THE COMMONWEALTH OF MASSACHUSETTS

APPLYING THE MASSACHUSETTS COASTAL WETLANDS REGULATIONS:

A Practical Manual for Conservation Commissions to Protect the Storm Damage Prevention and Flood Control Functions of Coastal Resource Areas

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Dear Conservation Commission Members and Agents:

The Massachusetts Office of Coastal Zone Management (CZM) and Massachusetts Department of Environmental Protection (MassDEP) are pleased to provide you with this document, *Applying the Massachusetts Coastal Wetlands Regulations: A Practical Manual for Conservation Commissions to Protect the Storm Damage Prevention and Flood Control Functions of Coastal Resource Areas*, otherwise known as the Coastal Manual.

The Coastal Manual builds on more than 40 years of efforts to protect the environmental resources of Massachusetts through the implementation of the Wetlands Protection Act (WPA) and its Regulations. The Coastal Manual is designed to provide technical guidance on the coastal resource areas under the WPA: land under the ocean, designated port areas, coastal beaches, coastal dunes, barrier beaches, coastal banks, rocky intertidal shores, and salt marshes. These often dynamic and shifting areas can be even more challenging to delineate and protect than their inland counterparts. In addition, the vulnerability of the coastline to regular storm activity and episodic and often catastrophic northeasters and hurricanes makes protection of coastal resources all the more important. The risk of damage from winds, waves, storm surge, and flooding continues to grow as the level of coastal development increases, and could potentially increase with rising rates of relative sea levels.

The Coastal Manual was drafted through the collaborative efforts of CZM and MassDEP, with additional input from a Technical Advisory Committee composed of representatives from federal and local government, as well as consulting, non-profit, and legal communities.

The Coastal Manual is based on questions CZM and MassDEP have received from Conservation Commissions and applicants in recent years, as well as recent legal decisions, and provides guidance on addressing proposed projects in areas where the storm damage prevention and flood control functions of coastal resource areas are applicable. It summarizes guidance and recent administrative decisions on interpreting the applicable WPA Regulations, clarifies the delineation of the resource areas, expands on the description of their beneficial functions, and provides practical information to applicants and Conservation Commissions on how to apply and meet performance standards to protect the existing functions. In addition, the manual describes the best available tools, data, and information for a complete and accurate project review.

We hope this information will help you in your efforts to protect the valuable coastal wetlands of Massachusetts, and we thank you for your continued dedication.

Sincerely,

Matthew A. Beaton, EEA Secretary

Martin Suuberg, MassDEP Commissioner

Bruce K. Carlisle, CZM Director

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Introduction

By administering the Massachusetts Wetlands Protection Act (WPA) at the local level, Conservation Commissions play an important role in protecting the natural functions of wetland resource areas and the vital public interests they provide, including water supply, flood control, storm damage prevention, pollution prevention, and habitat/fisheries protection. Conservation Commissions in coastal communities face an added challenge of protecting these interests in dynamic environments, where the coastal processes fueled by wind, waves, and tides are constantly at work. The purpose of this manual is to provide practical information to help Commissions evaluate projects proposed in coastal resource areas for their potential to impact the *storm damage prevention and flood control interests of the WPA*.

WHAT THIS MANUAL IS

This manual is an overview of how to address the impacts of proposed projects that are likely to affect the storm damage prevention and flood control functions of coastal resource areas. Along with practical advice on how to obtain and assess the information needed to evaluate these projects, the manual explains how Commissions should use tools, data, and information to determine the functions of the resource areas, assess potential project impacts, and evaluate whether the project meets or can be conditioned to meet the performance standards that protect the resource area functions. This manual sets forth the Massachusetts Department of Environmental Protection (MassDEP) policies concerning implementation of the WPA Regulations. Though MassDEP is not bound exclusively to these interpretations, the guidance provides a general framework upon which Commissions can base their decisions.

WHAT THIS MANUAL IS NOT

Although the manual does directly assist with implementation of the WPA in coastal resource areas, it does not provide detailed information on standard operating procedures for Conservation Commissions or specific instruction for completing the permitting process. Also, while explaining how coastal resource areas function, and how projects can impact those functions, this manual does not cover protection of any WPA interests other than storm damage prevention and flood control.[1] Evaluation of additional information beyond that which is described in this manual will be required to determine the potential effects of a proposed project on the other interests of the WPA. Many other references cover the other WPA interests and a list of references has been provided in Appendix G for those looking for further information. Appendix G also includes a resource list of coastal geology sources for those looking for more descriptive information on general coastal geology and coastal processes. As a final note, this manual is not meant to replace the WPA and its

[1]Although this manual does not cover interests other than storm damage prevention and flood control, relevant information about other interests of the Act is included in footnotes.

Regulations. The reader should review the Coastal Regulations in their entirety in addition to using this manual.

OVERVIEW OF THE MANUAL

The manual is divided into the following chapters and appendices:

Chapter 1 - Resource Area Delineations

This chapter defines the coastal resource areas under the Wetlands Protection Act and summarizes how to delineate them. The chapter gives practical advice on handling the realities of working in dynamic coastal environments with resource areas that move over time, the challenges of interpreting existing data, and the importance of addressing issues of scale. The chapter describes in detail what to look for on an applicant's plan and how to evaluate the applicant's delineation of the resource area through analysis of the site plans and other submitted data and information. This chapter also describes how Commissions can provide their own field verification by completing the Data Checklist that offers site characteristics of each coastal resource area and respective boundaries. The various tools and methods described in this chapter are to be used on a case-by-case basis depending on the level of detail needed for resource area delineations at the project site. Ultimately, a determination of resource area boundaries will be dependent on project type, design, and location, and whether these have potential to adversely impact the resource areas.

Chapter 2 - Resource Area Characteristics and Functions

This chapter lists the presumption of significance of each resource area, as articulated in the Wetlands Protection Act Regulations, and identifies the critical characteristics of the resource area that function to protect the interests of storm damage prevention and flood control. The chapter also focuses on factors that affect the capacity of the resource area to function, so that Commissions can properly evaluate existing functions that will require protection. The chapter includes diagrams and photographic examples to assist Commissions through the process of evaluating the functions of each resource area.

Chapter 3 - Performance Standards and Project Review

This chapter explains how to review a proposed project by applying relevant performance standards to the existing storm damage prevention and flood control functions of the resource areas. The chapter lists and describes the performance standards that protect the interests of storm damage prevention and flood control for each resource area, and provides examples of typical projects, their potential adverse impacts on these functions, and design principles for ensuring that these projects do not impair the functions of each coastal resource area. The chapter then describes general review guidelines for project evaluation to help Commissions determine if the proposed project can be designed to meet performance standards.

Chapter 4 - Selected Scenarios: From Principle to Practice

This chapter gives several hypothetical examples of a Conservation Commission evaluating typical projects to demonstrate how the concepts and tools provided in this manual can be used in practice.

Appendices

The appendices provide more detailed information on many of the topics covered in the manual.

- **Appendix A - Glossary**. This section provides a definition of common terms that are found throughout the manual.
- **Appendix B - Useful Data Sources**. This list includes links to maps, orthophotography, Federal Emergency Management Agency policies and guidelines, and other important sources of information and data to help Commissions review a site and a proposed project.
- **Appendix C - Technical Specifications for Delineating the Primary Dune Boundary**. These guidelines are to be used by an applicant/consultant and reviewed by a Commission when a proposed project in a dune warrants an exact determination of the primary dune boundaries.
- **Appendix D - Massachusetts Department of Environmental Protection Coastal Banks Policy**. This MassDEP policy (DWW Policy 92-1) is to be referenced when delineating the top of a coastal bank.
- **Appendix E - Measuring Slope on a Coastal Bank**. This section provides a description on how to apply the methodology from DWW Policy 92-1 to an applicant's site plan to measure slope ratios and determine the top of a coastal bank.
- **Appendix F - Using an Engineer or Architect Scale to Calculate Distances on a Plan**. This section describes the methods for using scales to measure distances on a site plan.
- **Appendix G - References**. These publications, websites, and court decisions were used as sources of information throughout the Manual and can be referenced by Commissions for more information on topics ranging from coastal geological processes to dune protection.
- **Data Checklists for the Delineation of Resource Areas**. These checklists, which are also found at the end of each section in Chapter 1, are provided as a separate attachment so that they can be taken out and used in the field.

A NOTE ON LOCAL BYLAWS

This manual provides specific information on ensuring that coastal projects meet the performance standards of the state's Wetlands Protection Act Regulations. Many coastal communities have enacted local wetlands bylaws that include specific standards that are more stringent than the state Regulations. While these communities will look at additional issues through the permitting process, the information provided in the manual will be useful as a foundation for delineating coastal resource areas, assessing the function of these resource areas, and ensuring that projects meet the minimum performance standards established by the state.

Chapter 1 - Resource Area Delineations

One of the most important steps in the project review process is the accurate delineation of the resource areas. Since each resource area has its own set of functions and performance standards, proper identification of the resource areas and establishment of accurate boundary lines will have ramifications for how the resource areas are protected. This chapter defines each of the coastal resource areas *that are significant to storm damage prevention and flood control* and summarizes the methodology for their delineation. It also provides practical advice on handling the realities of working in dynamic environments with resource areas that move over time, the challenges of interpreting existing data, and the importance of addressing issues of scale.

When requesting information and data from an applicant, Commissions must use their best professional judgment based on the circumstances of the project, the nature of the resource area, the potential impacts to its function, and whether a precise delineation of the resource area will be needed to apply the performance standards. An approximate boundary may be sufficient unless the project directly or indirectly affects the resource areas. Therefore, Commissions will not necessarily need to require or to review all the data and specifications that are detailed in this chapter. This section is to be used as a reference to understand the various methodologies for resource area delineations.

This chapter provides a section on each coastal resource area covered by the Wetlands Protection Act (WPA) Regulations that is significant to storm damage prevention and flood control (i.e., land under the ocean, Designated Port Areas, coastal beaches, coastal dunes, barrier beaches, coastal banks, rocky intertidal shores, salt marshes, and land subject to coastal storm flowage[2]). Each section begins with the regulatory definition of the resource area, followed by:

- **Special Considerations** - General information about the unique characteristics of the resource area with a description of the complexities of the particular dynamic landform, any data limitations and constraints, and the best way to handle delineation given the available information.

- **Applications and Plans** - A description of what Conservations Commissions should look for on an applicant's plan and how they should evaluate the applicant's delineation of the resource area through analysis of the site plans and other submitted data and information.

[2]Although, the WPA Regulations do not specifically state that land subject to coastal storm flowage is significant to the interests of storm damage prevention and flood control, it is listed as an area subject to protection under the Regulations (10.02(1)(d)), as well as under the Act (M.G.L. c. 131, § 40). In addition, the Regulations (10.03(5)) state, "Each area subject to protection…is presumed to be significant to one or more of the interests." Therefore, Commissions can presume that land subject to coastal storm flowage is significant to the interests of storm damage prevention and flood control because of its inherent functions.

- **How to Delineate and Review the Resource Area** - Information on how Commissions can make their own determinations of the resource area boundaries by utilizing the following tools:

    - **Field Observations** - Site investigations to help define the characteristics, processes, and boundaries of each resource area, which can be incorporated into Commission decisions.
    - **Data Checklist** - A checklist Commissions can use to help identify features on the plans and maps and to record information about characteristics and resource area boundaries at the site. These checklists can be used in combination with photographs that document site conditions. A checklist is not provided for Designated Port Areas since Commissions can refer to the DPA maps issued by the Massachusetts Office of Coastal Zone Management (CZM).

In this chapter, the general approach used to delineate boundaries is to work in a seaward to landward direction. In some circumstances, however, Commissions must work their way to the middle of two distinct resource areas, such as a dune and beach, to find the most accurate boundary line.

LAND UNDER THE OCEAN

The WPA Regulations (310 CMR 10.25) define land under the ocean as "the land extending from the mean low water line seaward to the boundary of the municipality's jurisdiction and includes land under estuaries."[3]

A subcategory of this definition is nearshore areas, which also extend from mean low water to the seaward limit of the municipality's jurisdiction, "but in no case beyond the point where the land is 80 feet below the level of the ocean at mean low water." The Regulations also specify three areas with a seaward boundary of the nearshore area shallower than 80 feet:

- Areas bordering Buzzard's Bay and Vineyard Sound (west of a line between West Chop, Martha's Vineyard, and Nobska Point, Falmouth) where the nearshore area extends seaward only to that point where the land is 30 feet below the level of mean low water.
- Provincetown's land in Cape Cod Bay where the nearshore area extends seaward only to that point where the land is 40 feet below the level of mean low water.
- Truro's and Wellfleet's land in Cape Cod Bay where the nearshore area extends seaward only to that point where the land is 50 feet below the level of mean low water.

Special Considerations

The mean low water line is defined by the Regulations as "the line where the arithmetic mean of the low water heights observed over a specific 19-year metonic cycle (the National Tidal Datum Epoch) meets the shore and shall be determined using hydrographic survey data of the National Ocean Survey of the U.S. Department of Commerce," which can be found on the National Oceanic and Atmospheric Administration (NOAA) nautical charts. Though the Regulations require that the mean low water line be determined by using this hydrographic survey data, NOAA has since revised their charts to reference mean lower low water (MLLW). While still providing an approximate idea of mean low water, these charts should not be relied upon for an exact determination since they no longer meet the definition as described in the WPA Regulations. The nautical charts will also provide an approximate identification of the seaward boundary of nearshore areas. These, as well as other bathymetric maps published by NOAA, can be used to provide an approximate location for the 80-, 30-, 40-, and 50-foot contour lines of the nearshore area.

Whether an applicant is required to precisely identify the location of mean low water, the seaward boundary of land under the ocean (i.e., the seaward extent of municipal jurisdiction), or the seaward

[3]The boundary of the municipality's jurisdiction is generally 3 miles offshore, with exceptions in parts of Massachusetts Bay, Cape Cod Bay, and Nantucket Sound where bay closure lines provide jurisdiction beyond 3 miles. The boundary line for the municipalities also defines the seaward boundary of Massachusetts submerged land pursuant to the Submerged Lands Act (SLA). In the Atlantic Region, the SLA boundary line is projected 3 nautical miles offshore from the baseline. Further information on the SLA and development of this line from baseline points can be found in *OCS Report MMS 99-0006: Boundary Development on the Outer Continental Shelf.* The SLA Boundary line layer can also be viewed on the Massachusetts Ocean Resource Information System, (MORIS) at www.mass.gov/service-details/massachusetts-ocean-resource-information-system-moris.

boundary of the nearshore area will depend on whether a project will affect the functions of the resource area and/or adjacent resource areas. Often, the adjoining resource areas (e.g., coastal beach, rocky intertidal shore) may have the same or similar performance standards to serve the interests of storm damage prevention and flood control and an exact dividing line may not be necessary for a Commission's review of the project application. In addition, Commissions may decide not to require a precise delineation if the project is clearly landward of (and will not impact) land under the ocean. However, if a project such as dredging is proposed in land under the ocean with potential impacts to both this and adjacent resource areas, such as tidal flats and salt marshes, a more exact determination of the boundary may be necessary. In these cases, survey data can be used to locate the mean low water elevation.

In the WPA, only the nearshore areas of land under the ocean are likely to be significant to the interests of storm damage prevention and flood control. Because of this, it is important to determine the seaward boundary of nearshore areas when proposed offshore projects, such as dredging or the placement of pipelines or cables, have the potential to impact these interests. If an exact determination of the nearshore boundaries is needed, a survey should be required.

Applications and Plans

Commissions should ensure that all surveys and plans reference (or be adjusted to) one consistent vertical datum. The datum points most often referenced are the North American Vertical Datum of 1988 (NAVD 88), National Geodetic Vertical Datum of 1929 (NGVD 29), and North American Datum of 1983 (NAD 83). NOAA's nautical charts have depths referenced to a mean lower low water (MLLW) datum. Federal Emergency Management Agency (FEMA) Flood Insurance Rate Maps (FIRMs) now reference NAVD 88 (older FIRMs referenced NGVD 29; see "Land Subject to Coastal Storm Flowage" beginning on page 1-67 for more details). Occasionally, an applicant will reference a local or assumed datum. Where possible, all data should be relative to the NAVD 88 datum to maintain consistency between floodplain elevations, bathymetry, and site topography. The NOAA National Geodetic Survey website (www.ngs.noaa.gov) and the NOAA Office of Coastal Survey website (www.nauticalcharts.noaa.gov) provide tools for computing datum conversions, such as VDatum, a tool that enables a user to transform elevation data between any two vertical datums among a choice of 28 orthometric, tidal, and ellipsoid vertical datums.

Commissions should require that, at a minimum, applicants show the mean low water line on the plan and indicate how it was derived. Commissions should also check the date of the bathymetric data to make certain that they are reviewing current information.

How to Delineate and Review Land Under the Ocean Boundaries

Commissions should be sure to check the best available hydrographic survey data (NOAA nautical charts) and/or tide charts to determine the nearshore depth elevations and the mean low water elevation. Approximate elevations may be sufficient unless the project directly or indirectly affects the resource area.

Commissions should also perform site visits and keep track of observations and data collected in the field. The following information on field observations and the data checklist can assist Commissions at the site.

Field Observations

Follow-up field observations should be made to verify delineations made from plan data. Commissions can find their own estimate of mean low water to review an applicant's delineation by going out to the site and observing tide lines, completing the Data Checklist below, and comparing it to the survey data supplied by the applicant.

Commissions should refer to the next section on coastal beaches for more information on the identification of the coastal beach resource area to help distinguish the defining characteristics of a beach from the characteristics of land under the ocean.

Data Checklist[4]

When a precise delineation of land under the ocean is needed, the following checklist can be used to: 1) identify features on the plans and maps, 2) record information about site characteristics and features in the field, and 3) determine if additional information is needed to delineate the resource area. (These indicators should only be used for an approximate boundary—a survey should be required for an exact delineation of seaward and landward boundaries of land under the ocean and the nearshore area.)

[4]This checklist can also be found in the Data Checklists for the Delineation of Resource Areas, a separate attachment that can easily be carried out to the field to record information about landform features and characteristics.

Check all that apply:

<table>
<tr><th>Indicators of the Seaward Boundary of Land Under the Ocean</th><th>If yes:</th></tr>
<tr><td>❑ Does hydrographic survey data indicate that the project location is beyond (seaward of) the boundary of the municipality (generally 3 miles offshore)?</td><td>The project is not within land under the ocean and not subject to the Wetlands Protection Act.</td></tr>
<tr><td>❑ Have you identified the nearshore area contour line that is applicable to your region and does the hydrographic survey data indicate that the project location is beyond (seaward of) the boundary of this contour line, but within (landward of) the boundaries of the municipality?</td><td>The project is within land under the ocean, but not within the nearshore area (and thus is not likely to be significant to the interests of storm damage prevention and flood control).</td></tr>
<tr><td>❑ Have you identified the nearshore area contour line that is applicable to your region and does the hydrographic survey data indicate that the project location is within (landward of) the boundary of this contour line and within (landward of) the boundaries of the municipality?</td><td>The project is within the nearshore area (and thus is likely to be significant to the interests of storm damage prevention and flood control).</td></tr>
<tr><td>Indicators of the Landward Boundary of Land Under the Ocean</td><td>If yes:</td></tr>
<tr><td>❑ Do you have an approximate idea of the location of the mean low water line?</td><td>You have an idea of the landward boundary of land under the ocean.</td></tr>
<tr><td colspan="2">If you do not have an approximate idea of mean low water, observe obvious characteristics of land under the ocean and beach, tidal flat, or rocky intertidal shore (as listed below) and work your way to the middle to identify the landward boundary of land under the ocean. The characteristics of the resource areas that are listed below are described in more detail in this section and in the sections for coastal beaches (beginning on page 1-8) and rocky intertidal shores (beginning on page 1-57).</td></tr>
<tr><td>❑ At a typical low tide, are your feet in the water?</td><td>You are on land under the ocean.</td></tr>
<tr><td>❑ At a typical low tide, are you standing on a tidal flat, nearshore sandbar, or wet sand area? or
❑ Are you standing on sediments that look like they have been primarily reworked by waves and tides?
Do you see:
❑ rill marks,
❑ ridges and runnels,
❑ swash marks,
❑ beach cusps (horns and embayments),
❑ berms, and/or
❑ wrack lines from the most recent high tides?</td><td>You are on a coastal beach (or tidal flat that precedes a salt marsh)</td></tr>
<tr><td>❑ At a typical low tide, are you standing on a rocky shore with a predominance of boulders or bedrock outcrops?</td><td>You are on a rocky intertidal shore.</td></tr>
<tr><td colspan="2">❑ Are field observations consistent with surveys, maps, and other references?</td></tr>
<tr><td colspan="2">❑ Other observations:</td></tr>
</table>

DESIGNATED PORT AREAS

The WPA Regulations define Designated Port Areas (DPAs) or Designation of Port Areas (310 CMR 10.26) as "those areas designated in 301 CMR 25.00: *Designation of Port Areas*." More specifically, 301 CMR 25.02 defines a DPA as "an area of contiguous lands and waters in the coastal zone that has been so designated by CZM in accordance with 301 CMR 25.00." These regulations complement and work in conjunction with provisions of the Waterways law (G.L. c. 91) and Regulations (310 CMR 9.00) and with the provisions of the Municipal Harbor Plan Regulations (301 CMR 23.00) governing review and approval of DPA Master Plans.

Special Considerations

Designated Port Areas are important due to their state, regional, and national significance to commercial fishing, marine commerce, transportation, and water-dependant industrial uses. The critical feature of a DPA is the existence of port infrastructure, where the waterways have already been developed and built for navigation and the land-based configuration and character is conducive to industry, public utility, associated businesses, and land-based transportation. To create new infrastructure elsewhere would require dredging, altering natural shorelines with fill and structures, and possibly encroaching upon upland resources or developed areas. Therefore, encouraging development in existing ports has less adverse impacts on resource areas and is more economical.

For this reason, the WPA Regulations require different protection standards for land under the ocean in a DPA than for land under the ocean outside a DPA. Rather than protecting the natural landform, the emphasis is to maintain the stability of coastal engineering structures, thereby protecting upland areas and development from storm damage and flooding. Delineation of this resource area is more straight-forward because the designation and boundaries have already been mapped and defined pursuant to 301 CMR 25.00.

Applications and Plans

Project applicants should show the boundaries of any Designated Port Area on their plans.

How to Delineate and Review Designated Port Area Boundaries

Official copies of the maps and official descriptions of the most current Designated Port Area boundaries are available from the Massachusetts Office of Coastal Zone Management on their Designated Port Area website (www.mass.gov/service-details/czm-port-and-harbor-planning-program-designated-port-areas). Be sure to check the most current maps and amendments to determine the DPA map boundaries.

COASTAL BEACHES

The WPA Regulations (310 CMR 10.27) define coastal beaches as, "unconsolidated sediment subject to wave, tidal and coastal storm action which forms the gently sloping shore of a body of salt water and includes tidal flats. Coastal beaches extend from the mean low water line landward to the dune line, coastal bank line or the seaward edge of existing man-made structures, when these structures replace one of the above lines, whichever is closest to the ocean." The size of the unconsolidated sediments that make up coastal beaches in Massachusetts range from fine particles, such as silt and sand, to larger diameter material, varying in size from gravel, pebbles, cobbles, and boulders. This is due to the range of sediments deposited in the area by glaciers.

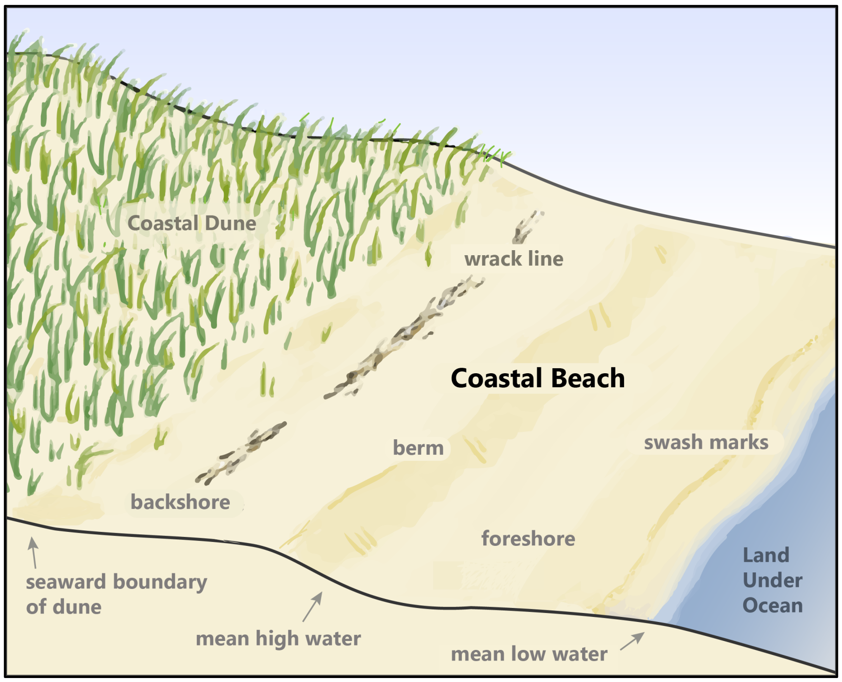


Figure 1.1. Illustration of beach cross section (also includes land under the ocean and coastal dune). Figure redrawn from *A Guide to the Coastal Wetland Regulations*, DEQE (now MassDEP).

A subcategory of the coastal beach definition is tidal flat, which is defined as, "any nearly level part of a coastal beach which usually extends from the mean low water line landward to the more steeply sloping face of the coastal beach or which may be separated from the beach by land under the ocean."[5] The latter part of this definition refers to tidal flats that are completely surrounded by water at mean low water and may be disconnected from the rest of the coastal beach and could include sandbars and clam flats.

The coastal beach (see Figure 1.1) is that area of the shore that is continuously reworked by waves and tides. The following general terms used to describe the parts of the coastal beach can assist Commissions with their delineation.

The foreshore is the seaward-sloping portion of the beach affected by the average tides. The foreshore's slope is related to the grain size of the beach sediments and the energy of the waves. When waves break on the beach, they form a sheet of water called the swash, which washes up and

[5]Though tidal flats do not necessarily require a boundary distinction for the storm damage prevention and flood control interests of the WPA, an exact delineation of the landward boundary of tidal flats may be necessary for the protection of the interests of marine fisheries, wildlife habitat, and land containing shellfish.

back down the foreshore of the beach in an area called the swash zone. Swash leaves behind thin lines in the sand called swash lines or swash marks, which are temporary traces that mark the most landward extent of the swash. Swash action can also form beach cusps—a series of depositional mounds or ridges called horns separated by crescent-shaped troughs called "embayments." The beach may also contain rill marks, which look like miniature erosional channels or streams crossing the intertidal zone carved out by water draining out of the beach at low tide (see Photograph 1.1). Ridge and runnel systems—beach parallel features consisting of bars (ridges) separated by shallow landward troughs that may collect water (runnels)—often form on shallow-sloped beaches by the interaction of tides, currents, sediments, and beach topography (see Photograph 1.2).

The backshore extends landward from the average high tide mark as a broad terrace or gently landward-sloping surface. Beach berms, horizontal plateaus of beach sediments deposited by waves and tides, can be found on either the upper part of the foreshore or the backshore. There may be more than one berm (e.g., spring tide berm, storm berm) or no berm at all. The wrack line or drift line is the most landward extent of material (e.g., seaweed, shells, debris) deposited by the swash for each tidal cycle.[6] There may be multiple wrack lines from different tidal cycles and storm events.

Photograph 1.1 Rill marks.

Photograph 1.2. A ridge and runnel feature.

Special Considerations

The coastal beach is a dynamic landform undergoing change on multiple temporal and spatial scales. The coastal processes that change and reshape the beach on a daily basis, including wind, waves, and tidal action, can make delineation of the coastal beach resource boundaries challenging. Beaches also change seasonally, tending to accrete during the summer months and/or after storm events, when sediments are deposited by relatively low-energy waves, and erode during the winter and/or storm events, when sediments are moved into nearshore sand bars by higher-energy waves (see Figure 1.2 on page 1-10). Therefore, interpretation of existing data, such as topographic maps or nautical charts, must be analyzed and evaluated in light of current shoreline conditions. Any reliance on existing data should be verified by on-site observations, particularly if a proposed project may

[6]See photographs of beaches on pages 1-12 and 1-13 for examples of wrack lines.

directly or indirectly impact the functions of a coastal beach resource area, as articulated in the Regulations.

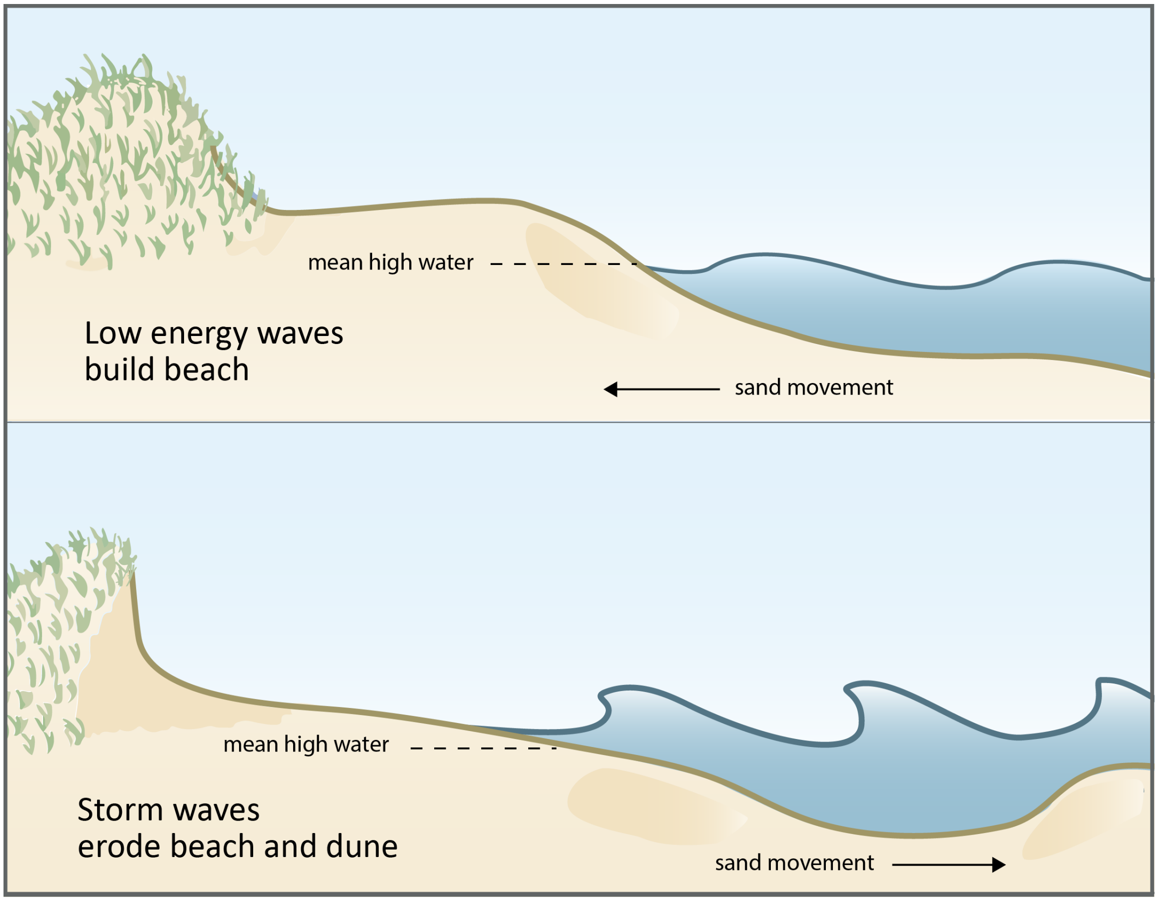


Figure 1.2. Beach profiles showing seasonal change—summer or post-storm periods when low energy waves move sand onshore (build) versus winter and/or storm events when high energy waves move sand offshore (erode). Figure redrawn from *Barrier Beach Management Sourcebook*, CZM.

Applications and Plans

Whether an applicant is required to precisely identify beach boundaries will depend on whether a project will affect the functions of the coastal beach and/or adjacent resource areas that are subject to performance standards. For projects that are unlikely to impact these resource areas, an exact delineation may not be necessary for a Commission's review of the project application. For projects that are likely to have impacts, applicants or their representatives should supply a large-scale surveyed plan with detailed topography of the site and delineation of the beach boundaries. A large-scale plan allows for more information and detail for a particular site. Whether the plans are derived from existing data sources or are based on a field survey, Commissions should ensure that the information is current and reflects the existing conditions of the beach. Where possible, all data should be relative to the NAVD 88 datum in order to maintain consistency between floodplain elevations, offshore bathymetry, and site topography. The NOAA National Geodetic Survey website (www.ngs.noaa.gov) and the NOAA Office of Coastal Survey website (www.nauticalcharts.noaa.gov) provide tools for computing datum conversions, such as VDatum, a tool that enables a user to transform elevation data between any two vertical datums, among a choice of 28 orthometric, tidal, and ellipsoid vertical datums.

A resource delineation is ultimately an interpretation of various pieces of information. Commissions will need to use their best professional judgment in reviewing the resource area boundaries for a coastal beach, as even experienced professionals may differ in boundary delineation on the same site. Commissions may want to hire a consultant to review delineations in difficult situations when more precise boundary lines are warranted for the project being reviewed. In cases where it is clear that a project will not affect the resource area, an approximate boundary will likely suffice. In most circumstances, Commissions should be able to follow the Data Checklist below to assist them in determining the coastal beach boundaries in the field.

How to Delineate and Review Coastal Beach Boundaries

Before going to the site, Commissions should review maps, site plans, and other available information to become familiar with the existing information for the site and the proposed project. Any questions or concerns about the maps and plans can then be addressed at the site visit or at the first meeting with the applicants.

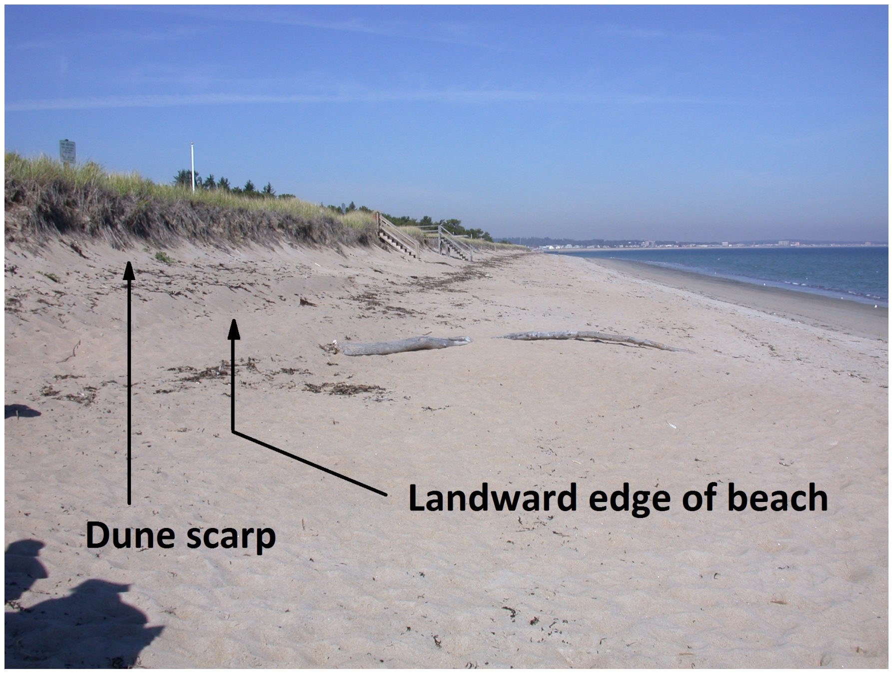
Commissions should perform site visits and keep track of observations and data collected in the field. The following information on field observations and the data checklist can assist Commissions at the site.

Field Observations

Once at the site, Commissions should walk around the area using the site plans to become oriented. They should then determine what procedure the applicant used to delineate the resource boundary. Using the Data Checklist below, Commissions can determine their own boundary delineation and assess the accuracy of the site plan. If questions arise about the location of the boundary, or if it appears that the plans were drawn incorrectly, the applicant should be required to adjust them accordingly.

To determine the seaward boundary of coastal beaches, Commissions should look for the seaward edge of the tidal flats and/or the mean low water line. An approximate boundary may be sufficient unless the project directly or indirectly affects this portion of the resource area. If the project is likely to have impacts, a survey should be required.

The landward edge of a beach relative to a coastal dune is where there is a change from sediments primarily reworked by waves and tides to sediments primarily reworked by wind or deposited by overwash (coastal dunes are not usually reached by normal high tides). In sandy beach and dune areas, beach sediments are typically heavier and larger grained than the adjacent dune because the wind transports the finer grains of sand onto the dunes, leaving the heavier grains behind. The primary distinguishing feature that demarcates the landward boundary of the beach and the beginning of a coastal dune is a distinct change in topography from a relatively mild slope to a steeper, seaward-facing slope. Often, however, this demarcation is not distinct.

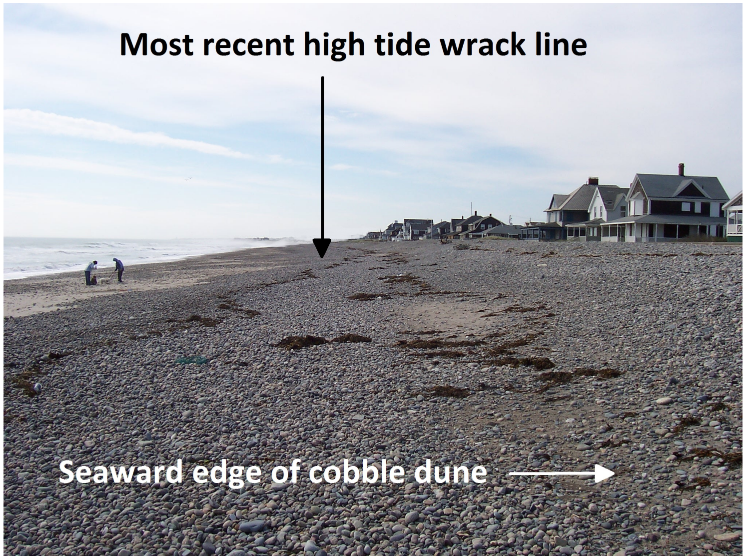


Photograph 1.3. Coastal beach and dune.

The best approach for delineating the boundary where no distinct or abrupt change in slope is apparent is to identify an area that is clearly a coastal beach (reworked by waves and tides—observe the location of swash marks, beach cusps, rill marks, and the high tide wrack line from the most recent tidal cycle),[7] and an area that is clearly coastal dune (see "Coastal Dunes" beginning on page 1-16 for dune characteristics). Commissions can then work their way between these two areas to determine where the change between the two types of processes occurs. This boundary is typically associated with a change in slope (see Photograph 1.3).

For beaches with mixed sediment (sand, gravel, and cobble), as well as those primarily composed of cobble, the foreshore of the beach is generally steeper than a sandy beach and has a more distinct berm at the landward extent of the regular tide and wave activity. Cobble dunes are deposited by overwash and storm events, landward of the regular tidal action. The boundary for the landward edge of the beach and the beginning of the coastal dune for these mixed-sediment or cobble environments is primarily determined by a change in slope. The coastal dune may look like a second berm and is higher in elevation than the beach (see Photograph 1.4).

[7]In the matter of Town of Plymouth, Docket No. WET 2009-016, Recommended Final Decision, February 18, 2010, adopted by Final Decision, March 16, 2010, piles of wrack and sand (wrack sand structures) are part of the coastal beach, because they are regularly subject to wave and tidal action. The wrack sand structures within the intertidal zone do not constitute coastal dunes. Moreover, vegetation must be present for an accumulation of wrack and sand to be characterized as an embryo dune.



Photograph 1.4. Mixed sediment beach. *Note multiple wrack lines from tidal cycles and storm events.*

For the demarcation between beach and coastal bank or man-made coastal structure, where there is no dune, the toe of slope is usually readily identifiable. However, it is important to note that there are many cases where there is a small dune at the toe of a coastal bank or other structure. This typically occurs where there is a wide enough beach so that the waves and tides do not reach the coastal bank or structure and the backshore stays dry enough for windblown sediment transport and deposition to occur (see Photograph 1.5).

There are also cases where the dune face has been eroded, creating a near vertical scarp or sand cliff, such as seen in Photograph 1.3. These areas should not be mistaken for coastal banks. The difference between coastal banks and coastal dunes will be discussed further in the next sections.

Photograph 1.5. Coastal beach that borders a small coastal dune before transitioning to a coastal bank.

Data Checklist[8]

When a precise delineation of the coastal beach is needed, the following checklist can be used to: 1) identify features on the plans and maps, 2) record information about site characteristics in the field, and 3) determine if additional information is needed to delineate the resource area. The person using this form is advised to work from the water line up to the landward interface of the beach with a dune, bank, or other resource area.

[8]This checklist can also be found in the Data Checklists for the Delineation of Resource Areas, a separate attachment that can easily be carried out to the field to record information about landform features and characteristics.

Check all that apply:

<table>
<tr><td>Indicators of the Seaward Boundary of a Coastal Beach
(These indicators should only be used for an approximate boundary—a survey should be required for an exact delineation.)</td><td>If yes:</td></tr>
<tr><td>❑ Do you have an approximate idea of the location of the mean low water line?</td><td>You have an idea of the seaward boundary of the coastal beach.</td></tr>
<tr><td colspan="2">If you do not have an approximate idea of mean low water, observe obvious characteristics of land under the ocean and beach (as listed below) and work your way to the middle to identify the seaward boundary of the coastal beach. The characteristics of these resource areas are described in more detail in this section and the section for land under the ocean beginning on page 1-3.</td></tr>
<tr><td>❑ At a typical low tide, are your feet in water?</td><td>You are on land under the ocean.</td></tr>
<tr><td>❑ At a typical low tide, are you standing on a tidal flat, nearshore sandbar, or wet sand area?</td><td>You are on a coastal beach.</td></tr>
<tr><td>Indicators of the Landward Boundary of a Coastal Beach with a Coastal Dune</td><td>If yes:</td></tr>
<tr><td>❑ Can you discern a change in slope to a steeper, seaward-facing slope of a hill, mound, or ridge landform? and
❑ Have you found the most recent high tide wrack line?</td><td>Look for the beach/dune boundary landward of the most recent high tide wrack line and where there is a change in slope.</td></tr>
<tr><td colspan="2">If there is not a distinct change in slope that appears to be a logical location for the beach/dune boundary, you should observe obvious characteristics of beaches and dunes and work your way to the middle to identify the landward boundary of the coastal beach. The characteristics of these resource areas are described in more detail in this section and in the section for coastal dunes beginning on page 1-16.</td></tr>
<tr><td>❑ Are you standing on sediments that look like they have been primarily reworked by waves and tides?
Do you see:
❑ rill marks,
❑ ridges and runnels,
❑ swash marks,
❑ beach cusps (horns and embayments), and/or
❑ wrack lines from most recent high tide?</td><td>You are on a coastal beach.</td></tr>
<tr><td>❑ Are you standing on a relatively flat terrace landward of the swash zone formed by deposition of beach sediments by waves or tides, which is relatively devoid of vegetation (or only sparse vegetation is present)?</td><td>You are likely on a coastal berm or backbeach, which is part of the natural form of a coastal beach.</td></tr>
</table>

❑ Are you standing on a hill, mound, or ridge of sediments landward of a coastal beach, which look like they have been primarily reworked by wind or overwash? Do you see: ❑ windblown (dry) sand ripples, ❑ windblown sand accumulation around wrack, pebbles, and shells, ❑ finer-grained sand than the beach (on beaches and dunes that are primarily sand), ❑ a fan-shaped deposit of sand, gravel, and/or cobble landward of the mean high tide line (i.e., overwash fan), and/or ❑ the presence of vegetation that traps and holds windblown sand? Dune vegetation may include: beachgrass (*Ammophila breviligulata*), beach pea (*Lathyrus japonicus*), poison ivy (*Toxicodendron radicans*), seaside goldenrod (*Solidago sempervirens*), rugosa rose (*Rosa rugosa*), and others.	You are likely on a coastal dune.
Indicators of the Landward Boundary of a Coastal Beach with Coastal Bank or Man-Made Structure	If **yes**:
The characteristics of the following are described in more detail in the section for coastal banks beginning on page 1-51.	
❑ Is there an abrupt change in topography—to a steep, seaward-facing slope primarily of glacial origin (typically poorly sorted sediments)?	You have located the landward boundary of the coastal beach with coastal bank (see the coastal banks section beginning on page 1-51 for more details on bank delineation—not all slopes will qualify as coastal banks).
❑ Is there a coastal engineering structure built on an adjacent landward landform?	You have located the boundary of the coastal beach with a man-made structure.
❑ Are field observations consistent with surveys, maps, and other references?	
❑ Other observation:	

COASTAL DUNES

The WPA Regulations (310 CMR 10.28) define coastal dunes as "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."

Also important to note is the definition of primary frontal dune or primary dune, which was added to the WPA Regulations in 2014 and defined as "a continuous or nearly continuous mound or ridge of sediment with relatively steep seaward and landward slopes immediately landward and adjacent to the beach and subject to erosion and overtopping from high tides and waves during coastal storms. The Primary Frontal Dune is the dune closest to the beach. The inland limit of the Primary Frontal Dune occurs at the point where there is a distinct change from a relatively steep slope to a relatively mild slope."

A dune begins to form when an obstacle that lies in the wind's path causes the wind to slow down and deposit the sand particles it is carrying. As the sand particles accumulate, a mound or dune can form. Dune sediments are typically finer grained than the adjacent beach because the wind picks up the finer grains of sand, leaving the heavier, larger grains behind. Coastal dunes can originate along the *highest* wrack line—the line of debris at the high spring tide or storm tide line—which can include dead algae, beach grass stems, plant seeds, seaweed, shells, and other materials left by the ebbing tide (see Photograph 1.3 on page 1-12 for an example of a wrack line). The debris, which is called wrack material, accumulates and gets covered by windblown sand, where plants seeds may germinate. Coastal dunes are not usually reached by normal high tides and are thus outside the intertidal zone.

Photograph 1.6. Cobble and gravel dune.

Cobble and gravel dunes (see Photograph 1.6) form through the activities of overwash and storm events, which transport and deposit the heavier materials landward of the beach. Cobble and gravel dunes do not have the same wind-blown characteristics that a sand dune exhibits. Both, however, provide the same storm damage protection and flood control interests by moving, shifting, and changing form to dissipate energy.

According to the WPA definition section, the dune closest to the coastal beach is known as the primary frontal dune or primary dune. Beyond (landward of) the primary dune may lie secondary dunes, which form from windblown sand deposition, as well as when storm surge and/or waves overtop the primary dunes, depositing sand, gravel, and/or cobble further inland. Secondary dunes are usually smaller in size and have flatter slopes than the primary dune. The size of coastal sand dunes depends on the volume of sand available in the system. For example, dunes at Race Point in Provincetown or on Crane Beach in Ipswich are much larger than dunes in Mattapoisett or Edgartown[9] due to the differences in sediment supply (the volume of sediment available to beaches, dunes, and barrier beaches).

Per Se Significance of Primary Dunes

While all coastal dunes are *likely* to be significant to storm damage prevention and flood control, all coastal dunes on barrier beaches and the coastal dune closest to the beach, also known as the primary frontal dune or primary dune as defined in 310 CMR 10.04, in any area are per se (inherently) significant to storm damage protection and flood control. (The term primary frontal dune is also defined by FEMA in 44 CFR 59.1; see page 1-33 for details.) This regulatory language distinguishes the dune closest to the coastal beach and all dunes within barrier beaches and conveys the importance of properly identifying these resource areas in order to appropriately apply the performance standards and protect the interests of storm damage protection and flood control. Identifying the primary dune is also important due to the relationship it has with the delineation of the velocity zone of the floodplain—per 10.28(1), the velocity zone or coastal high hazard area extends at a minimum to the inland limit of the primary frontal dune on an open coast (with the term "open coast" referring to areas that are not considered sheltered waters and where the dune is adjacent to a beach in a V Zone; see page 1-69 for additional information). See the end of this dune section and Appendix C for more details on how to delineate the primary dune, and the delineation section on land subject to coastal storm flowage for information on floodplain boundaries.

Special Considerations

Like coastal beaches, coastal dunes are dynamic landforms, transient by nature. Dunes constantly change through the deposition and reworking of sand, gravel, or cobble by wind or wave overwash. Due to the highly dynamic and migratory nature of this landform, the delineation of the regulatory border of a coastal dune is most often a professional judgment, based on existing conditions at a particular time. Commissions must use their best judgment to evaluate all the information to determine if an applicant's resource delineation is accurate. Many coastal dunes do not have the appearance people expect—a ridge of sand, beach grass, and a clear demarcation from the beach

[9]See figures on pages 1-20 and 1-21 for examples of profiles of both large- and small-volume dunes.

(see Photograph 1.7 for an example of what is considered a "typical" dune and Figure 1.3 on page 1-20 for a photograph and corresponding profile plot of a characteristic dune).

Photograph 1.7. Typical primary dune.

Photograph 1.8. Low elevation coastal dune partially disguised as lawn.

Photograph 1.9. Coastal dune with coastal engineering structures. Foreground: coastal dune landward of rock revetment. Background: coastal dune and beach landward of a deteriorated bulkhead.

Dunes often do not fit this mold, particularly in those areas with low sediment supply to the beaches and those on the back sides of barrier beaches, which are often very low-lying ridges with hummocky topography that can be either heavily or sparsely vegetated (see Figure 1.4 on page 1-21 for a photograph and corresponding profile of a moderately vegetated, low volume dune). In addition, it is not uncommon to see areas that have been graded, flattened, or established with lawns, potentially disguising the resource, as seen in the example in Photograph 1.8. These particular areas *may* still meet the regulatory definition of a coastal dune—i.e., when the *origin* of the underlying sediments are windblown or wave deposited *and* they still exhibit a hill, mound, or ridge form *relative to the beach* (as in the profile of Figure 1.4 on page 1-21). The alterations may have changed some functions of the resource, but this should be evaluated after the resource is delineated.[10] Landforms that meet the regulatory definition of coastal dunes can also be present in and around manmade structures, such as the example in Photograph 1.9 (note that the coastal engineering structure located on the coastal dune is *not* considered a coastal bank).

[10]The exception to this general rule is when the function of artificial fill needs to be assessed to determine whether it is defined as a regulatory dune or bank—see "Artificial Fill" on page 1-27 and Chapter 2 for more discussion about assessing coastal dune function.

In some instances, dunes may not meet the regulatory definition of coastal dunes because they are separated from the coastal beach by another resource area or an upland area. These include cliff-top dunes that overlie (or are landward of) a coastal bank, but are not touching the beach. Though these dunes may still constitute a hill, mound, or ridge of sediments, they do not meet the definition of "bordering" (touching the ocean or touching another resource area that touches the ocean), and therefore do not meet the requirements for being a dune subject to protection under the Wetlands Protection Act.[11]

Where windblown-sand deposits (that do border a beach or another dune) overlie glacial deposits with varying thickness, the delineation becomes more complicated. The methodology for these complex resource delineations can be found later in this section. The main point to emphasize is that dunes vary widely in size, shape, and performance, and applicants and Commissions need to examine the entire landform landward of the beach, the origin of the sediments, subsurface soil samples if necessary, the functions for storm damage prevention and flood control (if artificial fill), and all plan data and information in order to accurately identify and delineate the resource areas. The process for accomplishing this—such as through performing cross sections that help interpret whether the landform is a hill, mound, or ridge, and determining whether sediments are wind or wave deposited—will be described in more detail in the remainder of this section.

Whether they are large or small, sparsely vegetated with beach grass or densely vegetated with trees, Commissions should ensure that all landforms meeting the definition of coastal dune are delineated on the project plans. The level of protection required will depend on the functional analysis of the dune in question and the performance standards, as will be described in Chapters 2 and 3.

Applications and Plans

When reviewing plans, Commissions should ensure that the information is current and reflects the existing condition of the dune. As discussed on page 1-4, occasionally an applicant will reference a local or assumed datum. Where possible, all data should be relative to the NAVD 88 datum to maintain consistency between floodplain elevations, bathymetry, and site topography.

Whether an applicant is required to precisely identify dune boundaries will depend on whether a project will affect the functions of the coastal dune and/or adjacent resource areas that are subject to performance standards. Where the project may directly or indirectly alter the resource area, applicants should submit plans with detailed topography; cross sections depicting the dune shape, slope, and volume (i.e., a cross-shore profile plot); the dune boundaries; and if applicable, the location of subsurface/surface sediment samples. A profile plot, such as those shown in Figures 1.3

[11]In the matter of Granger Frost, Eric Frost and George Frost, Docket No. 97-091, Ruling on Summary Decision, October 20, 2000, adopted by Final Decision January 8, 2001, the Administrative Law Judge concluded that a dune was a non-jurisdictional dune since it was separated from the ocean by two wetland resource areas—a coastal beach and a coastal bank. A dune must either border the ocean or border another wetland resource area that borders the ocean in order for it to be an area subject to protection under the Act.

and 1.4 below, helps with the visual interpretation of the entire landform (e.g., whether it is a hill, mound, or ridge), particularly in low-volume dunes where the extent of the dune is not obvious relative to the surrounding topography while standing at the site (see Figure 1.4). Where appropriate, the applicant should identify the primary dune (as described at the end of this section on pages 1-32 through 1-38 and in Appendix C). The applicant or their representative should also include an explanation of the assessment method used to determine the dune boundaries.

Where the project is not likely to impact the coastal dune either directly or indirectly, an approximate boundary may be all that is necessary. Moreover, for small projects within the 100-foot buffer zone, the requirements for delineation may only include the landward boundary of the dune—the seaward boundary delineations and cross sections may not be necessary for a review of the proposed project. Commissions should use their best professional judgment when determining whether the applicant should be required to submit the various data and information described in this section based on the project type, location, and whether a precise delineation of the coastal dune resource area will be needed to apply the performance standards.

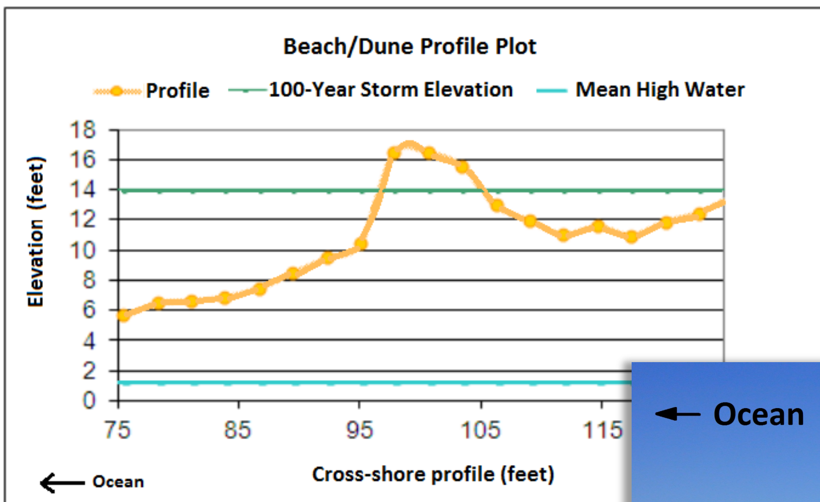
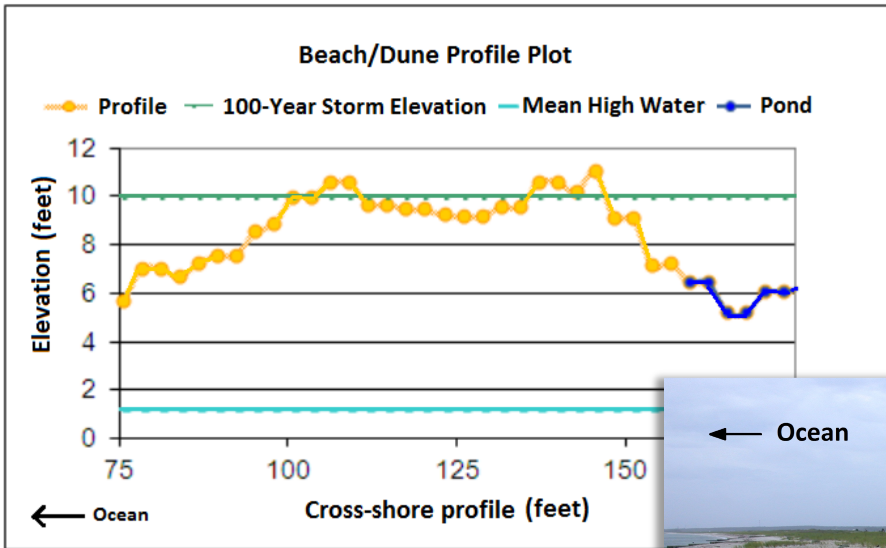


Figure 1.3. Example of profile plot and photograph depicting a characteristic dune. Field verifications in combination with an evaluation of a profile plot (with a vertical exaggeration of approximately 1.25:1) of the site make a determination of the seaward and landward boundaries of the dune easier and more accurate.



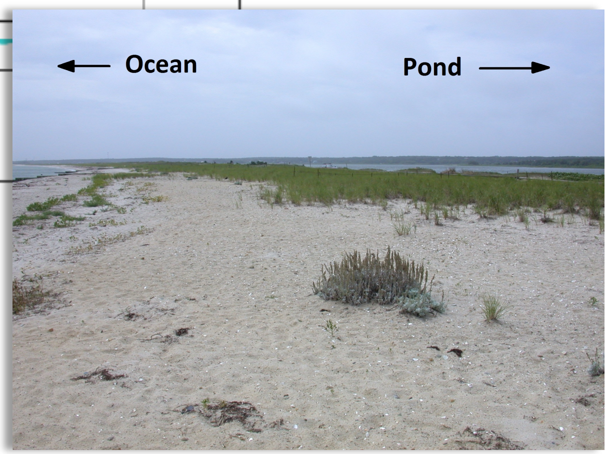


Figure 1.4. Example of profile plot and photograph depicting a low lying dune area. At the site, the hill/mound/ridge-shape topography of the dune is not obvious, while the profile plot (with a vertical exaggeration of approximately 4:1) makes it more clear.

How to Delineate and Review Coastal Dune Boundaries

Like the review of coastal beaches, it is important to understand topographic maps, site plans, subsurface soil information, and other available information before going out to the site to review the coastal dune boundary delineation. Surficial soil maps can be obtained through the National Resources Conservation Service (NRCS) Soil Surveys (see Appendix B for reference material). Although these maps are produced at a fairly broad scale, and the boundaries are not exact enough to replace a detailed resource delineation for a specific site, they can provide a general overview of soil classification, descriptions, and compositions to aid the characterization of the overall landform. This background information can help foster a greater understanding of the site and may help Commissions with their investigation of dune characteristics out in the field. In addition, the subsurface soil information may be particularly useful when distinguishing a coastal dune from a coastal bank, as described later in this section.

Commissions should also perform site visits and keep track of observations and data collected in the field. The following information on field observations, including how to perform more in-depth reviews of subsurface sediments and topographic profiles, and the data checklist can assist Commissions at the site. This section also describes how a Commission should go about reviewing the applicant's delineation of the inland limit of the primary frontal dune, also known as the landward toe of the primary dune, based on the methodology described in detail in Appendix C.

Field Observations

An accurate delineation of the coastal dune boundaries will require general site observations and may require a characterization of the sediments and profiles of the subsurface and surface sediments to define the overall landform. Commissions will also need to determine whether the sediments and landform meet the definitional requirements of a coastal dune. The following information can assist Commissions with performing these tasks.

General Site Observations of Seaward and Landward Extent of Dunes

When at the site, Commissions should first look for the seaward toe of the dune. As discussed in the previous section on coastal beaches, the best approach for delineating the boundary between beach and dune (whether they be sand, mixed sediment, or cobble and gravel) is to locate a distinct change in topography from the relatively mild slope of the beach to the steeper, seaward-facing slope of the dune. Sometimes, however, this line is not so distinct and other characteristics must play a role in the delineation. Where a clear and abrupt change of topography is not obvious, the best approach is to identify an area that is clearly a coastal beach (reworked by waves and tides) and an area that is clearly coastal dune (reworked by wind and/or overwash and part of a hill, mound, or ridge). To identify the characteristics of sandy coastal beaches, Commissions can observe the location of swash marks, beach cusps, rill marks, and the wrack line from the most recent tidal cycle, as well as any beach berm that may be present (see "Coastal Beaches" beginning on page 1-8 for information about beach characteristics). To identify the characteristics of sandy coastal dunes, Commissions can observe the presence of windblown sand ripples, the accumulation of sand around wrack, shells or pebbles, the presence of vegetation, and sediments that are typically finer grained than the adjacent beach—all of which must also be part of a hill, mound, or ridge of sediments and typically landward of normal high tides.[12] Commissions can then work their way between these two areas to determine where the change between the two types of processes (and the boundary) occurs.

Vegetation contributes to the formation and stability of the dunes (see Photograph 1.10 on page 1-23 for typical vegetation that is helping to stabilize a dune). The pioneer plants at the highest wrack line grow and trap windblown sand. The beach at this line of plants will likely rise to a height above the spring high tide elevation as sand accumulates vertically, allowing vegetation to become more established. A dune eventually forms as the roots hold the sand in place and more sand continues to build up around the plants. Commissions can look for plants, such as American beachgrass (*Ammophila breviligulata*), dusty miller (*Artemisia*

[12]See in the matter of Town of Plymouth, Docket No. WET 2009-016, Recommended Final Decision February 18, 2010, adopted by Final Decision, March 16, 2010. Because coastal dunes commence landward of the coastal beach and there is no overlap between beach and dune, the wrack sand structures (piles of wrack and sand) within the intertidal zone do not constitute coastal dunes. Moreover, vegetation must be present for an accumulation of wrack and sand to be characterized as an embryo dune.

stelleriana), beach pea (*Lathyrus japonicus*), seaside goldenrod (*Solidago sempervirens*), and rugosa rose (*Rosa rugosa*), which are helping to establish, build, and stabilize the dunes.


Photograph 1.10. Typical dune vegetation.

Remember that you will not always find this simple pattern. For example, blowouts may occur and create surfaces without vegetation within the dunes. Conversely, on an eroding dune where a scarp has formed, a measurable organic soil horizon and exposed plant roots may be visible. As discussed in the previous section, these vertical scarps might be misinterpreted as coastal banks.[13] Sometimes, newly deposited sand can be found lying immediately landward of an eroding dune; the wind has picked up the sand from the eroding face of the seaward side of the dune, allowing for landward migration of the dune in form and volume.

The landward extent of coastal dunes is the landward edge of the hills, mounds, or ridges of sediment deposited by wind or storm-wave overwash. The transition following the back dunes to the next landform could take one of many forms and be either gradual or sudden. For example, a coastal dune system could transition into a marsh or lagoon, or even in the case of barrier islands, a bay or ocean. Hollows, swales, and flat spots may separate dunes from one another[14] and sometimes bordering vegetated wetlands or vernal pool habitat can be found within them. Vegetation on back dunes could consist of typical dune vegetation, varying from beach grass to beach plum (*Prunus maritima*), or more complex and dense upland plants, varying from shrub growth to low forests, such as maritime forests. On the surface, you may see sand deposits that extend landward for long distances. These sand deposits do not necessarily define the landform as a dune—the surface sediments may be masking an underlying bank landform (see Figure 1.5 on page 1-29 for an example).

Conversely, dune sediments may overlie glacial deposits and still be part of the dune as a tapering landward edge. Where a determination of the landward extent of dune is difficult due to variations in the surface/subsurface sediments, vegetated cover, and complexities in

[13]See photographs on pages 1-12 and 1-26 for examples of vertical scarps on coastal dunes.
[14]See photograph on page 1-30 for an example of a flat area within a dune.

topography, general site observations may need to be augmented with subsurface sediment analysis and profiling of the landform (described below).[15]

On barrier beaches, it is important to note that if the area is not defined as a coastal beach, wetland area, or a glacial landform, the area is defined as a coastal dune, regardless of the vegetation type. Glacial landforms such as a moraines, drumlins, or kames, which are found within a barrier beach, are not considered part of the barrier beach for purposes of the WPA, but still may meet the definition for coastal bank or land subject to coastal storm flowage.

Characterizing Sediments, Examining Profiles, and Defining the Landform

The landward extent of a dune may be difficult to determine due to: the variation in vegetation that is supported by a dune, surficial deposits that may not accurately represent the underlying landform, and alterations to surface topography that may have occurred over time (possibly masking the distinction of hill, mound, or ridge topography). Where the landward extent is unclear through general site observations and where verification is necessary, information on the underlying (subsurface) sediments and their profiles should be provided by the applicant to determine whether the sediments and landform meet the definitional requirements of a coastal dune (see Figures 1.3 and 1.4 on pages 1-20 and 1-21 or Figure 1.5 on pages 1-29 through 1-31 for examples of beach/dune profiles).

In order to help with these relatively complex resource delineations, the following methodology can be used:

1. **Characterize the landform by defining the thickness and characteristics of the surface and subsurface sediment layers and the method of deposition (i.e., windblown, wave deposited, glacial, or artificially deposited).**

To accomplish this, the applicant will need to take multiple transects from the coastal beach landward across the site. Subsurface sediment samples should be obtained along these transects, such as with an auger, shovel, or corer, to help determine the characteristics and thickness of the surface and subsurface sediment layers. Depth of subsurface samples will depend on the height of the dune and the depth to underlying materials—an applicant may encounter glacial deposits fairly close to the surface thereby providing the necessary information; conversely, an applicant may not encounter glacial deposits at all, warranting sampling depths down to mean high water, or at a minimum, deep enough to confirm that subsurface sediments constitute more than a veneer (see page 1-27 and Figure 1.5 on pages

[15] In the matter of Michael P. Wyman, Docket No. 2003-007 Ruling on Motion to Dismiss and Stay, April 11, 2006, the Administrative Magistrate determined that the area in question was coastal dune based on test pit data that indicated the presence of well sorted fine to medium grain-sized sand indicative of windblown deposits and a United States Geological Survey Map that indicated the presence of dune deposits.

1-29 through 1-31 for more information on veneers of windblown sediment). Observing the sediment layers and the grain types, sizes, and features will help distinguish the sediment's method of deposition (i.e., whether they are windblown/wave deposited [dune sediments]; glacial in origin [bank or upland sediments]; or artificial fill).

Dune sediments, which are windblown or wave deposited, are typically rounded and well sorted. Dunes often have obvious layers that represent individual periods when the wind or waves picked up and deposited similar-sized sediments (see Photograph 1.11 for an example of layering).

It is helpful to look at the range of sediment sizes on the beach to put the subsurface sediments observed landward of the beach in perspective; you will find a similar range of sediment sizes and types in dune deposits. The larger the range of sediment sizes (fine sand to pebbles) and types (with variations in color) present in the beach, the more obvious the layers will appear in the subsurface dune sediments.

Photograph 1.11. Vertical face of eroded dune showing layering of sediments.

In contrast to dunes, many upland or coastal bank materials in Massachusetts were deposited by glacial processes and thus tend to be *relatively* unsorted and unstratified.[16] Glacial materials contain many different sized particles, ranging from clay to large boulders, all of which tend to have moderately angular edges from being physically weathered and eroded. Artificial fill, which may consist of a mix of glacial and dune sediments, may act—and thus be defined—as a coastal dune or a coastal bank depending on how it functions (this will be described in more detail on pages 1-27 and 1-28).

It is important to remember that there may be windblown sand deposited on the face or scarp of a seaward-facing landform, so observations of the weathered surface are not always a good indicator of the entire landform (see Photograph 1.12); core samples provide a more accurate representation of the landform. When looking at subsurface sediments, it is not

[16]It is important to note that not all coastal banks are deposited by glacial processes, such as banks consisting of bedrock or pre-glacial sedimentary deposits, the latter of which *are* relatively sorted and stratified. Furthermore, even banks that consist of glacial deposits may be somewhat stratified, particularly if they are a result of sorting and layering from glacier meltwater.

unusual to see the development of a soil profile in coastal dunes, which is dependent on how long the site has been vegetated. It is important to focus on the source of the sediments, not the color or presence of organics, to delineate the resource area.

Photograph 1.12. Eroded scarp. The photograph also shows windblown-sand deposition in front of the scarp—a natural process of recovery after a storm. The only way to tell whether this is an eroded dune or bank is to look at the subsurface sediments behind/under the veneer of windblown sand to determine if they were wind or wave deposits (dune) or were glacial deposits (bank).

Once the applicant and Commission have characterized the sediments and defined their thickness along the transect lines, they can plot the information on a cross-shore profile to help give a visual representation of the deposits relative to the overall landform (see Figure 1.5 on pages 1-29 through 1-31). Looking at the overall topography and depths of sediments can help depict whether the landform (or the area in question on the landform) is a dune or bank/upland and can provide a more accurate determination of dune boundaries. Determining the sediment profile is also important when distinguishing bank from dune sediments for the purposes of allowing a revetment on a coastal bank—see page 3-46 in "Coastal Banks" for more information.

2. **Determine if the deposits meet the definition of coastal dune or coastal bank as defined in the Wetlands Protection Act Regulations at 310 CMR 10.28 and 10.30 respectively.**

To be considered a coastal dune under the Regulations, the landform must meet the WPA definition for being located landward of a coastal beach, consisting of sediments that were deposited by wind action or storm overwash, and exhibiting hill, mound, or ridge topography (see Figures 1.3 and 1.4 on pages 1-20 and 1-21 for examples of topography meeting the definition of a hill, mound, or ridge).[17] The information obtained from the core

[17] In the matter of John Allen and Barbara Cordi-Allen Docket Nos. 2000-83, 2000-087 Recommended Final Decision, July 6, 2006, adopted by Final Decision on August 23, 2006, the Magistrate concluded that the landform is a coastal dune because it exhibits a key characteristic that distinguishes coastal dunes from coastal banks: it can move landward and reform in response to wind and water action. A coastal bank does not reform itself. The Magistrate noted that the landform on site exhibits undulating mound topography and is comprised of dune-like sediments; a dune scarp is present; sand accumulates on the property and is transported landward; and the landform has the ability to be modified by wind and water and to move landward.

samples along the transect lines will help the applicant and Commission interpret whether the subject landform meets these definitional criteria.

As seen in Figure 1.5 on pages 1-29 through 1-31, viewing a subsurface/surface profile illustrates more clearly where dune sediments that overlie glacial material are *part of* the overall landform (making it a tapering edge of a dune) and where they are not part of the hill, mound, or ridge (making them a veneer of sand). When looking at a profile, it is also easier to see where low, flat, graded, or flattened areas that consist of wind or wave deposits are still part of the overall morphology of the dune, thereby still meeting the definitional requirements of a coastal dune.

3. Determine the functions and significance of the resource areas based on the criteria outlined in the Wetlands Protection Act.

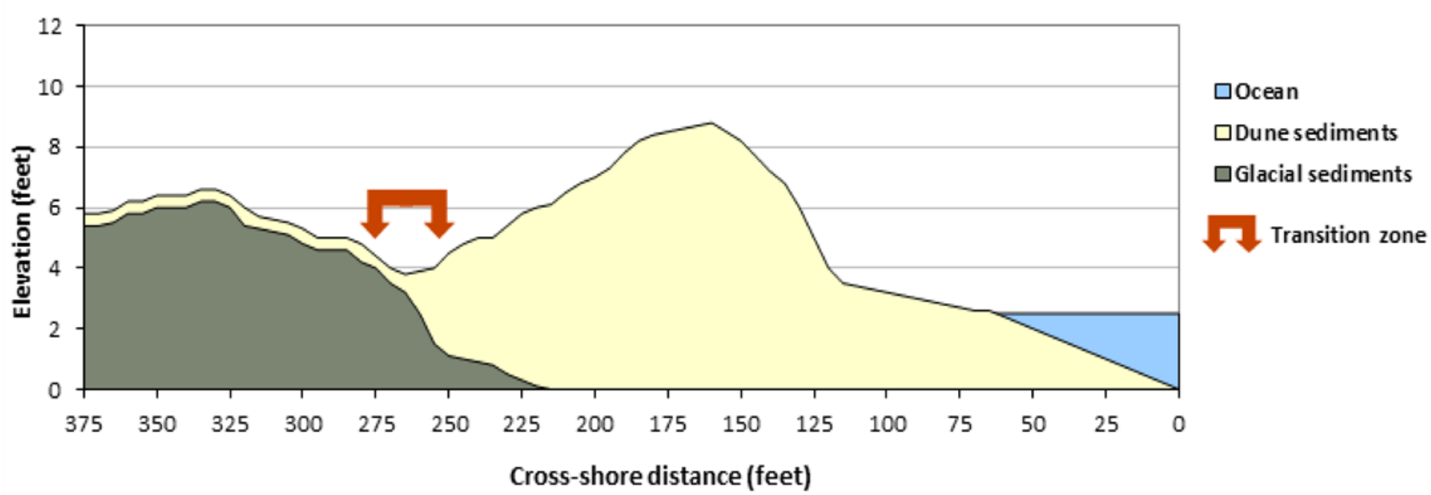
When delineating the coastal dune, only one circumstance warrants an assessment of the *function* of the resource area to help define the landform: when artificial fill has been placed on the resource area. The following information describes the criteria used to assess the function of artificial fill.

Artificial Fill - The Regulations include in their definition of coastal dunes "sediment deposited by artificial means serving the purpose of storm damage prevention and flood control." Therefore, when artificial fill (i.e., sediment; not construction debris or other materials) has been placed on coastal sites, the applicant and Commission must assess the *function* of that fill to help define the landform. Artificial fill can also be considered part of a coastal bank, serving the same purposes. The following factors indicate that the function of the artificial fill meets the regulatory definition of a coastal dune: 1) there is evidence of two-way exchange of sediment between the coastal beach and the landform, particularly during a coastal storm event (two-way exchange means the dune can erode and provide sediment to the beach, while the beach can act as a reservoir of sediment for the dune through wind or wave overwash); 2) the landform can conform and reshape to natural wind and water flow processes, particularly in a coastal storm event; and 3) the landform can migrate landward or laterally in response to wind, wave, or tides. If the artificial fill meets these requirements, it will likely be considered a regulatory coastal dune. Conversely, the landform may not be considered a regulatory dune if it is clearly landward of the 100-year floodplain and storm water cannot wash over the top of the landform and move sediments landward. Though the artificial deposits may have the appearance of a mound, hill, or ridge, and may provide sediment to the beach, the landform is functioning predominantly like a coastal bank and not a coastal dune if it *cannot* shift and move landward and laterally, reform in response to wind and water action, or provide a *two-way* exchange of sediments.[18]

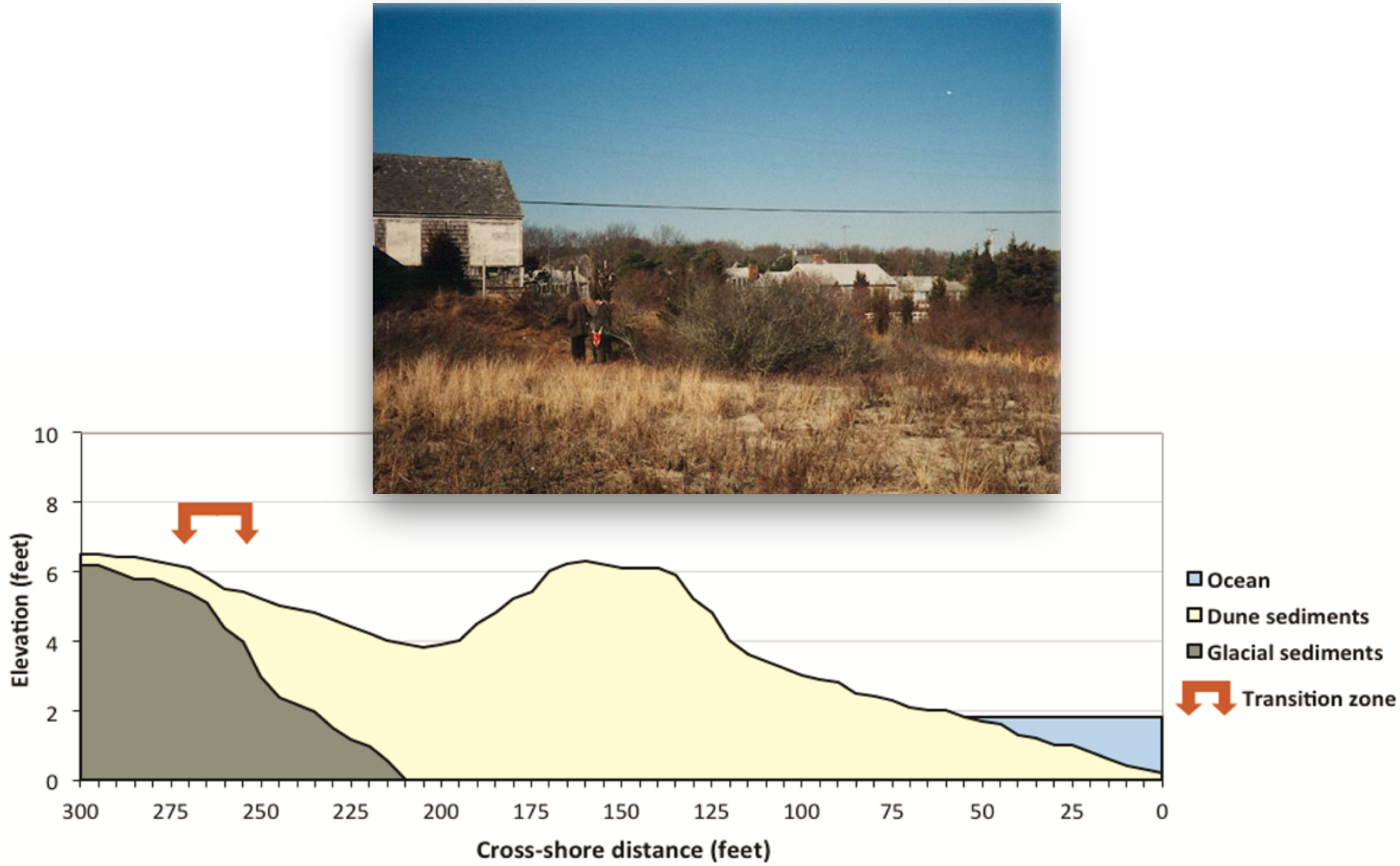
Dunes Not Composed of Artificial Fill - It is important to note that when a resource area is NOT composed of artificial fill, applicants and Commissions should not use the *function* of the landform to determine whether the resource area is a regulatory coastal dune. The delineation criteria—based on origin and type of sediments, the form of these sediments, and its location adjacent to the beach—will be the defining characteristics, regardless of the function. The function will come into play when reviewing performance standards that protect the existing functions of a dune for storm damage prevention and flood control.

[18]In the matter of Donald Kline, Docket Nos. 99-021, 99-022, 99-023, 99-024, 99-025, and 99-026, Final Decision, October 16, 2000, Final Decision denying Motion for Reconsideration, December 12, 2000, the Magistrate determined that fill placed on top of a natural dune system was a coastal bank and not a coastal dune (even though there was a thin veneer of windblown sand on top of the fill), because there was little evidence that the landform had the ability to move landward and reform itself, as would a dune.

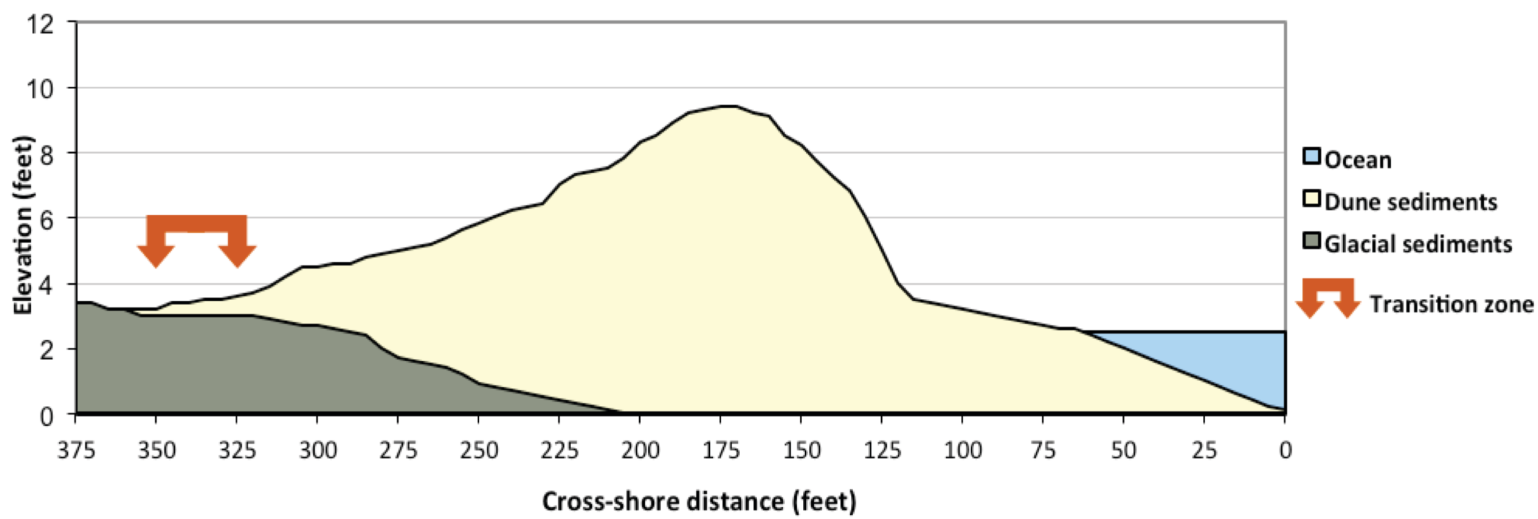
Figure 1.5. Three dune profiles showing a comparison between a veneer of dune sediments and a tapering edge of dune. The three profiles below provide an example of how steps one and two of the methodology described on pages 1-24 through 1-28 are used in practice to distinguish a dune from a bank or upland area. The types of deposits and their thickness along a transect line (cross-shore) help depict the topography of the landform and its relationship with underlying materials. The profiles help give a better idea of whether the overall landform (or parts of the landform) meets the definitional requirements of a coastal dune. More specifically, the three cross sections below help depict where a tapering edge of dune ends, and where a veneer of sand begins. Generally where a layer of sand with a consistent thickness follows the topography of the underlying glacial material, these sediments may not be considered part of a hill, mound, or ridge of a dune landform (see Profile A). Conversely, Profile C shows a dune landform with a tapering edge of a dune that extends landward for many feet. Though the underlying sediments are glacial, the tapering edge of sand is part of the overall hill, mound, and ridge of the dune. For a dune that transitions into a bank on its lateral edge (along-shore view), see Figure 1.10 on page 1-48 in the Barrier Beaches section.



Profile A. Coastal dune tapering landward into a veneer of dune sediments overlying glacial materials. Here, the landward edge of the dune is somewhere within 250-275 feet cross-shore distance. There is not necessarily a distinct boundary, but rather a transition zone (shown with red arrows) within which Commissions can use their judgment to delineate the dune/bank line. Without the subsurface profiles, the second landform may superficially appear as a secondary dune, though it is really a coastal bank.



Profile B. Low-lying primary dune with secondary dune tapering into coastal bank. Here, the dune/bank boundary is somewhere within 250-275 feet cross-shore distance, where the sediments that are part of the overall mound, hill, and ridge of a secondary dune transition into sediments that are consistent in depth and generally follow the contour of the underlying glacial materials—becoming a veneer of sediments. When standing at the site (see photograph), the low, flat area just landward of the primary dune could be mistaken for the end of the dune, yet by looking at the profile of subsurface sediments it becomes more obvious that the dune extends significantly landward of this point. In a low volume dune, even a thin layer of dune sediments is considered part of the coastal dune if it meets the criteria. Again, Commissions can use their best judgment when determining the boundary line within the transition zone (shown with red arrows).



Profile C. Coastal dune landform with tapering landward edge overlying glacial materials. Here, the landward edge of the dune is somewhere within 325-350 feet cross-shore distance (transition zone shown with red arrows). Though fairly thin, most of the landward layer of sand is still part of the overall dune landform. By looking at the overall topography of the landform at the site and through a review of the subsurface profiles, it is clear that this layer is part of the overall dune.

Delineating Primary Dunes

Because the dunes closest to the beach, known as primary frontal dunes or primary dunes, are considered per se significant to storm damage prevention and flood control, a Commission and the project applicant must often distinguish the primary dune from the secondary dune(s) to apply performance standards to protect their functions.[19] The Regulations were amended in 2014 to provide a definition and boundary description of the primary dune to further clarify the importance of delineating this landform. Identifying the primary dune is also critical when determining the extent of the velocity flood zones in dune areas (the landward toe of the primary dune being the minimum extent of the V Zone—see "Land Subject to Coastal Storm Flowage" beginning on page 1-67 for more information on delineating flood zones).[20] To delineate the inland limit of the primary dune (i.e., the landward toe of the primary dune), the Massachusetts Department of Environmental Protection (MassDEP) recommends that the applicant or his/her representative use the primary dune delineation methodology that is based on local geological processes, topography, and a mathematical analysis. This methodology has been peer reviewed by a panel of coastal geologists, FEMA technical consultants, and FEMA staff, as well as by FEMA's technical review group tasked with updating their specifications for flood zone mapping in coastal areas. FEMA found the methodology to be technically and scientifically acceptable for mapping primary frontal dunes and their consultants used a similar approach to update the flood zones on the FEMA maps (i.e., moving the landward extent of the V Zone to the landward toe of the primary dune). The methodology has also been peer reviewed by a Technical Advisory Committee convened by the MassDEP Commissioner to review this manual, and has been tested in adjudicatory hearings.[21]

Because of the degree of complexity in this methodology, it is recommended that the primary dune delineation be done by a professional trained in geomorphology and coastal geology. Applicants and consultants should follow the step-by-step procedures in Appendix C - Technical Specifications for Delineating the Primary Dune Boundary in order to properly use the best available topographic data, assess the dune dimensional characteristics, and employ a numerical approach in combination with knowledge of coastal geology to accurately delineate the primary dune. Commissions can review the

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[19]See in the matter of Stephen D. Peabody Trustee, Docket No. 2002-053, Final Decision, January 25, 2006, affirmed by Essex Superior Court sub nom Peabody v. Department of Environmental Protection, ESCV 2006-00299, September 21, 2007, and affirmed by Massachusetts Appeals Court, No. 08-P-674, Memorandum and Order Pursuant to Rule 1:28, 82 Mass. App. Ct. 1120, (November 8, 2012). All coastal dunes are likely to be significant to storm damage prevention and flood control and all coastal dunes on barrier beaches and coastal dunes closest to beach are per se significant to storm damage prevention (310 CMR 10.28(1)). Because dunes on barrier beaches and the coastal dune closest to the beach are singled out as intrinsically important to storm damage prevention and flood control, they warrant greater scrutiny.

[20]Another reason to delineate the primary dune is to delineate the velocity zone for purposes of Title 5; see 310 CMR 15.002.

[21]See in the matter of Miltiades and Phyllis Tzitzenikos, Office of Appeals and Dispute Resolution (OADR) Docket No. WET-2010-033, Recommended Final Decision, August 3, 2011, adopted by Final Decision, October 12, 2011, and affirmed in Essex Superior Court sub nom Tzitzenikos et al. v. Department of Environmental Protection et al., ESCV2011-02122-A, November 1, 2012. The Presiding Officer found a preponderance of evidence showing that the primary dune methodology relied on by MassDEP provided best available information and was effective in delineating the landward toe of the primary dune because it captured the entire dune structure, in contrast to the applicant's analysis which did not. Similarly, in the matter of Stephen D. Peabody, the Commissioner reached an independent conclusion about the landward extent of the primary dune by looking at the topography and profile of the project location.

methodology, as well as the guidelines on pages 1-33 through 1-38, to learn about the delineation procedure and how to perform a comprehensive review.

This primary dune delineation methodology, which includes site observations to verify the extent and characteristics of the landform, its dimensions, and the context to the surrounding area, can effectively delineate the landward toe of the primary dune and thereby distinguish the primary dune from secondary dunes. Like the process for other delineations, the applicant and Commission must draw a conclusion based on a review of the best available information, including the origin of the landform, site observations of landform features, and a general knowledge of the modifying forces of wind and waves and their effect on the shoreline. The primary dune delineation methodology will greatly enhance this information, reduce arbitrary on-the-ground decision making, and provide more consistent results.

Whether an applicant is required to precisely identify the landward extent of the primary dune will depend on whether such a distinction is necessary for a Commission's review of the proposed project. For example, a Commission may determine that an in-depth analysis of the primary dune boundary is not warranted when an applicant acknowledges that their project is within the primary dune or when an applicant is proposing a dune-enhancement project (e.g., vegetation and beach/dune nourishment). If a Commission concludes that a determination of the extent of the primary dune *is* necessary given the project proposal and potential impacts to the resource area (and that any existing maps do not adequately represent the site), the primary dune delineation methodology should be used. A more precise delineation of the resource area with this methodology can help project proponents and Commissions ensure that projects do not alter primary dunes, or if they do, that they meet performance standards. Though the burden is upon the applicant to provide an accurate delineation, an understanding of this process and methodology by Commissions will help them with their assessment and review of the primary dune delineation. At a minimum, when reviewing the applicant's delineation, the following guidelines should be used.

1. Review the Definition and Terminology of the Primary Dune

The Wetlands Protection Act and Regulations were amended in 2014 to include a definition of the primary dune that is consistent with the definition used by the Federal Emergency Management Agency (FEMA) (per 44 CFR 59.1).[22] The primary frontal dune is now defined in the WPA Regulations as "a continuous or nearly continuous mound or ridge of sediment with relatively steep seaward and landward slopes immediately landward and adjacent to the beach and subject to erosion and overtopping from high tides and waves during coastal storms. The Primary Frontal Dune is the dune closest to the beach. The inland limit of the Primary Frontal Dune occurs at the point where there is a distinct change from a relatively

[22]FEMA defines the "primary frontal dune" in CFR Section 59.1 as "a continuous or nearly continuous mound or ridge of sand with relatively steep seaward and landward slopes immediately landward and adjacent to the beach and subject to erosion and overtopping from high tides and waves during major coastal storms. The inland limit of the primary frontal dune occurs at a point where there is a distinct change from a relatively steep slope to a relatively mild slope."

steep slope to a relatively mild slope." The inland limit of the primary dune marks the minimum landward extent of the velocity zone or coastal high hazard area (as described in the Preamble for coastal dunes and the definition for velocity zone).

The main point to be emphasized in this definition is that the inland limit of the primary dune is the point where there is a *distinct* change from a relatively steep slope to a relatively mild slope. Though not all dunes have "steep" slopes, quantifying the "distinct change" by finding the greatest *rate of change* in slope (regardless of grade in slope) on the inland side (i.e., backslope) of the dune will result in the likely location of the landward toe of the primary dune. The primary dune delineation methodology in Appendix C describes the method for finding the greatest rate of change in slope by using second derivative slopes (SDS). In sum, first derivative slope is a measure of the rate of change of position (i.e., the slope), and the second derivative slope is a measure of the rate of change of the slope (i.e., slope of the slope). Finding the greatest rate of change of the slope (the highest positive value) will mark the location where there is a "distinct change" from a relatively steep slope to a relatively mild slope—likely marking the location of the landward toe of the primary dune. Profiles of SDS—overlying the dune topography profile—allow a visual representation of where the highest positive values of SDS represent a change in slope in the overall landform (described in detail below). Commissions can review Figure C7 in Appendix C on page A-C-14 for an example of what a SDS profile should look like and how it should be used.

In order to understand the terminology used to describe various parts of a dune system and get a better idea of the defining parameters that the applicant used to locate the landward toe of the primary dune, Commissions should review Figure 1.6 on page 1-35, which shows a ridge-type primary dune profile and a mound-type primary dune profile with the corresponding terminology. These profiles highlight the importance of considering the entire dune system when running transects, particularly in a mound-type dune system that has multiple peaks *within* the primary dune. Often, transects will not extend far enough landward or go beyond the property boundaries to account for secondary peaks in a primary dune, resulting in a delineation of the primary dune in an incorrect, more seaward location. Generally, secondary peaks occur in the top half of the primary dune and have shallow trough depths, whereas secondary dunes have lower heights (more specific information on determining secondary peaks can be found in Appendix C on pages A-C-11 through A-C-12). The landward toe of the primary dune will be found *landward* of any secondary peaks that are identified.

