



In addition to protecting communities from river flooding, the Philadelphia District managed a variety of projects along the New Jersey and Delaware coastlines. This type of work mainly involved beach erosion control, shoreline protection, navigation improvements, and beach replenishment. The district had constructed coastal projects as early as the 1910s, when it built jetties at Cape May Inlet along the New Jersey shore. However, the district's coastal work became more prevalent in the 1990s and 2000s, after a series of storms convinced New Jersey and Delaware to undertake a more concerted program of coastal protection. By 2008, the Philadelphia District's efforts on the Delaware and New Jersey shores had become one of

the largest coastal programs in the Corps, while making the district one of the leading experts in the United States on coastal engineering and planning.

According to the Corps of Engineers, shore protection projects were any "projects which reduce the damaging effects of coastal flooding, wave impacts, or erosion due to tides, surges, waves, or shore material deficits resulting from natural or human causes." They could involve the construction of several different features, including groins (structures built out from the seashore to reduce longshore sediment transport) and revetments, seawalls, bulkheads, levees, and surge barriers. Shore protection projects included beach nourishment, either through sand bypassing (transporting sand across

Facing page: Conducting shoreline surveys concurrent with dredging operations for beach nourishment at Dewey Beach, Del.

an inlet, from a wider updrift beach to the narrower downdrift beach) or through the direct placement of fill on eroding beaches.¹ As Jeff Gebert, chief of the district's Coastal Planning Section explained, "We're keeping sand on the beach . . . as well as high enough dunes to keep storm water . . . from flooding and damaging the coastal community." These kinds of projects were funded through the Construction General fund, both for initial construction and for periodic renourishment.²

As in the Corps in general, the Philadelphia District's initial shoreline work was not for protection but was part of the agency's navigation mission. At various inlets, the Corps provided maintenance dredging to ensure good navigability and constructed jetties to improve navigation. However, jetties sometimes impeded the transport of sand, thereby accelerating beach erosion. Therefore, solving navigation problems in the early part of the twentieth century led to different problems

The seawall at Avalon, N.J., upgraded by the district as part of the Townsends Inlet to Cape May Inlet Coastal Storm Damage Reduction Project



later on—problems that required coastal planning and engineering expertise.³ The district’s coastal engineering work in the 1970s and beyond continued to involve navigation improvements.

Early Coastal Protection Projects

The Corps’ involvement in coastal protection and beach erosion prevention was a relatively new responsibility. Beach erosion control along the Atlantic Coast was limited to isolated local initiatives until the early 1900s. Municipalities and private interests in New Jersey began looking at the problem in earnest after a series of hurricanes and other tropical storms battered the shore, all during a period of unprecedented and rapid growth in coastline development. According to one source, various parties implemented erosion control in an uncoordinated way, “often produc[ing] results that were minimally effective and in some cases, counterproductive.” As one Corps report on coastal protection noted, “It was soon realized that the efforts of individual property



owners were incapable of coping with the problem of coastal erosion and that a broader-based approach was necessary.” In 1930, Congress passed an act authorizing the Corps to work with state governments to provide shore protection to communities. Subsequent amendments

The Townsends Inlet to Cape May Inlet Shore Protection Project included seawall upgrades for two Jersey Shore communities: Avalon, along Townsends Inlet (top) and North Wildwood, along Hereford Inlet (bottom)

established the cost sharing of such projects as one-third federal and two-thirds nonfederal, but the River and Harbor Act of 1968 stated that beach restoration and nourishment projects would be funded 100 percent by the federal government. Additional legislation expanded the Corps' jurisdiction to work on private beaches "where substantial public benefits would result" and stated that periodic nourishment would be classified as construction projects. As more hurricanes and tropical storms affected the increasingly developed eastern seaboard in the 1950s and 1960s, Congress passed acts authorizing the Corps to construct several coastal protection projects.⁴ In addition, the Corps received authority under Section 103 of the River and Harbor Act of 1962 "to construct small shore and beach restoration or protection projects including periodic beach nourishment" without specific congressional approval, as long as the total cost of a project did not exceed \$1 million.⁵

One of the first areas to which the Philadelphia District turned

its newly expanded coastal protection attention was Delaware Bay. This work resulted from a Corps-wide study done in the late 1960s and early 1970s at the direction of Congress to develop "general conceptual plans for needed shore protection." The Corps produced this study in 1971; it said that, of the nine regions investigated, "the North Atlantic has the greatest percentage of critical erosion,"⁶ and New Jersey was fifth out of the ten states in that region for "miles of critical erosion." Accordingly, in 1972, the House Committee on Public Works issued a resolution requesting that the Philadelphia District review an earlier report on Delaware Bay to "determin[e] the advisability of providing improvements for beach erosion control, hurricane protection and related purposes along the Delaware Bay shore of New Jersey and the lower portion of the Delaware River in Salem, Cumberland, and Cape May counties."⁷

The Corps conducted the review and additional examinations of the issue in the 1970s, holding public meetings in 1973 on where



The Atlantic coastline of Cape May, N.J., before (above) and after (below) beach nourishment



erosion control was necessary and what measures would best alleviate the problem. At these hearings, and in correspondence to the Corps and to New Jersey's congressional delegation, it was clear that residents and businesses on the New Jersey shoreline believed that protection was necessary. For example, one citizen from Elsinboro, N.J., wrote, "We are losing shoreline at an alarming rate and are in danger of losing homes."⁸ Yet when the Corps issued its feasibility report on beach erosion control and hurricane protection along the Delaware Bay shore in 1979, it stated that, although there was "erosion damage . . . at damage centers along the river and bay in the study area," there were no "economically feasible alternative plans of improvement," meaning that the Corps could find no project with a benefit-cost ratio that exceeded 1.0. The Corps thus recommended that no new federal work be authorized at that time, although it did suggest that a study of erosion problems at Pennsville, N.J., be undertaken under the Continuing Authorities Program.⁹

This study highlighted the conundrum that some coastal communities faced. Residents might feel that coastal protection was necessary, but if projects did not meet or exceed the required benefit-cost ratio, the Corps could not implement them, regardless of the needs of communities and individuals. In addition, in the eyes of many, using federal money on coastal protection projects was not an acceptable option, because it benefited only a few (those residing on the shore). "The problem is we built too close to the ocean," one critic said. "Is the solution putting all this sand endlessly in front of these structures at taxpayers' expense?" Those who supported using federal dollars for coastal projects countered that coastal communities were tourist havens for a variety of people and that it was in the nation's interest to protect them.¹⁰ However, because of the criticisms against the Corps' involvement, President Bill Clinton's administration considered removing the Corps from beach erosion projects across the United States and even proposed



in its fiscal year 1996 budget that no other coastal erosion projects be funded. Some members of Congress, including Senator Bill Bradley (D-N.J.), fought against this proposal, and the administration finally relented, allowing projects to go forward.¹¹

Certain guidelines determined when the federal government could become involved in beach erosion control and coastal protection projects. According to the National Oceanic and Atmospheric

Administration, these included whether the beach was publicly owned, whether the area had a public access recreational component, and whether the economic return was sufficient, “measured by the increase in national economic development benefits.”

