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WH403
Wilmington Harbor
H&H Workshop

10/24/2023

Agenda

Introduction
USACE Climate Analysis
Delft3D Overview
Project Objectives
Modeling Intent
Model Outcomes
Discussion

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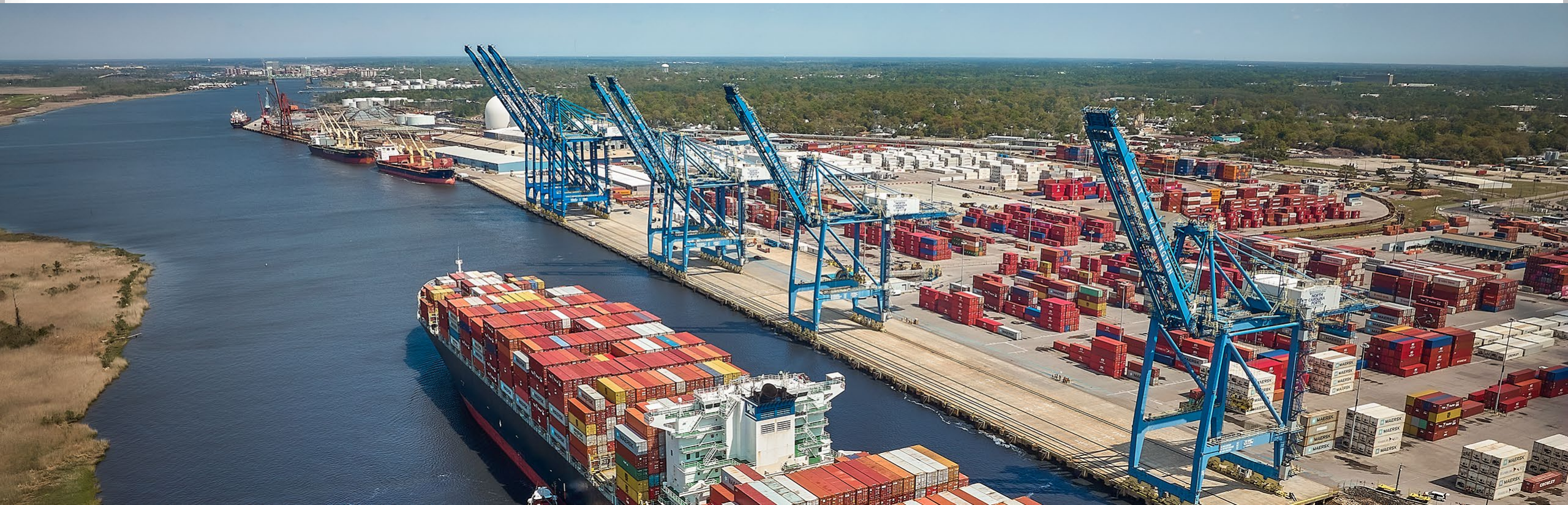
U.S. ARMY

Introduction

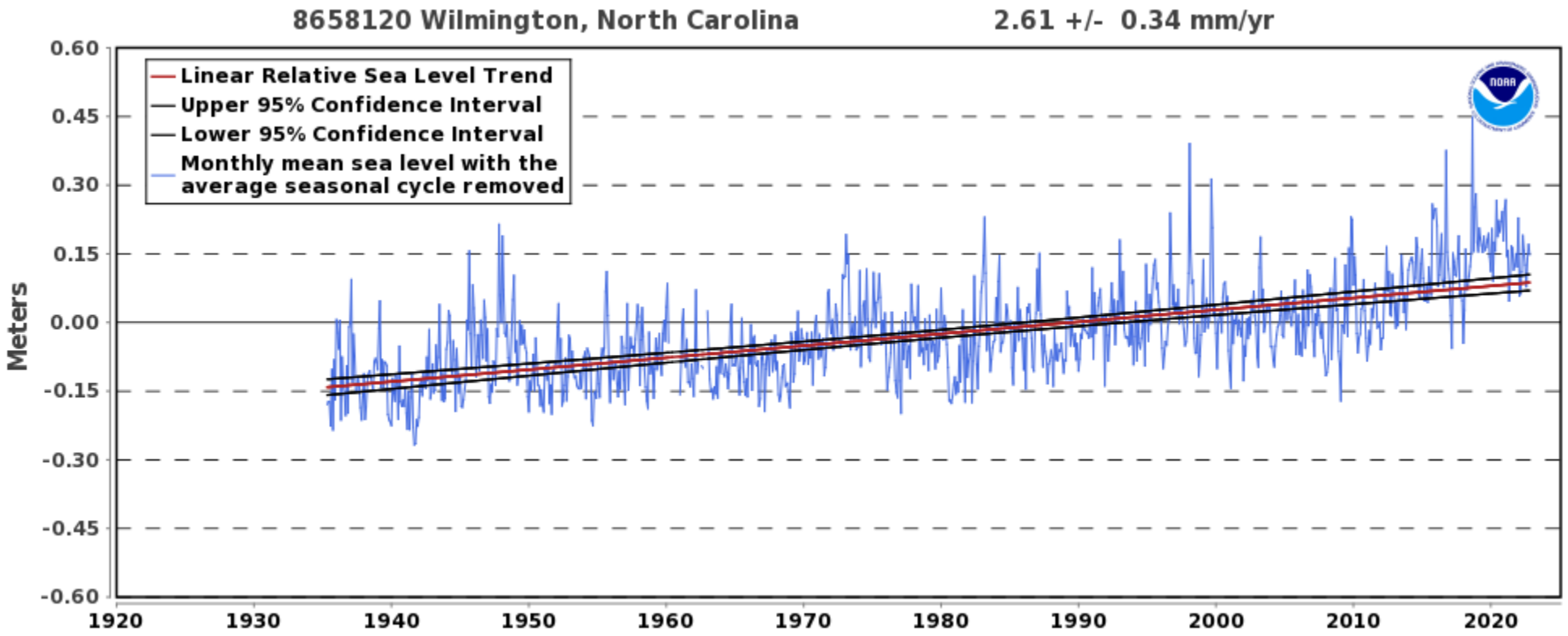


SEA LEVEL CHANGE

U.S. ARMY

NOAA tide gage at Wilmington, NC (Station #8658120)

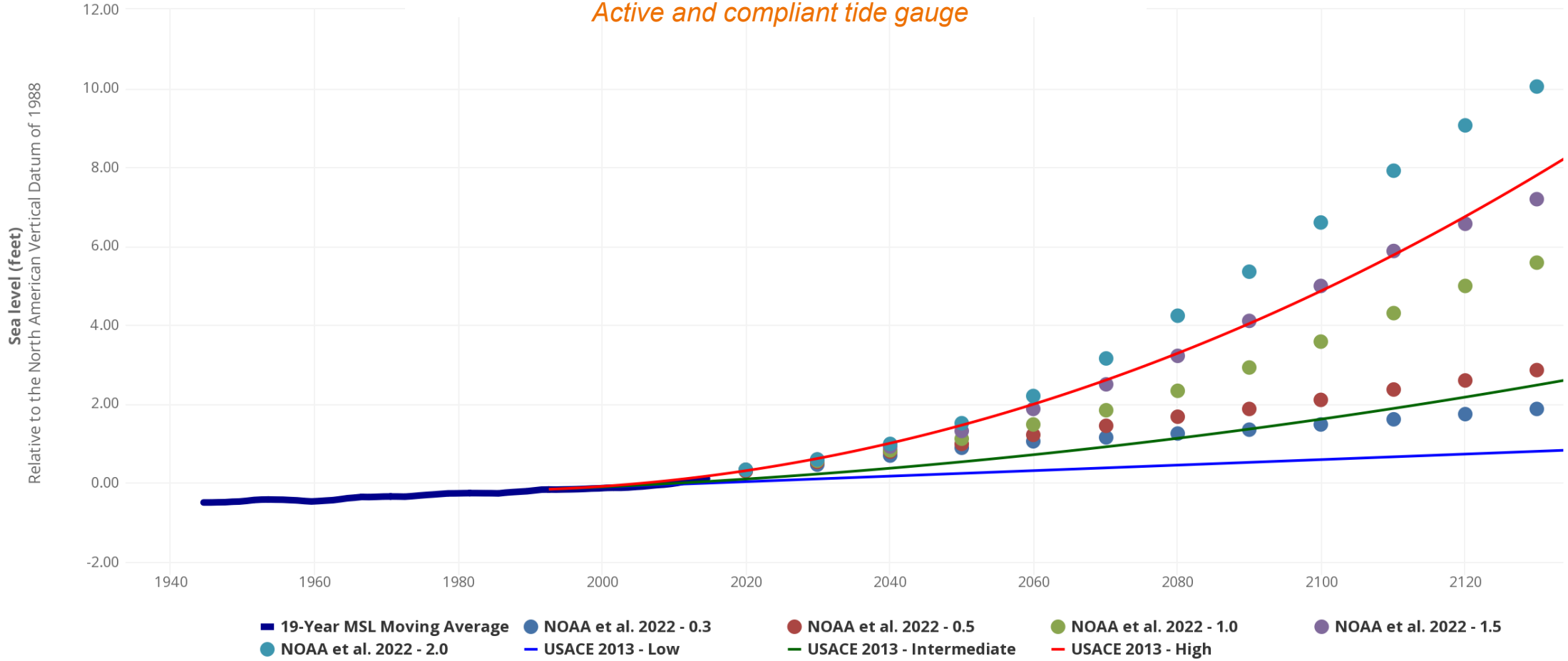
Historic Record 1935- Present



SEA LEVEL CHANGE PROJECTIONS

Sea Level Data and Projections for Wilmington, NC (8658120)

Active and compliant tide gauge

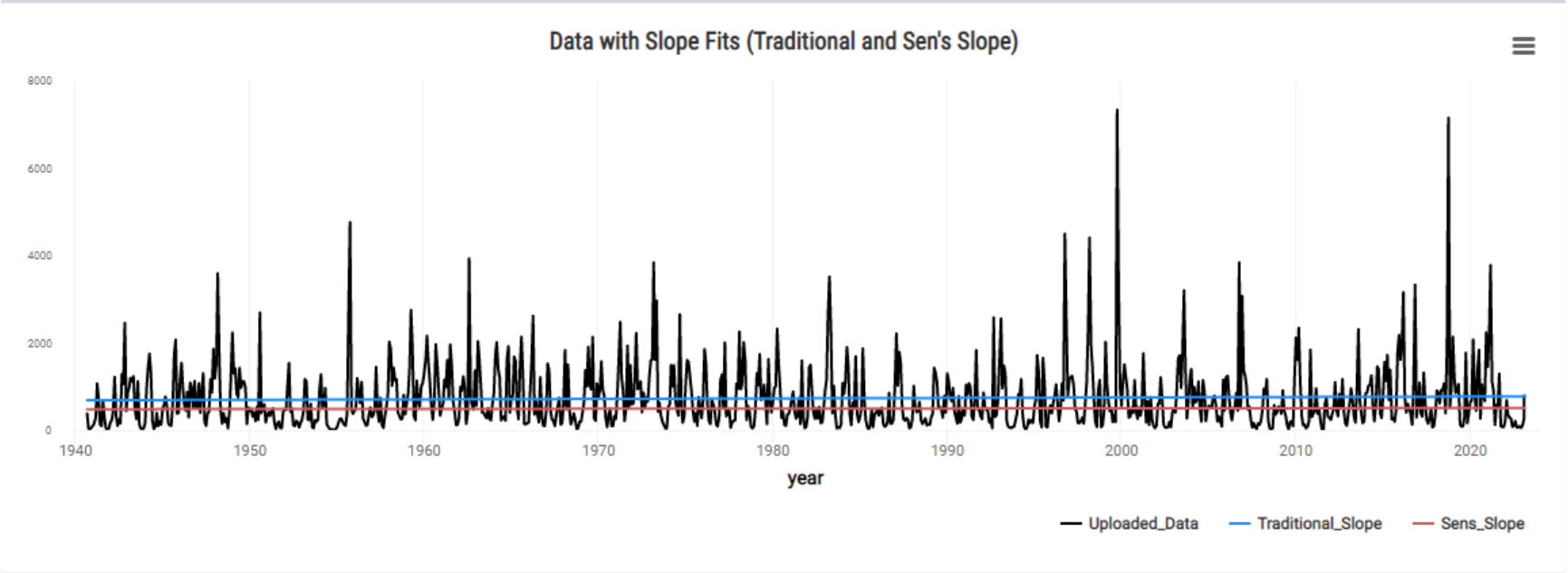


USACE Sea Level Change Predictions for Wilmington, NC (8658120) using the NAVD88 datum.
Timeframe: May, 1935 - Sep, 2023 (88 years, 5 months).
Timeframe contains 1060 missing points; the longest gap is 0 years, 0 months.
Rate of Sea Level Change: 0.00699 ft/yr (Regional 2006) .
Data points of NOAA point-in-time sources represent the median projection of sea level.

