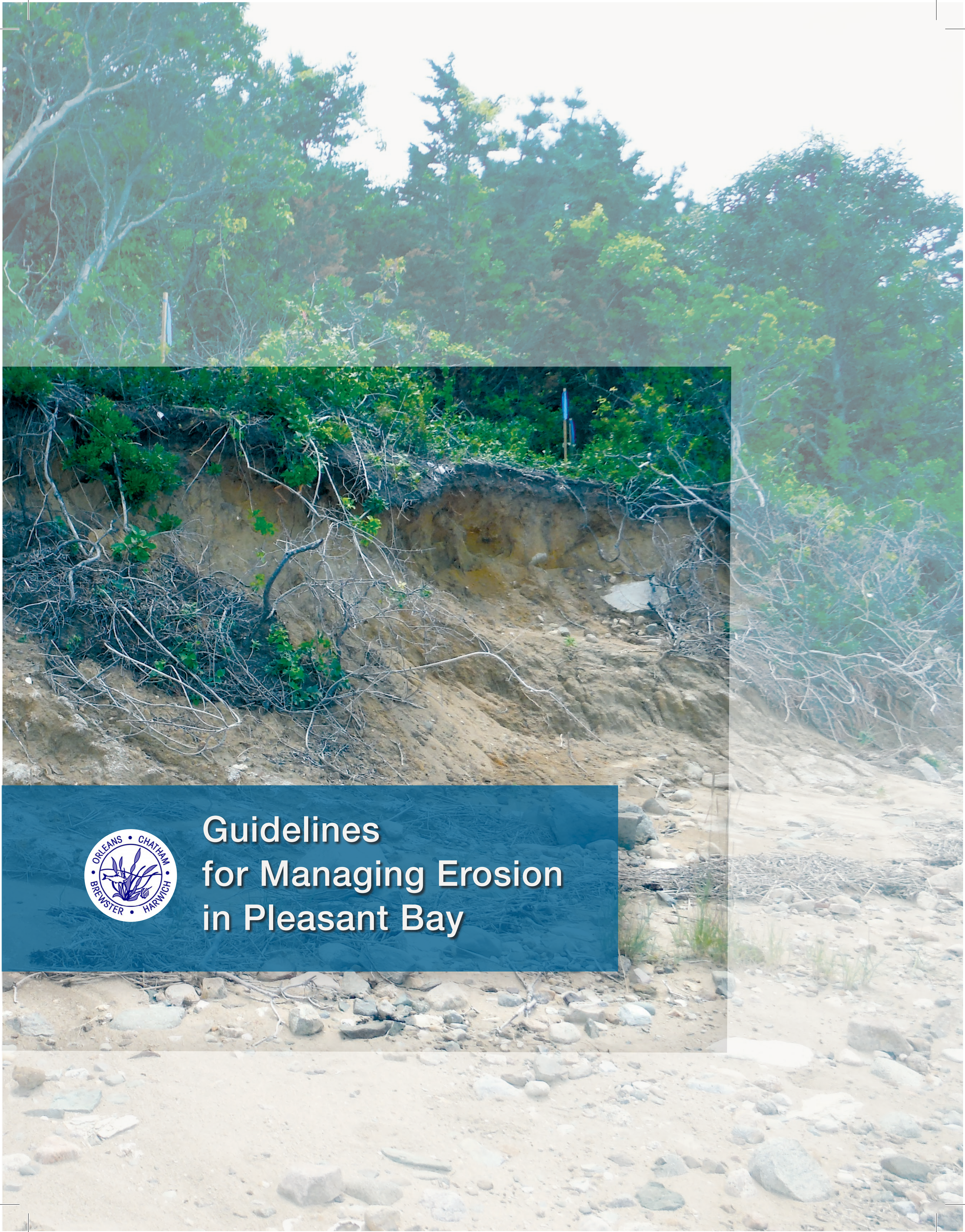

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Guidelines for Managing Erosion in Pleasant Bay

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Pleasant Bay
Alliance
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I. Introduction

The coastline is an increasingly attractive place to live. Nearly 70% of the state's population—and 100% of Cape Cod's—has chosen to live in a coastal county. There are many features that attract people to live in a coastal community: incredible beauty, diverse wildlife, and a range of recreational opportunities supported by ocean resources.

A much smaller percentage of people own property directly on the shoreline. Those who do can enjoy the benefits of coastal resources more readily than most others. However, with this enhanced access comes added responsibility, for such properties are located in a transition area between private property and public tidelands seaward of mean low water. This narrow transitional area plays a vital role in sustaining coastal landforms that provide upland storm protection and abundant habitat. Being located in this transition area results in a higher level of public oversight of shoreline activity, and also requires a higher level of vigilance and stewardship on the part of private property owners.

The increased public oversight is rooted in ancient law. In Massachusetts, state-owned coastal waters are "…impressed with a higher order of stewardship responsibility…" than applies to other public assets. This higher level of stewardship responsibility is enforced through the Public Trust Doctrine. The doctrine states that coastal waters are held in public trust, and the public has a solemn obligation to protect those interests, and "has far greater latitude in protecting societal interests than is generally the case for dry land." [1] In Massachusetts, the Public Trust Doctrine is the basis for regulations governing coastal resources. As a result, property owners face a higher degree of scrutiny and regulation with respect to activities that could infringe on or negatively impact pubic trust resources.

It is no wonder that shoreline property owners seek to protect their property from erosion caused by wind, waves, tides and storms. When coastal erosion affects shoreline property, owners may seek to install measures to slow or stop the natural process of erosion. However, measures that restrict the natural process of erosion also may result in a loss of sediment needed to sustain adjacent and downdrift beaches, marshes and dunes. In Pleasant Bay, and on all of Cape Cod, the on-going erosion and free movement of coastal sediments is necessary to preserve beaches, dunes, tidal flats and salt marshes and the ecological benefits these resource areas provide. Without the natural process of coastal erosion and deposition beaches, dunes and marshes throughout Pleasant Bay would diminish overtime.

Anyone who has spent four seasons on a coastal property knows the degree to which shorelines may change between seasons, or in the wake of a major storm event. However, the ever-changing nature of shorelines means that simple fixes or one-time measures to control erosion are not likely to succeed and may cause harm to resources or adjacent properties.[2] A strategy with a higher potential for managing erosion while minimizing impacts to coastal landforms is likely to involve ongoing management measures to protect property interests, adjacent properties, and adjacent and downdrift resources.

The process of selecting the right approach to managing private shoreline can be complex. The Pleasant Bay Alliance has prepared these *Guidelines* to assist property owners, Conservation Commissions and design professionals in the process of evaluating options for managing shoreline erosion in Pleasant Bay. The objective of the guidelines is to ensure that selected measures provide a means for property owners to manage erosion on their property while sustaining the natural process of sediment erosion, transport and deposition necessary for sustaining the health of the system.

How to Use the Guidelines

The Guidelines are intended to assist Conservation Commissions, homeowners, design professionals and other interested stakeholders in assessing alternatives for erosion management in Pleasant Bay. The Guidelines also have been submitted to the Massachusetts Department of Environmental Protection (MassDEP) for use in the review of Chapter 91 Waterways license applications in the Pleasant Bay ACEC and study area.

1 The Massachusetts Ocean Management Task Force Technical Report, p. 136, The Oceans as a Public Trust, March 2004, p. 136, http://www.mass.gov/eea/docs/czm/oceans/waves-of-change/tech-pt.pdf

2 Massachusetts Office of Coastal Zone Management Policy Guide, October 2011, http://www.mass.gov/eea/docs/czm/fcr-regs/czm-policy-guide-october2011.pdf

While the Guidelines are written to address conditions in Pleasant Bay, they reiterate and reinforce many of the protections of natural coastal processes set forth in the Massachusetts Wetlands Protection Act (WPA), the Massachusetts General Laws Chapter 91 Waterways Program, and Massachusetts Coastal Zone Management (MCZM) Policy Priorities.

The Guidelines have been developed in accordance with recommendations 7.3.3.1, 7.3.3.2 and 7.3.3.3 of the *Pleasant Bay Resource Management Plan, 2013 Update*, which was adopted by the Towns of Orleans, Chatham, Harwich and Brewster, and the Massachusetts Executive Office of Energy and Environmental Affairs. The Guidelines are intended for the Pleasant Bay Area of Critical Environmental Concern (ACEC) and management area, but may be applicable to other shoreline areas.

Erosion control structures located within the boundaries of the ACEC below mean high water may be subject to the existing Categorical Restriction on new Chapter 91 licenses issued by MassDEP (310 CMR 9.32 (1)(e).) Once guidelines and performance standards are completed in accordance with 7.3.3.1, adopted into regulation by the respective towns and approved by the state, they will replace the Categorical Restriction and provide guidance to DEP in issuing Chapter 91 licenses for such structures. Until then, DEP may apply regulatory discretion provided for in 310 CMR 9.3.2 (2) in its review of applications for Chapter 91 licenses for erosion control structures in the ACEC.

Following this introduction, the Guidelines are organized into the following sections:

- Section II describes the regulatory protection of natural coastal processes provided by state and local regulations and policies;
- Section III describes the predominant coastal processes that occur in Pleasant Bay, and the beneficial functions of coastal landforms and the free movement of sediment along the shoreline;
- Section IV describes alternative approaches to managing shoreline erosion, including hard and soft alternatives;
- Section V describes planning guidelines for selecting the appropriate measure or combination of measures to manage shoreline erosion;
- Section VI provides design guidance that should be incorporated once the appropriate approach to erosion management is selected from among alternatives;
- Section VII, VIII and IX provide a glossary of terms, sources used to develop the guidelines, and appendices, respectively.

II. Regulatory Protection of Natural Coastal Erosion

Coastal shorelines are dynamic systems subject to the constant influences of tides, waves, storm and tidal surges, currents and winds. These natural forces move coastal sediments, particularly from eroding coastal banks and dunes, in a process commonly referred to as erosion. Eroded sediments are then transported by wind, waves and currents and are deposited on beaches, dunes, marshes or offshore in a process referred to as deposition. Sand erosion, transport and deposition are key functions of a healthy coastal system.

Unlike some other coastal environments, the coast of Cape Cod does not receive a steady supply of sediments from a river discharging from a large watershed. Cape Cod's coastline is made up of glacial outwash deposits, sediments left at the terminal ends of glaciers or deposited by streams that flowed away from melting glaciers thousands of years ago. Like much of Cape Cod, glacial deposits surrounding Pleasant Bay form broad, gently sloping plains. Over thousands of years, rising sea levels have reworked the glacial sediments to form beaches, dunes and other coastal resources. The glacial sediments stored in coastal banks represent a fixed supply of material available to continuously feed beaches, dunes and other coastal resources. The ongoing erosion of coastal banks is a critical part of this feeding process.

Definition of Resource Affected by Coastal Erosion, Transport and Deposition

In Pleasant Bay, the primary coastal landforms affected by sediment erosion, transport and deposition include coastal beaches, coastal dunes, coastal banks, tidal flats and salt marshes. The state Wetland Protection Act (WPA) defines and differentiates the beneficial functions provided by these coastal resources:

Coastal Beaches are unconsolidated sediments subject to wave, tidal and coastal storm action which forms the gently sloping shoreline to a body of water. Coastal beaches extend from the mean low water line landward to the dune line, coastal bankline or the seaward edge of existing human-made structures, when these structures replace one of the above lines, whichever is closest to the ocean. ***Coastal beaches, which are defined to include tidal flats, are significant to storm damage prevention, flood control and the protection of wildlife habitat. In addition, tidal flats are likely to be significant to the protection of marine fisheries and where there are shellfish, to land containing shellfish.***

Coastal Dune means any natural hill, mound or ridge of sediment landward of a coastal beach deposited by wind action or storm overwash. Coastal dune also means sediment deposited by artificial means and serving the purpose of storm damage prevention or flood control. ***All coastal dunes are likely to be significant to storm damage prevention and flood control. In addition, all coastal dunes on barrier beaches and the coastal dune closest to the coastal beach, also known as the Primary Frontal Dune as defined in 310 CMR 10.04, are per se significant to storm damage prevention. Coastal dunes are also often significant to the protection of wildlife habitat.***

Coastal Bank means the seaward face or side of any elevated landform, other than a coastal dune, which lies at the landward edge of a coastal beach, land subject to tidal action, or other wetland. Coastal banks are likely to be significant to storm damage prevention and flood control. ***Coastal banks that supply sediment to coastal beaches, coastal dunes and barrier beaches are per se significant to storm damage prevention and flood control. Coastal banks that, because of their height, provide a buffer to upland areas from storm waters are significant to storm damage prevention and flood control.***

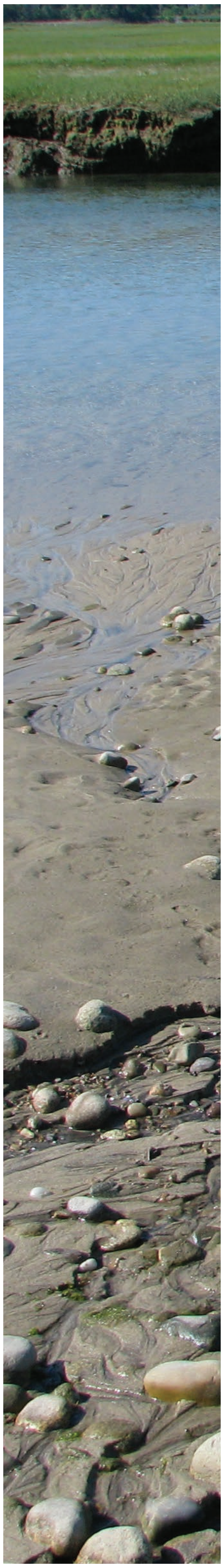
Salt Marsh means a coastal wetland that extends landward up to the highest high tide line, that is, the highest spring tide of the year, and is characterized by plants that are well adapted to or prefer living in, saline soils. Dominant plants within salt marshes typically include salt meadow cord grass (Spartina patens) and/or salt marsh cord grass (Spartina alterniflora), but may also include, without limitation, spike grass (Distichlis spicata), high-tide bush (Iva frutescens), black grass (Juncus gerardii), and common reedgrass (Phragmites). A salt marsh may contain tidal creeks, ditches and pools. ***Salt marshes are significant to protection of marine fisheries, wildlife habitat, and where there are shellfish, to protection of land containing shellfish, and prevention of pollution and are likely to be significant to storm damage prevention and ground water supply.***

Regulatory Protection of Natural Coastal Erosion

The significant ecological benefits and public interests associated with natural sediment erosion, transport and deposition are the basis for the state and local regulation intended to protect the functioning of coastal dunes, banks, marshes and beaches. These regulations are summarized below.