The federal government did not participate in any projects involving privately owned beaches with no public recreational component or projects that would protect undeveloped private lands.¹²

Only a thin ribbon of beach separated the Atlantic Ocean from the Boardwalk prior to initial beachfill placement at Atlantic City, N.J.

In addition, the Water Resources Development Act of 1986 (WRDA-1986) contained certain cost-sharing stipulations for coastal protection projects. According to that act, any beach erosion control projects would be designated as a flood control, non-structural flood control, or other purpose project, and costs would be shared according to the designation. Flood control projects required nonfederal interests to contribute up to 50 percent of the project costs, while nonfederal partners had to provide 35 percent of nonstructural flood control project costs. If a project

was designated as a hurricane and storm damage reduction project or as an environmental protection and restoration project, it required 35 percent from non-federal interests, while recreation projects required 50 percent of costs. The law also stated that the cost of using dredged material from federal navigation projects for beach nourishment would be cost-shared on a 50-50 basis.¹³ Because of these cost-sharing requirements, local interests became much more involved in the development of coastal protection projects. As Jeff Gebert explained, requiring nonfederal sponsors to provide cash for projects created “a higher level of involvement on the non-federal side . . . to make sure that the solution you come up with in the project . . . fits better” and is “more likely to be implemented.”¹⁴

However, one of the unresolved questions in WRDA-86 was what to do about periodic nourishment of beaches. Generally, in most beach erosion control projects, the Corps needed to replace sand on beaches at regular intervals, such as every three or four years. Under most

Sand being pumped ashore for beach nourishment at Cape May, N.J.



coastal projects, the nonfederal sponsor was responsible for the operation, maintenance, repair, and rehabilitation of the completed project. Did periodic nourishment fall into this category as well? In 1992, Brig. Gen. Stanley G. Genega, Director of the Corps' Civil Works Program, issued a memorandum stating that the placement of additional sand on beaches could be classified as continuing project construction and should be cost-shared along the same lines as general construction (65 percent federal, 35 percent nonfederal). As Acting Assistant Secretary of the Army (Civil Works) John H. Zirschky put it, "Projects that are in this long-term construction phase will continue as Federal projects through the term of the current agreements with non-Federal sponsors."¹⁵

As these new guidelines were being established, Congress directed the Philadelphia District to initiate a new study addressing both shores of Delaware Bay (as opposed to the New Jersey-only studies and previous separate studies of the Delaware side).

On 1 October 1986, the House Committee on Public Works and Transportation passed a resolution requesting that the district review "existing reports on communities within the tidal portion of the Delaware Bay" to develop plans for coastal protection and "to provide up-to-date information for state and local management of this coastal area." The committee also asked the district to decide whether any previous recommendations for the area should be modified.¹⁶

Accordingly, the district produced a reconnaissance report in 1991 that "identified a number of problem areas where erosion was negatively impacting the adjacent shorelines." It recommended that feasibility studies be conducted for projects in some of these areas (but not all, as some local communities were not interested in sharing the cost of additional studies), especially at Broadkill Beach, Roosevelt Inlet/Lewes Beach, and Mispillion Light in Delaware, and at Cape May Peninsula and Oakwood Beach in New Jersey.¹⁷ The district constructed several projects at these locations in the 1990s and 2000s.

Coastal Protection Projects in New Jersey

Meanwhile, Congress authorized the Philadelphia District to conduct a study of New Jersey's entire ocean shoreline to collect data that would serve "as the basis for actions and programs to prevent the harmful effects of shoreline erosion and storm damage." It also called specifically for "studies for beach erosion control, hurricane protection and related purposes . . . in areas identified as having potential for a project, action or response which

is engineeringly, economically, and environmentally feasible."¹⁸ Because of the studies initiated by the Philadelphia District at the request of Congress in the 1986 and 1987 resolutions, the number of coastal projects conducted by the district increased greatly in the 1990s. This followed a trend in the Corps of Engineers as a whole. According to one report, few beach restoration projects occurred in the 1980s "due to a lack of water resource authorization." The 1990s, however, saw "as many projects completed in the 1990-93 period as there were during the entire decade of the 80's."¹⁹

Another reason the Philadelphia District saw its coastal protection work grow was that the state of New Jersey became greatly interested in these projects, largely because of two storms that impacted the region. Around Halloween in 1991, a huge "nor'easter" hit the Atlantic coast, causing high winds and large waves along the coastline and flooding several areas. In December 1992, another nor'easter pounded the coast, causing "an astronomical

Construction of the Roosevelt Inlet/Lewes Beach Project (Del.) near the mouth of the Delaware Bay



high tide and rainfall, . . . flooding of coastal marshes and some additional coastal washover.”²⁰ Because of the damages caused by these two storms—both in monetary costs and beach destruction—the state of New Jersey passed legislation in 1992 establishing a shore protection fund using realty transfer fees. According to the law, these moneys could be used for “shore protection projects associated with the protection, stabilization, restoration or maintenance of the shore, including monitoring studies and land acquisition.” The state could also use the funds to provide “the non-federal share of any State-federal project.”²¹ This allowed New Jersey to partner with the Corps on several beach erosion control projects that the state wanted done. As Gebert explained, “Before those storms, the State of New Jersey didn’t have a program where they regularly set aside money every year . . . for shore protection.” With that funding, the state worked with the Corps on several coastal protection projects.²²

In the 1990s, the district began a number of projects along the New

Jersey shoreline, some of which were a part of the Delaware Bay studies the Corps had performed and some of which were in response to additional needs identified by the state. The first project to come to fruition was at Cape May on the southern tip of New Jersey, a community “dominated by a resort economy” and by “miles of ocean-front beaches.”²³ The Philadelphia District had long-standing involvement in beach erosion control in this area. In 1907, Congress authorized the Corps to construct two 4,400-foot-long jetties 850 feet from each other to provide “a stable inlet between Cape May Harbor and the Atlantic Ocean.” Although these jetties improved navigation, they facilitated erosion down the shore from the inlet, while creating accumulation up the shore. In the 1990s, the Corps “determined that 76 percent of the shoreline erosion in the Cape May Meadows area is caused by the existing Federal navigation works and the remaining 24 percent shoreline erosion is caused by natural forces.” Local and state interests had attempted to stabilize the shoreline through

groin construction, but additional measures were necessary.²⁴

In the 1970s, the Philadelphia District investigated implementing a beach erosion control and storm protection project from Cape May Inlet to Lower Township, N.J. The Water Resources Development Act of 1976 authorized the Corps to prepare a general design memorandum for the project, which consisted of constructing new groins along the coastline and placing beachfill from Cape May Inlet to Lower Township. The U.S. Coast Guard had considerable interest in the project because it was losing land to beach erosion, which threatened some of its training operations.²⁵

In the early 1980s, the Corps completed the Phase I general design memorandum for this project, based largely on mitigating the damage caused by the 1911 jetties; it called for new groins and beachfill up to the existing 3rd Street groin in the city of Cape May, plus a deferred deposition basin. The Corps began work in 1990 to add five hundred thousand cubic yards of sand at Cape May,

completing initial beach construction in 1991.²⁶

Just a year after Cape May, construction started on a second major beach nourishment effort along the Jersey shore. The Corps had initially become involved in the Great Egg Harbor Inlet and Peck Beach Project in 1970, when the House of Representatives authorized the district to begin a navigation and beach erosion control project around Ocean City. The state of New Jersey had problems funding its share of the project cost in the 1970s, but in 1983, it expressed interest in a “scaled-down project.”²⁷ Having received authorization for this under WRDA-86, the Philadelphia District completed a general design memorandum in 1989. The project planned by the district called for placing four million cubic yards of beachfill along a point extending from the Surf Road groin to 34th Street in Ocean City, using 835,000 cubic yards of sand to repair erosion along the shore, extending thirty-eight storm drain outfall pipes, and providing beach nourishment every three years.

