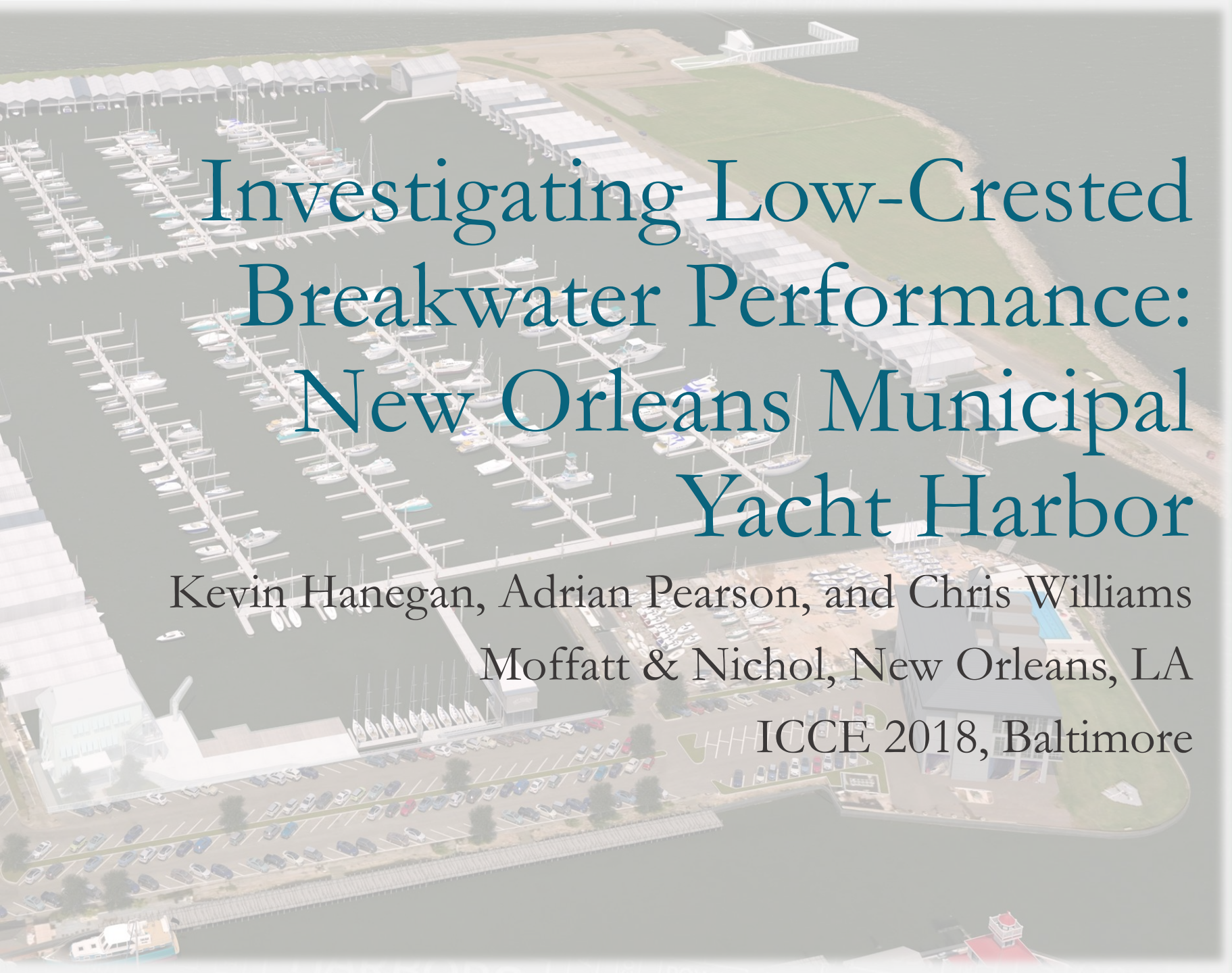


Investigating Low-Crested Breakwater Performance: New Orleans Municipal Yacht Harbor

Kevin Hanegan, Adrian Pearson, and Chris Williams

Moffatt & Nichol, New Orleans, LA

ICCE 2018, Baltimore

moffatt & nichol

Creative People, Practical Solutions.®

601 Poydras St., Suite 1860
New Orleans, LA, 70130
504-648-3560

moffattnichol.com

Chris Williams, Project Manager

Jessica McIntyre, Marina Design Expert

Nicole Pauly, Project Engineer

Jeanah Bauer, Renderings

Miguel Viteri, City of New Orleans

moffatt & nichol

Creative People, Practical Solutions.®

CITY OF NEW ORLEANS

moffattnichol.com

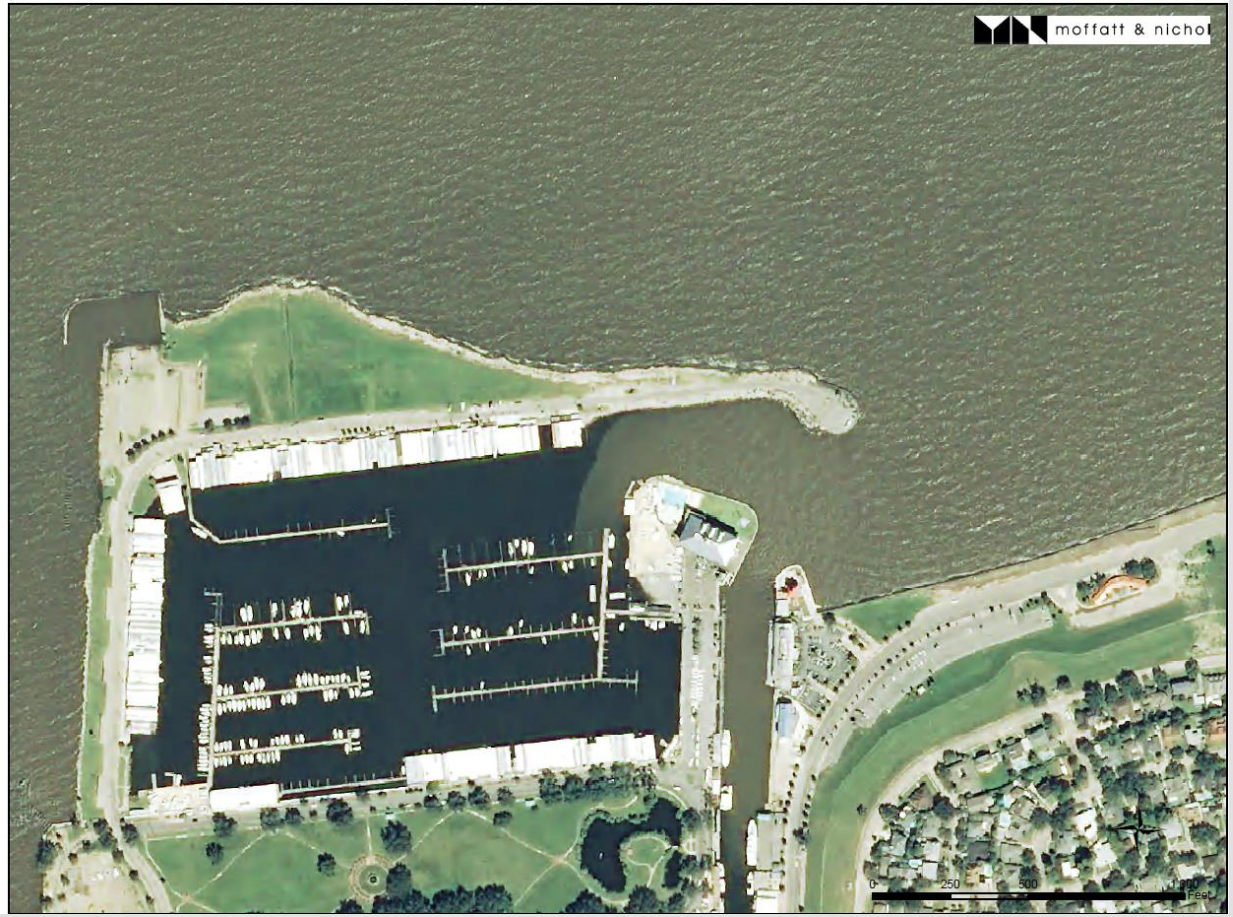
Presentation Outline

- Harbor History and Layout
- Project Overview
- Determining Offshore Wave Conditions
- Local Wave Modeling
- Wave Transmission
- Informing Project Design


Lake
Pontchartrain
New Orleans
Municipal
Yacht Harbor
0 750 1,500 3,000
Feet
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Esri, HERE, Garmin, © OpenStreetMap contributors, and the GIS user community, Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
N
Miles
0 4 8 16 24

