# The Richard Stockton College of New Jersey
# Coastal Research Center


# New Jersey Beach Profile Network
# Annual Report
# On
# Shoreline Changes In New Jersey
# Coastal Reaches One Through Fifteen
# Raritan Bay to Delaware Bay
# Spring of 2002 Through Fall of 2003

Prepared for:
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**EXECUTIVE SUMMARY**

Five years into the New Millennium, the New Jersey Beach Profile Network report is approaching its 20th year of observations on beach changes along the New Jersey coastline. Sites extend from the lower Raritan Bay, along the four-county oceanfront shoreline and into Delaware Bay along the western shoreline of Cape May County. Each report focuses on shoreline and beach volume changes presented as tables, photographs and topographic profiles for each of the 100 locations between spring 2003 and fall 2004 in this edition. The winter of 2002 to 2003 had over 14 individual northeast storms that impacted the New Jersey coastline with relatively minor damage to dunes and beach elevations. These conditions continued during the 2003 to 2004 winter with fewer storms, but with concentrations of events in the mid- to late-spring timeframe. The Borough of Mantoloking was again forced to undertake a dune restoration program where sand accumulating on the beach as the storms abated in mid to late June was pushed up to replace lost sand. Loss was limited to the dune toe and locations prone to erosional episodes during northeast wave conditions such as some of the groin field sites on Long Beach Island and the northern end of Seven-Mile Island. The accretional wave climate commenced in mid-June, but was less effective in building up the beach width and berm elevation in 2004.

The fall 2004 hurricane season ravaged the State of Florida, but fortunately the storms missed the Mid-Atlantic coastline. As the last hurricane faded to a tropical depression, the northeast storm events took over in a progression of repetitive mild storms. Analysis of weather patterns collected by the US Weather Service at the Atlantic City station showed that in a 517-day period between January 1, 2004 and May 31, 2005 winds averaging 19 MPH came from the northeast during 122 days of the record. The highest 2-minute wind gust was 34 MPH. Therefore, although no event could be classified as a "moderate" or "severe" storm, the frequency of mild events removed large quantities of sand from beach projects where northeast wave-driven impact has been a problem. The Atlantic City, Ocean City and Avalon beaches at the north end of each municipal shoreline suffered berm retreat into the manmade dune. The Ventnor City beach project ended at the Margate City boundary and was subject of north to south littoral currents that transported of much of the southern part of the project beach into Margate.

The level of beach nourishment activity by the US Army Corps of Engineers (ACOE) has subsided recently as funding has become more difficult to extract from Congress and many projects are in the maintenance phase. Progress continues toward construction on Long Beach Island, Ludlam Island, and eventually Northern Ocean County between the Manasquan River Inlet and Barnegat Inlet. Work was completed by the Philadelphia District on the Cape May Meadows and Borough of Cape May Point project in the late fall, early winter of 2004 to 2005 with over a million cubic yards of sand pumped onto the Cape May Meadows shoreline for environmental restoration purposes as well as continuing into Cape May Point as a shore protection effort. The only project set for construction in late 2005 is the relatively small effort along the City of Brigantine's northern shoreline in Atlantic County. Monitoring and evaluation of performance data continues at both the New York and Philadelphia Districts for planning of eventual maintenance of existing projects.

The Cape May Point 227 monitoring effort on the performance of "reef" structures in preventing sand loss offshore along Cape May Point will enter its third year of five. Results to date favor the 6-foot high "Beachsaver" concrete units over the standardized "Double Tee" concrete parking garage floor-beam units, which are only about 30 inches tall. Both types of "reef" structures perform better than no structure as evidenced by more erosion at the structure-free control beach in Cape May Point.

**ACKNOWLEDGEMENTS**

*This research was funded by the State of New Jersey Department of Environmental Protection, Division of Construction and Engineering under the Shore Protection legislation authorizing the stable funding of coastal projects (NJ PL 93 Chap 155). This is the final report under contract #4154.*

## INTRODUCTION:

Created in 1986, the New Jersey Beach Profile Network (NJBPN) provides regional information on coastal zone changes to document storm-related damage assessments to the New Jersey shoreline. Several reports have focused on long-term trends at sites to develop statistically meaningful information for State and local coastal zone managers. The database consists of 100 locations between Raritan Bay (three sites in the lower bay), the Atlantic Ocean coastline, and Delaware Bay (four sites on the western shoreline of Cape May County). Each site has been visited annually in the fall since 1986. Semiannual visits, each spring and fall, began in 1994 and have continued since. Information collected consists of photographs of the beach/dune system at each site, a topographic profile of the dune, beach and seafloor to a depth of 12 feet, and field notes on significant conditions or geologic change in progress. Any construction activity is noted and necessary information regarding quantity and duration of such activity is gathered. The field data is used to generate graphical cross section plots, which compare profiles across the width of the active coastal zone, and calculate sand volume and shoreline position changes. Analysis may be performed for any selection of survey dates at any site. This report is the latest in a series of annual reports prepared for the New Jersey Department of Environmental Protection (NJDEP) that began in 1987.

## SHORE PROTECTION IN THE STATE OF NEW JERSEY:

New Jersey has the reputation of being the most developed, congested shoreline in the country, but out of a 130-mile distance between Sandy Hook and Cape May Point, there are 31.2 miles of shoreline with no development on the coastal zone between the marshes and the sea. The Sandy Hook National Seashore occupies northernmost Monmouth County, followed by continuous development from Sea Bright south to Seaside Park in Ocean County. The 10.5-mile Island Beach State Park provides a nearly pristine coastal environment enjoyed by ever increasing recreational and eco-tourist activities. Long Beach Island has the Holgate unit of the Forsythe National Wildlife Refuge at its southern tip as part of a 10.8-mile gap in development consisting of Holgate, Little Beach Island and the northern part of Brigantine Island. Shorter segments of undeveloped shoreline exist on Pecks Beach (Corson's Inlet State Park), Wildwood, and the Cape May Meadows in Cape May County. Seventy six percent of the coast is developed, with intensely crowded public and private land use activities of great economic value to the State and its citizens.

Shore protection is the science and strategy of devising methods, structures, and practices that together, promote the art of living safely within an unstable environment with the constant threat of storm damage. The instability is caused by the nature of the Mid-Atlantic coastal plain that comprises the coast of New Jersey. Made of unconsolidated sediments, the New Jersey coastal zone is not able to resist alteration by waves, tides and storms that move sediment from place to place. The total absence of bedrock along the shoreline means that all the oceanfront is vulnerable to be removed and re-deposited elsewhere in relatively short periods of time.

Protection has involved many different structural solutions beginning with timber bulkheads and piles of brush contained inside a double row of cedar pilings (early groins). During the 20th Century truck transportation of large rocks added to the ability of placing large armor stone along erosional shorelines. Concrete came into play to create seawalls and other structural solutions. Finally, the development of large-scale methodology for moving millions of cubic yards of sand from areas of surplus at inlets or offshore to eroded beaches created the beach replenishment "industry". Between 1990 and 2005 hundreds of millions of Federal, State and local dollars were expended at over 50% of

the developed shoreline placing 10's of millions of cubic yards of sand on beaches between Sandy Hook and Cape May Point.

After 30 years of State regulation of the coastal zone, a large volume of policy has attempted to guide a safer development history especially along the inlet and oceanfront shorelines. Implemented by the Land Use Regulation Program (LURP) within the New Jersey Department of Environmental Protection (NJDEP), the shore protection aspect of the regulation has focused on building design, setbacks from the shoreline and the creation of a wider beach with a storm resistant dune system flanked by development and the beach. There has been abundant conflict between those who would build right to the high tide line on the beach and some who would advocate the abandonment of all public and private development on barrier islands. Since most individuals, corporations, and governments fall fairly close to the center of that range of positions, the major battleground has been over how big a setback, how wide a beach and how to "control" dune growth.

As the Federal/State and local beach restoration program emerged in the late 1980's, the projects' wider beaches have reduced storm damage to public and private property. The first reaches completed under the Federal program were northern Ocean City to 34th Street and Cape May City, NJ. Ocean City was completed in the summer of 1992 following the October 31, 1991 northeast storm which did over $4, 000,000 in damage just to the municipal boardwalk and other infrastructure along the shoreline. In December 1992 an equally intense event produced another Federal disaster declaration for New Jersey, but damage to the Ocean City oceanfront infrastructure was negligible. In Cape May City there was one minor area of overwash into the community at the very northern oceanfront street intersection.

Following the two early 1990's northeast storms, the State Division of Engineering and Construction reviewed the damage history and looked for ways to accelerate the Federal Shore Protection Program for other New Jersey beaches. In 1994 the NJ legislature established the "Shore Protection Stable Funding Act" that initially provided $15 million dollars annually for the specific purpose of conducting shore protection projects along the coastline. The policy was to provide 75% of the project cost with the State funds, with the local contribution equal to 25% of the project. Following consultation with the New Jersey Shore Partnership, local coastal public officials, coastal consultants, public and private, the decision was made to use the Stable Funding Act revenue to provide the required 35% matching funds to future Federal assistance. With the Federal Government paying 65% of the project cost, the local funds became leverage to proceed with far larger efforts than could be undertaken by the State and municipal entities alone.

The State and its municipal allies began the process of lobbying the Congress for authorization of Shore Protection work along the New Jersey shoreline. The Federal US Army Corps of Engineers (ACOE) is the agency charged with initiating, planning, designing, and carrying out the construction of these projects. With three distinct phases required to take a project from concept to construction, the effort proceeded to get started on nearly every shoreline reach in the State. By far the largest project was the Monmouth County Shore Protection Project covering 21 miles of shoreline between the Sandy Hook National Seashore and Manasquan Inlet. The New York District is the division of the ACOE responsible for Monmouth County. The first step is a Congressional authorization directing the ACOE to undertake a Reconnaissance Study of the selected shoreline to determine the nature and magnitude of the erosion or storm damage threat and recommend moving to the Feasibility Study phase. Federal funds cover the reconnaissance study, with the State matching funds for the Feasibility Study that follows. That study is conducted by the ACOE and is focused on providing engineering, geo-technical, environmental, and economic answers to the questions raised by the reconnaissance study. The Feasibility Report must (among other things) show a ratio greater than 1.25 when all benefit values are divided by the cost of the project in order to proceed to the next step.

The Planning and Engineering Design phase is where the actual project is laid out and cost documentation with predicted benefits to the region is formulated into a sizable document that will be used to generate a funding request from Congress to go to construction. Finally, after approval and signature at Department of the Army in Washington DC, the project is authorized to go to the construction phase. Most of the effort is expended in lobbying Congress, pursuing the goals of the

project and seeing that the State is on-board with the project design in order to go from reconnaissance to construction in less than 8 years. Projects were authorized in rapid succession for nearly all developed shoreline sections in the State. The political activism did accelerate the Monmouth County, Absecon Island, and Seven-Mile Island projects following the initial success of the Cape May City and Ocean City projects. Work has gone ahead on the two studies for all other reaches in the State.

The details on each of the projects follow in the body of this report under the county in which they are taking place. Recent developments have reduced Federal funding for beach restoration, but New Jersey is pursuing the continuation of projects already authorized to ultimately achieve their construction status, especially Northern Ocean County, Long Beach Island, and Ludlam Island. The only project ready to undergo construction is a relatively minor effort on the northern Brigantine Island shoreline set for the fall of 2005. Each project authorized for construction comes with an agreement to support the maintenance of the project for 50 years from the date of signature of the final Planning and Engineering Design documents. At the present moment the Federal government provides 65% of the maintenance costs as well, with the "local" share at 35% of the project cost. The "local" sponsor of any Federal project can be composed of any local, county or NJ State funding agency. With the State's program of 75% cost sharing of coastal projects, the municipal share of any Federally sponsored project is 25% of the 35% local share which amounts to 8.75% of the total project cost. That means for every million dollars in project cost, the municipal share of the project is 87,500 dollars. This is the fantastic local economic leverage built into Federal Shore Protection Projects.

The geomorphology of the New Jersey coastline is presented in Figure 1, below, by Nordstrom, 1977 and has been used to divide the State's coastline into five distinct zones with different characteristics. The variation is most dramatic between the bluff where the upland surface ends at the beach as a cliff in the older sedimentary deposits and the barrier spits or islands. The bays and lagoons are found to the south of Bay Head, NJ where the bluff finally is submerged below the edge of the rising sea level and its Holocene deposits. There are two long sand spits attached at the north end of the bluff (Sandy Hook) and at Bay Head, extending south to Barnegat Inlet. Tidal inlets occur about every 10 miles and number 11 from Shark River to Cold Springs Inlet. Finally, a shore segment of uplands bluff is exposed at Cape May Point where the Cape May County peninsula extends into Delaware Bay. A detailed discussion on the geologic changes and the present-day emergence of the New Jersey coastal plain and coastline has been included for a number of years in previous reports. This information is still found on the website devoted to the New Jersey Beach Profile Network data generated by the Richard Stockton Coastal Research Center (CRC)(page 5).

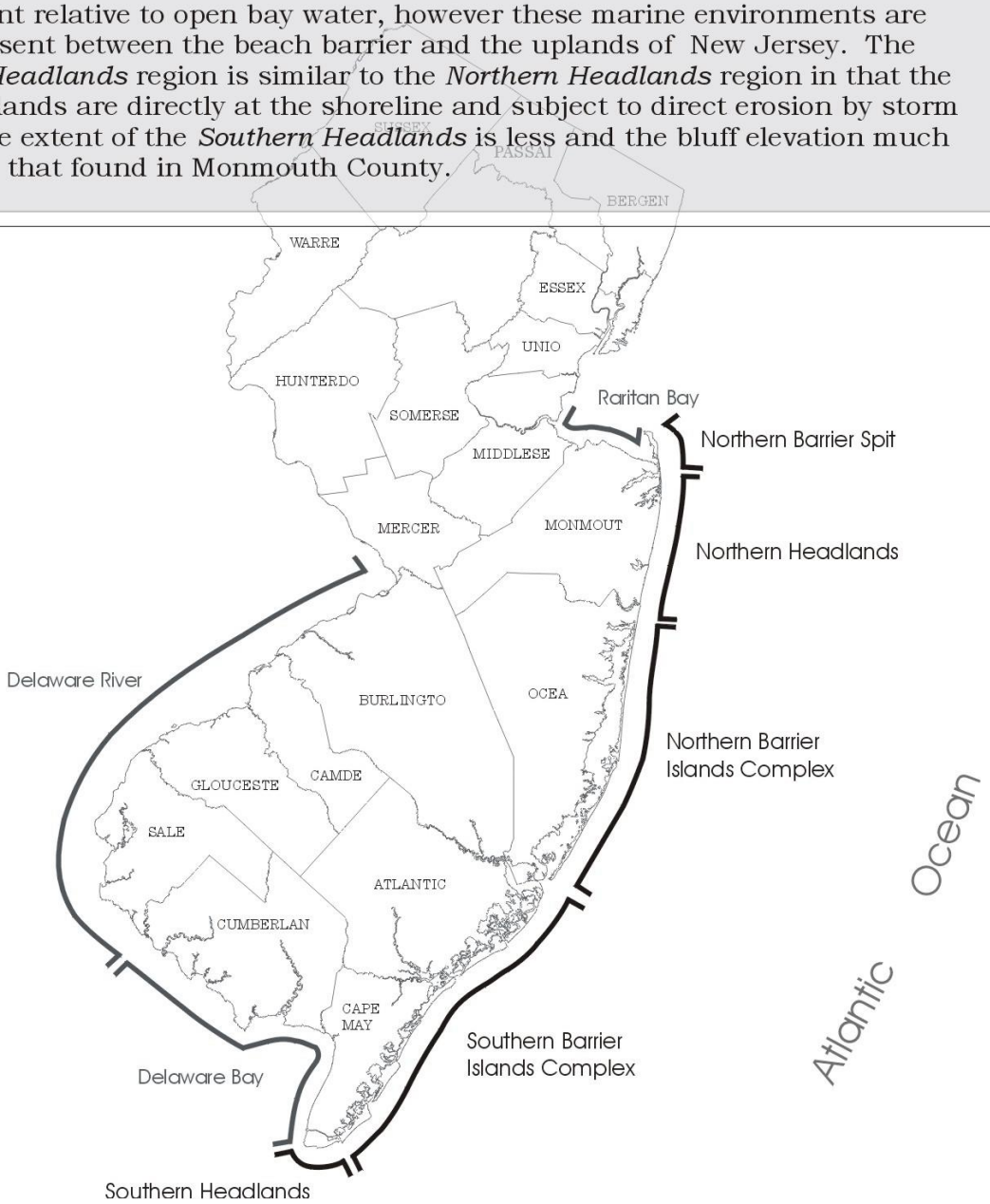
There is little evidence along the present shoreline of former stands of sea level such as ancient barrier islands, dune lines or inlet deposits. There is anecdotal evidence for earlier high stands of sea level, but research has yet to identify or quantify the information to provide the full geologic history of New Jersey's shoreline. Research has identified deposits of Holocene freshwater material now buried under up to 25 feet of salt marsh and other marine sediments that verify the fact that sea level is rising along the New Jersey shoreline. A report by Schwing and others 1977, found that the -5.5 meter elevation (below mean high tide) deposit of cedar forest peat found in the Absecon Creek marshes in Absecon, NJ had a radiocarbon date of 4,100 years before the present. Frequent encounters with back-bay marine deposits while dredging tidal inlets to –25-foot depths also indicate substantial shoreline migration to the west along the New Jersey oceanfront. Thus far, no clear evidence of former high sea level stands have been uncovered by research in New Jersey, but extensive investigation similar to Kraft's lifetime of work in the State of Delaware has not yet occurred in New Jersey.