The Corps characterized it as a “\$600 million, 50-year beachfill project.”²⁸

In September 1991, the state of New Jersey and the Corps concluded a local cooperation agreement for the project, and work began soon thereafter. When Hurricane Felix hit the Atlantic coast in August 1995, Philadelphia District Engineer Lt. Col. Robert Magnifico deemed the Ocean City project a success, as it “performed as designed. The event didn’t destroy the integrity of the project at all,” Magnifico said.

He characterized the project as “epitomiz[ing] what ‘partnering’ is all about.”²⁹

In the 2000s, the district supplemented this project with beach erosion control work from Great Egg Harbor Inlet to Townsends Inlet, N.J. This project involved placing beachfill from 34th Street to 59th Street in Ocean City, as well as nourishment of 403,000 cubic yards of sand every three years “synchronized with the existing Federal beachfill project at Ocean City (Great Egg Harbor Inlet to 34th Street).” The project’s

The Cape May Inlet to Lower Township Beach Nourishment Project





estimated cost was \$33.6 million in federal funding and \$18.5 million in nonfederal contributions.³⁰

Aside from Cape May and Ocean City, all the district's subsequent coastal storm damage reduction projects along the Jersey shore emerged from one comprehensive plan: the New Jersey Shore Protection Study, the bulk of which was conducted in the 1990s. Addressing the full length of that state's Atlantic coastline, it spun off a succession of interim feasibility studies within

The Atlantic coastline of Ocean City, N.J., before (above) and after (below) beach nourishment



Philadelphia District boundaries: Manasquan Inlet to Barnegat Inlet, Barnegat Inlet to Little Egg Inlet (Long Beach Island), Brigantine Island, Absecon Island, Great Egg Harbor Inlet to Townsends Inlet, Townsends Inlet to Cape May Inlet, Hereford Inlet to Cape May Inlet, and Lower Cape May Meadows and Cape May Point. By 2008, all but Hereford-Cape May had been authorized for construction, and the district had completed initial beach nourishment for the central portion of Long Beach Island (Surf City and Ship Bottom), Brigantine Beach, Atlantic City and Ventnor, Avalon and Stone Harbor, and Lower Cape May Meadows and Cape May Point, as well as seawall improvements at Avalon and North Wildwood. (Harvey Cedars would follow in 2010 as the second phase on Long Beach Island.)³¹

The most visible among these would be the Absecon Island Project, as it included Atlantic City—one of the preeminent entertainment and resort centers east of the Mississippi. Absecon Island—which extends 8.1 miles from Absecon Inlet to Great Egg



The Absecon Island Coastal Storm Risk Reduction Project

Initial beach nourishment at Brigantine, N.J.



Harbor Inlet and includes the communities of Ventnor, Margate, and Longport—had received much attention from the Corps in the twentieth century. In the 1920s, Congress authorized a navigation project for Absecon Inlet to establish an entrance channel twenty feet deep by four hundred feet wide. Congress also directed the Corps to conduct beach erosion control projects on Absecon Island in 1954. This work involved replacing damaged sheetwalls, building the Brigantine Jetty, groin construction, and widening of the Absecon Inlet. In addition, the Corps conducted periodic nourishment on the island. However, problems continued with beach erosion and in 1976 Congress authorized the district to proceed with Phase I Design Memorandum Stage of Advanced Engineering and Design for Absecon Island beach erosion. Congress reauthorized this project under WRDA-86. After the Corps completed a cost-sharing agreement for a feasibility study with the state of New Jersey in March 1993, it proceeded with the preparation of that study.³²

When the feasibility study was concluded, it proposed constructing a 200-foot-wide berm to an elevation of 8.5 feet NGVD (National Geodetic Vertical Datum of 1929, a geodetic vertical datum that can establish a vertical reference plane—elevation—relative to sea level) and a dune with an elevation of 16 feet NGVD at Atlantic City. The Corps would also place beachfill and a 100-foot berm and dune with an elevation of 14 feet NGVD at Ventnor, Margate, and Longport. Initial beachfill would consist of 7.1 million cubic yards of sand deposited over 42,825 linear feet; the Corps would also provide nourishments of 1.7 million cubic yards every three years. In addition, the district would construct two new bulkheads along the Absecon Inlet where it fronted Atlantic City to provide storm protection.³³ Congress authorized this project in the Water Resources Development Act of 1996 (WRDA-1996), estimating its total cost at \$52 million.³⁴

In July 2003, the Corps concluded a project cooperation agreement with the state of New

Jersey for construction, and the initial beachfill construction began in Atlantic City in December 2003 when 4.5 million cubic yards of sand was pumped from Absecon Inlet to the beach. Beachfill construction at Ventnor was completed in June 2004. In 2008, the Corps was still awaiting funding to complete the second nourishment cycle. However, the project promised to provide a measure of protection to Atlantic City and Ventnor that was not there before. Because of this, as one report stated, the work “brought unprecedented local publicity—most all positive—to the Corps’ shore protection efforts along the Jersey Shore.”³⁵

In 1999, the Philadelphia District developed another plan for the Cape May peninsula, whereby it would provide not only shore protection but ecosystem restoration as well. The Lower Cape May Meadows Ecosystem Restoration Project is discussed more fully in Chapter Five, but the protective features of the project included the building of a protective berm and dune system between the 3rd



Avenue terminal groin in Cape May City and the Central Avenue groin in Cape May Point. The Corps also scheduled placing 650,000 cubic yards of sand on the beach every four years for the next fifty years, using an offshore borrow site for the sand. According to Gebert, this was a significant project—before

Summer beachgoers at Cape May, in view of the Cape May Point Lighthouse

Initial beach nourishment at Surf City along New Jersey’s Long Beach Island



the district's work in the 1990s, there was no beach at Cape May. "The City of Cape May had no beach over most of the ocean shoreline at Cape May City for 40 or 50 years before 1990," Gebert said. "They just had no sand." The district had to be conservative in its periodic nourishment schedule to ensure that the beach remained.³⁶

