

Expanding the use of natural and nature-based infrastructure to enhance coastal resiliency

Interim Report (Year 1 of 3)

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Introduction

The vulnerability of coastal communities and the growing risks of coastal infrastructure continue largely due to past and ongoing patterns of development in high risk areas. This project is focused on increasing the use of natural and nature-based features (NNBFs) to increase resilience of coastal communities to flooding caused by extreme weather events. The project effectively addresses two problems:

- The natural capital of coastal communities is generally declining, and is projected to decline at an accelerating rate due to sea level rise and current land use practices.
- The use of NNBFs to sustain or increase resilience in coastal communities is restricted by the many competing needs for limited local resources.

There has been so much attention to the threats and potential consequences of storm driven flooding in coastal communities that almost no local government official is unaware of the issue. Most also have some general understanding of actions that can lower risks and increase resilience. The problem is that the resources required to undertake those actions are limited and, in the face of competing interests, it is difficult to rationalize making them a priority. One solution to accelerating the pace of building resilience is to find ways to address multiple needs with each action, taking advantage of the co-benefits available from carefully planned projects.

To that end, this project identifies local opportunities to increase community resilience through the use of natural and nature based shoreline enhancements. Specifically, the project identifies where living shorelines can enhance resiliency and offer nutrient reduction benefits as well as offering protection to shoreline undergoing erosion. The use of living shorelines for erosion control is the preferred method under Virginia law. When originally enacted into law, there was little attention to the co-benefits that living shorelines offer beyond erosion control.

This first year, of a proposed three year study, the Center for Coastal Resources Management, has focused on refining their existing Shoreline Management Model (SMM) to improve the suitability targeting for living shorelines along shorelines that have already been hardened with erosion control structures. This model upgrade represents a major improvement to the tool, which previously treated all shorelines equally. To better analyze for where resiliency and nutrient reduction credits could be applied through the construction of a living shoreline, the model had to address shoreline hardening and the limitations that existing structures impose on a living shoreline application.

Approach

The SMM (V4), which delineates where living shoreline treatments are suitable based on current shoreline conditions, had previously been run in nearly all coastal localities in Virginia (<http://www.vims.edu/ccrm/ccrmp/index.php>). The model (V4) is based on decision tree logic and guidance that has been vetted through the Center's Wetland Advisory Program and local wetlands boards over many years

(http://www.vims.edu/ccrm/ccrmp/bmp/decision_tools/index.php). In 2012, with the change in state policy regarding erosion control and living shorelines, the Center used GIS and available GIS data through the Virginia Shoreline Inventory, to model the logic represented in the existing decision trees for shorelines which were undefended (http://ccrm.vims.edu/decisiontree/decisiontree_manual.pdf) (CCRM, 2010) (Figure 1). This gave state and local managers the first comprehensive perspective on best management practices for tidal shoreline erosion control. Limitations in the model were always noted along some shoreline types; particularly those that have been altered. Included among those, was the ability for the model to accurately predict treatment options along shorelines that were already hardened with traditional erosion control structures.

The SMM model upgrade developed under this grant used the decision tree logic for shorelines that have been previously defended with bulkheads and revetments (Appendix 1). Shorelines with groin fields were already integrated into the model. The Virginia Shoreline Inventory (<http://www.vims.edu/ccrm/research/inventory/index.php>) provided the data necessary to determine where shoreline hardening has occurred. In addition, the model update addressed the conflict that intertidal, shallow water structures may encounter if submerged aquatic vegetation was present. Data from the VIMS SAV Mapping Program provided the spatial data necessary to integrate SAV presence into the model update (http://web.vims.edu/bio/sav/gis_data.html).

Deliverables

A protocol for converting the decision trees to a geospatial model was developed and initially tested on three pilot localities: Westmoreland County, and the cities of Poquoson and Newport News. Adjustment in the model coding was made in response to the QA/QC. In addition, improvements were made to the CCRM Fetch model at that time. The Fetch Model is one of the SMM data inputs, and it indicates the potential wave energy climate based on fetch distance from dominant directions. This is used to force the model to determine the correct type of living shoreline required to withstand anticipated wave energy. For example, in low fetch environments the model would recommend a living shoreline practice that is strictly nature based; such as marsh plantings or fiber logs. In contrast, a breakwater may be recommended if the fetch environment for a site was computed to be high.

