Living Shorelines 201

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NROC ENGINEERING LIVING SHORELINES IN NH WORKSHOP

26 OCTOBER 2017

Great Bay National Estuarine Research Reserve

NHCP

University of New Hampshire
CHART
Coastal Habitat Restoration Team

UNIVERSITY of NEW HAMPSHIRE

Overview of Talk

- Definitions
- Shoreline issues addressed by living shoreline solutions
- Driving forces resulting in erosion
- Erosion resisting forces
- Vegetation
- Shoreline ecosystems
- Regulations
- Challenges of northern shoreline projects
- Where to Use
- WHF data to date
- Measures of success

Definition

- *Living shorelines maintain continuity of the natural land–water interface and reduce erosion while providing habitat value and enhancing coastal resilience*. (NOAA, Guidance for Considering the Use of Living Shorelines, 2015)
- *Living shorelines maintain the continuity of natural land-water interface and provide ecological benefits which hard bank stabilization structures do not, such as improved water quality, resilience to storms, and habitat for fish and wildlife*. (COE NWP, 2016) – Focus is EROSION

Critical Living Shoreline Components

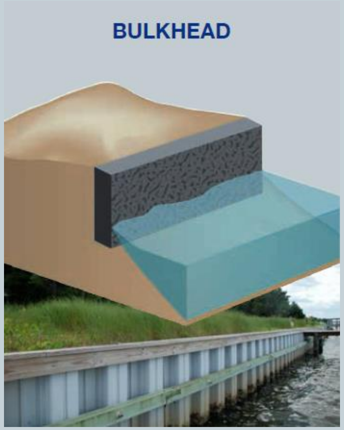
- Continuity of shoreline water-sediment characteristics
- Habitat
  - Aquatic
  - Riparian

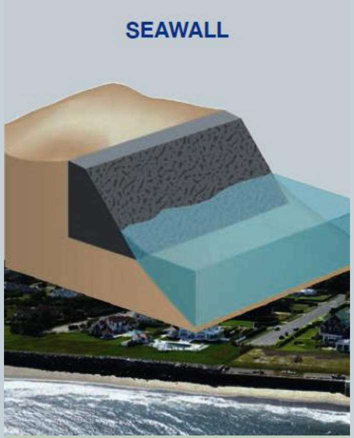
Does not necessarily include plants, but "*Living shorelines must have a substantial biological component…*" (COE, NWP, 2016)

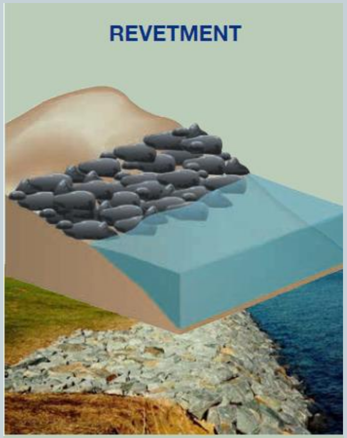
What Is Not "Living" Shoreline?

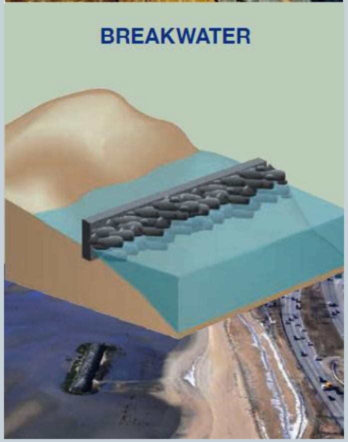
- Bulkhead
- Seawall
- Revetment
- Groins
- Breakwater
- Sills
- Composite

However some may be components of living shoreline systems

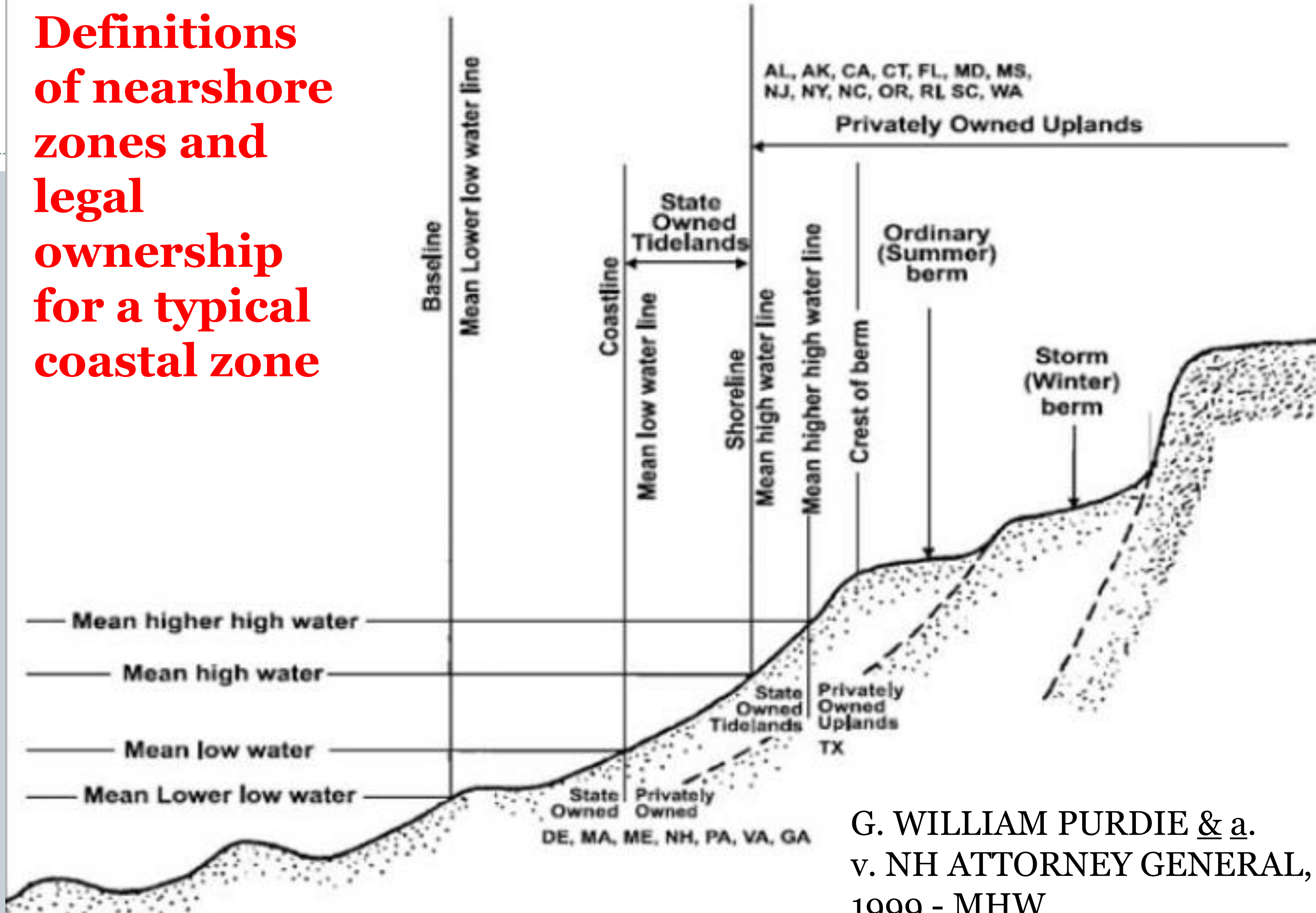








Definitions of nearshore zones and legal ownership for a typical coastal zone



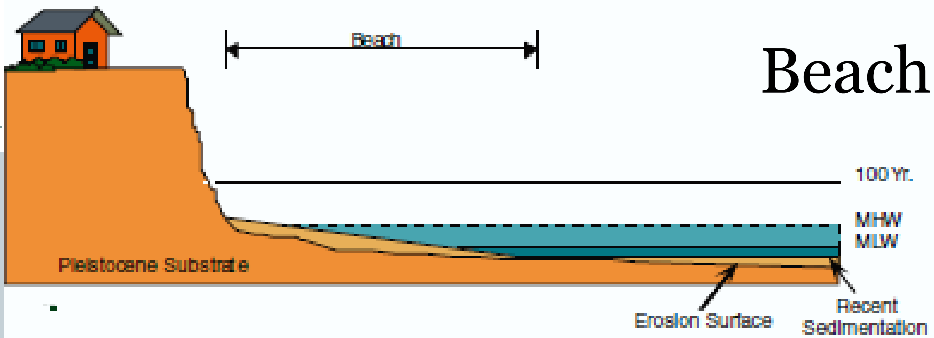
G. WILLIAM PURDIE & a. v. NH ATTORNEY GENERAL, 1999 - MHW

NRC, 2007, Mitigating Shore Erosion Along Sheltered Coasts

Common Sheltered Coasts

Beach

1



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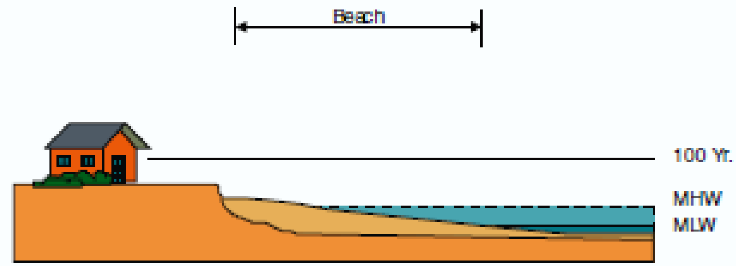
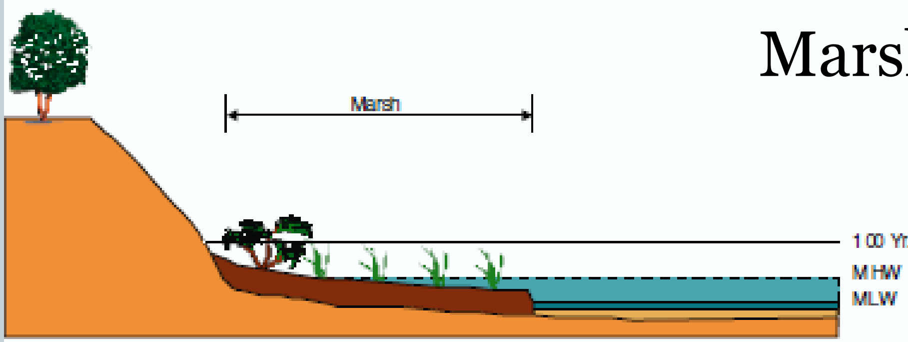


Marsh

2



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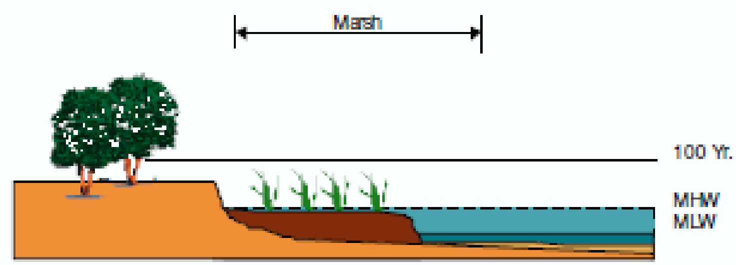
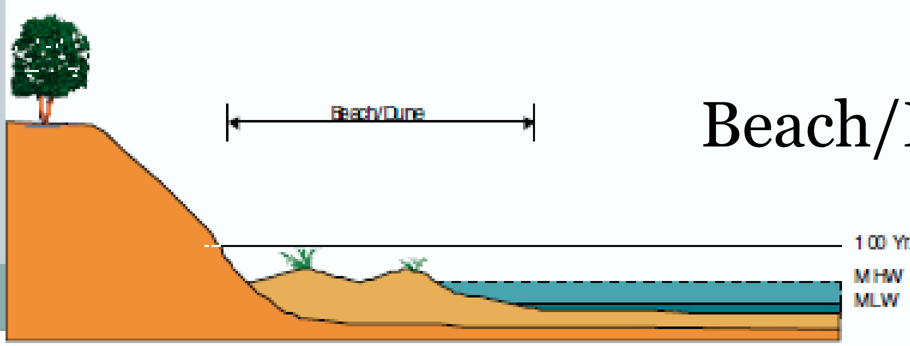


NRC, 2007, Mitigating Shore Erosion Along Sheltered Coasts

Beach/Dune

3



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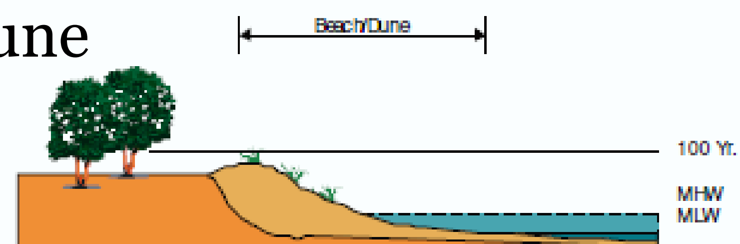


Shoreline Issues Addressed by Living Shoreline Solutions

- Erosion (from waves, currents–longshore drift, ice)
- Habitat loss (historic and recent losses of oyster reefs, salt marshes, tidal buffer zone)
- Sea level rise (salt marshes build with sea level rise – up to a point)
- Infrastructure protection (bridge abutments, roads, pipelines, sewers, etc.)

Elements leading to Erosion

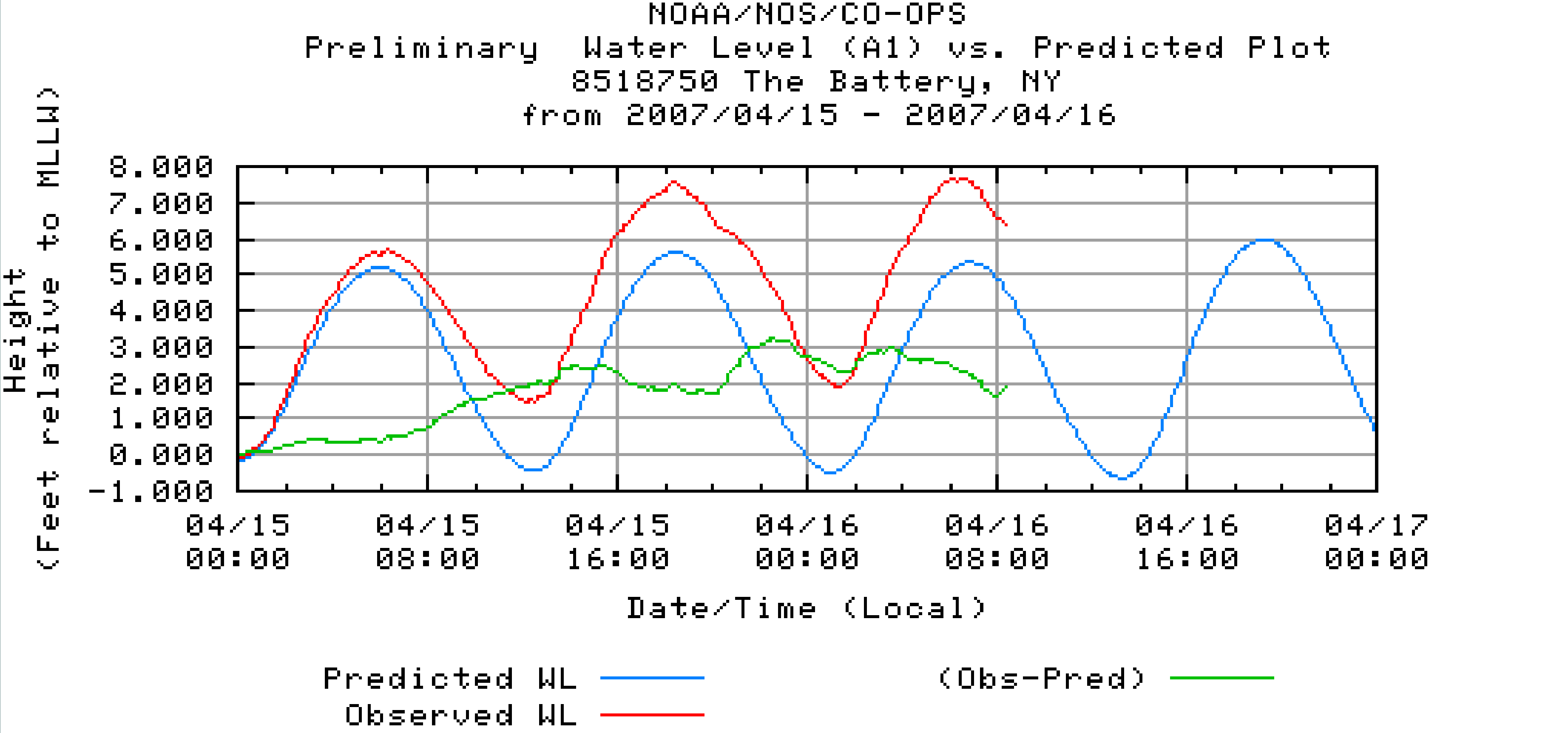
- Waves
- Currents
- Exposed soils
- Tidal range
- Ice
- Foot traffic
- Pollution
- Subsidence
- Sea level rise
- Loss of sediment supply
- Loss of vegetation

