MERRIMACK INLET SOUTH JETTY MAJOR MAINTENANCE STUDY

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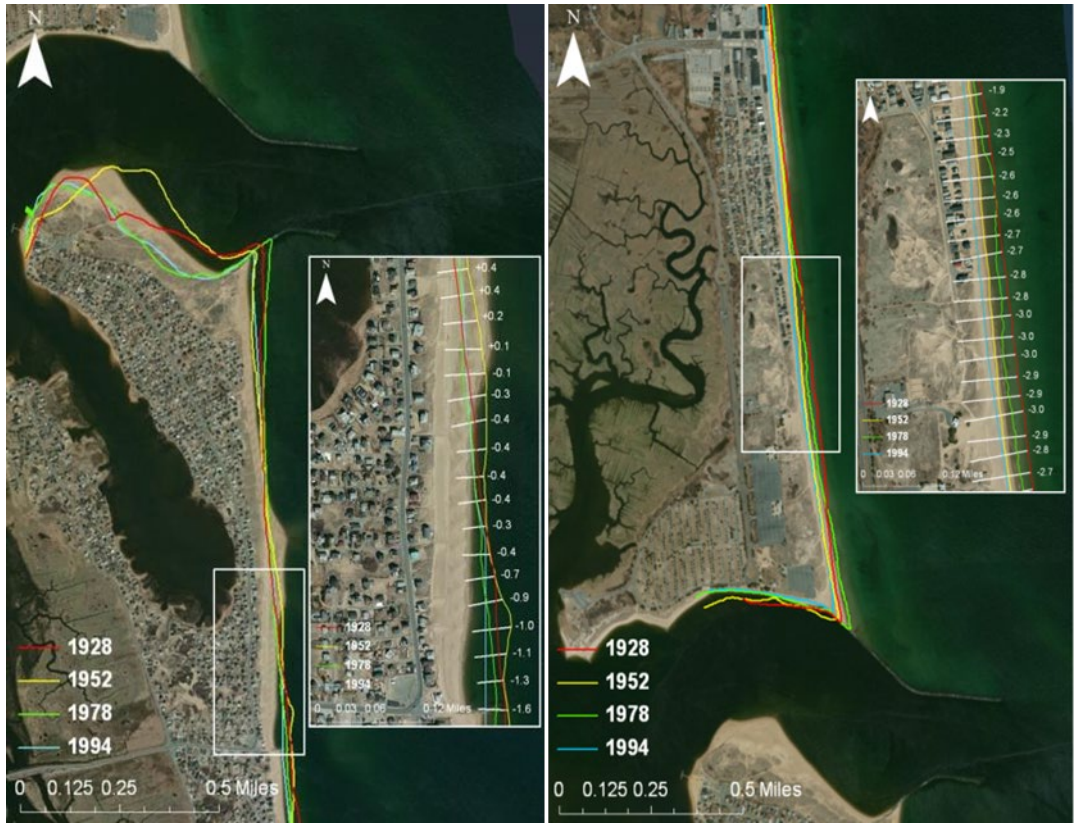
BACKGROUND – INLET SYSTEM

- Merrimack Estuary (inlet system)
- Merrimack Inlet: adjacent to Salisbury Beach and Plum Island
- Newburyport Harbor: 5.6 km (3.5 miles) from the mouth of Merrimack River
- Merrimack Embayment: mixed-energy and tide-dominated inlet
- Mean tide range: 2.6 m (8.5 ft)
- Significant wave height: 1.0 m (3.3 ft)
  Dominant wave direction: northeast
- Sediment: coarse to very coarse

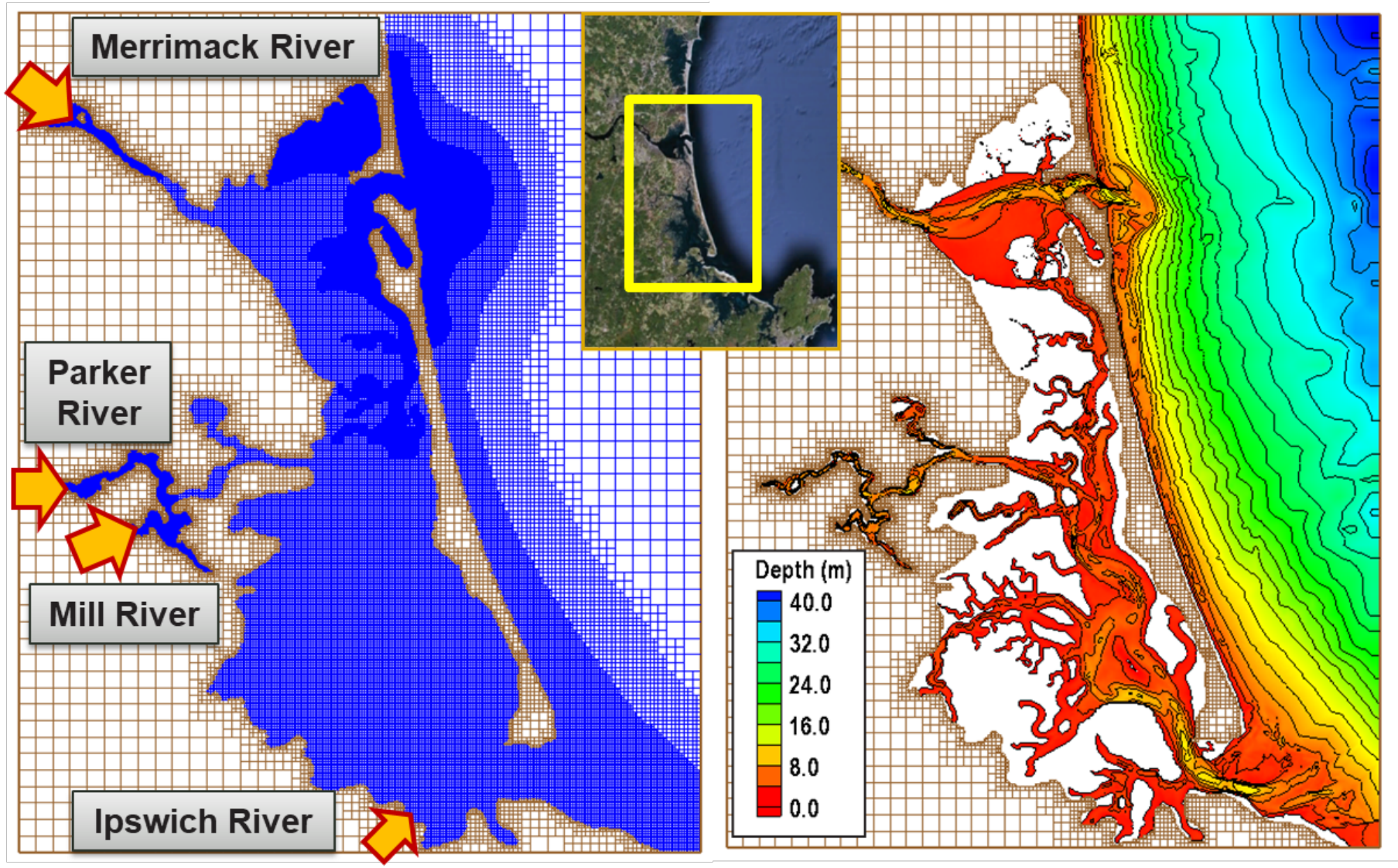
BACKGROUND - ISSUES

- Many of the beaches on Plum Island have experienced critical erosion and an average of 4 m (13 ft) of erosion between 2000 and 2009
- Post threat to coastal properties and infrastructures
- Salisbury Beach has also experienced chronic erosion and the trend of erosion will continue into the future
- Perform a numerical modeling study of alternatives



- Reduce erosion of the beaches, decrease shoaling in, and increase the navigability of the Inlet and Newburyport
- Increase performance of the jetties and develop a sand management strategy

