Living Shorelines
for Contractors and Project Designers

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Living Shorelines
for Contractors and Project Designers
Part 2

- Why We Need More Living Shorelines
- Alternatives Analysis
- **Site-Specific Designs**
- **Construction Planning**
- Monitoring and Maintenance
- Permit Process

- Field Site Visit

Non-Structural Methods

Bank Grading & Landscape Restoration

Planted Tidal Marshes

Fiber Logs

Bank Grading & Landscape Restoration

Bank Grading

High Bank, LLC, White Stone

- **Before grading, waves striking the bank toe would cause bank collapse from top to toe**
- **After grading, there is an elevation gradient for wave "run-up" and dissipation of wave energy**

Bank grading is appropriate when...

the bank condition is not providing erosion or water quality protection

- Unstable high banks with large, undercut trees
- Partially cleared or compromised forest buffers adjacent to wide or narrow marshes
- Construction access needed for necessary erosion protection structures

Examples Where Bank Grading May Be Appropriate

Sandy high bank with wide beach and lawn

No improvements close to shoreline

Short life expectancy for old trees with exposed roots
requires professional opinion

Bank grading may <u>not</u> be appropriate when...

the existing bank condition provides desirable ecosystem services

- Stable banks with no active erosion
- Undercut banks with stable forest above
- Low banks with active erosion but also mature riparian forest
- Erosion caused mostly by upland runoff that can be reduced in the upland

Bank grading may not be appropriate when...
there are human conflicts

- Buildings, utilities, accessory structures limit access or extent of grading
- Adjacent properties may be adversely affected
- Sentimental or historic trees are present
- Cultural resources would be disturbed

Examples Where Bank Grading May Not Be Appropriate

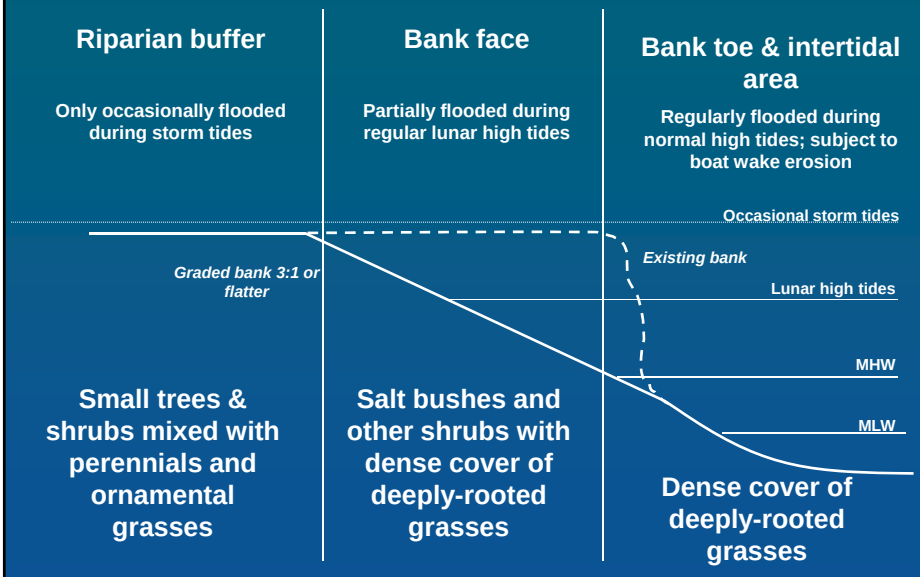
Historic Tree at Hull Springs Farm

Existing buildings near top of bank

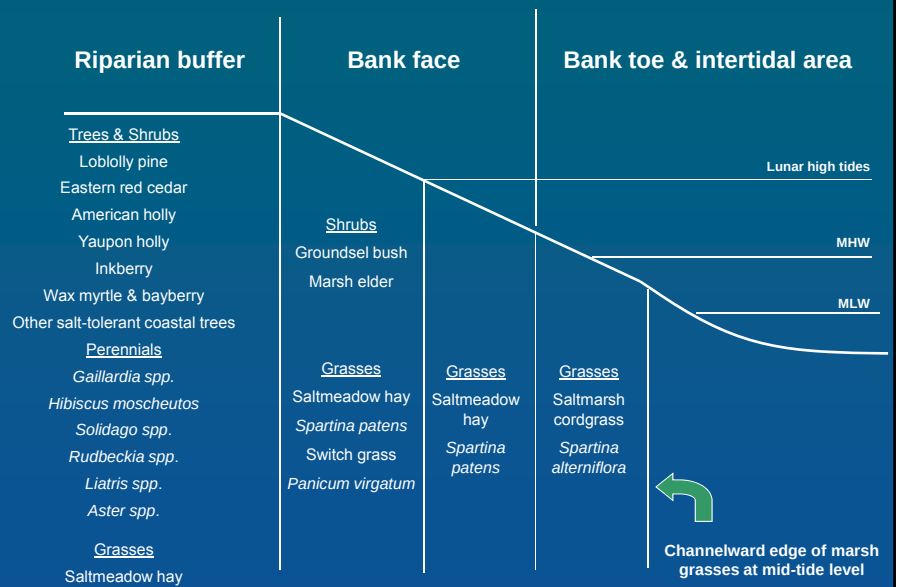
Landscape Restoration of Graded Banks

- Restore a vegetation buffer that intercepts runoff and stabilizes bank face
- Native shoreline plants are best suited to local soil, salt and wind conditions
- Non-native plants should be adapted to similar conditions
- Landscape design should comply with Chesapeake Bay Preservation Act requirements
- May require temporary irrigation until plants are established

Planting zones for graded banks



Suggested native plants for graded banks



Examples of Planting on Graded Banks

Low shrubs and ornamental grasses on graded bank above revetment

Various shrubs on graded bank required by Chesapeake Bay Preservation Act landscape agreement

Examples of Planting on Graded Banks

Various ornamental grasses in winter on graded bank

Ornamental grasses and daylilies in early spring on graded bank above bulkhead

Stark contrast to graded lawns on both adjacent parcels

What's Wrong With These Pictures ?