- **Massachusetts Wetlands Protection Act (WPA)** (310 CMR 10.30) seeks to sustain the natural functions of coastal landforms and protect the natural process of eroding coastal banks: *"Coastal banks composed of unconsolidated sediment and exposed to vigorous wave action serve as a major continuous source of sediment for beaches, dunes, and barrier beaches (as well as other land forms caused by coastal processes). The sediment is removed from banks by wave action, and this removal takes place in response to beach and sea conditions. It is a naturally occurring process necessary to the continued existence of coastal beaches, coastal dunes and barrier beaches which, in turn, dissipate storm wave energy, thus protecting structures of coastal wetlands landward of them from storm damage and flooding."* Therefore, any structure on a coastal bank or within 100 feet landward of the top of a coastal bank, unless it is protecting a building constructed before August 10, 1978, *"shall not have an adverse effect due to wave action on the movement of sediment from the coastal bank to coastal beaches or land subject to tidal action."*
- **Massachusetts Waterways Program (Chapter 91)** protects the public's interest in tidelands in accordance with the public trust doctrine codified in the Colonial Ordinances of 1641-47 and subsequent statutes and case law of Massachusetts. The public trust doctrine holds that tidelands seaward of the high tide line are *"held in trust for the common benefit of the public, for commerce, fishing, and other activities in which all citizens were free to engage."* [3] Therefore, any activity or structure located seaward of mean high water requires a Chapter 91 license. Erosion control structures located below mean high

3 The Massachusetts Ocean Management Task Force Technical Report, p. 136, The Oceans as a Public Trust, March 2004, p. 136. http://www.mass.gov/eea/docs/czm/oceans/waves-of-change/tech-pt.pdf



water within the ACEC may be subject to a categorical restriction. This means that MassDEP would not issue a new license for private fill or structures in the ACEC unless the license for fill or structure is consistent with a resource management plan approved by the towns and the state (310 CMR 9.32). However, MassDEP may issue a license for shoreline stabilization or rehabilitation of an existing structure *"provided that reasonable measures are taken to avoid, minimize, and mitigate any encroachment in a waterway." (310 CMR 9.3.2(2))*

- **Massachusetts Coastal Zone Management (MCZM)** – The application of the WPA and Chapter 91 must be consistent with MCZM policies. The MCZM Policy Guide calls for preserving the natural process of sediment erosion and deposition, and avoiding use of coastal engineered structures, which interfere with these processes and could diminish public trust rights. In reviewing projects for consistency with MCZM policies, *"Priority emphasis will be placed on first considering non-structural measures, such as dune, beach, and/or coastal bank nourishment, to preserve and restore the natural protective functions of coastal landforms and processes. Structural measures will be allowed only following an alternative analysis of hazard mitigation techniques that conclusively determines that no non-structural alternative is feasible."* The policy goes on to refer to coastal engineered structures (CES) as "expensive short term solutions, which frequently exacerbate problems elsewhere along the coast and foster a false sense of security." On the other hand, properly designed and constructed non-structural measures, *"such as beach and coastal bank nourishment, dune rebuilding, and stabilization by vegetative plantings, can closely simulate natural coastal processes and provide effective buffers against storm forces. These measures are generally substantially less expensive than engineered structures, are aesthetically more compatible with natural landforms, and avoid or minimize the creation of adverse effects on adjacent or downcoast areas. Therefore, non-structural alternatives should be favored over structural measures where feasible."*

Local Conservation Bylaws and Regulations in each of the four Pleasant Bay Alliance communities are intended to protect the wetlands, related water resources and adjoining land areas in the Town by controlling activities deemed by the Conservation Commission to have an impact or cumulative effect upon wetland values. Local bylaws can vary in their treatment of coastal structures, but may not be less stringent than requirements set forth in the state WPA. These guidelines are intended to provide a set of common policies Conservation Commissions can refer to when reviewing erosion management options in Pleasant Bay. In granting permits Conservation Commissions are responsible for ensuring the protection of public interests as defined by the WPA and local bylaws and regulations.

III. Natural Coastal Erosion Processes

Along most of the Pleasant Bay shoreline, tide-generated currents and wind-generated waves comprise the primary forces for moving sediments. The effect of these forces varies throughout the system, from the relatively straight, smooth outer shoreline, to inner estuarine areas where multiple islands break up the force of wind, waves and currents, resulting in an irregular coast. The natural variability in shoreline type influences how a particular shoreline stretch responds to the long-term effects of waves and tides, as well as the less frequent, short-term influence of periodic storm waves and surges.

Most of the wave energy that reaches the shoreline of Pleasant Bay originates within the Bay, from seasonally variable winds acting on the water surface. The intensity of wind-generated waves on the interior shoreline of Pleasant Bay depends on other factors, such as bathymetry (water depth) and fetch (distance wind travels over water). Generally, the forces of erosion are strongest during the winter, with prevailing northwest winds, higher wind speeds and more frequent storms. These erosional forces can be compounded in some areas of the Bay due to the formation of ice. The formation of ice can both protect and reduce coastal erosion during storm events, or can increase erosional forces due to ice scour. Relatively less erosion occurs during the summer, which is characterized by lower wind speed and predominantly southwest winds. The result of seasonal variation in wind direction and intensity is generally visible in the elevation of beaches, which tend to be lower in the winter and higher in the summer. This seasonal fluctuation in beach profile is an important consideration in the evaluation of erosion management measures.

Tides within Pleasant Bay and Chatham Harbor are semi-diurnal (two tidal cycles per day). The distance between high and low tide, referred to as tide range, varies greatly throughout the system, with an average range of approximately six (6) feet in Chatham Harbor, and approximately four (4) feet at Meetinghouse Pond in Orleans.

These tides are produced by the open continental shelf (Gulf of Maine) tides which, as they rise and fall, cause seawater to flow into and out of the estuary through the North inlet (formed in 2007) and the South inlet (formed in 1987). From time to time the Alliance undertakes studies to assess trends in tidal dynamics (Giese 2012 and 2015), shoreline change (Borelli, 2009), and migration of the barrier beach and inlet system (Giese, 2010 and Berman, 2015). The Alliance also commissioned a study of the impact of sea level rise on the Nauset barrier beach and inner shoreline of Pleasant Bay (Borrelli et al, 2017).

Highlights of these studies include:

- The barrier beach and inlet follow an approximately 150-year cycle of inlet formation and migration. In this cycle, a single dominant inlet would replace the current dual inlet system within a decade or two, and begin a southerly migration within another decade.
- As the southern inlet loses hydraulic efficiency and the Nauset barrier beach migrates to the south, North Beach Island is expected to continue to deteriorate and sediment from it is expected to move landward.
- Tide data from 2005 through 2016 taken from Meetinghouse Pond in Orleans and Chatham Fish Pier compared with outside Boston tides, is beginning to show a declining tide range throughout Pleasant Bay. This suggests that greater friction due to shoaling in southern Chatham Harbor is restricting tidal exchange at the south inlet, while the north inlet is becoming the dominant inlet.
- At the present time MLW elevations vary throughout the system, while mean high water level elevations seem to be relatively uniform throughout Pleasant Bay. Tide range in southern Chatham Harbor is decreasing, while in Pleasant Bay tide range seems to be similar to what it was before the 2007 break.
- Under projected rates of sea level rise, the barrier beach and inlet system will remain intact, but with a different configuration and rate of inlet formation and evolution than has been exhibited over the past 150 years. The inner shoreline of Pleasant Bay may lose a quarter to a half of its 392 acres of landside intertidal resource area through the end of the century. Installation of Coastal Engineering Structures to prevent the inland retreat of intertidal resources, such as salt marsh and tidal flats, would lower the elevation of an eroding beach by denying sediment input and reflecting wave energy, which increases the rates of erosion along the front and downdrift areas adjacent to these structures.

These studies underscore the dynamic nature of the system, while some provide informed assessments of future conditions. The inner shoreline, barrier beach and inlets of today will be very different in 10, 20 or 50 years. Plans to manage shoreline erosion need to factor in the best information available about likely trends and future conditions.

Types of Sediment Transport in Pleasant Bay

Wind, waves and tides combine to move sediments in various ways, depending on the characteristics of a given area of shoreline. The process of sediment movement or transport is constant. When the amount of material freely available to be moved by these forces is insufficient, erosion occurs. Coastal bank and dune erosion is often caused by direct wave action at the base of the bank or dune, followed by the slumping of material along the face of the bank. Barrier beach overwash occurs when a beach or dune crest is over-topped and sediment is carried down the backside of the dune.

The movement of sediment can be parallel to the shore, perpendicular to the shore, or both depending on the force behind it.

Most sediment transport in Pleasant Bay and Chatham Harbor is characteristic of longshore transport or tidally induced transport, which carry sediments parallel to the shore. **Longshore transport** occurs when waves breaking at an angle on the shore create a longshore current strong enough to suspend and carry sediments. **Tidally induced transport** is most prevalent near inlets or narrow, constricted channels, where tidal currents are strong enough to move sediments and shape beaches adjacent to the inlet.

Cross-shore transport, or the on-shore/off-shore movement of sediment, is an example of sediment movement perpendicular to the shore. A winter beach is an example of cross-shore transport where sediment is moved off-shore due to higher energy waves, while the summer beach shows the cross-shore transport where sediment is moved on-shore.

Aeolian transport occurs when winds are strong enough to blow sand from a beach or dune where it is deposited on another landform, and can carry sediments either parallel or perpendicular to the shoreline.

While the dominant littoral flow of sediment on the outer shoreline is consistently north to south, the direction of transport along the irregular interior shoreline of Pleasant Bay varies depending on fetch distance, wave direction, and orientation of the landform.

The constant movement of sediment throughout the Pleasant Bay system by these forces helps to sustain the beaches, dunes, marshes and tidal flats that make Pleasant Bay the uniquely beautiful and environmentally significant place that it is.

IV. Alternative Approaches to Managing Coastal Erosion

The challenge of responsible erosion management is to increase the resilience of the property while not negatively affecting the functioning of coastal landforms and the processes of sediment erosion, transport or deposition essential for healthy coastal resource areas. The wide range of alternative approaches to managing coastal erosion is generally grouped into two categories: hard or soft.

Hard and Soft Approaches

Whether an approach is considered hard or soft depends on its impact on the natural coastal system. However, drawing a distinct line between hard and soft alternatives is not always easy.

Hard approaches are often referred to as coastal engineered structures (CES). Common types of CES' are revetments, bulkheads, sea walls, groins or gabions. CES' are designed to prevent the process of sediment erosion, transport and deposition. CES' are structures typically made of rigid material such as stone, metal or wood. Hard structures restrict sediment movement and are considered to have a greater impact on natural coastal processes. In Massachusetts, CES' may be allowed on coastal banks where the building for which protection from storm damage is sought was built before August of 1978, and are prohibited on beaches (unless provided under 310 CMR 10.30(3)), barrier beaches, dunes or salt marshes. (310 CMR 10.30(3)) See Guideline 3, *Eligibility*.

Soft alternatives include measures such as vegetation, beach nourishment, sand fencing, or fiber rolls. Soft measures are designed to slow erosion and allow some sediment release during episodic storm events. For this reason, soft approaches have relatively less impact on coastal processes. Some techniques that have been considered "soft" are becoming increasingly fortified in their design. Fortified "soft" applications can function essentially as "hard" and could result in impacts similar to a CES.

In practice, very few projects employ only one method of erosion management, and often a successful approach will combine multiple methods. In cases where multiple measures are installed, the assessment of impact on natural coastal processes should focus on the hardest element. So-called hybrid approaches seek to combine a CES with one or more soft measures. The potential benefits and impacts of a hybrid approach have yet to be fully evaluated.

A proliferation of CES' diminishes natural sediment movement to the detriment of fronting or downdrift beaches, flats, dunes, and marshes.

Impacts of Hard Structures or CES'

A shorefront property owner alarmed by a loss or retreat of shoreline following a storm event often may seek to install a CES to prevent future erosion. However, a proliferation of CES' diminishes natural sediment movement to the detriment of fronting or downdrift beaches, flats, dunes, and marshes.

