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Little Creek Naval Amphibious Base Chesapeake Bay Shoreline

C. Scott Hardaway Jr.
Virginia Institute of Marine Science

Donna A. Milligan
Virginia Institute of Marine Science

George R. Thomas
Virginia Institute of Marine Science

Linda M. Meneghini
Virginia Institute of Marine Science

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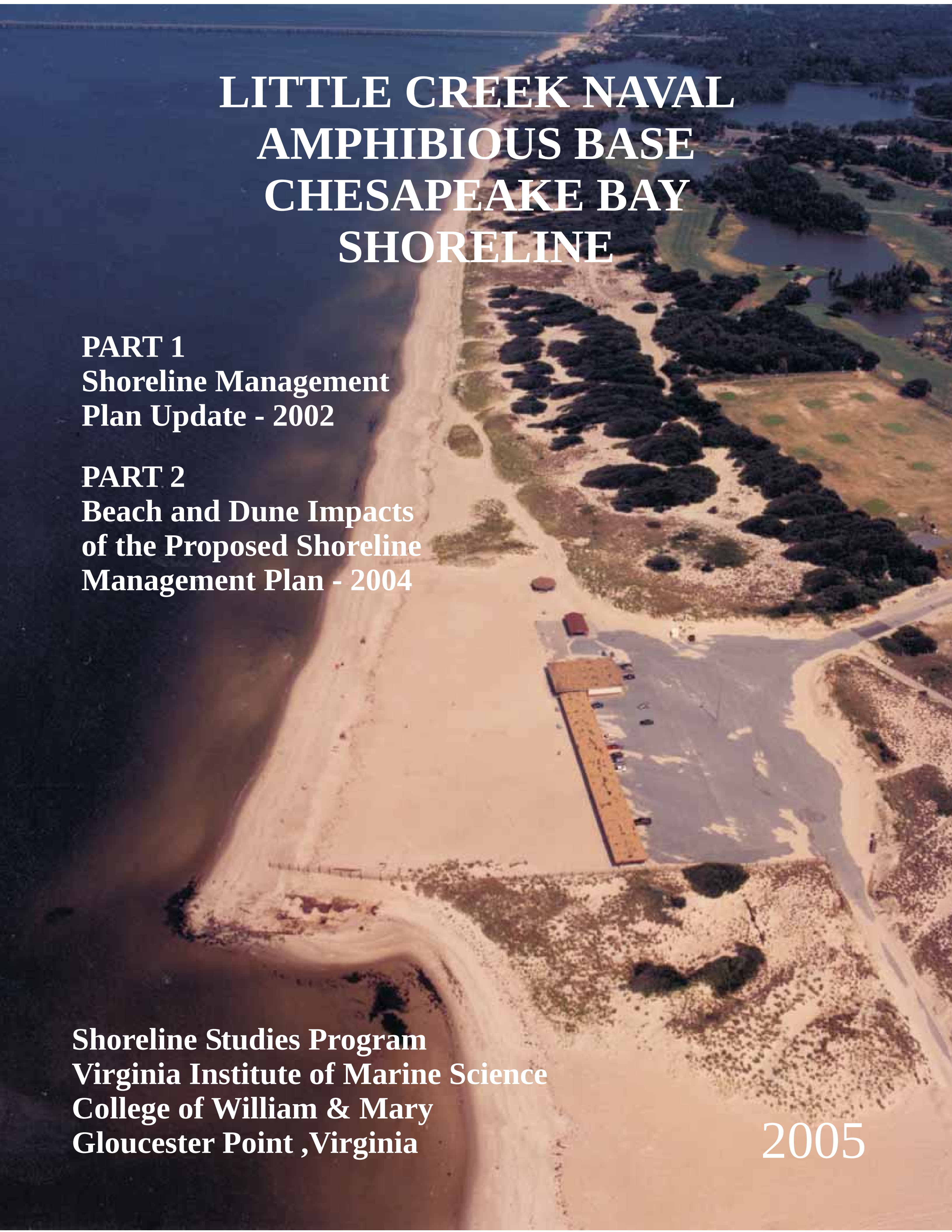

LITTLE CREEK NAVAL AMPHIBIOUS BASE CHESAPEAKE BAY SHORELINE

PART 1
Shoreline Management Plan Update - 2002

PART 2
Beach and Dune Impacts of the Proposed Shoreline Management Plan - 2004

Shoreline Studies Program
Virginia Institute of Marine Science
College of William & Mary
Gloucester Point ,Virginia

2005

LITTLE CREEK NAVAL AMPHIBIOUS BASE
CHESAPEAKE BAY SHORELINE

Shoreline Management Plan Update - 2002

By

C. Scott Hardaway, Jr.
Donna A. Milligan
George R. Thomas
Linda M. Meneghini

For

U.S. Army Corps of Engineers
Norfolk District
Norfolk, Virginia

&

U.S. Navy
Little Creek NAB

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I. Introduction

A. Purpose

Little Creek Naval Amphibious Base (NAB) is located in Virginia Beach, Virginia. It's shoreline along the southern Chesapeake Bay extends from Little Creek Inlet eastward approximately 1.5 miles to the NAB's eastern boundary. In 1997, a study and report entitled "LITTLE CREEK NAVAL AMPHIBIOUS BASE, CHESAPEAKE BAY SHORELINE, SHORELINE MANAGEMENT PLAN and OFFICER'S BEACH SHORE PROTECTION EVALUATION" was produced by VIMS's Shoreline Studies Program (Hardaway *et al.*, 1997). The purpose of that report was to assess the rates and patterns of beach change along the Chesapeake Bay shoreline at Little Creek NAB in order to develop a shoreline management plan, particularly for the Officer's Beach ("O" Beach). Field surveys, historical aerial imagery, empirical models and computer models were used to address these objectives. Plan recommendations resulted in the construction of a headland breakwater system and revetments at the "O" Beach as well as a series of proposed breakwaters along the length of the Little Creek NAB coast.

The purposes of the current effort is to update the Hardaway *et al.* (1997) study and to determine if additional management strategies should be implemented. Elements of the previous report will be presented to provide a background perspective and to bring the reader up-to-date. Generally, the shoreline subreach just west of the "O" Beach has continued to erode from the existing revetment westward toward the Enlisted Beach ("E" Beach). This trend was prevalent prior to 1997 and was predicted to continue in the previous study. The question is how long will this trend continue and what impact will it have on the Base's shoreline, particularly the Bay-fronting primary dune system which is eroding along much of the coast? In addition, this study should determine the net impacts of the breakwater installation at the "O" Beach and it will provide a framework for the next step in the shore management of the reach.

B. Background

The Little Creek NAB shoreline resides in a larger reach of shore that extends from Cape Henry westward to Willoughby Spit (Figure 1). Specifically, Little Creek NAB lies within a discreet subreach that is bounded by Lynnhaven Inlet on the east and Little Creek Inlet and its associated jetties on the west. Impacts to this reach include the creation and maintenance of Little Creek Inlet, maintenance dredging of Lynnhaven, periodic beach nourishment within the subreach from material related to dredging of both inlets, and the installation of groins and breakwaters on the Bay shoreline of Little Creek NAB.

At the "O" Beach, breakwaters and revetments were installed in 1998 (Figure 2). These structures were designed to maintain a beach at the "O" Beach yet allow some transport in their lee and along the outer boundary. This is often a difficult practice, and potential impacts to the immediate downdrift coast were expected.

II. Original Plan Summary

A. Coastal Setting

Wind data analysis for resultant wave conditions showed that the onshore wave climate along the southern shore of the Chesapeake Bay is characterized by low to medium wave energy; the waves are directed from the northern sector often at an angle of approximately 10° to 30° to the coast. Thirty years of wind data (1960-1990) at Norfolk International Airport (Table 1) showed that, for those components impacting the Little Creek NAB shore, the northerly and northeasterly directions are dominant. This analysis did not account for swell or shelf-originating wind waves that impact NAB (Hardaway *et al.*, 1997).

The mean tide range at Little Creek NAB is 2.7 feet with a spring tide range of 3.2 feet. Tidal currents acting along the southern shorelines of Chesapeake Bay were evaluated by Ludwick (1987), Das (1974), and Fleischer *et al*. (1977). Each study indicates that sediment transport along the nearshore region, including the area off Little Creek, is influenced by tidal currents. Fleischer *et al*. (1977) concluded that current velocities and bottom sediment erosion and transport tend to increase, from Little Creek westward toward Willoughby Spit, as the current floods. Ebb flow tends to spread out as it leaves Hampton Roads thus losing velocity and competence. Therefore, along the Little Creek shoreline, flooding mean tidal currents add a slightly westward component to the overall littoral drift system.

The historical occurrence of storm-related high water levels was determined by the U.S. Army Corps of Engineers as they have listed the annual maximum elevation of water surface each year since 1928 for a gage at Fort Norfolk (U.S. Army Corps of Engineers, 1983). The estimated 10 year, 20 year, and 50 year storm water elevation at MSL are 5.7 ft, 6.5 ft, and 7.5 ft, respectively. Boon *et al.* (1978) statistically determined storm surge frequency for both extratropical and tropical storm events. From their report, it was determined that in the Hampton Roads area, the storm surge levels above MSL for 10 year, 25 year, 50 year and 100 year events are 4.5 ft, 4.8 ft, 5.5 ft, and 6.1 ft, respectively. An obvious discrepancy exists between the two data sources due to differences in their calculation methods. In reality, true storm surges probably lie somewhere between the two data sources but neither can be discounted in any calculations for which storm surge is used.

B. Physical Setting Summary

The physical setting of Little Creek shoreline has been influenced by a variety of man-made activities that, along with an active wave climate and consequent littoral processes, have made significant impacts on shore change. The net direction of littoral, or sand transport, in the subreach, is to the west with a minor reversal just west of Lynnhaven Inlet. Maintenance dredging of Lynnhaven Inlet has occurred over the years, along with the occasional placement of sandy dredge material along the Ocean Park shoreline where it is subsequently transported westward and offshore. These dredge deposits have undoubtably worked their way toward the Base shoreline as part of the overall littoral transport system. The Little Creek channel, jetties, and groins have all acted to modify the natural littoral processes which has brought the shore morphology to its present state where significant erosion occurs along the eastern third of Little Creek's shoreline.

Table 1. Summary wind conditions at Norfolk International Airport from 1960-1990.

		WIND DIRECTION								
Wind Speed (mph)	**Mid Range (mph)**	**South**	**South west**	**West**	**North west**	**North**	**North east**	**East**	**South east**	**Total**
< 5	3	5497* 2.12+	3316 1.28	2156 0.83	1221 0.47	35748 13.78	2050 0.79	3611 1.39	2995 1.15	56594 21.81
5-11	8	21083 8.13	15229 5.87	9260 3.57	6432 2.48	11019 4.25	13139 5.06	9957 3.84	9195 3.54	95314 36.74
11-21	16	14790 5.70	17834 6.87	10966 4.23	8404 3.24	21816 8.41	16736 6.45	5720 2.20	4306 1.66	100572 38.77
21-31	26	594 0.23	994 0.38	896 0.35	751 0.29	1941 0.75	1103 0.43	148 0.06	60 0.02	6487 2.5
31-41	36	25 0.01	73 0.03	46 0.02	25 0.01	162 0.06	101 0.04	10 0.00	8 0.00	450 0.17
41-51	46	0 0.00	0 0.00	0 0.00	1 0.00	4 0.00	4 0.00	1 0.00	0 0.00	10 0.00
Total		41989 16.19	37446 14.43	23324 8.99	16834 6.49	70690 27.25	33133 12.77	19447 7.50	16564 6.38	259427 100.00

*Number of occurrences +Percent

In their study of the Little Creek shoreline, Byrne and Anderson (1978) found an historical (1852-1949) erosion rate of -4.4 ft/yr for the shoreline between Little Creek Inlet and the Chesapeake Bay Bridge Tunnel. For the region just east of Little Creek Inlet's east jetty they recorded an accretion rate of 1.2 ft/yr, which along with the previously described shore section, created an overall rate of change for the shore of -2.2 ft/yr. Later data compiled in the 1997 study showed that the rates of change were highly variable particularly in response to anthropogenic change (Figure 3 and Figure 4). Historically, net change was generally between -2 and -5 ft/yr until beach fill was placed along the shore in 1975. This resulted in a large positive change in shoreline rates, but subsequent years showed larger negative rates of change as the fill adjusted along the shore. Between 1985 and 1994, the overall rate of shore recession steadily decreased. However, today, as in 1997, the severest erosion occurs along 2,000 ft of shoreline west of the "O" Beach. For more detailed information on historic rates of change, see Hardaway *et al.* (1997).

C. Shoreline Management Strategies

Four basic approaches to shoreline management were discussed in Hardaway *et al.*, (1997): 1) No action; 2) Defend an erosional area with defensive structures such as bulkheads, seawalls or revetments; 3) Maintain and/or enhance existing shore zone features such as beach and dunes which presently offer limited protection; or 4) Create a shore zone system of beaches and dunes, using headland control with stone breakwaters.

In general, headland control was the recommended strategy in the original management plan. Most often headlands are created with large breakwaters. Headland control is a concept that allows long stretches of shoreline to be addressed in a more cost/effective way. It is either accomplished by accentuating existing features or by creating permanent headlands that will allow adjacent, relatively wide embayments to become stable. The headland approach can greatly reduce the cost of managing the shoreline reach by reducing the linear feet of structure necessary and by increasing the residency of associated beach nourishment. However, shore change between headlands will continue and may be accentuated as the shore planform adjusts toward dynamic equilibrium.

The shoreline management plan was developed with input from the Navy and was the first step in addressing beach stability to provide for long-term shoreline protection and recreation, while maintaining an environment suitable for military training (Figure 5). By utilizing the geomorphic shore planforms that have evolved through time, the Plan proposed headland control through enhancement of the existing groin features with stone breakwaters and the addition of structures at strategic points. A "leaky" system was proposed to minimize downdrift impacts. This would be accomplished with the use of low profile breakwaters that will allow sand to attach at a reduced elevation so that limited transport could occur. They were also broad in order to attenuate wave energy during storms. Finally, the plan called for the attachment of spurs to several groins in place of construction of some breakwaters, along with groin and revetment rehabilitation at the "O" Beach.