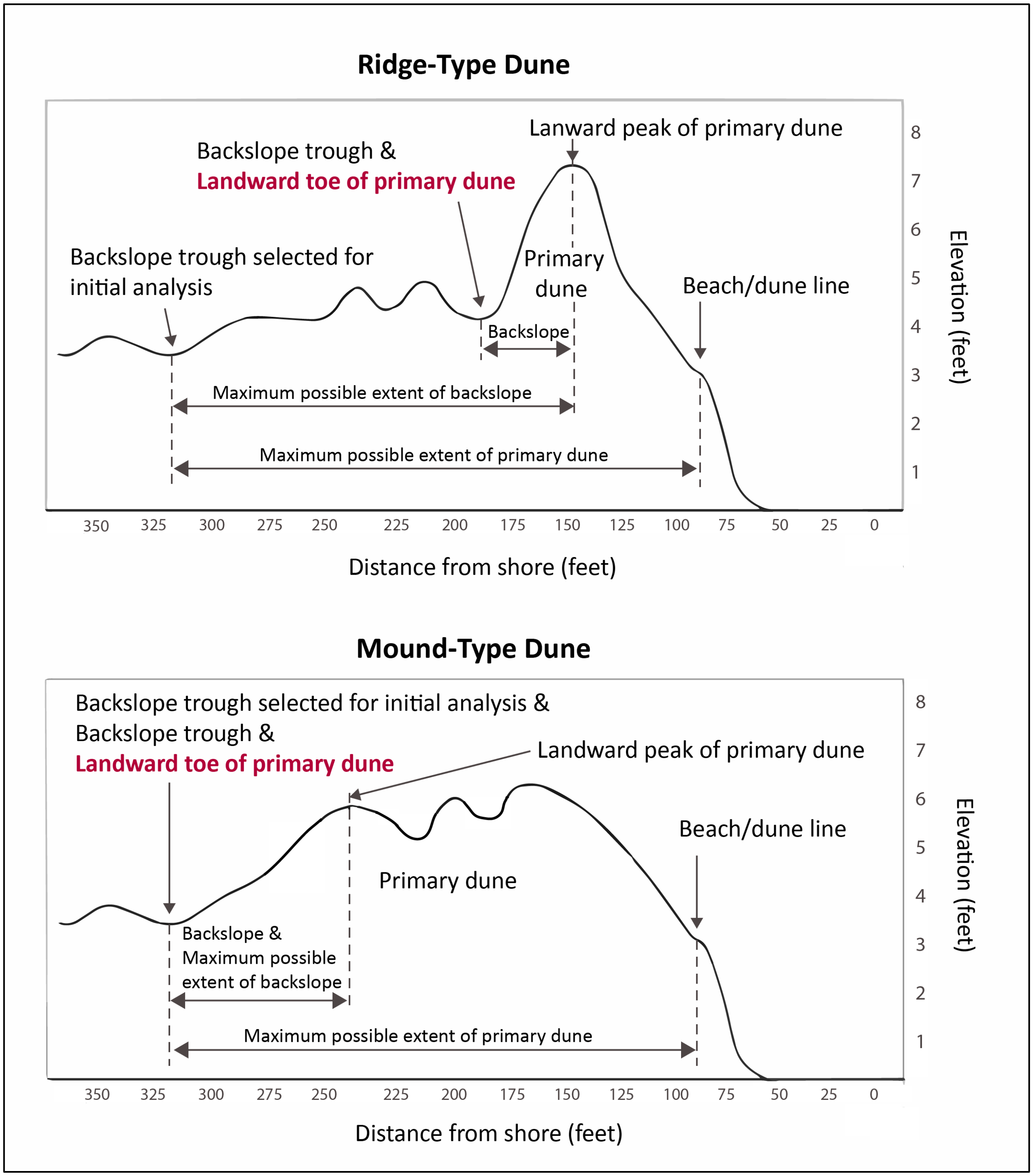

Figure 1.6. Ridge-type and mound-type primary dune profiles with dune terminology. The ridge-type profile shows one peak and mound-type profile shows multiple peaks. The primary dune extends from the beach/dune line landward to the backslope trough, where the landward toe of the primary dune is found. Regardless of dune shape, the backslope trough is always landward of the landward peak of the primary dune. In some cases, there are numerous backslope troughs as shown in the ridge-type profile. The most landward trough that meets the criteria described in the primary dune delineation methodology is selected and will mark the landward boundary for the maximum possible extent of the primary dune, and will also mark the landward boundary of the maximum possible extent of the backslope—identifying these parameters first will help accurately delineate the landward toe of the primary dune.

2. Review Applications and Plans

For proper delineation and review of a primary dune, the landward boundary should be delineated and mapped on a site plan. The plan should contain the information and data required within the primary dune methodology described in Appendix C. Specifically, the plan should show a minimum of two transects drawn perpendicular to the shoreline to accurately characterize the slope changes. The transects and profiles should begin at the mean high water line and extend landward beyond any secondary dune (if present), which is likely to be beyond the property boundaries. Commissions must assess whether the selected transects are representative of the site and the dune system. The selected point for the landward toe of the primary dune should be shown on each transect. The landward boundary line of the primary dune should be extrapolated, along the contour line where possible, between these two (or more) selected points.

The methodology in Appendix C specifies using the best available topographic data, which includes LIDAR (Light Detection and Ranging) data (a remote sensing technology that uses a laser beam of light to measure the height of features on the ground), and in many cases also includes professional surveys. The date, source, coordinate system, and other general settings of the LIDAR data (or other topographic data) should be provided to the Commission.[23] The Commission should ensure that the applicant compared the LIDAR data to field observations and/or surveyed topographic data to ensure that the landforms on the site have not changed significantly since the LIDAR was flown.

The site plan should be accompanied by a set of profiles of *each* transect showing the applicant's analysis of the dune system including topographic data overlaid with: smoothed topographic data[24] (if using LIDAR data) and second derivative slope data.

Commissions should compare the smoothed profile to the raw profile to ensure that important landform information was not lost in the process of smoothing the profile data (no more than 5 points [for approximately 1-meter or 3-foot intervals] should be averaged for dune profiling purposes—see Figure C2 in Appendix C on page A-C-6 for an appropriately smoothed profile). Commissions should also review the vertical exaggeration of the profiles (which the applicant should have noted) to understand the relationship between the horizontal distance and the relief of the dune. The profiles should be

[23]The submitted topographic data should comply with vertical accuracy specifications and general mapping protocols. The applicant should specify the vertical accuracy of the associated topographic data and ensure that it is a high enough accuracy to be meaningful and representative of the data (the specifics of each LIDAR data set are usually provided with the metadata). The topographic data should also be in the same coordinate system as that specified for the GIS (or other mapping software) layers, such as the orthophotographs and transects.
[24]Because of the density of LIDAR data points, it is often necessary to smooth the data (by taking a moving average) to remove small-scale landform features, such as scour marks and vegetation—see page A-C-6 and A-C-20 in Appendix C for more information on how to find a moving average to smooth the data.

accompanied by an analysis of whether the dune is a mound-type primary dune or ridge-type primary dune, and how the applicant defined the backslope.

Commissions should review the applicant's analysis and determine whether any peaks landward of the primary peak qualify to be secondary peaks within the primary dune. The SDS profile should show the point that the applicant/consultant chose as their highest SDS peak (greatest positive rate of change within the backslope) that defines the landward toe of the primary dune. The applicant should also provide an explanation if other higher SDS peaks within the backslope were not chosen—such as points representing micro-topography, vegetation, or human alterations of the landform (as explained in detail below).

3. Verify Profile Data and Primary Dune Boundary at the Site

Follow-up field observations should be made to verify that delineations made from profile data and as shown on the submitted plans reflect the actual *current* conditions at the site. Before going out to the site, Commissions should review the plans and profiles and the primary dune methodology described in Appendix C to become familiar with how to identify the landward toe of the primary dune.

Commissions will want to ensure that the applicant delineated the landward toe of the primary dune based on the overall slope of the landform and not the micro-topography. Observations should be made to distinguish large-scale landform features caused by largely natural forces, such as deposition and accretion of sand by wind and wave action (i.e., overall landform), versus small-scale landform features that result from natural disturbances, such as beach cusps, blowout holes, scarps, root systems uncovered by wind action, or mounds associated with tufts of grass or shrubs (i.e., micro-topography). It is also important that Commissions note any human-induced changes, such as roads, driveways, or dwellings, which may have created alterations in slope, elevation, and form, but not changed the overall extent of the primary or secondary dune landform. (For an example of a small-scale feature that should not be used to determine the landward extent of the primary dune, see Figure C7 in Appendix C on page A-C-14.)

With these observations, Commissions can determine whether the selected second derivative peaks on the profiles are representative of a break in slope of the overall hill, mound, or ridge of the dune (representing the landward toe of the primary dune), or whether they represent a break in slope due to a small-scale change or human alteration. Commissions should also check to make sure the selected SDS peak is not representative of vegetation or a structure that was not filtered out of the LIDAR during processing (see Figure C11 in Appendix C on page A-C-25 for an example). Comparing the transect profiles to each other as well as to adjacent dunes, particularly those with less alteration, may also help differentiate small-scale changes and/or human alterations from larger landform changes and facilitate a more accurate determination of the landward toe of the primary dune. If the Commission determines that the applicant selected a peak that is not representative of the overall landform or that the applicant located the landward toe in an incorrect seaward location, the Commission should require that the applicant use the second derivative slope analysis to select another peak that does represent a large-scale landform change and/or is *landward* of any secondary peaks of the primary dune. Once the point has been verified through profile and field observations, the landward toe of the primary dune should be revised on the site plan as necessary.

Where complex topography does not produce a readable result (i.e., many small-scale changes produce many spikes in a profile making delineation difficult), the applicant should choose another more representative transect line that contains fewer small-scale changes in topography.

If the selected landward toe is not appropriate for other reasons, such as alteration to the landform since the LIDAR data were flown (e.g., through waves, wind, and overwash), the applicant and Commission should use their best professional judgment to delineate a more appropriate primary dune boundary. The judgment call should be based on the most current available topographic data and the methods described for other resource area delineations, such as information regarding the origin of the landform, observation of landform features, and dimensional characteristics.

Data Checklist[25]

When a precise delineation of the coastal dune is needed, the following checklist should be used to 1) identify features on the plans and maps, 2) record information about site characteristics in the field, and 3) determine if additional information is needed to delineate the resource area. The person using this form is advised to work from the seaward edge up to the landward edge of the dune. In addition to site observations, information (such as subsurface sediment analysis) may be necessary to determine whether the landform feature is a coastal dune. If a delineation of the primary dune is needed, the applicant/Commission should follow the methodology described above on pages 1-32 through 1-38 and in detail in Appendix C.

[25] This checklist can also be found in the Data Checklists for the Delineation of Resource Areas, a separate attachment that can easily be carried out to the field to record information about landform features and characteristics.

Check all that apply:

<table>
<tr><th>Indicators of the Seaward Boundary of a Coastal Dune</th><th>If yes:</th></tr>
<tr><td>❑ Can you discern a change in slope to a steeper, seaward-facing slope of a hill, mound, or ridge landform? and

❑ Have you found the most recent high tide wrack line?</td><td>Look for the beach/dune boundary landward of the most recent high tide wrack line and where there is a change in slope.</td></tr>
<tr><td colspan="2">If there is not a distinct change in slope that appears to be a logical location for the beach/dune boundary, you should observe obvious characteristics of beaches and dunes (as listed below) and work your way to the middle to identify the seaward boundary of coastal dune. The characteristics of these resource areas are described in more detail in this section and in the coastal beaches section beginning on page 1-8.</td></tr>
<tr><td>❑ Are you standing on sediments that look like they have been primarily reworked by waves and tides?

Do you see:

❑ rill marks,
❑ ridges and runnels,
❑ swash marks,
❑ beach cusps (horns and embayments), and/or
❑ wrack lines from the most recent high tides?</td><td>You are on a coastal beach.</td></tr>
<tr><td>❑ Are you standing on a relatively flat terrace landward of the swash zone formed by deposition of beach sediments by waves or tides, which is relatively devoid of vegetation (or only sparse vegetation is present)?</td><td>You are likely on a coastal berm or backbeach, which is part of the natural form of a coastal beach.</td></tr>
<tr><td>❑ Are you standing on sediments (such as cobble or gravel) that look like they have been primarily reworked by overwash? and

❑ Can you discern a change in topography to a steeper, seaward-facing slope of a hill, mound, or ridge landform that lies landward of a coastal beach?</td><td>You are likely on a coastal dune.</td></tr>
<tr><td>❑ Are you standing on a hill, mound, or ridge of sediments (such as sand) landward of a coastal beach, which look like they have been primarily reworked by wind or overwash?

Do you see:

❑ windblown (dry) sand ripples,
❑ windblown sand accumulation around wrack, pebbles, and shells,
❑ finer-grained sand than the beach (on beaches and dunes that are primarily sand),
❑ a fan-shaped deposit of sand, gravel, and/or cobble landward of the most recent high tide line (i.e., overwash fan), and/or
❑ the presence of vegetation that traps and holds windblown sand?

Dune vegetation may include:

beachgrass (Ammophila breviligulata),
beach pea (Lathyrus japonicus),
poison ivy (Toxicodendron radicans),
seaside goldenrod (Solidago sempervirens), and
rugosa rose (Rosa rugosa), or other.</td><td>You are likely on a coastal dune.</td></tr>
</table>

Indicators of the Landward Boundary of a Coastal Dune	If **yes**:
❑ Are the subsurface sediments (given that an organic soil horizon may have formed or the weathered surface may disguise the underlying landform) those that have been deposited by wind or storm-wave overwash? Are the sediments: ❑ sorted and layered, representing periods of deposition by wind and waves, ❑ rounded, and ❑ of similar range in size (though generally finer grained) to those sediments on the beach? *and* ❑ Are the windblown deposits part of a hill, mound, or ridge that is landward of a coastal beach? (A Commission should review profiles of the surficial and underlying sediments to characterize sediments and determine overall topography of the landform.) *and* ❑ Does the vegetation consist of dune-type growth, such as beachgrass (*Ammophila breviligulata*), rugosa rose (*Rosa rugosa*), beach plum (*Prunus maritima*), bayberry (*Myrica pensylvanica*), or more complex and dense upland plants, shrub growth, and low forests?	The landform is a coastal dune (either a primary or secondary dune system).
❑ Are you standing at what appears to be a water body within dune ridges? *and* ❑ Do you see wetland vegetation?	You are likely within a hollow of the dune, which may contain a bordering vegetated wetland, isolated wetland, or vernal pool (and does not necessarily demarcate the edge of coastal dune).
❑ Are you standing in a low flat spot landward of a dune that is composed of windblown or wave deposited sediments?	You are likely between a primary dune and a secondary dune or between two secondary dunes, either of which are coastal dune by definition. Look at subsurface sediments and profiles to determine landward extent of dune. (See Profile B in Figure 1.5 on page 1-30.)
❑ Are you within a barrier beach but not on a coastal beach, glacial landform, or vegetated wetland/waterbody?	You are on a coastal dune within the barrier beach (see the barrier beaches section beginning on page 1-42).
❑ Are the subsurface sediments glacial in origin (typically poorly sorted sediments)?	The landform is a coastal bank or an upland.
❑ Are the subsurface sediments those that have been deposited by wind or storm-wave overwash? *and* ❑ Do these windblown deposits overlie glacial material? *and* ❑ Do these deposits appear to be part of the hill, mound, or ridge of the coastal dune? (A Commission should review profiles of the surficial and underlying sediments to characterize sediments and determine overall topography of the landform.)	This portion of the landform is the tapering edge of the coastal dune, which still meets the regulatory definition of coastal dune. (See Profiles B and C in Figure 1.5 on pages 1-30 and 1-31.)
❑ Are the subsurface sediments those that have been deposited by wind or storm-wave overwash? *and* ❑ Do these windblown deposits overlie glacial material? *and* ❑ Do these deposits follow the underlying topography of the glacial material with a relatively consistent thickness, and appear not to be part of the hill, mound, or ridge of the coastal dune? (A Commission should review profiles of the surficial and underlying sediments to characterize sediments and determine overall topography of the landform.)	These deposits constitute a veneer of sand *landward of* the landward edge of coastal dune (i.e., this area may not constitute a regulatory coastal dune). (See Profile A in Figure 1.5 on page 1-29.)

Indicators of a Non-Regulatory Dune (based on the definition)	If **yes**:
❑ Are the subsurface sediments those that have been deposited by wind or storm-wave overwash? *and* ❑ Do these windblown deposits overlie glacial material? *and* ❑ Do these deposits appear to be part of the hill, mound, or ridge of the coastal dune? *but* ❑ Do these deposits border (on the seaward side) something *other than* another dune or the coastal beach, such as glacial material? *and* ❑ Are these deposits landward of the 100-year floodplain?	This landform is not a regulatory coastal dune because it does not border the ocean or border the coastal beach that borders the ocean. You are likely on a cliff-top dune that *does not* meet the regulatory definition of coastal dune.
Indicators of a Regulatory/Non-Regulatory Dune (based on the function)	If **yes**:
For cases of artificial fill: ❑ Is there evidence of two-way exchange of sediment between the coastal beach and the landform? If not, would this occur during a large coastal storm event? *and* ❑ Is the landform conforming and reshaping to natural wind and water flow processes or would it in a coastal storm event? *and* ❑ Is the landform migrating landward or laterally in response to wind, wave, or tides? *or*	The artificial fill meets the regulatory definition of coastal dune.
❑ Is the landform eroding and providing sediment to the beach system in a manner consistent with a sediment-source type coastal bank?	The artificial fill may meet the regulatory definition of a coastal bank (see coastal banks section beginning on page 1-51).
❑ Are field observations consistent with surveys, maps, and other references?	
❑ Other observations:	

BARRIER BEACHES

The WPA Regulations (310 CMR 10.29) define barrier beach as "a narrow low-lying strip of land generally consisting of coastal beaches and coastal dunes extending roughly parallel to the trend of the coast. It is separated from the mainland by a narrow body of fresh, brackish or saline water or a marsh system. A barrier beach may be joined to the mainland at one or both ends."

If connected to the mainland at both ends, the barrier beach is known as a bay barrier; if connected at only one end, the beach is a barrier spit; and if not connected to the mainland at all, the beach is a barrier island (see Figure 1.7). Attached barrier beaches are commonly smaller in size and more variable in composition than barrier islands. Barrier islands can occur in chains; each island is separated from its neighboring islands by inlets. All of these types of barriers that meet the definition in the Regulations are regulated as barrier beaches under the WPA.

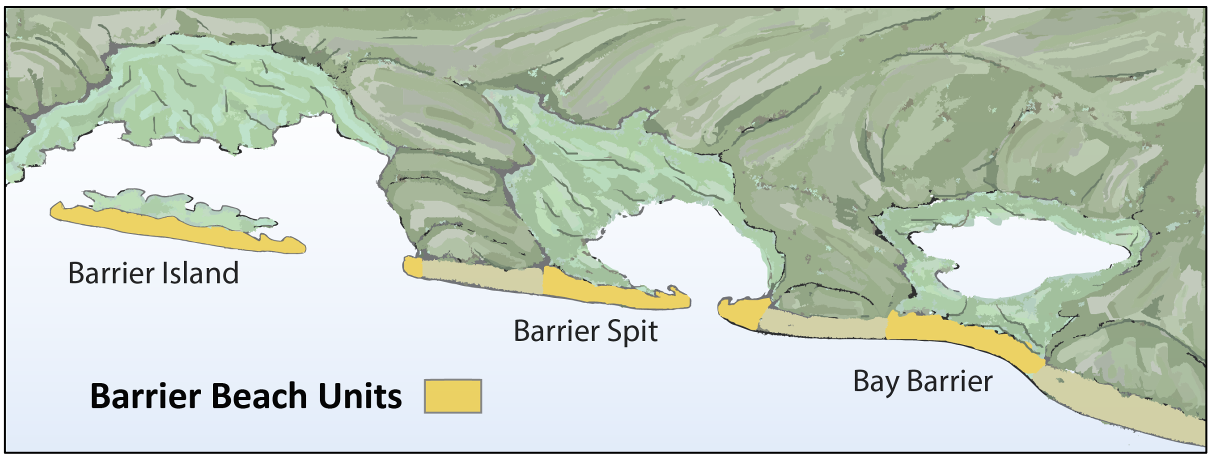

Figure 1.7. Types of barrier beaches and their margins. Figure modified from *Barrier Beach Management Sourcebook*, CZM.

A typical barrier coast consists of the sandy beach (foreshore and backshore), the dunes (primary and secondary dunes), marsh and/or tidal flats, and/or a body of water (see Figure 1.8). Barrier beaches in Massachusetts can be composed of sand, gravel, and/or cobble. Dune formation is essential to the stability and function of the barrier beach. The primary dune that forms closest to the coastal beach absorbs the brunt of the ocean's energy, providing protection to whatever is landward of the dune.

The transfer of sediment from the seaward side of the barrier to the back side of the barrier is critical for preserving the existence of the barrier beach. It allows the barrier beach to migrate landward in response to storms and relative sea level rise. Sediment is transferred landward by the processes of overwash, tidal inlet formation, spit formation, and wind. Overwash, the process where storm waves carry and deposit sand landward, most often occurs in low areas of the dune or within eroded sections of the primary dune ridge. The deposits that are left behind are called overwash fans. Secondary dunes form from windblown sand and/or when heavy storm waves erode and overwash the primary dunes, depositing sand farther inland. The secondary dunes may support a greater variety of plant growth in large dune systems where there is more protection from storm-wave overwash or where there is sufficient time between storm events. Often, a coastal thicket or a maritime forest will form on secondary dunes (and occasionally primary dunes). A barrier beach system may also contain tidal flats on the back beach, freshwater or saltwater marshes, and vernal pools within the barrier beach complex. Salt marshes that separate the barrier from the mainland are *not* part of the barrier beach.

Although the example below depicts a typical undeveloped barrier beach, even modified or highly altered and developed barriers are considered barrier beaches pursuant to the WPA regulatory language, provided the landform meets the definition of barrier beach as specified in 310 CMR 10.29.

Where barrier beaches attach to the mainland, the barrier beach "ends" where there is no longer a wetland or waterbody behind the landform (see Figure 1.7).

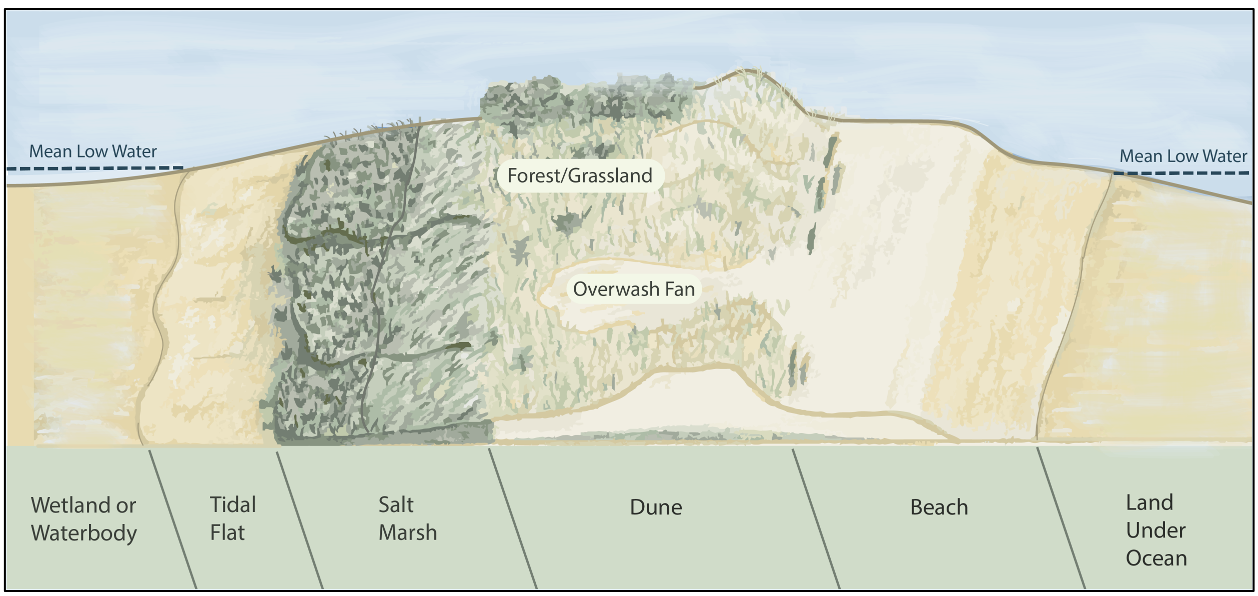

Figure 1.8. Morphology of a typical East Coast barrier. Figure modified and redrawn from *Barrier Beaches of the East Coast,* Godfrey.

Special Considerations

A barrier beach is a dynamic yet fragile buffer that protects landward areas from coastal storm damage and flooding. Together the beaches, dunes, marshes, tidal flats, and associated water bodies comprise the barrier beach ecosystem. These landforms were created and are constantly changed by coastal processes, such as erosion, overwash during storms, dune movement, and tidal inlet formation and migration. Barrier beaches provide essential storm damage protection and flood control functions to landward areas by reshaping and changing to dissipate wave energy in a storm event. Well-vegetated areas on the barrier appear somewhat stable (and *are* more stable than unvegetated dunes), but sediments migrate significantly and large storms can breach the barrier periodically. A 100-year storm event (1%-annual-chance flood) or even lesser storms can often cause dramatic erosion and/or overwash to a seemingly stable dune and barrier beach system.

These dynamic characteristics can make delineation of the barrier beach resource areas and the boundaries challenging. Applicants should supply—and Commissions should review—the most current information from a combination of maps, surveys, orthophotographs, and site observations to accurately delineate the resource areas.

It is important to recognize that though barrier beaches are labeled with different names (i.e., barrier island, bay barrier, barrier spit), they are all protected as barrier beaches under the WPA Regulations because they perform the same functions of providing storm damage protection and flood control to landward areas. Moreover, the regulatory language also distinguishes *all dunes* on barrier beaches as significant per se (inherently) to the interests of storm damage prevention and flood control, which conveys the importance of properly identifying the landform as a barrier beach in order to apply the performance standards. On barrier beaches, it is also important to note that if the area is not defined as a coastal beach, vegetated wetland area, or a glacial landform, the area is defined as a coastal dune, regardless of the vegetation type. Glacial landforms such as a moraines, drumlins, or kames, which are found within a barrier beach, are not considered part of the barrier beach for purposes of the WPA, yet still may be defined as coastal banks or land subject to coastal storm flowage.

Applications and Plans

To help facilitate identification of a barrier beach, applicants and Commissions should first review the Barrier Beach Inventory Project Maps distributed by the Massachusetts Office of Coastal Zone Management (CZM) or the state-designated barrier beach data layers available for online viewing. Two sources of online data are currently available: 1) the Online Data Viewer (OLIVER) of the Massachusetts Office of Geographic and Environmental Information (MassGIS), and 2) the Massachusetts Ocean Resource Information System (MORIS), an online mapping tool created by CZM (see Appendix B - Useful Data Sources for more information about the sources listed above). Though most of the barrier beaches along the Massachusetts coastline were identified in the barrier beach inventory and data layers, some smaller landforms (or portions thereof) may have been missed, or conversely, some portions may have been incorrectly identified as barriers.[26] Ultimately, Commissions should use the best available information as outlined in this chapter to make their findings and delineate the resource areas.

Whether an applicant is required to precisely identify barrier beach boundaries will depend on whether a project will affect the functions of the barrier beach that are subject to performance

[26]For example, the Conservation Commission in Duxbury identified a barrier beach that was not included in the inventory, while an identified barrier beach in Truro (unit #Tr-2) was de-designated and removed from the inventory.

standards. For projects that are unlikely to impact the resource areas, an exact delineation may not be necessary for a Commission's review of the project application. Most projects on or adjacent to a barrier beach will require surveyed plans containing a consistent datum reference with elevation contour lines of the site, depiction of beach and dune boundaries, cross sections showing slope and volume of dunes, and determination of any other resource areas found within the system. Although all dunes are considered significant on barrier beaches, a Commission may want to require the delineation of the dune closest to the coastal beach (the primary frontal dune or primary dune) because of its vulnerability to significant erosion and storm damage in a coastal storm event and its significance for the protection of inland areas (see "Delineating Primary Dunes" on pages 1-32 through 1-38).

Whether the plans are derived from existing data sources or are based on a field survey, Commissions should ensure that the information is current and reflects the existing conditions of the site. An explanation of the assessment method used to determine the boundary should also be included. Depending on project scope, Commissions can use their best judgment in determining what level of information and analysis the applicant should submit for a reasonable delineation.

How to Delineate and Review Barrier Beach Boundaries

Photograph 1.13. Barrier beach system. The two spits stemming off of the developed section *are* barrier beaches. Most of the heavily developed section *is not* considered barrier beach because it lies seaward of an upland, not a wetland or waterbody.

Before going out into the field to make observations, Commissions should consult the relevant maps, including the Barrier Beach Inventory Project Maps, and aerial photography to determine the overall morphology (form, structure, and configuration) of the barrier beach and surrounding coastline and to get a feel for the orientation of the proposed project relative to the entire landform (for an example, see Photograph 1.13). In many cases, this will be all that is needed to determine whether the site is on a barrier beach. For projects where an exact boundary of the barrier beach is needed, the barrier beach inventory maps should be used only as a general indicator, due to their small-scale depiction. The extent of the barrier beach units are available in MORIS, but since this layer is based on the barrier beach inventory maps and delineated primarily through interpretation of aerial photographs, field analysis should be conducted to determine the site-specific boundaries. Further analysis should be accomplished on site based on the definition and the criteria outlined in this section and the dune section.

Commissions should perform site visits and keep track of observations and data collected in the field. The following information on field observations and the data checklist can assist Commissions at the site.

Field Observations

A barrier beach may border a waterbody or wetland on both its landward and lateral (i.e., adjacent along the shoreline) edges. A barrier beach may border the mainland (coastal bank, dune-upland, bedrock, or land subject to coastal storm flowage) only on its lateral edge(s), because a wetland or waterbody must be present landward of it to define the landform as a barrier beach. The boundary lines of the barrier beach will depend on the type of landform, wetland, or waterbody that it borders. The following section provides descriptions of these barrier beach boundaries. Commissions can use this information to assist them with their delineation at the project site.

On the oceanside, the seaward boundary of the barrier beach is the seaward edge of the outer coastal beach (mean low water line). The discussion in the preceding section on coastal beaches is applicable.

Shrubby vegetation and maritime forests that are present *within* the dune system of the barrier beach complex are defined as *part of* the barrier beach (since *all dunes* extending from the beach to the waterbody are part of the barrier beach). Since all dunes within the barrier beach are presumed significant to storm damage prevention and flood control under the Wetlands Protection Act Regulations, these dune systems should be properly identified so that their beneficial functions can be protected.

For barrier beaches fronting a salt or freshwater pond, the landward edge of the barrier beach is the edge of the coastal dune or coastal beach that borders on the pond. If the embayment is tidally influenced, the landward edge is the mean low water line, which includes tidal flats. For barrier beaches fronting a marsh system (that separates the mainland from the barrier beach), the landward edge of the barrier beach is where the marsh begins.

For barrier beaches attached to the mainland, the lateral edge of the barrier beach is where the barrier adjoins a coastal bank, a coastal dune, or bedrock, and where there is no longer a wetland or waterbody behind the barrier, as illustrated in Figure 1.9 on page 1-47. The lateral boundary with a coastal bank—where the barrier beach borders glacial deposits, such as till, outwash, or glacial lake or marine deposits—is the most common type found in Massachusetts (see coastal bank boundary in Figure 1.9). In these areas, beach and dune deposits may overlie the glacial deposits making it difficult to determine the lateral boundary. Commissions may need to look at the subsurface sediments to determine the method of deposition to help characterize the landform and to facilitate the delineation of the resource areas and the barrier beach boundaries. A profile drawn parallel to the shore (Figure 1.10 on page 1-48) can help depict the transition zone where the dune becomes bank, and where the lateral boundaries of the barrier beach occur.

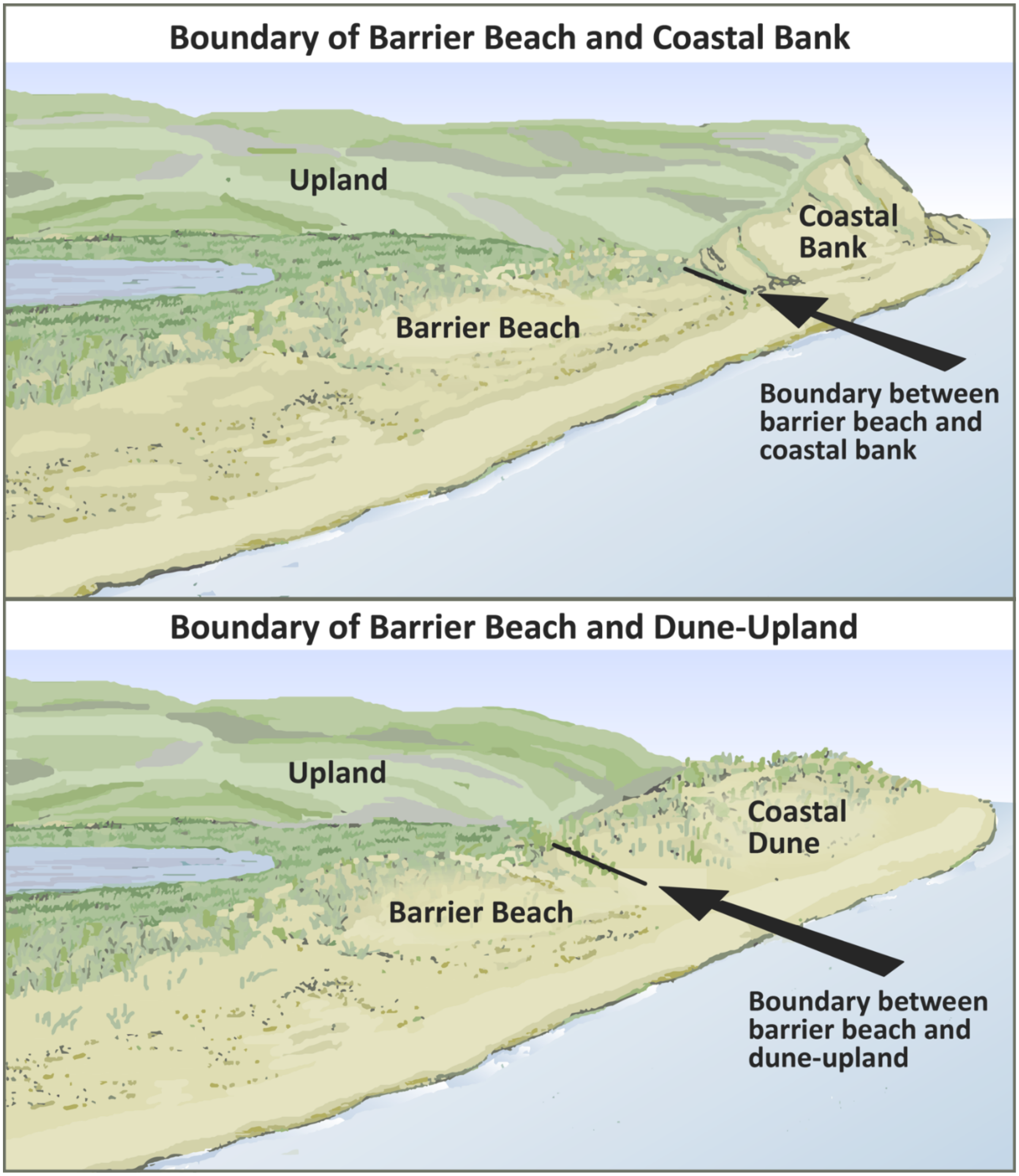

Figure 1.9. Two types of lateral upland barrier beach boundaries: coastal bank and dune-upland. Figure modified from *Barrier Beach Management Sourcebook*, CZM.

The lateral boundary with a dune-upland is where the barrier beach meets up with coastal dunes that are present seaward of an upland (see dune-upland boundary in Figure 1.9 on page 1-47). More specifically, the boundary lies where the beach or dune (on the barrier) transitions to a coastal dune with no wetland or waterbody behind (i.e., landward of) it, typically where the dune is underlain by geologic material that is not deposited by wind or waves. Though still a coastal dune subject to protection under the WPA, this resource area lying seaward (or on top) of an upland does not constitute a coastal dune *on a* barrier beach. Again, since beach and dune deposits may overlie irregular glacial surfaces, Commissions may need to look at the subsurface sediments and profiles to determine the lateral boundaries (such as in Figure 1.10). It is important to remember that in order for the dune area to be part of the barrier beach, a wetland or waterbody must lie landward of the dune.

Where a barrier beach borders a bedrock mainland, the lateral edge is where the barrier beach attaches itself to massive rock formations.

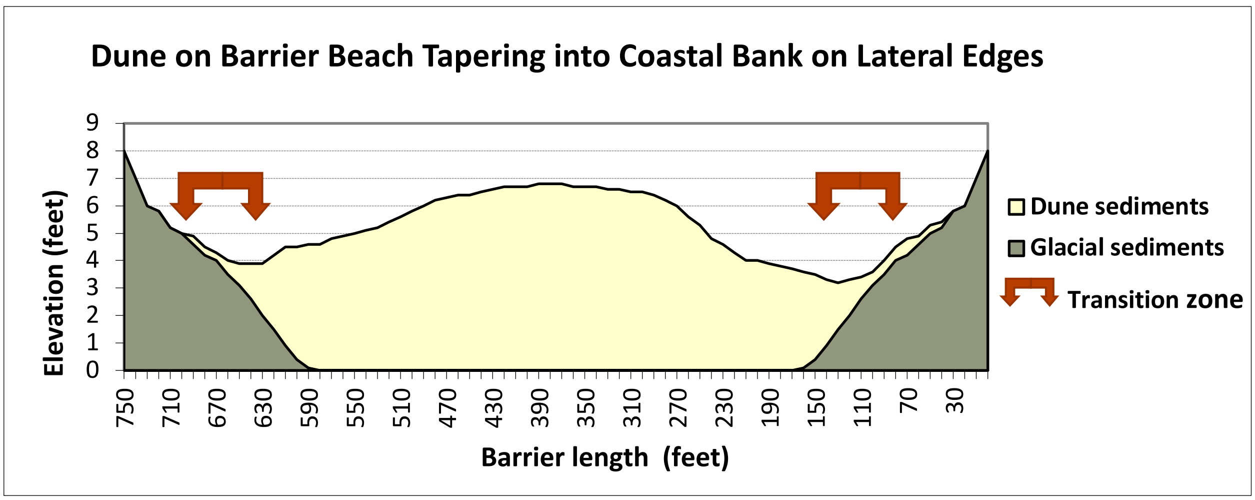

Figure 1.10. Along-shore transect showing the lateral edges of the barrier beach where the dune transitions into glacial material. The red arrows indicate the approximate location (transition zone) of the coastal bank margin of the barrier beach.

Data Checklist[27]

When a precise delineation of the barrier beach is needed, this checklist should be used to: 1) identify features on the plans and maps, 2) record information about site characteristics, and 3) determine if additional information is needed to delineate the resource area. The person using this form is advised to work from the seaward boundary to the landward boundary and then to the interface of the barrier beach with the lateral boundaries. In addition to site observations, information (such as subsurface sediment analysis) may be necessary to determine whether the landform feature is a barrier beach.

[27]This checklist can also be found in the Data Checklists for the Delineation of Resource Areas, a separate attachment that can easily be carried out to the field to record information about landform features and characteristics.

Check all that apply:

Indicators of a Barrier Beach System	If **yes**:
❑ Is the landform identified on the CZM Barrier Beach Inventory Project as a barrier unit, or is the landform labeled as a state-designated barrier beach within the data layers of MassGIS's Oliver or CZM's MORIS online viewing tools? *and* ❑ Looking at the overall landform, do you see a low-lying beach/dune system that is separated from the mainland by a narrow body of fresh, brackish, or saline water or a marsh system?	You have identified a barrier beach.[28] *Use these maps to establish general landform only.*
Indicators of the Seaward Boundary of a Barrier Beach (These indicators should only be used for an approximate boundary—a survey should be required for an exact delineation.)	If **yes**:
❑ Do you have an approximate idea of the location of the mean low water line?	You have an idea of the seaward boundary of the coastal beach/barrier beach.
If you do not have an approximate idea of mean low water, observe obvious characteristics of land under the ocean and beach (as listed below) and work your way to the middle to identify the seaward boundary of the barrier beach. The characteristics of these resource areas are described in more detail in the sections for land under the ocean (beginning on page 1-3) and coastal beaches (beginning on page 1-8).	
❑ At a typical low tide, are your feet in the water?	You are on land under the ocean.
❑ At a typical low tide, are you standing on a tidal flat, nearshore sandbar, or wet sand area?	You are on a coastal beach, as part of the barrier beach.
Indicators of Resource Areas within a Barrier Beach	If **yes**:
See Beach and Dune Data Checklist for indicators of beach and dune resource areas and then continue below.	
❑ If the landform is connected to the mainland, are the coastal beaches and dunes seaward of the waterbody or marsh that separates the barrier from the mainland?	You have identified beaches and dunes *as part of* the barrier beach.
If you have identified beaches and dunes *as part of* the barrier beach: ❑ Does the site contain forest-type vegetation? *and* ❑ Are the underlying sediments those that have been deposited by wind or storm-wave overwash? *Or*	You are within a maritime forest, *as part of* the dune system of a barrier beach.
❑ Are you standing at what appears to be a water body within dune ridges? *or* ❑ Are you standing on what appears to be freshwater wetland vegetation within dune ridges? *Or*	You are likely within a hollow of the dune, which may contain a vegetated wetland or vernal pool (and does not necessarily demarcate the landward boundary of barrier beach).

[28]Unit Tr-2 in the Barrier Beach Inventory Project has been de-designated as a barrier beach.

❑ Are you standing on a marsh *within a tidal creek or inlet* of the barrier beach, which shows evidence of salt-tolerant vegetation, such as: ❑ Smooth cordgrass (*Spartina alterniflora),* and ❑ Saltmeadow cordgrass (*Spartina patens)*?	You are standing on a salt marsh *within* the barrier beach (and does not necessarily demarcate the landward boundary of barrier beach).
Indicators of the Landward Boundary of a Barrier Beach	If **yes**:
❑ Are you standing on a tidal mudflat on the landward shore of the barrier beach?	You are standing on the barrier beach. The mean low water line of the tidal flat is the boundary of the barrier beach.
❑ Are you standing on a marsh separating the barrier from the mainland, which shows evidence of salt-tolerant vegetation, such as: ❑ Smooth cordgrass (*Spartina alterniflora),* and ❑ Saltmeadow cordgrass (*Spartina patens)*?	You are on a salt marsh that is *not part* of the barrier beach. The beginning of salt marsh vegetation is the boundary of the barrier beach.
Indicators of the Lateral Boundary of a Barrier Beach	If **yes**:
If the landform is connected to the mainland: ❑ Are the coastal beaches and dunes seaward of the upland? *Or*	You are on coastal beaches and dunes that are *not part* of the barrier beach.
❑ Are you standing on sediments (or bedrock) that look like they are glacial in origin (typically poorly sorted sediments) or that have deep organic soil horizons? *Or*	You are likely on a coastal bank or an upland area that is *not part* of the barrier beach.
❑ Are you standing on bedrock (more than a small outcrop)?	You are on bedrock or an upland area that is *not part* of the barrier beach.
❑ Are field observations consistent with surveys, maps, and other references?	
❑ Other observations:	

COASTAL BANKS

The WPA Regulations (310 CMR 10.30) define coastal banks 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."

Photograph 1.14. Coastal bank.

Many coastal banks in Massachusetts are glacial landforms, such as glacial drumlins, ground moraines, or deposits of glacial outwash. Some coastal banks are not glacial in origin, including bedrock banks or sediment banks that were deposited prior to the glaciers (though both may have subsequently been eroded, weathered, or displaced by glaciers). Regulatory coastal banks (as well as coastal dunes) may consist of artificially deposited fill, provided they serve the functions of storm damage prevention and flood control. Given their origin, coastal banks may be composed of various materials, ranging from solid bedrock to sediments consisting of silt, sand, or unconsolidated rocks and soil. The banks that are unconsolidated and are exposed to wave and wind energy are subject to erosion and may provide sediment to beaches and dunes (Photograph 1.14). Banks consisting entirely of bedrock (ledge) do not provide a source of sediment and are not subject to significant erosion. Coastal banks differ from dunes in that they have *not* been sorted and reworked by wind, tides, waves, or overwash.

The seaward edge (or bottom) of the coastal bank begins at the toe of the coastal bank slope, where other coastal wetland resource areas end. Coastal wetland, as defined in M.G.L. c. 131, §40, paragraph 6, is "any bank, marsh, swamp, meadow, flat or other lowland subject to tidal action or coastal storm flowage." Therefore, an adjacent resource area could be: a beach, dune, salt marsh, or rocky intertidal shore; or a body of water such as a lake, stream, or land under a salt pond; or a lowland provided that these areas are tidal or associated with coastal storm events up to the 100-year storm (1%-annual-chance flood) elevation or storm of record. The landward edge (or top) of the coastal bank is generally the top of, or the first major break in, the face of the coastal bank. Also note that the WPA Regulations specify a coastal bank as being an "elevated landform." Therefore, a coastal engineering structure (CES), such as a seawall, which is directly between a beach and a dune, is *not* considered a coastal bank. The delineation of boundaries when a CES is located *on* a coastal bank is discussed more on page 1-53.

Special Considerations

Unconsolidated coastal banks are constantly changing in response to storms, waves, winds, tides, sediment supply, changes in relative sea level, and human activities. Eroding coastal banks are a principal source of sediment for beaches, dunes, and barrier beaches in Massachusetts. There is a natural (and variable) erosion rate and landward migration for these eroding coastal banks. The slope, shape, composition, amount of vegetation covering a coastal bank, and width of the beach and dunes fronting the bank are directly related to the susceptibility of the bank face to ongoing erosion. In addition, the gravitational processes of creep, slumping, and landslides can modify the shape of the coastal bank. Bedrock coastlines, to the contrary, are consolidated and very strong; hence they are relatively resistant to erosion from waves and weather. Commissions must therefore interpret existing data in light of the nature of the landform and the current or changing shoreline conditions.

To accurately delineate the landward boundary of the coastal bank, Commissions should rely on the Massachusetts Department of Environmental Protection (MassDEP) Wetlands Program Policy 92-1 that clarifies the regulatory definition of coastal bank by providing guidance for identifying the "top of coastal bank." See Appendix D - Massachusetts Department of Environmental Protection Coastal Banks Policy. The guidance outlines a series of standards to conduct a site-specific analysis and to present a more accurate graphic representation of slope and "top of coastal bank" on a plan. The policy includes cross-sectional diagrams that illustrate the top of the coastal bank in various situations.

Applications and Plans

For proper delineation and review of a coastal bank, the coastal bank resource area should be delineated and mapped on a plan to a large scale, preferably 1"=20' (1:240), and include a detailed topographic survey with 1- to 2-foot contours. The plan should comprise a plan view and cross sections showing the slope profile. The plan view should show the transect lines perpendicular to all contour lines, which therefore may not necessarily be straight lines (see multiple segments of a cross section in Figure 1.11 on page 1-54). If the transect line is not perpendicular to contours, it cannot be used to accurately characterize the slope changes. To ensure that the entire coastal bank is considered, begin the transect line at the landward edge of the adjacent resource area seaward of the bank and extend it landward beyond the 100-year floodplain (1%-annual-chance flood), being sure to go beyond the highest elevation point. Going this far landward will account for the entire landform and allow for a more accurate calculation of slope.

The applicant should submit a plan with information and data that is also consistent with the requirements under MassDEP Wetlands Program Policy 92-1. The data should include slope ratio calculations along particular segments of the transect line and their corresponding cross sections (for the methodology to determine slope ratios, see Appendix E; for an example of a cross section, see

Figure 1.11 on page 1-54). The applicant must then identify which of the five diagrams illustrated in the MassDEP policy is representative of the site (see Appendix D). Follow-up field observations should be made to verify that delineations made using the slope calculations and as shown on the submitted plans reflect the actual conditions at the site. Where possible, all vertical data should be relative to NAVD 88 datums to maintain consistency between floodplain elevations, bathymetry, and site topography (conversions between datums can be performed by tools on the NOAA National Geodetic Survey website, www.ngs.noaa.gov and the NOAA Office of Coast Survey website, www.nauticalcharts.noaa.gov). Accuracy in determining the landward boundary of the flood zones is particularly important since this boundary influences the location of the top of the coastal bank.

How to Delineate and Review Coastal Bank Boundaries

Before going out to the site, Commissions should review the contour plans, Flood Insurance Rate Maps (FIRMs), and the MassDEP policy to become familiar with how to identify the top of the coastal bank on a plan. Using the contour lines and a ruler, Commissions can make their own determination of the slope for the site (for an example on how to delineate the slope for the site depicted in Figure 1.11, please see Appendix E).

Commissions should be sure the applicant has delineated the top of the bank based on the overall slope of the landform and not the micro-topography or small incremental breaks in slope.[29] In some cases, there may be a small break in slope, which is then immediately followed landward by a return in slope; this break would not necessarily constitute the top of the coastal bank. For example, in circumstances where there is a flat area at the top of a revetment or a footpath traversing a coastal bank, these artificial alterations are not considered changes in slope pursuant to the policy language (see footpath in cross section of Figure 1.11). In addition, there may be *multiple* coastal banks within the same site, when they are separated by land subject to coastal storm flowage (i.e., an area less than 10:1).

In order to help visualize the plan data as it relates to field observations, Commissions can review Figure 1.11, which shows an example of a typical coastal bank represented by: 1) a contour plan, 2) a cross section of the site, and 3) the corresponding MassDEP policy diagram representative of the cross section. Commissions can compare the three graphics (as well as review the information in Appendices D and E) to become familiar with the methodology for determining the top of the coastal bank.

Following the determination of the top of the coastal bank through a review of the maps, the contour lines on the plan, and profile(s) perpendicular to the contour lines, Commissions should

[29]See in the matter of J. John Brennan and Maureen Brennan, Docket No. 2002-069, Recommended Final Decision, May 6, 2003, where summary decision was granted for the Department because the evidence demonstrates that the slope measurements made on the landowners' behalf show an irregularity in the slope rather than a change in the slope that would demarcate the top of the bank.

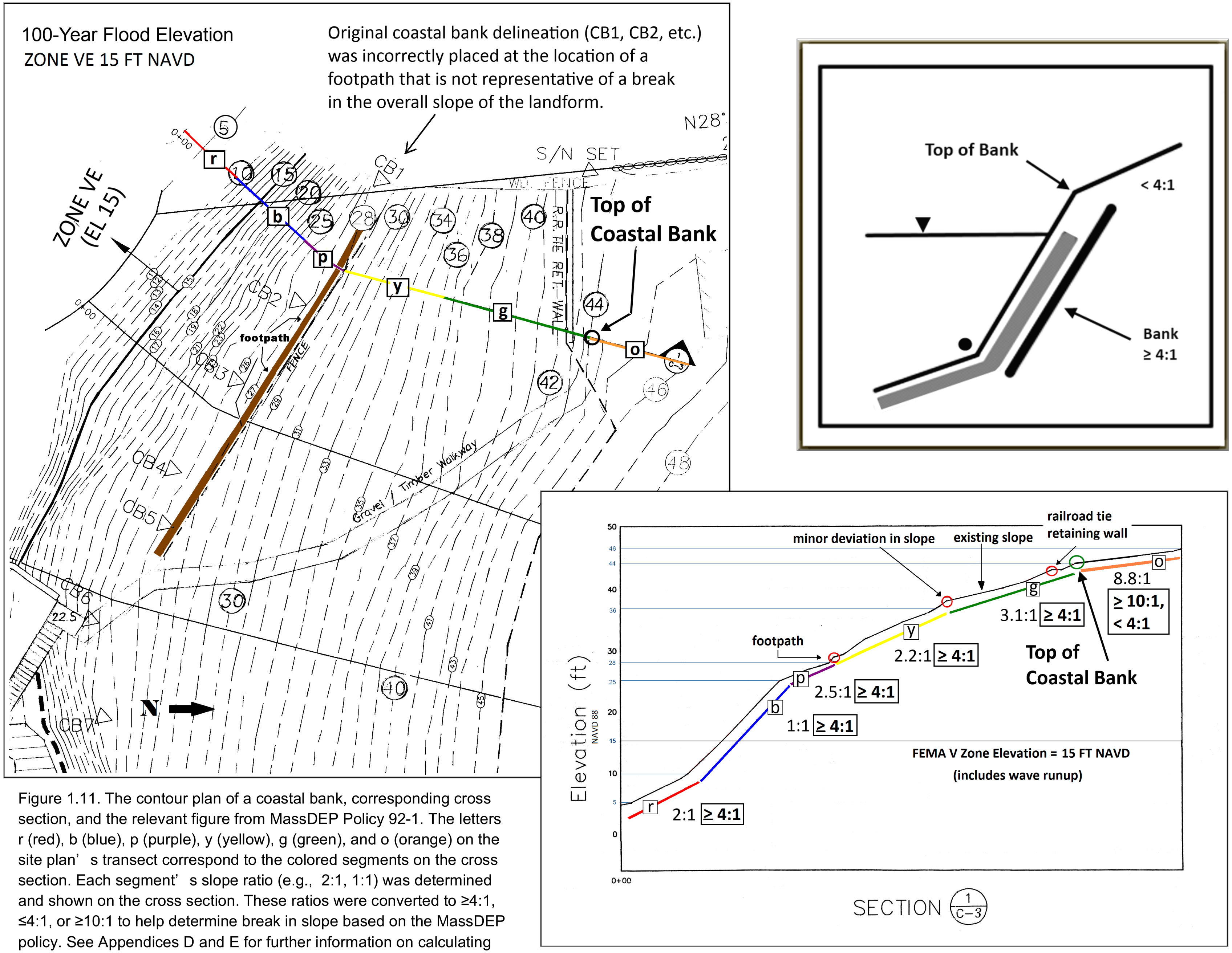

Figure 1.11. The contour plan of a coastal bank, corresponding cross section, and the relevant figure from MassDEP Policy 92-1. The letters r (red), b (blue), p (purple), y (yellow), g (green), and o (orange) on the site plan's transect correspond to the colored segments on the cross section. Each segment's slope ratio (e.g., 2:1, 1:1) was determined and shown on the cross section. These ratios were converted to ≥4:1, ≤4:1, or ≥10:1 to help determine break in slope based on the MassDEP policy. See Appendices D and E for further information on calculating slope ratios and the top of the coastal bank for this site.

verify the information in the field. Commissions should perform site visits and keep track of observations and data collected in the field. The following information on field observations and the data checklist can assist Commissions at the site.

Field Observations

Sometimes, averaging or interpolating data on maps can lead to errors, so Commissions should take a good look at the site to see if the cross section is representative of the whole landform, whether more than one profile needs to be provided, and if the top of the coastal bank boundary makes sense as it relates to the slopes and flood elevations. If it appears that the boundary was drawn incorrectly, the applicant or representative should be required to recalculate the slopes, reexamine the top of bank based on Policy 92-1, and adjust the line accordingly.

Data Checklist[30]

When a precise delineation of the coastal bank is needed, this checklist should be used to: 1) identify features on the plans and maps, 2) record information about site characteristics, and 3) determine if additional information is needed to delineate the resource area. The person using this form is advised to work from the seaward toe of the coastal bank to the top of the coastal bank. In addition to site observations, information (such as subsurface sediment analysis) may be necessary to determine whether the landform feature is a coastal bank. The applicant should be required to supply all the information necessary for a proper review of the landform and its boundaries.

[30]This checklist can also be found in the Data Checklists for the Delineation of Resource Areas, a separate attachment that can easily be carried out to the field to record information about landform features and characteristics.

Check all that apply:

Indicators of a Coastal Bank	If **yes**:
See other resource area Data Checklists to determine the landward boundaries for beach, dune, salt marsh, rocky intertidal shore, or land subject to coastal storm flowage, and then continue below. Keep in mind that when determining slope, the profile or transect lines must be perpendicular to the contour lines.	

❑ Is there an abrupt change in topography—to a steep facing slope (steeper than 10:1) or elevated landform that does not meet the criteria for beaches and dunes? *and*
❑ Does the 100-year flood (1%-annual-chance flood) reach this elevated landform? *and*
❑ Is the landform immediately landward of a beach, dune, salt marsh, or rocky intertidal shore; or a body of water such as a lake, stream, or land under a salt pond; or a lowland that is tidal or associated with coastal storm events up to the 100-year storm (1%-annual-chance flood) or storm of record? *and*
    ❑ Are the underlying sediments on the slope or elevated landform primarily glacial deposits (typically poorly sorted sediments)? *or*
    ❑ Does the landform consist of artificial fill that serves the functions of a coastal bank (sediment source or vertical buffer)?
	The landform is a coastal bank.

Indicators of the Seaward Boundary of a Coastal Bank	If **yes**:
❑ Have you found the landward boundary of the adjacent (seaward) coastal resource area (i.e., beach, dune, salt marsh, or rocky intertidal shore; or a body of water such as a lake, stream, or land under a salt pond; or a lowland that is tidal or associated with coastal storm events up to the 100-year storm or storm of record)? *and* ❑ Does this boundary border a landform that meets the criteria listed above?	You have found the seaward boundary of the coastal bank, which is often marked by an abrupt change in topography to a steep facing slope (steeper than 10:1). See the applicable sections in Chapter 1 to help refine the landward boundaries of the other coastal resource areas.
Indicators of the Landward Boundary of a Coastal Bank (Top of Coastal Bank)	If **yes**:
❑ Is the slope steeper than or equal to 10:1 but less than 4:1?	The 100-year flood elevation *is* the top of coastal bank.
❑ Is the slope steeper than or equal to 4:1?	The top of coastal bank is *above* the 100-year flood elevation and at the point where the slope becomes less than 4:1.
❑ Is there a coastal bank separated by land subject to coastal storm flowage that extends to another rise steeper than 10:1?	The area contains multiple coastal banks. Commissions should be careful to delineate the most landward coastal bank.
❑ Is there a small break in slope, such as at the location of the top of a seawall or a footpath, that is immediately followed landward by a return to a steep slope?	This is a human alteration and does not constitute a change in slope of the underlying landform or the top of coastal bank. Determine the slope of the *overall* landform, not the microtopography.
❑ Are field observations consistent with surveys, maps, and other references?	
❑ Other observations:	

ROCKY INTERTIDAL SHORES

The WPA Regulations (310 CMR 10.31) define rocky intertidal shores as "naturally occurring rocky areas, such as bedrock or boulder-strewn areas between the mean high water line and the mean low water line."

Rocky intertidal areas occur on rocky shores, such as headlands and cobble/boulder beaches. Although they tend to be more irregular in topography and have a greater predominance of bedrock outcrops, a rocky intertidal shore can also include the intertidal area of mixed sand, pebble, and/or cobble beach, provided there is a predominance of boulders present. Ledges exposed by the tide, which lie offshore, also fall under the definition of rocky intertidal shore.

Rocky intertidal shores are exposed at low tide and are underwater at high tide. Many plants and animals are specially adapted to live in this fluctuating environment. Species that typify the area include, but are not limited to, red alga (*Chondrus crispus* or Irish moss), mussels (*Mytilus edulis)*, barnacles (*Balanus balanoides)*, and brown *fucoid* algae.

Special Considerations

While this resource area is often mistakenly not delineated on an applicant's plan, identification of the rocky intertidal shore is necessary when coastal projects are likely to have a direct impact on its functions, including storm damage prevention and flood control. As with many of the other resource areas described here, an exact determination may not be necessary if the project is not likely to affect the functions of the rocky intertidal shore. The description below on how to identify and delineate the resource in the field should be satisfactory for the purposes of determining its significance for storm damage prevention and flood control and whether a proposed project will meet the performance standards. If an exact determination of the rocky intertidal shore boundaries is needed, a survey should be required.

Applications and Plans

The applicant should show the seaward and landward boundaries of the rocky intertidal shore, as defined by the mean low water and mean high water elevations, on a topographic map of the site. As with land under the ocean, the NOAA nautical charts can be referenced for an approximate boundary (since the charts currently reference mean lower low water). The applicant may also want to confirm these lines by going out into the field and observing evidence of the mean low and high water elevations by looking for water marks on the rocks, as well as the typical intertidal ecological communities.

How to Delineate and Review Rocky Intertidal Shore Boundaries

The rocky intertidal shore is a community dominated by invertebrates and non-vascular plants in a high-stress environment alternately covered by tides and exposed to desiccation and thermal stress. The communities of rocky shores are dominated by crustaceans, mollusks, and macroscopic algae. The rocky shore community shows a distinct zonation from the zone of complete inundation to the splash zone. These lower and upper limits can help determine the boundaries of the rocky intertidal area if an exact determination of mean low and mean high water cannot be made by looking at nautical charts, tide charts, or other surveys.

The rocky intertidal shores of pebble, cobble, and boulder beaches are home to fewer organisms due to the shifting nature of the shoreline (see Photograph 1.15 on page 1-59). Delineation of this type of rocky intertidal shore requires a determination of mean high and low water elevations through charts and surveys and an observation of these elevations through water marks or wrack lines in the field. Because these resource areas are also defined and protected as coastal beaches, an exact determination of the rocky intertidal boundary may not be necessary.

Although jetties, groins, and other coastal engineering structures do provide habitat for invertebrate and plant species and basically mimic a rocky intertidal area, they do not meet the regulatory definition of rocky intertidal shore, since they are not "naturally occurring rocky areas." Therefore, existing structures would not be subject to the performance standards for rocky intertidal shores but may be subject to those for land under the ocean and/or tidal flats if a project affects those areas.

Commissions should be sure to first check nautical and tide charts to help determine tidal range and approximate location of the mean low and high water elevations. A field visit can be performed at low tide when the resource area is not covered with water. The survey of the rocky shore should begin at the splash zone if the tide is ebbing (going out) and begin at the low tide zone if the tide is flowing (coming in).

Commissions should also perform site visits and keep track of observations and data collected in the field. The following information on field observations and the data checklist can assist Commissions at the site.

Field Observations

One way to approximate the general location of the mean low water line on rocky intertidal shores that have visible plant and animal communities is to look for blue mussels, which are often found in abundance just above and below the mean low water line.


Photograph 1.15. Rocky intertidal shore. A predominance of bedrock outcrops in combination with pebble and cobble sediments (i.e., overlapping pebble/cobble beach) within the intertidal zone make this a rocky intertidal shore. See Photograph 1.4 on page 1-13 for a comparison of a pebble/cobble beach that is not defined as a rocky intertidal shore due to the lack of existing bedrock or boulders.

Other typical species found within the intertidal zone include snails, limpets, barnacles, Fucus (rock weed), small anemones, and shore crabs.

Above the mean high water mark, the intertidal region becomes the splash zone, which does not constitute rocky intertidal shore as defined by the Regulations. The boundary between these two zones is therefore the landward limit of the rocky intertidal shore. The splash zone contains very few organisms, because it is usually dry (though occasionally wet by sea spray or wave splash) and only flooded during storms. Commissions may be able to identify the high tide line at the site by identifying very low percent cover of species in the splash zone compared to the more seaward zones. Beyond the mean high water line, the rocky intertidal shore transitions to other resource areas. For example, rocky headlands that are rocky intertidal shores at the base become coastal banks above the mean high water elevation.

For pebble and cobble intertidal shores, Commissions should find the mean high water wrack line or water marks on the rocks to determine the landward boundary of the rocky intertidal shore.

Data Checklist[31]

When a precise delineation of the rocky intertidal shore is needed, this checklist should be used to: 1) identify features on the plans and maps, 2) record information about site characteristics, and 3) determine if additional information is needed to delineate the resource area. (These indicators should only be used for an approximate boundary—a survey should be required for an exact delineation.)

[31]This checklist can also be found in the Data Checklists for the Delineation of Resource Areas, a separate attachment that can easily be carried out to the field to record information about landform features and characteristics.

Check all that apply:

Indicators of a Rocky Intertidal Shore	If **yes**:
❑ Are you standing between the mean low and high water elevation on rocky areas (e.g., pebbles, cobbles, and boulders) that look like they have been primarily reworked by waves, tides, or storm events?	You are on a rocky intertidal shore as part of the coastal beach.
❑ Are you standing between the mean low and high water elevation on rocky areas that look like they have been shaped and deposited by glacial processes? *and* ❑ Are you standing on rocky areas that tend to be more irregular in topography and have a greater predominance of bedrock outcrops or boulders that remain fairly static? *and* ❑ Does the relatively static nature of the rock material allow for the growth and survival of plants and animals that are specially adapted to live in the tidal environment?	You are on a rocky intertidal shore.
Indicators of the Seaward Boundary of a Rocky Intertidal Shore	If **yes**:
❑ At a typical low tide, are your feet in the water?	You are standing on land under the ocean (the subtidal region, which is not part of the rocky intertidal shore).
❑ At a typical low tide, are you standing on a wet pebble, cobble, or rocky area with a predominance of boulders or bedrock outcrops? *or* ❑ At a typical low tide, are you standing on a rocky area with a predominance of boulders or bedrock outcrops that are dominated by species such as: ❑ mussels (*Mytilus edulis)*, ❑ Irish moss (*Chondrus crispus*), ❑ rock weed (*Fucus* spp.), ❑ barnacles (*Balanus balanoides)*, ❑ snails and limpets, ❑ small anemones, and ❑ shore crabs?	You are standing on the rocky intertidal shore.
Indicators of the Landward Boundary of a Rocky Intertidal Shore	If **yes**:
❑ Are you standing on a rocky area with a predominance of boulders and bedrock outcrops that are dominated by barnacles (*Balancus balanoides*)? *and/or* ❑ At mean high tide, are your feet wet?	You are standing on the rocky intertidal shore.
❑ At mean high tide, are you standing on rocks exposed to the air that are wet from sea spray or wave splash? *and* ❑ Are there low densities of species that were identified above?	You are standing in the splash zone, which is not the rocky intertidal shore. The splash zone is part of the adjacent resource area (i.e., coastal beach, coastal bank).
❑ Are field observations consistent with surveys, maps, and other references?	
❑ Other observations:	

SALT MARSHES

The WPA Regulations (310 CMR 10.32) define salt marsh as "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."

Spring tide is defined as "the tide of the greatest amplitude during the approximately 14-day tidal cycle. It occurs at or near the time when the gravitational forces of the sun and the moon are in phase (new and full moons)."

Coastal wetland is defined by the Wetlands Protection Act (M.G.L. c. 131, § 40, paragraph 6) as "any bank, marsh, swamp, meadow, flat or other lowland subject to tidal action or coastal storm flowage."

Special Considerations

The regulatory definition characterizes the salt marsh boundaries based on the highest high tide of the year and the presence of salt-tolerant wetland vegetation. Freshwater wetlands may occur below the highest spring tide line (and up-gradient of a salt marsh) and should not be considered part of the salt marsh since bordering vegetated wetlands have different functions and performance standards than salt marsh systems (see Figure 1.12 on page 1-62 for a cross section showing the transition into adjacent resource areas). To properly locate the landward boundary of the salt marsh, therefore, it is necessary to perform a site visit to first identify the location of the highest tide line and then distinguish between the two types of vegetation. Keep in mind that the area up-gradient of the highest spring tide line may contain salt marsh vegetation, but by definition this area is not considered salt marsh.

The WPA Regulations were revised in 2014 to include other dominant plants typically found within a salt marsh, in addition to the two Spartina species that were listed in the original Regulations. The additional plants include, but are not limited to, spike grass, high-tide bush, black grass, and common reedgrass (*Phragmites*). This language change recognizes that an area can be defined as a salt marsh under the Regulations even if the Spartina species are not present. A broader list of plants that are well adapted to or prefer living in saline soils can now be used as indicators of salt marsh. Though common reedgrass can be found in both fresh and salt water systems, it should be considered an indicator of salt marsh when it is found below the highest spring tide line, but not when it is above the highest spring tide line. When this species is the dominant plant on the site, the identification of the highest high tide line is critical for proper delineation of the salt marsh boundary.[32]

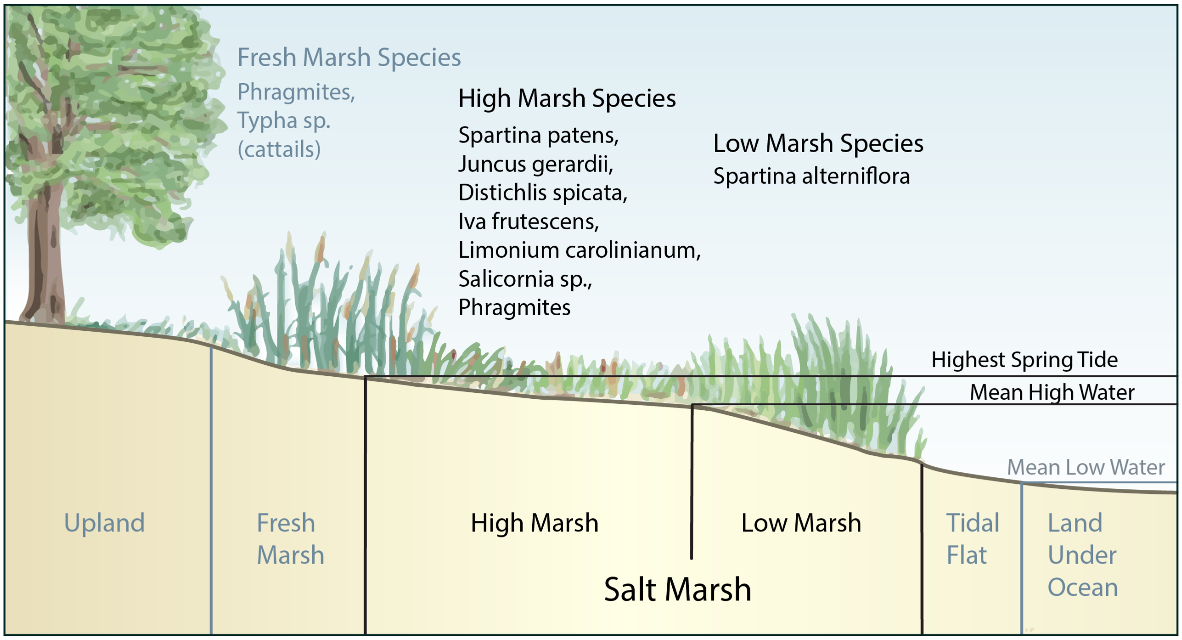

Figure 1.12. Cross section of a salt marsh. This example shows the highest spring tide line as the uppermost possible limit of the salt marsh (the boundary will be no farther landward, but may be farther seaward depending on the plant community).

Some useful references for salt marsh plant identification and tide information are:

1) *Field Guides*
   - *A Field Guide to Coastal Wetland Plants of the Northeastern United States*. Tiner, Ralph W. 1987. The University of Massachusetts Press, Amherst.
   - *Tidal Marsh Plants*. Bleuterius, Lionel N. 1990. Pelican Publishing Co., LA.

2) *A Volunteer's Handbook for Monitoring New England Salt Marshes*
   www.mass.gov/service-details/czm-coastal-habitat-program-a-volunteers-handbook-for-monitoring-new-england-salt - This handbook provides detailed information on how to collect and record data on salt marshes, including inventories of plants, invertebrates, tidal hydrology, and the general ecology of these resource areas.

3) *NOAA Tides & Currents Products*
   https://tidesandcurrents.noaa.gov/products.html - This website provides water level and tide predictions for various stations along the Massachusetts coastline.

[32]In the matter of Van Loan, Docket No. 2002-03, May 14, 2010, adopted by Final Decision, May 21, 2010, affirmed by Suffolk Superior Court sub nom Van Loan v. MassDEP, Civil Action No. 10-2495-B, July 27, 2011, the Presiding Officer concluded that the Site that was dominated by Phragmites (an invasive plant that is well adapted to saline conditions) met the regulatory definition of a salt marsh based on the fact that 1) the Site was appropriately characterized as a coastal wetland because it was subject to tidal action and because the salinity of the soils was above the 0.5ppt threshold for fresh water, and 2) the Site was characterized by plants that are well adapted to or prefer living in saline soils, which are not necessarily limited to Spartina species. In reaching this conclusion, the Presiding Officer determined that if the presence of Spartina sp. were mandatory, the regulations would have so stated instead of citing to the requirement of plant species that are adapted to or prefer saline soils. (The Regulations were changed in 2014 to clarify that other plants that are well adapted to saline soils may be used as indicators of salt marsh.)

Applications and Plans

Because of the high level of regulatory protection for a salt marsh (i.e., no adverse effect), it is important that the applicants or their representatives supply a detailed plan with a description of how they performed their delineation and how they distinguished the salt marsh from freshwater wetland or upland areas. The plan should include a survey with elevation contour lines of the site showing the highest high tide line and the salt marsh boundary. The applicants should rely on tide charts to find the astronomical high tide in reference to their plan datum (i.e., mean low water line, NAVD) or the spring tidal range relative to the mean tide level. Commissions should also ensure that the applicant has analyzed salt marsh vegetation to provide an accurate representation of the resource area. Commissions may find it helpful for the applicant to stake out the boundary of the surveyed highest tide line and salt marsh boundary for review in the field.

How to Delineate and Review Salt Marsh Boundaries

Before going out into the field, Commissions should check the tide data to determine the elevation of the highest high tide of the year, as discussed above. The applicant's elevations should be consistent with these findings, and if necessary, adjustments should be required. Commissions can become familiar with indicator species of salt marsh vegetation and review or bring field guides and other useful references to the site to aid in wetland and salt marsh identification.

Commissions should also perform site visits and keep track of observations and data collected in the field. The following information on field observations and the data checklist can assist Commissions at the site.

Field Observations

Once at the site, Commissions can begin the delineation at the landward edge. To identify the landward boundary of salt marsh, the highest spring tide line should be found by using the information gleaned from the tide charts, in combination with an observation of the high tide wrack lines. This process will be more straightforward if Commissions require the applicant to stake out the lines prior to the site visit. If the applicant has not staked the lines, Commissions will need to rely on field indicators (i.e., wrack lines) or estimates of the highest tidal height relative to the tidal heights on the day of the site visit.

Once Commissions have located the highest spring tide line, they may look at the plant community in the vicinity and determine if it is dominated by salt-tolerant vegetation. Sometimes, the plant community of a salt marsh is distinct and noticeably different from the surrounding upland vegetation. Other times, a gradual transition from an upland or a transition from freshwater marsh to salt marsh can make identification more challenging. Moving seaward, Commissions should determine where a significant percentage (i.e., greater than 50 percent) of the plants are salt tolerant.

If a count of plants or determination of percent cover within a plot reveals less than 50 percent salt-tolerant wetland species, then the area should not be considered a salt marsh (it may be bordering vegetated wetland). Commissions should continue to walk seaward until they identify a plot where the percentage is greater than 50 percent. That point will mark the location of the landward boundary of salt marsh. This boundary may be below the spring high tide line, but never above (i.e., landward of) this line.

Salt marsh vegetation within the high marsh may consist of, but is not limited to, salt meadow grass (*Spartina patens*), spikegrass (*Distichlis spicata*), blackgrass (*Juncus gerardii*), marsh elder (*Iva frutescens*), glass worts (*Salicornia sp.*), sea lavender (*Limonium carolinianum*), sea blite (*Suaeda maritima*), salt marsh aster (*Aster maritima*), and/or little sea-pink (*Sabatia stellaris*). *Phragmites* may also be found in the high marsh.

Low marsh vegetation is often dominated by salt marsh cordgrass (*Spartina alterniflora*). The low marsh transitions to the adjacent tidal flats and tidal waters. The boundary between the marsh vegetation and tidal flats will mark the location of the seaward boundary of the salt marsh. Exceptions to this rule are exposed areas of peat, which once served as substrate for salt marsh vegetation. These areas may have been denuded of vegetation through natural or artificial causes, but may still contain rhizomes and other subsurface plant material. The layers of peat may also serve the same interests for storm damage prevention and flood control and are therefore defined as salt marsh under the Regulations.

Tidal creeks, drainage ditches, salt pannes, and salt pools that are found in salt marshes, though containing little to no salt marsh vegetation, should also be considered salt marsh by definition if they are within or substantially surrounded by salt marsh vegetation. Large streams and rivers that flow through areas of salt marsh vegetation are not part of the salt marsh if they contain a substantial volume of water at mean low tide.

Data Checklist[33]

When a precise delineation of the salt marsh is needed, this checklist should be used to: 1) identify features on the plans and maps, 2) record information about site characteristics, and 3) determine if additional information is needed to delineate the resource area. The person using this form is advised to start at the landward edge of the salt marsh and work in a seaward direction.

[33]This checklist can also be found in the Data Checklists for the Delineation of Resource Areas, a separate attachment that can easily be carried out to the field to record information about landform features and characteristics.

Check all that apply:

Indicators of a Salt Marsh	If **yes**:

Are you standing on a coastal wetland (i.e., wetland subject to tidal action or coastal storm flowage) and:
❑ Is the area *below* (i.e., seaward of) the highest spring tide line, *and if so:*
    ❑ Is the area characterized by plants that are well adapted to or prefer living in saline soils?
    These plants may include:
        ❑ salt meadow grass (*Spartina patens*),
        ❑ spikegrass (*Distichlis spicata*),
        ❑ blackgrass (*Juncus gerardii*),
        ❑ marsh elder (*Iva frutescens*),
        ❑ glass worts (*Salicornia sp*.),
        ❑ sea lavender (*Limonium carolinianum*),
        ❑ sea blite (*Suaeda maritima*),
        ❑ salt marsh aster (*Aster maritima*),
        ❑ little sea-pink (*Sabatia stellaris*), and
        ❑ common reed (*Phragmites*)? *and/or*
    ❑ Have you identified peat areas that may have been denuded of vegetation through natural or artificial causes but may still contain rhizomes and other subsurface plant material? *and/or*
    ❑ Have you identified salt marsh features, such as drainage ditches, salt pannes, salt pools, and creeks that are substantially surrounded by salt marsh vegetation and are relatively drained at mean low tide?
or
	You may be standing on a salt marsh. (See indicators for landward and seaward boundaries below to make the determination.)

Are you standing on a coastal wetland (i.e., wetland subject to tidal action or coastal storm flowage) and: ❑ Is the area *above* (i.e., landward of) the highest spring tide line? *or* ❑ Is the area *below* (i.e., seaward of) the highest spring tide line, but exhibits none of the characteristics of a salt marsh listed above (i.e., plants, peat, or salt marsh features)? (See *Indicators of Landward Boundary of Salt Marsh* below for more information about the threshold of plant cover.)	You are standing on a coastal wetland (or a freshwater wetland or a bordering vegetated wetland), but *not* a salt marsh.
❑ Are you standing on a wetland associated with inland waters, which is not subject to tidal action or coastal storm flowage?	You are standing on a freshwater wetland or a bordering vegetated wetland that is *not* a salt marsh.
Indicators of the Landward Boundary of a Salt Marsh	If **yes**:
❑ Have you identified the highest spring tide of the year from tide charts and made observations of the high tide wrack lines? *and* ❑ Have you correlated this line to the plan and found and ground-truthed this line in the field?	You are at the uppermost possible limit of the salt marsh (the boundary will be no farther landward, but may be farther seaward).

❑ While standing at the line for highest spring tide of the year, have you identified a plant count or percent cover of *more than* 50 percent of salt-tolerant wetland vegetation, such as: ❑ salt meadow grass (*Spartina patens*), ❑ spikegrass (*Distichlis spicata*), ❑ blackgrass (*Juncus gerardii*), ❑ marsh elder (*Iva frutescens*), ❑ glass worts (*Salicornia sp*.), ❑ sea lavender (*Limonium carolinianum*), ❑ sea blite (*Suaeda maritima*), ❑ salt marsh aster (*Aster maritima*), ❑ little sea-pink (*Sabatia stellaris*), and ❑ common reed (*Phragmites*)?	You are in a salt marsh. The highest spring tide line will mark the landward boundary of the salt marsh.
❑ While standing at the line for highest spring tide of the year, have you identified a plant count or percent cover of *less than* 50 percent of salt-tolerant wetland vegetation, such as: ❑ salt meadow grass (*Spartina patens*), ❑ spikegrass (*Distichlis spicata*), ❑ blackgrass (*Juncus gerardii*), ❑ marsh elder (*Iva frutescens*), ❑ glass worts (*Salicornia sp*.), ❑ sea lavender (*Limonium carolinianum*), ❑ sea blite (*Suaeda maritima*), ❑ salt marsh aster (*Aster maritima*), ❑ little sea-pink (*Sabatia stellaris*), and ❑ common reed (*Phragmites*)?	You are not in a salt marsh. Continue seaward until you find the area where you can identify a plant count or percent cover of *more than* 50 percent of salt-tolerant wetland vegetation. This will mark your landward boundary of salt marsh.
❑ While standing at the line for highest spring tide of the year, have you identified that the plant count or percent cover of species of *freshwater wetland indictors* is more than 50 percent?	You are on a freshwater wetland or a bordering vegetated wetland. Continue seaward until you find the area where you can identify a plant count or percent cover of more than 50 percent of salt-tolerant wetland vegetation. This will mark your landward boundary of salt marsh.

Indicators of the Seaward Boundary of a Salt Marsh	If **yes**:
Observe obvious characteristics of the low marsh and the coastal beach and work your way to the middle of these points to find the seaward boundary of salt marsh. The characteristics of these resource areas can be found in more detail in this section and the coastal beaches section beginning on page 1-8.	
❑ Are you standing on salt-tolerant wetland vegetation, dominated by salt marsh cordgrass (*Spartina alterniflora*)? *or* ❑ Are you standing on peat, which once supported this low marsh vegetation?	You are on the low marsh, as part of a salt marsh.
❑ Are you standing on a tidal flat?	You are on a coastal beach, as defined by the Regulations.
❑ Are field observations consistent with surveys, maps, and other references?	
❑ Other observations:	

LAND SUBJECT TO COASTAL STORM FLOWAGE

The WPA Regulations (310 CMR 10.04) define land subject to coastal storm flowage 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."

Recognizing the need to provide delineation criteria for the 100-year storm that is consistent with the terminology used on the Federal Emergency Management Agency Flood Insurance Rate Maps, the WPA Regulations were amended in 2014 to further define the area that is flooded by the 100-year storm:

"Special Flood Hazard Area means the area of land in the flood plain that is subject to a 1% chance of flooding in any given year as determined by the best available information, including, but not limited to, the currently effective or preliminary Federal Emergency Management Agency (FEMA) Flood Insurance Study or Rate Map (except for any portion of a preliminary map that is the subject of an appeal to FEMA) for Land Subject to Coastal Storm Flowage, the Velocity Zone as defined in 310 CMR 10.04, and the Flood Insurance Study for Bordering Land Subject to Flooding as defined in 310 CMR 10.57." (The storm that has a 1% chance of occurring in a given year is also referred to as the 100-year storm [or flood] or the 1%-annual-chance-flood.)

Land subject to coastal storm flowage can also include areas landward of the special flood hazard area (SFHA) when credible evidence shows that the surge or storm of record extends farther landward. Commissions should use the best credible evidence that is available to delineate the predicted extent of land subject to coastal storm flowage.

Why Delineate the Land Subject to Coastal Storm Flowage Resource Area?

Though land subject to coastal storm flowage is not provided with presumptions of significance in the Preamble or performance standards in Part II of the Wetlands Protection Act, it is identified as an area subject to protection under WPA Section 10.02(1)(d) and can be protected if it is determined significant to the interests of the Act. WPA Section 10.24(1) allows a Commission to determine that a resource area *is* significant to an interest for which no presumption is stated and impose conditions as necessary to contribute to the protection of such interests. An accurate delineation of land subject to coastal storm flowage boundaries can help Commissions ensure projects will not adversely impact the beneficial functions of the resource area for storm damage prevention and flood control. Information about protecting the functions of land subject to coastal storm flowage can be found beginning on page 2-37.

Special Considerations

Because of the different levels of storm-related hazards and resource impacts found within land subject to coastal storm flowage, it is important to determine not only the most landward boundary of the resource area, but also the extent of the 100-year flood plain and the various flood zones within the flood plain. An accurate determination of the spatial extent and magnitude of the flood hazards within these zones is vital to understanding and protecting the functions of the landform for storm damage protection and flood control for a particular site. With an accurate delineation of the flood zones, Commissions will be better prepared to evaluate what effects a proposed project might have on the interests protected by the WPA.

Both FEMA and the WPA Regulations (as amended in 2014) provide terminology and definitions to help delineate the various flood zones within the SFHA. The following describes the flood zones and their types of hazards as described in the WPA Regulations and found on FEMA Federal Insurance Rate Maps (FIRMs) and the National Flood Hazard Layer (a digital dataset with the most current effective flood data). (See Figure 1.13 on page 1-73 for an example of flood maps depicting the various zones and their descriptions).

Velocity Zones

As amended in 2014, the WPA Regulations define Velocity Zone or V Zone, also known as the Coastal High Hazard Area, as "an area within the Special Flood Hazard Area that is subject to high velocity wave action from storms or seismic sources. The Velocity Zone boundaries are determined by reference to the currently effective or preliminary Flood Insurance Rate Map (FIRM) prepared by the Federal Emergency Management Agency (FEMA), whichever is more recent (except for any portion of a preliminary map that is the subject of an appeal to FEMA), or at a minimum to the inland limit of the Primary Frontal Dune, whichever is farther landward." In addition, the Preamble to Coastal Dunes (Section 10.28(1)), states "the Coastal High Hazard Area or Velocity Zone extends at a minimum to the inland limit of the Primary Frontal Dune along the open coast,"[34] with the term 'along the open coast' referring to areas that are not considered sheltered waters[35] and the requirement that the dune must be adjacent to a beach in a V Zone in order for the V Zone to extend to the inland limit of the primary frontal dune.

To clarify the description and extent of the primary frontal dune, the 2014 amendments to the WPA Regulations include the definition for Primary Frontal Dune or Primary Dune as "a continuous or nearly continuous mound or ridge of sediment with relatively steep seaward and landward slopes

[34]FEMA National Flood Insurance Program regulations similarly define coastal high hazard areas as "the area of special flood hazard extending from offshore to the inland limit of a primary frontal dune along an open coast and any other area subject to high velocity wave action from storms or seismic sources."
[35]For more information about the distinction between sheltered waters and open coasts, see Section D.2.2.2.1 within the *Atlantic Ocean and Gulf of Mexico Coastal Guidelines Update* (http://www.fema.gov/media-library-data/1388780453134-c5e577ea3d1da878b40e20b776804736/Atlantic+Ocean+and+Gulf+of+Mexico+Coastal+Guidelines+Update+(Feb+2007).pdf).

immediately landward and adjacent to the beach and subject to erosion and overtopping from high tides and waves during coastal storms. The Primary Frontal Dune is the dune closest to the beach. The inland limit of the Primary Frontal Dune occurs at the point where there is a distinct change from a relatively steep slope to a relatively mild slope."[36]

Velocity Zones are also known as V Zones or VE Zones on FIRMs (formerly V1-30 on older FIRMs). The "E" in VE indicates that a predicted elevation of water (e.g., the top of the waves in a 1%-annual-chance flood) has been determined and is designated on the FIRM. This elevation is referred to as the Base Flood Elevation (BFE). The following criteria are used to identify V Zones on FIRMs:

- Areas with a projected wave height of 3 foot or greater (wave height is the vertical distance as measured between the top of wave and the adjacent wave trough).
- Areas with a projected wave runup depth of 3 foot or greater (wave runup depth is the vertical distance between the calculated wave runup profile elevation and the ground contour elevation at that location).
- Areas within the splash zone (the area extending 30 feet landward of the seaward face of a seawall or other coastal engineering structure that is overtopped by waves).[37]
- The entire extent of the primary frontal dunes (dunes closest to the beach).[38]

FEMA uses these criteria to determine the V Zone boundaries along particular coastal transects (see the text box on page 1-74 for more details on how flood zones and elevations are mapped on FIRMs). Where multiple V Zone criteria apply, the V Zone extends to the landward-most criteria. See Figure 1.14 on page 1-75 for a profile illustrating the extent of the V Zone based on wave height and runup depth.

A Zones

A Zones are the areas subject to inundation by a 1%-annual-chance flood (i.e., the special flood hazard area) that do not meet any of the criteria listed above for being designated as a V Zone. On FIRMs, A Zones are often depicted as AE Zones (formerly A1-30), where the "E" indicates that a predicted elevation of water, or the BFE, has been determined and designated on the maps.[39] The following categories of A Zones also occur in coastal areas:

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[36]This definition is consistent with that of FEMA, which defines the "primary frontal dune" in 44 CFR Section 59.1 as "a continuous or nearly continuous mound or ridge of sand with relatively steep seaward and landward slopes immediately landward and adjacent to the beach and subject to erosion and overtopping from high tides and waves during major coastal storms. The inland limit of the primary frontal dune occurs at a point where there is a distinct change from a relatively steep slope to a relatively mild slope."
[37]Whether a splash zone is mapped behind a coastal engineering structure is determined by the amount of projected overtopping, as specified in FEMA's *Guidelines and Standards for Flood Risk Analysis and Mapping*.
[38]Note that V Zone conditions could extend beyond the landward toe of the primary dune if the dune is overtopped, eroded, or removed in a storm event (See "Delineating V Zones in Coastal Dune Areas" on page 1-85 for details).
[39]A Zones indicated on FIRMs without the "E" represent areas subject to inundation by a 1%-annual-chance flood where no elevations of water have been predicted or determined by a flood study. These A Zones, referred to as Unnumbered A Zones, are primarily only found in inland areas. (*For purposes of this document, the generic term "A Zone" refers to all A Zones, not just those that are "unnumbered."*)

Moderate Wave Action Areas (Coastal A Zones) and Minimal Wave Action Areas

Some A Zones in coastal areas are likely to be subject to moving water, overwash, breaking waves (with heights less than 3 feet), storm surge, and wave runup (with depths less than 3 feet)—all of which may cause erosion and scour. Because waves less than 3 feet (and as small as 1.5 feet) are still capable of causing structural damage to buildings with solid foundations, the A Zone has been further divided to reflect the different levels of hazards that may occur. The higher-hazard portion of the A Zone, which is called the Moderate Wave Action (MoWA) area or the "Coastal A Zone," is subject to wave heights between 1.5 and 3 feet during the 1%-annual-chance flood. The lower-hazard portion of the A Zone, which is landward of the MoWA, is the Minimal Wave Action (MiWA) area and is subject to wave heights less than 1.5 feet during the 1%-annual-chance flood. The boundary between these two zones is designated as the Limit of Moderate Wave Action (LiMWA) (see Figure 1.15 on page 1-76). The complete up-to-date LiMWA lines are only available through the FEMA Flood Map Service Center (https://msc.fema.gov/portal) as part of the National Flood Hazard Layer (NFHL)—see page 1-72 for more information.[40]

AH Zones, AO Zones

AH and AO Zones are defined by the type of inundation in a 1%-annual-chance flood. AH Zones are areas subject to shallow flooding, usually in the form of a pond with an average depth ranging from 1 to 3 feet. The flood elevation for the zone is designated on the FIRM. AO Zones are areas subject to inundation where flooding is characterized by shallow depths (averaging 1 to 3 feet) and/or unpredictable flow paths (usually sheet flow on sloping terrain). The flood depth is designated on the FIRM.

X Zones

X Zones are outside the areas inundated by the 1%-annual-chance flood (outside the SFHA). Shaded X Zones (formerly B on older FIRMs) designate areas subject to inundation by the 0.2%-annual-chance flood (also known as the 500-year flood). Unshaded X Zones (formerly C on older FIRMs) designate areas where the annual probability of flooding is less than 0.2 percent.

Applications and Plans

Applicants should delineate the land subject to coastal storm flowage boundaries on project plans so that Commissions can properly review projects and evaluate whether they meet standards to protect the storm damage prevention and flood control interests. (See Chapter 2 for more information on protecting the functions of this resource area.)

[40]Because the forces in the MoWA area are capable of damaging or destroying buildings, FEMA's *Coastal Construction Manual* (CCM) recommends building to V Zone standards in the MoWA. However, currently there are no regulatory requirements associated with the MoWA as of the publication date of this manual.

Commissions should request that the applications and plans have the appropriate amount of information that is necessary for project review. For most projects, applicants or their representatives should show each distinct flood zone and associated Base Flood Elevation on a contour plan of the site, provide a description of what sources of information were used, and explain how they performed the flood zone delineation. For certain projects, such as those approved under Section 10.28(5), including vegetative plantings, small pedestrian walkways, and dune fencing, a detailed delineation of the SFHA will not be warranted.

There are a number of methods for depicting the spatial extent of land subject to coastal storm flowage and methodologies have changed over time to better predict the extent of flood hazards. The following sources of information can be used by applicants (and Commissions) to determine the boundaries of flood zones, the extent of the SFHA, and the extent of the land subject to coastal storm flowage boundaries: Flood Insurance Rate Maps (including the digital National Flood Hazard Layer) and Flood Insurance Studies (pages 1-71 through 1-77); Letter of Map Change (page 1-78); Field Observations and/or Engineering Data (pages 1-78 through 1-79); Shoreline Change Maps, Hazards Characterization Atlas, and other Data Sources (pages 1-80); and the Primary Dune Delineation Methodology (page 1-81).

Flood Insurance Rate Maps and Flood Insurance Studies

To determine the spatial extent of flood zones, applicants and Commissions should begin by using the information available on the FIRMs published by the FEMA National Flood Insurance Program (NFIP). The FIRMS are official maps that depict the predicted extent of the SFHA, which is the area that would be flooded in a storm having a 1% chance of occurring in a given year. The current effective FIRMs are the maps that have been finalized by FEMA. The preliminary FIRMs represent draft revised maps that include changes proposed by FEMA for public comment (including an appeals process) and adoption by the community. The official flood zones are also provided on FEMA's National Flood Hazard Layer (NFHL), a digital dataset with the current effective flood data that includes all official map updates since the FIRMs were produced (see page 1-72 for information on how to access the NFHL).

Commissions should also use the information found within the Flood Insurance Studies (FISs), which are reports for each county that contain a narrative of the flood history of each community, the engineering methods used to develop the FIRMs, stillwater elevations (i.e., the level of the water without the waves), transect locations where detailed analyses were conducted, and details regarding all updates and revisions that have been made to the FIRMs.

The WPA Regulations now specifically include language that the SFHA boundary shall be determined by reference to the best available information, including, but not limited to, the currently effective or preliminary FIRM (which includes the NFHL). Therefore, where the preliminary FIRMs and FISs show that BFEs are increasing or flood zones are being extended, the applicant and

Commission should reasonably use this draft data (with the exception of any portion of a preliminary map that is under an appeal to FEMA).[41] In cases where the BFE decreases, however, this information should not be used until a Letter of Final Determination has been issued (or until all appeals have been resolved).[42] It is also important to note that Commissions should not consider an elevation or extent of flooding *less than* what has been interpreted from the *effective* FIRMs, unless the applicant has received a final written Letter of Map Revision from FEMA (described in more detail on page 1-78). Given the dynamic nature of the coastal environment, Commissions should be conservative in their review approach and use the most landward flood boundaries when assessing conflicting information.