Coastal Protection Projects in Delaware

New Jersey was not the only location of beach erosion protection projects; the Corps also performed this work along the Delaware coastline. Like New Jersey, the state of Delaware had a history of providing funding for this purpose; as of 2001, newspapers estimated that the state had spent \$19 million to rebuild eroded beaches. However, some communities were still in need of shore protection, and the state partnered with the district to provide it. For example, under Section 860 of WRDA-86, Congress directed the Corps to construct sand bypass facilities and stone revetments at Indian River

Inlet in Delaware. Between 1938 and 1940, the Corps had constructed parallel jetties in the inlet "to create a stable 500-ft-wide inlet that provided a navigation pass for recreational boats." However, the construction of these jetties led to "erosion of the unprotected interior inlet shoreline."³⁷ In 1984, the Corps determined that an environmentally and economically feasible solution to the erosion was to conduct "beach nourishment utilizing a fixed sand bypass plant" that would be constructed on the south side of the inlet. At the state's request, the fixed plant was replaced by a semimobile jet pump system in the plans. With this system, as a district report explained, "Sand would be removed from this zone of accretion, transported by pipeline north across the bridge over the inlet, and deposited along the 3500 foot section of beach immediately north of the Inlet."³⁸ After gaining approval for this project in WRDA-86, the district completed installation in 1990. Since then, the plants has been operated and maintained by the



state of Delaware with federal cost-sharing; it pumps an average of a hundred thousand cubic yards of material a year from the south shore across the inlet to the depleted north shore. According to Gebert, this was the first time the Philadelphia District had conducted sand bypassing operations, making it a landmark coastal protection project.³⁹ The district and the state of Delaware received an Outstanding Coastal Project Award from the American Shore and Beach Preservation Association

in 2001 for the sand bypassing operation, because it “successfully demonstrat[ed] ‘effective, long-term, fixed-sand bypassing using jet pump technology.’”⁴⁰

One of the biggest shore protection efforts in Delaware began in June 1988, when the Senate Committee on Environment and Public Works issued a resolution requesting that the Corps review an existing report on the Delaware Coast to see if any shore and hurricane protection projects were feasible from Cape Henlopen to

The sand bypassing plant at Indian River Inlet, Del., soon after construction in 1989

Fenwick Island, Del. The Corps had developed the existing report in 1957, outlining shore protection plans for locations along both Delaware Bay and the Atlantic Ocean, including Kitts Hummock, Slaughter Beach, Broadkill Beach,

Lewes Beach, Bethany Beach, and a stretch of coastline from Rehoboth Beach to the Indian River Inlet. However, the Corps had determined that the only economically feasible projects were those in the area from Rehoboth Beach to Indian River Inlet.

Accordingly, Congress directed the Corps in the River and Harbor Act of 1958 to restore beaches along that stretch of coastline and to provide periodic nourishment.⁴¹

Two of the communities the Corps envisioned protecting under this project were Rehoboth Beach and Dewey Beach. Located in Sussex County in southern Delaware, these adjacent towns are popular recreation destinations for residents of the mid-Atlantic, especially from the Washington-Baltimore area. The Corps conducted hurricane protection and beach erosion prevention studies in the 1960s, 1970s, and 1980s, but none of these projects were implemented. The need for such projects became more pressing in the late 1980s when Bethany Beach, South Bethany Beach, and Fenwick Island (farther

Bethany Beach (top) and South Bethany (bottom) show the effects of the 1992 nor'easter on Delaware's Atlantic Coast



south than Rehoboth and Dewey, but also in Sussex County) “experienced a loss of shoreline protection due to chronic erosion problems.” These issues led Congress to pass a resolution in 1988 asking the Corps to revisit its studies on this coastline. The Philadelphia District, working with the Delaware Department of Natural Resources and Environmental Control (DNREC), instituted feasibility studies to determine which coastal protection projects were financially desirable. The first study, which lasted from 1992 to 1995, dealt with Rehoboth Beach and Dewey Beach; the second (from 1995 to 1998) examined Bethany Beach and South Bethany; and the third (1997 to 2000) dealt with Fenwick Island.⁴²

In 1996, the Philadelphia District issued its feasibility study for Rehoboth Beach and Dewey Beach, recommending, according to one account, “the construction of a 125-foot-wide berm and a dune at Rehoboth Beach, a 150-foot-wide berm and a dune at Dewey Beach, and grass, dune fencing and periodic beach nourishment at



both locations.”⁴³ Congress authorized this project in WRDA-1996. According to this act, the project involved “storm damage reduction and shoreline protection” at Rehoboth Beach and Dewey Beach; it would cost \$9,423,000, with the nonfederal sponsor contributing \$3,298,000. The project also would provide periodic beach nourishment for fifty years at an annual cost of \$282,000.⁴⁴ The economic need for the project seemed obvious; the Federal Emergency Management Agency (FEMA) issued a report in June 2000 stating that the two towns might lose an average of three to four feet of beach each year for the next sixty years. “If the state were forced to buy and

Dredging and pumping operations for beach nourishment contracts typically continued round the clock



Beachfill operations at Rehoboth Beach, Del.

relocate oceanfront homes,” one report stated, “costs could rise as high as \$300 million.”⁴⁵

In December 2003, the Corps entered into a project cooperation agreement with DNREC to construct the project at Rehoboth Beach and Dewey Beach. This agreement established the department as the non-federal sponsor of the project’s construction and enabled the Corps to begin work on the necessary measures. By July 2005, the beachfill part of the project had been completed, and the placement of dune grass, dune fencing, and crossovers had occurred by January 2006. The

district estimated that periodic nourishment would be needed on the beaches “every three years to ensure the integrity of the design.”⁴⁶

Meanwhile, between 1995 and 1998, the Corps examined shore and hurricane protection measures for Bethany Beach/South Bethany. The district determined that the project was feasible and developed a plan to construct a 150-foot-wide berm to an elevation of 7 feet NAVD (North American Vertical Datum of 1988, an updated geodetic vertical datum that can be referenced to the aforementioned NGVD 29) and a dune to 16 feet NAVD over a 2.8-mile distance.⁴⁷ The district also proposed depositing an initial beachfill of 3.5 million cubic yards and nourishments of 480,000 cubic yards every three years. Congress authorized this project in the Water Resources Development Act of 1999, estimating that it would cost \$22,205,000, of which the nonfederal sponsor would pay \$7,772,000. Periodic nourishment would cost \$1,584,000 a year for fifty years. On 26 July 2006, the Corps signed

a project cooperation agreement with DNREC, committing the latter to serve as the project's nonfederal sponsor, and construction began. Initial construction was completed in June 2008.⁴⁸

The final part of the Corps' three-pronged approach to southern Delaware coastline protection was work at Fenwick Island. As mentioned earlier, the Corps conducted a feasibility study of that area from 1997 to 2000, recommending a project involving the construction of a 200-foot-wide berm to an elevation of 7.7 feet NAVD and a dune to 17.7 feet NAVD covering a 6,500-foot-long area extending from the Maryland border to Fenwick Island State Park. The Corps recommended placement of 595,400 cubic yards of beachfill at Fenwick Island, as well as nourishment every four years. Congress approved this project in the Water Resources Development Act of 2000, estimating the total cost at \$5,633,000, with a nonfederal share of \$1,972,000. In 2004, the Corps completed a project cooperation agreement with DNREC;