D. Plan Summary

The shoreline at Little Creek NAB has been retreating, for the most part, since at least 1852. To reduce sand movement into Little Creek's dredged channel, Inlet jetties were built in the late 1920s. In order to combat erosion, four groins were constructed in the early 1970s. These groins segmented the shoreline and, in some areas, served to at least reduce erosion for a time. In other areas, particularly at the "E" Beach, sand was trapped updrift of this groin, while the downdrift shoreline retreated as it adjusted toward a new equilibrium. In 1994, a stone revetment was built just west of the "O" Beach in order to address erosion along that section of shore.

Integration of results from an analysis of historical shoreline trends, wave climate analysis, shoreline change modeling, and the Navy's long- and short-term goals resulted in the development of a Shoreline Management Plan for the Little Creek NAB (Hardaway *et al.*, 1997). This plan intended to enhance the existing groins with spur breakwaters and provide two separate structures between the "O" and "E" beaches which would provide headland control along the whole length of the Base's shore.

In 1998, shore structures 5 and 6 (breakwater/spur) and 8 and 9 (revetments) were installed (Figure 5). The update of the shore management plan was developed in coordination with the U. S. Army Corps of Engineers (Norfolk District), the Navy, and VIMS in order to assess shore change since 1998 and to determine whether additional coastal structures were needed to maintain the shoreline.

III. Approach and Methodology for Plan Update

A. Limits of the Study Area

The shore reach between Lynnhaven and Little Creek Inlets was the main focus of the study performed in 1997 (Hardaway *et al.*, 1997). However, to better understand the processes occurring in the study area, the overall study area was extended to include the shore from Cape Henry to Little Creek Inlet (Figure 1). This shore management plan update includes Little Creek's Chesapeake Bay shoreline with focus on the reach between the "O" Beach and the "E" Beach.

B. Data Preparation and Surveys

Field survey data, historical aerial photos, and computer modeling were used to address the aforementioned report objectives. Historic and recent aerial images also were evaluated to map changes in shoreline position. Profile data was taken at locations set in the original plan (Figure 6). However, because of erosion at the site, many of the profiles had to be reset farther inland. The locations in 1996 and 2002 are listed in Table 2. The 1996 profiles were corrected to the 2002 benchmarks, and the two sets of data were plotted in cross-section to show shoreline change.

For the update report, data developed in the original plan were used as input to computer models. In Hardaway *et al.* (1997), the hydrodynamic forces existing along the NAB beaches were evaluated using RCPWAVE, a computer model developed by the US Army Corps of Engineers (Ebersole *et al*., 1986). RCPWAVE is a linear wave propagation model designed for engineering applications. This model computes changes in wave characteristics that result naturally from refraction, shoaling, and diffraction over complex shoreface topography. To this fundamental linear theory based model, oceanographers at VIMS added routines which estimate wave energy dissipation due to bottom friction in the bottom boundary layer (Wright *et al.*, 1987).

These wave data were input to GENESIS, a computer model used in the analysis of shoreline change (Hanson and Kraus, 1989 and Gravens *et al*., 1991). The GENESIS runs utilized the original calibration and verification data. The initial input shoreline was the same as that used in the original modeling effort, 9 August 1996. Additional GENESIS modeling scenarios were run based on the construction of breakwaters at the "O" Beach. All coefficients and parameters remained the same; only structure length and locations varied from the original GENESIS runs to the newer runs. For more information on all data, see Hardaway *et al.* (1997).

Table 2. Location of Little Creek profiles and control benchmark positions. Horizontal coordinates are in Virginia State Grid (South), NAD 83, feet. Vertical elevations are relative to NOS MLW in feet.

	1996			2002		
Name	**Northing**	**Easting**	**Elevation**	**Northing**	**Easting**	**Elevation**
NAB1	3,503,861	12,173,113	17.57	SAME		
NAB2	3,504,036	12,172,410	25.57			
NAB11	3,504,867	12,168,183	15.43			
NAB12	3,504,882	12,167,563	22.14			
VB	3,505,187	12,167,039	13.51	3,505,184	12,167,019	15.76
A4	3,505,147	12,167,708	8.99	3,505,092	12,167,690	15.96
A	3,505,020	12,168,072	16.75	3,505,027	12,168,067	11.98
AP	-	-	-	3,504,900	12,168,527	18.22
A3	3,504,879	12,168,977	9.01	3,504,820	12,168,959	16.04
A2	3,504,781	12,169,517	8.91	3,504,712	12,169,516	18.26
A1	3,504,705	12,169,977	8.81	3,504,623	12,169,960	17.02
E1	3,504,502	12,170,620	8.70	3,504,439	12,170,597	14.21
E2	3,504,321	12,171,248	8.80	3,504,262	12,171,237	17.72
E3	3,504,191	12,171,674	8.76	3,504,133	12,171,645	15.67
E	3,504,218	12,172,326	17.41	3,504,216	12,172,325	18.49
BW	3,504,206	12,172,364	8.25	3,504,193	12,172,381	7.16
F2	3,504,154	12,172,527	6.23*	3,504,128	12,172,515	6.16*
F1	3,504,115	12,172,650	5.58*	3,504,084	12,172,617	6.29*
E4	3,504,073	12,172,783	6.88	3,504,057	12,172,760	9.80
D2	3,504,061	12,172,888	8.33	3,504,041	12,172,861	16.09
D1	3,503,735	12,173,537	9.05	3,503,679	12,173,509	25.69

* Temporary Benchmarks

IV. Results

A. Profiles

The beach profile comparisons are shown in Figures 7A-7Q. Comparison of shoreline position from field surveys shows continued erosion along most of the coast between "E" Beach and the Base's east boundary. In particular, the subreach from Point A (Profile A1) to the "O" Beach revetment has areas eroding at greater than 10 ft/yr.

The morphologic shoreline trends between "E" Beach and Point A show accretion just east of Groin #4 (Profile VB, Figure 7A), no change at Profile A4 (Figure 7B), slight erosion at A (Figure 7C) and progressively increasing erosion toward Point A which itself (Profile A1, Figure 7G) is eroding at -10.5 ft/yr. The high erosion rates continue to E1 (Figure 7H), decrease to -1.7 ft/yr at E2 (Figure 7I), then increase again to -5 ft/yr at E3 (Figure 7J) which is adjacent to the revetment. The result is that the subtle cape feature, prominent in 1997 and before, is being sheared off as the shore reach responds to the "E" Beach and "O" Beach Headlands. The question now is how long and how far will this erosional pattern continue?

At the "O" Beach, the shore is continuing to adjust to the installation of the breakwaters as sand accretes at F2 (Figure 7M) and erodes at F1 (Figure 7N). What was once a relatively straight beach, has a formed into an embayment. Once the beach is in dynamic equilibrium, little shore change should occur. In an analysis of the reach on the western end of NAB, which extends from the "E" Beach to Little Creek Inlet and its associated jetties, it was determined that little has changed in the same time period judging from recent and historic trends and a qualitative comparison of low-level vertical aerial photography taken in 1997 and 2002.

B. Shore Modeling

Results of GENESIS and Tombolos runs performed in 1997 generally predict the current trend of the westward offset adjacent to "O" Beach. Model Tombolos over-predicted the rate probably because of the limiting boundaries placed on that analysis. It was emphasized by Hardaway *et al.* (1997) that this trend would have to be addressed in the future and proposed at that time measures to be phased in when needed (Figure 5). These measures included adding structures 3 and 4 and possibly structure 2 to further the process of segmenting the coast with strategically placed headland breakwaters to bring it into more dynamic equilibrium. Beach nourishment was also a part of this scheme.

GENESIS was run for several proposed scenarios that would address the changes taking place at Little Creek's shore in response to the installation of the breakwaters at the "O" Beach. Figure 8 shows the final run that indicated the best shore conditions as well as the final result from the original management plan. The structures show predicted shore planform adjustments that bring the coast into dynamic equilibrium. This assumes a continued input of littoral material from the east.

C. Management Plan Update

The suggested structures for the updated Shoreline Management Plan are shown in Figure 9. These are the result of the profiling and modeling effort performed for this report. The updated plan calls for the addition of structures #10 and #11 which are 200 ft breakwater units. The addition of structure #2 should also be considered but is not presently a priority because the existing groin is preforming as a major headland feature.

V. Discussion and Recommendations

The recent patterns of shoreline change (1996 to 2002) are mostly erosive between the "E" and "O" beaches. This may be due to a number of factors. These include, but are not limited to, more restricted alongshore sediment movement, severe storm attack including the 1998 Twin Northeasters and hurricanes Dennis and Floyd in 1999, and a lag in the time it takes beach fill from Ocean Park to reach the shores of Little Creek NAB. The latter factor is very difficult to ascertain, but we feel ongoing but intermittent dredging and subsequent disposal from Lynnhaven Inlet to Ocean Park is a positive factor in the long-term sediment budget of the larger reach.

In order to address the shoreline recession along Little Creek NAB, we are recommending the installation of 4 headland breakwaters generally coincident to the 1997 scheme. Adjustments to the shore morphology will occur as a result. The shore planform will evolve as the beach sands accumulate on the east side of each headland and recede on the west side toward a state of dynamic equilibrium. This will be most prominent on newly positioned breakwaters 3 and 4. The addition of beach fill to the project will be essential to minimizing the impact. Structures #10 and #11 should be further evaluated for siting as a result of the installation of breakwaters 3 and 4.

The proposed rock structures are an initial phase that will require ongoing monitoring as the shoreline adjusts toward dynamic equilibrium. Beach surveying will provide the data necessary to assess the shore changes resulting from structure installation as well as provide a basis for the phasing in of additional structures.

VI. References

Boon, J. D., C. S. Welch, H. S. Chen, R. J. Lukens, C. S. Fang, and J. M. Zeigler, 1978. A Storm Surge Model Study: Volume I. Storm Surge Height-Frequency Analysis and Model Prediction for Chesapeake Bay. Special Report No. 189 in Applied Marine Science and Ocean Engineering, Virginia Institute of Marine Science, College of William and Mary, Gloucester Point, Virginia, 155 pp.

Byrne, R. J. and G. L. Anderson, 1978. Shoreline Erosion in Tidewater Virginia. SRAMSOE Number 111. Virginia Institute of Marine Science, College of William and Mary, Gloucester Point, Virginia, 102 pp.

Das, M. M., 1974. Beach Erosion Study - Little Creak Naval Amphibious Base, Virginia. Technical Report TR-248, Department of the Navy, Naval Oceanographic Office, Washington, D.C., 69 pp.

Ebersole, B. A., M. A. Cialone, and M. D. Prater, 1986. RCPWAVE - A Linear Wave Propagation Model for Engineering Use. U.S. Army Corps of Engineers Report, CERC-86-4, 260 pp.

Fleischer P., G. J. McRee, and J. J. Brady, 1977. Beach Dynamics and Erosion Control, Ocean View Section, Norfolk, Virginia. Technical Report No. 50, Institute of Oceanography, Old Dominion University, Norfolk, Virginia, 185 pp.

Gravens, M. B., N. C. Kraus, and H. Hanson, 1991. GENESIS: Generalized Model for Simulating Shoreline Change, Report 2. Technical Report, CERC-89-19, Department of the Army, U.S. Army Corps of Engineers, Washington, D.C., 345 pp. + app.

Hanson, H., and N. C. Kraus, 1989. GENESIS: Generalized Model for Simulating Shoreline Change. Technical Report, CERC-89-19. Coastal Engineering Research Center, Waterways Experiment Station, U.S. Army Corps of Engineers, Vicksburg, Mississippi, 185 pp. + app.

Hardaway, C. S., Jr., D. A. Milligan, J. P.-Y Maa, and G. R. Thomas, 1997. Little Creek Naval Amphibious Base Chesapeake Bay Shoreline, Shoreline Management Plan and Officer's Beach Shore Protection Evaluation. Technical Report, Virginia Institute of Marine Science, College of William & Mary, Gloucester Point, Virginia.

Ludwick, J. C., 1987. Mechanics of Sand Loss from an Estuarine Groin System Following an Artificial Sand Fill. Department of Oceanography Technical Report 87-2, Old Dominion University, Norfolk, Virginia, 89 pp.

Wright, L. D., C. S. Kim, C. S. Hardaway, Jr., S. M. Kimball, and M. O. Green, 1987. Shoreface and Beach Dynamics of the Coastal Region from Cape Henry to False Cape, Virginia. Technical Report, Virginia Institute of Marine Science, College of William and Mary, Gloucester Point, Virginia.

U.S. Army Corps of Engineers, 1983. Willoughby Spit and vicinity, Norfolk, Virginia, Hurricane Protection and Beach Erosion Control Study. Feasibility Report and Final Impact Statement, Parts 1 and 2, Supporting Documentation.