What's Wrong With These Pictures ?

Non-native, invasive, short-lived <u>monocultures</u>

VIMS

Planted Tidal Marshes

Planted Tidal Marshes

Volunteers at Hull Springs Farm 2006

- Enhancing or creating suitable conditions for tidal marsh plants
- May require grading the bank and/or filling into the water
- Narrow marsh provides habitat value, wide marsh >15 ft provides wave reduction

How wide should the marsh be?

- The answer depends on the energy regime in your area—the bigger the waves, the wider the marsh
- Usually aim for a minimum of 15 feet
- Minimum target slope is 10:1 for drainage, 6:1 in high marsh acceptable
- You may need to grade the bank to widen the intertidal zone

Planting Tidal Marshes

Main Considerations

1. **Landscape Setting**
   - Plenty of sunlight without extensive tree removal (at least 6 hrs full sun daily in spring-summer)
   - Existing marshes in vicinity provide biological benchmarks

2. **Elevations**
   - Know local tide range, plant only above mid-tide level
   - Must be based on tidal datum (e.g. MLW) and most recent tidal epoch (1983-2001), not geodetic (e.g. NAVD 88)
   - Bank grading or fill needed if regular high tides reach upland bank
   - 10:1 slope ideal (1 ft rise for every 10 ft run)
   - Must have positive drainage, no standing water at low tide

Planting Tidal Marshes

Main Considerations

3. **Soil**
   - Sand is best; avoid muck soils, hard peat
   - If fill is needed to raise elevation, only clean sand fill allowed
   - If excavation is needed to lower elevation, take borings to proposed planting elevation to determine soil type
   - Wait 2-4 weeks after fill or grading for stabilization

4. **Tidal Marsh Plants**
   - Select plant species according to local salinity
   - Plant each species at correct elevations
   - Include both high and low marsh zones with overlapping planting where they join

Planting Tidal Marshes

Main Considerations

5. **Plant Sources**
   - Nursery stock most successful
   - Nursery stock must be gradually "hardened" to local salinity
   - Transplant from existing marshes only for small areas

6. **Time of Year**
   - Spring or early fall, avoid planting in summer heat

7. **Spacing**
   - 2-ft centers for average conditions, 1-ft centers for very rapid cover, 1.5-ft centers for rapid cover, 3-ft centers for large areas
   - Alternate species in transition areas
   - Plant above and below predicted elevations

Planting Tidal Marshes

Main Considerations

8. **Fertilizer**
   - ½ oz (1 Tablespoon) in each planting hole
   - Slow release e.g. Osmocote 18-6-12
   - Different release periods available depending on time of year (e.g. 9 month release for spring planting, 6 month for summer, 3 month for fall)

9. **Grazing Pressure**
   - Use goose exclusion fences if Canada geese or mute swans are in the vicinity

Typical Grass Species Used for Brackish Marsh

Low Marsh

Saltmarsh cord grass
Spartina alterniflora

High Marsh

Saltmeadow hay
Spartina patens

Salt grass
Distichlis spicata

Switch grass
Panicum virgatum

More species possible for low salinity or fresh water, select those that remain above ground during winter e.g. *Spartina cynosuroides, Juncus effusus*

Salt Bushes
planted at landward side of high marsh

Groundsel Bush
Baccharis halimifolia

Marsh Elder
Iva frutescens

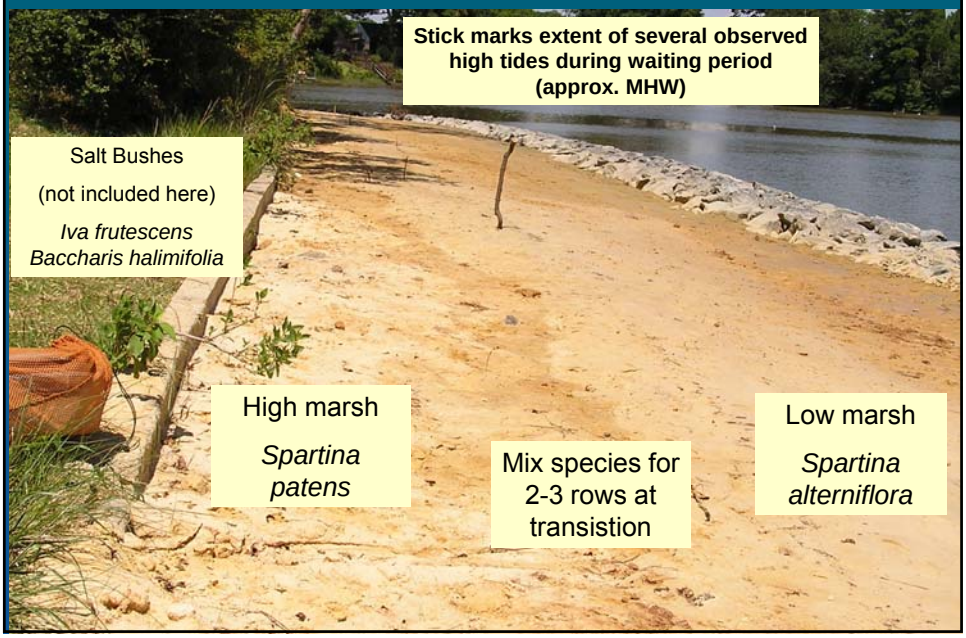
Not as flood tolerant, use at upland edge

