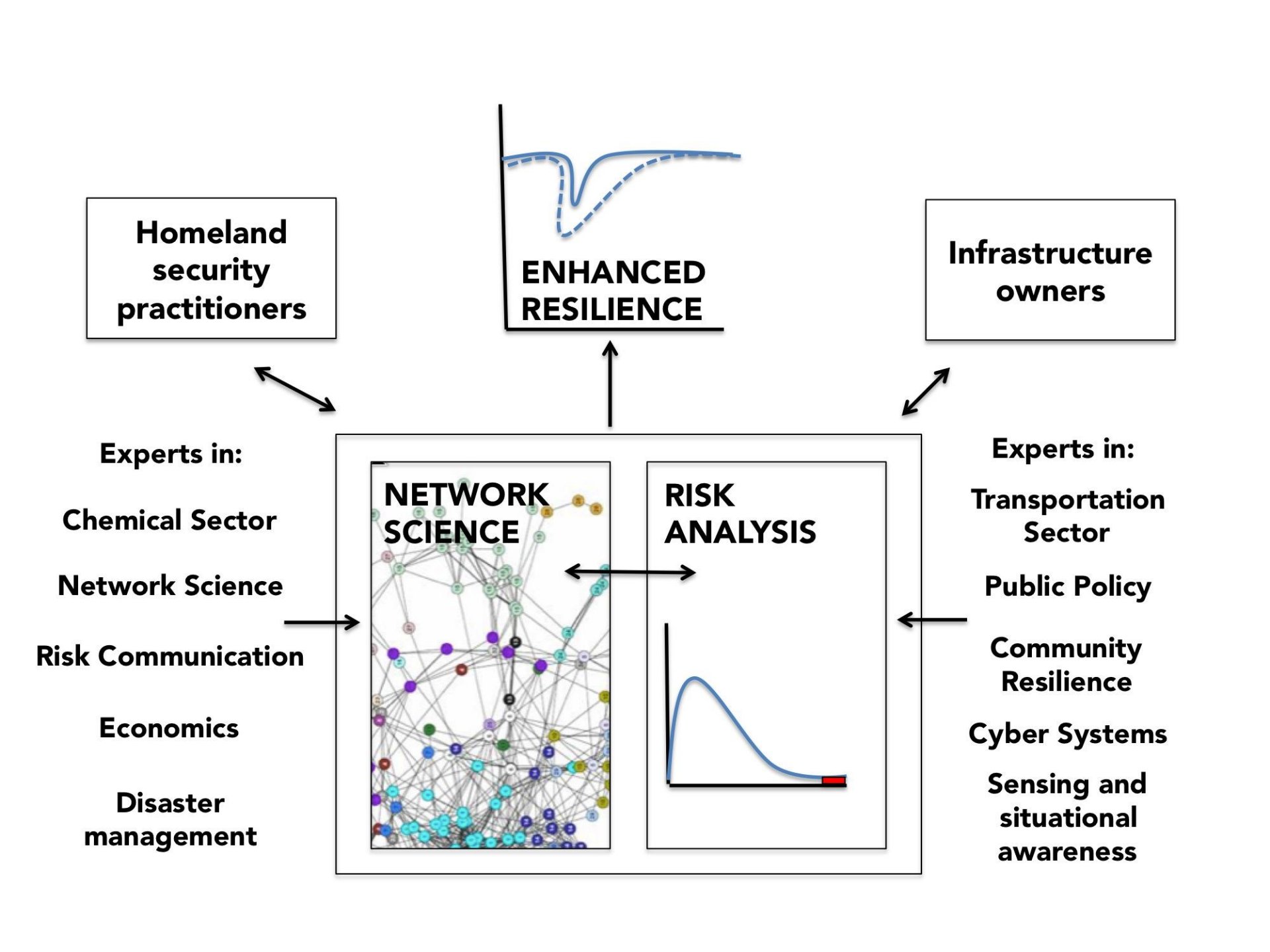
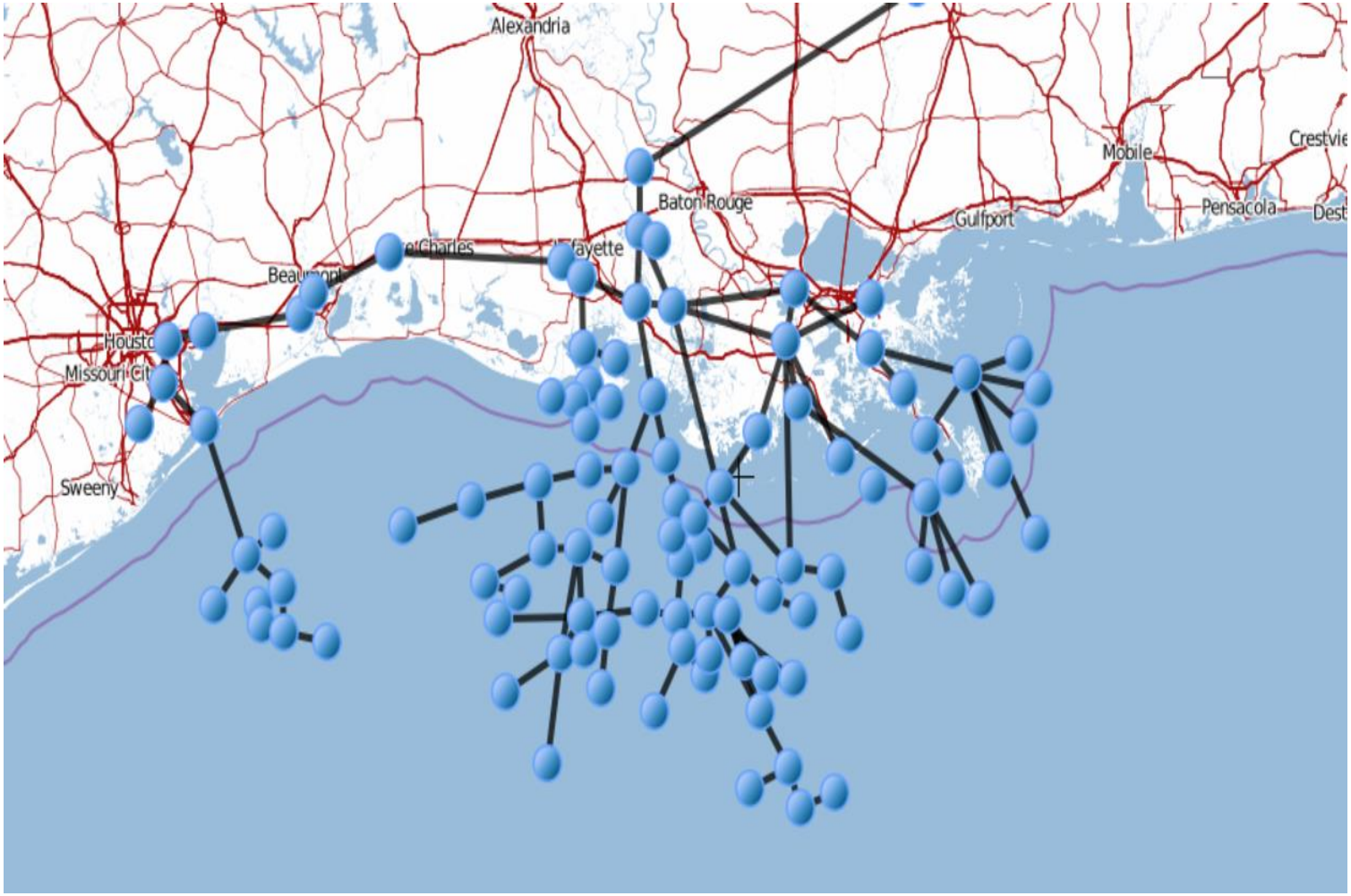
Critical Infrastructure Resilience