# Identification of Shoreline Zones

New Jersey coastal shoreline types as defined by Yasso & Hartman, 1975, and Nordstrom, 1977.

The Atlantic Ocean Coast of New Jersey can be sub-divided into five zones that have different physical features and relationships to the mainland. The main parameter used to define the five coastal shoreline types is the relative style of separation of the beach itself from the upland New Jersey coastal plain. The *Northern Headlands* segment of the coastline has the beach cut directly into and welded against the erosional bluff, in the various regional geologic formations of the New Jersey coastal plain. The *Northern Barrier Spit*, *Northern Barrier Islands Complex* and the *Southern Barrier Islands Complex* all have marine bays or lagoons separating the beach from the uplands. These marine water bodies vary in the quantity of salt marsh development relative to open bay water, however these marine environments are always present between the beach barrier and the uplands of New Jersey. The *Southern Headlands* region is similar to the *Northern Headlands* region in that the coastal uplands are directly at the shoreline and subject to direct erosion by storm waves. The extent of the *Southern Headlands* is less and the bluff elevation much lower than that found in Monmouth County.

**Figure 1**



**NJ BEACH PROFILE NETWORK (NJBPN) METHODOLOGY:**

The monitoring program performed by the Richard Stockton College of New Jersey Coastal Research Center (CRC) monitors shoreline and beachface conditions twice a year, capturing erosional and depositional trends. Each successive year that the profiles are surveyed adds to a time series of information about long-term erosion and deposition on the New Jersey coast. This data aids NJDEP regulatory and planning personnel in the following ways:

- Determining areas of potential erosion problems.
- Implementing policies to protect beaches, dunes, overwash fans and erosion hazard areas (EHA), as well as reducing risks to development in these high hazard areas.
- Facilitating assessment of disaster impacts following future storm events.
- Providing useful background information, when evaluating NJDEP permit applications.
- Providing evidence on dune development at any site.
- Assisting local municipal governments in developing policies or plans for dealing with coastal erosion or improving storm preparedness.

Beach survey stations were chosen based on the following criteria:

- Each location represented typical community beach conditions.
- Each shoreline community would have at least one site.
- Where possible, sites utilized positions with prior survey data.
- Control profiles were sited on State or County undeveloped beaches.

Presently there are 100 sites that must be profiled after the winter storm season has ended in spring. The second annual survey occurs before the summer beach accretion is removed by the increasing frequency of storms that occur in the fall and winter. The CRC crew uses a Sokkia Set-530-R Electronic Total Station, which transfers the data to an SDR-33 Electronic Field Book. The unit is initialized with position coordinates, the elevation for two known locations, transit height, and target height. Environmental factors such as temperature and atmospheric pressure, and unit columniation errors are entered. Field personnel equipped with an optical prism mounted to a range pole traverse the dunes, backbeach, shoreface, and continue into the water to a depth of -12.0 feet NGVD. The prism pole height can be changed between data points as necessary. The data is stored in the SDR-33 Electronic Field Book then downloaded at the office into a personal computer. A beach profile typically consists of 35 to 55 individual data points (Figure 2).

The survey information is edited, checked against field notes and sent to a database for use and storage. The profile plots and computations have been performed using ISRP27 a survey reduction program designed by the Coastal Engineering Research Center (CERC) of the ACOE. A new program called BMAP (Beach Morphology Analysis Package, v.2.0) is being used to format the survey data. Also designed by CERC, this program is "windows" compatible and has more versatile data presentation capabilities. The computation of the sand volume change between any two surveys can be set to run in several ways. These unit volumes are given in cubic yards of sand per foot of beachfront ($yds^3/ft$). These unit volumes are typically valid for up to 1000 feet north or south of any of the profile sites along the beachfront or to any groin/jetty structure. Structures invalidate the calculation because of their sand collecting or starving effect. All profiles were located as close to the center of any groin cell as possible to limit this impact on sand quantity and beach configuration. Corel Draw v12 is used to generate graphical images of the beach profile data. The Richard Stockton College website hosts the Coastal Research Center's digital reports as both .pdf files or as a navigable website for the 100-site file data since 1998. Annual reports are published for 1998, 2000, 2001, 2002, 2003 and 2004. In 2002 a special 15-year review of selected profile locations was done to view all the information gathered since 1986. A .pdf file is included that shows all the volume change and shoreline migration data for all 100 sites since 1986. This information is under the URL www.gannet.stockton.edu/njbpn. The site can also be reached by going to www2.stockton.edu and clicking on the VISITORS icon on the home page, then clicking on the NJ Beach Profile Network line on the pop-up menu to reach the NJBPN home page.

# Methodology

# New Jersey Beach Profile Network

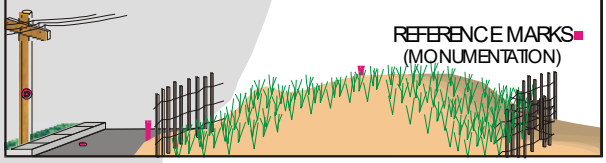
Figure 2

## Step 1: Site Selection

NJBPN profile sites were selected to be representative of the beaches in the surrounding area. This was done in order to gain the most accurate assessment of the State's beaches, with a feasible number of profile sites. Beach profiles are lines perpendicular to shore that are surveyed repeatedly to monitor beach changes. Today, there are a total of 100 beach profile sites in the New Jersey Beach Profile Network. These beach profile sites range from the Raritan Bay, along the Atlantic Ocean coast, into the Delaware Bay. It takes the CRC approximately two months time to survey all of the NJBPN sites, depending on the weather and ocean climate.

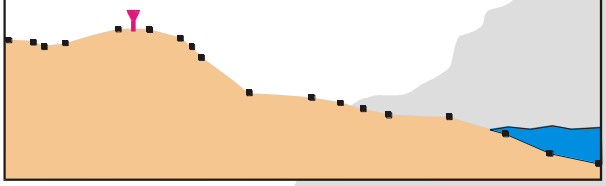
## eason.Step 2: Monumentation

Each profile site requires at least 2 known positions to use the survey instrument. The survey instrument station is set on an elevated but stable part of the dune. This assures that the majority of the profile is visible and that the monument will survive a storm. Back up monuments, in the event of serious storm damage, ensure that the CRC will be able to survey the same profile line the following season.

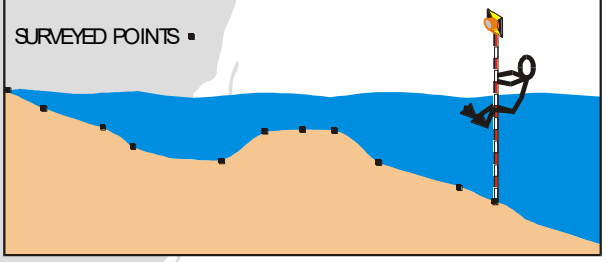



## Step 3: Survey the Profile

The survey instrument is oriented using the known reference markers. The profile is surveyed beginning in the back dune, then proceeding across the beach and into the water. Positions are taken for critical points on the profile, breaks in slope - etc., or about every 50 feet, otherwise. Typical profiles have 35 to 50 points. The data is electronically stored

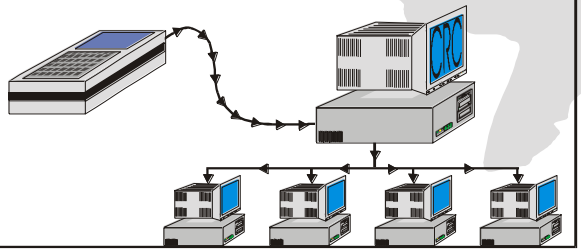



The profile survey continues until the swimmer reaches a depth of 12 feet, Mean Low Water. The survey is often carried out beyond -12 feet MLW. This happens when CRC personnel recognize the need to survey further to include a feature such as an offshore bar that may have migrated further seaward in response to a storm event.



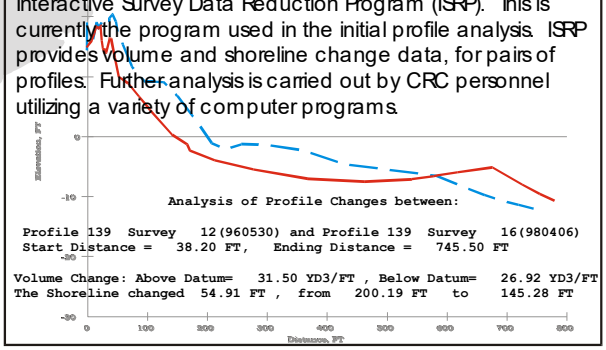

## Step 4: Download and edit data

The electronically logged data is downloaded to a Personal Computer at the CRC office. The data is then edited for any possible errors and/or omissions. Once the data has been edited, it is transferred to the NJBPN database.




## Step 5: Data Analysis

The data transferred to the NJBPN database is then input into the ACOE Coastal Engineering Research Center's (CERC) Interactive Survey Data Reduction Program (ISRP). This is currently the program used in the initial profile analysis. ISRP provides volume and shoreline change data, for pairs of profiles. Further analysis is carried out by CRC personnel utilizing a variety of computer programs.

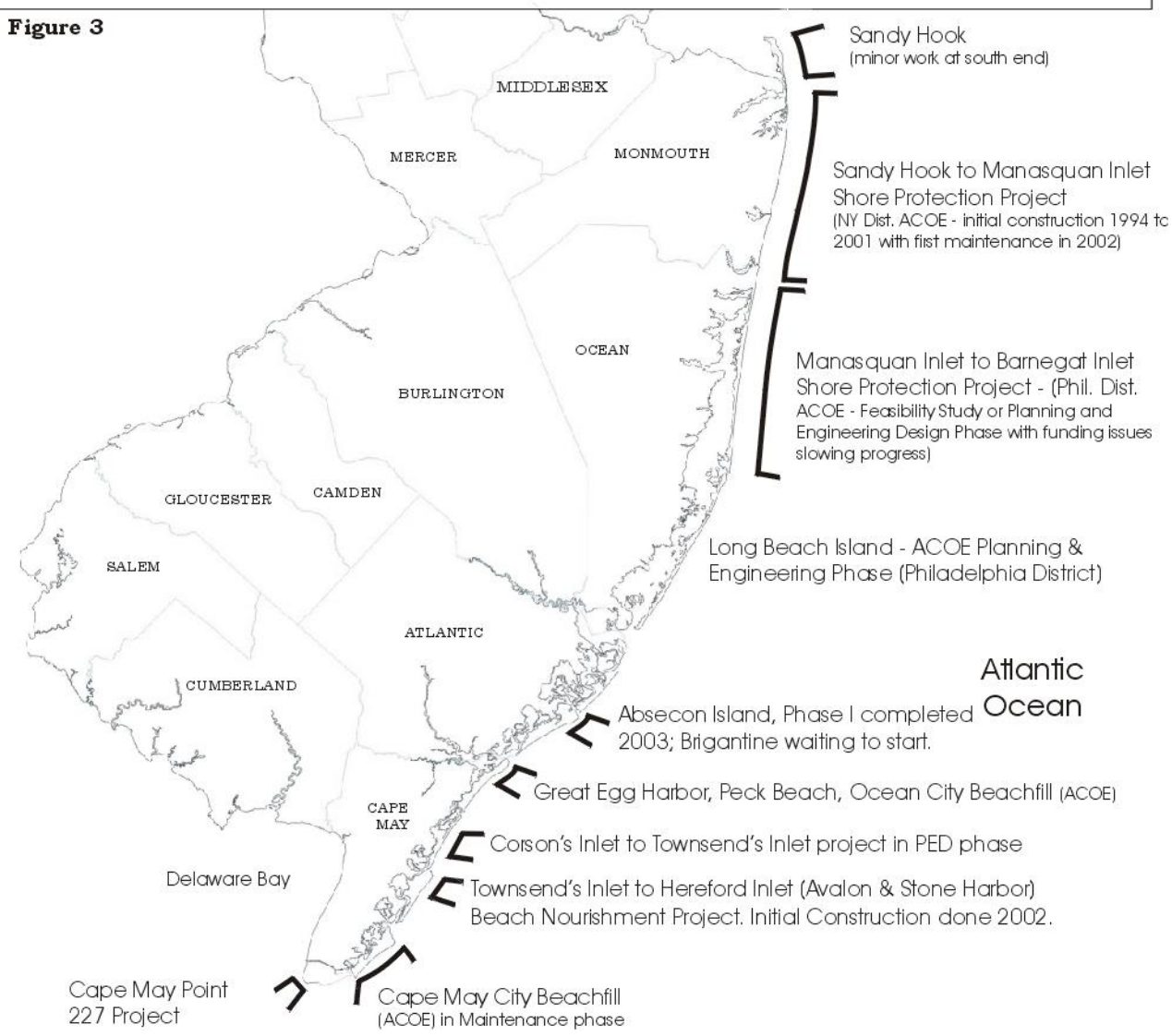


# Beach Nourishment in New Jersey: 2003 - 2004

(Information provide by ACOE New York & Philadelphia Districts and local entities.)

