Living Shoreline Design Training

Organized By

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Shoreline Studies Program

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Center for Coastal
Resources Management

March 2021

Design Elements: Marsh Sills

Presented by
Scott Hardaway

This project was funded by the Virginia Coastal Zone Management Program at the Department of Environmental Quality through Grant # NA19NOS4190163 Task 92.02

Virginia Coastal Zone MANAGEMENT PROGRAM

Shoreline Studies Program VIMS

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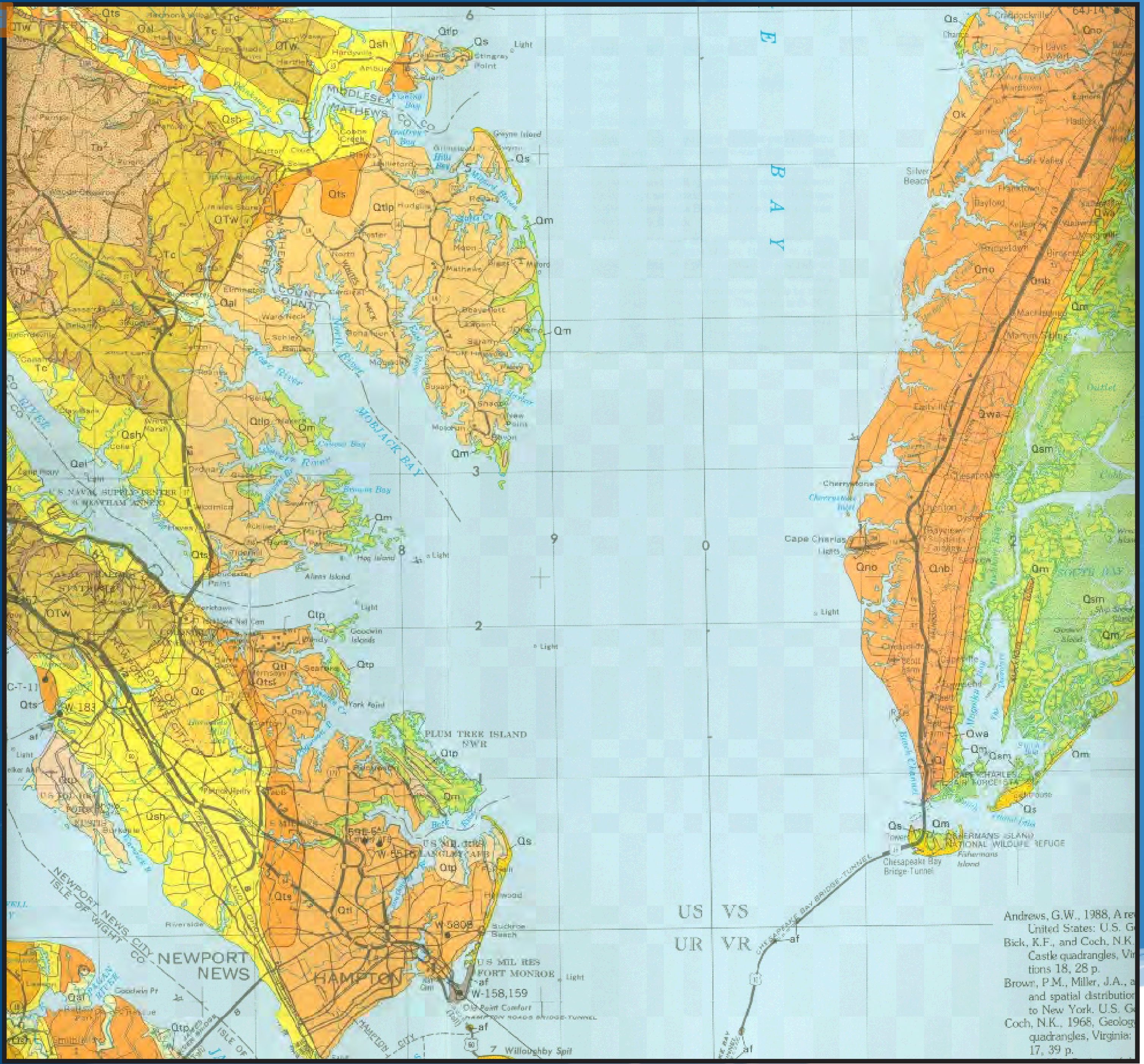
Primary Design Elements

- *Fetch*
- *Shoreline orientation*
- *Shore Morphology*
- *Bank Height-condition-Composition*
- *Shoreline Erosion Rate*
- *Nearshore morphology/stability*
- *SAV*
- *Tide range*
- *Storm Surge Frequency*
- *Boat wakes*
- *Sunlight (often over looked)*
- *Oyster Leases*
- *Access*

Virginia Coastal Plain Geology



From Mixon et al., 2005

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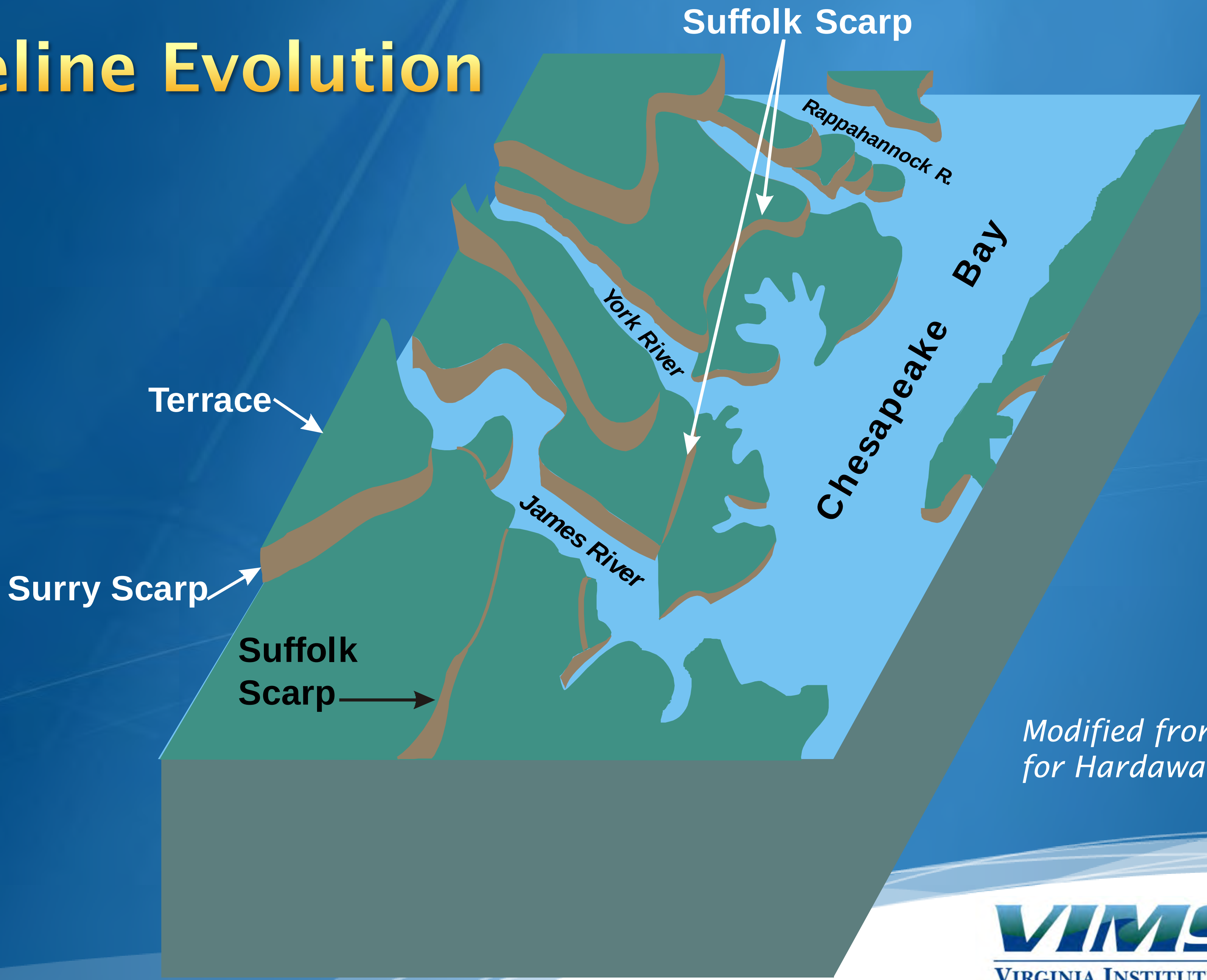
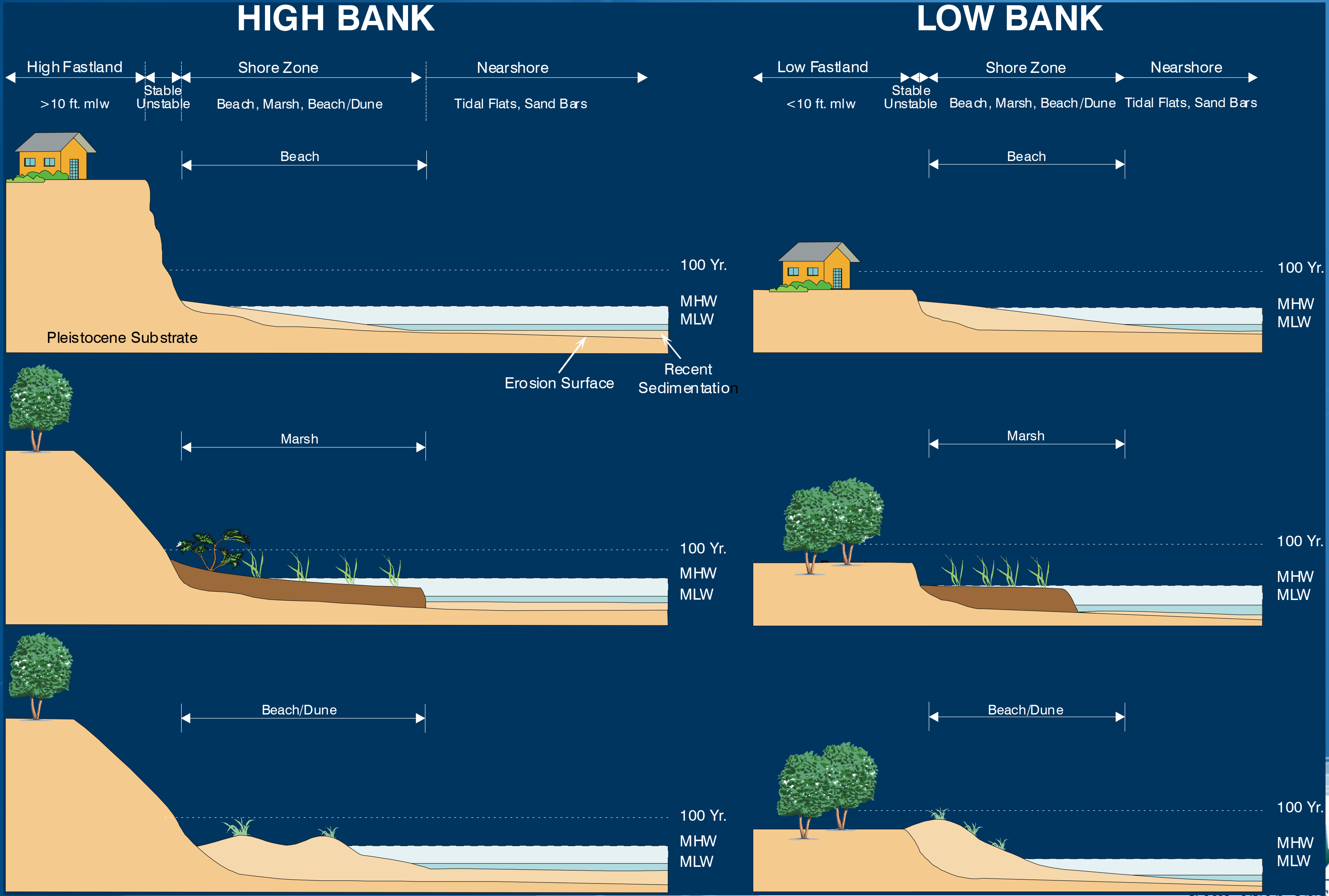
Shoreline Evolution



Modified from Peebles (1984) for Hardaway & Byrne (1999)

Shoreline Erosion



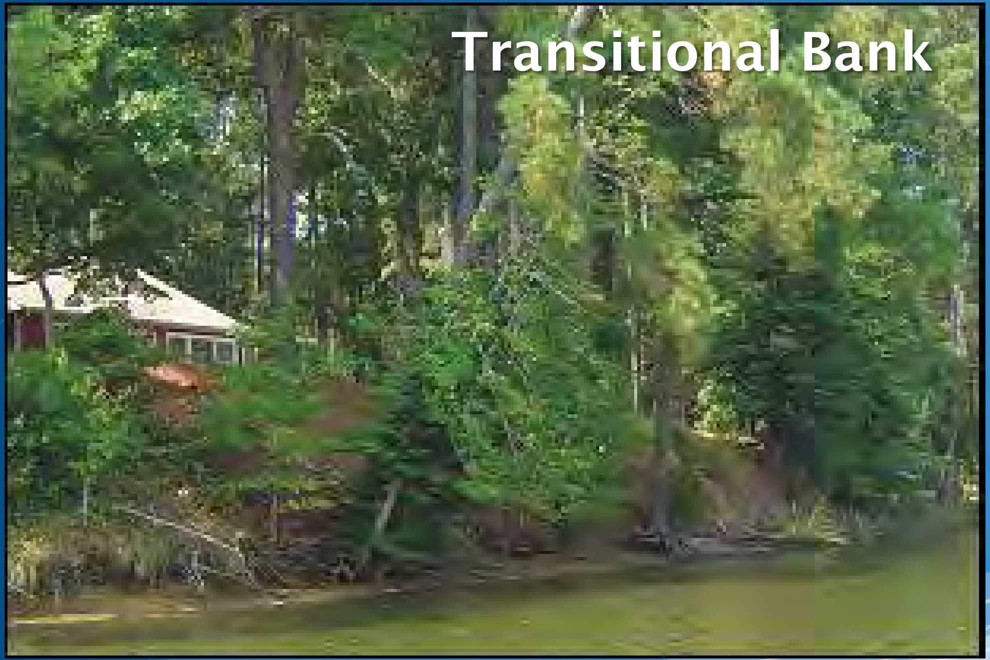
Six typical shoreline profiles occur in Chesapeake Bay.

