The First Open-Coast Beach Fill in Texas

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THE FIRST OPEN-COAST BEACH FILL IN TEXAS

Kimberly K. McKenna
Geologist, Coastal Division, Texas General Land Office,
1700N. Congress Avenue, Austin, Texas 78701-1495

Cheryl A. Brown, Nicholas C. Kraus
Research Scientist and Director, respectively, Conrad Blucher Institute for Surveying and Science,
Texas A&.M University-Corpus Christi,
6300 Ocean Drive, Corpus Christi. Texas 78412-5503

Abstract

Much of the Texas Gulf shoreline is receding. In response to this coastal erosion, in 1993 the city of Galveston, Texas, began the planning and permitting process for construction of a beach nourishment project that would provide both storm protection and a recreational beach. Few beach fills have been constructed along the Texas Gulf coast, and the Galveston beach replenishment project is considered the first official project along the Texas shoreline. The Galveston project is therefore precedent setting, and special emphasis is being given to its design to provide a standard for future beach replenishment projects in Texas. This project, funded by the City of Galveston, requires extraction of more than 710,000 cubic yards of sediment from one or more borrow sites located approximately one mile offshore of the nourishment site. Because of the large amount of material to be dredged, relatively shallow water of the borrow sites (15 to 25 ft mean low water), and proximity to the beach, the Texas General Land Office and the City of Galveston commissioned the Conrad Blucher Institute to conduct a wave transformation and shoreline response assessment. The objective of the assessment was to determine the shoreline impacts of the borrow dredging, if any, and to recommend the dredging practice that would minimize these impacts. This paper describes the history, project plan, shoreline change assessment, and the results that led to the recommended extraction procedure for the Galveston project.

INTRODUCTION

Beach replenishment as a method of erosion response has not been widely utilized along the Texas coast because of the lack of economical beach-quality sediment sources and the absence of a coordinated funding source. Only one major beach fill project has been constructed by the U.S. Army Corps of Engineers (COE), which was at a bayshore beach in Corpus Christi in 1971 (Kieslich and Brunt 1989). The beach was built solely for recreational purposes using an underlayer of dredged bay sediments capped by sediments from an upland source (COE 1969). The City of Corpus Christi cost shared 50% of the total cost.

Maintenance sediments from the dredging of the Gulf Intracoastal Waterway and from various jettied inlets have been placed on the Texas Gulf coast by the COE at Surfside Beach, Sargent Beach, Matagorda Peninsula, and Padre Island (COE 1993). At Galveston Island, a local hotel owner paid for placement of a small beach fill at the base of the Galveston Seawall. None of these projects had been permitted by state resource agencies.

This paper describes the state's erosion-response policy and the background of the Galveston beach fill project -the first open-coast beach fill in Texas. The steps taken to coordinate and achieve a successful major beach nourishment project without adversely impacting adjacent shore are summarized, together with lessons learned.

DESCRIPTION OF SITE

Galveston Island is located in the north-western portion of the Gulf of Mexico in the region of the upper Texas coast (Fig. 1). The tidal range along the Gulf shoreline is 1.8 to 2 ft (0.54 to 0.60 m), with average wave heights and periods in deep water hindcast of 1.1 m and 5.6 sec (Hubertz and Brooks 1989). Accordingly, this northeast-southwest trending island is classified as microtidal and wave-dominated (Hayes 1979). Predominant winds are from the south and southeast from March to November; however, strong winds from the north, or "northers," are common during the winter months (COE 1985).

Historically, shoreline change varies along the island, ranging from advance in the wave shadow of the south jetty to recession of more than 10 ft (3 m) per year at the west end of the seawall and at San Luis Pass (Morton 1993). There are 15 rubble stone groins located along the beach between 10th and 61st Streets, 11 constructed by the Federal government and four by the county (COE 1992). The COE (1985) determined that the shoreline within the groin system at the seawall is stable.

EROSION-RESPONSE MANAGEMENT: TEXAS PERSPECTIVE

State Law and Texas General Land Office (GLO) Rules

In 1991, the 72nd Texas Legislature enacted Senate Bill 1053, which promotes and gives preference to "soft" methods such as beach nourishment over seawalls and other rigid structures, for erosion response. The Texas Coastal Management Program supports the legislative decision (GLO 1994). In addition, GLO rules for management of the beach and dune system (31 TAC § 15.1-15.10) prohibit individual Gulf-front property owners from erecting erosion-response structures with the exception of retaining walls, which may be permitted 200 ft landward of the line of vegetation.

Beach nourishment projects are a common erosion-response method used on the Gulf of Mexico shoreline. Earlier projects were not well monitored or the data collection was sporadic, and the effectiveness of beach nourishment as method of shore protection has been questioned (Dixon and Pilkey 1989). There is always a risk involved in recommending beach nourishment as a method for erosion response, in part due to the unpredictable nature of meteriological events. However, because of the relatively small volume of sediment in the littoral system at Galveston Island, beach nourishment is viewed as a way of increasing the available coastal sediment volume while providing a recreational beach (a much-needed commodity for a city dependent upon its beach for tourist revenue).

