Broward County Convention Center
Expansion Project

Wave Modelling and Runup Analysis

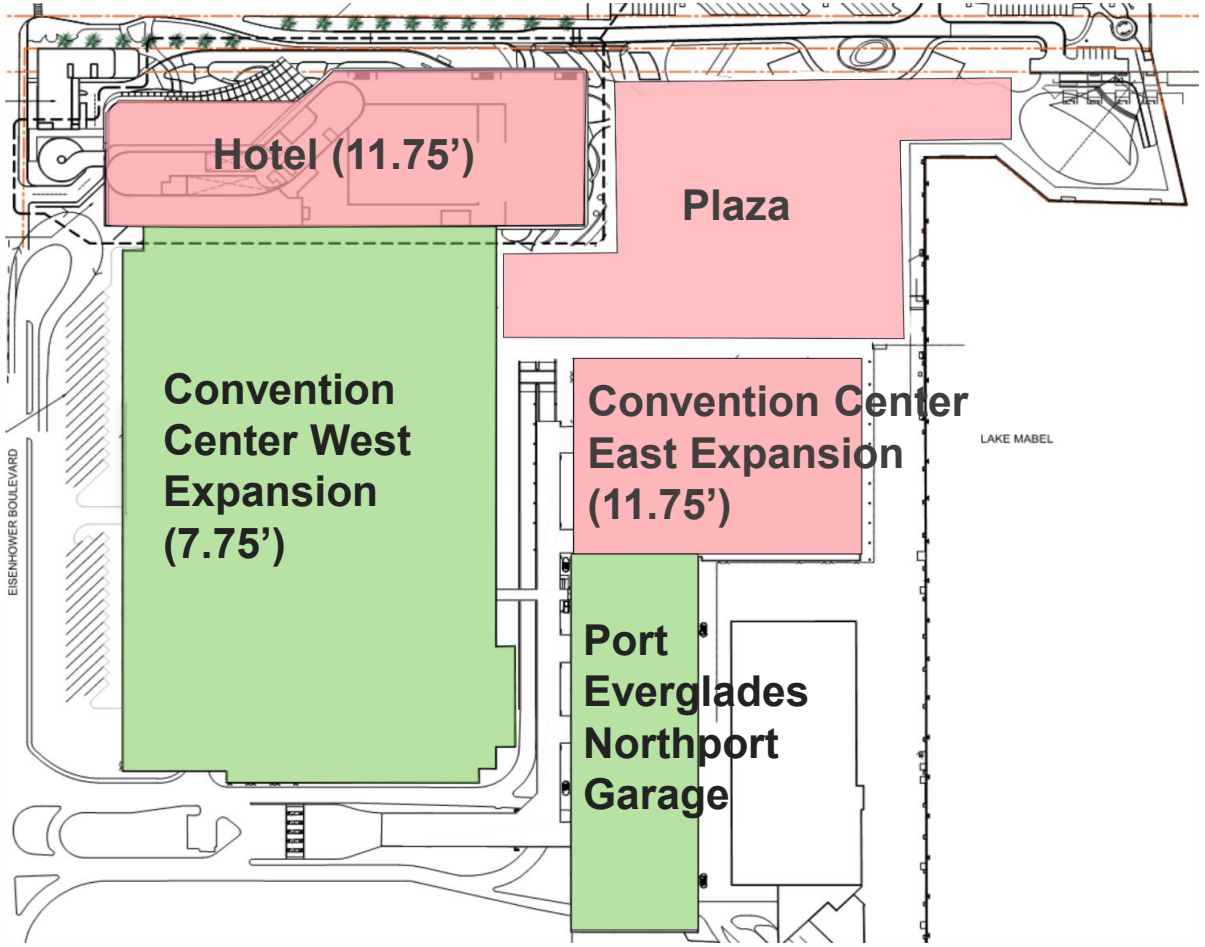
Aaron Chen, Jeff Tabar

Stantec

Outlines

1. Introduction
2. Data Analysis
3. SWAN and FUNWAVE
4. Runup and Overtopping
5. Design Recommendations

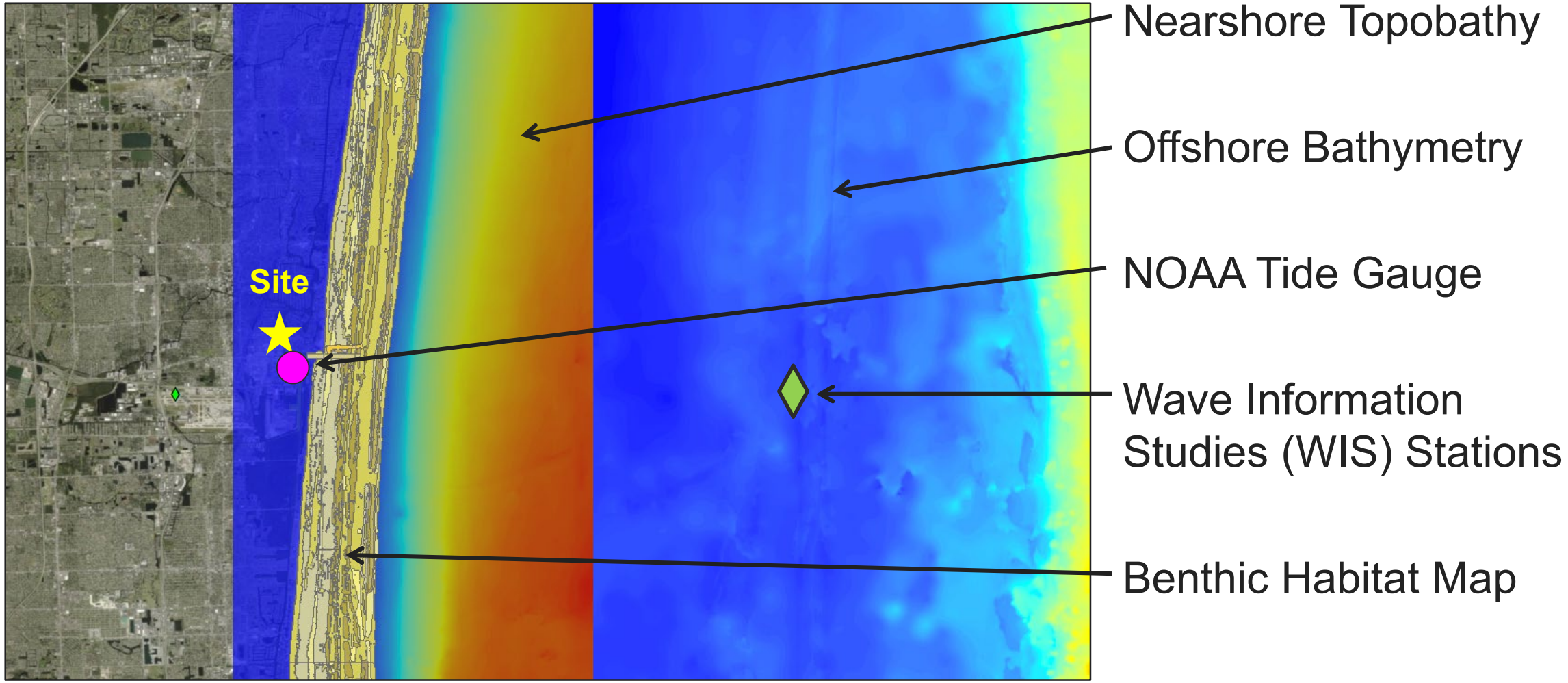
Site Layout



Objectives (100-yr event with 50-yr SLR)