Wax myrtle / Bayberry
Morella cerifera
M. pennsylvanica

Nursery Stock

Tidal marsh grasses grown in nurseries are irrigated with fresh water. The nursery must know what the local salinity is at the planting site ahead of time to gradually "harden" the plants before they are introduced.

Fringe Marsh Planting Zones



Plant Spacing & Growth Pattern

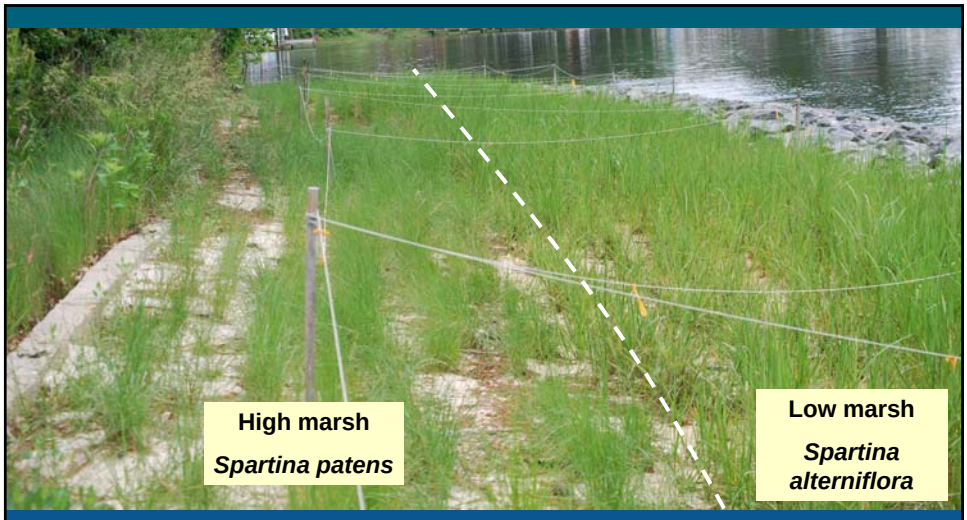
Plants spaced 18-24 inches apart

Closer spacing for more rapid cover

Increase spacing to cover large area with limited budget

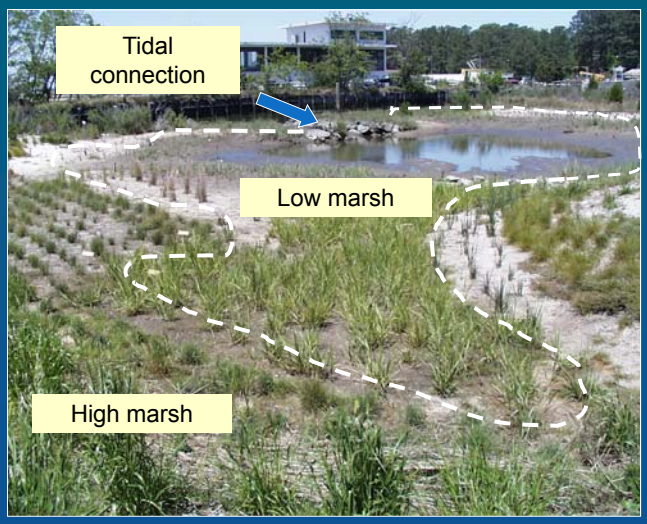
Marsh grasses will spread underground by rhizomes

Eventually space between plants will fill in naturally



Planted marsh must be sloped so it is completely exposed at low tide; plant failure may be caused by standing water

Embayed or "Pocket" Marsh



More complex planting zones

Upland excavation areas

VIMS Teaching Marsh
Gloucester Pt, VA

Planted Freshwater Marsh

Photo Courtesy NC Coastal Federation

Grazing Exclusion Devices

Mute Swans & Canada Geese can pull new plants out of the ground, but not established well-rooted plants; exclusion device can be removed after 1 growing season

Planted marsh vegetation may not be effective when…

1. There is heavy wave activity
2. There are heavy boat wakes
3. The water depth increases quickly close to shore
4. There are historically high erosion rates
5. There are highly erodible soils
6. There are anaerobic (low oxygen) soils

Fiber Logs

Coir or Fiber Logs

- **Manufactured biodegradable logs act as medium for plant propagation**
- **Slope stability increases with growth of fibrous root systems**
- **Decay within 5 yrs in marine environment**
- **Approximate cost $61 per running foot (in 1999 dollars)**

Fiber Logs

Main Considerations

1. **Landscape Setting**
   - Areas of low shear stress, low flow velocity (e.g. tidal coves, very shallow tidal creeks, lakes, ponds)
   - Not recommended as the primary toe stabilization measure in streams or rivers with currents

