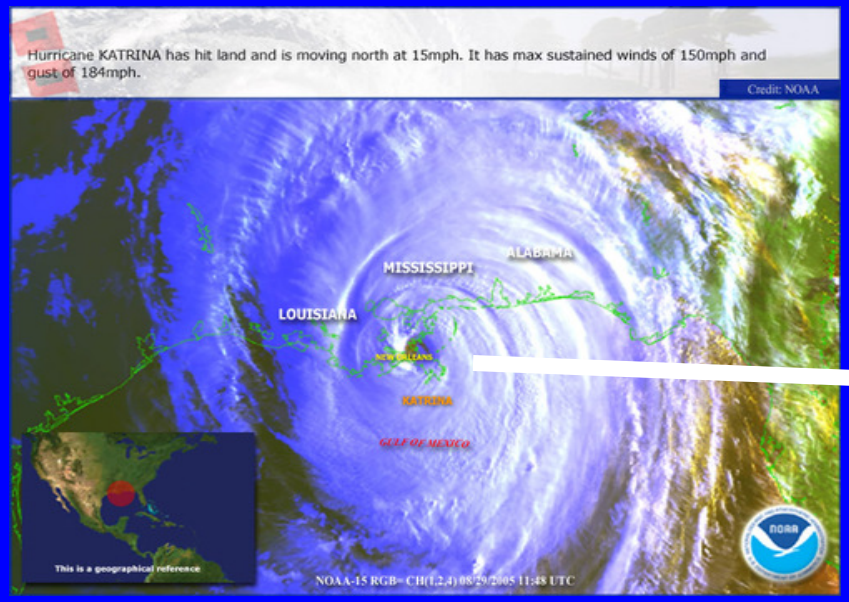
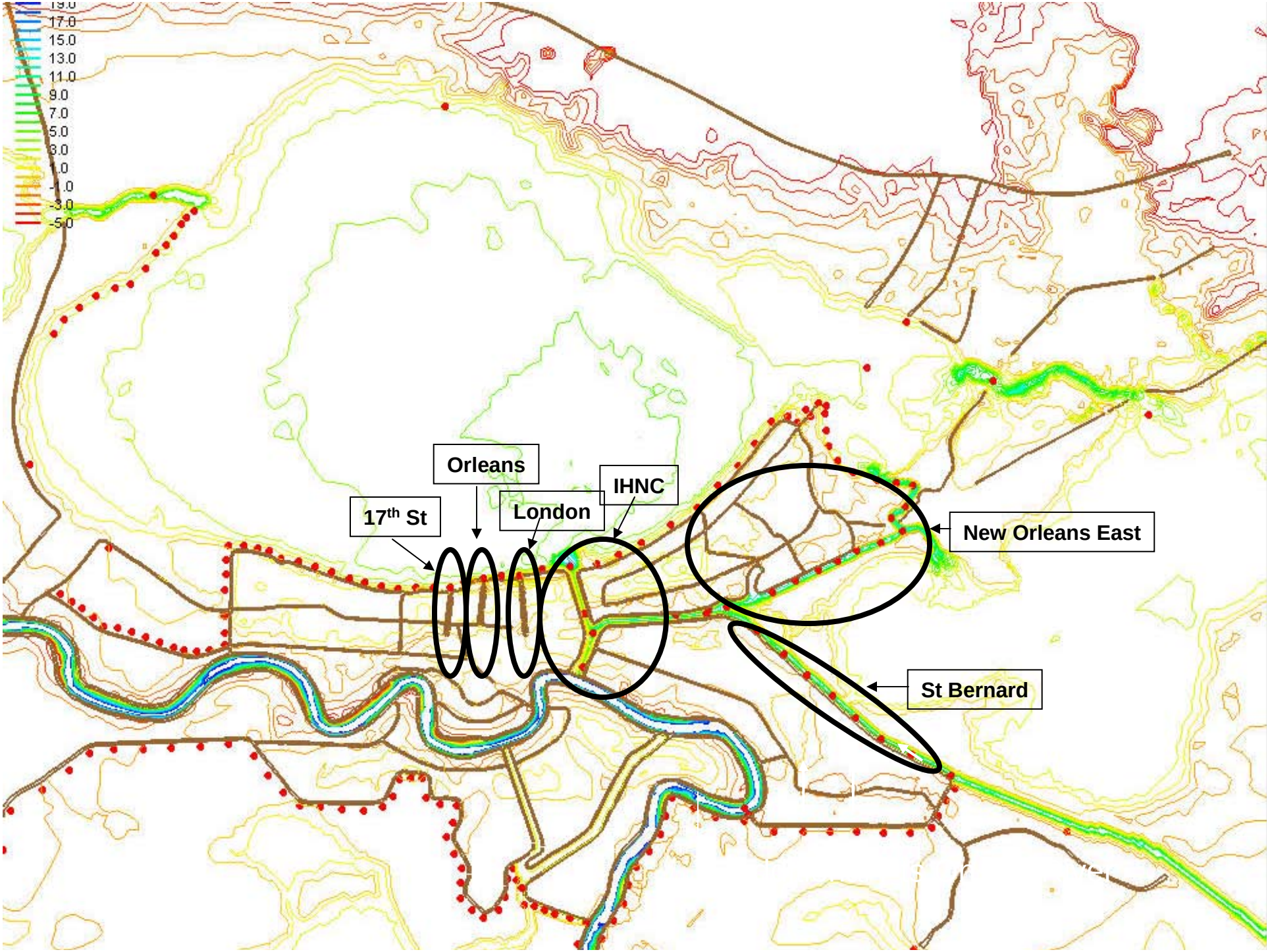
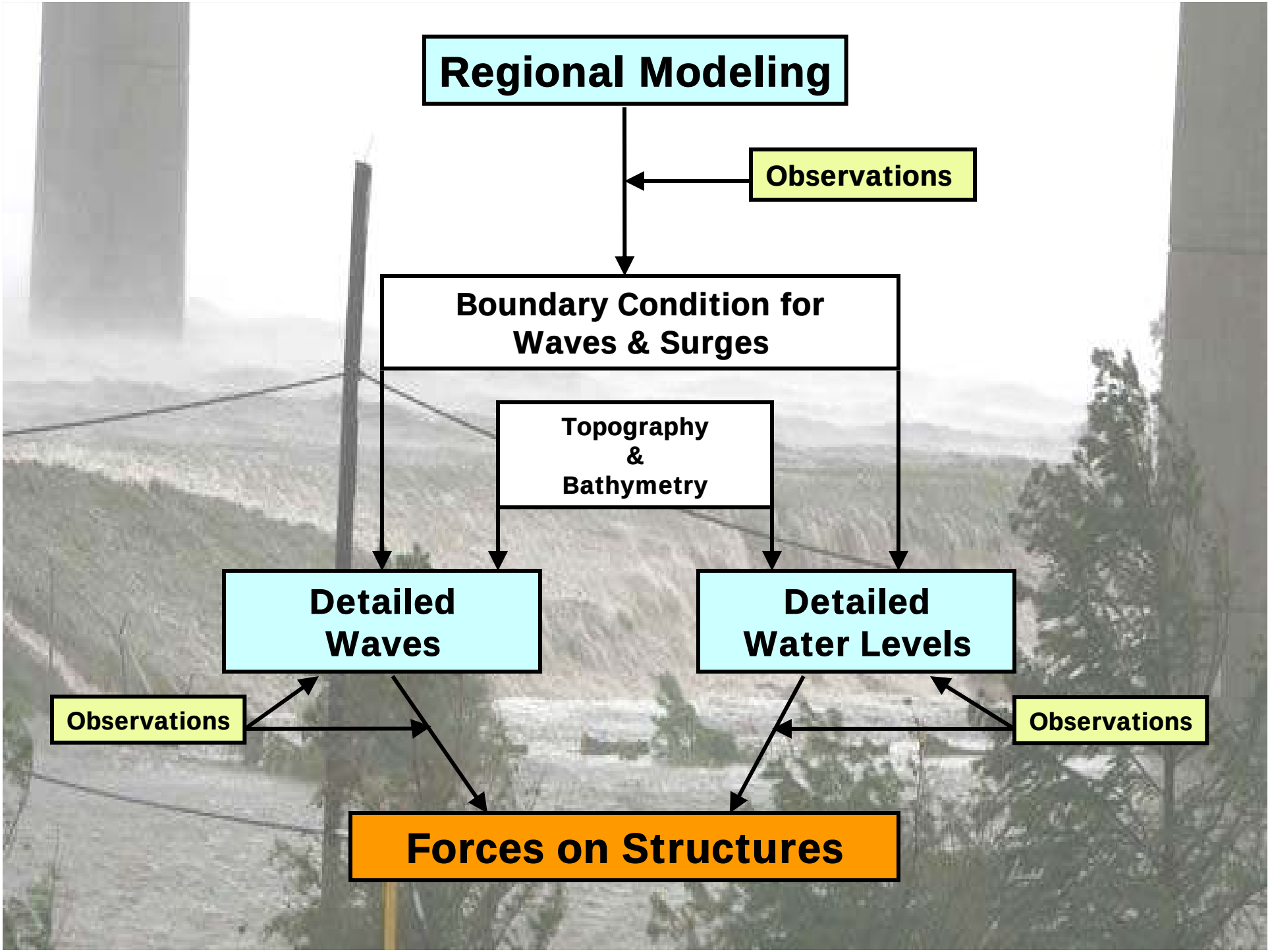
The Storm: Detailed Hydrodynamics