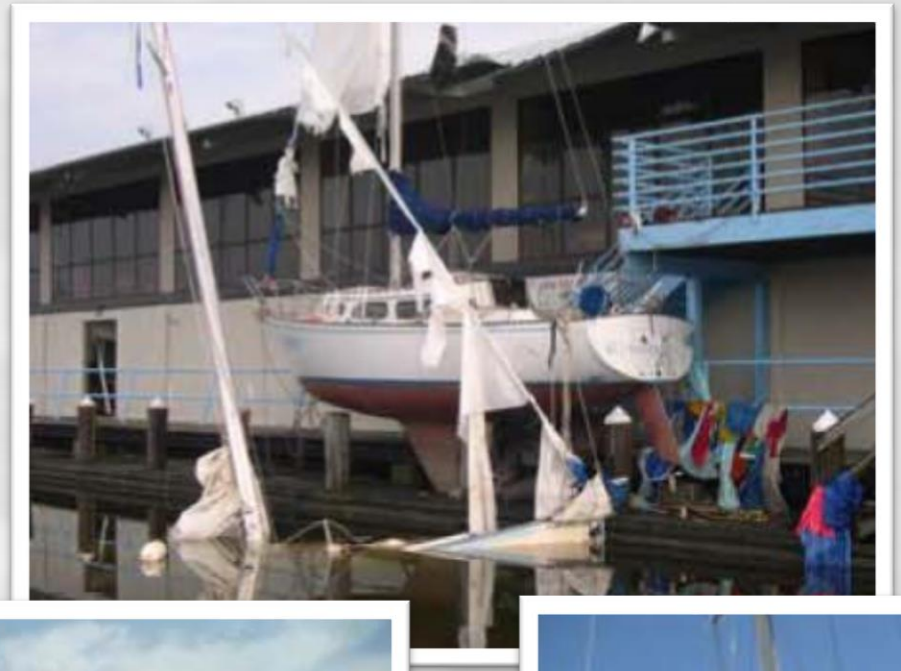
Harbor History and Layout

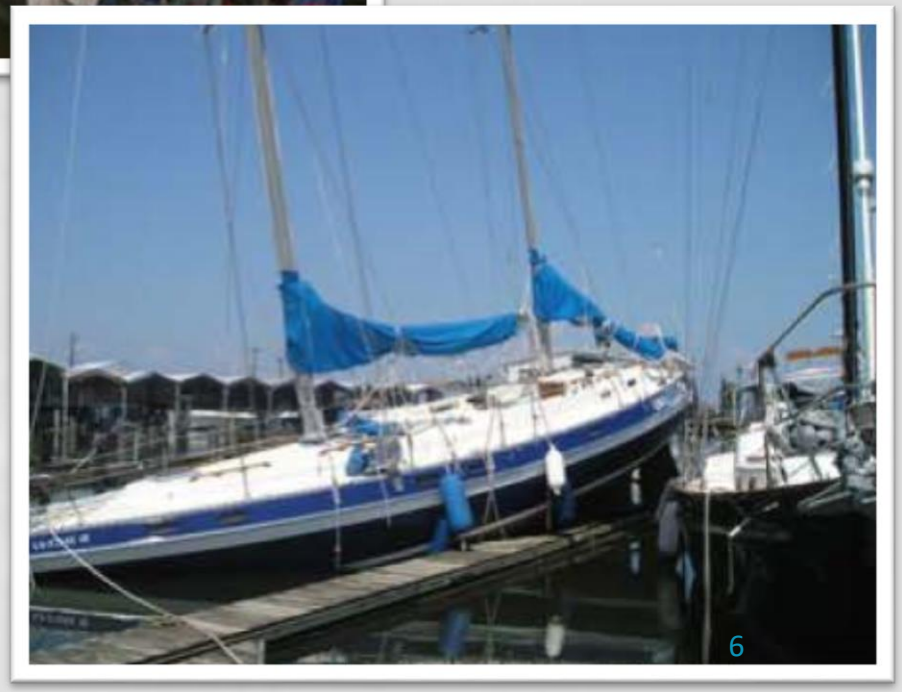
- Previously a 600-slip fixed dock with concrete decks and timber piles
- Protected by solid fill + riprap berm (average crest elevation of +3.5 ft), with concrete bulkheads and seawalls near harbor entrance
- WPA project constructed in 1941
- Host to 2nd oldest yacht club in the country
- Devastated by Hurricane Katrina



moffatt & nichol

Post-Katrina





Project Overview

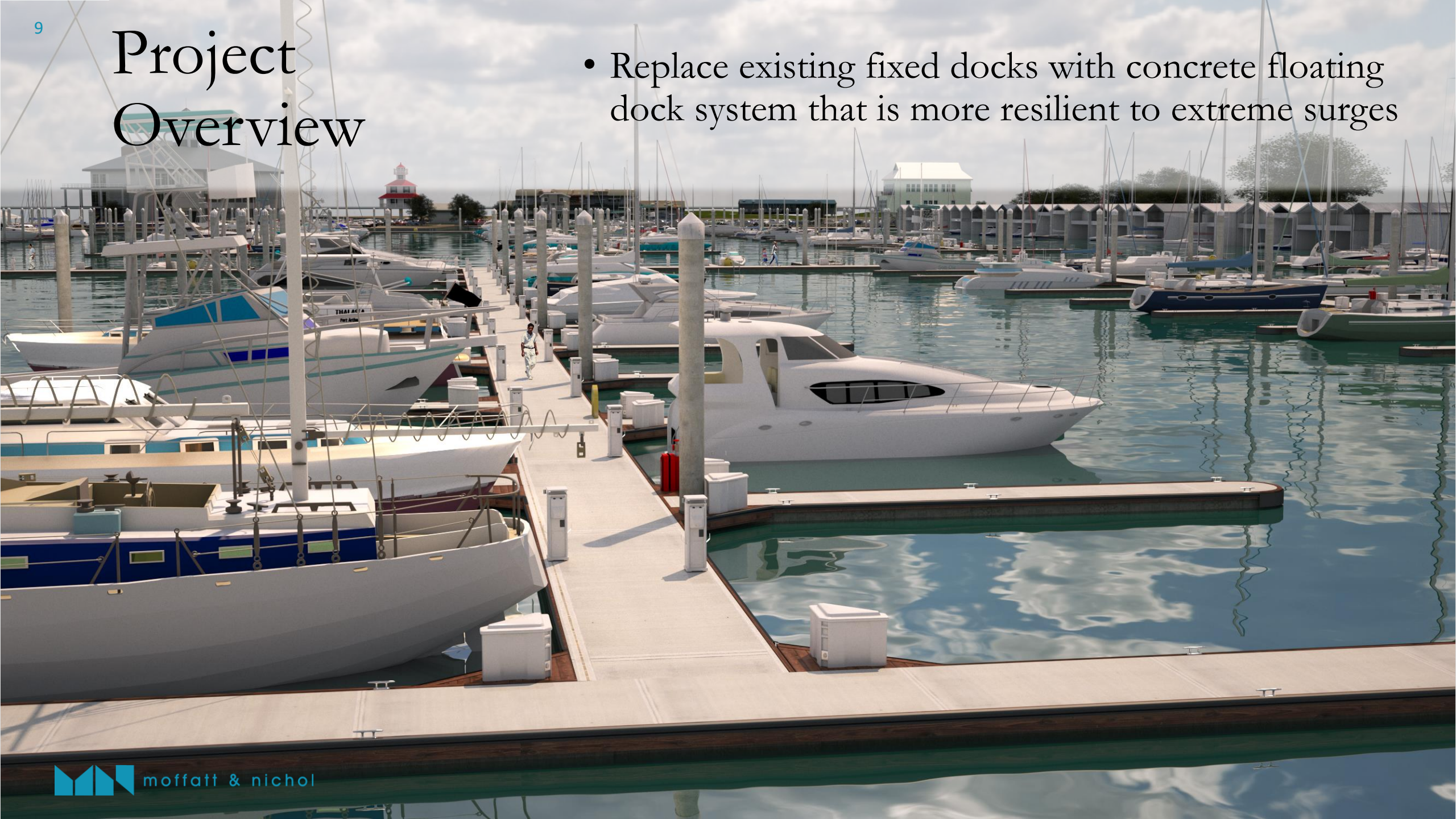
- Replace existing fixed docks with concrete floating dock system that is more resilient to extreme surges

Project Overview

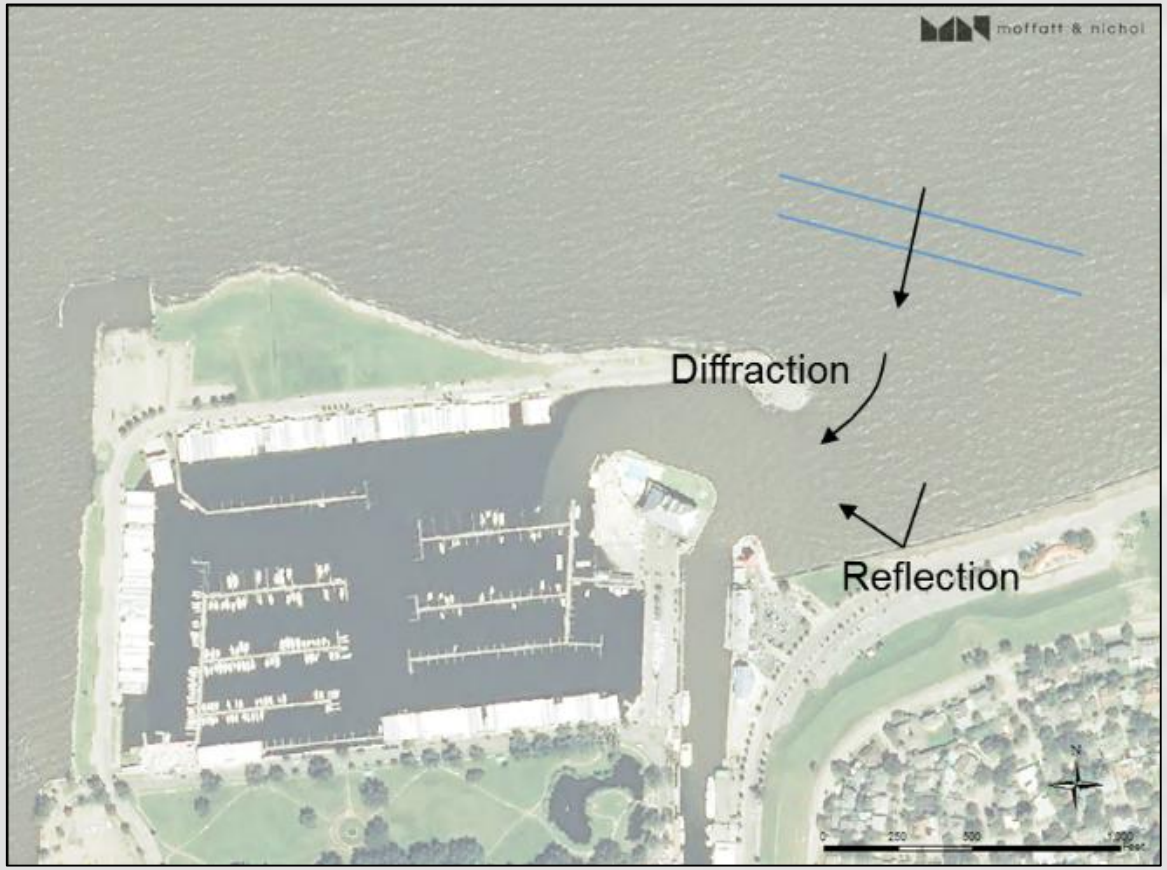
- Replace existing fixed docks with concrete floating dock system that is more resilient to extreme surges

