Beach Nourishment Master Plan Year 1 Summary

July 7, 2021

THE TOWN OF NAGS HEAD
NORTH CAROLINA

moffatt & nichol

Presentation Outline

➢ Basis for Pursuing a Beach Nourishment Master Plan

➢ Overview of Master Plan Year 1 Progress

➢ Data Collection Review and Historical Trends

➢ Estimate of Long-Term Sand Volume Need

➢ Cross-shore Modeling - Level of Protection

➢ Shoreline Change Model Calibration

➢ Upcoming Master Plan Year 2 Tasks

➢ Q&A/Discussion

Basis for Pursing the Master Plan and Programmatic Permits

Beach Management

- **Outcome-based, consistent level of protection along the shoreline**

- Profile based volumetric triggers for renourishment & FEMA coordination

- Plan for managing areas of higher background erosion

- Plan nourishment intervals based on modeling and working with nature

- **Agile renourishment procurement, allowing faster response to needs and dredging market conditions**

- **Support long-term financial plan**

- Coordinate regional partnerships with the County and other communities

Environmental Approvals

- **Expedited permit approval process for future renourishment events.**

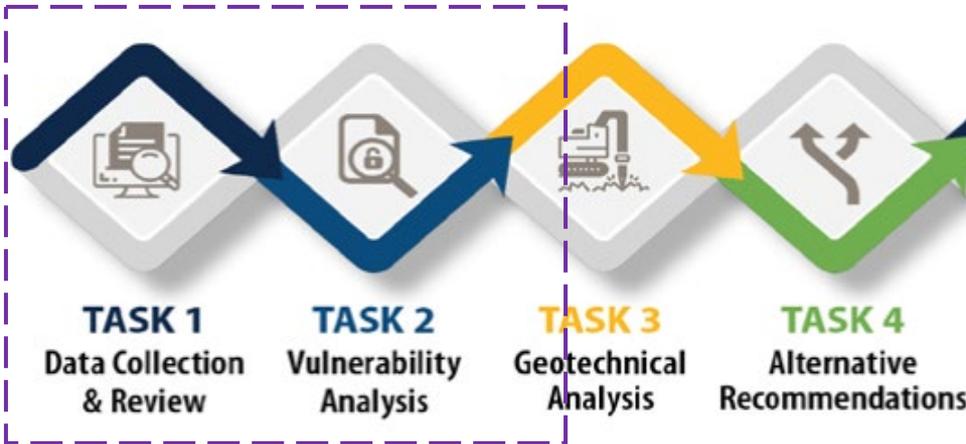# Master Plan Components

Engineering Analysis and Plan Development

TASK 1
Data Collection & Review

TASK 2
Vulnerability Analysis

TASK 3
Geotechnical Analysis

TASK 4
Alternative Recommendations

Programmatic Permitting & Funding

TASK 5
Permitting

TASK 6
Physical Monitoring Plan

TASK 7
Economic Analysis & Long-Term Funding

Economic / funding evaluations can move within the workflow to meet the Town's planning needs.

Master Plan Components

*Engineering Analysis and Plan Development*

TASK 1 — Data Collection & Review
TASK 2 — Vulnerability Analysis
TASK 3 — Geotechnical Analysis
TASK 4 — Alternative Recommendations

At the end of Year 1:

- Completed review of prior available data

- Completed Level of Protection (LoP) analysis for 'existing conditions'

- Completed first analysis of dune and beach profile increases to create consistent LoP along the shoreline

- Completed first analysis of long-term sand volume needs

- Calibrated shoreline change models for evaluating nourishment intervals

- Coordinated with the County and other communities

Engineering Work Plan
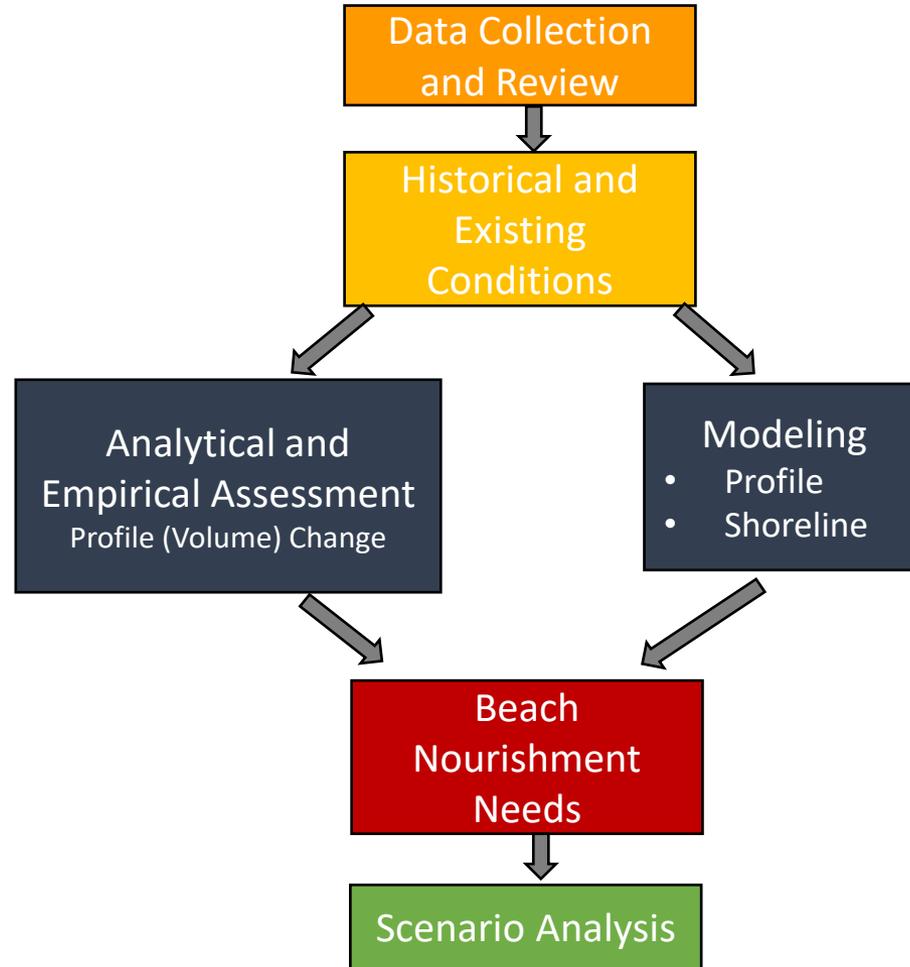
Data Collection and Review
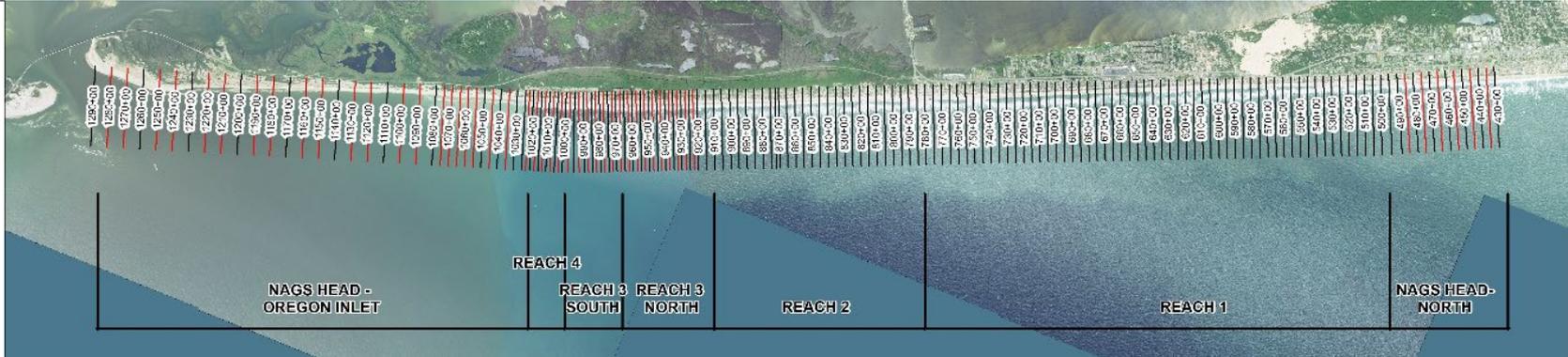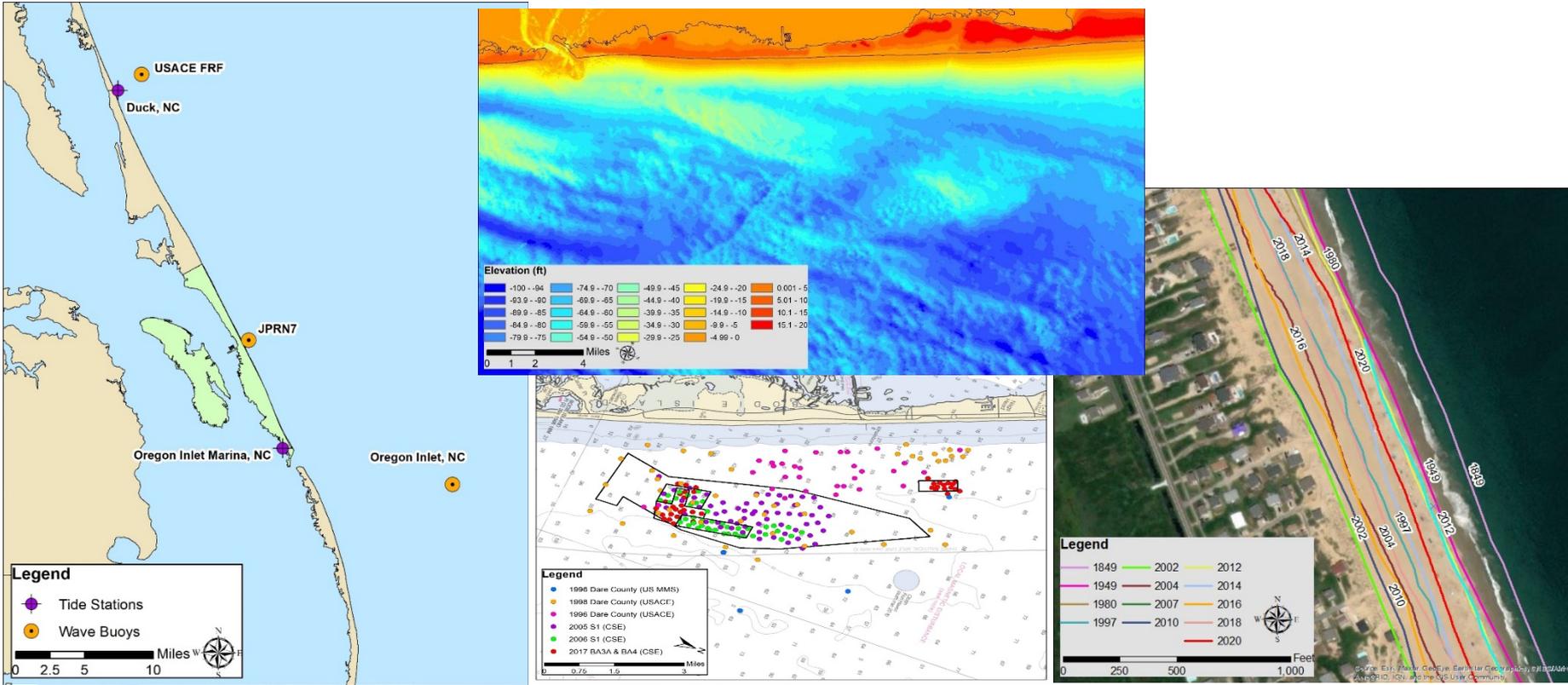
Analytical/Empirical Assessment

