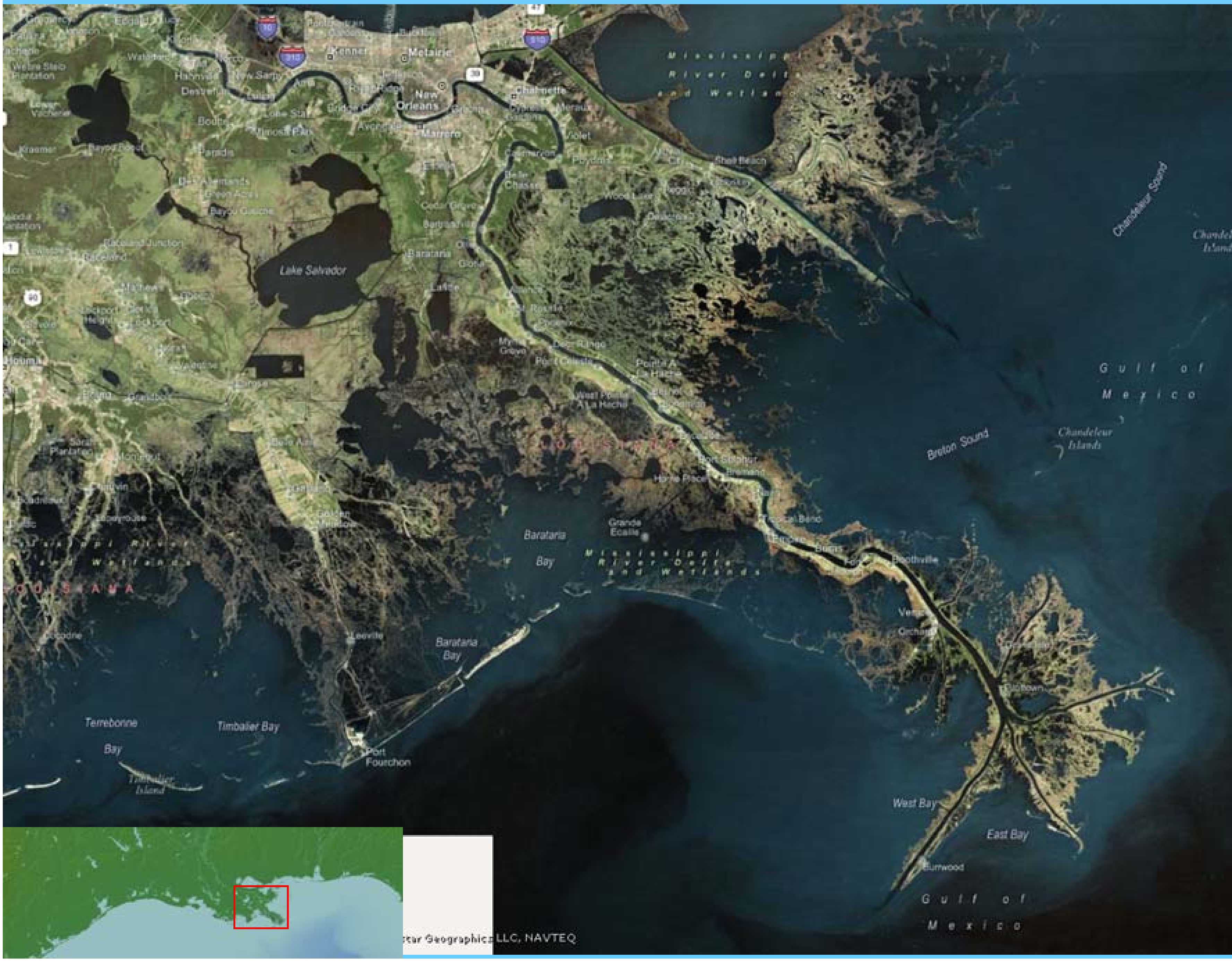
Caminada Bridge (LA): Coastal Engineering Analysis & Numerical Modeling in Support for Design (*Hurricane Wind and Wave Action*)

Hossein Ghara, P.E., M.B.A., State of Louisiana DOT&D
Artur Wagner, P.E., State of Louisiana DOT&D
Jenny Fu, P.E., State of Louisiana DOT&D
Vladimir Shepsis, P.E., PhD Coast & Harbor Engineering, Inc.
Matteo Tirindelli, PhD Coast and Harbor Engineering, Inc.

2008 LTRC Bridge Structures Conference

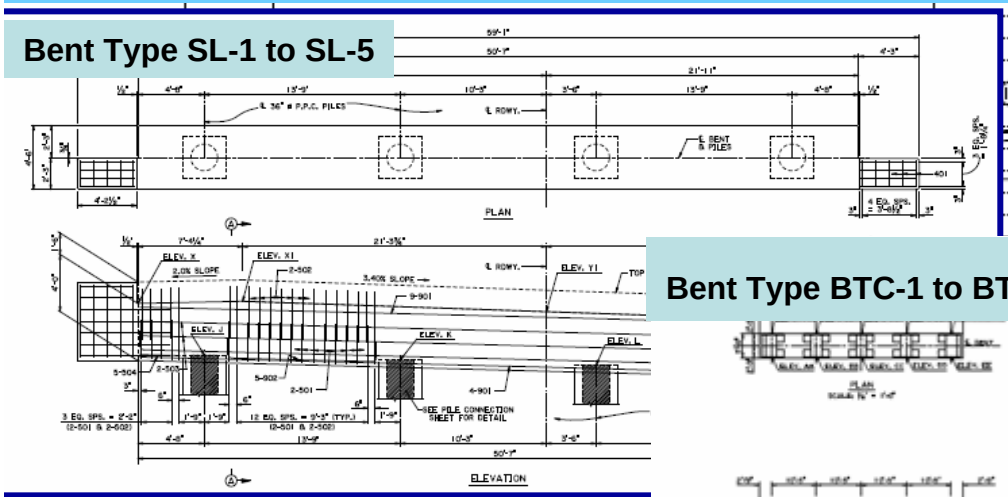
New Orleans
February 21, 2008

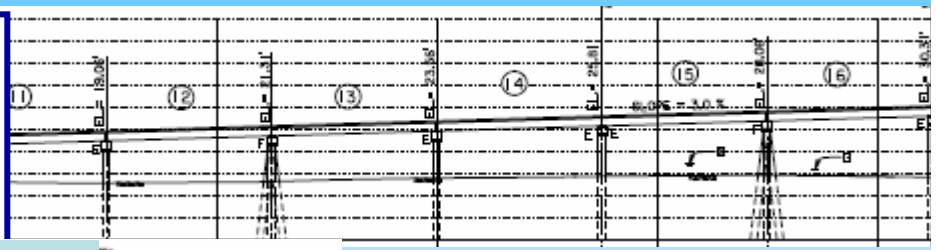
COAST & HARBOR ENGINEERING


Kenner
Metairie
New Orleans
Mississippi River Delta and Wetlands
Lake Salvador
Chandeleur Sound
Chandeleur Islands
Gulf of Mexico
Breton Sound
Barataria Bay
Terrebonne Bay
Timbalier Bay
Timbalier Island
Port Fourchon
West Bay
East Bay
LLC, NAVTEQ

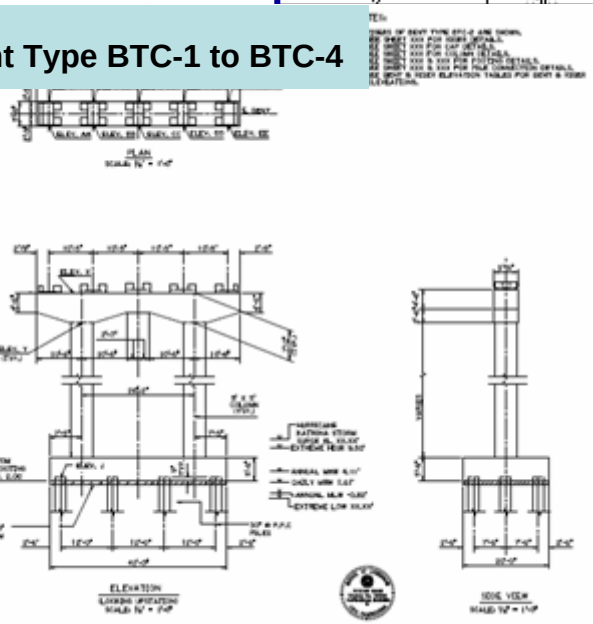
BOR
NG

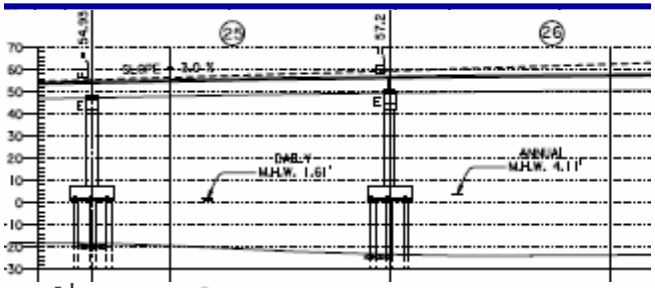
Bent Type SL-1 to SL-5

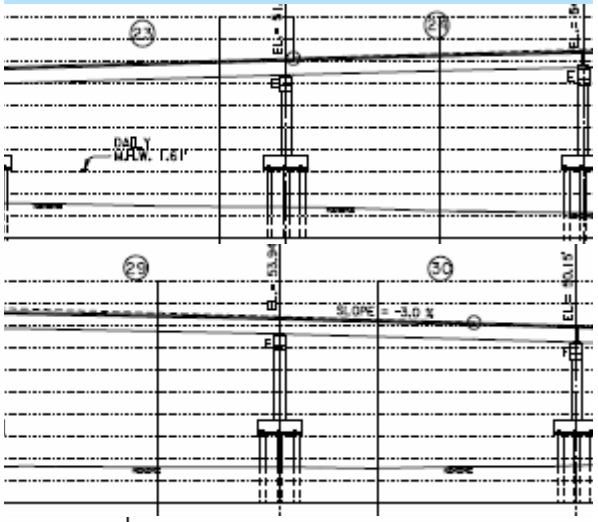


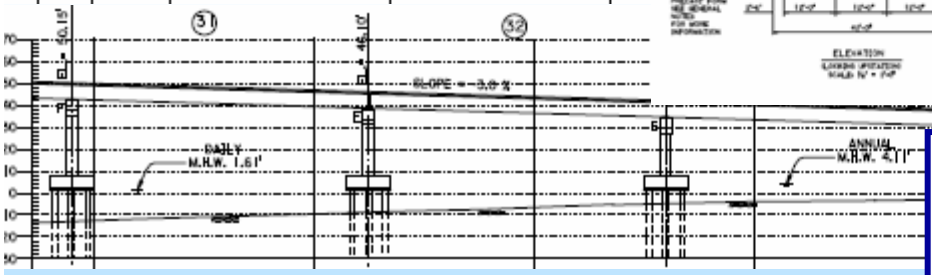


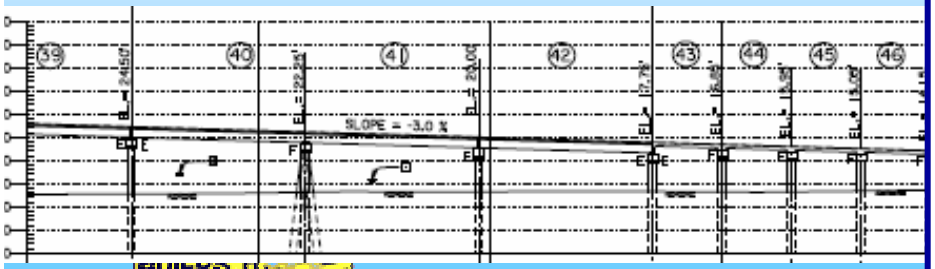
Bent Type BTC-1 to BTC-4



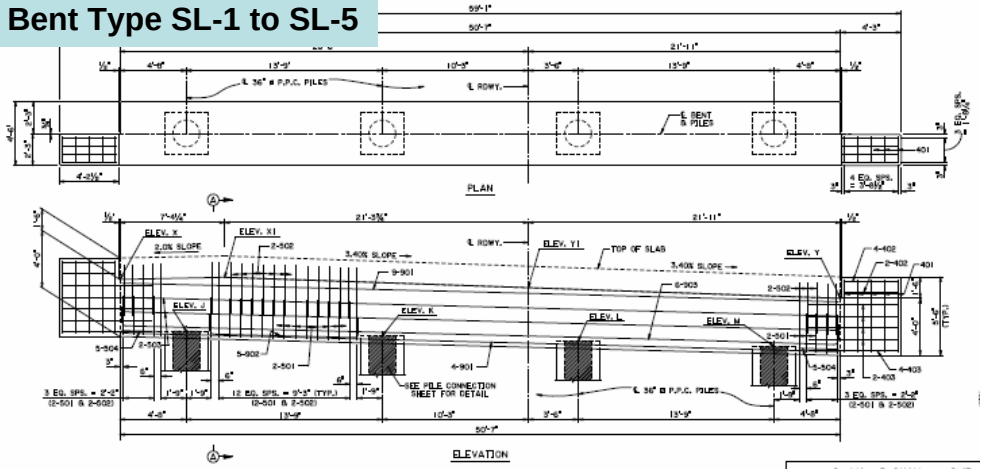








Bent Type SL-1 to SL-5

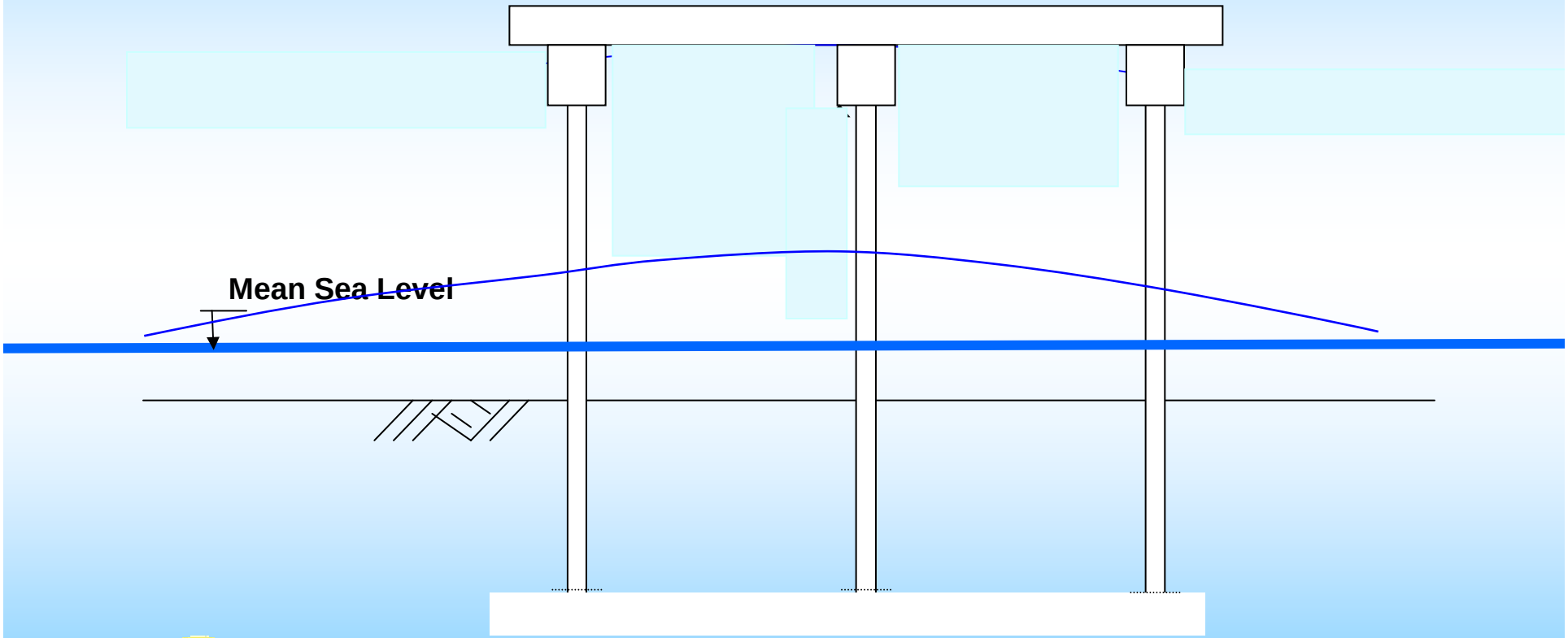


Objective

Provide reliable vertical and horizontal forces on bridge elements during design hurricane storm event. Bridge elements to compute forces include deck slabs, girders, piles, pile caps, columns, and footings

