SEDIMENT MANAGEMENT OPTIONS FOR GALVESTON ISLAND, TEXAS

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Abstract: Galveston Island is a major tourist and commercial center on the Gulf of Mexico at the mouth of Galveston Bay, Texas, USA. The shoreline along the Galveston Seawall regularly requires beach nourishment while the beach west of the Seawall has severely eroded. In order to protect the island and ensure it is available for generations to come, a 50-year sediment management plan was developed. A sediment budget using the Sediment Budget Analysis System was calculated and numerous alternatives were simulated with GenCade, a shoreline change and sand transport model. Finally, several alternatives ranging from no action to a comprehensive beach fill and backpassing system are presented as part of the sediment management plan.

Introduction

The Galveston Park Board of Trustees (GPB) enlisted the aid of the U.S. Army Engineer District, Galveston (SWG) and the U.S. Army Engineer Research and Development Center's Coastal and Hydraulics Laboratory (ERDC/CHL) to develop a long-term sand management plan for Galveston Island. By combining a review of the technical literature with a suite of engineering analyses and numerical modeling, alternatives that are technically realistic and have the potential for long-term sustainability are presented.

Galveston Island is a 47 km long sand barrier island along the upper Texas coast (Figure 1) and is located about 72 km south-southeast of Houston. The width of Galveston Island varies from 1 to 4.8 km and is oriented at an angle of approximately 235°. The island is bordered by the Gulf of Mexico, the Galveston Entrance Channel to the northeast, West Bay to the northwest, and San Luis Pass to the southwest. The eastern third of the island contains the residential and commercial heart of the city and is protected by the Seawall and was raised following the Galveston Hurricane of 1900. The western part of the island is not protected by the Seawall and consists mostly of limited development of single family homes and condominiums.

Along most of the northern and central Texas coastline, the direction of the net longshore sediment transport is to the southwest (USACE 1983). However, there is a reversal in the net direction along the western portion of the Galveston Seawall, resulting in a divergent nodal zone. East of this region, net sediment transport is toward the Galveston Entrance Channel while southwest of the region, net sediment transport is to the southwest toward the west end and San Luis Pass (King 2007; Morang 2006).

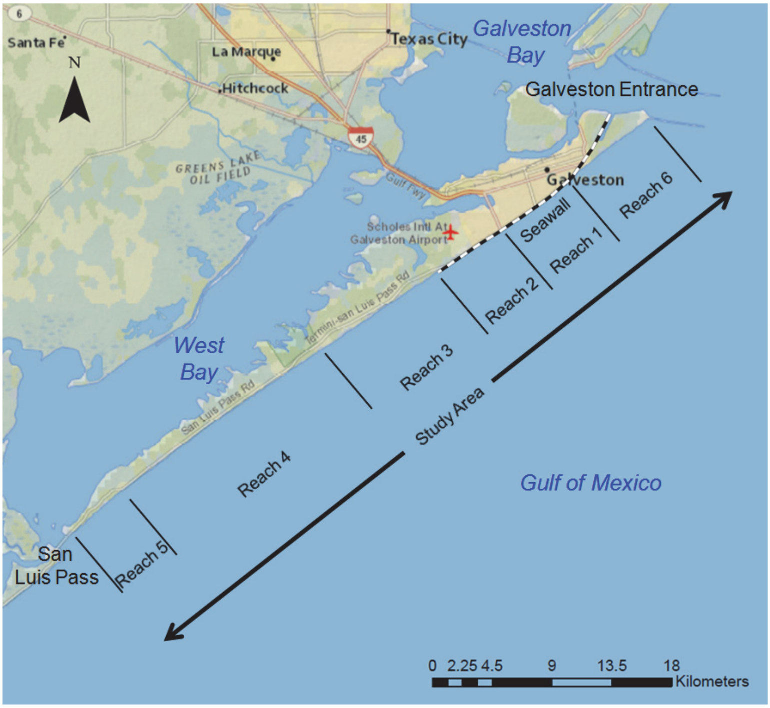

Fig. 1. Galveston Island, Texas, study area and reaches.

Galveston Island was divided into six reaches for the alternatives and the long-term plan. Reaches were classified by similar geography and priority. Reach 1 is the highest priority while Reach 6 is the lowest priority. Reach 1 extends from 14th St. to 61st St. and covers the eastern portion of the Galveston Seawall which contains the groin field. Shoreline position is relatively stable due to the Seawall and periodic beach nourishment. Reach 2 extends from 61st St. to 103rd St. and covers the western portion of the Galveston Seawall. There is no exposed beach for most of this reach. Reach 3, on the west end, covers 103rd St. to Galveston Island State Park. This region is experiencing erosion and net transport is to the southwest. Reach 4 is further west along western Galveston Island from Galveston Island State Park to Pointe San Luis. Reach 5 extends from Pointe San Luis to San Luis Pass. This reach is highly influenced by the inlet dynamics of San Luis Pass. Reach 6, along the far northeastern tip of the island, consists of the south jetty of the Galveston Entrance Channel to 14^{th} St. Both ends of the island (Reaches 5 and 6) have been experiencing long-term accretion, so they are considered lower priority for the GPB. Reaches 1-4 experience various rates of erosion, but Reach 1 is the highest priority since it is the part of the beach where most tourists visit and is considered the "Face of Galveston."

Sediment Budget

Morang (2006) calculated a sediment budget for the north Texas shore between Sabine Pass and San Luis Pass. Using additional and more recent data, the budget has been revised for Galveston Island. The present study includes 11 budget cells, extending from just north of the north jetty to San Luis Pass. The new budget represents average pre-Hurricane Ike conditions covering the mid-1980s to mid-2000s. There are many channels in the entrance to Galveston, and the dredging data for these channels were collected from SWG. Beach fills along the Seawall and west end were collected and incorporated into the sediment budget. Beach volume changes were based on shoreline change statistics and cross-shore beach profiles.

The sediment budget was completed by hand and then the results were added to the Sediment Budget Analysis System (SBAS). SBAS develops sediment budgets by calculating and illustrating sediment gains and losses within specified control volumes for inlets and adjacent beaches (Rosati and Kraus 2001 (rev. 2003)). The sediment budget equation for SBAS is expressed as

$$\sum Qsource - \sum Qsink - \Delta V + P - R = Residual \quad (1)$$

where *Qsource* and *Qsink* represent the sources and sinks to the cell, ΔV is the volume change within a cell, *P* is the volume of material placed within the cell, and *R* is the volume removed from the cell. *Residual* is the degree to which a cell is balanced (Rosati and Kraus 2001 (rev. 2003)); if the *Residual* is zero, the cell is balanced. The results of the sediment budget are shown in Figure 2.