Velocity
Shear stress

Erosion Resisting Elements

- Particle size and composition
- Vegetation (above and below ground)
- Slope
- Enhanced sediment supply

The Tide



NOAA/NOS/CO-OPS
Preliminary Water Level (A1) vs. Predicted Plot
8518750 The Battery, NY
from 2007/04/15 - 2007/04/16
Height
(Feet relative to MLLW)
8.000
7.000
6.000
5.000
4.000
3.000
2.000
1.000
0.000
-1.000
04/15 00:00
04/15 08:00
04/15 16:00
04/16 00:00
04/16 08:00
04/16 16:00
04/17 00:00
Date/Time (Local)
Predicted WL
Observed WL
(Obs-Pred)

Tidal Definitions

- Mean Tide – average of high and low tide observations over a long time period
- Mean High Tide – average of just all the high tides over a long time period
- Mean Higher High Tide - the average of the higher high water height of each tidal day observed over a long time period
- National Tidal Datum Epoch – 19 years. The present NTDE is 1983 through 2001 and is actively considered for revision every 20-25 years

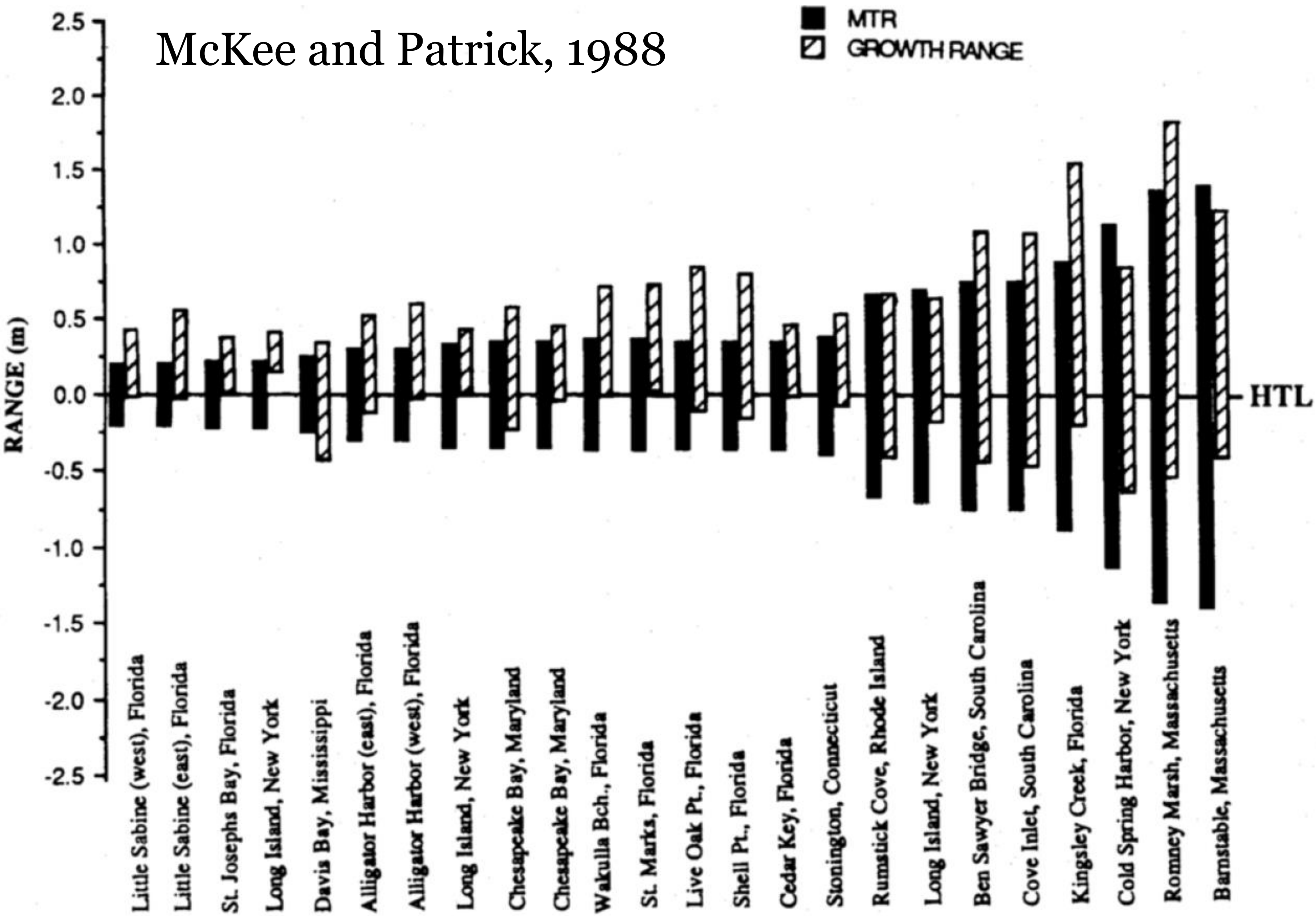
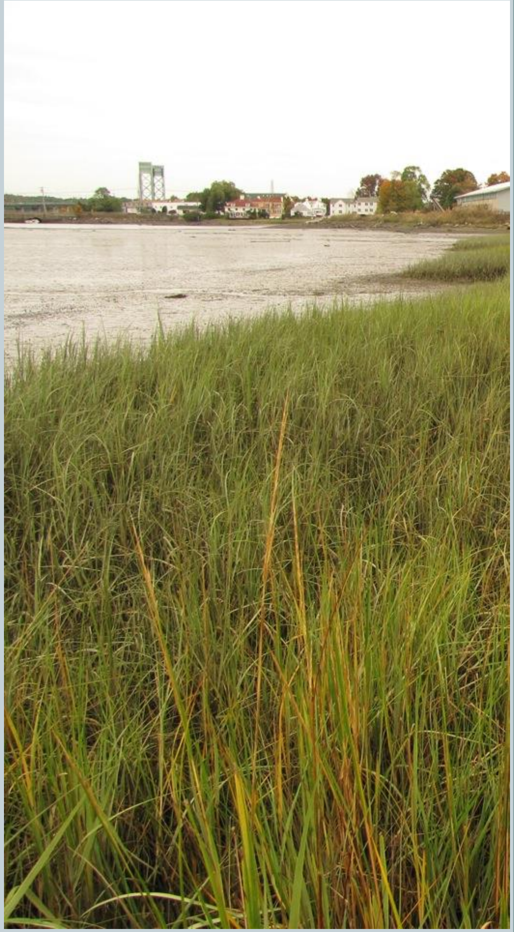


Fig. 2. The elevational range of growth of *Spartina alterniflora* relative to mean tide range (MTR) at selected locations along the Atlantic and Gulf coasts (arranged in order of increasing tidal amplitude). The half tide level (HTL) is the plane midway between mean high water (MHW) and mean low water (MLW).

Vegetation

- Low Marsh:
  - *Spartina alterniflora* (smooth cordgrass)
- High Marsh:
  - *Spartina patens* (salt hay)
  - *Puccinellia americana* (alkali grass)
  - *Distichlis spicata* (spike grass)
  - *Juncus gerardii* (black grass)
- Tidal Buffer Zone:
  - *Panicum virgatum* (switchgrass)
  - *Solidago sempervirens* (seaside goldenrod)



Spartina alterniflora

Ecozones

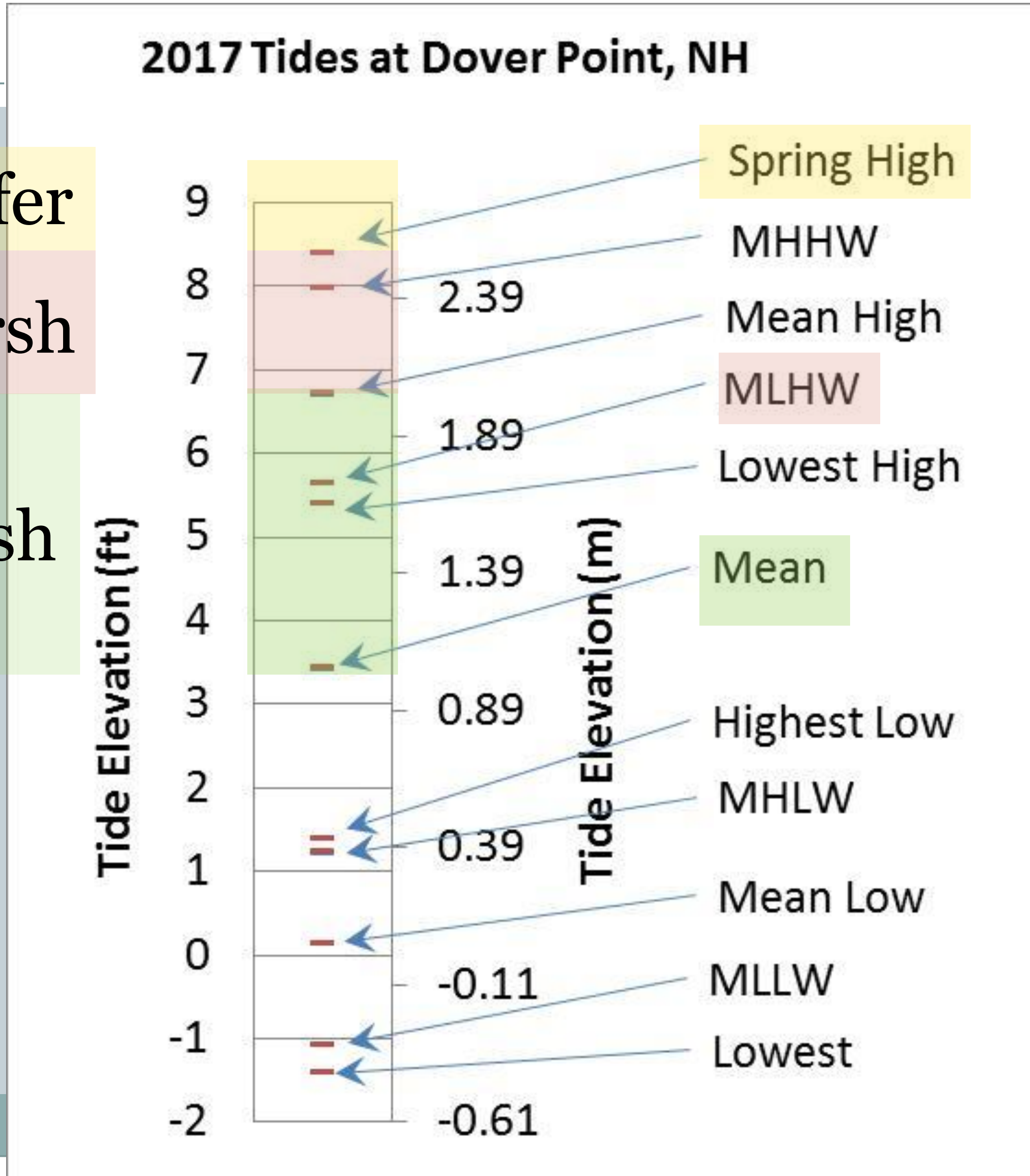
- Low Marsh - Near the MSL; (McKee and Patrick 1988). *Spartina alterniflora* is the only important plant.
- High Marsh - Begins at MHW and extends up to high tide line – A reasonable lower limit for a built/planted marsh might be 10 cm higher than that. Practically, it is best to plant *S. alterniflora* as much as 25 cm above MHW – it will do fine at these elevations; high marsh plants should be planted too and may replace *S. alterniflora* .
- Tidal Buffer Zone - Begins at or above the spring high tide but certainly below the highest observable tide (HOT) and extends as much as two feet higher, depending on exposure. - A transition from the highest of the high marsh plants (like seaside goldenrod and high tide bush) to quackgrass and then shrubs at even higher levels (beach plum, shad bush, bayberry, etc.)

The Zones

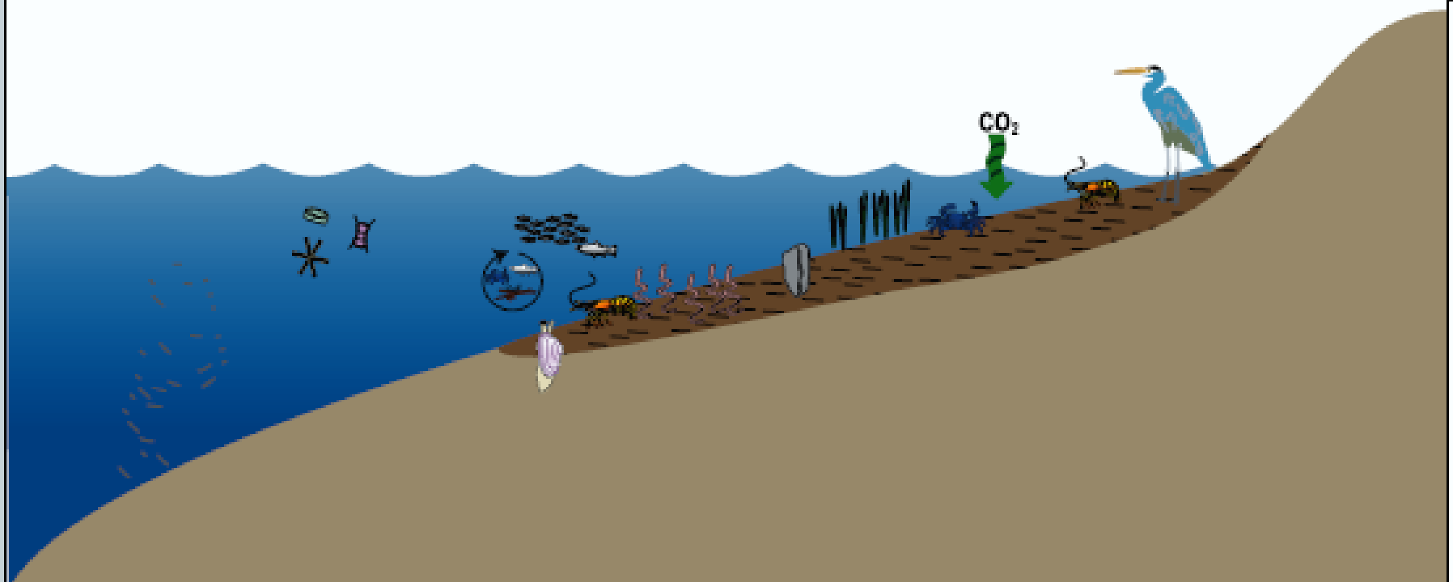
Tidal Buffer

High Marsh

Low Marsh



Shoreline Mudflat Ecosystems



Icon Key

- molluscs
- worms
- phytoplankton
- shrimp
- wading birds
- crabs
- mud
- sand

Importance and Features

Mudflats provide habitat for invertebrates, crustaceans and birds.

