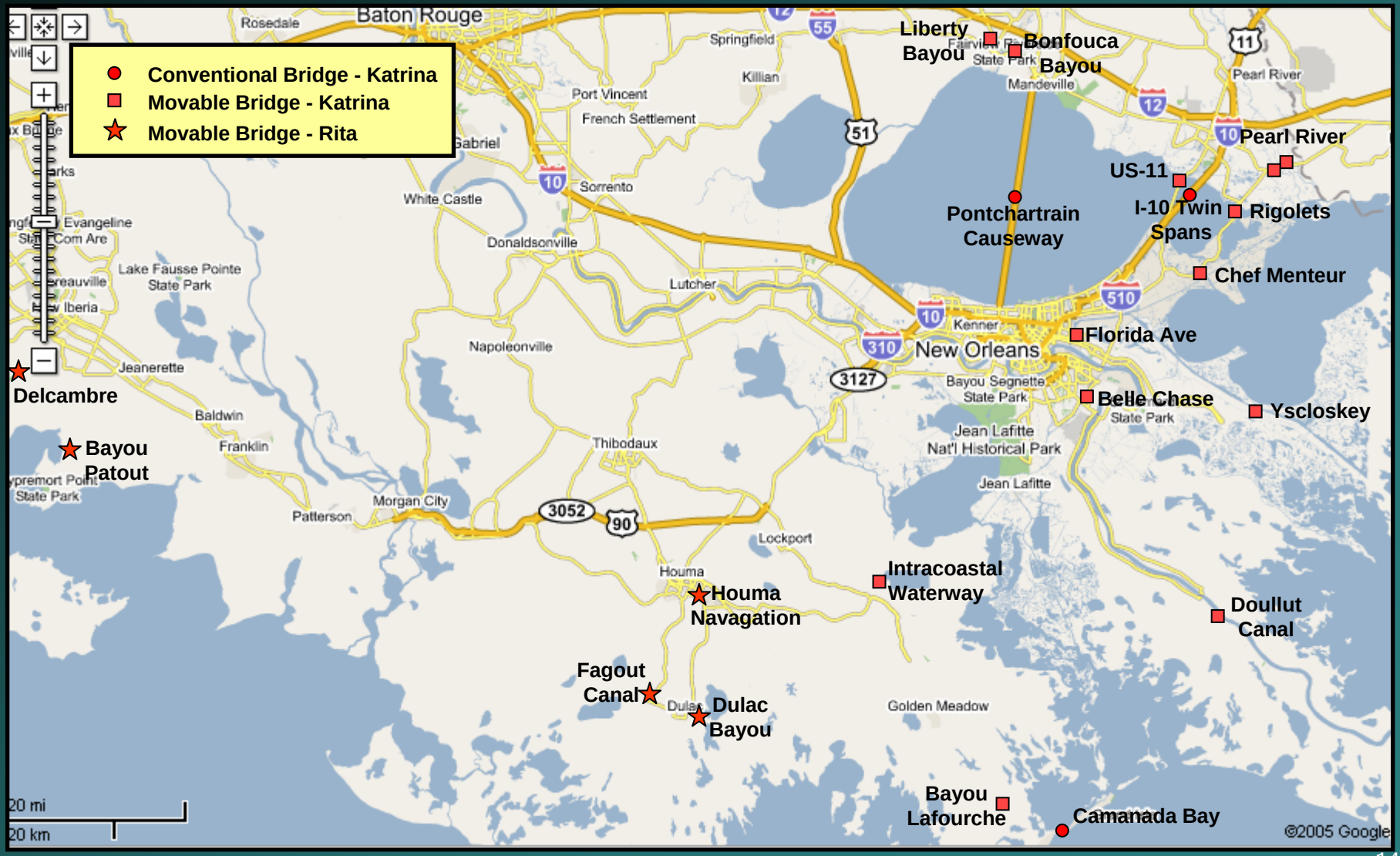
Cochrane-Africatown Cable Stayed Bridge

The hurricane picked up an oil drilling rig and smashed it into the Cochrane-Africatown Cable Stayed Bridge. Amazingly, the cables escaped major damage and the bridge is still carrying traffic (photo courtesy of

Cochrane-Africatown Cable Stayed Bridge



Overview of Bridge Damage in LA



Project Location and Team – DOTD Maint., Design, Contracts, Volkert & Assoc.

I-10 Twin Spans

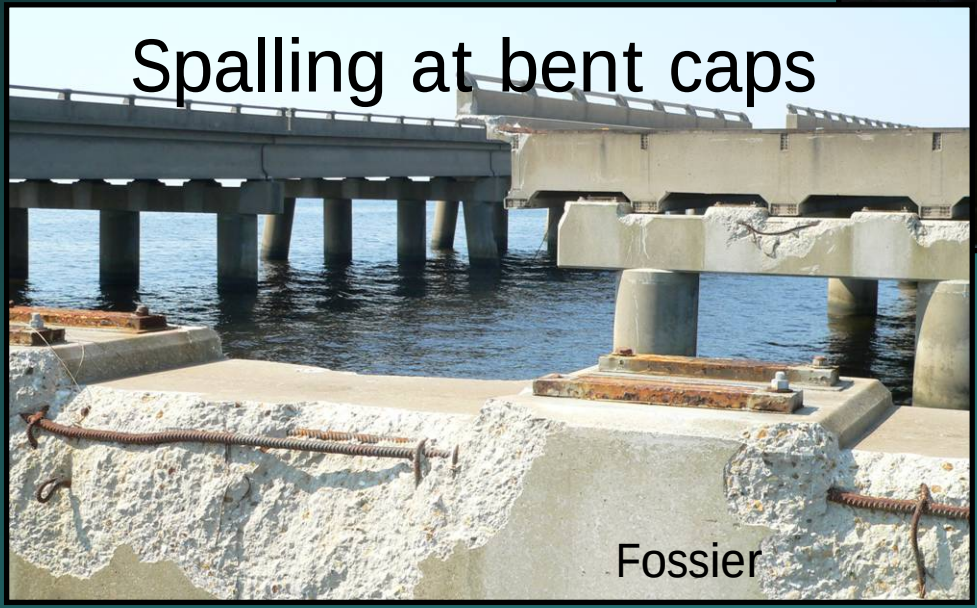
- 5.4 Miles
- 12-15 Feet Above Water
- Prestressed spans

I-10 Twin Spans – *Damage*

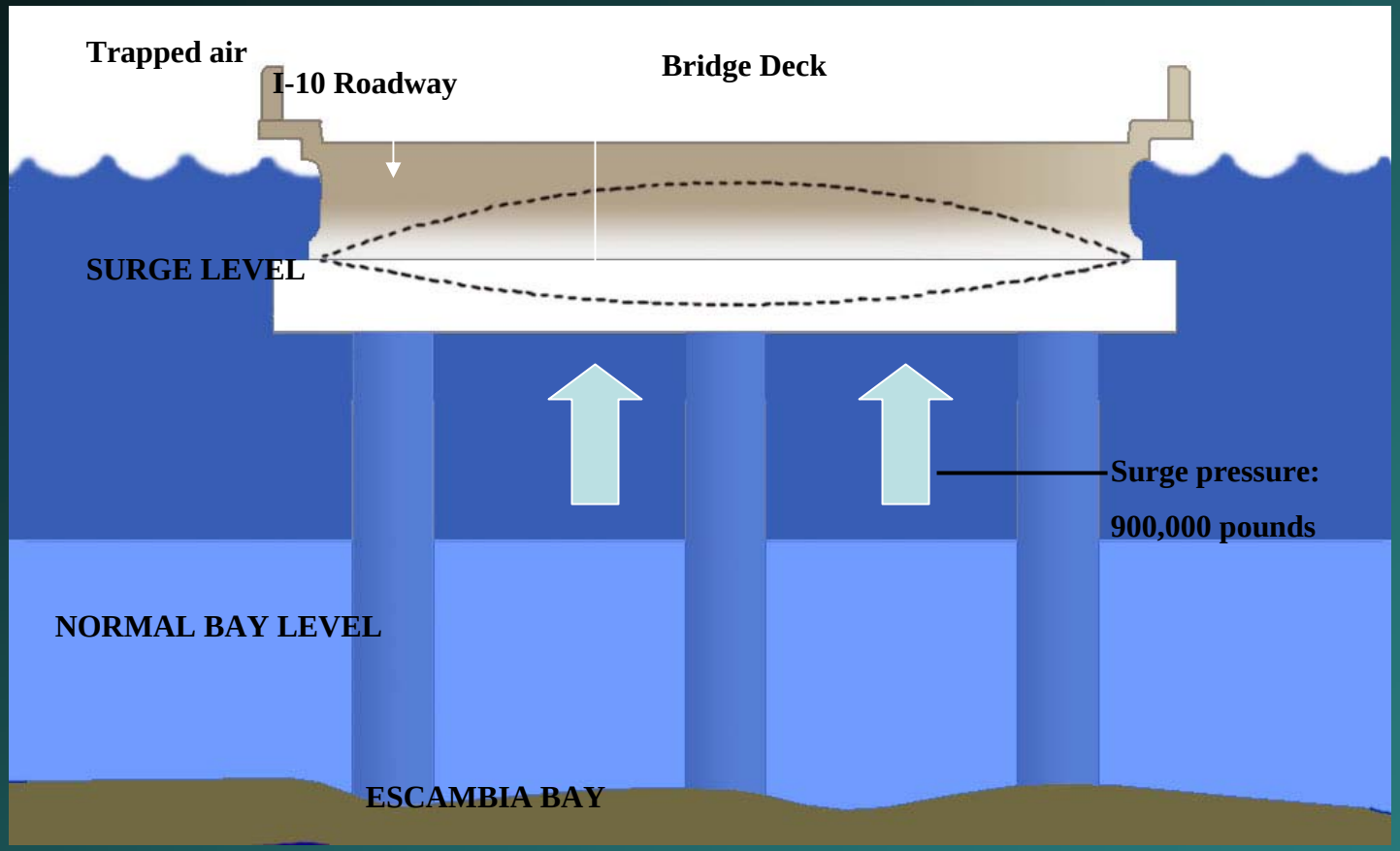
- 170 Eastbound spans shifted alignment
- 303 Westbound spans shifted alignment