COAST & HARBOR ENGINEERING

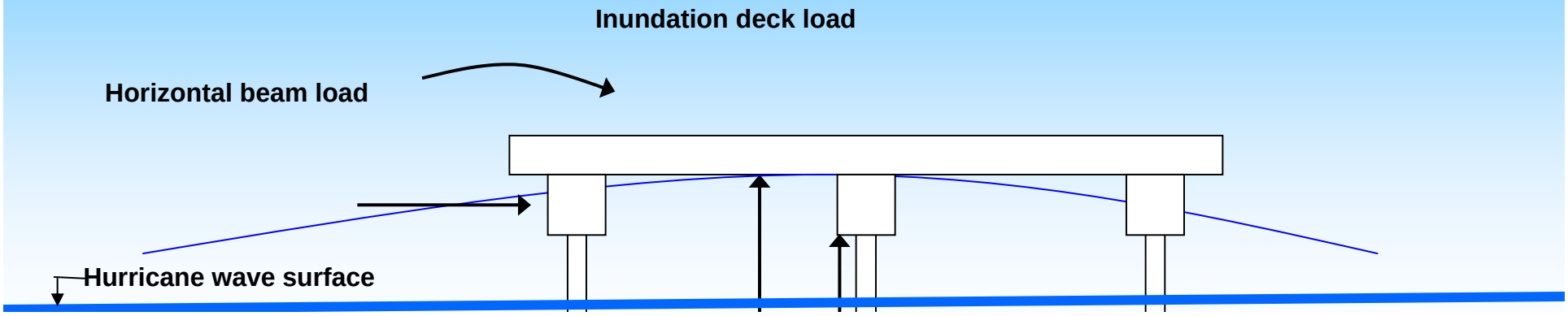
Wave Loads Diagram



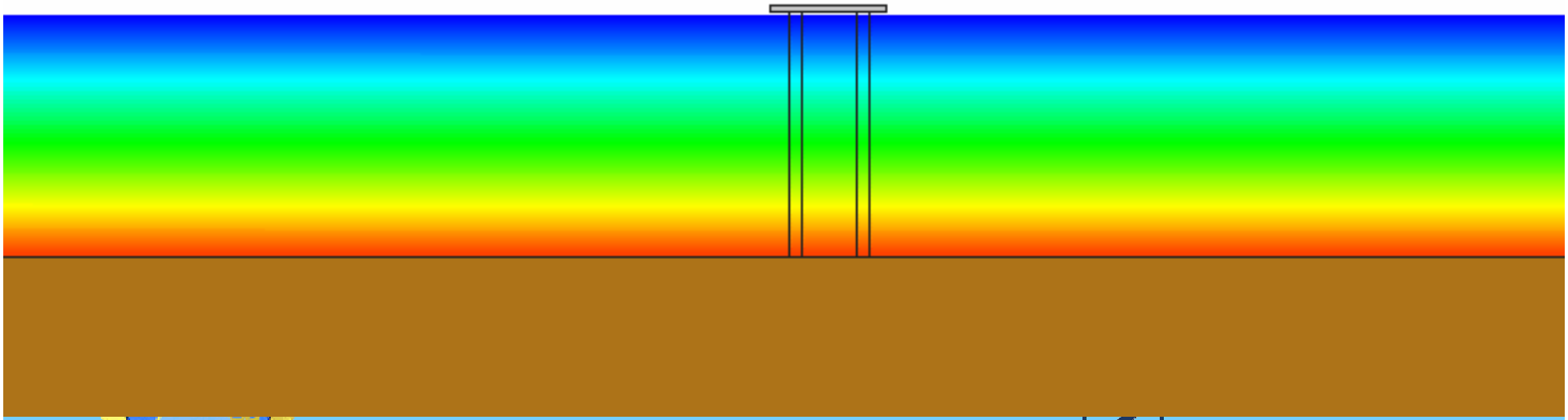
LOUISIANA'S ON THE MOVE... DOTD BUILDS THE WAY

COAST & HARBOR ENGINEERING

Wave Loads Diagram



7.10
Time (sec)



Scope

- Developing the design hurricane event parameters (water surface elevation and waves);
- Computing vertical and horizontal forces using different methodologies, including 90% AASHTO Guide; and
- Comparing the results of computations and selecting the recommended design forces.

LOUISIANA'S ON THE MOVE... DOTD BUILDS THE WAY

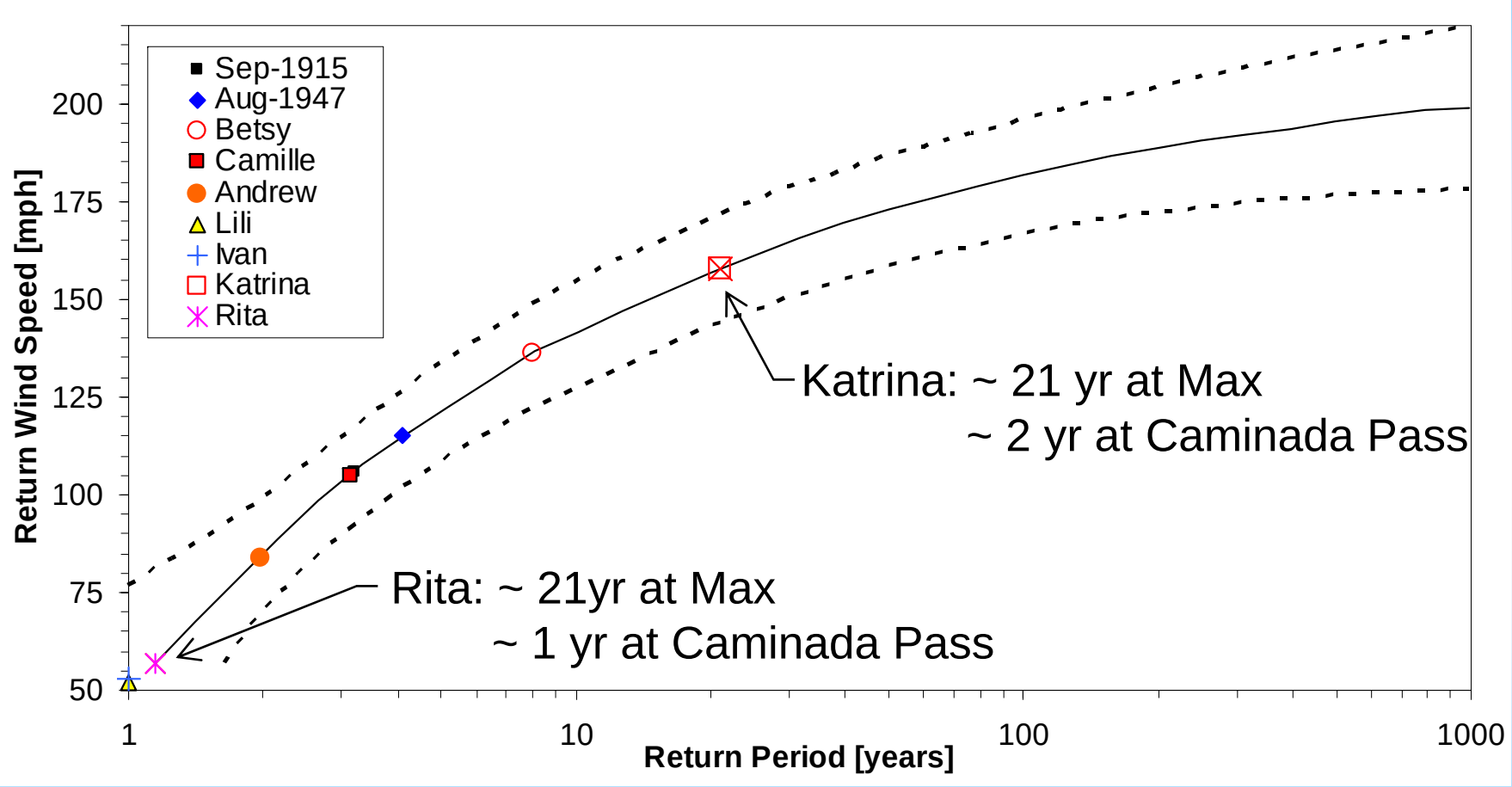
COAST & HARBOR ENGINEERING

Hurricane Event Return Periods

Major Factors

- Wind Speed
- Surge Elevation
- Minimum Pressure
- Size of Hurricane
- Storm Track
- Storm Speed

Winds Return Periods (Recommended)
Caminada Pass (*based on Jagger and Elsner, 2006*)



LOUISIANA'S ON THE MOVE... DOTD BUILDS THE WAY

COAST & HARBOR ENGINEERING

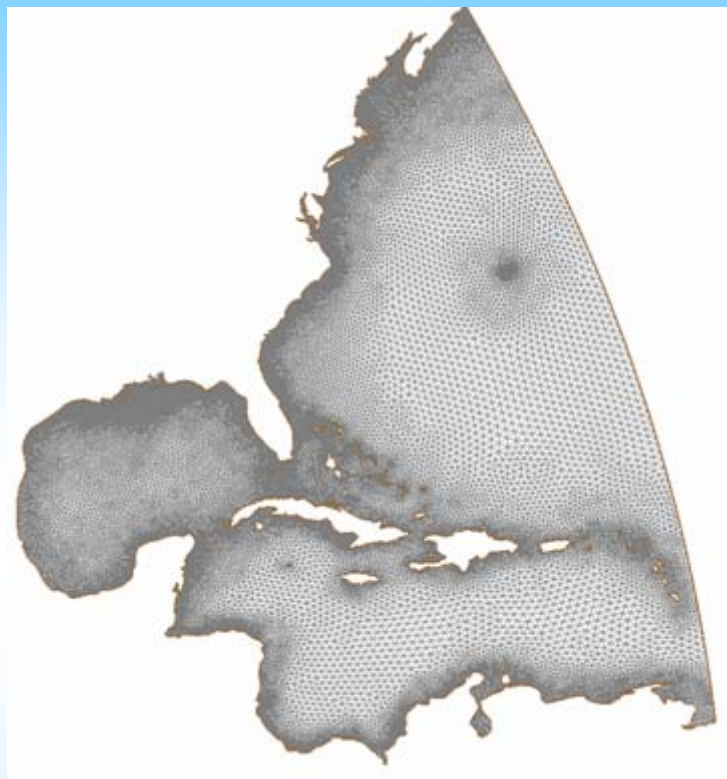
CHE Approach
Hurricane Event Return Periods

