HORRY COUNTY SHOREFRONT MANAGEMENT PLAN

From Briarcliffe Acres to Singleton Swash, and from Springmaid Beach to Garden City

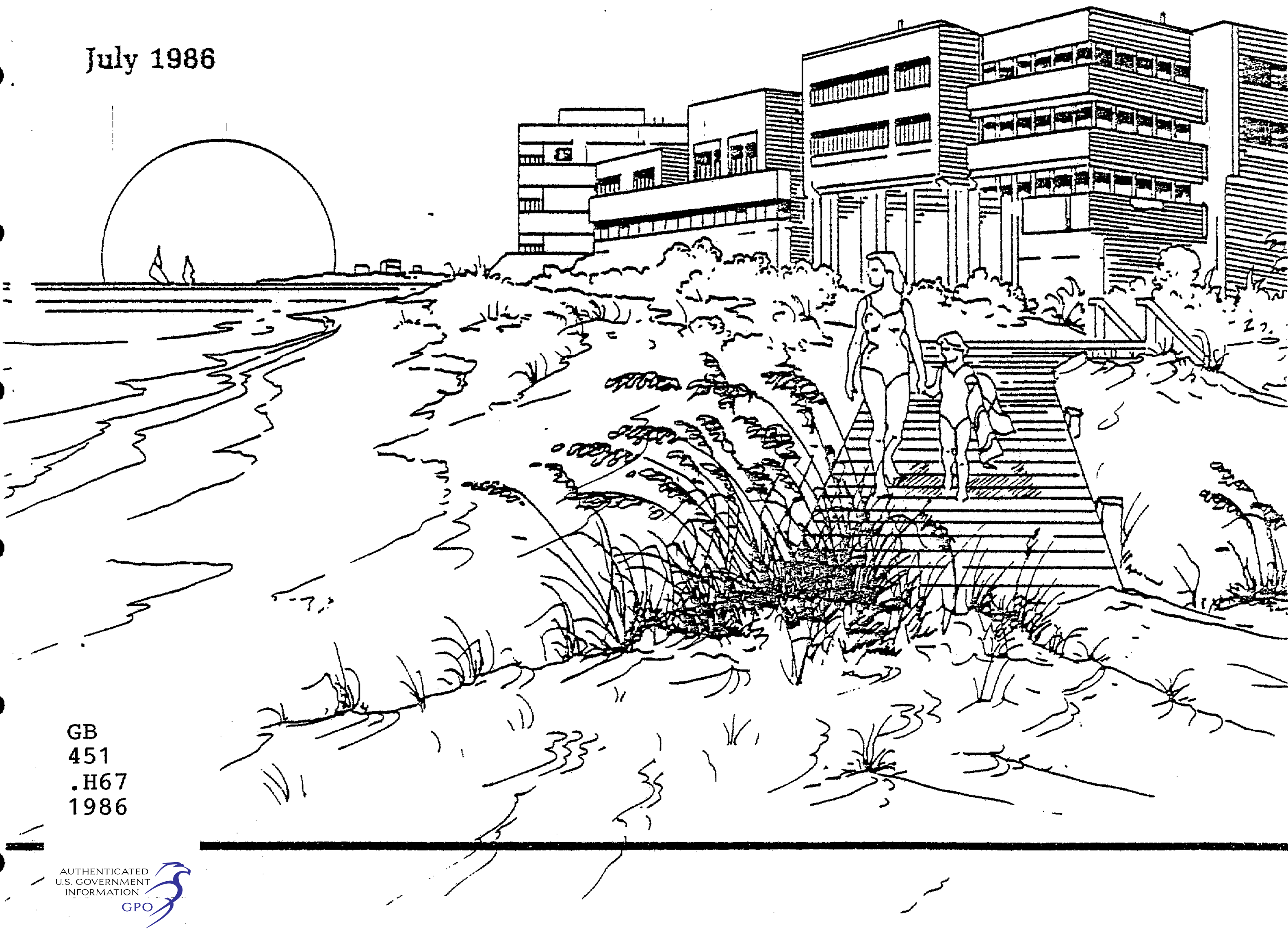
Prepared for:

SOUTH CAROLINA COASTAL COUNCIL

Prepared by:

APPLIED TECHNOLOGY AND MANAGEMENT, INC.
and
OLSEN ASSOCIATES, INC.

July 1986



HORRY COUNTY SHOREFRONT MANAGEMENT PLAN

FROM BRIARCLIFFE ACRES TO SINGLETON SWASH

AND FROM SPRINGMAID BEACH TO GARDEN CITY

Prepared for:

South Carolina Coastal Council
Charleston, South Carolina

By:

Applied Technology and Management, Inc.
Myrtle Beach, South Carolina

Olsen Associates, Inc.
Jacksonville, Florida

July 1986

TABLE OF CONTENTS

Page

LIST OF TABLES

LIST OF FIGURES

1.0 INTRODUCTION

1.1 PURPOSE

In 1979, the South Carolina Coastal Council completed a comprehensive management program for the eight-county coastal zone within the State. The program was approved by the General Assembly on February 14, 1979 and by the Federal government on September 29, 1979.

Accordingly, the Shorefront Management Plan included within this report specifically addresses the following two major goals formulated in the State plan:

1. The development of a program that will achieve a rational balance between economic development and environmental conservation of natural resources within the shorefront portion of the coastal zone of South Carolina.

2. The development of a permitting system for activities within the dynamic shorefront portion of the coastal zone that will serve to implement the goals and objectives of the management program and promote the best interest of all citizens of South Carolina.

The purpose of the Shorefront Management Plan is to make recommendations suitable for adoption by local government necessary for the protection of beach/dune resources, as well as both future and existing adjacent upland development. Accordingly, this study will address the following three major areas of coastal regulation:

1. Setbacks or similar controls necessary to both insure the long-term integrity of the dynamic beach/dune system and to prevent future development from ultimately being located on the active beach

face as a result of chronic or persistent beach erosion and shoreline recession. In addition, setbacks associated with storm related impacts to the beach/dune system will likewise be discussed.

2. Coastal construction zones within which minimum building standards should be implemented to insure that future major habitable structures are designed to properly accommodate the impacts associated with a 100-year storm event.

3. General erosion control policy guidelines dealing with the consideration of future permits requesting armoring, groins, beach restoration, bulkheads, and other coastal protection structures.

Within those sections of Horry County, as well as that portion of the Garden City section of coastline within Georgetown County, the methodologies utilized by this study to recommend building setbacks were similar to the formats developed for similar studies proposed by previous investigators for both Myrtle Beach and North Myrtle Beach. Simplistically, the methodology involves the determination of the "ideal present shoreline" (IPS) and the identification of the 25 and 50 year future dune crest based upon both the IPS and known rates of erosion or accretion (Kana, et al). This technique is based upon the long-term extrapolation of average annual rates of volume change in the beach face. It does not include short-term, and potentially more severe erosional effects associated with low frequency storm events (i.e., severe nor'easters, tropical storms and hurricanes). For that reason, a separate computer analysis has been included which models the erosion of the ideal present profile (IPP) during the occurrence of the 25 and 50 year storm. The latter can be expected to have an annual probability of occurrence of .04

and .02 respectively. A 25-year storm, for example, is an event which would be expected to be experienced or exceeded on the average, once in 25 years.

1.2 STUDY AREA

Located within the Grand Strand, the Horry County coastline in its entirety extends from Little River Inlet to a location 3.4 miles north of Murrells Inlet, a shoreline length of approximately 22 miles. From north to south, the areas investigated include the 3.5 miles of unincorporated shoreline beginning south of Briarcliffe Acres and extending to Singleton Swash, Springmaid Beach, Myrtle Beach State Park, Surfside Beach and the northern portion of Garden City. The study area is interrupted by a shoreline segment of approximately 10 miles, extending from Singleton Swash to Springmaid Beach which defines the incorporated area of Myrtle Beach, is not included in this study. This study report referred to the area between North Myrtle Beach and Myrtle Beach as "Myrtle Beach North" and the area between Myrtle Beach and Georgetown County as "Myrtle Beach South". Figure 1.2-1 shows the general location of the study area.

Extreme variability in development pressures, including both development patterns and density, exists between Briarcliffe Acres and Garden City. As the population along the coastline has grown, the contribution of South Carolina's northern beaches to the local and state economy has become considerable. The economic value of the Grand Strand should continue to increase as long as adequate sandy beaches suitable for recreation are properly preserved and maintained.

From Little River Inlet, the Grand Strand coastline follows a general arc to North Inlet at the southernmost point. Overall, specific stretches of Horry County's shoreline appear to be migrating as the result of long- and short-term

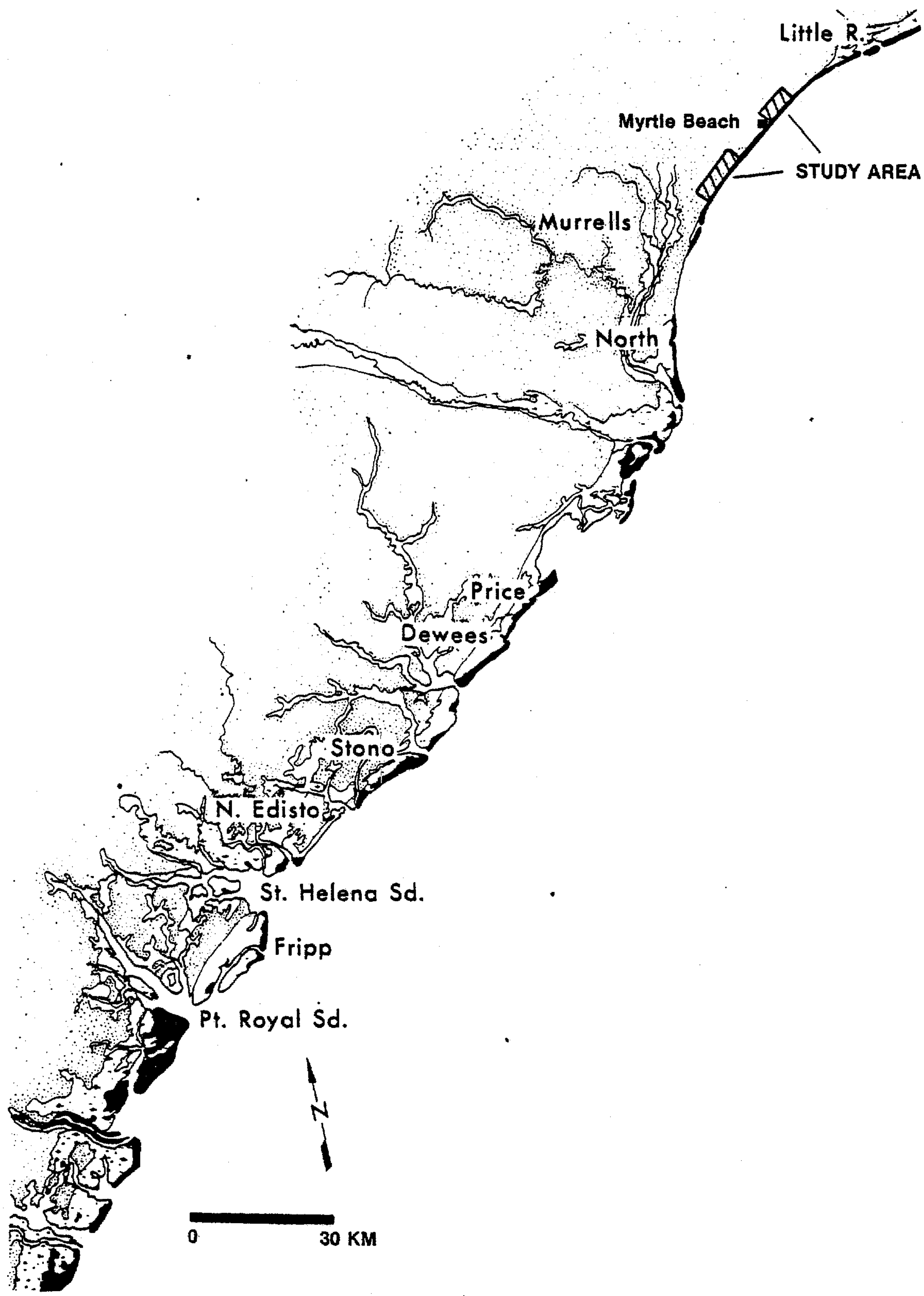


FIGURE 1.2-1
STUDY AREA LOCATION MAP

local differences in sand supply, shoreline orientation and the proximity to inlets, and coastal structures. The effect of sea-level rise on shoreline recession is relatively uniform along the coastline and results in a persistant net offshore sediment transport.

Coastal structures, including shoreline armoring and inlet improvements, were employed to protect and improve the coastal resources. In some cases, however, shoreline hardening has resulted in shoreline instability when the littoral processes were disturbed by man-made structures. Problems associated with the dynamic state of natural inlet channels are commonly magnified by dredge spoil disposal practices and the construction of inlet jetties. The Murrells Inlet stabilization project, completed in 1980, for example, has altered sediment transport in the nearshore littoral zone along the adjacent beaches.

Beach and offshore erosion is a condition that exists along the majority of Horry County's coastal areas. Erosional impacts from shoreline development are most directly related to the demand for shoreline armoring or hardening. In general, this area has had significant increases in both soft and hard shoreline protection measures such as seawalls, groins, rip-rap, sand bags, beach scraping, dune restoration and revegetation, sand fences and beach renourishment.

Groins, piers and jetties are man-made structural barriers, each of which interrupts the natural sand transport across the nearshore littoral zone. Net sediment transpor along the county coastline is generally southward, with periods of large reversals toward the north caused by longshore currents. The magnitude and direction of the longshore currents, created by waves breaking at an angle to the coast, determine sand transport along the coastline.

and .02 respectively. A 25-year storm, for example, is an event which would be expected to be experienced or exceeded on the average, once in 25 years.

1.3 STUDY AREA

Located within the Grand Strand, the Horry County coastline in its entirety extends from Little River Inlet to a location 3.4 miles north of Murrells Inlet, a shoreline length of approximately 22 miles. From north to south, the areas investigated include the 3.5 miles of unincorporated shoreline beginning south of Briarcliffe Acres and extending to Singleton Swash, Springmaid Beach, Myrtle Beach State Park, Surfside Beach and the northern portion of Garden City. The study area is interrupted by a shoreline segment of approximately 10 miles, extending from Singleton Swash to Springmaid Beach which defines the incorporated area of Myrtle Beach, is not included in this study. This study report referred to the area between North Myrtle Beach and Myrtle Beach as "Myrtle Beach North" and the area between Myrtle Beach and Georgetown County as "Myrtle Beach South". Figure 1.2-1 shows the general location of the study area.

Extreme variability in development pressures, including both development patterns and density, exists between Briarcliffe Acres and Garden City. As the population along the coastline has grown, the contribution of South Carolina's northern beaches to the local and state economy has become considerable. The economic value of the Grand Strand should continue to increase as long as adequate sandy beaches suitable for recreation are properly preserved and maintained.

From Little River Inlet, the Grand Strand coastline follows a general arc to North Inlet at the southernmost point. Overall, specific stretches of Horry County's shoreline appear to be migrating as the result of long- and short-term stabilization structures. They qualitatively described short-term stability as directly dependent on the number and intensity of extratropical and tropical storms occurring for a particular number of years.

After construction of two jetties at Murrells Inlet in 1977, the Corps of Engineer's Coastal Engineering Research Center (CERC) began a formal study to monitor the effect of the Murrells Inlet navigation project on both the inlet and the adjacent beaches. The Phase I monitoring program provided for quarterly surveys along 43 transect lines between 1979 and 1982. The scope was reduced at that time to include field surveys (Phase II) to monitor 18 transects semi-annually through October 1987.

The Murrells Inlet Monitoring Study provides valuable data to assess the effects of inlet stabilization on long- and short-term shoreline fluctuations for the Surfside and Garden City areas. This investigation is the most comprehensive study conducted within the study area, which includes a 10-year program for the continuous collection of coastal data. CERC's digitized survey data was acquired for comparative shoreline analysis in the Horry County study area.

The COE published a interim report (March 1985) to highlight and summarize their findings, particularly detailing those areas that are presently experiencing the greatest change. The following shoreline changes were noted:

1. Significant growth of the ebb tidal shoal extending seaward of the approximately 3400 foot long jetties.

2. Extreme erosion rates in a region between 2.5 and 3.5 miles south from the jetties.

3. The accretion of large volumes of sand on the south shoreline adjacent to the south jetty.

Preliminary results from the analysis of wave and directional current data suggest the directions of longshore sediment transport are variable in the vicinity of the jetties, while the sheltering effects of the jetties allow minimal southerly transport within an area 2.5 miles south from the jetties.

Maps of historical shoreline changes in the Georgetown County area are based on shoreline field surveys and vertically controlled photography compiled in a cooperative shoreline movement study by the National Ocean Service (NOS) and the U.S. Army Corps of Engineers Coastal Engineering Research Center (CERC). Shoreline positions were mapped beginning in 1872 and are compared with subsequent survey data of 1926, 1934, 1962-63 and 1983.

1.4 PRESENT STUDY

The objective of the present study is to formulate a comprehensive shorefront management plan based on an understanding of existing shoreline conditions specific to each coastal area. To provide background information, data collection efforts include the following control data:

1. Land use data,
2. Tide data,
3. Wind data,
4. Storm data,
5. Wave data,
6. Aerial photographs,
7. Historical shoreline movement data,
8. Inventory of major coastal structures and beach nourishments,

9. Sediment data,
10. Beach profile data,
11. Floodplane maps, and
12. Existing coastal management practices in the study area.

Shoreline data were evaluated in depth and the need for further data acquisition were identified. The present project initiated a comprehensive shorefront monitoring program to address the need for additional data. The monitoring efforts included:

1. Establishing thirty-eight survey stations along the Horry County shoreline; each station control point consisted of a permanent benchmark and a survey monument. Vertical elevations of these benchmarks were surveyed by professional surveyors, and carefully documented so that the data from future surveys can be replicated with confidence using the new control reference points.

2. Beach profiles were measured at each monitoring station in April 1986. The profile transects commenced landward of the primary dune and offshore to the -3 ft (mean sea level datum) wherever possible.

3. Sediment data were collected at 11 monitoring stations.

4. An extensive field investigation was conducted to document the existing shorefront condition and coastal structures including seawalls, bulkheads, rip-rap, groins, jetties, and stormwater discharge structures.

Using the historical information and the recently collected site specific data, the following analysis was conducted:

1. Development patterns were evaluated.

2. Sediment grain size analysis was conducted to provide sediment statistical parameters to provide essential information for estimating littoral processes and future beach nourishment design.

3. Volumetric changes of beach sand were computed using comparative beach profile data.

4. Short-term erosion rates were computed based on the mean high water contour movement derived from comparative beach surveys.

5. Long-term erosion rates were estimated using the historical shoreline maps. This shoreline recession rates, were subsequently used to predict 25 and 50 year future shoreline.

6. Ideal present profiles were established.

7. The storm impact zones were calculated by computer model simulation.

8. The inlet dynamics were assessed for Murrells Inlet, Midway Inlet, Pawley's Inlet, and North Inlet.

Upon examining the pertinent information and the results of the analyses, a comprehensive shorefront management plan was recommended.

2.0 LAND USE

2.1 EXISTING LAND USE

Horry County's establishment is said to have begun in 1731, when Governor Robert Johnson began to lay out 11 townships in South Carolina, among which the Kingston Township comprised most of the land now in Horry County. Horry County has had its name since the 1868 Constitution (Waccamaw Regional Planning and Development Council, 1983). Prior to the 1800's, the chief source of income was naval stores industry, farming, and trapping. From that time until the turn of the century, cotton was the major economic sector in the area. By the early 1900's, however, tobacco had replaced cotton as the major crop. Diversification of the economy began to take place in the 1920's, when new roads opened up many areas of the County to other markets in the region. During the post World War II period, the development of the coastal area as a tourist attraction became a dominant trend.

There are eight County Census Divisions (CCD) in Horry County.. Most of the present shorefront management study area, except Briarcliffe Acres, is located in the Myrtle Beach Division, the most populated CCD. The following presentation of land use data was extracted from the land use plan prepared by the Waccamaw Regional Planning and Development Council (1983).

The resident population trend in the Myrtle Beach Division from 1960 to 1980 is shown in Table 2.1-1. It shows a sharp increase in population from 1970 to 1980 which is more than the total increase in the three previous decades. The net migration into the County resulted in more than twice the natural increase in population. Because of the predominant tourism industry, the tourist population has a major seasonal impact on the Grand Strand area. The tourist population from 1972 to 1978 is shown in Table 2.1-2, which

Table 2.1-1. Myrtle Beach Census Division Resident Population Trends (1960-1980)

	1960	1970	1980	% change 1960- 1980
Myrtle Beach Division	17,619	21,211	34,827	97.7 %
Myrtle Beach	7,834	9,035	18,758	139.2 %
Surfside Beach	N/A	1,329	2,522	N/A
HORRY COUNTY TOTALS	68,247	69,992	101,419	48.6 %

Source: U. S. Department of Commerce, Bureau of the Census, Census of Population 1960, 1970, and 1980.

Table 2.1-2. Grand Strand Tourists 1972-1978

Year	Tourists	% of State
1972	2,900,000	36.1 %
1973	3,400,000	36.5 %
1974	3,600,000	35.5 %
1975	3,900,000	33.7 %
1976	4,200,000	33.5 %
1977	4,800,000	33.2 %
1978	6,500,000	38.0 %

Source: South Carolina Department of Parks, Recreation and Tourism, Travel and Tourism Data 1972-1978.

indicates an 124% increase in tourists in a six year period. The resident population projections are shown in Table 2.1-3. The projected tourist populations are shown in Table 2.1-4. Because of rapid increase of permanent resident population and the large influx of tourists, the future land use and coastal management plan should be compatible with the commercial and recreational needs as well as the public safety and conservation of the coastal resources.

The land use in the study area is dominated by residential development. The existing land use of the Myrtle Beach Division is shown in Table 2.1-5. The land use study indicated that the residential development in the Grand Strand is accelerated in a fast pace. Seasonal use accounts for much of this growth, but permanent residential use is also expanding. The area between North Myrtle Beach and Myrtle Beach has developed into an area for condominiums, apartments, and planned unit development. This same development pattern continues toward south of Myrtle Beach. The high cost of land, and lack of suitable land due to marsh and flood areas and soil conditions, is making it increasingly difficult to satisfy single-family residential needs. Future development is expected to continue in this same manner for the next 20 years.

2.2 FUTURE LAND USE

As the population of the Horry County grows, there will be additional land needed for each land use category. By considering the existing patterns of development, future goal and policies, and the population projection, the future land use for the Myrtle Beach Division was projected by the Waccamaw Regional Planning and Development Council (1983). The projections for year 2000 are shown in Table 2.1-1.

Table 2.1-3. Population Projections for 1985, 1990, 1995, and 2000

Census County Division	1985	1990	1995	2000
Myrtle Beach Division	42,853	50,447	60,151	69,421
Myrtle Beach	20,885	22,824	25,649	28,286
Surfside	3,122	3,709	4,312	4,903
HORRY COUNTY TOTALS	120,910	139,677	161,073	181,481

Source: South Carolina State Budget and Control Board, Research and Statistical Services Division; and Waccamaw Regional Planning and Development council, 1982.

Table 2.1-4. Tourist and Peak Day Population Projections for Grand Strand, Horry County

	1982	1987	1992	1997
Overnight transits	264,270	312,166	330,498	335,243
Day Visitors	38,600	44,726	51,825	60,000
Residents	52,000	70,000	89,000	103,075
Peak Day	354,870	426,892	471,323	498,418

Source: Grand Strand Environmental Impact Statement (EIS) 1977.

Table 2.1-5. Existing Land Use Myrtle Beach Division, 1981.

	Acres	% of Developed Land	% of Total Land
Residential	2,470	41.6 %	4.3 %
Commerical	537	9.0 %	0.9 %
Industrial	81	1.4 %	0.1 %
Public & Semi-Public	1,286	21.7 %	2.2 %
Roadways and Railroads	1,563	26.3 %	2.7 %
Total Developed Land	5,937	100.0 %	10.4 %
Myrtle Beach (City)	5,916		10.4 %
Surfside Beach (Town)	1,204		2.1 %
Agricultural or Undeveloped	43,903		77.1 %
CCD Total	56,903		100.0 %

Source: Waccamaw Regional Planning and Development Council, 1981.

Table 2.2-1. Year 2000 Land Use Projections for Myrtle Beach Division.

	1981	2000
Population		36,232
Residential (acres)	2,470	5,765
Commercial (acres)	537	1,333
Industrial (acres)	81	199
Public & Semi-Public (acres)	1,286	3,188
Roadway (acres)	1,563	3,876
TOTAL DEVELOPED LAND (acres)	5,937	14,361

Source: Waccamaw Regional Planning and Development Council, 1982

3.0 BACKGROUND INFORMATION AND DATA COLLECTION

3.1 TIDES

Tidal data have been collected by the National Ocean Survey (NOS) at four open-coast gages in the vicinity of the study area over the last 30 years. North to south, these locations include Hog Inlet Pier, Myrtle Beach Pier, Springmaid Pier and Pawley's Island Pier. The gage at Myrtle Beach Pier was operational between 1957 and 1978, with subsequent installation at Springmaid Pier for the period 1978 through 1982. The longest continuous tidal records are for the primary gage at Charleston and cover the period from 1920 to the present. Using spectral and harmonic analyses, these tidal data obtained at the Charleston and local gage locations require correlation for the computation of statistical parameters such as local daily MHW, MLW, tidal variation along the coastline (phase lag) and the rise in mean sea level.

Analyses of tidal data is completed on a periodic 19-year cycle, termed a Tidal Epoch. The tide gage installed at the Myrtle Beach Pier measured a rise in mean sea level equal to 0.34 feet between 1929 (NGVD-MSL) and the 1941-59 Tidal Epoch. Mean sea level increased an additional 0.13 feet between the 1941-59 and the 1960-78 Tidal Epoch along the gage stations adjacent to both Georgetown and Horry Counties. This translates into a 5.6-inch rise in sea level for the last 49 years in this coastal location.

A recent study conducted by the U.S. Environmental Protection Agency (EPA,1983) predicts a possible sea-level rise of 1 foot over the next 30 to 40 years and 3 to 5 feet over the next 100 years (Figure 3.1-1). This rise in sea-level will subject areas currently flooded in a 100-year storm event to extreme flooding during higher frequency events, particularly in coastal areas characterized by low barrier-crest elevations.

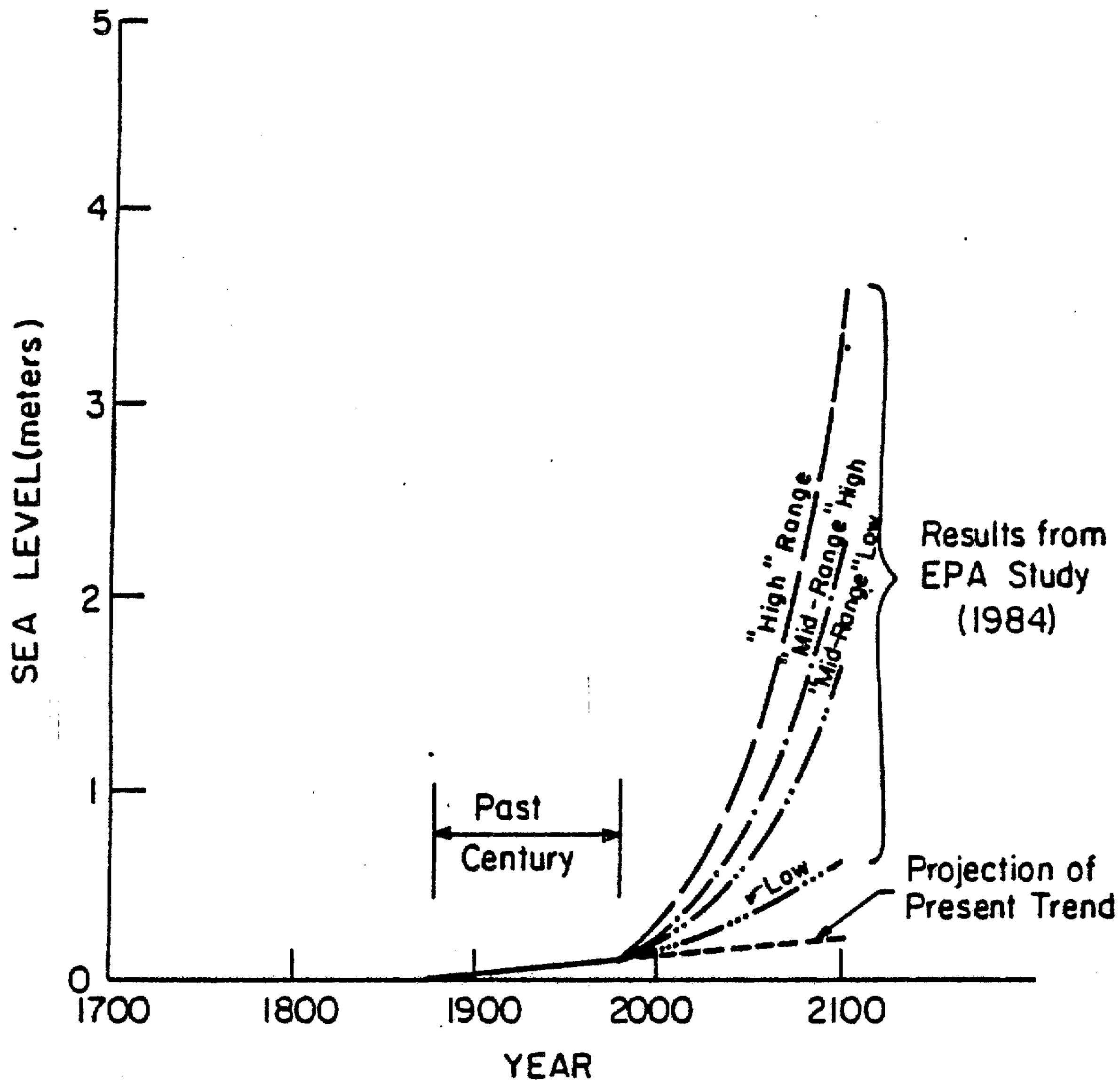


FIGURE 3.1-1
SEA-LEVEL RISE OVER THE LAST CENTURY AND PROJECTIONS BASED ON A RECENT EPA STUDY (EPA, 1983)

Records of water-level variation obtained from tide gages often include water elevations associated with storm tides, which are valuable for predicting flood elevations. Extreme storm-generated fluctuations in water-surface elevations over the last Tidal Epoch (1951-1978), including astronomical tides, are shown in Table 3.1-1. These are derived using data obtained at the Charleston gage and corrected for estimates of water-surface levels at the local gages within the study area.

3.2 WIND

A wind-rose diagram, indicating average annual occurrence of both wind speed and direction, is shown in Figure 3.2-1. This diagram was derived from wind information for the period 1942-1972 as observed at the U. S. Air Force Base at Myrtle Beach (U.S. Air Force, 1975) and may be considered representative of conditions throughout the study area. In-depth analysis of similar data presented for each month over the period 1942-1972 indicates the predominance of NNE winds during the fall months (October-December). This corresponds to the more frequent occurrence of northeasters and associated higher levels of wave energy resulting in net southerly sediment transport, as well as more noticeable beach erosion observed during this period.

Similar analysis indicates the predominance of southerly winds during the summer months (April-August) corresponding to net northerly sediment transport and a gradual re-building of the beach by the longer, lower frequency summer waves. The months of October and November have the lowest average wind speeds (5.2 ft/sec) and the greatest occurrence (over 20%) of calm periods (winds less than one knot). Table 3.2-1 lists average wind speeds and directions on a seasonal basis as measured at the Myrtle Beach Air Force Base. The shoreline orientation of the study area varies

Table 3.1-1. Tidal Elevation Along Horry And Georgetown County Coast

	TIDAL ELEVATION (FEET)				
Location	MHW	MLW	MSL	HHW*	LLW**
Hog Inlet Pier	5.00	0.00	2.50	10.00 MLW	-3.5 MLW
Myrtle Beach	5.10	0.00	2.55	14.00 MLW	-2.5 MLW
Springmaid Pier	5.25	0.20	2.72	8.50 MLLW	-3.0 MLLW
Pawley's Island Pier	4.91	0.00	2.45	10.00 MLW	-3.5 MLW

*Estimated highest high water observed based on extreme water levels at Charleston, SC..

**Estimated lowest low water observed.

Source: NOAA-NOS, 1986

AVERAGE WIND ROSE FOR 1942-1947 &1949-1972 AT MYRTLE BEACH, SOUTH CAROLINA

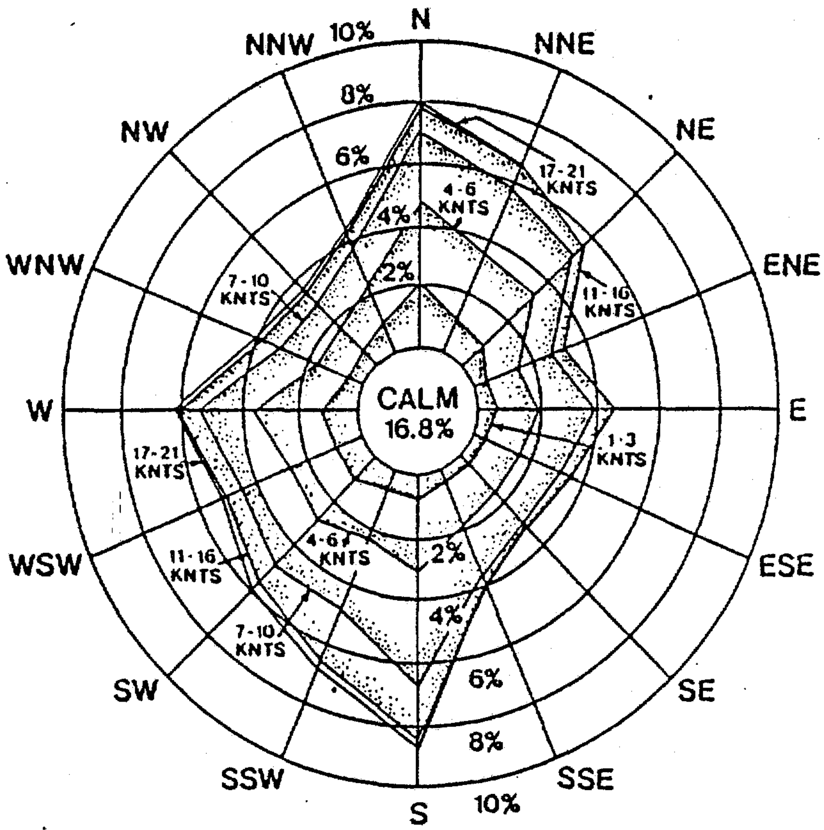


FIGURE 3.2-1
WIND ROSE AT MYRTLE BEACH, SOUTH CAROLINA

Table 3.2-1. Seasonal Mean Local Wind Speed Versus Wind Direction Given in Miles Per Hour (Measured at the Myrtle Beach Air Force Base).

	Wind Direction						
Season	ENE	E	ESE	SE	SSE	S	SSW
Jan-Mar	8.77	8.60	8.06	7.23	7.76	9.04	10.26
Apr-Jun	8.79	9.12	8.63	8.09	8.52	9.77	10.37
Jul-Aug	7.82	8.08	8.09	7.35	7.99	9.23	9.67
Sep-Dec	7.73	7.68	7.25	6.53	6.96	7.83	8.87

approximately 45° from an ENE-WSW orientation at the north end to a NNE-SSW orientation at the south end. As a result, wind from a particular direction will have a different bearing relative to the shoreline at different locations over the study area.

3.3 STORM DATA

The most severe hurricanes-of-record to affect Georgetown County struck the coast in 1822, 1854, and 1954. Hurricane Hazel (1954), characterized as a low-frequency storm produced peak storm tides of 6.0 to 10.0 feet along portions of the Georgetown County shoreline. Horry County was severely impacted by Hazel's 15.5 ft storm tides along Myrtle Beach and it was classified as a low-frequency 100-year return-interval storm event (COE, 1983).

Horry and Georgetown County have been adversely affected by significantly less severe hurricanes, the most recent being Hurricane David in 1979. The most recent significant hurricanes which made landfall along the South Carolina Coast are presented in Figure 3.3-1. High-frequency storms, referred to as northeasters, also produce a storm tide or super-elevation of the ocean that allows the propagation of greater wave heights onto the beach-dune face, often resulting in significant beach-dune erosion, vegetation loss and structural damage.

Often these more-frequent storms, which can severely impact the beach-dune system, are not well documented. During hurricanes, tropical storms and northeasters, the characteristic physical processes (current magnitude and direction, wave conditions, and sediment transport) in the nearshore zone may be drastically altered, resulting in the transport of large quantities of sand both offshore and along the coast. In addition, unstabilized inlets can be expected to undergo accelerated migration.

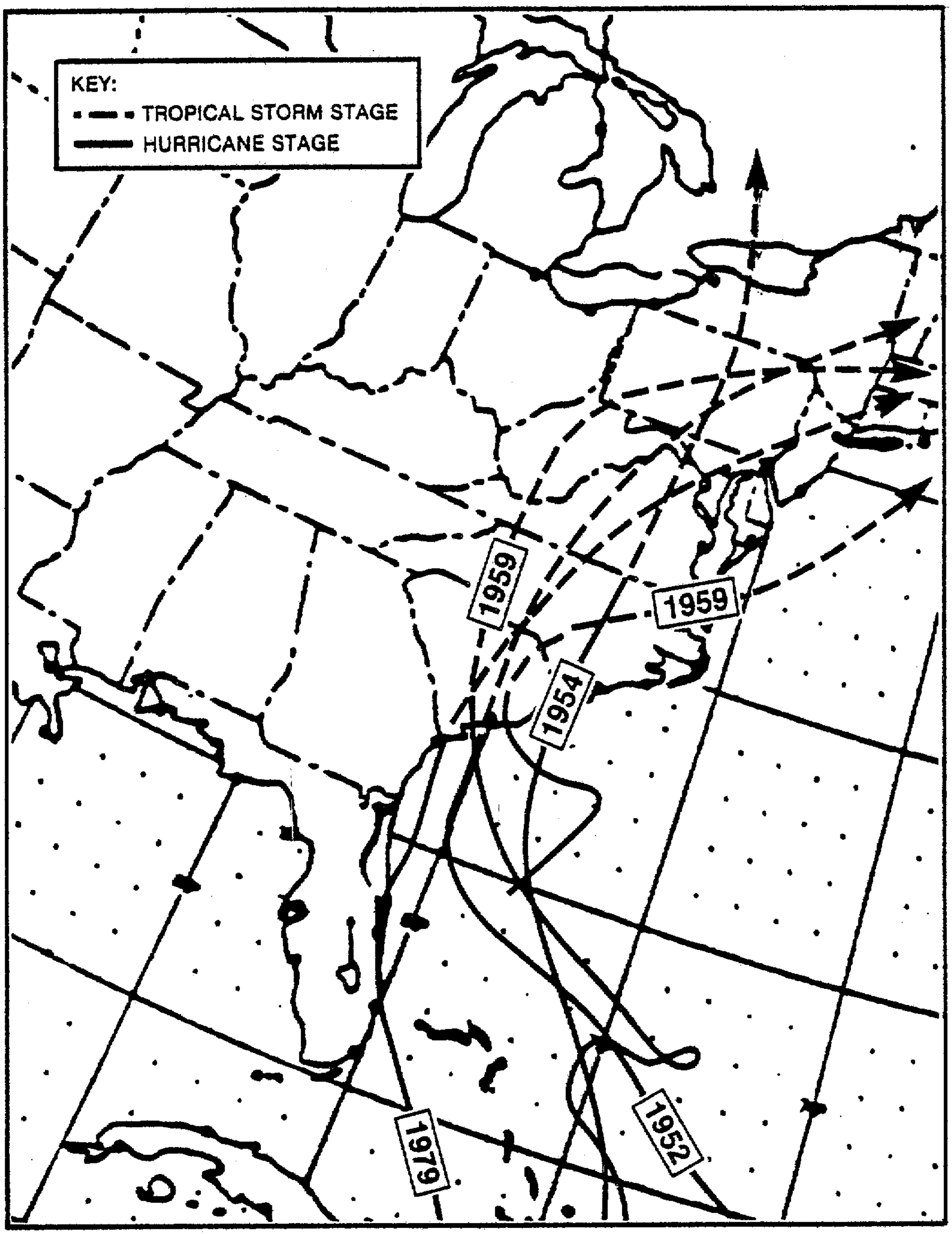


FIGURE 3.3-1
HURRICANE TRACKS FOR STORMS
IMPACTING THE SOUTH CAROLINA COAST
FROM 1952 TO 1979

Historically significant hurricanes that have tracked in relatively close proximity to the northern portion of the South Carolina coast have been analyzed by FEMA to determine site-specific hurricane characteristics. These historical storm parameters were applied in the estimation of future probabilities of the recurrence of flood conditions for the purpose of issuing flood insurance.

