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EVALUATION OF BEACH BEHAVIOR AND COASTAL STRUCTURE EFFECTS AT ATLANTIC CITY, NJ

by

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and

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ABSTRACT

The beaches at Atlantic City, New Jersey have had a history of significant erosion. Beach nourishment projects were carried out in 1948, 1963, and again in 1970 using sand dredged from adjacent Absecon Inlet. Another beach nourishment project is planned for 1985. This study was conducted to provide guidance for design of the nourishment project.

Specifically, this study involved an evaluation of the proposed beach fill borrow area and the impact of borrow material removal on adjacent shorelines and structures; an evaulation of present day beach behavior and beach behavior following past fills; recommendations regarding desirable fill volumes and the areal extent of the fill; and an evaluation of the effects of existing shoreline structures. These evaluations were carried out through an analysis of available existing data including aerial photographs, beach and nearshore surveys, and sand size distribution analyses. Some additional beach profiles, sand samples, and visual observations of beach processes were obtained by the authors during 1984.

The data are presented and evaluated; then specific recommendations are made addressing the above concerns regarding the proposed beach nourishment project.

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I INTRODUCTION

Atlantic City, NJ occupies the northern third of Absecon Island, an eight mile long barrier island having a northeast-southwest orientation (Figure 1) and located about 40 miles northeast of Cape May, NJ. At the northeast, Atlantic City is separated from Brigantine Island by the jettied Absecon Inlet. The Atlantic City ocean shoreline, which extends 3.5 miles from the Oriental Avenue jetty at Absecon Inlet to the southwest city limit, is fronted over its entire length by a boardwalk, five large commercial piers and numerous wood and stone groins (Figure 2). Beach berm widths presently vary from zero to five hundred feet (at Oriental Avenue jetty) out from the boardwalk. However, along several important beach segments, the berm width is fifty feet or less.

The beach at Atlantic City was nourished in 1948, 1963 and 1970 with sand taken from Absecon Inlet. Each time, much of the beach fill moved offshore and alongshore resulting in a fairly rapid deterioration of beach conditions. Recently, in an effort to improve beach stability, the Oriental Avenue jetty and three of the groins were enlarged. A beach fill project is scheduled for 1985 with the sand again to come from Absecon Inlet (see

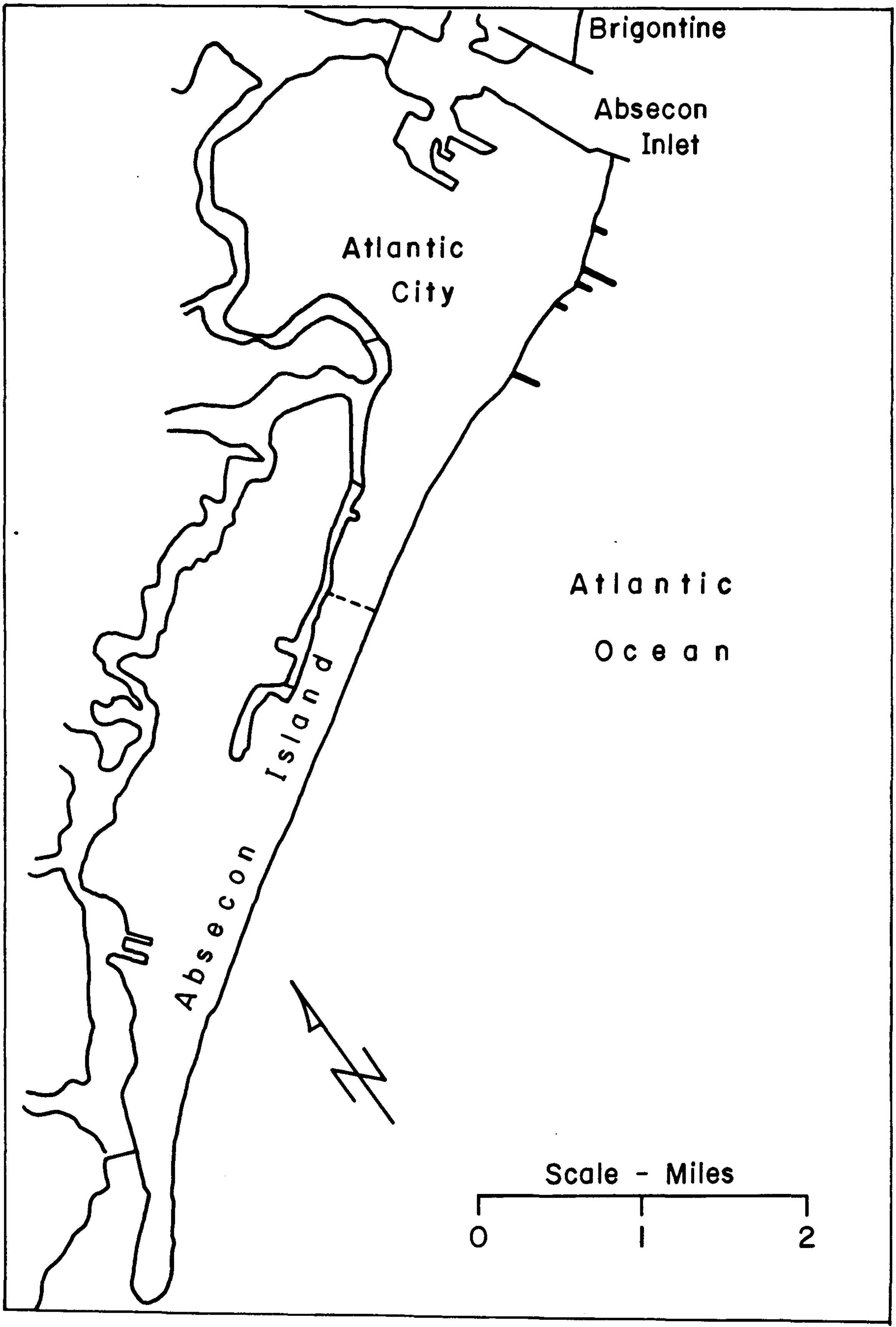

Figure 1 - Absecon Island and Atlantic City

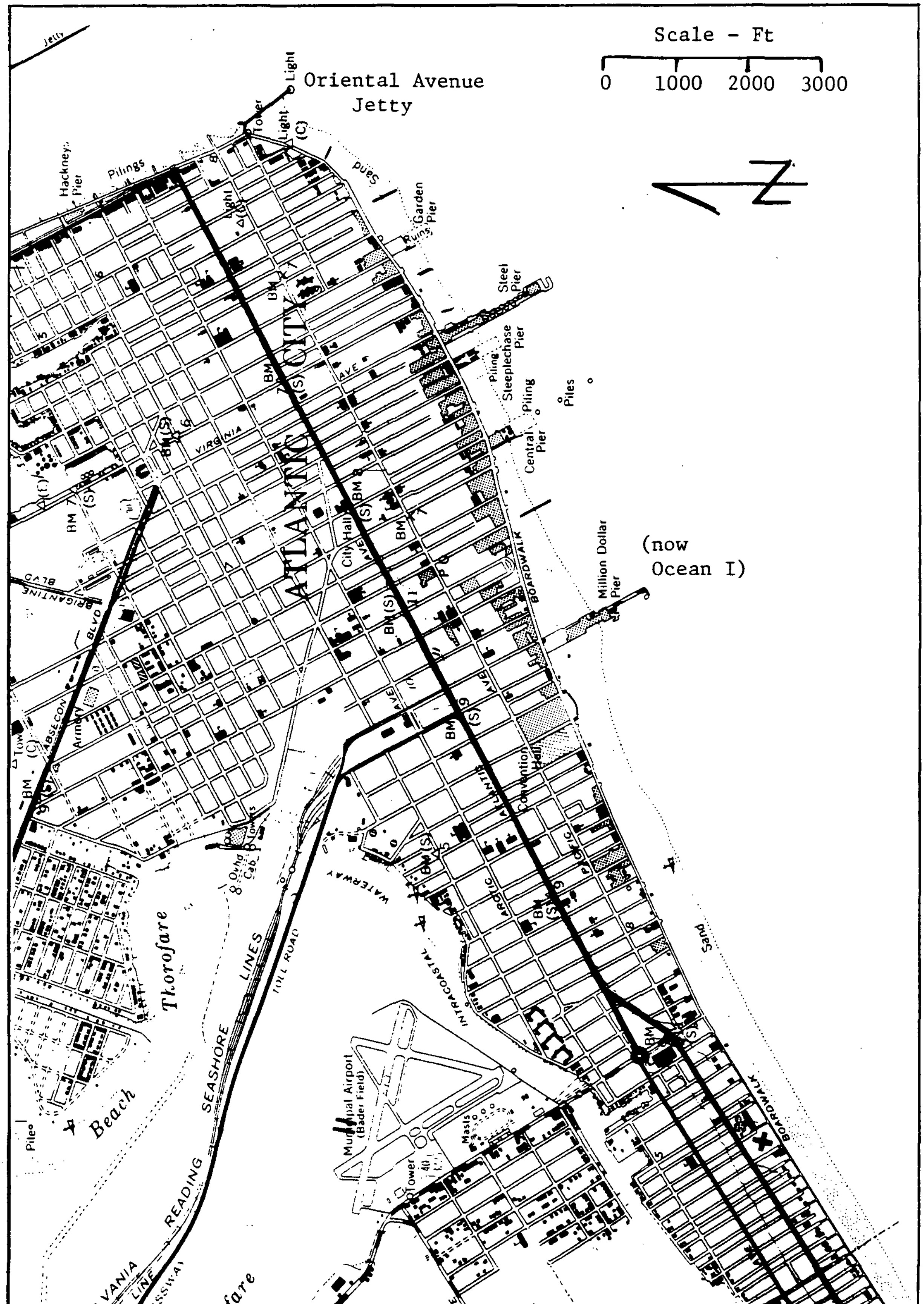

Figure 2 - Atlantic City, NJ

Figure 8). The purpose of this study is to evaluate the existing structures and shore processes at Atlantic City and to make appropriate recommendations concerning the structures and planned fill placement.

Specifically, this study has the following objectives:

* Evaluate the proposed borrow area in and seaward of Absecon Inlet to recommend the most desirable location for obtaining beach fill material; and to evaluate the impact of removing the borrow material from the inlet.
* Evaluate past beach behavior (including seasonal location of the nodal zone) in the proposed fill area. And, based on this, recommend the most desirable fill volumes and locations.
* Analyze exisiting shoreline structures and the recent structure modifications to evalute their positive/negative impact on retaining the planned beach fill. Are any futher structural modifications necessary?

The above objectives were accomplished through an evaluation of available field data supplemented by some field data collected during 1984 by the authors. Available field data includes results of sand sample analyses from Atlantic City beaches; periodic air photographs taken during the past two decades; beach and nearshore profile data plus inlet hydrographic data collected by the Corps of Engineers and the State of New Jersey; and wave, tide, surge and sea level change data from a variety of sources. Supplemental field data collected during 1984 includes bottom samples taken in and seaward of Absecon Inlet and along the beach in the proposed fill area; beach profile data collected in March, May and September occupying the same profile lines used by the Corps of Engineers during an eleven year survey period that covered the pevious two beach fills; air and ground photographs; and periodic site visits to evaluate nodal conditions and beach geometry at key structures.

The next section of this report gives an overview of the inlet and ocean shoreline processes prior to the construction of stabilizing structures, details the history of structure construction and past beach fill projects, and presents the recent modifications made to four of these structures. Subsequent sections present pertinent avialable field data and the data collected by the authors. Section V presents an evaluation of these data in light of the project objectives and Section VI presents specific recommendations based on the data evaluation as well as recommendations for future work.

II. SHORE PROCESSES AND COASTAL WORKS HISTORY

Inlet and Shoreline Prestructure History

The prevailing coastal processes at Absecon Inlet and their effect on Atlantic City's beaches prior to the construction of jetties and other control structures have been documented by FitzGerald (1981). Reliable historical shoreline charts for the vicinity of Absecon Inlet are available for the period starting about 1853. These data have been supplemented by FitzGerald (1981) with historical accounts of shoreline changes taken from local newspapers, lighthouse keeper's logs, and other documents. Based on these early charts and documentary accounts, Absecon Inlet does not seem to have migrated significantly, even in the absence of controlling jetties. (Everts et al. (1974) report that the inlet had only migrated 183 meters southward between 1840 and 1935.) A process of natural sand bypassing seems to have been operating which kept the location of the inlet relatively stable but caused large-scale navigation channel changes and shoreline fluctuations along adjacent beaches at Atlantic City.

The net longshore sand transport in the vicinity of Absecon Inlet is generally from north to south, or from Brigantine toward Atlantic City. The U.S. Army Corps of Engineers (1974) estimates a net southward longshore sand transport of 150,000 cu yd/yr based on a northward transport of 250,000 cu yd/yr and a southward transport of 400,000 cu yd/yr. For the inlet position to remain relatively fixed, the net transport must be bypassed from the Brigantine beaches to Atlantic City. The bypassing process that appears to have been operating at Absecon Inlet is described by FitzGerald (1981) as a periodic southward lengthening of the offshore, ebb-tidal shoal initially connected to the Brigantine shore; a corresponding lengthening and southwest shift of the thalweg of the inlet channel; the subsequent breakthrough of a new, shorter, straighter, and more hydraulically efficient channel; and the eventual onshore movement of the resulting offshore bar onto Atlantic City's beach. FitzGerald suggests that the period required for this cyclic process to take place is on the order of 10 to 20 years.

Figure 3 is a schematic representation of the process. The southward transport of sand from Brigantine beaches

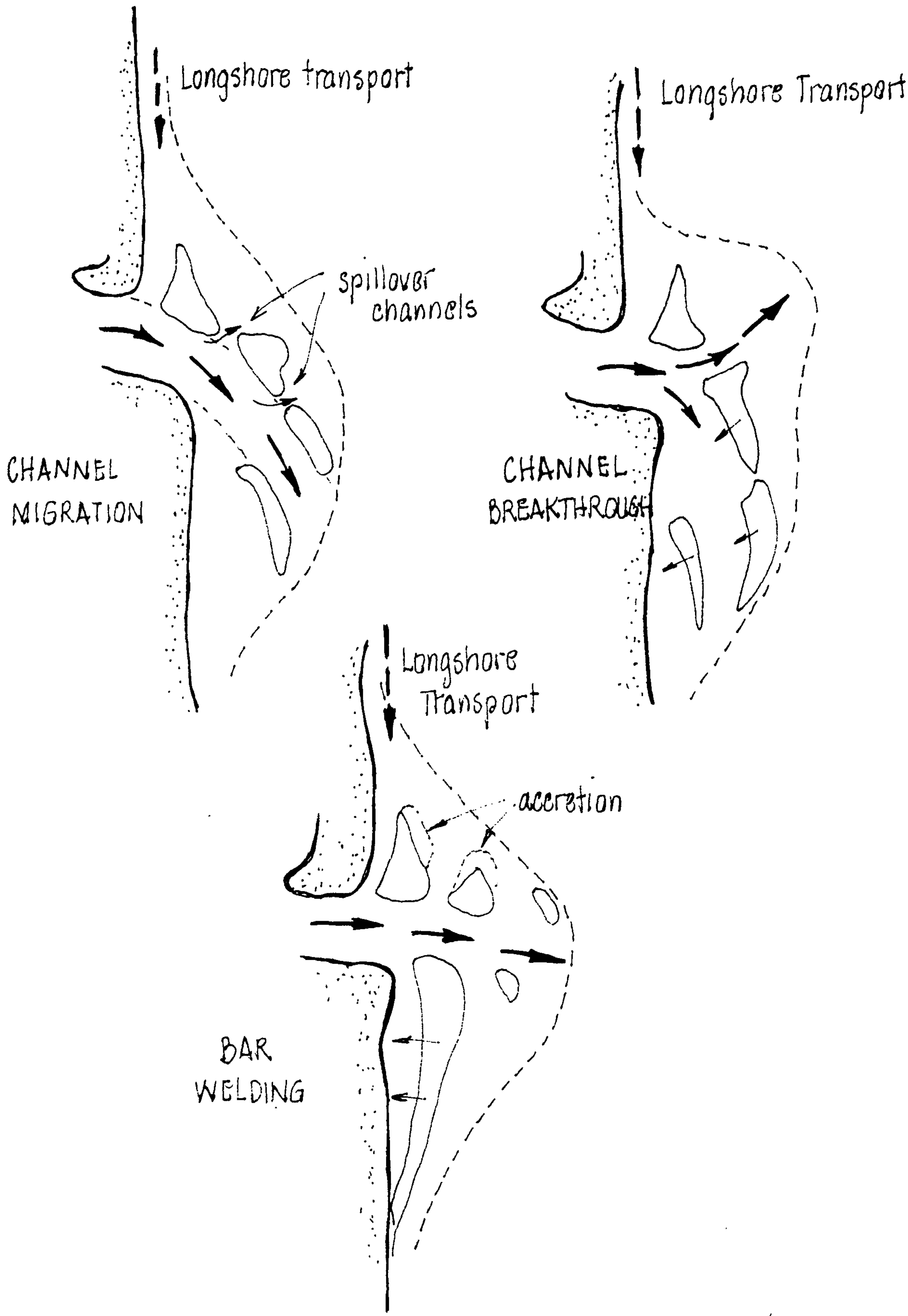

Figure 3 - Schematic representation of natural sand bypassing by ebb tidal shoal extension and subsequent breakthrough (after Fitzgerald, 1981)

into the inlet causes the ebb-tidal shoal to lengthen and to grow southward across the inlet entrance. Ebb-tidal currents deflect the sand offshore until the current velocity decreases below the velocity necessary to transport sediment and the sediment settles from suspension to form the offshore bar. The bar is held in a dynamic equilibrium between the ebb currents discharging from the inlet which tend to move the bar further offshore and the incident waves which tend to move it onshore. As more and more sediment is contributed to the bar from Brigantine's beaches, the bar lengthens and forces the inlet's main ebb channel against the Atlantic City beach. Erosion along the Atlantic City beach is thus accelerated in the vicinity of the inlet and the inlet channel is lengthened. The longer channel is less hydraulically efficient; also, the inlet's ebb currents erode the back of the ebb-tidal shoal and may breach it. Once the shoal is breached, most ebb flow follows the new channel rather than the more tortuous, less efficient, old channel and the dynamic equilibrium between ebb-tidal currents and incident waves is disrupted. With the tidal currents no longer acting to hold the severed shoal offshore, incident waves move the shoal onto Atlantic City's beaches. A "slug" of sand was thus contributed to Atlantic City's beaches in each 10 to 20 year cycle over which the process occurs. The process resulted in alternating periods of erosion and accretion of Atlantic City's beaches and associated large-scale fluctuations in the shoreline location.