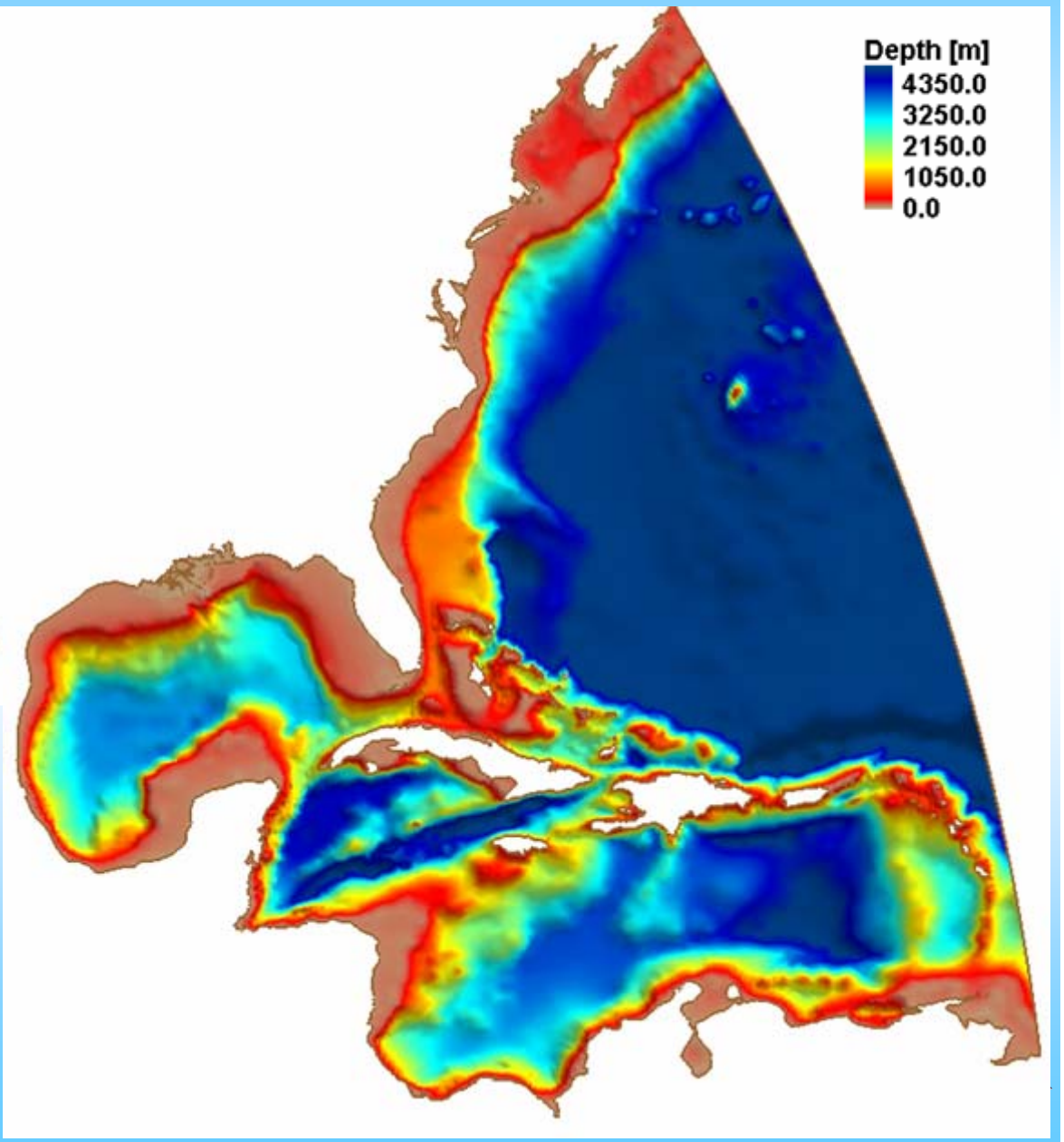
Major Factors

- Wind Speed
- Surge Elevation

COAST & HARBOR ENGINEERING

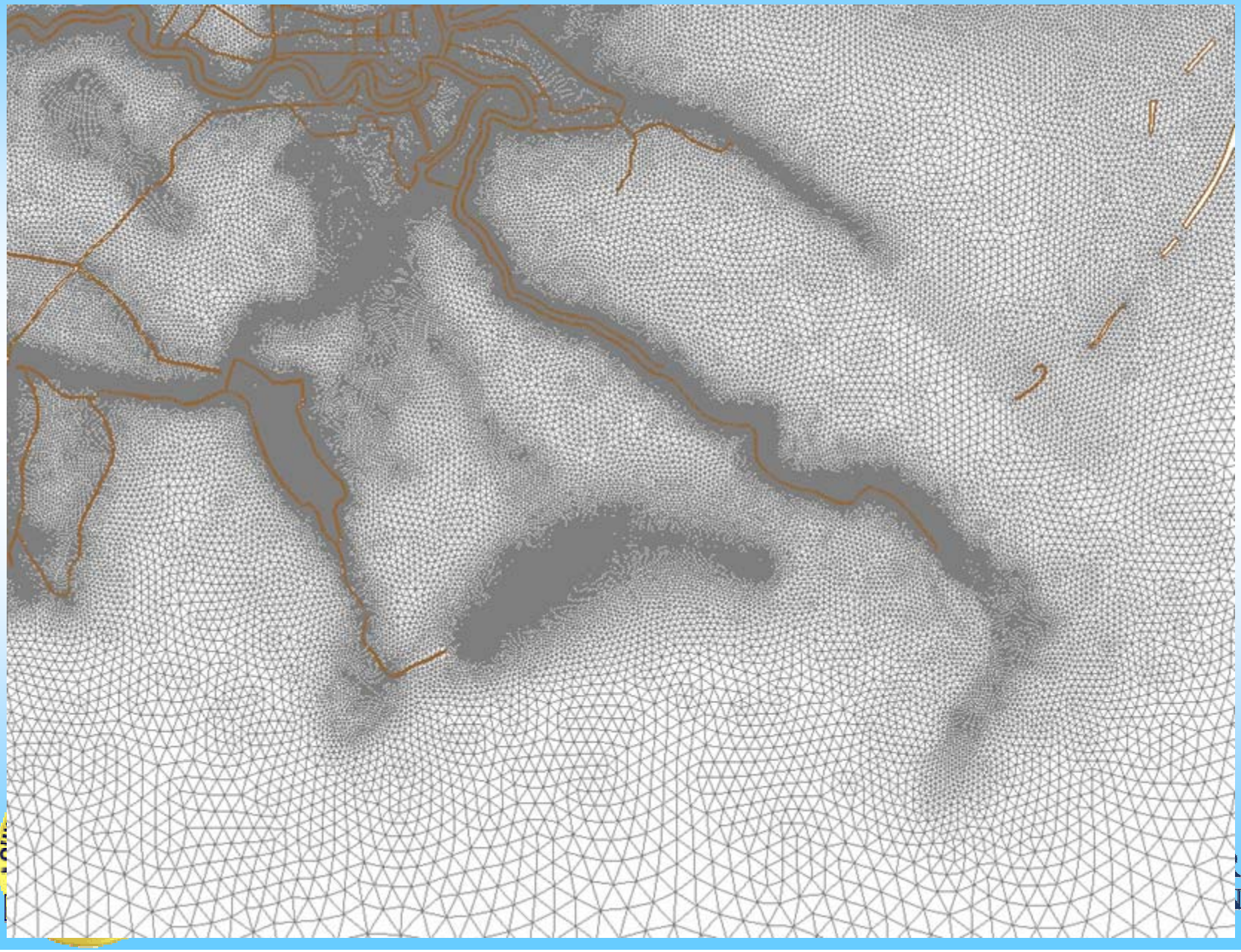
Surge Modeling



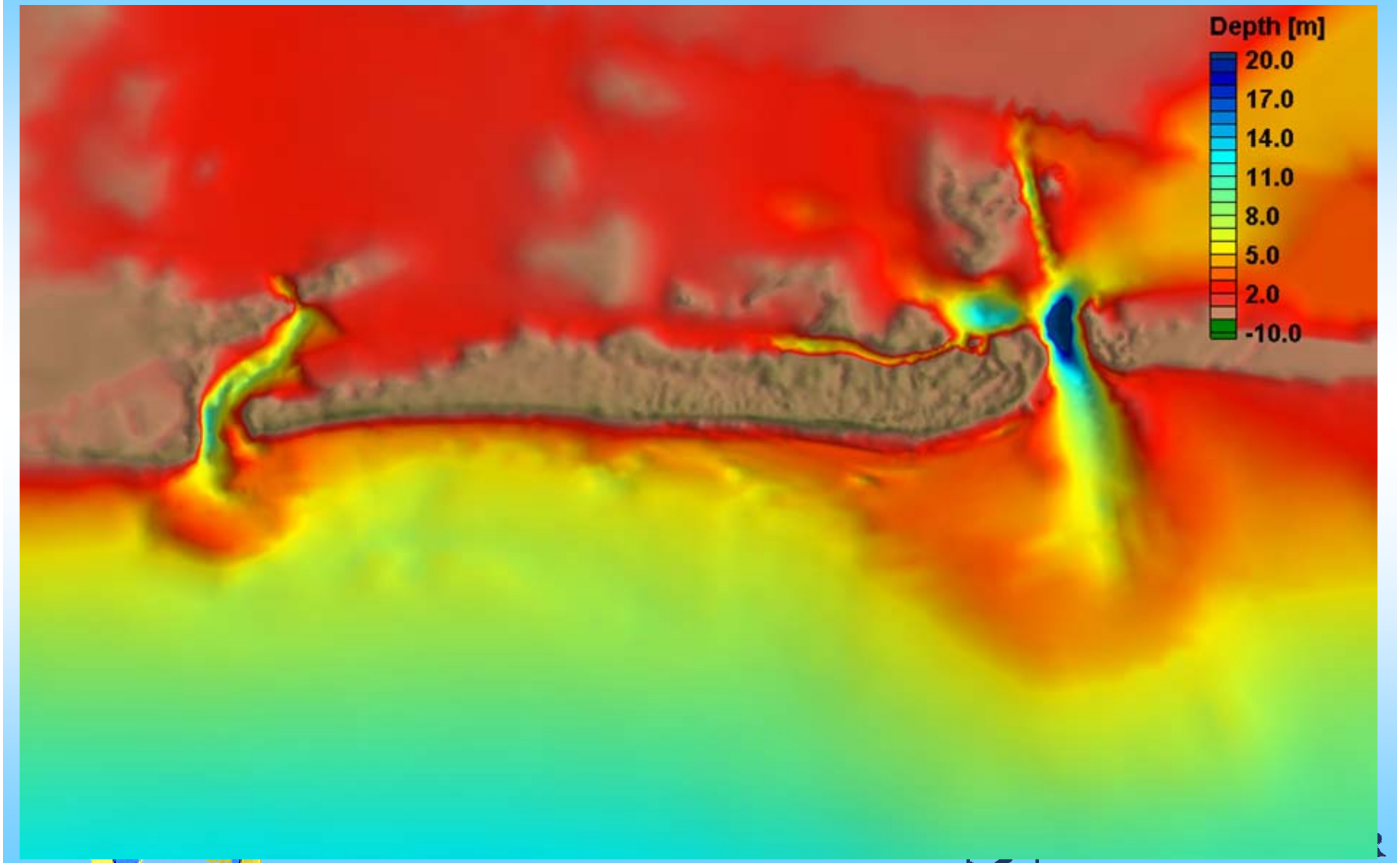


LOUISIANA'S ON THE MOVE...
DOTD
BUILDS THE WAY

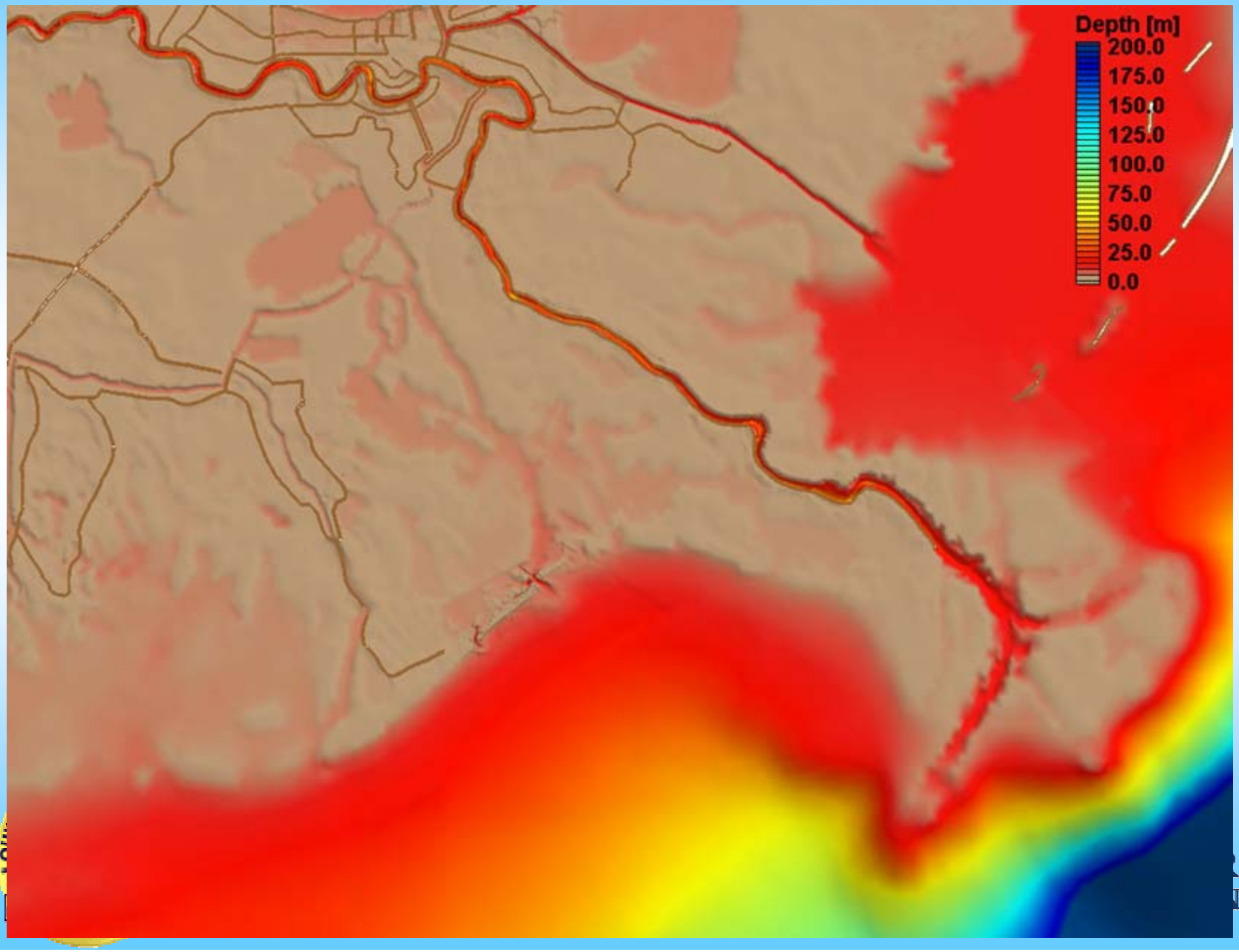
Surge Modeling (Modeling Grid)