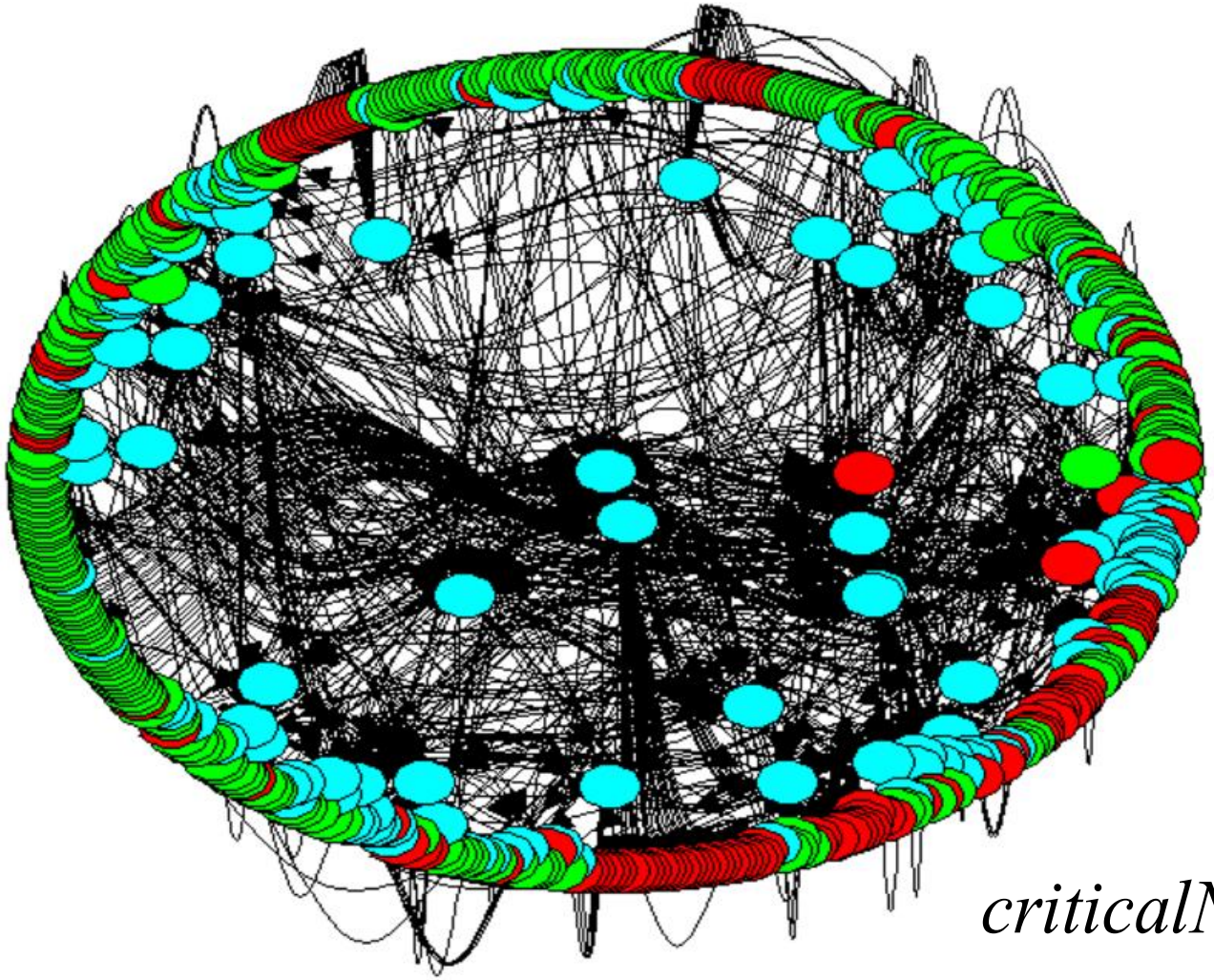
John Pardue, Ph.D., P.E.
Hazardous Substance Research Center
Louisiana State University
jpardue@lsu.edu


Homeland security practitioners
ENHANCED RESILIENCE
Infrastructure owners
Experts in:
Chemical Sector
Network Science
Risk Communication
Economics
Disaster management
NETWORK SCIENCE
RISK ANALYSIS
Experts in:
Transportation Sector
Public Policy
Community Resilience
Cyber Systems
Sensing and situational awareness

Network Model of Gulf of Mexico Crude Oil Production



Network Model of Bay Area Transit System



$$criticalNodes = \frac{n}{r}$$

$$criticalLinks = n - \frac{2n}{l}$$

Severe storms and bulk chemical storage

John H Pardue, LSU


Delta Terminal
West Bank, Harvey, LA
7/19/2015
Disaster Risk Reduction and Making Cities Resilient
Google earth
Tour Guide
1998
Imagery Date: 10/31/2014 29°54'26.24" N 90°05'18.85" W elev 0 ft eye alt 5823 ft