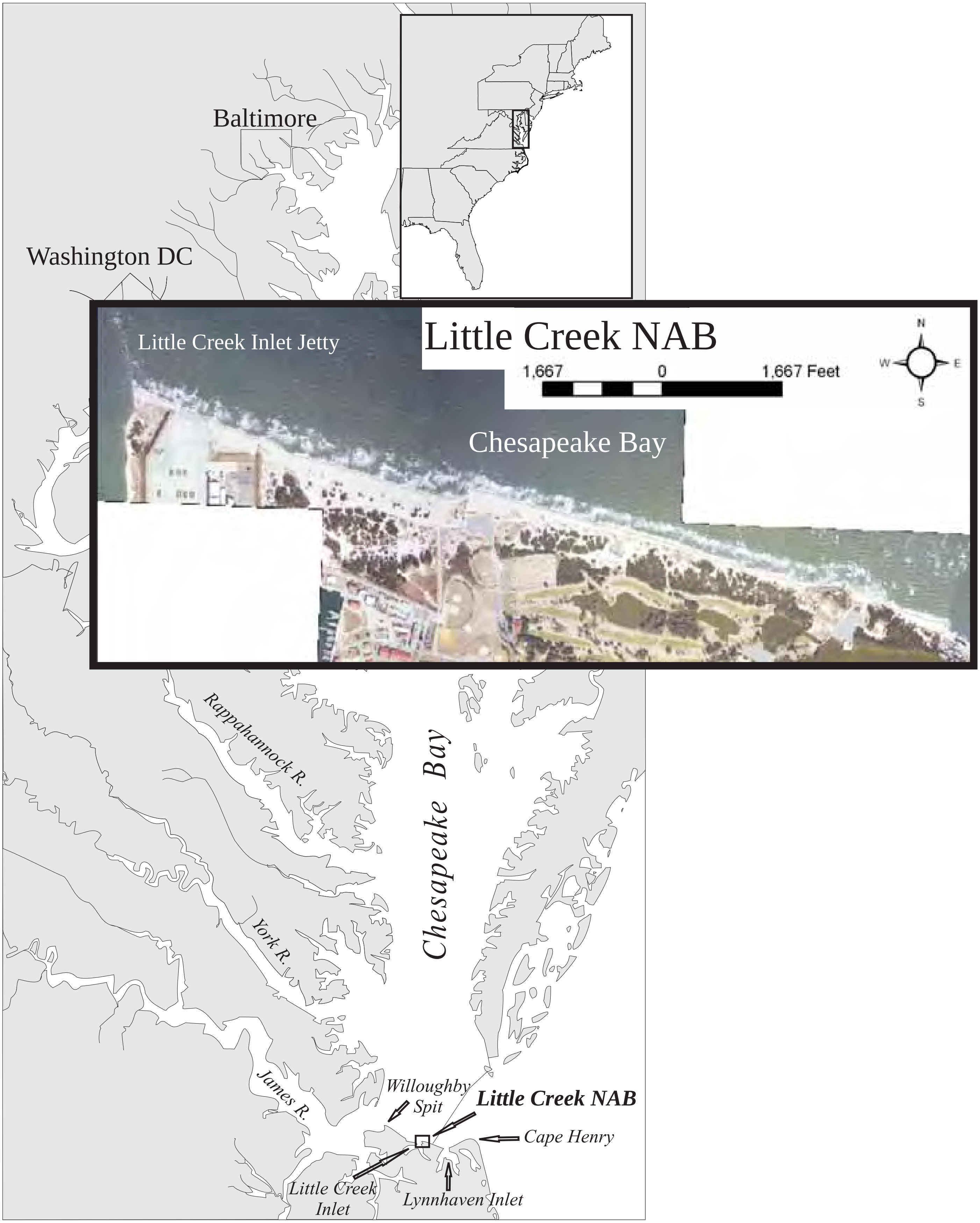


Figure 1. Study site location with 2002 aerial imagery showing Little Creek NAB's shoreline. Shoreline aerial imagery copyrighted 2002 Commonwealth of Virginia.

Figure 2. Aerial photo showing the breakwater project at the Officer's Beach and the entire Little Creek shore (photo date 12 June 2002).

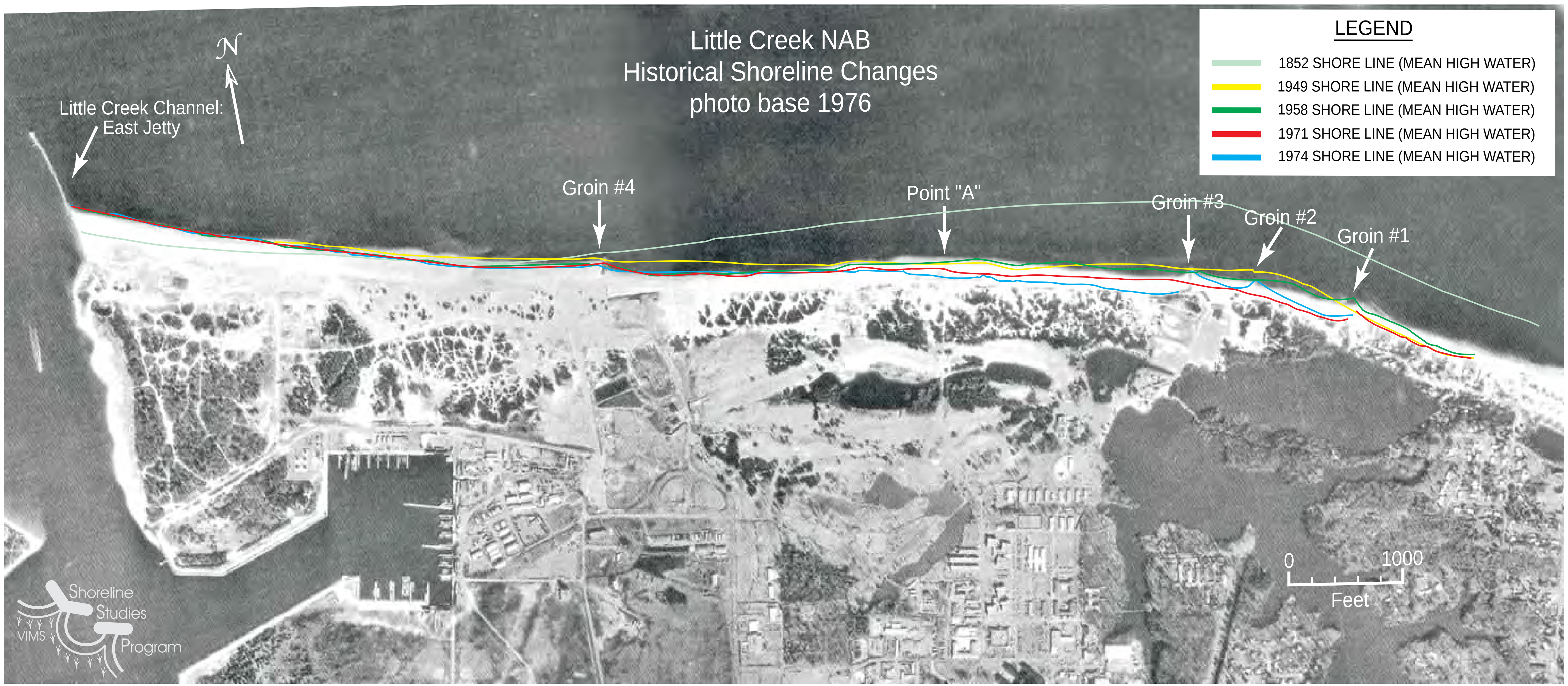
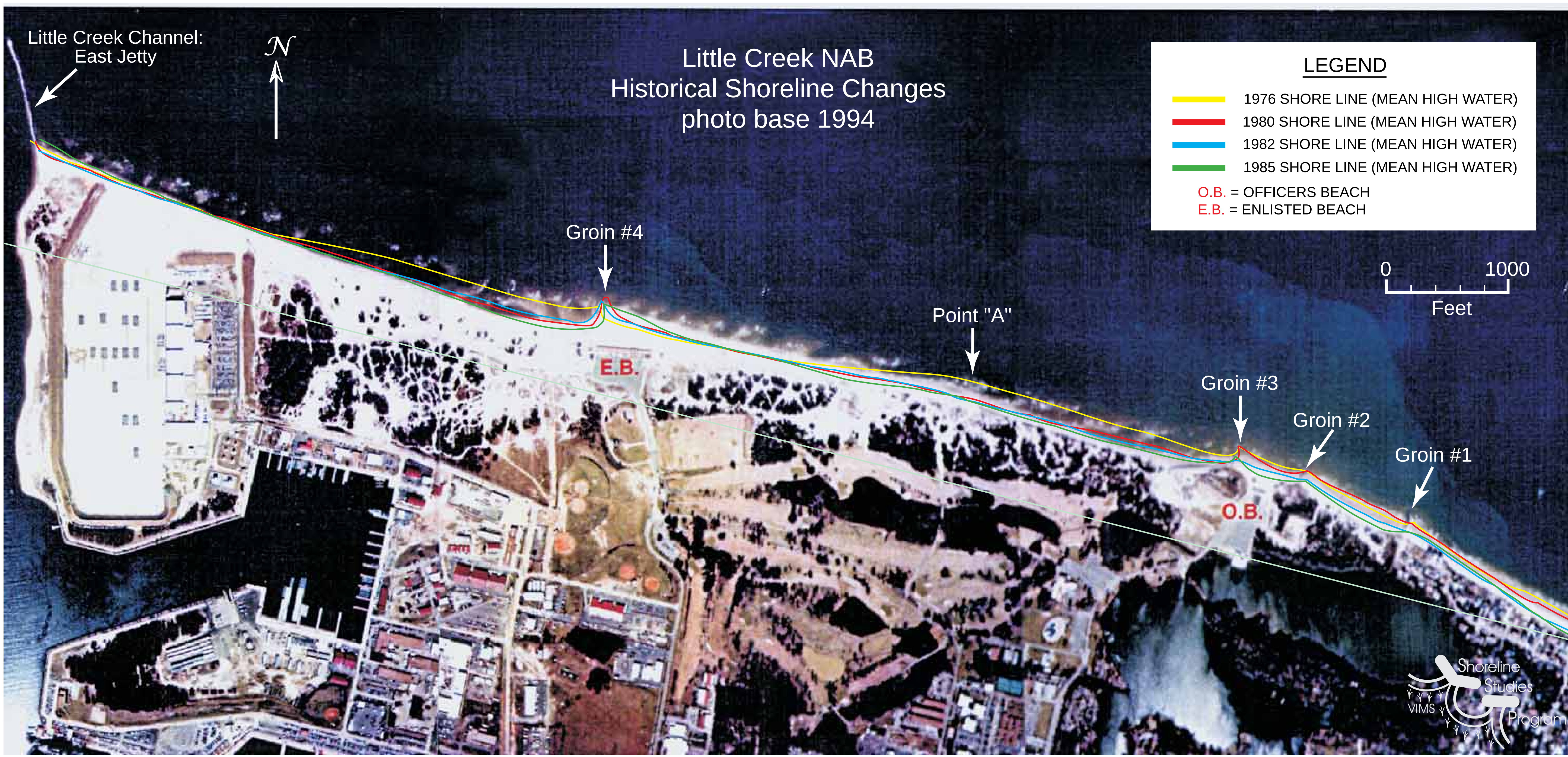


Figure 3. Non-rectified 1976 aerial photo showing MHW shoreline positions in 1852, 1949, 1958, 1971, and 1974 from Hardaway *et al*. (1997).



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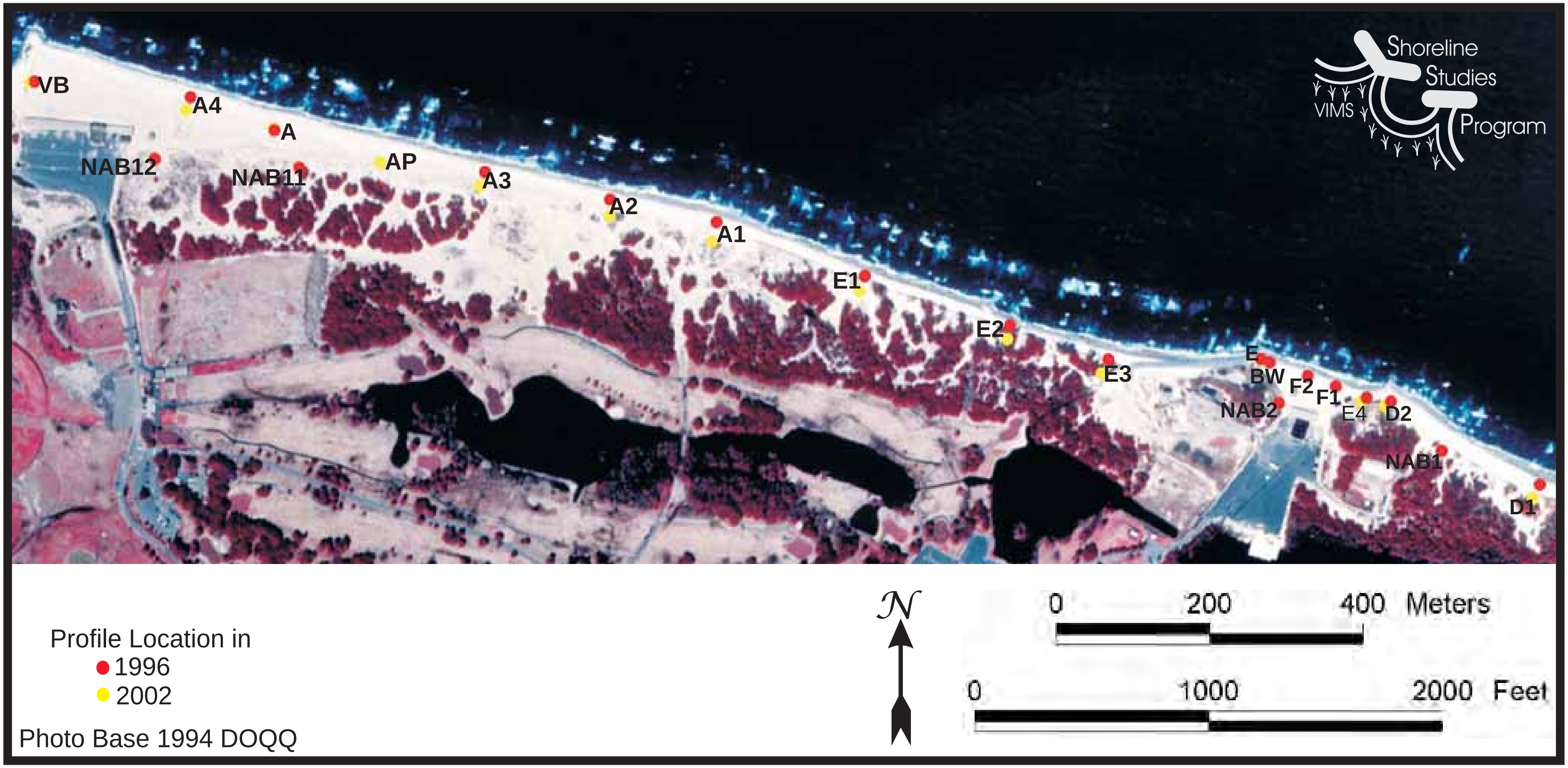
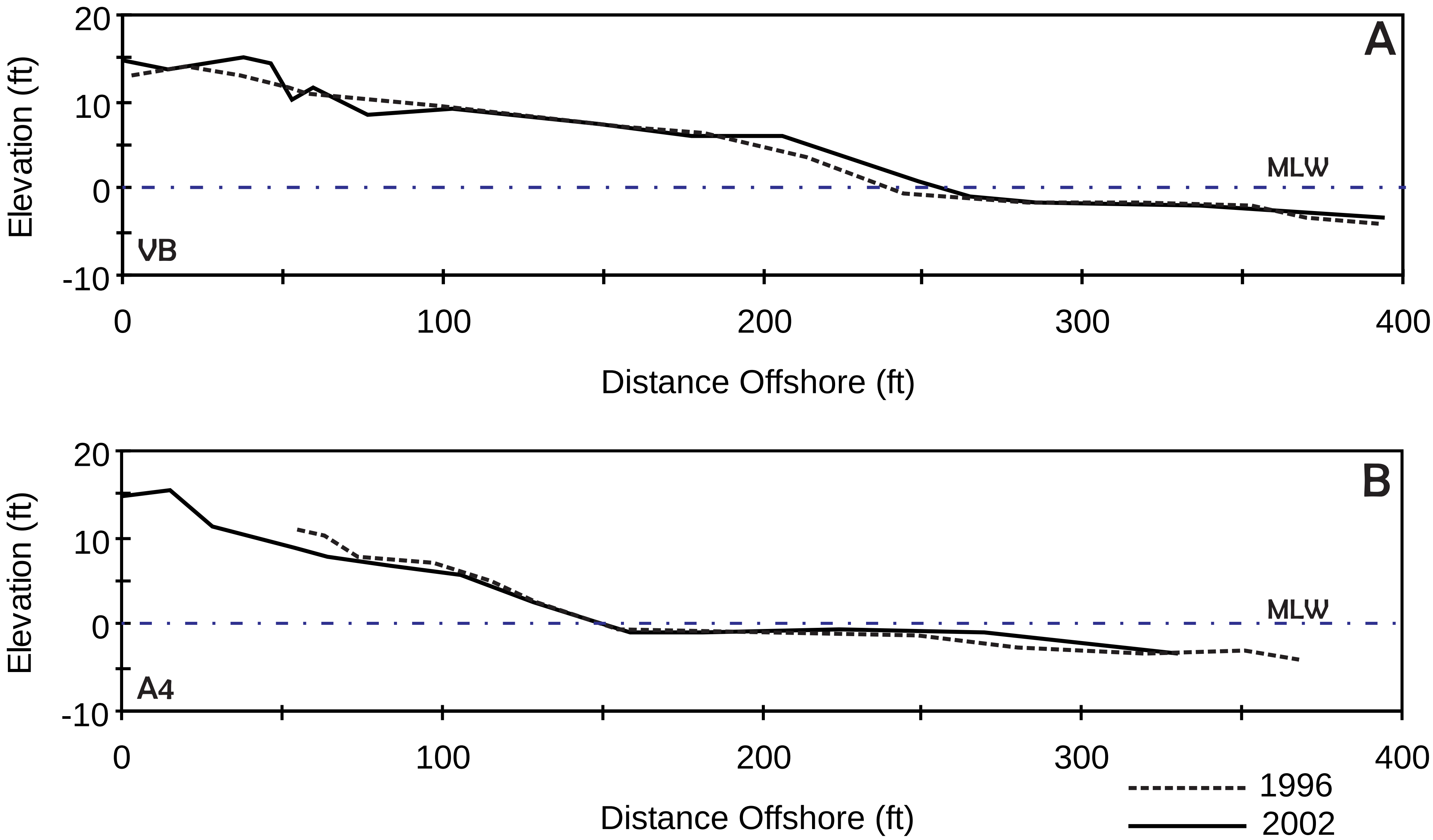


