FINAL REPORT
JUNE 2011




Dr. Bottero Road Chapin Beach Access Ramp Alternatives Analysis

Town of Dennis, MA

June 30, 2011

Prepared for:

Town of Dennis
Department of Natural Resources, Shellfish, and Conservation

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1.0 Introduction

The on-going “end effect” scour at the western end of the armor stone revetment protecting Dr. Bottero Road is a long-term concern and currently requires substantial routine maintenance in the form of regular small-scale sand nourishment to protect the roadbed from undermining. The current undermining of the revetment terminus indicates structural instability and it does not appear that the small-scale sand nourishment placed in this area provides enhanced protection during significant storms. To assure long-term shore protection of the roadway, a reassessment of the existing coastal armoring, as well as an evaluation of alternatives that would provide long-term shore protection for this region was jointly conducted by the Louis Berger Group, Inc. located in Needham and Applied Coastal Research and Engineering, Inc. located in Mashpee. This report expands upon limited shoreline change rate information provided in the Final Waterways Assets and Resource Survey Master Plan for Dredging and Beach Nourishment (2010) as the basis for shore protection design recommendations. Alternatives to enhance protection will include:

- Continuation of existing practices (i.e. repair and nourish, as needed);
- Extension of the existing revetment to the west;
- Beach nourishment;
- Beach nourishment enhanced by adjustable structures (e.g. timber groins); and
- Relocate Roadway to a More Landward Position.

Figure 1: Dr. Bottero Road Aerial View

The alternatives assessment was based primarily on available data for the site (e.g. shoreline change maps, aerial photographs, coastal processes information, etc.) with limited GPS survey work. To support the analyses and cost estimating, schematic designs were prepared. The schematic design drawings depict structures in both plan form and cross section. The locations, depths, and typical profiles of beach nourishment options are also provided. The plans depict and roughly quantify likely impacts to Resource Areas. The following report describes the basis of the designs and a discussion of the feasibility of construction, a conceptual cost estimate for further design, permitting, construction, and maintenance.

Observations of the Off-Road Vehicle (ORV) access ramp to Chapin Beach suggest it likely cannot be maintained in its present position, since the seaward extent of the dune has migrated landward of the existing paved ramp. As a result, the ramp necessary to provide access to the beach requires reconstruction each spring to allow vehicular access to the shoreline west of the existing beach parking lot. To address this issue, a schematic design for a managed retreat for the access ramp was developed along with a description of the basis of the design, feasibility of construction, and a conceptual cost opinion for further design, permitting, construction, and maintenance.

Figure 2: Chapin Beach Aerial View

A comprehensive beach management plan is beyond the scope of the present effort; however, should be considered by the Town in the future to maintain and/or enhance the valuable community assets, as well as the ecological conditions, of the beach, dune, and salt marsh resource.

2.0 Alternatives Development

Prior to eliminating alternatives from further consideration, it is important to develop a more formal screening process to describe the benefits and disadvantages associated with the full range of available alternatives. This process ensures that the most appropriate shore protection options are carried forward to the next design phase. The primary emphasis of the shore protection selection process is screening, where the process identifies the most appropriate alternative(s) based upon a series of exclusionary and discretionary criteria. There are no numerical thresholds that identify the best alternative; rather, the screening process is designed to assess a wide range of potential shore protection options and through comparative analysis, narrow the list of options until only the most appropriate remain. Appropriate is defined as those alternatives that best meet the "federal" Least Environmentally Damaging Practicable Alternative (LEDPA) standard, that are permittable under federal and state environmental regulations and which can be considered cost-effective. An overview of the screening process for alternatives is shown in Figure 3.

Screening criteria are characterized as either exclusionary or discretionary. Exclusionary criteria reflect potential available shore protection measures that are not technically feasible or are prohibited by state/federal regulations. For example, if the western terminus of the revetment protecting Dr. Bottero Road was located within an Area of Critical Environmental Concern (ACEC) that dictates shore protection measures can have no adverse impacts under state law, this exclusionary criterion for potential structural options would eliminate further evaluation of structural options. Based on the series of options evaluated below, no alternatives were categorically eliminated based upon exclusionary criteria.

Discretionary criteria are those that determine, when applied as a group, the shore protection alternatives that are least or best suited for the site. For example, the potential impacts to dune and beach resource areas are evaluated under discretionary criteria. The presence of such resource areas potentially impacted by an alternative would not automatically exclude the shore protection option from further consideration, but would identify that option as less desirable than one in which such resource areas were not adversely impacted or impacted to a lesser degree. The application of discretionary criteria is the main component of the screening process, and it is the process by which the shore protection alternatives are compared amongst themselves, using site-specific information to prioritize alternatives.

Potential alternatives are then reviewed using the discretionary criteria and assigned a relative ranking. Alternatives that have significant limitations receive low marks; alternatives with fewer limitations receive higher marks. Some examples of potential impacts that would receive low marks include:

- filling of salt marsh that provides essential fish habitat and shore bird foraging;
- direct and long-term adverse effects on benthic communities that may be associated with placement of shore protection structures or fill;
- reducing the sediment supply to downdrift beaches by armoring a portion of the eroding coastal dune system; or
- exacerbating nearshore scour due to wave reflection from coastal engineering structures.

