BEACH FILL RESPONSE ON GROIN AND JETTY COASTS

Final Project Report

U.S. Army Engineer Waterways Experiment Station
Coastal Engineering Research Center

Contract No. DACW39-92-K-0011

April, 1992 to March, 1993

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BACKGROUND

This is provided as a final report summarizing and completing all Mote Marine Laboratory (MML) work for the US Army Engineer Waterways Experiment Station (WES), Coastal Engineering Research Center (CERC), under contract no. DACW39-92-K-0011, "Beach Fill Response on Groin and Jetty Coasts." The one year contract was approved in March 1992 following negotiation and revisions to a MML proposal submitted under the WES Broad Agency Announcement. A contract modification was approved in August 1992, expanding the contract scope in one task area. The MML Principal Investigator for the project was Dr. Cliff Truitt. He was assisted in the modeling task by Dr. Don Hayward

The overall goal of the research was to improve capability to predict the evolution of beach restoration or other beach fill projects designed to include groins or jetties. The project approach used the CERC-developed shoreline change model GENESIS (e.g., Gravens, Kraus and Hanson. 1991) to numerically investigate how such structures function in relation to the fill sections and what design and/or employment modifications may be appropriate to increase the longevity and stability of the fill material.

The specific objectives of the project, as described in the original statement of work, were organized into four major task areas or phases. These were:

Task Area 1 - Beach Fill Evaluation System Architecture:

- Develop conceptual system operations schemes for evaluating cost and performance factors for various alternative design combinations of beach fill and shore-normal stabilizing structures.

- After concept review and with advice of CERC investigators, select a candidate scheme for implementation demonstration; develop schematic system architecture for that scheme and demonstrate concepts and functions (without actual calculation routines).

- Based on results and reviews of the implementation demonstration, provide written recommendations for continuation (to include scope), or termination of further development of the beach fill evaluation system architecture.

Task Area 2 - Field data compilation and analysis:

- Assemble existing field data including mean high water line surveys, beach profiles, controlled aerial photography, beach fill volumes and structure design details for sites on the Gulf coast of Sarasota County, Florida where groins exist in a functional condition.

- Reduce the information to common datums and formats to produce time series of shoreline positions.

- Develop, with the assistance of CERC investigators, an appropriate characterization of the wave climatology using WIS data and any University of Florida wave gage system data available.

Task Area 3 - GENESIS model verification:

- In cooperation with CERC investigators, calibrate and use GENESIS to model shoreline response to the groin structures; compare the results with the field data and suggest any modifications to the model which might be indicated.

Task Area 4 - Analysis, Revisions and Final Report:

- Use the verified model and the field data to systematically explore the way in which groins and similar structures function, to identify and rank the design parameters contributing to that functioning, and suggest possible improved beach fill designs which include shore-normal structures.

Task Area 1 was intended as a parallel effort which draws from, but was not directly dependent on the other tasks. This work was accomplished by Hecate Software, Inc., Fort Worth, Texas, as a fixed cost sub-contract. The scope was expanded for this task in the August 1992 modification based on field response to the initial product demonstration. The remaining three task areas were essentially sequential and correspond to phases in the MML project.

INTRODUCTION

Groins and jetties are among the oldest types of coastal structures. Early experiences clearly showed that such shore-normal devices were effective in trapping sand, and it was a logical application to use them in combination with beach fills in order to reduce the longshore movement of the fill material. With increases in coastal development pressure in the 1950s and 60s, however, there came a concurrent virtual explosion in the use of groins on eroding shorelines, usually without associated fill. Along the Southwest coast of Florida alone there are thousands of individual groins representing at least a dozen distinctive designs and employment geometries. The list includes several terminal and transition structures within beach fill projects.

Over time the adverse effects of groins on eroding, native beaches began to be recognized to include downdrift shoreline impact, debate over responsibility for maintenance and adjustment, and safety hazards to boaters and swimmers. As a result, opinion shifted in the opposite direction to the extent that new groins are essentially prohibited by most of the regulatory agencies and local governments in Florida and other states.

For example, a groin proposed in 1991 by the Corps of Engineers (USACE) Jacksonville District as part of the design of a Federal erosion control/beach restoration project received such negative review by the Florida Department of Natural Resources that it was withdrawn from the design. Even with state-of-the art tools, the District was not able to conclusively demonstrate either the positive physical and economic benefits of using a groin as a transition structure for the beach fill at a point of high shoreline curvature, nor the lack of negative effects outside the project.

The tasks in this current research project were intended as one contribution toward improving our ability to predict such effects, both positive and negative, and allow for more informed decision-making. The following sections describe the analyses and results by task area.

ANALYSES AND RESULTS

Task Area 1 - Beach Fill Evaluation System Architecture

Development of a PC-based demonstration program by Hecate Software began on award of the contract and was essentially completed by the end of June 1992. The intent of this program was to illustrate a possible system architecture which could be used (if fully-developed) to evaluate the costs and benefits associated with alternative beach fill designs.

The source and executable codes for the demonstration program, along with written documentation, were forwarded to the CERC Contracting Officer's Representative (COR) in mid-June 1992 for review. The reader is referred to that documentation for further technical details about this effort.

This submittal satisfied the deliverable product for the first task and constituted the first formal progress report on the contract (informal discussions and meetings have occurred periodically). The COR indicated his satisfaction with the technical quality of the program and we understand that system demonstrations were made during July to several USACE Districts and other groups.

The sub-contractor's experiences during the task development and feedback from the subsequent demonstrations led Hecate Software to suggest enhancements which might be made to the program. These recommendations are very briefly stated as:

- Including the concept of a ***reach***. This would allow a study area to be sub-divided, and the analyses performed on each area then combined into a project.

- Improve the program's ability to process economic data.

- Revise and improve the screen display (e.g., pan and scrolling).

These suggestions formed the basis for a requested unilateral contract modification to continue development on the Beach Fill Evaluation Module. The modification was approved in August 1992 and the additional work completed in October 1992. The sub-contractor demonstrated the upgraded module for the COR at WES on October 22-24, 1992 and provided the final codes and documentation. This completed all required work and submittals for Task Area 1.

Task Area 2 - Field data compilation and analysis

<u>General Study Area Description and History</u>. The field site chosen for investigation was Lido Beach on the Gulf of Mexico in Sarasota, Florida. The publicly-owned beach (900 to 1200 m

long) traditionally has been used as a placement area for sand dredged by USACE from the adjacent New Pass federal navigation project. At the southern end of the public beach is a single rock groin constructed originally as the terminal structure of a locally-sponsored large stabilization and revetment project (ca. 1960). Although the groin is relatively low and was not built using a multi-layer design, it is sufficiently impermeable to function with some degree of effectiveness, as clearly shown by a down-drift offset "signature."

Lido Key itself is the result of a massive fill project dating to the 1920s. A series of separate mangrove islands and shoals were in-filled to form a continuous island approximately 4 km long. Shoreline positions on the key since that time have varied greatly as the area underwent an initial adjustment and matured in response to the influences of the adjacent inlets. However, the trend within the past 40 years has been one of accelerating erosion of the middle third of the island creating an erosional "hot spot" with average annual losses on the order of 60,000 cu m.

Additional restorative fill was placed on the public beach as early as the 1950s and the frequency and average annual volume have increased with time. The federal channel has been dredged and the material placed on Lido Beach on the average of every 3 to 5 years since 1973. This beneficial use of the dredged material has served to off-set the serious erosion; it has also created a certain level of dependency on the mitigation process. When funding constraints delayed USACE from dredging the pass from a planned date in 1988 to 1990, the Lido Beach shoreline retreated over 8 m in the interval and undermined the upland pedestrian walk. While this effect was not critical, it did result in a monetary cost to the local government at the time, and it produced increased apprehension about the overall vulnerability of the area and the longevity of fill projects.

