Hydrodynamic Modeling for Living Shoreline Design
Queens, NY

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FSBPA Tech Conference
February 6, 2020

Summary

- Living shoreline design located at the mouth of Alley Creek in Little Neck Bay, NY

- Statistical analysis of existing wind and water level data

  - Extreme return period values

  - Joint probability of wind and water levels

- Coupled hydrodynamic and wave modeling of moderate-frequency events using Delft3D

- Wave and water level conditions for structure design

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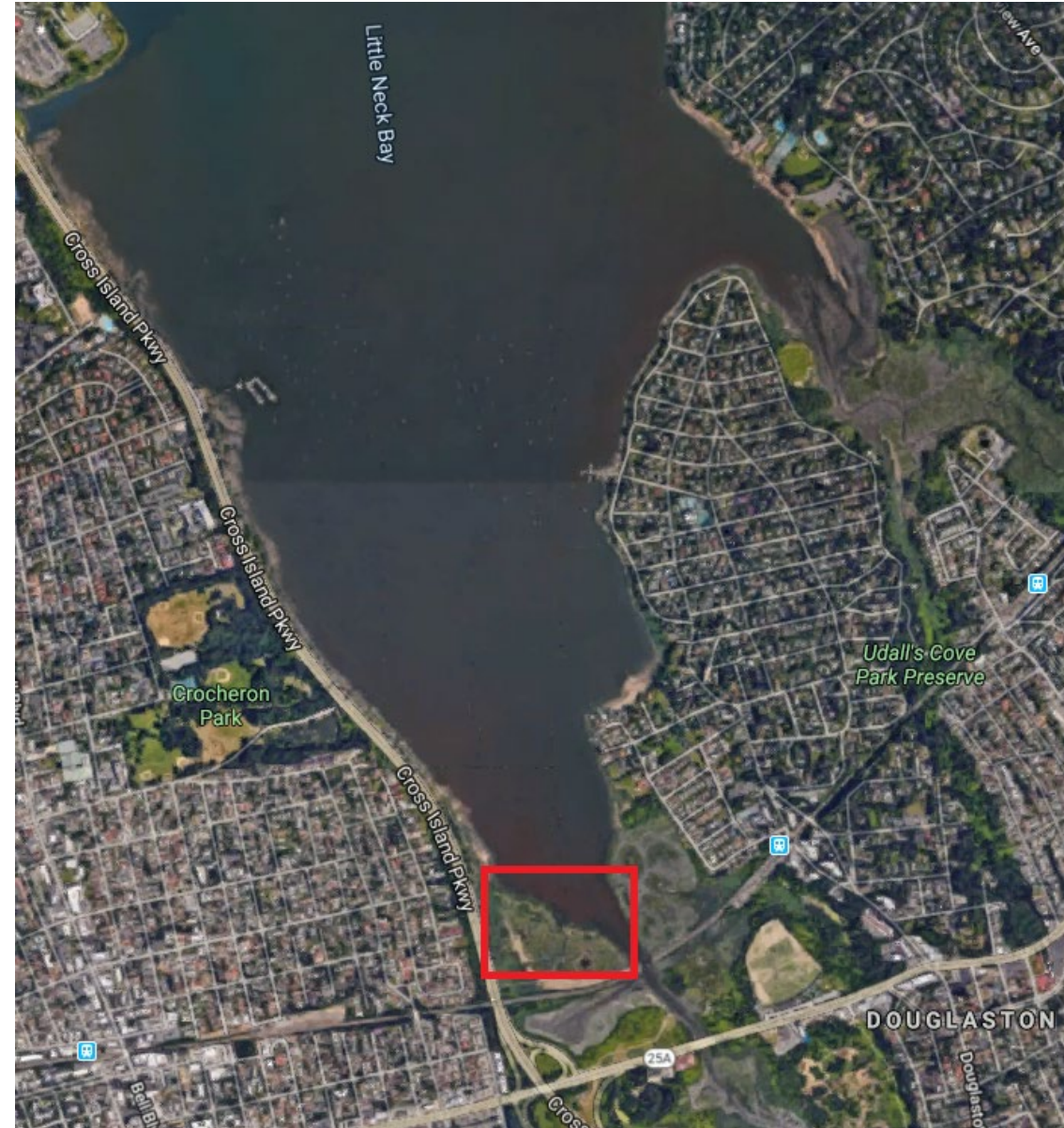
Measured Data

Water levels

- NOAA station 8516945, King's Point, NY
    - extreme return period analysis
    - joint wind and water level probability
    - model boundary condition
- NOAA station 8518750, The Battery, NY
    - model boundary condition

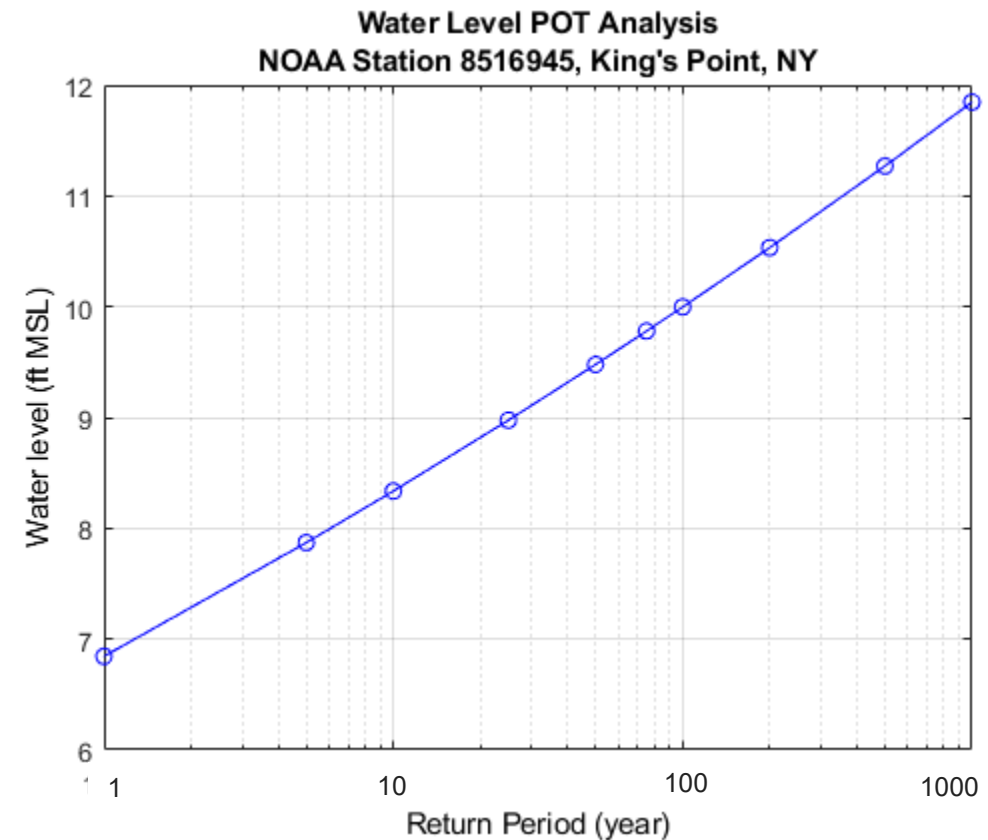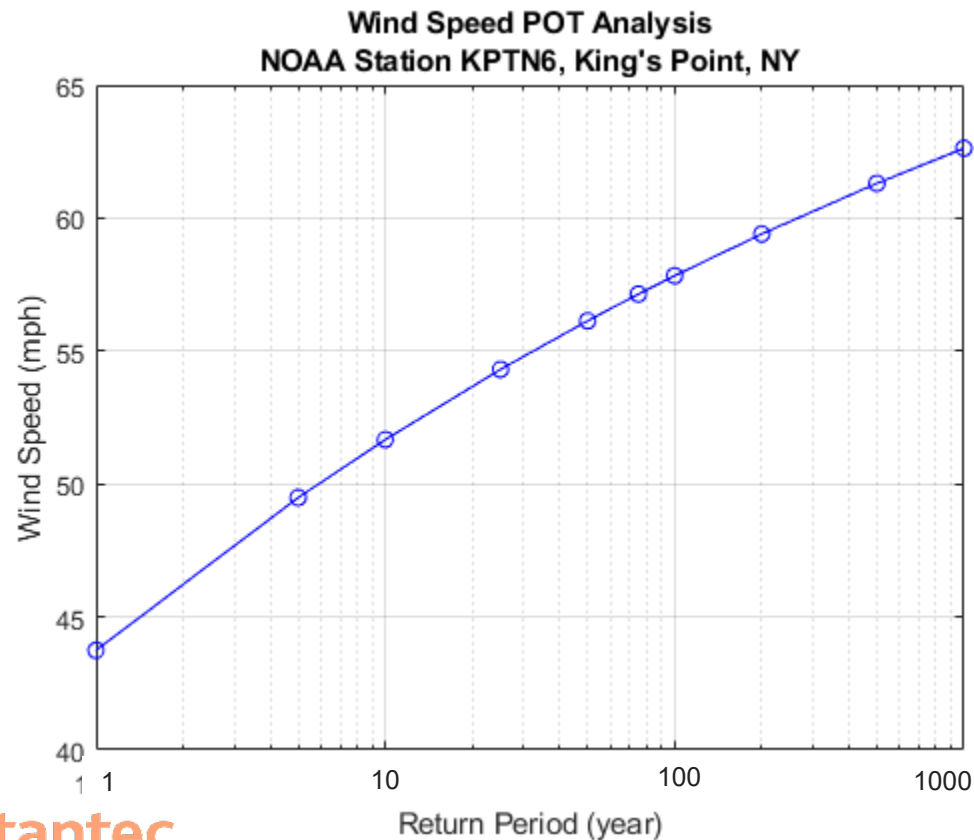## Wind speed