A CES is often an owner's preferred approach to protect a pre-August 1978 building because it appears to offer the greatest long-term protection. The purpose of a CES is to prevent erosion of sediments from coastal banks. By preventing erosion of coastal banks, CES' diminish the supply of sediments available for nourishment of beaches and salt marshes. A CES reflects wave energy in ways that can negatively affect adjacent or downdrift beaches and properties. CES' increase turbulence associated with breaking waves and wave energy. The increased turbulence can result in a loss of sediment in the front of the structure, and loss of the dry frontal beach. Another result of increased turbulence is a worsening of erosion at the terminal ends of a structure, causing "end-scour" and erosion of adjacent properties. When eroding beaches at the base of a revetment, sea wall or other CES are not adequately re-nourished with sand fill, fronting beaches can be lost. Periodic re-nourishment can minimize impacts from a CES, but can never fully mitigate the function of a naturally eroding coastal bank. Erosion can never be completely stopped, only displaced. While property upland of a CES is protected, the fronting or downdrift beach experiences accelerated erosion due to a depletion of sediment supply. The result is loss of dry beach at some or all levels of tide and, in some cases, complete loss of the intertidal area. Lateral pedestrian access is also lost, along with the habitat and storm prevention functions of the beach.

Within Pleasant Bay there is ample evidence that the installation of CES' has contributed to the loss of beach elevation and salt marsh. These areas, which include public beaches and other access points, are experiencing a transition from sandy to stony beaches and loss of vegetation, lack of sediment input, and resulting in the lowering or complete removal of the beachface. There are also examples where hardening has caused negative impacts to adjacent properties. Soft applications are generally preferred because they are inherently better at preserving the functions of the natural landform and the movement of sediment needed for surrounding natural resources.

Within Pleasant Bay there is ample evidence that the installation of CES' has contributed to the loss of beach elevation and salt marsh.

Only select properties are eligible for a CES. Eligible projects are required to demonstrate that the building the CES is designed to protect is vulnerable to storm damage, and must submit an alternatives analysis to demonstrate that the proposed CES is the only feasible method of protecting the building. In practice, alternatives analyses provided to support an application for a CES often consist of a cursory listing of alternatives with little or no site specific performance information. As a result, Conservation Commissions are left in a position to review proposals for a CES without the benefit of a thorough assessment of alternative approaches to avoid, minimize or mitigate project impacts, as required under the WPA and MCZM policies. Guideline 6 (below) outlines a thorough approach to conducting an alternatives analysis.

The definition of building in the WPA is vague, however it should not be overextended to include lawns, pools, or patios, etc. Relevant sections of the WPA are below:

- (310 CMR 10.30 (3)) "(3) No new bulkhead, revetment, seawall, groin or other coastal engineering structure shall be permitted on such a coastal bank except that such a coastal engineering structure shall be permitted when required to prevent storm damage to **buildings** constructed prior to the effective date of 310 CMR…including **reconstructions** of such buildings…"
- (310 CMR 10.23) "**Building** means any residential, commercial, industrial, recreational or other similar **structure**. For the purposes of 310 CMR 10.00, building may be interpreted to include a large, substantial structure such as a utility tower."

The bold text indicates key points which can be supplemented by some common definitions (i.e. Merriam-Webster Dictionary: "Building – a structure…with a roof and walls that is used as a place for people to live, work, do activities, store things, etc." and the Cambridge Dictionary: "Building - a structure with walls and a roof, such as a house or factory, to give protection to people, animals, or things"). Basically, a building has 4 walls and a roof. For example an indoor pool/spa could possibly qualify for protection as a recreational building under the 310 CMR 10.30 (3), however a standard outdoor pool/lawn/patio is not a building and would not qualify as something that can be protected by a CES.

It should also be noted that the WPA conveys pre-1978 status to "reconstructions of such buildings", however nowhere in the WPA is the word "reconstruction" defined. Some towns allow complete tear-down rebuilds to be considered "reconstruction" of a pre-1978 building, while some Pleasant Bay towns have taken it upon themselves to more narrowly define "reconstruction". Other towns may also want to define the word to ensure consistency between projects. The Town of Orleans defines "reconstructions" as follows:

- Orleans 196A-4. Definitions: "Reconstruction" shall mean alteration and rebuilding of up to 25% of the structure, measured by square footage of the foundation, or cubic footage of the structure. Alteration and rebuilding of over 25% of the structure shall be considered new construction.

V. Guidelines for Evaluating Approaches to Erosion Management

Due to the diversity of physical conditions throughout the Pleasant Bay system, a thorough assessment of site conditions, applicable regulatory performance standards, and feasible project alternatives is necessary in order to select the optimal approach to shoreline stabilization.

The following guidelines reflect the requirements of the WPA Notice of Intent (NOI) (310 CMR 10.00). Massachusetts Home Rule enables municipal to adopt regulations and bylaws that are stricter than state laws. Accordingly, some Alliance member towns have adopted aspects of local wetlands protection bylaws and regulations that are more stringent than the WPA.

The guidelines also ensure the availability of information and analysis needed by Conservation Commissions to allow them to undertake a thorough evaluation of erosion management measures.

Guideline 1: Determine Resource Areas Effected

One of the first issues that must be addressed with any proposal for shoreline erosion control is the delineation of resource areas. The delineation of resource areas is needed to determine the appropriate performance standards to be applied in reviewing the proposal.

In some cases resource delineations are very clear. However, in transition areas, such as between beach and dune and between dune and bank, or the determination of the top of coastal bank, the delineation may not be readily obvious and may be subject to different interpretations. Applicants are required to furnish Commissions with ample information or consultant support to make the appropriate delineation.

Resource delineations should identify all resources on the site and take into consideration:

- Topography.
- Mean High Water, Extreme High Water, Mean Low Water: how frequently the average high tides reach the toe of a dune or bank and the width of the dry beach are important factors to note in determining resource areas.
- Vegetation: is the vegetation sparse, dense, herbaceous or woody. Are the type of plants present invasive or native, salt-tolerant species?
- Soil conditions: what type of soils are present on site.
- Whether the resource is a primary or secondary dune; or a coastal bank that serves as a sediment source, a vertical buffer or both.
- Coastal flood plain delineation and anticipated impacts (velocity zone, Coastal A Zone (as differentiated from the rest of the AE Zone by the Limit of Moderate Wave Action) or regular AE zone); Is the floodplain delineation based on elevation or scaling? For more information on these zones and how to determine delineation techniques, see Interpreting Federal Emergency Management Agency Maps and Studies on the Coastal Zone.
- Steepness of bank, if present; is the lower section of the bank over-steepened by erosion?
- Has the top of bank, if present, been determined using the slope criteria defined by MassDEP Wetlands Program Policy 92-1: Coastal Banks (See Appendix A).
- How high is the toe of bank above the mean high water line and highest high tide line?
- Existing beach profile; how does this compare to adjacent areas? Is it steeper or more gradually sloping? Sandier or more gravelly?
- Determine if the project is near endangered species habitat and in or adjacent to: Shellfish Beds, Salt Marsh, Vegetated Shallows, Spawning Areas, or Rocky Sub-tidal Habitat. If so, assess potential impacts and confer with Massachusetts Division of Marine Fisheries and/or Natural Heritage and Endangered Species Program.

An applicant may provide information to assist the Conservation Commission in making a determination of resource delineation. However, the Conservation Commission is solely responsible for establishing resource delineations.

In making the determination the Commission is advised to:

- Visit the site;
- Consider information provided by the applicant;
- Obtain information and technical assistance on resource delineations from Massachusetts Coastal Zone Management and from the Barnstable County Extension Service Coastal Processes Specialist, as needed.

In case of an unresolved question about delineation, the Commission may hire, at the cost of the applicant, a third party consultant of the Commission's choosing to assist with the delineation.

Once resource areas are delineated, then it is possible to evaluate project eligibility and appropriateness, if a CES is proposed, and determine relevant performance standards that need to be met.

Guideline 2: Coastal Bank is Presumed to be a Sediment Source

Coastal Banks can serve as a sediment source and as a vertical buffer. In Pleasant Bay, all Coastal Banks that have fronting Coastal Beach should be presumed to serve as a sediment source. This presumption may only be overcome by a preponderance of evidence provided by an accredited professional that the Coastal Bank only serves as a vertical buffer even if the presumption is overcome it is not considered to be permanent. Instances where coastal banks serve only as a vertical buffer are rare, and would be evidenced by lack of fronting or adjacent beach, and presence of extensive mature marsh fronting the vertical buffer. There is no minimum amount of sediment that a bank must provide to be considered a sediment source.

Guideline 3: If A CES is Proposed, Determine Eligibility

It is recognized that a CES will have an impact on coastal processes. Dunes and beaches are ephemeral landforms that naturally migrate in response to coastal processes. Therefore, a CES is prohibited on a dune or beach, and only properties meeting specific criteria are eligible for a CES provided they meet performance standards set forth under the state WPA (310 CMR 10.30(3)).

Properties with buildings on coastal banks built before August 1978 that are threatened by storm damage are eligible to apply for a CES, but must be able to demonstrate that they meet performance standards:

- The CES is designed and constructed to minimize, using best available measures, adverse effects on adjacent or nearby coastal beaches, coastal banks and salt marshes, due to changes in wave action;
- The applicant demonstrates that no method of protecting the building other than the proposed CES is feasible.

This provision does not apply to lawn areas, pools, patios, flagpoles, roads, and other structures that are not considered buildings. Any of these types of structures, or any building built after August 10, 1978, including a residential dwelling or accessory building, is not eligible for a CES if the coastal bank is serving as a sediment source, and *"shall not have an adverse effect due to wave action on the movement of sediment from the coastal bank to coastal beaches or land subject to tidal action."* (310 CMR 10.30(4))

Pre-August 1978 buildings that are substantially renovated or rebuilt after August 10, 1978 may not qualify for grandfathering under local wetlands protection regulations. Some towns have defined standards for what is considered a substantial renovation or reconstruction and, therefore, ineligible for a CES.

Guideline 4: Identify the Appropriate Regulatory Performance Standards

WPA Regulations contain performance standards for activity within wetland resource areas. As described in Appendix B, the resource areas commonly affected by erosion control activities in the Pleasant Bay system are dune, coastal bank, coastal beach/tidal flats, and salt marsh. Once the resource delineation is established, it is possible to identify the appropriate performance standard to apply.

The performance standards ensure that the benefits of natural sediment flow, so important to healthy coastal systems, are not interrupted. The performance standards also provide the measure against which options for shoreline erosion control should be evaluated.

Any coastal bank that is a source of sediment to adjacent beaches intrinsically plays a role in storm damage prevention. Case law has determined that the question of significance of a sediment source is whether it "plays a role" in storm damage prevention and does not hinge on the volume of sediment eroding or feeding the adjacent beach, direction of transport, or duration on a beach since these conditions can change over time due to numerous factors.

Guideline 5: Evaluate Site Characteristics and Relation to System-wide Processes

A site assessment incorporates the resource delineation with other pertinent information needed to assess a proposal for erosion management. The site characteristics of interest include:

- Delineation of mean high and mean low water (state and federal agencies may require additional water level delineations, if applicable).
- Current bathymetry at subject area.
- Wave energy and fetch (more often than not, the longer the fetch, the higher the wave energy). Is it in an embayment, estuary, pond, or open ocean?
- Which way does the site face? Is it exposed to northeasters (our most frequent storms)?
- Sediment transport processes and direction, noting that both dominant and non-dominant direction of transport are relevant. Signs of sediment transport include accumulation of sediment on the updrift side of groins, bulkheads or other structures.
- Updrift, downdrift considerations– what will be possible impacts to adjacent properties and resource areas (e.g., shellfish beds, eelgrass, salt marsh and other habitat). Is there an existing CES on the adjacent property? If yes, how does the proposed project tie into it? If not, how will the proposed project effect erosion and wave energy on the adjacent site?
- Type of soils (e.g., grain size, consolidated v unconsolidated).
- Erosion – history, causes, rate, volume lost annually. Look at long term and short-term data available through the **CZM Shoreline Change Project**, as well as any data provided by the applicant.
- Distance of building (constructed prior to 1978) from top of coastal bank.
- Coastal flood plain delineation and anticipated impacts (velocity zone, Coastal A Zone or regular A zone). How high is the FEMA flood zone elevation above the existing ground elevation (i.e. how much water and waves will be flowing across the site in a storm?
- Steepness of lower and upper bank relative to surrounding banks; are there any sections that are over-steepened (possibly unstable)?
- Is there any evidence of upland runoff that may be contributing to erosion?

A key consideration in a site assessment is the role it plays in the larger coastal system. Applicants should provide information that shows how their property functions in relation to the larger system of beach, bank, dune or marsh. Conservation Commissions should consider information provided by the applicant in the context of the larger system of which the subject property is a part, and of cumulative impacts of erosion management within the system.

Guideline 6: Alternatives Analysis

All of the information garnered from guidelines 1 through 4 provides the preparation needed to conduct a thorough assessment of erosion management alternatives. An alternatives analysis should be required for the repair and reconstruction of existing erosion management measures as well as for new measures.

A thorough alternatives analysis should discuss each erosion management method in terms of feasibility, environmental effect, and impact on adjacent and down drift properties. Woods Hole Sea Grant and Cape Cod Cooperative Extension have produced a tool that can assist with the assessment of alternatives to manage coastal erosion. The *Spectrum of Erosion Control Methods* (Appendix B) presents a list of alternatives to managing erosion that range from those that cause the least interruption of natural sediment movement, to those that have the greatest potential to interrupt sediment movement.