Figure 1, produced during the data analysis, shows the general site including the adjacent inlets with their well-defined shoals. Neither inlet is jettied. The north end of Lido Key, south of New Pass, suggests a down-drift offset planform as discussed recently by Douglass (1991) and Galvin (1992). The concave shoreline in the study area, resulting from the transition to these inlet shoals and the irregular bathymetry at a water depth of about 4 m near the center of the key, proved to be somewhat of a challenge for modeling as discussed in later sections.

Bathymetric and Shoreline Change Data. We examined the two most recent full cycles of shoreline erosion, fill, and adjustment beginning in 1984 with an eroded project condition. Inlet maintenance dredging took place in the summer of 1985 and resulted in 145,000 cu m of fill being placed along a 900 m section of Lido Beach in a berm approximately 50 m wide at elevation +1.5 m (MLW) (approximately 161 cu m/m). We were able to monitor the performance of the fill using existing data over the subsequent five years until additional fill was placed in 1990-91. Three years of similar data were available following the second fill event.

A progress report, dated September 15, 1992, was submitted which describes in detail the dredging and fill events and the dates and sources of the surveys and aerial photography used in the analysis. Copies of preliminary shoreline change/position maps and profile plots were provided with the report and during a previous progress meeting with the COR. The following sections briefly summarize that data and our work in producing it. Figure 2 is an example of a shoreline change plot for the first fill adjustment period.

Bathymetry for the wave transformation had to be developed in three separate steps. Offshore bathymetry was initially constructed using digitized soundings available from NOS. This data set was very useful as a starting point for the RCPWAVE grid. The NOS database consists of all

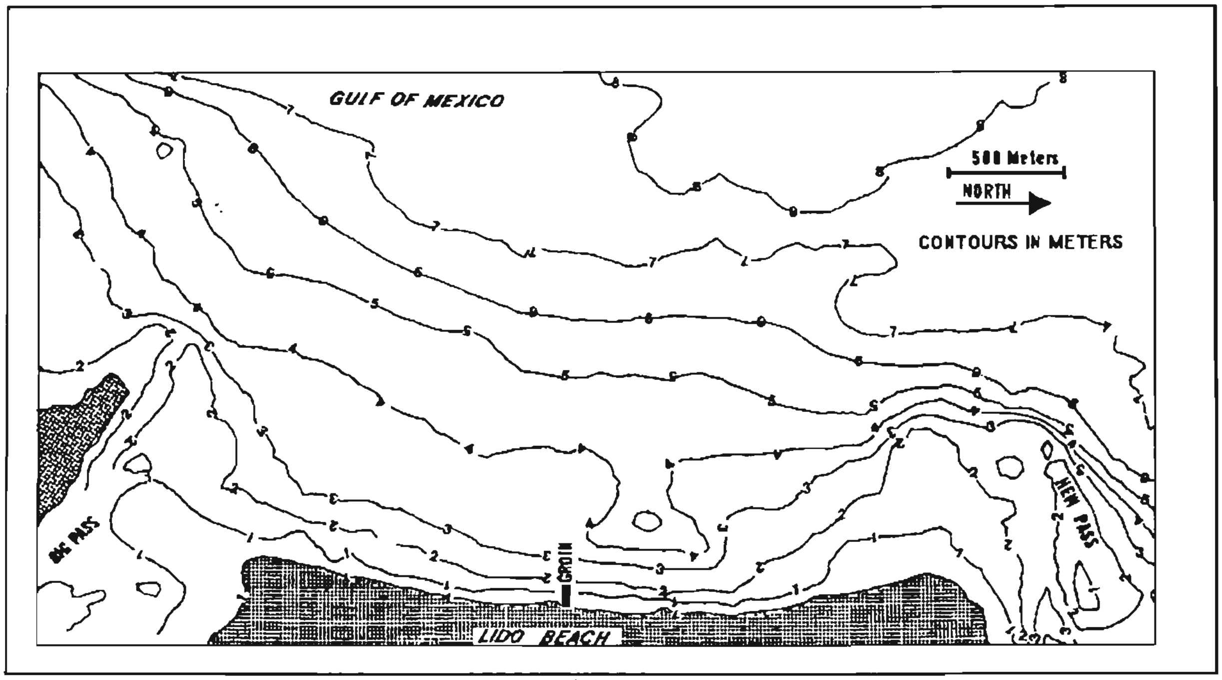

Figure 1. Study area.

soundings performed over time in the area (e.g., roughly 200,000 individuals points for our site). The amount of data and potential need to edit spurious points suggested we start with a CADD file. Because the NOS data consists of only bathymetric soundings, a "blanking" file had to be developed from a USGS "quad" sheet to insert a preliminary description of the upland area. The horizontal positioning of the NOS data in latitude and longitude also had to be transformed into state plane coordinates to be compatible with other data.

The second step was to refine the nearshore bathymetry using sources other than the NOS soundings. The age and somewhat irregular density of these data close to shore and at the inlet shoals made them less representative of current conditions. In addition, one of the original attractions about the Lido Beach site was the availability of other high quality, recent information.

Nearshore data was available in several formats from USACE condition surveys, controlled photography, and beach or mean high waterline surveys sponsored by the City of Sarasota. These data were adjusted to common datums and compatible formats and blended into the offshore data in the CADD file. Because of the relatively flat profile, many beach survey lines extended offshore for distances of 600 to 650 m, making the "fit" very accurate.

Figure 3 is an example of an interim product from the CADD system showing depth values "posted" to their horizontal positions. The locations and coverage of the surveyed profiles can be clearly seen, together with the effect of the shoreline blanking file. A preliminary contour fit is superimposed.

The resulting large number of bathymetric points provided enough information for useful statistical processing. Although the CADD program was efficient for the data entry and basic editing, it was not sufficiently mathematically sophisticated to generate the desired interpolated grid. We used the SURFER software (Golden Software, Inc.) and experimented with several Kriging methods to

