

ASSATEAGUE ISLAND BEACH RESTORATION

Section 7 Biological Assessment Piping Plovers and Seabeach Amaranth

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FINAL

Prepared for

U.S. Army Corps of Engineers
Baltimore District Office

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NOTE TO READER:

It is important for the reader to realize that this Biological Assessment was used to assist in the plan formulation process. The assessment was completed prior to the selection of a recommended plan and prior to the decision to include a monitoring and corrective action plan.

EXECUTIVE SUMMARY

Stabilization of the Ocean City Inlet through construction of jetties during 1934 greatly altered the sand supply and transport mechanisms on Assateague Island in Maryland. The jetties reduced the sand volume delivered to the island from the north via longshore transport, resulting in increased erosion rates and an accelerated retreat of the northern 13 km of shoreline. Although island retreat has been most pronounced in the northernmost 6.5 km of the island, it is believed that the northern 10km stretch may be vulnerable to breaching. Until a long-term restoration plan is implemented, several alternatives have been proposed for the immediate restoration of northern Assateague Island to return the sediment supply and prevent a breach.

The Coastal Engineering Research Center (CERC), through use of the SBEACH model, predicted nearshore wave transformation, beach profile changes, and water level responses. Based on these calculations, proposed alternatives for restoring the natural sand budget to northern Assateague Island were developed by the Baltimore District Office of the United States Army Corps of Engineers. "Dune Construction" alternatives include two dune heights with two volumes of sediment along two restoration lengths of the island. With the exception of the dune feature, the majority of the material will be placed intertidally. For the purpose of this document, a "No Action" and a "No Action, Repair Breach" will also be addressed as alternatives.

These alternatives may have impacts on piping plovers (*Charadrius melodus*) and seabeach amaranth (*Amaranthus pumilis*), which are both protected by the 1973 Endangered Species Act. Piping plovers have been monitored at Assateague Island National Seashore since 1986, and have ranged between 14 and 44 breeding pairs. During this time, the vast majority of nesting activity occurred along the northern 8 km of the island in sparsely vegetated habitats. In recent years, numbers of breeding pairs and productivity have increased, primarily in response to greater availability of nesting and foraging habitats, due to storm overwash, and lower predation rates. Seabeach amaranth is an annual plant endemic to barrier island systems along the Atlantic Coast, and has now been completely eliminated from six of the nine states where it historically occurred. Efforts to reestablish populations of seabeach amaranth are being considered by the Maryland Department of Natural Resources as part of overall federal recovery goals for this species.

Assuming a long-term restoration plan will be implemented within the next five years, the "No Action" alternative may benefit piping plovers by allowing current overwash frequencies to continue to maintain sparsely vegetated nesting areas and travel corridors for broods. Accreting sides of inlets, if a breach occurs, also provide suitable habitats for seabeach amaranth. However, the "No Action" alternative would result in the continuation of high erosion rates along the beach berm, which would not support seabeach amaranth.

Impacts from all dune construct alternatives, alternatives which involve placement of sediment on the island and along the intertidal zone, will depend on two factors: the magnitude and duration of storm events and the timing and type of construction activities. If predicted overwash effects are not realized, resulting in the invasion of vegetation into nesting and foraging habitats and/or creation of upland areas for den sites, adverse impacts to piping plovers are likely. However, if overwash frequencies and magnitude are enough to maintain open travel corridors between bayside and the ocean beach, adverse impacts are most likely to be minor. In addition, if construction activities are restricted to October through mid-March (time when the plovers are not present on the island) so that construction activities do not interfere with courtship, nesting, or brood-rearing, adverse impacts may be avoided. Placement of new material during the proper time may result in an increase in plover use and non-eroding habitats for seabeach amaranth. Differences in intensity or magnitude of impacts resulting from dune construct alternatives vary depending on dune height and volume of sand. Lowering the dune height increases the potential for effective overwash and decreasing the volume of sand decreases the length of time for construction activities. Mitigation measures incorporated into the proposed alternatives would lessen the severity of potential impacts and ensure protection of piping plovers and seabeach amaranth.

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1.0 INTRODUCTION

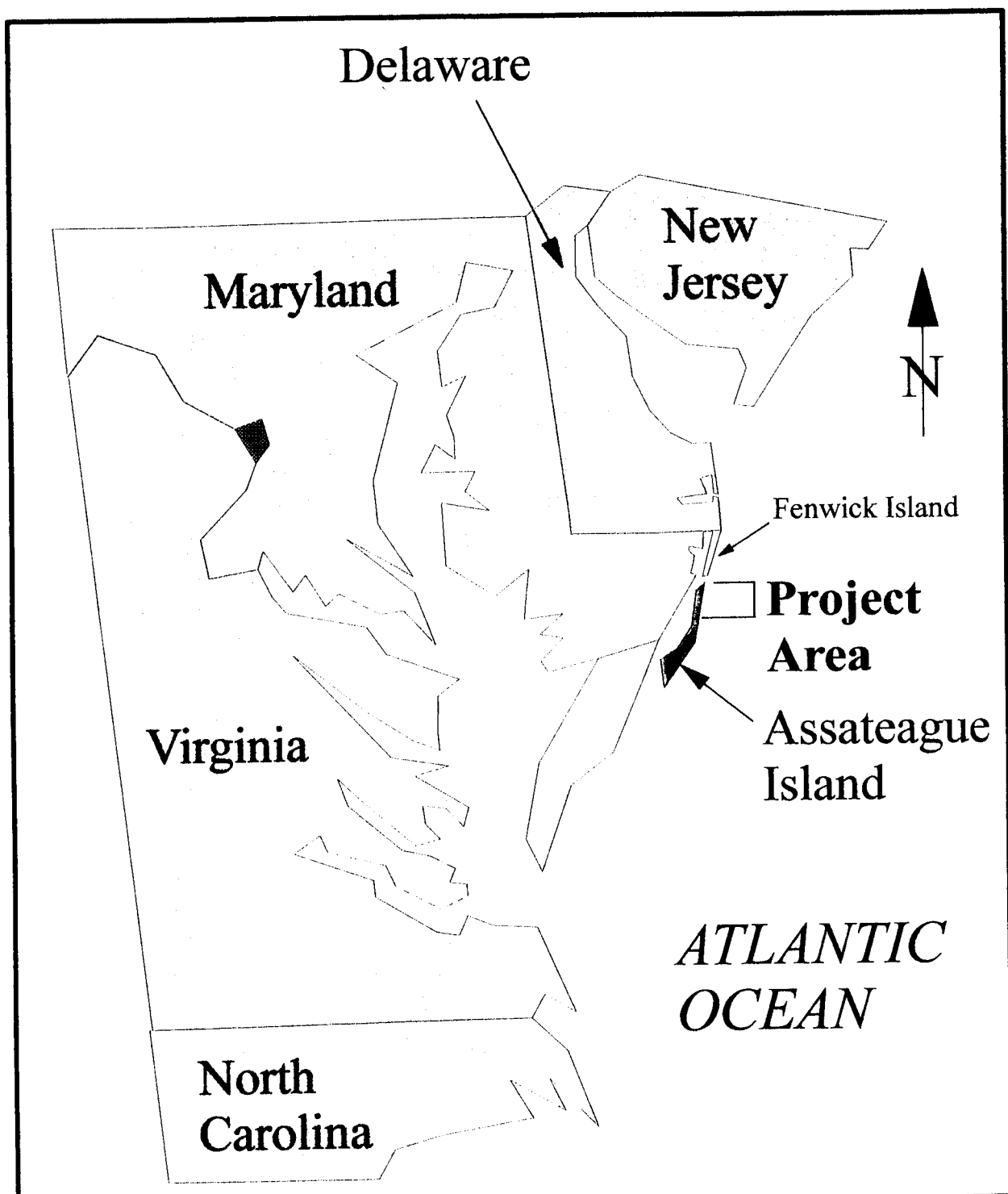
Sand supply and transport mechanisms on Assateague Island were greatly altered by the construction of jetties at the Ocean City Inlet, in Maryland, by the U.S. Army Corps of Engineers (USACE) in 1933-1935. Numerous physical, biological, and economic impacts to the northern portion of Assateague Island are now thought to have resulted from altering the Island's sand budget. Proposed alternatives for restoring the natural sand budget to northern Assateague Island are being developed by the Baltimore District Office of the USACE. These alternatives may have an impact on piping plovers (*Charadrius melodus*) and seabeach amaranth (*Amaranthus pumilis*), which are both protected by the 1973 Endangered Species Act (ESA), as amended. The ESA is administered by the U.S. Fish & Wildlife Service (USFWS).

Pursuant to Section 7 of the ESA, the USACE has prepared this Biological Assessment to evaluate the potential effects of the Assateague Island Beach Restoration Project on piping plovers and seabeach amaranth. The results of this assessment will be used by USACE and the USFWS to determine if formal consultation is necessary (Federal Register/Vol. 51, No. 106, Rules and Regulations 1986). If the USACE initiates formal consultation, the USFWS may use the assessment in formulating its biological opinion (50 CFR, Part 402.12(k)(2)). Findings of this assessment will also aid the USACE in determining a preferred project alternative.

2.0 REGIONAL AND PROJECT AREA DESCRIPTION

Assateague Island is located on the Delaware-Maryland-Virginia (Delmarva) peninsula long the Atlantic coastline (Figure 1). The island extends from Ocean City, Maryland, southward to Chincoteague Inlet, Virginia (Figure 2). The majority of Maryland's 35-km portion of the island is federal property managed by the National Park Service (NPS) as Assateague Island National Seashore (ASIS). The national park's boundary also includes the waters surrounding the island to one-half mile offshore, except where adjoining land masses restrict that distance and jurisdiction is reduced to half the distance to the adjacent shore (NPS 1993). The State of Maryland owns a 3.2-km section of the island that is managed as Assateague Island State Park. The Virginia portion of the island is under jurisdiction of the USFWS and managed as Chincoteague National Wildlife Refuge. The Maryland and Virginia island is approximately 58 km long and is separated from the Eastern Shore mainland by Sinepuxent and Chincoteague Bays. The island's width south of State Park is much wider than the northern end. The average width of the northern 8.5 km of the shoreline is only between 120 to 215 m. Assateague Island is the longest unbroken coastal barrier along the Delmarva Peninsula (Geotlle 1978).

The project area that may be directly affected by the proposed beach restoration project includes approximately the northern 13 km of the island between Ocean City Inlet and a point just south of Assateague Island State Park (Figures 3 and 4). This northern end of the island has experienced the highest rates of erosion, and relatively frequent overwash events make it more vulnerable to breaching than portions of the island to the south (Dean and Division of Beaches 1986).