- First step in understanding existing system and behavior as well as developing potential beach nourishment needs

- Serves as basis for modeling calibration/validation and alternatives analysis by default

- Analytical/empirical assessment includes:
    - Profile change (volume change)

Analytical/Empirical Assessment

Profile Volume Analysis - Profile Calculation Lenses
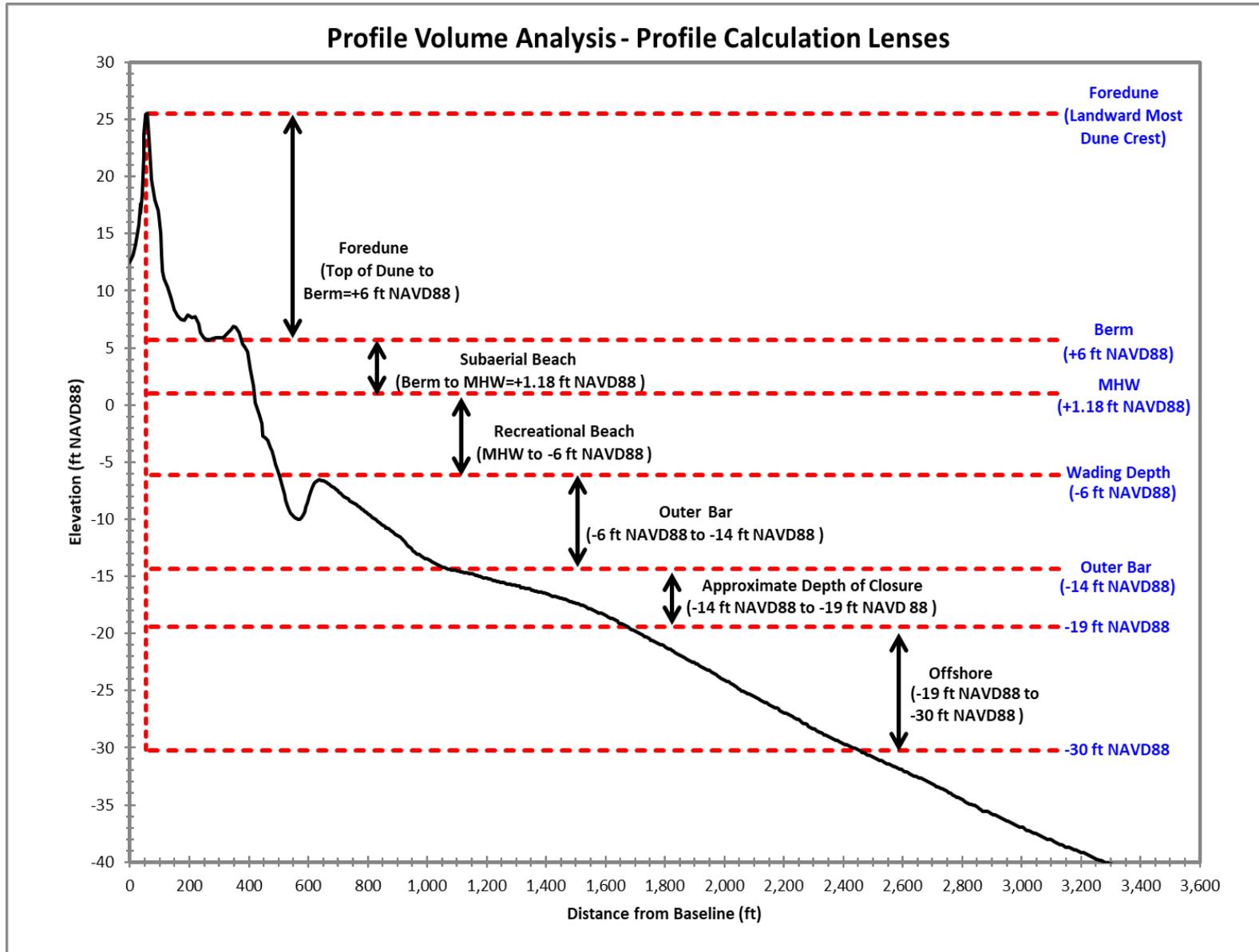
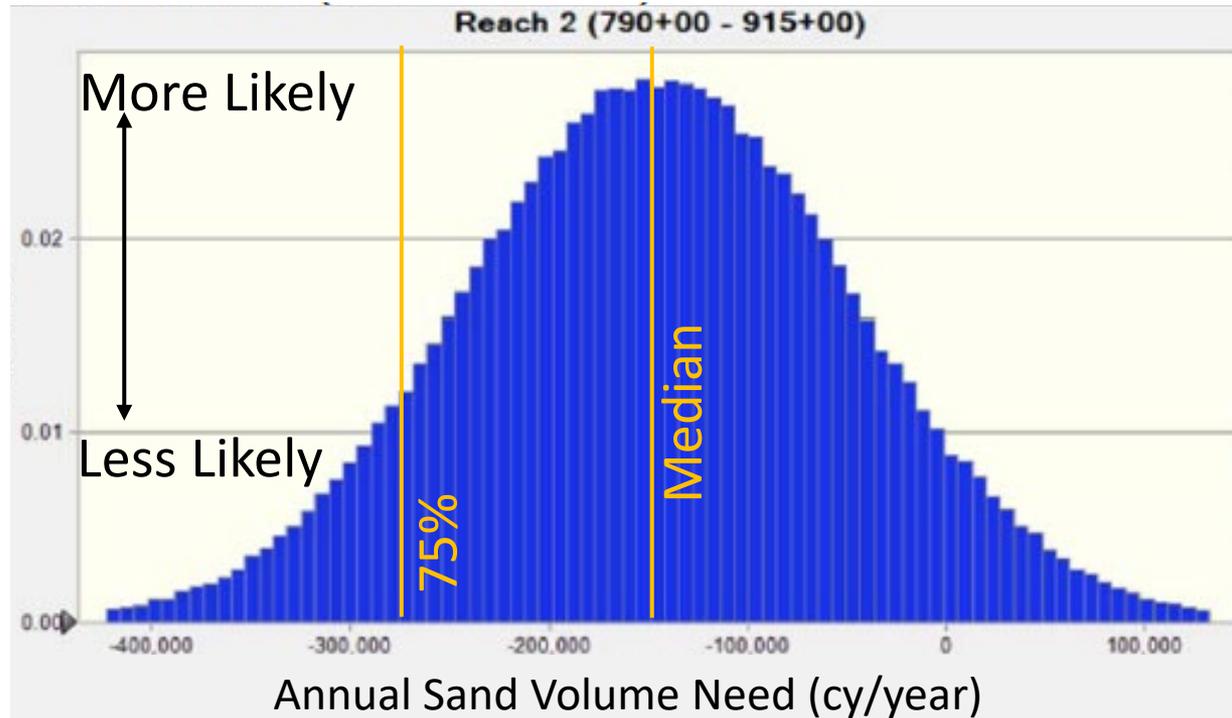# Summary of Findings – Background Erosion Rates

- Average Annual Background Erosion Rates (2011 - 2020)
  - Nourishment volumes subtracted from total volume changes above -19 ft NAVD88 between 2011 and 2020 and annualized over the nine-year time period.
  - Nags Head Reaches 3N, 3S, and 4 have considerably higher background erosion rates than the remainder of the oceanfront

Reach (Transects)	Length	Volume Change Above -19 ft NAVD88 (cy) 2011-2020	Nourishment Volume (cy)	Background Erosion (cy)	Average Annual Background Erosion Rates (cy/ft/yr)
Nags Head - North (430+00 - 495+00)	6,500	-198,028	0	-198,028	-3.4
Nags Head - Reach 1 (495+00 - 790+00)	29,500	822,560	1,762,213	-939,653	-3.5
Nags Head - Reach 2 (790+00 - 920+00)	13,000	24,257	885,587	-861,330	-7.4
Nags Head - Reach 3N (920+00 - 975+00)	5,500	-168,250	576,703	-744,953	-15.0
Nags Head - Reach 3S (975+00 - 1010+00)	3,500	-239,449	540,833	-780,282	-24.8
Nags Head - Reach 4 (1010+00 - 1025+00)	1,500	-118,289	239,298	-357,587	-26.5
Nags Head - Oregon Inlet (1030+00 - 1200+00)	17,500	-1,679,282	0	-1,679,282	-10.7
Nourished Oceanfront (495+00 - 1025+00)	**53,000**	**320,830**	**4,004,634**	**-3,683,804**	**-7.7**
Total Monitored Oceanfront (430+00 - 1200+00)	**77,000**	**-1,556,481**	**4,004,634**	**-5,561,115**	**-8.0**

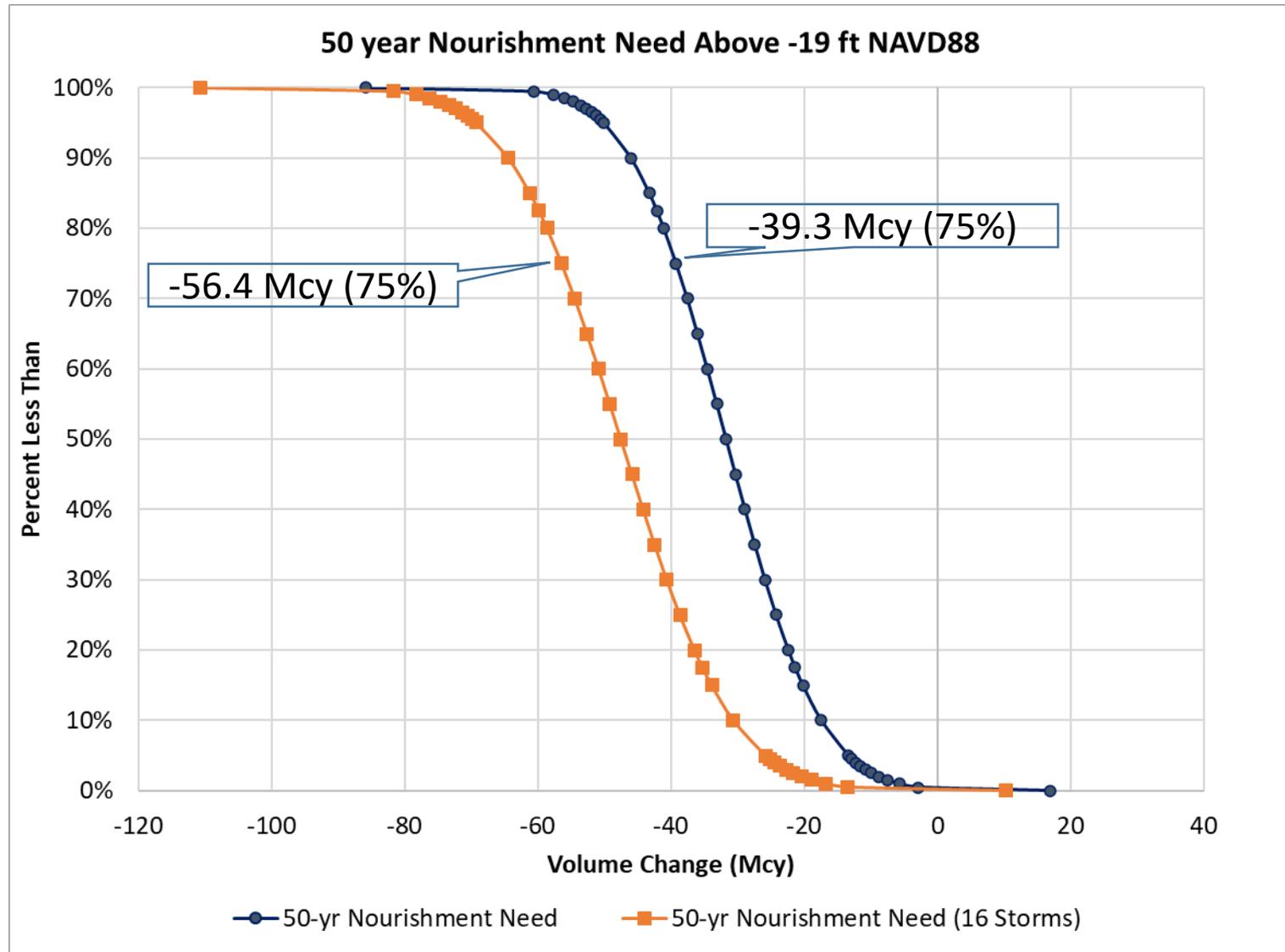# Profile (Volume) Change

Statistical Analyses

- Develops a data-driven basis of volume loss and sediment needs over the next 50 years

- 'Monte Carlo' probability simulation to calculate and record the results of thousands of different "what if" cases

- Reveals a range of possible outcomes, and their probability of occurring.