Following QA/QC, the model was re-run for all Tidewater localities where the model had been previously run. This accounted for a substantial amount of Virginia's Coastal Zone. The final model is represented in the flow charts illustrated in Appendix 2. Appendix 3 summarizes the treatment options. Revisions and updates to existing data portals (<http://www.vims.edu/ccrm/ccrmp/index.php>) and interactive map tools (<http://www.adaptva.org/index.html>) reflect the enhancements made to the model under this grant project. Shape files for the coastal zone covered under this project were delivered to the Virginia Coastal Zone Management Program along with metadata.

In subsequent years, this modeled data will be used to estimate the potential nutrient reduction benefits that are available to communities who elect to implement living shorelines for resiliency and shoreline erosion control.

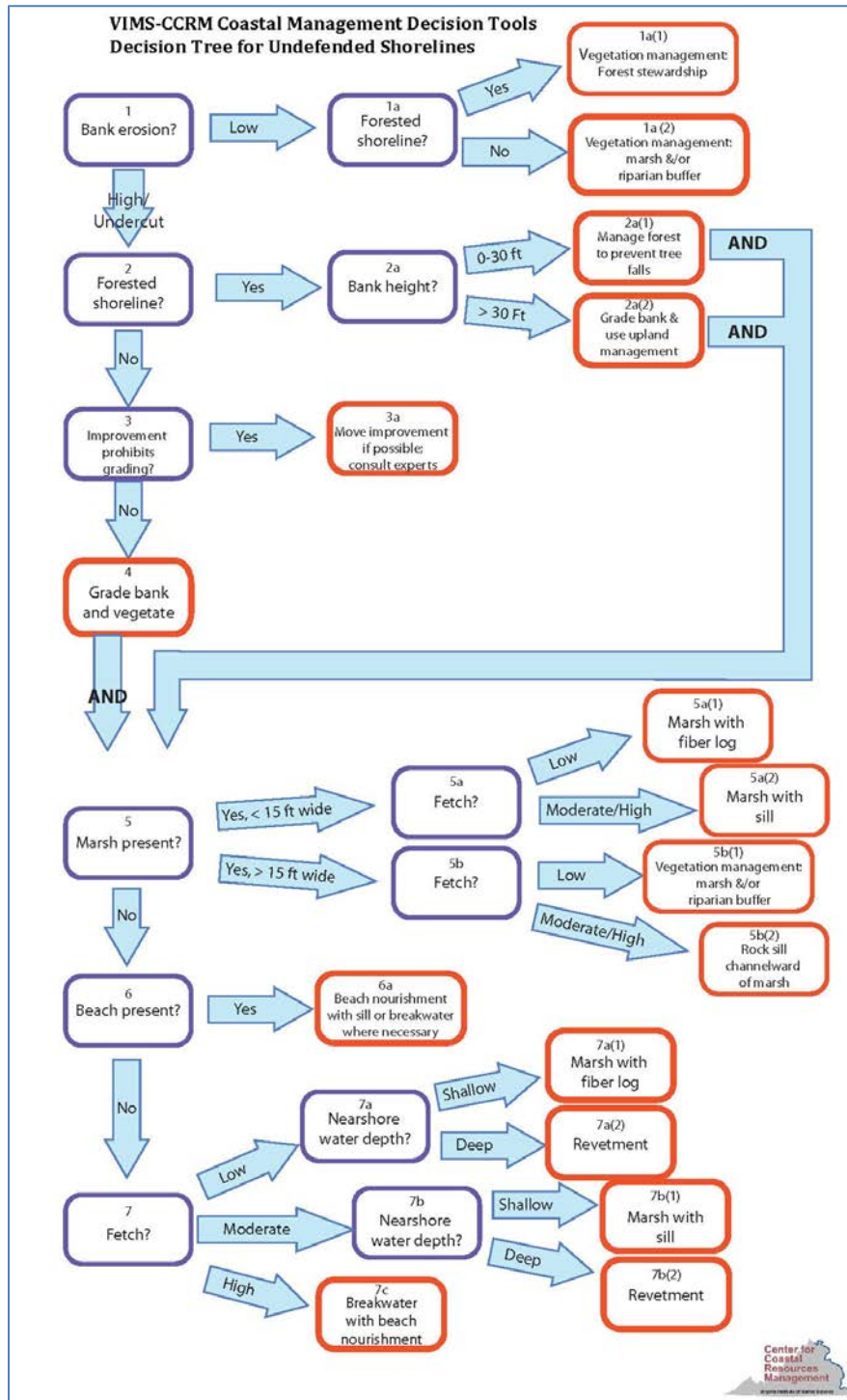


Figure 1. Original Decsion Tree for Undefended Shoreline (CCRM, 2010)