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FIGURE 1

Regional Project Area Location

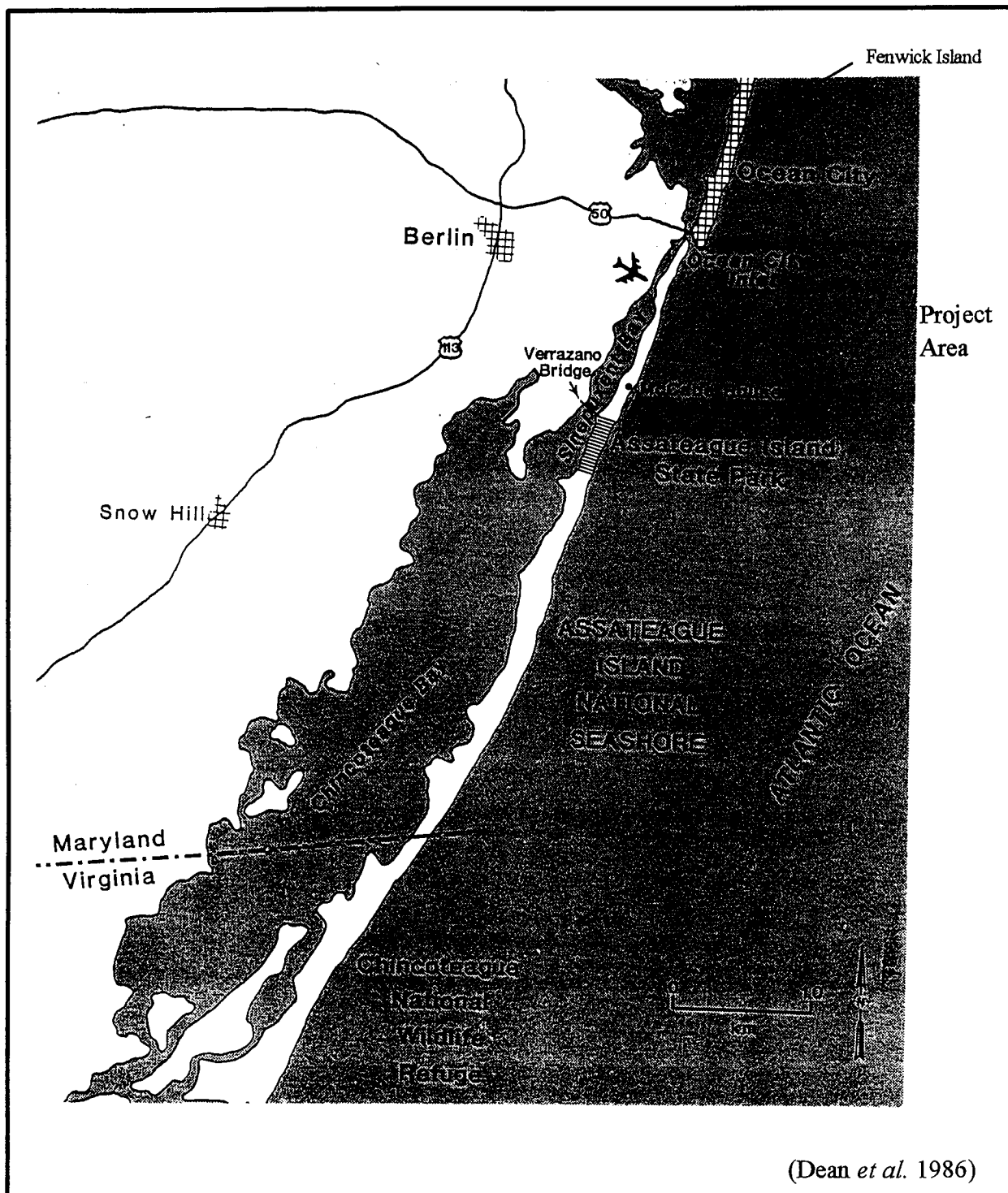


FIGURE 2
Project Area Location



Northern End of Project Area Looking South from Ocean City Inlet along Assateague Island, April 1992 (MacIvor 1992).



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FIGURE 3

Northern End of Project Area



Southern End of Project Area Looking North from Assateague State Park Boundary along Assateague Island, April 1996. (MacIvor 1996).



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FIGURE 4
Southern End of Project Area

2.1 Review of Island Characteristics and Changes

The northern end of Assateague Island has historically been characterized by narrow widths, low-lying dunes, and washover fans. Early accounts of grazing by horses, sheep, goats, hogs, and cattle on Assateague Island's salt marshes were reported by Perkins and Bacon (1928). However, the extent and cumulative impacts of grazing, especially by horses, on northern Assateague Island's vegetation has not been documented. Prior to the existence of Ocean City Inlet (Figure 5), Shreve *et al.* (1910) described the island's morphology as a series of low and comparatively stable dunes that were discontinuous along the ocean side. The predominant plant along the dunes was American beach grass (*Ammophila breviligulata*). Shreve described a small grove of loblolly pines (*Pinus taeda*) near Fenwick Light, at the extreme northern end of the sand bar, as being the only trees on the island's northern end, suggesting that maritime forest was absent. There was also indication of low shrub thickets and other low vegetation along the lee side of a continuous dunefield (Shreve *et al.* 1910).

Prior to 1933, what is currently known as northern Assateague Island was called Assateague Spit. Although Ocean City and Assateague Island were a part of Fenwick Island spit, Assateague Island was considered distinct from Fenwick Island. However, neither were actually islands and were instead extensions of the Bethany Beach, Delaware, headland (Underwood and Hiland 1995). On August 23, 1933, hurricane forces caused a major breach in the area now known as Ocean City Inlet, separating Fenwick Island to the north from Assateague Island to the south (Truitt 1967). Prior to stabilization, this inlet was approximately 3 m deep and 76 m wide (Underwood and Hiland 1995). One month later, the USACE began to stabilize the inlet through construction of stone jetties. Construction of the north jetty was initiated in September 1933 and completed by October 1934. South jetty construction began in October 1934 and was completed eight months later, in May 1935. Since that time, Ocean City Inlet has been maintained by dredging.

During 1849-50, island widths ranged from about 235 m to 527 m (770-1730 ft) (USACE 1994) and northern Assateague Island was thought to be migrating landward at the rate of approximately 2 m/yr (Underwood and Hiland 1995) (see Figure 6). At this time, a dynamic equilibrium existed between sand erosion and deposition, resulting in a relatively balanced sand budget. For example, sand lost during oceanside erosion processes was compensated for by sand deposition to the bayside through overwash processes. The Ocean City Inlet and jetties, resulting from the 1933 breach, interrupted the longshore transport of sand and caused sand accumulation on Ocean City beaches on the north side of Ocean City Inlet. In addition, offshore ebb-tidal and bay flood tidal shoals developed, trapping littoral materials before they reached Assateague Island. Sediment starvation on the south side of the inlet resulted in erosion on the ocean side of Assateague Island at a rate that outpaced formation of new land on the bayside. The impact on the northern-most 8.5 km was severe, with shoreline erosion and recession rates increasing to 9-12 m/yr (30 to 40 ft/yr) (Leatherman 1979).

Although accelerated retreat of the shoreline decreased the width and acreage of Assateague Island (see Figure 6) after 1934, it has been determined that net erosion (loss of volume) was occurring on northern Assateague Island even prior to inlet stabilization (USACE 1996). This indicates that the natural condition of the north end of the island was



Approximate Location
of Ocean City Inlet

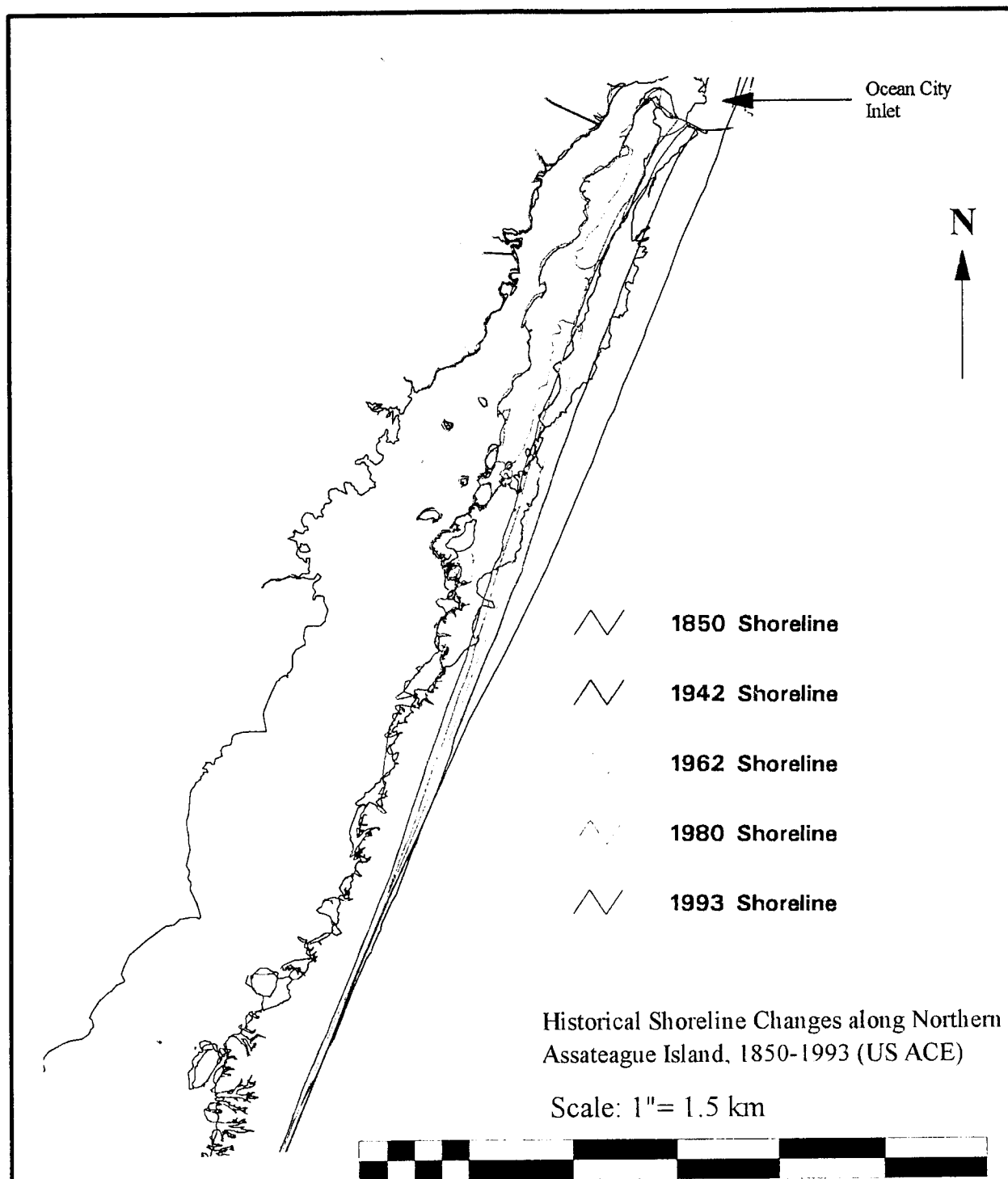
(Photograph taken in 1928)



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FIGURE 5

Ocean City Inlet Prior to 1933



typically narrow, low topography with frequent overwash. However, the rate of loss was much greater after the placement of the jetties. For example, between 1850-1933, the average net volume loss prior to inlet construction was 150,000 cubic meters per year, and between 1933-1995 was 255,000 cubic meters per year (USACE 1996). By the early 1950s, overwash deposition on the bayside appeared to reach a dynamic equilibrium with ocean-side erosion (USACE 1994), and by 1962 island widths ranged from about 161 to 311 m (530-1020 ft). Island width has actually increased since that year, partially due to routine and emergency placement of dredge material by USACE on northern Assateague.

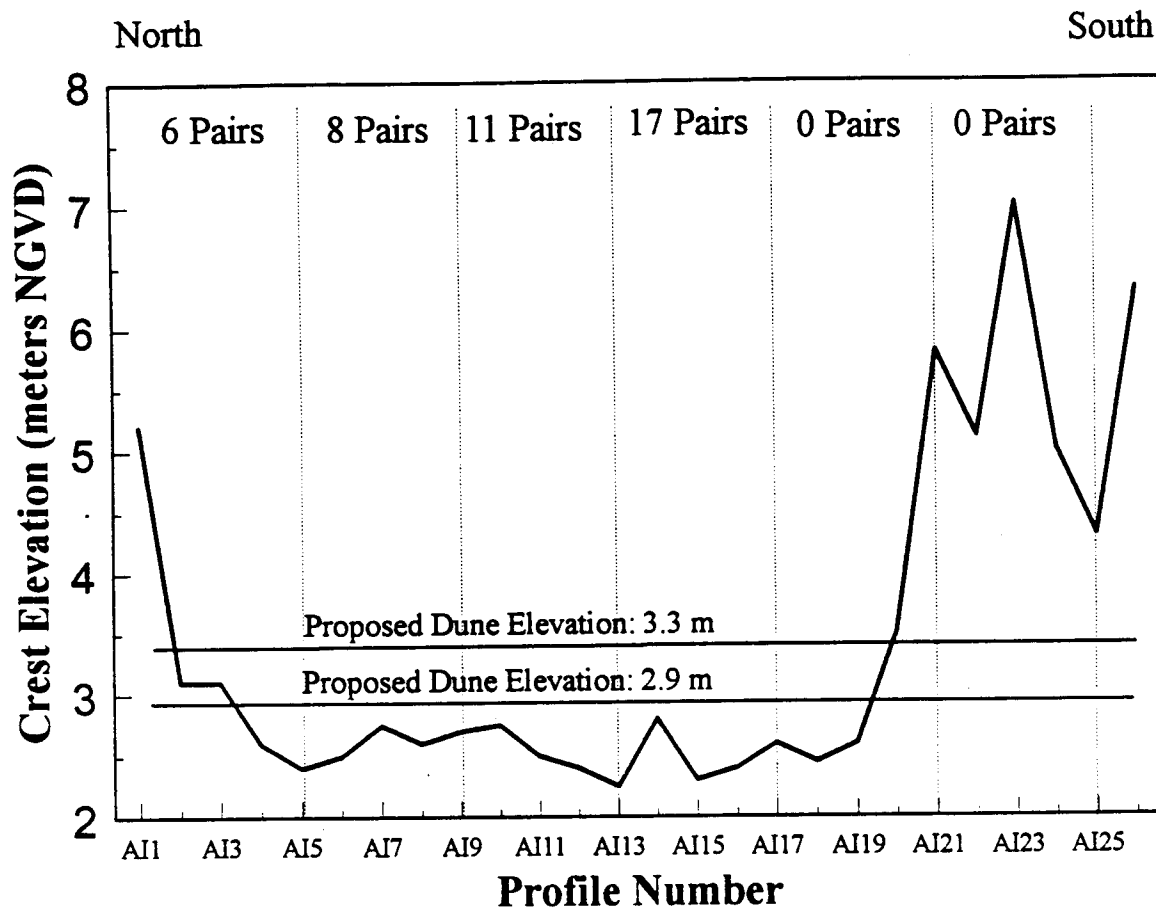
Strong northeasterly storms in November 1961 and March 1962 caused an additional two breaches on Assateague, one located at the inshore end of the south jetty (northern breach), and the other approximately 1.5 km south of Ocean City Inlet (Dean and Division of Beaches 1986). On March 9, 1962 the northern breach was calculated at mean low water (MLW) to be 122 m (400 ft) wide and 1.2 m (4 ft) deep. Since the southern breach was not affecting the navigation channel, it was not eligible for repair by the USACE. However, while construction activities were underway to fill the northern breach, some of the newly-deposited sand drifted to the southern breach and closed it off (Dean and Division of Beaches 1986). It is important to note that greater than one million cubic meters of sand were used to fill the northern breach in 1962. By 1965, this areas had breached again. A profile of the northern portion of the island and corresponding number of piping plover breeding pairs during 1995 are given in Figure 7.