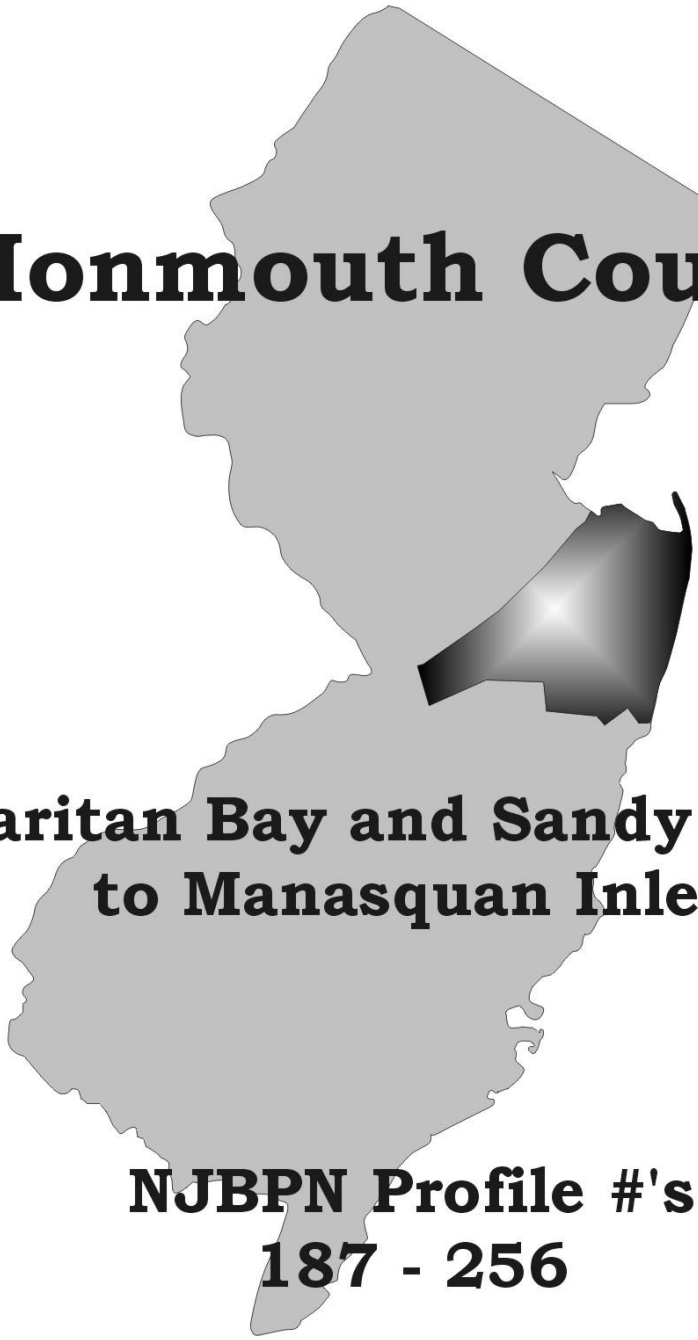
The oceanfront coast of New Jersey has received large scale Shore Protection projects co-sponsored by the State and the Federal US Army Corps of Engineers. *Sandy Hook* receives sand carried by littoral currents from the beaches in Sea Bright, nourished by the ACOE as well as direct placement at the end of the Sea Bright seawall. The *Sandy Hook to Manasquan Inlet Shore Protection Project* was completed by the ACOE New York District and has placed 22 million cubic yards of sand, to date. The Ocean County shoreline is in the Planning and Engineering Design phase of study by the Philadelphia District. The ACOE maintains the *Great Egg Harbor to Corson's Inlet (Peck Beach)* project area (Ocean City), placing over 9.9 million cubic yards thus far. Cape May City (1989 start), Avalon and Stone Harbor (2002), and most recently, Phase I on Absecon Island (Atlantic City & Ventnor City) are the recipients of long-term commitments to manage shore protection by the Philadelphia District. The District also is sponsoring two Ecosystem Restoration/Shore Protection projects in southern Cape May County as well as an experimental 227 project to evaluate wave barrier systems in Cape May Point. Beach nourishment provides both storm protection for public and private infrastructure and builds a recreational area, the latter supporting New Jersey's 31 billion dollar tourist economy. 22% of this figure is directly generated by beach and waterfront activities.

**Figure 3**



New Jersey Beach Profile Network

# Monmouth County

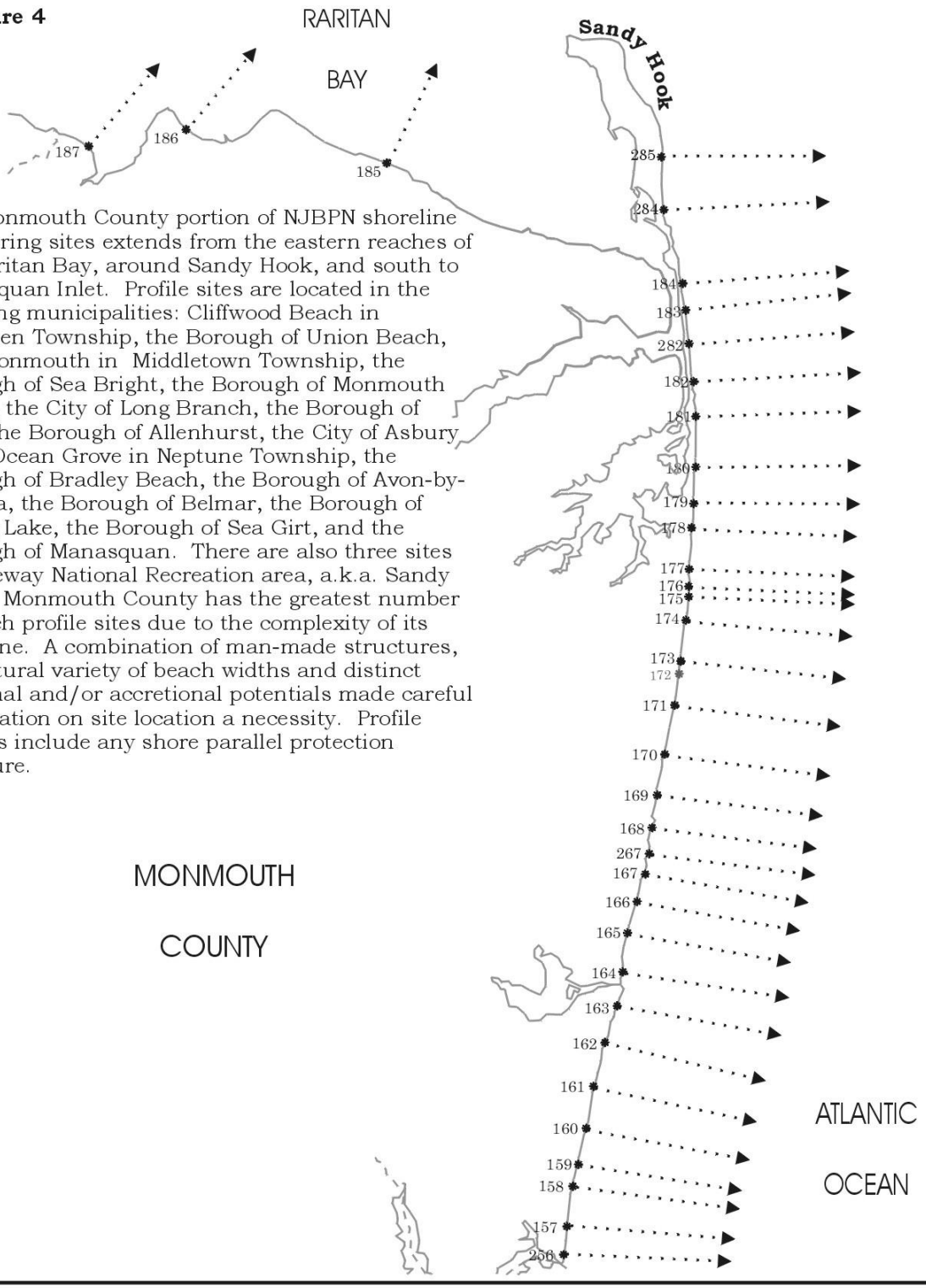


## Raritan Bay and Sandy Hook to Manasquan Inlet

## NJBPN Profile #'s 187 - 256

# New Jersey Beach Profile Network
## Monmouth County Profile Site Locations

**Figure 4**




The Monmouth County portion of NJBPN shoreline monitoring sites extends from the eastern reaches of the Raritan Bay, around Sandy Hook, and south to Manasquan Inlet. Profile sites are located in the following municipalities: Cliffwood Beach in Aberdeen Township, the Borough of Union Beach, Port Monmouth in Middletown Township, the Borough of Sea Bright, the Borough of Monmouth Beach, the City of Long Branch, the Borough of Deal, the Borough of Allenhurst, the City of Asbury Park, Ocean Grove in Neptune Township, the Borough of Bradley Beach, the Borough of Avon-by-the-Sea, the Borough of Belmar, the Borough of Spring Lake, the Borough of Sea Girt, and the Borough of Manasquan. There are also three sites in Gateway National Recreation area, a.k.a. Sandy Hook. Monmouth County has the greatest number of beach profile sites due to the complexity of its shoreline. A combination of man-made structures, the natural variety of beach widths and distinct erosional and/or accretional potentials made careful deliberation on site location a necessity. Profile surveys include any shore parallel protection structure.

Photoplate 1a. This photo was taken on May 31,2000 at NJBPN 171 (Pullman Avenue, Elberon). Although following the ACOE fill project by several years, the sand quantity present here remained insufficient to produce even a low-tide sand beach.

Photoplate 1b. By June 3, 2004 the site showed a substantial sediment accumulation allowing a beach at the rocks almost above the level of most high tides. This process has not been continuous with growth seen every six months between surveys, but the conclusion is that this material comes from Long Branch.

Photoplate 2a. Looking south from New York Ave. In Sea Girt, NJ with a stormwater outfall pipe emerging from the berm onto the low tide beach. The beach between the berm crest and the boardwalk is the result of the ACOE fill project along this shoreline. The picture was taken April 15, 2003

Photoplate 2b. By April 8, 2004 minor berm retreat has exposed only one more piling support section on the outfall pipeline. The shoreline retreated 1.2 feet during the time interval, as measured at the profile line (#159), with a sand volume gain of 14.6 cubic yards.

**TABLE 1**

**MONMOUTH COUNTY**

**ANNUAL BEACH VOLUME CHANGES**

**SPRING 2003 - SPRING 2004 & FALL 2003 - FALL 2004**

| | | Survey 26 - 28 | Survey 27 - 29 |
|---|---|---|---|
| **PROFILE SITE** | | **S2003 - S2004** | **F2003 - F2004** |
| **LOCATION** | | (volume expressed as cubic yards per foot) | |
| 187: | Cliffwood Beach Park | -2.67 | -0.44 |
| 186: | Union Beach | 2.63 | 2.11 |
| 185: | Port Monmouth, Spy House Museum | 1.72 | 2.96 |
| 285: | Gateway National R. A., Gunnison Beach | 24.64 | 71.14 |
| 284: | Gateway National R. A., Parking Lot E | 11.76 | 35.34 |
| 184: | Highland Beach, Gateway Entrance | -8.72 | -12.41 |
| 183: | Highland Beach, Via Ripa St. | 28.81 | 2.78 |
| 282: | Sea Bright, Shrewsbury Way | 9.12 | 21.65 |
| 182: | Sea Bright, North of Route 520 | 14.09 | -0.67 |
| 181: | Sea Bright, Municipal Beach | -15.58 | -25.56 |
| 180: | Sea Bright, Sunset Court | -8.93 | -25.91 |
| 179: | Monmouth Beach, Cottage Rd. | -82.00 | -66.77 |
| 178: | Monmouth Beach, Beach Club | -58.51 | -20.65 |
| 177: | Long Branch, 404 Ocean Ave. | 4.46 | 15.59 |
| 176: | Long Branch, Seven Presidents Park | 11.39 | -10.09 |
| 175: | Long Branch, North Broadway Ave. | -25.37 | -19.29 |
| 174: | Long Branch, Morris Ave. | -16.54 | -9.04 |
| 173: | Long Branch, West End Ave. | 12.19 | -15.41 |
| 172: | Long Branch | ** NO LONGER ACTIVE ** | |
| 171: | Elberon, Pullman Ave. | -16.17 | 20.37 |
| 170: | Deal, Roosevelt Ave. | -3.36 | -22.98 |
| 169: | Deal, Darlington Ave. | -3.52 | -18.90 |
| 168: | Allenhurst, Corlies Ave. | 39.99 | -40.77 |
| 267: | Asbury Park, 7th Ave. | -15.63 | -17.79 |
| 167: | Asbury Park, 3rd Ave. | -6.54 | -44.32 |
| 166: | Ocean grove, Ocean Pathway | -18.64 | -13.20 |
| 165: | Bradley Beach, McCabe Ave. | -46.56 | -13.55 |
| 164: | Avon-By-The-Sea, Sylvania Ave. | -27.85 | 6.84 |
| 163: | Belmar, 5th Ave. | 12.21 | 21.30 |
| 162: | Belmar, 18th Ave. | -23.14 | 14.21 |
| 161: | Spring Lake, Brighton Ave. | 41.87 | 3.47 |
| 160: | Spring Lake, Salem Ave. | -19.86 | -10.40 |
| 159: | Sea Girt, New York Ave. | 14.60 | 5.94 |
| 158: | Sea Girt, Trenton Ave. | 19.28 | 18.71 |
| 157: | Manasquan, Riddle Way | 24.68 | 23.80 |
| 256: | Manasquan, Pompano Ave. | -1.75 | -14.26 |

**TABLE 2**
**MONMOUTH COUNTY**
**ANNUAL SHORELINE CHANGES**
**SPRING 2003 - SPRING 2004 & FALL 2003 - FALL 2004**

| PROFILE SITE LOCATION | | Survey 26 - 28 S2003 - S2004 (shoreline change expressed in feet) | Survey 27 - 29 F2003 - F2004 (shoreline change expressed in feet) |
|---|---|---|---|
| 187: | Cliffwood Beach Park | -17.8 | -5.3 |
| 186: | Union Beach | 0.9 | 2.2 |
| 185: | Port Monmouth, Spy House Museum | -4.0 | -0.1 |
| 285: | Gateway National R. A., Gunnison Beach | -6.0 | 245.2 |
| 284: | Gateway National R. A., Parking Lot E | 28.3 | 38.1 |
| 184: | Highland Beach, Gateway Entrance | -9.8 | -3.3 |
| 183: | Highland Beach, Via Ripa St. | 22.2 | 30.2 |
| 282: | Sea Bright, Shrewsbury Way | -65.3 | 52.0 |
| 182: | Sea Bright, North of Route 520 | -0.1 | 20.1 |
| 181: | Sea Bright, Municipal Beach | -20.9 | -5.3 |
| 180: | Sea Bright, Sunset Court | -12.6 | -10.6 |
| 179: | Monmouth Beach, Cottage Rd. | -81.6 | -60.3 |
| 178: | Monmouth Beach, Beach Club | -57.6 | -20.5 |
| 177: | Long Branch, 404 Ocean Ave. | -27.1 | 56.3 |
| 176: | Long Branch, Seven Presidents Park | 49.3 | 8.4 |
| 175: | Long Branch, North Broadway Ave. | -22.2 | 12.0 |
| 174: | Long Branch, Morris Ave. | -46.7 | 2.3 |
| 173: | Long Branch, West End Ave. | 66.9 | 4.6 |
| 172: | Long Branch | ** NO LONGER ACTIVE ** | |
| 171: | Elberon, Pullman Ave. | 39.7 | 75.9 |
| 170: | Deal, Roosevelt Ave. | -0.5 | 5.8 |
| 169: | Deal, Darlington Ave. | 35.8 | -10.9 |
| 168: | Allenhurst, Corlies Ave. | 48.0 | -1.9 |
| 267: | Asbury Park, 7th Ave. | 47.9 | 40.3 |
| 167: | Asbury Park, 3rd Ave. | 37.3 | -27.9 |
| 166: | Ocean grove, Ocean Pathway | 17.2 | 55.7 |
| 165: | Bradley Beach, McCabe Ave. | -41.4 | 54.6 |
| 164: | Avon-By-The-Sea, Sylvania Ave. | -45.3 | -22.5 |
| 163: | Belmar, 5th Ave. | 4.8 | 76.6 |
| 162: | Belmar, 18th Ave. | -23.6 | 2.4 |
| 161: | Spring Lake, Brighton Ave. | 33.2 | -7.7 |
| 160: | Spring Lake, Salem Ave. | -44.9 | -35.3 |
| 159: | Sea Girt, New York Ave. | -1.2 | 10.0 |
| 158: | Sea Girt, Trenton Ave. | -3.4 | 12.1 |
| 157: | Manasquan, Riddle Way | 8.4 | 32.0 |
| 256: | Manasquan, Pompano Ave. | -10.2 | 37.2 |

