Galveston Island Sand Management Plan

Ashley Frey

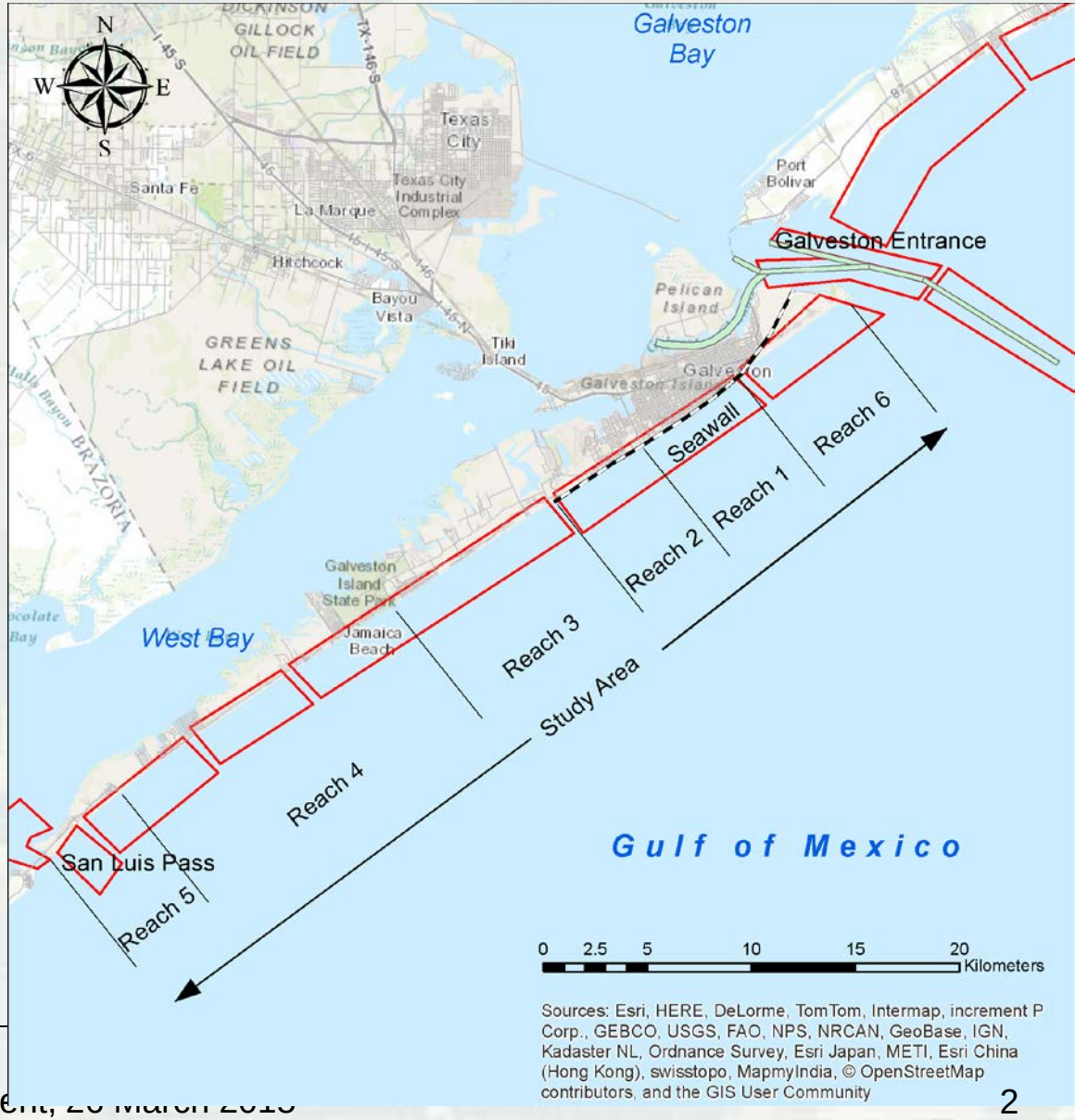
Coastal & Hydraulics Laboratory
Engineer Research & Development Center

26 March 2015

US Army Corps of Engineers
BUILDING STRONG®

Outline

- Problem Statement and Approach
- Sediment Budget
- GenCade Calibration
- Sand Management Options
- GenCade Alternatives
- Sand Management Alternatives and Plan
- Summary and Final Thoughts



Problem Statement/Approach

Recommend a long-term plan of actions to better manage sands on Galveston Island

Initial Tasks – Understand physical processes

- Update sediment budget
- Update shoreline change model

Final Tasks

- Evaluate potential solutions/actions
- Formalize and document Galveston Island Sand Management Plan

Sediment Budget Objectives

- Identify sources and sinks of sediment in coastal system
  - Beach fills
  - Littoral and offshore sources
  - Dredge data
- Compute quantities
- Determine direction of movement using morphologic evidence
- Evaluate sand management alternatives to reduce costs and improve beach resources

Sediment Budget Procedure

- Organize data (previously-assembled and new)
- Assemble GIS project, import data
- Tabulate dredging and fill statistics
- Modify budget cells along coast (from 2006 study)
- Tabulate sources and sinks
- Balance cells

Sediment Budget Equation

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

Where:

Q_{source} and Q_{sink} = sources and sinks to each cell

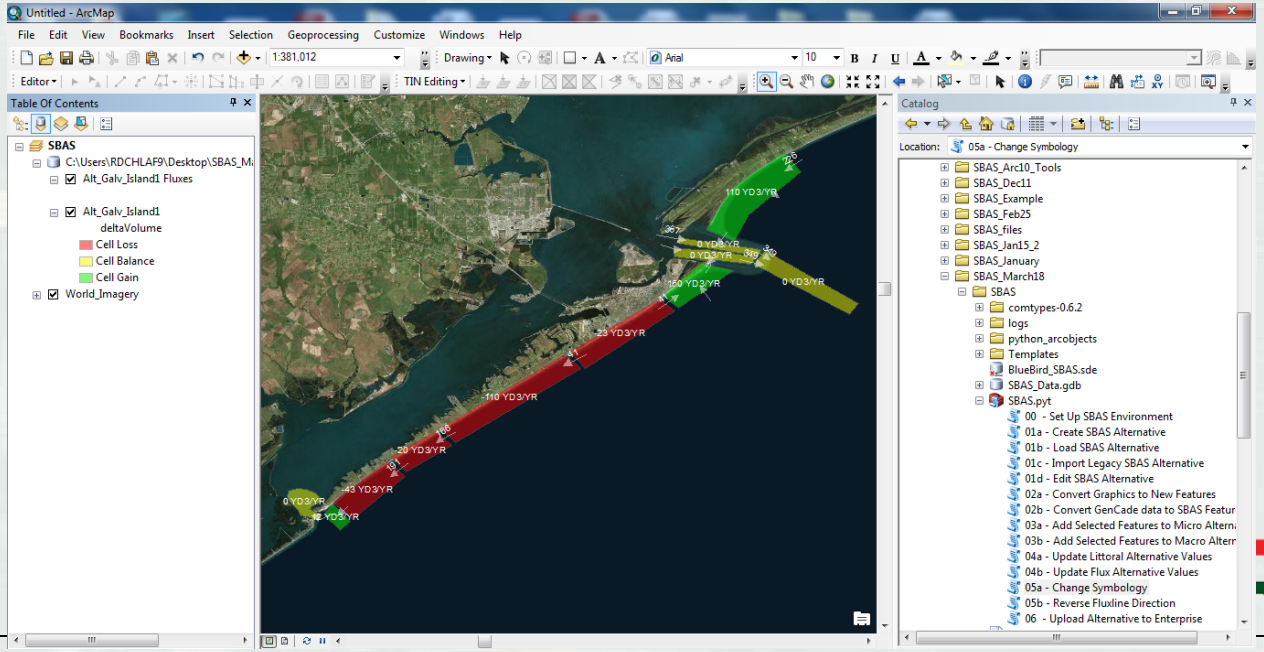
ΔV = net change in volume in each cell

P = material placed (beach fill)

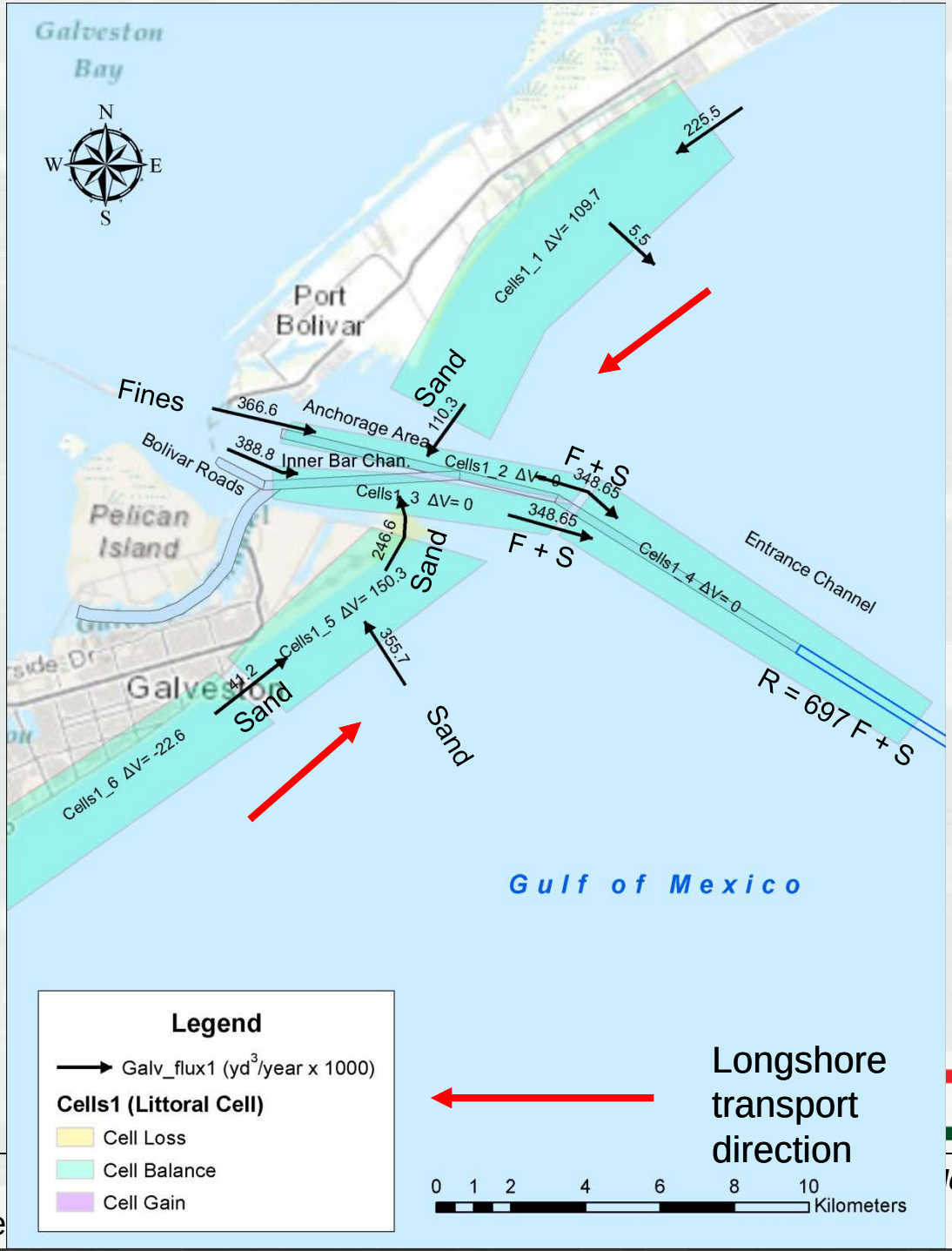
R = material removed (dredging)