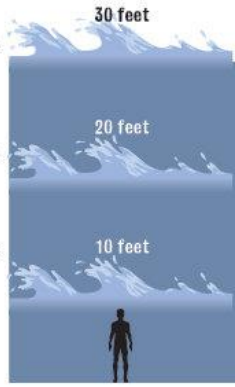

N
Image © 2015 DigitalGlobe
Google earth

Source: Interagency Performance Evaluation Task Force, Team Louisiana

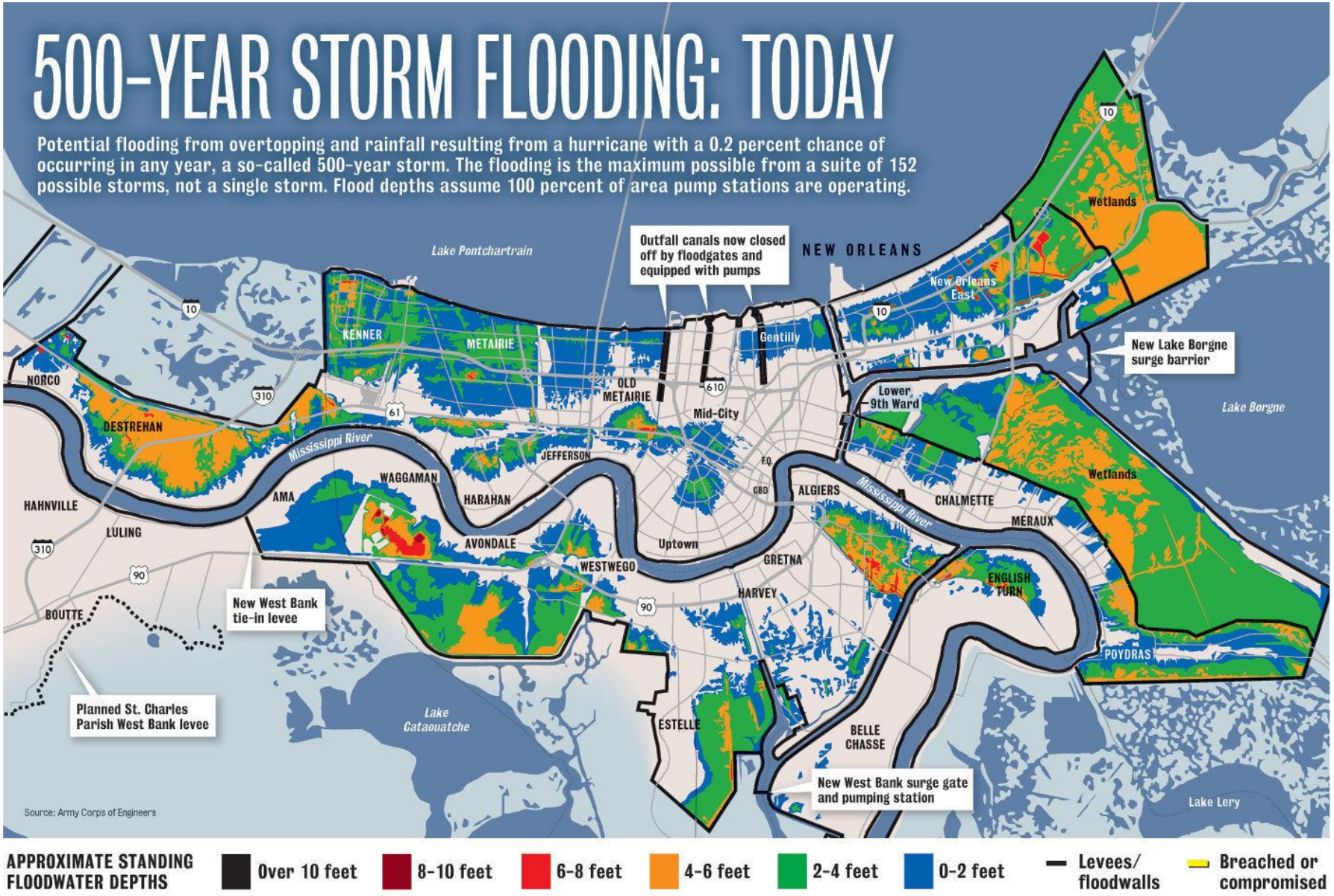
WHAT KIND OF STORM WAS KATRINA?

Hurricane Katrina is often called a 400-year storm, but that refers to the height of surge and waves. So actually, it all depends on where you live:

1. **Mississippi Gulf Coast:** 28 feet of surge and waves pounded the coast, a scenario with a 0.25 percent chance of occurring in any year. — **400-YEAR STORM**
2. **St. Bernard Parish:** At levees lining the parish, the surge and waves swelled 19.5 feet, which has a 0.4 percent chance of occurring in any year. — **250-YEAR STORM**
3. **New Orleans:** Along Lake Pontchartrain in New Orleans, the surge and waves reached between 10 and 13 feet, equal to a 0.6 percent chance of occurring in any year. — **150-YEAR STORM**



DAN SWENSON / GRAPHICS REPORTER


500-YEAR STORM FLOODING: TODAY
Potential flooding from overtopping and rainfall resulting from a hurricane with a 0.2 percent chance of occurring in any year, a so-called 500-year storm. The flooding is the maximum possible from a suite of 152 possible storms, not a single storm. Flood depths assume 100 percent of area pump stations are operating.
Lake Pontchartrain
Outfall canals now closed off by floodgates and equipped with pumps
NEW ORLEANS
Wetlands
New Orleans East
New Lake Borgne surge barrier
Lake Borgne
KENNER
METAIRIE
Gentilly
OLD METAIRIE
Mid-City
Lower 9th Ward
NORCO
DESTREHAN
Mississippi River
JEFFERSON
WAGGAMAN
AMA
HARAHAN
FQ
CBD
ALGIERS
CHALMETTE
MERAUX
HAHNVILLE
LULING
AVONDALE
Uptown
GRETNA
WESTWEGO
HARVEY
ENGLISH TURN
BOUTTE
New West Bank tie-in levee
POYDRAS
Planned St. Charles Parish West Bank levee
Lake Cataouatche
ESTELLE
BELLE CHASSE
New West Bank surge gate and pumping station
Lake Lery
Source: Army Corps of Engineers
APPROXIMATE STANDING FLOODWATER DEPTHS
Over 10 feet
8-10 feet
6-8 feet
4-6 feet
2-4 feet
0-2 feet
Levees/ floodwalls
Breached or compromised

Outline

- Katrina chemical spills
- Mechanisms of hurricane-induced spills
- Hurricane Isaac and Stolthaven
- Possible solutions

