PERFORMANCE, RESILIENCY, AND SEDIMENT RESOURCES FOR THE MASSIVE BEACH AND DUNE SYSTEM ALONG THE TEXAS COAST (COASTAL TEXAS PROJECT)

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USACE Galveston

3rd INTERNATIONAL WORKSHOP ON WAVES, STORM SURGES AND COASTAL HAZARDS

10/02/2023-10/06/2023

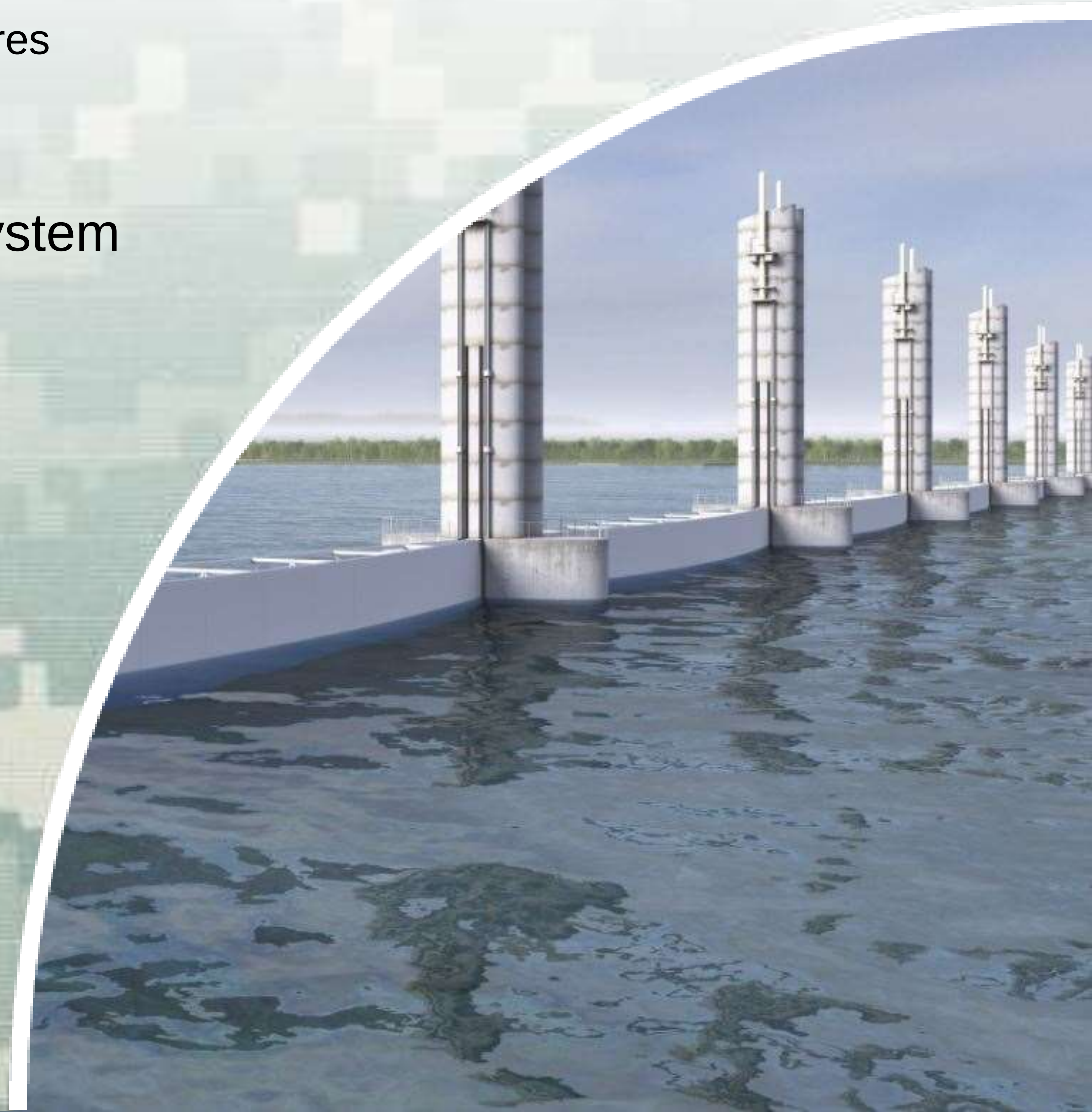
US Army Corps of Engineers
BUILDING STRONG®

Outline…..

1. Background on Coastal Texas Project
    a) Regional Vulnerability
    b) Recommended Plan, Key Features
    c) Evaluation Methodology

2. Design of Beach and Dune System
    a) Methodology
    b) Recommended Plan
    c) Sediment Needs (Initial)
    d) Sediment Needs (O&M)
    e) Source of Sediment

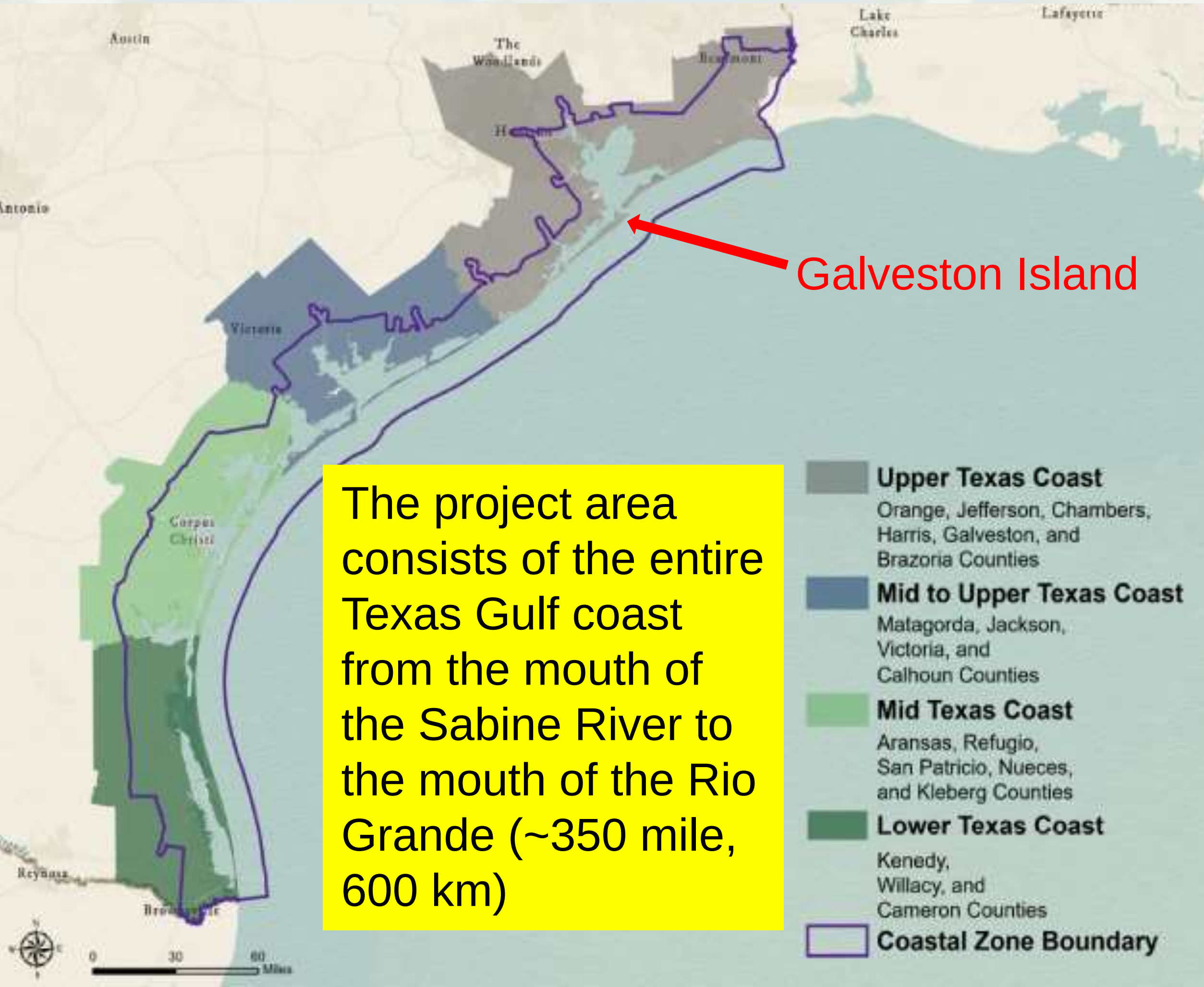
3. Summary, Q&A



Background: Coastal Texas Project

US Army Corps of Engineers
Galveston District

The U.S. Army Corps of Engineers has partnered with the Texas General Land Office to identify and recommend feasible projects to reduce risks to public health and the economy, restore critical ecosystems, and to make the Texas coastline more resilient & sustainable.