Cell1_1 is north of the Galveston north jetty and has accumulated a significant amount of sand since the jetties were built in the 1880s. The beach has continued to advance since the 1970s, which indicates sand input exceeds sand losses through the porous jetty. Based on the volume dredged from the anchorage area (Cell1_2) and sediment samples, it is assumed that 84,300 m^3/yr moves through the jetty into the Galveston anchorage area. Offshore sand loss is minor, but the term is necessary to balance the cell. Cell1_4 represents the Galveston Entrance Channel. The average maintenance dredging from 1979 to

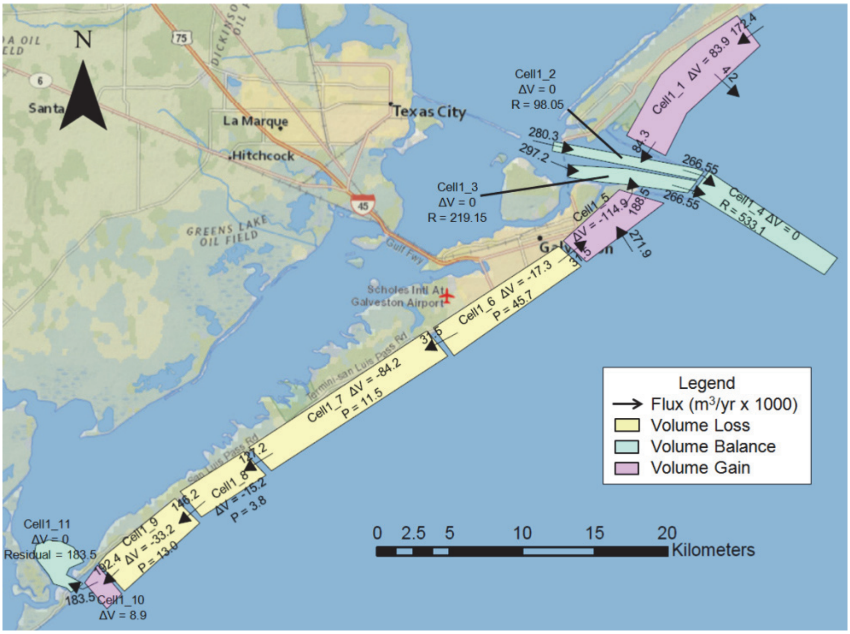

Fig. 2. Sediment budget for Galveston Island, Texas. ΔV = volume change, P = placement, R = removal.

2013 was 533,100 m^3/yr. Cell1_2, the anchorage area, experienced an average of 98,050 m^3/yr of dredging between 1978 and 1997. Cell1_3, the Inner and Outer Bar channels, were dredged 219,150 m^3/yr between 1980 and 1999. It is assumed that Cell1_2 and Cell1_3 both provide 266,550 m^3/yr of material to Cell1_4. East Beach, Cell1_5, is located south of the south jetty, and has grown steadily in the 120 years since the jetty was built. Although the south jetty is porous, sand has accumulated directly against the jetty. Based on dredging of the bar channels and sediment samples, it is assumed that 188,500 m^3/yr of sand moves through the jetty into the bar channels. It is also assumed that 271,900 m^3/yr of sand moves onshore since this volume is needed to balance the cell. Texas A&M University (Dellapenna, personal communications 2003) conducted seismic studies detecting sandy facies offshore of the south jetty making an offshore sand source feasible, and USACE (1993) indicated that some of the material deposited in the offshore disposal area could feed Big Reef; however, determining the volume of material moving onshore near East Beach needs to be evaluated in greater detail. Cell1_6, the Galveston Seawall, is the section of Galveston Island in which the City has been concerned about retaining a beach for recreation. Groins were built in the mid-20th century and the City and private interests have placed an average of 45,700 m^3/yr of sand on the beach between 1985 and 2009. Cell1_7, which represents Reach 3 and the eastern part of Reach 4, experiences net transport to the southwest. Beach placement is approximately 11,500 m^3/yr. Cell1_8, the western portion of Reach 4, is a semi-stable section of Galveston Island with a volume loss of 15,200 m^3/yr and a small beach placements of 3,800 m^3/yr. West Beach, Cell1_9, averages about 0.84 m/yr of retreat (volume loss of 33,200 m^3/yr). San Luis Pass East, Cell1_10, includes the dynamic section of shore on the east side of the mouth of San Luis Pass. Over the last 25 years, the shoreline east of the mouth has advanced 1.12 m/yr. It is assumed that all remaining littoral material not accounted for in beach growth enters San Luis Pass. All morphologic evidence shows that San Luis Pass (Cell1_11) is a major sediment sink; however, the volume change within the San Luis Pass flood shoal cannot be refined until bathymetric surveys are available, so this cell has residual.

GenCade Calibration

GenCade, a one-line shoreline change, sand transport, and inlet sand-sharing numerical model (Frey et al. 2012), was applied to Galveston Island to evaluate structural and engineering alternatives. Due to the large shoreline offset between the Galveston Seawall and the west end, two separate GenCade models were developed. Cell size ranged from 15 m near the groins to 60 m along the rest of Galveston Island. Hindcast waves from WIS (Wave Information Study) Stations 73070 and 73067 were used to drive the model. The 1995 shoreline position from the Bureau of Economic Geology (BEG 2014) was used as the initial shoreline position for the calibration. The model was calibrated to the 2000 shoreline position, and all beach fills between 1995 and 2000 were included in the model. K1 and K2, the longshore transport calibration coefficients, were 0.4 and 0.2, respectively. Initially, GenCade did not predict accretion adjacent to the south jetty. In order to balance Cell1_5 in the sediment budget, a term of 271,900 m^3/yr was added to the cell from offshore. Although the source of material is unknown, material must come from a source other than longshore transport in order to advance the shoreline at the observed rates. To calibrate the model, a volume of 271,900 m^3/yr was added to the GenCade cells adjacent to the jetty. Although this volume allows the calculated results to nearly match the observed shoreline change, it is difficult to predict if or how much sand may move onshore in the future. For that reason, a number of rates of onshore sand movement are modeled in the alternatives. Results of the five year calibration are shown in Figure 3. The modeled shoreline change in the groin field matches well with the observed rates. Along the west end, GenCade predicts erosion for the first 8 km (18-26 km from the jetty) as expected. The model calculates accretion near San Luis Pass but does not predict as much accretion further from the boundary as observed.

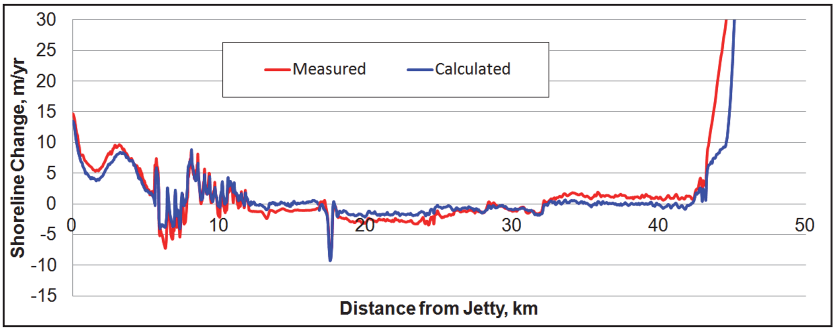

Fig. 3. Measured and calculated shoreline change for 1995 to 2000.

GenCade Alternatives

A number of 50-year alternatives were conducted with GenCade. The "No Action" cases were run to determine the position of the shoreline if no beach fills were added. In the GenCade calibration, a source term of 271,900 m^3/yr was added to the shoreline near the jetty to account for the increase in sand northeast of the 10^{th} St. groin. It is unknown whether or not the rate of sand moving onshore will remain the same or decrease, so rates of 272,000 m^3/yr and 138,000 m^3/yr were simulated to illustrate how much the rate of sand coming onshore affects the shoreline of Galveston Island (Figure 4).

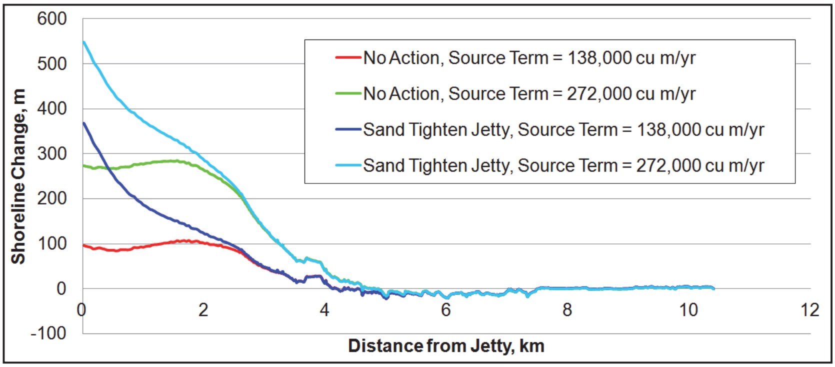

Fig. 4. Total shoreline change with and without a sand tightening jetty after 50 years.