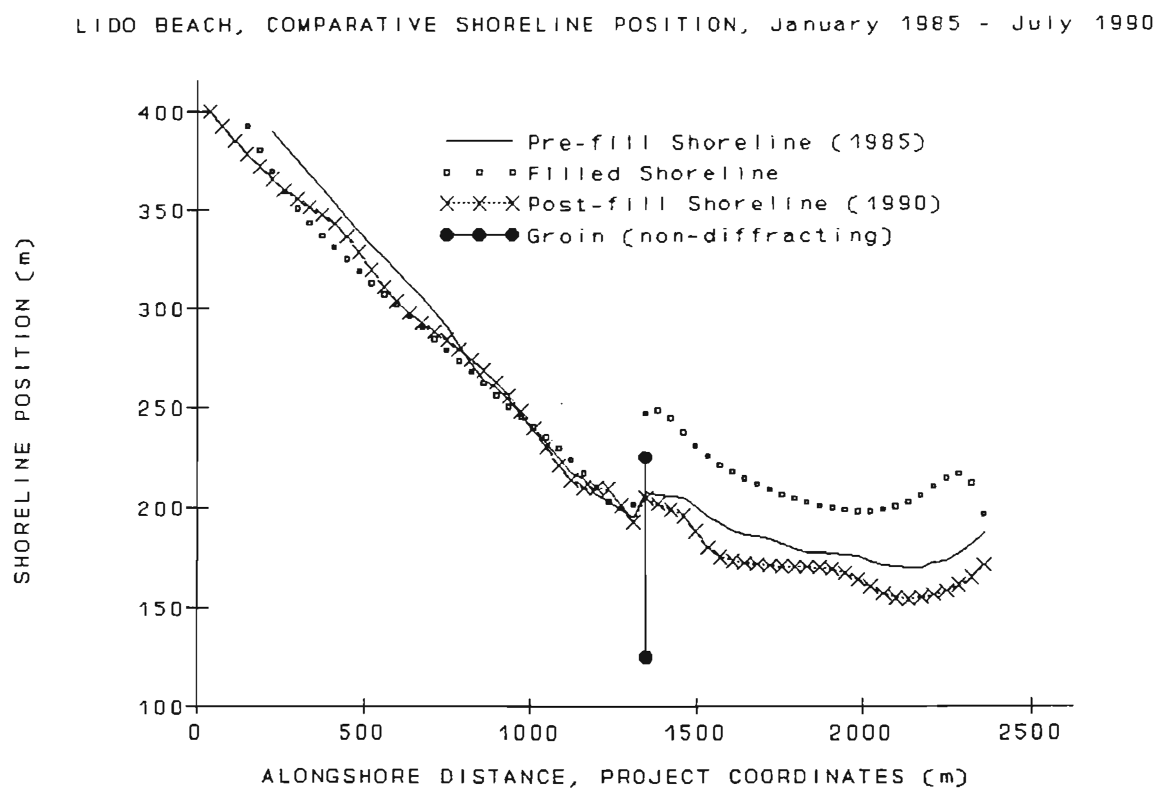

Figure 2. Example shoreline change plot.

generate the final grid.

Wave Data and other Littoral Conditions. As part of the project preparation we investigated wave data sources, possible sediment budgets, inlet histories, and anything else which might have been useful in interpreting simulation results. The average littoral conditions in this part of Florida might be considered benign when compared to other shorelines around the country. For example, we requested and examined the USACE Wave Information Study (WIS) statistics for Station 41. The deepwater wave heights were less than 0.5 m for 17 percent of the time and less than 1.0 m (cumulative) almost 70 percent of the time. The mean significant wave height for the hindcast was 0.8 meters and the largest significant height was 3.0 m. The tidal range is approximately 0.6 m. Perturbations from storms and the effects of local hydrodynamic and morphological conditions such as at the inlets or structures certainly play a large role in the shoreline response.

Net longshore transport in the region is generally considered to be from north to south and a persistent prograding spit can be seen on the south end of the key, projecting into Big Sarasota Pass. The shoreline at the north end of the island, however, has varied from eroding to accreting. Attempts have been made at constructing general sediment budgets for the area (e.g., CPE 1992, ATM ca. 1988), but without definitive success. The analyses have been compounded by factors such as designed variations in the dredged channel alignment within the pass, dredging volumes apparently in excess of the shoaling rates, multiple placement areas for the dredged material, and a decreasing background sediment supply from the eroded beaches to the north.

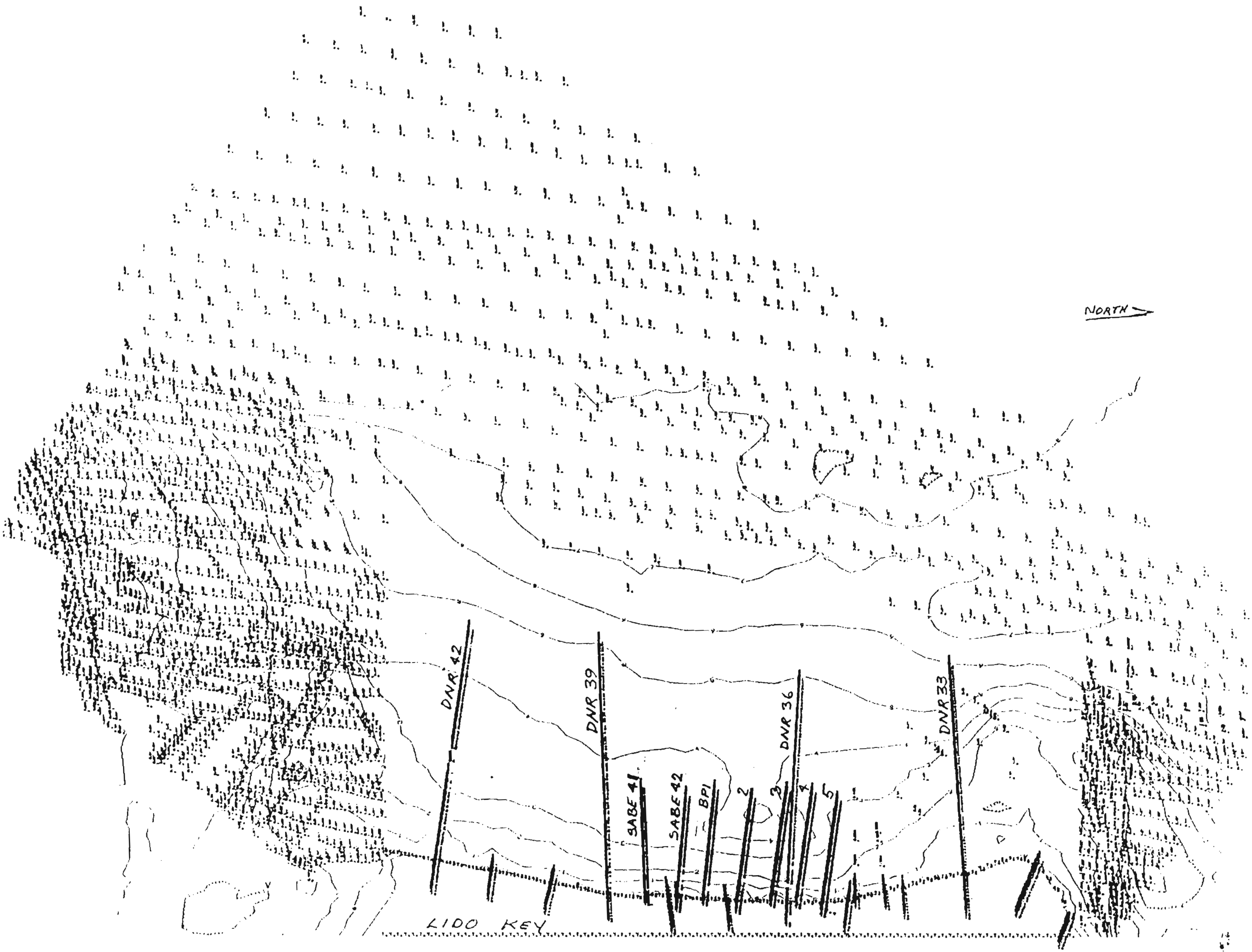

Figure 3. Sample interim bathymetry file plot.

Estimates of the average annual net transport are in the range of 40,000 to 50,000 cu m/year directed to the south, when computed over a relatively long period of record, to as much as twice these values when averaged over only the most recent several years. It is generally agreed by most observers that the actual rate varies along the key: potential transport increasing with distance from north to south, but a with a likely divergent nodal point or reversal near the northern portion of the key.

Some grain size information had been collected by USACE during a 1984 county erosion control study and in the New Pass shoals prior to dredging, but these data for native Lido Beach were limited and inconclusive for our purposes. In addition, the City's consultant reported (CPE, 1992) analyzing 6 beach samples and 7 shoal cores. The mean grain size in the CPE beach samples averaged 0.24 mm. No detail was given about sampling or compositing methodology. The shoal cores were typically 11 to 13 feet-long. The "weighted average" mean grain size of each composited core ranged from 0.15 mm to 0.47 mm. A simple average of all 7 composites was 0.25 mm. Larger-sized shell was reported in both the CPE and USACE samples from 5 percent to over 50 percent.

