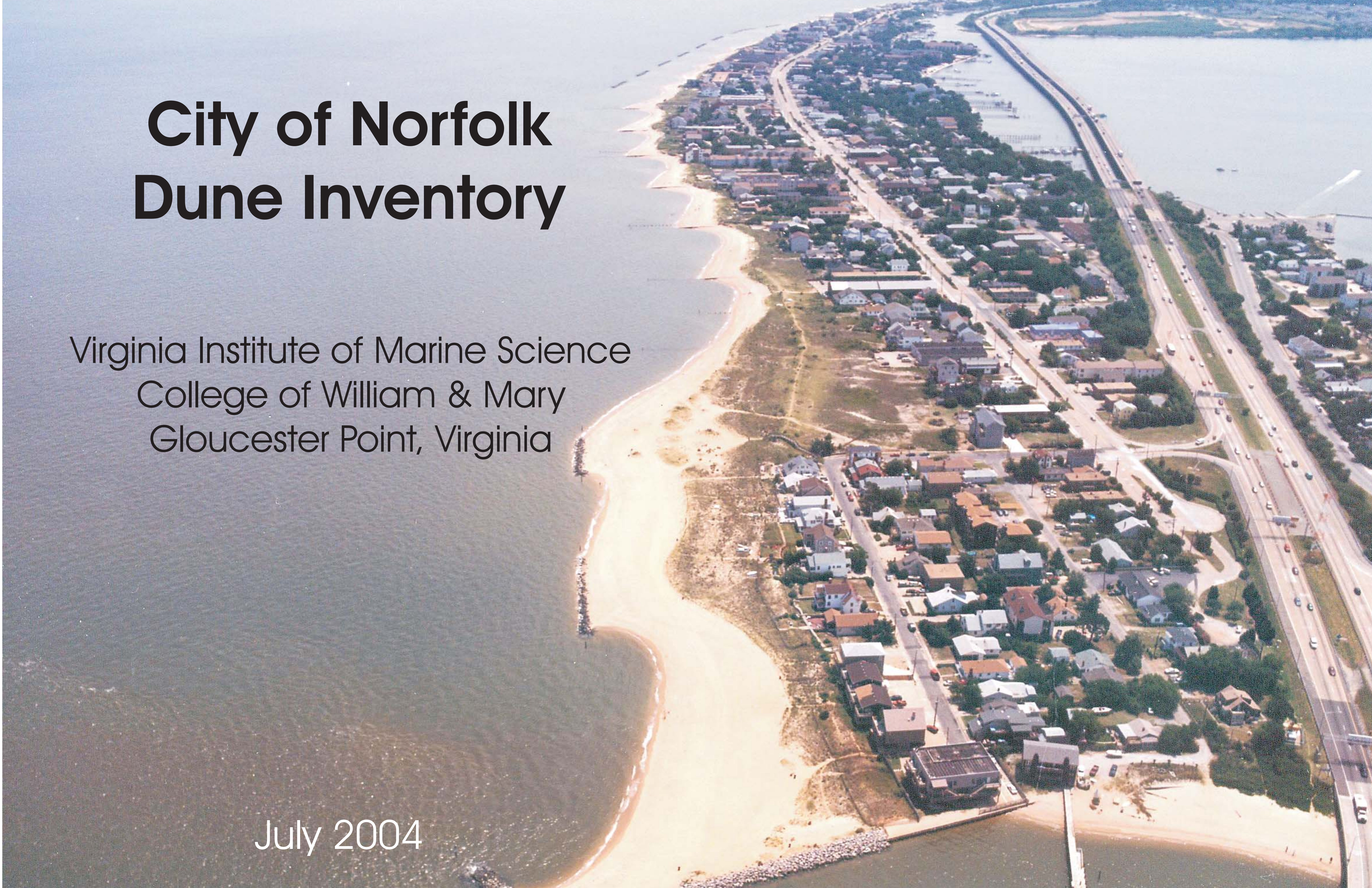
City of Norfolk Dune Inventory

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

July 2004



City of Norfolk Dune Inventory

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Cover Photo
Willoughby Spit, Norfolk, Virginia, 17 June 2002 taken by VIMS, Shoreline Studies Program.