4. Dealing With Erosion: The Spectrum of Coastal Erosion Control Methods, by Greg Berman, June 2015.

Using this approach, the assessment of alternatives begins with measures that have little or no interference with natural coastal erosion, such as planting vegetation, landward relocation of a structure, or beach nourishment. A next level of measures involve structures made of biodegradable materials that slow but do not stop erosion, including sand fencing, fiber rolls or coir envelopes. Beyond these measures are CES' which involve hardened structures designed to prevent erosion. These measures range from sand bags, rock filled gabions, revetments, sea walls or jetties.

"By starting at the top of the spectrum and addressing each method until a feasible alternative is reached, the applicant can show full diligence that all options that have lower potential impact have been examined. A good alternatives analysis should discuss each method in terms of feasibility, environmental effect, and impact on adjacent and downdrift properties." [4]

The Alliance strongly recommends that the local and state permitting agencies with jurisdiction in Pleasant Bay require use of the spectrum as a framework for a comprehensive alternatives assessment, to ensure that erosion management methods provide the least interruption with natural sediment movement.

VI. Design Guidance for Erosion Management Measures

Many site specific and system-related factors must be evaluated to determine the appropriate design of an erosion management system. The following design guidelines provide minimum Best Management Practices that should be augmented based on further site evaluation and system conditions and based on the Conservation Commission's best judgment. By no means is this a complete list of every potential type of erosion management, however it is anticipated that the majority of proposed projects will make use of one or more of the methods listed below.

As noted under Guideline 1 above, in all cases determine if the project is near endangered species habitat and in or adjacent to: Shellfish Beds, Salt Marsh, Vegetated Shallows, Spawning Areas, or Rocky Sub-tidal Habitat, or other sensitive marine resources. If so, assess potential impacts and confer with Massachusetts Division of Marine Fisheries and/or Natural Heritage and Endangered Species Program. In addition, the design of structures must meet all requirements for accommodating public access, as required under Chapter 91 and local bylaws.

Mitigation

Fronting and downdrift coastal resource areas may experience exacerbated erosion from CES (aka Hard Approaches) projects and, to a lesser degree, even some non-CES (aka Soft Approaches). Typically all CES projects will need some form of mitigation. Whenever a project slows or displaces erosion there may potentially be a need for compensatory nourishment as mitigation. The four main needs for compensatory nourishment to mitigate for projects that affect erosion are to:

- Make up for any reduction in sediment available for downdrift beaches (i.e. annual volume) due to the slowing or stopping of the coastal bank erosion. Careful thought should be given to what direction sediment moves when examining this project in order to make sure that sediment isn't deprived from an area that needs it. Standard annual compensatory nourishment can be calculated by multiplying the erosion rate, by the existing landform height and length to get a volume.
- Upon review of an NOI for repair or reconstruction of an existing erosion management measure, Commissions should consider the need for compensatory sand nourishment whether or not this mitigation was required under the previous permit.
- Address the fronting beach, immediately adjacent to the proposed structures (i.e. trigger volume). This is so that the beach in the vicinity of the project does not drop and change the coastal processes of the nearby area.
- Provide protection to the installed structure if required by design.

The applicant's proposal should adequately address how each of the three nourishment needs are met, and these nourishment requirements should be incorporated into the Order of Conditions and Certificate of Compliance as an ongoing requirement in perpetuity. The timing and use of machinery for beach nourishment should ensure that resource areas are protected at all times.

Soft Approaches [5]

Soft Approaches are non-structural projects that mimic and/or enhance natural resources in order to provide storm damage protection. These types of projects may provide sufficient protection against erosion, and have relatively reduced negative impacts on coastal resource areas when compared with Hard Approaches. Soft Approaches should be at least examined, preferably attempted, before implementing a Hard Approach.

If a Conservation Commission ever decides that the soft system should no longer be maintained in its existing location (ex. due to adjacent shoreline migration, moving buildings, etc.) the array could be abandoned and allowed to biodegrade in place. However care would need to be taken so that any non-biodegradable portions

Continued on page 20

Design Guidance for Controlling Overland Run-off [6]

Controlling Overland Run-off – run-off over a coastal bank, dune or beach can erode the resource and exacerbate other coastal erosion problems.

Applicability

Overland run-off is especially problematic when sparsely vegetated, irrigated or impervious upland areas slope toward a resource area.

Design Considerations

Reduce impervious surfaces.

Replace lawns with native plantings. Lawns provide little resistance to overland run-off.

Plant vegetated buffers along top of slope. A preferred buffer is 20 feet from the top of slope.

Install vegetated swales and rain gardens.

Re-grade site to direct water away from the shoreline. This would not apply to dunes.

Care should be taken to avoid impacts to adjacent properties.

Construct a vegetated berm.

Capture roof run-off.

Avoid irrigation systems in the buffer zone.

Use of non-biodegradable geotextiles with this approach is likely to lead to reclassification as a CES.

Example of erosion of coastal bank due to uncontrolled upland run-off

Maintenance

Many techniques, if properly installed, require little or no regular maintenance.

5 Massachusetts Coastal Zone Management has produced a series of ***StormSmart Coast*** fact sheets for various erosion management measures. Each fact sheet addresses appropriate site conditions for using the approach, design considerations, and maintenance issues. The following summaries have been excerpted from fact sheets on alternatives currently available (site). MCZM is in the process of developing additional fact sheets.

6 StormSmart Properties Fact Sheet 2: Controlling Overland Runoff to Reduce Coastal Erosion, Massachusetts Office of Coastal Zone Management, December 2013.

Design Guidance for Beach Nourishment [7]

Beach Nourishment - the most important factors for beach nourishment projects are the grain size distribution of the source material as compared to the native beach material, and the location of the project in relation to sensitive coastal resources.

Applicability

Beach nourishment can be used as a stand-alone soft erosion management approach a component used in concert with other measures, such as nourishment over a fiber roll array; or as compensatory nourishment to replace material lost due to a CES. Properties without pre-1978 buildings are not eligible for a CES. These properties have the option of beach nourishment such as a sacrificial berm to provide short term protection and help to elevate the adjacent beach.

Design Considerations

Nourishment material is generally placed either at the base of a bank, or over a CES or soft solution such as fiber rolls and held in place with vegetation. Prior to either type of installation, it is important to assess sediment transport patterns in the area to know where the nourishment material is likely to go.

Identify sources of compatible sediments. Grain size of the source material should be the same size or larger than the native beach sand to minimize erosion.

Berm elevation is one of the key components of a successful shore restoration. The berm elevation of material placed on a beach should be similar to the natural (equilibrium) condition to avoid scarping of the beach profile.

Use of non-biodegradable geotextiles with this approach is likely to lead to reclassification as a CES. Time of year restrictions that restrict use of machinery on beaches during the summer months (or other sensitive times based on resources present) should be employed.

Example of proactive placement of sacrificial sand to protect upland

Maintenance

Develop a beach monitoring/maintenance plan to document and evaluate whether the project is performing as designed, identify maintenance and re-nourishment requirements, and evaluate project impacts.

For example, in some areas of Pleasant Bay it might be possible to put in too much sand and affect other coastal resource areas and navigation.

A monitoring protocol should be established for any nourishment activity.

7 Beach Nourishment: Mass DEP's Guide to Best Management Practices for Projects in Massachusetts, March 2007

Design Guidance for Vegetation [8]

Vegetation – planting salt-tolerant vegetation with a good root system can help to mitigate erosion from overland run-off as well as from tidal energy, wind energy, waves and storm surges.

Applicability

Any bank or dune where sediments are exposed to wind and waves, or rain.

Design Considerations

Re-grade slope to create a better angle of repose for establishment of vegetation.

Select appropriate salt tolerant plants with extensive root systems for the site conditions (see www.mass.gov/czm/coastal_landscaping) and density/spacing of plants as appropriate for habitat type.

Allow plants to establish root systems by selecting appropriate salt tolerant plant types, limiting run-off, restricting pedestrian access and ensuring adequate water supply (1 inch per week) and nutrients (time-release organic fertilizer as needed) until the plants are established.

Plant in season according to best practices for the selected species.

Avoid use of invasive plant species because invasive species do not have deep root systems and can prevent the establishment of deep-rooted plants and shade other plants and may contribute substances into surrounding soils that are toxic to native plants. They should be removed professionally by an approach which will minimize disturbance of the resource, depending on site conditions.

Use appropriate live salt tolerant plants with extensive root systems for erosion control (no cut Christmas trees).

Use of non-biodegradable geotextiles with this approach is likely to lead to reclassification as a CES.

Maintenance

Maintenance is heaviest during the period of establishing plants, and after storm events.

Monitor regularly to replace dead plants as needed.

Replant eroded areas immediately to avoid further erosion. Adding fill to re-establish a stable slope (without moving the toe of slope seaward) may be needed first before you replant. A three-year monitoring and maintenance plan is recommended to ensure the longterm viability of plantings.

8 StormSmart Properties Fact Sheet 3: Planting Vegetation to Reduce Erosion and Storm Damage, Massachusetts Office of Coastal Zone Management, December 2013.

Design Guidance for Dune Nourishment/Artificial Dune [9]

Dune Nourishment/Artificial Dune – nourishment involves adding compatible sediment from an off-site source to nourish an existing dune, while an artificial dune involves creating a mound of compatible sediment from an off-site source along the back of a beach seaward of the area to be protected. Either provides a physical buffer between the bay and inland areas, and an additional sediment source.

Applicability

Dunes serve as a sediment source and a protective barrier of tides and waves.

Appropriate for almost any location where there is dry beach at high tide and sufficient space to maintain some dry beach after new dune sediments are added to the site.

Design Considerations

Added sediments should be compatible with existing. The percentage of sand, gravel or cobble sized sediments should match or be slightly coarser than existing sediments.

Appropriate volume of sediment will depend on flood elevation during a storm event and the size of dune needed to avoid over-topping or being completely eroded in a storm event.

Vegetation with native salt- and wind-tolerant species and sand fencing can augment success.

Seaward slope of the dune should be less than 3:1 (base: height).

Impacts to habitat can be minimized by locating dunes as far landward as possible and using compatible sediments.

Use of non-biodegradable geotextiles with this approach is likely to lead to reclassification as a CES.

Example of artificial dune stabilized with beach grass, shortly after planting

Maintenance

Maintenance activities will include replacing sediment and vegetation and sand fencing if used.

9 StormSmart Properties Fact Sheet 1: Artificial Dunes and Dune Nourishment, Massachusetts Office of Coastal Zone Management, December 2013.

Design Guidance for Sand Fencing [10]

Sand Fencing – aka snow fencing, slows wind speeds and results in blown sand being dropped in front of or behind the fencing. The deposited sand helps to build dune volume.

Applicability

Fencing can be used effectively at almost any site with wind blown sand that does not impact shorebird or turtle habitat, and is not reached by daily high tides and waves from minor storms.

Fencing is often used in conjunction with other methods.

Design Considerations

Fencing should be installed as far landward as possible and well above the high tide line.

Posts should be 2" x 4" (rectangular) or 3" (circular).

A minimum number of posts should be used, and should be 4-10 feet apart, and 4 feet in depth or deeper as necessary.

A ratio of 50% open space and 50% slats is optimal for sand accumulation while minimizing the potential for erosion and marine debris.

Fencing should be attached on the landward side of posts.

Placement of wind fencing should take into consideration the orientation of prevailing winds.

Standard wire and untreated wood slat fencing is preferred to minimize marine debris.

When a fence is 2/3 buried with sand, an additional row of fencing can be added if there is enough space above the high tide line.

Sturdy sand drift fencing is not common in Pleasant Bay because it can increase erosion around posts; act as a barrier to sand movement along the shoreline; and cause wind tunnel effect. However in some instances this type of fencing can help to stabilize the coastal landform and should be evaluated on a case by case basis. This type of fencing is more likely to interfere with coastal processes and may require mitigation as indicated in the StormSmart Properties Fact Sheet.

Property owners' name and SE# should be posted on all fencing in the event that storm damage dislocates portions of the fence.

Use of non-biodegradable geotextiles with this approach is likely to lead to reclassification as a CES.

Any fencing should accommodate the passage of wildlife.

A season after fence installation, accumulated sand is planted with beach grass

Maintenance

Regular monitoring, retrieval of storm damaged com-potents and replacement of damaged slats.

Depending on the style of fence some sand mitigation may be required.

10 StormSmart Properties Fact Sheet 6: Sand Fencing, Massachusetts Office of Coastal Zone Management, December 2013.

Design Guidance for Natural Fiber Blankets [11]

Fiber Blankets – mats made of natural fibers used to reduce erosion of exposed soil, sand, and other sediments from wind, waves and overland runoff.

Applicability

Can be used on almost any bank.

Natural fiber blankets are used on un-vegetated portions of banks to prevent erosion while native salt tolerant species take root.

The blanket helps to retain moisture that helps plants get established.

Fibers disintegrate over 6-12 months.

Design Considerations

Blankets made only of natural fibers should be used. Turf reinforcement blankets or similar products comprised of synthetic materials, which may be appropriate for highway embankments, should not be used.

Where the toe of bank is subject to erosion from tides or storm waves, blankets can be combined with coir rolls to provide more stability.