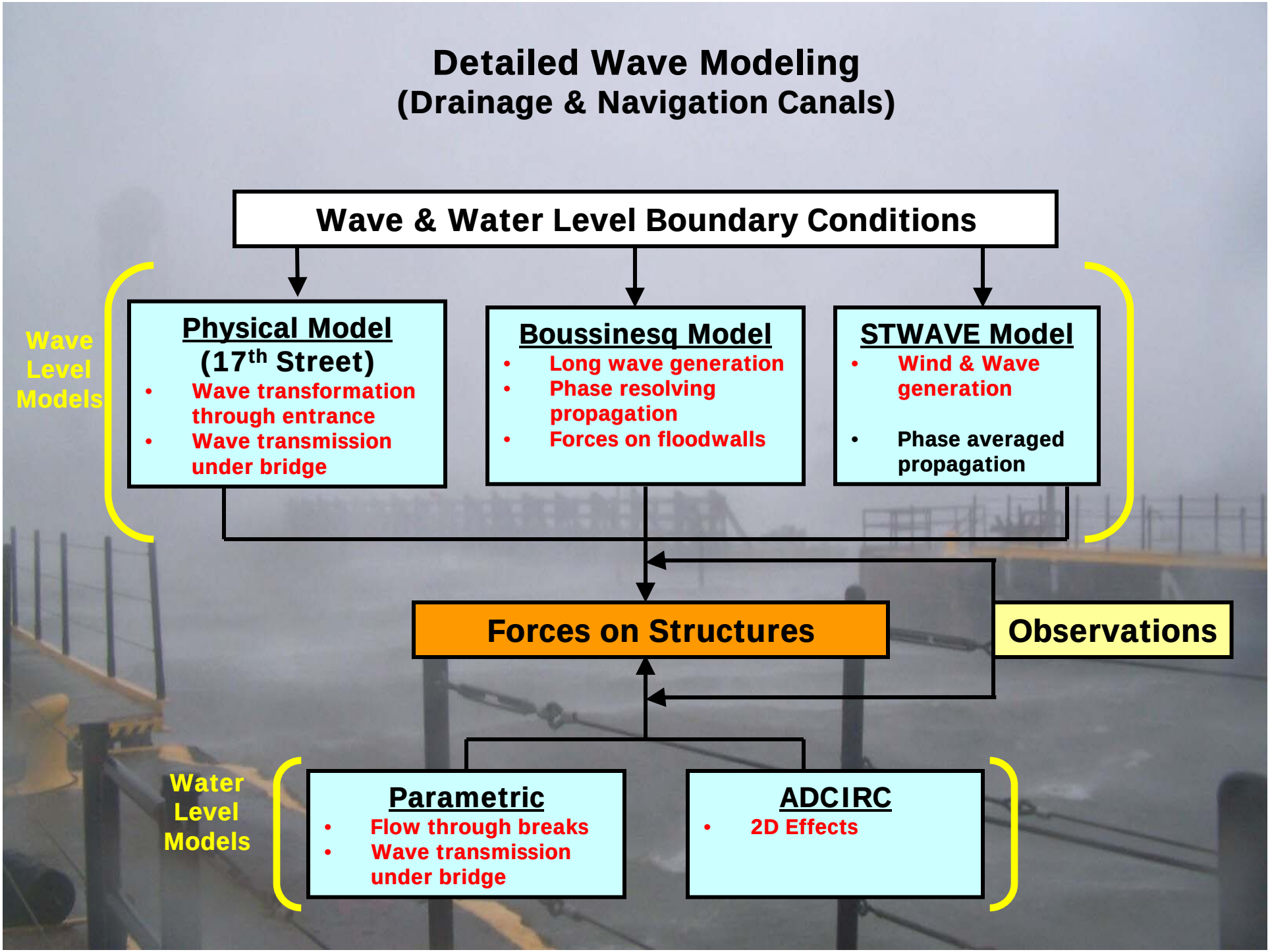


Co-leads:
D.T. Resio, Senior Scientist - CHL
R.G. Dean, Professor Emeritus
U. Of Florida


19.0
17.0
15.0
13.0
11.0
9.0
7.0
5.0
3.0
1.0
-1.0
-3.0
-5.0
Orleans
IHNC
17th St
London
New Orleans East
St Bernard


Regional Modeling
Observations
Boundary Condition for Waves & Surges
Topography & Bathymetry
Detailed Waves
Detailed Water Levels
Observations
Observations
Forces on Structures

Detailed Wave Modeling
(Drainage & Navigation Canals)