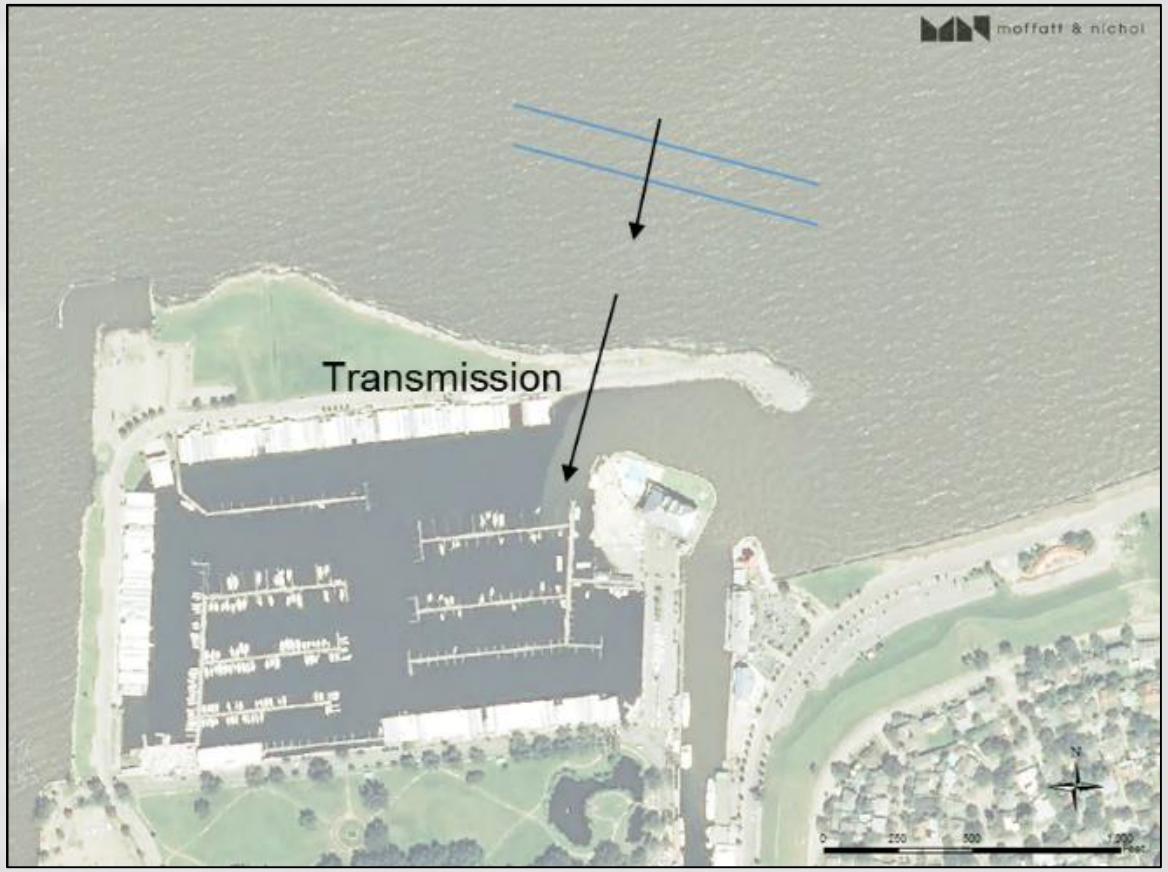
Project Overview

- Replace existing fixed docks with concrete floating dock system that is more resilient to extreme surges



MYH Wave Exposure





moffatt & nichol

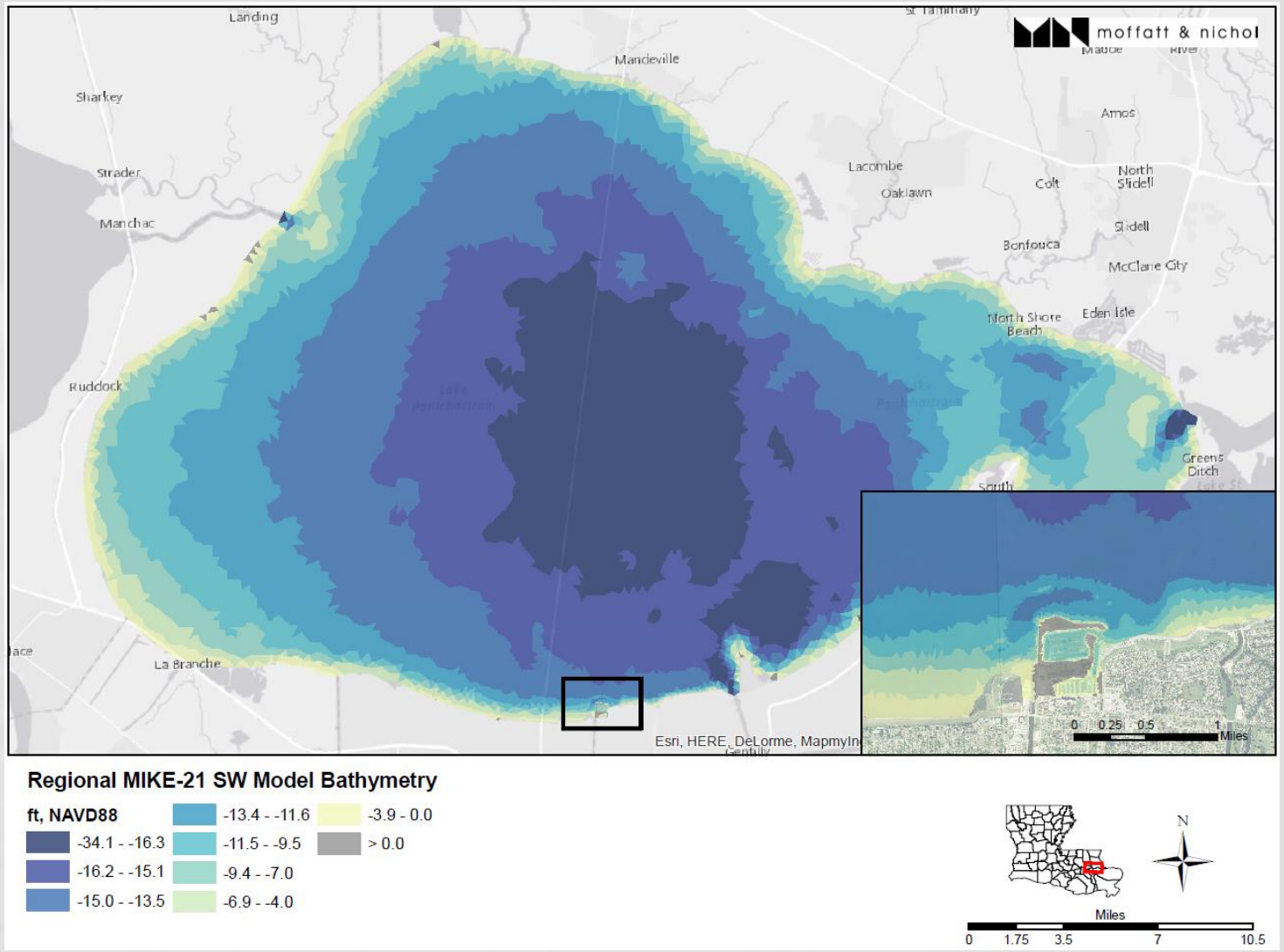
Breakwater Submergence

Date	Peak water level [ft. NAVD88]	Depth of water over breakwater [ft.]*	Event
August, 2005	11.5	8.1	Hurricane Katrina
August 30, 2012	6.3	2.9	Hurricane Isaac
September 12, 2008	5.3	1.9	Hurricane Ike
September 2, 2008	4.6	1.2	Hurricane Gustav
September 3, 2011	4.1	0.7	Tropical Storm Lee
October 26, 2015	3.6	0.2	Severe Thunderstorm