- NOAA station KPTN6, King's Point, NY

Datum	Value (ft)	Description
MHHW	3.91	Mean Higher-High Water
MHW	3.55	Mean High Water
NAVD88	0.27	North American Vertical Datum of 1988
MSL	0	Mean Sea Level
MLW	-3.61	Mean Low Water
MLLW	-3.89	Mean Lower-Low Water

Wind Rose, Annual, 2004-2018
NOAA Station KPTN6, King's Point, NY
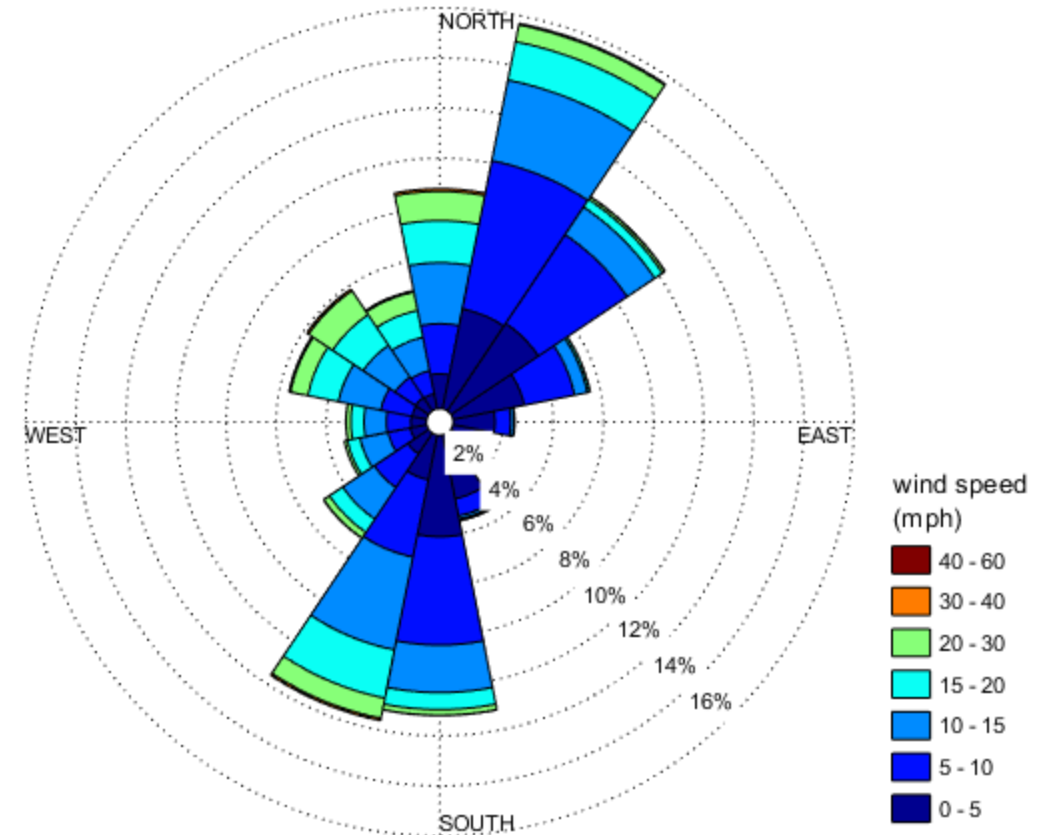
Extreme Return Period Analysis

- Peaks-Over-Threshold (POT) method for event selection
- Generalized Extreme Value (GEV) distribution for estimation of return interval events and joint probability of wind and water levels

Wind Speed POT Analysis
NOAA Station KPTN6, King's Point, NY

Wind Speed (mph) vs Return Period (year)

Water Level POT Analysis
NOAA Station 8516945, King's Point, NY

Water level (ft MSL) vs Return Period (year)
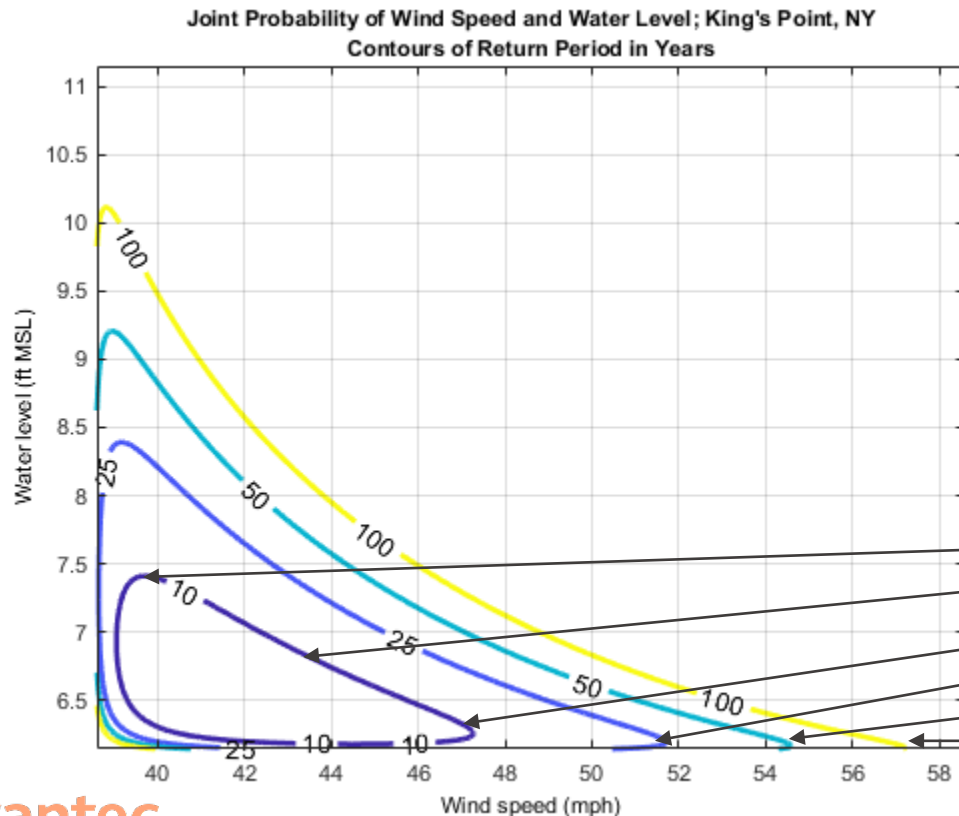
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Extreme Return Period Analysis