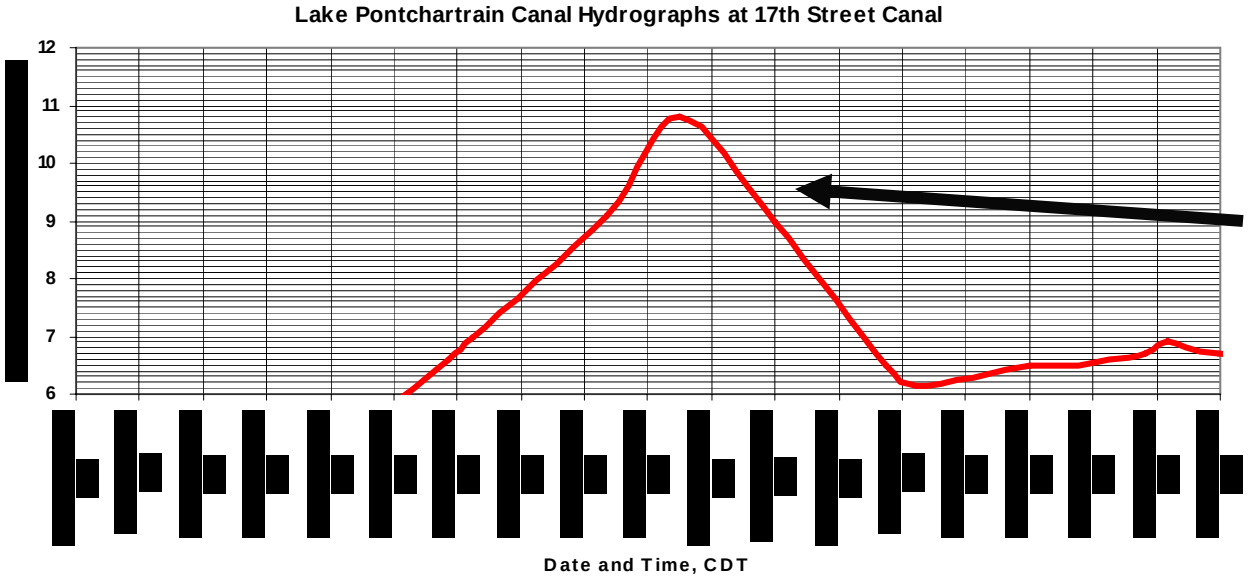


Robert E. Lee Blvd Bridge Breach

I10 Pump Station

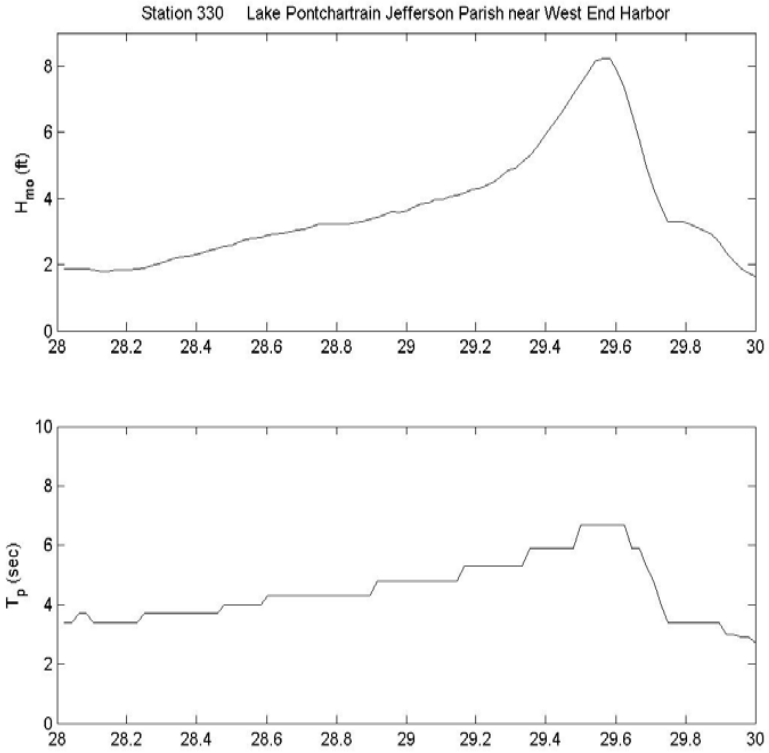
Pump Station 6

17th Street Canal

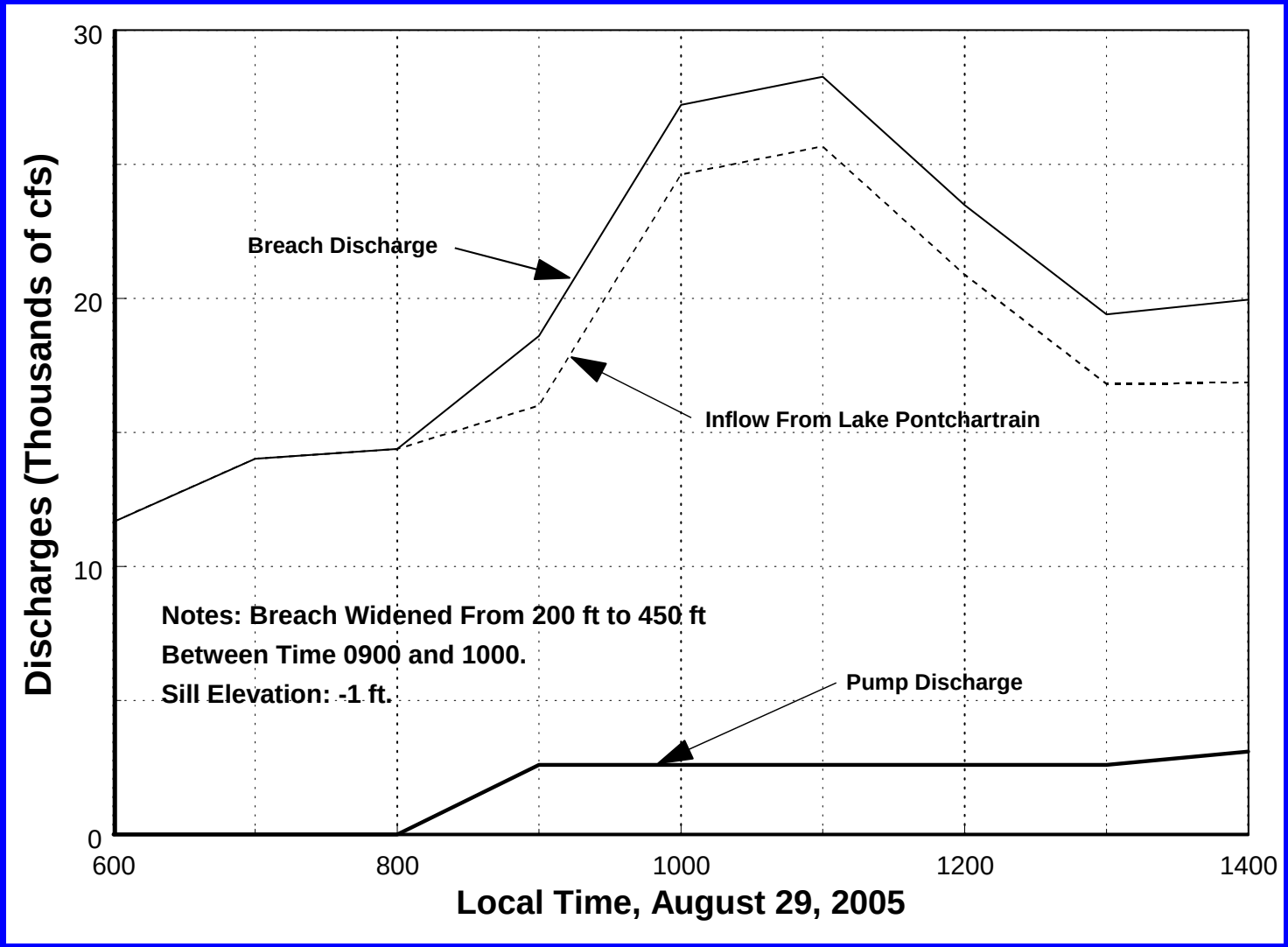


Information primarily from observations at marina

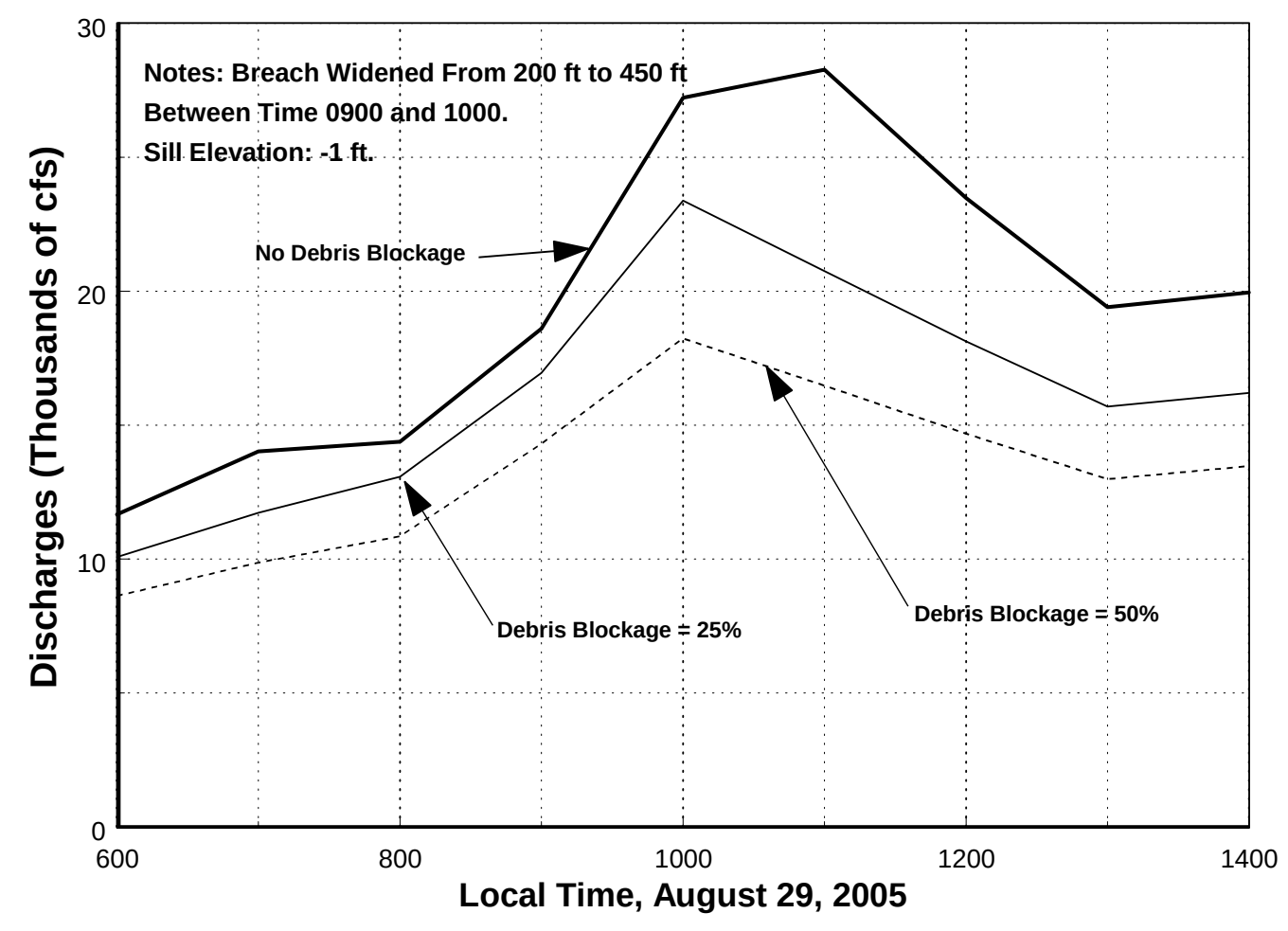
Water level and wave boundary conditions

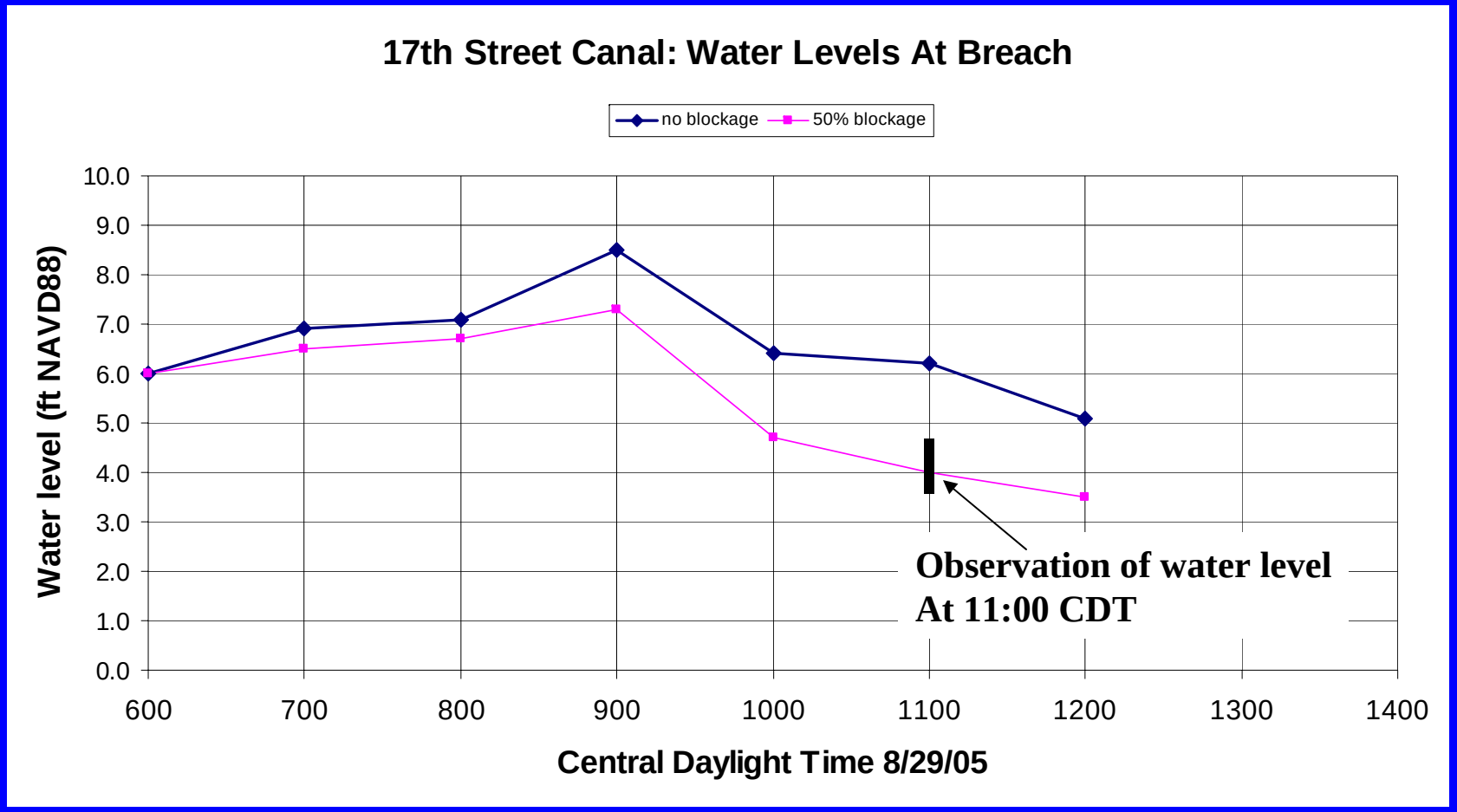


17th Street Breach Discharge

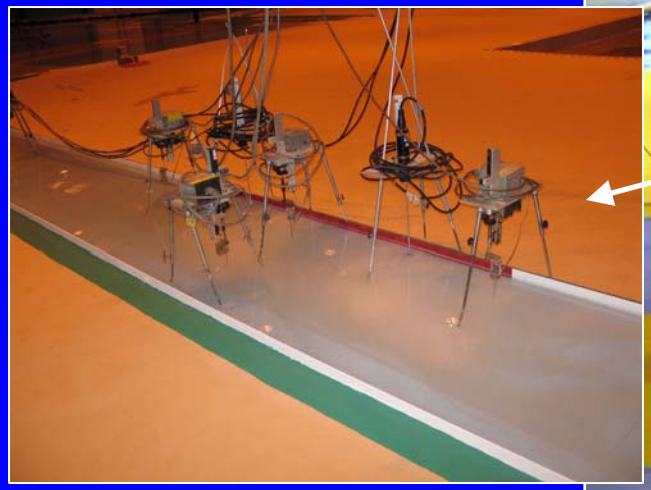


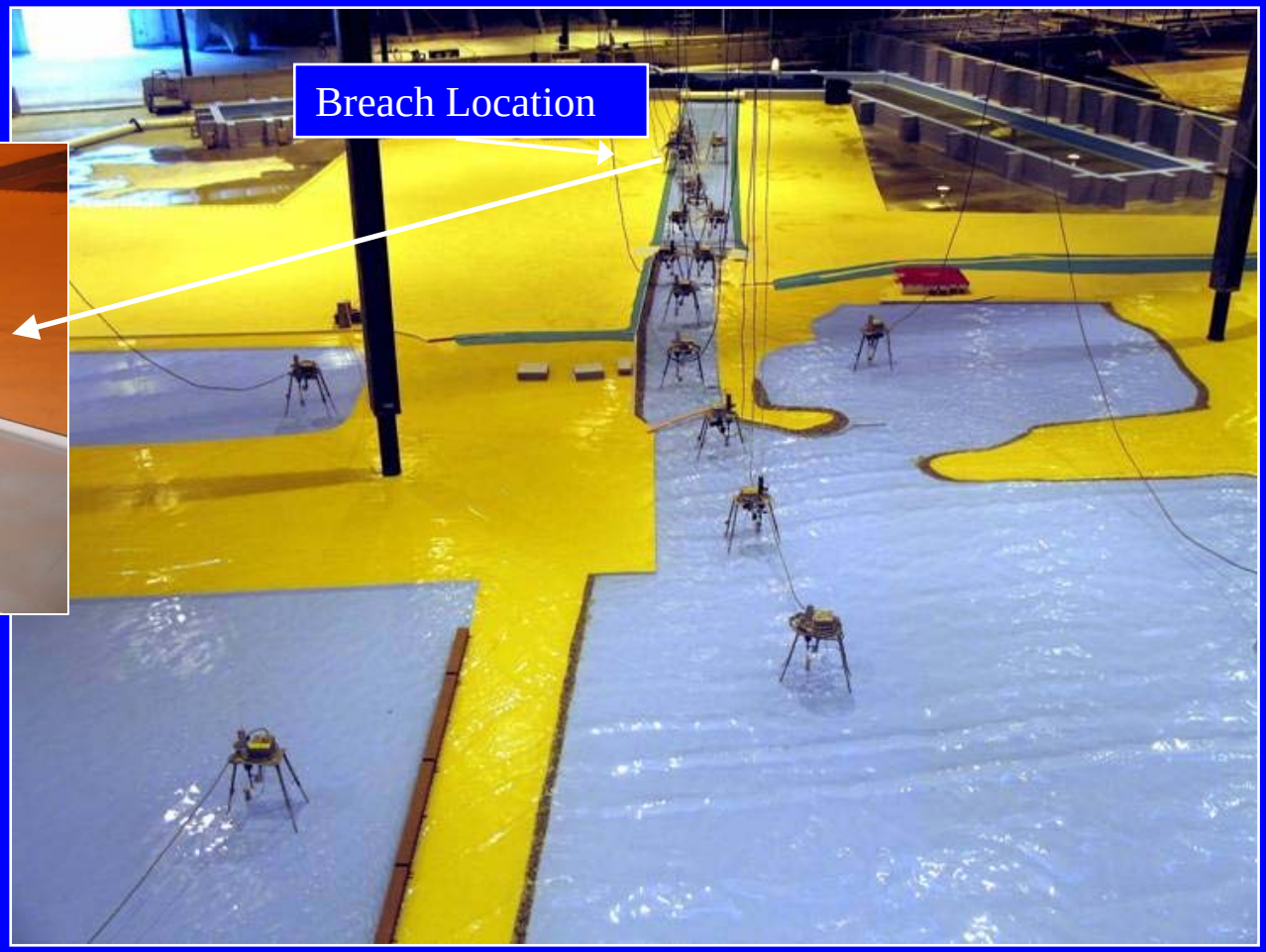
Sensitivity to Flow Blockage by Debris at Hammond Highway Bridge