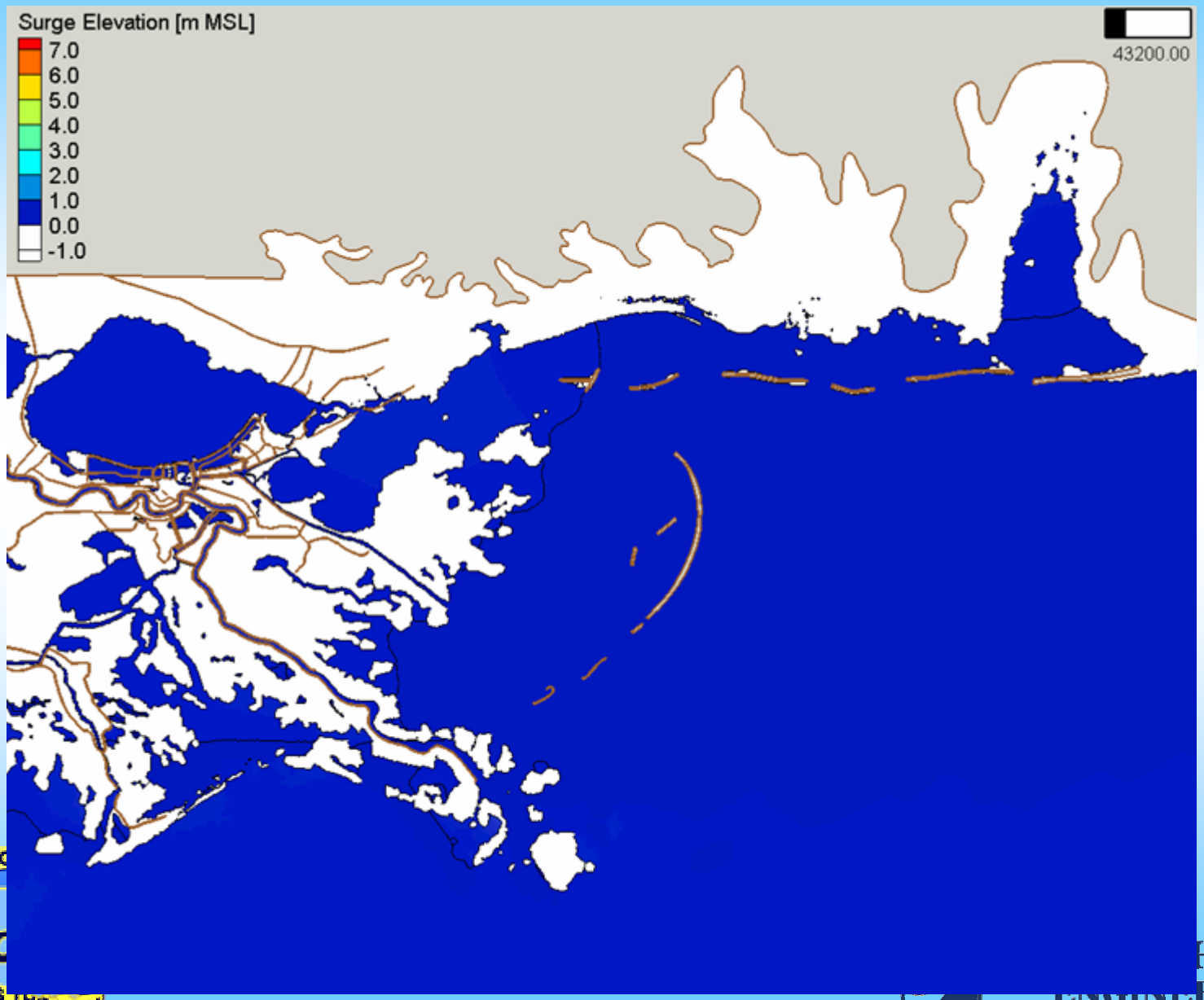
Surge Modeling



Surge Modeling

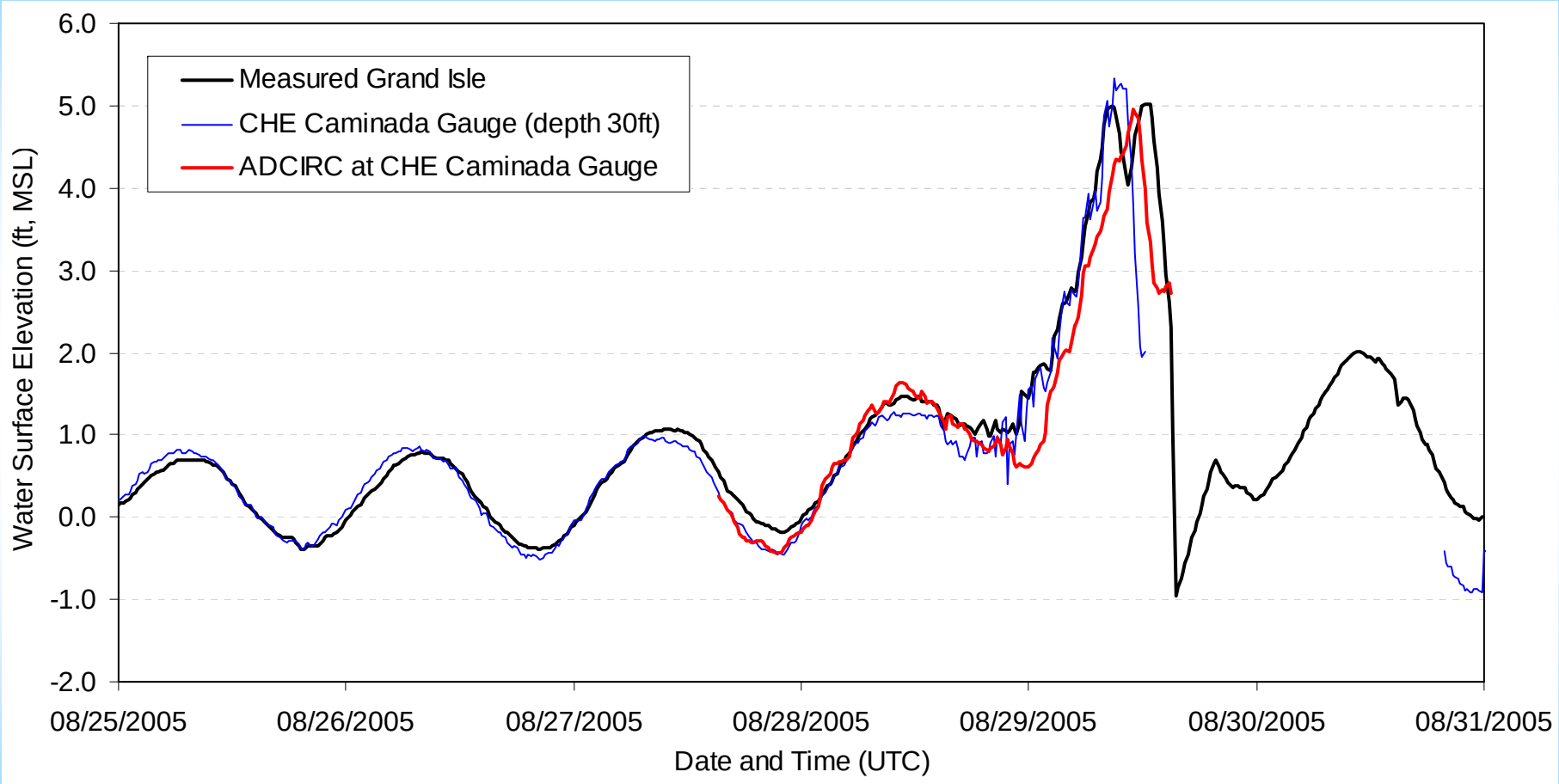


Modeling Real Katrina



HARBOR
ENGINEERING

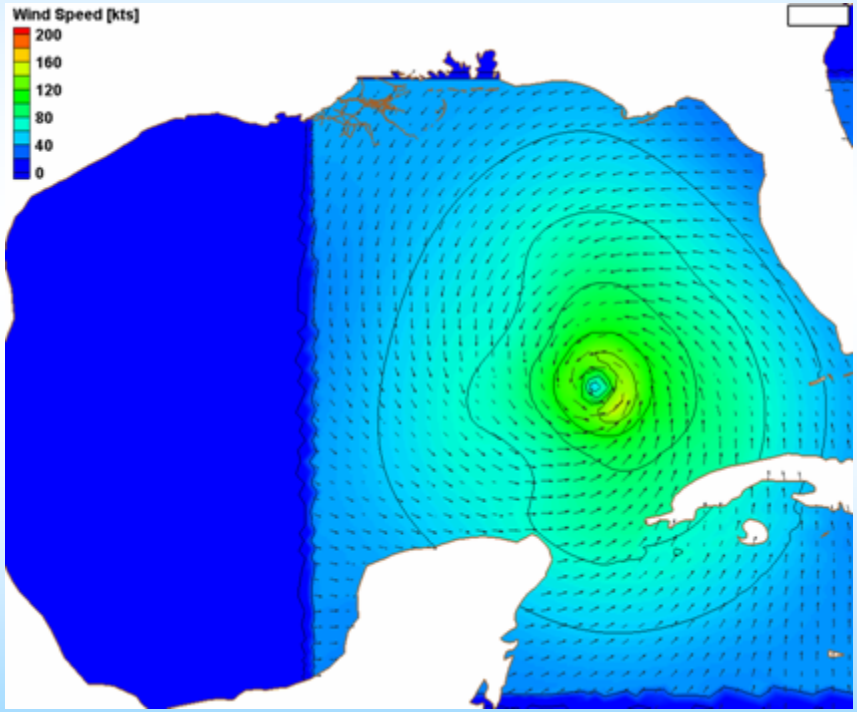
Katrina Surge Model Validation

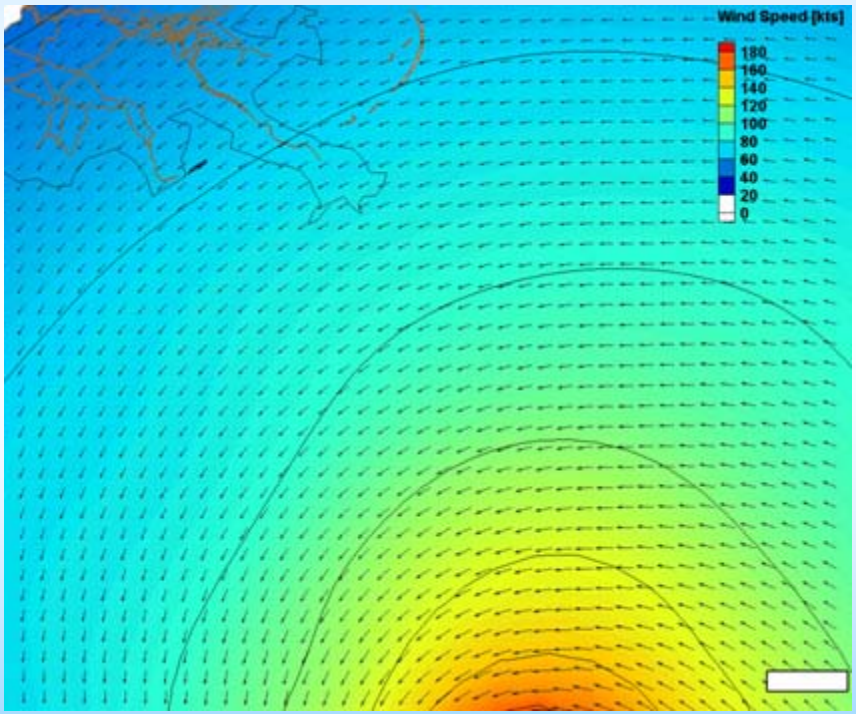


LOUISIANA'S ON THE MOVE... DOTD BUILDS THE WAY

COAST & HARBOR ENGINEERING

100 Years Wind Event Modeling

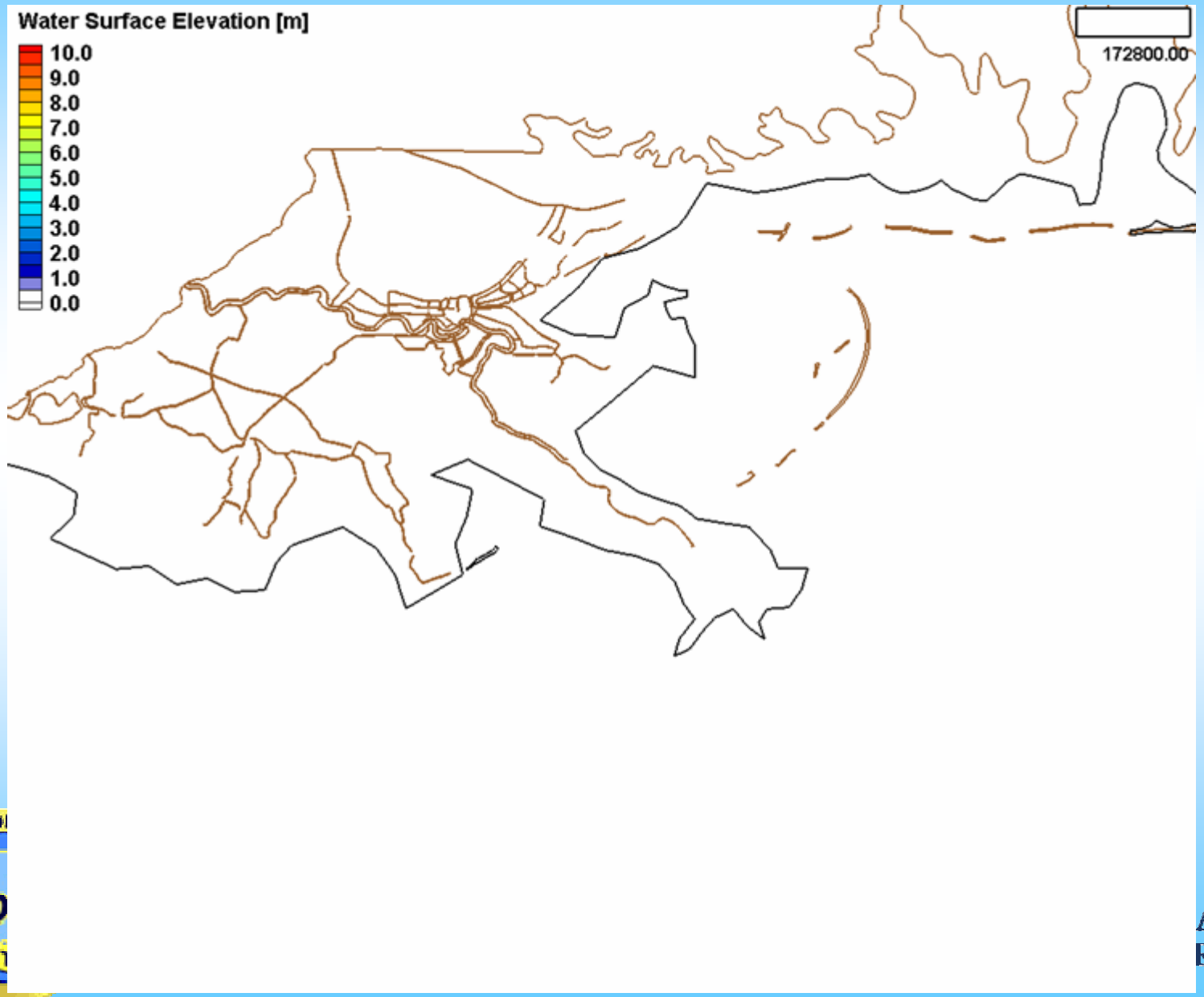




LOUISIANA'S ON THE MOVE...
DOTD
BUILDS THE WAY

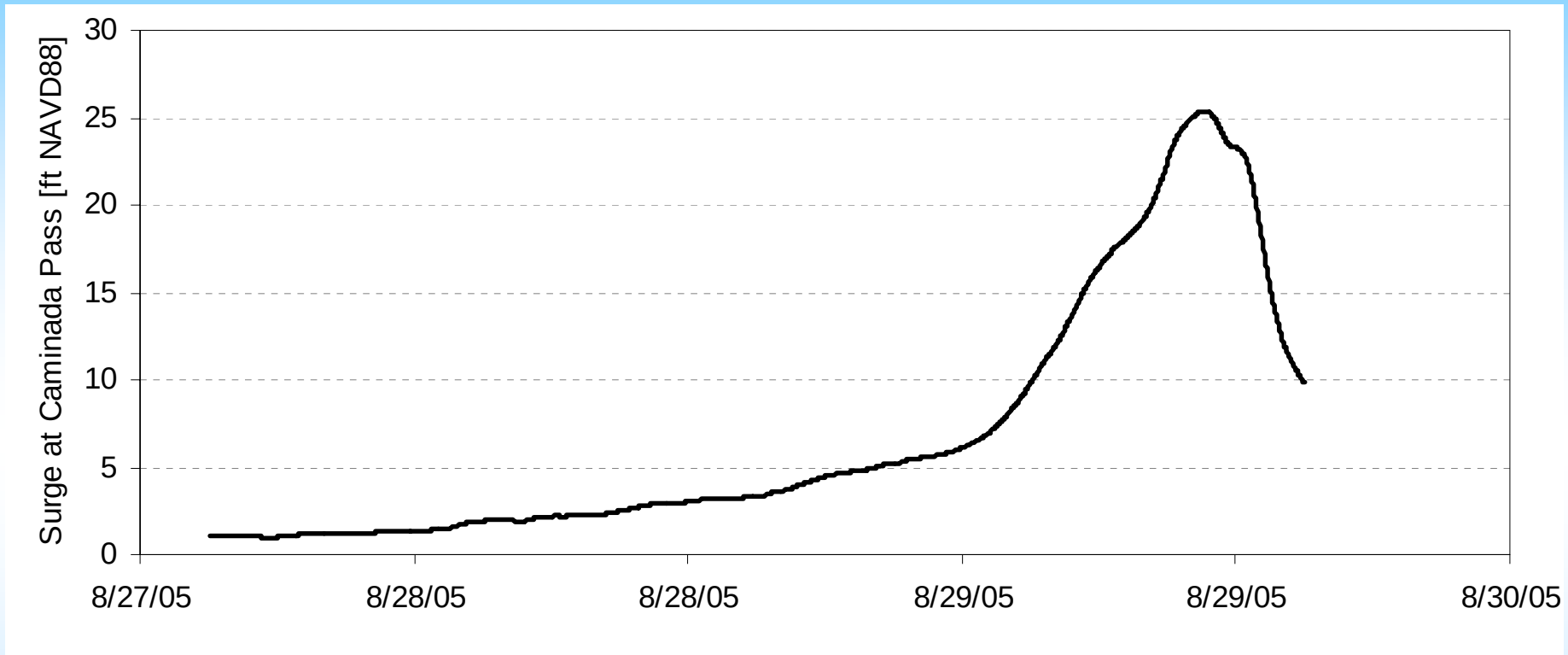
COAST & HARBOR
ENGINEERING

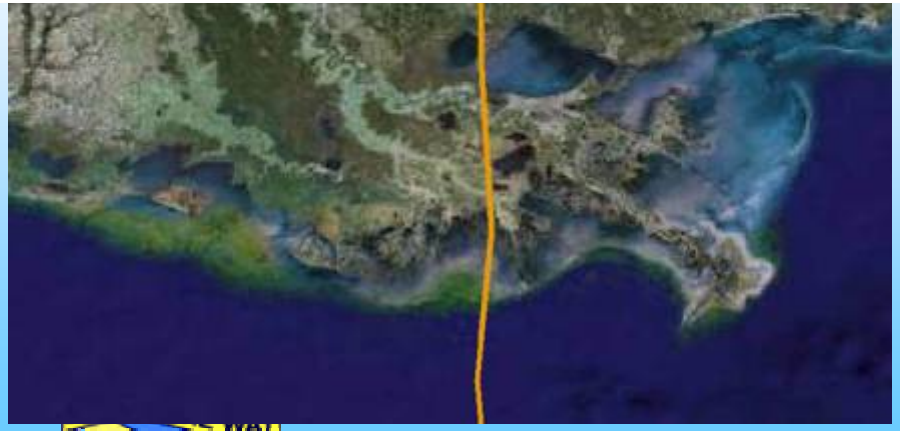
100 Year Wind Surge Modeling



ARBOR
RING

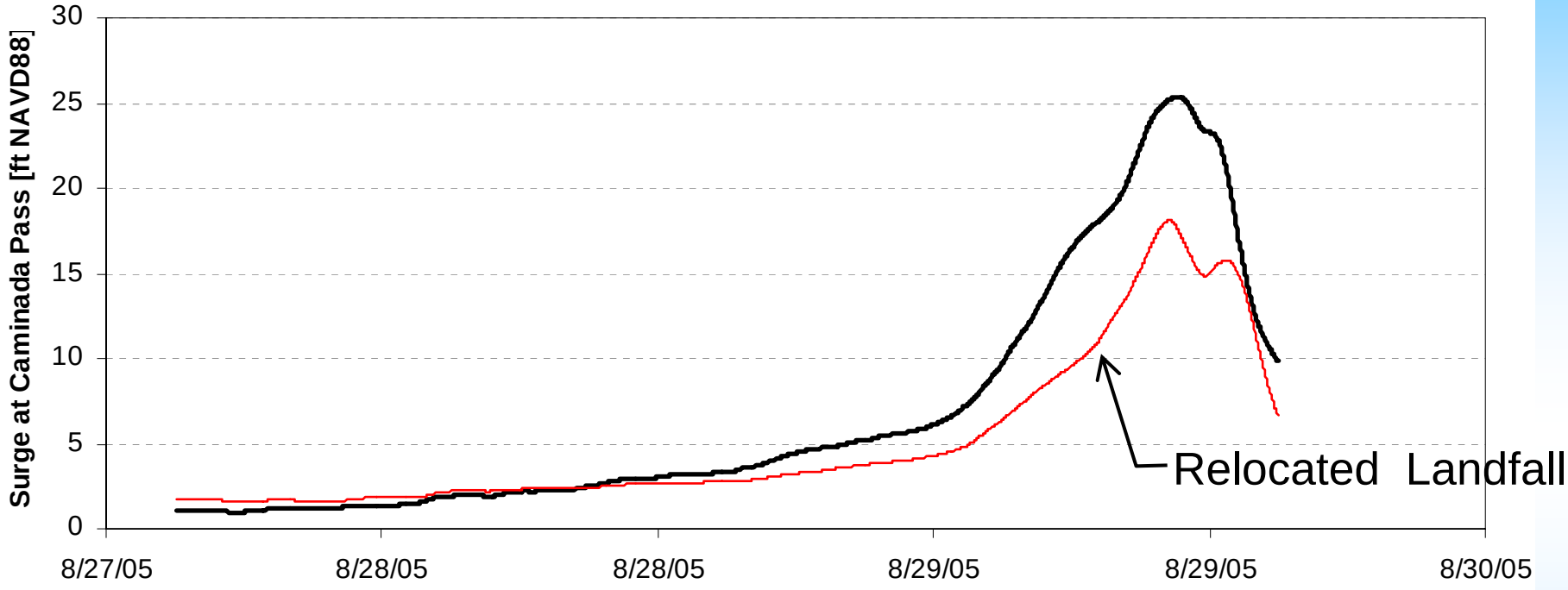
100-year Storm Surge Elevations
Caminada Pass Landfall

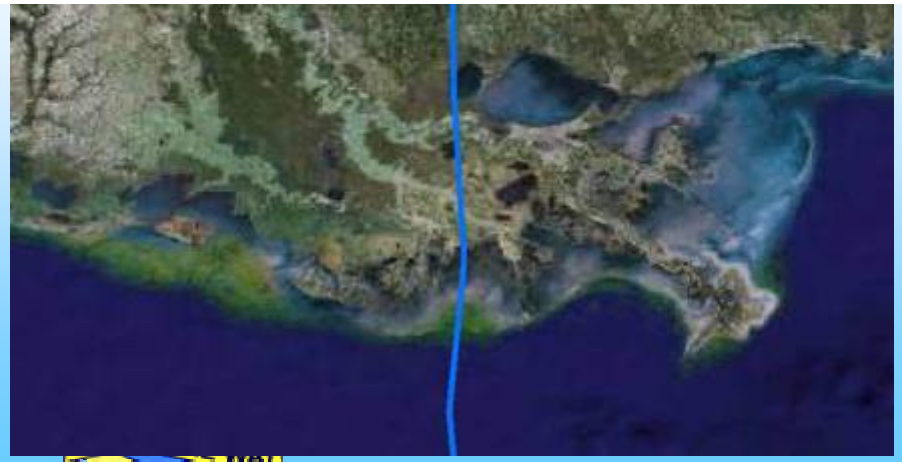




COAST & HARBOR
ENGINEERING

100-year Storm Surge Elevations
Caminada Pass Landfall





COAST & HARBOR
ENGINEERING

Storm Surge Elevations Return Periods
Caminada Pass (*based on US Army COE)*

Return Period [yr]	Storm Surge [ft NAVD88]
50	8.8
75	9.8
100	10.7
150	11.6
200	12.2
250	12.6
300	12.9
350	13.2
400	13.4
450	13.5
500	13.7

LOUISIANA'S ON THE MOVE... DOTD BUILDS THE WAY

COAST & HARBOR ENGINEERING

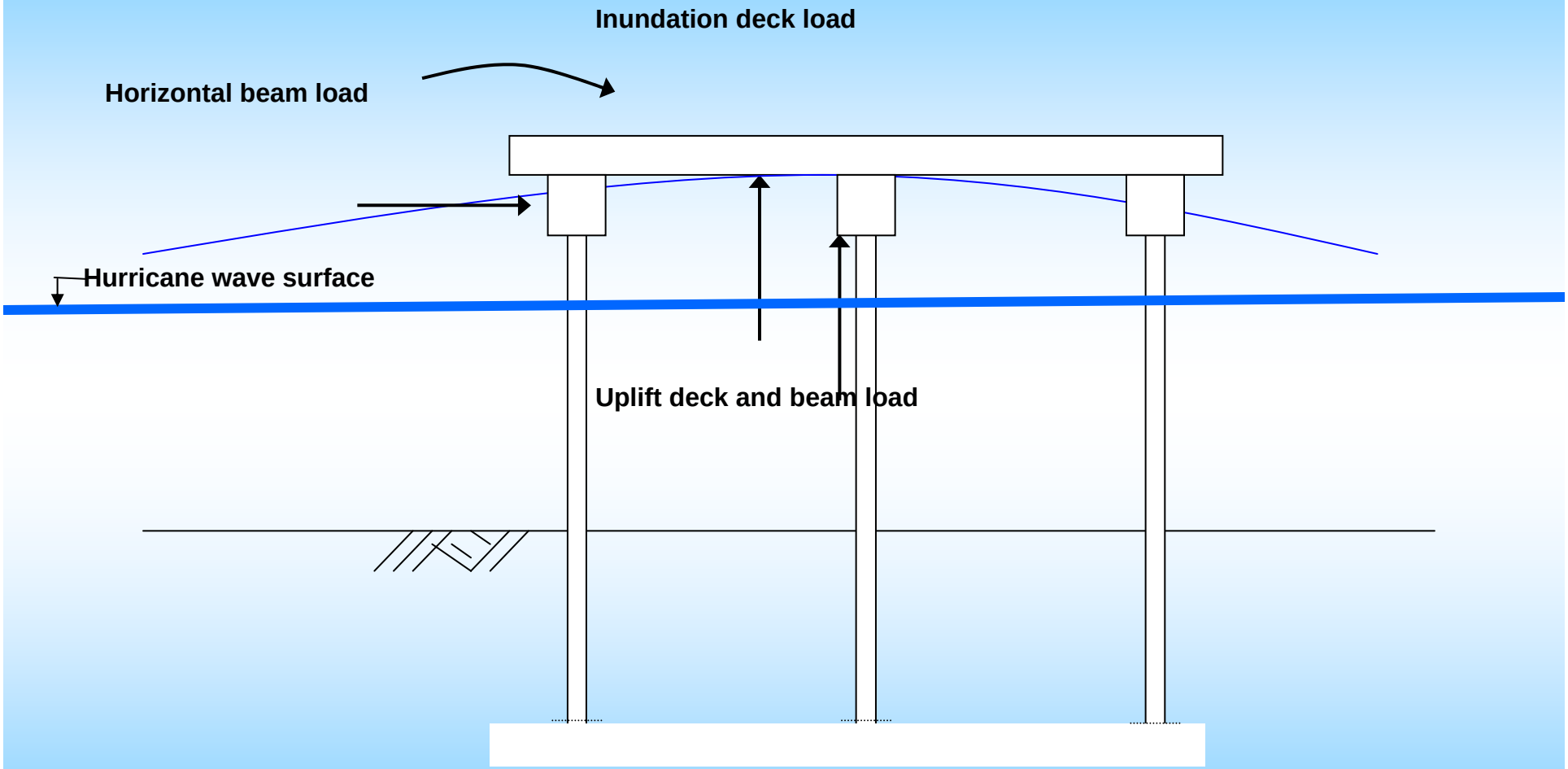
Storm Scenarios

Scenario	Wind Return Period (years)	Wind Speed (mph)	Surge Return Period (years)	Surge (ft NAVD88)
1	100	182	100	10.7
2	100	182	50	8.8
3	50	173	50	8.8