References

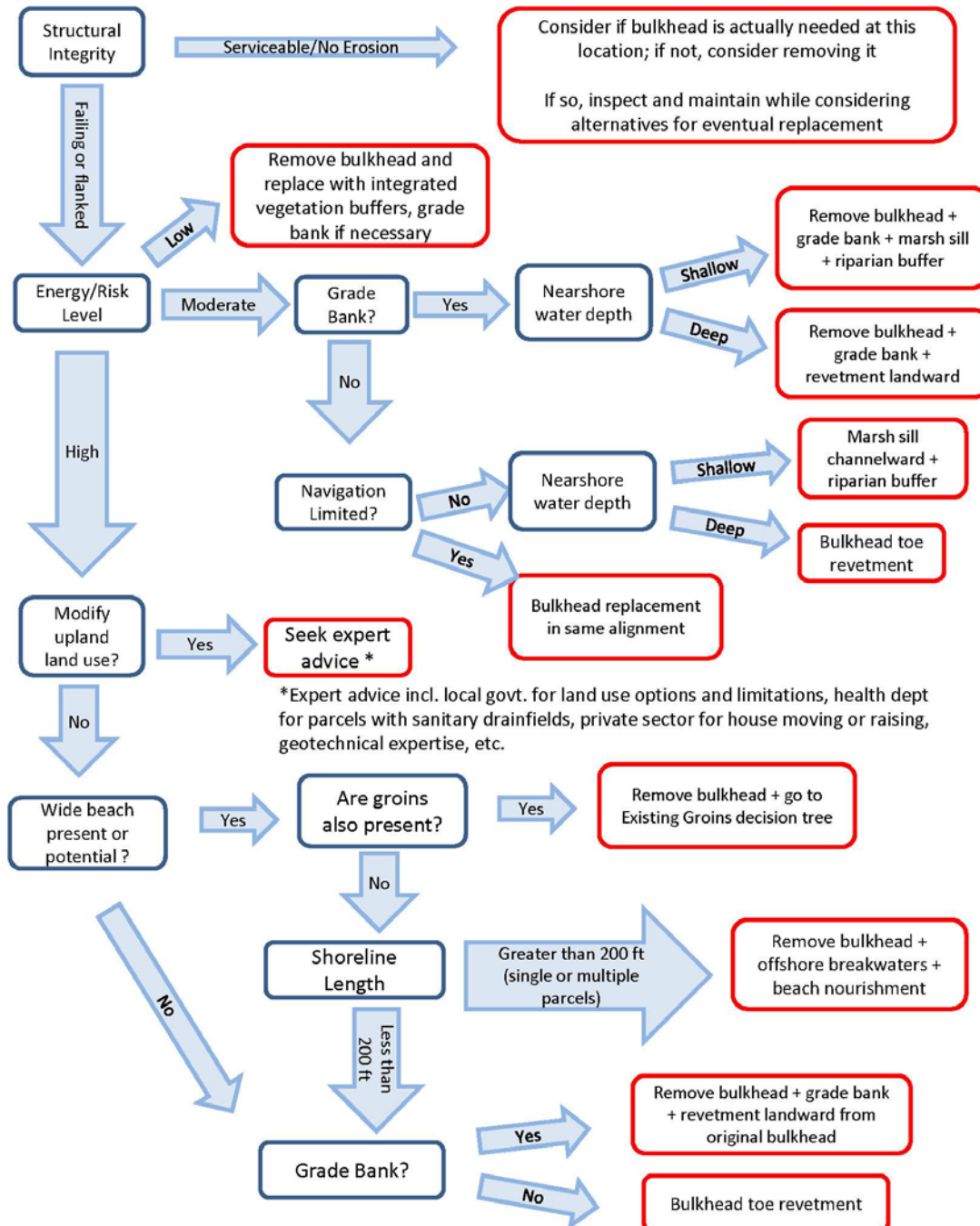
Center for Coastal Resources Management, 2010. Decision tree for undefended shorelines and those with failed structures, Center for Coastal Resources Management, Virginia Institute of Marine Science, Gloucester Point, Virginia, pp. 33.