COASTAL MODELING SYSTEM (CMS) MODELING GRID FROM PREVIOUS STUDIES



COASTAL MODELING SYSTEM (CMS) MODELING EFFORT FROM PREVIOUS STUDIES

Phase I

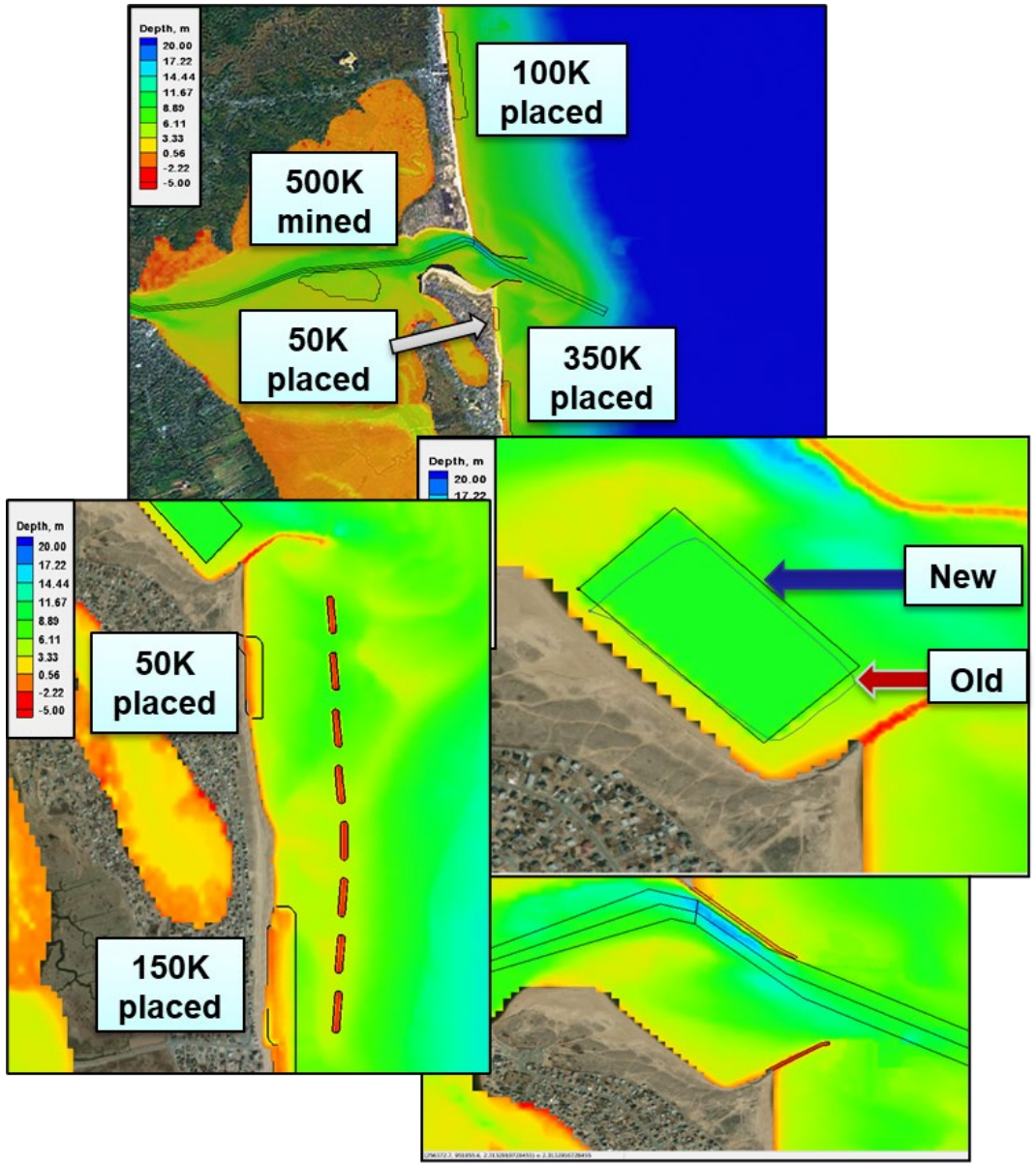
(initial screening, 1-month simulation)

- Simulations of high-energy month
- 19 alternative configurations provided by New England District
- Structural modification and sand management strategies

Phase II

(additional, 6-month simulation)

- 6 selected alternatives
- Mine flood shoal, subarea of north spit and place on beaches
- Move sedimentation basin further north to minimize adverse south jetty impacts
- Remove outer portion of jetties to minimize adverse impacts
- Extending detached breakwater system further south to provide more protection



REGIONAL SEDIMENT TRANSPORT PATTERNS

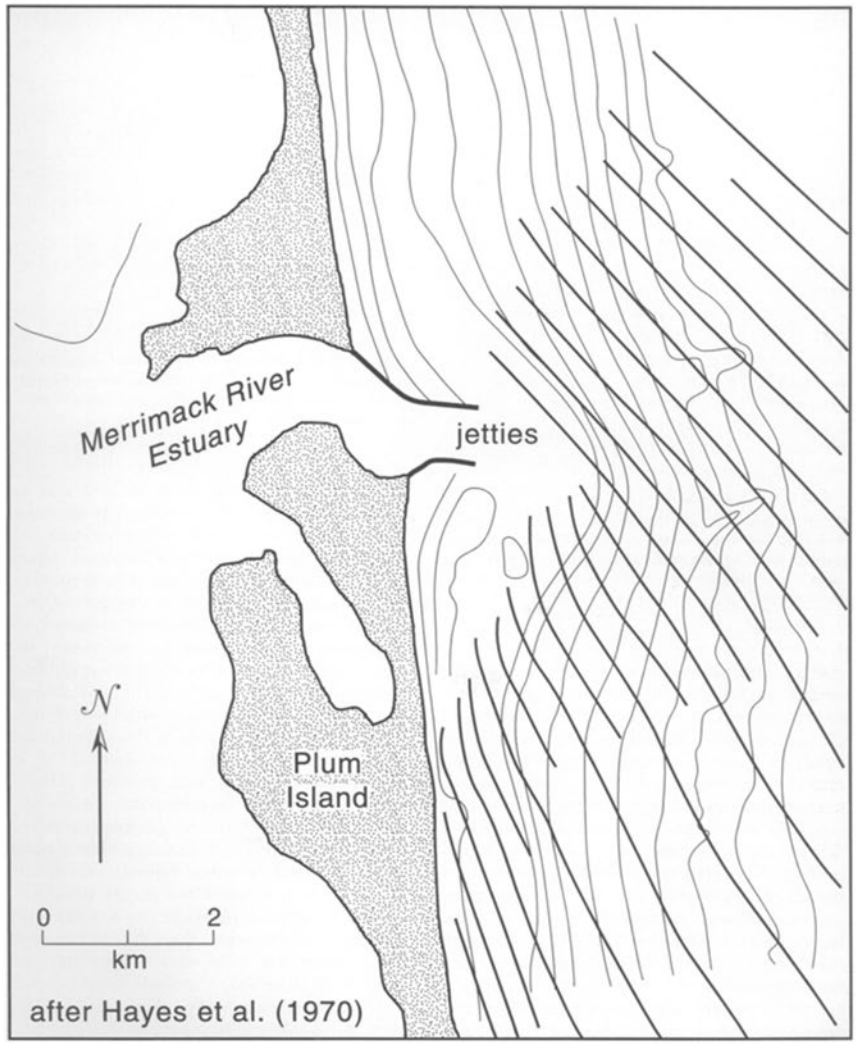


Figure 6. Wave refraction over the shoals of the ebb-tide delta of the Merrimack River Inlet, Massachusetts, resulting in the local reversal of the wave direction downdrift from the inlet. [*from* HAYES *et al.* (1970)]

Sediment transport patterns based on modeled flow patterns, imagery, and existing literature. (DCR, 2021)

- **Regional** littoral drift direction from North to South
- **Local LST reversal** immediately south of South Jetty
  - *Wave refraction over ebb shoal bypass bar*

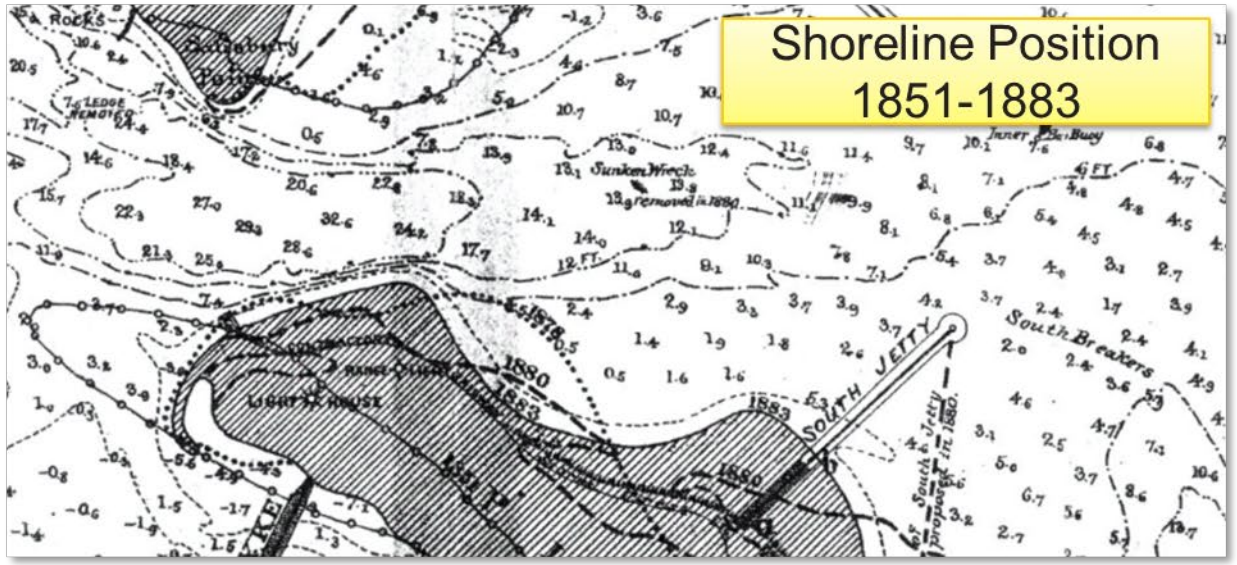
MERRIMACK INLET JETTY SEDIMENT TRANSPORT