CLIMATE ANALYSIS- PAST

U.S. ARMY

- USACE Timeseries Toolbox



Trend Line Coefficients

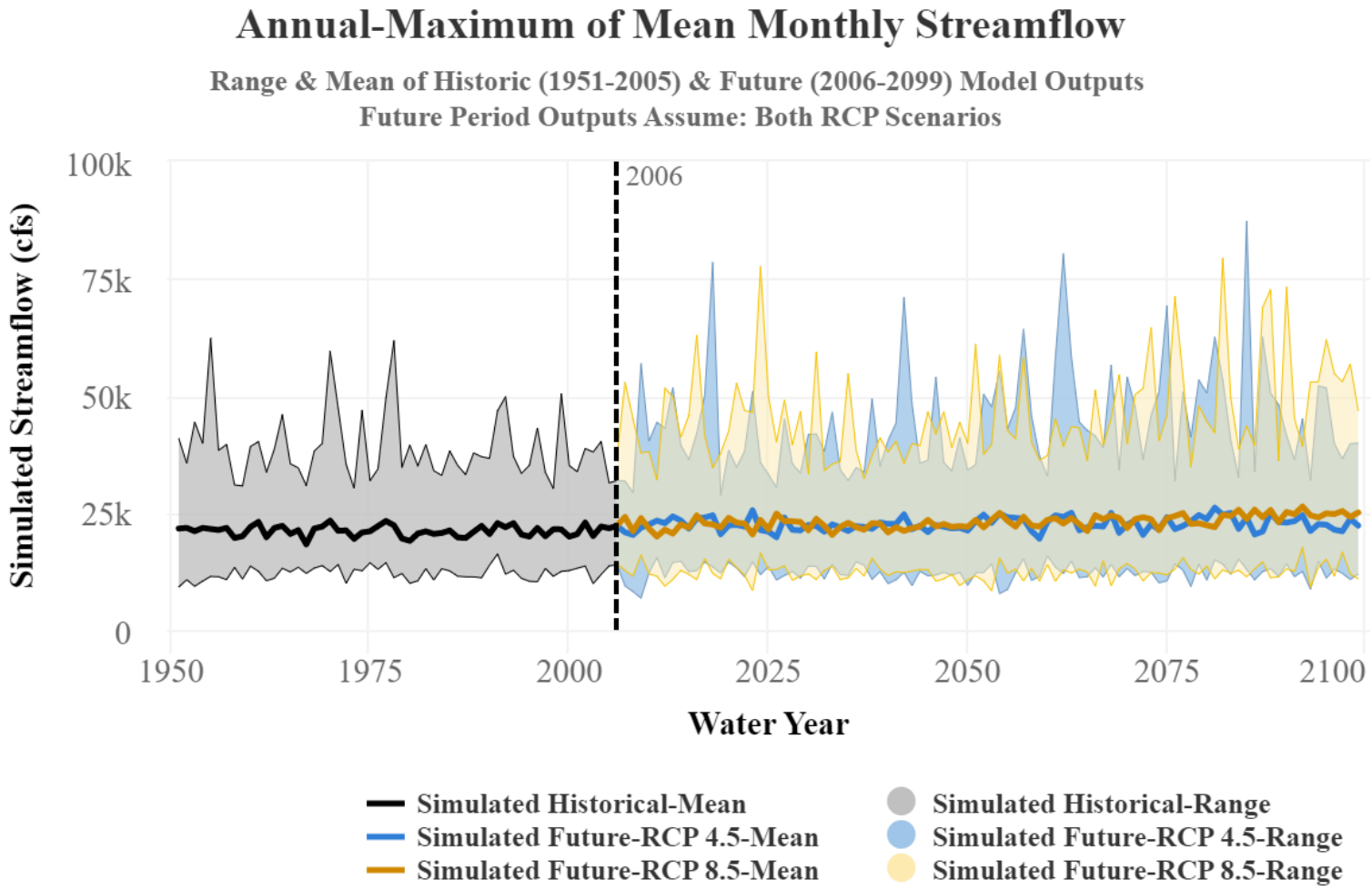
Method	Directionality	Slope	Intercept
Traditional Slope	Positive	1	-1404
Sen's Slope	Positive	0.3357692308	-176

Trend Hypothesis Test

Test	P-Value
t-Test	0.27511
Mann-Kendall	0.54181
Spearman Rank-Order	0.54942

CLIMATE ANALYSIS- FUTURE

- USACE Climate Hydrology Assessment Tool



Questions

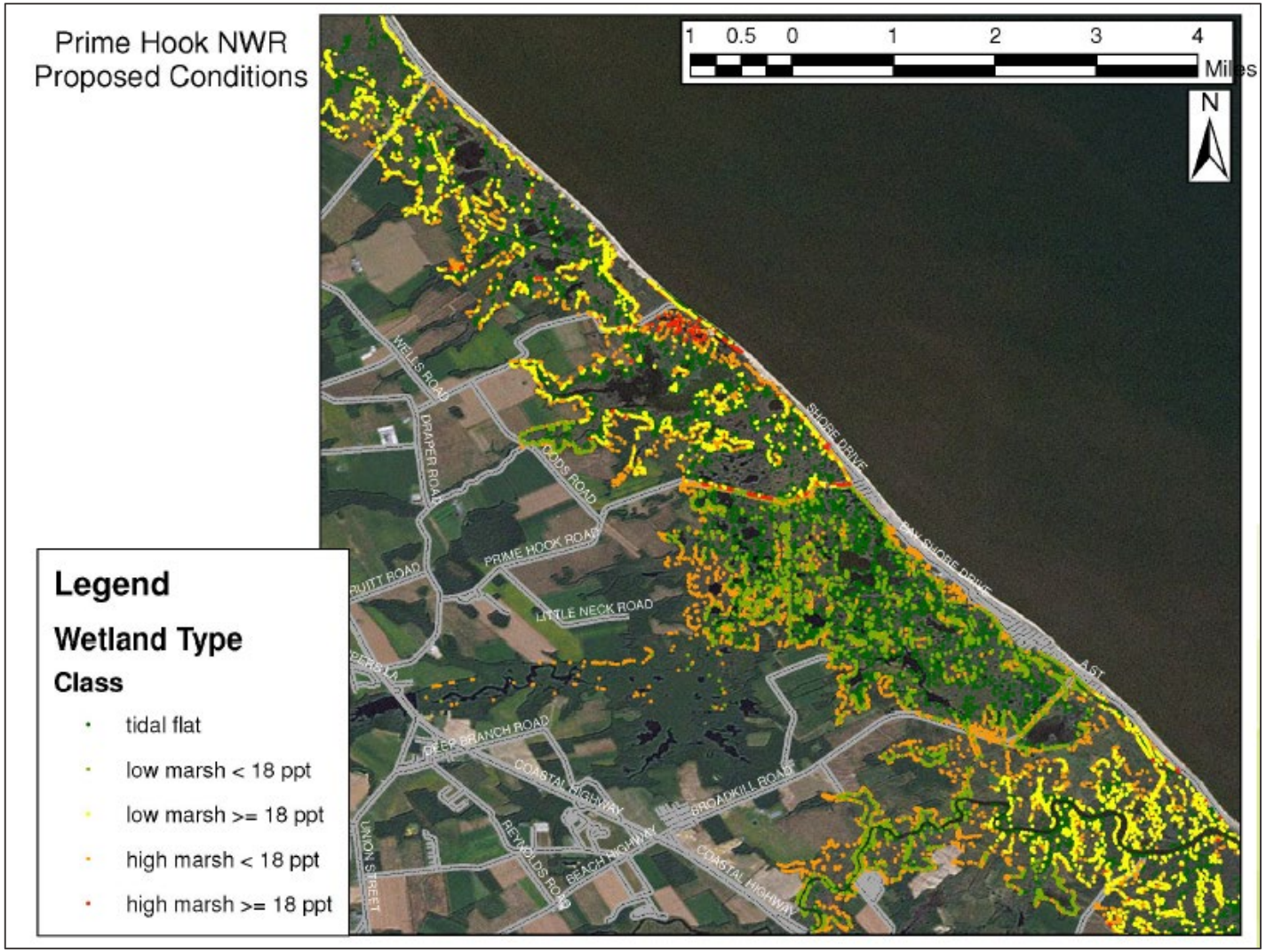
Delft3D Overview

Description

- Integrated, open-source software suite for computing physics of coastal, estuarine, and riverine areas
- Multidimensional (2D/3D) curvilinear grid

Components

- Hydrodynamics (flows)
- Waves
- Sediment transport & morphology
- Water quality
- Particle tracking
- GUI for pre/post-processing



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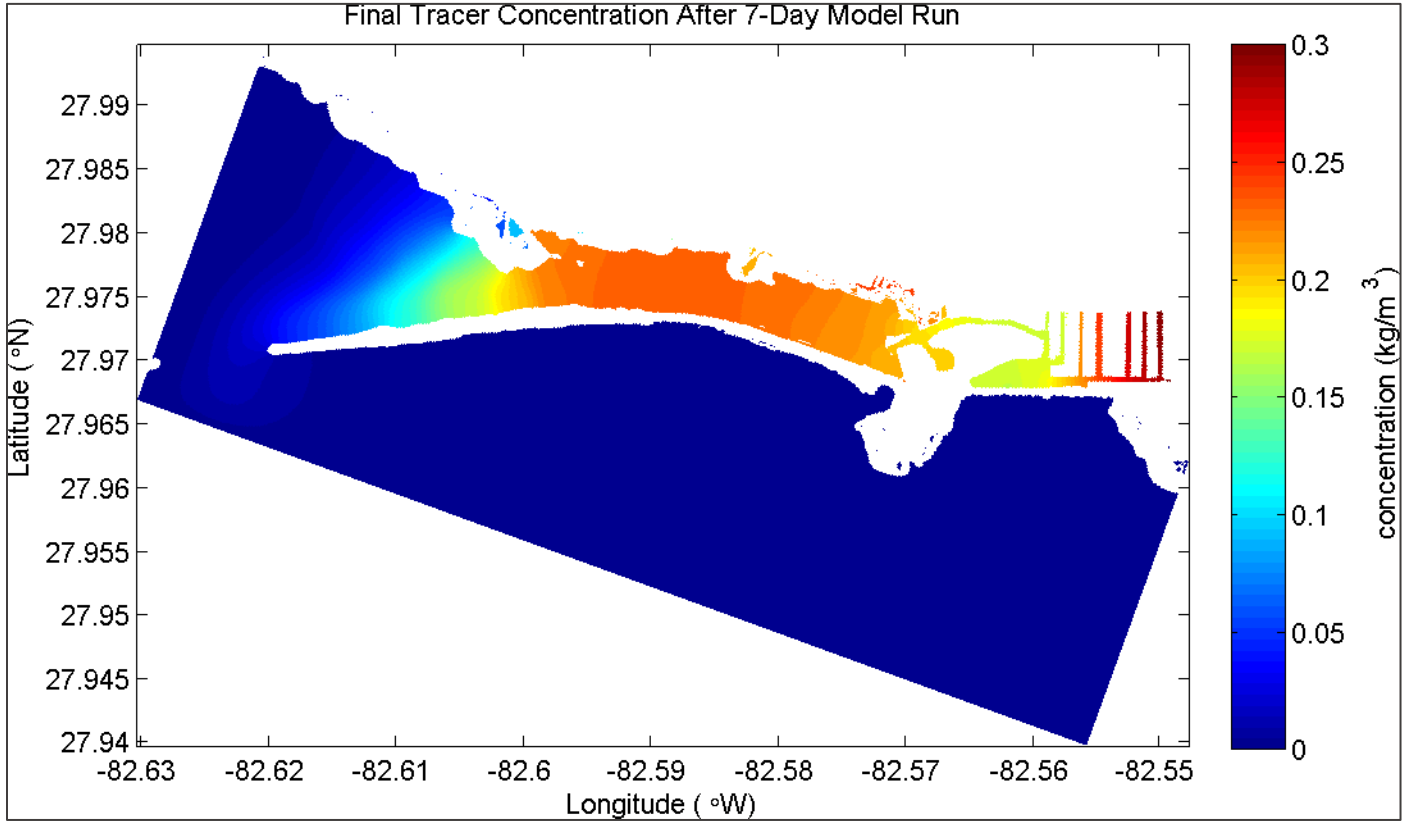
Delft3D Overview

Features

- Tidal forcing, Coriolis force
- Density-driven flows (temperature, salinity)
- Space and time varying wind
- Riverine discharges, sources/sinks
- Dynamic coupling of flows, waves, and sediment

Applications

- Tide and wind-driven flows (storm surge)
- River flows, salt intrusion
- Sediment transport and morphology



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Project Overview

Port of Wilmington Navigation Channel

- Channel deepening/widening
  - Future without project (FWOP)
  - 2 additional alternatives
  - Modeling idealized (fully authorized) templates
  - Sea level change (SLC) incorporated