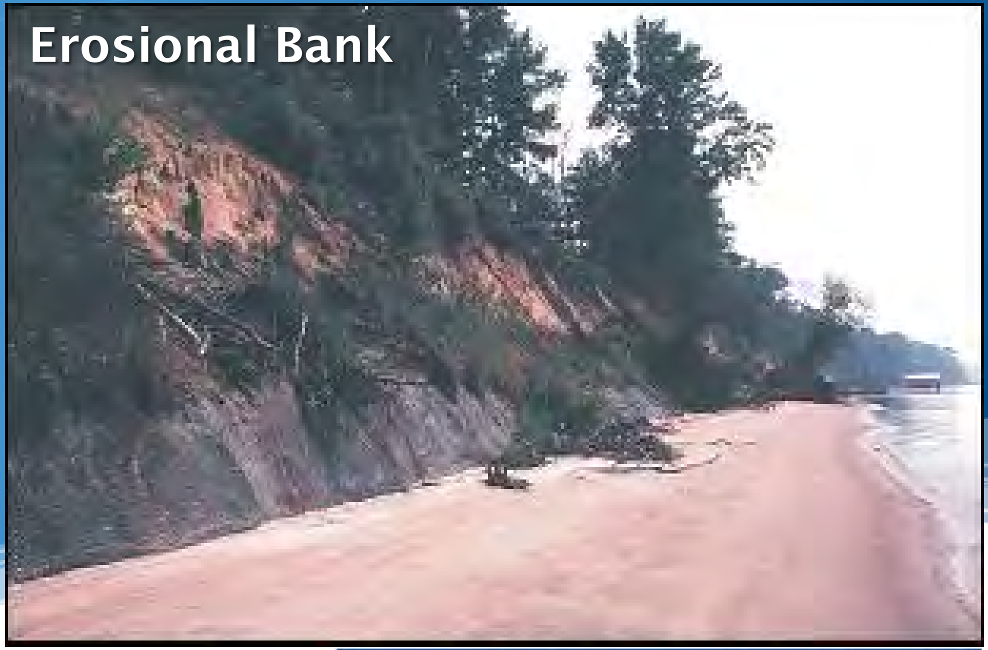
The stability of the bank face is dependent upon the width and type of shore zone features.

Wide beaches and dunes and marsh zones can offer significant wave protection even during storms.

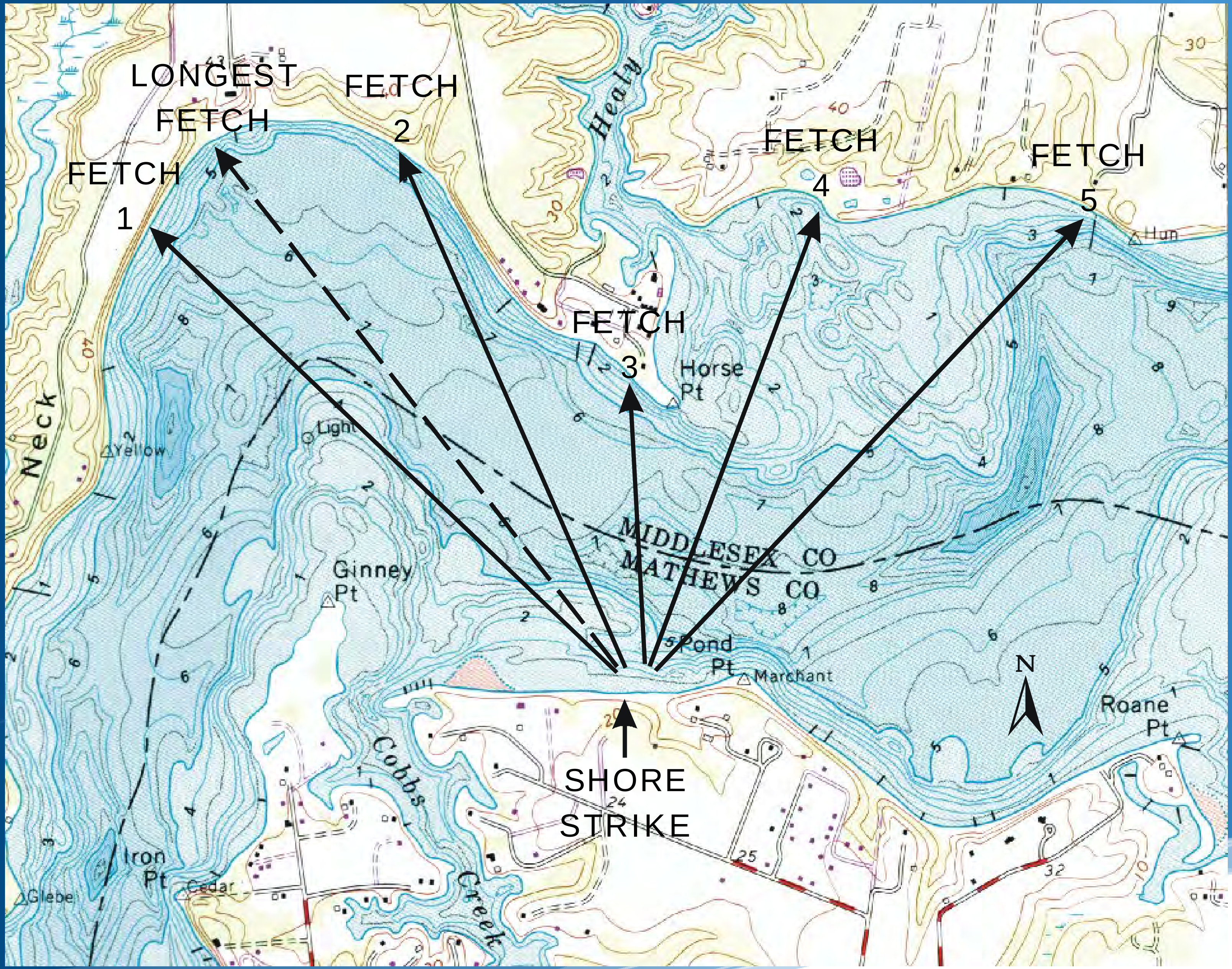
Shoreline Erosion

Shoreline Erosion





Reach Assessment



Measured parameters include average fetch (AF=(F1+F2+F3+F4+F5)/5) and longest fetch.

Also shown is shore strike from which the wind/wave window for fetch and shore orientation are established (after Hardaway & Byrne, 1999).

Shore orientation in this case is about due north.

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Wave Energy

Wave Energy in Chesapeake Bay relative to average fetch:

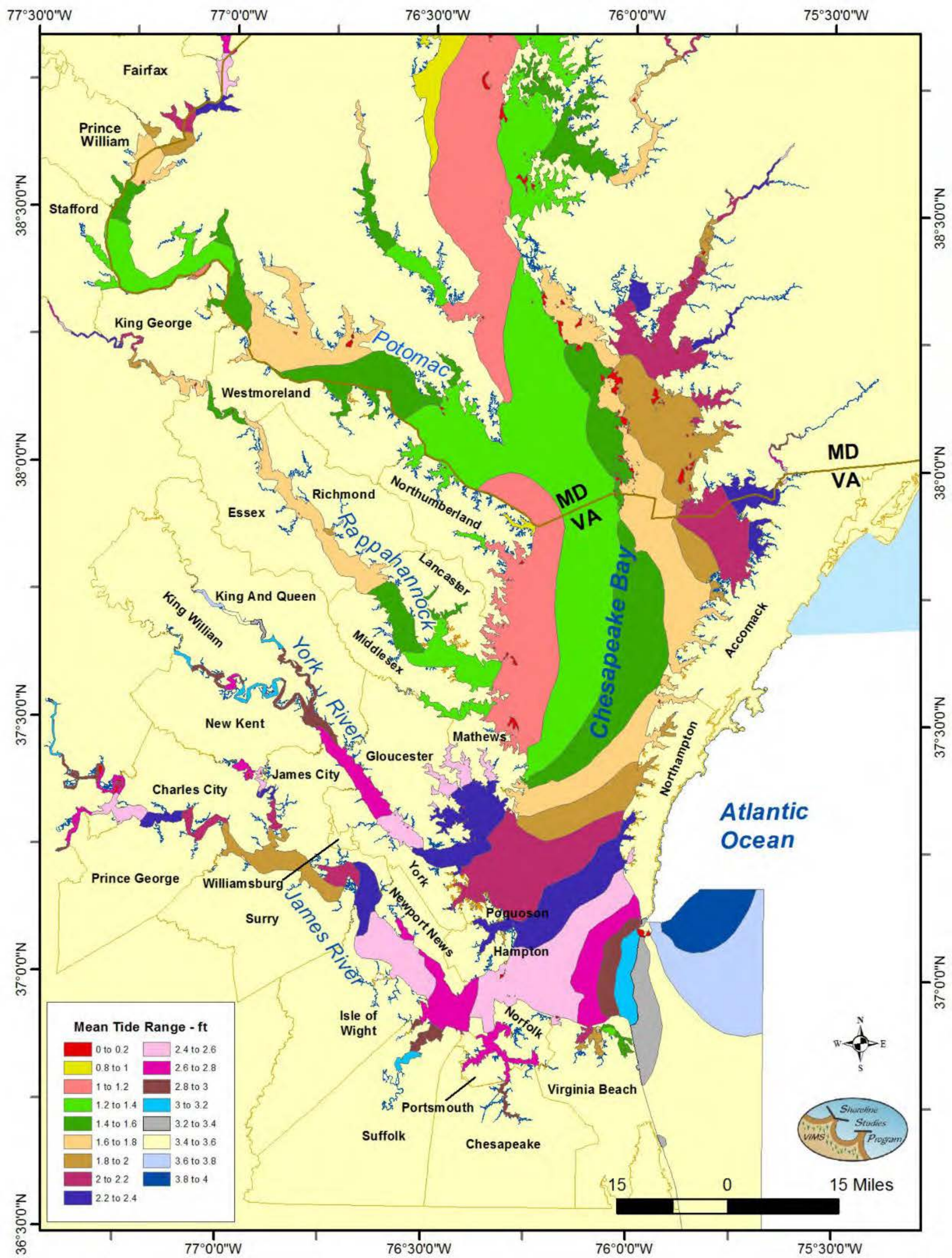
Low energy : < 1.0 mile

Medium energy : 1.0 to 5.0 miles

High energy: 5.0 to 10.0 miles

Very High energy: > 10.0 miles

Tide Range



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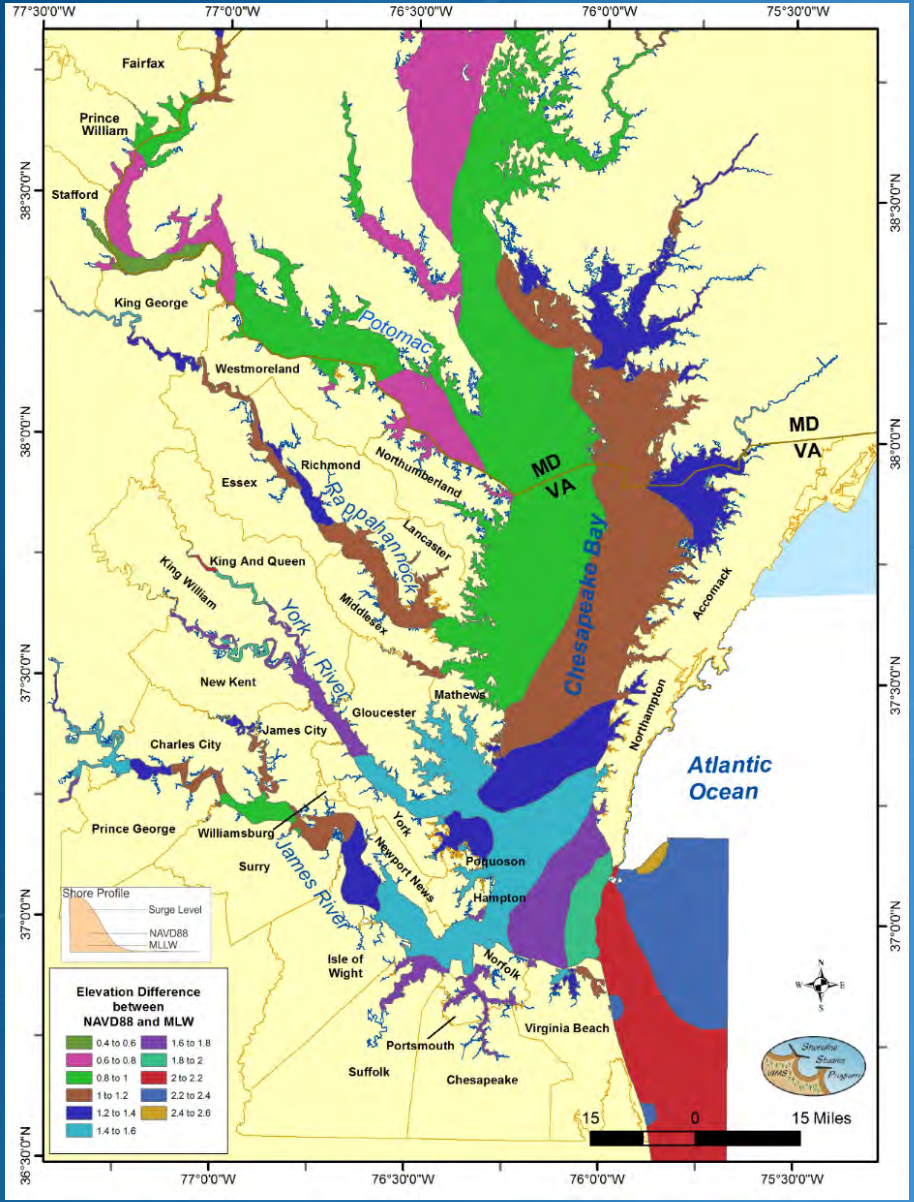


Conversion NAVD88 to MLW

Marsh Toe Revetment

Sill placed next to an existing wide marsh.