These pre-jetty shoreline fluctuations (1877-1948) are illustrated in Figure 4 which is based on charts presented in FitzGerald (1981). The historical location of the high water shoreline with respect to Absecon Inlet Lighthouse is presented as a measure of the large scale shoreline fluctuations near the inlet resulting from the natural bypassing process described above. (The distance to the high water shoreline from the lighthouse was measured on the charts in a generally northeasterly direction from the lighthouse.) Concern for the lighthouse's safety during the late 1870s led to construction of the first navigation channel/erosion control structures along the northern Atlantic City shoreline. At about this time, several groins appear on the charts. Subsequent construction of the jetties at Oriental Avenue in Atlantic City and at Brigantine as well as the groins have greatly reduced - but not entirely eliminated - channel and adjacent shoreline fluctuations.

McCann (1981) presents sets of beach profiles from four locations along the ocean shoreline in the study area. They were taken between 1936 and 1948 (i.e. before

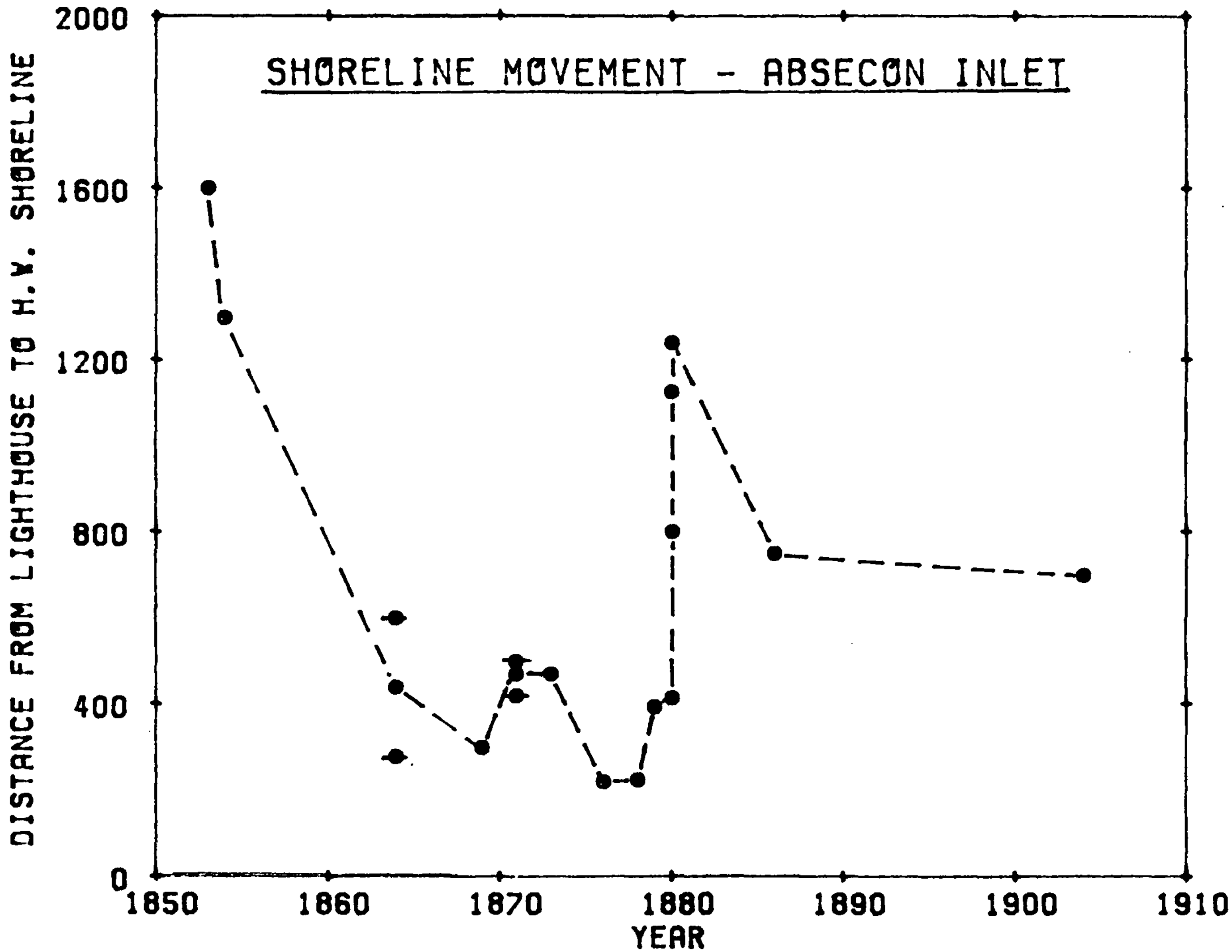

Figure 4 - Distance of highwater shoreline from Absecon Light House as a function of time (plotted from charts in Fitzgerald, 1981)

construction of the Oriental Avenue jetty) and illustrate a steady relative increase in beach profile stability from Absecon Inlet southward to the city limit.

Beach Nourishment Projects

There have been three major beach nourishment projects at Atlantic City. The earliest beach nourishment was done in 1948 when a total of 1,250,000 cu yd of sand were placed along the inlet and ocean shorelines. About 500,000 cu yd of the total were placed along the inlet shoreline and 750,000 cu yd were placed along the ocean shoreline northeast of Illinois Avenue (i.e. between the inlet and a point 6800 feet to the south). McCann (1981) briefly discusses the performance of this fill; most of the fill placed along the inlet shore is reported to have been lost very quickly. Total profile recessions of up to 150 feet occurred between 1948 and 1960.

The second beach fill was placed in 1963 following the March 1962 storm. It was undertaken as an emergency measure to restore Atlantic City's oceanfront beaches and to afford some protection against the occurrence of a similar storm. The 1963 fill involved placing 600,000 cu yd of sand along

3,800 feet of Atlantic City's oceanfront between the Oriental Avenue jetty and Virginia Avenue. The profiles in Appendix E-1 show where the sand was placed during the 1963 fill and the subsequent profile changes that occurred. At the Oriental Avuenue jetty (Profile 1) the MSL shoreline was extended seaward about 100 feet by the fill and the berm crest was built to an elevation of about +9 MSL (+11 MLW). After fill placement, the shoreline continued to move seaward, presumably because fill was moving northeastward into the sheltered area behind the Oriental Avenue jetty. In January 1970, about 7 years after the fill, the shoreline was still seaward of its post-fill location demonstrating the stabilizing effect of the Oriental Avuenue jetty on this reach of shoreline. However, the berm crest elevation had been reduced to an elevation of about +4 feet MSL. At Rhode Island Avenue (Profile 2) the shoreline and berm were extended about 330 feet seaward by the 1963 fill. Here the shoreline receded quickly following the fill so that within 9 months the shoreline receded 200 feet. The sand lost from this area presumably nourished beaches to the northeast near the Oriental Avenue jetty and the beaches southwest of Rhode Island Avenue. At Delaware Avenue the shoreline and berm were extended about 200 feet seaward. The shoreline here was relatively stable for several years following 1963; by 1970, however, the beach had receded to its pre-fill location. North Carolina Avenue was southwest of the filled area; however, Profile 4 shows the results of the fill's southwesterly movement. In the two years following placement of the fill the shoreline moved seaward as sand from the fill moved into the area. Subsequently, by 1970, the profile receded to about its pre-fill location. The performance of this fill, as well as the 1970 fill, is documented by Everts, et al. (1974).

In 1970, 830,000 cu yd of sand were placed along 4,800 feet of beach south of the Oriental Avenue jetty extending approximately to Illinois Avenue. The response of Atlantic City's beaches to the 1970 fill is shown on the profiles in Appendix E-2. The shoreline and berm at the Oriental Avenue jetty was extended seaward by about 160 feet. The berm crest elevation was initiallly at about +9 feet MSL but quickly lowered to about +5 MSL following the fill. About 6 months after placement, the shoreline had eroded about 100 feet and had retreated to its pre-fill location by April 1972. At Rhode Island Avenue the shoreline and berm were extended 250 feet seaward. The berm crest elevation was at about +10 MSL. Within about 4 months the shoreline had receded 200 feet and the berm crest elevation had been lowered by about 5 feet to +5 feet MSL. Between April 1971 and May 1984 the shoreline receded 100 feet to near its present location. At Delaware Avenue the shoreline was extended 150 feet seaward and the berm crest elevation raised to +9 MSL. Within 6 months the shoreline receded 100 feet and the berm about 130 feet with a resulting reduction of the subaerial beach slope. In May 1984 the beach was in essentially the same location as it was before the 1970 fill. At North Carolina Avenue the shoreline was initially widened by about 50 feet but subsequently eroded to its pre-fill location by April 1972.

Both the 1963 and 1970 fills responded quite similarly to Atlantic City's coastal environment. The sand placed along the northeasterly portions of the beach near the Oriental Avenue jetty served as a stockpile to nourish downdrift beaches by the normal southerly longshore transport. In general, volume loss rates were greatest immediately following placement of the fills and decreased thereafter. Initial losses were quite high in the northeasterly portion of the fill southwestward of the sheltered area adjacent to the Oriental Avenue jetty but decreased with time and distance southwestward from the jetty. Everts, et al. (1974) report that at the Oriental Avenue jetty the average sand loss rate is about 6.5 cu ft/ft during the time period it takes the above-MSL beach to erode to 10 percent of its initial volume. About 1,600 feet downcoast the average loss rate was 3.2 cu ft/ft and about 3,200 feet downcoast it was only 1.6 cu ft/ft. About

90 percent of the fill placed in the the segment south of the Oriental Avenue jetty was lost within 6 months after placement.

Coastal Structures

Coastal structures have been used along Atlantic City's beaches dating from about 1857-1876. The earliest structures appear to have been groins built to stabilize the shoreline in the vicinity of the Atlantic City (Absecon) lighthouse.

In 1935, the Works Progress Administration (WPA) built several sections of timber bulkhead between Caspian and Melrose Avenues and between Madison and Euclid Avenues to protect Atlantic City's shoreline adjacent to Absecon Inlet. The city, in 1946, 1950 and 1961 placed stone along the base of these bulkheads. In 1952 the city constructed 150 feet of bulkhead inside the inlet at the entrance to Clam Creek. Four timber groins, 110 to 165 feet long, were constructed by the city in 1930-32. The State of New Jersey and the city subsequently constructed four additional timber groins along the inlet shore. A stone end was added to the groin at Drexel Avenue in 1946 and to the groin at Adriatic Avenue in 1958. Between 1946 and 1954 the state and city constructed three stone groins, one timber & stone groin, and replaced two timber groins with stone. Between 1954 and 1958 the state and city undertook the addition of stone extensions to the groins presently along the inlet shore at Adriatic, Madison, Grammercy, Atlantic, Euclid and Pacific Avenues. These six groins comprise the present shore protection along the Absecon Inlet shoreline of Atlantic City. They stabilize the inlet channel in a position up against the Atlantic City side of the inlet owing to the channel's tendency to be driven southwestward by the dominant wave energy from the northeast.

The jetty on the southerly side of Absecon Inlet at Oriental Avenue in Atlantic City was built in 1946-48 to an initial length of 800 feet. In 1961-62 it was extended to its present length of 1177 feet. The initial crest elevation of this jetty was at about +7.0 feet MLW. By 1983 the jetty crest elevation varied from about +5.4 feet MLW to about +6.9 feet MLW. The state in 1983 rehabilitated the structure, raised its crest elevation and grouted the voids in the armor along the jetty crest. The jetty on the Brigantine side of the inlet was constructed by the Federal, State and Atlantic City governments to its present length of 3727 feet in 1952. (Its authorized length is 5749 feet.) The jetty's crest elevation is at +8.0 feet MLW.

Construction of groins along the ocean shoreline of Atlantic City dates back to 1914-16 when the city built four stone groins southwest of the Steel Pier. These groins were subsequently covered by sand accretion. In 1928 the state and city built a stone groin at Tennessee Avenue. Between 1930 and 1932 the state and city built four groins northeast of Tennessee Avenue. Of these four groins, three still remain: the one at Connecticut Avenue is in poor condition while the one at Vermont Avenue was rebuilt and extended in 1961 and again in 1983. It and remains in good condition. The one at Massachusetts Avenue was rehabilitated in 1983. Five timber and one stone groin were built south of Vermont Avenue in 1948-50 by the state and city. They remain in good condition (prior to 1984). The Illinois Avenue groin which was in poor condition was rehabilitated and extended in 1983. Between 1950 and 1961 at the time the Vermont Avenue groin was repaired and extended, five new timber groins were also constructed.

In 1983-84 the state and city undertook the improvement of four existing structures along Atlantic City's ocean coastline. The Oriental Avenue jetty (Figure

5a) was repaired and its crest elevation raised to +11.0 feet MLW to reduce wave overtopping and wind losses of sand. The dog-legged stone groin at Vermont Avenue (Figure 5b) was repaired and extended approximately 200 feet to a water depth of about -8.3 feet MLW and the crest elevation was raised to +7.0 feet MLW. In extending the groin, the new outer section was aligned in a more southwest-northeast orientation (more nearly shore-parallel) than the section to which it is connected; thus, in plan, the Vermont Avenue groin has a "C" shape. The stone groin at Massachusetts Avenue (Figure 5c) was repaired, its crest elevation raised to +7.0 feet MLW, and the voids in the armor on the structure crest grouted. In addition, the exisiting timber groin at Illinois Avenue was essentially replaced (Figure 5d) by building a new timber groin adjacent to the existing structure and adding a 270 foot-long stone extension. The new timber groin slopes from an elevation of +10 feet MLW at the boardwalk to an elevation of +9 feet MLW, 300 feet from the boardwalk, thence at a 1:30 slope to an elevation of +2 feet MLW. The stone extension then extends 270 feet seaward at an elevation of +2 feet MLW. The new groin terminates in a water depth of about -9 feet MLW.

Other structures along the Atlantic City shoreline have various levels of significance to the coastal

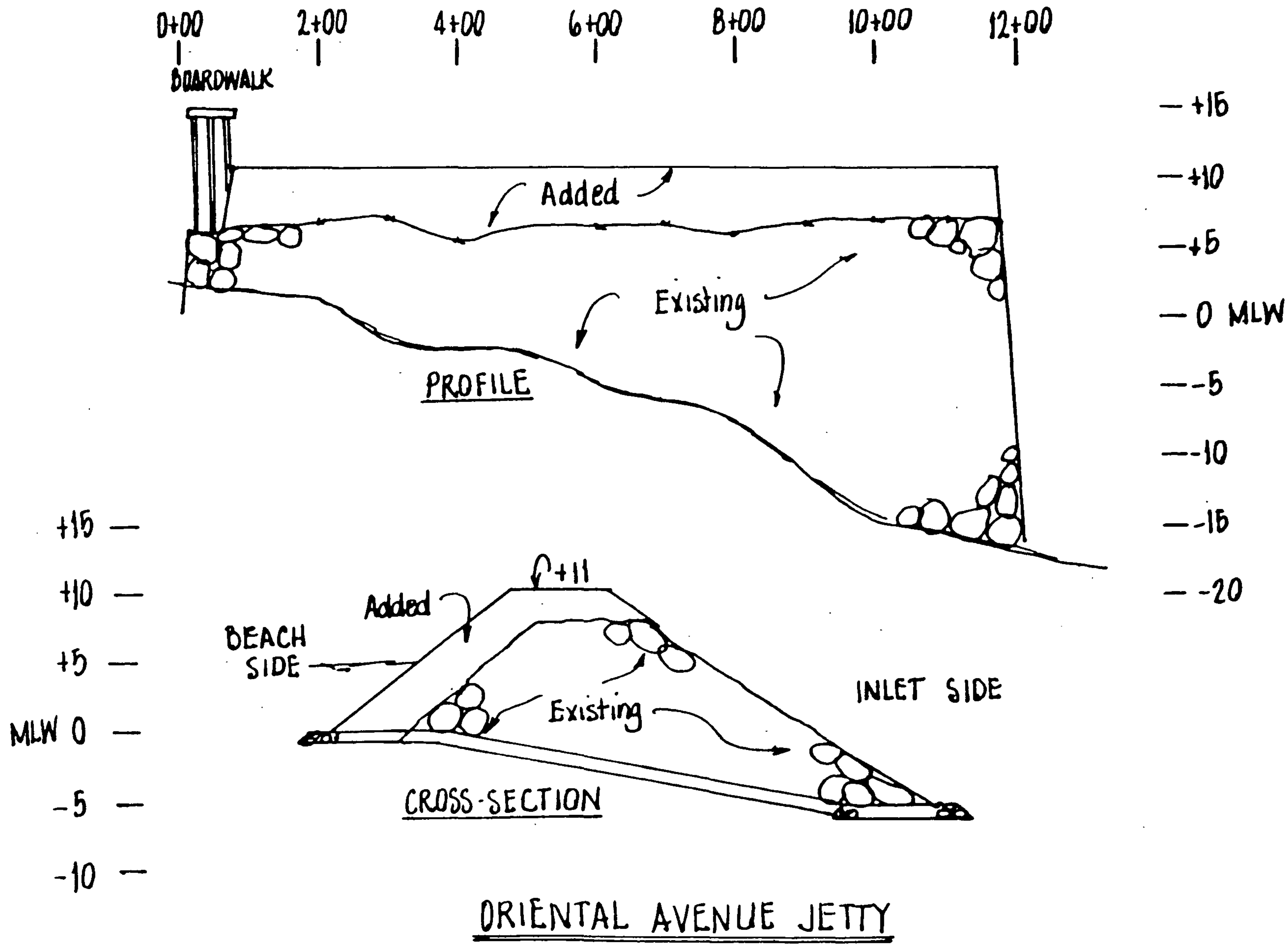

Figure 5A - Modifications to Oriental Avenue Jetty
(1983-84)