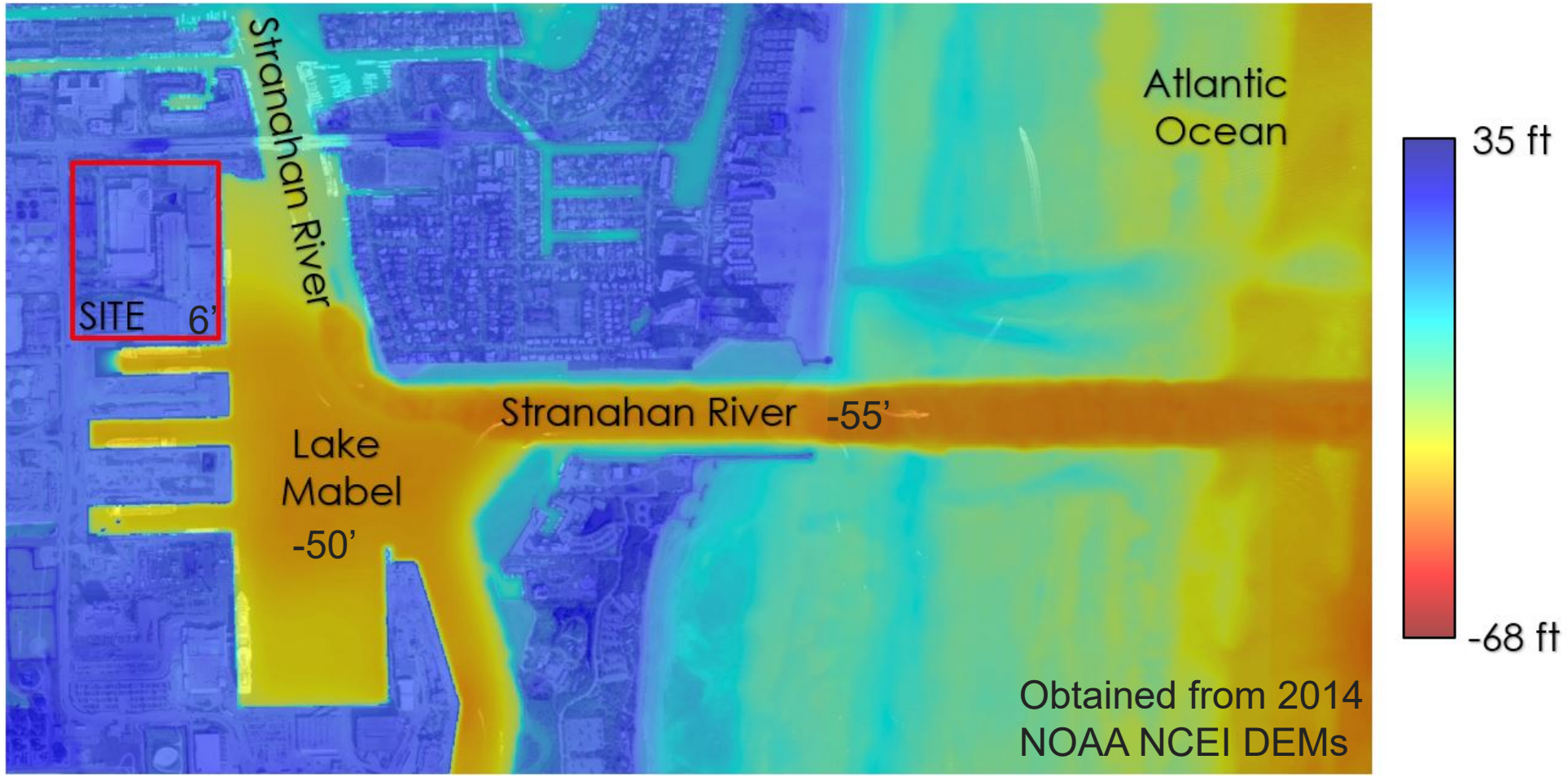
- Floor elevations at each building
- Building skirt heights
- Plaza and site elevations & slopes

Data Collection



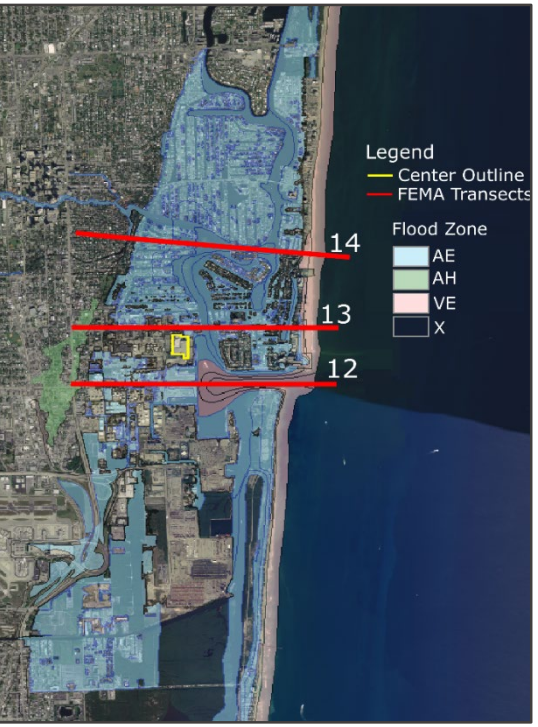
Data Investigation

Topography and Bathymetry

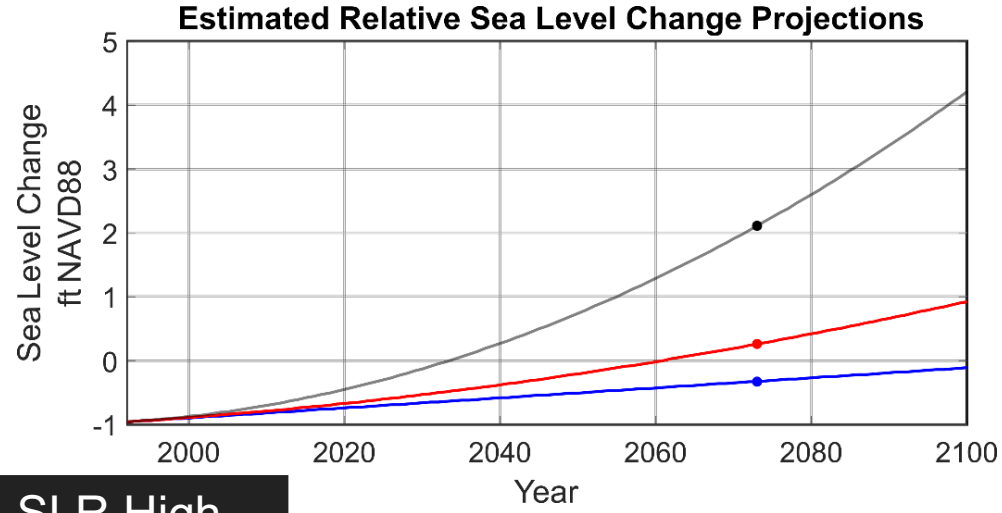


Data Investigation

Base Water Level



- Base Water Level (BWL) = SWEL + SLR
- SWEL from FEMA's in-progress FIS for Broward County
- 50-year SLR calculated using USACE SLR Change Calculator
  - NOAA gauge, 22 mi south of site
  - Data available 1931 to 1982
  - Estimated Construction Date: 2023



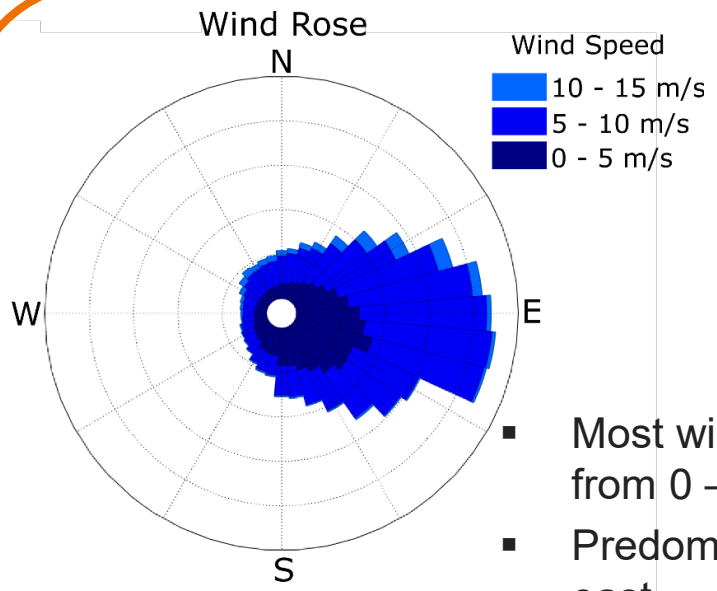
Three BWL cases

		SLR Low	SLR Int	SLR High
		0.525	1.108	2.958
SWEL	6.380	6.91	7.49	9.34

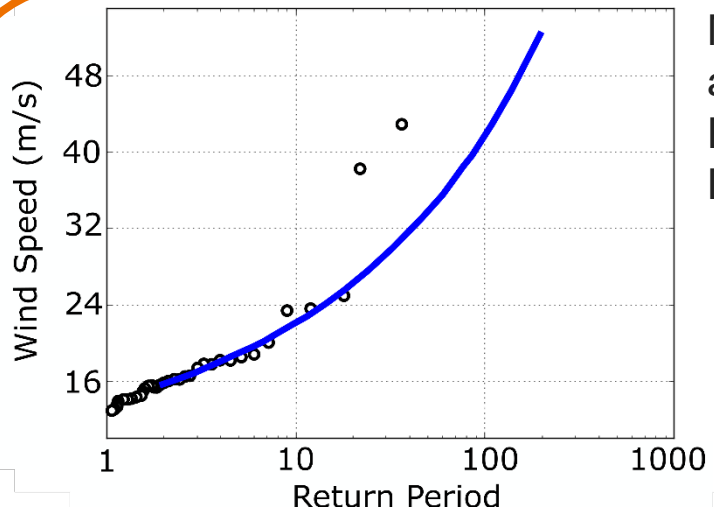
Data Investigation

Wind Conditions

- Data from USACE Wave Information Studies (WIS)
  - Hourly data 1980 to 2014



- Most wind speeds ranging from 0 – 15 m/s
- Predominantly from the east
- Maximum recorded wind of 42.9 m/s in 2005