2. **Elevations**
   - Must be in full contact with ground
   - On graded bank to support landscape restoration
   - At bank toe to support bank and marsh planting
   - Mid-tide level or higher to contain sand fill until plants become established

Fiber Logs

Main Considerations

3. **Staking (Absolutely Necessary)**
   - Hardwood stakes must be used every 3-4 feet to anchor logs into place
   - Opposite stakes on both sides
   - Pound stakes until 10-12 inches remains above logs
   - Notch stakes angle up near top, tie rope stake to stake
   - Pound stakes until rope is flush with log

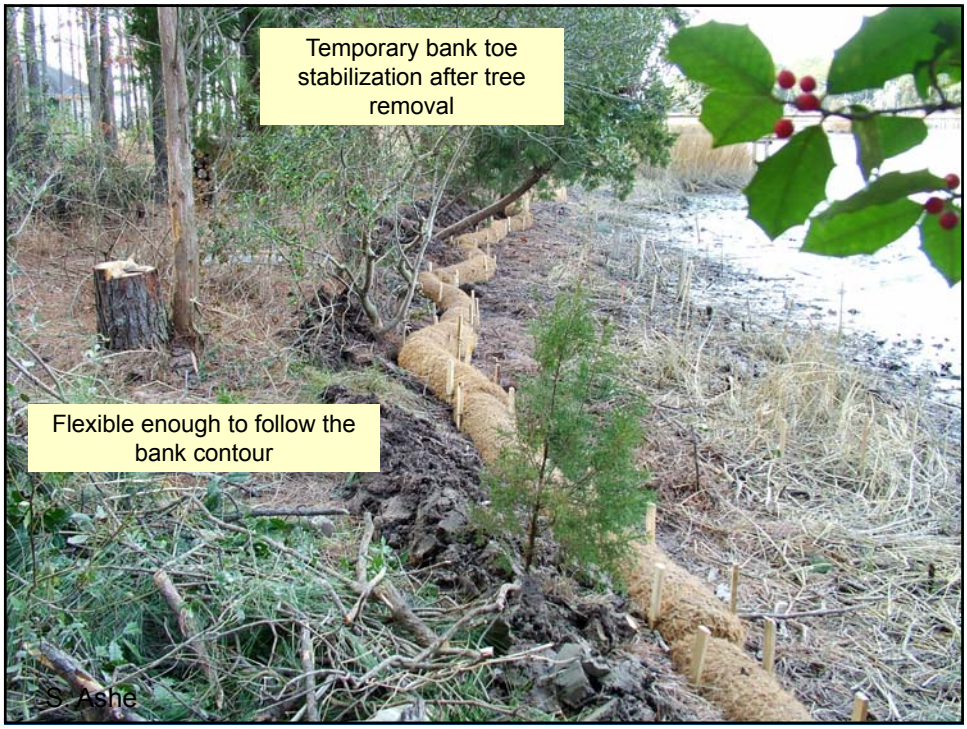
4. **Connecting logs together**
   - Ends of adjacent logs should be laced together with twine
   - Bend logs at the end into bank and bury to prevent water from intruding behind the roll and dislodging it
   - Stacked logs can also be used

Fiber Logs

Main Considerations

5. **Planting into logs**
   - Choose plants based on location and tidal inundation
   - Logs must be partially in the water unless plants can be irrigated
   - Install plants in a zig-zag pattern on top or sides of logs

6. **Backfill**
   - Sand fill for planted marshes most effective
   - Gradual accretion of eroding bank material less effective
   - Gradual accretion of tidally deposited sediment only in very low energy



Fiber log before sand fill & plants to repair storm erosion of natural marsh

Opposite stakes should be tied together across top of log

Fiber Logs

Sand fill contained by fiber logs with planted marsh

Will the planted marsh remain after the fiber logs decay?

Holly Point Nature Park, Deltaville by Middlesex Chapter Master Gardeners

Fiber Logs

Not effective as wave break where there is wide fetch or boat wakes

Marsh planting at grade, fiber logs near mean low water elevation

1 year later
The planted marsh was fine

Fiber Logs

May not be effective wedged into shady undercut banks

Hybrid Methods

Marsh Sills

Oyster Reefs

Breakwaters with Beach Nourishment

Marsh Sills

Marsh Sill

Hull Springs Farm

Marsh sill (foreground) compared to natural marsh (background)

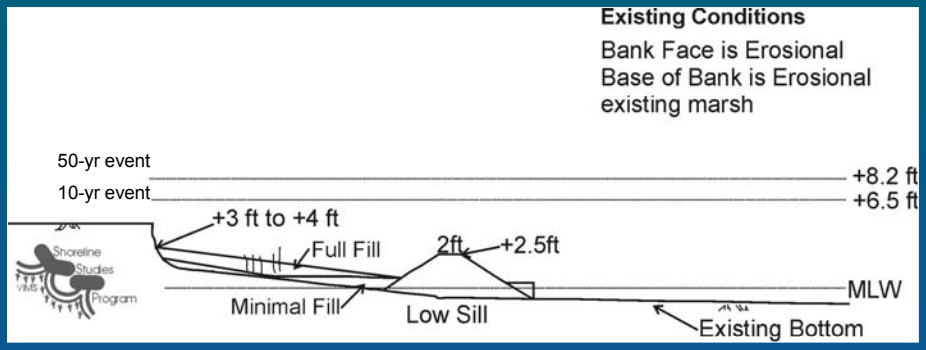
- Low profile revetment backfilled with sand to create or enhance tidal marsh
- Import sediment from upland source or use suitable bank grading material