*Construction of the Bethany Beach/
South Bethany Project*





Initial nourishment at Fenwick Island, southernmost of three storm risk reduction projects covering Delaware's Atlantic Coast

initial construction was completed in November 2005.⁴⁹

In view of the three major shore protection projects the Corps did for the state of Delaware in the 2000s, Gebert considers that decade as a “watershed” for the state. From Delaware’s perspective, protecting the shoreline—especially the resort areas of Rehoboth Beach, Dewey Beach, Bethany Beach/South Bethany, and Fenwick Island—was of paramount importance, as it was to New Jersey. As Gebert explained, coastal projects were generally done for “coastal

communities with a significant density of residential and business and public infrastructure [that was], for the most part, open to the public.” The increase in the district’s work in this area in the 1990s and 2000s expanded the number of employees working on coastal projects and gave the district the reputation as one of the Corps’ experts in coastal planning. In fact, beginning in the 2000s, the Corps had the Philadelphia District conduct an annual course for Corps planners on coastal engineering and planning.⁵⁰

Inlet Navigation Improvement Projects

In addition to its beach erosion control and shore protection projects, the Philadelphia District improved inlet navigation through its coastal program, funded largely from its operations and maintenance account. Barnegat Inlet in Ocean County, New Jersey, was one area where the Corps performed this type of work. The main link connecting the Atlantic Ocean and Barnegat Bay, Barnegat Inlet

separates Island Beach State Park and Long Beach Island.⁵¹ According to one source, the inlet had “a long history of shifting. . . . Before it was first stabilized in 1940, the inlet was known to move as much as 40 feet a year.”⁵² As a Corps engineer explained, “Fishermen could go out one week, come back a week later and the channel wasn’t in the same place as when they left.”⁵³

To deal with this problem, Congress authorized the Corps to take several measures as part of the

Barnegat Inlet, N.J., widely considered one of the most treacherous inlets on the Atlantic Coast before rehabilitation of the south jetty was completed in 1991



federal navigation project authorized in 1935. The Corps built a groin by Barnegat Lighthouse on the south side of the inlet, constructed a north jetty and a south jetty and dredged a flood shoal in 1939, and built a sand dike in 1943 “in an attempt to ‘train’ the tidal flow to follow a straighter path through the remaining channel.” Sediment deposition in the channel meant that the district had to dredge the channel “on an annual or semi-annual basis between 1972 and 1981.”⁵⁴ The goal of the dredging and the rest of the Corps’ work was to maintain

a channel 8 feet deep through the inlet and 10 feet deep through the outer bar, a channel of suitable hydraulic characteristics extending in a northwesterly direction from the gorge in the inlet to Oyster Creek channel and through the latter channel to deep water in the bay, and the maintenance of a channel 8 feet deep and 200 feet wide to connect Barnegat Light Harbor with the main inlet channel.⁵⁵

In the 1960s and 1970s, the Corps’ Waterways Experiment Station conducted studies that “concluded that the construction

of a new south jetty parallel to the existing north jetty and a 90-[meter] wide, 3-[meter] deep channel would provide inlet and channel stability.”⁵⁶ The Philadelphia District conducted its own study of whether any modifications to the 1935 navigation plan were warranted, determining in 1974 that modifications should occur along the lines outlined by the Waterways Experiment Station. Congress authorized preconstruction planning in 1976; in 1981, the Corps issued a general design memorandum that determined that, in the words of District Engineer Lt. Col. Roger Baldwin, “the most significant problem . . . was the instability and shoaling of the Barnegat Inlet navigation channel,” in large part because the south jetty’s alignment did not “properly confine the flow to any specific channel” and because sand brought in by ocean currents generally accumulated at the entrance to the channel.⁵⁷

In 1985, Congress authorized the Corps to begin the new construction, based on the Corps’ determination of a design

deficiency associated with the earlier project. Accordingly, when the Corps signed a local cooperation agreement with the state of New Jersey for the work in May 1986, the federal share of the cost was set proportionately higher. This agreement stated that the district would improve the navigation channel in the inlet by building a new south jetty and by dredging “a 10 foot deep, 300 feet wide navigation channel,” as well as removing a shoal between the proposed channel and the north jetty and constructing “jetty sport fishing facilities.”⁵⁸ As the non-federal sponsor, the state would contribute 35.4 percent of the cost of construction. After the passage of WRDA-1986, the agreement was amended so that the state would provide “a cash contribution equal to 10 percent of the total costs of construction of general navigation facilities” and up to 50 percent of the cost of the recreation facilities.⁵⁹ With these agreements in place, the Philadelphia District oversaw the construction of the new south jetty between 1987 and 1991. According to one report, part

of the work involved “angl[ing] the rocks more to the south of the due east direction that the old South Jetty had pointed, to better funnel the water flow.”⁶⁰

In the years that followed, the Philadelphia District continued to dredge the inlet periodically and to monitor project conditions. In addition, it conducted a variety of other work at Barnegat Inlet, including protecting the Barnegat Lighthouse when it discovered in 2000 that “underwater erosion was threatening the base of the lighthouse.” This \$1.38 million project involved “placing 160 stone-filled ‘mattresses’—each four inches thick, six feet wide



The plan for Barnegat Inlet involved construction of an entirely new south jetty backfilled with sand dredged from the inlet





*Improving erosion protection around
Barnegat Light*

and twenty feet long—in the deepest part of the slope to shore up the eroded rock.”⁶¹ In 2002, the district completed the installation of an anti-erosional geotextile fabric across the south jetty that would act as a filter to prevent sand loss. The Corps had discovered that “water was working its way through the jetty unimpeded,” causing erosion behind and underneath the structure. With the fabric in place, water would be able to

travel through without taking sand with it.⁶²

The innovative technology the district used at Barnegat Inlet illustrated the importance of staying abreast of new features in coastal planning. Because of its work on the New Jersey and Delaware shorelines, the Philadelphia District was often on the cutting edge of these technologies. This was especially evident in the Corps’ work at Manasquan Inlet, which divides

Monmouth and Ocean counties in New Jersey and is “the northernmost connection between the ocean and the New Jersey Intracoastal Waterway.” Between 1881 and 1883, and again in 1922, local interests attempted to stabilize the inlet, which tended to migrate as much as a mile north of its present location, by constructing timber jetties. When these failed to work, Congress authorized the Corps in 1930 to construct two parallel stone jetties four hundred feet apart. Although these jetties provided the necessary stabilization, they experienced frequent storm damage between 1935 and 1975, especially on the outer ends, where stone would be dislodged and displaced. In 1978, the Philadelphia District came up with an innovative solution to protect the jetties and, by extension, the inlet.⁶³ The district proposed rehabilitating the jetties using a slightly modified version of dolosse, structures designed by a South African coastline engineer to combat erosion. Described by one source as eleven-foot-high “concrete jacks” weighing sixteen



Manasquan Inlet, N.J., where “dolosse” were first used on the Atlantic Coast

tons and reinforced with steel, the dolosse interlocked to form an improved protective armor layer around the jetties. Between 1980 and 1982, the district placed 1,343 dolosse around the north and south jetties; this was the first time the structures had been used on the east coast of the United States. The dolosse provided much-needed protection, but between 1982 and 1997, about five of them were damaged and others moved from their original location. To provide further protection, the Philadelphia District placed forty CORE-LOC[®] structures (developed by the U.S. Army Engineer Research and



Putting the dolosse into place at Manasquan Inlet

Development Center) at the heads of the north and south jetties in 1997. Though similar to dolosse, the CORE-LOCs had “three ‘flukes’ (opposing sets of legs) instead of just two” and weighed three more tons. “The extra fluke helps strengthen the structure against breakage,” a district article noted, while “the extra weight makes the coreloc less susceptible to movement due to wave action.”