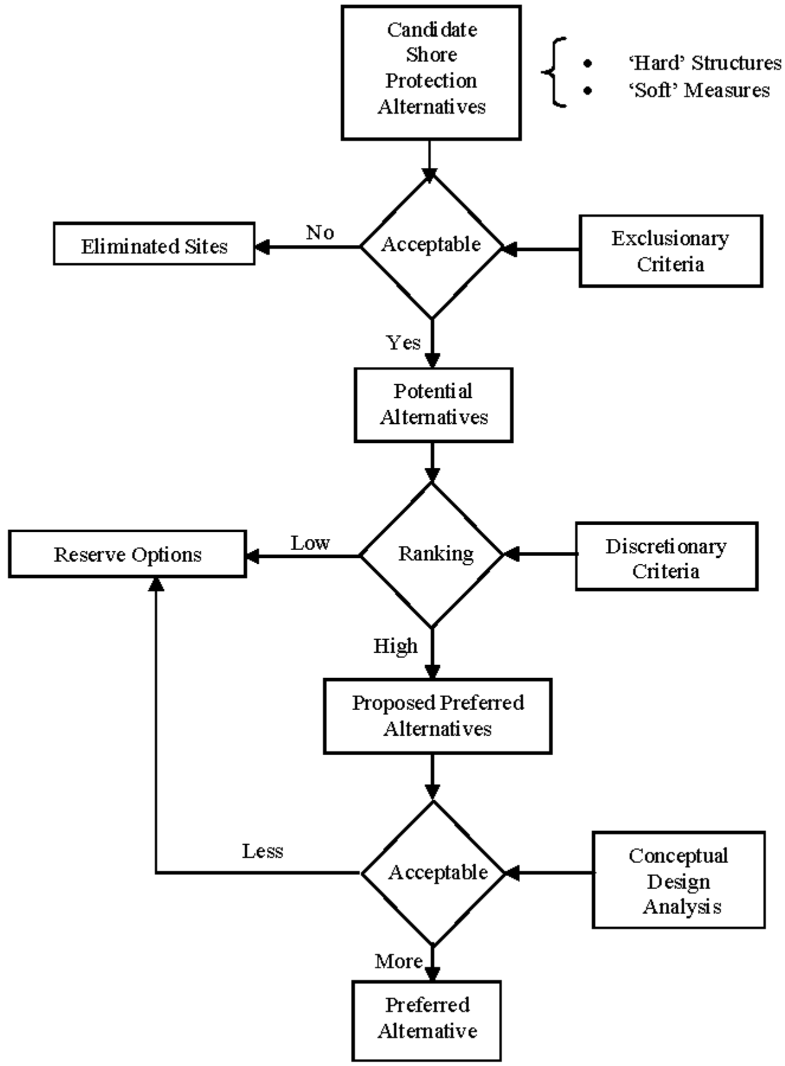

Figure 3: Screening Process Flowchart for Shore Protection Alternatives

Appropriate structural and non-structural alternatives were then examined and tested against the discretionary criteria. The following lists the alternatives that potentially could be utilized for shoreline stabilization at the revetment terminus on Dr. Bottero Road and provides a brief summary of available information. It should be noted that the regulatory constraints are similar for each shore protection alternative, where non-structural measures alone likely could be readily permitted. However, due to the open-Bay exposure of this shoreline, it may be cost-prohibitive and logistically problematic to construct and maintain 'soft' shore protection solutions at this site. For the 'hard' shore protection measures evaluated, the addition of mitigation strategies has been included to minimize potential adverse impacts to adjacent resource areas.

As envisioned, each of the alternatives would require similar require review and approval under various regulatory programs including:

- Environmental Notification Form (EOEA MEPA Unit);

- MESA conservation permit (MA Natural Heritage and Endangered Species Program);
- Order of Conditions (Dennis Conservation Commission);
- Section 404 Individual Permit (Army Corps of Engineers);
- Water Quality Certification-Section 401 (DEP-Wetlands and Waterways Program); and
- Chapter 91 License (DEP-Waterways Program)

The alternatives would likely exceed filing thresholds for state-listed species and alteration to wetland resource areas under the Massachusetts Environmental Policy Act (MEPA). An Environmental Notification From (ENF) is required for alteration of designated significant habitat. The beach and dune within the project area is coastal area is mapped as Estimated Habitat for piping plovers (Charadrius melodus). In addition, the alteration of coastal dune, barrier beach, or coastal bank requires the filing of an ENF. Other project triggers may include the extension of an existing unlicensed non-water dependent use of waterways or tidelands (provided that a Chapter 91 License is required) and construction, reconstruction or expansion of an existing solid fill structure within flowed tidelands.

The Natural Heritage and Endangered Species Program may comment on and approve a proposed project with conditions following a formal Information Request and Massachusetts Endangered Species Act (MESA) Project Review. If during the review it is determined that a project will result in a "take" of a state-listed species, the project would require a Conservation and Management Permit. To be eligible for a Conservation & Management Permit, the applicant must first (1) assess alternatives to both temporary and permanent impacts to state-listed species. Thus, certain projects that can be redesigned to avoid a "Take" may not be eligible for a Conservation & Management Permit. The Permit applicant must also (2) demonstrate that a proposed project will impact an insignificant portion of the local population of an affected state-listed species. Finally, the applicant must (3) design and implement a conservation and management plan that provides a long-term net benefit to the conservation of the affected state-listed species in the form of permanent habitat protection, management/restoration of state-listed species habitat or conservation research.

The Dennis Conservation Commission (WPA issuing authority) would have the discretion of approving the work without the need for a DEP issued variance. In the unlikely event that the issuing authorities deem a variance would be necessary, this would trigger an Environmental Impact Report (EIR) filing with waiver request.

It is anticipated that the US Army Corps of Engineers will request an Individual Permit application based on the sensitivity of the work zone, relatively large area of work below the High Tide Line, and the Corps' interest in providing additional opportunities for public comment.

Water Quality Certification under Section 401 is typically not required for tidal projects which avoid impacts to salt marsh. In addition, beach nourishment activities with a Final Order of Conditions under the Wetlands Protection Act are not required to file. However, projects requiring an individual 404 permit DEP may invoke discretionary authority to require an application for an individual water quality certification.

Any work below the Mean High Tide line will trigger DEP review under the Chapter 91

Waterways Program. Extending the existing revetment would require a modification to the existing license, assuming a valid one is in place.

3.0 Alternatives Evaluation

3.1 No-Action (Continuation of Existing Practices)

- erosion protection – poor, especially if the littoral system remains sediment starved
- potential environmental impacts – insignificant
- emergency maintenance beach fill required to protect the roadway-anticipated to increase in both cost and frequency

As a management tool, it is instructive to evaluate the 'no-action alternative to assess whether proactive shoreline management activities are necessary from both a short-term and long-term perspective. Based upon the historical shoreline change assessment, it is evident that the entire shoreline west of the Dr. Bottero Road revetment is experiencing significant erosion since 1994 (Figures 4, 5, and 6). As coastal erosion continues, primarily due to lack of sediment supply, the dune system extending to the west will continue to recede landward. Visual inspection of the dune system indicates overall stability; however, there are regions of extensive dune overwash, especially near the inlet of Chase Garden Creek marsh. To fully understand the ramifications of the no-action alternative, a quantitative analysis of recent historical shoreline change was performed.

Rates of change in high-water shoreline position for the time periods 1994 to 2001, 1994 to 2011, and 2001 to 2011 were evaluated along the northern end of Chapin Beach in Dennis. The 1994 and 2001 shoreline positions were visually interpreted from orthophotographs available to download from the MassGIS database website. The 2011 shoreline survey was conducted using a differential Global Positioning System (GPS). The location of the GPS shoreline was determined visually from morphologic features present on the beach and/or from a debris line when available.