**TABLE 3**
**MONMOUTH COUNTY**
**SEASONAL BEACH VOLUME CHANGES**

| PROFILE SITE LOCATION | | Survey 26-27 S03-F03 | 27-28 F03-S04 | 28-29 S04-F04 | 26-29 S03-F04 |
|---|---|---|---|---|---|
| | | (volume expressed as cubic yards per foot of beachfront) | | | |
| 187: | Cliffwood Beach Park | -3.76 | 1.01 | -1.64 | -4.49 |
| 186: | Union Beach | -1.20 | 3.61 | -1.60 | 1.08 |
| 185: | Port Monmouth, Spy House Museum | -2.12 | 4.14 | -1.21 | 0.70 |
| 285: | Gateway National R. A., Gunnison Beach | 2.90 | 21.77 | 48.82 | 71.93 |
| 284: | Gateway National R. A., Parking Lot E | -8.80 | 22.17 | 13.00 | 24.11 |
| 184: | Highland Beach, Gateway Entrance | -8.41 | -0.09 | -11.85 | -21.45 |
| 183: | Highland Beach, Via Ripa St. | 17.67 | 10.66 | -5.67 | 21.48 |
| 282: | Sea Bright, Shrewsbury Way | 2.95 | 6.29 | 15.85 | 25.10 |
| 182: | Sea Bright, North of Route 520 | 12.40 | 0.66 | -2.82 | 11.18 |
| 181: | Sea Bright, Municipal Beach | -5.80 | -9.74 | -15.86 | -31.12 |
| 180: | Sea Bright, Sunset Court | -6.74 | -2.24 | -23.84 | -32.46 |
| 179: | Monmouth Beach, Cottage Rd. | -55.97 | -26.37 | -40.31 | -122.99 |
| 178: | Monmouth Beach, Beach Club | -38.04 | -20.43 | -0.02 | -58.60 |
| 177: | Long Branch, 404 Ocean Ave. | -1.25 | 5.80 | 9.88 | 14.28 |
| 176: | Long Branch, Seven Presidents Park | 8.68 | 3.27 | -13.27 | -0.84 |
| 175: | Long Branch, North Broadway Ave. | -7.93 | -17.57 | -1.70 | -26.80 |
| 174: | Long Branch, Morris Ave. | 3.00 | -19.48 | 8.05 | -9.71 |
| 173: | Long Branch, West End Ave. | 1.14 | 10.84 | -26.21 | -15.63 |
| 172: | Long Branch | | ** NO LONGER ACTIVE ** | | |
| 171: | Elberon, Pullman Ave. | -16.82 | -0.25 | 20.85 | 4.38 |
| 170: | Deal, Roosevelt Ave. | -0.92 | -3.45 | -17.58 | -20.58 |
| 169: | Deal, Darlington Ave. | 12.22 | -16.47 | -3.09 | -5.53 |
| 168: | Allenhurst, Corlies Ave. | 72.49 | -32.66 | -8.50 | 30.86 |
| 267: | Asbury Park, 7th Ave. | 3.15 | -18.64 | 0.81 | -14.89 |
| 167: | Asbury Park, 3rd Ave. | 4.72 | -10.45 | -34.07 | -40.10 |
| 166: | Ocean grove, Ocean Pathway | -4.30 | -14.08 | 1.10 | -17.69 |
| 165: | Bradley Beach, McCabe Ave. | -37.68 | -11.96 | 0.47 | -51.33 |
| 164: | Avon-By-The-Sea, Sylvania Ave. | -21.24 | -7.13 | 12.78 | -11.48 |
| 163: | Belmar, 5th Ave. | -0.61 | 13.15 | 7.40 | 19.75 |
| 162: | Belmar, 18th Ave. | -13.90 | -9.41 | 23.83 | 0.62 |
| 161: | Spring Lake, Brighton Ave. | 26.43 | 15.17 | -9.41 | 31.38 |
| 160: | Spring Lake, Salem Ave. | -17.27 | -2.53 | -5.95 | -24.10 |
| 159: | Sea Girt, New York Ave. | 25.31 | -10.88 | 16.53 | 31.88 |
| 158: | Sea Girt, Trenton Ave. | -8.45 | 26.45 | -7.94 | 13.00 |
| 157: | Manasquan, Riddle Way | -5.01 | 30.00 | -4.90 | 22.29 |
| 256: | Manasquan, Pompano Ave. | 15.91 | -17.63 | 3.45 | 1.64 |

**TABLE 4**
**MONMOUTH COUNTY**
**SEASONAL SHORELINE CHANGES**

| | Survey | 26-27 | 27-28 | 28-29 | 26-29 |
|---|---|---|---|---|---|
| **PROFILE SITE** | | **S03-F03** | **F03-S04** | **S04-F04** | **S03-F04** |
| **LOCATION** | | | (shoreline change expressed in feet) | | |
| 187: | Cliffwood Beach Park | -8.9 | -8.9 | 3.6 | -14.2 |
| 186: | Union Beach | 0.5 | 0.5 | 1.8 | 2.7 |
| 185: | Port Monmouth, Spy House Museum | -4.7 | 0.8 | -0.9 | -4.9 |
| 285: | Gateway National R. A., Gunnison Beach | -14.5 | 8.6 | 236.6 | 230.7 |
| 284: | Gateway National R. A., Parking Lot E | 2.5 | 25.8 | 12.4 | 40.7 |
| 184: | Highland Beach, Gateway Entrance | -8.7 | -1.1 | -2.2 | -12.0 |
| 183: | Highland Beach, Via Ripa St. | 30.0 | -7.8 | 38.0 | 60.2 |
| 282: | Sea Bright, Shrewsbury Way | 1.1 | -66.4 | 118.4 | 53.1 |
| 182: | Sea Bright, North of Route 520 | -5.2 | 5.1 | 15.0 | 14.9 |
| 181: | Sea Bright, Municipal Beach | -19.4 | -1.4 | -3.9 | -24.7 |
| 180: | Sea Bright, Sunset Court | -15.6 | 3.0 | -13.6 | -26.2 |
| 179: | Monmouth Beach, Cottage Rd. | -57.0 | -24.6 | -35.7 | -117.3 |
| 178: | Monmouth Beach, Beach Club | -48.3 | -9.3 | -11.1 | -68.8 |
| 177: | Long Branch, 404 Ocean Ave. | -15.9 | -11.2 | 67.5 | 40.4 |
| 176: | Long Branch, Seven Presidents Park | 46.8 | 2.5 | 5.9 | 55.2 |
| 175: | Long Branch, North Broadway Ave. | -12.0 | -10.2 | 22.2 | -0.1 |
| 174: | Long Branch, Morris Ave. | -16.3 | -30.5 | 32.8 | -13.9 |
| 173: | Long Branch, West End Ave. | 21.6 | 45.3 | -40.7 | 26.2 |
| 172: | Long Branch | | ** NO LONGER ACTIVE ** | | |
| 171: | Elberon, Pullman Ave. | 2.0 | 37.7 | 38.2 | 77.9 |
| 170: | Deal, Roosevelt Ave. | 19.8 | -20.3 | 26.1 | 25.6 |
| 169: | Deal, Darlington Ave. | 28.9 | 6.9 | -17.8 | 18.0 |
| 168: | Allenhurst, Corlies Ave. | 65.0 | -17.0 | 15.2 | 63.2 |
| 267: | Asbury Park, 7th Ave. | 24.9 | 23.1 | 17.2 | 65.1 |
| 167: | Asbury Park, 3rd Ave. | 13.9 | 23.4 | -51.3 | -14.0 |
| 166: | Ocean grove, Ocean Pathway | -32.2 | 49.3 | 6.4 | 23.5 |
| 165: | Bradley Beach, McCabe Ave. | 6.4 | -47.8 | 102.3 | 61.0 |
| 164: | Avon-By-The-Sea, Sylvania Ave. | -12.0 | -33.3 | 10.8 | -34.5 |
| 163: | Belmar, 5th Ave. | -7.5 | 12.3 | 64.3 | 69.1 |
| 162: | Belmar, 18th Ave. | -1.0 | -22.7 | 25.1 | 1.5 |
| 161: | Spring Lake, Brighton Ave. | 46.0 | -12.8 | 5.1 | 38.3 |
| 160: | Spring Lake, Salem Ave. | -0.8 | -44.2 | 8.9 | -36.0 |
| 159: | Sea Girt, New York Ave. | 17.5 | -18.7 | 28.8 | 27.6 |
| 158: | Sea Girt, Trenton Ave. | -14.5 | 11.2 | 1.0 | -2.4 |
| 157: | Manasquan, Riddle Way | -11.6 | 20.0 | 12.1 | 20.5 |
| 256: | Manasquan, Pompano Ave. | 0.6 | -10.7 | 47.9 | 37.8 |

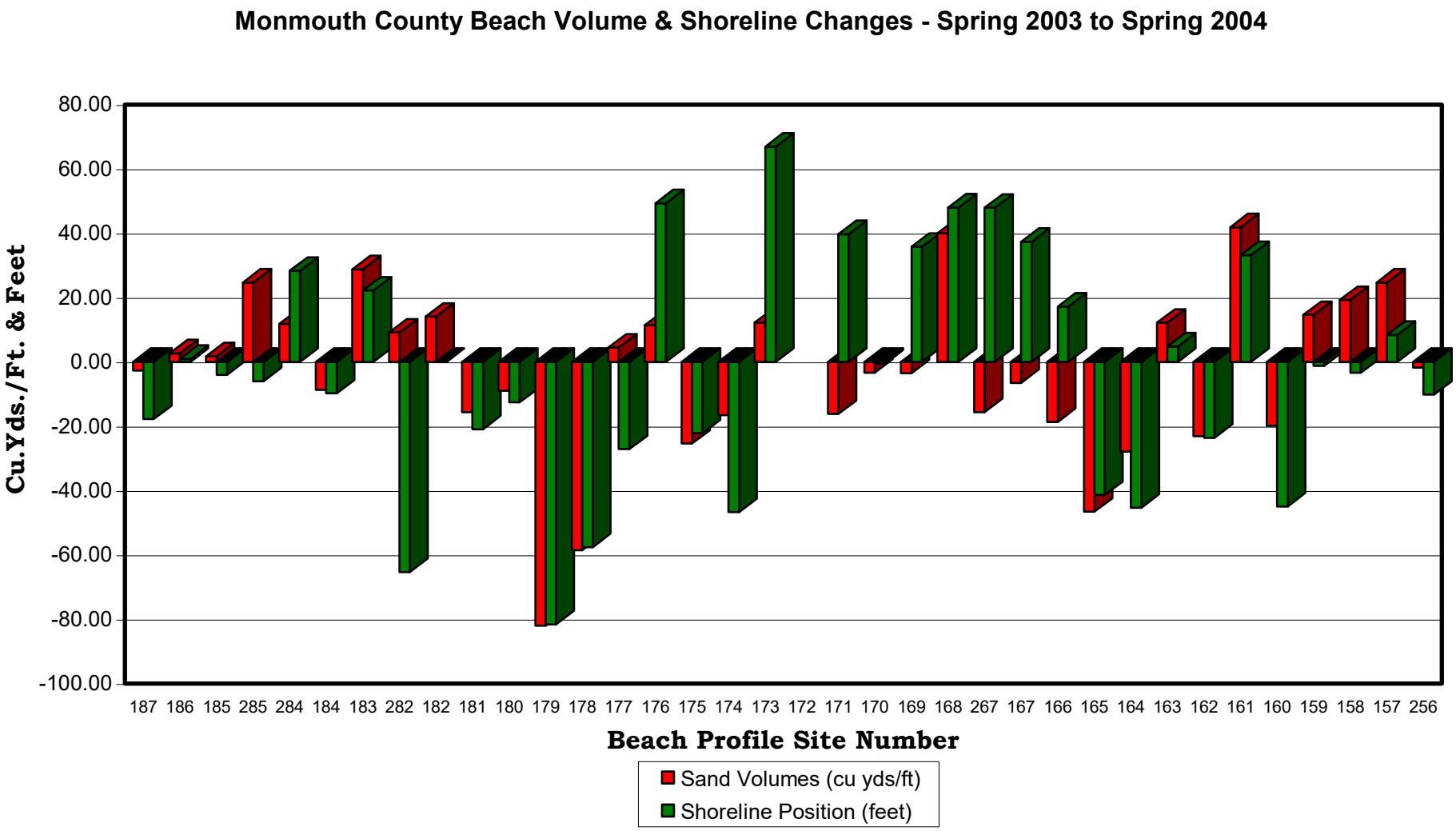



**Figure 5a. The Monmouth County annual comparison from Spring 2003 to Spring 2004 shows loss in Monmouth Beach, with gains in the Asbury Park to Ocean Grove region. Other changes were modest in size.**

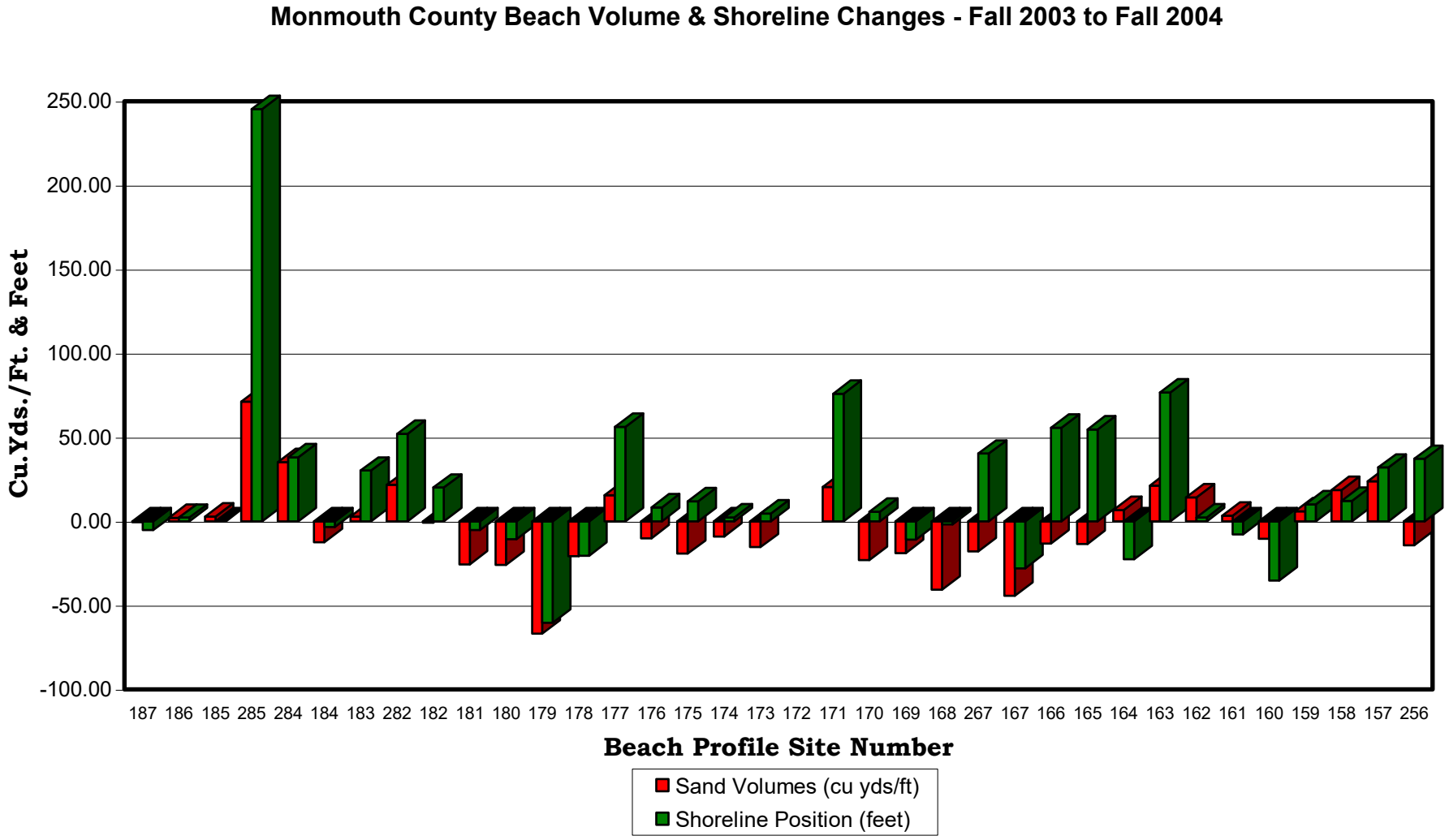



**Figure 5b. A similar comparison of data for a year, but between the fall of 2003 and the fall of 2004 that shows some sand accumulation, but randomly distributed. The northern cross section on Sandy Hook (#285) received abundant sand from transport from south to north along the beach. Losses at 179, 180, and 181 are related to the Monmouth Beach "hot zone" subject to maintenance filling in 2002.**