- Peaks-Over-Threshold (POT) method for event selection
- Generalized Extreme Value (GEV) distribution for estimation of return interval events and joint probability of wind and water levels

Joint Probability of Wind Speed and Water Level; King's Point, NY
Contours of Return Period in Years

Sandy (2012)

Wind speed	Water level
mph	ft MSL
32.5	10.1

Joint probabilities

Return period	Wind speed	Water level
yr	mph	ft MSL
*10	39.0	7.4
*10	43.0	6.9
*10	47.0	6.4
25	51.0	6.3
50	55.0	6.3
100	57.0	6.3

Independent probabilities

Return period	Water level
yr	ft MSL
1	6.8
5	7.9
10	8.3
25	9.0
50	9.5
100	10.0

Independent probabilities

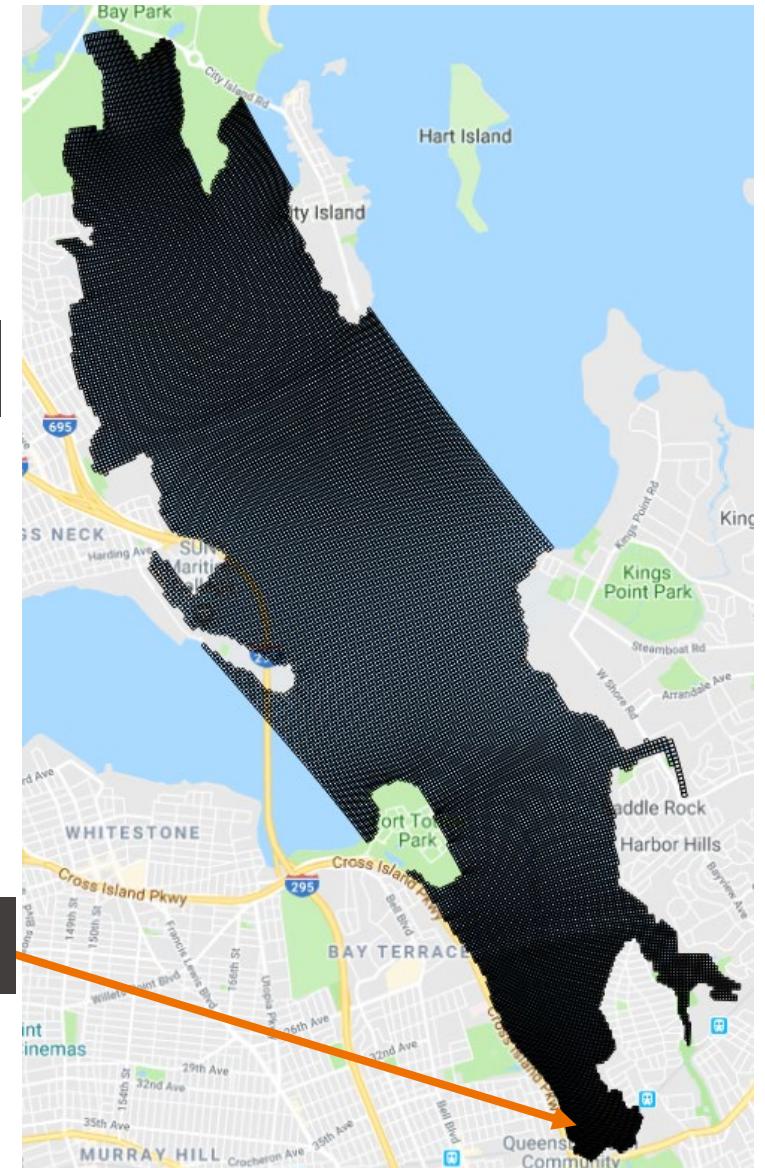| Return period	Wind speed
yr	mph
1	43.7
5	49.5
10	51.7
25	54.3
50	56.1
100	57.8

*the three 10-year events correspond to different points along the return period curve of the relationship between wind and water level to see which combination resulted in the largest wave at the site

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Delft3D Model Setup

- Dynamically-coupled 2D depth-averaged flow and wave model with separate grids for each
- Flow model spans between King's Point and The Battery with a tidal boundary condition at each from measured data and harmonic constituents
- Wave model encompassing the fetch of interest (330°)
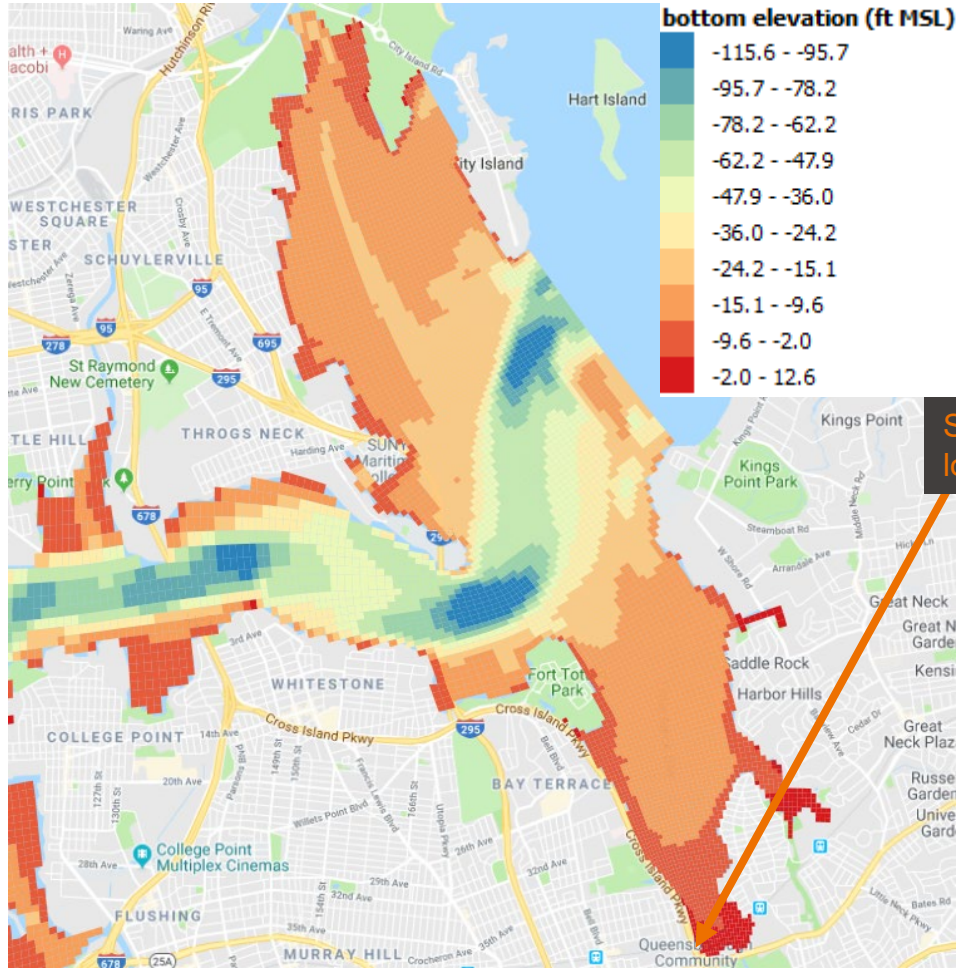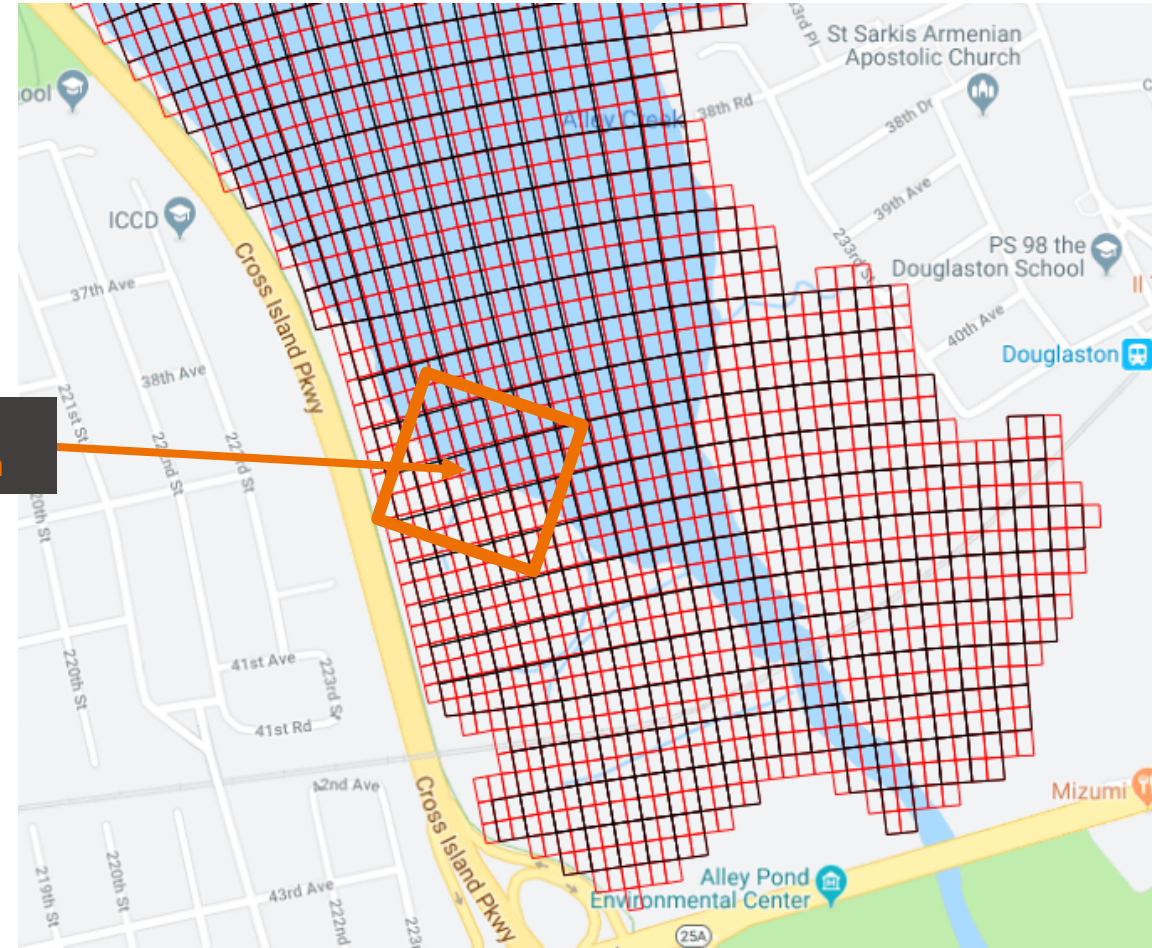- Bathymetry from NOAA's 1/9-arcsecond coastal DEM