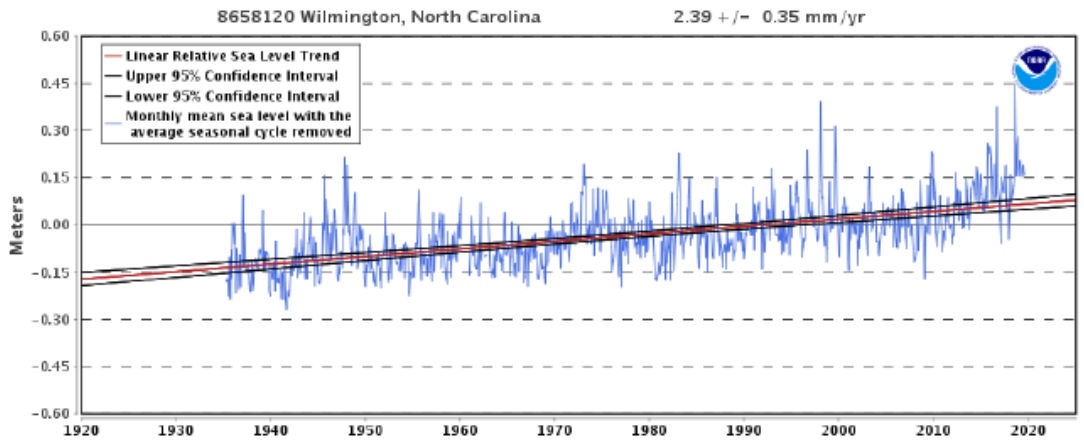

Figure 1-24: Historical Water Levels for Wilmington, NC

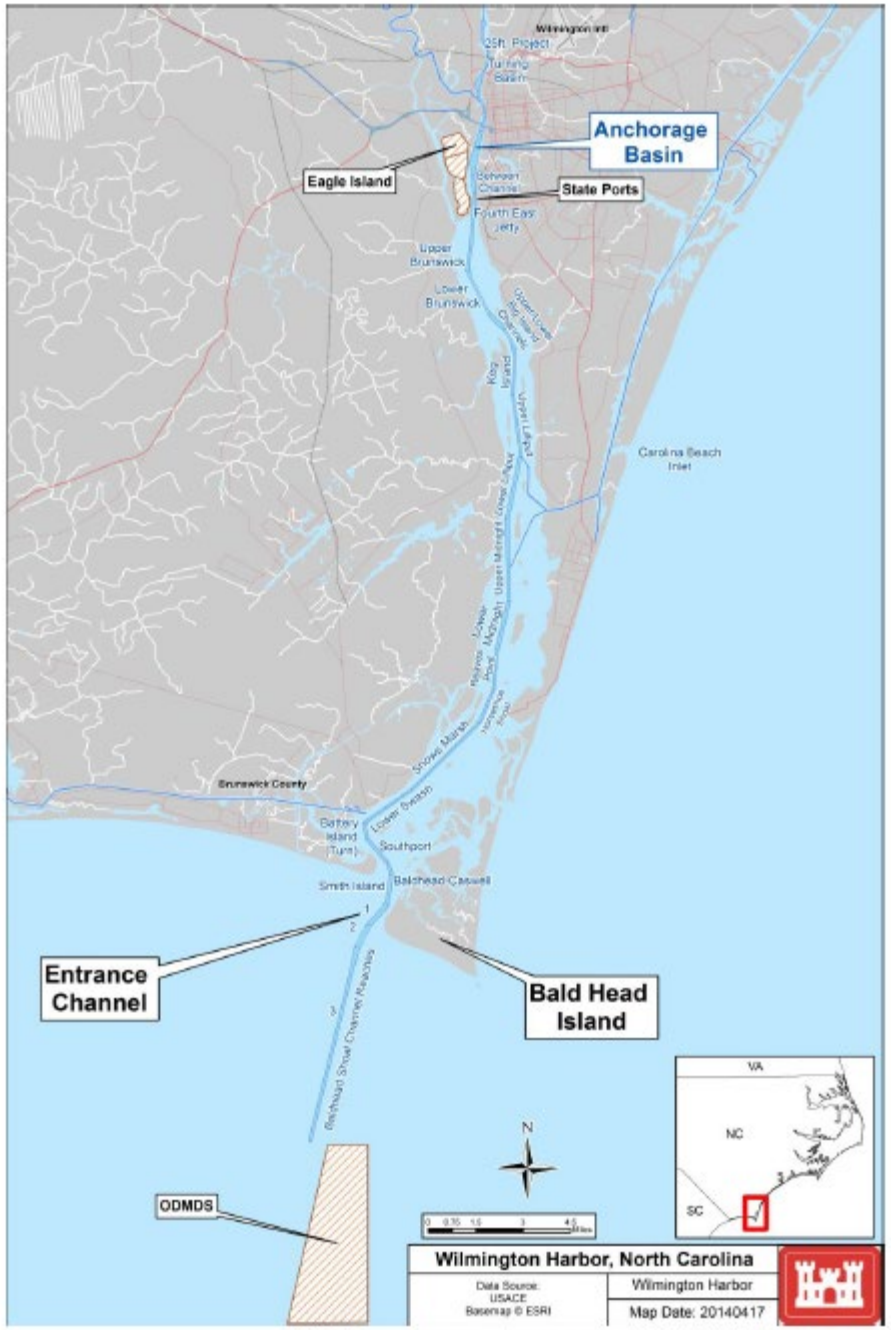

Figure 1-1: Cape Fear River Navigation Channel (USACE, 2014)

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Study Objectives

Update to NCSPA Section 203 Study and DEIS

- Delineate existing physical conditions – water levels, wind, waves, SLR, salinity, etc.
- Numerical modeling of existing and proposed alternatives
  - Hydrodynamics
  - Salinity
  - Suspended sediment
  - Water Quality
  - Offshore waves
  - Shoreline evolution
  - Inlet morphology
  - Vessel wake modeling

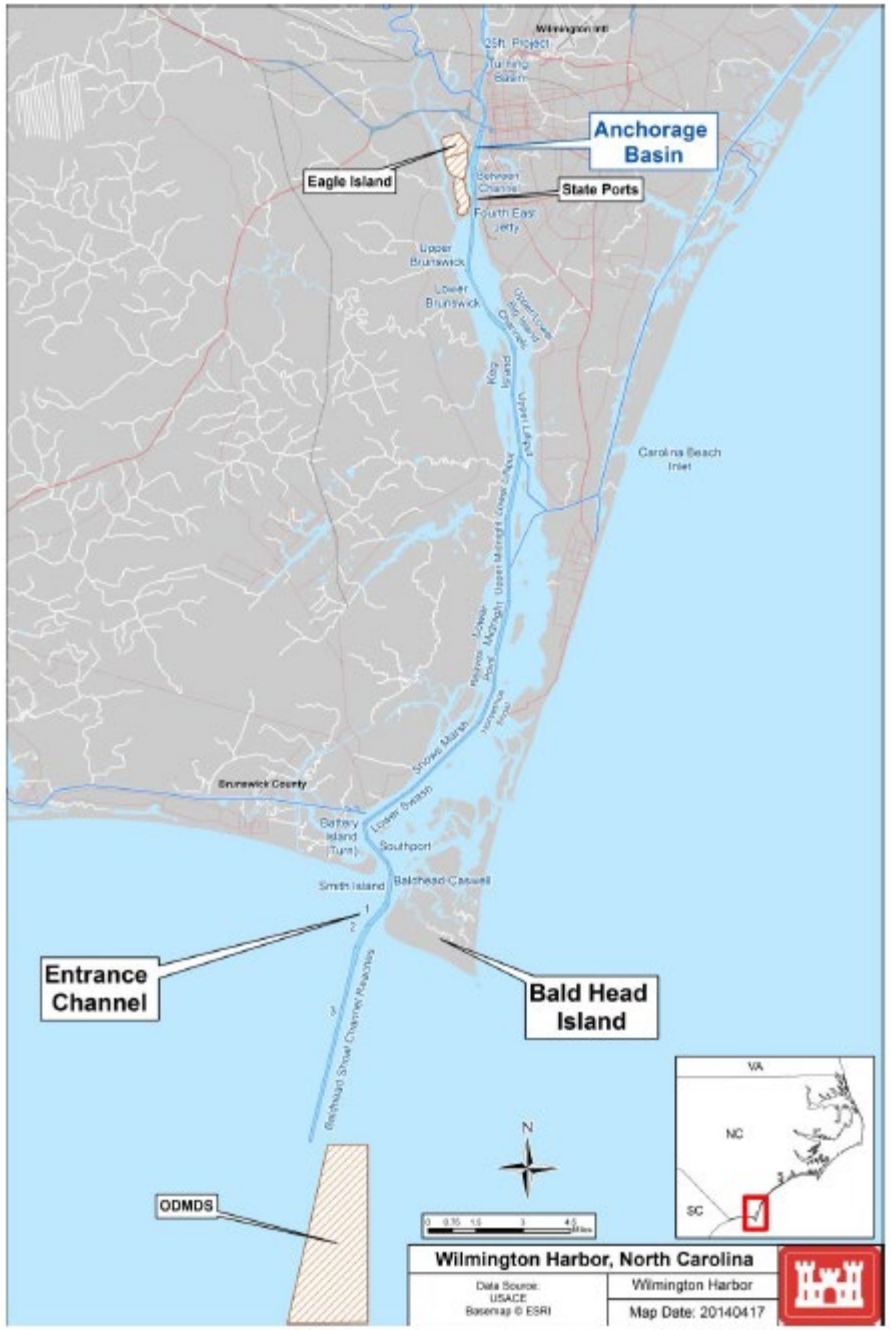

Figure 1-1: Cape Fear River Navigation Channel (USACE, 2014)

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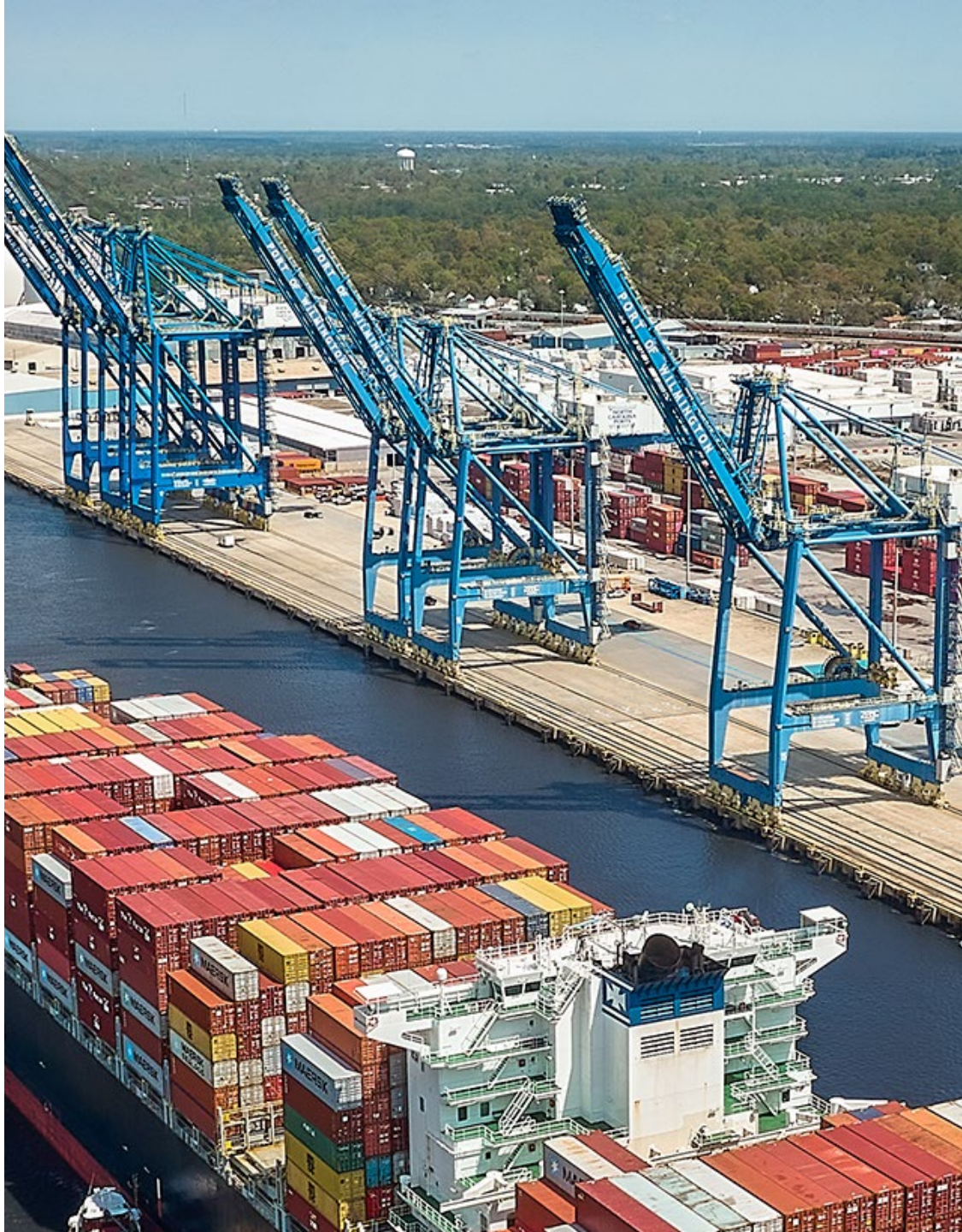
Study Objectives

Primary objective

- Evaluate multiple alternatives for navigation channel deepening
- Leverage NCSPA 203 study as much as possible to maximize efficiency and consistency
- Address unresolved comments of 2020 ASA(CW) Review Assessment
  - Climate hydrology
  - Sea level rise
  - Tide range impacts



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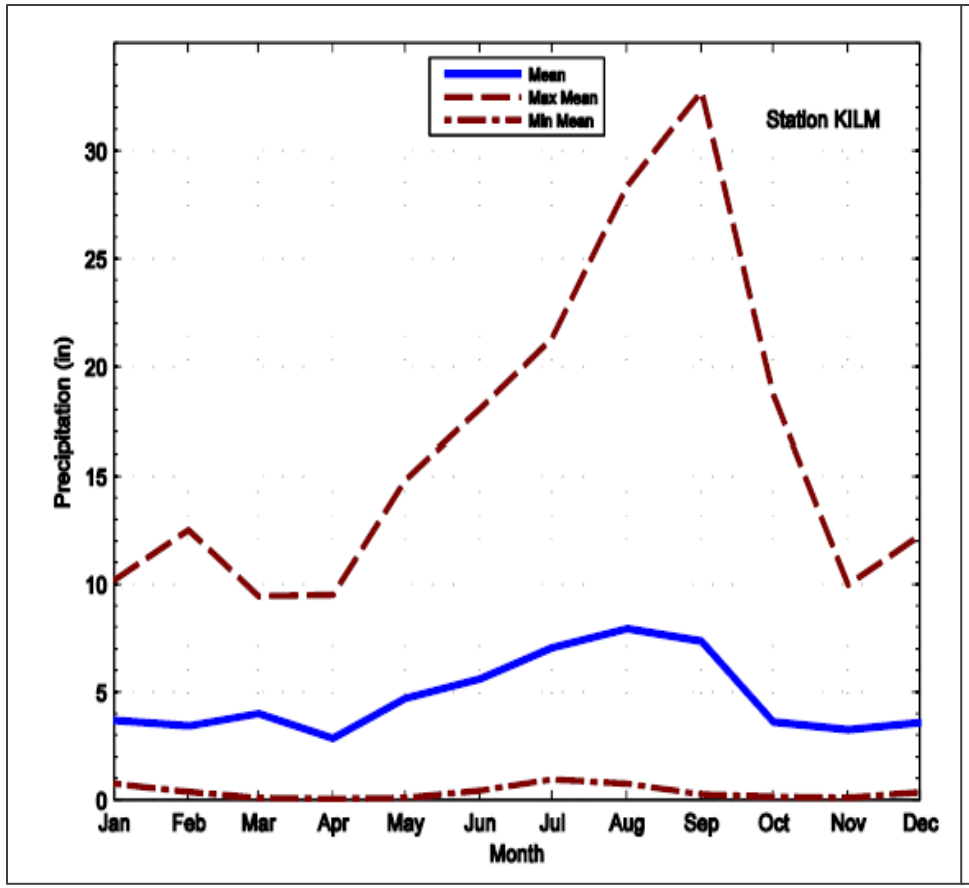
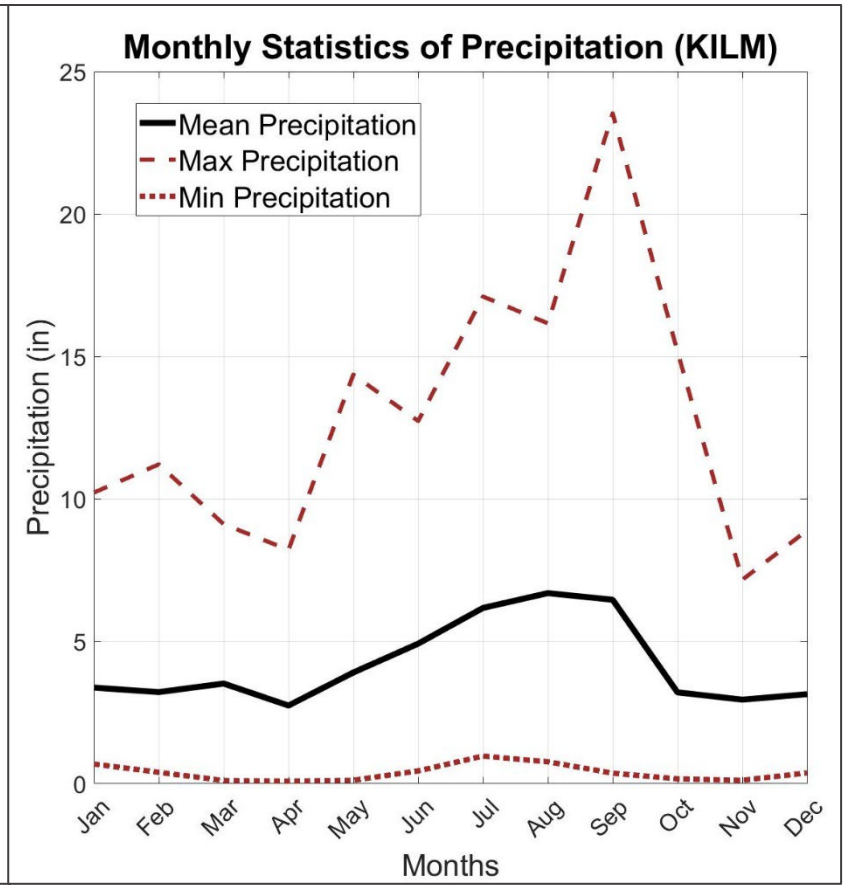
Update Physical Conditions