A statistical analysis of historical hurricane records along the Horry and Georgetown County and adjacent coastline areas was interpreted in a 1983 FEMA study to forecast the probable future incidence of a hurricane event. Relative to the Horry and Georgetown County shoreline orientation, 33° east of north, hurricanes were classified by their landfalling characteristics. Based on this analysis of documented tropical storms and hurricanes, the FEMA (1983) study estimates that 136 landfalling, exiting and alongshore storms can be expected to track within 150 nm of a point along the Horry and Georgetown County coast every 100 years. Figures 3.3-2 and 3.3-3 present storm tracks for hurricanes impacting the South Carolina coastline between 1883 and 1920.

A circle of radius equal to approximately 150 nm., whose locus is the center of Georgetown and Horry counties coastal segment defines the area where hurricane crossings could impact the Georgetown County coastal areas (Figure 3.3-4). Hurricanes tracking within 150 nm. of the coastline are designated as alongshore. Table 3.3-1 is a summary of the probability of occurrence of storm orientation reported in the 1983 FEMA study, using historical hurricane tracks for a 150-nm radius of the study area.

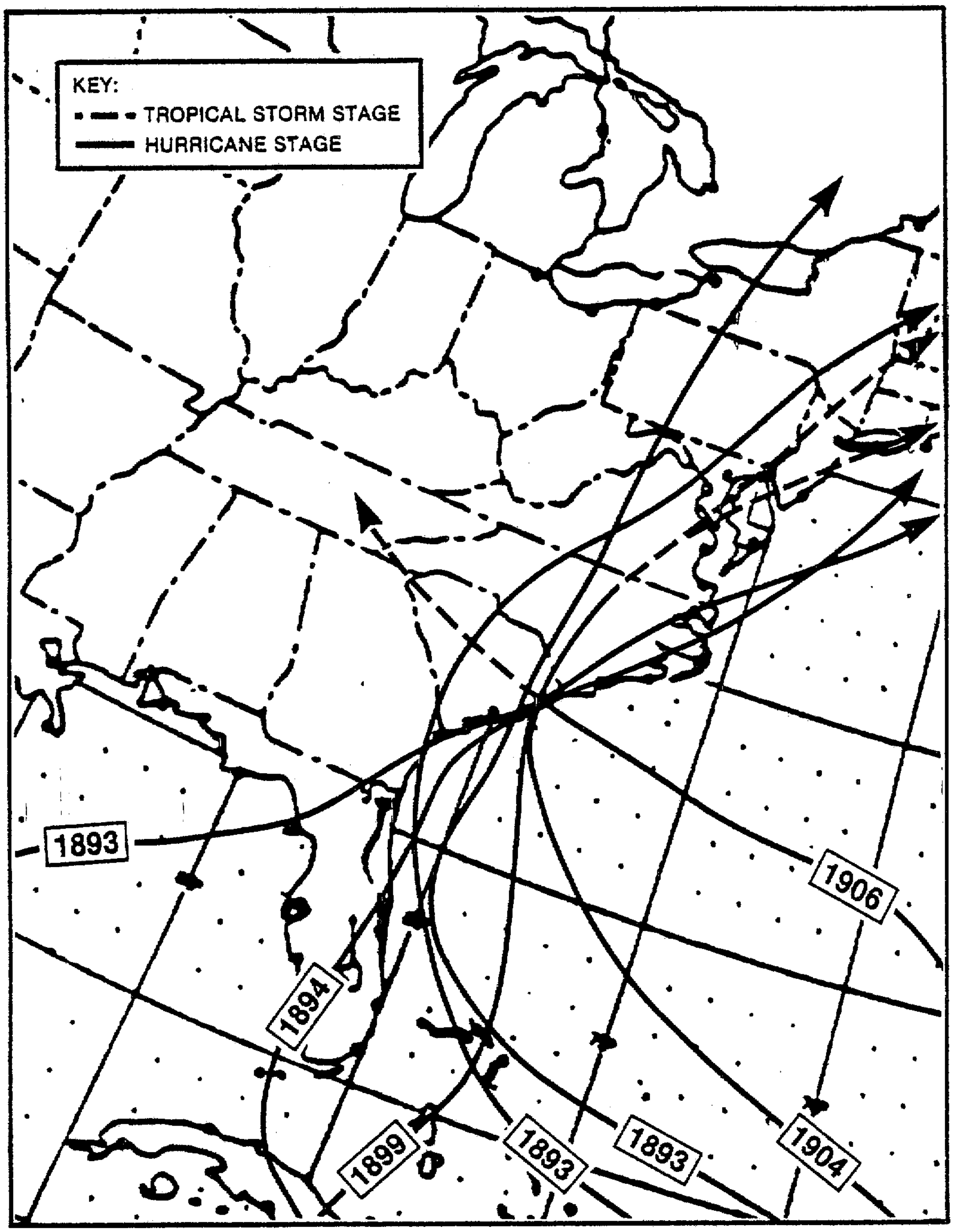


FIGURE 3.3-2
HURRICANE TRACKS FOR STORMS IMPACTING THE SOUTH CAROLINA COAST FROM 1883 TO 1906

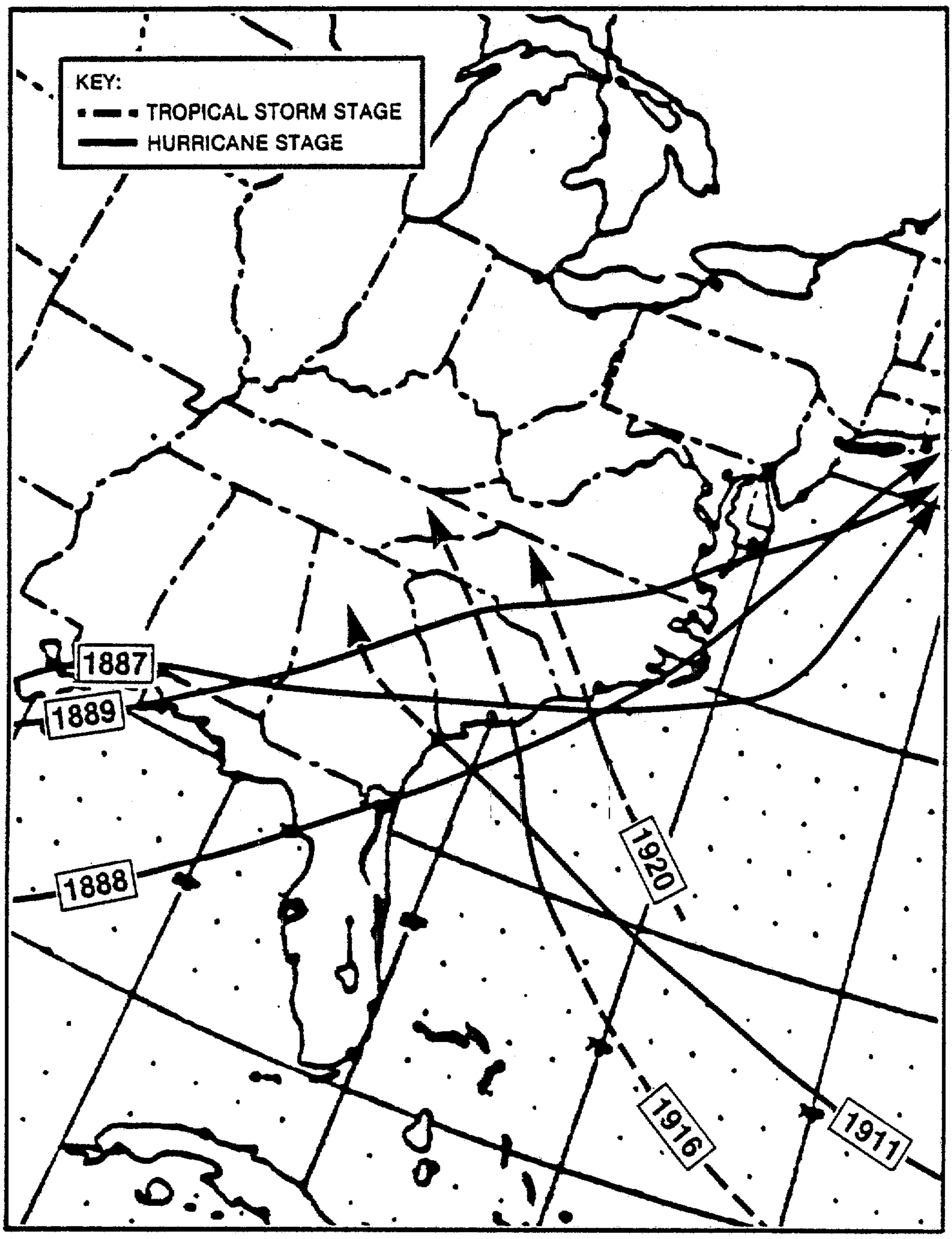


FIGURE 3.3-3
HURRICANE TRACKS OF STORMS IMPACTING THE SOUTH CAROLINA COAST FROM 1887 TO 1920

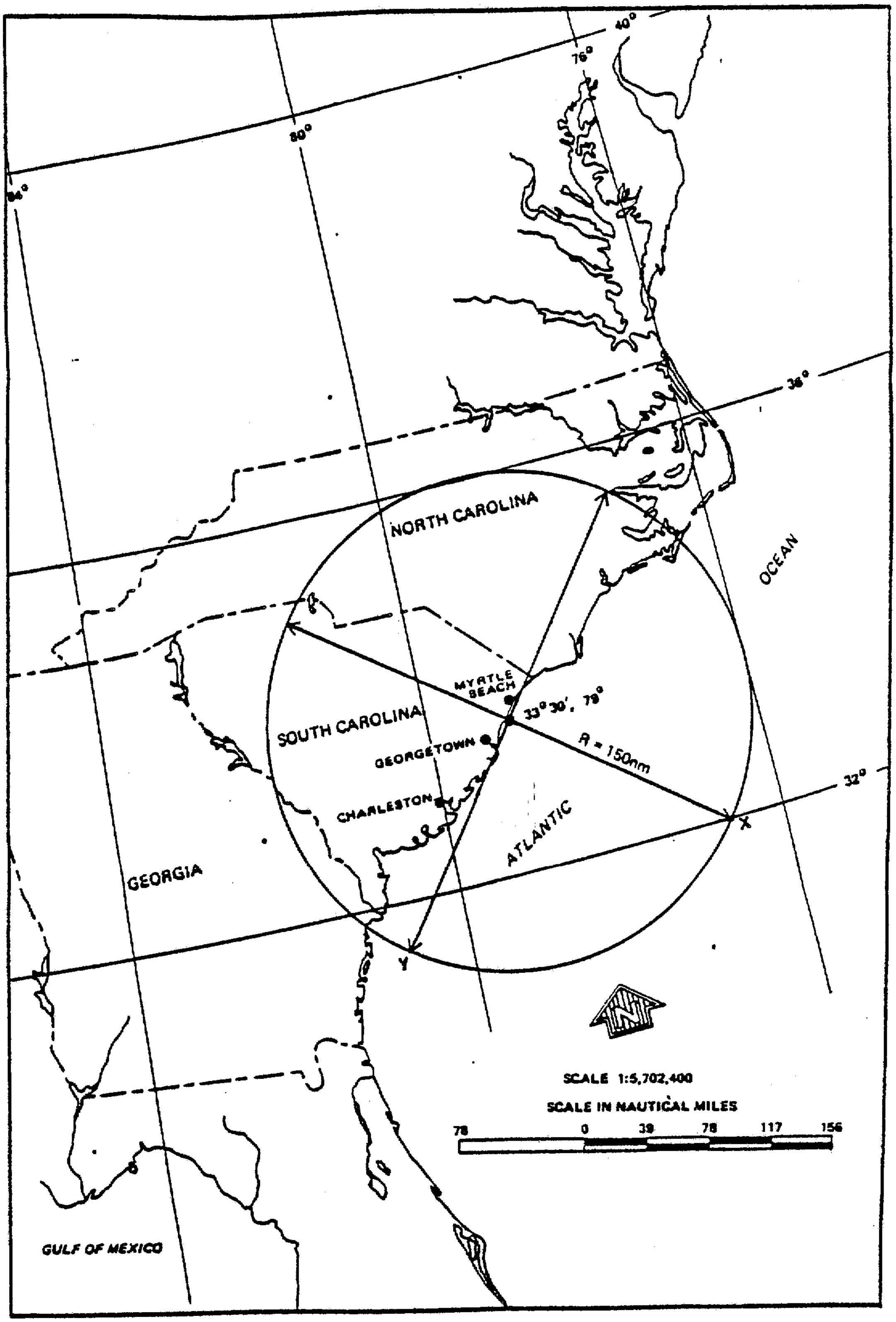


FIGURE 3.3-4
CROSSING AXIS AND CIRCLE FOR STORM STATISTICAL ANALYSIS - HORRY AND GEORGETOWN COUNTIES (FEMA, 1983)

TABLE 3.3-1

Landfalling storms	18.4%
Exiting storms	37.5%
Alongshore storms	44.1%

Predicted peak combined total storm tides for varying return intervals are presented in Figure 3.3-5 whereas Figure 3.3-6 presents the same for specific locations along the open coast.

An earlier study, done to determine maximum tide elevations for the entire coast of South Carolina, was conducted for the Federal Insurance Administration. Using the National Weather Service (NWS) SPLASH hydrodynamic model to calculate peak storm tides, Meyers (1975) predicted Hurricane Hazel's storm tide variation along the coast from Georgia to the South Carolina/North Carolina border (Figure 3.3-7). This particular hurricane struck the Myrtle Beach area at a time that coincided with that of the astronomical high tide. High water marks (which include wave effects) were documented as 15.5 feet at Myrtle Beach.

During a hurricane event, onshore winds displace the ocean water onto the local coastline. In the vicinity of an inlet along the adjacent low-lying shorelines, storm surge flooding with wave effects superimposed will erode the foreshore and, in some places, overtop the primary dunes. As an example, Hurricane Hazel caused seaside overtopping and breach of the spit extending south from Pawley's Island.

Hurricanes Grace (1959) and David (1979) are the most recent (since 1954) hurricanes to have directly impacted the Horry and Georgetown County shoreline. These storms were relatively moderate storms, characterized as high frequency 10-year return period events.

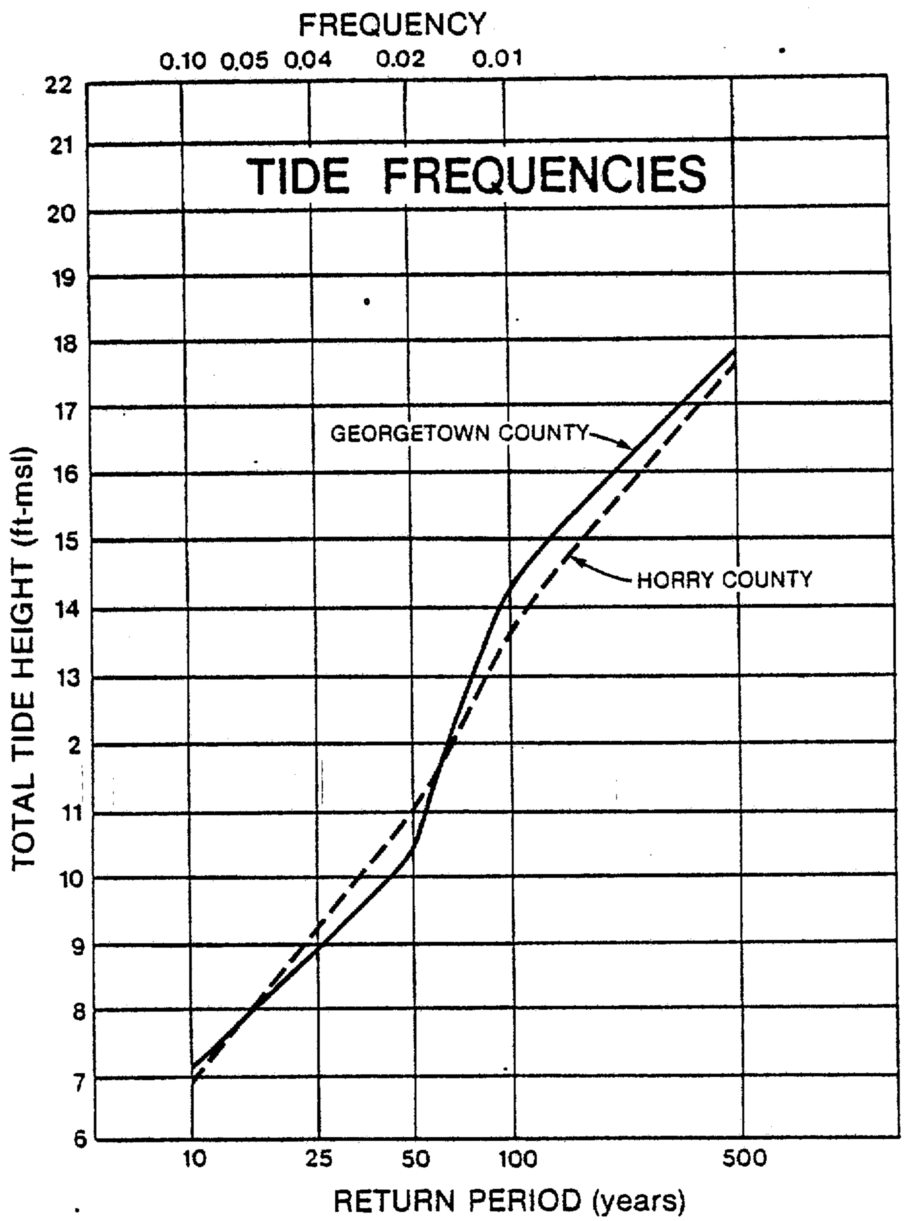


FIGURE 3.3-5
PREDICTED PEAK TOTAL COMBINED STORM TIDES FOR VARYING RETURN INTERVALS

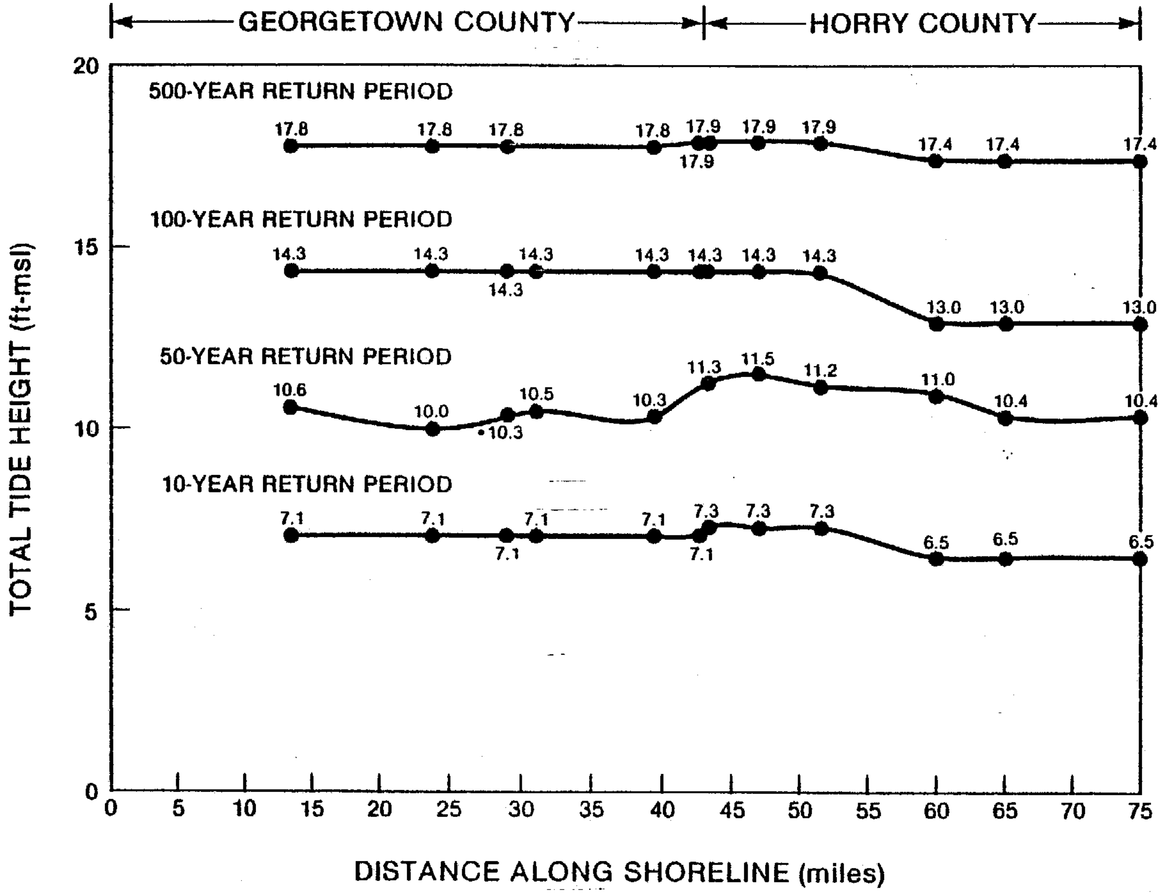


FIGURE 3.3-6
PREDICTED PEAK COMBINED TOTAL STORM TIDES ALONG THE HORRY AND GEORGETOWN COUNTY SHORELINE (FEMA, 1983)

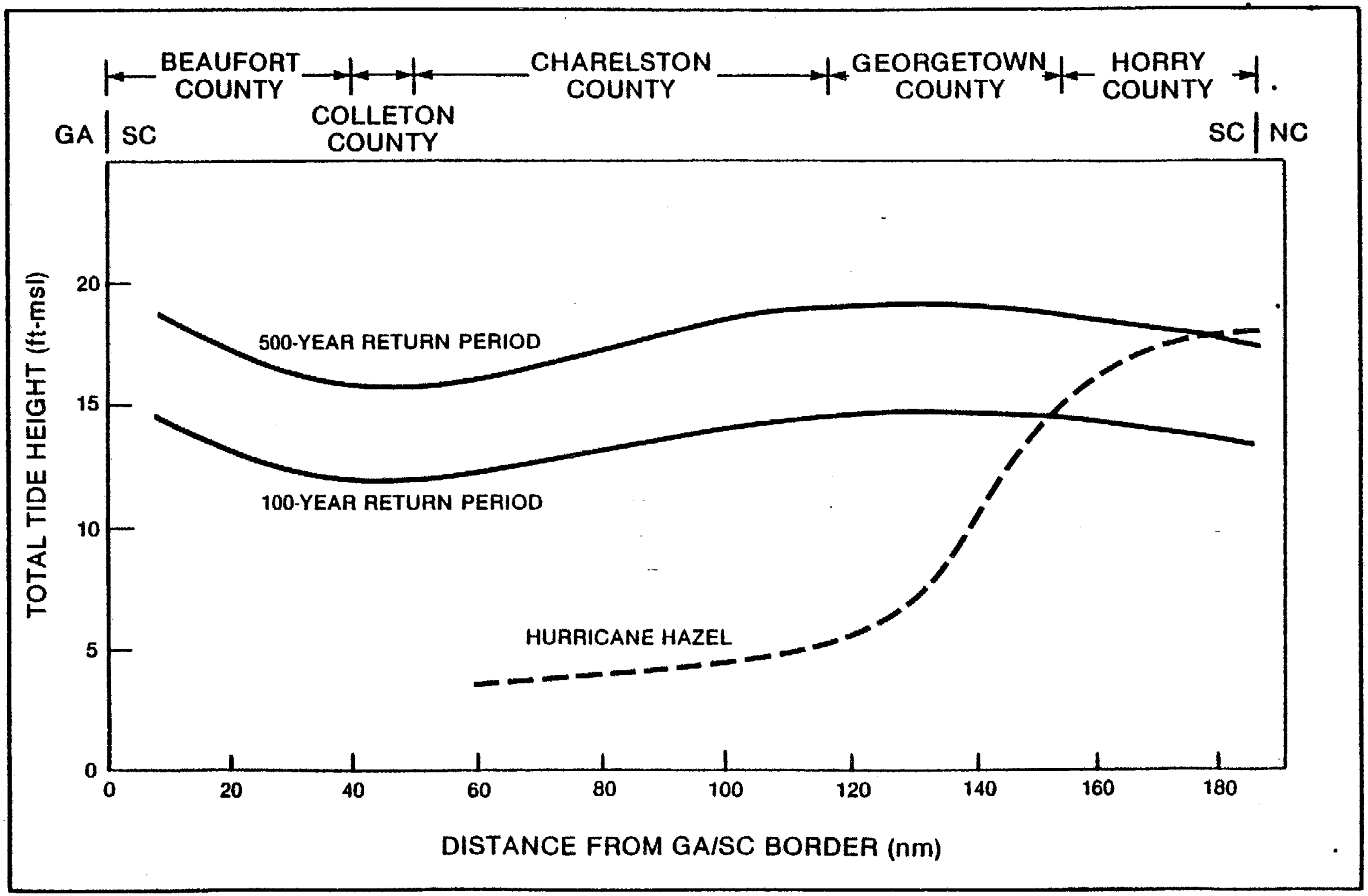


FIGURE 3.3-7
SPLASH SIMULATION OF HURRICANE HAZEL'S TOTAL COMBINED STORM TIDES ALONG THE SOUTH CAROLINA COAST (MEYERS, 1975)

3.4 WAVES

The Waterways Experiment Station (WES) of the U.S. Army Corps of engineers (USCOE) has compiled detailed hindcast wave statistics from a Wave Information Study (WIS) for the Atlantic Coast (USCOE, 1984). The data consists of wave height, period and direction computed for three-hour intervals, excluding tropical storms, over a 20-year period (1956-1975) at various stations located offshore along the coast. The data are presented in three phases:

> Phase I consists of large-scale numerical hindcast of deep water wave data from historical surface pressure and wind data.
>
> Phase II consists of numerical hindcasts at a finer scale to better resolve the sheltering effects of the continental geometry. Phase I data serve as the boundary conditions at the seaward edge of the Phase II grid.
>
> Phase III consists of transformation of Phase II wave data into shallow water and includes long waves.

Phase III wave data are not yet available for the stations appropriate to the study area; however, shallow water wave calculations have been made for Myrtle Beach by means of a wave-refraction computer model (Siah et al. 1984) utilizing the Phase II data. The results of these calculations are included as a general representation of shallow-water wave conditions typical of the study area.

WIS station 47, located at latitude 33.64° north and longitude 78.13° west, or approximately 40 miles due east of Myrtle Beach, is the closest station with available wave data for the study area. Accordingly, Phase II data from this station were summarized and input into the aformentioned wave refraction model to obtain shallow water wave data. Figure 3.4-1 presents a seasonal summary of this

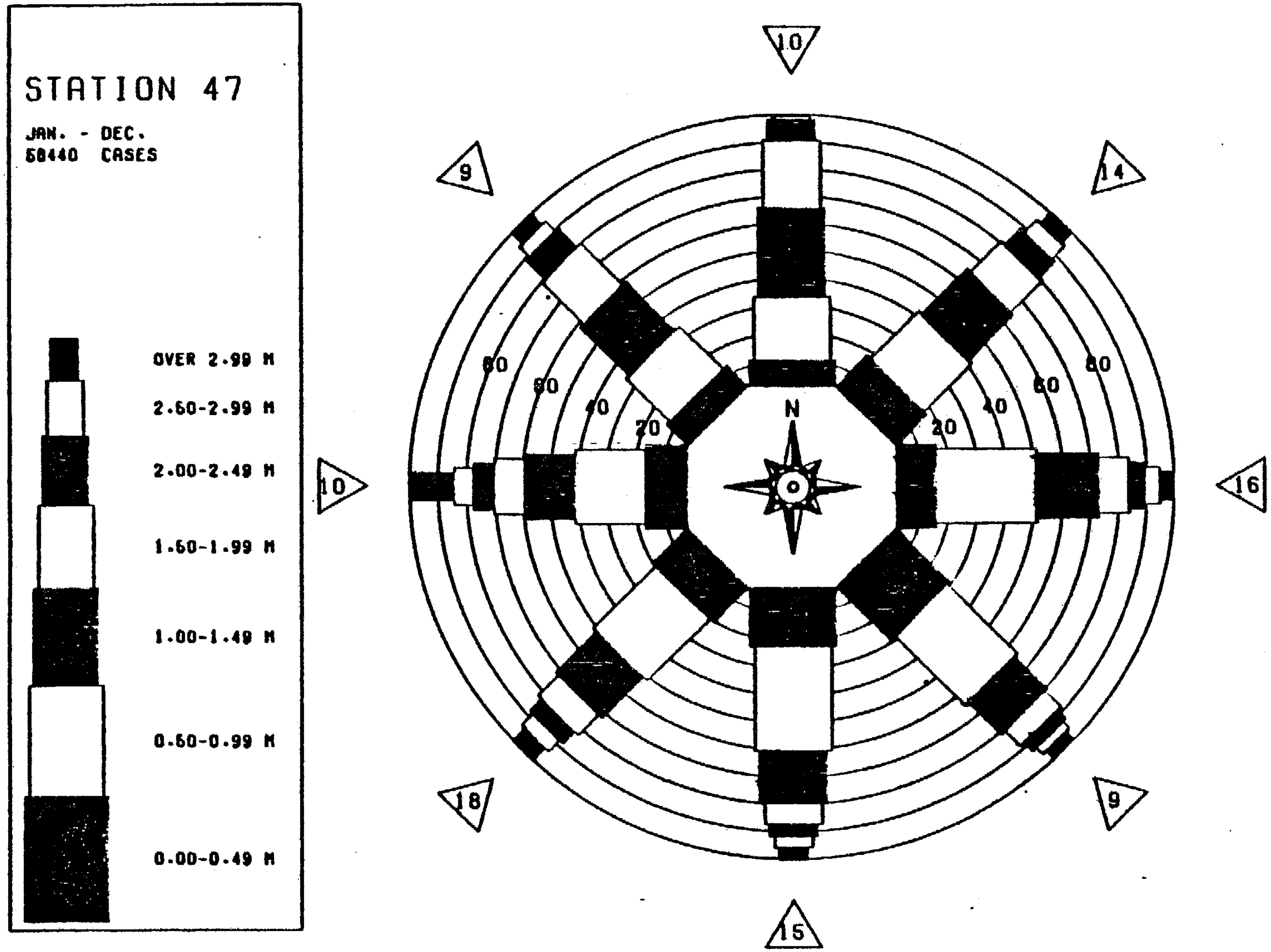


FIGURE 3.4-1
WAVE ROSE OFFSHORE OF MYRTLE BEACH

Phase II data in the form of a wave rose for waves refracted landward from deep water. Table 3.4-1 presents a seasonal summary of onshore wave conditions calculated by refracting the Phase II data over the nearshore bathymetry in the Myrtle Beach area. It should be noted that the onshore wave conditions depicted in Table 3.4-1 occurred only when weather conditions were conducive to their formation and therefore do not represent an annual average. Rather, they represent average conditions when waves actually occur from this direction window, during 49% of the year. The remaining 51% of the year may be considered as either calm or lacking any significant onshore wave energy component. Inclusion of these periods in the calculation of average wave conditions will result in lower average wave heights than presented in Table 3.4-1. It should also be noted that the approximately 45° shoreline variation over the study area, as well as localized refraction and shoaling in the vicinity of inlets will result in significant variations in wave orientation relative to the shoreline over the entire study area.

3.5 LITTORAL DRIFT ESTIMATES

Alongshore sediment transport, or littoral drift, is driven by the shore-parallel component of current velocities in the surf zone. In concurrence with onshore/offshore sediment transport, littoral drift is the primary factor that determines long-term changes in beach morphology. Unnoticeable on a day to day basis except during storms, this form of sediment transport becomes significant when interrupted by a shore normal structure such as a groin or jetty. The currents driving this littoral drift result primarily from the transfer of momentum by wave forces and secondarily from wind, tidal and Coriolis forces. Frictional forces near the bottom and turbulence resulting from velocity gradients across the surf zone act to reduce the current velocity.

Table 3.4-1. Average Occurring Wave Heights (ft) by Direction and Season for the Myrtle Beach Area (Siah et al,1984).

	Wave Direction						
Season	ENE	E	ESE	SE	SSE	S	SSW
Jan-Mar	4.4	4.8	4.4	4.5	4.3	4.2	4.4
Apr-Jun	3.1	3.2	3.1	3.2	3.1	3.0	2.9
Jul-Sep	2.9	3.3	2.8	2.2	2.4	2.1	2.4
Oct-Dec	4.1	4.3	4.0	3.8	4.1	3.9	3.8

The direction of littoral drift varies with the direction of longshore currents. Seasonal trends within the study area indicate southerly transport in the fall, winter, and early spring months and northerly transport in the summer. These trends, however, vary annually as well. As a result, annual gross transport volumes often far exceed annual net transport volumes. The direction and quantity of net transport depends primarily on the wave climate over the time period and the shoreline location. It should be noted that the largest percentage of the gross and net annual littoral transport occurs during storm events.

Many methodologies and associated formulas have been presented to quantitatively predict magnitudes of alongshore sediment transport. Generally, these formulas become quite complicated while the accuracy of their predictions often remains questionable. Rather than derive a new methodology or assess the validity of existing ones, Table 3.5-1 presents predictions of sediment transport rates made in previous studies of the northern reach of the South Carolina coast. From this table, a qualitative assessment of littoral drift rates may be made. It is important to note that the presence of groin fields, natural inlets as well as stabilized inlets, and the approximately 45° difference in shoreline orientation will result in significant localized variation in sediment transport rates over the study area.

3.6 HISTORICAL AERIAL PHOTOGRAPHS

The most comprehensive aerial photographic records of the South Carolina coastline, of reasonable resolution (1:20000), are available from the Agricultural Stabilization and Conservation Service (ASCS) and NOS. A detailed listing of aerial photographic records is available through the South Carolina Cartographic Information Center, Columbia, South Carolina.

Table 3.5-1 Previous Estimates of Net Littoral Drift Rates in the Myrtle Beach Vicinity

Source	Region	Net Drift Rate - Direction
CSE/OA (1985)	Myrtle Beach	3.4×10^5 yd^3/yr. - Southerly
Finely (1976) & Nummendahl & Humphries (1977)	Debidue, North Islands	$0.72 - 3.21 \times 10^5$ yd^3/yr* - Southerly
Kana (1976)	Capers Island	$0.82 - 2.72 \times 10^5$ yd^3/yr* - Southerly
Kana (1976)	Bull Island	1.67×10^5 yd^3/yr - Southerly
Knoth & Nummendahl (1977)	Bear Island	$0.74 - 1.89 \times 10^5$ yd^3/yr* - Northerly
USACE, Charleston (1975)	Murrell's Inlet	1.32×10^5 yd^3/yr - Southerly
Hubbard, et al. (1977)	Murrell's Inlet	2.28×10^5 yd^3/yr - Southerly

*Converted from tons/yr assuming a specific weight of 90 lbs/ft^3.

Aerial photographs are useful in assessing historical shoreline changes in order to distinguish between long-term trends and short-term trends. After corrections for true scale and camera tilt are included, limitations and errors in calculating shoreline movement are primarily due to water level corrections and locating the still water line excluding the effects of wave motion.

Aerial photos of Murrells Inlet and the adjacent shorelines were taken by the COE between 1977 and 1981 on a monthly basis. Extending over 14 miles of shoreline from the Surfside Holiday Inn area south to Midway Inlet, flights were continued through October 1982 on a quarterly basis.

Qualitative analysis along the entire Georgetown County shoreline using photographs from 1872 to 1973 (Hubbard, 1977) provides data to assess long-term shoreline variability. The summations of individual measurements were used to calculate the 25-, 50- and 100-year net accretion and erosion trends.

Using NOS-COE shoreline movement maps for Georgetown County from 1873, 1925-26, 1934, 1962-63, 1969-70, and 1983, shoreline changes were depicted for each of the inlet areas and described in more detail in Section 7.0.

In addition, assessment of both shoreline movement changes and shorefront development patterns relied upon historical aerial photographs provided by ASCS, NOS and SCCC. These data cover an extensive period of records beginning in 1939 with more frequent flights in later years.

3.7 SHORELINE DATA

Historical shoreline changes are a valuable indicator to measure erosion trends and assess littoral processes.

Qualitative depiction of the shoreline changes can be obtained from the comparison of aerial photographs. Section 3.9 lists the available aerial photographs within the study area. These photographs were usually taken at different tides, therefore they may not be adequate to represent short-term changes because of the resolution and accuracy. However, they represent the long-term shoreline changes reasonably well.

To qualitatively depict shoreline changes, the National Ocean Services (NOS) and Coastal Engineering Research Center have compiled aerial photographs, historical shoreline surveys, and U.S. Geological Survey base maps to construct a series of shoreline movement maps from Cape Henlopen, Delaware to Tybee Island, Georgia. These maps were horizontally controlled according to the 1927 North American datum. These shorelines indicate the location of local mean high water line relative to 1929 NGVD. Shoreline movement maps covering the study area were compiled from the January 1983 NOS aerial photography and field surveys performed in 1969-70, 1962-63, 1934, 1925-26, and 1872. Since these maps were both horizontally and vertically controlled, they were used as the primary data source to estimate the long-term erosion rate in the study area.

3.8 BEACH PROFILE DATA

Comparative beach-dune profiles derived from periodic field surveys relative to permanent vertically controlled stations provide a high quality data base. Initially these data collected for specific time intervals (5 to 10 year period) allow valuable estimates of short-term shoreline fluctuations. In future years (20 to 30), these data will be useful in predicting local long-term erosion rates. In addition, the shoreline recession associated with sea-level rise and storm effects can be more accurately quantified.

During a 1955-58 COE post-hurricane reconnaissance study for Horry and Georgetown Counties (COE,1983), surveys were conducted within Horry County along Surfside Beach and Garden City shoreline areas. In April 1958, 12 stations were established and profiles surveyed, of which 4 were located and replicated in the present study for comparative analysis. The seaward limit of these profiles was approximately -2.0 feet MSL (1929 NGVD). Subsequently, between November 1983 and March 1984 the COE resurveyed the stations established during the previous 1955-58 erosion study. In addition, 11 new stations were established along the shoreline between White Point Swash and Singleton Swash. Along the shoreline fronting Myrtle Beach State Park and Surfside Beach the COE established control points and surveyed 7 new stations. All beach profiles were surveyed by the Charleston District COE and referenced to MSL. Documentation of several profile surveys, provided by the COE, required considerable investigation to vertically and horizontally adjust these data into the 1986 replicated station data. Station control points (Bench Marks) were located and surveyed by Sur Tech (registered land surveyers) to assure vertical control for the analysis of comparative beach profiles in the present study.

Comprehensive monitoring to evaluate both the effects of the Murrell's Inlet jetties on the adjacent shorelines and the hydraulic performance of the jetties on sediment transport processes began in September of 1979. The COE has established brass-capped concrete monuments and documented bench marks extending north 7 miles to the northern limit of Surfside Beach and extending 7 miles south to Midway Inlet. Monitoring stations, extending both north and south, were located at greater spacing intervals with increasing distance from the inlet. A total of 43 offshore profiles were surveyed quarterly by the Charleston District COE over a 5-year period, after which 18 profiles are to be surveyed on a semi-annual basis through 1987. Profiles were surveyed offshore to the -18.0 ft contour for all profiles, using a fathometer at high tide to overlap points surveyed from land using a rod and level.

Profiles along the Horry County study area were located along the Surfside and Garden City shoreline extending from 2500 ft north of Surfside Fishing Pier south 2.8 miles to a point approximately 500 ft north of Kingfishers Pier. These profile transects were spaced at 5000 ft intervals perpendicular to the 1977 shoreline as shown in Figure 3.8-1.

Comparative beach surveys were analyzed using the CERC-developed program Interactive Survey Reduction Program (ISRP). Capabilities of ISRP include data reduction, editing, plotting and volumetric changes between successive surveys along the length of the profile.

A beach profile survey program was conducted by the project team in April 1986. After reviewing the historical beach profile data collected by U.S. COE and other investigators between 1958 and 1984, 38 survey stations were established in the Horry County study area. The spacing between the stations was generally 1/3 mile. Of these stations, 22 stations coincided with the historical survey stations which were either recovered or replicated according to the historical survey notes. The remaining 16 stations were new stations established during the present study. There were 13 stations located in the Myrtle Beach North area, 11 in the Myrtle Beach South area, 9 in Surfside Beach, and 5 in Garden City within Horry County. Figures 3.8-2 and 3.8-3 show the locations of each survey station.