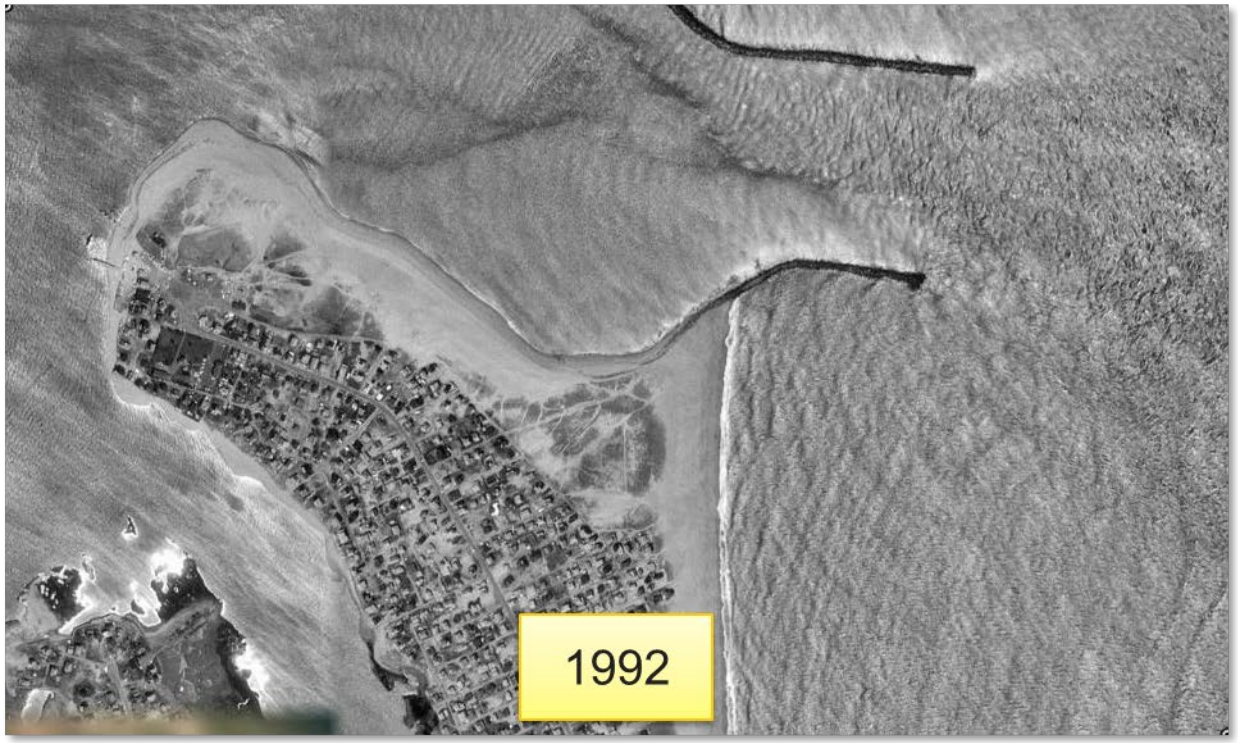
(A) Refracted northeast storm waves propagate through a beach in the South Jetty during high tide. (B) Merged panoramic of waves delivering sediment through the breach in the South Jetty to proximal Reservation Terrace. (C) Aerial view of northern Plum Island following jetty repair showing erosional beach of Reservation Terrace and growth of oceanfront beach south of Merrimack River Inlet South Jetty. (Hein, Fallon, Rosen, et al., 2019)

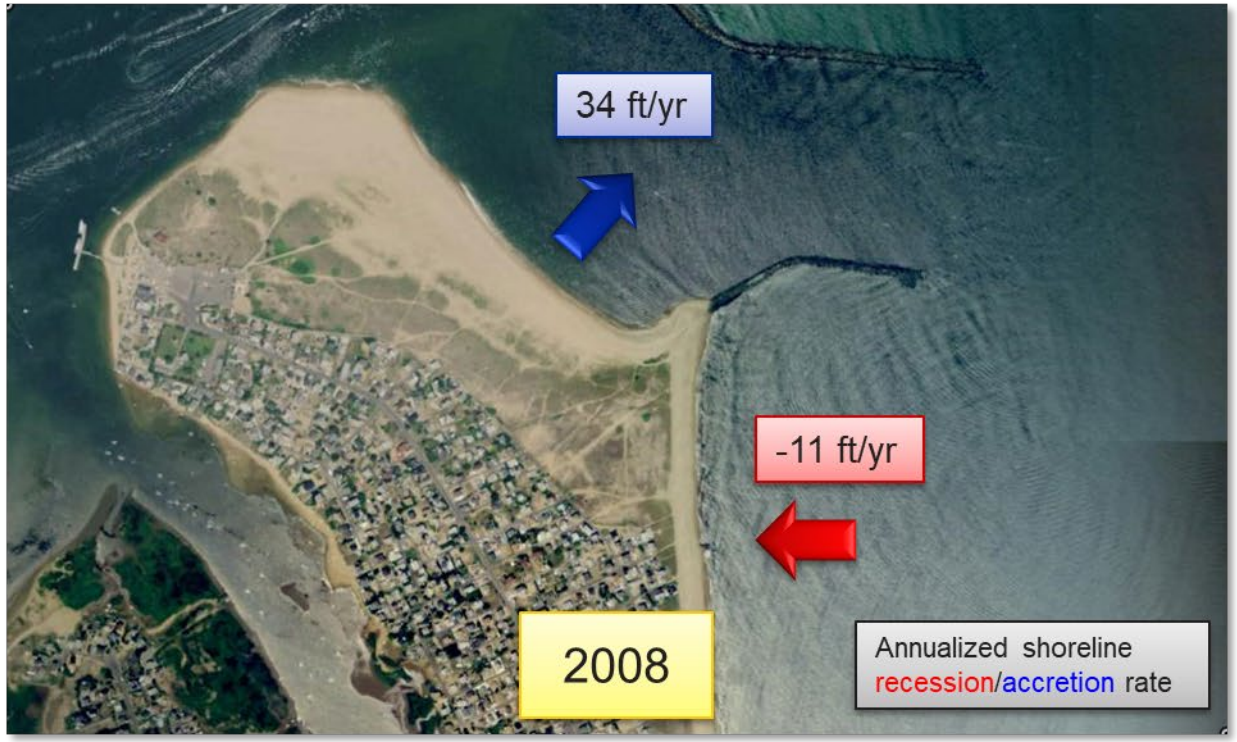
Sediment plume ebbing through Merrimack River Inlet in 2011. Note the stagnant water along Reservation Terrace at the top of the photo. The coloration also indicates a lack of mixing between the outward flow and the waters beyond the navigation channel. (DCR, 2021)

SITE CONDITIONS 1851-2008

- Cyclic erosion pattern along Reservation Terrace
- Erosion along Plum Island ocean shoreline

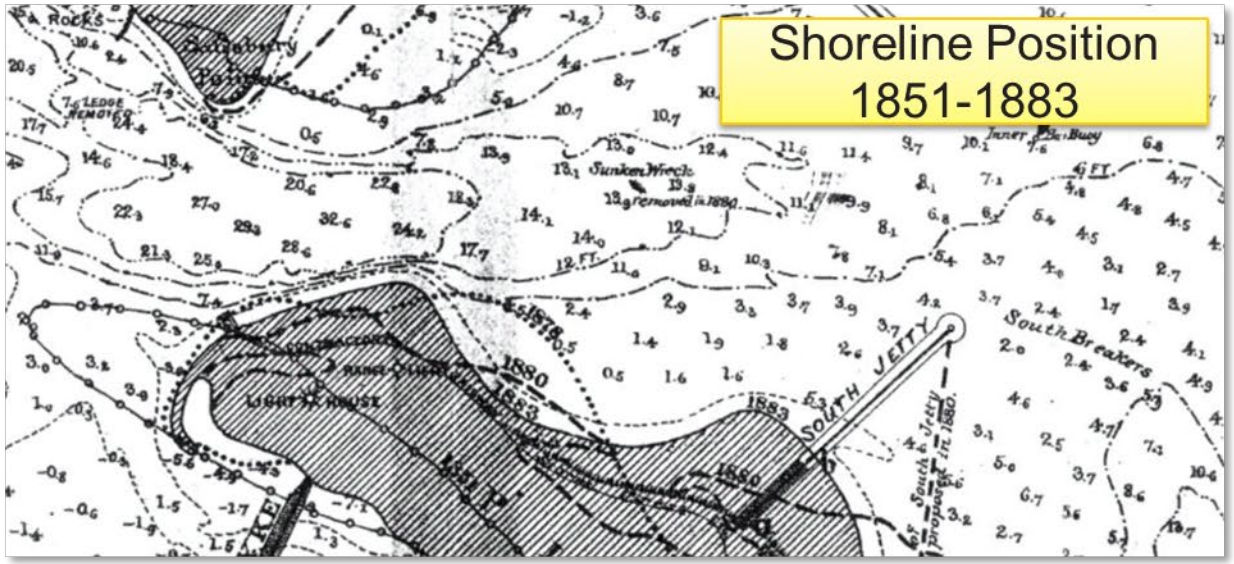






SITE CONDITIONS 1851-2020

- Cyclic erosion pattern along Reservation Terrace
- Erosion along Plum Island ocean shoreline