- 38 Eastbound spans fell in water
- 26 Westbound spans fell in water

I-10 Twin Spans – *Damage*



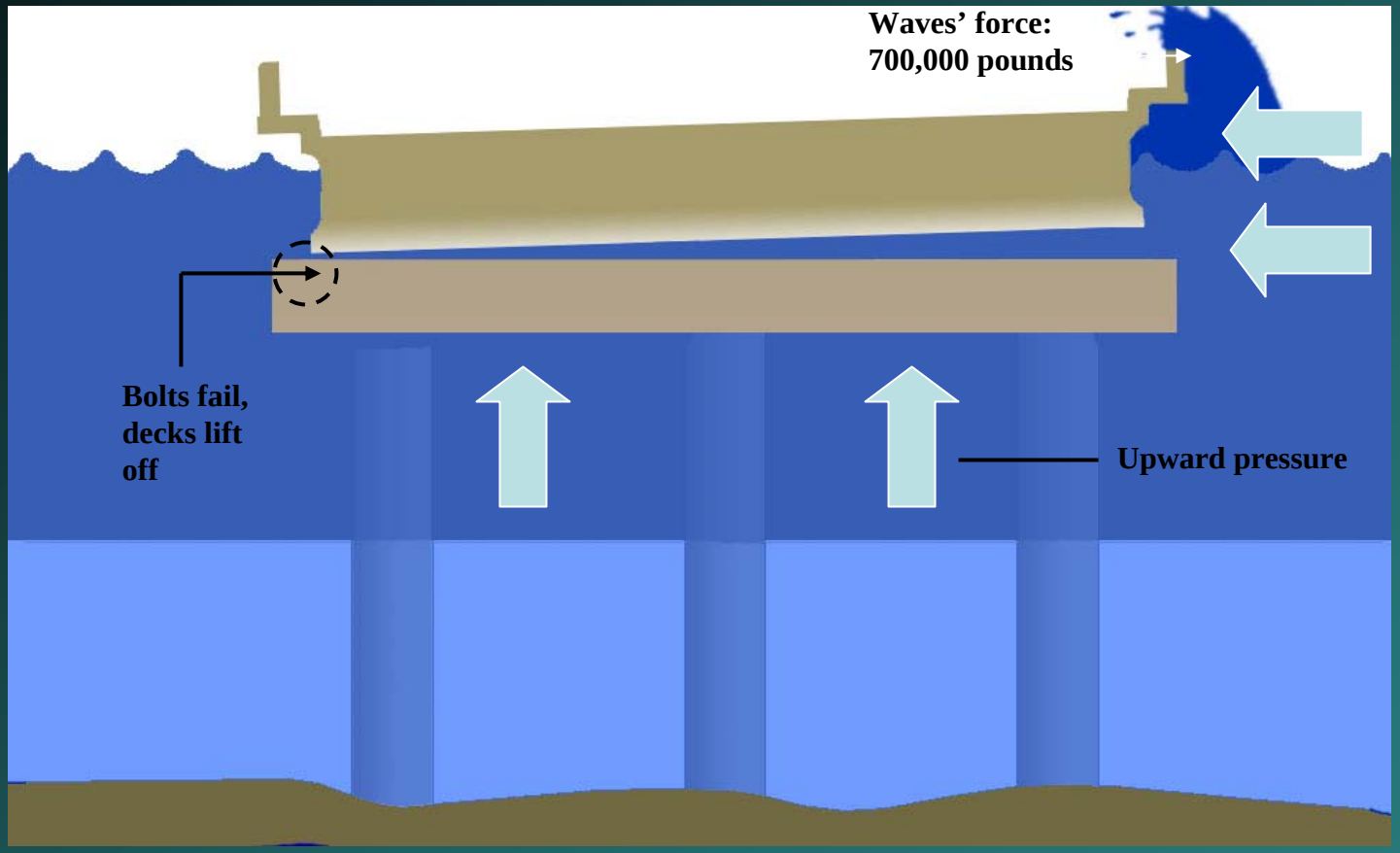
Water Hammer



1. The Lifting

   Storm surge rose to 14 to 16 feet above sea level beneath the bridge decks, where beams captured air beneath them, increasing the upward force to 900,000 pounds.

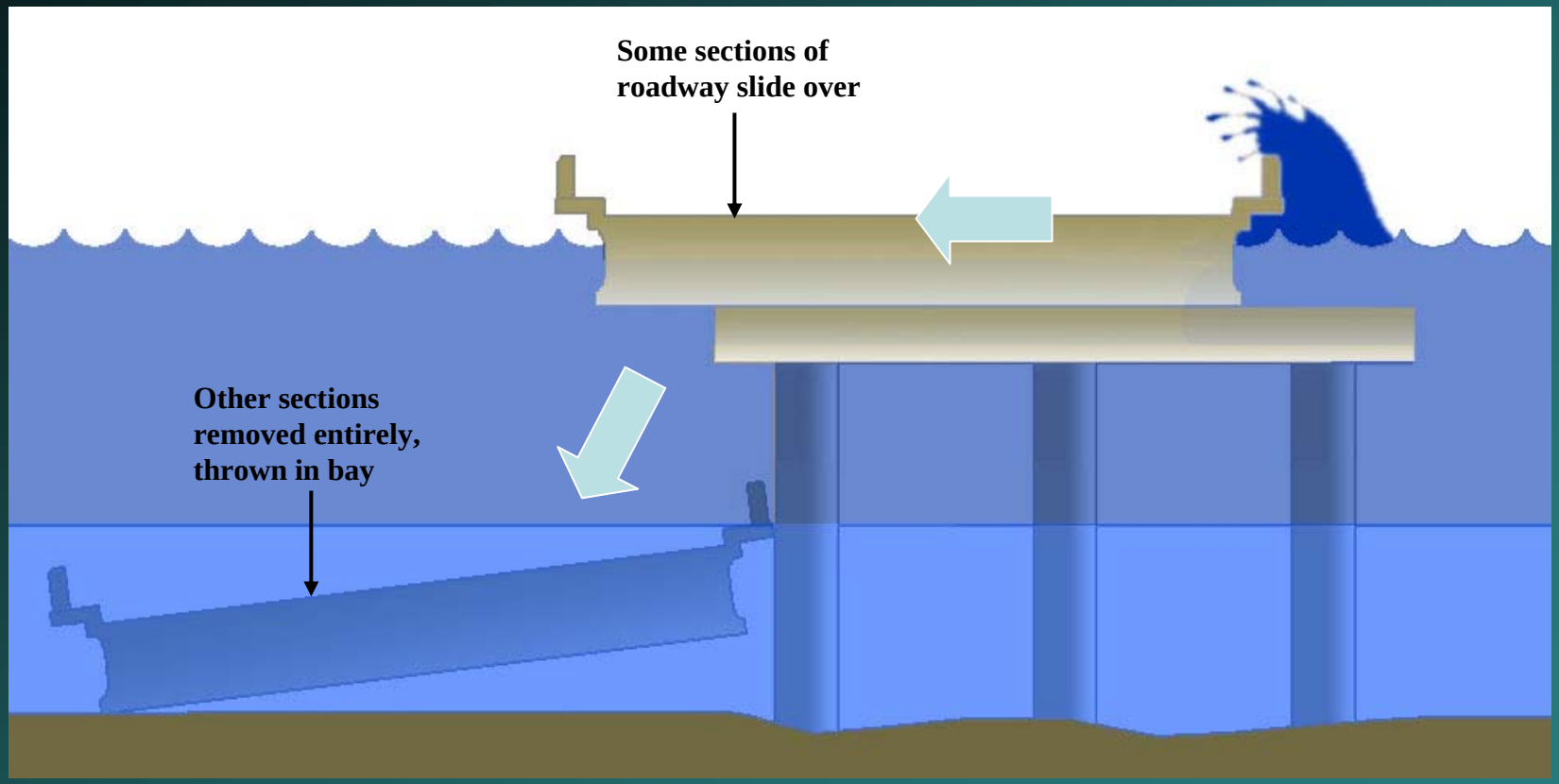
Water Hammer



2. The Pounding

At the same time, waves of 13 feet atop the surge hit the sides of the bridge decks with 700,000 pounds of force every 6.5 seconds at the height of the storm.

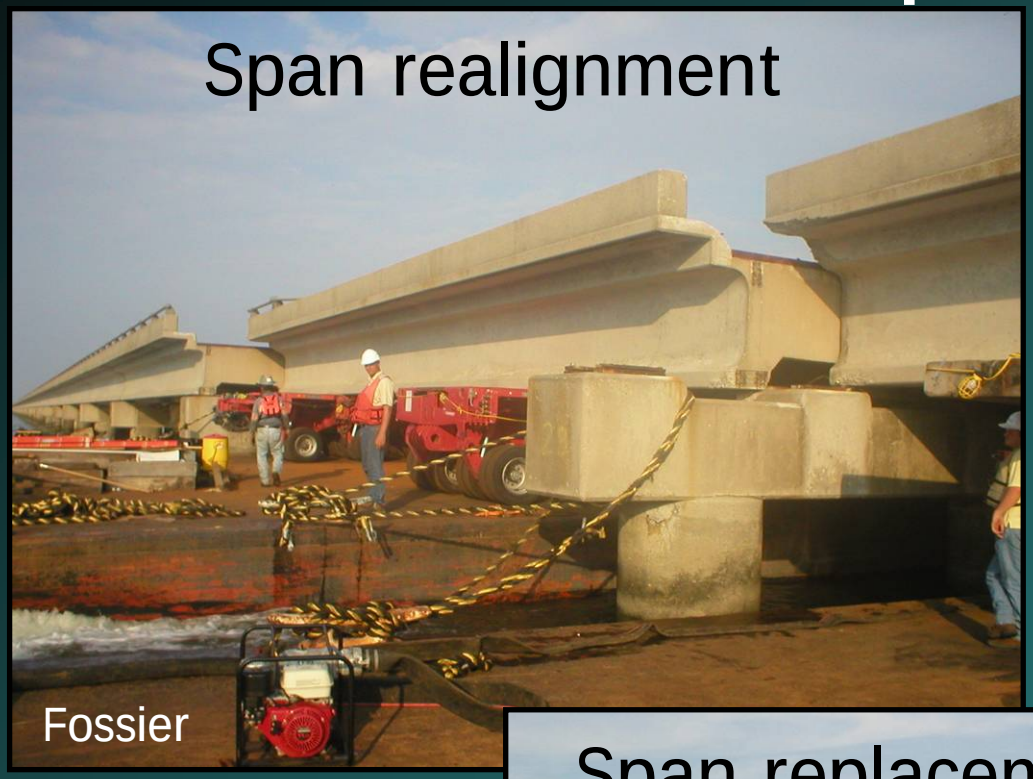
Water Hammer



3. The Breaking

The water's lifting and pounding broke the connections between 150-foot-deep pilings and piers supporting the bridge decks, allowing the decks to slide sideways or fall into the water.