1 INTRODUCTION

1.1 Purpose

City of Norfolk, Virginia is located on the southern shore of Chesapeake Bay (Figure 1). Thirteen dune sites were identified along it's Chesapeake Bay shore from Little Creek Inlet to Willoughby Spit (Figure 2). It is the intent of this publication to provide the user with information on the status of dunes in City of Norfolk. This information comes from research performed in 1999 and 2000 which was presented in a report entitled "Chesapeake Bay Dune Systems: Evolution and Status (Hardaway *et al.*, 2001). Although somewhat dated, the information provides a short historical perspective of the state of each site at the time of the site visit. Since much of the data was collected several years ago and the beach and dune systems may have changed, this report is intended only as a resource for coastal zone managers and homeowners; it is not intended for use in determining legal jurisdictional limits.

1.2 Dune Act

Coastal dune systems of the Commonwealth of Virginia are a unique and valuable natural resource. Dunes are important to both the littoral marine system (as habitat for flora and fauna) and the adjacent landward environment (as erosion control and protection from storms). These functions form the basis for the Coastal Primary Sand Dune Protection Act of 1980 (Act)[1] and the related resource management effort under which the primary dune and beach components of existing dune systems are protected. Secondary dunes are not protected under the Act; however, as they are an important part of the overall dune system, they were included in the original report (Hardway *et al.*, 2001) and analyzed as part of a risk assessment performed by Varnell and Hardaway (2002). In this inventory, both primary and secondary dunes are included.

Primary dunes must meet three criteria in order to fall under the Act's jurisdiction:

1. **Substance**: a mound of unconsolidated sandy soil contiguous to mean high water
2. **Morphology**: landward and lateral limits are marked by a change in grade from >10% to <10%.
3. **Character**: primary dunes must support specific plant species or communities which are named in the Act and include: American beach grass (*Ammophila breviligulata*); beach heather (*Hudsonia tometosa*); dune bean (*Strophostylis* spp.); dusty miller (*Artemisia stelleriana*): saltmeadow hay (*Spartina patens*); seabeach sandwort (*Arenaria peploides*); sea oats (*Uniola paniculata*); sea rocket (*Cakile edentula*); seaside goldenrod (*Solidago sempervirens*); and short dune grass *(Panicum ararum*).

[1]The General Assembly enacted the Coastal Primary Sand Dune Protection Act (the Dune Act) in 1980. The Dune Act was originally codified in Code § 62.1-13.21 to -13.28. The Dune Act is now recodified as Coastal Primary Sand Dunes and Beaches in Code § 28.2-1400 to -1420.