17th Street Canal: Water Levels At Breach
no blockage
50% blockage
Water level (ft NAVD88)
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
600
700
800
900
1000
1100
1200
1300
1400
Observation of water level
At 11:00 CDT
Central Daylight Time 8/29/05

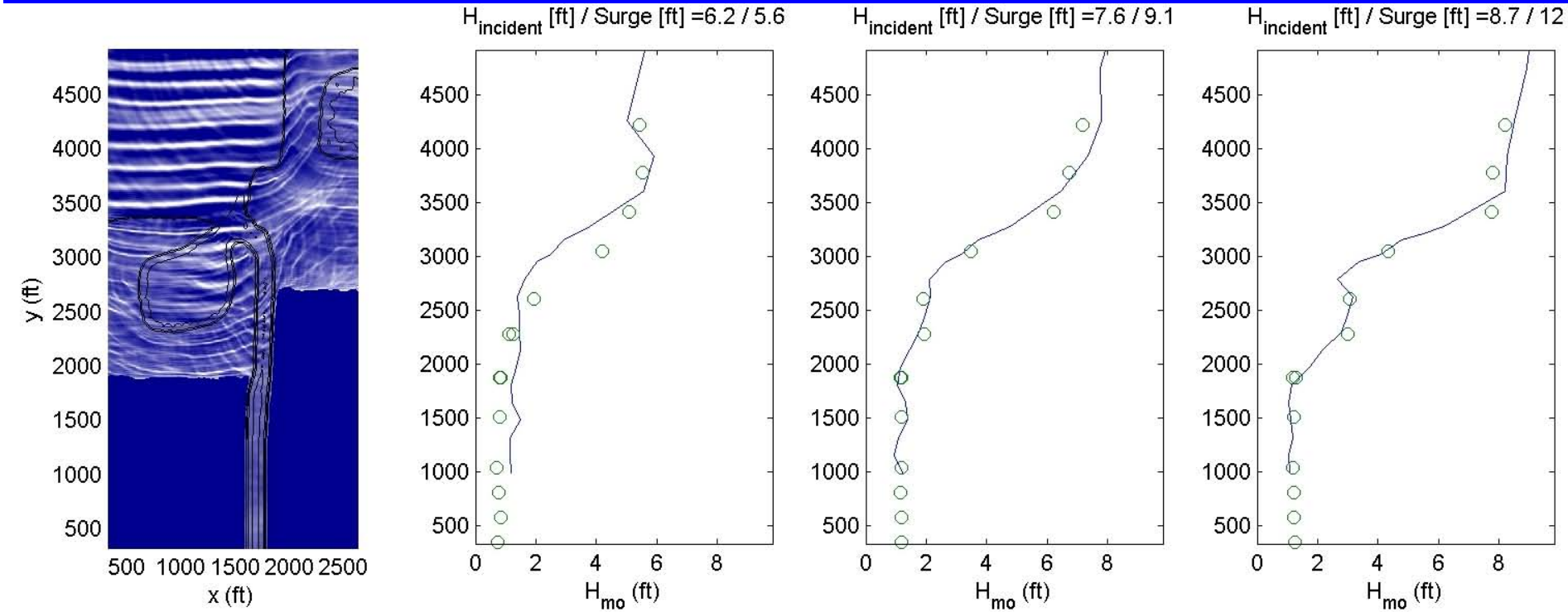
1:50 Scale Physical Model





Detailed Wave Hydrodynamics - 17th Street Canal

Model Validation and Comparison with Physical Model Data



Comparisons with Spectral Wave Generator (uni-directional) runs

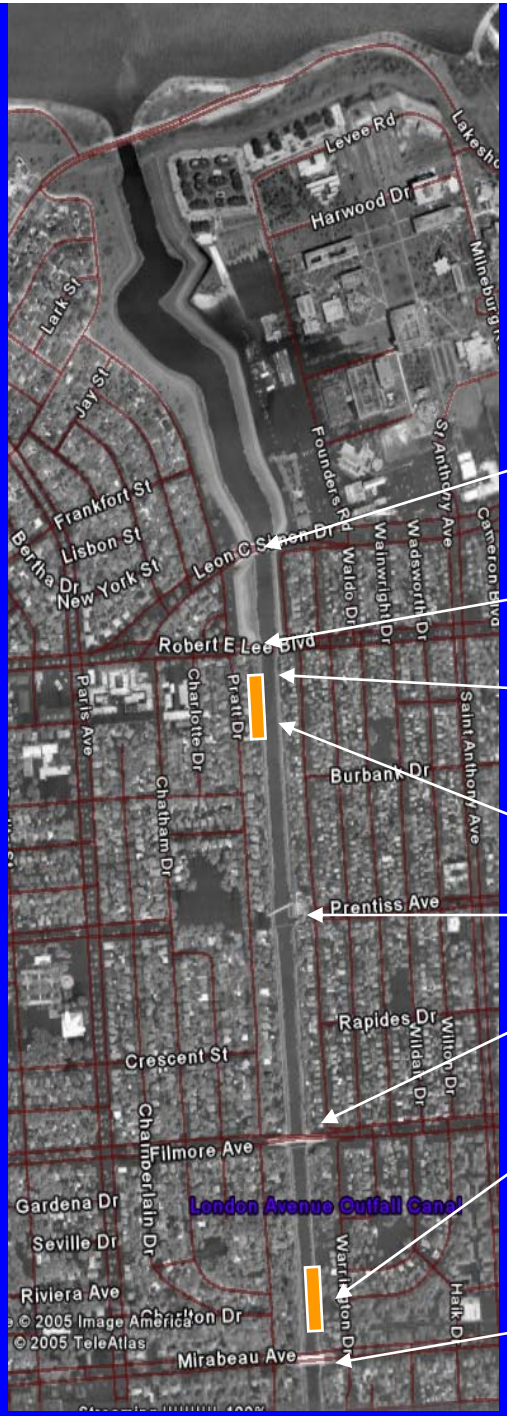
circle = experimental data

line = numerical results

Numerical model validated for bridge-wave interaction and canal entrance effect

Wave Height about 1 foot for much of the time period at breach

London Avenue Canal



Leon C. Simon Blvd Bridge
Flood-proofed in1996

Robert E. Lee Blvd Bridge
NOT Flood-proofed

Distressed section on East side

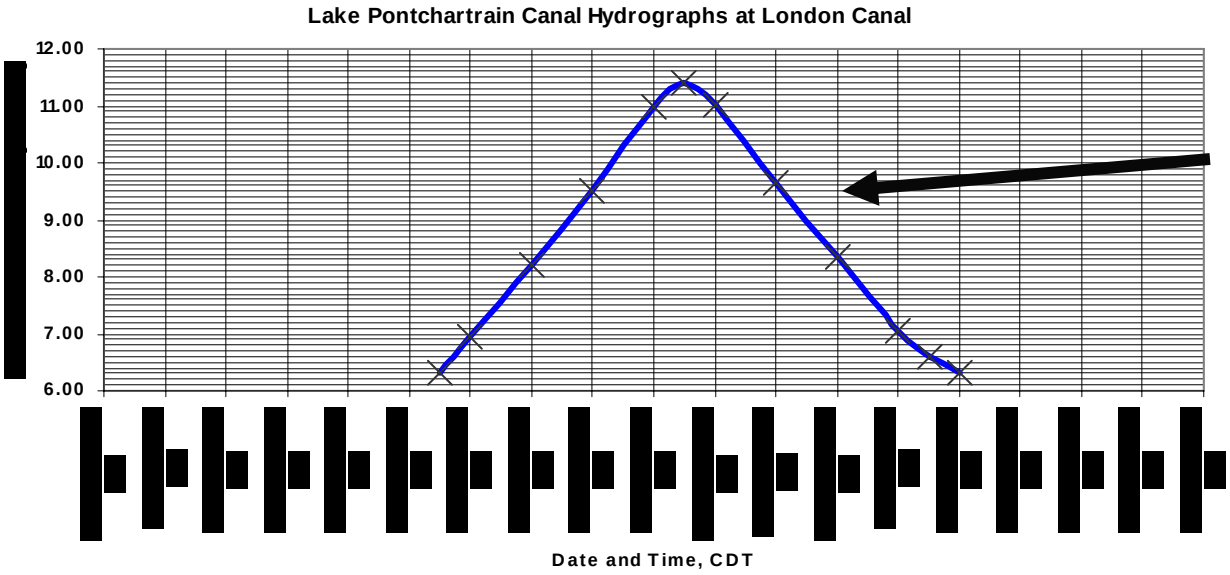
West side breach at Robert E. Lee Blvd

DP#4

Filmore Ave Bridge
Flood-proofed 1998

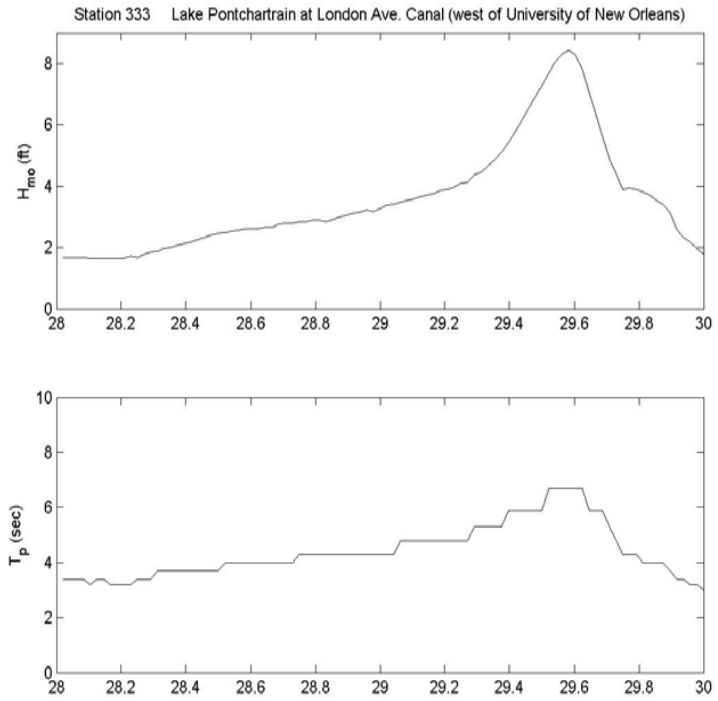
East side breach at Mirabeau Ave

Mirabeau Ave Bridge
Flood-proofed 1998



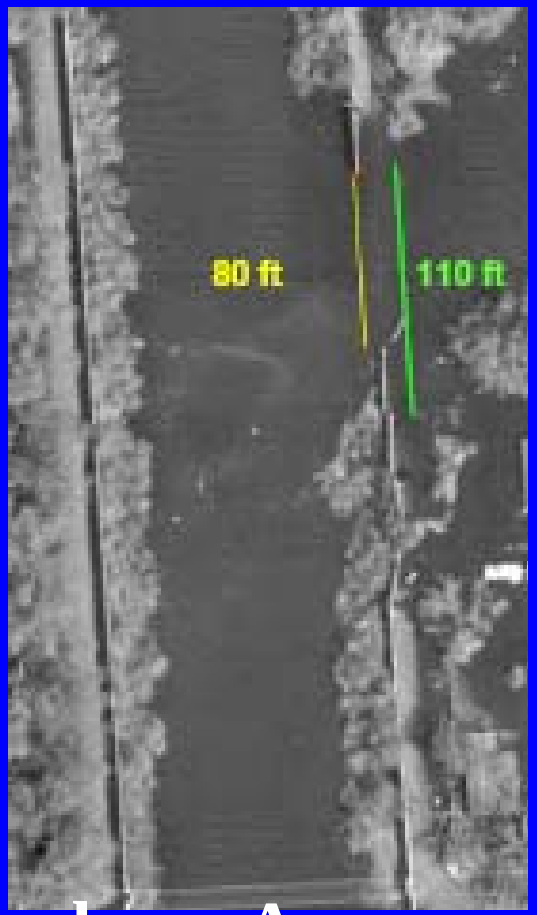
Information primarily interpolated from observations at marina and Lakefront Airport

