Living Shoreline Design Training

Pre-Workshop Learning

Determining Site-Specific Parameters for Living Shoreline Design

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Updated October 2022

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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Determining Site-Specific Parameters for Living Shoreline Design

The goal of this presentation is to demonstrate the tools that are available for effective living shoreline design in Chesapeake Bay.

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Site Evaluation Process

Each shoreline professional has a method for conducting site evaluations.

This presentation has suggestions and tools for standardized data collection.

Not all parameters have equal weight… professional judgment necessary.

A site evaluation worksheet is provided in Appendix A of the Living Shoreline Design Guidelines
https://scholarworks.wm.edu/reports/833/

An updated form is available online here:
https://www.vims.edu/research/departments/physical/programs/ssp/_docs/site_evaluation2022.pdf

Site Evaluation

Desktop or Map Parameters

Existing information available from maps or Internet resources

Not readily visible or measurable at ground level

Site Visit Parameters

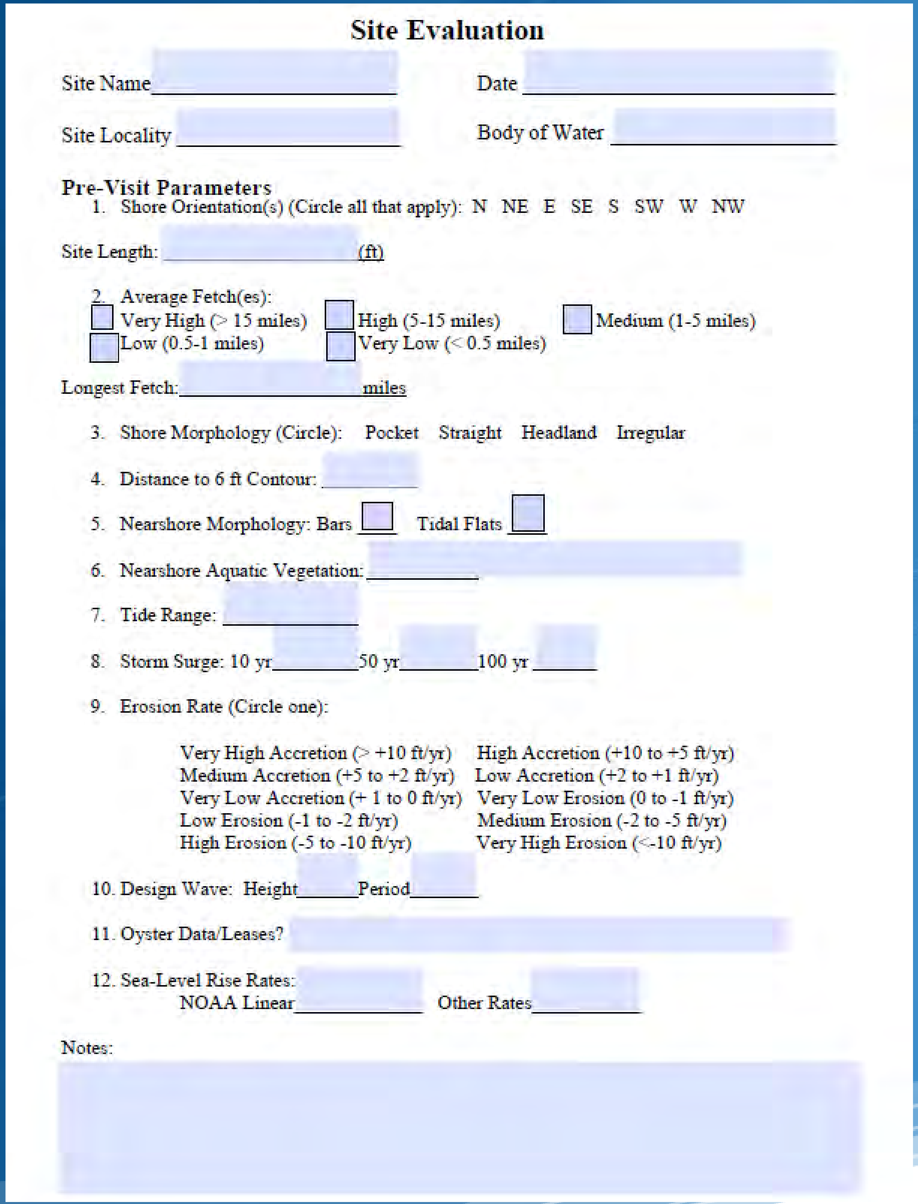
Site-specific characteristics

Local setting

Not easily captured by remote sensing

Site Assessment Fillable PDF

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



Site Evaluation

Site Name ______________ Date ______________

Site Locality ______________ Body of Water ______________

Pre-Visit Parameters

1. Shore Orientation(s) (Circle all that apply): N NE E SE S SW W NW

Site Length: ______________ (ft)

2. Average Fetch(es):
☐ Very High (> 15 miles) ☐ High (5-15 miles) ☐ Medium (1-5 miles)
☐ Low (0.5-1 miles) ☐ Very Low (< 0.5 miles)

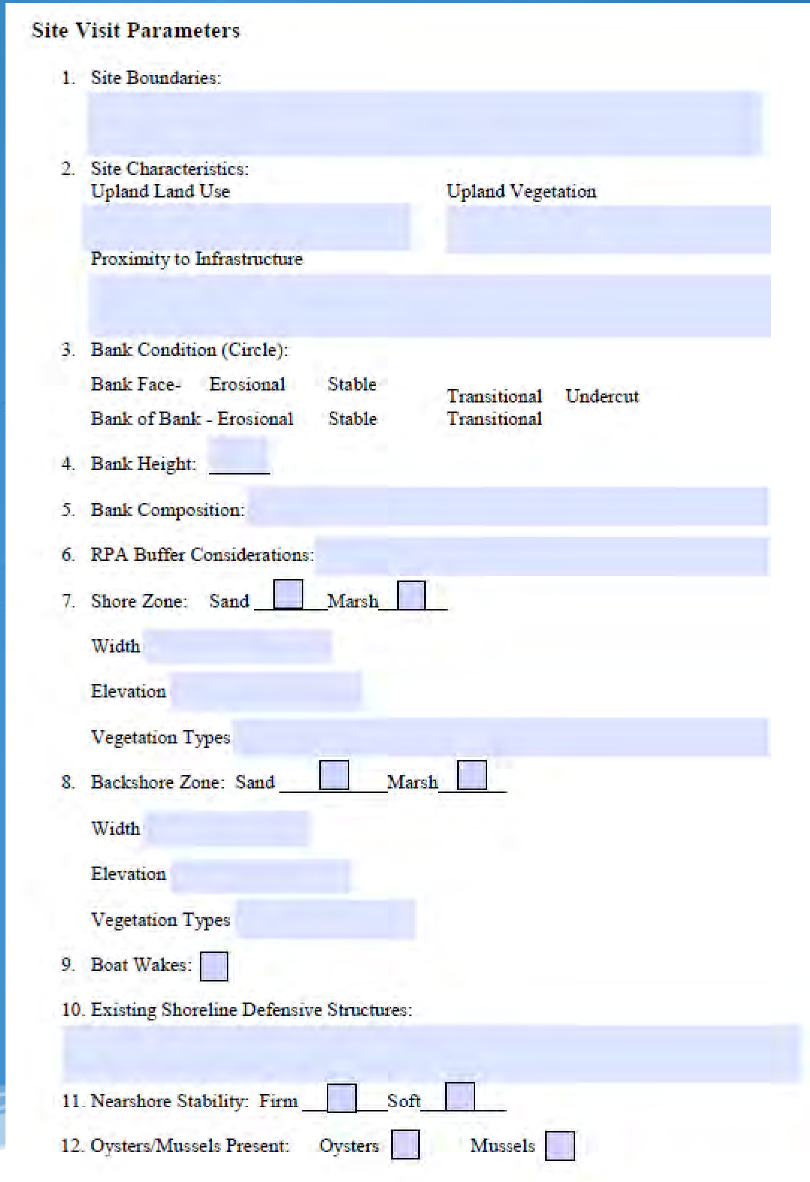
Longest Fetch: ______________ miles

3. Shore Morphology (Circle): Pocket Straight Headland Irregular
4. Distance to 6 ft Contour: ________
5. Nearshore Morphology: Bars ☐ Tidal Flats ☐
6. Nearshore Aquatic Vegetation: ________
7. Tide Range: ________
8. Storm Surge: 10 yr ________ 50 yr ________ 100 yr ________
9. Erosion Rate (Circle one):

Very High Accretion (> +10 ft/yr) High Accretion (+10 to +5 ft/yr)
Medium Accretion (+5 to +2 ft/yr) Low Accretion (+2 to +1 ft/yr)
Very Low Accretion (+ 1 to 0 ft/yr) Very Low Erosion (0 to -1 ft/yr)
Low Erosion (-1 to -2 ft/yr) Medium Erosion (-2 to -5 ft/yr)
High Erosion (-5 to -10 ft/yr) Very High Erosion (<-10 ft/yr)

10. Design Wave: Height ________ Period ________
11. Oyster Data/Leases? ________
12. Sea-Level Rise Rates:
NOAA Linear ________ Other Rates ________

Notes:



Site Visit Parameters

1. Site Boundaries:
2. Site Characteristics:
Upland Land Use Upland Vegetation
Proximity to Infrastructure
3. Bank Condition (Circle):
Bank Face- Erosional Stable Transitional Undercut
Bank of Bank - Erosional Stable Transitional
4. Bank Height: ________
5. Bank Composition:
6. RPA Buffer Considerations:
7. Shore Zone: Sand ☐ Marsh ☐
Width
Elevation
Vegetation Types
8. Backshore Zone: Sand ☐ Marsh ☐
Width
Elevation
Vegetation Types
9. Boat Wakes: ☐
10. Existing Shoreline Defensive Structures:
11. Nearshore Stability: Firm ☐ Soft ☐
12. Oysters/Mussels Present: Oysters ☐ Mussels ☐

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Google Earth

https://www.google.com/earth/

Search for your site by street address

Google Earth can be used to determine many of the desktop site parameters.

Several versions are available for free: https://www.google.com/earth/versions/

Google Earth Pro: Available for free download to your desktop and provides the most functionality. Create maps with advanced tools.

Google Earth: Available from anywhere on the web

Google Earth Mobile: Allows you to view maps and Google Earth files (*.kmz or *.kml) on your mobile device. Not particularly intuitive, but it can be handy.

Desktop or Map Parameters

Shoreline orientation – Google Earth

Fetch - Google Earth measuring tool

Shore Morphology - Google Earth

Depth Offshore – NOAA nautical charts

Nearshore Morphology - use Google Earth

Submerged Aquatic Vegetation – VIMS SAV online viewer

Tide Range – Use Shoreline Studies Program's Google Earth file or NOAA Vdatum online tool

Storm Surge – FEMA Flood Insurance Studies

Erosion Rate - Use Shoreline Studies Program's online viewer or Google Earth's time slider