In the words of Philadelphia District project manager Jerry Jones, the CORE-LOCs interlocked with the dolosse “in much the same way that armor mail once worked to protect a medieval knight.” Use of the CORE-LOCs was another example of the district’s ability to innovate; this was the first time they had been used in the United States.⁶⁴

* * * * *



Coastal projects were a large part of the workload of the Philadelphia District, whether they involved beach erosion control or navigation improvement. The district conducted a number of projects for the states of New Jersey and Delaware between 1972 and 2008, projects that together constituted one of the largest coastal programs in the nation. The district emerged from these projects as one of the leading authorities in the United States on coastal protection

and planning. Perhaps more important, the projects provided a previously unknown measure of protection to coastal communities, enhanced recreational opportunities along the coastline, and improved navigation of coastal inlets. Not everyone agreed that the federal government should foot the bill to protect these communities, but the district gained satisfaction from what it accomplished technically in meeting a challenge from Congress. 🏰

CORE-LOCs and dolosse working in combination along Manasquan Inlet

¹ Department of the Army, U.S. Army Corps of Engineers, "Hydraulic Design for Coastal Shore Protection Projects," Engineering Regulation (ER) No. 1110-2-1407, 1, B-1 <<http://140.194.76.129/publications/eng-regs>> (16 April 2010) (hereafter referred to as ER 1110-2-1407).

² Jeff Gebert interview by Joshua Pollarine, 19 October 2009, Philadelphia, Pennsylvania, transcript, 16–17, 29.

³ Gebert interview, 6–7. The Philadelphia District's coastal planning work (whether for beach erosion control, hurricane protection, or navigation improvement) initially was done out of the Coastal and Special Studies Section of the Planning Branch in the Engineering Division. When the Planning Division was created in 1987, the Coastal Planning Section shifted to the Project Development Branch of the Planning Division. John Tunnell email to Jeff Gebert and Joshua Pollarine, 10 May 2010; copy in possession of the authors.

⁴ Quotations in U.S. Army Corps of Engineers, Water Resources Support Center, Institute for Water Resources, *Shoreline Protection and Beach Erosion Control Study: Final Report: An Analysis of the U.S. Army Corps of Engineers Shore Protection Program*, IWR Report 96-PS-1 (Alexandria, Va.: U.S. Army Corps of Engineers, Water Resources Support Center, Institute for Water Resources, 1996), II-2 – II-6; see also Snyder and Guss, *The District*, 208–209.

⁵ U.S. Army Corps of Engineers, Philadelphia District, *Small Projects Program* (pamphlet) (Philadelphia: Philadelphia District, U.S. Army Corps of Engineers, n.d.), n.p.

⁶ Department of the Army, Philadelphia District, Corps of Engineers, "Survey Study, Beach Erosion Control and Hurricane Protection, Delaware Bay Shore, New Jersey, Plan of Survey," June 1974, 3, File Del. Bay Shore, N.J. Work Sheets, Box 223, Philadelphia District-AR.

⁷ As cited in Department of the Army, Philadelphia District, Corps of Engineers, "Survey Study, Beach Erosion Control and Hurricane Protection, Delaware Bay Shore, New Jersey: Feasibility Report," August 1979, 1 (hereafter referred to as Delaware Bay Shore Feasibility Report, 1979), File Delaware Bay Shore, New Jersey, "Final Feasibility Report," Report and Inclosures [sic], Box 223, Philadelphia District-AR.

⁸ T. R. Hudson to Corps of Army Engineers, U.S. Department of the Army, 28 October 1976, File 1518-01 Delaware Bay Shore of N.J., Correspondence 1975-76-77, Box 223, Philadelphia District-AR.

⁹ Delaware Bay Shore Feasibility Report, 1979, 33.

¹⁰ Quotation in Anthony R. Wood, "New Jersey Expected to Get \$20.7 Million for Beaches," *Philadelphia Inquirer*, 14 October 2009; see also "In Defense of Jersey's Shores," *Philadelphia Inquirer*, 8 March 2000, online edition <<http://marine.rutgers.edu/cool/education/coast09.html>> (14 April 2010).

¹¹ See "Navigation, Beachfill Projects Under New Scrutiny," *The Observer* (July 1995): 3; John H. Zirschky, Acting Assistant Secretary of the Army (Civil Works), to Mr. Stan Tait, President, Florida Shore and Beach Preservation Association, n.d., Harry Shoudy's Files, Office of History.

¹² National Oceanic and Atmospheric Administration, Coastal Services Center, "Beach Nourishment: A Guide for Local Government Officials" <<http://www.csc.noaa.gov/beachnourishment/html/human/law/history.htm>> (16 April 2010).

¹³ Water Resources Development Act of 1986 (100 Stat. 4082); NOAA, "Beach Nourishment: A Guide for Local Government Officials."

¹⁴ Gebert interview, 5–6.

¹⁵ Quotation in Zirschky to Tait, n.d.; see also Brigadier General Stanley G. Genega, Director of Civil Works, Memorandum for Major Subordinate Commands and District Commands, 17 November 1992, Harry Shoudy's Files, Office of History.

¹⁶ As cited in Department of the Army, Philadelphia District, Corps of Engineers, "Delaware Bay Coastline, Delaware and New Jersey: Reconnaissance Report, August 1991," 1, Box 246, Philadelphia District-AR.

¹⁷ Philadelphia District, "Delaware Bay Coastline," 133–135. The Corps had previously completed beach erosion control projects at Broadkill Beach and Lewes Beach, but by the early 1990s, "the 10 year period for federal involvement in period nourishment [had] lapsed." "Delaware Bay Coastline, New Jersey and Delaware, Reconnaissance Review Conference, 13 August 1992," 1, File Del. Bay RRC, Slides w/ Green Slide Book, Box 247, Philadelphia District-AR.

¹⁸ Committee on Public Works and Transportation, U.S. House of Representatives, "Resolution: Coast of New Jersey, Erosion and Storm Effects Study, Docket No. 2294," 10 December 1987, document provided by Jeff Gebert, Chief, Coastal Planning, Philadelphia District, Philadelphia, Pennsylvania.

¹⁹ ER 1110-2-1407, 1.