Existing Conditions

- Existing project
- Water levels
- Wind
- Waves
- Precipitation
- Riverine discharge
- Salinity
- Water quality
- Dredging
- Sea level rise
- Climate hydrology
- Data collection
- (water levels, currents, salinity)





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Numerical Modeling - Hydrodynamics

- Spatial resolution: 5 m to 90 m, 25 vertical layers
- Varying bottom friction
- Offshore tidal boundary from OSU Tidal DB
- Uniform wind and precipitation
- Multiple riverine discharges
- Calibrated w/ measured data (2017)

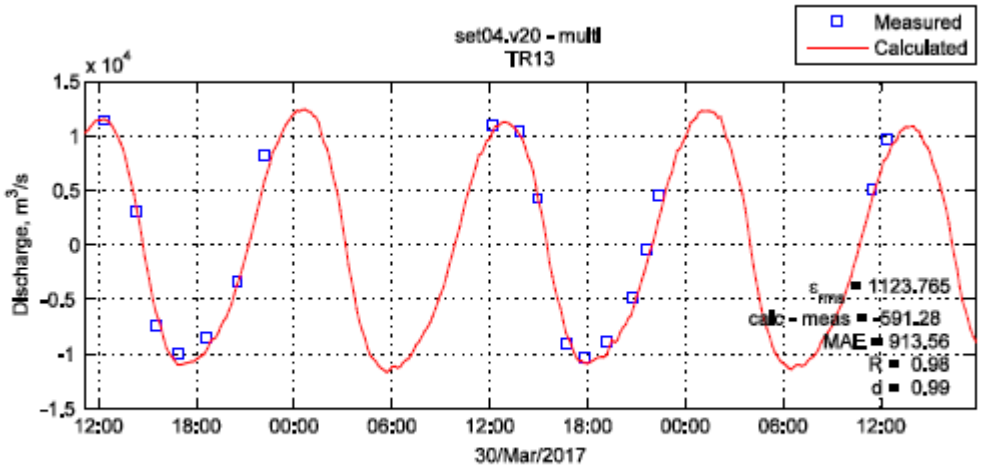

Figure 4-15: Comparison of discharge measurements to model results

Figure 4-2: Model domain and grid

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Numerical Modeling – Salinity

- Built upon hydrodynamic model

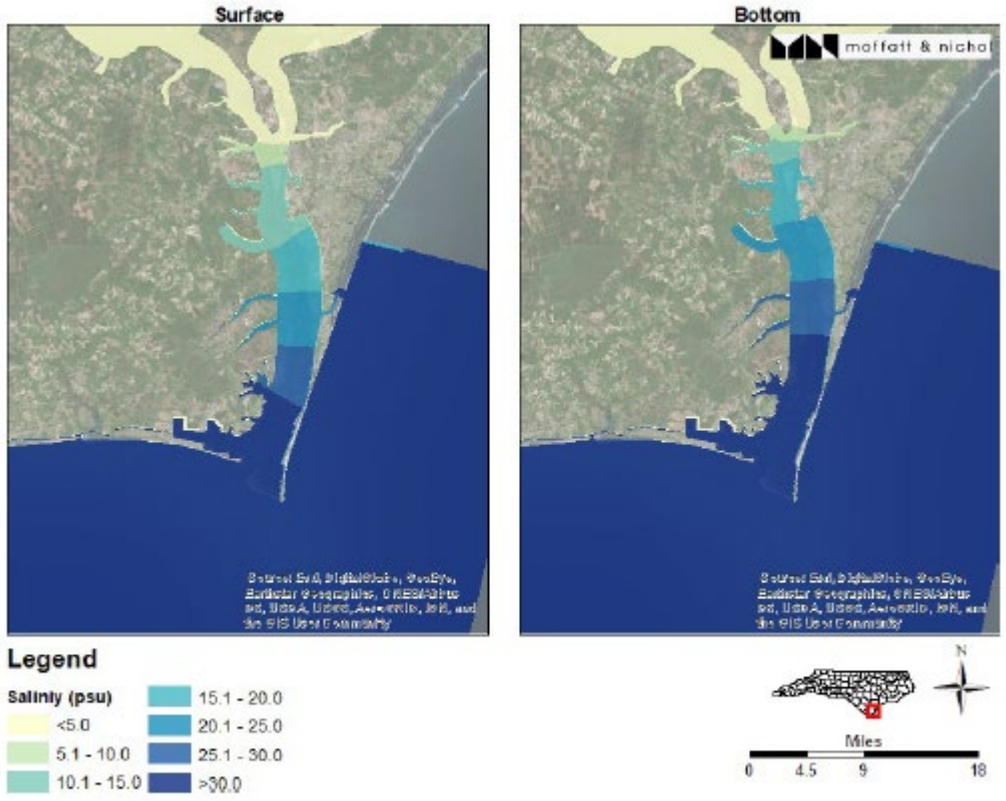
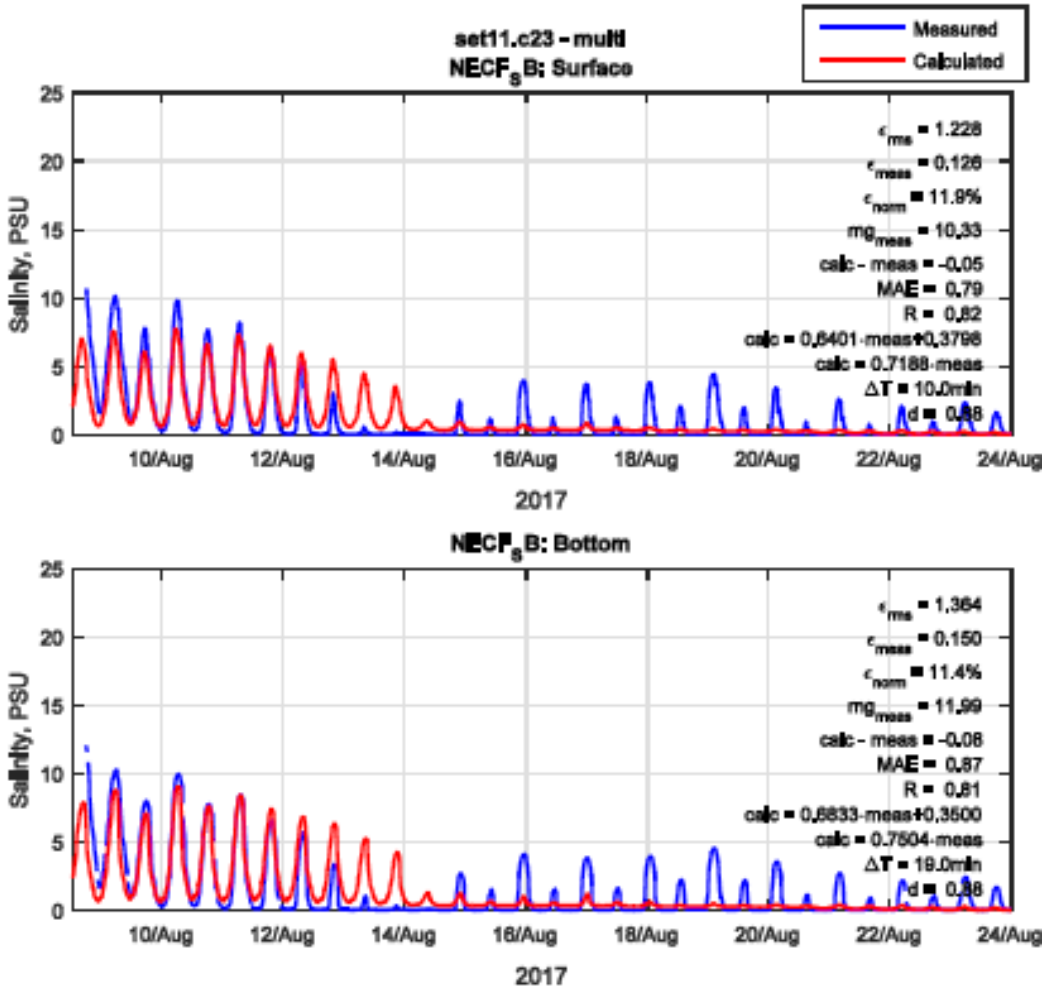


Figure 4-38: Surface (left) and bottom (right) initial salinity conditions for the late summer 2017 calibration period.



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Numerical Modeling – Suspended Sediment

- Built upon hydrodynamics/salinity
- Anchorage basin sedimentation

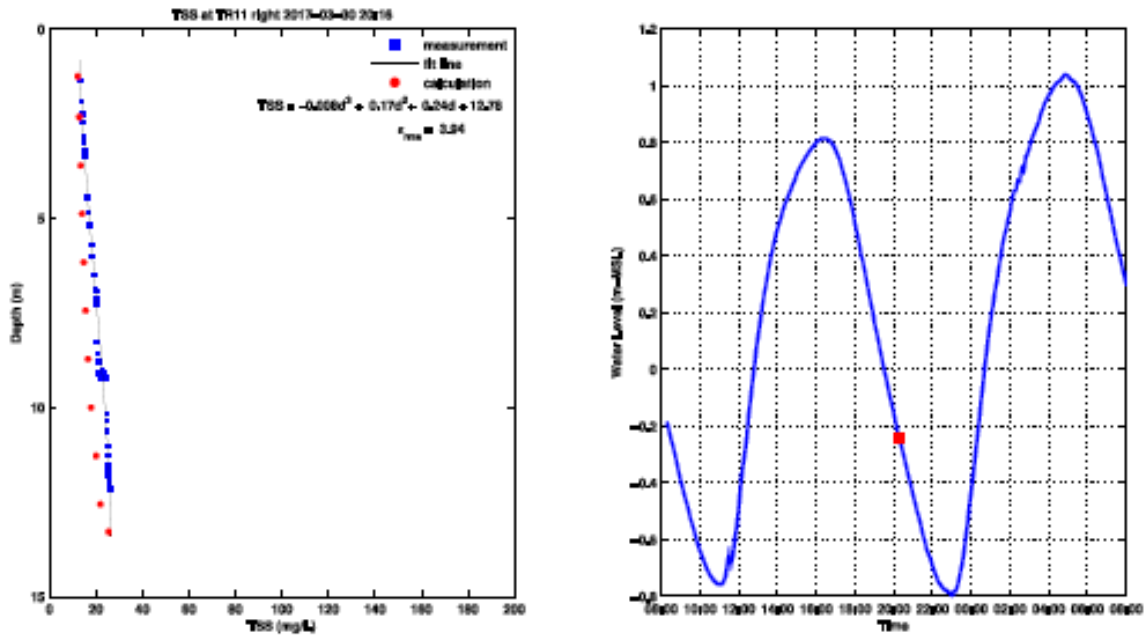

Figure 4-78: TSS cast at right side of TR11 during ebb tide

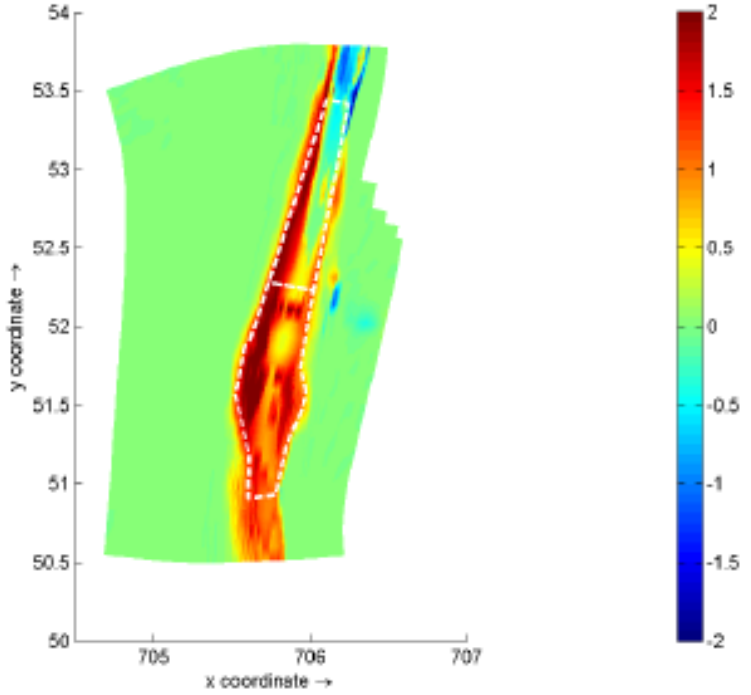

Figure 4-94: Cumulative erosion/sedimentation (ft/yr) for Extremely High Flow (Extremely High × 3)