The project area consists of the entire Texas Gulf coast from the mouth of the Sabine River to the mouth of the Rio Grande (~350 mile, 600 km)

Port of Houston is an integral part of the regional economy ~52 miles HSC

NATIONAL SIGNIFICANCE

Population Centers

- >$125B assets at risk, growing to $200B
- 18 coastal counties
- 6.1 million residents, growing to 9M in 50 yrs
- >24% of the TX population

Critical Infrastructure

- Nationally ranked deep-draft ports
- 450 miles of Gulf Intracoastal Waterway (GIWW)
- 40% of the Nation's petrochemical industry
- 25% of national petroleum-refining capacity
- NASA





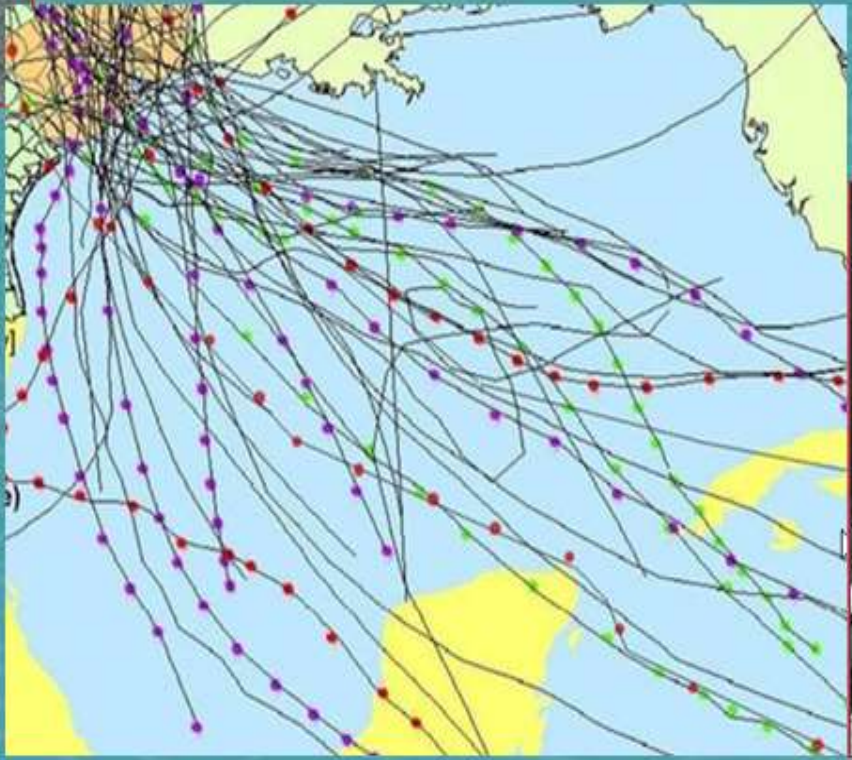
Coastal Ecosystems

- Wetlands, seagrass beds, oyster reefs, dunes, and beaches
- Critical threatened and endangered species habitat
- Nursery habitat and significant commercial fisheries for oysters, shrimp

Challenge: Regional Vulnerability

Extreme Impact on Community

13 major hurricanes (7 Cat 4) since 1851

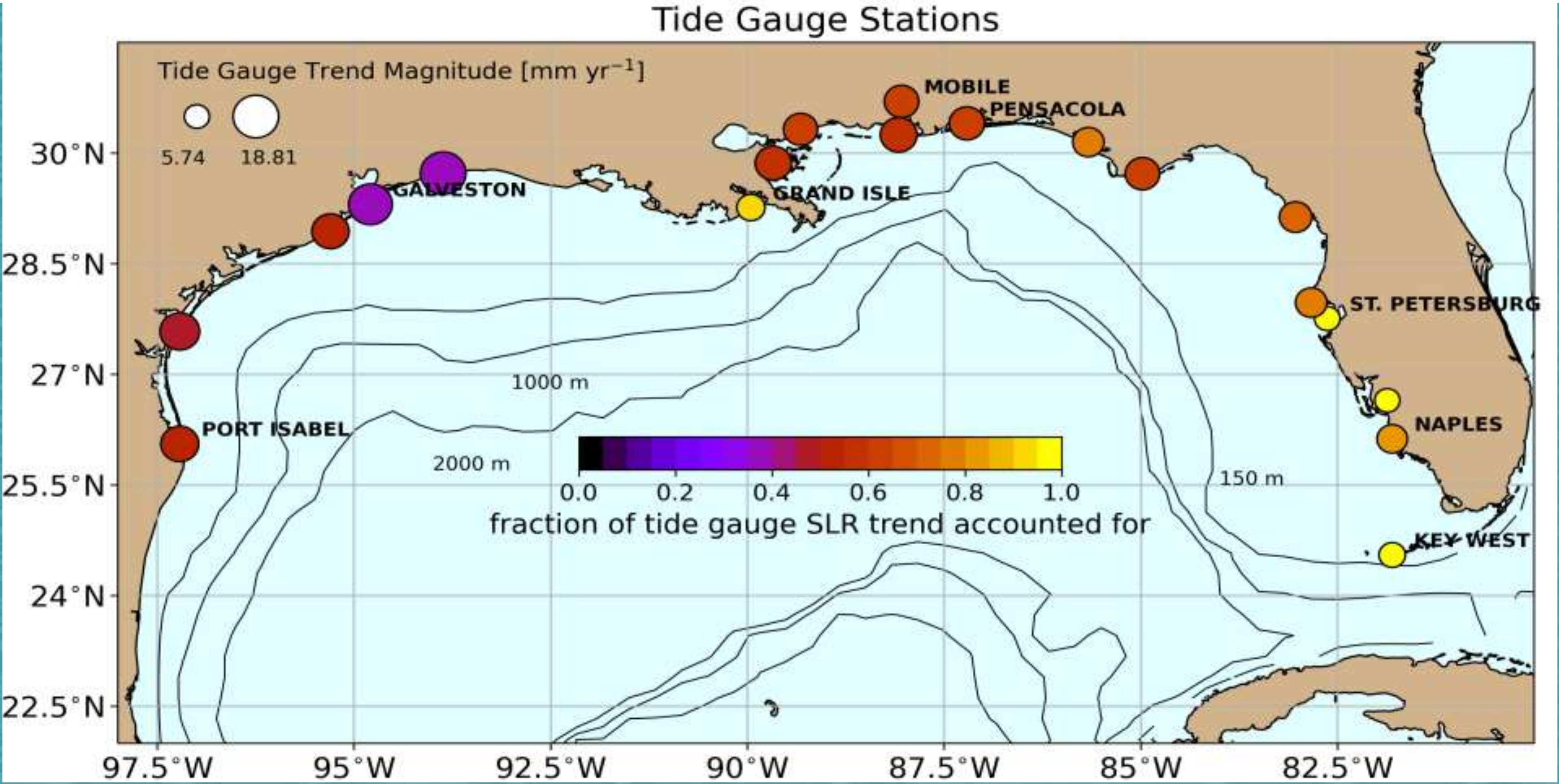


So…

It is not a question about When a next storm will hit

It is a question about How we can prepare ourselves ahead of storm to minimize damage