The high-water shoreline position change rates were calculated in the Automated Shoreline Analysis Program (ArcASAP) that is run as an extension in ArcGIS. This program requires a user-defined spatial interval (50 ft was used for this study) and the general shoreline orientation to determine the amount of shoreline advance or retreat for the time interval. ArcASAP performs the shoreline change calculations by casting normal transects from the earlier shoreline to the later shoreline at each analysis point specified along the input shoreline. The data output is a table of shoreline change magnitudes and rates for each transect where shoreline change denoted with a minus sign represents erosion.

All shoreline position data contain inherent errors associated with field and office compilation procedures. The potential measurement and analysis uncertainty between the data sets is additive when shoreline positions are compared. Because the individual uncertainties are considered to represent standard deviations, a root-mean-square (RMS) method was used to estimate the combined potential uncertainties in the data sets. The positional uncertainty estimates for each shoreline were calculated using the information in Table 1. These calculations estimated the total RMS uncertainty to be ±20.0 ft or ±2.8 ft/year for 1994 to 2001, ±20.0 ft or ±1.2 ft/year for 1994 to 2011 and ±20.0 ft or ±2.0 ft/year for 2001 to 2011.

Table 2 shows maximum, minimum, and average change rates for all three time intervals. During the 17 year time period, shoreline change rates ranged from -0.3 to -11.1 ft/year. These highest and lowest change rates both occurred during the 1994 to 2001 time period. The rates of shoreline change during the other time intervals were only slightly lower and the averages for each interval were very similar and ranged from -4.5 to -4.7 ft/year. All change rate values for this stretch of beach were negative. The highest erosion rates occurred 300 feet southwest of the ORV access ramp during the 1994 to 2001 time interval and northeast of the access ramp approximately 600 feet southwest of the end of the revetment fronting Dr. Bottero Road from 1994 to 2011 and 2001 to 2011. The lowest change rates for the entire time period were found in front of this revetment, as this structure prohibits natural landward migration of the shoreline.

The constant negative change rates show that the northern end of Chapin Beach has been consistently eroding from 1994 to 2011. The average change values for each time interval indicate that the rate of erosion has been fairly steady for the entire time period. Erosion is most likely related to the anthropogenic features located on this stretch of shoreline. The revetment and groin located at the northwestern end of the beach have probably had the largest effect on shoreline change rates. The armor stone revetment has been able to successfully protect the roadway; however, the revetment and groin have limited the natural transport of sand to the southwest. The sand trapped on the up-drift side of the groin has exacerbated sediment starvation on Chapin Beach and led to the constant erosion of the shoreline.

Table 1: Estimates of Potential Error Associated with Shoreline Position Surveys

Traditional Engineering Field Surveys	
Position of rodded points Location of plane table Interpretation of high-water shoreline position at rodded points Error due to sketching between rodded points	±3 ft ±7 to 10 ft ±10 to 13 ft up to ±16 ft
Cartographic Errors	Map Scale 1:10,000
Inaccurate location of control points on map relative to true field location Placement of shoreline on map Line width representing shoreline Digitizer error Operator error	Up to ±10 ft ±16 ft ±10 ft ±3 ft ±3 ft
Historical Aerial Surveys	Map Scale 1:10,000
Delineating high-water shoreline position	±16 ft
Orthophotography (1994, 2001)	
Delineating high-water shoreline position Position of measured points	±10 ft ±10 ft
GPS Surveys (2011)	
Delineating high-water shoreline position Position of measured points	±3 to ±10 ft ±3 to ±10 ft

Table 2: Shoreline Change Rates for Chapin Beach

	Maximum Erosion Rates (ft/year)	Minimum Erosion Rates (ft/year)	Average (ft/year)
April 1994 to April 2001	-11.1	-0.3	-4.5
April 1994 to May 2011	-8.0	-0.5	-4.6
April 2001 to May 2011	-10.7	-0.5	-4.7