First, structural alternatives were modeled along the seawall. Lengthening, shortening, and removing the existing groins had little effect on the shoreline position, so those alternatives are not shown here. The jetty at the Galveston Entrance Channel was sand tightened, and the shoreline after 50 years was compared to the no action case (Figure 4). Sand tightening the jetty results in more shoreline advance than the no action alternative and would produce more sand for backpassing alternatives. The effects of sand tightening the jetty are only felt within about 5 km of the jetty.

Next, beach fills of 76,000, 382,000, and 1,529,000 m^3 placed along Reach 1, 14^{th} St. to 61^{st} St., every five years were compared to the no action case (Figure 5). The shoreline in the no action case retreats to near the seawall in some locations, while the small beach fill of 76,000 m^3 every 5 years results in a shoreline position similar to the initial. The shoreline advances about 75 m for the 382,000 m^3 and 300 m for the 1,529,000 m^3 every five years placements.

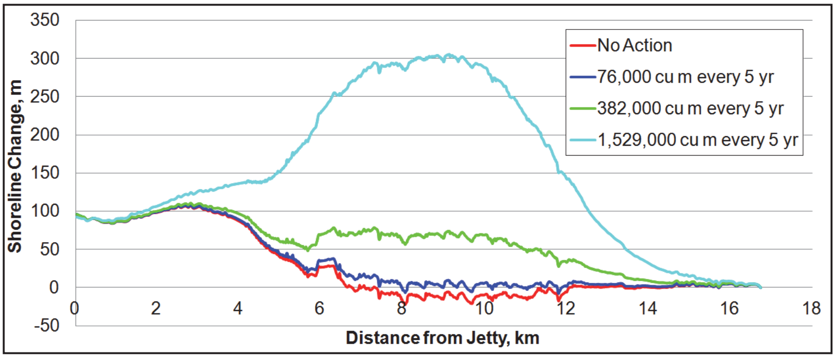

Fig. 5. Total shoreline change after 50 years with 76,000 m^3, 382,000 m^3, and 1,529,000 m^3 beach fills placed along Reach 1 every 5 years.

Beach fill volumes of 382,000, 765,000, and 1,529,000 m^3 were placed along Reaches 1 and 2 every five years (Figure 6). The shoreline advanced about 40 m, 85 m, and 175 m when 382,000, 765,000, and 1,529,000 m^3 of sand were placed every five years, respectively.

Backpassing sand from near the jetty to the Seawall was also investigated. Figure 7 compares backpassing 76,000 m^3/yr to Reach 1 with and without an initial beach fill of 1,485,000 m^3. Simply backpassing material to Reach 1 advances the shoreline about 50 m while backpassing with an initial beach fill advances the shoreline about 85 m. The shoreline retreats about 75 m near the jetty when 76,000 m^3/yr is backpassed. In the figures, the source term near the jetty is 138,000 m^3/yr unless otherwise noted. Figure 8 compares backpassing 76,000, 191,000, and 272,000 m^3/yr with source terms of 138,000 and 272,000 m^3/yr. Backpassing 76,000 m^3/yr with a source term of 272,000 m^3/yr advances the shoreline slightly in Reach 1 but does not impact the shoreline near the jetty as much as any of the other alternatives. A backpassing rate of 272,000 m^3/yr and a source term of 138,000 m^3/yr results in more than 300 m of shoreline advance in Reach 1 but shoreline erosion of more than 600 m near the jetty.

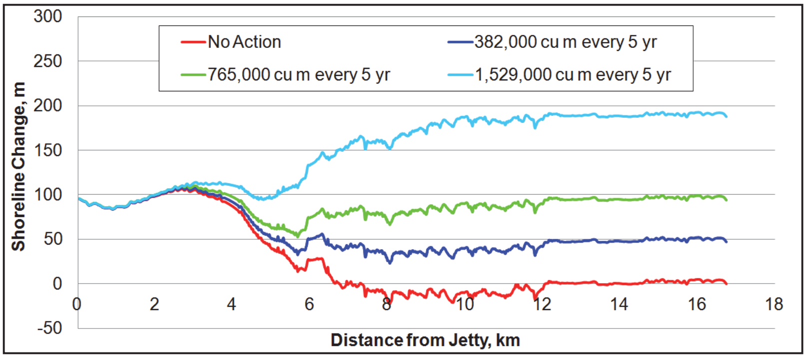

Fig. 6. Total shoreline change after 50 years with 76,000 m^3, 382,000 m^3, and 1,529,000 m^3 beach fills placed along Reaches 1 and 2 every 5 years.

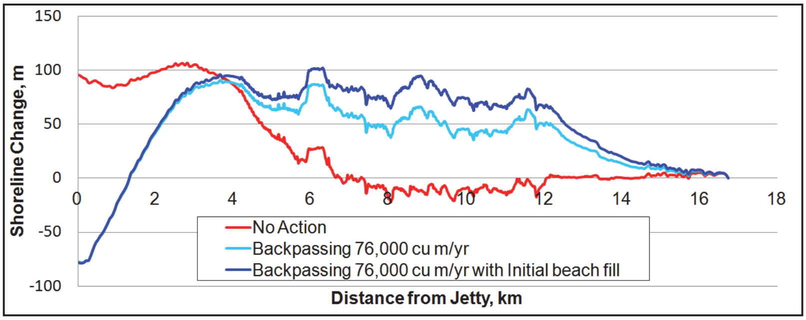

Fig. 7. Total shoreline change after 50 years with 76,000 m^3 backpassed with and without an initial beach fill along Reach 1.

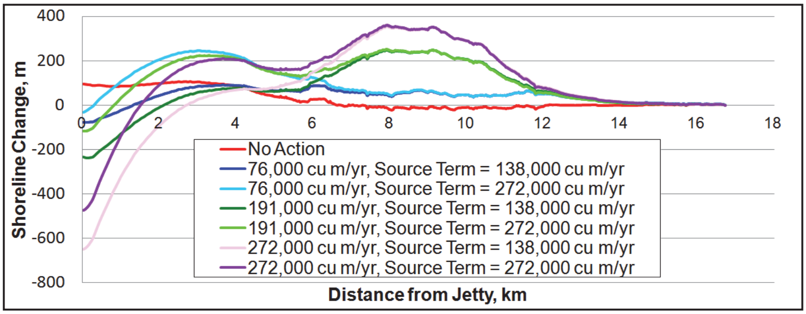

Fig. 8. Total shoreline change after 50 years with 76,000 m^3, 191,000 m^3, and 272,000 m^3 backpassed to Reach 1.

Figure 9 compares backpassing rates of 76,000, 191,000, and 272,000 m^3/yr onto Reaches 1 and 2 with source terms of 138,000 and 272,000 m^3/yr . When 272,000 m^3/yr is backpassed, the maximum shoreline advance along Reaches 1 and 2 is about 200 m. A rate of backpassing of 76,000 m^3/yr does not advance the shoreline significantly, but it will provide a beach width similar to present. The erosion near the jetty is identical to the scenarios illustrated in Figure 8.