LOUISIANA'S ON THE MOVE... DOTD BUILDS THE WAY

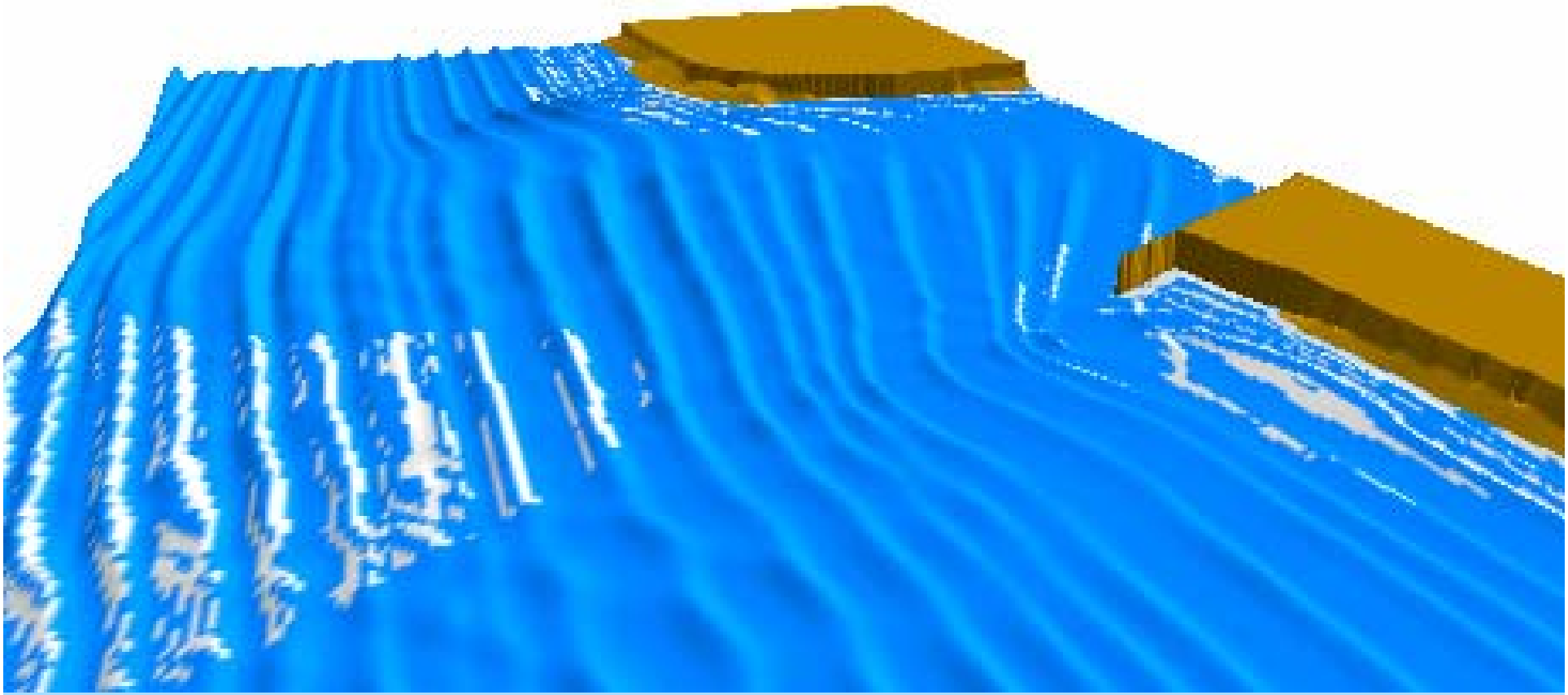
COAST & HARBOR ENGINEERING

Wave Loads Diagram



LOUISIANA'S ON THE MOVE... DOTD BUILDS THE WAY

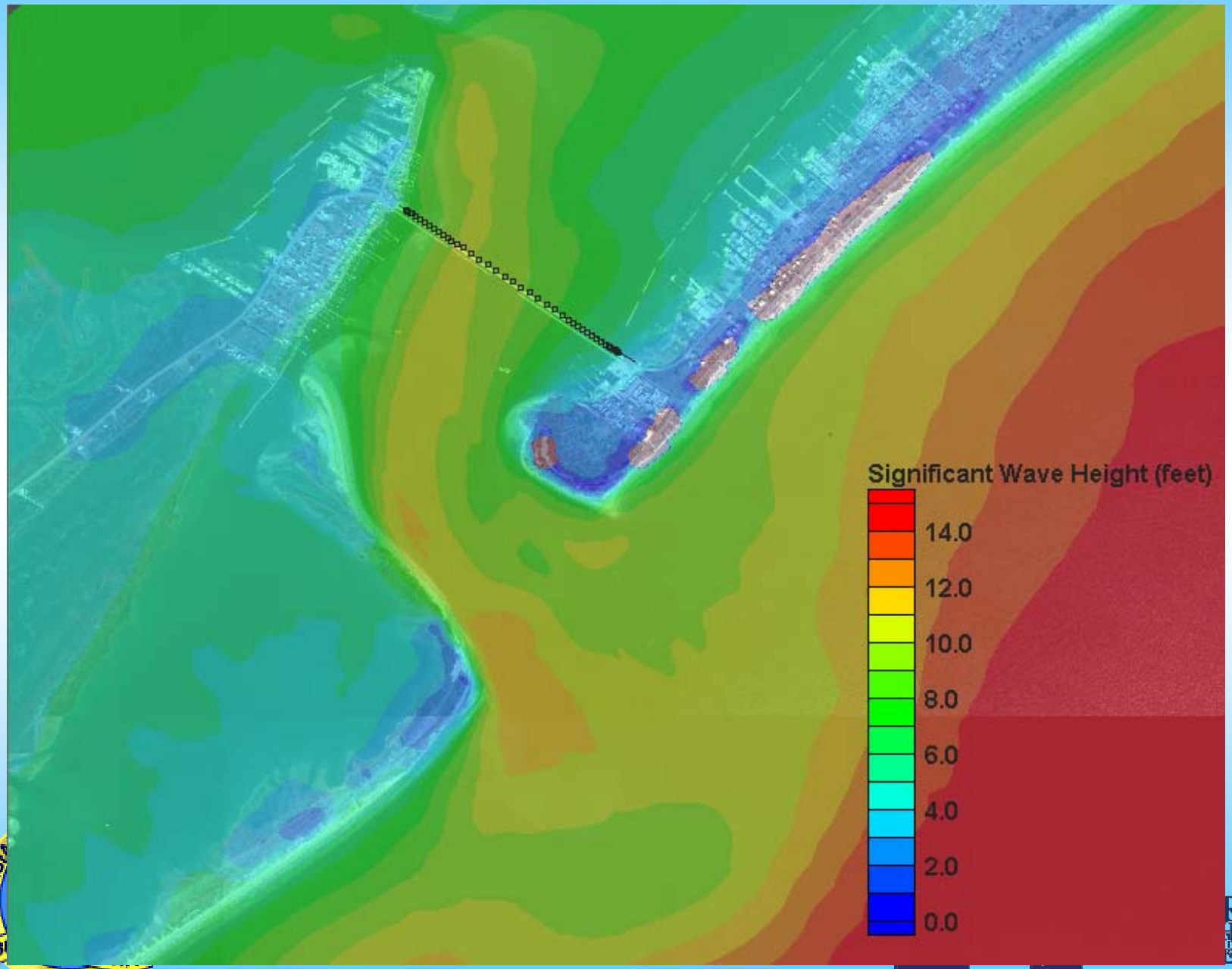
COAST & HARBOR ENGINEERING



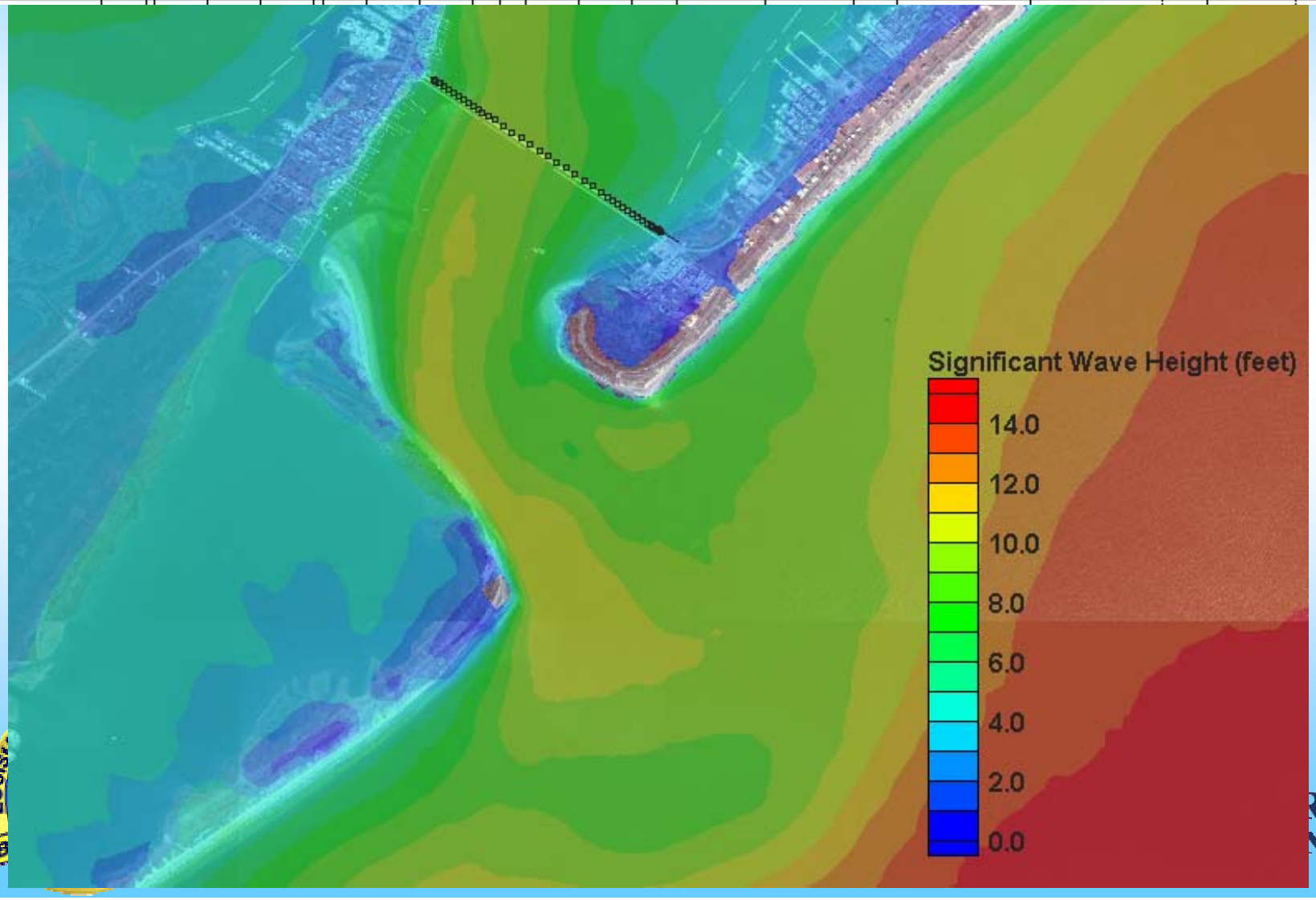
LOUISIANA'S ON THE MOVE...
DOTD
BUILDS THE WAY

COAST & HARBOR
ENGINEERING

Scenario 1 – Significant Wave Height



Scenario 2 – Significant Wave Height



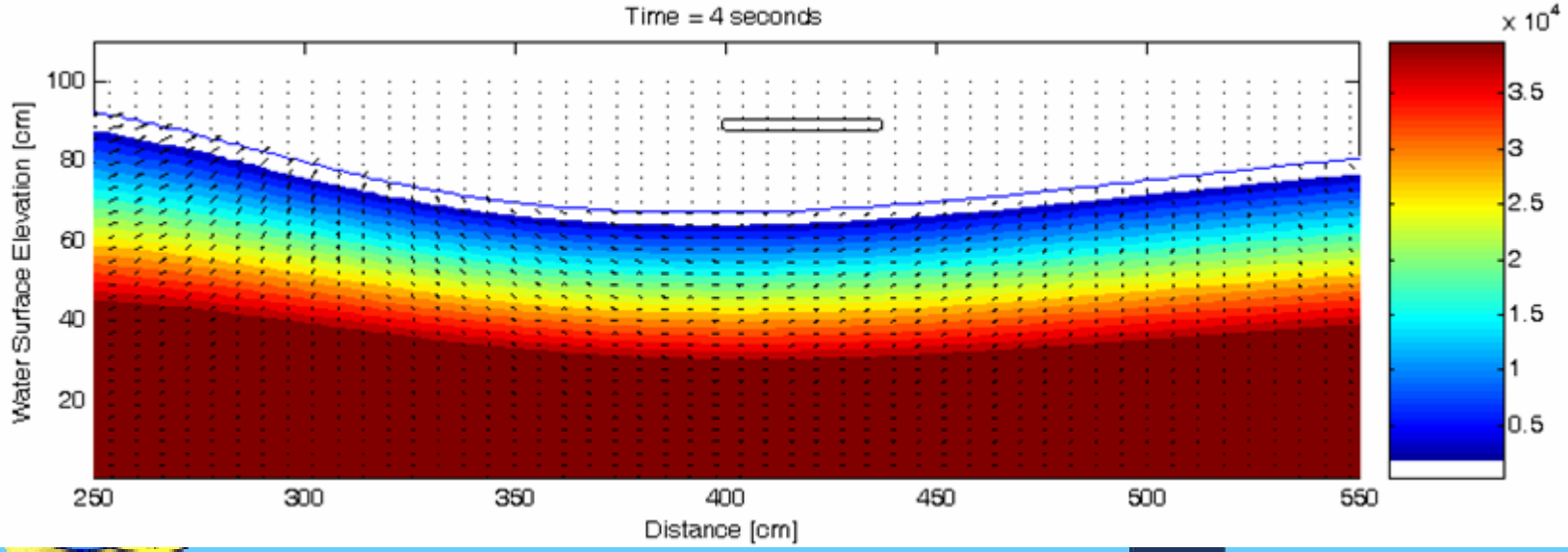
New Bridge Layout

Cuomo & Tirindelli

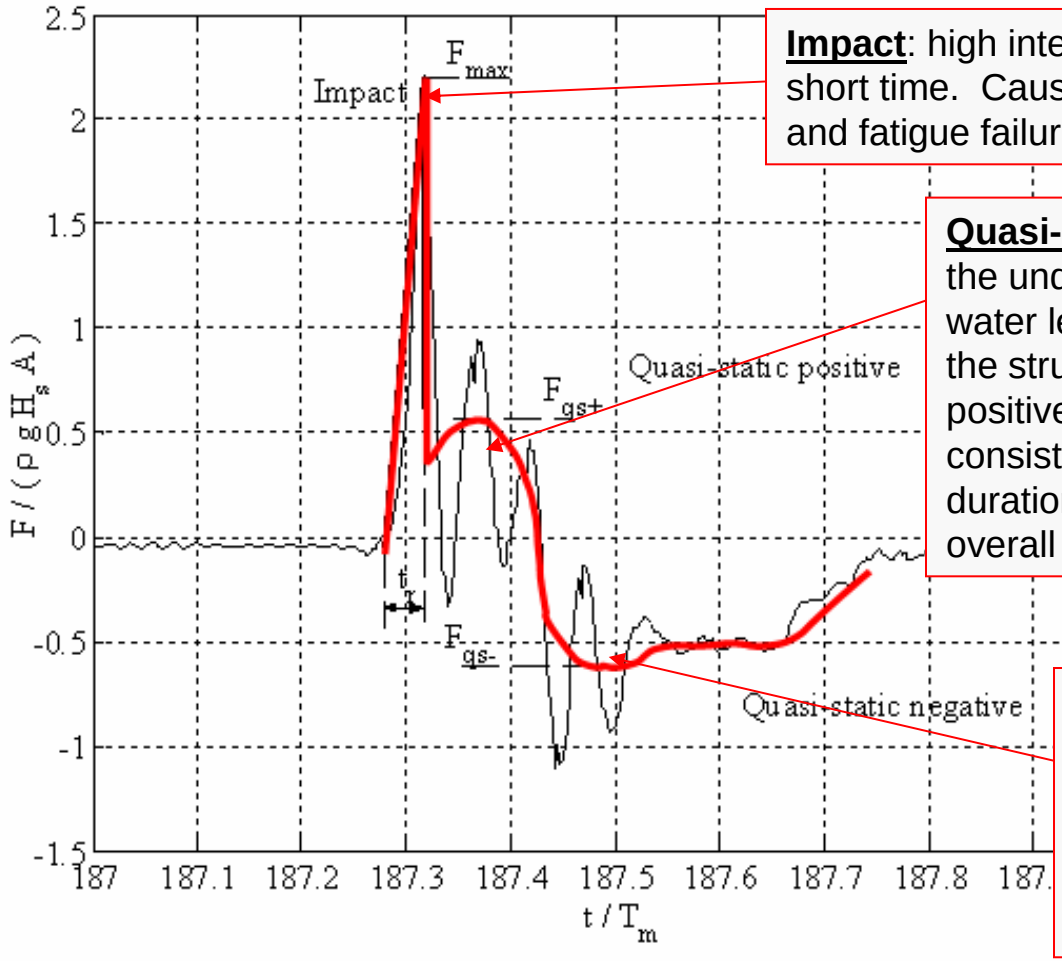
LOUISIANA'S ON THE MOVE...
DOTD
BUILDS THE WAY

COAST & HARBOR
ENGINEERING


15:01
7 12 2001


Time = 4 seconds
x 10^4
3.5
3
2.5
2
1.5
1
0.5
Water Surface Elevation [cm]
100
80
60
40
20
250
300
350
400
450
500
550
Distance [cm]

Vertical Wave Loading



Impact: high intensity forces acting on limited areas, for a short time. Causes severe local damage, local yielding and fatigue failure