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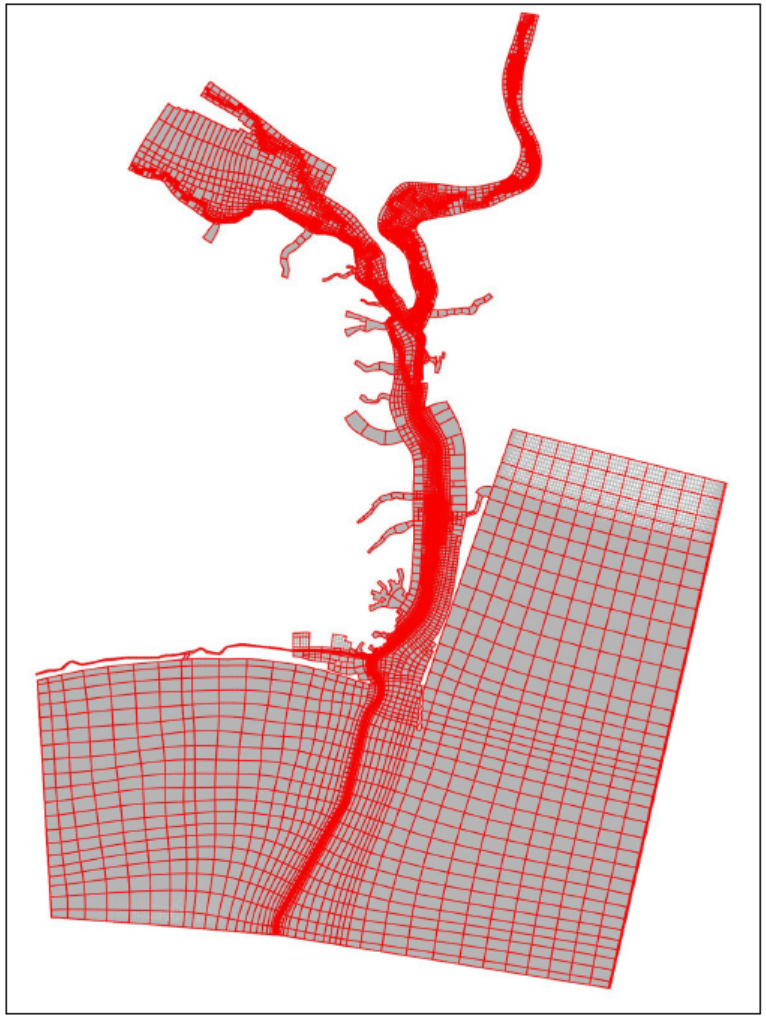
Numerical Modeling – Water Quality

- Built upon hydrodynamics, salinity, sediment output



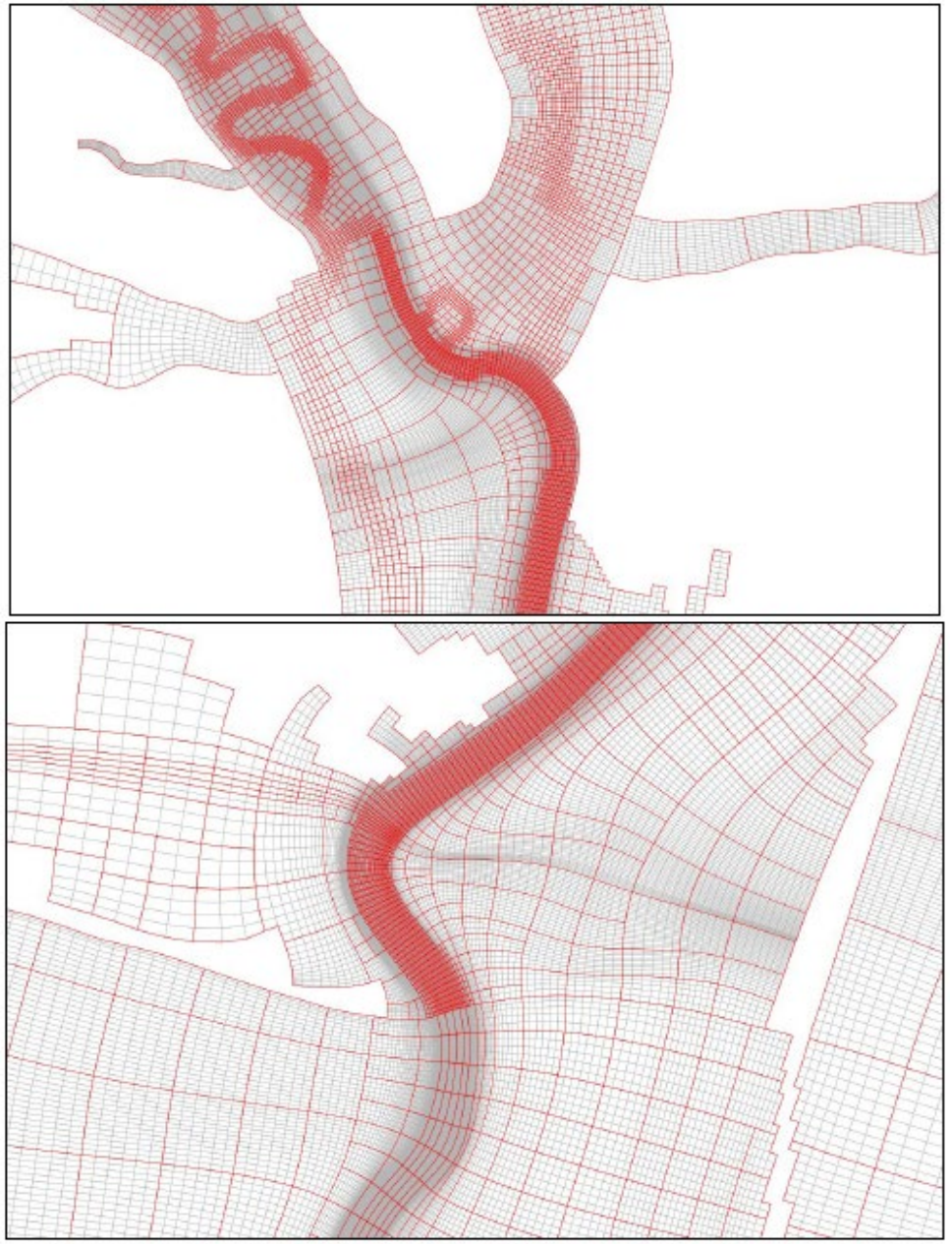


Figure 4-102: DELWAQ model horizontal grid aggregation adjacent to the Wilmington Port and the Cape Fear River entrance (red – aggregated DELWAQ grid; gray – hydrodynamic model grid)

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Numerical Modeling – Offshore Waves

- Get conditions for shoreline evolution and inlet morphology
- 3 nested model grids for varying detail
- Calibrated against ADCP wave data

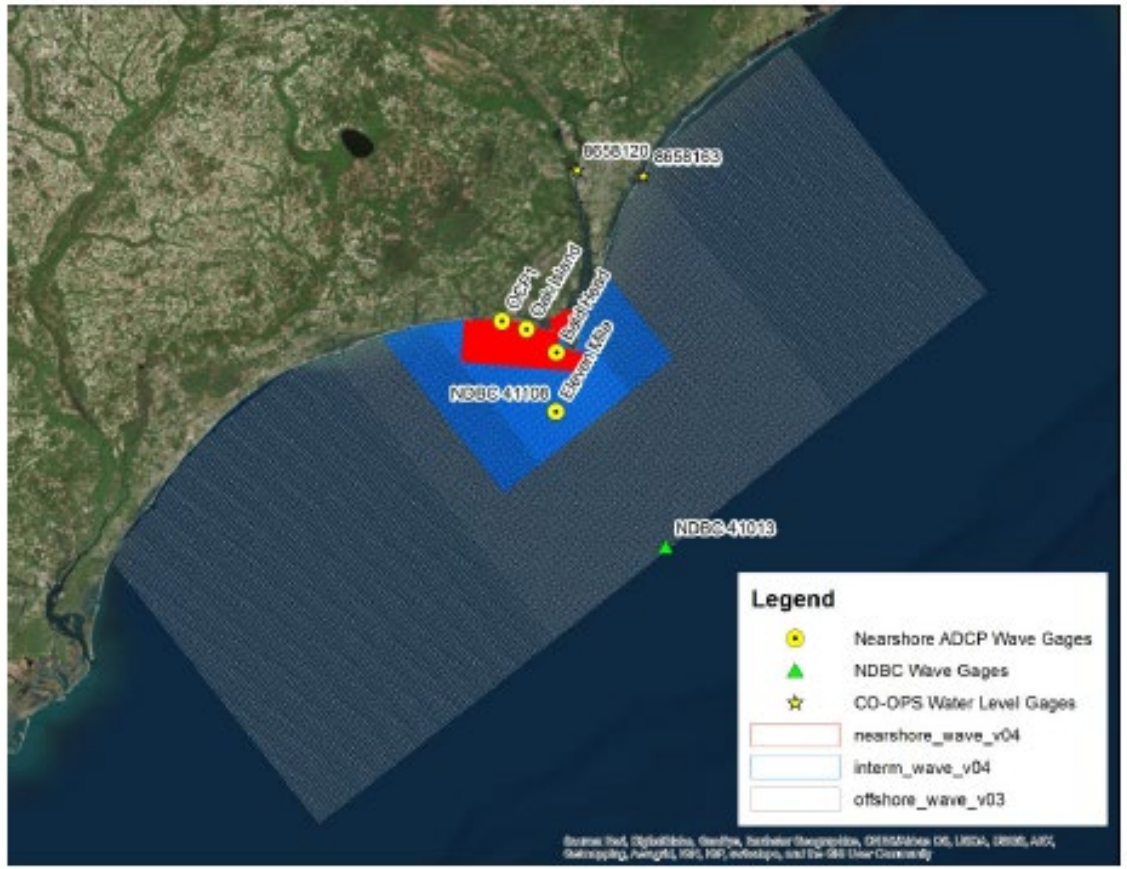

Figure 7-1: Wave model grids and wave gage locations

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Numerical Modeling – Shoreline Evolution