Water level and wave boundary conditions



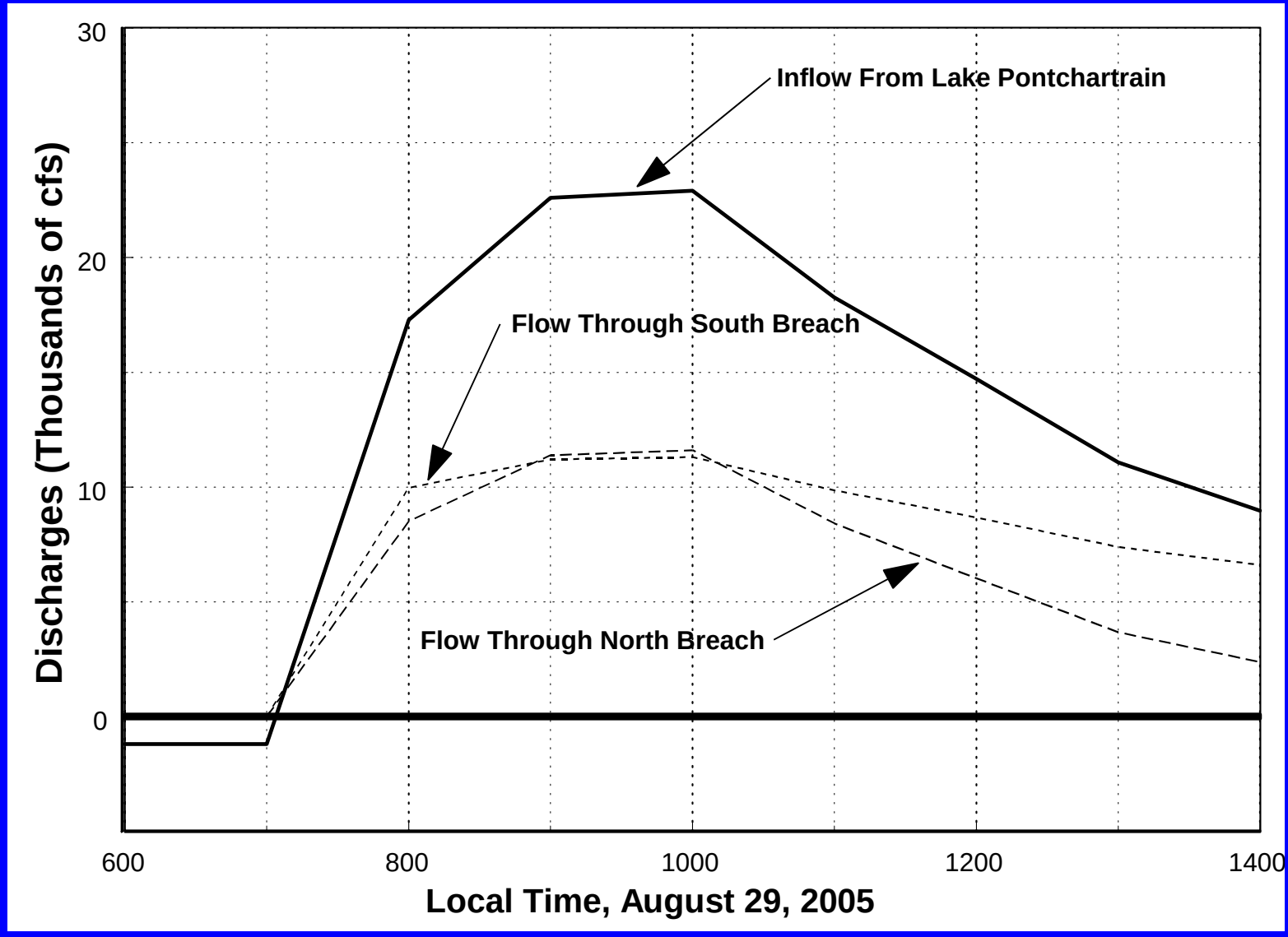
London Avenue Breaches

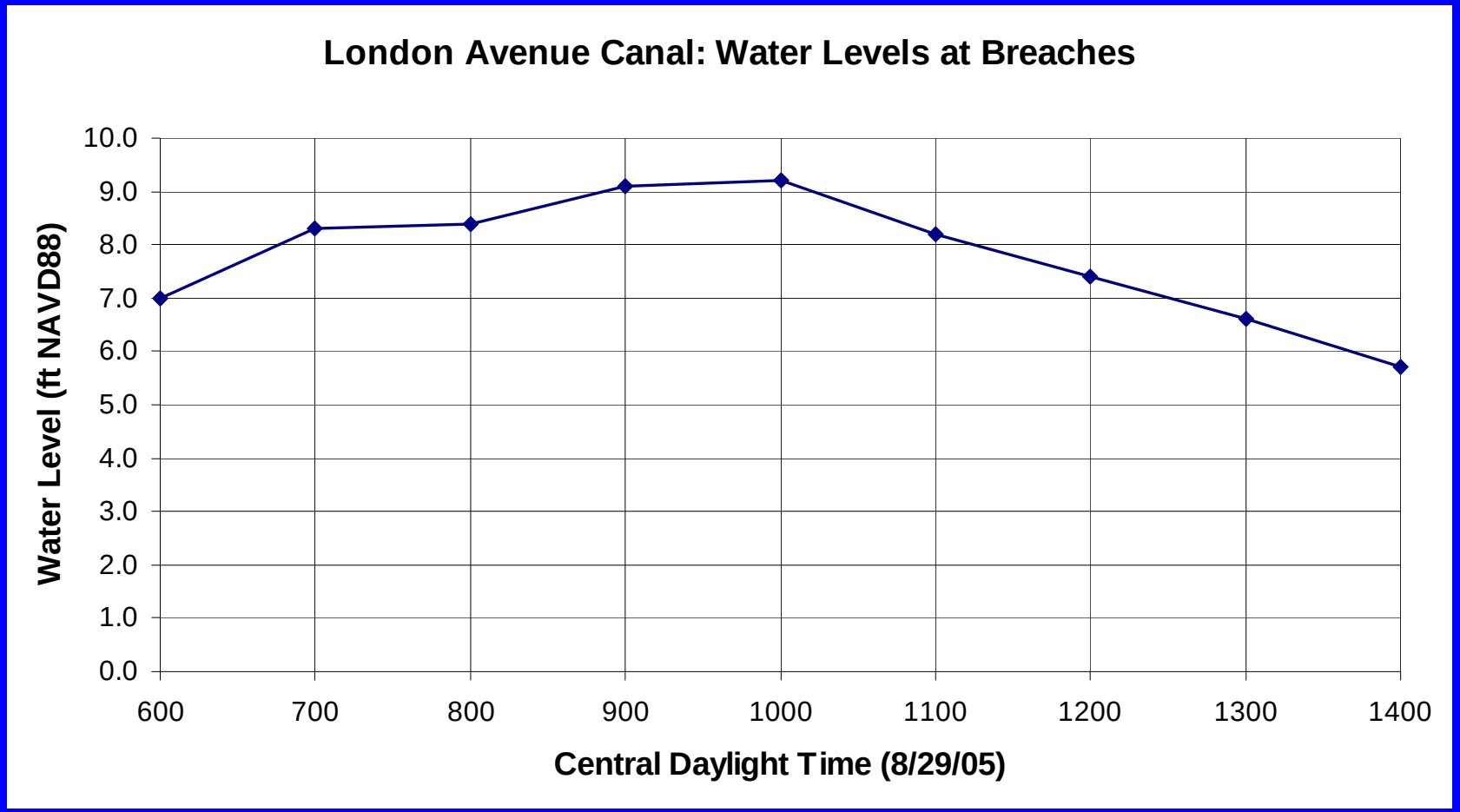
Robert E. Lee Boulevard Breach: 300 ft. Wide



Mirabeau Avenue Breach: 80 ft. Wide

Breach Discharges





Wave height about 1-2 feet at the breaches

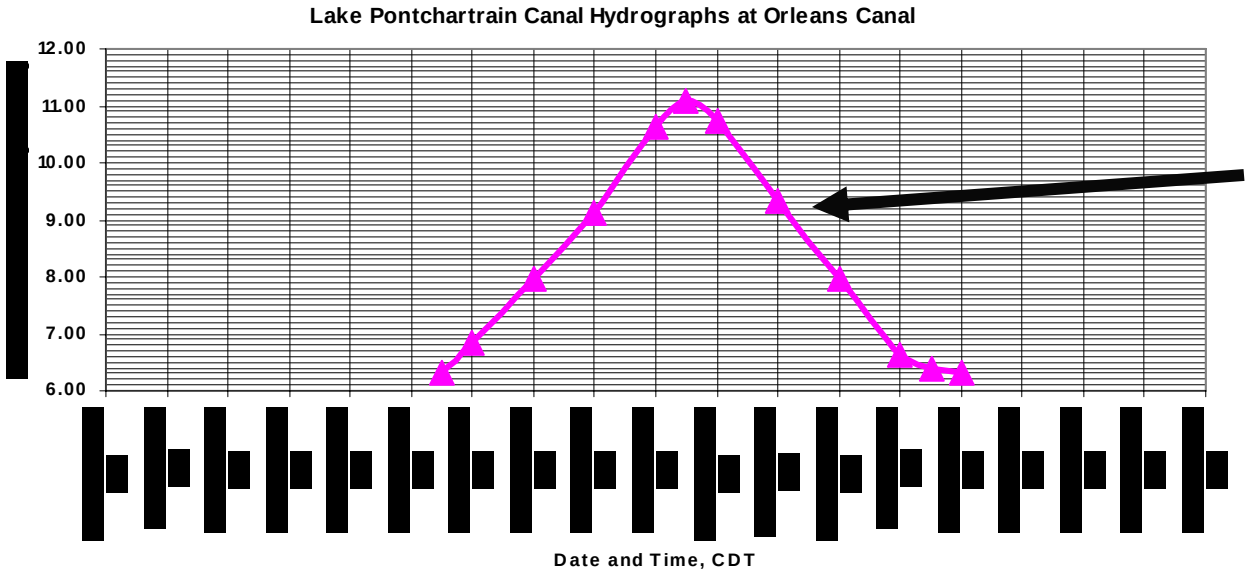
Orleans Canal
(no breaching)