Sediment Budget Analysis System (SBAS)

- Provides a framework for formulating, documenting, and calculating sediment budgets
- Available in ArcGIS or as a stand-alone PC program
  - New SBAS version in ArcGIS is available through the RSM website (rsm.usace.army.mil; under Tools and Databases)



Galveston Entrance



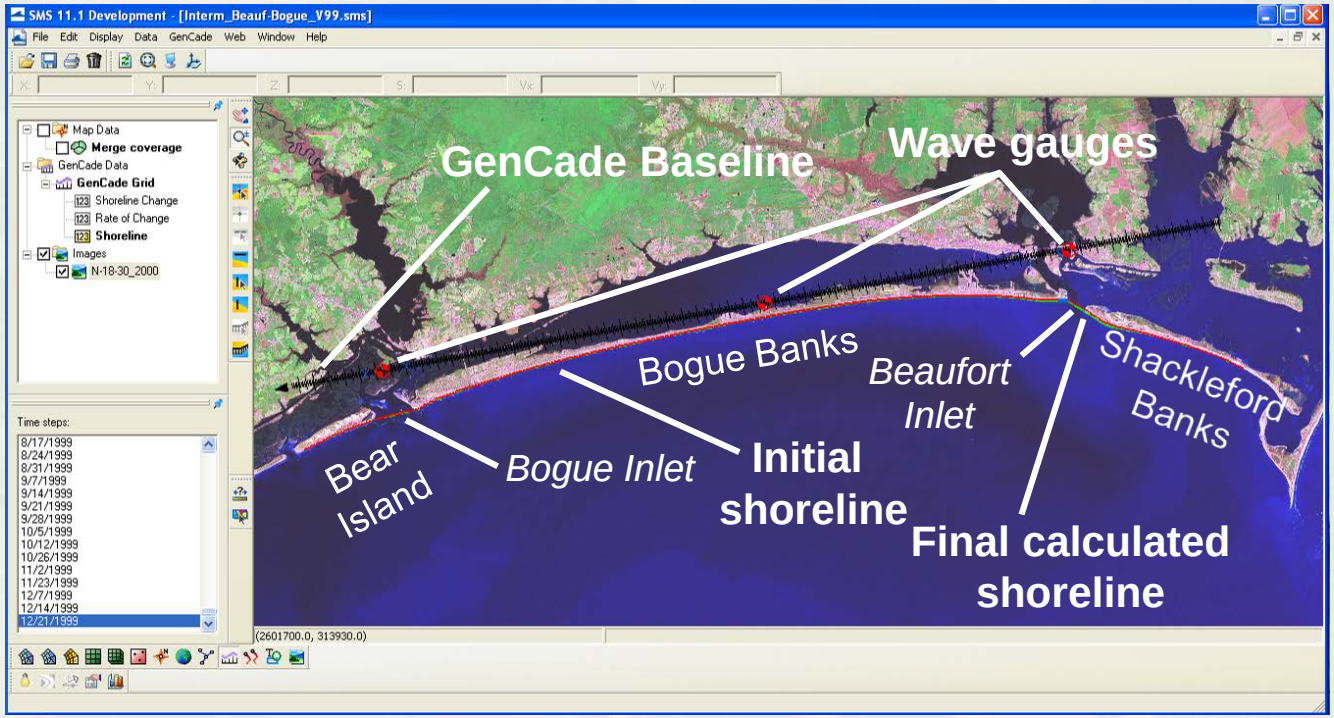
Central Galv. Island

San Luis Pass

GenCade Modeling

Purpose:

- Assess shoreline change and longshore transport
- Evaluate sediment management solutions

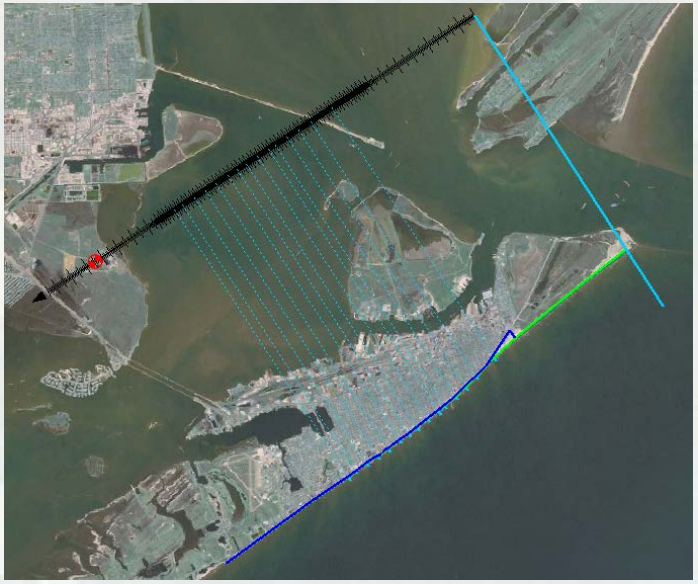


GenCade Calibration

GenCade Input:

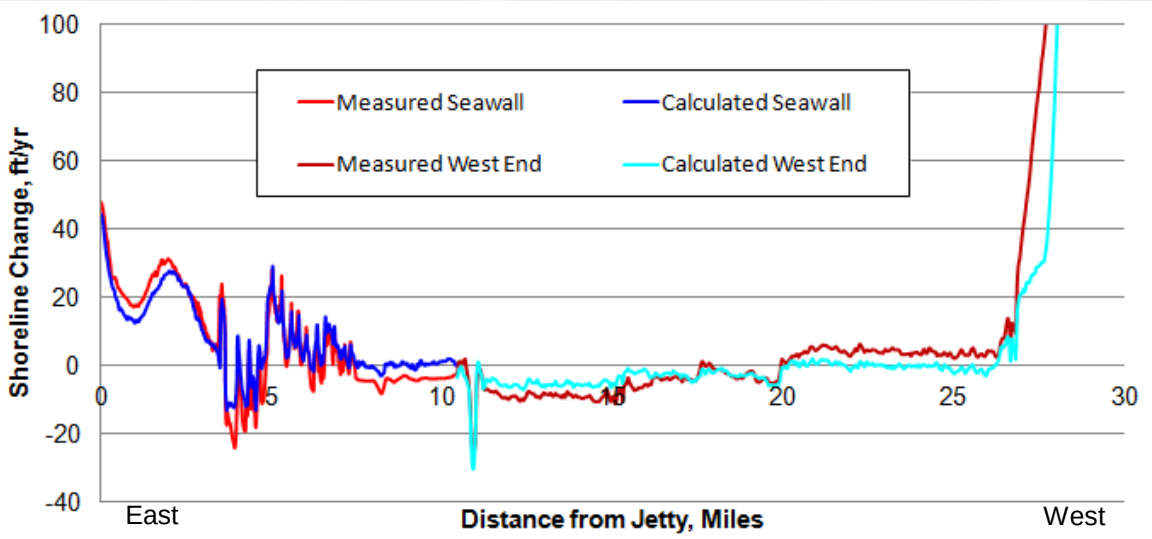
- Two separate grids were used in order to improve results near the west end of the seawall and increase efficiency
- 1995 and 2000 shorelines
- Historical shorelines averaged and smoothed to create regional contour
- Cell spacing ranging from 50 ft (near groins) to 200 ft
- Galveston seawall, groins, and beach fills
- Waves (WIS 73067, 73070)

GenCade Calibration



Parameter	Value
Start Date	1/1/1995 0:00
End Date	12/31/1999 0:00
Time Step	0.1 hr
Recording Time Step	168 hr
Effective Grain Size, mm	0.17
Average Berm Height, ft	4
Average Depth of Closure, ft	20
Left Lateral Boundary Condition, Seawall Grid	Gated
Right Lateral Boundary Condition, Seawall Grid	Pinned
Left Lateral Boundary Condition, West End Grid	Moving, -18 ft
Right Lateral Boundary Condition, West End Grid	Moving, 780 ft
K1	0.4
K2	0.2
ISMOOTH	11

GenCade Calibration: Shoreline Change Statistics



Cell	Average Shoreline Change, ft/year		RMS Error, ft/year	Brier Skill Score
	Measured	Modeled		
Jetty to first groin	18.2	15.1	3.8	0.96
Groin field	1.6	5.5	5.0	0.82
Seawall west of groin field	-3.4	0.5	4.0	0.87
West end (to 13 Mile Rd)	-8.1	-5.2	3.6	0.84
13 Mile Rd. to Jamaica Beach	-3.3	-2.9	1.3	0.87
Jamaica Beach	-0.7	-1.5	1.1	-0.27
Jamaica Beach to Indian Beach	-3.3	-3.4	0.9	0.94
Indian Beach to Sea Isle	4.1	0.5	3.8	0.22
Sea Isle area	3.6	-0.4	4.1	-0.23
West end 1	5.7	-1.2	4.7	0.54
West end 2	91.3	50.0	45.5	0.79