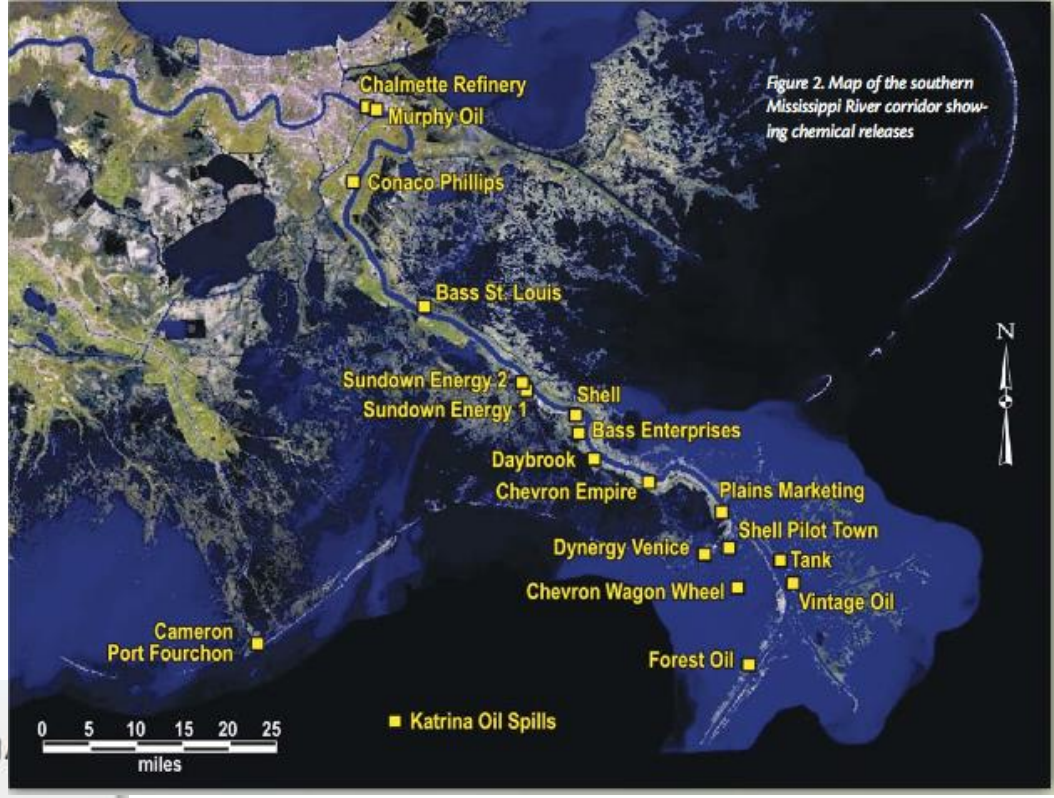


Figure 2. Map of the southern Mississippi River corridor showing chemical releases

BOX 1. CHEMICAL RELEASES FROM HURRICANE KATRINA IN THE LOWER MISSISSIPPI CORRIDOR

Bass Enterprises Production Company (Cox Bay): 3.78 million gallons discharged.

Shell (Pilot Town): 1.05 million gallons discharged.

Chevron (Empire): 991,000 gallons discharged.

Murphy Oil Corporation (Meraux): 819,000 gallons discharged.

Bass Enterprises (Point a la Hache): 461,000 gallons of oil discharged.

Chevron (Port Fourchon): About 53,000 gallons discharged.

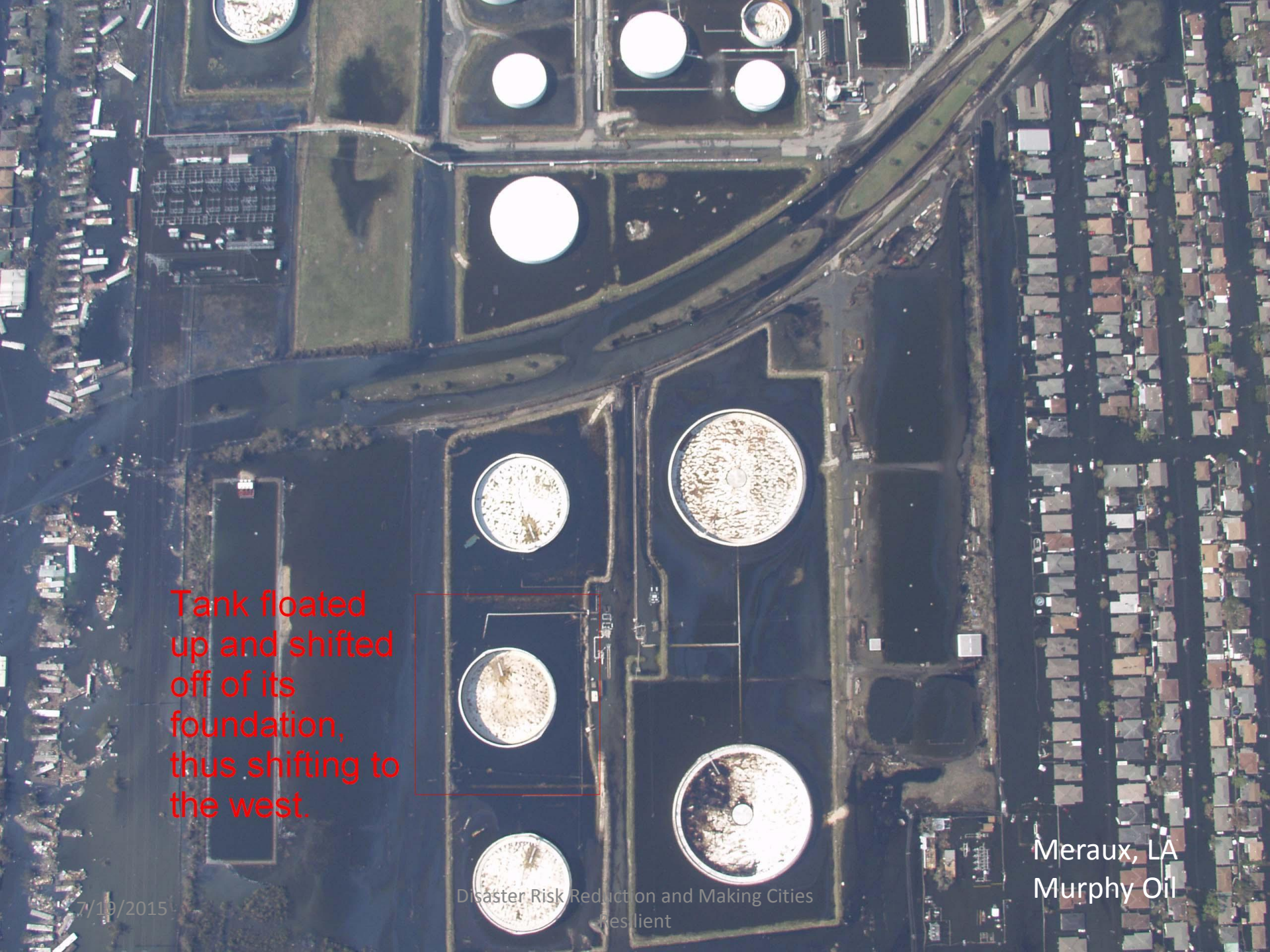
Venice Energy Services Company (Venice): 840,000 gallons discharged.

Shell Pipeline Oil (Nairn): 13,440 gallons discharged.