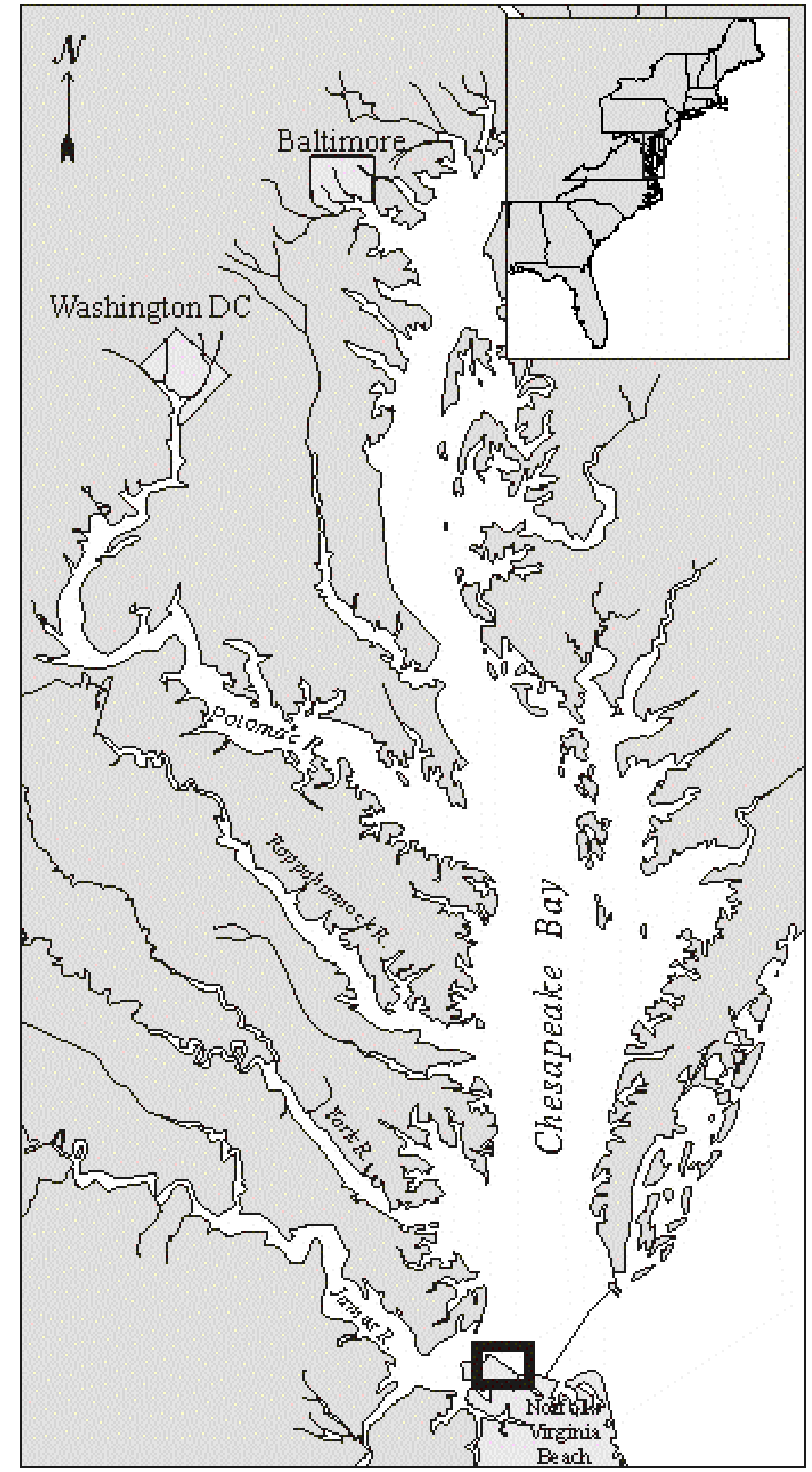

Figure 1. Location of City of Norfolk within the Chesapeake Bay estuarine system.