FIRMs and FISs can be viewed or downloaded from the FEMA Flood Map Service Center (https://msc.fema.gov/portal). The FIRMs are available as digital versions that can be viewed or downloaded as an image or a PDF (more specifically, click the "Map Image" icon to download an image of a FIRM Panel; click the "Dynamic Map" icon to download a PDF of a FIRMette). In addition, the National Flood Hazard Layer, a digital dataset with the most current effective flood data, is also available through the Service Center. The NFHL combines the flood hazard data from the FIRMs with all the official updates, including those issued through each Letter of Map Change (LOMC) to provide a complete view of the official maps (whereas the FIRMs are not updated to reflect LOMCs). The NFHL can be viewed through an interactive map viewer at the Service Center (to open the viewer, enter an address in the search function and select the "Go to NFHL Viewer" button). County or state data from the NFHL, which includes all data layers for effective FIRMs, can also be downloaded and used in a Geographic Information System (GIS). To download the NFHL, search by location and then click the "Show ALL Products" button, open the "Effective Products" folder, and download "NFHL Data" by state or by county. See Appendix B - Useful Data Sources for additional information.

Finding the LiMWA

The complete, up-to-date LiMWA lines are only available through the FEMA Flood Map Service Center as part of the National Flood Hazard Layer. To view the LiMWA, enter an address in the search function and select the "Go to NFHL Viewer" button, which will open an interactive viewer. Once in the viewer, click on the "Layer List" icon in the upper right corner of the page (hover over the icons to display the labels). Expand the NFHL layer to show the available options for this data. Select "Limit of Moderate Wave Action," which will show the LiMWA on the map (typically it is already selected). To accurately see the flood zone boundaries, you will also want to deselect the LiMWA line temporarily to see what lies beneath it. The entire NFHL database for the county or state, which includes the LiMWA layer, can be downloaded and used in GIS (as described above). The LiMWA data layer is named S_LiMWA.

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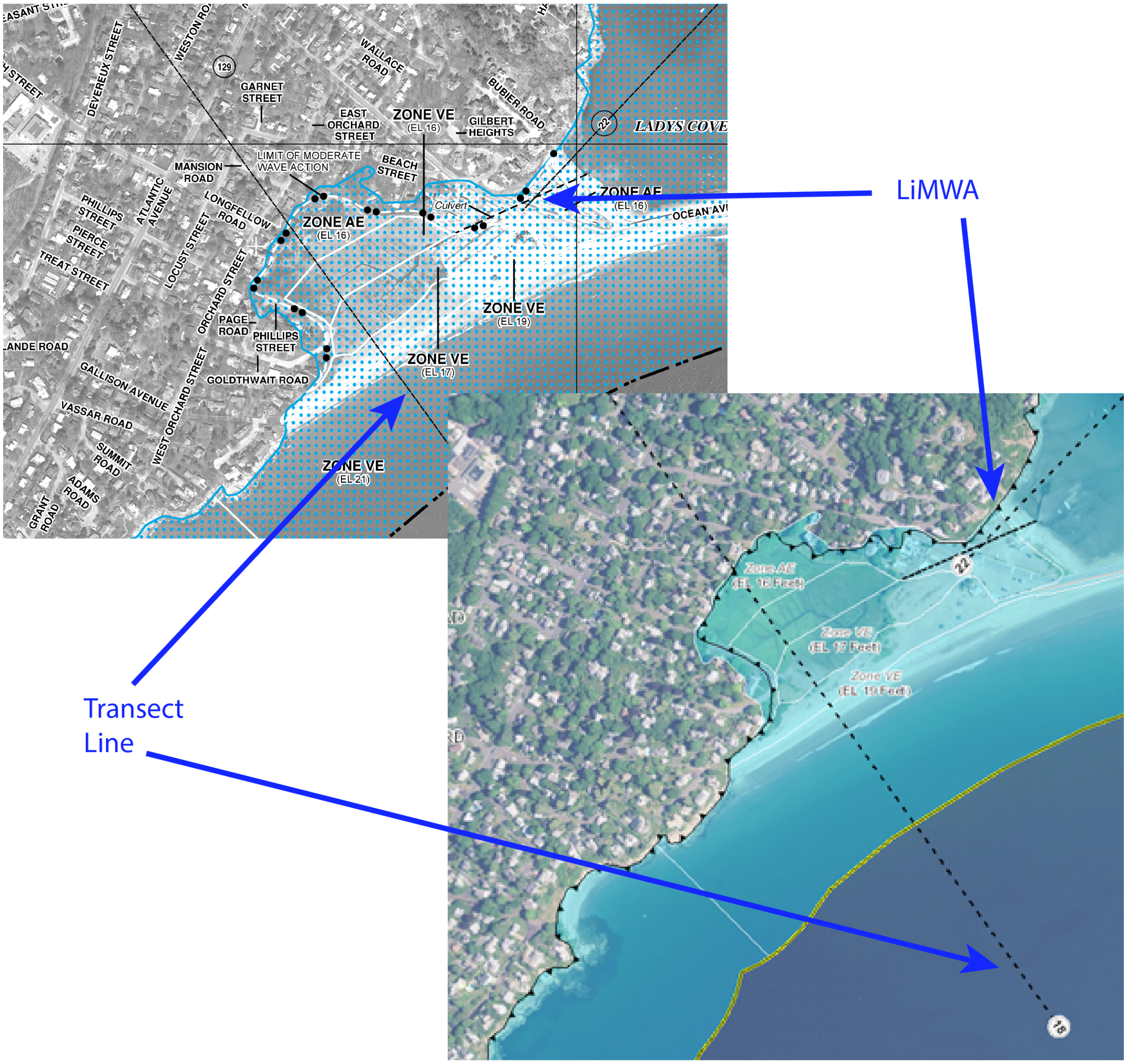
[41]Appeals must include detailed analyses and a proposed alternate delineation of the flood zones and BFEs that are consistent with FEMA's Guidelines and Standards for Flood Risk Analysis and Mapping (www.fema.gov/flood-maps/guidance-partners/guidelines-standards*)*. Objections or protests that do not include this level of analysis are not considered "appeals" by FEMA.

[42]More information can be found on FEMA's Use of Flood Insurance Study (FIS) Data as Available Data (www.fema.gov/sites/default/files/2020-07/fmbulletin_1_98.pdf - PDF, 482, KB).

1. FIRM (as viewed with “Map Image” tool from the FEMA Flood Map Service Center)



2. National Flood Hazard Layer (as viewed with “NFHL Viewer” tool from the FEMA Flood Map Service Center)

Figure 1.13. Example of two different views of official FEMA flood maps: 1) as a section of a FIRM and 2) through the National Flood Hazard Layer (NFHL) on FEMA’s NFHL Viewer. Both show the various flood zones and their Base Flood Elevations (BFEs) overlaid on an aerial photograph. The blue stipple pattern and blue line boundary (on the FIRM) and aqua shading (on the NFHL) show the extent of the Special Flood Hazard Areas (SFHA) subject to inundation by the 1%-annual-chance flood. The white lines are the boundaries between flood zones, such as between a V Zone and an A Zone. The Limit of Moderate Wave Action (LiMWA) designates the boundary between the Moderate Wave Action area (the Coastal A Zone, where wave heights are between 1.5 and 3.0 feet) and the Minimal Wave Action area (where wave heights are less than 1.5 feet). The LiMWA line on the FIRM is not as complete and updated as that on the NFHL and should not be used. The BFE is the elevation of the top of the water and waves relative to the NAVD 88 datum. The transect lines correspond with data provided in the Flood Insurance Study (in this example, transect #18 is shown). Commissions and applicants should use the NFHL on the map viewer available through the FEMA Flood Map Service Center as the first source of information for determining the spatial extent of the various flood zones.

How Flood Zones Are Mapped

When developing FIRMs, FEMA's mapping consultants conduct a series of analyses to predict what areas will be covered with water in a 1%-annual-chance flood, the extent and type of flood zones, and flood elevations. The detailed analyses are conducted at specific locations, called transects, which are shore-perpendicular cross-sections extending from offshore past the inland limit of the floodplain. Engineering judgment is used to connect the points between these transects.

At each transect, the analyses start with the identification of the predicted height of the stillwater during a 1%-annual-chance flood (also known as the storm surge). Computer models are used to determine how waves will break and taper down in elevation as they move onto the shore and across the floodplain in what is called a wave crest profile. The computer models are also used to determine the magnitude and extent of wave runup and wave setup.* The extent of the V and A Zones are then identified along the transect by finding the most landward point of each zone based on its definition. See Figure 1.14 on page 1-75 for a depiction of the stillwater elevation, wave crest and runup profiles, and the extent of the V and A Zones under both runup and non-runup scenarios.

Once the flood zones are defined and identified along the transect, V and A Zones are then subdivided into *elevation zones*; each flood zone is assigned elevation values based on their Base Flood Elevation, or BFE, which is the predicted height of the water, including surge and waves, in a 1%-annual-chance flood. Zones must have a minimum width of 0.2 inches on the FIRM to be assigned a distinct zone elevation—see more about minimum zone width in "Delineating the V Zone/X Zone Boundary" on page 1-84 and Figure 1.16 on page 1-76. In coastal areas, the BFE represents the top of the wave crest profile elevation and/or wave runup elevation (see Figures 1.15 and 1.16 on page 1-76 showing assigned BFEs along a transect).

These flood zone designations, their elevations, and their extents are then transferred from the transects to the FIRMs and the boundaries are connected between the transects using topographic information and engineering judgment. The BFE shown on the FIRM for each V Zone, therefore, is either: 1) the top of the waves (wave crest elevation for that zone), or 2) the calculated maximum wave runup elevation (if wave runup exists). The elevation shown on the FIRM for each A Zone refers to either: 1) the stillwater elevation (the elevation of the surge), including wave setup if appropriate, 2) the top of the waves, or 3) the calculated runup elevation (if runup exists).

For more information on all of the current techniques for mapping flood zones, see FEMA's Guidelines and Standards for Flood Risk Analysis and Mapping available on their website. In addition, *FEMA Coastal Construction Manual: Principles and Practices of Planning, Siting, Designing, Constructing, and Maintaining Residential Buildings in Coastal Areas* (CCM) provides information about flood hazard mapping and flood zone delineations. (See Appendix B-Useful Data Sources for information on how to obtain the CCM.)

*Wave setup is the elevated water level associated with waves coming ashore but not fully receding and is another factor that FEMA is now incorporating into their analyses of flood elevations. Wave setup is not addressed in detail here due to its complexity. A figure of wave setup can be found on page 7 in *Interpreting Federal Emergency Management Agency Flood Maps and Studies in the Coastal Zone* (www.mass.gov/service-details/interpreting-federal-emergency-management-agency-flood-maps-and-studies-in-the).

How Flood Zones Are Mapped (continued)

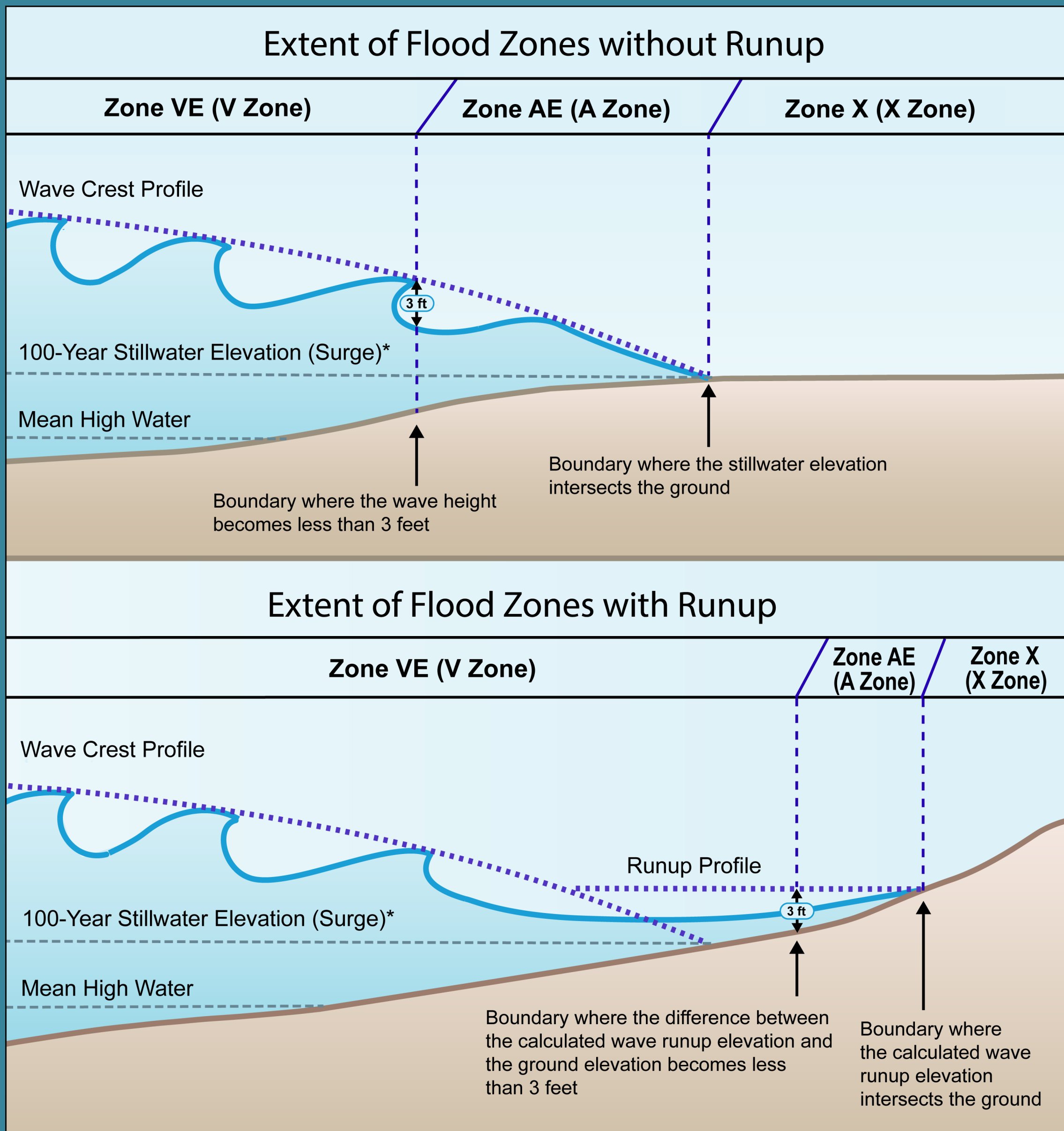


Figure 1.14. Cross-sectional diagrams of the shoreline showing the wave crest profiles, stillwater elevations, and the extent of flood zones in two scenarios: one without and one with wave runup. Computer models are used to determine how the waves will taper down in elevation as they reach land and how runup washes up onshore during a 1%-annual-chance flood. Runup occurs primarily in areas with steeply sloping shorelines or where there are sloping coastal engineering structures along the shoreline. The definitions of each flood zone are used to determine where the boundary occurs between zones.

***If wave setup effects are present, modeling is based on the Total Water Level (stillwater elevation + wave setup).**

How Flood Zones Are Mapped (continued)

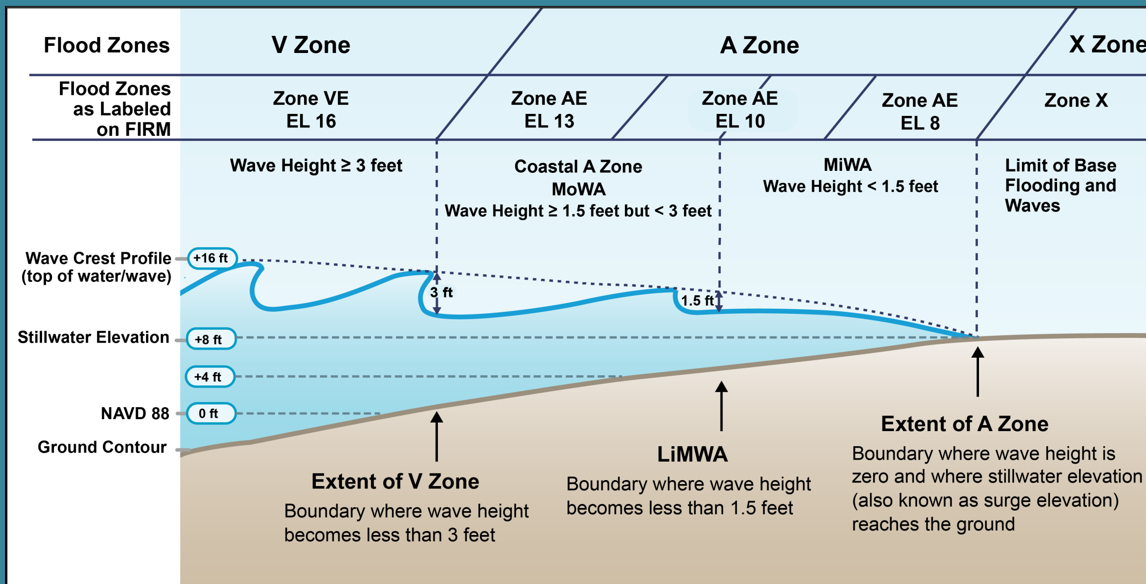


Figure 1.15. Cross-sectional diagram of flood zones on a gently sloping ground profile with no runup. Profile elevations and BFEs are shown in feet above the NAVD 88 datum (as indicated with 0 ft, +4 ft, +8 ft, +16 ft). Although the BFE for the seaward portion of this V Zone is 16 feet NAVD 88 (as indicated by the Zone VE EL 16 on the FIRM), the V Zone does not reach as far landward as the 16-foot ground elevation. Instead, as waves break and wave heights diminish in the landward direction, the V Zone ends (where wave heights become less than 3 feet), and the flood designation becomes an A Zone (with decreasing A Zone elevations—13, 10, then 8 feet NAVD 88) that extends landward to the 8-foot ground elevation. The LiMWA marks the landward limit of the Moderate Wave Action (MoWA) area, where wave heights are between 1.5 and 3 feet. Landward of the MoWA and the LiMWA boundary is the Minimal Wave Action (MiWA) area, where wave heights are less than 1.5 feet.

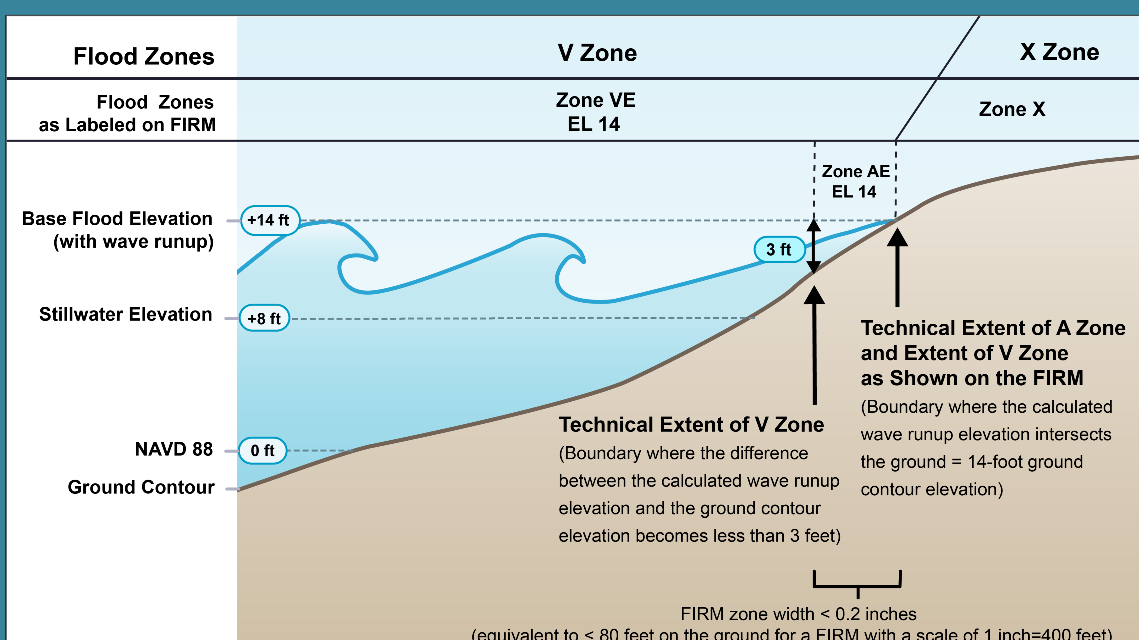


Figure 1.16. Cross-sectional diagram of flood zones on a steep embankment with runup. Here, an A Zone is shown in the profile, but would not be mapped on the FIRM because the zone is less than 0.2 inches in width on the FIRM—thereby not meeting the minimum zone width for mapping at the scale used for FIRMs. Where A Zones such as these are not mapped, the V Zone will extend to the designated ground elevation that corresponds to the V Zone BFE on the FIRM.

Limitations of FIRMs and FIRM Updates

The flood zone designations on FIRMs are a useful starting point, but should be used with caution due to the following limitations:

- FIRMs are graphic representations of engineering data. They are predictions of where the extent of the various levels of hazards will occur based on models of the conditions at the time of the study.
- Landforms often change after mapping occurs due to human modification (e.g., construction of seawalls) or natural processes (e.g., erosion).
- FEMA does not take future erosion or sea level rise into account on FIRMs.
- The detailed analyses are only conducted at specific transects and engineering judgment is used to connect the delineations between these transects.

FEMA has an ongoing process for updating the FIRMs based on priorities (including priorities identified by states) and available funding. There are several types of updates, some of which do not include any new analysis of the flood zones. A typical example includes adding an orthophotograph as the basemap and changing the paneling scheme to be consistent with the U.S. Geological Survey quadrangle maps. Other examples include updating the datum from the National Geodetic Vertical Datum of 1929 (NGVD 29) to the North American Vertical Datum of 1988 (NAVD 88) or redelineating the flood zone boundaries based on newer and more detailed topographic data (e.g., 2-foot topographic data instead of 10-foot data). FIRM updates are not always based on new engineering analyses or studies and do not always take into account the best available techniques for predicting the extent of the floodplain. Such updates may result in a change to flood elevations on the FIRM, even though new analyses or studies have not been performed.

Updates that *do* include new analysis typically involve using new topography at transects and using improved mapping techniques to assess the storm surge height and wave crest profile to predict the extent of flood hazards. Typically, FEMA only conducts new analyses of flood zones for limited sections of communities due to funding limitations. These sections are prioritized based on known, observed differences between the predicted and actual extent of flooding in a storm and the need to update FIRMs based on newer methods that better predict the extent of the hazards (e.g., delineating primary frontal dunes and taking into account wave setup).

Because of these limitations, local officials should always consult the FIS to better understand the history and scope of the FIRMs and their updates (e.g., when the flood study for the effective FIRMs was done, a description of the analysis for predicting the extent of flood hazards, what updates were made, the location of transects where detailed analysis was performed, and analysis of historic damage). The dates within the FIS, rather than the effective dates on the FIRMs, should be used for project purposes since the map dates do not reflect when the studies were performed. In addition, local officials are advised to review the NFHL, because it contains official map updates since the FIRMs were produced, including those issued through each Letter of Map Change (see page 1-78). Although the FIRMs and NFHL have limitations, they are the best available statewide data source for predicting the extent of the 1%-annual-chance flood.

Letter of Map Change (Letter of Map Amendment or Letter of Map Revision)

Another source of information that should be used to determine the spatial extent of flood zones and boundaries of land subject to coastal storm flowage is a Letter of Map Change (LOMC), such as a Letter of Map Amendment (LOMA) or a Letter of Map Revision (LOMR). These documents are issued by FEMA to provide official clarifications or changes to the effective FIRMs (i.e., changes that occurred since the FIRMs were adopted by the community). Local communities and property owners can request an official map change from FEMA when there is evidence that the FIRM flood zone designations do not reflect the actual flood hazards at a given site.[43]

A LOMA is an interpretation from FEMA of what the current FIRM depicts for a specific site—it does not reflect any change or update to the FIRM based on new data or detailed engineering analysis. Submissions for LOMA requests typically include site-specific ground elevations and an Elevation Certificate (certified elevation information) to demonstrate that the site is located outside the floodplain.

A LOMR, which is sometimes confused with a LOMA, is a change to the FIRM based on new, site-specific data and detailed engineering analysis. FEMA evaluates the information submitted by an applicant (typically a property owner or community) and, if warranted, issues a LOMR, which will officially revise the FIRM and sometimes the FIS. If the LOMR appears inconsistent with local knowledge, Commissions may want to seek technical assistance from the Massachusetts Department of Conservation and Recreation (DCR) Flood Hazard Management Program (see the Floodplain Management Guide for contact information at www.mass.gov/guides/floodplain-management).

All LOMAs and LOMRs become part of the effective FIRMs. These are available on the FEMA Flood Map Service Center and the individual letters issued by FEMA are available for download.[44] LOMAs and LOMRs are also incorporated into the NFHL, which can be viewed on the interactive NFHL viewer.[45]

Field Observations and/or Engineering Data

Conservation Commissions are not required to rely exclusively on the FIRM-designated flood zones and their delineations for the extent of land subject to coastal storm flowage boundaries. Under the WPA Regulations, the land subject to coastal storm flowage definition includes "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" (i.e., a Commission *can use evidence of higher flood*

[43]For example, a property owner may have more detailed topographic data for their property that shows they are outside the area inundated by the 1%-annual-chance flood.
[44]To determine whether a LOMC has been issued for your area, go to the Flood Map Service Center (https://msc.fema.gov/portal) and search by location, click the "Show all products" button, open the "Effective Products" folder, expand "FIRM Panels" and a list of available effective maps will open with a LOMC symbol indicating where Letters of Map Change have been issued. Each LOMC can be downloaded.
[45]To view LOMCs on the NFHL, search the Map Service Center (https://msc.fema.gov/portal) by location and click the "Go to NFHL Viewer" button, which will open the viewer with LOMC locations presented on the map.

elevations than shown on the FIRMs).[46] Moreover, FIRMs are based on *engineering predictions* of the nature and magnitude of the flood hazards in an area and they may not give an accurate picture of the land subject to coastal storm flowage boundaries at a particular site (given the uncertainties and variables in coastal processes during an extreme flood event). If a Commission finds that the FIRM flood zone designations, FISs, and Coastal A Zone delineations are NOT in basic agreement with past flooding patterns and current shoreline conditions, then the applicant and Commission should proceed to other sources of information, such as engineering studies and credible historic flood data.

To use evidence of higher flood elevations, a competent source must provide *credible evidence* relating to storm surge elevations, flood levels, and waves. Often, property owners and/or Commissions may be able to (and are encouraged to) provide written records, photographs, and evidence from past flooding events that may offer useful data for site-specific evaluations of flood hazards. Commissions and applicants can access the "StormReporter" tool on MyCoast: Massachusetts (https://mycoast.org/ma), a web-based portal, to help them provide and collect information on coastal storm damages in their communities. Commissions will need to use their best professional judgment on a case-by-case basis to determine whether the submitted information and evidence is credible. For instance, photographs that show flooding without any reference to a known point or landmark are not a reliable source of information; while field measurements presented on topographic data, with cross sections and reference points, are considered credible.

Commissions can also look for particular indicators in the field to help confirm the extent of flooding and storm damage. Field indicators can include overwash fans, evidence of erosion (such as the dune scarps as seen in Photograph 1.16 and in Photograph 1.12 on page 1-26), and storm wrack lines, which include seaweed, driftwood, and debris and are sometimes visible for many years after larger storm events. Matted beach grass (and a more landward wrack line), as seen in Photograph 1.17 also indicates moving water (not just stillwater) during a storm event.

Photograph 1.16: Storm erosion as seen on an eroded scarp on a coastal dune behind riprap. Windblown sand deposition in front of the scarp occurred subsequent to the storm.

Photograph 1.17: Evidence of a storm surge as seen on matted dune vegetation in a coastal dune.

[46]For purposes of meeting the requirements of the Massachusetts Basic Building Code (780 CMR), however, only the FIRMs may be referenced for a determination of the V Zones, A Zones, and Base Flood Elevations (BFEs).

Shoreline Change Maps, Hazards Characterization Atlas, and other Data Sources

Conservation Commissions may also need to consider various scenarios and future conditions that are beyond the scope of the FIRMs, such as sea level rise, shoreline change, and hurricane inundation. The following sources of information may be helpful for determining the predicted extent of flooding under various scenarios.

- The National Oceanic and Atmospheric Administration (NOAA) Sea Level Trends website (https://tidesandcurrents.noaa.gov/sltrends/sltrends.html) provides sea level rise data for various tide stations along the Massachusetts coastline.

- The Massachusetts Shoreline Change Project (www.mass.gov/service-details/massachusetts-shoreline-change-project) links to an interactive shoreline change browser showing the relative positions of historic shorelines, along with information on erosion since the mid-1800s. The site provides short-term (30 years) and long-term (100 years) rates of erosion and accretion.

- The Massachusetts Sea Level Rise and Coastal Flooding Viewer (www.mass.gov/service-details/massachusetts-sea-level-rise-and-coastal-flooding-viewer) provides interactive maps that illustrate the vulnerability of facilities and infrastructure in coastal communities based on flood extents and water level elevations associated with sea level rise scenarios, FEMA Flood Maps, and SLOSH zones.

- The StormSmart Coasts Assessing Vulnerability of Coastal Areas and Properties webpage (www.mass.gov/service-details/assessing-vulnerability-of-coastal-areas-and-properties) includes information regarding erosion rates, storm surge, sea level rise rates, and sea level rise inundation scenarios.

- Massachusetts Ocean Resource Information System (MORIS) (www.mass.gov/service-details/massachusetts-ocean-resource-information-system-moris), a web-based mapping tool for interactively viewing coastal data layers, provides shoreline change data, hurricane inundation zones from the National Weather Service's Sea Lake and Overland Surges from Hurricanes (SLOSH) maps, and sea level rise inundation scenarios.

Applicants *should not use* the digital floodplain layer available from MassGIS called the Q3 data, which is a digital representation of the paper FIRMs. The Q3 data layer was intended for FEMA's planning purposes and not for site-specific delineations. MassGIS has added a new and more current digital floodplain layer called the NFHL, however this layer is not as frequently updated as the NFHL on the FEMA Map Service Center (https://msc.fema.gov/portal). Applicants should use FEMA's NFHL viewer, the FIRMs, and FISs as the most current source of information and data depicting the flood zones.

The Primary Dune Delineation Methodology

Applicants and Commissions are not required to rely exclusively on the FIRMs for delineating the V Zone in dune areas, because the maps are often not detailed enough for a site-specific analysis. Though FIRMs *have* been updated and revised to include the entire primary frontal dune, the delineations were conducted at a broad scale with large spacing between transects (as described on page 1-77). If flood zone delineation issues arise in dune areas, a site-specific delineation of the landward extent of the primary dune may be warranted *to determine the minimum extent of the V Zone*. In these cases, the applicant and Commissions should refer to the primary dune delineation methodology described in the dune resource delineation section on pages 1-32 through 1-38 and detailed in Appendix C. In certain circumstances, the V Zone may extend farther than the landward toe of the primary dune and an additional analysis may be required. See "Delineating V Zones in Coastal Dune Areas" on page 1-85 for determining the appropriate method to use.

How to Delineate and Review Land Subject to Coastal Storm Flowage Boundaries

To better distinguish between flood hazards within the land subject to coastal storm flowage resource area, it is important to accurately interpret the information provided by the FIRMs and the FIS and understand the different methodologies for delineation. Delineating the inland extent of the floodplain (typically the landward boundary of the A Zone) requires a different method than delineating the boundaries between V and A Zones. In addition, delineating V Zones in coastal dune areas often requires an entirely different set of criteria. The following methods describe how to delineate the boundaries between each flood zone and determine the landward extent of the SFHA and land subject to coastal storm flowage.

Datum Conversions

It is extremely important to ensure that the topographic data on the site plan is relative to the same datum as that of the FIRMs (older FIRM elevations are typically referenced to NGVD 29 and the newer FIRM elevations are referenced to NAVD 88). *One* datum must be used to maintain consistency between floodplain elevations and site topography, allowing for a correct delineation of flood zones on the site. The conversion factor FEMA used in updating maps from NGVD 29 to NAVD 88 is included in the FIS. If datum conversions are necessary, the NOAA Office of Coastal Survey website (www.nauticalcharts.noaa.gov) provides tools for computing conversions, such as VDatum, a tool that enables a user to transform elevation data between any two vertical datums among a choice of 28 orthometric, tidal, and ellipsoid vertical datums. The NOAA National Geodetic Survey website (www.ngs.noaa.gov) provides a tool (VERTCON) that computes the difference in height between NGVD 29 and NAVD 88 for a given location.

Delineating the V Zone/A Zone Boundary

Based on the criteria on page 1-69, the boundary between the V Zone and the A Zone occurs where the wave height becomes less than 3 feet, where the wave runup depth becomes less than 3 feet, at the landward extent of the splash zone at a coastal engineering structure, or at the landward toe of the primary frontal dune, whichever is farthest landward. Since the BFE for the V Zone is the elevation of the top of the water with waves (or runup), locating the V Zone/A Zone boundary is not as simple as locating the topographic contour line corresponding to the BFE (see Figure 1.15 on page 1-76 where the V Zone BFE is elevation 16 feet NAVD 88, but the V Zone does not extend as far as the 16-foot ground contour line). As waves break and wave heights diminish in the landward direction, the V Zone ends (and becomes an A Zone) where wave heights become less than 3 feet. In runup situations, the V Zone ends and becomes an A Zone where the wave runup depth becomes less than 3 feet.

To properly locate the V Zone/A Zone boundary on a site plan, use one of the following two options:

1. The digital FIRMs or NFHL *can be overlaid* onto the site plan with the same scale and same projection using GIS software to determine the V Zone/A Zone boundary. It is very important that the projection and scale of both plans (the FIRM/NFHL and the site plan) are consistent to ensure the accuracy of the boundary location on the site plan. When overlaying data, do not use the Q3 data layer available from MassGIS, since it is outdated. Because FIRMs are now available as GIS layers, paper maps should not be digitized and geo-referenced to determine flood zone boundaries.

2. The FIRM's V Zone boundary *can be scaled* from a known, fixed point, such as a benchmark or road intersection, to the site plan for the project site. If scaling from a road on a FIRM, the center of the road should be used, since the lines may not represent road edges. Distances should be measured parallel and/or perpendicular to recognizable features and at least two reference points should be used. A shoreline location should not be used as a reference point, since its position changes over time.

Delineating the Limit of Moderate Wave Action

Since the Limit of Moderate Wave Action within the A Zone is based on wave heights and not ground elevations (see Figure 1.15 on page 1-76), the LiMWA can be delineated by overlaying or scaling this boundary from the National Flood Hazard Layer onto the site plan as described above for the V Zone/A Zone boundary. The NFHL—the official source for LiMWA data—is available on the FEMA Flood Map Service Center (see page 1-72 for details).

Delineating the A Zone/X Zone Boundary

The boundary between the A Zone and the X Zone occurs at the predicted landward extent of the floodwaters (extent of waves or runup) in a 1%-annual-chance flood (i.e., the landward extent of the SFHA). This boundary is located at the ground elevation that corresponds to the BFE of the most landward A Zone. This BFE typically corresponds to either the stillwater elevation or, at locations were wave setup exists, the Total Water Level (which is stillwater elevation including wave setup). The BFE does *not* typically correspond to the wave runup elevation, because runup scenarios often occur on steep or rapidly rising ground profiles where the A Zone does not meet the minimum FIRM width to be mapped (see "Delineating the V Zone/X Zone Boundary" on page 1-84 for more details).

The BFE on the FIRM (or NFHL) is rounded to the whole foot, but the stillwater elevation or Total Water Level is provided to the nearest tenth of a foot in the FIS. Although the elevation in the FIS should be consulted, there are circumstances where the BFE on the FIRMs should be used instead.

To determine which elevation to use, follow these guidelines:

1. First identify the BFE of the most landward A Zone on the FIRM. Next, look at the number given for the Total Water Level in the FIS. *[Please note: Total Water Level is not available for all coastal communities. For the communities where it is available in the FIS, it is referred to as "Total Water Level" or "stillwater elevation including setup." Table 1 on page 1-84 indicates which counties and communities have this information as of the printing of this document, along with whether it is referred to as "Total Water Level" or "stillwater elevation including setup."]* If this number can be rounded to the whole number used for the BFE on the FIRM, then the higher value (either the Total Water Level provided in the FIS or the BFE on the FIRM) should be used as the ground elevation for determining the A Zone/X Zone boundary.

2. If the Total Water Level cannot be rounded to the whole number provided on the FIRM (or if Total Water Level is not available), then compare the whole number for the BFE with the stillwater elevation (without setup) given in the FIS. If the stillwater elevation can be rounded to the BFE, then the higher value (either the stillwater elevation or the BFE on the FIRM) should be used as the ground elevation for determining the A Zone/X Zone boundary. *(Note: Use the 1%-annual-chance stillwater elevation, which is typically found in the same table as the Total Water Level in the FIS, or in another table immediately before or after it.)*

3. If neither the Total Water Level nor stillwater elevation rounds to the BFE provided on the FIRM, then the BFE value should be used as the ground elevation for determining the A Zone/X Zone boundary.

To delineate the A Zone/X Zone boundary on the site plan, locate the ground contour line corresponding to the selected elevation on a surveyed topographic plan (the plan that was generated for the proposed project or the most recent detailed topographic data available). If a contour line does not exist for the selected elevation, one should be created. Using this detailed topographic data, as opposed to observing the boundary relative to the FIRM's aerial photograph basemap (which is often based on less detailed topographic data), allows for a more accurate delineation/location of the boundary.

County	Communities with Total Water Level information	Table Number in FIS	Terminology used to indicate Total Water Level
Barnstable	All	Table #10	Total Water Level
Bristol	Berkley, Dighton, Fall River, Freetown, Rehoboth, Seekonk, Somerset, and Swansea	Table #15	Total Water Level
Dukes	All	Table #10	Stillwater elevation (including setup)
Essex	All except Newburyport and Salisbury	Table #10	Stillwater elevation (including setup)
Nantucket	All	Table #6	Total Water Level
Norfolk	Quincy	Table #19	Total Water Level
Plymouth	Cohasset, Duxbury, Kingston, Marshfield, Plymouth, and Scituate	Table #14	Total Water Level
Suffolk	All	Table #12	Total Water Level

Table 1. Reference table for determining which communities have Total Water Level information in their FIS (as of August 2017).

Delineating Unnumbered A Zones

If an A Zone is unnumbered (no flood elevations are provided), no hydrologic or hydraulic analyses have been conducted, or no flood profiles and transects are available, use the overlay or scaling method. Alternately, BFEs can be estimated based on the guidance and methodology in the Wetlands Protection Act Regulations at 310 CMR Section 10.57(2)(a)3 or FEMA Publication #265, *The Zone A Manual: Managing Floodplain Development in Approximate Zone A Areas*. A Letter of Map Change will likely be needed to show that FEMA agrees with the analysis (see page 1-78 for more information about Map Revisions and Map Amendments).

Delineating the V Zone/X Zone Boundary

In certain circumstances—typically where there is a steep or rapidly rising ground profile and wave runup—there is no A Zone shown on the FIRM. When no A Zone is shown landward of the V Zone, the V Zone/X Zone boundary is delineated at the ground contour elevation that corresponds to the most landward V Zone BFE shown on the FIRM, using the same method described above for delineating the A Zone/X Zone boundary. An A Zone will technically still exist (where wave runup depth—measured from wave runup elevation to ground elevation—is less than 3 feet), but is too narrow to be mapped (the minimum zone width is 0.2 inch on the FIRM). (Figure 1.16 on page 1-76 depicts a situation where the A Zone is too narrow to be mapped on the FIRM).

Delineating V Zones in Coastal Dune Areas

For sites partially or completely within—or immediately landward of—a coastal dune, the process for delineating land subject to coastal storm flowage, specifically the V Zone, includes an additional set of steps. As amended in the WPA Regulations, the *velocity zone now includes all primary frontal dunes*. Therefore, the inland limit of the V Zone, *at a minimum becomes the landward toe of primary dune*.[47] In order for this criterion to apply, the primary dune must be adjacent to a beach in a V Zone.

Commissions should determine whether the flood zone designations on the maps meet this regulatory definition for the extent of the V Zone—at a minimum the inland limit of the primary frontal dune. FIRMs in all coastal areas *have* been updated and revised to include the entire primary dune. Where these FIRM zone designations are consistent with flooding history, storms/surges of record, wave activity, and landform changes at the site, the applicant and Commission should use the flood zone designations as depicted on the FIRM, unless the shoreline and landform have changed significantly since the FIRM was updated (such as from storm events, ongoing erosion, and landward beach and dune migration).

However, because FEMA conducted primary dune delineations at a broad scale with large spacing between transects, a more site-specific delineation of the primary frontal dune (i.e., the landward toe of the primary dune) may be necessary. The primary dune delineation methodology described in Appendix C can be used to refine the boundary, particularly when this location is critical to the evaluation of the proposed project (see below for more details on when the methodology is warranted). Conservation Commissions may also require a site-specific delineation of the landward extent of the primary dune when the landform has changed significantly since a detailed analysis was conducted or where flood zone designations are not consistent with flood history and storms of record. If the landward extent of the primary dune is found to be seaward of the mapped V Zone, however, then the Commission should continue to use the more landward mapped boundary.[48]

For many projects, a delineation of the landward toe of primary dune will be useful information for marking the minimum extent of the V Zone. However, even this delineation may not give a complete picture of the real extent of velocity conditions; depending on the project (such as a project proposed immediately landward of the primary dune), it may be important to determine whether the V Zone extends farther landward.

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[47] Please note that the V Zone extends, at a minimum, to the landward toe of the primary dune even if a primary dune "passes" the 540 square-foot criteria, described on pages 1-86 through 1-89.
[48] By definition, the landward extent of the V Zone is located at the landward-most point of the four criteria (see page 1-69).

Therefore, absent accurate updated and revised FIRMs, Commissions should follow these steps to determine how best to delineate the extent of the V Zone.

Step 1 - Determine if a precise delineation of the V Zone is unnecessary.

Where an applicant acknowledges that a proposed project is *within* a primary dune, there is no need to precisely determine the landward toe of primary dune and the landward extent of the V Zone, as the subject site is admittedly *within* this high velocity zone. Similarly, for projects that are allowed or encouraged under the Regulations, such as beach and dune nourishment, sand fencing, and vegetative plantings, a precise determination of the landward extent of flooding may not be necessary.

Step 2 - Determine the landward toe of the primary dune to find the extent of the V Zone.

For proposed projects that may be (or are likely) *in* a primary dune, but where the exact boundary is in question, the applicant should first delineate the landward toe of primary dune by following the primary dune delineation methodology described on pages 1-32 through 1-38 and in Appendix C, and then marking the minimum extent of the V Zone at this boundary. If the delineation depicts the project *within* the primary dune, then this minimum landward extent of the V Zone (i.e., landward toe of dune) is sufficient information for project review. If the delineation depicts the proposed project immediately landward of the landward toe of dune (i.e., beyond the primary dune), the applicant should proceed to step 3. (If the proposed project is landward, but not *immediately* landward, Commissions should use their judgment about whether further analysis is warranted to determine if the V Zone extends farther landward, as described in Step 3.)

Step 3 - Determine if the V Zone will extend farther than the landward toe of dune using the 1,100-square-foot criterion (previously 540 square feet).

For projects proposed immediately *landward* of a primary dune, a determination of the landward extent of the V Zone is necessary for a complete review of the project. FEMA now recognizes that velocity conditions and wave action may extend *farther landward than depicted on the original FIRM or farther landward than the inland limit of the primary dune*. During a coastal storm, dunes often erode, providing sediment to the coastal beach and nearshore areas. Due to the dynamic nature and erosion potential of primary dunes, such as changes in the shoreline configuration from continuous or episodic erosion, sea level rise, and the impact of consecutive storms, coastal dunes may be overtopped or eroded completely resulting in V Zone conditions that extend farther landward than the primary dune (see Figure 1.17 on page 1-87).

FEMA developed a criterion to determine whether a primary frontal dune will be completely eroded in a 1%-annual-chance flood. The criterion states that primary frontal dunes will not be considered effective barriers to storm surges and associated wave action from a 1%-

annual-chance flood where the cross-sectional area of the frontal dune reservoir is equal to, or less than, 540 square feet. Figure 1.18 on page 1-88 demonstrates how the primary frontal dune reservoir is measured on both a ridge-type primary dune and a mound-type primary dune.[49]

Velocity conditions are likely to extend *farther* landward than the landward toe of the primary frontal dune if the frontal dune reservoir does not meet this 540-square-foot threshold. FEMA's *Coastal Construction Manual* states that post-storm assessments and analysis have since determined that a 1,100-square-foot threshold (rather than 540 square feet) more accurately accounts for long-term erosion rates, cumulative effects of multiple storms that may occur within short periods of time, and dune removal during a 1%-annual-chance flood. FEMA recommends that 1,100 square feet be used for planning purposes, but their Guidelines and Standards used to map flood zones on the FIRMs currently require the use of the 540-square-foot threshold.

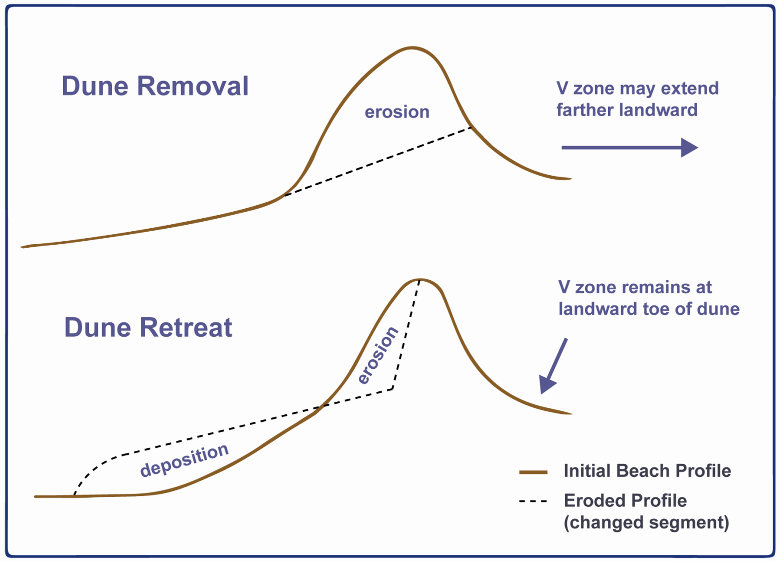

Figure 1.17. Two examples of eroded dune profiles: complete removal and retreat. The velocity zone may extend farther landward when the dune is removed. Figure modified from *Coastal Construction Manual*, FEMA.

If the cross-sectional area of the primary frontal dune reservoir is greater than 1,100 square feet, any erosion will result in retreat of the seaward dune face, but a dune remnant will likely remain as a barrier to storm surge or waves. However, even primary dunes that meet the 1,100-square-foot threshold—and any structures on these dunes—are still vulnerable to future storm events and the extreme conditions that occur in V Zones (i.e., significant wave action, hazardous flooding, high energy conditions, and erosion). The entire primary dune is considered V Zone in part to take into account these impacts.

[49]The baseline for calculating the 540 rule was changed to the Total Water Level by *Operating Guidance 15-13*, a technical memorandum issued by FEMA on October, 30, 2013 (www.fema.gov/media-library-data/1386337351905-03d00f8c6260a1a3589c7a8fc076b5f2/Operating%20Guidance%2015-13-Revised%20Guidance%20for%20Dune%20Erosion%20Analysis%20for%20the%20Atlantic%20Ocean%20and%20Gulf%20of%20Mexico%20Coasts%20%28Oct%202013%29.pdf). Some FISs (e.g., Essex County) list stillwater elevations with a footnote that they include wave setup, which is equivalent to Total Water Level (see Table 1 on page 1- 84 for a list of communities with FISs that use this terminology).

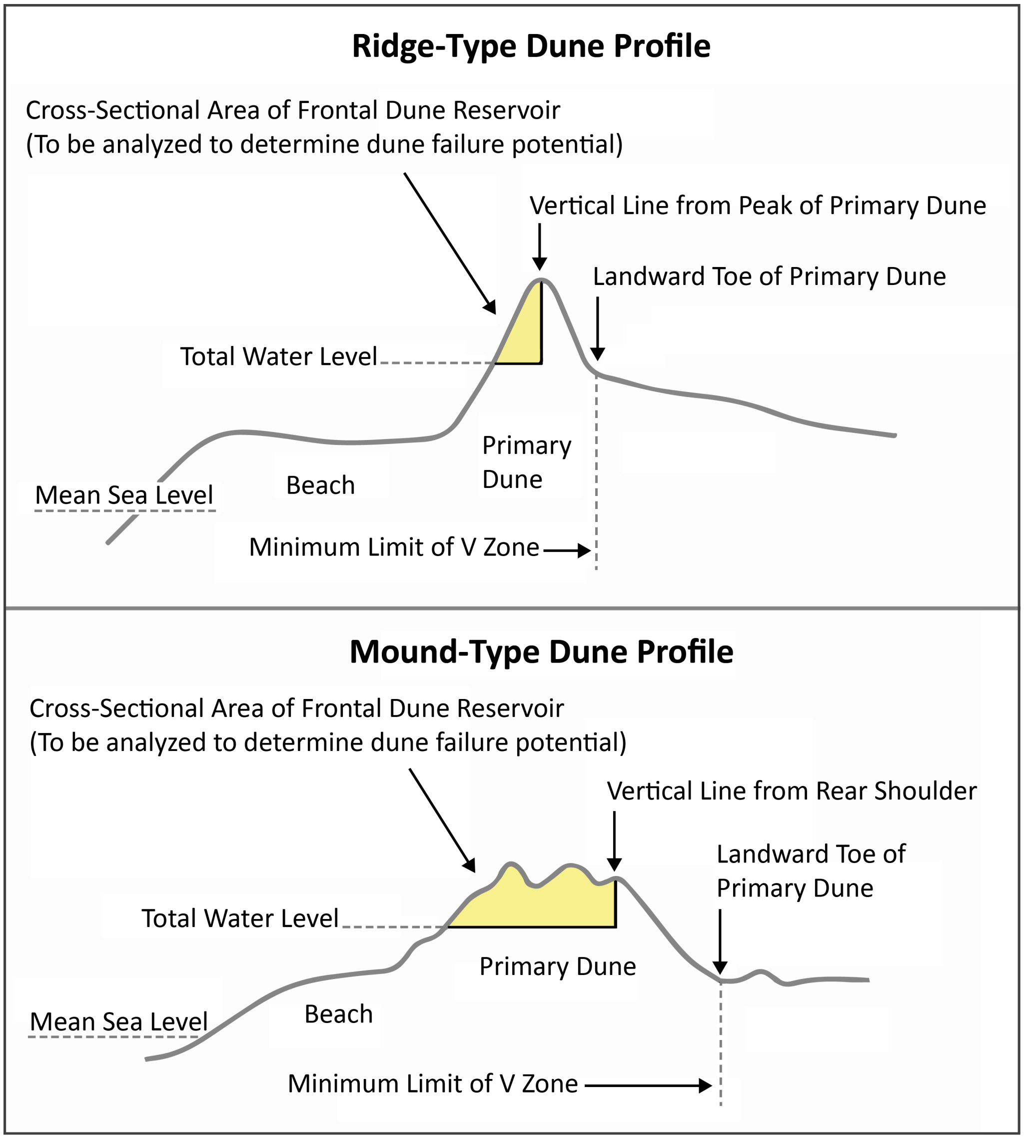

Figure 1.18. Cross-sectional diagram of the primary frontal dune reservoir of a ridge-type and mound-type primary dune. The shaded area is the primary frontal dune reservoir and is measured perpendicular to the shoreline, above the Total Water Level (the 100-stillwater elevation + wave setup; available in the FIS), and either seaward of the peak of a ridge-type primary dune or seaward of the rear shoulder peak on a mound-type primary dune. A rough calculation can be obtained by taking the area of the triangle, or a more precise calculation can be made using the data from the primary dune delineation plots that are described in Appendix C. If the area is less than 1,100 square feet, the assumption is that the primary frontal dune will be removed by erosion in a 1%-annual-chance flood and velocity conditions may extend farther landward than the landward toe of the primary frontal dune. (Figure modified from the FEMA *Coastal Construction Manual*.)

It is important to recognize that for flood zone mapping purposes, FEMA *does not* include artificial nourishment in the calculations of dune volume because artificial nourishment is not considered to be a permanent change in volume with an ability to protect landward areas from velocity flood conditions.

Step 4 - Determine the landward extent of the V Zone if the primary dune is completely removed (i.e., frontal dune reservoir is less than 1,100 square feet).

If the primary dune is predicted to erode and be completely removed during a 1%-annual-chance flood, further analysis may need to be performed (by a consultant trained to calculate eroded dune profiles) to find the maximum possible landward extent of the V Zone. The additional analysis involves assuming the dune is removed by erosion during the storm event (Figure 1.17 on page 1-87) and assessing the results of wave-height analysis and wave runup models on the removed dune profile (now low and gently sloping) to determine how far inland velocity conditions would extend. For more information on methodologies for evaluating site-specific conditions, performing wave elevation calculations, and determining coastal flooding elevations, see FEMA's Guidelines and Standards for Flood Risk Analysis and Mapping web page (www.fema.gov/flood-maps/guidance-partners/guidelines-standards).

Overall, in dune areas, the applicant should take into account dune volume, long-term shoreline change rates, and observed shoreline change at the site to ensure a more informed delineation of the V Zone and the land subject to coastal storm flowage boundaries. Obtaining this information will be critical for estimating the most landward shoreline that might be expected over the lifetime of a building or development and for protecting the functions of storm damage prevention and flood control on the site.

Data Checklist[50]

When a precise delineation of land subject to coastal storm flowage is needed, this checklist should be used to: 1) identify features on the plans, maps, and engineering data, 2) follow the procedures for identifying the various flood zones, 3) record information about site characteristics, and 4) determine if additional information is needed to delineate the resource area. For projects proposed in or adjacent to primary dunes, additional information (such as calculations of the primary frontal dune reservoir) may be necessary to determine whether the subject area is within the V Zone boundary.

[50]This checklist can also be found in the Data Checklists for the Delineation of Resource Areas, a separate attachment that can easily be carried out to the field to record information about landform features and characteristics.

Check all that apply:

<table>
<tr><th colspan="2">Considerations When Reviewing the Boundaries of Land Subject to Coastal Storm Flowage</th></tr>
<tr><td>❑ Have you considered the following evidence to determine the spatial extent of land subject to coastal storm flowage:
1) Flood Insurance Rate Maps (FIRMs),
2) Preliminary FIRMs,
3) Flood Insurance Studies (FISs),
4) National Flood Hazard Layer (NFHL) for:
• Letters of Map Change for the area, including Letters of Map Revision (LOMR) or Letters of Map Amendment (LOMA),
• Limit of Moderate Wave Action (LiMWA)
in combination with:
5) Historic flooding events and storm and surges of record,
6) Engineering data,
7) Field indicators, and
8) Other data sources, such as the Shoreline Change Maps, South Shore Hazards Characterization Atlas, and the StormReporter tool on MyCoast: Massachusetts web portal.

In addition, for coastal dunes:
1) Landward boundaries of primary dunes, and
2) Volume of primary dunes to understand potential for being completely eroded?</td><td>If yes, Commissions are using the best credible evidence to make an informed decision as to land subject to coastal storm flowage boundaries.

The applicant and Commission should not use MassGIS Q3 data layer for determining the extent of flood zones. In addition, although MassGIS has added a new and more current digital floodplain layer called the NFHL, this layer is not as frequently updated as the NFHL on the FEMA Flood Map Service Center. Therefore, the applicant and Commission should use the NFHL from the Service Center for site specific delineations.</td></tr>
<tr><td>❑ Have you determined that the elevations on the applicant’s plans reference the same datum as used on the FIRM?</td><td>The applicant must use one consistent datum so that the BFEs are relative to the same datum as the topographic data and are therefore delineated correctly on the maps. The applicant should convert to NAVD 88, if possible.</td></tr>
<tr><td>For FIRM zone designations (either on the original map or through an approved LOMA/LOMR) that are consistent with the flooding history, storms or surges of record, wave activity, and landform changes at the site:
❑ Have the applicant and Commission followed the delineation procedure as described on pages 1-81 through 1-89 for V Zones and A Zones?

And</td><td>V Zones (not in coastal dune areas):
Where an A Zone is mapped, the landward V Zone boundary is scaled or overlaid from FIRMs. Where no A Zone is mapped landward of the V Zone, the ground contour that corresponds to the most landward BFE is used to delineate the landward extent of the floodplain.
A Zones:
The ground contour that corresponds to the most landward BFE is used to determine the landward extent of the A Zone.
LiMWA within the A Zones:
The LiMWA boundary found on the NFHL is scaled or overlaid onto the contour plan.</td></tr>
<tr><td>❑ Have the applicant and Commission looked for particular indicators in the field, such as:
❑ overwash fans,
❑ evidence of erosion (such as dune scarps),
❑ storm wrack lines,
❑ matted beach grass, and
❑ records/photographs of these indicators from past storm events.</td><td>Field indicators can be useful for helping to confirm the extent of flooding and storm damage.</td></tr>
</table>

Considerations When Reviewing the Boundaries of Land Subject to Coastal Storm Flowage (continued)	
For FIRM zone designations that are *inconsistent* with the flooding history, storms or surges of record, wave activity, and landform changes at the site: ❑ Are flood elevations higher than depicted on flood maps based on recorded and *credible* evidence from a competent source? *or*	Commissions may use the higher elevation if the data or information is credible.
❑ Are flood elevations lower than depicted on flood maps?	Commission should use a lower elevation *only* if it is based on a LOMR approved by FEMA and *only if it takes into account site-specific information, particularly in dune areas.* If no LOMR has been issued, then a lower elevation should not be used; the applicant and Commission should rely on the original FIRM, provided it meets the other criteria in this checklist.
For Coastal Dune Areas	
Has the applicant determined that: ❑ The FIRM has been accurately updated and revised to reflect the delineation of the primary frontal dune? *and* ❑ The FEMA delineation is consistent with the detailed topography for the site? *and* ❑ The FIRM zone designations are consistent with the flooding history, storms/surges of record, and wave activity? *and* ❑ The site topography has not significantly changed since the primary dune was mapped for the FIRM?	If yes, then the FIRM designations may be used to locate the *minimum extent* of the V Zone. No further analysis is necessary. If no, proceed to the next step.
Absent accurate primary dune designations on FIRMS (*as described above*):	
❑ Has the applicant acknowledged that the proposed project is in the primary dune and in the V Zone?	If yes, there is no need to precisely determine the landward extent of flooding as the project is admittedly within the V Zone.
❑ Is the proposed project allowed under the WPA Regulations, Section 10.28(5)?	If yes, there is no need to precisely determine the landward extent of flooding.
❑ Is there a question whether the proposed project is in the primary dune and within the V Zone? *or* ❑ Is an exact determination of the primary dune boundary warranted?	If yes, the landward toe of primary dune should be delineated according to the methodology described in the coastal dunes section and Appendix C. Proceed to next step to determine extent of V Zone.
❑ Did the delineation of the primary dune depict the proposed project *within* or seaward of the primary dune?	If yes, the inland limit of the primary dune (landward toe of primary dune) will mark the extent of the V Zone. Skip next two steps. If no, proceed to next step.

<table>
<tr><th colspan="2">For Coastal Dune Areas (continued)</th></tr>
<tr><td>❑ Did the delineation of the primary dune depict the proposed project immediately landward of the primary dune?</td><td>If yes, the applicant/Commission will need to determine if the primary dune will be eroded or completely removed in a storm event—so that the most landward extent of V Zone conditions can be accounted for. Proceed to next step.

If no (i.e., the proposed project is landward, but not immediately landward), Commissions should use their judgment about whether further analysis is warranted to determine if the V Zone extends farther landward (as described next).</td></tr>
<tr><td>❑ Has the Commission reviewed the applicant's calculation of the primary frontal dune reservoir to determine if the dune will be eroded or removed in a storm event?

To determine the frontal dune reservoir, refer to Figure 1.18 on page 1-88.</td><td>If the frontal dune reservoir is less than 1,100 square feet, the dune is subject to complete removal, allowing velocity conditions to extend farther landward. Wave height analysis and wave runup models may need to be performed to determine how far inland the V Zone will extend.

If the frontal dune reservoir is greater than 1,100 square feet, the dune is likely substantial enough to withstand erosion during a base flood event; dune retreat may occur, but velocity conditions and wave action will likely only extend to the inland limit of the primary frontal dune. The landward toe of primary dune will therefore mark the extent of the V Zone.</td></tr>
<tr><td colspan="2">❑ Are field observations consistent with surveys, maps, and other references?</td></tr>
<tr><td colspan="2">❑ Other observations:</td></tr>
</table>

Chapter 2 - Resource Area Characteristics and Functions

For each resource area on a project site, the Conservation Commission must determine what public interests, as specified in the Wetlands Protection Act (WPA), are served by the particular functions and characteristics of that resource area. Under the WPA, eight public interests have been recognized for protection: public and private water supply, ground water supply, storm damage prevention, flood control, prevention of pollution, land containing shellfish, fisheries, and/or wildlife habitat. For purposes of this guidebook, the interests of storm damage prevention and flood control are the focus.

The WPA Regulations define flood control as the prevention or reduction of flooding and flood damage. Storm damage prevention is defined as the prevention of damage caused by water from storms. The damage averted includes, but is not limited to: erosion and sedimentation; damage to vegetation, property, infrastructure, or buildings (including adjacent properties); and damage caused by flooding, water-borne debris, or ice.

Coastal wetland resource areas help control flooding and prevent storm damage by:

- Slowing down flood waters and allowing them to flow across a natural landform surface, providing frictional resistance and reducing their energy and destruction potential.
- Allowing flood waters to spread over a wide area without obstructions. (Obstructions can cause channelization of flood waters and storm-wave overwash and an increase in the velocity and volume of flow to adjacent or landward areas.)
- Allowing flood waters to be detained, absorbed into the ground, or evaporated into the atmosphere.
- Providing a buffer from storm waves, elevated sea levels, and ice for landward properties and coastal wetlands.
- Eroding, moving, and shifting (changing form) to dissipate energy associated with moving flood water and/or waves.
- Stabilizing the substrate, such as with peat or vegetation in salt marshes or other vegetated areas, thereby protecting the land from storm erosion.

Each coastal resource area listed in the WPA is presumed significant to either or both of these two interests (with the exception of land subject to coastal storm flowage, which is not provided with specific presumptions of significance). The Regulations define a resource area as "significant" to an interest when such resource area "plays a role" in the provision or protection of that interest. The presumption of significance may be overcome only by a clear showing that the resource area does not play a role in storm damage prevention and flood control. The Regulations provide strict guidance on making such a determination. A Commission should not find that the presumption of significance has been overcome without serious consideration of the evidence presented at a public hearing.

When a resource area is significant to storm damage prevention and flood control, the Regulations specify critical characteristics that function to protect those interests. This chapter will list those critical characteristics for each coastal resource area and describe how they function. Although the resource areas listed here are presumed significant to the interests of storm damage prevention and flood control, resource areas vary in the degree to which they serve these functions. A highly developed site on a barrier beach, for example, may not function in the same manner for storm damage prevention and flood control as if it were undeveloped. The areas of a dune exposed to wave activity may not function in the same manner as the area within a relatively protected secondary dune. Therefore, Commissions should carefully evaluate the degree and type of function provided by each resource area at each individual site before determining project impacts.

In sum, each section within this chapter will cover an individual WPA resource area that is significant to storm damage prevention and flood control (i.e., land under the ocean, Designated Port Areas, coastal beaches, coastal dunes, barrier beaches, coastal banks, rocky intertidal shores, salt marshes, and land subject to coastal storm flowage[51]) and will include:

1) **The resource area's presumption of significance, as articulated in the Wetlands Protection Act Regulations, and an explanation of its meaning.**
2) **An identification of the *critical characteristics* of the resource area that *function* to protect the interests of storm damage prevention and flood control.**
3) **Factors affecting the capacity of the resource area to function.**

[51]Although the WPA Regulations do not specifically state that land subject to coastal storm flowage is significant to the interests of storm damage prevention and flood control, it is listed as an area subject to protection under the Regulations (10.02(1)(d)), as well as under the Act (M.G.L. c. 131, § 40). In addition, the Regulations (10.03(5)) state, "Each area subject to protection…is presumed to be significant to one or more of the interests." Land subject to coastal storm flowage is ordinarily determined to be significant to the interests of flood control and storm damage prevention.

LAND UNDER THE OCEAN

When reviewing a proposed project in land under the ocean, Commissions must first review the presumptions of significance of land under the ocean to the interests articulated in the WPA and determine the critical characteristics that function to protect these interests. Because the presumptions of significance are different for nearshore areas versus areas beyond the nearshore, the delineation discussed in Chapter 1 beginning on page 1-3 is particularly important for determining whether the land under the ocean resource area is significant to the interests of storm damage prevention and flood control. This section will describe how to determine the significance of land under the ocean to these interests and how to assess the functions and characteristics that need to be protected by the performance standards (which will be described in Chapter 3).

Land under the ocean may also be found in Designated Port Areas (DPAs), which will be briefly described below as well as in the separate DPA section.

Significance of Land Under the Ocean to Storm Damage Prevention and Flood Control

The Wetlands Protection Act Regulations at 310 CMR 10.25 state: "nearshore areas of land under the ocean are *likely* to be significant to storm damage prevention and flood control."[52] Similarly, the Regulations at 310 CMR 10.26 state: "land under the ocean in Designated Port Areas is likely to be significant to storm damage prevention and flood control."

The WPA Regulations makes a distinction between the nearshore area of land under the ocean and *beyond* (seaward of) the nearshore area of land under the ocean when determining significance to the interests of the Act. More specifically, when a proposed project involves the dredging, removing, filling, or altering of a *nearshore area*, Commissions should presume that such land *is* significant to the protection of storm damage prevention and flood control. When such activities are proposed *beyond* the nearshore area of land under the ocean, Commissions should presume that such land *is not*

[52] Land under the ocean is also likely to be significant to the protection of marine fisheries and, where there are shellfish, to protection of land containing shellfish, while nearshore areas are likely to be significant to protection of wildlife habitat. For further information on these interests that are not covered in this guidance document, please visit the Natural Heritage and Endangered Species Program (NHESP) Regulatory Review web page at www.mass.gov/ma-endangered-species-act-mesa-regulatory-review for town maps of Estimated Habitats of Rare Wildlife, the Division of Marine Fisheries (DMF) at www.mass.gov/orgs/division-of-marine-fisheries for assistance with the identification of fisheries habitat, or the local shellfish warden and/or DMF to determine if land containing shellfish is present at or adjacent to the project site. Also available on the DMF website is their report, *Summary of Marine Fisheries Resource Recommendations for Municipal Maintenance Hydraulic Dredging Activities on Cape Cod and the Islands*, which addresses potential impacts of dredging and beach disposal activities on marine resources and recommends time-of-year restrictions for various species and habitats of fish and shellfish. In addition, the Massachusetts Office of Coastal Zone Management (CZM) *Guidelines for Barrier Beach Management in Massachusetts* at www.mass.gov/files/documents/2016/08/vh/barrier-beach-guidelines.pdf (PDF, 12 MB) provides management measures for protecting wildlife and fisheries habitat on barrier beaches, including migratory shorebird habitat.

significant to the protection of these interests.[53] Generally, these offshore areas are distant and/or deep enough to have little impact on wave energy heading toward the shore.

The project proponent bears the burden of demonstrating that the nearshore area of land under the ocean or land under the ocean in Designated Port Areas is not significant to the interests of the Act, or that the proposed work will comply with the performance standards that protect those interests.

Characteristics and Functions of Land Under the Ocean

Before reviewing this section, please read the full language of the Preambles for land under the Ocean and Designated Port Areas within the WPA Regulations (www.mass.gov/regulations/310-CMR-1000-wetlands-protection-act-regulations), which is the scientific basis for the Regulations. To aid Commissions with their review of the functions of land under the ocean and Designated Port Areas, this section highlights the critical characteristics, but it is not intended as a substitute for the Regulations.

The WPA Regulations at 310 CMR 10.25 state: "when nearshore areas of land under the ocean are significant to storm damage prevention or flood control, the bottom topography of such land is critical to the protection of those interests."[54]

The WPA Regulations at 310 CMR 10.26 state: "when a proposed project in a Designated Port Area is on land under the ocean which is determined to be significant to storm damage prevention or flood control, the ability of such land to provide support for adjacent coastal or man-made structures is critical to the protection of such interests."[55]

The following describes these characteristics and why they are critical to the protection of the storm damage prevention and flood control interests.

> **Bottom topography** - The bottom topography (i.e., bathymetry) of land under the ocean helps reduce storm damage and flooding by diminishing and buffering the high-energy effects of storms. As waves move into the nearshore areas, they change in height, speed, and

[53]Areas within land under the ocean that are beyond the nearshore area are significant to other interests of the Act, such as marine fisheries and land containing shellfish.

[54]When land under the ocean is significant to the protection of other interests of the Act—marine fisheries, wildlife habitat, or land containing shellfish—the Regulations list other characteristics that are critical for protection of such interests. Specifically, when land under the ocean underlies an anadromous/catadromous fish run and is significant to the protection of marine fisheries, the following factors are critical to the protection of such interest: (a) the fish, (b) accessibility of spawning areas, (c) the volume or rate of the flow of water within spawning areas and migratory routes, and (d) spawning and nursery grounds. When land under the ocean is found to be significant to the protection of land containing shellfish and therefore also significant to marine fisheries, the following factors are critical to the protection of those interests: (a) shellfish, (b) water quality, (c) water circulation, and (d) the natural relief, evaluation, or distribution of sediment grain size of such land. When nearshore areas or other land under the ocean is significant to the protection of marine fisheries or wildlife habitat, the following factors are critical to the protection of such interests: (a) water circulation, (b) distribution of sediment grain size, (c) water quality, (d) finfish habitat, and (e) important food for wildlife.

[55]When land under the ocean in a Designated Port Area is determined to be significant to marine fisheries, the following factors are critical to the protection of such interests: (a) water circulation and (b) water quality.

direction because of refraction (bending of a wave as it moves into shallow waters), bottom friction (drag that dissipates energy), and percolation into the bottom sediments (which also dissipates energy). When waves enter water approximately as deep as the waves are high, the waves become unstable and break (see Figure 2.1 - Profile A on page 2-6). Waves may spill, plunge, or surge onto the beach depending on the slope of the bottom of the nearshore area.

Submerged bars are capable of protecting the shoreline from the full impacts of wave energy by causing the waves to break farther offshore and dissipating some of their energy before they reach the shoreline (see Figure 2.1 - Profile B). In addition, nearshore areas may function to provide a source of sediment for seasonal rebuilding of coastal beaches and dunes. The volume and form of the nearshore area and the adjacent beaches tends to shift and change seasonally and in storm related events (see Figure 1.2 on page 1-10). Higher energy and larger waves (typical for the winter season) and/or storm events tend to deposit sand offshore, while relatively small, lower energy waves (typical for the summer season) deposit sand back onshore. The natural shifting and adjustment of the nearshore and beach profile creates a dynamic feedback loop that allows the coastline to respond to storm events and effectively dissipate wave energy. Consequently, the bottom topography of the nearshore area of land under the ocean is critical for protecting the interests of storm damage prevention and flood control.

Support for adjacent coastal or man-made structures - Land under the ocean in Designated Port Areas is regulated differently than other nearshore areas because it differs in function for storm damage prevention and flood control. Landforms in these areas have been greatly altered from their natural shape, and coastal engineering structures have often replaced natural protection for upland areas from storm damage and flooding. Therefore, the ability of land under the ocean in Designated Port Areas to provide support for adjacent coastal or man-made structures is critical for protecting the interests of storm damage prevention and flood control.

Factors Affecting Function of Land Under the Ocean

Nearly all nearshore areas of land under the ocean function in some beneficial capacity to protect the interests of storm damage prevention and flood control. In essence, if the resource area is a nearshore area, the bottom topography *can* function to diminish and buffer the high-energy effects of storms and reduce flooding and erosion. If the resource area in question is beyond the nearshore area, it will not likely serve these functions. Commissions can therefore expect to apply the performance standards described in Chapter 3 for all projects in the nearshore area.

If the land under the ocean is within a Designated Port Area, the area will likely provide support for coastal or man-made structures, and therefore the performance standards described in Chapter 3 for Designated Port Areas will likely apply.

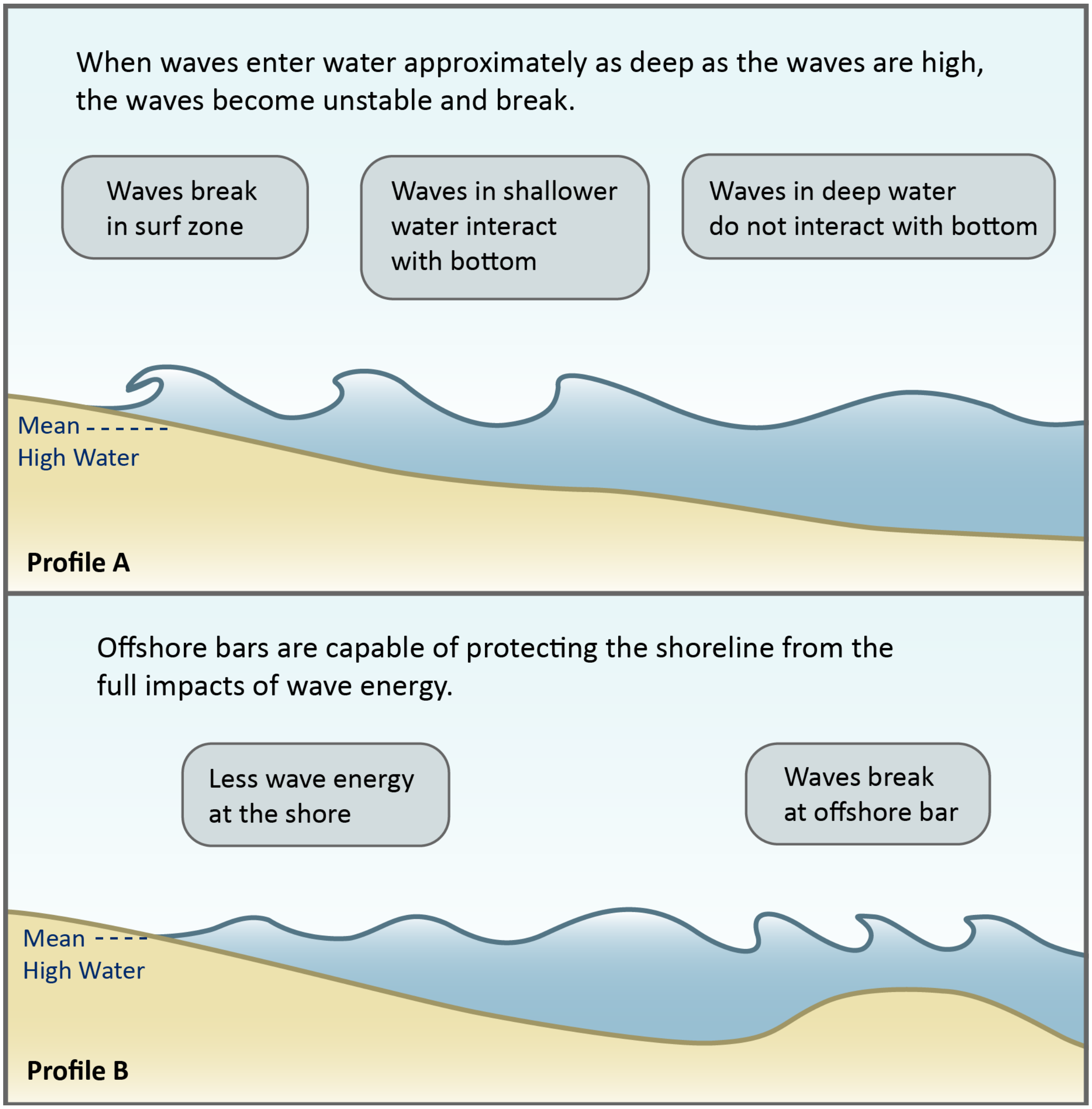

Figure 2.1. Interaction of waves with the bottom topography of land under the ocean. Profile A - waves entering shoreline and Profile B - waves over a submerged offshore bar.

DESIGNATED PORT AREAS

When reviewing a proposed project in Designated Port Areas, Commissions must first review the presumptions of significance of Designated Port Areas to the interests articulated in the WPA and determine the characteristics that function to protect these interests. Unlike other resource areas within Designated Port Areas, only land under the ocean is provided with a presumption of significance for the storm damage prevention and flood control interests. This section will describe how to determine the significance of land under the ocean within a Designated Port Area to these interests and how to assess the functions and characteristics that need to be protected by the performance standards (which will be described in Chapter 3).

Significance of Designated Port Areas to Storm Damage Prevention and Flood Control

The WPA Regulations at 310 CMR 10.26 state: "land under the ocean in Designated Port Areas is likely to be significant to storm damage prevention and flood control. In Designated Port Areas, salt marshes, coastal dunes, land under salt ponds, coastal beaches, tidal flats, barrier beaches, rocky intertidal shores, and land containing shellfish are not likely to be significant to storm damage prevention or flood control."[56]

The first presumption of significance (that land under the ocean is likely to be significant to the interests) may be overcome only upon a clear showing that land under the ocean in Designated Port Areas does not play a role in the protection of storm damage prevention or flood control, or that the proposed work will comply with the performance standards that protect those interests. The second presumption (of non-significance) may be overcome upon a clear showing that a salt marsh, coastal dune, land under a salt pond, coastal beach, tidal flat, barrier beach, rocky intertidal shore, or land containing shellfish in a Designated Port Area *does* play a role in storm damage prevention or flood control. The issuing authority must provide a written determination that demonstrates how the presumptions have been overcome.

Characteristics and Functions of Land Under the Ocean in Designated Port Areas

Before reviewing this section, please read the full language of the Preamble for Designated Port Areas within the WPA Regulations (www.mass.gov/regulations/310-CMR-1000-wetlands-

[56]DPAs are also likely to be significant to the protection of marine fisheries. For further information on the interests that are not covered in this guidance document, please visit the DMF website at www.mass.gov/orgs/division-of-marine-fisheries for assistance with the identification of fisheries habitat. Also available on the DMF website is the report, *Summary of Marine Fisheries Resource Recommendations for Municipal Maintenance Hydraulic Dredging Activities on Cape Cod and the Islands*, which addresses potential impacts of dredging and beach disposal activities on marine resources and recommends time-of-year restrictions for various species and habitats of fish and shellfish.

protection-act-regulations), which is the scientific basis for the Regulations. To aid Commissions with their review of the functions of land under the ocean in Designated Port Areas, this section highlights the critical characteristic, but it is not intended as a substitute for the Regulations.

The WPA Regulations at 310 CMR 10.26 state: "when a proposed project in a Designated Port Area is on land under the ocean which is determined to be significant to storm damage prevention or flood control, the ability of such land to provide support for adjacent coastal or man-made structures is critical to the protection of such interests."[57]

The following describes this characteristic and why it is critical to the protection of the storm damage prevention and flood control interests.

> **Support for adjacent coastal or man-made structures** - Land under the ocean in DPAs is regulated differently than land under the ocean outside of DPAs because of the difference in function for storm damage prevention and flood control. Landforms in Designated Port Areas are greatly altered from their natural shape, and coastal engineering structures are often used to protect port resources and upland areas from storm damage and flooding. Therefore, the ability of the land under the ocean in Designated Port Areas to provide support for adjacent coastal or man-made structures is critical for protecting the interests of storm damage prevention and flood control**.**

Factors Affecting Function of Designated Port Areas in Land Under the Ocean

If the land under the ocean is within a Designated Port Area, the area will likely provide support for coastal or man-made structures, and therefore the performance standards described in Chapter 3 for Designated Port Areas will likely apply. In most cases, other resource areas that are found within a Designated Port Area have been altered from their natural form and condition and are unlikely to provide any significant function for storm damage prevention or flood control.

[57]When land under the ocean in a Designated Port Area is significant to the protection of marine fisheries, the following characteristics are critical to the protection of such interests: (a) water circulation and (b) water quality.

COASTAL BEACHES

When reviewing a proposed project on a coastal beach, Commissions must first review the presumptions of significance of coastal beaches to the interests articulated in the WPA and determine the critical characteristics that function to protect these interests. This section will describe how to determine the significance of coastal beaches to the storm damage prevention and flood control interests and how to assess the functions and characteristics that need to be protected by the performance standards (which will be described in Chapter 3).

Significance of Coastal Beaches to Storm Damage Prevention and Flood Control

The WPA Regulations at 310 CMR 10.27 state: "coastal beaches, which are defined to include tidal flats, are significant to storm damage prevention and flood control."[58] The project proponent bears the burden of demonstrating that either the beach is not significant to the interests of the Act or that the proposed work will comply with the performance standards that protect those interests.

To better understand the significance of the beach to the interests of the Act, it is important for Commissions to understand the role the beach plays in functioning to protect landward areas from storm damage and flooding up to and in a *major storm event*. This knowledge will in turn give Commissions a better understanding of how a proposed project may impact those functions, as well as how a project may be designed to avoid adverse impacts. The remainder of this section is dedicated to beach characteristics and function, as well as methods for determining beach function at the project site.

Characteristics and Functions of a Coastal Beach

Before reviewing this section, please read the full language of the Coastal Beach Preamble within the WPA Regulations (www.mass.gov/regulations/310-CMR-1000-wetlands-protection-act-regulations), which is the scientific basis for the Regulations. To aid Commissions with their review of beach function, this section highlights the critical characteristics of beaches and their processes, but it is not intended as a substitute for the Regulations.

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[58]Coastal beaches are also often significant to the protection of marine fisheries and wildlife habitat; tidal flats are also likely to be significant to the protection of marine fisheries, and where there are shellfish, to land containing shellfish—interests not covered in this guidance document. For further information on these interests, please visit the NHESP website at www.mass.gov/orgs/masswildlifes-natural-heritage-endangered-species-program for town maps of Estimated Habitats of Rare Wildlife, the DMF website at www.mass.gov/orgs/division-of-marine-fisheries for assistance with the identification of fisheries habitat, or the local shellfish warden and/or DMF to determine if land containing shellfish is present at or adjacent to the project site. Also available on the DMF website is the report, *Summary of Marine Fisheries Resource Recommendations for Municipal Maintenance Hydraulic Dredging Activities on Cape Cod and the Islands*, which addresses potential impacts of dredging and beach disposal activities on marine resources and recommends time-of-year restrictions for various species and habitats of fish and shellfish. In addition, CZM's *Guidelines for Barrier Beach Management in Massachusetts* at www.mass.gov/files/documents/2016/08/vh/barrier-beach-guidelines.pdf (PDF, 12 MB) provides management measures to protect wildlife habitat, including migratory shorebird habitat.

The WPA Regulations at 310 CMR 10.27 state: "when coastal beaches are determined to be significant to storm damage prevention or flood control, the following characteristics are critical to the protection of those interests:

a) The volume (quantity of sediments) and form, and
b) The ability of the coastal beach to respond to wave action."[59]

Volume and Form of Beach - Coastal beaches provide storm damage prevention and flood control to landward areas by dissipating wave energy, reducing the height of storm waves, and providing sediment to other coastal resource areas. The form of the beach (elevation and slope) determines the way the beach responds to wave conditions, while the volume of the sediments determines how much energy can be dissipated—a larger volume of sediments both onshore and nearshore will provide better protection to dunes, banks, and other resource areas, as well as development or infrastructure landward of the beach. Wave energy can be dissipated before reaching the shore by interacting with the seafloor—the waves slow down and change height and shape in response to the depth of water and the slope of the seafloor and beach. Sediments in the subtidal area (offshore bars) cause the waves to either break offshore or to gently spill onto the beach surface with reduced energy (see Figure 2.1 on page 2-6). Wave energy that reaches the beach is also dissipated through the breaking of the wave, runup and backwash of water on the beach face, percolation through the sediments, and moving and shifting of sediments on the beach. The volume and form of beaches tend to shift and change seasonally and in storm-related events (see Figure 1.2 on 1-10). The beach flattens out during the winter months and/or storm events when higher energy waves move sand offshore; the beach accumulates and steepens during the summer months or after storm events when relatively low energy waves move sand back onshore. The natural shifting and adjustment of the beach profile creates a dynamic feedback loop that allows the beach to respond to storm events and effectively dissipate wave energy. Allowing the sediments to move back onshore *naturally* to recover to its original form and volume is critical for the long-term stability of the beach.

Ability of the Beach to Respond to Wave Action - The ability of the beach to respond to wave action is critical for the transport of beach sediments along the shore and across the shore. Wave action is one of the principal agents responsible for the transport of beach sediments. The angled approach of waves moves the sediment along the shoreline in the general direction of wave travel in a process called littoral drift. The net rate of littoral drift depends upon factors such as the grain size of beach sediment, the form of the beach, the angle of wave approach, the wave energy, and the wave steepness. Sediments also move

[59] When coastal beaches are significant to the protection of marine fisheries or wildlife habitat, the following characteristics are critical to the protection of those interests: (a) distribution of sediment grain size, (b) water circulation, (c) water quality, and (d) relief and elevation. When tidal flats are significant to land containing shellfish and are, therefore, also significant to marine fisheries, the following factors are critical to the protection of those interests: (a) shellfish, (b) water quality, (c) water circulation, and (d) the natural relief, evaluation, or distribution of sediment grain size of such land.

across-shore (on and offshore) from subtidal areas to beaches to dunes and back again, in a shifting caused by wind, waves, tides, currents, and storm events. This shifting and changing of the beach in response to wave action, which acts to dissipate wave energy and provide sediment to other coastal features, is consequently critical to storm damage prevention and flood control.

Factors Affecting Function of a Coastal Beach

To apply performance standards, Commissions will need to assess the existing coastal beach functions and characteristics that protect the interests of storm damage prevention and flood control. Commissions should recognize that with few exceptions, beaches function in some beneficial capacity to protect these interests. Even where the site has been altered, such as with revetments or bulkheads, the sediments on a coastal beach still have the ability to respond to wave energy. A resource for helping to determine the dominant sediment transport mechanisms (i.e., from waves, tides, winds, and storm events) is the *South Shore Coastal Hazards Characterization Atlas* at www.mass.gov/service-details/south-shore-coastal-hazards-characterization-atlas (at the site: click on "Main Content/Atlas Maps," the particular map region of interest, and the map for "Dominant Coastal Processes"). Another useful resource on sediment movement is the Woods Hole Sea Grant Program's publication, *Longshore Sediment Transport Cape Cod, Massachusetts* (www.capecodextension.org/wp-content/uploads/2016/04/Longshore-Sediment-Transport.pdf).

In general, if there are unconsolidated beach sediments subject to wave, tides, and storms along the shoreline, the coastal beach (including tidal flats) *can*:

- Respond to waves, tides, currents, and wind action by shifting and changing form and volume;
- Respond to waves, tides, and currents by transporting sediments to and from coastal beaches, thereby allowing the volume of the beach sediments to serve as a sediment source for dunes, subtidal areas, and downdrift coastal areas.

If there are no unconsolidated sediments subject to wave, tidal, and coastal storm action, then either the resource area is not a coastal beach as defined under the Regulations, or it will not be able to function like a coastal beach.

The photographs on page 2-12 show beaches with existing alterations. These examples demonstrate that although a beach may be altered, it still can retain beneficial functions for storm damage prevention and flood control. Each example highlights the functions that have been diminished and the functions that remain.

Coastal Beach with Jetty	Coastal Beach with Groins
 Photograph 2.1. Coastal beach with jetty. Although there is a jetty on this beach, the sand is still able to respond to wave/water activity by shifting and changing form as seen from the sand that is being eroded from behind the jetty. The amount of sediment exchange between the beach on the left and right of the rocks, however, has been restricted by the jetty.	 Photograph 2.2. Coastal beach with groins. The groins on this beach disrupt some longshore sediment transport and cause scour of the beach adjacent to each groin. However, they do not completely impede all sedimentary functions, such as the exchange of sand between the dunes, beaches, and subtidal areas of each groin cell.

Coastal Beach with Seawall

Photograph 2.3. Coastal beach with seawall. In spite of the seawall, this coastal beach is able to both shift and change form in response to waves and tides and to transport sediment along the shore. There is no longer a dune to serve as a reservoir of sediment for the beach.

Photographs 2.1, 2.2, and 2.3. Coastal beaches with various levels of alteration.

COASTAL DUNES

When reviewing a proposed project on a coastal dune, Commissions must first review the presumptions of significance of coastal dunes to the interests articulated in the WPA and determine the critical characteristics that function to protect these interests. This section will describe how to determine the significance of coastal dunes to the storm damage prevention and flood control interests and how to assess the functions and characteristics that need to be protected by the performance standards (which will be described in Chapter 3).

Significance of Dunes to Storm Damage Prevention and Flood Control

The WPA Regulations at 310 CMR 10.28 state: "all coastal dunes are likely to be significant to storm damage prevention and flood control, and 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, in any area are per se significant to storm damage prevention and flood control."[60] (The primary frontal dune is also known as the primary dune, as defined in the WPA Regulations.) The project proponent bears the burden of overcoming these presumptions, either by conclusively demonstrating that the dune is not significant to the interests of the Act or that the proposed work will comply with the performance standards that protect those interests.

The WPA Regulations draw a distinction between the dune closest to a coastal beach, known as the primary frontal dune or primary dune, and secondary dunes that form landward of the primary dune. This distinction is important because the regulatory standard that primary coastal dunes are *per se* (inherently) significant to storm damage prevention and flood control can very rarely be overcome.[61] *All* coastal dunes on barrier beaches, including secondary dunes, are also specified as being *per se* significant. They are deemed per se significant because their volume constitutes the major portion of the total volume of the barrier beach above high water, and it is this volume that determines the *capacity* of a barrier beach system (dunes and beaches) to protect landward areas from storm damage and flooding. Primary dunes and all dunes on barrier beaches typically function *in some capacity* for storm damage prevention and flood control. How they are significant (i.e., how they function) varies greatly—some dunes dissipate waves, some slow down overwash, and some serve as a reservoir of sand. Altered dunes may not exchange sand with the beach, but they can still erode and dissipate the energy associated with moving water and waves in a moderate to major coastal storm event.

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[60]Coastal dunes are also often significant to the protection of wildlife habitat—an interest not covered in this guidance document. For further information on the protection of wildlife habitat, please visit the NHESP website at www.mass.gov/orgs/masswildlifes-natural-heritage-endangered-species-program for their town maps of Estimated Habitats of Rare Wildlife. In addition, CZM's *Guidelines for Barrier Beach Management in Massachusetts* at www.mass.gov/files/documents/2016/08/vh/barrier-beach-guidelines.pdf (PDF, 12 MB) provides standards and management measures to protect wildlife habitat, including shorebird habitat.

[61]In the matter of Stephen D. Peabody Trustee, Docket No. 2002-053, Final Decision, January 25, 2006, affirmed by Essex Superior Court sub nom Peabody v. Department of Environmental Protection, ESCV 2006-00299, September 21, 2007, and affirmed in Massachusetts Appeals Court November 8, 2012, all coastal dunes are likely to be significant to storm damage prevention and flood control, and all coastal dunes on barrier beaches and the coastal dune closest to the coastal beach in any area are per se significant to storm damage prevention and flood control (310 CMR 10.28(1)). Because dunes on barrier beaches and the coastal dune closest to the beach are singled out as intrinsically important to storm damage prevention and flood control, they warrant greater scrutiny.

Because these functions will vary depending on the site-specific characteristics of the dune and the forces (such as wind and waves) that act upon the dune, Commissions will need to: 1) understand the natural functions of unaltered coastal dunes that play a role in storm damage prevention and flood control and 2) determine any factors that may be affecting the functions of the dune at the particular project site. In all cases, Commissions should evaluate the site-specific functions that the dune could perform up to and in a *major coastal storm event*—when the key interests of storm damage prevention and flood control come into play. Commissions and applicants may not readily recognize the full potential for wind and waves to act on the entire dune since most of the Massachusetts coast has not experienced a 100-year frequency coastal storm event (1%-annual-chance flood) since 1978 or earlier.

Characteristics and Functions of a Coastal Dune

Before reviewing this section, please read the full language of the Coastal Dune Preamble within the WPA Regulations (www.mass.gov/regulations/310-CMR-1000-wetlands-protection-act-regulations), which is the scientific basis for the Regulations. To aid Commissions with their review of dune function, the following section highlights the five critical characteristics of dunes and elaborates on certain coastal dune processes, but it is not intended as a substitute for the Regulations.