Maintain desirable marsh ecosystem services.

Natural accretion depends on local sediment supply.

Can also spot fill and plant to fill in non-vegetated areas

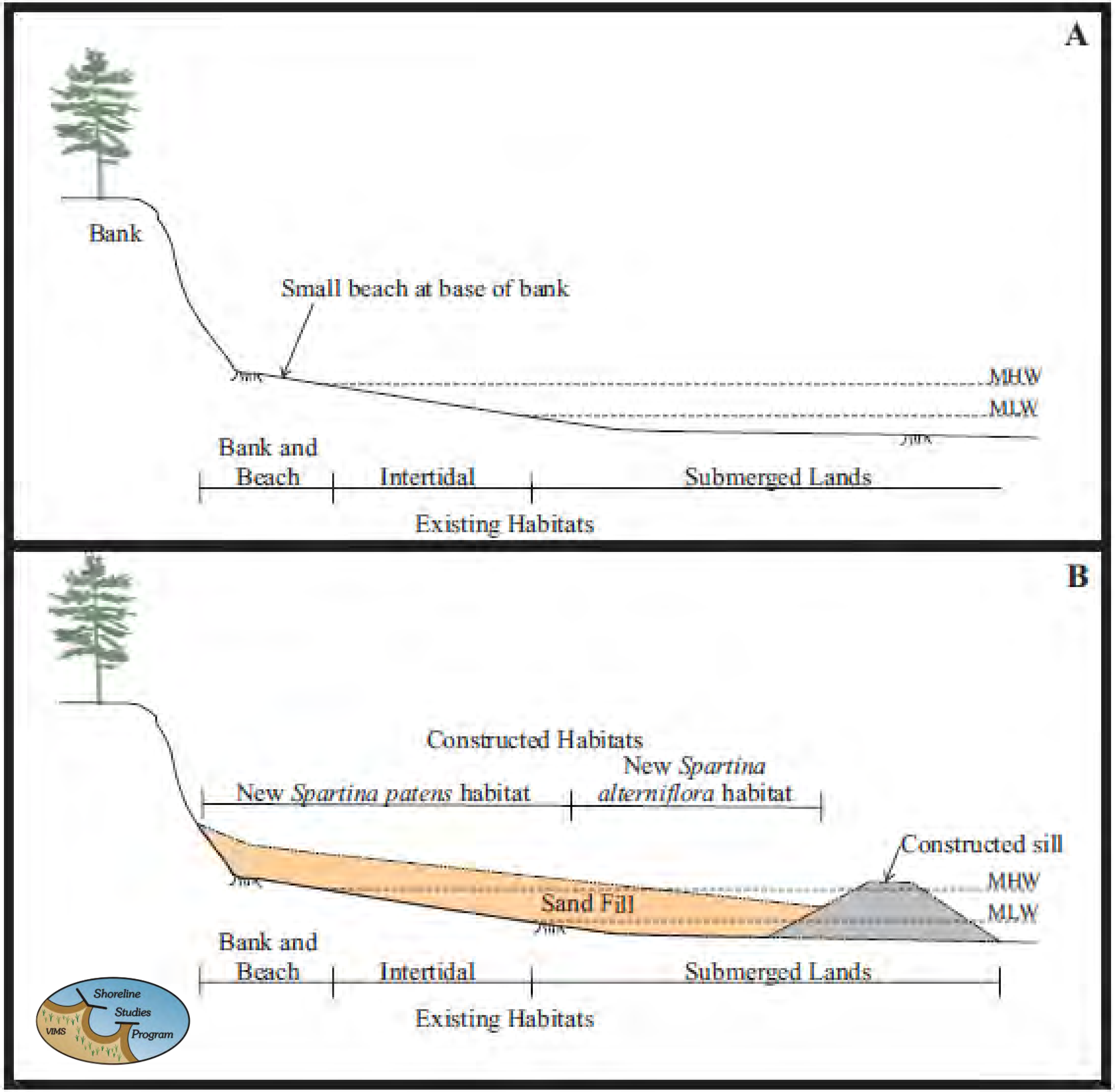
Marsh Sill

Stone structure placed near MLW

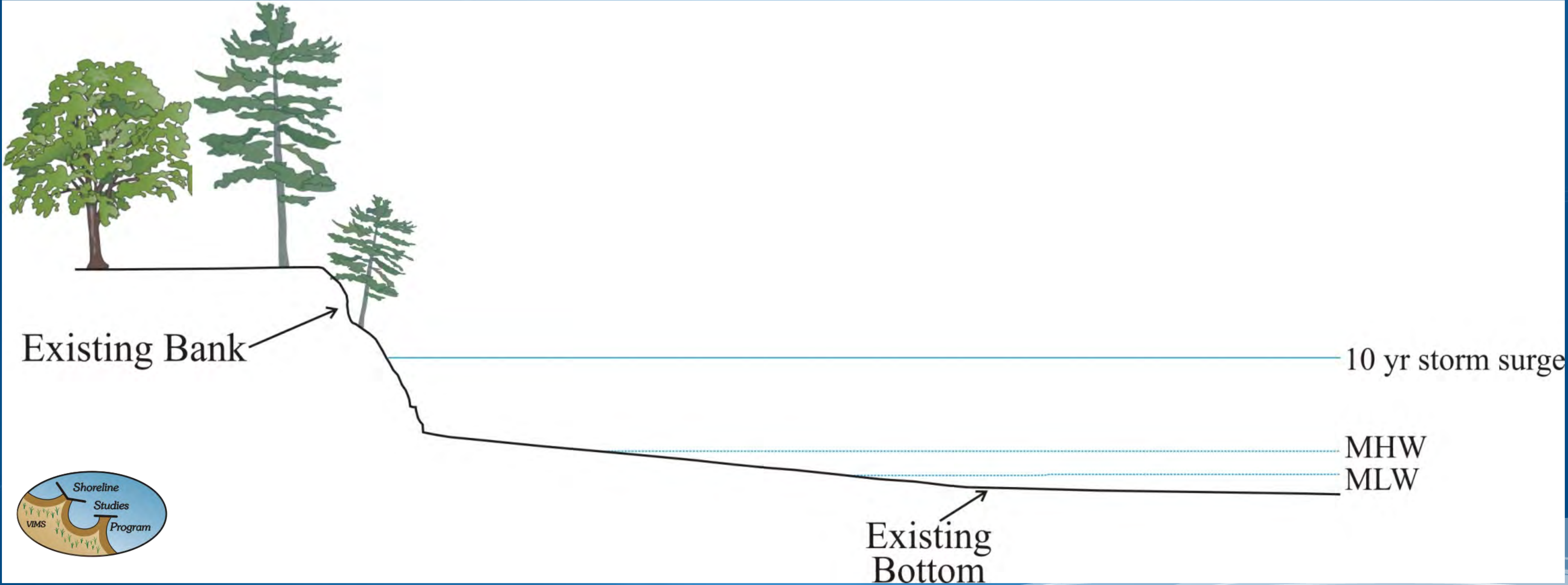
Backfilled with sand and planted with tidal wetland vegetation

- *Stone*
- *Sand*
- *Plants*

All 3 elements usually required for sustainable design


A
Bank
Small beach at base of bank
MHW
MLW
Bank and
Beach
Intertidal
Submerged Lands
Existing Habitats
B
Constructed Habitats
New Spartina
New *Spartina patens* habitat
alterniflora habitat
Constructed sill
MHW
Sand Fill
MLW
Bank and
Beach
Intertidal
Submerged Lands
Existing Habitats
Shoreline
Studies
VIMS
Program

Marsh Fringe Applications



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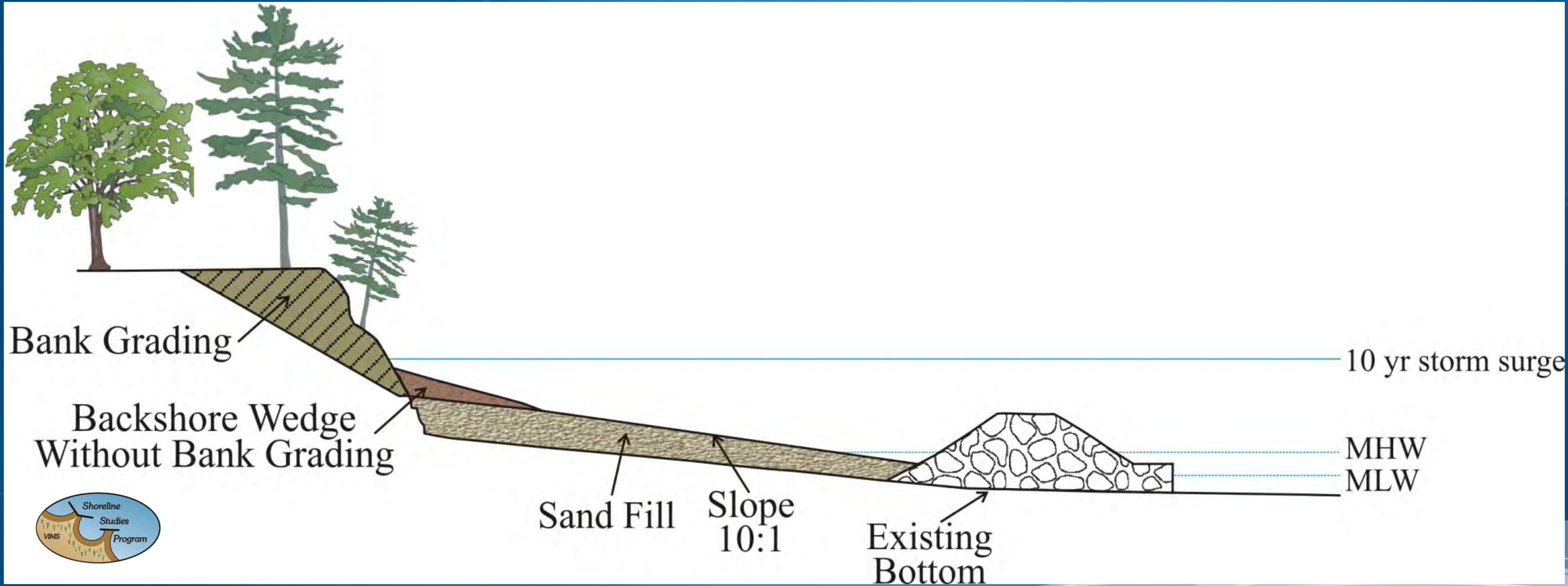
Marsh Fringe Applications



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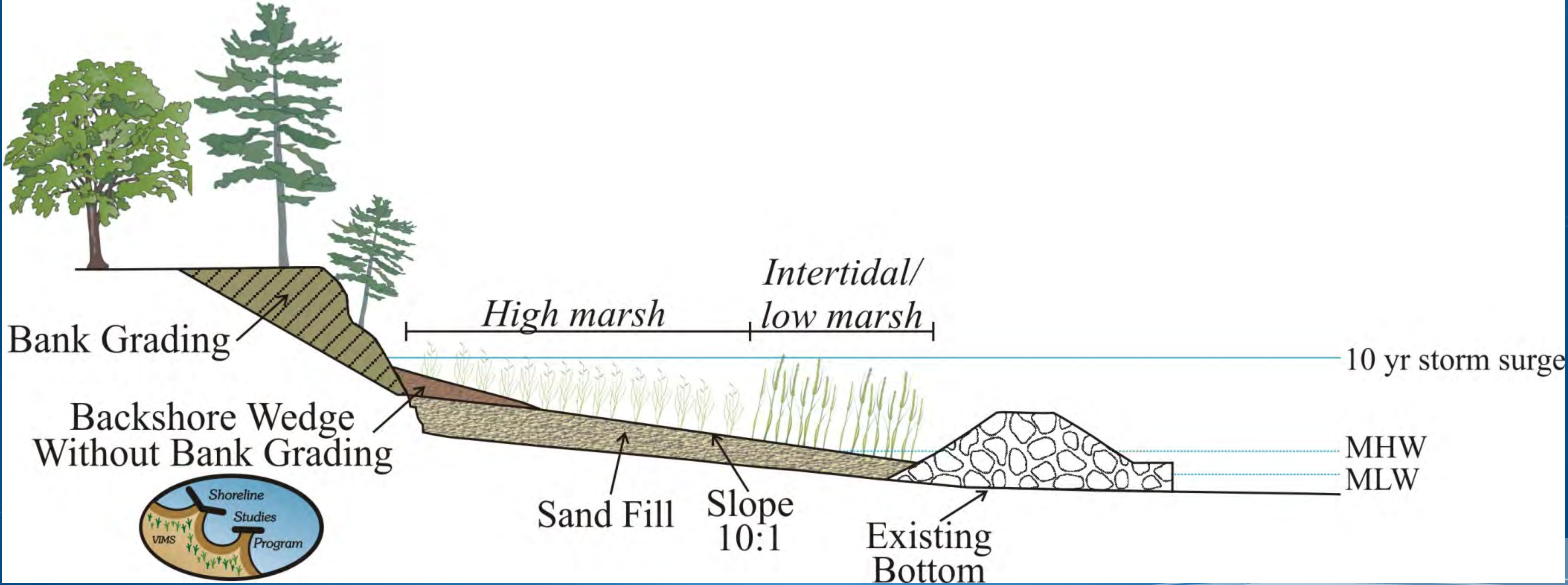
Marsh Fringe Applications