Quasi-static +: As the wave propagates along the underside of a deck, a difference between water level under the deck and that alongside the structure gives rise to the quasi-static positive force. The magnitude of this force is consistently lower than any initial impact, but its duration is of order 0.25·*Tm*. Important for overall structure stability

Quasi-static -: Finally, the wave surface falls below soffit level and moves inward below the deck, reducing the contact area with the wave. A quasi-static negative force is Increased when the wave inundates the deck

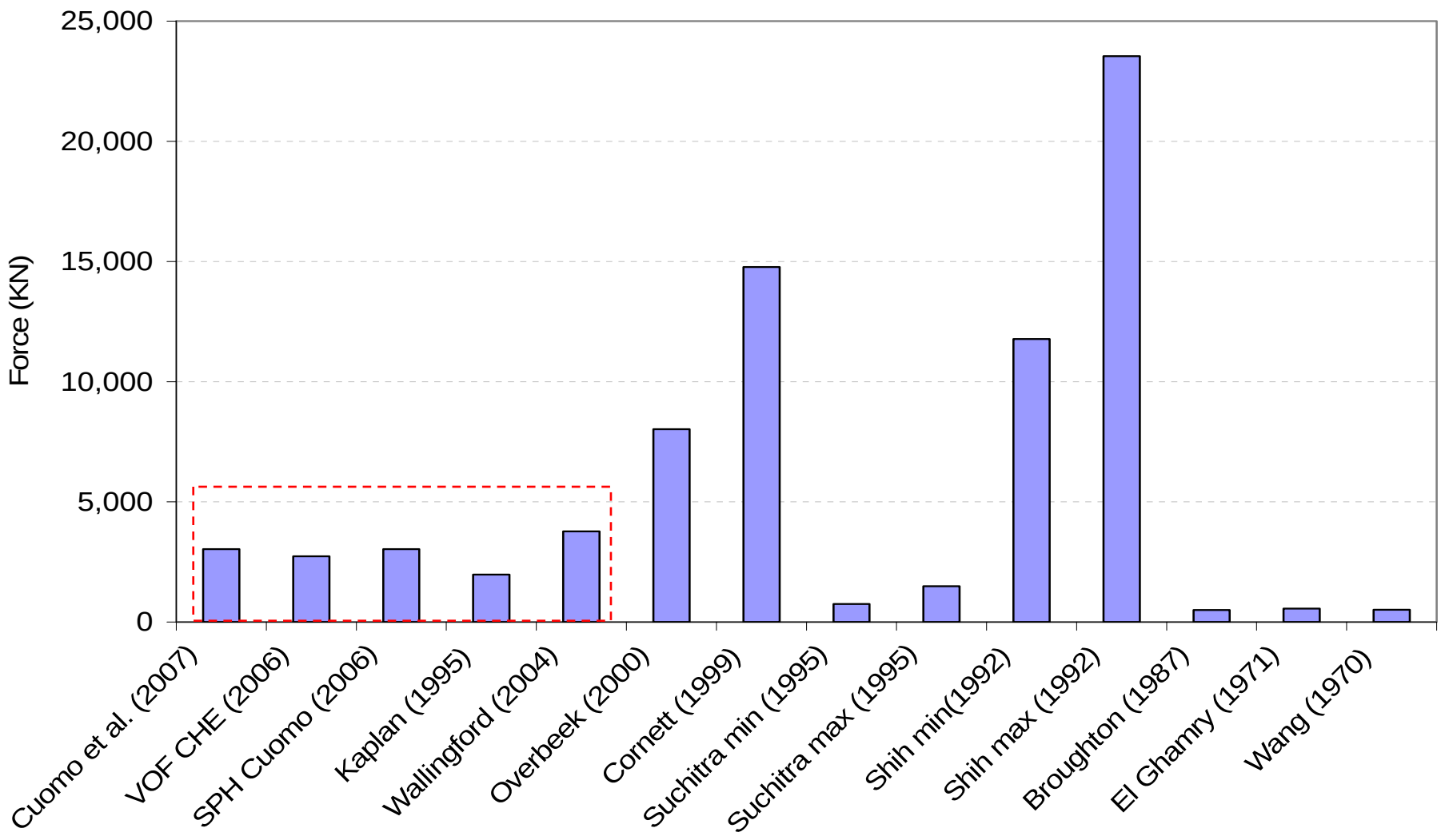
All 3 types of loading must be considered

LOUISIANA'S ON THE MOVE
DOTD
BUILDS THE WAY

COAST & HARBOR ENGINEERING

Evaluations of Uplift Loading

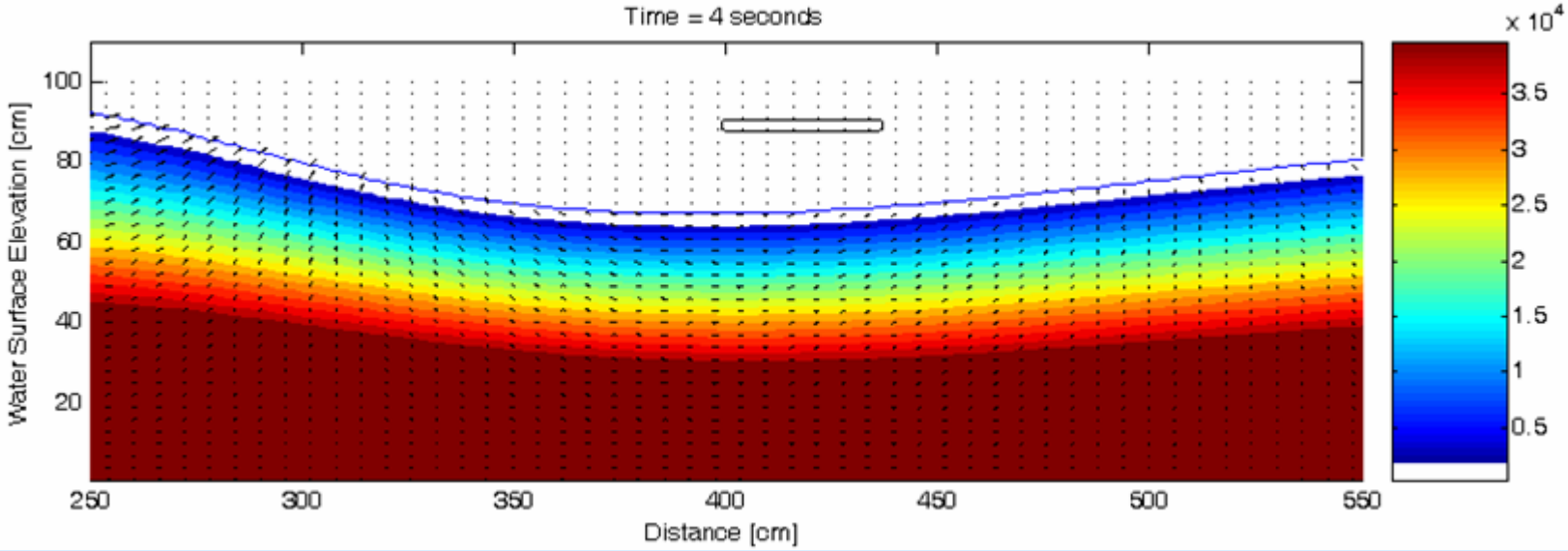
Hs = 3.4m; Tp = 7.4s; Depth = 15.3m; Clearance = 1.4m; Deck length = 7.4m; Deck Width = 11.6m



BUILDS THE WAY

COAST & HARBOR ENGINEERING

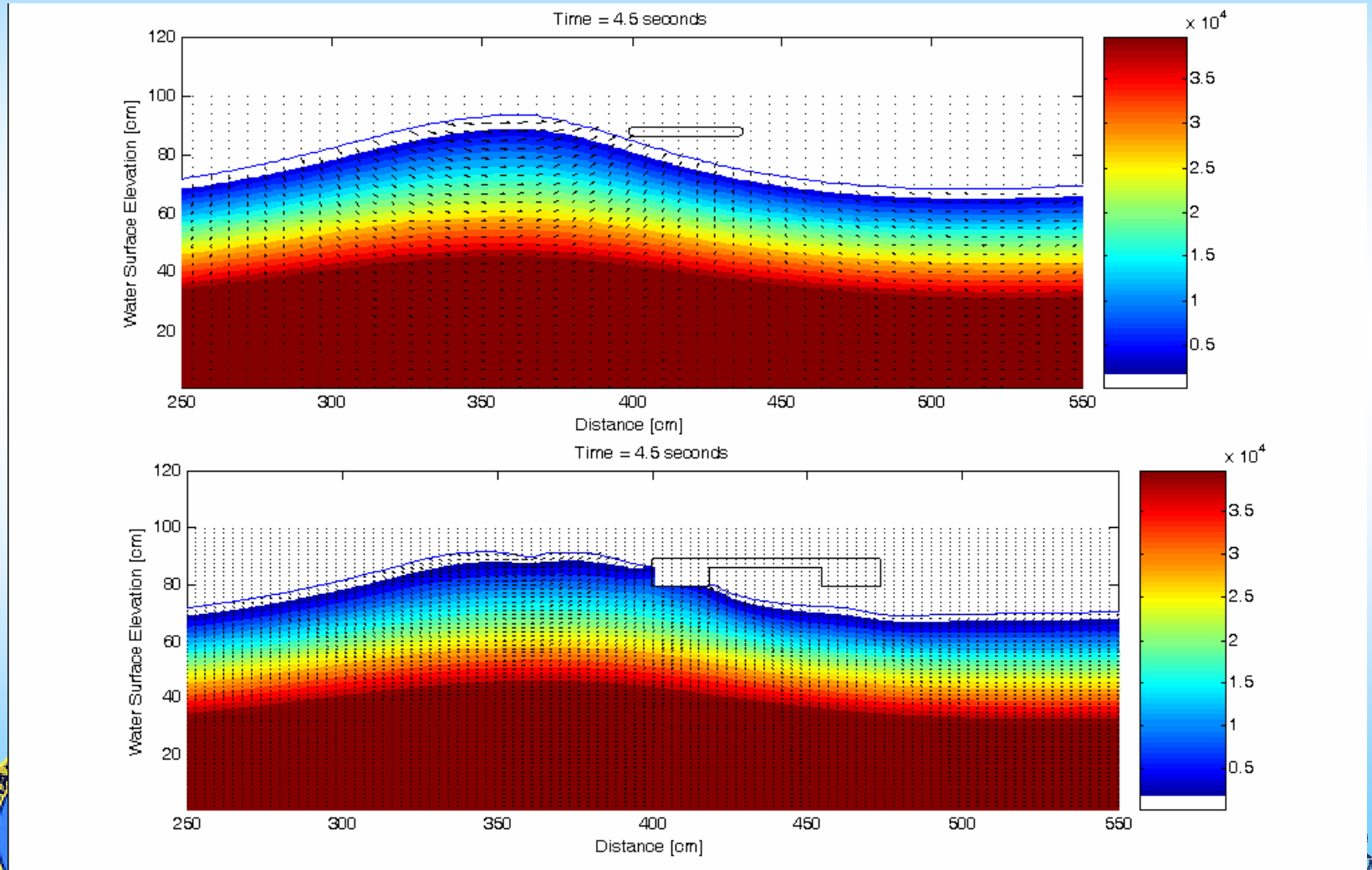
Dynes/cm^2



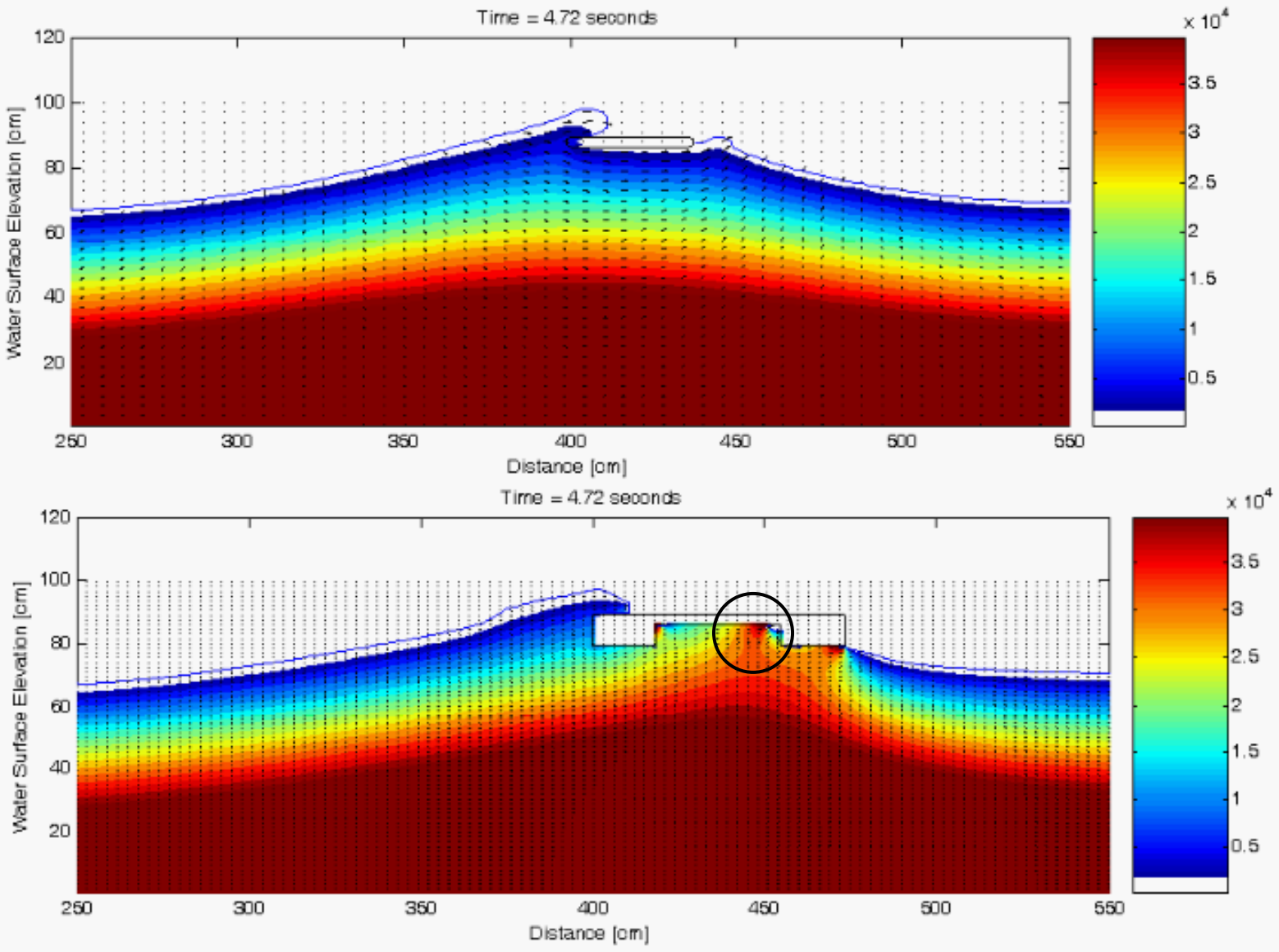
LOUISIANA'S ON THE MOVE...
DOTD
BUILDS THE WAY