Sediment Management Options

Identify sand sources

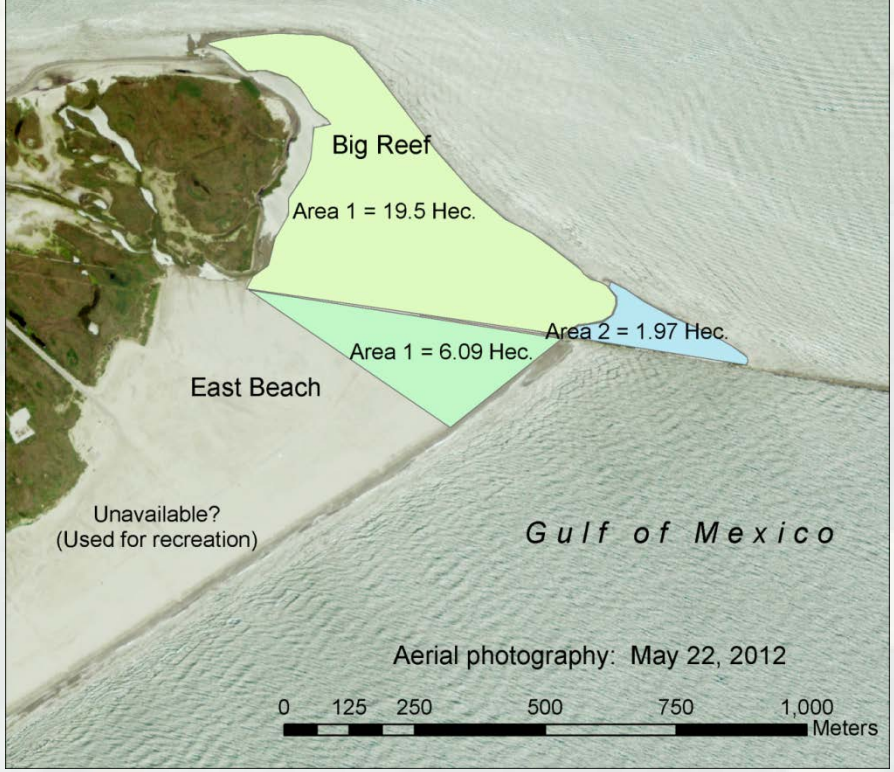
- Big Reef
- East Beach
- Offshore

Options

- Deposition basin off East Beach
- Reduce trans. through S. jetty
- Reduce Aeolian sand transport
- Sand backpass system

Sand Sources at Big Reef and East Beach

Big Reef and East Beach east of Boddeker Rd (without recreational or environmental restrictions) = 2+ million yd^3
(Incl. offshore Big Reef: 3+ million yd^3)



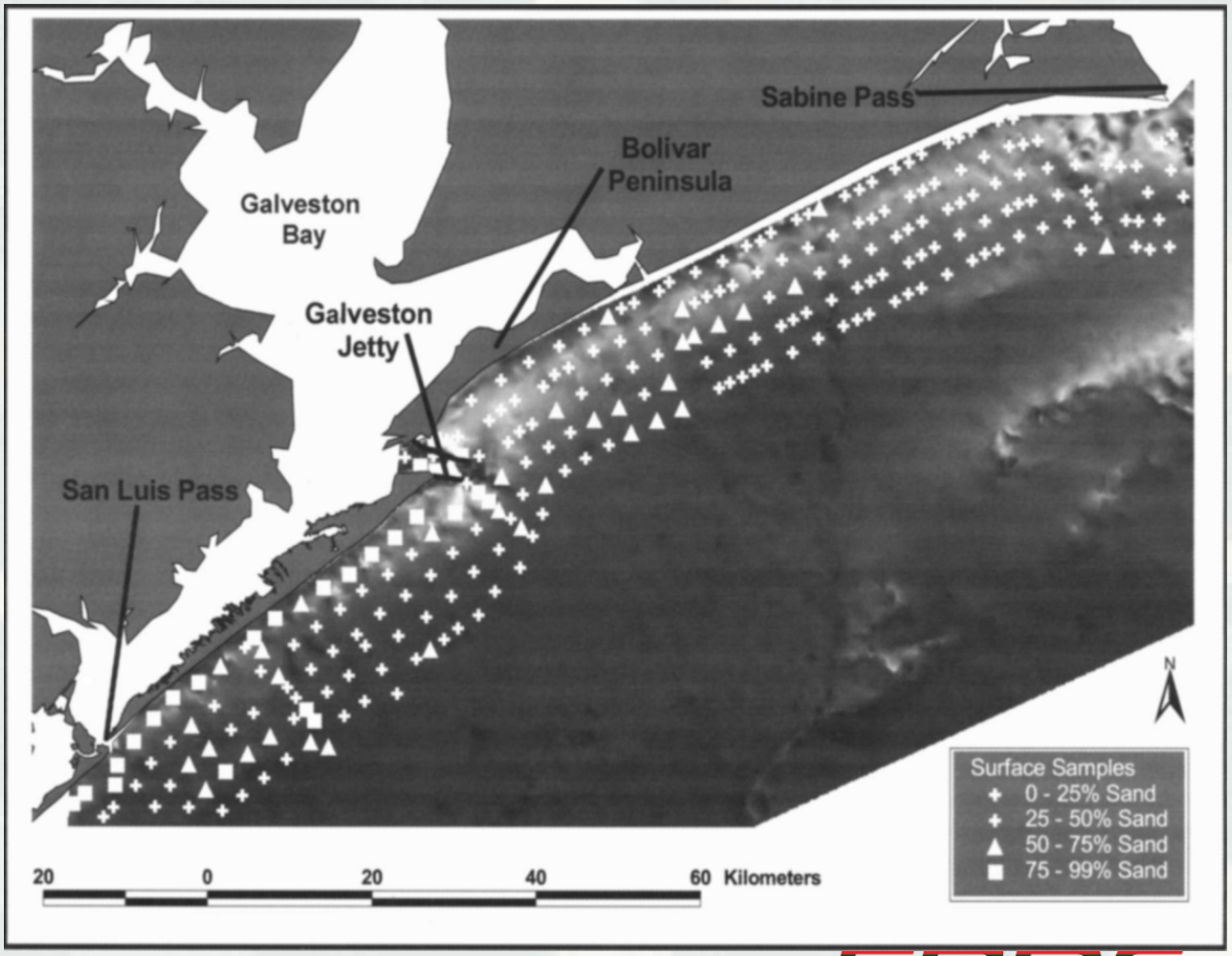
Potential Big Reef Mining Volumes

Polygon	Area (yd^2)	Vol. 1.1 yd layer (yd^3)	Vol. 2.2 yd layer (yd^3)	Vol. 5.5 yd layer (yd^3)
Big Reef Area1	231,900	255,100	510,100	1,275,300
Big Reef Area2	23,450	25,800	51,400	128,600
East Beach Area1	72,450	79,700	159,300	398,300
Total	327,800	360,600	720,800	1,802,200

Offshore Sand Sources

Heald Bank:
approximately 35 mi offshore with
~ 765,000,000 yd^3

Sabine Bank:
approximately 70 mi offshore with
~ 1,600,000,000 yd^3



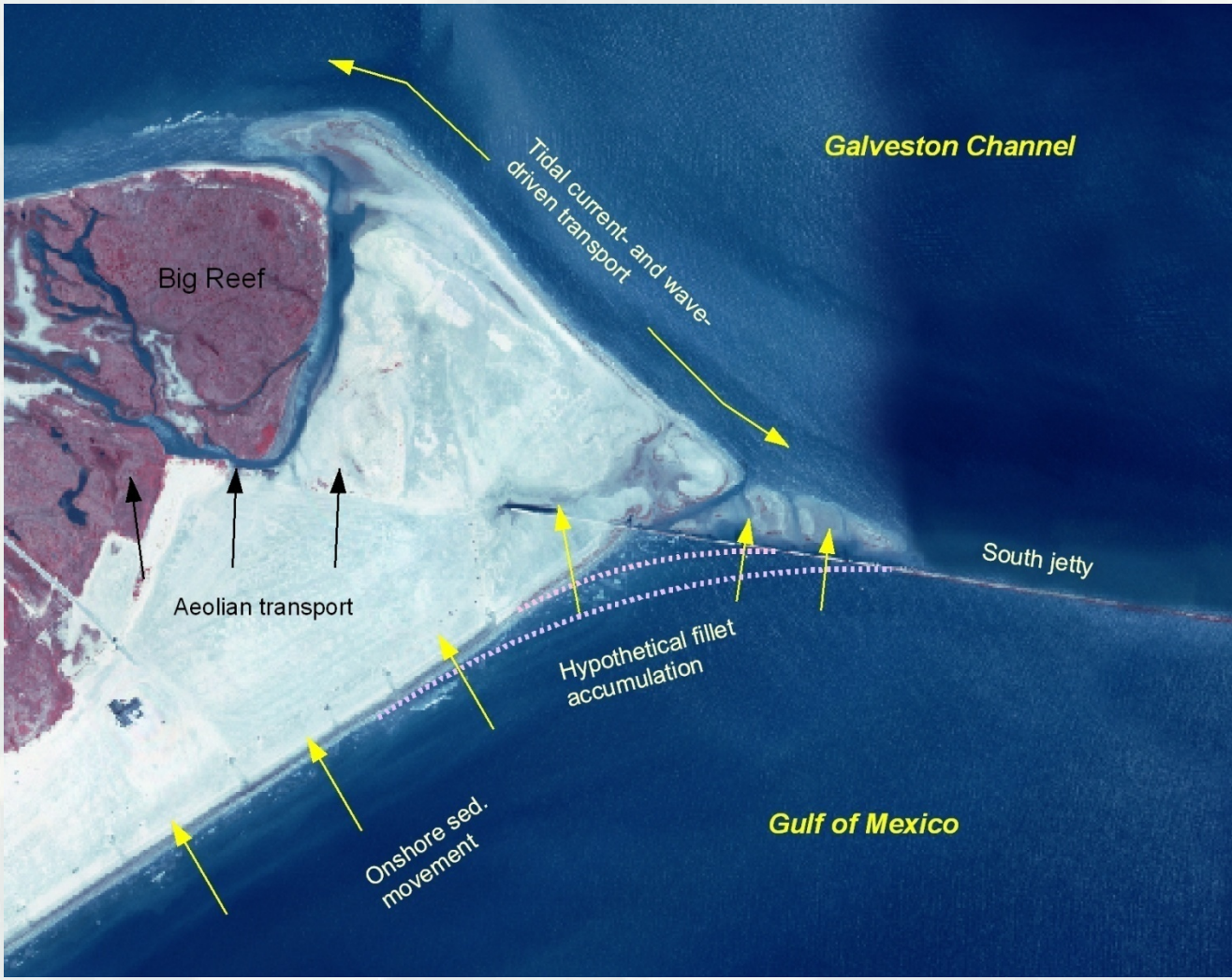
Deposition Basin off East Beach

Sediment Basin Parallel to East Beach

East beach coverage (percent)	Length (yd)	1 yd depth initial volume (yd^3)	2 yd depth initial volume (yd^3)	Annual vol. trapped at 50% efficiency (yd^3) (based on sed. budget)
50	3000	450,000	900,000	90,000
75	4500	675,000	1,350,000	135,000
100	6000	900,000	1,800,000	180,000

