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Coastal and Hydraulics Laboratory

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Coastal Inlets Research Program

Analysis of Dredged Material Placement Alternatives for Bottleneck Removal, Matagorda Ship Channel, Texas

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Final report

Prepared for U.S. Army Engineer District, Galveston
2000 Fort Point Road
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Abstract: The entrance of the Matagorda Ship Channel, connects the Gulf of Mexico to Matagorda Bay, Texas. In the landcut, the channel narrows from 2,000 ft to 950 ft (referred to as the bottleneck), greatly focusing the flow and increasing the current velocity in this area and on the Matagorda Bay side causing difficulties in navigation. A successful solution would be removal of the bottleneck to decrease current magnitudes while not compromising operation and maintenance of the Gulf Intracoastal Waterway, nor stability of the adjacent natural inlet, Pass Cavallo. Building upon previous studies and in consultation with the sponsor, a jetty configuration alternative that included removing the bottleneck was evaluated with a combined wave, sediment, and hydrodynamic numerical model that was first validated to the existing condition. Alternatives for placing the material removed from the bottleneck on Sundown Island and/or adjacent beaches in varying combinations were considered with the model for their effects on current magnitudes and sedimentation patterns. The alternatives including shoreline placement were evaluated with a long term shoreline response model. The interaction between the entrance and Pass Cavallo, the natural inlet to Matagorda Bay located southwest of the Matagorda Ship Channel entrance, was also examined in a regional approach.

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Preface

This study was conducted for the USACE Galveston District. The technical monitor was Jose D. Castro-Rivera. The Planning Lead was Cheryl Jaynes and the Project Manager was John Otis.

This report documents a study performed to examine placement alternatives for material removed from the entrance to the Matagorda Ship Channel, which connects the Gulf of Mexico to Matagorda Bay, Calhoun County, Texas.

This study concerned application of models and interface developed under the Coastal Inlets Research Program (CIRP) administered by Headquarters, U.S. Army Corps of Engineers (USACE). The mission of CIRP is to conduct applied research to improve USACE capabilities to manage federally maintained inlets, which are present on all coasts of the United States, including the Atlantic Ocean, Gulf of Mexico, Pacific Ocean, Great Lakes, and U.S. territories. CIRP objectives are to advance knowledge and provide quantitative predictive tools to (a) make management of federal coastal inlet navigation projects, principally the design, maintenance, and operation of channels and jetties, more effective and reduce the cost of dredging; and (b) preserve the adjacent beaches and estuary in a systems approach that treats the inlet, beaches, and estuary as sediment-sharing components. To achieve these objectives, CIRP is organized in work units conducting research and development in hydrodynamics; sediment transport and morphology change modeling; navigation channels and adjacent beaches; navigation channels and estuaries; inlet structures and scour; laboratory and field investigations; and technology transfer.

The CIRP is administered at the U.S. Army Engineer Research and Development Center (ERDC), Coastal and Hydraulics Laboratory (CHL) under the Navigation Systems Program for Headquarters, U.S. Army Corps of Engineers (HQUSACE). James E. Walker is HQUSACE Navigation Business Line Manager overseeing CIRP. Dr. Julie D. Rosati, CEERD-HF-CI, (ERDC-CHL), is the CIRP Program Manager.

The work was performed by the Coastal Engineering Branch (HN-C) of the Navigation Division (HN), U.S. Army Engineer Research and

Development Center – Coastal and Hydraulics Laboratory (ERDC-CHL). At the time of publication, Dr. Jeffery Waters was Chief, CEERD-HN-C; Dr. Rose M. Kress was Chief, CEERD-HN; and Jeffery Lillycrop was the Technical Director for Navigation. The Deputy Director of ERDC-CHL was Jose Sanchez and the Director was Dr. William D. Martin.

COL Kevin J. Wilson was the Commander and Executive Director of ERDC, and Dr. Jeffery P. Holland was the Director.

Unit Conversion Factors

Multiply	By	To Obtain
cubic yards	0.7645549	cubic meters
feet	0.3048	meters
miles (U.S. statute)	1,609.347	meters
tons (2,000 pounds, mass)	907.1847	kilograms

1 Background

MSC deep draft channel

The Matagorda Ship Channel (MSC) is a deep-draft channel located on the central Texas coast (Figure 1) and connects the Gulf of Mexico and the Port of Port Lavaca-Point Comfort. The MSC is about 25 miles long and passes through Matagorda Bay, where it intersects the Gulf Intracoastal Waterway (GIWW). The MSC Entrance (MSCE) cuts through the Matagorda Peninsula (Figure 2) for approximately 1 mile. The distance between the jetties on the Gulf of Mexico side is 2,000 ft. In the landcut, however, the channel narrows to 950 ft (referred to as the bottleneck), greatly focusing the flow and increasing the current velocity in this area and on the Matagorda Bay side.

Figure 1. Matagorda Ship Channel, located on the central Texas coast.

Figure 2. Detailed view of Matagorda Ship Channel Entrance and surroundings.

The Matagorda Ship Channel (MSC) averages under 11 million (M) tons of cargo annually (2005-2008; source, Waterborne Commerce Statistics Center –– WCSC (http://www.iwr.usace.army.mil/ndc/wcsc/pdf/wcusmvgc08.pdf). The majority of this cargo consists of imports of aluminum ore (average load 7 M tons), owing to the presence of a large ALCOA facility at Point Comfort. The MSC ranks first nationally for imports of aluminum ore, leading Corpus Christi, TX, as well as the entire Lower Mississippi River. Other commodities of note include imports of gasoline (average 700 K tons) and ammonia (average 450 K tons), and exports of sodium hydroxide (average 450 K tons). The MSCE typically sees about 700 deepdraft entrances and clearances or transits each year (WCSC). Ship pilots consider navigation of the MSCE to be dangerous because of strong along-channel and cross-channel currents, particularly on the bay side of the channel. In addition, the bottleneck provides limited space for maneuverability if vessels begin to turn sideways as a result of experiencing a cross-current on either the bay side or the Gulf of Mexico side of the entrance. A successful solution would be removal of the bottleneck to decrease current magnitudes while not compromising operation and maintenance of the GIWW (Kraus, et al. 2000), nor stability of the adjacent natural inlet, Pass Cavallo. Pass Cavallo is located in the southwest corner of the bay (Figure 2).

Pass Cavallo

Since the opening of the Matagorda Ship Channel in 1964, there has been concern that Pass Cavallo (see Figure 2) will close in response to reduced tidal current velocity that would be needed to keep the channel clear (USACE 1992). Conditions were last evaluated at Pass Cavallo in September of 2007 (Batten et al. 2007; Kraus and Batten 2008) in reports prepared for SWG. Those studies concluded that Pass Cavallo would reach a minimum width and cross-sectional volume and perhaps increase in those quantities after the ebb-tidal shoal had adjusted to the diminished tidal prism. However, recent anecdotal observations have raised concerns that inlet width was continuing to decrease. To examine changes in the geomorphic condition of Pass Cavallo, TX, this study updates the analysis of Pass Cavallo width by analyzing aerial photographs for the period of September 2007 to August 2010. Inlet conditions were evaluated from aerial photographs taken in March and August 2010 and compared to previous observations.

Pass Cavallo is a natural inlet connecting the Gulf of Mexico to Matagorda Bay on the central Texas coast. Pass Cavallo was the historic inlet serving Matagorda Bay. To address the need for improved and more reliable access to local ports, the Matagorda Ship Channel (MSC) was constructed between 1963 and 1964. Due to the more efficient tidal hydraulics in being centrally located in the bay, the MSC captured the majority of the tidal prism from Pass Cavallo. In response, Pass Cavallo experienced extensive shoaling and intrusion by growth of barrier spits from both Matagorda Peninsula to the east and Matagorda Island to the west, which decreased the inlet width by about 9,500 ft between 1964 and 1995. Previous observations indicated that MSC and Pass Cavallo achieved an equilibrium condition by 1995 and subsequently, inlet width at Pass Cavallo was observed to gradually widen. Inlet width has shown seasonal fluctuations, where the inlet tends to be slightly wider in the winter.

Changes in the inlet width at Pass Cavallo were previously categorized into three temporal epochs based on geomorphic behavior (Batten et al. 2007; Kraus and Batten. 2008):

- Era 1, prior to 1963: relative stability.
- Era 2, 1963-1995: rapid decrease in inlet width.
- Era 3, subsequent to 1995: relative stability and minor increase in width.

Using identical analysis methods, this study updates the inlet width analysis of Batten et al. (2007) and Kraus and Batten (2008) to 2010. Figure 3 shows the changes in inlet width from 1840 to present, while Figure 4 indicates that the inlet width remains stable or slightly increases during Era 3 (1995-2010). Matagorda Peninsula spit growth is shown in Figure 5, and Matagorda Island spit growth is represented in Figure 6. Figure 7 depicts the shoreline position from February 1995 to August 2010, with the August 2010 aerial photograph as reference. Recession of the Matagorda Peninsula spit can be observed in the aerial photo, while minor growth occurred for the Matagorda Island spit.

Alternatives for dredge material placements

A successful alternative for removal of the bottleneck encompasses beneficial use of the material dredged. Core borings in the area indicate that bottleneck removal will result in a good source of available clean fine sand that could be placed beneficially. The dredged material placement sites listed in Table 1 were identified by the SWG Project Delivery Team (PDT) and are taken from the Project Management Plan (PMP), where the notation is PA for Placement Area and ODMDS for Ocean Dredged

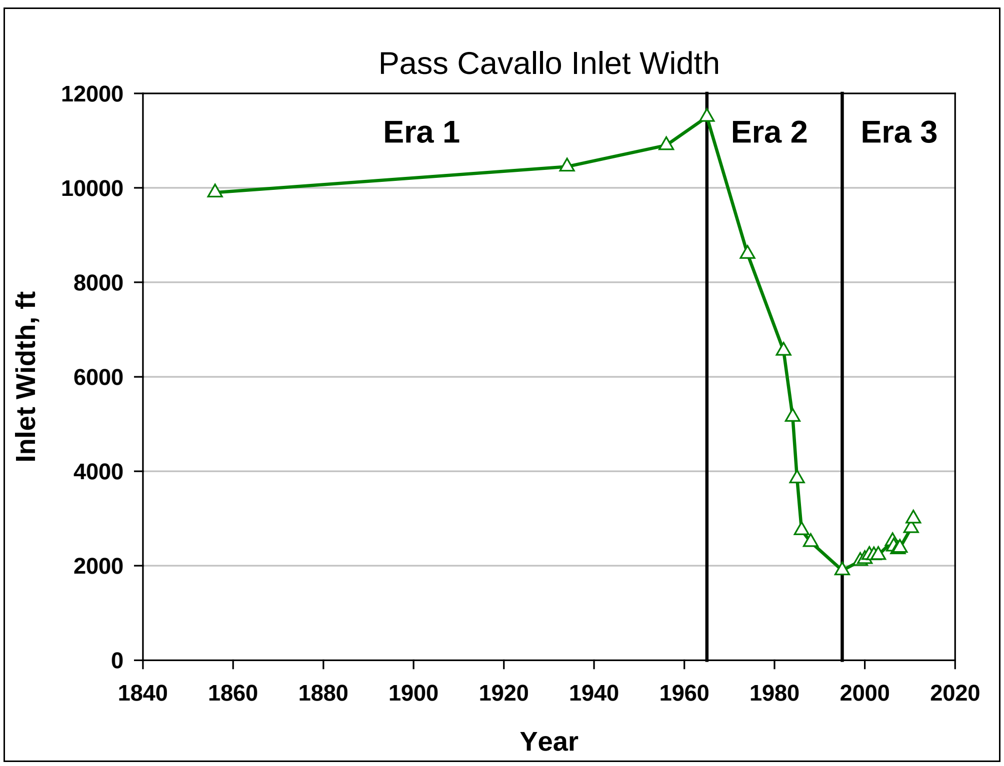

Figure 3. Historical inlet width at Pass Cavallo.

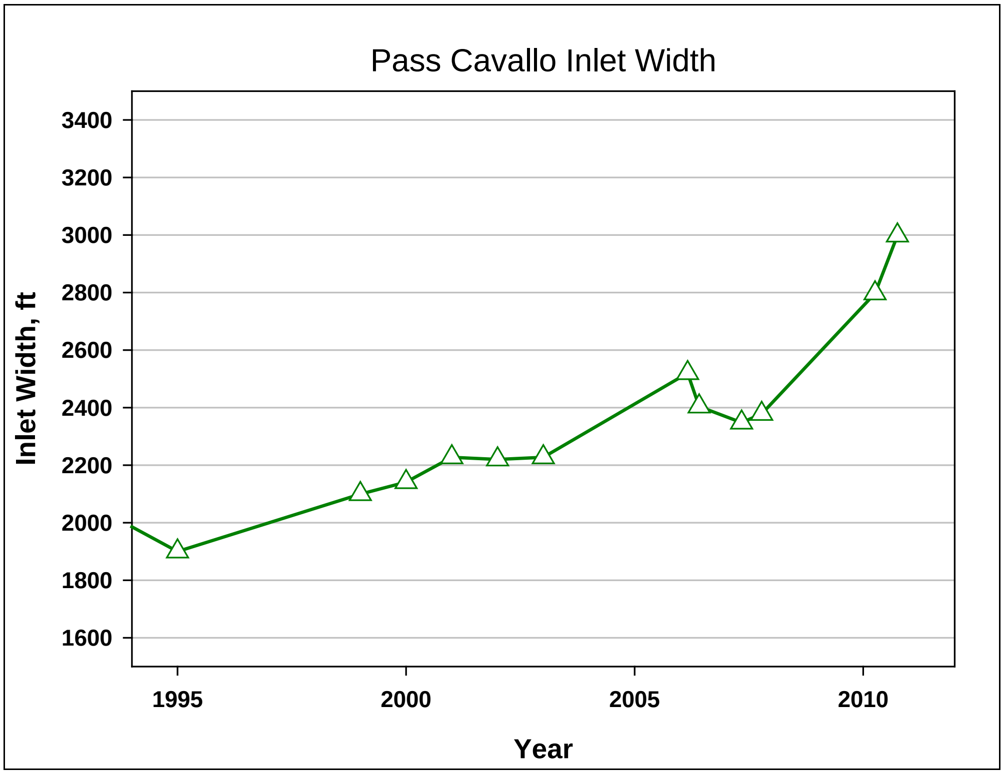

Figure 4. Inlet width change, 1995 to 2010.

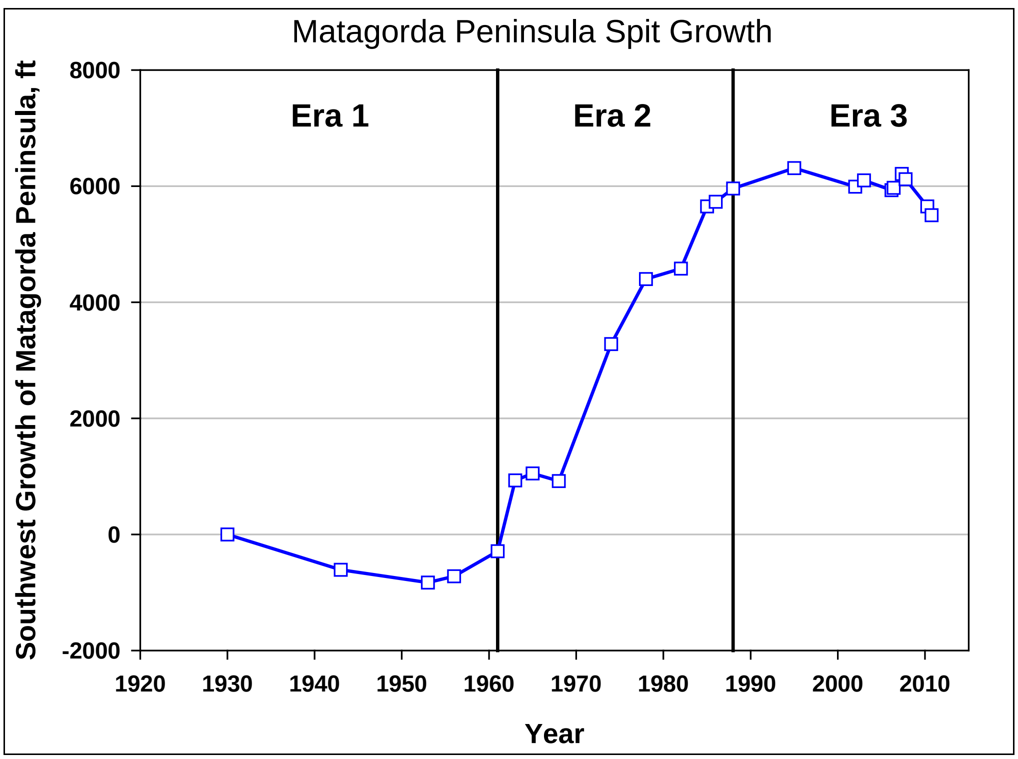

Figure 5. Summary of Matagorda Peninsula spit length, 1930-2010.

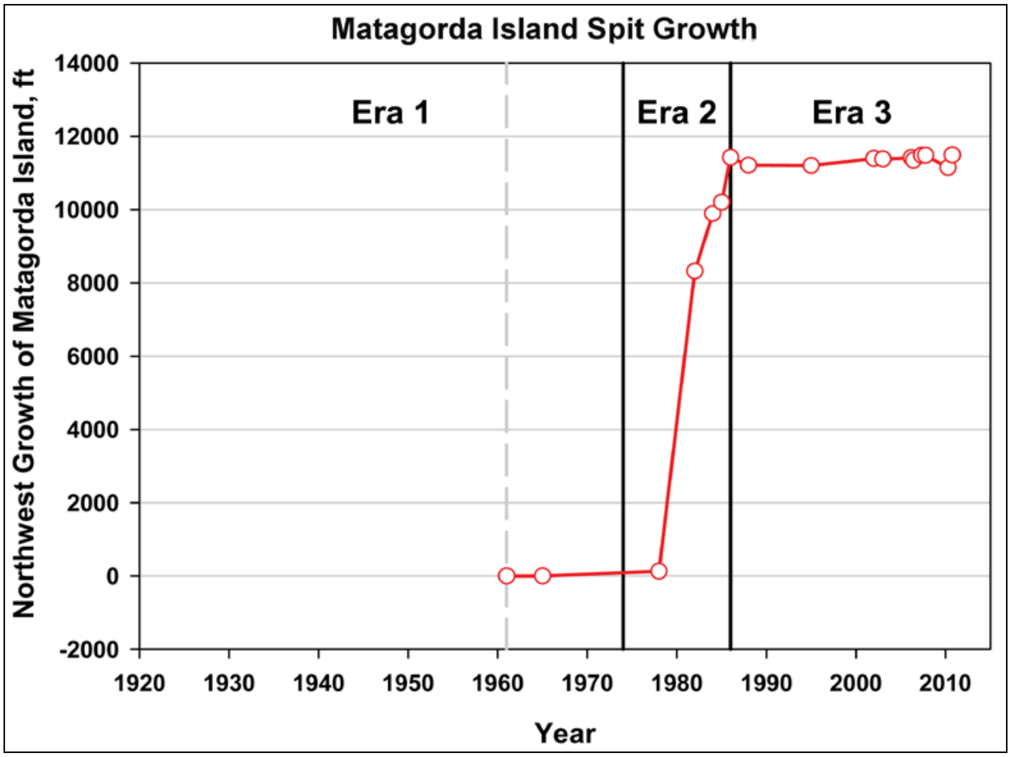

Figure 6. Summary of Matagorda Island spit length, 1960-2010.