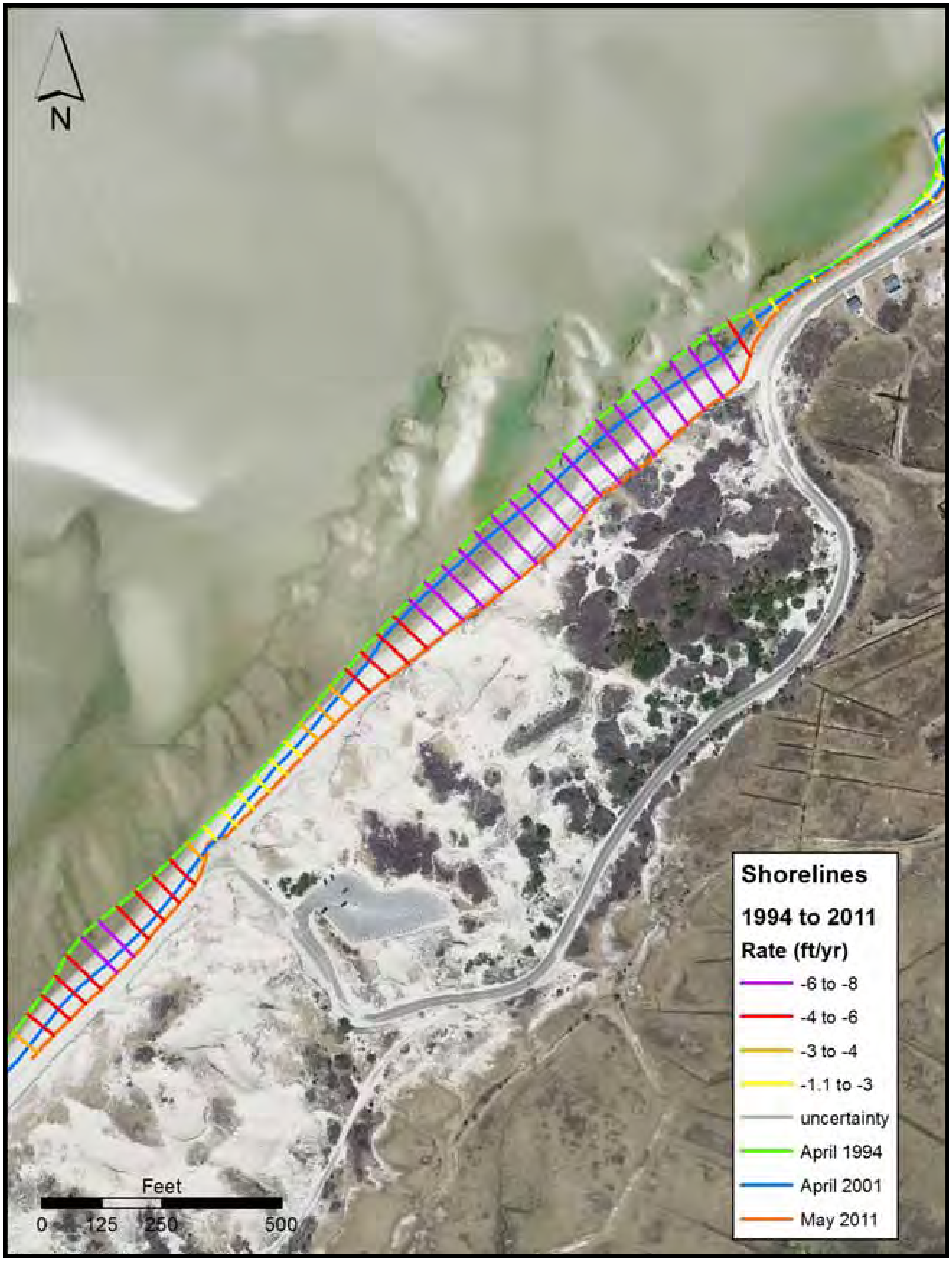

Figure 4: Shoreline Change Plot for the 1994 to 2011 Time Period

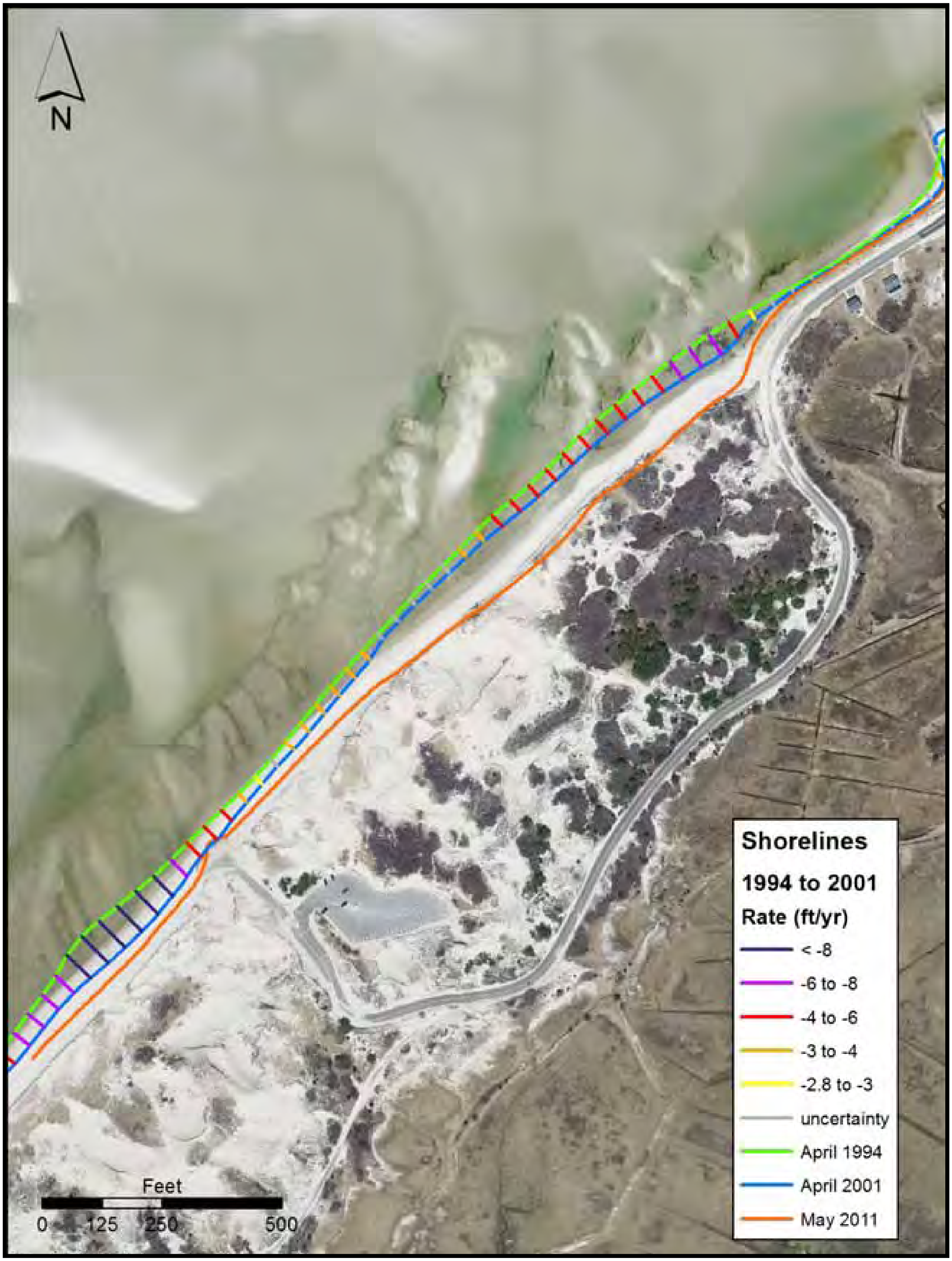

Figure 5: Shoreline Change Plot for the 1994 to 2001 Time Period

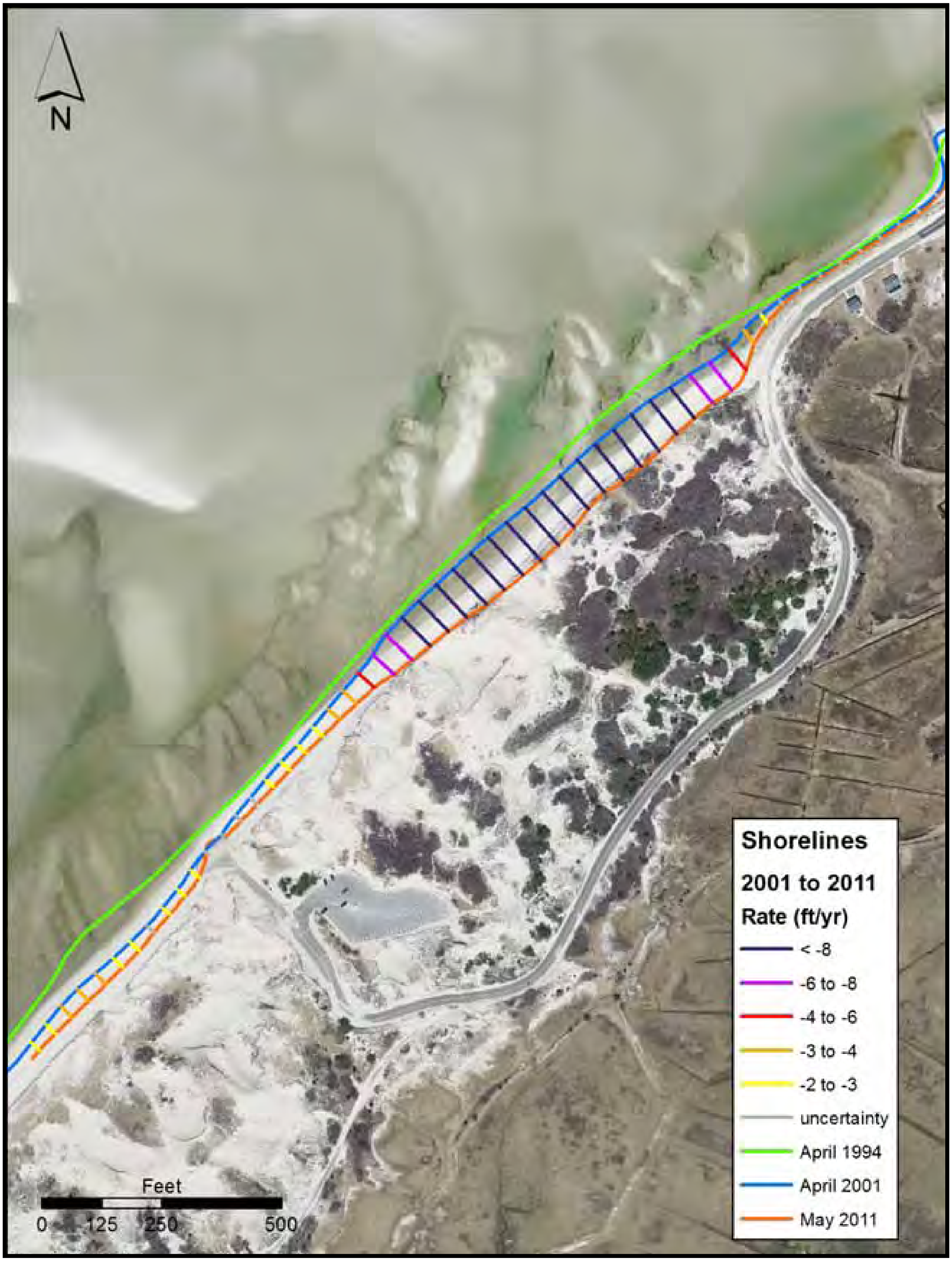

Figure 6: Shoreline Change Plot for the 2001 to 2011 Time Period

For the no-action alternative, coastal erosion can be expected to continue at its present rate. This will likely have significant consequences to the roadway leading to the beach parking lot, ORV access to the beach, and the Aquiculture Research Corporation. As the long-term littoral sediment deficit continues, the shoreline will continue to migrate landward at critical locations requiring additional shore protection. Specifically, the western terminus of the revetment fronting Dr. Bottero Road has been undermined during recent winter storms. At the ongoing