Wave grid

King's Point

Site location

The Battery
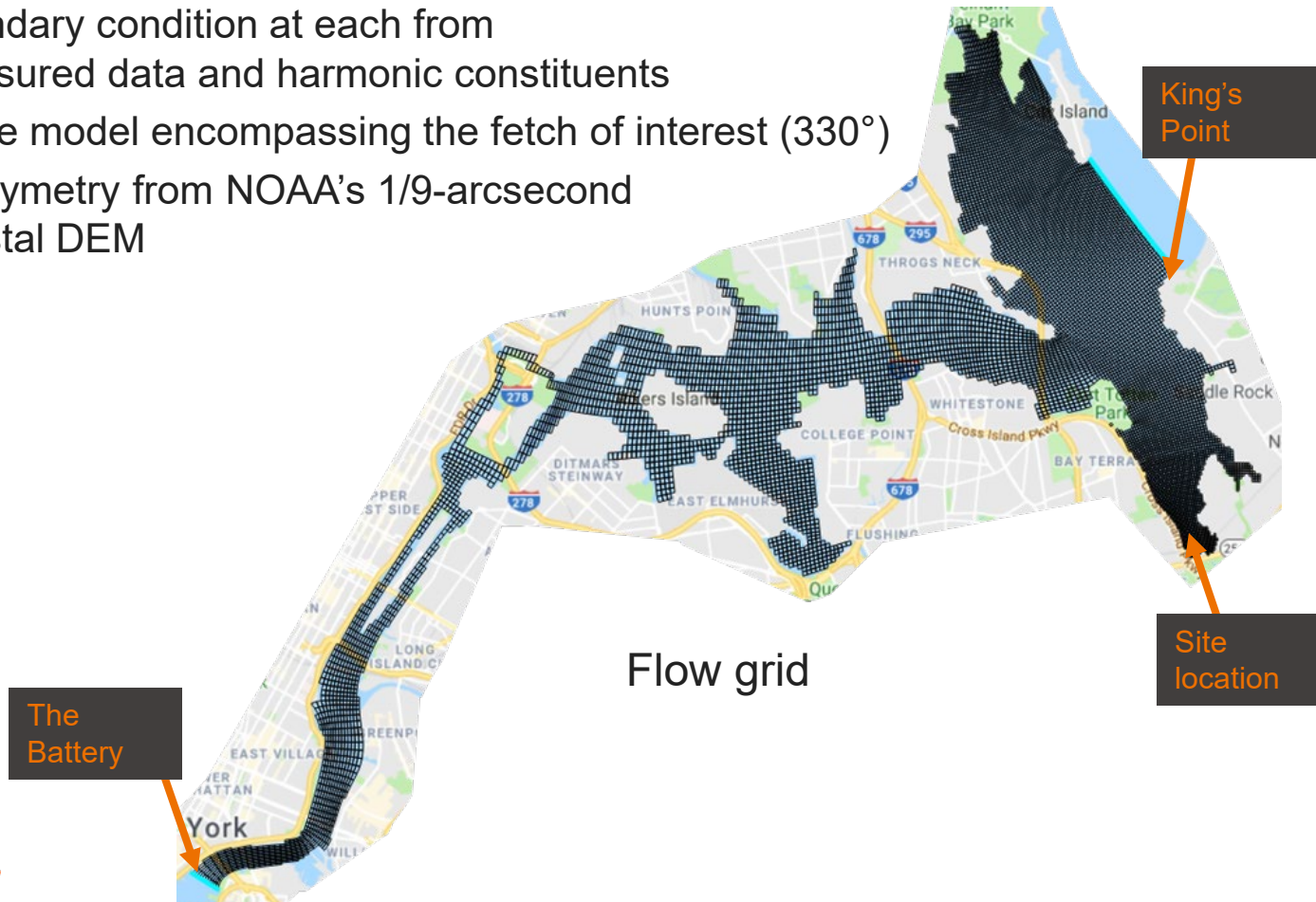
Flow grid

Delft3D Model Setup

Model bathymetry

Flow grid (black)
Wave grids (coarse – red, fine – orange)