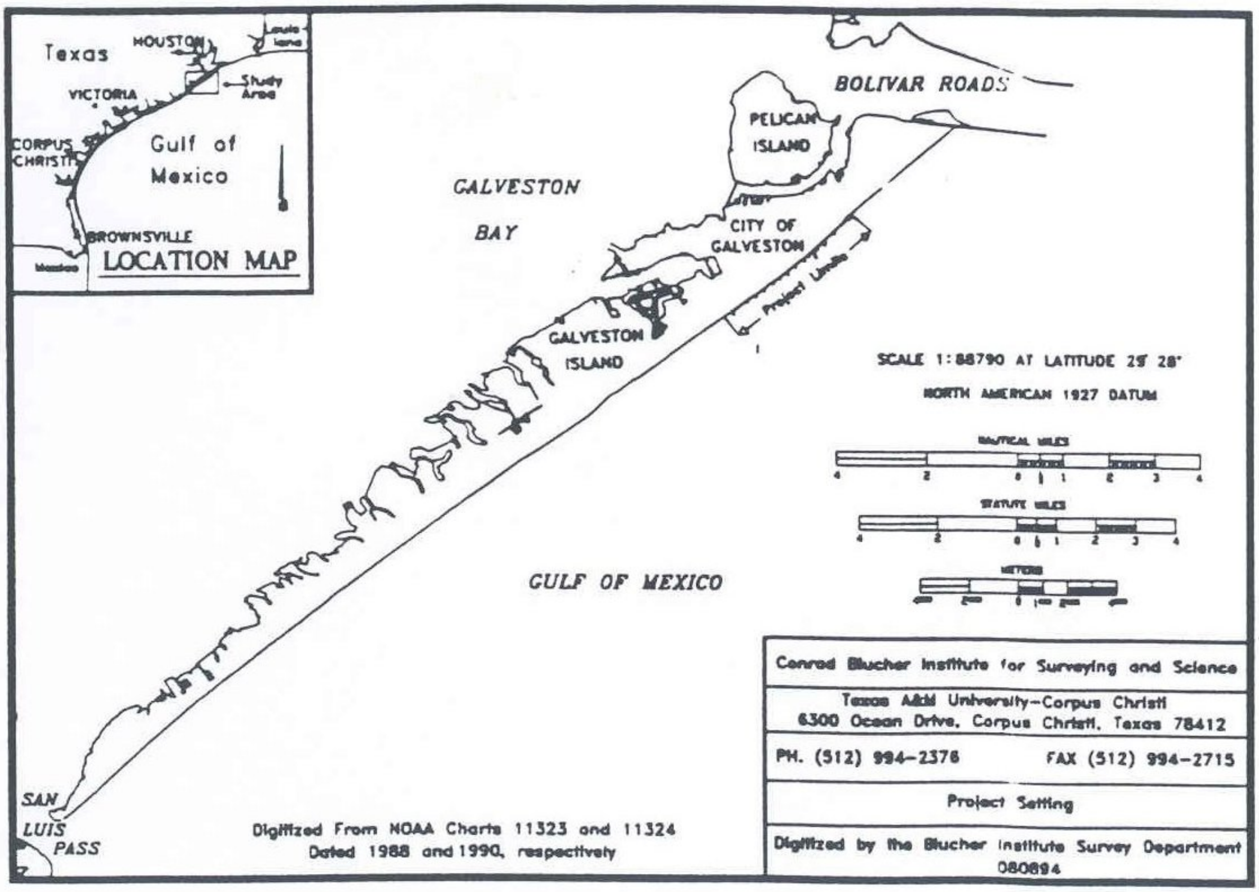

Figure 1. Location of study area

Many of the earlier beach nourishment projects in the nation, including the Corpus Christi Beach restoration, were funded for recreational benefits. However, based on Reagan Administration guidelines, in the late I980s the COE Headquarters policy changed to the funding of projects primarily for storm-protection benefits. This policy decision was a major disappointment to the City of Galveston (and to other beach- front communities across the nation in similar situations) because the COE determined that the award -winning Galveston Seawall provided adequate storm protection to the properties located behind it, and any beach fill project in front of the wall would therefore be viewed as a recreational benefit only.

GALVESTON BEACH NOURISHMENT PROJECT Galveston Seawall

Construction of the Galveston Seawall started in October 1902 as a method of flood protection for a city that had suffered severe property damage and loss of more than 6,000 lives in an unnamed hurricane in 1900 (Wiegel 1991). Fifteen groins were added to protect the seawall in 1936, and the last segments of the 10-mile long wall were completed in 1970 (COE 1992). Figure 2 shows the seawall and beach in 1911.