erosion rate of approximately 6.5 feet per year (Figure 4), additional emergency fill will not be able to maintain the roadway beyond the next 1-3 years. To illustrate the anticipated erosion effects in this region (shown in Figure 7), the existing beach transects, labeled A and B, are shown in Figures 8 and 9, along with projected future shoreline locations. Within 5 years, the shoreline location for Transect B will be in the roadway. With only the existing practice of placing emergency fill following storms, the roadway cannot be maintained; therefore, the ‘no action’ alternative was considered unacceptable.

Figure 7: Location of Beach Transects Measured at the West End of the Dr. Bottero Road Revetment

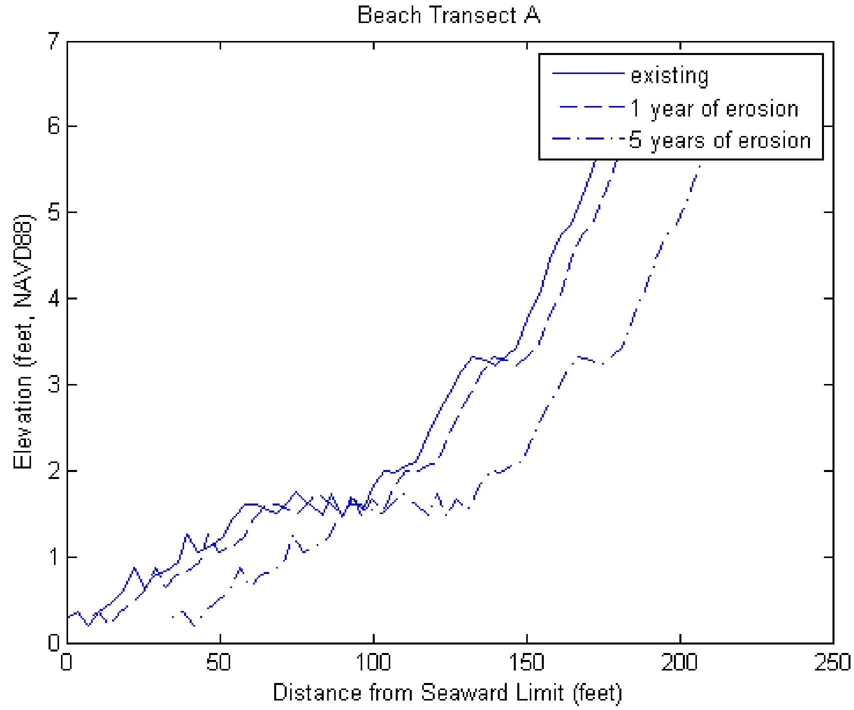

Figure 8: Beach Transect A for Existing Conditions, as well as Anticipated Positions after 1 Year and 5 Years of Ongoing Erosion