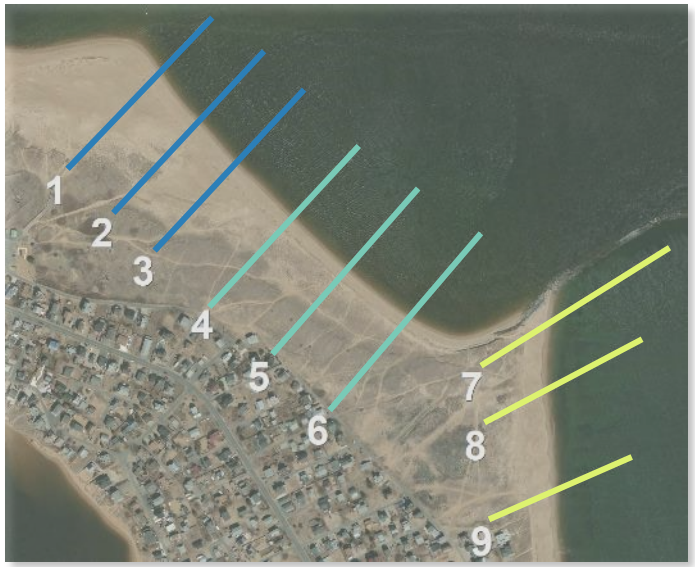


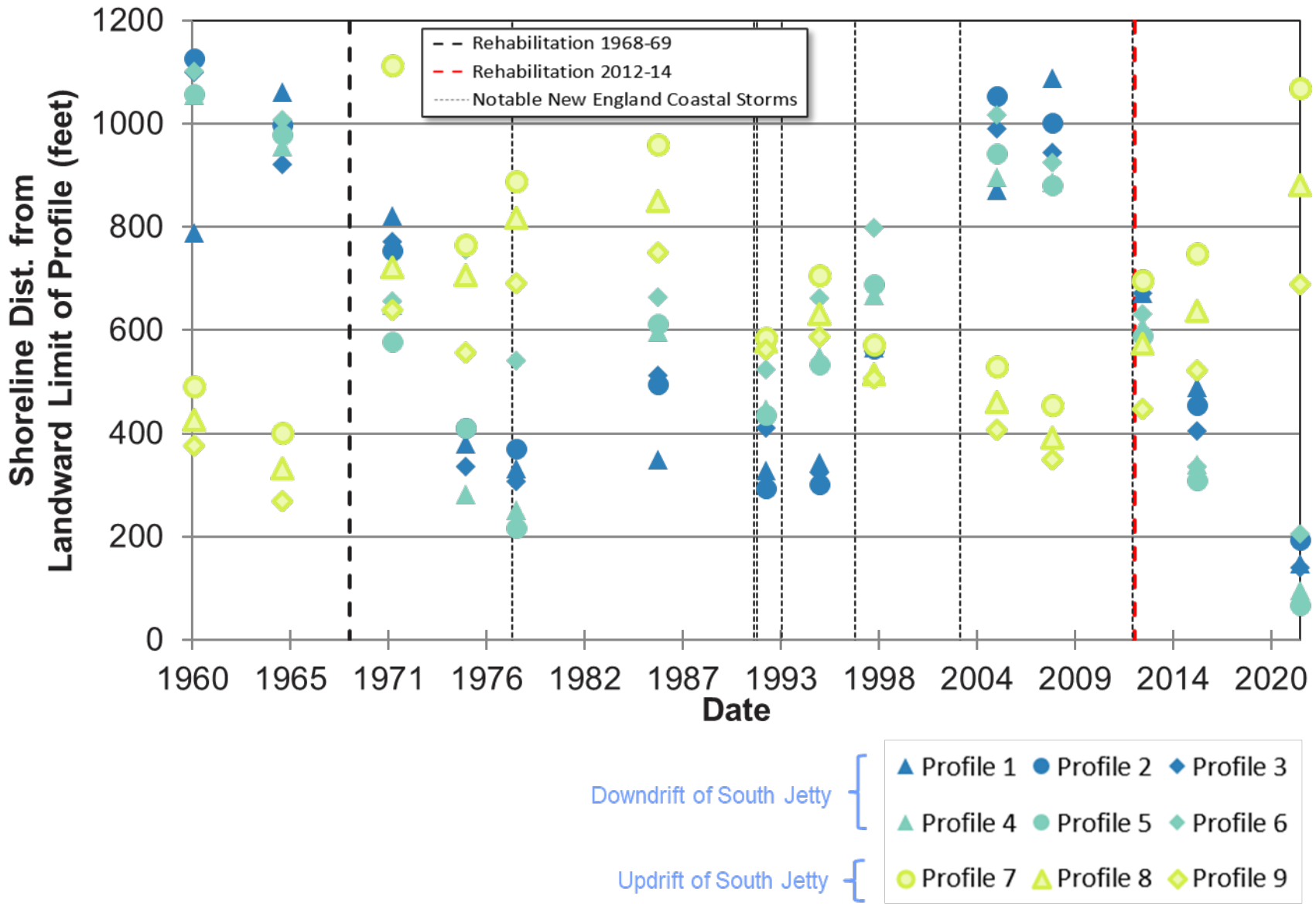
SITE CONDITIONS 2008-2023

- Cyclic erosion pattern along Reservation Terrace
- Erosion along Plum Island ocean shoreline
- Beach nourishment in 2023

HISTORICAL SHORELINE CHANGES AT NORTH PLUM ISLAND

Note: Profiles up- and downdrift of South Jetty exhibit <u>inverse</u> relationship.