- GenCade 1D shoreline model

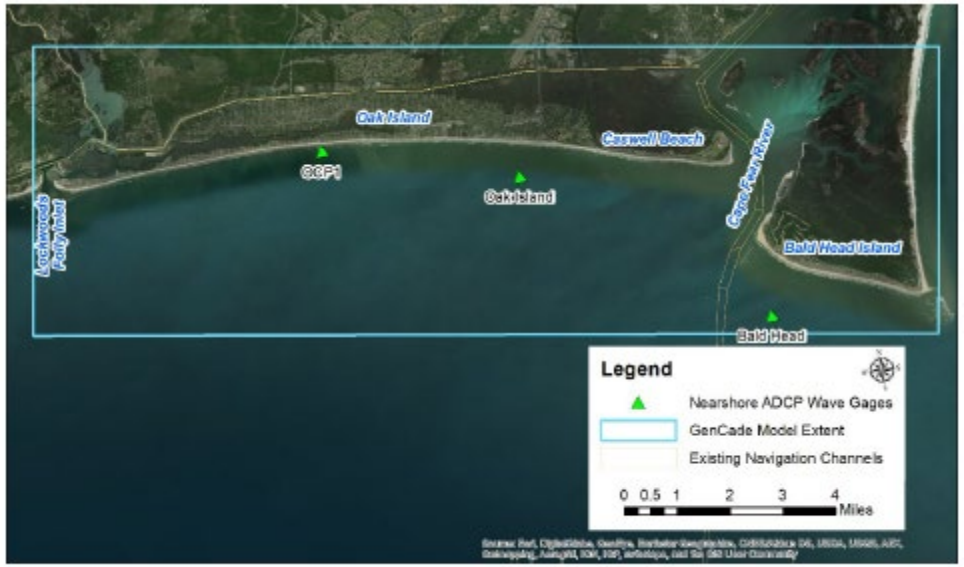

Figure 7-26: GenCade model extent

Figure 7-37: GenCade calibration – Oak Island shoreline changes

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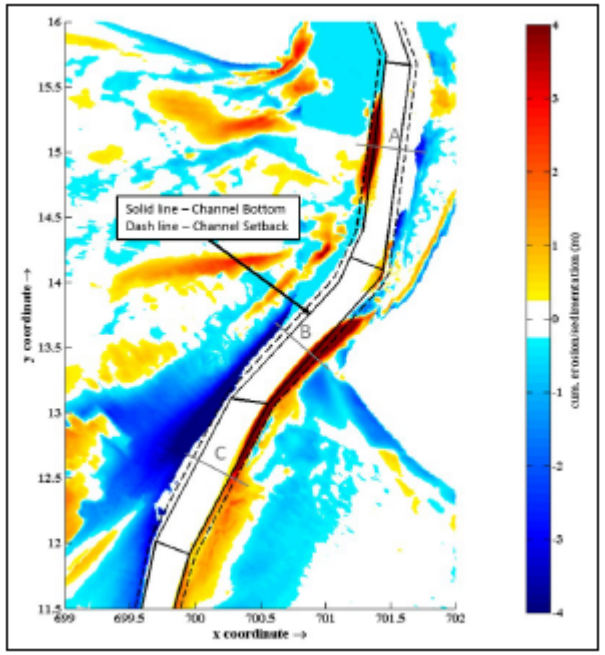
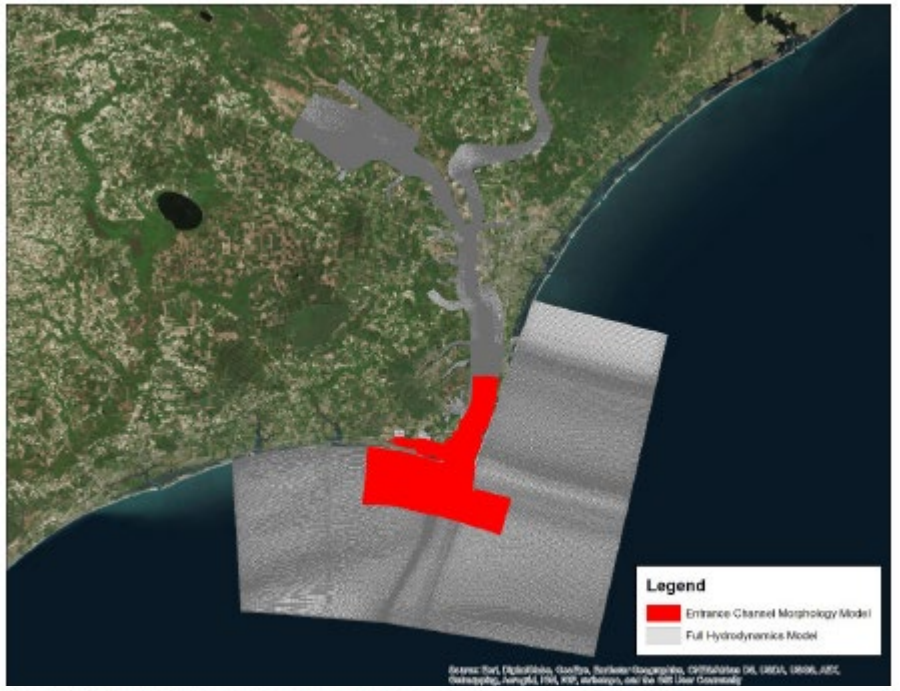
Numerical Modeling – Inlet Morphology

- Smaller, finer model surrounding inlet
- Based on hydrodynamic model results and wave model results
- Tide schematization – 'morphological tide'
- Wave schematization – OPTI method (Mol 2007)
- Shoaling volumes and rates





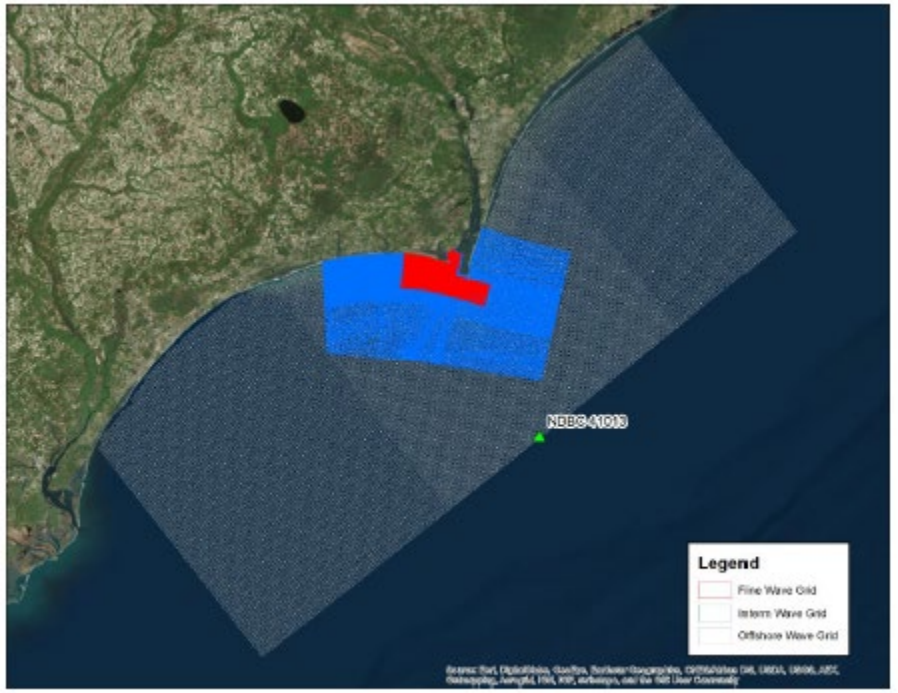


Figure 7-46: Wave grids for morphological modeling

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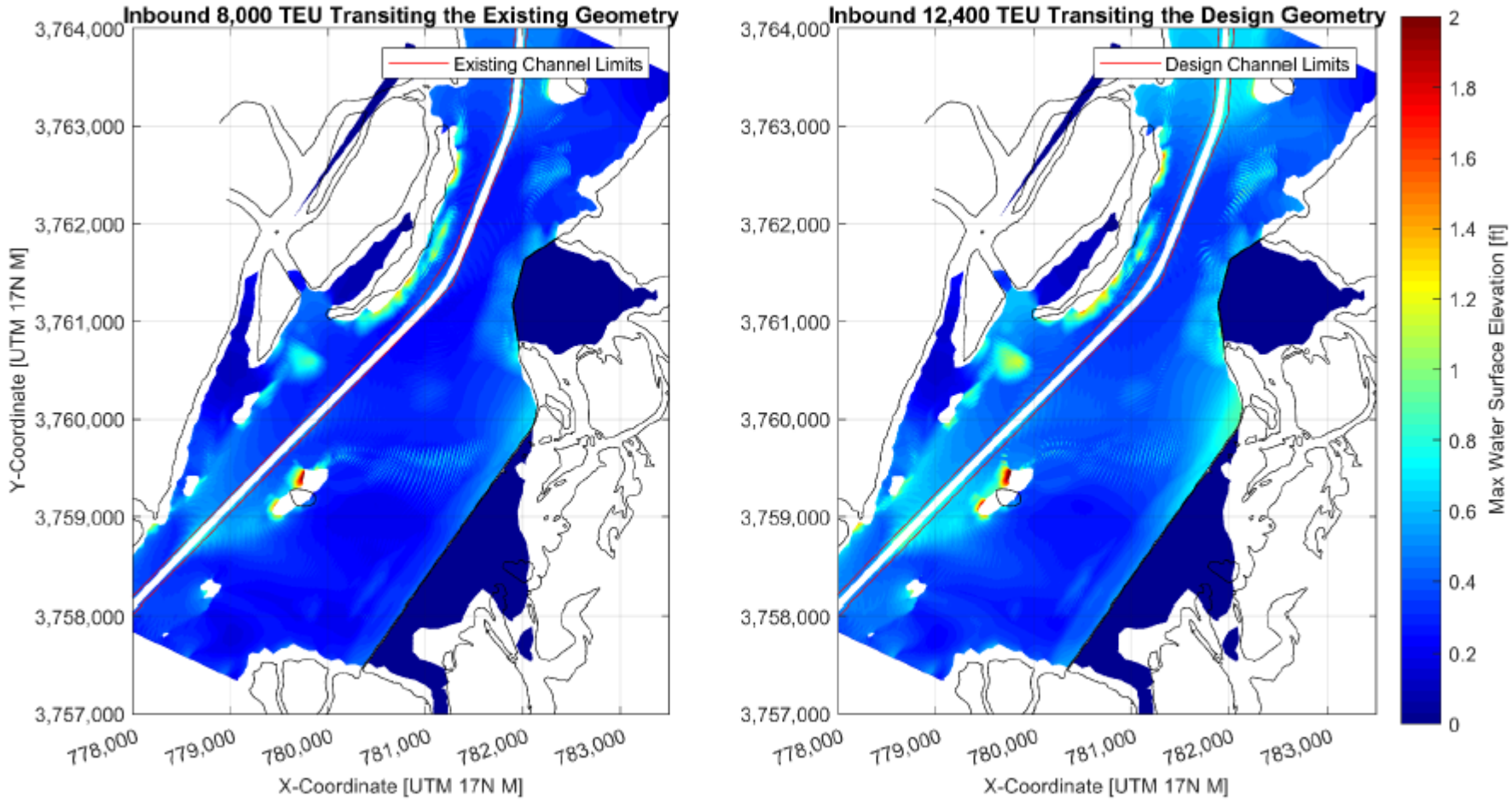
Numerical Modeling – Vessel Wakes

- XBeach model
- Changes in peak water surface elevation and bed shear stresses



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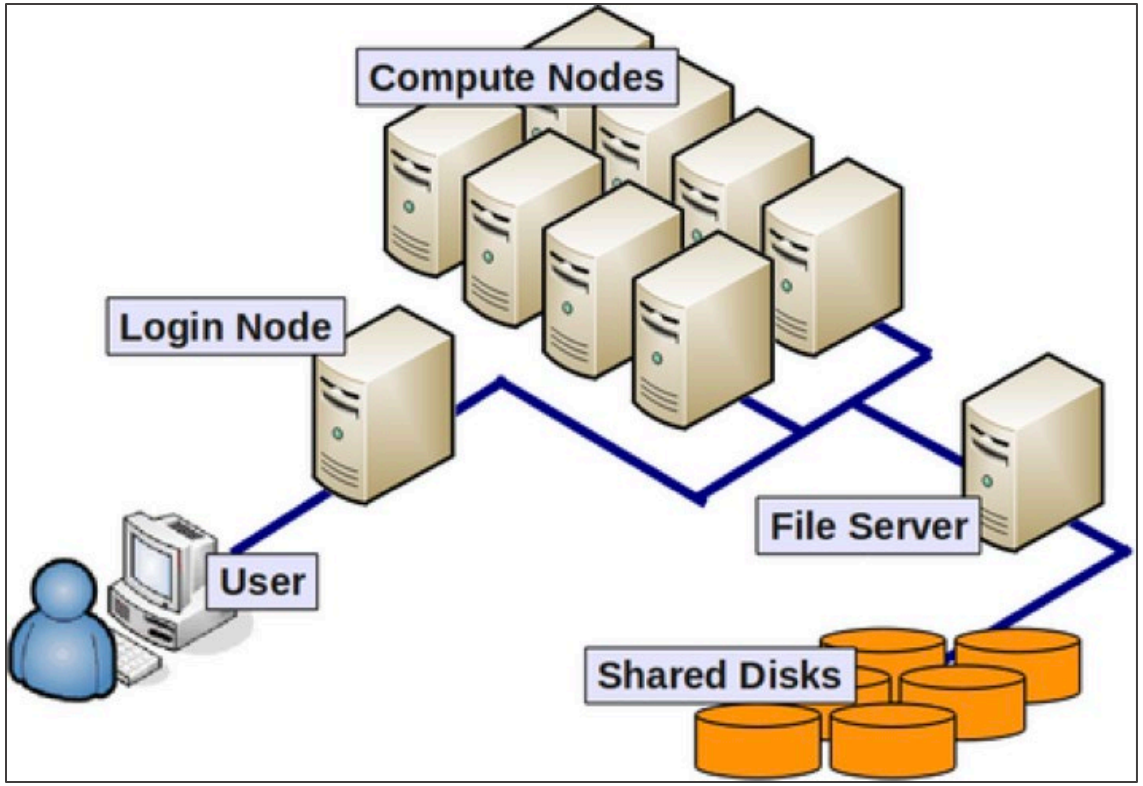
Questions

Numerical Modeling – Time and Computing Requirements

- Delft3D model is extremely detailed in space, time, and parameters
- High Performance Computing resources necessary to run models
- Hundreds of processors and days of 'wall time' for each run
- Massive storage requirements (16+ TB)
- Parameterized hydrodynamics (sequencing of select representative scenarios) to simplify and streamline computation, minimize resource needs



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Questions

Model Outcomes

- Compare changes to circulation, morphology, water quality
- Tidal range impacts
- Hurricane velocities and storm surge
- Salinity, water temp, DO
- Anchorage basin shoaling

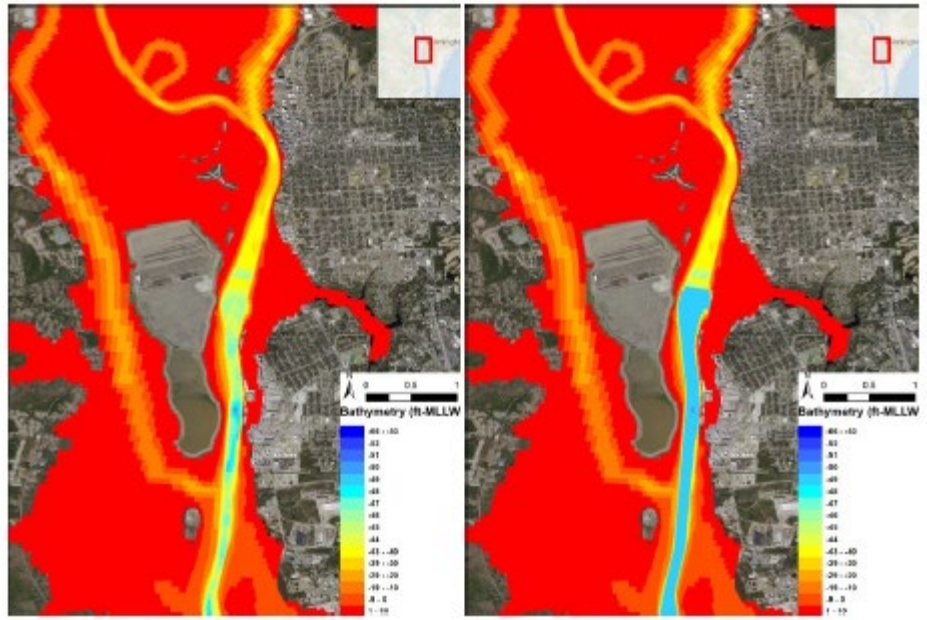

Figure 5-1: Bathymetry map near Wilmington (left: FwoP, right: FwP)