Challenge: Regional Vulnerability

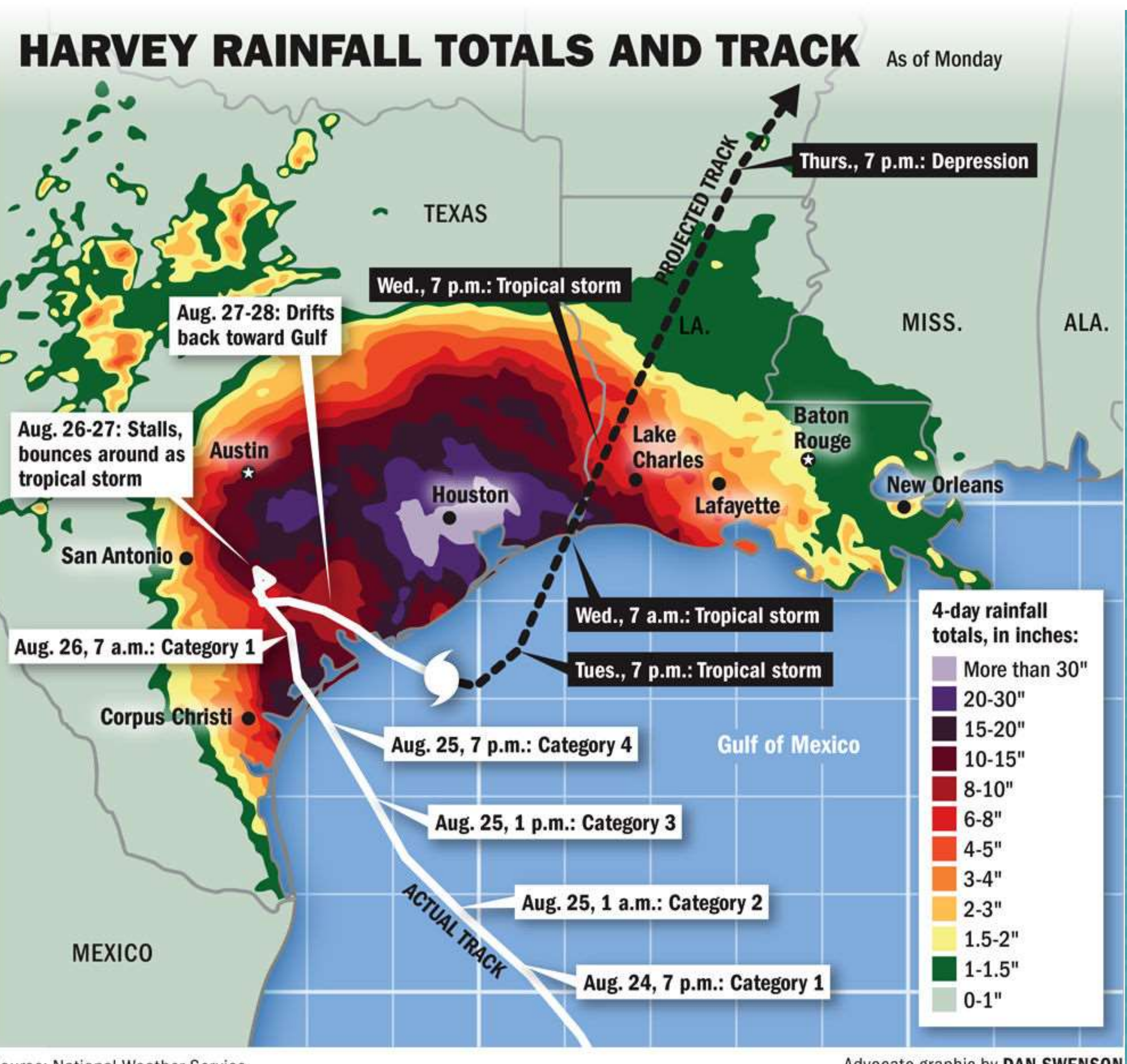


Jacob M. Steinberg et al., JGR, 2023

RSLC rates for GOM – 20.6 mm/yr Galveston
14.2 mm/yr Grand Isle
14.8 mm/yr Port Isabel
13.6 mm/yr Pensacola

3 to 8 ft sea level rise next 100 year

Challenge: Regional Vulnerability



Hurricane Harvey (2017)

20 Trillion Gallon of Rainfall

Weight of Water Caused Houston to Sink by 2 cm

Triggered new rainfall statistics (ATLAS 14)

Source : NWS, Climate.Gov

AUTHORIZED PLAN

US Army Corps of Engineers

https://coastaltexasprogram.com/

CoastalTXStudy

StoryMap: https://coastal-texas-hub-usace-swg.hub.arcgis.com/

Updated: 18 April 2023

Project Summary

THE CHALLENGE is to develop a comprehensive project that provides multiple lines of defense against hurricanes while restoring fish and wildlife habitat system-wide to enhance overall coastal resilience. We are taking a systems approach when reviewing the region's larger system context, with a focus on Critical infrastructure that emphasizes greater flexibility. This Multiple Lines of Defense strategy uses natural and nature-based solutions in combination with traditional engineering solutions and builds upon existing & proposed projects to maintain the existing landscape in the face of sea level rise and coastal erosion.

Project Schedule

ACTIVITY		DATE-
FR	S&A Review Complete	02-31 Jul 21
	Chief's Report	16 Sep 21
PED	WRDA	2022
	PED	2022-2025
CON	Construction	2025+

COASTAL TEXAS COSTS & BENEFITS BY THE NUMBERS...

~2.31 Billion EQUIVALENT ANNUAL BENEFITS

1.91 BCR FOR THE COMBINED CSRM MEASURES

IN A 1% ANNUAL EXCEEDANCE PROBABILITY SURGE EVENT:

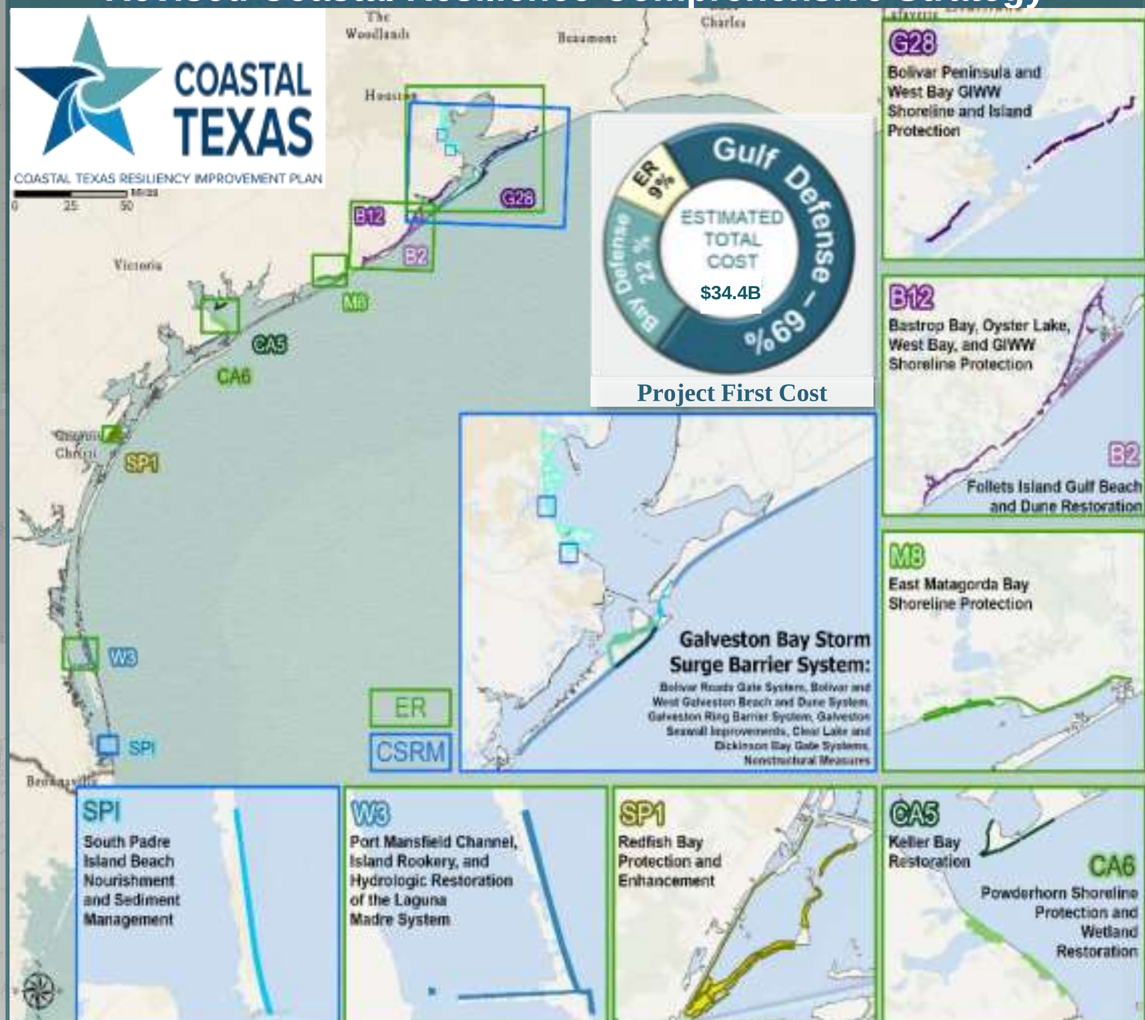
~77% REDUCTION IN DAMAGED STRUCTURES

~64% REDUCTION IN FLOODED CRITICAL INFRASTRUCTURE

6,610 ACRES HABITAT IMPROVED

$34.4 Billion TOTAL RECOMMENDED PLAN PROJECT COST (CSRM & ER)

Revised Coastal Resilience Comprehensive Strategy



Coastal Storm Risk Management

- 2 large & 4 small sector gates
- 15 vertical lift gates
- 16 shallow water environmental gates
- 1 mi combi-wall tie-in
- 3 mi levee tie-in
- 43 mi of gulf-side dune/beach barrier
- 21 mi of ring barrier
- 8 pumping stations
- 16+ drainage structures
- 4-ft high extension of the seawall
- 150+ gated closures (roads & rail)
- Non-structural measures anticipated
- 2 mi beach/dunes on South Padre
- 1,342 ac mitigation

Ecosystem Restoration (6,600+ ac)

- 114 mi of breakwaters
- 15.2 mi of bird rookeries
- 2,052 ac of marshes
- 12.32 mi of oyster reefs
- 19.5 mi of dunes/beaches

US Army Corps Of Engineers

PROJECT KEY FEATURES

https://coastaltexasprogram.com/

CoastalTXStud

StoryMap: https://coastal-texas-hub-usace-swg.hub.arcgis.com/

Updated: 28 Sep 2023

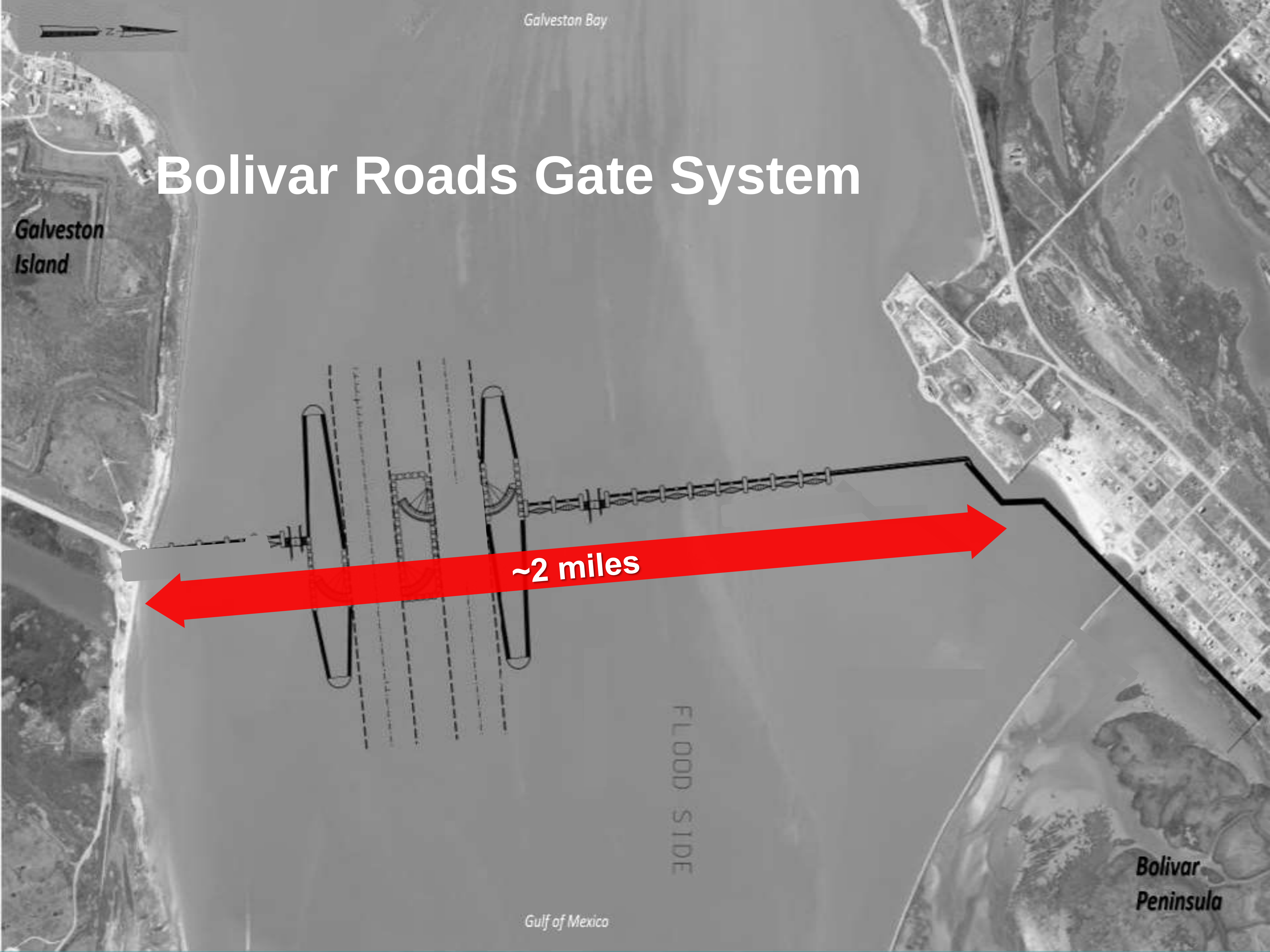
Gulf Defenses: Hardened Perimeter at the Gulf Inlet