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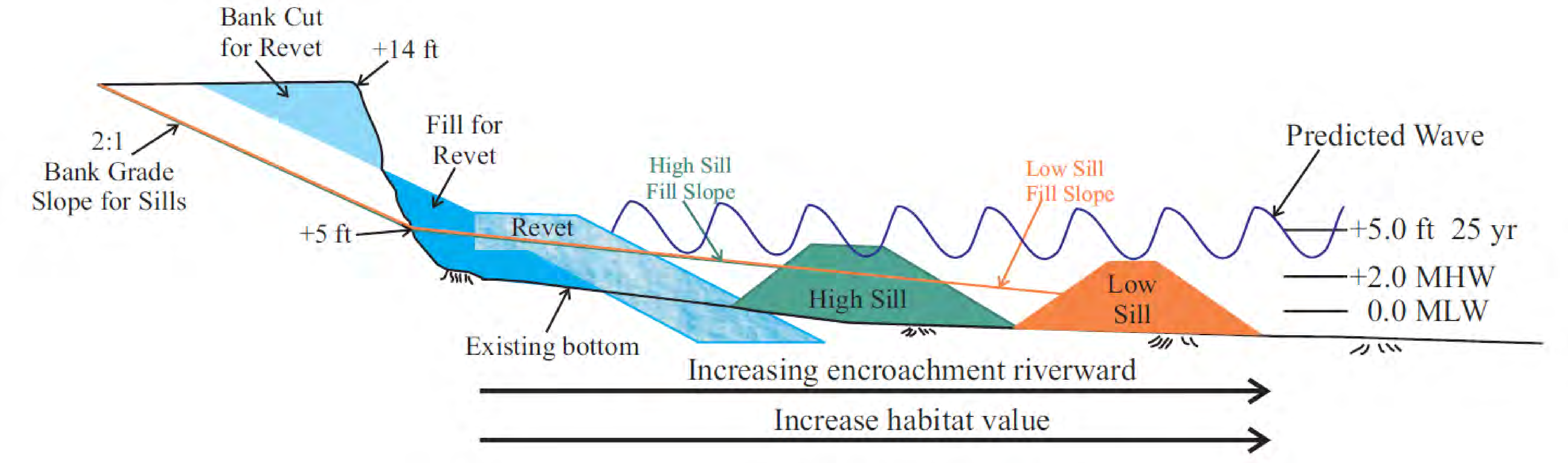
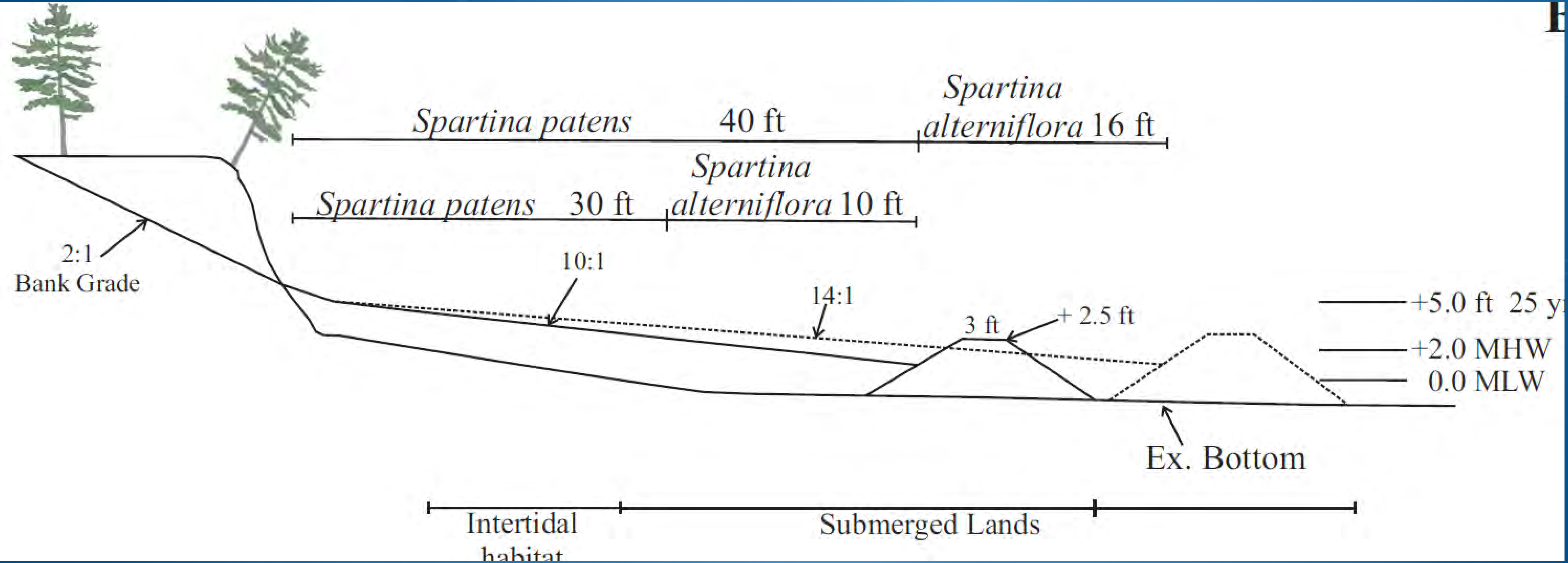
Structure Resiliency



Shore protection options with encroachment, level of protection and habitat value

From Hardaway et al., 2009
https://scholarworks.wm.edu/reports/561/

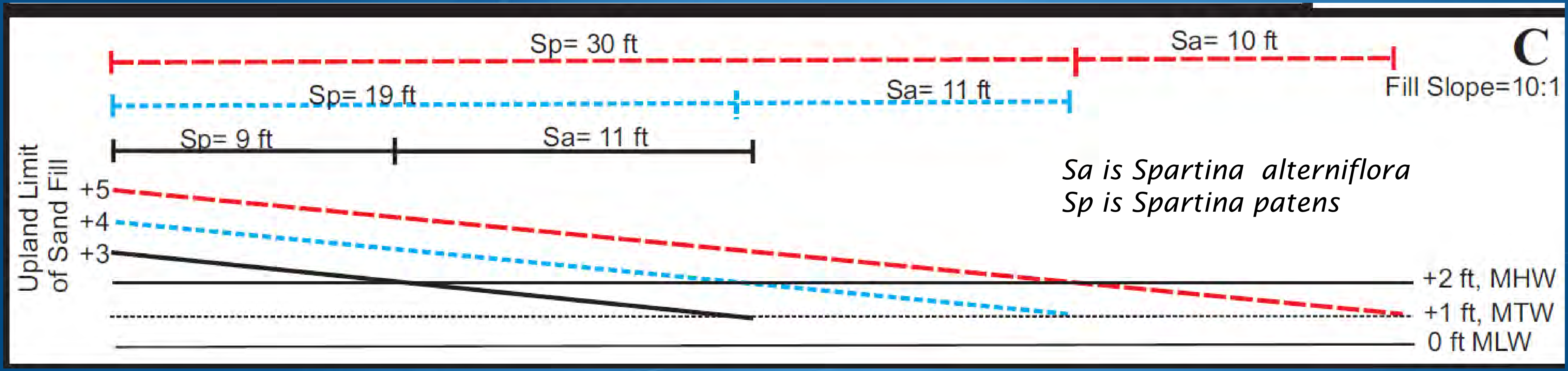
Encroachment



Two sill options showing the amount of encroachment and the amount of habitat gained.

From Hardaway et al., 2009
https://scholarworks.wm.edu/reports/561/

Encroachment



The sand fill model for a slope of 10:1.

The approximate width of the vegetated area on each slope is indicated.

The total width of Sp and Sa is the total encroachment if no structure is included. Stone sill structure design is site specific.

From Hardaway et al., 2009
https://scholarworks.wm.edu/reports/561/

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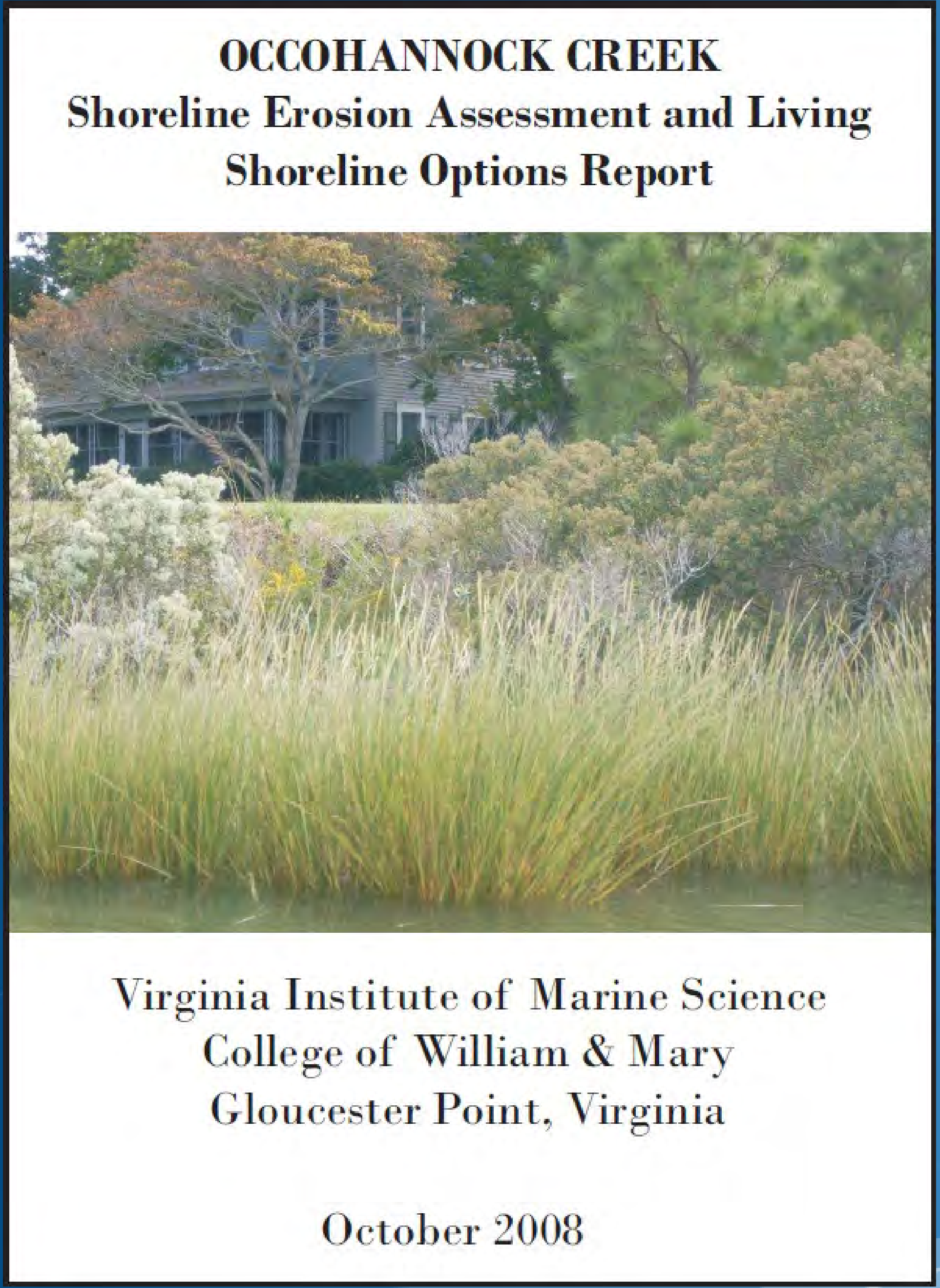
Shoreline Management Planning


OCCOHANNOCK CREEK
Shoreline Erosion Assessment and Living Shoreline Options Report

Virginia Institute of Marine Science
College of William & Mary
Gloucester Point, Virginia