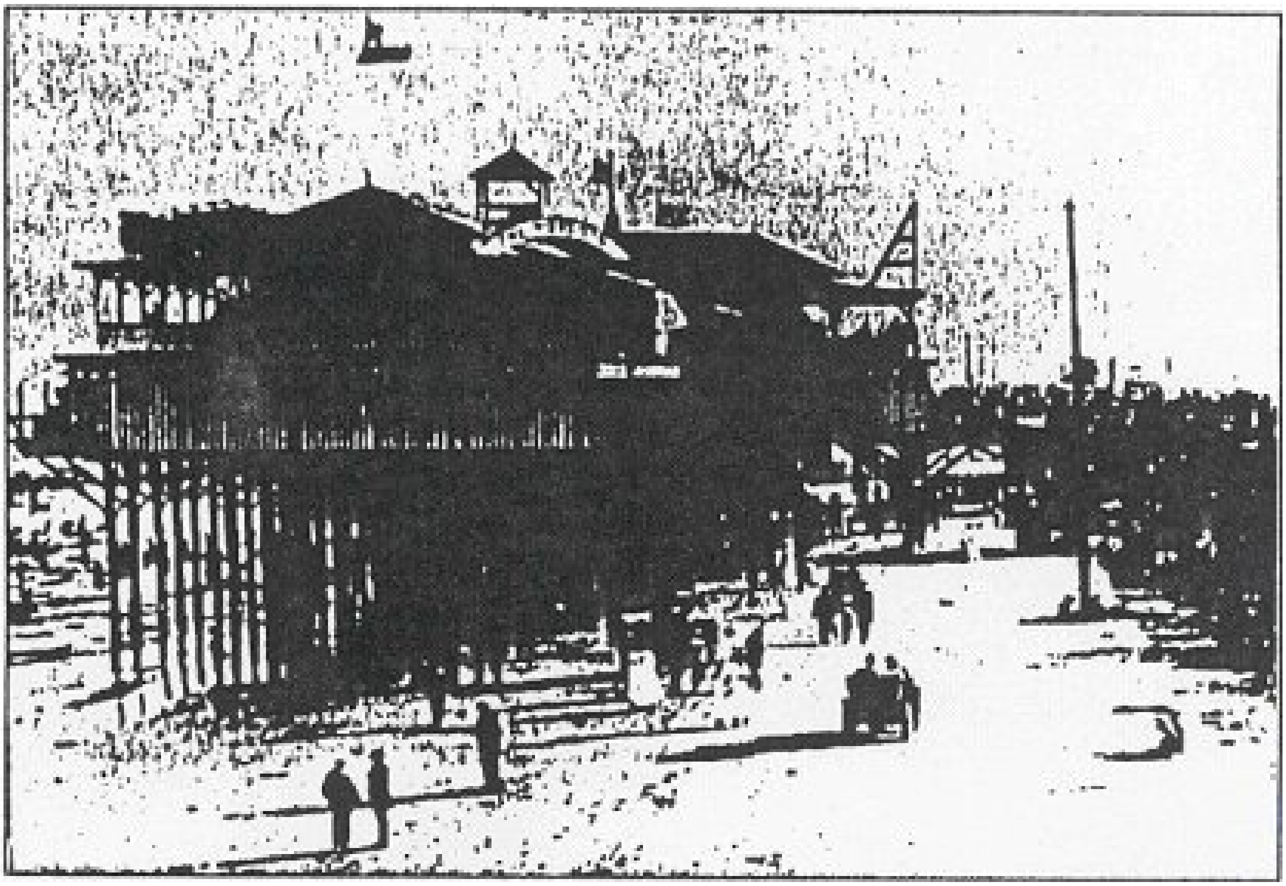

Figure 2. Galveston seawall circa 1911.

There are numerous reports and studies describing shoreline changes at Galveston Island and recommendations for stabilizing the shoreline (Seelig and Sorensen 1973, Moreton 1974, Williams. et al. 1979, and COE 1971,1985,1992,1993).

Choosing Beach Nourishment

In 1985, the Galveston District COE completed the Galveston County Shore Erosion Study which recommended beach nourishment for the 3.8-mile (6.I-km) segment of the beach in the groin field between 10th and 61st Streets. The recommended borrow area was Big Reef (a shoal on the east side of the Bolivar Roads south jetty) at an estimated cost of $15,388,000 using 1984 prices. It was determined that the non- Federal sponsor, Galveston County, should pay 85% of the total project cost. The county found the result unacceptable and did not pursue the project further.