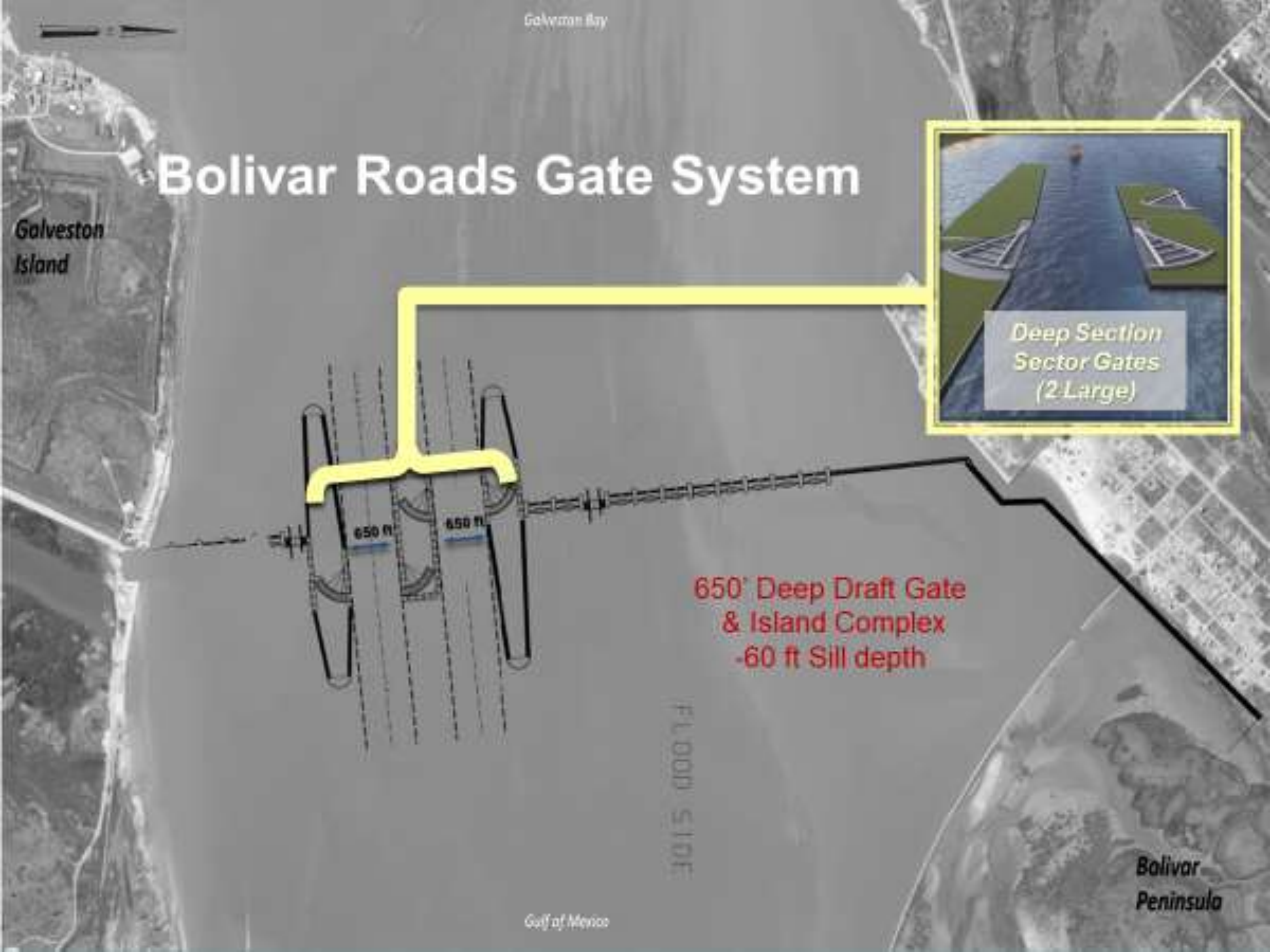
- ✓ Storm Surge Gates
- ✓ Combi-wall Flanking
- ✓ Dune Flanking
- ✓ Seawall Improvements

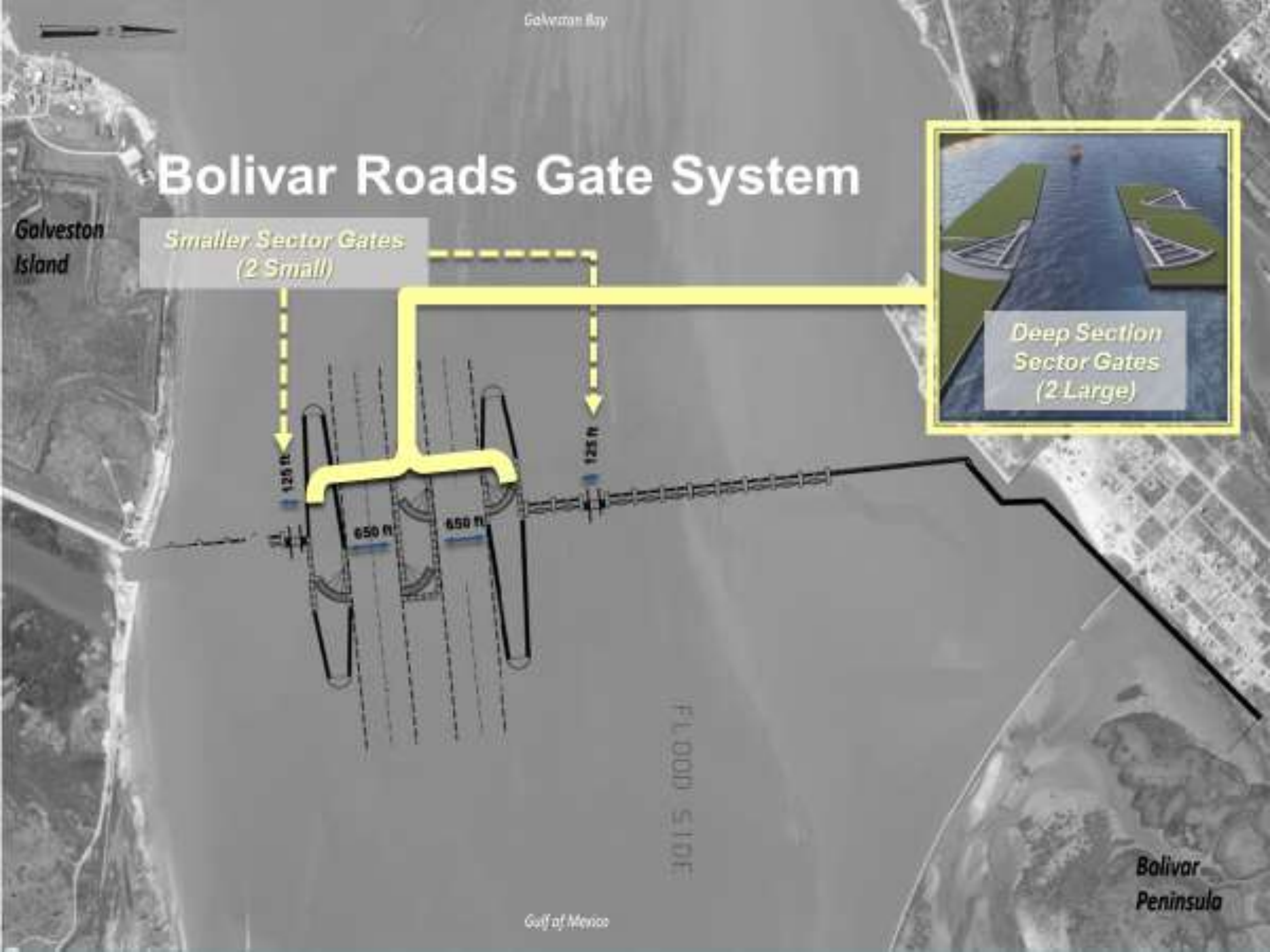
Bay Defenses: Lateral and Interior Features

- ✓ Ring Barrier
- ✓ Upper West Bay – Clear Lake, Dickinson Bay & Non-Structural Improvements
- ✓ GIWW Breakwaters
- ✓ Oyster Reefs & Marshes
- ✓ ER Site-specific restoration features (e.g., bird islands, hydrologic reconnection)