During the 1962 northeastern storm, 32 of the 50 dwellings located on Assateague were lost and several others were damaged. Federal assistance to implement shoreline protection measures was requested by private citizens, but was rejected by the federal government. As federally-protected coastal recreation areas became more and more desirable, however, interests grew for creating a National Seashore. Finally in 1965, the Assateague Island National Seashore was officially authorized.

2.2 Piping Plovers

In 1986, piping plover populations were listed as endangered or threatened under provisions of the ESA (USFWS 1985). The Atlantic Coast population, which is considered threatened under the ESA, breeds and nests on sandy beaches along the east coast of North America from Newfoundland to South Carolina. Piping plovers typically nest above the high tide line along ocean shorelines, along gently-sloping foredunes, in blowout areas behind primary dunes, overwash fans and sandflats at inlets or ends of barrier islands, and in washover areas caused by the flow of water moving across the storm berm (USFWS 1995a). Preferred foraging areas include intertidal zones along ocean beaches, washover areas that remain moist throughout the summer, mud and sandflats, wrack lines, and shorelines of ponds and salt marshes (USFWS 1995a). One of the primary objectives of the Atlantic Coast piping plover recovery effort includes achieving well-distributed increases in numbers and productivity of breeding pairs. In recent years, Maryland has contributed dramatically to this goal with breeding pairs and productivity numbers reaching record highs.

Piping plovers typically return to the mid-Atlantic region in mid-March, but have been



Longitudinal profile of the northern end of the island. Data is from 1995. Maximum elevations run along berm or dune crest. Profile numbers increase southward. Profiles are placed at 0.5 km intervals; profile AI20 is located 10 km south of Ocean City Inlet.

Number of breeding pairs of piping plovers are calculated per 2 kilometers (dashed lines) and are based on 1995 nesting data.

(US ACE 1995)



FIGURE 7

**Assateague Island Dune Crest Elevations
and Number of Breeding Pairs in 1995**

observed as early as February 24 in Virginia (Cross 1991). Males begin to establish territories by early April. First nests on northern Assateague Island have been found as early as the third week of April (NPS reports), but eggs may be present on the beach from mid-April to late July (USFWS 1995a). Southward migration to the wintering grounds extends from late July, August, and September, but plovers are occasionally sighted during October (USFWS 1995a).

Although piping plovers depend on habitats that may change between years, they typically exhibit great site tenacity within and between years (Haig and Oring 1988, Wiens and Cuthbert 1988, MacIvor 1990). Over a six-year period, approximately 70 percent of surviving adult plovers were site faithful in Manitoba, Canada. At four breeding localities in Minnesota, 84 percent of all breeding birds nested within 200 m of their nest site of the previous year. At ten breeding localities over a five year period along Cape Cod, Massachusetts, up to 80 percent of banded surviving adults returned to the same breeding area to nest, and site fidelity was greater in males than females (same authors as above).

In some years, frequent clutch failures due to predators and storms provide opportunities for birds to change mates within the breeding season. Piping plovers are known to exhibit high mate-retention within the nesting season, but do not typically retain the same mate between years even if both birds return the following year (Haig and Oring 1988, MacIvor 1990). During studies in Manitoba, Canada, adults typically kept mates after nest destruction, but changed territories (Haig and Oring 1988). Birds changed territories more often following nest destruction by storms than following destruction by predation.

Shoreline stabilization and development along the Atlantic seaboard have been major contributors to the piping plover's decline through degradation and direct loss of habitat (Wilcox 1959). Predation and disturbance by humans and pets are also major factors that have limited reproductive success at many Atlantic Coast sites (Cairns and McLaren 1980, Flemming *et al.* 1988, MacIvor 1990, Patterson *et al.* 1991).

Maryland's remaining population of piping plovers is restricted to the Assateague Island National Seashore portion of the Island. This population has been monitored since 1986. During 1986-95, Maryland's portion of Assateague Island has supported between 14 and 44 breeding pairs of piping plovers. Reproductive success, measured as the number of chicks fledged per nesting pair, has greatly varied due to effects of predation and low chick survival caused by restricted access to the bay side for foraging (Table 1). During this time, the vast majority of nesting activity occurred along the northern 8 km of the island.

On Assateague Island in Maryland, piping plovers typically nest in open sandy areas that are frequently mixed with shell and cobble and have little or no vegetation. During a three-year study on Assateague Island by Loegering (1992), 81 percent of 46 plover nests had no vegetation near the nest. Between 1992-95, 68 percent (98 of 145) of total nests occurred in open habitats without vegetation (NPS Annual Reports 1992-95).

Table 1. Summary of Piping Plover Reproductive Success on Assateague Island National Seashore, 1986-1995

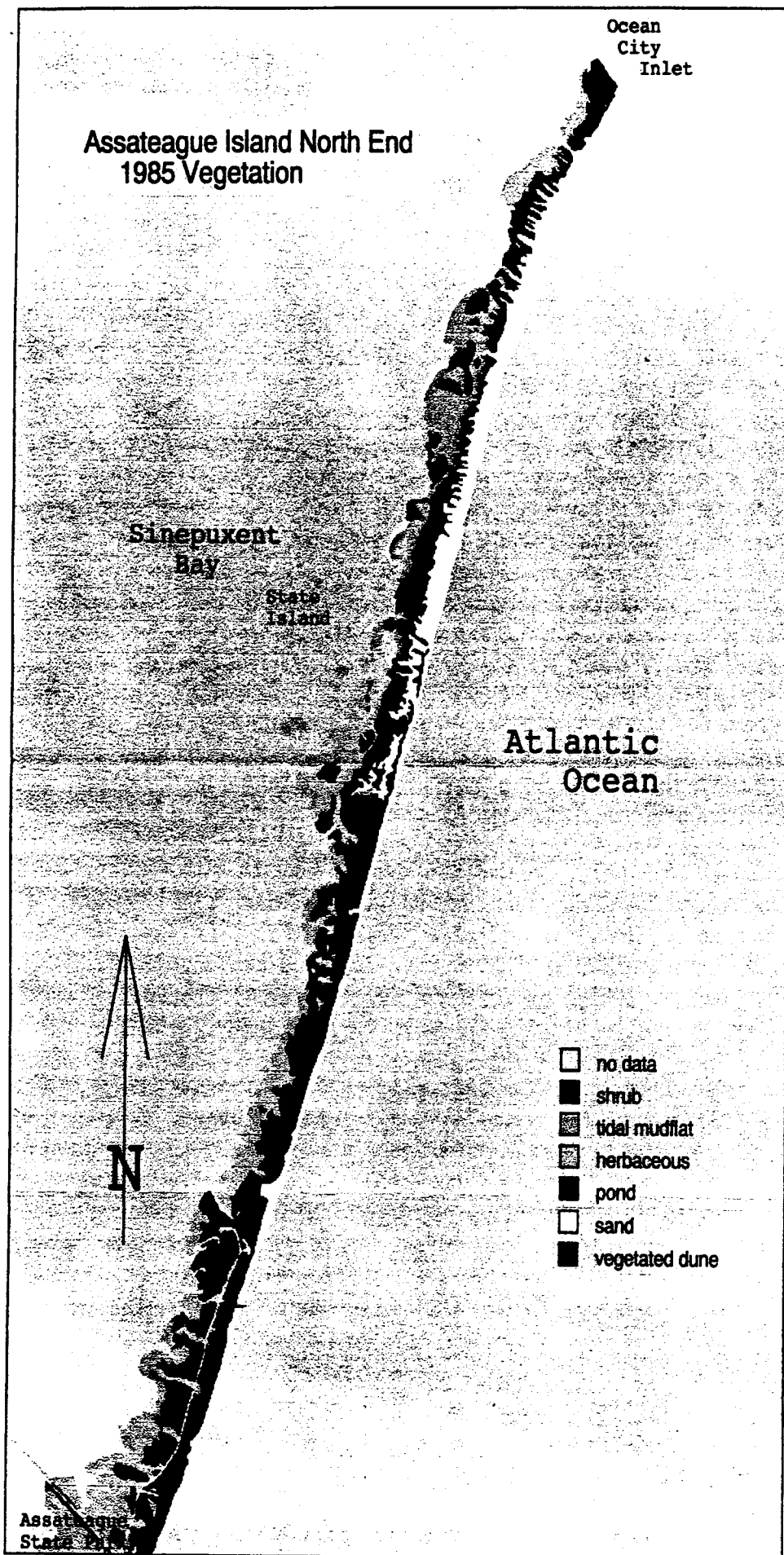
	86	87	88	89	90	91	92	93	94	95
Breeding Pairs	17	23	25 ^d	20 ^d	14 ^d	18	24	20	32	44
Nest Attempts	23	33	34	27	20	20	30	30	42	45
No. Eggs Laid	87 ^a	124 ^a	116	92	76	77	104	104	155	168
Chicks Hatched	38	46	37	36	25	47	43	39	104	148
Hatching Success (%) ^b	44	37	32	39	33	61	41	38	67	88
Chicks Fledged	18	27	13	18	11	07	24	34	77	76
Fledging Success (%) ^c	47	59	35	50	45	15	56	87	74	51
No. Fledged per Breeding Pair	1.06	1.17	0.52	0.90	0.78	0.41	1.00	1.70	2.41	1.73
No. Fledged per Nest Attempt	0.78	0.82	0.38	0.67	0.55	0.35	0.80	1.13	1.83	1.69

^a Estimated from available data (Patterson 1988)^b Number of chicks hatched per eggs laid^c Number of chicks fledged per chicks hatched^d Reproductive success was calculated from nesting pair (Loefering 1992)

Piping plovers on Assateague rear their broods on the bay beach, in the island interior, and on the ocean beach (Loefering and Fraser 1995). In certain years, vegetation blocked access between nest sites and the bay side, causing chicks to be restricted to ocean side foraging. Survival rates of chicks raised on the ocean beach were found to be lower than those of chicks reared on the bay beach (Patterson *et al.* 1991). During 1988-90, chicks with access to the bay side had higher daily survival rates than those without access (Loefering and Fraser 1995). Further, they found that piping plover chicks that occupied bay beach and island interior habitats had higher daily survival rates than chicks in ocean beach habitat. For chicks less than 20 days old, foraging rates on ocean beach were lower than on bay beach and island interior habitats. Findings from this study on northern Assateague indicated that ocean beaches had fewer insects, chicks foraged at a lower rate along the ocean beach, chicks weighed less, and exhibited higher mortality than chicks elsewhere.

Overwash has played an important role in maintaining suitable piping plover habitat on Assateague Island. Overwash was defined by Leatherman (1988) as any swash uprush that crosses the dune line or, if no dunes are present, the storm berm. Storm overwash can occur in a variety of situations, including through narrow dune gaps, over wide sections of the barrier with low dune topography, or over an entire stretch of the barrier island. Depending on storm magnitude and island width, the flow of water may or may not carry sand to the barrier flats and/or marsh on the bayside. An overwash fan was defined by Elias-Gerken (1994) as a break in a continuous dune or vegetation line where storm tides carry sand from oceanside to bayside, often clearing a vegetation-free path from ocean to bay. Usually overwashes occur during coastal storms, but a marginal event can occur during extremely high spring tide conditions at lower areas along the barrier dune line. On northern Assateague Island storm overwashes typically occur over wide sections of the barrier with low dune topography. During some storm events, overwashes have occurred over entire stretches of the island. During overwash, if scour of the barrier gets to an elevation below mean sea level, an inlet is created (Leatherman 1988). On the north end of Assateague Island, overwash processes appear to be essential in maintaining high quality piping plover nesting and brood rearing habitat (Loefering and Fraser 1995).