Note: Initial dredged volume based on basin 150 yd wide

Reduce transmission through South Jetty



Options:

- Grout
- Geotube
- Sheetpile

Need to be mined regularly

Reduce Wind-Blown Sand

Options:

- Moisture
- Mechanical traps (fencing)
- Vegetation
- 22,000 ft fence or oats = 60-80,000 yd^3/year

Sand Back-Passing/ Pumping

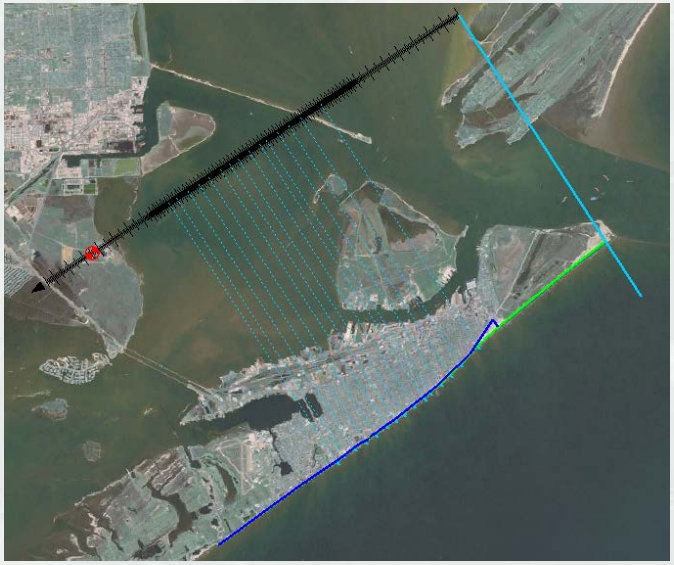
Design:
- Annual vol.
- Intake location
- Distance
- Intake equipment
  - Movable
  - Fixed plant
- Outlets

Advantages:
- No trucks
- Steady use most of year
- Electric supply
- Paved roads
- No need to cross water

Note: similar plant at San Luis Pass not shown

GenCade Alternatives

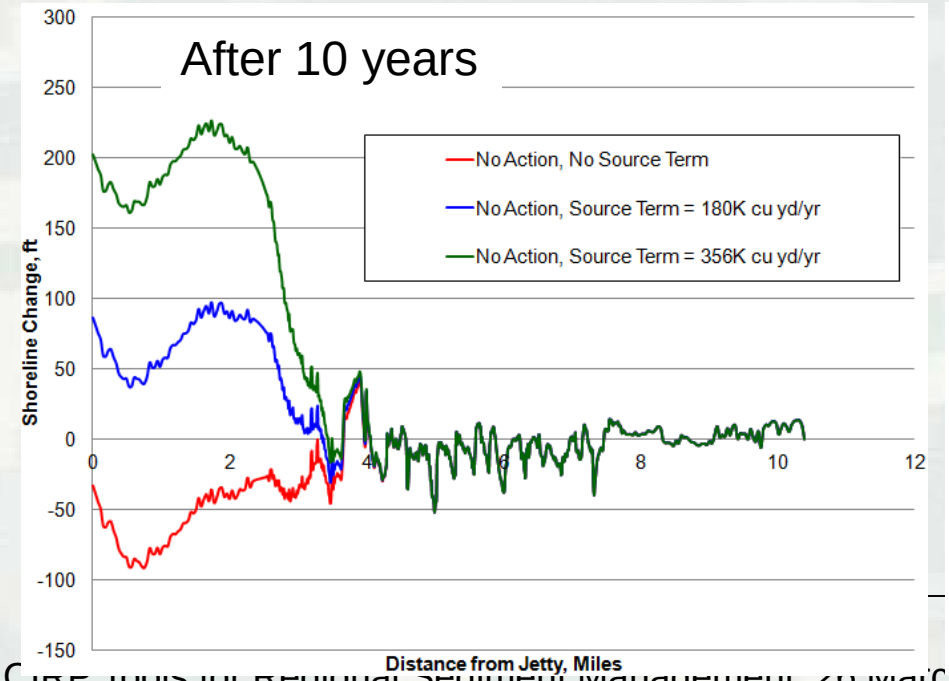
- No Action
- Groin modification
- Sand tighten jetty
- Beach fills
- Backpassing

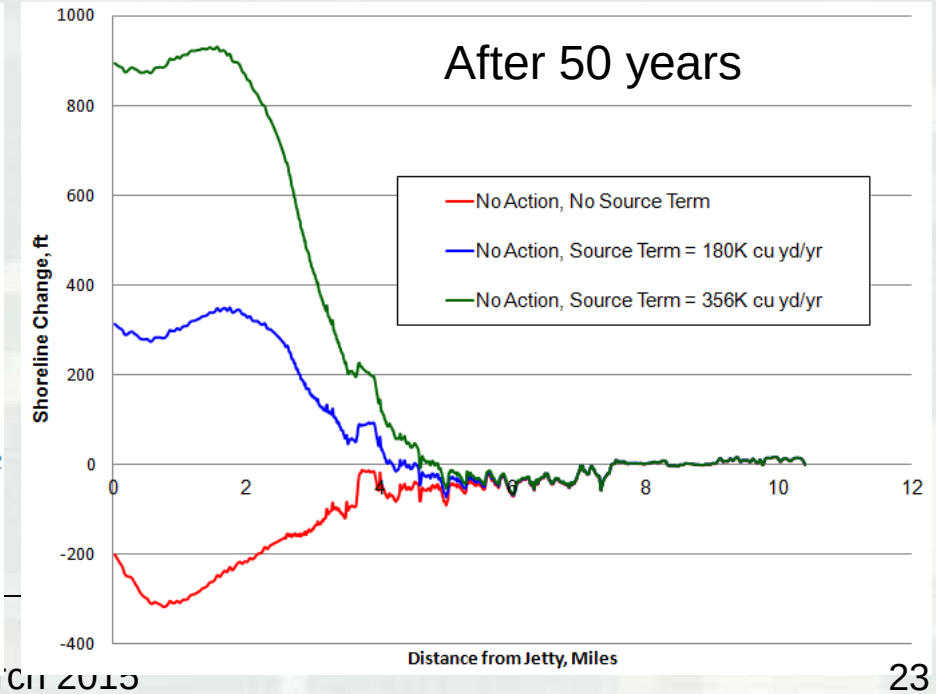


No Action (Along Seawall)

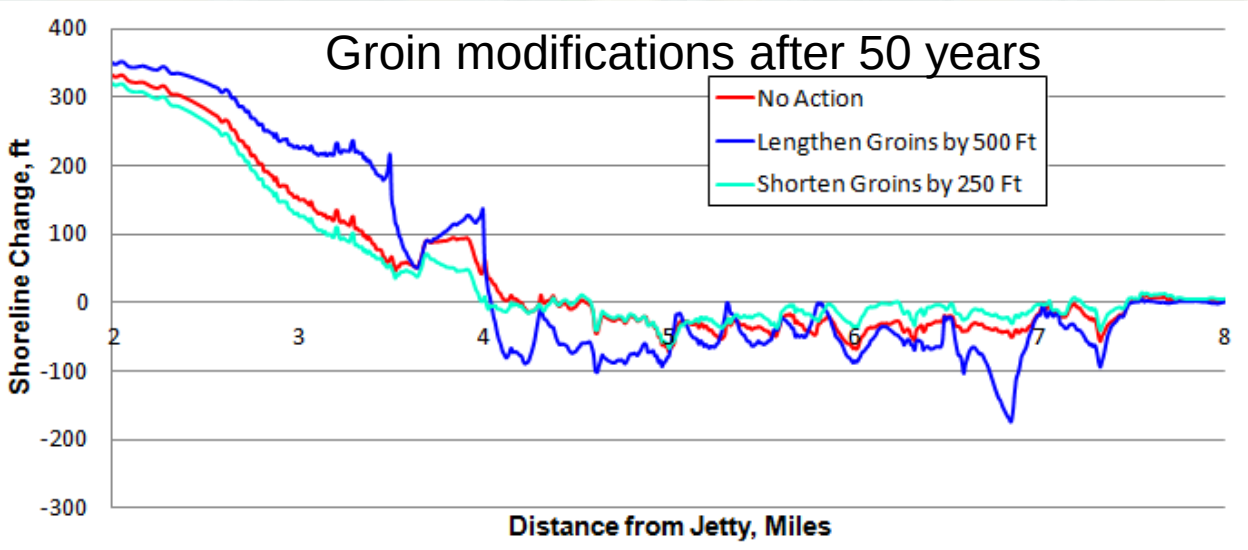
Simulated in order to compare to alternatives