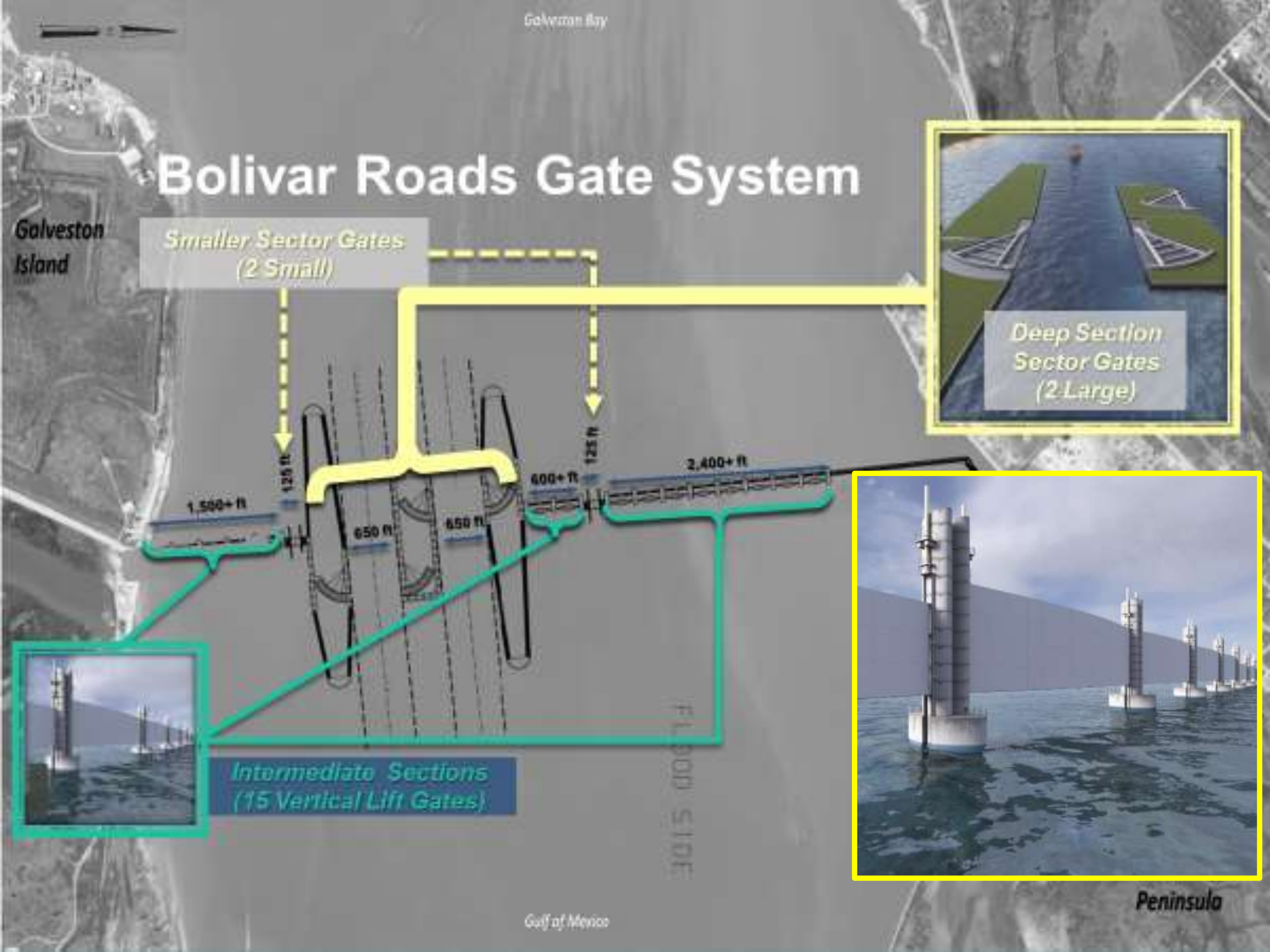
Bolivar Roads Gate System



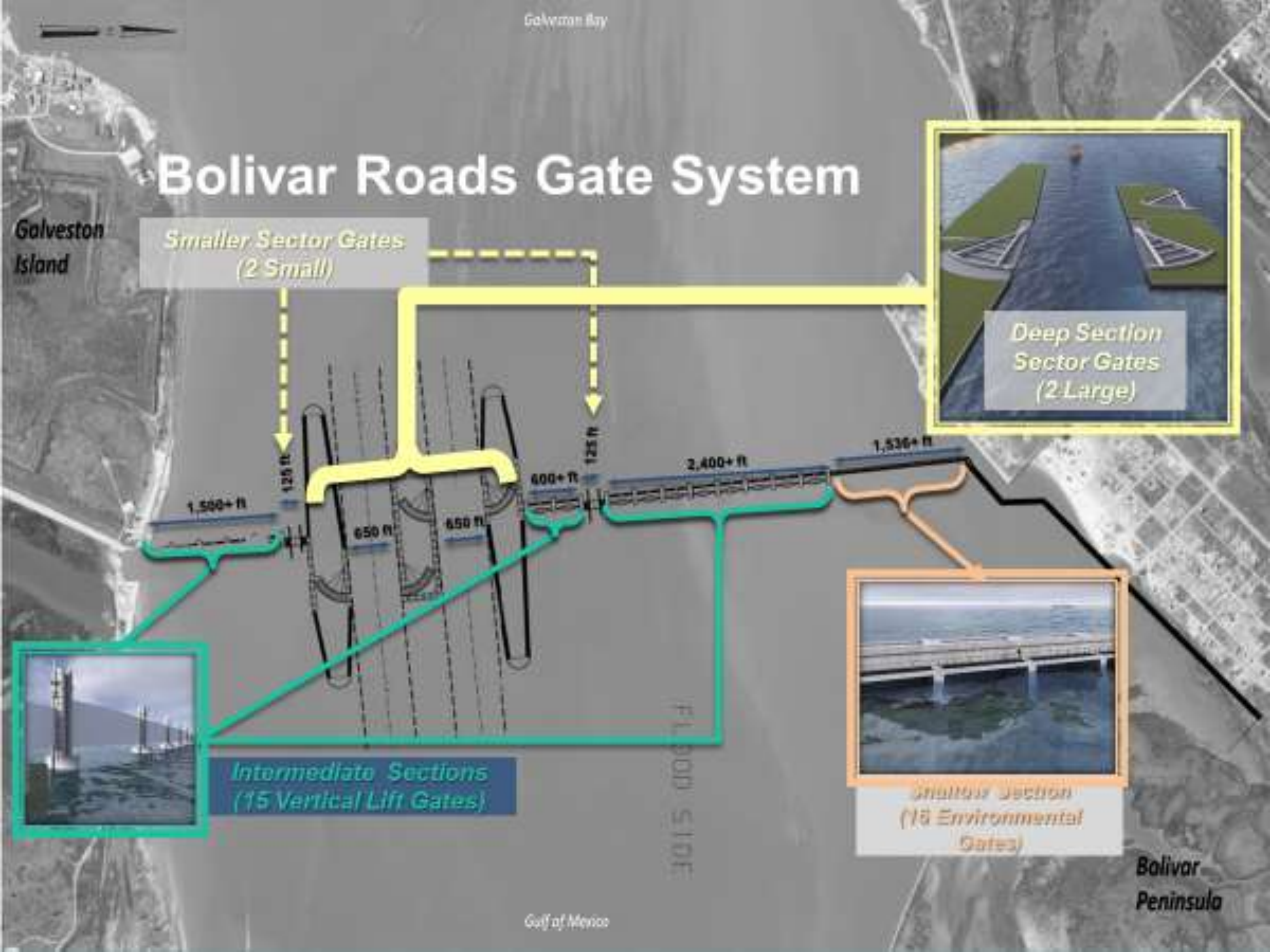

Galveston Bay
Bolivar Roads Gate System
Galveston Island
Deep Section Sector Gates (2 Large)
650 ft
650 ft
650' Deep Draft Gate & Island Complex -60 ft Sill depth
FLOOD SIDE
Bolivar Peninsula
Gulf of Mexico



Galveston Bay
Bolivar Roads Gate System
Galveston Island
Smaller Sector Gates (2 Small)
Deep Section Sector Gates (2 Large)
125 ft
125 ft
650 ft
650 ft
FLOOD SIDE
Bolivar Peninsula
Gulf of Mexico



Galveston Bay
Bolivar Roads Gate System
Galveston Island
Smaller Sector Gates (2 Small)
Deep Section Sector Gates (2 Large)
125 ft
125 ft
1,500+ ft
650 ft
650 ft
400+ ft
2,400+ ft
FLOOD SIDE
Intermediate Sections (15 Vertical Lift Gates)
Peninsula
Gulf of Mexico