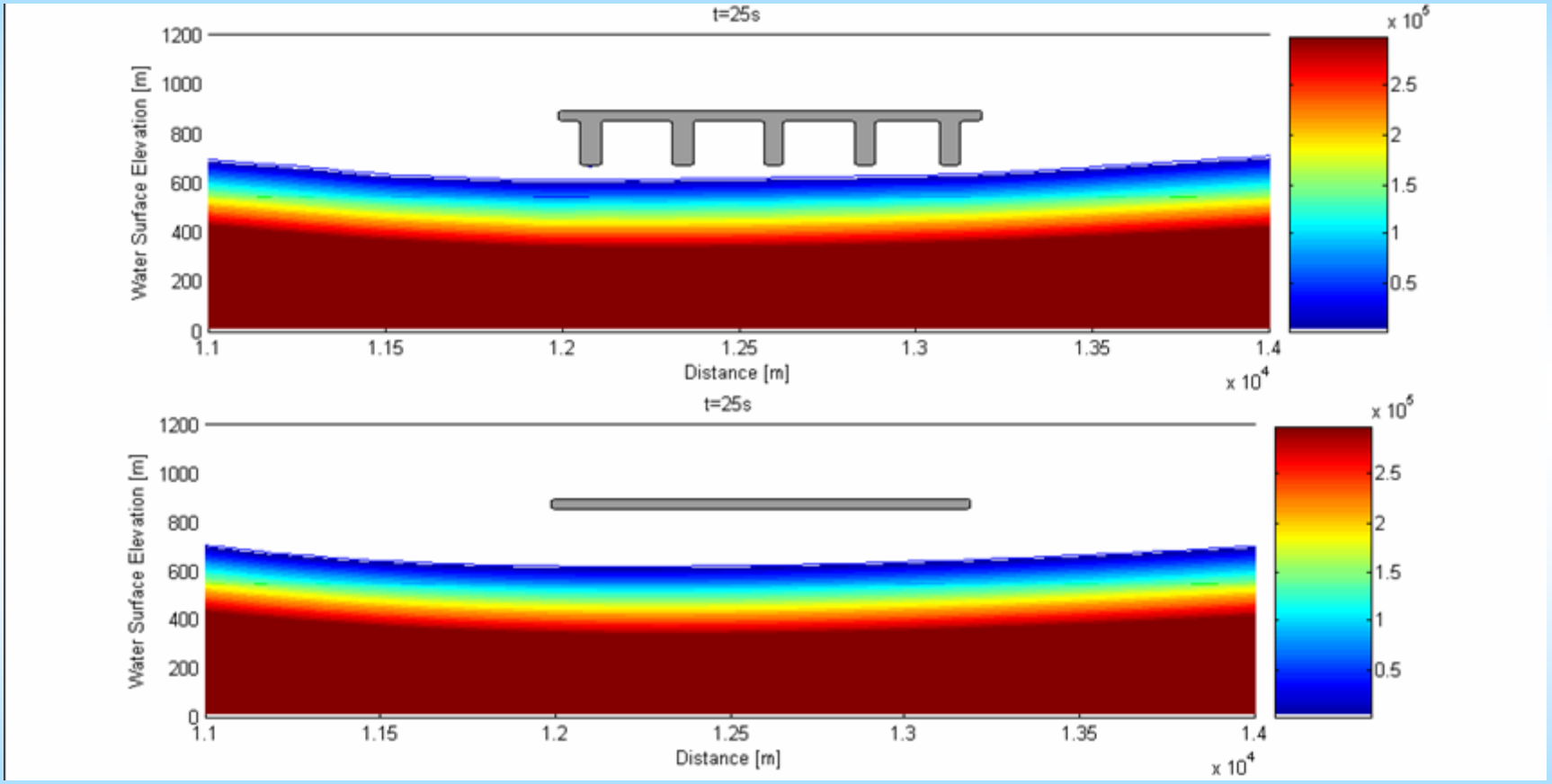
COAST & HARBOR
ENGINEERING

Influence of Down-standing Beams



Wave Loading Design Criteria
Influence of Down-standing Beams

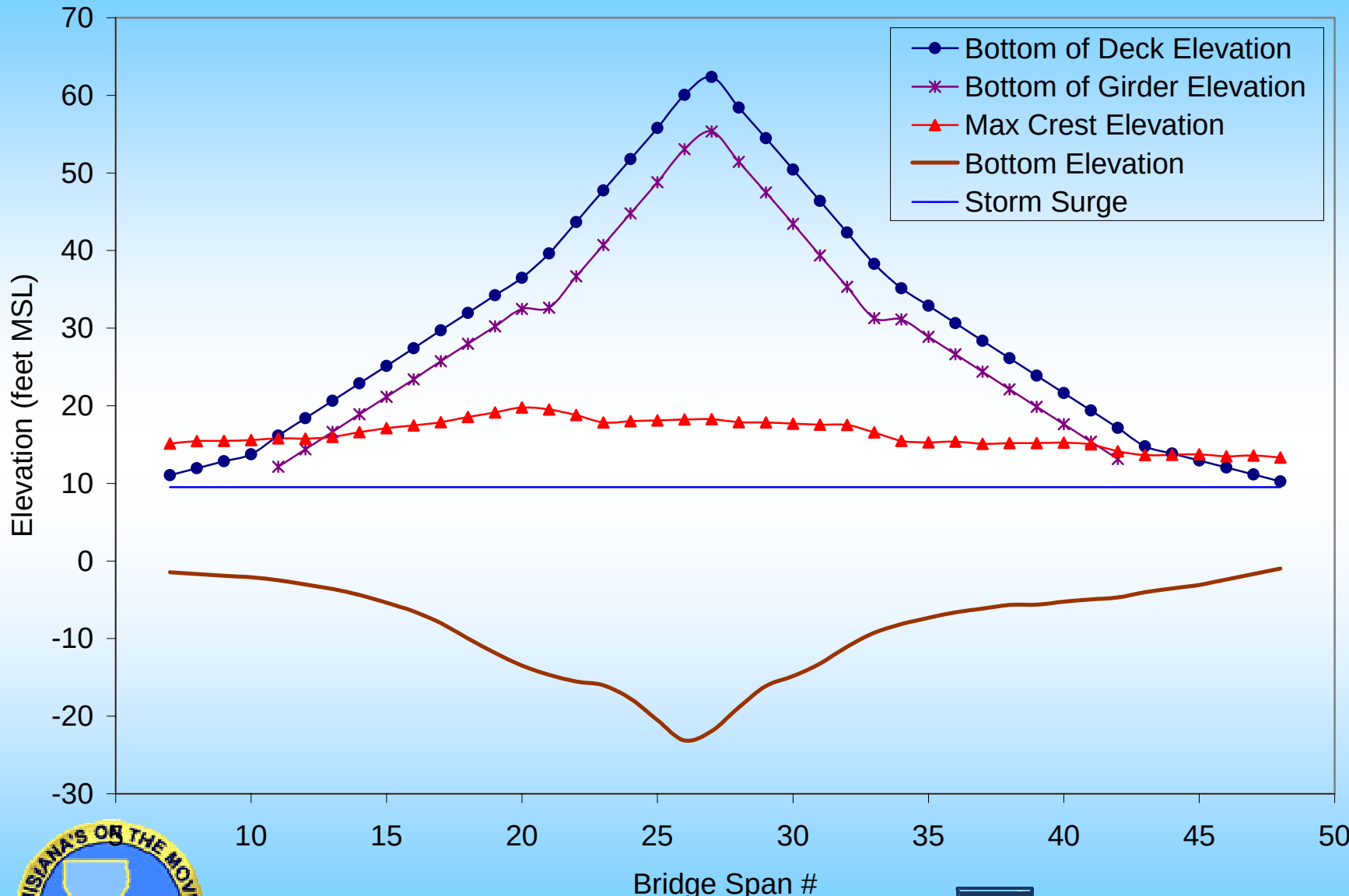




LOUISIANA'S ON THE MOVE...
DOTD
BUILDS THE WAY

COAST & HARBOR
ENGINEERING

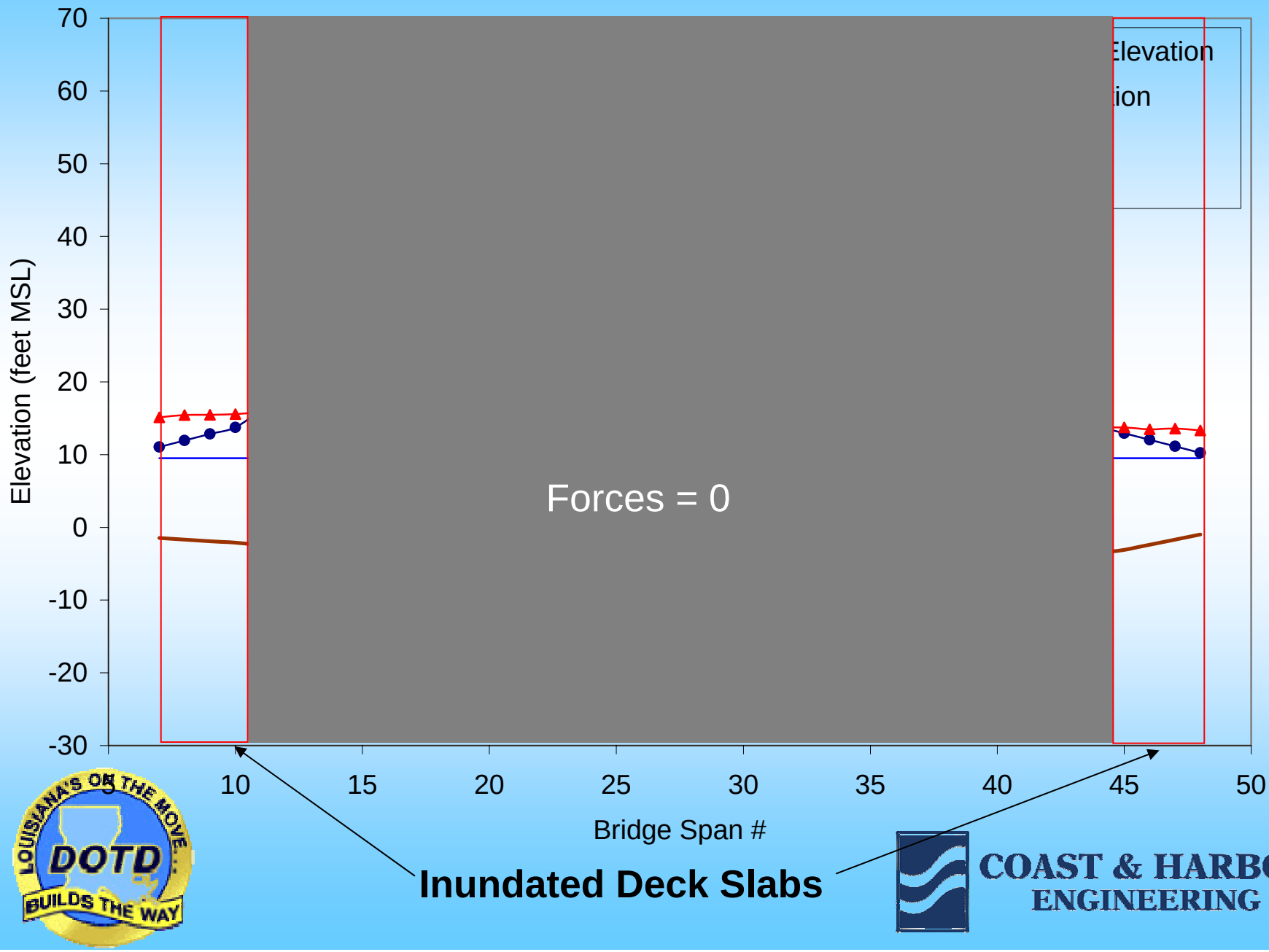
Scenario 1 – Max Crest Elevations



LOUISIANA'S ON THE MOVE... DOTD BUILDS THE WAY

COAST & HARBOR ENGINEERING

Scenario 1 – Max Crest Elevations



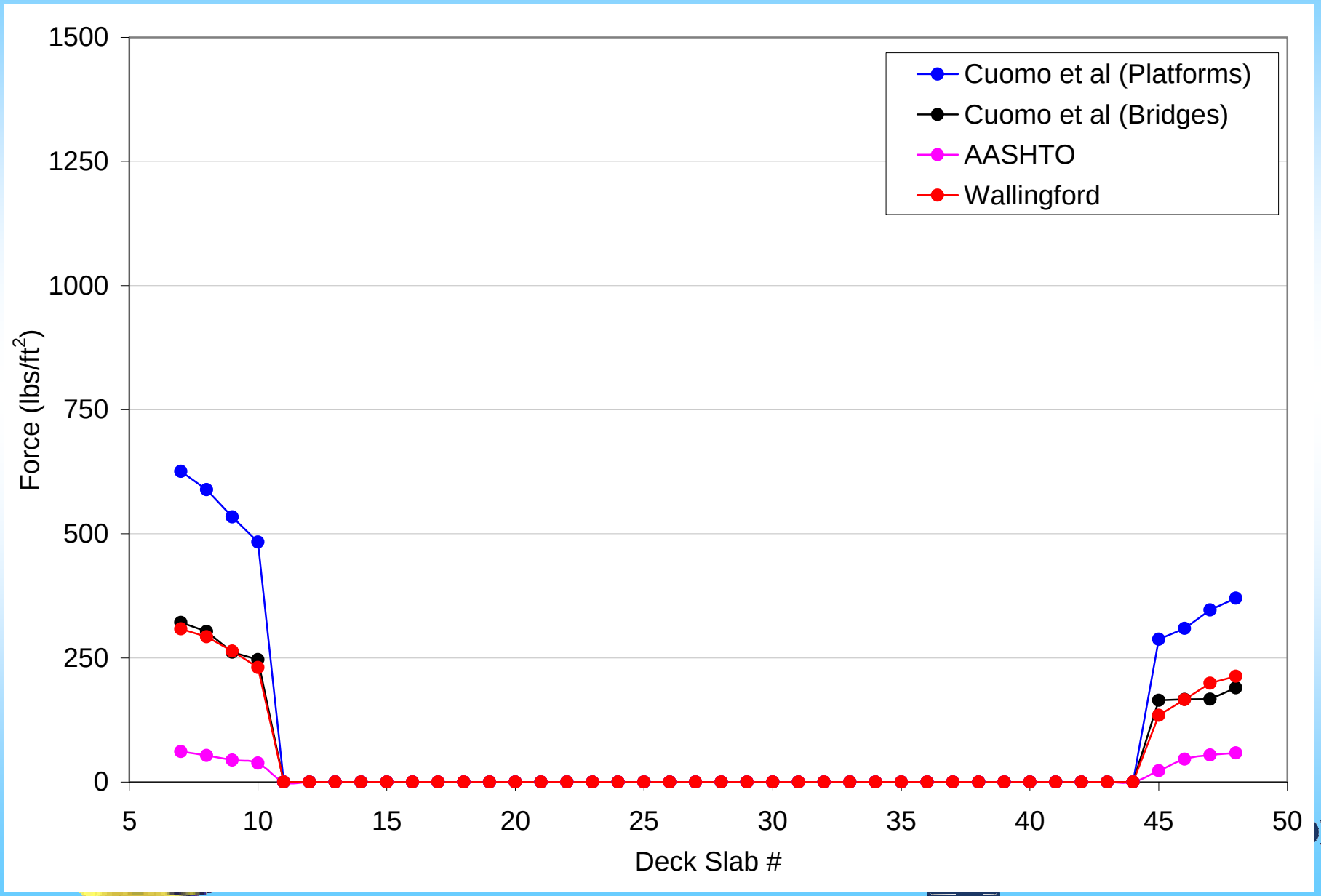
LOUISIANA'S ON THE MOVE... DOTD BUILDS THE WAY

COAST & HARBOR ENGINEERING

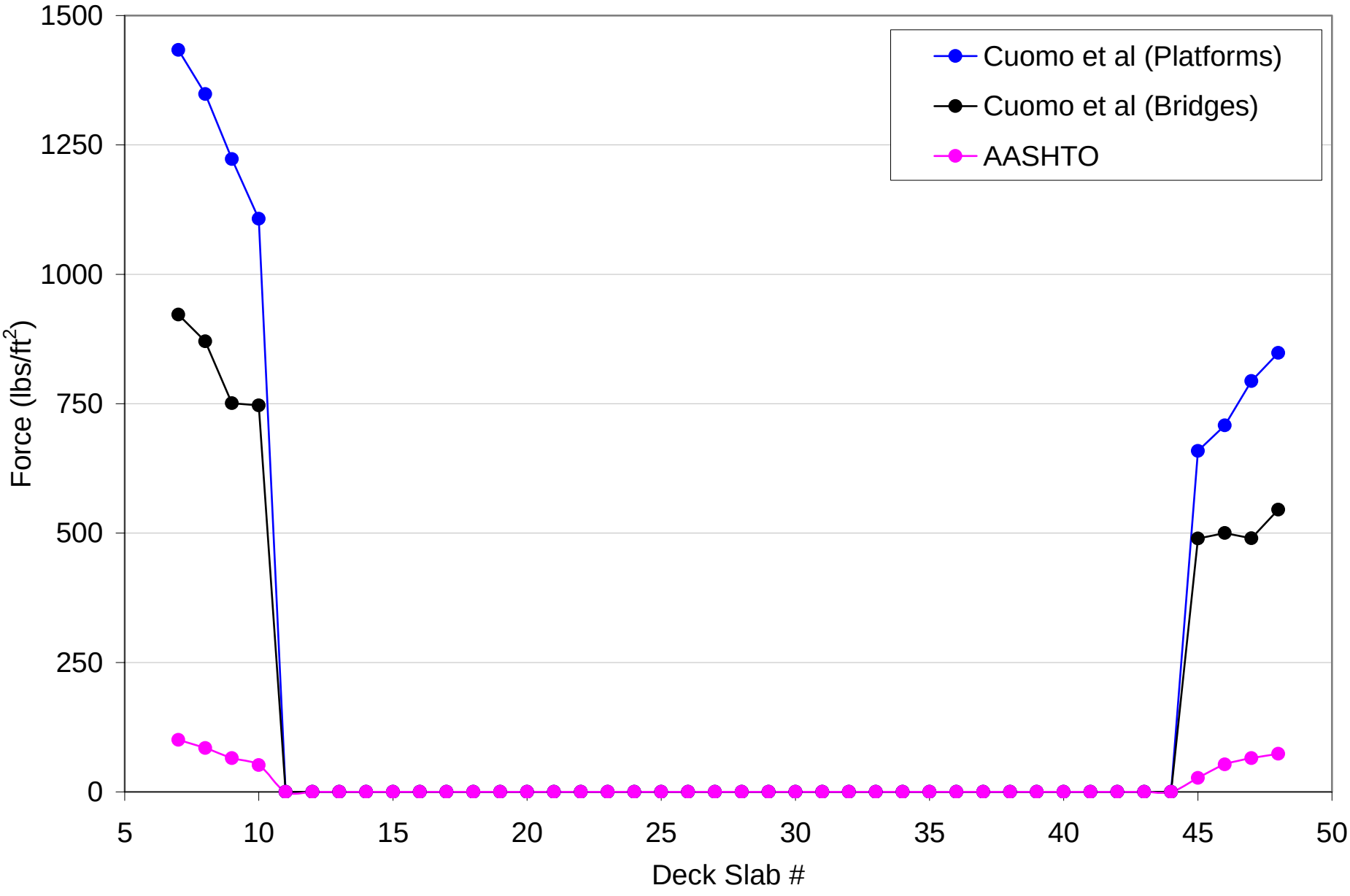
Methods Used for Wave Force Evaluation

Method	Year	Typology	Direct. of Force	Type of Force	Use
Cuomo et al.	2007a	Experimental	Horizontal / Vertical	QS[1] / Impact	Quantitative
Cuomo et al.	2007b	Experimental	Vertical	QS / Impact	Quantitative
AASHTO	2007	Experimental	Horizontal / Vertical	QS / Impact	Quantitative
Wallingford	2004	Experimental	Horizontal / Vertical	QS	Quantitative
VOF	2004	Numerical	Horizontal / Vertical	QS / Impact	Qualitative
Kaplan et al.	1995	Semi-analytical	Horizontal / Vertical	QS / Impact	Qualitative
Morison et al.	1950	Semi-analytical	Horizontal	QS / Impact	Quantitative