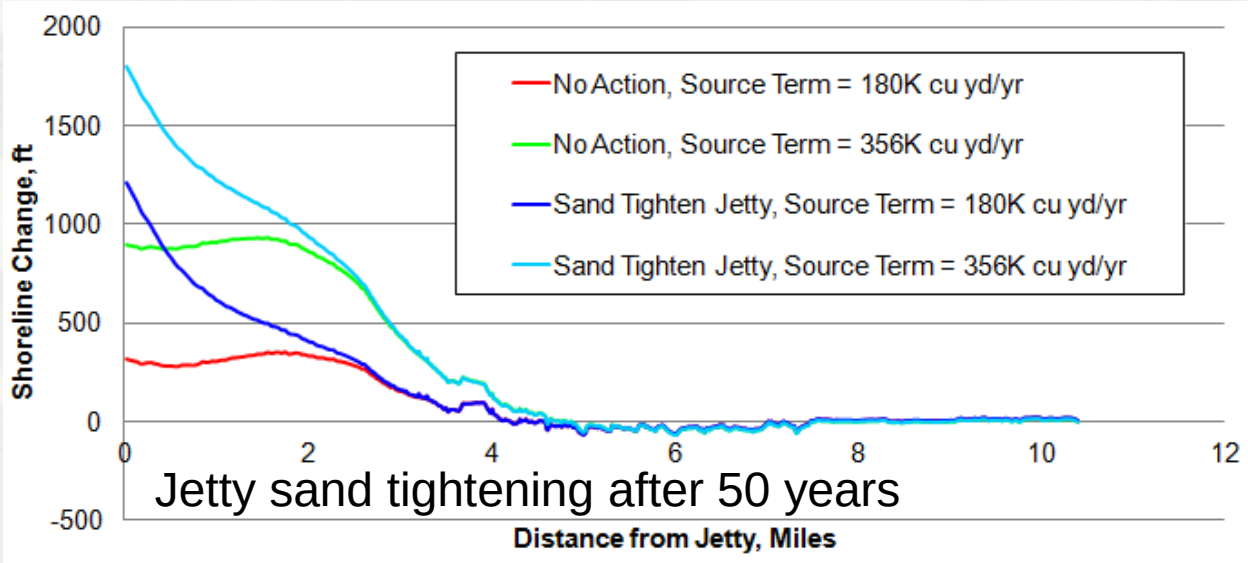
Rate of material moving onshore near jetty significantly impacts shoreline position





Structural Alternatives

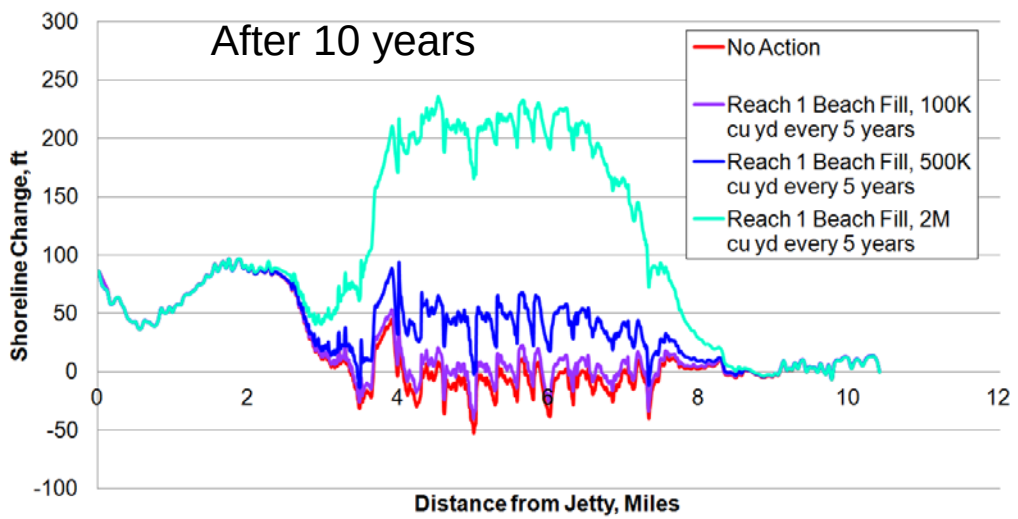


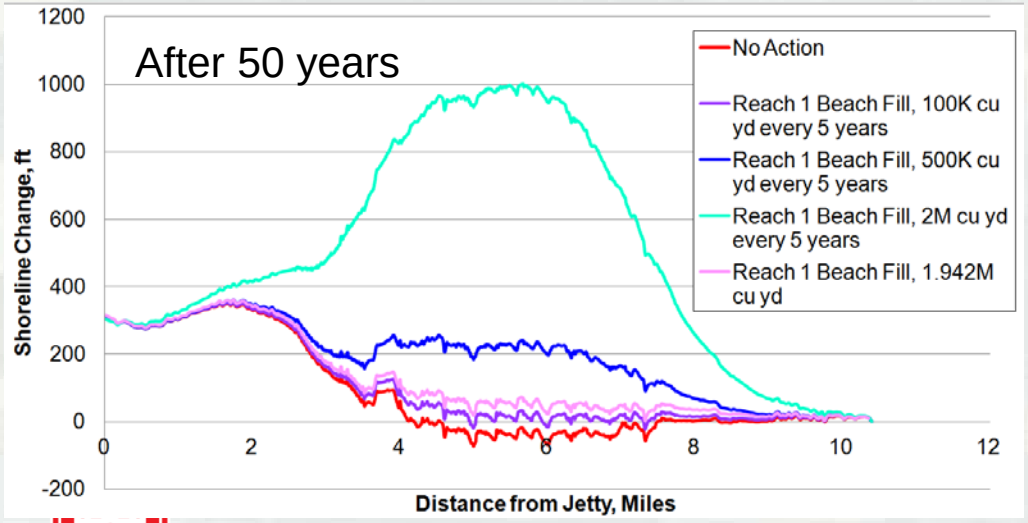


- Lengthening, shortening, or removing groins makes little difference in shoreline position after 50 years
- If a beach fill is also constructed, shortened or existing groins will mostly be buried
- Sand tightening the jetty advances the shoreline significantly and provides more material for backpassing and beach fills

ERDC

Beach Fill Alternatives (Seawall)

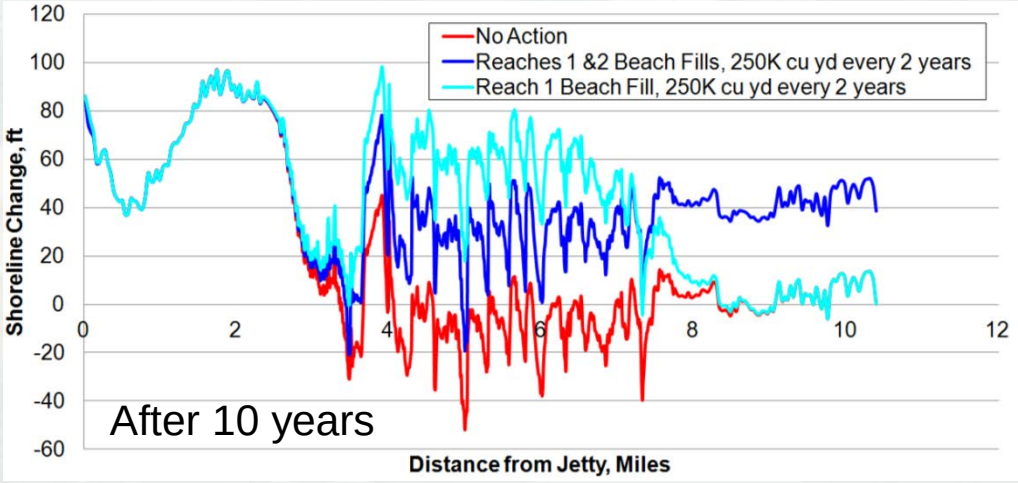


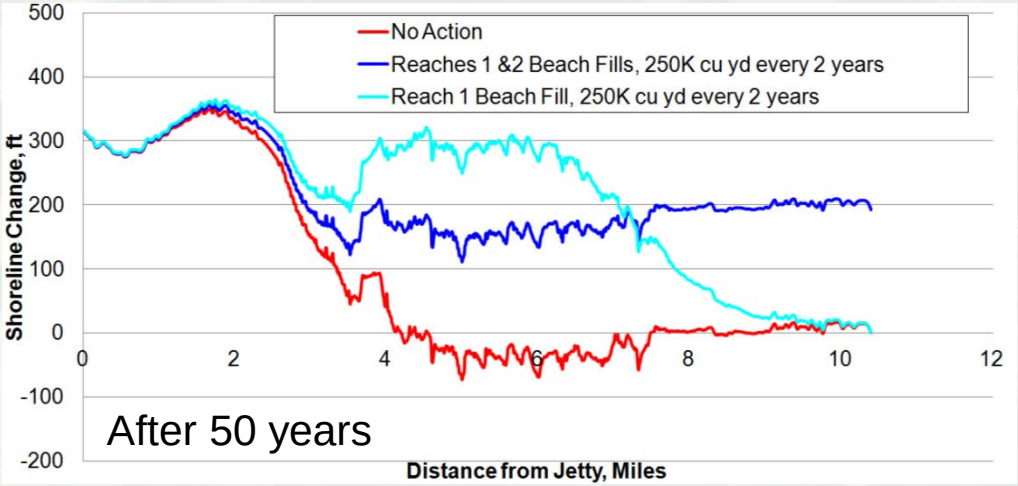


100,000 yd^3, 500,000 yd^3 and 2,000,000 yd^3 placed every 5 years in Reach 1

- Renourishment volume equal to initial fill volume
- 100,000 yd^3 every 5 years is enough to keep beach similar to present conditions
- 500,000 yd^3 advances beach 200 ft after 50 years
- Material not taken from near jetty (either channel dredging or offshore)

Beach Fill Alternatives (Seawall)