Figure 6. Non-rectified aerial photography showing the location of beach cross-sectional profiles taken at Little Creek in 1996 and 2002.



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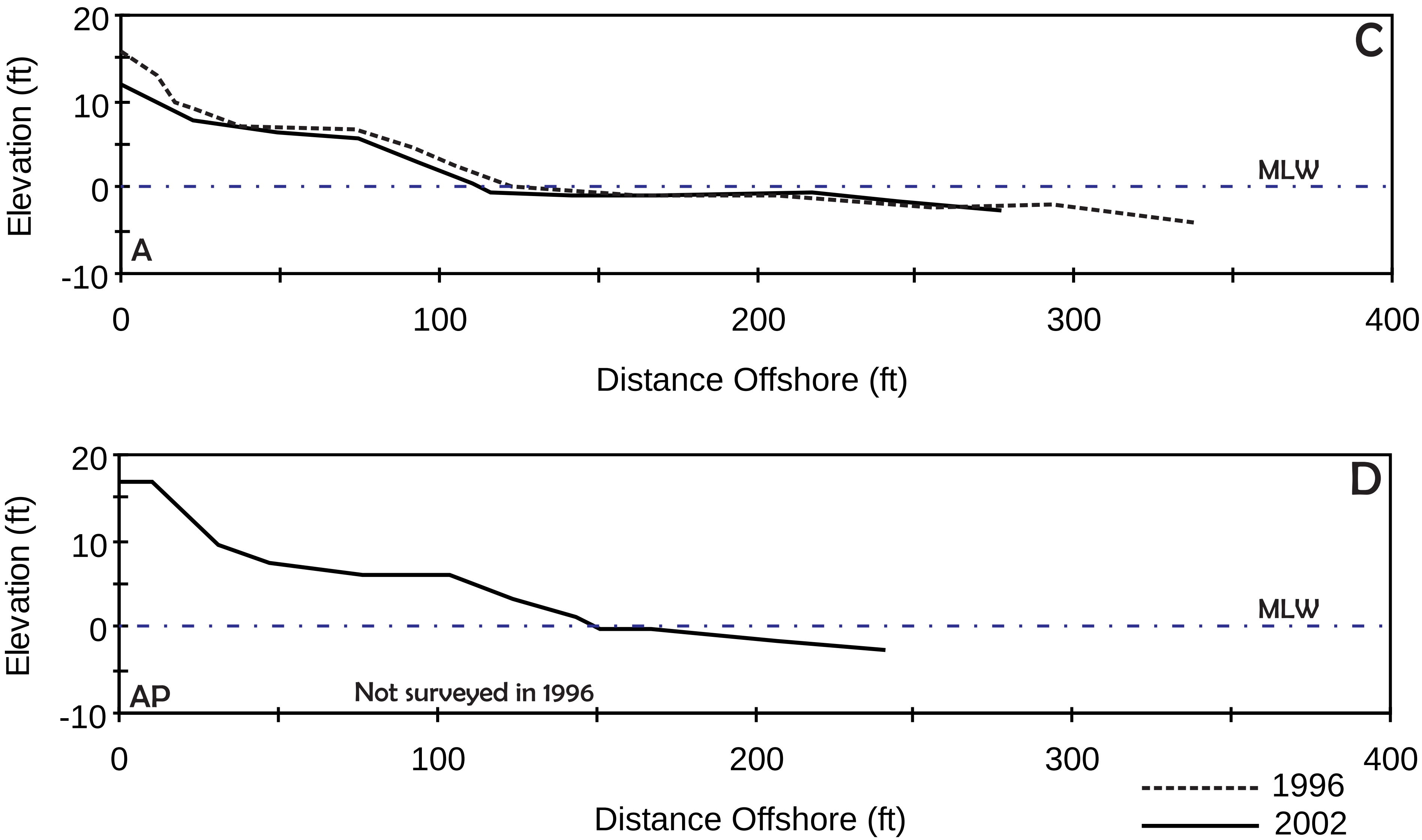

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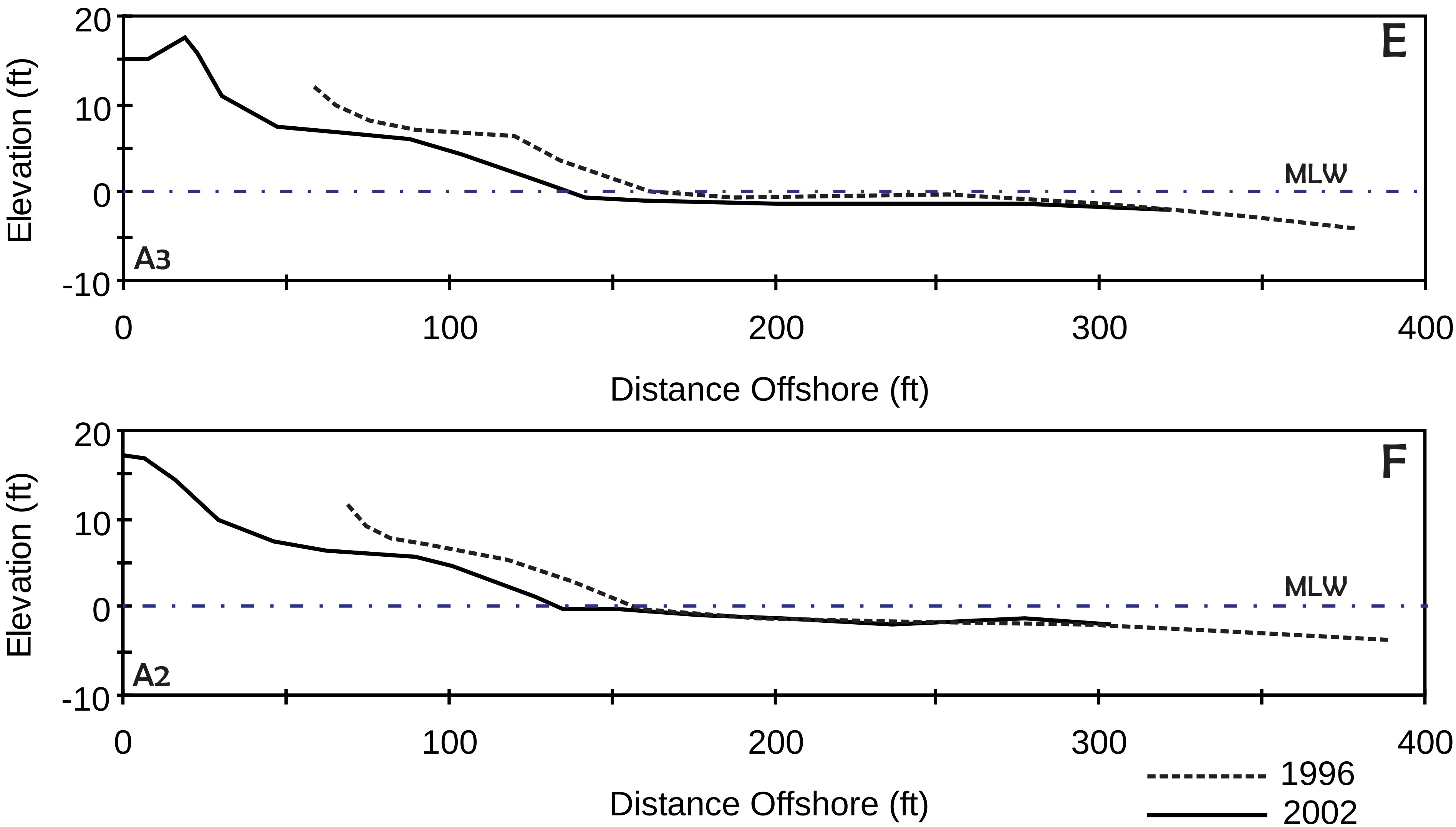

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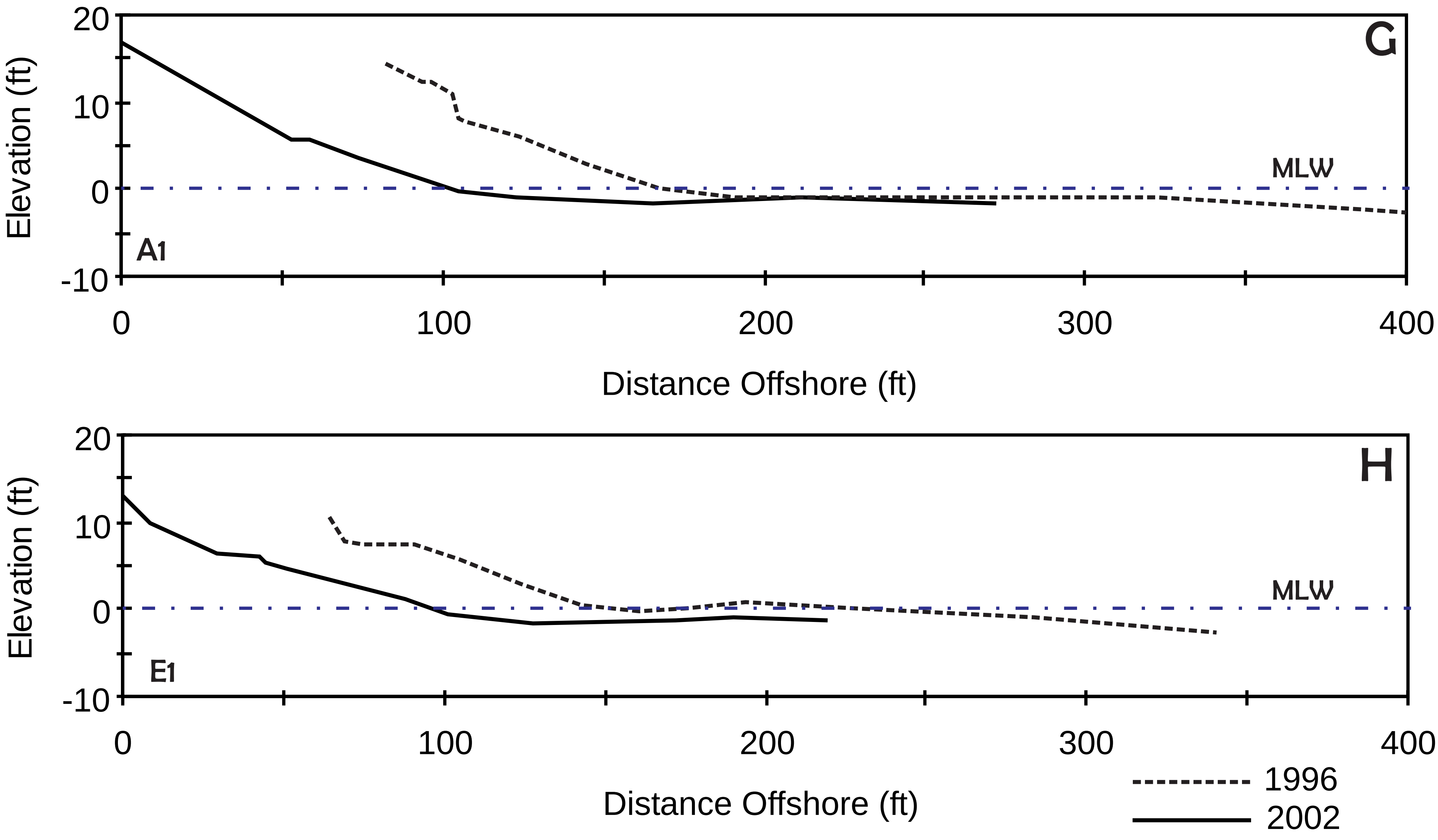