It is likely that piping plovers historically relied on winter storm events to create and maintain suitable nesting and foraging habitats by scouring and covering up vegetation (Loefering 1992). Maps showing overall vegetation cover along the northern 8 km of Assateague Island between 1985 and 1995 indicate great changes in the distribution of the island's plant communities (Figure 8). During Loefering's study, from 1988-90, there were no cross-island overwashing storm events and dramatic vegetative succession occurred within two years (Loefering, pers. comm.). He believes that the lack of overwash activity that resulted in vegetation encroachment, which reduces foraging opportunities for plovers, was a major factor in the population decline on northern Assateague Island during those three years (from 25 to 14 pairs). During this time, plover broods restricted to the ocean beach by either dunes or vegetation had adequate nest success but nearly all chicks died. A relationship between the presence of overwash corridors and piping plover productivity was documented during this study (Loefering and Fraser 1995). Loefering also predicted that a piping plover population increase would follow major storm events.



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FIGURE 8A
Northern Assateague Island Vegetation, 1985

(National Park Service)

Assateague Island North End
Plover Vegetation Map
1995

Sinepuxent
Bay

State
Island

Atlantic
Ocean

- chick forage areas
- ◆ plover nest
- no data
- shrub
- ▨ tidal mudflat
- ▩ herbaceous stand
- pond
- vegetated dune
- unconsolidated sand
- scattered herbaceous
- interior mudflat
- overwash sandflat



Northern Assateague Island Vegetation, 1995

FIGURE 8B

(National Park Service)

Following the January 1992 storm, much of the northern portion of Assateague Island experienced cross-island overwash that scoured or covered vegetation. Large expanses of vegetation-free areas were created, increasing the areas available for nesting and improving access to the bay side for foraging chicks. Data collected between 1992-95 also showed a preference for interior and bay habitats by chicks. During these four years, 91 percent (1,621 of 1,775) of all chick observations along the northern 8 km of the island were of chicks using interior and bayside habitats and 9 percent (154 of 1,775) were of chicks using ocean beach habitats (NPS Annual Reports 1992-95).

Based on aerial photographs between 1992 and 1996, it appears that there has been very little change in overall vegetation and sand cover. Large areas of sand with low-lying dunes remain and areas that allow cross-island overwash are common. The more recent photographs (Sept. 1995) indicate that there are more channel corridors from the bay side and that they cross farther over towards the ocean side than in 1992. The role that bay side flooding plays in maintaining overwash areas is not well understood.

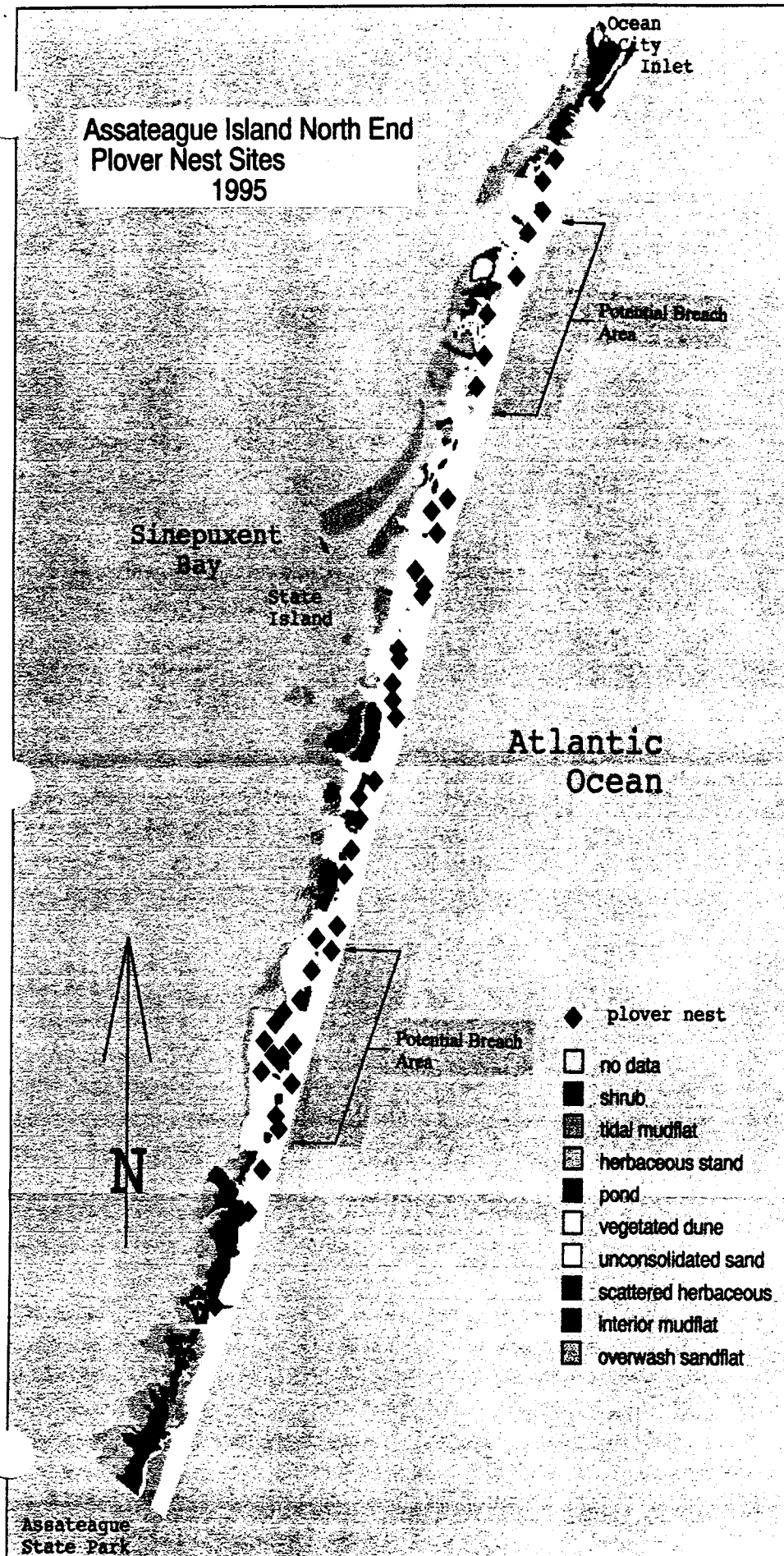
In 1995, the piping plover population increased to 44 breeding pairs, the highest number of pairs since monitoring began. Nearly 100 percent of the open areas were used by piping plovers for nesting and/or foraging (Figures 9 and 10). One of the two areas considered in this project as vulnerable to breaching consists of a large, mostly flat and unvegetated overwash area. (Figure 11). This low-lying area supported the highest concentrations of nesting plovers during 1995. However, reproductive success was lower in this area compared to other areas during 1995, potentially due to exposure to predators and weather because vegetation was completely lacking (Brady *et al.* 1995).

2.3 Seabeach Amaranth

Seabeach amaranth is an annual plant endemic to the barrier island beaches of the Atlantic Coast. Its primary habitat consists of overwash flats at accreting ends of islands, lower foredunes, and upper strands of noneroding beaches (USFWS 1995b). No vascular plant occurs at a lower topographic position on beaches than seabeach amaranth, though several others, notably saltwort (*Salsola australis*) and sea rocket (*Cakile edentula*), occur with amaranth. Seabeach amaranth occupies elevations from 0.2 to 1.5 meters (8 inches to 5 feet) above mean high tide and is usually found growing on nearly pure silica sand substrates, occasionally with a few shell fragments mixed in.

It historically occurred in nine states from Massachusetts to South Carolina. This species has now been completely eliminated from six of the States, including Maryland. Of the 55 remaining populations, 34 occur in North Carolina, 8 are in South Carolina, and 13 are in New York. Seabeach amaranth was federally-listed as threatened by the USFWS in 1993

due to its vulnerability to threats and its extirpation from two-thirds of its historic range (USFWS 1993). Proposed recovery objectives outlined in the Technical/Agency Draft Recovery Plan for Seabeach Amaranth calls for reestablishment of the species in eight of the nine states in its historic range (USFWS 1995b).



(National Park Service)



FIGURE 9
1995 Piping Plover Nest Sites
and Potential Breach Areas

**Assateague Island North End
Plover Forage Areas
1995**

Sinepuxent
Bay

State
Island

Atlantic
Ocean

Ocean
City
Inlet

— chick forage
areas

- ☐ no data
- ☒ shrub
- ☒ tidal mudflat
- ☒ herbaceous stand
- ☒ pond
- ☐ vegetated dune
- ☐ unconsolidated sand
- ☒ scattered herbaceous
- ☒ interior mudflat
- ☒ overwash sandflat



Piping Plover Brood Foraging Territories
1995

FIGURE 10

(National Park Service)



Area Vulnerable to Breaching, 6-7 km South of Ocean City Inlet, Assateague Island, April 1996 (MacIvor 1996).

Germination takes place over a relatively long period of time, generally from April to July (USFWS 1995b). Flowering can occur as early as June, but typically begins in July, and continues until the death of the plant in late fall. Seed production begins in late summer and continues until the death of the plant. Seeds are regularly produced by nearly all adult plants and seed fertility is assumed to be high. Under favorable conditions (without extreme weather events or webworm predation), the reproductive season may extend until January, or sometimes later in the south (Weakley and Bucher 1992). Presence of plants in any given year is evidence of reproduction in the former year, or even earlier reproduction and seed-banking. However, Ehrenfeld (1990) states that seed-banking in dune soils is small to nonexistent, likely due to the instability of the soil. Continual disturbance through deposition and erosion could either bury seeds too deeply for emergence or remove them entirely. However, it has been reported that dredged material placed on the beach harbored seabeach amaranth seeds that subsequently germinated and became established (pers. comm., N. Murdock, USFWS, to L. MacIvor on 30 May 1996). Based on morphology of the flower and inflorescence, seabeach amaranth is likely wind pollinated.

Seed dispersal is one of the most important characteristics of the biology of an annual plant such as seabeach amaranth. Lincoln *et al.* (1982) describe this species as a classic example of a fugitive species -- "...an inferior competitor which is always excluded locally under interspecific competition, but which persists in newly disturbed habitats by virtue of its high dispersal ability: a species of temporary habitats." Habitats for this species are sparsely vegetated barrier beach systems with annual herbs and, less commonly, perennial herbs and scattered shrubs. Many of these species are salt-tolerant and have life-histories that allow them to invade suitable habitat when it becomes available. Schafale and Weakley (1990) classified this vegetation type as Upper Beach.

Substantial or total mortality may be caused by early summer or fall hurricanes. This mortality does not necessarily result in population extirpation, but does reduce seed production, especially if the disturbance occurs during the growing season. For example, in 1989 Hurricane Hugo ended the amaranth season from Cape Fear south. However, amaranth populations that had been absent for several decades, reappeared in New York following Hurricane Hugo. Although this species may prefer disturbed overwash areas, such as washover flats and accreting ends of islands, storm tides during the early growing season can cause early mortality of young plants. Although hurricane flooding will generally kill seabeach amaranth plants, effects of a major hurricane such as Hugo on populations of this species need to be investigated (USFWS 1995b). Seabeach amaranth appears to be intolerant of competition and does not occur on well-vegetated beaches.

The absence of seabeach amaranth in certain portions of North Carolina corresponds closely with the artificial construction of a continuous barrier dune by the NPS. When looking at areas that represent altered and natural states of barrier islands in North Carolina, the most striking contrast is a large difference in beach width. The unaltered islands, which are more likely to have seabeach amaranth, have much wider beaches than the stabilized ones.

In Maryland, seabeach amaranth was last reported during botanical surveys on

Assateague Island in 1967 (Higgins *et al.* 1971). Hill (1986) returned to the reported location, but after extensive searches did not find it. The Maryland Natural Heritage Program is considering a reintroduction project on Assateague Island. Without the reestablishment of seabeach amaranth in Maryland, it is unlikely that the recovery objective will be met to reestablish populations in eight of the nine states where it historically occurred.