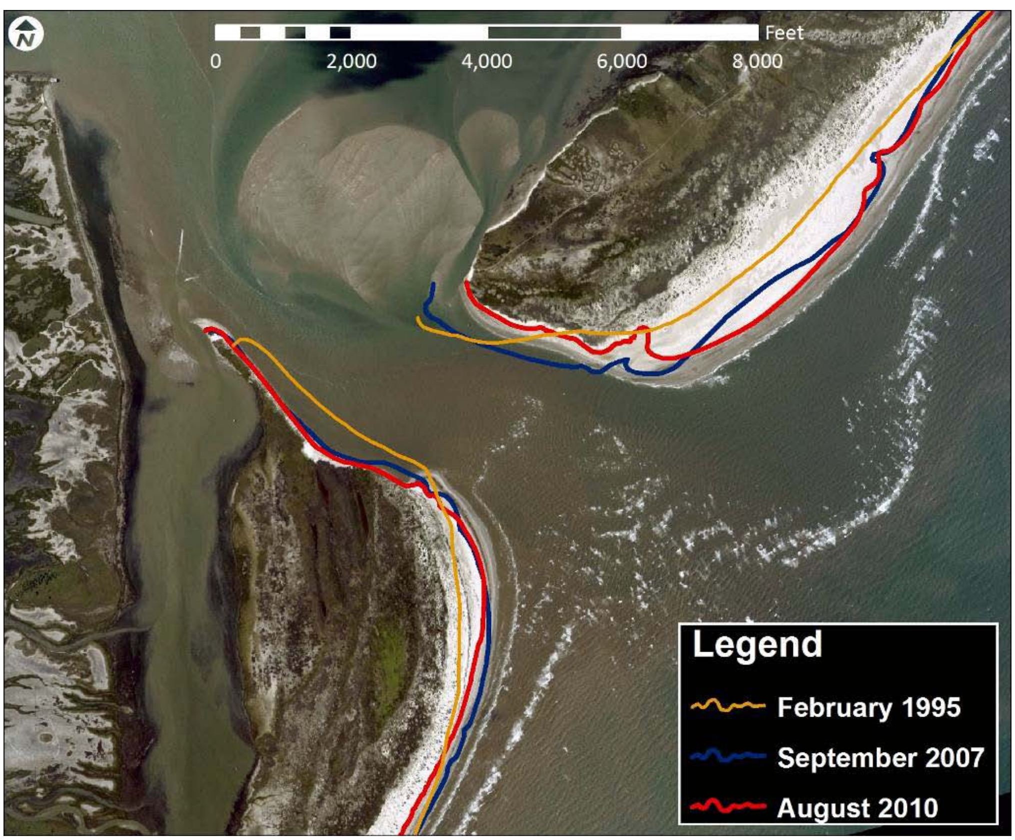

Figure 7. Shoreline positions in the inlet for 1995, 2007, and 2010, and August 2010 aerial.

Table 1. Potential dredged material disposal sites (modified from PMP; see Figure 8).

PA 1	Located offshore on the south side of the channel. Used for placement of material during the original construction of the jettied entrance channel.
ODMDS2	Located offshore south of the project area and PA 1, and designated for new-work dredged material.
PA 2	Located on the south.
PA 3	Sundown Island, a bird island created from the placement of dredged material; will be considered for expansion through beneficial-use placement.
Beach	Beach on the south side of Matagorda Peninsula and behind the south jetty; will be considered for beneficial use placement.
PA-N	Located on Matagorda Peninsula on north side of the channel. This location was used for the placement of material during original construction of the jettied entrance channel.

Material Disposal Site (USACE 2010). Figure 8, taken from the PMP (its Figure 7) depicts the PA locations visually. A principal objective of this study was to assist SWG in estimating the performance (fate) of placed material for each alternative.

Figure 8. Placement area locations (from PMP, Figure 7).

2 Placement Alternatives

The SWG PDT devoted substantial time to developing and evaluating bottleneck-removal alternatives, both structural and non-structural, as documented in the PMP. This long list of alternatives and variations was reduced to the short list shown in Table 2, based on a variety of filtering criteria and considerations. The short list of alternatives is examined in this MFR for physical performances such as change in flow, increasing sediment shoaling in the navigation channel or the GIWW, and longevity. Table 2 follows the notation of the PMP, for which BD means bottleneck-dredging, summarized as "Construct new stone protection on both sides in line with existing jetties, remove existing stone protection from both north and south bottleneck and spurs, and dredge both banks back to the new stone protection" (PMP).

Table 2. Placement alternatives investigated in this study.

Alt	Description: Sundown Island, Beach Placement Volumes in Mcy
1	Existing condition, no action
2	BD: 2.65, 2.65
3	BD: 1.3, 4.0
4	BD: 0, 5.3
5	All material to ODMDS2 (not simulated in this report)

Approximately 5.3 Mcy of clean fine-medium sand will become available upon removal of the bottleneck. In discussion with the PDT, the alternatives listed in Table 2 were developed. For example, Alt 2 places 2.65 Mcy on Sundown Island and 2.65 Mcy on the beach south of the south jetty. Alts 2 and 3 would enlarge the perimeter of Sundown Island to approximately 12,000 and 9,900 ft, respectively. Beach placement has the potential for increasing the transport of sand to Pass Cavallo, the natural inlet to Matagorda Bay located approximately 6 miles to the south of the south jetty. Contributing significantly to the closure of Pass Cavallo is considered to be unacceptable. Other constraints were that enlargement of Sundown Island should not increase shoaling in the alternative route of the GIWW, that material placed on the beach should not re-enter the MSC, and that placement of dredged material should not be detrimental to existing vegetation and habitat.

3 Numerical Modeling of Circulation and Morphology Change

A comprehensive modeling suite, the Coastal Modeling System (CMS, http://cirp.usace.army.mil/products/index.html) that calculates waves, flow, sediment transport, and morphology change was applied in this study to evaluate with-project changes to waves and currents at the entrance to the inlet and morphology change at Sundown Island. One objective of the CMS modeling was to reveal any subtle unintended consequences of dredged material placement alternatives under the complex conditions of rapid tidal flow, wind-induced flow, and waves.

Calibration – Water level

The CMS was calibrated against data published in previous reports, and CMS computed and measured data comparisons are shown for water level (Figures 9-12). In Texas bays, wind in winter and seasonal highs and lows in Gulf of Mexico water levels can exceed changes in water level generated by astronomical tides. Therefore, previous studies examined representative summer and winter conditions (for which the most complete data were available). Seasonal highs occur around May and October, and seasonal lows occur around August and December-January. There is approximately about a 0.3 m (1 ft) difference between summer highs and winter lows. Tidal range is typically greater in summer than in winter.

Gulf of Mexico forcing was specified by data available from the National Oceanic and Atmospheric Administration (NOAA) water level gauge at the Galveston Pleasure (Flagship) Pier. This gauge includes water level as influenced by wind blowing over the gulf in its vicinity. Wind on the present project grid was specified by measurements at the Port O'Connor gauge. Figures 9-12 indicate a close correspondence between the water level measurements at Port Lavaca (close to the State Highway bridge) and at Port O'Connor. Main discrepancies occur during wind events, but even so, trends in the increase or decrease in bay water levels are maintained.

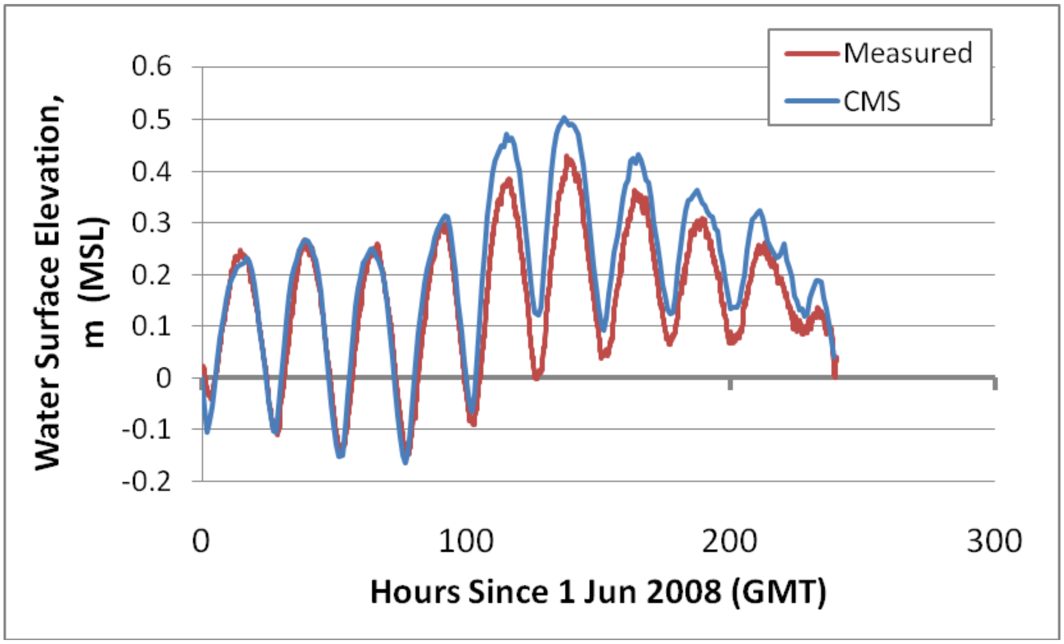

Figure 9. Port O'Connor summer water level comparison. Both the measured and CMS water levels are elevated after 100 hours (4 June 2008) because of a summer storm wind that elevated the bay water level.

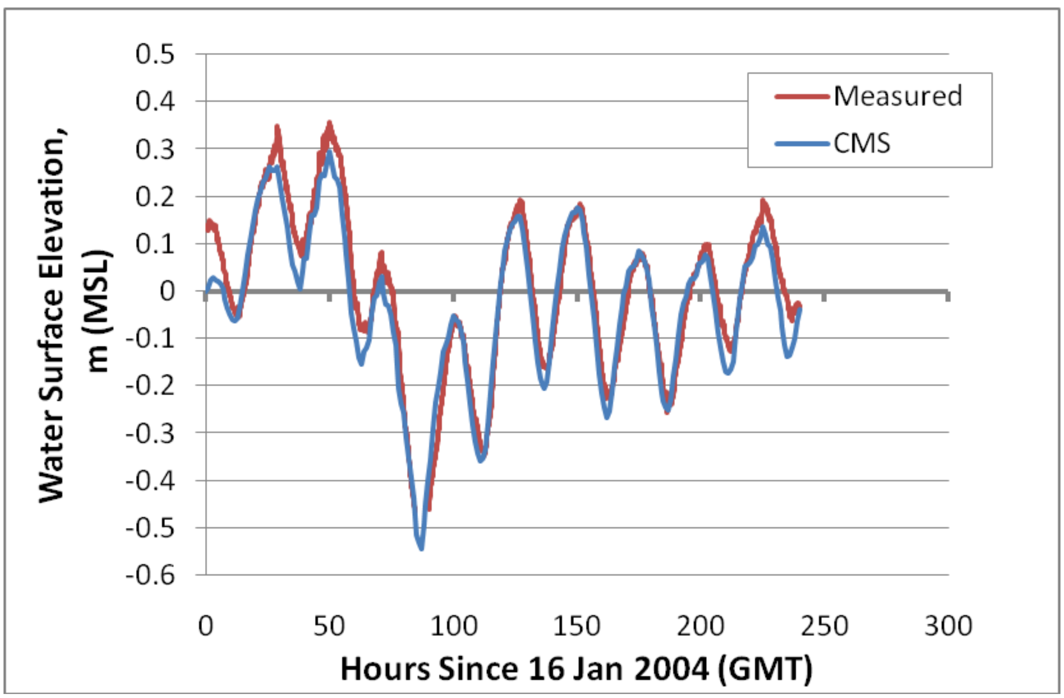

Figure 10. Port O'Connor, winter water level comparison. Note sharp decrease in water level around hour 80 caused by wind, which was well reproduced by the CMS.

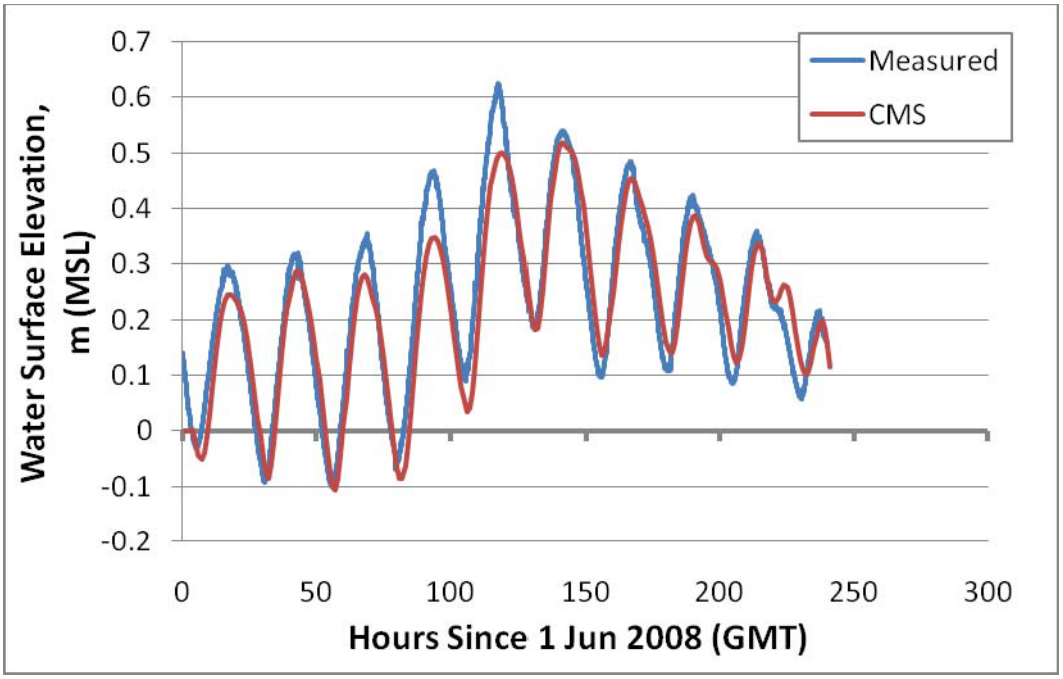

Figure 11. Port Lavaca, summer water level comparison. Mean of water level is high because of typical seasonal high in the summer.

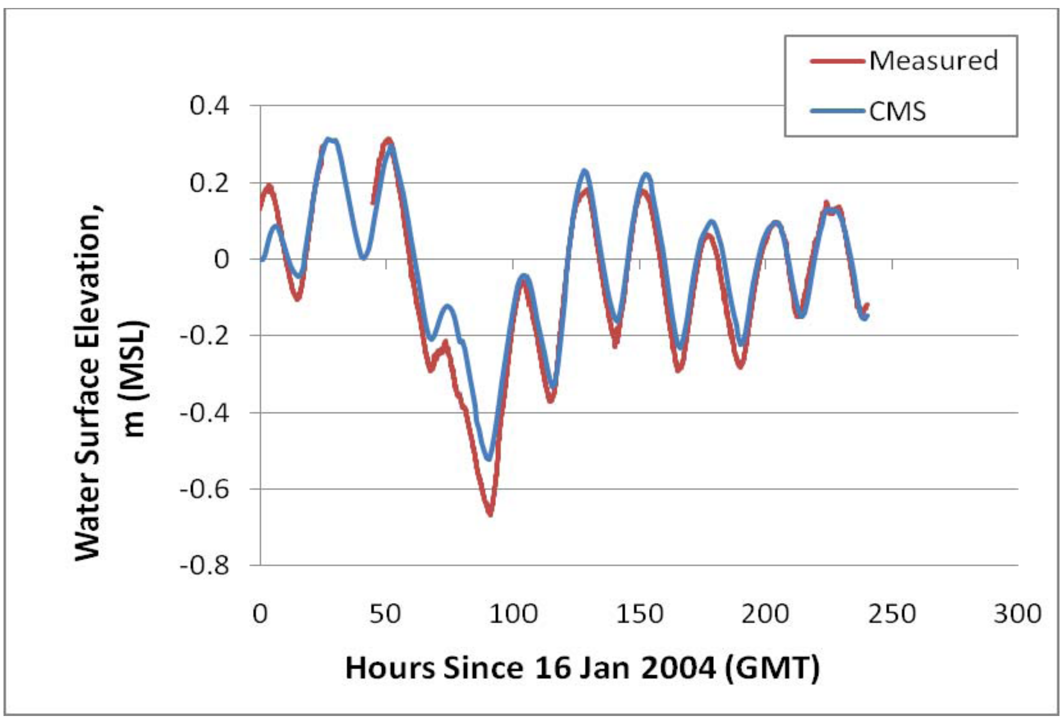

Figure 12. Port Lavaca, winter water level comparison.

Morphology change – Sundown Island

In this section, CMS results are presented for the alternatives listed in Table 2. Each alternative was run with wind, wave, and tidal forcing from two representative times, Jan 2004 and Jun 2008. Figures 13 through 20 depict the morphology change as calculated for a 1-month period for Sundown Island; warmer colors represent deposition and cooler colors represent erosion. The present island configuration is outlined with a solid black line and any additional placement to the island due to alternative design is represented with a dashed black line. Alternative 5 was not compared, because Alts 1 and 5 are the same concerning the configuration of Sundown Island.