Where used to stabilize the upper portion of a bank, care should be taken to avoid tying into toe protection, which may be subject to erosion or movement.

If the bottom portion of the bank has a steeper slope than the upper portion, the slope is not stable. The slope may need to be regraded prior to installation of blankets and vegetation.

Existing invasive species should be removed by hand or mechanically, whichever approach will minimize disturbance of the resource, depending on site conditions.

Address overland runoff prior to installing the blanket.

Remove debris.

Salt tolerant seed mix can be spread prior to blanket installation to quickly secure the soil.

Vegetation is planted through holes in the blanket.

Blankets should be installed from top to bottom down, and should overlap.

Stakes or staples made of wood or biodegradable material should be used to anchor the blanket. The blanket must be tight to the ground to avoid tenting and overheating of vegetation.

When covering the entire bank, anchor trenches are used at the top and bottom of bank. The trenches are parallel to the shore and are backfilled with sediments. Blankets start at the top trench and end at the bottom.

Blanket material, thickness and density depend on site conditions.

Use of non-biodegradable geotextiles with this approach is likely to lead to reclassification as a CES.

Natural jute fiber blanket to stabilize soil prior to vegetative plantings

Maintenance

On-going maintenance is required, and intensity will depend on site conditions.

The original permit should include a detailed maintenance plan.

Maintenance activities include: repairing stakes or staples, replenishing fill, and replacing vegetation.

11 StormSmart Properties Fact Sheet 5: Bioengineering – Natural Fiber Blankets on Coastal Banks, Massachusetts Office of Coastal Zone Management, December 2013.

Design Guidance for Fiber Rolls [12]

Fiber (Coir) Rolls – Fiber rolls are cylindrical rolls 12-20" in diameter, made of coir (coconut husks) and wrapped in mesh. Each roll is 10-20 feet long and can be stitched together to provide continuous shoreline coverage. Deep-rooted vegetation is planted into and above the rolls. Natural fiber blankets, nourishment, and prevention of overland run-off are often used in conjunction.

Applicability

Most effective in areas with higher beach elevations with some dry beach at high tide, where rolls are not constantly subject to erosion from tides and waves.

May not be appropriate in high-energy areas.

Design Considerations

If the bottom portion of the bank has a steeper slope than the upper portion, the slope is not stable. The slope may need to be regraded prior to installation of fiber rolls.

Overland run-off should be addressed in conjunction.

Beach nourishment in conjunction helps to ensure steady sediment supply and absorb wave energy.

Rolls should be installed end to end parallel to shore, laced together with jute or coir twine.

The number of rolls needed and their diameter depend on: how exposed the site is to waves; how frequently waves reach the base of bank; steepness of the bank face.

Densely packed rolls provide greater initial protection, but more loosely packed rolls allow for more vegetation to establish; often densely packed rolls are used on the lower part of the array only.

Rolls are buried at the base of bank, and should be covered with sediment to avoid UV damage, vegetated and anchored into coastal bank to prevent waves from getting around the ends.

Anchoring systems are needed, typically consisting of stakes on seaward side, earth anchors (duckbill anchor that extends into the bank) or both.

Vegetation shades the rolls and slows degradation of fibers. Natural fiber blankets also can protect rolls from sun damage.

Use of non-biodegradable geotextiles with this approach is likely to lead to reclassification as a CES.

Fiber rolls used to stabilize toe of re-vegetated bank

Maintenance

On-going maintenance is required and original permit should include a detailed maintenance plan.

Frequent inspection, particularly after heavy rains or storms is suggested.

Storm damage should be repaired immediately (ie., reset rolls, add covering sediment, replant vegetation).

This type of approach may require a trigger to maintain a sand cover over the biodegradable materials and annual nourishment in order to compensate for the lack of natural sediment input.

12 StormSmart Fact Sheet 4: Bioengineering – Coir Rolls on Coastal Banks, Massachusetts Office of Coastal Zone Management, December 2013

Design Guidance for Coir Envelopes or Sand Lifts [13]

Coir Envelopes – Coir Envelopes consist of coir fabric that is filled with beach compatible sediment. The envelope is then sewn closed. The lift remains open on one side. The coir should biodegrade over time and if the coir rips only sediment is released onto the beach. While typically much larger than fiber rolls coir envelopes or lifts can also be planted with vegetation, and survive longer if covered.

Applicability

Most effective in areas with higher beach elevations with some dry beach at high tide, where coir is not constantly subject to erosion from tides and waves.

May not be appropriate in high-energy areas.

Design Considerations

If the bottom portion of the bank has a steeper slope than the upper portion, the slope is not stable. The slope may need to be regraded prior to installation of fiber rolls.

Overland run-off should be addressed in conjunction.

Beach nourishment in conjunction helps to ensure steady sediment supply and absorb wave energy.

Rolls should be installed parallel to shore, laced together with jute or coir twine.

The number of rolls needed and their diameter depend on: how exposed the site is to waves; how frequently waves reach the base of bank; steepness of the bank face.

Densely packed rolls provide greater initial protection, but more loosely packed rolls allow for more vegetation to establish.

Rolls are buried at the base of bank, and should be covered with sediment to avoid UV damage, vegetated and tied into coastal bank to prevent waves from getting around the ends.

Anchoring system needed, consisting of stakes on seaward side, earth anchors (duckbill anchor that extends into the bank) or both.

Vegetation shades the rolls and slows degradation of fibers. Natural fiber blankets also can protect rolls from sun damage.

Use of non-biodegradable geotextiles and/or wire mesh with this approach is likely to lead to reclassification as a CES.

Maintenance

On-going maintenance is required and original permit should include a detailed maintenance plan.

Frequent inspection, particularly after heavy rains or storms is suggested.

Storm damage should be repaired immediately (ie., reset rolls, add covering sediment, replant vegetation).

This type of approach may require a trigger to maintain a sand cover over the biodegradable materials and annual nourishment in order to compensate for the lack of natural sediment input.

13 StormSmart Fact Sheet 4: Bioengineering – Coir Rolls on Coastal Banks, Massachusetts Office of Coastal Zone Management, December 2013

Continued from page 12

of the approach do not cause a hazard. Erosion doesn't stop in areas adjacent to a shoreline stabilization project and "holding the line" can become more and more difficult over time. Eventually there will be a time when the landward retreat of the stabilization project, to be more compatible with the surrounding, naturally eroding, shoreline will be the preferred course of action. Some potential indicators will likely exist when it is time to retreat: slumping of the top of the coastal bank, loss of vegetation, frequent maintenance, loss of the high tide beach, etc. Many of these will likely be present after a significant storm event. A section in the Work Protocol on the eventual retreat (or abandonment) of the soft approach might be helpful and inform monitoring activities to support the long-term longevity of the soft shoreline stabilization methods being utilized at a site.

Some properties may eventually qualify for a CES, once a pre-1978 becomes in danger from storm damage. At these sites, SoZ Approach projects, that delay (or even prevent) the need for a Hard Approach (CES), are positive for the coastal system and should be encouraged.

Hard Approaches/Coastal Engineering Structures

A 'Coastal Engineering Structure' (CES) under 310 CMR 10.30(3) & (7) "means, but is not limited to, any breakwater, bulkhead, groin, jetty, revetment, seawall, weir, riprap or any other structure that is designed to alter wave, tidal or sediment transport processes in order to protect inland or upland structures from the effects of such processes."

Typical rock revetment along coastal bank

Coastal engineering structures (aka Hard Approaches) were originally utilized to prevent erosion and protect development and infrastructure from waves and storm surge. The unintended effects of hard structures on the shoreline system were not initially well understood, however, and significant long-term impacts have been documented in areas where these structures were constructed.

It should also be noted that the WPA requires applicants who include a CES in a proposal to "minimize adverse effects". Some towns have requirements that any CES be below a certain elevation so the coastal resource area may still interact with the water during some events. For example if a revetment was built to withstand a 50-year storm, one might expect some erosion during a 100 year storm but the CES would still need to protect the pre-1978 building. Towns in Pleasant Bay may want to put limits on the height of CESs to ensure consistency between projects. The Town of Orleans limits CES elevation as follows:

Orleans 196A-12.G. General Guidelines (3): "Coastal Engineered Structures (CES) must be as low and short as consistent with toe protection. Structures designed for complete protection against catastrophic storms, and lot line to lot line protection will be closely scrutinized."

CES' should be designed to the minimum size necessary to prevent structural failure, protect the building, and allow some natural sediment release. In A zones within Pleasant Bay with relatively low fetch lengths and protection afforded the by a barrier beach and islands and shoaling, we are recommending toe protection in order to protect the building from storm damage but to allow some natural release of sediment during extreme storm events. For V zones, applicants will need to design the minimum height of structure to protect the building from storm damage with the maximum amount of bank left available for sediment release and natural habitat.

Continued on page 25

Design Guidance for Sand Bags or Geotextiles [14]

Sandbags or geotextiles are very similar to coir envelopes except that instead of coir,a plastic geotextile is used to contain the sediment. The geotextile does not biodegrade(the plastic may end up as marine debris) and over time the structure can become very hard, reflecting wave energy on the beach. In addition to bags, long tubes known as geotubes (can be >10' diameter and hundreds of feet long) are also used in this fashion. Most regulatory agencies in Massachusetts have determined Geotextile sandbags and geotubes have negative impacts similar other hard engineered structures such as revetments and bulkheads, which can cause wave energy to reflect off the hard surface and scour the beach, increasing the erosion rate on fronting and adjacent properties.

Applicability

Sand bags are generally used on a temporary basis to allow a property owner and the review agency time to determine a more appropriate approach that will address the problem on a long-term basis to help provide erosion, storm wave and flood protection.

Design Considerations

Should be considered for temporary protection only, often permitted under emergency order of conditions.

Designing the height of the structure for toe protection only to allow sediment release during extreme storm events.

Designing the shallowest possible slope to reduce wave energy – ideally shallower than 2:1.

Designing a return to reduce "end effect" erosion without resulting in a footprint that encroaches on resource areas.

Constructing hard structures as far landward of mean high water as possible.

Designing construction to be staged from the landward side of the structure, where possible, to minimize construction impacts on existing beach front, fringe marsh, and shellfish resources.

Designing sediment cover and periodic beach nourishment, with regular monitoring and maintenance.

Designing structures to be constructed with stairs, platform walkways, or other acceptable design, which would allow safe public access. Future erosion of beach-front should be considered relative to preserving public access and addressed in the structure design.

Maintenance

On-going maintenance is required and original permit should include a detailed maintenance plan.

Frequent inspection, particularly after heavy rains or storms is suggested. Rips should be repaired immediately.

Although temporary, triggers for re-nourishment should be monitored and maintained, particularly after heavy rains or storms, and repaired or restored as necessary.

Geotextile tubes can be damaged, deflated, or destroyed, resulting in the tube or portions of the tube becoming marine debris and a hazard to recreation and navigation. The Coast Guard declared bags that washed out of an installation along the south shore of Nantucket that became entangled in the Steamship Authority's propeller a hazard to navigation.

14 Dealing With Erosion: The Spectrum of Coastal Erosion Control Methods, by Greg Berman. June 2015.

Design Guidance for Gabions [15]

Gabions - are wire mesh baskets filled with rock. They have the benefit of allowing some transmission of wave energy and if covered with sediment vegetation may reduce the some of the negative impacts typically associated with a CES. Regular inspection and maintenance is important as rusty metal and freed rocks may degrade the environment.

Use of gabions as toe protection

Applicability

Typically installed in estuarine systems with minimal fetch and wave energy.

They survive well with some inundation as opposed to some natural fiber system.

In Pleasant Bay small (6”x1’x2’) baskets are typically utilized, being filled, and stacked nearly vertical like steps.

A more gradual slope is possible with gabions, but involves a different configuration, commonly known as a “gabion mattress”.

Design Considerations

Designing the height of the structure for toe protection only to allow bank erosion during extreme storm events.

Designing with rounded cobble (instead of angular) in the basket.

Designing with plastic coated wire for extended lifespan.

Design with proper anchoring system.

Geotextile fabric behind the array may provide additional stability, however no vegetation will be able to grow through this layer.

Designing the shallowest possible slope to reduce wave energy – ideally shallower than 2:1.

Designing a return to reduce “end effect” erosion without resulting in a footprint that encroaches on resource areas.

Constructing hard structures as far landward of mean high water as possible.

Designing construction to be staged from the landward side of the structure, where possible, to minimize construction impacts on existing beach front, fringe marsh, and shellfish resources.

Designing vegetative covering and periodic beach nourishment, with regular monitoring and maintenance.

Designing structures to be constructed with stairs, platform walkways, or other acceptable design, which would allow safe public access. Future erosion of beach-front should be considered relative to preserving public access and addressed in the structure design.

Designing compliance with beach re-nourishment requirements.

Maintenance

On-going maintenance is required and original permit should include a detailed maintenance plan.

Structures should be inspected regularly.

Storm damage should be repaired immediately.

Hog rings and anchor cables should be re-tightened immediately.

Re-nourishment and vegetative covering should be monitored and maintained, particularly after heavy rains or storms, and repaired or restored as necessary.

Triggers for re-nourishment and vegetative covering should be monitored and maintained, particularly after heavy rains or storms, and repaired or restored as necessary.

Annual compensatory nourishment will be necessary.

15 StormSmart Properties Fact Sheet 7: Repair and Reconstruction of Seawalls and Revetments, Massachusetts Office of Coastal Zone Management, 2016.