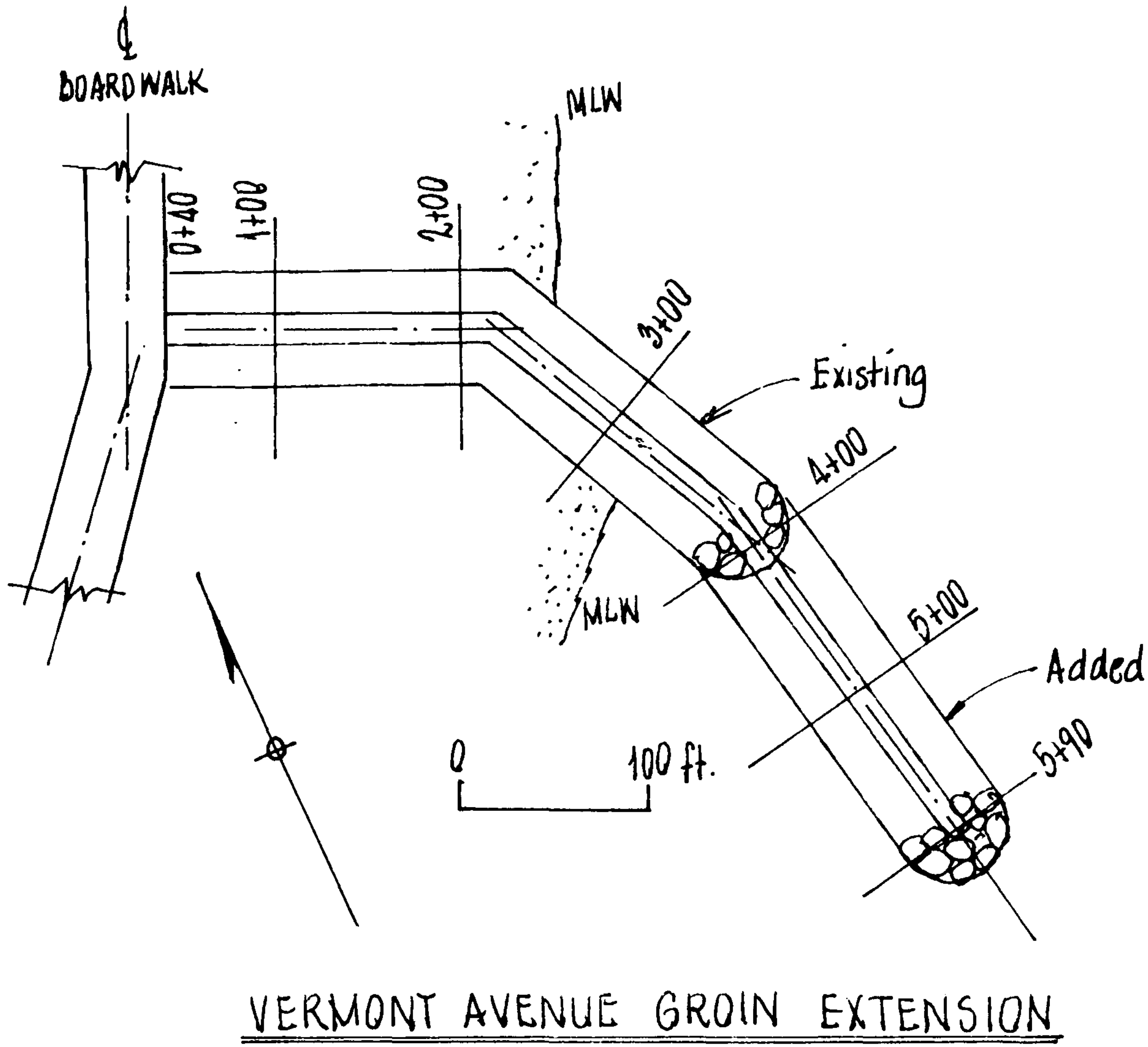

Figure 5B - Modifications to Vermont Avenue Groin (1983-84)

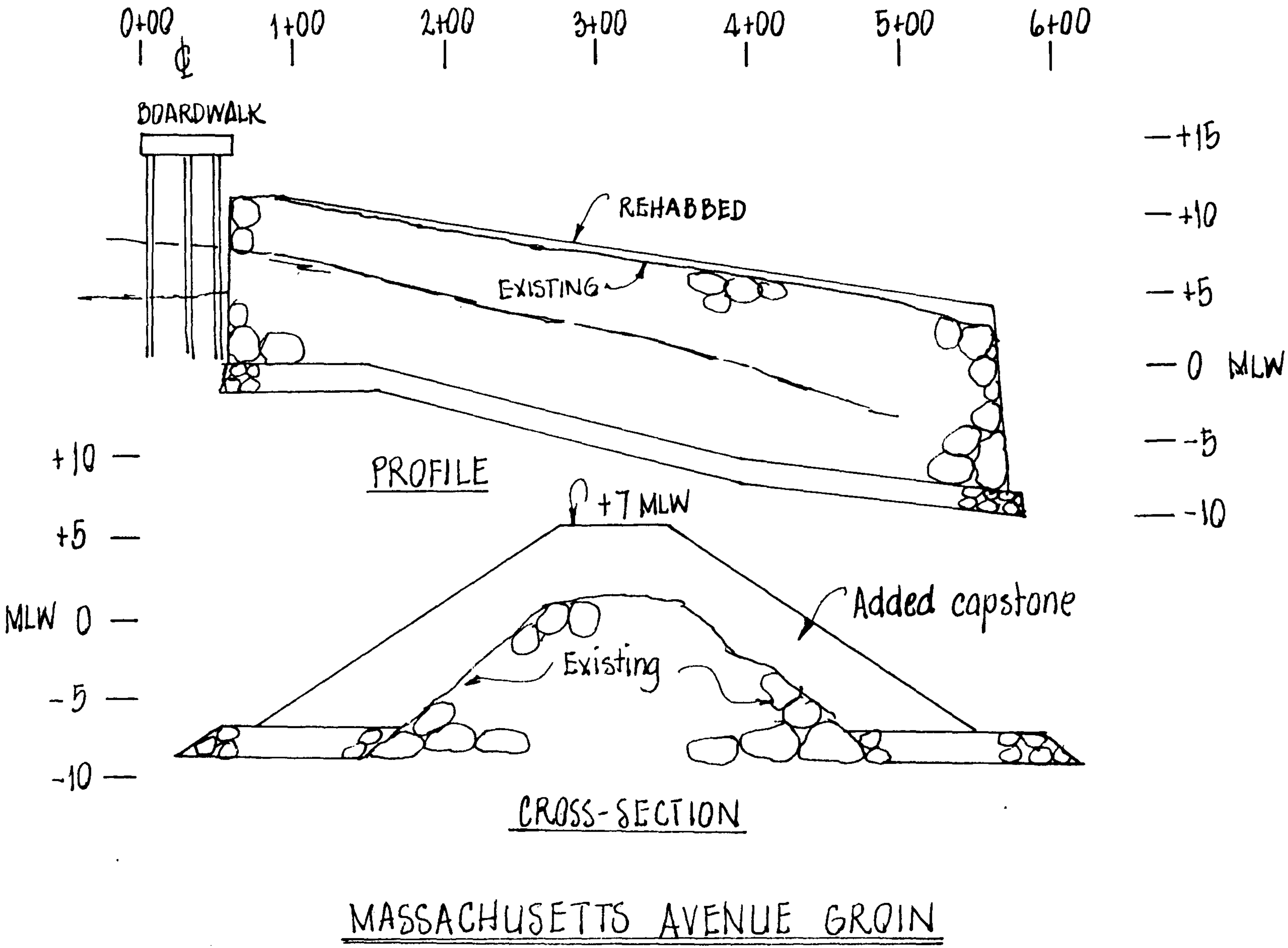

Figure 5C - Modifications to Massachusetts Avenue Groin (1983-84)

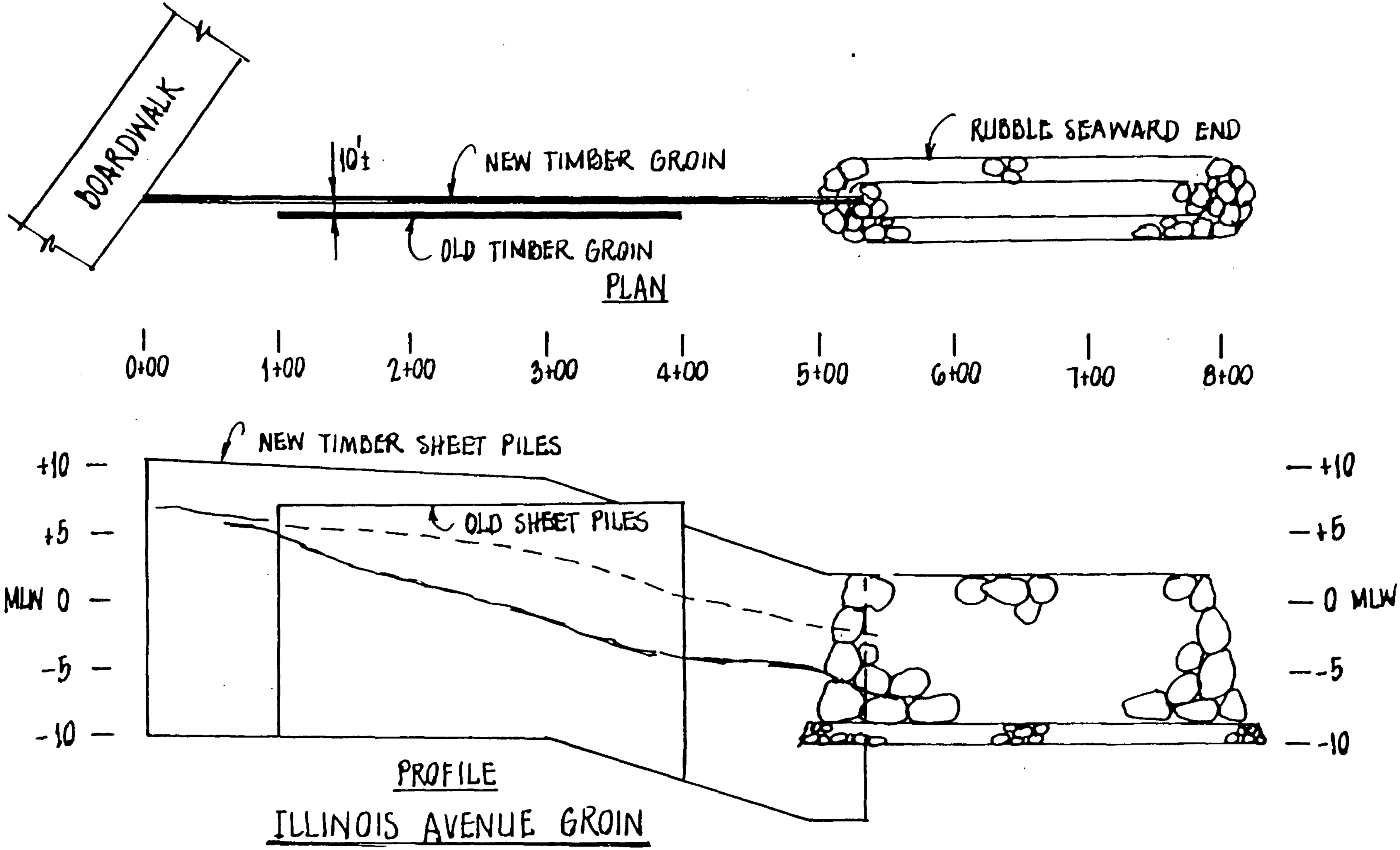

Figure 5D - Modifications to Illinois Avenue Groin
(1983-84)

processes that prevail there. There are numerous storm water outfalls that discharge water from Atlantic City's storm water collection system into the ocean. The effect of these structures on the nearshore sediment transport processes do not appear to be significant althought they do trap some small amount of sand where they intersect the beach. Once exposed, however, sand can usually move underneath them and their effect on longshore sand transport is negligible. There are also five pile supported piers which extend into the Atlantic Ocean from the boardwalk. Their effect on nearshore sediment transport depends on the pile density of their substructure. Piers with many piles per unit of beach area can function like a groin or as an offshore breakwater. A tombolo-shaped shoreline bulge develops at (or just downdrift of) the pier and varies in size and shoreline position as the wave climate varies. At some piers there are timber or stone groins associated with the piers so that the pier's effect on the beach is masked by the effect of the adjacent groin.

III AVAILABLE SITE INFORMATION

A variety of useful field data and other information are available for the Atlantic City - Absecon Inlet area. Of particular value to this study are published analyses of sediment samples; periodic aerial photographs; repetitive beach profiles and nearshore soundings in the inlet area; and environmental data on waves, tides, storm surge and sea level variations. General reports of value include the study of Atlantic City beach changes by McCann (1981) and the interim report on costal inlets and beaches from Barnegat Inlet to Longport, NJ published by the U.S. Army Corps of Engineers (1974).

Sediment Samples and Analyses

McMaster (1954) and Ramsey and Galvin (1977) collected and analyzed sediment samples from the beach foreshore in the study area. Three upper foreshore samples taken by McMaster along the Atlantic City beach in the study area varied in median diameter from 0.204 mm down to 0.164 mm (by sieving) with a decreasing size trend from north to south. Ramsey and Galvin (settling tube analysis) also found a decreasing median diameter trend from north to south but a coarser range of upper foreshore median diameters of around 0.23 to 0.27 mm. Lower foreshore median diameters were coarser yet, typically between 0.27 and 0.31 mm. There also was a small seasonal variation with the finest median diameters prevailing through the summer to October and the coarsest diameters through the winter.

Galvin and Ramsey explain their higher median diameter values as being due to McMaster having collected his samples only in June and August when surf activity is less (and beaches finer). Month to month variations in the CERC size data are of the same order of magnitude as the maximum differences between their data and McMaster's data.

Vibracore samples and high resolution seismic data were collected by the Coastal Engineering Research Center (Meisburger and Williams, 1982) to evauate potential borrow areas on the inner shelf off the central New Jersey coast. Included in the study is an area located 2 to 6 miles off Brigantine Island. Size analyses for samples from each core are given.

Aerial Photographs

Standard 9 in by 9 in, black and white, vertical, overlapping aerial photographs of the study area have been taken periodically since 1962. Not all of these photographs were available in the NJDEP Bureau of Coastal Engineering, Toms River, NJ. Those that were available were borrowed for analysis. They include:

Date	Coverage
October 31, 1963	4 photos, most of study area.
May 4, 1966	7 photos, entire study area.
January 9, 1967	5 photos, entire study area.
September 2, 1967	4 photos, Absecon Inlet entrance and entire beach in study area.
October 23, 1969	5 photos, entire study area.
May 7, 1970	1 photo, Absecon Inlet.
February 28, 1971	6 photos, entire study area.
March 20, 1978	part of Absecon Inlet entrance and part of beach area.
March 23, 1982	most of beach area.

Thus, photo coverage of the entire study area was available for January, February, May, September and October to give some indication of seasonal shoreline changes.

Beach Profiles and Nearshore Soundings

From 1962 to 1973 the Army Corps of Engineers conducted periodic beach surveys at seven profile lines in the study area. The surveys were made using standard level and rod procedures and the profiles were carried as far seaward as the rod person could wade. The locations of the Corps profile lines (hereinafter called the CERC BEP profiles) are shown in Figure 6 and documented in detail in McCann (1981). Beginning on November 24, 1962 and continuing to April 18, 1973, one hundred and ninteen profile surveys were conducted at each profile line. Thus the surveys were conducted on the average of once per month, with survey frequencey being greater than monthly during the winter and less than monthly during the summer (see McCann, 1981).

In addition, profile data were available from the NJDEP Bureau of Coastal Engineering and the Philadelphia District of the Corps of Engineers. These included several beach profiles adjacent to various shore structures in the study area in December 1983 (NJDEP), and Absecon Inlet soundings at different locations in January and June 1984.