Equilibrium profiles (distance to the 2/3 power) based on three different grain sizes were computed and plotted compared to the envelope of actual surveys (Figure 4). The profile calculated using an effective grain size of 0.25 mm was found to fit the offshore slope (beyond 300-400 m) very well, but was far too flat in-shore. The same plot for an effective grain size of 0.40 mm fit the measured surf zone slopes, but was too steep further offshore. As a matter of interest and instruction, we also calculated a profile for an effective size of 0.39 mm. The calculation for a profile's "A" factor based on grain size is a step function with one equation for diameters less than 0.4 mm and another for 0.4 mm and greater. Figure 4 shows the effect on profile shape of varying the grain size by 0.01 mm over this mathematical step.

Task 2 Conclusions. As noted earlier, a progress report was submitted to conclude this task. However, as a matter of practicality, data continued to be refined and modified as the subsequent modeling progressed. This is discussed further under Task 3, below.

In might be noted that this phase of the project consumed a considerable amount of time and expense. Although we had generally anticipated the steps required, the final effort far exceeded our expectation. Producing the bathymetric grid from all the various sources, times, formats and software was hardly a trivial exercise. In some cases the procedures were relatively straightforward, but problems such as software limitations on file size, or format compatibility, necessitated very long and tedious "chain" processing. For several other tasks (e.g., the shoreline "blanking" file, or the coordinate rotation), custom code had to be written for the procedure.

As we neared the end of our efforts in this task, the test draft of a Beach Morphology Analysis Package (BMAP) developed by CERC became available. This software integrates several processing tools, at least for profile data, mentioned above. We used the program briefly and found it to be very helpful, and recommend that development be continued. Some thought needs to be given to how BMAP might interface with DPLOT and to the various (differing) formats required by RCPWAVE and GENESIS, or other commercial software.

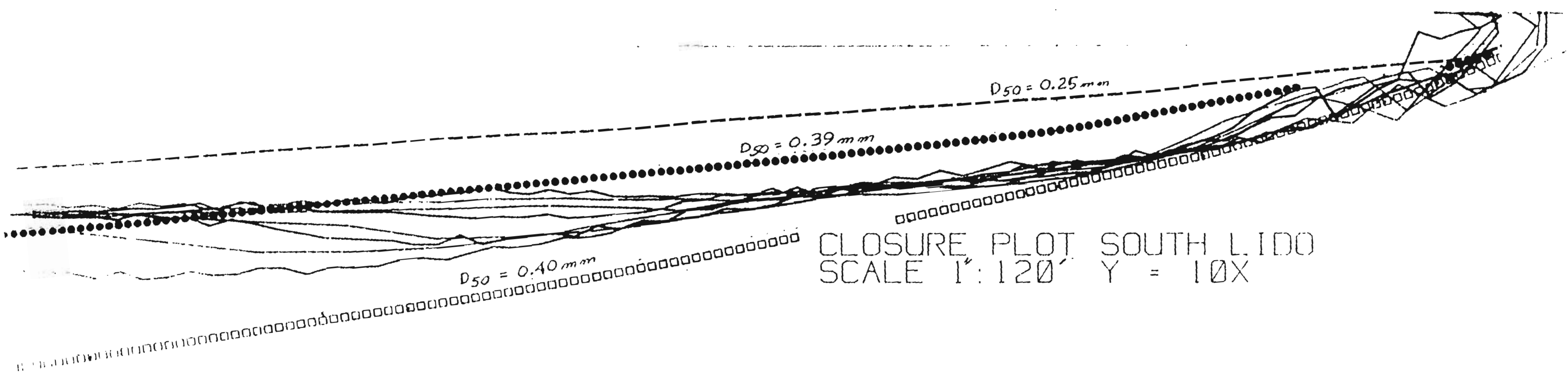

Figure 4. Calculated equilibrium profiles compared with surveys.

The point intended by this concluding discussion is simply that as shoreline change numerical models have become more sophisticated and capable of handling "real" situations, the planning, data management and file preparation requirements have also increased. Typical research, training and/or demonstration modeling projects are often conducted using abbreviated data files or simplified assumptions about the site. For our case, which is still relatively small compared to most fill sections, the ratio of preparation to simulation is estimated to have been on the order of 10 to 1.

Task Area 3 - GENESIS model verification

Approach. Performance of the fill was investigated using several techniques, including analysis of cross-sectional profiles and comparative plots of shoreline position (e.g., Figures 2 and 4). The GENESIS shoreline change numerical model (e.g., Gravens, Kraus and Hanson 1991) was used to gain a better understanding of the processes and their relative importance in fill performance.

The site and fill process were interesting modeling candidates because the dredged material placement typically "overfills" the profile significantly, extending the dry portion of the beach out to the tip of the short groin. In this configuration the modeling problem is one of a relatively short, wide fill with no structural interaction. As the profile adjusts to the wave climate and sand moves laterally, the groin becomes increasingly exposed and begins to function.

Other features of the area, however, clearly produced challenges to using a shoreline model in the analysis. These include project profiles which are difficult to represent by a traditional offshore distance to the 2/3 power equilibrium profile fit, high shell content in the fill with resulting problems selecting an effective grain size, and questionable applicability of a 1-D shoreline change model south of the groin because of a bypassing bar influence. However, the principal difficulty encountered was in re-creating the proper interaction between the waves and the bathymetry during calibration.

Model Calibration and Verification. Although the focus of this research was on the fill and groin performance, it may be helpful to other investigators to briefly share some of our experiences with the modeling process. The point is to guide future data collection or monitoring at other sites and to shape realistic expectations during similar analyses.

Because there were two very similar fill events at Lido Beach, one was used as an initial calibration for the model and the second as a verification. As noted, a WIS data hindcast for 1956-1975 was secured and used to estimate wave conditions during the simulation period from 1984-1993. Prior to running GENESIS we built a wave input file by randomly selecting 9 years of data from the 20-year hindcast. The RCPWAVE model (Ebersole, Cialone and Prater 1986) was used to transform the waves to the GENESIS nearshore reference line.

However, the first trial simulations using the randomly selected years of wave hindcast were very disappointing. Problems were encountered in producing an acceptable shoreline fit and in reproducing even the general shape of the transport rate curve, no less the magnitude of the transport. In fact, the first attempt introduced more sand onto the grid rather than eroding the fill.

In this first trial simulation and each subsequent case, we used both gated and pinned boundaries, varied values of the calibration coefficients, K_1 and K_2, and experimented with wave height and angle change factors. Each test matrix typically included 9 to 10 individual simulations.

The most positive results in the first trial came from changing the wave heights and angles, suggesting that insufficient energy was reaching the simulated shoreline. We reviewed the wave height, direction and breaking information from the RCPWAVE graphics utility. Through a series of iterations between RCPWAVE, the bathymetry files and GENESIS, we gradually smoothed the more severe irregularities in the nearshore contours, altered the specified depth along the nearshore reference line and identified the "better" years of hindcast waves.

With time and practice the shoreline shapes, transport direction and transport magnitude closed toward acceptable ranges. In all this process took 7 major iterations, or approximately 70 individual simulations. The result was a preliminary calibration sufficiently reasonable to try refining the model coefficients and test using the second fill event as a verification period.

Results of the first attempt at extending the calibration to the subsequent verification period (1990-1992) were not satisfactory. We noted two general problems areas: a recurring apparent loss of wave energy reaching the shoreline (i.e., not enough total recession), and calculated shorelines which increasingly diverged from the measured surveys with distance away from the central part of the study area.