APPENDIX 1.VIMS – CCRM Decision Trees for Defended Shoreline

VIMS-CCRM Decision Tree For Currently Defended Shorelines



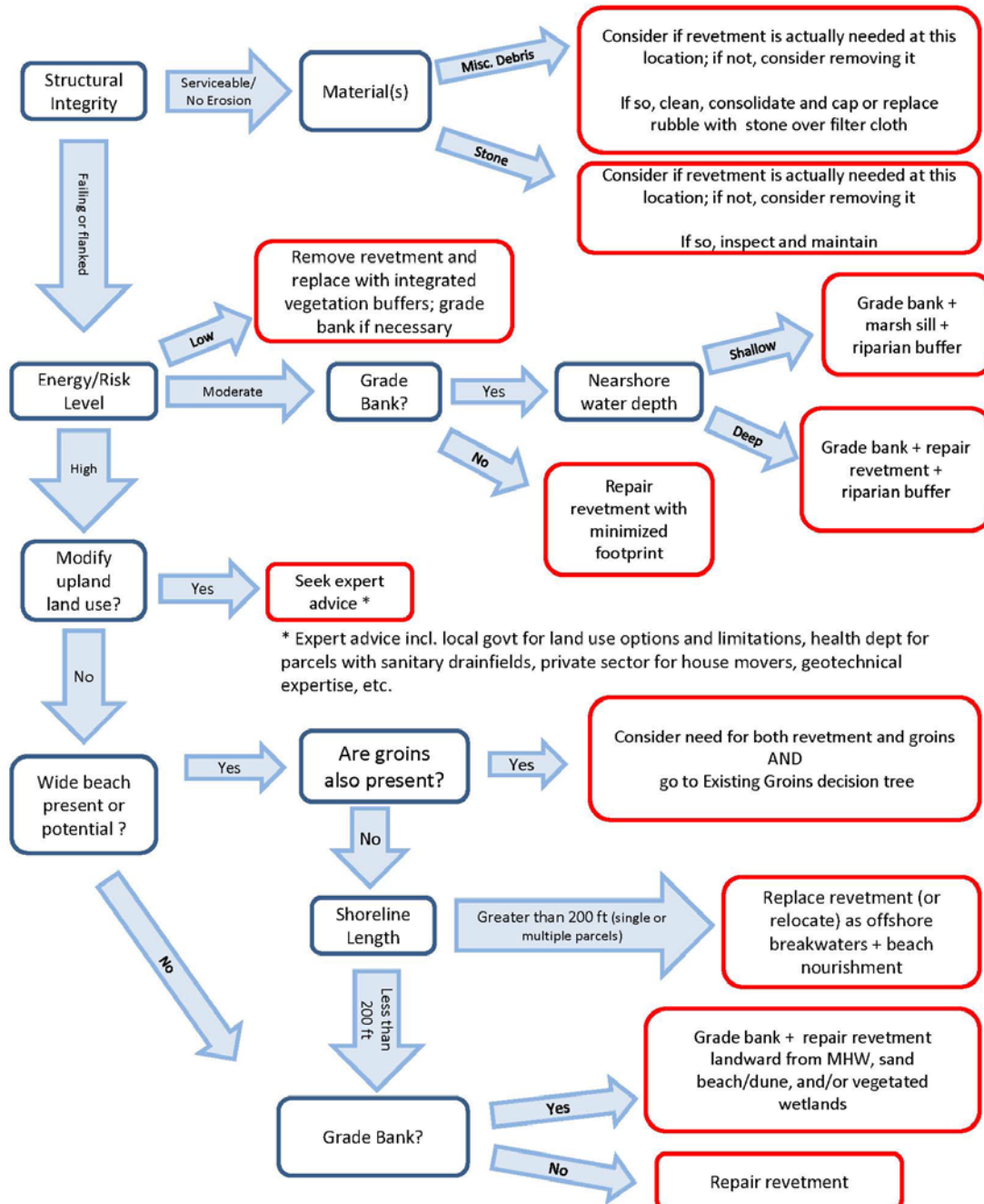
Existing Bulkheads



VIMS-CCRM Decision Tree For Currently Defended Shorelines

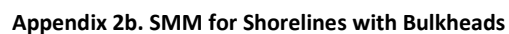


Existing Revetments



Appendix 2. Shoreline Management Model – Version 5.0

- a. SMM Flow Diagram for Undefined Shoreline
- b. SMM Flow Diagram for Shoreline with existing Bulkheads
- c. SMM Flow Diagram for Shoreline with existing Revetments