Each survey station consisted of a survey monument and corresponding benchmark (BM). The survey monument provides

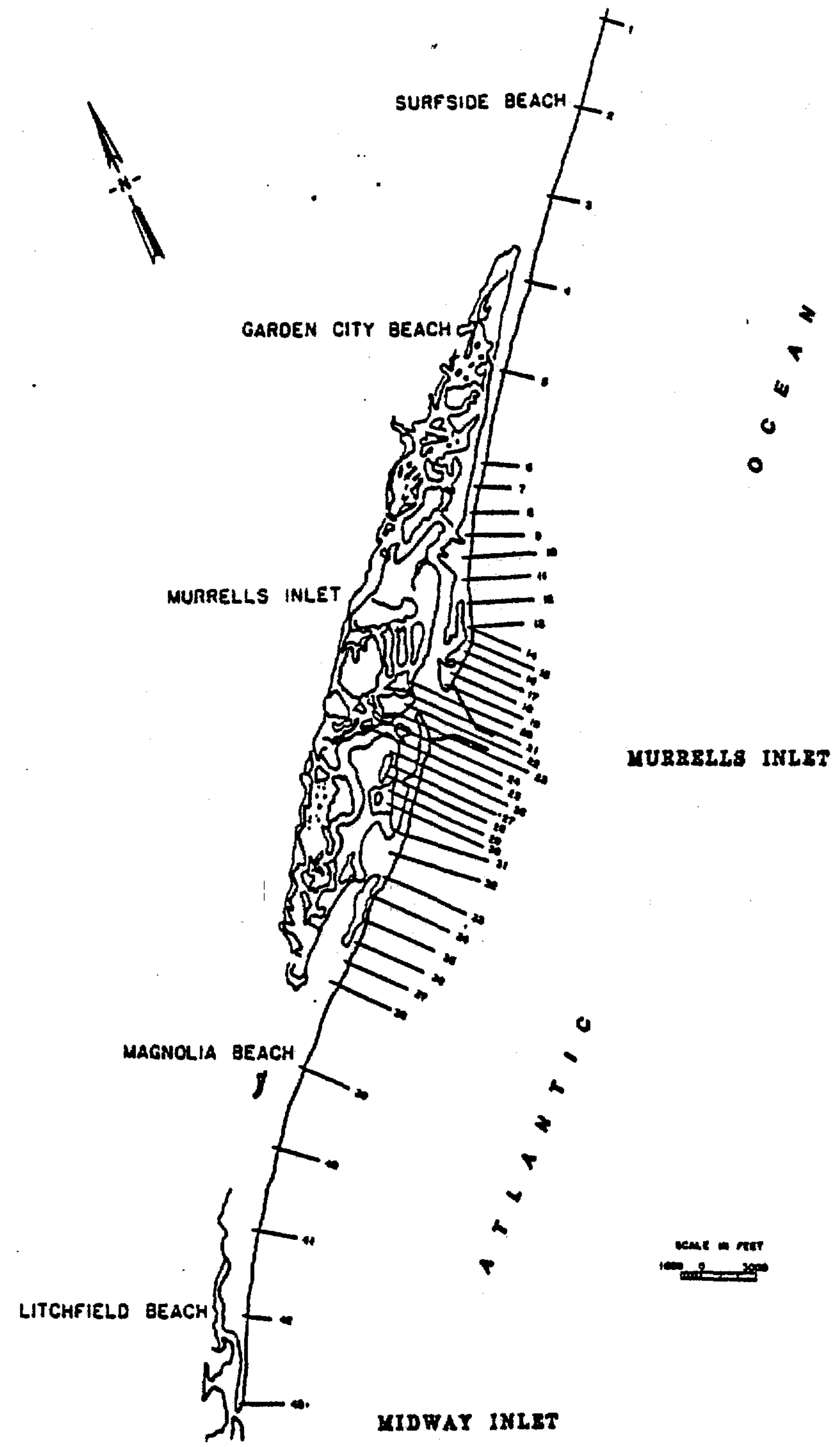


FIGURE 3.8-1
SURVEY PROFILE LOCATION MAP FOR
MURRELLS INLET MONITORING PROGRAM

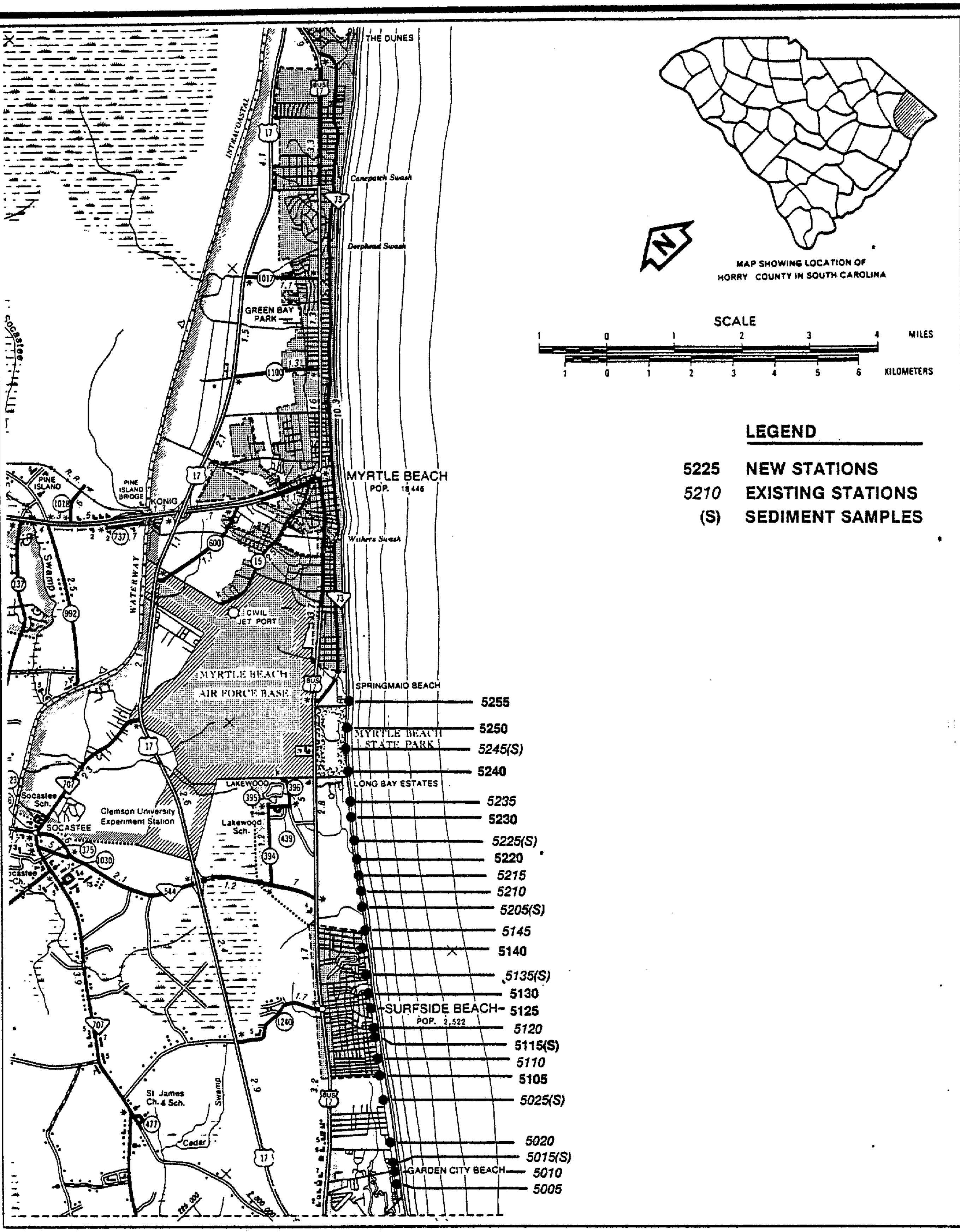


FIGURE 3.8-2
BEACH PROFILE SURVEY AND SEDIMENT SAMPLING STATIONS IN MYRTLE BEACH NORTH STUDY AREA

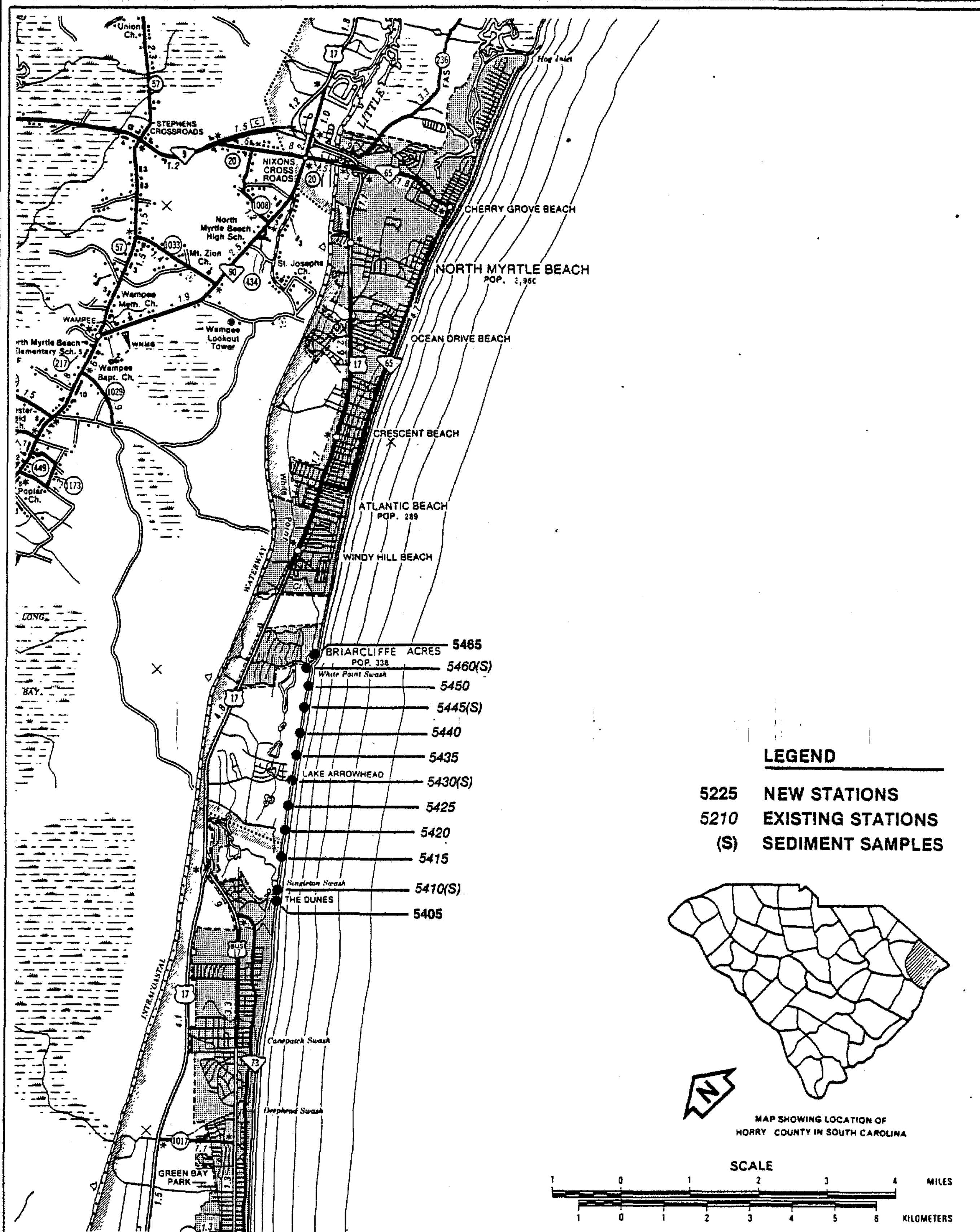


FIGURE 3.8-3
BEACH PROFILE SURVEY AND SEDIMENT SAMPLING STATIONS BETWEEN MYRTLE BEACH AND GEORGETOWN COUNTY

permanent demarcation of the station location as well as a reference point from which to conduct beach profiles. The location of the monuments were carefully documented with survey notes which include general location descriptions, monument descriptions and tie-in distances to nearby landmarks, profile azimuths and relative offsets. The documentation should allow survey replication on a later date even though the monument may be destroyed. Newly established or replicated survey monuments consisted of a P,K. nail and brass cap on which a 4-digit SCCC station number was inscribed, attached to either a permanent structure of an eight foot section of 4 in. by 4 in. wood post embedded near the sand dune in more remote areas. The associated BM, a vertically controlled reference point with elevation surveyed in relation to MSL, usually took the form of a railroad spike in a 4 in. by 4 in. post or a power pole, a P.K. Table 3.8-1 shows a list of the SCCC station numbers, the transect bearings, and the associated COE station number.

Profile azimuths were generally perpendicular to the shoreline orientation. Wherever possible, surveys commenced well landward of the actual beach foreshore in order to include all relevant portions of the active dune system or characteristic upland at each station. The profile surveys extended seaward to MLW at the majority of the stations. Sediment samples were taken from three locations at each of 11 survey stations for grain size analysis. The three sample locations corresponded to the toe of dune or existing seawall, MHW and MLW. Sediment sample stations are presented in Figures 3.8-2 and 3.8-3 and Table 3.8-1

3.9 SEDIMENT DATA

Previous studies to evaluate the native beach sand on Horry County's shoreline for grain size characteristics and statistics were collected and documented for this 1983 COE

Table 3.8-1. Survey Stations Cross-Reference Table.

Area	SCCC #	CERC # (1979-82)	COE # (1958-84)	Bearing	Sediment Sample
Myrtle Beach North	5465	--	--	S38E	
	5460	--	78+08	S32E	x
	5455	--	98+08	S32E	
	5450	--	118+08	S32E	
	5445	--	138+08	S32E	x
	5440	--	158+08	S32E	
	5435	--	178+08	S32E	
	5430	--	198+08	S32E	x
	5425	--	218+08	S32E	
	5420	--	238+08	S34E	
	5415	--	258+08	S36E	
	5410	--	278+08	S38E	x
	5405	--	--	S38E	
Myrtle Beach South	5255	--	--	S44E	
	5250	--	--	S44E	
	5245	--	500+00	S42E	x
	5240	--	540+00	S50E	
	5235	--	540+00	S50E	
	5230	--	--	S48E	
	5225	--	565+00	S54E	x
	5220	--	--	S54E	
	5215	--	594+55	S48E	
	5210	--	610+00	S50E	
	5205	--	630+00	S50E	x
Surfside Beach	5145	--	650+00	S44E	
	5140	--	--	S46E	
	5135	341+50	--	S52E	x
	5130	--	--	S44E	
	5125	--	--	S44E	
	5120	--	71+08	S44E	
	5115	291+50	--	S54E	x
	5110	--	93+33	S44E	
	5105	--	--	S44E	
Garden City	5025	241+50	--	S53E	x
	5020	--	151+08	S48E	
	5015	191+50	--	S55E	x
	5010	--	182+70	S53E	
	5005	175+00	--	S54E	

Sources: Applied Technology and Management, Inc. and Olsen Associates, Inc. 1986

Table 8.1-1. Ideal Present Dune Crest Locations

Station	IPS Location (ft)*
Garden City	
5005	89
5010	
5115	114
5020	174
5025	175
Surfside Beach	
5105	159
5110	194
5115	210
5120	233
5125	296
5130	281
5135	219
5140	193
5145	-16
Myrtle Beach South	
5205	-13
5210	-14
5215	-19
5220	80
5225	-6
5230	16
5235	-12
5240	-2
5245	8
5250	-6
5255	-17
Myrtle Beach North	
5404	-12
5410	-6
5415	-49
5420	-16
5425	-23
5430	-30
5435	-37
5440	-23
5445	-21
5450	-21
5455	-17
5460	7

*IPS location is measured seaward from the survey monument.

Reconnaissance Report, North Myrtle Beach Study (1986) and Myrtle Beach Study.. References to beach and dune sediments are described qualitatively in the geomorphology sections of recent shoreline studies (CSE; 1985 and Cubit, 1981) apparently sediment sampling was not included as a data collection task.

To provide basic sediment grain size statistics such as mean phi, median phi, and the relative grain size distributions(phi-84 and phi-16) along the Myrtle Beach shoreline, a summary of data collected in a 1955 COE study is presented. Surface sand samples were taken at Myrtle Beach during September and October field reconnaissane survey and analysed for grain size distributions. Samples were taken at 16 locations along the foreshore area at mid-tide. Table 3.9-1 presents a summary of these data averaged for all locations.

In 1972, sand samples were taken by the COE at three locations along Garden City and analysed for grain size distribution. The average mean grain diameter of these samples was 0.33 mm for a composite representing sediments sampled at the toe of the dune, mid berm "at water's edge".

Beach sediment samples along North Myrtle Beach (Kana, et. al.) were colleted in a 1985 study to determine the distribution of sediment characteristics along the beach foreshore area. Mean grain size, standard deviation, skewness and size fractions were computed at 3 locations along eight stations. They descibed these samples as well-sorted fine sands (2.0 to 3.0 phi or 0.25 to 0.125 mm) with average mean grain-size equal to 2.64 phi or 0.16 mm. Variation along the length of shoreline represented by these samples was found to be negligible and uniform across the profile. It should be noted that the sediments were collected at +6.0, +2.5 and -2.5 feet (MSL) elevations along

Table 3.9-1. Summary of Sediment Characteristics

NATIVE BEACH SAND AT THE MID-TIDE LEVEL

AVERAGE	Phi_{84} 1/	Phi_{16} 2/	Phi_{Mean} 3/	$Phi_{sorting}$ 4/	Median Dia (mm) 5/
15 surface samples	2.50 (0.18mm)	1.45 (0.37mm)	1.98 (0.26mm)	0.53	0.23
13 samples from 1 ft below surface	1.55 (0.17mm)	0.65 (0.64mm)	1.10 (0.33mm)	0.43	0.27
28 samples (both types)	2.53 (0.17mm)	1.18 (0.44mm)	1.86 (0.28mm)	0.68	0.24

1/ 84% of the sand has a diameter greater than that shown.
2/ 16% of the sand has a diameter greater than that shown.
3/ Average of Phi_{84} and Phi_{16}.
4/ One-half the difference between Phi_{84} and Phi_{16}.
5/ Half the sand is larger and half smaller than the indicated size.

GARDEN CITY BEACH NATIVE BEACH SAND SAMPLES

PROFILE SECTION	LOCATION ON PROFILE	16 PHI UNITS	84 PHI UNITS	MEAN PHI UNITS	S.D. PHI UNITS	MEDIAN DIAM PHI UNITS	MEDIAN DIAM mm	SHELL CONTENT
70 + 00	Toe of Dune	1.89	2.32	2.11	.22	2.12	.23	1%
	Mid Berm	1.94	3.06	2.50	.56	2.32	.20	1%
196 + 05	Toe of Dune	.32	2.32	1.32	1.00	1.84	.28	21%
	Mid Berm	1.43	2.47	1.95	.52	1.19	.27	1%
	Water's Edge	.80	2.40	1.60	.80	1.74	.30	1%
255 + 00	Toe of Dune	0.0	2.25	1.13	1.13	1.36	.39	32%
	Mid Berm	-.07	2.40	1.17	1.24	1.51	.35	34%
	Water's Edge	-.14	2.40	1.13	1.27	1.79	.29	39%
Composite		0.77	2.45	1.61	0.84			

Source: COE Reconnaissance Report, 1983

the profile.

From a comparison of sand from Garden City, North Myrtle Beach and Myrtle Beach, sand sizes vary consistently along the length of the shoreline. The average mean grain size for North Myrtle Beach, Myrtle Beach and Garden City were computed to be 0.16, 0.20 and 0.33mm, respectively. As part of the present study, sediment samples were taken from 21 survey stations. At each station, three samples were collected at the toe of the dune, MHW and MLW. The sampling stations are shown in Figures 3.8-2 and 3.8-3 and Table 3.8-1. The results of the sediment analysis are presented in Section 5.

3.10 BEACH MORPHOLOGY

Beach morphology varies considerably over the study area and an area-wide classification can only be given in general terms. Factors contributing to this overall variation include the proximity of tidal inlets and swashes, the amount and type of development along a particular reach, shoreline orientation, the existence of shoreline erosion control structures and the quantity of sediment supply available to the reach, in particular, local variations in supply.

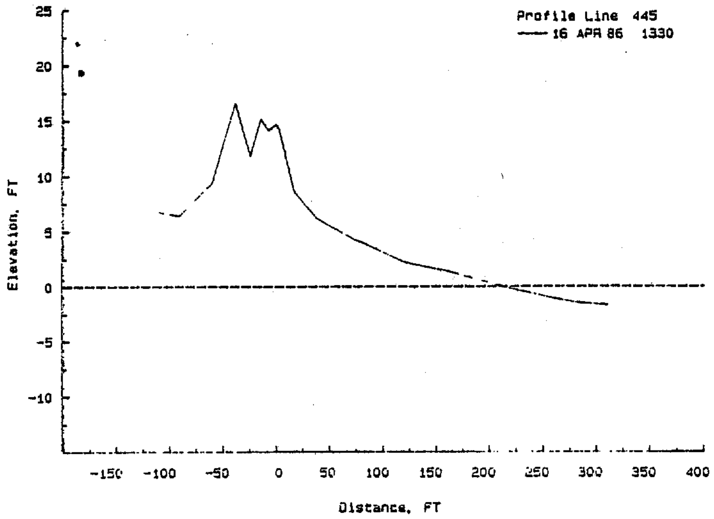
In general, the intertidal portion of the beaches in the study area may be classified as mildly sloping beach of low elevation. This combination results in a relatively wide, low-tide beach, and also results in minimal or nonexistent high tide beaches at many locations. This characteristic is a result of the considerable tide range combined with the relatively small grain size of the natural beach sediments that maintain a mild beach slope. Occasionally along the study area, this flat beach face is interrupted by an upper beach berm above the mean high water line (MHWL). It leads up to the dunes or to the immediate upland where the dunes have been removed or destroyed. At several locations along the study area, beach surveys showed evidence of active ridge and runnel and associated swash-trough systems indicating seasonal onshore transport that would be expected during the month of the survey, i.e. April. The shorelines adjacent to tidal swashes along barrier islands within the study area exhibit southerly migration trends in the form of migrating spits.

<u>White Point Swash to Singleton Swash</u>

The northern 1.7 miles of this reach are characterized by a well-developed, well-vegetated dune system consisting of 2 and 3 distinct dune ridges averaging +15 to +18 feet in elevation (NGVD). During the survey, the seawardmost dunes along the entire northern reach showed some evidence of scarping resulting from high water levels and run-up associated with storms and/or abnormally high tides. Scarping is potentially indicative of a receding shoreline. At the toe of these dunes begins the beach face at an average elevation of +6 ft. Due to the absence of a beach berm, the beach profile slopes continuously towards the ocean. A somewhat wider and flatter beach exists along the northernmost 1,000 ft of this reach as a direct result of the small shoal system in the vicinity of White Point Swash. Figure 3.10-1a presents a profile typical of this stretch of shoreline.

The remaining 2.2 miles of this reach, extending south to Singleton Swash, have been significantly affected and altered by coastal development. As a result, the high dune ridges that characterized the northern reach are virtually non-existent along the southern reach. Likewise, vegetation has been severely depleted here. The upper or back beach profile is typically defined by either shoreline armoring or the low (+10 ft or less) sand mounds which is typical of the campgrounds in the study area. Virtually the entire beach

A



B

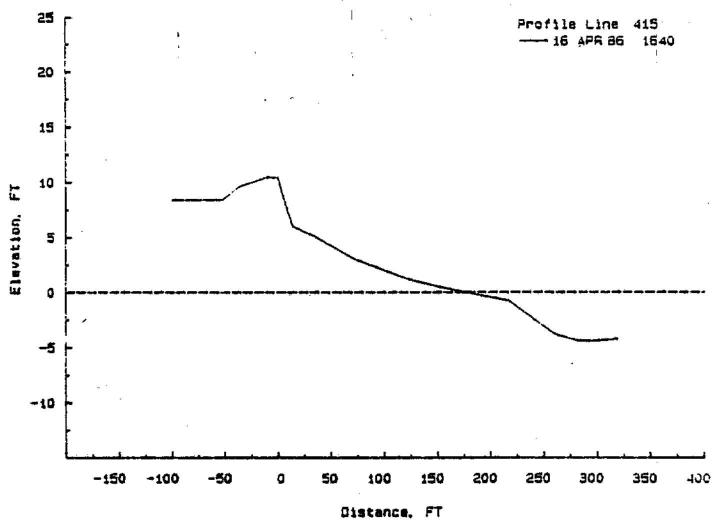


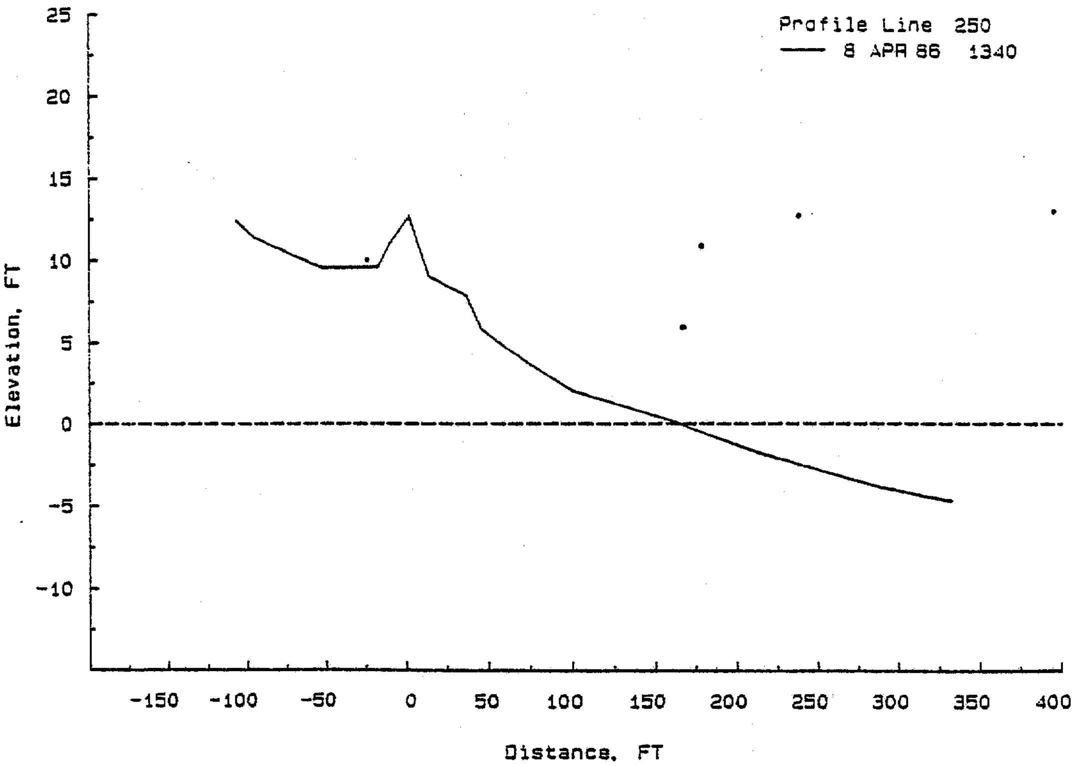
FIGURE 3.10-1
TYPICAL BEACH PROFILE OF
A) MYRTLE BEACH NORTH AREA NEAR
WHITE POINT SWASH
B) LAKE ARROWHEAD

face is below +5 ft in elevation resulting in a very narrow to sometimes non-existent high-tide beach. The beach face is also steeper at the southern end and therefore narrower at all phases of the tide. A small drainage swash is located at the northern end of this reach as well as culverts at varying intervals as one progresses southward. Typically, these small swashes and culverts result is a lowering of the beach face in their immediate vicinity, however, the significance of their effects on littoral transport was not determined. Figure 3.10-1b typifies the beach profile of this section of shoreline.

Springmaid Beach to Ocean Lake Campground

A distinct variation in beach morphology exists between the northern and southern reaches of this segment of shoreline. The northernmost 1.5-mile reach, extending along Springmaid Beach and Myrtle Beach State Park, exhibits a well-vegetated back beach profile and a single, apparently unaltered dune ridge with elevations ranging from +12.5 to +15 feet. The seaward toe of this ridge meets a narrow berm at an average elevation of about +9 ft. The transition from berm to beach face occurs at approximately +7 ft elevation, whereupon the beach presently slopes rather steeply seaward. Exposed peat deposits were present near the mean water line, which is a phenomenon usually indicative of long-term ocean encroachment. A small drainage swash empties onto the beach just south of the State Park Pier which has effectively lowered the beach face in its immediate vicinity. Figure 3.10-2a presents a profile typical of the shoreline along this reach during the April, 1986 survey.

The southern 2.4 miles of shoreline extending south to Surfside Beach are characterized by low dunes and a relatively steep beach face. These dunes can be described as a series of sand mounds rarely exceeding +10 ft in elevation. This condition is probably due to the high



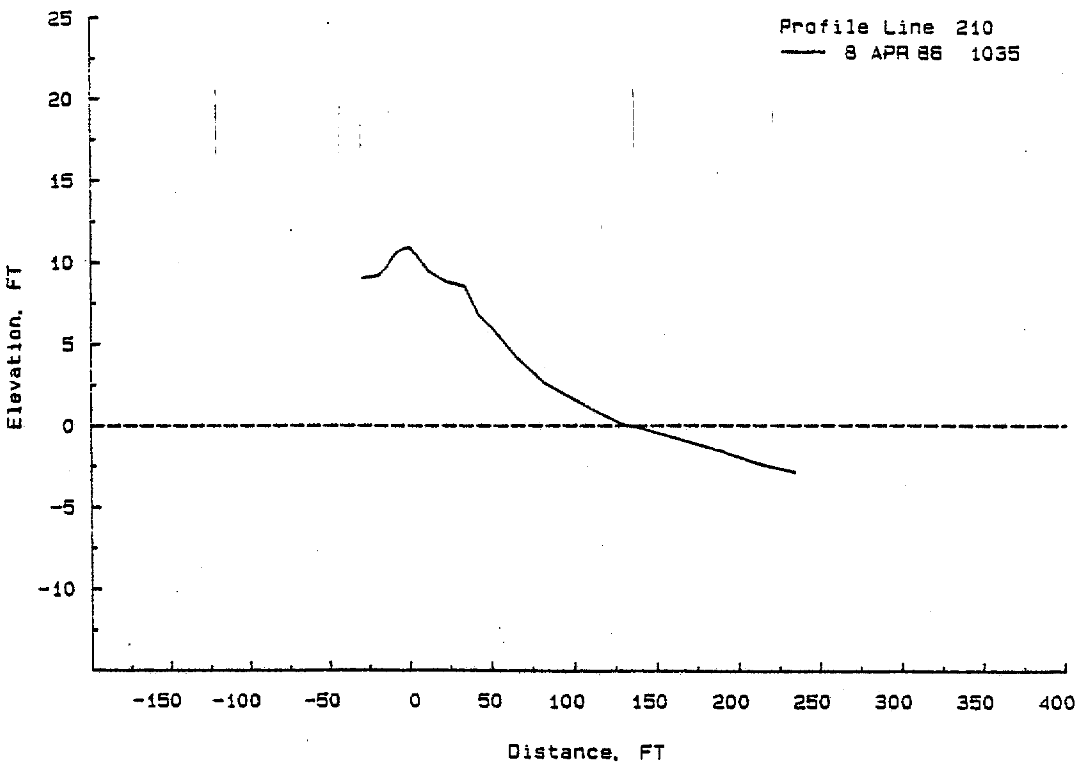


FIGURE 3.10-2
TYPICAL BEACH PROFILE OF
A) SPRINGMAID BEACH
B) OCEAN LAKE CAMPGROUND

volume of pedestrian foot traffic crossing the dunes when accessing the beach from the campgrounds and trailer parks. Fronting this segment of shoreline are a significant number of high-density trailer parks and campground developments. Specific attention should be given to the region near profile 5220, the northern extent of Lakewood Campground, where beach elevations barely reach +8 ft. Natural vegetation has been maintained to some degree along the northern half of this reach but this quickly diminishes progressively southward. Generally, a narrow plateau or berm meets the seaward toe of the dunes at approximately +7 ft in elevation and descends to the +5 ft contour at which point the beach face slopes rather steeply into the ocean. This steep beach face results in a relatively narrower beach at all phases of the tide. Recent evidence of scarping of the seaward berm face near the +5 ft contour elevation was observed during the field study. Small drainage swashes exist at the immediate northern, central and southern portions of this reach which, causes a local lowering of the beach face. A typical profile along this shoreline reach is presented in Figure 3.10-2b.

Surfside Beach

Surfside Beach is characterized by a well-vegetated back beach system with dune crest elevations rarely below +10 ft along this approximately 2.2-mile stretch of shoreline. In its natural state, a single dune ridge with an average crest elevation of +12 ft exists at the seaward edge of this back beach. Along much of the Surfside Beach shoreline, an artificial dune has been constructed to elevations exceeding +15 ft. This artificial dune is unvegetated and consists of coarser grain sizes than normally found in natural dunes, indicating that the dune was created from sand scraped from the lower intertidal beach. Along unaltered, natural reaches of shoreline, berm widths range from 20 ft to 30 ft at elevations between +8 ft and +9 ft. The beach face slope steepens progressively southward at Surfside Beach. Figure 3.10-3 presents the typical Surfside Beach profile.

An exception to this general morphological characterization of the study area is the beach in front of the Holiday Inn at the north end of Surfside Beach. At this location the construction of a seawall, +13 ft in elevation, defines the back beach. The sandy beach at this location consists of a 25 ft-wide berm at 8 ft elevation, dropping steeply to the ocean at high tide. The beach in the immediate vicinity of the Surfside Pier is also structurally armored with a seawall. The pier appears to act as a partial sediment trap (i.e. groin) thereby resulting in a generally wider beach at that location. Several culverts at intermittent locations, as well as drainage swashes 1,100 ft south and 1,950 ft north of the Surfside Pier, act to lower the beach face in their immediate vicinity.

<u>Garden City Beach</u>

The northern 1.5 miles of Garden City Beach lie within Horry County. The back beach along the entire stretch of this shoreline has been altered by shorefront development. The transition from back beach to beach face is defined by an unvegetated artificial dune at the extreme north end and seawalls along the central and southern portions. Natural salt-tolerant vegetation has been severely depleted. The crest of the artificial dune at the north end of this reach averages +13 ft in height and 20 ft in width and consists of coarser-than-average sediment sizes. A characteristic +25 ft-wide berm meets the toe of the dune at the +8.5 ft contour and the beach face at the approximate +7.5 ft contour. The beach face slopes rather steeply to the high water line whereupon it flattens out considerably towards the ocean. Figure 3.10-4a illustrates this artificial dune on a typical profile along the north end of Garden City Beach.

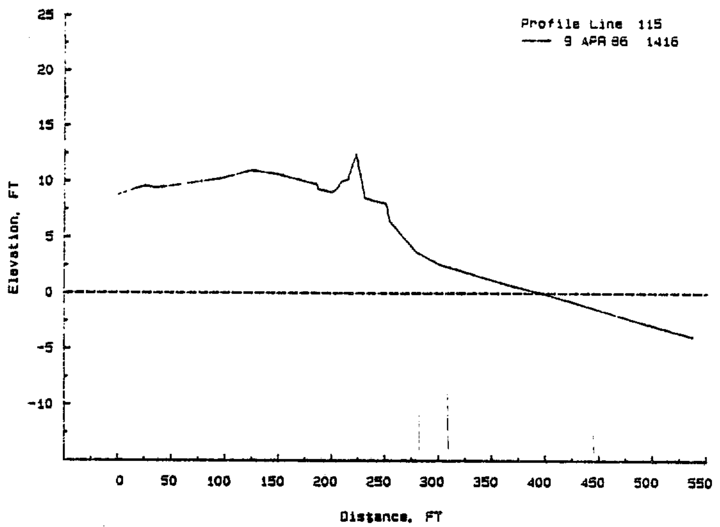
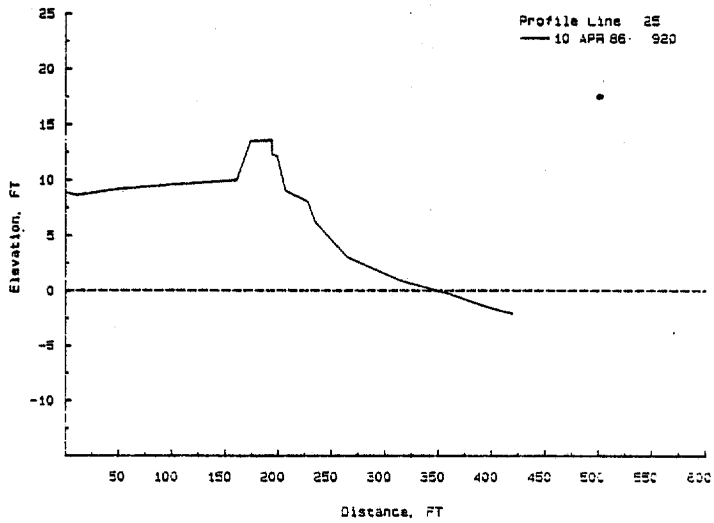


FIGURE 3.10-3
TYPICAL BEACH PROFILE OF SURFSIDE BEACH

A



B

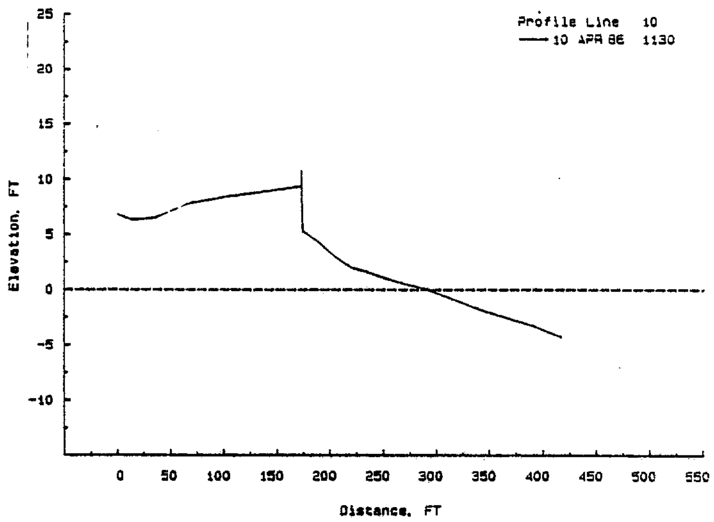


FIGURE 3.10-4
TYPICAL BEACH PROFILE OF
A) NORTHERN END OF GARDEN CITY
B) NEAR GARDEN CITY PIER

The shoreline along the central and southern portion of this reach exhibit a back beach system that is often paved or landscaped to an elevation of less than +10 ft and located immediately landward of the beach face. Progressing landward, elevations along this shoreline reach are characteristically between +5 ft and +8 ft, resulting in a low-lying upland region immediately adjacent to the back beach system. Seaward of the back beach system, the sandy beach face intersects seawalls or adjacent beach accesses at an elevation of +5 ft to +6 ft and steeply recedes to the high-water line. A minimal high-tide beach exists at this location. At survey station 5010, located near the Garden City Pier, the beach face is very low as it intersects the base of the seawall at elevation +3.6 ft. As a result, the beach is nonexistent at this location at high tide. Figure 3.10-4b depicts a typical seawalled profile along this shoreline segment.

3.11 COASTAL STRUCTURE INVENTORY

A wide variety of coastal structures exist throughout the study area. These structures vary greatly as to their type, function, condition, composition, and frequency of occurrence along the specific reaches of shoreline that comprise the study area. Types of structures include seawalls, bulkheads, sandbagging, revetments, groins, jetties and artificial dunes which are often referred to as a "soft structure". Structure functions include reclamation and retention of uplands, shoreline stabilization, inlet stabilization, dune and upland armoring, and beach enhancement. The condition of structures is widely varied and can generally be considered to be a function of age and original design. The U.S. Army Corps of Engineers, in a 1983 report assessing shoreline structural conditions north of Murrells Inlet, asserted that the majority would not be able to withstand a major hurricane. Structural composition varies among concrete, timber, rock, gravel, filter cloth and beach sand. Frequency of occurrence ranges from the heavily armored shoreline reaches of North Myrtle Beach to the virtually structure-free beach along the Myrtle Beach State Park shoreline.