The first area of difficulty still seemed to be in representing the wave spectrum appropriately. Yearly energy variability was not statistically significant when an entire 20-year wave data set was used, and were apparently still reasonable for the 6 year calibration period (or possibly we "adjusted" for it). However, the calculated shoreline response varied considerably if discrete sub-sets of the wave record were used to model short periods such as the two-year adjustment of the second fill selected for verification.

The problem seemed to include possible variations caused by wave sequencing as discussed by Gravens, Kraus, and Hanson (1991); it also was the result of less total energy in some years than in others, because increasing the height change factor usually improved results (up to premature breaking). Our experience was that it is very difficult in practice, with prototype-size wave files, to assess the relative influence of wave sequencing, angle changes (windows), and wave heights. As a matter of completeness, we also experimented with using the GENESIS internal wave transformation module (i.e., the scoping mode), but results were actually worse than with the external transformation.

This overall process is simply an indication of the problems likely when a specific, short timeframe is represented by generalized longer-term average data and, especially, over the complex bathymetry. We eventually resolved the situation by selectively repeating year-long wave sequences which gave the best compromise between the changes during the calibration period and those during the verification period. This seemed sufficient to produce at least consistent, repeatable results and allowed us to focus on potential causes of the problem with the shoreline shape.

In reviewing other possible problem sources, we revisited the difficulty of selecting a representative effective grain size. We reasoned that using a diameter of 0.25 rnm in the calibration may have produced an extremely flat profile with relatively shallow offshore depths. We might expect waves to break further offshore and the added berm widths from the fill to be "projected" farther seaward by the calculation slope. However, this was somewhat paradoxical because calculated transport rates were actually on the low side of expected ranges.

Rather than speculate over this dilemma, we performed GENESIS simulations using 0.25 mm, 0.39 mm and 0.4 mm for the input effective grain size. Figure 5 (a through c) shows the resulting calculated shoreline positions and Figure 6 (a through c) shows the corresponding shoreline change plots. The calculated shoreline positions within the grid area of interest (near the groin) did not differ in the extreme more than 2 m; most sections were identical. Because of this apparent minor influence, compared with other factors for this site, we proceeded using the 0.25 mm value for the effective grain size. The grain size influence is an area of investigation which might yield interesting information from further study.

No amount of adjustment of the other GENESIS parameters or varying boundary conditions solved the shoreline shape problems. If one end of the island and the groin signature were forced to fit, the other end of the calculated shoreline would be unacceptable, or vice versa.

After discussions and recommendations from the CERC Principal Investigator, our eventual solution to the calibration/verification problem was to incrementally trim the active calculation grid from the north, toward the fill area, until enough diverging shoal bathymetry had been eliminated to correct the transport trends and give a reasonable preliminary shoreline fit. Once this was done and an acceptable wave file was built, the other model parameters were re-adjusted, and the final fit between predicted and measured shorelines was acceptable (Figure 7). The verification results (Figure 8) were also judged to be acceptable for the purposes of this diagnostic study.

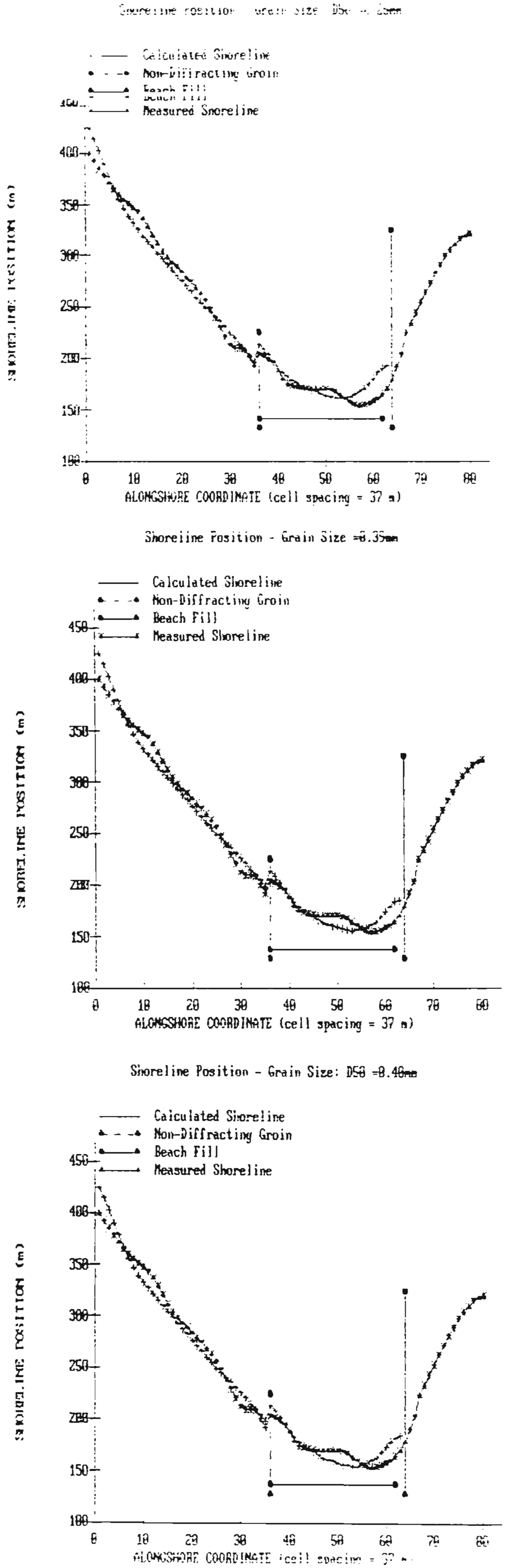

Figure 5. Calculated shoreline position for different effective grain sizes.