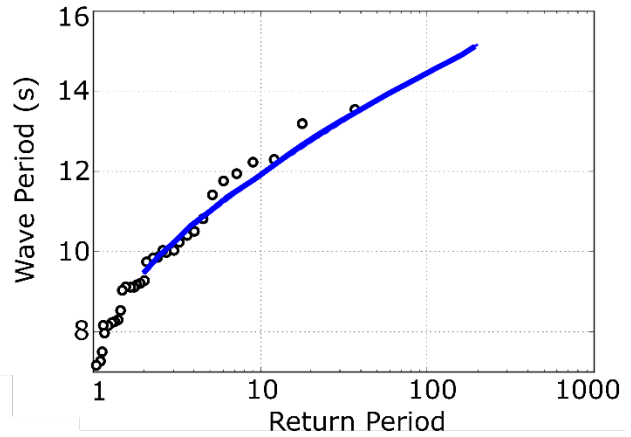
Maximum wind speeds analyzed using General Extreme Value Distribution (GEV)

25-yr	50-yr	100-yr
27.8 m/s	33.8 m/s	41.8 m/s

Data Investigation

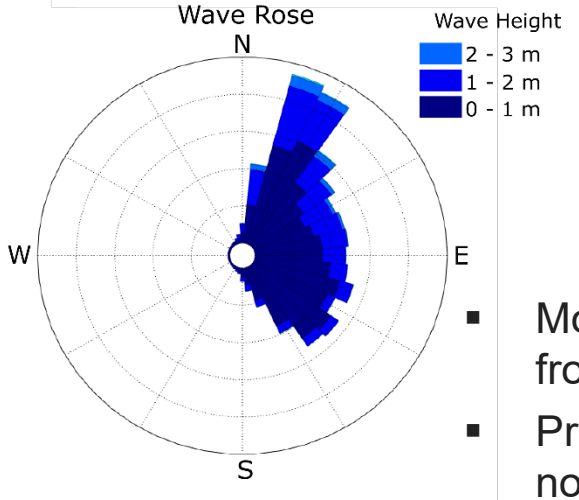
Wave Conditions

- Data from USACE Wave Information Studies (WIS)
  - Hourly data 1980 to 2014

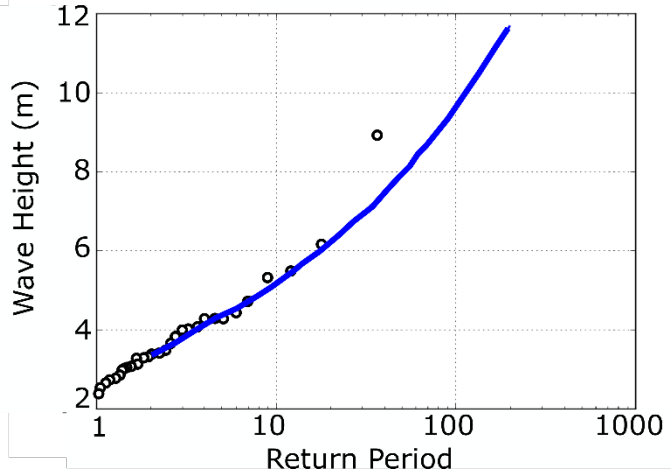


Maximum wave periods analyzed using GEV

25-yr	50-yr	100-yr
12.97 s	13.74 s	14.47 s



- Most wave heights ranging from 0 – 3 m
- Predominantly from the northeast
- Maximum recorded wave height of 8.93 m in 2005

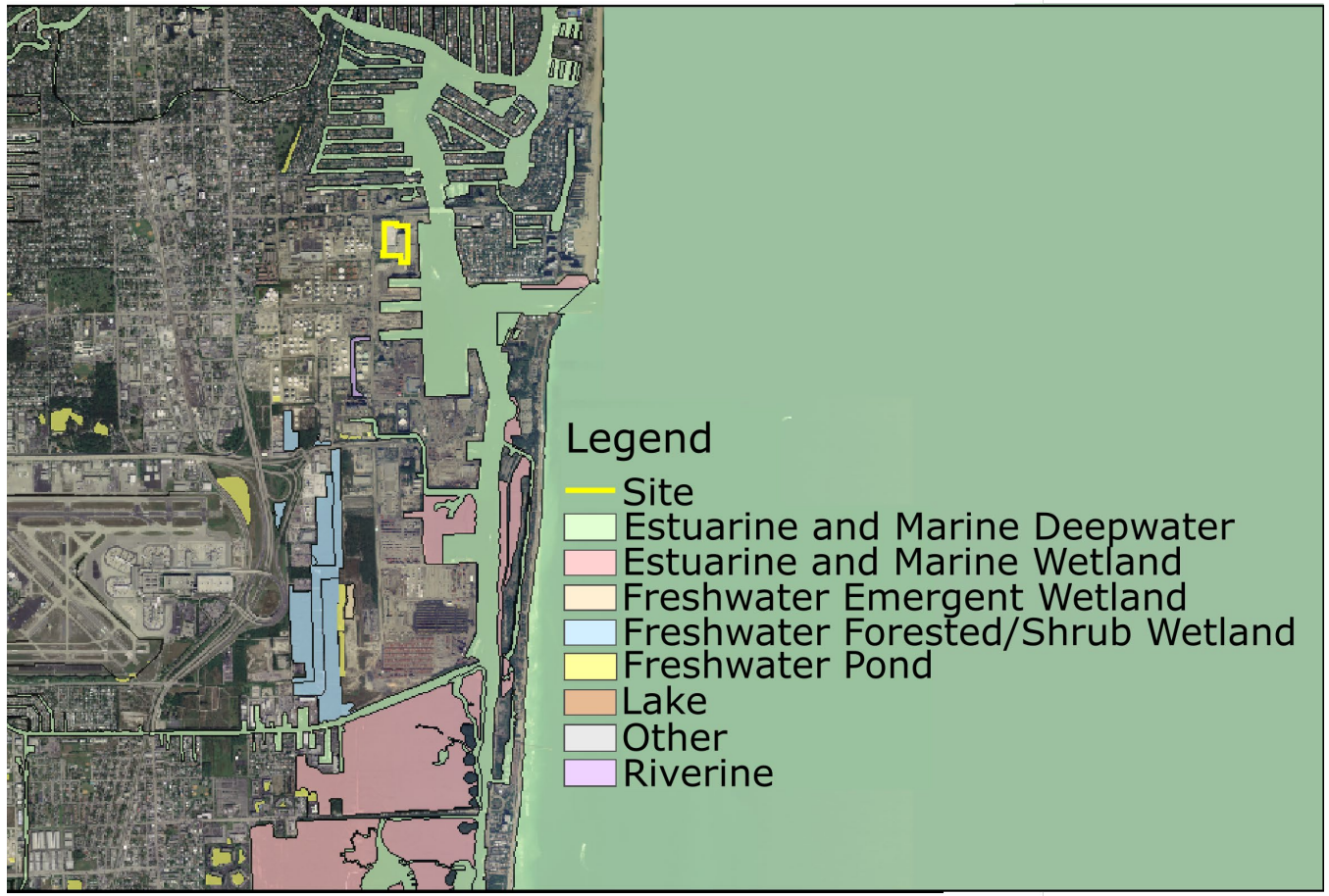


Maximum HS analyzed using GEV

25-yr	50-yr	100-yr
6.59 m	7.94 m	9.61 m

Data Investigation

Bottom Friction – Sediment & Vegetation



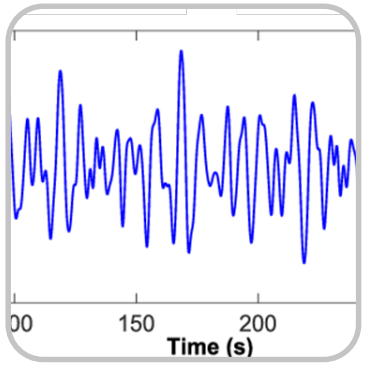
Sediment:

- Data collected from FL Fish and Wildlife's Unified Reef Map
- Nearshore environment: excavated harbor & inlet channel
- Excavated Bottom: unconsolidated; 25% smaller than stone

Vegetation:

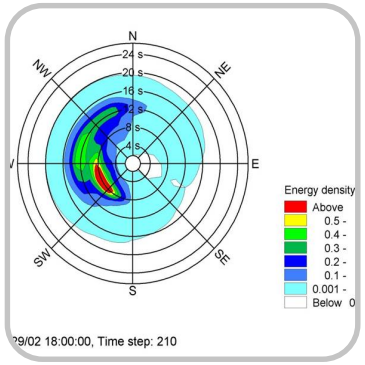
- Data collected from US Fish and Wildlife's National Wetland Inventory
- Harbor is classified as a subtidal estuarine environment with less than 30% vegetation cover

Phase-resolving vs Phase-averaged



Phase-resolving model - FUNWAVE

- resolve each individual wave
- capture wave refraction, dissipation, and diffraction
- capture runup and overtopping processes
- expensive to run (local)