In all alternatives and for each time period, there is an erosional pattern that is evident on the southwestern-most edge of the island. Also, for each alternative, deposition can be seen extending northward from the west and east side of the island. A similar pattern of these lobes has been observed in depth surveys of the island (Figure 21). During the summer month (June 2008), there is a noticeable increase in deposition in the eroded area between Sundown Island and the Matagorda Peninsula (eroded because of the strong tidal current there), as well as an increase in erosion on the Southwest corner of Sundown Island. This erosion pattern is one observation that gives weight to armoring the shoreline in this location.

With the simulation of various alternatives for this report, the placement of material resulted in an enlarged footprint of Sundown Island, and would cover existing vegetation. For Alt 2, the placement of 2.65 Mcy of material changed the perimeter of the island from approximately 9,300 to 12,000 ft. Likewise for Alt 3, 1.3 Mcy of material was placed onto Sundown Island, increasing the perimeter to approximately 9,900 ft. The remaining alternatives did not alter Sundown Island.

Longshore current generated by waves

For the two simulation periods chosen for the CMS morphology change comparisons, waves typically approached the Matagorda Peninsula and beach placement location nearly shore normal and would, therefore, produce little longshore current. To better understand the transport direction under oblique wave angles and examine possible unintended consequences, two additional simulations with the CMS were made, with constant wave directions from the northwest and southeast. For the purposes of these two CMS simulations, Alt 2 was selected to examine what would occur along the shoreline during oblique wave directions.

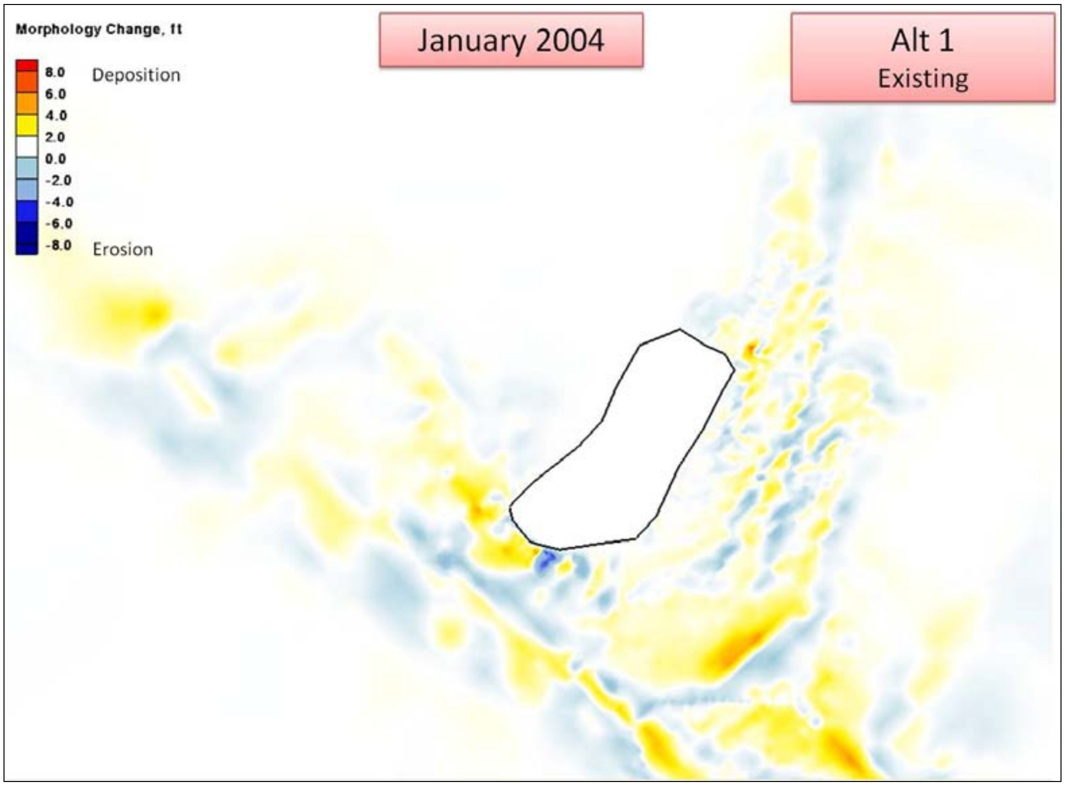

Figure 13. Morphology change for Alt 1 for the month of January 2004.

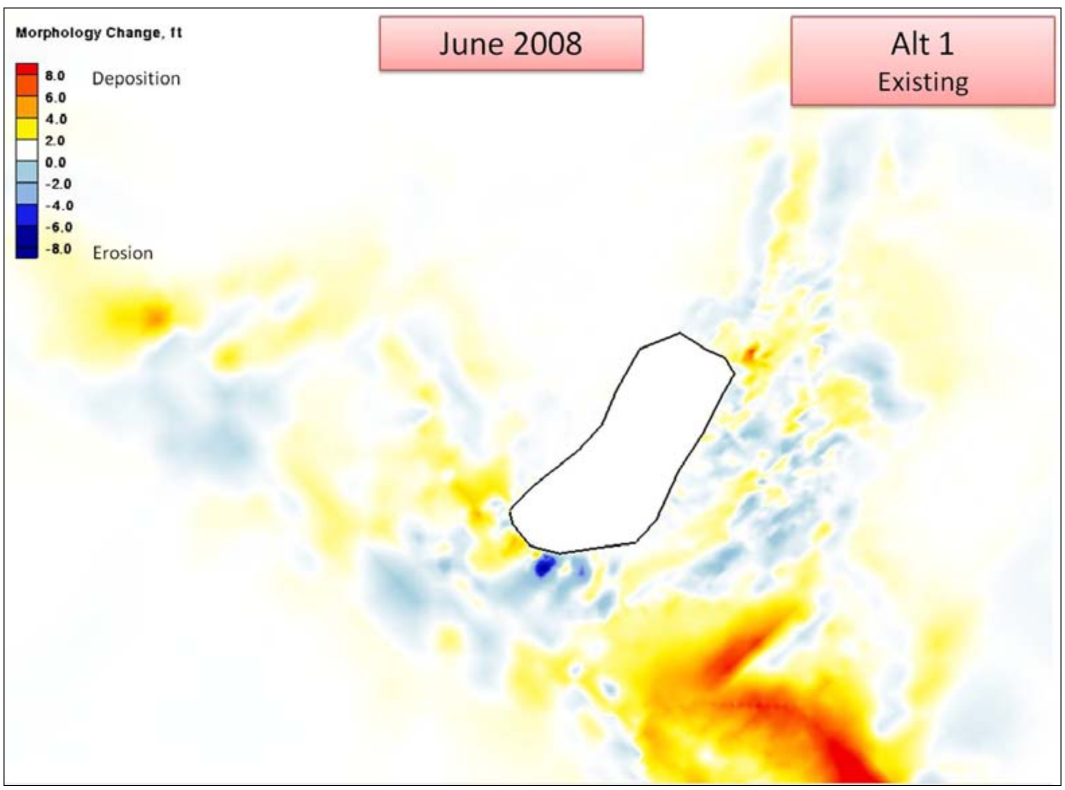

Figure 14. Morphology change for Alt 1 for the month of June 2008.

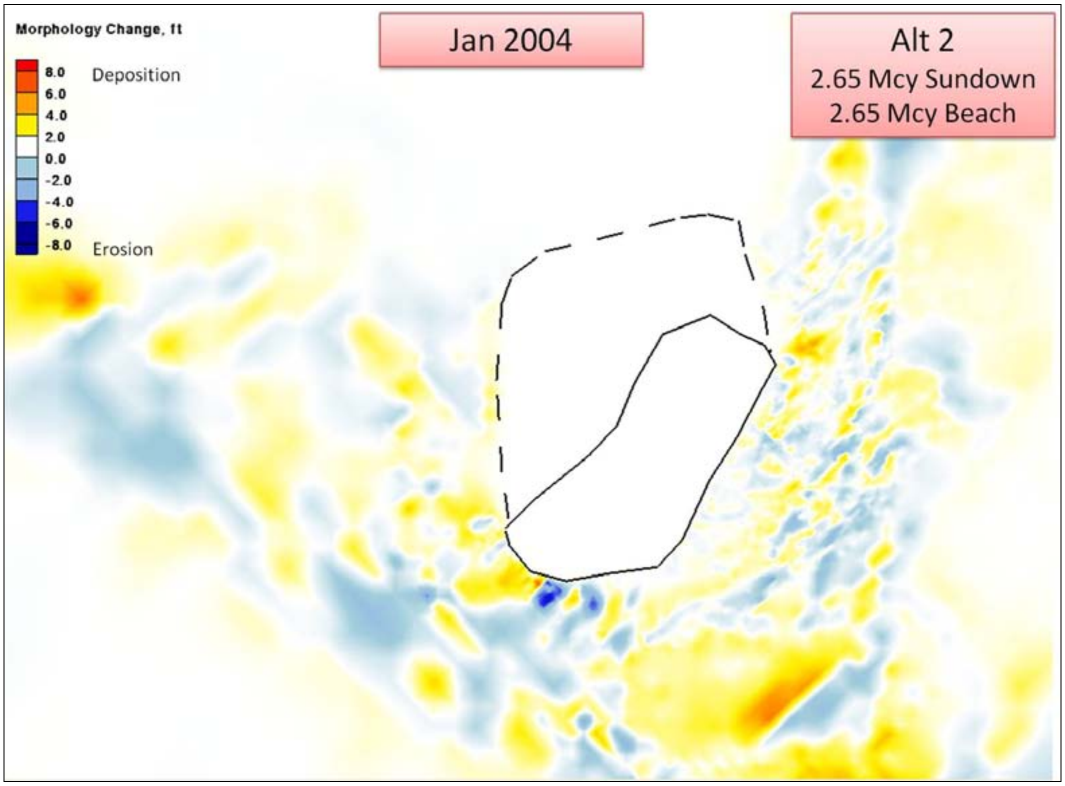

Figure 15. Morphology change for Alt 2 for the month of January 2004.

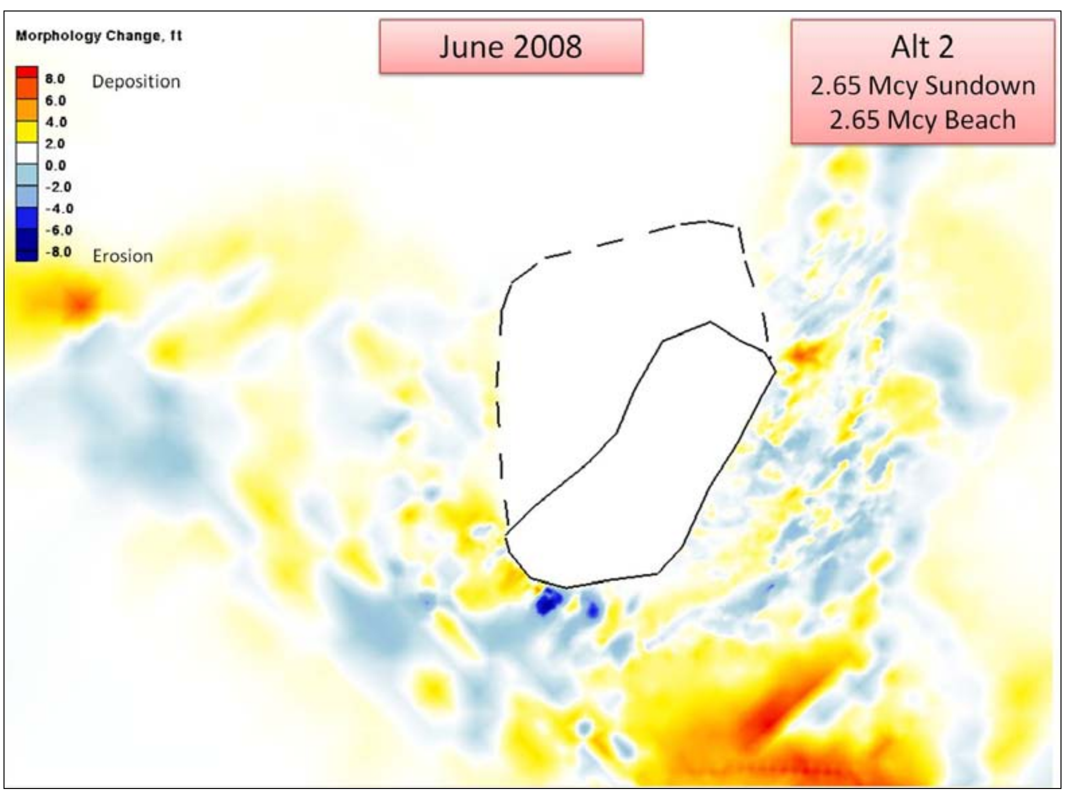

Figure 16. Morphology change for Alt 2 for the month of June 2008.

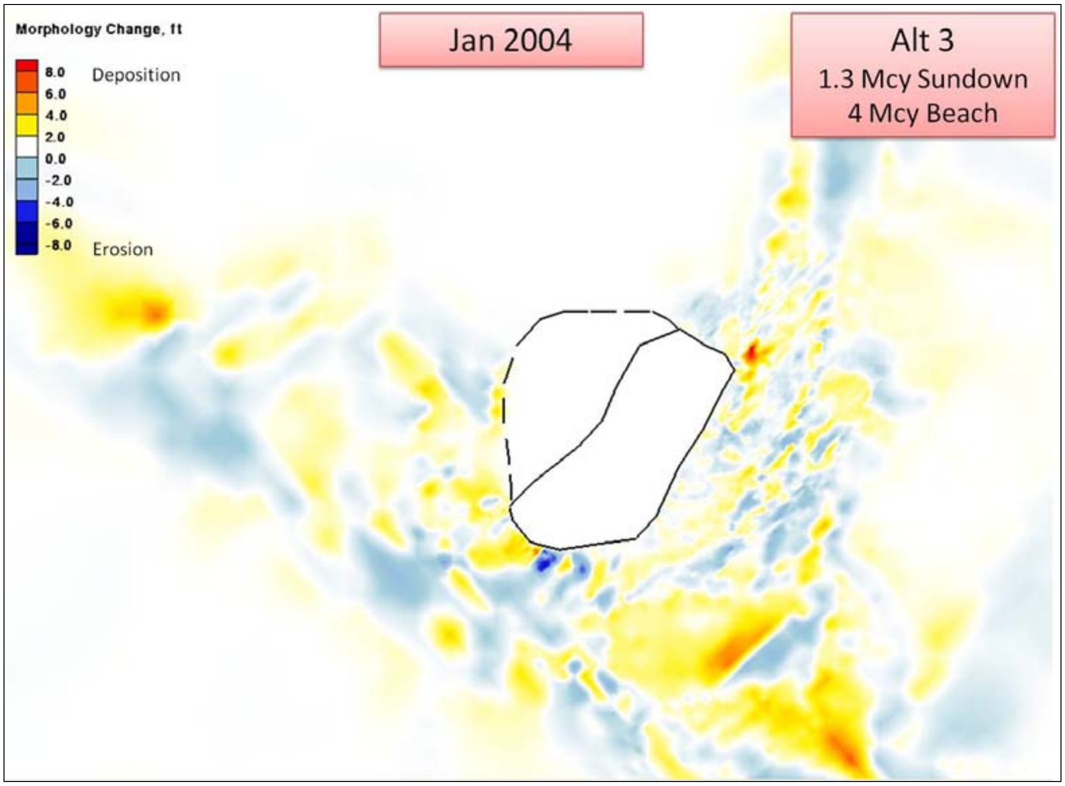

Figure 17. Morphology change for Alt 3 for the month of January 2004.

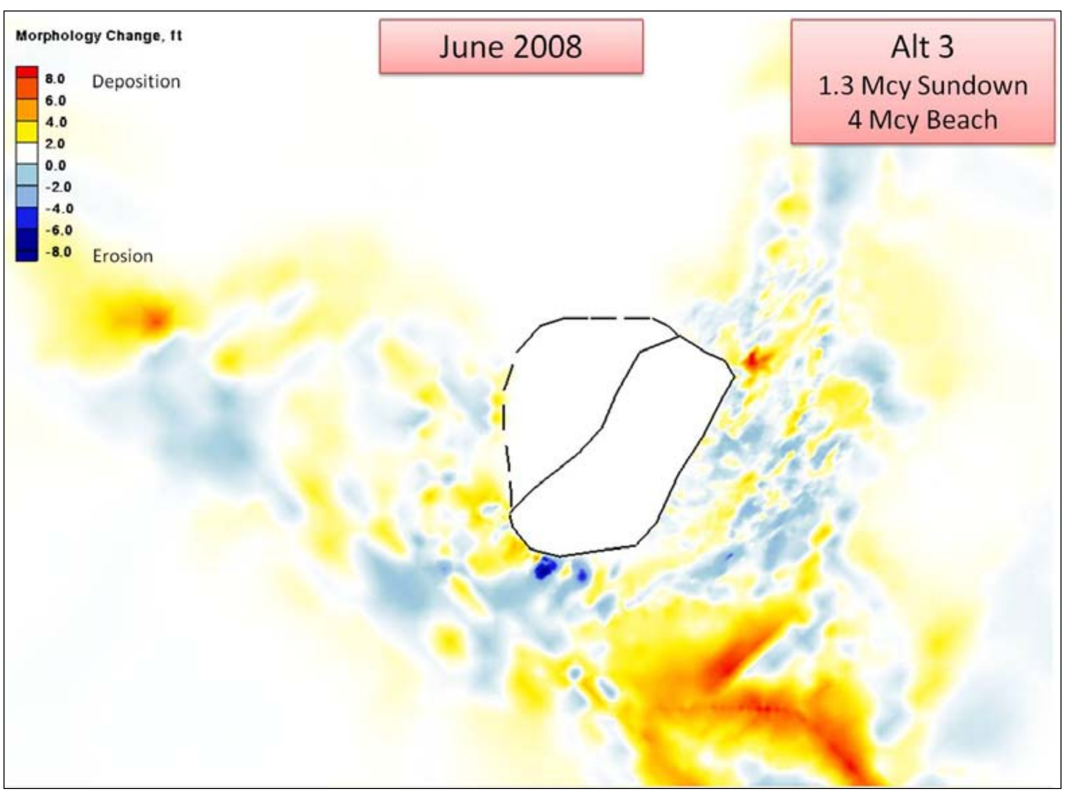

Figure 18. Morphology change for Alt 3 for the month of June 2008.