I-10 Twin Spans – *Repair*

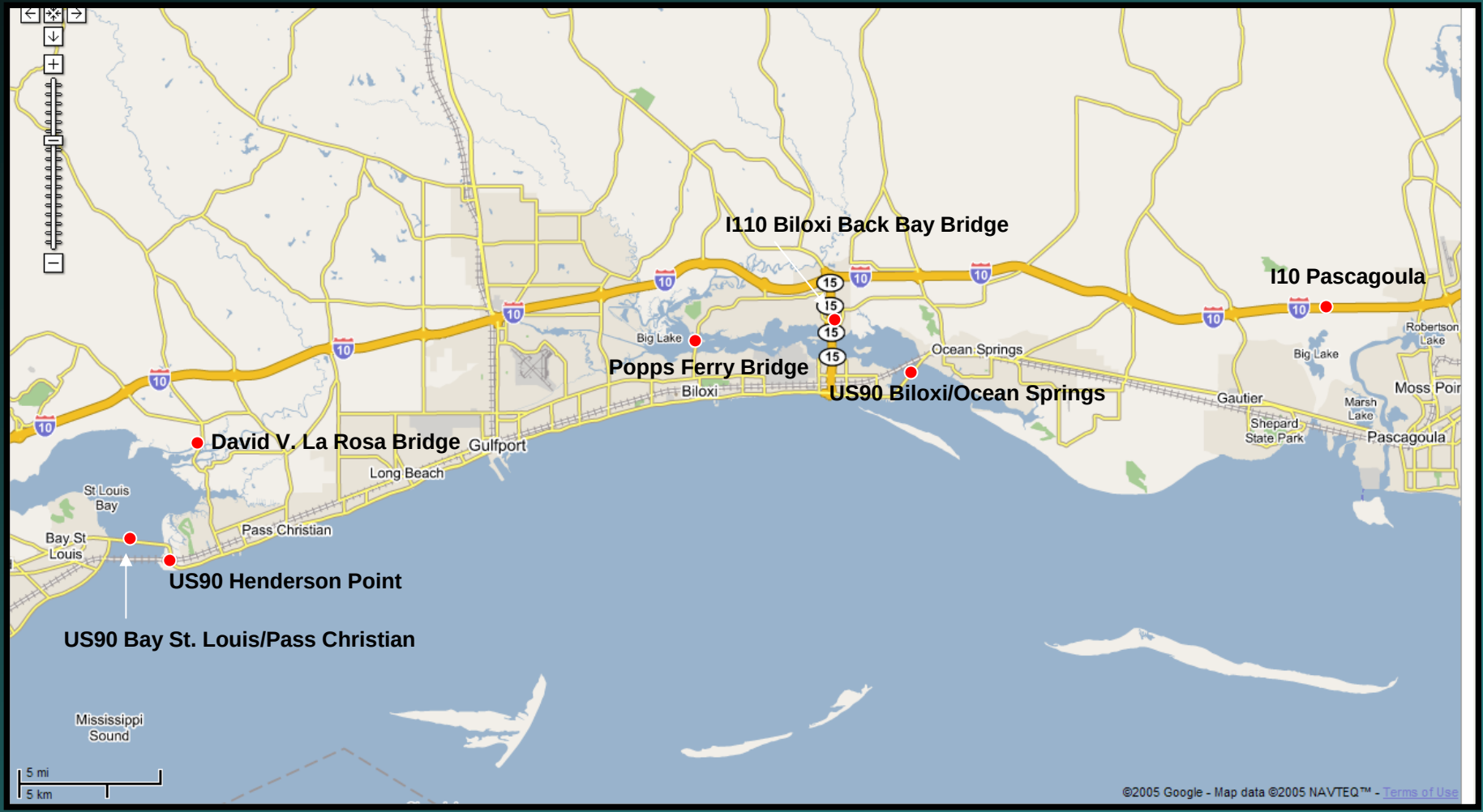


- Consult FLDOT
- Hire construction manager (Volkert)
- 1 span open October 10
- Repair bid at $31,000,000 w/ additional incentives

I-10 Twin Spans – *Repair*

- Replacement bridge in 3-4 years. Potentially bid in early 2006.
- Estimated cost of ~$600 M

Overview of Bridge Damage in MS

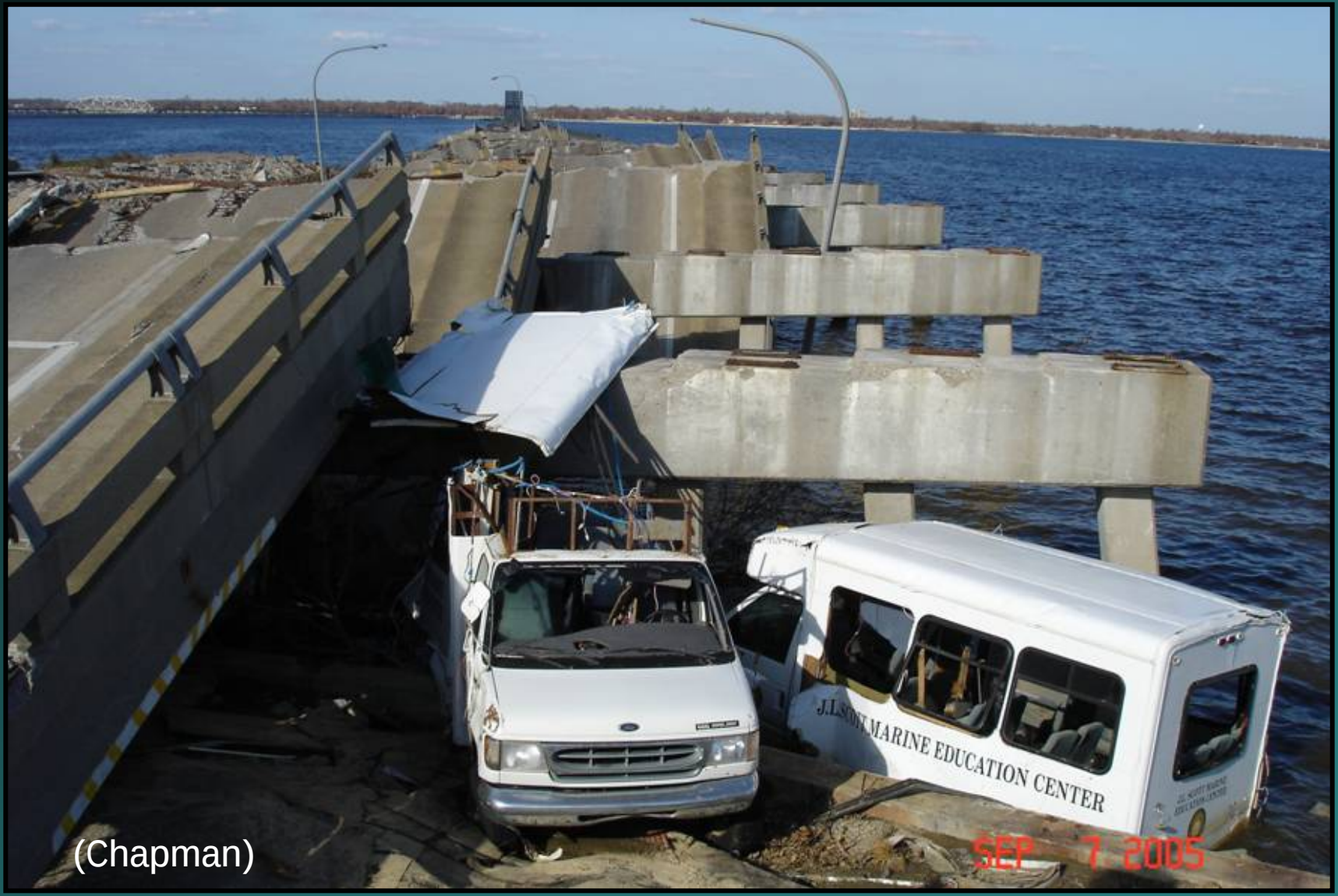


Overview of Damage - MS

- In Mississippi, bridges in three counties (Hacock, Harrison, and Jackson) were damaged

Bridge name	Carrier	Status as of 7 Nov	Repair cost	Expected downtime
Pacagoula River	I-10	Open	N/A	Partial close for 20 days
Bay St. Louis	US-90	Closed (Complete collapse)	$150,000,000	670 days
Handerson Point	US-90	Closed (Six spans drifted)	$2,100,000	172 days
Biloxi Ocean Springs	US-90	Closed (Complete collapse)	$150,000,000	550 days
I-110 Biloxi Back Bay	I-110	Open	$2,400,000	Partial close until repair
David V. LaRosa	Wittman Road	Open	N/A	N/A
Popps Ferry	Popps Ferry Road	Closed	N/A	176 days

US90 Biloxi-Ocean Springs Bridge *Damage*



(Chapman)

US90 Biloxi-Ocean Springs Bridge *Damage*

Abutment Damage and Loss of Backfill

Steel-Bronze Bearing Damage

US90 Biloxi-Ocean Springs Bridge *Repair*

- Complete Replacement with new 6-lane high-rise bridge
  - Avoid storm surge issues
  - Increased capacity
- Contracting
  - Design-build
  - Estimated at $150 million
  - Completion in May, 2007 (1.5 yrs)