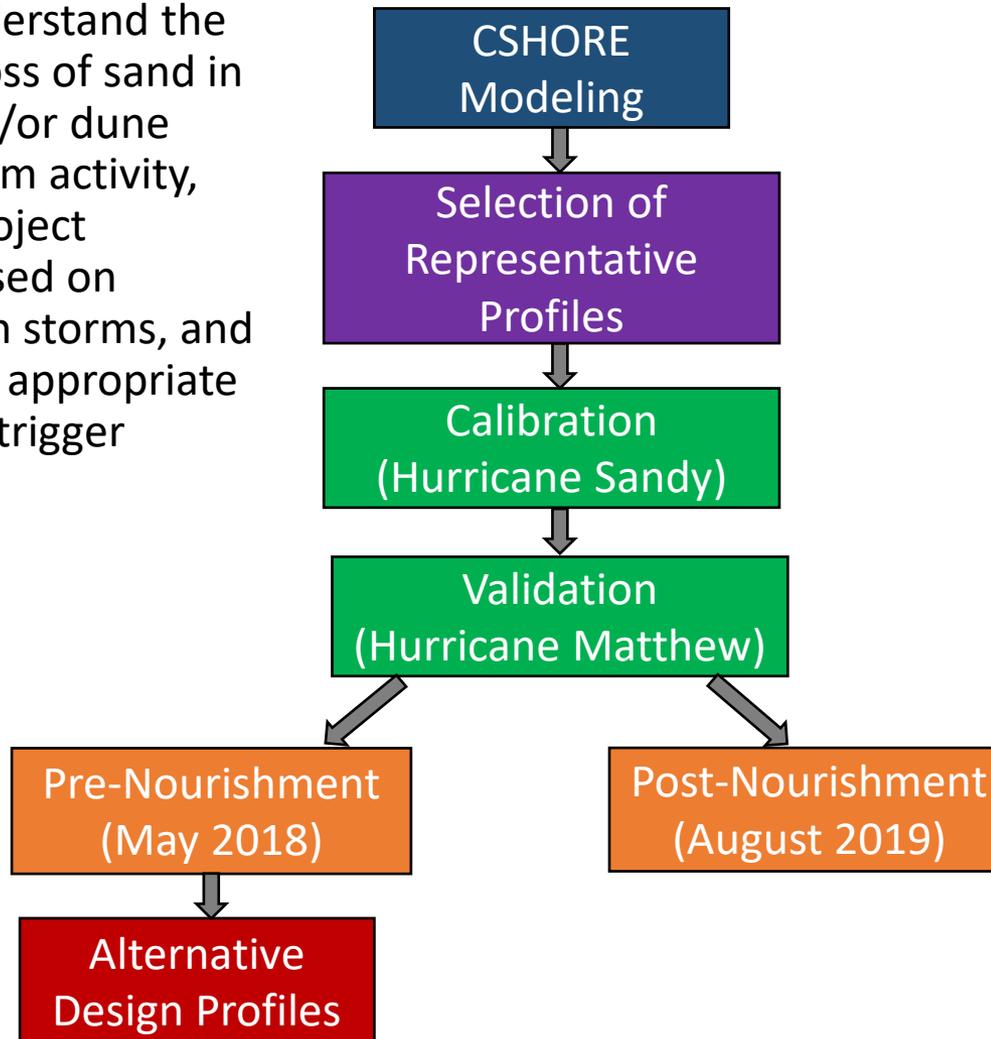**Reach 2 (790+00 - 915+00)**

More Likely

Less Likely

75%

Median

Annual Sand Volume Need (cy/year)

Statistics:	Forecast values
Trials	250,000
Base Case	0
Mean	-145,116
Median	-144,956
Mode	---
Standard Deviation	99,278

11

Profile (Volume) Change Statistical Analysis

50 year Nourishment Need Above -19 ft NAVD88

-39.3 Mcy (75%)

-56.4 Mcy (75%)

Percent Less Than

Volume Change (Mcy)

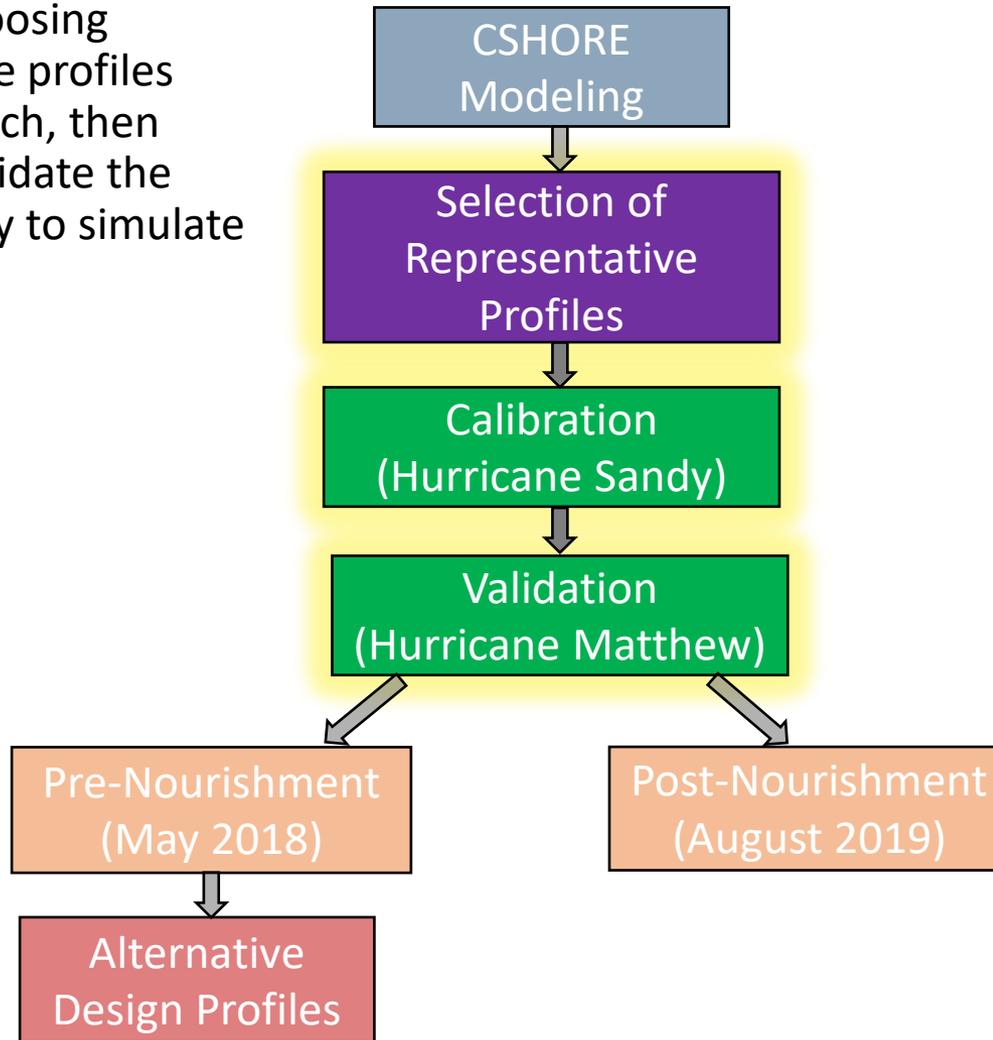50-yr Nourishment Need   50-yr Nourishment Need (16 Storms)

CSHORE Beach Profile Model

Goal is to understand the cross-shore loss of sand in the berm and/or dune following storm activity, determine project templates based on various design storms, and determine an appropriate nourishment trigger
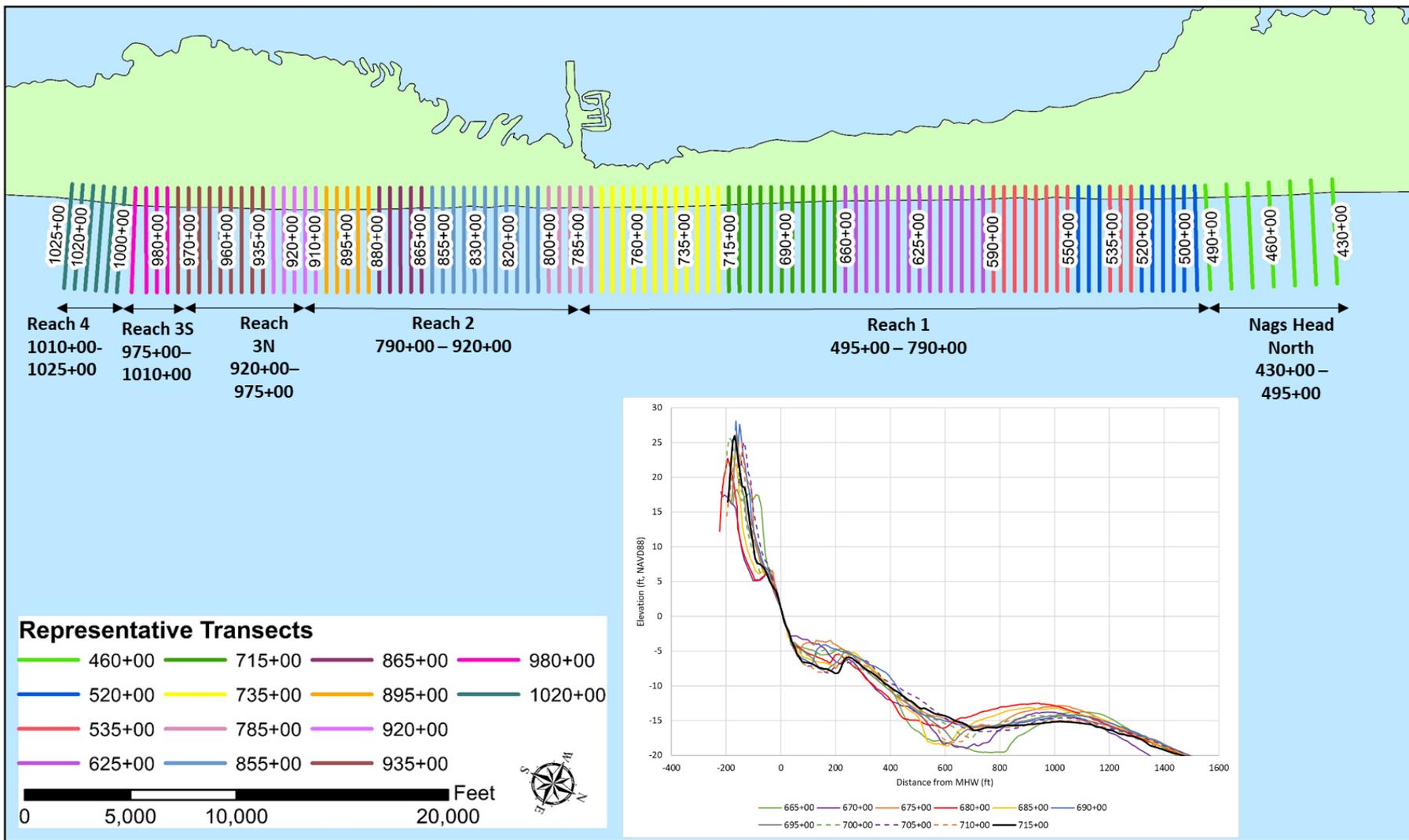
CSHORE Modeling