The inventory maps, included as Appendix D, provide a detailed depiction of the type, composition and frequency of structures presently in existence along the Horry County study area. The following paragraphs include discussion on the background, condition, function and apparent present day effectiveness of these structures over the specific shoreline reaches comprising the study area. Revegetation, sand fences, dune walkovers, and other minor structures are not included in this shoreline inventory.

Garden City Beach

Approximately 75% of the shoreline along that portion of Garden City Beach that falls within Horry County is armored. The remaining portion consists either of public right-of-ways, undeveloped shoreline or sections where artificial dunes have been constructed. The majority of shoreline armoring takes the form of timber seawalls of varying elevation and overall state of repair. These timber seawalls serve dual purposes: to withstand forces associated with water levels and wave run-up resulting from a moderate storm, and to serve as retaining walls to hold backfill for swimming pools, patios and other upland development facilities.

Concrete seawalls of significantly greater structural integrity are present at the Garden City Pier and in front of several larger, newer condominiums. Stone rip-rap that serves to attenuate scour and absorb wave energy at the base of the seawalls is present at several locations along this shoreline reach. Numerous discontinuities in lateral and seaward extent of shoreline armoring is the result of individual property owners building to different specifications along their property lines. As a result, back beach erosion is often intensified along these sections as they undergo the effects of flanking induced by adjacent seawalls.

The majority of unarmored shoreline is associated with the northernmost 1,000 ft of Garden City Beach. The seawardmost dune line along this stretch of beach has been enhanced by fill material scraped from the inter-tidal zone. Generally this sand is placed on top of and adjacent to the seaward face of the existing dune and sculpted to a designated elevation. Enhancement of the dune system makes it a more effective barrier to landward encroachment of the ocean during storms and it provides the dune system with an increased reservoir of sand prior to erosion of upland property.

The pier at Garden City is owned and operated by the adjacent Kingfisher Inn and is officially named the Kingfisher Pier. Built in the 1940's, it was destroyed by Hurricane Hazel in 1954 and rebuilt immediately thereafter. It has been repaired several times and in 1979 was expanded to its current 720 ft length and 20 ft width. The owners constructed a concrete block wall perpendicular to the shoreline at the base of the pier to function as a groin to retain sand. A slight buildup of sand was noted on the updrift side of the wall during the field survey. This concrete seawall does not function to pose significantly block littoral transport as it does not extend seaward to the mean high water line. The pier appears to be structurally sound to endure moderate storm conditions.

<u>Surfside Beach</u>

With the exception of an approximately 300 ft concrete seawall at the Surfside Pier and the 310 ft concrete seawall fronting the Holiday Inn to the north, the Surfside Beach shoreline is unarmored. Both of these seawalls serve to protect and retain the upland amenities that are part of the pierfront and hotel complex. Approximately 1.5 miles of Surfside Beach shoreline, divided over several sections, has continual dune restoration as the result of additional sand fill material scraped from the inter-tidal beach. The purpose and procedure of this sand scraping operation is similar to that described previously for Garden City Beach. These beach-scraping projects have been employed since the late 1970's (SCCC Permit Review) as a means to provide upland protection during storms along otherwise low-lying reaches of shoreline.

Myrtle Beach South

Of the approximately 4 miles of shoreline extending north from Surfside Beach through Springmaid Beach, only 1,200 ft fronting Lakewood Campground is armored with shore-protection structures. The structures along this stretch consist of stone rip-rap placed at a maximum elevation of +12.5 ft against a concrete block wall. The rip-rap serves to protect this wall and adjacent uplands from erosion and structural damage that may be caused by higher-than-normal water levels and wave heights.

Stone rip-rap extends approximately perpendicular to the shoreline along the swash that separates Lakewood and Pirateland Campgrounds. The rip-rap serves to prevent any further southerly migration of the swash and extends only as far seaward as the mean high water line. Therefore it probably does not have significant impacts on littoral processes.

Two piers are present along this stretch of shoreline. The pier at Myrtle Beach State Park was originally built in the

1940's about one-half mile north of its present location. In 1954, Hurricane Hazel destroyed most the of pier except for the pilings. The pier was subsequently rebuilt on top of these pilings at its present location in accordance with a request from the Myrtle Beach Air Force Base. Owned and operated by the State of South Carolina, the pier is 720 ft long (personal communication, Merl Roads).

Springmaid Pier was built in 1973 in conjunction with the Springmaid Beach development and is currently owned and operated by Spring Textile. It is approximately 1,050 ft in length and has a deck elevation of +25 ft. The pier serves as an official weather station for the U.S. Department of Commerce. Both this pier and the State Park Pier appear to be structurally sound.

Singleton Swash to White Point Swash

The southern end of that portion of Myrtle Beach shoreline that extends from Singleton Swash north to White Point Swash is lined with an assortment of seawalls, bulkheads, and rip-rap. Shoreline armoring differs considerably in height, eastern extent and design to exhibit significant shoreline irregularity. The shoreline along this southern reach is characterized by seawalls of varying elevations and horizontal offsets. At several locations, the exposed toe of the seawalls is generally no higher than about the high water line. The offset between two adjacent seawalls often results in localized accretion and erosion at various location along this shoreline reach. The majority of the seawalls along this reach appear to be structurally sound, with the exception of the timber bulkhead in front of the Hilton Hotel that appear to retain landscaped fill only. Commencing 1.75 miles north of Singleton Swash and extending to White Point Swash, the shoreline is entirely unarmored.

4.0 SHOREFRONT DEVELOPMENT PATTERNS

Shorefront development along the section of Horry County shoreline encompassed in this study may be generally classified as commercial and high-density multi-family. With the exception of sections of Surfside Beach and the single-family residential area just south of Myrtle Beach State Park, virtually the entire study area shoreline is lined with high-rise hotels and condominiums, low-rise motels, campgrounds and mobile home parks. This is in contrast to the Georgetown County shoreline, where virtually all buildings are either single-family residences, relatively low-density multi-family condominiums or resort complexes. Also in contrast to Georgetown County is the fact that only about 20% of the Horry County study area shoreline remains undeveloped while approximately 48% of the Georgetown County study area is still undeveloped. The following paragraphs present a more detailed breakdown of the shoreline development patterns along the Horry County study area.

Garden City Beach

With the the exception of a few vacant oceanfront lots, the entire 1.8-mile Horry County portion of Garden City Beach shoreline has been intensely developed. The 0.35-mile reach south of Garden City Pier consists primarily of single-family residences. Extending north from the pier, shoreline development becomes increasingly high-density multi-family and/or commercial. In all, development along the Garden City Beach (Horry County) shoreline is approximately 62% multi-family/commercial and 38% single-family residence. Most of the multi-family/commercial development has been constructed in the last 10 years while the majority of single-family residences are considerably older. Appendix E provides a chronological history of development trends along the Garden City shoreline. Figure 4.0-1 and 4.0-2 show examples of these exhibits. A discussion of these trends

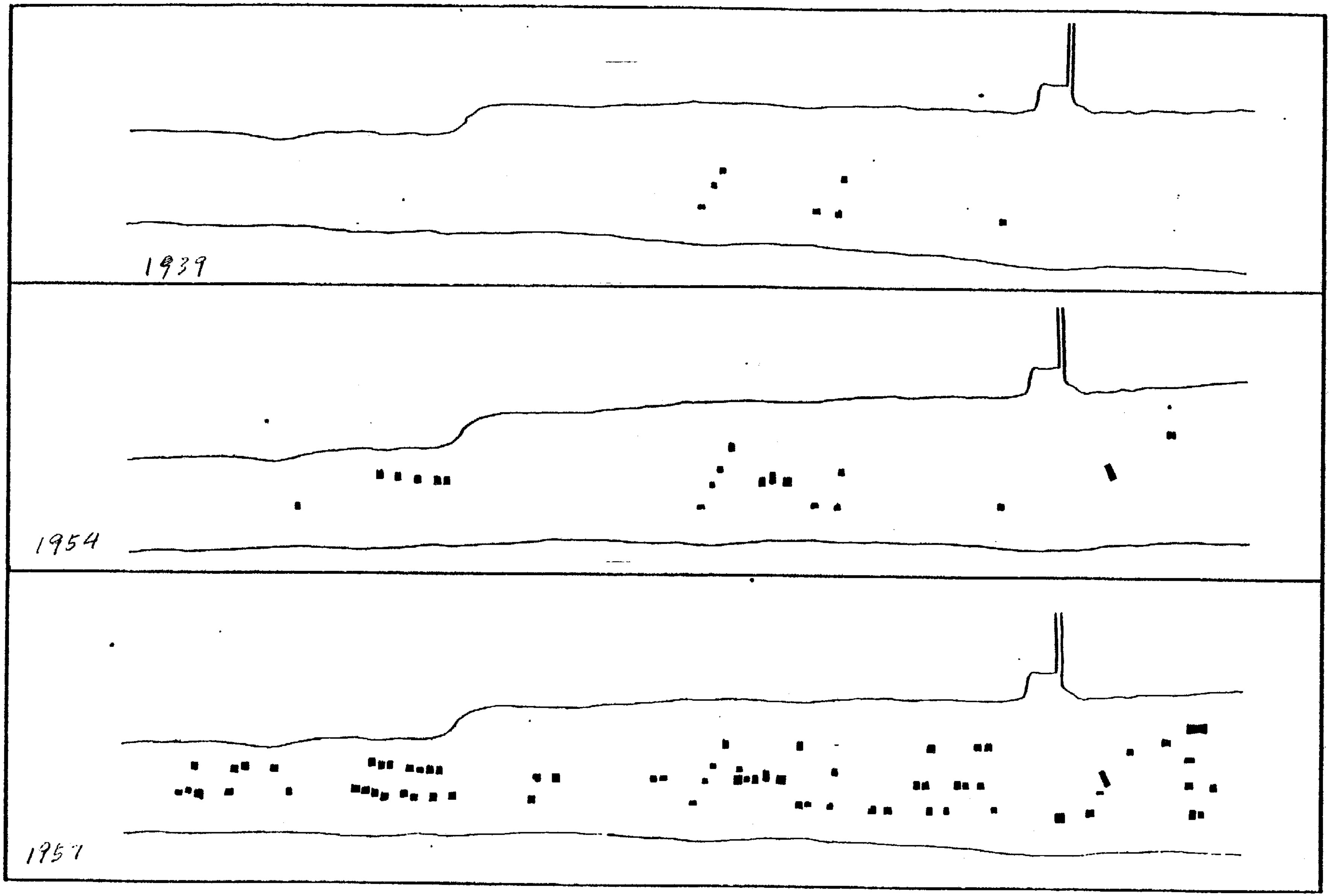
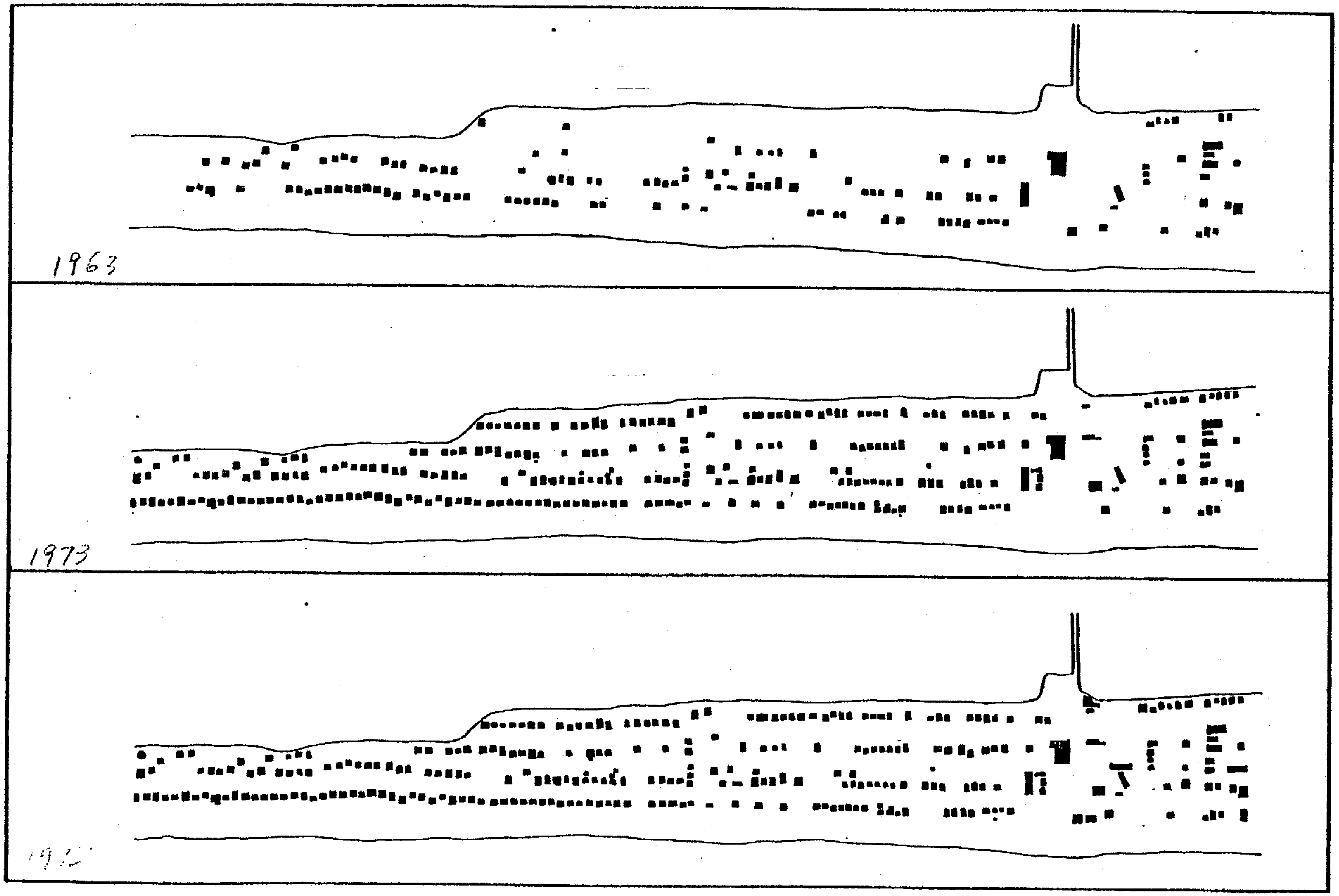


Fig. 4a-1


1963
1973

follows.

Garden City Beach Development History

Of specific interest to the South Carolina Coastal Council as outlined in the contract to perform this study was the development trend of the entire Garden City shoreline. Accordingly, in-depth research was performed that resulted in a chronology of development patterns within the immediate vicinity of the shoreline of both the Georgetown (3.4 mile) and Horry County (1.8) mile segments of Garden City.

This research consisted of acquiring historical aerial photography of the Garden City area for as many different years as possible and then analyzing the photography to determine periods of construction for all discernible buildings. Aerial photography was obtained from more than a half-dozen sources and was usually taken from high altitudes, thereby requiring a magnifying glass, or in some cases photo enlargements, in order to accurately identify individual structures. The final product, included as Appendix E, consists of a series of exhibits reduced from 1" = 200' aerial photo-maps (flown in 1982) coded to depict the oldest known date that each structure has been in existence. These maps do not necessarily depict buildings that were razed to make room for newer structures, however, the majority of those buildings erected along the coastline after 1982 have been included.

Examination of the various sources of photography indicates that in 1939, only seven houses had been built in the Garden City area. These houses were located in the immediate vicinity of the present-day Georgetown-Horry County line, presumably convenient to the nearest form of transportation to the mainland. Development obviously continued from this point forward, but the occurrence of Hurricane Hazel in 1954 destroyed or severely damaged much of the construction to that time. For example, post-storm photography indicates that approximately 75 homes within a one-mile radius of the county line successfully survived the hurricane. This included a building that is now the Kingfisher Inn. Analysis of the same photography, however, indicates that approximately 100 homes were blown or floated off their foundations, some all the way into the westward-lying marsh.

By 1957, the Garden City area appears to have recovered from the damage caused by Hurricane Hazel and development began to resurge. Approximately 200 homes existed at that time in the area and construction was beginning to spread both farther north and south of the county line. Development accelerated to the point that by 1963, several hundred homes extended as far as 1.75 miles south of the county line and all the way to the north end of the present-day Garden City limit. In addition, several large commercial buildings in the vicinity of the Kingfisher Inn had also been constructed. The period 1963 to 1973 was one of continual rapid growth and development throughout Garden City. Of particular note was the large number of single-family residences constructed to the south, extending to what is now the Garden City Point area adjacent to Murrell's Inlet.

By the mid-1970's Garden City consisted of well over 1,500 homes, condominiums and commercial buildings. Further development took place primarily along the northern and southern extremities of the city and on the remaining vacant parcels within the already developed area. From the late 1970's to 1984, residential development of Garden City Point and multi-family/commercial development towards the north end of Garden city continued. In addition, a relatively new form of construction, best described as multi-family low rise condominiums, came into the area. In some instances, older private homes were demolished to provide available land for this type of construction. Since 1984 development trends have consisted typically of single-family residences in the Garden City Point region and multi-family condominiums and high-rises in northern Garden City.

Surfside Beach

The 2.1 miles of shoreline within the incorporated boundaries of Surfside Beach represents the highest percentage of single-family residence of any reach along the study area. Commercial development is generally limited to the immediate vicinity of the Surfside Beach Pier and the Holiday Inn. to the north. Within the last 5 to 10 years, several condominium complexes have been constructed at intermittent locations along the shoreline. These complexes are generally low in density, ranging from 8 to 20 units. Most of the single-family residences are considerably older and in several cases, homes have been demolished to make way for new condominium development. In all, development along the Surfside Beach shoreline is approximately 68% single-family residences, 16% multi-family/commercial and 16% undeveloped.

Myrtle Beach South

Development trends exhibit distinct variations along this section of shoreline extending 3.9 miles north of Surfside Beach to the incorporated city limits of Myrtle Beach. The southern 2.4 mile reach is entirely multi-family/commercial consisting primarily of campgrounds and mobile home parks. Several new high-rise condominiums were built recently just south of the Lakewood campgrounds. Commencing north of the Pirateland campground/mobile home complex, single-family residences extend for some 2,000' to Myrtle Beach State Park. The Park shoreline is approximately 1.1 miles in length and is entirely undeveloped. Springmaid Beach, extending 0.4 miles north of the Park, includes a campground and adjacent resort complex and may be classified as multi-family/commercial. Overall, this 3.9 mile stretch of shoreline is approximately 62% multi-family/commercial, 10% single-family residence and 28% undeveloped.

Myrtle Beach North

Development trends along the shoreline extending from Singleton Swash north to White Point Swash exhibit a distinct variation between its north and south extremities. With the exception of the undeveloped portions along the southernmost 500' and a 700' gap near its midpoint, the southern reach of this shoreline is almost entirely multi-family/commercial. Hotels and condominiums line the southernmost 0.65 miles of this reach while campgrounds and mobile home parks are found over the remaining northern portion. The northern half of this shoreline is entirely undeveloped. The residential communities of Lake Arrowhead Dunes and Briarcliffe Acres, while maintaining access to the beach, have built well landward of the shoreline, leaving it in its natural state. Overall, this shoreline may be classified as 40% undeveloped, primarily along the northern half, and 51% multi-family/commercial entirely along the southern half.

5.0 SEDIMENT ANALYSIS

Beach sediment data were collected at 11 stations within the Horry County study area. With the exception of Garden City (1955), sediment data collection has not been included in previous investigations along the local shoreline of concern. Selection of the sample locations was done in consideration of the proximity to inlets, piers and shorefront structures to accurately represent the local shoreline sand characteristics along specific reaches.

Sediment samples were taken at approximately every third station and at stations adjacent to inlets to provide information on sediment statistics and grain size distribution. Surface sediment samples were collected at the following three locations along the profile; 1) toe of the primary dune or seawall, 2) locations of MHW or approximately +2.5 ft MSL, and 3) location of MLW or approximately -2.5 ft MSL. Representative samples containing at least 200 grams were collected, labeled and analyzed for size frequency distributions.

Sediment sizes are generally expressed by the grain diameter (mm) or using phi (ϕ) inits which are related to grain diameter by the expression: $\phi = -\log_2$ (mm). Figure 5.0-1 presents grain size scales with conversion tables and Wentworth size class descriptions. For all samples, grain sizes were expected to range between coarse sand (0.75 phi or 0.60 mm) and very fine sand (4.00 phi and 0.06 mm) which for unconsolidated sand required sieve analysis methods. As an extremely small portion (<1%) of the sample grains are in the silt range, requiring pipette or hydrometer analytical methods, analysis for this fraction of sediment grain sizes was not justified. Particle sizes equal to or greater than 0.75 phi were dried and weighed with a brief description of the visual characteristics of the remaining pan fraction noted. Although the majority of the samples were comprised

Millimeters (1 Kilometer)	Microns	Phi (ϕ)	Wentworth Size Class	
		-20		
4096		-12		
1024		-10	Boulder (-8 to -12ϕ)	GRAVEL
256		-8		
64		-6	Cobble (-6 to -8ϕ)	
16		-4	Pebble (-2 to -6ϕ)	
4		-2		
3.36		-1.75		
2.83		-1.5	Granule	
2.38		-1.25		
2.00		-1.0		
1.68		-0.75		SAND
1.41		-0.5	Very coarse sand	
1.19		-0.25		
1.00		0.0		
0.84		0.25		
0.71		0.5	Coarse sand	
0.59		0.75		
0.50	500	1.0		
0.42	420	1.25		
0.35	350	1.5	Medium sand	
0.30	300	1.75		
0.25	250	2.0		
0.210	210	2.25		
0.177	177	2.5	Fine sand	
0.149	149	2.75		
0.125	125	3.0		
0.105	105	3.25		
0.088	88	3.5	Very fine sand	
0.074	74	3.75		
0.0625	62.5	4.0		
0.053	53	4.25		MUD
0.044	44	4.5	Coarse silt	
0.037	37	4.75		
0.031	31	5.0		
0.0156	15.6	6.0	Medium silt	
0.0078	7.8	7.0	Fine silt	
0.0039	3.9	8.0	Very fine silt	
0.0020	2.0	9.0	Clay (Some use 2ϕ or 9ϕ as the clay boundry)	
0.00098	0.98	10.0		
0.00049	0.49	11.0		
0.00024	0.24	12.0		
0.00012	0.12	13.0		
0.00006	0.06	14.0		

FIGURE 5-1
GRAIN SIZE SCALES AND WENTWORTH SIZE CLASS DESCRIPTIONS (Folk and Ward 1957)

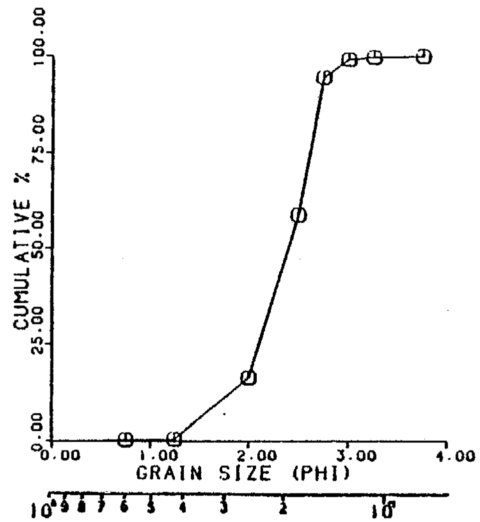
of grains smaller than 0.75 phi, a few samples contained an unusually large fraction of very coarse sand sizes with shell fragments.

Grain size data were entered into a computer data base and statistically analysed according to the graphic methods described by Folk and Ward (1957). Statistical methodology developed by Folk and Ward includes a greater portion of the grain size distribution of sediment sizes as opposed to alternative methods (Inman, 1952) which include only the distribution of sizes within the first standard deviation. The methods of Folk and Ward adequately analyze data which are skewed or demonstrate a bi-modal distribution.

Mean grain size, median grain size, standard deviation, skewness and kurtosis are the statistical parameters computed for evaluation of the sample data. Cumulative frequency plots of grain size distributions and a table summarizing phi, weight retained, cumulative weight, weight percent and cumulative percent are presented for each sample in Appendix B. Typical statistical parameters for sediment samples collected at the toe of seawall and mean high water line for Station #5430 are presented in Figure 5.0-2. Most commonly, to characterize a sample, the average grain size (mean) and the standard deviation ($\sigma(\phi)$) or degree of sorting are discussed. The greater the standard deviation, the less the sorting and greater variability of sediment sizes.

For more specific analysis, skewness (α) as a measure of the degree of departure from a normal distribution of grain sizes is computed. A positive value is skewed (contains a greater range of sediment sizes) to the right and a negative value (excess coarse grains) is skewed to the left. Kurtosis(β) is a measure of the peakedness of the distribution of sediment sizes, where $\beta = 1.0$ is associated

CUMULATIVE FREQUENCY CURVE OF SAMPLE: 5430 TOSW



SAMPLE: 5430TOSW DATE: 19860605 STATION: 5430
PROJECT: SCCC SAMPLE WEIGHT: 227.90 GRAMS

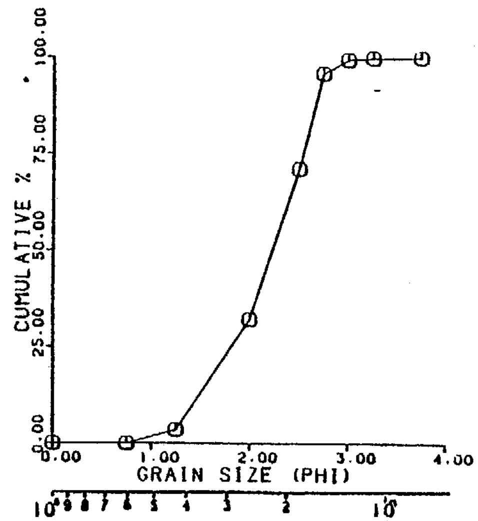
PHI	WEIGHT RET. (G)	CUMULATIVE WEIGHT (G)	WEIGHT PERCENT	CUMULATIVE PERCENT
0.75	0.60	0.60	0.3	0.26
1.25	0.30	0.90	0.1	0.39
2.00	36.20	37.10	15.9	16.28
2.50	96.70	133.80	42.4	58.71
2.75	81.30	215.10	35.7	94.38
3.00	10.90	226.00	4.8	99.17
3.25	1.20	227.20	0.5	99.69
3.75	0.70	227.90	0.3	100.00

PAN 0.00 GRAMS

STATISTICAL PARAMETERS

MEDIAN=	2.4
GRAPHIC MEAN=	2.4
INCLUSIVE GRAPHIC STANDARD DEVIATION=	0.4
INCLUSIVE GRAPHIC SKEWNESS=	-0.3
GRAPHIC KURTOSIS=	1.1

CUMULATIVE FREQUENCY CURVE OF SAMPLE: 5430 MHW



SAMPLE: 5430MHW DATE: 19860604 STATION: 5430
PROJECT: SCCC SAMPLE WEIGHT: 206.50 GRAMS

PHI	WEIGHT RET. (G)	CUMULATIVE WEIGHT (G)	WEIGHT PERCENT	CUMULATIVE PERCENT
0.00	0.00	0.00	0.0	0.00
0.75	0.00	0.00	0.0	0.00
1.25	7.30	7.30	3.5	3.54
2.00	59.10	66.40	28.6	32.15
2.50	80.30	146.70	38.9	71.04
2.75	50.80	197.50	24.6	95.64
3.00	7.50	205.00	3.6	99.27
3.25	1.00	206.00	0.5	99.76
3.75	0.50	206.50	0.2	100.00

PAN 0.00 GRAMS

STATISTICAL PARAMETERS

MEDIAN=	2.2
GRAPHIC MEAN=	2.1
INCLUSIVE GRAPHIC STANDARD DEVIATION=	0.5
INCLUSIVE GRAPHIC SKEWNESS=	-0.3
GRAPHIC KURTOSIS=	0.8

FIGURE 5-2
EXAMPLE OF SEDIMENT STATISTICAL PARAMETERS FOR SAMPLES COLLECTED AT STATION #5430 NEAR ARCADIAN SHORES

with a normal distribution.

Table 5-1 presents a summary of sediment statistical parameters for sample data collected between White Point Swash south to Singleton Swash and from a point 100 ft south of Myrtle Beach State Park Pier (#5245) to Garden City Beach. These samples, listed from north to south, indicate increasing grain sizes with some size variation across the profile (between the toe of the dune and mean low water). For the shoreline between North Myrtle Beach and Myrtle Beach grain sizes ranged from 2.1 to 2.5, or 0.23 mm to 0.18 mm. Generally, across the profile, sediments were well-sorted with slightly greater variation found between the dunes and MLW ($\sigma(\phi) = 0.4$ versus $\sigma(\phi) = 0.6$).

South along Myrtle Beach State Park, Surfside Beach and Garden City the distributions of grain sizes were characterized by moderate sorting where average standard deviations ranged from $\sigma(\phi) = 0.7$ to $\sigma(\phi) = 0.9$ across the profile. One explanation for the nonuniform sediment distributions is recent placement of artificial fill along this shoreline in combination with the renourishment project at Myrtle Beach may have significantly biased this data set. Analysis of samples with large fractions of very coarse grains was not found to provide valuable information to characterizing the natural equilibrium beach conditions. These samples are depicted by an asterik in the table of sediment characteristics for cases where grain size frequency analysis was insufficient to compute accurate values of standard deviation, skewness and kurtosis.

Assuming a possible bias associated with the overall distorted distribution of grain sizes, specific conclusions drawn from these sample data, regarding the beach-dune sediment characteristics, would be expected to change as the natural shoreline processes (waves conditions, nearshore

Table 5-1 Summary Sediment Statistical Parameters Along Horry County Shoreline

Station	TOD φ_{50}	TOD mm	TOD σ	TOD α	MHW φ_{50}	MHW mm	MHW σ	MHW α	MLW φ_{50}	MLW mm	MLW σ	MLW α
White Point Swash												
5460	2.5	0.18	0.3	-0.3	2.3	0.20	0.4	-0.3	2.3	0.20	0.5	-0.4
5445	2.4	0.19	0.4	-0.4	2.4	0.19	0.4	-0.4	2.2	0.22	0.7	-0.1
5430	2.4	0.19	0.4	-0.3	2.1	0.23	0.5	-0.3	2.1	0.23	0.6	-0.4
5410	2.1	0.23	0.5	-0.2	2.1	0.23	0.6	-0.3	2.4	0.19	0.5	-0.6
Singleton Swash												
	Avg = 2.4	0.19			Avg = 2.2	0.22			Avg = 2.3	0.20		
5245	2.4	0.19	0.4	-0.2	1.6	0.33	0.7	0.1	1.3*	0.41		
5225	1.6*	0.33			1.9	0.27	0.6	0.0	1.9	0.27	0.8	-0.5
5205	1.7	0.31	0.8	0.0	1.2	0.44	0.5	0.6	1.4*	0.38		
5135	1.5*	0.35			1.8	0.29	0.6	0.0	1.3*	0.41		
5115	1.8	0.29	0.8	-0.3	2.1	0.23	0.4	-0.2	2.1	0.23	1.0	-0.4
5025	1.8	0.29	0.8	-0.2	2.0	0.25	0.5	-0.1	2.0	0.25	0.9	-0.5
5015	1.5	0.35	0.6	0.0	1.2	0.44			1.8	0.29	0.9	-0.1
	Avg = 1.8	0.29			Avg = 1.7	0.31			Avg = 1.7	0.31		

*Large fraction of coarse-grained sediment

φ = grain size in phi units
σ = standard deviation in phi units
α = skewness

Source: Applied Technology and Management, Inc. and Olsen Associates, Inc. 1986 slope, shoreline orientation and normal sediment population) sort and distribute the artificially placed sediments.

6.0 BEACH PROFILE AND EROSION ANALYSIS

6.1 COMPARATIVE BEACH PROFILES

Previously surveyed beach-dune profiles, replicated by this study, were assembled for comparative analysis. Data were collected from 4 profile surveys conducted in 1958 and 17 new profiles established in 1983-84 by the USCOE, Charleston District. Shoreline response associated with the construction of the Murrell's Inlet jetties necessitated monitoring of adjacent beaches that provided yearly data from 1979 to 1982 for 4 new stations along Surfside and Garden City.

All available data, including field-survey notes, were collected and digitized. Profiles were entered into a common data base along specific shoreline segments and adjusted horizontally and vertically using both field survey notes and reference control point information. Comparative beach-profile survey data recovery is summarized in Table 6.1.1. Where vertical or horizontal control of comparative surveys could not be established, after judicious investigation, the data were flagged accordingly or deleted.

Qualitatively, successive surveys were reviewed for both consistency and quality. Comparative survey records covering the period 1958 to 1986 were considered for long-term erosion analysis. Profile data along Surfside and Garden City, collected between 1979 and 1986, were surveyed to monitor the spatial effects of the Murrell's Inlet jetties and represented short-term profile data. Short-term seasonal shoreline variation are represented when comparing survey data between November 1983 and April 1986. These were collected along the shoreline from Briarcliff Acres South to Singleton Swash.

Analysis of volumetric changes and shoreline movement using these comparative profile data were encumbered by the

Table 6.1-1. Inventory of Comparative survey data

AREA	PROFILE #	YEAR OF COMPARATIVE SURVEY DATA	COMPARATIVE DATA TOTAL NO. SURVEYS
NORTH MYRTLE	5405	1986	1
	5410	1983, 1986	2
	5415	1983, 1986	2
	5420	1983, 1986	2
	5425	1983, 1986	2
	5430	1983, 1986	2
	5435	1983, 1986	2
	5440	1983, 1986	2
	5445	1983, 1986	2
	5450	1983, 1986	2
	5460	1983, 1986	2
	5465	1983, 1986	2
SOUTH MYRTLE	5205	1984, 1986	2
	5210	1984, 1986	2
	5215	1984, 1986	2
	5220	1986	1
	5225	1984, 1986	2
	5230	1986	1
	5235	1984, 1986	2
	5240	1986	1
	5245	1984, 1986	2
	5250	1986	1
	5255	1986	1
SURFSIDE BEACH	5105	1986	1
	5110	1958, 1984, 1986	3
	5115	1979, 1980, 1981, 1982, 1986	5
	5120	1958, 1984, 1986	3
	5125	1986	1
	5130	1986	1
	5135	1979, 1980, 1981, 1982, 1986	5
	5140	1986	1
	5145	1984, 1986	2
GARDEN CITY	5005	Established 1986	1
	5010	1958, 1984, 1986	3
	5015	1979, 1980, 1981, 1982, 1986	5
	5020	1958, 1984, 1986	3
	5025	1979, 1980, 1981, 1982, 1986	5

limited data base. Accordingly, long-term erosion/accretion rates were limited to 4 stations within the entire Horry County study area. To supplement this limited data set, 12 new profiles were established at approximately 2,000-ft intervals. The survey profile locations were shown as Figure 3.8-2.

6.2 VOLUMETRIC ANALYSIS

Comparative beach-dune profiles were analyzed along Horry County's shoreline to determine the rates of long-term and short-term volume changes. Individual comparative profiles were examined to compute changes in profile volume where volume is defined as cross-sectional area multiplied by a unit width. As discussed in Section 6.1, data records representing 25 or more years (i.e. 1958 surveys) allowed an estimate of long-term profile volume changes, whereas the remaining data base (1979 to present) would allow only for estimating short-term volume variability.

Short-term profile changes are caused by severe storms or structural shoreline modifications, such as jetties, shorefront structures and dredging. Seasonal storms, termed northeasters and hurricanes or tropical storms, cause the beach to erode and the shoreline to fluctuate. Over a relatively short period of time (several days to many years), sand will be transported shoreward and the beach recovers by accretion or onshore sediment transport. In contrast, profile changes which maintain a consistent trend over a long period of time (generally greater than 25 years) are catagorized as long-term changes or trends. In response to the pervasive rise in mean sea level, the beach profile shifts landward to maintain a natural equilibrium state.

Two methods were used to compute volume changes, the first method follows a prescribed control-volume approach and the second method computes volume changes across the profile for the limits of the region in common comparison. Figure 6.2-1 and 6.2-2 defines the width of the profile over which volume changes are computed using the 1) control volume and 2) comparative profile segment approach, respectively.

In the control-volume method, volume changes were computed between the +10.0' and -3.0' contour wherever possible. When low dune-crest elevations and seawalls precluded using the +10.0' contour, an alternative maximum contour elevation was chosen. Unit control volumes, average annual volume changes and net volume changes are presented in Tables 6.2-1 and 6.2-2 for all comparative profiles. Negative volume changes represent erosion. The control volume, representing the portion of the profile used to determine volume changes, is limited by the initial position (x_{min} and x_{max} in Figure 6.2-1) of the earliest survey date. The control volume method analyzes only part of the dynamic portion of the beach profile, which includes the entire primary dune seaward to the point of limiting depth, or depth of closure, which is defined as the shoreward depth which experiences seasonal profile variations. Volume changes calculated using the landward and seaward limits established by the initial control volume may not and often do not represent the actual magnitude of the volumetric change over the active profile.