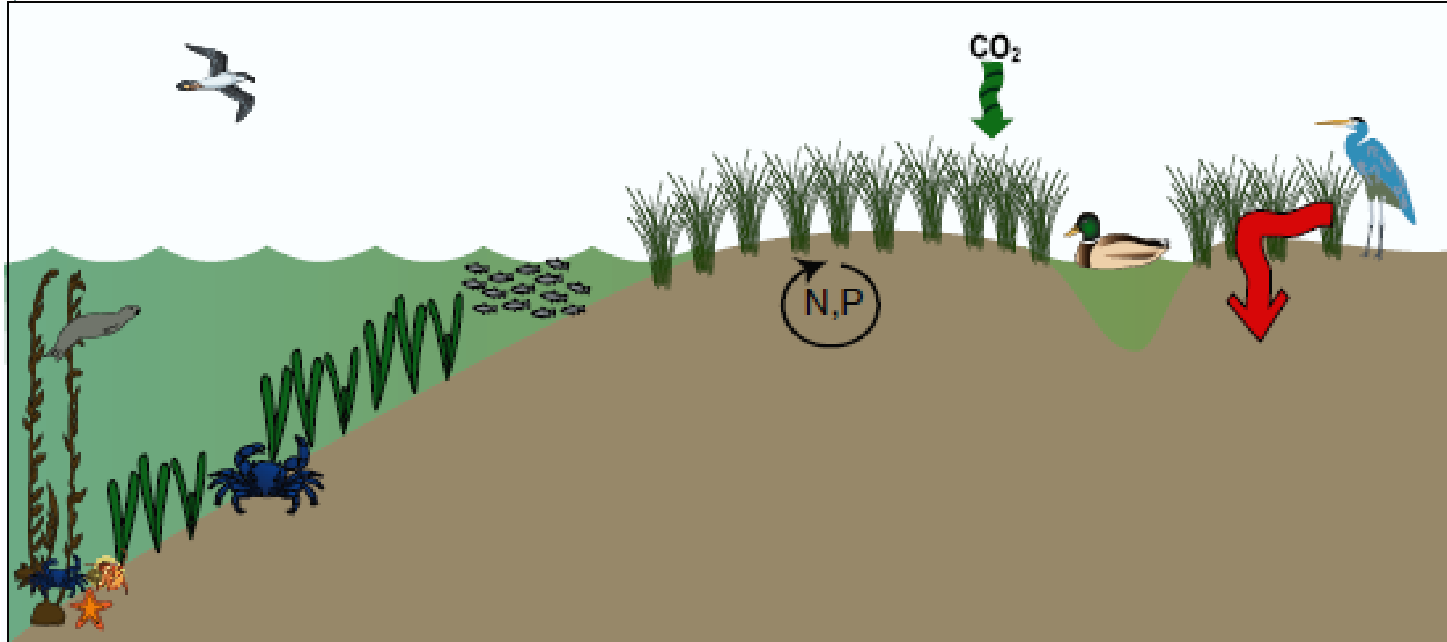
Microalgae on mudflats are important primary producers.

Seagrass may occur on mudflats.

Mudflats support a detrital food web.

NRC, 2007, Mitigating Shore Erosion Along Sheltered Coasts

Shoreline Salt Marsh Ecosystems



Icon Key

- native marsh grass
- birds and waterfowl
- kelp
- sea otter
- kelp associated fauna

Importance and Features

Salt marshes provide important nursery habitat for crabs and fishes.

Salt marshes act as a nutrient filter and is the site of nutrient cycle.

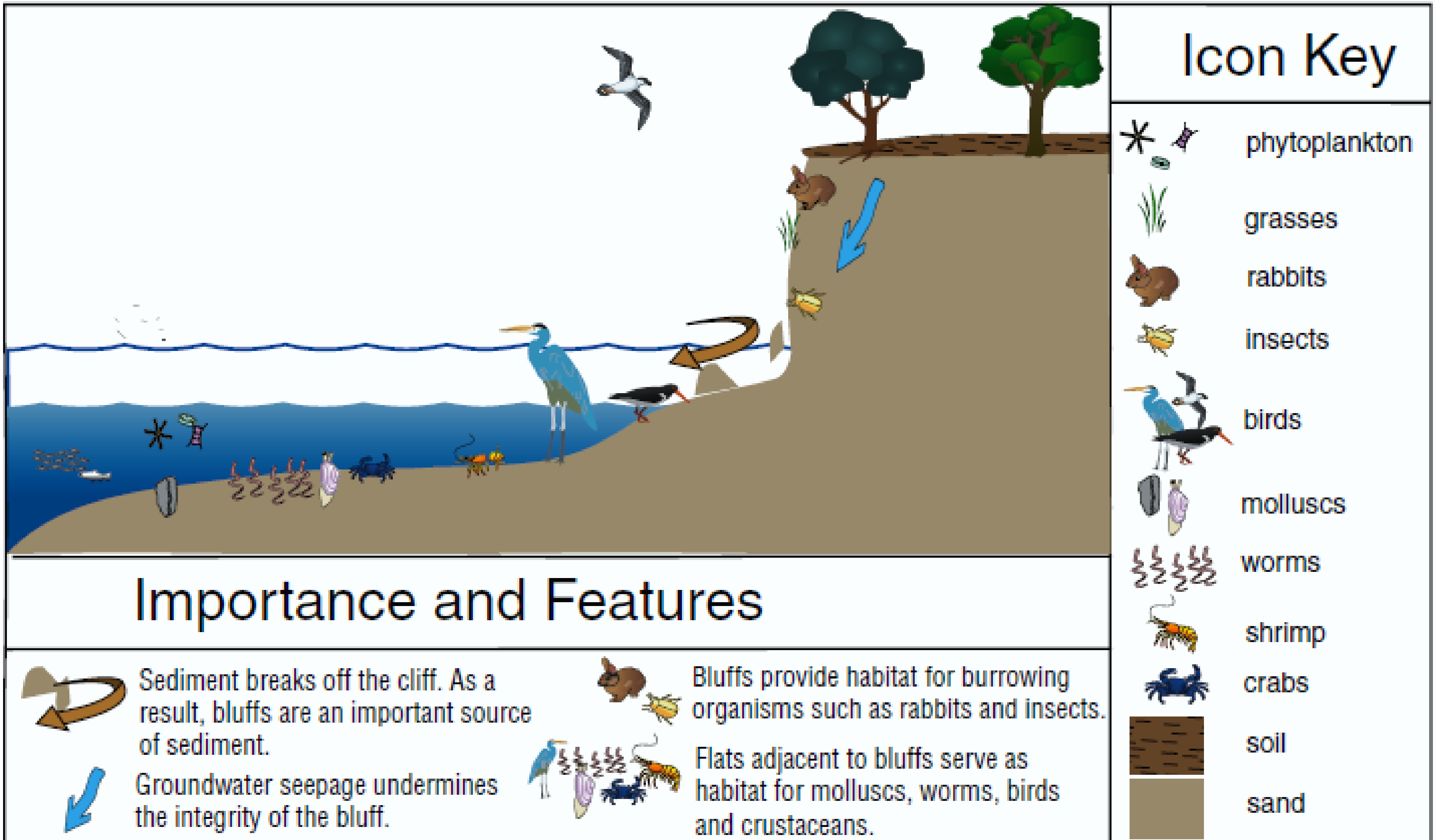
Salt marshes support high primary production.

Seagrasses may or may not occur adjacent to marshes.

Kelp and their associated organisms may occur offshore of salt marshes.

NRC, 2007, Mitigating Shore Erosion Along Sheltered Coasts

Shoreline Bluff Ecosystems



NRC, 2007, Mitigating Shore Erosion Along Sheltered Coasts

Where to Use Living Shorelines

- Living shorelines are effective primarily in sheltered, low- to mid- energy coasts (see the 2007 National Research Council Report entitled "Mitigating Shore Erosion along Sheltered Coasts"). (COE NWP, 2016)
  - Marshes
  - Mangroves
  - Nearshore coral reefs
  - Seagrass beds
  - Oyster reefs
  - Sand beaches
  - Dunes

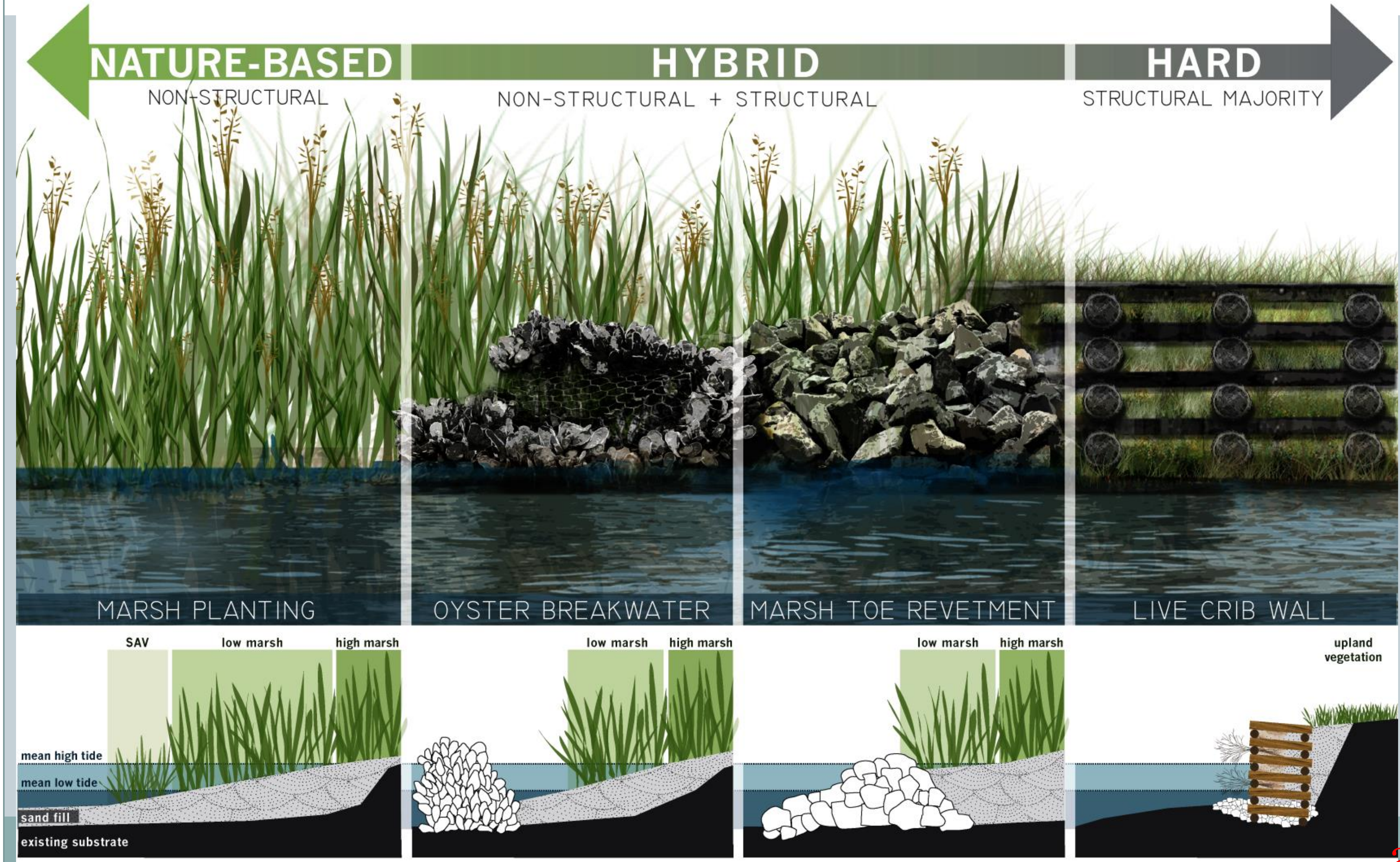
Laws and Regulations

- National Flood Insurance Act of 1968 (P.L. 90-448).National Flood Insurance Program
- Public Trust Doctrine (*Martin v. Lessees of Waddell*, 41 U.S. 367 (1842) and *Shivley v. Bowlby*, 152 U.S. 48 (1894)).
- Rivers and Harbors Act of 1899
- Federal Water Pollution Control Act (FWPCA; Clean Water Act) of 1972
- 1972 Coastal Zone Management Act as amended through Pub. L. No. 109-58, the Energy Policy Act of 2005

Challenges of northern shoreline projects

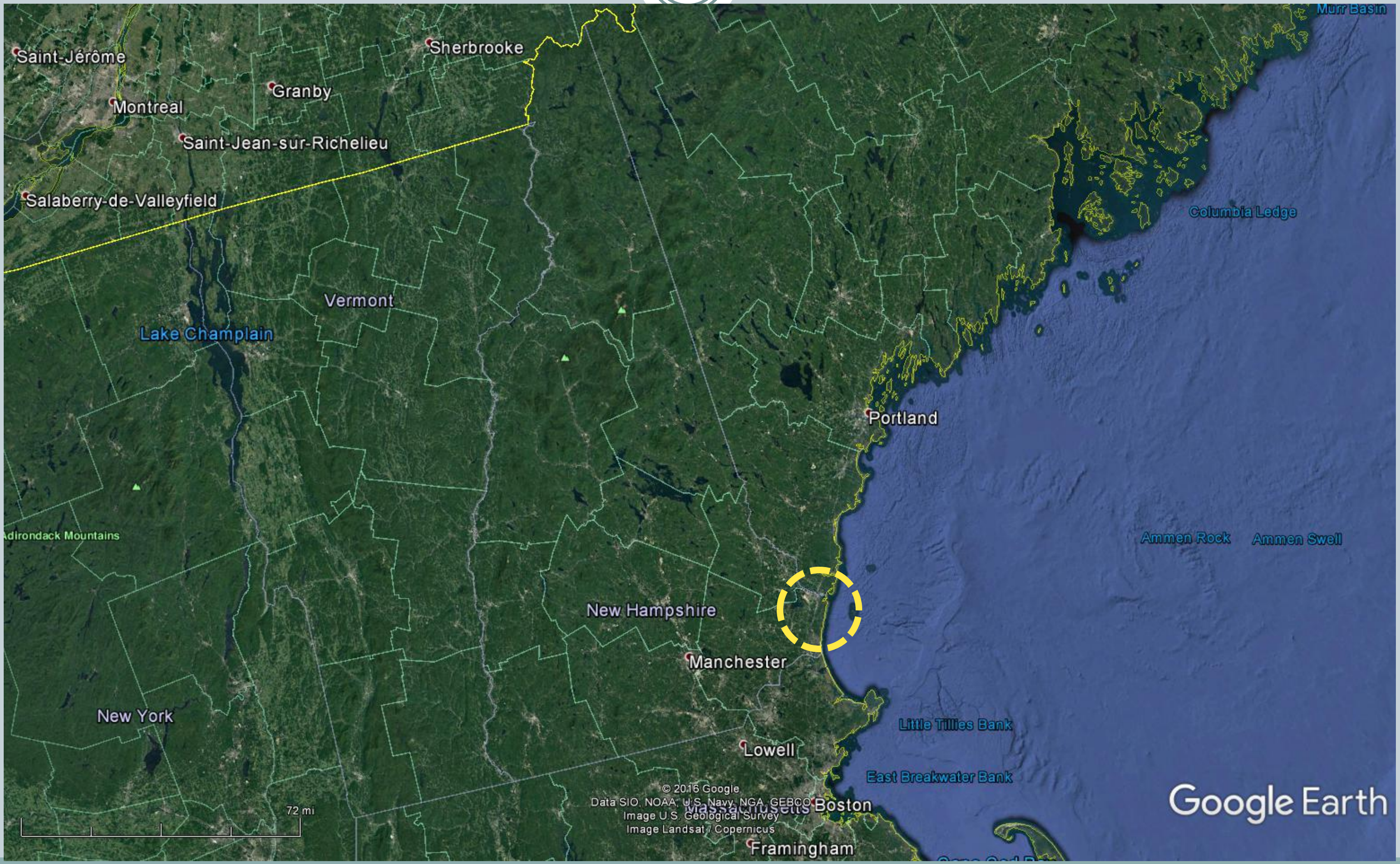
- Low light
- Short growing season
- Large tidal range
- Ice