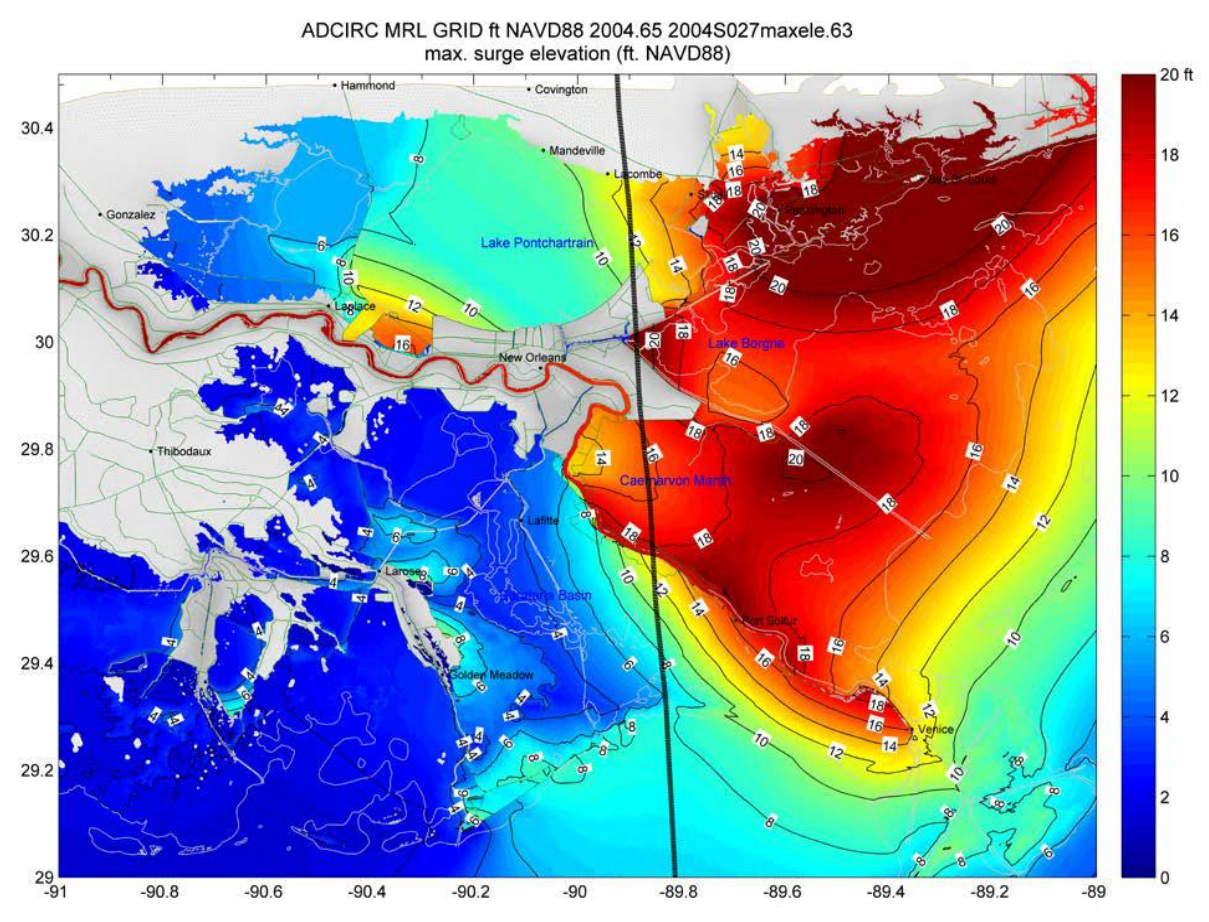
*Note: the average breakwater elevation is taken to be +3.4 ft. NAVD88.

Offshore Wave Conditions – Operational

- Operational-level conditions
  - Up to 25-yr Return Period
  - 20-yr hindcast of waves with measured wind and water levels at site (NOAA New Canal Station)
  - Mike21-Spectral Wave Model



Offshore Wave Conditions - Extreme



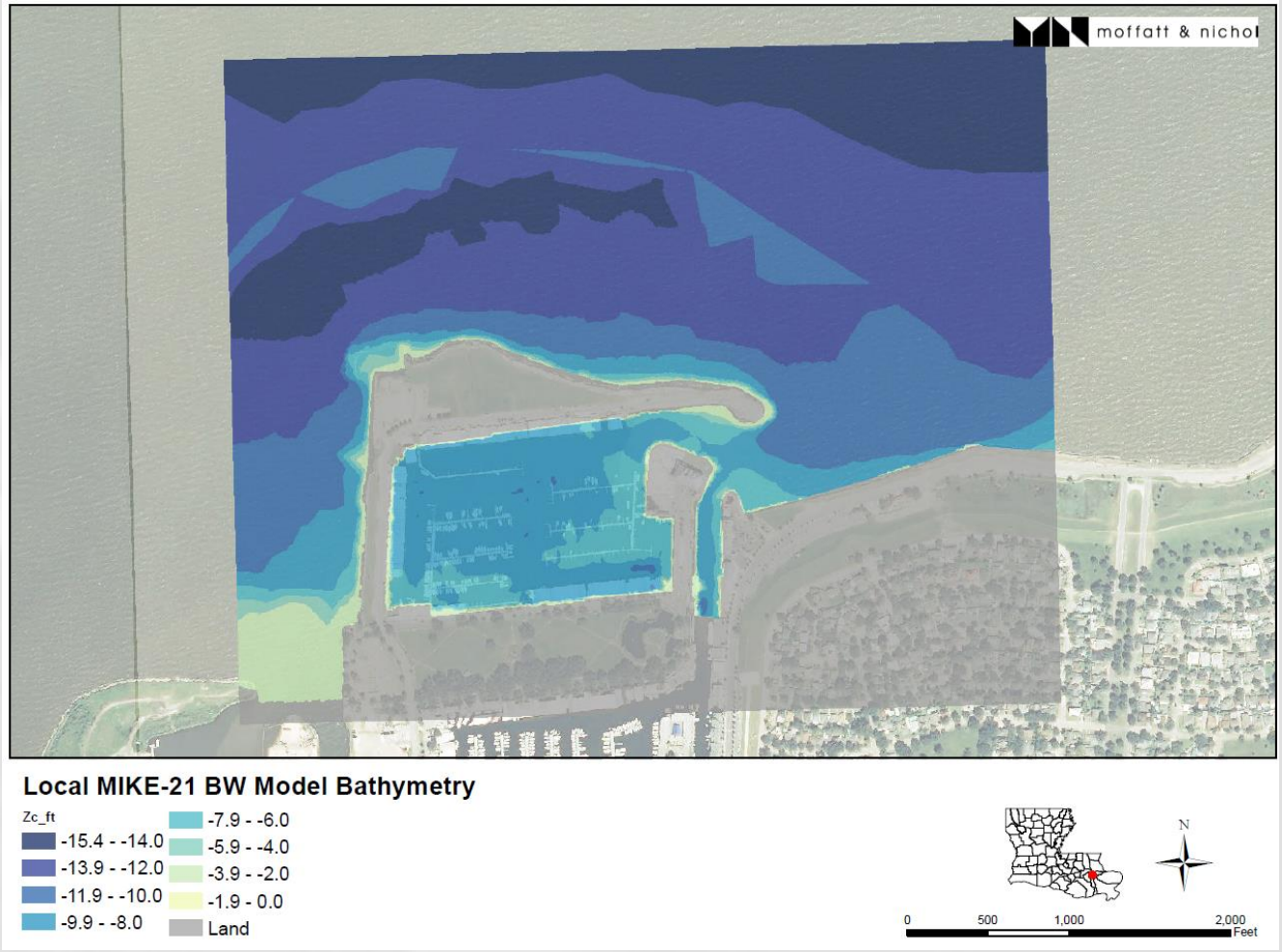
Source: US Army Corps *Elevations for Design of Hurricane Protection Levees and Structures: Lake Pontchartrain and Vicinity… Appendix A* (2014)

- Taken from USACE (2014) *Elevations for Design of Hurricane Protection Levees and Structures: Lake Pontchartrain and Vicinity*
- JPM-OS methodology ADCIRD+STWAVE

RP (yrs)	Hs (ft)	Tp (s)	WL (ft, NAVD88)
50	5.9	6.4	+7.5
100	8.2	7.2	+8.7

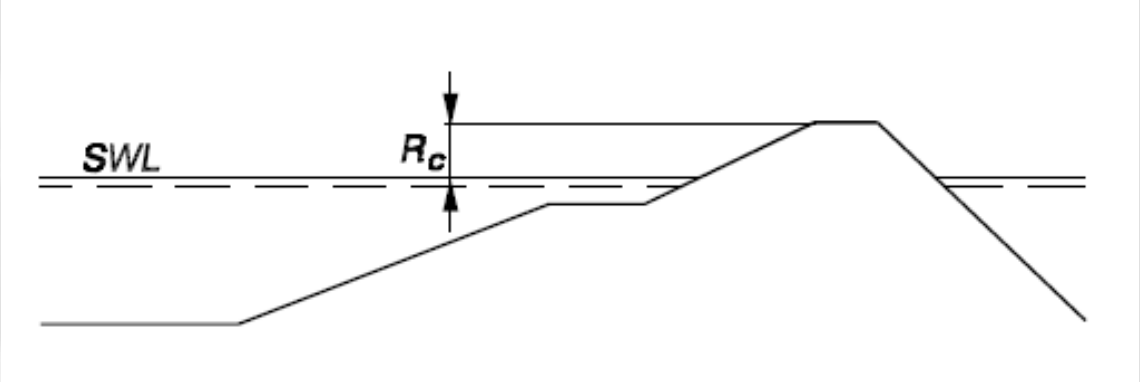
Local Wave Modeling

- Model propagation of offshore waves into harbor
  - Robust diffraction/reflection formulations
  - Mike21-Boussinesq Wave
- Operational wave conditions
  - Assumed that significant wave energy would not be transmitted over the breakwater
- Extreme wave conditions
  - Need to account for wave energy transmitted over breakwater