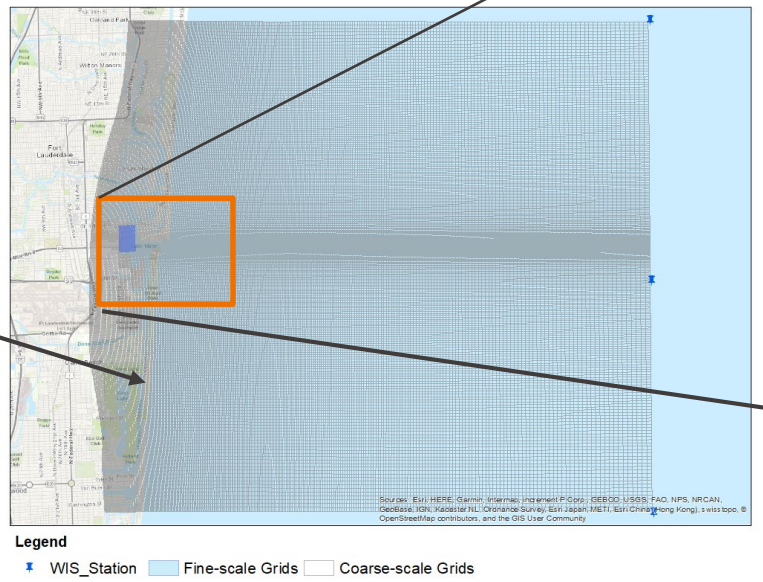
Phase-averaged model - SWAN

- resolve wave energy/spectrum derived at longer time scale
- capture wave generation, dissipation, refraction
- approximation for wave diffraction
- inexpensive to run (regional)