October 2008

Hardaway et al., 2008
https://scholarworks.wm.edu/reports/232/

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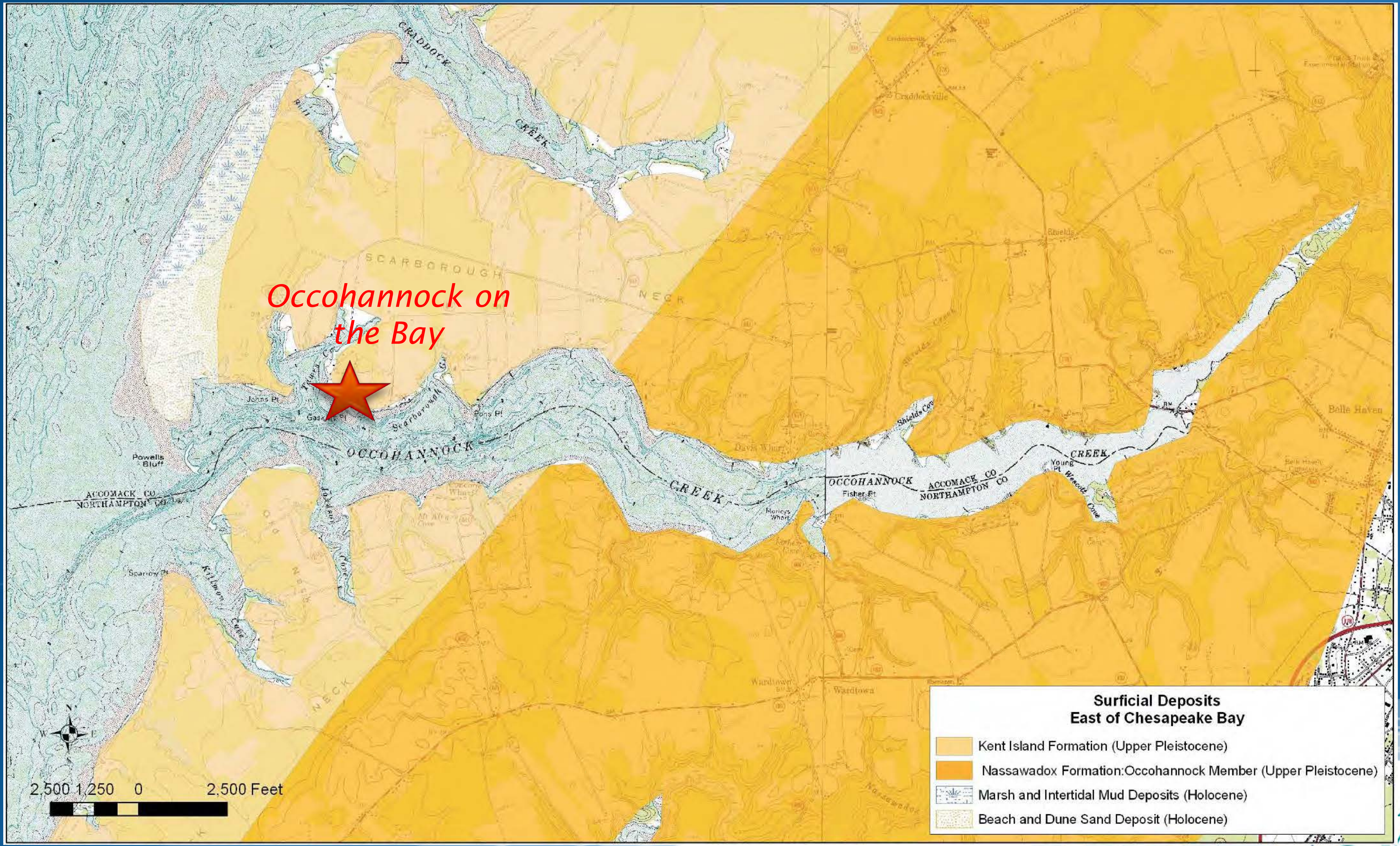
Geology of Occohannock Creek



From Hardaway *et al.*, 2008

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Occohannock on the Bay Shore Types

From Hardaway *et al.*, 2008

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Water Levels

Tide Range
Gaskins Point
Occohannock Creek, Virginia

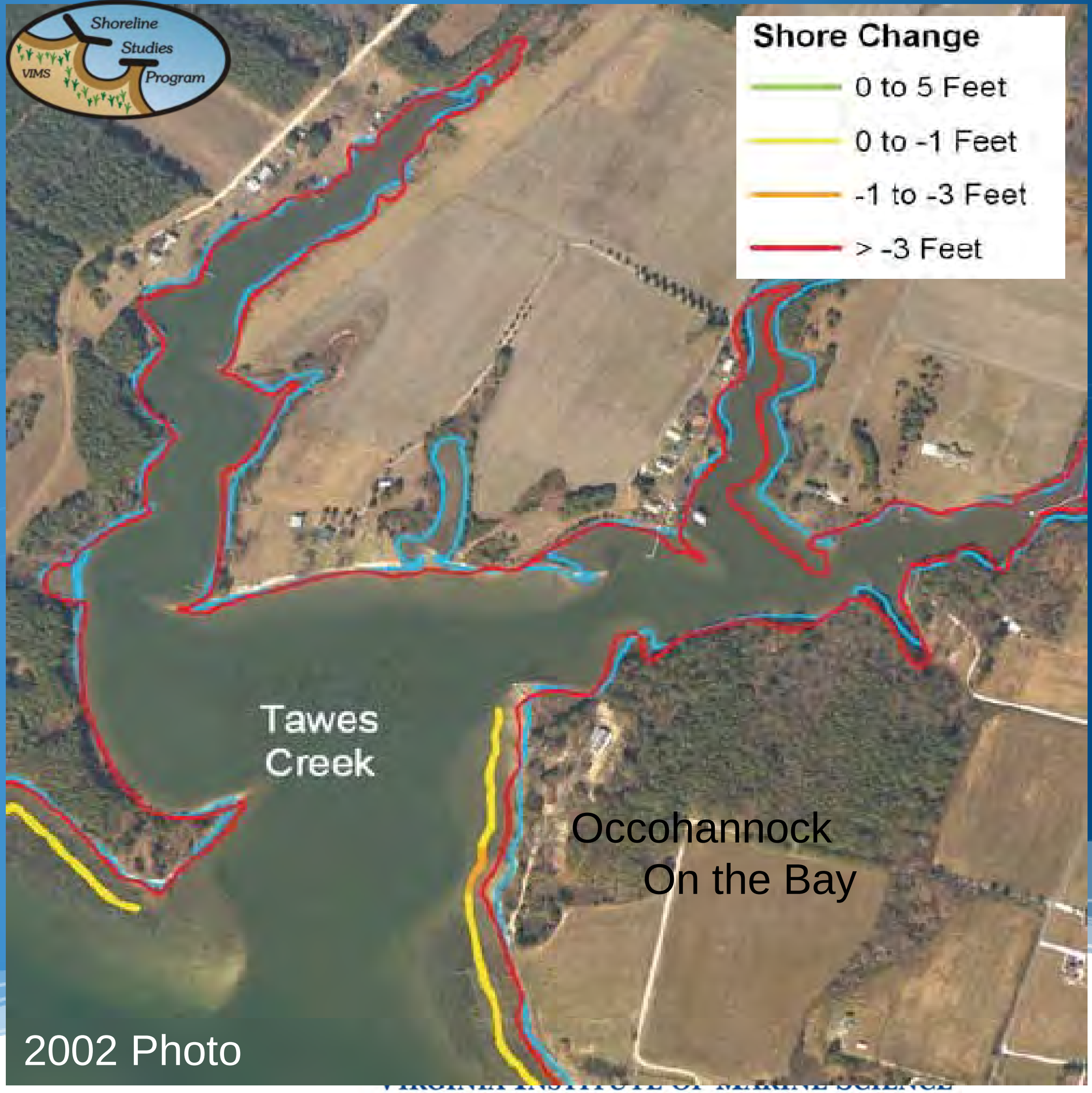
MHHW: 2.05 ft
MHW: 1.88 ft

MLW: 0.15 ft
MLLW: 0 ft

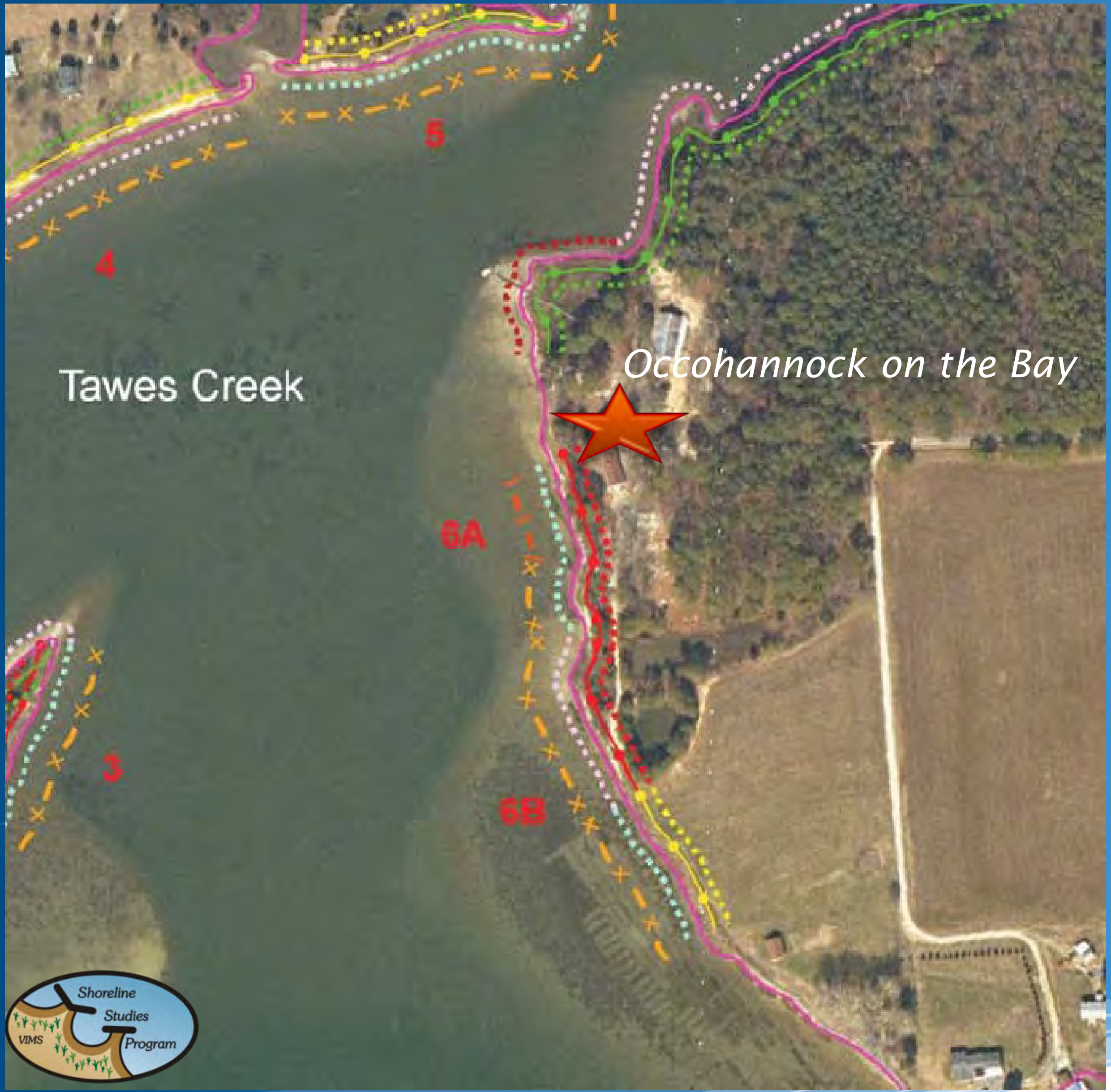
25 year Storm Surge
(FEMA 2015)

4.4 ft MLW

Shoreline Change



Shoreline Recommendations



From Hardaway *et al.*, 2008

Legend

2002 Shoreline

Bank Face		BankBase	
	Erosional		Erosional
	Stable		Stable
	Transitional		Transitional

Marsh Width		Structures Recommended	
	10-15		Breakwaters
	5-10		High Sill
	<5		Medium Sill
	>15		Low Sill,
Grading			Sand and Groins
	Yes		

Recommended structures numbered in red

Location of Occohannock on the Bay

Fetch: average = 5.5 miles.
Longest = 20 miles to SW

Storm Surge#: Transect 77

10 yr (10%) =4.4 ft. MLW
25 yr (4%) = 4.6 ft. MLW*
50 yr (2%) = 5.0 ft. MLW
100 yr (1%) = 5.5 ft. MLW

 # FEMA 2015
**interpolated*

FEMA Flood Insurance Data

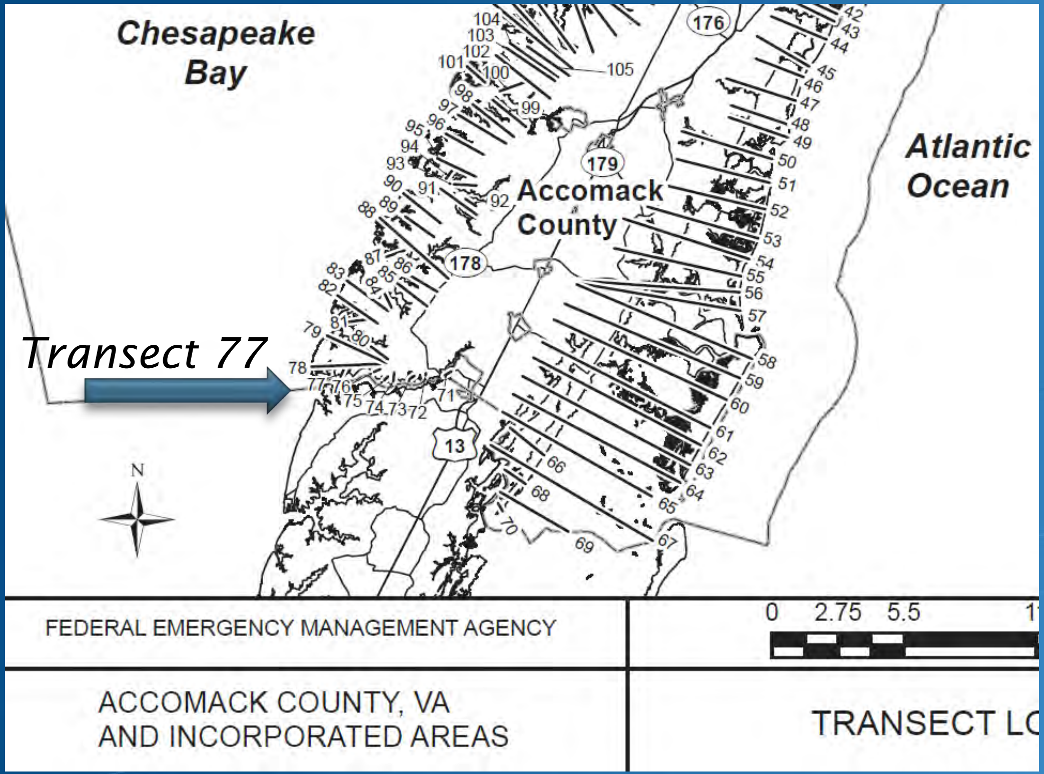


TABLE 3 – TRANSECT DATA (continued)