Design Guidance for Revetments [16]

Revetments are sloping structures comprised of large boulders that start at the toe of a coastal bank and are typically designed to an elevation that corresponds to an estimated storm period for this location. More gentle slopes and rough face tend to dissipate more wave energy.

Applicability

In general they can be used in high-energy exposed areas.

Because these structures can have negative impacts on the coastal system and neighboring properties, new construction of revetments is limited by regulation (see Guideline 3 above).

Maintenance or repair of these structures is more common than new construction.

Design Considerations

First address any overland run-off that may be contributing to erosion and also may affect the functioning of the structure.

Designing the height of the structure for toe protection only to allow sediment release during extreme storm events.

Slope should have no segment steeper than 1.5:1, preferably at 2:1 if possible.

Rough-face surfaces dissipate more wave energy.

Chinking (putting smaller stones in gaps between larger stones) may be appropriate to increase structural stability but small stones that can be released during a storm event to litter the beach should be avoided.

Designing a return to reduce “end effect” erosion without resulting in a footprint that encroaches on resource areas.

Constructing hard structures as far landward of mean high water as possible.

Maintain beach or dune fronting the structure through nourishment, to dissipate energy associated with waves, tides and currents.

On coastal banks where a structure is undergoing repair or reconstruction, project should include provision to add sediment to compensate for the bank no longer functioning as a sediment source.

Where possible, minimize height of the structures by stabilizing the top of bank with vegetation, or fiber blanket. Where higher structure is needed, balance with necessary sediment re-nourishment.

Designing construction to be staged from the landward side of the structure, where possible, to minimize construction impacts on existing beach front, fringe marsh, and shellfish resources.

Designing vegetative covering above the revetment and periodic beach nourishment, with regular monitoring and maintenance.

Designing structures to be constructed with stairs, platform walkways, or other acceptable design, which would allow safe public access. Future erosion of beach-front should be considered relative to preserving public access and addressed in the structure design.

In the case of a proposed reconstruction the foregoing design conditions should be evaluated and applied as appropriate.

Maintenance

On-going maintenance is required and original permit should include a detailed maintenance plan.

Structures should be inspected regularly.

Storm damage should be repaired immediately.

Triggers for re-nourishment and vegetative covering should be monitored and maintained, particularly after heavy rains or storms, and repaired or restored as necessary.

Annual compensatory nourishment will be necessary.

16 StormSmart Properties Fact Sheet 7: Repair and Reconstruction of Seawalls and Revetments, Massachusetts Office of Coastal Zone Management, 2016.

Design Guidance for Vertical-faced and Shore Perpendicular Structures

The **vertical-faced and shoreline perpendicular structures** are generally not appropriate for wave conditions in Pleasant Bay. However, they may be proposed from time to time based on special conditions. Upon proposal for repair or reconstruction of an existing vertical-faced or shore-perpendicular structure, other erosion management measures with less potential for negative environmental impacts should be fully evaluated. Examples of these structures include:

Vertical-faced structures such as bulkheads and sea walls, are installed at a steep (i.e., 90-degree) angle to the shoreline, which reduces their footprint in the resource area compared with revetments that require a sloping face. However, the resulting configuration increases reflective wave energy. According to StormSmart Properties Fact Sheet 7, these structures hold soil in place and prevent it from slumping into the water, but are not typically appropriate to address erosion. As previously discussed, gabions come in two styles: the mattress (which can conform to a gentle slope), and the gabion steps (which can only get down to a 1:1 slope and more often are installed at 1:2). Gabions steps on typical proposed project have a 3” step, leading to 6’ of elevation over 3’ of horizontal distance (1:2), much steeper than even a revetment. This type of near-vertical wall can lead to reflected wave energy during storms which may negatively affect the beach and nearby marsh. With a 6” step the 6’ of elevation would be more spread out over 6’ of horizontal distance (slope of 1:1), still steeper than a well-designed revetment but much more gentle than typical proposed gabion walls. The wall-like structure created by stacking gabions into steps may be considered vertical-faced and should only be used when the applicant can show less negative impact to the resource areas by using this method (ex. There is not enough horizontal footprint for a sloped structure to protect a pre-1978 house).

Shore perpendicular such as groins and jetties are built perpendicular to the shoreline designed to trap sand to nourish adjacent beach areas. However, by interrupting the free movement of sand they have the effect of starving downdrift beaches and resource areas of sand.

Any proposal for these types of structures would need to provide a thorough rationale for selection as a preferred alternative, encompassing all of the information and analysis outlined in these guidelines. Additionally, the state Wetlands Protection Act would require any new shore perpendicular structure would need to be of minimum length and height to maintain the beach, filled to entrapment upon construction, and contain a sand by-pass system.

Examples of timber groin (right) and rock groin (below).

Continued from page 20

Eligibility: No new coastal engineering structure shall be permitted on a coastal bank except when required to prevent storm damage to buildings constructed prior to August 10, 1978, including reconstructions of such buildings provided that:

- a coastal engineering structure or a modification thereto shall be designed and constructed so as to minimize, using best available measures, adverse effects on adjacent or nearby coastal beaches due to changes in wave action, and
- the applicant demonstrates that no method of protecting the building other than the proposed coastal engineering structure is feasible.

VII. Definitions and Glossary

Accretion: The process by which material is added to a landmass, such as a beach.

Aeolian transport: Material moved by the wind.

Area of Critical Environmental Concern (ACEC): a place in Massachusetts that receives special recognition because of the quality, uniqueness, and significance of its natural and cultural resources.

Bathymetry: The measurement of water depths, the underwater topography.

Beach nourishment (Beach Replenishment): The addition of material to a beach or similar area to offsets erosion.

Benthic: Pertaining to the sea floor.

Bulkheads: A retaining wall that has earth on one side, and is partially protected against waves or tidal action along the other.

Cross-shore sediment transport: The movement of sediment perpendicular to the shoreline in either direction through a combination of winds, waves and tides.

CZM: Coastal Zone Management. (http://www.mass.gov/czm/)

Estuary: A partly enclosed coastal body of water with a free connection to the open sea where fresh water and salt water mix.

Estuarine: Having to do with an estuary.

Fetch: The distance that a given wind blows over a body of water without interruption.

Flood and ebb shoal: A shoal formed and or maintained by flood- or ebb-tidal currents.

Gabions: Wire cages filled with stones or other materials and stacked vertically or at an angle to protect objects or structures behind them.

Geomorphology: The scientific study of landforms and the processes that shape them.

Hydrodynamics: The movement of fluids; the branch of science that deals with the dynamics of fluids in motion.

Intertidal: The intertidal zone is the area of the coast that lies between the highest normal high tide and the lowest normal low tide.

Littoral: 1) Of or relating to the coastal area of a lake, sea, or ocean; 2) Of or relating to the coastal area (zone) between the limits of high and low tides.

Littoral cell: A section of shoreline where longshore sediment transport occurs without interruption during non-storm conditions.

Littoral drift: See Littoral transport.

Littoral transport: The movement of sediment in the littoral zone due to the action of wave derived currents.

Littoral processes: The interaction of winds, waves, currents, tides, sediments, and other phenomena in the littoral zone.

Longshore current: The flow of water roughly parallel to the shoreline due to the action of wind, waves and currents.

Longshore sediment transport: The movement of sediment roughly parallel to the shoreline due to the action of winds, waves and currents.

MHW (Mean High Water): A tidal datum. The average of all the high water heights observed over the National Tidal Datum Epoch.

MLW (Mean Low Water): A tidal datum. The average of all the low water heights observed over the National Tidal Datum Epoch.

National Tidal Datum Epoch: The specific l9-year period adopted by the National Ocean Service as the official time segment over which tide observations are taken and reduced to obtain mean values (e.g., mean low water, etc.) for tidal datums. It is necessary for standardization because of periodic and apparent secular trends in sea level. The present National Tidal Datum Epoch is 1960 through 1978. It is reviewed annually for possible revision and must be actively considered for revision every 25 years.

NHESP (The Natural Heritage & Endangered Species Program): Agency charged with the protection of the state's wide range of native biological diversity. It is part of the Massachusetts Division of Fisheries and Wildlife and is one of the programs forming the Natural Heritage network.

NOAA (National Oceanic and Atmospheric Administration): A federal agency in the Department of Commerce that attempts to understand and predict changes in Earth's environment and conserve and manage coastal and marine resources to meet economic, social, and environmental needs.

Outwash: Sediment deposited by streams flowing away from a melting glacier.

Overwash: The process of ocean water carrying sediment over low-lying coastal areas typically during high energy events (storms).

Revetments: A sloped structure consisting of masonry, stone, sandbags, etc. constructed to protect objects or structures behind it.

Shoal: Typically a long, narrow (linear) bar of sand or gravel, also 'sand bar', 'gravel bar', 'bedform'.

Sub-embayment: A smaller embayment within a larger embayed body of water.

Subtidal: The area of the seafloor below the low tide line that is always covered by water.

Subtidal shoals: A shoal that is always covered by water.

Surficial geology: The characteristics of surficial deposits and including soils.

Tidal amplitude: The difference in elevation between low and high tides at a particular point in a body of water.

Tidal prism: The total volume of water that flows into an embayment, or inlet and out again with movement of the tide, excluding any fresh water flow.

Tide range: The difference in height between consecutive high and low waters. The Mean tidal range is the difference in height between mean high water (MHW) and mean low water (MLW).

USGS (United States Geological Survey): A federal agency in the Department of Interior that provides impartial information on: the health of ecosystems and environments; natural hazards; natural resources; the impacts of climate and land-use change; and core science systems in order to provide timely, relevant, and usable information.

Washover fans: A thin, fan-shaped deposit of sediment emplaced during an overwash event, typically a high-energy event such as a storm.

Sources:

Glossary of Geology, by J. A. Jackson. 2005 Approx. 900 p. 5th revised and enlarged ed. ISBN 3-540-27951-2. Berlin: Springer, 2005.

http://water.epa.gov

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VIII. Sources and Acknowledgments

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Dealing With Erosion: The Spectrum of Coastal Erosion Control Methods, by Greg Berman. June 2015.

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The Massachusetts Ocean Management Task Force Technical Report, p. 136, The Oceans as a Public Trust, March 2004, p. 136. http://www.mass.gov/eea/docs/czm/oceans/waves-of-change/tech-pt.pdf

M.G.L. c. 131, §40, Massachusetts Wetlands Protection Act
Massachusetts Wetlands Protection Act Regulations, 310 CMR 10.-0

MGL c. 91, the Massachusetts Public Waterfront Act

Massachusetts Waterways Regulations, 310 CMR 9.00

Massachusetts Office of Coastal Zone Management Policy Guide, October 2011

Town of Orleans Wetlands Regulations, Chapter 196A

Pleasant Bay Resource Management Plan 2013 Update, April 2013

StormSmart Properties Fact Sheet 1: Artificial Dunes and Dune Nourishment, Massachusetts Office of Coastal Zone Management, December 2013.

StormSmart Properties Fact Sheet 2: Controlling Overland Runoff to Reduce Coastal Erosion, Massachusetts Office of Coastal Zone Management, December 2013.

StormSmart Properties Fact Sheet 3: Planting Vegetation to Reduce Erosion and Storm Damage, Massachusetts Office of Coastal Zone Management, December 2013.

StormSmart Fact Sheet 4: Bioengineering – Coir Rolls on Coastal Banks, Massachusetts Office of Coastal Zone Management, December 2013

StormSmart Properties Fact Sheet 5: Bioengineering – Natural Fiber Blankets on Coastal Banks, Massachusetts Office of Coastal Zone Management, December 2013.

StormSmart Properties Fact Sheet 6: Sand Fencing, Massachusetts Office of Coastal Zone Management, December 2013.

StormSmart Properties Fact Sheet 7: Repair and Reconstruction of Seawalls and Revetments, Massachusetts Office of Coastal Zone Management, 2016.

Acknowledgements

This report was developed by the Pleasant Bay Alliance under the guidance of the Alliance's Coastal Processes Work Group. The following work group members contributed to this report:

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IX. Appendices

Appendix A – Massachusetts DEP Wetlands Policy 92-1: Coastal Banks

Coastal Banks: Definition and Delineation Criteria for Coastal Bank (DWW Policy 92-1) Issued: March 3, 1992

Purpose The purpose of this policy is to clarify the definition of coastal bank contained in the Wetlands Regulations, 310 CMR 10.00, by providing guidance for identifying 'top of coastal bank'. Regulatory Standards Coastal wetlands are defined in the Wetlands Protection Act (MGL c. 131, s.40) as:

> "any bank, marsh, swamp, meadow, flat or other lowland subject to tidal action or coastal storm flowage".

Coastal banks are defined at 310 CMR 10.30(2) as:

> "the seaward face or side of any elevated landform, other than a coastal dune, which lies at the landward edge of a coastal beach, land subject to tidal action, or other wetland".

When these two definitions are read together, coastal banks can be inferred to be associated with lowlands subject to tidal action or subject to coastal storm flowage. Coastal banks, therefore, can occur around non-tidal ponds, lakes and streams provided that these elevated landforms confine water associated with coastal storm events, up to the 100-year storm elevation or storm of record. Land Subject to Coastal Storm Flowage, in turn, is defined at 310 CMR 10.04 as:

> "land subject to any inundation caused by coastal storms up to and including that caused by the 100-year storm, surge of record or storm of record, whichever is greater".