²⁰ Quotation in Kelvin W. Ramsey, John H. Talley, and Darlene V. Wells, "Summary Report: The Coastal Storm of December 10-14, 1992, Delaware and Maryland," State of Delaware Geological Survey Open File Report No. 37, February 1993, 22, document provided by Jeff Gebert; see also NOAA Satellite and Information Service, "The Perfect Storm: October 1991" <<http://www.ncdc.noaa.gov/oa/satellite/satelliteseye/cyclones/pfctstorm91/pfctstorm.html>> (16 April 2010); Gebert interview, 8.

²¹ Senate Budget and Appropriations Committee, Statement to Assembly No. 1676, State of New Jersey, 10 December 1998, document provided by Jeff Gebert.

²² Gebert interview, 8.

²³ "Cape May County," 195–196, File Delaware Bay Shore, Erosion Rater (George Hicks), Box 223, Philadelphia District-AR.

²⁴ Quotations in Lieutenant General Joe N. Ballard, Chief of Engineers, to The Secretary of the Army, 5 April 1999, document provided by Jeff Gebert; see also "Appendix D, Study of Sand Bypassing Options at Cape May Inlet, New Jersey," 31 January 1991, document provided by Jeff Gebert.

²⁵ See U.S. Army Corps of Engineers, Philadelphia District, "Cape May Inlet to Lower Township, New Jersey: Phase I General Design Memorandum," Draft, March 1980, document provided by Jeff Gebert; John E. Tunnell email to Jeffrey Gebert and Joshua Pollarine, 3 May 2010, copy in possession of the authors.

²⁶ U.S. Army Corps of Engineers, Philadelphia District, "Cape May Inlet to Lower Township, New Jersey: Phase I General Design Memorandum," Draft, March 1980, document provided by Jeff Gebert; John E. Tunnell email to Jeffrey Gebert and Joshua Pollarine, 3 May 2010, copy in possession of the authors; see also Ballard to The Secretary of the Army, 5 April 1999; "Nourishment Continues at Cape May," *The Observer* (December 1992): 5; U.S. Army Corps of Engineers, Philadelphia District, "Project Factsheet: Cape May Inlet to Lower Township, N.J., January 2010" <http://www.PhiladelphiaDistrict.usace.army.mil/cePhiladelphiaDistrict-dp/projects/factsheets/NJ/4CG_CapeMayInlet_to_LowerTwp.pdf> (20 April 2010).

²⁷ Unpublished Morgan Draft District History, 88–89.

²⁸ Quotations in "Felix is No Match for Jersey Shore Partnership," *The Observer* (September 1995): 10; see also "Ocean City Beach Replenishment Begins: City's Ocean Front Gets a Facelift," *The Observer* (November 1994): 3; Unpublished Morgan Draft District History, 88–89; "Local Cooperation Agreement Between the Department of the Army and the State of New Jersey for Construction of the Great Egg Harbor Inlet and Peck Beach, New Jersey Project," 18 September 1991, document provided by Jeff Gebert; Gebert interview, 10.

²⁹ Quotations in "Felix is No Match for Jersey Shore Partnership," *The Observer* (September 1995): 10; see also "Ocean City Beach Replenishment Begins: City's Ocean Front Gets a Facelift," *The Observer* (November 1994): 3; Unpublished Morgan Draft District History, 88–89; "Local Cooperation Agreement Between the Department of the Army and the State of New Jersey for Construction of the Great Egg Harbor Inlet and Peck Beach, New Jersey Project," 18 September 1991, document provided by Jeff Gebert; Gebert interview, 10.

³⁰ Lieutenant General Carl A. Strock, Chief of Engineers, to The Secretary of the Army, 24 October 2006, document provided by Jeff Gebert.

³¹ Edward Voigt, Chief, Public & Legislative Affairs, Philadelphia District, personal communication with Joshua Pollarine, 4 April 2011.

³² House, *New Jersey Shore Protection Study: Communication from the Acting Assistant Secretary (Civil Works), the Department of the Army, Transmitting a Report on a Storm Damage Reduction and Shoreline Protection Project for Brigantine Inlet to Great Egg Harbor Inlet, Absecon Island, New Jersey, Pursuant to Pub. L. 104-303, Sec. 101(b)(13)*, 105th Cong., 1st sess., 1997, H. Doc. 105-153, serial 14432, 15–16.

³³ House, *New Jersey Shore Protection*, 187; "Brigantine Inlet to Great Egg Harbor Inlet, Shore Protection Project," *The Observer* (October/November 2003): 9; Lieutenant

General Joe N. Ballard, Chief of Engineers, to The Secretary of the Army, 23 December 1996, document provided by Jeff Gebert.

³⁴ Water Resources Development Act of 1996 (110 Stat. 3658).

³⁵ Quotations in “Coastal Construction Moves Forward in N.J., Del.,” *The Observer* (Autumn 2004): 7; see also “Brigantine Inlet to Great Egg Harbor Inlet, Shore Protection Project,” 9; U.S. Army Corps of Engineers, Philadelphia District, “Project Factsheet: New Jersey Shore Protection, Brigantine Inlet to Great Egg Harbor Inlet, Absecon Island, N.J.,” March 2010 <http://www.Philadelphia District.usace.army.mil/cePhiladelphia District-dp/projects/factsheets/NJ/4CG_NJShore%20Protection_Absecon%20Island.pdf> (30 April 2010); “Project Cooperation Agreement Between the Department of the Army and the State of New Jersey Department of Environmental Protection, Brigantine Inlet to Great Egg Harbor Inlet, Absecon Island, NJ, Shore Protection Project,” 31 July 2003, document provided by Jeff Gebert.

³⁶ Quotation in Gebert interview, 11; see also Ballard to The Secretary of the Army, 5 April 1999; “Nourishment Continues at Cape May,” *The Observer* (December 1992): 5; U.S. Army Corps of Engineers, Philadelphia District, “Project Factsheet: Cape May Inlet to Lower Township, N.J., January 2010” <http://www.Philadelphia District.usace.army.mil/cePhiladelphia District-dp/projects/factsheets/NJ/4CG_CapeMayInlet_to_LowerTwp.pdf> (20 April 2010). In addition to these projects, the Philadelphia District completed a variety of other coastal protection projects for the state of New Jersey in the 1990s and 2000s, including projects involving seawall construction at Avalon and Stone Harbor.

³⁷ Quotations in The Committee on Tidal Hydraulics, “Indian River Inlet: An Evaluation by the Committee on Tidal Hydraulics,” July 1994, 6, document provided by Jeff Gebert; see also Water Resources Development Act of 1986 (100 Stat. 4082).

³⁸ U.S. Army Corps of Engineers, Philadelphia District, “Atlantic Coast of Delaware: General Design Memorandum and Environmental Assessment,” July 1984, Syllabus, copy in Philadelphia District-Library.

³⁹ Gebert interview, 6–7.

⁴⁰ “Two District Projects Receive National Recognition,” *The Observer* (Summer 2001): 10. The article noted that the bypass operation was “now operated and maintained by the Delaware Department of Natural Resources and Environmental Control”; Voigt personal communication.