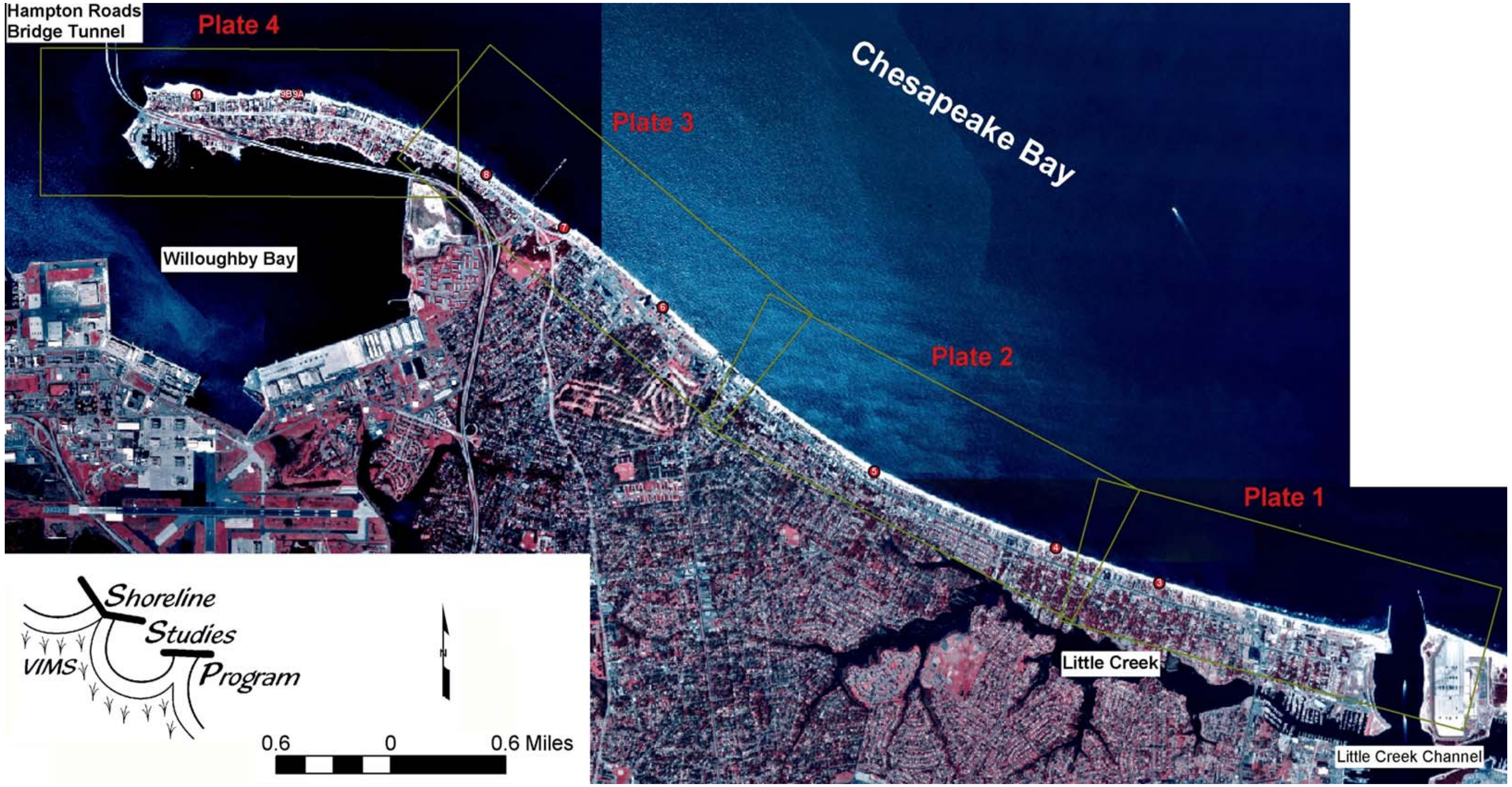

Figure 2. Geographic extent of dunes in City of Norfolk.

2 BACKGROUND

Coastal primary sand dunes form by the accumulation of sand due to the interaction of wind and wave action along the shore. Sand deposited on the beach during periods of relatively low wave energy is moved landward by onshore winds. The deposition of material above the intertidal zone allows vegetation to take root along the wrack line which then acts as a baffle, slowing wind speed and causing wind-borne sand to settle and be trapped in the vegetation, thereby resulting in further accretion of the dune. Therefore, the size and location of a primary dune is determined by the amount of sand available and the ability of wind and waves to move it as well as the degree to which any existing vegetation can act to trap it. Just as the intensity, direction, and duration of winds and waves constantly change through the seasons, so too, do coastal dunes. They exist in a state of flux.

Dunes act as a reservoir of sand which can buffer inland areas from the effects of storm waves and, in the process, act as natural levees against coastal flooding. During high energy conditions, such as the northeast storms which frequent the Eastern Seaboard, primary dunes may be subject to attack by wind-driven waves aided by storm surges. The dune may be eroded, and the sand deposited in an offshore bar. Then, under low-energy conditions, the sand may move back to the beach.

All dunes in the Chesapeake Bay estuarine system are mobile features especially with regards to coastal zone management. Unlike ocean dune fields that are relatively continuous features exposed to the open ocean, the dunes of the Chesapeake form across a temporal and spatial geomorphic matrix driven by sand volume, varying wave climate, and shoreline geology. The coastal geology, in large part, determines whether shoreline erosion acts upon the upland (high bank) or marsh (low bank). Sand supply and the long-term local wave climate are significant factors in the location of dunes. The stability or ability of a dune/beach system to accrete over time is necessary for the formation of secondary dunes.

Natural dunes in the Chesapeake Bay estuarine system vary in size and nature, but all require an accreted feature, such as a beach washover or a spit to become vegetated above the intertidal zone. Vegetation and a continuous beach/dune profile are required to create the jurisdictional primary dune. If the dune/beach forms across a low marsh shoreline, the system will move landward in response to storms, and only a low primary dune will exist. If sand can accrete bayward due to shoals, spits, or man-made features such as jetties and groins, then a secondary dune may develop from the original primary dune.

Hardaway *et al.* (2001) found that the occurrence of dunes around Chesapeake Bay is due, in part, to three factors: 1) morphologic opportunity (*i.e*., relatively stable setting), 2) abundant sand supply in the littoral transport system, and 3) conducive onshore wind/wave climate. Deposited sand must remain above a stable backshore to allow dune vegetation to become established. Each dune documented by Hardaway *et al.* (2001) has its own history of change -- growth and decay; natural and anthropogenic. Many miles of natural dunes have been altered by development, and many have been formed in response to processes altered by man's influence. Dunes around the Chesapeake Bay estuarine system in the localities within the Act encompass only about 40 miles of shoreline (Hardaway *et al.*, 2001). This is about 0.4% of the total Bay shore - making it an important, but rare, shore type.