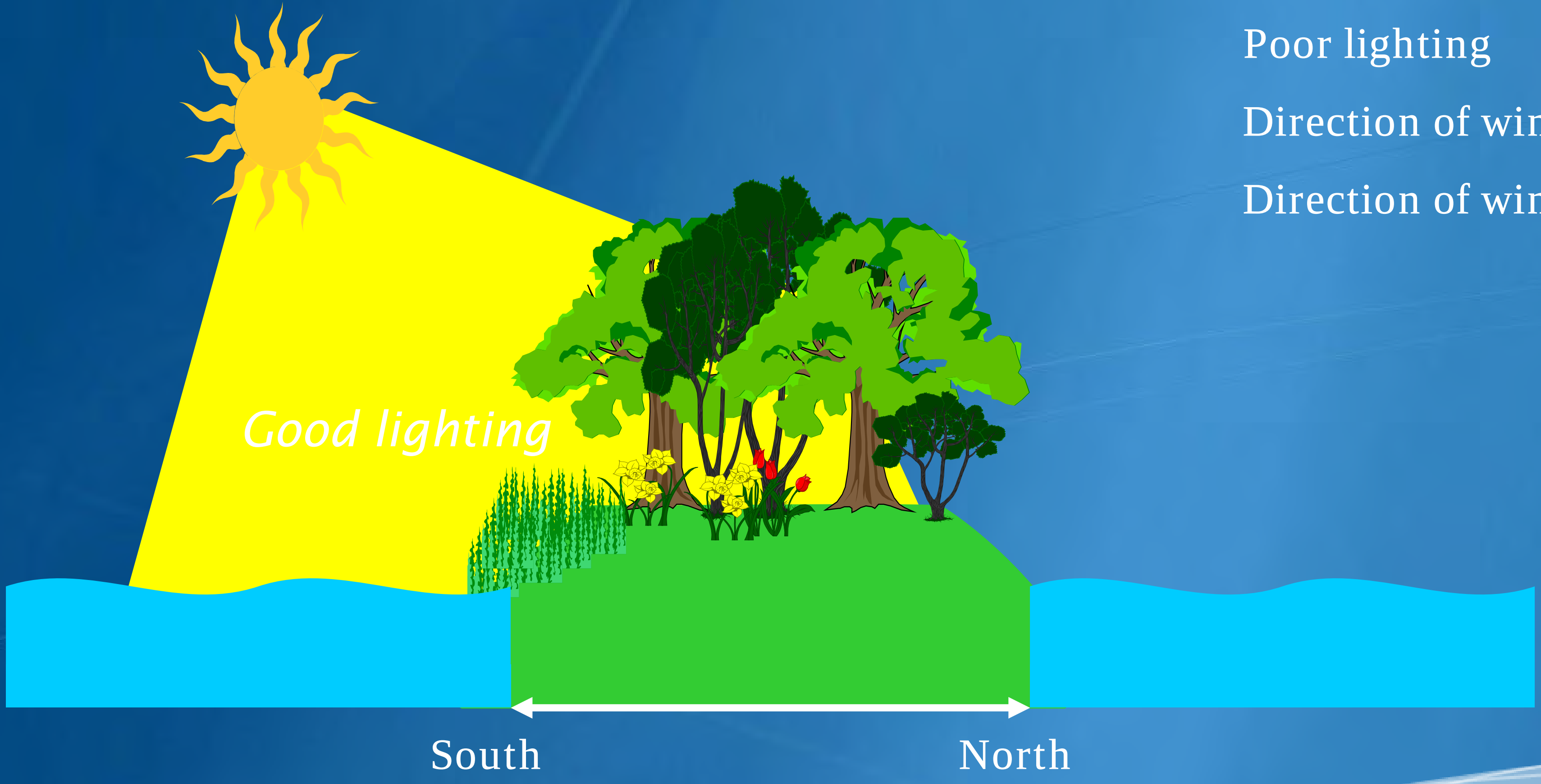
Design Wave – VDOT shore protection graph

Sea-Level Rise – Various tools including NOAA and USACE curve generator

Shoreline Orientation

The direction that is perpendicular to the shoreline.

Why it is important at some sites:



Poor lighting

Direction of winds under normal conditions

Direction of winds during storms

Rule of thumb, not always a determining factor

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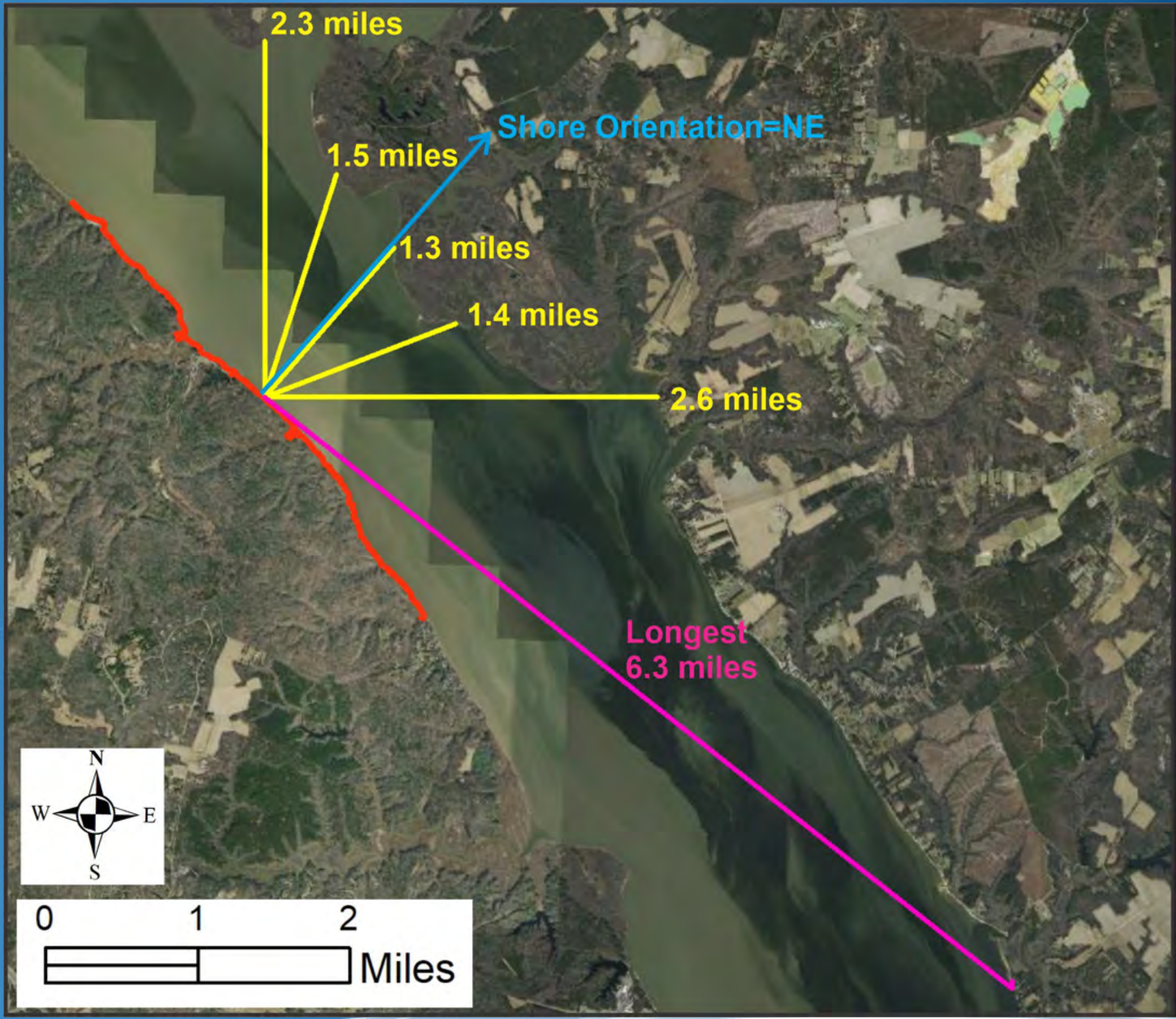
Fetch

- Length of water over which a given wind can blow without obstruction.
- It is a proxy measure for wind/wave energy impacting the shoreline.
- The larger the fetch, the more energy potentially impacting the shoreline.

<u>Longest Fetch</u>
Purple line

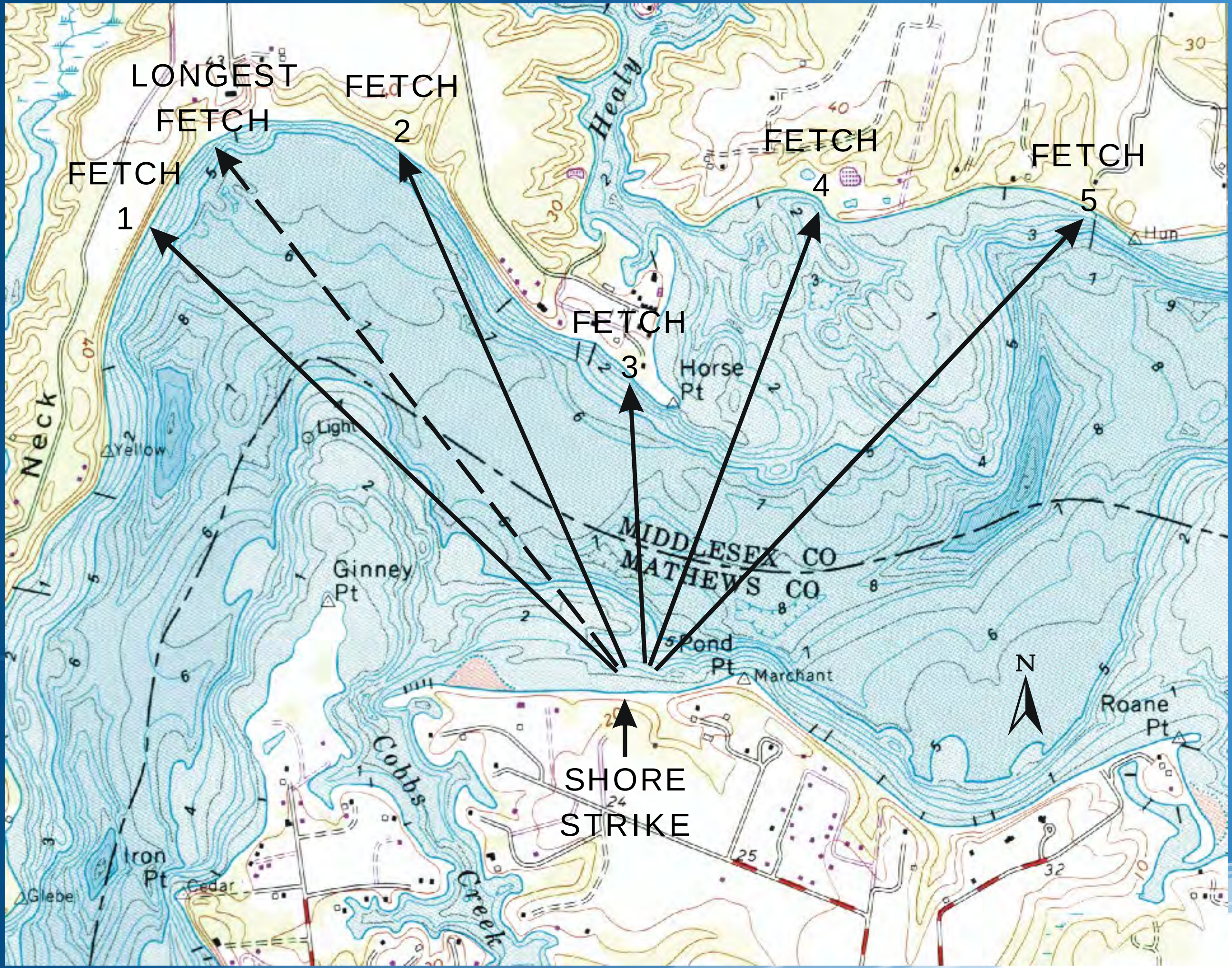
<u>Average Fetch </u> measure 5 yellow arrow vectors (45 deg. Apart on either side of the shore orientation) and take an average



Notes: If a site faces more than 1 direction, you made need more than 1 fetch calculation.

Fetch Calculation

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 (Hardaway & Byrne, 1999). Shore orientation in this case is about due north.