Sundown Energy (West Potash): 13,000 gallons discharged.


Chevron Empire facility


Bass Enterprises


Tank floated up and shifted off of its foundation, thus shifting to the west.
Meraux, LA
Murphy Oil

Murphy Oil Spill

Sample Locations (>4500)

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Common failure mechanism

$F_b = 0.134 V_t \gamma FS$

Where:	F_b	is the buoyancy force exerted on the tank, in pounds.
	V_t	is the volume of the tank in gallons.
	0.134	is a factor to convert gallons to cubic feet.
	γ	is the specific weight of flood water surrounding the tank (generally 62.4 lb/ft³ for fresh water and 64.1 lb/ft³ for salt water.)
	FS	is a factor of safety to be applied to the computation, typically 1.3 for tanks.

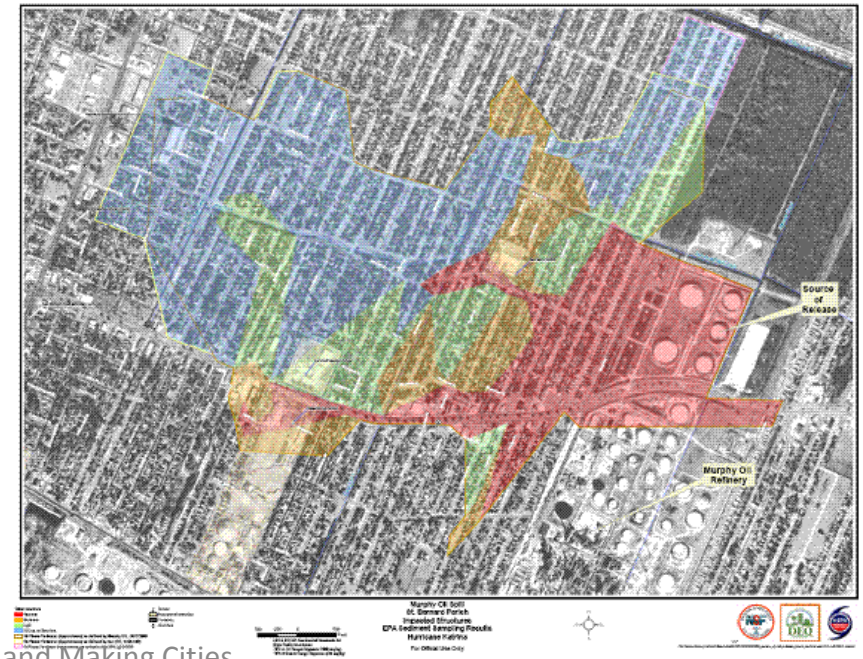
Secondary Containment Regulations

- Designed or operated to contain 100% of the capacity of the largest tank within its boundary.
- Designed or operated to prevent run-on or infiltration of precipitation into the secondary containment system unless the collection system has sufficient excess capacity to contain run-on or infiltration. Such additional capacity must be sufficient to contain precipitation from a 25-year, 24-hour rainfall event.
- Free of cracks or gaps.
- Designed and installed to surround the tank completely and to cover all surroundings likely to come into contact with the waste if the waste is released from the tank(s) (i.e., capable of preventing lateral as well as vertical migration of the waste)


1203
3
1203
2
7 11:02 AM


OIL CO., INC.
7 11:02AM

Meraux Oil Spill (Murphy Refinery, 2005)



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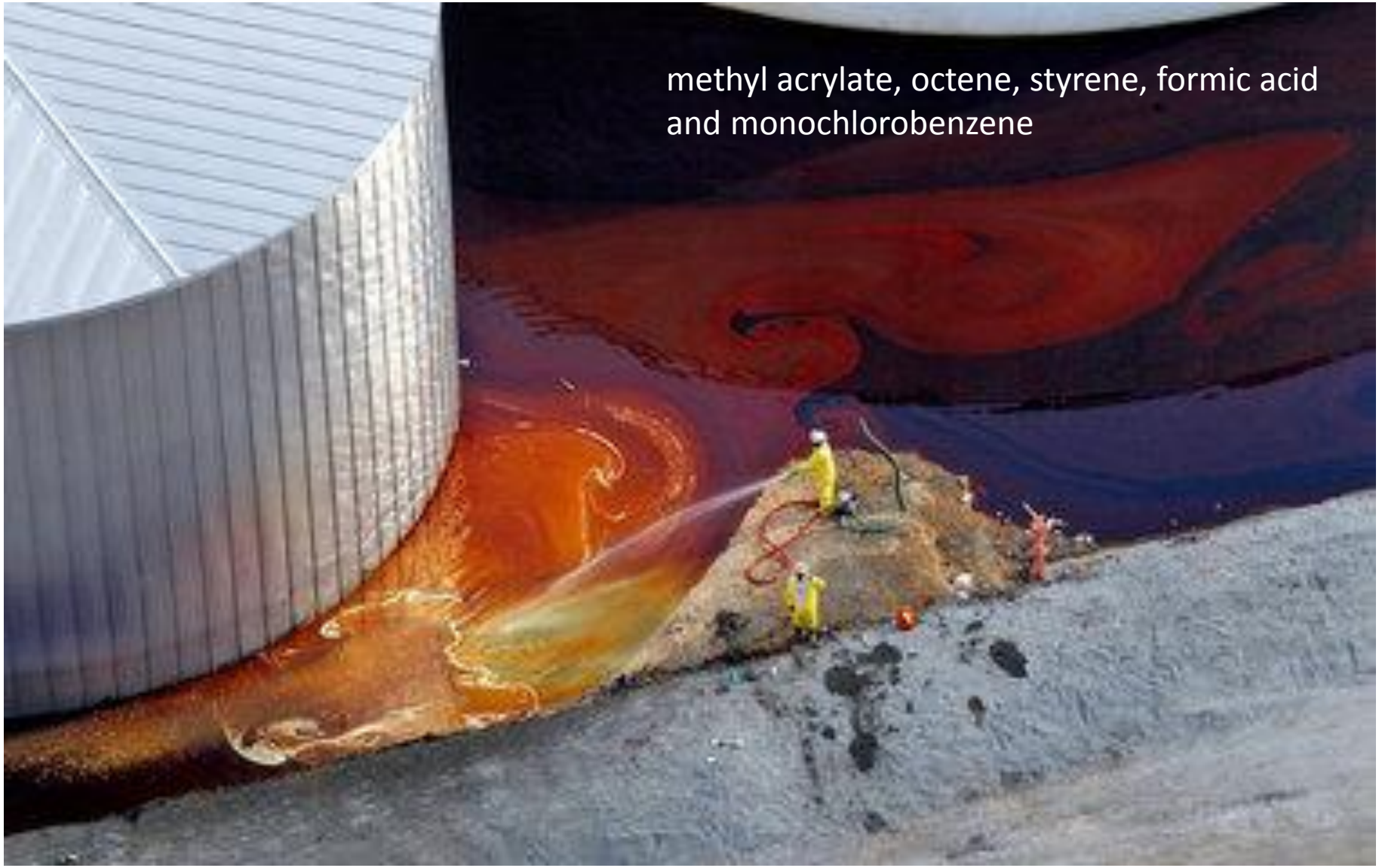
Google
Map data ©2012 Google - Terms of Use
Report a map error