The WPA Regulations at 310 CMR 10.28 state: "when a coastal dune is significant to storm damage prevention and flood control, the following characteristics are critical to the protection of those interest(s):

a) The ability of dunes to erode in response to coastal beach conditions;
b) Vegetative cover;
c) Dune form, which must be allowed to change through wind and natural water flow;
d) Landward or lateral movement of dunes; and
e) Dune volume." [62]

The ability of dunes to erode in response to coastal beach conditions - The ability of the dunes to erode by waves, tides, currents, storm-elevated sea levels (storm surges), and wind is essential for supplying sand to the beach system. The coastal dunes, beach, and nearshore area are part of a sediment-sharing system that dissipates the energy associated with waves, tides, and currents. Sediment sharing also occurs through ongoing windblown exchange between the beaches and dunes, as well as between primary and secondary dunes. Without the supply of sediment from coastal dunes (and coastal banks and shoals), beaches would gradually be depleted of sediment and disappear. Even a seemingly stable dune that has not been affected by a major storm in many years can erode, shift, and supply sediment during a major storm event. Alterations or modifications to these dunes will affect the ability

[62]When a coastal dune is significant to the protection of wildlife habitat, the Regulations list critical characteristics a-e, as well as one additional characteristic: f) the ability of the dune to continue serving as bird nesting habitat.

of the dune to provide these functions. Consequently, the ability of all dunes to store sediment and erode is critical to the long-term capacity of dunes and beaches to serve the interests of storm damage prevention and flood control.

Vegetative cover - Plant cover contributes to the formation, growth, and stability of coastal dunes. Dune vegetation helps to slow the speed of the wind and water allowing conditions favorable for sediment deposition. The extensive root systems of the vegetation help bind the sediments and contribute to dune stability (see Figure 3.3 on page 3-50 for a depiction of different types of grasses and their roots). Coastal dunes often develop along the spring tide wrack line of the beach (the line of seaweed, plant seeds, and debris), where wind-blown sediment is trapped, new vegetation germinates and grows, and sand accumulates vertically into dunes. Dunes move or migrate landward or laterally in response to wind, high tides, and waves. The amount and type of vegetation can determine the rate of dune growth and migration—native beach and dune plants have root systems that are most beneficial for dune stability. The extent and health of the vegetative cover is therefore critical to the growth and stability of the dunes and the interests of storm damage prevention and flood control. For additional information, see StormSmart Properties Fact Sheet 3: Planting Vegetation to Reduce Erosion and Storm Damage (www.mass.gov/service-details/stormsmart-properties-fact-sheet-3-planting-vegetation-to-reduce-erosion-and-storm).

Dune form, which must be allowed to change through wind and natural water flow - Through changes in form, the dune acts to dissipate wave energy by moving and shifting and providing sediment to different areas of the shore. In addition, the height and width of the coastal dune provides a buffer that protects landward areas from storm waves, storm surges, and extreme high tides. The form of a dune may result from a combination of factors, including: geographic and topographic setting (exposed or protected shoreline, wave climate); grain size and volume of sediment supply to the beach and dune system; wind regime; type and density of vegetation; and human alteration. Geographic setting and sediment supply, combined with the effects of storm activity and seasonal fluctuations, are often the most important of the factors that control coastal dune form. Wind is also an important factor, with prevailing winds and storms often driving the dune formation and migration. Storm-wave overwash is important to the process of carrying sediment landward to initiate dune formation or facilitate landward migration. Therefore, the ability of the dune to conform to natural wind and water flow patterns and maintain overall volume is critical to the interest of storm damage prevention and flood control.

Landward or lateral movement of dunes - The landward and lateral movement of dunes functions to protect landward areas from storms and flooding. On eroding shorelines, the ability of coastal dunes to move landward at the rate of shoreline retreat allows the dunes to maintain their form and volume over time. If dunes cannot move landward, they will gradually be eroded away from the seaward side and diminish in size (width, height, and volume). Such loss in size would reduce the capacity of the dune to protect landward areas during coastal storms and could potentially result in the dune being overwashed or completely eroded in a storm event. Wind-blown sediment from dunes can also contribute to the elevation of adjacent salt marshes, if present, and make them less susceptible to potential inundation from sea level rise. Lateral movement of dunes occurs when wind and water move sediment parallel with the shoreline among and between the dunes; the direction of the waves and winds determines which way the sediment shifts. This process is similarly important for maintaining the size and form of a dune and its capacity to protect inland areas from storms and flooding.

Dune volume - The volume of the dune determines the *capacity* of a dune to protect landward areas from storm damage and flooding. Coastal dunes provide a buffer, protecting landward development from storm damage and flooding by dissipating wave energy and/or blocking storm elevated sea levels and storm waves altogether. Greater heights, widths, and volumes offer greater protection against storm damage and flooding. Greater volumes also provide a larger reservoir of sediment that can be provided to the beach and nearshore area, which acts to dissipate energy in a storm event. Therefore, maintaining the height, width, and volume of the dune is critical to protecting the interests of storm damage prevention and flood control.

Factors Affecting Function of a Coastal Dune

Coastal dunes do not all function in the same way for storm damage prevention and flood control. Consequently, Commissions must properly assess the existing dune functions and characteristics of the proposed project site. This assessment is particularly important when the function of a dune is in question due to alterations on, or adjacent to, the proposed project. Commissions may at times find that where the storm damage prevention and flood control capacity of a dune has been significantly diminished, redevelopment or development may be permitted, if it is designed to protect the existing functions of the resource areas. For instance, in areas that have been highly developed or are urbanized where dunes remain only as vestigial forms, additional alteration may not have significant adverse effects because the beneficial capacity of the dune has already been severely diminished. However, even in areas where certain functions may be diminished, there are likely other functions that require protection (or functions that could be improved through project design—see coastal dunes performance standards in Chapter 3). Consequently, all functions must be evaluated before project impacts are assessed.

When assessing dune function, both the surrounding coastal environment and the dune site itself must be examined.

Surrounding Coastal Environment

To assess the existing functions of the dune, Commissions should consider the context of the dune—that is, its relationship to the surrounding area. To determine context, Commissions must understand the dynamic coastal processes that occur among and between the dunes, beaches, and the nearshore area. (For additional information, see the function section of each resource area.) In general, the function of a dune system and its interaction with the surrounding area is dependent on the modifying forces of wind and wave activity. For a dune, these forces will depend on the location of the dune relative to the shoreline and whether that shoreline is enclosed, somewhat protected, or exposed to the ocean. Those areas that are more exposed to wind and wave activity will experience a more dynamic exchange of sand within the system and may function to protect landward areas from storm damage and flooding more *frequently* than a relatively protected, stable coastline. In a major storm event, however, even the dunes of a protected shoreline will perform functions of storm damage prevention and flood control.

Another factor to consider is sea level rise and its effect on coastal dunes. Though the WPA Regulations do not speak specifically to sea level rise, they recognize the dynamic nature of the shoreline and the coastal resources that have been (and continue to be) moving and shifting in response to sea level rise for over 10,000 years. In addition, the Regulations specifically address shoreline retreat—the process of landward migration of a coastal landform. Retreating shorelines are especially vulnerable to storm damage and flooding if the form and volume of the dune is not allowed to shift landward at the rate of shoreline retreat. The performance standards incorporate a process for dealing with sea level rise by requiring that landforms be able to move, shift, migrate, and respond to changes in water levels and storms. As the densely populated coast of Massachusetts faces substantial increases in the extent and frequency of coastal flooding, erosion, and property damage, current science and management principles are continuing to evolve to better adapt to the effects of increasing rates of sea level rise. Commissions can consult CZM's *Sea Level Rise: Understanding and Applying Trends and Future Scenarios for Analysis and Planning* (www.mass.gov/files/documents/2016/08/vp/slr-guidance-2013.pdf) to better understand the current sea level rise trends. Commission may also want to review tide gauge records to document changes in sea level rise over time.[63]

To better understand how quickly the shoreline is eroding or accreting in the short and long term, Commissions should refer to the Massachusetts Shoreline Change Project Maps (www.mass.gov/service-details/massachusetts-shoreline-change-project) or the *South Shore*

[63]The NOAA tide gauge records document changes in sea level rise over time and are available online at: www.tidesandcurrents.noaa.gov/sltrends/sltrends.html. Two other useful references about climate change and associated sea level rise are: *The Northeast Climate Impacts Assessment (NECIA) report* (https://climateshift.com/climate-collapse-news/northeast-climate-assessment-reports.htm) and the associated state summary for Massachusetts (https://climateshift.com/downloads/northeast/massachuetts_necia.pdf).

Coastal Hazards Characterization Atlas (www.mass.gov/service-details/south-shore-coastal-hazards-characterization-atlas) and accompanying reports. The variables report for the *South Shore Coastal Hazards Characterization Atlas* contains maps characterizing several variables, including sea level rise, for the entire Massachusetts coastline.

The degree of existing alterations to the surrounding area is another factor affecting function. Extensive alterations to the area may have reduced the exchange of sand among the area's beaches and dunes, thereby hindering the ability of the dune at the project site to serve some of the functions of storm damage prevention and flood control. Alterations to the dune site will be discussed in more detail on page 2-21.

The Dune Site

Once Commissions have a general sense of the surrounding area and its relationship to the dune system, they will need to determine existing functions of the dune at the project site. There are two general considerations when determining functions of the dune: 1) *exposure to wind and wave activity* and 2) *degree of existing alterations*.

Exposure to Wind and Wave Activity

The exposure of the dune to wind and wave activity ultimately determines its critical characteristics and functions. For instance, an area outside of the 100-year floodplain and landward of the primary dune, where only wind activity occurs, will be relatively stable, particularly with stabilizing dune vegetation. This area can function (and is therefore still significant) as an area for landward migration on eroding or retreating coastlines and as a reservoir of sand exchange with the dune, beach, and/or nearshore area. In contrast, the portion of the dune closest to the beach, where high wind and wave energy dominate, will likely exhibit the ability to perform all of the dune functions. Here, waves can erode sand from the beach more frequently with *significant rates of erosion* occurring in a major storm event, the dune can be reshaped, and sediments can easily move landward and laterally. Vegetative cover on this portion of the dune is extremely important for stability. The areas of the dune that are landward of the primary dune, but still *within* the floodplain, may experience significant wave activity, depending on the volume of the dune and the flood zone elevations at the site, as described next. (See Figure 2.2 for a full description of the wind and wave activity within an example dune system.)

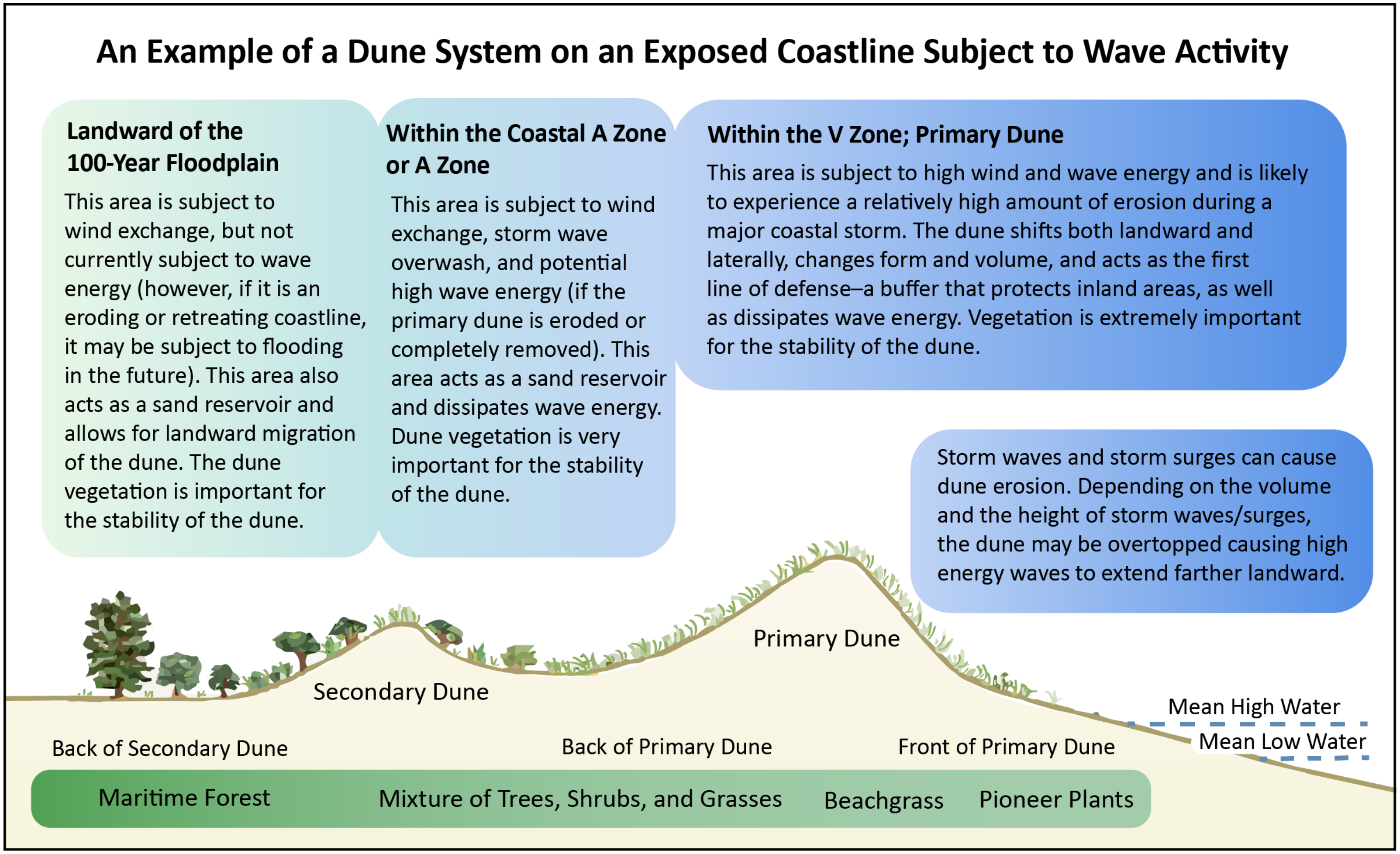

Figure 2.2. Dune profile depicting exposure to wind and wave activity and relative function. To delineate the landward boundary of the primary dune, see “ Delineating Primary Dunes” beginning on page 1-32 and Appendix C.

In addition to looking at the influence of wind and waves based on location within the dune, Commissions must also consider dune volume. The dune volume affects the exposure of landward areas of the dune to wind and wave activity during storms. Dunes with greater volumes will offer a higher level of protection to landward areas from storm waves and storm surges. Dunes with lower sediment volumes, although offering an area for energy dissipation, will pose greater risk of overtopping that allows wave energy to extend farther landward. High-volume dunes may also erode (dissipating energy in the process) and ultimately retreat, making them more vulnerable to *future* storm events. It is important to recognize that coastal dunes need to be protected for their various functions, regardless of the volume. Commissions must look at the dune form and volume in conjunction with the exposure to wind and wave activity, as described above, to properly determine the overall functions of the coastal dune that need to be protected.

To more precisely locate the floodplain and the extent of wave activity, and determine whether dune volume will influence the landward extent of flooding, Commissions should review all relevant and available data sources and guidance. Commissions should use the best available information that is applicable to site conditions and pertinent to the project proposal and determine whether there is *a need* for a more in-depth analytical evaluation.

The following information can be used to help determine the extent of floodplain and wave activity in dune areas and can be found in detail on the pages provided in "Land Subject to Coastal Storm Flowage" in Chapter 1:

- Flood Insurance Rate Maps (FIRMs) and Flood Insurance Studies (FISs) (pages 1-71 through 1-77) and any Letters of Map Change (page 1-78) identify the predicted extent of the 1%-annual-chance flood in a community.
- The National Flood Hazard Layer (NFHL), which can be viewed on the NFHL Viewer at the FEMA Flood Map Service Center, shows the Limit of Moderate Wave Action (LiMWA)—the approximate boundary of the 1.5-foot breaking wave (see page 1-72 for details on finding the LiMWA layer).
- Field Observations and/or Engineering Data (pages 1-78 through 1-79) may be warranted when the delineations on the maps are not in basic agreement with past flooding patterns and current shoreline conditions.
- Shoreline Change Maps, Hazards Characterization Atlas, and other Data Sources (pages 1-80) depict various scenarios and future conditions that are beyond the scope of the FIRMs.
- The Primary Dune Delineation Methodology (pages 1-32 through 1-38, page 1-81, and Appendix C) provides a process for performing a site-specific delineation of the landward extent of the primary dune to determine the minimum extent of the V Zone.

- The 1,100- (previously 540-) square-foot criterion (pages 1-86 through 1-89) helps determine whether velocity conditions extend farther landward than the inland toe of the primary dune due to dune erosion.

In many circumstances and depending on the project, an in-depth analytical review will not be necessary to make findings; a review of the FIRMs/FISs and confirmation through field indicators may be all that is necessary.

Degree of Existing Alterations

The second consideration in determining the capacity of the dune to function is to assess the degree of existing alteration to the dune and surrounding area. A site (or area) that has been paved, armored, and built upon will have rather different functions than an area that is relatively pristine. Below is a series of photographs that depict variations of each of the five major functions/critical characteristics based on degrees of alteration. Each photograph describes the functions that exist and the functions that are limited or constrained by the alteration. Although certain functions may be diminished, Commissions should recognize the functions that are still present, given that these will be subject to the performance criteria described in Chapter 3.

<table>
<tr><th>Dune with Natural Erosion</th><th>Dune with Constrained Erosion</th></tr>
<tr><td>
Photograph 2.4. Dune with natural erosion. This dune is able to erode and provide sand to the adjacent beach and nearshore area, as well as accrete sand with the help of the stabilizing dune vegetation.</td><td>
Photograph 2.5. Dune with constrained erosion. This highly developed dune has lost some of its ability to erode and supply the beach with sediment because the houses are on solid foundations instead of open pilings. In a major storm event, however, this dune will still function to dissipate wave energy and supply sediment to the beach. During these events, the houses will likely exacerbate scour, which may undermine the structures.</td></tr>
</table>

Highly Vegetated Relatively Stable Dune

Photograph 2.6. Highly vegetated relatively stable dune. This dune is vegetated with beachgrass and goldenrod and is relatively stable compared to an area with no vegetation or an area with a blowout. Sand that is captured in the dune vegetation can later be used to supply the beach during periods of wave erosion, and to a certain extent, the dune vegetation and its dense root network can act to buffer the effects of storm erosion. This dune can still erode in a large storm event and will dissipate energy very effectively.

Dune with Blowout and Destabilization

Photograph 2.7. Dune with blowout and destabilization. This blowout is likely due to impacts associated with pedestrian use for beach access. Here the sand is unstable and eroding from the dune at a faster rate than adjacent vegetated areas. This area is also a weak point in the dune system, channeling overwash of water and sand landward. This area of the dune still functions to provide sand to the beach and nearshore area, as well as to shift and change form both landward and laterally.

Unmodified Dune Form

Photograph 2.8. Unmodified dune form. The form of this secondary dune system has relatively minor alterations and retains the ability to shift and change due to wind activity and storm-wave overwash.

Modified Dune Form

Photograph 2.9. Modified dune form. This parking lot and seawall have significantly modified the dune form and have diminished its capacity to shift and change form to dissipate wave energy. In storm events, the flood water and waves will increase in velocity as they move across the pavement and likely extend farther landward than if no pavement was present. The vegetated dune landward of the parking lot can still dissipate wave energy through the friction of the vegetation and by shifting and changing form in a storm event.

Barrier Beach with No Constraint to Landward Movement	Barrier Beach with Partial Constraint to Landward Movement
	
Photograph 2.10. Barrier beach with no constraint to landward movement. The barrier beach is able to shift landward since there are few alterations, developments, or constraints that would inhibit this movement.	Photograph 2.11. Barrier beach with partial constraint to landward movement. Since it hasn't experienced a major storm in more than 10 years, dense beach grass and shrubs on this barrier beach are able to grow on the back side. The dunes on the seaward and landward side of the road can still erode and supply sediment to the beach in a storm event and perform all other dune functions. The function of the dune under the road has been diminished. However, in a large storm event, the pavement does break up and the dune can provide more function. *Photograph courtesy of Jim Mahala, MassDEP.*
High Volume Dune	**Low Volume Dune**
	
Photograph 2.12. High volume dune. This dune has a large volume of sand, serving as a reservoir for sand exchange with the coastal beach and nearshore area, as well as providing an elevated buffer that protects inland areas from storm waves.	Photograph 2.13. Low volume dune. Relative to the beach, this *is* a mound or ridge of sand deposited by wind and/or waves. This dune provides an *area* for dissipation of storm wave energy, but will not provide enough volume to prevent high energy waves from extending farther landward. The dune still has the ability to erode and shift and move landward and laterally.

Photographs 2.4-2.13. Coastal dunes with various levels of alteration.

BARRIER BEACHES

When reviewing a proposed project on a barrier beach, Commissions must first review the presumptions of significance of barrier beaches to the interests articulated in the WPA and determine the critical characteristics that function to protect these interests. The presumptions of significance for coastal beaches and coastal dunes should also be reviewed since barrier beaches are generally composed of coastal beaches and coastal dunes. This section will describe how to determine the significance of barrier beaches to the storm damage prevention and flood control interests and how to assess the functions and characteristics that need to be protected by the performance standards (which will be described in Chapter 3).

Significance of Barrier Beaches to Storm Damage Prevention and Flood Control

The WPA Regulations at 310 CMR 10.29 state: "barrier beaches are significant to storm damage prevention and flood control." The Regulations at 310 CMR 10.28 state: "all coastal dunes on barrier beaches are *per se* significant to storm damage prevention and flood control."[64] The project proponent bears the burden of demonstrating that the barrier beach and any dunes potentially impacted by the project are not significant to the interests of the Act or that the proposed work will comply with the performance standards that protect the interests.

To better understand the significance of barrier beaches to the interests of the Act, it is important for Commissions to evaluate the function of the barrier beach system, and its beaches and dunes, in protecting landward areas from storm damage and flooding up to and in a major storm event. This knowledge will in turn give Commissions a better understanding of how a proposed project may impact those functions, as well as how a project may be designed to avoid adverse impacts.

Characteristics and Functions of a Barrier Beach

Before reviewing this section, please read the full language of the Barrier Beach Preamble within the WPA Regulations (www.mass.gov/regulations/310-CMR-1000-wetlands-protection-act-regulations), which is the scientific basis for the Regulations. To aid Commissions with their review of barrier beach functions, Commissions will also want to read the preambles for beaches and dunes and their corresponding function sections within this chapter.

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[64]Barrier beaches are also often significant to the protection of marine fisheries and wildlife habitat, and where there are shellfish, to land containing shellfish—interests not covered in this guidance document. For further information on these interests, please visit the NHESP website at www.mass.gov/orgs/masswildlifes-natural-heritage-endangered-species-program for town maps of Estimated Habitats of Rare Wildlife, the DMF website at www.mass.gov/orgs/division-of-marine-fisheries for assistance with the identification of fisheries habitat, or the local shellfish warden or DMF to determine if land containing shellfish is present at or adjacent to the project site. In addition, CZM's *Guidelines for Barrier Beach Management in Massachusetts* at www.mass.gov/files/documents/2016/08/vh/barrier-beach-guidelines.pdf (PDF, 12 MB) provides management measures to protect wildlife habitat, including migratory shorebird habitat.

The WPA Regulations at 310 CMR 10.29 state: "when a barrier beach is significant to storm damage prevention and flood control, the characteristics of coastal beaches, tidal flats, and coastal dunes listed in 310 CMR 10.27(1) and 10.28(1) and their ability to respond to wave action, including storm overwash sediment transport, are critical to the protection of the interests specified in 310 CMR 10.29."[65]

The following describes these characteristics and why they are critical to the protection of the storm damage prevention and flood control interests.

Characteristics of Coastal Beaches, Tidal Flats, and Coastal Dunes - The characteristics of the resource areas that comprise the barrier beach resource area, including beach and dune sediments that move and shift in wind and waves, are important for the interests of storm damage prevention and flood control. The coastal dunes and beaches on barrier beaches protect landward areas by providing a buffer from storm waves and from storm-elevated sea levels. In particular, barrier beaches are able to protect other landward resource areas, such as salt- and fresh-water marshes, estuaries, lagoons, and ponds from wave action. Barrier beaches are also able to dissipate wave energy to protect landward development and infrastructure. Greater volumes of beach and dune sediments on a barrier beach will offer greater protection against storm damage and flooding and provide a larger reservoir of sediment to be exchanged between and among the resources of the barrier beach and the nearshore system.

Ability to Respond to Wave Action - The ability of a barrier beach to respond to wave action allows sediments to move, maintaining the form and volume of barrier beaches. The movement of sediments occurs through the following processes:

- Storm-wave overwash (the sediment transport process that overtops coastal dunes, depositing sediment farther landward),
- Longshore movement of beach sediments (the sediment transport process along the length of the shoreline), and
- Tidal inlet deposition (accretion of sediments transported by waves, tides, and/or currents).

Wind action is another factor that supplies and moves sediment to and from coastal dunes and beaches. The landward movement of sediment by storm-wave overwash, tidal currents, and wind allows barrier beaches to migrate landward. Longshore movement of sediment through waves, tidal currents, and wind allows barrier beaches to migrate in a downdrift direction. The continuation of these migration processes maintains the form and volume of

[65] When a barrier beach is found to be significant to the interests of marine fisheries, wildlife habitat, or the protection of land containing shellfish, the same characteristics that are listed for storm damage prevention and flood control are listed as being critical for protection of marine fisheries, wildlife habitat, and land containing shellfish.

the landform, as well as the elevation, and thus sustains its ability to protect landward areas relative to rising sea levels, shoreline retreat, and storm forces.

These characteristics of barrier beaches, in addition to those for coastal beaches and coastal dunes, are consequently critical to storm damage prevention and flood control.

Factors Affecting Function of a Barrier Beach

The distinction between the regulatory language of barrier beaches from that of coastal dunes is the specification (within the Coastal Dune Preamble) that *all dunes* on a barrier beach, not just the dunes closest to the shore, are per se significant. The intent of this language is to recognize that dune function is essential to the stability and function of the entire barrier beach. However, even with this strong presumption of significance, barrier beaches do not all function in the same capacity for storm damage prevention and flood control. These landforms must remain relatively free from alterations in order to maximize function as natural buffers. Since many barrier beaches are developed and therefore may have diminished capabilities in providing storm damage prevention and flood control, Commissions will need to critically evaluate the functions of the barrier beach before applying the performance standards. The existing functions of the barrier beach should be protected. Frequently, projects proposed on developed areas of a barrier beach provide opportunities to improve existing storm damage and flood control functions, including reducing impervious area, elevating buildings on open piling foundations, and restoring native vegetation. Commissions are advised to review the sections for coastal beaches and coastal dunes within this chapter (particularly the section on existing alterations, including photographs) and determine the existing functions of each resource area, as well as the functions of the barrier beach as a whole. Other coastal resource areas, such as salt marsh, should also be reviewed if present on site.

COASTAL BANKS

For a proposed project on a coastal bank, Commissions must first review the presumptions of significance to the interests articulated in the WPA and determine the critical characteristics that function to protect these interests. Depending on the type of coastal bank (i.e., glacial deposits, rock, or a combination of materials), the functions will vary. This section will describe how to determine the significance of coastal banks to the storm damage prevention and flood control interests and how to assess the functions and characteristics that need to be protected by the performance standards (which will be described in Chapter 3).

Significance of Coastal Banks to Storm Damage Prevention and Flood Control

The WPA Regulations at 310 CMR 10.30 state: "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."[66]

The project proponent bears the burden of demonstrating that either the bank is not significant to the interests of the Act or, if the bank is significant, that the proposed work will meet the performance standards to ensure these interests are protected. The presumption that sediment-source coastal banks are *per se* (intrinsically) significant is very rarely overcome. Moreover, the Regulations provide strict performance standards to protect the ability of the coastal bank to supply sediment to other coastal resource areas.

Characteristics and Functions of a Coastal Bank

Before reviewing this section, please read the full language of the Coastal Bank Preamble within the WPA Regulations (www.mass.gov/regulations/310-CMR-1000-wetlands-protection-act-regulations), which is the scientific basis for the Regulations. To aid Commissions with their review of coastal banks, this section highlights the two types of coastal bank functions and their critical characteristics, but it is not intended as a substitute for the Regulations.

The WPA Regulations at 310 CMR 10.30 state: "when the issuing authority determines that a coastal bank is significant to storm damage prevention or flood control because it supplies sediment to

[66] Although the Regulations do not specify that coastal banks are significant to any other interests of the Act, such as wildlife habitat, Commissions must still take into account specified habitat sites of rare vertebrate or invertebrate species, as identified by procedures in the Regulations.

coastal beaches, coastal dunes or barrier beaches, the ability of the coastal bank to erode in response to wave action is critical to the protection of that interest(s)."

These Regulations also state: "when the issuing authority determines that a coastal bank is significant to storm damage prevention or flood control because it is a vertical buffer to storm waters, the stability of the bank, i.e., the natural resistance of the bank to erosion caused by wind and rain runoff, is critical to the protection of that interest(s)."

The following describes these characteristics and why they are critical to the protection of the storm damage prevention and flood control interests.

Sediment-Source Banks and Their Ability to Erode - Coastal banks composed of unconsolidated sediment that are *exposed to wave action* serve as a continuous or episodic source of sediment for beaches (including tidal flats), dunes, and barrier beaches (as well as other coastal land forms, such as nearshore bars and salt marshes). Wave action is the primary force that removes sediment from banks. The naturally occurring erosion (of varying quantities) of sediment from coastal banks from wave activity is necessary to sustain the volume of coastal beaches, coastal dunes, and barrier beaches, all of which dissipate storm wave energy and protect landward areas from storm damage and flooding. Consequently, the ability of unconsolidated coastal banks to erode in response to wave action is critical for protecting the interests of storm damage prevention and flood control.

Vertical-Buffer Banks and Their Stability - Nearly all coastal banks function in some capacity as a vertical buffer to storm waves and flood waters. The height and stability of the coastal bank function as a natural wall that protects upland areas from storm damage and flooding. Per the Massachusetts Department of Environmental Protection (MassDEP) Policy (92-1), "when a landform has a slope that is so gentle and continuous…(i.e., <10:1)… that it does not act as a vertical buffer and confine elevated storm waters, that landform does not qualify as a coastal bank." (See Appendix D for Policy 92-1.) Therefore, any coastal bank that meets the definition under the Wetlands Protection Act and is delineated pursuant to the MassDEP policy must have sufficient height to act as a vertical buffer. Coastal banks may have *decreased* function as a vertical buffer if the stability is compromised or if the resistance to erosion has been reduced (see "Factors Affecting Function of a Coastal Bank" on page 2-29 for more information). Consequently, the height (the ability of the bank to act as a buffer to upland areas from storm waves and flooding), the continued stability of the bank, and the bank's resistance to erosion from wind and rain are critical for protecting the interests of storm damage prevention and flood control.

A particular coastal bank may serve *both* as a sediment source and as a buffer, or it may serve only one role.

Factors Affecting Function of a Coastal Bank

As with all resource areas, Commissions will first need to determine the existing functions of the coastal bank that protect the interests of storm damage prevention and flood control. For coastal banks, this means determining whether the bank is a sediment source or a vertical buffer or both. This determination is necessary for applying the relevant performance standards described in Chapter 3. Commissions should review the following information to help them determine the function/type of the coastal bank. The type of coastal bank may also be influenced by the degree of alteration, such as armoring, which will be addressed below.

Sediment-Source Banks

To determine if a coastal bank acts as a sediment source for adjacent coastal dunes, beaches, barrier beaches, and other coastal landforms, Commissions should look for evidence that wave activity does cause or has caused (such as in a major storm event) erosion of a coastal bank. This means that: 1) there must be a receiving landform, specifically a beach, dune, or barrier beach, that is the recipient of the sediment, and 2) there is some current or historical evidence that the bank erodes—based on floodplain and wave activity (including run-up and splash-over) and/or based on information about historic floods that can help determine whether the bank has eroded or has the *potential* to erode in a storm event. More specifically, a Commission will need to look for evidence of erosion through shoreline change data (www.mass.gov/service-details/massachusetts-shoreline-change-project), evidence of erosional scarps, the presence of compatible materials on adjacent beaches/dunes, historic flood data, prior permits (or applications) for erosion control projects, or other historical documentation of storm damage and flooding. If a Commission can find no evidence of erosion, then it is unlikely that the bank is a sediment source.[67]

Generally, banks of unconsolidated sediment exposed to the open ocean that lie adjacent to coastal beaches are likely to be a sediment source, whereas those found in protected estuaries that are not subject to wave action (even in a storm event) are less likely to be a sediment source. Banks that only experience wave action in a storm event—allowing them to become well vegetated and appear stable in the long intervals between storms—*may* have the potential to erode and supply sediment in storm events, but these banks can only be designated as sediment sources if current or historical evidence of erosion is identified (as described above).

[67] In the matter of Stuart Bornstein, Docket No. 98-168, Recommended Final Decision, January 11, 2001; Final Decision, April 9, 2001, the Administrative Law Judge concluded that the coastal bank on the Site served as a source of sediment to a coastal beach (regardless of the volume it provided) and thus served as both a vertical buffer to wave action and as a source of sediment; whereas another coastal bank on the Site did not serve as a source of sediment to a coastal beach, coastal dune, or barrier beach (because the resource area seaward of the bank was a salt marsh), and thus served only as a vertical buffer to wave action.

Coastal banks that are armored may provide sediment if the area of the bank *above the top of the wall* is subject to wave activity and can still erode sediment from the bank. Erosion of armored coastal banks may also occur above the structure—even if the wall was built to the mapped flood elevation—from the effects of splash over, wave run up, and sea level rise.

Vertical-Buffer Banks

In general, all coastal banks will function in some capacity to serve as a vertical buffer, provided they meet the definition for coastal bank under the WPA Regulations and MassDEP policy. Therefore, even coastal banks that are eroding or banks that are low lying (yet are steeper than a 10:1 slope) that act to confine storm waves and flood waters *will* function to protect against storm damage and flooding.

Although natural erosion of a coastal bank provides sediment to other coastal resource areas, activities that *exacerbate* erosion or *destabilize* the bank should be avoided. Human-induced disturbances may increase erosion and decrease stability, thereby compromising the function of the bank to provide a buffer to landward areas from storm damage and flooding. Surface water runoff, increased by additional impervious surfaces or improper drainage, that flows overland or within rills and gullies can cause erosive scour to the top and face of the bank and can lead to bank failure. Perched water tables—where water collects over a relatively impermeable layer—can also lead to destabilization where the water flows out at the face of the coastal bank as seeps or springs. The overall stability of the bank can also be compromised by the development itself (the weight of structures) or intrusion of water into the soils (such as from a septic system or irrigation system). Geotechnical analysis may be required to assess the impact of the proposed project on the stability of the bank.

Other human activities that may reduce the stability of the bank include increased pedestrian traffic near or on the bank, removal of plants that grow on the bank, and dumping of debris on the face of the bank. Removing plants from the bank is discouraged since this activity can result in significant erosion. In addition, discarded vegetation (such as brush, vegetative debris, old Christmas trees, and other materials) that is often placed on banks with the intention of preventing erosion, acts to limit the natural growth and establishment of plants whose root systems would otherwise help bind the soils.

In certain cases, plant removal may be warranted, such as when invasive species are preventing establishment of beneficial erosion-control vegetation. In these cases, the invasive plants should be removed and replaced with appropriate native plants in accordance with an Order of Conditions governing the work. This effort is particularly warranted when bank stability is severely compromised by the invasive plant or when unruly and overgrown invasives can be replaced with lower-growing native species to stabilize the bank and improve coastal views. Because this removal of vegetation can temporarily destabilize the bank, consultation with a professional is recommended. For more information on removing invasive species and replacing them with natives, see CZM's StormSmart Fact Sheet 3: Planting Vegetation to Reduce Erosion and Storm Damage (www.mass.gov/service-details/stormsmart-properties-fact-sheet-3-planting-vegetation-to-reduce-erosion-and-storm).

Activities that *enhance* the stability of a coastal bank and help prevent erosion from wind, rain, and stormwater runoff include the planting of vegetation. Small trees, shrubs, and grasses have root systems that structurally reinforce and bind soils, reducing their susceptibility to erosion from wind or rain. In addition, plants take up water directly from the ground, absorb water through their leaves, break the impact of raindrops or wave splash, and physically slow down the rate of water runoff, decreasing flows that can lead to erosion (see also the performance standard for planting vegetation on coastal banks on pages 3-50 through 3-51 for more information).

In areas where the stability of a bank has been diminished, it is extremely important to protect the remaining function of the bank as a vertical buffer. Any activities that cause adverse impacts by increasing erosion and/or destabilizing the bank should be avoided, which will be described in more detail in Chapter 3.

Below are photographs illustrating the two different types of coastal banks (or a combination thereof) and their functions.

Coastal Bank Serving as a Sediment Source and a Vertical Buffer	**Coastal Bank Serving as a Vertical Buffer**
	
Photograph 2.14. Coastal bank serving as a sediment source and a vertical buffer. This eroding coastal bank acts as a sediment source to the adjacent beach. This bank also functions as a vertical buffer due to its significant height.	Photograph 2.15. Coastal bank serving as a vertical buffer. This rocky coastal bank and seawall act as a vertical buffer to protect inland areas. The base flood elevation is below the top of the coastal bank (top of wall) and erosion of materials above the wall (or rocky bank) has not occurred. This bank therefore does not serve as a sediment source due to its inability to erode by wave action and does function as a vertical buffer—withstanding erosion from waves, wind, and rain.

Coastal Bank (with Riprap) Serving as a Sediment Source and a Vertical Buffer	Destabilized Coastal Bank
	
Photograph 2.16. Coastal bank (with riprap) serving as a sediment source and a vertical buffer. In spite of the riprap, this coastal bank does act as a sediment source to the adjacent beach, since wave activity can erode the bank. The bank can also function as a vertical buffer due to its height, and can withstand erosion from wind and rain because of the stabilizing vegetation.	Photograph 2.17. Destabilized coastal bank. The construction of, use of, and stormwater runoff from this pavement has contributed to erosion and destabilization of the top and face of the coastal bank, yet due to its significant height, this bank still acts as a vertical buffer. This bank also provides sediment to the adjacent beach.

Coastal Bank with Vertical Scarp

Photograph 2.18. Coastal bank with vertical scarp. The erosional scarp on the side of the bank indicates that this coastal bank is acting as a sediment source, while also maintaining its ability to act like a vertical buffer through its height.

Photographs 2.14-2.18. Coastal banks with various levels of alteration.

ROCKY INTERTIDAL SHORES

When reviewing a proposed project in rocky intertidal shores, Commissions must first review the presumptions of significance of rocky intertidal shores to the interests articulated in the WPA and determine the critical characteristics that function to protect these interests. This section will describe how to determine the significance of rocky intertidal shores to the storm damage prevention and flood control interests and how to assess the functions and characteristics that need to be protected by the performance standards (which will be described in Chapter 3).

Significance of Rocky Intertidal Shores to Storm Damage Prevention and Flood Control

The WPA Regulations at 310 CMR 10.31 state: "rocky intertidal shores are likely to be significant to storm damage prevention and flood control."[68] The project proponent bears the burden of demonstrating that either the rocky intertidal shore is not significant to the interests of the Act or that the proposed work will comply with the performance standards that protect those specified interests.

Characteristics and Functions of a Rocky Intertidal Shore

Before reviewing this section, please read the full language of the Rocky Intertidal Shore Preamble within the WPA Regulations (www.mass.gov/regulations/310-CMR-1000-wetlands-protection-act-regulations), which is the scientific basis for the Regulations. To aid Commissions with their review of the functions of rocky intertidal shores, this section highlights the critical characteristics, but it is not intended as a substitute for the Regulations.

The WPA Regulations at 310 CMR 10.31 state: "when a rocky intertidal shore is determined to be significant to storm damage prevention and flood control, the form and volume of exposed intertidal bedrock and boulders are critical to the protection of those interests."[69]

The following describes this characteristic and its importance for protecting the interests of storm damage prevention and flood control.

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[68]Rocky intertidal shores are also likely to be significant to the protection of marine fisheries and wildlife habitat, and where there are shellfish, protection of land containing shellfish—interests not covered in this guidance document. For further information on these interests, please visit the NHESP website at www.mass.gov/orgs/masswildlifes-natural-heritage-endangered-species-program for town maps of Estimated Habitats of Rare Wildlife, the DMF website at www.mass.gov/orgs/division-of-marine-fisheries for assistance with the identification of fisheries habitat, or the local shellfish warden and/or DMF to determine if land containing shellfish is present at or adjacent to the project site.

[69]When a rocky intertidal shore is significant to the protection of marine fisheries or wildlife habitat, the characteristics critical for protection of those interests are: water circulation and water quality. When the rocky intertidal shore is found to be significant to the protection of land containing shellfish and is, therefore, also significant to marine fisheries, the following factors are critical to the protection of those interests: (a) shellfish, (b) water quality, (c) water circulation, and (d) the natural relief, evaluation, or distribution of sediment grain size of such land.

Form and Volume of Exposed Intertidal Bedrock and Boulders - Rocky intertidal shores can function as barriers to flooding and are significant protection against coastal storms. Rocky intertidal shores may consist of large bedrock outcrops or incorporate a range of pebbles, cobbles, and rocks, provided boulders or bedrock outcroppings are present (to meet the WPA definition). Rocky shores may be exposed to high to moderate wave energy or may be sheltered, depending on shoreline orientation and exposure to the ocean. The exposed bedrock, boulders, and rocks can act to reflect wave energy or dissipate energy as waves and wave runup travel over their surfaces. Consequently, the form and volume of exposed intertidal bedrock and boulders is critical for the protection of storm damage prevention and flood control.

Factors Affecting Function of a Rocky Intertidal Shore

If the resource area meets the definition for rocky intertidal shore, the form and volume of exposed rock will likely function in some beneficial capacity to protect landward areas from storm damage and flooding. The size and form of exposed rock will determine the extent of this capacity, particularly in its ability to act as a barrier and to dissipate wave energy.

SALT MARSHES

When reviewing a proposed project in a salt marsh, Commissions must first review the presumptions of significance of salt marshes to the interests articulated in the WPA and determine the critical characteristic that function to protect these interests. This section will describe how to determine the significance of salt marshes to the storm damage prevention and flood control interests and how to assess the functions and characteristics that need to be protected by the performance standards (which will be described in Chapter 3).

Significance of Salt Marshes to Storm Damage Prevention

The WPA Regulations at 310 CMR 10.32 state: "salt marshes are likely to be significant to storm damage prevention."[70] The project proponent bears the burden of demonstrating that either the salt marsh is not significant to this interest of the Act or that the proposed work will comply with the performance standards that protect those specified interests.

Characteristics and Functions of a Salt Marsh

Before reviewing this section, please read the full language of the Salt Marsh Preamble within the WPA Regulations (www.mass.gov/regulations/310-CMR-1000-wetlands-protection-act-regulations), which is the scientific basis for the Regulations. To aid Commissions with their review of salt marsh functions, the following section highlights the two characteristics of salt marsh that are critical for storm damage prevention, but this is not intended as a substitute for the Regulations.

The WPA Regulations at 310 CMR 10.32 state that when a salt marsh is significant to the interest of storm damage prevention, the following characteristics are critical to the protection of such interest(s):[71]

a) The growth, composition, and distribution of salt marsh vegetation, and
b) The presence and depth of peat.

[70]Salt marshes are also significant to the prevention of pollution, the protection of marine fisheries and wildlife habitat, and where there are shellfish, to the protection of land containing shellfish; salt marshes are likely to be significant to ground water supply. For further information on these interests that are not covered within this guidance document, please visit the NHESP website at www.mass.gov/orgs/masswildlifes-natural-heritage-endangered-species-program for town maps of Estimated Habitats of Rare Wildlife; the DMF website at www.mass.gov/orgs/division-of-marine-fisheries for assistance with the identification of fisheries habitat; or the local shellfish warden or DMF to determine if land containing shellfish is present at or adjacent to the project site. In addition, CZM's *Guidelines for Barrier Beach Management in Massachusetts* at www.mass.gov/files/documents/2016/08/vh/barrier-beach-guidelines.pdf (PDF, 12 MB) provides management measures to protect wildlife habitat and fisheries, including spawning and nursery sites for fish.

[71]When a salt marsh is significant to the protection of marine fisheries, wildlife habitat, and prevention of pollution, the following characteristics are critical to the protection of such interests: (a) the growth, composition, and distribution of salt marsh vegetation and (b) the flow and level of tidal and fresh water. When a salt marsh is significant to ground water supply or the prevention of pollution, the characteristic critical for protection of such interests is the presence and depth of peat.

Growth, Composition, and Distribution of Salt Marsh Vegetation - The salt marsh vegetation provides a buffer that reduces wave energy and wave damage to inland areas. The roots and rhizomes of salt marsh vegetation, such as salt marsh cordgrass (*Spartina alterniflora*) and salt meadow cordgrass (*Spartina patens*), bind sediments together producing a sturdy substrate that is resistant to erosion from typical wave action. The vegetation is also able to slow waters and wave energy that runs over its surface. In addition, the marsh acts as a protective barrier against storm damage and flooding by absorbing flood waters before they reach uplands.

Presence and Depth of Peat - The underlying peat of the salt marsh is also resistant to erosion and can dissipate wave energy, thereby providing a buffer that reduces wave damage. In addition, the salt marsh vegetation—with its roots and rhizomes—traps sediments and provides organic material to the underlying peat, helping to build the height of the marsh to further protect inland areas from sea level rise and storm waves.

Therefore, the salt marsh vegetation and presence of peat are characteristics that are critical to the function of storm damage prevention.

Factors Affecting Function of a Salt Marsh

With few exceptions, all salt marshes function in some beneficial capacity to protect the interest of storm damage prevention. In general, if the salt marsh meets the regulatory definition, then it is able to function as a buffer and dissipate wave energy. Since the performance standards are not exclusive as they relate to the protection of the interests of storm damage prevention, marine fisheries, wildlife habitat, prevention of pollution, and groundwater supply—i.e., all salt marshes are afforded a high degree of protection regardless of how they function—it is not as critical to assess each specific function. Instead, the delineation of the salt marsh (as discussed in Chapter 1) will play a more critical role when it comes to applying the performance standards.

LAND SUBJECT TO COASTAL STORM FLOWAGE

Although the WPA Regulations do not specifically define presumptions of significance, functions, or performance standards for land subject to coastal storm flowage, Commissions should determine the significance of the resource area to the interests of storm damage prevention and flood control and assess the functions and characteristics that need to be protected. This section will describe how to make these findings and determine whether a project can meet the general criteria to protect the characteristics and functions of land subject to coastal storm flowage.

Significance of Land Subject to Coastal Storm Flowage to Storm Damage Prevention and Flood Control

Although the WPA Regulations do not specifically state that land subject to coastal storm flowage is significant to the interests of storm damage prevention and flood control, it is listed as an area subject to protection under the Regulations (10.02(1)(d)) and the Act (M.G.L. c. 131, § 40), and is provided with a definition: "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." In addition, the Regulations (10.03(5)) state: "Each area subject to protection…is presumed to be significant to one or more of the interests." Moreover, the 2014 amendments to the WPA Regulations include definitions for the special flood hazard area and velocity zone to specify that land subject to coastal storm flowage is a resource area with potentially significant flood and storm wave hazards that are relevant to the storm damage prevention and flood control interests.

Specifically, land subject to coastal storm flowage can:

- Slow down flood waters and allow them to flow across a natural landform surface, providing frictional resistance and reducing their energy and destruction potential.
- Allow flood waters to spread over a wide area without obstructions. (Obstructions can cause the channelization of flood waters and storm-wave overwash and an increase in the velocity and volume of flow to adjacent or landward areas.)
- Allow flood waters to be detained, absorbed into the ground, or evaporated into the atmosphere.
- Protect the land from storm erosion by providing a substrate for vegetation that helps to stabilize sediments and slow down flood waters.

Though the 100-year storm event (or surge or storm of record) is designated in the Regulations as the demarcation of the landward boundary of land subject to coastal storm flowage, lesser storm events that occur more frequently can be just as significant in moving and shifting sediment and playing a role in the function of underlying coastal resource areas. Flood zones in coastal areas are generally subject to repeated storm damage, which can result in loss of life and property, increasing public expenditures for storm recovery activities, taxpayer subsidies for flood insurance and disaster relief, and increased risks for personnel involved in emergency management. These more frequent events should therefore be recognized and taken into account when applying performance standards to protect the functions of the resource areas on the subject property and adjacent or landward properties.

Under the WPA Regulations, land subject to coastal storm flowage *can* be protected if it is determined significant to the interests of the Act—WPA Section 10.24(1) allows a Commission to determine that a resource area *is* significant to an interest for which no presumption is stated and impose conditions as necessary to contribute to the protection of such interests. Commissions should consider the following characteristic and functions that protect the storm damage prevention and flood control interests.

Characteristics and Functions of Land Subject to Coastal Storm Flowage

Where land subject to coastal storm flowage overlaps other coastal resource areas, it plays an important role in determining the delineation and function of these resource areas, specifically coastal beaches and dunes, barrier beaches, and coastal banks. For instance:

- The landward extent of the 100-year flood zone is figured into the delineation of the top of the coastal bank;
- Storm waves that erode a coastal bank help define the bank as a sediment source;
- The extent of wave (and wind activity) on a coastal dune helps establish the functions of the dune and how it should be protected.

Clearly, the relationship of coastal storm flowage with landforms and sediments is one of the major forces controlling the overall dynamics along the coast, and this interaction is a function that the WPA Regulations aim to protect.

Where areas delineated as land subject to coastal storm flowage do not overlap another coastal resource area or overlap another resource area with diminished functions (because of extensive alterations), they can still be significant for storm damage prevention and flood control. Particular physical characteristics of land subject to coastal storm flowage that are critical to the protection of the flood control and storm damage prevention interests include: the topography, slope, surface area, soil characteristics (i.e., composition, size, shape, and density of material), vegetation, erodability, and permeability of sediments. Topography, slope, and permeability, for instance, are critical for determining how effective an area is in dissipating wave energy, absorbing flood waters, and protecting areas within and landward of these zones from storm damage and flooding. Seaward-sloping land surface with lower slopes and greater permeability can more effectively reduce wave energy. Areas with sediments that erode and move allow wave energy to be expended and provide sources of sediments along the shore that can further buffer the effects of storms and flooding. In addition, areas that allow water and waves to percolate through the sediments and other porous surfaces are able to lessen the effects of backrush, scour, and erosion. For hydraulically constricted areas, such as A or AH Zones that are subject to ponding due to overwash (often in conjunction with heavy rainfall events) or areas with a pipe, culvert, dike, or other flow restriction, the ability of the area to store the flood waters will determine the level of flood impacts.

Factors Affecting Function of Land Subject to Coastal Storm Flowage

Within land subject to coastal storm flowage, there are a number of complex and inter-related factors that determine the wave height and the landward extent of wave run-up, including shoreline orientation, nearshore/offshore bathymetry, onshore topography, wave fetch, storm frequency and magnitude, and the presence of coastal engineering structures. These factors are important components of the delineation of the resource area that are discussed in detail on pages 1-67 through 1-89. These factors, in combination with a determination of the physical characteristics of the site, will also help determine the extent that the area is able to function to protect the storm damage prevention and flood control interests. The landforms must remain relatively free from alterations in order to function effectively to control and prevent storm damage and flooding. Where land subject to coastal storm flowage has been altered, the ability to reduce wave energy and slow flood waters may have been diminished. The functions of land subject to coastal storm flowage that have not been diminished should be protected. Frequently, projects proposed on developed areas within land subject to coastal storm flowage provide opportunities to improve existing storm damage and flood control functions, including reducing impervious areas, elevating buildings, removing landscape walls and curbing, and restoring vegetated areas.

Considerations for Project Review

Since performance standards are not currently defined in the WPA Regulations for land subject to coastal storm flowage, the section on land subject to coastal storm flowage in Chapter 3 does not include specific guidance. Nevertheless, when reviewing projects, Commissions should 1) presume that land subject to coastal storm flowage performs functions for the storm damage prevention and flood control interests, 2) consider whether the project adversely impacts these functions and interests, and 3) impose conditions to contribute to the protection of the interests. The following guidelines may help inform Commissions in their project review.

When Commissions determine that land subject to coastal storm flowage overlays other resource areas listed in the Regulations, the applicable performance standards for each resource area should be applied and the project should be appropriately conditioned to protect all stated interests.

When Commissions determine that land subject to coastal storm flowage does not overlay another resource area, Commissions should consider the impacts of the proposed project on the landform and whether the project increases the elevation or velocity of flood waters or increases flows due to a change in drainage or flow characteristics (e.g., change in direction) on the subject site, adjacent properties, or any public or private way.

The following projects may diminish the ability of land subject to coastal storm flowage to function to control flooding or prevent storm damage:

- **Projects that reduce vegetation and pervious areas** in the coastal floodplain may reduce the surfaces that can detain, absorb, slow, or evaporate flood waters, thereby changing the drainage characteristics in a manner that could cause increased flood damage on adjacent properties. See Photograph 2.19 on page 2-41 for an area that has the ability to detain and slow flood waters.

- **Buildings on solid foundations, slabs, and curbs and landscaping walls, fill, and other hard and impervious surfaces** may have the effect of channeling flood waters, which increases the velocity of flow to adjacent areas. These obstructions to water flow may also deflect, reflect, or redirect wave energy, overwash, and flood waters onto adjacent resource areas, properties, and private and public roads (see Photograph 2.20 on page 2-41).

- **Filling hydraulically restricted areas** with sediments or other materials could displace the area where flood waters would otherwise be confined or detained and increase flood levels on the subject and adjacent properties (see Photograph 2.21 on page 2-42). Hydraulically restricted areas include areas where ponding occurs from overwash or where pipes, culverts, dikes, or other physical restrictions limit water flow.

- **Coastal engineering structures in V Zones or Coastal A Zones** may deflect, reflect, and redirect storm waves, affecting adjacent properties, landward areas, and the subject property with wave energy, overwash, and flood waters (Photograph 2.22 on page 2-42). See the design requirements in the coastal banks section on pages 3-43 through 3-46, for methods for reducing these impacts.

- **Dredging or the removal of materials** within the coastal floodplain allows storm waves to break farther inland and to impact upland and wetland resource areas.

It is important to recognize that flood waters on coastal properties have the potential to cause substantial property damage and impacts to resource areas whether the waters eventually drain to the ocean or are detained or retained. Therefore, it is important that Commissions scrutinize activities in this resource area and carefully apply the relevant performance standards for other resource areas as they relate to the functions of land subject to coastal storm flowage, or where there are no other overlapping resource areas (that are functioning), apply best measures to maintain and improve the inherent functions of this landform for the interest of storm damage prevention and flood control for the subject and adjacent properties.

Below are photographs depicting the various functions of land subject to coastal storm flowage.

Land Subject to Coastal Storm Flowage with Ability to Detain and Slow Flood Waters

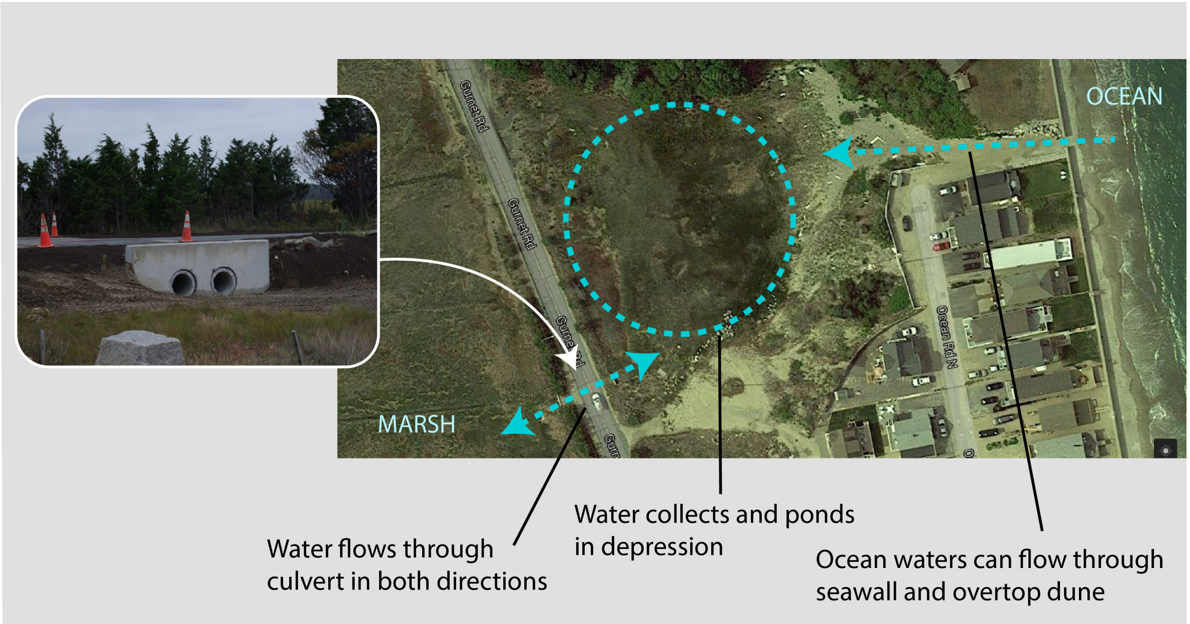
Photograph 2.19. Land subject to coastal storm flowage (and altered dune) with ability to detain and slow flood waters. Here, the area that is delineated as land subject to coastal storm flowage (consisting of gravel, portions of asphalt, and vegetation) has the ability to retain, collect, absorb, and slow water as evidenced by the extensive pool of storm-wave overwash and flood waters that collected after a storm event. If this area were to be developed with solid foundation walls, filled, or paved, the ability of the land to detain and slow the flood waters would be severely diminished, ultimately affecting adjacent properties. The photograph is taken looking toward the ocean (in distance).

Land Subject to Coastal Storm Flowage with Diminished Ability to Slow Flood Waters or Reduce Storm-Wave Overwash

Photograph 2.20. Land subject to coastal storm flowage with diminished ability to slow flood waters or reduce storm-wave overwash. The solid foundations and pavement in this area of land subject to coastal storm flowage has led to an increased velocity of storm-wave overwash and a channeling of flood waters toward landward areas.[72] In this picture, the ocean is behind the houses (that are on a developed and altered dune). In such an area where the dune has lost most of its ability to exchange sediment with the beach and dissipate wave energy, it is all the more important to protect the functions of land subject to coastal storm flowage. Photograph courtesy of Margo Clerkin, former Hull Conservation Agent.

[72]Though paved, the landward area still provides some function to dissipate energy and slow down water before it reaches residential/commercial structures.

Land Subject To Coastal Storm Flowage with a Hydraulically Restricted Area



Photograph 2.21. Hydraulically restricted portion of land subject to coastal storm flowage. Water flows into the depression between the dune and the road from both the ocean (over the dune) and from the marsh through the culvert. The only way for water to leave this depression is to flow through the culvert into the marsh, infiltrate into the ground, or evaporate.

Land Subject To Coastal Storm Flowage with Diminished Ability to Reduce Wave Energy

Photograph 2.22. Land subject to coastal storm flowage with diminished ability to reduce wave energy. Here, a coastal engineering structure deflects, reflects, and redirects storm waves, affecting adjacent properties, landward areas, and the subject property with wave energy, overwash, and flood waters. The pavement in this area of land subject to coastal storm flowage has also led to an increased velocity of storm-wave overwash and a channeling of flood waters toward landward areas.

Photographs 2.19-2.22. Land subject to coastal storm flowage with various levels of alteration.

Chapter 3 - Performance Standards and Project Review

Once the existing functions of the resource areas at a site have been evaluated, a Conservation Commission is equipped to review a proposed project and determine if it meets or can be conditioned to meet the performance standards that protect those functions.

The Wetlands Protection Act (WPA) Regulations specify particular performance standards to protect the existing functions of each resource area.[73] The performance standards are set up within the Regulations to require "no adverse effect" and/or to minimize adverse effects by using "best available measures" and "best practical measures." The WPA Regulations define an adverse effect as: "a greater than negligible change in the resource area or one of its characteristics or factors that diminishes the value of the resource area to one or more of the specific interests of (the Act), as determined by the issuing authority. 'Negligible' means small enough to be disregarded."

Commissions must make the determination of whether the project has an adverse effect. The determination is a judgment call based on the review of the site, an evaluation of all components of the project, and a determination of whether there is an overall diminishment of the value of the resource area to the interests—for purposes of this guidance document, storm damage prevention and flood control.

This chapter lists the performance standards that protect the interests of storm damage prevention and flood control for each resource area, followed by a more detailed explanation of the requirements for each performance standard.[74,75,76] For each resource area, examples of typical project activities, the potential adverse effects of these projects, and measures for minimizing the impacts (if any) to the critical functions of the resource area are also described. These examples can help inform Commissions when reviewing proposed projects with the same or similar impacts.

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[73]The Regulations do not specify performance standards for land subject to coastal storm flowage.

[74]The performance standards for other interests of the WPA, such as protection of wildlife habitat, marine fisheries, and land containing shellfish and the prevention of pollution, are not listed unless they also serve the storm damage prevention and flood control interests or as otherwise noted.

[75]The Commission should also be aware of the provision for Limited Projects, listed and described in the Regulations 310 CMR 10.24(7), allowing approval of particular projects with conditions without meeting all performance standards. In determining whether to approve the limited projects, the Commission shall consider the following factors: "the magnitude of the alteration and the significance of the project to the interests identified in M.G.L. c. 131, § 40, the availability of reasonable alternatives to the proposed activity, and the extent to which adverse impacts are minimized and the extent to which mitigation measures including replication or restoration are provided to contribute to the protection of the interests identified in M.G.L. c. 131, § 40. Adverse effects to be minimized include without limitation any adverse impacts on the relevant interests of M.G.L. c. 131, § 40, due to changes in wave action or sediment transport or adjacent coastal banks, coastal beaches, coastal dunes, salt marshes or barrier beaches."

[76]If a project meets the criteria for an Ecological Restoration Project or Ecological Restoration Limited Project, the Commission and applicant are advised to refer to the amended Regulations, sections 10.12, 10.13, 10.14, 10.24(8), (9), and (10) for further guidance. Some provisions, such as 10.13(1)(e), directly relate to the protection of the interests of flood control and storm damage prevention on the built environment (i.e., the project shall not result in a significant increase in flooding or storm damage affecting buildings, wells, septic systems, roads or other man-made structures or infrastructure).

Lastly, this chapter guides Commissions through the process of determining whether a proposed project meets the performance standards for each resource area. This section provides general informational requirements for project evaluation, as well as guidance on how to determine if the project meets the performance standards based on the site-specific functions of the resource area under review.

In sum, each section within this chapter will cover an individual WPA resource area that is significant to storm damage prevention and flood control (i.e., land under the ocean, Designated Port Areas, coastal beaches, coastal dunes, barrier beaches, coastal banks, rocky intertidal shores, salt marshes, and land subject to coastal storm flowage) and will include:

1) **The performance standards that protect the interests of storm damage prevention and flood control.**
2) **An interpretation of the requirements of each performance standard.**
3) **Typical project activities, their effects on each type of resource area, and methods to avoid or minimize any adverse effects.**
4) **Project evaluation—assessment of both the direct and indirect impacts of all components of work.**
5) **General review guidelines—a methodology to determine if a proposed project meets the performance standards for each type of resource area.**

LAND UNDER THE OCEAN

For a proposed project on land under the ocean, Commissions must evaluate whether the project meets or can be conditioned to meet the performance standards that protect the characteristics and functions of the land under the ocean (as described in Chapter 2).

Performance Standards for Land Under the Ocean

The following are the performance standards that serve the storm damage prevention and flood control interests of land under the ocean listed within the WPA Regulations[77] (unless otherwise noted):

310 CMR 10.25(3)[78]
"Improvement dredging for navigational purposes affecting land under the ocean shall be designed and carried out using the best available measures so as to minimize adverse effects on such interests caused by changes in:

a) bottom topography which will result in increased flooding or erosion caused by an increase in the height or velocity of waves impacting the shore; and
b) sediment transport processes which will increase flood or erosion hazards by affecting the natural replenishment of beaches…"

310 CMR 10.25(4)[79]
"Maintenance dredging for navigational purposes affecting land under the ocean shall be designed and carried out using the best available measures so as to minimize adverse effects on such interests caused by changes in marine productivity which will result from the suspension or transport of pollutants, increases in turbidity, the smothering of bottom organisms, the accumulation of pollutants by organisms, or the destruction of marine fisheries habitat or wildlife habitat."

310 CMR 10.25(5)
"Projects not included in 310 CMR 10.25(3) or 10.25(4) which affect nearshore areas of land under the ocean shall not cause adverse effects by altering the bottom topography so as to increase storm damage or erosion of coastal beaches, coastal banks, coastal dunes, or salt marshes."

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[77]The performance standards for other interests of the WPA, such as protection of land containing shellfish and marine fisheries, are not listed here unless they also serve the storm damage prevention and flood control interests.
[78]Other standards for improvement dredging listed in 10.25(3) (regarding water circulation and marine productivity) are designed to avoid adverse impacts on marine fisheries, shellfish, and wildlife and are therefore not listed here because they do not serve the storm damage prevention and flood control interests.
[79]Although 310 CMR 10.25(4) does not relate to the interests of storm damage prevention and flood control, it is listed here because Commissions do have the ability to make a finding that land under the ocean in a pre-existing dredged channel is significant to storm damage prevention and flood control (pursuant to 310 CMR 10.24(1)) and to apply the improvement dredging performance standards to maintenance dredging projects.

The following are the performance standards for the storm damage prevention and flood control interests of land under the ocean in Designated Port Areas listed within the WPA Regulations:

310 CMR 10.26(4)
"Projects shall be designed and constructed, using the best practical measures, so as to minimize adverse effects on storm damage prevention or flood control caused by changes in such land's ability to provide support for adjacent coastal banks or adjacent coastal engineering structures."

Interpreting the Performance Standards

This section provides information on interpreting the specific requirements of the performance standards for land under the ocean[80] and is divided into the four categories of projects that parallel the WPA performance standards articulated above:

310 CMR 10.25(3)(a) and (b) - Improvement Dredging

As required in 310 CMR 10.25(3)(a) and (b), proposed improvement dredging projects must be designed to *minimize* adverse effects caused by: 1) changes in bottom topography that will increase the height or velocity of waves impacting the shore, and 2) changes in the sediment transport processes that will affect the natural replenishment of beaches. More information about improvement dredging can be found below in "Typical Project Activities and Their Effects on Land Under the Ocean," which begins on page 3-5.

310 CMR 10.25(4) - Maintenance Dredging

The standards listed in the Regulations under 310 CMR 10.25(4) (and listed above) are only for protection of interests related to marine fisheries, wildlife habitat, and shellfish. The absence of language for protection of storm damage prevention and flood control interests under maintenance dredging means that these interests are not presumed significant for maintenance dredging projects. However, Commissions do have the ability to *make a finding* that land under the ocean in a pre-existing dredged channel *is significant* to storm damage prevention and flood control, pursuant to 310 CMR 10.24(1) (determining that a resource area is significant to an interest for which no presumption is stated and imposing conditions as are necessary to contribute to the protection of such interests). When land under the ocean is determined to be significant to storm damage prevention or flood control, the WPA Regulations state that the bottom topography of such land is critical to the protection of those interests. Therefore, the performance standards for improvement dredging (i.e., minimizing adverse effects caused by changes to the bottom topography and changes in sediment transport processes) should apply. In addition, the same performance standards for

[80] If a project meets the criteria for an Ecological Restoration Project or Ecological Restoration Limited Project, the Commission and applicant are advised to refer to the amended Regulations, sections 10.12, 10.13, 10.14, 10.24(8), (9), and (10) for further guidance.

improvement dredging should apply to maintenance dredging projects that *expand* or *enlarge* an existing dredged area and thereby change bottom topography and sediment transport processes.

310 CMR 10.25(5) - Projects Other than Maintenance or Improvement Dredging

The standard for review of non-dredging projects, as articulated in 310 CMR 10.25(5), requires that a project not cause adverse effects by altering the bottom topography so as to increase storm damage or erosion of coastal resource areas. Typical examples of proposed projects in the nearshore area of land under the ocean are listed on pages 3-5 through 3-8.

310 CMR 10.26(4) - Designated Port Areas

The performance standard for land under the ocean in Designated Port Areas as written in 310 CMR 10.26(4) differs because of the existing alterations to land under the ocean and other coastal resources and the nature and function of a port. Here the requirement is to protect the stability of coastal engineering structures and the functions they provide in protecting landward areas from storm damage and flooding.

Typical Project Activities and Their Effects on Land Under the Ocean

Below are examples of typical activities proposed within land under the ocean, potential impacts of these activities on the storm damage prevention and flood control interests, and measures that can be implemented to avoid or minimize adverse impacts to the critical functions of the area.

- **Dredging** projects that deepen the nearshore bottom may result in an increase in the height of waves impacting the shore. A channel may interrupt the sediment transport processes, thereby interrupting the natural nourishment of adjacent beaches. Dredging projects should be designed to minimize the depth and width of the channel. Whenever possible, the channel should be oriented away from the predominant storm wave direction to avoid focusing storm waves through the channel and into the harbor. When the channel is dredged, compatible sediments should be deposited on downdrift beaches to prevent a loss in the net sediment supply to these beaches. Maintenance dredging should not extend beyond the depth, width, or length of the original dredging project and should not fill in existing dredged areas.

- **Dredging nearshore areas for re-use of materials on a beach or dune** is often proposed to help protect buildings or landward areas from storm damage and flooding. However, maintaining sediment in the offshore will often be more beneficial for preventing storm damage and flooding than redistributing that material to build up a dune or bank. The removal of material from the nearshore will cause adverse impacts to the bottom topography by removing a source of sediment from the sediment transport system and allowing wave energy to travel farther landward. Because of these adverse impacts, dredging of the nearshore area for re-use will not likely meet the performance standards. Dredged material from other sources, such as maintenance of navigation channels, may be more appropriate (see "Re-use of dredged material" below).

- **Re-use of dredged material** (from such areas as channels or navigation ways) can be very beneficial if performed in a way that minimizes impacts and maximizes potential benefits.[81] Clean dredged material deposited in land under the ocean in the nearshore area will typically be redistributed by wave action and sediment transport processes, providing a beneficial sediment source to beaches, dunes, and other nearshore areas. The dredged material that is deposited in the nearshore area should be compatible with the beach, dune, and nearshore system because materials that are too fine grained may quickly erode and potentially smother nearby salt marsh, eelgrass, and shellfish beds. Re-use of dredged material on beaches or dunes can also be beneficial provided that the dredged sediments are compatible with existing beach and dune sediments and potential adverse impacts to the adjacent resource areas and sensitive habitats, including land containing shellfish and eelgrass beds, are minimized or avoided (see also performance standards for a coastal beach, which begins on page 3-13). Sediments that are not compatible can alter the way in which the system responds to wave energy and/or tides and can dramatically change sediment transport and wave dissipation patterns in the nearshore area. For more guidance, see *Beach Nourishment: MassDEP's Guide to Best Management Practices for Projects in Massachusetts, March 2007* (www.mass.gov/files/documents/2016/08/op/bchbod.pdf - PDF, 1.6 MB) and the technical attachments (www.mass.gov/files/documents/2016/08/uh/bchtech.pdf - PDF, 1.2 MB).

- **Shore-parallel coastal engineering structures, such as seawalls, bulkhead, and revetments** placed on or landward of land under the ocean may cause a reflection of wave energy, increase turbulent water flow, and interfere with the movement of sediments, potentially scouring and depleting sediments within areas of land under the ocean. This change in bottom topography may also increase the potential for erosion of coastal beaches, coastal banks, coastal dunes, or salt marshes. These projects are generally not permitted because of these adverse effects on bottom topography. The exception to this rule is where a structure is allowed on a coastal bank and its base lies on land under the ocean. In these circumstances the project should be designed so that the base of the structure is located as close as possible to the toe of the coastal bank (see also performance standards for coastal banks, which begins on page 3-38).

[81]The Conservation Commission will also need to consider impacts to other interests of the WPA, such as the protection of land containing shellfish, marine fisheries, and wildlife habitat (such as bird habitat), and to other coastal resource areas, such as adjacent salt marsh or coastal beaches. See *Beach Nourishment: MassDEP's Guide to Best Management Practices for Projects in Massachusetts, March 2007* (www.mass.gov/files/documents/2016/08/op/bchbod.pdf - PDF, 1.6 MB) for more information on designing a nourishment project to balance competing interests and protect resources.

- **In Designated Port Areas, coastal engineering structures, such as seawalls, bulkheads, and revetments** may be permitted provided they do not affect the ability of the area to provide support for adjacent coastal banks or adjacent coastal engineering structures. To minimize adverse effects on storm damage prevention and flood control, the placement or replacement of structures within Designated Port Areas should be designed and constructed so as to avoid excessive scouring of the adjacent land under the ocean, which would diminish the resource area's ability to provide support for the structure.

- **Groins and jetties, either offshore or shore-connected**, act as a barrier to longshore sediment transport and redirect and/or reflect waves. These structures can therefore cause a reduction in the volume of downdrift coastal beaches and deepen the nearshore land under the ocean, while also causing scour directly adjacent to them. Groins should only be allowed for beach nourishment projects and designed so that they are the minimum length and height demonstrated to be necessary to maintain beach form and volume and designed and constructed with rough, as opposed to smooth, faces to maximize energy dissipation and minimize reflected wave energy (e.g., no filling of spaces between the rocks with concrete or capping the top of the structure with concrete).. The groin should also be filled to entrapment capacity with sediment that is compatible with the beach sediment at the site. For jetties that trap littoral drift material, sand by-passing systems should be incorporated into the project to allow for the transfer of sediments to the downdrift side of the inlet. As an alternative, these areas could be periodically redredged to provide beach nourishment to ensure that downdrift or adjacent beaches are not starved of sediments. See performance standards for coastal beaches on pages 3-13 and 3-19 for additional requirements for solid fill coastal engineering structures.

- **Sediment bypassing**, which involves dredging and/or excavation of sediments that have accumulated on the updrift side of jetties at inlets and placement of this sediment as beach nourishment on the downdrift side of the inlet, may be permissible if the volume that is excavated is similar to the volume that is trapped by the jetty on a yearly basis and the excavation will not increase storm damage to properties landward of the excavation.

- **Sediment backpassing**, which involves dredging and/or excavation of sediments that have accumulated on the downdrift end of a sediment transport system and placement of this sediment as beach nourishment on the updrift beach and/or dune, may be permissible if sediment transport studies demonstrate that the excavation will not deprive downdrift areas of sediment moving alongshore and the excavation will not increase storm damage or flooding to landward areas.

- **Breakwaters**—structures constructed in the nearshore or offshore to protect coastal areas from the effects of waves and wave energy—may be permissible if they do not have an adverse effect on longshore sediment transport or wave patterns that would increase storm or flood damage landward or adjacent to the project. Breakwaters can be made of concrete, rock, or other structural components.

- **Offshore energy facilities**, such as wind turbines or other electric generation facilities, fossil fuel-related importation facilities, and their associated pipelines and transmission lines, may affect the bottom topography of land under the ocean depending on the size and extent of the project and the physical characteristics of the site. These offshore projects should be designed to avoid changes in wave energy, alterations in sediment transport processes, or reductions in the natural buffering capacity of the nearshore area. A geophysical survey showing topography and sediment characterization of the proposed site and an analysis showing any alterations in waves and sediment transport should be provided for review of potential project impacts. Additional analyses will be needed to assess habitat impacts.

- **Piers, docks, wharves, floats, and piles** may be permitted provided they are designed to avoid changing the bottom topography and the way the beach and nearshore system responds to wave energy. As described in *A Guide to Permitting Small Pile-Supported Docks and Piers, MassDEP* (www.mass.gov/files/documents/2016/08/st/smaldock.pdf - PDF, 789 KB), best management practices can be employed to avoid and/or minimize adverse effects. For instance, the project should be constructed so that piles are spaced to allow no impediment to water flow and wave activity. Rather than "jetting" (i.e., the use of high pressure hoses), the installation of the piles should be accomplished by "driving" (i.e., using weight to drive the pile into the ground) or by using helical or screw piles, since these methods of pile installation cause fewer disturbances to surrounding vegetation and bottom sediments. To avoid compaction of bottom sediments, work should be done from a floating platform, such as a barge. Where possible, the builder should work from completed sections of the pier/walkway. Construction should be performed during winter months when there are typically fewer adverse environmental impacts. Floats should rest at least 18 inches from the bottom, as measured at low tide, and should be removed during the off-season.

Project Evaluation

Commissions must evaluate each project on a case-by-case basis to ensure that the project will not have an adverse impact to the existing functions of land under the ocean.

The first step to evaluate the project is to assess both the direct and indirect impacts of all components of work, including:

- The site preparation activities, which may include dredging, filling, or grading.
- The type of project, such as whether it includes placement of solid structures, dredged materials, or construction of coastal engineering structures.

- Construction or alteration activities, including the type of equipment and machinery required to complete the project and how the work is to be accomplished.[82]
- A plan for operation and maintenance activities, such as for repairs to coastal engineering structures or for maintenance dredging activities, which may be necessary in the future.

Commissions should ensure that enough information has been supplied by the applicant to allow for a proper review.

General Review Guidelines

To meet the storm damage prevention and flood control performance standards for the nearshore area of land under the ocean, Commissions will need to make certain that the project and all components are designed to prevent or minimize changes to the bottom topography that could cause flooding or erosion of landward resource areas—either by decreasing the ability of the bottom topography to diminish wave energy before it reaches the shore, increasing the height and velocity of waves that do reach the shore, or changing sediment transport processes and the natural replenishment of beaches. Commissions may use their discretion in looking for opportunities to *mitigate or improve* existing conditions (primarily to landward resource areas) through activities such as beach nourishment. If a project's adverse impacts cannot be avoided, minimized, or mitigated, then a project must be denied.

[82]The Commission should also assess *when* the project activities will be taking place, as work may not commence during fish/shellfish spawning or nursery seasons.

DESIGNATED PORT AREAS

For a proposed project in a Designated Port Area (DPA), Commissions must evaluate whether the project meets or can be conditioned to meet the performance standards that protect the characteristics and functions of the Designated Port Area. As described in Chapter 2, only land under the ocean in a DPA is presumed significant to storm damage prevention and flood control; other resource areas in a DPA are not likely to be significant to these interests. The presumption of *non-significance* can be overcome by a clear showing (and written determination) by Commissions that these resource areas do play a role in storm damage prevention and flood control. Commissions should refer to other sections of this chapter for the relevant performance standards for any resource area that has been determined significant.

Performance Standards for Designated Port Areas

The following is the performance standard for the storm damage prevention and flood control interests of land under the ocean in Designated Port Areas as written within the WPA Regulations: [83, 84]

310 CMR 10.26(4)
"Projects shall be designed and constructed, using the best practical measures, so as to minimize, adverse effects on storm damage prevention or flood control caused by changes in such land's ability to provide support for adjacent coastal banks or adjacent coastal engineering structures."

Interpreting the Performance Standards

The following section provides information on interpreting the specific requirements of the WPA performance standard for Designated Port Areas listed above.

310 CMR 10.26(4) – Designated Port Areas

The performance standard for land under the ocean in a Designated Port Area differs from the performance standards for land under the ocean due to the nature and the function of a port area. Because existing alterations to land under the ocean and other coastal resources have diminished the capacity of the natural resources to prevent storm damage and flooding, it is the coastal engineering structures that offer this stability and function. The performance standard, therefore, requires minimizing changes in the ability of land under the ocean to provide support for adjacent coastal

[83]Performance standard 310 CMR 10.26(3) relating to adverse effects on marine fisheries is not listed here because it does not serve the storm damage prevention and flood control interests of the WPA.
[84]If a project meets the criteria for an Ecological Restoration Project or Ecological Restoration Limited Project, the Commission and applicant are advised to refer to the amended Regulations, sections 10.12, 10.13, 10.14, 10.24(8), (9), and (10) for further guidance.

banks or coastal engineering structures—thereby protecting their stability and the function they provide in protecting landward areas from storm damage and flooding.

Typical Project Activities and Their Effects on Land Under the Ocean in Designated Port Areas

Below are examples of typical activities proposed within land under the ocean in a Designated Port Area, along with the potential impacts of these activities and measures that can be implemented to minimize adverse impacts to the critical functions of the area.[85]

- **Coastal engineering structures, such as seawalls, bulkhead, and revetments**, may be permitted provided they do not affect the ability of the area to provide support for adjacent coastal banks or adjacent coastal engineering structures. To minimize adverse effects on the storm damage prevention and flood control interests, the placement or replacement of structures within Designated Port Areas should be designed and constructed so as to avoid excessive scouring of the adjacent land under the ocean, which would diminish the resource area's ability to provide support for the structure.

- **Piers, docks, wharves, floats, and piles** may be permitted provided they minimize adverse effects on the storm damage prevention and flood control interests of land under the ocean in the DPA. Whenever possible, they should be designed and constructed according to the standards for piers, docks, and piles (as described in the land under the ocean section on page 3-8) to avoid adversely changing the way the shore or port area responds to wave energy. Propeller scour from vessels can also affect the land's ability to provide support for structures, and therefore the docks, piers, and floats should be designed with enough water at low tide to accommodate vessels and avoid this adverse effect. See *A Guide to Permitting Small Pile-Supported Docks and Piers,* MassDEP (www.mass.gov/files/documents/2016/08/st/smaldock.pdf - PDF, 789 KB) for additional guidelines.

- **Dredging projects** are permitted provided they minimize changes to the bottom topography that may increase wave heights and increase their potential destructive energy in a port area. When improvement or maintenance dredging is proposed, the project should be designed to minimize dredging area and volume and when possible the channel should be oriented away from the predominant storm wave direction to avoid focusing storm wave energy through the channel and into the harbor.

[85] Since land under the ocean in Designated Port Areas is also likely to be significant to marine fisheries, these projects may require other design considerations to minimize adverse effects to this interest.

Project Evaluation and General Review Guidelines

Commissions must evaluate each project on a case-by-case basis to ensure that the project will not have an adverse impact to the existing functions of land under the ocean in a Designated Port Area.

In general, the performance standards allow support for coastal engineering structures and coastal banks to protect landward areas from storm damage and flooding. Likewise, projects such as piers and wharves are not discouraged since they are unlikely to have adverse effects on storm damage or flooding, and they are appropriate for a port location. Unless a project significantly increases the height and velocity of waves or changes sediment transport processes that would undermine the land's ability to provide this support, then it will likely meet performance standards. If a project's adverse impacts cannot be avoided, minimized, or mitigated, then a project must be denied.

COASTAL BEACHES

For a proposed project on a coastal beach, Commissions must evaluate whether the proposal meets or can be conditioned to meet the performance standards that protect the characteristics and functions of the beach (as described in Chapter 2).

Performance Standards for Coastal Beach

The following are the performance standards for the storm damage prevention and flood control interests of the coastal beach listed in the WPA Regulations:[86,87]

310 CMR 10.27(3)
"Any project on a coastal beach, except any project permitted under 310 CMR 10.30(3)(a),[88] shall not have an adverse effect by increasing erosion, decreasing the volume or changing the form of any such coastal beach or an adjacent or downdrift coastal beach."

310 CMR 10.27(4)
"Any groin, jetty, solid pier, or other such solid fill structure which will interfere with littoral drift, in addition to complying with 310 CMR 10.27(3), shall be constructed as follows:

a) It shall be the minimum length and height demonstrated to be necessary to maintain beach form and volume. In evaluating necessity, coastal engineering, physical oceanographic and/or coastal geologic information shall be considered.
b) Immediately after construction, any groin shall be filled to entrapment capacity in height and length with sediment of grain size compatible with that of the adjacent beach.
c) Jetties trapping littoral drift material shall contain a sand by-pass system to transfer sediments to the downdrift side of the inlet or shall be periodically redredged to provide beach nourishment to ensure that downdrift or adjacent beaches are not starved of sediments."

310 CMR 10.27(5)
"Notwithstanding 310 CMR 10.27(3), beach nourishment with clean sediment of a grain size compatible with that on the existing beach may be permitted."

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[86]The performance standards for other interests of the WPA, such as protection of wildlife habitat, marine fisheries, and land containing shellfish, are not listed here unless they also serve the storm damage prevention and flood control interests.
[87]If a project meets the criteria for an Ecological Restoration Project or Ecological Restoration Limited Project, the Commission and applicant are advised to refer to the amended Regulations, sections 10.12, 10.13, 10.14, 10.24(8), (9), and (10) for further guidance.
[88]310 CMR 10.30 (3)(a) prohibits new coastal engineering structures except when required to prevent storm damage to buildings constructed prior to August 10, 1978 (or constructed pursuant to a Notice of Intent filed prior to August 10, 1978), provided that the coastal engineering structure is designed and constructed to minimize, using best available measures, adverse effects on adjacent or nearby coastal beaches due to changes in wave action.

Interpreting the Performance Standards

The following section provides information on interpreting the specific requirements of the performance standards for coastal beaches. The section is divided into three categories of projects that parallel the WPA performance standards: 1) no adverse effect, 2) solid fill structures, and 3) beach nourishment.

310 CMR 10.27(3) - No Adverse Effect

Projects on coastal beaches must meet the performance standards by causing *none of the* adverse effects listed in 310 CMR 10.27(3) (with the exception of projects that are permitted under 310 CMR 10.30(3)(a), which specifies that coastal engineering structures built on coastal banks be designed and constructed to *minimize* adverse effects on adjacent or nearby coastal beaches due to changes in wave action[89]).

A project must specifically:

- **Not have an adverse effect by increasing erosion.** Activities that may increase erosion include those that change the way the beach responds to wave energy, such as construction of bulkheads or seawalls that reflect the waves and cause scouring of the beach sediments. Activities that inhibit longshore transport, such as jetties and groins, may also cause erosion by blocking sediment transport to the downdrift side of the structure over time and causing scour adjacent to the structure due to wave reflection. Stormwater discharges, such as where culverts daylight or where parking lots drain, may also cause erosion of a beach if not properly designed. All of these activities should be examined to determine if they have an adverse effect on the overall functions of the beach. More information about activities that potentially increase erosion and the measures for mitigating these adverse effects is provided in "Typical Project Activities and Their Effects on Coastal Beaches" on pages 3-15 through 3-20.

- **Not have an adverse effect by decreasing the volume or changing the form of any coastal beach or an adjacent or downdrift coastal beach.** Activities that decrease the volume and change the form (or shape) of a beach include grading, scraping and removing sediment, and placing structures that prevent natural shifting and movement of sediments and that change the overall shape and/or volume of the beach. If not properly designed, structures that inhibit transport of sediment to and from coastal beaches, such as seawalls and bulkheads, and those that inhibit longshore sediment transport, such as jetties and groins, may also have an adverse effect on the functions of the beach. More information

[89] These coastal engineering structures are allowed under very specific requirements that will be further described beginning on page 3-43 within the coastal banks section.

about activities that potentially decrease the volume and change the form of the beach and measures for mitigating these adverse effects is provided in "Typical Project Activities and Their Effects on Coastal Beaches" below.

310 CMR 10.27(4) - Solid Fill Structures

Groins, jetties, piers, and other similar solid fill coastal engineering structures must also not have an adverse effect as described in 310 CMR 10.27(3), as well as comply with the additional requirements provided in 310 CMR 10.27(4). These additional requirements are intended as mitigation measures for any adverse impacts that could not be avoided with construction of the project. Projects such as these are approved only with careful consideration and absolute necessity. See "Typical Project Activities and Their Effects on Coastal Beaches" below for further information.

310 CMR 10.27(5) - Beach Nourishment

Beach nourishment projects are allowed and can be considered beneficial changes to the form and volume of the beach, as long as compatible grain size sediments are used to avoid adverse impacts to adjacent resources.[90] When properly designed, nourishment or fill with compatible sediments will lead to an improvement in the way the beach responds to wave energy and enhance the ability of the beach to provide storm damage protection and flood control to landward areas.

Typical Project Activities and Their Effects on Coastal Beaches

Below are examples of typical project activities proposed on coastal beaches, along with the potential impacts of these activities and measures that can be implemented to minimize adverse impacts to the critical functions of the beach.

- **Scraping, grading, and raking** of the coastal beach changes the form and may remove sediment from the beach, thereby decreasing its ability to dissipate wave energy or provide sediment to other resource areas. In particular, bulldozing sand from the intertidal zone to the base of the dunes can cause increased erosion of the subject beach and adjacent beaches. Lowering the elevation of a beach and creating a steeper profile allows waves to break farther landward (as opposed to breaking farther seaward), causing increased potential for net erosion of the beach and storm damage to landward or adjacent areas (see Figure 3.1 on page 3-16). The volume of sand that is bulldozed landward is effectively taken out of the littoral (tidal) sediment transport system, depriving adjacent beach areas of sediment and compromising the level of flood control and storm damage prevention that these beaches

[90]The Conservation Commission will also need to consider impacts to other interests of the Act, such as the protection of land containing shellfish, marine fisheries, and wildlife habitat (such as bird habitat), and to other coastal resource areas, such as adjacent salt marsh or land under the ocean (e.g., eelgrass beds, shellfish habitat). See *Beach Nourishment: MassDEP's Guide to Best Management Practices for Projects in Massachusetts, March 2007* (www.mass.gov/files/documents/2016/08/op/bchbod.pdf - PDF, 1.6 MB) for more information on designing a beach nourishment project to balance competing interests and protect resources.

provide. In addition, the sediment placed on the dune is loose and more easily eroded by wind and waves, resulting in increased erosion of sediment from the system. For these reasons, grading operations should generally not be permitted, with the exception of moving sediment that has been deposited as the result of beach and/or dune nourishment activities supplied by an *offsite source*.

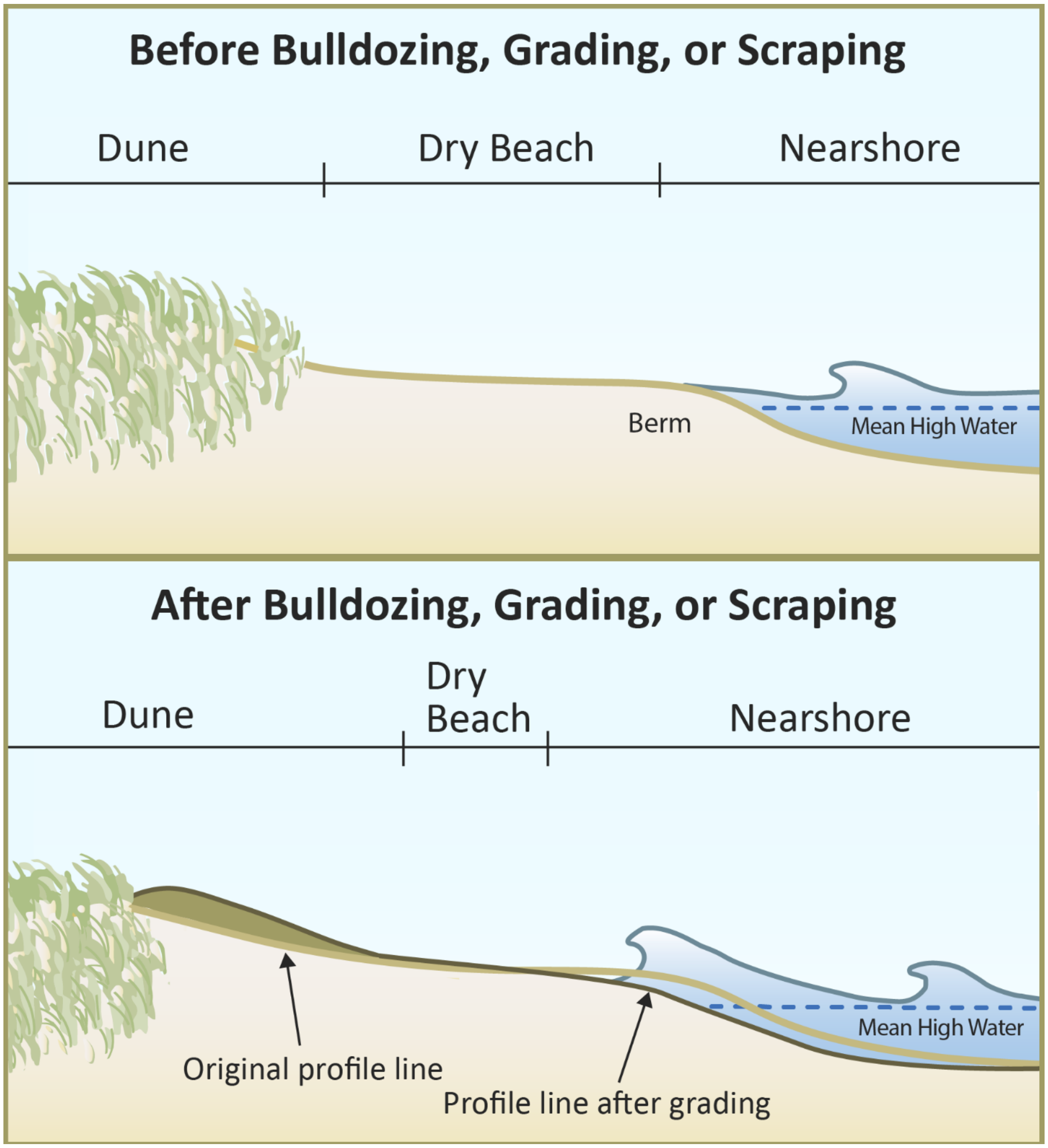

Figure 3.1. Beach and dune profiles—before and after bulldozing, grading, or scraping. The shallow slope of the beach and nearshore area in the top profile (before bulldozing, grading, or scraping) allows wave energy to be dissipated over a broad area before reaching the shore. Sediment is transported in a downdrift direction. The bottom profile depicts the beach and dune after sediments were bulldozed, graded, or scraped from the foreshore and berm of the beach to the dune (with the original profile line shown in comparison). These activities take sediment out of the littoral sediment transport system and create a lower foreshore area and a narrower beach with a steeper profile that allows waves to more easily reach the base of the dune. The steeper profile is also less effective in dissipating energy, resulting in more erosion of adjacent areas.