Appendix 3. Shoreline Management Model – Version 5.0 Treatment Options

Shoreline Management Model version 5 – Preferred Shoreline Best Management Practices Glossary

Defended Shoreline (Existing Bulkhead or Riprap)

Option 1. Remove structure; replace with integrated vegetation buffer, grade bank if necessary. Depending on your salinity and tidal conditions, consider living shoreline enhancements such as oysters or marsh.

Option 2. Remove structure, grade bank if possible, plant marsh with sill and enhance the riparian buffer; consider shoreline enhancement options appropriate for your setting (e.g. oyster castles).

Option 5. When grading not possible, repair structure with minimized footprint. Plant marsh with sill or other shoreline enhancement option channelward of existing structure.

Option 6. Consider need for both the structure and groins. Repair/replace groins, add beach nourishment.

Option B0. Replace bulkhead with revetment landward of bulkhead. If navigation or infrastructure limited, replace bulkhead in the same alignment or landward. Include vegetation buffers where possible.

Option B3. When grading not possible, construct bulkhead toe revetment. If navigation limited, replace structure in same alignment.

Option B4. Grade bank if possible, remove bulkhead, construct revetment landward of bulkhead alignment; restore riparian vegetation; consider a shoreline enhancement project.

Option B7. Bulkhead toe revetment; AND consider a shoreline enhancement project.

Option B8. If shoreline is less than 200 feet in length and grading possible, remove bulkhead and construct revetment landward from original bulkhead alignment; If grading not possible, construct a bulkhead toe revetment; consider shoreline enhancement strategies.

Option B9. If shoreline exceeds 200 feet in length, remove bulkhead and construct off shore breakwaters with beach nourishment; consider adding plantings to the nourished areas.

Option R0. Replace revetment landward. If navigation or infrastructure limited, replace revetment in the same alignment or landward. Include vegetation buffers where possible.

Option R3. When grading not possible, repair revetment in same alignment. If not navigation limited, consider a shoreline enhancement project.

Option R4. Grade bank if necessary, reconstruct revetment landward of alignment, consider a shoreline enhancement project.

Option R7. If shoreline is less than 200 feet in length, repair revetment with a minimized encroachment; enhance sand beach/dune, and/or vegetated wetlands; consider a shoreline enhancement project.

Option R8. If shoreline is greater than 200 feet in length, replace or relocate as an offshore breakwater or wave attenuation device with beach nourishment.

Special Areas

Ecological Conflicts. Management options for this shoreline maybe limited by the presence of Submerged Aquatic Vegetation (SAV). Seek advice from the Virginia Marine Resources Commission Habitat Management Division <http://www.mrc.virginia.gov/>

Highly Modified Area. Management options for this shoreline maybe limited due to the presence of highly developed upland or immediate infrastructure and will depend on the need for and limitations posed by navigation access and erosion control. Riparian and or marsh vegetation buffers should be included where possible. Where erosion protection is needed, revetments are preferred over bulkheads. Bulkheads should be limited to restricted navigation areas.

No Action Needed. No specific actions are suitable for shoreline protection, e.g. boat ramps, undeveloped marsh, and barrier islands.

Special Geomorphic Feature. Management of this shoreline is best suited for maintenance of the natural condition allowing for unimpeded movement of sediment and the corresponding response of the wetlands, beach and/or dune.

Undefended Shoreline

Shoreline - Tidal Wetland – Beach Areas

Groin Field with Beach Nourishment – A series of several groins built parallel to each other along a beach shoreline. Established groin fields with wide beaches can be maintained with periodic beach nourishment; repair and replace individual groins as needed.

Maintain Beach OR Offshore Breakwaters with Beach Nourishment – Preserve existing wide sand beach if present, allow for dynamic sand movement for protection; nourish the beach by placing good quality sand along the beach shoreline that is similar to the native sand.