Chalmette
46
Orleans
Mississippi River
Meraux
Algiers
STOLTHAVEN: 191,000 gallons of chemicals spilled from plant during Isaac
Violet
Jefferson
39
23
Poydras
Braithwaite
Belle Chasse
St. Bernard
39
23
Scarsdale
Plaquemines
THE TIMES-PICAYUNE


methyl acrylate, octene, styrene, formic acid
and monochlorobenzene


4WWL

Stolthaven impacts

- 68 storage tanks were in service on the terminal before the storm.
- 14 tanks and piping systems were damaged.
- Several of the tanks have lost product. The containment system around the tanks captured much of this and protective booms were placed around the tanks and the entire terminal to collect any spilled product and keep it contained within the terminal.
- 142 railcars were derailed by the storm. All of those rail cars have been rerailed, and are being inspected and repaired.

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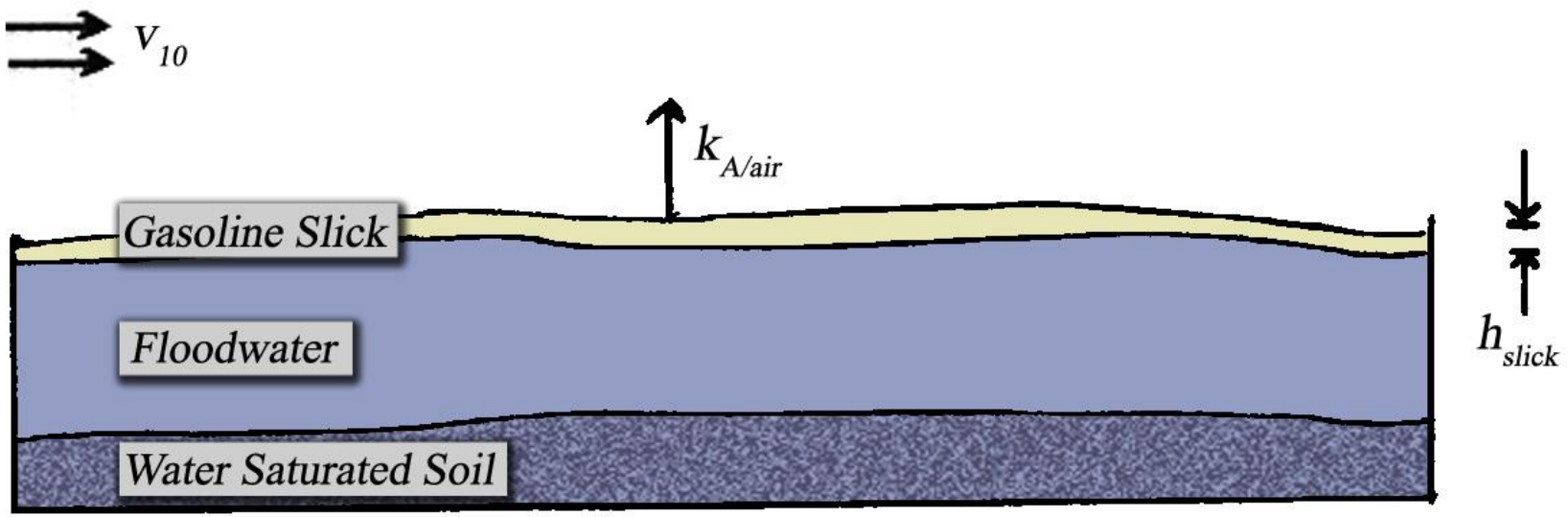
Possible solutions

- Determine worst case scenarios and educate first responders
- Develop structural solutions to common failure mechanisms
- Improve reporting and assessment post-spill



$$N_{A0} = k_{A/air} \frac{P_{vap}}{R \cdot T} x_A \cdot \exp(-K_{evap} \cdot t)$$

$$C_{A,air} = 27 \cdot \frac{N_{A0}}{v_{10}}$$

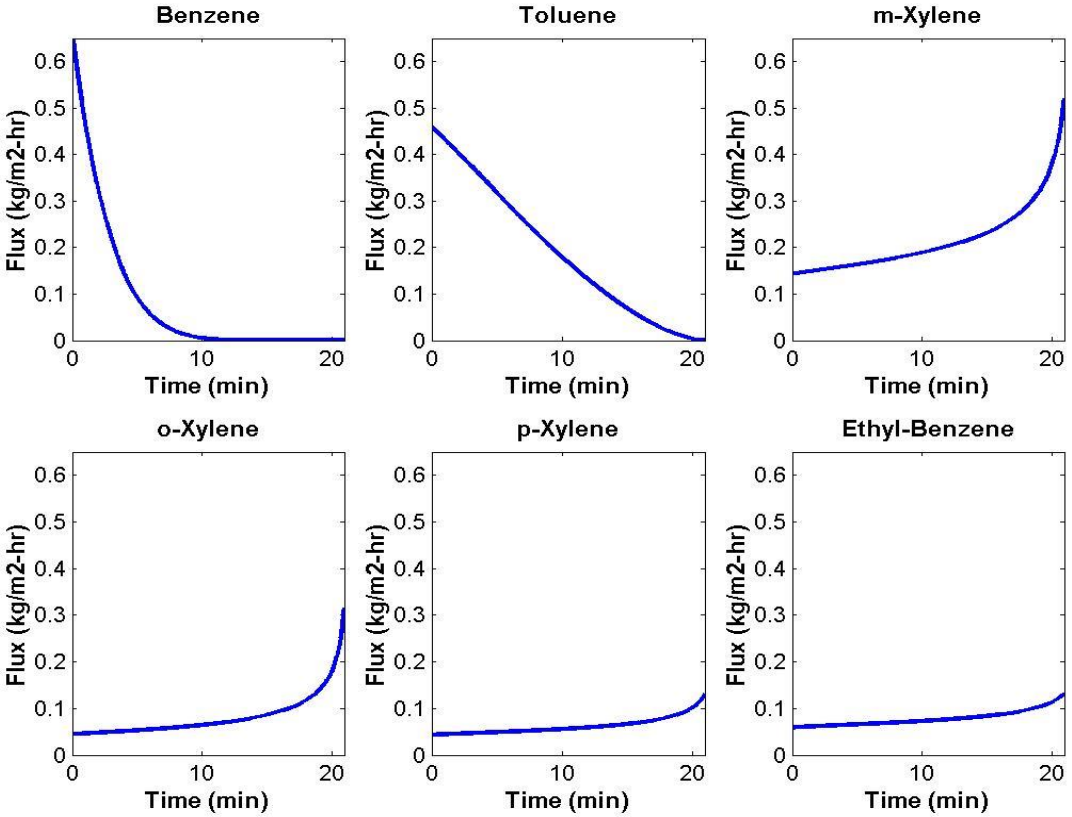
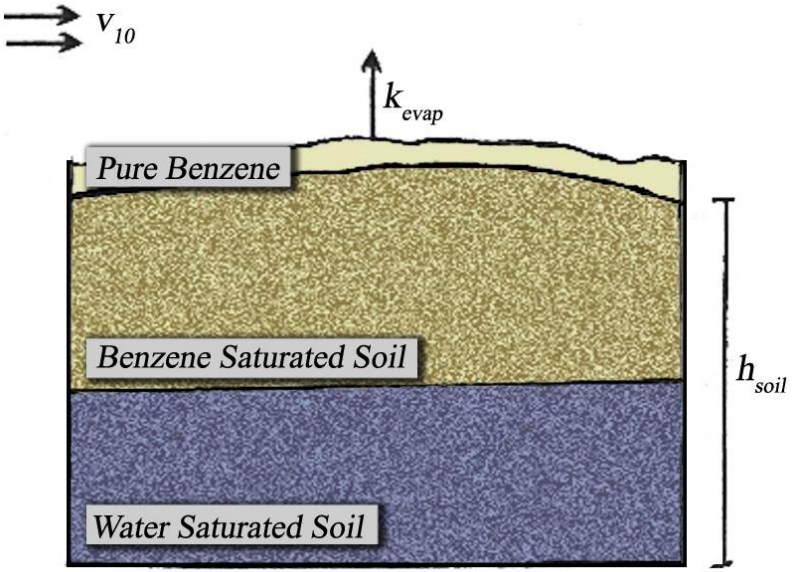