I-10 Pascagoula River Bridge *Damage*

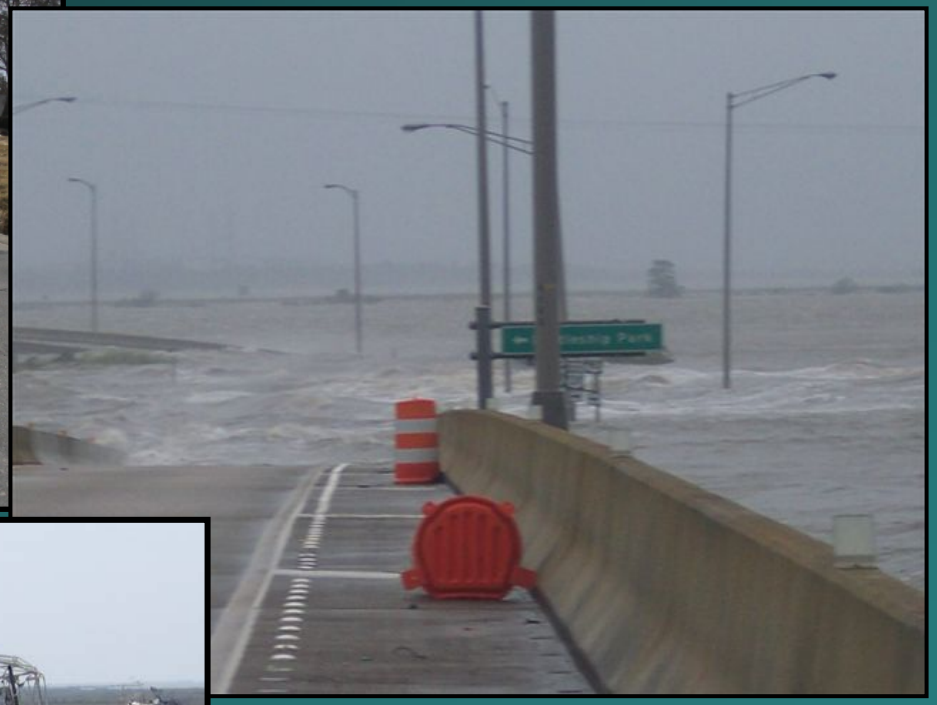
Damage to 6-span East-bound section due to Barge Impact

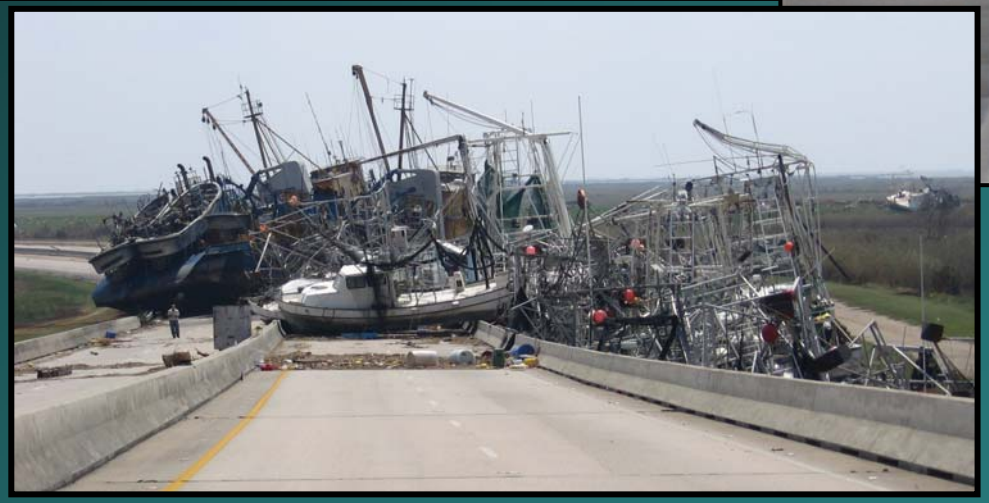
Typical Damage to Movable Bridges

Typical Damage to Movable Bridges

- Deck/pier damage from debris collision
- Water damage to mechanical and electrical systems from prolonged submersion:
  - Drive motors and their limit switches
  - Bridge control rooms
  - Bearings, sheaves and c
  - Navigation lights
  - Electronic traffic gate
- Soil scour and slope fail

Performance and Repair of Roads





Road US90 (Biloxi to Bay St. Louis) *Damage*

- Extensive debris and 4 ft of sand covered the road after Katrina.
- Damage to the pavement, sliding of asphalt, and damage to culverts and stormwater systems also inhibited traffic.

Road US90 (Biloxi to Bay St. Louis) *Repair*

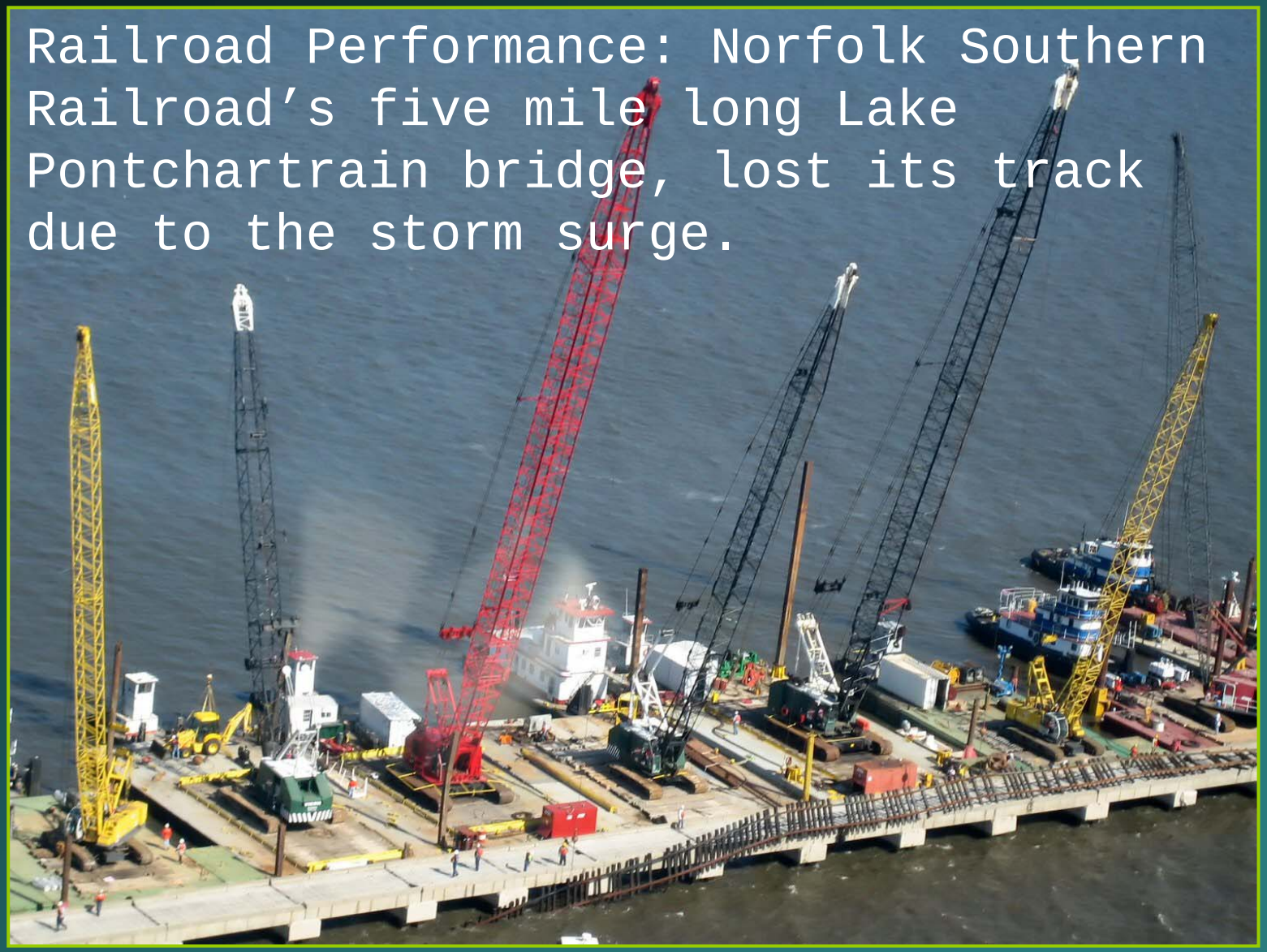
- 1 week to clear debris
- 2 months to allow 2 of 4 lanes open to traffic
- Expected repair completion by mid-December

Performance and Repair of Railroad Bridges

Summary of Railroad Performance

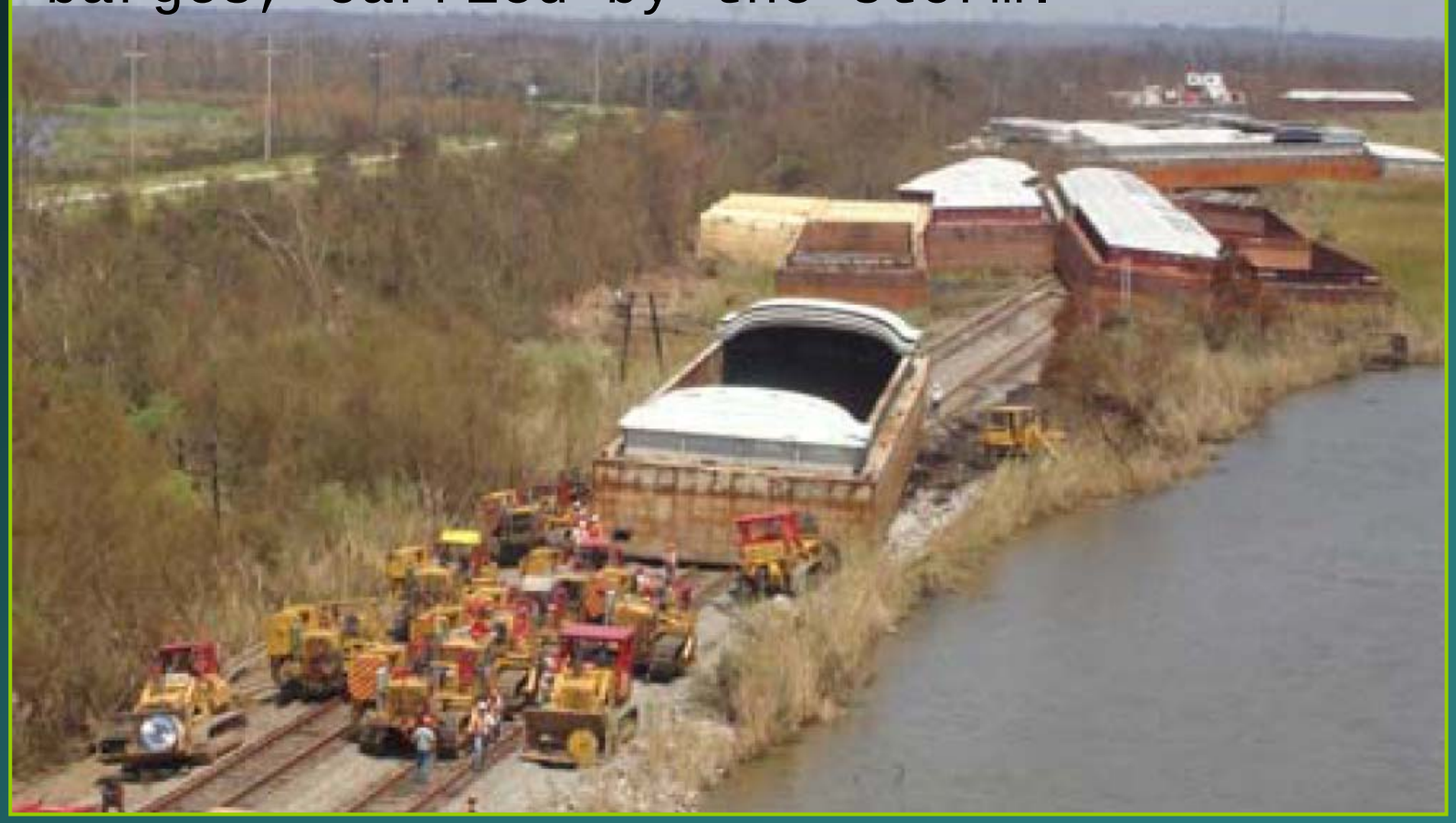
Location of railroads and railroad bridge damage due to Katrina