Because wrack material often becomes covered with sediment and helps to increase the elevation of the beach, extensive removal of wrack material may cause a significant amount of sediment to be removed, thereby changing the elevation and form of the beach.[91] To avoid impacts, the cleaning of coastal beaches with mechanized equipment, such as "beach sanitizers" or mechanical rakes, should generally be avoided. When this activity is determined essential for public health and safety, it should be accomplished in such a manner as to preserve the existing form, volume, and grain-size distribution of the beach. This may include removing raked material by hand, shaking out the sediment before wrack removal, burial on site, or other site-appropriate options to minimize impacts to the storm damage prevention and flood control interests. In addition, since wrack at the base of a dune serves as both a trap for sand and a source of seeds for new plant growth, removing wrack from this area may adversely affect the stability and development of the dune. Therefore, the dune should be avoided when raking or removing wrack material. For additional details, see CZM's *Managing Seaweed Accumulations on Recreational Beaches* (www.mass.gov/files/ documents/2018/06/29/seaweed-guidance.pdf) and *A Primer on Beach Raking* (www.capecodextension.org/wp-content/uploads/2016/04/BeachRaking Primer_FINAL.pdf) by Woods Hole Sea Grant Program and Barnstable County's Cape Cod Cooperative Extension.

- **Beach nourishment** with clean sediment of a grain size compatible with that on the existing beach may be allowed and encouraged under the Regulations. However, in order to be effective and minimize adverse effects to the resource areas, sediments from upland or offshore sources, beneficial re-use of clean dredge materials, or other beach nourishment sources should be compatible with the existing grain size and type on the beach, as well as be appropriately placed on the beach or nearshore area to mimic the typical adjacent beach profile conditions. When the proposed nourishment profile varies significantly from the existing profile, the material will adjust quickly as the beach system tries to re-establish a stable slope. For instance, when an overly steep profile is created by placing sediments above the mean high water line (often in an effort to simplify permitting), the sediment often erodes quickly and is deposited into the nearshore area or moves alongshore.

  If the sediments brought in are finer grained than the sediments on the existing beach, they may also erode rapidly and could smother nearby sensitive resource areas, such as salt marsh, eelgrass, shellfish beds, and endangered species habitat. If the existing beach is composed of gravel, pebble, and/or cobble material, the material used to nourish the site should be rounded instead of angular[92] to ensure that it will function to dissipate energy like the native beach materials. Commissions should therefore strive to maintain the existing conditions

[91] Removal of extensive amounts of wrack material may also deprive shorebirds of foraging habitat.

[92] Sand and gravel pits typically crush larger gravel, pebble, and cobble materials (which are rounded) to produce gravel (which are angular). However, these larger rounded materials may also be screened out and available upon special request.

(grain size distribution, grain shape, and general profile) of the beach as any changes have the potential to affect not only the project site, but adjacent beaches and nearshore areas.

When designing a beach nourishment project, the applicant or his/her consultant should fully consider the costs, sediment quality and quantity, and environmental implications of a "borrow source." Upland or offshore locations, or appropriate material from nearby dredging projects, may be feasible sources of sediment. If considering the use of material from a navigational dredging project, coordination with the dredge project applicant will be necessary. If considering a potential offshore location, the application should consult the Massachusetts Ocean Management Plan at www.mass.gov/service-details/massachusetts-ocean-management-plan. Nourishment projects can vary in scale and cost depending upon the level of storm damage protection desired. Commissions should review *Beach Nourishment: MassDEP's Guide to Best Management Practices for Projects in Massachusetts, March 2007* (www.mass.gov/files/documents/2016/08/op/bchbod.pdf - PDF, 1.6 MB) and the technical attachments (www.mass.gov/files/documents/2016/08/uh/bchtech.pdf - PDF, 1.2 MB) for detailed information on determining beach stability, characterizing "receiving beach" and source materials, and drafting beach monitoring plans. The Office of Coastal Zone Management (CZM) StormSmart Properties Fact Sheet 8: Beach Nourishment (www.mass.gov/service-details/stormsmart-properties-fact-sheet-8-beach-nourishment) provides additional guidance on beach nourishment practices.

- **New point source discharges**, such as pipes, ditches, channels, and conduits, may cause erosion and change the form and volume of a beach. Headwalls and supports may interrupt sediment transport and reflect wave energy. To prevent erosion and sedimentation, pipes and other conveyances must be properly designed, installed, and maintained. The use of level spreaders or other practices at the point of discharge can minimize erosion in some situations. In addition, the discharge should be appropriately treated to avoid impacts to water quality.[93]

- **New vertical seawalls, revetments, bulkheads, or other coastal engineering structures** can cause damage to the coastal beach, as they eliminate a sediment source and contribute to erosion seaward of the structure over time. Therefore, these projects should not be permitted unless coastal engineering structures are proposed on an eroding coastal bank where there are no other feasible alternatives to prevent storm damage to a building that was constructed prior to the effective date of the Regulations, August 10, 1978. In these circumstances, a sloping, rough-faced structure (instead of a flat-face) is strongly preferred to a vertical structure, because the sloped and rough-faced structure will better dissipate wave energy and cause less wave reflection and erosion of the coastal beach. To minimize impacts

[93] The *Massachusetts Stormwater Handbook* (www.mass.gov/guides/massachusetts-stormwater-handbook-and-stormwater-standards), or the Stormwater Management Standards that are now incorporated in the Wetlands Protection Act, can be referenced for more detailed information about recharging groundwater and preventing stormwater discharges from causing or contributing to the pollution of the surface waters and groundwaters of the Commonwealth.

to the coastal beach from wave reflection, grout or cement also should not be placed between the rocks of a revetment. The base of the structure must be located as close as possible to the toe of the existing coastal bank to avoid encroachment onto the beach and not be overly steep to minimize wave reflection. See performance standards for coastal banks on pages 3-43 through 3-46 for more information on the standards and the design requirements for coastal engineering structures and mitigation measures to avoid or minimize adverse impacts and the CZM StormSmart Properties Fact Sheet 7: Repair and Reconstruction of Seawalls and Revetments (www.mass.gov/service-details/stormsmart-properties-fact-sheet-7-repair-and-reconstruction-of-seawalls-and). Non-structural options, such as beach and dune nourishment, should be considered as an alternative to a coastal engineering structure, and at a minimum, as mitigation for the impacts from any permitted structure. See the CZM StormSmart Properties Fact Sheets series (www.mass.gov/service-details/stormsmart-properties) for more information on non-structural alternatives for shoreline management.

- **New piers or wharves** that cross over a coastal beach and extend into the water may be permitted provided that they are designed with piles adequately spaced and sized so as to minimize the effect of creating a barrier to longshore sediment transport and other adverse impacts to the volume and form of downdrift beaches. For more information on the proper design of docks and piers, see *A Guide to Permitting Small Pile-Supported Docks and Piers*, MassDEP (www.mass.gov/files/documents/2016/08/st/smaldock.pdf- PDF, 789 KB).

- **Groins and jetties, solid piers, or other shore-perpendicular solid fill structures** that extend into the water can adversely affect the volume and form of downdrift coastal beaches by creating a barrier to longshore sediment movement and by interfering with waves, which are the driving force of longshore sediment transport. These solid structures trap sediment on the updrift side while depriving the downdrift side. In addition, the structures reflect wave energy and cause rip currents leading to increased erosion of adjacent beaches. For these reasons, such projects should be critically evaluated and either not permitted, or at a minimum, designed to meet the strict performance standards. Both new and reconstructed or modified groins, jetties, solid piers, or other solid fill structures should be the minimum length and height necessary to maintain beach form and volume and designed and constructed with rough, as opposed to smooth, faces to maximize energy dissipation and minimize reflected wave energy (e.g., no filling of spaces between the rocks with concrete or capping the top of the structure with concrete). Immediately after construction, all groins should be filled to entrapment capacity with sediment of grain size compatible to the adjacent beach. The project should include a plan for monitoring the effects of the groin on adjacent beaches and other resource areas, maintenance of the fill to entrapment, and mitigation for any adverse effects. Where jetties are used, a sand by-pass system should be constructed to transfer sediments to the downdrift side of the inlet, or beach nourishment should be provided to ensure that downdrift or adjacent beaches are not starved of sediments.

- **Sediment bypassing**, which involves dredging and/or excavation of sediments that have accumulated on the updrift side of jetties at inlets and placement of this sediment as beach nourishment on the downdrift side of the inlet, may be permissible if the volume that is excavated is similar to the volume that is trapped by the jetty on a yearly basis and the excavation will not increase storm damage to properties landward of the excavation.

- **Sediment backpassing**, which involves dredging and/or excavation of sediments that have accumulated on the downdrift end of a sediment transport system and placement of this sediment as beach nourishment on the updrift beach and/or dune, may be permissible if sediment transport studies demonstrate that the excavation will not deprive downdrift areas of sediment moving alongshore and the excavation will not increase storm damage or flooding to landward areas.

- **Breakwaters**—structures constructed in the nearshore or offshore to protect coastal areas from the effects of waves and wave energy—may be permissible if they do not have an adverse effect on longshore sediment transport or wave patterns that would increase storm or flood damage landward or adjacent to the project. Breakwaters can be made of concrete, rock, or other structural components.

Project Evaluation

As described in Chapter 2, the coastal beach will always function in some capacity for the purposes of storm damage prevention and flood control. Consequently, the performance standards for avoiding adverse impacts will always apply. Commissions will need to gauge adverse effects by evaluating the project proposal, as well as the best available and best practical measures that can be incorporated into the project to meet performance standards.

The first step in evaluating the project is to assess both the direct and indirect impacts of all components of work, including:

- The types of activities associated with the site preparation, such as dredging, filling, grading, altering, and compacting soils and sediments.
- The impacts from the extent and type of construction on site (including docks, piers, cofferdams [a temporary structure designed to keep water and/or soil out], dewatering systems, and coastal engineering structures), as well as the construction activities associated with them (including type of equipment, access to the site, and modifications necessary for equipment access).

- Operation, monitoring, maintenance, and mitigation activities (such as sand bypass system operations, beach nourishment and revegetation monitoring, and routine seawall maintenance and repairs).
- If applicable, plans for decommissioning structures that are not permanent, restoration plans for impacted sites, and reporting requirements for monitoring and mitigation plans.

Commissions should require that the applicant submit enough information on all activities to warrant a proper review of impacts and measures for avoiding impacts.

General Review Guidelines

Commissions should make certain that the project and all components are designed to allow, at a minimum, *the same level of beach function* that currently exists, including:

- The same level of erosion and transport of sediments, and
- Protection of the volume and form of the beach and adjacent and downdrift beaches.

In general, the project should not adversely affect the way in which the beach responds to wave action. Commissions may use their discretion in looking for opportunities to *improve* existing beach conditions through activities, such as beach and/or dune nourishment, sand fencing designed to try to build up dunes, and vegetative planting to help dune development and stabilization, which will positively affect the beach.[94] If a project's adverse impacts cannot be avoided, minimized, or mitigated, then a project must be denied. See CZM's StormSmart Properties Fact Sheets 1-6 and 8 (at www.mass.gov/service-details/stormsmart-properties) for more information on where these options are appropriate, how to minimize impacts, and design considerations to maximize their effectiveness.

[94]If located in threatened or endangered species habitat identified by Natural Heritage and Endangered Species Program (NHESP), some of these activities may not be appropriate or will only be permitted with certain conditions, such as timing restrictions to avoid impacts to state-listed species and their habitats. Before doing any type of work in the beaches and dunes, check with NHESP or their most recent Priority Habitat and Estimated Habitat Maps, which are available online (www.mass.gov/service-details/regulatory-maps-priority-estimated-habitats) to determine if a project is in or near mapped endangered species habitat.

COASTAL DUNES

For a proposed project on a coastal dune, Commissions must evaluate whether the project meets or can be conditioned to meet the performance standards that protect the characteristics and functions of the coastal dune (as described in Chapter 2).

Performance Standards for Coastal Dune

The following are the performance standards for the storm damage prevention and flood control interests of the coastal dune listed in the WPA Regulations:[95, 96]

310 CMR 10.28(3)
"Any alteration of, or structure on, a coastal dune or within 100 feet of a coastal dune shall not have an adverse effect on the coastal dune by:

a) affecting the ability of waves to remove sand from the dune;
b) disturbing the vegetative cover so as to destabilize the dune;
c) causing any modification of the dune form that would increase the potential for storm or flood damage;
d) interfering with the landward or lateral movement of the dune;
e) causing removal of sand from the dune artificially; or
f) interfering with mapped or otherwise identified bird nesting habitat."[97]

310 CMR 10.28(4)
"Notwithstanding the provisions of 310 CMR 10.28(3), when a building already exists upon a coastal dune, a project accessory to the existing building may be permitted, provided that such work, using the best commercially available measures, minimizes the adverse effect on the coastal dune caused by the impacts listed in 310 CMR 10.28(3)(b) through 10.28(3)(e). Such an accessory project may include, but is not limited to, a small shed or a small parking area for residences. It shall not include coastal engineering structures."

310 CMR 10.28(5)
"The following projects may be permitted, provided that they adhere to the provisions of 310 CMR 10.28(3):

a) pedestrian walkways, designed to minimize the disturbance to the vegetative cover and traditional bird nesting habitat;

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[95]The performance standard 310 CMR 10.28(6), which relates to adverse effect on specified habitat sites of rare vertebrate or invertebrate species, is not listed here since it does not serve the storm damage prevention and flood control interests.
[96]If a project meets the criteria for an Ecological Restoration Project or Ecological Restoration Limited Project, the Commission and applicant are advised to refer to the amended Regulations, sections 10.12, 10.13, 10.14, 10.24(8), (9), and (10) for further guidance.
[97]Though 310 CMR 10.28 (3)(f) does not directly relate to the storm damage prevention or flood control interests of coastal dunes, it is listed here because many projects that are designed to minimize storm damage prevention and flood control may be incompatible with bird nesting habitat. It is important that all interests of the Act are taken into consideration when reviewing a project.

b) fencing and other devices designed to increase dune development; and
c) plantings compatible with the natural vegetative cover."

Interpreting the Performance Standards

This section describes each performance standard for coastal dunes by first elaborating on its requirements and then highlighting specific activities that are likely to cause the adverse effect described in that performance standard. The section is split into three basic categories of projects that parallel the three performance standards above: 1) new development and redevelopment, 2) accessory projects, and 3) beneficial projects permitted by the Regulations.

310 CMR 10.28(3) - New Development and Redevelopment

A project proponent must demonstrate that new projects, including additions, garages, and in-ground pools, meet the performance standards by proving that the proposed work *will not have an adverse effect* on the coastal dune by causing any impacts listed in 310 CMR 10.28(3)a-f.[98] These same standards apply to redevelopment projects that do not meet the definition of accessory projects as defined in 310 CMR 10.28(4). Below is a bulleted description of 310 CMR 10.28(3)a-f and how the requirements translate to new or redevelopment activities.

Any alteration of, or structure on, a coastal dune or within 100 feet of a coastal dune shall not have an adverse effect on the coastal dune by:

- **310 CMR 10.28(3)(a)** - **Affecting the ability of waves to remove sand from the dune**. A project should not affect the ability of the waves to remove sand from a dune. Activities that may affect this ability are those that limit or prevent the natural movement of a dune—such as paving, construction of new solid structures, or coastal engineering structures. The closer the project site is to wave energy or moving floodwater in a major coastal storm event, the more likely the project will impede erosion by waves and storm surge. A site in a back dune area, although farther away from recurrent wave energy, can still be eroded by wave activity in a major storm event, such as the 100-year frequency storm or even in smaller yet more

[98]In the matter of James E. Fox, (Phase II), Docket No. 80-2, Final Decision, March 30, 1984, the applicant sought permission to construct a septic system on a coastal dune on a barrier beach. Although the septic system was needed to serve a proposed new single family house, MassDEP issued a Superseding Order of Conditions denying the applicant permission to construct the septic system finding that it did not meet the applicable performance standards. The Hearing Officer concluded that the MassDEP denial was necessary to prevent construction that would weaken the dune system, impact the function of the entire stretch of barrier beach as a buffer against the full force of wave action, and be incompatible with the natural dune migration on the site. The Hearing Officer found that although the denial caused a substantial diminution in the value of the applicant's property, it did not so restrict the property as to prevent all practical use and constitute an unconstitutional taking. In the matter of Miltiades and PhyllisTzitzenikos, Office of Appeals and Dispute Resolution (OADR) Docket No. WET-2010-033, Recommended Final Decision, August 3, 2011, adopted by Final Decision, October 12, 2011, and affirmed by Essex Superior Court sub nom Tzitzenikos et al. v. Department of Environmental Protection et al., ESCV2011-02122-A, November 1, 2012, the Presiding Officer found that a preponderance of evidence shows that the project is located in a primary dune and that it will not comply with the applicable performance standards, because it will adversely affect the ability of the coastal dune and barrier beach to aid in storm damage prevention and flood control.

frequent storms. Despite this standard, the planting of vegetation is allowed and often encouraged as a natural mechanism to bind sand and reduce erosion.

- **310 CMR 10.28(3)(b)** - **Disturbing the vegetative cover so as to destabilize the dune**. A project should not disturb vegetative cover so as to destabilize a dune. Disturbances to vegetation include removal of the vegetation, as well as cutting and shading activities that cause mortality of the vegetation. Loss of vegetative cover leads to a loss of the root systems that help hold sediments in place and stabilize dunes. These disturbances are not allowed if they make the dune susceptible to blowouts or erosion by wind or waves. New development that will shade or remove and adversely affect vegetation in the primary dune will likely destabilize the dune—due to the intensity of wave (and wind) energy. New development that may shade or remove some vegetation in a dune *outside* land subject to coastal storm flowage is not as likely to destabilize the dune—because less wave action and floodwaters reach these areas.

- **310 CMR 10.28(3)(c)** - **Causing any modification of the dune form that would increase the potential for storm or flood damage.** A project should not cause any modification of the dune form that would increase the potential for storm or flood damage. Activities that can cause modification of the dune form that would increase storm or flood damage, whether they are within or beyond the floodplain, include such activities as grading, removal of sediment, construction of a solid foundation, retaining walls or curbing, solid fencing, placement of solid structures in the dune (e.g., swimming pools and gas tanks), paving (e.g., asphalt, pavers, porous pavement, bricks, cobblestones, and earth confinement systems), and hardening materials used for driveways and roadways (e.g., stone dust, lime, and dense grade). In particular, the form of the dune closest to the beach (i.e., the primary dune—where the most active erosion and reshaping occurs) should not be modified in a way that would increase the potential for storm damage and flooding. Changes to the form of a dune that improve its ability to provide storm damage protection and flood control, such as beach or dune nourishment projects, sand fencing, and plantings, are allowed with proper designs. How the dune form is managed and maintained over time makes a significant difference in a storm event; improper management or maintenance of dune form may significantly diminish the ability of the dune to provide storm damage protection and flood control functions. For additional beach and dune management and maintenance guidelines for all beaches and dunes, review the *Guidelines for Barrier Beach Management in Massachusetts,* Massachusetts Office of Coastal Zone Management (CZM) (www.mass.gov/files/documents/2016/08/vh/barrier-beach-guidelines.pdf - PDF, 12 MB). See CZM's StormSmart Properties Fact Sheets 1, 3, 6 and 8 (www.mass.gov/service-details/stormsmart-properties) for more details on successful implementation of these shoreline management techniques.

- **310 CMR 10.28(3)(d)** - **Interfering with the landward or lateral movement of the dune**. A project should not interfere with landward or lateral movement of a dune. What the

Regulations intend to avoid are impacts associated with activities like the building of new structures or paved roads within a coastal dune or barrier beach. Some types of structures that will impede or prevent landward or lateral movement of the dune include solid foundations, retaining walls, grade beams, footings, concrete slabs, coastal engineering structures, solid fences, sand bags, in-ground or above-ground pools, sheds or garages at grade, paving (see list in bullet above), and hardening materials (see list in bullet above). These activities would prevent the dune from shifting in response to wave or wind activity and may cause the need for future human manipulation of the dune to preserve the structure or roadway. These same projects may also prevent lateral movement of dune sediments. A new house on pilings that is built landward of the primary dune and that is not subject to wave energy, however, is not as likely to interfere with landward or lateral movement of a dune.

- **310 CMR 10.28(3)(e)** - **Causing removal of sand from the dune artificially**. A project should not cause artificial removal of sediment from a dune. Here, the Regulations are trying to avoid alterations or activities that would cause any direct or indirect reduction in the height and volume of the dune, such as through site preparation work, dune/beach grading activities, or even the construction of structures that create wind or wave scour and cause sediments to be removed from the dune. The artificial reduction in dune volume would consequently reduce the dune's ability to protect landward areas from storm waves and flooding and/or affect the ability of the dune to act as a sediment reservoir for the beach system.

- **310 CMR 10.28(3)(f)** - **Interfering with mapped or otherwise identified bird nesting habitat**. Though this standard relates to the interest of wildlife habitat, it is mentioned in this section because many projects that are designed to minimize storm damage and flooding may be *incompatible* with bird habitat, particularly if located in threatened or endangered species habitat. Before undertaking activities such as boardwalks and walkways to minimize disturbances to or enhance vegetative cover, or activities such as sand fencing and/or dune grass planting to increase dune development, check with the Natural Heritage and Endangered Species Program or their most recent Priority Habitat and Estimated Habitat Maps, which are available online (www.mass.gov/service-details/regulatory-maps-priority-estimated-habitats) to determine if a project is in or near mapped endangered species habit and if the project must be reviewed for Massachusetts Endangered Species Act compliance.

The standards for review of new projects on relatively undeveloped dunes are quite rigorous. Few projects—particularly those within the zone of high wind and wave energy—are able to meet the performance standards of no adverse effect.[99] A review of these types of projects, where the function and impacts are clear, is therefore fairly straightforward. A review of new development projects in previously altered areas or redevelopment projects, however, is often more challenging. As discussed in Chapter 2, the function of these dunes may be diminished and the effect of the proposed project on the continued functions of these dunes may not be as obvious. In many cases, developed areas often lose some ability to exchange sediment with the beach system, but are able to retain other storm damage protection and flood control functions to protect landward areas. The greater the degree of urbanization, the more compromised the functions. In these circumstances, project proponents and Commissions should consider the extent to which the dune is functioning and look for *opportunities to improve the function* of the altered area as a result of a project. If feasible, project proponents should remove or minimize impervious surfaces and replace them with pervious materials (e.g., gravel, pea stone, crushed shells, vegetation); remove at- or below-grade structures; remove foundations and support the structures on pilings; and not extensively expand existing development making conditions (or adverse effects) worse (see more in "Typical Project Activities and Their Effects on Coastal Dunes" on pages 3-27 through 3-34).

310 CMR 10.28(4) - Accessory Development

When a building already exists, the performance standards allow accessory projects if they *minimize the adverse effect* on the coastal dune caused by the impacts listed in 310 CMR 10.28(3)(b-e). However, the *no adverse effect* standard still applies under 310 CMR 10.28(3)(a), and therefore accessory development shall have *no* adverse effect on the ability of the waves to remove sand from a dune.

Projects that pave or otherwise harden the dune adversely affect the ability of waves to remove sand from the dune, and therefore are not allowed as accessory projects. To meet the requirement for accessory development, projects should be relatively small in size (such as a small deck), as implied by the language of the Regulations. The examples provided within the Regulations—a small shed or small parking area for residences—communicate that larger-scale projects, such as additions or complete reconstructions and enlargements of existing structures, should be considered new development or redevelopment, requiring the application of the no adverse effect standard.

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[99] In the matter of Stephen D. Peabody Trustee, Docket No. 2002-053, Final Decision, January 25, 2006, affirmed by Essex Superior Court sub nom Peabody v. Department of Environmental Protection ESCV 2006-00299, September 21, 2007, and affirmed by Massachusetts Appeals Court, No. 08-P-674, Memorandum and Order Pursuant to Rule 1:28, 82 Mass. App. Ct. 1120 (November 8, 2012), the applicant was denied permission to construct a single family house on pilings on an undeveloped area within a primary frontal dune on a barrier beach because it failed to meet performance standards. The loss of dune stability and related changes in form and volume from the project could not be mitigated by the planting of additional vegetation to promote dune growth in other areas at the site. In the matter of Miltiades and Phyllis Tzitzenikos, Office of Appeals and Dispute Resolution (OADR) Docket No.WET-2010-033, Recommended Final Decision, August 3, 2011, and affirmed by Essex Superior Court sub nom Tzitzenikos et al. v. Department of Environmental Protection et al., ESCV 2011-02122-A, November 1, 2012, the Presiding Officer found that a preponderance of evidence shows that the project is located in a primary dune and that it will not comply with the applicable performance standards because it will adversely affect the ability of the coastal dune and barrier beach to aid in storm damage prevention and flood control.

Redevelopment projects are not considered accessory projects. Commissions should review the above guidance for new development and redevelopment for further information.

310 CMR 10.28(5) - Projects Permitted by the Regulations

The third performance standard, 310 CMR 10.28(5), lists three smaller projects—pedestrian walkways, fencing and other devices, and plantings compatible with the natural vegetative cover—that may be permitted when they are designed to minimize disturbances to (or enhance) the vegetative cover or to increase dune formation. If carried out properly, these projects positively contribute to the function of the resource area. For more information about planting in dune areas, see the CZM StormSmart Properties Fact Sheet 3: Planting Vegetation to Reduce Erosion and Storm Damage (www.mass.gov/service-details/stormsmart-properties-fact-sheet-3-planting-vegetation-to-reduce-erosion-and-storm), the CZM Coastal Landscaping website (www.mass.gov/service-details/stormsmart-coasts-coastal-landscaping-in-massachusetts), and CZ-Tip: Dune Building with Beachgrass (www.mass.gov/service-details/cz-tip-dune-building-with-beachgrass). For techniques to ensure that fencing is designed to minimize potential adverse impacts, see CZM's StormSmart Properties Fact Sheet 6: Sand Fencing (www.mass.gov/service-details/stormsmart-properties-fact-sheet-6-sand-fencing). Also be sure to check with the Natural Heritage and Endangered Species Program (NHESP) to avoid impacts to threatened or endangered species habitat, as described above in 310 CMR 10.28(3)(f).

Typical Project Activities and Their Effects on Coastal Dunes

Below are examples of typical activities proposed on coastal dunes, along with the potential impacts of these activities and measures that can be implemented to avoid adverse impacts to the critical functions of the dune.

- **Construction of solid structures, such as building foundations/structures, walls, solid fences, and pavement** on a coastal dune can adversely impact all of the critical characteristics of a dune. In particular, these activities will adversely affect the dune's natural ability to change form and move laterally in response to wind and wave action, impede the ability of the dune to erode and supply sediment to the beach, and partially or completely destroy and/or shade vegetative cover. Therefore, new *solid* structures in a dune are highly unlikely to meet performance standards, particularly in the area of the dune subject to high wave energy. New structures, improvements or expansions of the building footprint, and complete reconstruction or replacement of buildings *may* be designed to meet performance standards if the building is placed on *open pilings*. However, new development in *primary dunes* is unlikely to meet the no adverse standard even if elevated on open pilings, due to shading and other impacts that disturb the vegetative cover and destabilize the dune (primarily where there is high wind and wave energy).[100] Although activities in secondary dunes are less likely to impact the flood control and storm damage interest of the Act, destabilization of secondary dunes by removal of vegetation or other alterations that increase flooding could occur and projects must be designed to avoid these impacts. Pilings that support structures and decks must be a minimum of 2 feet above the ground elevation and high enough—as determined by the discretion of the Commission—to allow for migration of the dune underneath, as well as meet elevation requirements pursuant to the Building Code.[101] Break-away walls are highly unlikely to be permitted (and lattice work around pilings is highly discouraged) because they cause shading impacts, hinder the natural movement of sediments, and become potential projectiles and a debris hazard in a storm events.

In these dynamic dune environments, appurtenances to new development—such as impervious driveways or parking areas or at- or below-grade structures—are highly unlikely to be permitted. The installation of pavers (even as a replacement for asphalt or pavement) is also discouraged on a dune, particularly a dune subject to high wind and wave activity. Pavers prohibit the movement of sediment, do not dissipate wave energy, and are likely to become projectiles in storm events. Therefore, pervious and *unconsolidated* materials, such as peastone, gravel, and crushed stone (without added hardeners), are a better option for new driveways or for replacing existing asphalt or pavement and improving the dune's ability to shift, move, and dissipate energy.

- **Accessory projects**, such as a small shed, small parking area, or deck, are permitted per 310 CMR 10.28(4), as long as they have no adverse effects on the ability of waves to remove sand from the dunes and they *minimize* the effects on the functions listed in 310 CMR 10.28(3)b-e. So as not to impede erosion, minimization measures may include limiting the size of accessory projects, elevating them above grade on open pilings, and prohibiting solid foundations.

- **The installation of a new septic system** in a primary coastal dune or other dune with high wave and wind activity is highly unlikely to meet performance standards. Septic system

[100]In the matter of Stephen D. Peabody Trustee, Docket No. 2002-053, Final Decision, January 25, 2006, affirmed by Essex Superior Court sub nom Peabody v. Department of Environmental Protection ESCV 2006-00299, September 21, 2007, and affirmed by Massachusetts Appeals Court, No. 08-P-674, Memorandum and Order Pursuant to Rule 1:28, 82 Mass. App. Ct. 1120 (November 8, 2012), the applicant was denied permission to construct a single family house on pilings on an undeveloped area within a primary frontal dune on a barrier beach because it failed to meet performance standards.

[101]The 8th Edition Massachusetts Basic Building Code (780 CMR) requires that the lowest horizontal structural member of proposed or substantially renovated buildings/structures in a high-hazard zone (V Zone) be elevated at least 2 feet above the base flood elevation (BFE) (called freeboard). The elevation requirement applies to construction projects located within the V Zone, including new buildings and all buildings undergoing substantial improvement or lateral additions, or buildings that suffer substantial damage or need substantial repair to the foundation. For Building Code purposes, the V Zone boundaries and BFEs are determined by reference to the effective FIRM. In addition, the Code requires that building permits only be issued when work in a coastal dune is permitted under the Wetlands Protection Act (WPA) by the local Conservation Commission and the specific requirements of the Order of Conditions, Order of Resource Area Delineation, Determination of Applicability, or Notice of Non-significance are met. Note that the WPA does not rely solely on the FIRMs for delineation of V Zones, A Zones, and BFEs, because the extent of land subject to coastal storm flowage may go beyond the 100-year floodplain as shown on the FIRM.

placement involves site stabilization (i.e., the system is permanently fixed within the ground), which would interfere with the landward or lateral movement of the dune. A new septic system would also impede erosion and destroy vegetation, activities that are not allowed under the performance standards. Title 5 contains additional prohibitions and criteria for septic systems in a velocity zone.[102]

- **The replacement or reconstruction of a septic system** in a primary coastal dune or other dune with high wave and wind activity may be allowed pursuant to 310 CMR 28(4) if the old system has been damaged, removed, destroyed, or has failed, or if the intent is to improve the conditions of groundwater supply, public water supply, and fisheries and shellfish habitat (e.g., a cesspool that is not failing but warrants an approved Title 5 system). Alternatives for placing the system landward of the primary dune should be assessed first. If there are no alternatives to placing the system landward of the primary dune, the system may be permitted in the dune.[103] The replacement or enlargement of a septic system (such as enlargement of the soil adsorption system/leach trench) should not be allowed in a primary dune if the intent is to increase the flow of the system to accommodate more bedrooms. Alternative systems, such as tight tanks, may be allowed for existing development only when no other feasible method is available (such as a failing system where there is no ability to provide a soil adsorption system). Because the placement of a tight tank in these cases may alter the natural migration of the dune, or cause deflection of wave energy and scour, the tank must be elevated above the area of highest wave action (on pilings or within the house; *not* elevated with fill).

- **New seawalls, revetments, bulkheads, and other coastal engineering structures** cannot be designed to prevent adverse effects on the ability of waves to remove sediment from the dune, and therefore these new structures do not meet performance standards.[104] If reconstructing or renovating existing structures, the project should be designed to: reduce the potential for reflection of wave energy (i.e., avoid vertical structures in areas of high wave energy—upgrade to sloping riprap); prevent end scour (e.g., by tapering ends and not extending the structure to the property line); and reduce encroachment of the base of the structure on the beach (i.e., position the base as far landward as possible without creating an

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[102]Title 5 of the State Environmental Code, 310 CMR 15.000, states that no (new) septic tank or humus/composting toilet shall be constructed in a velocity zone on a coastal beach, barrier beach, or dune, or in a regulatory floodway. Replacement or reconstruction may be allowed—see "replacement or reconstruction of a septic system." A soil absorption system is also prohibited in the velocity zone, unless very particular criteria have been met—see Title 5 for more details. For purposes of Title 5, the V Zone extends to the boundary as shown on the FIRM *or* the inland limit of the primary frontal dune, whichever is farther landward. Any septic systems installed in violation of this prohibition would not be entitled to the presumption that they adequately protect the interests identified in the Wetlands Protection Act.

[103]Title 5 allows replacement of a septic tank in existence on the site as of March 31, 1995, that has been damaged, removed, or destroyed, where placement of the tank outside of the velocity zone or regulatory floodway, either horizontally or vertically, is not feasible. The soil absorption system must also meet certain criteria to be allowed.

[104]See Nelson vs. Commonwealth, No. 92-P-827, Memorandum and Order Pursuant to Rule 1:28, 36 Mass. App. Ct. 1105 (February 28, 1994), where the court determined that the coastal regulations were scientifically based and that there was good reason to treat coastal dunes differently (impose more stringent restrictions) than coastal banks for purposes of installing a seawall.

overly steep face that may cause erosion of the beach). When a structure is replaced or substantially improved, beach nourishment is recommended to mitigate the adverse effects of the structure (i.e., reduction of a sediment source, reflection, and scour) and monitoring is recommended to assess any future impacts of the structure. See CZM's StormSmart Properties Fact Sheet 7: Repair and Reconstruction of Revetments and Seawalls (www.mass.gov/service-details/stormsmart-properties-fact-sheet-7-repair-and-reconstruction-of-seawalls-and) for more detail on reducing the impacts of coastal engineering structures. All factors relating to the cause of the erosion problem, such as upland runoff, should also be addressed. See CZM's StormSmart Properties Fact Sheet 2: Controlling Overland Runoff to Reduce Coastal Erosion (www.mass.gov/service-details/stormsmart-properties-fact-sheet-2-controlling-overland-runoff-to-reduce-coastal) for more detail. Applicants are encouraged to use erosion control vegetative plantings to stabilize the dunes (in lieu of hard coastal engineering structures, or at a minimum, in addition to them) within areas that are eroding. For more planting tips, see CZM's StormSmart Properties Fact Sheet 3: Planting Vegetation to Reduce Erosion and Storm Damage (www.mass.gov/service-details/stormsmart-properties-fact-sheet-3-planting-vegetation-to-reduce-erosion-and-storm). For more information on the requirements for coastal engineering structures, see pages 3-43 through 3-46.

- **Pedestrian walkways**, **boardwalks, and stairways** are allowed and encouraged by the Regulations, provided they minimize disturbances to the vegetative cover and protect bird nesting habitat. If designed properly, the presence of a walkway, boardwalk, or stairway (which is preferable to an at-grade pathway), defines and maintains pedestrian access in one location and discourages widespread trampling of the vegetation, thereby improving vegetative cover and the stability and form of the dune. However, to be beneficial to the dune resource area, boardwalks, walkways, and stairways must be designed appropriately and be constructed to a reasonable size. In general, construction of excessively wide boardwalks, walkways, or stairways on coastal dunes removes dune grass, increasing the potential of destabilizing the dune or creating a blow-out. In addition, if built excessively large, these elevated structures may interfere with the landward or lateral movement of the dune and may interfere with the ability of waves to remove sand from the dune.

  To minimize adverse impacts, walkways, boardwalks, and stairways on coastal dunes should be: 1) constructed no wider than 4 feet and elevated at least 2 feet above grade of the surrounding dune to prevent shading of vegetation and to allow the sediments to naturally migrate; 2) adjusted to allow for increasing the height of the dune as needed; 3) designed to minimize storm damage to the whole walkway; and 4) constructed at an angle to the dominant wind and wave direction to avoid creating a wind or wave tunnel through the dune (See Figure 3.2, Example A). To avoid making an excessively long boardwalk at that continued angle, a break in the angle can be constructed in an area that is close to the beach, yet more sheltered from the wind (see Figure 3.2, Example B). Where roll-out, at-grade boardwalks or sectional boardwalks are used, they should be removed during the off-season to reduce the potential for storm debris and to allow the dune to function unimpeded when the demand for beach access is reduced and wind-driven sediment transport is generally higher.[105]

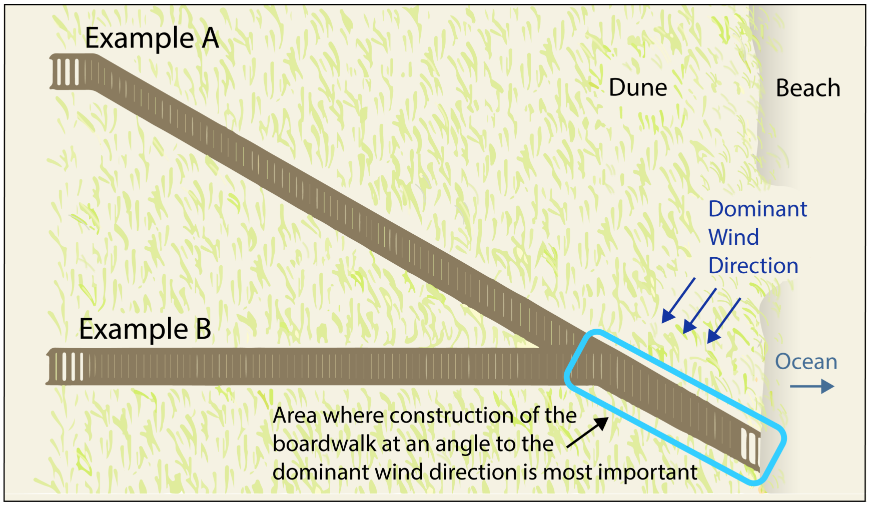

Figure 3.2. Boardwalks correctly constructed at an angle to the dominant wind direction. Example A indicates where the boardwalk would extend if it continued straight; Example B shows where the boardwalk would extend if it cut to the left and created a shorter overall distance (the break still being setback far enough from the wind).

- **Four-wheel drive vehicle trails** have the potential to compact dune sediments, destroy vegetation, destabilize dune form and function, and limit new dune formation. Where off-road vehicle use takes place or is proposed to take place, corridors should be designated and located to avoid sensitive resource areas, vegetated areas on coastal beaches and dunes, overwash areas, and areas with wildlife habitat (such as nesting shorebird areas). See the *Guidelines for Barrier Beach Management in Massachusetts,* CZM (www.mass.gov/files/documents/2016/08/vh/barrier-beach-guidelines.pdf- PDF, 12 MB) for detailed requirements for off-road vehicle use and management of trails.

- **Removal of sediment** from a coastal dune reduces the potential supply of sediment to coastal beaches, as well as the dune's capacity to function as a barrier to storm-wave overwash, and therefore should be avoided. Removal of sediment could also destroy vegetative cover, impairing the growth and stability of the dune. Removal of sediment that has *overwashed* from storm events may be detrimental to the overall beach and dune system—the overall volume of sediment in the system will be depleted. Commissions should discourage the removal or regrading of overwash areas and allow beach and dune systems to respond naturally to shoreline erosion and sea level rise, so as to preserve widths for recreation, storm damage protection, and flood control purposes (see "Scenario Two - The Importance of Protecting the Function of a Resource Area" beginning on page 4-16 for

[105]For more information on building boardwalks, see CZ-Tip: Basics of Building Beach Access Structures that Protect Dunes and Banks (www.mass.gov/service-details/cz-tip-basics-of-building-beach-access-structures-that-protect-dunes-and-banks).

more information about managing storm overwash materials on a public roadway on a barrier beach).

- **Dune nourishment** to increase the volume of the dune for storm damage protection is allowed and encouraged, provided the project is properly designed so that the ability of the beach and dune to respond to wave action and migrate landward and laterally is maintained. Sediments of compatible grain size or slightly coarser relative to those on the existing dune should be used; otherwise they may be rapidly destabilized and eroded to adjacent beaches or nearshore locations. Ideally, the grain size of the source material should be the same size or slightly coarser [106] than the native sediments to minimize erosion. The nourishment should consist of clean sediments and be placed in a way to minimize disturbances to vegetation (replanting and monitoring may be required to ensure proper revegetation). For more information, see CZM's StormSmart Properties Fact Sheet 1: Artificial Dunes and Dune Nourishment (www.mass.gov/service-details/stormsmart-properties-fact-sheet-1-artificial-dunes-and-dune-nourishment).

- **Dredged material** to be used for dune nourishment, from a nearby channel, for example, should also be compatible with dune sediments. Finer-grained sediments may otherwise erode more rapidly than the native dune sediments, resulting in the potential need for additional dredging and/or resulting in a plume of fine grained sediments being released by erosion or in a storm event and potentially smothering sensitive resources (e.g., eelgrass, shellfish beds, and salt marsh). For more information on identifying suitable sand for nourishment projects, see the *Best Management Practices for Beach Nourishment in Massachusetts, MassDEP,* available online at www.mass.gov/files/documents/2016/08/op/bchbod.pdf - PDF, 1.6 MB. If considering a potential offshore location, the applicant should consult the Massachusetts Ocean Management Plan at www.mass.gov/service-details/massachusetts-ocean-management-plan.

- **Fill materials** used in the yard and around new structures and driveways, such as for purposes of raising the grade of a site or for landscaping projects, must also be compatible with existing dune sediments to the maximum extent possible, be placed in a way that avoids channelizing floodwater onto adjacent properties, and placed in a manner that minimizes impacts to native dune vegetation. Where appropriate, the area covered with the fill should be re-vegetated with native vegetation.

- **Disturbance of vegetative cover** that would destabilize or lead to destabilization of the dune, such as through removal and shading of the vegetation, should be avoided. Disturbance of vegetative cover that does *not* destabilize the dunes is not necessarily an adverse effect. For instance, the construction of a new house landward of land subject to

[106] Larger or coarser materials may be used if they will not adversely affect the natural function of the beach, dune, or near shore resources, or cause adverse changes in the wave reflection or refraction. However, coarser material could affect recreational use and aesthetics.

coastal storm flowage that is elevated on open pilings with a minimally sized, unpaved driveway may *not* destabilize the dune; while construction of a house large enough that it covers and eliminates most of the vegetation on the lot or causes dieback *is very likely to* destabilize the dune. In addition, construction of a new house on a primary dune or in a high energy wave zone that disturbs the vegetative cover *will* likely destabilize the dune (even if constructed on pilings). Whether the particular project will disturb vegetative cover enough to cause destabilization of the dune will also depend on other site-specific factors, such as the extent of existing vegetative cover and existing alterations and development. Each of these factors needs to be taken into consideration when reviewing a project for adverse effects to the stability of the dune.

- **Scraping, grading, and raking** of coastal dunes are activities likely to destroy or damage dune vegetation and thereby destabilize the dune. These activities may also modify the dune form and decrease the dune volume, thereby increasing the potential for storm and flood damage. Grading sand from the beach to the dune is not generally permitted because this activity ultimately removes sand from the foreshore of the beach and allows wave energy from a storm event to be extended farther landward (see Figure 3.1 on page 3-16). Removal of wrack material from the beach or seaward face of the dune may also compromise dune formation and the propagation of vegetation. Therefore, grading and raking by mechanical means on the beach should be seaward of the edge of dune vegetation and permitted in a manner that preserves the form and volume of the beach (see "scraping, grading, and raking" of coastal beaches on page 3-15). All municipalities would benefit from the approval of town-wide beach management plans that prioritize the highest use areas and the timing for cleaning and wrack removal.[107] Removal of debris from dunes may be accomplished manually in such a manner as not to disturb dune volume, form, or vegetative cover or interfere with dune formation (e.g., by hand).

- **Sand fences** that are used to trap sand and maintain or enhance dune formation may be permitted because they are designed to improve the function of the resource area. Although fencing is beneficial year round for pedestrian control and protection of dunes, sand fences are most beneficial in the winter when public access is at a minimum and the movement of sand is at a maximum. Sand fences are not to be confused with privacy fences that are constructed around yards or properties, which are likely to have deleterious effects on the dune's ability to migrate and may artificially cause erosion of the dune. In addition, a type of sand fence known as sturdy drift fencing is not recommended. Typically used in areas subject to strong waves, sturdy drift fencing is often intended to break wave energy, rather than to capture blowing sand, and is constructed with more robust structural elements (e.g., nails and larger posts) than standard wire and slat fencing. Sturdy drift fencing can increase

[107]Since extensive removal of wrack material also deprives shorebirds of foraging habitat, recommendations for the timing and amount of wrack removal should be included in any plan. The Natural Heritage and Endangered Species Program (www.mass.gov/orgs/masswildlifes-natural-heritage-endangered-species-program) should be consulted when drafting the plan.

erosion issues since it acts as a physical barrier that interferes with the natural flow of sediment along the shoreline and causes a wind-tunnel effect that increases erosion of non-vegetated sediments landward of the fence. This type of fencing also increases marine debris impacts and threatens public safety when significant numbers of nails and posts are left on the beach after the fencing is damaged during storms. Like traditional sand fencing, sturdy drift fencing negatively impacts nesting areas for protected shorebird and turtle species. In most cases, therefore, thin wooden slat and twisted wire sand fencing is recommended over sturdy drift fence to trap sand. If sturdy drift fencing is used, methods for reducing the potential impacts and increasing the longevity and effectiveness of the project include: 1) installing the fencing far enough landward so that it will not be reached by tides or storm waves from regularly occurring storms (though they may still be affected by large storm events); 2) adding sediment with a similar or slightly coarser grain to the existing beach and/or dune when the fencing is installed to reduce impacts to natural sediment flow and enhance the longevity of the fencing; 3) periodically adding additional sediment to renourish the beach system; 4) labeling fence components and actively retrieving any debris generated by storm damage; 5) cutting notches in the boards at the bottom of the fence for animal access and avoiding use in nesting habitat for protected shorebirds and turtles. For more information, see CZM's StormSmart Properties Fact Sheet 6: Sand Fencing (www.mass.gov/service-details/stormsmart-properties-fact-sheet-6-sand-fencing).

Project Evaluation

Commissions must evaluate each proposed project on a case-by-case basis and *may not* permit a proposed project on a functioning dune if the performance standards are not met. As outlined above, the performance standards require a no adverse effect for new or redevelopment projects on a functioning dune. For proposed development in altered areas (with diminished function), there should be *no further loss* to any existing beneficial functions of the dune and there should be net improvement in function, such as enhancing the ability of the dune sediments to shift and move by removing impervious surfaces. For accessory development, adverse effects must be minimized. Commissions will need to gauge adverse effects by evaluating the project proposal, as well as the best available and best practical measures—including mitigation measures—that can be incorporated into the project to meet performance standards.

The first step to evaluate the project, therefore, is to assess the condition and function of the dune by looking at such factors as whether the dune is on a barrier beach, whether it is in the floodplain, the context of the dune to the surrounding area, the extent of existing vegetative cover, historic patterns of shoreline change, and existing alterations and development of the site (see Chapter 2 for more information about coastal dune function).

Once Commissions have determined the relevant functions that need to be protected, they should assess both the direct and indirect impacts of all components of work, including:

- The types of activities associated with the site preparation, such as removing vegetation, demolition of existing structures, dredging, filling, and altering form and shape.
- The impacts from the extent and type of construction on site (including the building structure, garages, driveways, walls, and coastal engineering structures), as well as the construction activities associated with them.
- Operation and maintenance activities that are associated with the particular components of the project, such as that needed for access-ways, driveways, parking areas, stormwater devices, and landscaping activities.

The applicant should provide as much information as is necessary on the nature and type of these activities to allow for proper review. If a Commission believes that the application data and information are inadequate, they may request additional information before or during the deliberation process. If after these requests, the information that is submitted by the applicant is still not sufficient to describe the site, the work, or the effect of the work on the interests, the Commission may issue an Order of Conditions prohibiting the work based on lack of information under 310 CMR 10.05(6)(c).

General Review Guidelines

Commissions should make certain that the project and all components are designed to allow, at a minimum, *the same level of dune function* that currently exists (and preferably some improvement in these functions), including the same:

- Rate of erosion.
- Degree of stability from vegetative cover.
- Ability of the dune form to protect against storm or flood damage.
- Rate of landward and lateral movement.
- Ability of the dune height, width, and volume to protect inland areas.

This general methodology can help Commissions determine how projects should be designed to avoid adverse impacts relative to the site-specific functions. See Chapter 2 for information on how function can vary based on exposure to wind and wave activity and existing alterations. Commissions should attempt to preserve those functions that are still viable. In addition, whether it is new development or redevelopment, the project should not make conditions worse; it is often possible to avoid, reduce, or minimize impacts through a variety of engineering and other measures, such as elevating structures onto open pilings without footings. Commissions may use their discretion in looking for opportunities to *improve* existing conditions through mitigation. In addition, if impacts occur, there may be opportunities for mitigation or compensation, such as beach nourishment or sand fencing. If a project's adverse impacts cannot be avoided, minimized, or mitigated, then the project must be denied.

BARRIER BEACHES

For a proposed project on a barrier beach, Commissions must evaluate whether the project meets or can be conditioned to meet the performance standards that protect the characteristics and functions of the barrier beach and its beaches and dunes (as described in Chapter 2).

Performance Standards for Barrier Beach

The following is the performance standard for the storm damage prevention and flood control interests of barrier beaches in the WPA Regulations:[108, 109]

310 CMR 10.29(3)[110]

"310 CMR 10.27(3) through 10.27(6) (coastal beaches) and 10.28(3) through 10.28(5) (coastal dunes) shall apply to the coastal beaches and to all coastal dunes which make up a barrier beach."

Interpreting the Performance Standards

The following will help Commissions understand the specific requirements of the WPA performance standard for barrier beaches listed above.

310 CMR 10.29(3) - Standards for Coastal Beaches and Coastal Dunes on Barrier Beaches

The barrier beach performance standard reiterates the standards for coastal beaches and coastal dunes, with the exception that they be applied to *all coastal dunes on the barrier beach*. A project proponent must demonstrate that the proposed work will not cause any adverse effects that are defined and described in the coastal beaches and coastal dunes sections, but with the added specification that *all* coastal dunes be subject to the same level of protection (due to their per se significance). For a proposed development on an unaltered barrier beach, this means no loss to any existing functions of the beach, which are described in Chapter 2 on pages 2-9 through 2-12, and no loss to any existing functions of any of the dunes, which are described in Chapter 2 on pages 2-13

[108] The performance standard 310 CMR 10.29(4), which relates to adverse effect on specified habitat sites of rare vertebrate or invertebrate species, is not listed here because it does not relate to the storm damage prevention and flood control interests.
[109] If a project meets the criteria for an Ecological Restoration Project or Ecological Restoration Limited Project, the Commission and applicant are advised to refer to the amended Regulations, sections 10.12, 10.13, 10.14, 10.24(8), (9), and (10) for further guidance.
[110] Performance standard 310 CMR 10.29(3) also protects the interests of marine fisheries and wildlife habitat.

through 2-23.[111] For a proposed development in an altered area of a barrier beach with diminished function, no adverse effects requires no further loss to any remaining functions of the beach and dunes.[112] Commissions should also review and apply the performance standards for other resource areas, such as salt marsh or freshwater wetland, if they are present on the site.

Typical Project Activities and Their Effects on Barrier Beaches

Refer to the performance standard sections for coastal beaches (beginning on page 3-13) and coastal dunes (beginning on page 3-22) for activities, potential impacts of these activities, and measures that can be implemented to minimize adverse impacts to the critical functions of the resource areas.

Project Evaluation and General Review Guidelines

As with beaches and dunes, each project on a barrier beach must be reviewed on an individual basis. Projects should be evaluated with the same considerations that were described in the sections for beaches and dunes.

Once a Commission has been given enough information to properly evaluate the project, the Commission should apply the guidelines for both beaches and dunes, with an added emphasis on *all dunes* within the barrier beach. Commissions should make certain that the project and all components are designed to allow, at a minimum, *the same level of beach, dune, and barrier beach functions* that currently exist (and would occur in a major storm event), including the ability of the landform to shift and change and maintain form and volume. A project should not worsen conditions; projects can provide opportunities for enhancement of the barrier beach functions, such as relocating or elevating structures, removing impervious surfaces, planting beach and dune vegetation,[113] and providing beneficial beach nourishment.

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[111]In the matter of Stephen D. Peabody Trustee, Docket No. 2002-053, Final Decision, January 25, 2006, affirmed by Essex Superior Court sub nom Peabody v. Department of Environmental Protection ESCV 2006-00299, September 21, 2007, and affirmed by Massachusetts Appeals Court, No. 08-P-674, Memorandum and Order Pursuant to Rule 1:28, 82 Mass. App. Ct. 1120 (November 8, 2012), the applicant was denied permission to construct a single family house on pilings on an undeveloped area within a primary dune on a barrier beach because the project would adversely affect the natural dune processes of changing form and moving laterally in response to wind and wave action. In the matter of Giles H. Dunn and Gail W. Dunn, Docket No. 89-072 Final Decision, September 10, 1996, the applicant was denied permission to build a new pile supported house and septic system on a primary dune and barrier beach on an undeveloped lot adjacent to an existing house. In the matter of James E. Fox, Docket No. 80-2, Final Decision (Phase II), March 30, 1984, the Hearing Officer determined that proposed construction of a new single family house and septic system on a coastal dune on a barrier beach, which did not meet the interests of the WPA and Coastal Regulations and was denied by MassDEP, did not constitute an unconstitutional taking of a private property. In the matter of Miltiades and Phyllis Tzitzenikos, Office of Appeals and Dispute Resolution (OADR) Docket No.WET-2010-033, Recommended Final Decision, August 3, 2011, adopted by Final Decision, October 12, 2011, and affirmed by Essex Superior Court sub nom Tzitzenikos et al. v. Department of Environmental Protection et al., ESCV2011-0122-A, November 1, 2012, the Presiding Officer found that a preponderance of evidence shows that the project is located in a primary dune and that it will not comply with the applicable performance standards, because it will adversely affect the ability of the coastal dune and barrier beach to aid in storm damage prevention and flood control.

[112]In the matter of Carol Henderson, Docket No. 2009-059, Recommended Final Decision, April 12, 2010, adopted by Final Decision April 27, 2010, the Presiding Officer concluded that the Wetlands Protection Act governs not only undeveloped resource areas, but resource areas that have been altered by human activity.

[113]Before planting vegetation in the beaches and dunes, check with NHESP or their most recent Priority Habitat and Estimated Habitat Maps, which are available online (www.mass.gov/service-details/regulatory-maps-priority-estimated-habitats), to determine if a project is in or near mapped endangered species habitat and whether it is subject to review under the Massachusetts Endangered Species Act.

COASTAL BANKS

For a proposed project on a coastal bank, Commissions must evaluate whether the project meets or can be conditioned to meet the performance standards that protect the characteristics and functions of the bank (as described in Chapter 2).

Performance Standards for Coastal Bank

The following are the performance standards for the storm damage prevention and flood control interests of the coastal bank.[114,115] The performance standards are listed separately for sediment-source banks and vertical-buffer banks.

Sediment-Source Banks

When a coastal bank is determined to be significant to storm damage prevention or flood control because it supplies sediment to coastal beaches, coastal dunes, or barrier beaches, 310 CMR 10.30(3) through (5) shall apply.

310 CMR 10.30(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 10.21 through 10.37 or constructed pursuant to a Notice of Intent filed prior to the effective date of 310 CMR 10.21 through 10.37 (August 10, 1978), including reconstructions of such buildings subsequent to the effective date of 310 CMR 10.21 through 10.37, provided that the following requirements are met:

(a) 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
(b) the applicant demonstrates that no method of protecting the building other than the proposed coastal engineering structure is feasible.
(c) protective planting designed to reduce erosion may be permitted."

310 CMR 10.30(4)
"Any project on a coastal bank or within 100 feet landward of the top of a coastal bank, other than a structure permitted by 310 CMR 10.30(3), 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."

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[114]The performance standard 310 CMR 10.30(8), which relates to adverse effect on specified habitat sites of rare vertebrate or invertebrate species, is not listed here because it does not relate to the storm damage prevention and flood control interests.
[115]If a project meets the criteria for an Ecological Restoration Project or Ecological Restoration Limited Project, the Commission and applicant are advised to refer to the amended Regulations, sections 10.12, 10.13, 10.14, 10.24(8), (9), and (10) for further guidance.

310 CMR 10.30(5)
"The Order of Conditions and the Certificate of Compliance for any new building within 100 feet landward of the top of a coastal bank permitted by the issuing authority under M.G.L. c. 131, §40 shall contain the specific condition: 310 CMR 10.30(3), promulgated under M.G.L. c. 131, §40, requires that no coastal engineering structure, such as a bulkhead, revetment, or seawall shall be permitted on an eroding bank at any time in the future to protect the project allowed by this Order of Conditions."

Vertical-Buffer Banks

When a coastal bank is determined to be significant to storm damage prevention or flood control because it is a vertical buffer to storm waters, 310 CMR 10.30(6) and (7) shall apply:

310 CMR 10.30(6)
"Any project on such a coastal bank or within 100 feet landward of the top of such coastal bank shall have no adverse effects on the stability of the coastal bank."

310 CMR 10.30(7)
"Bulkheads, revetments, seawalls, groins or other coastal engineering structures may be permitted on such a coastal bank except when such bank is significant to storm damage prevention or flood control because it supplies sediment to coastal beaches, coastal dunes, and barrier beaches."

Interpreting the Performance Standards

This section will describe each performance standard for coastal banks by first elaborating on its requirements and then highlighting specific activities that are likely to cause the adverse effect described in each performance standard. The section is split into two basic categories of projects according to the type of coastal bank specified above (and as identified in Chapter 2): 1) sediment-source banks and 2) vertical-buffer banks.

Sediment-Source Banks

The following information describes the details of the performance standards (for coastal engineering structures, general projects, and future condition in perpetuity) for coastal banks that serve as a sediment source.

- **310 CMR 10.30(3)** - **Coastal engineering structures**. New coastal engineering structures are not permitted on sediment-source coastal banks with very few exceptions. This standard does provide a mechanism for protecting existing buildings with coastal engineering structures under certain circumstances. Specifically, a building to be protected must have been built (or a Notice of Intent submitted) prior to the enactment of the Coastal

Regulations, 310 CMR 10.21 through 10.37 (August 10, 1978), and an applicant must demonstrate that there is no other feasible way to protect the building. Non-structural alternative approaches to reducing erosion and increasing storm damage protection are preferred, such as moving the building landward, eliminating the use of irrigation systems, regrading the land at the top of the bank to redirect stormwater landward, planting stabilizing vegetation on the top of or on the coastal bank, or bioengineering with natural biodegradable materials (e.g.., coconut fiber, jute; no rocks, wire mesh, or polysynthetic netting) to stabilize the bank face (see Photograph 3.1). (For more information about non-structural alternatives, see the CZM StormSmart Properties website at www.mass.gov/service-details/stormsmart-properties). If alternatives are not feasible, and all the other criteria have been met, the project must be designed and constructed to *minimize adverse effects* to adjacent or nearby beaches that occur from changes in wave action.[116] See pages 3-42 through 3-46 within "Typical Project Activities and Their Effects on Coastal Banks" for further guidelines and criteria on meeting this performance standard.

Photograph 3.1. Coconut fiber rolls used to stabilize the toe of a coastal bank. These rolls (some of which were wrapped in natural fiber blankets) were later covered with sand and planted .

- **310 CMR 10.30(4)** - **General projects**. A project proponent must demonstrate that proposed work will not have an adverse effect due to wave action on the movement of sediment from coastal banks to beaches and tidal areas. Activities that may affect this ability are those that limit or prevent the natural movement of sediment from a bank—such as construction of new solid structures (e.g., buildings) or coastal engineering structures (e.g., seawalls, revetments, bulkheads, and Geotubes® [large sandbags]). Although this provision aims to protect the natural movement of sediment, it does not allow for projects that destabilize the coastal bank and exacerbate erosion. The weight of new structures on a sediment source coastal bank may cause destabilization, and larger impervious surfaces may increase overland flows and redirect subsurface flows intensifying erosion. In general, new buildings should be located as far landward as possible (taking into account setbacks,

[116]In the matter of Helen Valovcin, Docket No. 97-028 Tentative Final Decision, March 12, 1998, Final Decision, September 29, 1998, the proposed plan did not meet the requirements of 310 CMR 10.30(3) because it failed to minimize, using best available measures, adverse effects on adjacent or nearby coastal beaches; the applicant was ultimately allowed to construct a revetment pursuant to a revised revetment plan that included design elements that satisfied the Regulations. In the matter of Scott Glass, Trustee of Hill and Dale Nominee Trust, Docket No. WET 2009-040, Recommended Final Decision, April 1, 2011, adopted by Final Decision April 26, 2011, the Presiding Officer determined that the revetment did not meet the performance standard because it was not necessary to protect the house. The Presiding Officer found that the house would not be vulnerable to damage from erosion of the coastal bank for many decades, perhaps as long as a century.

property boundaries, additional lots, and other requirements or restrictions) to avoid destabilizing the bank and causing erosion and to provide a setback for the structure from wind and wave damage, particularly during a storm. This is especially important when the relative position of the structure to the top of the coastal bank changes over time due to natural landward retreat *and* given that no new coastal engineering structures will be allowed to protect buildings constructed post-1978. See "Typical Project Activities and Their Effects on Coastal Banks" beginning on page 3-42 for other activities that may cause adverse effects on the movement of bank sediments.

- **310 CMR 10.30(5)** - **Future condition in perpetuity**. In order to make certain that *new coastal engineering structures are not allowed in the future for protection of any project approved under the Regulations*, Commissions *shall* insert a condition in an Order of Conditions and Certificate of Compliance that specifies that no coastal engineering structure, such as a bulkhead, revetment, or seawall, shall be permitted on an eroding bank at any time in the future to protect the project allowed by the Order of Conditions (see 310 CMR 10.30(5)). This should be a continuing condition that survives the issuance of the Certificate of Compliance. In addition, the Conservation Commission may request that the property owner place a conservation restriction on their property that would prohibit the construction of a coastal engineering structure.

Vertical-Buffer Banks

The following information describes the details of the performance standards (for general projects and coastal engineering structures) for coastal banks that serve as a vertical buffer.

- **310 CMR 10.30(6)** - **General projects**. A project proponent must demonstrate that the proposed work will not have an adverse effect on bank stability. The susceptibility of the bank to erode, collapse, or fail will depend on such factors as the type and proximity of the project to the top of bank, and the composition and characteristics of the bank. Activities that may adversely affect the stability of a coastal bank include those that exceed load-bearing capacities of the bank soils and cause bank failure or collapse (such as large structures on the top of the bank). Other activities, such as those that alter surface water or groundwater flow (e.g., diverting water flow toward a coastal bank and using lawn irrigation systems) can create saturated soils, scour, and gullies, and destabilize the top and face of the bank. Creating large impervious surfaces landward of the coastal bank that increase stormwater runoff may also increase erosion of the bank and decrease bank stability. Removing natural stabilizing vegetation to plant a lawn or improve views can reduce surface and groundwater uptake and disturbs soil. See "Typical Project Activities and Their Effects on Coastal Banks" for other activities that may cause adverse effects. Proposed activities should undergo the proper analysis to determine their short- and long-term effects on the stability of the coastal bank.

- **310 CMR 10.30(7)** - **Coastal engineering structures**. New coastal engineering structures may be allowed on coastal banks that *do not* provide sediment to other resource areas, as long as they are designed so that they do not have impacts on adjacent coastal banks and other resource areas. The impacts of such structures may include deflection of water and waves and reflection of energy onto adjacent beaches, banks, and areas; adverse impacts on groundwater and surface water runoff; and destabilization of the bank and adjacent banks. To protect bank stability, non-structural alternatives, such as coconut fiber rolls and plantings, are strongly preferred over structural alternatives (see Photograph 3.1 on page 3-40 for an example of coconut fiber rolls).

Typical Projects Activities and Their Effects on Coastal Banks

Examples of typical projects proposed on a coastal bank are listed below. Each project's potential adverse effects and measures for minimizing the impacts (if any) to the critical functions of the bank are described.

- **Construction of buildings** on or within 100 feet of the coastal bank has the potential to destabilize the bank by: disturbing vegetation, altering the rates and direction of runoff and flow of groundwater, adding weight that exceeds the bank capacity, and increasing human access that causes unnatural erosion of the coastal bank. If permitted, the buildings should be located as far landward as possible, should not remove or disturb native vegetation that provides stability or prevents erosion on or near the top of the coastal bank, should be designed to avoid any weight or water flow alterations that would cause slumping, landslides, or other slope failures, and should be constructed so that a coastal engineering structure will *not* be necessary to protect the building in the future, since this is prohibited by the Regulations. A septic system should be reviewed and sited carefully because these projects provide additional inputs of water to the soils, which can destabilize the bank sediments and make them more susceptible to increased rates of erosion. Irrigated lawns are discouraged because of these same impacts.

- **Pedestrian and vehicular traffic** that accompanies buildings can also damage the protective vegetation and/or lead to gully erosion or deep blowouts on unconsolidated banks. Traffic should be kept as far landward as possible, and if allowing access to the shoreline, projects should incorporate elevated walkways (see "elevated walkways, boardwalks, and stairways" on page 3-51) or other best management practices to minimize adverse impacts to the bank.

- **New coastal engineering structures, such as seawalls, bulkheads, revetments, and Geotubes® or other sand-filled synthetic bags/containers, on banks** that ***act as a sediment source*** can prevent the removal of sediments from the bank that supply the beach, dune, barrier beach, and nearshore systems. These structures may also reflect or deflect wave action, which may adversely alter the volume and form of adjacent and downdrift beaches and banks by increasing erosion. Over the long term, the loss of sediment to downdrift beaches is likely to result in beaches that are lower in elevation and less capable of providing protection from wave activity and storm surges. Since there are no methods of constructing new coastal engineering structures to *avoid* these effects, these structures are not permitted on a coastal bank that supplies sediments to adjacent beaches, dunes, or barrier beaches unless they meet the criteria for the exception listed below.

- **New coastal engineering structures on banks that *act as a sediment source* are allowed when they are required to prevent storm damage to a building that was constructed (or when a Notice of Intent application was filed) prior to the enactment of the Regulations (August 10, 1978)**. Since this performance standard is intended to "prevent storm damage" to a building, the applicant must prove the storm damage threat by documenting historic shoreline change in relation to the distance between the building and the top of the coastal bank. An alternatives analysis is also required to ensure that there are no other feasible methods of protecting the building other than the proposed coastal engineering structure and/or that the design of the structure will reduce or minimize adverse impacts (see list of design considerations below that minimize adverse impacts).[117]

  Once Commissions have determined that: 1) the resource is a coastal bank that provides sediment, 2) the coastal engineering structure (CES) is being proposed to protect a building constructed prior to August 1978, 3) there is indeed a storm damage threat to the building, and 4) there are no other methods to protect the building other than this structure (such as moving the building, bioengineering, artificial dunes or berms, or protective plantings), they may approve the construction of the structure with the following design considerations.

  - All sources of erosion, including stormwater runoff, should be identified and addressed as part of the project design to ensure the success and longevity of the structure.
  - Bioengineered products (e.g., coconut fiber rolls and natural fiber blankets in combination with deep-rooted plants) used to reduce erosion and provide bank stability should be considered in lieu of, or in combination with, the hard structure. These products should be accompanied by a monitoring and maintenance plan for long-term effectiveness. For details regarding these techniques, see CZM's StormSmart Properties Fact Sheets 1, 3, 4, 5, and 8 (www.mass.gov/service-details/stormsmart-properties).
  - The CES should be located as far landward as possible to minimize interaction with waves and tides and avoid the reflection of waves onto the beach and adjacent

[117] In the matter of Scott Glass, Trustee of Hill and Dale Nominee Trust, Docket No. WET 2009-040, Recommended Final Decision, April 1, 2011, adopted by Final Decision April 26, 2011, the Presiding Officer determined that the revetment did not meet the performance standard because it was not necessary to protect the house. The Presiding Officer found that the house would not be vulnerable to damage from erosion of the coastal bank for many decades, perhaps as long as a century.

resources. The CES should overlap onto the fronting coastal beach or land under the ocean only to the extent necessary to achieve structural stability and desired slope. The CES should not be located seaward of the existing bank face to reclaim eroded land.

- The CES should be sloping—sloping CESs dissipate wave energy more effectively than vertical structures and their shallow slopes reduce wave reflection that causes erosion and storm damage. Commissions will need to assess projects on a case-by-case basis to determine the appropriate slope based on site-specific conditions, including beach width and elevation, bank height, erosion rate, and wave energy. To limit erosion of fronting beaches and adjacent properties, the CES should have a slope no steeper than 1.5:1, but should also not extend farther seaward than the existing toe of the bank. To achieve a shallower slope without extending the structure farther seaward, the bank or other landform behind the CES can be regraded and the top of the structure moved landward. Though this landward extension results in a loss of ground surface between the CES and the dwelling or infrastructure behind it, the property will be better protected through the increased longevity of the CES and reduced erosion rates.
- Vertical concrete seawalls can be designed to have a curved face at the top of the structure, which can help direct some of the reflected water and waves out and away from the wall. An uncurved vertical seawall reflects the water straight down and straight up. The wave energy that is reflected downward erodes the beach, while the wave energy that goes straight up can cause erosion behind the wall and potential damage to the development being protected.
- The height of the CES should be considered carefully in light of the additional erosion that may be caused. The higher the seawall or revetment, the more surface area there is to reflect wave energy. The design height of seawalls and revetments is typically determined by balancing the desired level of protection to landward areas with construction costs and the need to minimize erosion of the fronting beach, which can compromise the structure in the future. For sites with high banks, the bank itself also serves as a vertical buffer to waves and storm surge. Rather than increasing the height of the structure in these areas, efforts can be made to stabilize the upper bank using vegetation, natural fiber blankets, and/or coir rolls. Other techniques, including maintaining the level of the fronting beach to dissipate waves before they reach the wall, can also reduce the height of the structure needed.
- The face of the revetments and other sloping CESs should be rough, as opposed to flat and smooth, to maximize energy dissipation and minimize reflected wave energy. In addition, no grout (e.g., cement) should be used in between the rocks in revetments because it creates a smooth surface. Chinking (filling gaps with stones) should also only be done to the extent needed to structurally stabilize the revetment. Filling every void with small stones should be avoided because it reduces wave dissipation and the small stones can become projectiles in a storm.

- The CES should follow the natural shape of the shoreline without any segments extending seaward from the main structure. Portions of the CES that extend out have the potential to refocus wave energy, which exacerbates erosion of the beach and reduces the longevity of the structure.
- Every effort should be made to align the ends of the CES with those on neighboring properties. The CES should be pulled landward of other structures where possible and should not extend farther seaward than those on adjacent properties.
- Applicants should mitigate for any end effects of the proposed CES. For instance, unless connecting to an existing CES on an adjacent property, the proposed CES should terminate approximately 15-20' from the neighboring property lines (where feasible and where adequately protective of the pre-1978 building) to ensure that any end effects caused by the structure shall occur primarily on the applicant's property rather than on the adjacent property. The ends of the CES should be tapered in elevation and slope to avoid wave energy reflection onto adjacent resource areas. Natural fiber blankets, coir rolls, artificial dunes, beach nourishment and vegetation can be used at the end of a structure to reduce the end effects, while still providing protection to buildings.
- During construction, access for heavy equipment must be carefully planned to avoid destruction of existing vegetation; creation of ruts; destabilization of banks, dunes, or other landforms; and related impacts. To the extent possible, heavy equipment operators should avoid running over beaches multiple times, which can compact sediments and prevent them from moving and shifting to effectively dissipate wave energy.
- To minimize erosion during construction, hay bales, natural fiber blankets, or other erosion-control techniques should be used during construction and up to the time vegetation takes hold or becomes established.
- Destroyed or damaged vegetation should be replaced after the structure has been completed. If the vegetation consists of invasive species, weeds, or large trees that cause destabilization to the top of the coastal bank, the vegetation may be replaced with native grasses and/or shrubs (see detailed information about selective removal of invasive vegetation beginning on page 3-48).
- The project should include a monitoring and mitigation plan to compensate for any impacts of the structure on the fronting and adjacent beach and coastal banks for the life of the structure (e.g., reflected wave energy that increases erosion).
- To mitigate for the structure and the elimination of a sediment source for the beach, the project should include a provision that compatible sediment be added on a periodic basis to ensure that the form and volume of the beaches are not adversely affected. The minimum volume required should be based on the historic shoreline erosion rate or more recent erosion rate (available from sources, such as the CZM Shoreline Change Project at www.mass.gov/service-details/massachusetts-shoreline-

change-project).[118] The minimum volume required is typically calculated by multiplying the height of the bank, the length of the project and the erosion rate. Monitoring the beach after nourishment to document erosion and the need for further mitigation are also recommended. Additional sediment nourishment may be needed to maintain the level of the beach seaward of the structure, as natural ongoing shoreline erosion continues and wave reflection lowers the beach over time. Maintaining the beach elevation in front of the structure will increase its longevity and maintain the ability of the beach and nearshore to dissipate waves before they reach the structure, reducing overtopping. For an example of beach nourishment requirements to mitigate for armoring a coastal bank, see pages 4-43 through 4-45.

- Where beach nourishment or any other mitigation provisions are required, the conditions should be noted on the Order of Conditions and be extended to the Certificate of Compliance as conditions in perpetuity.
- Design considerations for sensitive habitats must also be considered.[119]

Commissions should also be aware that new revetments or other coastal engineering structures are not allowed on coastal dunes, and therefore the delineation of the resource area should be reconfirmed. This is particularly important where there are both coastal dune (glacial deposits reworked and sorted by water or wind) and coastal bank sediments (relatively unsorted glacial deposits) present (see Photograph 3.2 on page 3-47 for an example). To determine if a coastal engineering structure is allowed on eroding shorelines where there are coastal dune sediments *and* coastal bank sediments overlying each other, the proponents must first assess the percent of coastal dune and percent of coastal bank sediments that are present between the surface of the landform and the mean high water line. For purposes of evaluating proposed revetments, MassDEP generally defines a coastal bank as any elevated landform composed of sediment deposited as a result of glacial processes. If the subsurface sediments consist of 50 percent or greater *windblown or storm-overwash deposits* (measured from above the mean high water elevation to the top of the landform), then the resource is considered a dune and a revetment is *not allowed* in this resource area.[120] Sometimes there is a veneer of wind-blown sediment or slumped glacial material on the face of a landform, warranting sub-surface investigations to determine the

[118]Whether a long- or short-term rate is used will depend on which best represents the current trends of the site. Both the long- and short-term rates must be analyzed and evaluated in light of current shoreline conditions, the effects of human-induced alterations to natural shoreline movements, and whether the shoreline fluctuates between erosion and accretion. In no case should the long-term shoreline change rate be used exclusively before the short-term rates and contributing factors are understood and assessed. See the Massachusetts Shoreline Change Project (www.mass.gov/service-details/massachusetts-shoreline-change-project) for more information about interpreting the shoreline change rates.

[119]Projects must be designed to reduce the amount of wave reflection and erosion and prevent changes to sediment levels in the beach system, which can lead to loss of habitat for shorebirds and other species. In addition, restrictions on the time of year when repair or reconstruction can be conducted may be required to avoid impacts to protected species. The Natural Heritage and Endangered Species Program of the Massachusetts Division of Fisheries and Wildlife (https://www.mass.gov/orgs/masswildlifes-natural-heritage-endangered-species-program) can be contacted for additional information. In addition, projects proposed near horseshoe crab spawning areas should not be conducted during the spawning season from May through July. The Massachusetts Division of Marine Fisheries Habitat Program can provide additional information on horseshoe crab protection (www.mass.gov/fisheries-habitat-restoration-and-monitoring).

[120]This guidance is derived from a MassDEP technical assistance letter to the Town of Chatham, dated December 22, 1988.

landform's origin.[121] See pages 1-24 through 1-26 for more information on distinguishing between wave/wind-blown sediments and glacial sediments.

Commissions and applicants are encouraged to consult CZM's StormSmart Properties Fact Sheet 7: Repair and Reconstruction of Revetments and Seawalls (www.mass.gov/service-details/stormsmart-properties-fact-sheet-7-repair-and-reconstruction-of-seawalls-and) and Fact Sheet 8: Beach Nourishment (www.mass.gov/service-details/stormsmart-properties-fact-sheet-8-beach-nourishment) for additional guidance on these topics.

Photograph 3.2. Coastal dune sediments overlying glacial coastal bank sediments on an eroded landform.

- **New coastal engineering structures, such as seawalls, bulkheads, and revetments on banks that *act as a vertical buffer*** may be permitted provided that the coastal bank does not contribute any sediment to coastal beaches, dunes, or barrier beaches and that the structures are designed to avoid adverse effects to the bank and adjacent resource areas. Such structures may deflect water and waves; reflect energy onto adjacent, unprotected coastal banks or beaches; and cause erosion and bank destabilization. These structures may also prevent groundwater seepage from the bank face, resulting in a backup that could cause the collapse and slumping of the bank and structure. Clay seams or layers in glacial till could also worsen the problem by creating a perched water table (collection of water on a relatively impermeable layer) behind the structure. In addition, stabilizing vegetation may be damaged

[121] The subsurface sediment analysis can be performed by core samples or by scraping off the veneer of sediments on the face of the landform to expose the underlying sediments. The depth from the top of the landform to mean high water is measured, as is the depths of the wind-blown/overwash deposits. Then the percentage of windblown/overwash sediments to the total depth is calculated. If this percentage is greater than or equal to 50%, a revetment is not allowed.

or destroyed during construction. Consequently, if a coastal engineering structure is to be approved on this type of coastal bank, where possible, it should be located above the extent of wave activity and designed to taper at the ends to minimize end effects to adjacent resource areas. The design should also include weep holes or other site-specific remedies to allow groundwater to drain, berms or other methods to divert surface water landward, or vegetation to diffuse runoff. Non-structural alternatives, such as planting deep-rooted salt-tolerant vegetation and installing bioengineering products (see Photograph 3.1 on page 3-40), are also effective for stabilizing exposed slopes and reducing erosion. See CZM's StormSmart Properties Fact Sheets series (www.mass.gov/service-details/stormsmart-properties) for information on many non-structural techniques to reduce erosion and storm damage.

- **Repair, maintenance, or improvement work to existing seawalls, bulkheads, and revetments** on banks may be permitted provided that the structures are not significantly enlarged and that construction activities minimize impacts to the resource areas. If allowing repair or maintenance, Commissions should require that impacts to the resource areas be minimized during the course of work and that the repair or maintenance to the structure not worsen existing impacts to the resource areas. If allowing significant repair, reconstruction, or improvement to the structure, Commissions should require that the applicant adhere to the design requirements for *new CESs* as described on pages 3-43 through 3-46 to the maximum extent feasible. Improvements should include changes that reduce impacts to the fronting and adjacent resources, such as pulling a CES farther landward where erosion has occurred behind it, so that it lies against the existing landform; replacing a vertical wall with a rough-faced sloping revetment; aligning or tapering the ends of the CES to prevent end-effects on neighboring properties; and other practices described for new CESs. The StormSmart Properties Fact Sheet 7: Repair and Reconstruction of Existing Revetments and Seawalls (www.mass.gov/service-details/stormsmart-properties-fact-sheet-7-repair-and-reconstruction-of-seawalls-and) provides additional guidance on this topic.

- **Reconstruction or enlargement of existing seawalls, bulkheads, and revetments** should adhere to the guidelines and design standards for new construction to the maximum extent feasible. Commissions have the discretion to allow a structure to be replaced in-kind if they deem that impacts to the resource areas have been minimized. In this case, an alternatives analysis may be required to ensure consideration of other design scenarios that may have less impact. Bioengineering methods, such as using coconut fiber rolls or erosion control blankets in combination with deep-rooted erosion-control vegetation, should also be considered in lieu of, or in combination with, any hard structure.

- **Selective and limited removal of vegetation on a coastal bank**, including removal of non-native invasive species, may be allowed on a case-by-case basis. Common coastal invasive species, such as Oriental bittersweet, bush honeysuckle, vine honeysuckle, autumn olive, and porcelain berry vine, are problematic because they have shallow roots, spread rapidly, and can secrete toxic compounds that prevent the growth of other plants with deep root systems. Japanese knotweed, another common invasive on coastal sites, has deep roots but can easily be torn out of the ground, taking large chunks of the soil with it. Because of these growth characteristics, even dense stands of these six species do little to reduce erosion by storm waves, runoff, and wind. Therefore, if invasive plants are present and preventing the establishment of beneficial erosion-control vegetation, they should be removed and replaced with appropriate native plants. This effort is particularly warranted when bank stability is severely compromised by the invasive plant or when unruly and overgrown invasives can be replaced with lower-growing native species to stabilize the bank.

Removing invasive plants to replace them with non-invasive native species, however, can temporarily destabilize the bank. For sites where bank regrading is not needed, invasive plants should be cut off at ground level, keeping the roots in place to minimize site disturbance. Many invasive plants can be effectively eliminated by applying limited amounts of herbicide to the cut stems, which kills the remaining root material. A direct and targeted application of herbicides, as opposed to spraying, helps to minimize adverse impacts to existing native vegetation, soils, groundwater, and coastal waters. Invasive plants should also be removed by hand when possible, rather than with heavy equipment. For sites where regrading is needed, the roots of invasive plants can be pulled out to minimize resprouting. Regardless of the method used, when vegetation is cut or removed, the exposed soils will become more vulnerable to erosion from wind, rain, and waves. Proper scheduling and sequencing of invasive species removal and replanting with non-invasive native species will minimize this problem, as will the use of other soil stabilization techniques. A professional experienced in replacing invasives with native plants in erosion-prone areas should be involved in designing and implementing a plan for the site.

In addition to non-native invasive removal, removing trees from the coastal bank may be allowed when the trees or their roots are jeopardizing bank stability and hindering the growth of more valuable native species. Removal of trees should not be based on whether the trees are obstructing views. If removal of vegetation is allowed (e.g., trees, invasive species, weeds, lawn area), Commissions should require hand removal or cutting, replanting with native species, and routine maintenance to ensure the survival of the desired species and eradication of the invasive vegetation. Any cut vegetation should be completely removed from the site so that it does not hamper the growth of stabilizing vegetation. For more information on removing invasive species and replacing them with natives, see CZM's StormSmart Properties Fact Sheet 3: Planting Vegetation to Reduce Erosion and Storm Damage (www.mass.gov/service-details/stormsmart-properties-fact-sheet-3-planting-vegetation-to-reduce-erosion-and-storm). For the most current information about invasive plants, see the Invasive Plant Atlas of New England website (www.eddmaps.org/ipane/), which provides a comprehensive web-accessible database of invasive and potentially invasive plants in New England or the Massachusetts Invasive Plant Advisory Group's *Evaluation of Non-Native Plant Species for Invasiveness in Massachusetts* (https://massnrc.org/mipag/docs/MIPAG_FINDINGS_FINAL_042005.pdf - PDF, 272 KB).

When it comes to pruning activities, the Regulations define vista pruning as, "the selective thinning of tree branches or understory shrubs to establish a specific "window" to improve visibility. Vista pruning does not include the cutting of trees which would reduce the leaf canopy to less than 90% of the existing crown cover and does not include the mowing or removal of understory brush." Pursuant to 310 CMR 10.02(2)(b)(2)(c), vista pruning is a minor activity in the buffer zone that is not subject to the Regulations provided the activity is located more than 50 feet from the resource areas. With regulatory review, vista pruning may also be allowed *within* 50 feet of the resource area, provided the activity will not destabilize the landform.

- **Planting native vegetation** on or landward of the coastal bank has many beneficial effects on slope stability. Trees, shrubs, and smaller plants have root systems that structurally reinforce and bind soils, reducing their susceptibility to erosion from wind or rain (see Figure 3.3 depicting the root structure of various grasses). In addition, plants reduce surface and groundwater flows by taking up water directly from the ground, absorbing water through their leaves, evaporating water off their surfaces, and physically slowing down the rate of runoff. The trunks, branches, stems, and leaves of plants create resistance and a buffer to the impact of raindrops, wave-splash, and wind. Trees planted further landward can also take up groundwater and surface water and reduce flows toward the coastal bank. Reducing new lawn area by planting a buffer zone of native vegetation along

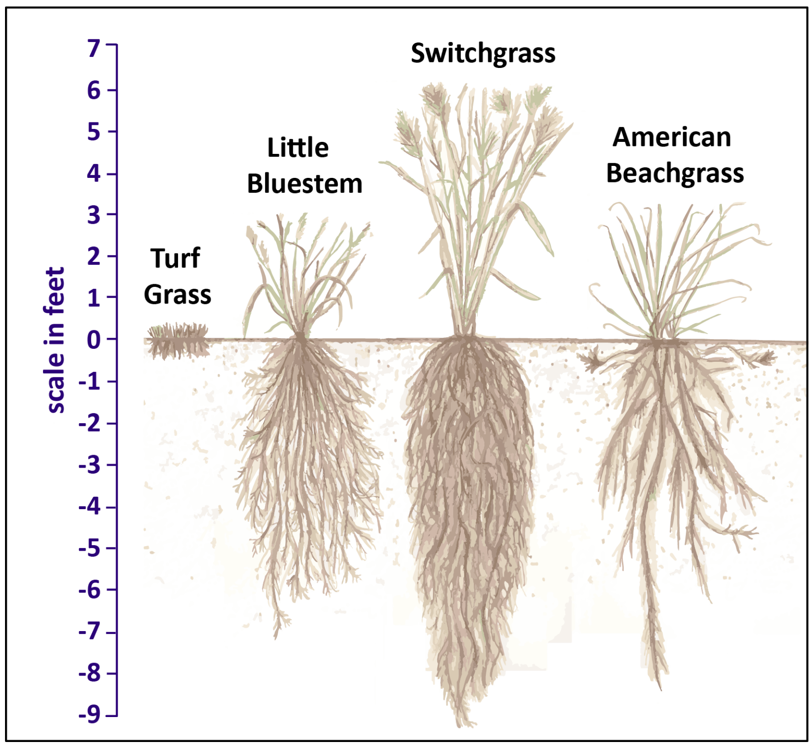

Figure 3.3. Root structure of various grasses. Plants such as little bluestem, switchgrass, and American beachgrass have longer roots systems than turf grass and are therefore more effective at helping to bind soils, take up water, and reduce erosion.

the top of a coastal bank can also serve to filter pollutants, provide wildlife habitat, and enhance aesthetics along the coast. Permanent irrigation systems are discouraged since they exacerbate surface water and groundwater flows that may cause erosion and destabilization of the bank. For additional information, see the CZM StormSmart Properties Fact Sheet 3: Planting Vegetation to Reduce Erosion and Storm Damage (www.mass.gov/service-details/stormsmart-properties-fact-sheet-3-planting-vegetation-to-reduce-erosion-and-storm). For more information about native plant selection and planting plans, see the CZM Coastal Landscaping website (www.mass.gov/service-details/stormsmart-coasts-coastal-landscaping-in-massachusetts).

- **Elevated walkways, boardwalks, and stairways** are preferred to at-grade pathways on a coastal bank for pedestrian traffic because they typically minimize the trampling of vegetation, reduce the erosion of the bank sediments, and maintain one general location for access. In order to be effective and reduce impacts to an eroding coastal bank, they must not interfere with the supply of sediment to coastal beaches or impact the growth of stabilizing vegetation. Therefore, to limit impacts to the resource areas, boardwalks and stairways should be: 1) constructed no wider than necessary and elevated at least 2 feet above grade to minimize shading of vegetation to maintain the stability of the bank; 2) designed to minimize storm damage to the whole walkway and/or designed to be removable; 3) designed without risers in the stairs to reduce shading; and 4) monitored for adverse effects. In addition, stormwater should be redirected away from the top of the bank, particularly at the access point to avoid creating a gully, and the area under the walkway should be re-vegetated as needed. Vehicular access paths on coastal banks should be avoided or minimized since they may disturb vegetation and destabilize the bank and exacerbate erosion.

- **Fill material for construction and development** may act to destabilize the bank if not correctly designed and applied. On a bank that acts as a vertical buffer, the fill may smother vegetation making it more vulnerable to wind and rain runoff. The weight of the fill placed on the top of a sediment source or vertical buffer coastal bank may also destabilize the bank. Where large amounts of fill material are proposed on the top or face of coastal bank, the condition of the bank and the stability of the existing slope should be assessed. Moderately to severely sloped banks may warrant a geotechnical analysis to ensure the bank can support the additional weight of the fill without eroding or collapsing.

- **Fill used to nourish a bank or recreate a stable slope** on the face of a bank may be beneficial if designed correctly. Fill placed at the toe of the bank to provide stability should be similar in grain size to the existing beach. Fill placed on any portion of the bank should be stabilized with temporary erosion control measures, such as natural fiber blankets, straw, and overtopped with a seed mix or planted with vegetative cover as soon as conditions permit to prevent erosion. Blankets containing synthetic fibers should be avoided due to the potential for the material becoming marine debris and harming wildlife. To avoid impacts to sensitive resources such as salt marsh, shellfish, and eelgrass, the fill should not contain more than

20% silt or clay, even if the natural bank sediments contain that material.[122] No additives should be incorporated into the fill that would result in hardening the fill material (e.g., lime).

- **Stormwater discharges**, such as culverts that daylight on a coastal bank, or impervious surfaces that drain toward the coastal bank may cause an increased rate of erosion, disturb vegetation, and destabilize the bank (as well as contribute to the pollution of the ocean and waterbodies).[123] Surface runoff should be diverted away from the face of the bank or the velocity reduced through the planting of vegetation to avoid these impacts. Any outflow should be designed so as to not cause scour, gullies, or erosion, or disturb vegetation. Stormwater runoff and its associated impacts can be reduced by eliminating or minimizing the amount of impervious surfaces on or near the site. Commissions should require that driveways or patio areas be made of pervious materials and that the footprints of structures near the coastal bank be minimized. See CZM's StormSmart Properties Fact Sheet 2: Controlling Overland Runoff to Reduce Coastal Erosion (www.mass.gov/service-details/stormsmart-properties-fact-sheet-2-controlling-overland-runoff-to-reduce-coastal) for other stormwater controls, or the Executive Office of Energy and Environmental Affairs Smart Growth/Smart Energy Toolkit (www.mass.gov/smart-growth-smart-energy-toolkit-information-and-resources) for low impact development (LID) methodologies.

Project Evaluation

Commissions must evaluate whether the project will protect the existing functions of the coastal bank. Commissions may not permit a proposed project on a coastal bank, or 100 feet landward of the top of the coastal bank, if it does not meet the performance standards. Commissions will need to evaluate the project proposal, with consideration of the best available and best practical measures that can be incorporated into the project to meet performance standards.

The first step in evaluating the project is to assess both the direct and indirect impacts of all components of work, including:

- The types of activities that are associated with the site preparation, such as removing vegetation, demolition, filling, grading, and compacting soils.
- The extent and type of construction, as well as the associated construction activities on the site. This review should take into account the weight of any equipment to be used within 100 feet of the top of the coastal bank and its potential to affect the stability of the bank, as well

[122]The Commission can review *Beach Nourishment: MassDEP's Guide to Best Management Practices for Projects in Massachusetts, March 2007* (www.mass.gov/files/documents/2016/08/op/bchbod.pdf - PDF, 1.6 MB), for specific guidelines on appropriate source material.
[123]The *Massachusetts Stormwater Handbook* (www.mass.gov/guides/massachusetts-stormwater-handbook-and-stormwater-standards) can be referenced for more detailed information about recharging groundwater and preventing stormwater discharges from causing or contributing to the pollution of the surface waters and groundwaters of the Commonwealth.

as consideration of the impervious surfaces, stormwater impacts, and the effects of other additional water inputs, such as septic systems and permanent irrigation systems.

- Operation, monitoring, and maintenance activities, such as repairs and routine maintenance to coastal engineering structures and stormwater devices and monitoring of the growth and establishment of vegetation.

If the project includes a coastal engineering structure on a sediment-source bank to protect a structure built prior to the Regulations, the applicant will need to submit additional information as described on page 3-43.

Commissions should require that the applicant submit enough information on all activities to warrant a proper review of impacts and measures for avoiding impacts, including monitoring and mitigation.

General Review Guidelines

In general, Commissions will need to make certain that the project and all components are designed to maintain the *function* of the bank as a sediment source or as a vertical buffer (bank height and stability) or both—particularly the function that would occur in a major coastal storm event based on current site conditions.

To do this, projects should be designed so as to avoid impacts to these functions. Commissions should ensure that the following design standards have been considered for projects on (or landward of) the coastal bank:

- Locate buildings, decks, pools, patios, and other structures as far landward as possible to minimize weight-bearing or user impacts that may destabilize the bank, to protect the building from storm damage from wind and wave activity, and to provide a setback of safety from the edge of the bank, particularly if the coastline is naturally retreating (and since new coastal engineering structures will not be allowed to protect new developments).
- Avoid new and reduce existing impervious surfaces and provide proper drainage or infiltration measures to decrease stormwater impacts to the coastal bank. Often, runoff may need to be redirected landward, such as into gardens, raingardens, or stormwater infiltration devices.
- Avoid irrigating lawns adjacent to the top of the bank, particularly with automatic irrigation systems that may operate and saturate soils during wet weather.
- Maintain stabilizing vegetation to protect the bank from erosion and stabilize slopes (as well as to provide a filter for polluted stormwater before it reaches oceans, bays, and harbors). If they do not already exist on site, plant native, salt-tolerant plants as a vegetative buffer along the top of the bank to limit disturbance, act as a stabilizing feature, and filter runoff. For more information, see the CZM StormSmart Properties Fact Sheet 3: Planting Vegetation to

Reduce Erosion and Storm Damage (www.mass.gov/service-details/stormsmart-properties-fact-sheet-3-planting-vegetation-to-reduce-erosion-and-storm) and the CZM Coastal Landscaping website (www.mass.gov/service-details/stormsmart-coasts-coastal-landscaping-in-massachusetts).