⁴¹ House, *Beach Nourishment Project: Communication from the Acting Assistant Secretary (Civil Works), the Department of the Army, Transmitting a Report on the Storm Damage Reduction and Shoreline Protection Project for Rehoboth Beach and Dewey Beach, Delaware, Pursuant to Section 101(b)(6) of the Water Resources Development Act of 1996*, 105th Cong., 1st sess., 1997, H. Doc. 105-144, serial 14429, 9, 16-18 (hereafter referred to as *Beach Nourishment Project*); “Delaware Shore Plans Unveiled at Public Hearing,” *The Observer* (March 1996): 5; Lieutenant General Joe N. Ballard, Chief of Engineers, to The Secretary of the Army, 23 December 1996, document provided by Jeff Gebert; “Public Perspective,” *The Observer* (January/February 2001): 16; Voigt personal communication.

⁴² House, *Beach Nourishment Project*, 9; Voigt personal communication.

⁴³ “Delaware Shore Plans Unveiled at Public Hearing,” 5.

⁴⁴ Water Resources Development Act of 1996 (110 Stat. 3667).

⁴⁵ “Public Perspective,” *The Observer* (January/February 2001): 16. This was a reprint of an article published in the *Baltimore Sun* on 18 February 2001.

⁴⁶ Quotations in U.S. Army Corps of Engineers, Philadelphia District, “Project Factsheet: Delaware Coast from Cape Henlopen to Fenwick Island, Rehoboth Beach/Dewey Beach, DE,” January 2010 <http://www.Philadelphia District.usace.army.mil/cePhiladelphia District-dp/projects/factsheets/DE/4CG_DelCoast_Rehoboth%20Dewey.pdf> (27 April 2010); see also “Project Cooperation Agreement Between the Department of the Army and the Delaware Department of Natural Resources and Environmental Control for Construction of the Delaware Coast from Cape Henlopen to Fenwick Island, Delaware, Rehoboth Beach and Dewey Beach, Delaware Project,” 19 December 2003, document provided by Jeff Gebert.

⁴⁷ In 1988, the NGVD was renamed North American Vertical Datum.

⁴⁸ U.S. Army Corps of Engineers, Philadelphia District, “Project Factsheet: Delaware Coast from Cape Henlopen to Fenwick Island, Bethany Beach/South Bethany, DE,”

January 2010 <http://www.Philadelphia District.usace.army.mil/cePhiladelphia District-dp/projects/factsheets/DE/4CG_DelCoast_Bethany%20S%20Bethany.pdf> (28 April 2010); Water Resources Development Act of 1999 (113 Stat. 269); Lieutenant General Joe N. Ballard, Chief of Engineers, to The Secretary of the Army, 21 April 1999, document provided by Jeff Gebert; “Project Cooperation Agreement between the Department of the Army and the Delaware Department of Natural Resources and Environmental Control for Construction of the Delaware Coast from Cape Henlopen to Fenwick Island, Bethany Beach to South Bethany, Delaware, Hurricane and Storm Damage Reduction Project,” 26 July 2006, document provided by Jeff Gebert.

⁴⁹ U.S. Army Corps of Engineers, Philadelphia District, “Project Factsheet: Delaware Coast from Cape Henlopen to Fenwick Island, Fenwick Island, DE,” January 2010 <http://www.Philadelphia District.usace.army.mil/cePhiladelphia District-dp/projects/factsheets/DE/4CG_DelCoast_Fenwick%20Island.pdf> (28 April 2010); Lieutenant General Robert B. Flowers to The Secretary of the Army, 29 December 2000, document provided by Jeff Gebert; Water Resources Development Act of 2000 (114 Stat. 2572); “Project Cooperation Agreement between the Department of the Army and the Delaware Department of Natural Resources and Environmental Control for Construction of the Delaware Coast from Cape Henlopen to Fenwick Island, Delaware Project,” 13 September 2004, document provided by Jeff Gebert.

⁵⁰ Quotations in Gebert interview, 9, 29, 32-33; see also “Planning Associates Coastal Course,” 27 April-1 May 2009, Powerpoint presentation provided by Jeff Gebert.

⁵¹ William C. Seabergh, Mary A. Cialone, and John W. McCormick, “Inlet Modifications and the Dynamics of Barnegat Inlet, New Jersey,” *Journal of Coastal Research* 19 (2003): n.p., document provided by Jeff Gebert.

⁵² “‘Old Barney’ Gets New Lease on Life,” *The Observer* (January/February 2001): 4.

⁵³ As cited in Maria Scandale, “Rock Steady: Jetty Stones Shored Up To Stem Erosion,” *The Observer* (September/October 2002): 15.

⁵⁴ Seabergh, Cialone, and McCormick, “Inlet Modifications and the Dynamics of Barnegat Inlet, New Jersey,” n.p.

⁵⁵ U.S. Army Corps of Engineers, Philadelphia District, “Project Factsheet: Barnegat Inlet, Ocean County, NJ,” January 2010 <http://www.Philadelphia District.usace.army.mil/cePhiladelphia District-dp/projects/factsheets/NJ/50M_BarnegatInlet.pdf> (30 April 2010).

⁵⁶ Seabergh, Cialone, and McCormick, “Inlet Modifications and the Dynamics of Barnegat Inlet, New Jersey,” n.p.

⁵⁷ Quotations in U.S. Army Corps of Engineers, Philadelphia District, “Barnegat Inlet, Ocean County, New Jersey, Transcript, 26 August 1981 Public Meeting,” 3–5, copy in Philadelphia District-Library; see also U.S. Army Corps of Engineers, Philadelphia District, “Barnegat Inlet, Ocean County, New Jersey: Phase II, General Design Memorandum,” August 1984, Syllabus, copy in Philadelphia District-Library.

⁵⁸ Quotations in “Agreement Between the Department of the Army and the State of New Jersey for Local Cooperation at Barnegat Inlet, Ocean County, New Jersey,” 19 May 1986, document provided by Jeff Gebert; see also Act of 15 August 1985 (99 Stat. 293); Voigt personal communication.

⁵⁹ “Modification No. 1 to the Agreement Between the Department of the Army and the State of New Jersey for Local Cooperation at Barnegat Inlet, Ocean County, New Jersey,” 20 March 1987, document provided by Jeff Gebert.

⁶⁰ Scandale, “Rock Steady,” 15.

⁶¹ “‘Old Barney’ Gets New Lease on Life,” 4.

⁶² “Jetty Work Almost Done, Summerlong Repairs Will Leave Sinkholes Fixed,” *The Observer* (July/August 2002): 17.

⁶³ Quotation in Jeffrey A. Gebert and J. Michael Hemsley, “Monitoring of Jetty Rehabilitation at Manasquan Inlet, New Jersey,” Monitoring Completed Coastal Projects Program Miscellaneous Paper CERC-91-8, September 1991, 1-2, document provided by Jeff Gebert; see also Gebert interview, 13–14; “Manasquan Inlet History,” document provided by Jeff Gebert.

⁶⁴ Quotations in “Another ‘First’ Set in Place at Manasquan Inlet,” *The Observer* (September/October 1997): 3; see also “Manasquan Inlet History”; Gebert interview, 13–14; Voigt personal communication.