Norfolk Southern



CSX Between Bay Saint Louis and Biloxi Bay

East of Saint Louis Bay, the CSX track was littered with debris, including barges, carried by the storm.



US90 – Biloxi-Ocean Springs

Note: No Damage to Railroad Bridge Adjacent to US90

US90 – Biloxi-Ocean Springs

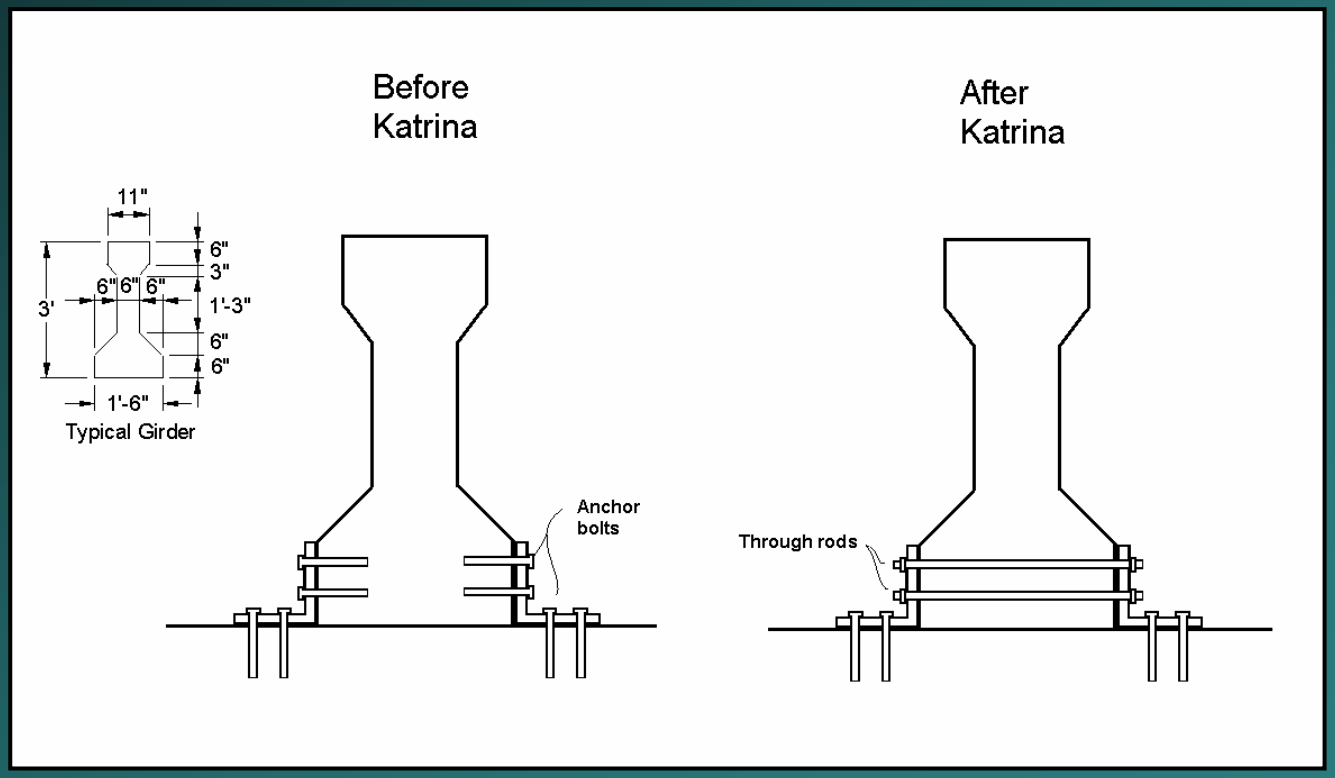
Note: No Damage to Railroad Bridge Adjacent to US90

Re-Routing & Traffic Demands - MS

Increased Traffic Count and Demands on I-10 *Post* Katrina.

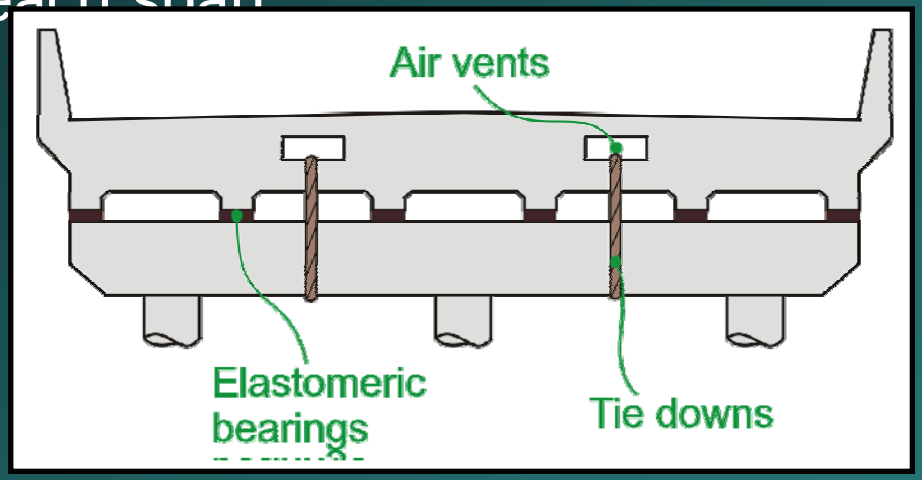
Impact on New Design - AL

Because of the many broken anchor bolts and damaged angle clips on the US90 to I-10 Ramp, Fred Conway (the Chief Bridge Engineer for the Alabama DOT) said they will switch from anchor bolts to through rods on the connections to the precast I-girders on new construction. A better connection to the bent caps will also likely be required.



Impact on New Design - LA

For segments of the bridge which must be below surge levels, provide vertical tie downs and air vents for each span



Take measures to protect rebar from corrosion

-Coated rebar

-High performance concrete

Impact on New Design – LA, MS

Build bridges well above the projected storm surge levels.

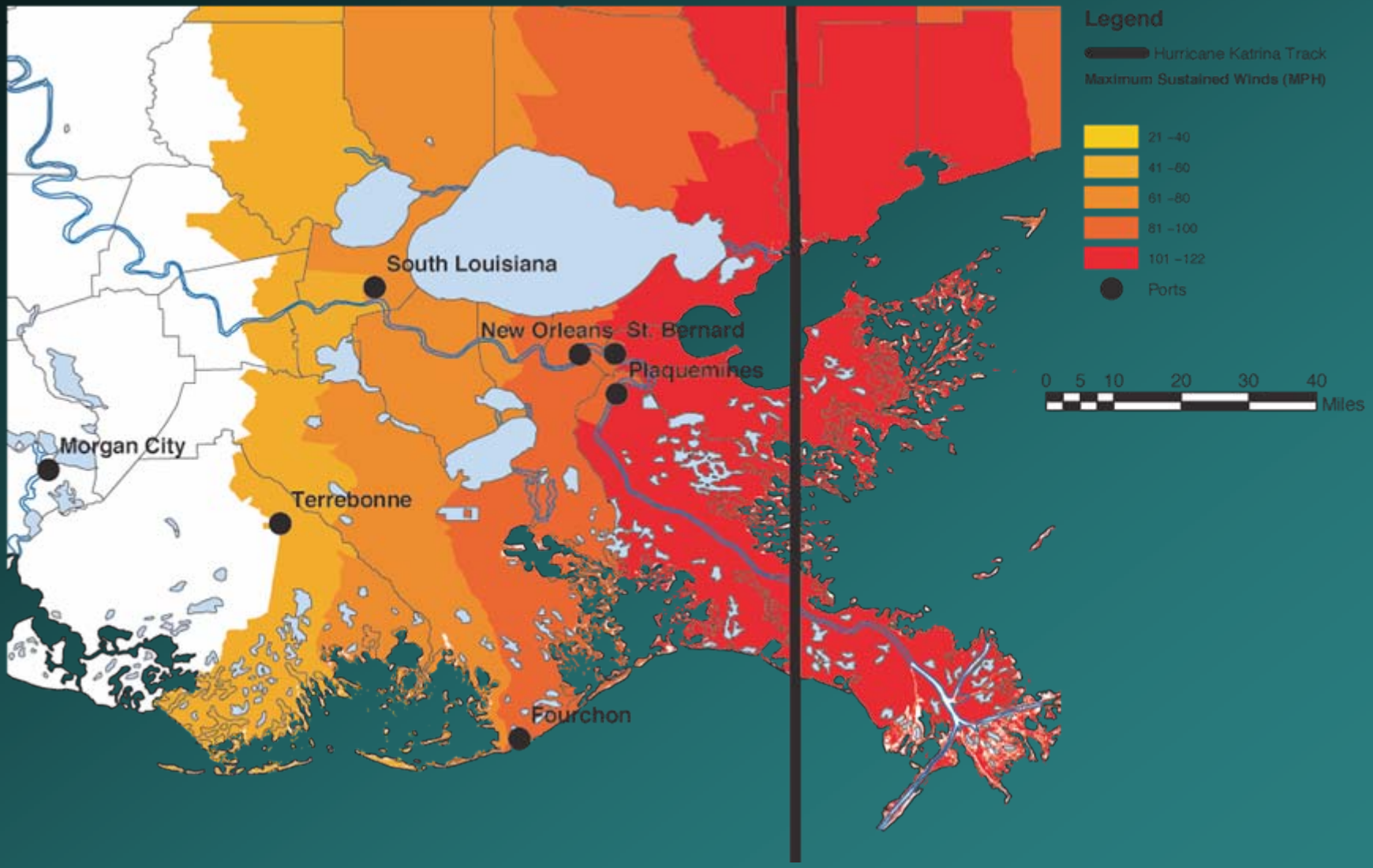
Summary and Conclusions

- Over 45 bridges had moderate to significant damage (estimated cost – $1 billion)
- Significant debris on roads
- Major disruption to rail traffic
- Appears that simple measures (shear keys, air vents) may be effective in limiting damage