If the bank requires protection from erosion, Commissions should ensure that the following assessment criteria, alternative analysis, and design standards have been considered:

- Identify the cause of erosion before designing a plan to address the problem. If the cause of erosion is upland runoff, reduce these stormwater flows (by replacing impervious with pervious surfaces), redirect the flows, avoid use of permanent irrigation systems, and/or maintain a vegetated buffer of salt-tolerant, erosion-control plants to intercept the waters, reduce erosion, and provide stability (see StormSmart Properties Fact Sheet 2: Controlling Overland Runoff to Reduce Coastal Erosion at www.mass.gov/service-details/stormsmart-properties-fact-sheet-2-controlling-overland-runoff-to-reduce-coastal for additional guidance).
- Identify the degree of threat to the existing building. The erosion rate of the bank and/or shoreline in relation to the distance between the building and the top of the coastal bank shall be considered in evaluating the degree of threat. Bank erosion rates can be based on historic shoreline change rates or more recent erosion rates,[124] aerial photographs, and/or a site-specific analysis. The height and angle of the bank should also be taken into consideration when determining short- or long-term stability.
- Ensure that there are no other feasible methods of protecting a pre-1978 building other than the proposed coastal engineering structure through a detailed alternatives analysis. The applicant should consider the following alternative methods:
    - Restore and protect the bank through non-structural measures, such as coastal bank nourishment and plantings, which are preferable to “hard” coastal engineering structures. These non-structural alternatives still provide buffering capacity while also being able to maintain natural coastal processes. This approach can also be less expensive than structural measures (see the StormSmart Properties website at www.mass.gov/service-details/stormsmart-properties for additional guidance on non-structural alternatives, such as coir rolls, natural fiber blankets, and plantings on a coastal bank).
    - Relocate buildings landward if necessary and if possible to avoid a storm damage threat and eliminate the need for any protective structure.

If a coastal engineering structure is to be constructed, replaced, or substantially repaired, projects should be designed so as to *minimize* adverse impacts to the functions of the resource areas.

[124]The CZM Shoreline Change Maps are available at www.mass.gov/service-details/massachusetts-shoreline-change-project. Commissions and applicants are encouraged to read the introductory material on how to use the shoreline change browser and interpret the data to better understand the use and limitations of the shoreline change maps and data, and to help determine whether bank erosion rates should be based on the long- or short-term data.

To do this, Commissions should ensure that the following design standards have been considered for each project:

- Build the coastal engineering structure according to the design guidelines described in "Typical Project Activities and Their Effects on Coastal Banks" on pages 3-43 through 3-46 to the maximum extent feasible and build to the minimum size necessary to protect the pre-1978 dwelling. Often, it is sufficient to armor only the toe of the bank and stabilize the upper sections of the bank with erosion-control vegetation, thereby allowing the upper portions to continue to contribute sediment to the system during major storms. Any project should, however, be designed on a case-by-case basis as appropriate to protect the properties and structures while minimizing impacts to the resource areas. The design should be based on conditions at and adjacent to the site, including the height of the bank, the amount of wave energy reaching the shore, the proximity of the house to the shore, and existing armoring on neighboring properties. Where a property is open to the ocean and has a narrow beach allowing wave energy to travel to the bank face, bioengineering projects or armoring only the toe of the bank may not be sufficient to withstand the impacts of wave activity, particularly during storm events.
- Where there is a reduction in the source of sediment as a result of a coastal engineering structure, compensate for this loss by placing on the beach a commensurate volume of compatible material that is currently eroding (i.e., average long-term erosion rate) from the coastal bank into the beach and nearshore system. It should be noted that even when this newly deposited sediment erodes into the nearshore area and may seem "lost," the material is still acting beneficially within the system to reduce storm damage and flooding. The volume of sediment available to the system from coastal banks is critical for maintaining coastal beaches, coastal dunes, and their storm damage prevention and flood control functions.

Commissions must evaluate each project and determine if the applicant has met the performance standards and avoided adverse impacts to the functions of the bank. For coastal engineering structures, Commissions should ensure that the applicant has thoroughly identified the cause/source of the erosion problem and addressed it accordingly, looked at feasible alternatives to a hard structure, and incorporated the design standards necessary to avoid adverse effects to the resource areas. If a project's adverse impacts cannot be avoided, minimized, or mitigated, then a project must be denied.

ROCKY INTERTIDAL SHORES

For a proposed project on a rocky intertidal shore, Commissions must evaluate whether the project meets or can be conditioned to meet the performance standards that protect the characteristics and functions of the rocky intertidal shore (as described in Chapter 2).

Performance Standards for Rocky Intertidal Shore

The following is the performance standard for the storm damage prevention and flood control interests of the rocky intertidal shore listed in the WPA Regulations:[125, 126]

310 CMR 10.31(3)[127]
"…any proposed project shall be designed and constructed, using the best practical measures, so as to minimize adverse effects on the form and volume of exposed intertidal bedrock and boulders."

Interpreting the Performance Standards

The following will help Commissions interpret the specific requirements of WPA performance standard for rocky intertidal shores listed above.

310 CMR 10.31(3) - Minimize Adverse Effects

The regulatory standard for the storm damage prevention and flood control interests of rocky intertidal shores requires that a project *minimize* adverse effects on the form and volume of exposed bedrock and boulders, rather than have *no* adverse effects.[128] Adverse effects include anything that physically changes the size, shape, volume, and form of the rocks so that it would cause a change in the way the coast responds to wave energy and flooding.

Typical Project Activities and Their Effects on Rocky Intertidal Shores

Below are examples of typical projects proposed on a rocky intertidal shore. Each project's potential adverse effects and measures for minimizing the impacts (if any) to the critical functions of the rocky intertidal shore are described.

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[125]The performance standards for other interests of the WPA, such as protection of wildlife habitat, marine fisheries, and land containing shellfish, are not listed here unless they also serve the storm damage prevention and flood control interests.
[126]If a project meets the criteria for an Ecological Restoration Project or Ecological Restoration Limited Project, the Commission and applicant are advised to refer to the amended Regulations, sections 10.12, 10.13, 10.14, 10.24(8), (9), and (10) for further guidance.
[127] Performance standard 310 CMR 10.31(3) also protects the wildlife habitat interest of the WPA.
[128]Performance standard 310 CMR 10.31(4), which protects the interests of wildlife habitat and marine fisheries, has a no adverse effect standard for non-water-dependent projects.

- **Dredging, blasting, or other removal** of material from rocky intertidal shores will reduce the volume and change the form of the nearshore and/or coastal beach. This activity will affect the ability of the rocky intertidal shore to dissipate wave energy and provide a buffer to inland areas. Therefore, in order to minimize adverse effects, dredging projects (if allowed) or other removal activities, such as blasting and removing rock, should be designed to ensure that the area of removal be of the same roughness, consistency, and material as existed prior to the removal of the materials. For more dredging project requirements, see the performance standards for land under the ocean on pages 3-5 through 3-6.

- **Nourishment** of rocky intertidal shores with compatible sediments (i.e., sediments of a similar grain-size distribution, such as pebbles, cobbles, and boulders) is not likely to have an adverse effect on the storm damage prevention and flood control functions of the rocky intertidal shore.[129] Because rocky intertidal areas often overlap with coastal beaches, this type of project activity is usually performed in conjunction with a beach nourishment project (see the guidelines for beach nourishment on page 3-17 through 3-18). When selecting a compatible sediment source for gravel, cobble, and pebble nourishment, it is important that the sediments are rounded (from a glacial deposit), not angular (from crushing). Commissions should also refer to: *Beach Nourishment: MassDEP's Guide to Best Management Practices for Projects in Massachusetts, March 2007* (www.mass.gov/files/documents/2016/08/op/bchbod.pdf - PDF, 1.6 MB) for more detailed information.

- **Coastal engineering structures, such as seawalls, revetments, and bulkheads** on rocky intertidal shores may reflect wave energy, which may increase erosion or scour on adjacent beaches and adjacent land under the ocean. Adjacent structures may also be subject to amplified wave energy caused by reflected waves. Coastal engineering structures should be designed to avoid these impacts by following the guidelines for coastal engineering structures on coastal banks found on pages 3-42 through 3-48.

- **Groins or jetties** placed on rocky intertidal shores are likely to have an adverse effect on the form and volume of exposed intertidal bedrock and boulders, generally causing a diminishment in the rocky shore's ability to diffuse and absorb wave energy. These structures may also cause wave energy to be focused or reflected to other resource areas. Therefore, when allowed, groins should be located so as to minimize the reflection of wave energy to nearby structures and/or resource areas. See the performance standards for coastal beaches on page 3-19 for additional requirements for solid fill coastal engineering structures.

- **Piers and pilings** are unlikely to have an adverse effect on the form and volume of exposed intertidal bedrock and boulders, provided they are designed so that their footprint on the bedrock is minimized and the areas between pilings are maximized to maintain circulation

[129]Nourishment of a rocky intertidal shore may have temporary or long-term adverse impacts on other interests of the Act, including wildlife habitat and marine fisheries.

and to minimize changes to wave energy. Any potential blasting for installation of the pilings should also be carefully reviewed for effects on the stability of the bedrock.

Project Evaluation and General Review Guidelines

Commissions should make certain that the project and all components of the project are designed to minimize adverse impacts to the form and volume of the rocky intertidal shore to maintain its ability to protect landward areas from storm damage and flooding. In general, the project should not change the way in which the shore responds to wave action. If a project's adverse impacts cannot be avoided, minimized, or mitigated, then a project must be denied.

SALT MARSHES

For a proposed project in a salt marsh, Commissions must evaluate whether the project meets or can be conditioned to meet the performance standards based primarily on the delineation of the salt marsh on the project site. Since all salt marshes are afforded a high degree of protection regardless of how they function, it is not as critical to assess each specific function in order to apply the performance standards.

Performance Standards for Salt Marsh

The following are the performance standards for the storm damage prevention interest of the salt marsh listed in the WPA Regulations:[130, 131]

310 CMR 10.32(3)
"A proposed project in a salt marsh, on lands within 100 feet of a salt marsh, or in a body of water adjacent to a salt marsh shall not destroy any portion of the salt marsh and shall not have an adverse effect on the productivity of the salt marsh. Alterations in growth, distribution and composition of salt marsh vegetation shall be considered in evaluating adverse effects on productivity. This section shall not be construed to prohibit the harvesting of salt hay."

310 CMR 10.32(4)
"Notwithstanding the provisions of 310 CMR 10.32(3), a small project within a salt marsh, such as an elevated walkway or other structure which has no adverse effects other than blocking sunlight from the underlying vegetation for a portion of each day, may be permitted if such a project complies with all other applicable requirements of 310 CMR 10.21 through 10.37."

310 CMR 10.32(5)
"Notwithstanding the provisions of 310 CMR 10.32(3), a project which will restore or rehabilitate a salt marsh, or create a salt marsh, may be permitted in accordance with 310 CMR 10.11 through 10.14, 310 CMR 10.24(8), and/or 310 CMR 10.53(4)."

Interpreting the Performance Standards

The following will help Commissions apply the specific requirements of the performance standards for salt marshes. The section is divided into the three categories of projects that parallel the

[130]Performance standard 310 CMR 10.32(6) that relates to adverse effects on specified habitat sites of rare vertebrate or invertebrate species is not listed here because it does not serve the interest of storm damage prevention. The performance standards that are listed here also protect the interests of marine fisheries, wildlife habitat, land containing shellfish, ground water supply, and the prevention of pollution.
[131]If a project meets the criteria for an Ecological Restoration Project or Ecological Restoration Limited Project, the Commission and applicant are advised to refer to the amended Regulations, sections 10.12, 10.13, 10.14, 10.24(8), (9), and (10) for further guidance.

WPA performance standards articulated above:

310 CMR 10.32(3) - No Destroying Salt Marsh and No Adverse Effect on Productivity

A project proponent must demonstrate that the project meets performance standard 310 CMR 10.32(3) by proving that the proposed work will not destroy any portion of the salt marsh or will not have an adverse effect on the productivity of the salt marsh. This differs from other resource area performance standards in that protection is required for the resource area itself rather than the functions of the resource area. Because of these strict requirements, few projects are allowed on a salt marsh.

310 CMR 10.32(4) - Small Projects such as Elevated Walkways

The Regulations 310 CMR 10.32(4) allow projects such as boardwalks or piers that minimize the effects of trampling a salt marsh provided that specific guidelines are followed to prevent damage to the resource area (see page 3-61 for more guidelines on elevated structures). These projects should not be allowed if they have an adverse effect on the salt marsh (other than blocking sunlight from the underlying vegetation for a portion of each day).

310 CMR 10.32(5) - Rehabilitating or Creating Salt Marshes

Projects that enhance or create salt marshes are also allowed under 310 CMR 10.32(5), provided they follow a particular course of action for restoration. In 2014, the Regulations were amended to include a definition for an ecological restoration project as "a project whose primary purpose is to restore or otherwise improve the natural capacity of a resource area(s) to protect and sustain the interests identified in M.G.L. c. 131, section 40, when such interests have been degraded or destroyed by anthropogenic influences."[132] The eligibility criteria and conditions for ecological restoration projects and ecological restoration limited projects are listed in detail in sections 310 CMR 10.11 through 10.14, 310 CMR 10.24(8), and 310 CMR 10.53(4). A Commission interested in restoring or enhancing a salt marsh can also contact the Division of Ecological Restoration of the Department of Fish and Game (www.mass.gov/orgs/division-of-ecological-restoration) for more information.

Typical Project Activities and Their Effects on the Salt Marsh

Below are examples of typical activities proposed on salt marshes, along with the potential impacts of these activities and measures that can be implemented to minimize adverse impacts to the critical functions of the salt marsh.

[132]The term ecological restoration project shall not include projects specifically intended to provide mitigation for the alteration of a resource area authorized by a final order or variance issued pursuant to 310 CMR 10.00 or a 401 Water Quality Certification issued pursuant to 314 CMR 9.00.

- **Construction of buildings, coastal engineering structures, or other solid structures; removal of vegetation; dredging projects; and disposal of dredged material or fill material** are unlikely to be conditioned to meet performance standards since they alter and destroy the salt marsh vegetation, which is prohibited under 310 CMR 10.32(3).[133]

- **Pathways and four-wheel drive vehicle trails** have the potential to destroy portions of the salt marsh, through trampling, filling, soil compaction, and prohibiting growth of salt marsh vegetation. This destruction of vegetation can alter the salt marsh's resistance to erosion and the ability to dissipate wave energy. Construction of pathways on fill or at-grade and four-wheel drive vehicle trails cannot avoid adverse effects on the salt marsh.

- **Elevated structures, such as boardwalks, piers, docks, wharves, floats, and associated piles** can affect the salt marsh by disturbing the vegetation and peat layers during construction and installation of the pilings and through the effects of shading from the structures. These disturbances may cause loss of salt marsh vegetation and marsh edges that become more vulnerable to wave activity. Boardwalks (which are preferred to at-grade pathways), piers, docks, wharves, and pilings should follow particular standards to avoid these adverse effects. In particular, elevated structures should be constructed in such a manner so as to avoid shading effects and disturbances to salt marsh plant productivity by:

  1) limiting width and length of the structure,
  2) elevating the structure 1 foot above the marsh for every foot of its width,
  3) providing spaces in the deck planks (or open grating) to allow light to penetrate to underlying salt marsh vegetation (at least ¾ inch apart),
  4) orienting the structure as close as possible to a north-south orientation, and
  5) spacing piles to the maximum extent possible to allow for unimpeded water flow and to minimize impacts.

  The installation of the piles should be accomplished by "driving" (i.e., using weight to drive the pile into the ground) or by using helical or screw piles rather than "jetting" (i.e., the use of high pressure water), since pile driving causes fewer disturbances to surrounding vegetation and bottom sediments. To avoid trampling or compaction of salt marsh vegetation, work should be done from low-ground-pressure equipment and vehicles, from the use of pads or swamp mats, or from a floating platform such as a barge. Where possible, the builder should work from completed sections of the structure. Construction should be performed during the non-growing season of the marsh grasses and should not disturb any area other than the immediate area of the structure. Floats should rest at least 18 inches from

[133]In the matter of John Van Loan, Recommended Final Decision, May 14, 2010, adopted by Final Decision, May 21, 2010, affirmed by Suffolk Superior Court sub nom John Van Loan vs. Massachusetts Department of Environmental Protection, Suffolk Superior Court Civil Action No. 10-2495-B, July 27, 2011, the Presiding Officer found that a proposed structure will "destroy" the salt marsh resource area through the installation of the pilings and will likely destroy a larger area through shading impacts that will diminish or eliminate growth of vegetation beneath the structure.

the bottom, as measured at low tide, and should be removed during the off-season and not stored on the salt marsh. See MassDEP's *A Guide to Permitting Small Pile-Supported Docks and Piers* (www.mass.gov/files/documents/2016/08/st/smaldock.pdf- PDF, 789 KB) for additional guidelines.

Where these elevated structures cannot be designed to meet the no adverse effect standard, they should not be permitted.

Project Evaluation

Commissions must evaluate each project on a case-by-case basis to ensure that the project will not have an adverse impact to the salt marsh.

The first step to evaluate the project is to assess both the direct and indirect impacts of all components of work, including:

- The site preparation activities, which must avoid any impacts to the salt marsh.
- The type of project and the design of the project (such as the placement of footings or piles).
- Construction or alteration activities, including the type of equipment and machinery required to complete the project and how the work is to be accomplished.[134]
- Operation and maintenance plans and activities, such as for repairs to a boardwalk or pier, which may be necessary in the future.

Commissions should ensure that enough information has been supplied by the applicant to allow for a proper review.

General Review Guidelines

To meet the performance standards for salt marshes, Commissions will need to make certain that the project and all components are designed to prevent any destruction of the salt marsh. Commissions may use their discretion in looking for opportunities to mitigate or improve existing conditions through activities such as salt marsh restoration or creating an elevated boardwalk that alleviates existing or future damage to the salt marsh. If a project's adverse impacts cannot be avoided, minimized, or mitigated, then a project must be denied.

[134] The Commission should also assess when the project activities will be taking place, as work may not commence during certain plant growing seasons or fish/shellfish spawning or nursery seasons.

LAND SUBJECT TO COASTAL STORM FLOWAGE

Since performance standards are not currently defined in the WPA Regulations for land subject to coastal storm flowage, this manual does not provide specific guidance in this chapter. Nevertheless, when reviewing projects, Commissions should: 1) presume that land subject to coastal storm flowage performs functions for the storm damage prevention and flood control interests, 2) consider whether the project adversely impacts these functions and interests, and 3) make these findings, request changes to the project design, and impose conditions in the Order of Conditions to contribute to the protection of the interests. The descriptions and guidelines found in the land subject to coastal storm flowage section of Chapters 1 and 2 (beginning on pages 1-67 and 2-37, respectively) may help inform Commissions in their project review.

Commissions should evaluate a project as it relates to maintaining the function of the resource areas under the Wetlands Protection Act and not rely on the State Building Code, which is designed to protect the structural integrity of a building, *not* the function of the underlying resource area. [135] Similarly, FEMA's National Flood Insurance Program (NFIP) Regulations are designed to provide appropriate protection against flooding and minimize exposure of buildings to flood losses. Recent publications by FEMA and changes to the State Building Code have begun to recognize that the function of the underlying resource area can affect building integrity and the potential for flood damages and losses experienced by the applicant and neighboring properties. The current building code standards for dune areas—including the requirement to elevate structures on open pilings and eliminate concrete pads and footings—minimize the erosive effects that waves and flood waters have on building foundations in coastal dunes. An applicant must ultimately meet all relevant regulations when designing a project, many of which will be regulated by other town boards and commissions.

[135] In addition, the Massachusetts Basic Building Code (780 CMR) only references the Flood Insurance Rate Maps (FIRMs) to determine the V Zones, A Zones, and Base Flood Elevations (BFEs), while the WPA Regulations allow other sources of information to be used to determine the land subject to coastal storm flowage boundaries (the definition for land subject to coastal storm flowage not only references the 100-year floodplain, but also any inundation caused by the *surge or storm of record,* whichever is greater).

Chapter 4 - Selected Scenarios: From Principle to Practice

To demonstrate how the concepts and tools provided in this manual can be used in practice, this chapter gives examples of typical project proposals and the Conservation Commission hearing and review process for the storm damage prevention and flood control interests of the Wetlands Protection Act (WPA). More specifically, this section depicts the permit process—delineation of the resource areas and their functions, review of potential project impacts, and design of projects to avoid or minimize adverse impacts and meet performance standards—through the different perspectives of the applicant and the Commission. These scenarios are hypothetical (or are real projects that have been modified), but represent typical projects that are presented to a Commission, helping to illustrate the recommended process for ensuring a comprehensive review of proposed projects. Though not necessarily depicted here, the Commission has the ability to hire a consultant to provide technical assistance and enhance the Commission's knowledge of the issues during the review process (under the authority of M.G.L. c. 44, §53G).

The chapter contains the following three hypothetical examples:

- A new building, pool, and patio on multiple resource areas to emphasize the challenges associated with accurately delineating coastal resource areas—specifically a dune versus a bank.
- The maintenance of a public roadway on a barrier beach to emphasize the importance of determining the function of a resource area and balancing the competing interests of public access and protection of the resource area functions.
- The renovation of a seawall on a coastal bank to emphasize the importance of determining factors that affect function and of implementing design principles to meet performance standards.

It is important to note that the applicant's version within each of the three examples will contain statements and figures that are subject to further review. The examples presented are those that are often proposed in reality, complete with common misinterpretations of information, inaccuracies in delineations and function descriptions, incomplete analysis of adverse impacts, and insufficient designs. Therefore, when reading through this chapter, please read both the applicants proposal and the Commission's review to get a complete picture of the project, the potential adverse impacts to the resource areas, and methods for ensuring compliance with the performance standards. To aid with your reading and interpretation of accurate versus inaccurate statements, an asterisk (*) will follow any text in the applicant's version that is subject to clarification. It is also important to note that this chapter does not depict a review of any interests of the WPA other than storm damage prevention and flood control. A complete review of a project proposal would require an assessment of the characteristics and functions of all the resource areas present on the site for the other interests of the Act and application of the relevant performance standards.

SCENARIO ONE - THE CHALLENGES AND IMPORTANCE OF ACCURATELY DELINEATING A RESOURCE AREA

This scenario emphasizes the importance of accurately delineating the resource areas for a thorough review of a project.

Scenario One - Applicant's Proposal

The following is a hypothetical application for a residential project (pool, patio, and retaining walls) proposed on multiple resource areas. This example illustrates the challenges associated with accurately delineating various coastal resource areas. This scenario represents a typical proposal made by an applicant to a Commission and therefore contains common mistakes and misinterpretations that warrant further review and clarification by the Commission. The reader should note that the statements followed by an asterisk (*) will be addressed and/or corrected within the next section—"Commission Review and Findings."

Project as Proposed by Applicant

This Notice of Intent filing is in support of an in-ground pool, a patio, and retaining walls to surround and support the pool and patio area (see Figure 4.1 on page 4-6 for the plan). The project is being proposed within an existing lawn area on land subject to coastal storm flowage* and partially within the 100-foot buffer zones to a coastal bank, salt marsh, and coastal beach. The proposed footprint of the project totals 2,500 square feet.

Existing Site Conditions as Determined by Applicant

The site, located at 100 Dune Road, includes an existing house constructed in 1965, a driveway, and a landscaped yard with an extensive lawn (see Photograph 4.1 on page 4-3). The property is abutted by the open ocean to the south, a public way to the east, Dune Road to the north, and another residential lot to the west. The property extends down to mean low water. An existing low-lying riprap revetment adjacent to the beach provides some protection to the property and demarcates the top of the coastal bank.* The property slopes up from the shore to its highest point in the middle of the property and then gently slopes back down again. The house and surrounding slab is located approximately 10-15 feet landward of the riprap wall and a lawn area extends from the house to the road. To the north of Dune Road lies a salt marsh.

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*Text in the "Applicant's Proposal" section contains misinterpretation of information, inaccurate data, incomplete analysis, or insufficient design considerations. Please read the "Commission's Review and Findings" section to get a complete picture of the project, the potential adverse impacts to the resource areas, and methods for ensuring compliance with the performance standards.

Resource Areas as Delineated by Applicant

The property extends from Dune Road seaward to the mean low water line. Coastal wetland resource areas on the property are presented on the attached plan (Figure 4.1 on page 4-6) and include coastal beach, coastal bank, land subject to coastal storm flowage, and buffer zones to coastal beach, coastal bank, and salt marsh.

Photograph 4.1. Lawn area within land subject to coastal storm flowage. This lawn is the location of the proposed storage area, pool, and patio. Seaward of the house is the existing riprap revetment/coastal bank* (as delineated by applicant), coastal beach, and ocean.

Coastal Beach

The beach extends from the mean low water line up to the existing riprap revetment. Sediments consist of sand and small pebbles.

Coastal Bank

Landward of the beach lies the riprap revetment that acts as the coastal bank.* This abrupt change in topography with an elevated landform meets the definition of a coastal bank.* The top of the revetment at elevation 8 feet NGVD is delineated as the top of the coastal bank.

Land Subject to Coastal Storm Flowage

The site is within the 100-year floodplain; within the VE Zone elevation 18 feet and AE Zone elevation 15 feet NGVD according to the FIRM (effective date 7/3/1992).* The existing house is located almost entirely within the VE Zone, between elevations 9 feet and 10 feet NGVD. The majority of the proposed in-ground pool, patio, and retaining walls are located in the AE Zone, with existing grades at elevations 6 to 8 feet NGVD, and to be built to a finished grade of 8.15 feet NGVD. The area where the project is proposed is currently lawn.

Buffer Zones to Coastal Bank and Salt Marsh

The 100-foot buffer zones to both the coastal bank and salt marsh are shown on the plan. The coastal bank is the existing riprap revetment* and the buffer extends landward from the

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*Text in the "Applicant's Proposal" section contains misinterpretation of information, inaccurate data, incomplete analysis, or insufficient design considerations. Please read the "Commission's Review and Findings" section to get a complete picture of the project, the potential adverse impacts to the resource areas, and methods for ensuring compliance with the performance standards.

top of the revetment. The salt marsh that lies off the property to the north (beyond the road) has a 100-foot buffer zone that extends into the middle of the property.

Resource Function as Determined by Applicant

The following explains how the resource areas described above function for the storm damage prevention and flood control interests.

Coastal Beach and Coastal Bank

The coastal bank, which is not a sediment-source bank because of the existing revetment, is a vertical-buffer bank.* The revetment protects the house and property from flooding during storm events and prevents erosion. Both the beach and the bank function and will continue to function without adverse impacts since no part of the proposed project is within these resource areas.

Land Subject to Coastal Storm Flowage

Land subject to coastal storm flowage does not have any designated functions under the Wetlands Protection Act.* The site is open to the ocean so that any waves or flood waters that come onto the site are able to drain off the site back into the ocean without impact to landward areas.* The existing riprap revetment protects landward areas from flood waters and waves.

Buffer Zones to Coastal Bank and Salt Marsh

The buffer zones do not function in a typical way since the existing house stands between the coastal bank and the proposed projects and a road buffers the salt marsh from the property.*

Performance Standards and Project Design as Proposed by Applicant

The following describes how the project will meet the performance standards to protect the storm damage prevention and flood control interests of the resource areas on site.

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Coastal Beach and Coastal Bank

Since no components of the project are proposed on the coastal beach, the project will not have an adverse effect by increasing erosion, decreasing the volume, or changing the form of the beach or any adjacent beaches. The project, though within 100 feet of the coastal bank, will not have an adverse effect on the stability of the bank, particularly since the proposed project is landward of the existing house and farther away from the resource area.*

Land Subject to Coastal Storm Flowage

There are no designated performance standards for land subject to coastal storm flowage under the WPA Regulations. Nevertheless, the project will have minimal impact on flood waters since the majority of impervious surfaces will be located beyond the velocity zone.* The existing house, located within the VE Zone, effectively blocks landward areas from waves. In addition, the landform has already been altered and no further effects are expected from the proposed project.*

Salt Marsh

The components of the proposed project that are on land within 100 feet of the salt marsh will not destroy any portion of the salt marsh and will not have an adverse effect on the productivity of the marsh. No alterations in growth, distribution, and composition of the salt marsh vegetation will occur as a result of the project.

Summary

This Notice of Intent filing for a proposed in-ground pool, patio, and retaining walls on a lawn area within land subject to coastal storm flowage and partially within the 100-foot buffer zones to a coastal bank, salt marsh, and coastal beach will not impact the functions of the resource areas on site and will meet the relevant performance standards for each resource area.*

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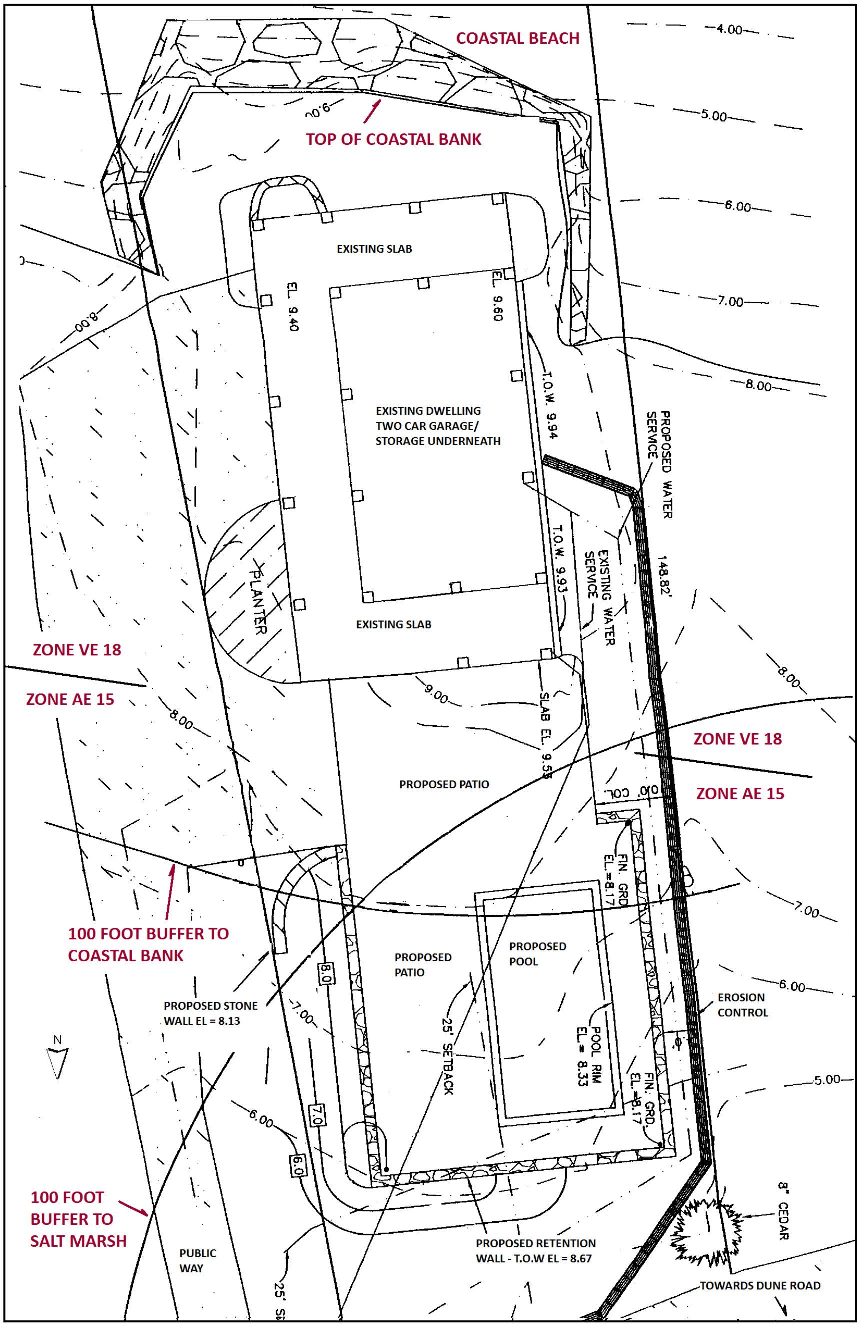


Figure 4.1. An applicant's plan showing a proposed pool, patio, and retaining walls, along with resource areas and buffer zones as delineated by the applicant.

Scenario One - Commission Review and Findings

The following is a hypothetical example of a Commission's review of the applicant's proposal for a pool, patio, and retaining walls on multiple resource areas that was presented on pages 4-2 through 4-6. This section illustrates the Commission's statements made during the hearing process, including the deliberations, requests for additional information, and the Commission's findings and responses to the proposal. The statements made within the previous section, "Applicant's Proposal," that were followed by an asterisk (*) are corrected or clarified within this section. Editorial notes are included in italicized text to provide context for the scenario or to list references for additional information.

Proposed Project

The applicant describes the project as a proposed in-ground pool, a patio, and retaining walls on a lawn area within land subject to coastal storm flowage and partially within the 100-foot buffer zones to coastal bank, salt marsh, and coastal beach.

Resource Areas

Editorial Note: The Commission performed a site visit once the application had been received to confirm the applicant's delineation of the resource areas and to make observations. The following are the Commissions statements presented at the hearing following the site visit.

The Commission has made observations at the site and finds that additional resource areas are located on the subject property. The following describes our observations and determinations.

Coastal Beach

The Commission confirms the delineation and boundaries of the coastal beach as proposed on the plan. The beach consists of a mix of sand and pebbles.

Land Subject to Coastal Storm Flowage

The Commission disagrees with the delineation of the VE Zone on the plan (plan seen in Figure 4.1 on page 4-6). A delineation done correctly does not mark the VE/AE Zone boundary on the plans at the designated VE Zone elevation because the height refers to the elevation of the top of the waves within a zone established by FEMA and shown on the FIRMs. On shorelines with gently sloping profiles, wave heights diminish and the BFE for the VE Zone is reduced in the landward direction (see Figure 1.16 on page 1-76). In this case, the V Zone BFE of 18 feet NGVD does not reach as far landward as the 18-foot ground elevation. Instead, the V Zone ends where wave heights become less than 3 feet and the flood designation become an AE Zone (more specifically, a Coastal A Zone).

In addition, the applicant used an old Flood Insurance Rate Map, not the current, effective map, to delineate the flood zones on this site. The new flood maps now include the Limit of Moderate Wave Action (LiMWA), which is the landward limit of the Moderate Wave Action (MoWA) area. The MoWA area, also known as the Coastal A Zone, is where base flood wave heights are projected to be between 1.5 and 3 feet in height and where wave effects, quick-moving water, erosion, and scour are capable of damaging or destroying a building that is constructed to traditional A Zone building standards (i.e., solid foundation with openings). Both the revised V Zone boundary and the LiMWA should be added to the project plans and presented at the next hearing.

Editorial Note: The complete, up-to-date LiMWA lines are only available through the FEMA Flood Map Service Center (https://msc.fema.gov/portal) as part of the National Flood Hazard Layer (NFHL). To view the LiMWA, enter an address in the search function and select the "Go to the NFHL Viewer" button, which will open an interactive viewer. Once in the viewer, click on the "Layer List" icon in the upper right corner of the page (hover over the icons to display the labels). Expand the NFHL layer to show the available options for this data. Select "Limit of Moderate Wave Action," which will show the LiMWA on the map (typically it is already selected). To accurately see the flood zone boundaries, you will also want to deselect the LiMWA line temporarily to see what lies beneath it. The entire NFHL database for the county or state, which includes the LiMWA layer, can be downloaded and used in GIS. To download the NFHL, search by location and then click the "show all products" button, open the "Effective Products" folder, and download "NFHL Data" by state or by county. The LiMWA data layer is named S_LiMWA.

To delineate the flood zone boundaries, the Commission requests that the applicant use Geographic Information System (GIS) software to overlay the V Zone/A Zone boundary and the LiMWA line from the NFHL onto the site plan. It is very important that the projection and scale of the site plan and the maps (the FIRMs or NFHL) are consistent to ensure the accuracy of the boundary location on the site plan. If overlaying is not feasible, the flood zone boundaries can be scaled from a known, fixed point, such as a benchmark or road intersection, to the site plan for the project site. If scaling from a road on a FIRM, the center of the road should be used, since the lines may not represent road edges. Distances should be measured parallel and/or perpendicular to recognizable features and at least two reference points should be used. A shoreline location should not be used as a reference point, since its position changes over time.

The newly delineated flood zone boundaries should be shown on a revised plan and presented at the next hearing.

Editorial Note: For more information on determining flood zone boundaries, see "Land Subject to Coastal Storm Flowage" beginning on page 1-67.

Coastal Dune Rather than Coastal Bank

In contrast to what was stated in the Notice of Intent, the Commission notes what appears to be a slight hill, mound, or ridge on the property that suggests the site may be a coastal dune resource area. Though the area is currently covered in lawn grass, it does not negate the presence of a resource area. In addition, the fact that a riprap revetment was built to act like a coastal bank does not mean that the resource area is a coastal bank or even functions as a coastal bank.

Editorial Note: Because of the uncertainty in the delineation, the Commission asked the applicant to provide more information to further review whether the landform is a coastal dune or coastal bank. In this case, an on-site investigation to determine the origin of the landform was necessary to accurately delineate the resource area. As described below, both the Commission (and their consultant) and applicant looked at subsurface sediments at the site in the area of the proposed pool through the use of a hand auger to determine whether they were wind- or wave-deposited (and therefore likely to be part of a coastal dune) or whether they were glacial sediments (and therefore more likely to be part of a coastal bank or a buffer zone to a bank). The following are the Commissions statements presented at the hearing subsequent to the additional site visit.

The Commission and applicant have found well-sorted quartz sands with some rounded pebbles, similar to the sediments found on the coastal beach, beneath the grass and loam fill. Based on the composition and sorting, the origin of the landform is likely wind- or wave-deposited sediments. The Commission also noted the presence of organic material mixed in with the wind- or wave-deposited sediments, which indicates the lawn hasn't been disturbed by wave action or a storm event in many years. The site is also distinctly mound shaped, similar to the adjacent lots that are clearly on a state-designated barrier beach unit pursuant to the Massachusetts Barrier Beach Inventory Project (see "Barrier Beach" next). Based on the evidence, the Commission finds the site to be a coastal dune landward of the coastal beach. Since the site is completely within the flood zone with flood elevations well above grade, the fill and lawn grass would perform the functions of storm damage protection and flood control (e.g., dissipating wave energy and eroding in response to waves in a large storm event), consistent with a coastal dune.

Barrier Beach

To further confirm the landform's designation as a coastal dune, the Commission has reviewed the Barrier Beach Inventory Project Maps and has determined that this site is located in or adjacent to a barrier beach unit. Since these maps delineate barrier beach units based primarily on aerial photograph analysis, a site-specific delineation is needed. Therefore, to confirm the delineation, the extent of the wetlands landward of the state-designated barrier beach unit was reviewed at the site visit. Based on observations, the salt marsh is present landward of the project site, even with the presence of some fill (see Photograph 4.2

on page 4-10). The Commission therefore finds the project site to be part of the barrier beach.

Photograph 4.2. Project site shown on a barrier beach. The subject property is shown within the red circle. The salt marsh extends behind the landform, defining the area as a barrier beach. Photograph courtesy of the Office of Geographic Information (MassGIS) and United States Geological Survey (USGS) Color Ortho Imagery 2008 30cm.

The Commission requests that the applicant revise the plans to show the delineation of the barrier beach and coastal dune resource areas and its buffer zone, rather than a coastal bank. When drawing buffer zone lines, the line should be marked 100 feet from the boundary of the resource area and not an arc around a fixed point. On the original plans (see Figure 4.1 on page 4-6), the applicant incorrectly marked the buffer zones to the coastal bank and salt marsh with this arc. The revised plans shall be presented at the next hearing.

Resource Function

Editorial Note: The following are the Commissions statements presented at the hearing regarding their observations and determinations of the functions of the resource areas at the site.

Although much of the resource area has been covered with lawn grass and particular functions have been diminished (such as exchanging sand with the beach and shifting form through regular wind and natural water flows), the Commission believes the dune and the barrier beach still have the ability to function in a storm event (such as by shifting, dissipating wave energy, and slowing down moving water). The following describes the Commission's observations and determinations.

Coastal Dune and Land Subject to Coastal Storm Flowage

Because the site is completely within the floodplain, the Commission finds that the dune—though altered—provides some functions for storm damage protection and flood control. The dune retains the ability, though compromised with fill and lawn grass, to erode in response to waves, overwash, and storm-elevated sea levels (storm surges); the form of the dune still has some ability to shift and change through natural water flow (particularly in a storm event); and there is a mound or ridge of sediments that provide dune volume and elevation—all of which can continue to dissipate wave energy, slow down moving water, and/or protect landward areas from storm-elevated sea levels and storm waves. The artificial fill meets the regulatory definition of a coastal dune because it performs the functions of a dune for storm damage prevention and flood control.

The FEMA flood zone elevation indicates that the elevation of the floodwater and waves would be approximately 7 to 13 feet above the existing grade in a 100-year event (since existing grade is 5 to 8 feet and flood zones are 15 to 18 feet NGVD). This amount of water and wave action would easily erode the lawn grass, allowing the dune to perform the beneficial functions of eroding, changing form, and migrating laterally and landward to dissipate wave energy.

The flood zone transitions from a VE Zone to an AE Zone landward of the existing dwelling, which means the wave height decrease from at least 3 feet to less than 3 feet. However, a portion of the AE Zone is designated as a MoWA area (as seen by the LiMWA line delineated on the NFHL), where wave heights are less than 3 feet but greater than 1.5 feet. The site is therefore subject to wave effects, quick-moving water, erosion, scour, or combinations of these forces. In this particular AE Zone, 7 to 10 feet of water (including wave heights) are capable of damaging or destroying buildings and property. *Editorial Note: For more information, see "Land Subject to Coastal Storm Flowage" beginning on page 1-67*.

Barrier Beach

The WPA Regulations define all coastal dunes on barrier beaches as being per se significant to storm damage prevention and flood control. This presumption, combined with the fact that this site is located entirely within coastal flood zones, reinforces the significance of this area in providing storm damage prevention and flood control functions. Though some function of this dune has been lost due to alterations (e.g., wind exchange of sediments with the beach), the Commission finds that it still retains the ability to function in a storm event by eroding, shifting, changing form, and dissipating wave energy.

Editorial Note: The following are the Commission's statements presented at the hearing, including determinations of the relevant performance standards, potential adverse impacts from the project, and design principles to avoid or minimize adverse impacts and meet the performance standards.

Performance Standards

The Commission requires that the proposed project meet the following performance standards to protect the storm damage prevention and flood control interests of each resource area.

Coastal Dune

Pursuant to the performance standards for a coastal dune "any alteration of, or structure on, a coastal dune or within 100 feet of a coastal dune shall not have an adverse effect on the coastal dune by: a) affecting the ability of waves to remove sand from the dune; b) disturbing the vegetative cover so as to destabilize the dune; c) causing any modification of the dune form that would increase the potential for storm or flood damage; d) interfering with the landward or lateral movement of the dune; e) causing removal of sand from the dune artificially; and f) interfering with mapped or otherwise identified bird nesting habitat."

Land Subject to Coastal Storm Flowage

The applicant is correct that there are no performance standards for land subject to coastal storm flowage under the WPA Regulations. In this case, however, the functions of land subject to coastal storm flowage are generally protected under the performance standards for dunes, because the flood zone directly overlaps the dune resource area—and inherently affects the functions of the dune. In addition, the project must comply with the state building code, which includes requirement for elevating buildings in flood zones and constructing lateral expansions on open pilings in coastal dunes.

Barrier Beach

The barrier beach performance standard reiterates the standards for coastal beaches and coastal dunes, with the exception that they be applied to all coastal dunes on the barrier beach. This language reinforces the importance of designing a project to avoid adverse impacts to the functions of any dune on a barrier beach.

Potential Adverse Impacts

The Commission finds that the construction of the new solid structures and impervious surfaces has the potential to impede natural erosion of the dune, modify the form of the dune, prevent landward or lateral movement of the landform, and cause a reduction in the height and volume of the dune, all of which can diminish the ability of the dune to protect landward areas (as well as neighboring properties) from storm damage and flooding.

More specifically, the proposed in-ground pool and patio would interfere with the ability of the coastal dune (with lawn) to dissipate wave energy and slow down the floodwaters. In fact, the solid surfaces of the large patio will increase the velocity of floodwaters flowing landward, potentially increasing damage to town roads and infrastructure, such as the water, sewer, and other utility lines. The proposed pool, patio, and retaining walls would change the water flow patterns across the site, channeling and deflecting wave energy and moving waters. This wave energy and channelized overwash is likely to increase erosion adjacent to the proposed walls and/or potentially be deflected onto the neighboring properties and road.

Moreover, since the FIRM designates the site as being within a VE and AE Zone with water depths predicted to be 10-12 feet above grade in a major storm event, the site is considered a high hazard area subject to erosion and structural damage. In addition, the NFHL shows a LiMWA, which is the landward extent of the MoWA area where wave heights are predicted to be between 1.5 and 3.0 feet. Therefore, MoWA areas may also be subject to wave effects, quick-moving water, erosion, scour, or combinations of these forces. FEMA has recommended, and the Commission is requiring, that construction within the MoWA area be built on open pilings to minimize the impacts to the floodplain functions.

Based on the above and how the coastal dune will function in a storm event, the Commission finds that the proposed work will adversely affect the ability of the coastal dune to provide the beneficial functions of storm damage prevention and flood control to the subject and adjacent properties. The proposed project will likely cause increased erosion on site, as well as to the public road landward of the site, and structural damage to the subject and adjacent private properties. Although a dwelling with a slab already exists in the VE Zone (built before the Regulations were enacted), proposed projects should not worsen conditions—additional hard surfaces and structures will have an added impact on the coastal dune and its storm damage prevention and flood control functions.

Design Principles to Avoid or Minimize Adverse Impacts

The Commission requests that the applicant revise the plan to include particular measures to minimize the potential adverse impacts of the proposed project on the beneficial functions of the coastal dune and barrier beach. Below are design considerations to avoid or minimize adverse impacts and meet the performance standards. Revisions shall be made to the plan and presented at the next hearing for review and approval.

- **The proposed pool, patio, and retaining walls should be eliminated from the plan** - There are unlikely any alternative designs for the proposed pool, patio, and retaining walls that would minimize adverse effects on the function of the dune, such as the deflection of waves and increase in floodwater velocity, scour, and erosion of the subject and neighboring properties. These components of the application and plans should therefore be eliminated.

- **A patio may meet performance standards if it is reduced in size and constructed of pervious materials** - The large size of the proposed patio with its hard impervious surface may deflect wave energy, increase the velocity of water moving across it, and prevent the dune from being able to erode and shift to dissipate wave energy, all of which may lead to storm damage and flooding on the subject and adjacent properties. However, given that the location of the proposed patio is landward of the existing at-grade house, a patio that is substantially reduced in size and constructed of pervious materials may meet performance standards. Pervious materials could consist of crushed stone or shells, pea stone, or gravel.

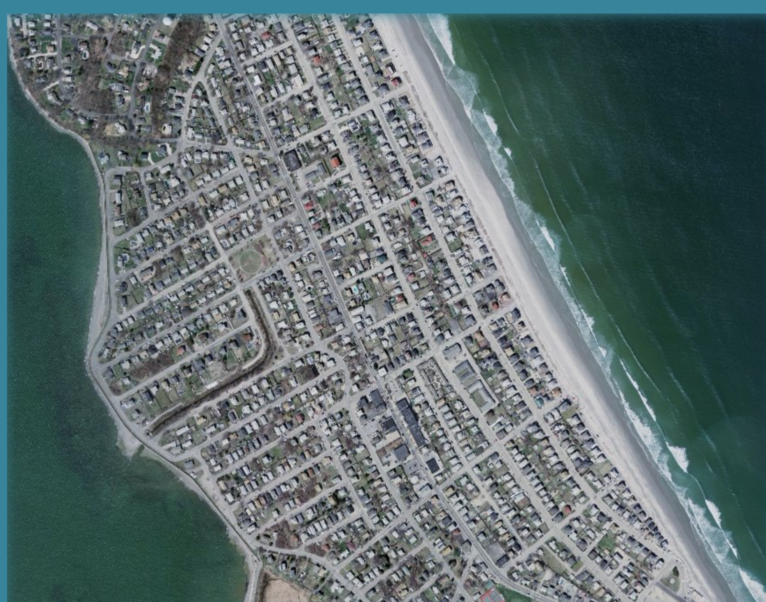
Editorial Note: The applicant eliminated the pool, patio, and retaining walls from the proposed plan.

As an alternative to a patio area, the applicant proposed an 8x10-foot elevated deck on piles. The applicant noted that the deck qualifies as an accessory project that need only minimize the adverse effect to the coastal dune caused by the impacts listed in 310 CMR 10.28(3)(b) through 10.28(3)(e), while still maintaining no adverse effect caused by the impact listed in 310 CMR 10.28(3)(a) (affecting the ability of waves to remove sand from the dune). Since the small deck area is to be placed on pilings and is to be located just landward of the existing house, it will minimize adverse effects listed in 310 CMR 10.28(3)(b-e) and have no adverse impact stated in 310 CMR 10.28(3)(a). In addition, the applicant proposed planting hardy, salt-tolerant native grasses directly around the deck area. The hardy grasses will not only provide aesthetic value, but will minimize wind scour and enhance the stability of the sediments under and around the deck area.

At the following hearing, the Commission reviewed the plan with the proposed deck area on pilings and agreed that it met the requirements for an accessory project under 310 CMR 10.28(3). The Commission also agreed that the plantings would enhance the stability of the site and are preferable to the existing lawn area. The Commission approved the revised application and plan.

Editorial Note: A Dune on a Barrier Beach with Diminished Functions

In contrast to the above scenario where a dune on a barrier beach was determined to function for storm damage and flood control, a highly developed area (such as this section of barrier beach in Photograph 42) will not necessarily function to the same degree. For instance, a parcel of land in the middle of the developed section of this wide portion of the barrier beach (which is still technically a dune) has likely lost much of its natural ability to dissipate wave energy, shift and change form, and move landward or laterally because of the effect of the many hard surfaces (houses, driveways, roads, etc.) that impede sediment movement. In addition, the significant width of the barrier beach and the low rates of sediment transport (erosion or accretion) on portions of this landform suggest that some areas are not currently acting like a barrier beach and dune and therefore have fewer functions that must be protected by the performance standards. It is important to note, however, that the area may still be subject to flooding, and possibly more so due to diminished beach and dune function. The landform does still have some ability to slow down water flow and dissipate wave energy. Moreover, though the dune functions are severely compromised, a project proposal should not make conditions worse—there should be *no further loss* to any existing beneficial functions of the dune, and the Commission may use their discretion to look for opportunities to *improve* existing conditions through mitigation.



Photograph 4.3. Barrier beach that has lost much of its ability to function. Photograph courtesy of the Office of Geographic Information (MassGIS) and United States Geological Survey (USGS) Color Ortho Imagery 2008 30cm.

SCENARIO TWO - THE IMPORTANCE OF PROTECTING THE FUNCTIONS OF A RESOURCE AREA

This scenario emphasizes the importance of determining and protecting the functions of a resource, while balancing the need for recreation, public access, and public safety.

Scenario Two - Applicant's Proposal

The following is a hypothetical example of an application for a project proposing maintenance of an existing public roadway on an undeveloped barrier beach. More specifically, the Town Department of Public Works (DPW) as the applicant is proposing reconstruction and repaving of a roadway, the widening of a portion of the roadway to provide paved parking for scenic viewing and beach access (referred to as a "parking lane"), and the construction of riprap armor reinforcement on a barrier beach that is subject to flooding in a 100-year storm (1%-annual-chance flood). This scenario illustrates a typical proposal made by an applicant to a Commission and therefore contains common mistakes and misinterpretations that warrant further review and clarification. The reader should note that the statements followed by an asterisk (*) will be addressed and/or corrected within the next section, "Commission Review and Findings."

Project as Proposed by Applicant

The DPW is requesting to reconstruct and repave a road that was destroyed during a recent winter storm (and has been damaged repeatedly by past storm events). An approximate 300-foot section of the paved road, which has been impassable since the storm, needs to be regraded and repaved.* This proposal also includes a request to widen a portion of the road to create a paved parallel parking lane just seaward of the road on what is now an unofficial sandy parking lane. The road and parking lane are overwashed with sand, pebbles, and cobbles in coastal storm events. They require plowing, clearing, and cleaning on a routine basis to keep them in accessible condition—work that is easier and less damaging to trucks and equipment when operating on a continuous paved surface.

In conjunction with the pavement work, the DPW is proposing additional riprap for reducing the amount and frequency of storm-wave overwash, as well as for preventing further erosion of the dune.* The DPW fears that if measures are not taken to hold off storm waves, the overwash will continue to damage the roadway and parking lane and fill in the pond behind the road, while storm waves will continue to erode sediment from the dune leading to an undercutting of the roadway. Therefore, the DPW is proposing to provide additional boulder and stone armor reinforcement to an existing riprap slope on the beach side of the road. The existing riprap, which includes beach

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stone infill and dumped boulders, has developed significant spacing and gaps between the boulders. Where this occurs, coastal storm-wave action is able to flow around the boulders and undermine the roadway edge. In addition, the energy deflected by the rock is directed landward, increasing erosion of the road—which is what happened to the 300-foot section of the roadway that was destroyed in the recent winter storm. By infilling the riprap and placing large boulders in and amongst the existing riprap and above the toe of the slope, the DPW hopes to stabilize the slope and reduce overwash, erosion, and undercutting of the roadway.* This level of protection should be effective up to the 10-year coastal storm event.

The DPW has discussed with other town boards and officials various options for addressing the situation of damages to the road after each coastal storm over the years. At this time, the DPW would like to continue to manage this public road to: provide continued access on the coastal loop drive that connects two public ways, particularly to provide fire truck access in the interest of public safety; protect existing recreational beach parking and access; and preserve the pond system behind the barrier beach.

Existing Site Conditions as Determined by Applicant

The site includes a sand, pebble, and cobble barrier beach, a coastal dune, and a shallow, brackish coastal pond located behind the dune (see Photograph 4.4 on page 4-19). The 18-foot-wide paved road that has been in existence for more than 100 years (although unpaved for the first 50 years) travels across the dune and a portion of the barrier beach for approximately a quarter of a mile. Three hundred feet of the paved portion of the road were damaged and removed by a recent coastal storm and are now comprised of dirt and stone, as well as cobble and sands from the storm overwash. On the seaward side of the road, a row of riprap helps to stabilize the roadway; on the landward side of the road, the dune slopes down to the coastal pond. A 24-inch metal pipe runs under the road, which provides a water overflow outlet from the pond and to some extent tidal water exchange. Where the road crosses the beach, it is subject to periodic overwash by coastal storm events.

Resource Areas as Delineated by Applicant

The following resource areas (land subject to coastal storm flowage, barrier beach, coastal beach, and coastal dune) were delineated at the project site.

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Land Subject to Coastal Storm Flowage

The FEMA FIRM for this area shows the beach and the seaward side of the dune up to the roadway as a V Zone, subject to the 100-year coastal flood with velocity flood zone elevations (breaking wave crests) ranging from 14 to 18 feet (NGVD). Landward of the road, the pond area is mapped as an A Zone with a floodwater elevation of 9 feet (NGVD). According to NOAA's tide data, the mean high water mark reaches elevation 4.6 feet NGVD on the beach face. During the monthly spring tide, the high-water mark reaches elevation 5.2 feet NGVD. The proximity of the roadway to these tidal elevations shows how vulnerable the road is to potential elevated water levels in storm events.

Barrier Beach

The barrier beach has been mapped by the Barrier Beach Inventory Project. As a barrier beach, the landform is composed of coastal beach and coastal dune resource areas. This barrier beach system separates the Atlantic Ocean from the pond and the developed upland.

Coastal Beach

The coastal beach consists of cobbles, pebbles, and sand. The beach width has narrowed and steepened over time as sediment has been lost over the course of past storm events. Rock outcroppings are becoming more apparent with this sediment loss.

Coastal Dune

The dune, which rises to an elevation ranging between 11 to 15 feet high (NGVD), is comprised of a mix of cobbles, pebbles, and sand, as well as a row of placed riprap. While the mean high water line is seaward of the dune ridge (and roadway), surges and wave action can easily overtop and/or erode the dune and road in a coastal storm. The vegetation of the dune primarily consists of Virginia rose (*Rosa virginiana*) and Carolina rose (*Rosa carolina*).

Resource Functions as Determined by Applicant

The roadway is located on a barrier beach, an area in constant transition. Storm events cause much shifting of sediments to occur. The profile of the beach and dune and the location of the road have changed over time, migrating toward the pond in response to erosion, migration, and sea level rise.

Long-term coastal erosion is also affecting this study area. The CZM Shoreline Change Project data show that the time-averaged rate of shoreline retreat (from the mid-1800s to 1994) in this area is 0.5

to 1 foot per year. The DPW hopes to prevent additional loss of sediment from the dune by performing the proposed work.*

Photograph 4.4. Road on a barrier beach. The subject road can be seen running along the beach and dune in front of a coastal pond. Beach parking is located along the seaward side of the roadway edge in the western portion of the photograph. Photograph courtesy of Office of Geographic Information (MassGIS) and United States Geological Survey (USGS) Color Ortho Imagery 2008 30cm.

Performance Standards and Design Principles to Avoid or Minimize Adverse Impacts

The performance standards for a barrier beach require that the standards for coastal beaches and coastal dunes be applied to the coastal beaches and all coastal dunes that make up a barrier beach.

Coastal Beach

Any project on a coastal beach shall not have an adverse effect by increasing erosion, decreasing the volume, or changing the form of any such coastal beach or an adjacent or downdrift coastal beach. The project will not negatively impact the coastal beach as no portion of the project is on un-altered areas of the coastal beach—additional riprap will be placed above the toe of the existing riprap slope and will not create any further encroachment onto the beach.* The wave energy that reflects off the riprap is not expected

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to create scour because of the dissipative quality of the sloped, rough, spaced surface of the riprap.*

Coastal Dune

Any project on a coastal dune shall not have an adverse effect on the dune by:

a) **Affecting the ability of waves to remove sand from the dune** - The reconstruction of the road and riprap will not result in any new alteration to the dune in terms of affecting the ability of the waves to transport sand from the site.* The site has already been altered with the existing riprap and pavement, and the reconstruction will not negatively impair this function.*

b) **Disturbing the vegetative cover so as to destabilize the dune** - The area is currently disturbed and is minimally vegetated.

c) **Causing any modification of the dune form that would increase the potential for storm or flood damage** - The modification to be made to the dune form with the reconstruction of the riprap will not increase the potential for storm or flood damage but rather protect it from these forces.*

d) **Interfering with the landward or lateral movement of sand through the dune** - The existing roadway to some degree has already altered this function; the reconstruction of the road and riprap will not further hinder this process.* Overwash of sediments and wind-blown sediment transport will still likely occur in major storm events, but will be of a less serious (and less damaging) nature.*

e) **Causing removal of sand from the dune artificially** - No removal of sediment is being proposed.*

In addition, the repaving of the existing road can be considered a limited project pursuant to 310 CMR 10.24(7)(c)1 provided it complies with applicable provisions for limited projects. Specifically, the Regulations allow for "maintenance and improvement of existing public roadways, but limited to widening less than a single lane, adding shoulders, correcting substandard intersections, and improving drainage systems." This proposed project will maintain an existing public roadway (and only widen it by an additional lane width along a particular portion of the roadway to accommodate the proposed parking lane).

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The Regulations also warrant consideration of the following factors when approving limited projects: "the magnitude of the alteration and the significance of the project to the interests identified in M.G.L. c. 131, § 40, the availability of reasonable alternatives to the proposed activity, and the extent to which adverse impacts are minimized and the extent to which mitigation measures including replication or restoration are provided to contribute to the protection of the interests." The DPW believes that the repaving of the road does not create any further alterations, as the road was already in existence, and adverse impacts are being minimized by maintaining the road in its original location.*

Summary

The DPW is trying to balance the need for beach public access and parking to the beach, another route of access for private residences, and the need to minimize excessive town costs and labor associated with routine maintenance of the roadway and parking lane.* The DPW finds that abandonment of this roadway is not a viable option. By "taking no action," the Town will lose a valuable recreational asset that has been in existence for years. The DPW has also assessed whether it is possible to relocate the roadway landward and out of the zone of storm damage and flooding but has concluded that there is no viable alternative route that meets safety standards associated with emergency egress. The DPW believes this proposal is the best alternative, meeting the goals of environmental protection, safety, recreation, and cost-effectiveness.*

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Scenario Two - Commission Review and Findings

The following is a hypothetical example of a Commission's review of the applicant's project proposing reconstruction and repaving of a roadway, the paving of a parking lane, and construction of riprap armor reinforcement on a barrier beach in the coastal floodplain that was presented on pages 4-16 through 4-21. This section illustrates the Commission's statements made during the hearing process, including the deliberations, requests for additional information, and the Commission's findings and responses to the proposal. The statements made within the previous section, "Applicant's Proposal," that were followed by an asterisk (*) are corrected or clarified within this section. Editorial notes are included in italicized text to provide context for the scenario or list references for additional information. Though it is not illustrated in this example, it is recommended that the DPW (or any applicant) set up a pre-application meeting with the Commission or its agent to discuss the project proposal and methods for best meeting the requirements of the WPA before the hearing process. A pre-application meeting will help applicants and Commissions make more efficient and effective use of the permit review process.

Proposed Project

The DPW is requesting to reconstruct and repave the road and widen a portion of the roadway to formalize a paved parking lane along the beach for scenic viewing and beach access. Both the roadway and the existing sand/dirt parking area were damaged by a recent storm and have been repeatedly damaged in previous storm events. To help preserve the longevity of the road, the DPW is also proposing to reconstruct the existing riprap to help reinforce the dune and roadway. The DPW is attempting to seek the most effective method to manage the public road to provide access to private property, protect existing recreational beach parking and access, and preserve the pond system behind the barrier beach.

Resource Areas

Editorial Note: The Commission performed a site visit once the application had been received to confirm the applicant's delineation of the resource areas and to make observations. The following are the Commissions statements presented at the hearing related to their findings at the site visit.

The Commission concurs with the applicant's delineation of the resource areas—land subject to coastal storm flowage, barrier beach, coastal dune, and coastal beach.

Resource Function

Editorial Note: The following are the Commissions statements presented at the hearing related to their observations and determinations of the functions of the resource areas at the site.

The Commission finds that the functions of the resource areas on the site are extremely important for the long-term stability of the barrier beach system and for the longevity of the road. The following describes our observations and determinations.

Barrier Beach—Coastal Dune and Beach

The majority of the sediment sources that supplied this barrier beach are either depleted or armored; the volume of sediment feeding the beach is greatly reduced. The sea level trend measurements show us that sea level has also been rising at 0.86 feet per 100 years in this region, which means that high tide heights and storm wave heights can affect areas of the beach and dune farther landward and more frequently than in the past. Although onshore-to-offshore exchange of sediment occurs, no appreciable longshore current (accretion or erosion to or from adjacent beaches) is generated because this is a pocket beach between two headlands. As such, the barrier beach will continue to be inundated by storm waves and to migrate and reshape in response to particular storm events. *Editorial Note: For sea level trends, see the NOAA website at www.tidesandcurrents.noaa.gov/sltrends/sltrends.html.*

As part of the barrier beach's function to dissipate energy and protect landward areas, the beach and dune sediments will be carried both landward as overwash and seaward as nearshore storm bars. The Commission notes that there are overwash fans extending landward of the road and into the pond. Due to reduced sediment supply and sea level rise, the entire barrier beach profile is shifting landward during storm events. This ability to reshape and migrate landward in response to relative sea level rise and natural overwash processes associated with coastal storms creates a natural dynamic equilibrium. To maintain this equilibrium, the Commission believes that all anthropogenic uses, such as roads and parking areas, must be flexible so that they can shift as the barrier beach profile migrates landward. Otherwise, not only will the stability and safety of these uses be jeopardized, but trying to maintain the road in a static location will result in increased erosion of the beach and dune and more frequent damage from high tides and coastal storms, as well as the constant need to remove overwash materials from and repair the road (see Photograph 4.5 on page 4-24).

As a coastal dune within a barrier beach and coastal dune closest to the beach (i.e., primary dune), the resource area is *per se* significant to protecting the interests of storm damage and flooding. This implies that protection of the various functions of the dune is particularly important. *Editorial Note: All dunes within a barrier beach are per se significant. For other areas of the coast, only the dune closest to the beach is per se significant.*

Photograph 4.5. Damaged pavement and overwashed sediment after a recent storm on a barrier beach. Photograph courtesy of Eric Hutchins, National Marine Fisheries Service.

Performance Standards

Editorial Note: The following are the Commission's statements presented at the hearing, including determinations of the relevant performance standards, the potential adverse impacts from the project, and design principles to avoid or minimize adverse impacts and meet the performance standards. The following statements are also a result of the ongoing discussions that have taken place with the DPW over the course of many years in regard to addressing the damages and options for fixing the road after each storm event. Since the most recent storm destroyed more of the pavement, it prompted more scrutiny of the option of maintaining the road in its current location versus adapting to the changing conditions on a dynamic barrier beach.

The performance standards for a barrier beach require that the standards for coastal beaches and coastal dunes be applied to the coastal beaches and all coastal dunes that make up a barrier beach. Any project on a coastal beach shall not have an adverse effect by increasing erosion, decreasing the volume, or changing the form of any such coastal beach or an adjacent or downdrift coastal beach. Any project on a coastal dune shall not have an adverse effect on the dune by: affecting the ability of waves to remove sand from the dune, disturbing the vegetative cover so as to destabilize the dune, causing any modification of the dune form that would increase the potential for storm or flood damage, interfering with the landward or lateral movement of sand, or causing removal of sand from the dune artificially.

Potential Adverse Impacts

The Commission finds that the project as proposed has the potential to adversely affect the functions of both the beach and dune and ultimately the barrier beach system.

The repaving of the road will convey the storm wave energy and overwash farther landward by increasing the velocity of the water. The pavement will also prevent sediment from being able to naturally shift and move and dissipate wind and wave energy. Increasing the width of the pavement to pave the parking lane would adversely affect the ability of the dune to erode, increase erosion, and shift the pavement footprint further seaward, making it more vulnerable to erosion.

Continually pushing and bulldozing overwash sediment back onto the seaward portion of the barrier profile artificially places this material on a different part of the profile (usually the steepened seaward face). The system will try to re-establish the natural profile, resulting in net erosion of sediments from the beach and dune and a net loss of volume from the barrier beach system (i.e., hastened narrowing of the barrier beach). Manipulation of surficial sands and cobbles has and will continue to become more frequent as the profile migrates landward, as has been the case over the past 10 years for this beach—maintaining the road in its current location has led to more frequent overwash, while relatively small storm events have torn up increasing amounts of pavement. In general, the Town will risk losing some of the sediments offshore following each coastal storm resulting in decreased sediment volume in the barrier beach to dissipate waves and flooding from storms. In addition, as the barrier migrates landward or erodes, the road and other man-made features, if not moved, will eventually end up on the steepened, seaward portion of the barrier. As the barrier beach erodes and shifts landward, the storm damage protection and flood control functions will continue to diminish, likely increasing storm damage and flooding on adjacent private properties

Although previously altered with dumped riprap, the existing riprap has gaps between the rocks that allow sediment to be exchanged with the beach. In contrast to what the applicant stated, the Commission believes that reconstruction of the riprap armor with additional boulders will further alter the natural ability of the dune to shift and erode and prevent the exchange of sediment between the beach, dune, and nearshore area. New riprap material placed on the beach/dune slope will also reflect wave energy more so than it currently does—leading to worsened beach scour and erosion.

Design Principles to Avoid or Minimize Adverse Impacts

To minimize adverse impacts, the Commission requests that the DPW look at alternatives to the reconstruction of a paved road, expansion of the pavement, and riprap armor protection. Below are design considerations to avoid or minimize adverse impacts and meet the performance standards for a barrier beach. Revisions shall be made to the plan and presented at the next hearing for review and approval.

Road and Parking Lane

The following alternatives should be considered to maintain the storm damage prevention and flood control interests of the resource areas and to sustain the longevity of the road and parking area.

- **Maintain the road in its landward location—where the last storm shifted the overwash sediments** - The Commission's preferred alternative for overall road management is to allow the location of the road to shift landward and upward in elevation (now and in the future) in response to changes in the beach and dune profile from storm events. By adapting to the coastal changes, the DPW will be helping to minimize the alteration to the beach and dune profile and reduce the frequency of overwash and necessary maintenance of the road. Less work (time and money) will be expended and the road will likely sustain less damage in the next storm if the town allows the road to shift in location and does not try to maintain the road in its previous location on the beach face.

- **Install and maintain the road as gravel and not asphalt, particularly in the areas where pavement was damaged or destroyed by the storm** - Although the repaving of the road could be permitted as a limited project per 310 CMR 10.24(7)(c)1, the Commission recommends that the DPW install and maintain the road as gravel and not asphalt, particularly in the areas where pavement was damaged or destroyed by the storm (in combination with shifting the roadway landward as described above to reduce the frequency with which storm waves reach the roadway). A gravel road is a more sustainable option that would maintain access to private property for both general and emergency access and to the beach for recreation. The gravel road would improve the ability of the barrier beach system to dissipate storm-wave energy and possibly reduce the volume of overwash that ends up on the road and in the pond after each storm. The new portion of the gravel road that is constructed more landward and at a higher elevation (where it was shifted in the last storm event—approximately elevation 13 feet) should be graded to meet the existing sections of roadway as smoothly as possible. No heavy equipment should be used to remove the loose asphalt debris and any debris should be disposed of properly. No additives should be mixed in with the compacted gravel and no de-icing chemicals should be used for the maintenance of this roadway.

- **Reassess the need for the parking lane in its current location** - The Commission believes that the proposal to widen the pavement for the parking lane in its current location may also decrease the storm damage protection provided by the beach and dunes. Currently, the overwash has narrowed the parking lane considerably. Pushing the dunes seaward to create additional room for paved parking along the seaward side of the road would produce a narrower beach with a steeper slope and interfere with the ability of the barrier beach to reshape and migrate landward in response to relative sea level rise and natural overwash processes associated with coastal storms. In addition, the Commission finds that any widening of the roadway can only be done at their discretion under the limited project provision and that the proposal does not meet the limited project requirement for widening "less than a single lane." The DPW should therefore assess alternatives for parking and at a minimum maintain this area as gravel rather than pavement.

Coastal Dune and Beach Management

Editorial Note: The Commission contacted both the Natural Heritage and Endangered Species Program and the Massachusetts Office of Coastal Zone Management (CZM) for information on dune and beach management practices and potential alternatives to protect the functions of the resource area. Though the burden is typically upon the applicant to design a project, a Commission can benefit from the general guidance provided by state and federal agencies. The Commission is thereby informed of alternatives to the project as proposed and better prepared to request that the applicant revise the project plan to meet performance standards.

The following alternatives shall be considered to maintain the functions of the resource areas while balancing the need for beach public access and recreation.

- **Construct a beach/dune in lieu of the riprap reinforcement** - The Commission requests that in lieu of the additional placement of riprap, the DPW construct a dune on the seaward side of the road. A constructed dune will increase the volume of sediments in the dune and beach system, improving its ability to dissipate storm waves and reduce the frequency of waves overtopping the road. Beach nourishment—rather than or in addition to a dune—can also be considered. Sediments used to nourish the dune and beach should NOT come from the overwash fans on the pond-side of the road, nor should they come from the storm deposits on the roadway, since these are to remain there for purposes of building up the elevation of the road. The source of the sand, gravel, and cobble for the reconstruction and creation of the dune/beach should therefore come from an off-site source. These materials should be compatible with the existing beach and dune. This compatible material should be graded to create a gentle slope that meets up with the road shoulder. Care should be taken not to bury existing vegetation on the beach or dunes—since this vegetation is helping to stabilize the resources.[136] To limit impacts to the pond ecosystem, sediment should not be piled on the landward side of the road. For further guidance, the DPW is advised to consult CZM's StormSmart Properties Fact Sheet 1: Artificial Dunes and Dune Nourishment (www.mass.gov/service-details/stormsmart-properties-fact-sheet-1-artificial-dunes-and-dune-nourishment).

[136] Short-term impacts to the vegetation are often necessary to provide long-term enhancement of the storm damage and flood control functions by increasing the volume of the dune.

- **Plant beach and dune vegetation to help build and stabilize dunes** - The Commission also requests that the DPW enhance the *natural* accumulation and build-up of the dunes by planting vegetation, primarily American beachgrass *(Ammophila breviligulata*). Beachgrass is equipped with thick fibrous root systems that capture and stabilize windblown sediments, helping to build up and stabilize the dune. The coastal dune overwash fans located on the pond-side of the road should also be re-vegetated with beach grass to limit sediments washing into the pond. Because it is a cool-season grass, the best time to plant beachgrass in New England is from mid-November through mid-April (but not when the ground is frozen). In areas exposed to strong wind or waves, it is best to plant beachgrass in the early spring to reduce the likelihood that it will be washed or blown away in winter storms. Each planting hole should be dug 8-12 inches deep, to prevent the beachgrass stem and roots from drying out, and be spaced 18 inches apart. Plant 2-3 culms per hole and compact sediment around the plants. Stagger each row to provide maximum erosion control and sand trapping potential. An organic, slow-release, water-insoluble fertilizer may be used to establish beachgrass plantings. The Commission also encourages using a mix of native grasses, perennials, groundcovers, and shrubs to diversify the landscape and reduce the potential for loss to disease or pests. For more information on coastal plantings, the DPW is encouraged to consult CZM's Coastal Landscaping website (www.mass.gov/service-details/stormsmart-coasts-coastal-landscaping-in-massachusetts) or the StormSmart Properties Fact Sheet 3: Planting Vegetation to Reduce Erosion and Storm Damage (www.mass.gov/service-details/stormsmart-properties-fact-sheet-3-planting-vegetation-to-reduce-erosion-and-storm).

  The town maps of Estimated Habitats of Rare Wildlife indicate that the project is found to be within Estimated Habitat of Rare Wildlife. The Commission notes that the applicant has properly filed a copy of the Notice of Intent with the Natural Heritage and Endangered Species Program (NHESP) of the Division of Fisheries and Wildlife (www.mass.gov/orgs/masswildlifes-natural-heritage-endangered-species-program). NHESP has provided a response letter that finds the proposed project to be in a wetland resource area habitat for a state-listed rare wildlife species, but also finds that the proposed project will not have an adverse effect on the habitat. Any modifications to the application, however, must be provided to NHESP for their reassessment of impacts.

- **Monitor and maintain the establishment of beach and dune plants to ensure that they are taking hold and providing effective stabilization** - Percent cover is a good indicator of plant establishment—replanted native dune grass plants should provide a 50% ground cover after the first growing season and a 75% ground cover after the end of the second growing season. If this level of success is not achieved, replanting should be conducted until the required 75% cover is achieved. Sand fencing erected around the re-vegetated areas will allow better protection of the new culms until they become established, will discourage people from walking over the vegetated dunes, and can demarcate where cars should drive and park.

- **Restore the dune and install a boardwalk or an at-grade ramp for beach access through the dune** - Though no proposal has been set forth by the applicant regarding beach access, the existing gap in the dune that provides foot access to the beach has created a weak point in the dune through which waves and sediment can easily flow—decreasing the storm damage protection value and increasing the vulnerability of the road to overwash and erosion. The dune should be restored to the original height by filling in the gap with sediments compatible with the existing material. To provide access to the beach, a boardwalk or an at-grade ramp could be constructed for use on this site, either of which could be designed in a way that facilitates removing them during the winter storm season to prevent loss or damage.

Pond Management

The following measures shall be considered to maintain the functions of the pond resource area and sustain its health and longevity.

- **Clean out the culvert to the pond on a regular basis and avoid placing overwash deposits on the pond side of the road** - The culvert that allows exchange of water between the pond and the ocean is apparently blocked. Since this culvert provides the major exchange of water between the pond and the ocean, the Commission requests that it be cleaned out and put on a regular inspection and maintenance schedule to address concerns regarding the health of the pond. The DPW should plant additional vegetation, such as beachgrass, on the landward and seaward side of the road to reduce the velocity of overwash, filter out sediments, and minimize the likelihood that they will be washed into the pond. In addition, to prevent overwash sediments from infilling the pond, the DPW should be sure that any material cleared from the road should not be deposited on the landward side of the road in the vicinity of the pond.

Long-Term Management

The following measures for the long-term management of the road shall be considered.

- **Adapt to changing shoreline conditions for the long-term management of the road** - The Commission believes that the barrier beach system will continue to shift landward over time with future storms. Bulldozing the overwash material from the road seaward onto the beach is working against the natural barrier beach migration/erosion process and will eventually become ineffective, particularly with the increased frequency of artificial manipulation that has taken place over the past 10 years. To be safe and cost-effective, the roads and parking lane must move landward or be abandoned at some point in the evolution of the barrier beach—consistent with its landward migration or erosion rate. While the actions of manipulating the profile may have been justified in the past, the DPW may want to start considering a long-range perspective. Since the DPW has determined that the road cannot be completely abandoned or moved at the present time, allowing a portion of road to be shifted landward and replacing that portion's asphalt with gravel is a better way to work with the system, increasing the ability of the landform to dissipate energy and shift naturally with wind and waves. This method will also work for the best interests of fire access, public access, and recreation, since the newly established road is less likely to be overwashed and damaged. The natural materials are also more appropriate and will not contribute to storm debris.

- **Add sediment volume to the dune and beach to help increase storm damage protection to the road and enhance the resource areas without detrimental effects to the environment** - Beach and dune nourishment can be important elements for the success of this project. In order to slow down the landward migration of the beach, the Town needs to add sediments to the beach and dune system to make up for the lack of natural sediment supply. Regular monitoring of the barrier beach profile to better understand seasonal and storm-induced changes will allow the DPW to address whether periodic re-nourishment of sediments is needed to maintain the profile conditions that maintain stability of the area.

Editorial Note: The applicant revised the plan to include a re-positioning of the road landward, using gravel rather than asphalt. Since no other feasible alternative location could be located for the parking lane, the DPW proposed a revision to the plan that included reducing the proposed parking lane width, but adding some gravel to prevent cars from getting stuck in soft sand, which has happened frequently at the site. In lieu of the additional boulder and stone armor reinforcement to the existing riprap slope on the beach side of the road, the applicant revised the plan to include a 5-foot high, 10-foot base mixed sediment (sand, gravel, and cobble) dune with pre-existing riprap as the core. The applicant proposed to bring in sediments from an off-site source and place it on top of the existing riprap seaward of the road. They also proposed to bring in extra sediment to fill in the gap within the existing dune caused by current foot access to the beach, and then redirect access to one consolidated path.

The DPW referenced Coastal Dune Protection and Restoration, Using Cape American Beachgrass and Fencing—*a Marine Extension Bulletin from Woods Hole (www.whoi.edu/fileserver.do?id=87224&pt=2&p=88900 - PDF, 3.2 MB), as well as* Guidelines for Barrier Beach Management in Massachusetts *(www.mass.gov/files/documents/2016/08/vh/barrier-beach-guidelines.pdf - PDF, 12 MB) and made additional revisions to the plan to include the planting of beachgrass on top of the constructed dune and existing dune (where sediment was added). The DPW scheduled the proposed planting for the months of March and April for maximum establishment and included the other specifications recommended by the Commission and above sources.*

The DPW also provided an inspection and maintenance plan for periodic cleaning of the culvert to the pond.

At the next hearing, the Commission reviewed these changes, determined that the revised project met the performance standards for the beach and dune, and approved the revised application and plan.

SCENARIO THREE - THE IMPORTANCE OF DESIGNING A PROJECT TO MEET PERFORMANCE STANDARDS

This scenario emphasizes the importance of designing a project to minimize adverse impacts and meet performance standards that protect the resource areas.

Scenario Three - Applicant's Proposal

The following is a hypothetical example of an application for a proposed seawall on a coastal bank. This example depicts the challenges of determining factors that affect function and the importance of implementing design principles to protect the functions. This scenario illustrates a typical proposal made by an applicant to a Commission and therefore contains common mistakes and misinterpretations that warrant further review and clarification. The reader should note that the statements followed by an asterisk (*) will be addressed and/or corrected within the next section—"Commission Review and Findings."

Project as Proposed by Applicant

This Notice of Intent filing is in support of a proposed installation of a new seawall to armor a coastal bank, which is currently armored with a deteriorating riprap revetment. The proposal involves constructing a new cast-in-place vertical concrete seawall with backfill, resetting the existing stone riprap behind and in front of the seawall, and replacing a timber stairway (see plans in Figures 4.2 and 4.3 on page 4-35). The proposed concrete portion of the structure extends to the proponents northern property line, and the proposed riprap extends farther seaward than the existing riprap revetment. The proposed project also includes the loaming and seeding of the coastal bank above the proposed riprap on the top of the coastal bank.

Existing Site Conditions as Determined by Applicant

The site located at 123 Seaview Road includes an existing house constructed in 1975, a driveway, a landscaped yard, a stairway to the beach, and a deteriorating riprap revetment. The lot fronts on Seaview Road and backs up to the Atlantic Ocean. The lot is between two other residential developments, both with their own existing seawalls (subject revetment is connected to the seawall on the southern property but not connected to seawall on the northern property). The revetment at the subject property has been in a state of disrepair for many years and storm waves have accelerated its deterioration.

Resource Areas as Delineated by Applicant

The property extends from Seaview Road to the mean high water line at elevation 4.5 feet. Coastal wetland resource areas on the site are presented on the plan on page 4-35 and include land subject to coastal storm flowage, rocky intertidal shore, and coastal bank.*

Land Subject to Coastal Storm Flowage

The flood zones for the site, as indicated on the Flood Insurance Rate Map, are V Zone elevation 24.2 feet transitioning to an X Zone.* The V Zone is delineated on the plan at the indicated elevation of 24.2 feet (NGVD).* The reference datum on the plan for the topography is Mean Low Water.* The proposed project is located almost entirely within the V Zone.

Rocky Intertidal Shore

The rocky intertidal shore extends seaward from the mean high water line to the mean low water line. It is delineated as a rocky intertidal by meeting the criteria as defined in the WPA Regulations: "naturally occurring rocky areas, such as bedrock or boulder-strewn areas between the mean high water line and the mean low water line."

Coastal Bank

The seaward extent of the coastal bank is the toe of the riprap slope. The top of the coastal bank has been delineated based on the break in slope above the floodplain from a ≥4:1 slope to a <4:1 slope, according to the MassDEP policy (DWW Policy 92-1). *Editorial Note: See Appendix D for the MassDEP policy defining and delineating the criteria for determining top of coastal bank, Appendix E for information on calculating slope, and Appendix F for how to use an engineer scale to calculate distance on a plan.*

As part of this application, Figure 4.4 on page 4-36 shows a cross section and slope analysis corresponding to the colored line (transect A) shown on the contour plan in Figure 4.2 on page 4-35. The run and rise for each segment were calculated and the top of the coastal bank is shown where there is a break in slope (between segments purple and blue) where the slope went from approximately 1:1 (which is steeper than 4:1) to a slope of 5:1 (which is less steep than 4:1). An existing concrete wall is located at this break in slope. The land flattens out landward of the wall as seen on the cross section, indicating that there is only one coastal bank at this site.

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Resource Function as Determined by Applicant

The coastal bank at this site functions as a vertical buffer to storm waves and flood waters. The height and stability of the coastal bank contribute to its function as a natural wall that protects upland areas from storm damage and flooding. However, with the deterioration of the existing riprap from wave action and storm-related incidents, there are concerns that the stability of the bank has been reduced and that landward development may be jeopardized.

Due to the armoring of the coastal bank, this bank does not act as a sediment-source type bank.*

Performance Standards and Project Design as Proposed by Applicant

The following describes how the project will meet the performance standards to protect the storm damage prevention and flood control interests of the resource areas on site.

Land Subject to Coastal Storm Flowage

There are no performance standards for this resource area. Nevertheless, no impacts are expected from flooding as the top of the seawall is above the V Zone elevation.*

Rocky Intertidal Shores

The performance standard for a rocky intertidal shore (310 CMR 10.31(3)) requires that any proposed project shall be designed and constructed, using the best practical measures, so as to minimize adverse effects on the form and volume of exposed intertidal bedrock and boulders. This project is not expected to have an adverse effect by changing the form or volume of the rocky intertidal shore, as no components of the project extend into this zone.*

Coastal Bank

The project is consistent with the performance standard for a coastal bank that acts as a vertical buffer (310 CMR 10.30(6)) in that the construction shall not have an adverse effect on the stability of the coastal bank. The project will improve the stability of the coastal bank.* The existing riprap revetment is being undermined and sediment will continue to erode from the bank as a result of tides and wave action unless remedies are taken to prevent further loss. If a new seawall is not installed, the function of the coastal bank to act as a vertical buffer protecting the landward property will be compromised and the residence will

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be at risk.* The proposed seawall is intended to reduce sediment loss, stabilize the coastal bank, and protect the landward property.

In addition, this bank is not a sediment source,* and therefore bulkheads, revetments, seawalls, groins, or other coastal engineering structures may be permitted on such a coastal bank pursuant to Performance Standard 310 CMR 10.30(7).

Summary

Due to the current state of disrepair of the existing revetment, the continued loss of sediment from the bank, and further undermining of the riprap, the applicant believes this proposal is necessary to protect the existing home and property.* The proposed vertical concrete seawall, backfill, and stone riprap behind and in front of the seawall will help stabilize the bank and protect landward development. Because this is a replacement of an existing coastal engineering structure on a vertical buffer bank, no further adverse impacts to the resource areas will result on site.*

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*Text in the "Applicant's Proposal" section contains misinterpretation of information, inaccurate data, incomplete analysis, or insufficient design considerations. Please read the "Commission's Review and Findings" section to get a complete picture of the project, the potential adverse impacts to the resource areas, and methods for ensuring compliance with the performance standards.

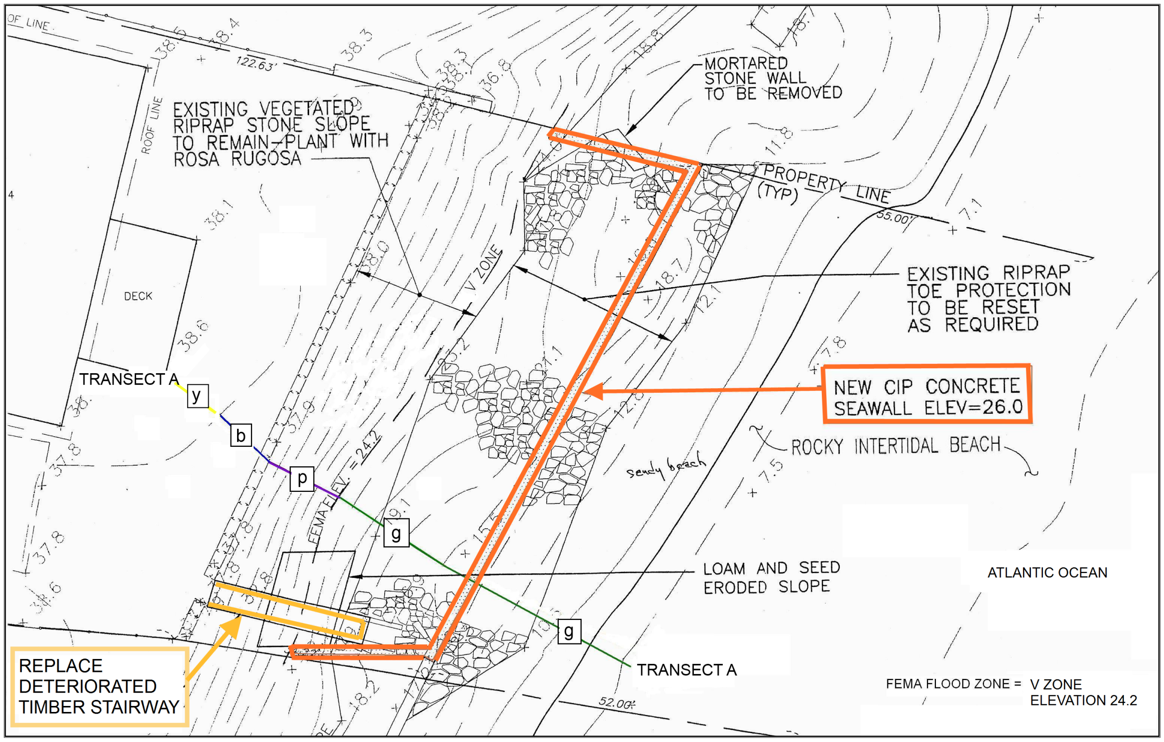

Figure 4.2. An applicant's plan proposing bank armoring with a vertical concrete seawall. The multi-colored line (Transect A) (also coded by "y" for yellow, "b" for blue, etc.) that is perpendicular to the contour lines is for determining slope (as described in the slope analysis on page 4-36).

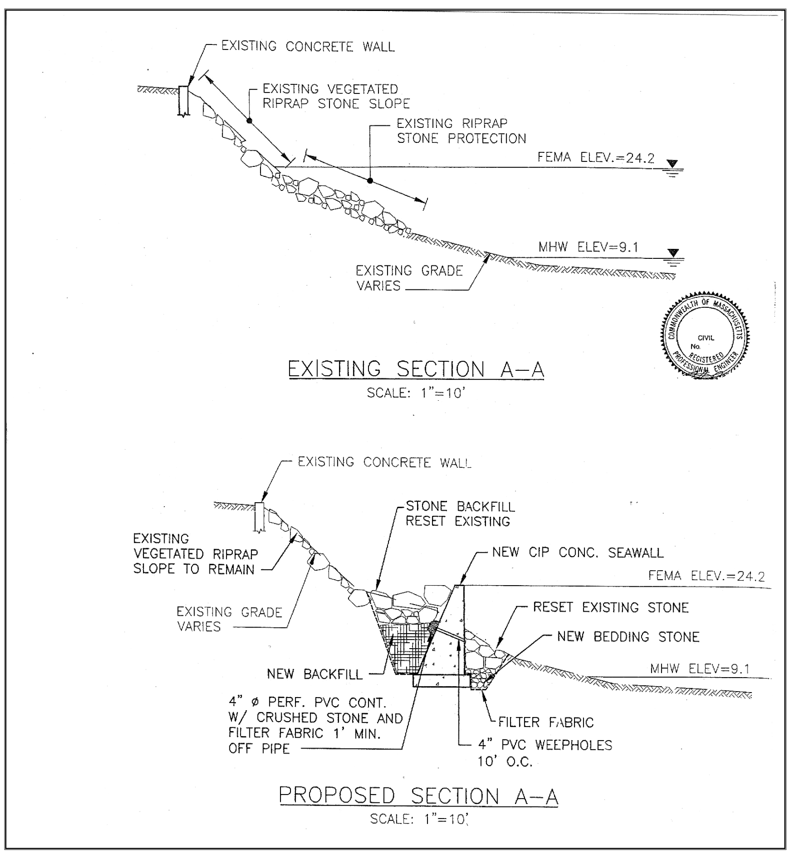

Figure 4.3. Cross sections of existing slope and proposed armoring with concrete seawall.