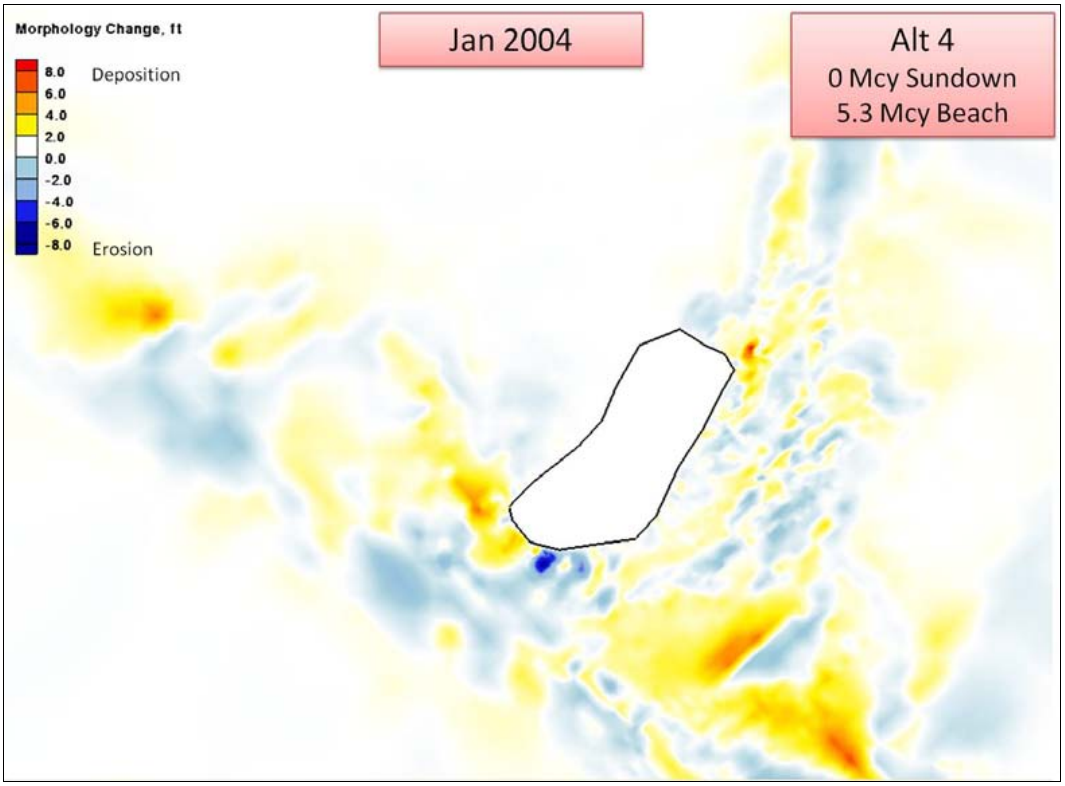

Figure 19. Morphology change for Alt 4 for the month of January 2004.

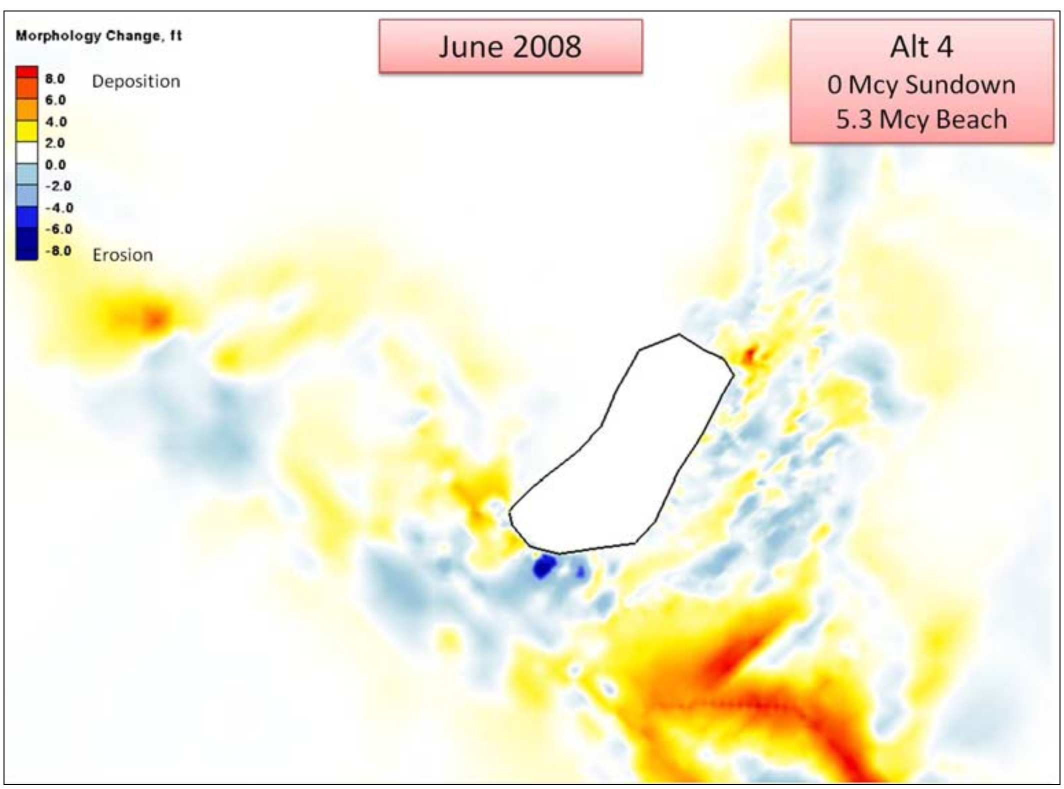

Figure 20. Morphology change for Alt 4 for the month of June 2008.

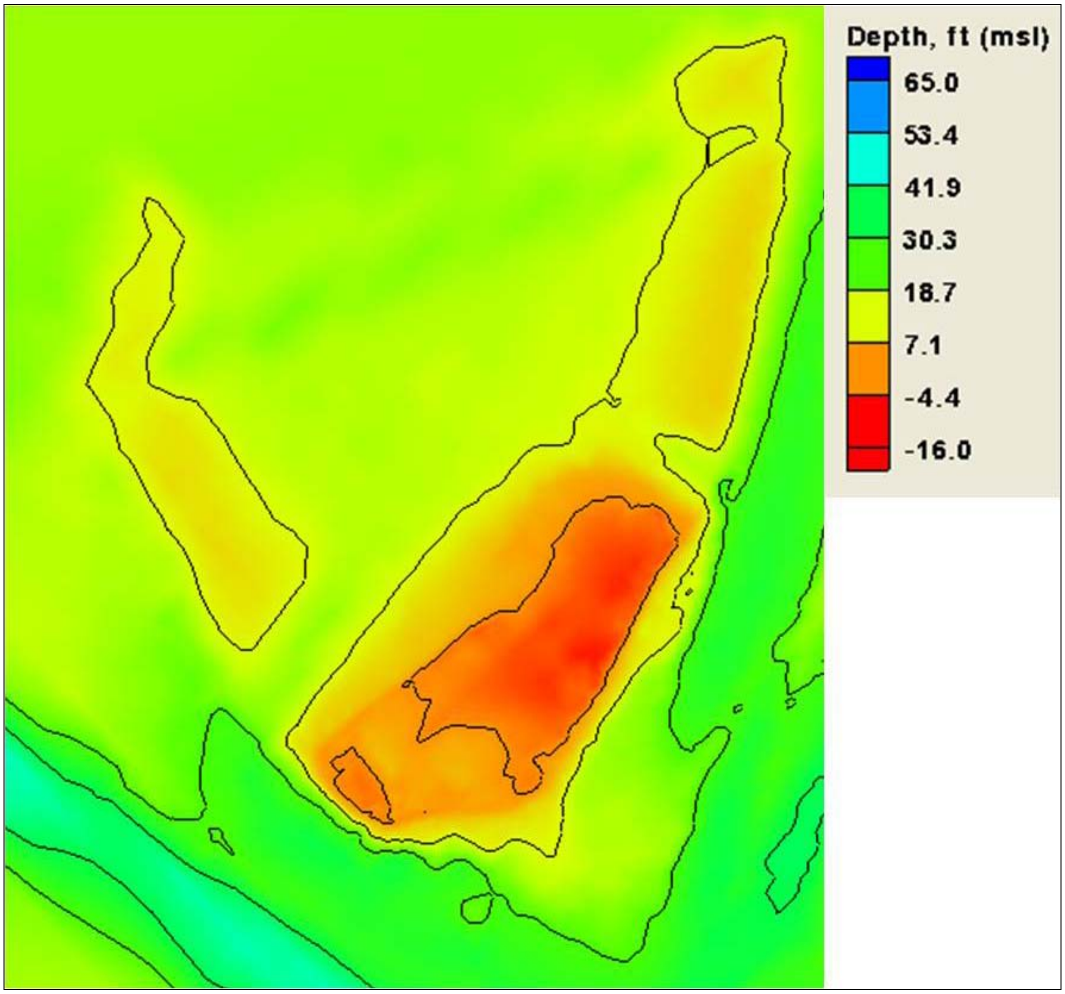

Figure 21. Bathymetry as obtained from survey data showing lobes extending from Sundown Island further into Matagorda Bay (and the GIWW).

The CMS was forced with a constant wave angle from the northeast (-40 deg from shore normal), resulting in a longshore current directed towards the south along the entire beach placement area and the main stretch of beach (Figure 22). This current would be the driving force for longshore sand transport, as calculated in the next section with the GenCade model. In analyzing CMS output with a constant wave angle from the southwest (40 deg from shore normal), a different pattern was observed. In that simulation, a longshore current developed along the beach placement area toward the south; however, along the main beach, a northerly longshore current developed (Figure 23).

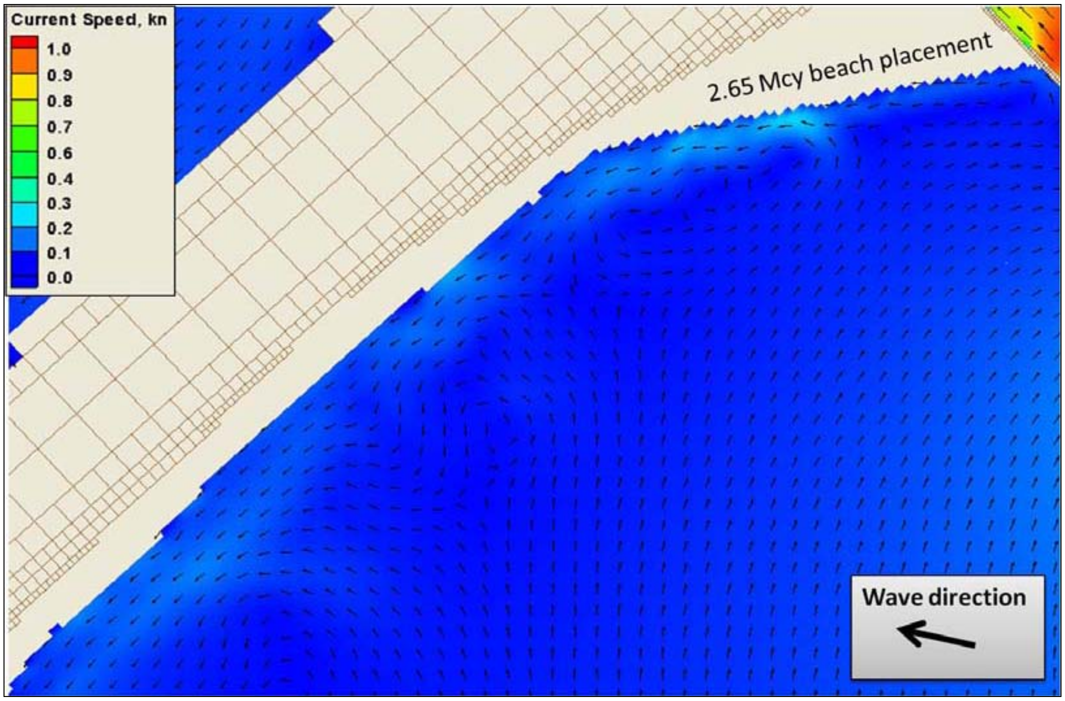

Figure 22. Current speed in knots as observed for the CMS simulation with constant waves incident from the southeast.

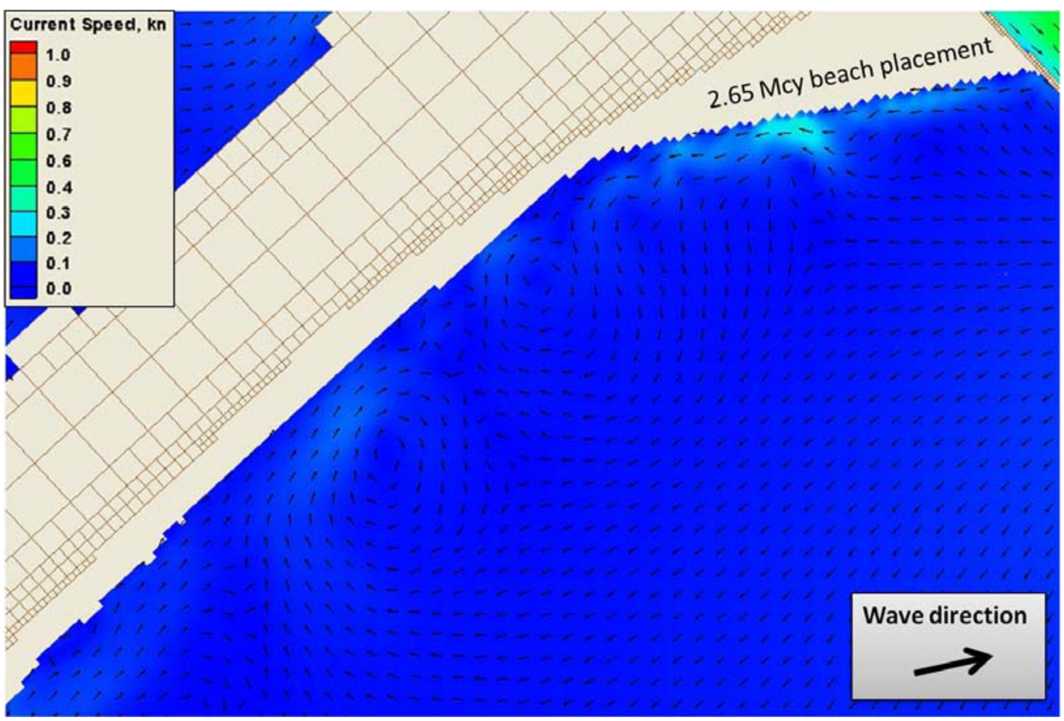

Figure 23. Current speed in knots as observed for the CMS simulation with constant waves incident from the southwest.

Velocity comparison

The summer 2008 condition was selected to compare alternatives because the tide range is greater than in the winter. Within the summer condition time period, maximum flood and ebb currents (occurred around 100 and 1100 hours, 3 Jun 2008 GMT) were selected for a tide cycle and consistently evaluated for all the alternatives. The maximum computed current along the channel axis was evaluated for each simulation, as well as a cross-channel current. The maximum cross-channel current was evaluated along a line (Figure 24) extending from the jetties toward Sundown Island. These results are summarized in Table 3.

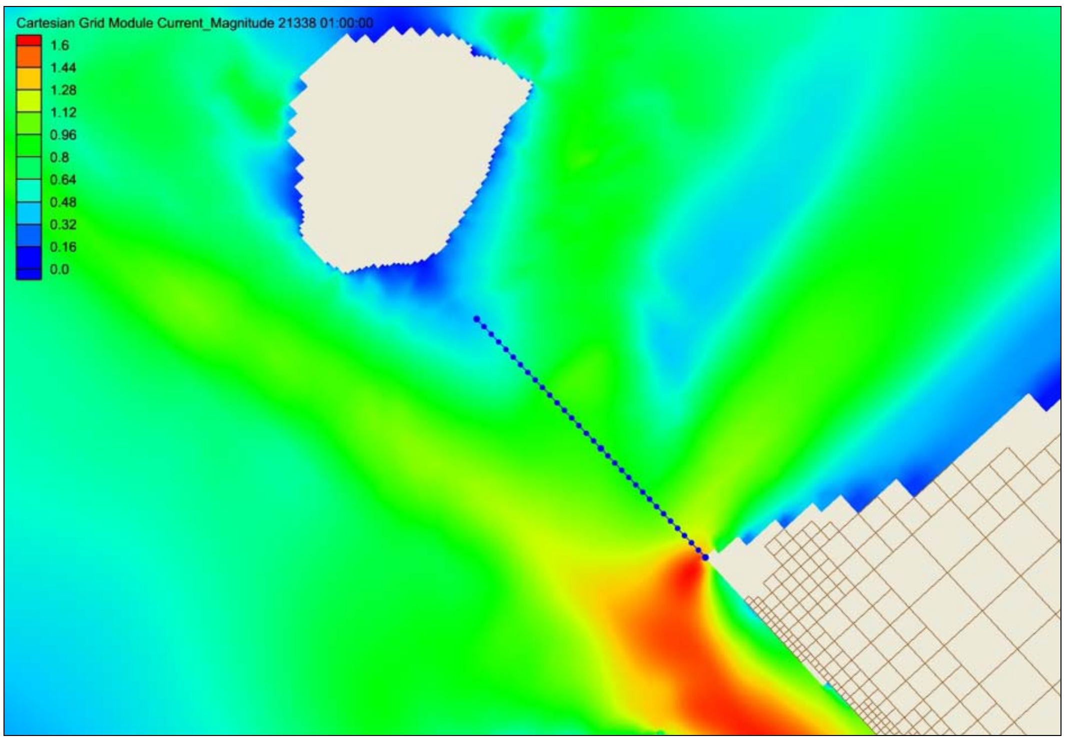

Figure 24. Line upon which the cross-current was determined.

Table 3. Velocity Comparison – Summer 2008 Condition, kt.

Alt	Max Flood Current (along channel)	Max Flood Cross Current	Max Ebb Current (along channel)	Max Ebb Cross Current
1	4.1	2.4	4.1	2.7
2	3.5	2.1	3.4	2.5
3	3.5	2.1	3.5	2.5
4	3.6	2.3	3.5	2.5

Consistent with previous work (Kraus, et.al. 2006), the bottleneck removal option results in significantly weaker along-channel current velocities within the inlet as compared to the existing condition (Alt 1). Also, the magnitudes of the cross current are reduced as compared to the existing condition.

Roving Acoustic Doppler Current Profile (ADCP) measurements were made through the MSC and near Sundown Island on 17 November, 2004. Figure 25 displays sample transects of ADCP data along one of the data-collection boat paths. The white arrows display the velocity and magnitude of the measurements, and the black arrows show the CMS calculations. The CMS computed with a time step of 15 min and a minimum grid size of 12.5 m. The ADCP measurement points are typically measured about 5 sec apart along the moving boat path. Both the CMS calculations and ADCP data are depth averaged. The ADCP data in Figures 25-27 were collected within +/- 15 min of the specified time (1730 GMT).