In 1989, there was a grass-roots effort by many Galveston citizens to educate state lawmakers that coastal erosion was a problem, and that local governments needed assistance in funding shore-protection projects. The result of this effort was the range of a bill that delegated to the GLO the authority for coordinating coastal erosion planning. With a grant from the Texas Water Development Board, in 1991 the GLO entered into a cooperative effort with the COE, through the COE's Planning Assistance to States, Section 22 Program, to evaluate the feasibility of placing maintenance material dredged from the Galveston Harbor Channel (Bolivar Roads) on the Galveston Beaches. This plan proved to be the most cost-effective approach for restoring the shoreline. However, after a detailed evaluation of the channel sediments, the COE determined that the quality was not suitable (containing 30-40% silt and clay) for beach replenishment, and placed the sediments in a nearshore berm located approximately 6500 ft (2000 m) offshore in 21-ft (6.4 m) water depth (McLellan, personal communication).

Once again, the GLO and COE acquired funds for another Section 22 Planning Assistance to State

Program evaluation of the quality and quantity of material in the Big Reef borrow source, to determine a basic beachfill template, and to identify construction procedures (COE 1993). Using the COE's recommendations, the City of Galveston decided to pursue the construction of the beach nourishment project, and in November 1993, voters passed a bond to approve a 1/8 cent sales tax increase to fund the beach nourishment project. The rate shall be imposed for 15 years to repay loans acquired from the Texas Water Development Board. A coastal engineering consulting firm, Coastal Planning and Engineering. Inc.. of Boca Raton, Florida, was engaged to help the City obtain the necessary permits and complete the final engineering specifications. Table 1 shows the state and Federal agencies which issue permits for beach nourishment projects, and the agency's role in resource management. The City obtained all of the necessary permits for the Big Reef borrow source in 1993.

Table 1. Beach fill permitting agencies (modified from Texas Coastal Management Plan, Inventory of Coastal Management Authorities, June 1993).

Agency	Method of Regulation	Resource Management Role	Regulation
U. S. Army Corps of Engineers U. S. Environmental Protection Agency	Permit License	Discharge of dredged or fill materials into the waters and adjacent wetlands of the U.S.	33 CFR 323.1 et seq. 40 CFR 230.1 et seq.
Texas Natural Resource Conservation Commission	Certification Permit	Discharges in water.	31 TAC 305,307
Texas General Land Office	Lease	Dredging and filling state-owned lands.	31 TAC §§13.11-13.12
Texas Parks and Wildlife Department	Permit	Removal of marl, sand, and gravel.	31 TAC §§57.61-57.76

However, in a surprise development, when the bids were opened, the lowest bid was nearly $2 million over the City's proposed budget. Because of the promises made to the Galveston citizens that the beach would be constructed, the City sought an alternative and less expensive borrow site. Their consultant recommended that they look offshore and the City contracted with Rice University to evaluate the sediment quality and determine quantities from the proposed offshore borrow site locations (Anderson, et. al. 1994). The best quality sand for the beach fill was found approximately 3,300 ft (1,000 m) offshore of the eastern portion of Galveston Island at Stewart Beach in approximately 16-ft (5-m) water depth (Fig. 3). Analysis of core samples showed a composition of greater than 95% sand. The median grain size of the beach is very fine sand, 0.13 -0.14 mm (Williams, et. al. 1979). Fine sand (0.13 mm) is confined to the upper few feet of the proposed borrow area (Borrow Area 3).

In a nourishment project of Grand Isle, Louisiana, borrow dredging close to shore caused two large salients to emerge on the beach behind the borrow sites (Comb and Soileau 1987). Because of the precedent-setting nature of the Galveston project, the GLO was concerned about adverse impacts of the borrow practice design on the adjacent shoreline. The GLO and the City therefore contracted the Conrad Blucher Institute for Surveying and Science, Texas A&M University-Corpus Christi, to conduct a study of wave refraction and shoreline change for the Galveston project. The purposes of the study were (1) to estimate possible maximum adverse impacts of the extraction of 1.5 million cubic m or more of sand from the identified nearshore borrow sites, and (2) to make recommendations for borrow area design and sediment extraction methods which will least impact the shoreline.