3.0 PURPOSE AND NEED FOR PROJECT

Although major shoreline retreat rates have been evident along northern Assateague Island between 1850 to 1993 (Figure 6), the recession and erosion rates have noticeably increased along the northern 8.5 km since 1933. The natural opening of the Ocean City Inlet by the 1933 hurricane, and subsequent stabilization and maintenance of the Inlet, has resulted in sediment starvation at the north end of Assateague Island. This has resulted in a very low-profile barrier island with increased vulnerability to breaching, a reduction of the island's buffering effect of the mainland during storm events, and altering of ecological character. Due to the accelerated erosion and landward migration of the island, as well as the potential impacts on natural resources and visitor use, the NPS identified the erosion problem as a priority management concern. It has been reported that if erosion continues at its present rate, the island is likely to breach by the formation of a new inlet at any time and is expected before the year 2020 (Dean and Division of Beaches 1986).

3.1 Project History

In February 1986, the NPS sponsored a workshop with the purpose of identifying appropriate management alternatives for addressing the erosion problem and its impact on island geomorphology, estuarine biology, and socioeconomic factors (Dean and Division of Beaches 1986). In July 1990, staff from NPS met with the U.S. Army Corps of Engineers Waterways Experiment Station's Coastal Engineering Research Center (CERC) to discuss physical and ecological changes occurring along northern Assateague Island. By 1992 a contract was in place to continue work on analyzing historical shoreline erosion trends along northern Assateague Island and evaluate how they may correlate with the Ocean City Inlet ebb-shoal growth (Underwood and Hiland 1995).

In 1994, the USACE completed a comprehensive study of navigation, storm damage, environmental quality, and water resources and evaluated how they are impacted by the dynamic processes associated with Assateague's barrier island and bays (USACE 1994). The reconnaissance surveys defined the general scope of the problems within study area and determined federal interests (USACE 1994). This study included a discussion of endangered, threatened, and rare species, but did not address specific impacts to these resources.

3.2 Current Problems

Sections within the northern 10 km portion of the island now appear to be highly vulnerable to breaching and this threat may even extend to 13 km south of the Ocean City Inlet jetties. However, available data suggest that the greatest amount of island retreat is along the northernmost 8 km. Current erosional conditions do not favor the reestablishment of natural dunes. Also, destruction of the primary dune system on the northern end of the island has diminished the ability of northern Assateague to buffer the mainland from coastal storms.

The Ocean City Water Resources (OCWR) study team has recently proposed a problem statement, objectives, and alternative solutions for immediate measures to restore the sediment supply and prevent a breach on northern Assateague Island until a long-term solution is implemented.

3.3 Proposed Project Description

Although long term goals by ASIS include environmental restoration of Assateague Island to counter effects of sand starvation caused by artificial stabilization of Ocean City Inlet, long-term management solutions are only in the initial planning stages at this time. This assessment will address the impacts of the short-term actions only for the immediate restoration of northern Assateague Island. Realizing that the proposed alternatives for the immediate actions will likely provide the island with only temporary protection and short-term restoration of sand, future implementation of a long-term restoration program is critical.

The current project area encompasses approximately the northern 13 km of the island (Figure 2). The area considered for the short-term assessment occurs between Ocean City Inlet and the State Park (Figures 3 and 4). However, the area of most concern is the northern-most 8 km due to its low lying topography and susceptibility to overwash. Two areas have been identified as being vulnerable to breaching (Figure 9). One location, approximately 1.5 km to 3 km south of the Inlet, was identified as having the highest shoreline erosion rate within the northern 10 km (Dean and Division of Beaches 1986). This study predicted that within a few years the barrier morphology would be so low and narrow that breaching would likely occur. The other area was recently identified as vulnerable based on its low topography and its frequent overwash activity. This area is located between 6.0 km to 7.5 km south of the Inlet (USACE 1996).

Sediment restoration and breach prevention were identified as co-principal objectives by the OCWR study team. To address restoring the sediment supply, a restoration volume was calculated based on the year the National Seashore was established. CERC determined that since 1965, over 3,000,000 m³ of sand has failed to reach Assateague Island due to the interruption of the normal longshore transport system caused by the placement and maintenance of the jetties. The proposed lengths of the island considered for restoration are based on historical and current data, reports, maps, and aerial photographs indicating where accelerated retreat has occurred.

Based on longitudinal profiles of the northern 13 km of the island (Figure 7), a 9.2-km reach of the island is especially vulnerable to breaching. To reduce the probability of a breach, the OCWR study team proposed that island height and width be increased. However, CERC predicted that only a small decrease in water level response will result from a width increase alone and that island height is a much more important variable. Based on these findings, alternatives that rely on increasing width alone were excluded. The locations for placing sediment are along the shoreline of the restoration reach.

Two dune heights along two restoration shoreline lengths using two volumes of sand have been proposed under alternatives involving dune construction (Table 2). To maintain quality habitat for nesting plovers by keeping out woody vegetation and preventing a

Table 2. List of Alternatives Involving Dune Construction

Preliminary Restoration Length (km) (measured from inlet)	Preliminary Volume of Material (m ³)	Berm Height (m) NGVD	Berm Extension (m)
~10	~1,500,000	2.9	To be determined
		3.3	To be determined
	~3,000,000	2.9	To be determined
		3.3	To be determined
~13	~1,500,000	2.9	To be determined
		3.3	To be determined
	~3,000,000	2.9	To be determined
		3.3	To be determined

dominance of perennials, it was determined that an overwash frequency of at least one event per one to two years or less (i.e., cross-island overwash) was required (pers. comm., A. Weakley, The Nature Conservancy, N.C., to USACE, 4 December 1995). Although the importance of overwash seasonality is unknown, overwash activity would be most expected during hurricane and northeaster seasons (Dolan *et al.* 1988). Based on water level responses for frequent storm events over the past six years near Assateague, CERC calculated that the maximum berm height that would allow for the needed overwash frequency of once per year or less would be 3.3 m NGVD (National Geodetic Vertical Datum). The other height that was proposed is 2.9 m NGVD.

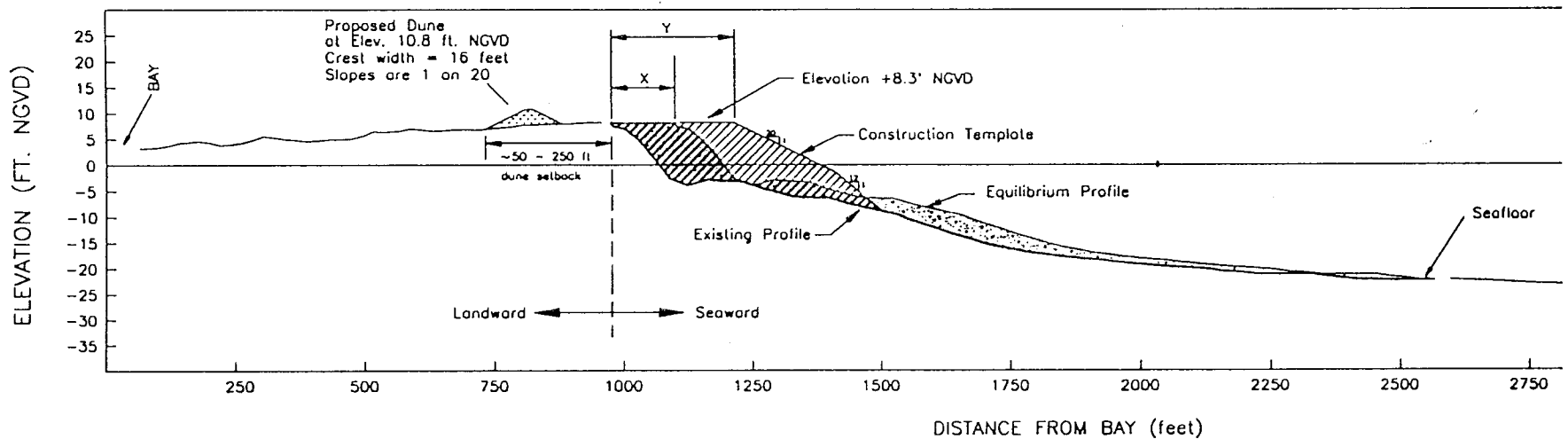
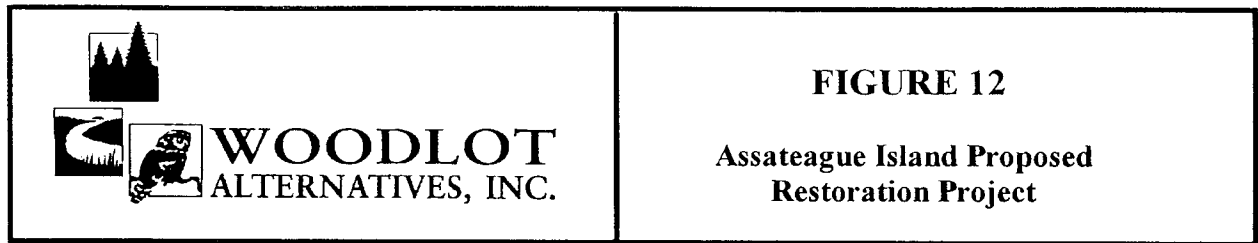
The proposed dune heights of 3.3 m and 2.9 m are not above current elevations, but are above sea level. Berm elevations in the low relief areas along northern Assateague Island ranged between 2.3 - 2.8 m during 1995. The proposed heights would, therefore, increase the existing berm elevation between 1.0 to 0.2 m (to reach 3.3 m dune height) and 0.6 to 0.1 m (to reach 2.9 m dune height), resulting in low overall topographical relief (Figure 7).

Variables governing the berm configuration include restoration length, berm height, and sediment volume to be placed on the island. Berm extension widths will be largely determined by the total volume of material to be placed. Local beach conditions may induce need for local variation in berm width. For example, 3,000,000 m³ along a 6.5 km length is the maximum berm width that would be created/restored if this volume was placed uniformly along this reach.

With the exception of the dune feature, all of the "Construct Dune" alternatives involve placement of material seaward of the existing high water berm at an elevation at or below existing conditions (Figure 12). The dune feature, itself, may be overlaid on either the existing beach or the new berm extension. The majority of the depositional material will be placed at or below the existing berm elevation in what is currently the intertidal zone. The volume of material to be incorporated in the dune will be less than three percent of the entire proposed volume of sand to be restored.

The source for sand has not yet been determined, but an offshore shoal is likely to be used for restoration material. USACE (1995) sampled 13 northern Assateague profiles for sand grain-size. Grain-size ranged from an average of 1.76 ϕ at the dune base, to 1.15 ϕ at mean low water, to 2.23 ϕ on the nearshore sand bar crest. For the proposed action alternatives, sand grain-size will be approximately 1.62 ϕ with a standard deviation of 0.80 ϕ .

If an action alternative is selected, sand will be transported by barge or piped to the island after being hydraulically mined from an offshore shoal. Material will then be hydraulically deposited on the beach berm and/or in the surf zone, or dumped from a hopper into the surf zone. It has not been determined whether any earth-moving equipment will be used for placement and shaping. For any action alternative, there will be no effort to maintain or re-nourish the newly-added material following deposition and configuration of sediment. ASIS is not interested in a solution that depends upon routine beach nourishment and maintenance, but wants to allow the natural coastal processes to drive the system. All alternatives relating to berm construction are designed for meeting project objectives for a



Notes:

1. Section Based on Assateague Island Profile NPS 175m, taken September 28, 1995.
2. Profile shows sand as initially placed (construction template) and after adjustment due to the action of waves for several months (equilibrium profile). Profile also shows range of design width and setbacks under consideration.
3. Vertical exaggeration is 10x.
4. Dune elevation is based on the 3.3m alternative.
5. X = Design width, Y = Construction width.

short-term period (approximately 5 years) until a long-term restoration project can be implemented. Currently, ideas for the long-term restoration project include a sand by-pass plant at Ocean City, or a program of periodic beach nourishment to Assateague Island using sand from one of the offshore shoals.

Any construction activities or related action from this project must minimize impacts to threatened and endangered species. Piping plovers are currently the only remaining federally-listed species on Assateague Island. However, another federally-listed species, seabeach amaranth, historically occurred along Assateague Island but has not been seen in Maryland since 1967 (Higgins *et al.* 1971). A reintroduction program for this species is being considered by the Maryland Department of Natural Resources and may be essential to meet the recovery goals for seabeach amaranth.

As a follow-up to the reconnaissance report, the OCWR study team was formed during 1995, including staff from USACE, NPS, USFWS, Maryland DNR, Worcester County, and the Town of Ocean City to determine specific problems and initiate a feasibility study for the immediate restoration of Assateague Island. To formulate potential alternatives for the immediate restoration project for northern Assateague, the OCWR study team developed a list of preliminary objectives:

1. Restore volume of sediment
2. Reduce probability of breach
3. Develop mitigation protocol for response to future breaching events
4. Minimize impacts to piping plovers
5. Promote natural diversity

These objectives provided guidance in the formulation of alternative solutions for Assateague Island's restoration. Several alternatives were excluded due to political, economic, or environmental concerns, including removal of the existing jetties and construction of offshore breakwaters. A preferred alternative has not been selected.