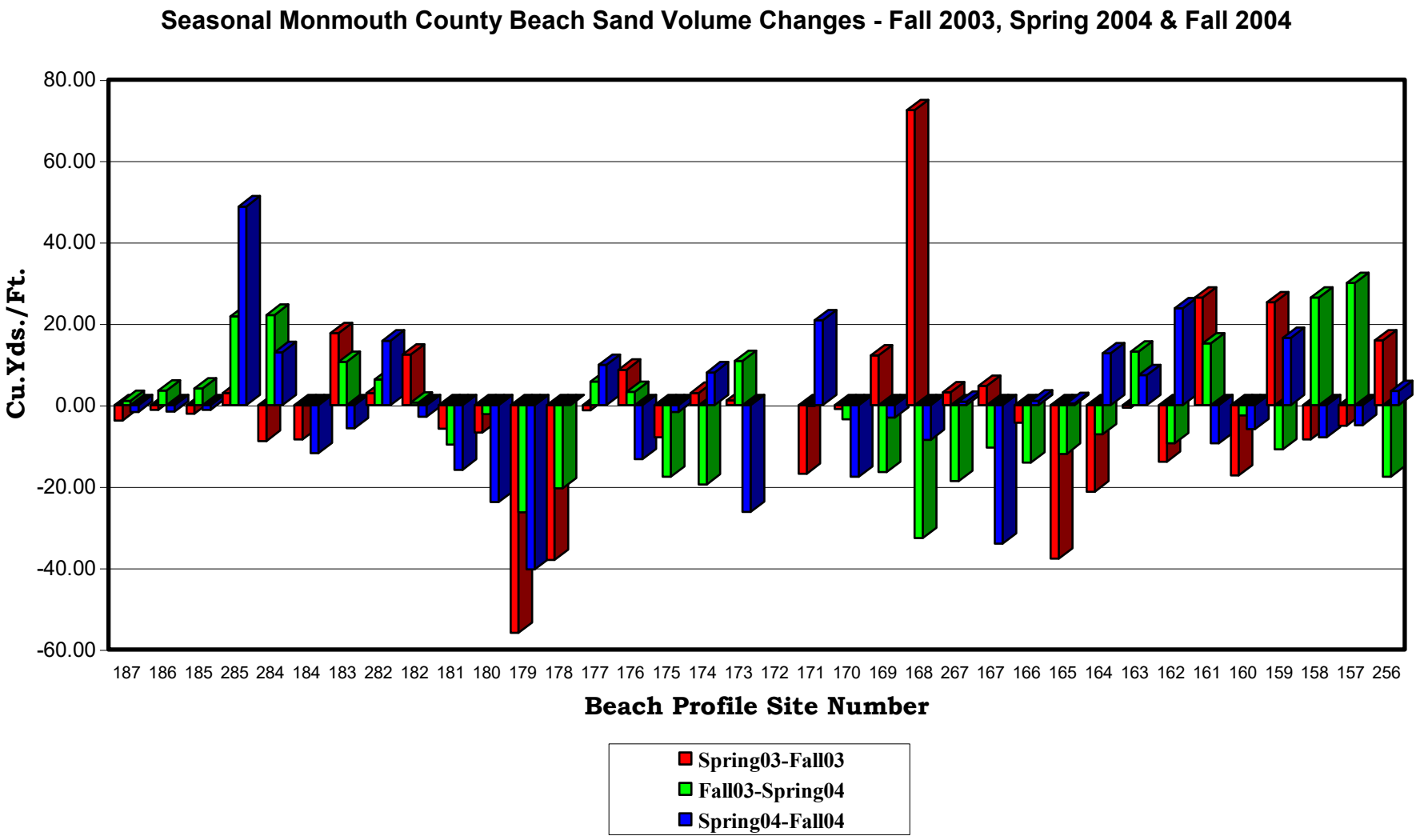



**Figure 5c. Seasonal changes really emphasize the continuous loss at Monmouth Beach (179 – 181). The tall Spring – Fall 2003 gain at #168 was probably due to sand bypassing the northern Asbury Park groin. There appears to be a trend toward accretion of sand toward the south in the county.**

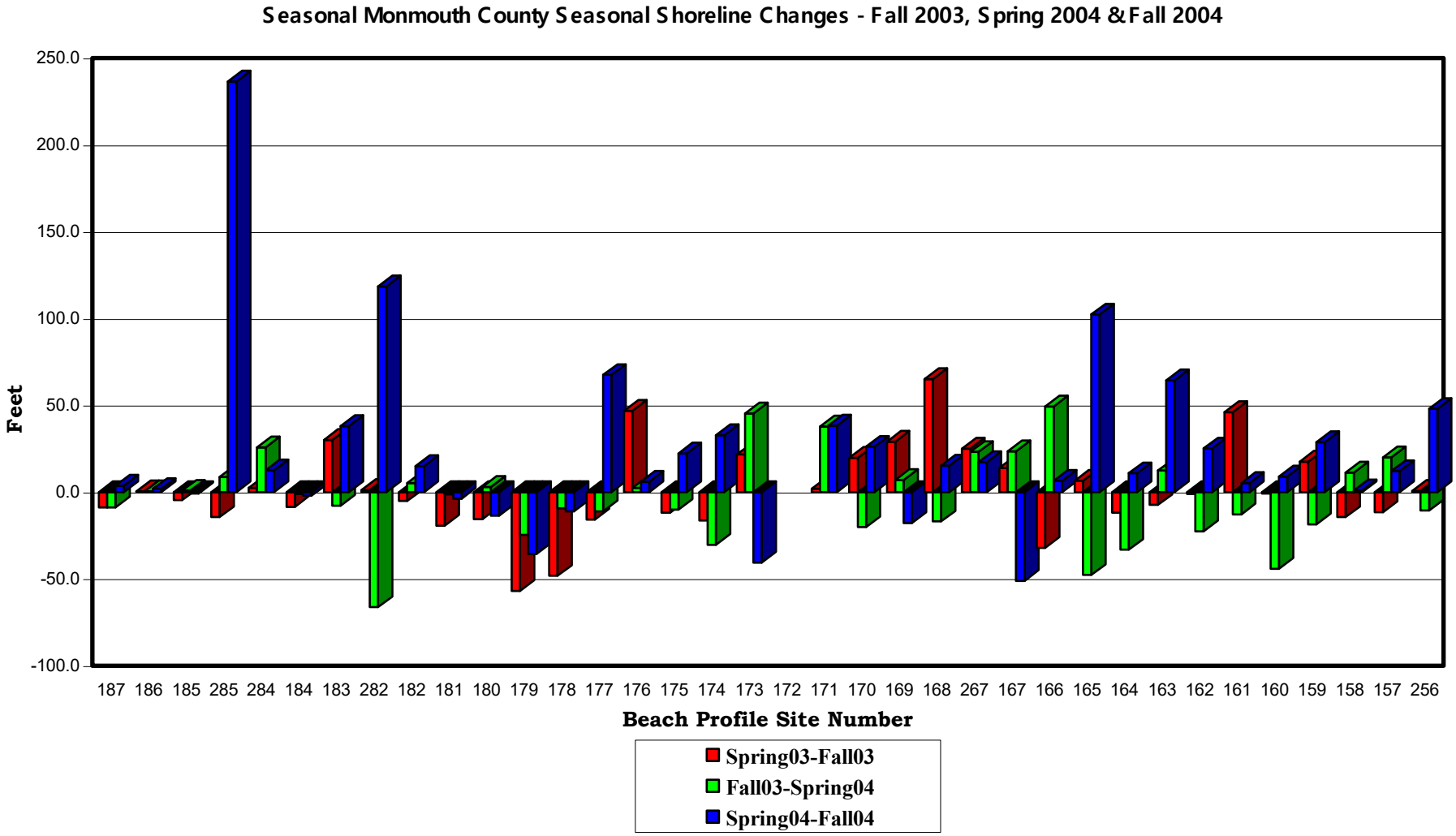



**Figure 5d. The shoreline data reflects a fairly strong tendency toward advance especially at Sandy Hook's Gunnison Beach site. Other locations show ranges between 0 and 50 feet as common changes.**

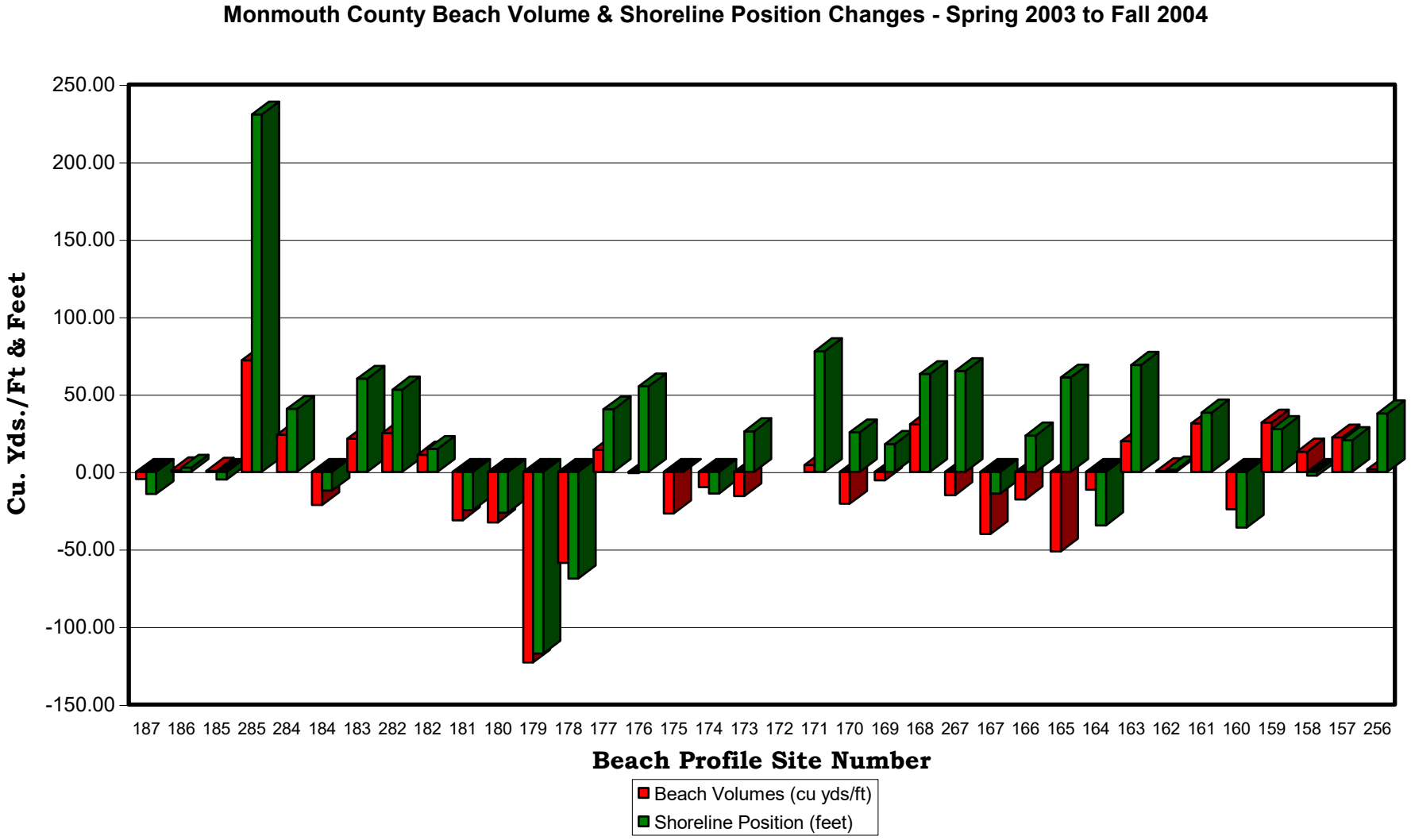



**Figure 5e. The entire study interval of 18 months demonstrated modest loss or gain at all but the three "hot zone" sites at Monmouth Beach. Sand Hook's Gunnison Beach site bucked the trend with large gains.**

## SUMMARY OF INDIVIDUAL SURVEY STATIONS LOCATED IN MONMOUTH COUNTY

- **Profile #187 - Beach Park, Cliffwood Beach** (fig. 6)

The Cliffwood Beach Park profile begins on the landward side of Lenox Road, includes the curbs and street and continues over the reconstructed dune, across the beach and into the water over 500 feet from the shoreline. Dune grass has propagated and spread to cover most of the dune between the landward and seaward toe. Bayberry, beach plum and sumac have appeared on the landward slope and appear to be flourishing limiting the dune grass coverage on the slope. A foredune ridge continued to grow about 100 feet seaward of the carsonite reference post, located along the primary landward dune crest. Dune grass and early colonizing plants provide abundant ground cover between the primary seaward toe and seaward crest of the foredune. The dune is vegetated with a variety of marine plants during the two decades since the beach was re-developed into a public recreation area. Wave activity is limited to local fetch across Raritan Bay with northeast and northwest wind direction the only major forces acting to generate the local waves. Waves do impact the shoreline, but the range of elevations is limited by the low tidal range and limited wave size.

The beach advanced substantially during the summer of 2003, but then retreated that next winter, recovering only a tiny volume of sand on the beachface. The shoreline changed only slightly and the sand volume remained essentially the same, declining by only 4.49 $yds^3$/ft. since April 2003. Due to the low wave energy along this shoreline, no changes were observed in the offshore part of the profile.

- **Profile #186 - Union Avenue, Union Beach** (fig. 7)

At this site a PK nail along the centerline of Union Avenue is the current reference position, replacing the original reference disk located on a curbside utility pole destroyed when the pole was replaced during recent local improvement projects. The profile includes the curb, bayside parking lot, asphalt walkway and wooden bulkhead all constructed during the same improvement projects. This site originally consisted of a sandy beach that sloped gently from the sidewalk to the water lacking any dune system or hard structure for storm protection. Instead, today the relatively new hard structures provide adequate shore protection for the shore front property and infrastructure that occupy the area where dunes would naturally occur if the beach were free from development. The profile continues seaward from the base of the bulkhead across an apron of rock riprap that covers most of what little sandy beach remains, partially exposed at low tide.

Between the rock apron toe and the low water edge is a narrow 20-foot wide swash zone with another 20 feet of the beachface toe below the datum extending the slope to the seafloor where only very minor changes occurred during the study period. This bay shoreline is also located in a low energy wave environment, similar to Cliffwood Beach. Consequently, the seafloor is unaffected by the small waves generated by the wind fetch across Raritan Bay. With very little exposed beach subject to erosion and a lack of littoral energy to effectively transport sand laterally the net changes from April 2003 to October 2004 were minor, 1.08 $yds^3$/ft of sand gained with 2.7 feet of shoreline advance.

- **Profile #185 - Spy House, Port Monmouth** (fig. 8)

Profile #185 begins on the seaward side of Port Monmouth Road in front of the Spy House Museum at Bayshore Waterfront Park. The profile includes the park's grass yard and parking lot, continuing to the seaward dune crest where a relatively steep slope in the bluff and dune plunges 8 feet to the beach below. Dune grass has been largely replaced by other native species as ground cover on the seaward crest and along a portion of the upper seaward slope. From the dune toe, a narrow beach approximately 80 feet in width, at low tide, slopes towards the water's edge. The seafloor is flat from the beachface toe continuing out over 1000 feet to the limit of the survey.

The seaward dune slope has experienced periodic episodes of erosion and retreat during the past 19 years. Beach losses and shoreline retreat are associated with these events. This erosion has been directly related to northeast storm wave activity due to this site shoreline orientation toward the northeast. Dune restoration earlier in the past decade, dune grass planting, installation of fences and walkways over the dune to prevent foot traffic losses has enhanced this site's stability. Since April 2003, the site has changed very little. The net loss in beach face volume was –2.67 $yds^3/ft.$, compensated for offshore so the net site change was 0.70 $yds^3/ft.$ The shoreline retreated 4.7 feet.