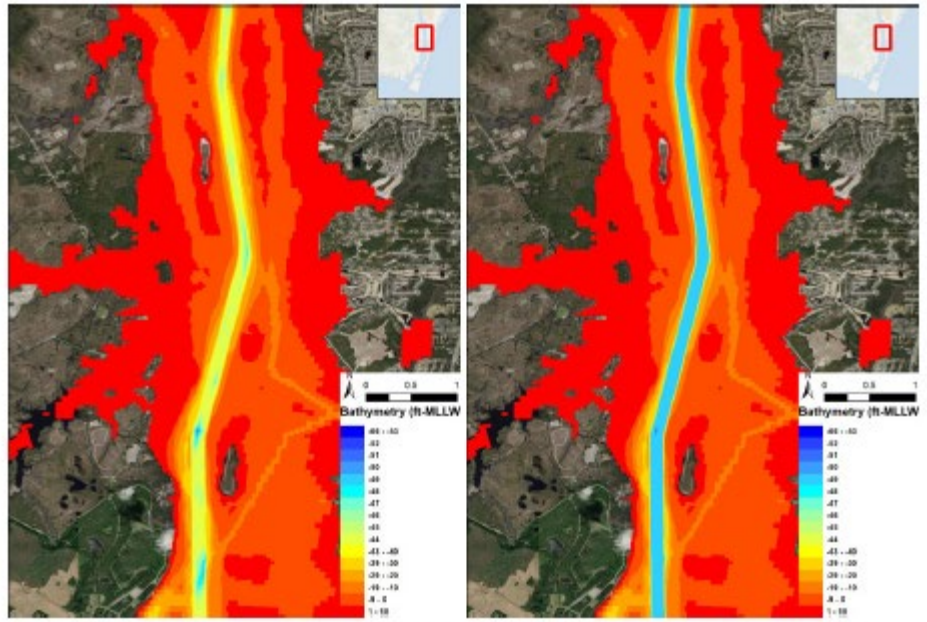

Figure 5-2: Bathymetry map near Lilliput Reach (left: FwoP, right: FwP)

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Model Outcomes

- Spatial resolution as high as 5 m for physical parameters, 20 m for WQ parameters
- Temporal resolution as high as 1 hr
- Episodic (storm) events
- Long term annual conditions – dry year, typical year, wet year
- Future without Project, Alternative 1, Alternative 2

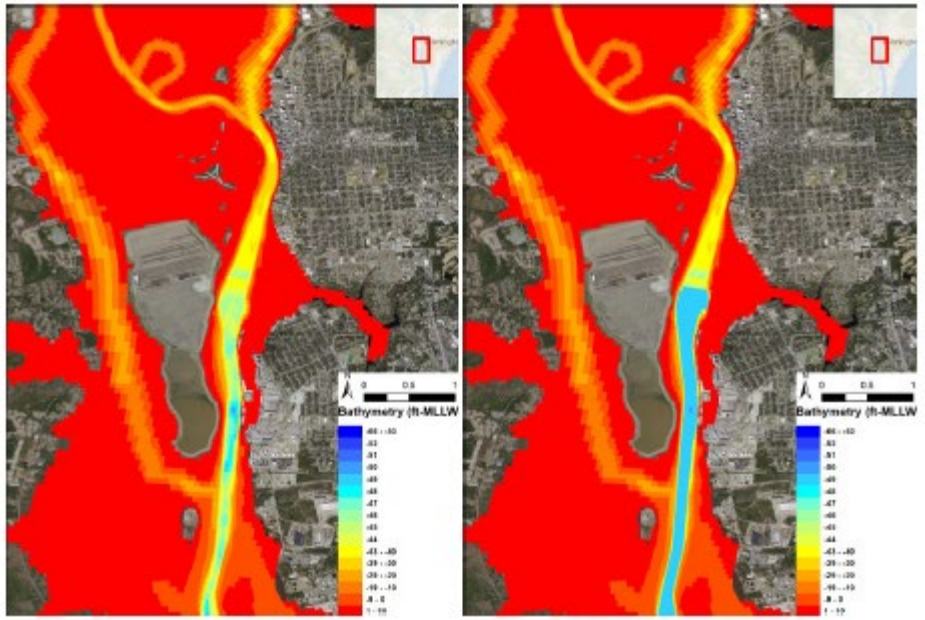

Figure 5-1: Bathymetry map near Wilmington (left: FwoP, right: FwP)

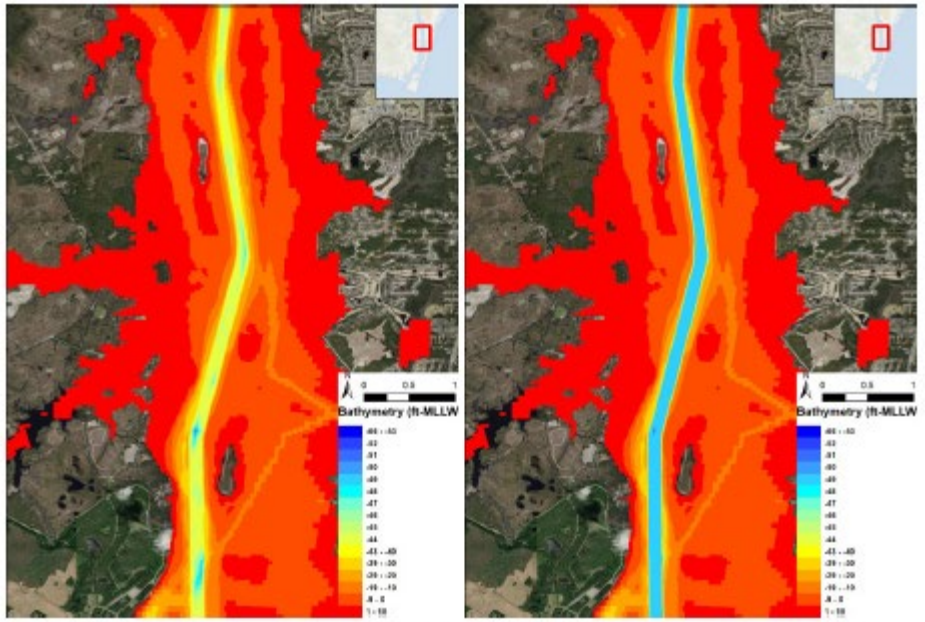

Figure 5-2: Bathymetry map near Lilliput Reach (left: FwoP, right: FwP)

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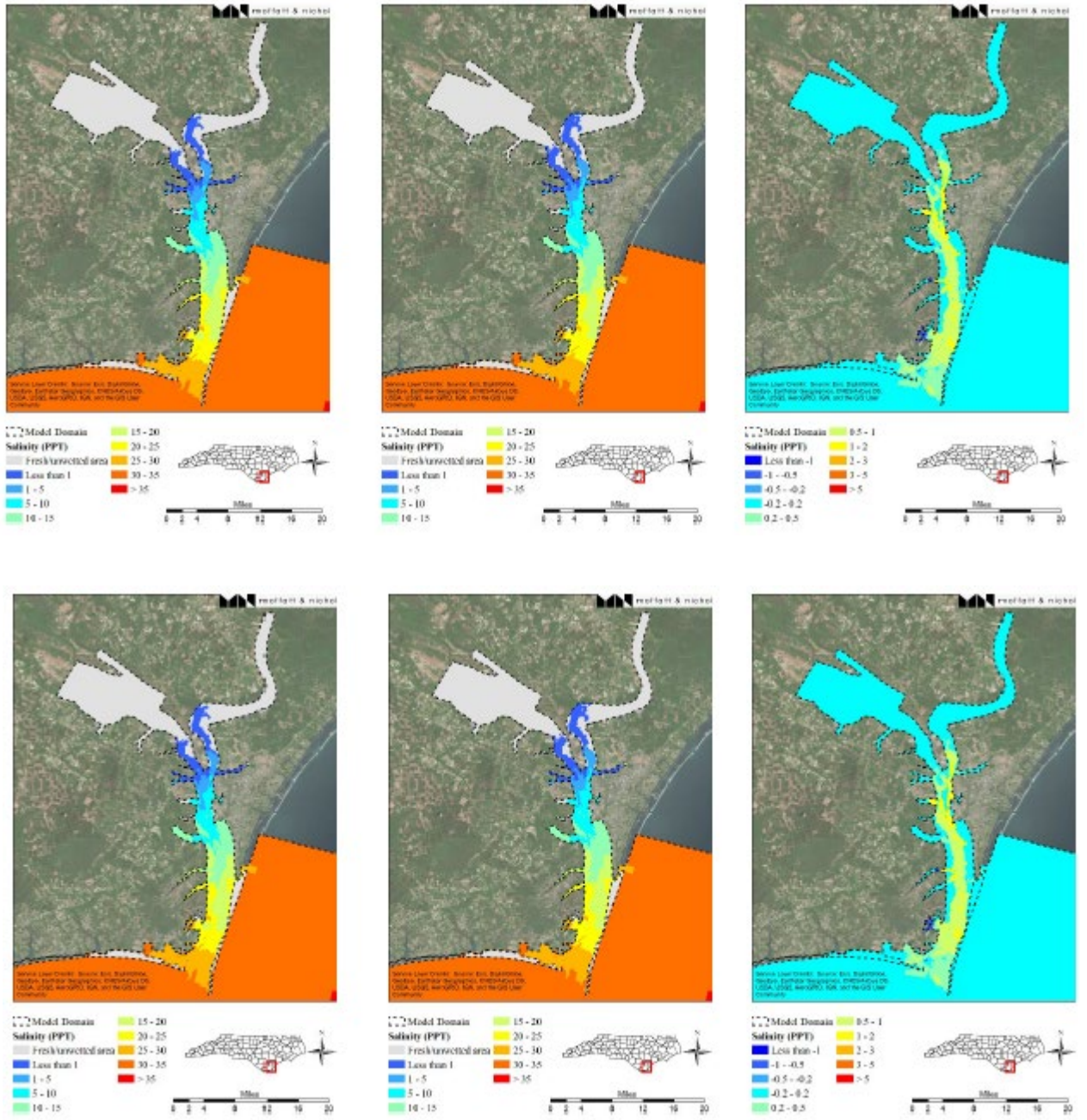
Model Outcomes

- Compare between FWoP conditions and proposed project conditions
- Tidal datums (MHW, MLW, etc.)
- Salinity peaks and ranges (summer, winter, surface, bottom, etc.)
- Dissolved oxygen peaks and ranges
- Results in graphical form (2D maps, vertical profiles, time series)
- Results in tabulated form (tables and spreadsheets of parameters of interest)



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Questions

Numerical Modeling – Water Quality

- Runs on hydrodynamic/salinity/sediment output
  - Hydrodynamics run in 2 week ‘representative’ segments and stitched together for long term simulations
- WQ model is computationally intensive
  - Grid aggregated (reduced resolution) from hydro grid - 3x to 8x less detailed spatially (20 m to 100 m horizontally, 25 reduced to 14 layers vertically [top and bottom groups consolidated])
  - Balance between smaller spatial resolution and longer timespan

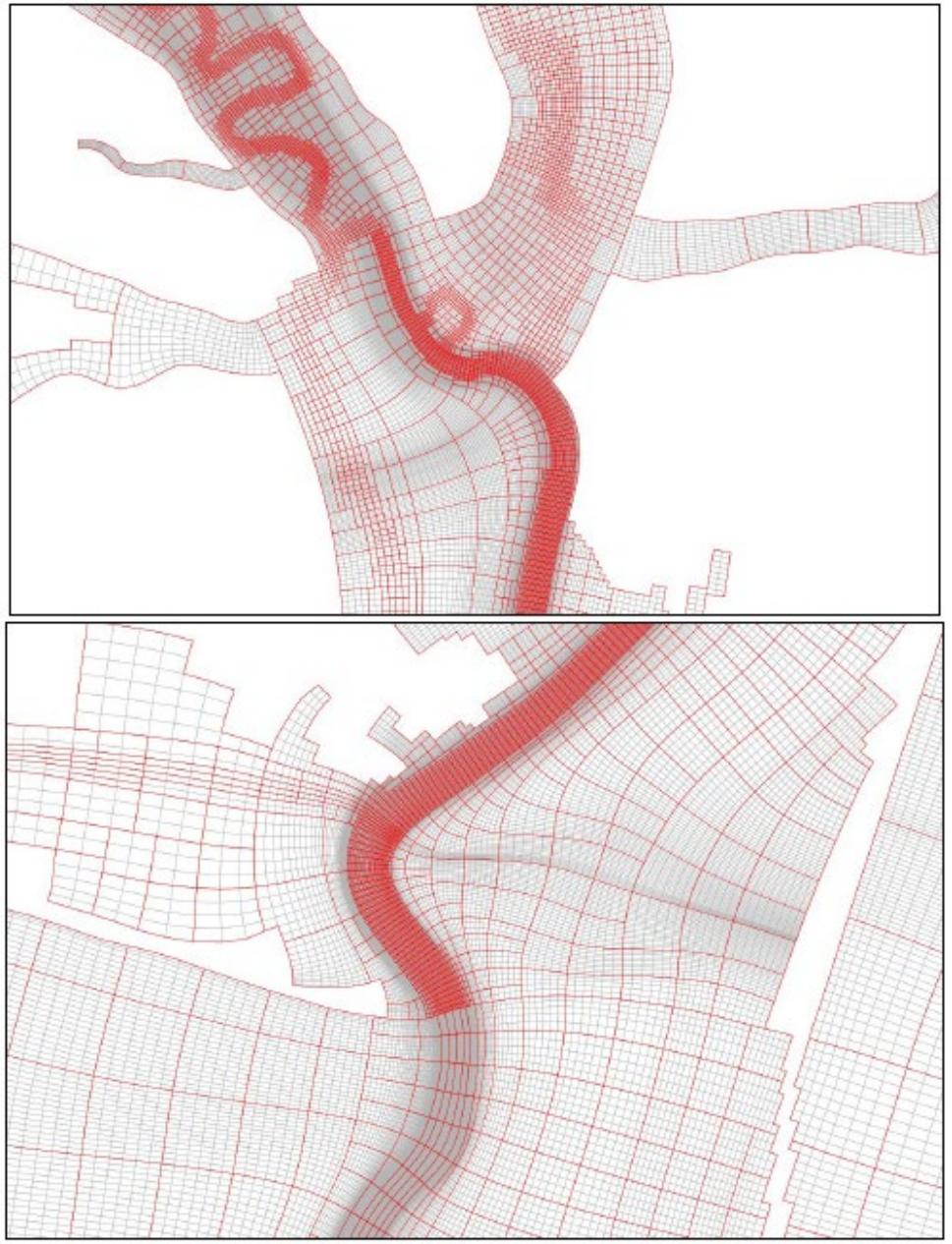

Figure 4-102: DELWAQ model horizontal grid aggregation adjacent to the Wilmington Port and the Cape Fear River entrance (red – aggregated DELWAQ grid; gray – hydrodynamic model grid)