↓

Selection of Representative Profiles

↓

Calibration (Hurricane Sandy)

↓

Validation (Hurricane Matthew)

↓ ↓

Pre-Nourishment (May 2018)   Post-Nourishment (August 2019)

↓

Alternative Design Profiles

CSHORE Beach Profile Model

Start with choosing representative profiles along the beach, then calibrate / validate the model's ability to simulate past storms.
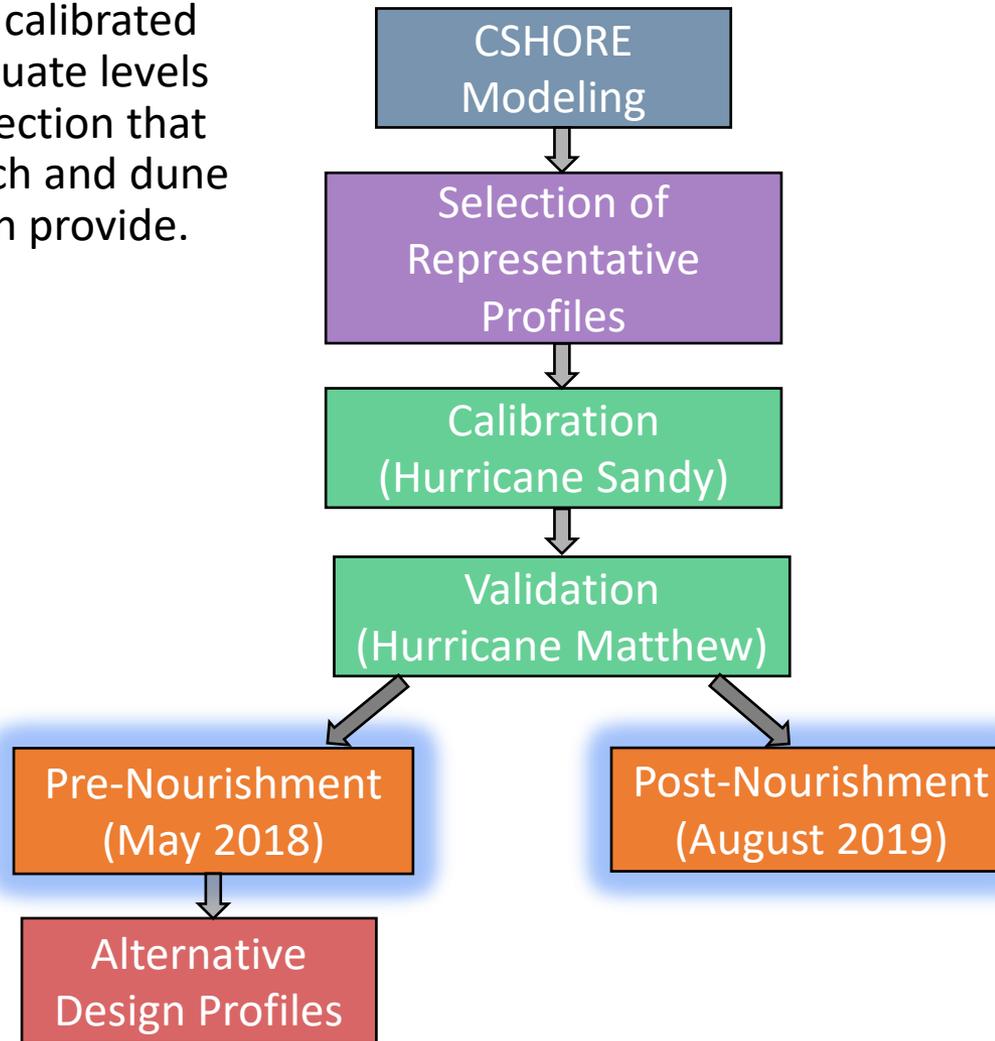
```
           ┌─────────────────┐
           │     CSHORE      │
           │    Modeling     │
           └────────┬────────┘
                    ↓
           ┌─────────────────┐
           │  Selection of   │
           │ Representative  │
           │    Profiles     │
           └────────┬────────┘
                    ↓
           ┌─────────────────┐
           │   Calibration   │
           │ (Hurricane Sandy)│
           └────────┬────────┘
                    ↓
           ┌─────────────────┐
           │   Validation    │
           │(Hurricane Matthew)│
           └──┬───────────┬──┘
              ↓           ↓
  ┌──────────────┐  ┌──────────────┐
  │Pre-Nourishment│  │Post-Nourishment│
  │  (May 2018)  │  │ (August 2019)│
  └──────┬───────┘  └──────────────┘
         ↓
  ┌──────────────┐
  │ Alternative  │
  │Design Profiles│
  └──────────────┘
```

CSHORE Beach Profile Model

Next, use the calibrated model to evaluate levels of storm protection that different beach and dune conditions can provide.

CSHORE Modeling

↓

Selection of Representative Profiles

↓

Calibration (Hurricane Sandy)

↓

Validation (Hurricane Matthew)

↓ ↓

Pre-Nourishment (May 2018)

Post-Nourishment (August 2019)

↓

Alternative Design Profiles

Synthetic Storms

Return Period	H_s feet	T_P seconds	Water Level feet NAVD88
2-year	14.7	10.1	4.88
5-year	16.1	10.4	5.18
10-year	20.1	11.8	5.41
25-year	23.2	12.4	5.73
50-year	26.2	13.8	6.06
100-year	29.9	14.1	6.39

A typical pattern or "shape" of storm surge and waves was created based on Hurricane Isabel's and Hurricane Dorian's patterns and an empirical relationship between peak storm wave intensity and duration of the rising and falling legs.
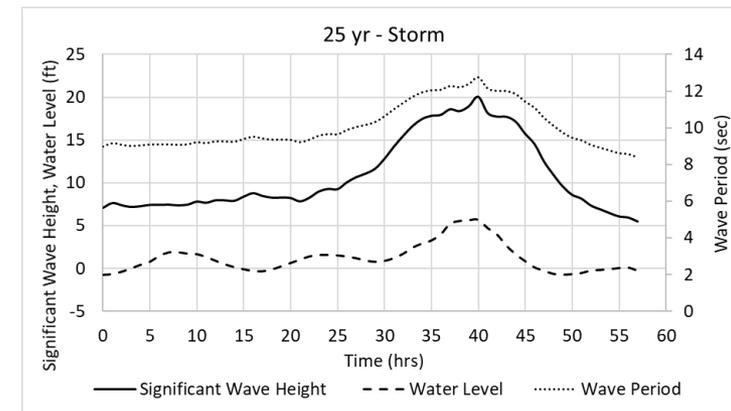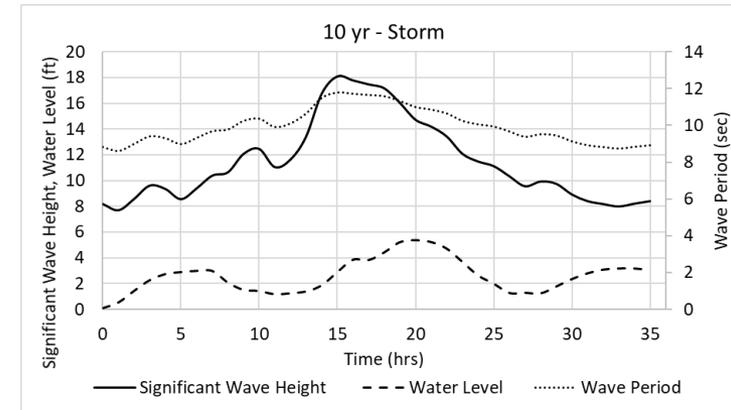
CSHORE – Evaluating Level of Protection (LOP)

A key element of the project purpose is to provide an equivalent level of protection (LoP) to upland structures across all of Nags Head – **not equal sand, but equal protection**.

This LoP determination is also critical in confirming and adjusting the Town's nourishment triggers which are used both for Town nourishment project planning and for coordination with agencies such as FEMA.

No Impact – Neither the eroded profile, water level, nor the maximum wave crest elevation indicate that sediment movement or moving water will occur at the first row of structures.

935+00
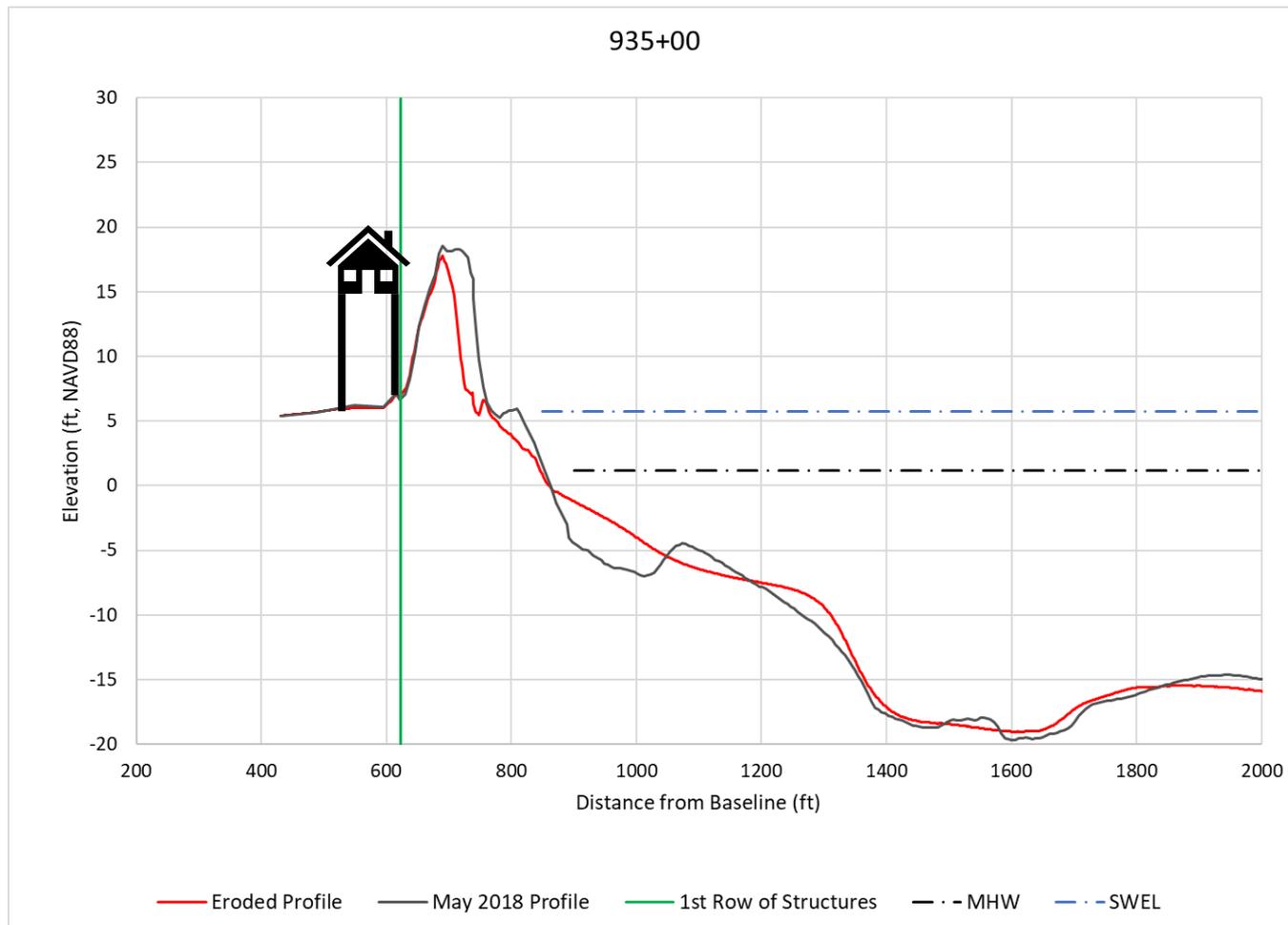
Minor Overtopping – Eroded profile, water level, and maximum wave crest elevation indicate that the dune would be overtopped, but overtopping at first row of structures appears to be minimal.