Flood Source	Transect	Coordinates	Starting Wave Conditions for the 1% Annual Chance: Significant Wave Height H_s (ft)	Starting Wave Conditions for the 1% Annual Chance: Peak Wave Period T_p (sec)	Starting Stillwater Elevations (ft NAVD88): 10% Annual Chance	Starting Stillwater Elevations (ft NAVD88): 2% Annual Chance	Starting Stillwater Elevations (ft NAVD88): 1% Annual Chance	Starting Stillwater Elevations (ft NAVD88): 0.2% Annual Chance
Occohannock Creek	71	N 37.556361 W -75.839708	2.0	2.9	3.3	4.4	5.0	7.3
Occohannock Creek	72	N 37.556389 W -75.854311	1.9	2.3	3.3	4.4	5.0	7.3
Occohannock Creek	73	N 37.554337 W -75.866590	1.9	2.2	3.3	4.4	5.0	7.3
Occohannock Creek	74	N 37.552938 W -75.878772	1.9	2.3	3.3	4.3	4.9	6.5
Occohannock Creek	75	N 37.553869 W -75.885854	2.2	2.3	3.3	4.2	4.8	6.4
Occohannock Creek	76	N 37.558926 W -75.893467	2.5	2.3	3.2	4.1	4.7	6.3
Occohannock Creek	77	N 37.556441 W -75.918867	2.6	2.4	3.2	3.9	4.4	5.8

See the 2021Part 2 Determining Site-Specific Parameters for Living Shoreline Design presentation on how to find this data. Link below.

https://www.vims.edu/research/departments/physical/programs/ssp/shoreline_management/living_shorelines/class_info/index.php

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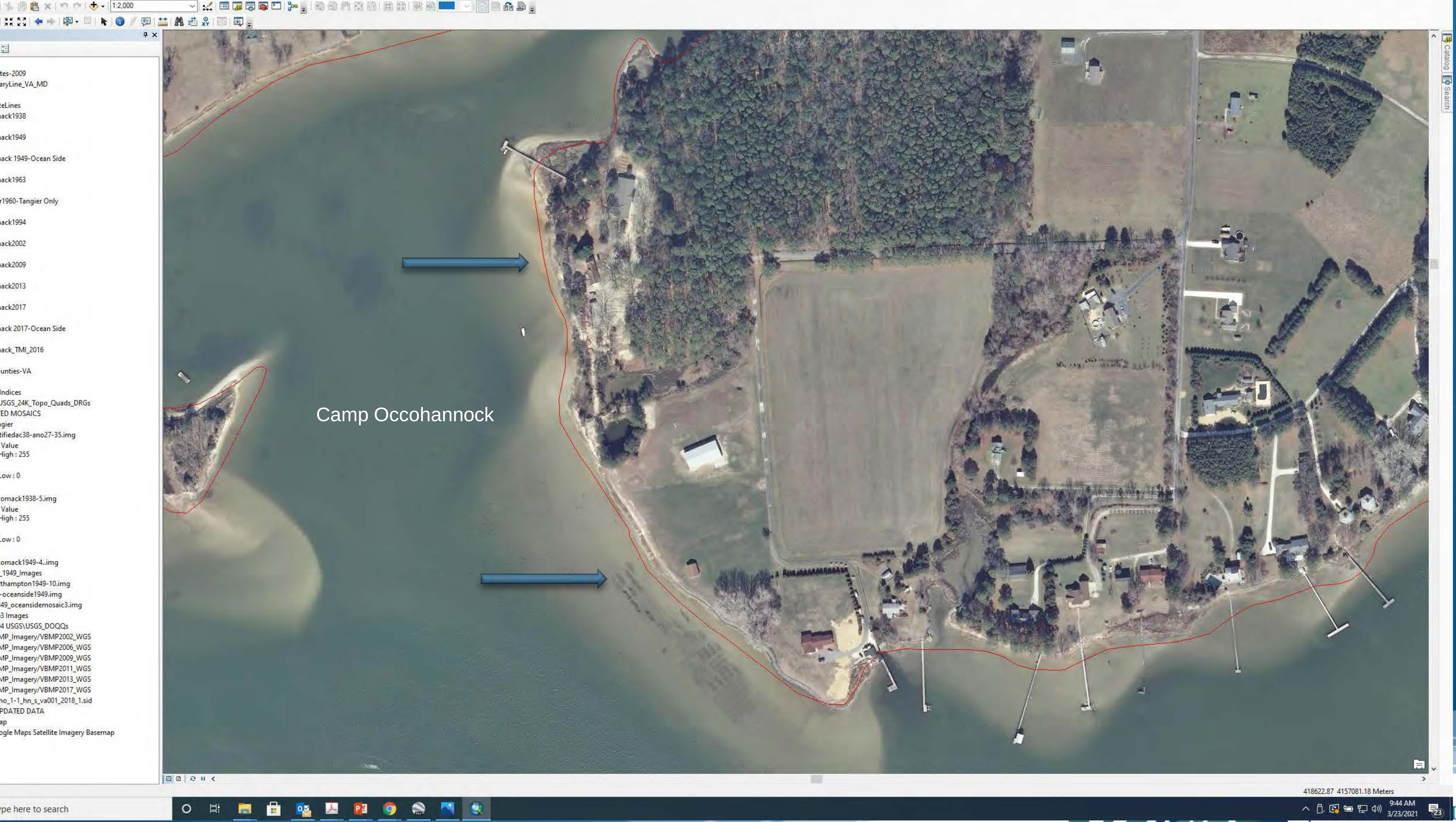

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Developing a Site Specific Design

Eroding low upland bank and access road

- *Survey existing conditions including elevations, existing structures and natural resources (SAV)*
- *Determine goals of landowner*

Eroding marsh. Proposed cobble Sill. Note SAV in nearshore.

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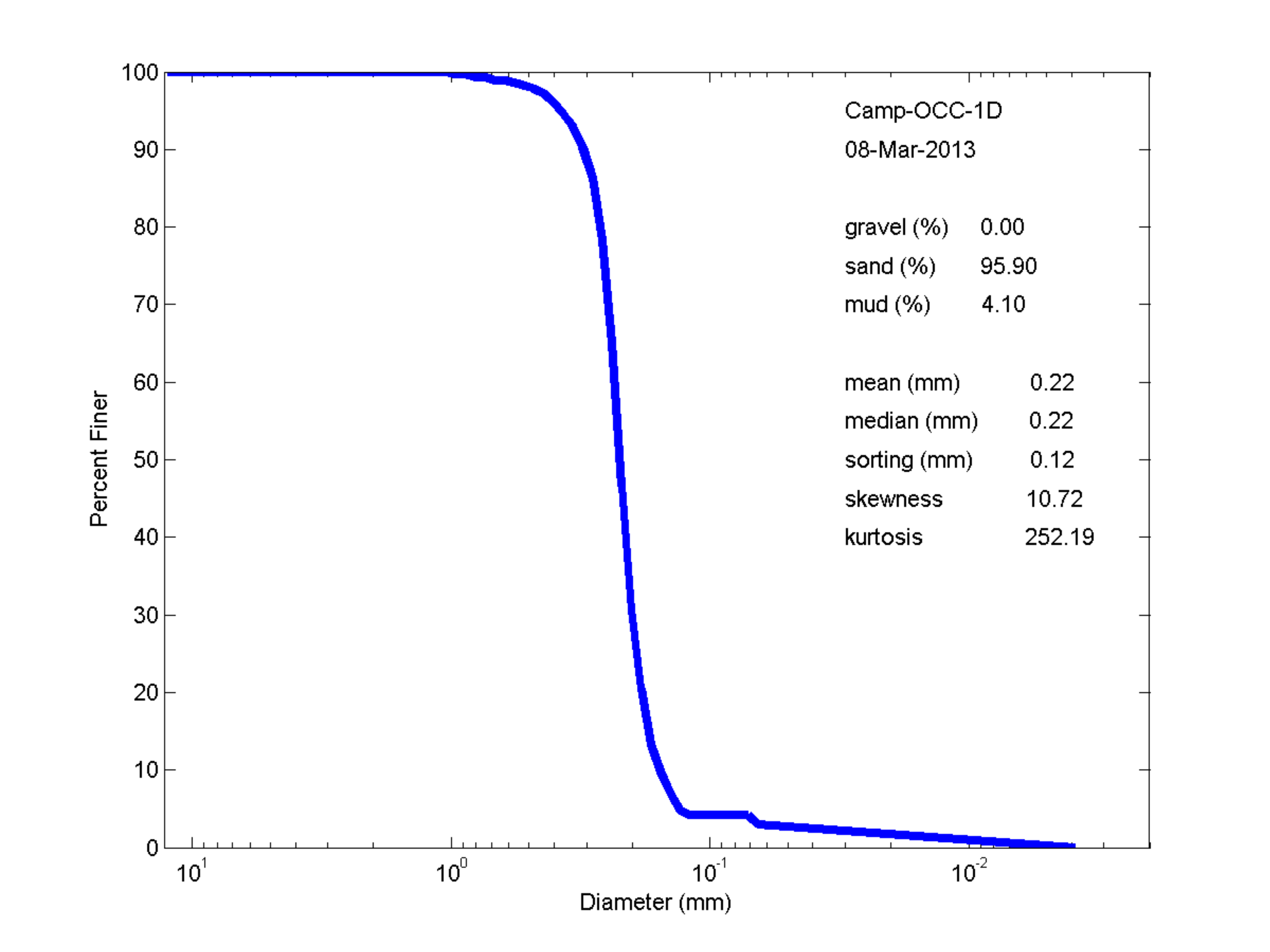
Eroding high bank with sparse marsh fringe

Bank sample analysis



Westward transition from high bank to low bank and canoe beach

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Westward transition from low Bank to marsh shoreline

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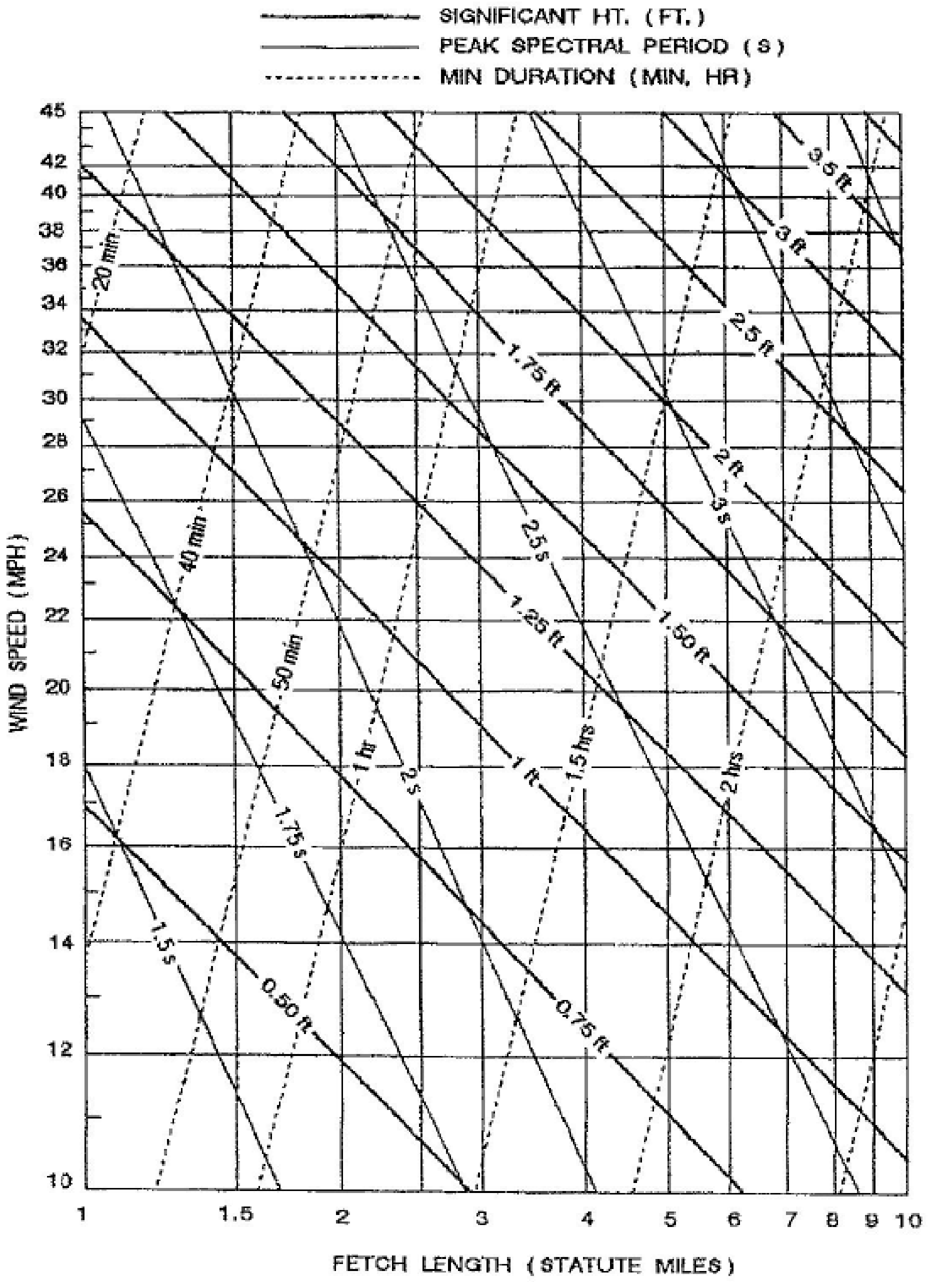
Long fetch exposure to the SW over 20 miles out of the mouth of Occohannock Creek

Shore Survey

Appendix 13B-1 Nomographs of Significant Wave Height Prediction Curves as Functions of Windspeed, Fetch Length, and Wind Duration



Simple Wave Estimation

Fetch: 40 mph wind

H1/3	Ho (ft)	T (s)	E (ft-lb/ft2)	W(lbs)
1 mile:	1.2	2.0	11.5	20 lbs
5 miles:	2.8	3.3	62.7	230 lbs
10 miles:	3.7	4.0	109.0	531 lbs

H1/10

H1/10	Ho (ft)	T (s)	E (ft-lb/ft2)	W(lbs)
1 mile:	1.5	2.0	18.0	35 lbs
5 miles:	3.6	3.3	103.0	589 lbs
10 miles:	4.7	4.0	176.0	1088 lbs

http://www.virginiadot.org/business/locdes/hydra-drainage-manual.asp

VDOT Drainage Manual Chapter 13: Shore Protection, Pg 30

Wave Energy in Chesapeake Bay

relative to average fetch with rock size

Wave Energy and Fetch	*Rock Size: 2:1 slope*
Low energy : > 1.0 mile	*Class I – 50 to 150 lbs*
Medium energy : 1.0 to 5.0 miles	*Class II -150 to 500 lbs*
High energy: 5.0 to 10.0 miles	*Class III- 500 to 1500 lbs*
Very High energy: > 10.0 miles	*Type I – 1500 to 4000 lbs*

Stone size can be modified up or down depending on site conditions. Increase in front slope grade to 1.5:1 may require increase in rock size.