2.1 Dune System Classification

The Chesapeake Bay dune classification was developed in Hardaway *et al.* (2001) and is portrayed in Figure 3. This classification is based on factors that are unique to certain dune systems and has a basis in the dune field evolution, vegetative zones, lateral and vertical extent of primary and secondary dune features, and anthropogenic impacts.

Dunes are categorized as Natural (1), Man Influenced (2), or Man Made (3). These three types reflect how the state of the dune is most impacted. The parameters (A through G) are most influential in defining the status of a given dune system. Parameter values within each category assign a range of limits or characteristics. Categories A, B, and C relate to the nature of the impinging wave climate at a given site while categories D, E, and F relate to geologic parameters. Dune parameter G relates to the type of anthropogenic influence.

Fetch Exposure (A) is a qualitative assessment of the wave exposure and wave climate across open water. Wave impact is the dominant natural process driving shoreline erosion and sediment transport along the Bay coasts. Riverine, Bay Influenced (A.1) is somewhere between the Open Bay exposure (A.2) and Riverine Exposure (A.3). Generally, A.1 sites have fetches of 5-10 nautical miles (nm); A.2 have fetches of >10 nm; and A.3 have fetches <5 nm.

Shore Orientation (B) is the direction the main dune shore faces according to eight points on the compass. Shoreline exposure to dominant directions of wind and waves is a component of fetch exposure (A) and wave climate as well as aeolian processes that assist in dune growth and decay.

Nearshore Gradient (C) controls wave refraction and shoaling that, in turn, affect the nature of wave approach and longshore sand transport as well as onshore/offshore transport. The presence or absence of bars indicates the relative amount of nearshore sediment available for transport.

The Morphologic Setting (D) is significant in the genesis of a particular dune site. Aerial imagery from VIMS SAV Archive and field observations were used to determine and classify the Morphologic Setting. Four basic categories were developed including: 1) Isolated dunes, 2) Creek mouth barrier dune/spit, 3) Spit and 4) Dune fields. Morphological Settings 1 and 4 are distinguished only by shore length (*i.e.* Morphologic Setting 1 < 500 ft and Morphologic Setting 4 > 500 ft) as an arbitrary boundary. These categories were subdivided to reflect the nature of the setting into four subcategories which are 1) Pocket, 2) Linear, 3) Shallow Bay and 4) Salient.

The Relative Stability (E) of a dune is very subjective. It is meant as a value judgement as to the overall current and future integrity at the time of the site visit. If the site had wave cut scarps along the primary dune face and/or was actively moving landward (overwash), it was termed Land Transgressive/Erosional (E.3). If the backshore/dune face had a slight gradient with stabilizing vegetation, it was stable (E.2) or, possibly, accretionary (E.1).

Dune Classification System

Dune Type

1. Natural **2. Man Influenced** **3. Manmade**

Dune Parameters

A. Exposure: fetch
1. Riverine, Bay Influenced
2. Open Bay
3. Riverine

B. Shore Orientation (direction of face)
1. North
2. Northeast
3. East
4. Southeast
5. South
6. Southwest
7. West
8. Northwest

C. Nearshore Gradient (Distance to the 6 ft contour)
1. 0 to 1,000 ft
2. 1,000 to 3,000 ft
3. Greater than 3,000 ft

→ 1. Extensive Bars
→ 2. No Bars

D. Morphologic Setting
1. Isolated (less than 500 ft alongshore)
   1. Pocket
   2. Linear
   3. Shallow Bay (curvilinear)
   4. Salient (point)
2. Creek Mouth Barrier/Spit
3. Spit
4. Dune Field (greater than 500 ft alongshore)
   1. Pocket
   2. Linear
   3. Shallow Bay (curvilinear)
   4. Salient (point)

E. Relative Stability
1. Stable
2. Accretionary
3. Land Transgressive/Erosional

F. Underlying Substrate
1. Marsh/Creek Bottom
2. Upland

G. Structure/Fill
1. Groin
2. Revetment/Bulkhead
3. Breakwater
4. Jetty
5. Beach Fill

Figure 3. Classification system for Chesapeake Bay identified dune systems (from Hardaway *et al.*, 2001).

The underlying substrate (F) is a general category for the type of substrate or sediment the dune resides on and against. Two broad categories were chosen - marsh and upland. The marsh category includes creek bottoms which should be a separate category because beach/dune development can occur across the mouth of a creek bottom without a true marsh. The distinction between upland and marsh was that the marsh substrate is usually a low bank subject to washover processes, whereas the upland area offered a "backstop" to land beach/dune migration.