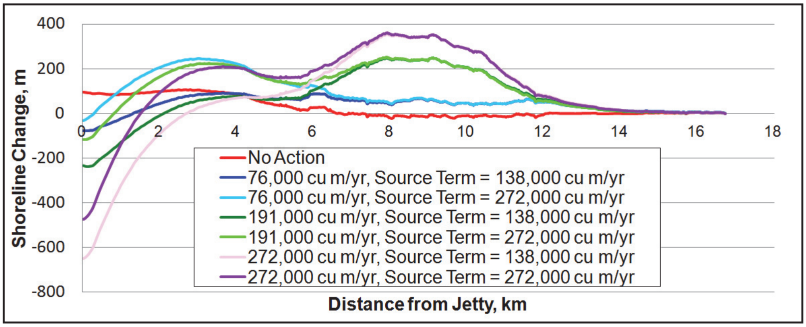

Fig. 8. Total shoreline change after 50 years with 76,000 m^3, 191,000 m^3, and 272,000 m^3 backpassed to Reach 1.

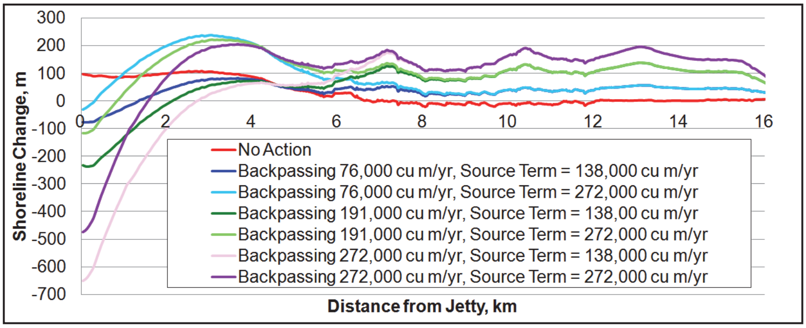

Fig. 9. Total shoreline change after 50 years with 76,000 m^3, 191,000 m^3, and 272,000 m^3 backpassed to Reaches 1 and 2.

Figures 10-12 compare the no action case to beach fill alternatives along the West End. In Figure 10, 15,000 m^3 of sand was placed at each of the four GPB properties every year, 2 years, 5 years, and 10 years for a period of 50 years. Although the shoreline erodes in all cases, placing 15,000 m^3/yr at each property only resulted in about 40 m of erosion after 50 years. Without action, the shoreline is predicted to erode about 80 m. Beach fills of 38,000 and 76,000 m^3 are placed along the first 2.4 km of Reach 3 and all along Reach 3 every 2 years (Figure 11). The only alternative which resulted in shoreline advance anywhere along Reach 3 was the case placing 76,000 m^3 every 2 years along the first 2.4 km of Reach 3. In Figure 12, beach fills of 191,000 and 765,000 m^3 every 2, 5, and 10 years were placed along Reaches 3 and 4. An alternative with an initial beach fill only of 5,275,000 m^3 was compared. Although all of the alternatives reduced the erosion of the no action case, only the alternative with a beach fill of

765,000 m^3 placed every 2 years resulted in shoreline advance along the entire extent of Reaches 3 and 4 after 50 years.

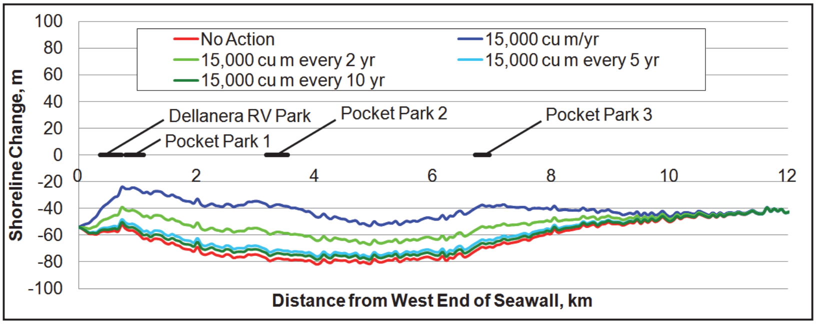

Fig. 10. Total shoreline change after 50 years with 15,000 m^3 placed at each Galveston Park Board property every year, 2 years, 5 years, and 10 years.

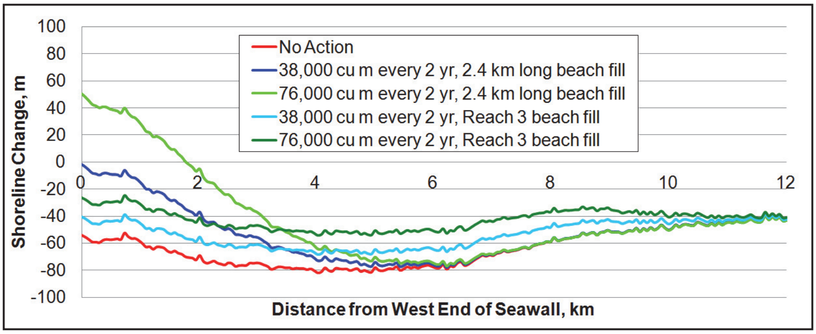

Fig. 11. Total shoreline change after 50 years with 38,000 m^3 and 76,000 m^3 placed along first 2.4 km of West End or along Reach 3.

Figures 13 and 14 illustrate backpassing sand from near San Luis Pass to locations along Reaches 3 and 4. In Figure 13, 38,000 or 153,000 m^3/yr is backpassed to locations along the first 2.4 km of Reach 3 or to locations along Reach 3 for 50 years. An initial beach fill of 1,900,000 m^3 is also compared. When 153,000 m^3/yr is backpassed to locations along Reach 3, the shoreline advances regardless of whether or not an initial beach fill is placed. With an initial beach fill and 38,000 m^3/yr placed along Reach 3, the shoreline only recedes about 25 ft after 50 years. In Figure 14, material is backpassed to multiple locations along Reaches 3 and 4 with and without an initial beach fill of 5,275,000 m^3. If 230,000 m^3/yr is backpassed, the shoreline begins advancing 4 km west of the west end of the Seawall. When 115,000 m^3/yr is backpassed, the shoreline begins advancing at a distance of 8 km west of the west end of the Seawall. If 230,000 m^3/yr is backpassed, the shoreline near San Luis Pass will erode nearly 200 m.

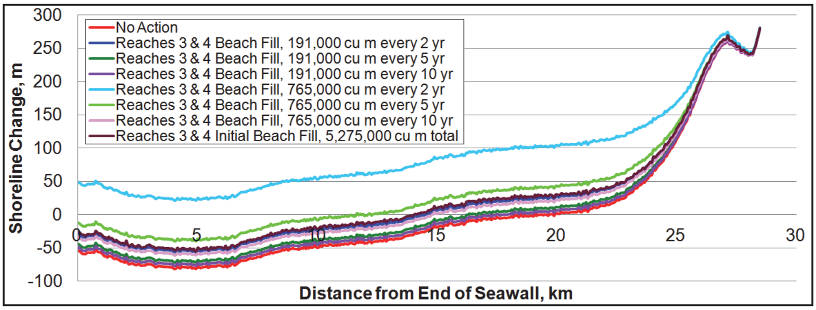

Fig. 12. Total shoreline change after 50 years with an initial beach fill only and 191,000 m^3 and 765,000 m^3 placed along Reaches 3 and 4 every 2, 5, and 10 years.