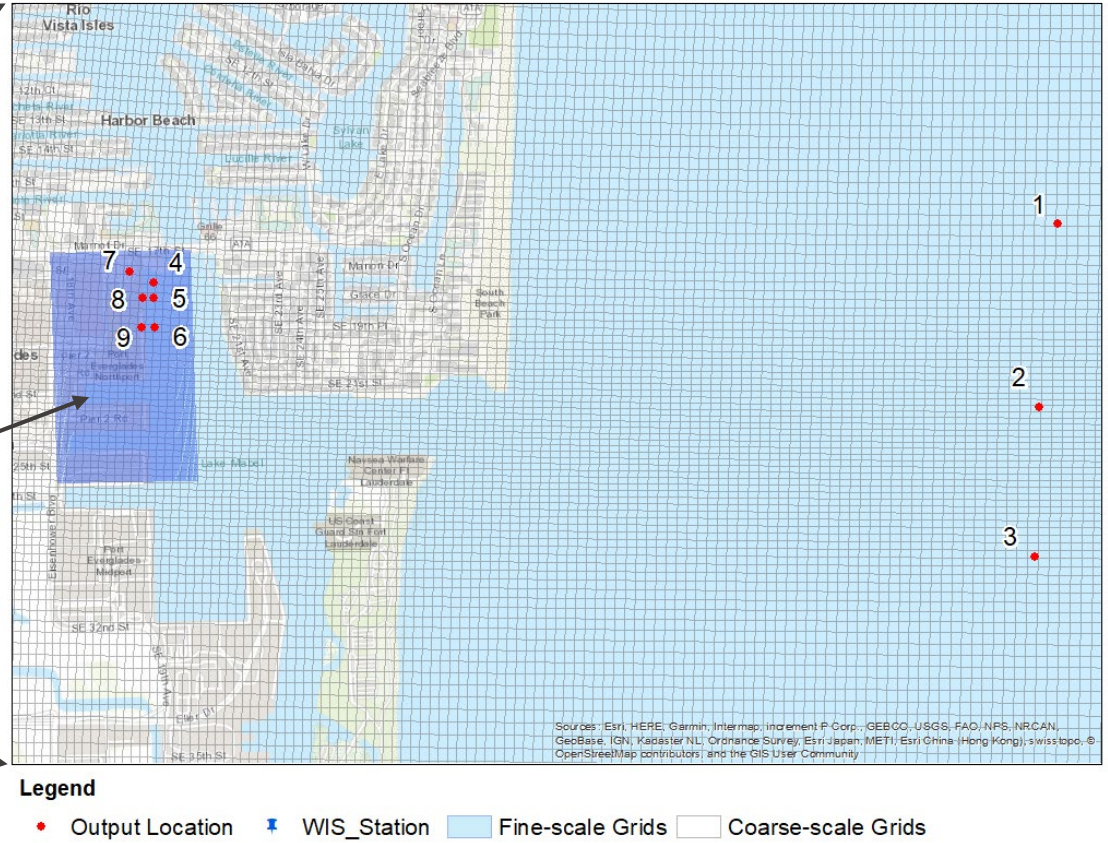
Phase-averaged model

SWAN Model

Coarse-scale grid



Fine-scale grid

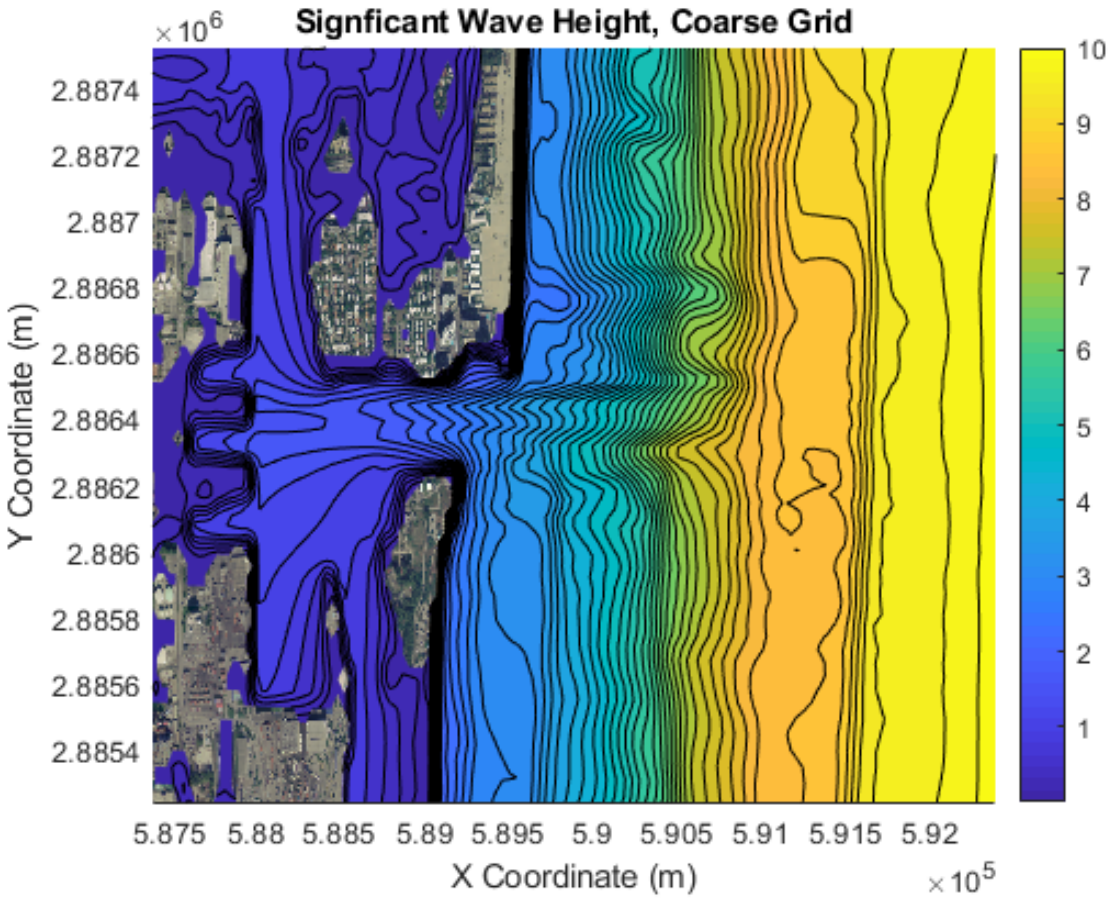


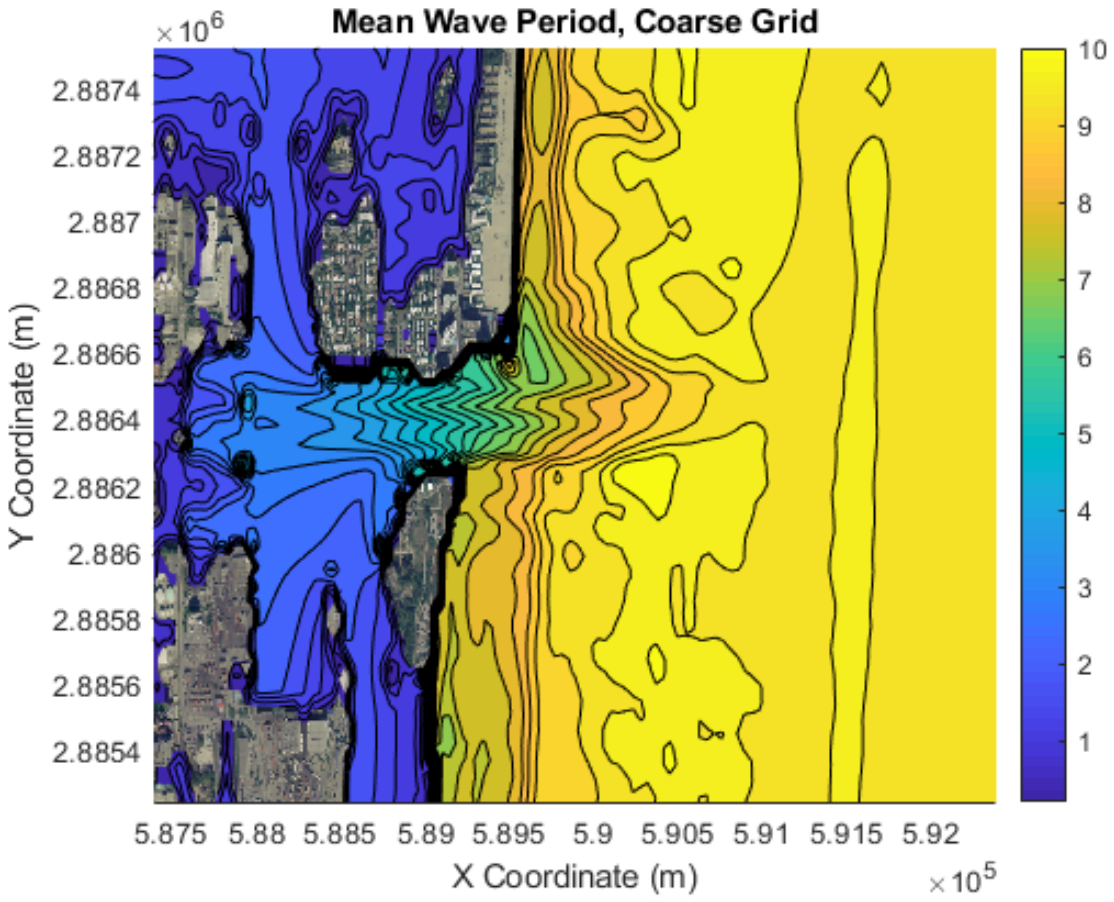
- Landward to high ground
- 25 m resolution at the inlet
- Forced by the 100-yr event from east
  - Wave from the WIS Station
  - Wind at the surface

- 2 m resolution for the project site
- Nested within the coarse-scale grids
- NOAA Topobathy DEM with building footprint incorporated as elevated block

Phase-averaged model

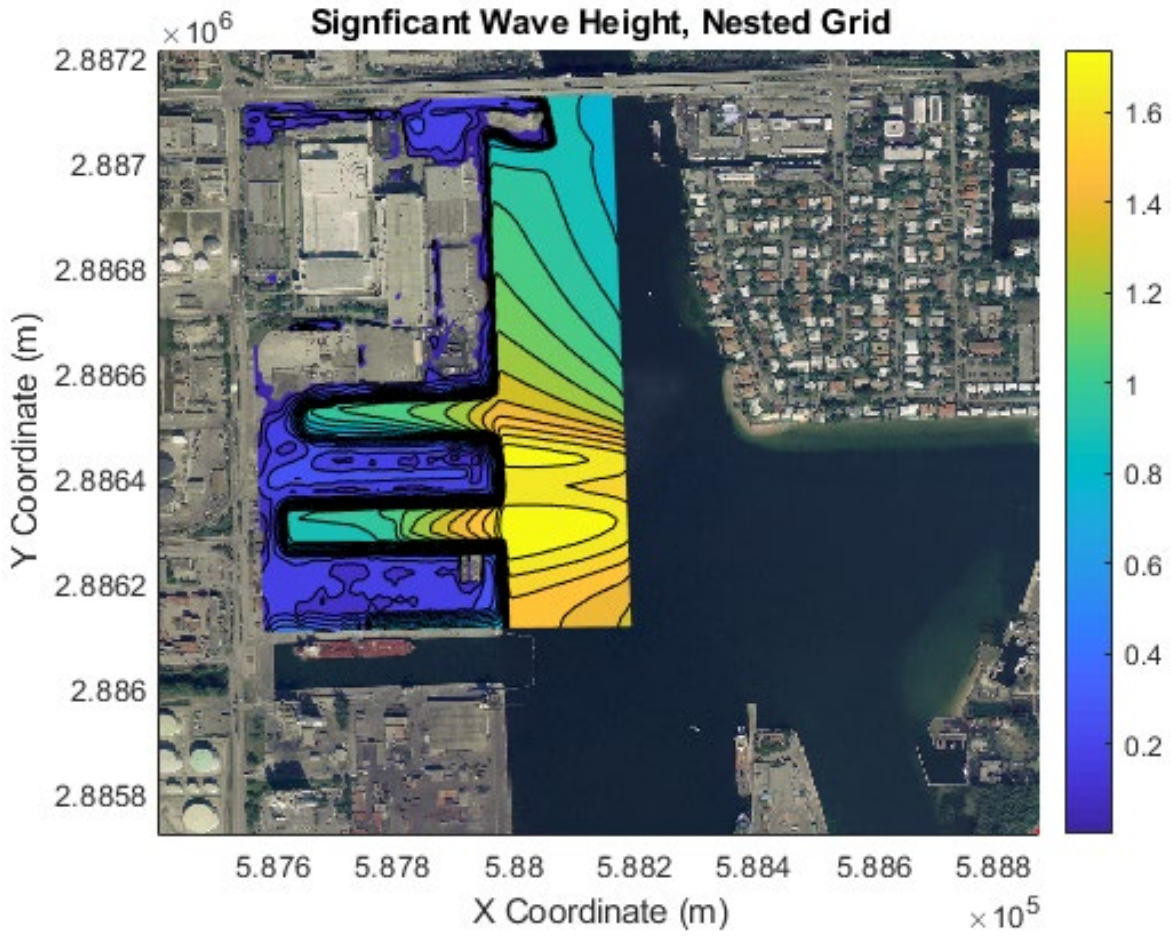
H_s and T_{mean} from Coarse-scale Model