Ports Visited

- River ports
  - Port of New Orleans
  - Port of South Louisiana
  - St. Bernard Port, Harbor, and Terminal District
  - Plaquemines Port, Harbor, and Terminal
- Coastal ports
  - Port Fourchon
  - Port of Terrebonne
  - Port of Morgan City

Ports Visited



Port of South Louisiana

- 54 river miles in length
- 249 million tons of cargo in 2004
- Largest tonnage port in the Western Hemisphere and 4th largest in the world
- More than 50% of all U.S. grain exports
- Primary import is crude oil
- 23rd largest U.S. port by cargo value in 2003

Port of South Louisiana

- Minor wind damage to grain conveyors and

Port of South Louisiana

- Operational impacts from closure of Mississippi River downstream due to navigation hazards, loss of communications and electrical power, and displacement of work force
- Normal operations restored within one week

Port of New Orleans

Port of New Orleans

- Diverse general cargo and passenger port
- 12th largest U.S. port by cargo value in 2003
- Principal imports include steel, petroleum products, rubber, plywood, coffee, machinery, and foodstuffs
- Principal exports include wood and paper products, foodstuffs, steel, chemical products, cotton, and rubber

Port of New Orleans

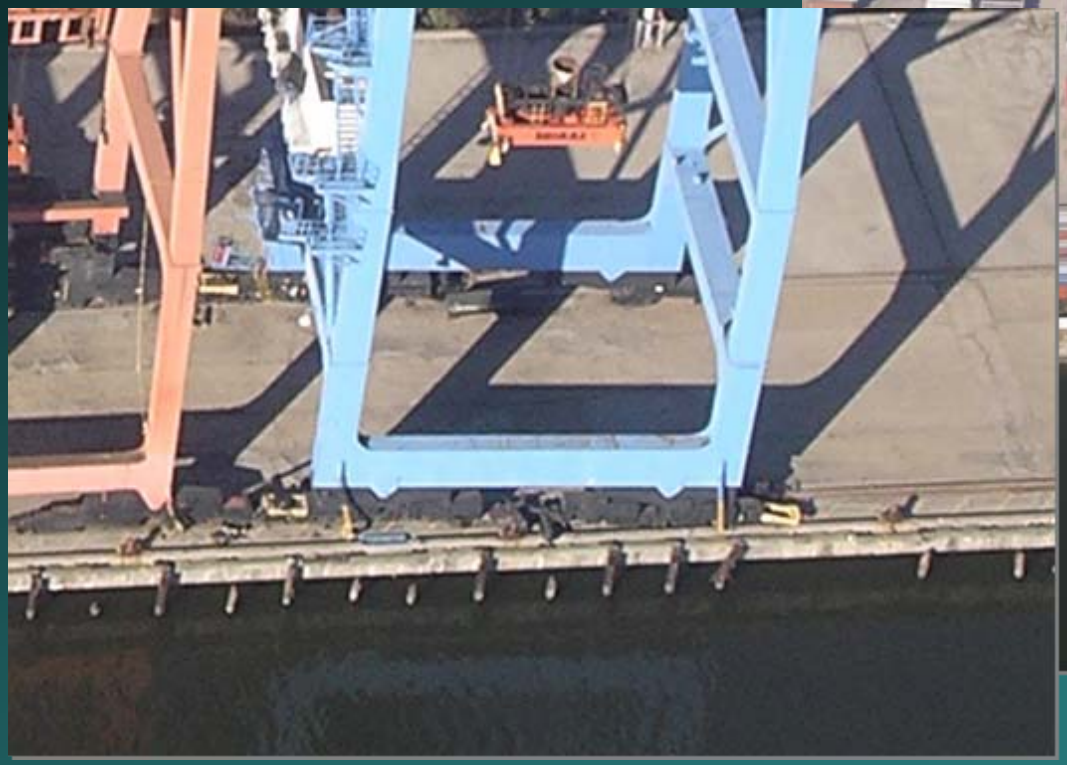
- Minor wind damage

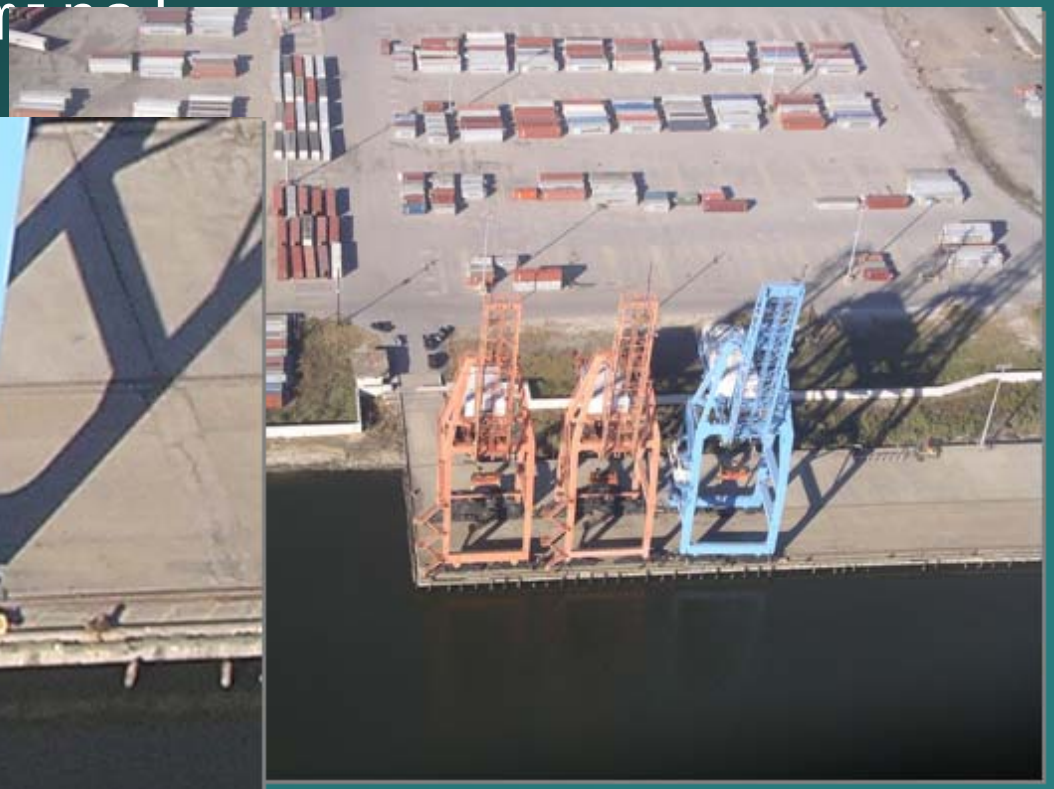
Port of New Orleans

- Fire at Mandeville Wharf caused by exploding propane gas cylinders

Port of New Orleans

- Damage to container cranes at the France Road Terminal



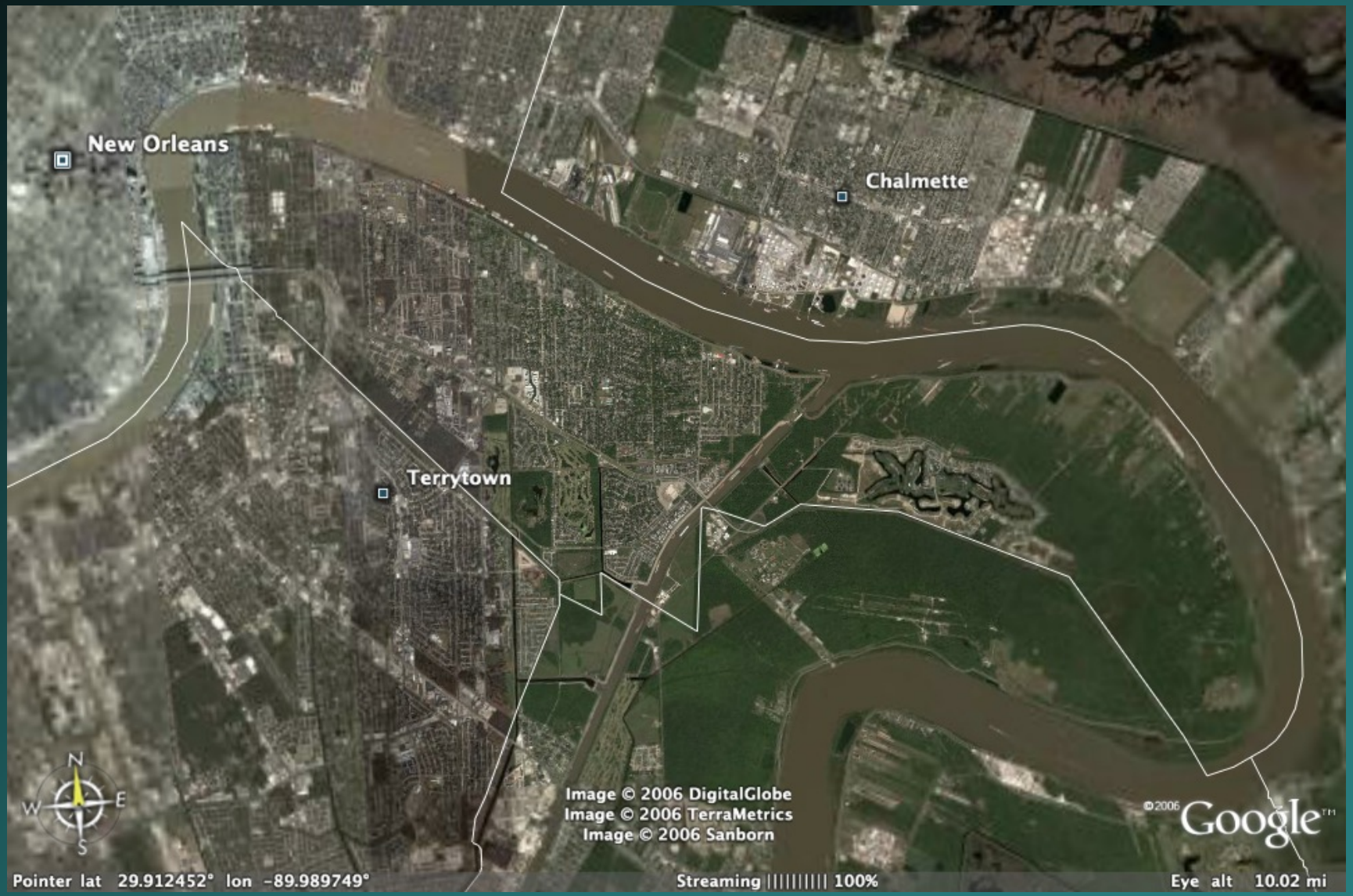


Port of New Orleans

- Primary operational impacts due to displaced labor force including stevedores, longshoremen, and truck drivers