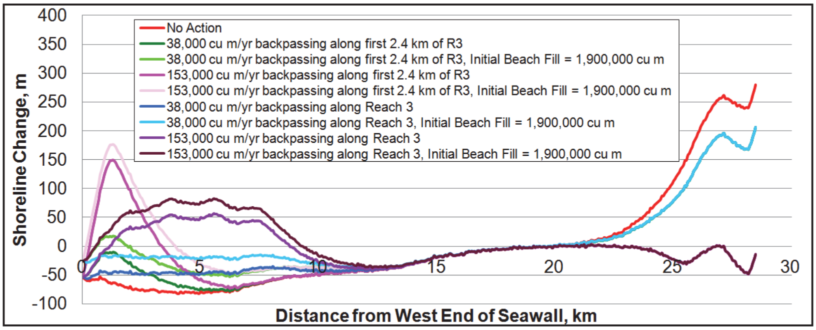

Fig. 13. Total shoreline change after 50 years with 38,000 m^3 and 153,000 m^3 backpassed to the first 2.4 km of the West End and Reach 3 with and without an initial beach fill.

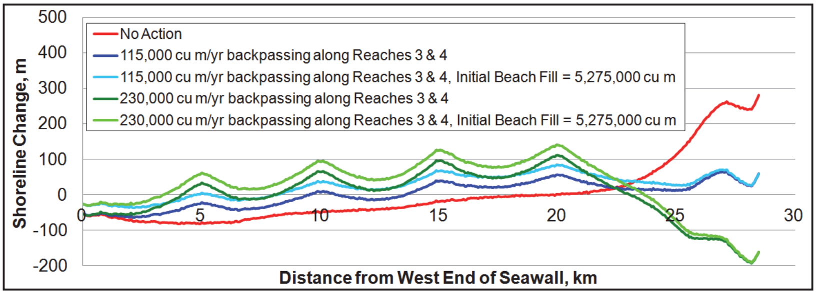

Fig. 14. Total shoreline change after 50 years with 115,000 m^3 and 230,000 m^3 backpassed to Reaches 3 and 4 with and without an initial beach fill.

Sediment Management Plan

The main purpose of this study was to develop a sediment management plan for Galveston Island. The sediment budget was conducted to further understand present conditions and GenCade helped illustrate different alternatives which were used to develop the plan. Table 1 shows an overview of the alternatives.

Table 1. Overview of plan alternatives.

Plan	**Reaches**	**New Material (Offshore or other sources)**	**Management and recycling of existing sand sources and dredge material**	**Perfor-mance moni-toring**	**Notes**
1. Comprehensive beach fill	1, 2, 3, 4, 5	X	X	X	Beach revitalization plan
2. Limited area beach fill	1, 2, 3	X	X	X	Most critical areas only
3. Systematic recycle	1, 2		X		Reuse existing sediment in system without external new sediment
4. Present action plan	1, 2				Reacts to storms or emergencies
5. No action					Baseline

The plans are listed from most comprehensive to least comprehensive. Plan 1 is a beach fill along most of Galveston Island (Reaches 1-5) with systematic maintenance in the form of renourishment and beach monitoring. This includes improved management of existing sand accumulations at East Beach, Big Reef, and San Luis Pass and recycling of dredge material. While this is the most expensive option, it may promote significant development along central and west Galveston Island. Backpassing plants at East Beach and San Luis Pass with sediment pipelines to redistribute sand onto the beaches would be a part of this plan. Plan 2 is similar to Plan 1 except that the beach fill will only be placed in the most vulnerable areas of the island. Reach priority is related to historical rates of erosion and accretion, amount of infrastructure, and the likelihood that a beach fill will be appropriate in the future. Reach 1 is the most likely candidate for future fills while Reaches 5 and 6 are presently accreting and will not require fill unless conditions change. Placing a beach along the eastern end of the Seawall is expected to be a component of any final design plan. Other alternatives falling under Plan 2 include placing material in front of Reaches 1 and 2, in front of the Seawall and Reach 3, and in front of the Seawall and Reach 4. Plan 3 involves recycling and managing the sediment that currently accumulates at East Beach and San Luis Pass. Recycling dredge material for beaches is also involved, but new beach material from offshore sources is not included. Plan 4 continues the present practice of reacting to storms and emergency conditions on an as-needed basis. This plan consists of hauling sand by truck from East Beach to the beaches along the seawall. It does not effectively use the sand already in the system and does not use dredge material from the Galveston Entrance Channel. Plan 5 is no action. Neither Plan 4 nor Plan 5 (No action) is recommended as a long-term strategy for Galveston Island.

As part of the plan, it is necessary to determine where the material for the beaches is to be obtained. The first place to look for sand is offshore deposits. Finkl et al. (2004) investigated offshore sediments near Galveston Island and only found limited pockets of sand. Heald Bank, approximately 55 km away, contains about 450,000,000 m^3 of sediment while Sabine Bank, which is twice as far away, consists of 920,000,000 m^3 of beach quality sand (Morton and Gibeaut 1995). The Galveston Entrance Channel is dredged on a regular basis. It is a good regional sediment strategy to use that material along Galveston Island. Truckhaul backpassing from East Beach to the Seawall is a proven technology and generally understood. In addition, a pipeline backpassing system is a key component of most of the plans. If material is only placed along the Seawall, a backpassing plant is only necessary at East Beach. If a plan that includes the West End is chosen, a second backpassing plant is necessary near San Luis Pass.

Summary and Conclusions

The main purpose of this study was to develop a 50-year sand management plan for Galveston Island. Based on the sediment budget and GenCade simulations, initial beach fills and backpassing plants on both ends of the island are the best strategies to widen the beaches of Galveston Island, improve tourism, and better protect the island from storms. If there are funding restrictions or limited sand sources, more localized beach fills could be constructed to keep the future beaches similar to the existing ones. Before a plan is finalized, it is recommended that the rate of material moving onshore at East Beach be studied in further detail, a beach profiling program be initiated, and wind-blown transport be reevaluated.

Acknowledgements

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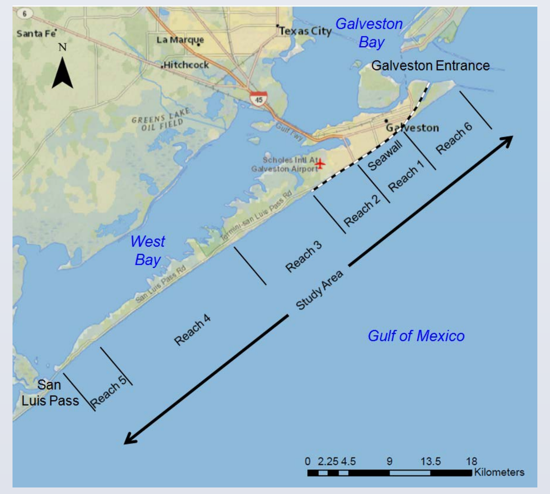
BUILDING STRONG

ABSTRACT

Galveston Island is a major tourist and commercial center on the Gulf of Mexico at the mouth of Galveston Bay, Texas, USA. The shoreline along the Galveston Seawall regularly requires beach nourishment while the beach west of the Seawall has severely eroded. In order to protect the island and ensure it is available for generations to come, a 50-year sediment management plan was developed. A sediment budget using the Sediment Budget Analysis System was calculated and numerous alternatives were simulated with GenCade, a shoreline change and sand transport model. Finally, several alternatives ranging from no action to a comprehensive beach fill and backpassing system were evaluated as part of the sand management plan.