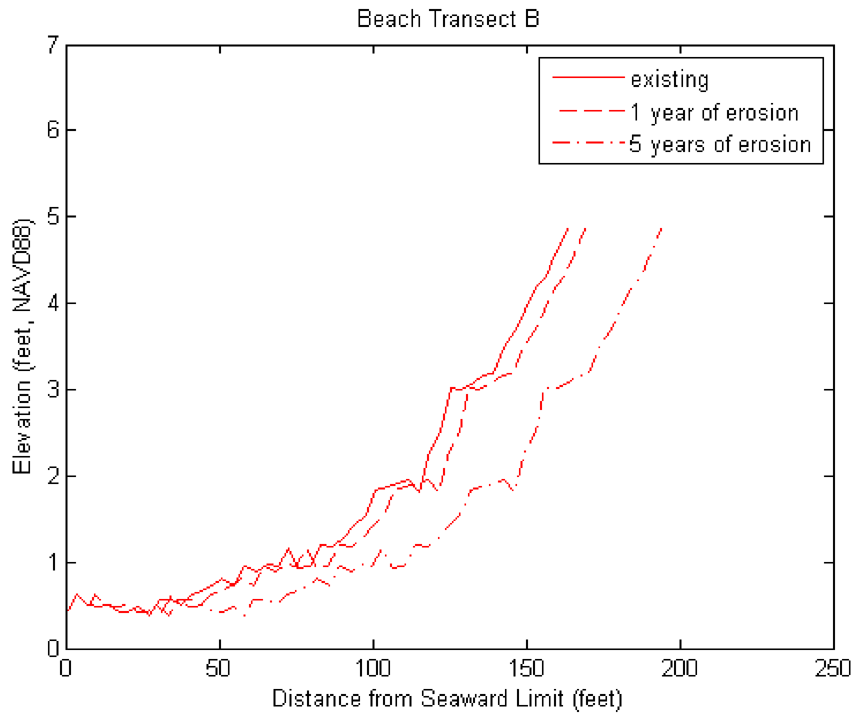

Figure 9: Beach Transect B for Existing Conditions, as well as Anticipated Positions after 1 Year and 5 Years of Ongoing Erosion

3.2 Relocate Roadway to a More Landward Position

- erosion protection – limited due to the narrow dune system at the location of the coastal erosion problem along Dr. Bottero Road
- potential environmental impacts – substantial due to placement of the roadway on existing coastal dunes; however, re-establishment of dune system landward of the relocated roadway could potentially mitigate for a portion of the impacts
- due to the high regional coastal erosion rates, this alternative does not provide a lasting solution to the long-term erosion problem

One potential option for addressing on-going coastal erosion for the threatened portion of Dr. Bottero Road is to re-position the roadway to a more landward location. The furthest extent of this roadway re-positioning, based on maintaining the road within the existing upland (i.e. coastal dune resource areas), is shown in Figures 10A and 10B.

In Figure 10A, the proposed road has been shifted approximately 50 feet east from where the road is presently situated. Approximately 440 feet of road would be realigned under this alternative. Design standards specific to the Town of Dennis Engineering Department were researched and used in creating a conceptual layout of the road relocation alternative. The proposed road has a radius of curvature of 375 feet while the minimum required by the Town is 150 feet. The minimum road right-of-way defined by the Town is 40 feet. Therefore, an easement of land would be required to be purchased from the property at 53 Dr. Bottero Road. Furthermore, the vertical alignment of the road is proposed to be consistent with the existing vertical alignment to allow smooth transitions around the curve.

To achieve the road relocation, excavation of the existing coastal dune would need to occur to allow for the existing vertical grades of the road. The abandoned road would be removed and disposed of and filled with sand and beach grass to create a dune restoration. The roadway realignment is estimated to impact approximately 9,950 square feet of vegetated coastal dune (barrier beach).

As a result of shifting the road, several utilities would be impacted. Approximately 4 overhead utility poles would be impacted as a result of the realignment and would need to be adjusted from their present condition. Coordination with the electric utility would be required to adjust the utility poles. In addition, the water service line that runs along the shoulder of the existing road would need to be relocated and a new line and water meter installed along the right-of-way of the new road. Preliminary construction costs associated with the construction of the road relocation can be seen in Appendix A.

Landward re-location of the roadway is a managed retreat strategy that is often utilized if the solution will yield long-term sustainability and/or reduced environmental impacts. The local erosion rate of between 6.5 and 7.0 feet per year indicates that the re-located roadway could become unstable within 8 to 10 years. In this case, due to the types of resource areas impacted, as well as the limited longevity, it does not appear to be a viable option.

3.3 Revetment Extension

- erosion protection – good, if the beach elevation fronting the structure is maintained with periodic beach nourishment
- potential environmental impacts – substantial both during construction and in the long-term
- constructability is straight-forward with the appropriate heavy equipment to excavate the affected dune/beach area and place the armor units
- limited maintenance required of hard structure
- protection of upland beach and dune resources with associated beach nourishment

As illustrated by the shoreline change analysis, landward migration of the beach system at the western terminus of the existing structure has accelerated during the most recent time period (2001-2011). Due to the landward curvature of the roadway, extension of the revetment would allow continued protection of the roadway as the dune system recedes. This shore protection alternative generally would extend landward from the coast and only armor the existing roadway constructed within the dune system. In this manner, the overall armored shoreline length relative to the sediment supply is minimized.

From a regulatory perspective, ‘hard’ methods of shore protection typically are not allowed within coastal dune resource areas. This prohibition is intended to allow natural migration of the dune features that are critical to the long-term stability of a barrier beach system. In the case of Dr. Bottero Road., the dune system to the east has been completely armored by a combination of armor stone revetments and groins. This portion of the coastal system no longer functions as a dune due to the combination of shoreline armoring and the paved roadway. Therefore, extension of the revetment in a landward direction will not alter the shoreline extent of the ‘hard’ armoring. However, this alternative alone will not mitigate for the reduced coastal sediment supply created by the coastal armoring in place to the east.

Extension of the revetment by approximately 160 feet along the seaward edge of the roadway will extend the life of the coastal road system by approximately 20 years, based on an annual dune recession rate of 6.5 to 7.0 ft/yr. Due to the state regulatory constraints, this alternative will likely be difficult to permit and/or require a substantial commitment to ongoing mitigation, including sacrificial beach nourishment. Based on typical annual erosion rates, the annual volume is estimated to be approximately 300 cubic yards of beach nourishment. A schematic representation of the revetment extension is shown in Figures 11A and 11B. The revetment extension would result in approximately 1,780 square feet of impact to coastal beach and 2,080 square feet of impact to coastal dune (both within barrier beach system).