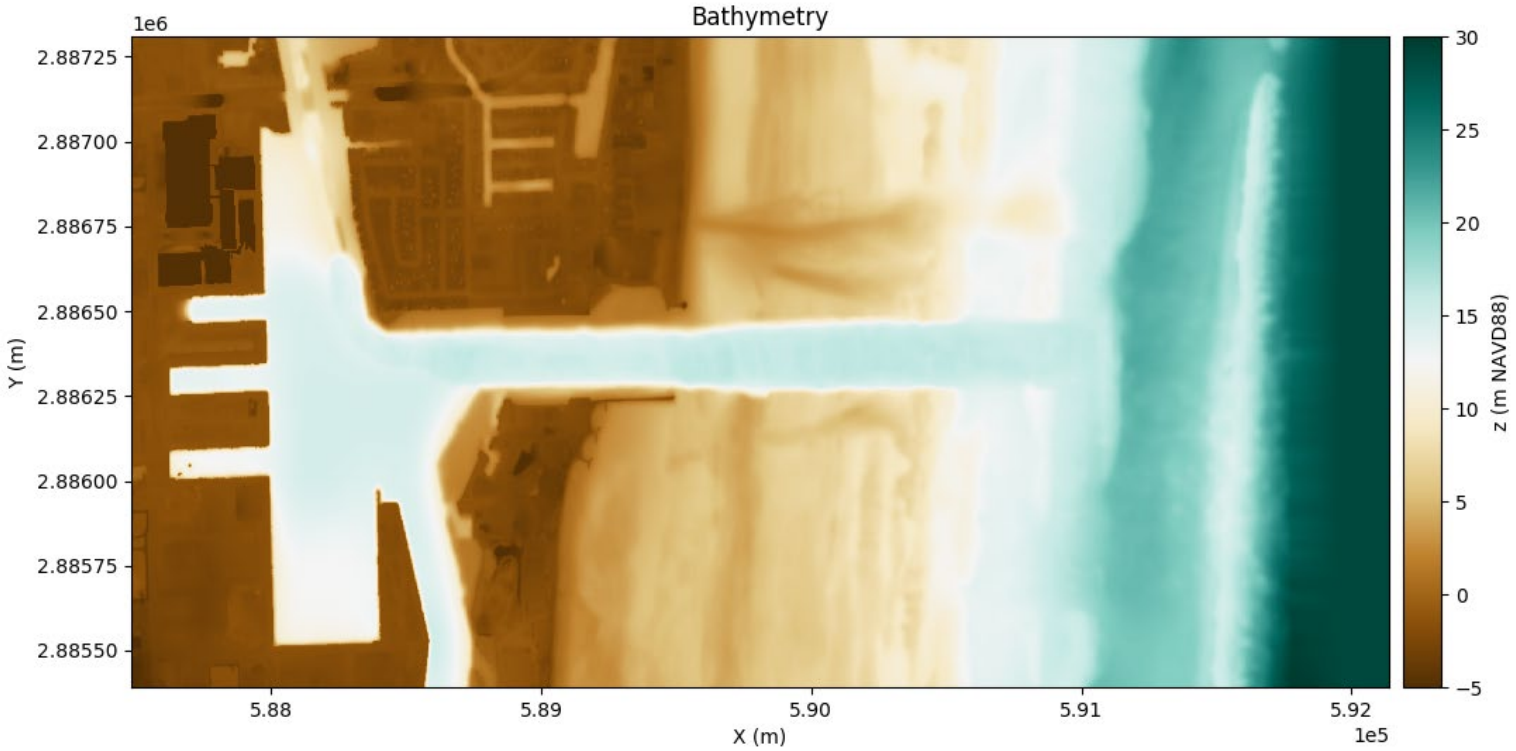
Phase-averaged model

H_s from Nested Model



Phase-resolving model

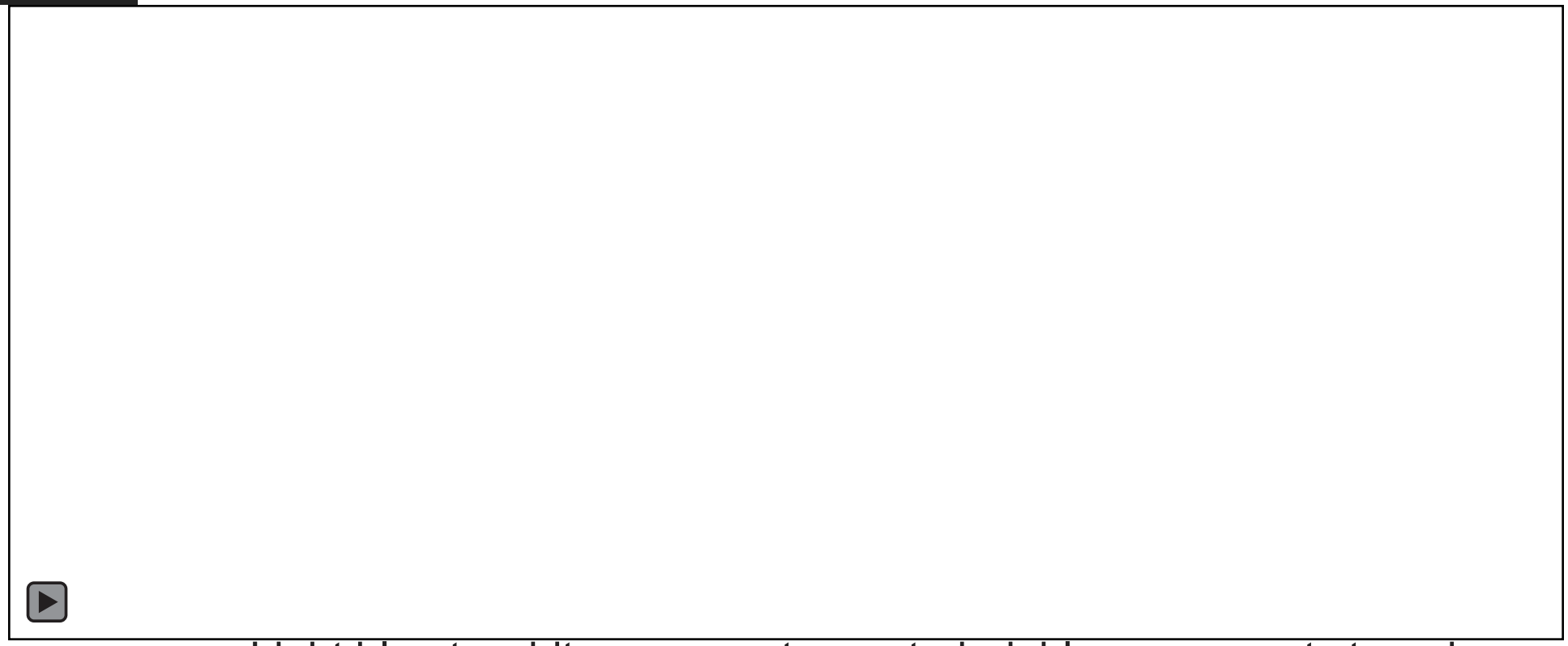
FUNWAVE Model



- 2 m resolution grids
- Forced by wave conditions at 29-m depth contour from SWAN model

Phase-resolving model

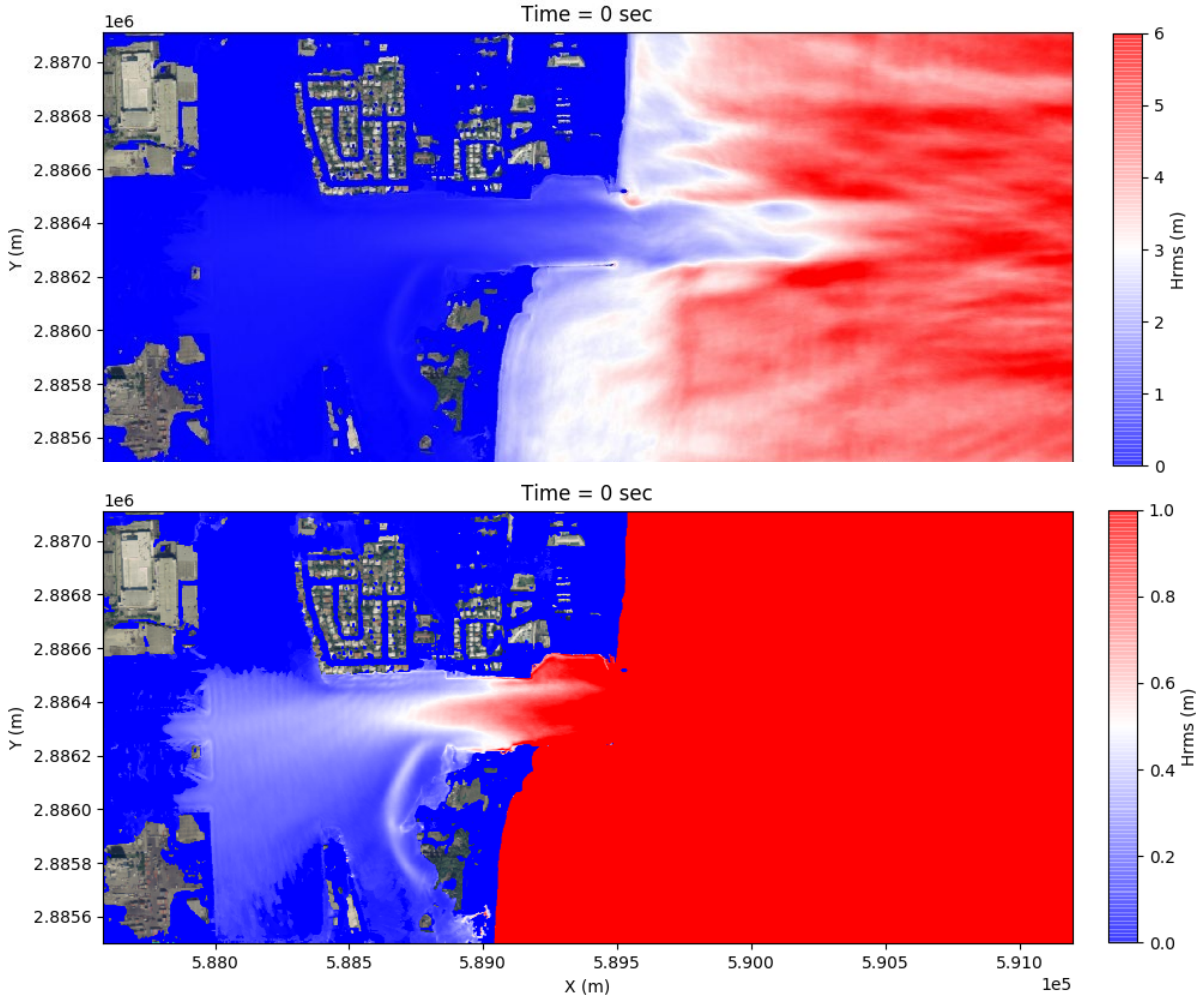
Instantaneous Water Surface Elevation



- Light blue to white represents crest, dark blue represents trough
- Contrast of the plot indicates wave height
- Diffraction pattern inside Lake Mabel

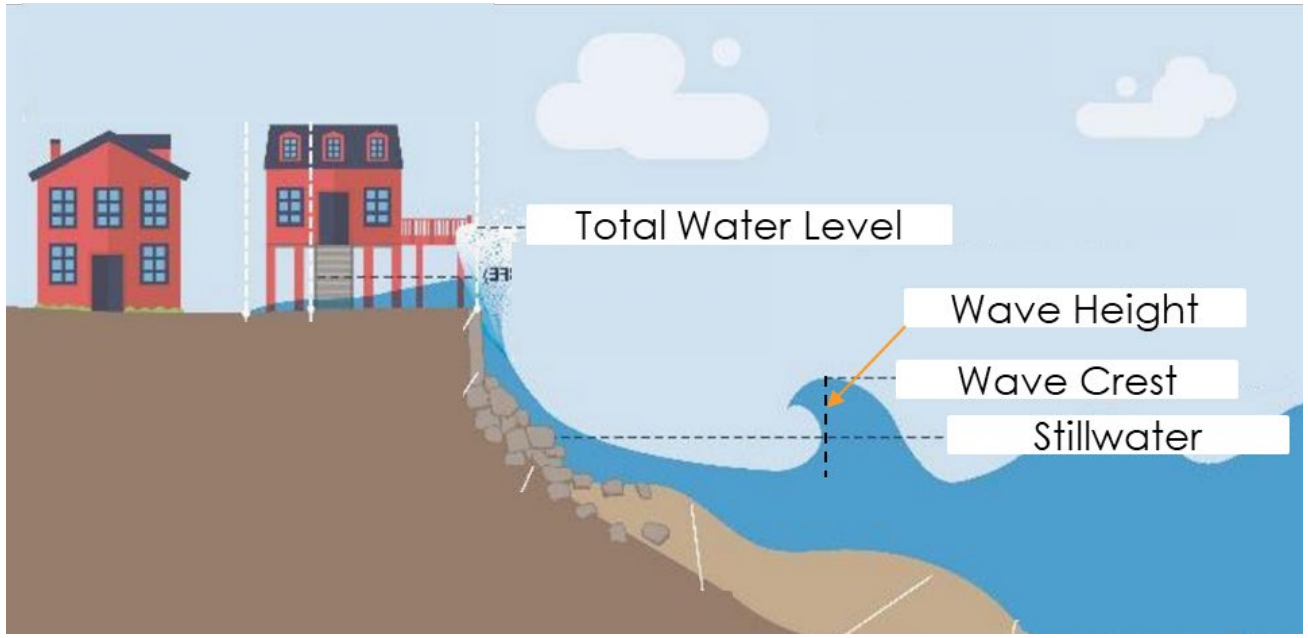
Phase-resolving model

Hs from FUNWAVE Model



- The inlet blocks long waves associated with storm conditions due to
  - Wave refraction over deep channel
  - Length of the wave >> width of the inlet
- Predominantly wind-generated waves
- Phase-averaged model is sufficient