INTRODUCTION AND BACKGROUND

1. Study Area ~ 47 km long; Reach 1 is highest priority; Reach 6 is lowest priority



2. Sediment Budget Analysis System (SBAS)

SBAS provides a framework for formulating, documenting, and calculating sediment budgets

SBAS sediment budget equation (Rosati and Kraus 2001, rev 2003)

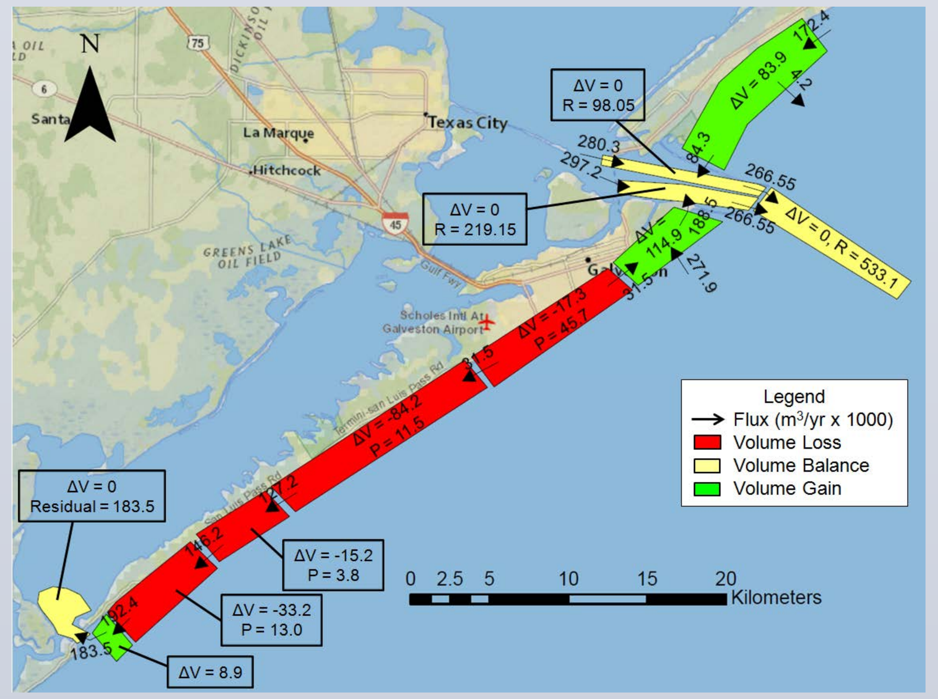
$$\Sigma Q_{source} - \Sigma Q_{sink} - \Delta V + P - R = Residual$$

ΣQ_{source}, ΣQ_{sink} = sources and sinks to the cell; ΔV = volume change rate within a cell; P = volume rate placed; R = volume rate removed; *Residual* = degree to which a cell is balanced

3. GenCade is a one-line shoreline change, sand transport, and inlet sand-sharing model (Frey et al. 2012) which combines the project-scale, engineering-design level calculations of GENESIS (Hanson and Kraus 1989) with the regional-scale, planning-level calculations of Cascade (Larson et al. 2003).

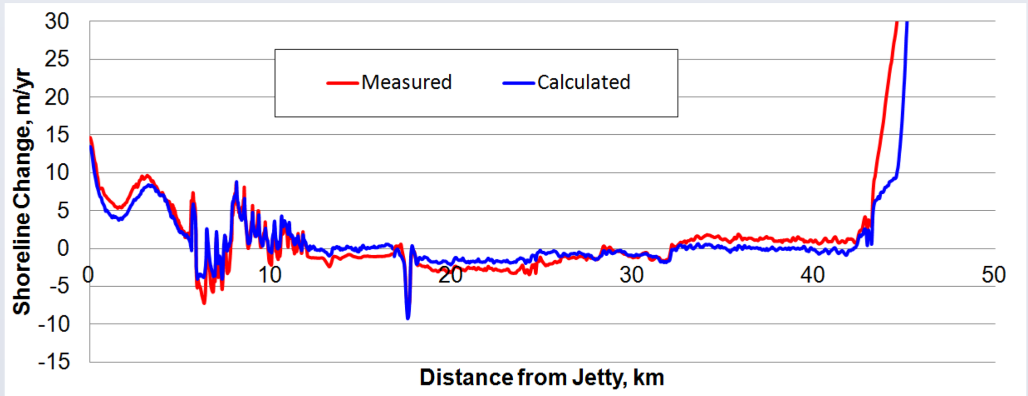
RESULTS: SEDIMENT BUDGET

- Updated from Morang (2006)
- Budget consists of 11 cells and pre-Hurricane Ike conditions
- 271,900 m^3/yr moving onshore needed to balance cell near jetty; sand may be coming from offshore disposal area (USACE 1993) or other source



RESULTS: GENCADE CALIBRATION

- Two grids used to improve results near west end of Seawall and increase efficiency
- Initial shoreline = 1995; calibrated to 2000 shoreline
- Cell spacing between 15 and 60 m
- Galveston Seawall, groins, and beach fills included in simulation
- Waves (Wave Information Study (WIS) Station 73070 and WIS 73067)
- Source term of 271,900 m^3/yr added near South jetty (from sediment budget)
- Longshore sand transport calibration coefficients: K1 = 0.4, K2 = 0.2



SAND MANAGEMENT OPTIONS

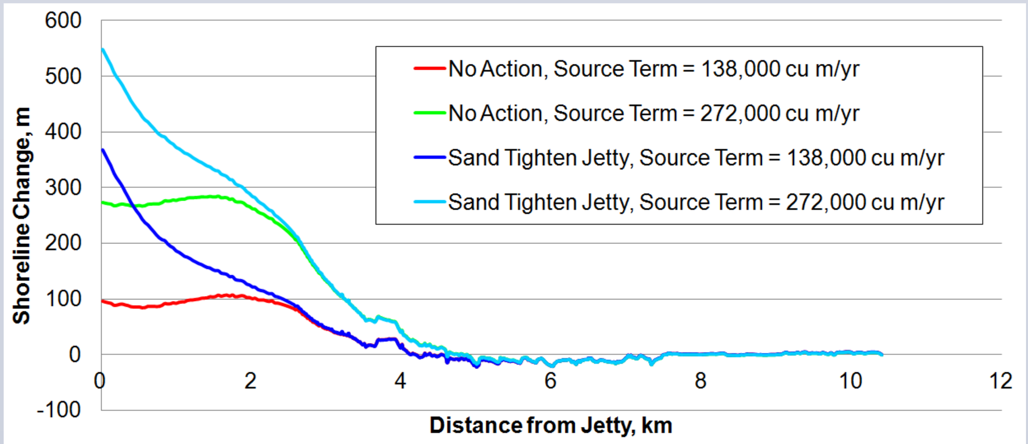
Sand borrow sources:
- East Beach (300,000 m^3)
- Big Reef (1,100,000 m^3)
- Heald Bank (55 km offshore = 585,000,000 m^3)
- Sabine Bank (110 km offshore = 1,200,000,000 m^3)

Options to recycle sand:
- East Beach deposition basin (up to 136,000 m^3/yr)
- Reduce transmission through South jetty*
- Reduce wind-blown sand (~ 45,000-60,000 m^3/yr)
- Sand Backpassing*

* Modeled with GenCade

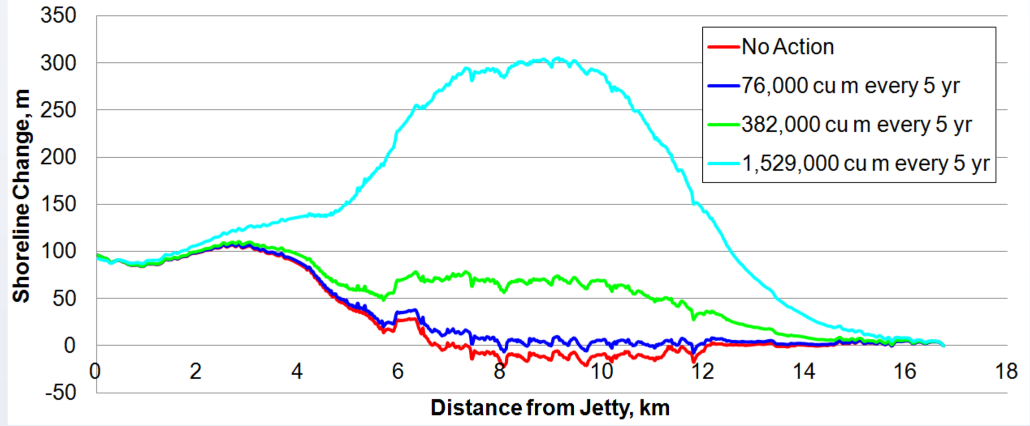
RESULTS: GENCADE ALTERNATIVES

1. Seawall (Reaches 6, 1, and 2)
- No action and sand tightening jetty with onshore Source term of 272,000 m^3/yr and Source term of 138,000 m^3/yr (future rate of sand moving onshore could decrease; more studies needed)