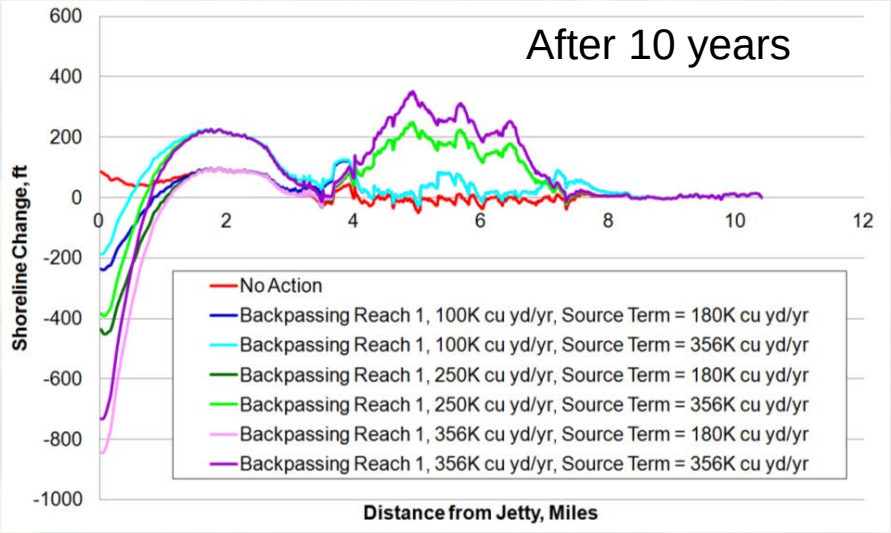


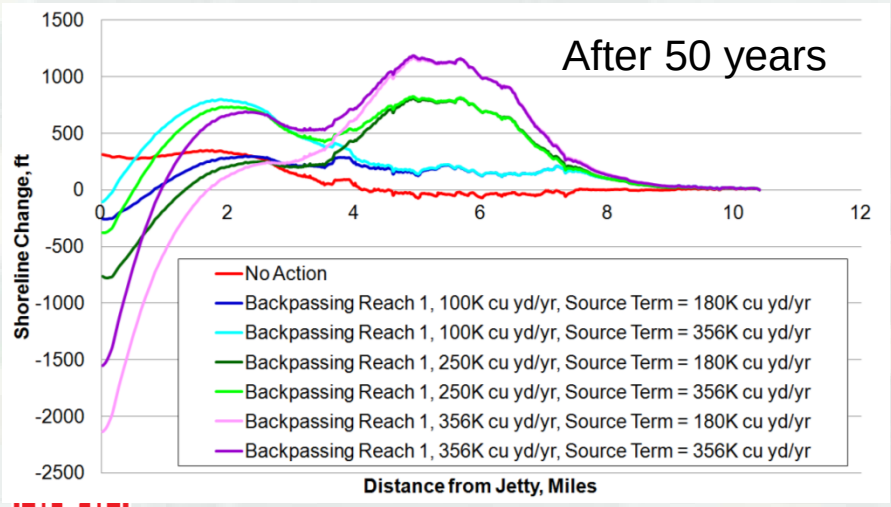


250,000 yd^3 every 2 years

- Comparing material placed only on Reach 1 versus placement on Reaches 1 and 2
- 6,250,000 yd^3 placed in 50 years
- Material not taken from near jetty (either channel dredging or offshore)

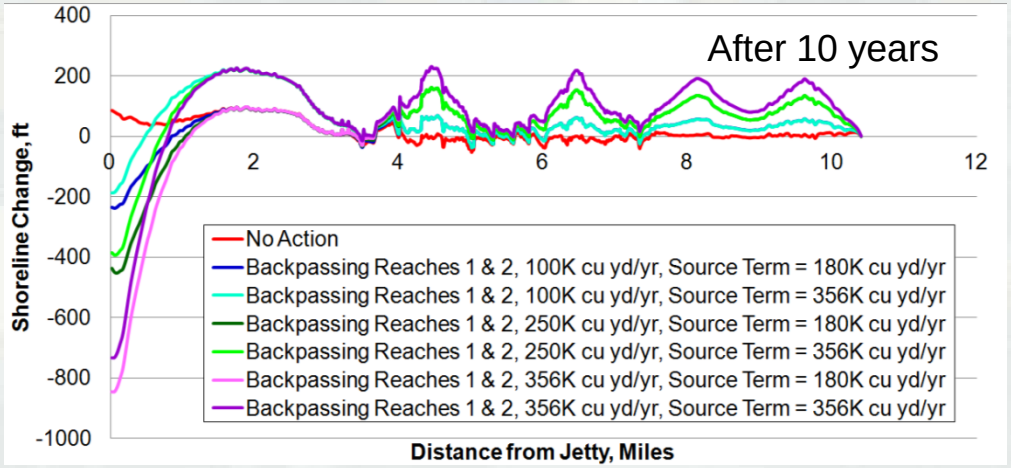
Backpassing (Seawall)

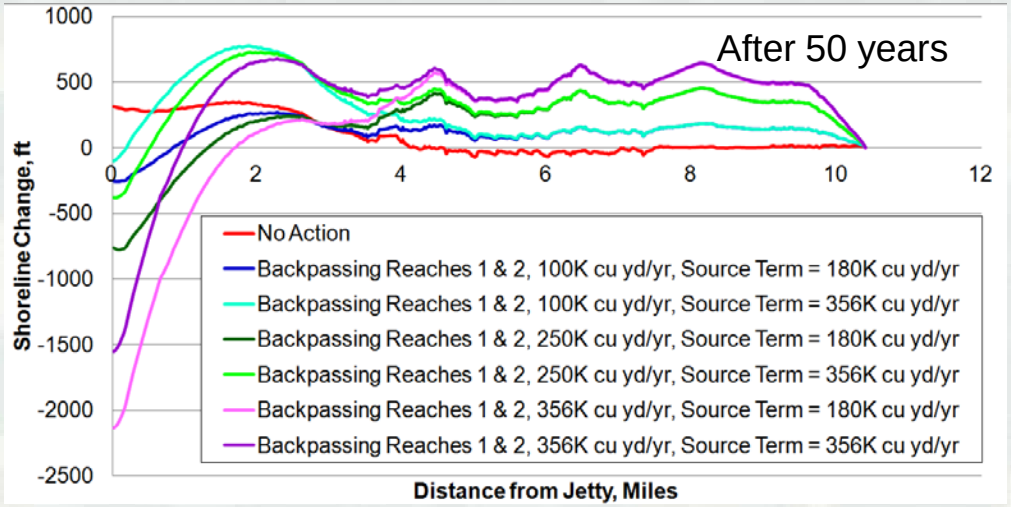




100,000, 250,000, and 356,000 yd^3 backpassed with different rates of material moving onshore

Backpassing (Seawall)

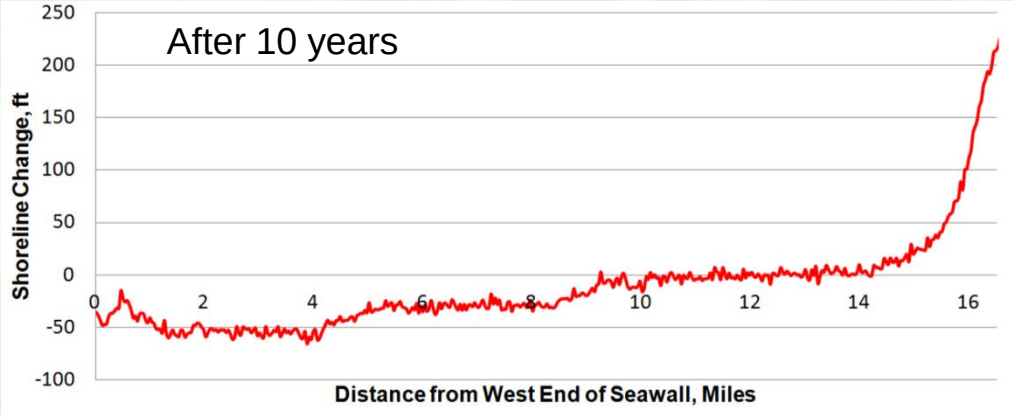


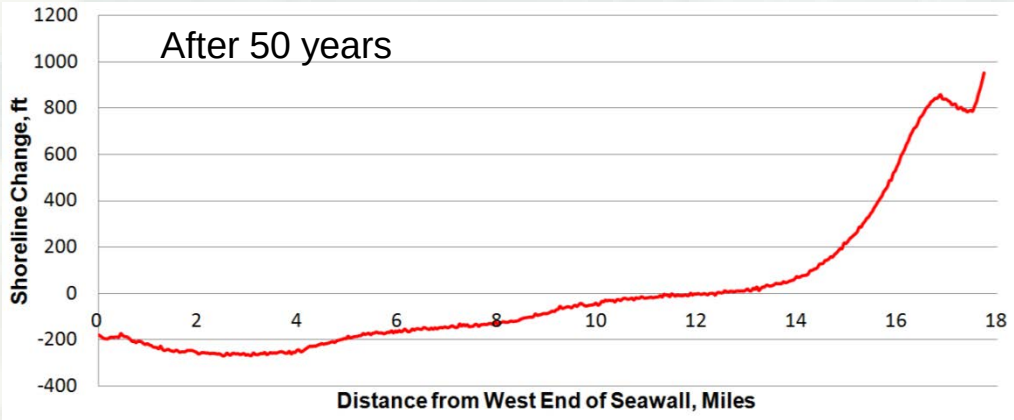


100,000, 250,000, and 356,000 yd^3 backpassed onto Reaches 1 and 2

- Various rates of sand moving onshore to illustrate impact on shoreline

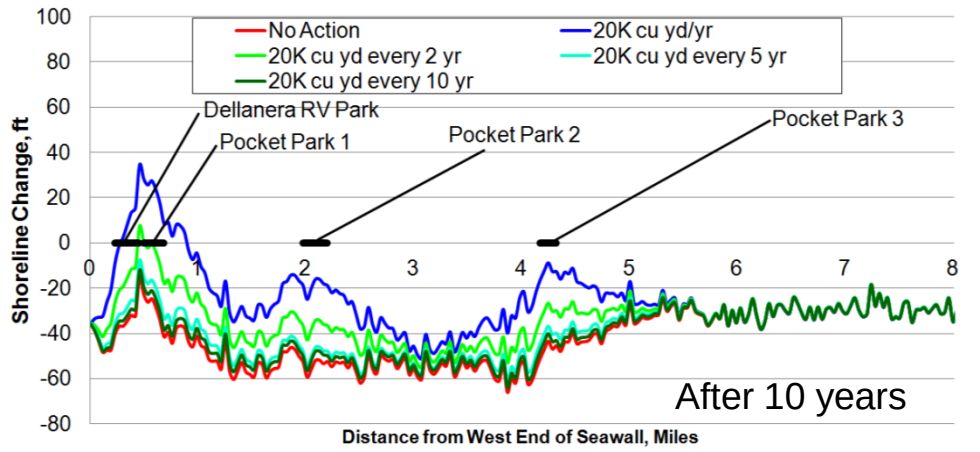
No Action (West End of Island)