Average Fetch Length Categories

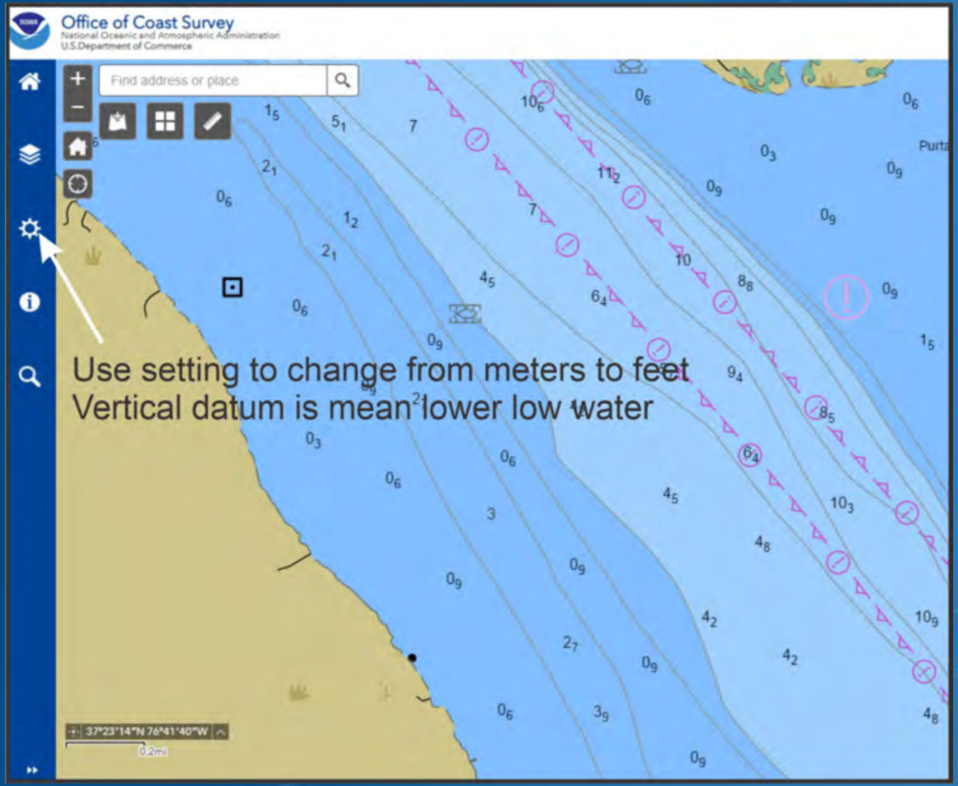
Very low <0.5 mile
Low 0.5-1 mile
Medium 1-5 miles
High 5-15 miles
Very high >15 miles

Hardaway & Byrne, 1999
https://scholarworks.wm.edu/reports/581/

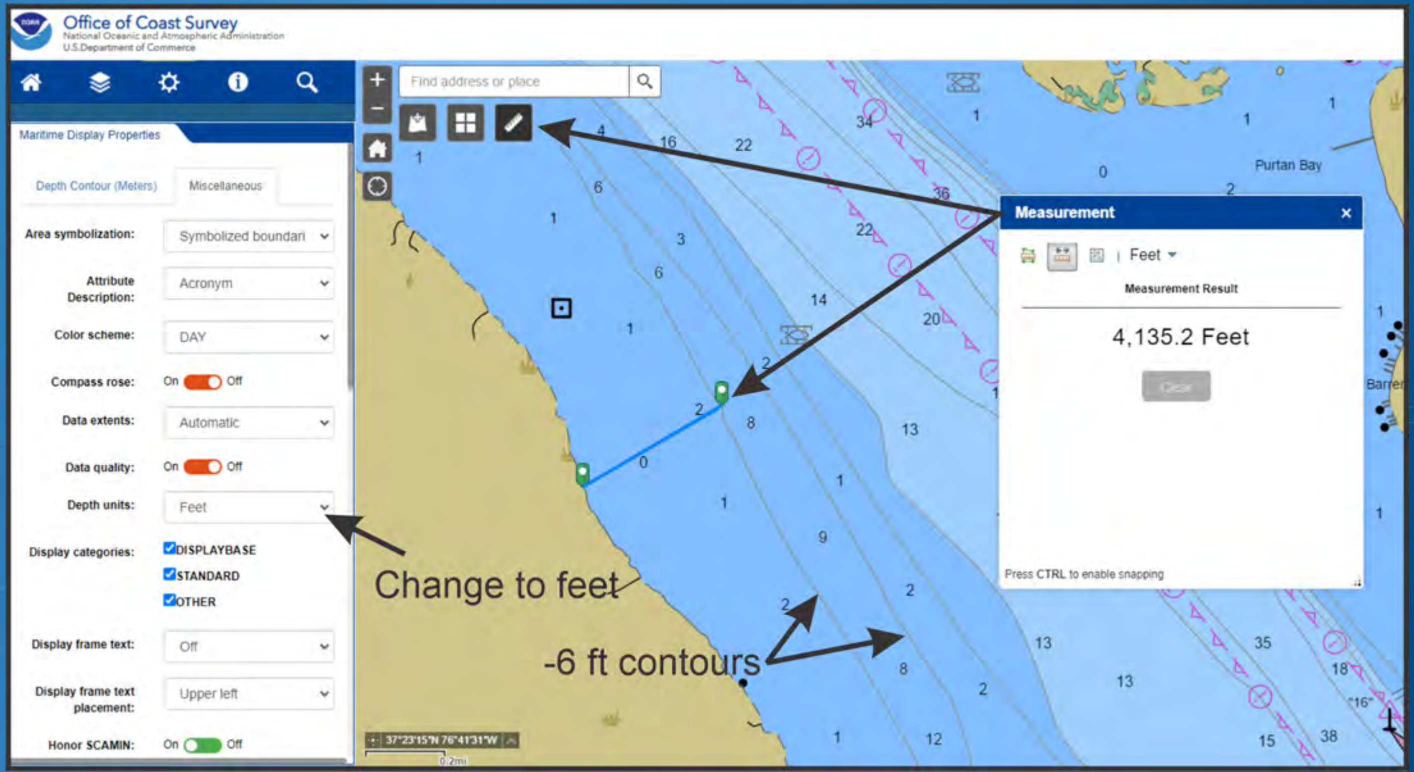
Shore Morphology

- Pocket or embayed shorelines tend to cause waves to diverge and spread wave energy out.
- Straight and headland shorelines receive the full impact of the wave climate.
- Irregular shorelines tend to break up wave crests.

Depth Offshore
Distance to 6 ft or 2m contour



A broad shallow nearshore has different wave attenuation than narrow deep water with same fetch



NOAA Nautical Charts Online Viewer
https://www.nauticalcharts.noaa.gov/enconline/enconline.html

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Nearshore Morphology

VIMS, SSP Photography

Presence or absence of nearshore tidal flats and sand bars indicate sand supply, bottom conditions

Important consideration for sills and breakwaters
Hard supportive substrate vs. soft, fine-grained sediment

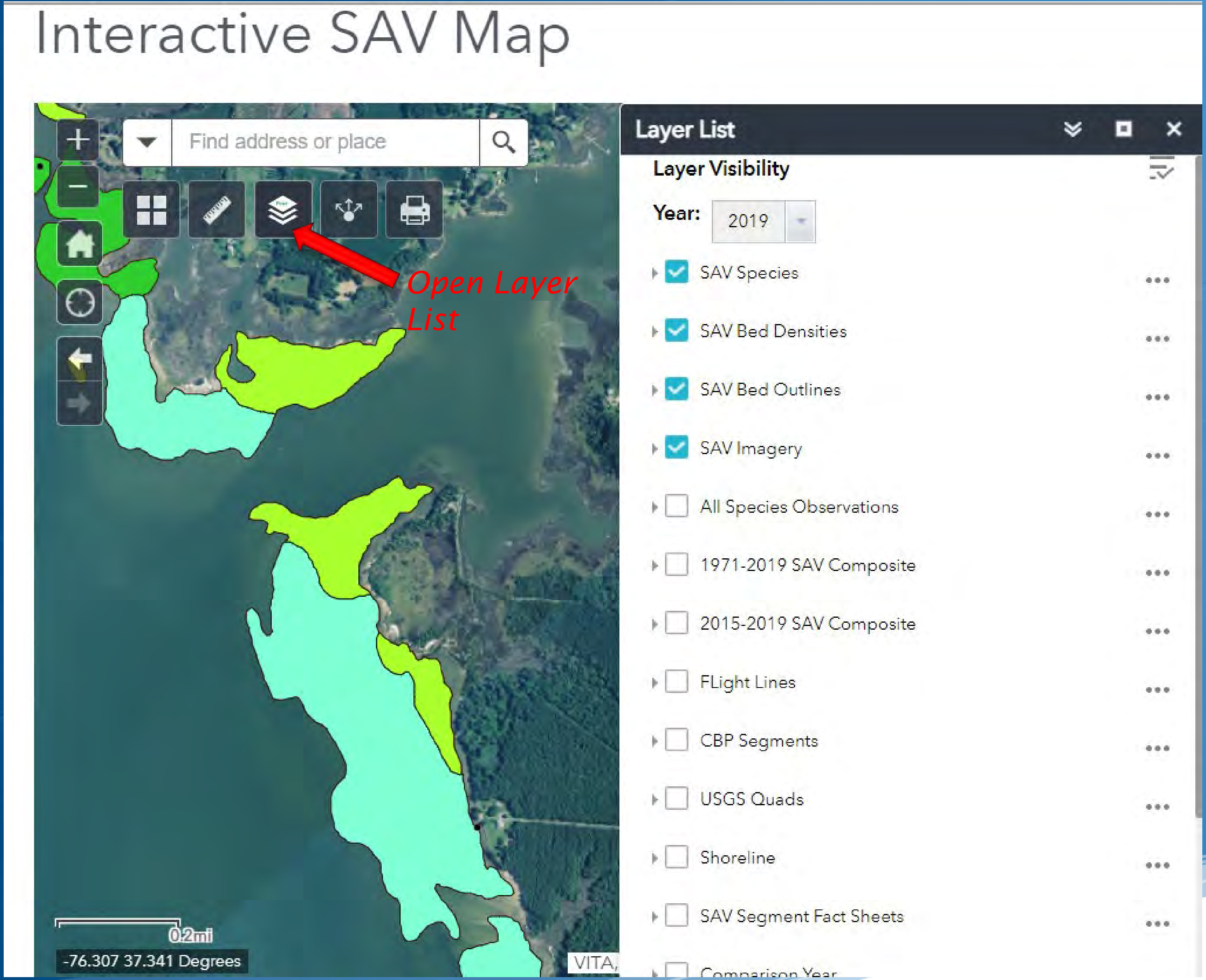
The nearshore morphology often can be determined in Google Earth or during a site visit.

Submerged Aquatic Vegetation

Shallow sand flat with Submerged Aquatic Vegetation (SAV)

Google Earth Imagery

Submerged Aquatic Vegetation



VIMS SAV online viewer displays species and densities by year

Click on Layer List to change viewer options

Click on Full Page Map to expand view

https://www.vims.edu/research/units/programs/sav/access/maps/index.php

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NOAA Tides and Currents

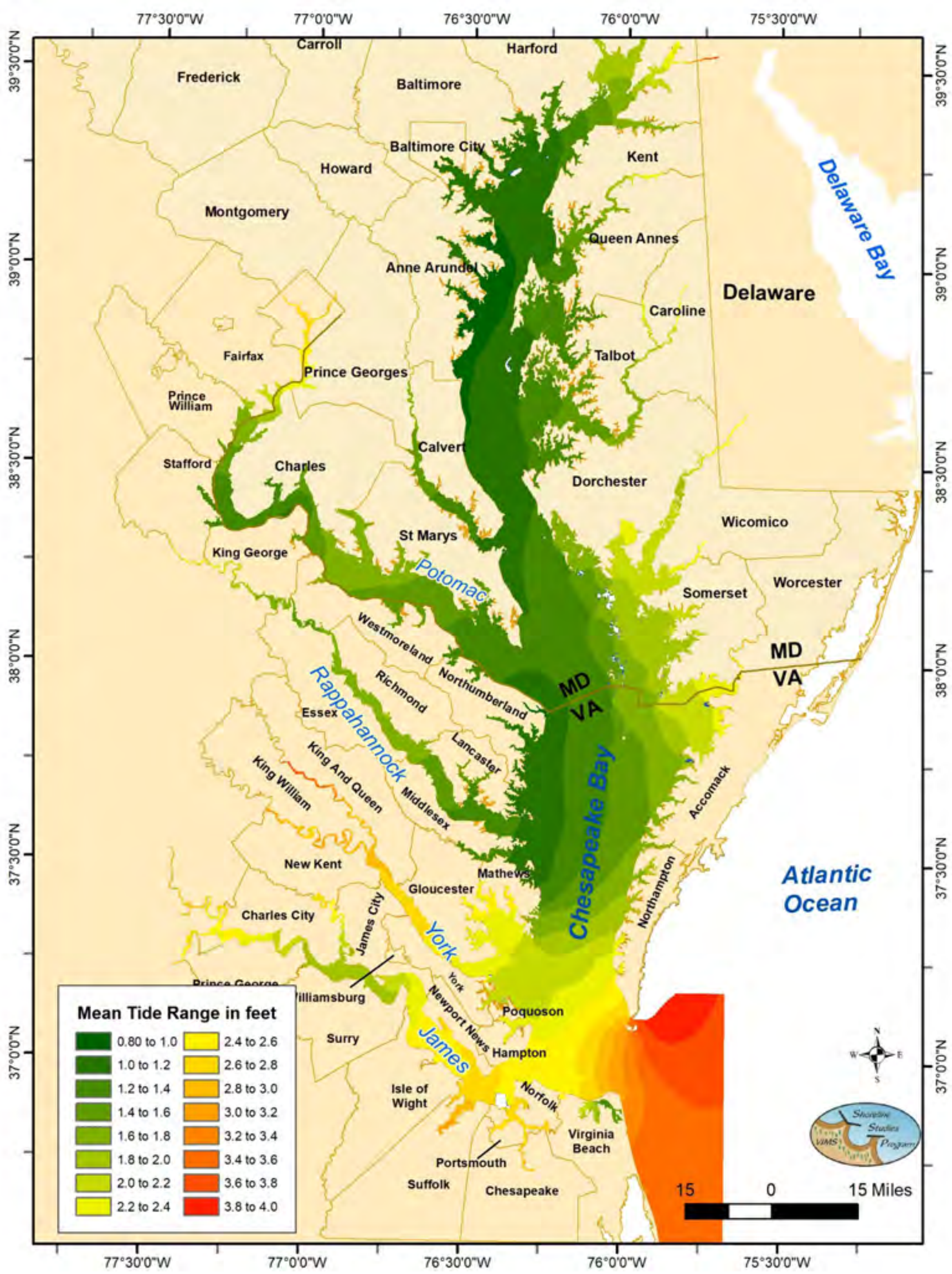
NOAA provides access to a great deal of marine data necessary for shore protection design.