Wave Transmission (1)

- Due to difficulty of modeling transmission processes directly on larger scale, we used hybrid analytical-numerical approach
- Wave transmission over low-crested structures (negative freeboard)
  - *EurOtop* 2016 empirical equations
  - Eqn. 5.67 for low, wide-crested rubble mound breakwaters
  - Eqn. 5.63 for smooth, low-crested structures with narrower crests

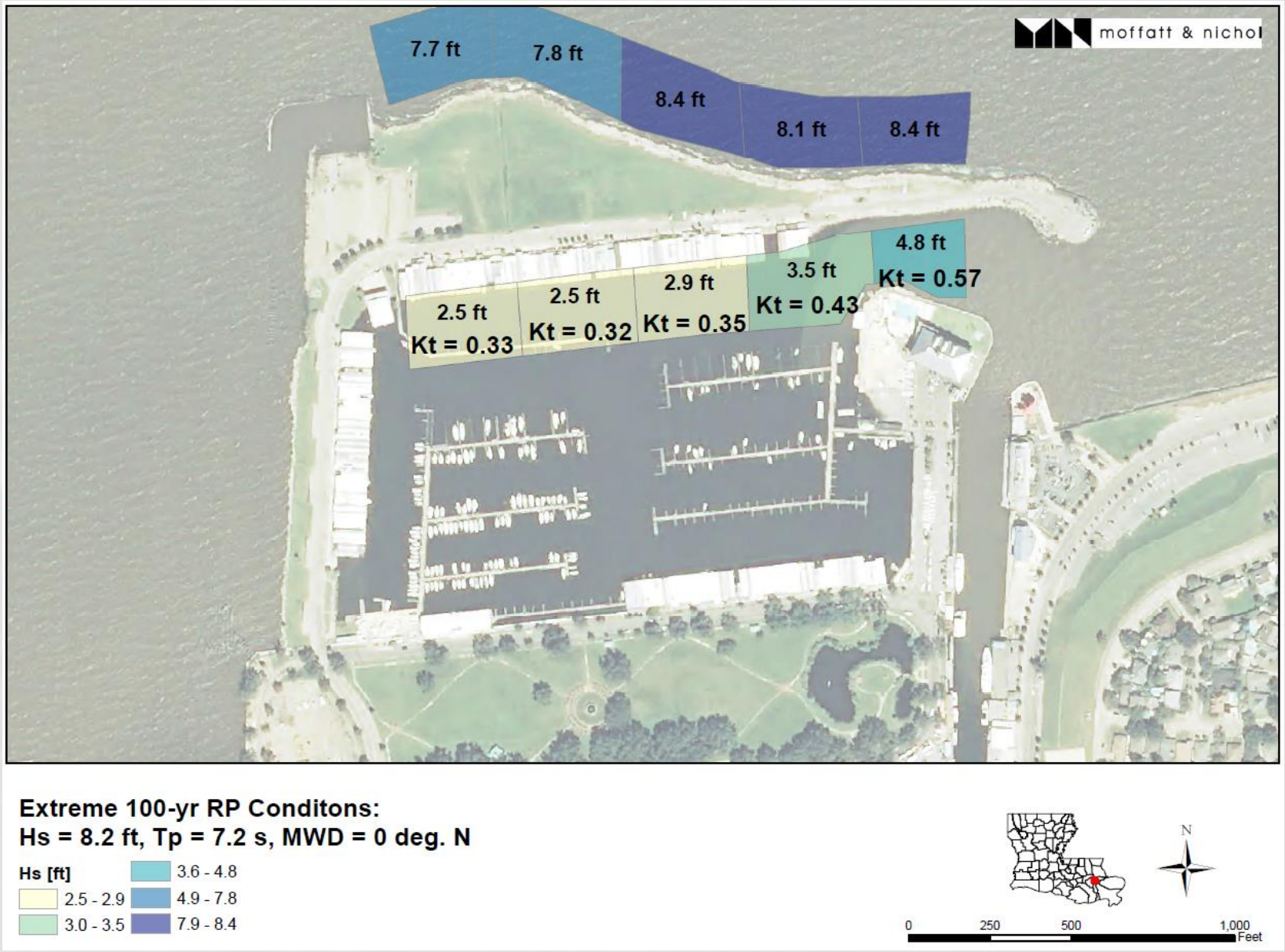


USACE (2008) *Coastal Engineering Manual*

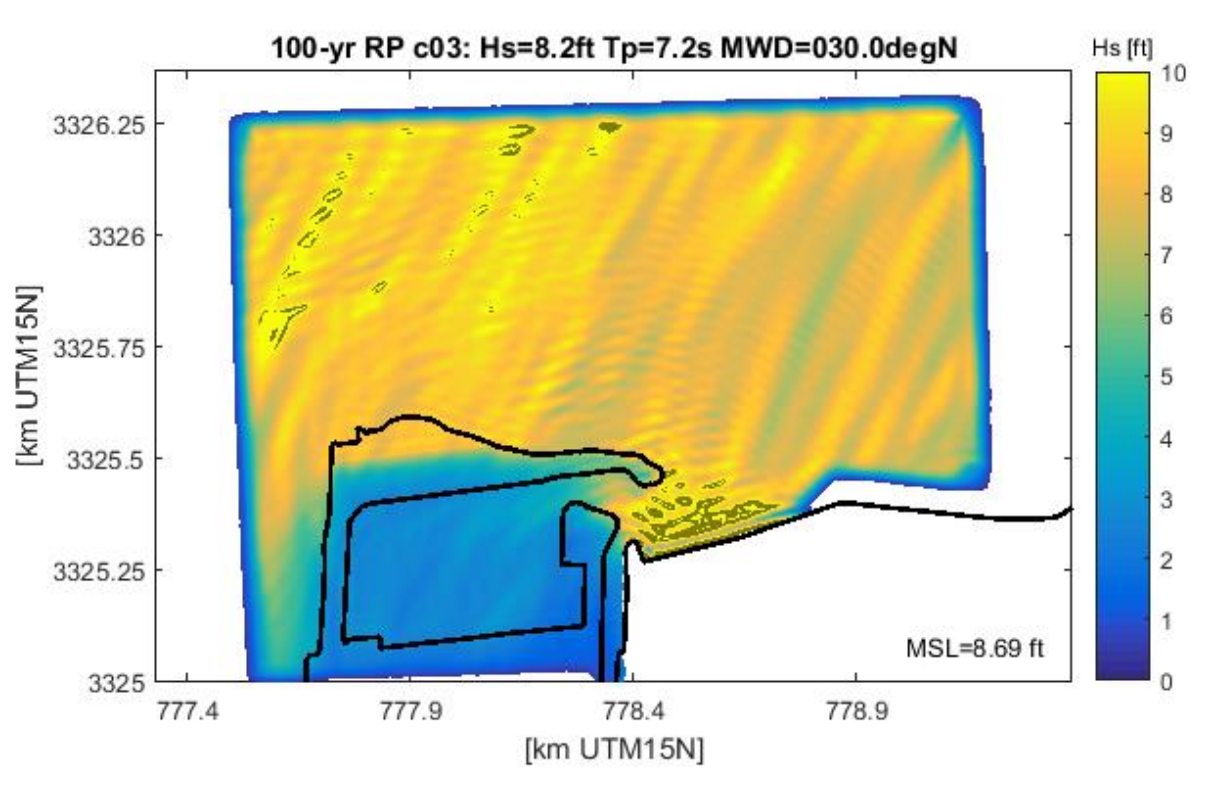
- For 100-yr RP conditions, the more conservative equation gives $K_t = 0.46$ using an average breakwater crest and width

Wave Transmission (2)

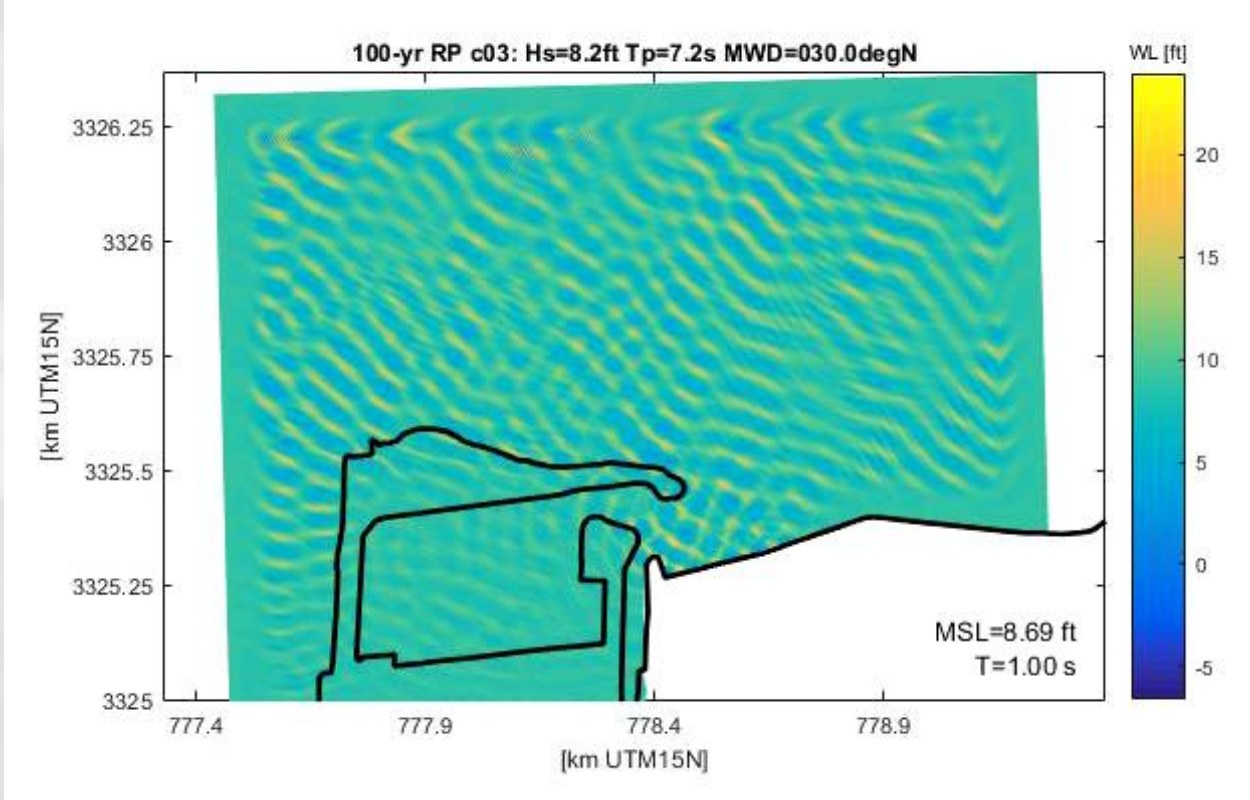
- Tune numerical porosity of breakwater to match goal K_t for 0° incidence case at narrower breakwater sections