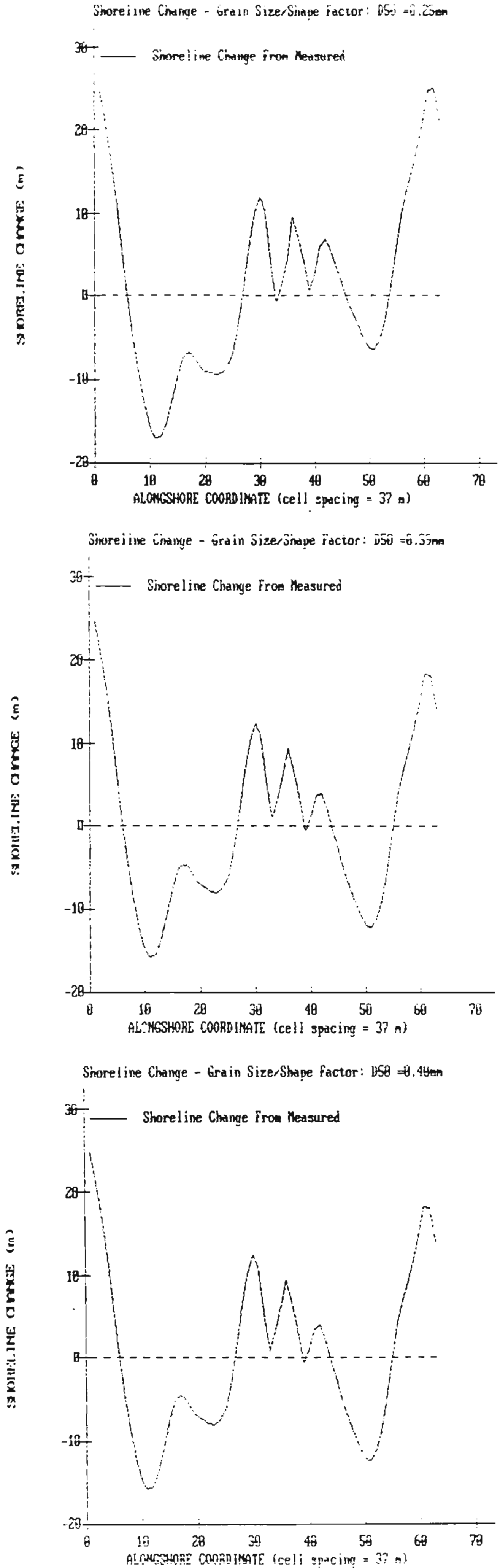

Figure 6. Shoreline change for different effective grain sizes

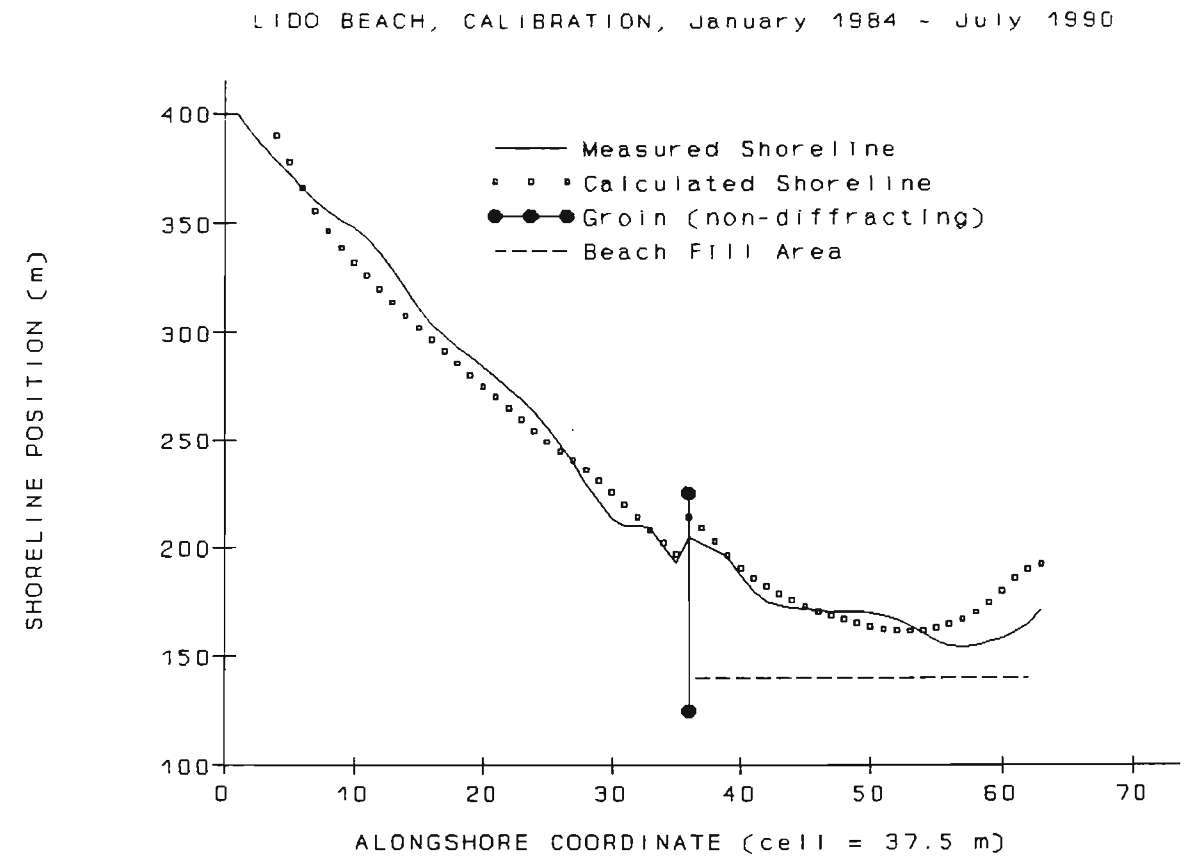

Figure 7. GENESIS model calibration.

The final model configuration used a "pinned" end condition on the south where actual shoreline positions varied little over time and a "gated" condition on the north end. The gate was set with a permeability such that it was transparent to the sand transport. The input wave height factor was adjusted upward by 10 percent and values of the calibration coefficients, K_1 and K_2, were relatively high, but within their allowable ranges.

Task 3 Conclusion. It should be emphasized that the problems encountered during the calibration were not any unexpected limitation of the model, but a practical case of establishing the approximate influences of the type of wave data and the adjacent inlet bathymetry by trial and error during the shoreline change model calibration. The greatest frustration was not with the model or the calibration process, but in having fixed time and resources which limited our ability to pursue issues such as wave sequencing or grain size effects in greater detail.

Task Area 4 - Analysis, Revisions and Final Report

The overall intent of the project was to review the performance of the dredged material as beach fill and understand the groin's influence on littoral processes at the site. As the work progressed, an irresistible adjunct was to evaluate various alternatives in the geometry of the fill and groin. This proved to be a rewarding exercise, but it should be clearly understood that these are very preliminary and speculative results. No project modifications are under consideration by the local sponsor, nor does this research recommend any.

Given the short longevity of fill placed at this site (typically 3 to 4 years), a reasonable beginning point would be to consider if the groin has any positive effect at all. The calibrated and verified model was re-run with the same parameters and fill geometry as in the verification, but

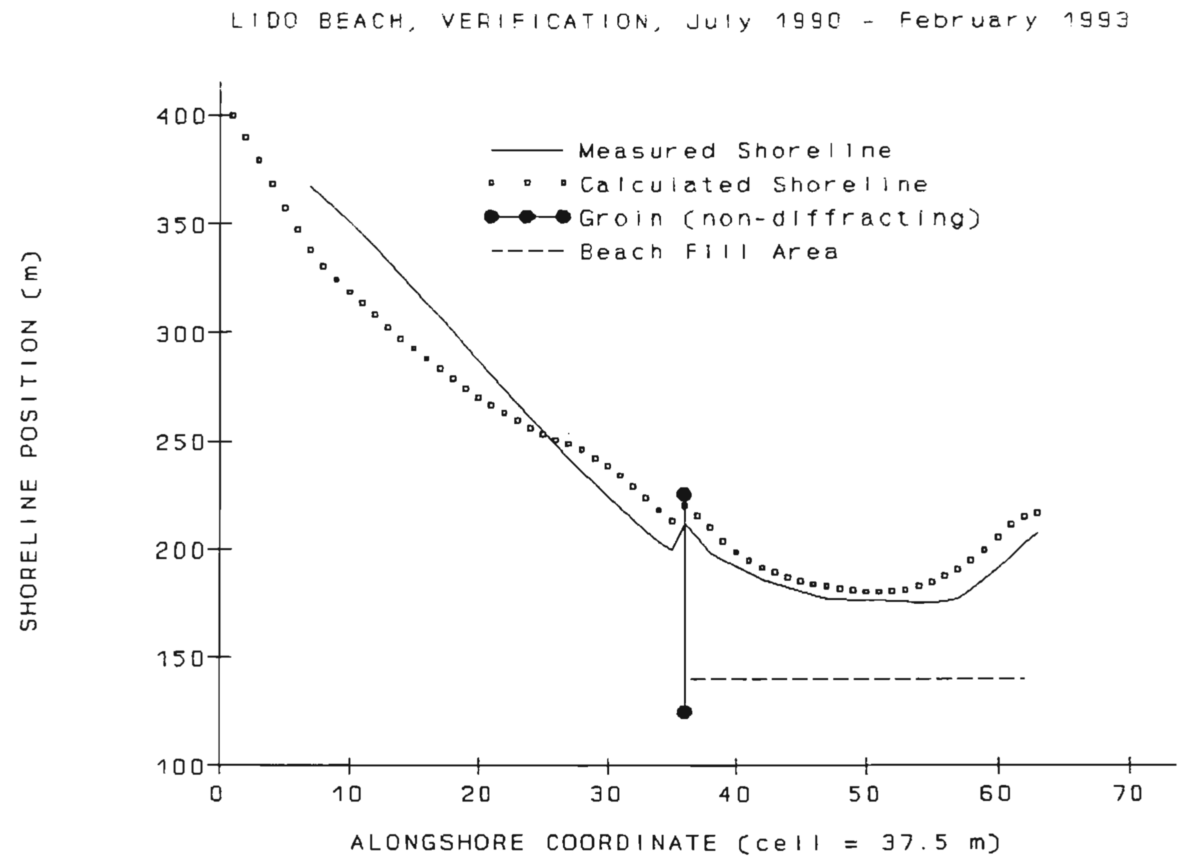

Figure 8 Model verification.

with the groin eliminated. Figure 9 shows the results. The comparison made is between a calculated shoreline position without a groin and a "reference" position which is the measured shoreline from Figure 8. The model predicts that over the same time period the fill area would retreat further landward by 5 to 10 m if the groin were not present.