To construct the revetment extension, excavation of existing coastal dune would need to occur. Approximately 3,500 cubic yards of coastal dune would need to be excavated, removed, and disposed. The areas excavated would be graded towards the ocean with the least amount of slope possible to allow for dissipation of the wave energies occurring in this area. Anticipated construction costs associated with this alternative are shown in Appendix A.

3.4 Beach Nourishment

- erosion protection – marginal, due to the lack of updrift sediment source to re-supply the beach system
- potential environmental impacts – limited, assuming the volume required does not cover nearshore salt marsh resources approximately 200 feet offshore
- constructability is straight-forward; however, the volume required to create a lasting project would likely need an offshore or estuarine source that could be pumped to the site by a hydraulic dredge and may be prohibitively expensive
- depending on the size of the project, frequent (annual) re-nourishment may be required

Due to the open-Bay exposure of the site and the associated erosion rates in excess of 6.5 feet per year since 1994, beach nourishment alone is likely not a viable solution. To effectively establish a stand-alone nourishment project, a relatively large volume of material would be required in the region updrift (east), as well as fronting, the unstable roadway area. Impacts to nearshore salt marsh areas can be anticipated from a nourishment program of this magnitude, especially in the area immediately offshore of the western terminus of the existing revetment, where salt marsh resources are less than 200 feet of the high water line. Due to an order of magnitude increase in project costs, this alternative was dismissed from further consideration.

3.5 Beach Nourishment with Adjustable Groins

- erosion protection – good, with enhancement of beach fill with groins to maintain beach width fronting the roadway
- potential environmental impacts – substantial if mitigation nourishment does not maintain the groin field to ensure that each cell is filled to entrapment
- maintenance nourishment likely will be required once every year to minimize potential downdrift impacts

To extend the design-life of a potential nourishment project, adjustable timber groins could be placed to maintain a high tide beach fronting the western portion of the existing unstable revetment. Once nourishment within the groin 'cells' has been established, on-going nourishment will be required to prevent downdrift impacts. Annual fill likely would be required to keep the groin field filled to entrapment. Based on typical annual erosion rates, this volume is estimated to be approximately 300 cubic yards of beach nourishment.

Similar to the environmental permitting constraints for the revetment extension, 'hard' engineering methods are strongly discouraged in coastal dunes. In this case, the purpose of the adjustable groin would be to mitigate for the influence of the existing 'end effect' at the western terminus of the existing revetment. This solution would maintain nourishment to downdrift shorelines and not require 'hard' shoreline protection along the seaward face of the roadway west of the existing structure. The beach nourishment with adjustable groins would result in approximately 14,500 square feet of impact to coastal beach. A schematic representation of the revetment extension is shown in Figures 12A and 12B. Costs associated with the construction of this alternative can be seen in Appendix A. In addition, Figures 13 and 14 show examples of timber groins similar to the type proposed, where horizontal lagging can be removed as necessary to allow by-passing of sediment to downdrift beaches.

Figure 13: Example of Timber Groin, where Height cannot be Adjusted

Figure 14: Example of Timber Groin, where Lagging can be Readily Removed or Added to Adjust Height

4.0 Chapin Beach Access Ramp

As shown in Figure 6, recent shoreline change in the vicinity of the Off-Road Vehicle (ORV) ramp is slightly lower than the rate of dune recession for neighboring portions of the shoreline. However, this short-term reduction in the local erosion rate relative to the 1994 to 2001 time period (Figure 5) is likely a result of sediment trapping updrift (to the east) of the armor stone fronting the ORV ramp. As coastal erosion continues in this area, the armor stone fronting the ORV ramp will become ineffective as ongoing coastal erosion 'flanks'. Based on the relatively high regional shoreline recession rates, the best short-term management plan for maintaining the ORV ramp is a strategy of managed retreat. This strategy involves periodic reconstruction of the armor fronting the ramp at a landward location.

A shore-perpendicular transect was surveyed at the ORV ramp to evaluate potential options relative to existing elevations and slopes. The location of this transect is shown in Figure 15, where the position of the observed 2011 high water line is also illustrated. The recent shoreline position indicates that the existing armoring is causing a perturbation in the shoreline and may be causing accelerated beach/dune erosion to the west. In addition, the surveyed transect (Figure 16) indicates that the existing dune height at the location of the ramp is only slightly greater than the 100-year flood zone elevation. To maintain the dune integrity, the roadway elevation should be maintained at this height as the coastal features migrate landward.

The conceptual plan for managed retreat is shown in Figures 17A, 17B, 17C, and 17D, where the existing armor is moved to a landward position that re-establishes a 'straight' shoreline with the adjacent beach areas (shown by the dashed line). Repositioning of the armor stone to protect the eastern portion of the ramp is also recommended to maintain the ramp during moderate northeast storm events. In addition to shifting of the armor stone and the ramp access to the beach, the Town should consider removal of the seaward portion of pavement and possibly providing an access path to the beach at the eastern terminus of the armoring.

Regulatory permitting for the managed retreat of the access ramp is envisioned to be substantially less complex than the work at Dr. Bottero Road. The footprint of the alteration to Coastal Dune would be relatively small and would not require any work below the Mean Tide Line or require additional revetment stone. An ENF may still be required for alteration of designated significant habitat and alteration of coastal dune, barrier beach, or coastal bank. Following consultation with NHESP, it is unlikely a formal Conservation and Management Permit will be required. An Order of Conditions from the Dennis Conservation Commission is the only additional permit envisioned for this work to proceed.