Extreme Conditions Results

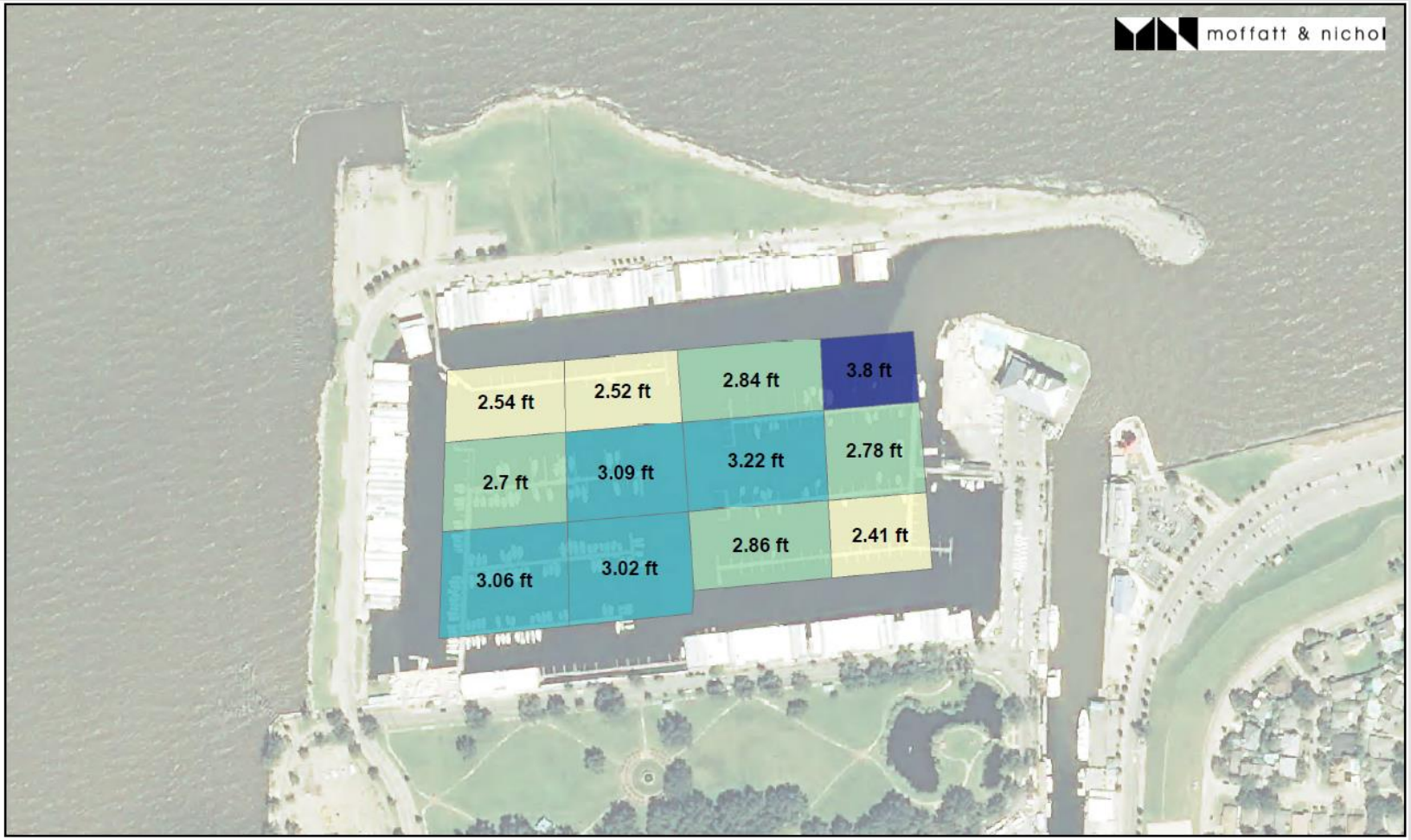


Significant Wave Height, Hs [ft]



Water Surface Elevation, WL [ft, NAD88]

Extreme Conditions Results: Max from all directions



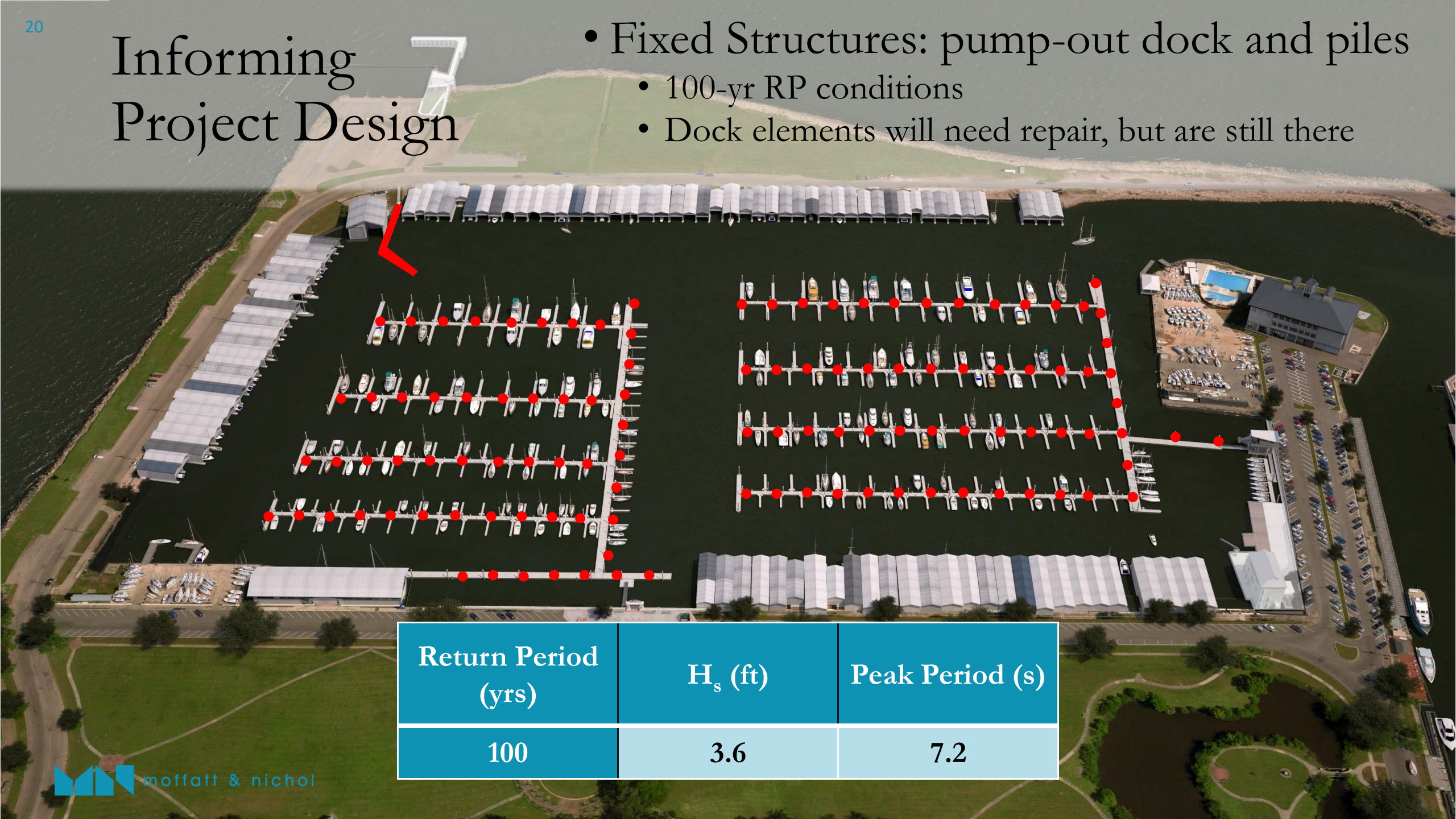
moffatt & nichol

Operational and Extreme Results

Return Period (yrs)	H_s within harbor (ft)		H_{max} within harbor (ft)		Peak Period (s)
	Max	Min	Max	Min	
1	1.1	0.7	1.7	1.2	3.4
2	1.3	0.8	2.0	1.4	3.6
5	1.6	1.1	2.6	1.9	3.9
10	1.9	1.3	3.0	2.2	4.1
25	2.3	1.6	3.6	2.7	4.4
50	2.8	2.1	4.3	3.4	6.4
100	3.6	2.7	5.1	3.9	7.2