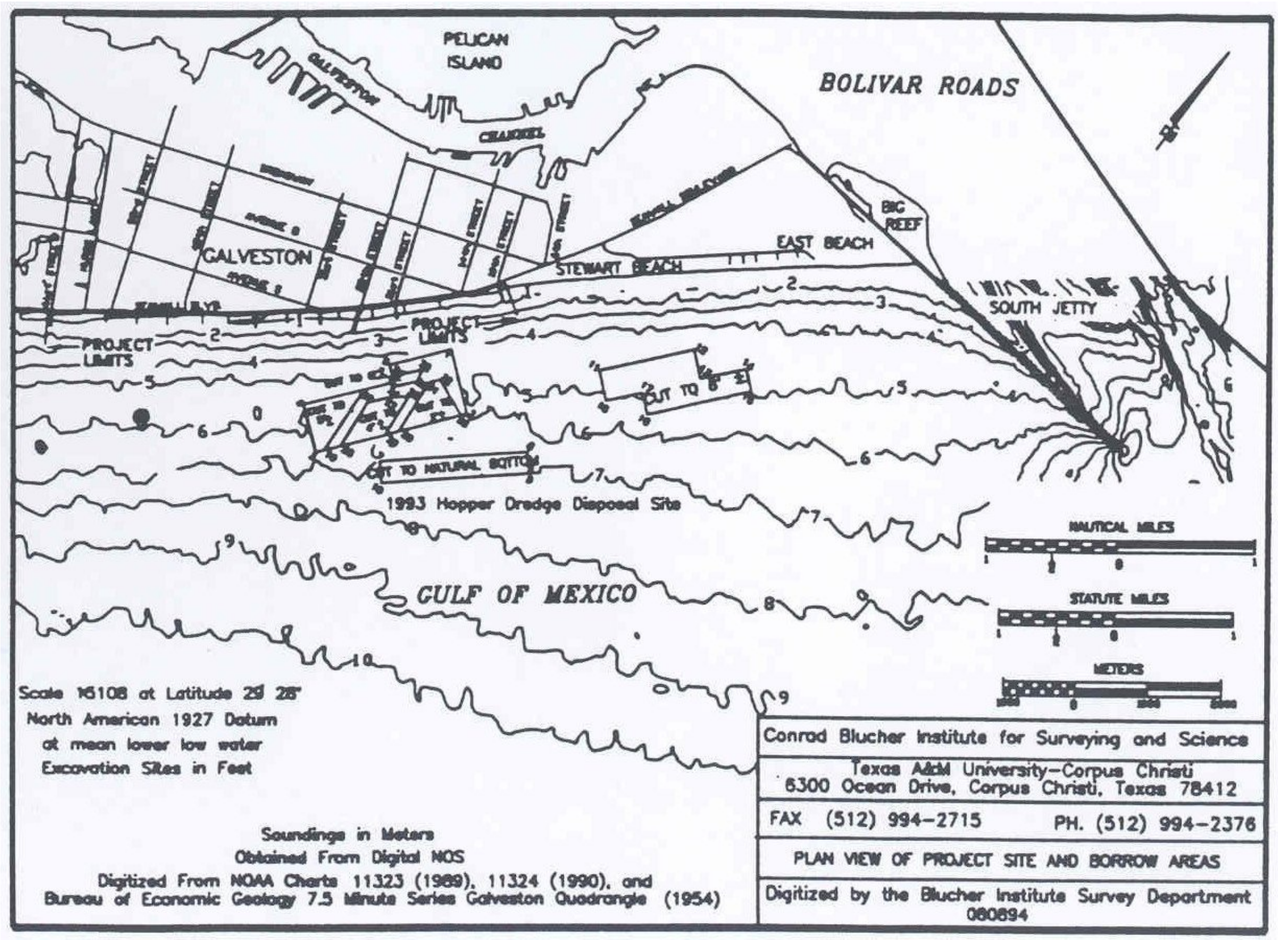

Figure 3. Plan view of project and borrow areas

SHORELINE RESPONSE MODELING

Alterations in bottom bathymetry, as through excavation of sand from borrow sites, can change the wave pattern alongshore and produce localized areas of erosion and accretion as documented in Grand Isle, Louisiana. To evaluate objectively the impacts of alternative borrow site configurations on the adjacent shoreline, a wave transformation analysis was performed to quantify the effects of the borrow site excavation on the waves and results from this analysis were used to drive a shoreline change numerical model.

Wave Transformation Study

Representative wave conditions were eliminated from the COE Wave Information Study (WlS) hindcast (Hubertz and Brooks 1989). Twelve directional wave spectra were generated for average and storm conditions at WIS Station 11, situated approximately 2.7 miles (43 km) offshore of the study area at a depth of 61 ft (18.6 m). These representative wave spectra provided the boundary conditions for the analysis. The analysis was performed with a random wave transformation model (Resio 1987, 1988). The refraction model grid consisted of 703 cells across shore and 558 cells alongshore, with cell spacings of 100ft (30.5 m) alongshore and 200 ft (61 m) across shore. This relatively fine-meshed grid spacing was selected to be able to resolve the offshore borrow sites and the jetty in the grid. The grid extends from the south jetty to approximately 2,500 ft (762 m) south-west of 61st Street and approximately 2.7 (43 km) miles offshore to the WIS station.

Depth values for the grid were obtained from digital bathymetry data provided by the Bureau of Economic Geology, University of Texas. The bathymetry was modified to include the 1993 dredged material placement site data provided by U.S. Army Engineer District, Galveston. Wave transformation simulations were performed for five borrow site alternatives: (1) existing condition (bathymetry without borrow-site excavation for use in comparisons), (2) removal of 3.3 million cubic yards of material from the borrow site off of Stewart Beach, (3) removal of 1.6 million cubic yards of material from the borrow site off of Flagship Pier, (4) a maximum-impact alternative which is a combination of Alternatives 2 and 3, and (5) a minimum-impact alternative. The minimum-impact alternative was designed to reduce the impact of the excavation of the borrow site by dredging in the borrow site as far offshore as possible and dredging in continuous, linear cuts to a uniform depth of 2 ft (0.61 m).