The Department uses the 100-year coastal flooding event as defined and mapped by the Federal Emergency Management Agency (FEMA) per the National Flood Insurance Program, as the maximum flood elevation associated with land subject to coastal storm flowage, unless recorded storm data reveals a higher flood elevation (which is the storm of record). Analysis Top of Coastal Bank Delineation The phrase "top of coastal bank" is used to establish the landward edge of the coastal bank (310 CMR 10.30). There is no definition for "top of coastal bank" provided in the Act or the Regulations. A Guide to the Coastal Wetlands Regulations, prepared by the Massachusetts Coastal Zone Management Office, upon which Conservation Commissions and the Department have relied for guidance, states that the landward boundary of a coastal bank is "the top of, or first major break in, the face of the coastal bank", and implies that it is easily identified using United States Geologic Survey topographic quadrangles. However, the scale of topographic quadrangle maps generally do not allow for parcel specific analysis. No further definition of "top of" and "major break" is provided. The following standards should be used to delineate the "top of coastal bank" [refer to figures 1-7 for a graphic presentation of the information below]:

A) The slope of a coastal bank must be greater than or equal to 10:1 (see Figure 1).

B) For a coastal bank with a slope greater than or equal to 4:1 the "top of coastal bank" is that point above the 100-year flood elevation where the slope becomes less than 4:1. (see Figure 2).

C) For a coastal bank with a slope greater than or equal to 10:1 but less than 4:1, the top of coastal bank is the 100- year flood elevation. (see Figure 3).representative of the site. Averaging and/or interpolating contours on plans can result in inaccurate delineations. Therefore, it is strongly recommended that follow-up field observations be made to verify delineations made from engineering plan data and as shown on the submitted plans. The final approval of resource boundary delineations rests with the issuing authority (Conservation Commission or Department of Environmental Protection).

D) A "top of coastal bank" will fall below the 100-year flood elevation and is the point where the slope ceases to be greater than or equal to 10:1. (see Figure 4).

E) There can be multiple coastal banks within the same site. This can occur where the coastal banks are separated by land subject to coastal storm flowage [an area less than 10:1]. (See Figures 5 and 6).

When a landform, other than a coastal dune, has a slope that is so gentle and continuous that it does not act as a vertical buffer and confine elevated storm waters, that landform does not qualify as a coastal bank. Rather, gently sloping landforms at or below the 100-year flood elevation which have a slope less than 10:1 shall be regulated as "land subject to coastal storm flowage" and not as coastal bank (see Figure 7). Land subject to coastal storm flowage may overlap other wetland resource areas such as coastal beaches and dunes. Information Requirements for Project Review Due to the complex topography associated with coastal banks, the following requirements are intended to promote consistent delineations. In order to accurately delineate a coastal bank, the following information should be submitted, at a minimum, to the Conservation Commission and the Department of Environmental Protection: the coastal bank should be delineated and mapped on a plan(s) to a scale of not greater than 1 inch = 50 feet, including a plan view and a cross section(s) of the area being delineated showing the slope profile, the linear distance used to calculate the slope profile, and the location of this linear distance. In addition, there must be an indication which of the five diagrams mentioned above is (are) representative of the site. Averaging and/or interpolating contours on plans can result in inaccurate delineations. Therefore, it is strongly recommended that follow-up field observations be made to verify delineations made from engineering plan data and as shown on the submitted plans. The final approval of resource boundary delineations rests with the issuing authority (Conservation Commission or Department of Environmental Protection).

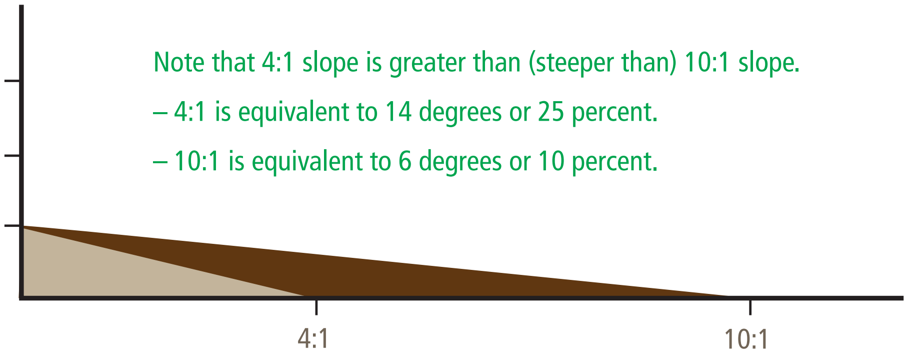


Figure 1.

Legend for Figures 2-7 (not to scale):

- 100 year flood elevation (as shown on community FIRM) or storm of record
- Land subject to coastal storm flowage (LSCSF)
- Coastal Bank
- Toe of bank which lies at the landward edge of a coastal beach, land subject to tidal action, or other wetland

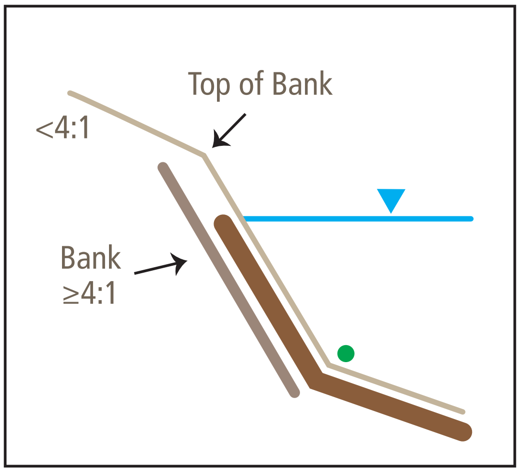


Figure 2.

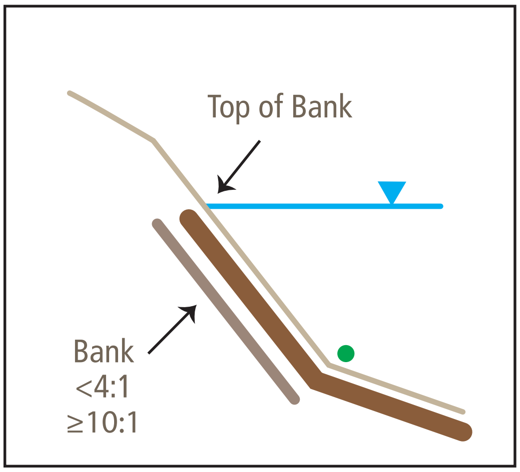


Figure 3.

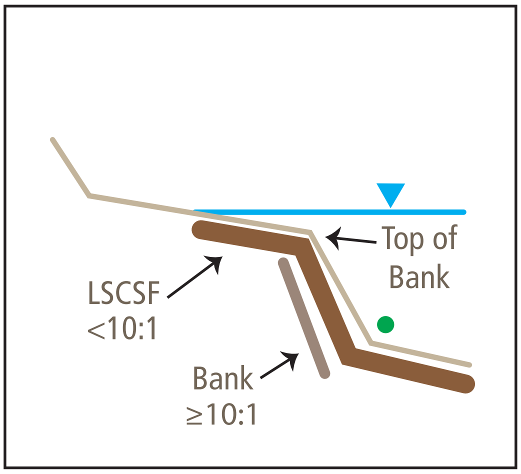


Figure 4.

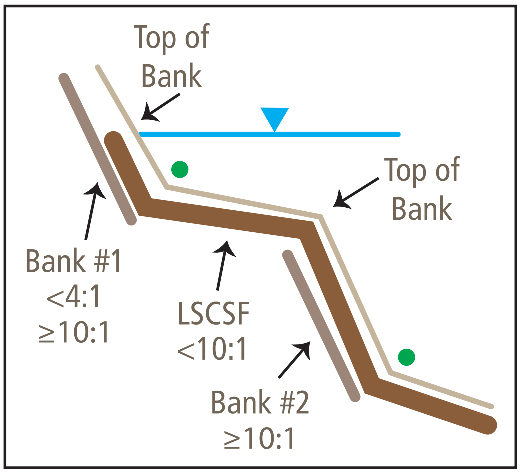


Figure 5.

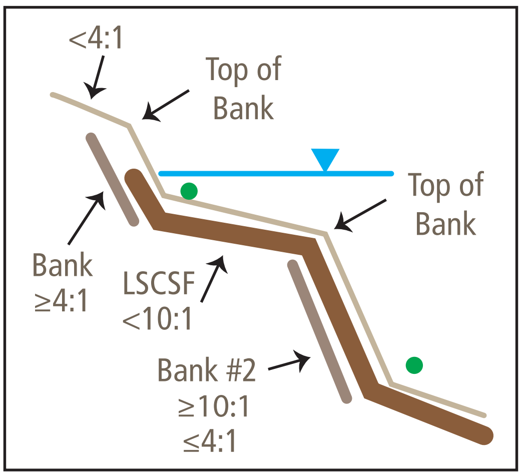


Figure 6.

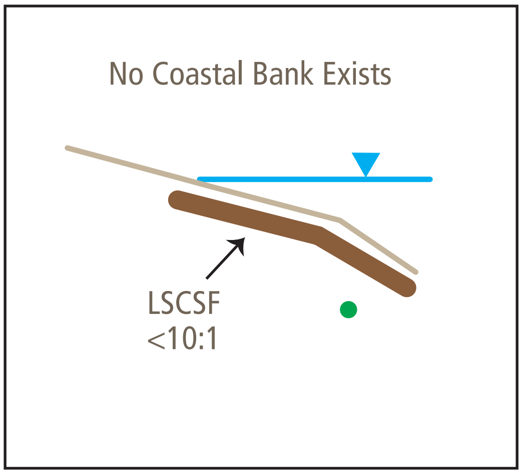


Figure 7.

Appendix B – Spectrum of Erosion Control Measures

There are times when the desire to protect upland property conflicts with the ecosystem services provided by natural landforms. The key to responsible erosion control is to increase the resilience of the property while not negatively affecting the coastal resource areas.

How To Use This Spectrum

Under the Massachusetts Wetlands Protection Act (GL Ch 131, s.40) a Notice of Intent (NOI) must be filed for any activity in a natural resource area subject to protection (e.g., coastal banks, dunes, beaches, etc.). A NOI for shoreline stabilization should demonstrate that no other feasible method exists for protecting the building that would be less damaging to resource areas. (Note that it is the building that may be protected—not the lawn, pool, patio, etc.) At a minimum, an alternatives analysis looks at the difference between doing nothing and the proposed action. The alternatives analysis within an NOI can be greatly enhanced by considering the various options, including those found within the spectrum (see reverse). By starting at the top of the spectrum and addressing each method until a feasible alternative is reached, the applicant can show full diligence that all other options that have lower potential impact have been examined. A good alternatives analysis should discuss each method in terms of feasibility, environmental effect, and impact on adjacent and downdrift properties.

Things To Keep In Mind

This is not a complete list. There are more methods, and many variations of the methods found on the reverse of this brochure. Additionally, new methods are frequently being invented and/or modified. Additionally, some techniques may harden a soft method to the point of being considered a Coastal Engineering Structure (CES) (e.g., wire or plastic wrapped fiber rolls). Very few projects employ only one method. When we are determining a project’s effect on coastal resource areas (as well as if it is a CES) the “hardest” aspect of the project should be considered. The images below show vegetation (very low potential impact) combined with fiber rolls and fencing (higher potential impact), therefore the entire proposed project should likely be considered as the component with the highest potential impact. If the cover of sand and vegetation erodes during a storm then the fiber rolls will be interacting with the environment.

What is a Coastal Engineering Structure (CES)?

According to the Wetlands Protection Act, a CES “means, but is not limited to, any breakwater, bulkhead, groin, jetty, revetment, seawall, weir, rip-rap or any other structure that is designed to alter wave, tidal or sediment transport processes in order to protect inland or upland structures from the effects of such processes.” Some town bylaws may have a more stringent definition. Basically, if a shoreline structure alters a wave’s ability to erode sediment (perpendicular to beach) or transport sediment (parallel to beach) it likely qualifies as a CES. Typically biodegradable materials and methods that work to enhance natural land form stability are not considered a CES. It is ultimately a local Conservation Commission or MA DEP that makes this determination. CES’s are never allowed on dunes as they can impede the important function of the resource and damage the beach as well as adjacent properties. For coastal banks (i.e. glacial deposit), a building constructed before August 10, 1978 may be considered “grandfathered,” so if there is no other way to protect the building a CES may be permitted.