If the site was not Natural (1), then the nature of man's impact was determined by the type of modification. The shore structures include Groins (G.1), Bulkheads and Revetments (G.2), Breakwaters (G.3), Jetties (G.4), and Beach Fill (G.5). The degree of impact any given structure or combination of structures had on the dune site was not always clear. The Relative Stability (E) relates in part to whether man's influence was erosive (destructive) or accretionary/stable (constructive).

2.2 Site Characteristics

Coastal zone profile and vegetation types present on dunes were determined by site visit. Beach profile transects were performed at most sites to measure the primary and secondary dune (where present) within 100 feet of the shoreline. Standard surveying and biological procedures were utilized. Not all dune sites were surveyed.

Each surveyed transect used the crest of the primary dune as the horizontal control and mean low water (MLW) as the vertical control. The primary dune crest was determined on site. The MLW line was indirectly obtained from water level measurements. The observed water level position and elevation were checked against recorded tidal elevations at the nearest NOAA tide station and time of day to establish MLW on the profile.

The typical dune profile has several components (Figure 4). A continuous sand sheet exists from the offshore landward and consists of a 1) nearshore region, bayward of MLW, 2) an intertidal beach, berm, and backshore region between MLW and base of primary dune, 3) a primary dune from bayside to landside including the crest, and, where present, 4) a secondary dune. All profiles extended bayward beyond MLW and landward to at least the back of the primary dune. The secondary dune crest, where present, was always measured, but the back or landward extent of the secondary dune could not always be reached. The dimensions, including lateral position and elevation of various profile components were measured. These include: primary dune crest elevation, distance from primary dune crest to back of dune, distance from primary dune crest to MLW, secondary dune crest elevation, secondary dune crest to back of primary dune, secondary dune crest to back of secondary dune, distance from back of primary dune to back of secondary dune, width of secondary dune, and width of primary and secondary dune.

During each site visit, dominant plant communities occupying the primary and secondary dunes (if present) were analyzed (Figure 4). Plant species distribution is based on observed percent cover in the general area of profiling and sampling within the identified dune reach.