4.0 PIPING PLOVER IMPACT ASSESSMENT

This section includes an assessment of potential impacts on piping plovers from the proposed alternatives by the USACE for the immediate restoration of northern Assateague Island. There are ten scenarios being proposed under six main alternatives, including the "no action" alternative and five alternatives that involve some level of construction. A discussion of the potential impacts on piping plovers for each of the scenarios is provided in the following subsections. The discussion focuses on actions likely to occur within the short-term, defined as the next five years.

4.1 Alternative 1 - No Action

In the event that a breach does not occur, the overwash zone area is expected to continue to expand southward and increase in size (Dean and Division of Beaches 1986). Island height is expected to remain constant or to decrease slightly. Island width is also expected to change little, although island retreat and erosion rates will increase southward. If a breach occurs, and no repairs take place, erosion patterns similar to those observed in 1962

will likely occur. Overwash zone areas will continue to expand southward (Dean and Division of Beaches 1986, USACE 1996). There are two locations where breaches are likely to occur within the next few years (see Figure 9, Section 3.3).

In the short term, implementing the no action alternative may increase the amount of suitable plover habitat because open, sparsely vegetated areas will be maintained and will continue to form in overwash zones. Preferred nesting, brood rearing, and foraging habitats will be available as the overall breeding population of plovers increases. While plovers nesting in overwash areas are expected to experience a temporary decrease in productivity from increased loss of eggs due to flooding, this mortality should be localized. Further, minor losses in productivity will be more than offset by subsequent increases in available habitat, which should lead to increased nesting opportunities. If no action is taken and there is a very large storm event (i.e., a hurricane), however, there may be a drastic decrease in plover habitat. Nesting plovers would then be subjected to a higher frequency of flood tides, likely resulting in poor nesting success. If a hurricane results in the island breaching, it is possible that piping plovers might be isolated from predators on the north side of the breach. Further, suitable habitat for seabeach amaranth might be created on the accreting edges of the new inlet

4.2 Alternative 2 - No Action but Repair Future Breaches

Under this alternative, there would be no beach restoration until a breach occurs. When this happens, the overwash area will be filled with dredged material to a level consistent with that of its pre-breach character. This alternative assumes that a decision-making protocol for breach repair will be in place when a breach occurs. A breach contingency plan will be developed by the USACE so that detrimental environmental impacts from plan implementation will be minimized.

In the event of a breach, there will likely be both positive and negative impacts to plovers. The positive impacts are similar to those discussed above and would include a potential increase in the amount of plover habitat, and overall plover productivity if other factors like predation levels continue to be low. Impacts to plover populations from a breach would depend on the time of year when the breach occurs. For example, if a breach occurs and is repaired during the winter, when plovers are not on-territory (occupying a nest site), there would be no direct impacts. However, if the breach occurs during the summer nesting season, there would be direct impacts from the breach itself, and indirect impacts from the repair activities. Although a breach is most likely to occur during the hurricane/northeaster season (August to April), breach repair may occur at any time of year, depending on lag time between breach and repair action implementation. The extent of disturbance to plovers from repair activities will also vary with the size and location of the breach, numbers of plovers attempting to nest or reneest near the breach, and the specific construction techniques used for repair. Adult plovers may be discouraged from nesting along the edges of the breach site and move to less optimal sites, possibly resulting in lower productivity. In the event of a major breach, it is possible that there would be an overall decrease in plover productivity if the overwash lowers island topography to a level where summer high tides flood nests.

Potential adverse impacts to piping plovers may occur as breach repair results in

forestalling the natural inlet migration. Areas that form behind migrating inlets often support excellent nesting and foraging habitats for piping plovers. The southern most potential breach area currently supports sparsely vegetated suitable nesting habitat. If this area breaches and is repaired with pre-breach character, net loss of habitat will likely be minimal. However, it is possible that due to the vegetated area of the northern potential breach area, loss of opportunities for formation of suitable habitat may be substantial.

4.3 Alternative 3 - Construct 3.3-m Dune Along 9.2 km of Shore

Under this alternative, a 3.3-m high dune will be constructed along the northernmost 9.2 km of the island. The dune will have 1:20 side slopes and a 4.9-m crest width. The western toe-of-slope of the dune will be, at most, 76 m from the existing berm crest. Dune location will depend on the volume of sand added and the resultant berm width. This proposed dune alternative is either in, or adjacent to, areas that were occupied by 44 pairs (100 percent of the Island's population) of nesting piping plovers in 1995 (Brady *et. al.* 1995). In 1995 three nests were directly within the proposed work area, 30 (67 percent) were within 150 m of the proposed work area, and 42 (93 percent) were within 225 m of the proposed work area. The proposed year of construction and seasonal schedule for completing the work are unknown at this time. In addition, it is unknown whether a berm will be constructed in the intertidal area as a sacrificial beach. The timing and physical placement of this dune alternative may affect the degree of impacts to piping plovers.

If placement of sand and dune construction occurred outside of the nesting window, direct impacts could be eliminated. Assuming the newly placed material has similar substrate qualities and the newly constructed dune maintains a gradual slope (seaward and landward), it is likely that plovers will occupy this new area for nesting the following spring. Based on the recent increase in numbers of breeding pairs and high reproductive success, recruitment rates into the population are likely to be high, resulting in a concomitant increase in numbers of plovers using Assateague Island. Although additional suitable habitat is likely to be used by plovers on Assateague Island for nesting, it is critical that any new nesting habitat also has access to brood-rearing and foraging areas, and promotes good reproductive success.

4.3.1 Width Based on 1,500,000 m³ of Sand

If this alternative is implemented there will likely be a decrease in the frequency and intensity of overwashes from that which presently occurs. This factor may be the single most important consideration for the maintenance of piping plover habitat on Assateague Island. If the proper number and intensity of overwashes do not happen, plant succession will likely begin in as little as 1-2 years, and areas that are now devoid of vegetation or sparsely vegetated may become dominated by plants, rendering them less suitable for plovers. The key to plover success on Assateague Island is maintaining vegetation-free corridors between the bay and ocean (Loefering and Fraser 1995). These corridors are primarily maintained by cross-island overwashes from both the bay and the ocean (Dean and Division of Beaches 1986, Loefering and Fraser 1995). Overwashes control vegetation by killing species intolerant of high salinity, and by transporting sand and burying plants.

Assuming that the constructed dune will not be maintained after initial placement of material, it is possible that there will be a lowering of the constructed dune/berm following

the first overwash event. If this occurs, large portions of the restored area may be prone to overwash, although less so than what currently occurs today.

Dune and berm construction activities may also cause impacts to plovers on Assateague Island. If dune or berm construction occurs during March-August using heavy equipment, there will be direct and indirect impacts to plovers. In 1995, three nests were located in the area where the dune is proposed for construction. Further, the proposed location of the dune is adjacent to areas that contained 39 nesting pairs of plovers. All breeding pairs had nests that were located within 225 m of the proposed dune and could potentially be affected by disturbance from construction activities. Trucks or bulldozers, for example, could trample plover chicks, or noise from their operation could impact mate selection, courtship displays, and territorial defense. Exact timing and methods of construction are needed to determine these types of potential impacts.

Based on the upward trend that Maryland's population of piping plovers is currently experiencing, it is likely that the newly placed dune/berm material will be used by nesting piping plovers assuming that substrate types are similar to current conditions. Although monitoring data from Assateague Island indicate that some plover broods travelled long distances from their nest sites to foraging areas, farther distances are more costly energetically and broods suffer higher risks to predation and exposure from inclement weather (Loefering 1992). However, these risks may be offset by the potential benefits (increased number of breeding pairs) associated with the creation of suitable habitat resulting from sand placement. If needed overwash frequencies are not met, however, due to the proposed increased height and width, and result in travel corridors being blocked by vegetation, broods will be restricted to the beach side for foraging and resting. Plover broods restricted to the ocean beach on Assateague Island by either dunes or vegetation had adequate nest success but nearly all the chicks died (Loefering and Fraser 1995). Increasing number of breeding pairs without good productivity will not meet overall recovery goals for the Atlantic Coast piping plover population.

By placing sediment inter- and supra-tidally, lower densities of macroinvertebrates may result. Although northern Assateague Island broods typically forage on the bayside, adults often feed along the intertidal zone during migration and during territory establishment. It is unknown how rapidly intertidal populations of macroinvertebrates may recolonize. Moist areas (including ephemeral pools) provide excellent foraging habitats for adult and chick plovers. Maintaining these sites by promoting the occurrence of cross-island overwash can benefit plovers by providing a diversity of habitat types.

4.3.2 Width Based on 3,000,000 m³ of Sand

This alternative may result in similar, but worse, impacts as those outlined above in Section 4.3.1. Impacts may be potentially more adverse due to the increased amount of construction effort and time needed to place and configure more material. For example, if a conservative two-month operating window is used outside of the nesting season, the 3,000,000 m³ alternatives would take approximately 6.8 months and the 1,500,000 m³ would take 3.4 months. There is also more potential for sand to be carried inland creating more upland habitats and/or carried inland into the interior wetlands of the island. The greater amount of

depositional material, the more potential for longer duration of impacts, including the creation of more upland areas, establishment of more vegetation, and the larger storm that may be required to remove it once established

4.4 Alternative 4 - Construct 3.3-m Dune Along 12.9 km of Shore

The actions proposed under this alternative are similar to those discussed above under Section 4.3, except that the project area is 3.7 km longer. The barrier island is well-vegetated in the 3.7 km area and it is also wider. There were no known nesting plovers within this additional area in 1995.

4.4.1 Width Based on 1,500,000 m³ of Sand

Under this scenario 1,500,000 m³ of sand will be deposited along 12.9 km of beach. Impacts to plovers under this alternative will likely be similar to those discussed above. Berm width will likely be more narrow as the restoration length increases and volume decreases. Impacts from construction activities could affect most of the birds using the island from March-August. Impacts to the plovers will depend on the specific construction techniques used and the time-frame in which they occur. Construction during September-February will likely have little direct impact on plovers, while construction during March-August could have adverse impacts.

In the short-term, if this alternative is implemented with extending the berm seaward, some additional plover habitat may be created. Suitable nesting habitat will be created on the seaward side of the dune. However, this is not the preferred side for nesting on northern Assateague Island. Chicks from these nests may still move to the interior or bayside habitats for foraging and resting, which will increase their vulnerability to predation, disturbance, and exposure to inclement weather. However, by increasing the width of the island, there will be more available habitat for the breeding population. In recent years, Assateague's plover population has undergone an increase due to greater availability of preferred nesting and foraging habitats, lower predation pressure, and increased management.

4.4.2 Width Based on 3,000,000 m³ of Sand

Under this scenario 3,000,000 m³ of sand will be deposited along 12.9 km of beach. The impacts of this alternative to piping plovers will likely be very similar to those discussed under Sections 4.3 and 4.4.1.

4.5 Alternative 5 - Construct 2.9-m Dune Along 9.2 km of Shore

Under this alternative a dune will be constructed at elevation 2.9 m for a distance of 9.2 km along the island. The difference between this alternative and that presented in Section 4.3 is that the final elevation of the dune crest will be 0.4 m lower. This lower dune height would likely allow a greater frequency of overwashes at least in the initial stages of sand placement. However, due to the non-maintenance protocol proposed, it is likely that both proposed heights may decrease in elevation following wave activity capable of toppling the dunes. It is unknown, however, if the overwashes will be capable of maintaining and creating unvegetated habitats preferred by plovers. Based on CERC's storm event data, of the 14 storms that occurred during the last six years, 12 would have potentially overwashed a 2.9-m-high dune. Based on the 3.3-m dune elevation, only 6 of 14 storms would have had waves

potentially overwashing the dune. The magnitude and duration of storm will determine whether waves will overtop the dune crest with sufficient water volume to substantially contribute to the maintenance of corridors to interior or bayside plover brood-rearing and foraging habitats.

4.5.1 Width Based on 1,500,000 m³ of Sand

If this alternative is implemented it is possible that the desired overwash frequency will be met in the short-term. These overwashes should maintain habitat conditions favorable for plovers, similar to those discussed under Alternatives 1 & 2.

All of the potential dune and berm construction activities that may impact plovers, described in Section 4.3 and 4.4, would be pertinent under this alternative as well. Depending on how, when, and where construction activities take place, there could be impacts to plovers.

4.5.2 Width Based on 3,000,000 m³ of Sand

The potential impacts to plovers under this alternative are very similar, but greater, to those just described. Impacts would likely be greater because twice as much sand will be used to build the dune. The area occupied by the dune would be larger and would have the potential to displace more pairs of plovers. In addition the amount of time and level of effort to build the dune would also be greater, which could cause more impacts to plovers if work is conducted from March-August.