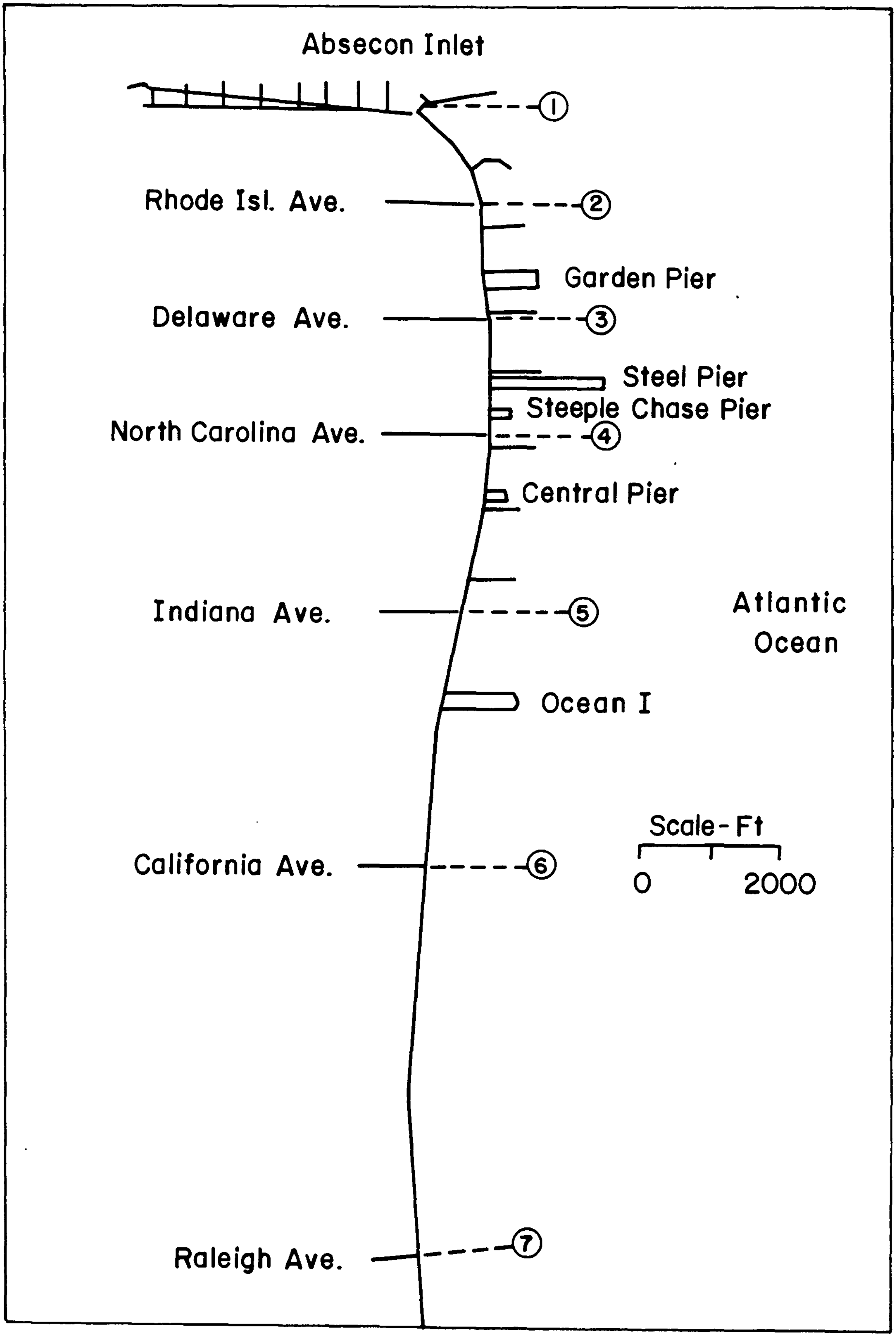

Figure 6 - Location of seven CERC BEP profile lines

Wave, Tide, Surge and Sea Level Data

A variety of wave, tide, storm surge frequency and sea level history data are available for the study area. These data and their sources are summarized in McCann (1981). An additional source of wave information postdating McCann is the Waterways Experiment Station's tabulation of twenty years of wave hindcast data for 166 Atlantic Coast stations including Atlantic City (Jensen, 1983).

IV PROJECT DATA

To supplement previously available site data, additional field data were collected during 1984. This data falls into three categories: sediment samples, beach profiles, and air and ground photographs and visual observations.

Sediment Samples

On March 12, 1984 seven surface samples were collected with a 1-1/2 inch diameter coring tube. The locations of the first four samples, which were taken in the inlet at wading depths, are shown as numbers 1 to 4 in Figure 7. The remaining three samples were collected on the beach face at CERC BEP profile lines 3, 5 and 6 (samples 5 to 7).

Eleven more samples were collected in Absecon Inlet on November 17, 1984. They were taken from a boat with a grab sampler and their locations are also shown in Figure 7 (samples 8 to 18). The boat sample stations were located by triangulation using two transit triangulation stations on the Oriental Avenue jetty.

The eighteen samples were analyzed for size distribution by settling tube. Results of the analyses are tabulated in Appendix A.

Beach Profiles

The periodic surveys conducted by the Corps of Engineers at the seven CERC BEP profile lines were discontinued in 1973. In 1975-76 the Corps of Engineers installed bronze disk stations at each profile line so they could be reoccupied. As part of this project, beach profiles were measured out to low-tide wading depth at the seven CERC BEP profile lines plus at an eighth profile line added between CERC BEP profiles 5 and 6. This added profile line, 5A, is in front of Bally's Parkplace Casino (using

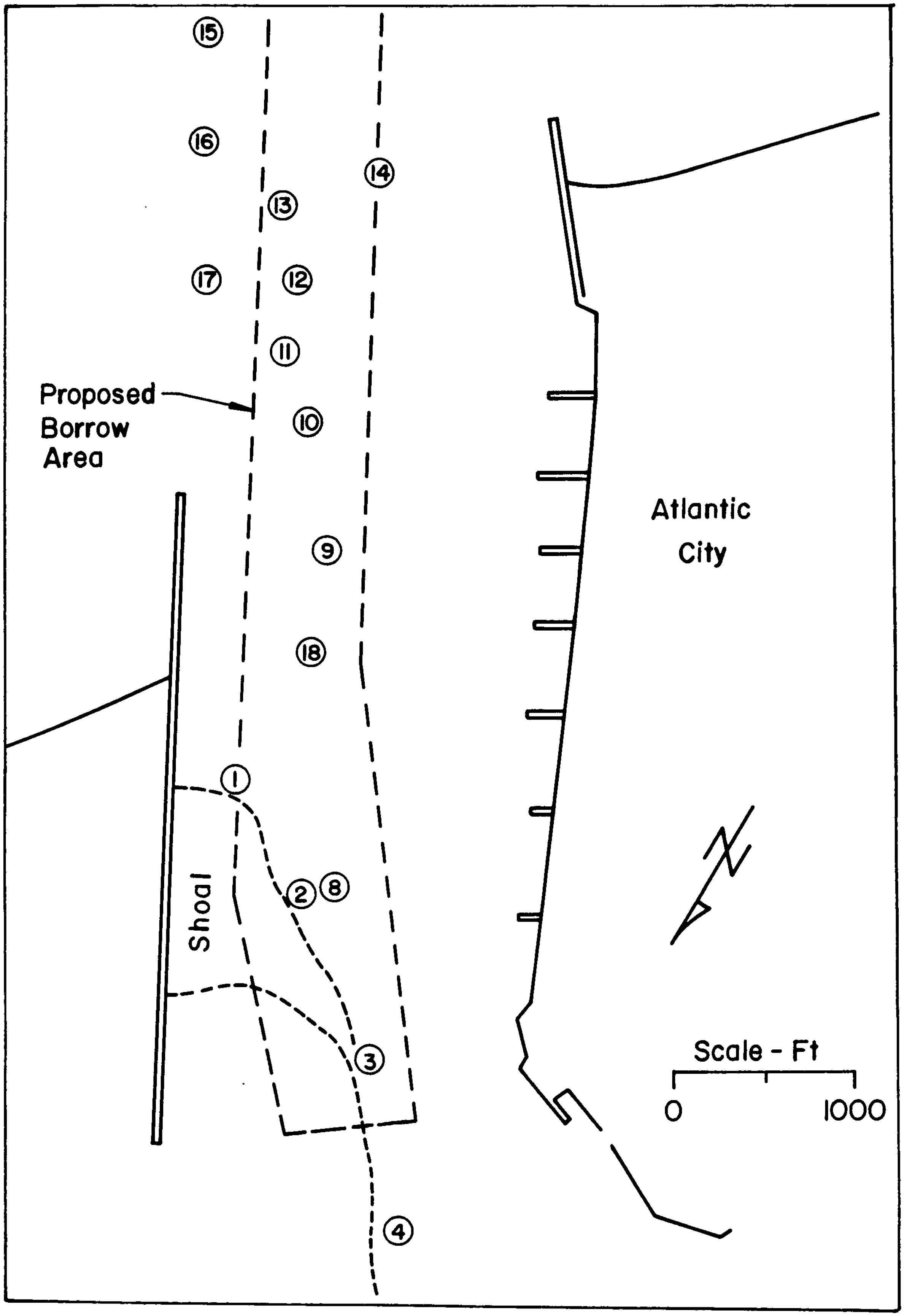

Figure 7 - Absecon Inlet bottom sample locations

the boardwalk fire hydrant 65 paces northeast of Michigan Avenue as a monument). The eight profile lines were surveyed on March 12, May 29 and September 15, 1984. Appendix B presents a tabulation of this data. Plots of the profiles are presented in Appendix C.

Photographs and Field Observations

During the trips to the site to collect sediment samples and beach profile data, photographs were taken and visual observations were made to document shoreline nodal conditions and beach conditions at shore structures. In addition, periodic visits were made just to document shoreline and structure conditions. One of the latter visits was by air to obtain low level aerial photographs of the Atlantic City shoreline. A list of these field efforts follows:

January 27-28, 1984 - Tour site, photograph structures, observe shoreline conditions.

March 12-13, 1984 - Beach and inlet sediment samples, beach profiles, shore observations.

March 28, 1984 - Post storm observation of structural damage, shore conditions.

May 29-30, 1984 - Beach profiles, shore observations.

September 15-16, 1984 - Beach profiles, shore observations.

September 21, 1984 - Flight at low altitude to photograph entire study area.

November 17, 1984 - Inlet sediment samples from boat.

December 21, 1984 - Tour site, photograph structures, observe shoreline conditions.

V. DATA EVALUATION

Borrow Area

Sand Size - The beach face sand samples taken at CERC BEP profile lines 3, 5 and 6 had median diameters of 0.255 mm, 0.282 mm and 0.196 mm respectively. These median diameters fall within the general range of values found by Ramsey and

Galvin (1977) (settling tube analysis) and are coarser than the general range of values found by McMaster (1954) (sieving analysis). The fifteen samples taken from the inlet were generally finer than the beach face samples, having a range of median diameters of 0.140 mm to 0.231 mm with an average median diameter of 0.171 mm.

No strong spatial trend is sizes was observed for the inlet samples, although generally the finer median diameters were in the inner channel section (samples 1, 2, 3, 4, 8, 9 and 18) and on the bar seaward of the Brigantine Jetty (samples 15, 16 and 17). The samples collected in the proposed borrow area (see Figure 7) along the east shoulder of the channel (samples 10, 11, 12 and 13) were the coarsest of all the inlet samples (but finer than the beach face samples).

Consequently, considering sand sizes, there is no apparent need to dredge borrow material from some other inlet location outside the proposed borrow area. Within the borrow area, again considering only sand sizes, the section of the proposed borrow area seaward of the outer end of Brigantine jetty provides the coarsest sand.

Since the inlet sand sizes are finer than the beach face sizes the overfill factor (see U.S. Army Coastal Engineering Research Center, 1984, p 5-10) will be larger than unity (more than one cubic yard of borrow material will be needed to provide one cubic yard of beach fill having the native size characteristics). Owing to the range and variability of both inlet and beach face sample size characteristics (caused, no doubt, somewhat by sampling and analysis techniques) it is not considered worthwhile to attempt calculation of an overfill factor.

No exhaustive search of other potential borrow areas could be made. However, it does not appear that any sources of fill coarser than the sand in Absecon Inlet would be found close to the fill location. The offshore surveys conducted by the Coastal Engineering Research Center indentified two borrow areas (H and J in Table 3 of Meisburger and Williams, 1982) which have sufficient volumes of sand and are somewhat coarser than the borrow and native materials in the study area. The median diameters in these offshore borrow areas ranged from 0.20 to 0.49 mm. Their water depths vary from 30 to 50 feet and their distance from Atlantic City ranges from 3.5 to 6 nautical miles. Considering these factors, it is unlikely that the offshore sources would be more economical than the proposed borrow area in Absecon Inlet.

Brigantine Jetty - The predominant wave direction at Brigantine and Atlantic City is from north of east resulting in a net longshore sediment transport at the inlet to the south-southwest. Dominant storm waves also come from the northeast. The net south-southwest wave driven sediment transport interacts with the ebb tidal flow from the inlet: 1) to develop the shoal situated seaward of the Brigantine jetty, 2) to move the interior inlet channel section up against the Atlantic City side of the channel, and 3) to cause the channel section seaward of the Oriental Avenue jetty to migrate southwestward. The seaward channel section will often go through a 10-20 year cycle by migrating to the southwest, then having a new channel break through the bar in line with the jetties, which starts the migration anew (see dicussion in Section II).

The sand for beach nourishment will probably all be taken from area B and the seaward end of area A of the proposed borrow area (see Figure 8 and Section VI). If so, the impact on the Brigantine jetty and shoreline will be negligible. The outer end of the existing natural channel lies a short distance southwest of the borrow area B. Depths in area B presently vary between -15 ft MLW and -25 ft MLW so a dredged borrow section will result in a 600 ft wide trench varying in depth from 0 to 10 ft. A new channel may form through the trench and start to migrate southward to combine with the existing channel which will then continue its migratory cycle. Or, the trench will slowly fill with wave and current driven sand, In either case, the

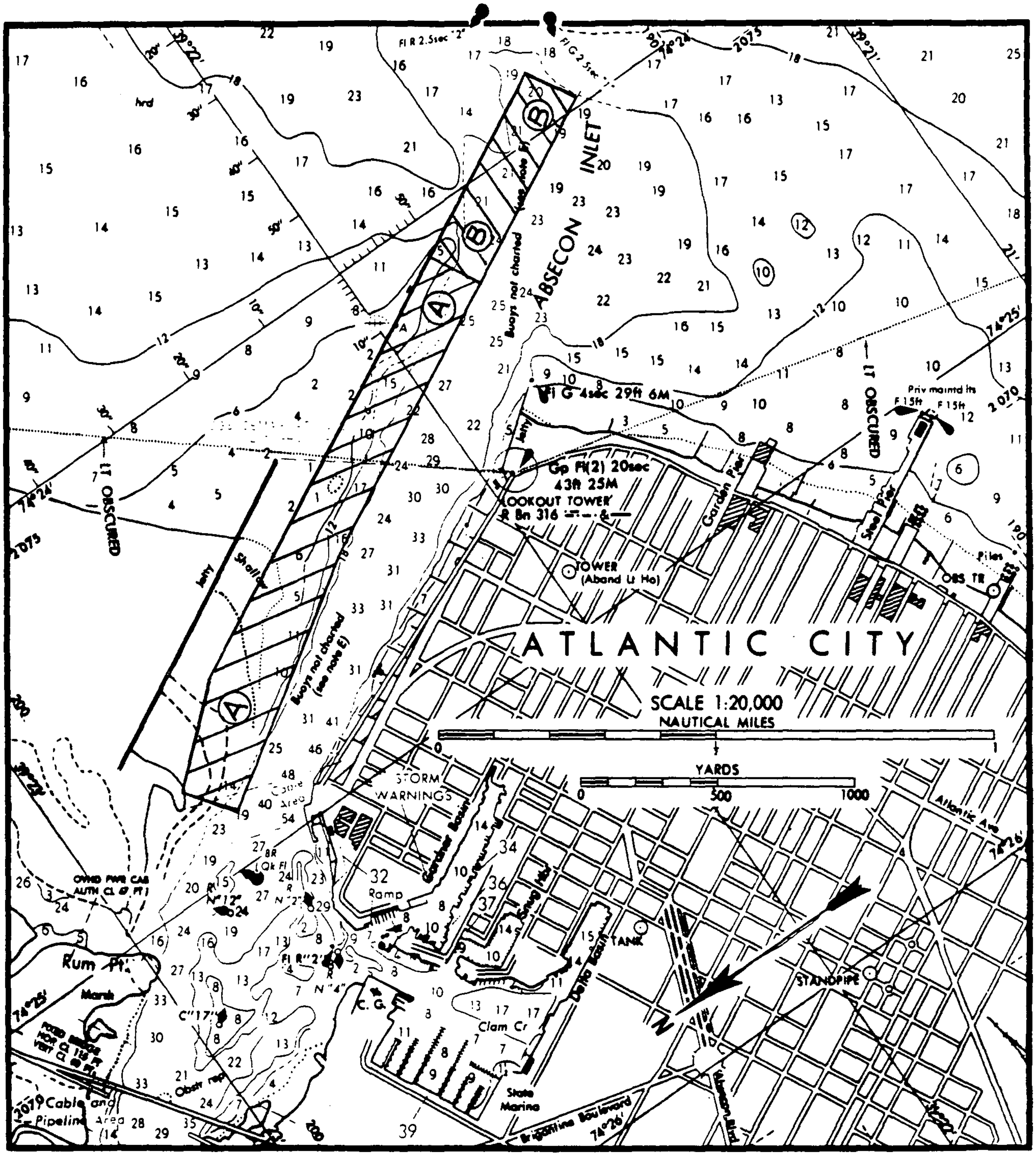

Figure 8 - Proposed borrow area

trench (while it exists) will have little effect on waves that travel over it and reach the Brigantine jetty and shoreline.

If the sand for beach nourishment is all taken from proposed borrow area A, the net effect on the inlet channel will be to increase its cross-sectional area beyond the normal hydraulically stable cross-sectional area for the inlet-bay system. Consequently, sand will deposit in the channel to reduce the cross-sectional area back to its predredged stable condition. As discussed above, the resulting channel will continue to be situated up against the Atlantic City side of the inlet. The sand that deposits in the channel will be carried in by flood tidal flow from offshore where it is supplied by the longshore transport system.