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Rock: Durable igneous or metamorphic rock with minimum weight of 165 lbs/cubic foot.

Sand: Typically grain size D50 0.6mm (=/-0.25mm) with less than 10% passing the 100 sieve.

Plants: Typically Spartina alterniflora (smooth cordgrass) planted from Mid-tide Level to MHW
Spartina patens (saltmeadow hay) planted above MHW

Graded Banks: Minimum usually 2:1 but 4:1 provides additional buffer

Permit Application

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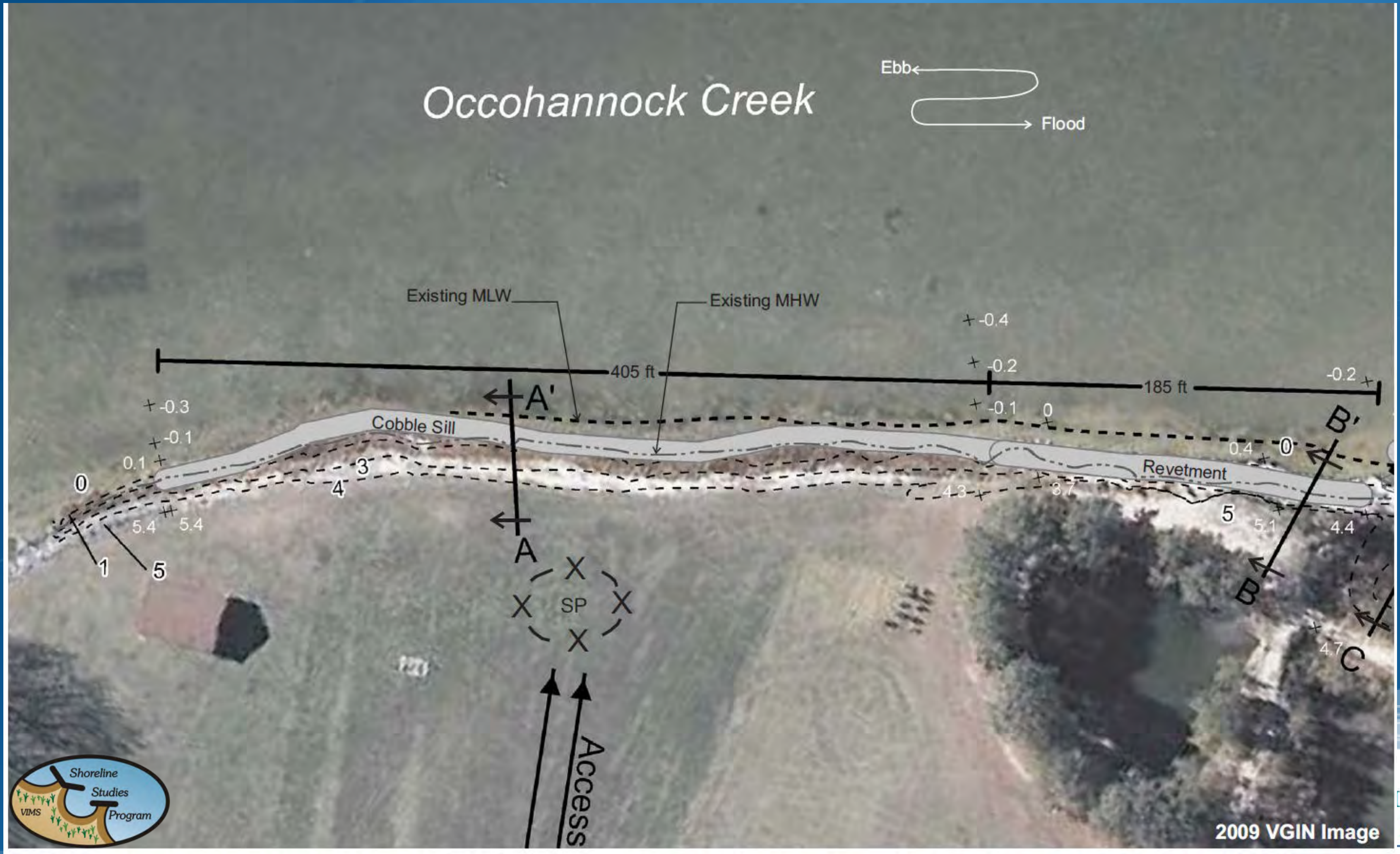
Permit Application



Permit Application

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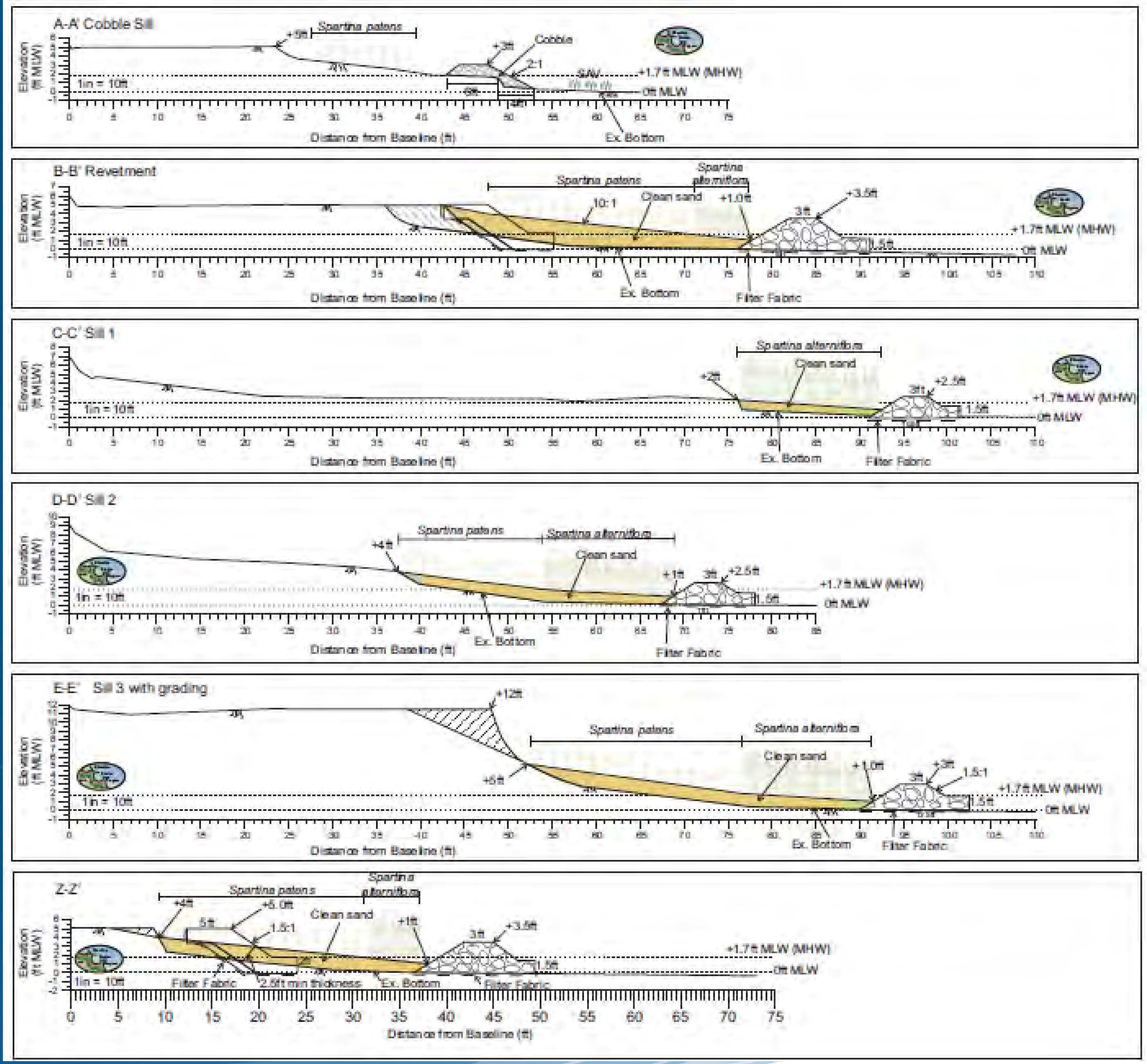
Final Plans

Proposed MLW
Existing MLW
Proposed Sill
(April 23, 2013)
Proposed Revetment
(March 13, 2013)
Proposed Cobble Sill
Sill 1 = 100'
Sill 2 = 120'
Sill 3 = 220'
185'
405'
Existing MHW
Access
SP
SCE
Shoreline Studies Program
VIMS

Final Cross-Sections



"Bi-modal" sand slope
Sa = 20:1
Sp = 7:1

Habitat Created and Impacts

			Habitat Created		Impacts: Rock					Impacts: Sand					
		Length	Sa (ft^2)	Sp(ft^2)	Max	Max	Vegetated	Nonveg	Subaqueous	Fill	Veg.	Volume		Area	
Typical	Structure				MHW	MLW	Wetlands	Wetlands	Bottom		Wetlands	<MLW	>MLW	<MLW	>MLW
X-Section	Type	(ft)			(ft)	(ft)	(ft^2)	(ft^2)	(ft^2)	(cy)	(ft^2)	(cy)	(cy)	(ft^2)	(ft^2)
A-A'	Cobble Sill	405			12	3	1,920	1,620	50						
B-B'	new sill	185	1,260	4,140	45	18			2,520	360	290	360			5,400
C-C'	Sill	100	1,500		30	12		100	1,200	60		0	5	0	1,500
Bay A	Bay														
D-D'	Sill	120	1,800	1,800	50	25		660	660	192	100	1	70	20	3,600
Bay B	Bay									68	0	1	65	200	1,800
E-E'	Sill	220	3,300	5,500	45	20		5,280	2,640	484	612	1	242	20	8,360
Total		1,030	7,860	11,440	**182**	**78**	**1,920**	**7,660**	**7,070**	**1,164**	**1,002**	**363**	**382**	**240**	**20,660**