Knowing the mean tide range and spring tide range are critical information for planted marshes.

Knowing the tide level at the time of the site visit (whether tide is running higher or lower than normal for example) is important to understanding the site.

Click on map for your state
Click on closest tide gauge
Click on the "More Data" down arrow to access verified water levels, tide predictions, datums, meteorological data, sea-level trends, and other information.

https://tidesandcurrents.noaa.gov/



Tide Range

Google Earth files are available to determine mean and spring (great diurnal) tide ranges in feet (link below). The files can be downloaded from the SSP website and opened in Google Earth Pro.

Once open in GE, click on a polygon near your site to get the tide range data.

The maps also are printed in the Living Shoreline Design Guidelines

Polygons interpolated from NOAA data points

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

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Storm Surge

Use FEMA Flood Insurance Studies web site
Predicted water level during certain storms
Return frequencies – probability a water level will occur in any given year

- 100-yr storm = 1% chance
- 50-yr storm = 2% chance
- 10-yr storm = 10% chance

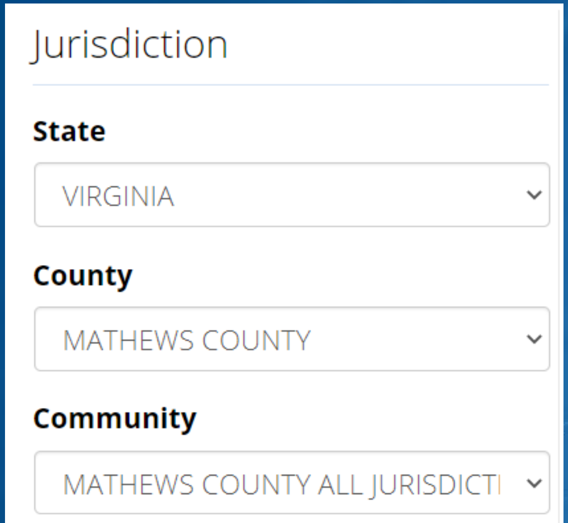
Using the advanced search option on the FEMA Flood Map Service Center, select the state, county and all jurisdictions – see next page

https://msc.fema.gov/portal/advanceSearch

Storm Surge

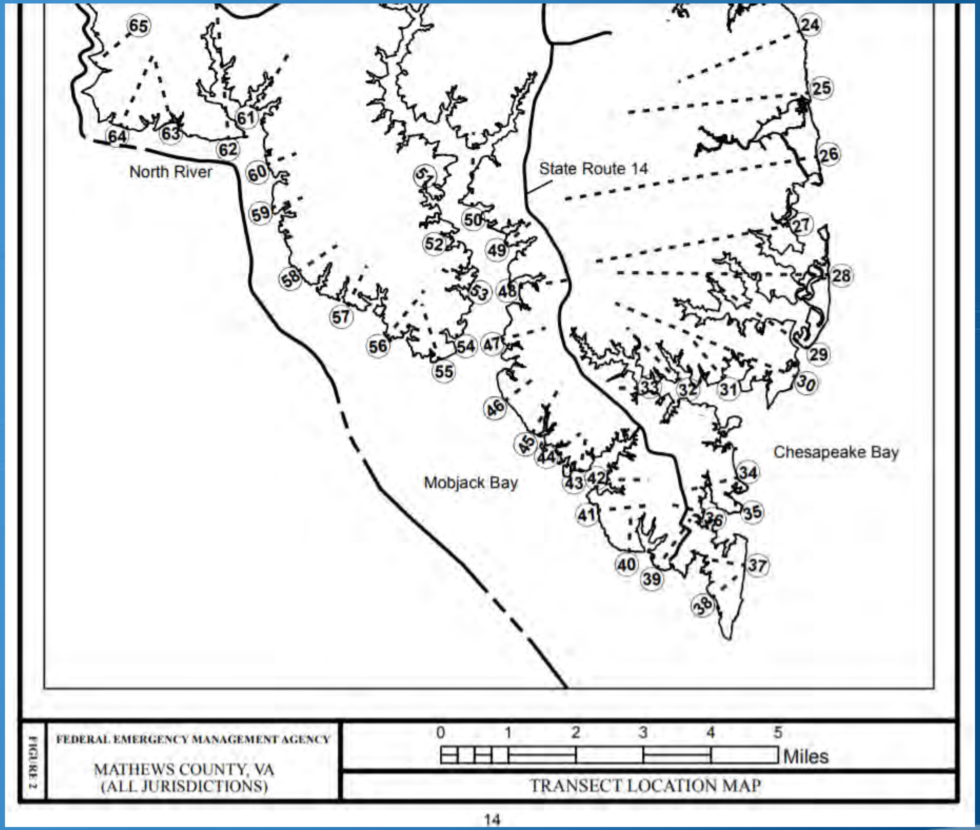
https://msc.fema.gov/portal/advanceSearch

1. Using the advanced search option on the FEMA Flood Map Service Center, select the state, county and all jurisdictions



2. In the search results, select "Effective Products", then "FIS Reports". Download the document.

3. Find the transect location map and determine the closest transect to your site.



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Storm Surge

https://msc.fema.gov/portal/advanceSearch

4. The transect data table lists the wave height and period for the predicted 100 year storm (1%) and the stillwater elevations for the 10-yr (10%), 50-yr (2%), 100-yr (1%), and 500-yr (0.2%) storms.

TABLE 2 - TRANSECT DATA - continued

Flood Source	Transect	Starting Wave Conditions for the 1% Annual Chance			Starting Stillwater Elevations (ft NAVD88)			
		Coordinates	Significant Wave Height H_s (ft)	Peak Wave Period T_p (sec)	10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
CHESAPEAKE BAY	29	N 37.37035 W -76.25371	8.3	7.4	3.8	4.8	5.1	6
CHESAPEAKE BAY	30	N 37.36430 W -76.25730	8.4	7.4	3.8	4.7	5.1	6
CHESAPEAKE BAY	31	N 37.36413 W -76.27675	3	2.6	4	5	5.4	6.5

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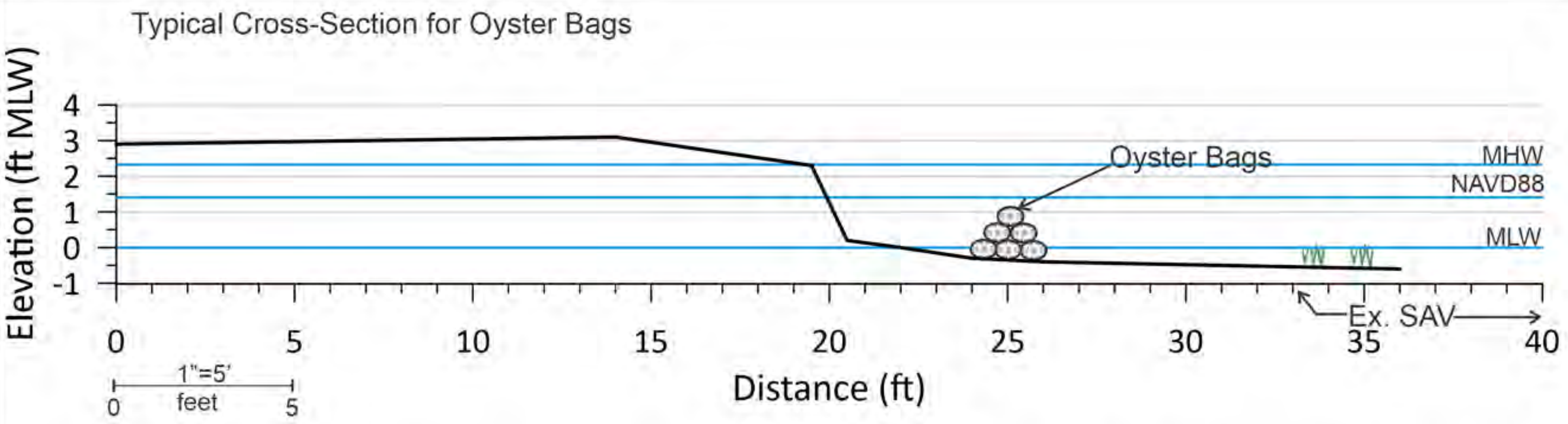
NAVD88 Conversion

The elevation data is relative to the North American Vertical Datum (NAVD88). In Virginia, NAVD88 generally is around a mid-tide level.

To convert the NAVD88 elevations to a local tide level (mean low water), SSP has developed a Google Earth Pro tool. It is available for download on the SSP website. Add the conversion factor from the tool to the NAVD88 value to get the Stillwater elevation relative to MLW.

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



If you collect your survey data in NAVD88, at this site at the mouth of the York River, the conversion between NAVD88 and MLW from our Google Earth app is in the 1.4-1.6 ft range. Because our location is nearer to the 1.2-1.4 range, we used 1.4 ft as our conversion. That means that NAVD88 is 1.4 ft above MLW at this site. To convert survey data to MLW, add 1.4 ft to all of your survey elevations.

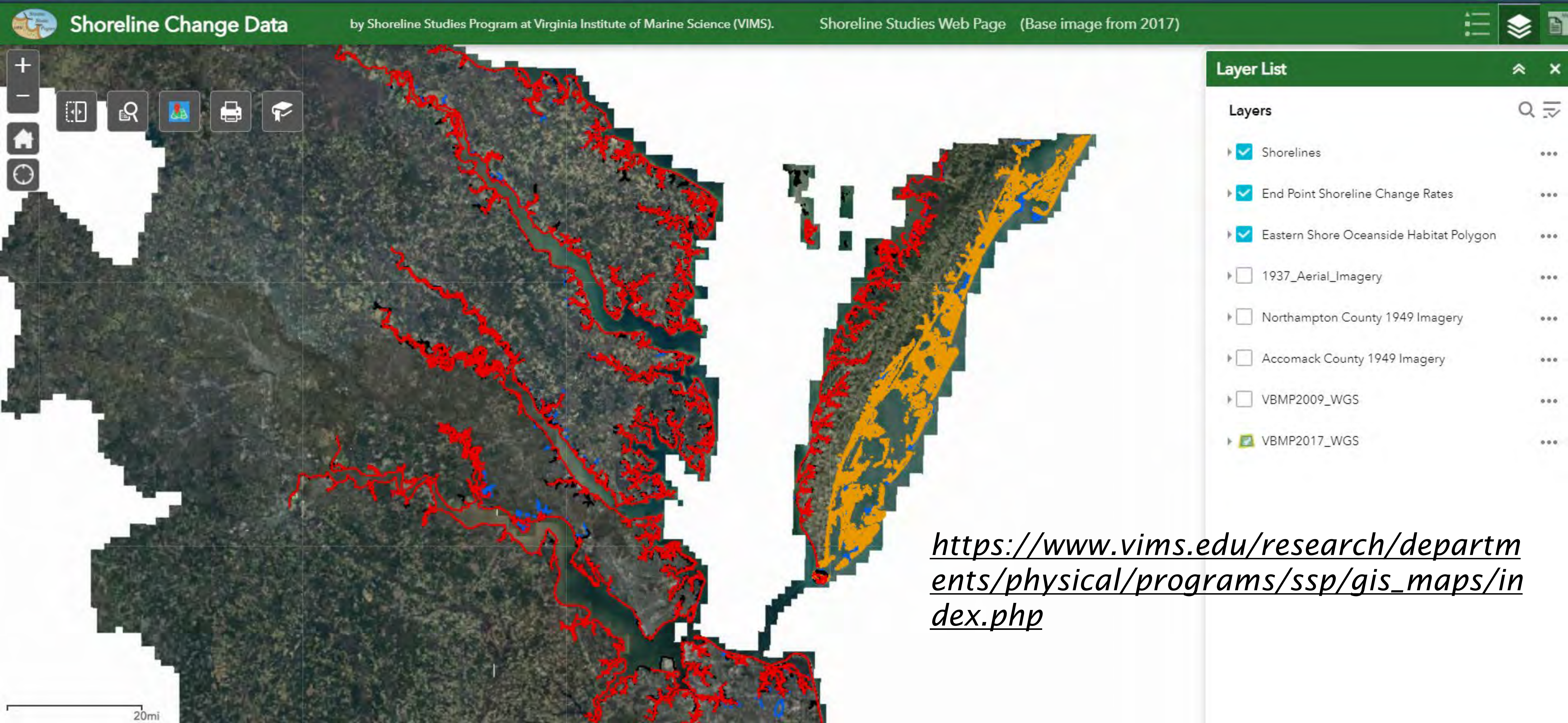
Example: a point that is 2 ft above NAVD88 (+2 ft NAVD88) will be at +3.4 ft MLW.
a point that is 2 ft below NAVD88 (-2 ft NAVD88) will be at -0.6 ft MLW

Conversion elevations differ by location so it is important to check the conversion app for each site.