The Constructed Shoreline Spectrum



Case Study – Salt Marsh Restoration

- Wagon Hill Farm, Durham, NH


Saint-Jérôme
Sherbrooke
Granby
Montreal
Saint-Jean-sur-Richelieu
Salaberry-de-Valleyfield
Vermont
Lake Champlain
Columbia Ledge
Portland
Adirondack Mountains
Ammen Rock
Ammen Swell
New Hampshire
Manchester
New York
Little Tillies Bank
Lowell
East Breakwater Bank
© 2016 Google
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image U.S. Geological Survey
Image Landsat / Copernicus
Boston
Framingham
72 mi
Google Earth


Wagon Hill
Cutts Cove
North Mill Pond
2.02 mi
Google Earth

Wagon Hill Farms

Wagon Hill Farm 2009

Ellen Snyder ponders erosion at a site visit

Change from 1992 to 2015

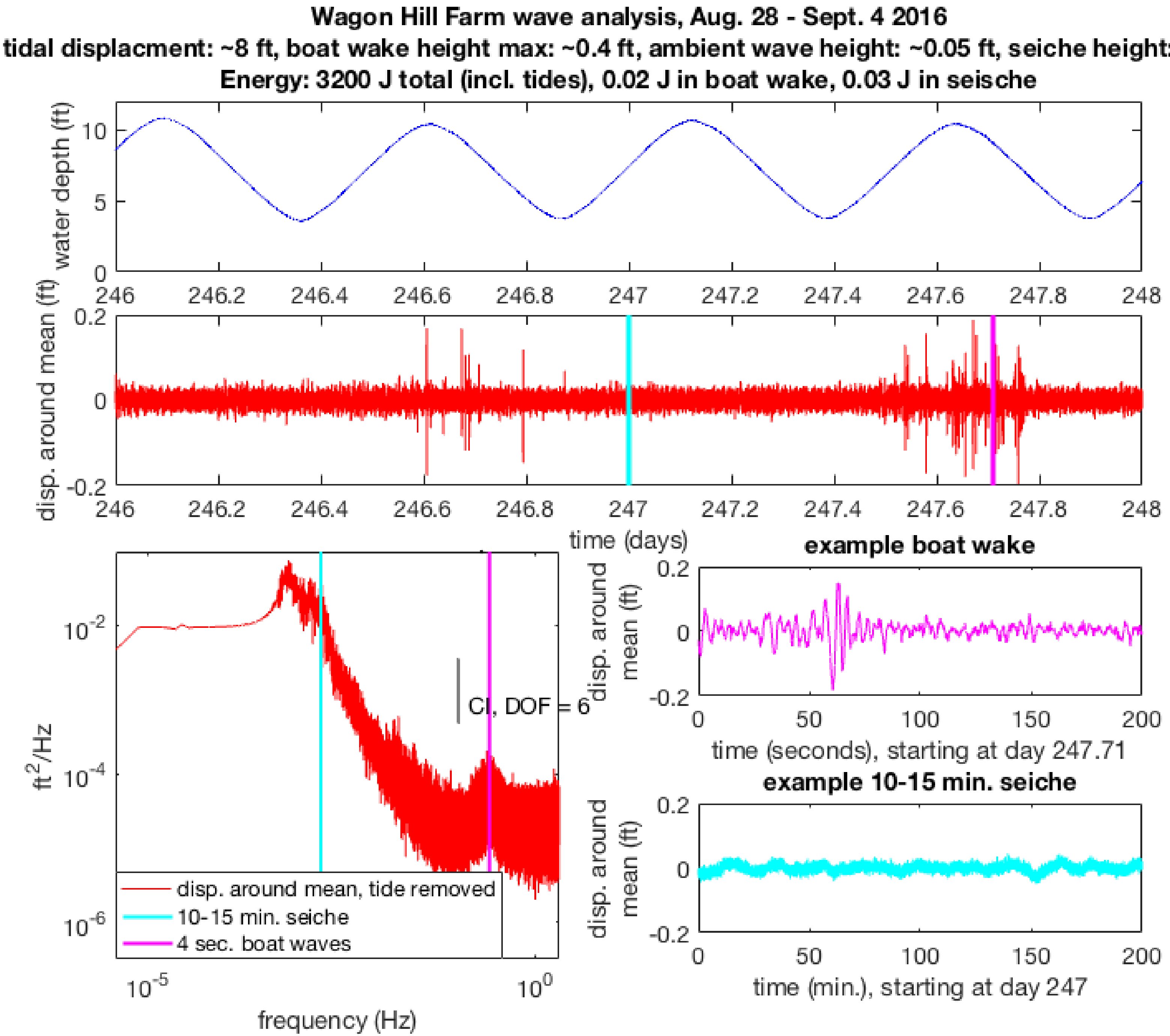
Low Tide

Observed Erosion Most Tidal Cycles

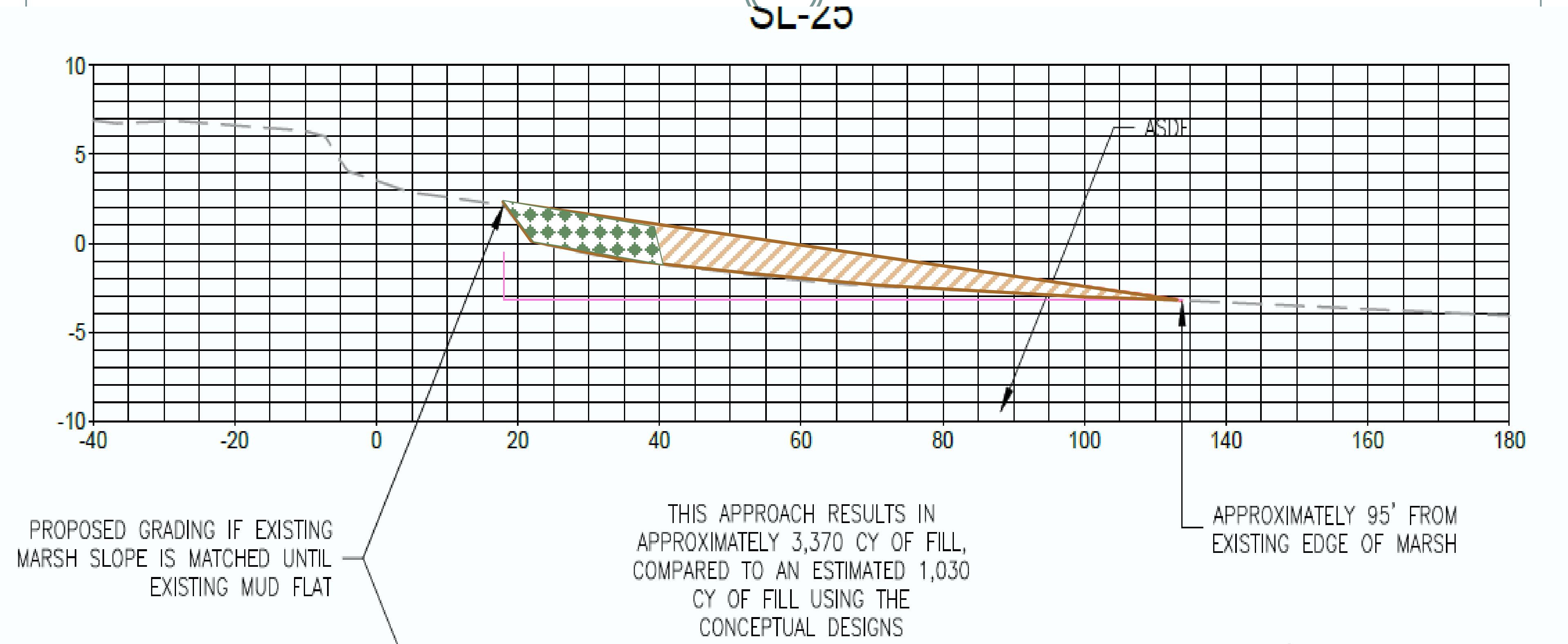
Erosion Pins Monitored Quarterly

The Groundwater Well Installed in 2000

The 2009 Tree

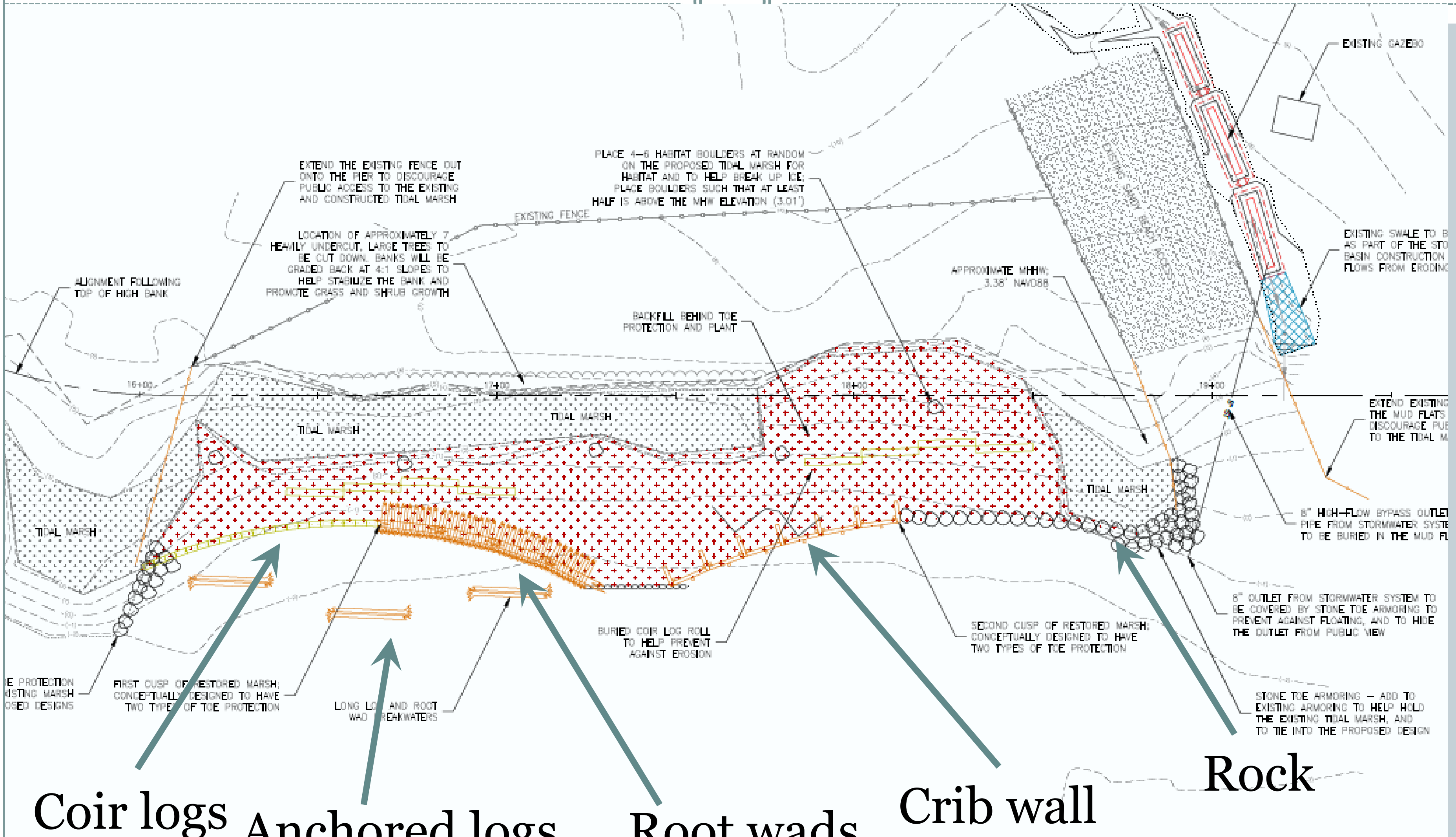

Wagon Hill Farm wave analysis, Aug. 28 - Sept. 4 2016
tidal displacment: ~8 ft, boat wake height max: ~0.4 ft, ambient wave height: ~0.05 ft, seiche height: ~0.1 ft
Energy: 3200 J total (incl. tides), 0.02 J in boat wake, 0.03 J in seische
water depth (ft)
disp. around mean (ft)
time (days)
ft^2/Hz
frequency (Hz)
CI, DOF = 6
disp. around mean, tide removed
10-15 min. seiche
4 sec. boat waves
example boat wake
disp. around mean (ft)
time (seconds), starting at day 247.71
example 10-15 min. seiche
time (min.), starting at day 247