Some examples of sill designs for different shoreline types…

Source: Occohannock Creek Shoreline Erosion and Living Shorelines Options Report, VIMS Shoreline Studies Program, 2006

http://web.vims.edu/physical/research/shoreline/docs/OccohannockCreek/OccohannockCreek.pdf

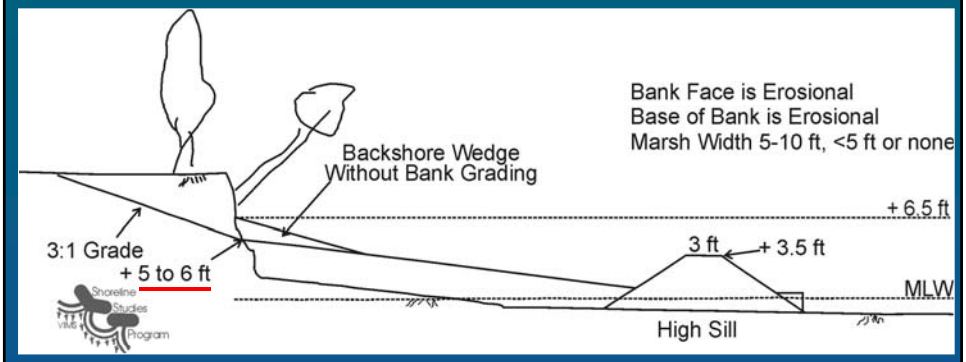
Low Bank



"Full fill" if existing marsh can be covered with sand

"Minimal fill" if existing marsh cannot be covered with sand

High Bank - Unstable

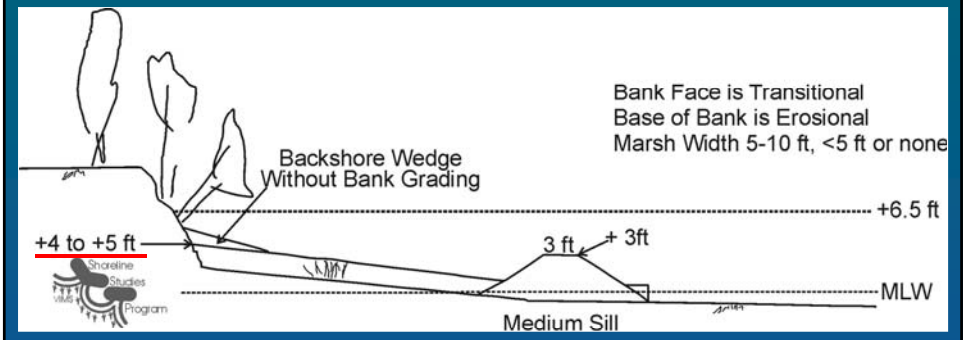


Bank grading ties into sand fill

"Backshore wedge" is additional sand against bank if not graded

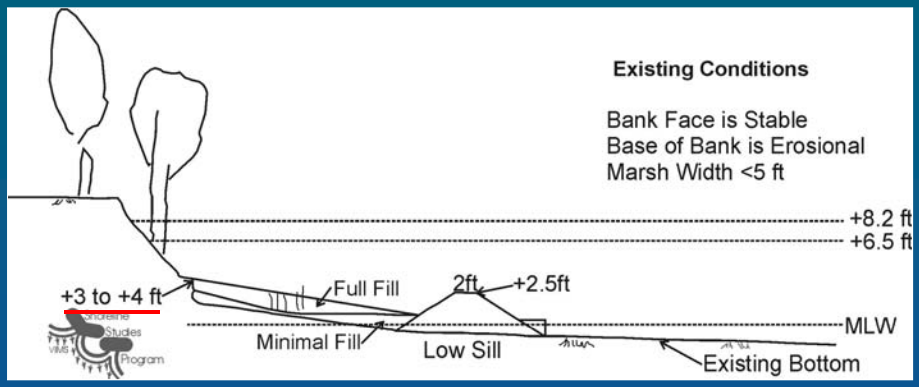
OR revetment

High Bank - Transitional



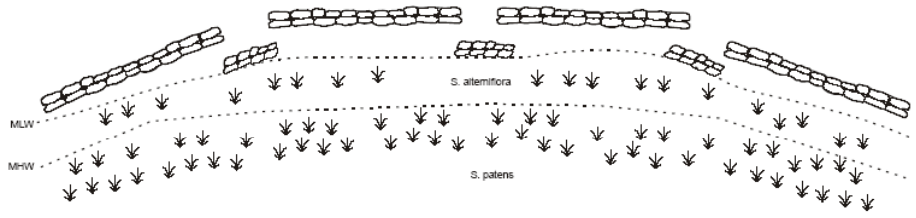
Vegetation is present on bank face, bank grading not necessary or desirable