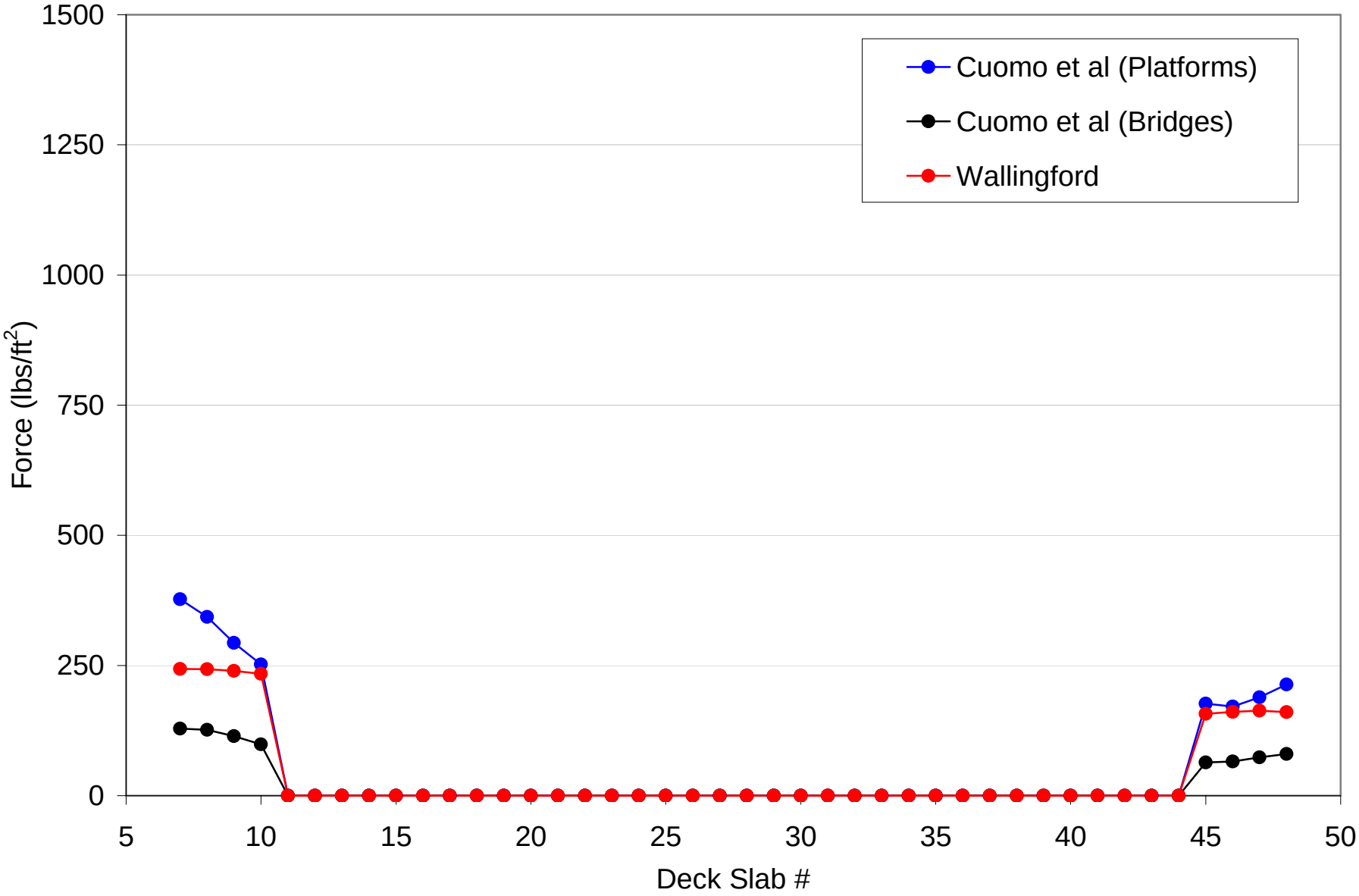
Vertical Quasi-Static Positive Forces on Deck Slabs for Scenario 1



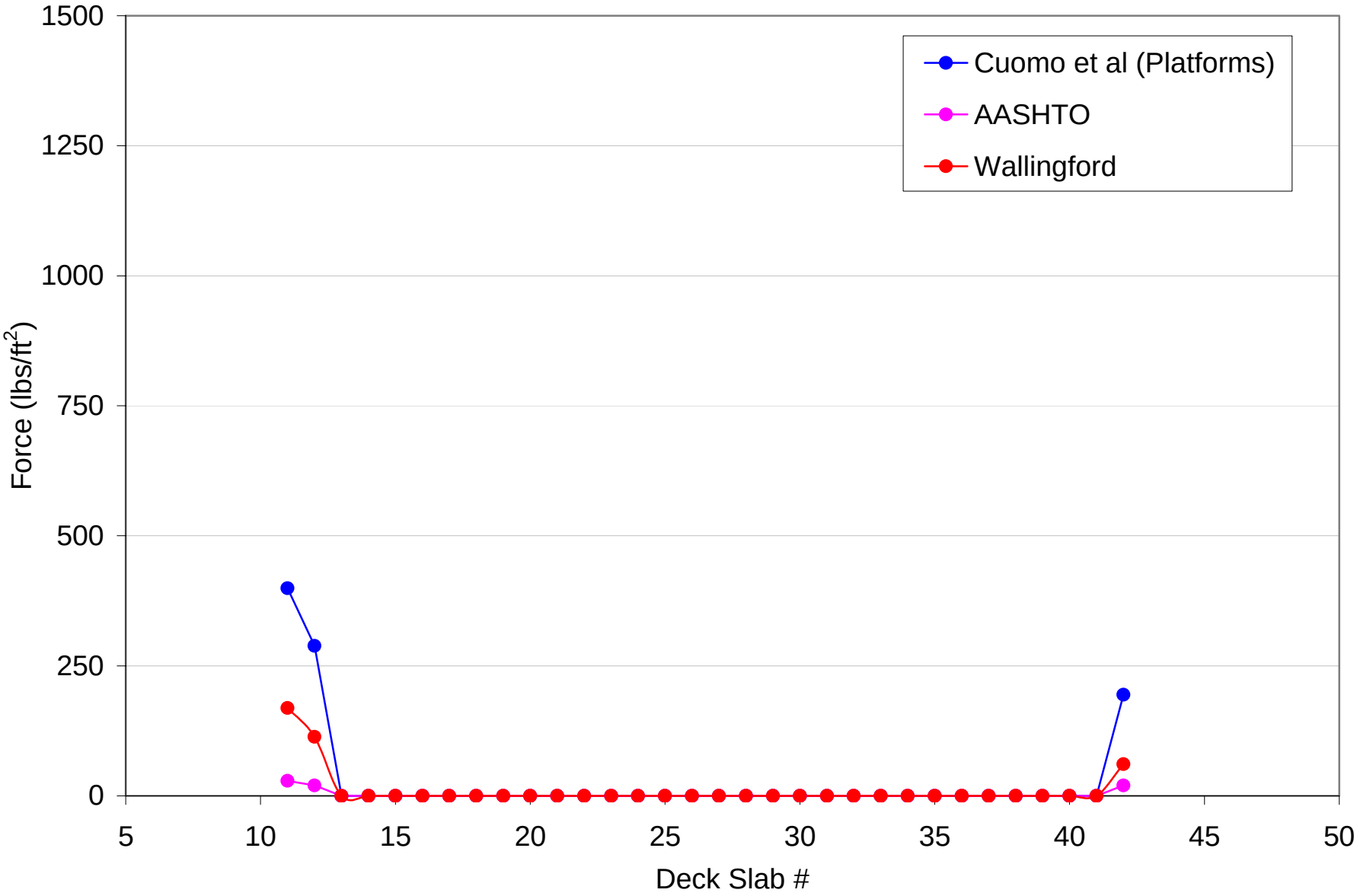
Vertical Impact Forces on Deck Slabs for Scenario 1



Vertical Quasi-Static Negative Forces on Deck Slabs for Scenario 1



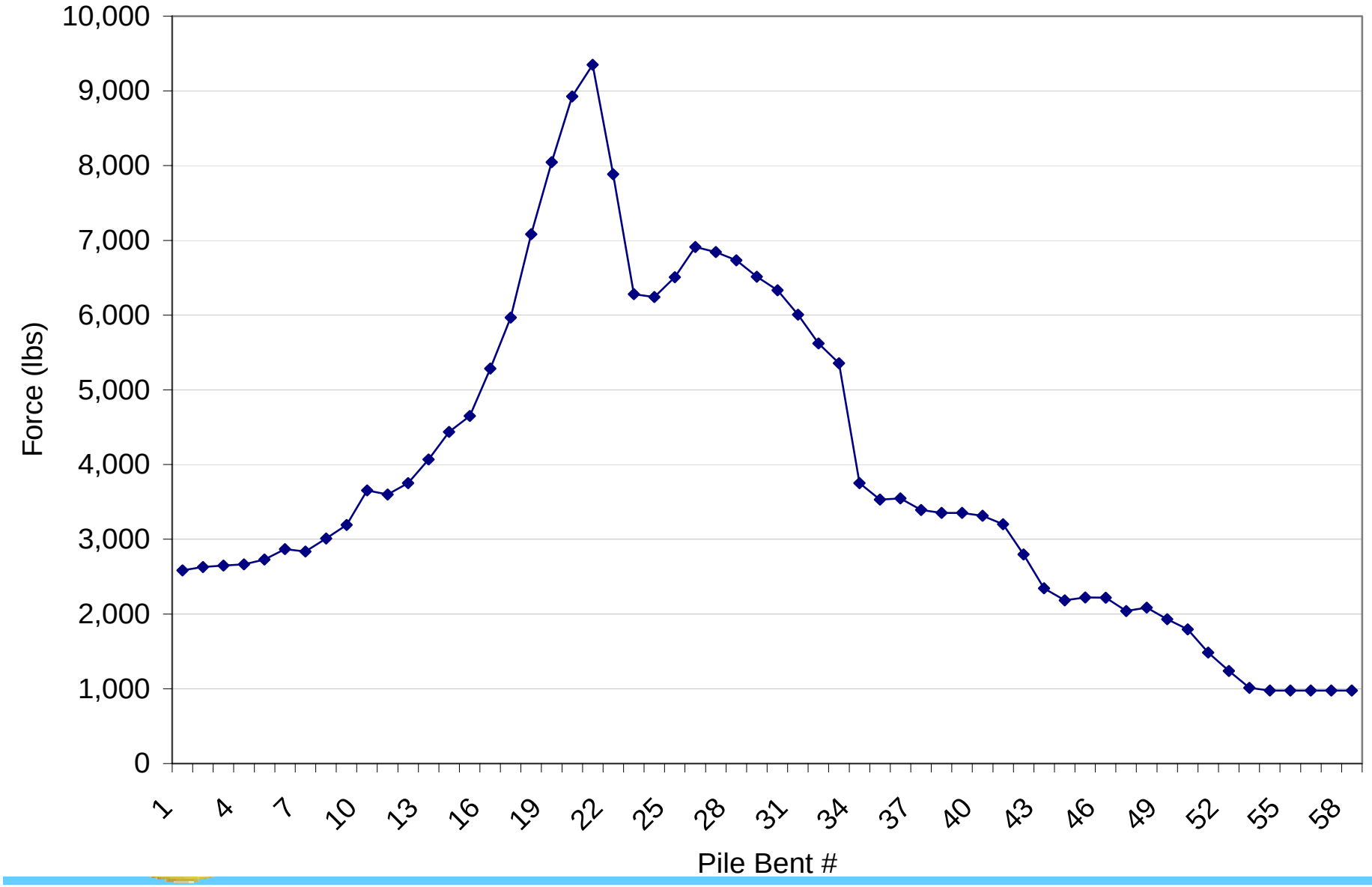
Horizontal Quasi-Static Forces on Girders for Scenario *1*



Fi

)R

Horizontal Wave Forces on Piles for Scenario 1



Vertical Wave Forces on Deck Slabs at Caminada Bridge for Scenario 1

Bridge Span	Impact (lbs/ft^2)	QS+ (lbs/ft^2)	QS- (lbs/ft^2)
7	1180	470	250
8	1110	450	230
9	990	400	200
10	930	370	180
11-44	0	0	0
45	570	230	120
46	600	240	120
47	640	260	130
48	700	280	150

Bridge Elements	Computed Wave Loads	
	Vertical	Horizontal
Deck slabs	20	n/a
Girders	3	3
Railings	n/a	20
Pile Caps	33	33
Piles	n/a	52
Columns	n/a	13
Footings	13	13

LOUISIANA'S ON THE MOVE... DOTD BUILDS THE WAY

COAST & HARBOR ENGINEERING

European Research Foundation Grant 2008-2009

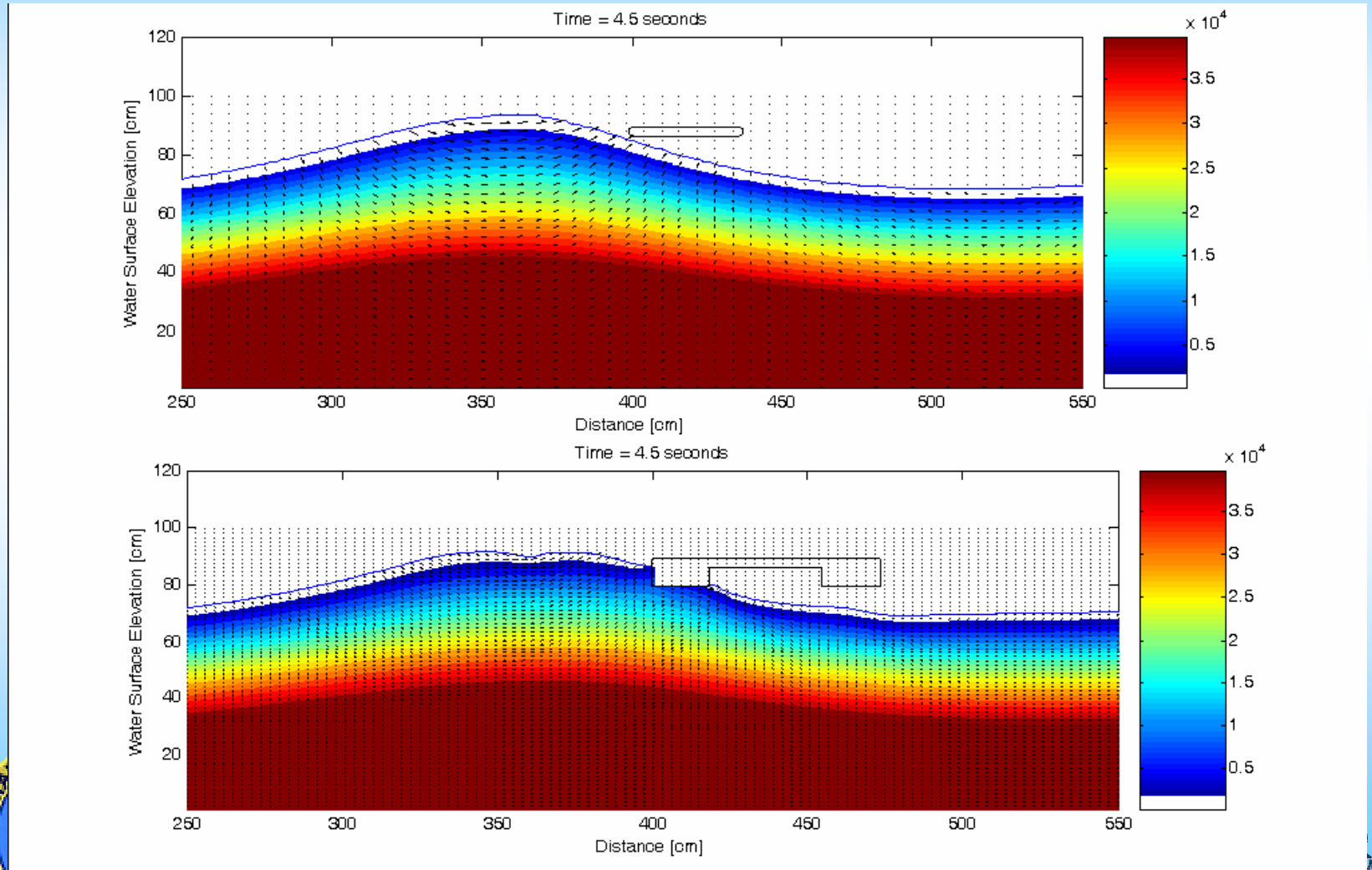
Vertical Wave Loads on Piers, Decks, and Bridges during Extreme Events

International Team of Scientists and Engineers

- **University of Bologna, Italy**
- **University of Rome, Italy**
- **University of Edinburgh, UK**
- **Coast & Harbor Engineering, USA**

COAST & HARBOR ENGINEERING

Influence of Down-standing Beams



ForschungsZentrum Küste

Gemeinsame Zentrale Einrichtung der Universität Hannover und der Technischen Universität Braunschweig

Merkurstrasse 11, 30419 Hannover, Germany

DOTD BUILDS THE WAY

COAST & HARBOR ENGINEERING

Example Projects at Large Wave Channel

Low Crested and Submerged Breakwaters in Presence of Broken Waves, EU, 2002

LOUISIANA'S ON THE MOVE... DOTD BUILDS THE WAY

COAST & HARBOR ENGINEERING

Example Projects at Large Wave Channel

Breaking Wave Impacts on Steep Fronted Coastal Structures (BWIMCOST, 2003)

COAST & HARBOR ENGINEERING

Caminada Bridge (LA): Coastal Engineering Analysis & Numerical Modeling in Support for Design
(*Hurricane Wind and Wave Action*)

Hossein Ghara, P.E., M.B.A., State of Louisiana DOT&D
Artur Wagner, P.E., State of Louisiana DOT&D
Jenny Fu, P.E., State of Louisiana DOT&D
Vladimir Shepsis, P.E., PhD Coast & Harbor Engineering, Inc.
Matteo Tirindelli, PhD Coast & Harbor Engineering, Inc.

Thank You

New Orleans
February 21, 2008

LOUISIANA'S ON THE MOVE... DOTD BUILDS THE WAY

COAST & HARBOR ENGINEERING