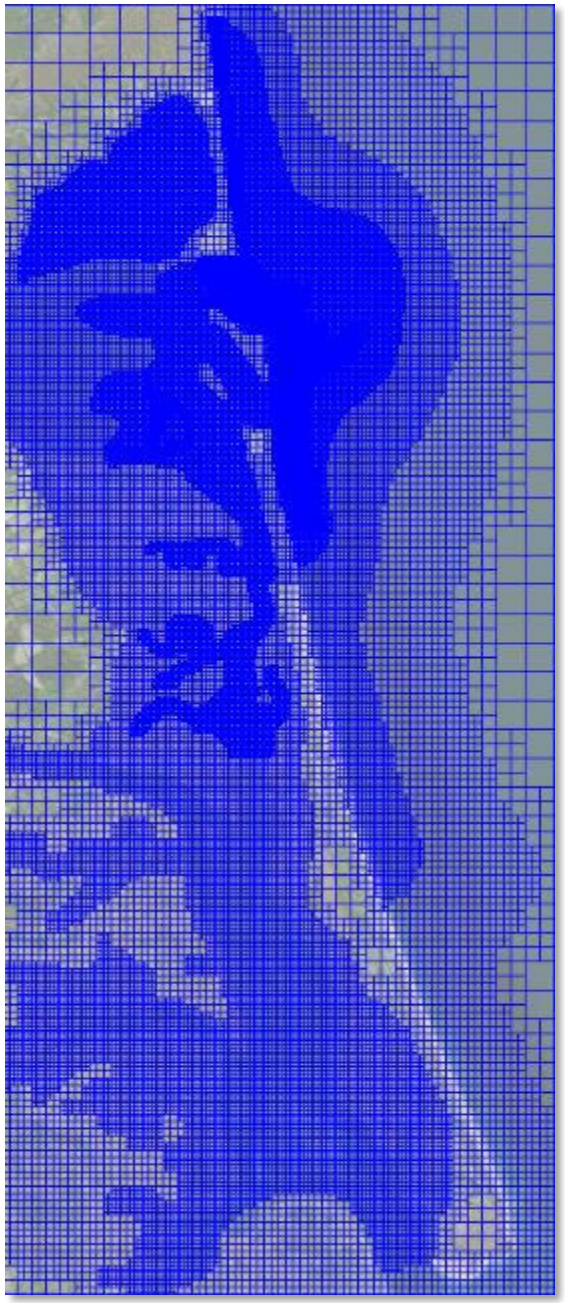




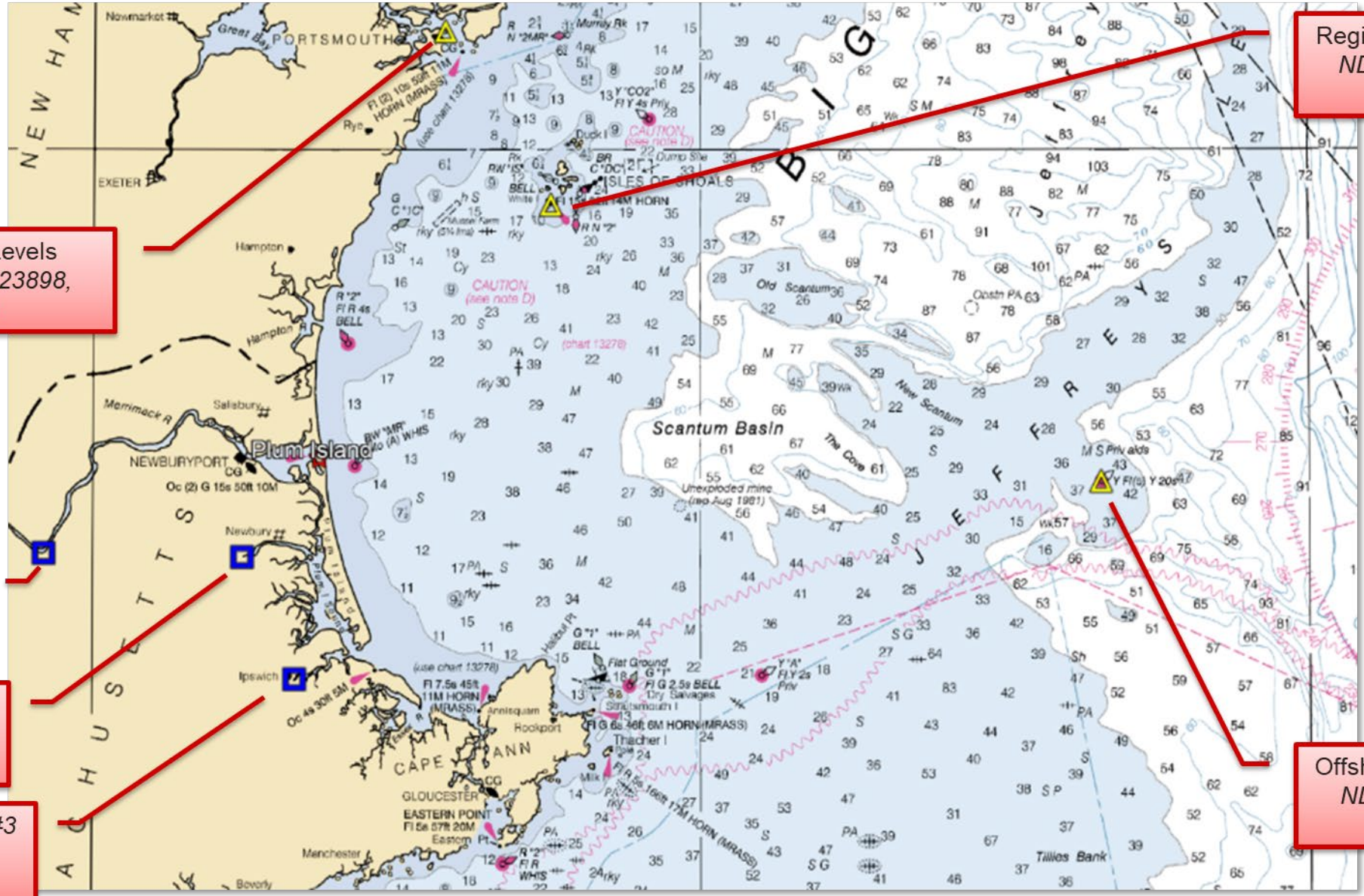
Shoreline data from 2018 DOTS study

STUDY AUTHORITY AND APPROACH

- Study Authority: Major Maintenance Study
  - *Must be modification to existing structure*
  - *Construction cost under $8M and be completed in less than 2 years*
- Leverage previous modeling and studies.
  - *ERDC/CHL (2018)*
  - *VIMS (2019)*
  - *DCR (2021)*
- Refine 2018 model grid within inlet, around jetties, and near North Point shoreline.
- Examine period of time around most recent shoreline trend reversal (2014-2015); allows us ability to leverage two consecutive JABLTCX surveys at that time.
- Evaluate modification alternatives for South Jetty and impacts to regional sediment management including shorelines both up and downdrift of structure.