4.6 Alternative 6 - Construct 2.9-m Dune Along 12.9 km of Shore

Under this alternative a dune will be constructed at elevation 2.9 m for a distance of 12.9 km. This alternative is very similar to that described in Section 4.5 except that the proposed dune would extend for 3.7 km further south.

4.6.1 Width Based on 1,500,000 m³ of Sand

Based on the CERC model, overwash would have occurred during 12 out of 14 storms in a six-year period, given the 2.9 m high dune. This indicates that preferred plover habitat may be maintained in the short-term if water traveled through the overwash corridors. In addition, because the 1,500,000 m³ of sand would be deposited over a longer area, the footprint width of the dune would be smaller than that of the alternative described in Section 4.5.1. This would indicate that less plover habitat would be impacted by construction activities than under all other alternatives except for the no action alternatives. All of the potential impacts to plovers from construction of the dune described above would also apply under this alternative. If construction activities take place in March-August, and heavy equipment is used to build the dune and berm, there is a high likelihood that plovers will be negatively impacted.

4.6.2 Width Based on 3,000,000 m³ of Sand

The potential impacts from implementation of this alternative are similar to those described in Section 4.6.1, except for the fact that a much larger area of plover habitat may potentially be impacted. The primary reason that there is a potential for more impacts is that the footprint of the constructed dune will be much larger.

4.7 Summary of Potential Impacts

A summary of potential impacts is provided in Table 3.

4.8 Mitigation Measures

Mitigation measures designated to lessen the severity of adverse impacts to piping plovers would be incorporated into the project alternatives. A summary of mitigation measures is listed in Table 4.

5.0 SEABEACH AMARANTH IMPACT ASSESSMENT

Seabeach amaranth is an annual plant endemic to the barrier island beaches of the Atlantic Coast. Its primary habitat consists of overwash flats at accreting ends of islands, lower foredunes, and upper strands of noneroding beaches (USFWS 1995b). This species prefers temporary habitats and does not occur on well-vegetated beaches. Due to its high dispersal ability, it can persist in newly disturbed habitats (USFWS 1995). In these ways, its habitat requirements are very similar to those of piping plovers. Just like plovers, its habitat is maintained by overwash actions, which prevent establishment of competing vegetation, yet hurricane flooding generally curtails seed production and may locally eliminate seabeach amaranth populations.

Impacts on seabeach amaranth from the proposed alternatives are very similar to those on piping plovers, but the analysis is more speculative because no populations currently exist on the island. However, if this species was re-established on Assateague Island, one of the major factors limiting its survival is anticipated to be grazing by horses.

5.1 Alternative 1 - No Action

Given that the current habitat on northern Assateague Island is being maintained by overwash frequencies that are preventing establishment of woody vegetation and perennial dominance in the overwash corridors, a no action alternative would likely impact seabeach amaranth the least of all the alternatives in the short term. This species' zone of growth is extremely narrow, typically about 10 m wide. Although it requires unvegetated habitats, it may be intolerant of occasional flooding during its growing season (May into the Fall). It needs extensive areas of barrier beaches and inlets, functioning in a relatively natural and dynamic manner. This allows it to move around in the landscape to occupy suitable habitat as it becomes available.

However, due to seabeach amaranth's dependency upon noneroding beaches, it may not become established along the upper berm along the shoreline due to the high erosion rate that northern Assateague Island is currently experiencing.. Due to the current rate of beach erosion, upper beach zone habitats are uncommon along northern Assateague. Although this habitat is currently available on northern Assateague Island at a few locations, the no action alternative may result in an increase in overwash activity over a greater area than currently exists, reducing the availability of these habitats.

If a breach occurs and creates an inlet, more desirable habitat for seabeach amaranth may be created if upper beach habitat results from the presence of the inlet. Higher densities of this plant are usually encountered along island-end flats and inlet edges as opposed to

Table 3. Summary of Potential Impacts to Piping Plovers from Proposed Alternatives

<u>Alternatives</u>	<u>Potential Impacts</u>
4.1 No Action	1. Increase in suitable nesting and foraging habitats as overwash zone continues to expand southward and increases in size. 2. Increase in number of breeding pairs as suitable habitat is maintained and created by current overwash frequencies. 3. Temporary decrease in productivity from egg loss due to flooding in certain areas. 4. Decrease in plover habitat if hurricane occurs. 5. Increase in isolation of plovers from predators on north side of breach if breach occurs. 6. Increase in mortality of eggs and/or chicks if storm/breach occurs during nesting season.
4.2 No Action Breach repair	1. Increase in nesting and foraging habitats if beach is subject to annual overwash after repair. Repair is restricted to pre-nesting season. 2. Stable high productivity if travel corridors are maintained and predation levels remain low. 3. Increase in mortality of eggs and/or chicks if breach occurs during nesting season. 4. Increase in direct impacts from construction activities; if repair occurs between mid-March and September when plovers are present. 5. Reduction in formation of excellent nesting and foraging habitats, due to forestalling natural inlet migration.
<u>The following are potential impacts from all dune construction alternatives.</u>	
4.3 3.3m dune along 9.2km	1. Increase in number of breeding pairs due to increase in berm width.
4.3.1 1,500,000 m3	2. Decrease in effects of overwash compared to current conditions.
4.3.2 3,000,000 m3	3. Increase in formation of discontinuous dunes providing more upland habitat for woody vegetation and den sites for predators.
4.4 3.3m dune along 12.9km	4. Adverse impacts are likely if dune construction occurs during nesting season e.g., disturbance, mortality, and habitat destruction.
4.4.1 1,500,000 m3	5. Increase in chick mortality, and subsequent decrease in breeding pairs, if travel corridors are not maintained with adequate overwash.
4.4.2 3,000,000 m3	6. Destruction or decrease in habitat quality for macroinvertebrates due to depositional material in the intertidal zone resulting a decrease in value of foraging habitats for piping plovers.
4.5 2.9m dune along 9.2km	7. Forestalling of potential nesting habitat due to downdrift of material to southern portion of Seashore where suitable habitat is recently forming from overwash activity.
4.5.1 1,500,000m3	8. Decrease in likelihood of piping plover habitat loss through a hurricane or major storm
4.5.2 3,000,000 m3	9. Increase in duration of impacts, as amount of depositional material increases.
4.6 2.9m dune along 12.9km	
4.6.1 1,500,000 m3	
4.6.2 3,000,000 m3	

Table 4. Mitigation Measures to Minimize Impacts Based on Alternatives Involving Sand Placement and Construction

1. All construction activities involving placement of sediment on the terrestrial portion of the island (dune or berm construction would not be conducted between mid-March and September, or until piping plovers are no longer observed using the Maryland portion of Assateague Island. Construction in areas that are not used by piping plovers, such as the State Park, could be initiated within this window as long as the area is being monitored to ensure that no plovers are present.
2. Earth-moving equipment (bulldozers, etc.) would be restricted to use on the island to avoid the nesting season. The creation of trenches for trapping sand and dune configuration would be done outside of the nesting season. Bulldozers may be used to assist in moving pipelines in piping plover-free areas, but would not be allowed to cross occupied habitats to reach work area.
3. A piping plover expert would be present during sand placement into the intertidal zone to insure that restoration can proceed within the nesting window on certain reaches along the shoreline. This assumes that no plover activity is observed along the target reach of the shoreline prior or during the pumping action, and that all construction equipment is located on the water (hopper dredges, booster pumps). Large buffer zones would be established around the pumping activity to insure no direct impact to nesting or foraging plovers. It is critical that plover monitors are on site to insure that there is no disturbance from the placement and movement of the steel pipelines.
4. A piping plover monitoring plan would be prepared prior to construction to protect plovers and chicks from predatory animals, including gulls and crows, which are attracted to dredged material pumped along the shoreline.
5. Impacts to other state endangered species, especially beach tiger beetles, would also be considered. Staff of the Maryland Department of Natural Resources would be consulted concerning potential impacts to these other species.
6. A vegetation control program would be developed to prior to construction and implemented should the predicted overwash not be realized and rapid vegetation encroachment occurs in the nesting and travel corridor habitats, or important habitats, such as ephemeral pools and moist, flat, low-lying portions of the island, become dryer.
7. A monitoring study of the re-establishment of seabeach amaranth as well as the behavior of plovers would be developed and implemented as part of the proposed alternatives.
8. Any mitigation measures and monitoring options need to be coordinated with the policies of the National Park Service as part of a long-term management plan and agreement between the Seashore and the USACE.

beaches (USFWS 1995b). If a breach occurs, suitable habitat for seabeach might be created on the accreting edges of the new inlet. During inlet migration, one side is experiencing accretion of sand while the other side is eroding. On the eroding side of the inlet, habitat for seabeach amaranth is usually small or absent. Accreting sides of inlets are the most favorable habitat for the plant. However, it is possible that if a breach occurs and is followed by a large storm during the growing season, re-established populations on Assateague could be destroyed.

5.2 Alternative 2 - No Action but Repair Future Breaches

If breaches occur and are repaired, populations of seabeach amaranth may or may not be affected depending on their location and distribution in relation to the breaches. There would likely be no direct impact from this action as long as no sediment was placed on top of the plants or the habitat configuration where the plants occurred was not altered (i.e. upper beach habitats were maintained). As long as the topography after repair was similar to the pre-breach character, and woody and/or perennial plant invasion did not occur, overwash activities would likely continue to maintain habitats for seabeach amaranth. However, filling of the new inlet would eliminate some of the best potential habitats for seabeach amaranth reestablishment.

5.3 Alternatives 3-6 - Dune Construction

Seabeach amaranth continues to be threatened by destruction or adverse alteration of its habitat. The primary reason it has been eliminated from approximately two-thirds of its historic range is beach stabilization efforts and storm-related erosion. The absence of this species along certain Atlantic coast habitats are thought to be due to artificial construction and maintenance of continuous barrier dunes.

Beach replenishment projects and placement of dredged material can have impacts on seabeach amaranth (USFWS 1995b). If dredging and placement of material occurs during the winter when amaranth exists primarily as seeds, impacts on individual plants are likely to be minor. However, if seeds are buried the population could suffer adverse impacts depending on this species' seedbanking capabilities, which need further study.

Seabeach amaranth does not occur on eroding beaches. Beach replenishment has been known to rebuild habitats for seabeach amaranth and have long-term benefits. At two beaches in North Carolina, Wrightsville Beach and Atlantic Beach, placement of large amounts of material apparently aided in the reestablishment of seabeach amaranth populations. At one site, plants were reestablished four years after renourishment. However, another large renourishment project at Carolina Beach failed to help seabeach amaranth.

As long as accreting areas are present (along inlet edges or beach berm), overwash is frequent enough to maintain habitats, and off-road vehicle activity is kept to a minimum during the growing season, amaranth populations may do well along the shoreline of Assateague Island if sand was placed along the nearshore and berm habitats. Because seabeach amaranth is typically a front-line plant (occurring on the outer edge of the accreting berm or inlet) close to the water, it is especially vulnerable to wave action. Major storms during the growing season can cause severe mortality of plants, but winter storms have less

impact on mortality.

Efforts to reestablish populations in the southern portion of the National Seashore may be futile. Recently, overwash activity at the south end has created habitats which could potentially support seabeach amaranth. However, downdrift of the newly-placed sand as proposed in the "dune construction" alternatives may potentially effect the maintenance of these habitats by reducing the amount of overwash. Overwash corridors need to be maintained to prevent colonization of woody vegetation and perennials to promote habitats which will support populations of seabeach amaranth. However, sites which historically supported populations of this species have experienced re-established populations as a result of sediment being deposited in areas that contained a seed bank (pers. comm., N. Murdock, USFWS, to L. MacIvor, 30 May 1996). Reproductive success for these plants, however, is unknown.

Considerations for reintroducing seabeach amaranth populations to Assateague Island (except on an experimental basis) should be delayed until: (a) results from implementing the long-term restoration project (sand by-pass) can be evaluated, and (b) the horse population has been largely reduced or eliminated. Under current conditions, experimental and small-scale introductions may be helpful in determining if habitats on Assateague Island can support this species.