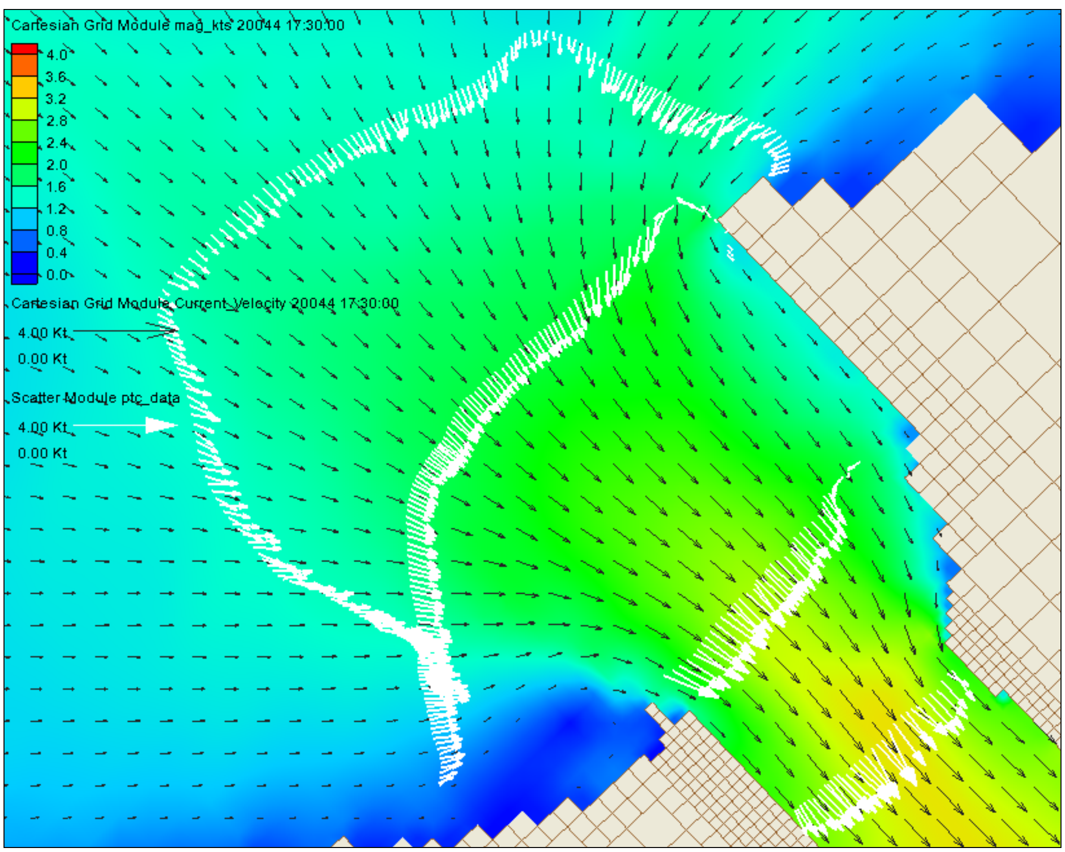

Figure 25. CMS calculated velocities (black arrows) compared with ADCP measured velocities (white arrows), 17 Nov 2004, 1730 GMT.

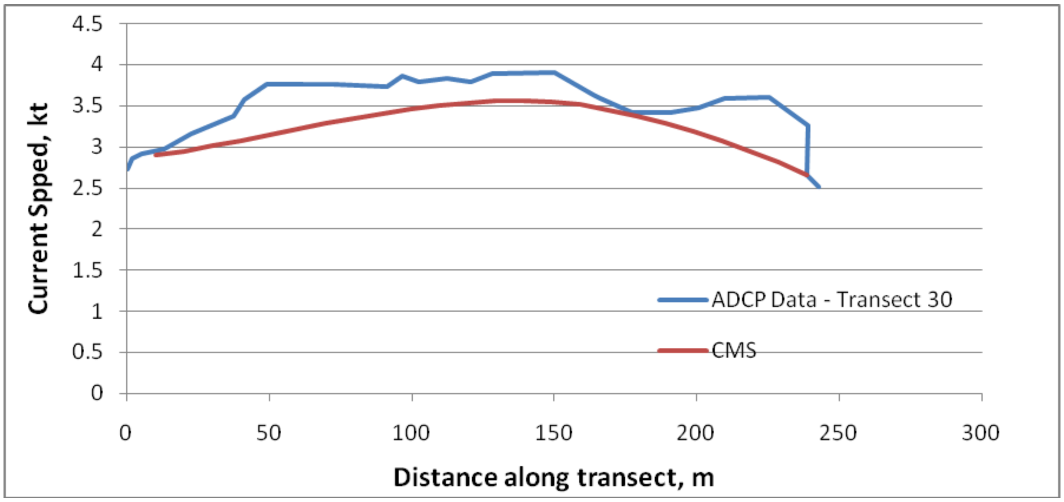

Figure 26. CMS – ADCP comparison along transect 30.

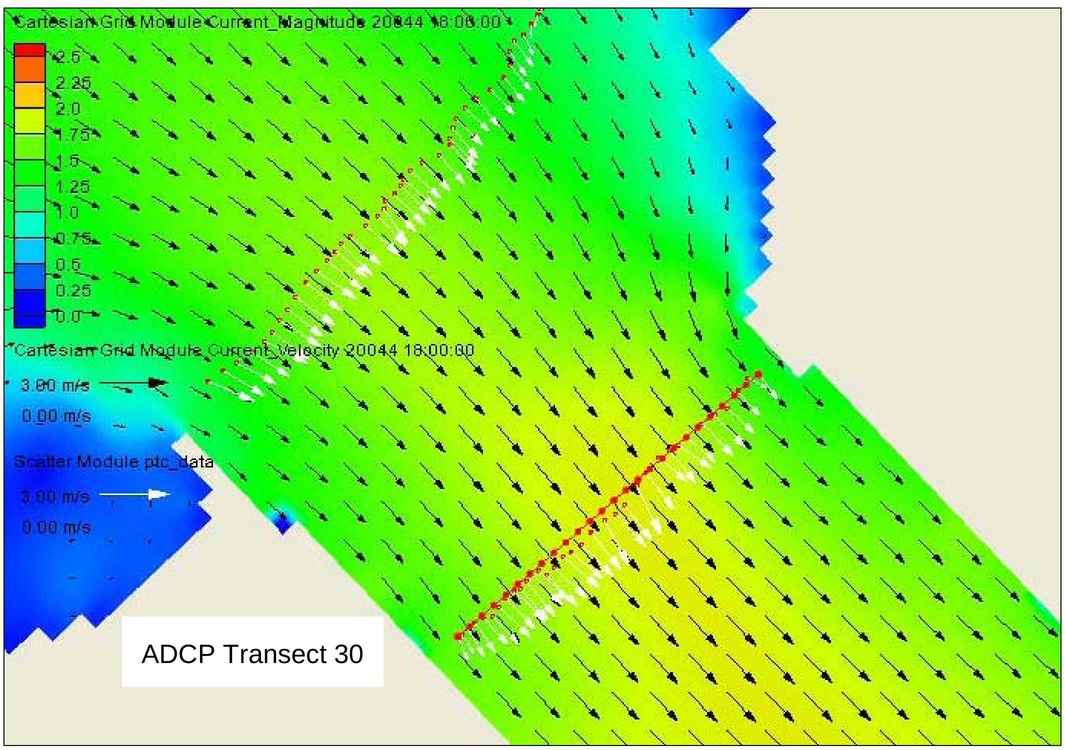

Figure 27. Location of ADCP Transect 30 and CMS calculations.

Figure 26 compares the measured and the calculated current magnitudes for "sampling transect 30." Figure 27 shows the location of ADCP transect 30, which was located inside the inlet and sampled at near peak ebb tide. The ADCP data were averaged to be compatible with the spatial scale of the CMS computational cells. CMS slightly under-predicts the peak currents for this transect, while capturing the overall shape of the cross-channel current. The main driving force controlling the current for a given bathymetry condition is the amount of the difference in water level inside and outside the inlet. As stated in a previous report (Kraus, et.al. 2006), uncertainties in bathymetry and offshore forcing conditions are considered to be the main factors contributing to differences between observed and computed current speeds.

Island placement considerations

Considerations involved in designing the island placement are to minimize (1) possible hindrance to navigation, and (2) maintenance costs due to sedimentation of the GIWW. Also, extension of the island footprint into the area between the existing island and the Matagorda Peninsula may increase the cross current. Furthermore, the island shape should minimize the island perimeter, which is directly related to the cost of shore protection. Confining the island placement footprint to the area within the existing sediment lobes (Figure 21) and at least 500 ft outside the GIWW meets these constraints and does not adversely increase flow toward the inlet.

4 Gencade Beach Placement Analysis

The objective of this portion of the study was to estimate shoreline change south of the south jetty of Matagorda Peninsula for each alternative. Dredged material placed in the nearshore on the gulf side would serve to protect the landward end of the south jetty. Some portion of this material would be transported toward Pass Cavallo. A possible resultant increase in longshore sand transport toward Pass Cavallo was investigated with the GenCade model. GenCade calculated long-term shoreline position and longshore sand transport rates as a function of initial shoreline position, wave-induced surf zone sand transport, and sheltering by the south jetty.

Long-term simulations of the longshore sand transport rate and the associated shoreline change were performed with the GenCade model. Shoreline position data and process data for this coast are limited. A median grain size of 0.18 mm was specified. Initially, wave input was taken from the Corps' Wave Information Study (WIS) hindcast, which provides a 20-year record. However, calculated shoreline change was opposite to that observed at the site. Therefore, an 11-year record from the NOAA National Wave Buoy Center (NWBC) buoy 42019 with data from 1997 to 2008 was accessed. This buoy is located offshore of the MSCE. One-hundred seventy-four days were missing data, and were populated with adjacent periods for which data were available. Sensitivity tests with GenCade were conducted to evaluate how the interpolation method affected long-term shoreline response; no notable differences were observed. Comparison of the WIS and NWBC data indicated that the winter "northers" were not accounted for adequately in the WIS hindcast.

Shoreline change and longshore sand transport observations

It is known from SWG dredging records that at the Mouth of the Colorado River (MOCR), the net direction of longshore transport is to the south (or west as commonly referenced at that site), and the magnitude is on the order of 500,000 cy/year. The MOCR is about 23 miles to the northeast of the MSCE. Because the orientation of the shoreline at the MOCR is little influenced by the updrift weir jetty there, the longshore transport rate reaches full potential on the east beach. In contrast, at the MSCE, it is expected that the rate of longshore transport is much less because the shoreline has adjusted to the jetties.

Recent shoreline change rates (between May 2002 and May 2006) in the vicinity of the MSCE (available from Kraus and Batten, 2008, ERDC/CHL TR-08-6) were compared to GenCade calculations as a measure of model skill. Analysis in TR-08-6 was based on a visually interpreted shoreline position from aerial photographs and could not be related to a vertical datum and, therefore, contains appreciable uncertainty. Figure 11 of that report indicates that the shoreline adjacent to the north jetty was unchanged, implying that it has reached equilibrium position with the long-term wave and storm climates, and natural sand bypassing the jetty. Change in shoreline position on the beach adjacent to the south jetty was small and indicated advance of about 3-4 ft/year near the south jetty and recession of about 6-7 ft/year about 2 miles south of the jetty.

Calculations

In the following, five figures are presented for each alternative: shoreline position after 10, 25, and 50 years superimposed upon an aerial photograph of Matagorda Peninsula obtained from the Texas Natural Resources Information System, and comparisons of calculated shoreline positions and longshore sand transport rates. In the aerial photographs, the present shoreline position is denoted with red, and the calculated shoreline is always in blue. The plots of shoreline change and longshore sand transport rates have an approximate 1:45 vertical exaggeration.

For this project, GenCade is driven by 11 years of available wave measurements that are repeated to achieve the 25- and 50-year time intervals. Therefore, the waves are partially random, yet have a pattern. Calculated shoreline evolution will contain these characteristics. As general trends, it is expected that the shoreline near the south jetty will advance or be stable, whereas the middle of south Matagorda Peninsula will continue to experience recession. The southern terminus of Matagorda Peninsula is both an accumulation area for sand moving south along the peninsula and an attachment bar for Pass Cavallo (accumulating sand that bypasses the pass from south to north).

Alt 1, Existing condition

The predicted shoreline position after 10, 25, and 50 years is shown to scale on Figures 28-30, and in comparison on Figure 31. The shoreline near the south jetty to about 0.3 miles advances, because of sheltering of waves by the jetty. The calculated positions adjacent to the jetty after 10 and 50 years are the same because of randomness in the forcing waves. The calculated rate of advance near the jetty is about 2.5 ft/year, and the rate of recession 1-2 miles south of the jetty is about 5.5 ft/year, with both values in agreement with observations discussed in the preceding section. Maximum recession after 50 years was 275 ft, located about 1.25 miles down-drift. Longshore transport rates decrease through time (Figure 32), as the island moves toward an equilibrium configuration. The longshore transport rate shown in Figure 32 and similar figures is zero at the south jetty, because it is assumed that the structure is impermeable, meaning that sand can neither leave the beach to enter the channel nor come from the channel to be transported toward the beach.

The longshore transport rate decreases through time from a maximum of 157, 103, and 66 Kcy/year, respectively for 10, 25, and 50 years, indicative of the shoreline reaching an equilibrium configuration with the jetty and incident waves. The GenCade model accounts for wave diffraction at the south jetty, providing a sheltered area for waves incident from the northeast. It is feasible for the “diffraction current” to move sand toward the jetty under these waves.

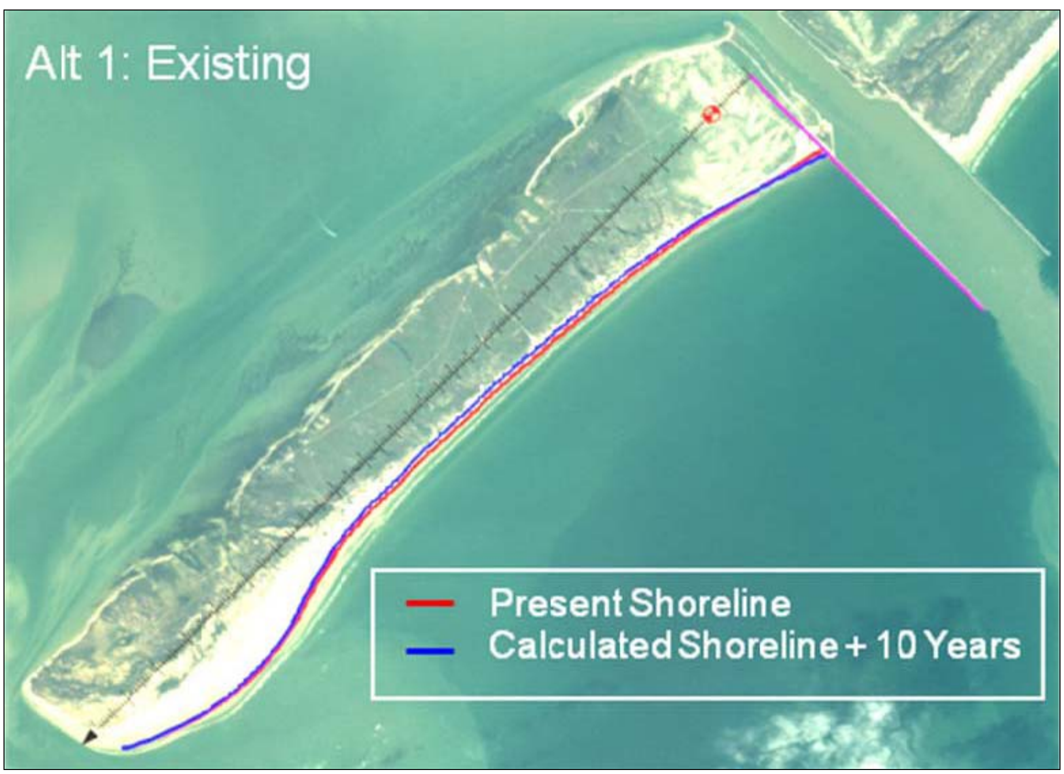

Figure 28. Shoreline position for Alt 1 after 10 years.

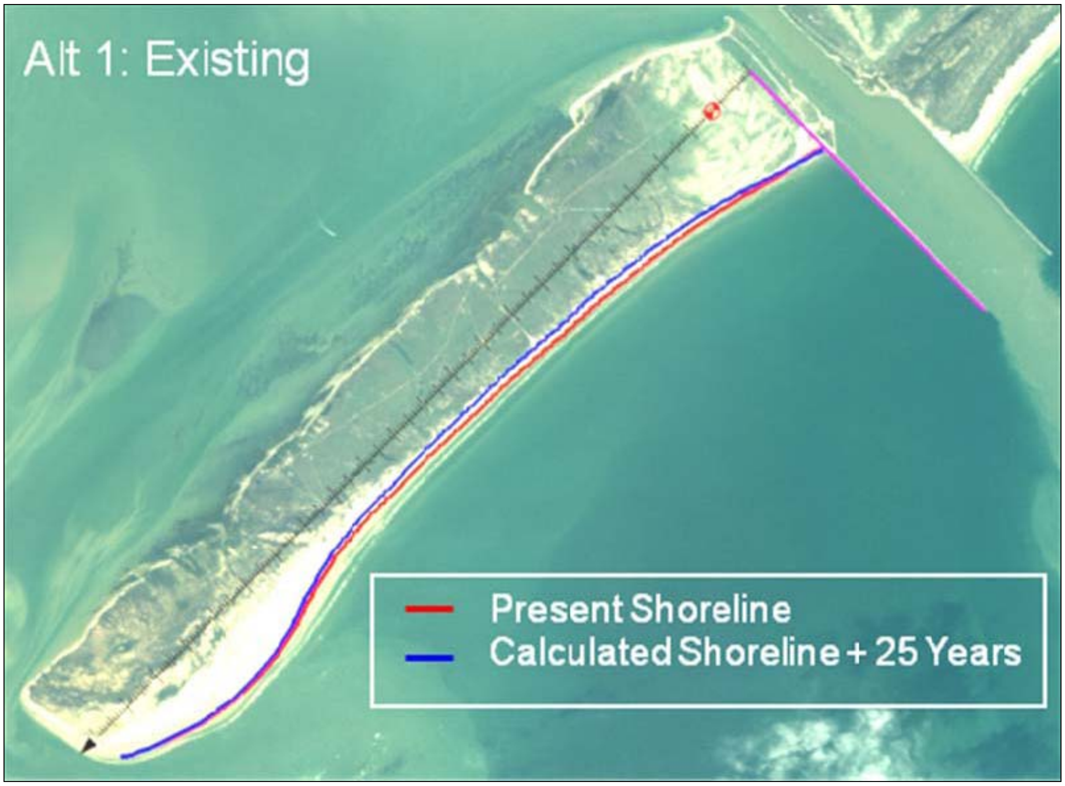

Figure 29. Shoreline position for Alt 1 after 25 years.