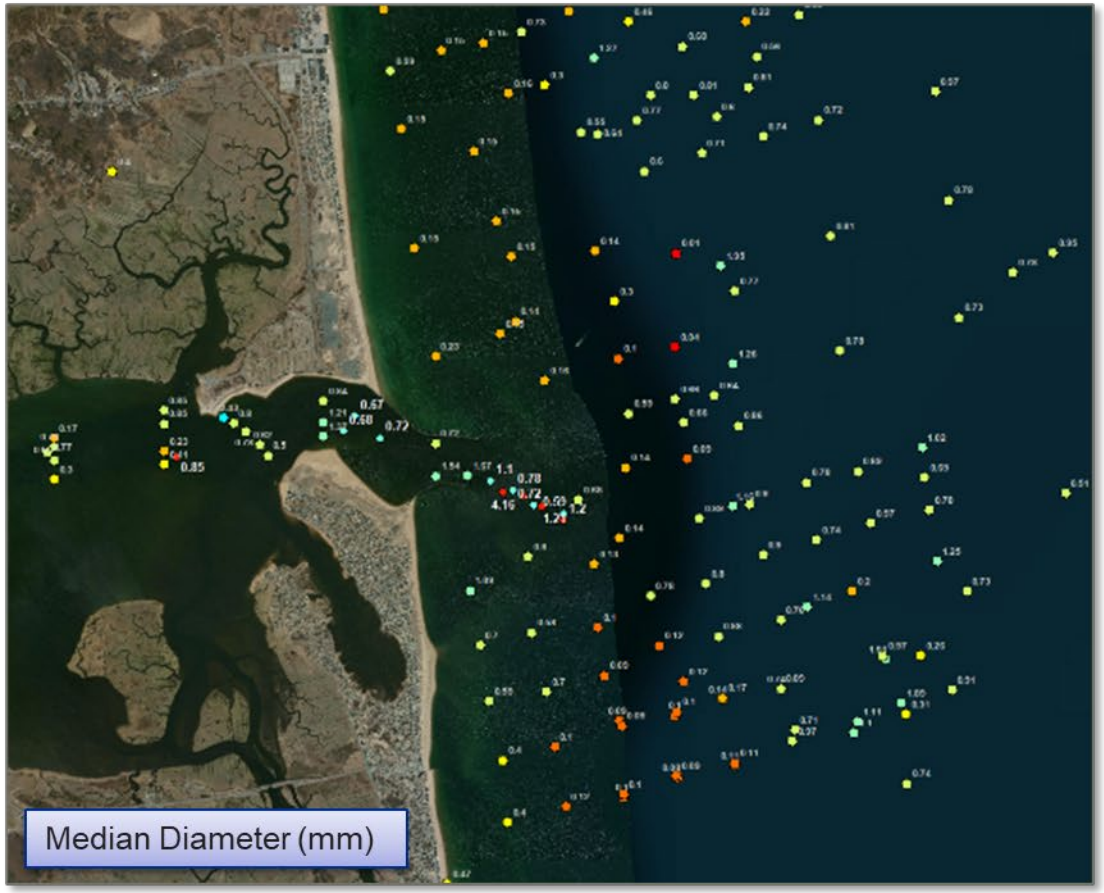


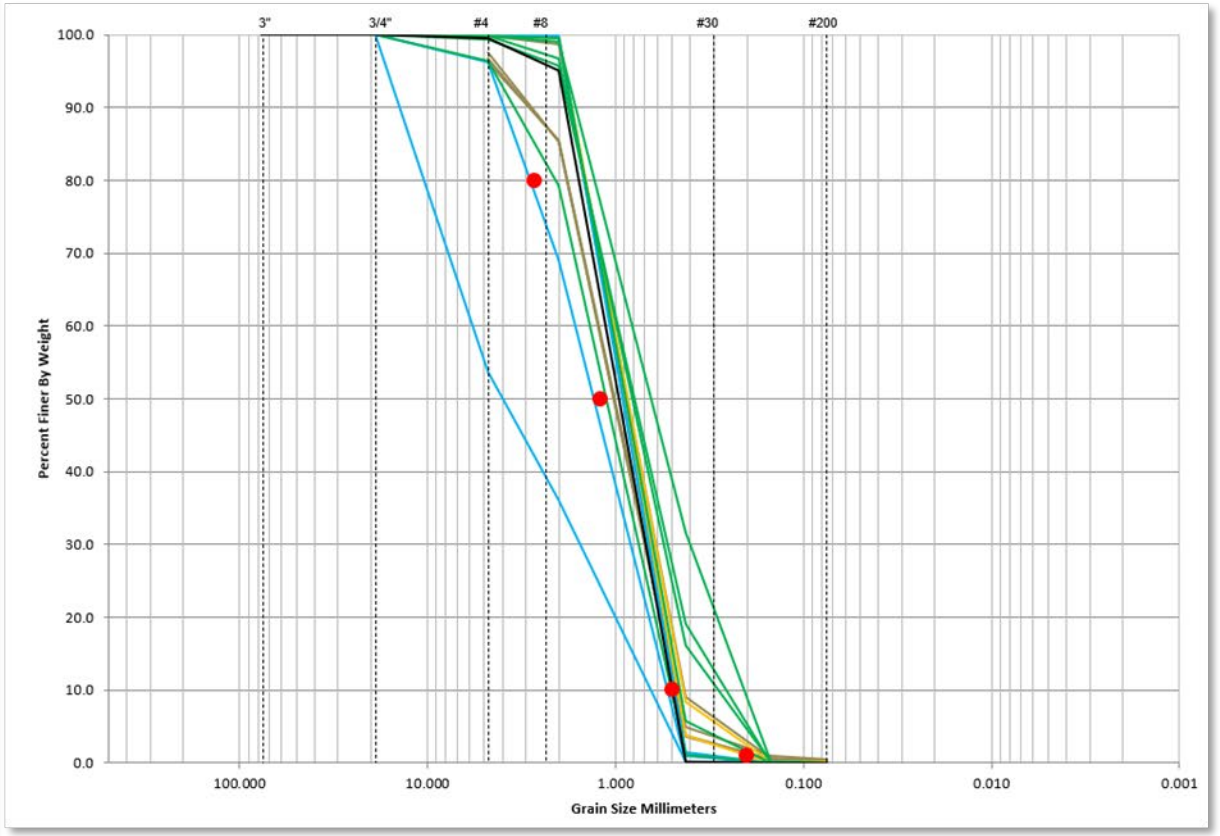
MODEL DOMAIN AND FORCING CONDITIONS



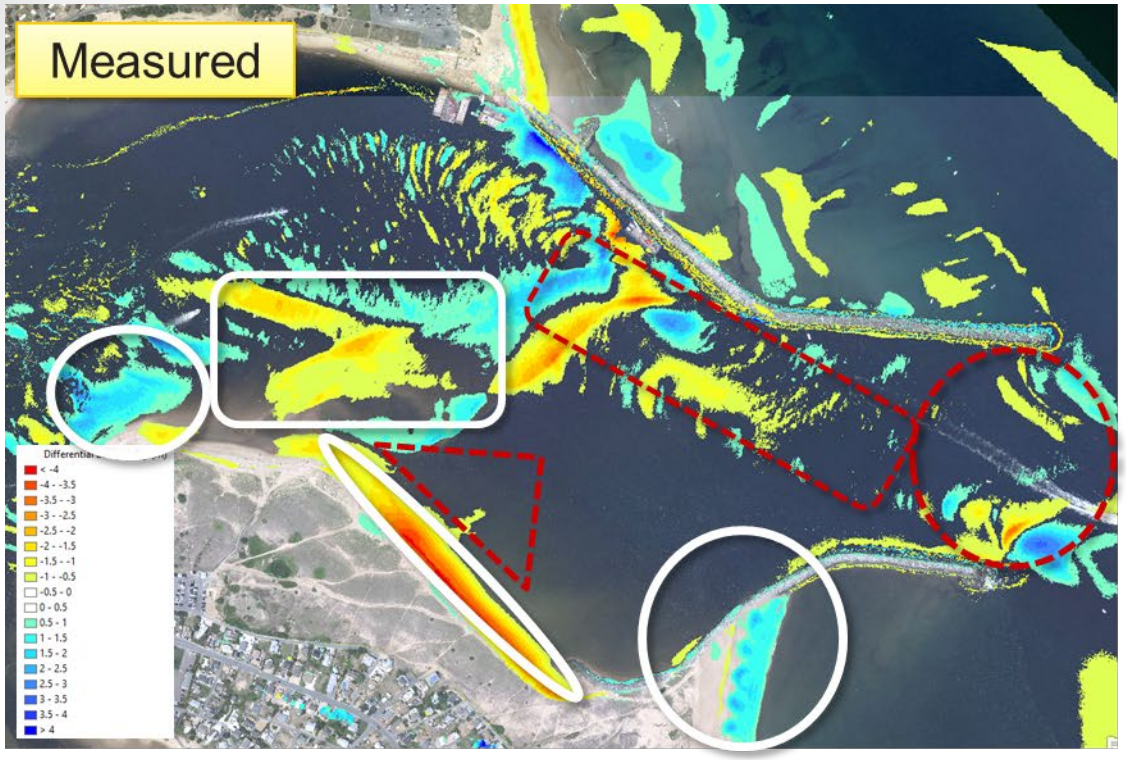
SEDIMENT GRAIN SIZE DATA

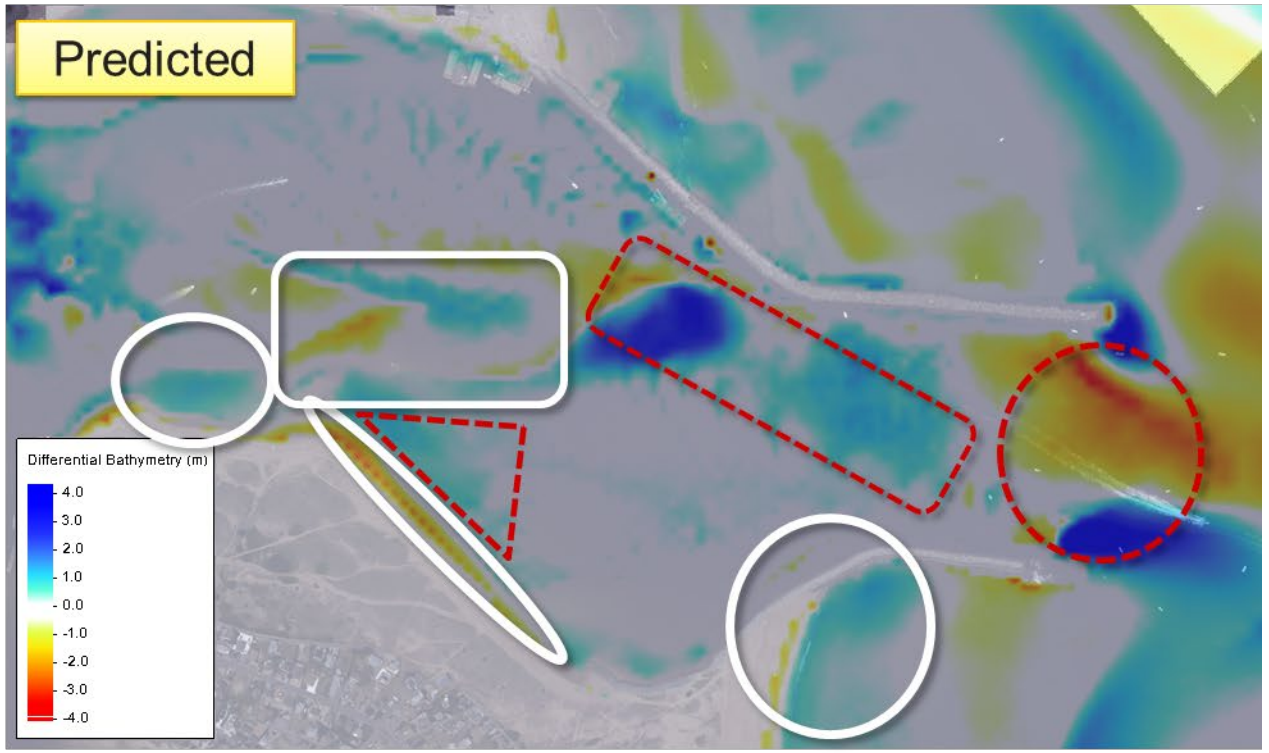
- Sediment transport model including grain size data from multiple surveys.
- Four classes of sediment
  - *0.2, 0.5, 1.2, and 2.7 mm*
- Transport formula: Lund-CIRP





MODEL CALIBRATION (DEC 2014 - JUN 2015)





Conclusions

- Sediment transport/morphology generally in good agreement in shallow to intermediate water depths.
- Deeper water (e.g., within FNP) tends to over-predict sediment erosion/deposition.