Wave refraction simulation were performed for each borrow site alternative for 12 wave conditions. The change in wave height and angle for Alternative 4 at the nominal 13.1-ft (4-m) depth contour due to propagation over the borrow sites is presented in Figure 4. This plot was generated using the average offshore condition (Hs = 3.6 ft (1.1 m), Tp. = 5.6 s, and Ang = 0 deg). The upper curves represent differences between the wave height and angle computed with and without the dredged borrow site, where a positive value denotes an increase in wave height or angle. Landward of the borrow sites there are regions with lower than average wave height, and at both ends there are regions of higher than average wave height.

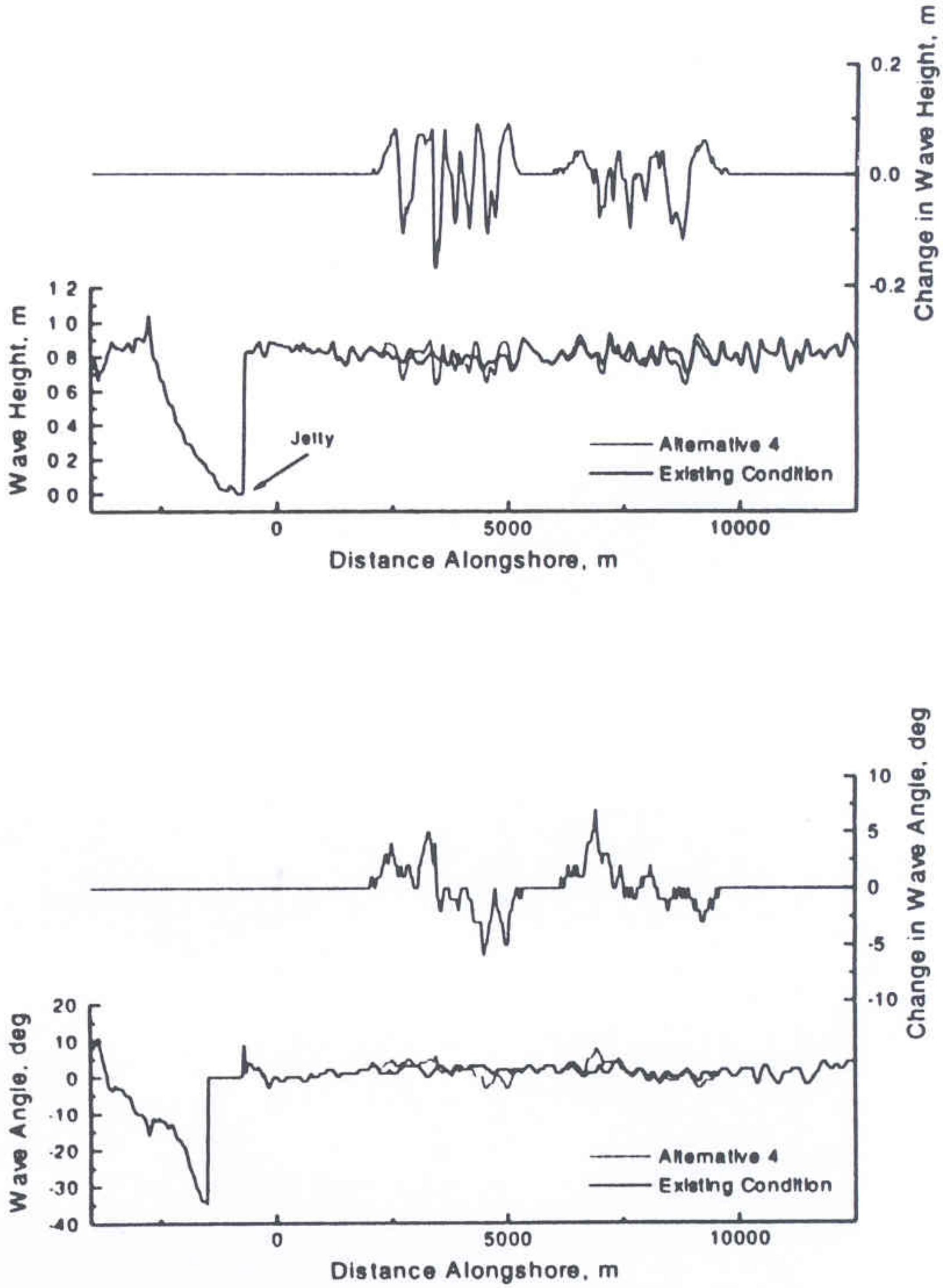

Figure 4. Change in (a) wave height and (b) wave angle at the nominal 4-m depth for waves propagating over Alternative 4.