935+00

Overtopping < 0.65 ft³/hr per ft

20
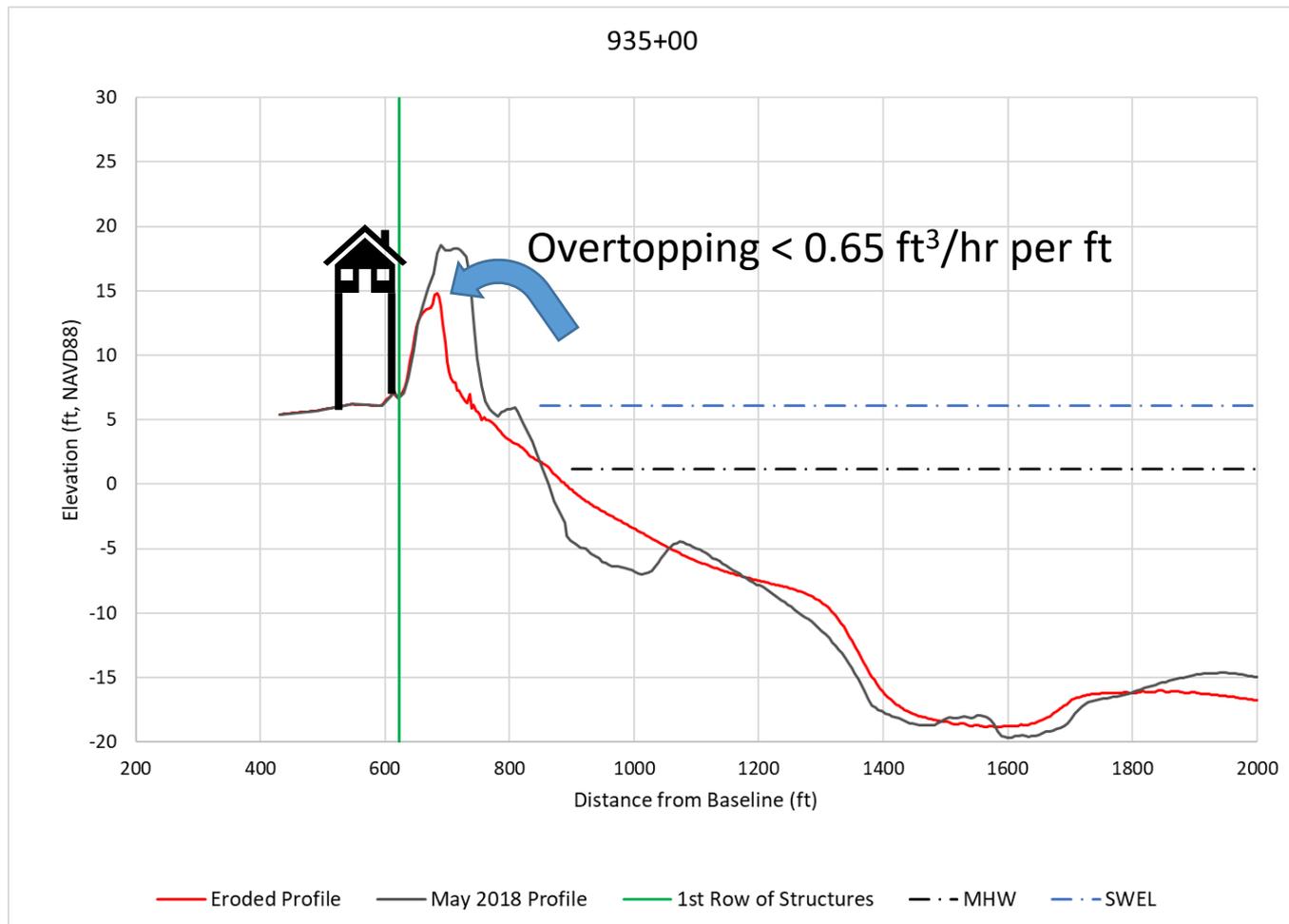
Major Overtopping – Eroded profile, water level, and maximum wave crest elevation, combined with position and elevation of first row of structures, indicate that the lower levels of structures are likely to be flooded or impacted by moving water.

935+00

Overtopping ≥ 0.65 ft³/hr per ft

Elevation (ft, NAVD88)

Distance from Baseline (ft)

— Eroded Profile   — May 2018 Profile   — 1st Row of Structures   — · — MHW   — · · — SWEL

21
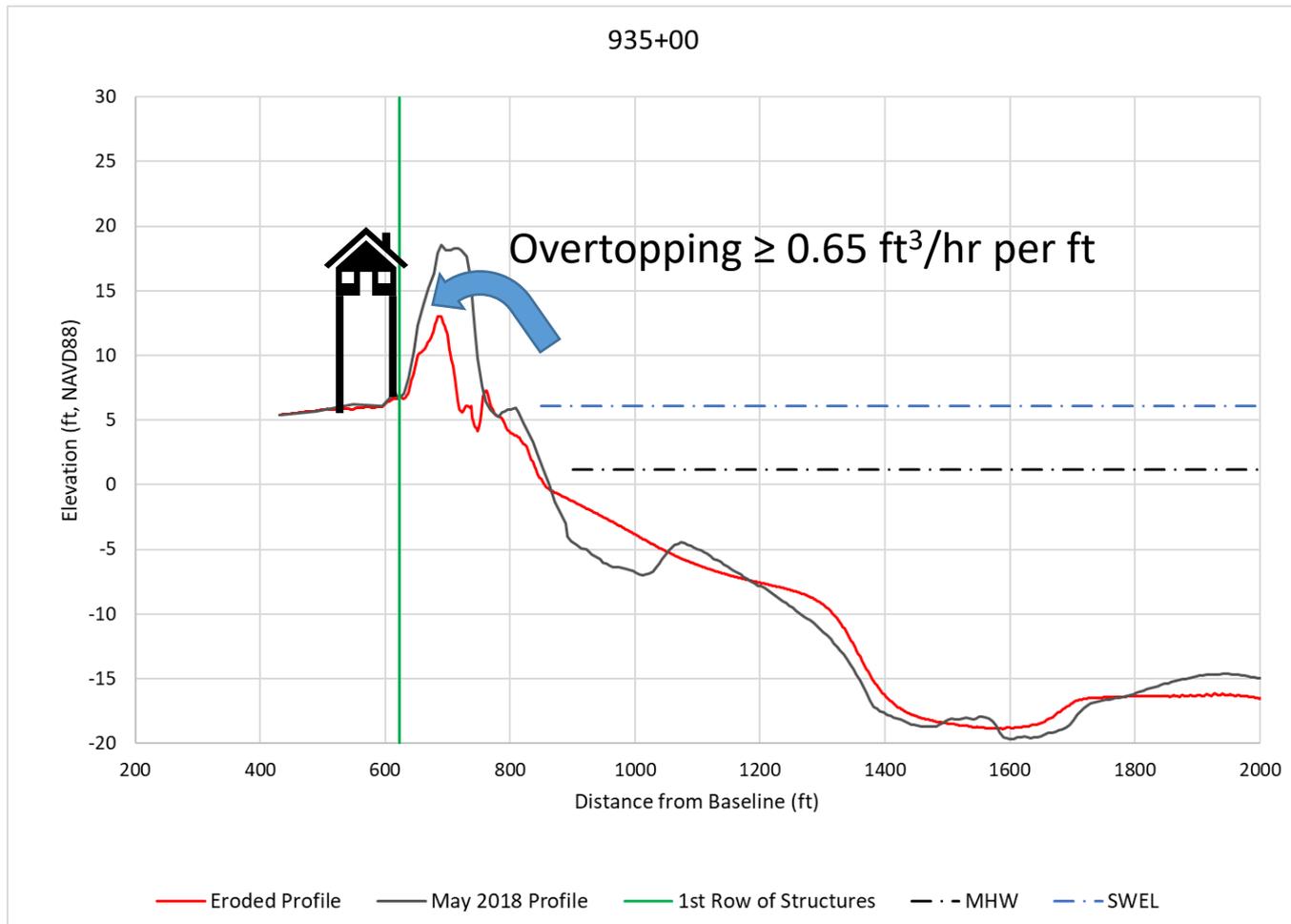
Threatened – Profile eroded to very near the seaward limits of the first row of structures, such that the stability of the foundations may be threatened.