CONCEPTUAL ALTERNATIVES

Focus:

- Bypassing Weir in South Jetty
  - *DCR recommendations for weir; 80-100 feet*
  - *Study will evaluate various configurations*

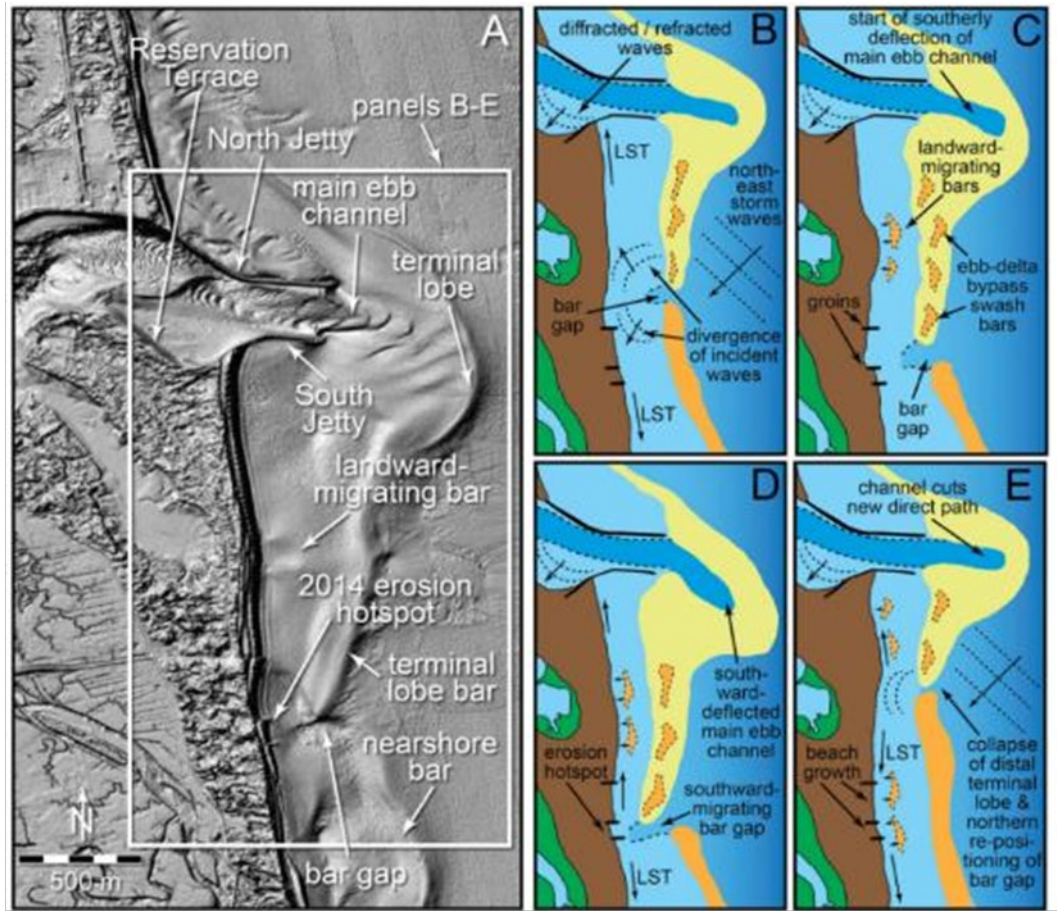
Stakeholder Feedback:

- Removal of Outer Leg of South Jetty
  - *Harbormaster recommendation*
  - *Further study may be required to determine impact on safe navigation*

Holistic Approach

- Impacts to other areas must be considered in evaluation, namely:

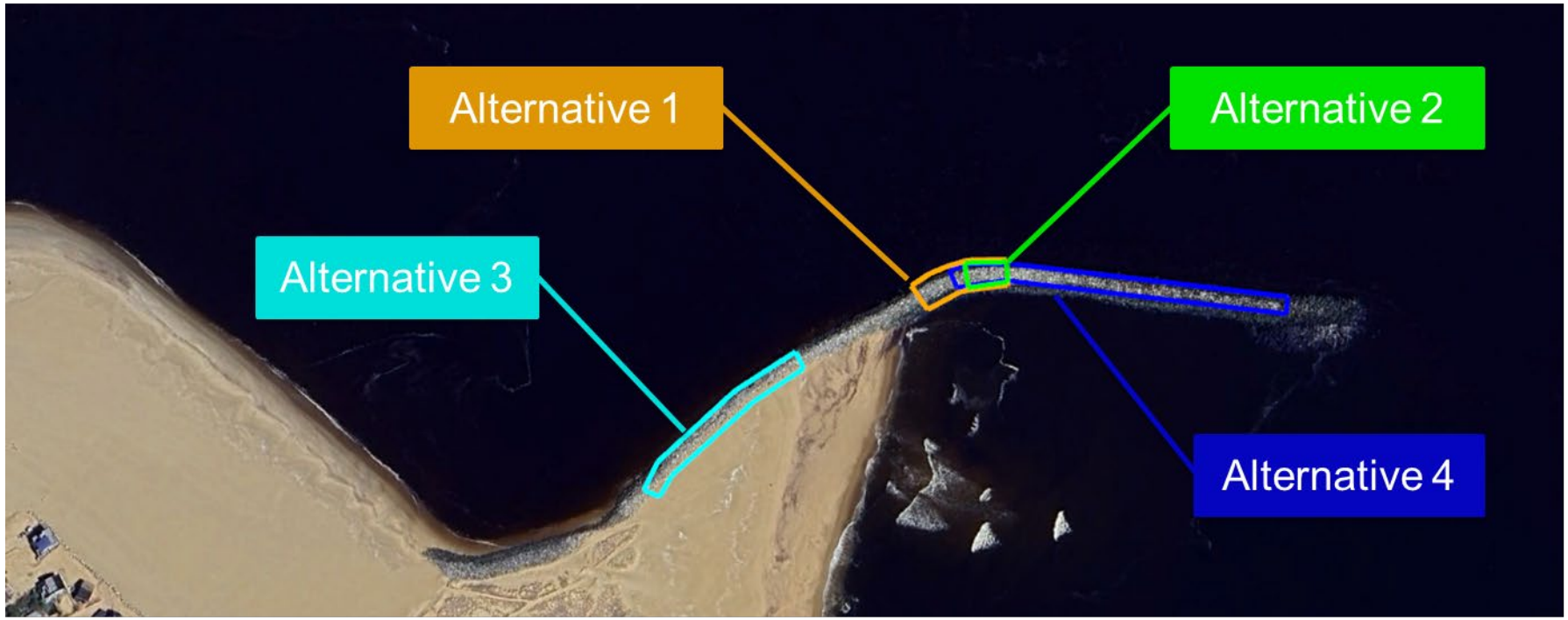
Increased shoaling of Federal Navigation Project
Increased erosion along ocean-facing shoreline

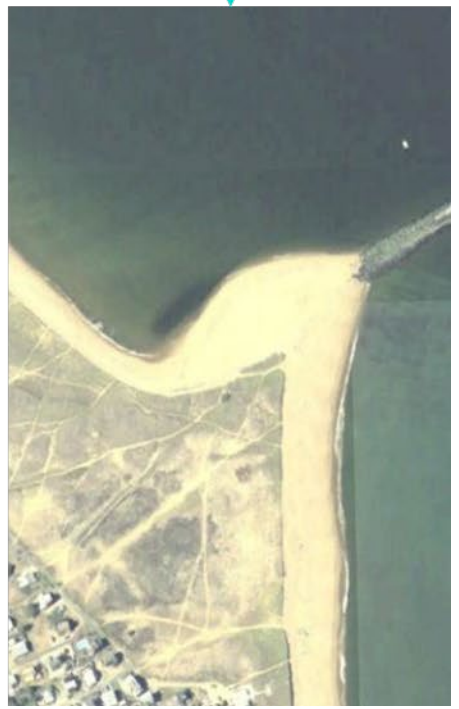


Conceptual model of hotspot formation, growth, and downdrift migration along Plum Island oceanfront beach. (Hein, Fallon, Rosen, et al., 2019)

ALTERNATIVE SUMMARY

Alternative No.	Alternative Name	Weir Length (feet)	Weir Crest Elevation (feet MLLW)	Existing Jetty Crest over Alternative (feet MLLW)
1	Swash Zone Weir	200	4.3 (mean sea level)	13-14.5
2	Break Point Weir	80	4.3 (mean sea level)	13-13.5
3	Runup Weir	400	8.7 (mean higher high water)	15.3-19.3
4	Dog Leg Removal	650	varies	12.3-14