Shoreline Response Modeling

The impact of various borrow site alternatives on the adjacent shoreline was simulated using the numerical modeling system GENESIS (Hanson and Kraus 1989). GENESIS calculates longshore sand transport by breaking waves and allows representation of beach fills, groins, jetties, detached breakwaters, and seawalls.

The shoreline change model grid extends from the south jetty to 1,200 ft (366 m) southwest of the 61st Street groin, consisting of 400 cells with an along shore spacing of 100 ft (30.5 m). The positions of the shoreline, jetty, groins, seawall, and planned beach fill were obtained from digitized aerial photographs dated November 25, 1991, provided by Coastal Planning and Engineering, Inc. The south jetty was represented in the shoreline change model as non-diffracting because the random wave model transformed waves into the nearshore, well shoreward of the seaward end of the jelly. The 15 groins in the project reach were represented as diffracting groins with permeabilities set equal to 0.2. It was assumed that Flagship Pier and the other piers did not influence the longshore transport. An effective grain size diameter of 0.14 mm provided the best fit for specifying the equilibrium beach profile used in GENESIS. The depth of closure was taken to be 15 ft (4.6 m), and the height of the berm was taken to be 3 ft (0.9 m). The beach fill was introduced over an interval of one month in equal daily increments to achieve the design width on the plans.

The lateral boundary condition to the north (the south jetty) was imposed as no transport, and the lateral boundary condition to the south was imposed as a pinned beach, meaning sand could enter and leave the grid freely. Output from the random wave model was saved at longshore grid spacings at l00-ft (30.5 m) intervals along the nominal 13-ft (4-m) contour for driving GENESIS.

It was found that, although the net transport rate differed between types of waves used, the development of protruding salients with eroded flanks did not vary significantly. Therefore, to save time, conditions with wave incidence normal to the coast (0 deg) were used in the simulations. The tests also showed that typical wave conditions with the default GENESIS calibration parameters called K1 and K2 equal to 0.4 and 0.2 gave annual longshore transport rates in the range of about 100,000 to 150,000 cubic yards (76,000 to 115,000 cu m), which is considered a reasonable order of magnitude. Therefore, the default parameters were used.

Shoreline change simulations were performed for two representative years, whose offshore conditions are summarized in Table 2. The first representative year consists of simulating the shoreline change under typical conditions for a period of six months, subjecting the shoreline to Storm Type-1 conditions for one week, and then typical conditions for another six months. The second representative year consists of typical conditions for six months, a week of Storm Type-2 conditions, and then six months of typical conditions.

Table 2. Wave conditions used as input to shoreline change model.				
Wave Condition	Duration	H_s (m)	T_p (sec)	Wave Angle
Typical	6 months	1.1	5.6	0
Storm Type 1	7 days	2.0	10.0	0
Storm Type 2	7 days	4.0	10.0	0

Figure 5 is a plot of change in shoreline position for Alternative 4 resulting from the representative wave conditions, including a Type-1 storm. Under typical conditions, areas of accretion form in the lee of the borrow sites. These accretionary features are flanked on either side by areas of localized erosion. Under typical storm conditions, these accretionary features, as well as the regions of erosion, become more prominent. After six months of typical conditions, the accretionary features decrease in size but are still present, indicating that the salients have become semi-permanent features. The minimum impact borrow site configuration substantially reduced the evolution of the salients.

Recommendations

By well-planned excavation design and implementation, the induced shoreline changes can be minimized and are not expected to reduce the effectiveness of the beach nourishment project. Based on observations made in this study and prudent coastal engineering practice, the following guidelines were recommended (Brown and Kraus 1994) for excavation of the borrow sites:

- Remove sediment from the farthest possible location(s) offshore.
- Remove sediment in linear strips alongshore, not in irregularly shaped areas.
- Excavate to minimum depth over the widest area.
- If different grain sizes are available, use the coarser grained sediments.
- Minimize use of the northern-most site located offshore of Stewart Beach.
- Be prepared to smooth the beach plan form periodically, perhaps annually, to cut down the accretionary cusps and to fill eroded neighboring areas.
- Monitor the shoreline, beach profile, and borrow sites for several years.

PROJECT STATUS

In 1994, the City received the permits to rebid the project using the offshore borrow sources. Contractors were given three alternatives from which to bid and two different start dates. As a result, the City of Galveston contracted with T. L. James & Company to construct a beach between 10th and 61st Streets using approximately 10,000 cubic yards (542,000 cu m) of beach-quality sediment excavated from an offshore borrow site (No. 3). Permit conditions require that the project performance be monitored for at least two years following construction and a plan for addressing shoreline erosion. In December, 1994, pre-construction beach profile surveys and a determination of the pre-project mean high water line (a legal boundary in the state of Texas) were performed by the Bureau of Economic Geology and the Blucher Institute, and pumping of sediment began on Christmas Eve, 1994. Initial sediment quality was good, and the amount pumped onto the beach is averaging 870 cubic yards (660 cu m) per day. Completion of the beach fill is expected in April of 1995.