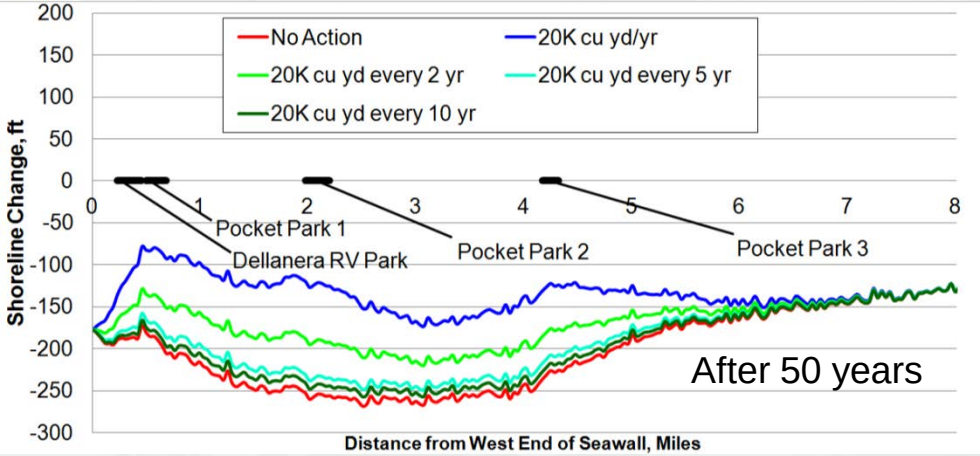




Simulated to compare to other alternatives

Beach Fills (West End)

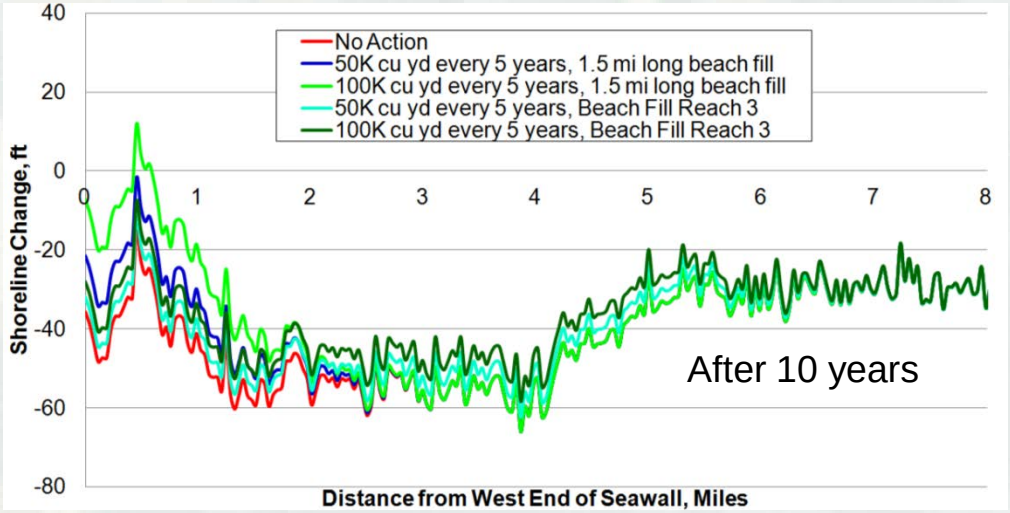


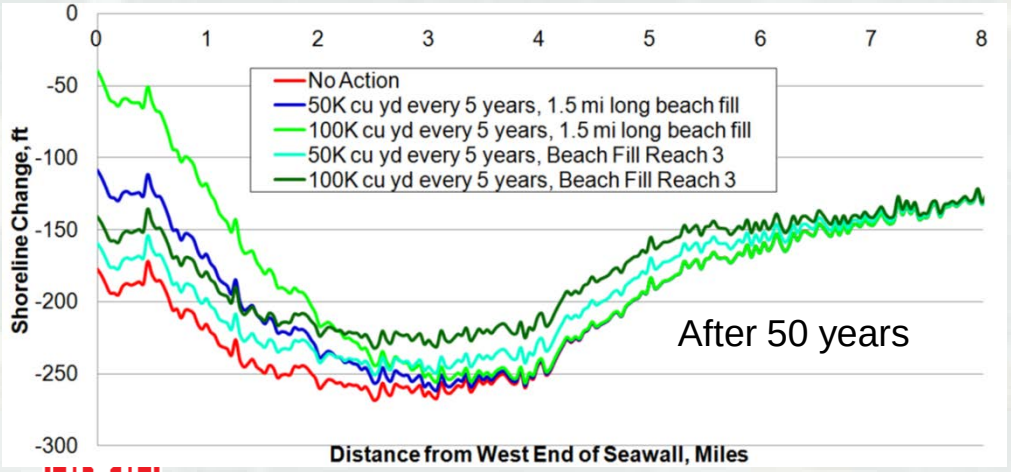


Beach fills placed on Park Board property

- 20,000 yd^3 at each property = 80,000 yd^3 total per placement
- Placement every year = 4,000,000 yd^3 total; still more than 100 ft of erosion

Beach Fills (West End)

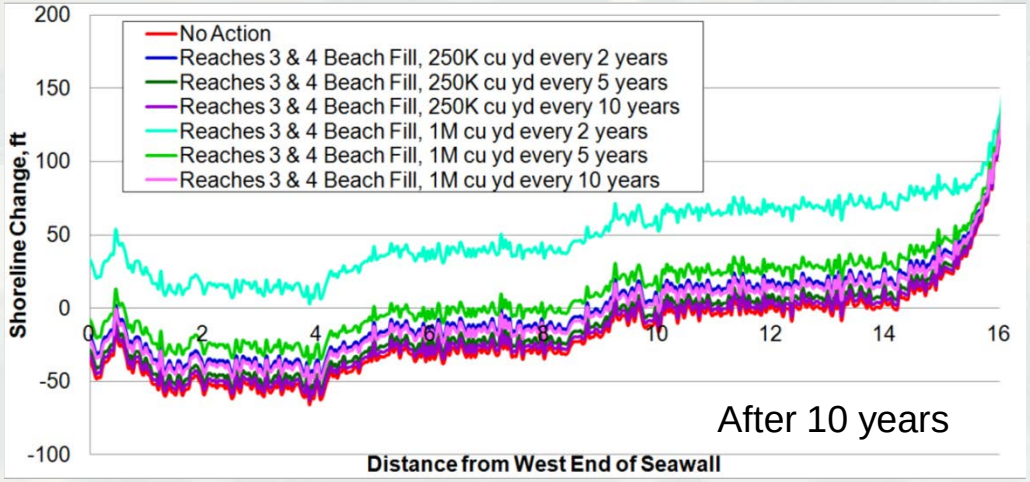


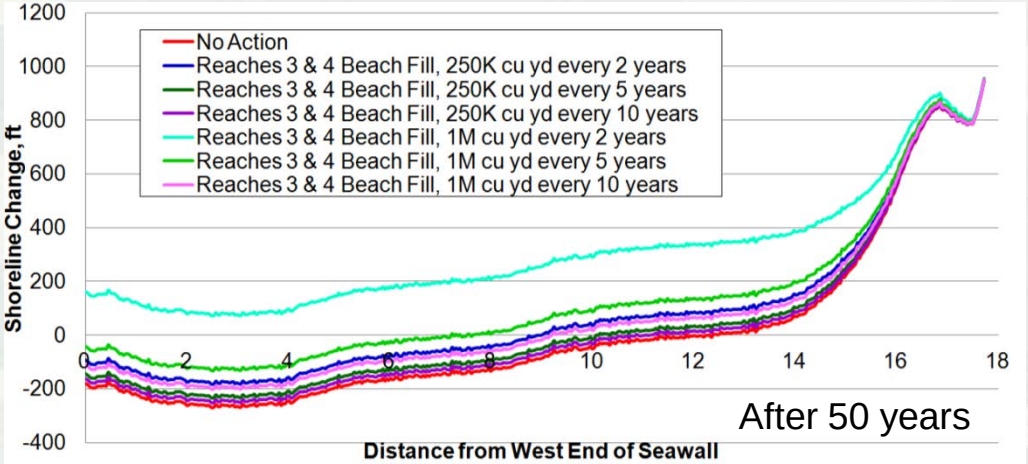


Beach fills along first 1.5 mi past seawall and along Reach 3

- 50,000 or 100,000 yd^3 placed every 5 years
- After 50 years, no alternative results in shoreline advance along Reach 3

Beach Fills (West End)

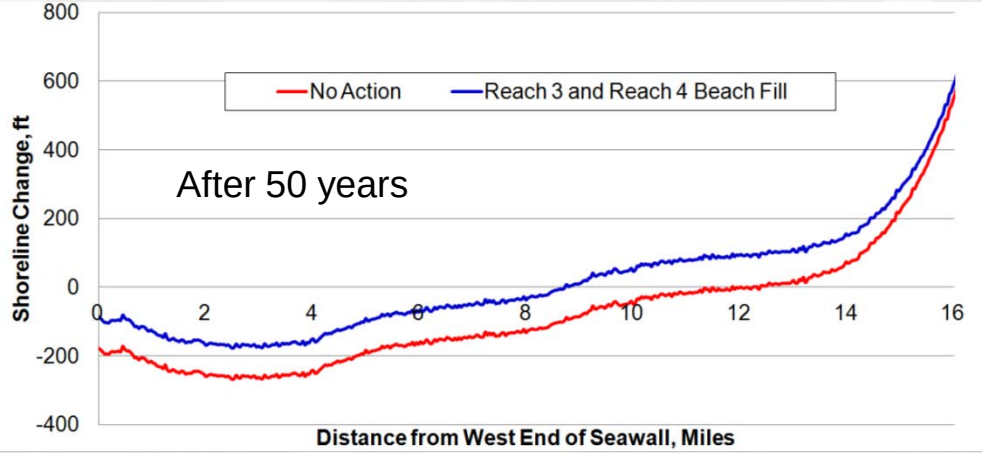




Beach fills along Reaches 3 and 4

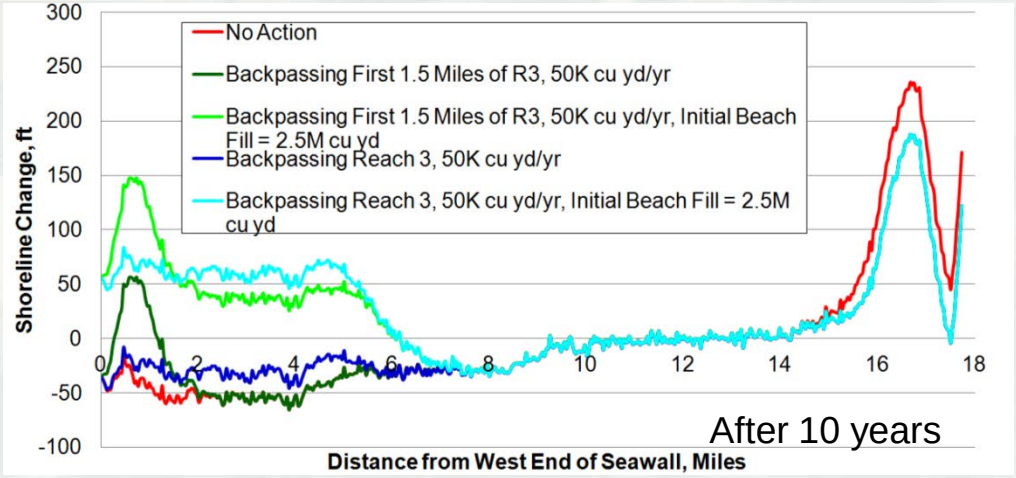
- 250,000 or 1,000,000 yd^3 placed every 2, 5, or 10 years
- After 50 years, the only alternative resulting in shoreline advance is 1,000,000 yd^3 placed every 2 years