Any dredging done in borrow area A will be done at least 400 ft from the Brigantine jetty leaving a sufficient buffer of sand with a surface elevation near or above MLW. The most destructive waves from the northeast will be unaffected by the dredging as far as the Brigantine jetty and shoreline are concerned. The 400 ft wide buffer area will be sufficient to protect the jetty and no increased flooding should occur owing to waves that enter the channel along its axis from the southeast.

Placement of Beach Fill

Nodal Zone - During most of the site visits by the authors and from several of the more complete sets of available aerial photographs, a distinct diverging nodal zone for longshore transport could be indentified. This zone was defined primarily from the shoreline offset at successive groins and at some of the piers. Wave and dye transport pattern observations give only an indication of the instantaneous local transport pattern whereas groin offsets integrate the effects of conditions prevailing over some time period preceding the observations. A tabulation of observed nodal zone locations follows:

Date	Nodal Zone Location
May 4, 1966	Garden Pier
Jan 9, 1967	Garden Pier-Steel Pier
Oct 23, 1969	Garden Pier-Steel Pier
Mar 23, 1983	Garden Pier
Jan 27, 1984	Garden Pier-Steel Pier
Mar 12, 1984	Steel Pier
Mar 29, 1984	Garden Pier
Sep 15, 1984	Garden Pier
Dec 21, 1984	Garden Pier

Thus, the nodal zone was generally located at Garden Pier (between Massachusetts Avenue and Delaware Avenue) during the spring to fall months, but shifted southward to Steel Pier at times during the winter to early spring months (see Figure 6). During all observations, offsets indicated transport to the south at North Carolina Avenue and to the north at Massachusetts Avenue.

Contemporary Berm Widths - Beach profiles measured by NJDEP in December 1983 and by the authors in March 1984 were analyzed to determine the berm width seaward of the boardwalk at points along the boardwalk in the study area. Results are tabulated in Appendix D. These profile data from December and March indicate beach conditions that would exist prior to summer and early fall when natural beach building occurs.

The berm width progressively decreases to less than 100 feet as one moves in a southwesterly direction from the Oriental Avenue jetty to about Station 5+00. The berm crest is under the boardwalk for the next 1300 feet and is less than 100 feet wide beyond Station 30+85 which is between Garden Pier and Steel Pier. There is a bulge at Steel Pier and Steeple Chase Pier, then the berm width again decreases up to the smaller bulge at Central Pier. The berm is then less than 100 feet wide down to the vicinity of the recently extended groin at Illinois Avenue. Downdrift of the groin the berm is less than 100 feet wide as far as Station 112+24 except for the bulge at Ocean I where the berm width reaches 300 feet. Thus, between Stations 0+00 and 115+00 there is about 7,700 feet of beach with a berm width of about 150 feet or less. The berm width exceeds 150 feet only updrift of the longer Oriental Avenue jetty and the Illinois Avenue groin, and near the larger piers. The piers, particularly Ocean I, act as permeable groins, trapping a bulge of sand at or just downdrift of the pier and forming a narrowing fillet in the updrift direction (see Miller et al., 1983, for an interesting discussion of the impact on adjacent shorelines of a pier with a very low pile density).

Historic Beach Profiles - A comparison of selected beach profiles from the 1962-1973 CERC BEP profile series and the 1984 profiles collected by the authors gives some indication of the behavior of the 1963 and 1970 beach fill projects (also see Section II). CERC BEP Profiles 1-3 are in the 1963 fill area and Profiles 1-4 are in the 1970 fill area. To evaluate the two fills, Profiles 1-4 are plotted for the time just prior to fill placement, just after placement, one year later, two years later, and about a decade later. Specifically, Appendix E-1 shows the four sets of profiles for February 1963, March 1963, January 1964, January 1965, and January 1970. Appendix E-2 shows the four sets of profiles for May 1970, August 1970, April 1971, April 1972, and May 1984.

The profiles only extend to wading depths and thus only give a limited picture of the behavior of the two fills. However, from the profiles some key response characteristics can be seen and the response of both fills was about the same.

At Profile 1, adjacent to the Oriental Avuenue jetty, fill raised the berm two to three feet above the jetty crest elevation (+7 feet MLW). By the following spring the berm crest elevation was lowered to its prefill elevation. It is likely that much of this material was transported over the jetty into the channel by wind.

Profiles 2 and 3 are at locations where the present berm widths extend less than 50 feet seaward from the boardwalk. The fill extended the berm width to about 300 feet, but most of the fill was lost by the end of the following winter. This was followed by a slow recession of the profile back to about the prefill condition during the following several years.

Profile 4, which was outside the 1963 fill area and at the edge of the 1970 fill area, is downdrift of the nodal zone. Profile 3 is in the nodal zone and profile 2 is downdrift on the other side. While rapid early erosion occurred at Profile 2, Profile 4 was generally stable after 1963 and showed slower erosion (than Profile 2) after 1970. (McCann, 1981, shows similar behavior for Profiles 5, 6 and

7 after the 1963 fill and for the shorter observation period after the 1970 fill). This behavior is ascribed to the net southerly drift at Atlantic City (see Everts, et al., 1974). Much of the fill placed in 1963 and 1970 was lost offshore and over the jetty, but a significant portion of the fill was tranported to the southwest to nourish beaches outside the fill area.

Natural Beach Profile - The median sand grain diameter for the beach face (from this study and from Ramsey and Galvin, 1977) varies from about 0.2 mm to 0.3 mm. Using a typical value of 0.25 mm, Figure 4-35 of the Shore Protection Manual (U.S. Army Coastal Engineering Research Center, 1984) yields a foreshore slope of 1:20 for New Jersey-North Carolina beaches. Profiles measured during 1984 in the study area (except for steeply eroded Profile 2) had foreshore slopes between 1:20 and 1:30. Some of the profiles measured by NJDEP in December 1983 reached to -10 feet MLW and had slopes between 1:30 and 1:50 seaward of MLW.

The NJDEP profiles and the authors' profiles in the project area show a natural berm elevation that varies between +8 feet and +11 feet MLW. The natural berm crest elevation is approximately equal to the average wave runup elevation during high tides. It is the appropriate elevation for the berm in a filled section.

Fill Volume - Assuming a berm elevation of +10 feet MLW and a beach foreshore slope of 1:30, the volume of fill required for a given extension of the berm can be calculated. Using the berm widths given in Appendix D as the given unnourished beach conditions, required fill volumes were calculated for a 100 ft, 150 ft, 200 ft and 300 ft berm. Typically, the exisiting beach profiles intercepted the 1:30 fill profile at around -15 MLW so, for ease of calculation, the fill required per foot of beach was taken as 25 ft x berm extension. No overfill factor was used. Results obtained were:

Berm Width from Boardwalk (feet)	Fill Volume Required (cubic yards)
100	408,200
150	733,500
200	1,069,200
300	2,803,800

Thus, to achieve a 200 ft berm over the entire study area requires about one million cubic yards of sand; whereas, to achieve a 300 ft berm width to Ocean I and then taper to 200 ft (see Section VI) requires nearly three times as much sand. Considering the behavior of the 1963 and 1970 fills where rapid erosion occurred during the first year, it seems wise to only fill to a berm width of about 150 to 200 feet. Also, considering the net drift to the southwest and the increased cost (increased sand volume and increased pumping distance) to fill beyond Ocean I, it seems wise to only fill to Ocean I (i.e. to Station 82 rather than to Station 117).

Structures

The structural modifications made in 1983-84 should result in some local changes in the general shoreline orientation and in the behavior of the proposed fill when compared with the behavior of past fills. The structural modifications, in general, should help retain the fill on the project beaches for a longer time.

Raising the crest elevation of the Oriental Avenue jetty from about +7 ft. MLW to +11 ft. MLW will reduce the amount of wind blown sand carried across its crest into Absecon Inlet. CERC BEP Profile 1 surveys taken after both the 1963 and 1970 fills show that the berm crest elevation near the jetty is quickly reduced from its post-fill elevation of about +11 feet to the then jetty crest elevation of +7 feet MLW (approximately +5 feet MSL). The berm crest elevation was subsequently stable at near the jetty crest elevation. Also, the northerly side (channel side) of the jetty is exposed to waves from the northeast and was frequently overtopped when its crest was at only +7 feet MLW. Overtopping often resulted in the formation of a channel parallel to the jetty along its southwesterly (beach) side. This channel carries the overtopping return flow with entrained sand back to the ocean. Periodic overtopping thus contributed to local beach erosion. The higher crest elevation of the jetty will reduce the frequency of such overtopping.

Extension of the dog-leg shaped groin at Vermont Avenue should have an overall beneficial effect on the shoreline between it and the rehabilitated groin to its southwest at Massachusetts Avenue. As shown by the profiles at Rhode Island Avenue (CERC BEP Profile 2), the beach berm in this area is behind the boardwalk. The groin extension should result in an equilibrium shoreline which is located farther seaward than the present shoreline. Coupled with the proposed beach fill, these structural modifications will result in a wider beach berm in this area and a longer retention time for the fill placed here. In this area, north of the nodal zone at Garden Pier, transport is often northward and the extended Vermont Avenue groin will hold more sand in a fillet against its southwesterly side.

Similarly, the rehabilitated groin at Massachusetts Avenue should act to retain more sand in a fillet southwestward of it.

The extensive reconstruction and extension of the groin at Illinois Avenue will probably result in widening the updrift beach northeast of it; in fact, some widening of this beach appears to have started. Unless beach fill is placed on the beach between the reconstructed Illinois Avenue groin and the Ocean I Pier, sediment trapping and the redistribution of sand in response to the groin extension could have a detrimental effect on the beaches between the groin and the Ocean I Pier. Presently, however, the Ocean I Pier functions much like a groin to stabilize the beach updrift of it and thus maintains an equilibrium for the beach between the Illinois Avenue groin and the pier.

Generally, the structural modifications to the Oriental Avenue jetty and the groins at Vermont and Massachusetts Avenues, coupled with the proposed beach fill, should be beneficial to the Atlantic City shoreline. The groin extension at Illinois Avenue, however, seems to contribute little additional benefits since the beaches updrift of the groin are already fairly wide and the downdrift beaches are narrow. Thus, the additional sand trapped by the groin is held where it is not needed and kept from the downdrift beaches.

Future Work

The results of past data collection efforts at Atlantic City have been extremely useful in estimating the probable behavior of the proposed beach fill. The beach profile data collection program conducted by the Coastal Engineering Research Center has provided a historical record of beach changes following both the 1963 and 1970 beach fills. The design of future fills and other coastal projects at Atlantic City would benefit from a continuing beach profile measurement program. Initially, work should be aimed at monitoring the perfomance of the currently proposed fill. Specifically, the seven BEP profiles established by CERC in Atlantic City should be surveyed on a regular basis. The seven CERC profiles should be supplemented by at least 5 additional profiles. Profile 5A, established under the present study, additional profiles between CERC BEP Profiles 1 & 2 and 2 & 3, and two south of the Ocean I Pier should be added to the measurement program. To evaluate the perfomance of the beach fill, the twelve profiles should be surveyed before the fill, immediately following the fill, and at approximately one-month intervals thereafter for a period of at least two years. The State should obtain long profiles extending seaward to a depth of about 30 feet just before and just after placement of the fill.

A sand sampling program should also be instituted. Samples should be taken from the dredge discharge line at the time of the fill and their size distributions compared with the size distributions of the native beach sand. Sand samples should then be taken regularly along and downdrift of the nourished beach to monitor the downdrift movement of the fill and the winnowing out of fines in the fill material. Contemporaneously, a wave and current observation program along the lines of the Corps' Littoral Environmental Observation (LEO) Program should be instituted. Data obtained under the LEO Program routinely includes breaker height, period, direction; current speed and direction; wind speed and direction; and other beach characteristics such as foreshore slope and the presence of cusps, rip currents, etc. Two LEO stations should be established: one at the north end of the island near the middle of the fill project and one south of the influence of the Ocean I Pier. The total monitoring program should be conducted for at least two years following placement of the fill.

A beach fill monitoring program is especially important at this time because jetty and groin modifications recently made by the State should result in a different shoreline orientation in the vicinity of the modified structures and might improve the structures' ability to retain fill on the nourished beaches. The recommended project monitoring program will quantify any differences.

VI RECOMMENDATIONS

This section summarizes specific recommendations concerning the location and volume of beach fill, the borrow area and impact of borrow material removal and exisiting shore stabilization structures. To put these recommendations in perspective, the 1981 New Jersey Shore Protection Master Plan recommendations for Atlantic City are first summarized. Then the requests in the NJDEP permit applications pertaining to the proposed fill are given.

Shore Protection Master Plan

In addition to the shore protection work completed with 1977 Beach and Harbor Bond Issue funding, a master plan for New Jersey shore protection and recreational development was prepared by the consulting firm of Dames and Moore (1981). The New Jersey shoreline was subdivided into fifteen reaches including No. 9, Absecon Island, for evaluation and recommendation of specific coastal works. For Absecon Island, the following alternate plans were developed:

(1) Storm Erosion Protection

- 75 ft berm in groin field at northern end of island, 100 ft berm elsewhere.
- beach nourishment at 3-year intervals.
- maintenance of exisiting functional structures.

(2) Recreational Development

- initial fill to 400 ft recreational berm width in Atlantic City; tapered to 150 ft at Jackson Street; 150 ft elsewhere.
- beach nourishment at 3-year intervals.
- maintenance of exisiting functional structures.

(3) Combination Storm Erosion Protection and Recreational Development

- same as (2) above.

(4) Limited Recreation

- beach fill to 100 ft berm width at Longport.
- beach nourishment at 3-year intervals.
- maintenance of existing functional structures.

(5) Maintenance

- maintenance of existing functional structures.
- post storm berm repair.

The Recreational Development alternative having a benefit/cost ratio of 1.45 and an estimated total present worth (1981) cost of $ 29.4 million was recommended. Every three years 975,000 cu. yd. of beach fill would be added. Seven existing groins and some bulkheading would be repaired and regularly maintained.

Permit Applications

In the spring of 1984 the NJDEP Bureau of Coastal Engineering issued a permit application requesting permission to hydraulically dredge approximately 2.6 million cu. yd. of sand from Absecon Inlet and place it on the beach between Oriental and Morris Avenues in Atlantic City. The fill would create a berm that is 300 ft wide (measured seaward from the boardwalk) from Oriental Avenue to Arkansas Avenue (Ocean I), tapers to 200 ft wide at Florida Avenue, and continues at 200 ft in width to Morris Avenue. The berm elevation would be at +10 ft MLW and the beachface slope would be 1:30. Sand would be dredged from the 7,200 ft-long borrow area shown in Figure 8 (Area A) to a maximum depth of -25 ft MLW. The borrow area would extend no closer than 400 ft to the Brigantine Jetty.

In the fall of 1984, a requested permit modification extended the proposed borrow area 2,300 ft seaward (see Figure 8). Sand will most likely be taken from the outer half of the entire proposed 9,500 ft-long borrow area (personal communication, B. Moore, NJDEP Bureau of Coastal Engineering).

Project Recommendations

Based upon the material presented in previous sections, particularly Section V - Data Evaluation, specific conclusions and recommendation are presented here. They address the specific objectives listed in Section I - Introduction.

1. The proposed borrow area in Absecon Inlet (Figure 8) is the preferred area for obtaining beach fill material.

Positive factors include its proximity to the fill area, the lack of any other superior borrow area located within an economically acceptable distance of the fill area, and that sand removal from the borrow area should not have any adverse impact on adjacent structures and shorelines. Dredging of the proposed volume of fill material from any location within the proposed borrow area should not endanger the Brigantine jetty nor cause increased flooding of shorelines near the jetty. The expanded inlet channel (resulting from borrow material removal) should quickly fill back to pre-borrow conditions, causing no long term effect on channel migration and no negative impact on Atlantic City beaches.

2. Although, based on a benefit/cost analysis, the Shore Protection Master Plan recommends filling Atlantic City's beaches to a 400 ft berm width, the initial rapid erosion of the 1963 and 1970 fills and the large volume of fill required to develop a 300 ft or 400 ft berm indicate that fill to a smaller berm width is more desirable. The smaller berm should suffer much less initial erosion than a 300 ft or 400 ft berm because the initial beach recession rate appears to be greater for a greater initial berm width. Fill to a smaller berm width at a lower cost with its corresponding slower sand loss rate make it economically

easier to justify nourishing the beach at a given subsequent time. There would be less extreme variation in beach conditions over a period of years which, in the long run, should be more satisfactory to the public. Thus, it is recommended that fill be placed between Oriental Avenue Jetty and Ocean I Pier to develop a berm width of 200 ft with a crest elevation of +10 ft MLW and a beach face slope of about 1:30.

3. No modifications to existing structures are recommended at this time. Recent modifications to the Oriental Avenue jetty and the groins at Vermont and Massachusetts Avenues should be beneficial to the beach fill project by helping retain sand within the project area longer. The extended groin at Illinois Avenue will probably decrease the amount of sand moving from beaches northeast of the groin to the beach between the groin and the Ocean I Pier. However, the Ocean I Pier and the groin will act to contain the beach between them and, coupled with the sand placed during the beach fill, may maintain a reasonably stable beach in this area. Reducing the height of this groin to allow more sand to bypass it to nourish the downdrift beach is probably not warranted at this time. The horizontal section of the groin is at an elevation of + 10 ft MLW and extends 300 feet from the boardwalk. The recommended fill in this area will

extend 200 feet from the boardwalk, also with berm elevation of + 10 ft MLW. Thus, while the groin is longer than desirable, it would not be economical to lower or shorten it at this time. The possibility remains, however, that the extended groin at Illinois Avenue may have a detrimental effect on the reach of shoreline between the groin and the Ocean I Pier if it deflects southwestward moving longshore transport offshore and the Ocean I Pier is not effective in reducing longshore transport out of the area. If, following the fill, the groin is observed to seriously affect the downdrift beach, further consideration should be given to modifying it.