Robert E. Lee Blvd Bridge

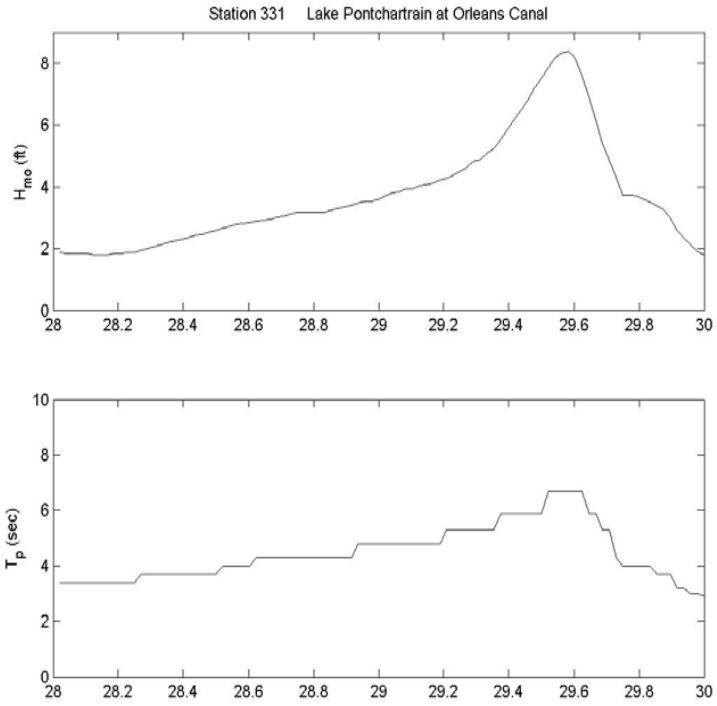
Filmore St. Bridge

Harrison Ave. Bridge

Pump Station 9



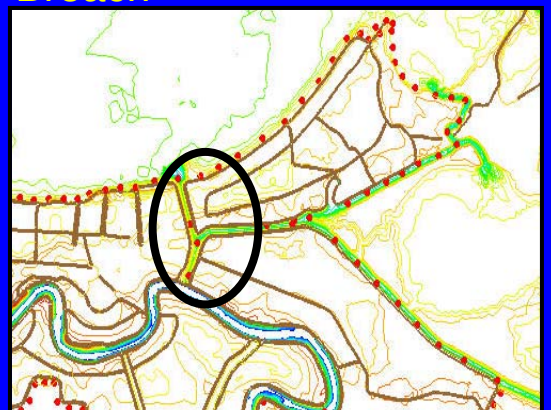
Information primarily interpolated from observations at marina and Lakefront Airport