Date	Estimated Capacity
October 20, 2005	40%
December 2005	60%
February 2006	80%

St. Bernard District



St. Bernard District

- Significant wind and flooding damage

Plaquemines District

Plaquemines District

- Distributed facilities composed of cargo transfer terminals for coal, grain, oil, and other raw materials
- Operational center for the offshore oil and gas industry
- Thin “ribbon” of land protected by Mississippi River levees and “back levees”

Plaquemines District

- 17 failures of back levees

Plaquemines District

- Catastrophic flooding

Plaquemines District

- Runaway barges and boats

Plaquemines District

- Long-term impacts of displaced workforce
  - CHS Grain Terminal
  - As of October 20, 200 an estimated 40% of t workforce was unaccou for and 10% to 20% we frequently absent

Port Fourchon

Port Fourchon

Port Fourchon

- Service port for offshore oil and gas production
  - Supports production of 16% - 18% of U.S. energy supply
- Land base of the Louisiana Offshore Oil Port (LOOP), which handles 13% - 15%

Port Fourchon

- Minor wind damage

Port Fourchon

- Maintenance and replenishment of surrounding marsh areas

Port Fourchon

- Debris fences

Port Fourchon

- Elevated telecommunications infrastructure

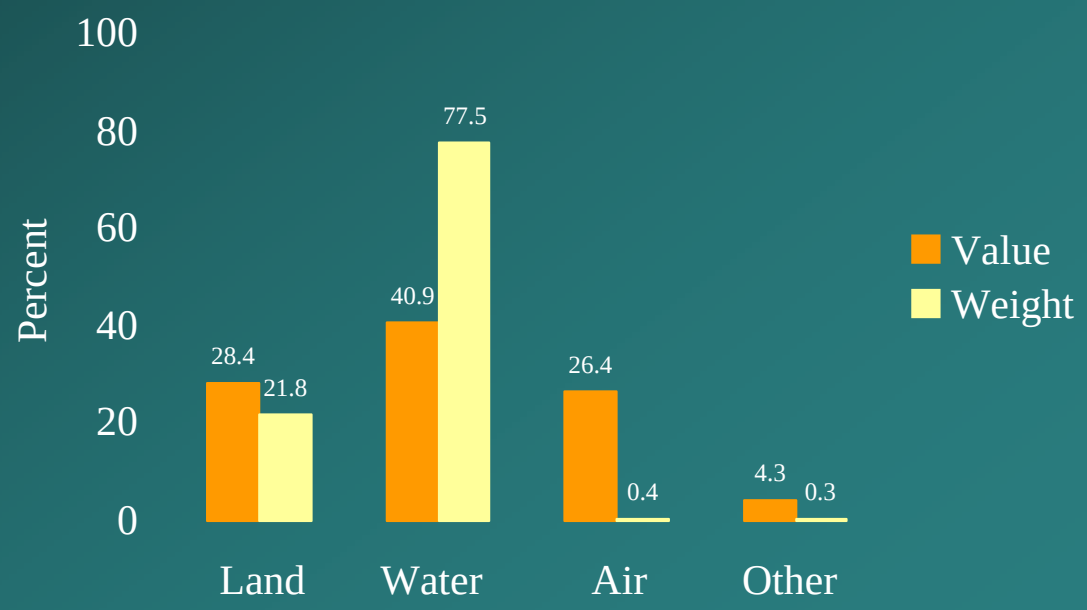
Preliminary Damage Estimates

Port	Estimated Damage
Port of New Orleans	$730 million (private) $270 million (public)
St. Bernard Port, Harbor, and Terminal District	$20.1 million
Port Fourchon	$6.3 million
Plaquemines Port, Harbor, and Terminal District	?