4. Because of the proven value of past data collection efforts in quantifying the performance of past beach fills at Atlantic City and because of recent modifications to coastal structures and their anticipated effect on the performance of the proposed beach fill, a monitoring program is strongly recommended. The monitoring program, which would include obtaining beach profiles and nearshore environmental observations, would quantify the performance of the present fill and the effect of the structures in containing the fill within the project area. It would also determine whether any further modifications are needed to the Illinois Avenue groin.

VII ACKNOWLEDGEMENTS

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IX APPENDICES

Appendix A - Sediment Sample Statistics

Eighteen sediment samples were collected at the locations given in Section IV. Ten of these samples were analyzed using a settling tube available in the Geology Department at Lehigh University. The settling tube yields the settling diameter size distribution by measuring the accumulating weight of sediment at the bottom of the tube. The weight, continuously measured by strain gage, is fed to a minicomputer to automatically calculate the cumulative size fequency relationship and related Inman (1952) and Folk and Ward (1957) parameters. The sample number, ϕ_{16} , ϕ_{50} (d_{50} in mm), and ϕ_{84} sizes and the phi deviation measure $\sigma_{\phi} = 0.5(\phi_{84} - \phi_{16})$ are given for each sample.

Sample No.	ϕ_{16}	ϕ_{50}	d_{50}	ϕ_{84}	σ_{ϕ}
1	1.88	2.39	(.175)	2.71	0.42
2	2.42	2.67	(.140)	2.87	0.45
3	1.68	2.36	(.180)	2.70	0.51
4	2.26	2.53	(.156)	2.77	0.26
5	1.47	1.98	(.255)	2.23	0.38
6	1.59	1.88	(.282)	2.31	0.36
7	1.72	2.26	(.196)	2.54	0.41
8	2.21	2.54	(.155)	2.73	0.26
9	2.34	2.58	(.150)	2.76	0.21
10	1.81	2.08	(.231)	2.32	0.26
11	1.91	2.14	(.218)	2.37	0.23
12	2.00	2.20	(.207)	2.40	0.20
13	2.06	2.25	(.197)	2.43	0.19
14	2.26	2.47	(.164)	2.63	0.19
15	2.27	2.50	(.160)	2.67	0.20
16	2.39	2.63	(.144)	2.80	0.20
17	2.46	2.67	(.140)	2.82	0.18
18	2.34	2.56	(.152)	2.72	0.19

Appendix B - Project Profile Data

This Appendix contains the profile data for the eight profile lines surveyed by standard level and rod procedures on March 12, May 29, and September 15, 1984. Profiles 1 to 7 were at the same location as the original CERC BEP profiles (McCann, 1981). The line azimuths, zero stations and elevation datums are as given in McCann (1981), pp 58-64. Profile 5A has the same line azimuth and elevation datum as CERC BEP profile 5. The zero station is the southwest bolt on the head of the fire hydrant located 65 paces northeast of Michigan Avenue along the boardwalk.

Under each date are eight pairs of columns. The top number is the profile number, the left column gives the station in feet and the right column gives the elevation in feet above MSL (NGVD, sea level datum of 1929).

March 12, 1984

(1)		(2)		(3)		(4)	
50	6.6	0	8.1	0	10.8	50	8.9
100	6.1	50	7.8	50	8.7	100	8.8
150	5.4	60	8.3	100	6.2	150	8.8
200	5.1	100	7.0	150	4.4	200	7.4
250	5.0	115	5.4	200	2.7	250	4.8
300	4.9	150	1.6	250	0.9	300	3.1
350	5.8	200	-2.8	300	-0.1	350	0.7
400	6.5	241	-5.3	350	-1.1	400	-1.0
450	7.5			400	-2.5	450	-1.8
500	7.9			450	-3.5	500	-2.4
522	7.3						
550	5.9						
584	5.6						
600	4.4						
650	0.9						
700	-0.2						
750	-1.1						
800	-2.2						

March 12, 1984 (cont.)

(5)		(5A)		(6)		(7)	
0	8.8	50	9.0	0	7.4	0	5.5
50	5.2	85	9.3	70	8.5	50	5.5
100	2.7	86	8.2	100	6.4	100	6.3
150	0.4	100	7.0	150	4.2	150	7.0
200	-0.9	150	4.1	200	2.6	200	7.2
250	-1.5	200	2.5	250	1.6	250	7.6
300	-2.2	250	0.6	300	0.6	300	7.4
		300	-1.5	350	-0.8	350	5.4
		338	-3.1	390	-1.7	400	3.4
						450	1.4
						500	0.3
						550	-0.9
						580	-1.8

May 29, 1984

(1)		(2)		(3)		(4)	
50	5.8	80	9.0	0	10.1	50	8.9
100	5.2	114	6.1	50	8.1	100	9.1
150	4.8	115	5.0	100	6.6	150	8.5
200	4.9	150	1.2	150	5.2	200	5.9
250	4.9	200	-1.8	200	3.4	250	4.9
300	5.0			250	1.1	300	2.9
350	5.4			300	-0.5	350	0.6
400	5.5			350	-2.3	400	-1.2
450	5.4					450	-2.0
500	4.7					500	-2.5
550	5.1						
580	6.2						
600	4.0						
650	-0.2						
680	-1.6						

May 29, 1984 (cont.)

(5)		(5A)		(6)		(7)	
0	5.8	50	8.7	0	7.6	0	6.2
50	3.8	85	7.2	50	6.4	50	5.5
100	1.6	150	4.5	100	5.3	100	6.4
150	0.2	200	2.5	150	4.7	150	7.6
200	-0.7	250	0.9	200	2.4	200	7.7
250	-1.6	300	-0.5	250	0.5	250	7.1
300	-2.6	350	-2.2	300	-0.8	300	6.1
				350	-1.3	350	4.3
				390	-2.2	400	3.2
						450	1.9
						500	1.0
						550	0.4
						600	-0.9

September 15, 1984

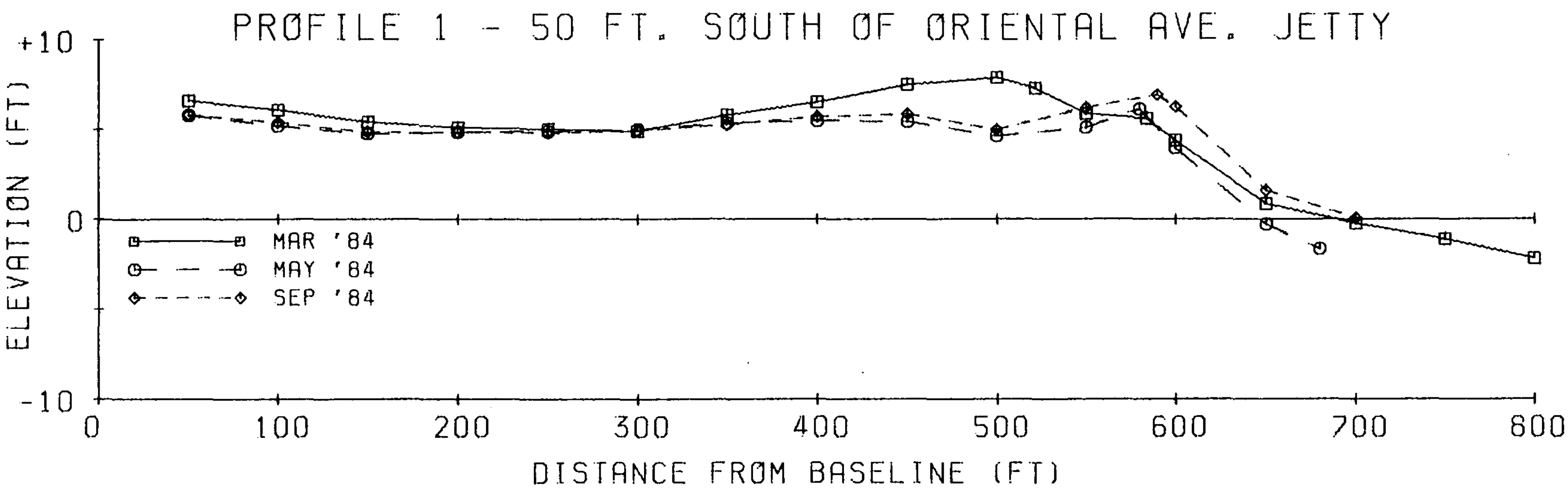
(1)		(2)		(3)		(4)	
50	5.9	100	6.9	0	10.5	50	8.9
100	5.4	141	2.3	50	8.2	100	9.2
150	4.9	150	1.6	100	6.9	150	8.5
200	4.9	200	0.0	150	6.8	200	6.3
250	4.8			200	3.8	250	6.6
300	4.9			250	1.7	300	3.2
350	5.3			300	-0.1	350	0.5
400	5.7					400	-0.9
450	5.9						
500	5.0						
550	6.2						
590	7.0						
600	6.3						
650	1.6						
700	0.1						

September 15, 1984 (cont.)

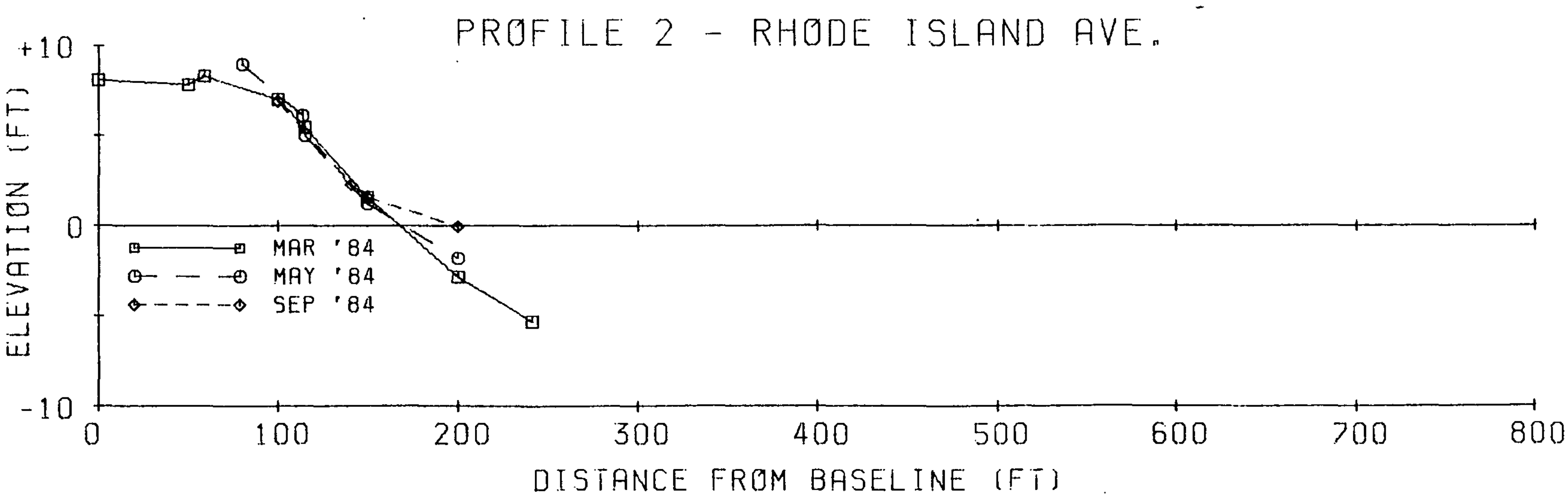
(5)		(5A)		(6)		(7)	
37	6.1	9	9.3	0	8.5	0	5.7
58	6.2	102	6.4	50	6.9	50	5.5
87	2.8	147	6.1	100	5.9	100	6.7
137	0.4	202	2.6	150	5.9	150	7.8
187	-0.6	252	0.7	166	5.9	200	8.0
237	-1.9	302	-0.4	200	3.7	250	7.3
		352	-1.2	250	1.4	300	6.3
				300	0.3	350	5.1
				350	-1.0	400	5.6
				410	-1.7	450	3.7
						500	1.3
						550	0.0
						600	1.6

Appendix C - Project Profile Plots

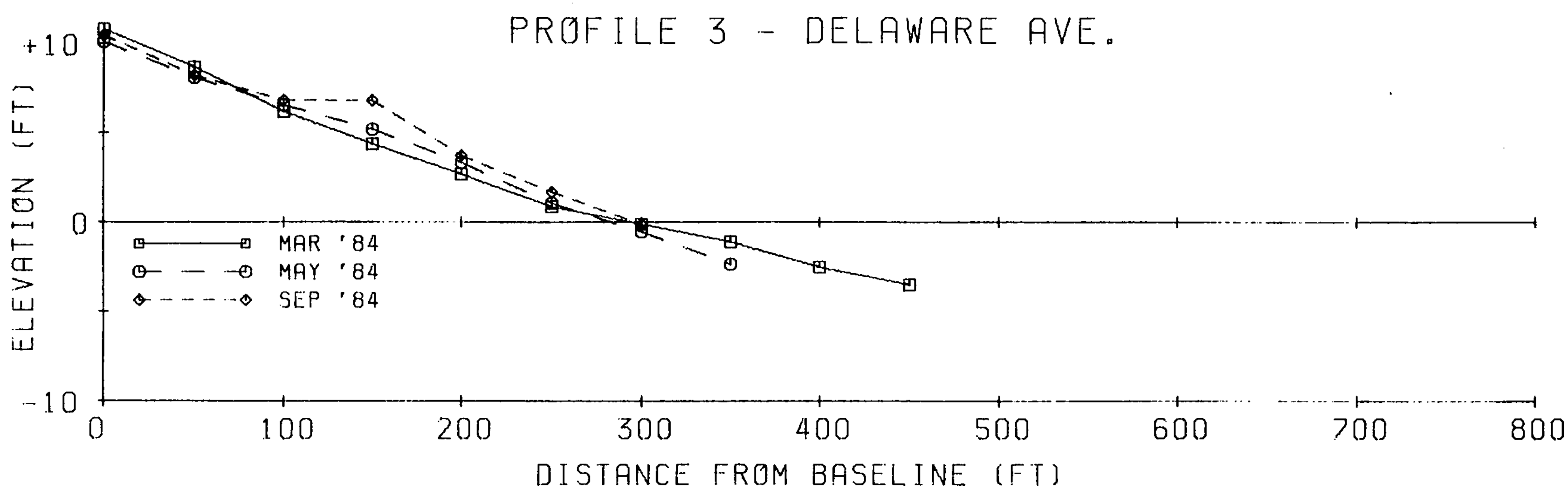
The following four plots present the project profile data presented in Appendix B.

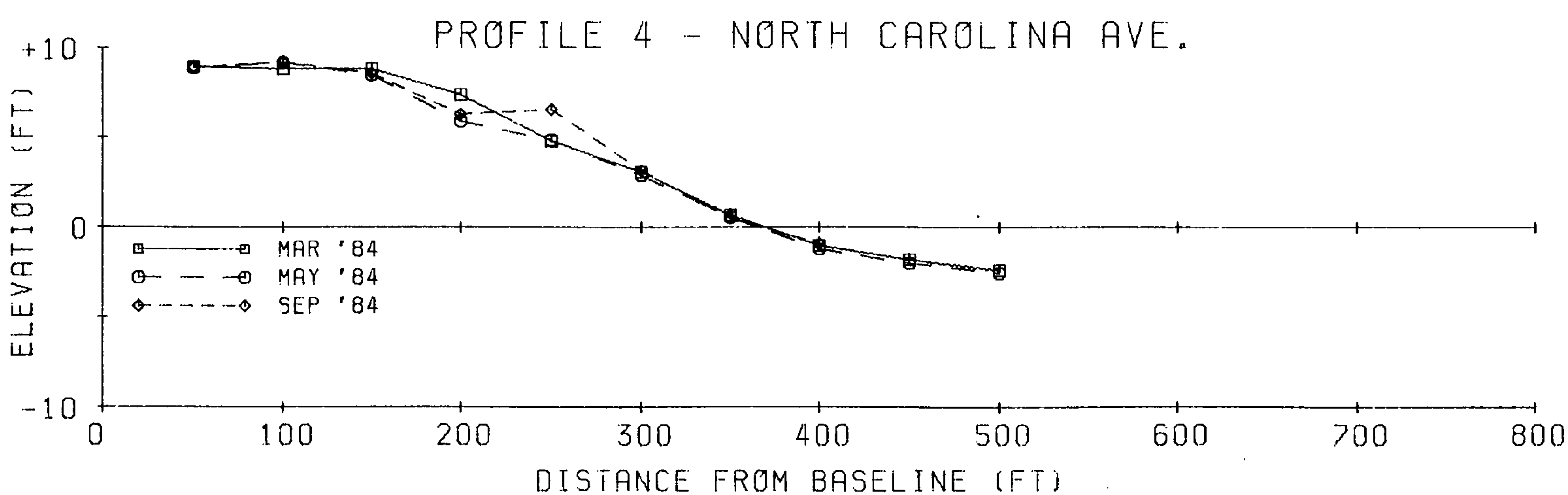


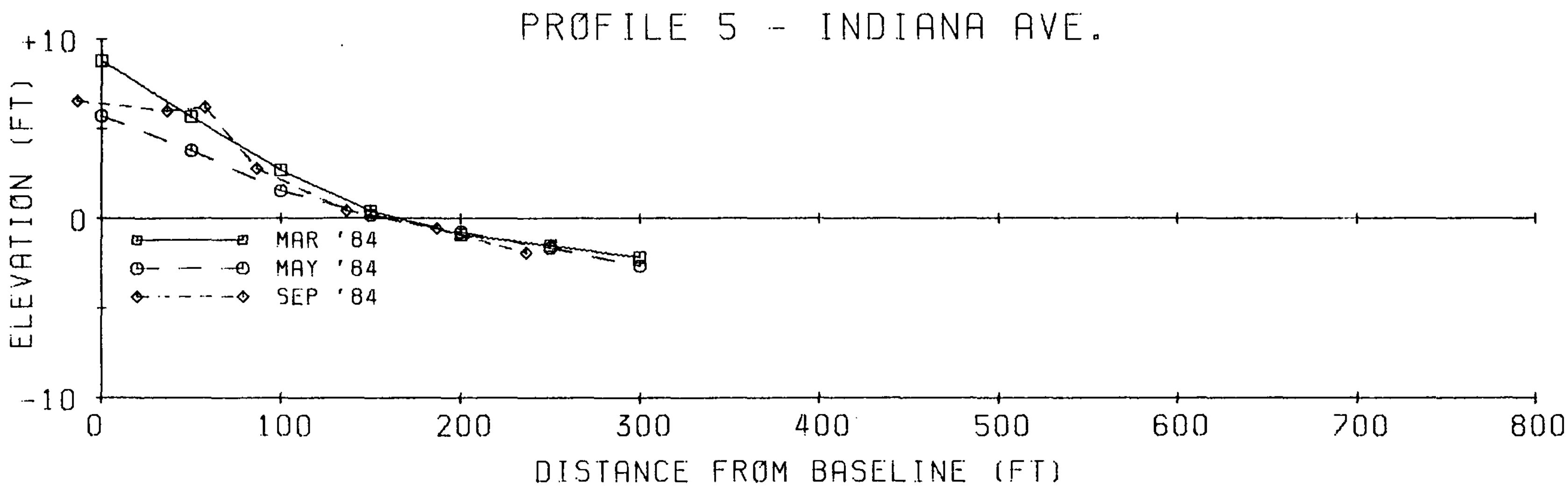
PRØFILE 1 - 50 FT. SØUTH ØF ØRIENTAL AVE. JETTY
+10
0
-10
ELEVATIØN (FT)
MAR '84
MAY '84
SEP '84
0
100
200
300
400
500
600
700
800
DISTANCE FRØM BASELINE (FT)