High Bank - Stable



Tidal Openings

Offset or Staggered Vented Sill

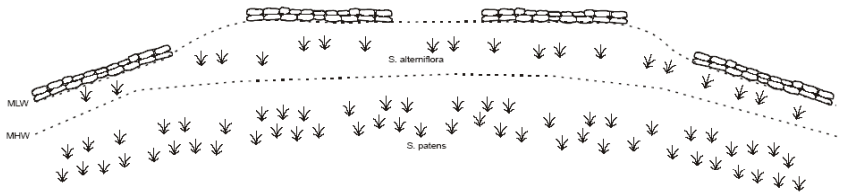


Allows access for fish, crabs, terrapins
Facilitates tidal flooding and drainage

4/06

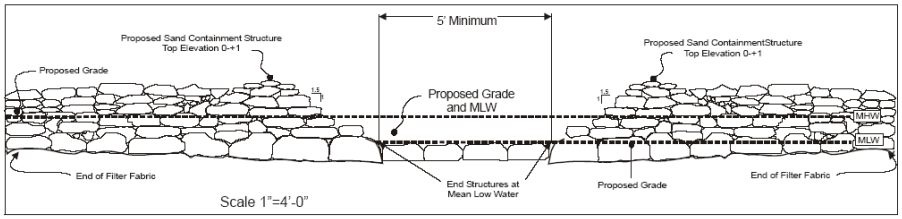
Source: Maryland Department of the Environment

Linear Vented Sill



Also known as a weir

Linear Sill Vent Detail With Armor



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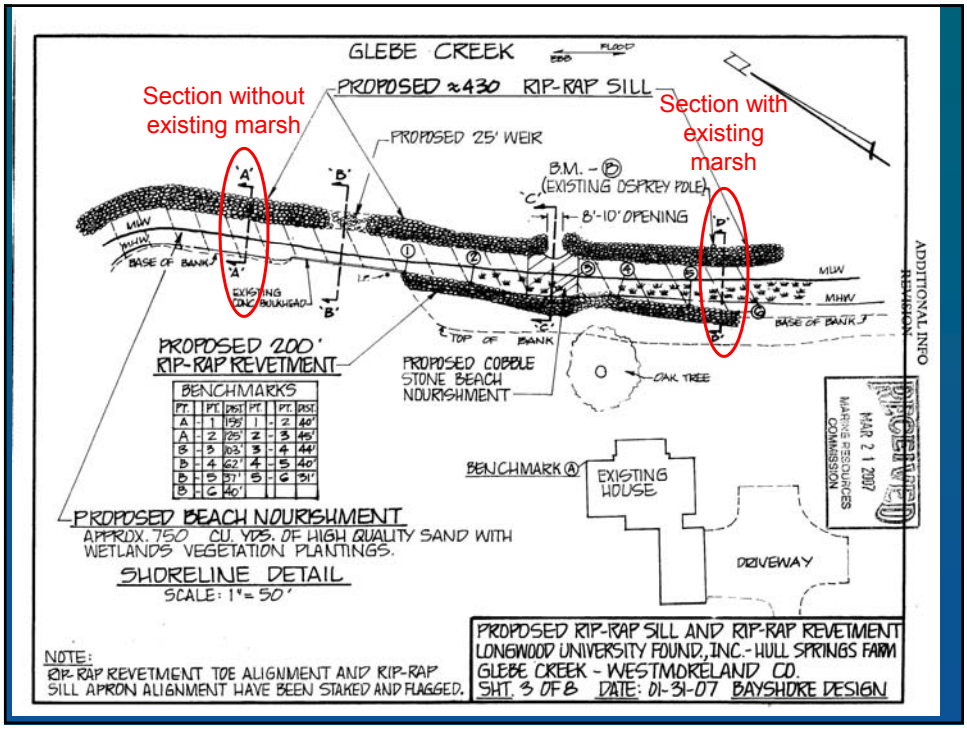
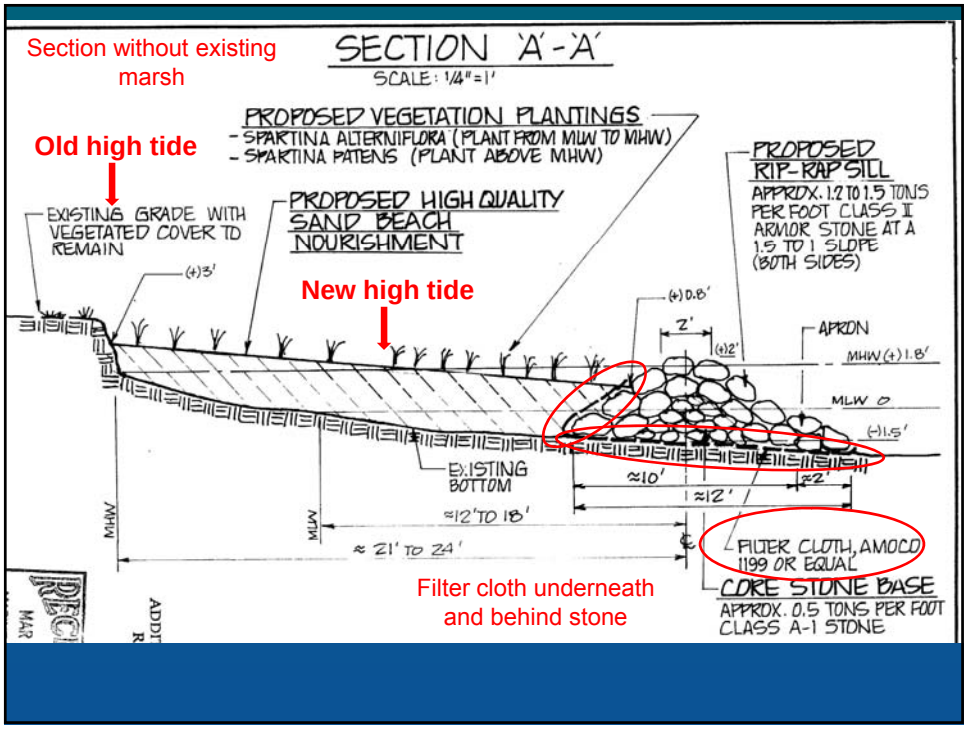
Source: Maryland Department of the Environment