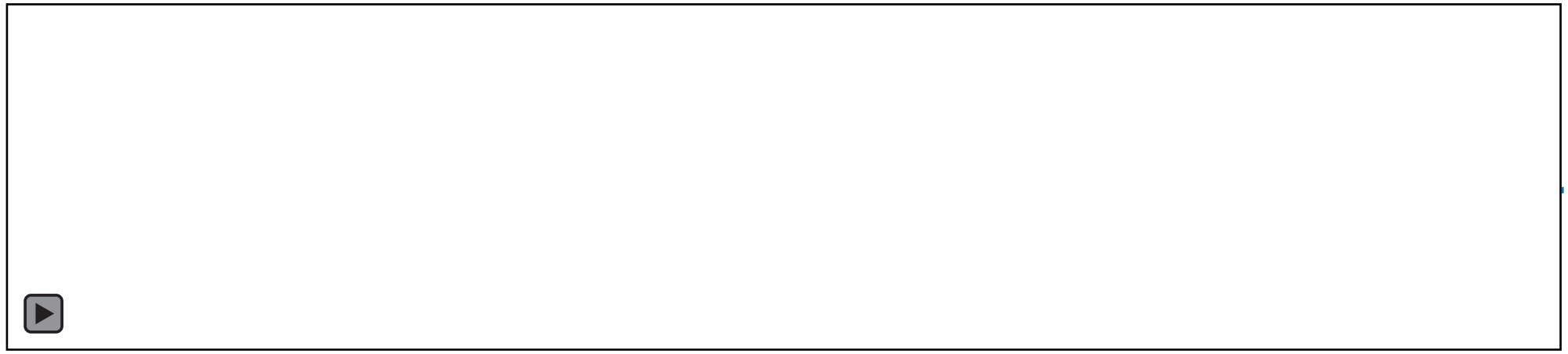
Overview

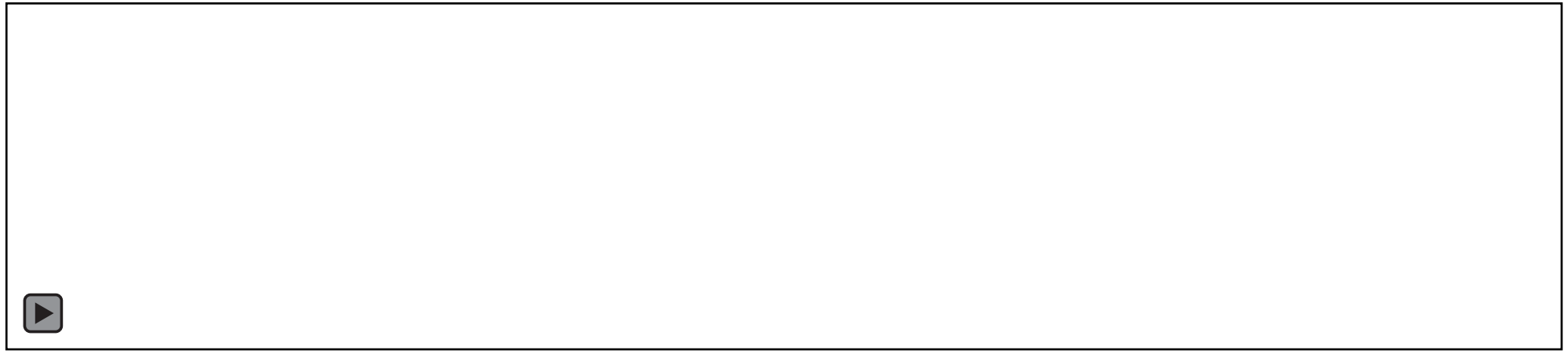


The SWEL is dynamic during a storm:

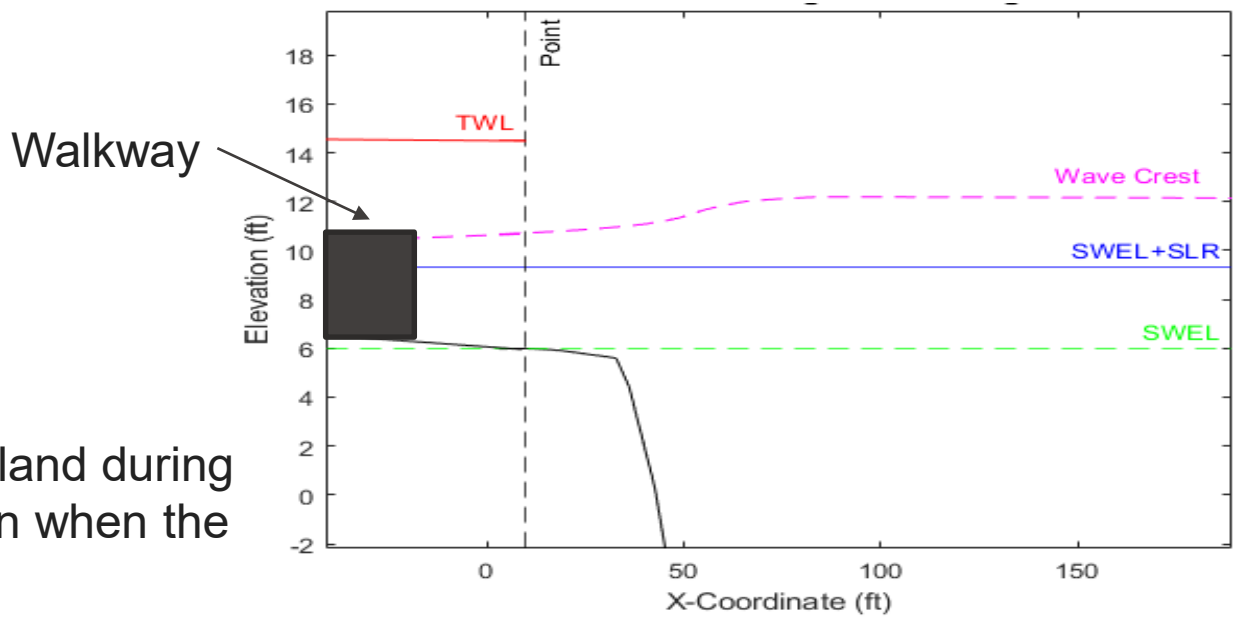
- Before the site is inundated, waves push water up against the face of the bulkhead, causing runup and overtopping (OT)
  - Results in high velocity hazards
- After the site is inundated, wave runup may occur against the flood prevention structure further inland
  - i.e. convention center building skirt, or plaza

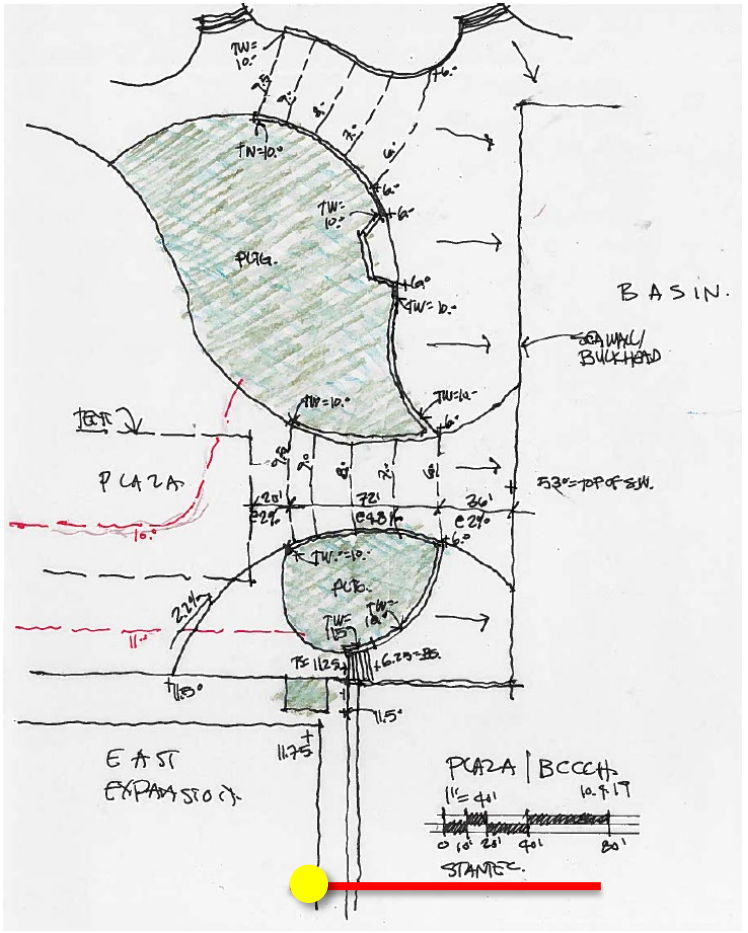
Overview: Runup Versus Overland Wave Propagation