- **Profile #285 – Gunnison Beach, Sandy Hook, Monmouth County** (fig. 9)

This profile begins on the landward side of Atlantic Avenue, includes the sidewalk and promenade where comfort stations and gazebos are located. The profile continues across the large primary dune over a developing foredune and onto a wide flat low elevation beach that extends approximately 600 feet from the foredune toe across the beach, then slopes upward to the berm. From the berm ridge the profile continues seaward changing dramatically as huge volumes of sand arrive from the south. The offshore portion frequently contains wide ridges close to the beach and even larger bars offshore. Beyond the bar the seafloor slope is steep dropping quickly to an elevation of –16 feet NGVD.

Due to the extreme width of this profile most of the stable primary dune has been omitted from the profile plot. The primary dune is 200 feet wide from landward toe to seaward toe with a crest elevation of about 15 feet NGVD. This dune is very stable with grasses and various native species providing ground cover. Large bayberry shrubs and other woody trees flourish along the primary crest and landward slope. A small foredune has accumulated around dune fencing installed approximately 200 feet seaward of the primary dune which is located on the plot about 700 feet seaward of the reference position. The upper beach upon, which this foredune developed, is relatively flat and stable despite a low elevation, 4 to 5 feet NGVD, it then rises steeply at the berm ridge to almost 9 feet NGVD.

From the berm seaward this site produces dramatic variations in nearshore and offshore bar bathymetry. Large volumes of sand accumulate on the beachface and nearshore seafloor then migrate onshore and offshore. During late May 2003, one of these nearshore ridges of sand migrated onto the beachface leaving a narrow trough between the old berm and a growing ridge that resembled a beach in its own right. It took a year for the trough to fill in, and by April 2004 the berm had advanced 175 feet seaward. All this time the beachface remained nearly in the same position. During the summer and fall of 2004 a sand volume of 70.13 $yds^3/ft.$ moved onto the beachface and nearshore slope producing a 237-foot advance in the zero elevation shoreline. The origin of this sand is likely material lost from the "cove area" that precipitated the nourishment cycle that added sand to the beaches north of the end of the Sea Bright seawall. It might be the sand that was pumped onto those beaches in 2002, but the restoration was initiated by sand losses that could be represented as the gain observed at this site.

- **Profile #284 – Parking Lot E, Sandy Hook, Monmouth County** (fig. 10)

Profile #284 begins in a dense shrub and wooded area of the back dune at a utility pole with a reference disk attached, which was destroyed when the pole was cut to just a few feet above the ground during recent utility upgrades to underground cables. The profile crosses through this back dune area, over the primary and foredune ridges onto a wide dry upper beach. From the berm ridge the beachface slopes steeply into several feet of water. The dune is well developed with a thickly vegetated back dune area composed of large bayberry trees and other woody plants indigenous of a maritime forest, indicative of an extended period of stability. From the primary dune crest seaward to the foredune crest dune grass and other native non-grass species (i.e. Seaside Goldenrod, Poison Ivy, etc) combine to form abundant ground cover, which adds stability to this more recent accumulation. Sporadic dune grass rhizomes with a few early colonizing plants (i.e. Sea Rocket) inhabit the seaward foredune slope.

The 2002 beach maintenance project placed 72.33 $yds^3$/ft of sand along this beach that produced 83 feet of shoreline advancement. The berm and recreational beach elevation was enhanced from 10 feet to 12 feet NGVD significantly improving the recreational area and shore protection potential of this beach. This beach appears stable since the sand placement in 2002, because the net change over the 18-month time interval was a gain of 24.11 $yds^3$/ft. and a 41-foot shoreline advance. The December 2004 cross section line is almost 100% higher and further seaward than any of the other three survey lines. This evidence of northerly littoral sand transport gives credence to the theory that the huge volume change seen at Gunnison Beach was sand removed along the affected shoreline to the south prior to the 2002 beach fill.

- **Profile #184 – Highlands Beach, Sandy Hook, Monmouth County** (fig. 11)

This profile begins on the landward side of Hartshorne Drive, it includes the curbs and grass lot seaward of the road. The profile continues over the large rock and concrete seawall seaward across the re-nourished beach to the berm ridge.

The location is the northernmost NJBPN site that actually received fill from the initial N.Y.C.O.E. Monmouth County beach nourishment project, completed here in the summer of 1996. There has been no effort made to establish a dune here. The seawall appears to occupy the natural dune location since sand accumulation along the rocks by aeolian accretion is actively colonized by dune grass and other early colonizing plant species. Natural propagation of these plants indicates that wave run up does not encroach on this region. By December 2004 a tiny dune had accumulated just seaward of the rock seawall.

A beach maintenance nourishment cycle was completed prior to December 2002 survey as part of the Sandy Hook project, which placed 73.96 $yds^3$/ft of sand along the profile. This project added over 3 feet of elevation relief to the beach, formed a new secondary berm ridge, extended the shoreline 65 feet and raised the seafloor elevation offshore.

This data was taken six months after the project was complete. The berm grew to its maximum size by the fall of 2003 (survey 27) as sand was transferred from offshore onto the beach. The winter of 2003 – 2004 reversed this process moving 14.14 $yds^3$/ft. from the beach and depositing 13.89 $yds^3$/ft. offshore. The net winter's sand volume change was a microscopic 0.09 $yds^3$/ft. loss with a one-foot shoreline retreat. The last survey comparison including the summer of 2004 saw a minor loss of 11.85 $yds^3$/ft. and a 2-foot shoreline retreat. The beach elevation has been reduced substantially by the changes since the fill was completed, but the data suggests that little sand has left this part of the shoreline because it is found offshore between 400 and 700 feet from the reference position.

- **Profile #183 – Via Ripa Street, Sea Bright, Monmouth County** (fig. 12)

Profile #183 starts along the seaward side of Route 36. It includes an open lot seaward of Route 36 and the large seawall described above. A narrow swale formed between the seawall and a dune that formed around installed fences and dune grass plants. A 150-foot wide dry beach extends seaward from the dune toe to the berm ridge. The relative stability of this beach is remarkable considering the recent history of this site prior to beach nourishment when no beach existed at all along this section of the Highlands Beach and Sea Bright seawall. Early NJBPN surveys document the depleted beach conditions when waves reached the rocks even at high tide.

Since the beach nourishment project, efforts to stimulate dune growth through fence installation and dune grass planting have been successful. A dune is well established and stabilized by moderate coverage of dune grass. The overall project performance here continues to be good with over 250 feet of beach width consistently maintained seaward of the seawall. During periods of seasonal advances the beach width grows to over 300 feet, seaward of the seawall. This provides substantial room for dune growth, significant protection against storm damage to property and public infrastructure.

The beach adjusted for climatic changes between a berm ridge positioned at 200 feet from the reference position out into the water to about 600 feet. Sand was transferred lower onto the beach face by December 2004, but the net 18-month sand volume change was plus 21.48 $yds^3$/ft. with a 60-foot shoreline advance. The general trend of all four cross sections was to converge on the same surface by the 700-foot distance from the reference.

- **Profile #282 – Shrewsbury Way, Sea Bright, Monmouth County** (fig. 13)

This profile starts along the landward side of Route 36 and includes the road, curbs and an open lot between Route 36 and the seawall. A small swale separates the dune from the seaward seawall toe. The primary dune has remained relatively stable since its formation shortly after the project's completion. Abundant dune grass mixed with a variety of other native non-grass plants (i.e. Seaside Goldenrod) has propagated providing ground cover that further stabilized this feature. A foredune ridge developed between November 1999 and May 2000, and continued to grow in subsequent surveys. Dune grass rhizomes and early colonizing plants have spread seaward across much of the upper beach enhancing this foredune development. Limited use of this beach by the general public for recreational use and the lack of associated beach maintenance raking operations further promotes this spread of plants across the dry beach. Between April 2002 and November 2002 foredune development accelerated advancing the seaward toe 75 feet to a position nearly 140 feet seaward of the seawall. Development of this naturally occurring foredune system creates new habitat for migrating shorebirds and other native wildlife and plants. This habitat continues to expand in the absence of raking and other maintenance activities associated with a municipal recreational beach or any large storm events to generate waves large enough to overwash the area.

The dune and upper dry beach have remained stable with ever-increasing vegetation between the rock wall and the berm. Change in the topography reach inland to a point 300 feet from the reference. Sand has been washed or blown onto the higher beach as sand moved onto and off the shore's active zone. Change was more dramatic during the 2004 summer than the summer previous (2.95 $yds^3$/ft. gained vs. 15.85 $yds^3$/ft. gained in 2004). This segment of the Sea Bright shoreline has been very stable since the Monmouth County project was completed almost 10 years ago.

- **Profile #182 – Public Beach Lot, Sea Bright, Monmouth County** (fig. 14)

This site is located at the public beach just north of the Rumson Road (Route 520) and Route 36 intersection. The profile includes the public parking lot and seawall then continues seaward across a small dune onto a wide-open beach. Aeolian deposition collected around fencing installed near the seawall to form a small dune. Sand accumulation has been limited by the dunes' location near the seawall. At this site the seawall is offset landward by a westerly jog in the wall just a few hundred feet to the south. A few hundred feet to the north is a beach club with buildings occupying the footprint where dunes should be. The combination of these conditions creates a partially sheltered pocket beach where these structures limit effective aeolian sand transport to just an easterly wind direction. Consequently, the width and height of the dune is significantly less than that seen at the other sites along this stretch of shoreline. The dune is covered with dune grass mixed with several native non-grass species helping to stabilize the feature. By November 2002 a field of small foredune hummocks had developed 240 to 300 feet seaward of the seawall, essentially in line with the seaward edge of the beach club. These features have developed rapidly into a double ridge of dunes by December 2004. The total sand accumulation amounted to 3.26 $yds^3$/ft. just in these dunes.

The upper beach extends over 350 feet seaward from the seawall and was extremely stable to accretional during the study period. The beach changed between a survey with a wide, high berm (survey 27) and the next observation (survey 28) when the beach had developed a ridge attached to the beach as sand was moving back onto the shoreline. Offshore there were few changes to

report. The net volume change was an increase of 11.18 yds$^3$/ft. with a 15-foot shoreline advance.

- **Profile #181 – Municipal Lot, Sea Bright, Monmouth County** (fig. 15)

Profile #181 includes the municipal parking lot, the boardwalk access ramp and promenade, which extend over the parking lot's bulkhead position. A small aeolian deposit accumulated along the seaward base of the bulkhead from sand blown across the wide swale that extends approximately 90 feet from the bulkhead to the landward toe of the primary dune. This dune was established after the initial beach project was completed and continued to accumulate sand each season, developing into three small but distinct ridge crests that eventually blended into one larger continuous feature by November 2002. Dune grass and a few other non-grass species have colonized the dune system providing ground cover and stabilization but no rhizomes or pioneer plants extend seaward of the seaward dune toe unlike the previous northern sites in this region. It is likely that increased activity levels associated with this heavily used public recreational beach thwarts colonization across the upper beach. Another contributing factor is the location of the dune system midway across the upper beach. This location effectively eliminated any substantial area seaward of the primary dune feature stable enough for natural expansion or colonization.

The 18-month trend has been one of retreat in the shoreline position (-19, -1, and –4 feet) and small volumes losses (-5.80, -9.74, and –15.86 yds$^3$/ft.) for each of the three comparisons for the summer of 2003, winter of 2003 – 2004 and the summer of 2004. Direct comparison of survey 26 with survey 29 produced a shoreline retreat of 24.71 feet and a 31.12 yds$^3$/ft. sand volume loss. This is not a sand deficit but, one worth following into the future to see if it continues.

- **Profile #180 – Sunset Court, Sea Bright, Monmouth County** (fig. 16)

The Sunset Court profile begins landward of the seawall and includes the road, concrete pad landward of the seawall and the seawall structure. At the seaward structure base a narrow swale separated the seawall and dune system. The dune was established after the initial beach project was completed with the installation of fences and planting of dune grass. Aeolian accretion occurred quickly around the fence installation rapidly forming a small dune. Dune grass along with some associated native plant species have propagated onto the upper beach resulting in additional sand collection and dune growth. The dune width as of December 2004 occupied a 60-foot wide footprint on the upper beach and extended 80 feet from the seawall to the seaward dune toe. The dune has not continued to grow seaward. The profile cross sections show almost no change over almost 300 feet of upper beach. There is moderate recreational activity along this section of beach that might contribute to the modest dune development.

Like site 181 to the north, this location's sand volume trend has been slightly negative with slow shoreline retreat combined with modest sand loss. 32.46 yds$^3$/ft. in volume loss is just about equal to that seen at the municipal parking lot beach.

- **Profile #179 – Cottage Road, Monmouth Beach, Monmouth County** (fig. 17)

At Cottage Road the profile starts along the landward side of Route 36 and includes the road, curbs, sidewalk and seawall. The landward dune toe begins at the seaward base of the seawall and has grown seaward 80 feet with a continuing foredune accumulation. Dune grass propagation has developed a thick stand of grass over the region stabilizing the system and contributing to additional growth. A stable upper beach continues 40 feet seaward of the foredune toe.

The fall 2002 maintenance project added 203.93 yds$^3$/ft of sand to the profile, which extended the berm 250 feet and the shoreline position 240 feet. Survey 26 occurred about 6 months following the project. During the summer of 2003, 55.97 yds$^3$/ft. in sand volume vanished. This was followed during the following winter with another loss of 26.37 yds$^3$/ft. The summer of 2004 saw

an additional 40.31 yds$^3$/ft. taken from the beach (-122.99 yds$^3$/ft. in the survey 26 to survey 29 comparison). The shoreline retreated 57, 25, and 36 feet during each interval. This "hot spot" for erosion continues to remain hot, probably because of the significant seaward offset in the rock seawall just south of this location.

- **Profile #178 – Monmouth Beach Club, Monmouth County** (fig. 18)

Profile #178 includes the municipal beach club parking lot and the club pavilion. The bulkhead and rock revetment structure was aligned along the seaward edge of the pavilion, which was buried by the dune here. Improvements to the beach club pavilion extended the width of the pavilion deck 20 feet seaward, covering a portion of the existing landward dune slope. The landward dune crest is less than 10 feet from the edge of the extended deck. Subsequent aeolian deposition along the dune toe raised the beach elevation 1 foot signaling a resumption of future growth. Dune grass propagation was limited here producing only modest ground cover and limited expansion onto the upper beach. Prolific seasonal recreational and associated maintenance activities also inhibit colonization and foredune expansion onto the upper beach.

The initial 200 feet of dry beach seaward of the bulkhead was stable to accretional, but loss rapidly following the 2002 renourishment project. The first two comparisons show moderate loss, but the last one shows stability. The net change was a sand volume loss of 58.60 yds$^3$/ft. and a shoreline retreat of 69 feet. This site is south of the "hot spot" to some extent and did not suffer the extensive losses seen at site 179. Offshore there were few changes.

- **Profile #177 – Ocean Avenue, Long Branch, Monmouth County** (fig. 19)

This site is part of the Monmouth County park system known as Seven Presidents Park. Public access is good offering abundant space for recreational use. The profile starts on the landward side of Ocean Avenue and includes the curbs, road, sidewalk and concrete seawall. There has been no significant attempt to establish a dune system on the line at this site since completion of the A.C.O.E. nourishment project. In contrast, several hundred feet north and just to the south of this site dune establishment was successful. However, along the profile line and immediately adjacent the upper beach was relatively flat with only a small volume of sand accumulation ramped along the seaward base of the seawall. The remainder of the upper beach was relatively stable for the first 200 feet seaward of the seawall providing abundant space for recreational use.

The back beach has slowly accumulated sand raising its elevation by a few tenths of a foot. The berm position retreated about 80 feet between April 2003 and November 2004 but the slope on the beachface became flatter. This sand appears to have been deposited in the swash and shallow offshore creating a bar by November 2004. The 18-month trend was positive in sand volume (14.28 yds$^3$/ft.) with a shoreline advance of 40 feet due to the flatter beachface slope.

- **Profile #176 – Seven Presidents Park, Monmouth County** (fig. 20)

This site was established near the main entrance to the park. The profile begins at the entrance to the beach and includes the road and an open sandy playground near the parking area. Since the site's establishment, a substantial dune has developed north and south of the profile line with abundant dune grass. However, this dune configuration is not represented in the cross section because the profile line is set between a playground and pump house that is effectively maintained clear of sand intrusion. The relatively small dune shown on the plot was formed by wind blown sand collecting along the chain link security fence around the pump station. This minor feature continues to accumulate a small volume of sand while scattered colonizing plants have begun to flourish. Unfortunately, the profile site selection pre-dated the dune development and to improve representation of the surrounding area would require moving the profile a hundred feet north or south.