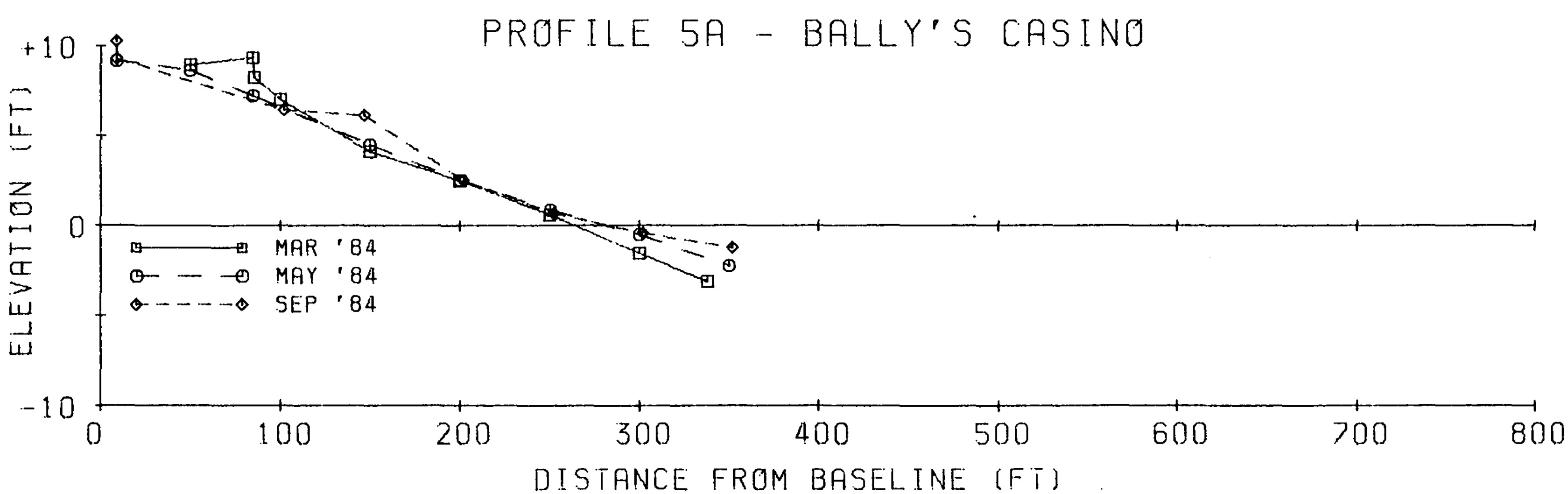


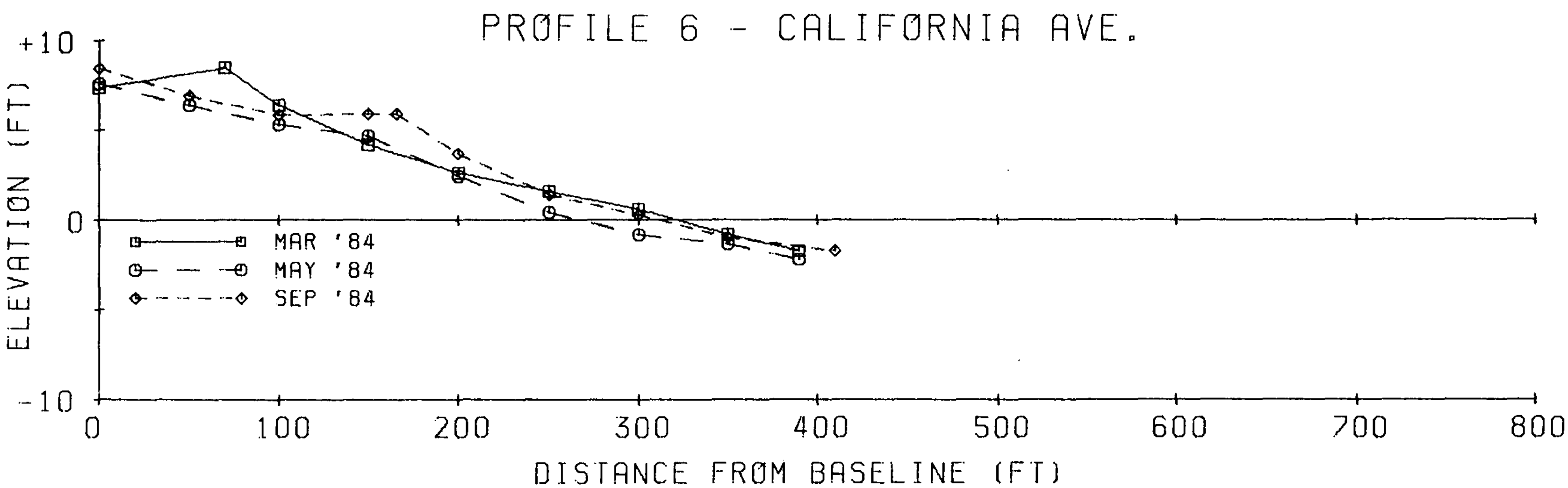
PRØFILE 2 - RHØDE ISLAND AVE.
+10
0
-10
ELEVATIØN (FT)
MAR '84
MAY '84
SEP '84
0
100
200
300
400
500
600
700
800
DISTANCE FRØM BASELINE (FT)


PRØFILE 3 - DELAWARE AVE.
+10
0
-10
ELEVATIØN (FT)
0
100
200
300
400
500
600
700
800
DISTANCE FRØM BASELINE (FT)
MAR '84
MAY '84
SEP '84

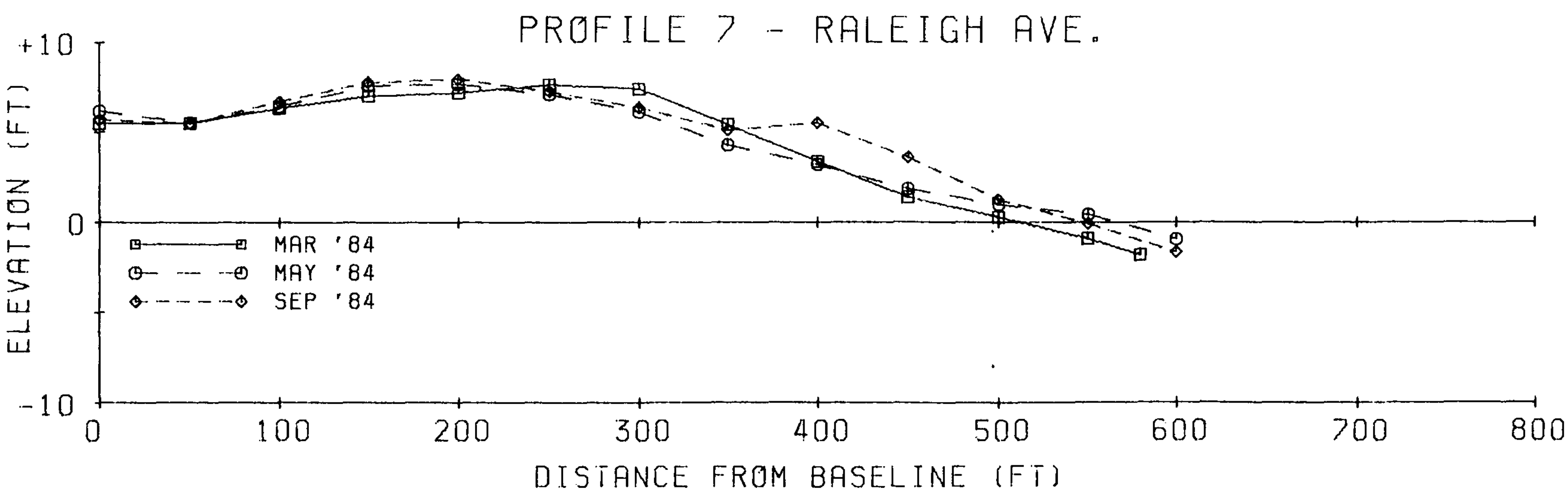

PRØFILE 4 - NØRTH CARØLINA AVE.
+10
0
-10
ELEVATIØN (FT)
0
100
200
300
400
500
600
700
800
DISTANCE FRØM BASELINE (FT)
MAR '84
MAY '84
SEP '84


PRØFILE 5 - INDIANA AVE.
+10
0
-10
ELEVATIØN (FT)
MAR '84
MAY '84
SEP '84
0
100
200
300
400
500
600
700
800
DISTANCE FRØM BASELINE (FT)


PRØFILE 5A - BALLY'S CASINØ
+10
0
-10
ELEVATIØN (FT)
MAR '84
MAY '84
SEP '84
0
100
200
300
400
500
600
700
800
DISTANCE FRØM BASELINE (FT)



PRØFILE 6 - CALIFORNIA AVE.
+10
0
-10
ELEVATION (FT)
0
100
200
300
400
500
600
700
800
DISTANCE FROM BASELINE (FT)
MAR '84
MAY '84
SEP '84



PRØFILE 7 - RALEIGH AVE.
+10
0
-10
ELEVATION (FT)
0
100
200
300
400
500
600
700
800
DISTANCE FROM BASELINE (FT)
MAR '84
MAY '84
SEP '84

Appendix D - Beach Berm Widths

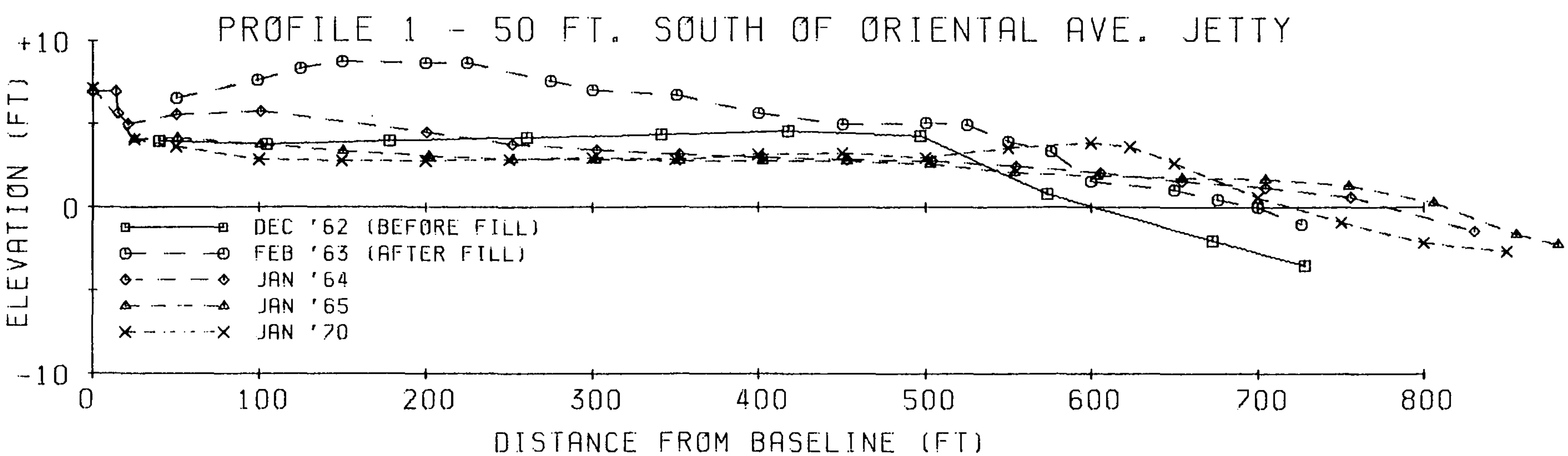
Berm widths were measured from beach profile data collected by the NJDEP Bureau of Coastal Engineering in December 1983 plus profile data collected by the authors in March 1984. Stations are measured along the boardwalk from the Oriental Avuenue Jetty and berm widths are measured out from the seaward edge of the boardwalk. Where the berm crest elevation is poorly defined the distance out to the +10 ft MLW elevation is given.

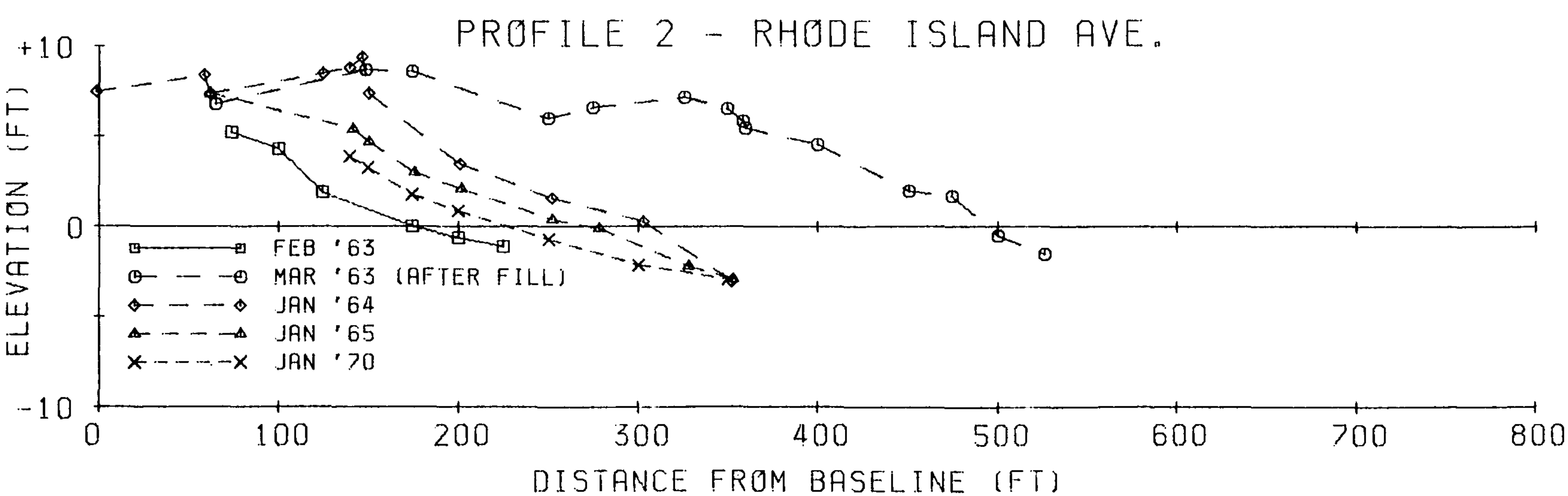
Station	Berm Width (feet)	Remarks
0+00	475	Near Oriental Ave jetty
1+40	420	
2+25	340	
3+85	180	Vicinity N.Hampshire Ave
4+65	150	" " "
5+45	60	" " "
6+35	0	Berm under boardwalk to 10+00 and then behind boardwalk to 18+00
18+44	50	Vicinity Massachusetts Ave
19+55	50	" " "
22+55	50	Vicinity Connecticut Ave
24+69	40	Near Garden Pier
26+94	80	Vicinity N.Jersey Ave
30+85	50	Vicinity Delaware Ave
37+99	200	Vicinity Virginia Ave
40+77	250	Near Steel Pier
42+55	200	Vicinity Pennsylvania Ave
44+40	200	" " "
47+64	300	Vicinity N.Carolina Ave Berm crest +7 MLW
48+14	130	
50+46	100	Vicinity S.Carolina Ave
53+96	150	Vicinity Tennessee Ave Central Pier
55+91	0	Vicinity St.James Ave
59+91	0	Vicinity Westminster Ave
65+91	150	Vicinity Illinois Ave Berm crest +8.5 MLW
66+52	125	
70+00(approx)	15	C.L. Indiana Ave
74+30	20	C.L. Ohio Ave
82+28	200	C.L. Arkansas Ave Ocean I Pier