Informing Project Design

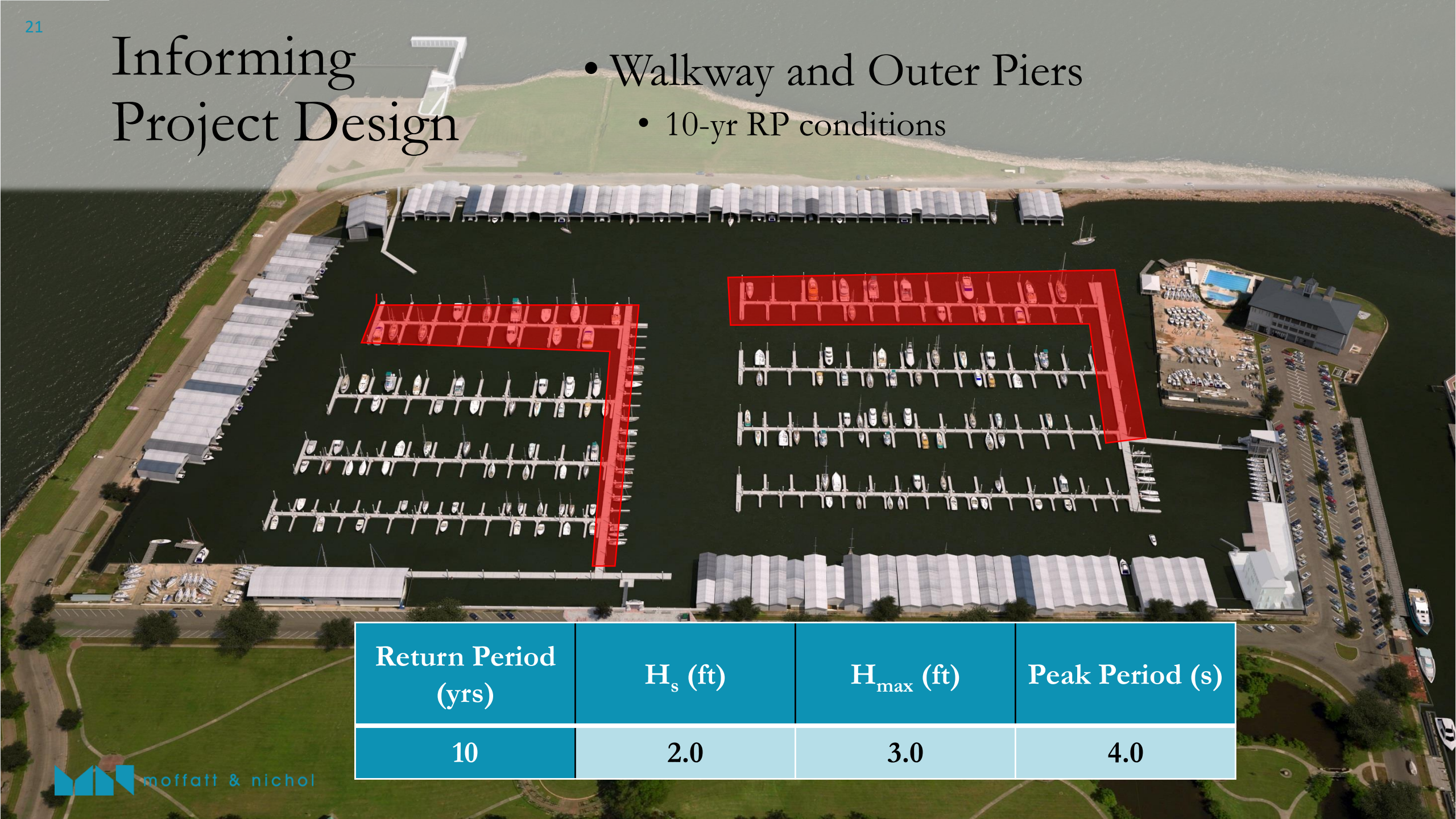
- Fixed Structures: pump-out dock and piles
  - 100-yr RP conditions
  - Dock elements will need repair, but are still there



Return Period (yrs)	H_s (ft)	Peak Period (s)
100	3.6	7.2

Informing Project Design

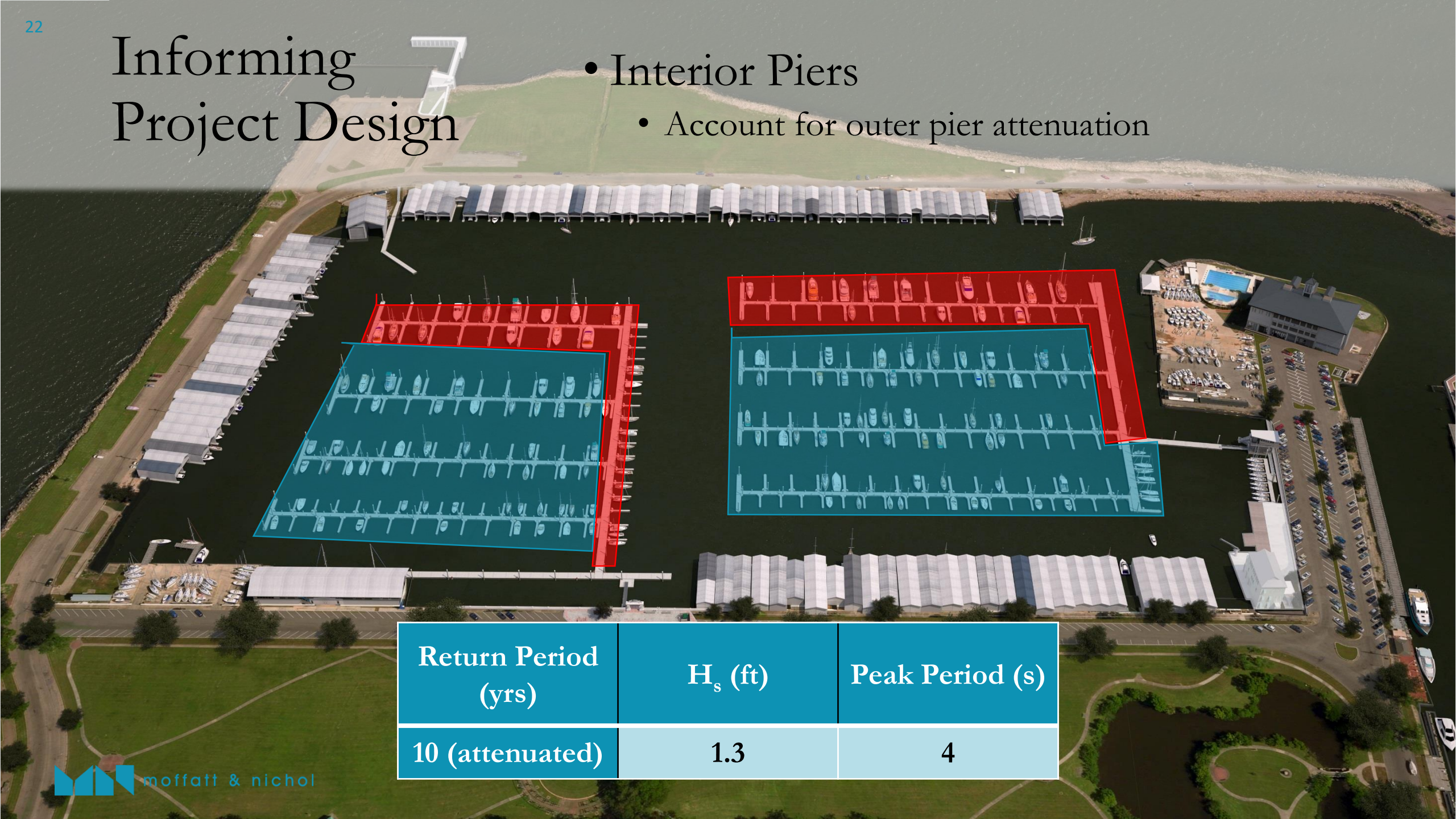
- Walkway and Outer Piers
  - 10-yr RP conditions