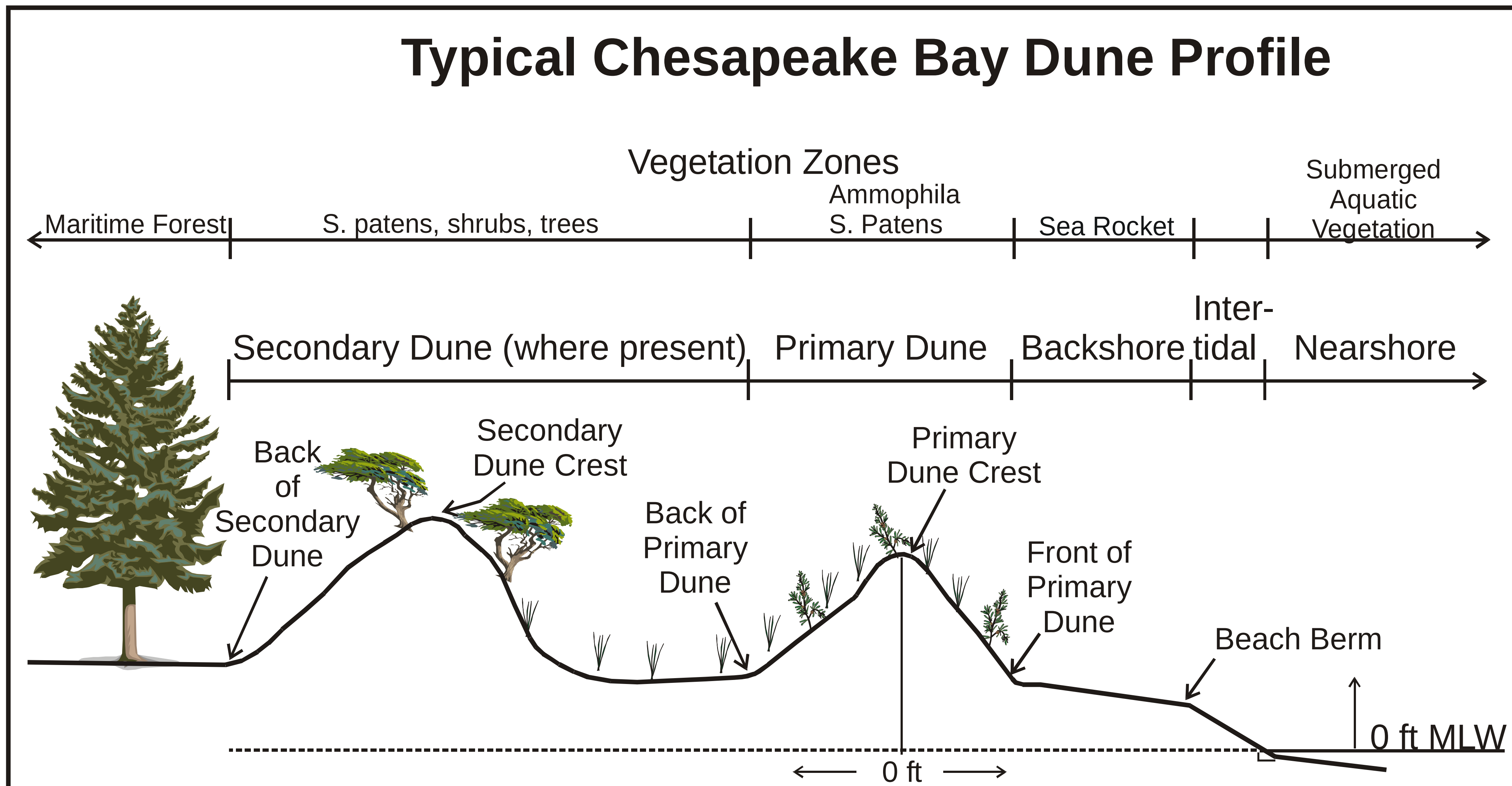

Figure 4. Typical profile of a Chesapeake Bay dune system (from Hardaway *et al.*, 2001).

3 DUNE DATA SUMMARY

Approximately 4.5 miles of dune shore have been identified along Norfolk's Bay shore. Previous work by Hardaway *et al.* (2001) indicated a total of 13 possible dune sites in Norfolk, but site visits verified 8. All the dunes cover a wide variety of fetch exposures and site conditions. Dune lengths vary from a hundred feet to a thousand feet. Dunes reside in areas of sand accretion and stability such as around tidal creek mouths, embayed shorelines, in front of older dune features, as washovers, as spits and against man-made structures like channel jetties or groin fields. Site visits occurred in 1999 and 2000; site characteristics may now be different due to natural or man-induced shoreline change.

In City of Norfolk, 4 of the 8 dune sites have both primary and secondary dunes. The average length of primary dune only sites is 300 ft while the average length of the primary with secondary dunes is 3,870 feet (when profiles 9A and 9B are combined to reflect one site). Clearly, the wider sites with secondary dunes are also the longest. The 3 main categories of Natural, Man-Influenced and Man-Made were initially utilized to portray a sites most influential element. In the City of Norfolk, no sites are considered Natural. One site, at the terminus of Willoughby Spit is considered Man Made; the other 7 sites are Man-Influenced.

The height of the primary dune varied along the City of Norfolk's coast between 9-21 feet MLW. However, the secondary dune heights were much more consistent at approximately 11 ft MLW. The distance between crests was somewhat consistent as well except for the site at the terminus of Willoughby Spit. That site is the recipient of a large amount of sand since littoral transport is to the west along this coast. This has allowed the site to continue to accrete both in beach width and dune width.

Table 1. Identified dune sites in City of Norfolk as of 2000. Site characteristics may now be different due to natural or man-induced shoreline change.

Dune Site No.	Location^ Easting (Feet)	Location^ Northing (Feet)	Date Visited	Dune Shore Length (feet)	Primary Dune Site?	Secondary Dune Site?
3	2,672,300	226,250	03-Aug-2000	2,750	Yes	No
4	2,669,000	227,300	03-Aug-2000	2,780	Yes	No
5	2,663,600	229,300	03-Aug-2000	7,390	Yes	Yes
6	2,658,250	233,200	03-Aug-2000	3,530	Yes	No
7	2,655,050	235,550	03-Aug-2000	680	Yes	No
8	2,653,500	236,350	03-Aug-2000	2,500	Yes	Yes
9A	2,647,400	238,850	03-Aug-2000	1,300	Yes	Yes
9B	2,647,100	238,900	03-Aug-2000	250	Yes	Yes
11	2,644,800	238,650	06-Jul-2000	2,680	Yes	Yes

^Location is in Virginia State Plane South, NAD 1927.

Table 2. Dune site measurements in City of Norfolk as of 2000. Site characteristics may now be different due to natural or man-induced shoreline change.