NOAA also has an online datum conversion tool available.

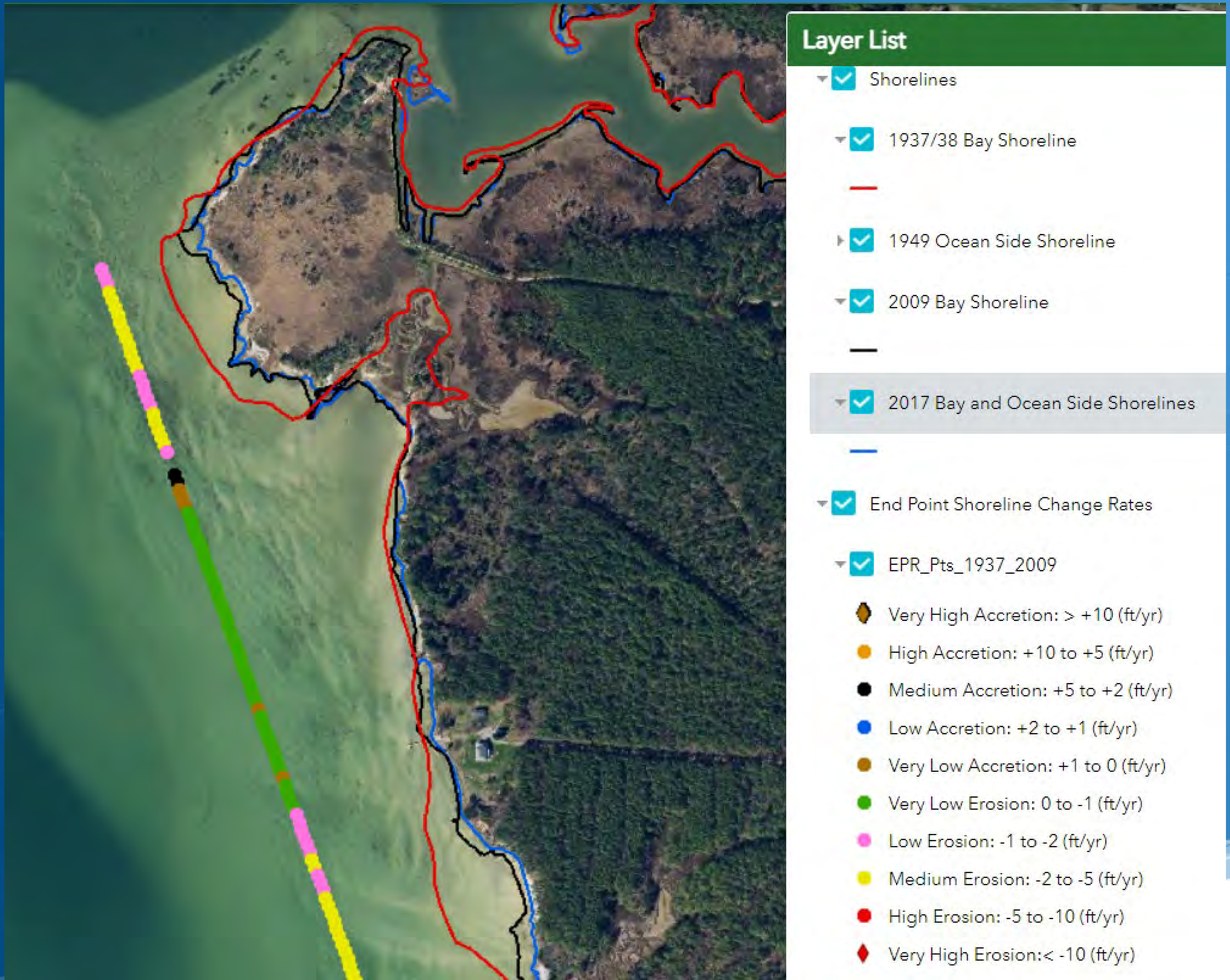
https://vdatum.noaa.gov/vdatumweb/

Shoreline Change Rates
Shoreline Studies Program Online Viewer



https://www.vims.edu/research/departments/physical/programs/ssp/gis_maps/index.php

Shoreline Change Rates
Shoreline Studies Program Online Viewer



The rate of change has been calculated between 1937 and 2009 for most of the Virginia portion of Chesapeake Bay. It is represented by dots offshore of the shoreline.

Using the layer list, the shorelines, 1937/38 images, and rates of change can be turned on and off by checking/unchecking boxes.

Sites can be found by searching by address

If the 1937/38 image is turned on, the swipe tool can be used to view change

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Maryland Shoreline Change

Maryland Historic Shorelines Online
https://maryland.maps.arcgis.com/home/webmap/viewer.html?useExisting=1&layers=b7dec3418668473c82002ee28e280eae

Maryland Shoreline Change Transects
https://maryland.maps.arcgis.com/home/webmap/viewer.html?useExisting=1&layers=b8f6e338ff064611b3137265feee12ba

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Design Wave

Significant wave heights are the average of the highest 33% of the wind/wave field

Wave heights for the highest 10% should be noted to determine rock size.

Predicted waves may be more or less than actual storm wave

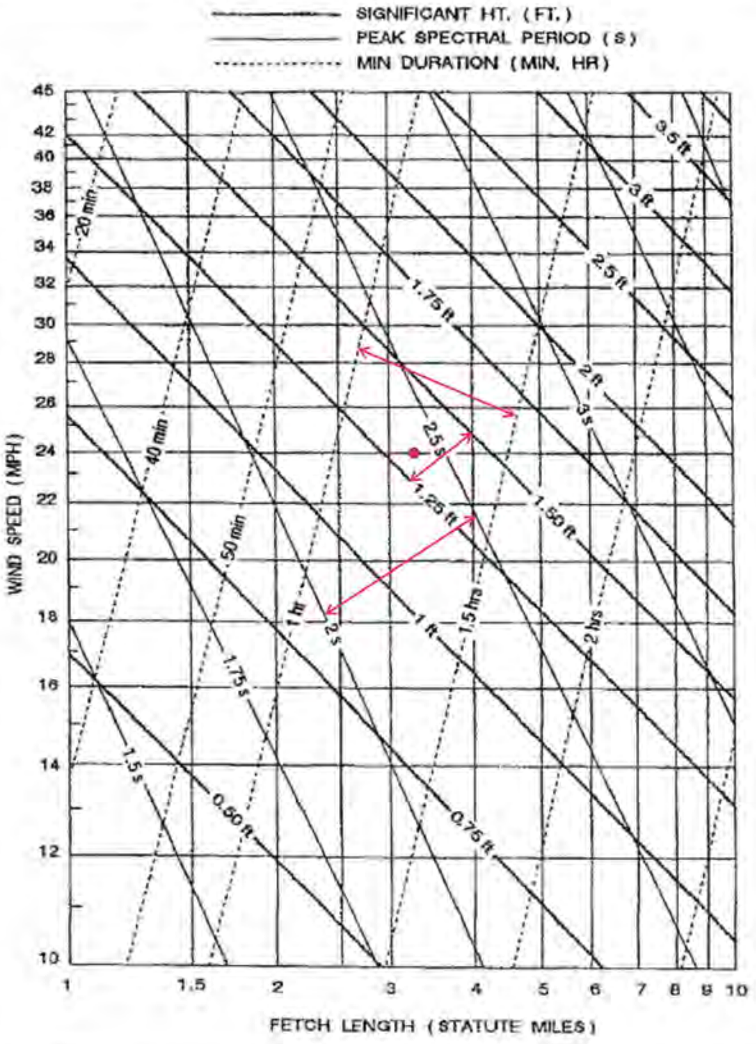
Many sophisticated wave prediction models can be used

Simple method uses forecasting curves

The FEMA 100-yr storm predicted wave may not be practical for shore protection design. Projects designed to this elevation may be too costly.

Simple Wave Estimation

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



Source: HEC-11

Interpolate on the graph to estimate wave height, period, and minimum duration based on wind speed and fetch length.

Other options are available to determine a design wave, but the VDOT method for determining wave height for shore protection is readily available and easy.

Wind Speed
24 mph
Fetch
3.3 miles

Resulting Wave
1.3 ft
2.4 sec
1.2 hr min duration

http://www.virginiadot.org/business/locdes/hydra-drainage-manual.asp
Chapter 13: Shore Protection, Pg 30

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Sea Level Rise (SLR)

The projected rise in mean sea level is a concern for management of the coastal zone in the longer term. The potential impacts of sea level rise over time include:

- Higher projected storm surge and inundation levels.
- Landward recession or erosion of shorelines. Depending on the rate and scale of sea level rise, the environmental, social and economic consequences or shoreline recession within low lying inter-tidal areas, in particular, may be significant in the medium to long term.
- Salt water intrusion and landward advance of tidal limits within estuaries. This may have significant implications in the medium to long term for freshwater and salt water ecosystems and development margins, particularly building structures and foundation systems within close proximity to the shoreline.

When sea levels rise, even a small increase can have devastating effects on coastal habitats farther inland, it can cause destructive erosion, wetland flooding, aquifer and agricultural soil contamination with salt, and lost habitat for fish, birds, and plants.

Sea-Level Rise

Linear rates of change are available on the NOAA Tides and Current Site (https://tidesandcurrents.noaa.gov/). Click on state, then a red or red and yellow gauge closest to your site. Click on more data, then sea level trends. This provides the rate of sea-level rise using historic water level data.

VIMS provides low, medium, and high quadratic rates of change at some of the NOAA sites that include acceleration of the rate over time rather than just a linear rate (https://www.vims.edu/bayinfo/bay_slrc/index.php).

Local scenarios can be found for the NOAA gauges on the NOAA online viewer (https://coast.noaa.gov/slr/) and the impact of chosen water levels at your site.

See the next 2 pages.