MDE

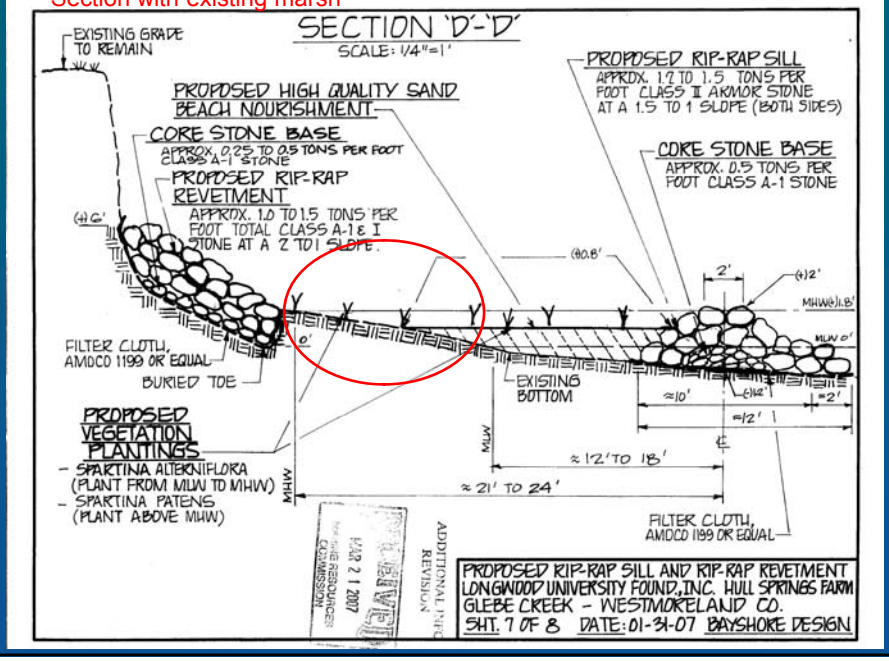
Marsh Sill Design at Hull Springs Farm

- High Bank unstable, moderate energy
- Variable sill height and stone sizes
- Marsh width ± 20 ft with high and low marsh
- Sand fill height ± 2 ft, upland sand source
- Weir, cobblestone, and 2 end openings
- Existing marsh mostly avoided


GLEBE CREEK
PROPOSED ≈430 RIP-RAP SILL
Section without existing marsh
Section with existing marsh
PROPOSED 25' WEIR
B.M. - (EXISTING OSPREY POLE)
8'-10' OPENING
PROPOSED 200' RIP-RAP REVETMENT
PROPOSED COBBLE STONE BEACH NOURISHMENT
TOP OF BANK
OAK TREE
BENCHMARKS
BENCHMARK A
EXISTING HOUSE
DRIVEWAY
PROPOSED BEACH NOURISHMENT
APPROX. 750 CU. YDS. OF HIGH QUALITY SAND WITH WETLANDS VEGETATION PLANTINGS.
SHORELINE DETAIL
SCALE: 1"= 50'
NOTE:
RIP-RAP REVETMENT TOE ALIGNMENT AND RIP-RAP SILL APRON ALIGNMENT HAVE BEEN STAKED AND FLAGGED.
PROPOSED RIP-RAP SILL AND RIP-RAP REVETMENT
LONGWOOD UNIVERSITY FOUND., INC.- HULL SPRINGS FARM
GLEBE CREEK - WESTMORELAND CO.
SHT. 3 OF 8 DATE: 01-31-07 BAYSHORE DESIGN
ADDITIONAL INFO REVISION
MAR 21 2007
MARINE RESOURCES COMMISSION


Section without existing marsh
SECTION 'A'-'A'
SCALE: 1/4"=1'
PROPOSED VEGETATION PLANTINGS
- SPARTINA ALTERNIFLORA (PLANT FROM MLW TO MHW)
- SPARTINA PATENS (PLANT ABOVE MHW)
Old high tide
EXISTING GRADE WITH VEGETATED COVER TO REMAIN
PROPOSED HIGH QUALITY SAND BEACH NOURISHMENT
New high tide
PROPOSED RIP-RAP SILL
APPROX. 1.2 TO 1.5 TONS PER FOOT CLASS II ARMOR STONE AT A 1.5 TO 1 SLOPE (BOTH SIDES)
APRON
MHW (+) 1.8'
MLW 0
(-)1.5'
EXISTING BOTTOM
≈10'
≈12'
≈2'
≈12' TO 18'
≈ 21' TO 24'
MHW
MLW
FILTER CLOTH, AMOCO 1199 OR EQUAL
CORE STONE BASE
APPROX. 0.5 TONS PER FOOT CLASS A-1 STONE
Filter cloth underneath and behind stone

Section with existing marsh



Construction Access

Access "ramp" for heavy equipment to haul in sand and stone

Filter Cloth

Filter cloth distributes weight of stone, limits settling and lowering of sill height, contributes to structural integrity, helps contain sand fill

Sill Construction – North Section

Sand fill needed first at north section to support excavator

Sill Construction – South Section

Experienced contractors provide close oversight during construction

Cobblestone Tidal Opening

New design prevents shoaling and interruption of tidal inundation

Tidal Marsh Planting

After a 1 month waiting period for the sand fill to settle, volunteers planted marsh sill

Nor'easter Storm Protection ?