Modeled Events

1-year return period wind w/ astronomic tide

5-year return period wind w/ astronomic tide

10-year return period wind w/ astronomic tide

*10-year joint probability wind and water level – high wind

*10-year joint probability wind and water level – split wind and water level

*10-year joint probability wind and water level – high water level

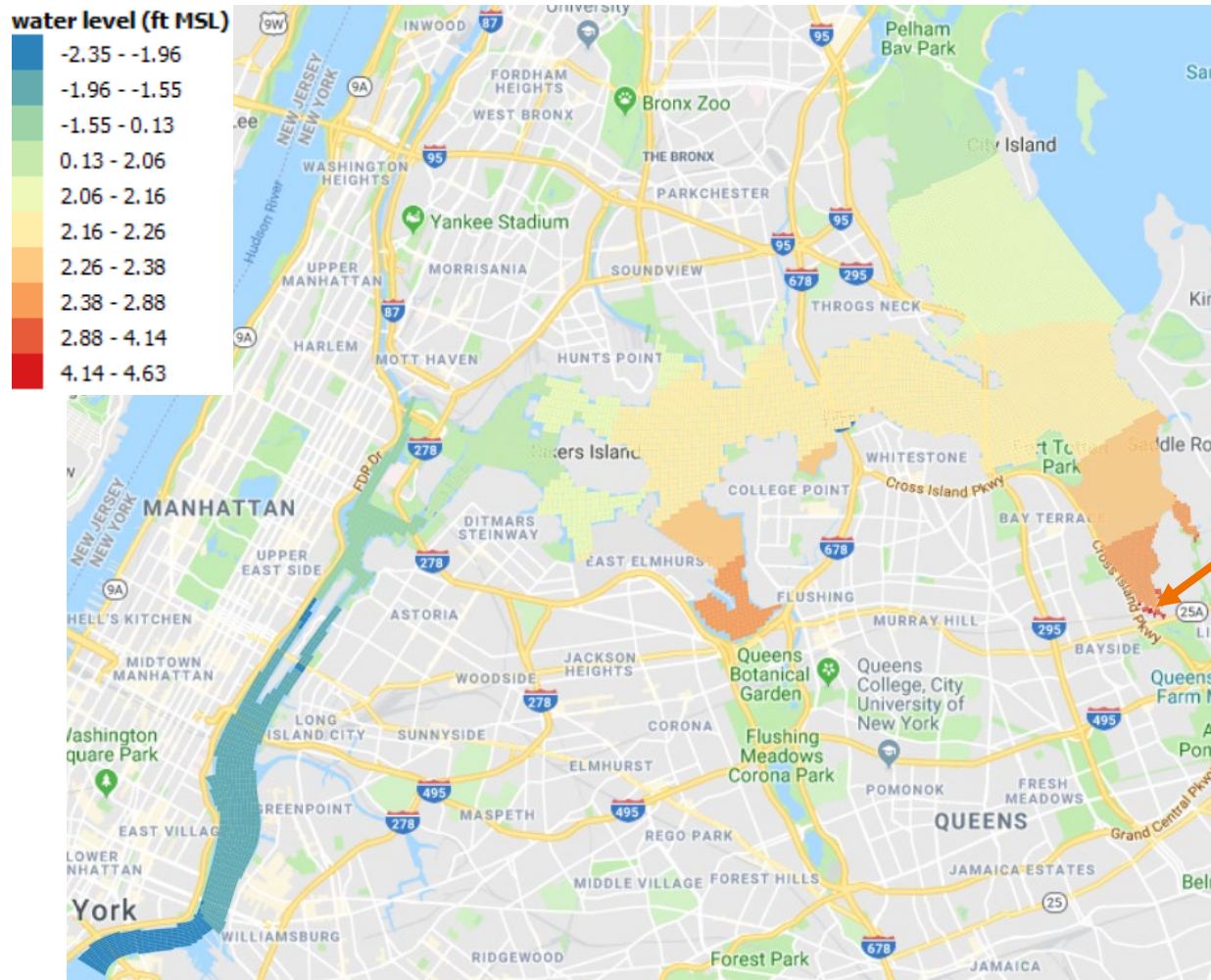*25-year joint probability wind and water level – high wind

*50-year joint probability wind and water level – high wind

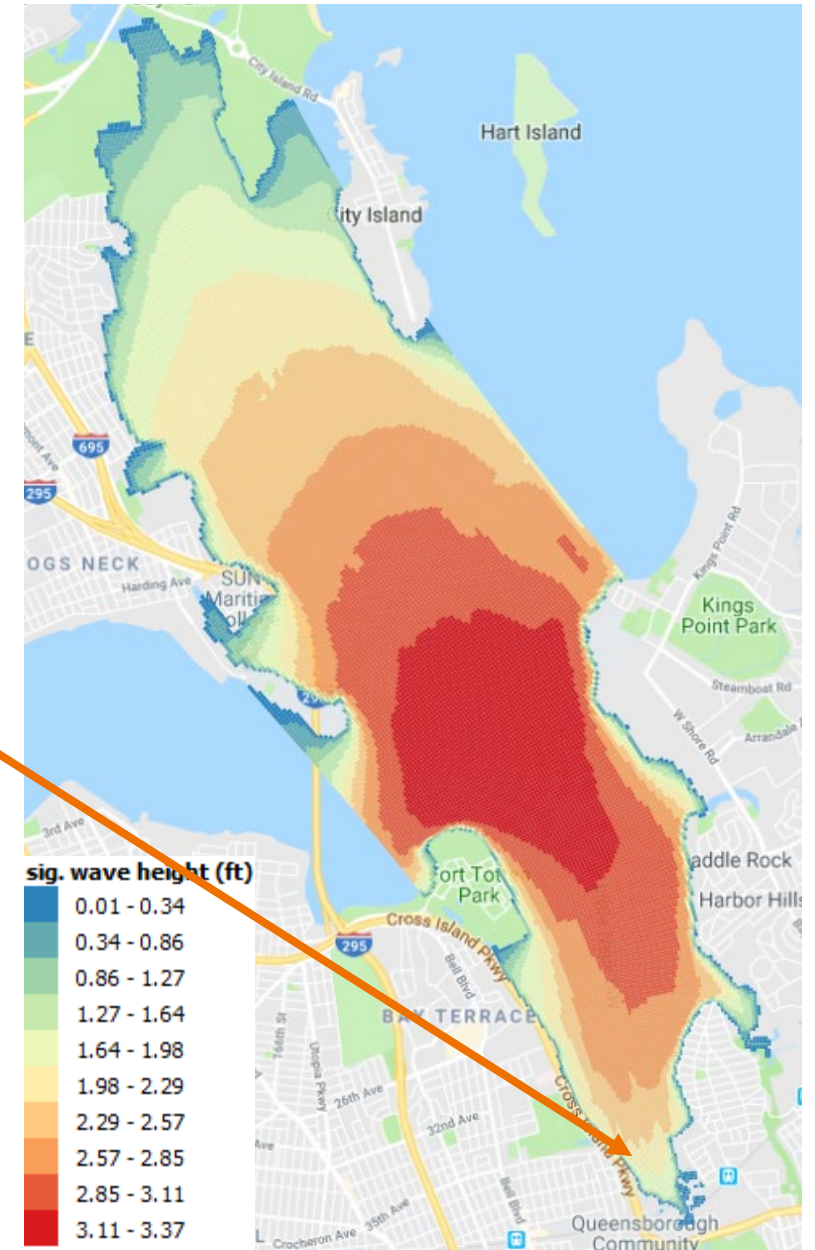*100-year joint probability wind and water level – high wind

Hurricane Sandy (2012) using measured wind and water levels

*stationary, waves-only model run w/ static water level

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Example Output –
1-Year Return Period Event

water level (ft MSL)
- -2.35 – -1.96
- -1.96 – -1.55
- -1.55 – 0.13
- 0.13 – 2.06
- 2.06 – 2.16
- 2.16 – 2.26
- 2.26 – 2.38
- 2.38 – 2.88
- 2.88 – 4.14
- 4.14 – 4.63