Native Vegetation and Fiber Rolls

Native Vegetation and Sand

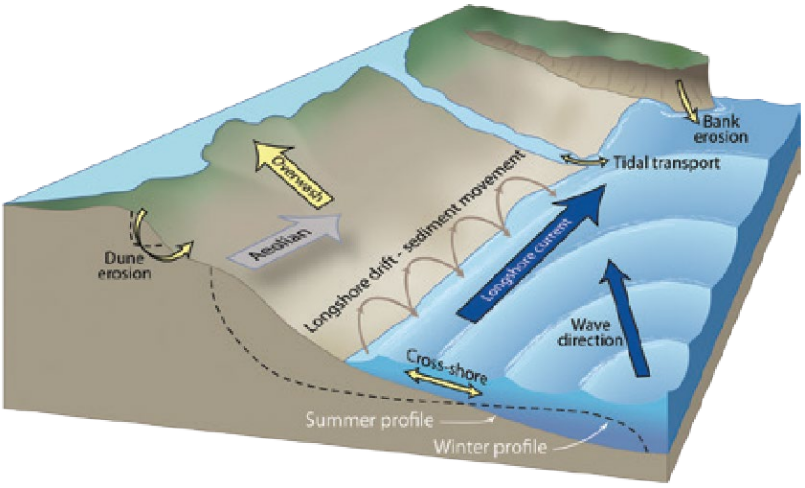
Slat Fencing

Drift Fencing

Pile Wall

CES's affect shore parallel and/or perpendicular transport

CES's can be classified as affecting sediment transport in two ways. CES's affecting perpendicular transport (e.g., gabions, revetments, seawalls, etc.) are designed to slow the shoreline retreat by stopping a coastal bank from eroding. However by stopping this source of sediment beaches are often deprived of material. CES's affecting parallel transport (e.g., groins and jetties) are designed to slow longshore sediment transport. They build up a higher and wider beach on the updrift side of the structure, but often reduce sediment supply in the downdrift direction. Beaches that are stable are actually in a state of dynamic equilibrium, which means there is as much sand entering the area as leaving the area. Erosion occurs when more sand is moving out of the area than is coming in.



Types of Sand Fence

There are many different types of fencing used for erosion control. Slat fencing, installed with small posts, has 50% porosity which slows down the wind causing sand to accumulate near the fence. It does not survive long when exposed to waves but, if installed landward of the reach of high tide, has relatively low potential negative impacts. Drift Fencing is typically composed of 2x3s installed with 12" pilings. This type of fencing can withstand some waves, but cannot be installed seasonally like slat fencing and has a higher potential for reflecting wave energy. Some projects have used 12" pilings spaced 1" apart. The spacing (8% porosity) allows for some exchange of sediment and water, however not as much as the slat or drift (required 50% porosity) fence. There is also a much greater chance for enhanced beach erosion due to wave reflection in addition to altering the wave environment and sediment transport processes. As porosity is reduced the structure begins to look and act more like a bulkhead than a fence. For these reasons multiple state agencies have classified this type of piling configuration as a CES.

Additional Information

Massachusetts Office of Coastal Zone Management, StormSmart Properties Fact Sheets Project:
http://www.mass.gov/eea/agencies/czm/program-areas/stormsmart-coasts/stormsmart-properties/

MassDEP
http://www.mass.gov/eea/agencies/massdep/water/watersheds/wetlands-protection.html

Woods Hole Sea Grant
www.whoi.edu/seagrant

Cape Cod Cooperative Extension
www.capecodextension.org/marine-programs/coastal-processes-2/

Local Officials
Call the local town hall. Conservation departments are a good place to start.

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This information would not have been possible without support and input from numerous individuals, including Rebecca Haney and Betsy Rickards (Massachusetts Coastal Zone Management), John Jannell (Town of Orleans), Kristin Andres (Town of Chatham), Carole Ridley (Ridley & Associates, Inc.) and Jim Mahala (Massachusetts Department of Environmental Protection).

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PHOTO CREDITS:

All photos by Woods Hole Sea Grant and Cape Cod Cooperative Extension unless otherwise noted.

Beach nourishment: Ted Keon

Do nothing: Ann McNichol

Remove Invasive species: USDA/MassWildlife

Managed Retreat: Bill Brine, courtesy of the Vineyard Gazette

Start at the top and work your way down until you can safely protect the building.

Note that more detail on most of these methods is available at:

www.mass.gov/eea/agencies/czm/program-areas/stormsmart-coasts/stormsmart-properties/

Do Nothing

March 2013

May 2013

Coastal shorelines are dynamic; if the building is far enough away from the water then **"Do Nothing"** may be an option, which will allow natural processes to continue. Structural erosion control may only be permitted if the Conservation Commission finds it is required to protect a building. Rapid erosion due to storms can be followed by rapid beach recovery. The images to the left show an area that accumulated over 5' vertically of sand in less than 2 months.

Managed Retreat

If there is room on the parcel, **retreating** from an eroding shoreline can significantly lengthen the usable lifespan of property. If flooding is more of a concern than erosion elevating the building in place (e.g., on pilings) can reduce flood damage.

Vegetation

Native vegetation

Native vegetation can take up water, break the impact of rain, waves, and wind as well as slow down runoff. Live roots stabilize sediment. Controlling foot-traffic and removing invasive species while restoring with native plants will serve to stabilize the landforms.

Remove invasive species

Beach Nourishment

Beach nourishment can be accomplished by trucking from upland sources, or by dredging. This has the benefit of adding new material to the system instead of depriving downdrift beaches like most other methods. If combined with plantings beach nourishment can lead to dune creation. Nourishment sand, as opposed to dune creation, is typically considered "sacrificial" as it is placed to erode instead of what it's protecting. The placed material should be compatible with the beach.

Sand Fencing

Sand fencing slows wind, causing sand to drop out and accumulate. More details on the back of this brochure. Some materials are not suitable for the coast.

Regrade

If a slope is too steep it may prevent vegetation from stabilizing the landform. Stormwater runoff from above can rapidly destabilize the landform (left). **Regrading** a coastal bank landward to a more gentle slope, followed by extensive planting, can allow for faster stabilization.

Before

After (pre-planting)

Fiber Roll

Fiber rolls (aka bio logs, coir logs, etc.) are composed of biodegradable coconut (aka coir) fibers surrounded by twine netting. Planting native vegetation in and around the rolls can provide additional longer term stabilization. Fiber rolls should be covered with sediment, as sunlight and wind can cause rapid degradation. Proper height is also important as frequent inundation can also lead to failure. Secure anchoring is essential as if fiber rolls break free during a storm they may damage other properties, however use of other non-biodegradable components (e.g., filter fabric) should be avoided.

Coir Envelope

Coir Envelopes consist of coir fabric that is filled with appropriate sediment, then sewn closed. The coir should biodegrade over time (otherwise it would be considered a CES) and if the coir rips only sediment should be released onto the beach. While typically much larger than fiber rolls coir envelopes can also be planted with vegetation, and survive longer if covered. Use of non-biodegradable components (e.g., filter fabric) should be avoided.

IS NOT A CES

Once an erosion control structure has enough impact on coastal resource areas it is classified as a **Coastal Engineering Structure (CES)**, with major implications for permitting. Depending on how some of the above methods are designed and installed (e.g., coir envelopes, fiber rolls, fencing) they can approach being classified as being a CES. Only certain properties are allowed to have a CES. See reverse side for details.

IS A CES

Geotextile Sand bag/Geotube

Geotextile sand bags are very similar to coir envelopes except that instead of coir, a plastic geotextile is used to contain the sediment, which may end up as marine debris. The geotextile does not biodegrade and over time the structure can become very hard, reflecting wave energy on the beach. In addition to bags, long geotubes (can be >10' diameter and hundreds of feet long) are also used in this fashion.

Gabion

Gabions are wire mesh baskets filled with rocks. They have the benefit of allowing some dissipation of wave energy and if covered with sediment, vegetation may reduce some of the negative impacts associated with a CES. Coated wire last longer than bare, but are not intended for high wave energy. Regular maintenance is important as rusty metal and freed rocks may degrade the environment.

Breakwater

Breakwaters (not typical for a homeowner) are rock structures, built offshore and parallel to the shore, that reduce wave energy reaching the shoreline. Sills are similar to breakwaters however they are designed to be under water during portions of the tide. The reduction in wave energy can build the beach seaward towards the structure, however it may also slow or block the flow of sediment to downdrift coastal areas.

Groin

A **groin** (not typical for a homeowner) is designed to slow sediment transport thereby building a higher/wider beach on the updrift side. Eventually the sediment should overtop or go around the groin to allow longshore sediment transport. In many areas there is not enough sediment supply to the beach system to minimize adverse impacts from the groin. There is often erosion on the downdrift side of the groin where the beach is deprived of sediment.

Revetment

Revetments are comprised of large boulders that start at the bottom (aka toe) of a coastal bank and should only extend as far up the bank as needed to protect the building. Above that salt-tolerant vegetation can help control erosion. More gentle slopes and rough face tend to dissipate more wave energy. Without a proper return end scour can damage the bank.

Seawall

Seawalls are cement structures that are typically vertical and therefore highly reflective of wave energy. The increased turbulence at the base of the seawall tends to erode the sediment, leading to a beach that narrows and lowers in height over time. (New seawalls are generally not permissible since they fail to minimize adverse effects).

Bulkhead

Bulkheads are vertical wooden (sometimes steel or vinyl) structures and therefore reflect wave energy and often lead to a lowering of beach height. Unlike a seawall, bulkheads are typically found in bays and rivers that do not experience frequent strong waves.

Jetty

Jetties stabilize navigation channels that connect bodies of water. A jetty is similar to a groin in that it affects longshore sediment transport, however while a groin is intended to allow sediment to pass a jetty is intended to completely stop sediment. As sediment can no longer naturally bypass the inlet, it will need to be manually bypassed or the updrift side will allow sediment to flow over and around the jetty and the downdrift side will experience severe erosion.

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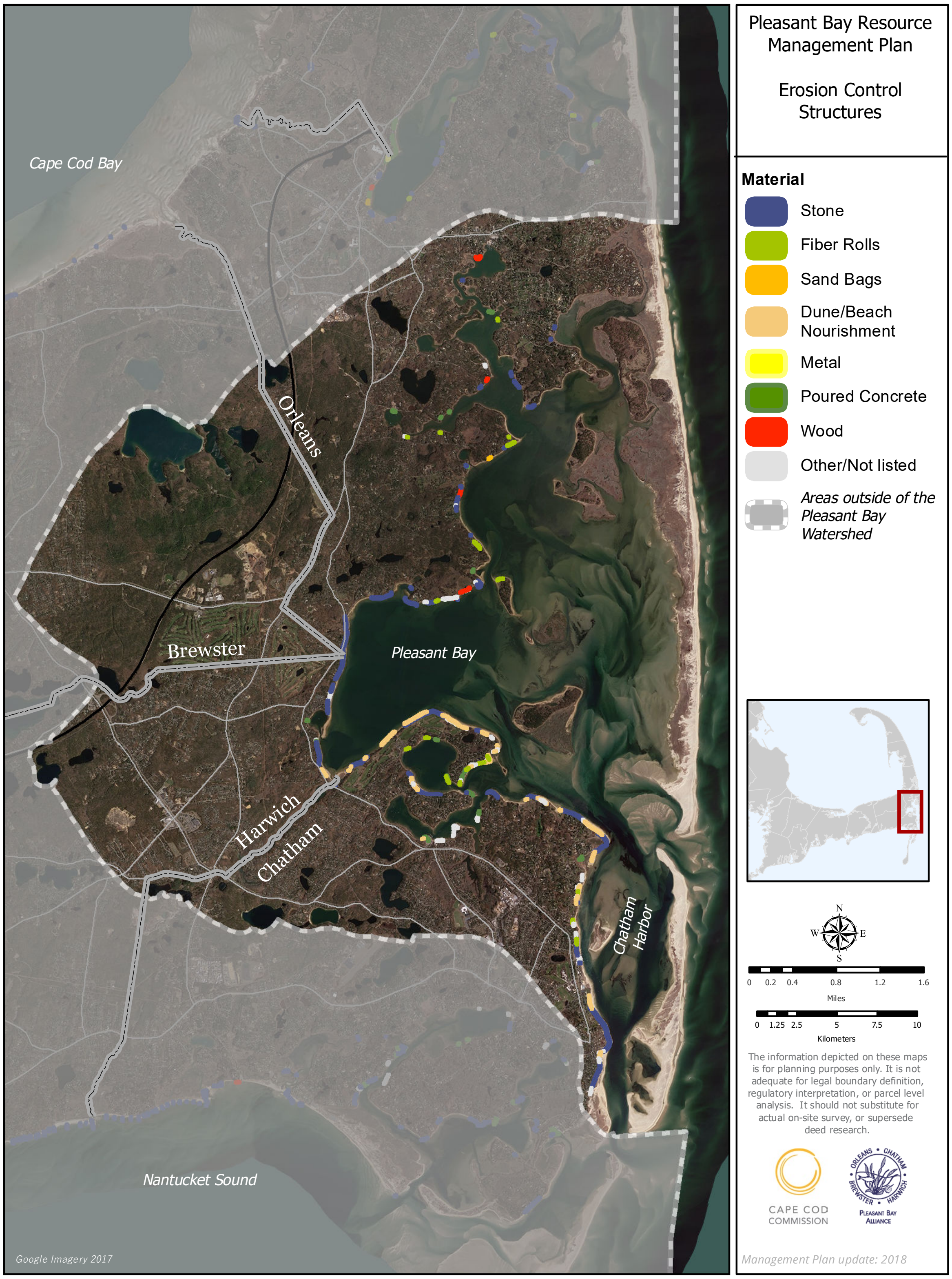
Pleasant Bay Alliance

Appendix C – Map of Erosion Control Structures in Pleasant Bay



About the Pleasant Bay Alliance

The Pleasant Bay Alliance is a municipal organization formed by the Towns of Orleans, Chatham, Harwich and Brewster to coordinate the resource management plan for the Pleasant Bay ACEC and watershed. The Alliance's projects, programs and studies promote healthy natural resources and safe public access throughout Pleasant Bay. Alliance programs encompass technical research, policy analysis, and public outreach in the areas of coastal processes, watershed planning, navigation, fisheries, wetlands protection, and water quality monitoring.

For more information about Alliance and its programs and reports, visit www.pleasantbay.org