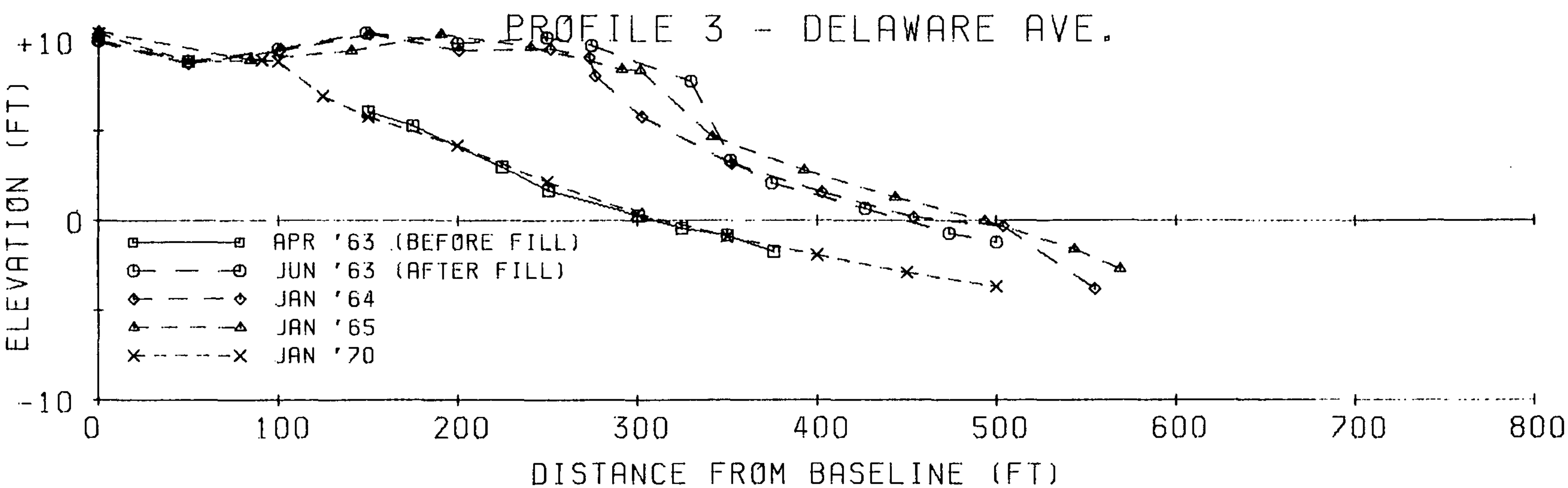
Station	Berm Width (feet)	Remarks
84+83	300	Vicinity Missouri Ave
94+70	100	Convention Hall
102+30	50	
112+24	100	C.L. Stenton Ave
117+46	200	C.L. Morris Ave
123+66	200	C.L. Montpelier Ave
127+86	300	C.L. Boston Ave Berm width is 200 to 300 feet to 169+94

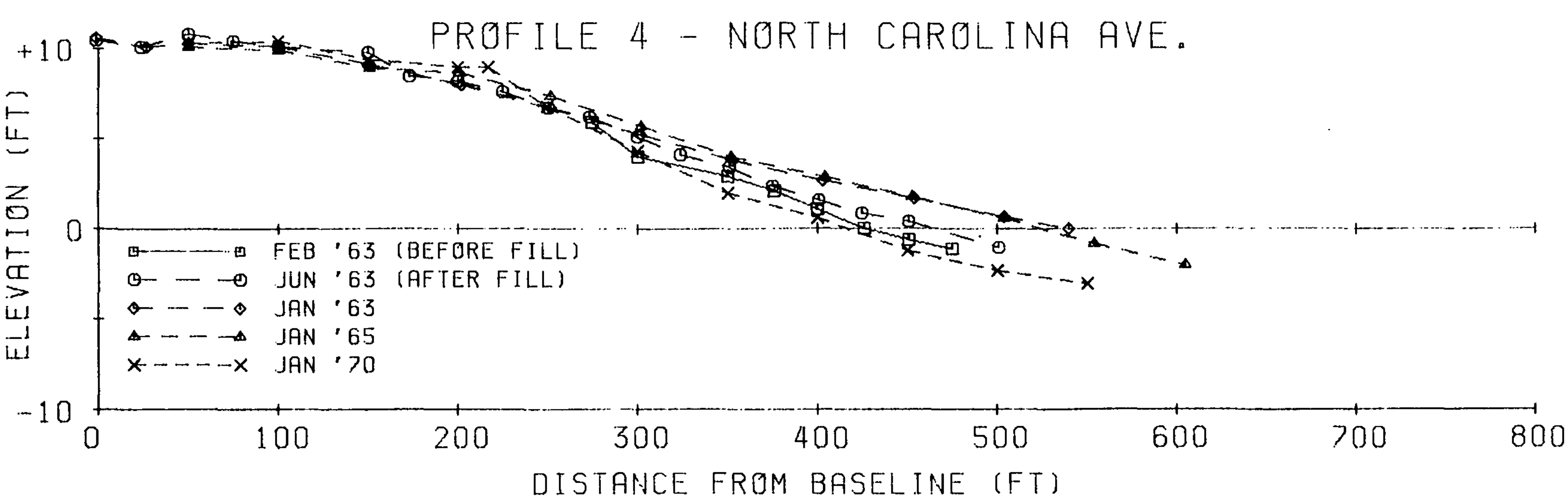
Appendix E - Historic Beach Profiles

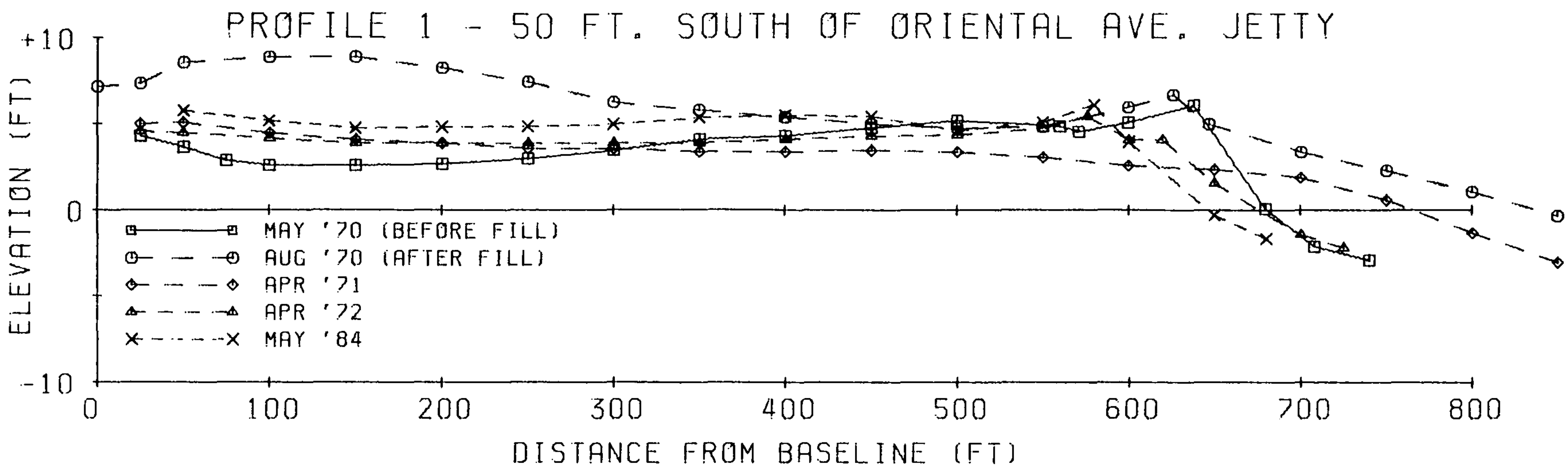
The next two pages present CERC BEP Profiles 1-4 for February 1963, March 1963, January 1964, January 1965, and January 1970. The next two pages following present the same profiles for May 1970, August 1970, April 1971, April 1972, and May 1984. The datum for all elevations is MSL.

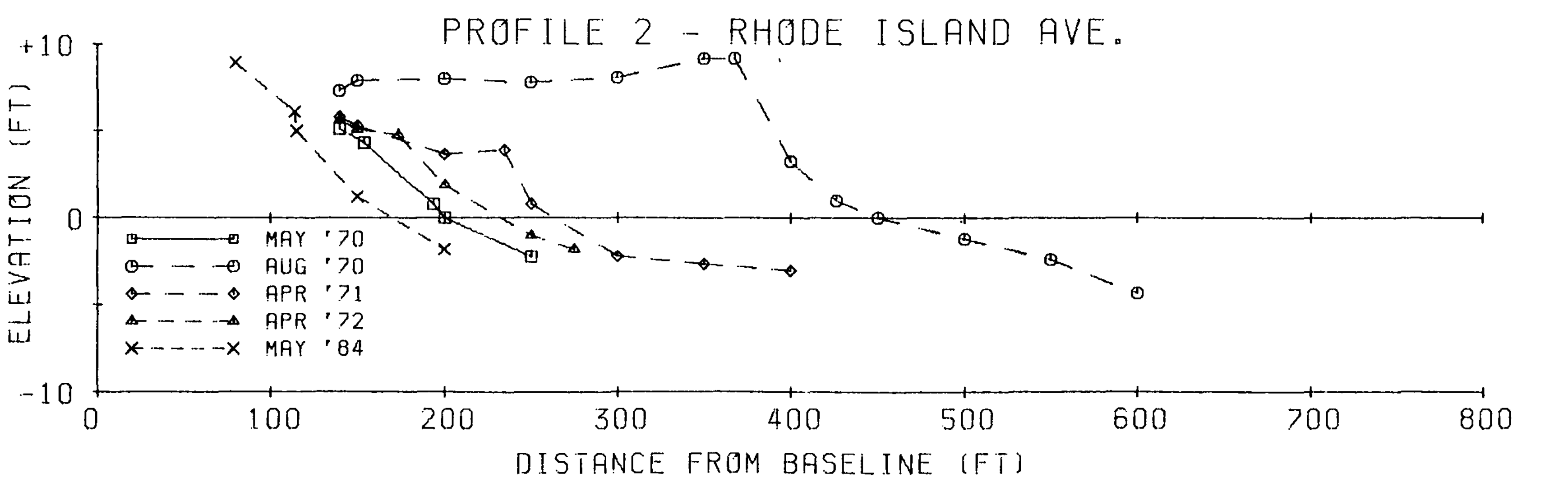

PROFILE 1 - 50 FT. SOUTH OF ORIENTAL AVE. JETTY
ELEVATION (FT)
+10
0
-10
DEC '62 (BEFORE FILL)
FEB '63 (AFTER FILL)
JAN '64
JAN '65
JAN '70
0
100
200
300
400
500
600
700
800
DISTANCE FROM BASELINE (FT)

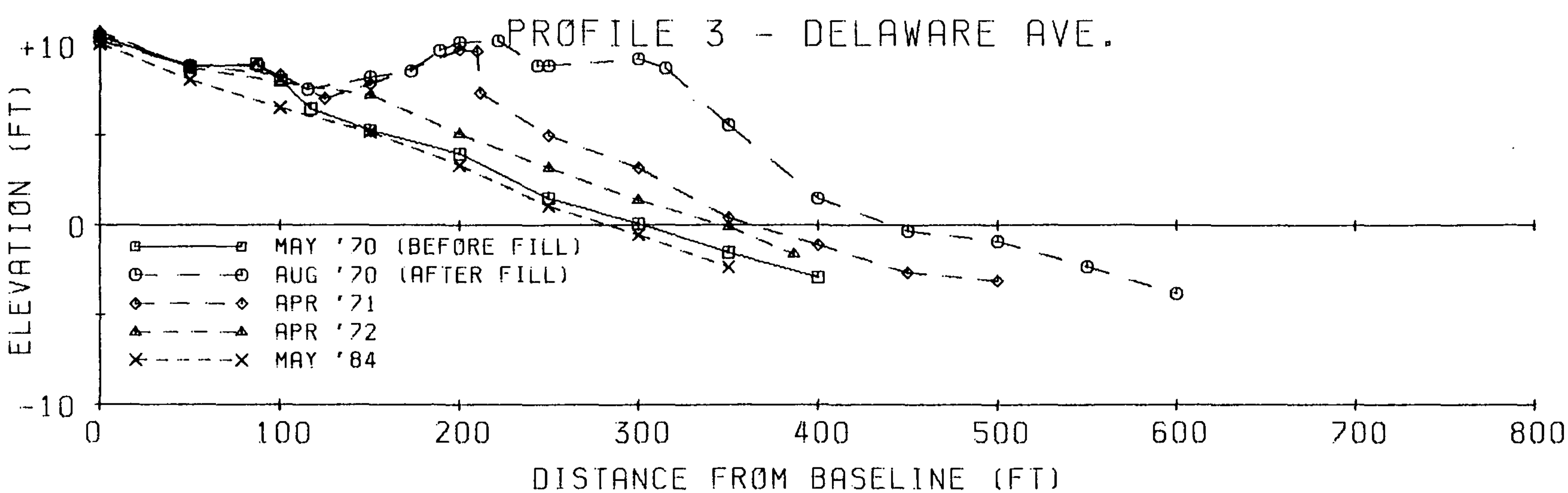

PROFILE 2 - RHODE ISLAND AVE.
ELEVATION (FT)
+10
0
-10
FEB '63
MAR '63 (AFTER FILL)
JAN '64
JAN '65
JAN '70
0
100
200
300
400
500
600
700
800
DISTANCE FROM BASELINE (FT)


PROFILE 3 - DELAWARE AVE.
ELEVATION (FT)
+10
0
-10
0
100
200
300
400
500
600
700
800
DISTANCE FROM BASELINE (FT)
APR '63 (BEFORE FILL)
JUN '63 (AFTER FILL)
JAN '64
JAN '65
JAN '70

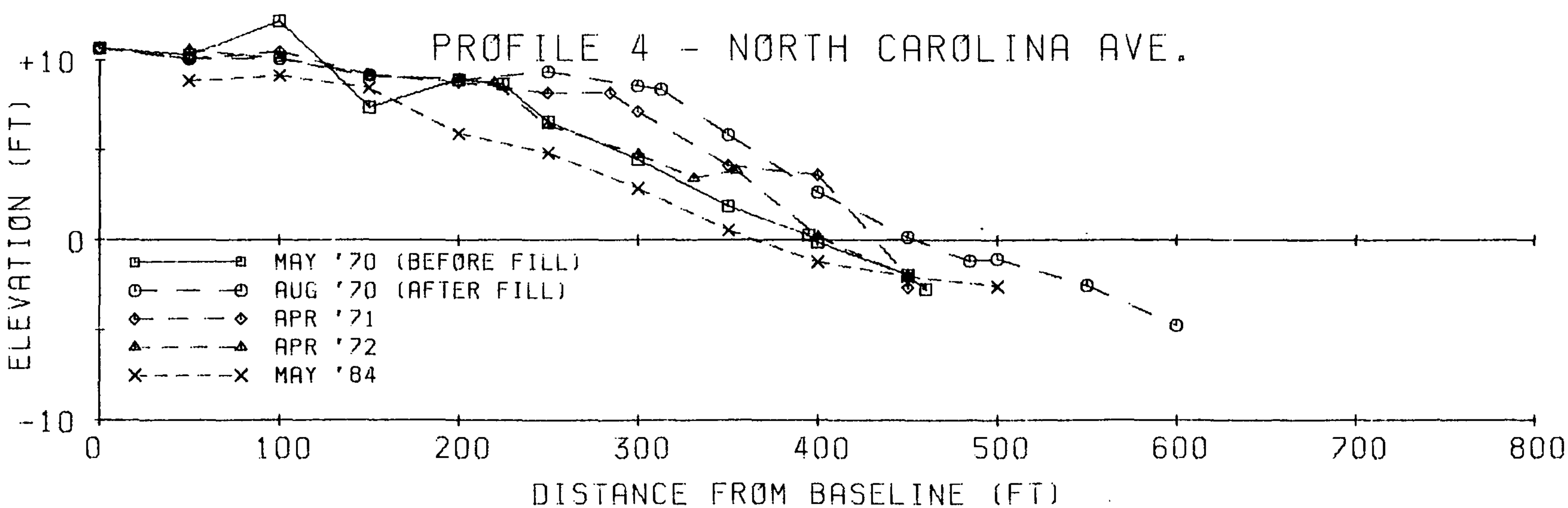

PROFILE 4 - NORTH CAROLINA AVE.
ELEVATION (FT)
+10
0
-10
0
100
200
300
400
500
600
700
800
DISTANCE FROM BASELINE (FT)
FEB '63 (BEFORE FILL)
JUN '63 (AFTER FILL)
JAN '63
JAN '65
JAN '70


PROFILE 1 - 50 FT. SOUTH OF ORIENTAL AVE. JETTY
ELEVATION (FT)
+10
0
-10
0
100
200
300
400
500
600
700
800
DISTANCE FROM BASELINE (FT)
MAY '70 (BEFORE FILL)
AUG '70 (AFTER FILL)
APR '71
APR '72
MAY '84


PROFILE 2 - RHODE ISLAND AVE.
ELEVATION (FT)
+10
0
-10
0
100
200
300
400
500
600
700
800
DISTANCE FROM BASELINE (FT)
MAY '70
AUG '70
APR '71
APR '72
MAY '84



PROFILE 3 - DELAWARE AVE.
+10
0
-10
ELEVATION (FT)
0
100
200
300
400
500
600
700
800
DISTANCE FROM BASELINE (FT)
MAY '70 (BEFORE FILL)
AUG '70 (AFTER FILL)
APR '71
APR '72
MAY '84



PROFILE 4 - NORTH CAROLINA AVE.
+10
0
-10
ELEVATION (FT)
0
100
200
300
400
500
600
700
800
DISTANCE FROM BASELINE (FT)
MAY '70 (BEFORE FILL)
AUG '70 (AFTER FILL)
APR '71
APR '72
MAY '84