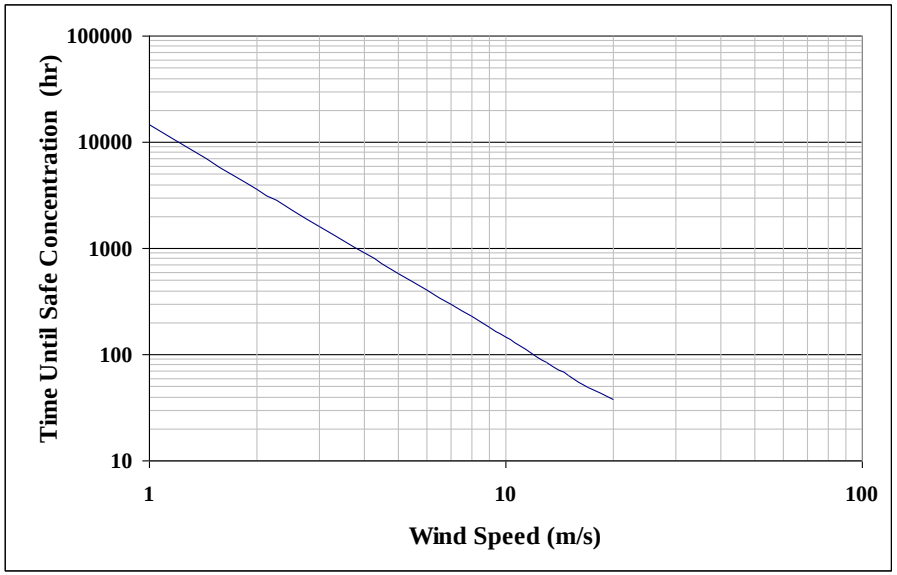
Table 2.5. Time for total evaporation of gasoline (minutes).

Slick Height (mm)	Wind Speed (m/s)								
	.1	**.25**	**.5**	**1**	**1.5**	**2.0**	**5.0**	**10.0**	**20.0**
1	18.3	17.4	16.1	14.0	12.4	11.2	7.2	5.2	3.2
2	35.9	34.1	31.5	27.3	24.1	21.6	13.4	8.5	5.4
3	53.5	50.8	46.9	40.5	35.8	32.0	19.7	12.3	7.3
4	71.2	67.5	62.2	53.8	47.4	42.4	26.1	16.1	9.3
5	88.8	84.2	77.6	67.1	59.1	52.9	32.4	19.9	11.5



$$n_{A0} = \frac{\left(P_{vap} - P_{A,air}\right)\frac{MW_A}{R \cdot Temp}}{\left[\left(\frac{1}{k_{A1}}\right)^2 + \left[\frac{2\left(P_{vap} - P_{A,air}\right)\frac{MW_A}{R \cdot Temp} \cdot t}{D_{A,soil} \cdot \rho_{A,soil}}\right]\right]^{0.5}}$$