6.0 OTHER SPECIES OF CONCERN

Barrier beach habitats used by piping plovers are dynamic, storm-maintained ecosystems. Other species, considered threatened or endangered by the State of Maryland, share these habitats with piping plovers on Assateague Island and are similarly affected by man's activities. These species include state endangered least terns (*Sterna antillarum*), and beach tiger beetles (*Cicindela dorsalis media*). Breeding populations of both species occur in the proposed project area. State listed species that historically occurred on Assateague Island include seabeach amaranth, seaside knotweed (*Polygonum glaucum*), and Wilson's plover (*Charadrius wilsonia*). These species could potentially be affected by the proposed project if populations become extant. Maryland Department of Natural Resources should be consulted concerning potential impacts to state listed species. Observations of federally-listed roseate terns (*Sterna dougallii*), bald eagles (*Haliaeetus leucocephalus*), and peregrine falcons (*Falco peregrinus*) within the proposed project area have also been recently recorded, but adverse impacts to these species from the proposed project are unlikely. If the proposed alternatives are modified, potential impacts to these additional federally listed species should be addressed.

7.0 CUMULATIVE IMPACTS

Three existing water resource projects by USACE are located in the Ocean City Area. One, the Atlantic Coast Shoreline Protection Project, is located along the southern 8.6 miles of Fenwick Island's shoreline. This project included adding significant volumes of sand, which increased height and width to this portion of the island, and involved constructing a 16 foot high artificial vegetated dune to provide protection against a 100-year storm on the Atlantic Ocean. Periodic beach nourishment and dune maintenance occurs every four years. The Ocean City Harbor and Inlet and Sinepuxent Bay Project provides dredged channels for boat

travel between the Atlantic Ocean and the bays and harbors west of the barrier islands. Portions of these channels are dredged approximately every three years. The Isle of Wight Bay Project resulted in the construction of stone toe bulkhead protection and a new tie-back system to stop the bayward movement of the bulkhead in Ocean City, Maryland.

Land adjacent to northern Assateague Island is primarily urban and is developed. Private marinas are scattered along the mainland shoreline. There has been a significant increase in proposed and constructed marinas within Worcester county, some of which have resulted in increased boat traffic to Assateague Island.

Assateague Island is the only large undeveloped area remaining in Worcester County. Land-use and development, and increased shoreline stabilization efforts in the Ocean City area continue to have cumulative impacts on the barrier island system of Assateague Island.

8.0 DISCUSSION

Expansive sections of open beaches along the mid-Atlantic coast are typically results of large-scale environmental forces (e.g., hurricanes, extratropical storms, surge tides) (Dolan *et al.* 1988), and are primarily formed by dune overwash. These sparsely vegetated habitats used by piping plovers for foraging and nesting are relatively short-lived within the mid-Atlantic region (Watts and Bradshaw 1991) because dune recovery and plant succession can occur rapidly within barrier systems (Godfrey *et al.* 1979). Overwash areas on North Carolina barriers may be nearly revegetated by buried *Spartina patens* only one year after the initial overwash disturbance. Vegetation began to invade old overwash areas on northern Assateague Island within 1-2 years due to the lack of major storms. Piping plover habitat availability over any extended period may be only possible on beaches that are subjected to high rates of disturbance. For example, beaches with an elevation of less than 0.5 m will be washed over twice daily by normal tides and higher beaches with greater than 3 m elevation will be reopened only once every few decades (Watts and Bradshaw 1991). Overwash frequency and impact of the disturbance will largely depend on the storm's magnitude and duration. Between 1985-91 on northern Assateague Island, vegetation invasion was rapid and severe due to lack of overwash events. As overwash areas filled in with vegetation, travel corridors for chicks became less available resulting in high mortality of chicks (Loefering and Fraser 1995). Following the major storms in 1991 and 1992, large overwash areas were created on northern Assateague. Since then storms and even some high tides have maintained these habitats. Northern Assateague Island currently supports the highest productivity and number of breeding pairs since monitoring began ten years ago. However, one large overwash area towards the south end of the project area (Figure 9) is now characterized by low topographical relief and almost no vegetation. Nesting plovers in this area experienced lower fledging success than other areas during the 1995 nesting season (Brady *et al.* 1995). Recently during the 1996 season, some nests in this area were lost to flooding (pers. comm., P. Railey, MD Dept. of Natural Resources, to L. MacIvor, 3 June 1996). Flooding has been an uncommon cause of egg mortality on northern Assateague Island. In general, piping plovers would likely benefit the most on beaches with a high enough overwash rate to maintain open habitats but infrequent enough during the breeding season to allow for successful incubation. For early successional species, such as piping plovers and seabeach amaranth, a disturbance regime is an important determinate of habitat distribution and

availability. From a biological perspective, promoting these dynamics should be one of the primary considerations for the development of long and short-term beach restoration projects.

Alternative 1, the "no action" alternative, will likely benefit piping plovers in the short-term (within the next 5 years) because suitable habitat currently exists and is being maintained by natural processes. Assateague Island now provides large expanses of overwash areas and access to bayside feeding sites for plovers. Given current conditions, if a breach occurs on Assateague, use by piping plovers for nesting and foraging will likely increase along the accreting ends of barrier islands and sandflats adjacent to inlets, or in the area of old inlets that have closed in (Elias-Gerken 1995, USFWS 1995c). These old inlets typically consist of large moist sandflats and sparse vegetation. During 1994 in North Carolina, 28 percent (15 of 54) of the entire State's nesting population was located on either side of an inlet at Cape Lookout National Seashore (McConnaughey *et al.* 1990). Between 1929 and 1941, storms breached sections of the Long Island barrier in New York forming inlets along a 28 km stretch. During this time numbers of plover breeding pairs increased from approximately 4 pairs (prior to the formation of inlets) to 64 pairs after sections were breached (Wilcox 1959). Numbers then gradually decreased, a decline that Wilcox attributes to deposition of dredged material to rebuild dunes, planting of beach grass, and construction of homes and roads. Given the potential likelihood of a breach in the near future on northern Assateague, there may be an increase in the numbers of breeding pairs and use by adults and broods, particularly along the edges and recurved spits of the inlet. The disruption of key coastal processes that contribute to the creation of piping plover (and seabeach amaranth) habitat has been identified as a major factor contributing to these species' decline (USFWS 1995a,b). One of the priority one recovery tasks in the 1995 Draft Revised Piping Plover Recovery Plan is to "discourage interference with natural inlet formation, migration, and closure processes".

However, the low-lying and sparsely vegetated topography that piping plovers prefer can also reach a habitat quality that becomes counter productive for good nesting success. A few areas that currently exist on northern Assateague Island are so low and completely void of vegetation that nests at these sites may become susceptible to flooding during summer high tides, and shade and resting areas may become less available for chicks. For the short term, adding sand to these specific areas to slightly increase height (as long as overwash areas are maintained) and especially width could benefit productivity at these sites.

Alternative 2, the no action with future breach repair, is likely to have minor adverse impacts on piping plovers as long as there are no direct construction activities in areas where plovers are engaged in courtship, nesting, or brood-rearing. If construction activities occur near plover use areas, dredging and construction operations may prevent plovers from using the area, forcing them to relocate into less favorable habitats. There may also be a loss of productivity due to construction, disturbance, and harassment. Further, there could be direct loss of piping plover nests or chicks. As long as construction activities do not disturb plovers and the repair site is returned to its pre-breach character, there should be no adverse effects.

Increases in numbers of nesting pairs have been reported to occur when breaches have been filled (USACE 1995). Five pairs of piping plovers nested during 1993 prior to the

closure of Pikes Inlet on Long Island, New York. The USACE closed the inlet and created an "artificial overwash". During 1994, 1995, and 1996, numbers of nesting pairs increased to 14, 19, and 24, respectively. All broods had access to bay tidal flats (Elias-Gerken and Fraser 1994). Number of breeding pairs at Westhampton, Long Island, increased threefold (5 to 15 pairs) following a breach closure by USACE, with several pairs nesting on the sand used to fill the breach (USACE 1995). The USACE speculates that the characteristics which provide piping plovers with the most suitable habitat including flat berms, overwash fans, spits, and open travel corridors for chicks, are the result of storm events, not necessarily the continued existence of a breach. However, biologists have expressed concern that artificial habitat formed in this way may be susceptible to accelerated plant succession that will decrease the long-term carrying capacity compared to what it might have been if the inlet had been allowed to persist, migrate, and eventually close on its own (Elias-Gerken and Fraser 1994b).

Alternatives 3-6, the proposed alternatives involving deposition of sand on the island, have the potential to result in adverse impacts to piping plovers depending on the magnitude and duration of future storms along Assateague Island. Increasing island height and sand deposition along the nearshore to increase width may be either beneficial or detrimental to piping plovers. On beaches that have become heavily vegetated, deposition of material along the beach can substantially improve the quality and availability of plover habitat by creating nesting areas that are higher, wider, and less vegetated than before (Melvin *et al.* 1991). However, benefits to piping plovers are typically very short-term because encroachment of vegetation can begin as early as one to two years after beach nourishment takes place.

One of the primary concerns for artificial stabilization of areas supporting piping plovers is the increased susceptibility for accelerated plant succession, which over time becomes unsuitable for nesting and foraging. Wilcox (1959) observed plovers colonizing beaches with storm-created, early successional stage habitats. As the establishment of vegetation reached later successional stages, plovers failed to return to the area. Following the 1938 hurricane, piping plovers reached a 20th century peak in Rhode Island, but declined as habitat was lost due to post-World War II stabilization efforts and summer home construction (Raithel 1984). A recent hurricane along the east coast leveled dunes at a beach on Martha's Vineyard, Massachusetts resulting in a low, flat beach profile with a wide overwash area between ocean and the bayside. To reduce the probability of breaching, the county placed snow fencing along the beach berm resulting in sand accretion and an increase in beach elevation (peak elevation = approx. 2.4 m - 2.9 m) (pers. comm., R. Culbert, Dukes County Beach Manager, Martha's Vineyard, MA, to L. MacIvor, 24 May 1996). This height increase resulted in reduced overwash action from the ocean to the bayside. Since that time, vegetation has increased in certain areas along the bayside. Although the banning of off-road vehicle activity may have confounded effects, the lack of overwash is thought to be the primary factor for the invasion of vegetation. If vegetation continues to increase at the same rate for the next 2-4 years at this site, nesting habitat for plovers may become unsuitable or degraded (pers. comm., S. Melvin, MA Div. of Fisheries and Wildlife, to L. MacIvor, 11 April 1996).

Although increases in breeding pair and productivity numbers following major storm events have been well documented, factors such as predation and off-road vehicles can

confound the effects of the presence of optimal habitat on nesting and foraging success. On Assateague Island, numbers of piping plovers and productivity substantially increased following the 1991 and 1992 winter storms (Bottitta *et al.* 1993). These increases are primarily due to overwash action and lower predation rates. Due to the occurrence of cross-island overwashes since 1992, northern sections of Assateague Island currently provide optimal nesting habitats, sparsely-vegetated travel corridors between ocean and bayside for foraging access, and quality brood rearing habitats consisting of resting areas and shade for broods. These changes have resulted in a large increase in the breeding population, increased reproductive success, and likely higher recruitment rates into the overall population. Providing changes to northern Assateague Island, by depositing a large amount of sand at one time, may jeopardize the current success of the piping plover population if the current overwash frequency is reduced such that travel corridors are not maintained.

If one of the proposed "dune construction" alternatives (involving placement of sand on the island) was selected, it is essential that the frequency of cross-island overwash is sufficient to maintain open nesting areas, travel corridors, ephemeral pools, and bayside mudflats. The greater volume of material that is deposited on the island, the greater potential for longer duration of impacts. Potential impacts include the creation of upland habitats for predatory species (currently, there is a scarcity of potential den sites), greater chance for establishment of vegetation, and the larger storm that may be required to remove it once established. Given the unpredictability of storm frequency, duration, and magnitude in the next five years, it may be impossible to accurately assess impacts from placement of sand along northern Assateague Island.

Alternative 6, however, would likely be the least disruptive to plovers on Assateague Island. This configuration would provide a dune with the smallest volume of sand (less construction time) and lowest dune elevation (increased potential for overwash). An even smaller volume of sand would likely adversely impact northern Assateague Island's piping plover population less and may provide some habitat benefits to low relief areas that are becoming more vulnerable to flooding during the nesting season.

Assuming the newly placed dune/berm material will not be maintained after initial placement, it is possible that following the first overwash event, a rapid lowering of the constructed area will occur over portions of northern Assateague Island, resulting in sections of the restored area becoming prone to overwash. Due to the likelihood that the "dune construction" alternatives will result in some discontinuous dunes being formed along the berm, it is unknown how much area will experience overwash even if the initial dune height becomes quickly lowered after the first overwash event. Following the 1962 breach at the north end of the island, almost 1.2 million m³ of sand was placed to fill the breach only to breach again 2-3 years later. An unknown volume of material was added again to repair the breach. Since that time, island width has increased or remained stable in the northern end, yet island height appears to have decreased. It is unknown what grain size of the sand was used to fill the breach. If grain size was too large, it is likely that much of the material was rapidly washed away.

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