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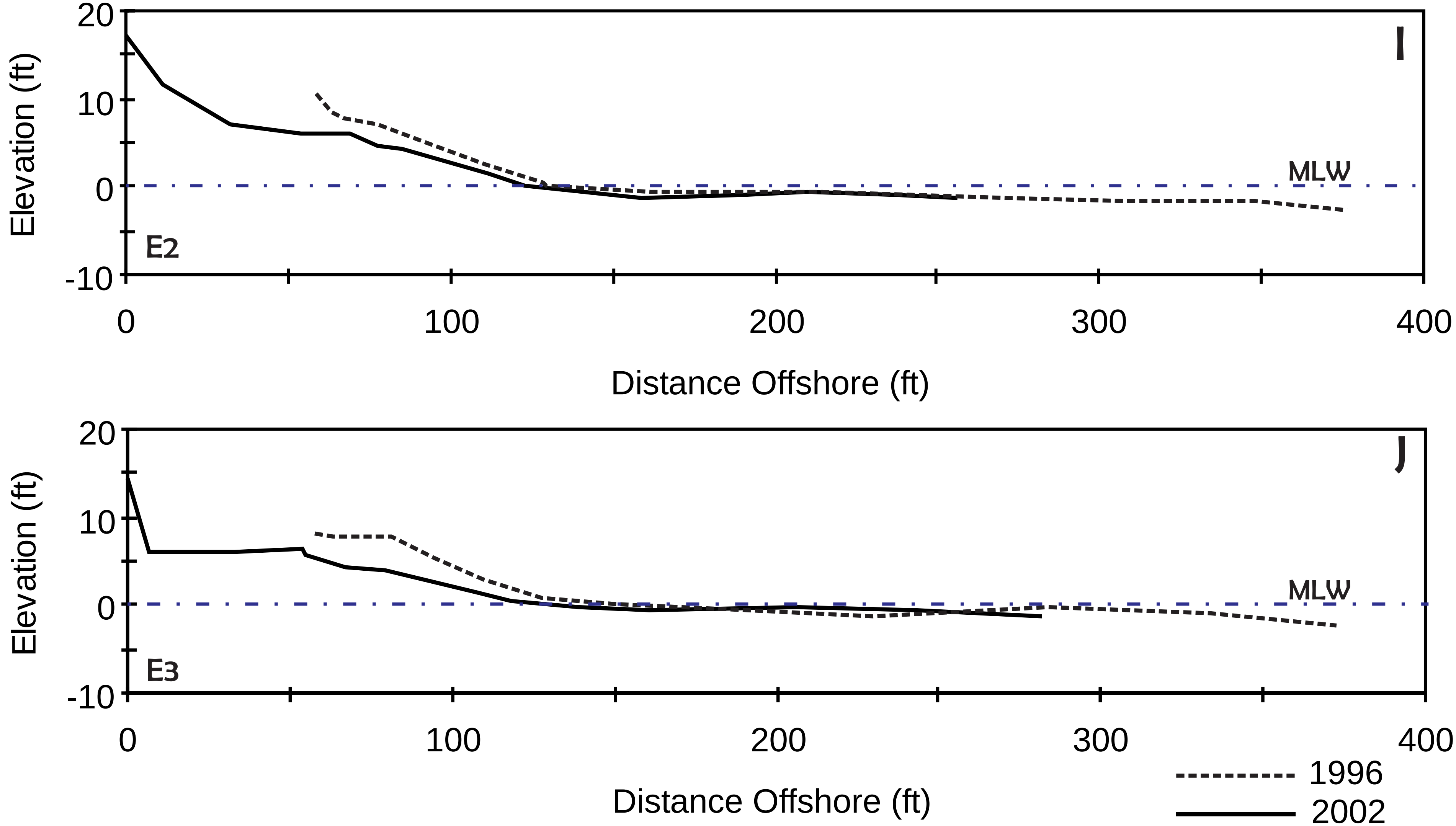

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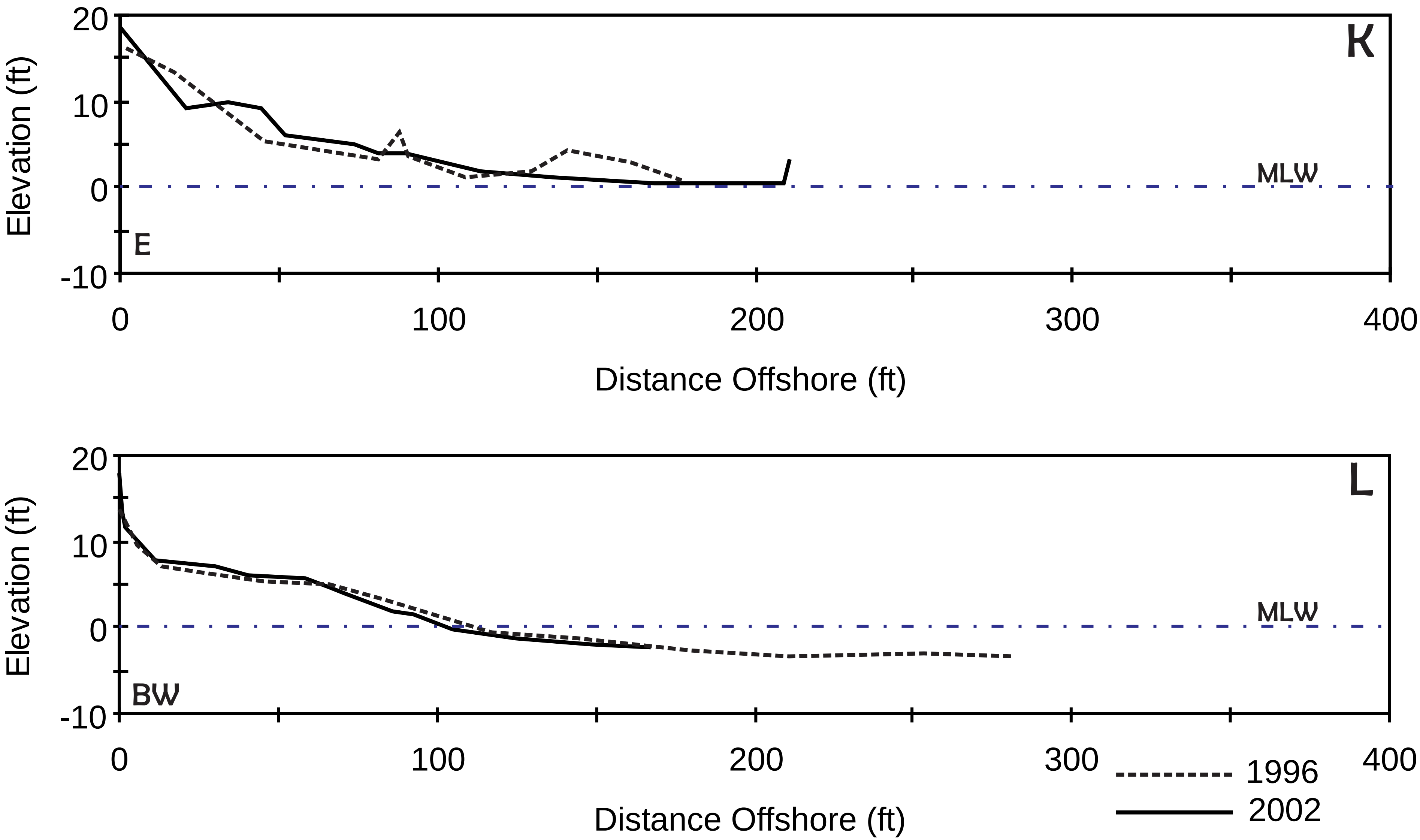
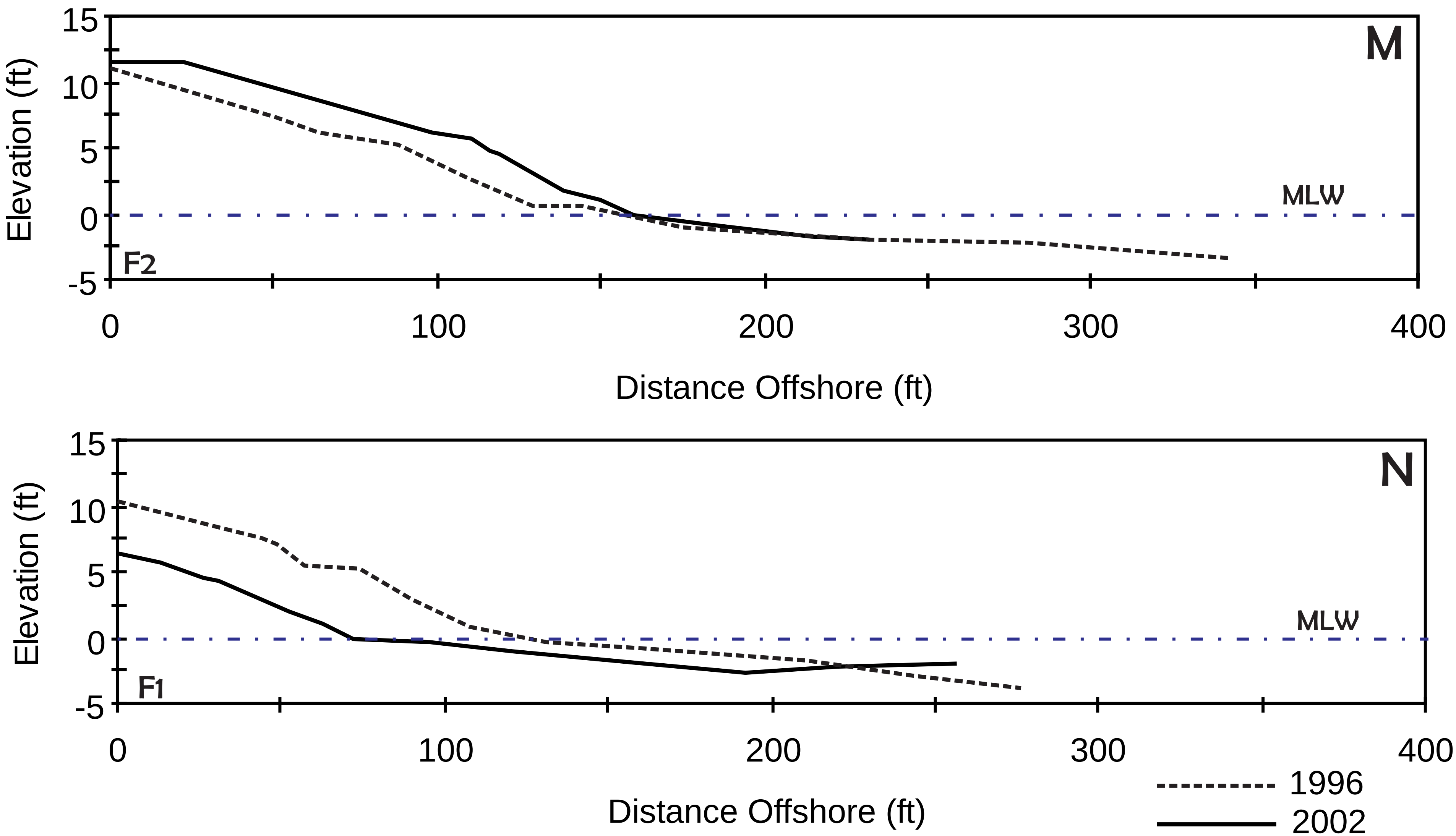


Figure 7. Beach profile shore change between 1996 and 2002 at profiles K) E and L) BW.