855+00

22
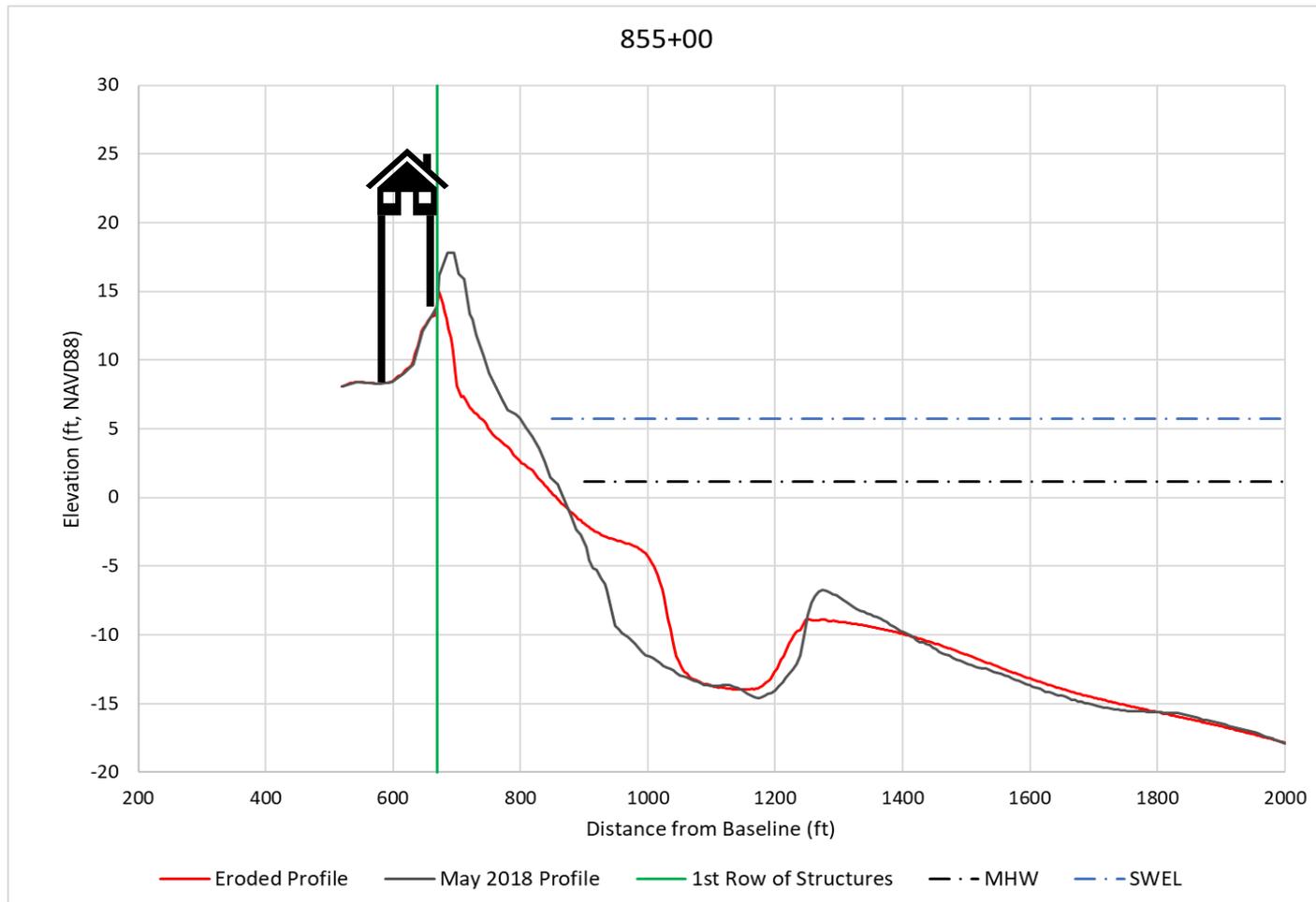
CSHORE – Evaluating Level of Protection (LOP)

Undermined – Profile eroded to the position of (or landward of) the first row of structures, thus undermining their foundations.
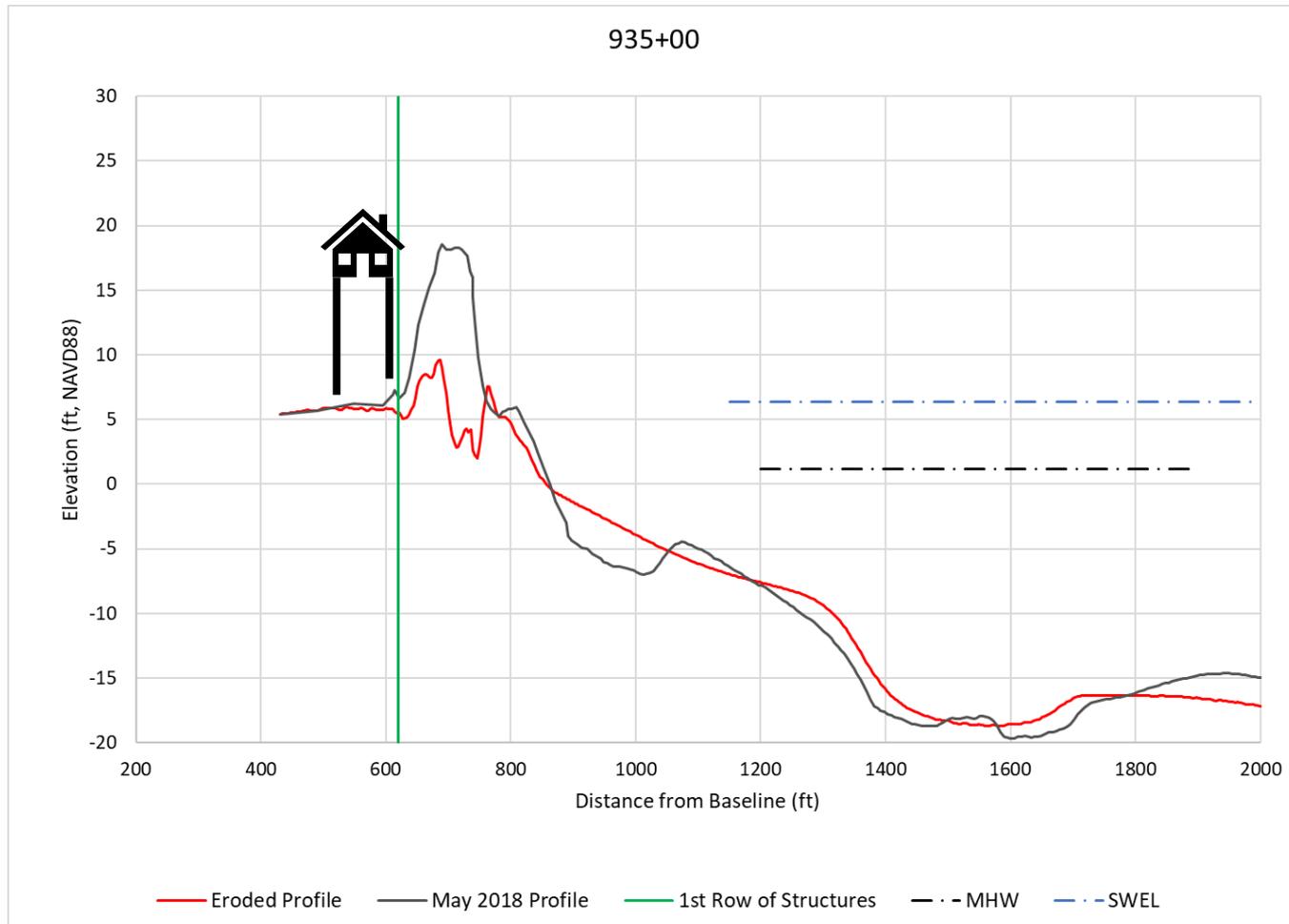
CSHORE – LOP – Pre-Nourishment (May 2018)

- Prior to 2019 nourishment, levels of protection varies significantly along the Town's shoreline