Site location

sig. wave height (ft)
- 0.01 – 0.34
- 0.34 – 0.86
- 0.86 – 1.27
- 1.27 – 1.64
- 1.64 – 1.98
- 1.98 – 2.29
- 2.29 – 2.57
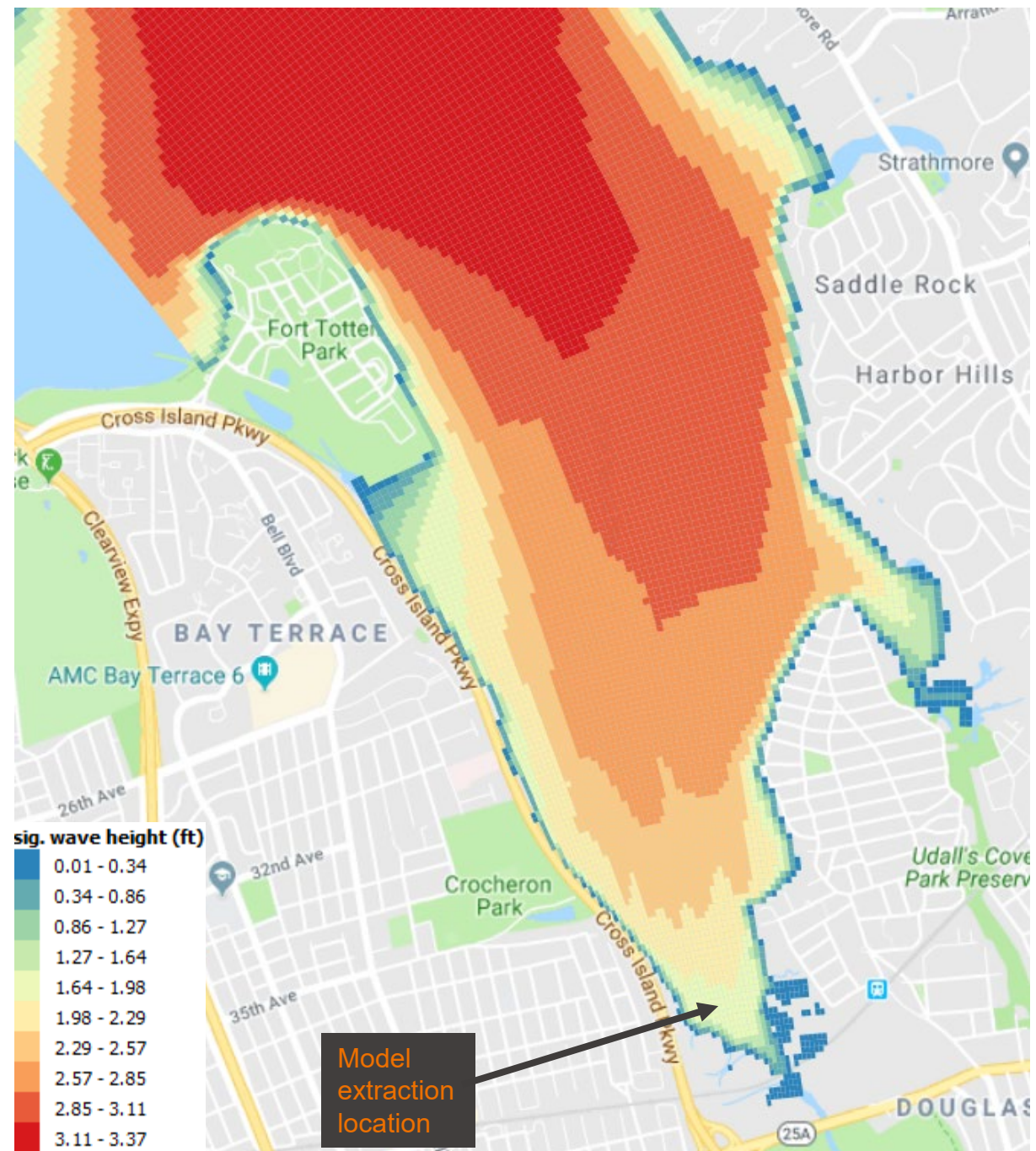- 2.57 – 2.85
- 2.85 – 3.11
- 3.11 – 3.37

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Model Results – Peak Values

Wind events w/ astronomic tide

Return period	Wind speed	Sig. wave height	Peak wave period	Water level
yr	mph	ft	s	ft MSL
1	43.7	2.0	3.2	4.4
5	49.5	2.1	3.2	4.5
10	51.7	2.2	3.3	4.5

Joint probability events

Return period	Wind speed	Water level	Sig. wave height	Peak wave period
yr	mph	ft MSL	ft	s
10	39.0	7.4	2.0	3.1
10	43.0	6.9	2.1	3.3
10	47.0	6.4	2.3	3.4
25	51.0	6.3	2.4	3.3
50	55.0	6.3	2.5	3.3
100	57.0	6.3	2.6	3.3

Sandy (2012)

Wind speed	Water level	Sig. wave height	Peak wave period
mph	ft MSL	ft	s
32.5	10.1	1.1	2.3

sig. wave height (ft)
- 0.01 – 0.34
- 0.34 – 0.86
- 0.86 – 1.27
- 1.27 – 1.64
- 1.64 – 1.98
- 1.98 – 2.29
- 2.29 – 2.57
- 2.57 – 2.85
- 2.85 – 3.11
- 3.11 – 3.37

Model extraction location

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Modeled Scenarios for Structure Effects

| Wind speed (mph)	Water level (ft MSL)	Structure height (ft MSL) and position
57 (100-yr JP)	6.3 (100-yr JP)	no structure
		+2.0, Phase I alignment
		+1.0, Phase I alignment
		+2.0, extended alignment
	3.6 (MHW)	no structure
		+2.0, Phase I alignment
		+1.0, Phase I alignment
		+2.0, extended alignment
	0.0 (MSL)	no structure
		+2.0, Phase I alignment
		+1.0, Phase I alignment
		+2.0, extended alignment

Model observation locations (1-6), currently-designed Phase I structure footprint (red), and extended footprint (orange).