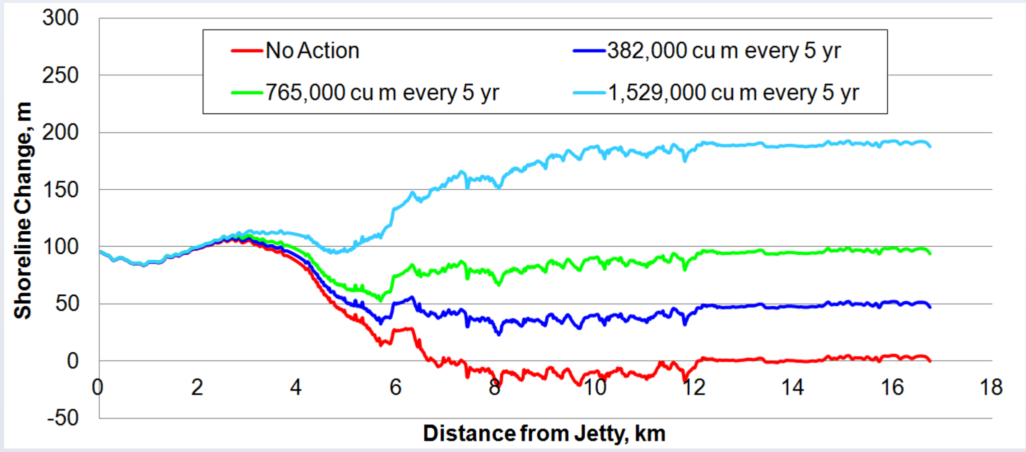


RESULTS: GENCADE ALTERNATIVES

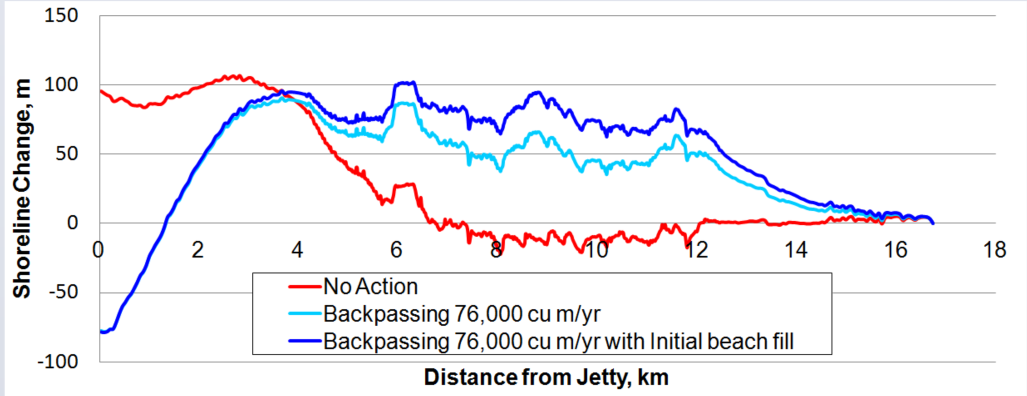
- Beach Fills
  - Reach 1 placement every 5 years (Source term = 138,000 m^3/yr)



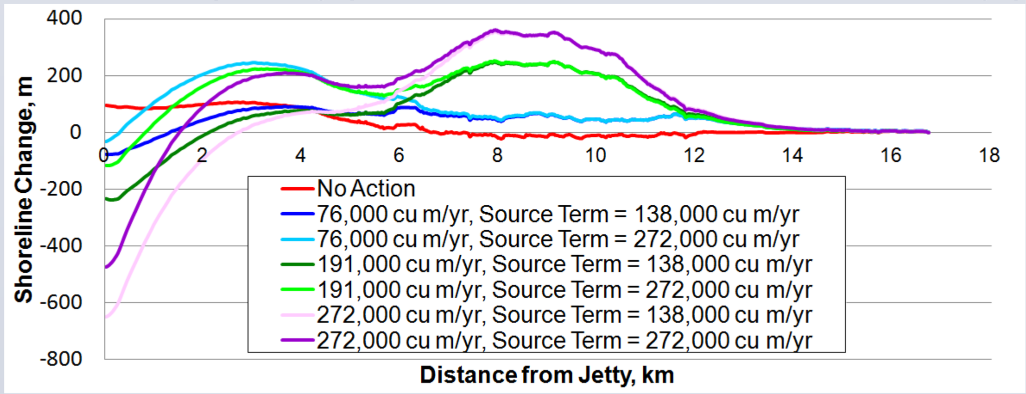
  - Reaches 1 and 2 placement every 5 years



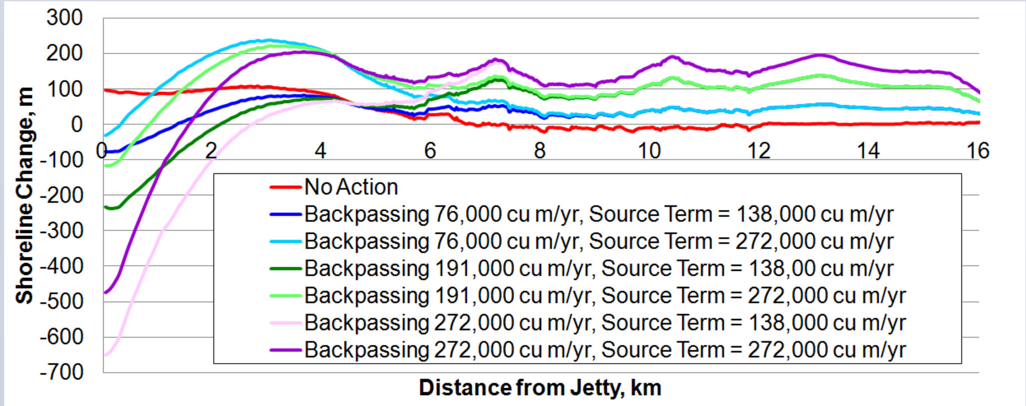
- Backpassing
  - Reach 1 backpassing with/without 1,485,000 m^3 initial beach fill



  - Reach 1 backpassing (Source term = 138,000 or 272,000 m^3/yr)

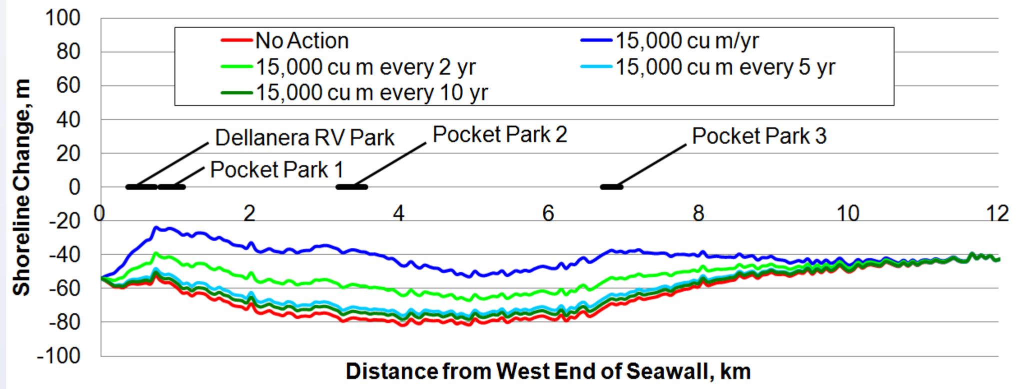


  - Reach 1 and 2 backpassing (Source term = 138,000 or 272,000 m^3/yr)