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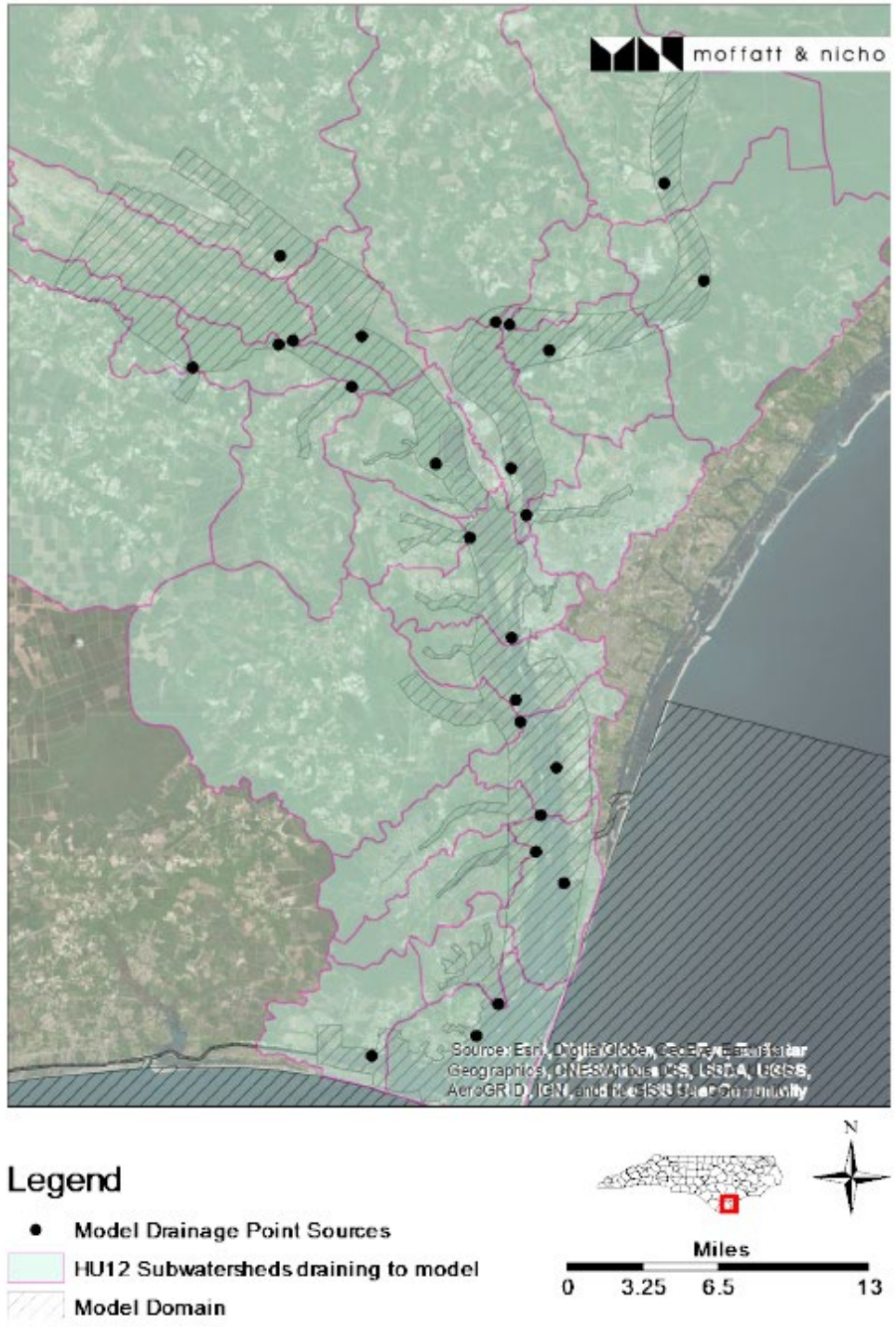
Numerical Modeling – Water Quality

- Loadings from rivers and point discharges
- Main parameters – salinity, temperature, dissolved oxygen
- Secondary – Nitrogen, phosphorus, carbon, chlorophyll, BOD, etc.
- Changes in surface/bottom values, effects to benthic habitat



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Numerical Modeling – Shoreline Evolution

- GenCade 1D shoreline model
- Wave input from offshore wave model, shoreline position, beach sediment characteristics
- Coastal structures, beach fill, inlet shoal volumes
- Changes in shoreline position and longshore transport

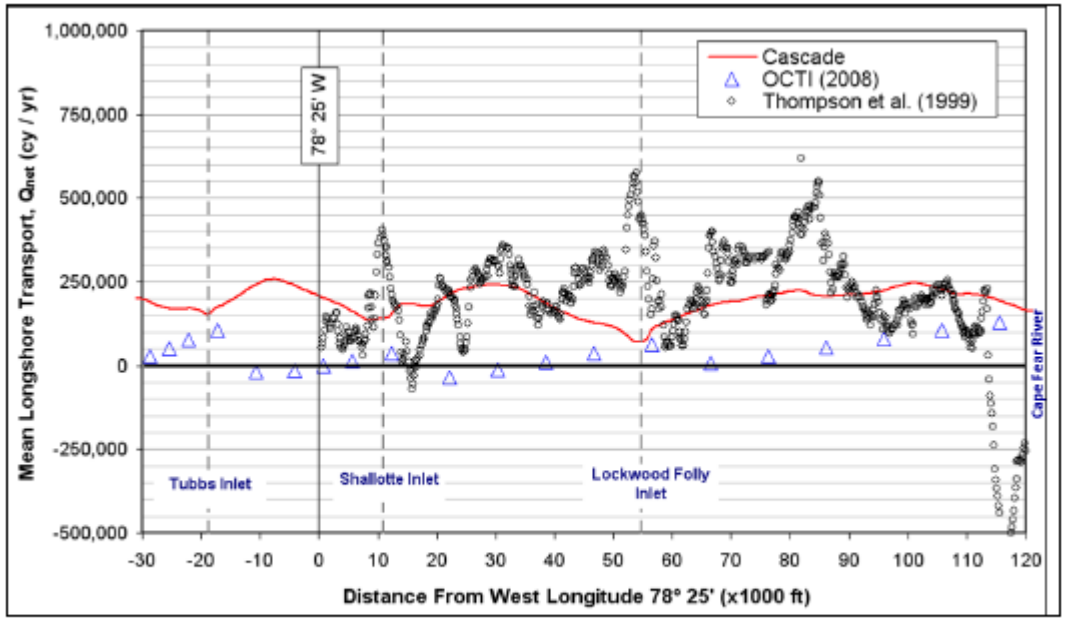

Figure 7-34: Historically calculated potential net longshore sand transport rates west of Cape Fear River (USACE, 2012a)

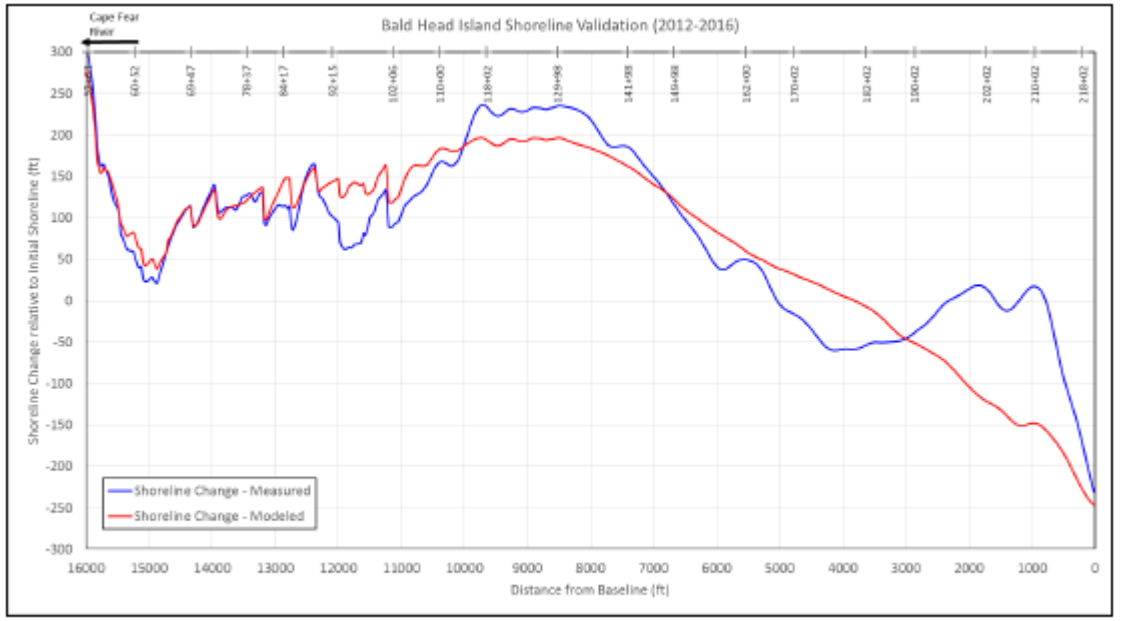

Figure 7-40: GenCade validation – shoreline change along Bald Head Island

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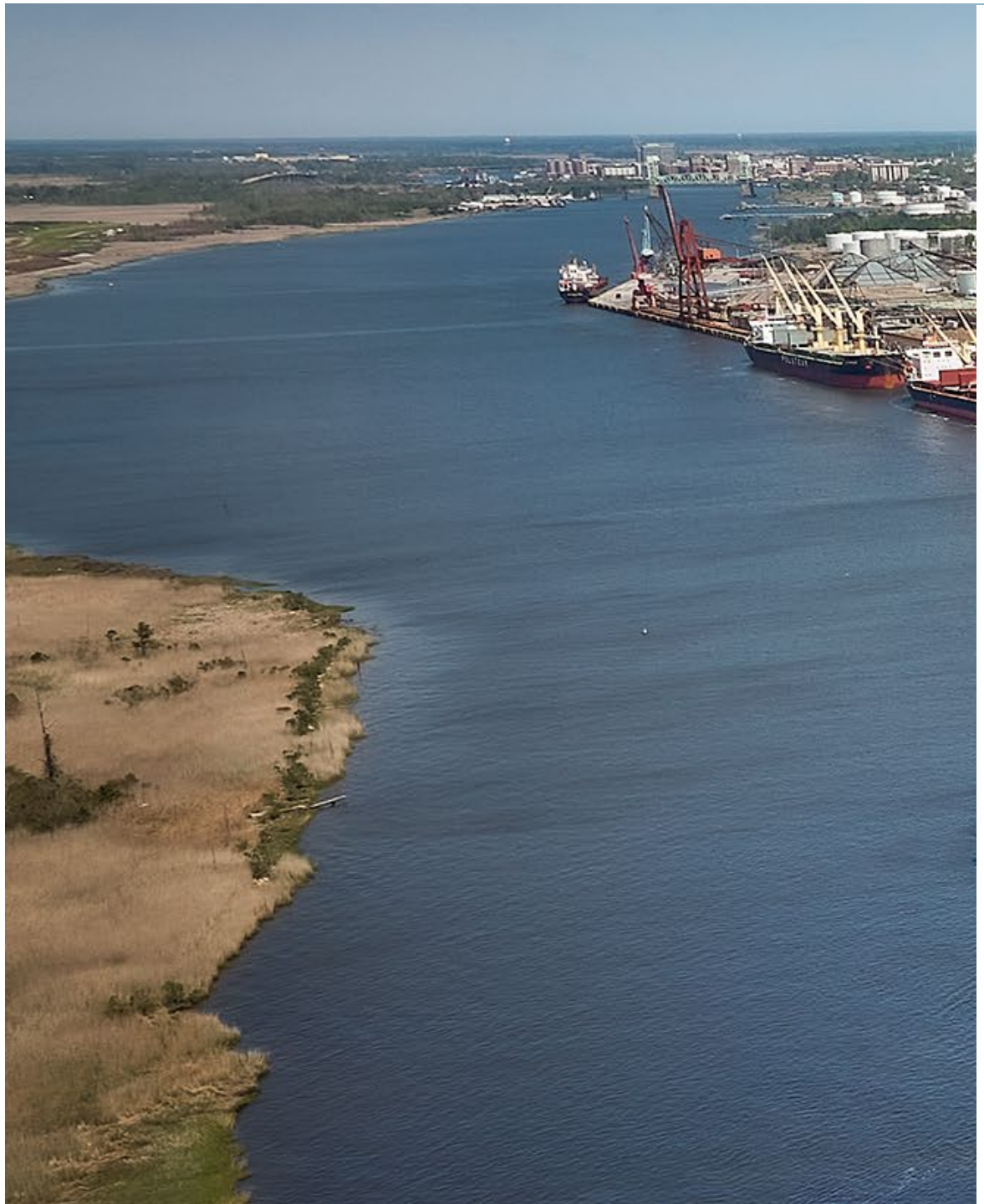
Questions



Project Information

- 403 Letter Report and EIS Website https://www.saw.usace.army.mil/Missions/Navigation/Dredging/Wilmington-Harbor-403-Letter-Report-and-EIS/

- Interactive GIS webpage:

https://wilmington-harbor-usace-saw.hub.arcgis.com/