Galveston Bay
Bolivar Roads Gate System
Galveston Island
Smaller Sector Gates
(2 Small)
Deep Section
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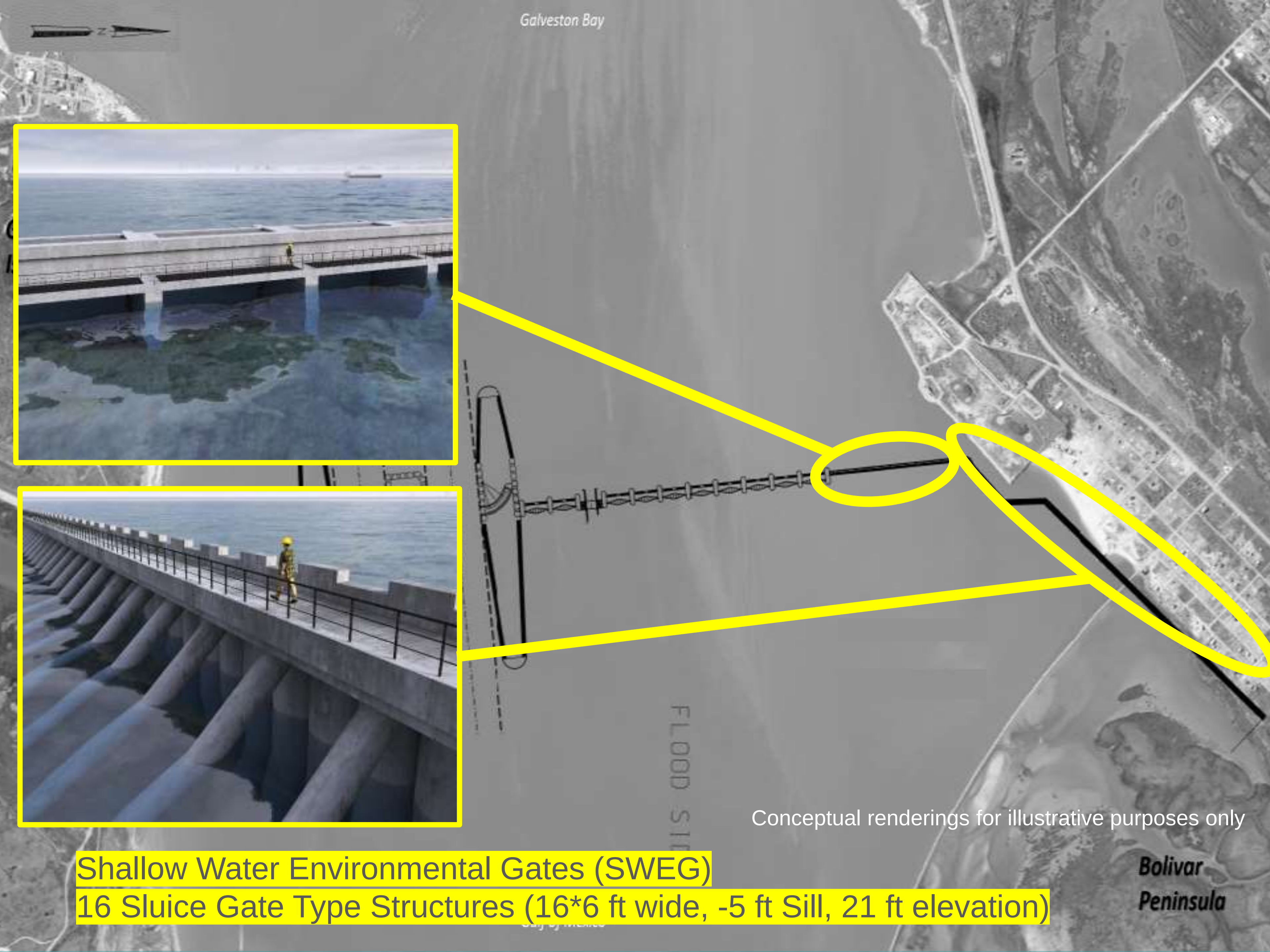
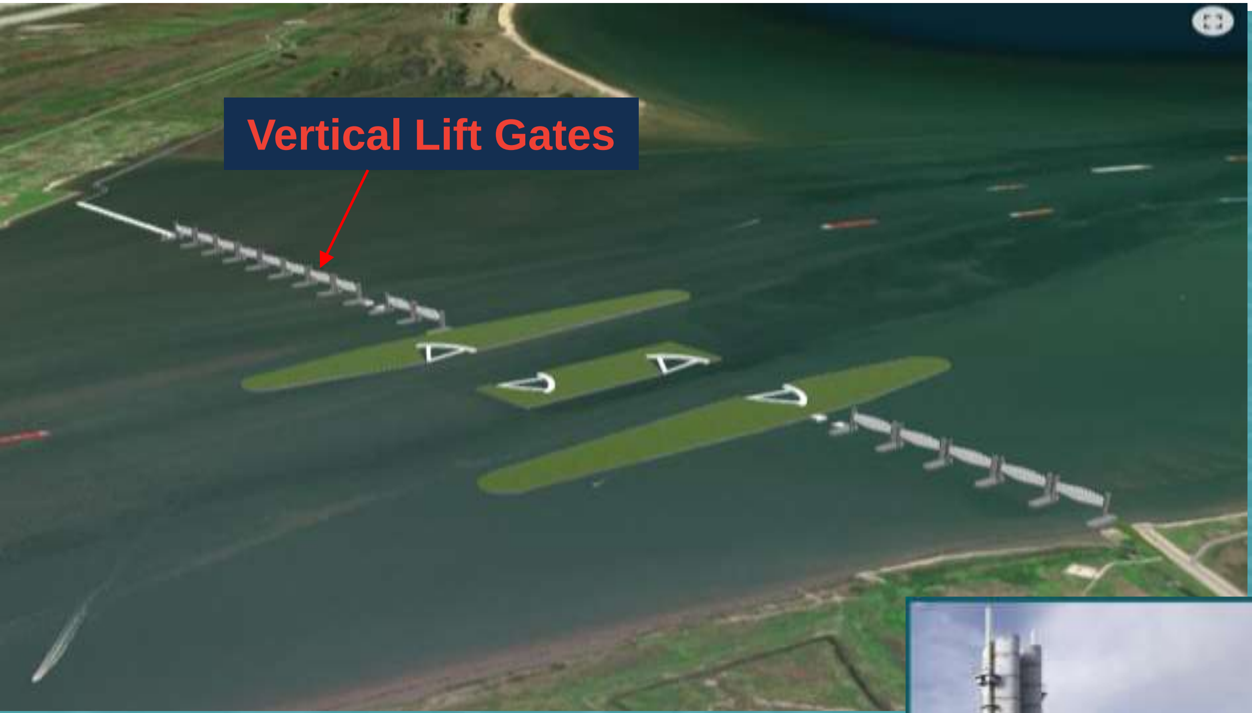
(2 Large)
1,536+ ft
2,400+ ft
125 ft
400+ ft
125 ft
1,500+ ft
650 ft
650 ft
FLOOD SIDE
Intermediate Sections
(15 Vertical Lift Gates)
Environmental
Gates)
Bolivar
Peninsula
Gulf of Mexico

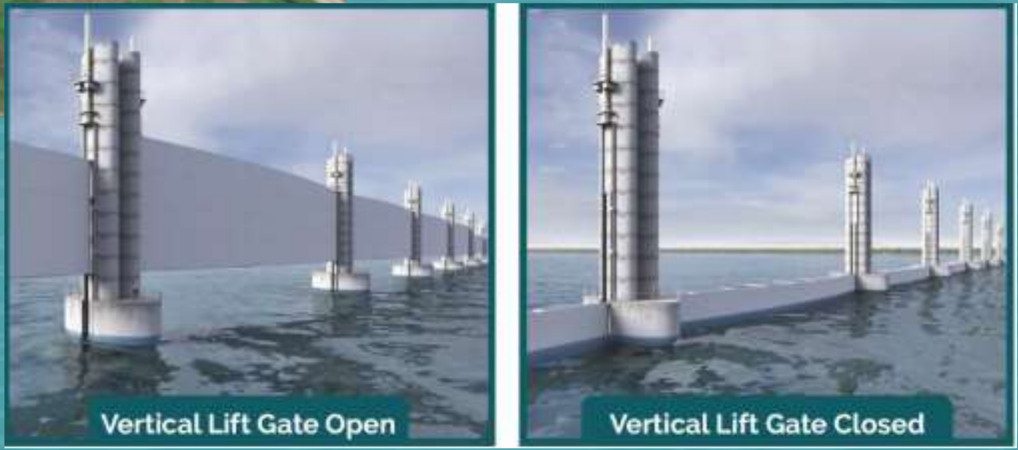


Galveston Bay
Conceptual renderings for illustrative purposes only
Bolivar Peninsula
Shallow Water Environmental Gates (SWEG)
16 Sluice Gate Type Structures (16*6 ft wide, -5 ft Sill, 21 ft elevation)