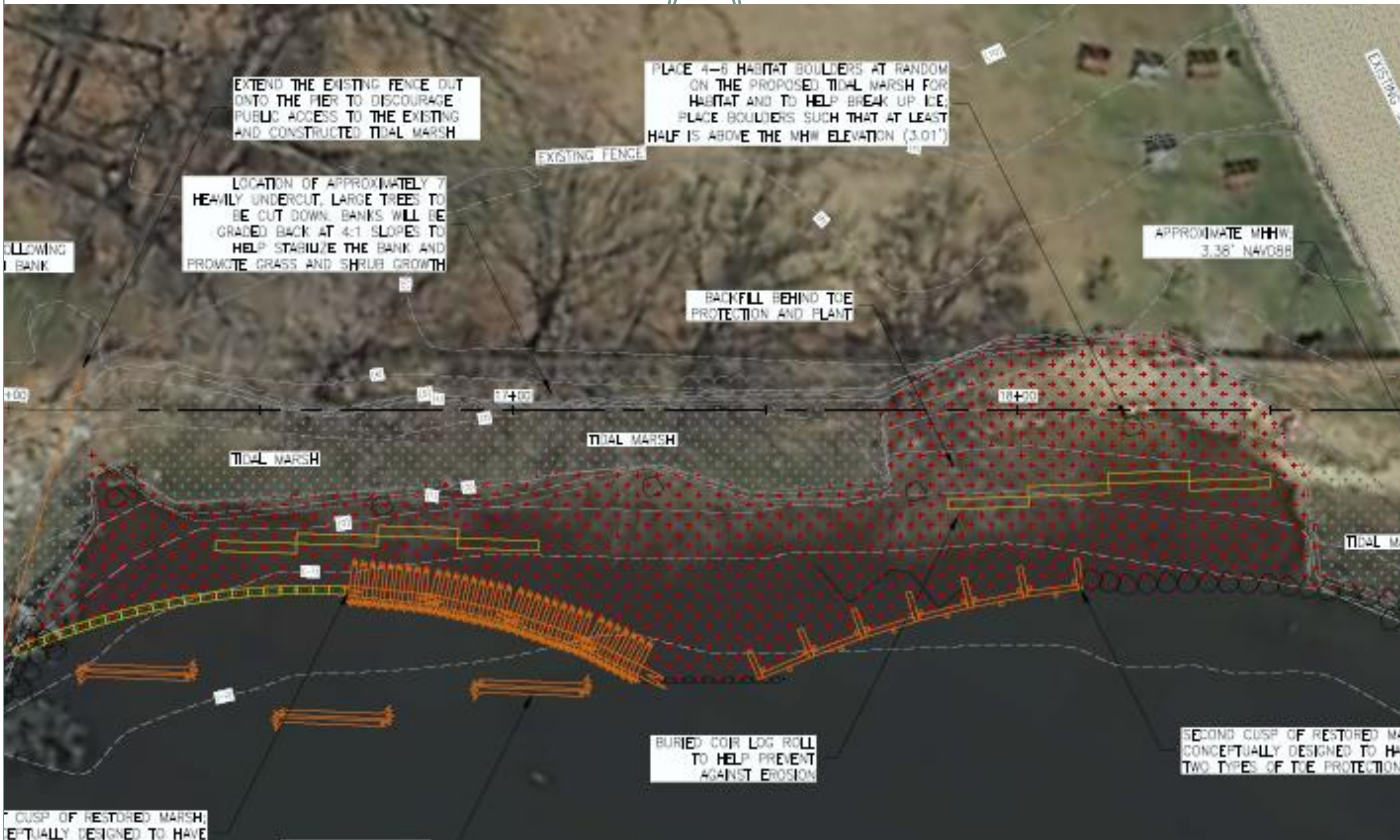
“Softer” Edge



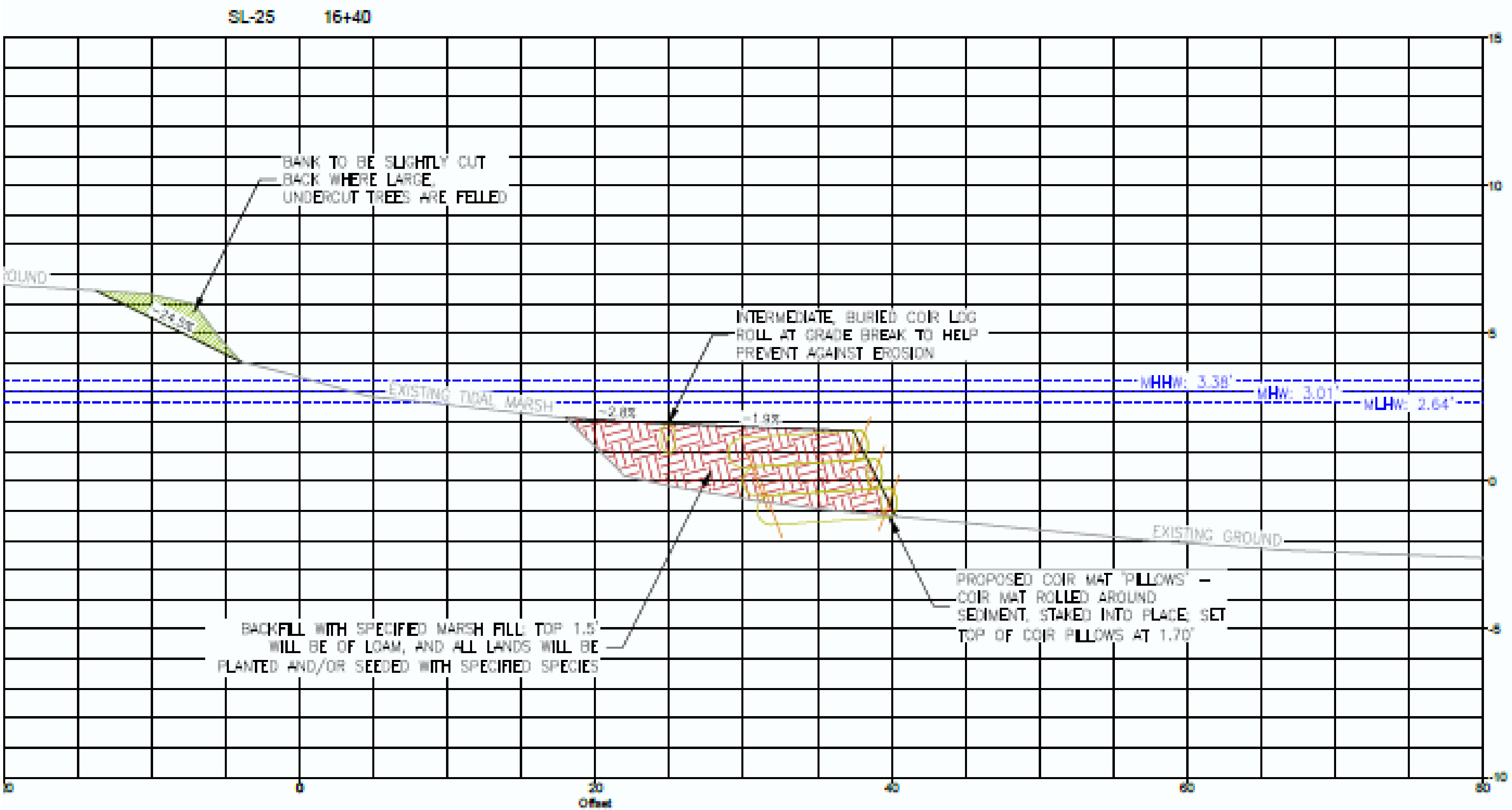
Can extend the sediment to avoid hard edge, but cannot grow anything over most of the fill. Would most likely erode

Potential First Phase - Plan

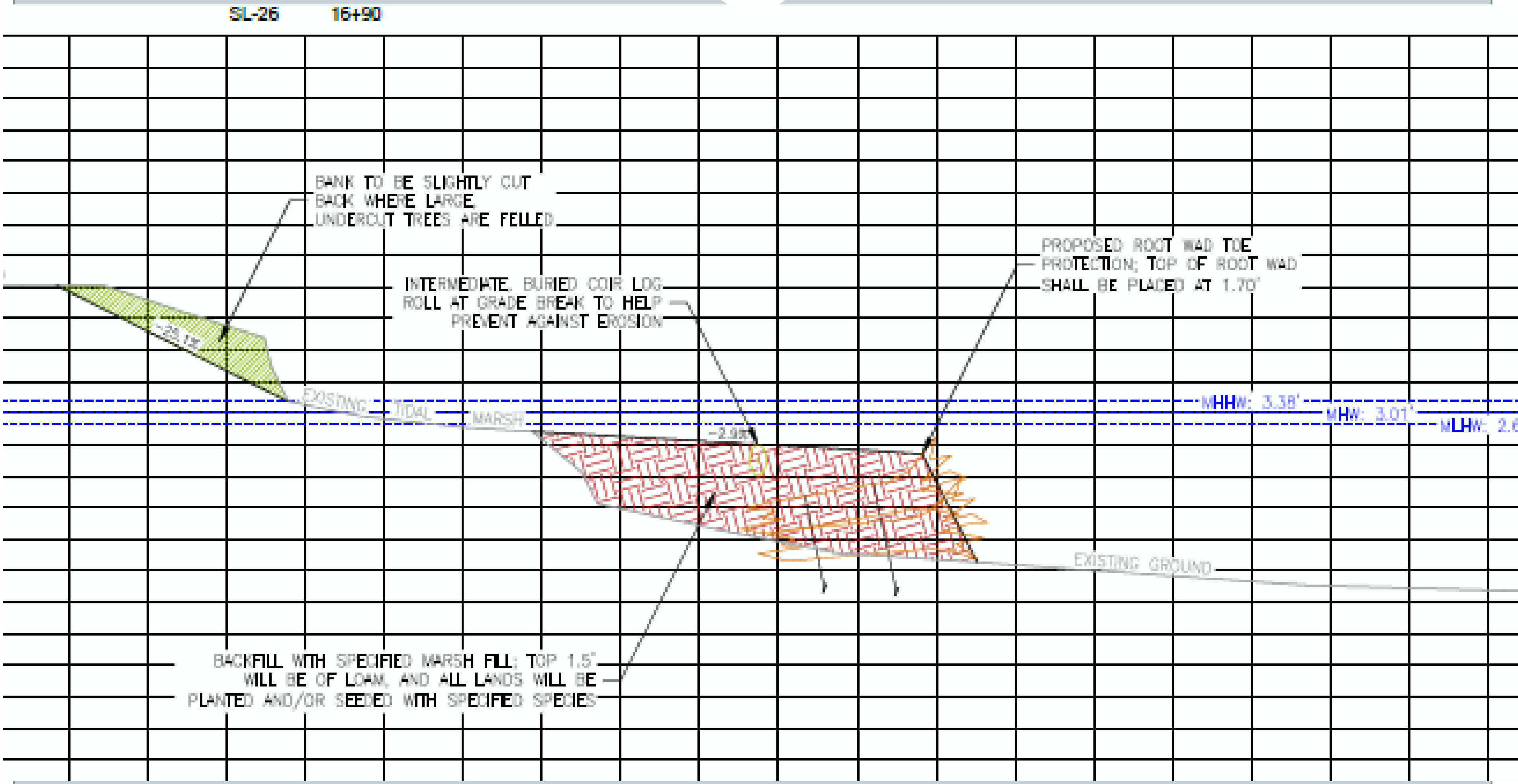



EXTEND THE EXISTING FENCE OUT ONTO THE PIER TO DISCOURAGE PUBLIC ACCESS TO THE EXISTING AND CONSTRUCTED TIDAL MARSH
PLACE 4–6 HABITAT BOULDERS AT RANDOM ON THE PROPOSED TIDAL MARSH FOR HABITAT AND TO HELP BREAK UP ICE; PLACE BOULDERS SUCH THAT AT LEAST HALF IS ABOVE THE MHW ELEVATION (3.01')
EXISTING FENCE
LOCATION OF APPROXIMATELY 7 HEAVILY UNDERCUT, LARGE TREES TO BE CUT DOWN. BANKS WILL BE GRADED BACK AT 4:1 SLOPES TO HELP STABILIZE THE BANK AND PROMOTE GRASS AND SHRUB GROWTH
APPROXIMATE MHHW: 3.38' NAVD88
BACKFILL BEHIND TOE PROTECTION AND PLANT
17+00
18+00
TIDAL MARSH
TIDAL MARSH
BURIED COIR LOG ROLL TO HELP PREVENT AGAINST EROSION