A second approach to evaluate volumetric changes examines volume changes over a greater portion of the active profile. This method will attempt to qualify and substantiate the control volume methodology that may inadequately represent the magnitude of erosion/accretion along a profile. Tables 6.2-3 and 6.2-4 present the average annual volume changes and the net volume changes including notes depicting locations of man-induced profile modifications using the comparative profile segment approach. For all comparative

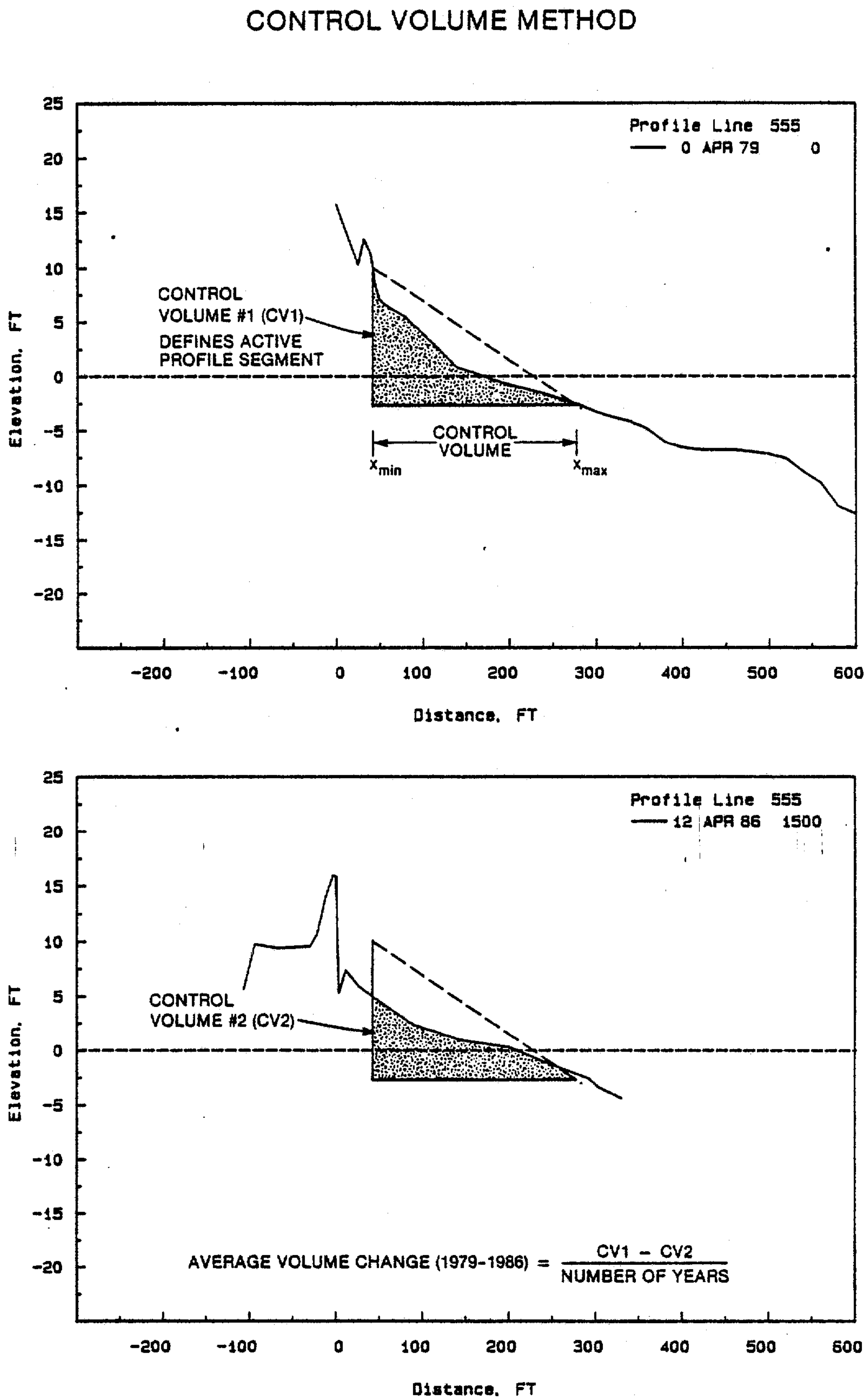


FIGURE 6.2-1
DEFINITION SKETCH FOR COMPUTING AVERAGE VOLUME CHANGES USING THE CONTROL VOLUME METHOD AT PROFILE #4555

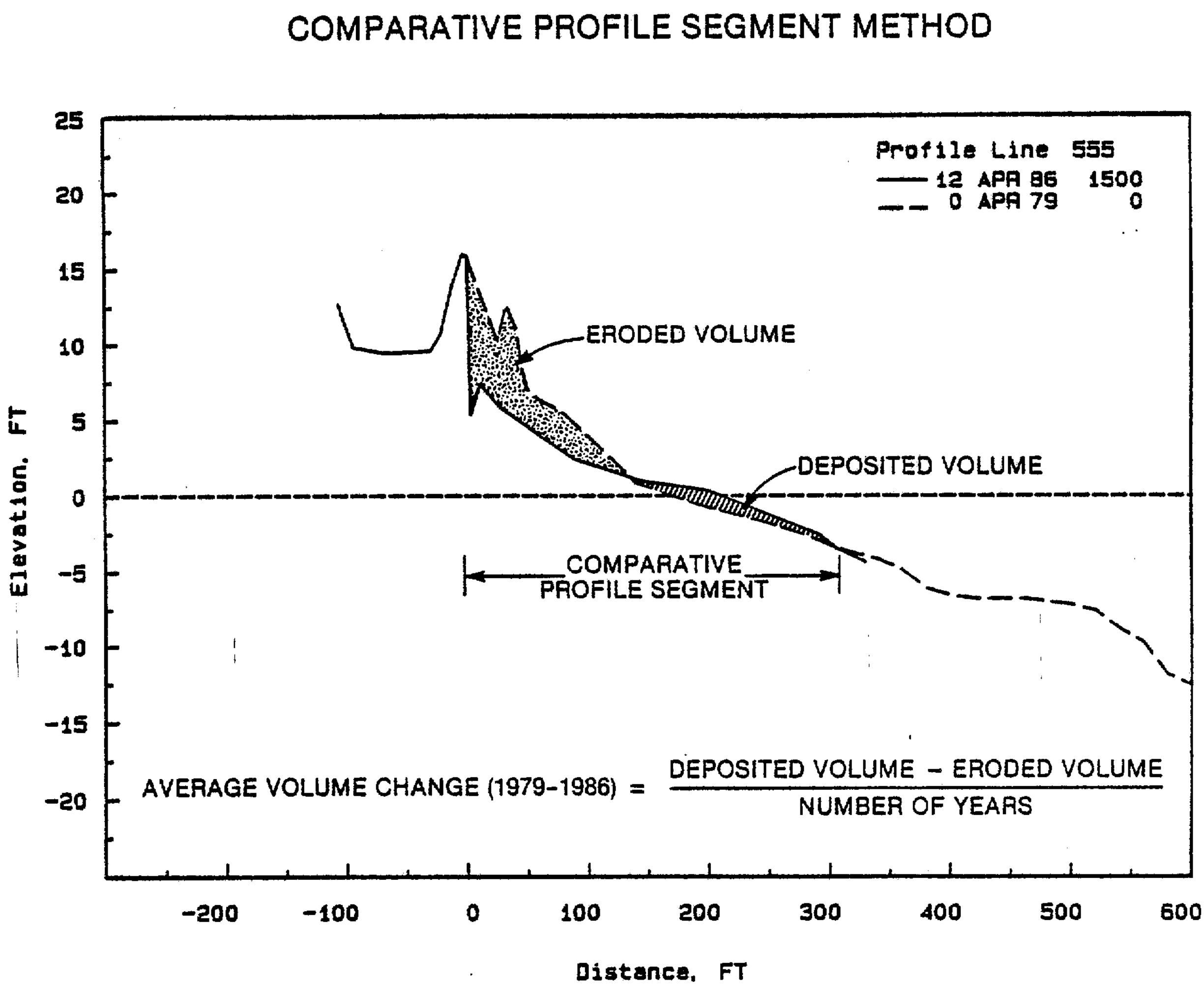


FIGURE 6.2-2
DEFINITION SKETCH FOR COMPUTING AVERAGE VOLUME CHANGES USING THE COMPARATIVE PROFILE SEGMENT METHOD AT PROFILE #4555

Table 6.2-1. Average, Net, and Unit-width Volume Changes between +10.0 ft and -3.0 ft MSL

	Average Volumetric Change ($yd^3/ft/yr$)	Gross Volumetric Changes (yd^3/ft)	Unit-Width Volume (yd^3/ft)	
Station	1983-86 (2.4 yrs)	1983-86 (2.4 yrs)	Nov 1983	April 1986
Myrtle Beach North				
5460	6.4	15.7	68.4	84.0
5455	16.0	38.4	68.7	107.1
5450	3.0	7.2	86.7	93.7
5445	2.0	4.9	28.9	33.8
5440	1.1	2.7	52.5	55.2
5435	-6.8	-16.3	91.0	74.7
5430	3.0	7.3	50.9	58.2
5425	-2.3	-5.4	67.8	62.4
5420	1.1	2.7	54.9	57.6
5415	-2.8	-6.7	45.1	38.5
5410	-6.3	-15.2	71.7	56.5

	Average Volumetric Change ($yd^3/ft/yr$)	Gross Volumetric Changes (yd^3/ft)	Unit-Width Volume (yd^3/ft)	
Station	1984-86 (2.1 yrs)	1984-86 (2.1 yrs)	Nov 1983	April 1986
Myrtle Beach South				
5205	4.1	2.0	32.9	36.9
5210	0.5	0.3	37.1	37.6
5215	0	0	36.2	36.2
5225	-1.3	-0.6	50.3	49.0
5235	6.5	3.2	35.5	41.9

Table 6.2-2. Average, Net and Unit-Width Changes Between +10.0 ft and -3.0 ft MSL

	Average Volumetric Change ($yd^3/ft/yr$)						Net Volumetric Changes (yd^3/ft)		
Station	1958-84 (26 yrs)	1979-80 (1 yr)	1980-81 (1 yr)	1981-82 (1 yr)	1982-86 (4 yrs)	1984-86 (2 yrs)	1979-86 (7 yrs)	1958-86 (28 yrs)	1984-86 (2 yrs)
Surfside									
5110	0.1					-1.3		-0.6	
5115		-1.2	-5.8	-5.4	-0.1		-12.9		
5120	-0.1					2.8		2.4	
5135		2.8	4.1	-5.7	0		1.1		
5145						1.1			2.1
Garden City									
5010	0.1					-3.7		-4.8	
5015		5.8	-1.0	-3.4	0.9		4.8		
5020	-0.3					-1.7		-11.9	
5025		13.1	0.3	-6.0	-2.2		-1.3		

	Unit-Width Volume (yd^3/ft)						
Station	January 1958	Sept 1979	Sept 1980	Sept 1981	Sept 1982	March 1984	April 1986
Surfside							
5110	63.8					65.8	63.2
5115		54.4	53.3	47.5	42.0		41.6
5120	148.9					145.7	151.2
5135		34.1	37.0	41.1	35.4		35.3
5145	40.9						43.0
Garden City							
5010	44.6					47.2	39.9
5015		29.0	34.8	33.8	30.5		33.9
5020	39.8					31.3	27.9
5025		46.7	59.7	35.9	54.1		45.3

Table 6.2-3. Average and Net Volume Changes Between Comparative Profile Surveys (Myrtle Beach North and South)

Station	Average Volumetric Change ($yd^3/ft/yr$)	Net Volumetric Changes (yd^3/ft)	Notes
Station	1983-86 (2.4 yrs)	1983-86 (2.4 yrs)	
<u>Myrtle-North</u>			
5460	4.8	11.6	
5450	0.3	0.8	
5445	1.0	2.5	
5440	0.5	1.3	
5435	-9.2	-22.1	
5430	3.2	7.6	
5425	-1.0	-2.4	
5420	1.3	3.2	
5415	-2.3	-5.6	
5410	-4.8	-13.7	
Station	1984-86 (2 yrs)	1983-86 (2.4 yrs)	Shoreline Structures Nourishment, etc.
<u>Myrtle-South</u>			
5205	1.2	2.3	
5210	0.1	0.2	
5215			
5225	-1.5	-3.0	
5235	3.1	6.1	

Table 6.2-4. Average and Net Volume Changes Between Comparative Profile Surveys (Garden City and Surfside)

	Average Volumetric Change (yd^3/ft/yr)			Net Volumetric Changes (yd^3/ft)			Notes
Station	1958-86 (28 yrs)	1979-86 (7 yrs)	1984-86	1979-86 (7 yrs)	1958-86 (28 yrs)	1984-86 (2 yrs)	
Garden City							
5010	-0.2					-5.7	
5015		1.4		9.5			
5020	-0.3				-9.3		
5025		-2.0		-14.2			
Surfside							
5110	-0.2				-6.5		
5115		-1.9		13.0			
5120	0.1				2.8		
5135		0.2		1.1			Artif. Fill
5145			0.8			1.6	

surveys analyzed, the nature of the variability, either erosion of accretion, was consistent between the control volume and the comparative profile segment approach.

The nature of seasonal variation in profile cross-section is well-documented and accepted. Winter profiles result from offshore sand transport, with sand stored in a bar. During summer months the beach recovers as moderate wave conditions transport this bar onshore, resulting in a summer profile. Figure 6.2-3 represents the seasonal profile variations of a hypothetical survey depicting volume changes which result from winter and summer wave conditions.

Singleton Swash to White Point Swash

In general, volume changes along the shoreline reach extending south from Singleton Swash some 8000 ft depict depositional trends. It is important to note that the profile data collected along the shoreline north of Myrtle Beach were measured in late fall and the 1986 profiles were surveyed in early spring. Accordingly, the short-term volume changes presented in Table 6.2-1 along the Myrtle Beach north shoreline represent seasonal shoreline variation, i.e. summer/winter profiles and must be regarded as representing a seasonal short-term shoreline change. Erosional trends were measured for the station fronting Trav-1 Campground (#5435) and the station fronting Lake Arrowhead Campground (#5425). Volume changes for the shoreline immediately north and south from White Point Swash ranged -2.8 to -6.3 yd^3/ft/yr between November 1983 and April 1986.

Springmaid Beach to Myrtle Beach State Park

Short-term beach profile volume changes along this shoreline reach should not reflect seasonal variation as successive surveys were during March 1983 and April 1986.

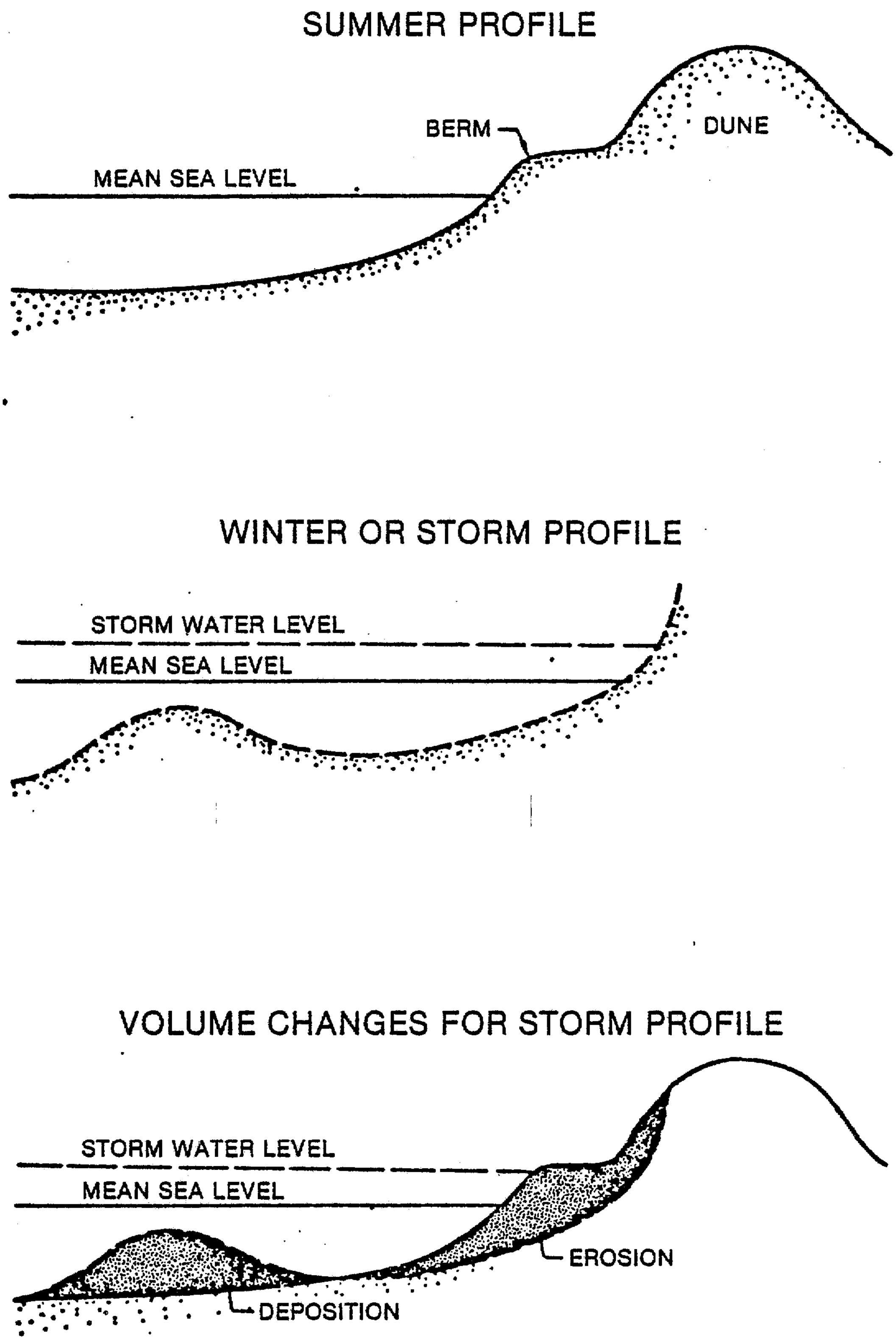


FIGURE 6.2-3
IDEALIZED SEASONAL PROFILE VARIATION AND THE ASSOCIATED VOLUME CHANGES

Profile variability, based on average annual volume changes along the shoreline segment south from Myrtle Beach State Park to Surfside (denoted Myrtle Beach South), was greatest at stations 5205 and 5235. Net accretion occurred at these two profiles, one located adjacent to Ocean Lake Campground and another profile fronting Long Bay Estates. Short-term volume changes computed using the comparative profile segment method were generally lower and ranged between +3.1 to -1.5 $yd^3/ft/yr$. Erosional trends were observed at profile 5225, located adjacent to Pirateland Campground.

Surfside Beach to Garden City

Long-term volumetric changes were computed at 4 stations along the Surfside and Garden City shoreline. These beach profiles exhibited average long-term erosional trends ranging from +0.1 to -0.3 $yd^3/ft/yr$ during the 28-year period. The accretion shown for station 5120 appears to be the result of beach scraping along the shoreline fronting this station. Short-term volume changes ranged from +1.4 to -2.0 $yd^3/ft/yr$ for the Surfside and Garden City shoreline between the 1979 and 1986 surveys.

Profile 5025 presents a fair example of the differences in the two methods, the control volume fails to account for erosion landward or seaward of the original control points (X_{min} and X_{max}) established using the dune profile of the earliest survey. Thereby, areas with large volumetric fluctuations or surveys that represent a steeper winter/storm profile may not be adequately assessed. Also, the dynamic portion of the profile out to the depth of closure, or the limiting depth associated with an active profile, is not represented in these results.

6.3 SHORT-TERM SHORELINE EROSION RATE

Shoreline changes or beach erosion can be characterized using the following categories:

1. Initial volume changes can be caused by a discrete event such as a storm or beach nourishment. These sudden shoreline perturbations can occur within several days or overnight.

2. In response to sudden shoreline perturbations, beach profile will undergo a period of recovery. As an example, immediately following storm erosion, beach fill, or coastal structure construction, the beach profile will re-adjust as it reaches a new state of equilibrium. The rate of changes is greater at the initial stage of recovery, and decreases as it approaches equilibrium. The period of recovery normally is less than 10 years except for unusually large disturbances.

3. Beach profiles will experience periodic changes as it adjusts to differences in seasonal wave climate. The lower frequency summer waves will cause onshore sediment transport, resulting in a mild beach slope and wide beach face. The high energy winter wave climate results in offshore sediment transport and formation of offshore bars which characterize the winter profile. A mature stable shoreline will endure seasonal erosion/accretion and yet maintain long-term stability.

4. Long-term changes are caused by sea level rise, wind and wave climate, shoreline orientation, offshore bathymetry, inlet dynamics, and other geological features. Long-term variation is typically much smaller than the short-term changes. A stable shoreline with negligible long-term erosion trends may have substantial seasonal variation. Therefore

large quantity of time series data will be required to filter out short-term changes and accurately quantify long-term trends.

The first three categories are considered short-term changes and are evaluated according to contour movement based on comparative beach profile data.

Beach survey data were available between 1979 and 1986. A few stations also have the 1958 data. At individual stations, the number of surveys is no greater than 5 sets of data. The time period between consecutive surveys was from 7 months to 4 years, excluding the 1958 data. The comparisons between consecutive profiles are presented in Appendix B.

Two methods were used to assess the short-term erosion rate and both were based on the comparative profile data: a) contour movement rate, and b) volumetric erosion rate.

The shoreline changes, or the contour movement of the beach topography, can be interpreted as the shoreline recession rate. However, an appropriate elevation should be selected for the contour in order to get meaningful results. The beach face near MSL usually has a mild slope (about 2%), consequently, the MSL contour position is very sensitive to profile changes. For example, when the dune was eroded, the material may be deposited to the foreshore area. Therefore, the MSL contour is moved offshore. The MSL contour appeared to be the result of beach accretion, but in reality it would be the result of dune erosion. Therefore, the movement of a contour in a dynamic zone below MSL could yield misleading results. The mean high water line (about 2.98' NGVD) was located on a steeper beach slope (about 5%) and consequently was less influenced by the special redistribution of the beach material and would reflect erosion.

Tables 6.3-1 and 6.3-2 show the MHW contour locations and recession rate in the Myrtle Beach North and Myrtle Beach South area respectively between 2 consecutive dates. Tables 6.3-3 and 6.3-4 show the MHW contour movement in the Garden City/Surfside Beach area.

The short-term shoreline recession rate calculated from the available beach-profile data base showed a wide range of values, from 108 ft/yr accretion to 135 ft/yr erosion. Most of the large erosion/accretion rates were derived from data between short term period (about 1 year) and reflected the effects of seasonal changes and storm events.

Although the seasonal and yearly shoreline changes were large, the average recession rates over 2 to 7 years were much smaller (from 24 ft/yr accretion to 43 ft/yr erosion). Table 6.3-5 summarizes the short-term shoreline recession rates for each area. The results showed the variability of the data. Since the temporal data base is small (5 profiles or less), it is difficult to make conclusive predictions about the short-term erosion rates. As an example, the 1982-86 data showed mostly erosion in the Garden City area, but 1980-81 data showed mostly accretion in the same area.

Myrtle Beach North

The only available comparative beach profile data in Myrtle Beach North area were from November 1983 and April 1986. Table 6.3-1 shows large spatial variation of the erosion rate ranging from 23 ft/year accretion to 33.5 ft/year erosion. The spatial average of the MHWL changes between these dates was about 1.5 ft/year accretion. It should be emphasized that Table 6.3-1 only depicts the MHWL changes between two specific dates, and it can not be soley used as a basis to make any future predictions.

Table 6.3-1. Mean High Water Contour Position (Myrtle Beach North Area)

Station	MHW Position (ft) 11/83	4/1986	Rate of change* (ft/year)
5410	147	128	-7.9
5415	71	73	0.8
5420	91	107	6.6
5425	95	117	9.1
5430	78	135	23.6
5435	168	87	-33.5
5440	85	99	5.8
5445	119	103	-6.6
5455	91	100	3.7
5460	105	138	13.7

* Negative value indicates erosion.

Table 6.3-2. Mean High Water Contour Position (Myrtle Beach South Area)

Station	MHW Position (ft) 3/1984	MHW Position (ft) 4/1986	Rate of change* (ft/year)
5205	71	82	5.3
5215	82	78	-1.9
5225	111	82	-13.9
5235	60	83	11.1
5245	189	100	-42.8

* Negative number indicates erosion.

Table 6.3-3. Mean High Water Contour Position (Garden City and Surfside Beach)

Mean High Water Contour Position (feet from baseline)

Station	1/1958	4/1979	4/1980	9/1981	4/1982	3/1984	4/1986
5015		202	212	235	217		211
5020	341					312	266
5025		291	300	307	266		265
5110						295	281
5115		343	349	354	332		292
5120						327	318
5135		319	339	402	323		315
5145						81	81

Sources: Applied Technology and Management, Inc. and Olsen Associates, Inc., 1986

Table 6.3-4. Mean High Water Contour Movement (Garden City and Surfside Beach)

Mean High Water Contour Movement Rate (ft/year)
(Negative number indicates erosion)

Station	1979-80	1980-81	1981-82	1982-86	1980-82	1979-86	1980-86	1958-84	1984-86
5015	10.0	16.2	-30.9	-1.5	2.5	1.3	-0.2		
5020								-1.1	-22.1
5025	9.0	4.9	-70.3	-0.3	-17.0	-3.7	-5.8		
5110									-6.7
5115	5.0	3.5	-37.7	-10.0	-8.5	7.3	-9.5		
5120									-4.3
5135	20.0	44.5	-135.4	-2.0	-8.0	-0.6	-4.0		0.0
5145									

Table 6.3-5 Summary of Short-Term Shoreline Recession Rate in Horry County

	Myrtle Beach North	Myrtle Beach South	Garden City/ Surfside Beach
2 year maximum	23.6	11.1	-4.3
2 year minimum	-33.5	-42.8	-22.1
2 year average	1.5	-8.4	-11.0
4 year maximum			-0.3
4 year minimum			-10.0
4 year average			-3.5
6 year maximum			-0.2
6 year minimum			-9.5
6 year average			-4.9
7 year maximum			1.3
7 year minimum			-7.3
7 year average			-2.6

*Negative value indicates erosion

Source: Applied Technology and Management, Inc. and Olsen Associates, Inc., 1986

Myrtle Beach South

The only available comparative beach profile data in Myrtle Beach South area were from March 1984 to April 1986. The MHWL movement rate ranged from 11 ft/year accretion to 43 ft/year erosion. The spatial average is about 0.7 ft/year erosion.

Garden City and Surfside Beach

There were a total of 7 sets of survey data available for Garden City and Surfside Beach, however, only 5 or less were available at an individual survey station. Table 6.3-4 indicates that this area has experienced moderate short-term erosion. The spatial average of 1980-1982 MHWL changes in this area was 7.8 ft/year erosion, and the spatial average of 1984-1986, 1982-1986, and 1979-1986 (all in April) were 11.0, 3.5, and 2.6 ft/year erosion respectively.

The changes between April 1980 and September 1981 showed an average accretion of 17.3 ft/year which indicated the changes from winter profile to summer profile. Similarly the spatial average of September 1981 to April 1982 was -68.5 ft/year (erosion) which reflected the effects of winter waves.

6.4 LONG-TERM SHORELINE EROSION RATE

The NOS shoreline movement maps described in Section 3.7, were used to estimate long-term erosion rate. The survey stations were located on the shoreline movement maps, and the lateral changes of the shoreline position were measured relative to the 1983 shoreline. With the assistance of magnifying devices, the accuracy of the shoreline position is about 7 feet. Since the time periods between shoreline surveys were 9, 21, 28, and 50 years, the accuracy of the long term shoreline recession rate is about 0.3 ft/year.

The time series of the shoreline position at each station were shown in Figures 6.4-1 to 6.4-3 for different section of the study area. The data indicates that the Horry County coastline was relatively stable in long-term. The shoreline fluctuated but on a smaller scale than other part of the South Carolina coasts. To obtain a long-term trend, linear regression analysis was used to predict the future erosion rate using the last 50 years data. The results were shown in Tables 6.4-1 and 6.4-2 and Figures 6.4-4 and 6.4-5.

In general, the Myrtle Beach North area was quite stable and the long-term erosion rate had a spatial trend of a higher rate toward the southern portion of Surfside Beach. The maximum recession rate occurred at station 5110 where the erosion rate was 4.8 ft/year.

6.5 EFFECTS OF SEA LEVEL RISE

As presented in Section 3.1, one important result of sea level rise is the readjustment of the beach profile along the study area shoreline to maintain an equilibrium condition, which results in a net offshore sediment transport. To evaluate the shoreline movement in response to sea-level rise using the equilibrium beach-profile concept, one must assume the beach profile is relatively stable for a given mean water level and local wave conditions. The average shoreline recession (horizontal) rate in response to sea- level rise depends on sediment grain size, wave climate and location along the coast. An estimate of horizontal recession using a representative profile can be calculated using the Bruun method from the following empirical formula:

$$R = S \frac{W_*}{(h_* + B)}$$

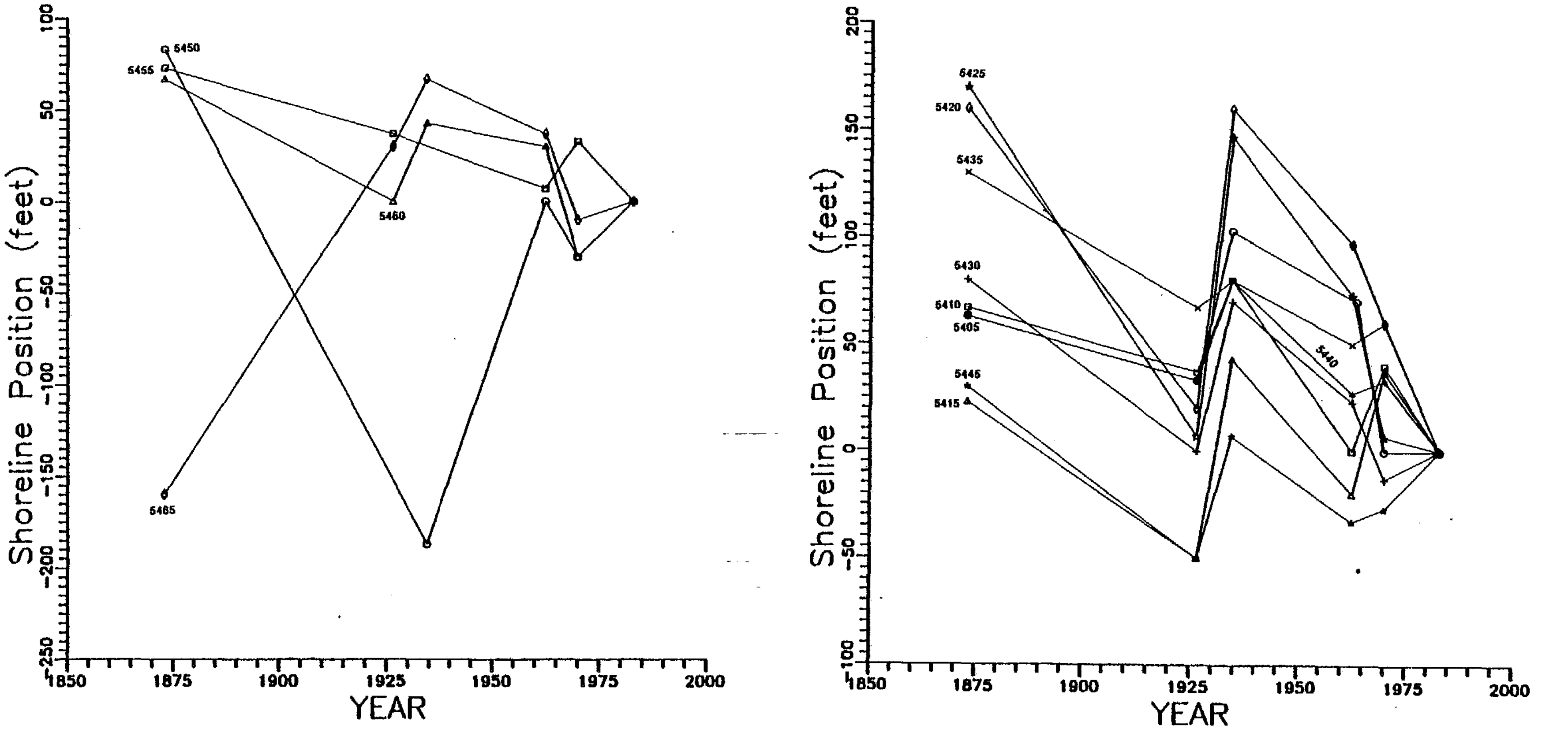


FIGURE 6.4-1
SHORELINE MOVEMENT ALONG MYRTLE BEACH NORTH AREA

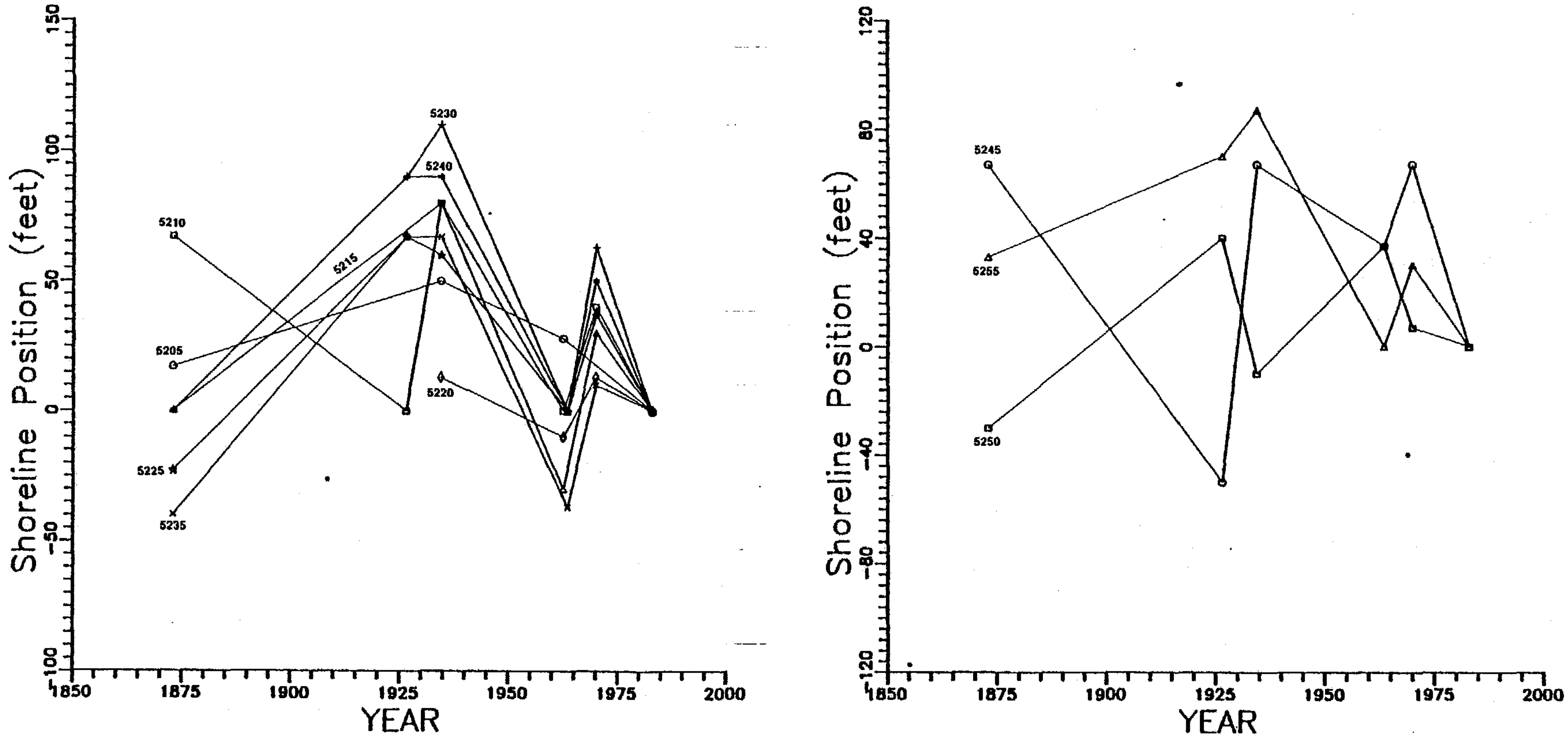
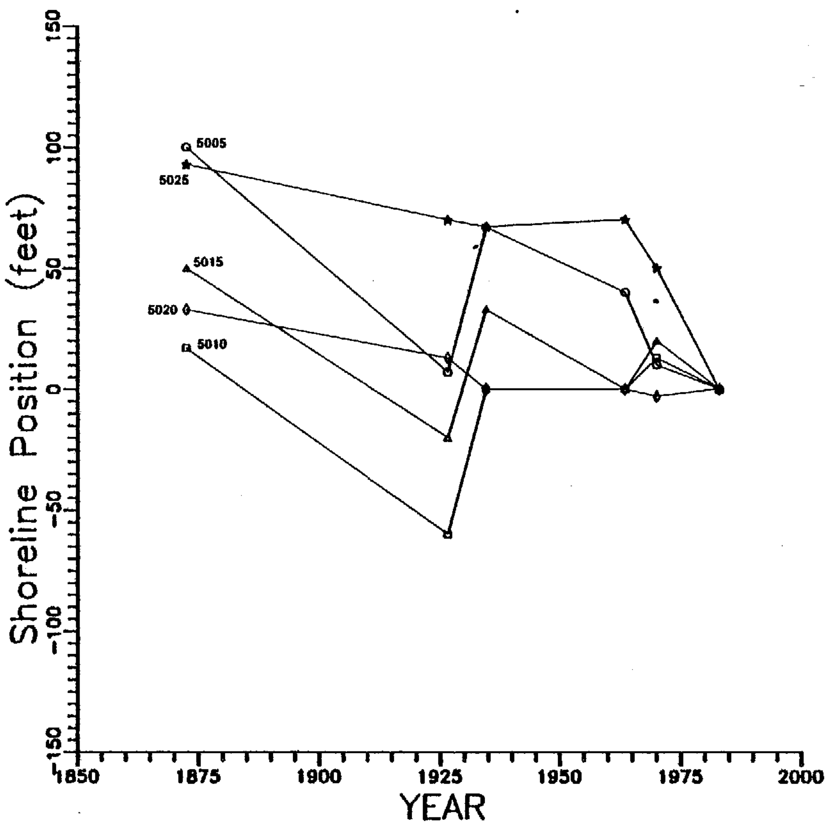


FIGURE 6.4-2
SHORELINE MOVEMENT ALONG MYRTLE BEACH SOUTH AREA



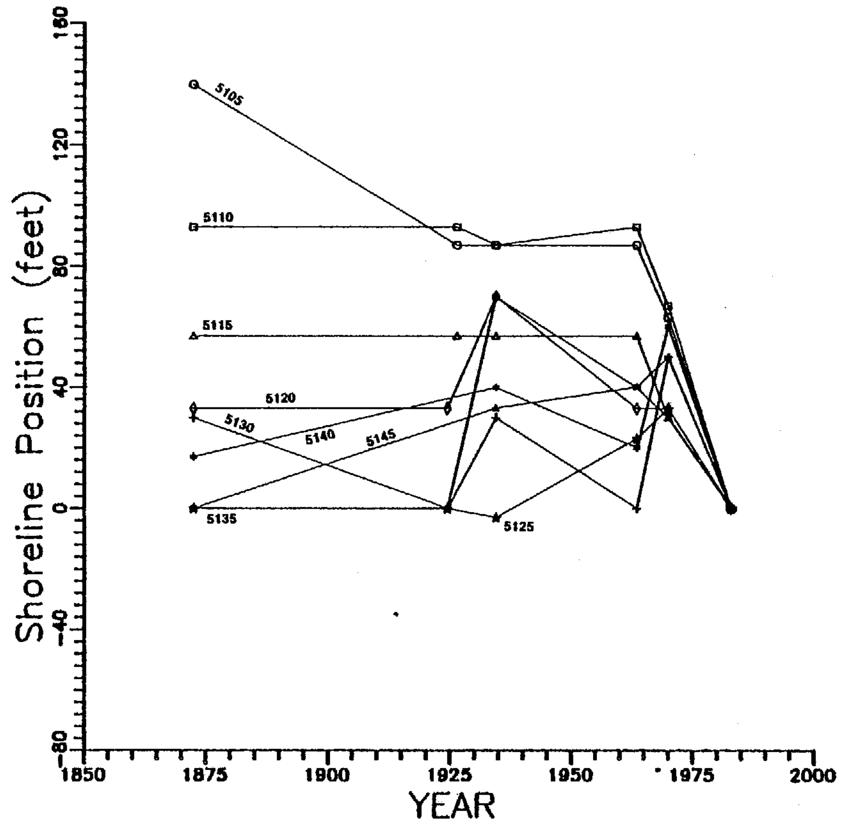


FIGURE 6.4-3
SHORELINE MOVEMENT ALONG SURFSIDE BEACH AND GARDEN CITY

Table 6.4-1. Long-term shoreline accretion/erosion rate (Garden City and Surfside Beach)

Station	Erosion Rate* (ft/yr)
<u>Surfside Beach</u>	
5105	-4.5
5110	-4.8
5115	-2.8
5120	-1.8
5125	-1.4
5130	-0.5
5135	-2.1
5140	-1.5
5145	-2.3
<u>Garden City</u>	
5005	-1.9
5010	-0.1
5015	-0.2
5020	0.0
5025	-3.6

* Negative value indicates erosion.

Source: Applied Technology and Management, Inc. 1986

Table 6.4-2. Long-term shoreline accretion/erosion rate (Myrtle Beach and Myrtle Beach South area)

Station	Erosion Rate* (ft/yr)
<u>Myrtle Beach North Area</u>	
5405	-2.3
5410	-1.5
5415	-0.7
5420	-3.2
5425	-3.2
5430	-1.6
5435	-1.4
5440	-1.6
5445	-0.3
5450	4.0
5455	-0.6
5460	-1.1
5465	-1.5
<u>Myrtle Beach South Area</u>	
5205	-1.0
5210	-1.5
5215	-1.6
5220	-0.2
5225	-1.1
5230	-2.1
5235	-1.5
5240	-1.7
5245	-1.1
5250	-0.3
5255	-1.8

* Negative value indicates erosion.