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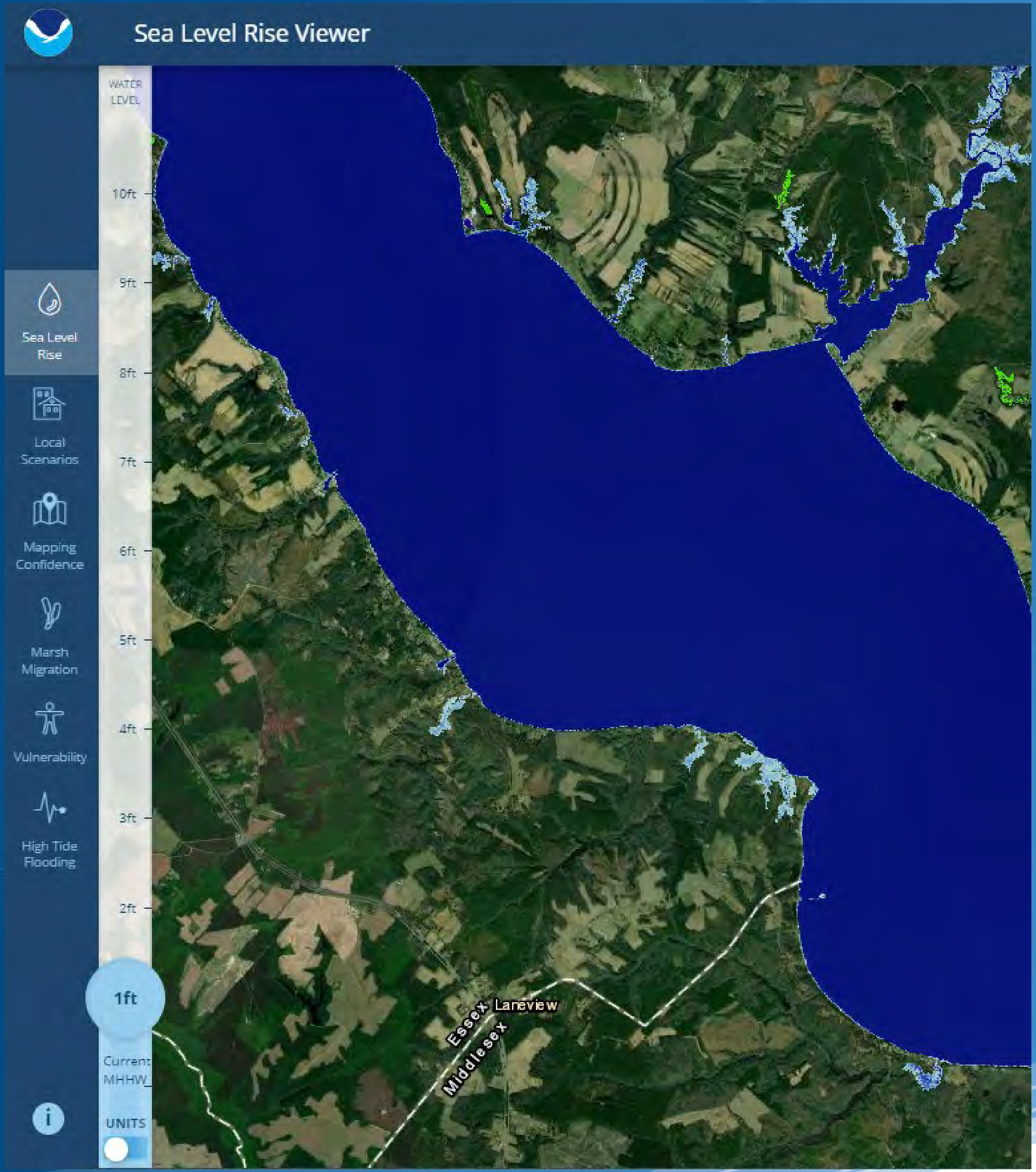
Sea Level Rise



Use the NOAA sea-level rise online viewer to determine SLR near your site.

Change the vertical slider to see the affect of sea level rise on the site.

Use the local scenarios to see what the proposed sea-level rise scenarios are.

https://coast.noaa.gov/slr/

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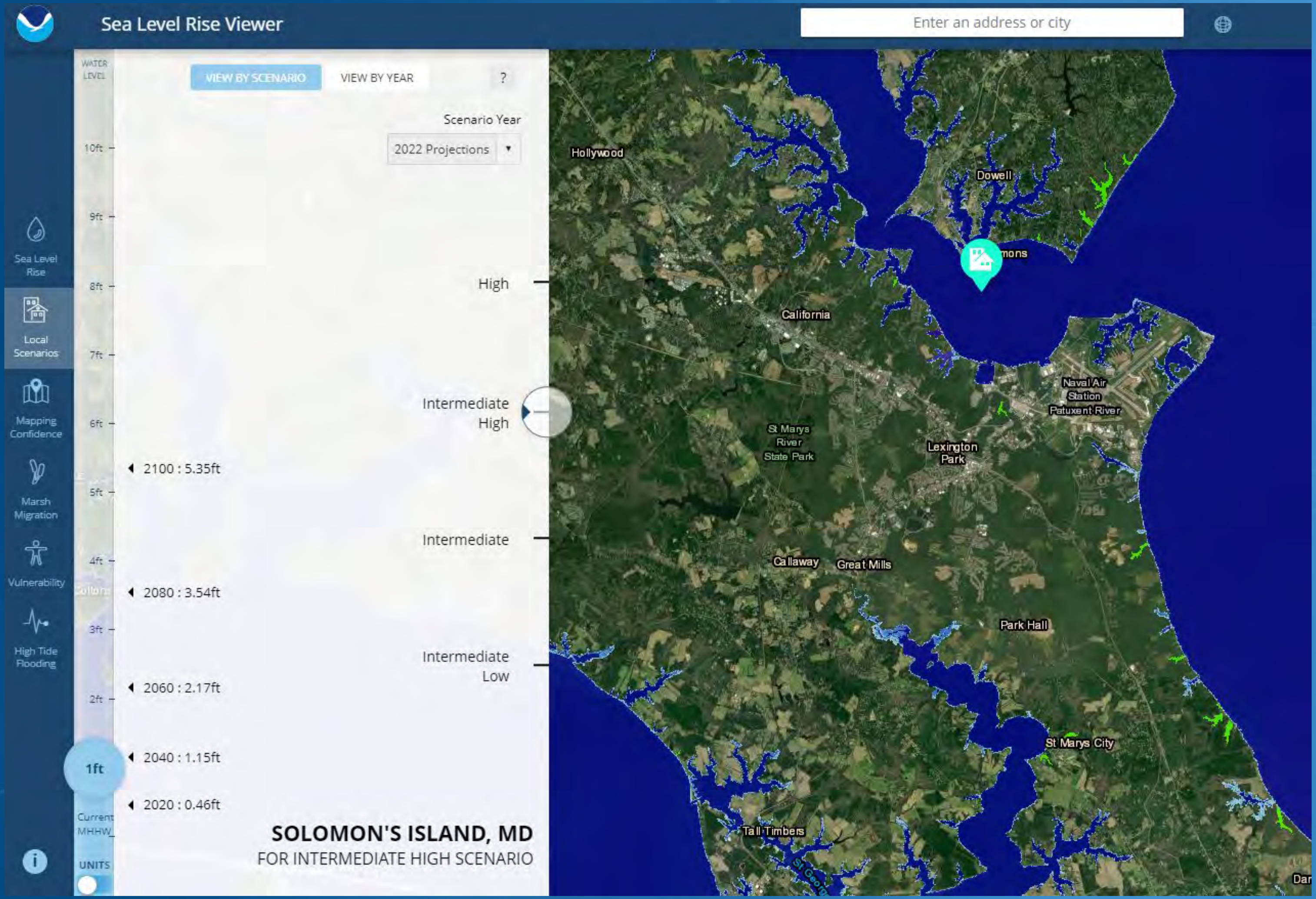
Sea Level Rise



https://coast.noaa.gov/slr/

Only 10 active NOAA tide gauges occur in Chesapeake Bay

They are typically located near the mouth of the rivers flowing into the Bay.

Pick the one closest to your site.

Intermediate and high scenarios for changes in sea level can be shown.

Uncertainty exists about how fast SL will rise in the future.

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Oysters

Virginia Only data:
Private and public oyster grounds and other habitat information.
https://webapps.mrc.virginia.gov/public/maps/chesapeakebay_map.php

Virginia Oyster Stock Assessment and Replenishment Archive
Oyster reef information
https://cmap22.vims.edu/VOSARA/

Oyster Restoration
https://www.chesapeakeprogress.com/abundant-life/oysters

Site Visit Parameters

Additional data on these parameters are discussed in the Living Shoreline Design Guidelines
https://scholarworks.wm.edu/reports/833/

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Site Visit Parameters

Site boundaries
Site characteristics
RPA Buffer

Bank condition
Bank height
Bank composition

Shore zone
- width and elevation

Backshore zone
- width and elevation

Existing shoreline defense structures
Boat wake potential
Nearshore Stability
Vegetation types present
Shellfish types present

VIMS, SSP Photography

Site Boundaries

Legal property limits

In addition to talking to the homeowner and looking for boundary markers, many localities have their parcel data available online which shows the actual extent of the property.

Determines where end effects and downdrift impacts should be considered

Construction access options should be considered.

Site Characteristics

Current and future upland land use

Locate visible and invisible improvements

- Primary and accessory structures
- Underground utilities
- Drainfields
- Groundwater wells

Presence or absence of improvements determines level of protection needed

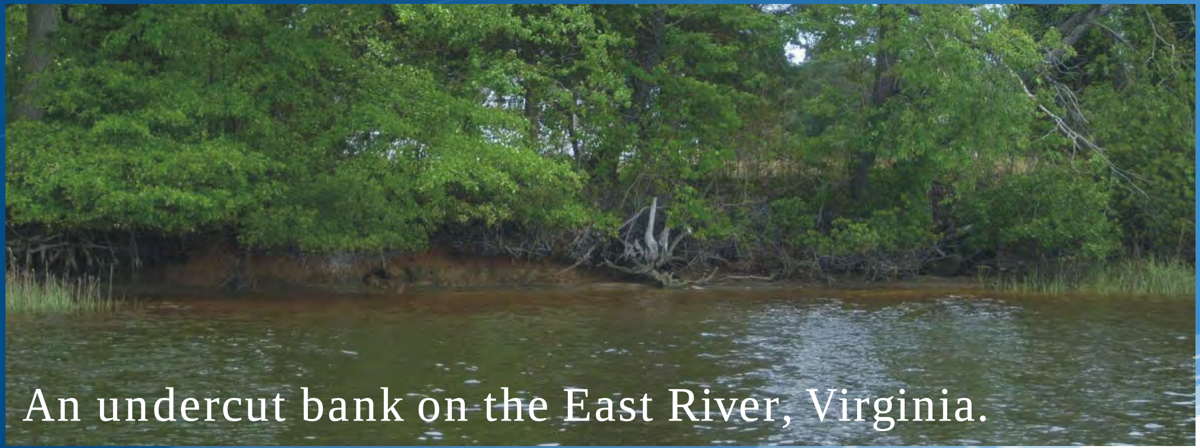
Bank Condition

VIMS, SSP Photography

A stable base of bank and bank face that has been graded and planted with vegetation. James River, Virginia

VIMS, SSP Photography

An unstable base of bank and bank face. The different colored layers indicates different types of material. Piankatank River, Virginia



An undercut bank on the East River, Virginia.