The plots of the four surveys show virtually no change to the upper dry beach or the dune present in front of the fence surrounding the pumping station. The berm alters its configuration by expanding seaward during the fall and spring of 2003 – 2004, then retreating slightly beyond the May 2003 position by November 2004. The general response was a cross-shore transfer of sand onto the shoreline during the berm advances followed by a growth in the sand volume offshore during the periods when the berm retreated. The sand volume change was only -0.84 $yds^3$/ft. over 18 months of study while the shoreline advanced 55 feet due to fortuitous position of the little bar present in the swash zone at the time of the November 2004 survey.

- **Profile #175 – Broadway Avenue, Long Branch, Monmouth County** (fig. 21)

At North Broadway Avenue the profile begins along the landward side of the promenade, it includes the promenade and bulkhead revetment. Wind blown sand continued to accumulate along the base of the bulkhead creating a ramp effect but no effort has been made to create a dune system. Dune grass propagation ends near the beginning of the promenade that begins several blocks north of this site at the southern limit of Seven Presidents Park. Here plants sparsely populate the beach, although there is a 100-foot wide stable upper beach upon which a dune system could be established. However, currently shore protection is limited to the promenade bulkhead revetment and the restored beach itself.

The pattern of growth in the berm and its stability through the winter of 2003 – 2004 then a retreat by November 2004 held true south into Long Branch. The sand volume was exchanged between the berm and offshore in a similar pattern. There was a net sand loss during the winter of 2003 – 2004 (-17.57 $yds^3$/ft.) that was not recovered the following summer. The 18-month sand volume change was -26.80 $yds^3$/ft. with no change in the shoreline position. This loss is visible in the offshore and a gradually increasing divergence between the May 2003 cross section and the survey done in late November 2004. The two-foot elevation difference seen at the end of the cross section 700 feet seaward of the reference point shows that sand movement was taking place farther out into the ocean than a swimmer could take the prism, however the last survey did end in 16.4 feet of water.

- **Profile #174 – Morris Avenue, Long Branch, Monmouth County** (fig. 22)

Profile #174 starts along the west side of Ocean Avenue, includes the road, boardwalk, and rock seawall. During the summer of 1998, the Monmouth County beach nourishment project reached this location; the total placement volume was 217.7 $yds^3$/ft with an advance in the shoreline of 325 feet. A minor volume of sand collected on top of the rocks along the seaward base of the boardwalk and a larger volume accumulated along the seawall but no attempt at dune development has occurred since the project was finished. The upper beach is stable for 150 feet seaward of the seawall and should provide a sizable platform for dune growth but a significant recreational use and a lack of installed dune fence or dune grass hinders the formation of a dune. Unlike the Sea Bright and Monmouth Beach segments the Long Branch beaches are open to the public with sufficient parking and abundant access points. Although public access to these restored beaches is desirable, unrestricted recreational and associated maintenance activities prevents the type of natural dune growth documented along the Sea Bright shoreline.

The Morris Avenue beach has a ten-foot elevation berm remaining from the Army Corps project descending to a naturally-built berm that has responded to changing wave conditions by shifting positions seaward or landward. There was greater convergence in the four profiles offshore at this site indicating that the surveys cover a higher percentage of the sand volume movements than seen at Broadway Avenue. The net changes over 18 months amounted to a 14-foot shoreline retreat combined with a sand volume loss of 9.71 $yds^3$/ft. An interesting comparison begins to emerge between Morris Avenue and West End Avenue about a mile to the south due to the termination of the beach nourishment project south of West End Avenue in 1999 because of unresolved public access and real estate issues in municipalities of Elberon and Deal.

- **Profile #173 – West End Avenue, Long Branch, Monmouth County** (fig. 23)

The West End Avenue profile begins west of the asphalt promenade, includes the boardwalk, grass covered bluff and rock seawall. No dune development was attempted here since the project was completed. However, shore protection is adequate with the presence of the seawall and natural bluff that brings the boardwalk elevation overlooking this beach to an elevation of nearly 32 feet NGVD. The beach is heavily used for recreation with easy access and street parking allowed. This site is several blocks north of Lake Takananssee where the beach nourishment project work terminated.

This site received as wide a beach as was placed at Morris Avenue, but this site suffers from "open-end effects" that increase the rate of beach erosion. Sand eroded from the project beach is transported by littoral currents north and south. Sand carried south is lost along the depleted beaches of Elberon and Deal so it is not able to feed back north to Long Branch when the littoral currents reverse. This creates a net sand budget deficit and results in relatively continuous and rapid beach loss. The wide 10-foot elevation beach is gone with a ramp of sand leading from the natural berm up to the rocks. This is still about 100 feet wide as shrinkage continues in the width between the rocks and the berm crest. The net change was much smaller than previously seen over 18 months because the 2000 to 2002 erosion cost 89.24 $yds^3$/ft. with a 113-foot shoreline retreat. This 18-month interval produced a much smaller 15.63 $yds^3$/ft. loss with a 26-foot advance in the shoreline.

The absence of any sizable gain at the Morris Avenue site, several blocks north of West End Avenue, indicates that a significant percentage of the material lost was carried south towards the unfilled beaches of Elberon and Deal.

- **Profile #172 – Brighton Avenue, Long Branch, Monmouth County**

The site was abandoned in 1994 because of its proximity to Profile #173. During 2000, construction of a multi-unit-housing complex effectively eliminated the site.

- **Profile #171 – Pullman Avenue, Elberon, Monmouth County** (fig. 24)

At Pullman Avenue the profile starts along the north side of the street end and includes the street end, curb and large bluff. The bluff was reconstructed and dune grass planted on the seaward slope to stabilize the feature, after being severely eroded during northeast storm events in the early 1990's. Dune grass propagation has produced a relatively stable slope and rhizomes have spread from the toe towards the bulkhead and rock revetment that is the primary shore protection structure here. No stable dry beach has existed seaward of this revetment since the inception of the NJBPN program. This trend continued through June 2000 when the waves at low tide still reached the rocks. By November 2000, a large wedge of sand moved onshore to form the largest documented beach here since 1986. This deposit of sand eroded rapidly and by June 2001 the dry beach was gone. A smaller volume of sand migrated onshore during the summer of 2001 forming a small beach at the toe of the revetment during the November 2001 survey. However, this accumulation was also temporary and by May 2002 the site was devoid of any dry beach area along the seaward toe of the revetment. This beach configuration continued through September 2002. The base of the rocks was at the zero datum in both the June and November 2003 surveys. Bars were present offshore, but not in substantial volume. By June 2004 a wedge of sand had appeared on the rocks with a uniform slope seaward. This accretion continued through to November 2004 yielding a hundred feet of sand beach between the rocks and the zero datum.

The sand volume added to the beach between June 2003 and November 2004 amounted to13.29 $yds^3$/ft. Two thirds of the material came from offshore (8.81 $yds^3$/ft.) and has been moved up the slope and deposited as a beach along this section. This process is similar to conditions observed in November of 2000. Cross shore transport of sand seems capable of creating a minor beach at this rock-armored coast, but does the sand come from erosion seen at the southern end of the

ACOE project in Long Branch? This site is south of Lake Takanassee, the present southern terminus of the Long Branch segment of the beach nourishment by the New York District Corps of Engineers. This site may be within the influence of sand derived from the Long Branch contract because these changes do exceed most observed during 18 years of monitoring. The addition of this sand here provides support for the theory that sand lost from West End Avenue area in Long Branch moved south.

In lieu of the project's completion south to Asbury Park, sand will likely continue to pass through this site associated with losses and periodic renourishment schedules in Long Branch. Where the nourishment project ends in Long Branch, these "end beaches" will erode much faster than in the central regions of the fill where sand is able to move equally in both directions parallel to the improved shoreline.

- **Profile #170 – Roosevelt Avenue, Deal, Monmouth County** (fig. 25)

The profile configuration at Roosevelt Avenue consists of a rock seawall that provides the only shore protection for the property landward of the wall. A well-manicured private lawn is landward of the seawall and extends for several hundred feet to the main residence. Since the establishment of this site, a lack of any dry beach area seaward of the wall has prevented any development of dunes.

Wet beaches have frequently been observed around high tide but often waves reach the rocks even at lower tide levels. Typical seasonal fluctuations dominated the beach configuration during the 18 months of this report. Sand moved onshore from late spring through early fall enhancing the beach elevation and width then eroded during the winter. There was a "mini-beach" present during each of the fall surveys and the zero datum was at the base of the rocks during both spring surveys. While the small beach reappeared by the fall of 2004, the sand volume counting changes offshore declined by 20.58 $yds^3/ft.$ in spite of the migration of some sand onto the shoreline. Careful observation of the sand distribution and changes north or south indicates that no Monmouth County beach nourishment sand has arrived along this mid-Deal municipal coast.

- **Profile #169 – Darlington Avenue, Deal, Monmouth County** (fig. 26)

Profile #169 begins at the seaward street end and includes the bluff. This site is somewhat unique because the uplands bluff is not completely armored with stone or wooden bulkheads common along the Elberon and Deal shoreline. However, wooden bulkheads have been installed in recent years to stabilize the slope on adjacent private properties. There is no dune system present along this shoreline; shore protection is reliant on the rocks, bulkheads and the bluff itself.

A narrow dry beach has been present at the base of the bluff since the site was established and varies in width seasonally. Offshore bar and beach berm geometry vary between deposition offshore and accumulation of sand on the beach. Large rock groins confine about 1000 feet of beach preventing even marginal exchange of sediment over, around or through the structures. The net change here was -5.53 $yds^3/ft.$ with an 18-foot shoreline advance largely due to changes in the angle of the beach's seaward slope. The positive element is that there is enough sand to provide a beach, but little change in gross volume ever occurs due to the groin system.

- **Profile #168 – Corlies Avenue, Allenhurst, Monmouth County** (fig. 27)

The Allenhurst beach extends approximately two thousand feet south from Deal to the southern border with Loch Arbour (the smallest beach community in New Jersey located north of the Deal Lake spillway flume and Allenhurst) located just beyond the landward toe of the concrete seawall protecting the Allenhurst pool club. This beach is held in place by a large L-shaped groin positioned at the northern boundary with Deal. The groin forms a pocket beach that provides an area for recreational use but the beach width tapers towards the south. The profile is located just

south of the end of the L-shaped groin extension but north of a smaller timber/rubble groin seaward of the pool club. At this site a concrete seawall armors the bluff with a boardwalk on the landward side and a dry sand beach seaward of the wall. There is no dune present along this section of beach. Therefore, storm protection for public infrastructure and private property is reliant upon the seawall.

Allenhurst/Loch Arbour did not receive any ACOE beach nourishment. There has been no real trend of accretion due to sand bypassing the terminal groin in Asbury Park. Observations at the Deal Lake exit flume have determined that shoaling has hindered the flow of water from the lake into the ocean and some focus has been made on determining a solution to the excess sand. The beach along this short shoreline segment varies with seasons gaining a berm as offshore bars migrate toward the beach providing the sand across the shoreline, not parallel to it. The largest change occurred between May and November 2003 as 72.49 $yds^3$/ft. arrived from offshore. This coincides with the appearance of excess sand around the Deal Lake flume and may signal some sand moving north from Asbury Park. However, just fewer than half that gain disappeared the following winter not to reappear during the 2004 summer. The 30.86 $yds^3$/ft. 18-month gain may represent modest sand bypassing of the terminal Asbury Park groin at 8$^{th}$ Avenue.

- **Profile #267 – Seventh Avenue, Asbury Park, Monmouth County** (fig. 28)

The profile consists of a boardwalk established on a low grassy bluff. Initial beach nourishment was completed here between April 1999 and November 1999 adding 174.34 $yds^3$/ft of sand, which significantly expanded the beach width. Despite the enhanced beach conditions no effort was made by the city to establish a dune system through fence installation or dune grass planting. Aeolian transport moved some sand from the berm up onto the dry upper beach, which accumulated along the base of the boardwalk, increasing the beach elevation seaward of the boardwalk by over one foot, which slowly continues. This natural aeolian accretion along the boardwalk indicates that dune development would occur rapidly if fences were installed. In the absence of dune development the beach provides the only storm protection for the boardwalk, public infrastructure and property landward of the boardwalk. Although the beach does provide ample area for recreational use and is easily accessed by the general public a significant storm surge would allow storm waves to impact the boardwalk, resulting in potential infrastructure damage, property loss and street flooding. Generally, south of Allenhurst, Monmouth County beaches are open to the public. Beach access and parking is readily available in most towns, which supports a lucrative tourist industry, unlike many towns in northern Monmouth County where beach access is limited and parking is restricted.

The berm does occasionally become larger than usual, as in October 2003, but most of the changes are in where the slope of the beachface intersects the zero datum line. Little change seems to occur offshore, but the weather conditions over the past 18 months have been relatively mild with no significant storms. The net 18-month change was -14.89 $yds^3$/ft. with a 65-foot advance in the shoreline position again largely due to a more gently beachface slope following the fall of 2004.

- **Profile #167 – Third Avenue, Asbury Park, Monmouth County** (fig. 29)

As seen at the previous site there was no dune development or effort to establish a dune on the Third Avenue beach in Asbury Park during this study interval. The NY District ACOE project was completed at this site prior to the October 1999 survey. The project placed 165.36 $yds^3$/ft creating a 145-foot wide berm at an elevation of 10.2 feet NGVD 29.

Sand has been transferred landward toward the boardwalk over the past 18-months, raising the elevation by a couple of feet close to the boardwalk. The City built a handicapped access ramp from the boardwalk to the beach that lies across the cross section line. The apparent slope from the boardwalk down to the beach on the November 2004 profile line really shows the distance between the boardwalk and the sand across the ramp's surface. Next survey the ramp surface

will be shown as a pair of "steps" down to the sand. There has been substantial loss in sand volume during the summer and fall of 2004 (-34.07 $yds^3$/ft.) while the 18-month loss was -40.10 $yds^3$/ft. This decline appears across the entire cross section plot from the berm crest seaward.

- **Profile #166 – Ocean Pathway, Ocean Grove, Monmouth County** (fig. 30)

In contrast to Asbury Park, Ocean Grove has made substantial efforts to establish a dune system along the restored beachfront. The cross section aligns with Pilgrim Pathway and crosses the floor of an open gazebo onto the beach. Consequently, a small dune has developed as sand accumulated around installed fence and subsequently dune grass was planted to help stabilize the sand. These efforts have been ongoing for several years culminating in a modest dune 50 feet in width at the toe with a crest elevation of 19 feet NGVD. Growth continued during most of the time shown in this study. The upper dry beach did not change in elevation as sand crossed it to add to the dune. The berm remained in narrow limits with little changes seen offshore. 17.69 $yds^3$/ft. of sand volume was lost over 18 months, but the shoreline advanced 24 feet.

- **Profile #165 – McCabe Avenue, Bradley Beach, Monmouth County** (fig. 31)

This profile includes the road, sidewalk, open lot, promenade and bulkhead. The wooden bulkhead supporting the seaward side of the promenade also provides shore protection for public infrastructure and property landward. The beach nourishment project was completed prior to the December 1999 survey and added 199.03 $yds^3$/ft to the cross section, pushing the berm 300 feet seaward of the bulkhead. Just prior to the October 2000 survey, the municipality installed a new dune fence and between October 2000 and May 2001 wind transported sand accumulated around the fence to form a small dune approximately 25 feet wide, which was subsequently planted with dune grass. Subsequent surveys have followed the growth of this dune to a feature that equals the height of the promenade and is about 50 feet wide at the base as of November 2004.

Three of four surveys follow very similar positions for the berm, bars and offshore region with the exception of the May 2004 berm position. The winter loss was recovered by the fall of 2004 and the 18-month change in sand volume (-51.33 $yds^3$/ft.) was found to exist entirely offshore as the sea bed elevation decreased from April 2003. No significant change occurred from the reference out to the 473-foot distance (-0.93 ft. elevation).