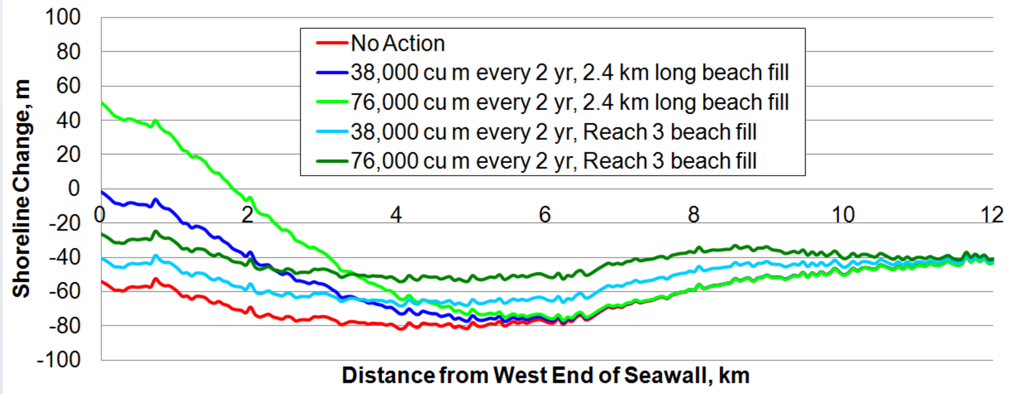


RESULTS: GENCADE ALTERNATIVES

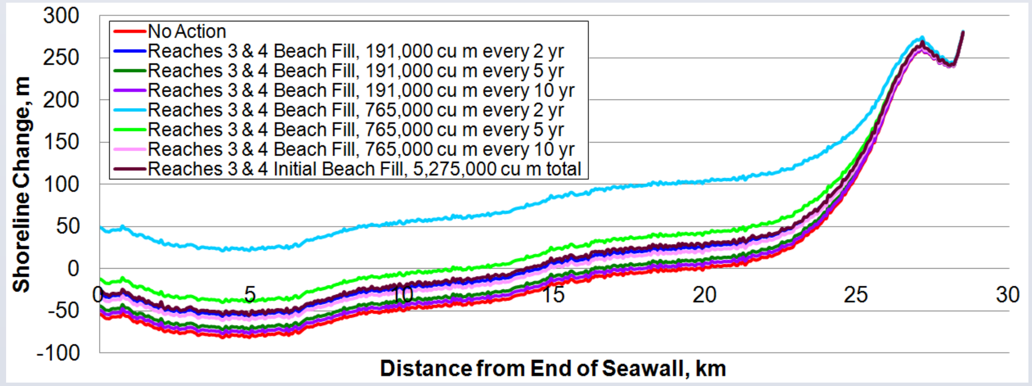
2. West End (Reaches 3, 4, and 5)
- Beach Fills
  - Placement on Galveston Park Board properties only



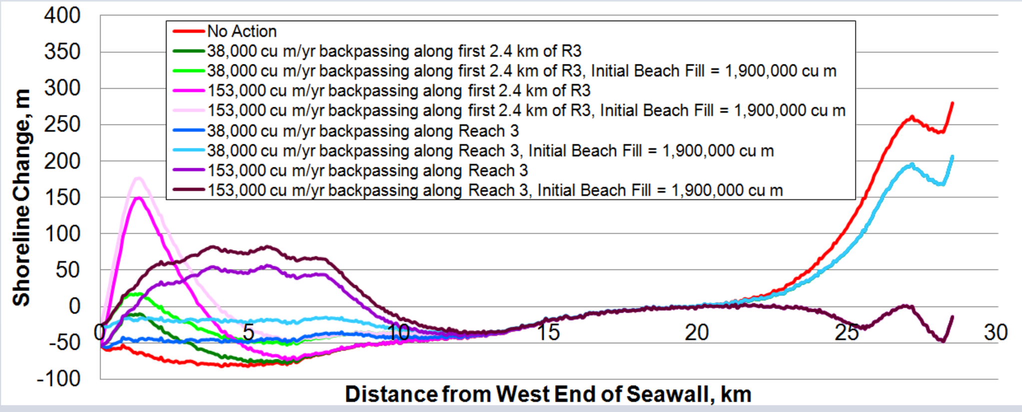
  - Placement on first 2.4 km of West End or Reach 3 every 2 years



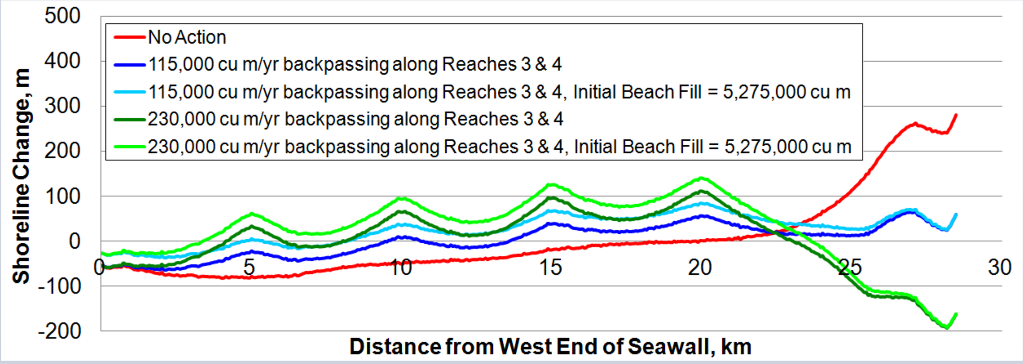
  - Placement on Reaches 3 and 4 every 2, 5, and 10 years



- Backpassing
  - Backpassing along first 2.4 km of West End or Reach 3; with/without 1,900,000 m^3 initial beach fill



  - Backpassing along Reaches 3 and 4; with/without 5,275,000 m^3 initial beach fill



SEDIMENT MANAGEMENT PLAN

Plan (Most to least comprehensive)	Reaches	New Material (Offshore or other sources)	Management and recycling of existing sand sources and dredge material	Perfor-mance moni-toring	Notes
Comprehensive beach fill & backpassing	1, 2, 3, 4, 5	X	X	X	Beach revitalization plan
Limited area beach fill & backpassing	1, 2, 3	X	X	X	Most critical areas only
Systematic recycle	1, 2		X		Reuse existing sediment in system without external new sediment
Present action plan	1, 2				Reacts to storms or emergencies
No action					Baseline

SUMMARY AND CONCLUSIONS

The main purpose of this study was to develop a 50-year sand management plan for Galveston Island. Based on the sediment budget and GenCade simulations, initial beach fills and backpassing plants on both ends of the island are the best strategies to widen the beaches of Galveston Island, improve tourism, and better protect the island from storms. If there are funding restrictions or limited sand sources, more localized beach fills could be constructed to keep the future beaches similar to the existing ones. Before a plan is finalized, it is recommended that the rate of material moving onshore at East Beach be studied in further detail, a beach profiling program be initiated, and the magnitude and direction of wind-blown transport be quantified.

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