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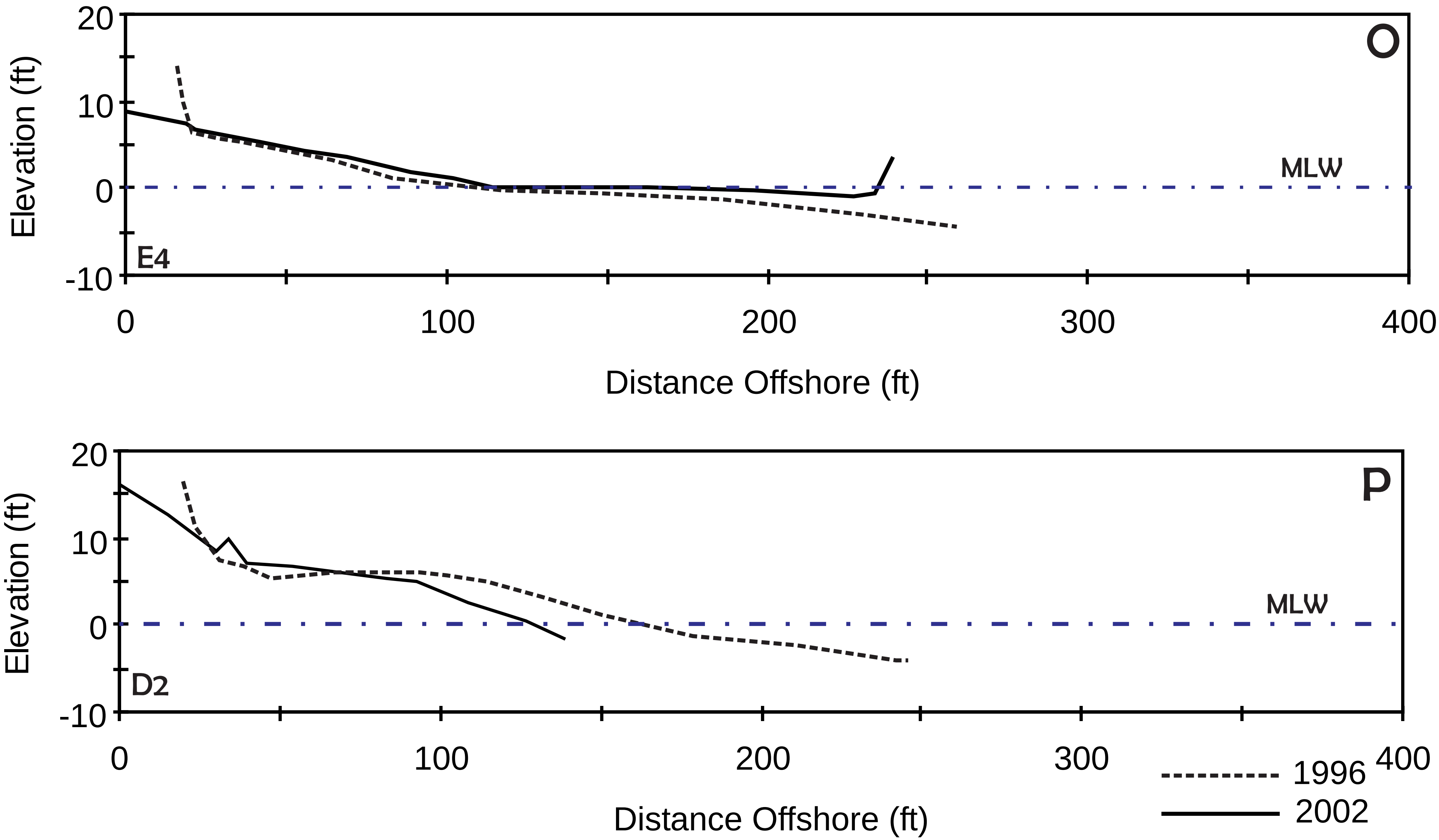

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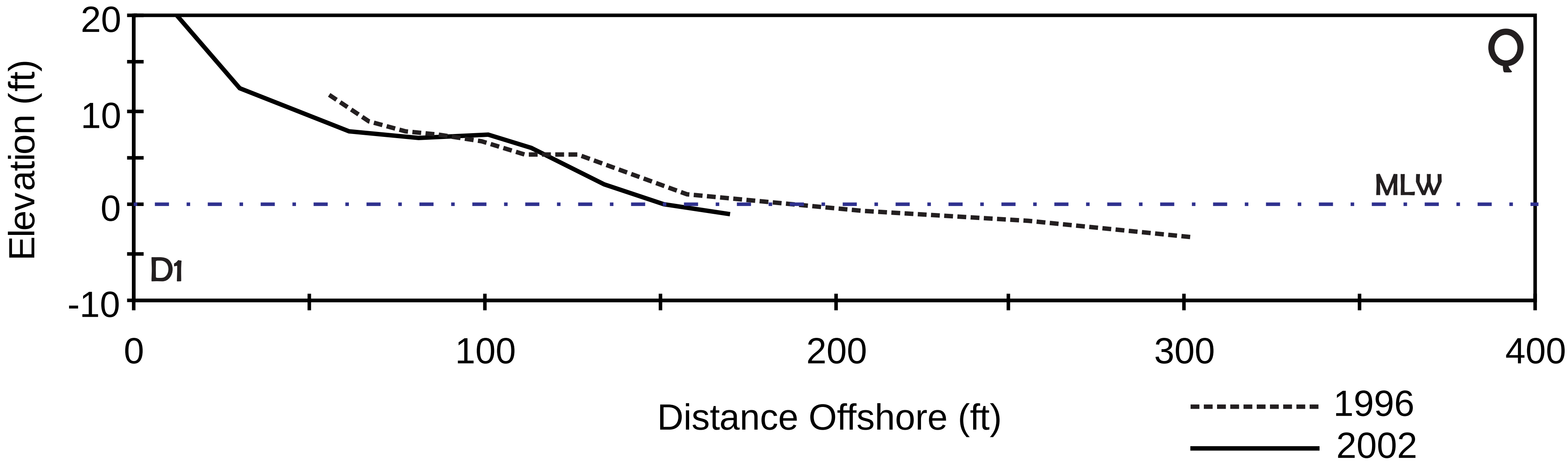

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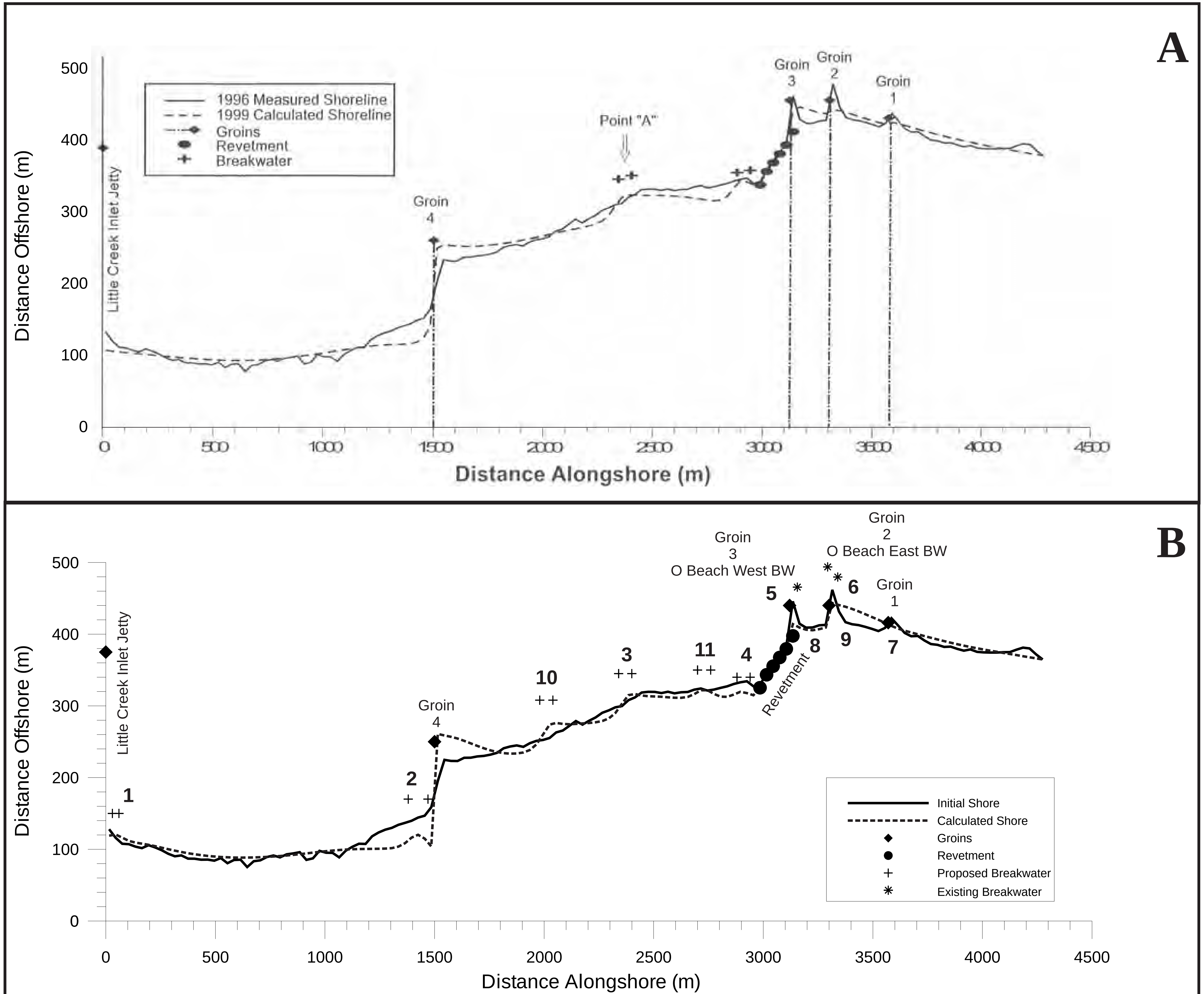

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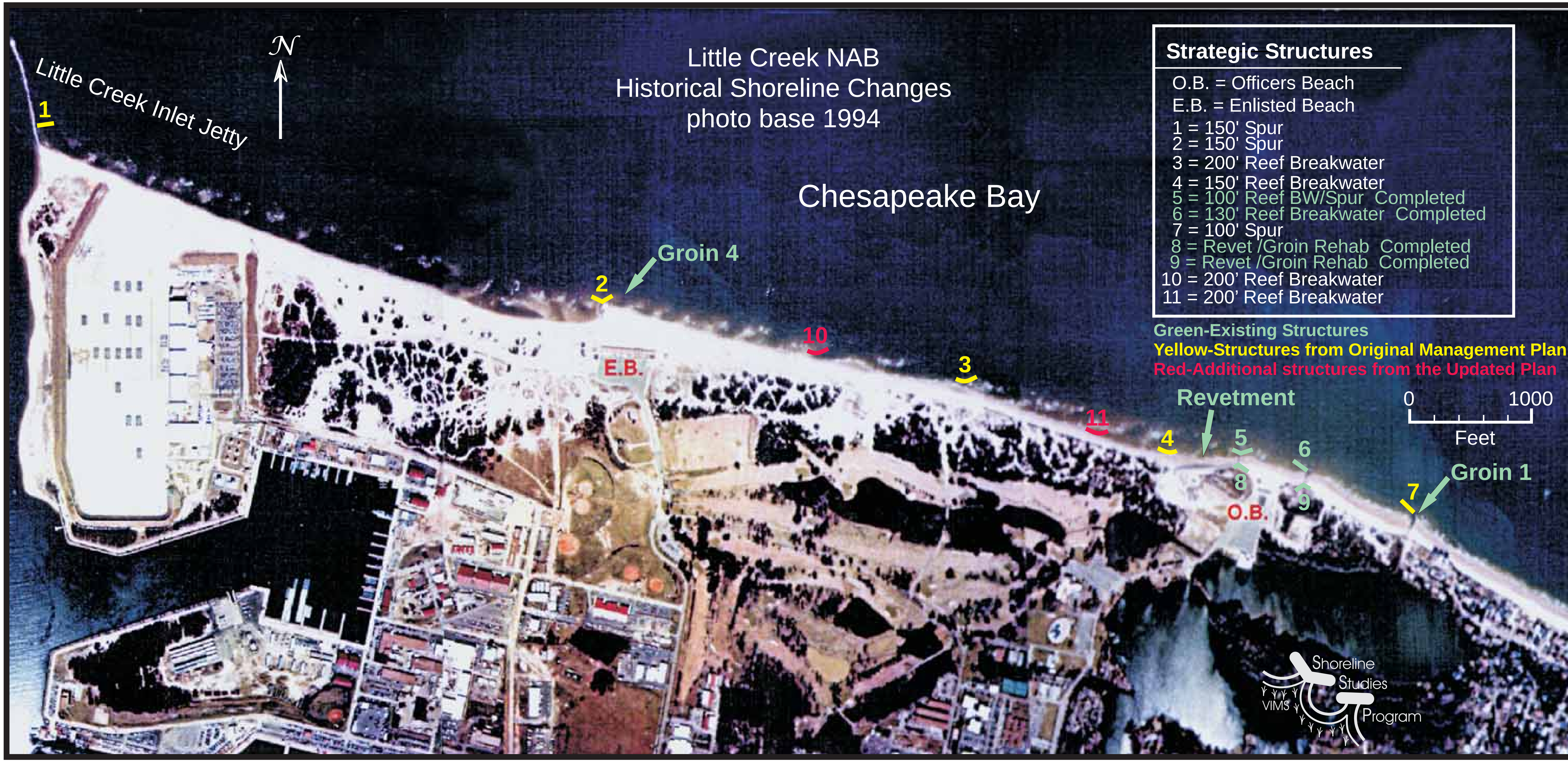

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LITTLE CREEK
NAVAL AMPHIBIOUS BASE
CHESAPEAKE BAY SHORELINE

Beach and Dune Impacts of the
Proposed Shoreline Management Plan - 2004

By

C. Scott Hardaway, Jr.
Donna A. Milligan
George R. Thomas
Linda M. Meneghini

For

Geo-Marine, Inc.
Newport News and ACC Program Office
Newport News, Virginia

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I. Introduction

A. Purpose

Little Creek Naval Amphibious Base (NAB) is located in Virginia Beach, Virginia. It's shoreline along the southern Chesapeake Bay extends from Little Creek Inlet eastward approximately 1.5 miles to the NAB's eastern boundary. In 1997, a study and report entitled "LITTLE CREEK NAVAL AMPHIBIOUS BASE, CHESAPEAKE BAY SHORELINE, SHORELINE MANAGEMENT PLAN and OFFICER'S BEACH SHORE PROTECTION EVALUATION" was produced by VIMS's Shoreline Studies Program (Hardaway *et al.*, 1997). The purpose of that report was to assess the rates and patterns of beach change along the Chesapeake Bay shoreline at Little Creek NAB in order to develop a shoreline management plan, particularly for the Officer's Beach ("O" Beach). Field surveys, historical aerial imagery, empirical models and computer models were used to address these objectives. Plan recommendations resulted in the construction of a headland breakwater system and revetments at the "O" Beach as well as a series of proposed breakwaters along the length of the Little Creek NAB coast.

In 2002, an update to the shoreline management plan was performed (Hardaway *et al.*, 2004). The purposes of that effort were to update the Hardaway *et al.* (1997) study and to determine if additional management strategies should be implemented. Elements of the previous report were presented to provide the background perspective and bring the reader up-to-date. Generally, the shoreline subreach just west of the "O" Beach has continued to erode from the existing revetment westward toward the Enlisted Beach ("E" Beach). This trend was prevalent prior to 1997 and was predicted to continue in the previous study. The question is how long will this trend continue and what impact will it have on the Base's shoreline, particularly the Bay-fronting primary dune system which is eroding along much of the coast?