MODEL RESULTS

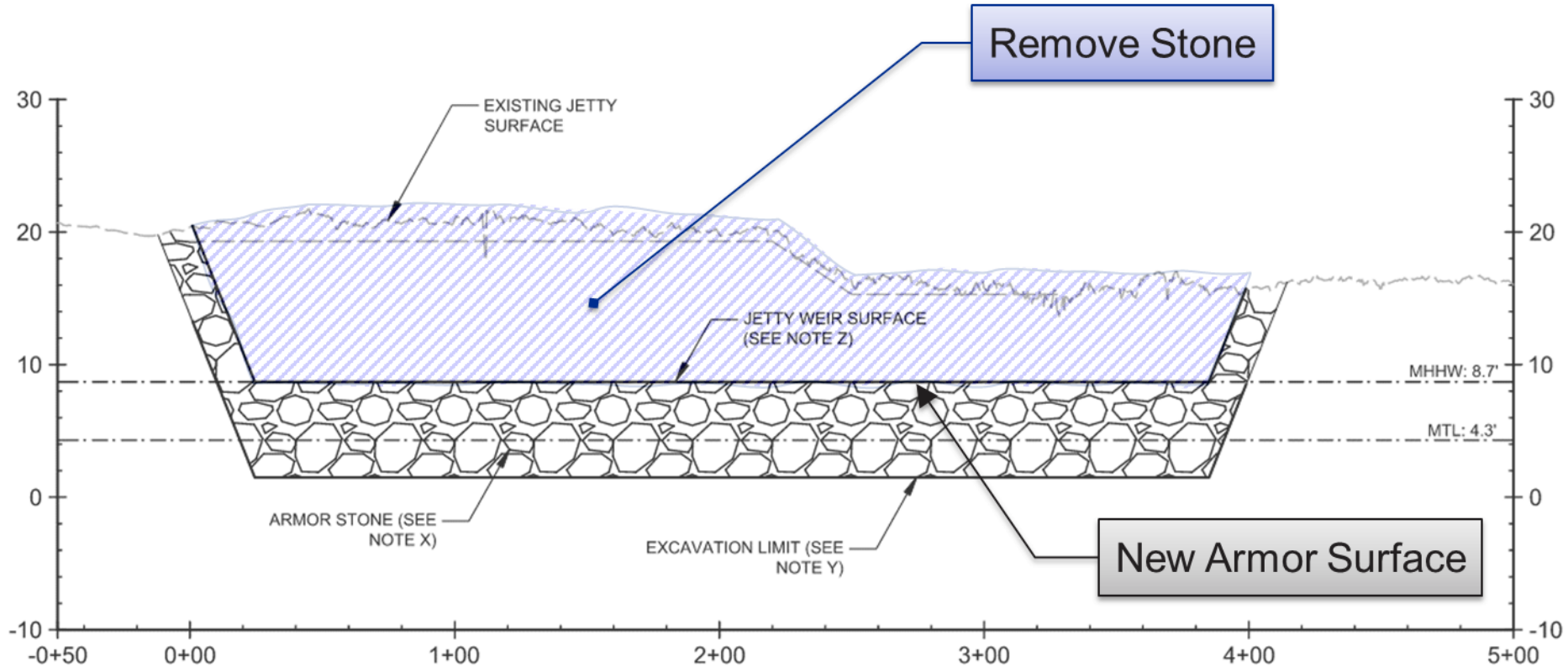
Predicted Net Erosion/Deposition (cy) from December 2014 to June 2015

Area of Interest	Base Conditions	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Adjacent Federal Channel	127,000	125,000	142,000	71,000	64,000
Reservation Terrace	(9,000)	(4,000)	(6,000)	3,000	(2,000)
Seaside of South Jetty	6,000	(10,000)	2,000	0	(16,000)
Newbury Beach to Plum Island Turnpike (~1 mile)	1,000	(7,000)	(3,000)	6,000	8,000

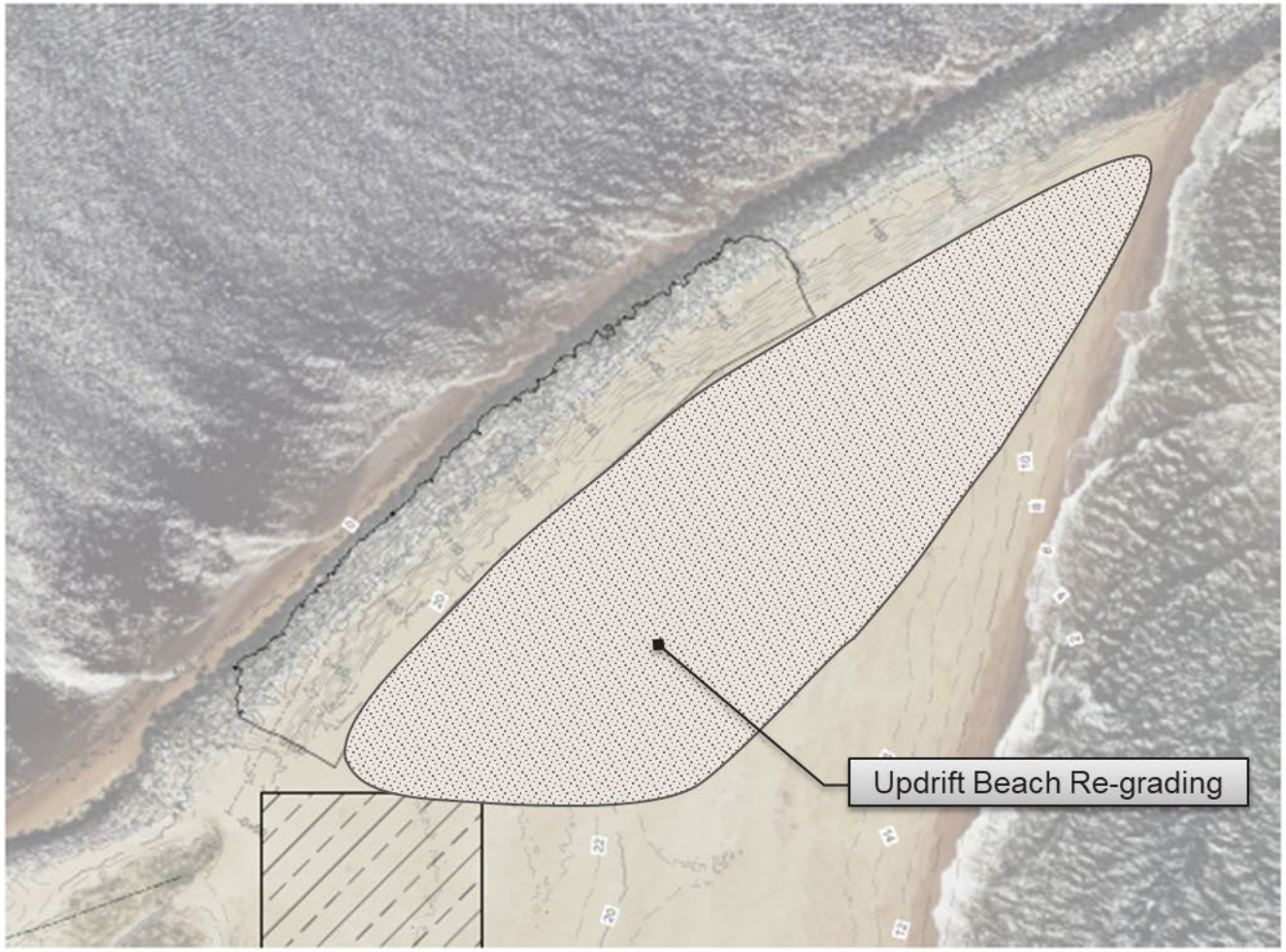
Alternative 3 (Runup Weir) has a positive impact to Reservation Terrace, the least negative impact to the channel, and a neutral impact to the seaside of the South Jetty. Predicted impacts along Newbury Beach are negligible considering the larger area.

ALTERNATIVE 3 CONCEPT DESIGN - PROFILE

- **Design refinement**
  - Jetty weir elevation to be refined
  - Determine extents of tie-in at ends of repair area
  - Armor stone sizing to be determined
  - Significant excavation of sand required to regrade updrift beach and allow for access work area
  - Determine location for relocated stone and sand in project vicinity



ALTERNATIVE 3 CONCEPT DESIGN – PLAN VIEW



- Objective is to allow sediment bypassing only during moderate to extreme events.

PATH FORWARD

- Major Maintenance Study provided “proof of concept”
  - Present to MRBA (5 APR 2024)
  - Major Maintenance Report (MMR) to be finalized in summer 2024
  - MMR needs to be reviewed by District personnel and approved by District Commander

- NAE has expressed FY26 capabilities for design and environmental coordination efforts
  - Once additional funds received, team to develop scope and schedule for design, permitting and construction phases and begin work.
    - MMR modeling looked at a 6-month period; design phase will look at “typical” year of performance
    - Engineering to move from concept to design phase
    - Develop construction cost estimate and contract documents (e.g., plans and specifications)
    - Environmental and Real Estate coordination

THANKS!!

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