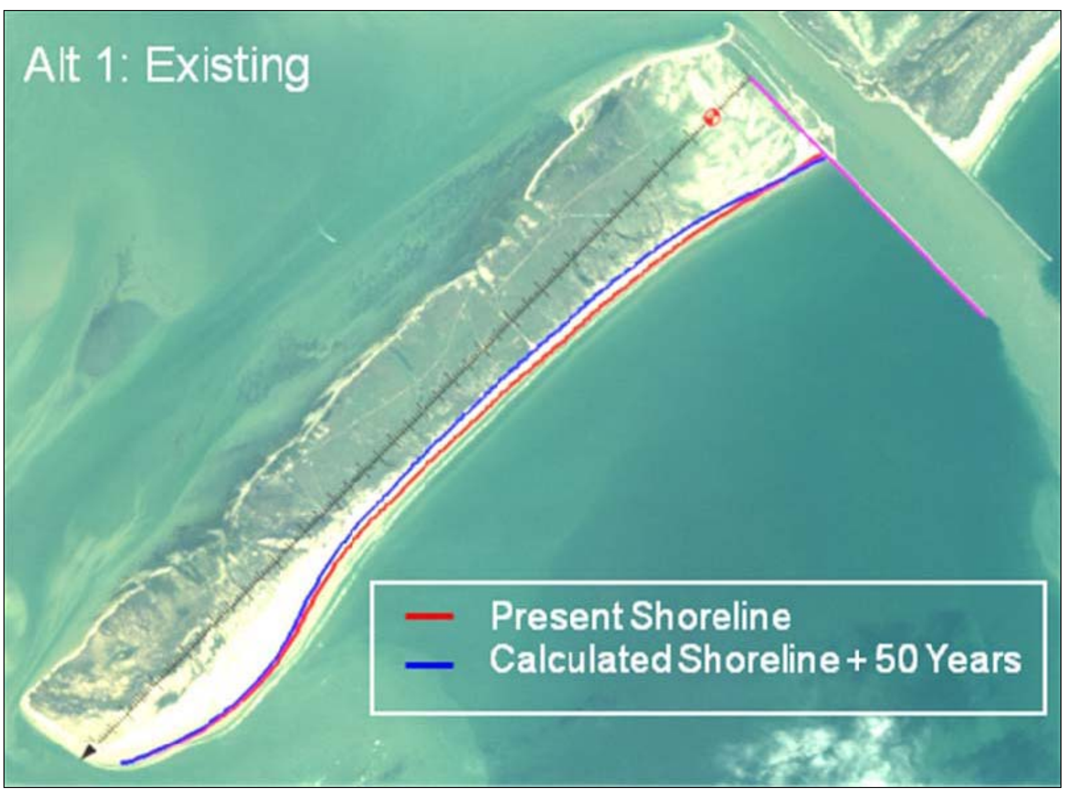

Figure 30. Shoreline position for Alt 1 after 50 years.

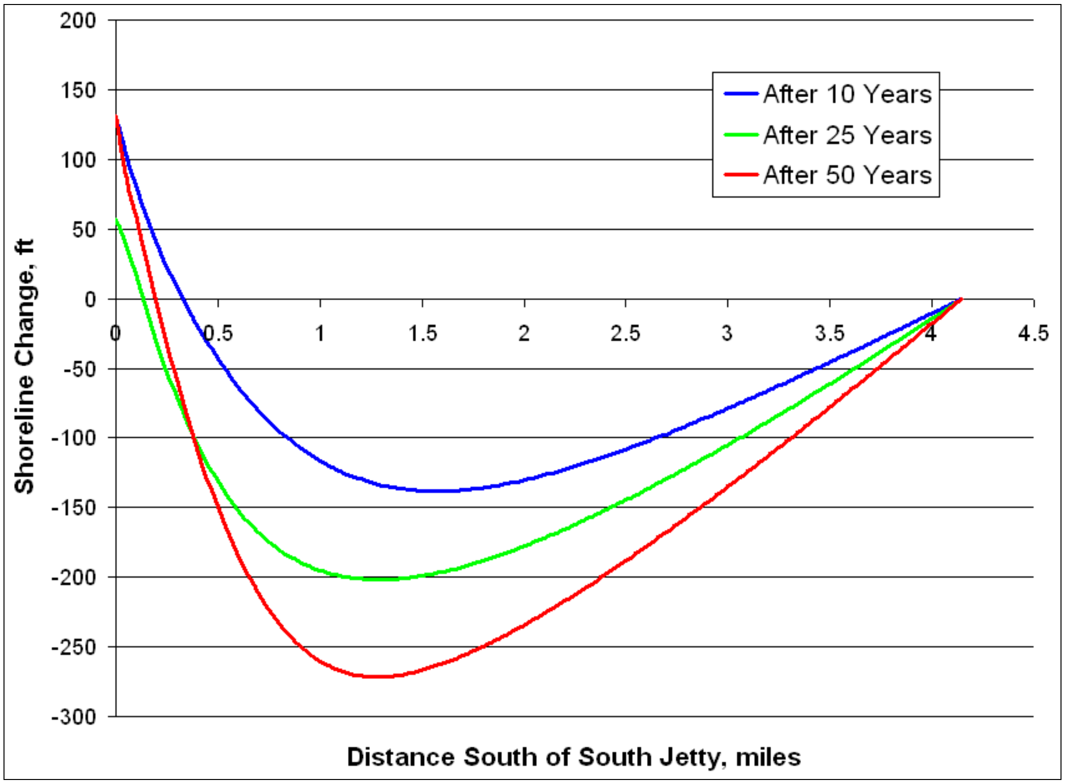

Figure 31. Summary of calculated shoreline positions for Alt 1.

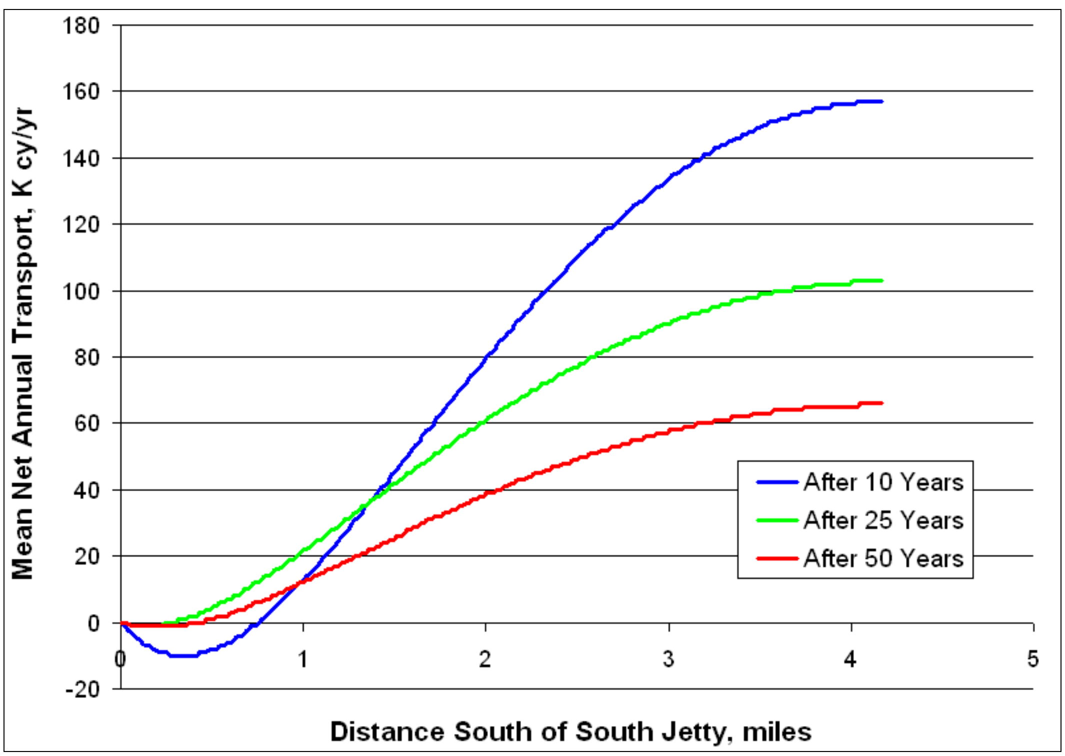

Figure 32. Mean net annual transport rate for Alt 1.

Alt 2, 2.65 Mcy Sundown Island, 2.65 Mcy beach placement

This alternative equally shares sand between Sundown Island and the beach south of the south jetty. The initial placement is denoted with a yellow line in Figures 33-35. The beach was translated gulfward at the same elevation as the existing beach for the simulation. After 10 years, the shoreline next to the south jetty remains at slightly more than 300 ft from the present-day shoreline, and there is no recession past the present shoreline. After 25 and 50 years, the shoreline adjacent to the jetty is calculated to be located approximately 150 ft seaward of the present shoreline. Maximum recession occurs about 1-1.5 miles south and is 120 and 245 ft, respectively, for 25 and 50 years into the future. Shoreline advance near the jetty after 10 years is double that for the existing condition (Figure 36). At 25 years, however, the shoreline moves to the same position as predicted for the existing condition. Maximum recession after 50 years is about 30 ft less than for the existing condition and occurs about 1.25 miles south of the jetty.

Longshore sand transport rates on the down-drift beach (Figure 37) are greater than for the existing condition because the shoreline is out of equilibrium, and sand is more readily transported. Net transport starts at zero at the jetty. The net transport rates after 10, 25, and 50 years are 220 K, 179 K, and 120 Kcy/year at the southernmost end of the calculation grid.

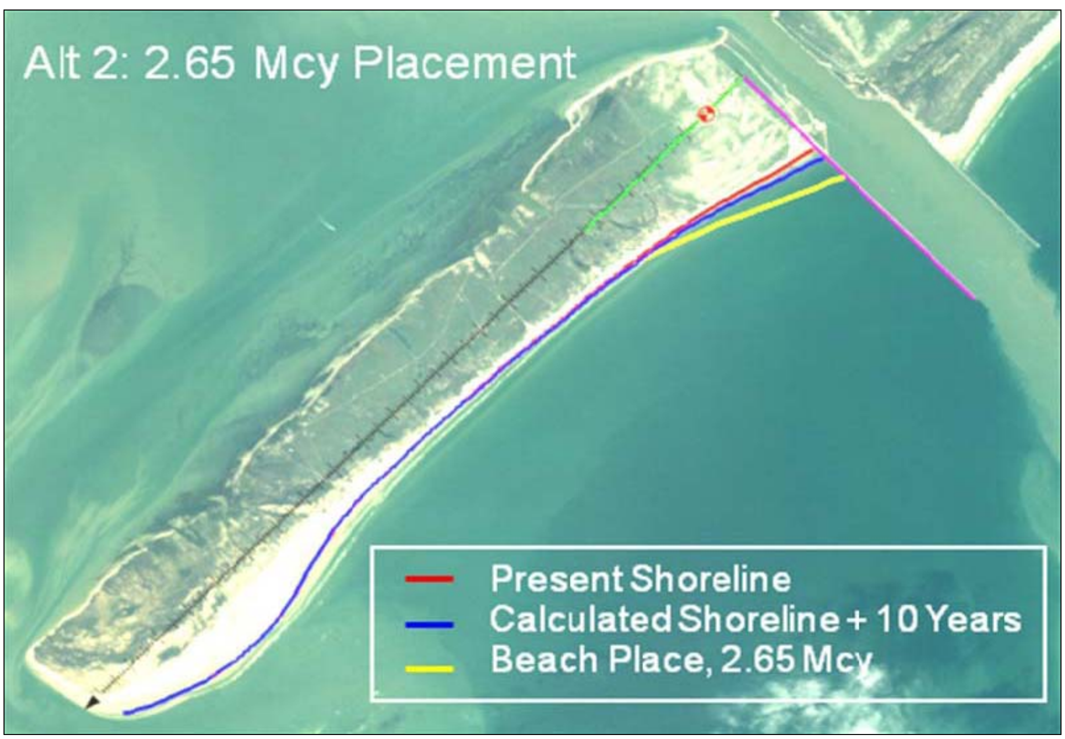

Figure 33. Shoreline position for Alt 2 after 10 years.

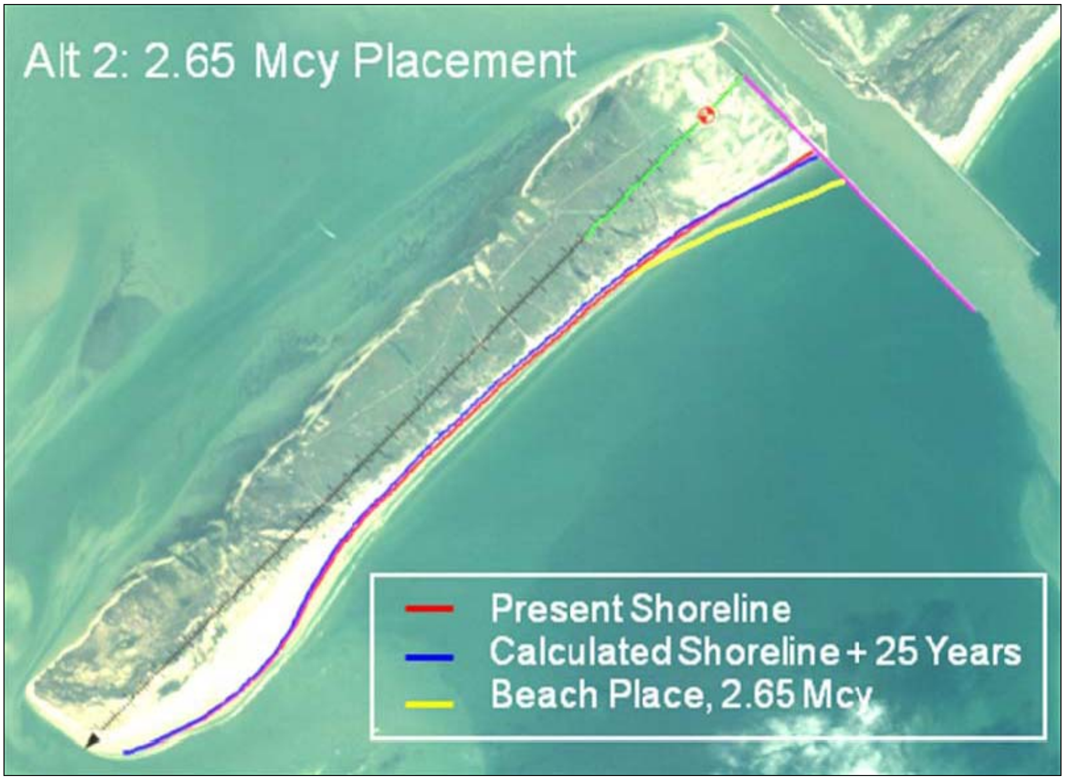

Figure 34. Shoreline position for Alt 2 after 25 years.

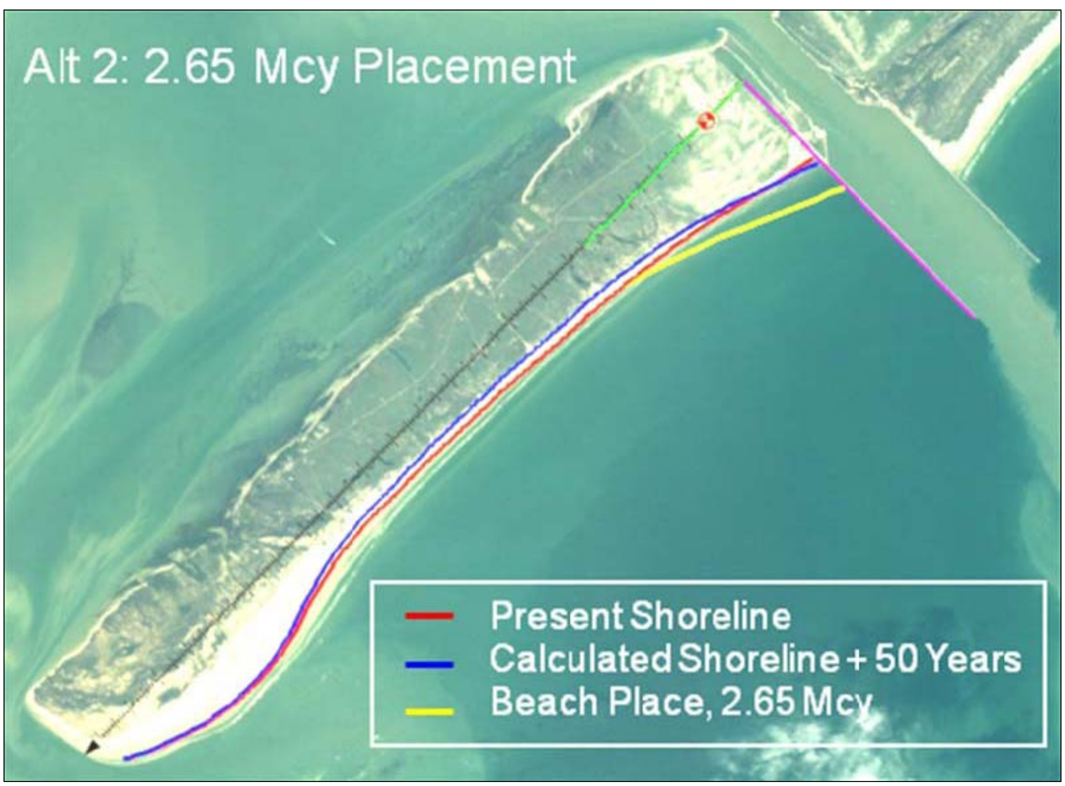

Figure 35. Shoreline position for Alt 2 after 50 years.