Transportation Networks

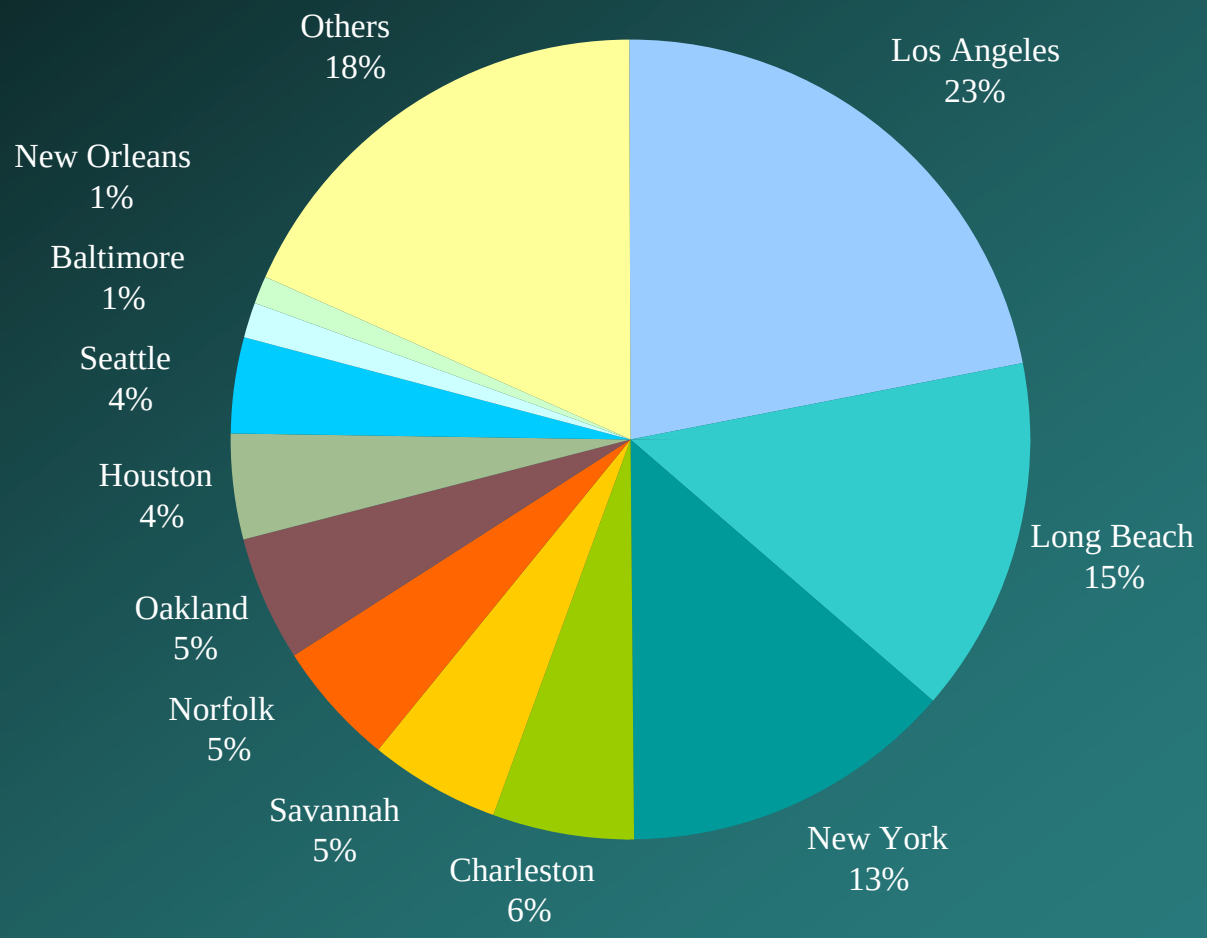
Value of U.S. Waterborne Trade

2003 Modal Share



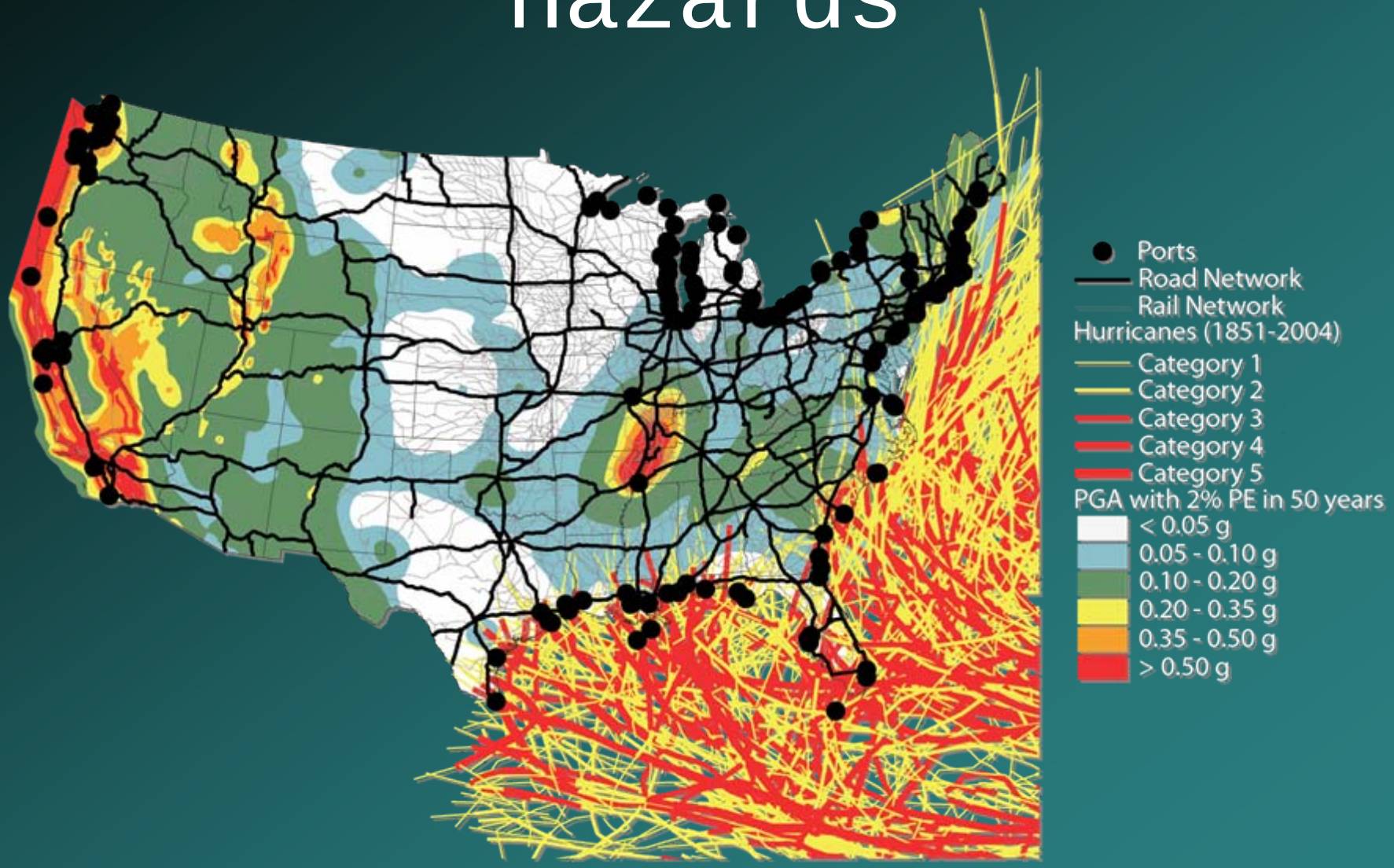
Source: Bureau of Transportation Statistics (2004)

2003 Container Trade (TEU)

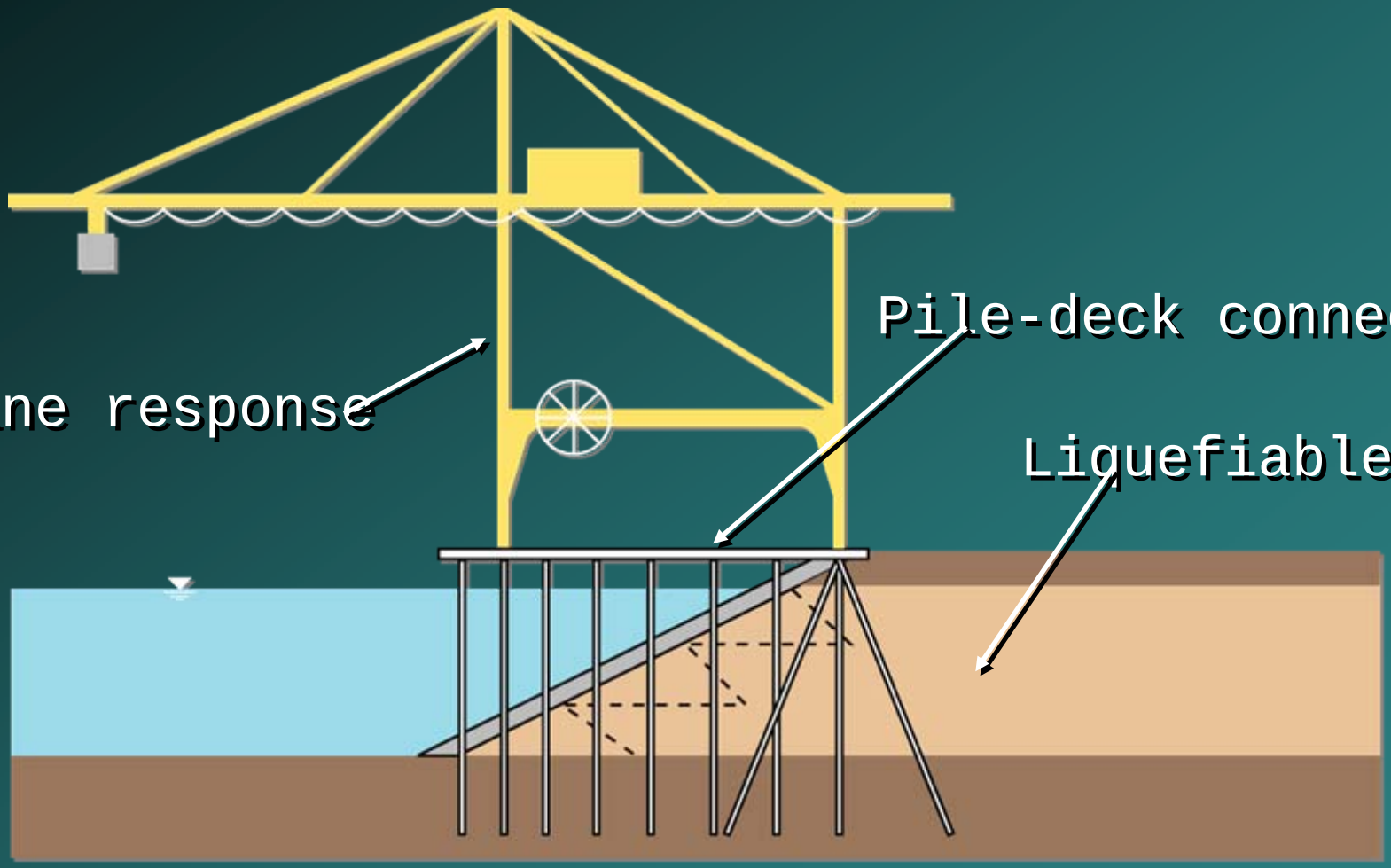


Source: Port Import/Export Reporting Service (PIERS)

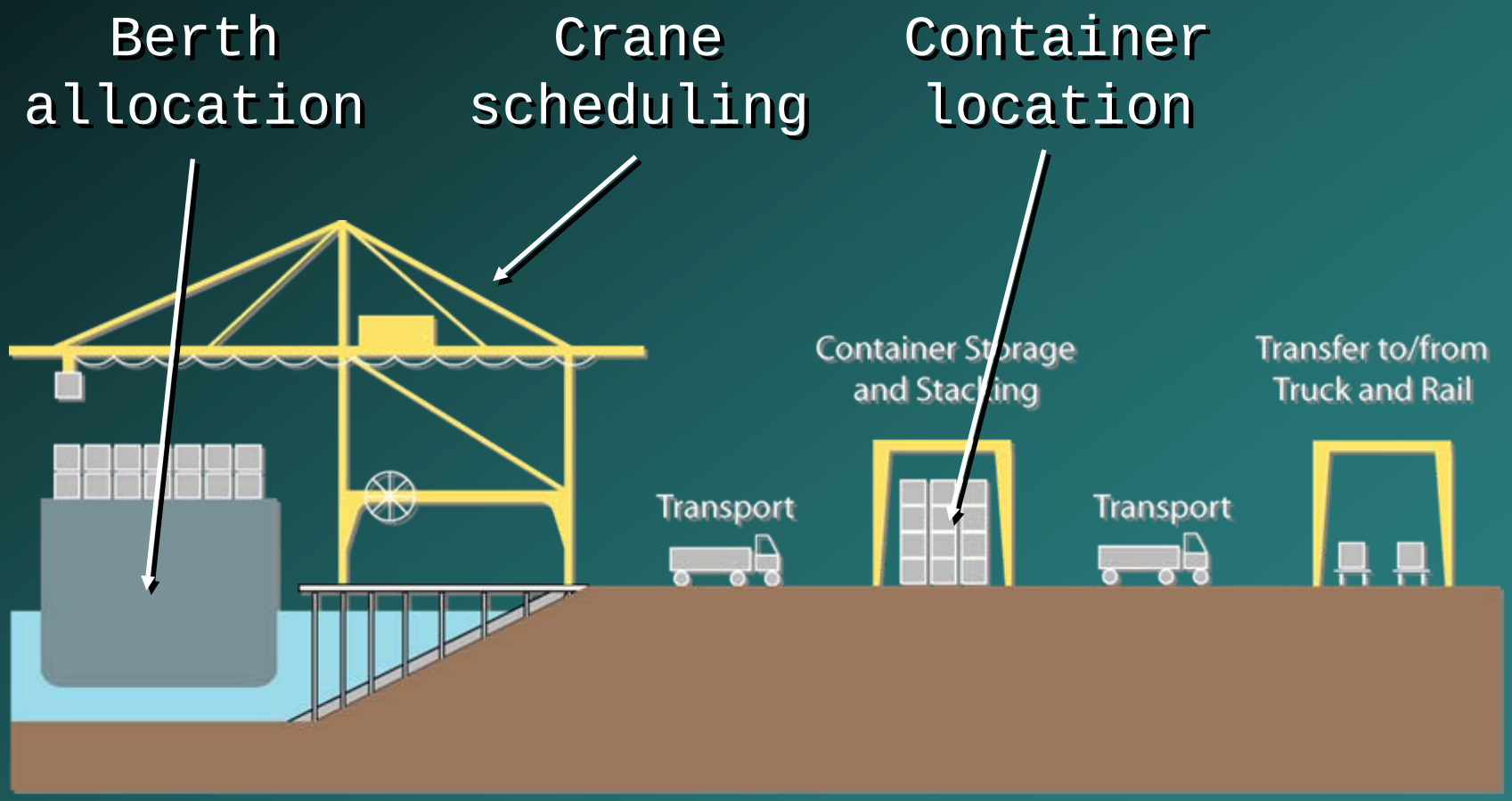
Seismic and Hurricane Hazards



Component Performance



System Performance



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- Karen St. Cyr
- Henry Sullivan
- Tim Tregle
- Urban Treuil
- Ed Watson
- Paul Zimmerman
- People of South Louisiana