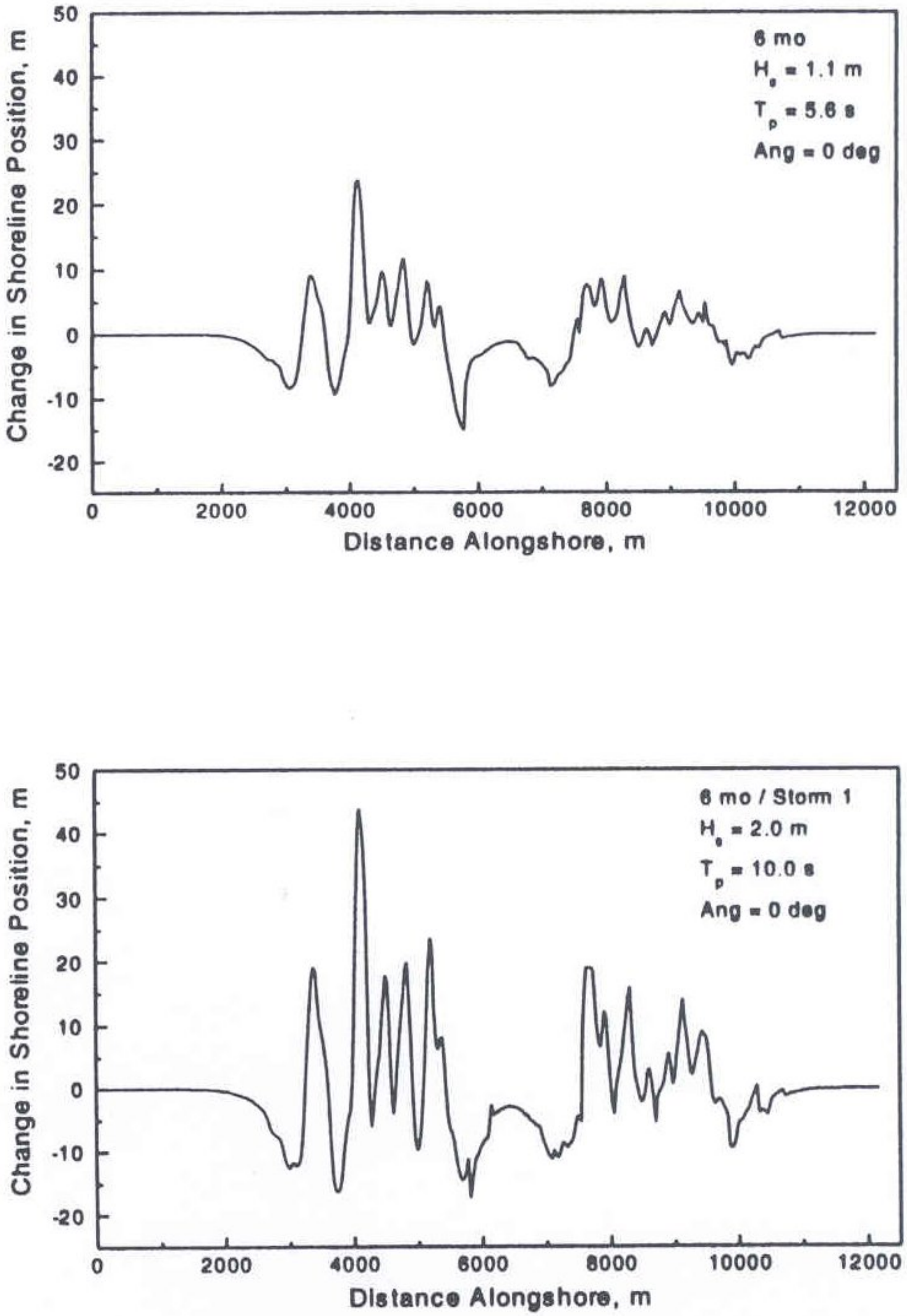

Figure 5. Change in shoreline position for Alternative 4 Typical Conditions (upper panel) and Typical Condition / Storm 1 (lower panel).

LESSONS LEARNED AND EPILOGUE

Although experienced in permitting of a Gulf Beach fill project, regulatory agencies were supportive and worked with the City to complete the applications and necessary studies. As part of the COE's Section 404 permitting process, many dredge-and-fill projects are coordinated with the other resource agencies through the COE's joint processing and evaluation meetings. Permitting agencies involved in the meetings are able to convey their concerns on a proposed project.

Wave transformation analysis analysis and shoreline response modeling provided valuable information for determining the amounts and locations of material to be extracted from the borrow sites. However, due to construction costs, the City was unable to implement all of the recommendations. With this in mind, it is all the more important to monitor the borrow process and beach and to address any erosion should it occur.