East Expansion





Runup is calculated on land during the peak storm condition when the project site is inundated

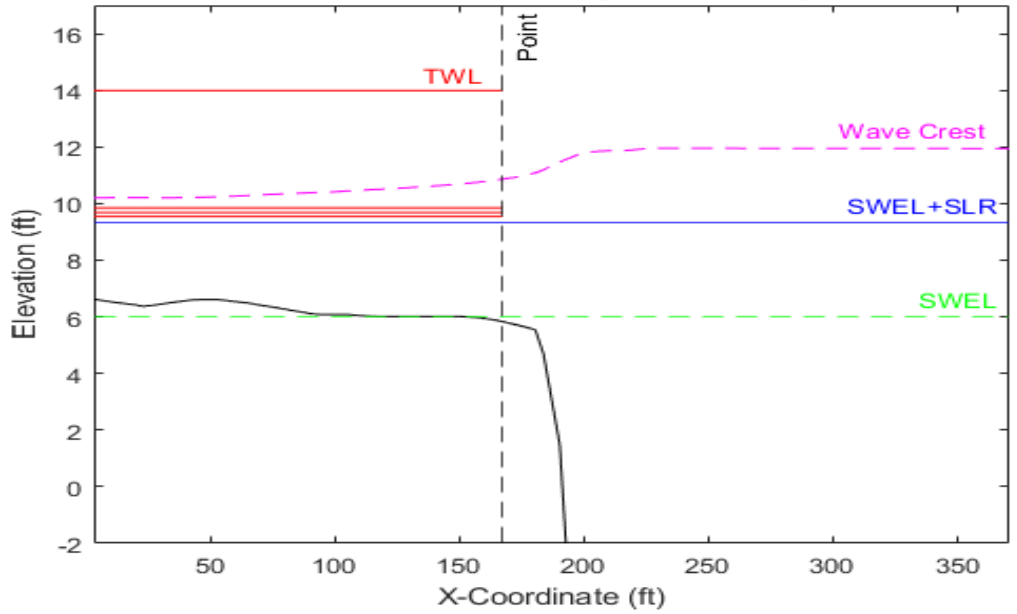
Inland at Building Skirt					
100-yr SWEL (ft*)	SLR	SWEL +SLR (ft*)	Hs (ft)	Wave Crest (ft*)	TWL (ft*)
6.38	Low	6.91	1.08	7.66	10.39
	Mid	7.49	1.53	8.56	12.07
	High	9.34	2.28	10.93	14.51

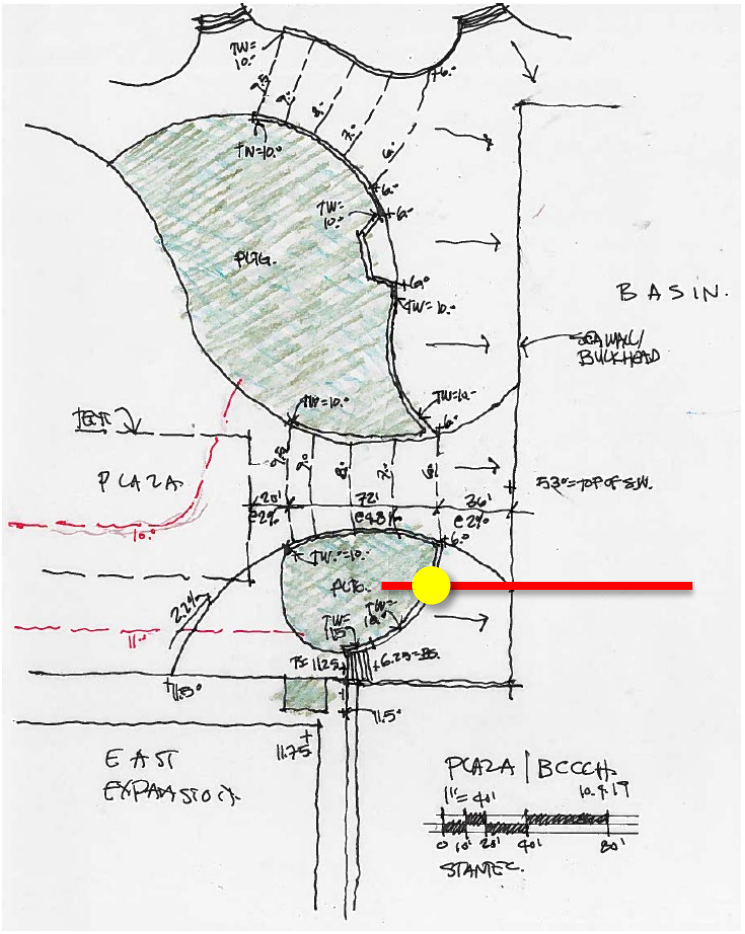
Elevation required for no OT

- Recommended elevation for the walkway
- Walkway width is to tolerate OT distance
- Recommended minimum 6” knee wall or skirt

Plaza

Runup is calculated on land with different slopes during the peak storm condition when the project site is inundated



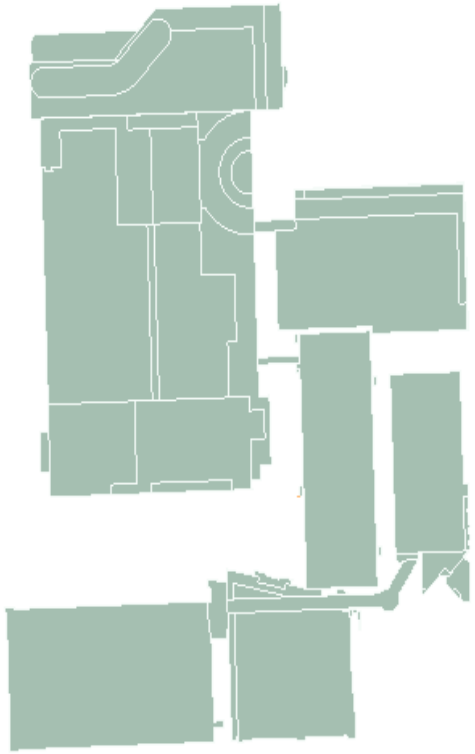


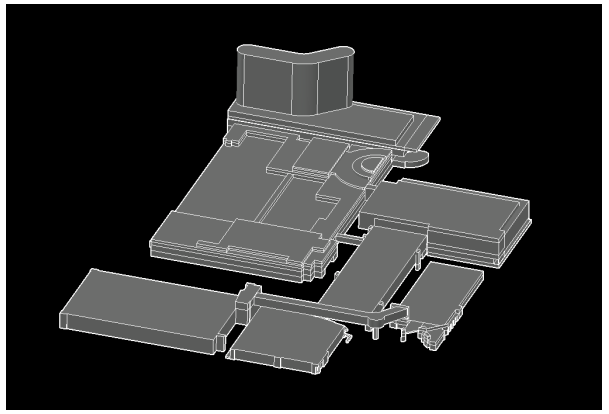
Inland at Plaza								
100-yr SWEL (ft*)	SLR	SWEL +SLR (ft*)	Hs (ft)	Wave Crest (ft*)	TWL (ft*)			
					1:50	1:30	1:20	Wall
6.38	Low	6.91	0.98	7.59	7.04	7.13	7.24	9.94
	Mid	7.49	1.42	8.48	7.66	7.77	7.91	11.59
	High	9.34	2.18	10.86	9.54	9.68	9.85	13.99

- Recommended elevation for no waves but with OT
- Lower elevation for ramps or a gently graded slope

Elevation required to minimize wave activities

Design





Recommendations

- **Convention Center Expansion**
  - Minimum walkway elevation should exceed wave crest elevation of 10.9 ft NAVD88
  - Recommend 6 ft setback with 6” knee wall or skirt to avoid OT impact
  - Walkway should drain toward the promenade
- **Plaza**
  - To prevent waves from propagating over the plaza, it should have a minimum crest elevation of 9.3 ft NAVD88
  - To minimize OT flow, the plaza should have a minimum crest elevation of 10.9 ft NAVD88; however ramps or a gently graded slope have a lower minimum elevation
- **Existing Convention Center & Hotel**
  - Inundated under SWEL + SLR, but no wave forces if is designed above 9.3 ft NAVD88