$$C_{A,air} = 27 \cdot \frac{N_{A0}}{v_{10}}$$



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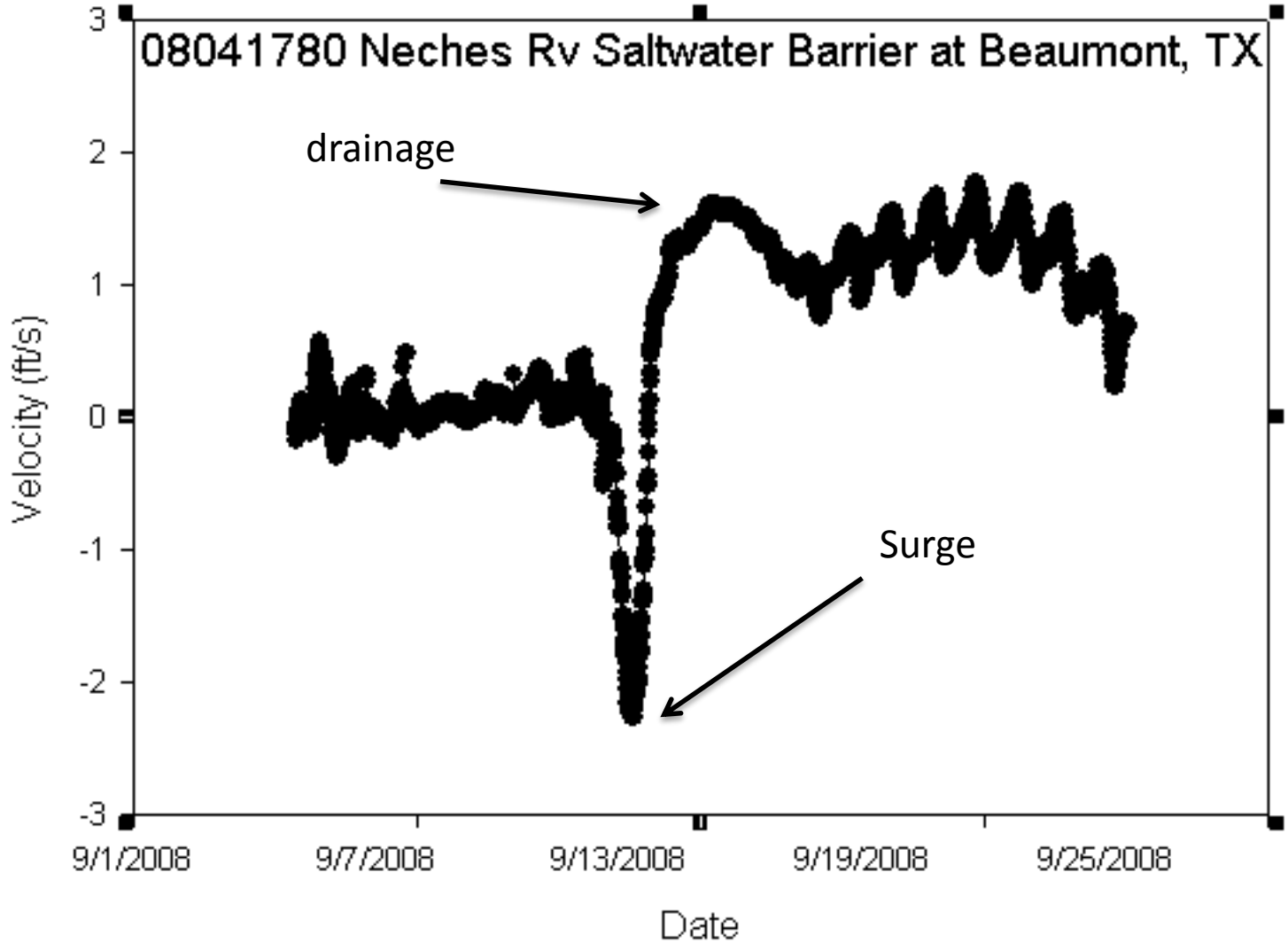
08041780 Neches Rv Saltwater Barrier at Beaumont, TX
drainage
Surge
Velocity (ft/s)
3
2
1
0
-1
-2
-3
9/1/2008
9/7/2008
9/13/2008
9/19/2008
9/25/2008
Date

Possible solutions

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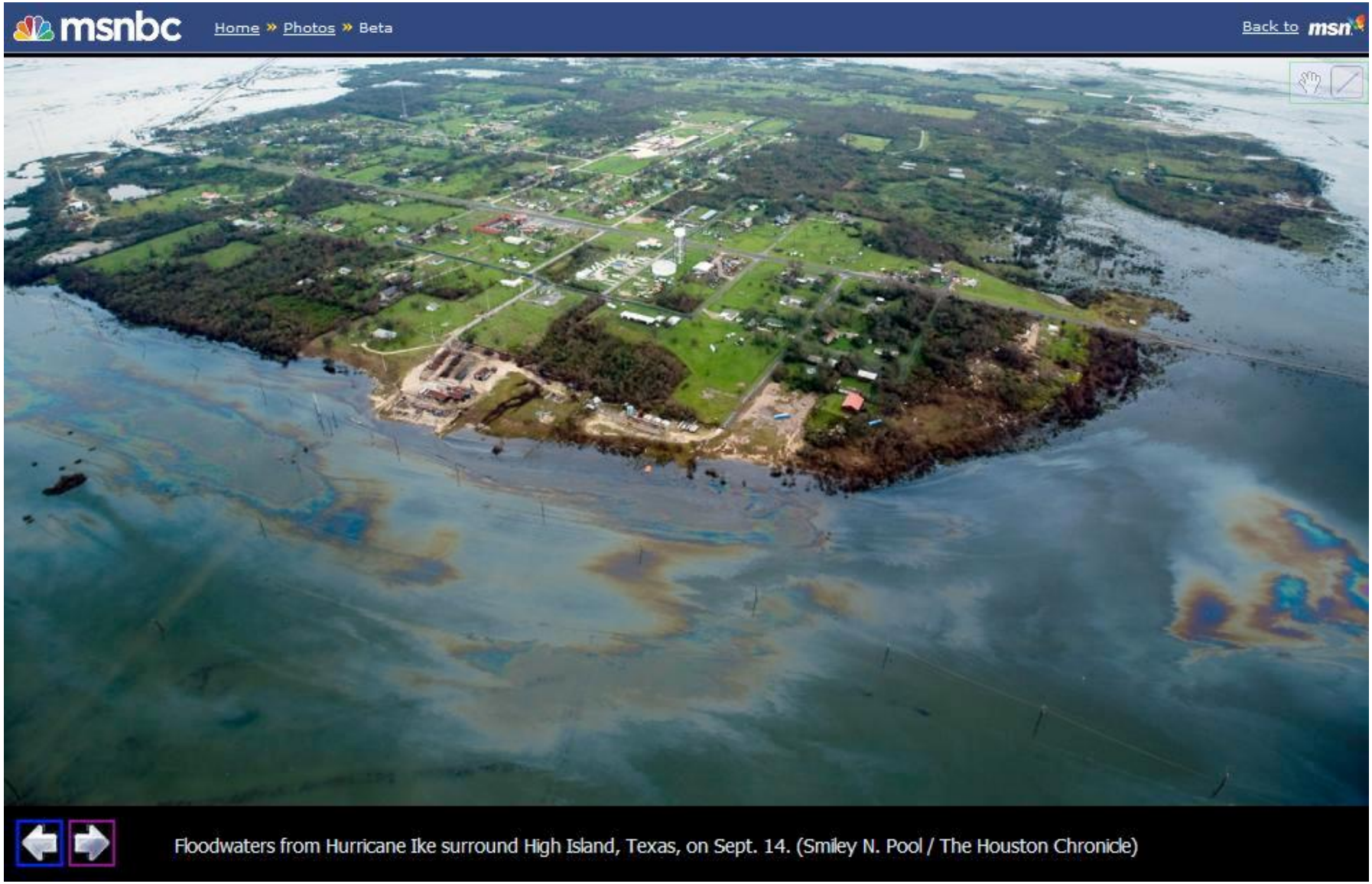
Questions?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Floodwaters from Hurricane Ike surround High Island, Texas, on Sept. 14. (Smiley N. Pool / The Houston Chronicle)