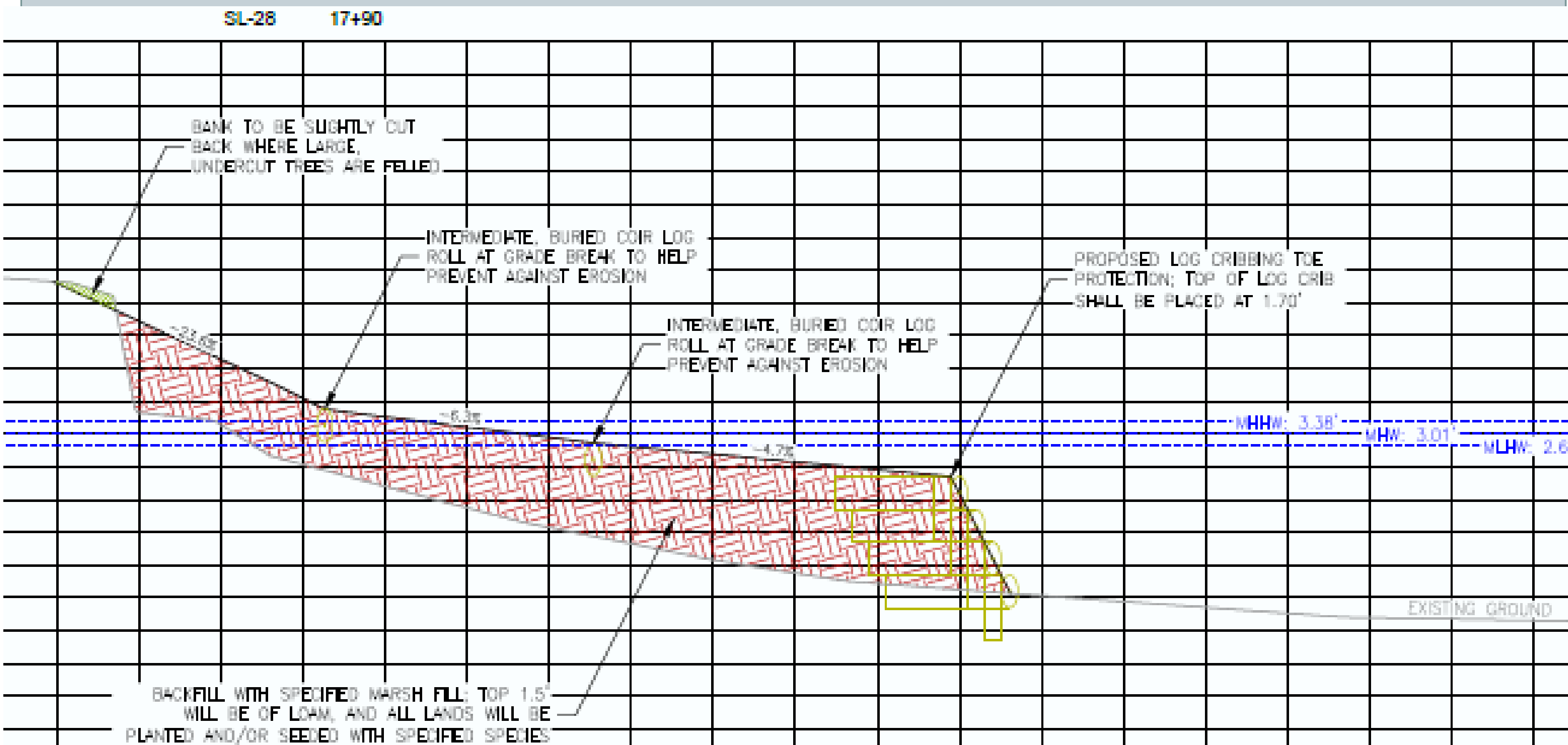
Profile Type 1 – Coir Log



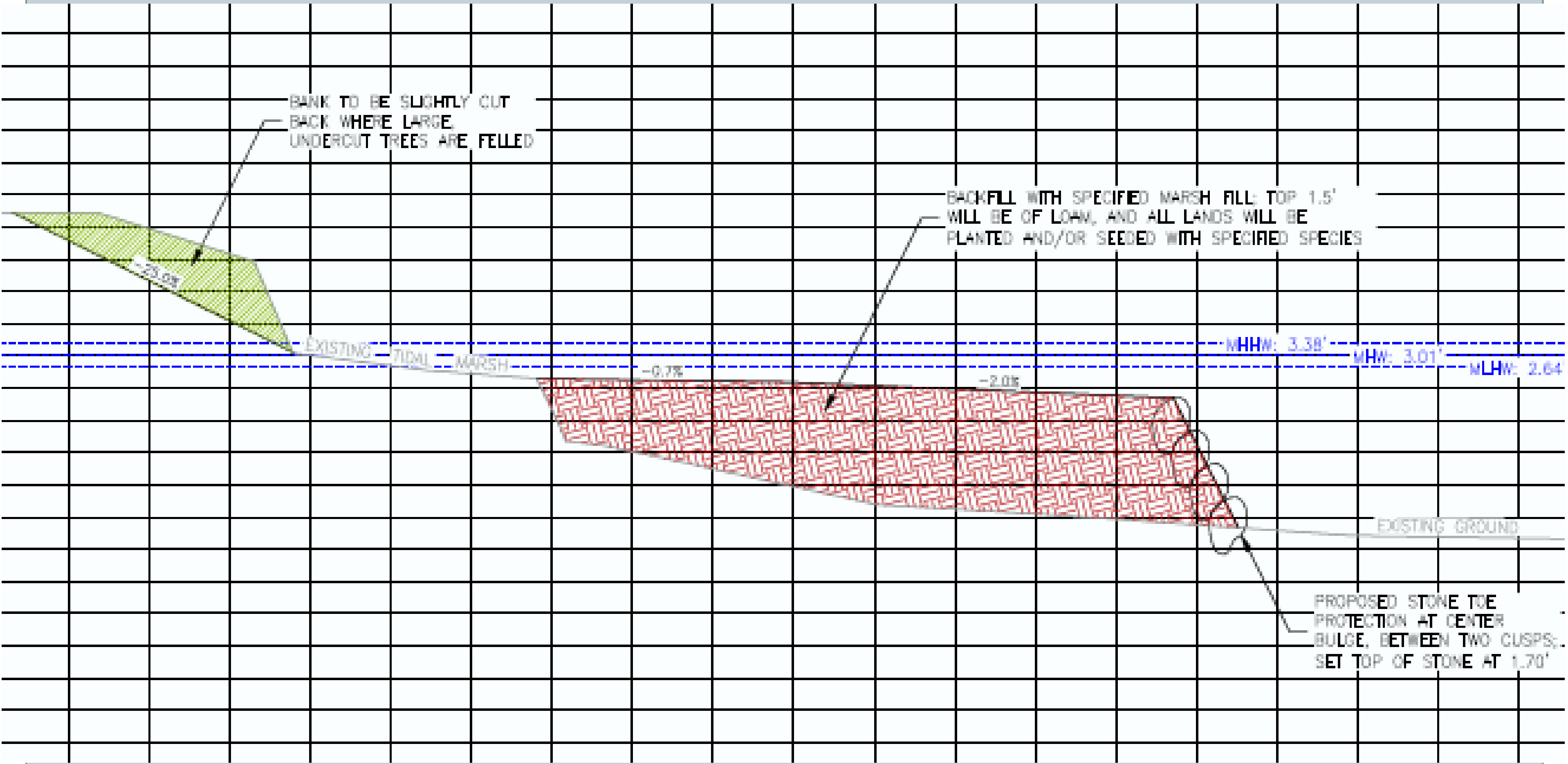
Profile Type 2 – Root wads



Profile Type 3 – Crib wall



Profile Type 4 - Rock

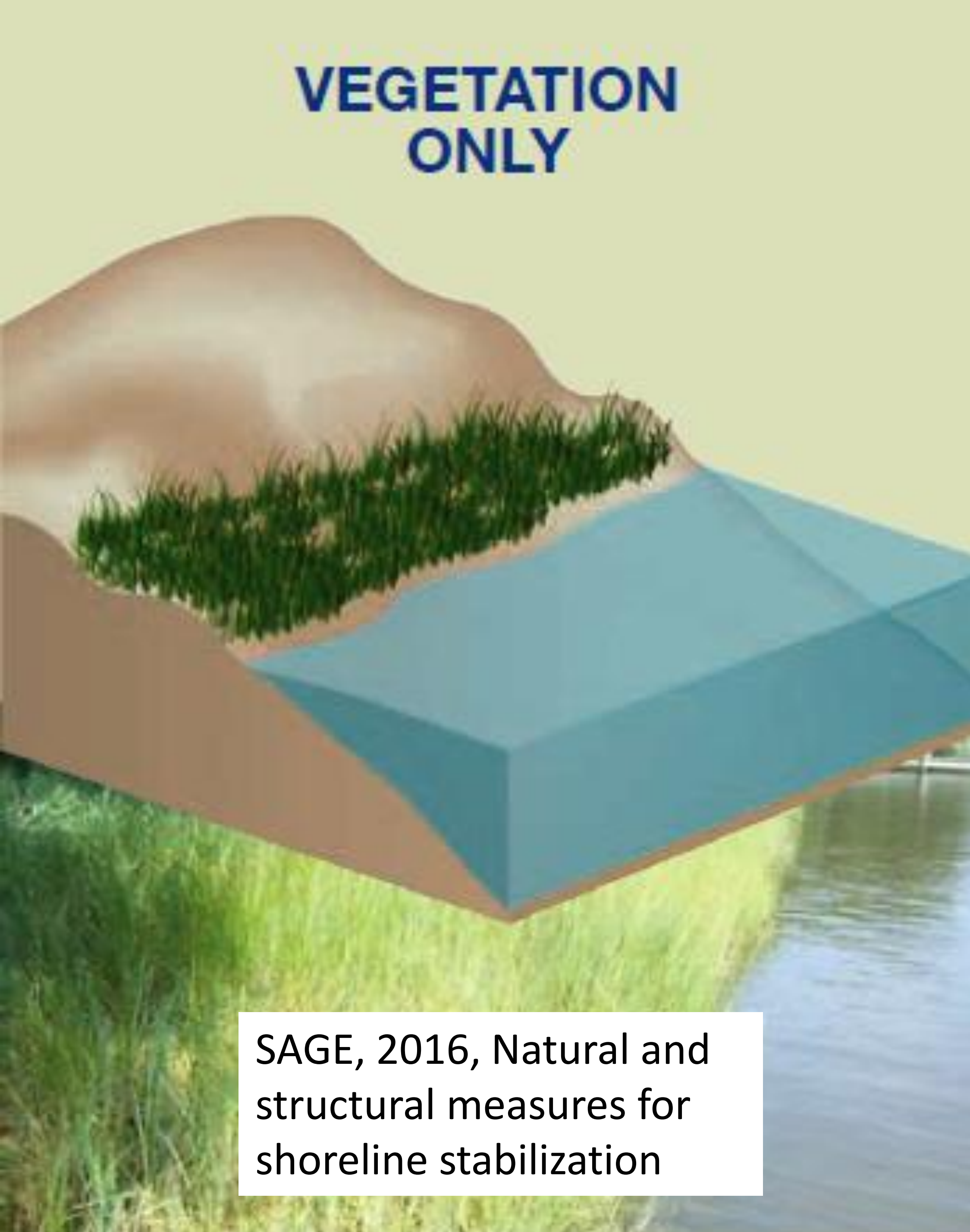


Coir Logs and Root Wad

Living Shorelines for Engineers

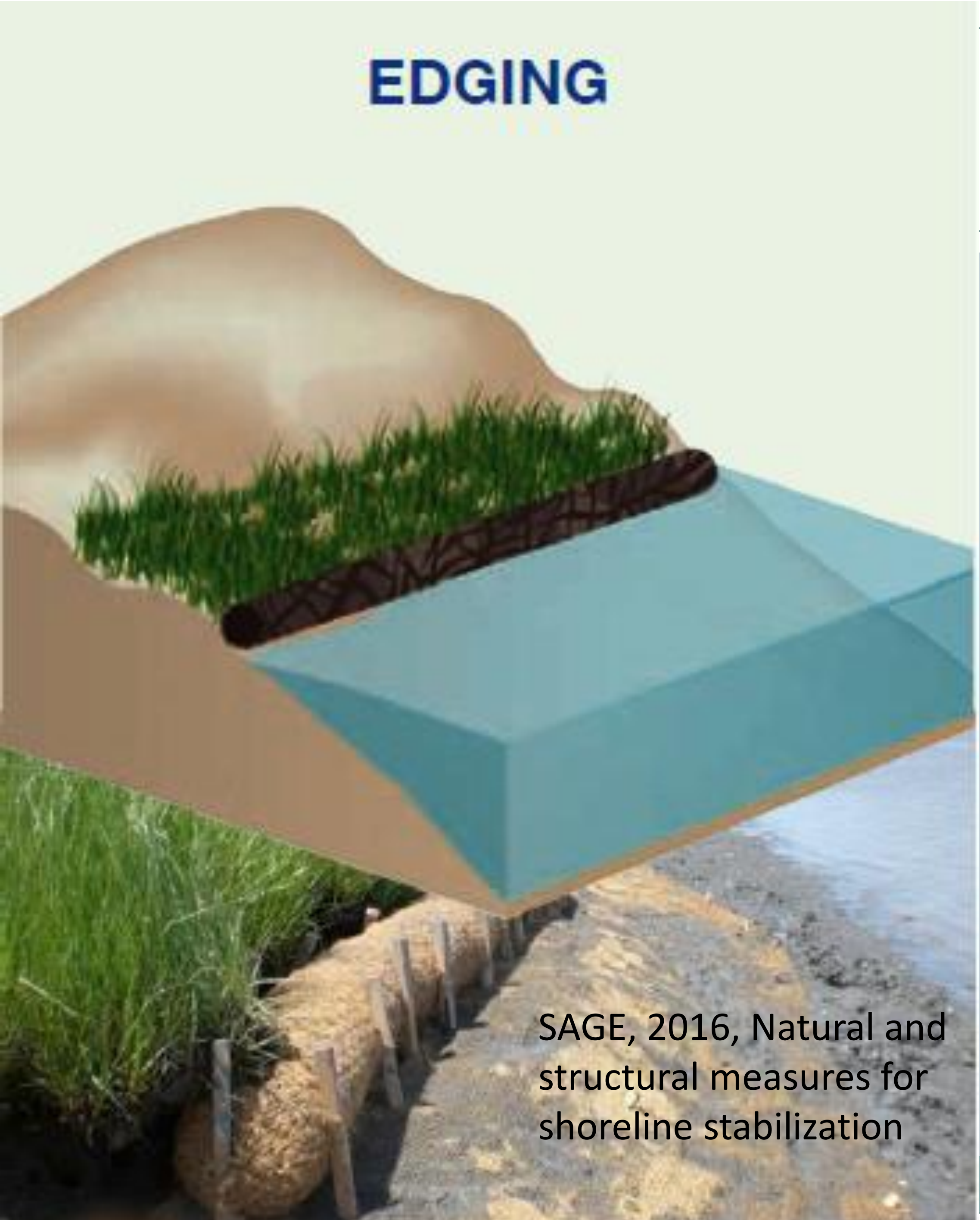
David “Flotsam” Burdick and Gregg “Mudflat” Moore, Jackson Estuarine Lab,
Tom “Klondike” Ballestero, Civil and Environmental Engineering,
University of New Hampshire

University of New Hampshire
COASTAL HABITAT
CHART



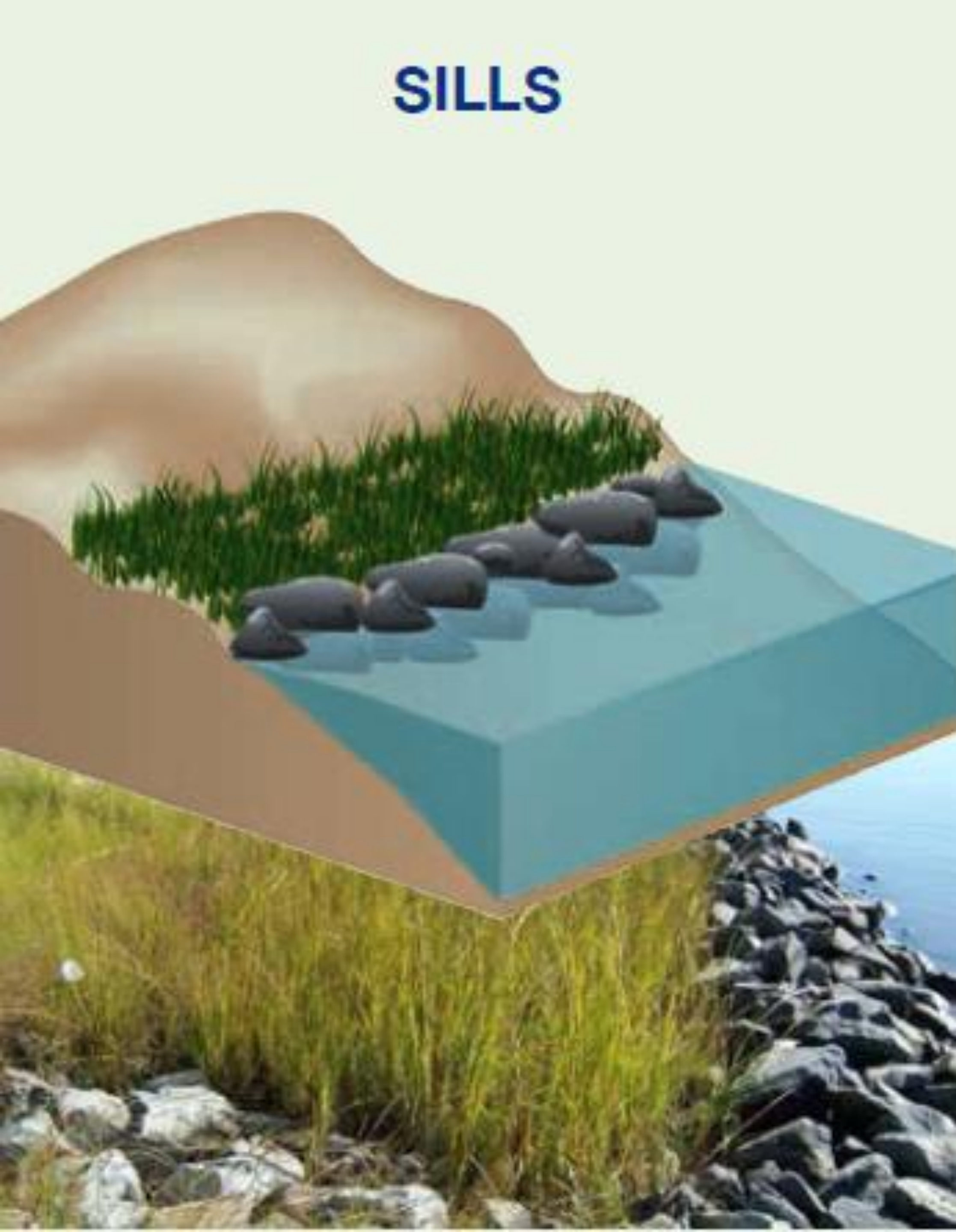
SAGE, 2016, Natural and structural measures for shoreline stabilization

Mill Pond Way berm removal, North Mill Pond, Portsmouth, NH



SAGE, 2016, Natural and structural measures for shoreline stabilization

Brewster Street Mitigation on North Mill Pond (Stantec)



Marsh built in South Mill Pond 2001, Portsmouth, in front of seawall and behind sill constructed from existing rocks on site.

SAGE, 2016, Natural and structural measures for shoreline stabilization

The Case for Building Salt Marshes into Living Shorelines

- Loss of 30% of historical salt marshes
- Future for marshes is not bright - SLR/CC
- Salt marshes and peat develop slowly as sea levels rise – most marshes are over 1,000 years old
- Created marshes erode EVEN if shoreline protected
  - 1993 salt marsh creation lost 20% of area in five years in North Mill Pond
- Salt marshes protect, survive and heal following storms
  - Gittman et al. 2014

Conceptual Model of Salt Marsh Processes

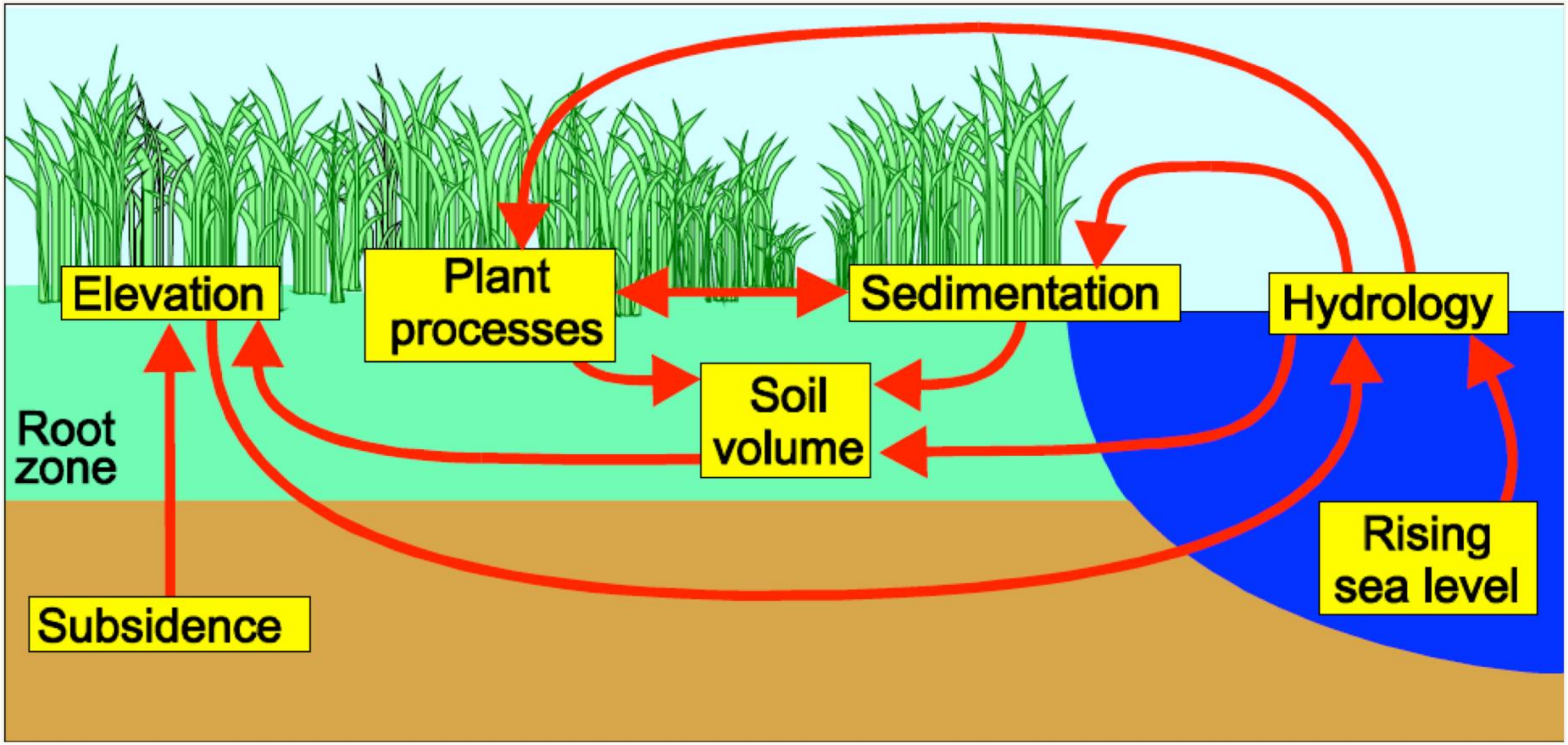


Figure 4. Conceptual model of salt marsh (Cahoon and Lynch http://www.pwrc.usgs.gov/set/).