VIMS, SSP Photography

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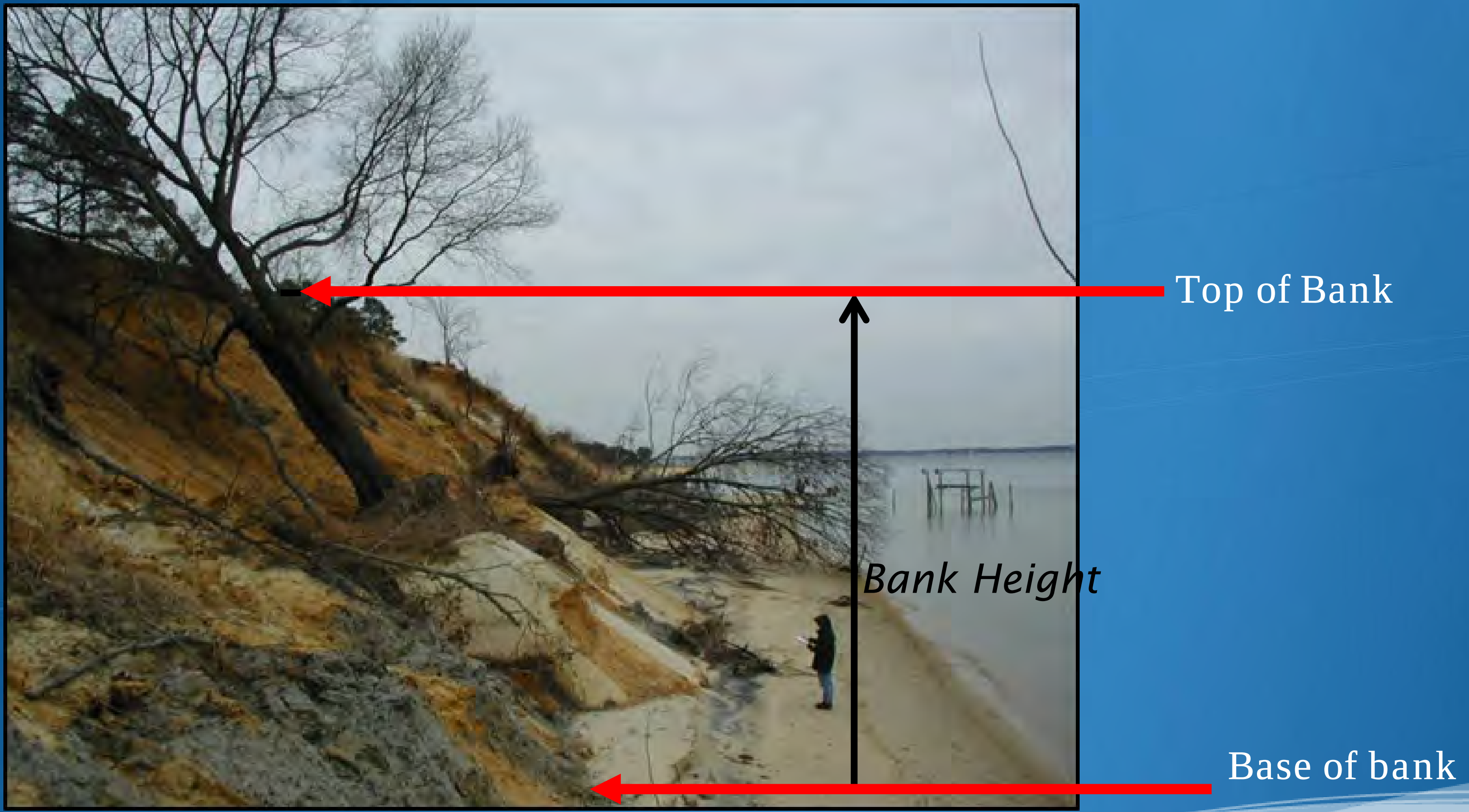
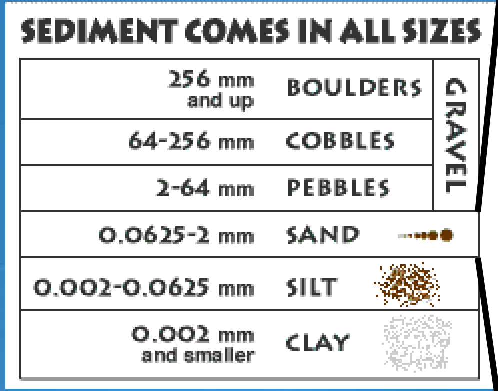
Bank Height & Composition



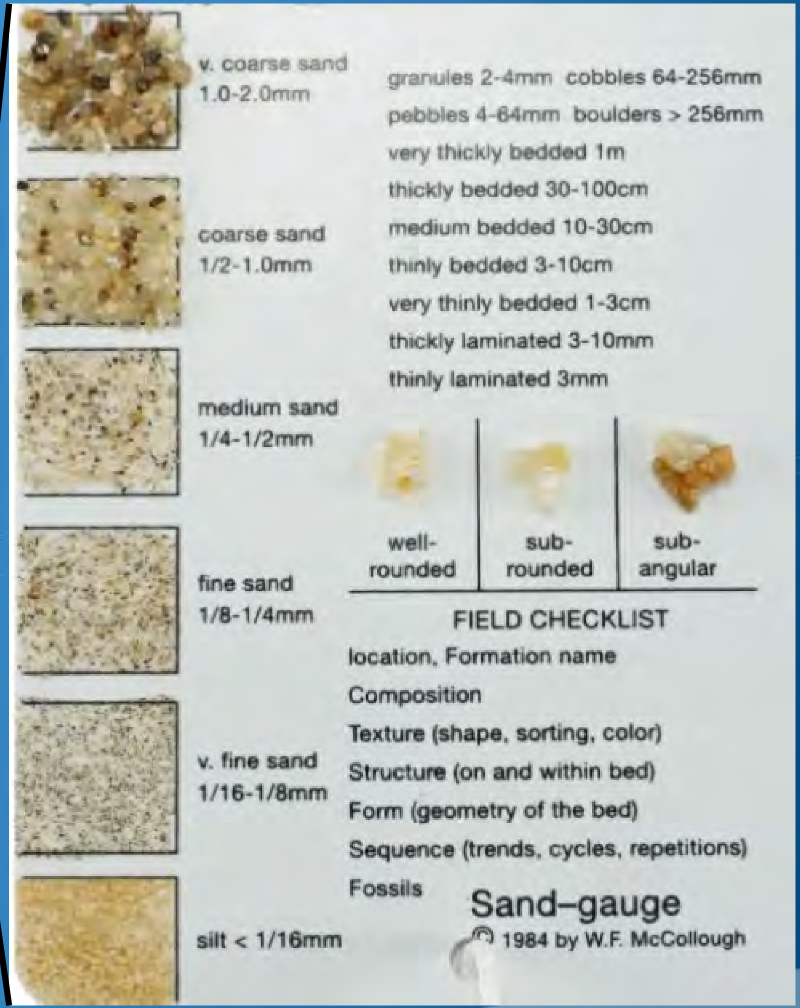
Bank Height & Composition

Bank height can be determined from an onsite survey, a topographic map, or from on online viewer.
https://en-us.topographic-map.com/map-pz85gt/Chesapeake-Bay/



SEDIMENT COMES IN ALL SIZES

256 mm and up	BOULDERS	GRAVEL
64-256 mm	COBBLES	GRAVEL
2-64 mm	PEBBLES	GRAVEL
0.0625-2 mm	SAND	
0.002-0.0625 mm	SILT	
0.002 mm and smaller	CLAY	



Silt:
very small grains can be felt
Clay:
individual grains cannot be felt

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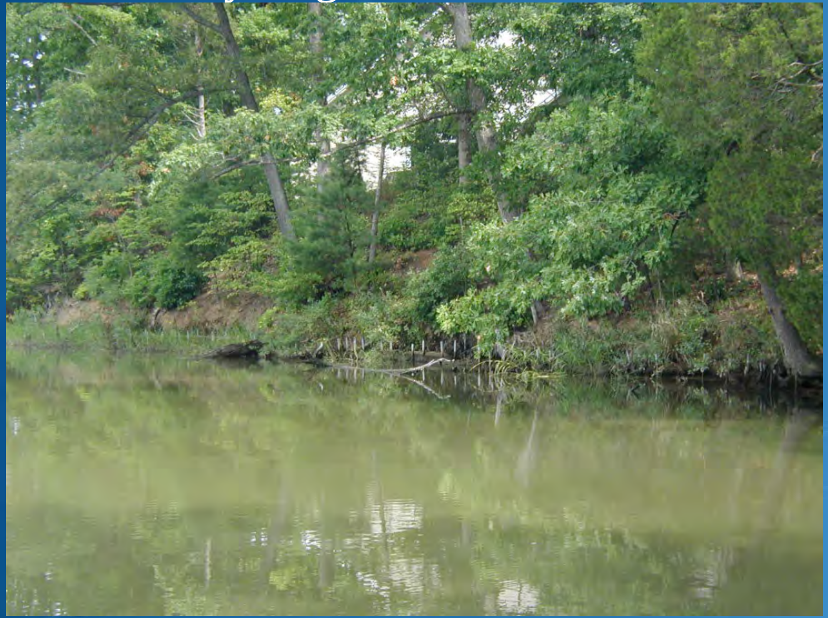
Bank Vegetation Cover
Resource Protection Area Buffer

Densely Vegetated / Forested



VIMS, SSP Photography

Previously Cleared

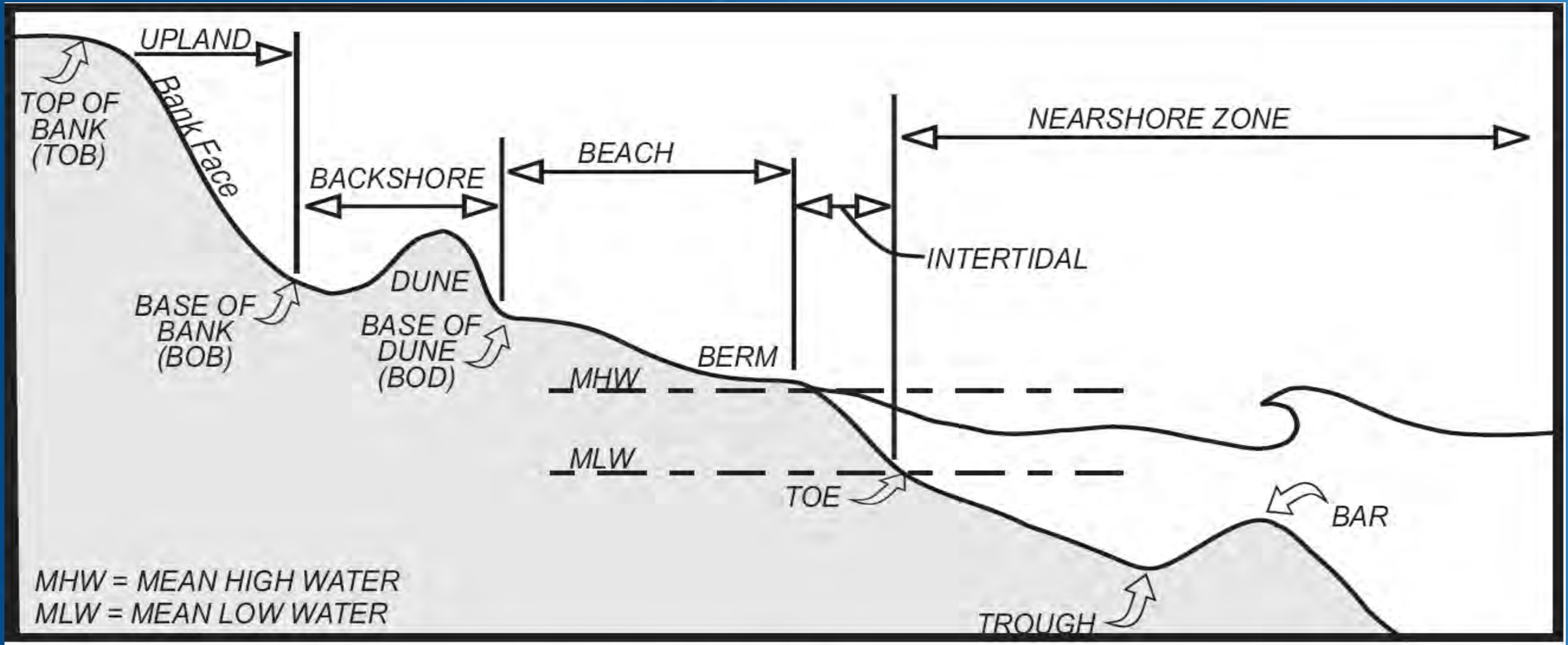
VIMS, SSP Photography

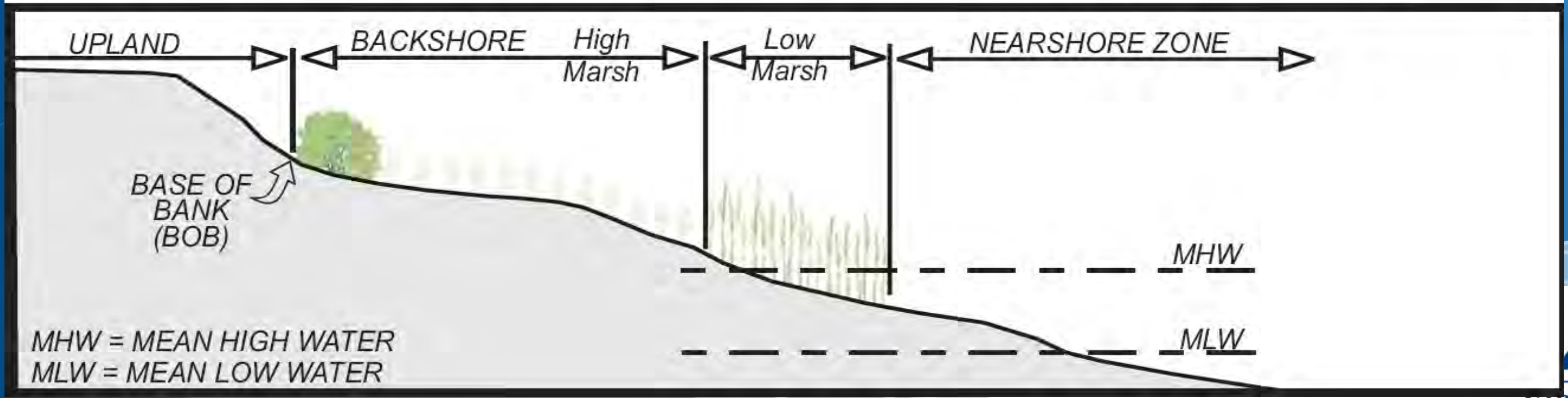
Does vegetation cover contribute to erosion protection or problem?