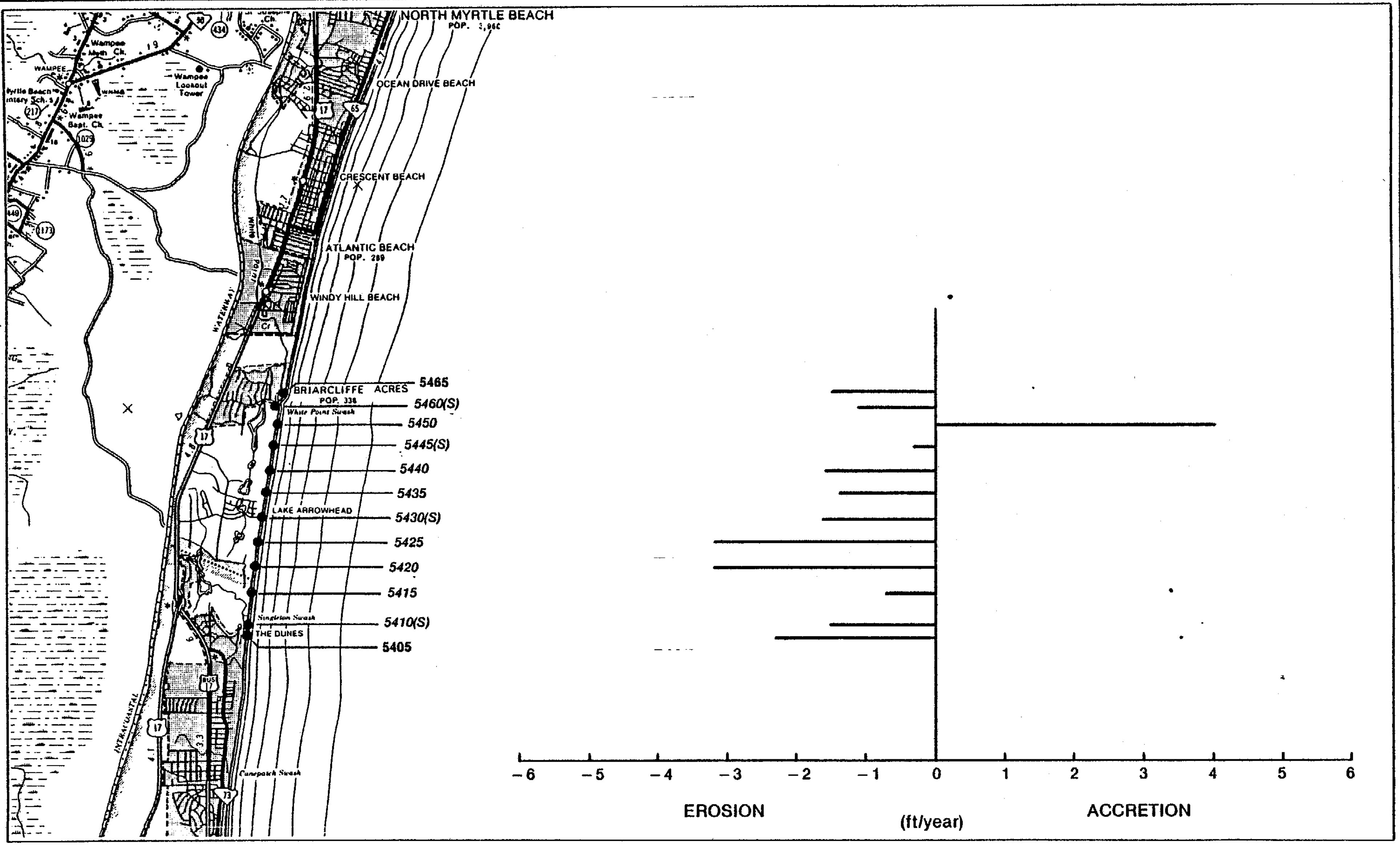


FIGURE 6.4-4
LONG-TERM EROSION RATE IN MYRTLE BEACH NORTH AREA

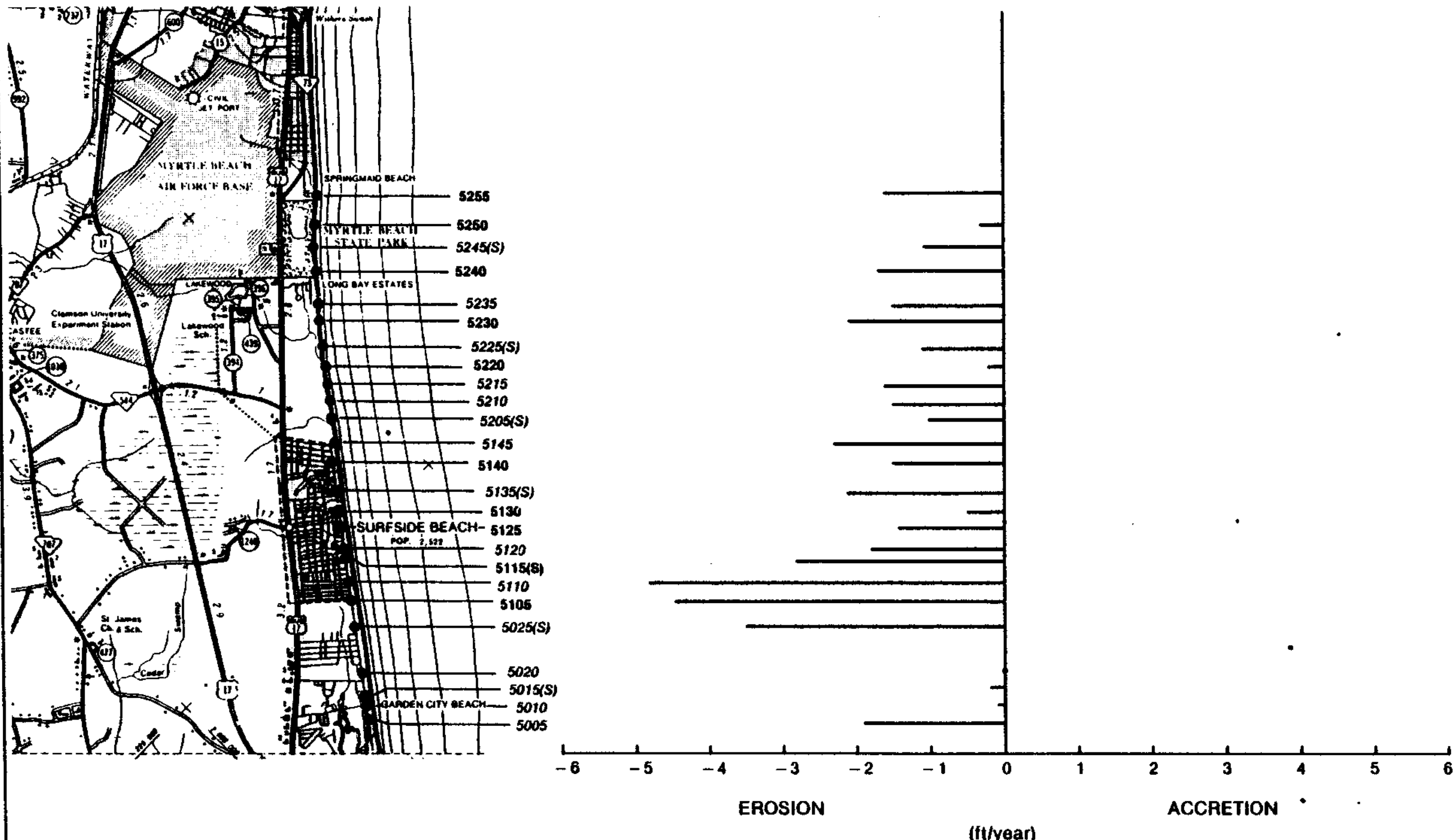


FIGURE 6.4-5
LONG-TERM EROSION RATE BETWEEN
MYRTLE BEACH AND GEORGETOWN COUNTY

where: R = horizontal recession

S = vertical water rise in sea-level

W_* = active width of the equilibrium profile

h_* = limiting depth associated with active profile

B = berm or dune height

The limiting depth (h_*) associated with the active portion of the beach profile was determined using a composite of 4 profiles representing the Garden City and Litchfield Beach shorelines. Using offshore beach profile data at Stations 4525 and 4540 and the local rise in sea-level, the horizontal rate of shoreline recession along Garden City is computed as

$$R = \frac{\frac{0.4667\ \text{ft}}{49\ \text{years}}\ (1118.\text{ft})}{(18.0\ \text{ft} + 17.5\ \text{ft})} = 0.3\ \text{ft/year}$$

The shoreline recession caused by sea level rise is small when compared with short- and long-term erosion that is the combined result of seasonal variation and storm impacts.

6.6 THE IDEAL PRESENT PROFILE

In accordance with the prescribed methodology outlined in the contract for this study, an Ideal Present Profile analysis was performed for several reaches in the study area. This procedure was developed by Research Planning Institute, Inc. (RPI), as "the most objective way of determining where today's shoreline would 'ideally' be located in the absence of structures" and as "a means of averaging the high and low areas along the beach and evening-out the distribution of sand." The steps in determining the "ideal" present shoreline are presented as follows (Eiser et al., 1986).

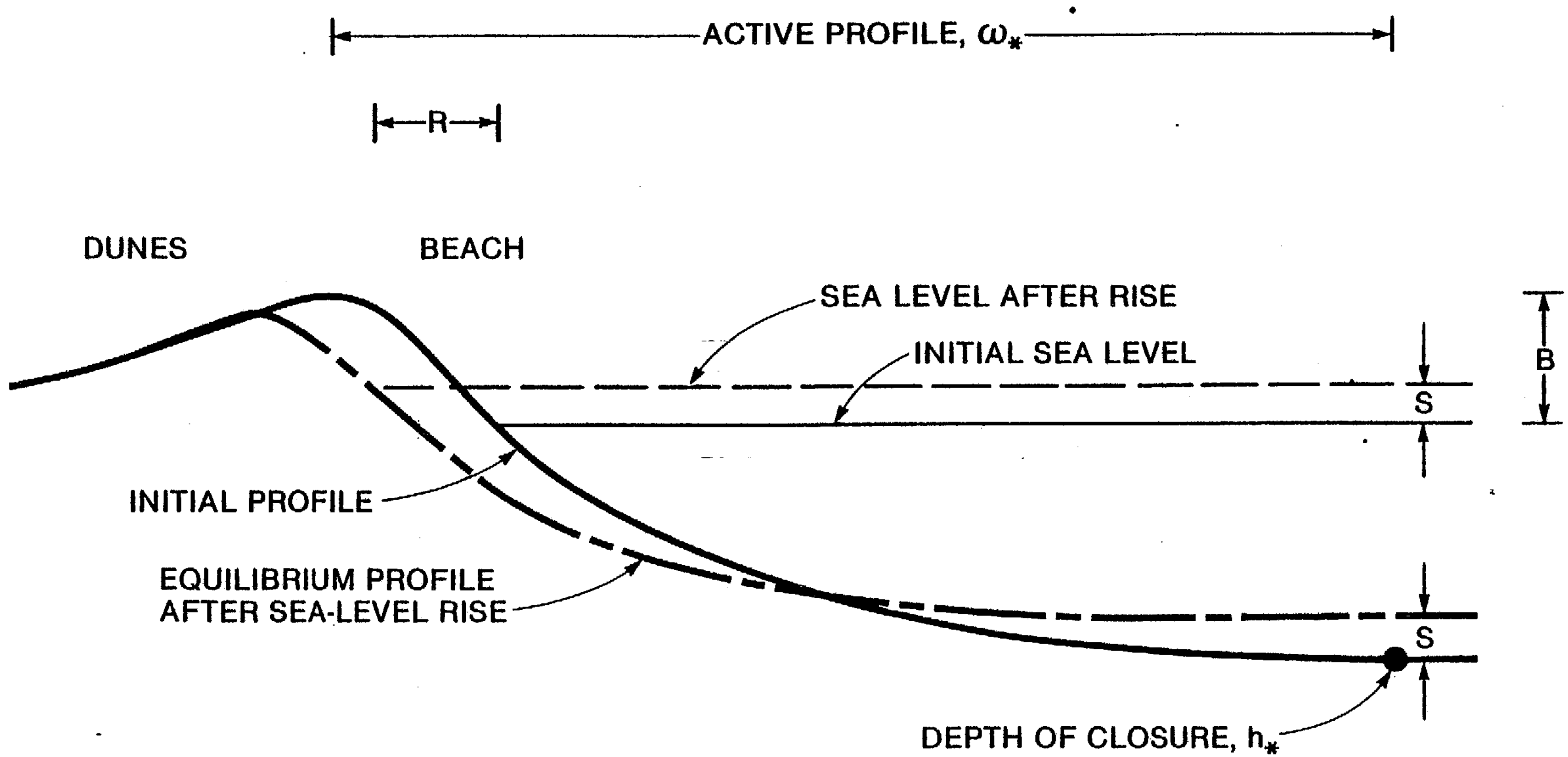


FIGURE 6.5-1
EQUILIBRIUM PROFILE RESPONSE TO SEA-LEVEL RISE (BRUUN METHOD)

1. Select existing "unaltered" profiles within the study area that have a minimal dune (no structure), intertidal beach, and a typical unit width volume of sand. Profiles around tidal inlets, piers, or other littoral obstructions are not included.

2. Develop a statistical composite profile (ideal present profile) from the selected profiles.

3. Compute the reference unit width volume of sand between the +10' and -5' MSL contour.

4. Superimpose the ideal present profile (IPP) on each surveyed profile so that the beach volume under each is the same (apply minor corrections around piers or near inlets).

5. Determine the ideal shoreline position as the point at which the ideal dune crest falls on each surveyed profile, measured from the survey monument.

This methodology has been applied in the shorefront management plans for Myrtle Beach, prepared by RPI (Kana et al., 1984) and North Myrtle Beach (Eiser et al., 1986) prepared by Coastal Science and Engineering, Inc. (CSE). In both of these applications, the study area consisted of one continuous shoreline of approximately 9 miles in length, uninterrupted by major inlets and, with the exception of piers, devoid of any shore-perpendicular structures (littoral barriers). In contrast, the present study area consists of 31 miles of disjunct shoreline interrupted by several major inlets, municipal boundaries and man-made littoral barriers along certain sections. As a result, the IPP methodology was applied separately to several reaches of the study area shoreline. The methodology as employed in this study is presented in the following paragraphs that essentially paraphrase the methodology presented in the North Myrtle Beach Shorefront Management Plan performed by CSE (Eiser et al., 1986).

IPP Generation

In order to insure that the IPP methodology and procedure was properly understood and executed, it was first applied to the section of North Myrtle Beach (Horry County) shoreline between Singleton Swash and Withers Swash. As mentioned above, previous investigators had performed IPP analyses over 9 miles of shoreline both to the north and to the south of this reach. The results from these studies were used as a comparison and check of the results obtained in this application. As these shoreline reaches are adjusted to each other, it was expected that the IPP's should be similar, as should the computed reference unit width volumes of sand.

Eleven stations along the shoreline reach between Singleton Swash and Withers Swash were examined for suitability in the determination of the IPP. Profiles affected by inlets, shore-protection structures, littoral barriers or any form of beach maintenance were rejected as not meeting the criteria of an "unaltered" profile. Remaining profiles were then examined to insure that the criteria of a well-developed upper beach face and dune, as well as a typical unit-width volume of sand were met. Six profiles met all these criteria and were therefore determined suitable for the generation of the IPP over this shoreline reach. These profiles were taken at survey stations 5425, 5435, 5440, 5445, 5450 and 5455.

In accordance with the prescribed procedure, the first step in determining the IPP is to align all the profiles about a common reference point, thereby resulting in a composite or mean profile. Selection of this reference point is determined as that point which results in the least variation about the mean profile. In their Myrtle Beach study (Kana et al., 1984), RPI determined that the procedure resulting in the least variation about the mean was to overlay all profiles such that the location of the +10' contour became a point in common for each profile. The +10' contour was likewise used as the common reference point for IPP generation in the subsequent North Myrtle Beach study. Observations made when shifting profiles for this and other shoreline reaches in the present study indicate that the +10' contour does not always represent the point resulting in the least variations about the mean. For this particular shoreline reach, this point was determined to be the +2.5' contour, corresponding closely to the approximate mean high water line. Figure 6.6-1 shows the superposition of the six profiles shifted about a common reference point of +2.5'.

Having established this composite profile, the elevation of each individual shifted profile was determined at 10 foot increments by means of linear interpolation between actual profile data points. The IPP was then calculated by averaging the elevation of the six profiles at each 10' distance increment. The resulting "Ideal" Present Profile (IPP) is presented in Figure 6.6-1 by a solid heavy line.

The reference unit volume of sand was computed as the volume between the +10' and -2.5' contours. The -2.5' contour, rather than the -5' contour as used in prior studies, was the approximate seaward limit of beach-profile surveys in this study and therefore the limit of available data. A volume of 47.1 yd^3/ft was calculated between the +10' and -2.5' contours for the IPP along this reach of shoreline. The IPP has a dune crest elevation of +12', a dune width of 40' and a beach width of 312' between the +10' and -2.5' contours (NGVD datum).

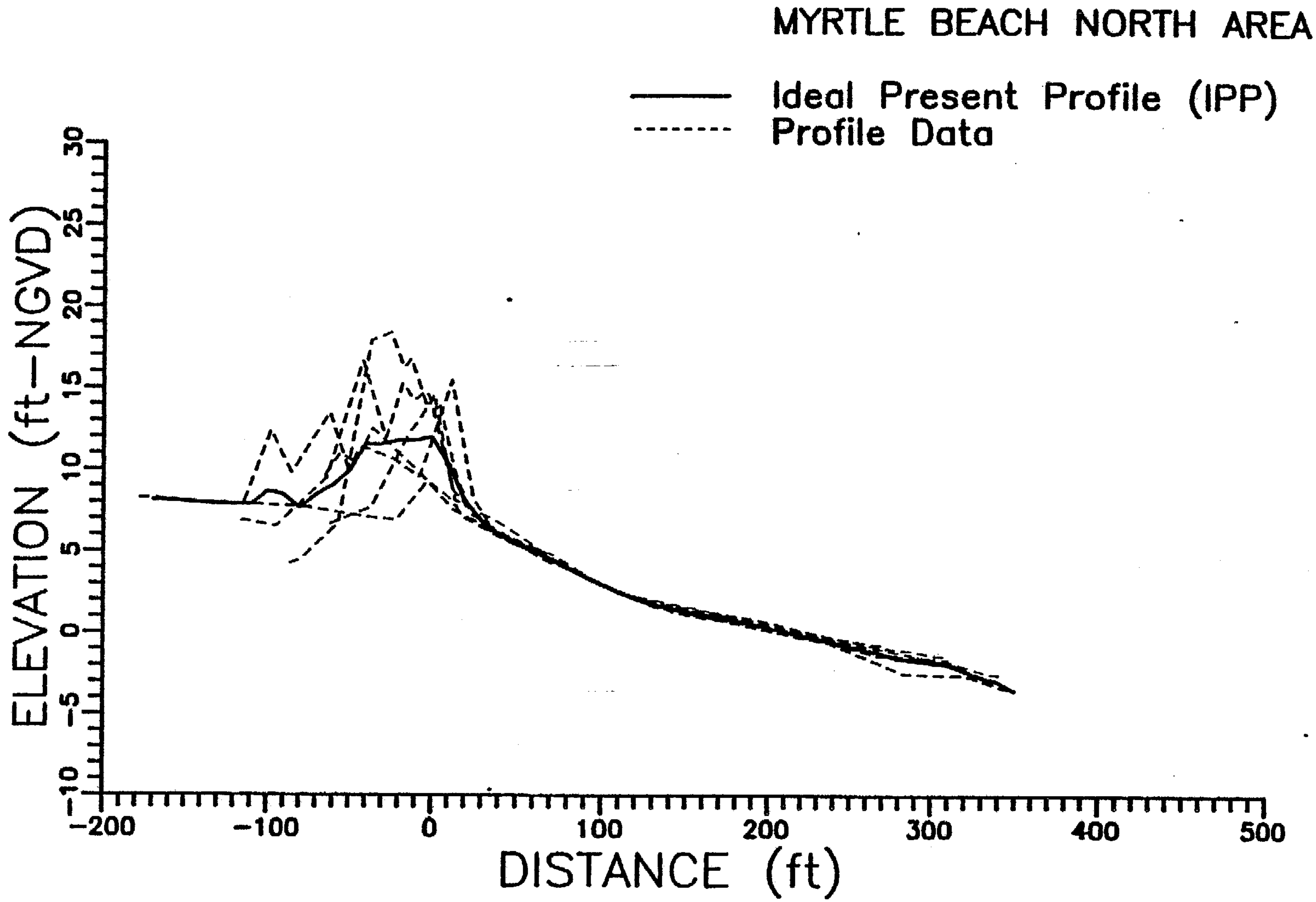


FIGURE 6.6-1
IDEAL PRESENT PROFILE FOR MYRTLE BEACH NORTH AREA

Figure 6.6-2 presents a comparison between the IPP derived in this study for the section of Horry County extending from Singleton Swash to White Point Swash and the IPP derived by CSE and RPI for the shoreline reaches to the north and south. Table 6.2-1 presents the reference unit volumes and other pertinent dimensions for each calculated IPP. Comparisons of the data presented in this table, as well as the profiles presented in Figure 6.6-2 indicate that profile characteristics, unit volumes, and other pertinent dimensions of the IPP generated in this study are quite comparable to those of the IPP presented in the previous CSE and RPI studies. The plotted IPP profile falls between adjacent IPP profiles (as do most dimensions magnitudes and volumetric quantities) and corresponds appropriately between the reaches associated with the two previous studies. The results of this comparison provide an adequate level of confidence as to the proper understanding and execution of the IPP methodology. Accordingly, the IPP methodology was applied to the shoreline reach extending from Springmaid Beach to Garden City Beach. A summary of procedure and results for this application is presented below.

Springmaid Beach-Surfside-Garden City Beach

The approximately 11.1-mile stretch of beach beginning at Springmaid Beach and extending south to Murrells Inlet is one continuous shoreline, uninterrupted by inlets, featuring a more-than-sufficient number of adequate profiles along its entirety for the generation of an IPP. Accordingly, an IPP was developed for this entire reach of shoreline to be used in the analysis and depiction of an Ideal Present Shoreline for each of the municipalities along this reach.

A total of 36 profiles were originally examined for suitability in the determination of an IPP. Of the 36, 10 were determined to meet all relevant criteria for selection.

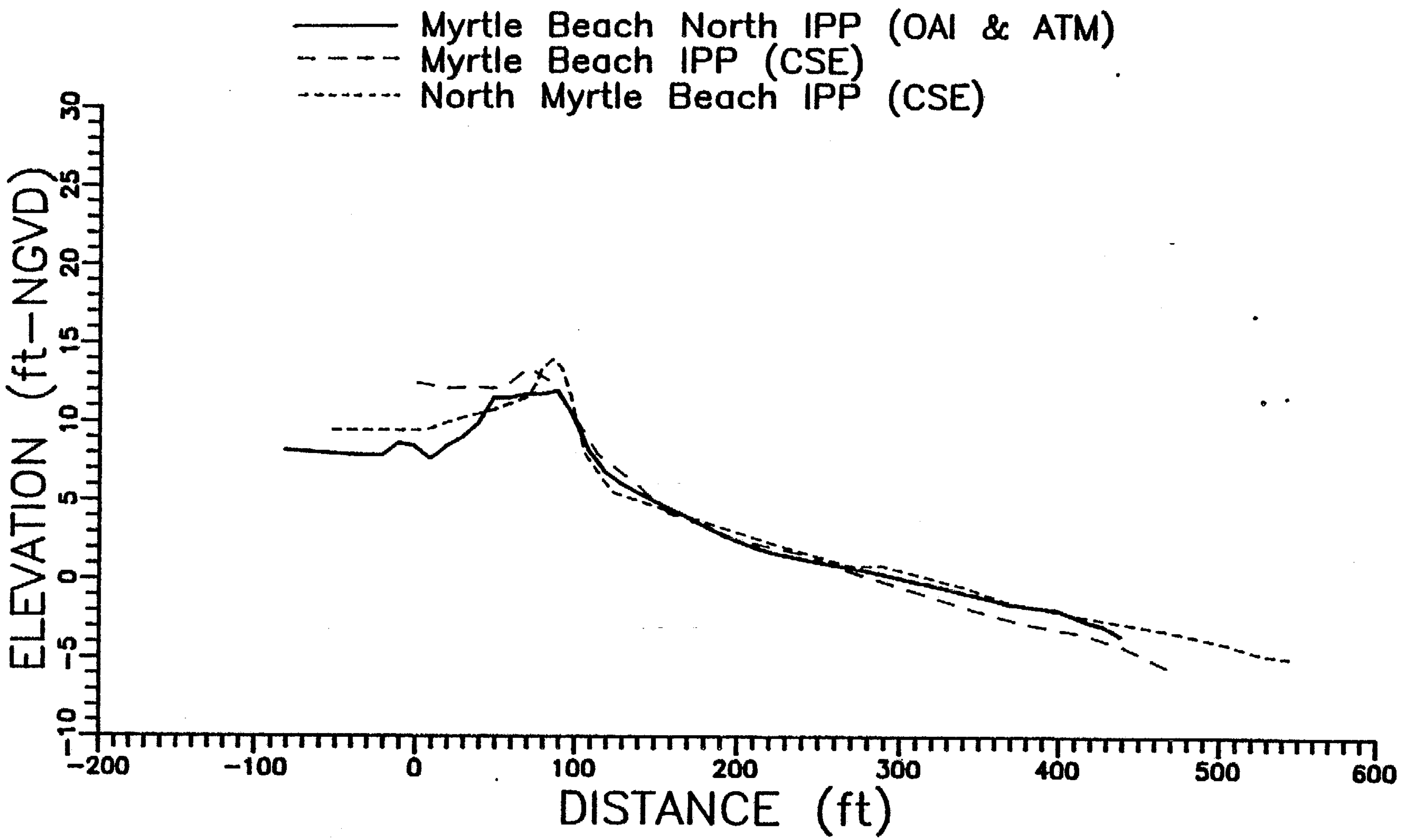


FIGURE 6.6-2
COMPARISON OF THE IDEAL PRESENT PROFILE COMPUTED FOR MYRTLE BEACH NORTH, MYRTLE BEACH AND NORTH MYRTLE BEACH SHORELINE AREAS

Table 6.6-1. Comparison of Profile Characteristics for the IPP Generated in This Study and Those Generated in Previous Studies

Study Area	Unit Volume*	Dune Crest Elevation	Dune Width	Beach Width**
North Myrtle Beach (CSE)	51.7 cy/ft	13.5 ft.	22 ft.	333 ft.
Singleton-White Point Swash	47.1 cy/ft	12.0 ft.	40 ft.	312 ft.
Myrtle Beach (CSE)	44.4 cy/ft	13.0 ft.	50 ft.	263 ft.

*Volume calculated between +10' and -2.5' contours

**Distance between +10' and -2.5' contours

These 10 profiles were taken at stations 5235, 5240, 5245, 5250 and 5255 in South Myrtle Beach, stations 5115 and 5140 at Surfside Beach, and stations 4630, 4635 and 4640 at Garden City Beach. The +5'MSL contour was determined as the common reference point resulting in the least variation about the mean when superimposing all 10 survey profiles. Figure 6.6-3 depicts the superimposition of the 10 profiles shifted about a common reference point of +5' MSL. The solid heavy line on Figure 6.6-3 presents the IPP generated by averaging the elevations of each of these profiles at 10' increments. A reference unit volume of 35.7 yd^3/ft was calculated between the +10' MSL and -2.5' MSL contours for the IPP along this shoreline reach. The IPP has a dune crest elevation of +11.5', a dune width of 44' and a beach width of 242' between the +10' and -2.5' MSL contours (NGVD Datum).

6.7 IPP COMPARISON

In accordance with the prescribed procedure, the IPP computed for each shoreline reach was superimposed on the April 1986 profile at each station along that reach. The IPP was then shifted horizontally in a manner such that the volumes under both profiles were equal. Wherever possible, volumes were calculated between the +10' and -2.5 contours, however, in a few instances the existence of seawalls, lack of sufficient dune heights, extensive survey data or other profile anomalies necessitated the selection of alternative contours for volumetric computations. Accordingly, the IPP was superimposed over the actual profile and shifted over the distance necessary to equate the volumes between these contours. Table 6.7-1 presents the unit volumes under each profile (April 1986), the variation between this volume and the IPP unit volume and the position of the IPP dune crest relative to the actual dune crest once the volumes have been equated. Once superimposed correctly, the actual and

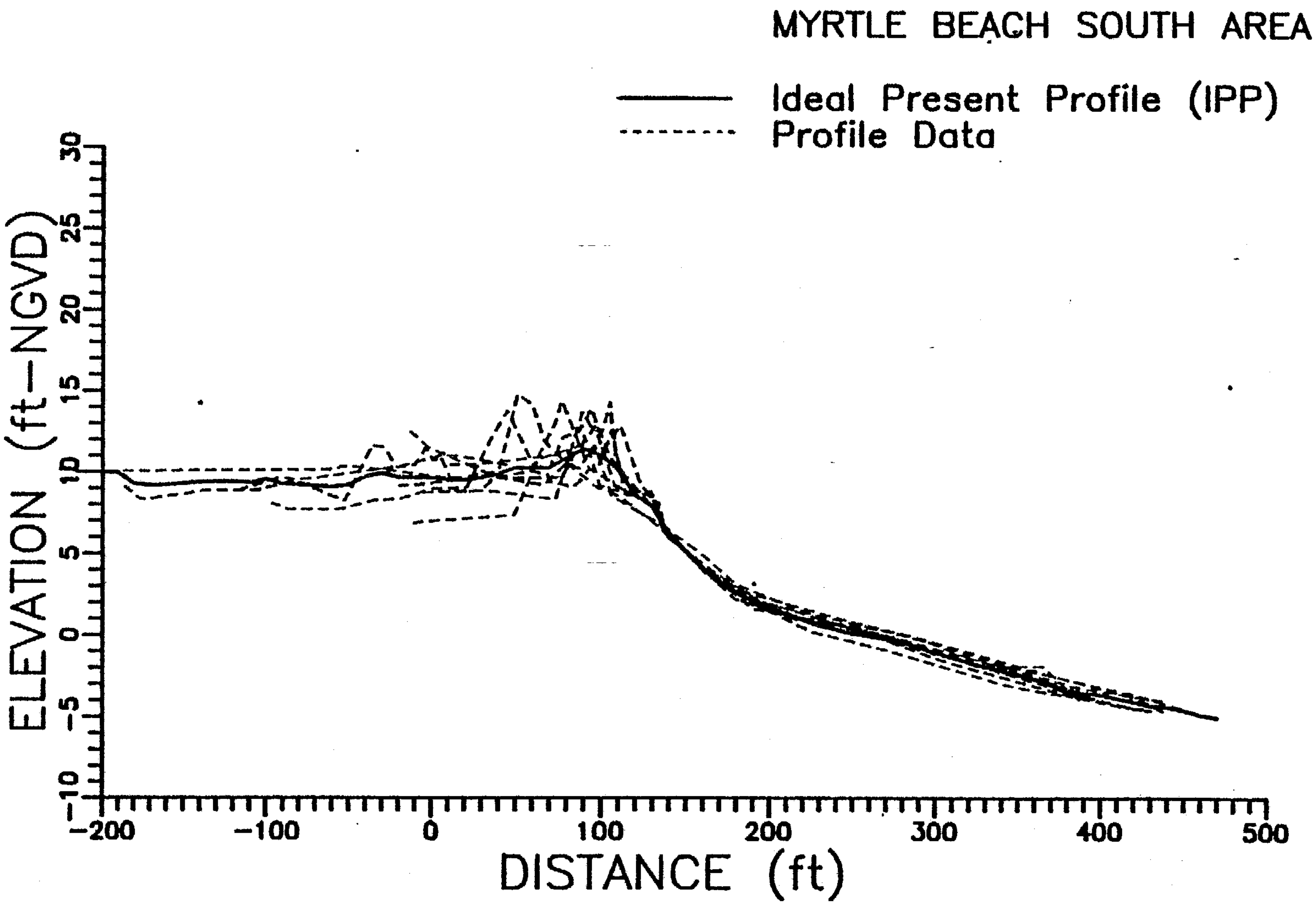


FIGURE 6.6-3
IPP FOR MYRTLE BEACH NORTH AREA

Table 6.7-1 Unit Sand Volumes, variation with IPP Unit Volume and position of IPP Dune Crest Relative to Actual Dune Crest When Equating Volumes Under the Profiles Along the Horry County Shoreline.

Station	Unit Volume (cy/ft)	Variation With IPP Volume (cy)	IPP Dune Crest Relative to Actual Dune Crest
5405	46.95	-0.15	Landward
5410	51.80	4.70	Landward
5415	38.85	-8.25	Landward
5420	53.85	6.75	Landward
5425	54.40	7.30	Seaward
5430	46.94	-0.16	Landward
5435	47.09	-0.01	Landward
5440	45.27	-1.83	Landward
5450	26.82	-20.28	Landward
5455	49.92	-2.82	Landward
5460	41.54	-5.56	Seaward
5465	60.82	13.72	Landward
5255	33.71	-1.99	Landward
5250	38.00	2.30	Landward
5245	47.46	11.76	Landward
5240	37.56	1.86	Landward
5235	37.42	1.72	Landward
5230	33.18	-2.52	Landward
5225	36.51	0.81	Landward
5220	51.15	15.45	Landward
5215	29.01	-6.69	Landward
5210	35.69	-0.01	Landward
5205	37.94	2.24	Landward
5145	39.53	3.83	Landward
5140	32.83	-2.87	Landward
5135	54.48	18.78	Landward
5130	34.08	-1.62	Landward
5125	34.42	-1.28	Landward
5120	41.11	-5.41	Landward
5115	39.75	4.05	Landward
5110	36.32	0.62	Landward
5105	34.16	-1.54	Landward
5025	36.28	0.58	Landward
5020	15.81	-19.89	Landward
5015	30.72	-4.98	Landward
5011	25.09	-10.61	Landward
5010	23.09	-12.61	Landward
5005	40.34	-4.64	Landward

shifted IPP profiles were plotted together. Figures 6.7-1a and 6.7-1b are two example plots showing the superposition of the IPP on the profiles at Stations 5020 and 4625 respectively.

Station 5020, located at the Atalaya Towers in Garden City Beach, is an extreme example of IPP superposition on an armored shoreline. In this case a seawall was built and backfilled at or near the seaward extent of the upland property line. Accordingly, the beach system in front of the seawall, either due to erosion or the initial seaward placement of the wall, does not include a dune, is of relatively low elevation, and therefore, has a lower unit volume than the IPP. As a result, when superimposing the IPP on this profile, it must be shifted well landward in order to equate the beach volumes under both profiles. This results in the IPP dune crest being located well landward of the seawall. This condition is characteristic of the shoreline extending north from Singleton Swash, as well as other armored sections of the Horry County shoreline.

Station 4625 is located along a residential section of Garden City Beach in Georgetown County. It is presented in Figure 6.7-1b in order to provide a clear example of the shifted IPP dune crest falling seaward of the actual profile dune crest. In this case, the unit volume of sand for the actual profile is greater than that of the IPP. In order to equate the volumes under the profiles, the IPP must therefore be shifted seaward. This results in the IPP dune crest being located seaward of the existing dune crest. In presenting the IPP methodology, its originators infer that "in cases where localized erosion of a natural dune has accelerated...this methodology makes allowance for artificial loss and places the ideal dune crest somewhat seaward of its present position" (CSE-1986). While it is not readily apparent how this allowance is made based upon

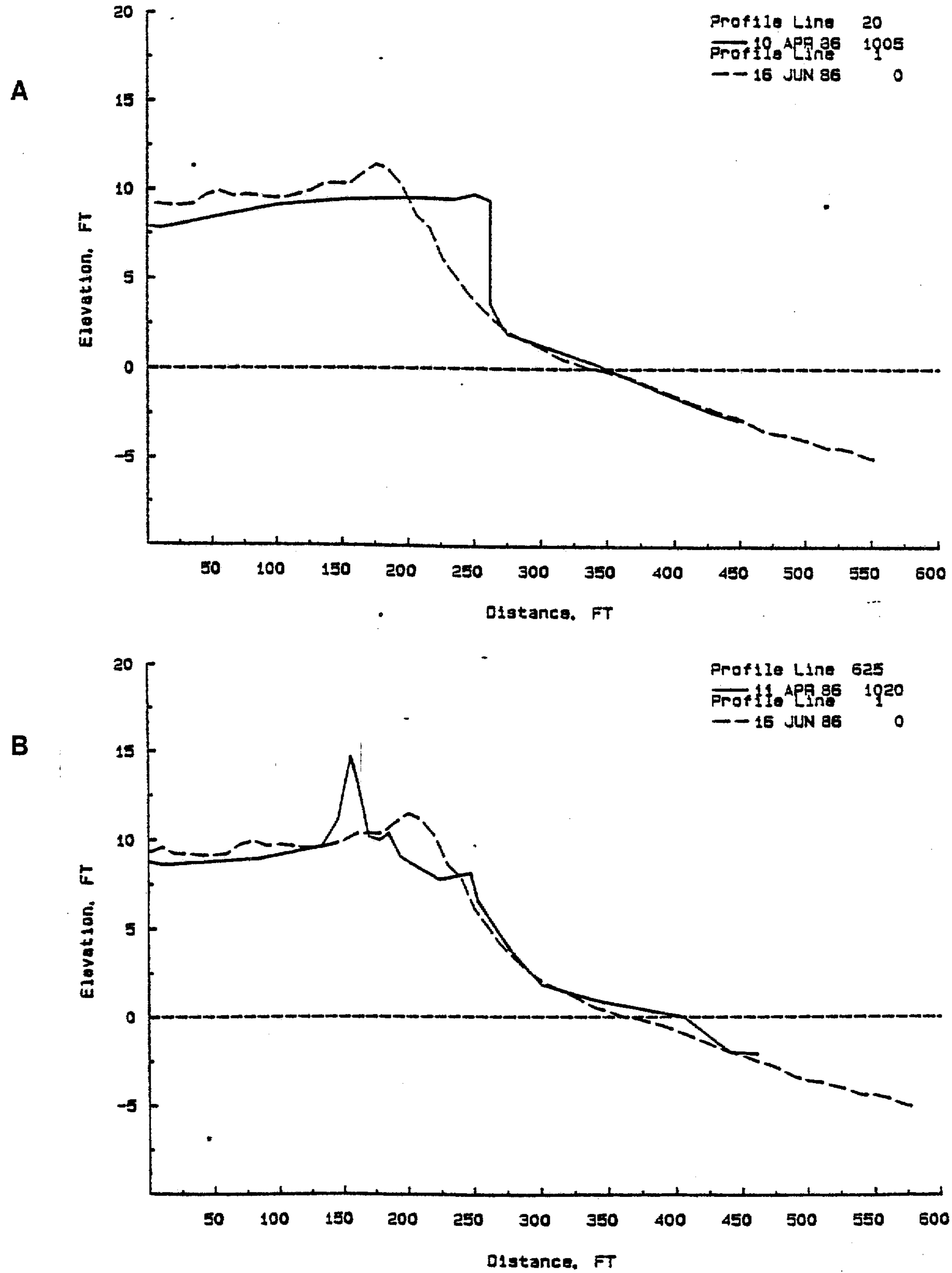


FIGURE 6.7-1
COMPARISION BETWEEN IPP AND
A) STATION 5020
B) STATION 4625

equating volumes (particularly in view of the preceding example), it is obvious that localized erosion is not a factor in this case. The location of the IPP dune crest seaward of the actual dune crest is a result of excess sand volume rather than a sand deficit. It is doubtful, in this case, that the IPP dune crest represents the location of the actual dune crest in the absence of structures along the shoreline. In the application of the IPP in this study, all instances where the IPP dune crest fell landward of the actual dune crest were attributable to excess unit volumes rather than sand deficits.

7.0 INLET ANALYSIS

Tidal swashes assume an important role in both the long and the short-term fluctuations of adjacent shorelines within the study area. For example, longshore sediment transport, also referred to as littoral drift, is continually directed toward a swash or gorge. Flood tidal currents transport and deposit these sediments within the lagoon or embayment, whereas ebb tidal currents return the sediments to the ocean. Typically the updrift beach builds and migrates in the predominating downdrift direction. This is the basic mechanism by which the swash naturally migrates in the direction of the predominating longshore currents. Correspondingly, the swash channel may likewise migrate, in some cases break through at a new location on either the updrift or downdrift shoreline as a result of low frequency storm events.

Inlets, swashes, channels, etc. are examples of natural non-structural barriers to littoral processes, whereas groins, piers and jetties are man-made structural barriers. Significant erosion problems can result when a barrier effectively blocks a large portion of the longshore sediment transport thereby resulting in sand starvation at some locations. Sediment trapping potential exists at both Singleton and White Point Swash. Since tidal channels are continuously affected by reversals in longshore transport, it is those shorelines closest to tidal inlets which typically experience the greatest variation in erosion rates and fluctuations of the beach and dune system. The area of influence along a coast affected by a tidal swash is related to the tidal prism which is an expression of the quantity of water that moves through the inlet.

The stabilization of any naturally functioning tidal swash by dredging and/or the construction of groins and rip-rap placement may modify the hydraulics of the prior regime, and therefore upset the long term dynamic equilibrium previously in existence. The consequence is the initiation of a new balance between hydraulic and sedimentary forces which causes a reconfiguration of the adjacent shorelines.

The adjacent shorelines of most natural swashes, since formed of unconsolidated sand, are obviously dynamic landforms easily subjected to the effects of storm-surge flooding. During a hurricane, the surge and wave set-up along the open coastline are the primary driving mechanism of flow patterns into the embayments. Extraordinarily high discharges through swashes during hurricane storm tides characteristically both erode and flood the adjacent channel margins as the increased flow converges in the vicinity of the entrance channel.

These dynamic areas require adequate coastal planning and building criteria for protection of property in close proximity to tidal swashes from the hazards of hurricane induced flooding. Channel migration, often associated with unstabilized inlets, may have severe impacts on the stability of adjacent swash channel banks during these severe storm events.