The Case for Building Salt Marshes into Living Shorelines

- What functions and values are lost?
  - Plant productivity, food web support, $2^{\circ\ ary}$ production, biodiversity
  - Nutrient and sediment removal from water
  - Ability to grow with sea level rise
  - Ability to reduce wave energy and heal following storms
  - Carbon storage
  - Aesthetic value

The Case for Building Salt Marshes into Living Shorelines

- Loss of 30% of historical salt marshes
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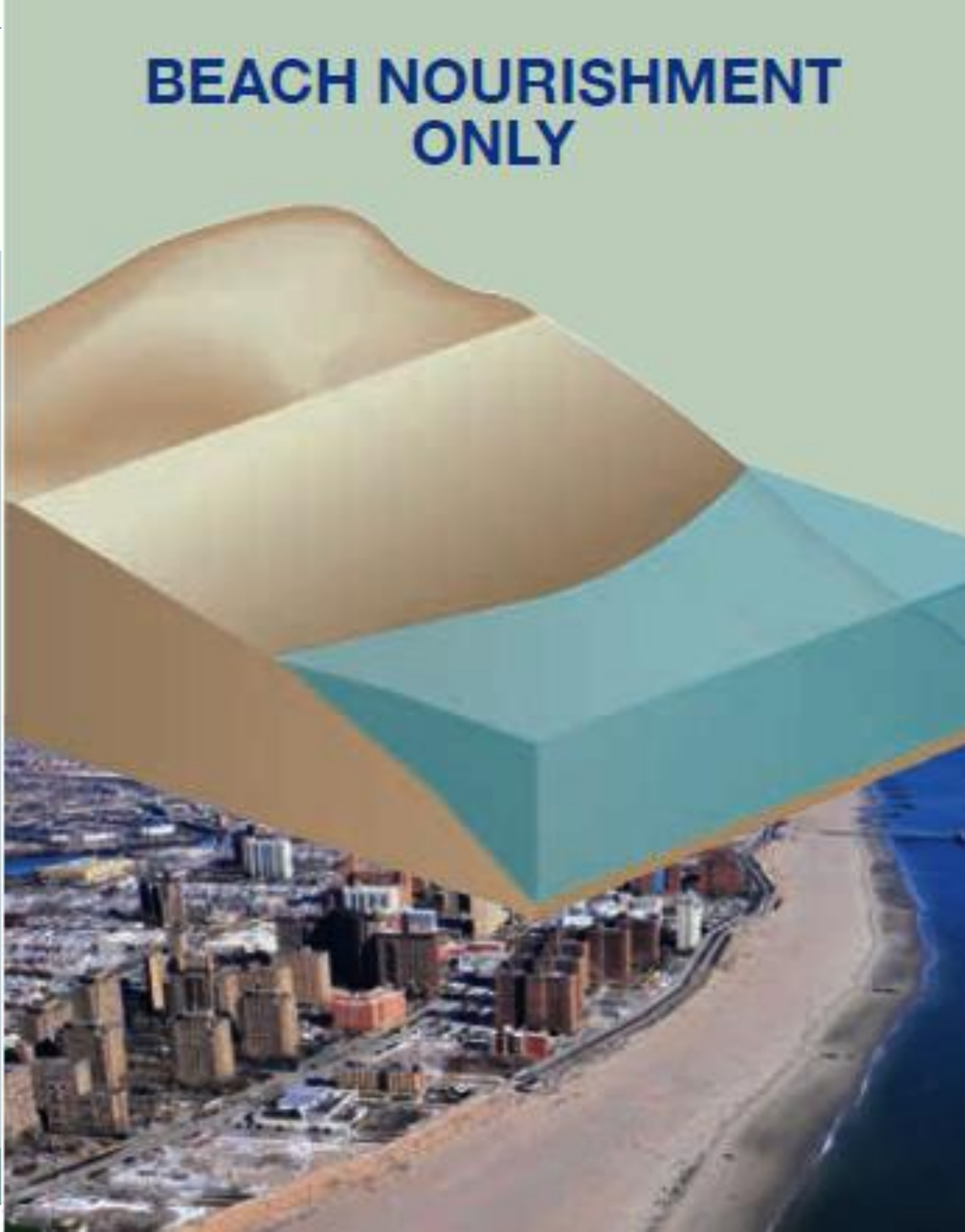
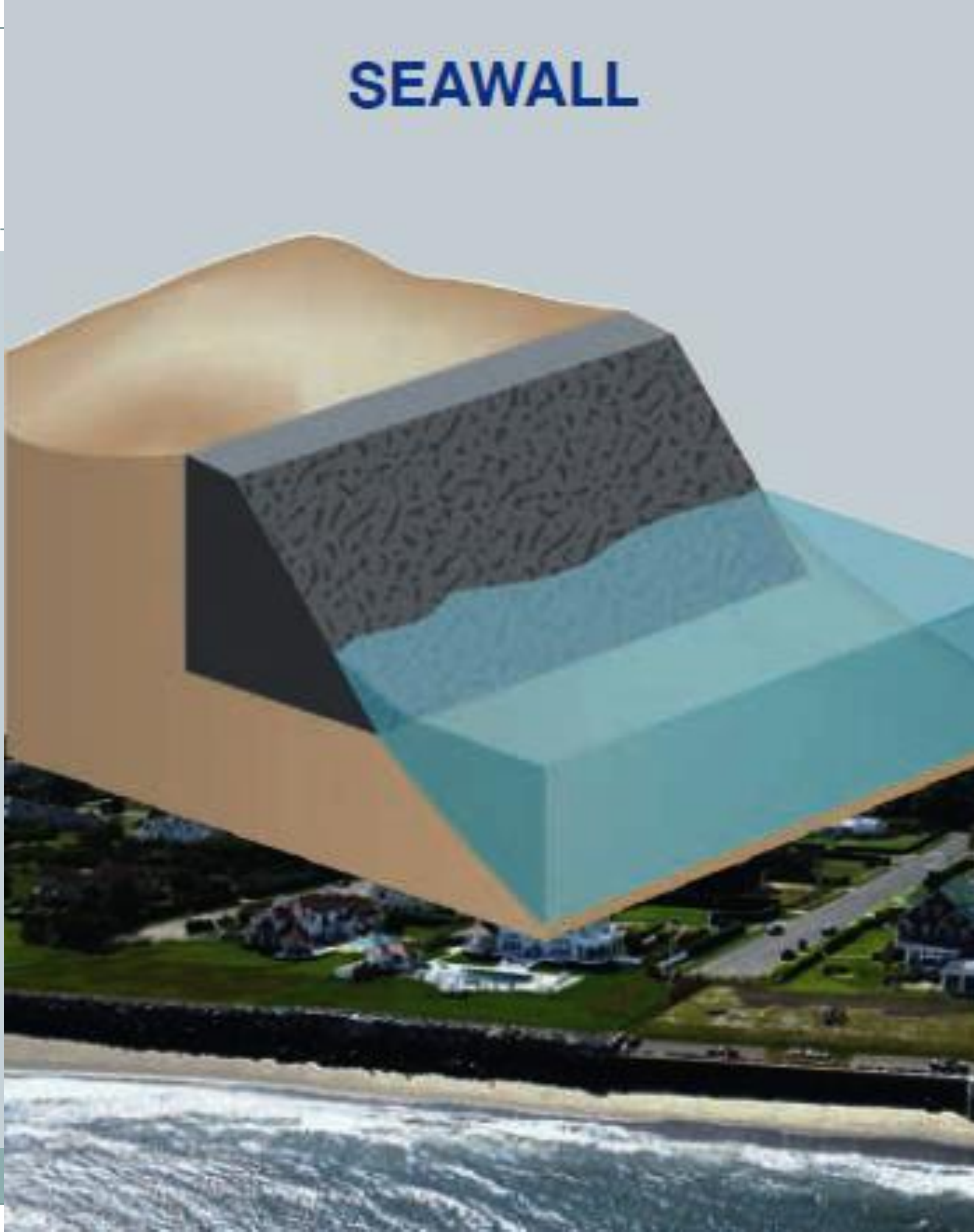
- Created marshes erode EVEN if shoreline protected
  - 1993 salt marsh creation lost 20% of area in five years in North Mill Pond
- Salt marshes protect, survive and heal following storms
  - Gittman et al. 2014
- SO . . . living shorelines are needed if we are to:
  - 1) Protect existing marsh where needed
  - 2) Create new marsh to replace historic and new losses
  - 3) Protect eroding shorelines



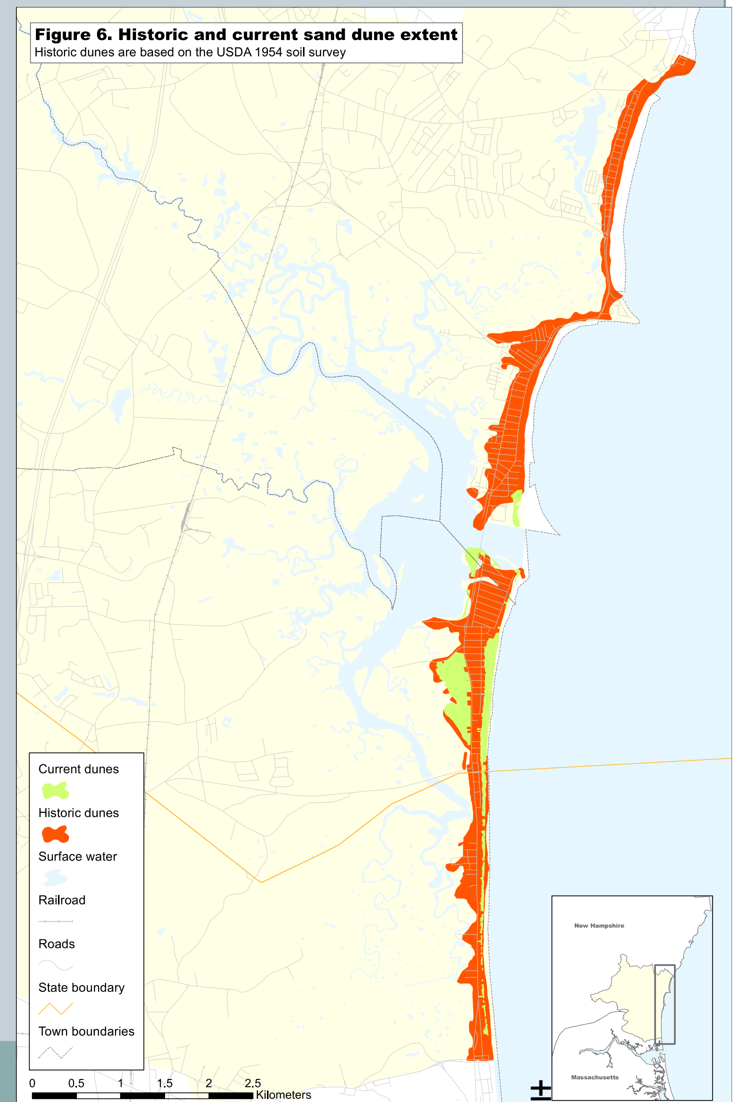
SAGE, 2016, Natural and structural measures for shoreline stabilization



SAGE, 2016, Natural and structural measures for shoreline stabilization

The Case for Living Shorelines along Beaches (and Dunes)

- Loss of most beach/dune systems
- Future for valuable beaches, businesses, residences, uncertain
- Potential losses from storms high
- The wider and taller the dune, the greater protection
- Dunes are needed to store sand onshore for the loss/rebuilding cycle



Dune Restoration

Fences and plants collect sand for onshore storage

- Sacrificial
- Reduce need for $$ nourishment
- Rip-rap / seawalls cannot store sand

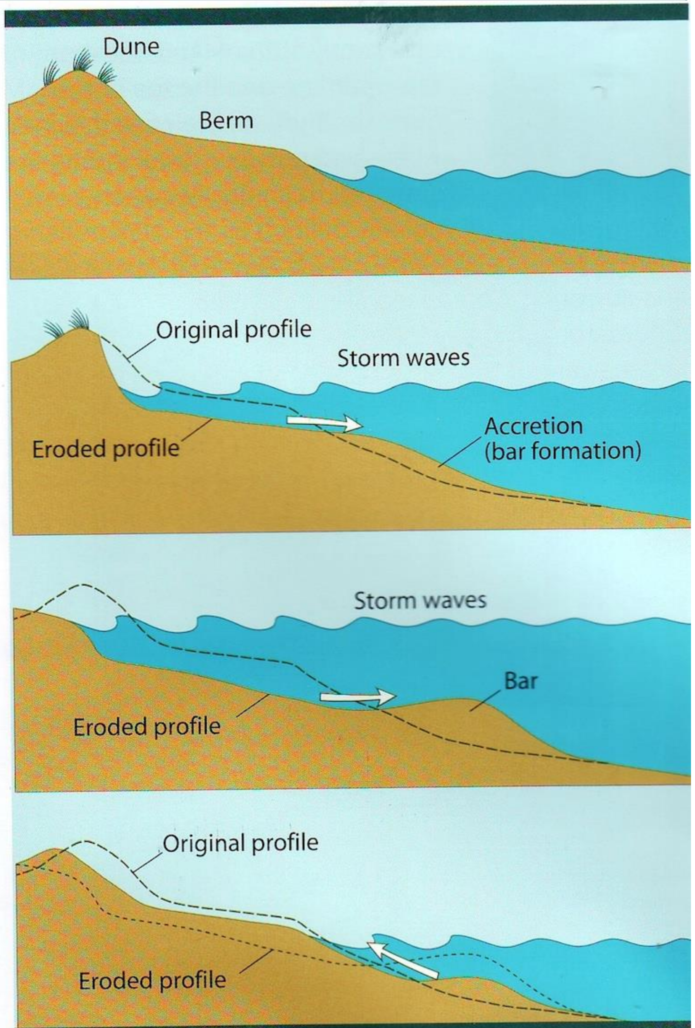


Figure 4. Beach response to storm waves. (Illustration by John Norton)

The Case for Building Dunes

What functions / values are lost Compared to Seawall?

- High value recreational areas (beaches)
- Plant productivity, food web support, 2°ary production, biodiversity (ESA – plovers)
- Ability to grow with sea level rise
- Ability to reduce wave energy and heal following storms
- Aesthetic value

What functions lost Compared to Nourishment Alone?

- Plant productivity, food web support, 2°ary production, biodiversity (ESA – plovers)
- Ability to reduce wave energy and heal following storms
- Aesthetic value ?

Monitoring

- Survey
- Erosion pins
- Plant density and abundance by species
- Soil particle size distribution
- Soil carbon and accretion
- Wildlife

Inspection

- Gullying and other signs of erosion
- Invasive species
- Nuisance species
- Plant mortality
- Wrack
- Ice damage

Maintenance

- Repair gullies
- Improve/enhance drainage
- Sill repair
- Replant/reseed

What do we still need to find out about LS and how can engineers help us

How much light is needed for ‘healthy’ salt marsh to grow?