This report attempts to detail the potential impacts to Little Creek NAB Chesapeake Bay coast if the updated management plan is implemented. It was determine that the impact will be to the shoreline position and consequently to the associated beach/dune system. The management recommendations of the updated plan are to create headland features with large stone breakwaters and to allow the adjacent coast to continue to recede toward dynamic equilibrium. Dynamic equilibrium is a concept whereby shoreline embayments, whether natural or man-made, will attain a state where the shore planform is stable given the input and output of littoral sands. In the case of Little Creek NAB, the input of sand from ongoing beach nourishment efforts west of Lynnhaven Inlet is a significant factor.

B. Background

The Little Creek NAB shoreline resides in a large reach of shore that extends from Cape Henry westward to Willoughby Spit (Figure 1). Specifically, Little Creek NAB lies within a discreet subreach that is bounded by Lynnhaven Inlet on the east and Little Creek Inlet and its associated jetties on the west. Impacts to this reach include the creation and maintenance of Little Creek Inlet, maintenance dredging of Lynnhaven, periodic beach nourishment within the subreach from material related to dredging of both inlets, and the installation of groins and breakwaters on the Bay shoreline of Little Creek NAB.

Byrne and Anderson (1978) found an erosion rate of 4.4 ft/yr for a shoreline which extended from 0.8 miles east of Little Creek Inlet to the Chesapeake Bay Bridge Tunnel. They also found that the shoreline from Little Creek Inlet's east jetty to 0.3 miles further east is accreting at a rate of 1.2 ft/yr. A detailed analysis of the Virginia Beach shoreline in this region by Owen *et al.* (1978) described accretion rates along the shoreline fronting the noise berm west to the jetty. These final conclusions were reached in their report. There was little or no change along the shoreline between the berm and the "E" Beach. From the "E" Beach to the west edge of the golf course, moderate erosion occurred. The remaining stretch of Little Creek's shoreline had severe erosion (Owen *et al.*, 1978). Today, as in 1997, the most severe erosion occurs along 2,000 ft of shoreline west of the "O" Beach.

The net direction of littoral or sand transport in the subreach is to the west with a minor reversal just west of Lynnhaven Inlet. Maintenance dredging of Lynnhaven Inlet has occurred over the years and, occasionally, sandy dredge material is placed along the Ocean Park shoreline where it is subsequently transported westward and offshore. These dredge deposits have worked their way toward the Base shoreline as part of the overall littoral transport system. The Little Creek channel, jetties, and groins have all acted to modify the natural littoral processes and have brought the shore morphology to its present state where significant erosion occurs along the eastern third of the Little Creek shoreline.

C. Shoreline Management Strategies

There are four basic approaches to shoreline management: 1) No action; 2) Defend an erosional area with a defensive structures such as bulkheads, seawalls or revetments; 3) Maintain and/or enhance existing shore zone features such as beach and dunes that presently offer limited protection; or 4) Create a shore zone system of beaches and dunes, generally using headland control with stone breakwaters.

A management strategy based on the first approach listed above may be appropriate in areas where no property improvements are threatened by erosion and/or the shoreline is stable or accretional; although accretion in the form of a spit or a widening beach may pose problems to navigation or access to the waterfront. Defending an erosional area generally means protecting upland structures threatened by erosion and not the beach in front of the structure. Defensive structures such as seawalls and revetments can, in some cases, increase erosion rates in front of them and, in many cases, alter the natural beach profile. Approaches 3 and 4 are similar in that the shore zone system is either maintained or created along an entire shoreline reach. Generally, this is accomplished with groins, breakwaters and/or headland control with beach nourishment or maintaining beach features being part of this approach.

Headland control is a concept that can allow long stretches of shoreline to be addressed in a more cost/effective way. It is accomplished by accentuating existing features or creating permanent headlands that allow adjacent, relatively wide embayments to become stable. This can greatly reduce the cost of managing the shoreline reach by reducing the linear feet of structure necessary and by increasing residency of associated beach nourishment.

Headlands generally are created with breakwaters. Offshore breakwaters are considered an "offensive" strategy to shoreline erosion control since they address the impinging waves before they reach the shore. However, breakwaters, groins, seawalls and beach nourishment all may play a part in developing a shoreline protection system. The dimensions and position of any shore protection system are dependent on wave climate, costs, type of shore being protected and what level of protection is desired (i.e. design storm surge and wave height).

The use of breakwaters for headland control has been tested repeatedly in the Chesapeake Bay. Since 1981, over 60 attached or headland breakwater systems have been built in the Chesapeake Bay for the purposes of shoreline erosion control and maintaining recreational beaches. Hardaway *et al*. (1991) evaluated 15 breakwater systems in terms of numerous parameters including breakwater length, gap, distance offshore and the indentation of the adjacent embayments. These breakwater installations have shown that a stable beach planform can exist with subtidal attachments. The advantage to a subtidal attachment is that wetland habitat is increased in the breakwater's lee, while beach stability is not compromised.

Of the four aforementioned shoreline management strategies, the use of headland control is the most appropriate for the greater than 2 miles of shoreline at NAB. The proposed shoreline management plan was developed with input from the Navy and is the first step in addressing beach stability for long term shoreline protection and recreation while maintaining an environment suitable for military training.

D. Geo-Marine: Beaches and Dunes Management Unit

In 2000, Geo-Marine, Inc. produced a report entitled "Ecological Assessment of the Beaches and Dunes Management Unit at Naval Amphibious Base Little Creek, Virginia Beach, Virginia" which detailed the vegetative communities along the Little Creek NAB Bay shoreline which included beaches, dunes, and maritime forest. The report showed additional shoreline elements such as the boundaries of the training beaches, training routes, wetlands, infrastructure, research plots, and dune management schemes. The Geo-Marine report was used as our basis in determining the potential impacts to the beach/dune system if the proposed shoreline management plan update is initiated.

II. Approach and Methodology

A. Limits of the Study Area

The shore reach between Lynnhaven and Little Creek Inlets were analyzed in detail in 1997 (Hardaway *et al.*, 1997). However, in this report, the overall study area has been extended to include the shoreline from Cape Henry to Little Creek Inlet (Figure 1). The shore management plan update includes the NAB's Chesapeake Bay shoreline while focusing on the reach between the "O" Beach and the "E" Beach which is an area of recent erosion.

B. Shoreline Impacts Assessment

Results of the VIMS's updated shoreline management plan suggests that the placement of offshore breakwaters at strategic locations between the "O" Beach and the "E" Beach (Figure 2). This plan included two additional structures to those proposed in the 1997 report (#10 and #11). This plan was overlain onto two maps produced by Geo-Marine 1) vegetative communities and 2) vehicle training routes (Figure 3A and 3B). The predicted stable shore planform was superimposed onto each map based on GENESIS shoreline modeling in the updated plan.

The areas of impact to the beach, dune and vegetative communities were calculated using ArcView 3.3. The impacts to the vehicle training routes were qualitatively assessed. The Geo-Marine data were based on geo-rectified aerial photography taken in 1996. Substantial shoreline change has occurred along sections of the study area since 1996. In addition, one of the assumptions used in the update plan is that beach nourishment shall be ongoing along the shoreline west of Lynnhaven Inlet from the inlet dredging. Reduction in the transport of littoral sands onto the Little Creek coast may result in increased bay offsets which would move the shore planform landward.

III. Results

A. Shoreline Plan

The updated shoreline plan (Hardaway *et al.*, 2004), from east to west, begins at structure #4 which is proposed to reduce the flanking west of the existing revetment. The original plan (Hardaway *et al*., 1997) placed the next structure at position #3. Ground surveys between 1996 and 2002 showed this area to be eroding at up to 10 ft/yr. Shoreline equilibrium would proceed far into the beach, dune, woodlands and maritime forest. Therefore, an additional structure (#11) was inserted to reduce the long size of the embayment while creating two bays along the same reach.

The original plan (1997) placed shore structure #3 at what was called Point A, which appears as a slight turn or cape feature alongshore. The idea was to allow shore equilibrium to proceed between structure #3 and "E" Beach where the existing broken concrete groin would be enhanced with a spur/breakwater (structure #2). Once again, a very long stretch of shoreline was to be allowed to evolve toward equilibrium and in order to further segment the shore, another structure was proposed, structure #10. Additional structures could be added, however, these may alter the nature of the training beaches beyond what the Navy desires.

B. Shoreline Impacts of Updated Shore Plan

An analysis of shoreline and habitat change due to the placement of structures along the beach shows that a significant amount of beach, dune and even maritime forest impact will occur (Table 1). Conceptually, Figure 4 shows the detail of the proposed habitat enhancement provided by the installation of shore attached breakwaters. These zones provide the basis for habitat change determination. The amount of beach area impacted totals approximately 6 acres. However, with the formation of tombolos additional beach area will be gained directly behind the breakwater structures. This approximately 2 acre gain was calculated between the structure and the 1996 shoreline. Shoreline length will actually increase by approximately 10%. Once again, significant change likely has occurred along portions of the study area between 1996 and 2002.

Table 1. Habitat change due to placement of proposed structures.

Habitat Type^	**Area Change**	
	(sq. ft.)	**(acres)**
Beach Impacted	270,300	6.2
Dune Grassland Impacted	26,800	0.6
Maritime Scrub Impacted	10,300	0.2
Dune Woodland Impacted	3,500	0.1
Area Created*	74,000	1.7

^Based on Geo-Marine's designation
*Area behind proposed breakwaters but bayward of the 1996 shoreline.

IV. Discussion and Recommendations

The recent patterns of shoreline change (1996 to 2002) are mostly erosive which may result from a number of factors, including but not limited to, more restricted alongshore sediment movement, severe storm attack including the 1998 Twin Northeasters and hurricanes Dennis and Floyd in 1999, and the lag time it takes beach fill from Ocean Park to reach the shores of NAB Little Creek. The latter factor is very difficult to ascertain, but we feel intermittent but ongoing dredging from Lynnhaven Inlet and subsequent disposal in Ocean Park will factor into the long-term sediment budget of the larger reach.

The shoreline plan update creates a series of headlands and pocket beaches along much of the Little Creek NAB coast. The beaches and dunes areas between “O” Beach and “E” Beach will not be lost but reformed into curvilinear embayments. In fact, the actual length of shoreline will increase by approximately 10%. Impacts to the vegetative communities is not insignificant, but with time, displaced dune and woodland features could migrate toward the areas of the tombolos or even be part of the design. Similar features have been incorporated into other shoreline management plans. Even though, small areas of maritime forest may be impacted, these could initially be enhanced behind each headland structure. Finally, no infrastructure is threatened and training areas will not be lost but realigned as the shoreline moves toward equilibrium. In this vehicle routes may have to be altered to accommodate the evolving shore planform.

V. References

Byrne, R. J. and G. L. Anderson, 1978. Shoreline Erosion in Tidewater Virginia. SRAMSOE Number 111. Virginia Institute of Marine Science, College of William and Mary, Gloucester Point, Virginia, 102 pp.

Hardaway, C. S., Jr., and J. R. Gunn, 1991. *Headland breakwaters in Chesapeake Bay*. Proceedings: Coastal Zone '91, Long Beach, California, p. 1267-1281.

Hardaway, C. S., Jr., D. A. Milligan, J. P.-Y Maa, and G. R. Thomas, 1997. Little Creek Naval Amphibious Base Chesapeake Bay Shoreline, Shoreline Management Plan and Officer's Beach Shore Protection Evaluation. Technical Report, Virginia Institute of Marine Science, College of William & Mary, Gloucester Point, Virginia.

Hardaway, C. S., Jr., D. A. Milligan, G. R. Thomas, and L. M. Meneghini, 2004. Little Creek Naval Amphibious Base Chesapeake Bay Shoreline, Shoreline Management Plan Update. Technical Report, Virginia Institute of Marine Science, College of William & Mary, Gloucester Point, Virginia.

Owen, D. W., L. Morgan, and N. M. Sturm, 1978. Shoreline Situation Report - City of Virginia Beach. SRAMSOE Number 163. Virginia Institute of Marine Science, College of William and Mary, Gloucester Point, Virginia, 91 pp.

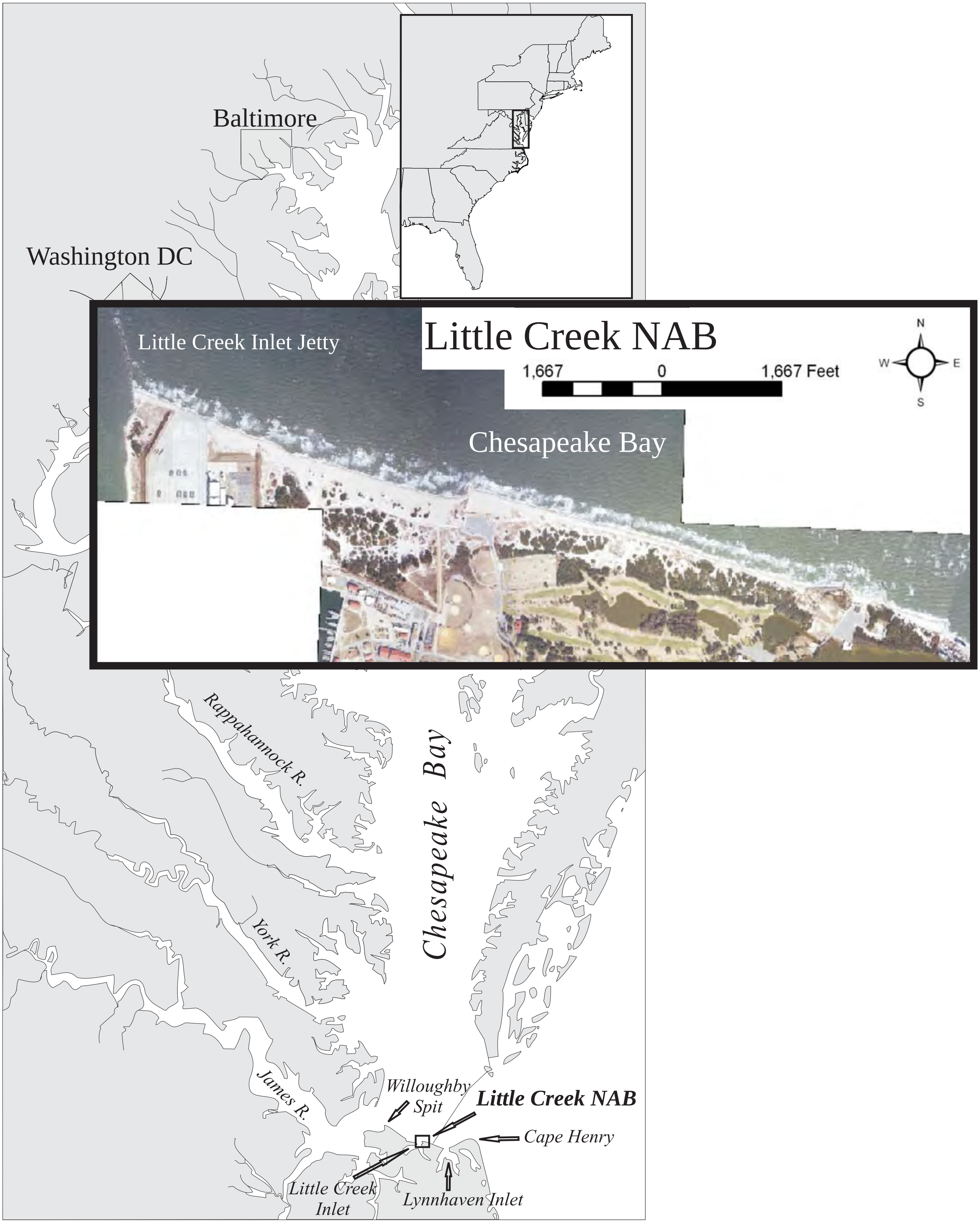


Figure 1. Study site location with 2002 aerial imagery showing Little Creek NAB's shoreline. Shoreline aerial imagery copyrighted 2002 Commonwealth of Virginia.