Use offshore breakwaters with beach nourishment only where additional protection is necessary. These are a series of large rock structures placed strategically offshore to maintain stable pocket beaches between the structures. The wide beaches provide most of the protection, so beach nourishment should be included; periodic beach re-nourishment may be needed. The site-specific suitability for offshore breakwaters with beach nourishment must be determined, seek expert advice.

Maintain/Enhance/Create Marsh - Provide stabilization through marsh vegetation; the target area for marsh buffer should extend from mid-tide to an elevation 1.5 times the tide range above mean low water (the upper limit of which may be observed by the presence of upland vegetation), with wetland vegetation planted at appropriate elevations.

Preferred approaches for marsh buffer management may include one or a combination of the following: Provide or enhance wave attenuation by maintaining or widening existing marsh or planting new marsh which may require the placement of sand fill and/or fiber logs. Encourage both low and high marsh areas. Periodically monitor marsh for signs of damage and dead plants, especially after a storm and after installation. Marsh that is designed to allow for landward migration is preferred in order to accommodate sea level rise. A channelward design usually requires sand fill to create suitable elevations. Marsh management includes avoidance of using herbicides near marsh.

Along some shorelines, it may be appropriate to reduce the steepness of the bank slope to allow wave run-up and to improve growing conditions in order to sustain vegetation. Grading should only be conducted where essential and done as minimally as possible to achieve the necessary slope. Banks that are graded should be stabilized with a variety of native plants placed at appropriate elevations. The feasibility to grade a bank may be limited by upland structures, existing shoreline defense structures, and/or adjacent property conditions. In

certain cases, it may be beneficial to the tidal wetland ecosystem to remove existing structures, if possible, to achieve a properly graded and vegetated bank.

Plant Marsh with Sill – Plant tidal marsh (or maintain/widen existing marsh) and construct a rock sill placed offshore from the marsh. The site-specific suitability for a sill must be determined, including bottom hardness, navigation conflicts, construction access limitations, orientation and available sunlight for marsh plants. If existing marsh is greater than 15 ft. wide, consider placing sill just offshore from marsh edge. If existing marsh is less than 15 ft. wide or absent, consider widening marsh by grading bank landward to accommodate sea level rise and/or providing sand fill channelward to increase marsh width and/or elevation and placing sill just offshore new marsh edge.

Revetment – A sloped structure constructed usually with riprap placed against the upland bank for erosion control. The size of a revetment should be determined by the wave height expected to strike the shoreline. The site-suitability for a revetment must be determined, including bank condition, tidal marsh presence, and construction access limitations.

Upland and Bank Areas

Land Use Management. Where bank and/or shoreline approaches are extremely difficult to implement or limited in effectiveness due to existing land use conditions; reduce risk by modifying the upland land use. This may include relocating or elevating buildings, utilities, and other infrastructure and/or managing stormwater. All new construction should be located 100 feet or more from the top of bank. Actions may also include requesting zoning variances for relief from setback and other land use requirements or restrictions that may increase erosion risk.

Maintain/Enhance/Restore Riparian Buffer - Provide stabilization through maintaining, enhancing, or restoring the vegetation in the riparian buffer. The target area for riparian buffer should extend 100 feet back from the top of bank. Preferred approaches for riparian buffer management may include one or a combination of the following: Preserve existing riparian vegetation in the buffer area; manage vegetative cover by selectively removing and/or pruning dead, dying, and severely leaning trees as necessary; enhance the riparian area by planting appropriate vegetation or allowing for natural regeneration of small native trees and shrubs; replace waterfront lawns with a variety of native deep-rooted grasses, shrubs, and small trees and; remove invasive species, if present, and replace with native vegetation.

Along some shorelines, it may be appropriate to reduce the steepness of the bank slope to allow wave run-up and to improve growing conditions in order to sustain vegetation. Grading should only be conducted where essential and done as minimally as possible to achieve the necessary slope. Banks that are graded should be stabilized with a variety of native plants placed at appropriate elevations. The feasibility to grade a bank may be limited by upland structures, existing shoreline defense structures, and/or adjacent property conditions. In certain cases, it may be beneficial to the tidal wetland ecosystem to remove existing structures, if possible, to achieve a properly graded and vegetated bank.