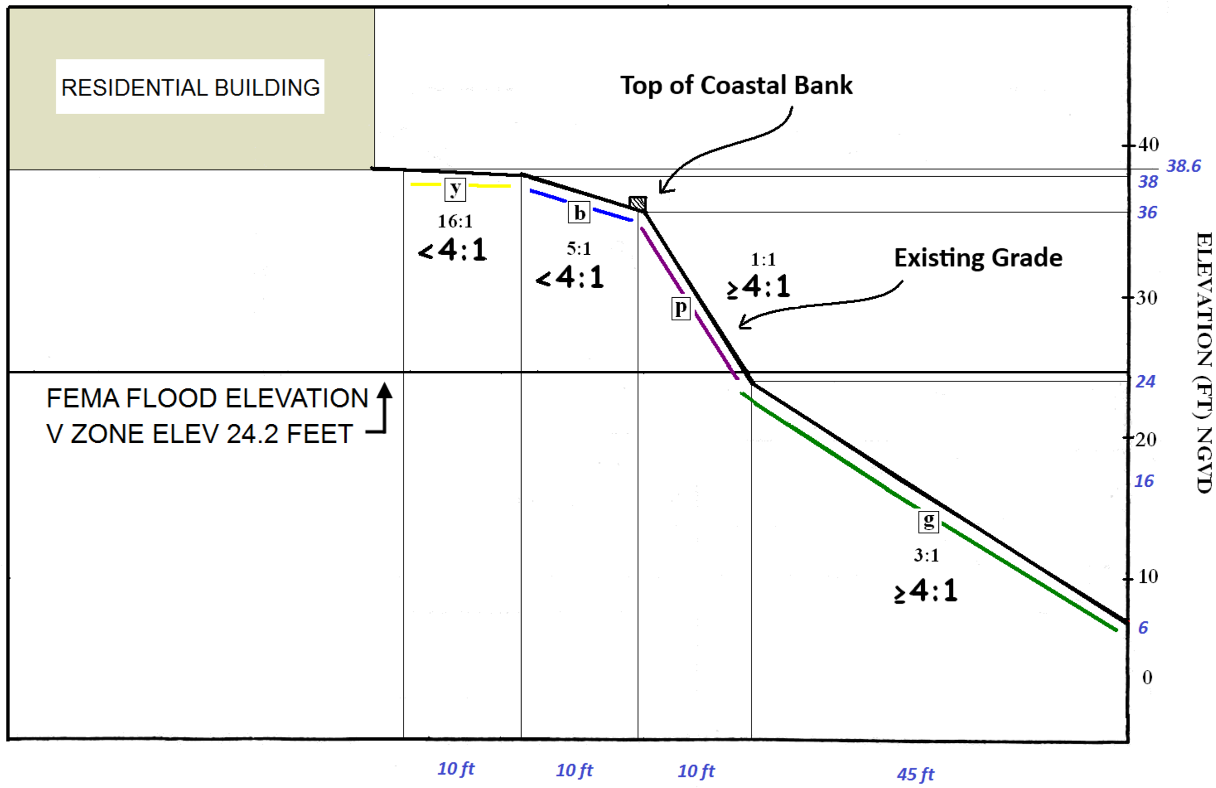

Figure 4.4. Cross section and slope analysis of the coastal bank. The colored segments (with noted elevations and landward runs) (also coded with "y" for yellow, etc.) correspond to the line segments (Transect A) drawn perpendicular to the contour lines on the plan in Figure 4.2. The slope of the green segment is approximately 3:1, the purple is approximately 1:1, the blue is 5:1, and the yellow is 16:1. The top of the coastal bank is where there is a break in slope above the floodplain elevation from a ≥4:1 slope to a <4:1 slope—between purple and blue at elevation 36 feet (and where the existing concrete wall is located). *Editorial Note: For more information on calculating slope, see Appendix E. For more information on determining the FEMA V Zone elevation for a steep bank, see "Land Subject to Coastal Storm Flowage" beginning on page 1-67).*

Scenario Three - Commission Review and Findings

The following is a hypothetical example of a Commission's review of the applicant's proposal for a new seawall on a coastal bank that was presented on pages 4-31 through 4-36. This section illustrates the Commission's statements made during the hearing process, including the deliberations, requests for additional information, and the Commission's findings and responses to the proposal. The statements made within the previous section, "Applicant's Proposal," that were followed by an asterisk (*) are corrected or clarified within this section. Editorial notes are included in italicized text to provide context for the scenario or list references for additional information

Proposed Project

The applicant describes the project as the installation of a new seawall to armor a coastal bank, which is currently armored with a deteriorated riprap revetment (see Photograph 4.6). The applicant proposes to construct a new cast-in-place vertical concrete seawall with backfill, reset the existing stone riprap behind and in front of the seawall, and replace a timber stairway. The proposed concrete portion of the structure will extend to the proponents northern property line, and the proposed riprap will extend farther seaward than the existing riprap revetment. The proposed project also includes the loaming and seeding of the coastal bank above the proposed riprap on the top of the coastal bank. Along with the Notice of Intent, the applicant submitted an engineered stamped plan of the project proposal, cross sections of existing and proposed slopes, and a slope analysis.

Photograph 4.6. Pre-existing riprap on coastal bank and coastal beach. The rocky intertidal shore can be seen in the distance.

Resource Areas

Editorial Note: The Commission performed a site visit once the application had been received to confirm the applicant's delineation of the resource areas and to make observations. The following are the Commissions statements presented at the hearing related to their findings at the site visit.

The Commission has confirmed the accuracy of some of the resource area delineations but has encountered a few problems with the applicant's delineation of some others. The following describes the Commission's observations and clarifications of each resource area on site.

Land Subject to Coastal Storm Flowage

The project plan indicates a V Zone with an elevation of 24.2 feet. The Commission requests clarification of the method of determining this elevation, since the Flood Insurance Rate Map shows the site within a V Zone elevation 20 feet transitioning landward to an X Zone. The applicant has used mean low water as a reference datum on the project plans. Since FEMA elevations reference NAVD 88 for newer maps and NGVD 29 for older maps, the applicant should convert the topographic data and structure data from their mean low water datum to NGVD 29 (since flood zone designations of this area are based on an *older* map), to accurately reference the data on the FIRMs.

Because there is no A Zone mapped landward of the V Zone and this shoreline is a rapidly rising ground profile, the landward V Zone BFE (the base flood elevation provided on the FIRMs) is based on the wave run-up elevation. The applicant was, therefore, correct in delineating the landward extent of the V Zone by locating the corresponding topographic contour on the plans (and cross section). This differs from a coastline that has a gently sloping ground profile, where wave heights diminish in the landward direction as waves break, and velocity conditions do not reach as far landward as the ground contour elevation corresponding to the V Zone BFE (in these cases, overlaying the FIRM on the contour plan or scaling the flood zone boundary onto the plan would be required). *Editorial Note: For more information on determining flood zone boundaries, see "Land Subject to Coastal Storm Flowage" beginning on page 1-67.*

Rocky Intertidal Shore and Coastal Beach

The project plan shows a rocky intertidal shore extending landward from the mean low water line to the mean high water line. The applicant determined this to be a rocky intertidal shore based on the WPA Regulations definition. Even though much of the intertidal area is comprised of cobbles and pebbles (which also make it a coastal beach—see below), the Commission agrees that this area is a rocky intertidal shore based on the predominance of boulders and/or bedrock in the intertidal zone.

Based on the coastal beach resource area definition that states a beach is comprised of "unconsolidated sediment," with no specification as to the size of sediment, the area extending landward from the mean low water line to the bottom of the coastal bank slope would also be considered coastal beach. Therefore, the coastal beach and rocky intertidal shore overlap within the intertidal region (between mean high and low water). The Commission requests that the applicant delineate the coastal beach resource area on the plan.

Coastal Bank

The plan shows the topography of the coastal bank from the toe up to the top of the coastal bank. The applicant shows the landward extent of the bank being at elevation 36 where the steeper than 4:1 slope becomes less steep than 4:1 above the 100-year flood elevation. This also corresponds to the location of the existing concrete wall. A site visit and review of the plans provided by the applicant in Figures 4.2 and 4.3 on page 4-35 and of the slope analysis in Figure 4.4 on page 4-36 confirmed this delineation as accurate. The Commission believes this bank best conforms to the graphic depiction shown in Figure 2 of the MassDEP Coastal Bank Policy (see Appendix D). *Editorial Note: For more information on slope analysis and determining the top of a coastal bank, see the section on coastal banks beginning on page 1-51 and Appendix D and E.*

The Commission requests that the applicant make the necessary revisions to the resource area delineations on the plan and present it at the next hearing for review.

Resource Functions

Editorial Note: The following are the Commissions statements presented at the hearing regarding their observations and determinations of the functions of the resource areas at the site.

The Commission agrees that the coastal bank at this site functions as a vertical buffer to storm waves and flood waters. The height and stability of the coastal bank contribute to its function as a natural wall that protects upland areas from storm damage and flooding. The existing riprap at the site has been undermined due to beach erosion. The beach erosion, in turn, results from less sediment being contributed to the littoral system by the updrift, adjacent, and on-site armored coastal banks and from the reflection of the wave energy from the riprap on this site and from other coastal engineering structures along the shoreline. Without a supply of sediment from eroding coastal banks and/or other sediment sources to sustain the volume of the coastal beach, the ability of the beach to help dissipate storm-wave energy and control flooding has been reduced.

In contrast to what the applicant stated in the Notice of Intent, the Commission finds this coastal bank *is* a sediment-source bank, despite the diminished function, since it can still erode and provide sediment to the coastal beach. The riprap on the face of the bank has deteriorated to the point where erosion from behind the structure can occur from tides, storm surges, or waves. The applicant has confirmed this finding by stating, "The existing riprap revetment is being undermined and sediment will continue to erode from the bank as a result of tides and wave action unless remedies are taken to prevent further loss." This being the case, the bank does function as a sediment-source bank, and the applicable performance standards will be addressed below.
The applicant made the determination that the stability of the bank has been reduced because wave action and storm-related incidents have caused deterioration of the riprap. However, the applicant

did not address whether other problems are causing instability of the bank. The Commission's site observations indicated that upland runoff is also causing erosion of the coastal bank—small sinkholes were found immediately landward of the concrete wall at the top of the bank, rills and gullies were found on the face of the bank, and no vegetation was present to slow the flow of stormwater and hold the bank sediments in place. If runoff is determined to be the primary cause of bank instability and erosion, the problem may be addressed without the need for a larger coastal engineering structure (such as with coastal native plantings or regrading the top of bank to direct flow landward). However, since the applicant and Commission have confirmed that erosion caused by wave action or storm damage is also threatening bank stability, replacing the existing structure may be justified (see more on next page). Nevertheless, the Commission requests that the applicant identify all causes of erosion and the reasons for failure of the structure through site observations and analysis of shoreline change history before proposing alternatives to remedy the problems.

Performance Standards

Editorial Note: The following are the Commission's statements presented at the hearing, including determinations of the relevant performance standards, the potential adverse impacts from the project, and design principles to avoid or minimize adverse impacts and meet the performance standards.

The Commission finds that the project must meet the following performance standards for each of the resource areas delineated on site.

Coastal Beach

Pursuant to the performance standards, any project on a coastal beach, except any project permitted under 310 CMR 10.30(3)(a), shall not have an adverse effect by increasing erosion, decreasing the volume, or changing the form of any such coastal beach or an adjacent or downdrift coastal beach. The coastal bank section, 310 CMR 10.30(3)(a), allows coastal engineering structures or a modification thereto (that meet particular requirements—see "Coastal Bank" below) to be designed and constructed using best available measures to minimize adverse effects on adjacent or nearby coastal beaches due to changes in wave action.

Rocky Intertidal Shore

The standards for a rocky intertidal shore require that any proposed project shall be designed and constructed, using the best practical measures, so as to minimize adverse effects on the form and volume of exposed intertidal bedrock and boulders.

Coastal Bank

The performance standards for a coastal bank (that acts as a vertical buffer) require that any project on such a coastal bank or within 100 feet landward of the top of such coastal bank shall have no adverse effects on the stability of the coastal bank. In addition, bulkheads, revetments, seawalls, groins, or other coastal engineering structures may be permitted on such a coastal bank, except when the bank supplies sediment to coastal beaches, coastal dunes, and barrier beaches. In this case, the bank still has the ability to erode and contribute sediment to the coastal beach—as witnessed by the undermining of the riprap, the compatible source of sediment found on the beach, and the confirmation by the applicant that the bank is eroding because of the deterioration of the existing riprap from wave action and storm-related incidents. The Regulations, 310 CMR 10.30(3), allow the construction of coastal engineering structures, or a modification thereto, on sediment-source type banks when necessary to protect buildings constructed prior to August 10, 1978, provided there are no other feasible methods of protecting the building, and that the structure is designed to minimize, using best available measures, adverse effects on adjacent or nearby coastal beaches due to changes in wave action.

Potential Adverse Impacts

Given that the house to be protected was built prior to August 10, 1978, the applicant is allowed a new or modified coastal engineering structure, provided that they meet the particular requirements as described above. Specifically, there should be no other feasible method of protecting the building other than the proposed coastal engineering structure, and the design of the structure should use the best available measures to minimize adverse effects. The project as proposed with a vertical seawall configuration (Figures 4.2 and 4.3 on page 4-35) will have adverse impacts on the fronting and adjacent coastal beaches, rocky intertidal shore, and coastal banks through increased reflection of wave energy—in comparison to a sloped/rough riprap revetment that will dissipate wave energy more effectively (for an example, see Figure 4.5 on page 4-46). In addition, the placement of large amounts of riprap in front of the vertical seawall will cause further encroachment onto (and permanent loss of) the coastal beach, which will also interact with waves and tides more frequently, causing increased rates of beach erosion. Since the proposed concrete portion of the structure extends to the proponents northern property line but does not connect to the northern seawall, the proposed structure will likely deflect waves onto the unarmored portion of the adjacent property, adversely affecting storm damage and flood control functions and increasing erosion of that bank and beach. The result is likely to increase storm damage to adjacent properties.

Design Principles to Avoid or Minimize Adverse Impacts

The Commission requests that the applicant revise the project narrative and plans to include particular measures to minimize the potential adverse impacts of the proposed project on the beneficial functions of the coastal beach and bank. Below are design considerations to avoid or minimize adverse impacts and meet the performance standards. Revisions shall be made to the narrative and plans and presented at the next hearing for review and approval.

- **Address and remediate stormwater runoff to reduce erosion and lessen the need for structural stabilization and erosion controls** - Based on observations at the site, it appears that runoff from the top of the bank is contributing to erosion of the bank as evidenced by the sinkholes, rills, and gullies. The applicant should address all factors contributing to the erosion as part of a comprehensive approach to providing protection to the pre-1978 dwelling. By addressing the runoff problem, the proponents will reduce one of the forces causing erosion, which may ultimately reduce the need for a larger coastal engineering structure to protect the dwelling, or at a minimum improve the life of the structure by reducing runoff that could destabilize it. For more information, the applicant is encouraged to consult the Massachusetts Office of Coastal Zone Management (CZM) StormSmart Properties Fact Sheet 2: Controlling Overland Runoff to Reduce Coastal Erosion (www.mass.gov/service-details/stormsmart-properties-fact-sheet-2-controlling-overland-runoff-to-reduce-coastal). The upper portions of the bank should be vegetated with erosion control plantings and jute mesh can be used to stabilize sediments until the vegetation becomes established. Instead of the proposed loam and seed, it is recommended that the proponents use appropriate salt-tolerant erosion control plants for this site. More information is available on the CZM Coastal Landscaping website (www.mass.gov/service-details/stormsmart-coasts-coastal-landscaping-in-massachusetts) or within the StormSmart Properties Fact Sheet 3: Planting Vegetation to Reduce Erosion and Storm Damage (www.mass.gov/service-details/stormsmart-properties-fact-sheet-3-planting-vegetation-to-reduce-erosion-and-storm).

- **Perform an alternatives analysis to examine other methods of providing protection** - An alternatives analysis should be performed to examine other methods of providing protection to the pre-1978 dwelling, such as addressing the upland runoff to reduce erosion of the bank, providing erosion-control plantings on the bank face, and/or constructing a sediment dune or other non-structural measures to stabilize the toe of the bank and dissipate wave energy before it reaches the bank.

- **Redesign the hard structure to minimize adverse effects** - If a "hard" structure is deemed necessary to protect the dwelling, the applicant should use a design that minimizes adverse effects, such as a rough-faced sloping riprap revetment (as seen in Figure 4.5 on page 4-46). In addition, the proposed structure should be located as far landward as possible so as to avoid encroachment onto the beach, given there is space between the top of the coastal bank and any dwellings. The applicant should also look at redesigning the riprap revetment to mimic the existing bank slope, with an effort to keep the slope less steep than 3:1 to reduce wave reflection and beach erosion. Other considerations should be a redesign of the ends of the structure to taper down in slope and elevation to minimize the potential adverse impacts to adjacent properties. Vegetative plantings and non-structural methods should also be implemented and maintained at these north and south property lines on the face of the bank to help stabilize the soils, mitigate for end effects, and reduce erosion. For more information, the applicant is encouraged to consult the StormSmart Properties Fact Sheet 7: Repair and Reconstruction of Seawalls and Revetments (www.mass.gov/service-details/stormsmart-properties-fact-sheet-7-repair-and-reconstruction-of-seawalls-and).

- **Redesign the timber stairway to avoid adverse impacts** - Walkways and stairways have the potential to cause reflection of wave energy in the V Zone and become damaged in a storm—leading to a source of debris that can cause structural damage to adjacent buildings and structures. Because of these concerns, the Commission requests that the proponent provide plans, including a cross-sectional view, depicting the proposed configuration for the timber stairway so that this component of the project can be reviewed in detail. The applicant should consider alternative designs for the access, including: 1) a pile-supported walkway with breakaway sections to minimize impacts to the stability of the bank if a section is destroyed, and 2) stairs constructed with treads but no risers to reduce shading effects on vegetation. The applicant should also consider steps built in to the proposed revetment to avoid the installation of an additional structure within the V Zone that could cause storm debris and damage to the subject property and adjacent properties. *Editorial Note: For more information on design considerations for new or substantially enlarged coastal engineering structures, see "Typical Project Activities and Their Effects on Coastal Banks" on pages 3-42 through 3-46.*

- **Provide beach nourishment to compensate for the amount of sediment that would have eroded from the coastal bank or the amount necessary to mitigate for any adverse impacts from the reconstructed stone revetment** - For new or substantially improved or enlarged coastal engineering structures, it is generally required that the applicant mitigate for the amount of sediment that would have eroded from the bank by adding sediment to the fronting beach. The Commission considers this a substantially improved structure because: 1) the new vertical seawall that is replacing the existing riprap (which allowed sediment to be supplied to the beach and nearshore area) will completely inhibit the existing sediment supply, and 2) the placement of large amounts of riprap in front of the new vertical seawall will further encroach onto the beach. A volume of compatible sediments (from an off-site source) representing what would have eroded from the coastal bank (based on the shoreline change rate maps) can be added to the littoral system at regular intervals.[137] In this particular case, it is more difficult to determine the sediment volume since a revetment existed on site. Therefore the Commission requires that the applicant monitor any loss of sediment from the fronting beach by using a secure visible marker on the coastal engineering structure that represents the current elevation of beach sediments. If the beach elevation falls below the marker elevation at designated intervals, compatible sediments must be added to the beach from an offsite source to restore the beach to a previous elevation. The yearly assessments of the beach elevation should be made at the same time of year as the original designation of the marker elevation, since beach elevations are subject to seasonal fluctuations. The applicant should always use clean sediment of grain size compatible with that on the existing beach. *Editorial Note: If an applicant used the shoreline change rate maps to quantify sediment volume, the marker elevation method can be used to monitor the need for higher volumes of sediment to mitigate any adverse effects of the structure.*

For more information on beach nourishment practices, the applicant is advised to consult the StormSmart Properties Fact Sheet 8: Beach Nourishment (www.mass.gov/service-details/stormsmart-properties-fact-sheet-8-beach-nourishment).

- **Submit an Operation and Maintenance Plan with the Application** - The Commission requests that the applicant submit a plan for maintenance, monitoring, and mitigation as part of their application to address any impacts associated with the proposed work. Operation and Maintenance Plans (O&M Plans) can also be used to determine future maintenance and monitoring activities that do not require a new Notice of Intent filing (only notification to the Commission). An O&M Plan should include a methodology for re-planting the bank with vegetation as needed, a proposed beach nourishment procedure and schedule to mitigate for the armoring of a sediment source, and a schedule for the monitoring of the beach and bank, which will determine when nourishment is needed.

[137] To determine a volume of sediment for beach nourishment based on shoreline change data, use the following formula: (rate of shoreline change) x (the bank length of the property) x (the total height of the bank—not just the height of a seawall or vegetated area) = (amount) cubic feet/year. (Whether the short- or long-term rate of shoreline change is used will depend on which best represents the current trends at the site. The short- and long-term rates must be analyzed and evaluated in light of current shoreline conditions, the affects of human-induced alterations to natural shoreline movements, and whether the shoreline fluctuates between erosion and accretion. In no case should the long-term shoreline change rate be used exclusively before the short-term rates and contributing factors are understood and assessed.) The amount calculated above is the amount that should be placed on the beach annually to supply what would have been provided by the coastal bank. The Commission may choose to use variations of the amount, such as three times the amount applied in 3-year intervals.

Editorial Note on Beach Nourishment

Beach nourishment can be applied as a non-structural method to help stabilize a site and/or replace material that has been lost due to erosion, mitigate for the volume of sediment that will no longer be provided by erosion of the bank, and replace what the natural longshore sediment transport system is no longer providing to maintain the beach elevation. It is important that the sediments used to nourish a beach be brought in from an off-site source (typically an inland sand and gravel pit) and that they be similar in grain size to the existing beach. The Commission should review *Beach Nourishment: MassDEP's Guide to Best Management Practices for Projects in MA*, March 2007) for detailed information. It is also important to consider that the volume of sediment placed on a beach for the type of project outlined in this scenario is intended to supply the beach system with sediment, not create a stable recreational beach. Where greater quantities of sediment are needed for large-scale projects, such as recreational beaches, other considerations will come into play (such as appropriate sources of sediment, costs, and impacts to fish and shellfish habitats). The requirements for smaller projects such as this are proportionally fewer. More information is available in the MassDEP guidance referenced above.

Editorial Note: In lieu of the vertical concrete seawall with backfill, the applicant revised the plan to include a rough-faced sloping riprap revetment that mimics the existing bank slope and reinforces the existing riprap (see Figure 4.5 on page 4-46 for revised plan). Given the space between the top of the coastal bank and the dwelling, the applicant was able to locate the proposed structure approximately 10 feet farther landward to avoid encroachment onto the beach, while also keeping the slope of the revetment less steep than 3:1 to reduce wave reflection and beach erosion.

*In lieu of loaming and seeding the coastal bank above and on top of the proposed riprap, the applicant proposed planting a mix of hardy native coastal plants to improve the ability of the upper bank to withstand wind, waves, and runoff. The applicant submitted a landscape plan with a mix of salt-tolerant, deep-rooted grasses, including little bluestem (*Schizachyrium scoparium*), American beachgrass (*Ammophila breviligulata*), and switchgrass (*Panicum virgatum*), to help stabilize the soils and slopes. The landscape plan also showed regrading of the area of existing lawn at the top of the bank so that runoff is directed away from the top of the bank. The applicant proposed planting this existing lawn area with a buffer (5-10 feet wide) of native coastal vegetation that includes northern bayberry (*Myrica pensylvanicum*), beach plum (*Prunus maritime*), bearberry (*Arctostaphylos uva-ursi*), and shore junipers (*Juniperus sp.*) to stabilize sediments, help filter pollutants, and provide wildlife habitat. The landscape plan included a monitoring and maintenance plan to ensure the plants became established and to replace any substantial loss of vegetation.*

Rather than replacing the existing deteriorated timber stairway in kind, the applicant revised the stairway design to included pile-supports with breakaway sections and stairs constructed with treads but no risers.

The applicant submitted a Beach Nourishment Operation and Maintenance Plan. The proposed beach nourishment plan included a procedure for assessing the loss of sediment by observing the secure visible markers, a schedule for analyzing and mitigating any loss of sediments, and a method for determining the volume of sediment needed to *renourish the beach. The applicant also included a methodology for analyzing sediment compatibility and for determining where and how to obtain a compatible source of sediments.*

The Commission reviewed the revisions to the plans at the following hearing, determined that the project as revised would meet performance standards for coastal bank, beach, and rocky intertidal area, and approved the application and plans.

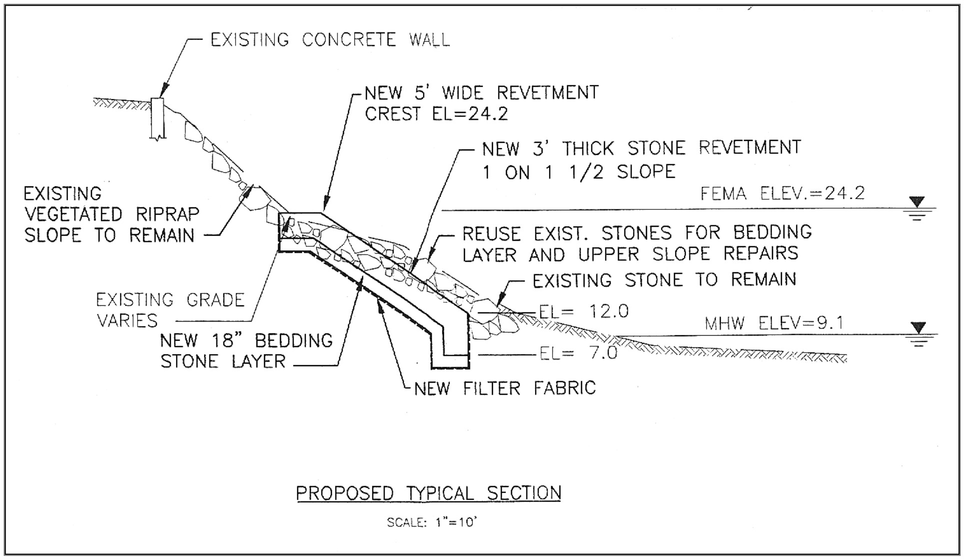

Figure 4.5. Revised plan with a sloped stone revetment. The sloped revetment is preferable to the applicant's original plan with a concrete seawall (shown in Figures 4.2 and 4.3 on page 4-35), because the sloped rough surface will cause less wave reflection and beach scour.

Appendix A - Glossary

The following glossary defines terms used throughout this manual. Unless otherwise noted, the definition was developed by the Massachusetts Office of Coastal Zone Management. For terms followed by an author or organization in parentheses, the definition was based on one of the following sources as indicated:

U.S. Army Corps of Engineers (USACE). 2002. *Coastal Engineering Manual*. Engineer Manual 1110-2-1100, U.S. Army Corps of Engineers, Washington, D.C.

Bascom, W. 1980. *Waves and Beaches*. Garden City, NY: Anchor Press/Doubleday.

Beachapedia. *Definitions*. Retrieved on October 11, 2012. (www.beachapedia.org/Category:Definitions)

Davis, Richard A., Jr., and Duncan M. Fitzgerald. 2004. *Beaches and Coasts*. Malden, MA: Blackwell Publishing.

Executive Office of Environmental Affairs (EEA). 1994. *Designation of Port Areas (310 CMR 10.25*). Effective date December 15, 1994. Boston, MA: Executive Office of Environmental Affairs.

Federal Emergency Management Agency (FEMA). 2011. *FEMA Coastal Construction Manual: Principles and Practices of Planning, Siting, Designing, Construction, and Maintaining Residential Buildings in Coastal Areas (CCM)*. 4th Ed. Washington, DC: Federal Emergency Management Agency, Mitigation Directorate.

FindLaw. *Law Library*. Retrieved on June 9, 2010. (https://dictionary.findlaw.com/)

Ingram, Roy L. 1989. *Grain-size Scales*. In Dutro, J.T., Dietrich, R.V. and Foose, R.M. (Eds.), A.G.I. Data Sheets for Geology in the Field, Laboratory, and Office. American Geological Institute, p.28.1.

Massachusetts Barrier Beach Task Force. 1994. *Guidelines for Barrier Beach Management in Massachusetts*. Boston, MA: Massachusetts Coastal Zone Management.

Massachusetts Department of Environmental Protection (MassDEP). 2005. *The Massachusetts Wetlands Protection Act Regulations (310 CMR 10.00) for Administering the Wetlands Protection Act (M.G.L. c. 131, § 40)*. Effective date March 1, 2005. Boston, MA: Department of Environmental Protection.

Massachusetts Department of Environmental Quality Engineering (DEQE). 1979. *A Guide to the Coastal Wetland Regulations*. Amherst, MA: Cooperative Extension, University of Massachusetts. Out of publication.

Pidwirny, Michael. 1999. "*Glossary of Terms*." Pidwirny. Retrieved on January 1, 2007. Kelowna, British Columbia, Canada. (www.physicalgeography.net/)

Pilkey, Orrin H., Tracy Monegan Rice, and William J. Neal. 2004. *How to Read a North Carolina Beach: Glossary*. Chapel Hill, NC: University of North Carolina Press.

United States Geological Survey (USGS). 2007. "*Glossary of Glacier Terminology*." Prepared by Eleyne Phillips. Retrieved on June 23, 2011. (https://pubs.usgs.gov/of/2004/1216/text.html)

100-Year Storm (1%-Annual-Chance Storm or Flood) (FEMA) - A flood of a certain magnitude having a 100-year recurrence interval, i.e. a flood of a certain magnitude having a 1% chance of happening in any year; also called the base flood.

Accretion (Massachusetts Barrier Beach Task Force) - The buildup of land, solely by the action of the forces of nature,…by deposition of water- or air-borne material. Artificial accretion is a similar buildup of land by reason of human intervention, such as the accretion formed by a groin, **breakwater**, or beach fill deposited by mechanical means.

A Zone (FEMA) - The area within the special flood hazard area (subject to inundation by the 1%-annual-chance flood) that is not within the coastal high hazard area. Zones AE, AO, AH, and A are collectively referred to as A Zones. Some A Zones in coastal areas are subject to wave effects, quick-moving water, erosion, scour, or combinations of these forces. See the Limit of Moderate Wave Action and Moderate Wave Action area for information on identifying the portion of the A Zone affected by wave heights greater than 1.5 feet (also known as the Coastal A Zone). A Zones that are not depicted as AE, AO, or AH Zones on the FIRM are areas subject to inundations by a 1%-annual-chance flood, but the predicted elevation of the water has not been determined by a flood study (also referred to as Unnumbered A Zones; these zones are typically found in inland areas).

AH Zones (FEMA) - An area with a 1%-annual chance of shallow flooding, usually in the form of a pond, with an average depth ranging from 1 to 3 feet.

AO Zones (FEMA) - An overwash area (usually sheet flow on sloping terrain) for which flood depths range from 1 to 3 feet and flow velocities and paths vary.

Alongshore - Parallel to the shore.

Backshore (Massachusetts Barrier Beach Task Force) - Zone of the beach lying beyond (landward of) the foreshore and acted upon by waves only during severe storms, especially when combined with exceptionally high water.

Backslope - The landward face of the primary dune, starting from the landward peak of the primary dune and extending landward to the backslope trough. See also maximum possible extent of the backslope.

Backslope Trough - A trough that lies on the landward side of the backslope of the primary dune and marks the transition between the primary and secondary dunes, or in some cases, wetlands or waterways. See also backslope trough selected for initial analysis.

Backslope Trough Selected for Initial Analysis - The most landward backslope trough that is still at the same or lower elevation than the seaward troughs. This backslope trough is determined by drawing lines from the seaward toe of the dune landward to a point where the line does not intersect (over or through) another more landward trough. This backslope trough is selected to mark the landward extent of the maximum possible extent of the primary dune and the maximum possible extent of the backslope.

Backwash (Pidwirny) - The return water flow of swash. This sheet of water flows back to the ocean because of gravity.

Bald-Earth Data - A digital representation of the Earth's surface without any above ground obstructions, such as vegetation, cars, and buildings.

Barrier Beach (MassDEP) - A narrow, low-lying strip of land generally consisting of coastal beaches and coastal dunes extending roughly parallel to the trend of the coast. It is separated from the mainland by a narrow body of fresh, brackish, or saline water or a marsh system. A barrier beach may be joined to the mainland at one or both ends.

Barrier Island (Massachusetts Barrier Beach Task Force) - A barrier beach where both lateral boundaries have terminated at a water body, marsh, or inlet and therefore are not connected to the mainland.

Barrier Spit (Massachusetts Barrier Beach Task Force) - A barrier beach that is connected at only one end to the mainland.

Base Flood Elevation (BFE) (FEMA) - The elevation associated with the flood event having a 1 percent annual chance of being equaled or exceeded in any given year (also known as the 100-year flood). The BFE is shown on the Flood Insurance Rate Map.

Bay Barrier (Massachusetts Barrier Beach Task Force) - A barrier beach that is connected at both ends to the mainland.

Beach/Dune Line - The term used in beach and dune delineations (including primary dune delineations) that defines the boundary between the coastal beach and the coastal dune.

Bedrock (Pidwirny) - Rock at or near the earth's surface that is solid and relatively unweathered.

Berm (Beachapedia) - Feature usually located at mid-beach and characterized by a break in slope, separating the flatter backshore from the seaward-sloping foreshore.

Bordering Vegetated Wetlands (BVW) (MassDEP) - Freshwater wetlands that border on creeks, rivers, streams, ponds, and lakes. The types of freshwater wetlands are wet meadows, marshes, swamps, and bogs. BVWs are areas where the soils are saturated and/or inundated such that they support a predominance of wetland indicator plants.

Bottom Topography - The vertical and horizontal dimension of the seafloor.

Boulder (Ingram) - Large fragment of rock that has a diameter greater than 256 millimeters (10 inches). The presence of boulders in the intertidal zone is used as one of the parameters for defining a rocky intertidal shore.

Breakwater (USACE) - A man-made structure protecting a shore area, harbor, anchorage, or basin from waves.

Clay (Ingram) - Mineral particle with a size less than 0.004 millimeters in diameter (0.000157 inches)—smaller than silt and sand.

Coastal A Zone (FEMA) - See definition for Moderate Wave Action area.

Coastal Bank (MassDEP) - 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 Beach (MassDEP) - Unconsolidated sediment subject to wave, tidal, and coastal storm action that forms the gently sloping shore of a body of salt water and includes tidal flats. Coastal beaches extend from the mean low water line landward to the dune line, coastal bankline, or the seaward edge of existing man-made structures, when these structures replace one of the above lines, whichever is closest to the ocean.

Coastal Dune (MassDEP) - 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.

Coastal Engineering Structure (MassDEP) - Coastal engineering structure means, but is not limited to, a breakwater, bulkhead, groin, jetty, revetment, seawall, weir, riprap or any other structure that is designed to alter waves, tidal or sediment transport processes in order to protect inland or upland structures from the effects of such processes.

Coastal High Hazard Areas (also known as the Velocity Zone) (MassDEP) - An area within the special flood hazard area that is subject to high velocity wave action from storms or seismic sources. The velocity zone boundaries are determined by reference to the currently effective or preliminary Flood Insurance Rate Map (FIRM) prepared by the Federal Emergency Management Agency (FEMA), whichever is more recent (except for any portion of a preliminary map that is the subject of an appeal to FEMA), or at a minimum to the inland limit of the primary frontal dune, whichever is farther landward.

Coastal Thicket - A dense stand of trees or tall shrubs in the coastal zone.

Coastal Wetland (MassDEP) - Any bank, marsh, swamp, meadow, flat, or other lowland subject to tidal action or coastal storm flowage.

Cobble (Ingram) - Rocks between 64 and 256 millimeters (2.5 to 10 inches) in diameter—larger than pebbles but smaller than boulders.

Contour Line (Pidwirny) - Line on a topographic map that connects all points of the same elevation.

Creep (Pidwirny) - Slow mass movement of soil downslope, which occurs where the stresses on the slope material are too small to create a rapid failure.

Cross Section - A side view (profile) of a site plan as opposed to an overhead view (plan view). A cross section is usually taken along a transect line on a site plan.

Cross-Shore - Perpendicular to the shoreline.

Datum - A reference from which measurements are made. In surveying and geodesy, a vertical datum is used for measuring the elevations of points on the Earth's surface. Vertical datums are either tidal, based on sea levels, or geodetic, based on ellipsoid models of the Earth. The datum points most often referenced are the National Geodetic Vertical Datum of 1929 (NGVD 29) and the North American Vertical Datum of 1988 (NAVD 88). Occasionally, a reference point can be zeroed to a pre-established datum held on a local bench mark and data will be acquired relative to this position.

Dense Grade - A type of limestone crushed stone (comprised of stone dust and crushed stone) serving as a base material for walkways, driveways, patios, and walls. The angular stone and dust lock together making an extremely firm base that can harden when compacted.

Designated Port Areas or **Designation of Port Areas** (MassDEP and EEA) - An area of contiguous lands and waters in the coastal zone that has been so designated by the Massachusetts Office of Coastal Zone Management in accordance with 301 CMR 25.00.

Downdrift - In the direction of the predominant movement of sediment along the shore.

Dredge (MassDEP) - To deepen, widen or excavate, either temporarily or permanently, land below the mean high tide line in coastal waters and below the high water mark for inland waters. The term dredge shall not include activities in bordering or isolated vegetated wetlands.

Dredged Material (MassDEP) - Sediment and associated materials that are moved from below the mean high tide line for coastal waters and below the high water mark for inland waters during dredging activities.

Drift Line (Pilkey, et al.) - A mass of natural and artificial debris (e.g., seaweed, *Spartina* straw, fishing nets, lumber, driftwood, plastic bottles) indicating the previous landward extent of the high-tide line and/or wave swash.

Drumlin (USGS) - An elongated ridge of glacial sediment sculpted by ice moving over the bed of a glacier. Generally, the down-glacier end is oval or rounded and the up-glacier end tapers.

Ebbing Tide (Pidwirny) - Time during the tidal period when the tide is falling. The ebb tide is in contrast to the flood tide.

Ecological Restoration Project (MassDEP) - A project whose primary purpose is to restore or otherwise improve the natural capacity of a Resource Area(s) to protect and sustain the interests identified in M.G.L. c. 131, §40, when such interests have been degraded or destroyed by anthropogenic influences. The term Ecological Restoration Project shall not include projects specifically intended to provide mitigation for the alteration of a Resource Area authorized by a Final Order or Variance issued pursuant to 310 CMR 10.00 or a 401 Water Quality Certification issued pursuant to 314 CMR 9.00 other than projects implemented pursuant to a U.S Army Corps of Engineers-approved in-lieu fee program.

Effective FIRM (FEMA) - The National Flood Insurance Program Map issued by the Federal Emergency Management Agency that is currently in effect. Please note: FIRMs may not include all official map changes. The official flood zones and all current map changes are provided on the National Flood Hazard Layer (NFHL), which is available through the FEMA Flood Map Service Center.

Entrapment Capacity (Massachusetts Barrier Beach Task Force) - When the updrift side of a groin or jetty is filled completely with beach sediment.

Erosion (Massachusetts Barrier Beach Task Force) - The wearing away of land by the action of natural forces. The carrying away of sediment by wave action, tidal currents, littoral currents, or deflation.

Estuary (Pidwirny) - A somewhat enclosed coastal area at the mouth of a river where nutrient-rich fresh water meets with salty ocean water.

Fetch (Pidwirny) -The distance of open water in one direction across a body of water over which wind can blow.

FIRM Database - Compilations of digital GIS data representing the information for preliminary or pending Flood Insurance Rate Maps. When FIRMs and FIRM Databases become effective, that data is incorporated into the National Flood Hazard Layer (NFHL).

FIRMette - A section of a FIRM that is considered an official copy. It can be created, formatted, and printed from the FEMA Flood Map Service Center (https://msc.fema.gov/portal). Please note: the FIRMette does not include the complete LiMWA line or official changes to the FIRMs, such as Letters of Map Change, which are available in the NFHL.

Flood Control (MassDEP) - The prevention or reduction of flooding and flood damage.

Flood Insurance Rate Maps (FIRMs) (FEMA) - A map on which the floodplains for a 1%- and 0.2%-annual-chance flood (i.e., 100-year and 500-year flood), Base Flood Elevations, and risk premium zones are delineated to enable insurance agents to issue flood insurance policies to homeowners in communities participating in the National Flood Insurance Program.

Flood Insurance Study (FIS) (FEMA) - A report available from the Federal Emergency Management Agency for each community/county that generally contains a narrative of the flood history of a community, the engineering methods used to develop the Flood Insurance Rate Maps, and the date of their completion.

Flood Tide (Pidwirny) - Time during the tidal period when the tide is rising. The flood tide is in contrast to the **ebb tide**.

Floodplain (FEMA) - Any land area susceptible to being inundated by water from any source.

Foreshore (Massachusetts Barrier Beach Task Force) - The part of the shore, lying between the crest of the seaward **berm** (or upper limit of wave wash at high tide) and the mean low water line, that is ordinarily traversed by the uprush and backrush of the waves as the tides rise and fall.

Form - The general shape, slope, and elevation of the sediments that comprise a landform.

Frontal Dune Reservoir (FEMA) - The portion of a primary frontal dune analyzed by the Federal Emergency Management Agency to determine whether the dune is likely to withstand a 1%-annual-chance flood or be completely eroded. The frontal dune reservoir is above the total water level and seaward of the peak of the primary frontal dune. For mound-shaped primary frontal dunes, the landward-most peak is used as the crest.

Geographic Information Systems (GIS) - A geographic information system merges information in a computer database with spatial coordinates on a digital map.

Glacial Deposits/Glacial Drift (USGS) - A collective term used to describe all types of glacier sedimentary deposits, regardless of the size or amount of sorting. The term includes all sediment that is transported by a glacier, whether it is deposited directly by a glacier or indirectly by running water that originates from a glacier.

Glacial Outwash - Glacially eroded, sorted sediment that has been transported beyond the foot of the glacier by meltwater.

Glacier (USGS) - A large, perennial accumulation of ice, snow, rock, sediment, and liquid water originating on land and moving down slope under the influence of its own weight and gravity; a dynamic river of ice. Glaciers are classified by their size, location, and thermal regime.

Gravel (Ingram) - A rock particle with a diameter from 2 to 256 millimeters (0.08 to 10 inches)—larger than sand (typically includes pebbles, cobbles, and boulders).

Groin (Massachusetts Barrier Beach Task Force) - A narrow, elongated, coastal engineering structure constructed on the beach perpendicular to the trend of the beach; its intended purpose is to trap longshore drift to build up a section of beach.

Hardening Materials - Material, such as stone dust and dense grade, used for preparing the base for walkways, driveways, patios, and walls. When compacted, the angular dust and stone lock together, making an extremely firm base, often hardening like asphalt. Additives such as lime, an ingredient in concrete, can also produce a similar result.

Headlands (Massachusetts Barrier Beach Task Force) - A high, steep-faced bluff extending into the sea.

Hurricane (Massachusetts Barrier Beach Task Force) - An intense tropical cyclone with winds that move counterclockwise around a low pressure system; maximum winds exceed 75 miles per hour.

Improvement Dredging (MassDEP) - Any dredging under a license in an area which has not previously been dredged or which extends the original dredged width, depth, length or otherwise alters the original boundaries of a previously dredged area.

Inland Limit of the Primary Frontal Dune (i.e., Landward Toe of the Primary Dune) - The landward boundary of the primary dune located within the backslope trough. The inland limit of the primary dune marks the minimum landward extent of the velocity zone for dune areas on an open coast.

Intertidal Zone - The zone between the mean low and mean high water level.

Jetty (Massachusetts Barrier Beach Task Force) - A coastal engineering structure constructed perpendicular to the shoreline at inlets; designed to prevent longshore drift from filling the inlet and to provide protection for navigation.

Kame (USGS) - A sand and gravel deposit formed by running water on stagnant or moving-glacier ice. Kames form on flat or inclined ice, in holes, or in cracks. A kame terrace forms between the glacier and the adjacent land surface. Shapes include hills, mounds, knobs, hummocks, or ridges.

Lagoon (Pidwirny) - (1) A body of seawater that is almost completely cut off from the ocean by a barrier beach; (2) the body of seawater that is enclosed by an atoll (a ring-like coral island and reef).

Land Subject to Coastal Storm Flowage (MassDEP) - 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.

Land Subject to Tidal Action (MassDEP) - Land subject to the periodic rise and fall of a coastal water body, including spring tides.

Land Under the Ocean (MassDEP) - The land extending from the mean low water line seaward to the boundary of the municipality's jurisdiction and includes land under estuaries.

Landward - Positioned or located away from the ocean or sea and toward the land.

Landward Peak of the Primary Dune - The most landward of any secondary peaks of a mound-type primary dune, or the peak of a ridge-type primary dune, which marks the seaward starting point for the backslope of the primary dune.

Landward Toe of the Primary Dune (i.e., Inland Limit of the Primary Frontal Dune) - The landward boundary of the primary dune located within the backslope trough. The landward toe of the primary dune marks the minimum landward extent of the velocity zone for dune areas on an open coast.

Lateral Margins of Barrier Beaches (Massachusetts Barrier Beach Task Force) - The side boundaries of a barrier beach, which include upland margins and water body or wetland margins. The three basic types of upland margins include coastal bank, dune-upland, and bedrock margins. The coastal bank margin consists of glacial sediments, such as till, outwash, or glacial lake or marine deposits. The dune-upland margin can form when a barrier beach builds laterally in front of upland or when a barrier migrates landward and attaches itself to upland. This margin also occurs when the landward marsh or water body behind a barrier has changed to upland as a result of filling of a portion of the marsh/wetland area. The bedrock margin, where rock material has been formed by metamorphic, igneous, or sedimentary processes, is found in several areas along the coast.

Letter of Map Amendment (LOMA) (FEMA) - An interpretation from the Federal Emergency Management Agency of the flood zone boundaries that currently exist on a Flood Insurance Rate Map; it does not reflect any change to the FIRM based on the evaluation of new data.

Letter of Map Change (LOMC) (FEMA) - A general term used to refer to a clarification or change to a Flood Insurance Rate Map that can be accomplished by letter, including a Letter of Map Amendment (LOMA) and a Letter of Map Revision (LOMR).

Letter of Map Revision (LOMR) (FEMA) - A request to FEMA by an applicant (typically a property owner or community) to change the Flood Insurance Rate Map based on new, site-specific data and detailed engineering analysis. All LOMR determinations become part of the effective FIRM and can be viewed on the National Flood Hazard Layer viewer.

LIDAR (Light Detection and Ranging) - A remote sensing technology used to collect topographic and bathymetric (bottom topography) data.

Limit of Moderate Wave Action (LiMWA) (FEMA) - The approximate boundary of the 1.5-foot breaking wave; the boundary between the Moderate Wave Action (MoWA) area and the Minimal Wave Action (MiWA) area.

Littoral Processes (i.e., Littoral Drift) (MassDEP) - The movement of sediment, including gravel, sand or cobbles, along the coast caused by waves or currents.

Longshore Transport (Pidwirny) - The transport of sediment in water parallel to a shoreline.

Maintenance Dredging (MassDEP) - Dredging under a license in any previously dredged area which does not extend the originally-dredged depth, width, or length but does not mean improvement dredging or backfilling.

Map Scale (Pidwirny) - The ratio between the distance between two points found on a map compared to the actual distance between these points in the real world.

Maritime Forest - Vegetative communities with wooded habitat that are often found on higher ground than dune areas, but are able to grow on secondary dunes.

Maximum Possible Extent of the Backslope - The entire aerial extent of the landward side (i.e., backslope) of the primary dune landform and adjacent secondary dunes, marked on the seaward side by the landward peak of the primary dune and on the landward side by the backslope trough selected for initial analysis.

Maximum Possible Extent of the Primary Dune - The entire aerial extent of a primary dune landform and portions of the adjacent secondary dunes, marked on the seaward side by the beach/dune line and on the landward side by the backslope trough selected for initial analysis.

Mean High Water Line (MassDEP) - The line where the arithmetic mean of the high water heights observed over a specific 19-year metonic cycle (the National Tidal Datum Epoch) meets the shore and shall be determined using hydrographic survey data of the National Ocean Survey of the U.S. Department of Commerce.

Mean Low Water Line (MassDEP) - The line where the arithmetic mean of the low water heights observed over a specific 19-year Metonic Cycle (the National Tidal Datum Epoch) meets the shore and shall be determined using hydrographic survey data of the National Ocean Survey of the U.S. Department of Commerce.

Minimal Wave Action (MiWA) Area (FEMA) - The portion of the special flood hazard area in coastal areas where base flood wave heights are less than 1.5 feet.

Moderate Wave Action (MoWA) Area (i.e., Coastal A Zone) (FEMA) - The portion of the Special Flood Hazard Area in coastal areas where base flood wave heights are between 1.5 and 3.0 feet, and where wave characteristics are deemed sufficient to damage typical A Zone construction.

Moraine (USGS) - A general term for unstratified and unsorted deposits of sediment that form through the direct action of, or contact with, glacier ice. Many different varieties are recognized on the basis of their position with respect to a glacier.

Mound-Type Primary Dune - A primary dune with more than one peak.

National Flood Hazard Layer (NFHL) (FEMA) - A digital dataset that contains all of the Federal Emergency Management Agency's current effective digital flood hazard data that are available as of the dataset release date. See page 1-72 for information on how to access the NFHL.

National Flood Insurance Program (NFIP) (FEMA) - The Federal Emergency Management Agency regulatory program under which flood-prone areas are identified and flood insurance is made available to residents of participating communities.

Neap Tide (Pidwirny) - Tide that occurs every 14 to 15 days and coincides with the first and last quarter of the moon when the gravitational forces of the moon and sun are perpendicular to each other. This tide has a small tidal range in contrast with a spring tide.

Nearshore Areas (MassDEP) - The area of land under the ocean that extends from mean low water to the seaward limit of the municipality's jurisdiction, but in no case beyond the point where the land is 80 feet below the level of the ocean at mean low water. However, the nearshore area shall extend seaward only to that point where the land is 30 feet below the level of the ocean at mean low water for municipalities bordering Buzzard's Bay and Vineyard Sound (west of a line between West Chop, Martha's Vineyard, and Nobska Point, Falmouth), 40 feet below the level of the ocean at mean low water for Provincetown's land in Cape Cod Bay, and 50 feet below the level of the ocean at mean low water for Truro's and Wellfleet's land in Cape Cod Bay.

Northeaster (Massachusetts Barrier Beach Task Force) - A large, asymmetrical, low-pressure storm system that produces counterclockwise winds from 30 to 70 miles per hour, which strike northeast-facing coastal areas.

Ocean (MassDEP) - The Atlantic Ocean and all contiguous waters subject to tidal action.

Outwash (Pidwirny) - Sediments deposited by meltwater streams at the edge of a glacier.

Overwash and Overwash Fans (Massachusetts Barrier Beach Task Force) - The uprush and overtopping of a coastal dune by storm waters. Sediment is usually carried with the overwashing water and deposited as an overwash fan on the landward side of the dune or barrier.

Pebble (Ingram) - A rounded piece of rock with a particle size of 2 to 64 millimeters in diameter (0.08 to 2.5 inches)—smaller than cobble and larger than sand.

Per Se (FindLaw) - Inherently, strictly, or by operation of statute, constitutional provision or doctrine, or case law.

Plan View - A view of a plan of land that may include topography, landform features, structures, and appurtenances from an overhead perspective (as opposed to a cross-sectional view).

Preliminary FIRM (FEMA) - Draft revised Flood Insurance Rate Map issued to the community for review and public comment.

Primary Frontal Dune/Primary Dune (MassDEP) - A continuous or nearly continuous mound or ridge of sediment with relatively steep seaward and landward slopes immediately landward and adjacent to the beach and subject to erosion and overtopping from high tides and waves during coastal storms. The primary frontal dune is the dune closest to the beach. The inland limit of the primary frontal dune occurs at the point where there is a distinct change from a relatively steep slope to a relatively mild slope. See page 1-32 in Chapter 1 and Appendix C for an expanded definition and information on how to delineate the primary dune.

Project Site (MassDEP) - The area within the project locus that comprises the limit of work for activities, including but not limited to, dredging, excavating, filling, grading, the erection, reconstruction or expansion of a building or structure, the driving of pilings, the construction or improvement of roads or other ways, and the installation of drainage, stormwater treatment, environmentally sensitive site design practices, sewage and water systems.

Revetment (Massachusetts Barrier Beach Task Force) - An apron-like, sloped, coastal engineering structure constructed on a bank or fronting a seawall; designed to dissipate the force of storm waves and prevent erosion or undermining of a seawall.

Ridge and Runnel - A series of asymmetrical beach features that consist of bars (ridges) running parallel to the coast separated by shallow troughs (runnels) running parallel to and landward of the ridge. The water trapped in a runnel can often move out between ridges and create a rip channel.

Ridge-Type Primary Dune - A primary dune with one distinct peak.

Rill Marks (Pilkey, et al.) - Small erosional channels in the sand carved out by either fresh- or saltwater draining out of the beach sand at low tide. At the end of each rill the sand is deposited.

Rocky Intertidal Shores (MassDEP) - Naturally occurring rocky areas, such as bedrock or boulder-strewn areas between the mean high water line and the mean low water line.

Runoff (Pidwirny) - The topographic flow of water from precipitation to stream channels located at lower elevations. Occurs when the infiltration capacity of an area's soil has been exceeded. It also refers to the water leaving an area of drainage. Also called overland flow.

Salt Marsh (MassDEP) - 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.

Sand (Ingram) - Loose material that consists of grains of rock material ranging between 0.062 and 2.0 millimeters in diameter (.002 and .08 inches)—larger than silt and clay and smaller than pebbles.

Scale - A representative fraction of a paper map distance to ground distance. Example: 1:12,000 is the representative fraction in which one unit of measure on the map is equal to 12,000 of the same units of measure on the ground. Often map scales are expressed in a ratio of 1" of map distance equal to a given number of feet on the ground. In the case of 1:12,000, the scale represents that one inch on the map equals 12,000 inches on the ground (or 1,000 feet).

Scarp (Davis & Fitzgerald) - A steep, erosional face of a sedimentary deposit, such as the dune scarp that is formed during storm-induced erosion of the face of a dune.

Scour (Massachusetts Barrier Beach Task Force) - Removal of underwater material by waves and currents, especially at the base or toe of a shore structure.

Seawall (Massachusetts Barrier Beach Task Force) - A vertical, wall-like, coastal engineering structure constructed parallel to the beach and usually located at the base of a coastal bank.

Seaward (Pidwirny) - Positioned or located away from land and toward an ocean or sea.
Secondary Dunes - Dunes that lie beyond (landward of) the primary dunes and form when heavy storm waves breach the primary dunes, depositing sediment farther inland. Secondary dunes are usually smaller in size and have slopes that are less steep.

Sediment (Massachusetts Barrier Beach Task Force) - Solid fragmental material that originates from weathering of rocks and is transported or deposited by air, water, or ice. Essentially all unconsolidated materials.

Shaded X Zone (FEMA) - See definition for X Zones.

Silt (Ingram) - Mineral particle with a size between 0.004 and 0.062 millimeters in diameter (0.000157 and 0.002440 inches)—larger than clay and smaller than sand.

Slope Failure (Pidwirny) - The downslope movement of soil and sediment by processes of mass movement.

Slumping (Pidwirny) - A form of mass movement where material moves suddenly along a plane that is curvilinear (formed, bounded, or characterized by curved lines).

Soil (Pidwirny) - Layer of unconsolidated material found at the Earth surface that has been influenced by the soil-forming factors: climate, relief, parent material, time, and organisms. Soil normally consists of weathered rock and mineral particles, dead and living organic matter, and air space.

Soil Erosion (Pidwirny) - Transport of soil mineral particles and organic matter by wind, flowing water, or both. Human activities that disturb the soil surface or remove vegetation can enhance this natural process.

Soil Horizon (Pidwirny) - A layer within a soil profile that differs physically, biologically, or chemically from layers above and/or below it.

Soil Profile (Pidwirny) - Vertical arrangement of layers or horizons in soil.

Special Flood Hazard Area (SFHA) (MassDEP) - The area of land in the flood plain that is subject to a 1% chance of flooding in any given year as determined by the best available information, including, but not limited to, the currently effective or preliminary Federal Emergency Management Agency (FEMA) Flood Insurance Study or Rate Map (except for any portion of a preliminary map that is the subject of an appeal to FEMA) for Land Subject to Coastal Storm Flowage, the Velocity Zone as defined in 310 CMR 10.04, and the Flood Insurance Study for Bordering Land Subject to Flooding as defined in 310 CMR 10.57.

Spit (Pidwirny) - A long and narrow accumulation of sand and/or gravel that projects into a body of ocean water. These features form as the result of the deposition of sediments by longshore drift.

Splash Zone (for purposes of land subject to coastal storm flowage) (FEMA) - The portion of the V Zone that extends beyond and farther landward than a coastal engineering structure that is overtopped by waves. The splash zone is typically 30 feet from the seaward side of the seawall. Whether a splash zone is mapped behind a coastal engineering structure is determined by the amount of projected overtopping, as specified in FEMA's *Guidelines and Standards for Flood Risk Analysis and Mapping*.

Splash Zone (for purposes of the rocky intertidal shore) - The area of the shore that lies above the mean high water line and is exposed to moisture from wave splash during high tide. Because it lies above the mean high water line, it does not constitute rocky intertidal shore, as defined by the Wetlands Protection Act Regulations.

Spring Tide (MassDEP) - The tide of the greatest amplitude during the approximately 14-day tidal cycle. It occurs at or near the time when the gravitational forces of the sun and the moon are in phase (new and full moons). This tide has a large tidal range in contrast with a neap tide.

Stillwater Elevation (FEMA) - Projected elevation that flood waters would reach (referenced to the National Geodetic Vertical Datum of 1929, North American Vertical Datum of 1988, or other datum) in the absence of waves resulting from wind or seismic effects. The stillwater elevation includes the storm surge.

Storm Damage Prevention (MassDEP) - The prevention of damage caused by water from storms, including, but not limited to: erosion and sedimentation; damage to vegetation, property, or buildings; or damage caused by flooding, water-borne debris, or water-borne ice.

Storm Surge (FEMA) - The water, combined with normal tides, which is pushed toward the shore by strong winds during a storm. This rise in water level can cause severe flooding in coastal areas, particularly when the storm coincides with the normal high tides. The height of the storm surge is affected by many variables, including the storm intensity, storm track and speed, presence of waves, offshore depths, and shoreline configuration.

Strand Line (Massachusetts Department of Environmental Quality Engineering) - Another term for the wrack line, used in particular examples where the pioneer plants grow, trap windblown sand, and create a line of vegetation.

Swash (Pidwirny) - A thin sheet of water that moves up the beach face after a wave of water breaks on the shore.

Swash Mark (Pilkey, et al.) - A line formed at the edge of swash advance when a wave breaks. As water soaks into the beach, the material being carried by the swash or floating on its edge is deposited to form the line.

Swash Zone - The area of the beach where the swash washes up and down the foreshore.

Tidal Flat (MassDEP) - Any nearly level part of a coastal beach, which usually extends from the mean low water line landward to the more steeply sloping face of the coastal beach or which may be separated from the beach by land under the ocean.

Tidal Inlet (Massachusetts Barrier Beach Task Force) - A breach in a coastal barrier generally opened by a major storm and maintained by tidal flow.

Tidal Zone (Pidwirny) - The area along the coastline that is influenced by the rise and fall of tides.

Tide (Pidwirny) - The cyclical rise and fall of the surface of the oceans, which is caused by the gravitational attraction of the sun and moon on the Earth.

Till (USGS) - An unsorted and unstratified accumulation of glacial sediment, deposited directly by glacier ice. Till is a heterogeneous mixture of different sized material deposited by moving ice (lodgement till) or by the melting in-place of stagnant ice (ablation till). After deposition, some tills are reworked by water.

Toe of Slope - The area where a gentle slope breaks and becomes a steeper slope.

Tombolo (Beachapedia) - A deposition landform in which an island is attached to the mainland by a narrow piece of land such as a spit or bar.

Top of the Coastal Bank - See Appendices D and E.

Topographic Maps - A scaled map showing the position, shape, and elevation of the terrain (and may include man-made features). Contour intervals vary, depending mainly on the type of terrain and the **scale** of the map.

Topography (Pidwirny) - The relief exhibited by a surface.

Total Water Level - For purposes of flood mapping, the elevation that is equal to the calculated stillwater elevation plus the effects of wave setup.

Updrift (Massachusetts Barrier Beach Task Force) - The direction opposite that of the predominant movement of sediment along the shore.

Upland (Massachusetts Barrier Beach Task Force) - A general term for high land or ground that is elevated above the floodplain.

Velocity Zones (V Zones) (i.e., Coastal High Hazard Areas) (MassDEP) - An area within the **special flood hazard area** that is subject to high velocity wave action from storms or seismic sources. The velocity zone boundaries are determined by reference to the currently effective or preliminary Flood Insurance Rate Map (FIRM) prepared by the Federal Emergency Management Agency (FEMA), whichever is more recent (except for any portion of a preliminary map that is the subject of an appeal to FEMA), or at a minimum to the inland limit of the primary frontal dune, whichever is farther landward.

Vernal Pool Habitat (MassDEP) - Confined basin depressions which, at least in most years, hold water for a minimum of two continuous months during the spring and/or summer, and which are free of adult fish populations, as well as the area within 100 feet of the mean annual boundaries of such depressions, to the extent that such habitat is within an Area Subject to Protection Under M.G.L. c. 131, § 40 as specified in 310 CMR 10.02(1). These areas are essential breeding habitat and provide other extremely important wildlife habitat functions during non-breeding season as well for a variety of amphibian species, such as wood frog (*Rana sylvatica*) and the spotted salamander (*Ambystoma macultum*), and are important habitat for other wildlife species.

Volume (of sediments) - The quantity of sediments.

Wave Crest Profile - The predicted height of flood waters (including waves) that is plotted along a transect. The wave crest profile tapers down in elevation as it moves onto the shore and across the floodplain.

Wave Height (Pidwirny) - The vertical distance between the wave crest (the highest part of the wave) and the adjacent wave trough (the lowest part of the wave).

Wave Runup (FEMA) - The movement of water that occurs as waves break and flow up beaches, sloping surfaces, and vertical surfaces. Wave runup can drive large volumes of water against or around coastal buildings, inducing fluid impact forces (albeit smaller than breaking wave forces), current drag forces, and localized erosion and scour.

Wave Runup Depth (FEMA) - The depth that equals the vertical distance between the calculated wave runup profile elevation and the ground contour elevation at that location.

Wave Runup Elevation (FEMA) - The elevation reached by wave runup, referenced to the North American Vertical Datum of 1988 (NAVD) or other datum.

Wave Setup (FEMA) - The elevated water level associated with waves coming ashore but not fully receding.

Wrack - The debris that accumulates at the landward limit of high tide or storm wave uprush, typically consisting of seaweed, shells, marine debris, and submerged dead organisms.

Wrack Line - The line of wrack material that indicates the previous landward extent of the high-tide line and/or wave swash. See also drift line and strand line.

X Zone - The area beyond (landward of) the 1%-annual-chance floodplain (i.e., beyond the V, AE, AO, and AH Zones) that may be shown on Flood Insurance Rate Maps. Shaded X Zones designate areas subject to inundation by the 0.2%-annual-chance flood (also known as the 500-year flood). Unshaded X Zones designate areas where the annual probability of flooding is less than 0.2 percent.

Appendix B - Useful Data Sources

The following sources of data and information, including links to policies, guidance documents, maps, and orthophotographs, are referenced throughout this manual as useful tools in the project review process.

Aerial Photography, Massachusetts Office of Geographic Information (MassGIS)
https://docs.digital.mass.gov/dataset/massgis-data-layers#img

Many sets of ortho image data are available as MassGIS datalayers. These orthophotographs can be used to obtain a visual reference of the entire area before going out to the site. Users may access the data by free download from the MassGIS site or by ordering the data on DVD. The MassGIS Online Data Viewer, Oliver (http://maps.massgis.state.ma.us/map_ol/oliver.php), is also an extremely useful tool for the online viewing of these orthophotos, as well as the United States Geologic Survey (USGS) topographic maps and all point, polygon, and vector data for the state.

Barrier Beach Inventory Project Maps, Massachusetts Office of Coastal Zone Management (CZM)
www.mass.gov/service-details/massachusetts-barrier-beach-inventory

In 1982, CZM completed a comprehensive effort to identify 681 barrier beaches in Massachusetts and to place them on topographic maps. The barrier beach units were identified primarily through interpretation of aerial photographs and are not detailed enough to delineate the exact boundaries of barrier beaches for site specific projects. An on-site evaluation by a qualified professional is necessary to determine the exact boundaries of the resource areas. CZM distributes copies of the maps generated through this project. The maps are numbered according to the Index Map of USGS Topographic Quadrangles for the Barrier Beach Inventory Project. The extents of the barrier beach units delineated on the maps are also available on the Massachusetts Ocean Resource Information System (MORIS) (see below for more information).

Beach Nourishment: MassDEP's Guide to Best Management Practices for Projects in Massachusetts (March 2007), Massachusetts Department of Environmental Protection (MassDEP)
www.mass.gov/files/documents/2016/08/op/bchbod.pdf - PDF, 1.6 MB

This document, in combination with the technical attachments (www.mass.gov/files/documents/2016/08/uh/bchtech.pdf - PDF, 1.2 MB), provides guidance to those proposing beach nourishment projects. The guidance includes measures to minimize erosion and impacts to natural resource areas while maximizing the time sediment remains on the beach; promotes the beneficial reuse of clean, compatible, dredge material; and provides strategies to expedite regulatory review. The document includes detailed information on determining beach stability, characterizing receiving beach and source materials, and drafting beach monitoring plans.

Coastal Construction Manual: Principles and Practices of Planning, Siting, Designing, Construction, and Maintaining Residential Buildings in Coastal Areas, 4th Edition (FEMA P-55) (CCM), 2011, Federal Emergency Management Agency (FEMA)

www.fema.gov/sites/default/files/2020-08/fema55_voli_combined.pdf - PDF, 42 MB

The FEMA CCM includes recommendations based on lessons learned from various coastal storm events, an overview of coastal processes and coastal flood hazards, definitions of terms related to the floodplain and coastal flood events, guidance regarding hazard identification, definitions and further information for identifying and understanding the Limit of Moderate Wave Action, the Moderate Wave Action and Minimal Wave Action Areas, and an overview of building codes and other regulations.

Digital Coast, NOAA Coastal Services Center
https://coast.noaa.gov/digitalcoast/

NOAA Coastal Services Center's Digital Coast provides a wide variety of data, tools, training, and information that can assist Conservation Commissions and other resource managers with addressing coastal issues, such as hazards, marine spatial planning, and climate change.

Flood Insurance Rate Maps (FIRMs), FEMA

FIRMs are available to be viewed and downloaded for free from the FEMA Flood Map Service Center (https://msc.fema.gov/portal) through an "Address Search" or a "Search All Products" function. The Flood Map Service Center provides effective FIRMs, as well as preliminary and historic maps. On this website, you can also create a FIRMette (a section of a FIRM that is considered an official copy of the FIRM), which can be formatted and printed. (Note that FIRMettes and FIRMs will not include official changes made after the FIRMs were produced, such as Letters of Map Change. To view the official map with all effective map changes, see the National Flood Hazard Layer.) Paper FIRMs can be viewed at local government offices, such as the Building Inspector, Planning Board, or Conservation Commission. (For an overview of the Flood Map Service Center and its products and services, see http://www.msc.fema.gov/portal/resources/productsandtools; for additional details on finding a specific FIRM, see https://msc.fema.gov/portal/howto#msc-findmap.)

Flood Insurance Studies (FIS), FEMA

The FIS is a report for each county that contain a narrative of the flood history of each community, the engineering methods used to develop the FIRMs, stillwater elevations (level of the water without the waves), transect locations where detailed analyses were conducted, and details regarding the dates of the original flood study and all updates and revisions that have been made to the FIRMs. FISs can be viewed or downloaded for free through the FEMA Flood Map Service Center (https://msc.fema.gov/portal) through the "Search All Products" function (search by jurisdiction and then expand the "Effective Products" folder in the search results to find "FIS Reports").

Geodetic Toolkit, National Oceanic and Atmospheric Administration (NOAA) National Geodetic Survey
www.ngs.noaa.gov/TOOLS/

NOAA's National Geodetic Survey provides a Geodetic Toolkit that gives on-line interactive computation of geodetic values, including conversions of datums. One of the conversion tools, VERTCON, computes the modeled difference in orthometric height between the North American Vertical Datum of 1988 (NAVD 88) and the National Geodetic Vertical Datum of 1929 (NGVD 29) for a given location specified by latitude and longitude.

Geologic Quadrangle Maps, United States Geologic Survey (USGS)
https://ngmdb.usgs.gov/ngmdb/ngmdb_home.html

The National Geologic Map Database is the primary source for geologic map and related geoscience information. The database provides access to more than 100,000 geologic maps and other types of geoscience reports and data published from the early 1800s to the present day by the USGS, the State Geological Surveys, and hundreds of other organizations. The catalog (https://ngmdb.usgs.gov/ngm-bin/ngm_compsearch.pl) includes citations, viewable documents, and links to downloadable files and is supported by mapView (https://ngmdb.usgs.gov/mapview/), an interactive viewer.

Guide to Permitting Small Pile-Supported Docks and Piers, MassDEP
www.mass.gov/files/documents/2016/08/st/smaldock.pdf - PDF, 789 KB

A guide to assist with the design and construction of small, pile-supported docks or piers or other small, water-related structures accessory to a residential development. The work standards in the guidance documents are consistent with the Massachusetts Wetlands Protection Act and the Massachusetts Public Waterways Law, Chapter 91.

Guidelines and Specifications for Flood Hazard Mapping Partners, 2002, FEMA
www.fema.gov/media-library-data/1521647157152-d6f4f08714e2b75aa47d69d2e2aa0dc2/Guidelines_and_Specifications_for_Flood_Hazard_Mapping_Partners _Appendix_D-Guidance_for_Coastal_Flooding_Analyses_and_Mapping_(Apr_2003)_SUPERSEDED.pdf - PDF, 4 MB

Though superseded by *Guidelines and Standards for Flood Risk Analysis and Mapping*, this guidance provides useful technical requirements for coastal flooding analyses and mapping.

Guidelines and Standards for Flood Risk Analysis and Mapping, FEMA
www.fema.gov/guidelines-and-standards-flood-risk-analysis-and-mapping

The guidelines and standards define the specific implementation of the statutory and regulatory requirements for NFIP flood risk analysis and flood zone mapping and address the performance of flood risk projects, processing of Letters of Map Change, and related activities.

Guidelines for Barrier Beach Management in Massachusetts, CZM
www.mass.gov/files/documents/2016/08/vh/barrier-beach-guidelines.pdf - PDF, 12 MB

Compiled by the Barrier Beach Task Force in 1994, these guidelines were designed to serve as a reference tool to those charged with preparing, reviewing, and implementing barrier beach management plans. The guidelines set forth more specific definitions for delineation of barrier margins, particularly the lateral margins.

Hydrographic Survey Data, NOAA
www.nauticalcharts.noaa.gov/index.html

The hydrographic survey data that is referred to in the mean low water definition can be found on the NOAA Nautical Charts. NOAA revised their maps, however, and the reference for tidal water depths is now Mean Lower Low Water (MLLW). While still providing an approximate idea of mean low water, these maps should not be relied upon for an exact determination since they no longer meet the definition as described in the Wetland Protection Act Regulations. The nautical charts will still provide an identification of the seaward boundary of nearshore areas. These, as well as other more accurate bathymetric maps published by NOAA, can be used to locate the 80-, 30-, 40-, and 50-foot contours.

Interpreting Federal Emergency Management Agency Flood Maps and Studies in the Coastal Zone, CZM
www.mass.gov/service-details/interpreting-federal-emergency-management-agency-flood-maps-and-studies-in-the

This publication developed by CZM in cooperation with the Department of Conservation and Recreation's Flood Hazard Management Program provides guidance on how to use FEMA Flood Maps and Studies to better understand the potential effects of flooding on buildings, properties, and the underlying natural resource areas. This information can be used by homeowners, consultants, and public officials to ensure that the safest possible coastal projects are designed to minimize storm damage, protect public safety, and reduce the financial burden on individuals and municipalities from losses due to coastal storms.

LIDAR Data (MassGIS)
https://docs.digital.mass.gov/dataset/massgis-data-lidar-terrain-data

The MassGIS LIDAR Terrain Data website provides links to LIDAR datasets covering eastern Massachusetts. The data consists of bare-earth Digital Elevation Model (DEM) tiles that can be downloaded for free and classified LAS files that can be ordered. The data layers are organized into multiple project areas and the details about accuracy, point spacing, format, projection, and size are provided in the project-specific metadata.

Managing Seaweed Accumulations on Recreational Beaches, CZM
www.mass.gov/files/documents/2018/06/29/seaweed-guidance.pdf - PDF, 2.1 MB

This guidance was developed to help local officials and beach managers effectively address seaweed accumulations on recreational beaches while protecting coastal resources.

Massachusetts Coastal Erosion Commission Report, Executive Office of Energy and Environmental Affairs
www.mass.gov/service-details/massachusetts-coastal-erosion-commission

This report presents the work, findings, and recommendations of the Massachusetts Coastal Erosion Commission's effort to investigate and document the levels and impacts of coastal erosion in the Commonwealth and to develop strategies and recommendations to reduce, minimize, or eliminate the magnitude and frequency of coastal erosion and its adverse impacts on property, infrastructure, public safety, and beaches and dunes. The report includes the technical findings of three working group: erosion impacts, legal and regulatory, and science and technology.

Massachusetts Flood Hazard Management Program, DCR
www.mass.gov/guides/floodplain-management#-massachusetts-flood-hazard-management-program-(fhmp)-

DCR's Flood Hazard Management Program can assist applicants and Commissions with identifying flood hazards in their region. DCR is available to help applicants and officials understand the flood zone designations on the Flood Insurance Rate Maps, the history and relevance of map updates, the flood insurance studies, and any other flood insurance or data issues.

Massachusetts Ocean Resource Information System (MORIS), CZM
www.mass.gov/service-details/massachusetts-ocean-resource-information-system-moris

MORIS is an online mapping tool created by CZM and MassGIS. MORIS can be used to search and display spatial data pertaining to the Massachusetts coastal zone. Users can interactively view various data layers (e.g., state-designated barrier beaches, tide gauge stations, eelgrass beds, etc.) over a backdrop of aerial photographs, political boundaries, natural resources, human uses, bathymetry, or other data. Users can quickly create and share maps and download the actual data for use in a Geographic Information System (GIS).

Massachusetts Shoreline Change Maps, CZM
www.mass.gov/service-details/massachusetts-shoreline-change-project

To better understand how quickly the shoreline is eroding or accreting in the short and long term, Commissions may also want to reference the shoreline change maps, which illustrate how the shoreline of Massachusetts has shifted between the mid-1800s and 2009. Using data from historical and modern sources, the maps show up to eight shorelines depicting the local high water line and transects at 50-meter (approximately 164-foot) intervals along the ocean-facing shore. For each of these more than 26,000 transects, data are provided on net distances of shoreline movement, shoreline change rates, and uncertainty values. To correctly interpret the shoreline change data, both long- and short-term data must be analyzed and evaluated in light of current shoreline conditions, the affects of human-induced alterations to natural shoreline movements, and whether the shoreline fluctuates between erosion and accretion.

Massachusetts State Hazard Mitigation and Climate Adaptation Plan, Massachusetts Emergency Management Agency
www.mass.gov/service-details/massachusetts-integrated-state-hazard-mitigation-and-climate-adaptation-plan

The State Hazard Mitigation and Climate Adaptation Plan provides both short-term and long-term strategies for implementing hazard mitigation measures for state agencies and local municipalities. The plan identifies actions that will lower the risks and costs of natural hazards and includes individual plan components on topics such as coastal erosion, floods, hurricanes, and nor'easters.

Massachusetts StormSmart Coasts - StormSmart Properties, CZM
www.mass.gov/service-details/stormsmart-properties

Developed by CZM as part of StormSmart Coasts, the StormSmart Properties program gives coastal property owners important information on a range of measures that can effectively reduce erosion and storm damage while minimizing impacts to shoreline systems. Fact sheets are available for various non-structural alternatives, such as beach and dune nourishment; coir rolls, natural fiber blankets, and plantings on coastal banks; sand fencing; and reducing overland runoff; as well as design standards for structural methods, such as new, reconstructed, or repaired seawalls.

Mitigation Assessment Team Report: Hurricane Sandy in New Jersey and New York, FEMA P-942
www.fema.gov/media-library-data/1386850803857-025eb299df32c6782fdcbb6f69b35b13/Combined_Sandy_MAT_Report_508post.pdf - PDF, 26 MB

This report presents the conclusions and recommendations made by the Mitigation Assessment Team following Hurricane Sandy. The report includes engineering concepts, codes and standards, mitigation measures and considerations that can be used in the planning and recovery process to help minimize future damage to structures and their related utility systems.

National Flood Hazard Layer (NFHL), FEMA
https://msc.fema.gov/portal

The NFHL combines the flood hazard data from the FIRMs with the updates issued through LOMRs to provide a unified view of the flood hazards. The NFHL data can be accessed at the FEMA Flood Map Service Center through an interactive NFHL viewer or downloaded for use in GIS. To access the NFHL in the viewer, go to the Service Center, search by location and then click on the "Go to NFHL Viewer" button. To download NFHL data, search by location and then click the "show all products" button, expand "Effective Products," and downloaded "NFHL Data" by state or by county. A full list of the layers available in the NFHL may be found in the NFHL GIS Services User Guide (www.fema.gov/media-library-data/1510944498802-158ae747182fa5f8b5418ea72fe5f219/NFHL_GIS_Services_Flyer.pdf – PDF, 166 KB). Please note: The version of the NFHL in MassGIS and MORIS does not include all of the data layers available in the FEMA NFHL database.

Online Data Viewer (OLIVER), MassGIS
http://maps.massgis.state.ma.us/map_ol/oliver.php

OLIVER is a general-purpose, online data viewer where users can browse, view, and download any data layer that MassGIS has available for public distribution. Available data layers include aerial photographs, state-designated barrier beaches, surficial geology, and wetlands. Users can make their own map by picking and choosing from a wide variety of possible data layers.

Protecting Wetlands and Open Space: MACC's Environmental Handbook for Massachusetts Conservation Commissioners, Massachusetts Association of Conservation Commissions (MACC)
www.maccweb.org/page/PubEhandBook

The MACC Environmental Handbook (now in electronic format) covers topics ranging from the purpose, powers and duties of Conservation Commissions to wetland functions and values to jurisdictional resource areas to the permitting process. The 10th Edition is online and interactive, providing word search capabilities, pop-up definitions of terms, active internal and external links, and the ability to make and keep notes in the electronic text for future reference. In addition, this online version can be updated to reflect current laws, regulations, and policies as they change.

Regulatory Maps: Priority and Estimated Habitats, *Natural Heritage and Endangered Species Program (NHESP)*
www.mass.gov/service-details/regulatory-maps-priority-estimated-habitats

The maps depict the regulatory protection of rare species and their habitats as codified under the Massachusetts Endangered Species Act (MESA) and Wetlands Protection Act (WPA). Priority Habitat is based on the known geographical extent of habitat for all state-listed rare species, both plants and animals. Estimated Habitats are a sub-set of the Priority Habitats and are based on the geographical extent of habitat of state-listed rare wetlands wildlife, which does not protect plants. Priority Habitat and Estimated Habitat maps are used for determining whether or not a proposed project must be reviewed by the NHESP for MESA compliance and are available online. Habitat alteration within Priority Habitats or Estimated Habitats may result in a take of a state-listed species and is subject to regulatory review by the NHESP.

Sea Level Rise: Understanding and Applying Trends and Future Scenarios for Analysis and Planning, CZM
www.mass.gov/files/documents/2016/08/vp/slr-guidance-2013.pdf - PDF, 3.2 MB

This 2013 guidance document was developed by CZM to help coastal communities and others plan for and address potential sea level rise effects on residential and commercial development, infrastructure and critical facilities, and natural resources and ecosystems. The document includes background information on local and global sea level rise trends, summarizes the best available sea level rise projections, and provides general guidance in the selection and application of sea level rise scenarios for coastal vulnerability assessments, planning, and decision making for areas that may be at present or future risk from the effects of sea level rise.

Soil Survey, National Resources Conservation Service (NRCS)
https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm

These surveys (now in an online format) provide useful information about surface sediments. Although these maps are produced at a fairly broad scale and the boundaries are not exact enough to replace a detailed resource delineation for a specific site, they can provide a general overview of soil classification, descriptions, and compositions to aid the characterization of the overall landform. In addition to the soil surveys, the NRCS website offers other information, including a publication that introduces several soil-related risks and hazards that are important for planning and building purposes.

South Shore Coastal Hazards Characterization Atlas, CZM
www.mass.gov/service-details/south-shore-coastal-hazards-characterization-atlas

For South Shore communities, this atlas (completed in 2005) contains updated maps that illustrate shoreline variables at a scale of 1:40,000 and depict such features as littoral cell boundaries, short-term shoreline change (1938/1950s to 2001), shoreline type, distribution of properties with multiple federal flood insurance claims between 1978 and 2002, and beach width fronting coastal banks. The geographic scope extends along the ocean-facing shores from Hull through Plymouth to the Cape Cod Canal and will expand to additional regions in the future. Tide range, sea level rise, and storm susceptibility are also characterized for the entire coast, while wave climate is characterized on a sub-regional scale.

Tides and Currents Products, NOAA
https://tidesandcurrents.noaa.gov/products.html

NOAA's Center for Operational Oceanographic Products and Services provides Tide/Water Levels, including 1-minute water level data and tide predictions for various stations along the Massachusetts coastline. This site also provides sea level trend measurements, including sea level rise or sea level fall, computed using a minimum span of 30 years of observations at each location.

Topographic Quadrangle Maps, USGS
www.usgs.gov/products/maps/topo-maps

Both the U.S. Topo series and Historical Topographic Map Collection (HTMC) can be found (in GeoPDF format) through The National Map (www.usgs.gov/core-science-systems/national-geospatial-program/national-map) and now in additional formats through topoView (https://ngmdb.usgs.gov/topoview/viewer/#4/39.98/-100.06). Both sources provide a series of 7.5-minute quadrangle maps that cover the entire area of the 48 contiguous states and Hawaii. On these maps, the mean low water line represents the value of zero (0) feet and all nautical soundings are measured in feet below this line. The seaward extent of the tidal flats and landward extent of mean low water is shown in a black dot pattern. The USGS charts give an indication of the mean low water line for a particular site, which can then be transferred to an applicant's plans. The contour lines on the USGS topographic sheets indicate abrupt changes in topography. Because the changes may indicate either the edge of dune, coastal bank, or man-made coastal engineering structure, use of the maps should be supplemented with site observations to shed light on the landform and its boundaries.

VDatum, NOAA's Office of Coast Survey (OCS)
https://vdatum.noaa.gov/

The OCS provides a vertical datum transformation tool, VDatum, developed by the National Ocean Service, which allows the transformation of elevation data between any two vertical datums, among a choice of orthometric, tidal, and ellipsoid vertical datums. VDatum allows users to convert their data from different horizontal/vertical references into a common system and enables the synthesis of diverse geospatial data in desired reference levels.

Zone A Manual: Managing Floodplain Development in Approximate Zone A Areas (FEMA 265), 1995, FEMA
www.fema.gov/media-library-data/20130726-1545-20490-4110/frm_zna.pdf - PDF, 2 MB

This manual provides engineering guidelines for determining Base Flood Elevations in Special Flood Hazard Areas studied by approximate methods only and are labeled Zone A on the effective FIRM.

Appendix C - Technical Specifications for Delineating the Primary Dune Boundary

Due to the per se significance of the dunes closest to the beach and the importance of applying performance standards to protect their functions, the primary dune, also known as the primary frontal dune, must often be distinguished from the secondary dune(s). Identifying the primary dune is also critical when determining the extent of the velocity zones in dune areas (the landward toe being the minimum extent of the V Zone). To delineate the landward toe of the primary dune, the Massachusetts Department of Environmental Protection (MassDEP) recommends that the applicant or more specifically, their consultant, use the primary dune delineation methodology based on local geological processes, topography, and a mathematical analysis. This methodology has been peer reviewed by a panel of coastal geologists, Federal Emergency Management Agency (FEMA) technical consultants, and FEMA staff, as well as by FEMA's technical review group tasked with updating their specifications for flood zone mapping in coastal areas. FEMA found the methodology to be technically and scientifically acceptable for mapping primary frontal dunes and is currently using a modified version of this methodology to update the flood zones on the FEMA maps (i.e., moving the landward extent of the V Zone to the landward toe of the primary dune). The methodology has also been peer reviewed by a Technical Advisory Committee convened by the Massachusetts Department of Environmental Protection (MassDEP) Commissioner to review this manual, and has been tested in an adjudicatory hearing.[138]

This methodology, combined with site observations and an understanding of the landform features and functions, can delineate the landward toe of the primary dune more consistently and effectively than a delineation based on site observations alone.

Whether an applicant is required to precisely identify the landward extent of the primary dune will depend on whether such a distinction is necessary for a Commission's review of the proposed project. For example, an in-depth analysis of the primary dune boundary may not be warranted when an applicant acknowledges that the project is within the primary dune or for dune enhancement projects (e.g., vegetation and beach/dune nourishment). If the project proposal will result in potential impacts to the resource area (and existing maps do not adequately represent the site), the methodology should be used to determine the extent of the primary dune. The methodology can be used for assisting project proponents in properly delineating resource areas to avoid alterations of primary dunes and for designing projects to meet dune performance standards.

[138] In the matter of Miltiades and Phyllis Tzitzenikos, Office of Appeals and Dispute Resolution (OADR) Docket No. WET-2010-033, Recommended Final Decision, August 3, 2011, adopted by Final Decision, October 12, 2011, affirmed by Essex Superior Court sub nom Tzitzenikos et al. v. Department of Environmental Protection et al., ESCV2011-02122-A, November 1, 2012, the Presiding Officer found a preponderance of evidence showing that the primary dune methodology relied on by MassDEP provided best available information and was effective in delineating the landward toe of the primary dune because it captured the entire dune structure, in contrast to the applicant's analysis, which did not.

Steps 1 through 7 below outline the procedures for working through a primary dune delineation to determine the landward toe of the primary dune. It is recommended that the steps of the primary dune delineation that involve initial site assessments, interpretation of data, and final site verifications be performed by a professional trained in coastal geomorphology and coastal geology, while the steps of the methodology that involve using LIDAR or other elevation data, working in GIS programs, and exporting data to Excel be performed by professionals trained in GIS. The last section of this appendix (pages A-C-16 through A-C-28) is devoted to a case study example, which details the methodology step-by-step through the perspective of an applicant. This example provides detailed descriptions, examples, and figures of how to use ArcMap, Excel, and other components of the methodology to find the landward toe of the primary dune. Note that the term "applicant" in this section refers to the professional consultant hired to perform the relevant work.

Step 1 - Review the definitions of the primary dune.

The Wetlands Protection Act Regulations were amended in 2014 to include a definition of the primary frontal dune and to provide clarification in the Preamble to Coastal Dunes (310 CMR 10.28(1)) that the dune closest to the beach is known as the primary frontal dune. According to the revised Regulations, a primary frontal dune or primary dune is "a continuous or nearly continuous mound or ridge of sediment with relatively steep seaward and landward slopes immediately landward and adjacent to the beach and subject to erosion and overtopping from high tides and waves during coastal storms. The Primary Frontal Dune is the dune closest to the beach. The inland limit of the Primary Frontal Dune occurs at the point where there is a distinct change from a relatively steep slope to a relatively mild slope."

The main point to be emphasized in this definition is that the inland limit of the primary dune is the point where there is a *distinct* change from a relatively steep slope to a relatively mild slope. Though not all dunes have "steep" slopes, quantifying the "distinct change" by finding the greatest *rate of change* in slope (regardless of grade in slope) on the inland side (i.e., backslope) of the dune will result in the likely location of the landward toe of the primary dune. The landward toe of the primary dune is the transition point between primary and secondary dunes, or in some cases, between the primary dune and wetlands or waterways.

Step 2 - Perform a site inspection to thoroughly understand the general topography; the dune form, size, scale, and type; and the degree of development.

The applicant should perform a site visit to obtain a basic understanding of the overall morphology of the dune(s) and its relationship to the shoreline to better understand dune scale, volume, and form and how the modifying forces of wind and waves act upon the dunes and beach (see "Coastal Dunes" on page 2-13 for more information). Observations should be made to distinguish small-scale landform features, such as beach cusps, blowout holes, scarps, root systems uncovered by wind action, or mounds associated with tufts of grass or shrubs, that result from small natural disturbances versus large-scale landform features, such as deposition and accretion of sand by wind and wave action, caused by larger natural forces. It is also important that the applicant identify human-induced changes, such as roads, driveways, and dwellings (or even the clearing of roads and properties that result in the mounding of the storm overwash materials), which may have created minor alterations in slope, elevation, and form, but may not have changed or influenced the overall extent of the primary or secondary dune landform. These distinctions will help later when the applicant evaluates whether certain features of the landform are part of the overall hill, mound, or ridge of the dune, or whether they are small-scale changes within the underlying landform.

Site observations of the dune may help identify whether the dune exhibits a ridge-type profile (one peak within the primary dune) or a mound-type profile (multiple peaks within the primary dune). Applicants should make sure they walk and observe the entire landform—starting on the beach and going well beyond (landward of) the project site or what they might initially perceive as the landward extent of the primary dune, since multiple peaks may occur within the dune. In addition, the applicant should recognize that small changes in topography within the dune may not be representative of the primary dune boundary.

Photograph C1. The top of a mound-type primary dune. The multiple peaks of the primary dune appear relatively flat and are difficult to distinguish at the site.

Site observations may not give the complete picture of dune morphology, however, because often it is more difficult to discern large-scale changes in topography (i.e., landform size, shape, and height) while standing on the site, particularly if houses, roads, driveways, and/or vegetation are present (see Photograph C1). The overall morphology of the dunes will become more obvious (and a delineation will become easier) when the elevation data are obtained, plotted, and analyzed in cross sections as described in the following steps.

Step 3 - Review best available topographic data.

For applicants to properly analyze and review profile data of the dune in question, they will need access to the best and most accurate topographic data that are available. Appropriately scaled topographic survey data and cross sections from a professional surveyor are an option. A source of free topographic data is Light Detection and Ranging (LIDAR) data from the MassGIS Data - LiDAR Terrain Data (https://docs.digital.mass.gov/dataset/massgis-data-lidar-terrain-data). Because of its accuracy, usability, cost-effectiveness, large spatial extent, and density of data, the applicant is able to capture data from surrounding areas beyond just their property boundaries, unlike a site-specific survey.[139] In addition, LIDAR data are highly dense (points as close as one per square meter), allowing the production of highly detailed base topographic data. Whatever the source of data, it must be high enough resolution to depict the topography of the dune system—both on and adjacent to the site and for both large and small dunes. In particular, data points along transect lines should be close enough to depict all changes in elevation—no more than 10 feet apart where there is little or no elevation change and closer where there are changes. Sites with larger dunes may also be appropriately captured with less dense data (yet no greater than 10-foot intervals), while smaller dunes may require denser spacing to more fully reflect the small changes inherent in the landform.

The applicant will need to ensure that the data is in bald-earth format, where the data has been "processed" so as to remove the ground clutter including cars, buildings, trees and shrubs, or any other non-landform objects that cannot be penetrated by the LIDAR laser. In many cases, the LIDAR data available from MassGIS have already been processed. The processing interpolates (i.e., best connects) the areas beneath buildings and vegetation from the surrounding topography. An applicant will know if the data have been processed if there is little-to-no evidence of buildings/structures (i.e., rapid elevation changes) in the topographic representation of the data.[140]

Once at the MassGIS data site, the applicant can view the LiDAR Terrain Data Index (as a reference) and LiDAR Terrain Data layers, which are organized into multiple project areas. The data can be imported into common Geographic Information System (GIS) software (such as ArcGIS), where contour lines can be added at particular intervals, representative transect lines can be drawn, and point data extracted along those lines, as explained below.[141]

If LIDAR is the source of topographic data used, an applicant should field check the site and/or look at the most recent topographic survey of the site (if available) in comparison with the LIDAR data to determine if the landform has changed since the LIDAR was flown. If the landform has changed and updated topographic data are unavailable, the applicant will still likely be able to use the LIDAR data provided the applicant reviews the changes to dune topography in the field and makes adjustments to the location of the landward toe of the primary dune on the existing profile (typically more landward as a result of overwash and wind deposition). Alternatively, if the entire landform

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[139]The WPA Regulations do not authorize entry or access to a site for data collection. If data needs to be gathered from surrounding sites while performing a survey, applicants will need to obtain permission from adjacent property owners to gain access to their site.

[140]If raw LIDAR data have not been processed, a consultant can process the data with specialized programs (e.g., bald-earth algorithms). In addition to processing the data, applicants should check that the LIDAR data have been assessed and corrected for vertical accuracy according to state spatial accuracy specifications and general mapping protocols. Applicants should specify in their application the vertical accuracy associated with the topographic data and ensure that it is meaningful and representative of the data. The specifics of each data set are usually provided with the LIDAR metadata. Sources that provide guidance and formulas for determining elevation data accuracy standards include: Guidelines for Digital Elevation Data (National Digital Elevation Program, 2004), American Society for Photogrammetry and Remote Sensing (ASPRS) Guidelines, *Vertical Accuracy Reporting of LIDAR Data* (ASPRS, 2004), and *National Standards for Spatial Data Accuracy* (Federal Geographic Data Committee, 1998).

[141]Whatever the source of LIDAR may be (e.g., MassGIS, internal server), the applicant should ensure that the settings that are specified are consistent with the coordinate system and the map display units that are later specified in the data frame properties of the GIS software.

has changed *substantially* since the LIDAR was flown, the applicant may need to use survey data to obtain the most updated topographic data.

Step 4 - Create transects.

To perform initial analysis of the data in the GIS software, the applicant should lay out representative transects perpendicular to the shoreline at particular intervals (see Figure C1).[142] Spacing of transects depends on the size of the project site and site- or region-specific conditions, such as existing alterations or naturally occurring changes in the landform. Highly complex shorelines with numerous nuances in topography will warrant tighter transect spacing, while simpler, undeveloped shorelines may be adequately represented by wider transect spacing. Larger projects will also likely warrant more transects to reflect the underlying project site and landform, while smaller projects may warrant fewer. At a minimum, however, two transects should be provided for a particular project site. Transects should be placed on areas that are as unaltered as possible to get the most representative dune topography—i.e., avoid placing transects through landscaped and excavated areas, driveways, and blowout areas around a home, which would not represent the natural form of the dune. (If the applicant is not able to obtain two representative transects on the site, a second transect may be taken on an adjacent site to provide another reference of dune topographic data on which to base a delineation). The seaward-most point of the transects should be located at the water's edge and the transect line should extend beyond any secondary dunes (if present) and beyond the property boundaries if necessary. Figure C1 provides an example of LIDAR data of a dune site with two transects spaced 90 feet apart. The applicant should import an orthophotograph (such as seen underlying the LIDAR

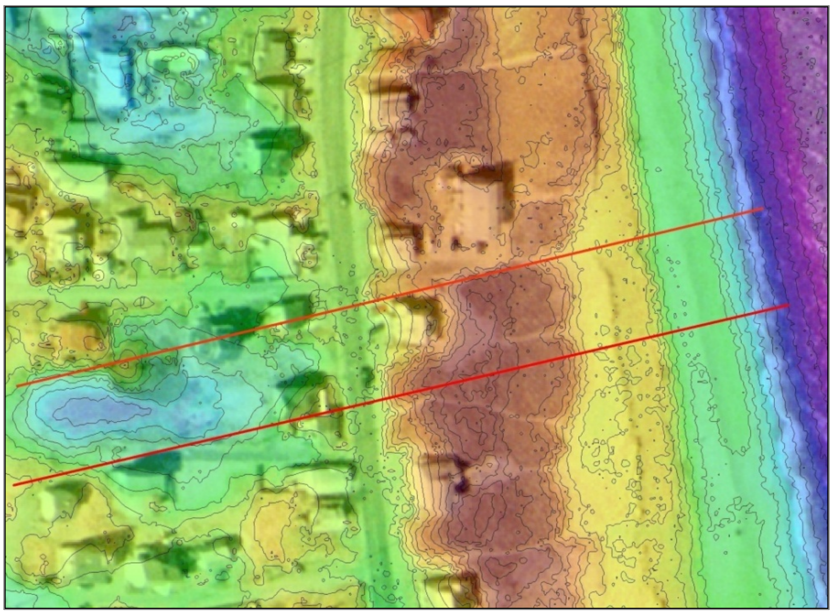


Figure C1. LIDAR data of a site with two transects spaced at a 90-foot interval and contour lines added at 3-foot intervals. Color ramp: low elevation = purple; high elevation = brown. The underlying layer shows existing houses to give the viewer a frame of reference.