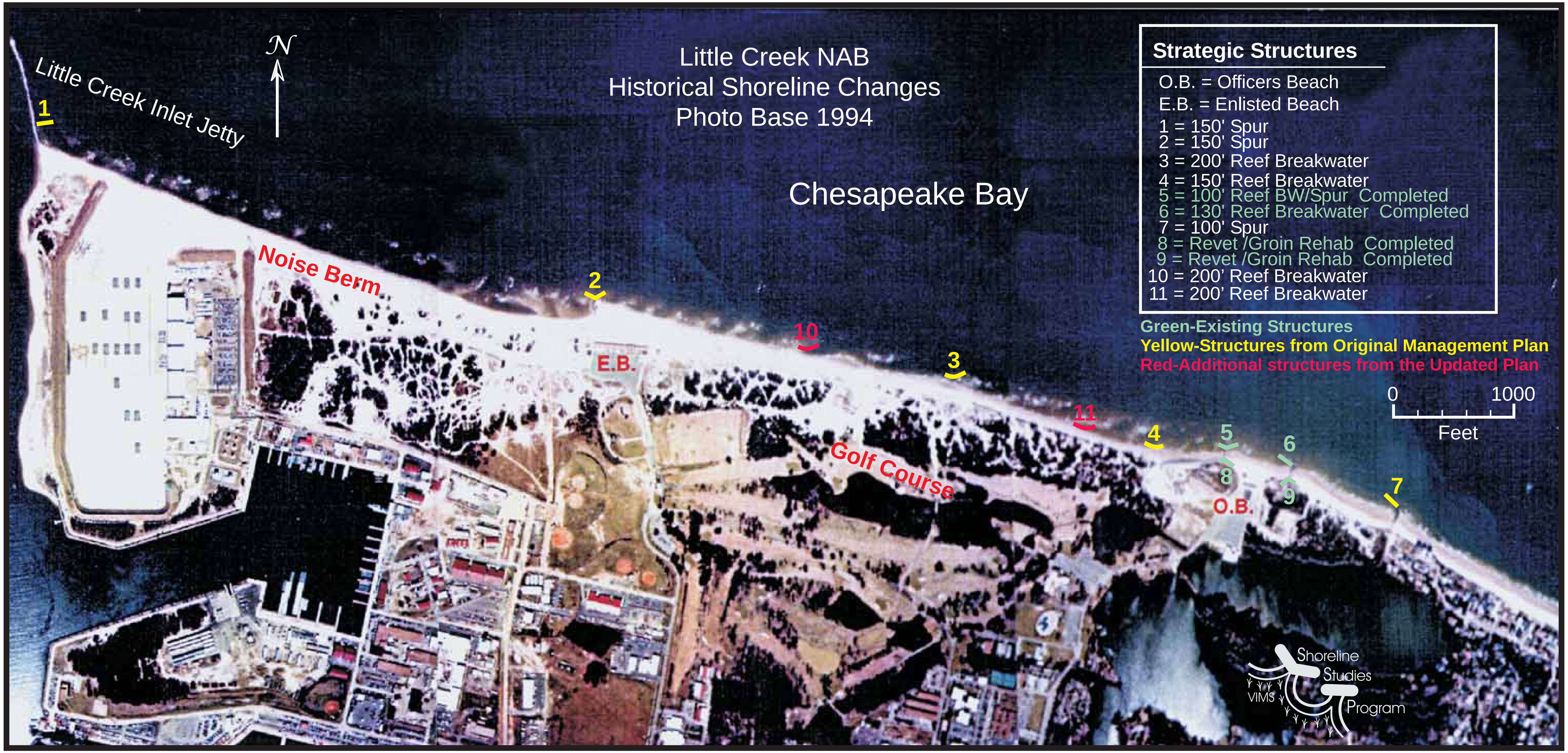


Figure 2. Non-rectified aerial photos showing the Shoreline Management Plan's suggested structures for Little Creek NAB's shoreline from Part 1 of this report.

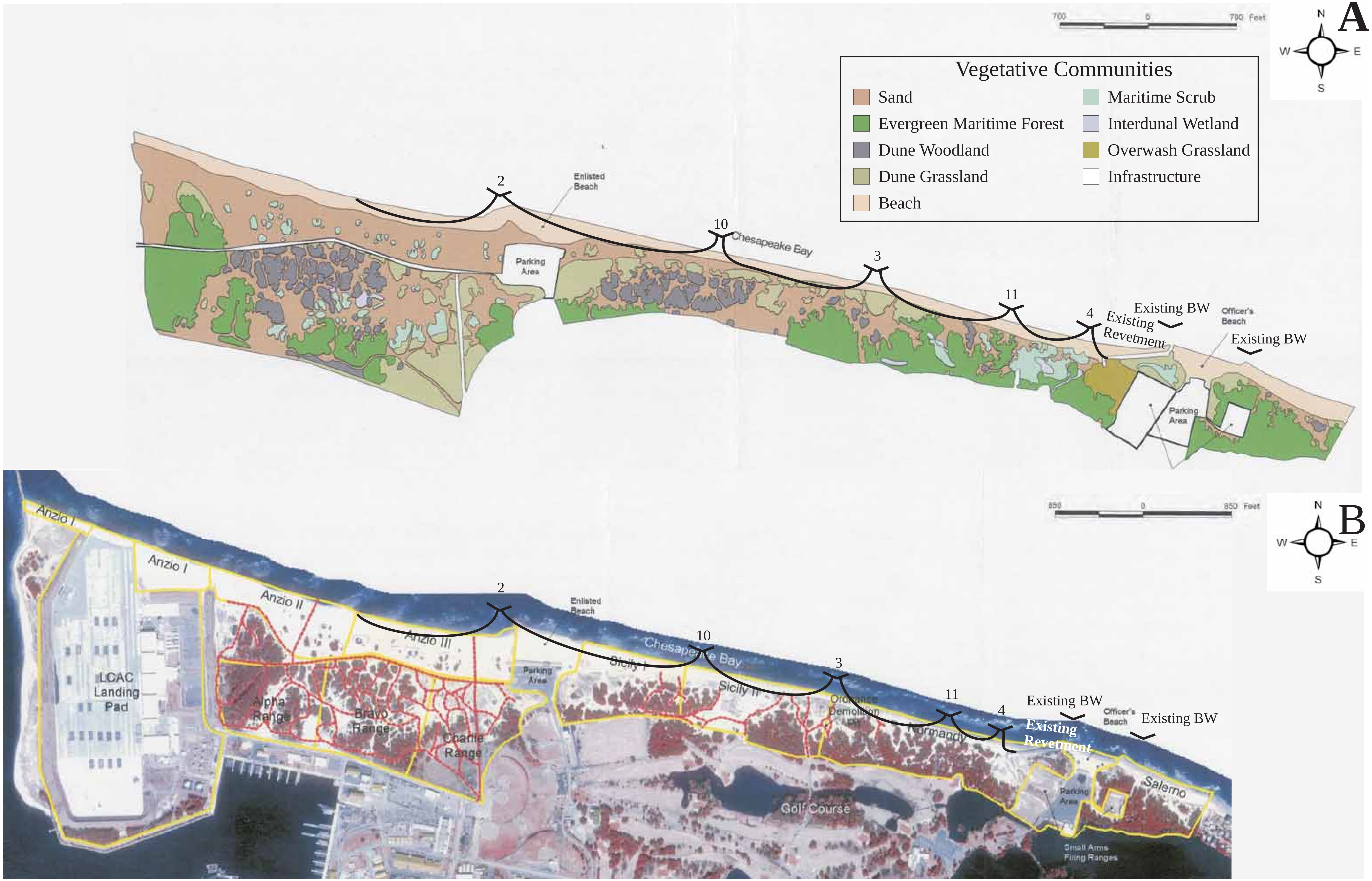
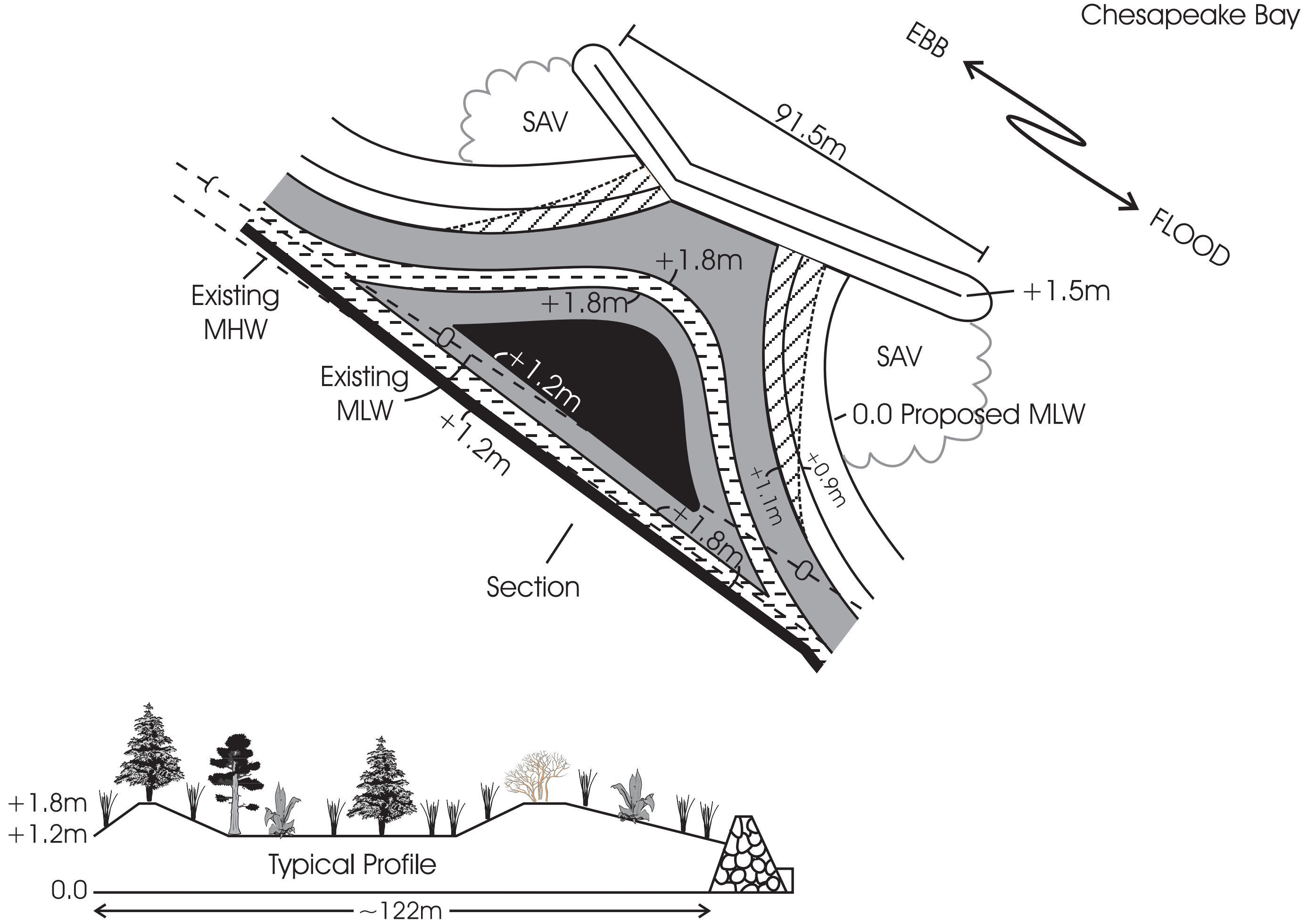


Figure 3. Impacts to the Little Creek A) vegetative communities and B) training routes after implementation of the proposed structures (data from Geo-Marine, 2000).



Mean High Water=0.7m
Upper Limit Wetlands=1.1m

Beach

Marsh Mix Saltmeadow Hay- *Spartina patens,* Smooth Cordgrass- *Spartina alterniflora*

Beach Mix Saltmeadow Hay- *Spartina patens,* American Beachgrass- *Ammophilia breviligulata* Bitter Panicgrass- *Panicum amarum*

Shrub Mix 1 Beach Plum- *Prunus maritima*, Black Cherry- *Prunus serotina,* Wax Myrtle- *Myrica cerifera,* Yaupon- *Ilex vomitoria,* Inkberry- *Ilex glabra*

Shrub Mix 2 Red Cedar- *Juniperus virginiana*, Choke Cherry- *Aronia melanocarpa,* Blueberry- *Vaccinium corymbosum,* Groundsel Tree- *Baccharis halimifolia,* Switchgrass- *Panicum virgatum,* Persimmon- *Diospyros virginiana*

Figure 4. Detail of a typical shoreline management plan with habitat enhancement.