- **Profile #164 – Sylvania Avenue, Avon-By-The-Sea, Monmouth County** (fig. 32)

The Avon profile is located just north of the Shark River Inlet and includes the road, sidewalk, bulkhead and boardwalk. Public access to the beach is easy with abundant street parking and boardwalk stairways. A lack of any natural dune development and no effort to establish a dune by the municipality has continued since the ACOE project was completed. Natural development is inhibited by regular maintenance grading and raking from the berm to the seaward base of the boardwalk. Consequently, shore protection for the infrastructure and shorefront properties is more dependent on the beach width and the presence of an old bulkhead 15 feet landward of the boardwalk. The addition of 132.32 $yds^3$/ft of sand to the beach during the initial beach nourishment project pushed the berm ridge 300 feet seaward of the boardwalk. Sand has ramped up to the boardwalk over time, but little elevation change has been observed on the dry upper beach surface. Berm position shifts and offshore bar elevation changes have been minor and have involved only a net loss of 11.48 $yds^3$/ft. in sand volume. The shoreline has retreated 34 feet.

- **Profile #163 – Fifth Avenue, Belmar, Monmouth County** (fig. 33)

This site is located just south of the Shark River Inlet jetties. The profile includes the boardwalk but because beach access steps were attached to the seaward edge of the boardwalk at the profile line, the steps cover the small dune that has accumulated along the seaward base of the boardwalk not illustrated by the cross-section. This dune feature is less than 10 feet in width with a maximum crest elevation flush with the boardwalk at 13 to 14 feet NGVD. Seaside

Goldenrod and dune grass sparsely colonized the feature. Any storm protection provided by this feature would be minimal.

This site did not receive any direct volume of sand from the nourishment project that was completed in the region between Shark River Inlet and Manasquan Inlet prior to the November 1997 survey.

The upper beach was remarkably stable for the initial 200 feet seaward of the boardwalk. The berm ridge has been very stable, changing by under 25 feet every 6 months. Offshore the deep trough that was present in April 2003 filled in and added elevation as sand moved onshore over the remaining time. The net change in sand volume over 18 months was 19.75 $yds^3$/ft. with a 69-foot shoreline advance.

- **Profile #162 – Eighteenth Avenue, Belmar, Monmouth County** (fig. 34)

The profile includes the road and boardwalk but this line also occurs at a boardwalk beach access, which crosses over the small dune along the seaward base of the boardwalk north and south of the site. As described at the previous site this dune feature is also minimal, less than ten feet in width with the crest elevation flush with the boardwalk at 13 to 14 feet NGVD. This site is used by large numbers of patrons for recreational activities much of the year, which inhibits natural dune growth seaward of the fenced region with no significant effort by Belmar to enhance this small dune feature by adding additional fence seaward of the current location. The beach nourishment project was completed here prior to November 1997.

Sand has been transported onto and off of the dry beach seasonally. The berm advanced and retreated within similar ranges the two summers with the loss period coinciding with the winter storm season. A well defined trough and offshore bar system was present in October 2004. In spite of these changes, the net sand volume was a gain of 0.62 $yds^3$/ft. with a 1.45-foot shoreline advance. This site ended the 18-month period right where it began.

- **Profile #161 – Brighton Avenue, Spring Lake, Monmouth County** (fig. 35)

Unlike the Belmar sites, this profile includes a dune located between Ocean Avenue and the landward side of the boardwalk. The feature pre-dates the beach nourishment project and is well established with flourishing vegetation that provides stability. With a crest elevation of 21 feet NGVD this dune provides substantial storm protection for property and public infrastructure landward of the boardwalk but does nothing to protect the boardwalk from wave assault. The initial nourishment project was completed here by November 1997 and stability seems to have followed initial sand redistribution. The upper beach at the base of the boardwalk has an elevation of about 13 feet NGVD and slopes gently seaward for 100 feet to a berm at elevation 10 feet NGVD.

The municipality bulldozed a boardwalk storm protection ridge on the middle of the upper dry beach during the winter of 2002 – 2003, seen on the April 2003 survey prior to being graded out for the summer. This was not seen in 2003. A deep trough, present in 2003, filled in with 45.03 $yds^3$/ft. creating a wider berm and substantially shallower nearshore region. This sand came from elsewhere along the shoreline because it far exceeds the sand volume annually crossing the shoreline. The net volume change of 31.38 $yds^3$/ft. underscores the value of this filling in of the trough, because the net change is only slightly smaller than the trough volume filled. The shoreline advanced 38 feet.

- **Profile #160 – Salem Avenue, Spring Lake, Monmouth County** (fig. 36)

The Salem Avenue profile includes the road and the dune between the boardwalk and an open grass lot along Ocean Drive, which was established over 50 years ago. The dune is stabilized with dune grass, which has flourished as a thick ground cover on the landward slope and crest. Along

the seaward slope, grass coverage is sparse and the sand is relatively unconsolidated. A deposit of wind blown sand accumulated on both sides of the boardwalk and on the dune. The berm retreated about 85 feet between September 2003 and May 2004, but did not readvance the following summer. The loss in berm was stabilized during 2004. The net change in sand volume was -24.10 $yds^3$/ft. with a 36-foot shoreline retreat.

- **Profile #159 – New York Avenue, Sea Girt, Monmouth County** (fig. 37)

At New York Avenue the profile includes the sidewalk, road and street end parking along the west side of the boardwalk. A dune system is absent at this site despite the wide beach created by the beach nourishment project in 1997. Immediately south of the site a well-established dune has developed west of the boardwalk in front of the shorefront property but at the profile site and to the north, Ocean Avenue and street end parking occupy the location of the dune footprint. No attempt has been made to establish a dune seaward of the boardwalk. The beach is heavily used for recreational activity and is maintained as part of the municipal public beach system, consequently natural dune development is inhibited. Apparently Sea Girt pushed up a dune ridge to protect the boardwalk during the winter of 2003 – 2004 that was re-graded before the 2004 summer commenced. Little change appeared at the berm, but offshore there was migration of bars and the corresponding troughs over a wide range of distances seaward of the reference. The net sand volume change was 31.88 $yds^3$/ft. and the shoreline advanced 28 feet.

- **Profile #158 – Trenton Avenue, Sea Girt, Monmouth County** (fig. 38)

Profile line #158 is located between homes that were built near the landward toe of the natural dune. These property owners have nurtured a well-established dune crest with abundant and diversified plant species that help stabilize the feature. Accretion on the seaward slope has buried all but a few pilings of a bulkhead constructed for shore protection following bluff erosion during the December 1992 northeast storm, prior to the beach nourishment project. Sand has continued to accumulate along the seaward slope and toe between the boardwalk and buried bulkhead.

The berm and upper dry beach changed little if at all during 18 months, but offshore sand appeared in the shallow nearshore region raising the seabed 4 feet. This bar represents sand from outside the profile envelope. 13.00 $yds^3$/ft. accumulated on this cross section over 18 months, but the shoreline retreated 16 feet.

- **Profile #157 – Riddle Way, Manasquan, Monmouth County** (fig. 39)

The Riddle way profile includes the asphalt promenade and small dune, established by the Borough of Manasquan prior to the beach nourishment project. The dune feature is approximately 40 feet wide at the toe and accumulated a small volume of sand along the seaward slope during the report period but the overall width change was minimal. Dune grass mixed with seaside goldenrod produce a modest ground cover across most of this feature providing sand stabilization.

The upper beach changed incrementally and was reduced in elevation by less than a foot at the end of the time. The berm advanced seaward after retreating over the summer of 2003. A large offshore bar grew and advanced toward the beach adding 22.29 $yds^3$/ft. to the net sand volume accreting on this profile. The shoreline advanced 20 feet.

- **Profile #256 – Pompano Avenue, Manasquan, Monmouth County** (fig. 40)

The profile at Pompano Avenue beach in Manasquan is located about a thousand feet north of the Manasquan Inlet jetty and is the last cross section in the county. This profile includes the road, a steeply sloped lot between beachfront homes, the asphalt promenade and a small dune established just seaward of the walkway. The homes and the promenade occupy the footprint of

the pre-development dune system, a fact that explains a substantial storm damage history along this municipal coast. The Manasquan portion of the Monmouth County beach nourishment project was completed between the spring and fall of 1997.

The Pompano Avenue cross section saw a berm elevation reduction of about a foot combined with a berm advance by the end of the 2004 summer. A small volume of bar activity occurred offshore, but not nearly the size seen at Riddle Way. The net 18-month sand volume change was only 1.64 $yds^3/ft.$ with a 15-foot shoreline retreat.

**SUMMARY OF MONMOUTH COUNTY:**

Monmouth County's beaches are developed on a sedimentary bluff that the waves have eroded into Cretaceous and early Tertiary-aged sandy sediments. This bluff rises to 35 feet above the ocean in Elberon and gradually drops in elevation until it barely exceeds sea level at Manasquan. It disappears from the oceanfront in Bay Head, just south of the Manasquan Inlet, replaced with Holocene-aged barrier spit and eventually barrier islands. The two geologically modern features extend to the north from Long Branch/Monmouth Beach ending at the Sandy Hook spit enclosing part of Raritan Bay and a sand spit extending south from Bay Head in northern Ocean County ending at Barnegat Inlet.

Development commenced in earnest along the Monmouth County shoreline by 1870 with the construction of the New York and Long Branch Railroad. This access allowed tourism to develop and eventually permitted commuting to the urban north by full-time residents. The early tourist hotels built in Long Branch, Asbury Park, Ocean Grove and Spring Lake were set back from the edge of the bluff. The exact retreat rate is unknown, but relatively soon, property owners were beginning to construct wooden walls at the base of the bluff, parallel to the shoreline and add timber groins on the beach perpendicular to the shoreline. Improvements in engineering design and better technology allowed more durable and larger projects to essentially armor the bluff shoreline with walls of concrete timber and rock. The same effort was also applied to dividing the beach into cells separated by rock groins sometimes spaced under 700 feet apart. Groin design knew no limits during the 1960's and every Monmouth County shorefront municipality built at least one of these structures. Spaced frequently at every other street-end, the groins severely reduced the meager sand supply's ability to move in any direction except directly offshore during bigger storm events.

Little by little the Monmouth County beaches became very narrow with miles of shoreline without a sand beach of any kind. The ultimate armored shoreline was found in Sea Bright where a seawall started by the long-gone railroad company to protect tracks laid parallel to the dunes at the end of the 19th Century, had been rebuilt ever stronger during the 20th Century. Groins were also included about every quarter mile along the 12-mile shoreline. The only bathing beaches were found in tiny pockets tucked into the corner made by the seawall and one of the groins. The situation was slightly better from Asbury Park to the south, but storm damage to boardwalk and other public infrastructure was commonplace. The 1991 Halloween and 1992 December storms did substantial damage to the entire Monmouth County shoreline, piling the boardwalk into Ocean Avenue as splintered debris in Belmar, Avon-by-the-Sea, and Spring Lake. Damage to homes occurred in Manasquan as the ocean easily overtopped the beach and modest dune along that oceanfront. Even the Sea Bright seawall was not sufficient to prevent sand, debris and millions of tons of seawater from landing in Ocean Avenue.

By 1994 the State of New Jersey became serious about finding a solution to this shoreline loss and turned to a Federal project initially authorized in July of 1958 to undertake a Federal study to determine the best method of beach erosion control in Monmouth County. This work, modified under the Federal Water Resources Development Acts of 1986, 1988 and 1992 progressed through the three Federal phases leading to construction. The Federal lead agency is the New York District of the US Army Corps of Engineers with the local sponsor as the New Jersey Department of Environmental Protection. The NY Corps District carried the project through the Reconnaissance phase into the jointly sponsored Feasibility phase that chose a design plan. The

State spent years in negotiations with local municipalities along the Monmouth County coast to generate detailed plans and define local and State financial and governance responsibilities. Real estate issues and public access to the federally funded project where likewise long, tedious and frequently frustrating. Finally the Army Corps approved the Planning and Engineering Design for construction and Congress authorized the funding to start construction of the nation's largest beach restoration project ever attempted.

The project consists of 21 miles of shoreline from the Township of Sea Bright to the Manasquan Inlet in Monmouth County, New Jersey. The protection is provided by the construction of a 100-foot wide beach berm at an elevation of 10 feet above mean low water (MLW). The project also called for notching existing stone groins and extending storm water outfall pipelines. The project includes periodic nourishment of the restored beaches on a 6-year cycle for a period of 50 years from the start of the initial construction.

Construction commenced following the January 1994 award of the initial contract for Monmouth Beach. Over the next six years 24.9 million cubic yards of sand were pumped from about a mile offshore to the beach at a cost of $210,000,000. Beach nourishment efforts have provided a vast supply of new sediment to the beaches of 9 out of 12 oceanfront municipalities. The earliest sites with sand added have responded well, requiring little augmentation since the project started. Some early maintenance work was done at Monmouth Beach due to sand losses when material migrated south toward Long Branch in 1997. General maintenance was complete in 2002 placing under 70 $yds^3$/ft. at most sites. Over the past nine years, the extensive shoreline advances and large increases in sand volume have provided tremendous increases in shore protection, vastly increased ecologic habitat and new recreational opportunities to all municipalities involved.

Prior to the project, the Sea Bright coastline was a virtual disaster with little sand, waves at the rock seawall at low tide for 70% of the 8-mile shoreline distance, and almost no recreation use. Fishermen did use the seawall to surf cast into the sea, but no other normal beach activity was possible. Nourished in 1995 and touched up during late 1997 in Monmouth Beach, and maintained in 2002 the eight cross sections between the entrance to the Sandy Hook Park and the Long Branch border provide the data that show that the project has performed far better than all expectations. Critics labeled it a giant boondoggle and predicted total loss of the sand within a year or two. Nature assisted the success by not sending any intense storm to impact the project, but the average change in sand volume for the eight cross sections listed below show low rates of sand loss. The numbers are expressed in cubic yards of sand per foot of shoreline, and then multiplied by the number of feet in eight miles for each survey.

| | | | |
|---|---|---|---|
| +0.19 $yds^3$/ft | times 8 miles = | 3,801.6 cy | Fall 1998 |
| +0.02 $yds^3$/ft | times 8 miles = | 844.8 cy | Spring 1999 |
| –3.05 $yds^3$/ft | times 8 miles = | -128,832.0 cy | Fall 1999 |
| -5.59 $yds^3$/ft | times 8 miles = | -236,121.6 cy | Spring 2000 |
| -3.28 $yds^3$/ft | times 8 miles = | -138,547.2 cy | Fall 2000 |
| –3.96 $yds^3$/ft | times 8 miles = | -167,270.4 cy | Spring 2001 |
| -5.51 $yds^3$/ft | times 8 miles = | -232,742.4 cy | Fall 2001 |
| -0.14$yds^3$/ft | times 8 miles = | -5,913.6 cy | Spring 2002 |
| +69.43 $yds^3$/ft | times 8 miles = | 2,932,723.2 cy | Fall 2002 |
| -13.51 $yds^3$/ft | times 8 miles =. | -570,662.4 cy | Spring 2003 |
| -10.24 $yds^3$/ft | times 8 miles = | -432,537.6 cy | Fall 2003 |
| -5.16 $yds^3$/ft. | times 8 miles = | -217,958.4 cy | Spring 2004 |
| -10.57 $yds^3$/ft | times 8 miles =. | -446,476.8 cy | Fall 2004 |

These beaches lost only an average of 2.67 $yds^3$/ft. seasonally of their initial placement volumes for a net loss of 21.32 $yds^3$/ft from placement to the spring of 2002. Loss rates increased slightly following the maintenance fill in 2002, but averaged in the range of 5 to 10 cubic yards of sand lost per year per foot of shoreline for all eight profiles. The average loss rate from 1998 to 2004 (omitting the 2002 fill) was -5.067 $yds^3$/ft., converted to a loss in cubic yards across the 8 miles of shoreline; **the entire Sea Bright coast has lost 428,032 cy/year since 1998**. The placement volume was approximately 10,560,000 cubic yards, with 2,933,000 added in 2002. The Monmouth County beach restoration project has been one of the most successful ever attempted.