Return Period (yrs)	H_s (ft)	H_{max} (ft)	Peak Period (s)
10	2.0	3.0	4.0

Informing Project Design

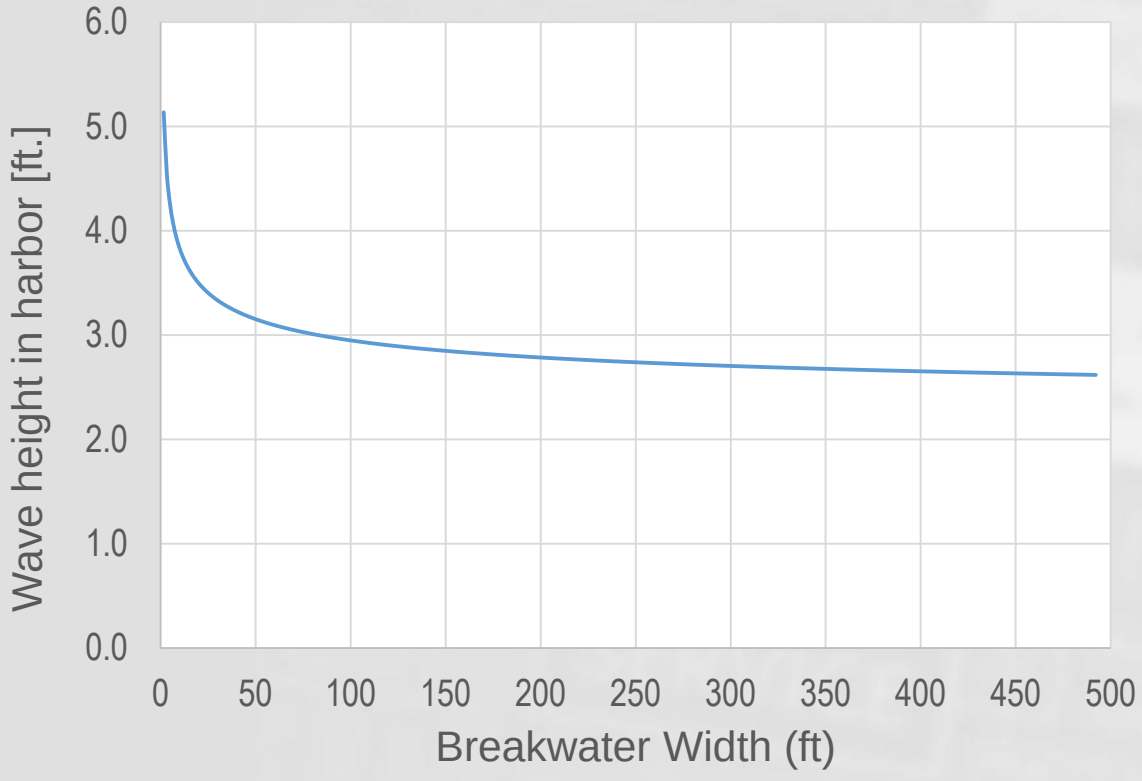
- Interior Piers
  - Account for outer pier attenuation

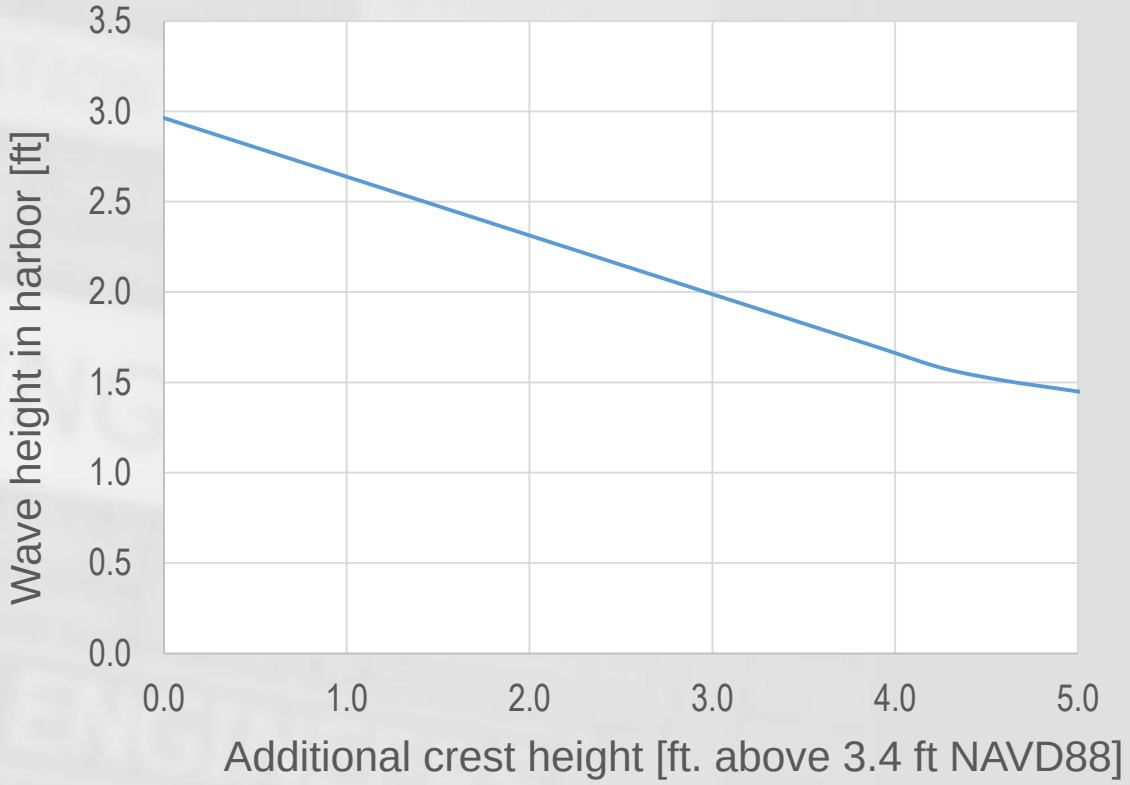


Return Period (yrs)	H_s (ft)	Peak Period (s)
10 (attenuated)	1.3	4

moffatt & nichol

Potential Breakwater Modifications





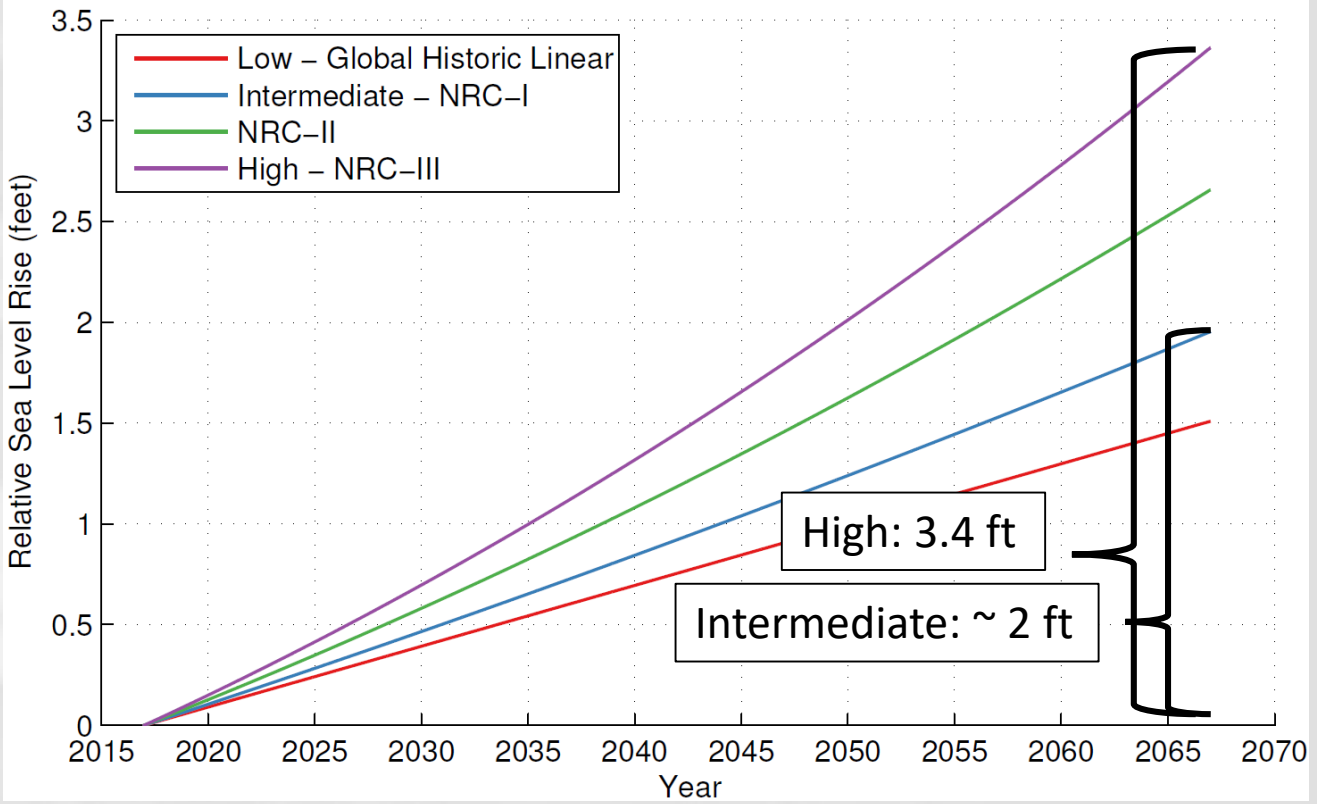
THANK YOU!

moffattnichol.com

Municipal Yacht Harbor: Master Plan

Sea Level Rise

- Land subsidence rate of **7.5 mm/yr.**
  - *West Shore Lake Pontchartrain Hurricane and Storm Damage Risk Reduction Study* (US Army Corps of Engineers, 2014).
- Global mean sea level rise rate of **1.7 mm/yr.**
  - Intergovernmental Panel on Climate Change (IPCC, 2014)
- Projection equations, which account for **accelerated rates** of mean sea level rise and subsidence
  - *Engineering Technical Letter 1100-2-1: Procedures to Evaluate Sea Level Change* (US Army Corps of Engineers, 2014).



- Recommend using **Intermediate** value for design, while also assessing cost implications for accommodating **High** scenario

moffatt & nichol

Planning for the future

- Conservative, scientifically sound sea level rise and subsidence projections
- Future hurricane waves and surge based on HSDRRS project – most rigorous data available
- Pile caps (how high docks can rise with surge) are set at +22’ NAVD88 – more than 10.5’ higher than Katrina’s high water mark at MYH