Should the bank be graded or not?

Is the absence of vegetation due to active erosion or previous land disturbance?

Combined Shore and Backshore Zone Width and Elevation





VIMS, SSP Graphic

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Shore Zone Width and Elevation

Existing tidal wetland

- Non-vegetated
- Salt or freshwater marsh
- Cypress trees

Existing sand beach

- Intertidal beach

Combination

- Patchy marsh headlands with pocket beaches

-Measure width of each feature in profile on previous page

-Identify plant species, jurisdictional limits

-Do existing beach and marsh contribute to erosion protection?

-Can they be temporarily disturbed or enhanced?

Common Native Plants
https://www.vims.edu/ccrm/outreach/teaching_marsh/native_plants/index.php

Backshore Zone Width and Elevation

Existing high marsh
- Saltmeadow hay
- *Phragmites*
- Salt bushes

Existing supratidal beach > MHW
- Overwash sand
- Primary & secondary dune features

Backshore terrace
- Bank slumping
- Upland grasses and trees

Measure width of each feature in profile

Identify plant species, jurisdictional limits

Do existing features contribute to erosion protection?

Can they be temporarily disturbed or enhanced?

Common Native Plants
https://www.vims.edu/ccrm/outreach/teaching_marsh/native_plants/index.php

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Boat Wakes

Boat wake effects are difficult to determine. However, often the homeowner can provide information for this assessment.

High boat traffic in narrow waterways will produce severe wave climate not indicated by other parameters (fetch)

Presence or absence of docks, marinas, marked channels

Local knowledge and judgment calls are required to weigh this parameter

Existing Shoreline Defense Structures

Target Shoreline

Serviceable or failing

Contributing to erosion protection or problem ?

Failed structures indicate wave climate, other design alternatives

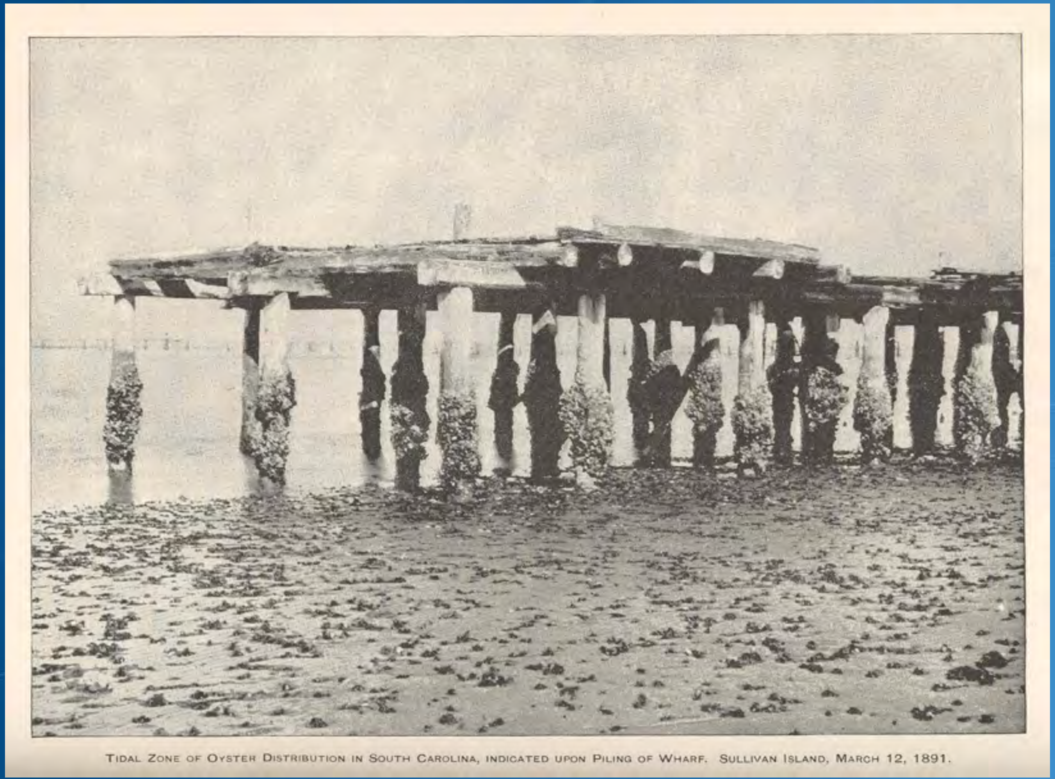
Adjacent Shoreline

Consider effects on structural integrity

Opportunities for reach-based solutions?

Oyster Restoration

If oyster restoration is a consideration in the project, look at the nearshore to determine if oysters are present attached to structures in the nearshore or in the marsh.



https://upload.wikimedia.org/wikipedia/commons/1/18/FMIB_37957_Zone_of_Oyster_Distribution_in_South_Carolina%2C_indicated_upon_piling_of_wharf%2C_Sullivan_Island%2C_March_12%2C_1891.jpeg

VIMS, SSP Photography

Captain Sinclair Recreational Area Oyster bag sill project after 5 years.

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Coastal Profile

Combine all parameters for site-specific conditions

Are all parameters weighed equally?

Consider how integrated habitats can influence shore protection, water quality and habitat functions

Each element in the system works to reduce wave energy impacting the upland

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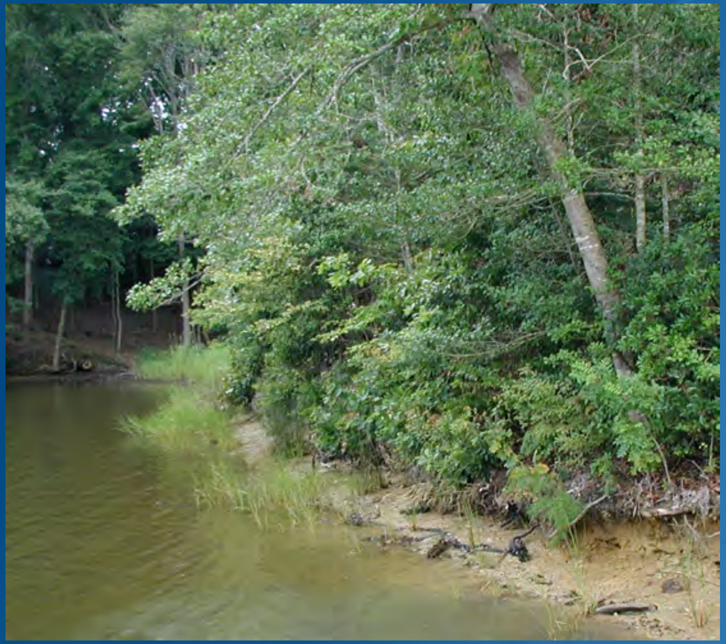
Bringing it Together



VIMS, SSP Photography

VIMS, SSP Photography

First consider if any action is needed at all.

If No Action is not acceptable, what is the least impacting solution to solve the particular erosion problem?

A slightly undercut bank could possibly have trees trimmed to improve light and marsh grass planted in existing substrate to enhance the marsh.

More obvious erosion may take a structural component to protect the shoreline.

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Other Considerations
Level of Protection and Design Storms

Maximum wind-wave climate expected

Amount of risk or damage property owner is willing to accept

Balanced with cost-effectiveness

Though everyone would like to protect for the 100 yr event, it likely is not practicable. For most homeowners, structures can be designed for the 25 yr event. Government agencies may look at longer-term protection as well as coastal resiliency considerations with the 50 yr event.

Design storms

- 10 yr
- 25 yr
- 50 yr
- 100 yr

Set elevations against eroding upland bank so that storm waves do not undercut the bank.

Other Consideration
Encroachment / Habitat Tradeoffs

Landward

Bank grading

Tree removal

Upland conversion to tidal wetlands

Channelward

Non-vegetated to vegetated tidal wetland

Shallow water conversion to stone and vegetated marsh

SAV

Sand movement & navigation channels

Shellfish lease areas

https://webapps.mrc.virginia.gov/public/maps/chesapeakebay_map.php

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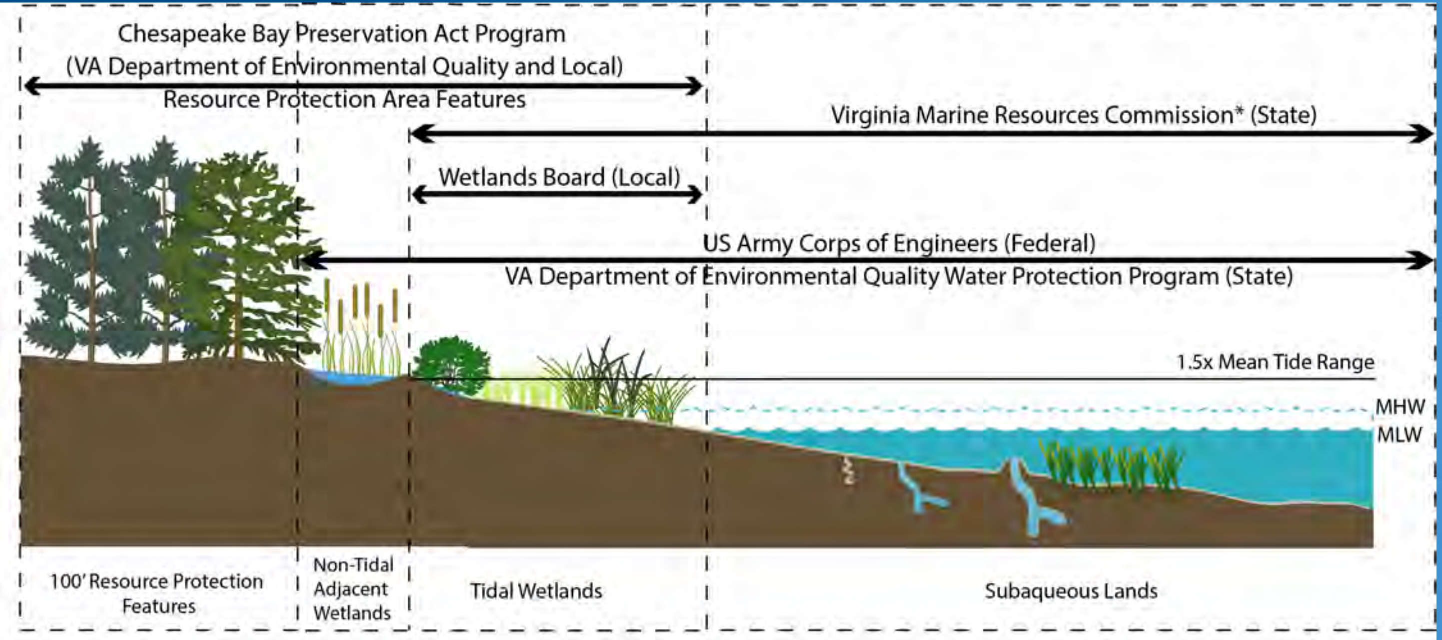
Permitting

Virginia Permitting Authorities



* VMRC has oversight authority for the Tidal Wetlands Act and administers the Act in localities without a wetlands zoning ordinance and local wetlands board.

Virginia Shorezone Jurisdictions: legally defined shoreline resources and the relevant local, state and federal authorities. Note that some authorities cross resource boundaries and most resources have at least two responsible regulatory authorities. Symbols courtesy of the Integration and Application Network (ian.umces.edu/symbols/), University of Maryland Center for Environmental Science.

https://www.vims.edu/ccrm/advisory/ccrmp/handbook/laws/index.php

Tidal Wetlands Guidelines-VMRC
https://mrc.virginia.gov/Regulations/Final-Wetlands-Guidelines-Update_05-26-2021.pdf

Maryland Living Shoreline Laws & Regulations

https://digitalcommons.odu.edu/cgi/viewcontent.cgi?article=1004&context=hraforum_24

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