Modeled Scenarios for Structure Effects
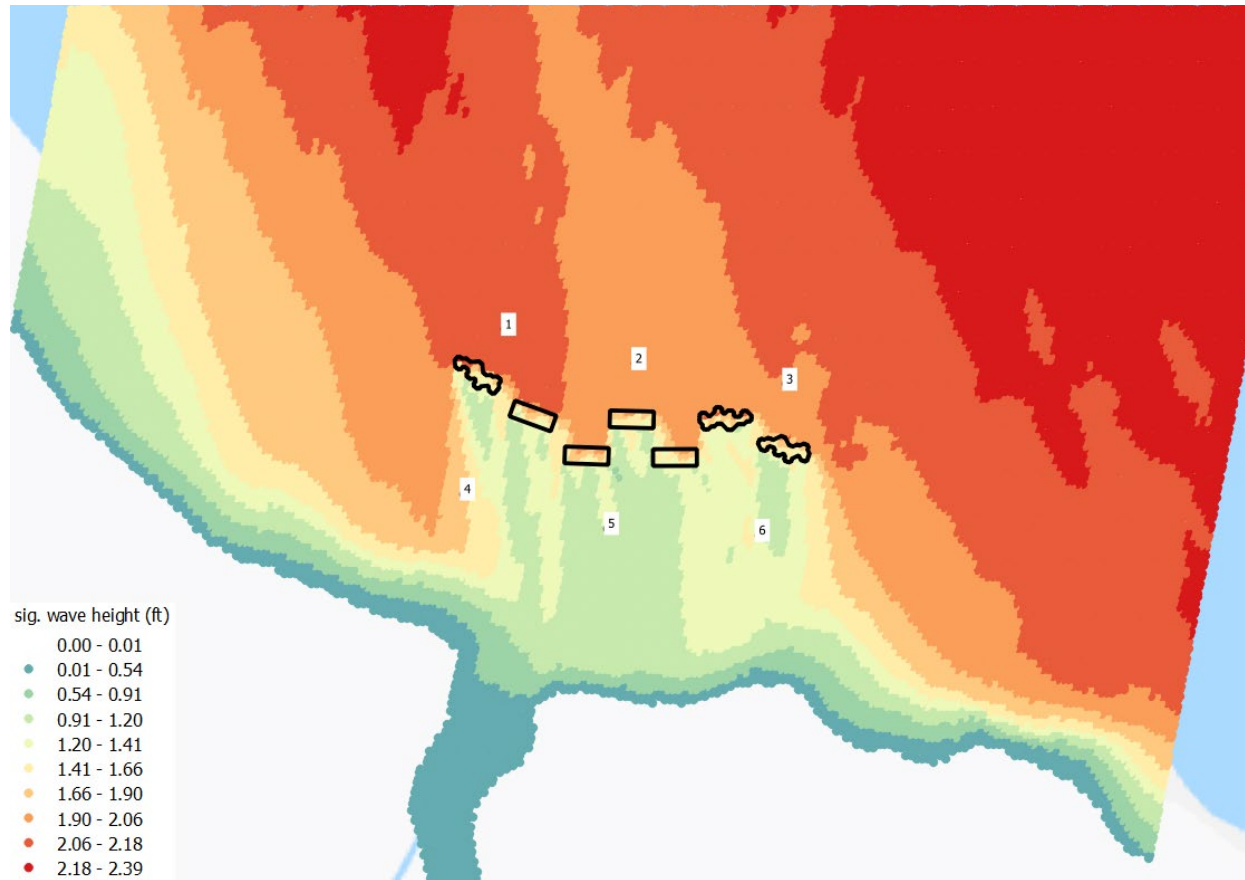
Significant wave height, 100-yr JP wind, MHW, current structure footprint at +2.0 ft MSL.
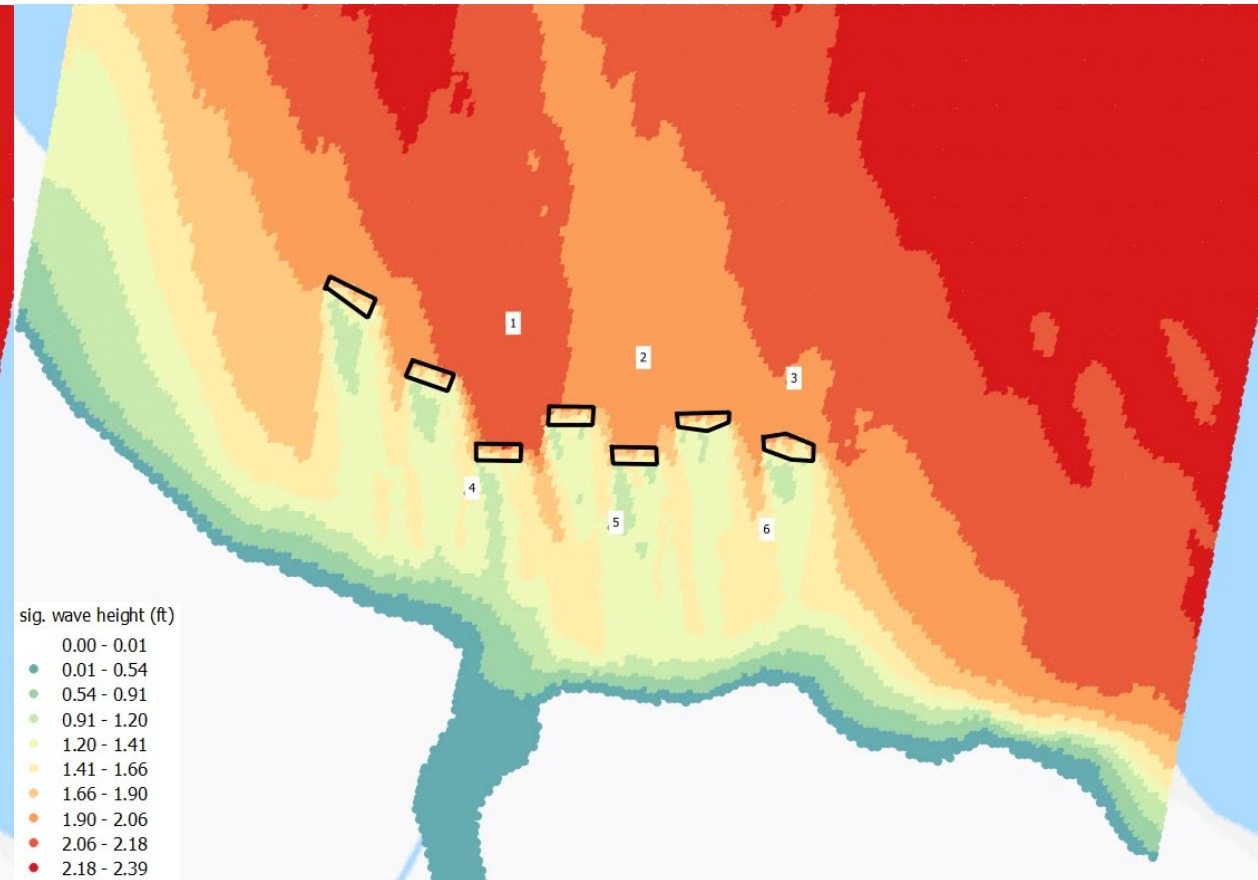
Significant wave height, 100-yr JP wind, MHW, extended structure footprint at +2.0 ft MSL.