During a severe storm, the wave height reaching the upland bank is reduced by the "roughness" of the sill and planted marsh

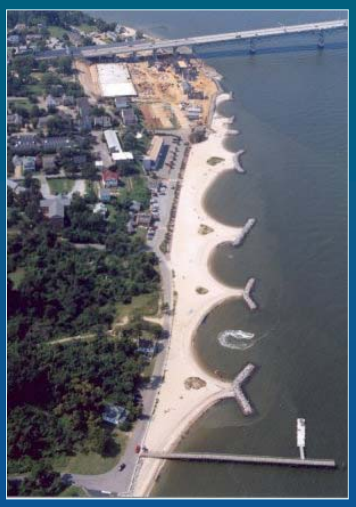
Oyster Reefs

- Habitat for native oyster restoration
- Not always effective for wave reduction
- Monitoring & research underway by VIMS, CBF, TOGA, et al.

VIMS

Breakwaters with Beach Nourishment

Offshore Breakwater System



Yorktown, VA

- A series of revetments positioned offshore to refract waves producing a scalloped but stable shoreline
- Used for high energy beaches
- Requires large volume of beach nourishment

Headland Breakwaters

This approach controls existing points of land (i.e. headlands) or strategically creates new points of land with stone breakwaters and **lets the land between erode** into a predicted embayed shape.

The potential effect of offshore breakwaters on sand transport, adjacent shorelines, and navigation channels must be considered

Considerations for breakwater design include…

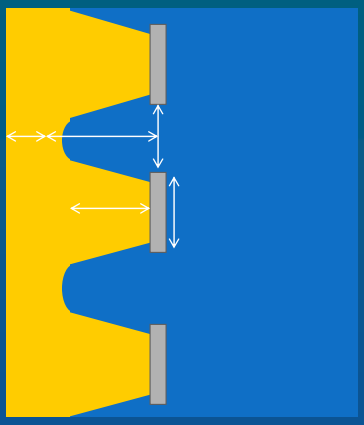
- **"Following work by Irribarren (1938, 1950), comprehensive investigations were made by Hudson (1953, 1959, 1961) at the U.S. Army Corps of Engineer Waterways Experiment Station (WES) and a formula was developed to determine the stability of armor units on rubble structures. The stability formula, based on the results of extensive small-scale model testing and some preliminary verification by large-scale model testing, is known by** Hudson Formula**".** ***Shore Protection Manual, 1984.***

$$W = \frac{w_r H^3}{K_D (S_r - 1)^3 \operatorname{cotg}(\theta)}$$

1. Design wave height
2. Weight of armor unit
3. Weight of water (varies with salinity)
4. Slope of structure
5. Constant for breaking/non-breaking waves
6. Type of armor units

Considerations for breakwater design include…

7. Breakwater gap length
8. Bay indentation
9. Initial beach width
10. Finished beach width
11. Ratio of gap to indentation, resulting in a stable embayed shoreline



From: Hardaway and Byrne. 1999. Shoreline Management in the Chesapeake Bay. See for more details.

What does all that mean?

- **Designing breakwaters properly is an engineering task**
- **Improperly designed breakwaters may not work and may have adverse effects on adjacent shorelines or navigation channels**
- **Therefore, breakwater design is best left to the experts!**

Construction Planning

Basic Construction Sequence

1. Clear site of debris and unstable trees
2. Remove derelict structures and dispose properly
3. Stage materials out of sensitive areas
4. Install construction mats where needed
5. Install sand containment structures then backfill
6. Waiting period for settling before planting to verify tide levels
7. Temporary erosion and sediment control measures until vegetation cover is restored
8. Planting according to recommended schedules
9. Grazing exclusion devices
10. Inspection and corrections until stabilization is apparent

Minimize construction access impacts

- Water access or hand-placement if possible
- For upland access, minimize vegetation removal
- Limit number of access paths
- Downsize equipment
- Use construction mats to distribute weight of machinery crossing through forest buffers and tidal marshes

Material Staging

Stockpile areas for stone and sand should be planned and located outside of sensitive areas, e.g. wetlands, forested areas, underground drainfields

Construction crew and delivery vehicles should park in designated areas

Construction Mats

Plywood mats recently used for sill access

Mats placed across a tidal marsh will crush vegetation, but the marsh should recover naturally during the next growing season

Restoration of these access paths may be needed if natural recovery does not occur after 2 growing seasons

Minimize Damage to Preserved Trees

Trees may gradually die when heavy equipment compacts the soil or scars the trees during clearing

Dead and dying trees in disturbed area with lag time

Timeframes

- Tidal marsh planting should be done in the early or late part of the growing season (Mar-May, Sept-Oct)
- Beach nourishment should be scheduled to avoid impacting protected species. Avoid the following months when these species are present:
  - Northeastern beach tiger beetles: June - Sept
  - Piping plover: May – Aug
  - Terns/Black skimmers: Apr – Aug
  - Loggerhead sea turtles: May - Nov

End of Part 2

Contact Information:

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