What is the best plant density to use in New England?

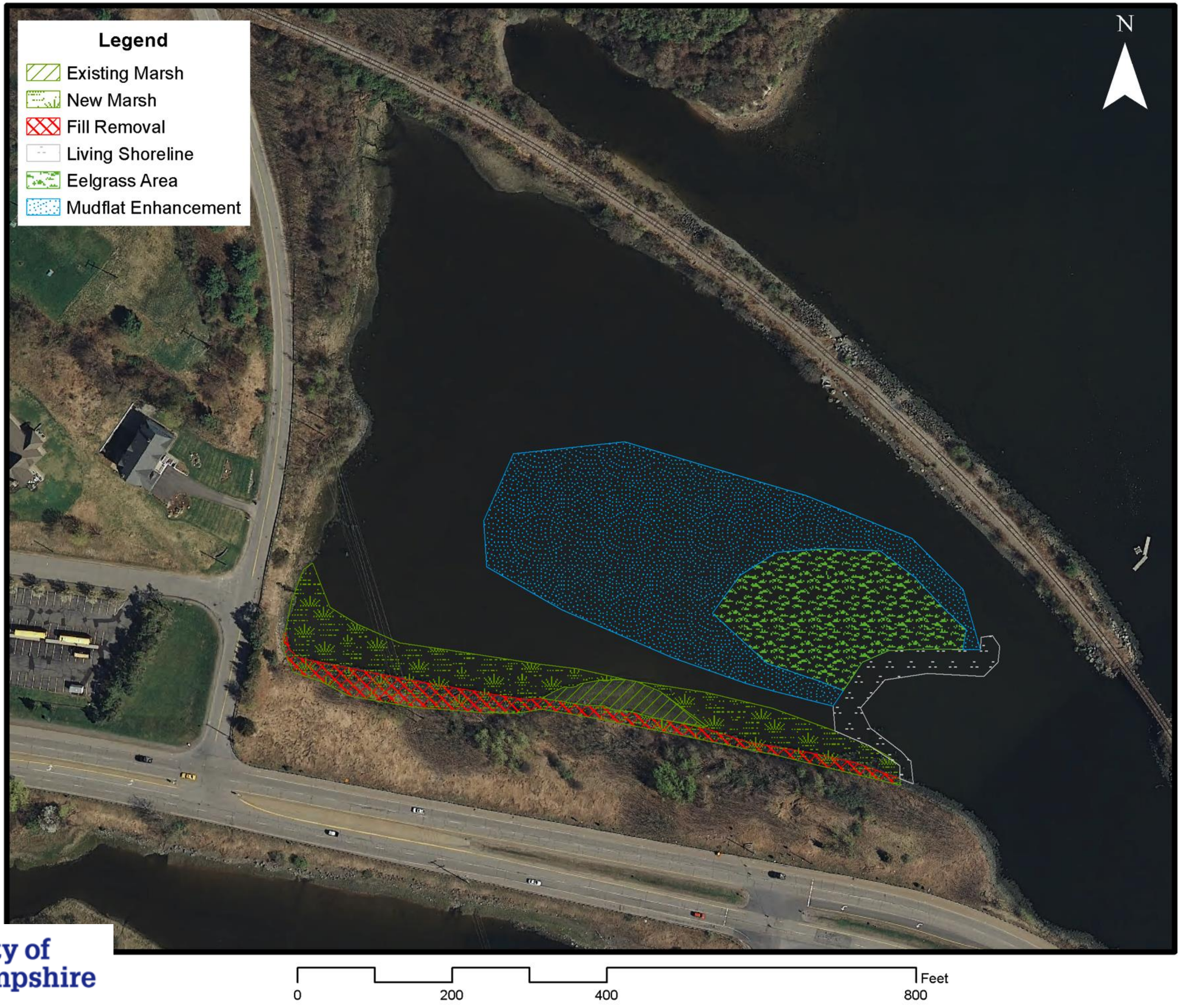
What species of plants should be used in the tidal buffer to enhance marsh migration?

Cutts Cove

95
Forrest St
Brigham Ln
Cutts Ave
Michael Succi Dr
Chase Dr
Market St
Clark Dr
Sarah Mildred Long Bridge
1

Rip Rap Armor at Cutts Cove

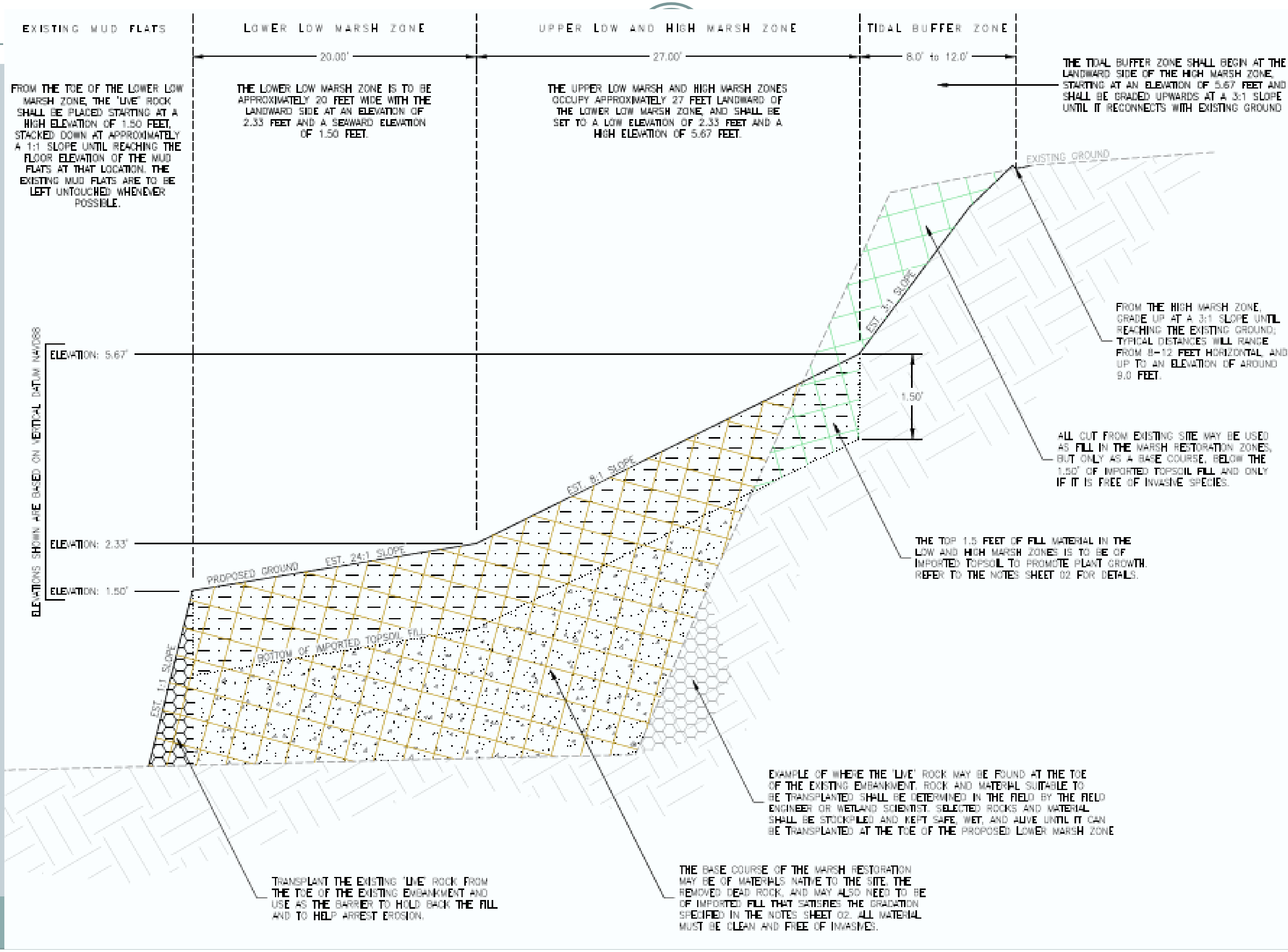
Cutts Cove Concept



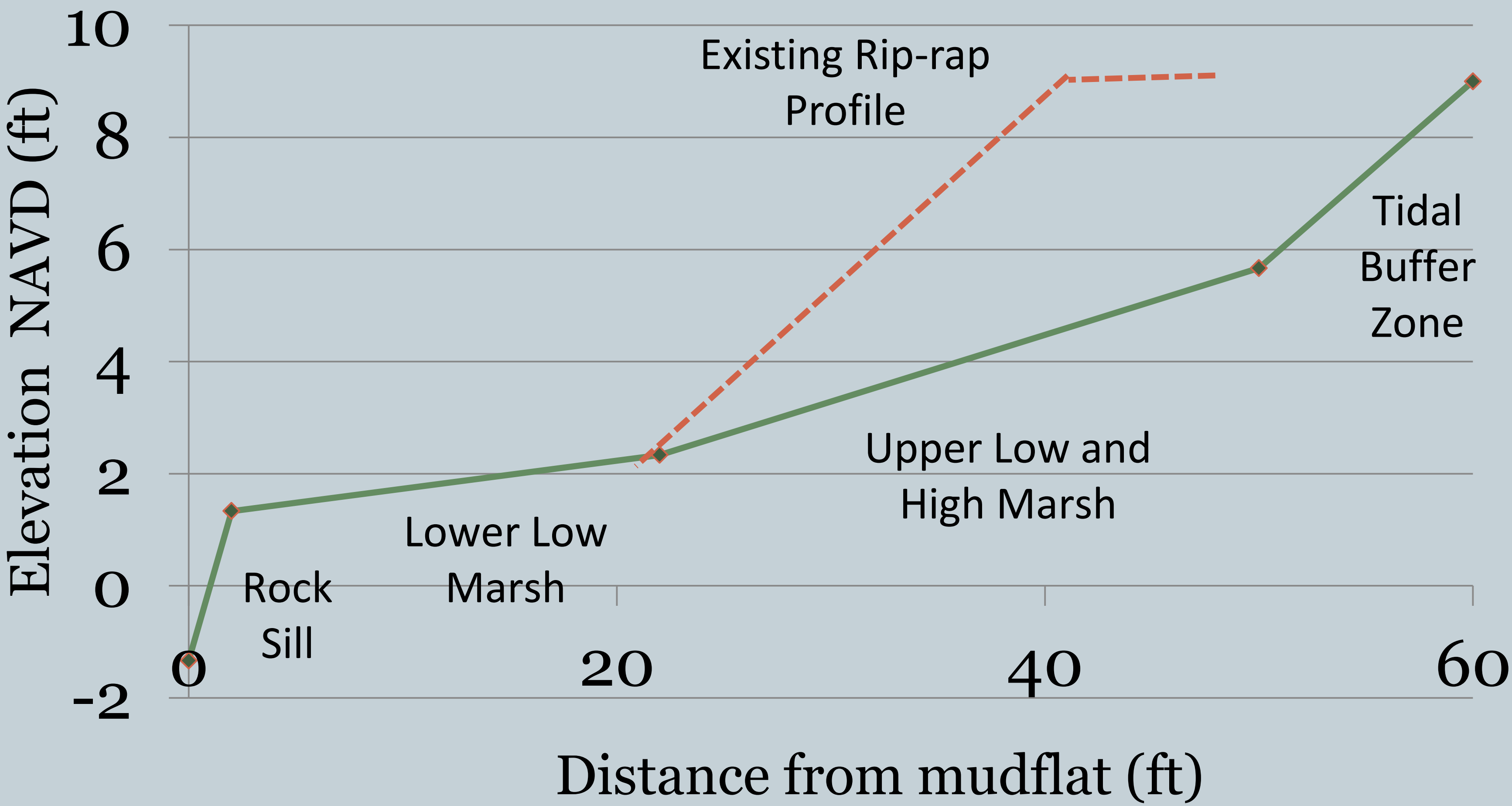
University of New Hampshire

Enhanced Mudflat -shell from oyster conservationist and recycling program

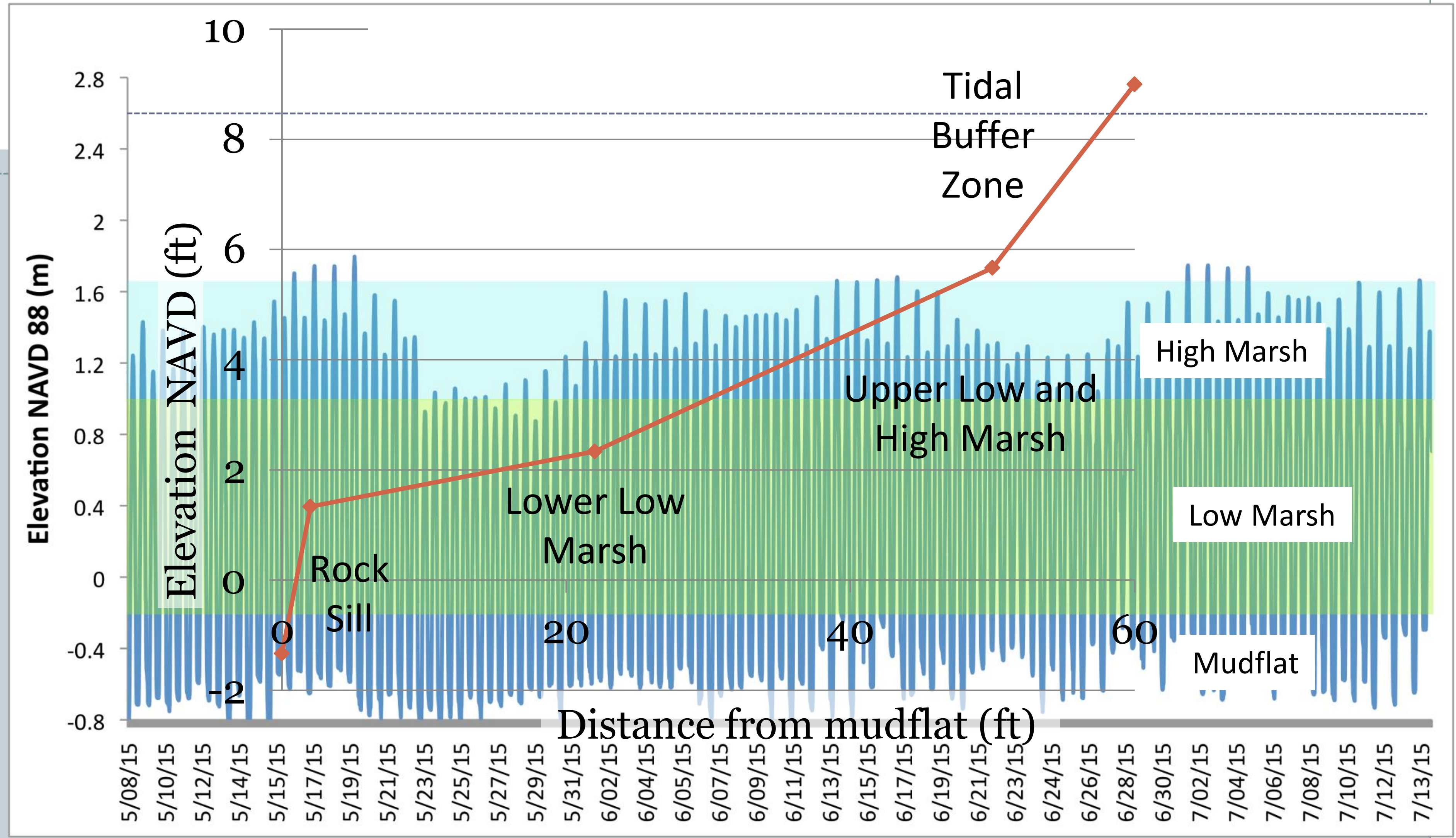
Proposed Cutts Profile



Cutts Profiles and Ecosystems



Tides and existing marshes in Cutts Cove



Measures of Success

- Monitoring
  - Erosion
  - Plant establishment and growth
  - Animal use of habitat
- Maintenance

Winter Can Be Cruel