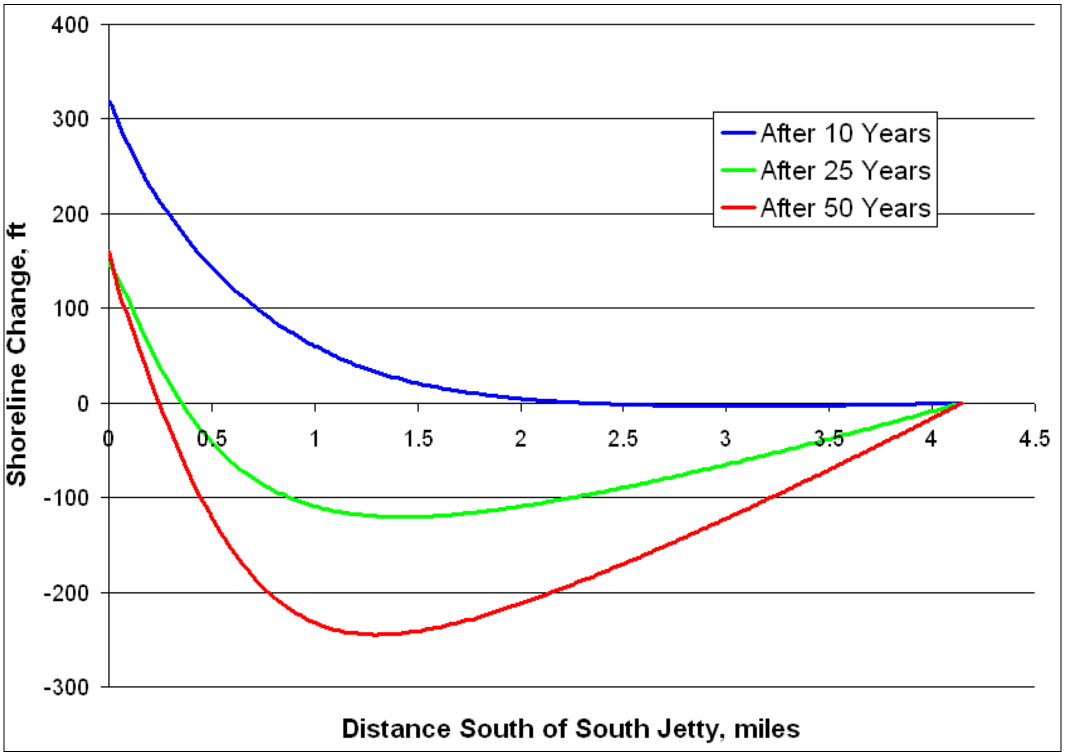

Figure 36. Summary of calculated shoreline positions for Alt 2.

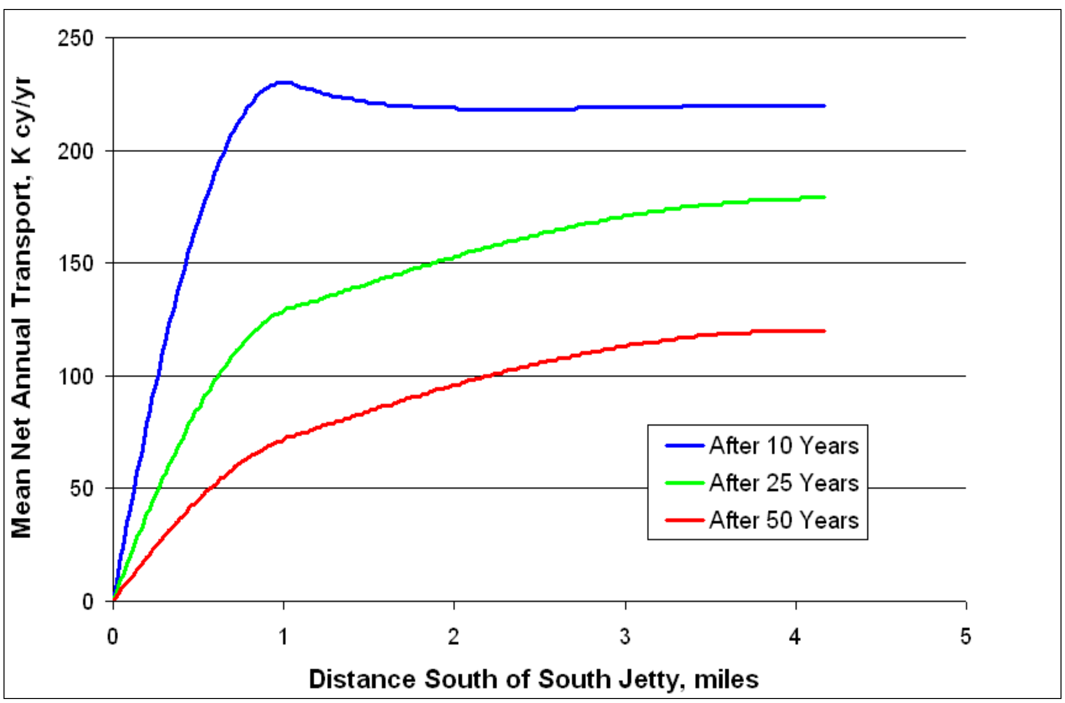

Figure 37. Mean net annual transport rate for Alt 2.

Alt 3, 1.3 Mcy Sundown Island, 4 Mcy beach placement

The initial placement is denoted with a yellow line in Figures 38-40. The beach was translated gulfward at the same elevation as the existing beach for the simulation. After 10 years, the shoreline next to the south jetty remains at slightly more than 400 ft from the present-day shoreline, and there is no recession past the present shoreline. After 25 and 50 years, the shoreline adjacent to the jetty is calculated to be located approximately 187 and 173 ft seaward of the present shoreline. Maximum recession occurs about 1-1.5 miles south and is 85 and 230 ft, respectively, for 25 and 50 years into the future. Maximum recession after 50 years is about 45 ft less than for the existing condition and occurs about 1.25 miles south of the jetty.

Longshore sand transport rates on the down-drift beach are greater than for the existing condition because the shoreline is out of equilibrium, and sand is more readily transported. The transport rates after 10, 25, and 50 years are 250 K, 213 K, and 144 Kcy/year at the southernmost end of the calculation grid.

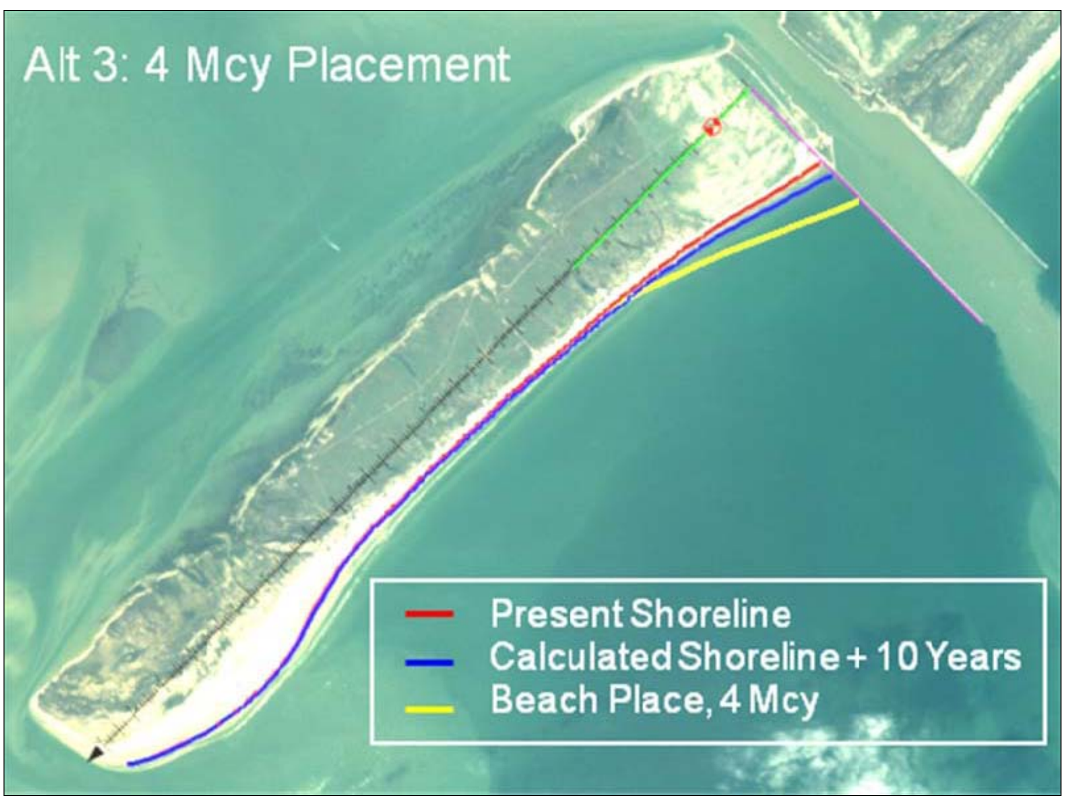

Figure 38. Shoreline position for Alt 3 after 10 years.

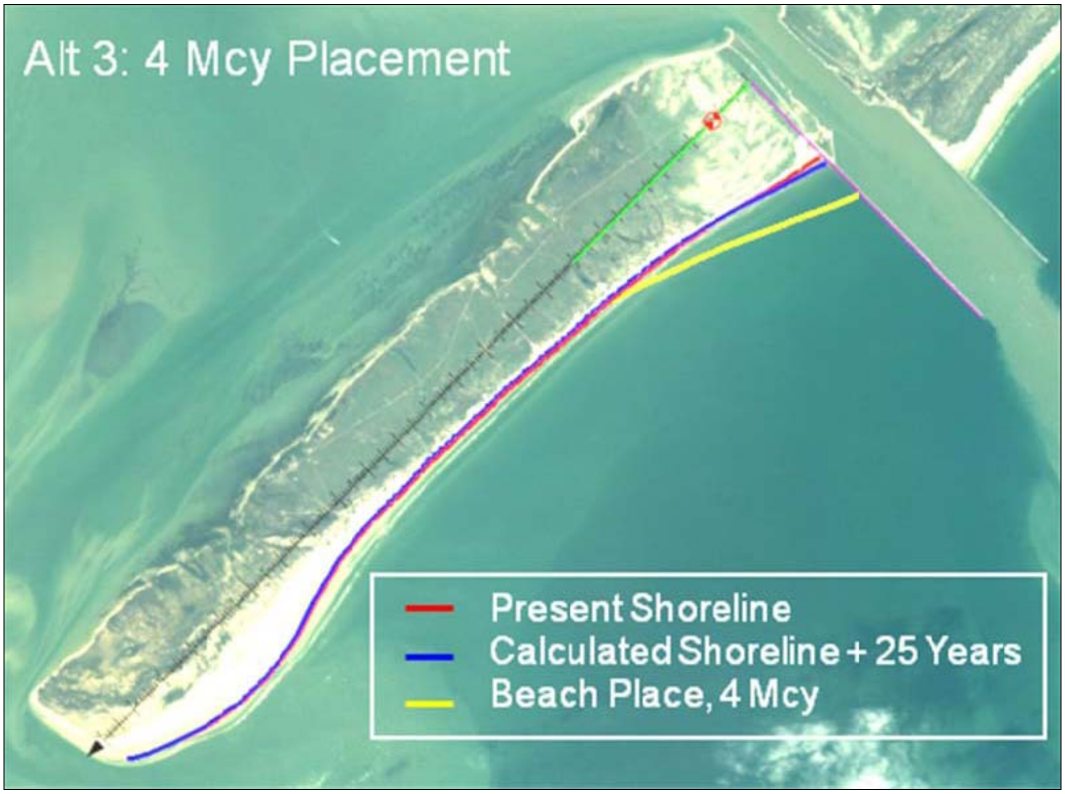

Figure 39. Shoreline position for Alt 3 after 25 years.

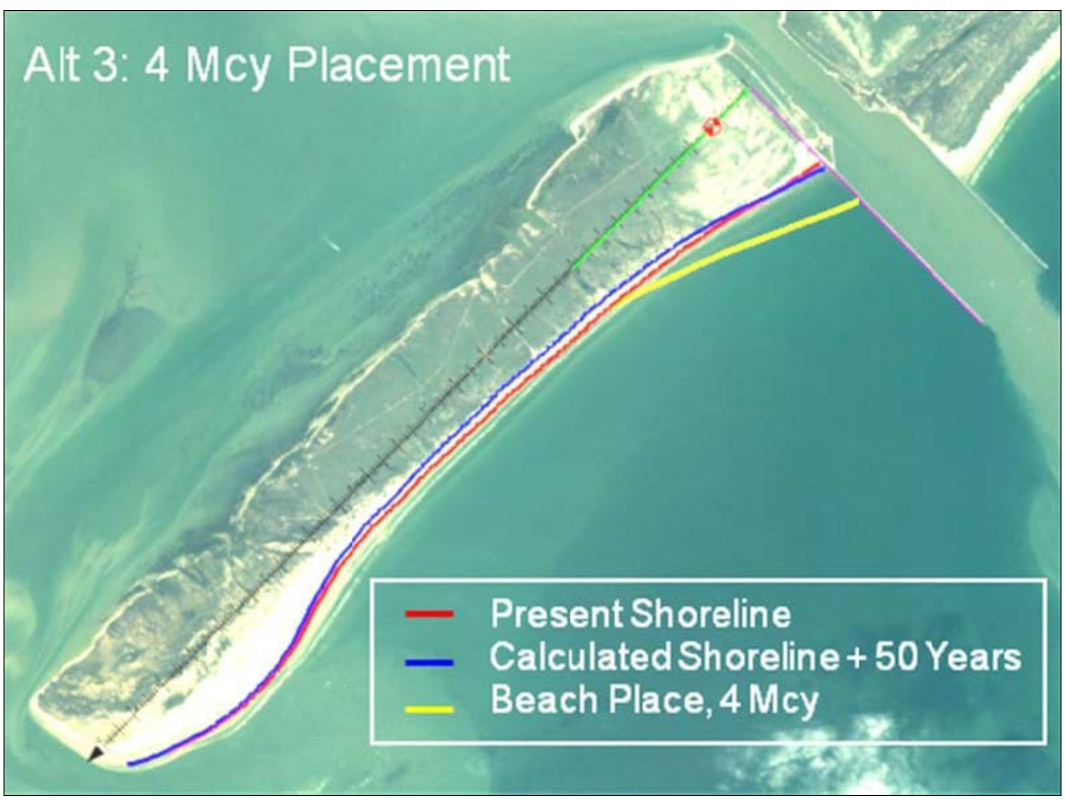

Figure 40. Shoreline position for Alt 3 after 50 years.

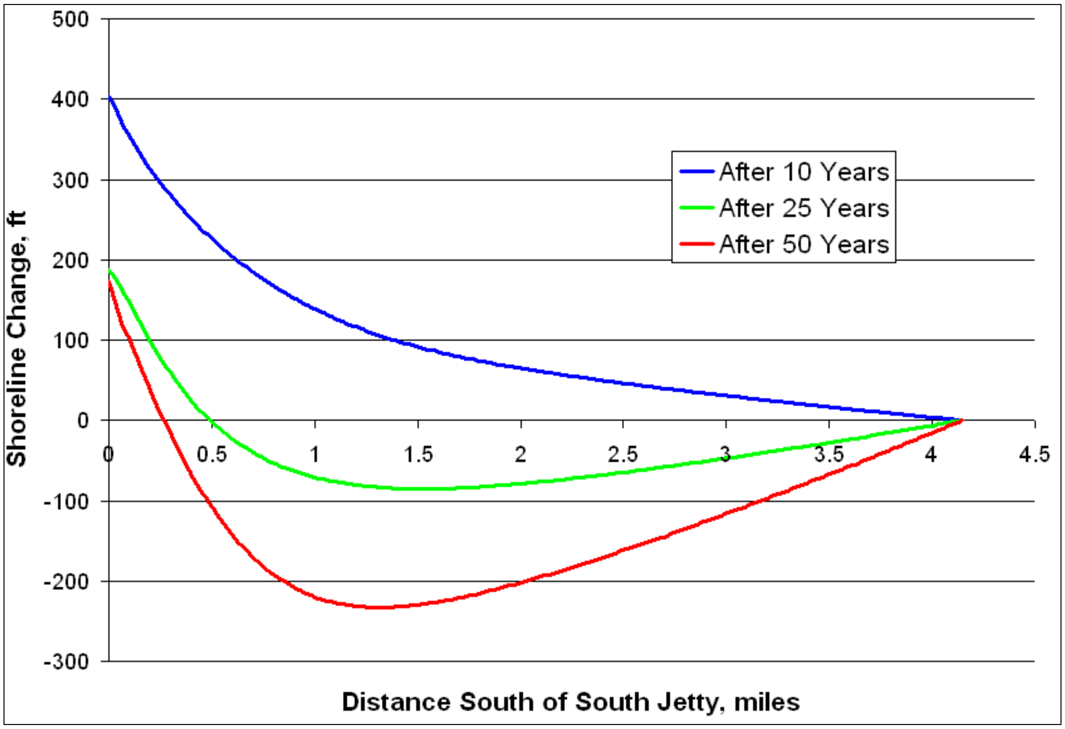

Figure 41. Summary of calculated shoreline positions for Alt 3.

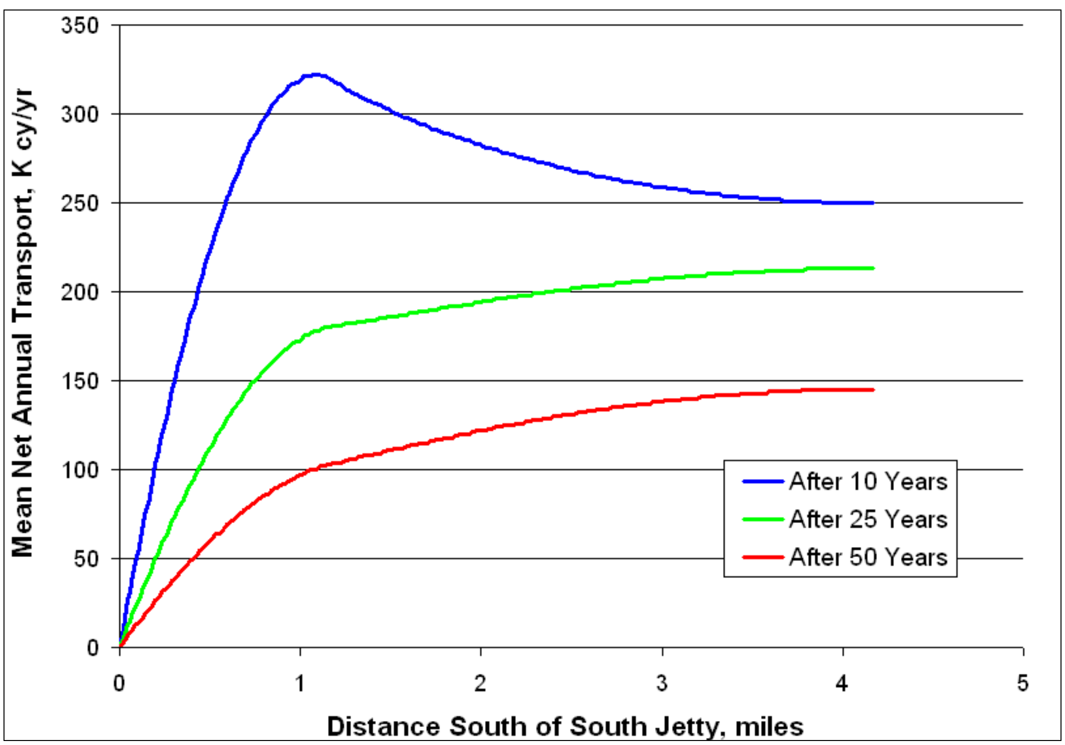

Figure 42. Mean net annual transport rate for Alt 3.