[142] For an example of how to draw transects in GIS software, see page A-C-19 in "Case Study Example - Primary Dune Delineation."

data in Figure C1) into GIS for orientation when viewing LIDAR data, drawing transects, and reviewing profiles.[143]

When using available LIDAR data, the applicant can export elevation data at a set of defined intervals (horizontal distances) from each transect to a spreadsheet (e.g., Excel).[144] Once in a spreadsheet, the data should be smoothed with a moving average to help further remove small-scale landform features, such as vegetation and scour marks around root systems. A moving average of 5 points or less for an interval distance of 1 meter (3 feet) is appropriate for dune profiling purposes (see Figure C2 for an illustration of appropriate smoothing). The applicant will need to ensure that the data are not averaged for large horizontal distances, which may over smooth the data resulting in a visible loss of both small-scale and large-scale landform features. Performed correctly, the smoothed data make interpretation of larger landform morphology easier.

Once the data are smoothed, they can then be plotted as an XY scatter chart with the cross-shore distance on the x-axis, and the elevation on the y-axis—the end result being a profile of the entire dune/beach system.[145]

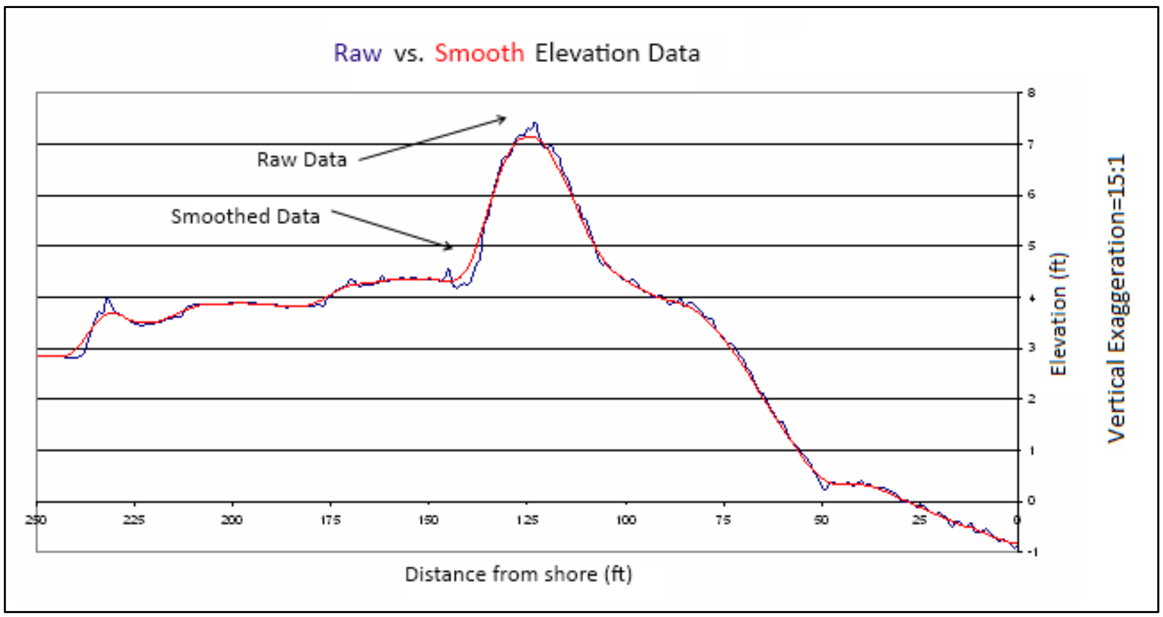


Figure C2. Raw and smoothed LIDAR elevation data displayed on a chart. Smoothing the data with a running average reduces small-scale changes that do not represent major landform features. This profile is vertically exaggerated (approximately 15 horizontal feet =1 vertical foot).

[143]MassGIS provides various datalayers, including ortho imagery layers, which are available for download and use in ArcGIS. Visit the datalayer page (https://docs.digital.mass.gov/dataset/massgis-data-layers) to get access to the aerial images and for obtaining information on downloading, formatting, and displaying the images. Aerial photographs are also available for separate viewing on the Online Data Viewer (OLIVER) at http://maps.massgis.state.ma.us/map_ol/oliver.php.
[144]For an example of extracting data along the transects and exporting them to Excel, see page A-C-19 in "Case Study Example - Primary Dune Delineation."
[145]For an example of finding a moving average and plotting elevation data and smoothed elevation data in Excel, see page A-C-20 in "Case Study Example - Primary Dune Delineation."

The applicant should make note of the vertical exaggeration that is automatically performed when graphing data in programs such as Excel (e.g., 8 horizontal feet=1 vertical foot). These programs scale the profiles to fit on the chart and thereby often create a vertical exaggeration when the horizontal distance along the transect line is great compared to the relief of the profile. To determine the vertical exaggeration, the applicant can use the chart to scale the horizontal axis to the vertical axis). The vertical exaggeration helps produce more visible landform features and will be useful for helping to determine the maximum possible extent of the primary dune (described in Step 5A below) and will not affect the second derivative slope data (described in Step 5C). If the landform (such as a very low-relief dune) needs greater enhancement, the applicant may need to extend the maximum point on the horizontal axis and/or change the minimum and maximum points on the vertical axis to create greater vertical exaggeration.

Step 5 - Use the Profiles to Identify Parts of the Dune System.

Once the profiles are plotted, smoothed, and ready to use, an applicant can begin the process of locating various points on the profile that will help narrow down the search for the landward toe of the primary dune. To better understand the terminology used in this section, see Figure C3 on page A-C-8 for a graphic depiction of the dune terminology.

On the profile, the primary dune extends from the seaward-most point of the primary dune (i.e., beach/dune line as determined in Chapter 1) to the landward toe of the primary dune. The landward toe of the primary dune is located within the backslope trough, which marks the end of the backslope of the primary dune.

In general, the applicant will need to identify the boundaries within which the landward toe of the primary dune *could possibly* be located—somewhere between the backslope trough selected for initial analysis and the landward peak of the primary dune—and then refine the search to find the landward toe of the primary dune within those boundaries (see Figure C3 for a description of all terminology).

The shape of a primary dune can either take the form of a ridge-type primary dune with one peak or a mound-type primary dune with multiple peaks within the primary dune. Determining the shape so as to accurately account for the entire landform, and finding the most landward peak of that primary dune, will be essential for finding the correct landward toe. The process of identifying these features will be described in steps 5A-5C.

A. Delineate the maximum possible extent of the primary dune.

As stated earlier, the applicant will need to first define the maximum extent for where the toe of the primary dune *could possibly* be located and then refine the search to within those boundaries. To begin, the applicant will need to determine the maximum possible extent of the primary dune on the profile (see Figure C3), which runs from the beach/dune line on the seaward side to a landward extent (i.e., the backslope trough selected for initial analysis) that will be described below. By finding this maximum possible extent, the entire horizontal area of the landform and its surroundings are under consideration, which will ensure that the dune is being properly delineated in context to adjacent secondary dunes, wetlands, waterways, or other landforms, as well as in relation to its landform profile (i.e., mound- or ridge-type dune). Evaluating an area well landward in the initial analysis of the primary dune delineation will help avoid the common mistake of delineating the primary dune in an incorrect more-seaward location (particularly on mound-type primary dune profiles), such as seen in Figure C4 on page A-C-9.

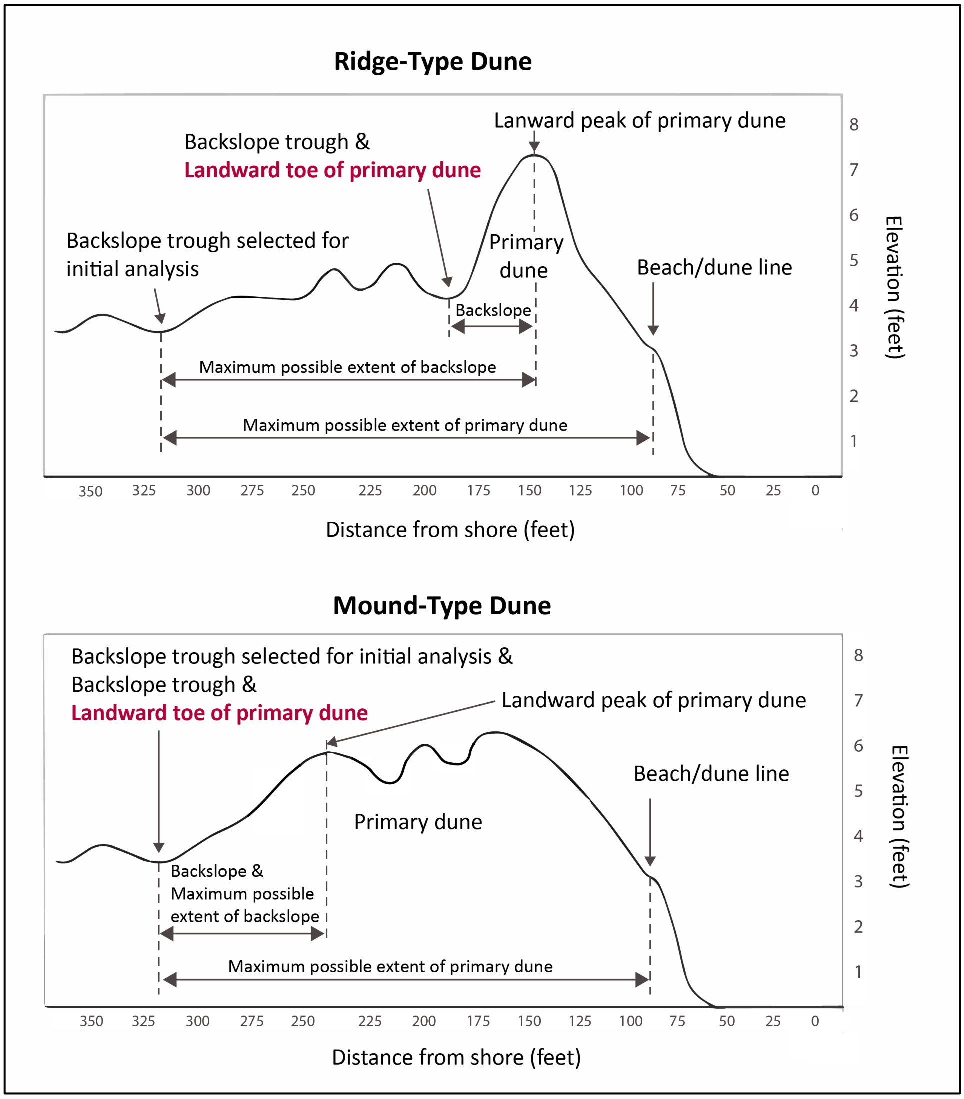
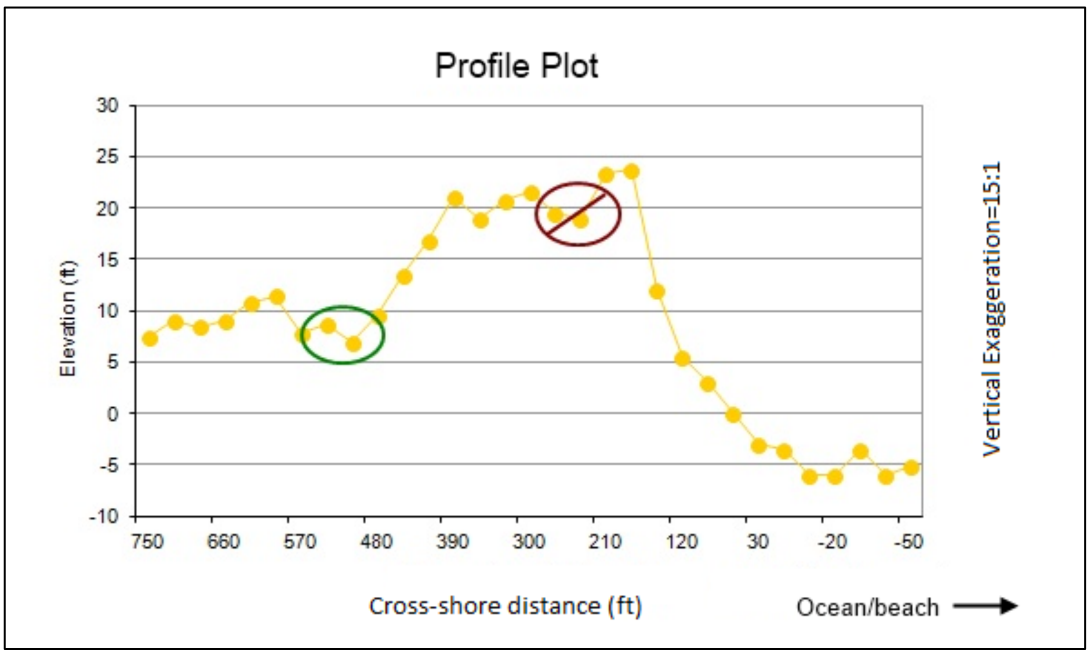


Figure C3. Dune schematics and primary dune terminology for a ridge-type and a mound-type primary dune profile. The primary dune extends from the beach/dune line landward to the backslope trough, where the landward toe of the primary dune is found. Regardless of dune shape, the backslope trough is always landward of the landward peak of the primary dune. In some cases, there are numerous backslope troughs as shown in the ridge-type primary dune profile. The most landward trough that meets the criteria described in step 5A (pages A-C-7 through A-C-10) is selected and will mark the landward boundary for the maximum possible extent of the primary dune and will also mark the landward boundary of the maximum possible extent of the backslope—identifying these parameters first will help accurately delineate the landward toe of the primary dune.

Figure C4. Photograph (left) of a mound-type dune and a comparative view of the same area as plotted in a profile (below). A distinct primary dune with multiple peaks can be seen in the profile (with a vertical exaggeration), but these features are not as obvious at the site. While at the site, the applicant mistakenly identified the landward toe of the primary dune at the trough of the primary peak of a mound-type dune (shown with the red circle and line). The green circle shows a more appropriate location for the landward boundary of the primary dune—at the toe of the backslope, *landward of* the secondary peaks.



To determine the maximum possible extent of the primary dune, the applicant will need to determine the seaward point and then the landward point as follows:

The Seaward Point of the Maximum Possible Extent of the Primary Dune - To find the seaward point of the maximum possible extent of the primary dune, the applicant will need to identify the beach/dune boundary as described in Chapter 1.

The Landward Point of the Maximum Possible Extent of the Primary Dune -
To find the landward point of the maximum possible extent of the primary dune, the applicant must find the backslope trough selected for initial analysis. The applicant must find the most landward backslope trough that takes into account the full extent of the landform—generally, the most

landward trough that is still at the same or lower in elevation than the adjacent seaward troughs (see Figure C5).

The following method should be used:

- On the dune profile, run a straight line between the seaward boundary of the dune (i.e., beach/dune line) and the bottom of the first backslope trough. (Figure C5 shows the lines in the order they were drawn.)
- Continue to draw a line to each successive landward trough, if present.[146]
- Stop when the connecting line does not extend *over or through* another more landward trough.
- That last trough will be chosen as the backslope trough selected for initial analysis—meaning it is the *most landward* possible extent of the primary dune.

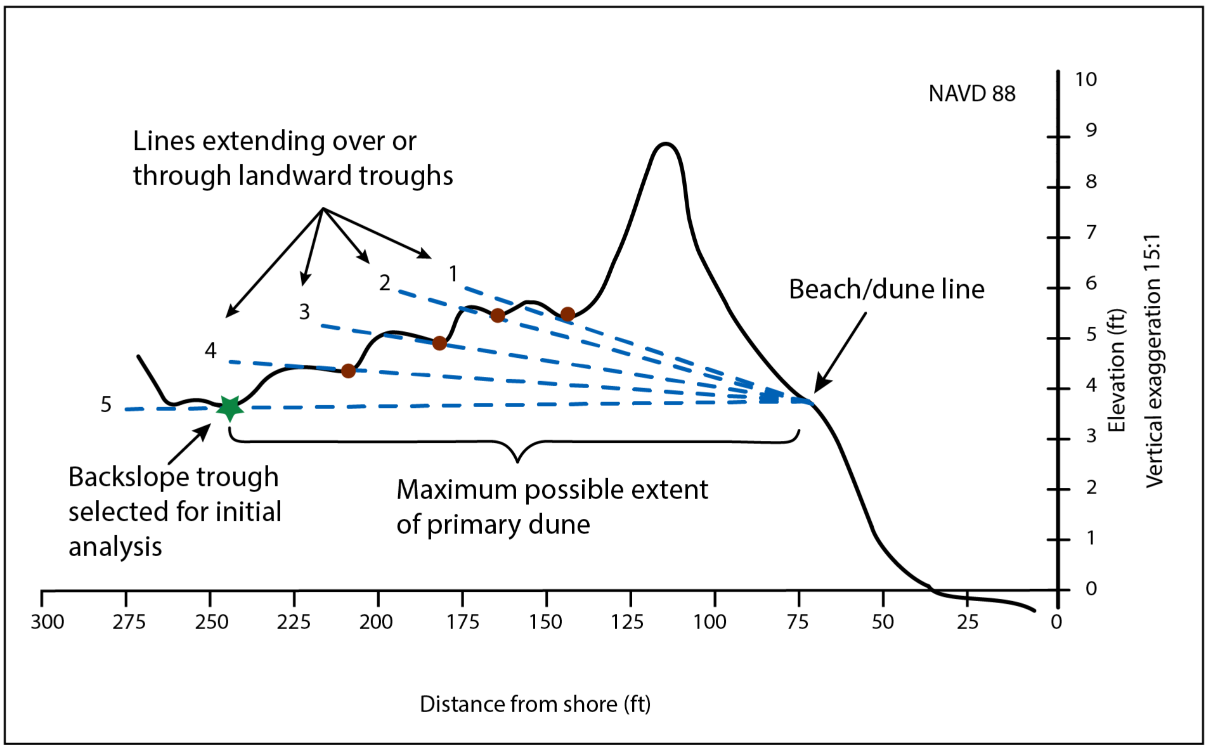


Figure C5. Profile depicting how to identifying the backslope trough that represents the most landward possible extent of the primary dune. The dashed blue lines (#1-#4) that connect the beach/dune line to each trough (at red circles) all extend over or through more landward troughs (to the left), whereas the last line (#5) does not. The trough that line #5 connects to (at green star) is the backslope trough selected for initial analysis, which marks the *preliminary* most landward extent of the primary dune. The distance between the dune/beach line and the selected backslope trough forms the maximum possible extent of the primary dune. Vertical exaggeration of profile: approximately 15 horizontal feet=1 vertical foot.

[146]For more information on drawing lines to the landward trough in Excel, see page A-C-22 in "Case Study Example - Primary Dune Delineation."

B. Identify the backslope.

Next, the applicant will need to find the backslope of the primary dune, which begins at the landward-most peak of the primary dune. Finding the landward-most peak of the primary dune will help avoid making incorrect delineations in a more seaward location (as seen in Figure C4 on page A-C-9). This is particularly important on mound-type dunes that have multiple peaks within the primary dune, since these peaks are often confused with secondary dunes. On mound-type dunes, the correct seaward starting point for the backslope is the landward-most peak of the multiple peaks, since they are part of the primary dune.

The criteria[147] listed below and shown in Figure C6 on page A-C-12 will help: 1) determine whether secondary peaks are present (making it a mound-type primary dune), and 2) locate the landward-most peak of that dune.

- The applicant should first identify the primary peak (peak of dune closest to the beach).
- To determine if other segments of the landform represent a secondary peak, rather than a *secondary dune*, the following criteria must be met:

    - The peak must occur landward of the primary peak.
    - The peak must occur in the top half of the primary dune (total height of the primary dune is measured from the baseline elevation at the beach/dune boundary to the top of the primary peak).
    - The trough depth must be less than 1/3 of the total height of the primary dune (trough depth is measured from the peak in question to the bottom of the immediate seaward trough).

    (The reasoning behind the second two criteria is that, in general, peaks occurring in the upper half of the primary dune with shallow troughs are related to clusters of vegetation and small-scale blowouts, while peaks occurring in the lower half of the dune, or those with a trough depth deeper than 1/3 the total height, typically correspond to either the beginning of the secondary dune, large-scale blowouts, or major landform changes.)

- If secondary peaks are found (making it a mound-type primary dune), the highest point of the most landward secondary peak should be marked (see Figure C6 for an example). If no secondary peaks are found, the highest point of the *primary peak* should be marked (see Figure C3 on page A-C-8, Ridge-Type Dunes).

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[147]Criteria derived from *Technical Report: Primary Frontal Dune Delineation: A Geologically Based Quantitative Methodology for Sandy Beaches in Northeastern Massachusetts*, Revised March 30, 2006; prepared by D. Sampson and R. Haney, Massachusetts Office of Coastal Zone Management.

This point—the landward peak of the primary dune—will mark the seaward starting point for the maximum possible extent of the backslope (see Figure C6). This backslope area will extend landward to the backslope trough that was identified in Step 5A. The next step will explain how the applicant will locate the landward toe of the primary dune within this area.

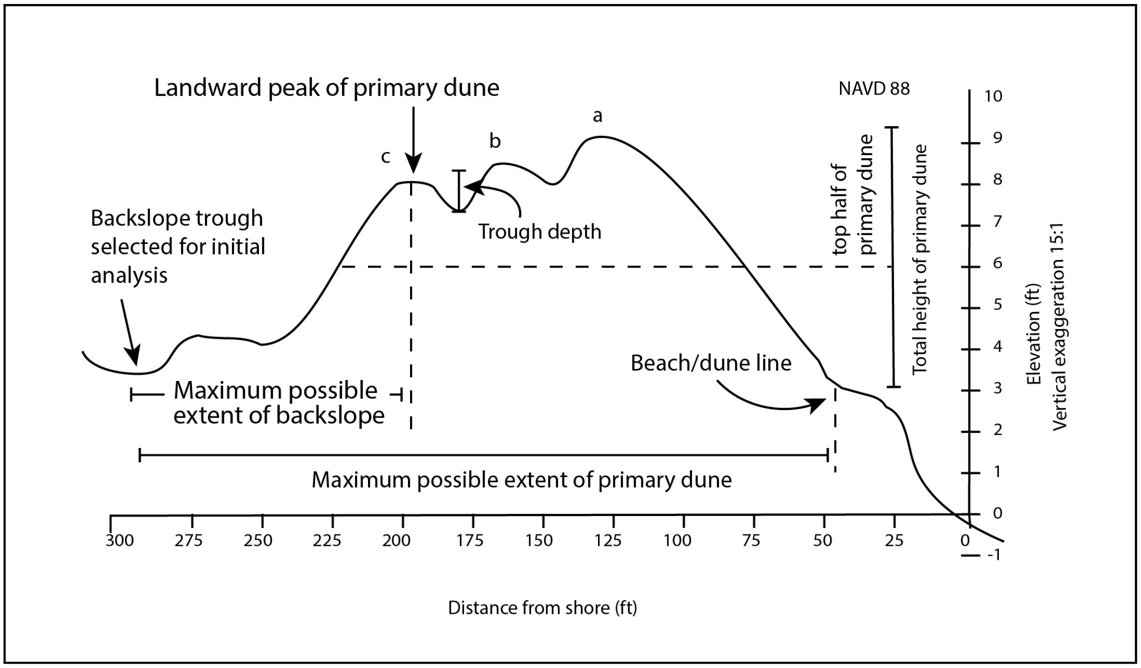

Figure C6. Profile showing the maximum possible extent of the backslope. This maximum extent is measured from the landward peak of the primary dune to the selected backslope trough. In this example, the primary dune has three peaks, *a*, *b*, and *c*. Peak *a* is the primary peak, being closest to the beach. The most landward of the other peaks (peak *c*) meets the criteria of a secondary peak, thereby marking the landward-most peak of the primary dune. These criteria are: peak *c* occurs landward of the primary peak, its elevation occurs in the top half of the total primary dune height, and the depth of the trough between peaks *c* and *b* is less than one-third the total height of the primary dune. Vertical exaggeration of profile: approximately 15 horizontal feet =1 vertical foot.

C. Find the landward toe of the primary dune with second derivative slope.

Now that the applicant is looking at the maximum possible extent of the backslope of the primary dune, they can use second derivative slope of the elevation data to find the *greatest rate of change* in that backslope to find “the point where there is a distinct change from a relatively steep slope to a relatively mild slope.” The second derivative slope (SDS) is basically the rate of change of slope. Positive (+) second derivative slopes quantify where the slope *increases* over a given interval (when the slope goes from a positive value to a more positive value or a negative value to a *less* negative value over a given interval). The highest value of second derivative slope *within the backslope* is the point of the greatest rate of change (i.e., distinct change from relatively steep to mild slope—or mild to steep slope, depending on the orientation of the profile).

Second derivative slopes can be calculated in the Excel spreadsheet containing the exported LIDAR data by first finding the slope of the smoothed elevation data ($\Delta y/\Delta x$—where y is vertical distance and x is horizontal distance) and then finding the change of the slope per change in horizontal distance in the same manner ($\Delta m/\Delta x$ - where m is the slope).[148]

The second derivative slope data can be added to the transect profile to give a visual presentation of the peak values (see pink overlay on Figure C7 on page A-C-14). The positive (+) second derivative slope values (positive peaks of the pink overlay) represent the dune troughs; while negative (-) second derivative slope values (negative peaks of the pink overlay) represent dune ridges. Therefore, the highest *positive* second derivative slope peak *within the backslope* will mark the *possible* location of the landward toe of the primary dune. This is only a possible location, however, because the applicant will need to assess whether the peak represents small-scale or large-scale topographic changes—first on the profile plot and then through field observations. Before analyzing the profile, the applicant should refer back to any observations and notes that were made at the initial site visit to help identify appropriate SDS peaks.

To analyze the profile for SDS peaks, the applicant should first look for small elevation changes on the dune profile that are causing a spike in second derivative slopes (see Figure C7 for a high SDS peak that represents small-scale topography). If a particular peak represents a change that is likely a small-scale topographic feature or one that is caused by human alterations (such as roads and mounding of plowed overwash sediments), the next highest peak that represents the overall landform should be selected. All of this analysis will later be verified in the field. Once a peak is verified to be representative of a larger landform change through profile *and* field observations, it should be marked as the landward toe of the primary dune. The applicant should look at other transect profiles to confirm their results. Generally, the points chosen as the landward toe of the primary dune should be located at an approximately equivalent cross-shore distance among the different transects (for site-specific delineations). Comparing the transect profiles to each other as well as to adjacent dunes, particularly those with less alteration, may also help differentiate small-scale changes and/or human alterations from larger landform changes and facilitate a more accurate determination of the landward toe of the primary dune.

Once the landward toe of the primary dune points are selected on the profiles, they can be transferred to the transect lines in ArcMap to better visualize the results and verify accuracy on the orthophotograph.[149] Plotting these points along the transect line and printing an image to take out to the site will also be helpful for field verifications (described in Step 6).

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[148]For more information on using Excel to find the slope and the second derivative slope of the smoothed elevation data and plotting a second derivative slope profile, see page A-C-20 in "Case Study Example - Primary Dune Delineation."

[149]For more information on selecting the landward toe of the primary dune points along the transect lines in ArcMap, see page A-C-26 in "Case Study Example - Primary Dune Delineation."

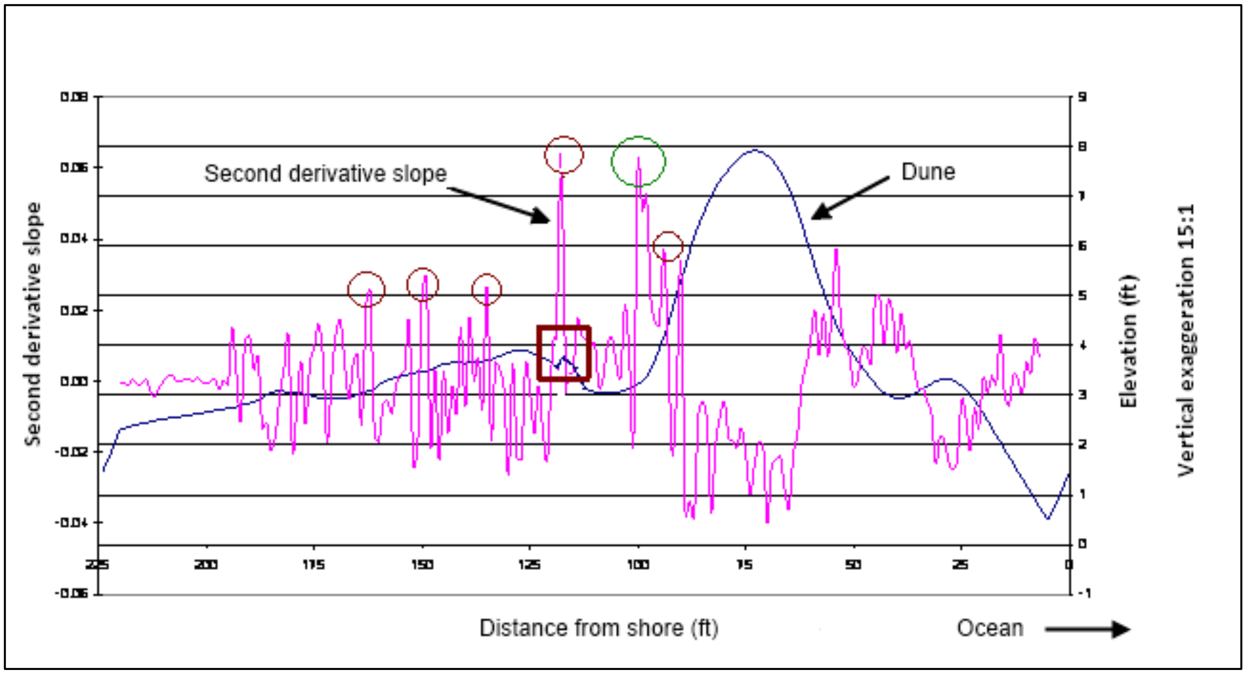

Figure C7. Profile showing second derivative slope (SDS) data. Second derivative slope (SDS), a measure of rate of change, has been added to the smoothed transect profile. A positive (+) SDS value indicates that the slope is increasing (as you move to the right on the plot) from a positive value to a more positive value, or a negative value to a less negative value—basically dune troughs; while negative (-) values indicate that the slope is decreasing (as you move to the right on the plot) from a positive value to a less positive value, or a negative value to a more negative value—basically dune ridges/peaks. To find the second derivative slope that marks the appropriate location for the landward toe of the primary dune, the highest SDS peak in the backslope should be selected first and the scale of the underlying topography should be assessed to determine if it represents a larger landform change. If the peak represents a small-scale feature, then the next highest SDS peak should be selected and the scale of topography should again be determined. In the SDS profile above, the highest peak (third from right) represents a small-scale landform feature as seen on the dune profile (in the square box). The second highest peak (second from right, shown with green circle) represents a large-scale feature and is identified as the likely location for the landward toe of the primary dune. Vertical exaggeration of profile: approximately 15 horizontal feet=1 vertical foot.

Step 6 - Verify results in the field.

The applicant, having determined the location(s) of the landward toe of the primary dune on the profile plans and transect lines, should perform a site inspection to verify results and ground truth the data. As mentioned in Step 5C, spikes in second derivative slopes may be caused by small-scale topographic features, such as large clumps of vegetation (not filtered by processing of the LIDAR), uncovered root systems, blow-out holes, and scarps. In addition, human-made features such as driveways, roads, and access paths may cause rapid changes in elevation. These features *should not* be considered a larger landform change that determines the landward toe of the primary dune.

While standing at the site, the applicant should refer to the ArcMap image that shows the selected landward toe of the primary dune points along the transect lines. The applicant should also refer to the SDS profiles to compare the positive (+) second derivative peaks along a particular transect line with landform features in the field. By reconciling plan data with features in the field, the applicant can get a better idea if the selected landward toe points represent a significant change in slope that is representative of a change in the landform itself and not of an artificial alteration or nuance in small-scale topography.[150] Observing features at the site will also help determine whether the selected landward toe of the primary dune points make sense in context to the surrounding dune environment (i.e., the types and scale of landforms in the area), and whether the applicant went far enough landward in their overall analysis.

If the applicant selected an SDS peak that is not representative of the overall landform (i.e., the peak represents a small-scale change in elevation or a small-scale feature), or located the landward toe in an incorrect seaward location (i.e., the trough of a secondary peak of a mound-type primary dune), then the applicant should use the SDS profile to select another peak that does represent a large-scale landform change within the *appropriate backslope* of the primary dune. Once the point has been verified through profile and field observations, the landward toe of the primary dune should be revised on the profile and transect line as necessary.

In some cases, the landward toe selected through this methodology will not be appropriate because of highly complex topography that did not lend itself to quantification by second derivative slopes. If a transect line exhibits many small-scale changes, which cause spikes in second derivative slopes throughout the profile, it may be difficult to discern what peak does represent an overall landform change—even while standing at the site. Often, this can be remedied by selecting a more representative (i.e., "cleaner") transect line that contains less small-scale changes in topography. No new survey is required to obtain data for another transect line if LIDAR data are being used.

In other cases, the selected landward toe will not be appropriate for reasons such as alterations to the landform since the LIDAR data were flown or site modifications that altered dune form, particularly on the backslope of the dune. If site observations indicate that the landward toe points are inaccurate for these or other reasons, and where appropriate attempts to modify transect lines to gain a more representative profile have already been made, the applicant should use their best professional judgment to find more appropriate points for the landward toe of the primary dune (see Step 7 for more information about determining the overall primary dune boundary line).

Step 7 - Locate points (landward toe of the primary dune) on a site plan.

Now that the applicant has gone out to the site to verify that the landward toe of the primary dune points are accurate on the profiles and transect lines, these selected points (and the location of the transect lines) can be transferred to a site plan. Multiple points for the landward toe of the primary dune (that result from multiple transect lines) should be connected along the contour line on the site plan to create the primary dune boundary line. Since the landward toe of the primary dune does not generally change significantly in elevation or slope over short distances (such as for small project sites), this method should be appropriate for site-specific delineations. For larger project sites, more numerous transects lines should have been plotted in the data collection and processing stage,

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[150] Another reason to reconcile plan data with features in the field is to ensure that there are no issues with incompatible coordinate systems or other specifications in the GIS program that caused an incorrect layering of data in ArcMap.

allowing for less extrapolation between the points. If points (from each transect) are generally not consistent along a contour line, then results for one or more of the transects may need to be reanalyzed and a more appropriate point for landward toe of the primary dune may need to be chosen. Choosing the appropriate locations of these points will require further ground-truthing out at the site.

If the primary dune delineation methodology produces an overall delineation that is not appropriate for the reasons indicated in Step 6 (e.g., complex topography, outdated LIDAR data, site alterations), the applicant should use their best professional judgment to find a more appropriate primary dune boundary. The judgment call should be based on the most current available data and the methods described for other resource area delineations, such as observations of landform features, examination of dimensional characteristics, observations from adjacent primary dunes with less alterations, and assessment of existing functions. Information derived from current data and observations of landform features, as well as experience with delineating dunes, will be helpful for a general determination of the primary dune landform.

In most cases, however, in contrast to dune delineation practices that provide no consistent approach, this primary dune delineation methodology will provide a more reliable process and more accurate depiction of a primary dune and greatly reduce the margin of error in locating the landward boundary.

Case Study Example - Primary Dune Delineation

The following is a hypothetical example of an applicant (i.e., a hired consultant) working through the primary dune delineation methodology to determine the landward toe of a primary dune and the primary dune boundary line for a site on a coastal dune. This example details the step-by-step process of navigating through GIS programs, using Excel spreadsheets and profiles, and performing site visits. Each numerical heading refers to the specific step of the methodology referred to previously in this appendix.

Step 1 - The applicant reviewed the definition.

According to the WPA Regulations, the inland limit of the primary frontal dune occurs at a point where there is a distinct change from a relatively steep slope to a relatively mild slope. To find this distinct change, the applicant set out to locate the greatest *rate of change* in slope on the inland side (i.e., backslope) of the dune to find the likely location of the landward toe of the primary dune.

Step 2 - The applicant performed a site visit to obtain a basic understanding of the overall morphology.

Before going out into the field to delineate the dune boundaries, the applicant reviewed a site plan with topography to get a better sense of the site. The applicant took the site plan out to the site to help with orientation, to provide a cross-reference, and for noting any observations that will later aid with the delineation. At the site, the applicant noticed a few mounds associated with tufts of grass or shrubs, a roadway that is bounded by banks of sediment at each edge, and some alterations in topography around the house foundation. These features were noted on the site plan so that they could be referred to later when reviewing the SDS profiles. The applicant also walked well landward of the project site to determine if the dune in question was a mound-type primary dune versus a ridge-type primary dune. The applicant had difficulties determining the type of dune while standing at the site and therefore decided to rely on the transects and profiles to discern large-scale changes in topography, which could then be field checked for accuracy. In order for the overall morphology to be considered, the applicant made note to extend the transects well-landward of the road.

Step 3 - The applicant reviewed the best available topographic data.

The applicant used LIDAR data because of its dense data points, ease of use, and free availability on the MassGIS LiDAR Terrain Data website. Once the applicant downloaded and saved the data, it was opened and formatted for use in the GIS program (and compatible settings[151] were set within the GIS program). The applicant also pulled an orthophotograph into GIS to help with orientation for the next steps of drawing transects and viewing profiles. The applicant went to the MassGIS data layers page (https://docs.digital.mass.gov/dataset/massgis-data-layers?_ga=2.15378928.774954747.1576259977-1514556810.1576259977) to find the desired LIDAR data for downloading and displaying. (See the box "Obtaining and Using LIDAR Data" on page A-C-18 for details on these steps.)

Step 4 - The applicant created transects, exported the elevation data to Excel, and calculated second derivative slopes for the smoothed elevation data.

Using ArcGIS, the applicant laid out three representative transects perpendicular to the shoreline at approximately 20-foot intervals (see the box below for further information). Since the shoreline was fairly complex with some nuances in topography, the applicant determined that three transects were warranted (See Figure C8 on page A-C-21). Once the transects were created, the elevation data from each transect were exported to Excel (also detailed in the box below). Once in an Excel spreadsheet, new data were calculated to provide values for: smoothed data, slope, and second derivative slopes, and these values were then plotted in a scatter chart for future analysis (see the "Calculating Slopes and Plotting Profiles in Excel" box on page A-C-20 for further information and Figures C9, C10, and C11 on pages A-C-21, -24, and -25 for examples).

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[151]Using the same coordinate system for the ArcMap data frame properties, the LIDAR data layer, and the transect shapefile is critical for obtaining accurate results.

Obtaining and Using LIDAR Data

(This box presents one method for obtaining and using LIDAR Data; other options may be available. Different versions of ArcGIS may result in the need to modify the steps outlined below.)

The applicant performed the following steps to obtain LIDAR data and provide settings.

- The applicant went to the MassGIS LiDAR Terrain Data website at https://docs.digital.mass.gov/dataset/massgis-data-lidar-terrain-data to download the most appropriate LIDAR data for the project site.
  - At the MassGIS website, the applicant followed the directions for locating and downloading LIDAR data for the area of interest (using OLIVER to identify the most current LIDAR data and downloading a .zip file containing the DEM for the selected tile.)
  - For this project, the most current dataset was "2013-2014 Sandy"—which had the following metadata: acquired in Fall 2013 and Spring 2014, projection: "UTM Zone 18N & 19N," resolution: "meters," horizontal datum: "NAD83," and vertical datum: "NAVD88."
- The applicant extracted the files from the zip file and saved them to a designated folder for use in the following steps.
- The applicant opened ArcCatalog within ArcGIS (version 10.4.1) and located the LIDAR data that was downloaded and saved (to be used for later use).
- Next, the applicant opened ArcMap and specified settings and a coordinate system in the data frame properties of a new map (the *same* coordinate system as the LIDAR data).
  - The applicant opened ArcMap within ArcGIS (version 10.4.1) and selected "a new blank map."
  - The applicant set the coordinate system for the data frame by:
    - Clicking on "view" from the "main menu" at the top of the screen and selecting "data frame properties."
    - From the "coordinate system" tab, expanding the "projected coordinate system" folder, expanding the "UTM" folder, expanding the "North America" folder, selecting "NAD 1983 (2011) UTM Zone 19N" and clicking "apply." From the "general" tab, verifying that map and display units were set to "meters." Clicking "ok."

    Note: An alternative way to set the coordinate system is to drag the LIDAR file into ArcMap first, which often sets the data frame properties to be consistent with that layer. You can confirm by checking the data frame properties within ArcMap after importing the LIDAR file.

- The applicant dragged the LIDAR file that was saved in ArcCatalog over to ArcMap screen and dropped it just under "layers" and clicked "yes" to create pyramids. Then the applicant used the magnify tool to refine the area of interest, and saved the map for use for the next steps of drawing transects.

  (*If the LIDAR file is in a .tiff format, it will appear as one color {i.e., all black}. If this occurs, the .tiff file will need to be saved in a different format. To do this, right click on the LIDAR layer in ArcCatalog, click on "export" "raster to different format." In the "output raster dataset" field, delete the file extension .TIFF [and leave no extension] and click "okay." A new file starting with a "c" will appear in the file. Drag this file over to ArcMap and delete the other. The LIDAR layer will now appear as a spectrum of color showing elevations.*)

- To help with orientation when drawing the transects and viewing the profiles, the applicant downloaded the desired ortho-imagery from the MassGIS datalayer page by following their directions for download, unzipped and extracted the files, and dragged them to ArcMap. Some users will already have basemap ortho-imagery available in ArcMap. To add an image to the map, click "file," "add data" and "add basemap" and select "imagery." Move this data to the top in the layers panel to make it visible.

Creating Transects and Exporting Elevation Data to Excel (Using 3D Analyst)

(This presents one method for creating transects and exporting elevation data to Excel; other options may be available.)

The applicant performed the following steps to create transects in ArcGIS 10.4.1.

- In the main menu, the applicant selected “Customize” and “extensions” and clicked on “3D Analyst.” Then the applicant went back to “Customize” and “toolbars” and once again clicked on “3D Analyst” to make it visible in the toolbar.
- The applicant double clicked the LIDAR data to make it active in the “3D Analyst” toolbar.
- The applicant selected “interpolate line” and clicked just seaward of the wet/dry line of the shoreline to establish the starting point for a transect, drew a line perpendicular to the shoreline by dragging the line to the desired endpoint, and double-clicked.
- The applicant then selected “profile graph” and a small profile popped up on a screen.
- The applicant right-clicked the profile and clicked “export.” A screen popped up with options for export. The applicant chose the “data” tab and clicked “excel” format. In the “include” tab, the applicant chose “point labels” and “header.” The applicant saved the file to their desired location and clicked “close” to close the pop-up export screen.
- The applicant repeated the above steps to create three interpolated lines and three graph profiles that were exported to three excel files.

Calculating Slopes and Plotting Profiles in Excel (Using 3D Analyst)

The applicant performed the following steps to open and use the Excel spreadsheet to plot profiles based on the calculations of the smoothed elevation data, the slope of the smoothed elevation data, and second derivative slope data.

- The applicant opened up the Excel files that were saved above.
- Excel opened and X and Y data (data along the transect) populated the spreadsheet—the X coordinate was the horizontal distance (Column A) and the Y coordinate was the elevation data (Column B). In this case the horizontal distance was in 1 meter increments as per the LIDAR data mapping.
- To smooth the raw data and help further remove small-scale landform features (e.g., vegetation and scour marks around root systems), the applicant used a moving average.
    - The applicant took the average of a subset of five vertical data points and placed this value within a new column labeled “Smoothed Elevation.” As shown in Figure C9 on page A-C-21, the value of fx=SUM(B2:B6)/5 was placed in C4, the value of fx=SUM(B3:B7)/5 was placed in C5, and so on to the bottom of the column leaving the last two cells blank (where column B is the elevation data and column C is the smoothed elevation data).
    - The profiles for the smoothed data from column C and the raw data from column B were compared to ensure that the data were not overly smoothed, resulting in a visible loss of both small-scale and large-scale landform features. To plot the profiles, the applicant:
        - Selected Column A (Distance) and Column C (Smoothed Elevation), and then selected “Insert,” “Scatter Chart,” and “Scatter with Smooth Lines,” which plotted the smoothed data.
        - Right clicked on the profile, selected “Select Data,” selected “Add” to get an additional series, inserted cursor in the series X values, and selected Column A (Distance), inserted cursor in the series Y values and selected Column B (Raw Elevation Data), and clicked “okay,” and then “okay” again to plot the data. The two profiles appeared on the plot allowing for a comparison.
- Once the data were smoothed, and while still in Excel, the applicant calculated the slope of the smoothed elevation data, and then calculated the slope of the slope to obtain the second derivative slopes.
    - The applicant named column D “Slope,” entered the formula: =SUM(C4-C5)/(A4-A5) in D5; and copied the formula down to the bottom of the column.
    - The applicant named column E “SDS” (second derivative slope), entered the formula: =SUM(D5-D6)/(A5-A6) in E6, and copied the formula down to the bottom of the column.
- The applicant plotted the profiles of the smoothed elevation data and the second derivative slope data in another scatter chart.
    - The applicant selected Columns A (Distance), C (Smoothed Elevation), and E (SDS).
    - The applicant selected “Insert,” “Scatter Chart,” “Scatter with Smooth Lines.”
    - A profile with cross-shore distance on the X-axis, and the two elevations on the Y-axis appeared in the worksheet. The zero (0) point was the *seaward* side of the transect/profile.
    - To give a better visual presentation of the SDS peak values, the applicant overlaid the SDS profile on the smoothed elevation profile by: right clicking the SDS profile, selecting “format data series,” and plotting the series on “secondary axis.”
    - The applicant moved the plot to a new chart by right clicking the profile, selecting “move to new sheet,” and “new sheet.”
- The applicant noted and marked the vertical exaggeration (approximately 20:1) by scaling the horizontal to vertical axes on the chart (using an engineer scale).

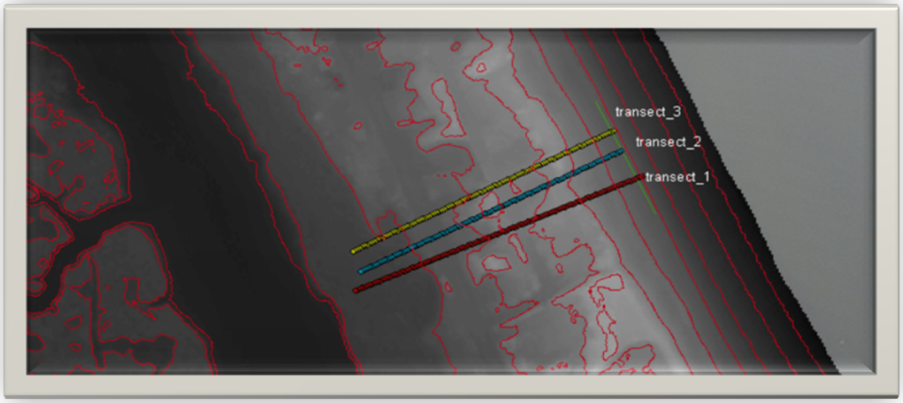
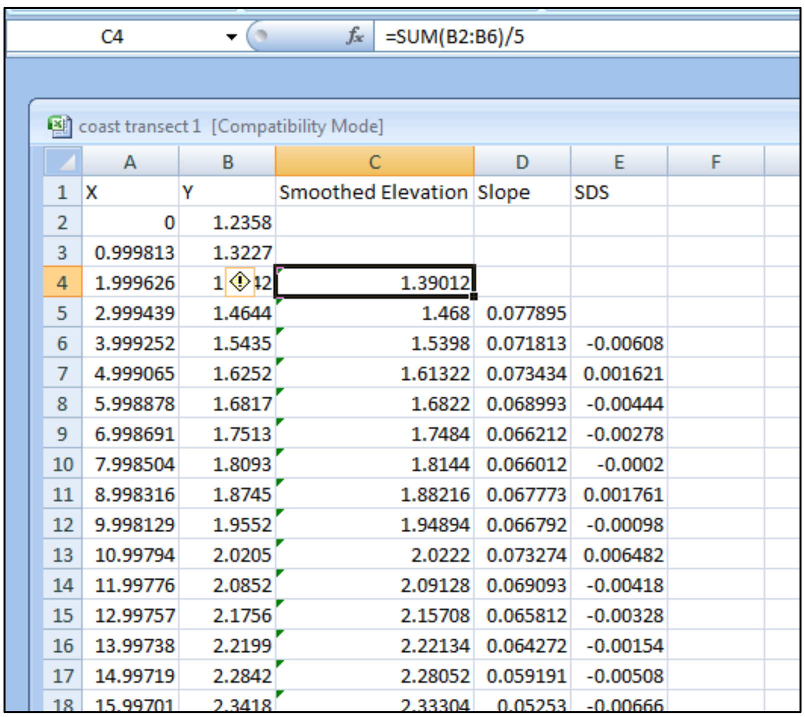


Figure C8. A screen view of ArcMap showing three transects that overlie the LIDAR data and contour data. (Contour data can be added with the 3D Analyst “create contour” function.) The orthophotograph (USGS Color Ortho Imagery 2008) is visible underneath these layers.



C4 | =SUM(B2:B6)/5

coast transect 1 [Compatibility Mode]

	A	B	C	D	E	F
1	X	Y	Smoothed Elevation	Slope	SDS	
2	0	1.2358				
3	0.999813	1.3227				
4	1.999626	1[illegible]42	1.39012			
5	2.999439	1.4644	1.468	0.077895		
6	3.999252	1.5435	1.5398	0.071813	-0.00608	
7	4.999065	1.6252	1.61322	0.073434	0.001621	
8	5.998878	1.6817	1.6822	0.068993	-0.00444	
9	6.998691	1.7513	1.7484	0.066212	-0.00278	
10	7.998504	1.8093	1.8144	0.066012	-0.0002	
11	8.998316	1.8745	1.88216	0.067773	0.001761	
12	9.998129	1.9552	1.94894	0.066792	-0.00098	
13	10.99794	2.0205	2.0222	0.073274	0.006482	
14	11.99776	2.0852	2.09128	0.069093	-0.00418	
15	12.99757	2.1756	2.15708	0.065812	-0.00328	
16	13.99738	2.2199	2.22134	0.064272	-0.00154	
17	14.99719	2.2842	2.28052	0.059191	-0.00508	
18	15.99701	2.3418	2.33304	0.05253	-0.00666	

Figure C9. A screen grab of an Excel worksheet showing the X and Y coordinates, smoothed elevation, slope, and second derivative slope. The X Coordinate is the distance along the transect in meters and the Y Coordinate is the elevation data along the transect in meters. The new columns that the applicant created are: (C) smoothed elevation, (D) slope, and (E) second derivative slope. The applicant inserted the appropriate formulas (such as that displayed for smoothed elevation) and copied them down to the appropriate row.

Step 5 - The applicant used the profiles to identify parts of the dune system.

Once the profiles were plotted, smoothed (with the smoothed data profile checked against the raw data profile), and ready to use, the applicant began the process of locating various points on the profile that helped narrow the search for the landward toe of the primary dune.

To begin, the applicant determined the maximum possible extent of the primary dune on the profile, which runs from the beach/dune line on the seaward side to the backslope trough selected for initial analysis. To find the backslope trough selected for initial analysis, the applicant used the profile to draw a line to the appropriate landward trough (see the "Determining the Maximum Possible Extent of the Primary Dune" box below for more details and Figure C10 on page A-C-24 for an example).

Determining the Maximum Possible Extent of the Primary Dune

On the profile in Excel, the applicant selected the smoothed elevation profile with the cursor; clicked "insert shapes," "lines;" clicked and held the cursor on the point that represented the beach/dune line; and dragged the line to the trough where the line did not extend over or through other more landward troughs (see Figure C10). The applicant reviewed the orthophotograph to confirm the beach/dune line.

Next, the applicant identified the backslope of the primary dune to find the correct seaward starting point. The backslope of the primary dune begins at the landward-most peak of the primary dune. Since multiple peaks existed on the plot, the applicant needed to determine if the secondary peak was part of the primary dune or was a secondary dune. The applicant determined that the secondary peak *was* part of the primary dune (see the "Determining Secondary Peaks" box on page A-C-23 for more detail). This secondary peak was marked at its highest point as the starting point for the backslope (see Figure C10 on page A-C-24).

Determining Secondary Peaks

The applicant used the smoothed elevation profile to confirm the following criteria and determine that the secondary peak was part of the primary dune (and the beginning of the backslope).

- The secondary peak was landward of the primary peak,

  and

- The secondary peak occurred in the top half of dune:
  - The total height of the primary dune was 1 meter (the applicant held the cursor over the primary peak to get the elevation value of 4.3 meters and subtracted the elevation of the beach/dune line, 3.3 meters);
  - The top half of dune was therefore between elevation 3.8 and 4.3 meters;
  - The secondary peak at elevation 3.9 meters occurred in the top half of dune.

  and

- The secondary peak trough depth was less than 1/3 of the total height of the primary dune:
  - The trough depth was 0.1 meters (the applicant held the cursor over the landward peak to get an elevation value of 3.9 meters and subtracted the elevation of the trough just seaward of the peak in question, 3.8 meters);
  - 1/3 total height of the primary dune was 0.3 meters;
  - Trough depth of 0.1 meters was less than 1/3 total height of the primary dune.

Next, the applicant used the second derivative slope (SDS) of the elevation data to find the greatest rate of change in the backslope. The applicant determined the highest SDS value by finding the highest peak in the backslope area. The applicant looked at the profile, as well as the orthophotograph to verify that the chosen point was not a man-made alteration, such as part of the house footprint, deck, vegetation, or a road. The highest peak within the backslope *was* representative of a break in slope to the overall landform and was therefore chosen as the landward toe of the primary dune. To ensure this point was an appropriate choice, the applicant looked at other high peaks in the backslope area and determined what they represented using the orthophotograph, topographic data for the site, and knowledge of the site from the field visit. The second highest peak—the only other significant peak—was indicative of a clump of vegetation (that was not filtered out in the processing of the LIDAR data) and was therefore not an appropriate choice (this was later confirmed in the field).

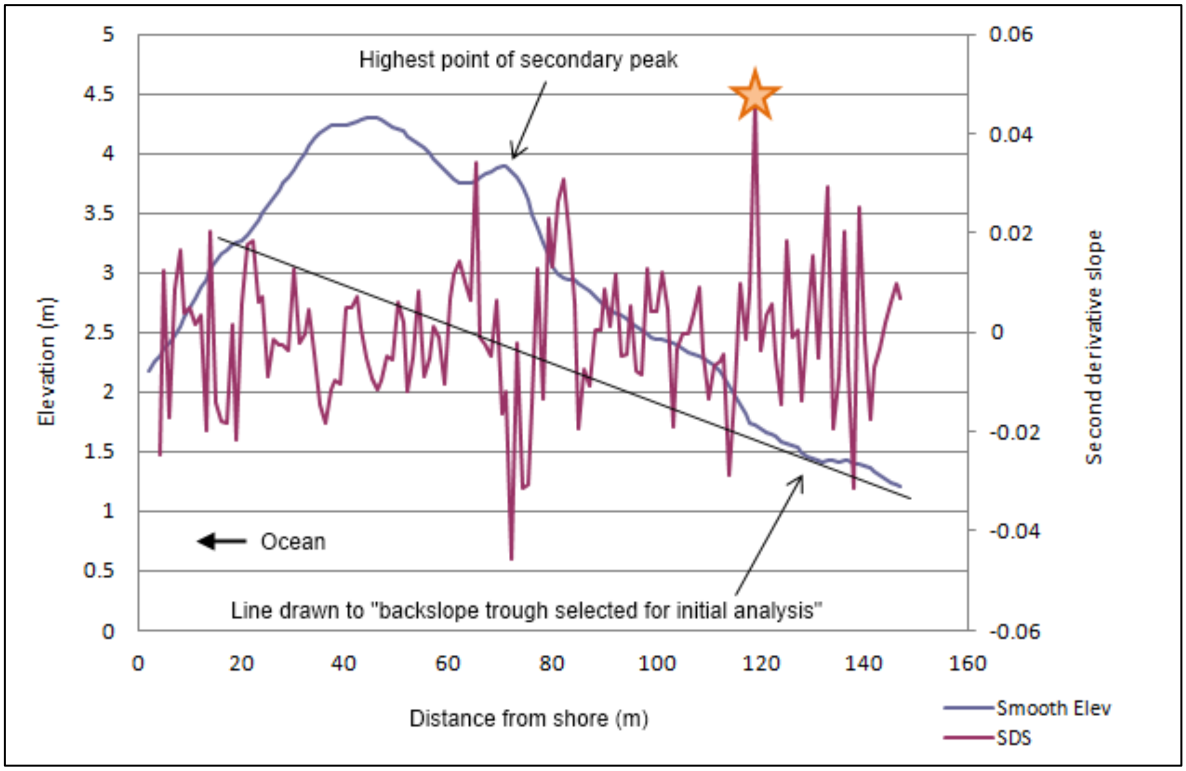


Figure C10. Profile of transect data with smoothed data and second derivative slope data shown as an overlay on a secondary axis. A line has been drawn to the “backslope trough selected for initial analysis.” The highest point of the secondary peak has been selected. The backslope of the primary dune lies within these two boundaries. The peak that is representative of a break in the overall slope of the entire landform is designated above by an orange star (approximately 120 meters cross-shore distance). The second-highest peak (within the backslope area), though appearing as a likely location for the landward toe of dune, actually represents micro-topography (a mound of vegetation not filtered out in the processing of the LIDAR as determined by the orthophotograph) and was consequently not chosen. (*If an applicant/Commission prefers to use feet rather than meters, the LIDAR data could have originally been downloaded in feet, or the elevations and distances shown on the chart can be converted to feet in the spreadsheet.*)

To further confirm the findings from the first transect profile, the applicant looked at another transect to compare the profiles and ensure consistent results. The second profile (see Figure C11 on page A-C-25) showed numerous spikes that represented changes in slope associated with the clearing and flattening of the dune for the house lot, as well as large clumps of vegetation (noted in the initial site visit) that were not removed from LIDAR data when being processed by bald-earth algorithms. These numerous peaks in the SDS profile were not representative of a break in slope to the overall landform and were consequently not used. The highest SDS spike that was representative of a break to the slope of overall landform was chosen and compared to the point chosen from the previous transect profile. Both were approximately 120 meters cross-shore distance and therefore the likely location of the primary dune boundary. (The third transect profile, not depicted in a figure, produced a similar result).

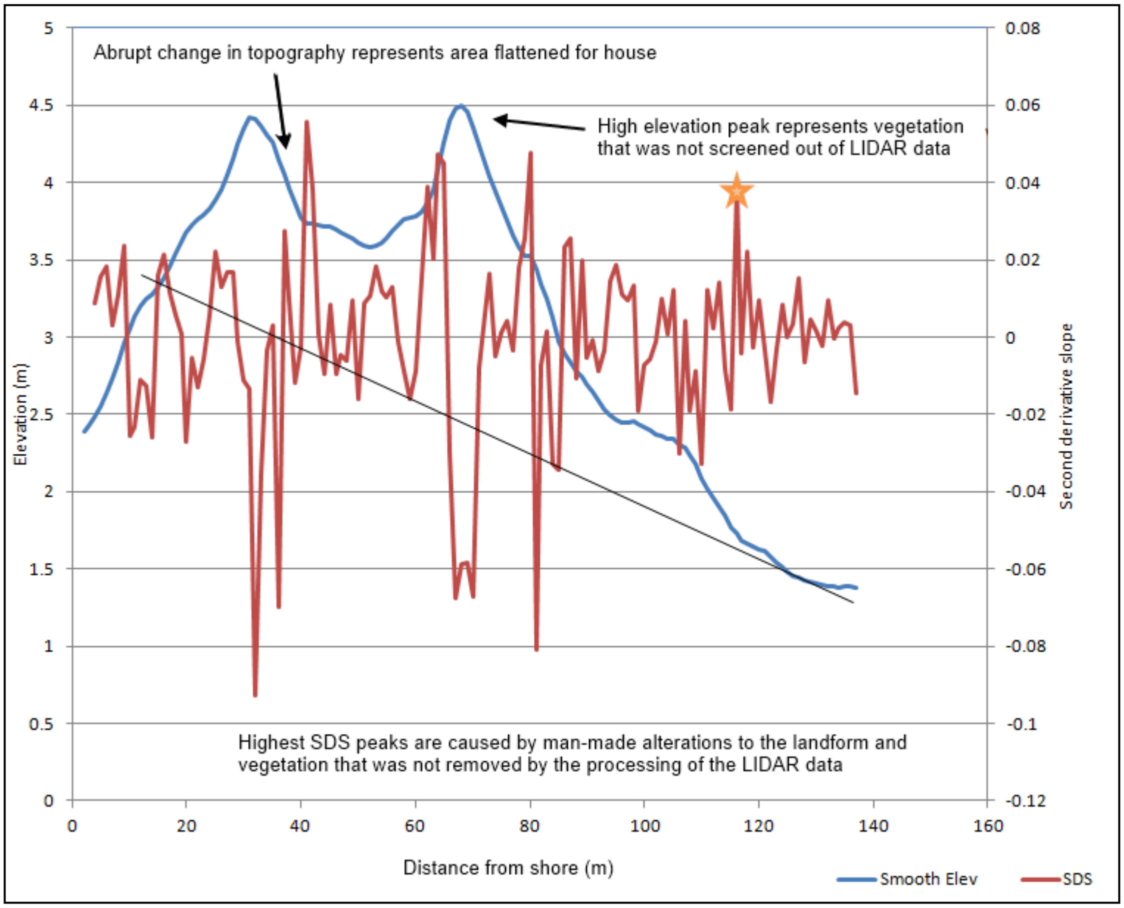


Figure C11. Profile of data from second transect used to compare the landward toe of the primary dune points. A review in the field helped determine that the abrupt break in the topography of the primary peak was caused by the man-made alterations of the dune (for the house and yard area). The second peak in topography was determined to be representative of clump of trees and shrubs that was not removed through the processing of the LIDAR data. The resulting spikes in the second derivative slope (SDS) profile from these topographic changes are not representative of a break in the overall slope of the landform. The SDS spike that is indicative of the landward toe of the primary dune is depicted with an orange star. The consistency between the landward toe of the primary dune designations at approximately 120 meters cross-shore distance on both transect profiles (Figures C10 and C11) indicates that this is the likely location of the primary dune boundary, which will later be confirmed in the field.

The applicant, having determined the location of the landward toe of the primary dune on two profile plans, transferred the selected points to the transect lines in ArcMap to better visualize results and verify where the points overlaid the orthophotograph (see page A-C-26 for "Selecting Points Along the Transect Lines" and Figure C12 for a depiction).

Selecting Points Along the Transect Lines (Using 3D Analyst)

The applicant performed the following steps to select the landward toe of the primary dune points along the transect lines.

- In ArcMap, the applicant returned to the profile graph from which the Excel data was exported. The applicant clicked on the point that was determined as the landward toe of dune (through the Excel profile) and right-clicked the mouse, and clicked "identify." A pop-up screen appeared with location information about that point. In the "location" box, the applicant selected "meters" from the drop-down menu and made note of the X and Y coordinates to be used for the next step.
- The applicant then went to the "go to XY" button in the main menu to find the coordinates on the map. In the pop-up screen, he selected units: meters, filled in the X and Y values (that were determined in the previous step), and clicked on the "add labeled point" button. The point appeared along the transect line.
- The applicant verified that the point was not a small-scale landform feature by looking at its location on the orthophotograph.
- The applicant continued to put the landward toe of the primary dune points on all the transect lines.

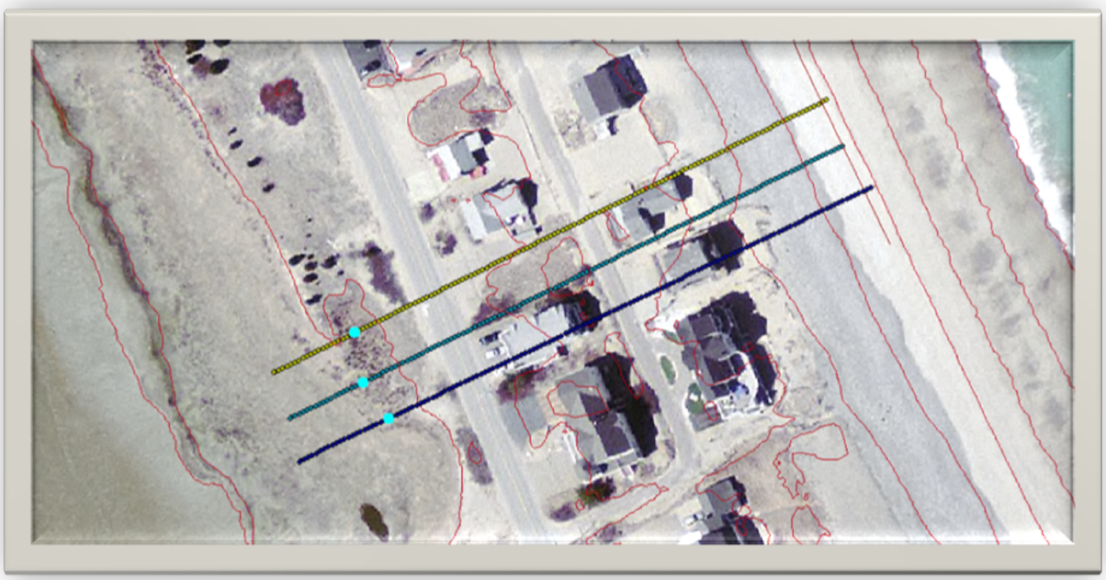


Figure C12. A screen view of ArcMap with landward toe of the primary dune points selected along three transect lines. The landward toe of the primary dune point is found at approximately 120 meter cross-shore distance on each transect line. The visible layers include the orthophotograph (USGS Color Ortho Imagery 2008) and contour data.

Step 6 - The applicant performed a site inspection.

The applicant, having determined the location(s) of the landward toe of the primary dune points on the profile plans and transect lines, went back out to the site to perform a field inspection to verify results and ground truth the data. The applicant was able to determine that the selected landward toe points did represent a significant change in slope representative of a change in the landform itself and not of artificial alterations or nuances in small-scale topography. Observing features at the site also helped confirm that the transect lengths were appropriate and that the applicant did go far enough landward for the overall analysis.

Step 7 - The applicant located these points (landward toe of the primary dune) on a site plan.

After confirming that the points did not appear to represent small-scale topography, the applicant transferred the selected points (and the location of the transect lines) to a site plan in order to help the Commission locate these points and surrounding features in the field. The two points were then connected along the contour line as the landward boundary of the primary dune (which was landward of the project site).

Appendix D - Massachusetts Department of Environmental Protection Coastal Banks Policy

Coastal Banks: Definition and Delineation Criteria for Coastal Banks (DWW Policy 92-1)

Issued: March 3, 1992

The following policy is copied verbatim from the Massachusetts Department of Environmental Protection Wetlands Protection Program Policies (March 1995), Coastal Banks: Definition and Delineation Criteria for Coastal Banks (DWW Policy 92-1), pages 23-26.

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, §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 reveal 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 attached figures (1-7) for a graphic presentation of the information below]:

A. The slope of a coastal bank must be ≥10:1 (see Figure 1).

B. For a coastal bank with a slope of ≥4:1, the "top of coastal bank" is that point above the 100-year flood elevation where the slope becomes <4:1. (see Figure 2).

C. For a coastal bank with a slope ≥10:1 but <4:1, the top of coastal bank is the 100-year flood elevation. (see Figure 3).

D. A "top of coastal bank" will fall below the 100-year flood elevation and is the point where the slope ceases to be ≥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 <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 <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 shown on the submitted plans. The final approval of resource boundary delineations rests with the issuing authority (Conservation Commission or Department of Environmental Protection).

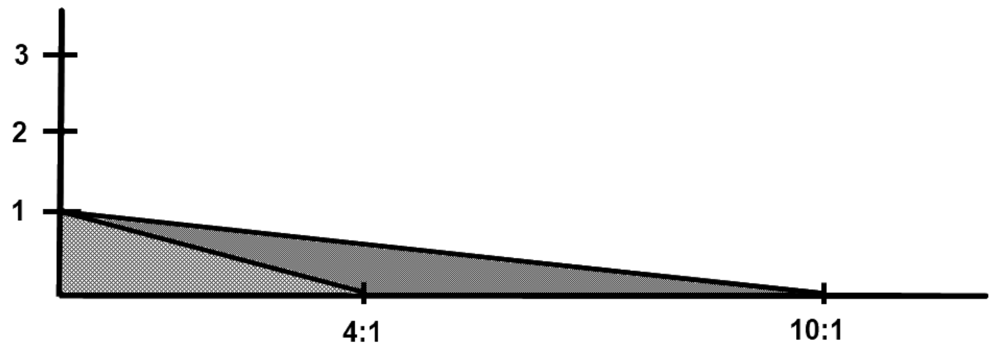


Figure 1

Note that 4:1 slope is greater than (steeper than) 10:1 slope.

- 4:1 is equivalent to 14 degrees or 25 percent.
- 10:1 is equivalent to 6 degrees or 10 percent.

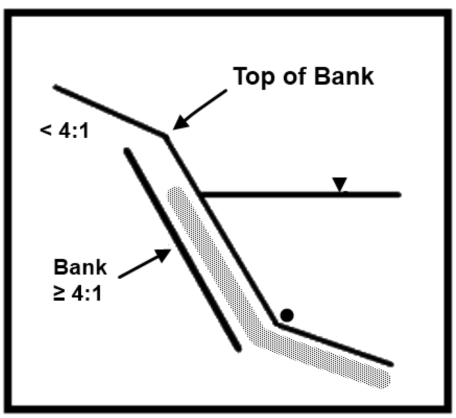


Figure 2

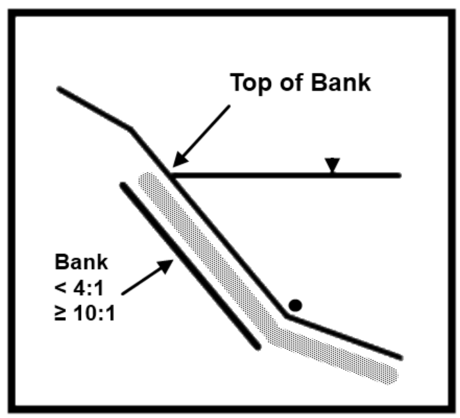


Figure 3

Legend - Figures 2 and 3 are 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

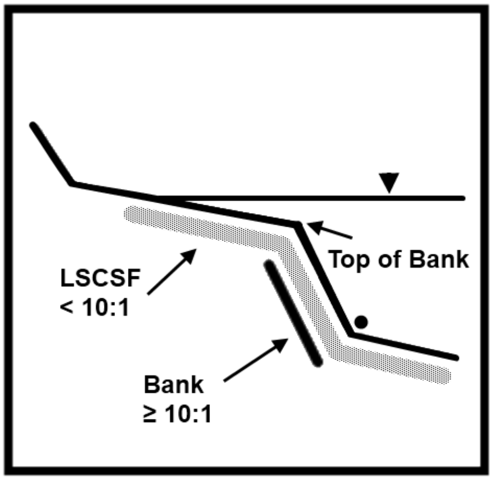


Figure 4

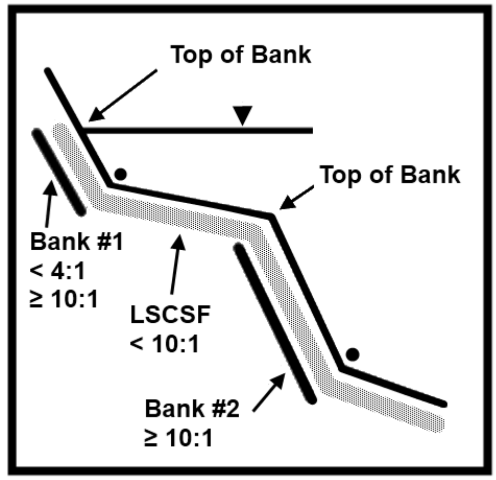


Figure 5

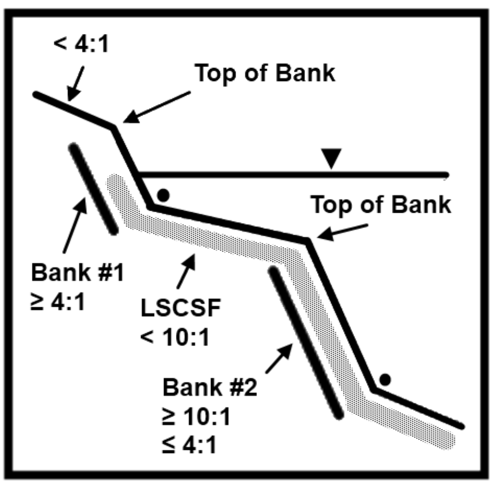


Figure 6

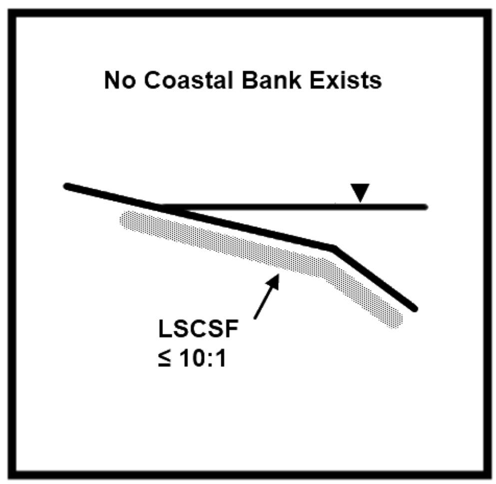


Figure 7

Legend - Figures 4, 5, 6, and 7 are not to scale

▼ 100 year flood elevation (as shown on community FIRM) or storm of record

▬ Coastal Bank

░ Land subject to coastal storm flowage (LSCSF)

● Toe of bank which lies at the landward edge of a coastal beach, land subject to tidal action, or other wetland

Appendix E - Measuring Slope on a Coastal Bank

The following guidance can be reviewed by Commissions (and performed by applicants) to determine slope ratio measurements and the delineation of the top of a coastal bank on a contour plan.

To begin, Commissions should review the transect line (or lines) drawn on the contour plan by the applicant or engineer. The line(s) should be perpendicular to the contour lines on the plan. Remember that contour lines often bend, so a line drawn perpendicular to contours will not always be a straight line. Next, Commissions should determine whether the cross section (the profile that is derived from the transect line) is representative of the entire landform. To do this, Commissions should determine whether the coastal bank is fairly uniform across its width or whether other areas of the coastal bank differ enough in slope, alignment, or height to warrant another line (and section) be drawn. Multiple transect lines may need to be drawn through the bank (and multiple sections analyzed) to represent the entire landform. Commissions can then review the coastal bank cross section provided by the applicant. The applicant/engineer should have chosen discrete segments of the bank and determined whether their slope ratio is <10:1, ≥10:1, <4:1, or ≥4:1. The segments should be representative of the general landform and not the micro-topography of the landform (as described below).

After reviewing the plans, Commissions can make their own determination of the slope ratios of the coastal bank using the following methodology (if needed, Appendix F provides additional information about using engineer scales):

1) Look at the contour plan and select particular segments of the transect line that appear to be uniform in slope for that particular length and mark them on the contour plan. Figure E1 on page A-E-3 depicts 6 segments represented by different colors (they are also coded by "r" for red, "b" for blue, etc.) on the contour plan. Note that it is the bend in the contour lines on the contour plan that warrants two separate segments be drawn between purple and yellow and NOT the small deviation in slope caused by the footpath (shown shaded), which is not an overall change in the slope of the landform. (Likewise, separate segments should not necessarily be drawn for deviations in slope caused by manmade features, such as a seawall. In many cases, a segment should be drawn *through* the artificial feature, to account for the underlying landform and its overall slope.)
2) For the first segment, measure the *run of the distance* by measuring with a ruler to the scale of the plan the distance of the chosen segment (if necessary, see Appendix F for using engineer scales). For example, at a scale of 1"=20' on the plan in Figure E1, the run of the distance of the first segment shown in red (between elevations 5 and 10) measures out to be a half inch or 10 feet.

3) Next, measure the distance of the *rise in elevation* for that same segment by finding the difference in contour lines on the plan or by looking at the section elevations. For example, the segment shown in red starts at elevation 5 ft and rises up to elevation 10 ft ; 10 - 5 = 5.
4) Once you have these numbers, depict the run to the rise as a ratio, such as in this case 10:5 or 2:1. The lower the ratio of run (horizontal distance) to rise (vertical distance), the steeper the slope. Therefore, a 2:1 slope is steeper than a 4:1 slope. You would mark this segment as ≥4:1 *on the profile view* (see Figure E2 on page A-E-4 for an example).
5) Follow this sequence for the next chosen segments.

Segment blue (b):	run: 3/4 inch = 15 feet rise: 25 - 10 = 15 ratio of run to rise: 15:15 or 1:1; which is steeper than 4:1 (i.e., ≥4:1)
Segment purple (p):	run: 3/8 inch = 7.5 feet rise: 28 - 25 = 3 ratio of run to rise: 7.5:3 or 2.5:1; which is steeper than 4:1 (i.e., ≥4:1)
Segment yellow (y):	run: 7/8 inch = 17.5 feet rise: 36 - 28 = 8 ratio of run to rise: 17.5:8 or 2.2:1; which is steeper than 4:1 (i.e., ≥4:1)
Segment green (g):	run: 1 ¼ inches = 25 feet rise: 44 - 36 = 8 ratio of run to rise: 25:8 or 3.1:1; which is steeper than 4:1 (i.e., ≥4:1)
Segment orange (o):	run: 7/8 inches = 17.5 feet rise: 46 - 44 = 2 ratio of run to rise: 17.5:2 or 8.8:1; which is not steeper than 4:1, but is steeper than 10:1 (i.e., ≥10:1 but <4:1)

6) Look at the Massachusetts Department of Environmental Protection Coastal Banks Policy (DWW Policy 92-1) to determine which standard and corresponding figure best fits your calculations. In this case, it would be Standard B or Figure 2: for a coastal bank with a slope of ≥4:1, the top of coastal bank is that point above the 100-year flood elevation where the slope becomes <4:1. Therefore, you would delineate the top of coastal bank at elevation 44, where the green segment stops and the orange segment begins. (The flood elevation on the FEMA Flood Insurance Rate Map is designated as Zone VE = 15 feet NAVD. In circumstances where the coast is a steep bank and there is no mapped A Zone, this V Zone elevation accounts for wave runup. The V Zone boundary can therefore be delineated on the contour plan at the given elevation. See "Land Subject to Coastal Storm Flowage" beginning on page 1-68 for more information on delineating the 100-year flood zone elevation on your plan.)
7) Follow the same steps (1-6) for the other profiles to delineate the top of coastal bank.
8) Delineate the top of coastal bank on the contour plan by drawing a line between your points and using best judgment to follow the topography and break in slope in-between points.

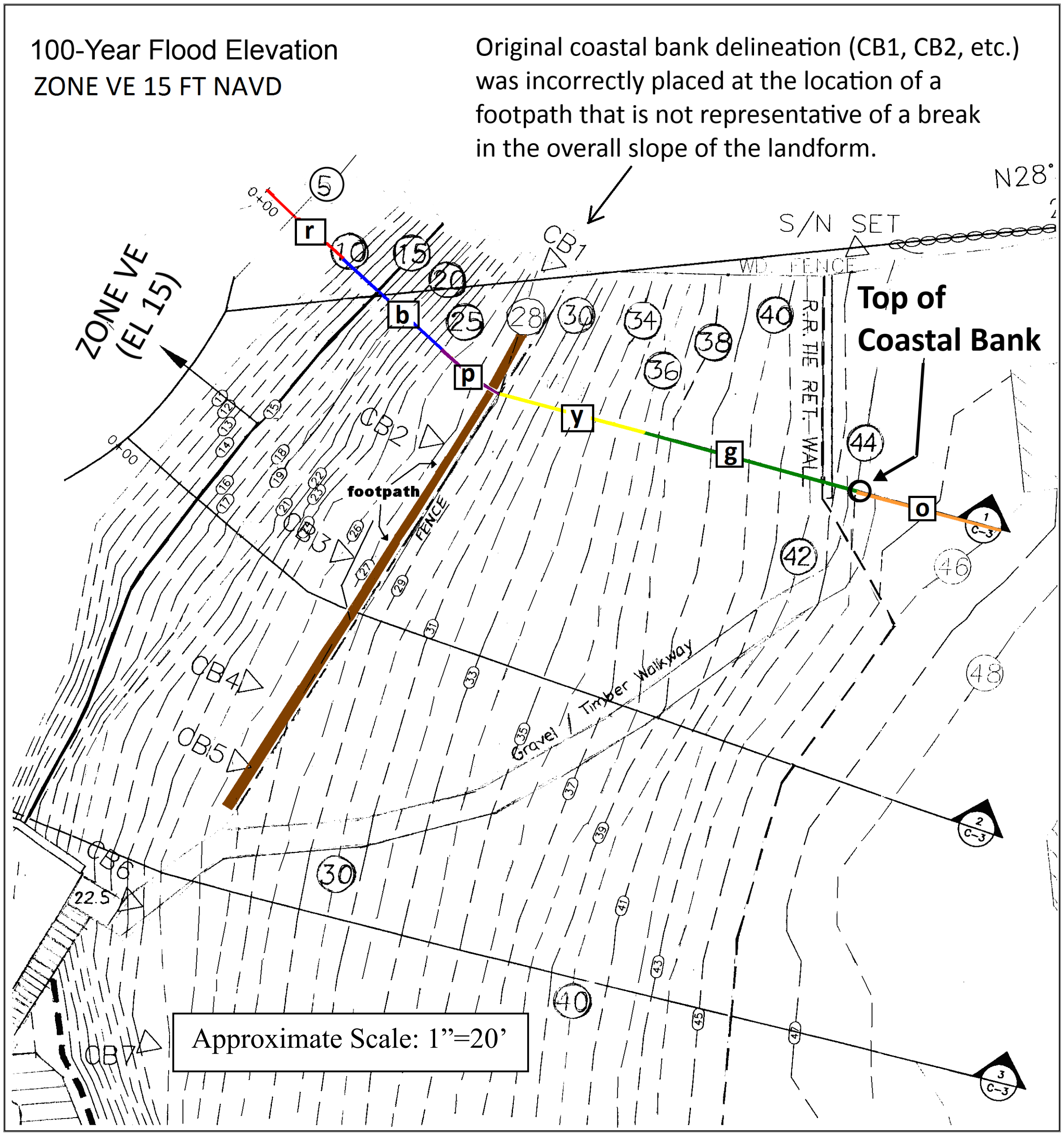


Figure E1. Contour plan used to measure the slope for particular segments of the coastal bank.

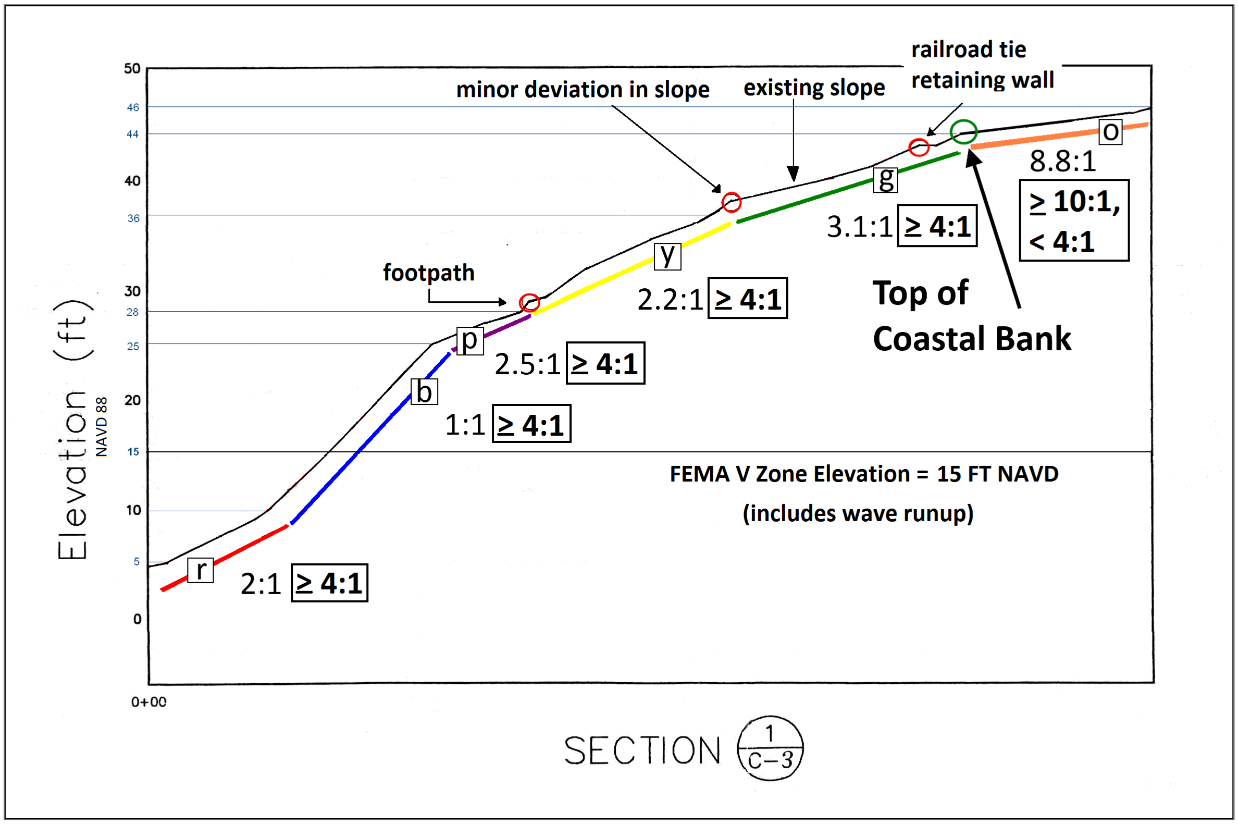


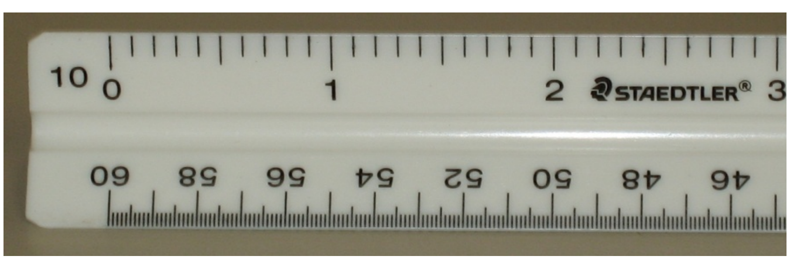
Figure E2. Cross section (profile view) of coastal bank showing segments and their slope ratios. The cross section depicts transect 1/C-3 with: colored segments correlating to the segments on the contour plan; the slope ratio for each segment; the flood zone delineation (V Zone elevation=15 feet); and top of coastal bank. The top of coastal bank is where there is a break in overall slope from ≥4:1 to < 4:1 (elevation 44 feet) above the 100-year flood elevation. As labeled in the figure, the minor deviations in slope shown within the red circles are *not* representative of a change in the slope of the overall landform and are therefore not considered a break in slope for delineation purposes.

Appendix F - Using an Engineer or Architect Scale to Calculate Distances on a Plan

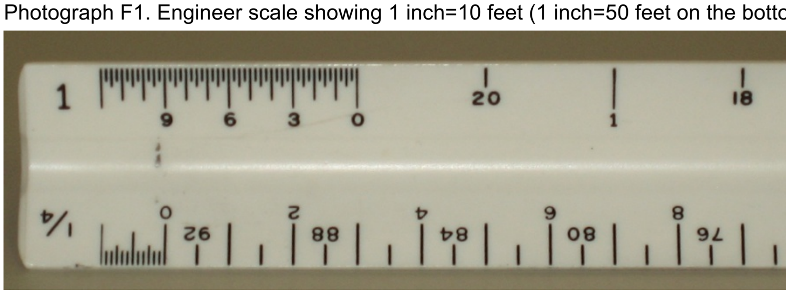
Engineered plans are drawings that provide a two-dimensional representation of a project drawn to scale. Scaled plans convert the dimensional information about a project into smaller measurements on paper, allowing for a rendering of a project at a manageable size. Scaled plans allow for a more accurate and precise rendering than conceptual plans that are not drawn to scale. The plan reviewer can use a tool, called a scale, to measure the objects on the plan to determine the actual size of the project. The word "scale" thus refers both to the size reduction of the drawing and the tool used for measuring the objects.

Engineer scales, such as 1"=10' or 1"=50', are used for measuring roads, water mains, buildings, and topographical features. The distance relationships also may be shown as 1:10 or 1:50. Conversely, architect scales, such as 1/4"=1' (1/48 size) or 1/8"=1' (1/96 size), are used for more detailed architectural plans. Both scales are read as a ratio of measurement on the drawing to measurement on the ground (e.g., 1:10 means 1 inch on the drawing is equal to 10 feet on the ground).

Engineer scales have numbers that run incrementally from *left to right.* Architect scales have numbers that run incrementally both from *left to right* and from *right to left* (see Photographs F1 and F2 below). On an engineer scale, the whole number value that is identified must be multiplied by 10 to get the actual length on the ground; the small lines between the whole numbers represent individual feet. On an architect scale, the whole number value that is identified *is* the length on the ground. The architect scales (and some engineer scales) show small lines "below" the "0," which provide fractions (inches) of the whole number (feet).



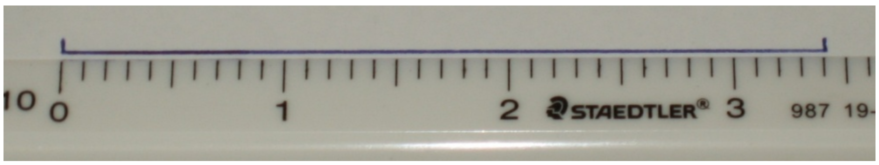
Photograph F1. Engineer scale showing 1 inch=10 feet (1 inch=50 feet on the bottom).



Photograph F2. Architect scale showing 1 inch=1 foot (1/4 inch=1 foot on the bottom).

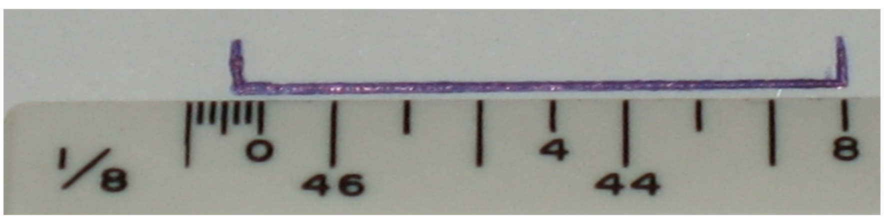
To properly use the scale:

1) Identify the scale shown on the plans (e.g., 1/8 inch=1 foot; 1:40; etc.).
2) Select the object you wish to measure and select the appropriate *architect* or *engineer* scale tool.
3) Align your scale tool with the selected scale shown on the plan (usually on the bottom) to verify they match.
4) Align the "0" on your scale tool with one end of the object to be measured as a starting point (see Figure F3).
5) If using an architect scale tool, the number measured represents the object's length; if using an engineer scale, you must multiply the number by 10.



Photograph F3. Using an engineer scale. Where a plan indicates the scale is 1"=10', this line measures 34 feet using the engineer scale (the line measured 3.4 and 3.4x10= 34 feet).

6) If the object's end point does not align exactly with a corresponding foot mark, you can use an architect scale (and some engineer scales) to take your reading from the other end where the fractional marks (smaller lines) below the "0" will provide you with length in inches (see Photograph F4).



Photograph F4. Using an architect scale. To find the length of this line on a plan at a scale of 1/8"=1', you first find the 1/8-inch scale on your architect scale tool (represented by the number 1/8 on the upper left corner of the scale tool) and place the "0" where you would like to start measuring. Say the endpoint of your measurement aligns at a value just beyond "8" on the scale. You must line the "8" up with your endpoint and then look below the "0" to see what fractional value (smaller lines) your start point corresponds with. On the 1/8-inch scale, there are 6 small lines per large line (i.e., 6 lines per foot), and therefore each small line is equivalent to 2 inches. Therefore, if the measured distance aligns with the second line below the "0" (representing 4 inches), then the entire measured dimension would be 8' 4."

Appendix G - References

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Matthew A. Beaton, Secretary

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Martin Suuberg, Commissioner

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