<u>White Point Swash</u>

White Point Swash is located 1700 ft south of Kitts Pier along the shoreline fronting Briarcliffe Acres. Kitts Pier extends 750 ft seaward of the local shoreline and appears to shelter the shoreline reach immediately north of White Point Swash. In recent years, short-term (2.4 years) volume changes indicate the beach transects both north and south (#5460 south to #5440) from White Point Swash have experienced depositional trends. Well-vegetated sand dunes and a depositional spit characterize the adjacent shoreline of the north bank.

The long-term shoreline trends indicate the north bank of White Point Swash migrated approximately south 3800 ft between 1873 and 1925, as presented in Figure 7-1. This shoreline consistently migrated north from 1925 to 1962 and has subsequently remained relatively unchanged. The White Point Swash entrance channel is presently oriented along a line approximately 50° west of the adjacent open ocean coastline. In recent years, rip-rap was placed over nearly 200 ft of the south bank along White Point Swash in an apparent effort to prevent southerly migration of the swash channel. The size and placement of this rock (0.8-1.5 ft diameter) should offer protection during normal wave conditions. The tidal prism associated with White Point Swash has been sufficient for this swash to remain open for the past 100 years. The flow appears to be tidally dominant while providing a route for stormwater drainage from upland areas.

Singleton Swash

Singleton Swash north bank is located along the shoreline fronting Lake Arrowhead and fronting The Dunes. In recent years short-term (2.4 years) beach profile changes indicate the shoreline segment extending 2000 ft north of this swash has experienced an erosional trend. The adjacent shoreline north from Singleton Swash suffers erosion along the foreshore area, in part due to discontinuous seawalls in close proximity to the shoreline which has resulted in significant shoreline irregularity.

In recent years, Singleton Swash has been relatively stable, as shown in Figure 7-2. Singleton Swash moved north prior to 1962 and has remained stable. A two foot vertical scarp was observed along the south channel bank during the April 1986 field investigation. Breaches of the dunes along the south channel margin were apparent although dunes were generally higher and well vegetated.

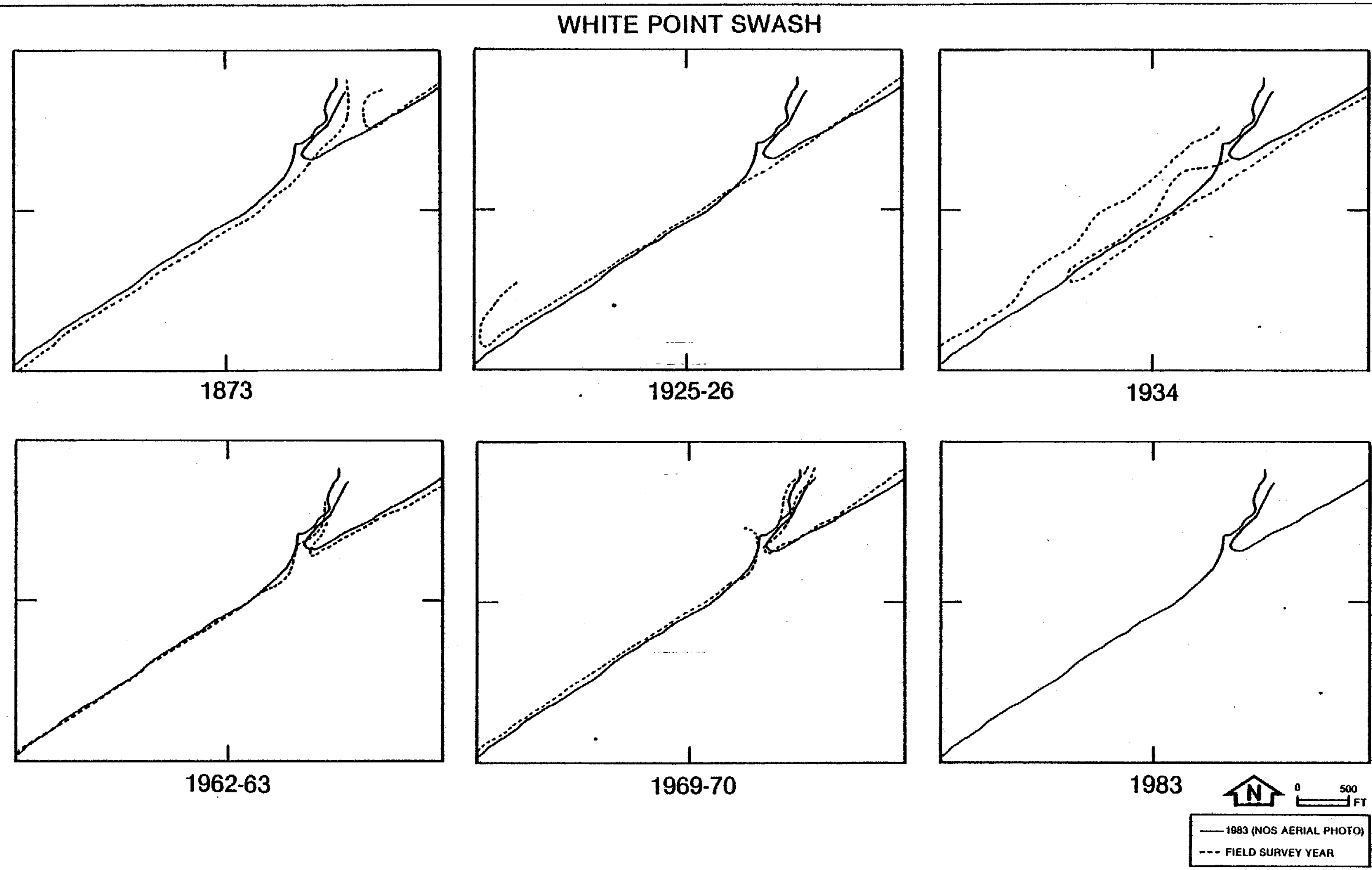


FIGURE 7-1
HISTORICAL SHORELINE POSITIONS
NEAR WHITE POINT SWASH

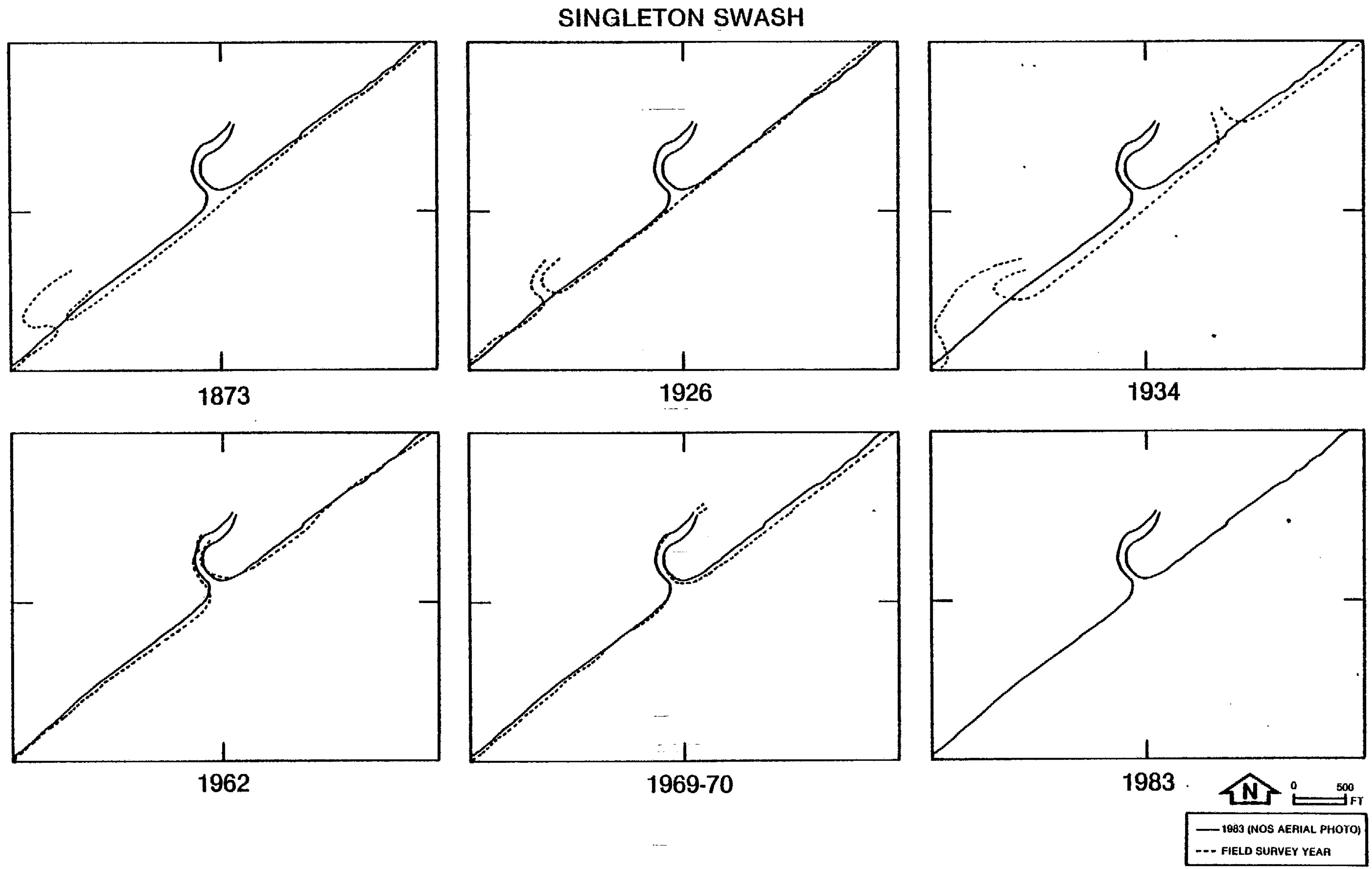


FIGURE 7-2
HISTORICAL SHORELINE POSITIONS NEAR SINGLETON SWASH

Peat deposits are exposed along the north channel bank. This adjacent shoreline has 12 ft. dune heights which follow a recurved spit along the channel margin.

Evidence of a recent washover were observed during the April 1986 field survey along the southern property boundary of the condominium immediately north of Singleton Swash. Initially this washover channel (30-40 ft wide) probably scoured in part due to wave action along the terminal point of this condominium's seawall. During high tides, water appears to flow into a marsh area formed by the recurved spit. In addition, stormwater runoff from the condominium parking area is directed into this washover channel.

8.0 FUTURE SHORELINE PREDICTION

8.1 IDEAL PRESENT SHORELINE

The ideal present profiles (IPP) of Myrtle Beach North and Myrtle Beach South were established as presented in Section 6.6. Once the IPP for each shoreline reach was overlaid on the April 1986 profiles such that the volumes under the two were equal, the location of the ideal present dune crest relative to each station was calculated. In accordance with the prescribed methodology the ideal present dune crest was determined as either the peak of the IPP dune or the midpoint of the IPP dune crest, whichever was applicable along each reach. The location of the ideal present dune crest relative to each station was then plotted on the base maps presented as Appendix D. The points representing these locations were connected by a line on the base maps that, in accordance with the prescribed methodology represents the ideal present shoreline (IPS).

The ideal present shoreline is subject to some degree of interpretation, primarily in areas where the ideal present dune crest falls seaward of the existing dune crest. As discussed in the application of the IPP methodology, this situation occurred due to an excess of sand in the profile unit volume rather than as an allowance for artificial loss due to localized erosion. Accordingly, shifting the ideal present dune crest seaward of the existing seawardmost dune line in order to account for excess sand volume was considered to be a miscomputation inherent in the methodology if interpreted literally. In such instances, the point representing the IPS defaulted landward to the existing dune crest. Similarly, in other cases the line representing the IPS tended to bulge seaward at stations in the immediate vicinity of piers, reflecting their effect as partial sediment traps. In accordance with the prescribed methodology, the IPS was maintained as a straight line in the vicinity of piers or similar structures.

Contrary to prior applications of the IPS, no concessions were made in this study in the event that the IPS fell sharply landward or on top of existing structures due to sand deficits in the profile unit volumes. Prior investigators have incorporated hypothetical assumptions that such sand deficits may be made up by artificial means, primarily beach nourishment, thereby justifying a seaward shift of the IPS. While beach nourishment projects are considered as the preferred means of providing a recreational beach and protecting existing upland development, they are not designed to encourage or accommodate seaward encroachment of building construction. Accordingly, artificial shoreline modifications such as beach nourishment will not be considered as justification for less stringent building codes and/or setbacks within this study. Therefore incorporation of such assumptions in the establishment of any line that may be used to determine building setbacks of other coastal development restrictions is unjustified, potentially harmful to the beach-dune system as well as coastal development permitted under this premise and inconsistent with accepted coastal management practice. Table 8.1-1 presents the locations of IPS in relation to the survey monuments at each monitoring station in the study area.

8.2 PREDICTED 25 AND 50 YEAR SHORELINES

It has been established in this study and several previous ones, that with isolated exceptions, the shoreline along the study area is undergoing a long-term erosional trend which varies spatially in magnitude. This erosion is attributable to several factors including sea-level rise, localized littoral deficits, storms and, to a minor extent, armoring of the shoreline. Whether expressed in volumetric or linear terms, the net result of this long-term erosion is a recession of the shoreline, a reduction of the dry beach as

Table 8.1-1. Ideal Present Dune Crest Locations

Station	IPS Location (ft)*
Garden City	
5005	89
5010	
5115	114
5020	174
5025	175
Surfside Beach	
5105	159
5110	194
5115	210
5120	233
5125	296
5130	281
5135	219
5140	193
5145	-16
Myrtle Beach South	
5205	-13
5210	-14
5215	-19
5220	80
5225	-6
5230	16
5235	-12
5240	-2
5245	8
5250	-6
5255	-17
Myrtle Beach North	
5404	-12
5410	-6
5415	-49
5420	-16
5425	-23
5430	-30
5435	-37
5440	-23
5445	-21
5450	-21
5455	-17
5460	7

*IPS location is measured seaward from the survey monument.

both a recreational amenity and a valuable storm buffer, and an ever increasing encroachment on upland development. Predictions of long-term shoreline recession rates are essential in the determination of setback lines, building codes and erosion control permitting procedures; all of which are elements of a prudent shorefront management plan.

Estimations of long-term shoreline recession rates are usually made based on extrapolation of observed historical rates into the future. Accordingly, the accuracy of and confidence level associated with these predictions is directly related to the quality and quantity of information comprising the historical database. The practice of conducting beach profile surveys for the specific purpose of quantifying shoreline change rates is relatively new along the South Carolina coast. As a result, the existing database is somewhat limited for the study area under consideration. Shoreline change maps have been compiled from other sources of shoreline information such as boat sheets, navigation charts, aerial photographs and boundary surveys. These maps while difficult to apply on a site-specific basis, provide a large scale indication of shoreline change rates over a longer period of time than any existing profile data for the study area. Application of rates obtained from these maps preclude the large degree of uncertainty that is often associated with the variation in short-term erosion in rates observed at individual profiles. As a result, the maps are quite appropriate in determining an average long-term erosion rate over a particular shoreline reach.

Once average long-term erosion rates were determined for each individual shoreline reach along the study area, they were then applied in the determination of future predicted shorelines. Specifically, the rates were applied to either the IPS or the existing dune line, whichever applicable, over a period of 25 and 50 years thereby resulting in the predicted 25 and 50-year shorelines. The setback distance associated with these lines was consistent over each shoreline reach with the exception of areas in the vicinity of inlets. As previously discussed, shorelines in the immediate vicinity of inlets are subject to significant translation in the event of storms, as well as, long-term natural inlet migration. Accordingly these areas are designated as Inlet Impact zones and are assigned an extra buffer during the prediction of future shoreline locations.

Predictions of potential short-term shoreline recession along the open coast resulting from hurricanes, and long-term recession resulting from sea-level rise, have also been presented in this study. The former are intended to indicate the immediate area of influence associated with erosion resulting from severe storm events while the latter is extracted as one component of the predicted overall long-term recession rates. In determining predicted future erosion rates for a specific shoreline reach, all available data for that reach were compiled and subjectively evaluated for accuracy and applicability. In order to maintain continuity over each shoreline reach, an average rate was obtained from individual profiles and applied to that reach. Correspondingly, in the prediction of storm-related erosion, the relevant distances were derived from average or representative profiles and were directly applied to each reach. A discussion of the available database and methodology utilized in predicting future erosion rates and distances over each shoreline reach is presented in the following paragraphs.

<u>Singleton Swash to White Point Swash</u>

Shoreline movement data for this reach of shoreline consisted of: 1) beach profiles taken in November, 1983 and April, 1986, 2) long term linear MHWL changes obtained from the NOS-CERC shoreline movement maps for the period 1934-1983, and 3) volumetric and linear rates determined by Kana et. al. for the shoreline immediately adjacent to the north and south of this reach. In addition, the IPP profile was used in the calculation of erosion associated with the occurrence of the 25 and 50 year storm.

In accordance with the IPP methodology, predicting the future position of the IPS is done by first calculating a historical annual volumetric change rate and then calculating the distance over which the IPS must be shifted to account for the total volume obtained when applying that volumetric rate over the number of years in question. The determination of an accurate annual volumetric change rate was not possible, however, with the limited amount of profile data available for this reach. The difference in profile volume associated with the short term, seasonal differences between the November, 1983 and April, 1986 beach profiles would severely bias any attempt to assign a long term, annual volumetric change rate using only these two sets of survey data. In order to remain consistent with methodology used in previous studies to predict the future IPS position along adjacent shorelines to the north and south of this reach, volumetric change rates determined in these studies were employed here.

In the RPI study (Kana et. al. 1984) a long term linear recession rate of 0.68 ft/yr was determined from volumetric erosion rates for the Myrtle Beach shoreline south of the reach under consideration. Likewise, in the CSE study (Eiser et. al. 1986) a long term linear recession rate of 0.40 ft/yr was determined from volumetric erosion rates for the North Myrtle Beach shoreline north of this reach. Analysis of the data and procedures employed in each of these studies, along with the previous determination that beach profiles over this reach and the shorelines to the north and south are quite similar, resulted in the application of a long term linear recession rate of 0.60 ft/yr which corresponds to a distance of 15 and 30 feet respectively over 25 and 50 years. These distances were applied to the previously determined IPS for this reach in order to represent the predicted 25 and 50 year shorelines.

<u>Springmaid Beach to Garden City</u>
Shoreline movement data for this reach of shoreline consisted of: 1) beach profiles at various locations taken in 1958, 1979, 1980, 1981, 1982, 1984, and 1986 and 2) long term linear MHWL changes obtained from NOS-CERC Shoreline Movement Maps for the period 1934-1983. In addition, the IPP profile generated for this reach was used in the calculation of erosion associated with the occurrence of the 25 and 50 year storm.

Based on the limited number of 1958 profiles as well as the potential for extreme bias in beach volumes due to recent nourishment, as well as inlet effects, it was concluded that the available profile data were inadequate for the prediction of long term annual volumetric change rates. Accordingly, the shoreline movement maps were referred to in the determination of an average erosion rate for this reach of shoreline. Approximate erosion rates were calculated at each station along the reach and averaged to obtain a uniform rate. Stations that were armored or considered subject to inlet or swash migration were not considered in calculating the average rate. The resulting average long term erosion rate was 1.5 ft/year which corresponds to a distance of 37.5 and 75 feet respectively over 25 and 50 years. These distances were applied to the previously determined IPS for this reach in order to represent the predicted 25 and 50 year shorelines.

8.3 STORM IMPACTS

As with any shoreline along the southeastern Atlantic coast, the beaches included within the study area are subject to substantial temporal erosion due to the effects of . northeasters, tropical storms, and hurricanes. These events are associated with short term superelevations of the water level (storm surge) and increased onshore wave energy. The setup of the water level allows wave breaking and wave runup processes to occur at an increased elevation on the beach foreshore thereby subjecting the existing dune system and/or upland development to direct wave attack and consequential displacement and damage. The predictable result is a large scale dune erosion or loss, dramatic rates of shoreline recession and destruction of upland structures.

In most instances, however, eroded material in not totally lost from the littoral system, but rather deposited in nearshore bar formations. On a relatively stable shoreline, seasonal variations in local wave climate will return much of the eroded sediment to the beach foreshore and dunes over a period of years, barring the occurrence of similar storms during the rebuilding period. As a result, the extent of erosion that takes place during such events is not always accurately represented or accounted for when assessing long-term erosion rates. When establishing a shorefront management plan, short-term erosion events should be considered to avoid potentially disastrous impacts associated with major storm events.

The predicted storm surge elevations for the study area are discussed in Section 3.3 of this report. Although substantial damage along the study area shoreline has been documented as a result of land-falling hurricanes, much more frequent erosion occurs from northeasters. It is interesting to note that the beach erosion caused by a long duration northeasters and associated high water levels can often exceed that of a hurricane passing offshore. More moderate hurricane-induced erosional impacts are due to the relatively shorter storm duration and lack of immediate proximity of the relatively fast moving tropical storm to the local shoreline. Nevertheless, erosion associated with the occurrence of the predicted 25 or 50 year hurricane has been considered as the "worst case" condition when evaluating setback type criteria in this study.

A numerical model has been employed in this study in order to predict the extent of potential future erosion that may be expected along the various study area shoreline reaches as a result of the occurrence of the predicted 25 and 50-year hurricanes. The theoretical basis for the computer model was developed by Dr. Robert G. Dean of the University of Florida and is currently applied by the State of Florida Department of Natural Resources - Division of Beaches and Shores (DNR-DBS) Coastal Construction Control Line Program. Simplistically, the model calculates the erosion of a characteristic beach profile at each time interval associated with a synthesized storm surge hydrograph. The model predicts linear erosion of the beach-dune system but does not account for dune overtopping or breaching. The hydrograph represents the rise and fall of the water level over time that occurs during a tropical storm. The IPP or other representative profiles along each reach were simplified and input into the model as the pre-storm profile. Water levels associated with the 25 and 50-year hurricane along each reach were input as the peak of the storm surge hydrograph for each simulation. The hurricane hydrograph was simulated using the characteristics of an actual storm surge hydrograph. The components of the hypothetical hydrograph correspond with the peak water elevations of the 25- and 50-year hurricane for a 36-hour total storm duration. The hydrograph was skewed with a long rising limb (i.e., time to peak) and a slow falling limb.

The rising portion was approximately 20 hours; maximum or peak levels occurred for approximately 10 hours. The falling or receding position was approximately 6 hours. Specific input parameters and the results of these simulations are presented in the following paragraphs.

<u>White Point Swash to Singleton Swash</u>

The previously determined IPP for this reach of shoreline was utilized to represent the pre-storm profile condition. Input requirements of the model necessitate simplifying the profile as a series of straight line slopes above the prestorm water level and an exponential equilibrium profile below that water level. The maximum IPP dune height of 12 ft was input in to the model as were 25 and 50-year maximum storm surge elevations of +9 ft and +11 ft (NGVD), respectively. Landward IPS erosion of 95 ft and 130 ft resulted from the model simulation for the 25 and 50-year storm surge, respectively. Figure 8.3-1 presents the IPP, the simplified IPP input as the pre-storm profile and the eroded profiles resulting from the simulated 25 and 50-year storm surge. Of particular note is the fact that the IPP dune is breached as a result of both these simulations. While the simulations of the IPP erosion represents an average condition, it is in this case a condition that would result in considerable landward propagation of the flooding and wave action associated with these storm events.

<u>Springmaid Beach to Garden City</u>

The previously determined IPP for this reach of shoreline was utilized to represent the pre-storm profile condition in this simulation as well. Likewise, the profile was simplified to meet input requirements of the model. The maximum IPP dune height of 11.5 ft and maximum storm surge elevations of 9.5 ft and 11.5 ft were input into the model for simulation of the 25 and 50-year storm events, respectively. Landward dune erosion of 116 ft and 152 ft

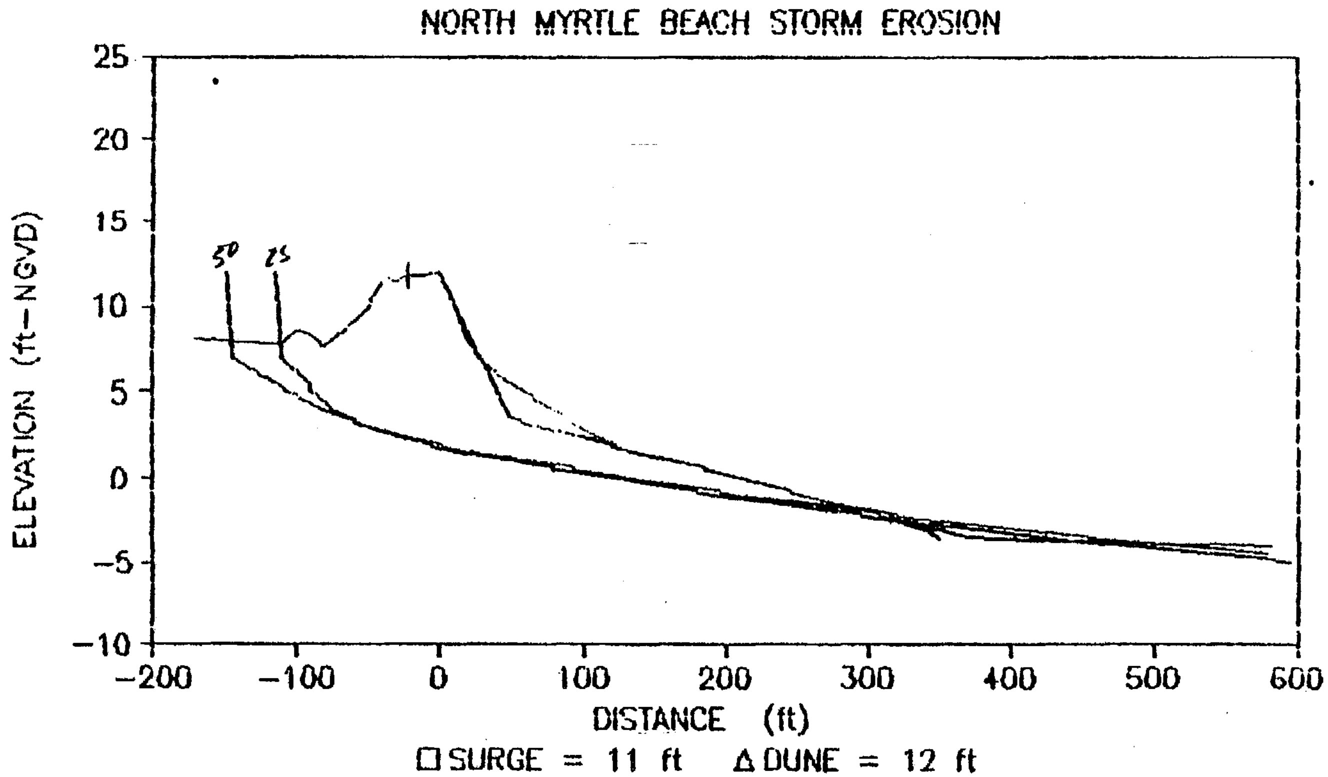


FIGURE 8.3-1
PREDICTED 25- AND 50-YEAR STORM EROSION
(BETWEEN NORTH MYRTLE BEACH AND
MYRTLE BEACH)

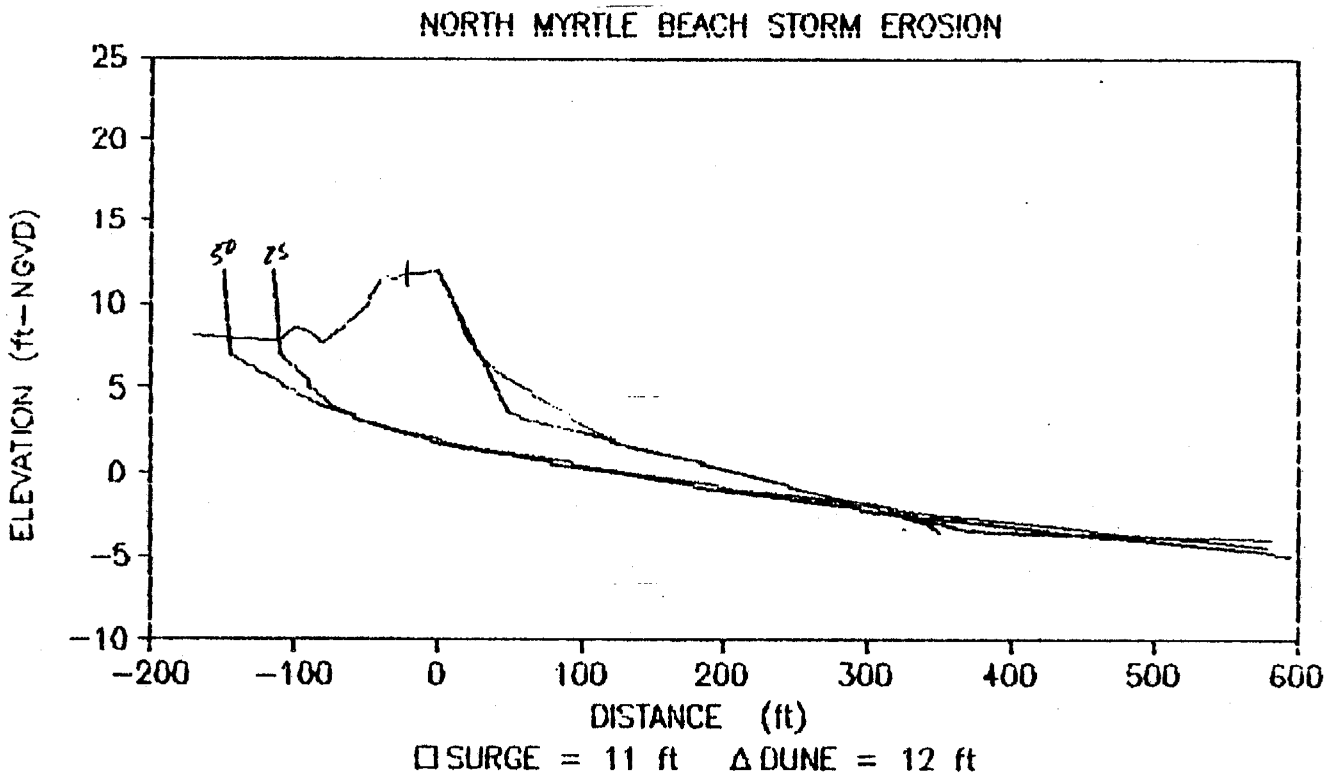


FIGURE 8.3-2
PREDICTED 25- AND 50-YEAR STORM EROSION
(BETWEEN MYRTLE BEACH AND SURFSIDE
BEACH)

resulting from the model simulation of the 25 and 50-year storm surges is shown in Figure 8.3-2. Again, it should be noted that the primary IPP dune is breached in both of these simulations. Likewise, while erosion of the IPP represents an average condition along the shoreline reach, it is in this case a condition that would result in considerable landward propagation of the flooding and wave action associated with these storm events.

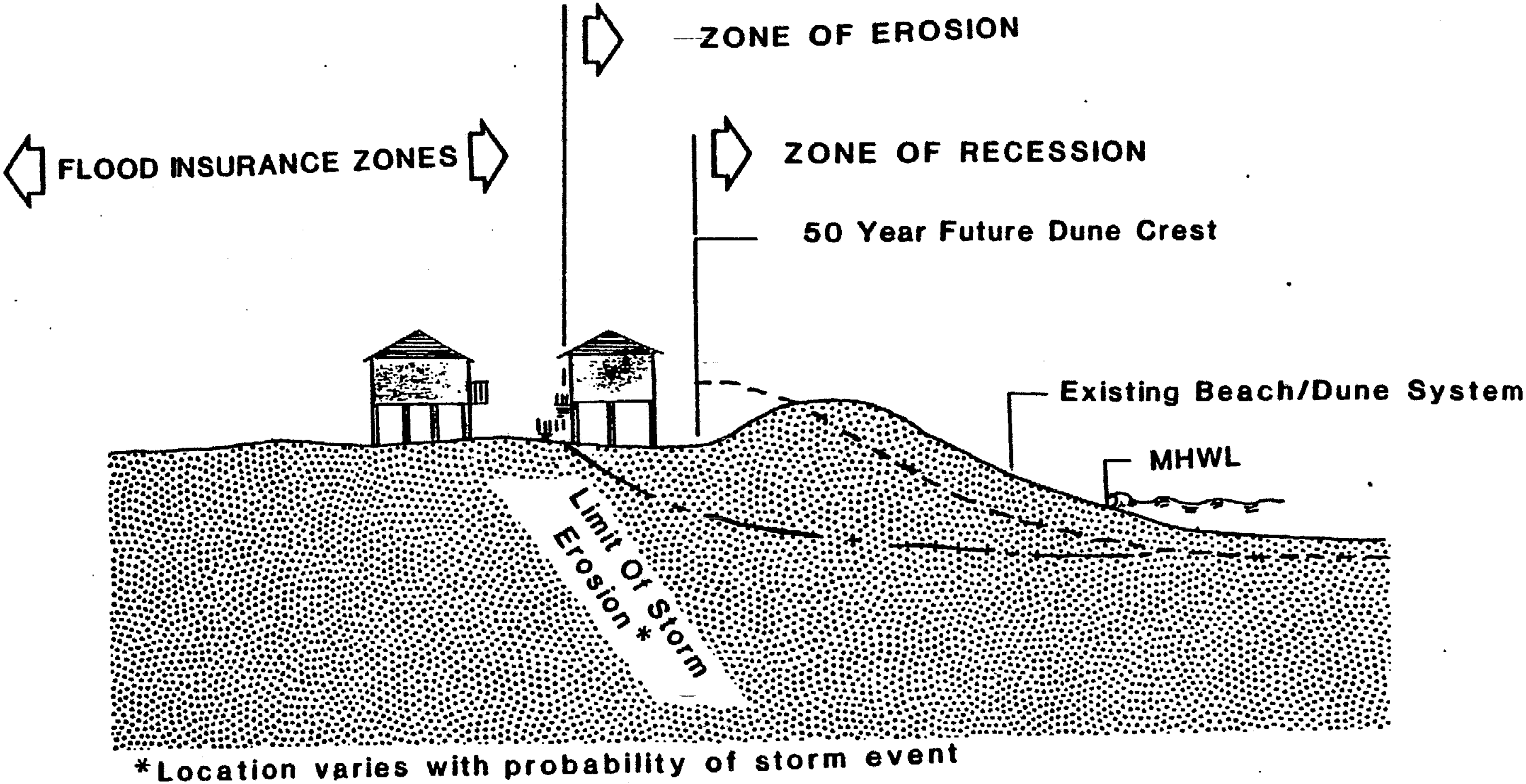
9.0 SHOREFRONT MANAGEMENT RECOMMENDATIONS

9.1 HAZARD ZONES

In contrast to similar efforts by previous investigators, the Shorefront Management Study under consideration has identified multiple coastal hazard zones which are, at present, not currently or effectively regulated by federal, state and local governments along the shoreline of interest. These zones are associated with the:

- Future location of the beach/dune system as a result of erosion and shoreline recession,
- Limit of upland erosion resulting from low frequency storm events, and
- Existing Flood Insurance Zones which in numerous locations under-predict the level of impact for a 1-in-100 year storm.

A conceptual depiction of these coastal hazard zones relative to an existing beach/dune system is included as Figure 9.1-1. It is important to note that the indicated seawardmost two (2) zones are related to the expected long and short-term dynamic fluctuation of both the beach and dune, where existent. The flood insurance zones are the result of the federal government's (i.e. FEMA) efforts to map the impact zones of a 100-year storm for the purpose of making available federally subsidized flood insurance. It should be understood that the flood insurance zones depicted by FEMA for "A" and "V" zones respectively, are indicative of the flooding limits without, and with waves greater than three ft in height, resulting from a probabilistically determined 100-year storm event. The FEMA methodology does <u>not</u> however, include the prediction of shoreline fluctuations and erosion during the 100-year storm. For that reason, the predicted landward limits of V-zones in



COASTAL HAZARD ZONES

SHOREFRONT MANAGEMENT PLAN

FIGURE 9.1-1
SCHEMATIC DIAGRAM OF THE COASTAL HAZARD ZONES

coastal areas with dunes can be extremely unreliable and inaccurate when the elevation of the existing dune crest exceeds the computed theoretical elevation of the 100-year storm surge. To a large degree, this condition predominates throughout the study area. Hence the necessity for this shorefront management study to address existing flood insurance zones and the propriety of considering additional building construction guidelines within these extremely high-hazard areas.

9.2 EXISTING SHOREFRONT REGULATORY PROGRAMS

At present, the following three (3) types of developmental regulations are in effect along the Horry County shoreline of interest above the approximate MHWL:

- State of South Carolina Coastal Council permitting requirements along the beach and within the adjacent primary oceanfront sand dune "critical area" (via Act 123 of 1977),

- Federal Flood Insurance requirements for construction within "A" or "V" Zones (44 CFR, Parts 59 and 60), and

- Where existent, any locally adopted zoning ordinances and/or setbacks; developer's covenants and restrictions; etc.

Coastal Council regulatory authority allows for the protection of existing fragile beach/dune resources by calling for their classification as "critical areas". The limit of Coastal Council jurisdiction in most instances is a function of the location of the primary oceanfront dunes which by definition are "those dunes which constitute the front row of dunes adjacent to the Atlantic Ocean". Accordingly, the "critical area boundary" is further defined in the governing Rules and Regulations for Permitting as follows:

> If the crest of a primary front row sand dune is not reached within 200 feet landward from mean high water, that sand dune is not considered adjacent to the Atlantic Ocean. Council permitting authority shall extend: (1) to the landward trough of the primary front row sand dune if the crest of this dune is reached within 200 feet landward from mean high water; (2) to the seaward side of any maritime forest or upland vegetation if reached before the primary front row sand dune; and (3) to the seaward side of any permanent man-made structure which was functional in its present form on September 28, 1977.

At present, the Coastal Council's regulatory authority is limited strictly to existing conditions. No allowances are made for where the dune crest and/or beach face will be in the future as a result of shoreline recession in areas with historically known rates of erosion. Furthermore, the Council cannot consider the adverse effects of low frequency storm events which can both literally destroy the primary dune in a matter of hours and correspondingly adversely impact life, limb and property.

In accordance with the published regulations for the National Flood Insurance Program, FEMA defines "coastal high hazard areas" as "areas subject to high velocity waters, including, but not limited to hurricane wave wash". These areas are designated by means of maps as V-zones. Construction of habitable structures within such areas must comply with elevation and limited building standard criteria. Areas of "special flood hazard" (i.e. 100-year storm flooding) are likewise designated by mapping for insurance purposes as A-zones. Both A and V zone phenomena are considered to have a one percent or greater chance of occurrence in any given year (i.e. probability of .01). As previously discussed, the methodology for the prediction of 100-year flooding and simultaneous wave action utilized by FEMA does not account for erosion of the beach/dune system. Accordingly, the landward limits of the V-zone for much of the Horry County shoreline is grossly inaccurate and therefore unconservative. The result of this shortcoming in the methodology is that both existing and future new construction and/or substantial reconstruction is occurring in certain high hazard areas without having to consider appropriate design criteria. Without state or local intervention, this shortcoming is not expected to change in the foreseeable future.

The third general area of potentially existing regulation of construction within coastal high hazard areas is either "local government", or developer initiated control. For the project area under consideration, the only local beach and dune type setback restrictions in existence are enforced within the Town of Surfside Beach. Simplistically, zoning ordinances at that location required the establishment of a "Shore Protection Line (SPL) on all lots lying contiguous to the Atlantic Ocean. In such areas, the SPL is determined to be a line twenty (20) linear feet landward of the property line nearest the Atlantic Ocean (i.e., rear property line), or the line twenty (20) linear feet landward of the landward trough of the primary ocean front sand dune, as determined by the SCCC, whichever line is more landward. In areas where the primary dune is non-existent, a new dune must be constructed prior to construction. In such cases the setback must be fifteen (15) feet. No construction is allowed seaward of the SPL except for dunes, vegetation, minor non-habitable structures, and emergency erosion control measures. Structures seaward of the SPL which in the future that suffer 51% or more damage will be considered to be non-conforming and subject to removal at the owner's expense.

- Although not necessarily physically-based, such resource oriented setbacks as adopted by the Town of Surfside Beach are a reasonable first approach to the preservation of the beach/dune system.