Sa=*Spartina alterniflora*

Sp=*spartina patens*

SAV Impact= 180 ft2 of intermittent widgeon grass

Living Shoreline Plan

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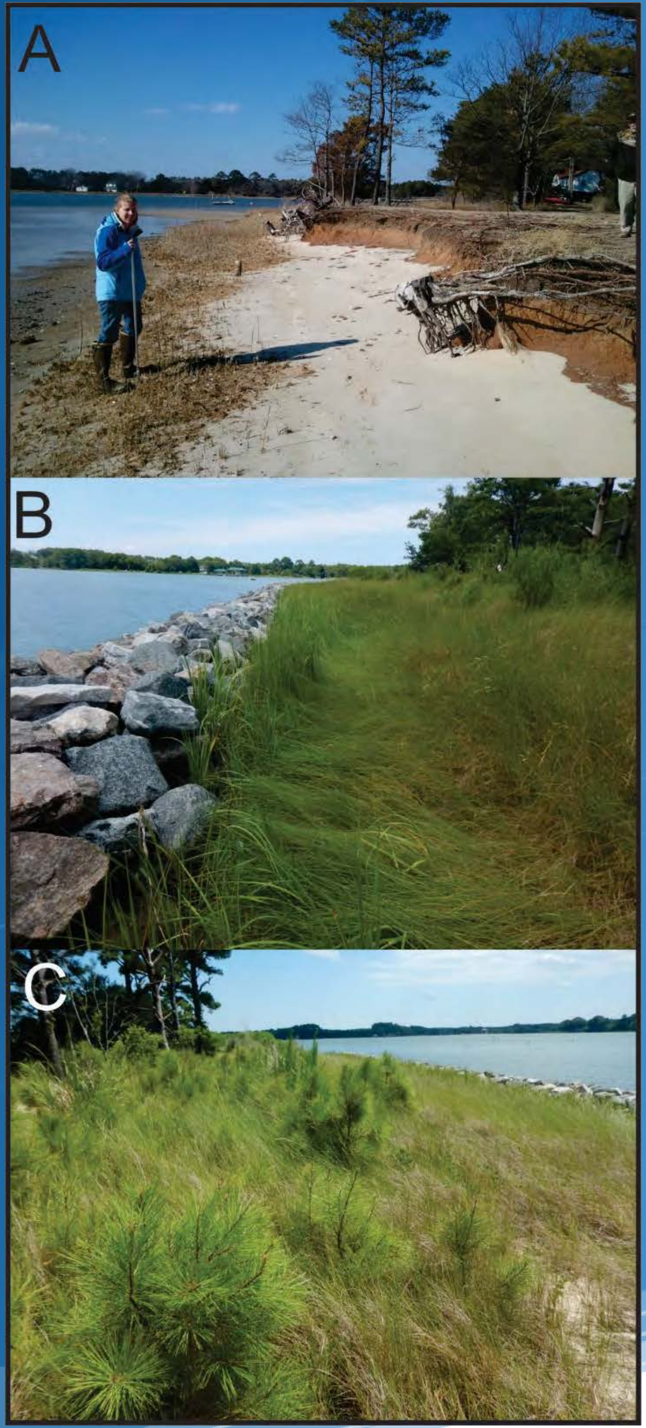
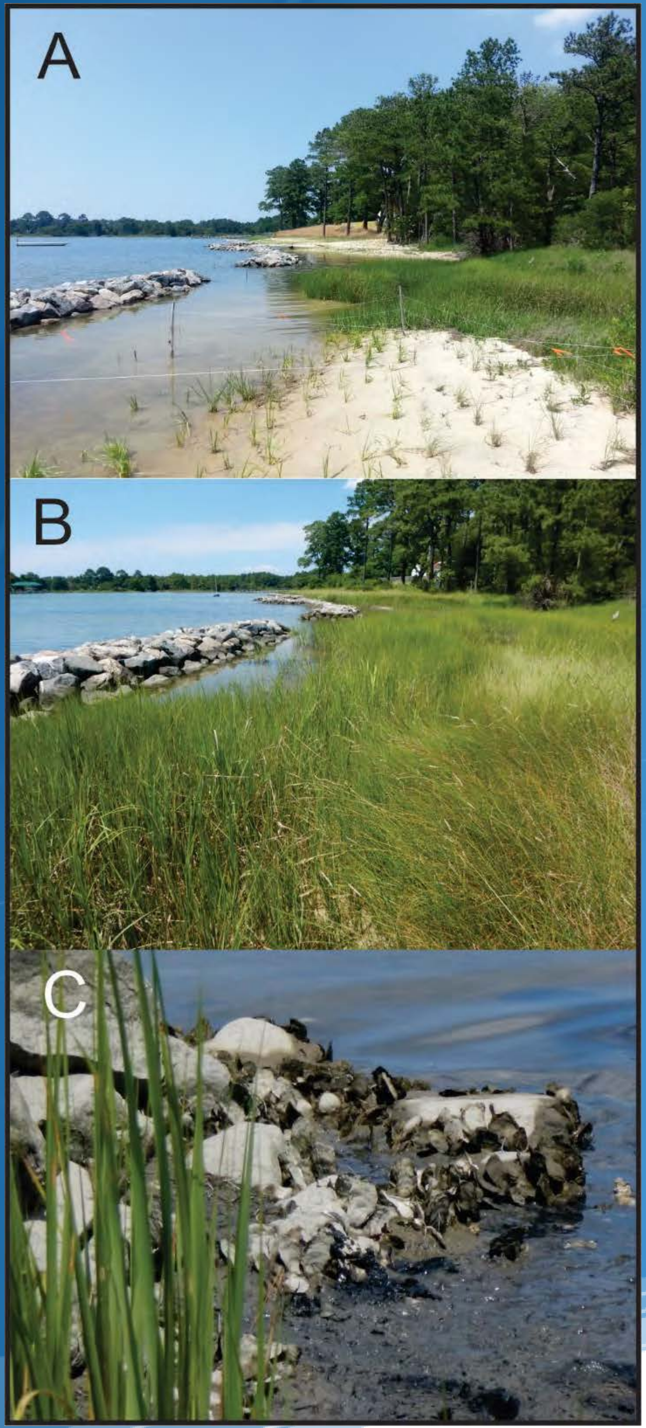


Photos of Reach 1 at Occohannock on the Bay A) before installation (April 2013),

B) after 5years (July 2018),

C) after 5 years, the backshore is being colonized by trees.



Photos of Reach 2 at Occohannock on the Bay A) after planting (May 2013),

B) after 5 years(July 2018),

C) after 5 years there is abundant oyster growth around the end and outsides of the rock sills.

Oyster growth and small fish utilization along sill structures at high water

Photos of Reach 3 at Occohannock on the Bay A), before construction (March 2013),

B) After planting (May 2013),

C) after 5 years.

Camp Occ. Living Shoreline Project

Project Purpose:

Demonstrate living shorelines as cost-effective, hybrid green-gray infrastructure approach for protecting local communities from coastal hazards while enhancing coastal resilience and ecosystem health.

WILDLIFE CONSERVATION SOCIETY

DORIS DUKE CHARITABLE FOUNDATION

WILDLIFE CONSERVATION SOCIETY CLIMATE ADAPTATION FUND

CHESAPEAKE BAY TRUST

Eastern Shore of Virginia COMMUNITY FOUNDATION

An affiliate of Hampton Roads Community Foundation

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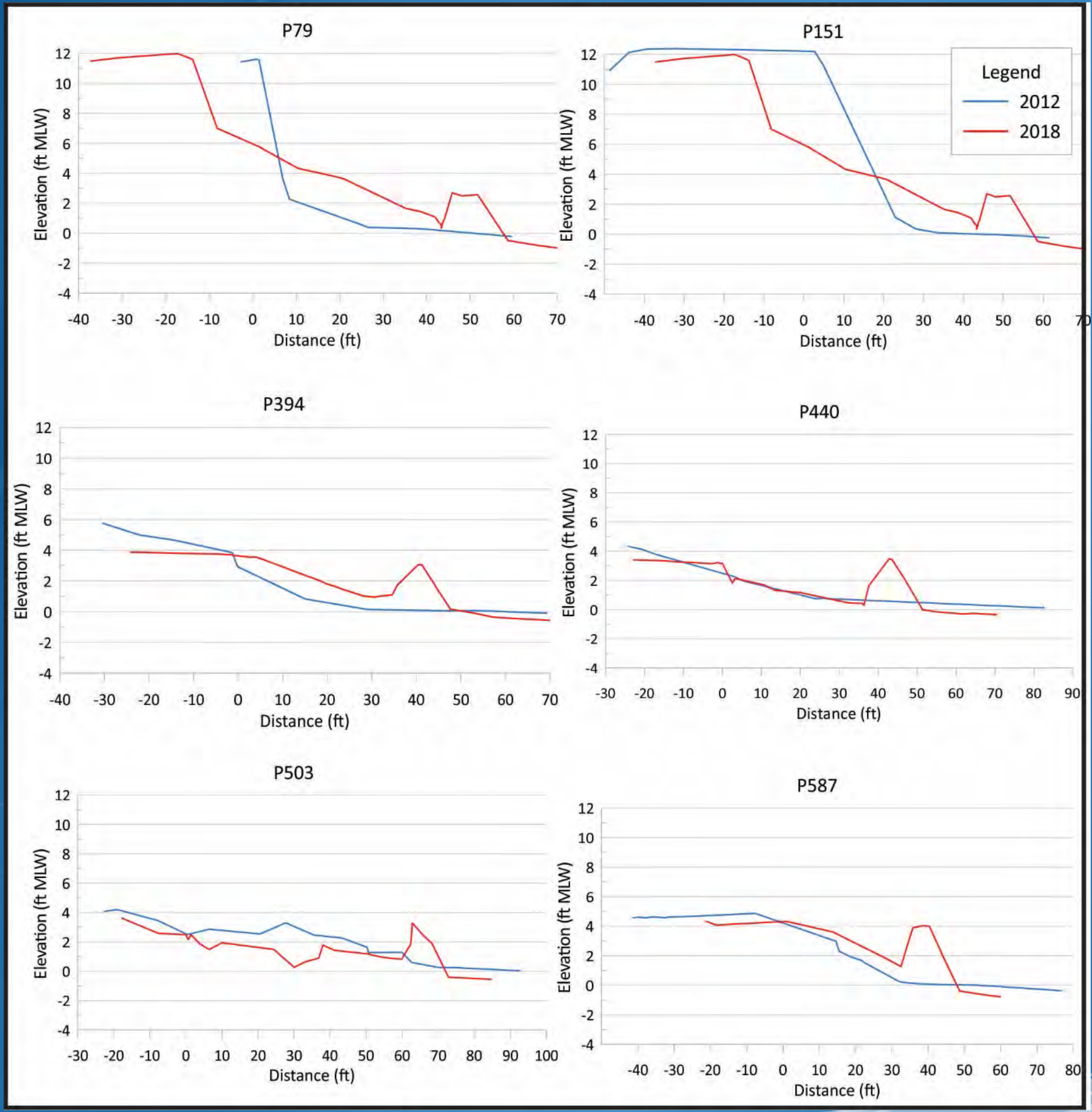
Location of cross-sectional profiles At Occohannock and the 2018 surveyed position of mean high water.

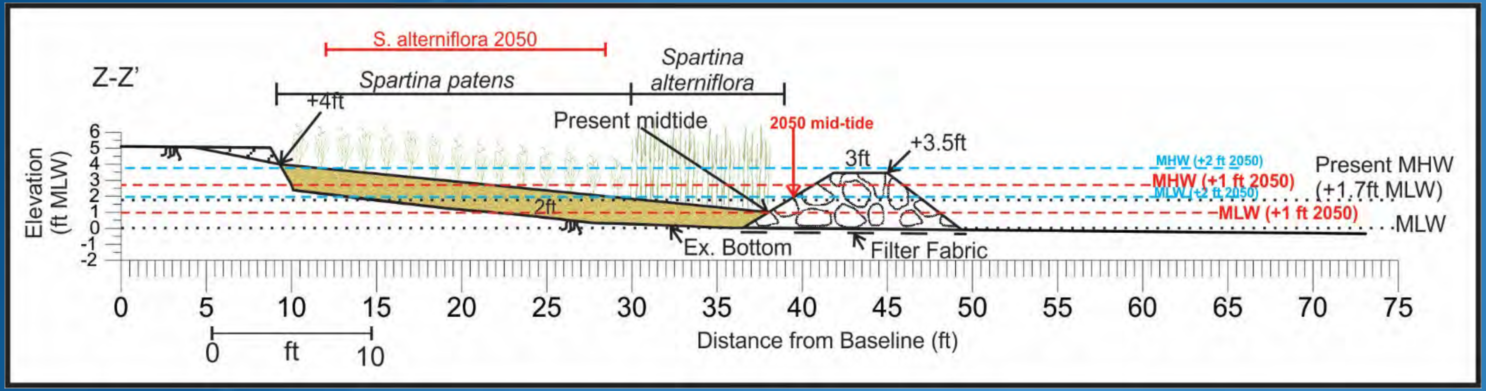
Reach 3

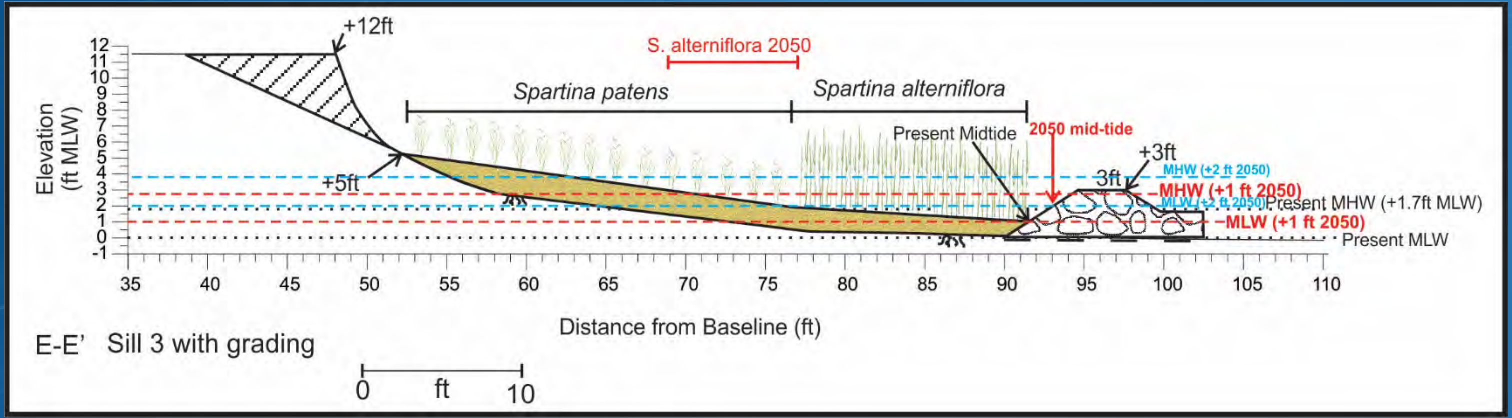
Reach 2

Reach 1



Cross-sectional profiles at Occohannock taken before [illegible] installed and in 2018.





Sea-level rise scenarios modeled at Occohannock. Also shown is the adaptive management strategy coastal resiliency of the living shoreline. Rock and sand could be added to the system to "reset" it thereby protecting the base of the bank.

Summary: Marshes

- *As fetch exposure increases so does the marsh width and elevation needed to attenuate wave action.*

- *At some point (> 0.5 nm fetch) a sill may be needed for long term marsh fringe stabilization.*

- *Marshes can provide long term protection if properly maintained.*

- *A large data base of marsh sites exists around the Bay along with various brochures and reports to support the Living Shoreline concept.*

- *This historical site data allows us to proclaim that shore erosion control can be achieved by creating* ***Living Shorelines (i.e. marsh fringes).***

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THE END

http://web.vims.edu/physical/research/shoreline/

Links to Additional Resources

VIMS: Living Shoreline Design Guidelines
https://www.vims.edu/research/departments/physical/programs/ssp/shoreline_management/living_shorelines/class_info/index.php

VIMS: Why a Living Shoreline?
http://ccrm.vims.edu/livingshorelines/index.html

NOAA: Living Shoreline Implementation Techniques
http://www.habitat.noaa.gov/restoration/techniques/livingshorelines.html

Chesapeake Bay Foundation: Living Shoreline for the Chesapeake Bay Watershed
https://www.cbf.org/about-cbf/locations/virginia/issues/living-shorelines/index.html

Virginia Department of Conservation and Recreation
http://www.dcr.virginia.gov/soil-and-water/seas

VIMS: **Shoreline Management In Chesapeake Bay**, Hardaway and Byrne 1999
https://scholarworks.wm.edu/reports/581/

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