- Most of the shoreline was vulnerable in the 50-year storm event and some areas in 25-yr event
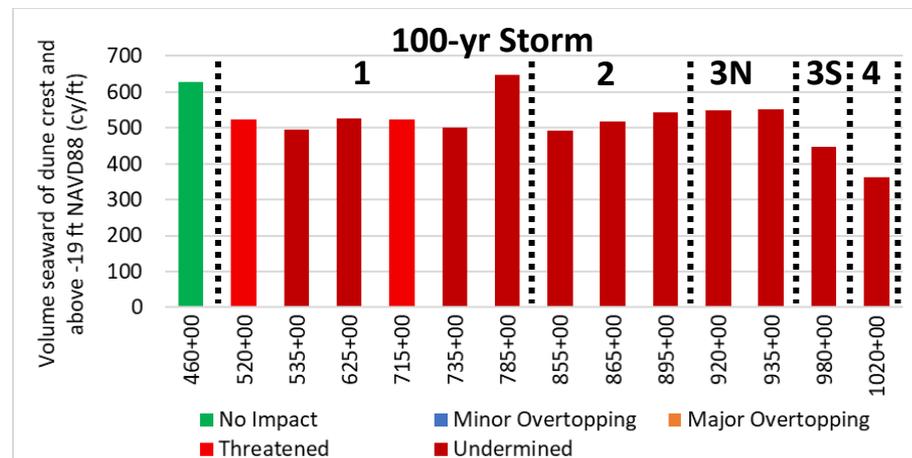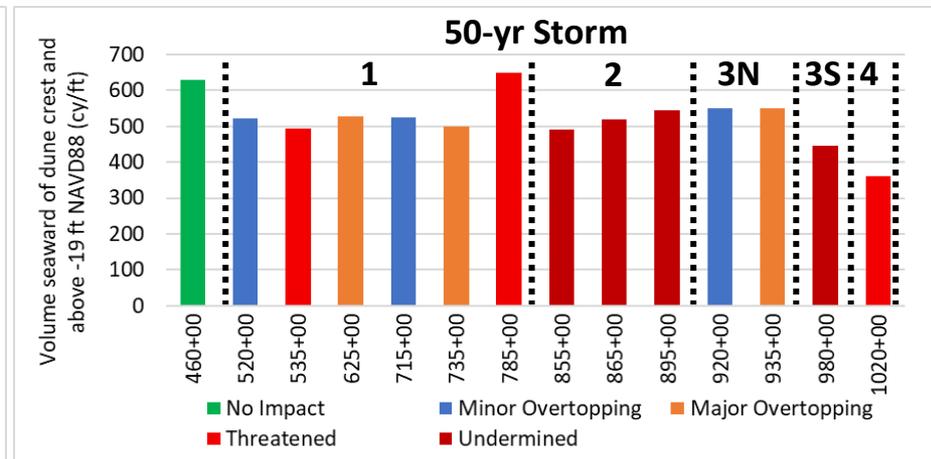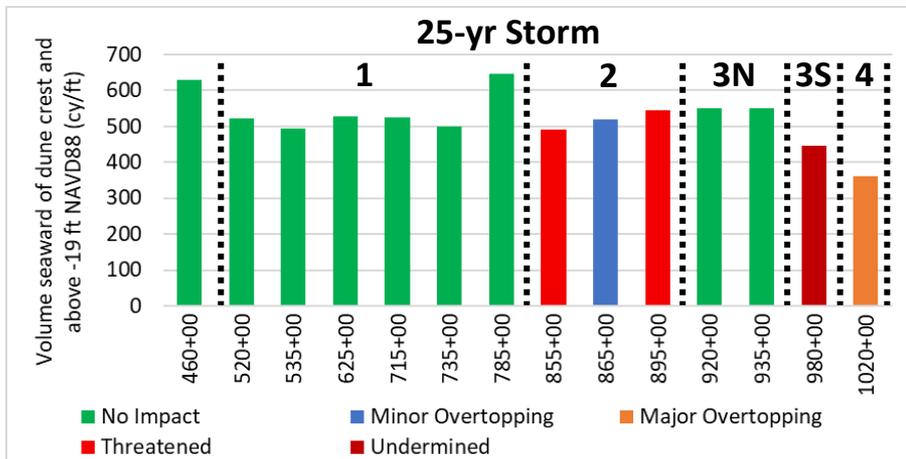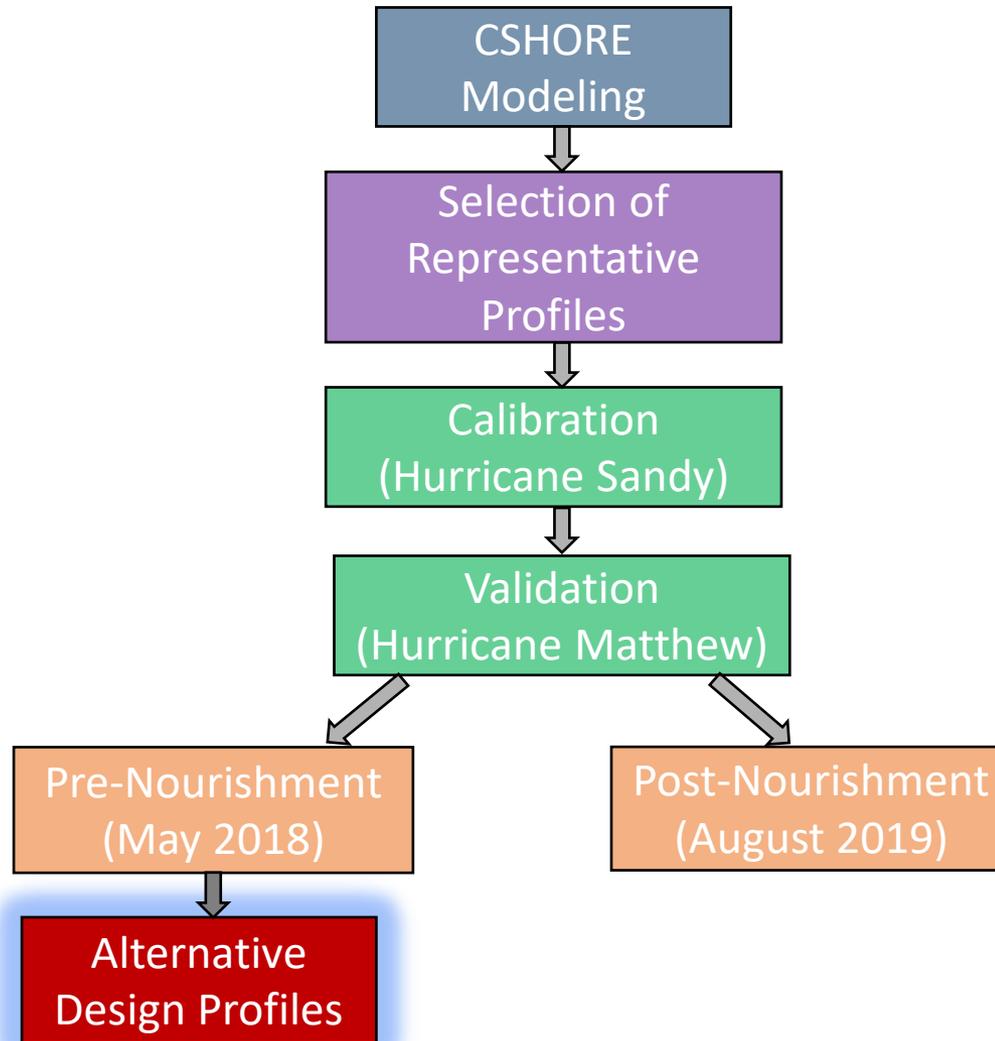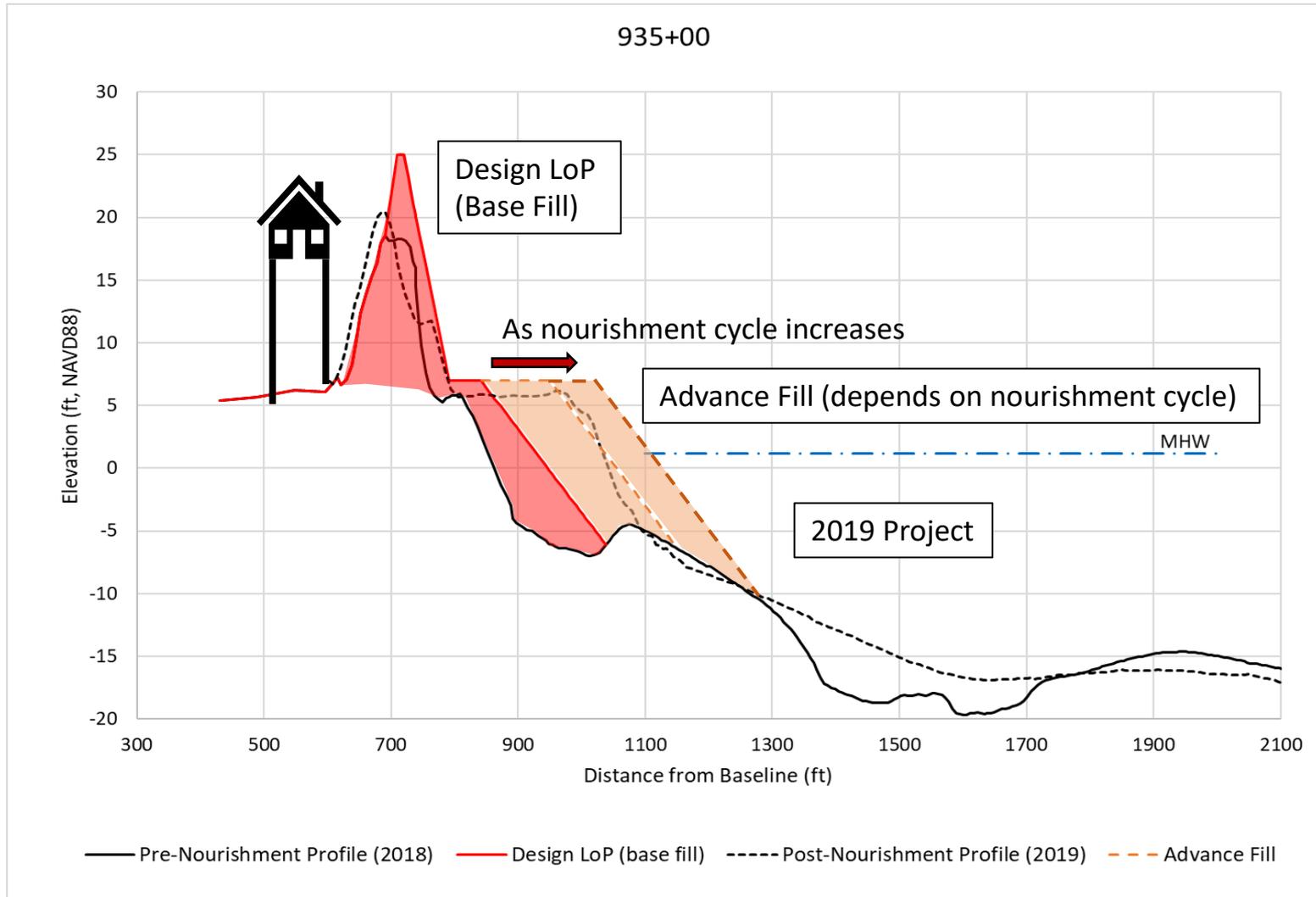
CSHORE – LOP – Post Nourishment (Aug 2019)

- The 2019 nourishment resulted in greater protection, and made the LOP more consistent along the shoreline

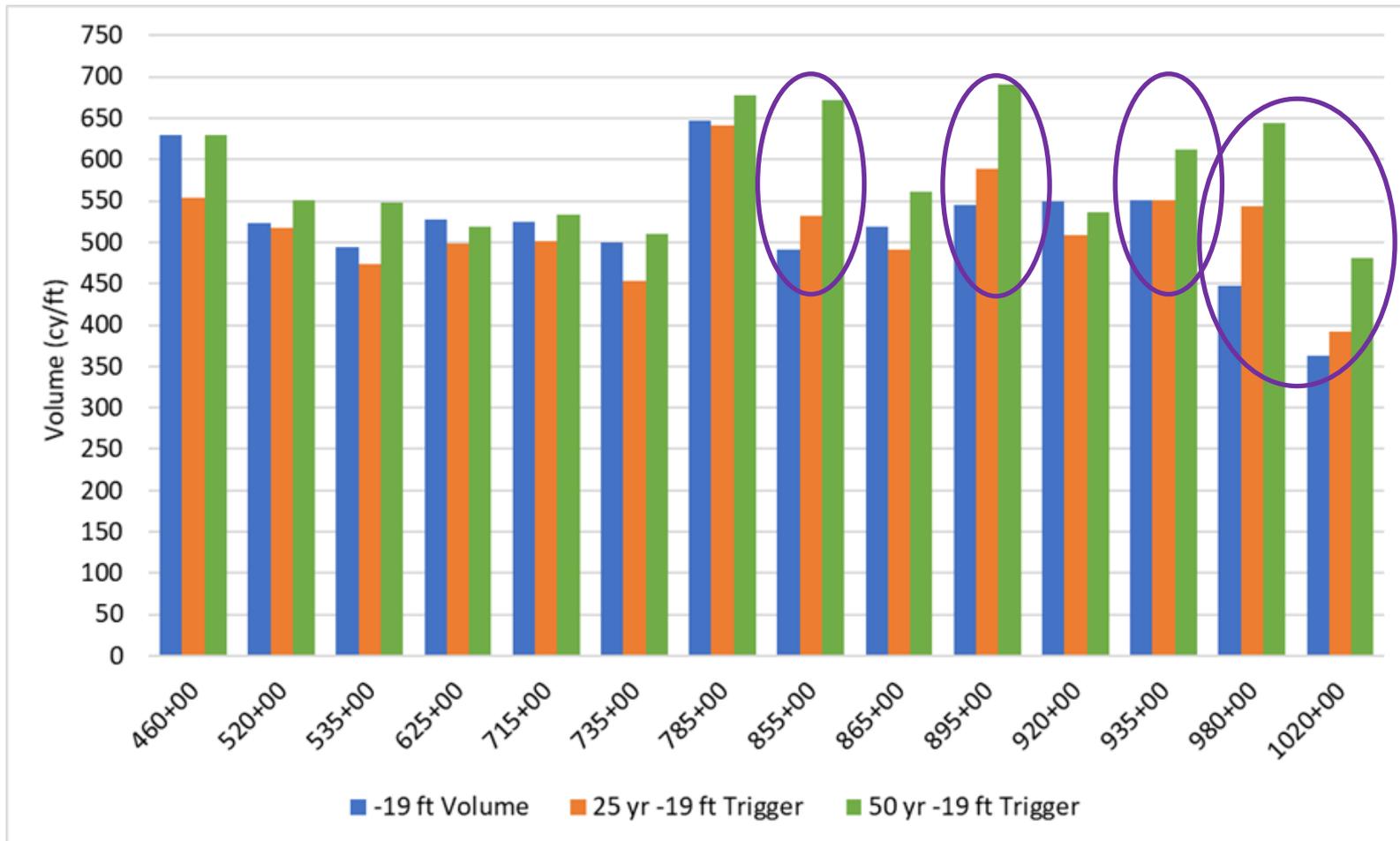- Some segments continued to be vulnerable to these storms
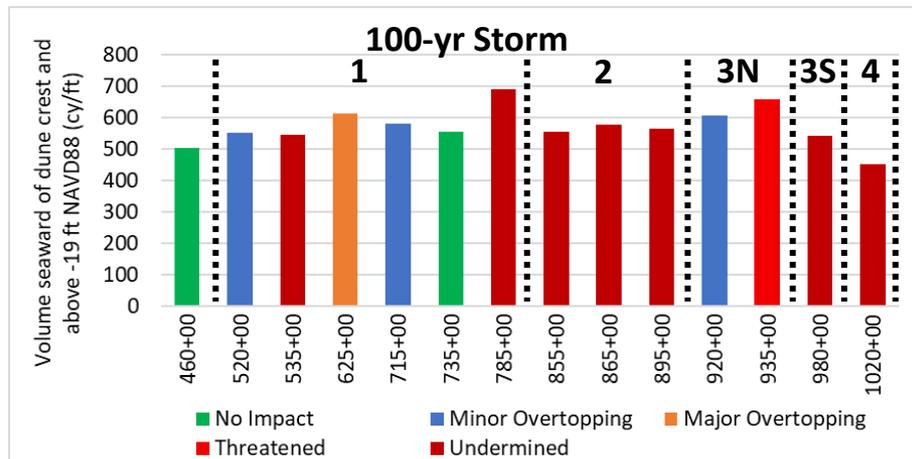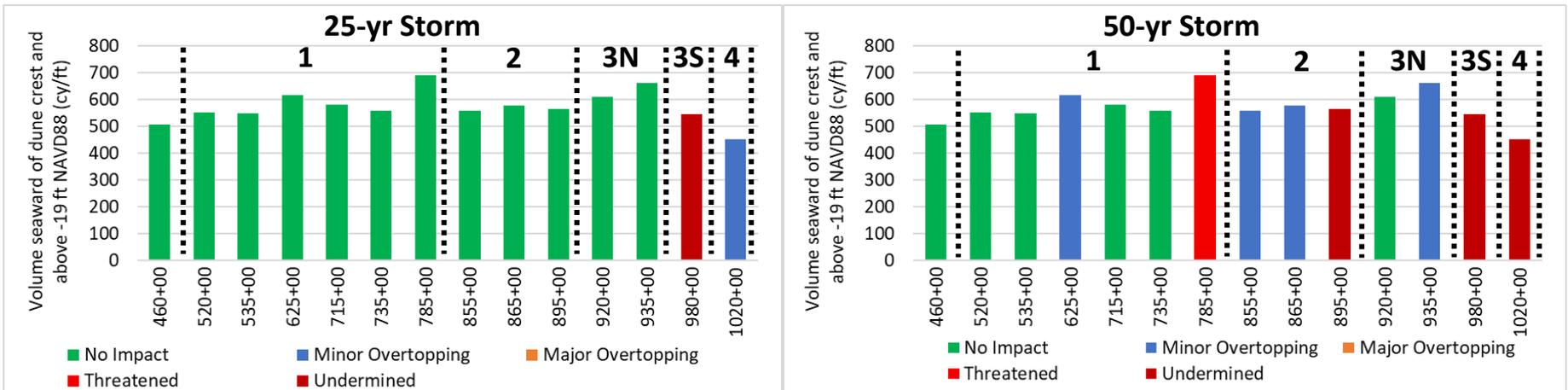
CSHORE