Alt 4, No placement on Sundown Island, 5.3 Mcy beach placement

The initial placement is denoted with a yellow line in Figures 43-45. The beach was translated gulfward at the same elevation as the existing beach for the simulation. After 10 years, the shoreline next to the south jetty remains at 486 ft from the present-day shoreline, and there is no recession past the present shoreline. After 25 and 50 years, the shoreline adjacent to the jetty is calculated to be located 228 and 186 ft, respectively, seaward of the present shoreline. Maximum recession occurs about 1-1.5 miles south and is 50 and 220 ft, respectively, for 25 and 50 years into the future. Maximum recession after 50 years is about 55 ft less than for the existing condition and occurs about 1.25 miles south of the jetty.

Longshore sand transport rates on the down-drift beach are greater than for the existing condition because the shoreline is out of equilibrium, and sand is more readily transported. The transport rates after 10, 25, and 50 years are 282 K, 249 K, and 171 Kcy/year at the southernmost end of the calculation grid.

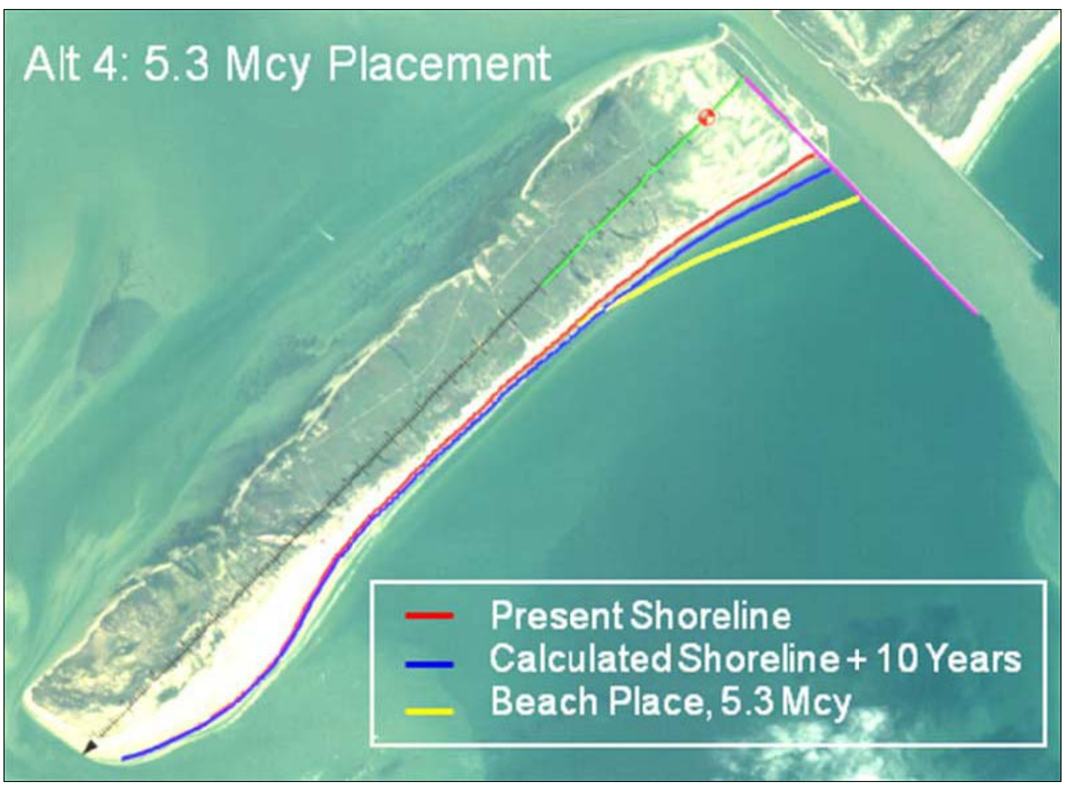

Figure 43. Shoreline position for Alt 4 after 10 years.

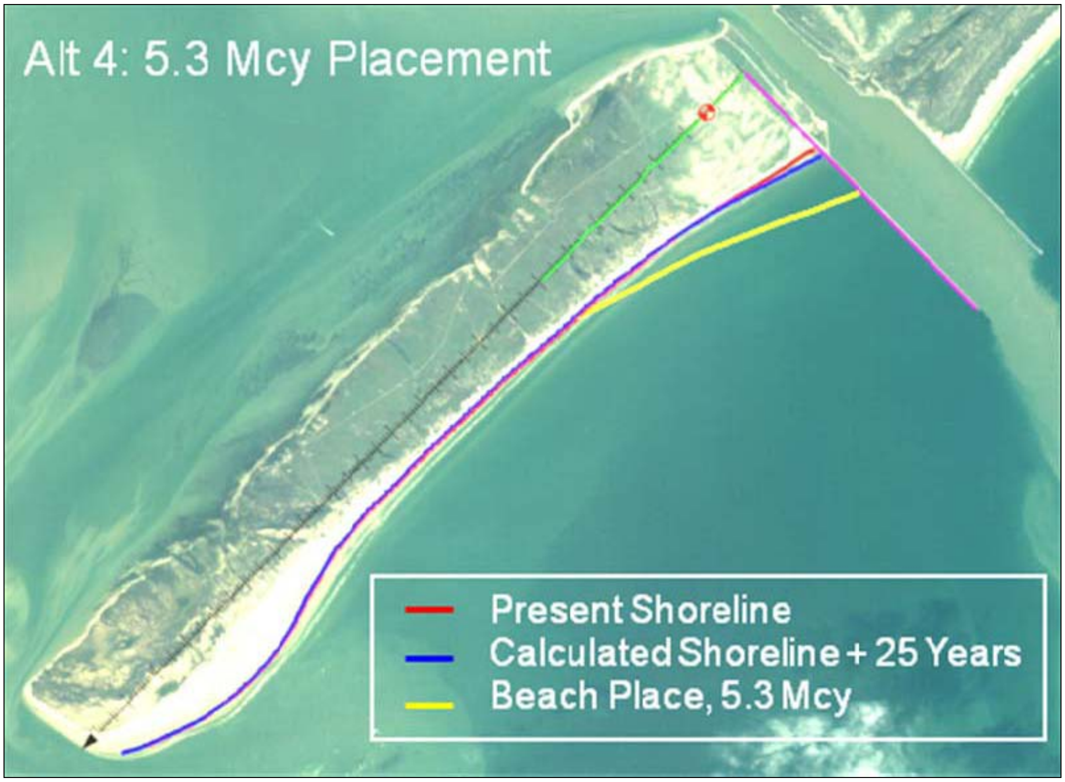

Figure 44. Shoreline position for Alt 4 after 25 years.

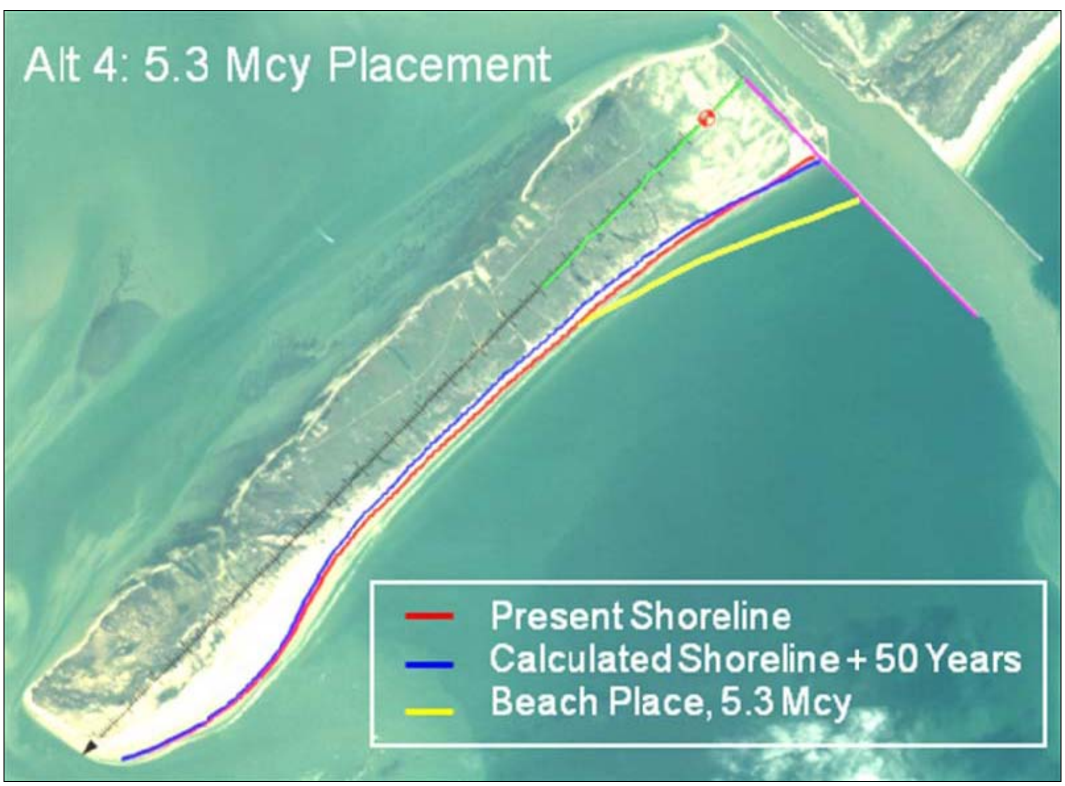

Figure 45. Shoreline position for Alt 4 after 50 years.

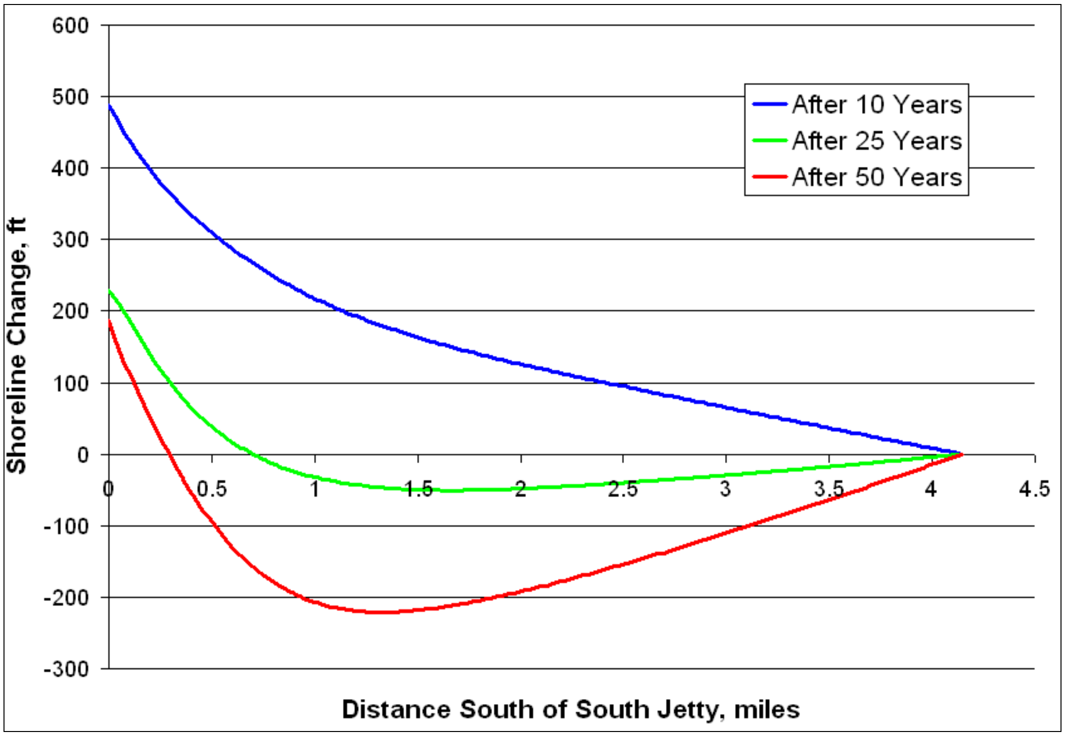

Figure 46. Summary of calculated shoreline positions for Alt 4.

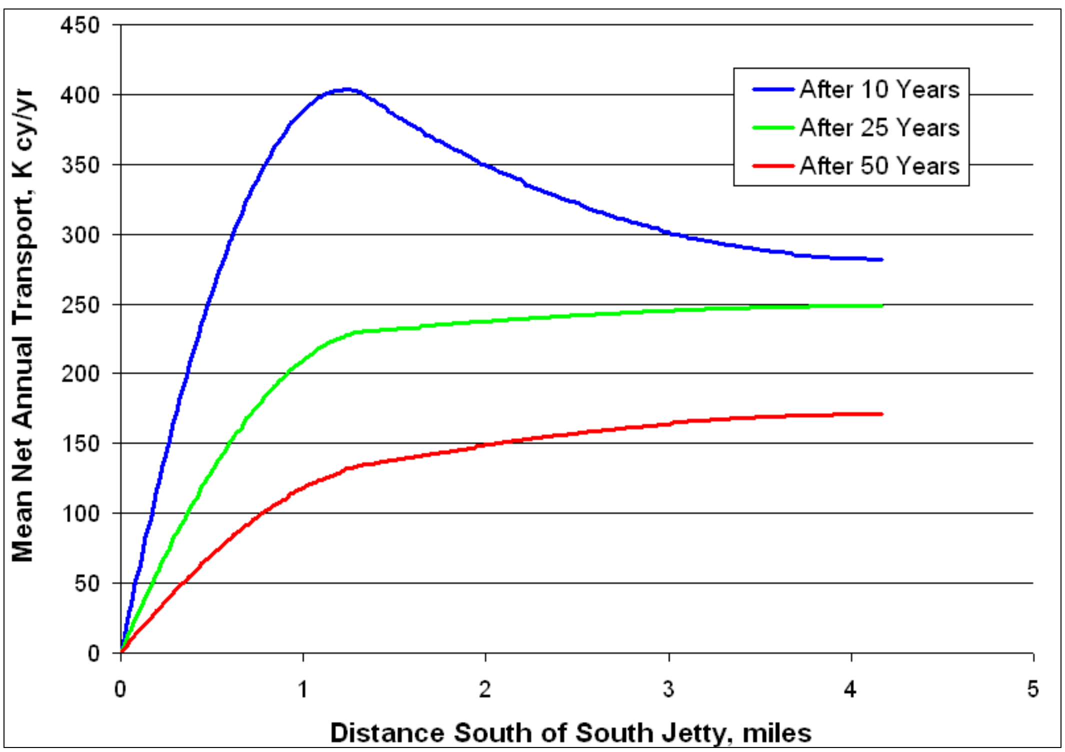

Figure 47. Mean net annual transport rate for Alt 4.

5 Discussion and Conclusions

This TR examined potential changes in Sundown Island and the beach south of the south jetty for four dredged material placement alternatives, including the existing condition, being considered by SWG in connection with removal of the bottleneck at the MSCE. The two numerical models employed in this study were validated with available data, and results are judged to be rational and consistent among alternatives.

Alternatives 2 and 3 place a volume of 2.65Mcy and 1.3Mcy on Sundown Island, resulting in an increase its perimeter from an existing 9,300ft to 12,000ft and 9,900ft respectively. Therefore, shore protection is recomm-ended in construction of any alternative expanding of the island. Removal of the bottleneck decreased currents relative to the existing condition both along the channel axis and cross-channel currents. Expansion of Sundown Island did not significantly increase MSC cross-channel current velocity.

Beach placement protects the base of the south jetty and has the benefit of reducing the recessional trend of the shoreline at mid-island, preserving the beach and its habitat. However, the rate of longshore transport towards Pass Cavallo increased as the volume of beach material placement increased, because the resultant initial shoreline is displaced further from equilibrium as given by its present configuration. Much of this material would likely be deposited on the southern end of Matagorda Peninsula and would become part of the Pass Cavallo ebb shoal complex. Pass Cavallo is located in the southwest corner of Matagorda Bay, a characteristically stable location for inlets in Texas because of the significant wind-induced water level setup in the bays and subsequent flushing that occurs with the passage of each winter cold front (Batten et al. 2007). Thus, sand deposited within the Pass Cavallo ebb shoal complex would be frequently reworked with passage of winter cold fronts and the inlet would maintain its present-day equilibrium width. In conclusion, all alternatives for beach placement are considered viable.

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14. ABSTRACT
The entrance of the Matagorda Ship Channel, connects the Gulf of Mexico to Matagorda Bay, Texas. In the landcut, the channel narrows from 2,000 ft to 950 ft (referred to as the bottleneck), greatly focusing the flow and increasing the current velocity in this area and on the Matagorda Bay side causing difficulties in navigation. A successful solution would be removal of the bottleneck to decrease current magnitudes while not compromising operation and maintenance of the Gulf Intracoastal Waterway, nor stability of the adjacent natural inlet, Pass Cavallo. Building upon previous studies and in consultation with the sponsor, a jetty configuration alternative that included removing the bottleneck was evaluated with a combined wave, sediment, and hydrodynamic numerical model that was first validated to the existing condition. Alternatives for placing the material removed from the bottleneck on Sundown Island and/or adjacent beaches in varying combinations were considered with the model for their effects on current magnitudes and sedimentation patterns. The alternatives including shoreline placement were evaluated with a long term shoreline response model. The interaction between the entrance and Pass Cavallo, the natural inlet to Matagorda Bay located southwest of the Matagorda Ship Channel entrance, was also examined in a regional approach.

15. SUBJECT TERMS

Matagorda Bay	Numerical model	Pass Cavallo
Navigation channel	Placement	Sundown Island

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