Water level and wave boundary conditions

Inner Harbor Navigation Canal

RR Crossing Breach



Overtopping of inner floodwall

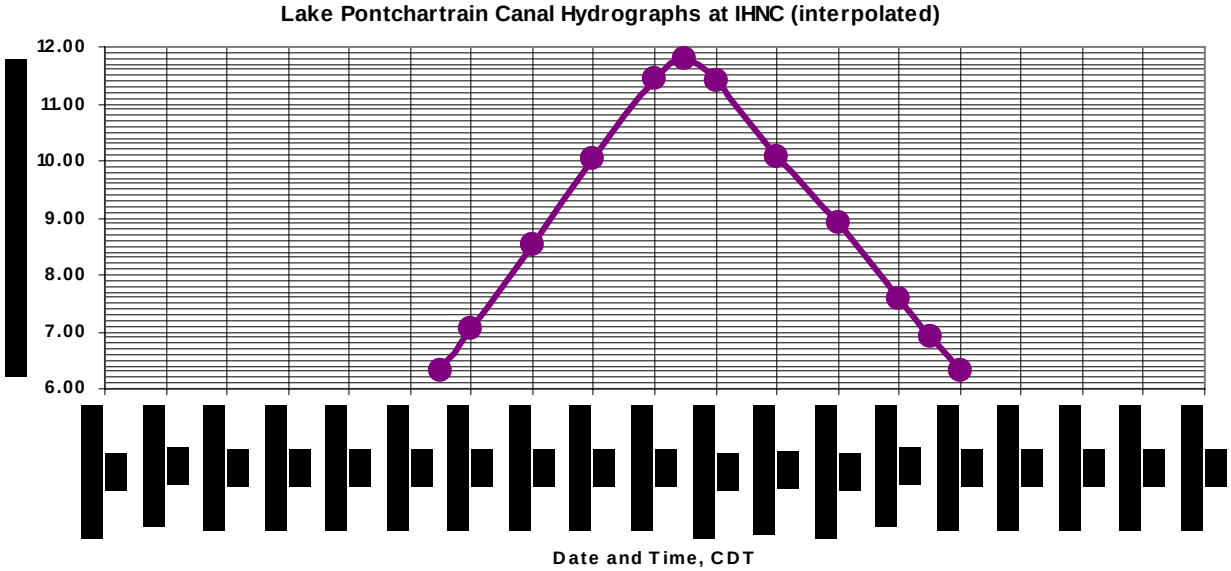
North Port Levee Breach

South Port Levee Breach

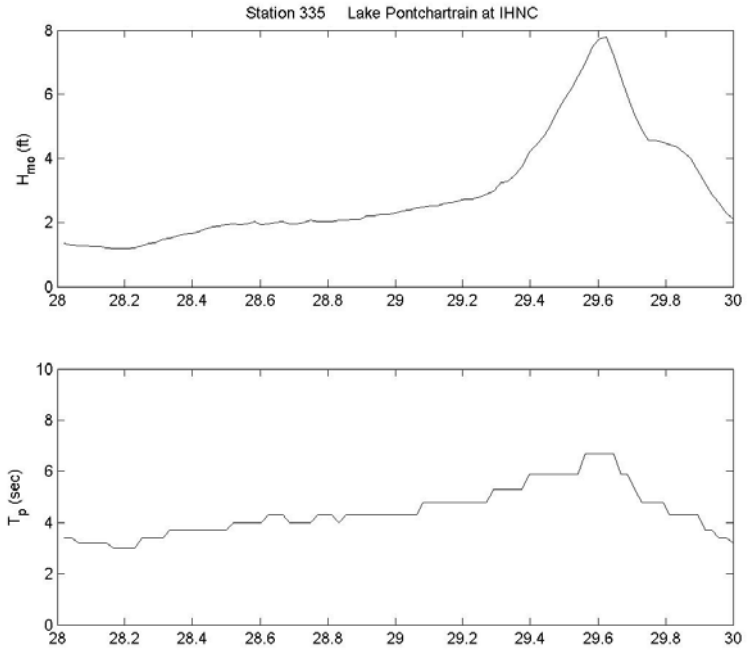
Lower Ninth Ward N. IHNC breach

Overtopping of floodwall

Lower Ninth Ward S. IHNC breach

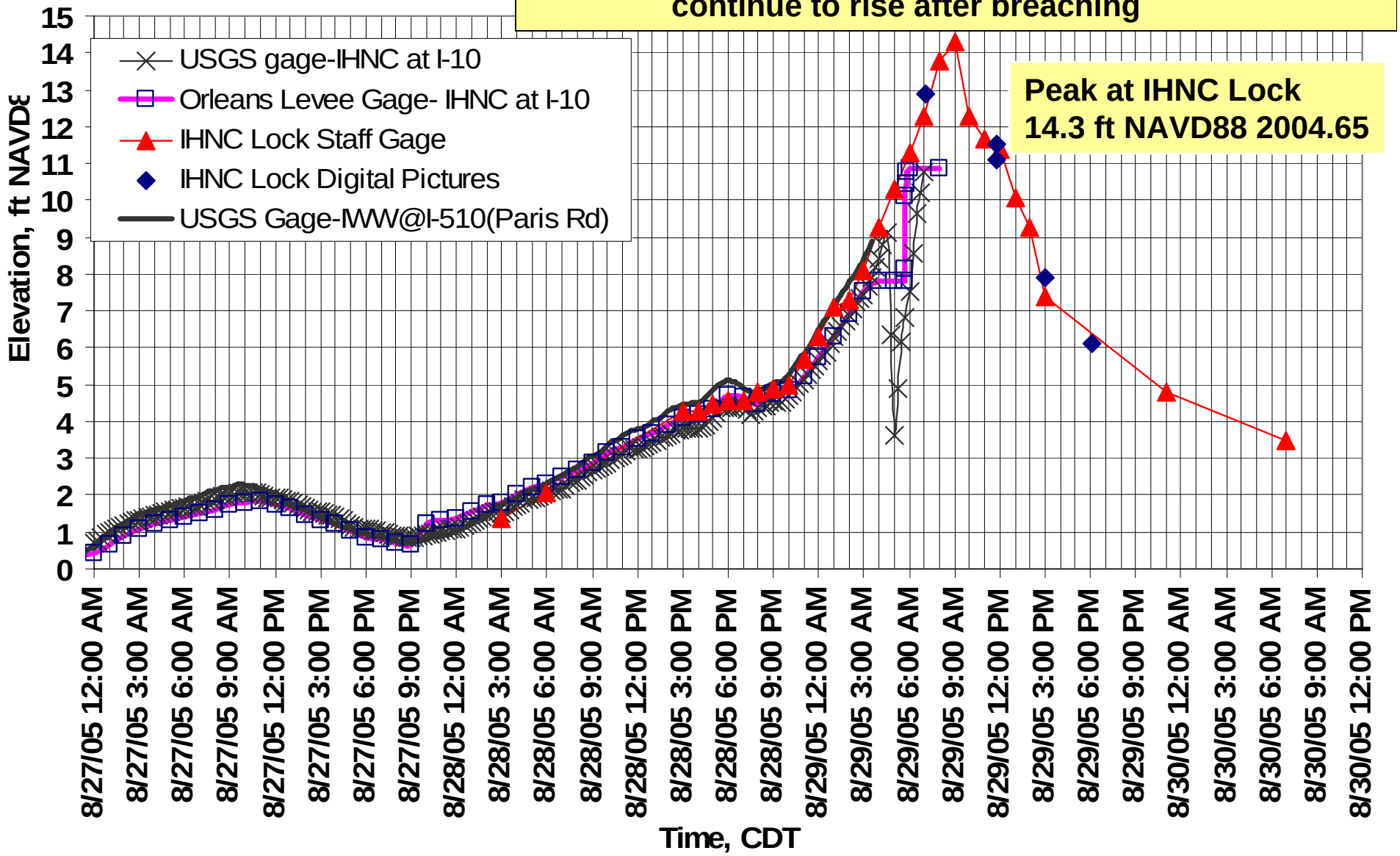


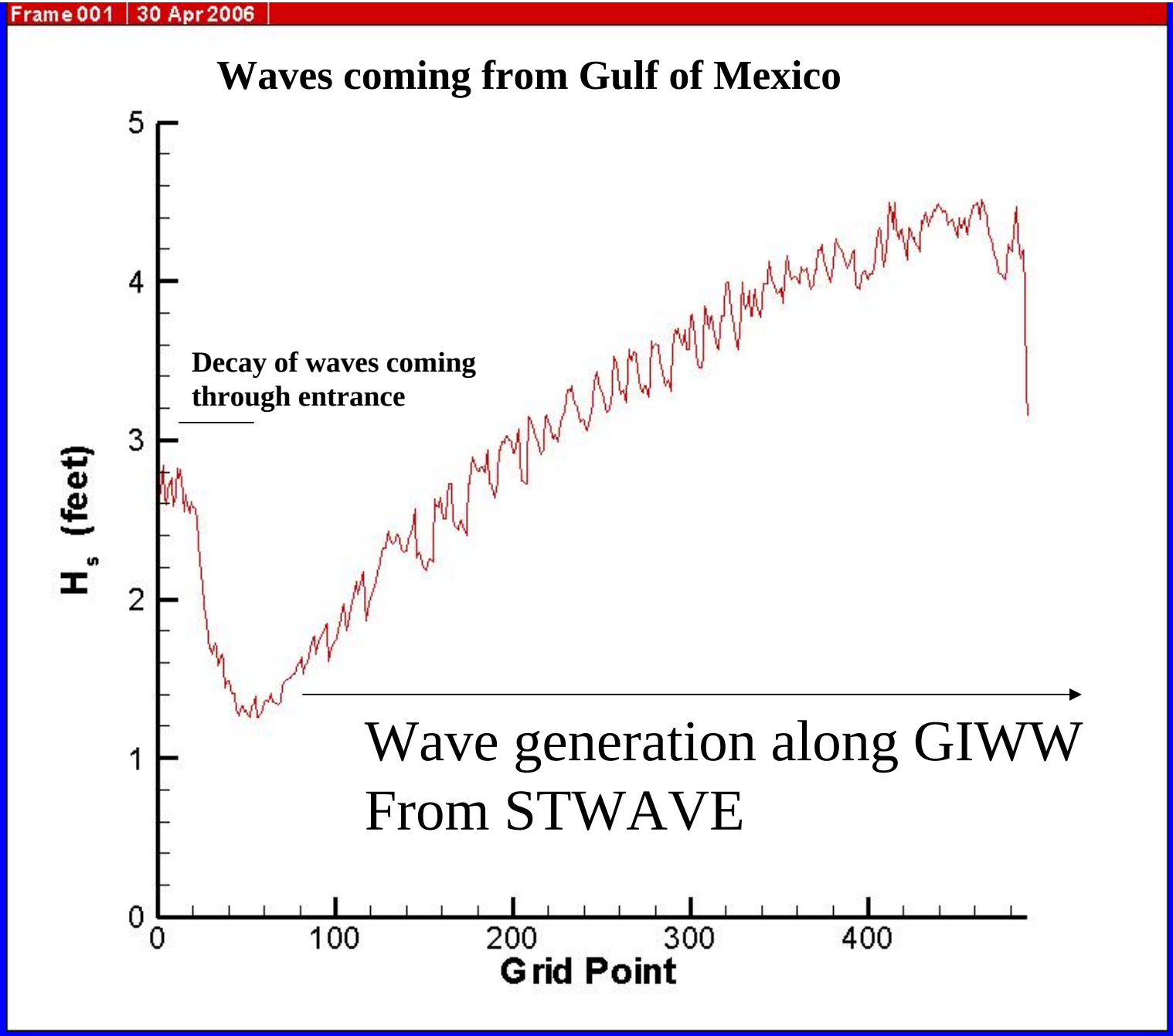
Water level and wave boundary conditions



Measured Hydrographs

- **IHNC Lock Gage – used to modify water levels in IHNC**
- **GIWW &IHNC conveyance allowed water levels to continue to rise after breaching**





Local wave generation important inside IHNC/GIWW

Barge Response to Wind (IHNC)

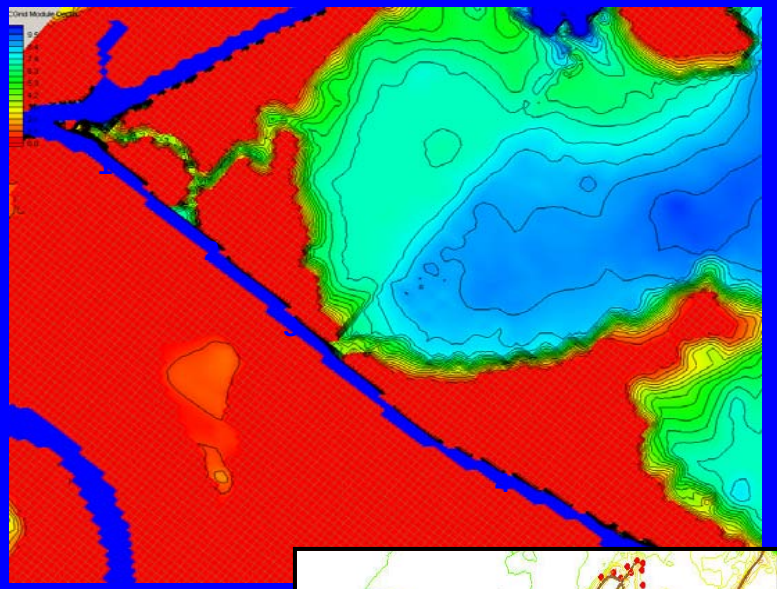
Equations Developed and Examples Worked

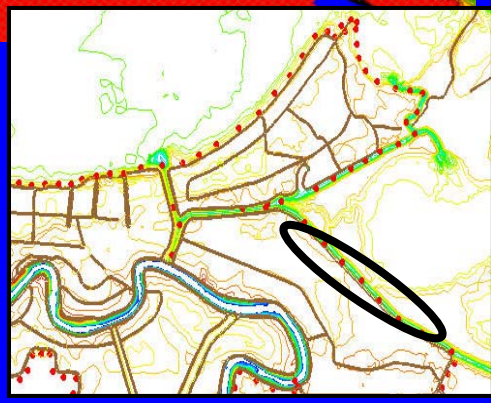
Found:

- **Barge Achieves Terminal Velocity Rapidly Under Action of Wind**
- **Static Wind Forces and Moments on Barge Small Relative to Hydrostatic Forces on Flood Wall**
- **Dynamic Impact Forces and Moments are Potentially Large Compared to Hydrostatic Forces. Depends on Attitude of Barge Upon Impact. Also Depends on Impact Interaction Characteristics**

Detailed Wave Hydrodynamics – St Bernard

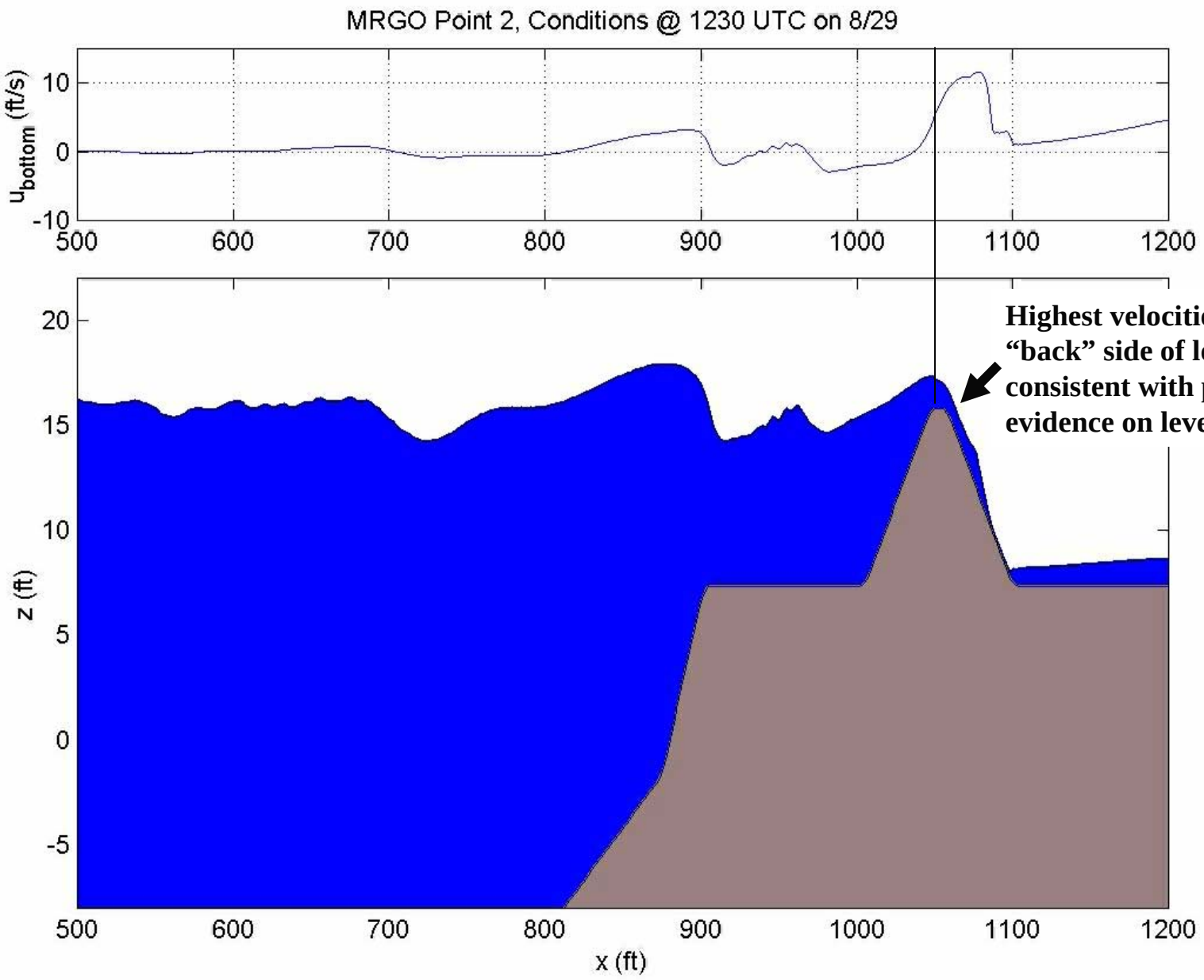
- Four locations examined
  - Levee profile taken from DM
  - Profile shifted vertically to match pre-Kat crest elevations from Chance lidar
    - Crest elevations vary from ~13.5’ to 19’ along the length of the MRGO
  - Setup reduced to 2D (vertical) transect, as dominant wave approach is shore normal
  - Waves from STWAVE 95%
    - Modeled wave peak heights from ~5’ to 6’
  - Surge from ADCIRC 95% iterated to include benchmark information
    - Modeled surge varies from ~17.5’ to 18.6’