CSHORE – Evaluating Level of Protection (LOP)

935+00

50-yr Event Trigger vs. 25-yr Event Trigger vs. 2018 Volume (-19 ft NAVD88)

GENCADE Calibration for use in Year 2

Shoreline Change Model Scope

- Goal:
  - To understand the historical longshore sediment transport patterns along the Nags Head Shoreline and evaluate numerous shoreline stabilization and restoration alternatives

- Process:
  - Calibration: June 2015 to June 2019 →Completed
  - Validation: June 2012 to June 2016→Completed
  - Possible Alternatives: various nourishment projects

Validation: June 2012 to June 2016
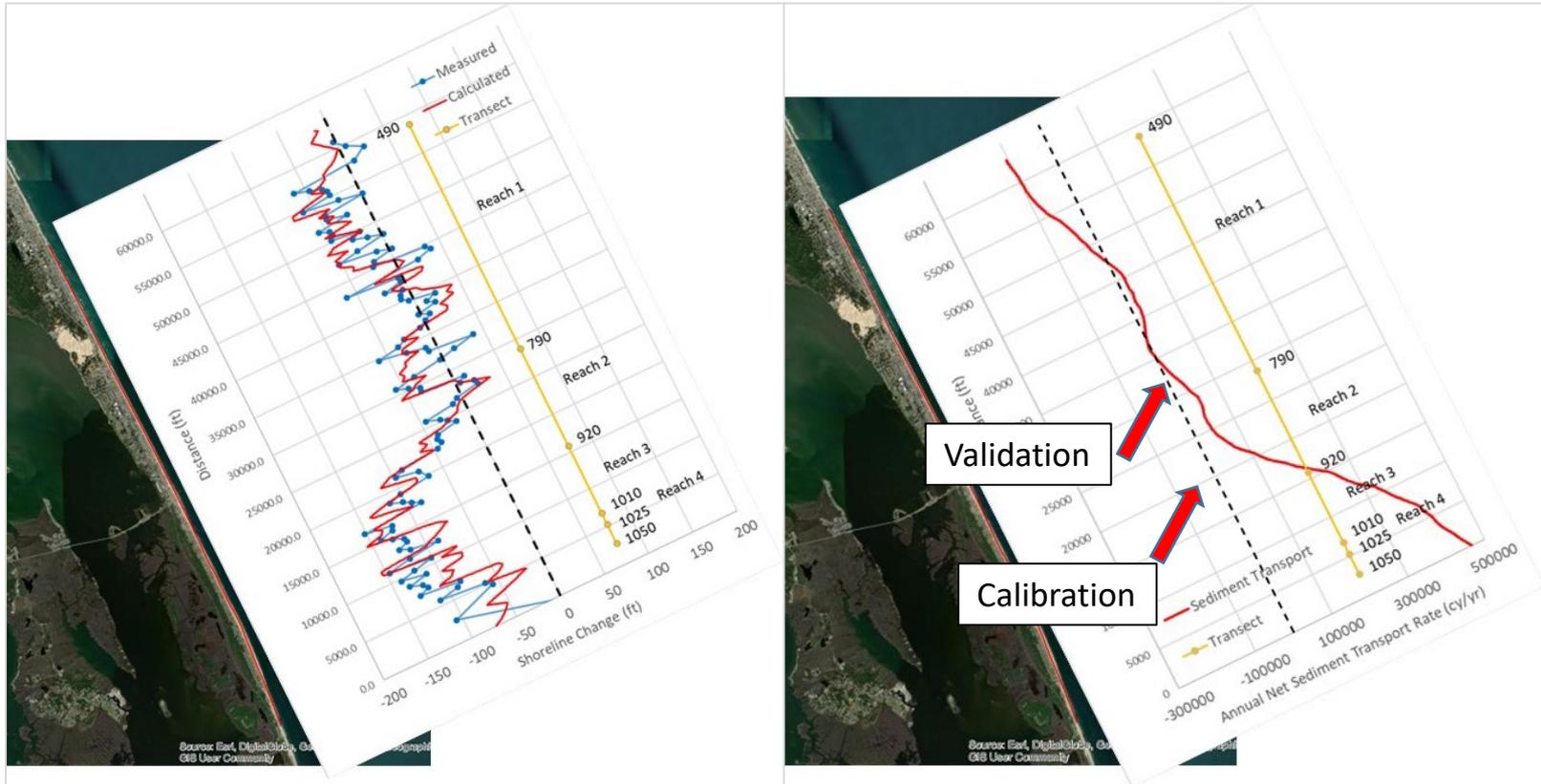
GENCADE MODELING - Calibration

Next Steps

- The trends of the nodal point will be analyzed further

- Nourishment intervals will be explored

- Possible Nourishment Alternatives will be investigated
    - What would happen if no stabilization or restoration measures were to take place?
    - Various nourishment alternatives in targeted areas as determined from CSHORE runs

Upcoming Master Plan Year 2

*Engineering Analysis
and Plan Development*

TASK 1 Data Collection & Review

TASK 2 Vulnerability Analysis

TASK 3 Geotechnical Analysis
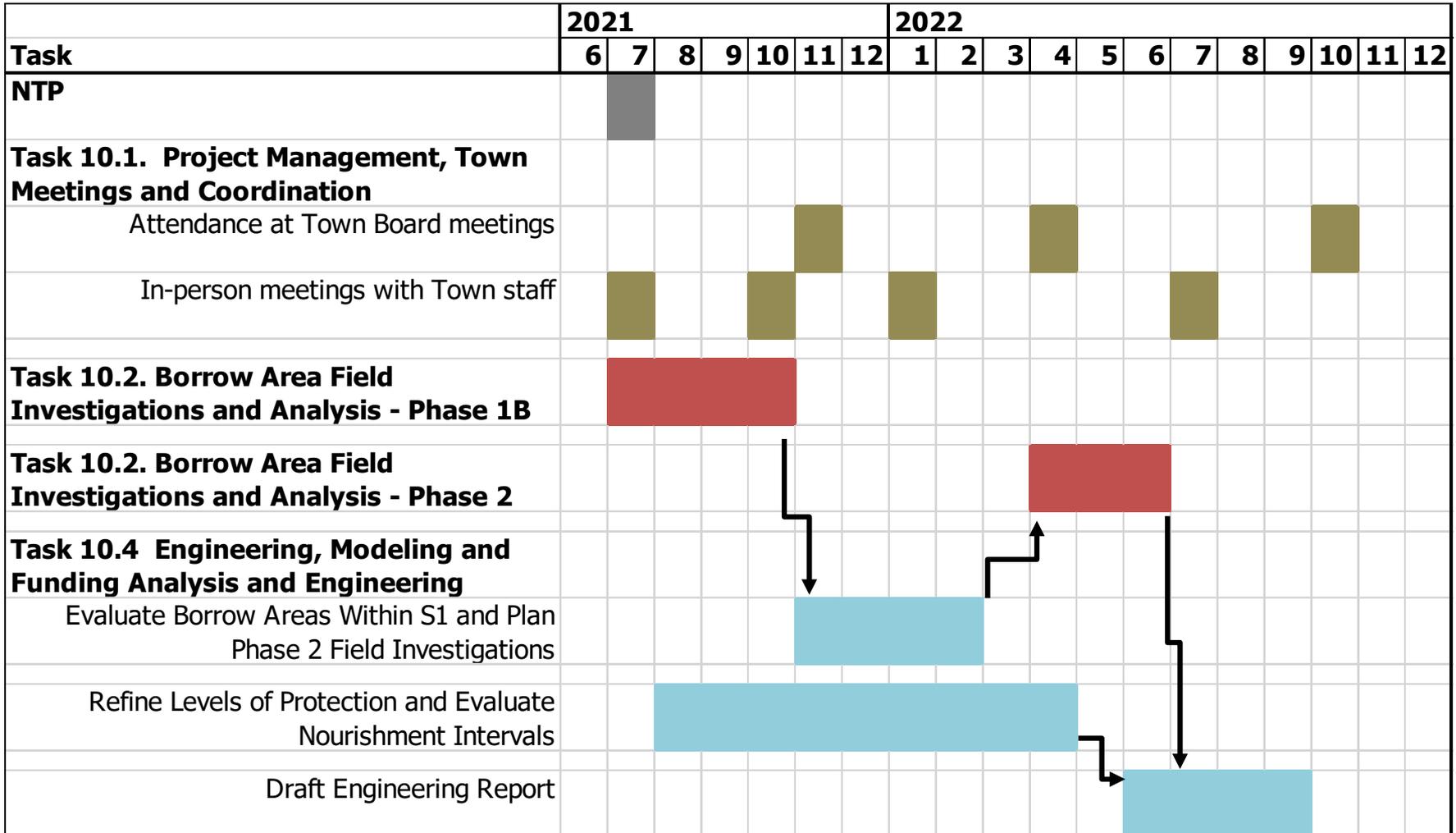
TASK 4 Alternative Recommendations

Proposed Year 2 Scope:

- Survey, geophysical, and vibracore analysis of available sand in borrow area S1

- Determine logical areas within S1 to dredge to representative depths

- Refinement of LoP beach templates in collaboration with the Town

- Evaluate different nourishment intervals, phasing plans and management of differing erosion rates

- Draft Engineering Report

- Continue to coordinate with the County and northern towns

Upcoming Master Plan Year 2

Proposed Year 2 Task Schedule:

Task	2021							2022										
	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12

Q&A / Discussion

THANK YOU

moffatt & nichol