Dune Site Measurements									
	Dune	Primary Dune			Secondary Dunes				
	Shore Length	Crest Elev	Distance from Crest				Distance From		
			landward to back base	To MLW	2nd Dune	Crest Elev	Primary Crest to 2nd Crest	2ndCrest landward	2nd Crest seaward to 1st back base
Site No.	(feet)	(ftMLW)	(feet)	(feet)	Site	(ftMLW)	(feet)	(feet)	(feet)
3	2,750	21.6	46	227	No				
4	2,780	20.7	27	166	No				
5	7,390	14.7	35	156	Yes	11.3	54	19	18
6	3,530	13.9	32	97	No				
7	680	17.8	81	166	No				
8	2,500	11.7	24	85	Yes	11.7	53	23	29
9A	1,300	9.6	20	82	Yes	10.5	44	22	24
9B	250	12.1	27	132	Yes	10.9	38	46	11
11	2,680	9.7	30	144	Yes	11.6	117	198	87

Table 3. Dune site parameters in City of Norfolk as of 2000. Site characteristics may now be different due to natural or man-induced shoreline change.

Dune Site Parameters										
		Fetch Exposure	Shoreline Direction of Face	Nearshore Gradient		Morphologic Setting		Relative Stability	Underlying Substrate	Structure or Fill
Site No.	Type	A	B	C		D		E	F	G
3	Man Inf	Open Bay	North	Steep	bars	Dune Field	Linear	Erosional	Upland	Beach Raking
4	Man Inf	Open Bay	North	Steep	bars	Dune Field	Linear	Stable	Upland	Beach Raking
5	Man Inf	Open Bay	North	Steep	bars	Dune Field	Linear	Stable	Upland	Beach Raking
6	Man Inf	Open Bay	Northeast	Steep	bars	Dune Field	Linear	Erosional	Upland	Groin
7	Man Inf	Open Bay	Northeast	Steep	no bars	Dune Field	Linear	Erosional	Upland	Groin
8	Man Inf	Open Bay	Northeast	Steep	no bars	Dune Field	Linear	Erosional	Upland	Groin, BW
9A	Man Inf	Open Bay	North	Steep	no bars	Dune Field	Pocket	Erosional	Upland	Groin
9B	Man Inf	Open Bay	North	Steep	no bars	Isolated	Pocket	Erosional	Upland	Groin
11	Man Made	Open Bay	North	medium	no bars	Dune Field	Linear	Accretionary	Upland	Groin, BW, Beach Fill

4 INVENTORY

Each dune site is located on plates in Appendix A. The individual site inventory sheets are in Appendix B. Due to the mobile nature of dunes, their extent and morphology changes through time. The data presented in this report represents the status of the site at the time of assessment and to the best of the author's knowledge. This information is for general management purposes and should not be used for delineation. For detailed delineation of any dune site, the reader should contact the local wetlands board or Virginia Marine Resources Commission. See Figures 3 and 4 for description of the site parameters and measurements listed below.

Each dune site has the following information on its inventory page:

1. Date visited
2. Central site coordinates in Virginia South State Plane Grid NAD 1927
3. Coordinates of profile origin
4. Site length in feet
5. Plate Number
6. Site Type
7. Fetch Exposure
8. Shoreline Direction of Face
9. Nearshore gradient
10. Morphologic Setting
11. Relative Stability
12. Underlying Substrate
13. Type of structure or fill (man-influenced only)
14. Primary Dune Crest Elevation in feet above Mean Low Water (MLW)
15. Landward extent of Primary Dune from Dune Crest in feet
16. Distance from Dune Crest to MLW
17. Secondary Dune Crest Elevation in feet above MLW (if present)
18. Distance between Secondary Dune Crest and Primary Dune Crest
19. Landward extent of Secondary Dune from Secondary Dune Crest
20. Primary Dune vegetation communities
21. Secondary Dune vegetation communities
22. General Remarks

Also included on the dune site inventory page is the site cross-section, if surveyed, and ground photos, if taken. Some sites may have been represented with two or more profiles because the general morphology differs alongshore. Each profile was intended to be representative of that dune portion of the site (NF 9A and NF 9B).

5 REFERENCES

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Appendix A
Location of Dune Sites

Plate 1 – 2

Plate 3 - 4

Appendix B

Individual Dune Inventory Sheets

NF3
NF4
NF5
NF6
NF7
NF8
NF9A
NF9B
NF11