This recession may not seem to be significant if viewed spatially, but it is very significant if we put it into the context of time. From Figure 2 and the associated discussion, this is exactly the amount of additional shoreline retreat that occurred within the two years over which the planned 1988 fill cycle was delayed. Therefore, the functioning of the groin can be thought of as equivalent to two years' reduction in fill loss from the area. Because the period analyzed was from early 1985 to mid-1990, or about 5-1/2 years, this beneficial functioning translates to more than a 40 percent improvement in fill performance resulting from the groin's presence.

Figures 8 and 9 also show that this benefit is not without some adverse impact to the shoreline positions south of the groin. If we compare the calculated shoreline positions, the beach might be a similar 5 to 10 m wider over a length of approximately 400 m without the groin. In contrast to the groin's effect on the fill section, however, this down-drift signature seems to be less variable over time. The surveys show that the shoreline position in this signature area changed by less than 2 or 3 m during the two year delay in dredging.

A possible explanation for this apparent equilibrium was suggested by comparing several aerial photographs. A bypassing bar forms from the tip of the groin to toward the south, but not typically across the fill section. The bar may offer a degree of wave sheltering to the southern

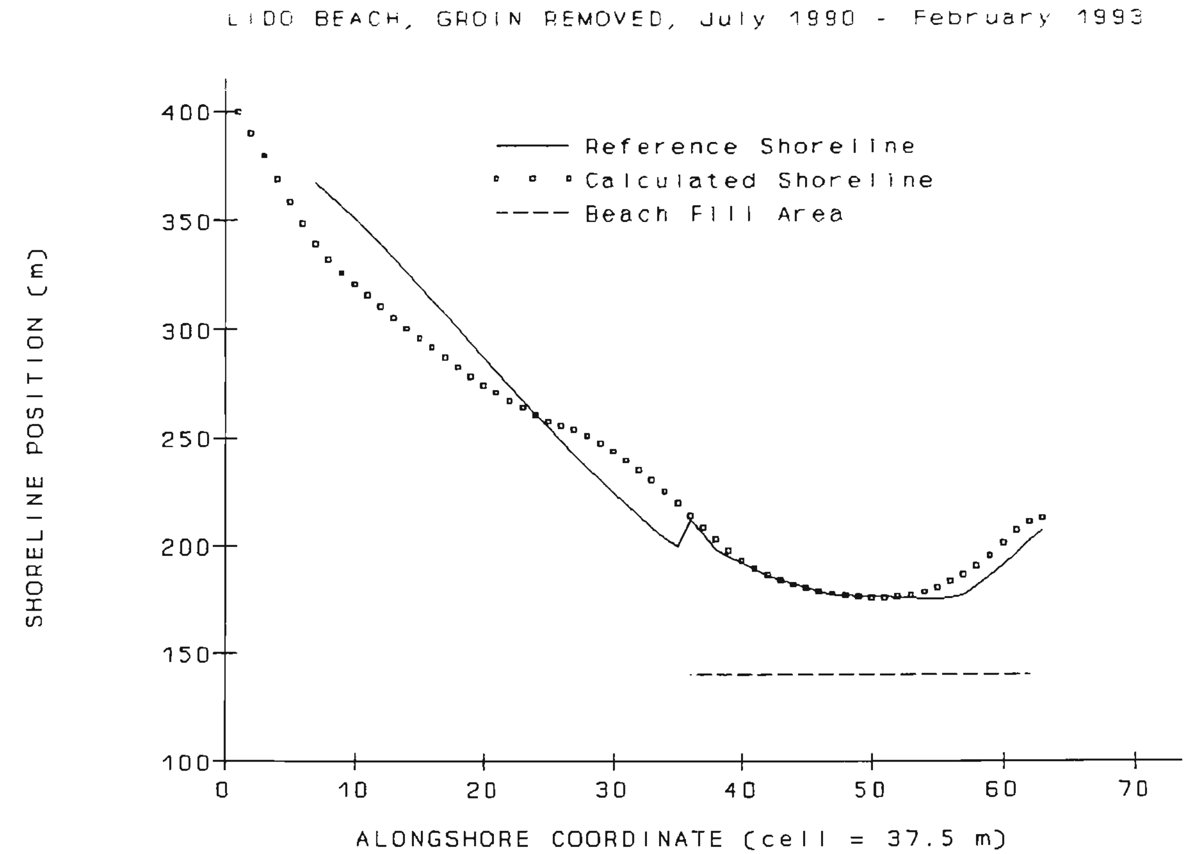

Figure 9. Calculated shoreline without groin.

beach but, because the bar does not re-connect to the shore, there is no direct nourishment to the area (except perhaps infrequent cross-shore movement). The relative differences on opposite sides of the groin could also result from the numerical effects of wave sequencing and/or the effective grain size or slope as discussed above.

The apparent benefit to the fill area from the presence of the groin led us to investigate the possible consequence of extending the structure seaward. Figure 10 shows a hypothetical groin which has an effective length of twice the original structure (approximately 25 m more), but with the same volume of fill placed. The calculated shoreline in the fill area ranges from 16 to 40 m further seaward than the reference over the same time. If viewed from the perspective of performance time, this configuration more than doubles the longevity of the fill under the same assumed conditions.

Predictably, the potential adverse effect of the extension also increases. The maximum signature recession increases by approximately 10 m for the longer groin and some degree of influence along the down-drift shoreline can be seen for 700 to 800 m compared with the previous distance of about 400 m. Because the impact is not directly proportional to the retained fill, some other factor must be influencing the downdrift beaches. The hypothesis of a bypassing bar influence still seems reasonable. However, the groin signature effects which did appear suggest that the bar's sheltering influence must be only partial. Some further adjustment of the specified groin permeability might influence this result and is another area of potential work.