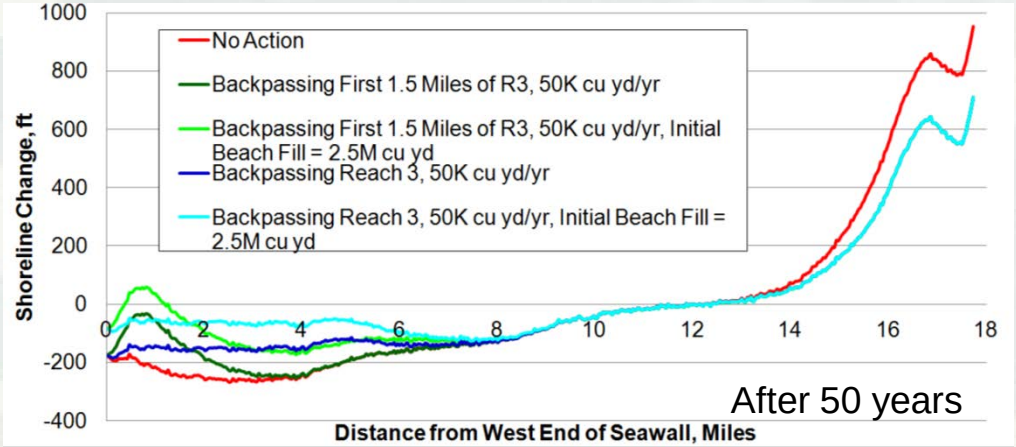
Beach Fills (West End)



Large-scale beach fill along Reaches 3 and 4 (2,519,000 yd^3 along Reach 3 and 4,408,000 yd^3 along Reach 4)

Backpassing (West End)

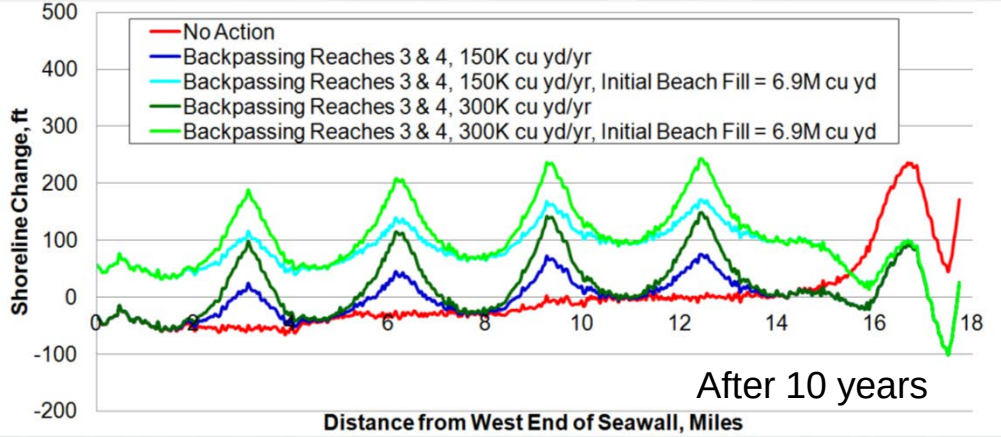


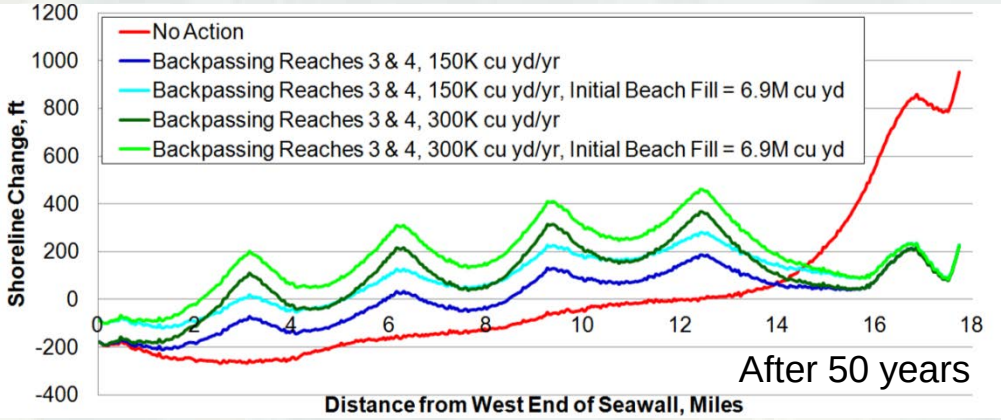


Backpassing to first 1.5 mi beyond seawall and to Reach 3

- 50,000 yd^3/yr backpassed
- With and without initial beach fill along Reach 3 = 2,518,800 yd^3

Backpassing (West End)





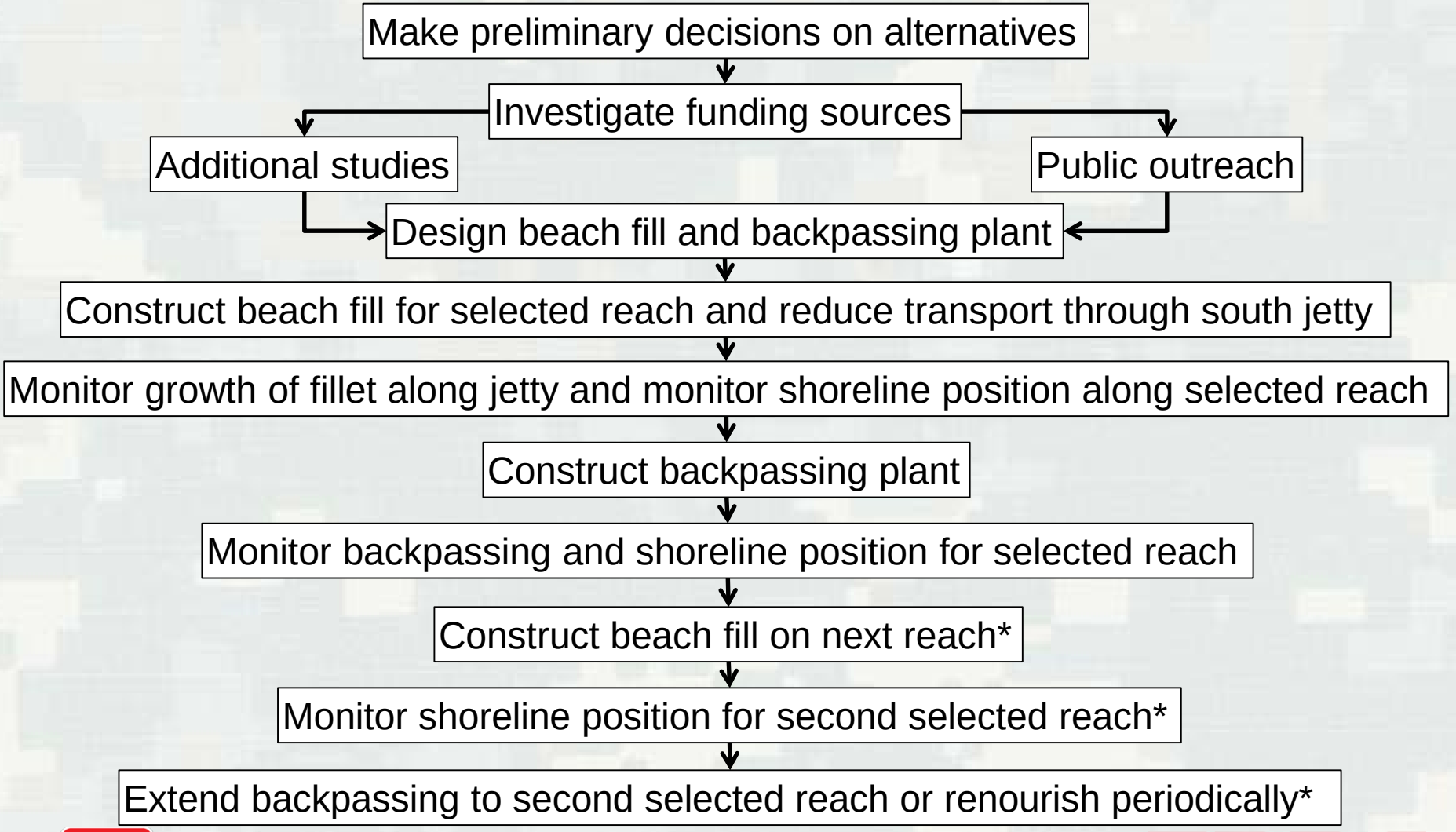
Backpassing to Reaches 3 and 4

- 150,000 and 300,000 yd^3/yr backpassed
- With and without initial beach fill = 6,926,700 yd^3

Sand Management Alternatives

Plan	Coverage	New Material (offshore or other sources)	Management and recycling of existing sand sources and dredge material	Performance monitoring
Comprehensive beach fill	Reaches 1-5	√	√	√
Limited area beach fill	1, 2, 3(?)	√	√	√
Systematic recycle	1, 2		√	√
Present action plan	1		√	
No action				

Sand Management Plan



Adaptive Management and Monitoring

- Implement adaptive management strategy
  - Construct limited fill and monitor to ensure it is responding as expected
  - Modify design if necessary
- Recommended monitoring actions
  - Beach profiles, lidar, and/or shoreline position should be collected prior to and every 6 months after construction
  - Georeferenced aerial photography once a year

Ashley Frey
Ashley.E.Frey@usace.army.mil