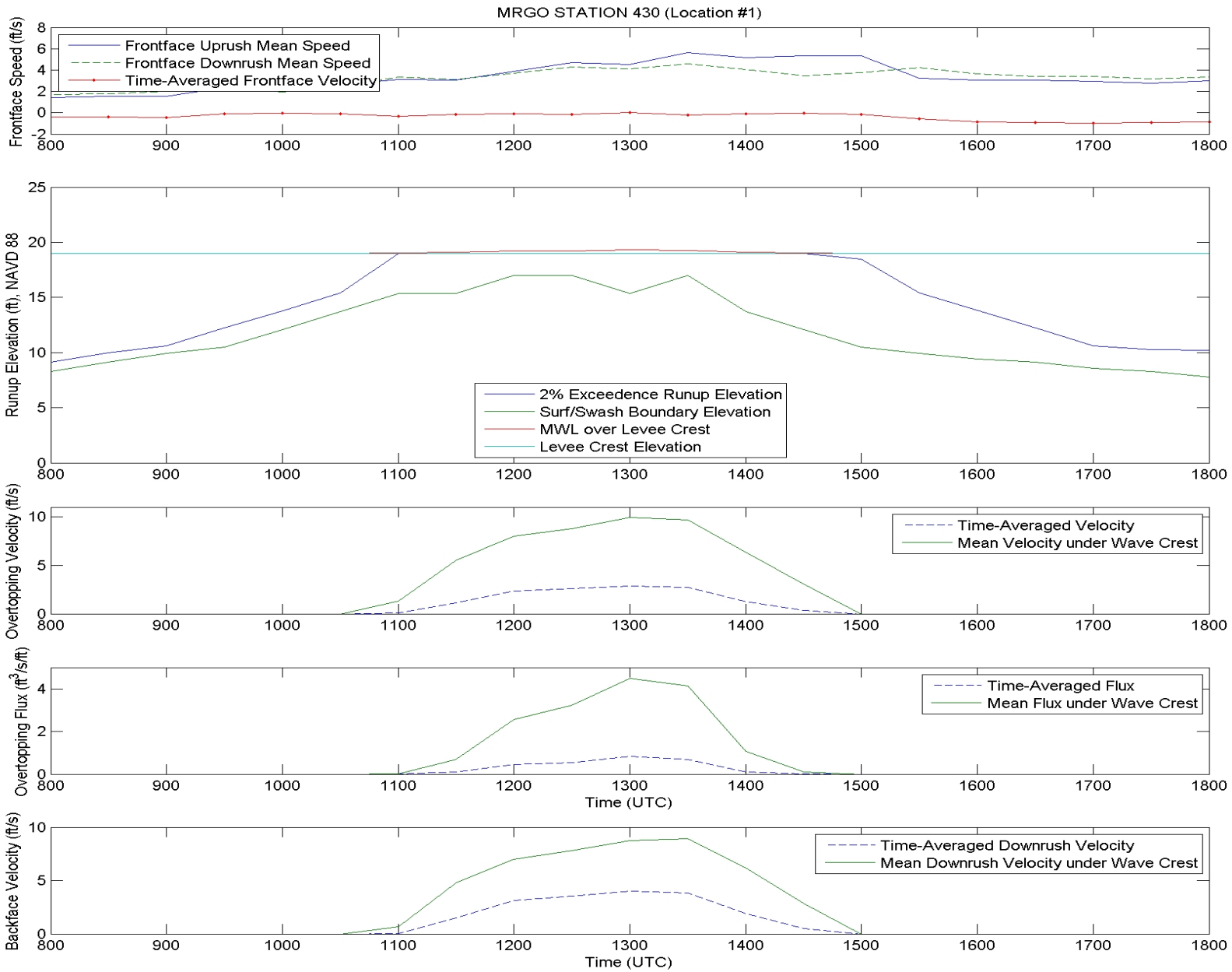


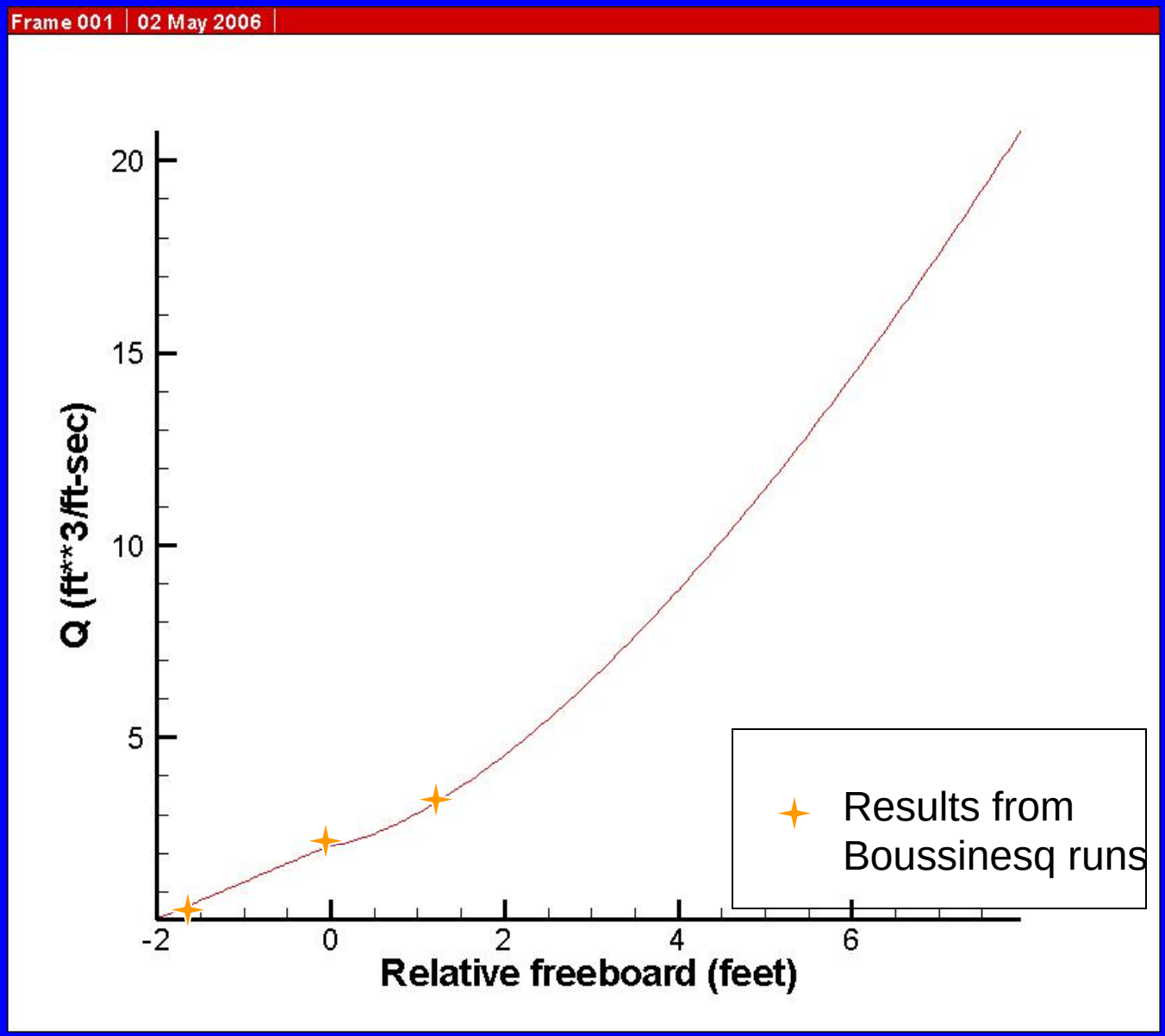
- Output provided
  - Time-averaged (mean, wave-averaged) values of velocity in front, over crest, and down backside of levee
  - Mean velocities under the wave crest (represents max condition)
  - Overtopping flux
  - Runup, wave setup, and mean water level over levee crest.

Detailed Wave Hydrodynamics – St Bernard



Highest velocities on "back" side of levees consistent with physical evidence on levees


MRGO STATION 430 (Location #1)
Frontface Speed (ft/s)
Frontface Uprush Mean Speed
Frontface Downrush Mean Speed
Time-Averaged Frontface Velocity
Runup Elevation (ft), NAVD 88
2% Exceedence Runup Elevation
Surf/Swash Boundary Elevation
MWL over Levee Crest
Levee Crest Elevation
Overtopping Velocity (ft/s)
Time-Averaged Velocity
Mean Velocity under Wave Crest
Overtopping Flux (ft3/s/ft)
Time-Averaged Flux
Mean Flux under Wave Crest
Time (UTC)
Backface Velocity (ft/s)
Time-Averaged Downrush Velocity
Mean Downrush Velocity under Wave Crest
Time (UTC)


Frame 001 | 02 May 2006
20
15
10
5
Q (ft**3/ft-sec)
-2
0
2
4
6
Relative freeboard (feet)
Results from
Boussinesq runs

Detailed Wave Hydrodynamics – New Orleans East Levees

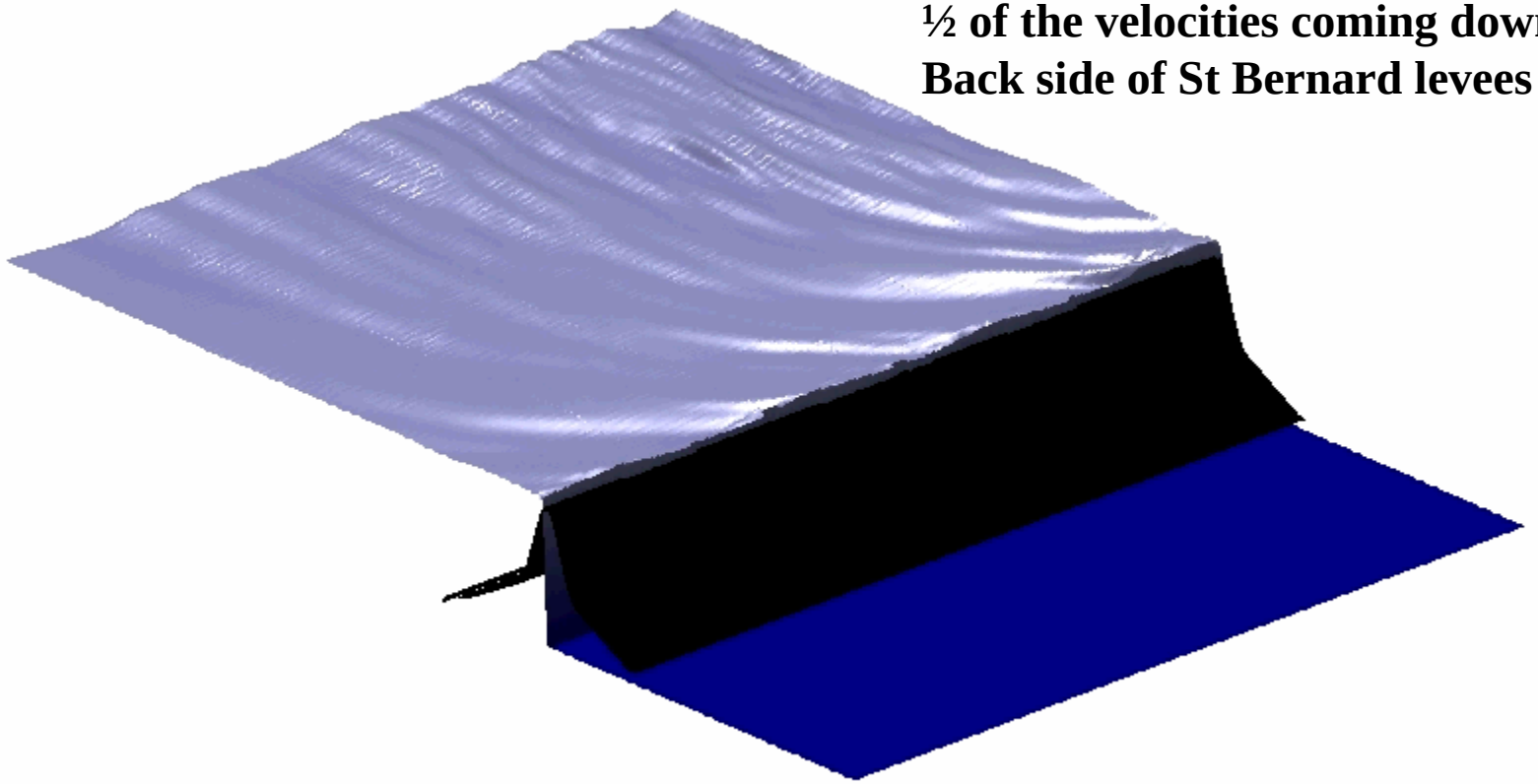
Crest Elevation: 13.6 ft NAVD88 2004.65

Surge: 13.1 ft NAVD88 2004.65 @ 1230 UTC

Waves: 3.5 ft @ 1230 UTC

Modeled instantaneous velocities along the levee backside ~ 3-5 ft/s

Note: these velocities are about ½ of the velocities coming down Back side of St Bernard levees



Lessons Learned

The accuracy of force estimates is critically dependent on water level relative to the height of the levee crest plus wave action

- maximum velocities occur with waves superposed on mean-flow overtopping
- small differences in water levels can make a large difference on overtopping rates (overtopping volumes may be pumpable for up to 2 ft over-topping/no breaching)

Water levels and waves need to consider all appropriate forcing processes

- local wave induced setup
- local wave generation by wind

Estimates of forces on large flood protection levees require detailed information on waves

- wave direction relative to levee significantly affects the dynamic loading
- highest velocities occur on the leeward side of the levee crest, which is consistent with field evidence of levee erosion

Impact forces due to barges can be as large or larger than static loads on floodwalls


QUESTIONS??