Figure 15: Location of Beach Transect Measured at the ORV Ramp Leading to Chapin Beach

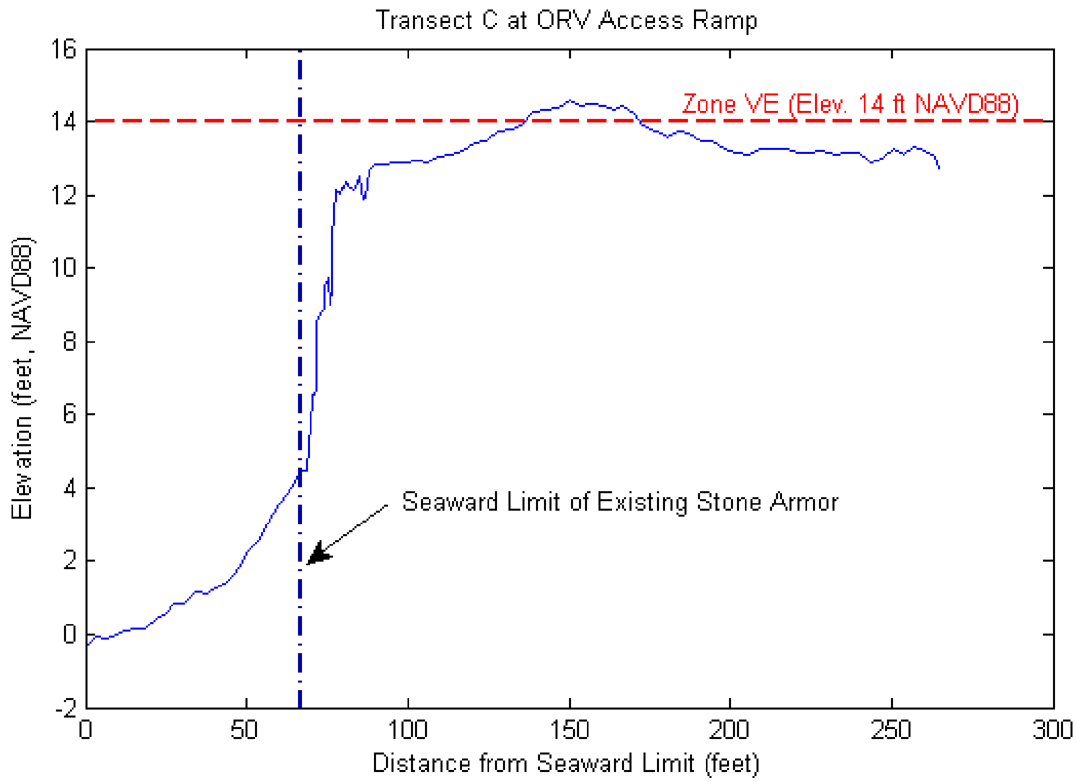

Figure 16: Beach Transect C for Existing Conditions, Showing the Seaward Limit of the Existing Armor Stone Protecting the ORV Ramp, as well as the Predicted 100-year Flood Zone Elevation

APPENDIX A

Preliminary Opinion of Construction Cost
Dr. Bottero Road Realignment

Item	Unit	Quantity	Unit Price	Price
Excavation	CY	2,225	$15.00	$33,375
Hauling	LCY	2,780	$9.25	$25,715
Clearing and Grubbing	LS	1	$7,500.00	$7,500
Waterline R&D	LF	470	$11.00	$5,170
2-Inch Watermain	LF	450	$60.00	$27,000
2-Inch Gate Valve	EA	2	$1,500.00	$3,000
Sawcut	DAY	1	$1,500.00	$1,500
Pavement R&D	SY	1,160	$9.00	$10,440
12-Inch Crushed Stone Subbase	CY	350	$40.00	$14,000
Proposed Asphalt Road	SY	1,075	$70.00	$75,250
Overhead Utility Relocation	LS	1	$50,000.00	$50,000
Dune Restoration	SF	5,525	$5.50	$30,388
Snow Fence	LF	825	$4.50	$3,713
Erosion/Sedimentation Control	LS	1	$7,500.00	$7,500
Subtotal				***$294,550***
Mobilization (10%)				$29,455
Bonds/Insurance (2.5%)				$7,364
Engineering/Design/Survey				$28,500
Permitting				$55,000
Contingency (30%)				$88,365
Total=				**$503,234**

**Note: Costs Associated with Required Easements are Excluded from Estimate*

Preliminary Opinion of Construction Cost
Dr. Bottero Road Revetment Extension

Item	Unit	Quantity	Unit Price	Price
Excavation	CY	3,575	$7.25	$25,919
Hauling	LCY	4,195	$9.25	$38,804
Clearing and Grubbing	LS	1	$800.00	$800
Fill	CY	220	$25.00	$5,500
Revetment Extension	LF	160	$1,500.00	$240,000
Erosion/Sedimentation Control	LS	1	$7,500.00	$7,500
Beach Nourishment (Initial)	CY	750	$30.00	$22,500
Dune Restoration	SF	1,600	$5.50	$8,800
Subtotal				***$349,823***
Mobilization (10%)				$34,982
Bonds/Insurance (2.5%)				$8,746
Engineering/Design/Survey				$25,000
Permitting				$55,000
Contingency (30%)				$104,947
Construction Total=				**$578,497**
Annual Maintenance Nourishment	CY	300	$30.00	**$9,000**

Preliminary Opinion of Construction Cost
Beach Nourishment with Adjustable Timber Groin

Item	Unit	Quantity	Unit Price	Price
Beach Nourishment (Initial)	CY	3600	$30.00	$108,000
Grading	DAY	2	$6,500.00	$13,000
Timber Piles (25' Length Per Pile)	LF	1050	$36.00	$37,800
Wooden Lagging (Materials and Installation)	LS	1	$35,000.00	$35,000
Erosion/Sedimentation Control	LS	1	$3,000.00	$3,000
Subtotal				***$196,800***
Mobilization (10%)				$19,680
Bonds/Insurance (2.5%)				$4,920
Engineering/Design/Survey				$20,000
Permitting				$55,000
Contingency (30%)				$59,040
Total=				**$355,440**
Annual Maintenance Nourishment	CY	300	$30.00	**$9,000**

Preliminary Opinion of Construction Cost
ORV Access Ramp Rehabilitation

Item	Unit	Quantity	Unit Price	Price
R&D Pavement	SY	85	$9.00	$765
Excavation	CY	985	$7.25	$7,141
Stone Revetment Repositioning	DAY	5	$6,500.00	$32,500
Beach Nourishment (Initial)	CY	110	$30.00	$3,300
Hauling	LCY	1,095	$9.25	$10,129
Erosion/Sedimentation Control	LS	1	$3,000.00	$3,000
Dune Restoration	SF	1,500	$5.50	$8,250
Walkway (Path)	LS	1	$1,500.00	$1,500
Subtotal				***$66,585***
Mobilization (10%)				$6,659
Bonds/Insurance (2.5%)				$1,665
Engineering/Design/Survey				$8,500
Permitting				$17,500
Contingency (30%)				$19,976
Total=				**$120,884**