9.3 EXISTING FLOOD INSURANCE ZONES AND STANDARDS

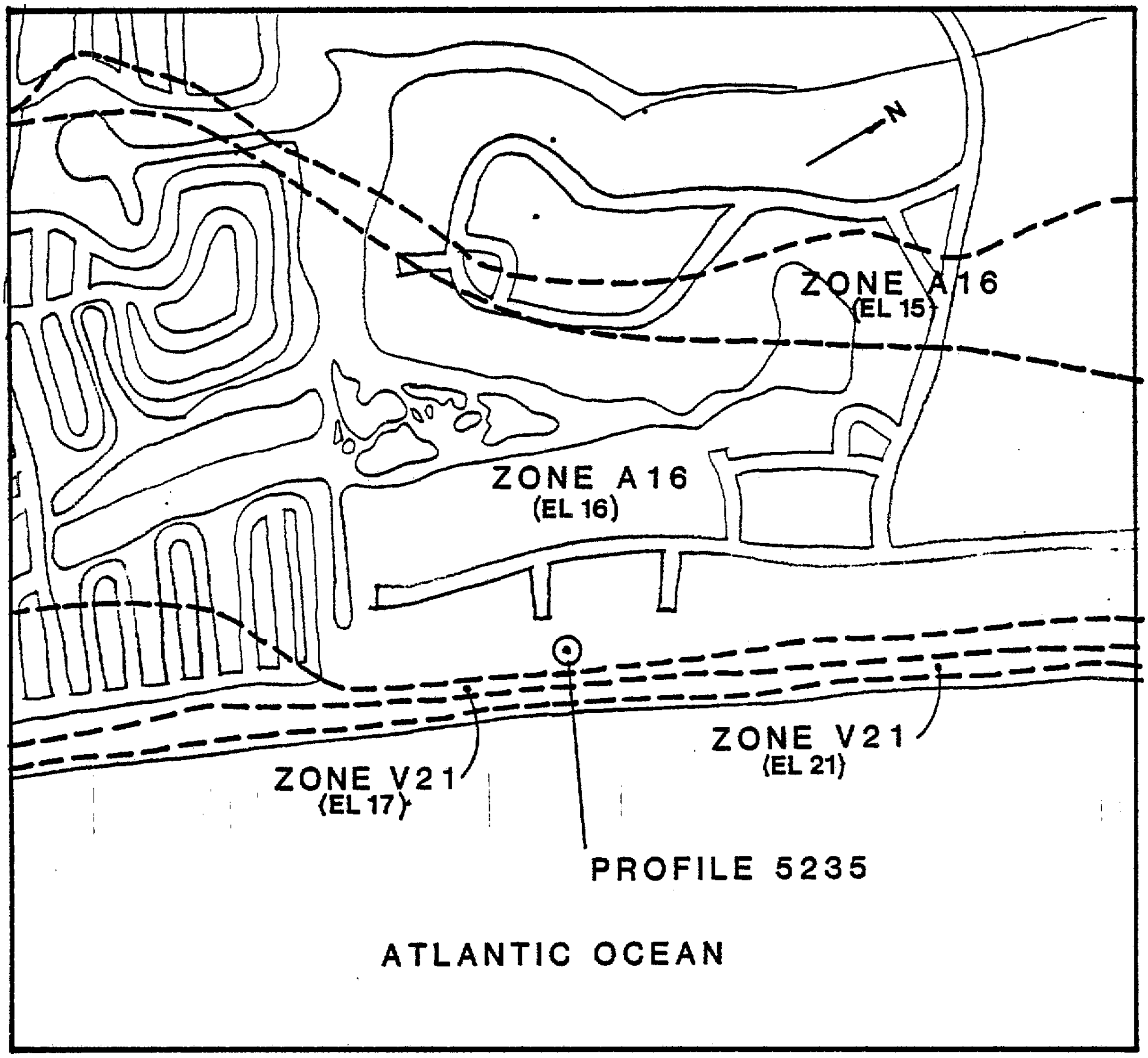
Both a review of the existing Flood Insurance Rate Maps (FIRMs) for the study area in Horry County, as well as the preliminary results of the storm impact analyses, indicate that the V-zone conditions depicted by the FIRMs are extremely unconservative. Along the Horry County coast, the V-zones terminate at/or about the seaward face of any dune or similar feature that has an elevation exceeding the predicted base flood elevation (BFE) for a 100-year storm. Due to the adoption of nationwide uniform standards for the performance of Flood Insurance Studies by subcontractors, FEMA does not consider erosion of existing beach/dune systems, or other features in the prediction of V-zones.

In Horry County, as well as in adjacent counties, this shortcoming results in a gross underestimation of the shore normal extent of the impact zone with waves greater than three feet in height expected to occur coincident with a 100-year storm event. Of immediate concern is not only the specified elevation for future construction within V zones, but more importantly the <u>types</u> of construction allowed immediately landward of the beach/dune system. For example, A-zone standards do not require pile foundation, nor the consideration of wave forces. Areas which are mapped as A-zones, but in reality will be subject to severe wave effects during a 100-year storm, therefore are not necessarily subject to prudent building requirements for not only single-family residence construction, but also multi-family and commercial buildings. The potential future consequences of this situation are intuitively obvious.

As a specific example, Figure 9.3-1 is an excerpt from FIRM No. 450104 0309 C for an area located immediately south of Myrtle Beach State Park in unincorporated Horry County. As noted, the landwardmost V-zone which terminates at the dune line is at elevation +17 ft. Landward of that point is an A-zone at elevation +16 ft. Also noted on Figure 9.3-1 is the location of survey profile No. 5235 that was established as part of this study. The depiction of the FEMA flood zones as they relate to the cross section of the beach at profile station 5235 is shown in Figure 9.3-2.

Previously referenced erosion analysis of the IPP typical of this area for both 25 and 50 year storm events, have indicated the dune at this location can reliably be considered to be eroded away as a result of erosion during a 100-year storm. For that reason, the actual physical phenomena expected with such an event will not be as depicted on FIRM 450104 0309 C and as interpreted by Figure 9.3-2. Instead, the expected nearshore impact zones will be as shown in Figure 9.3-3 which demonstrates the recalculated elevation and location of the V-zone concurrent with the 100-year storm, including erosion. As shown in this Figure, any structure built immediately landward of the dune should be constructed in accordance with V-zone criteria at elevation +18, and not A-zone criteria at elevation +16 ft. The situation highlighted by this example is typical of existing condition throughout the majority of the Horry County shoreline considered by this study.

Correspondingly, a major recommendation of this study is the implementation of a building construction zone(s) landward of the MHWL which will result in the consideration of design



REFERENCE:

COMMUNITY PANEL NO. 45104 0309 C
Feb. 15,1984
HORRY COUNTY,S.C.

FIGURE 9.3-1
FLOOD INSURANCE MAP NEAR LONG BAY ESTATE

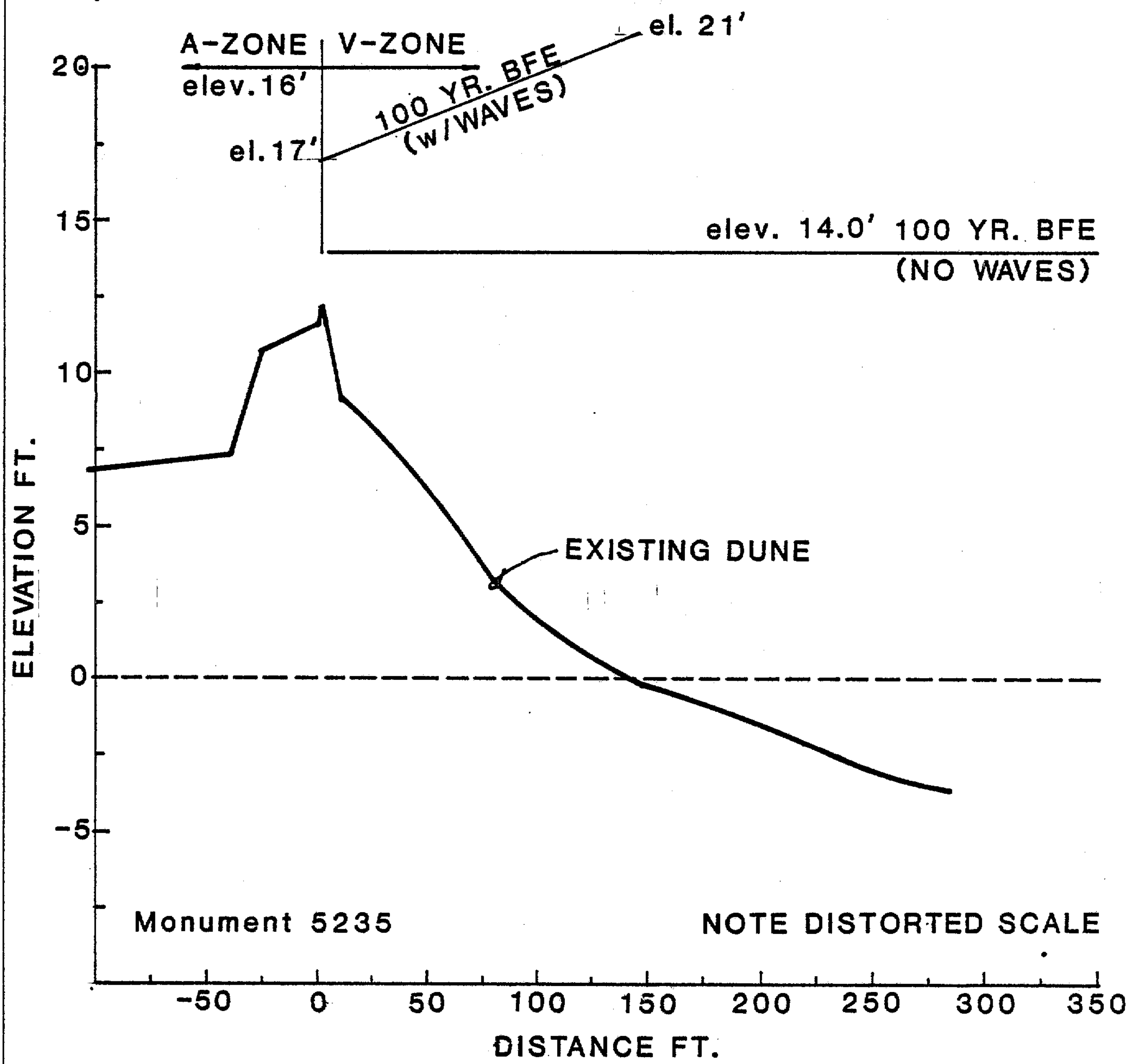


FIGURE 9.3-2
DEFINITION OF V-ZONE WITHOUT
CONSIDERATION OF STORM IMPACTS

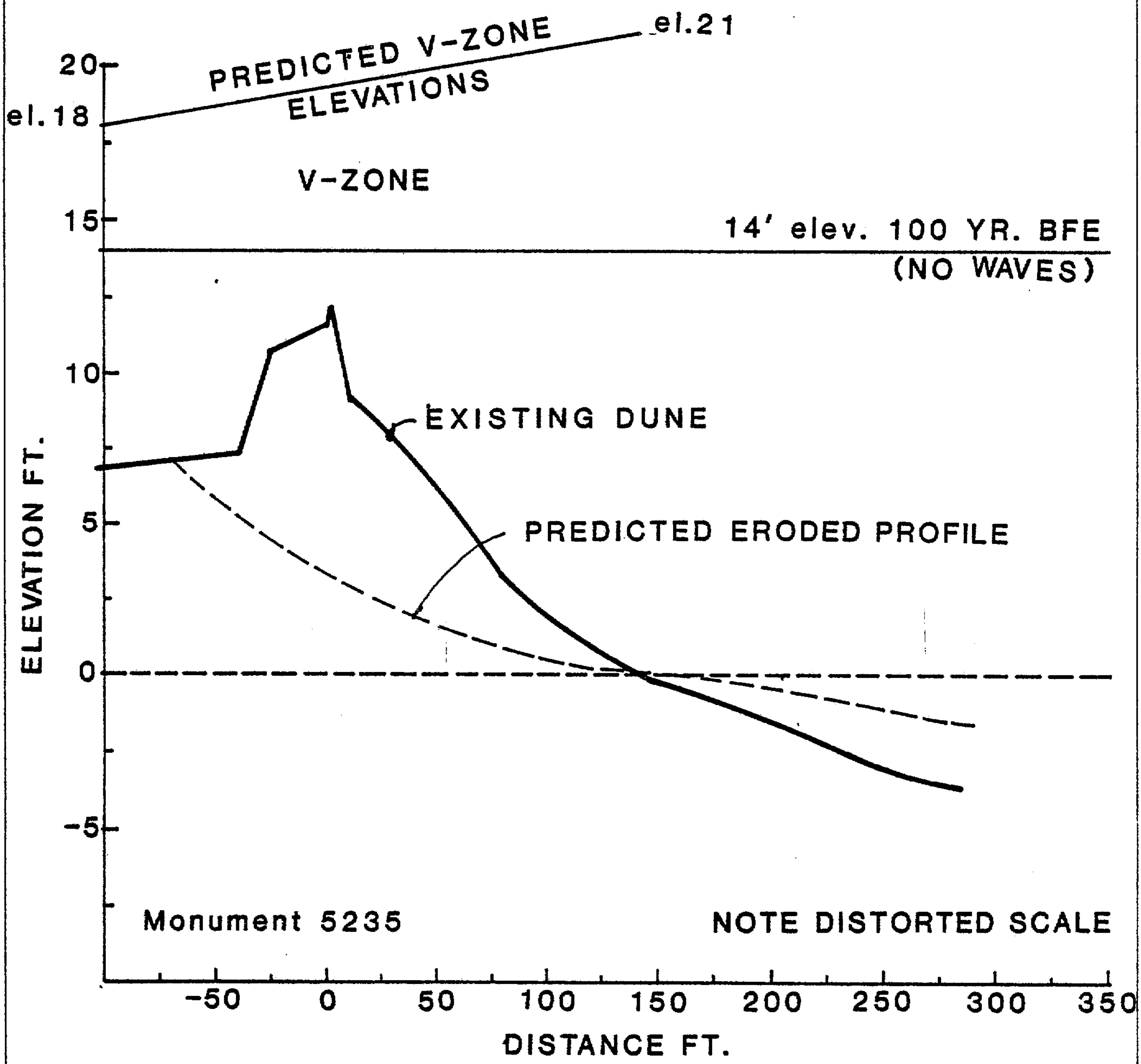


FIGURE 9.3-3
PREDICTED V-ZONE CONSIDERING THE STORM IMPACTS NEAR LONG BAY ESTATE

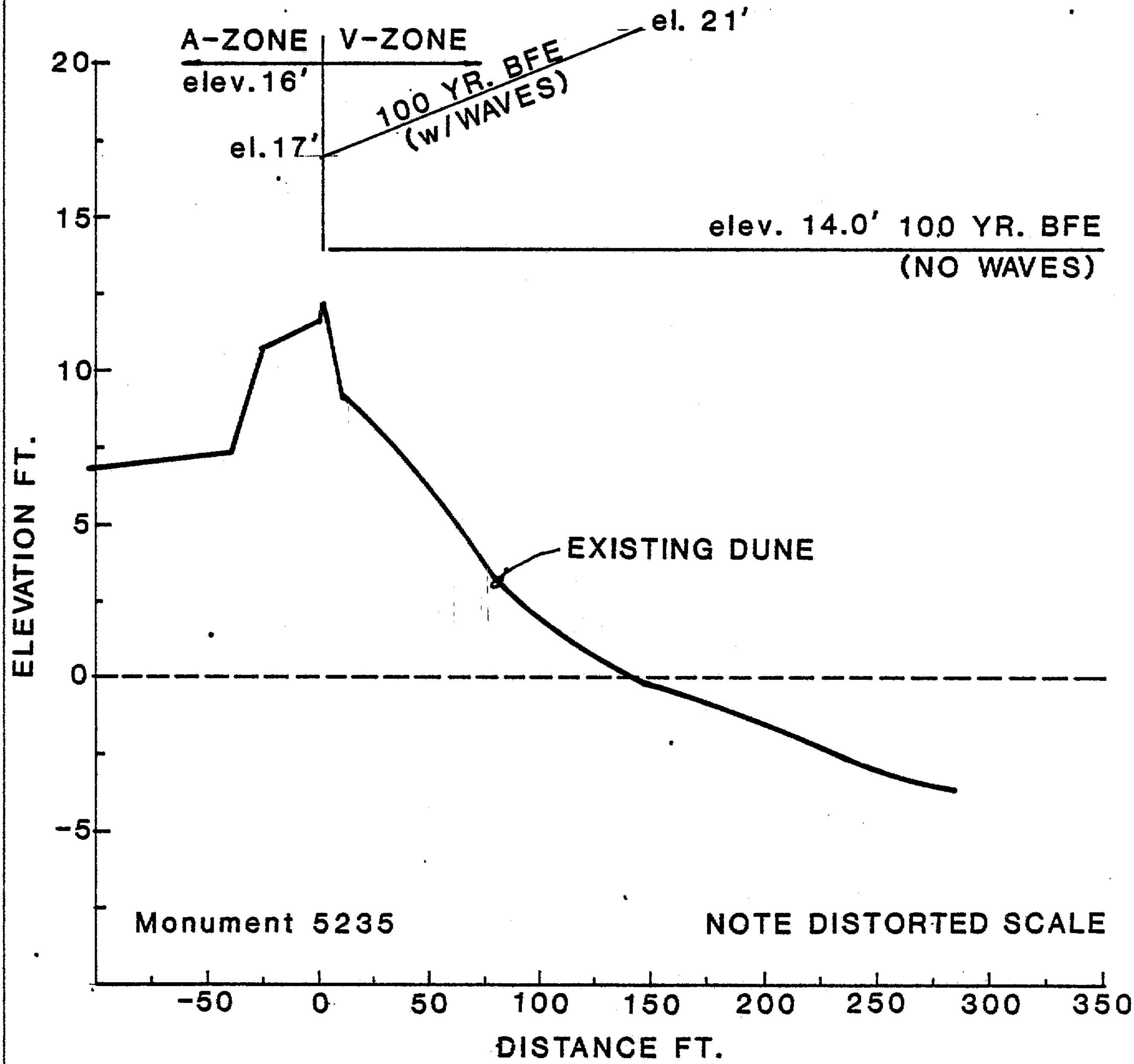


FIGURE 9.3-2
DEFINITION OF V-ZONE WITHOUT
CONSIDERATION OF STORM IMPACTS

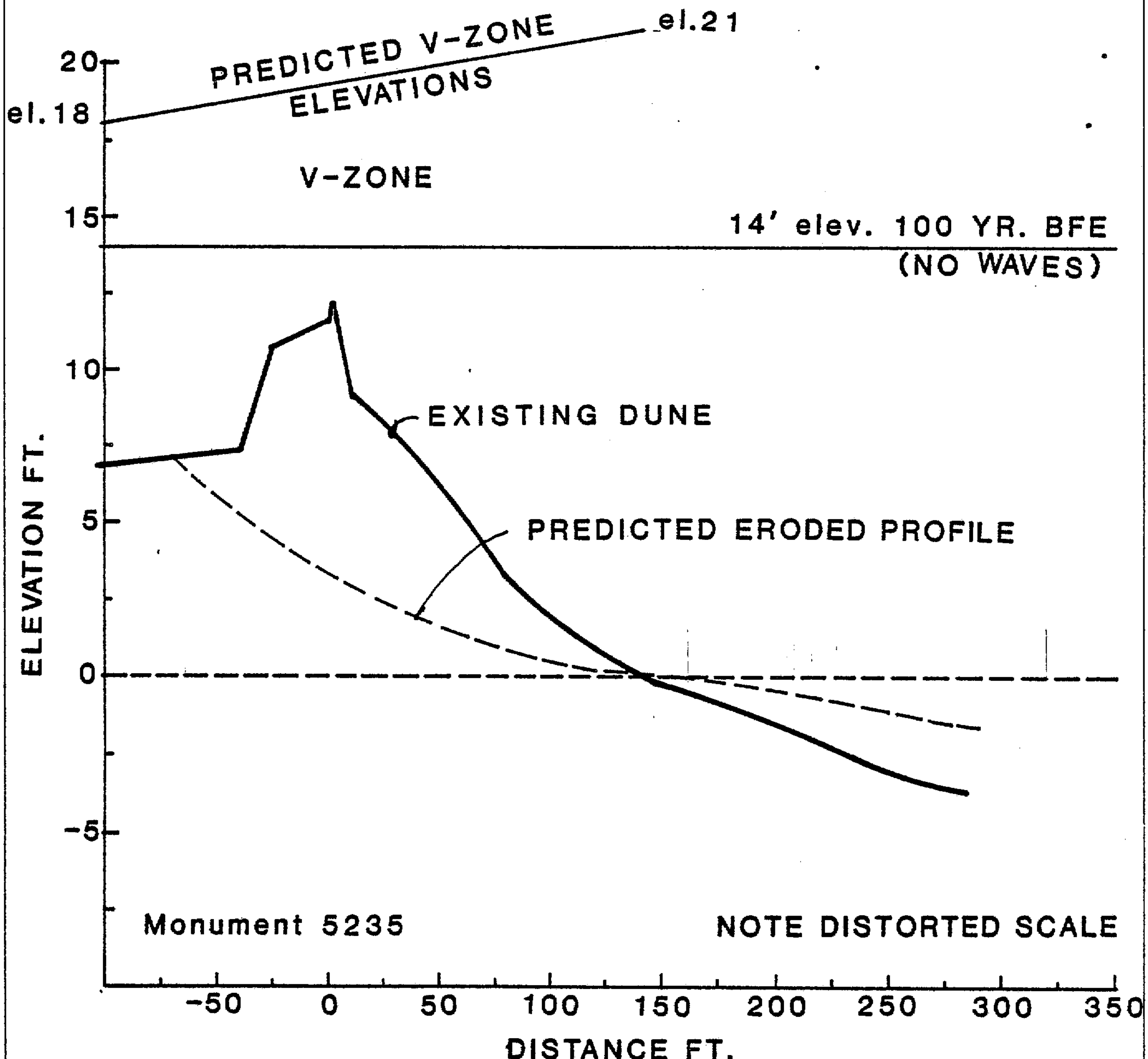


FIGURE 9.3-3
PREDICTED V-ZONE CONSIDERING THE
STORM IMPACTS NEAR LONG BAY ESTATE

criteria sufficient to accommodate the expected impacts of a 100-year storm.

9.4 RECOMMENDED SETBACKS

<u>Unincorporated Area Between Briarcliffe Acres and Singleton Swash</u>

Similar studies performed by Kana, et. al. for both Myrtle Beach and North Myrtle Beach have indicated a continuing trend of erosion and shoreline recession for this general section of the Grand Strand in northern Horry County. These rates have been likewise corroborated by this analysis. Correspondingly, the predicted 50-year future shoreline has been computed to be landward of its existing location throughout that section of the area of interest in Horry County.

It should be noted, however, that anomalous conditions associated with piers, inlets, etc. which theoretically result in the prediction of a future seaward progradation of the shoreline due to small-scale temporal sand storage, have been "averaged out" in this analysis. The purpose of this action is to preclude physical discontinuities which could be detrimental to area wide recommendations for future shoreline management practices.

On the average, the 50-year future shoreline recession for this section of incorporated Horry County resulting from a volumetric analysis is expected to be about 30 feet landward of the predicted ideal present shoreline (IPS). As previously discussed, this landward recession is hypothesized solely on historical long term volumetric erosion rates and does not account for short term effects. Figure 8.3-1 is a depiction of the results of computer modeling of the IPP for the study shoreline for both the 25-year and 50-year storm event. As noted, this analysis indicates that the impact zone of the 50-year storm is expected to be as much as 5 times greater than the long-term recession rate, or about 130 ft. landward of the crest of the IPP. Similarly, the 25-year storm recession is computed to be about 95 ft. landward of the IPP or between 3 and 4 times the predicted long-term rate.

It is intuitively obvious that in order to adequately protect existing and future beach/dune resources, both the predicted short-term and long-term shoreline impact zones must be accounted for in an enforceable shorefront management plan. For example, the premise of a minimum setback from the 50-year future shoreline is simplistically an effort to keep construction landward of the location where the active beach is expected to be 50 years hence, conservatively assuming relatively modest but continuous annual rates of beach erosion.

On the other hand, additional magnitudes of setback associated with storm impacts serve two functions:

1. To protect upland development from being constructed in an area subject to significant fluctuation due to storm induced erosion, and

2. To allow for sufficient rebuilding of a comparable dune system by natural processes subsequent to severe storms. Without such, the expected result will be a proliferation of shoreline stabilization necessitated by buildings in eminent danger of structural damage and/or loss. The latter would literally preclude natural dune reconstruction and would result in the expected ultimate loss of the dry recreational beach and the requirement for large scale beach restoration at significant expense.

For the unincorporated area under consideration in northern Horry County, the minimum recommended setback from the beach/dune system should be that distance dictated by the 50 year future shoreline location as predicted by a volumetric analysis. Allowances for construction of major habitable structures seaward of that setback should only be made if a building cannot be constructed or reconstructed landward of that location, and if the setback would result in denial of "reasonable use" of property. The latter should be considered to be no more than single family residence usage. Non-habitable structures should not be allowed seaward of this point except for dune overwalks, sand fencing, and erosion control measures, where warranted. In no event should these recommendations take precedence over existing or future setbacks or regulatory programs which are considered to be more stringent.

Unincorporated Area Between Myrtle Beach and Surfside Beach

Although existing land use practices within this section of the study shoreline are dramatically different than that of adjacent Myrtle Beach to the north, intense developmental pressures in the future can reasonably be expected to occur, except within the limits of Myrtle Beach State Park. For that reason, the adoption of appropriate setbacks is similarly recommended for this area. All recommendations, however, should be considered to apply equally to both privately and publicly owned lands.

Analyses of shoreline erosional trends indicate long-term shoreline recession rates based upon a linear shoreline erosion analysis result in a 25-year future shoreline location approximately 37.5 feet landward of the predicted ideal present shoreline (IPS). It should be noted that the 25 year linear shoreline recession analysis used in this section of Horry County can be considered to be approximately equivalent to the 50-year volumetric analysis employed along the shoreline between Singleton and White Point Swash. As expected, the storm related short term recession predictions for the same area are significantly greater. The computer calculations for the IPP typical of this area predict that the shoreline recession resulting in a 25-year storm will be about 3 times greater than the long term recession rates, or about 116 feet landward of the crest of the IPP. Figure 8.3-2 is a depiction of the computer modeling of storm erosion of the IPP typical of the shoreline south of Myrtle Beach for both a 25 and 50-year storm event.

For the unincorporated area under consideration south of Myrtle Beach, the minimum recommended setback from the beach/dune system should be that distance dictated by the future location of the 25-year shoreline as predicted by a linear recession analysis. Allowances for construction of major habitable structures seaward of that setback should <u>only</u> be made if a building cannot be constructed or reconstructed landward of that location, and if the setback would result in denial of "reasonable use" of property. The latter should be considered to be no more than single family residences. In no event should these recommendations take precedence over more stringent future, or existing setbacks or regulations. Non-habitable structures seaward of the proposed setback should be limited to dune overwalks, sand fencing and erosion control measures where warranted and fully permitted.

<u>Surfside Beach and Unincorporated Garden City Beach</u>

Along the approximate 4 mile stretch of shoreline encompassed almost equally by Surfside Beach and the section of unincorporated Garden City Beach within Horry County analyses of shoreline processes continue to indicate a prognosis of long term erosion and associated recession. At present, existing shorefront development within the limits of Surfside Beach is predominantly single family residences. In contrast, in the northern portion of Garden City where new and reconstructed development is occurring, the trend is predominantly high density multi-family usage.

With the evolving reorientation of the general shoreline from Garden City southward attributable to the stabilization of Murrells Inlet, the segment of Garden City Beach within Horry County can be expected to potentially suffer accelerated rates of erosion and recession. In areas where the shoreline location has been fixed by means of seawalls, groins, etc., recession may be terminated, but vertical erosion of the wet or dry beachface is expected to occur.

The quantification of shoreline erosion trends for this section of the study area based upon a linear analysis indicates shoreline recession rates resulting in a 25-year future shoreline location approximately 37.5 feet upland of the predicted IPS. In accordance with similar recommendations made for the remainder of the County, the minimum recommended setback from the beach/dune system should be the future location of the 25-year shoreline.

Again, allowance for construction of major habitable structures seaward of an adopted setback should only be made if a building cannot be constructed or reconstructed landward of that location, and if the setback would result in denial of "reasonable use" of property. The latter should be considered to be no more than single family residences. In no event should these recommendations take precedence over more stringent future or existing setbacks. Non-habitable structures seaward of the proposed setback should be limited to dune overwalks, sand fencing and erosion control measures, where warranted and fully permitted.

9.5 Coastal Construction Zones

The implementation of minimum coastal construction standards landward of the MHWL are recommended as a result of the analyses performed in conjunction with this study. These standards should be in addition to all existing building codes and should not supercede local, state or federal standards which can be considered to be more stringent.

The most obvious technique for the local implementation of such standards is through the adoption of a zone specifying an area of interest extending landward from the MHWL a specified distance. Within this "coastal construction zone", the following minimum criteria should be addressed:

- Design wind speed should be computed in accordance with the 1986 revisions to the 1985 Standard Building Code.
- Effects of waves where appropriate. All wave, hydrostatic and hydrodynamic loads should be considered during design as acting concurrent with the design wind speed.
- Elevation criteria of the lowest supporting structural member in the shore parallel direction which would include the effects of waves.
- Erosion during a 100-year storm event which would affect foundation design.
- Others.

For ease of implementation at the local level, all new or substantially improved structures built within such a zone should be certified by an appropriate design professional as to compliance with the adopted standards.

9.6 Erosion Control Permitting Procedures

The analyses and results contained herein indicate that long term erosion trends are expected to continue unabated throughout the majority of the study area. Short term variations in this prediction include lower rates of erosion and varying accretion in depositional areas adjacent to tidal inlets or within designated spoil areas north and south of Murrells Inlet.

In the long run, however, continuing shoreline recession and the effects of development pressures, both old and new, will result in the requirement for permit requests for erosion control structures. Additionally, it is easily shown that average annual long term recession rates will be exceeded by the impacts of low frequency storms, which statistically can be expected to occur. Due to the demonstrated proximity of existing lines of construction to not only the 50 year future shoreline position, but also the zone of impact of even a 25 year storm, a comprehensive and consistent policy should be developed and enforced regarding future erosion control measures.

Erosion along South Carolina's shoreline has progressed to a degree that a substantial number of habitable structures are jeopardized by future major storms. It is in the State's general interest to allow protection of upland property, but not in a manner that will damage or degrade the beach-dune system. Beach restoration is unequivocally the protective measure considered as most beneficial to the beach-dune system. However, in some locations, economics may not favor beach restoration; and even if restoration is expected, the time scales for implementation of such projects may be so long that interim protection for upland structures in immediate jeopardy may be justified. Coastal armoring, for example, sloping stone revetments, is a possible means of providing such interim protection. However, it is known that armoring can potentially adversely impact the adjacent beach-dune system.

Simplistically, seawalls and shoreline armoring can be expected to adversely affect the beach/dune system in the following ways:

1) They can interfere with alongshore sediment transport processes,
2) They prevent sand from being added to the littoral system during storms, and
3) They can cause additional erosional stress on adjacent non-armored properties during storms.

Regardless, armoring or hardening of natural shorefront areas is detrimental to the beach/dune system and should be avoided if at all possible. Since it is logical, however, to assume that future structures will be required, it is likewise logical to require applicants for permits required to construct such erosion control measures to mitigate their known quantifiable impacts.

Prior to the issuance, or local approval of any shoreline armoring permit, the following minimum type of assessment should be made:

1) Alternative to Armoring - Possible alternatives to armoring include: (a) relocating the endangered

structure landward, (b) elevating the structure on piling, or (c) both.

2) <u>Legality of Structure</u> - If the structure to be protected was constructed legally, this would tend to favor armoring.

3) <u>Degree of Jeopardy of Structure</u> - This factor addresses the possibility that a moderate storm could jeopardize the integrity of the structure. If the foundation type and degree of erosion are such that a storm of moderate intensity (return period of 10 to 20 years) would jeopardize the stability of the structure, this would tend to favor the issuance of a permit to armor.

4) <u>Conforming or Non-Conforming Structure</u> - If a structure has a conforming (i.e. pile-supported) foundation, then the structure is not as vulnerable to erosion damage as if the structure were on shallow footings or a slab foundation. A conforming foundation can lose all fill beneath the structure as a result of a severe storm and retain the structural integrity. Hence the recommendations for coastal construction zones.

5) <u>Presence of Other Armoring in the Area</u> - If there exists armoring along the same alignment as proposed, this would tend to favor armoring. Filling in small gaps along heavily armored shorelines is in some instances desirable.

6) <u>General Potential for Adverse Impact on Beach/Dune System</u> - Consideration should be given to the magnitude of the effect that armoring would have on the supply of sediment to the beaches and the potential for interference with the longshore sediment transport.

Similarly, a quantitative assessment should be made to establish a required annual volume of mitigative sand placement in order to ensure no adverse impact to the beach-dune system would result from the issuance of the requested permit. Although the methodology for establishing such mitigation is beyond the scope of this study, such an approach would take the form of quantifying the volume of sediment that would be lost to the beach system due to gradual erosion in addition to possibly adverse alongshore effects.

The end result of quantifying "sediment impacts" would be to allow for the addition of appropriate permit stipulations requiring mitigation through sand placement on an average annual basis, concurrent with all future permit applications for shoreline armoring or hardening.

9.7 <u>Shoreline Restoration</u>

As previously mentioned, large scale beach restoration or "nourishment" is the preferred erosion control alternative for a section of shoreline for the following major reasons:

- It can result in substantial protection of upland property,

- It results in the creation and/or maintenance of a beach suitable for active and passive recreational activities, and

- It compensates for the long term effects of erosional forces by offsetting deficits in the littoral budget.

Since the success of beach nourishment projects constructed to date has generally been demonstrated to be directly related to the length of shoreline restored, the solution does not necessarily lend itself to small scale applications in either a practical or cost-effective manner. The determination of applicability is best performed on a case-by-case basis. There is no question, however, that the beach nourishment experience has been proven to be a technically viable approach to mitigating beach erosion.

In cases where large scale beach restoration is not feasible, the combination of smaller sand fills in combination with stabilizing structures should be considered. Typically, the latter take the form of terminal groins at the ends of barrier islands and/or groin fields. The utilization of stabilizing structures is generally most viable when the adverse effects of inlets must be accounted for such as in lower Horry County. For example, on Pawley's Island, which can be considered to be a high probability "candidate" for future beach restoration, the upgrading of the existing groin field could serve to greatly increase the longevity of a nourishment project constructed at that location.

Short-term, smaller scale erosion control measures which can address either limited or emergency type erosional conditions without resorting to armoring would include:

- Beach scraping from the intertidal beach,

- Jet-pumping of sediment from the outer reaches of the alongshore bar or littoral zone, and

- Trucking of beach quality fill from an acceptable upland source or inlet shoals.

Except for the placement of compatible fill from a remote source, both scraping and jet-pumping should not be carried out on a frequent basis without the requirement for monitoring to determine the response of the local shoreline to the removal of sediment from the intertidal beach, since the latter could potentially adversely affect adjacent properties and the beach/dune system.

9.8 Long-Term Monitoring of Shoreline Processes

The South Carolina Coastal Council has recently embarked on a longterm program to monitor statewide beach conditions by means of beach surveys performed several times per year. The purpose of the effort is to generate a data base of historical shoreline trends and to begin to develop a capability to predict future trends. Portions of the survey baseline used to acquire this data will result from the utilization of the monumented baseline established for this study and by those of similar studies performed along the Grand Strand and other areas of the State.

Recommendations for future expansions of this data acquisition program based upon similar efforts in other coastal states would include the following at a minimum:

a. The acquisition of offshore data for eventual comparative purposes on an annual basis. Ideally, offshore profiles should be taken at no less than one per mile and should extend to the limit of active sediment transport which is typically -15 to -20 ft.

b. Aerial photography of the state's coastline on a yearly basis. Any contract for such work should allow for re-flights of specific areas within seven (7) days of a major storm event affecting the South Carolina coast.

c. The eventual rigorous monumenting of a statewide survey baseline to include both vertical and horizontal control (i.e., South Carolina State Plane Coordinate System) and appropriate legal descriptions of the resultant baseline.

REFERENCES

Baca, B.J., Siah, S.J., and Kana, T.W. 1986. A Wetlands Enhancement Plan for Debordieu Development. Coastal Science and Engineering, Inc., Columbia, South Carolina.

Clemson University, Clemson. Department of Forestry. 1976. Debidue Beach and North Inlet Land Form History Since 1733. Technical Paper No. 4.

County of Georgetown. 1981. Pawley's Island, South Carolina, Beach Erosion Management Strategy. Georgetown, South Carolina. Cubit Engineering, Limited. Clemson, South Carolina.

Douglass, S.L. 1985. Coastal Response to Navigation Structures at Murrells Inlet, South Carolina. U.S. Army Coastal Engineering Research Center Technical Report CERC-85-8. Vicksburg, Mississippi.

Eiser, W.C., Kana, T.W., and Williams, M.L. 1986. Analysis of Historical Erosion Rates and Prediction of Future Shoreline Positions. Summary Report for the City of North Myrtle Beach, South Carolina. Coastal Science and Engineering, Inc., Columbia, South Carolina.

Federal Emergency Management Agency. 1983a. Flood Insurance Study, County of Horry, South Carolina.

Federal Emergency Management Agency. 1983b. Flood Insurance Study, Georgetown County, South Carolina.

Jordan, L.W., Dukes, R., and Rosengarten, T. 1986. A History of Storms on the South Carolina Coast. South Carolina Sea Grant Consortium, Charleston, South Carolina.

Kana, T.W., Siah, S.J., Williams, M.L., and Sexton, W.J. 1984. Analysis of Historical Erosion Rates and Prediction of Future Shoreline Positions. Summary Report for the City of Myrtle Beach, South Carolina. Coastal Science and Engineering, Inc., Columbia, South Carolina.

Myers, V.A. 1975. Storm Tide Frequencies on the South Carolina Coast. NOAA Technical Report NWS-16. Silver Springs, MD.

North Inlet Corporation and Prince George Corporation. 1985. Shoreline and Environmental Assessment of the Debidue, Arcadia I, and Arcadia II Tracts, Debidue Island, South Carolina. Prepared by RPI Coastal Science and Engineering, Inc., Columbia, S.C.

North Inlet Corporation. 1985. Debordieu, South Carolina, A Planned Unit Development: Development Standards. Georgetown, South Carolina.

Nummedal, D. and Humphies, S.M. 1978. Hydraulics and Dynamics of North Inlet, South Carolina, 1975-76. Prepared for U.S. Army Coastal Engineering Research Center, GITI Report 16. Vicksburg, Mississippi.

South Carolina Coastal Council. 1981. A Study of Shore Erosion Management Issues and Options in South Carolina. Columbia, South Carolina. Prepared by the South Carolina Sea Grant Consortium, Charleston, South Carolina.

South Carolina Coastal Council. 1979. Guidelines and Policies of the South Carolina Coastal Management Program. Columbia, South Carolina.

South Carolina Sea Grant Consortium. 1984. Beach Erosion Inventory of Charleston, South Carolina: A Preliminary Report. Charleston, South Carolina. Prepared by the University of South Carolina, Geology Department, Columbia, South Carolina.

South Carolina Sea Grant Consortium. 1977. Beach Erosion Inventory of Horry, Georgetown, and Beaufort Counties, South Carolina. Prepared by University of South Carolina, Coastal Research Division, Geology Department, Columbia, South Carolina.

Town of Surfside Beach. 1985. Land Use Plan for Surfside Beach, South Carolina. Surfside Beach, South Carolina.

U.S. Army Corps of Engineers. Charleston District. 1983. Myrtle Beach, Horry, and Georgetown Counties, South Carolina: Reconnaissance Report on Beach Erosion Control and Hurricane Protection. Charleston, South Carolina.

U.S. Army Corps of Engineers. Charleston District. 1977. Specifications for Construction of Channel and Jetty System: Murrells Inlet Navigation Project. Charleston, South Carolina.

U.S. Army Corps of Engineers. Charleston District. 1976. Revision of Weir System and Jetty and Channel Alignments: Murrells Inlet Navigation Project. Charleston, South Carolina.

U.S. Army Corps of Engineers. 1962. Interim Hurricane Survey of Myrtle Beach, South Carolina. Charleston, South Carolina.

Waccamaw Regional Planning and Development Council. 1983. Horry County Land Use Plan, 1980. Conway, South Carolina.

Wilson, H.S., ed. 1983. South Carolina's Migrating Beaches. Proceedings of a Conference Sponsored by the South Carolina Sea Grant Consortium. The South Carolina Sea Grant Consortium, Charleston, South Carolina.

Zarillo, G.A., Ward, L.G., and Hayes, M.O. 1985. An Illustrated History of Tidal Inlet Changes in South Carolina. South Carolina Sea Grant Consortium, Charleston, South Carolina.