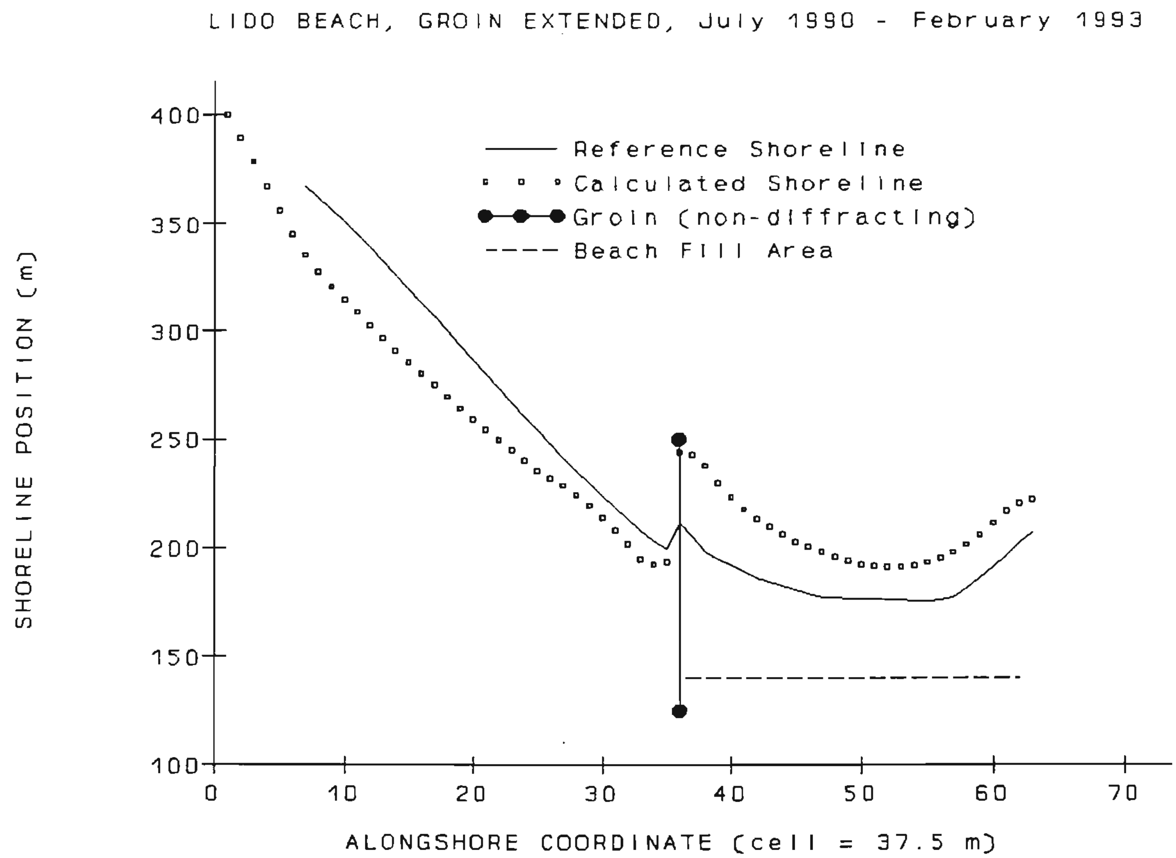

Figure 10. Calculated shoreline with an extended groin.

We concluded this portion of the project by modeling possible mitigation fills placed on the down-drift side of the groin. For example, Figure 11 shows the results of placing an extended fill section 30 m wide for a shoreline length of approximately 250 m south of the groin. This amount of additional fill is roughly equal to 15 percent of the overall volume typically placed on the public beach. Notice that based on the model calculations this volume exactly offsets the additional signature recession caused by doubling the effective length of the groin. The stabilizing benefits realized by the increased groin length remain the same (cf. Figure 10).

Results using comparative model simulations indicate that the existing groin does have a stabilizing influence over part of the fill length, although the typical life of the fill is still only 3 to 4 years. The apparent benefit from the groin can be phrased in terms of improving fill longevity by over 40 percent.

Increasing the effective length of the groin could further improve the fill performance (even doubling its life), but with an associated potential for increased down-drift shoreline recession. The magnitude of the downdrift impact is significantly less than the benefit produced. The model predicts that a volume of sand equal to approximately 15 percent of the total fill could be placed down-drift of the groin and offset the negative impacts of the groin extension without decreasing the benefits.

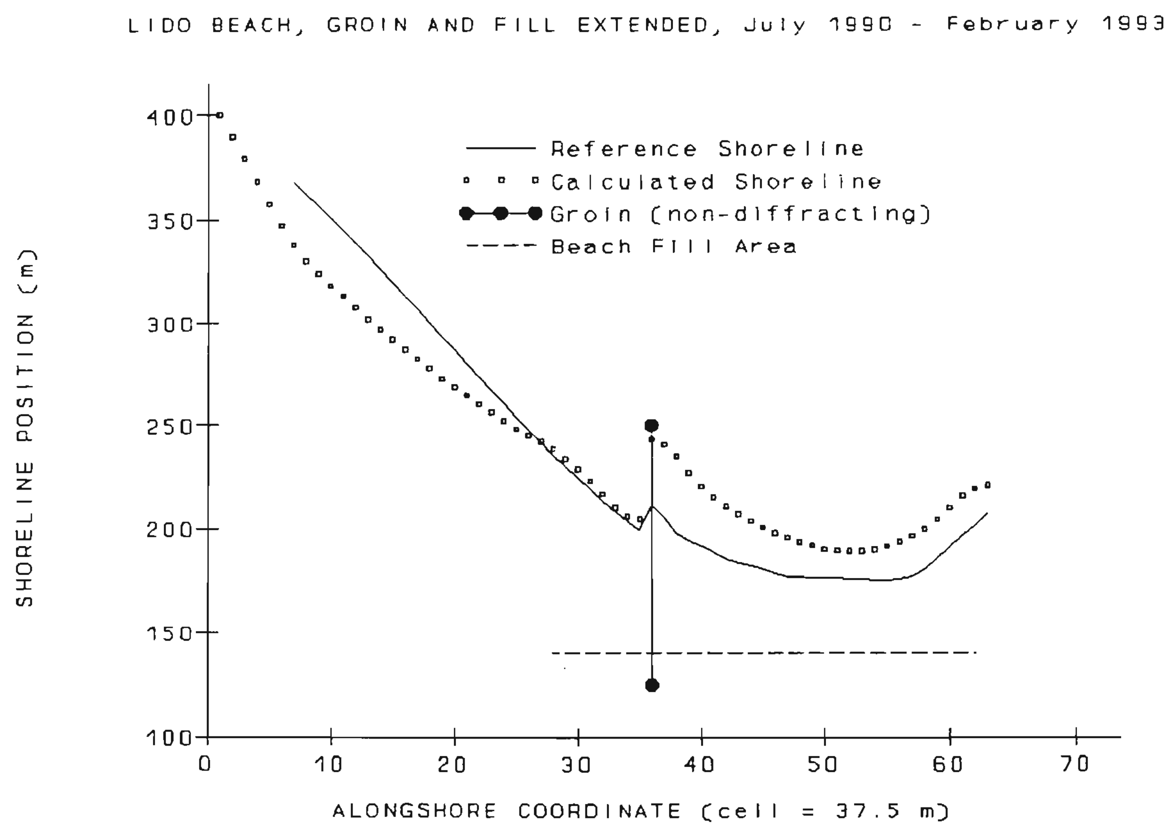

Figure 11. Calculated shoreline with groin and fill extended.

<u>Task 4 Conclusions</u>. The comparative analyses described above, when added to the calibration and verification process, represent approximately 100 individual GENESIS simulations. The following observations and recommendations are based on that experience.

As mentioned, substantial bypassing is evident around the groin on aerial photography. Losses also seem to occur from the other end of the fill (opposite the groin), suggesting that adjacent ebb shoal bathymetry is altering the incident wave energy to produce a situation more complex than a simple uni-directional transport system. We were unable to exactly duplicate this system using the model within the scope of this study, but results were obtained by focusing on the areas immediately adjacent to the groin.

Future analyses might investigate the effects of placing a second groin at the exposed end of the fill section. A directional wave gage is planned for installation in the area during 1993. Data from it could be used to look in greater detail at the effect of varying sequences of waves on the site. Grain size influences could also be further examined.

In addition to interim reports, the Beach Fill Module software, and this final project report, a conference paper describing the technical results was prepared for Coastal Zone '93.

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