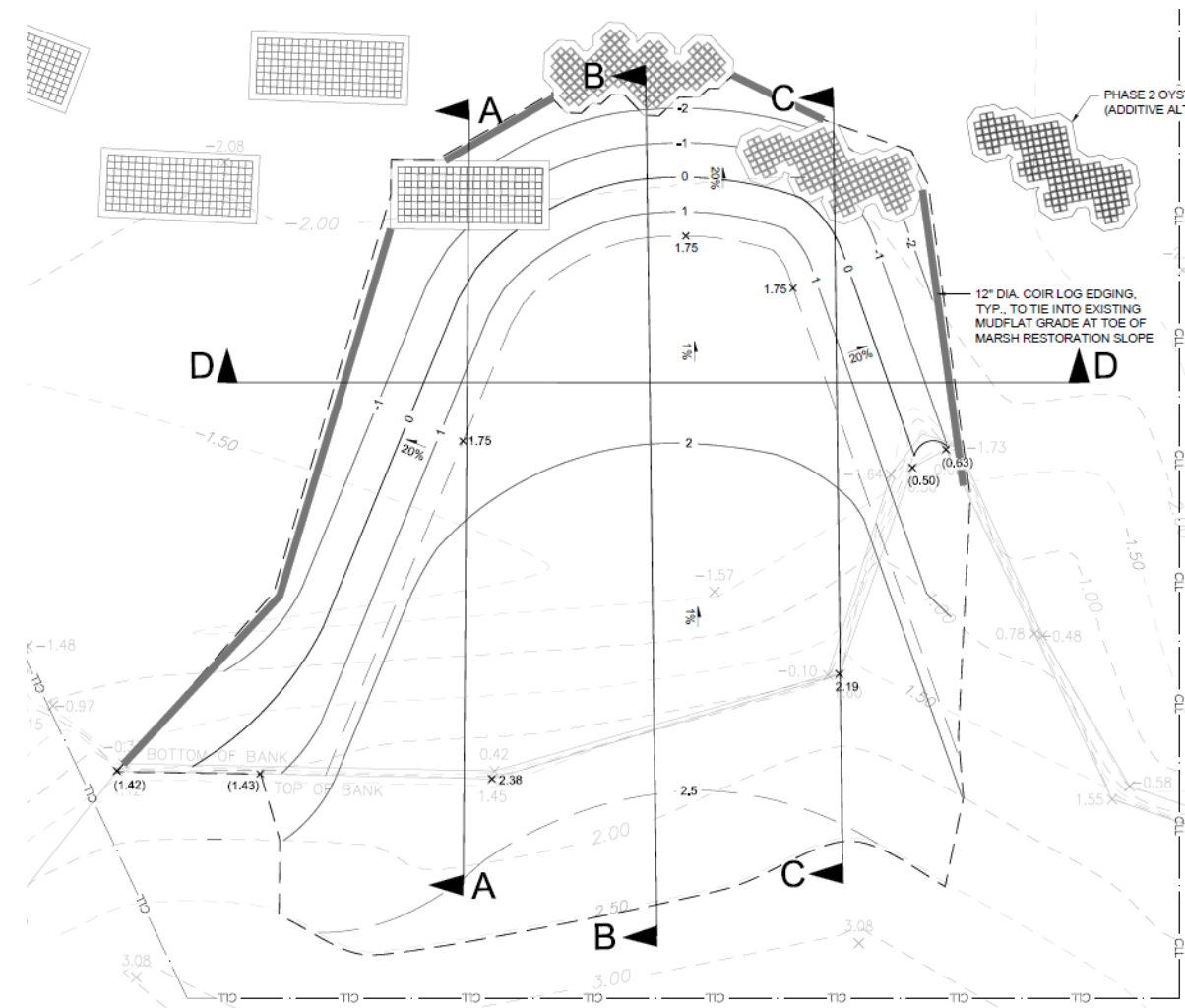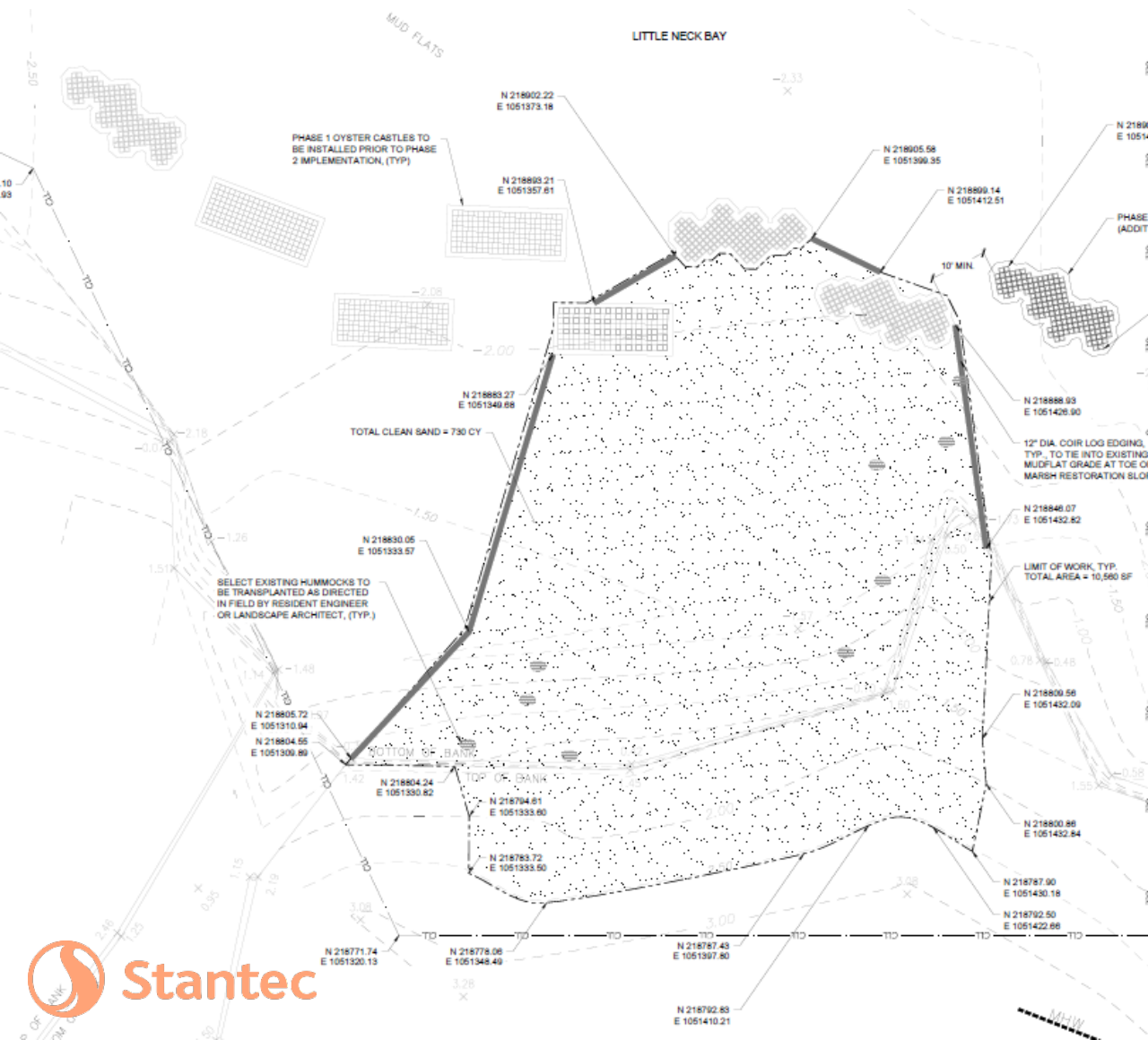# Modeled Scenarios for Structure Effects

- Extended footprint most effective at 100-yr WSE
- +2.0 ft Phase I footprint most effective at MHW and below (20-40% reduction in wave height behind structure vs. existing no-structure)
- +2.0 ft Phase I footprint carried forward to design
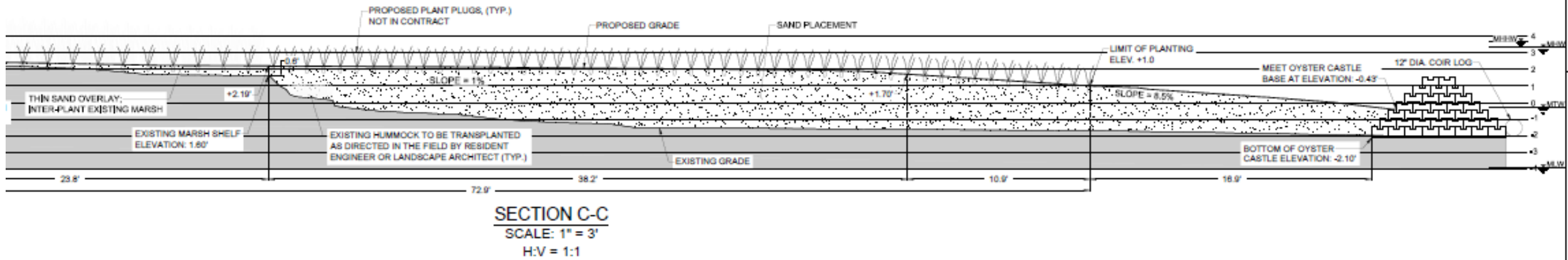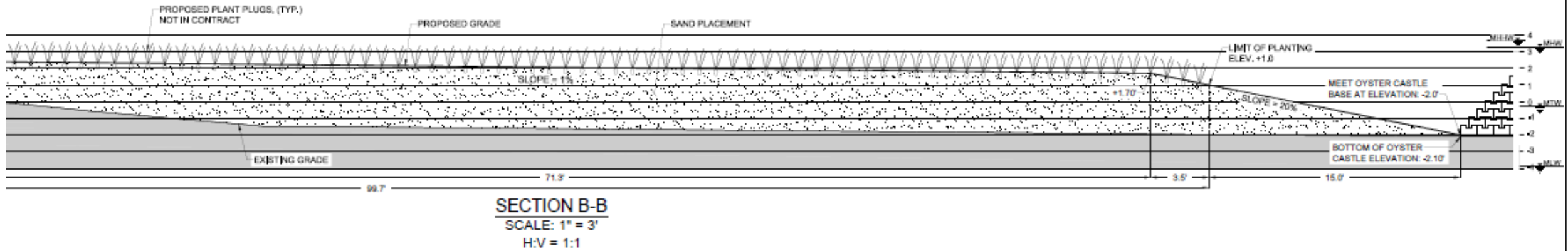
Bio-Benchmarks for Planting Elevations

Tidal Datum	NYCDPR bio-benchmark data (ft NAVD88) [1]	King's Point Tide Gauge (ft NAVD88)	Proposed plant zones	Elevation range (ft NAVD88)
Mean higher high water (extent of HM)	4.96	3.64	High marsh	3.5-5.0
Mean high water (avg SPPA)	3.76			
Mean high water (lowest SPPA)	3.25	3.28	High marsh / low marsh transition	3.5-4.0
Mean high water (highest SPAL)	3.94			
Mean high water (avg SPAL)	1.37			
Mean tide level (lowest SPAL)	-1.72	-0.3	Low marsh	1.5-3.5
Mean low water		-3.88	[Mudflat]	

(1) Derived from NYCDPR biobenchmark survey with RTK (ES, CH, KA) on 12/17/18

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Phase I Fill and Planting Plan

Phase I Fill and Planting Plan

Current Status

- 100% Plans and Specs complete and under review

- Permitting underway

- Start of construction est. fall 2020

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Thank you!
Questions?

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