Deep Draft Navigation Sector Gate

Vertical Lift Gates (VLG)





7 Shallow Vertical Lift Gate (300 ft wide, -20 ft Sill)
8 Deep Vertical Lift Gate (300 ft wide, -40 ft Sill)

Holland Ijssel Type

US Army Corps Of Engineers

BARRIER DESIGN CONSIDERATIONS

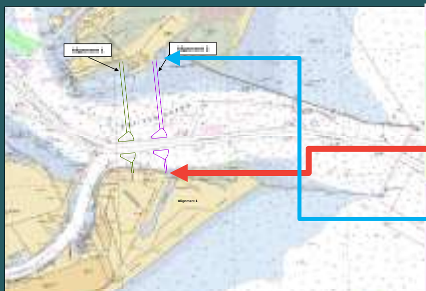
https://coastaltexasprogram.com/

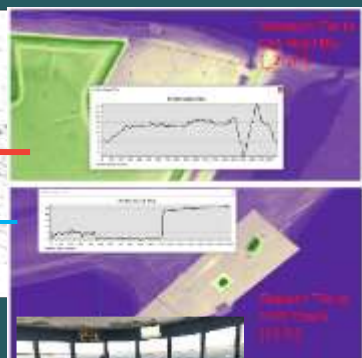
CoastalTXStud

StoryMap: https://coastal-texas-hub-usace-swg.hub.arcgis.com/

Updated: 28 Sep 2023

ALIGNMENT

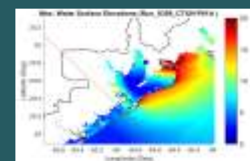


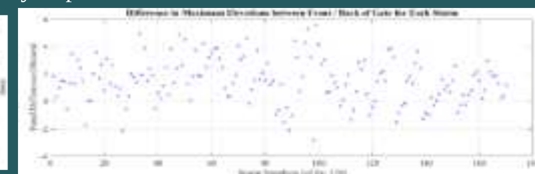


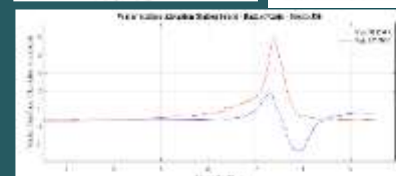
Alignment #2 is preferred after considering infrastructure, conducting ship simulation

HYDRAULICS

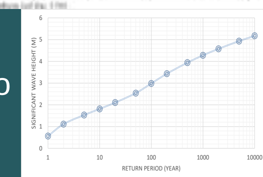
Structure must handle significant hydrostatic head difference (>25 ft) and some reverse head condition. The structures will be subject to substantial wave loads and potentially impact loads from vessels.





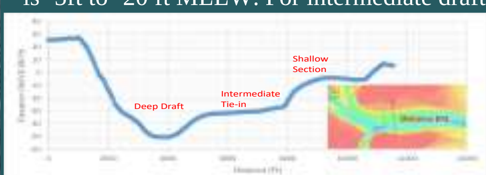


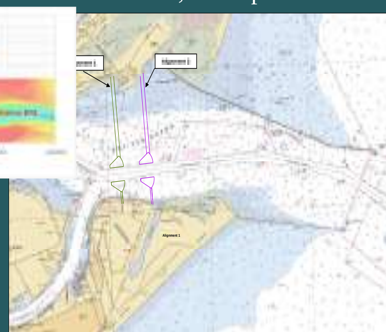
Wave Condition



SILL DEPTH & NAV OPENING

Deep, Intermediate, and Shallow Draft Sill Depth: Structure must handle required depth and changing bathymetric condition. For deep draft, the depth is -60 ft MLLW. For shallow draft structures, the depth requirement is -5ft to -20 ft MLLW. For intermediate draft structures, the depth

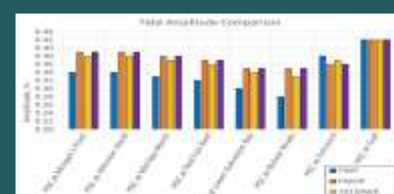


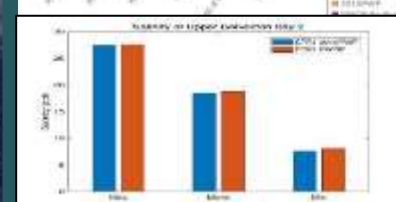


Future expansion of navigation channel?

ENVIRONMENTAL

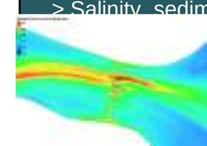
To minimize the ecological impact, cross section of the inlet must be considered seriously (>> at least 70% for Coastal Texas)

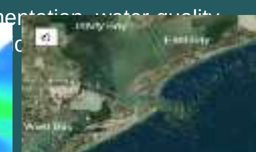




> Consider both Direct and Indirect impacts

> Salinity, sedimentation, water quality





BARRIER DESIGN CONSIDERATIONS

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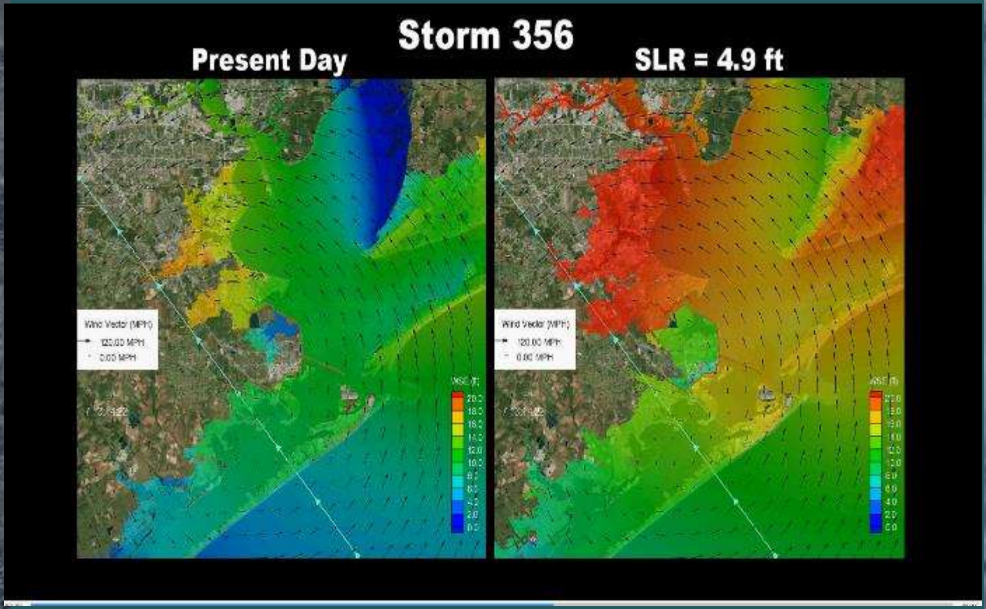
ADAPABILITY: CLIMATE CHANGE



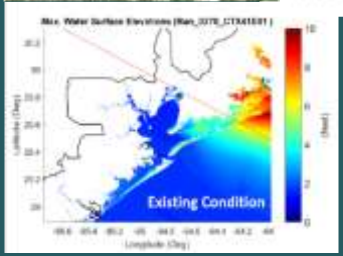
OPS – RELIABILITY & SUSTAINABILITY

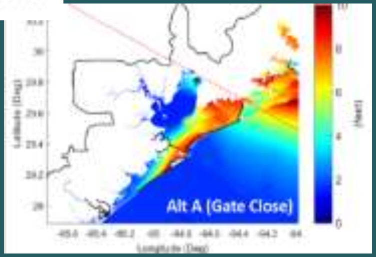
"Installing a barrier system is like buying an insurance"
(Marc Walraven, RWS)

Sustainability : Closure frequency over time ?

- Trigger ??
- Frequency of Gate Operation may change over time
- However, the gate closure will be driven by more than storm frequency or trigger elevation.
- 1 to 2 closures each year for maintenance or inspections, that alone dominates the number of closures apart from storms.

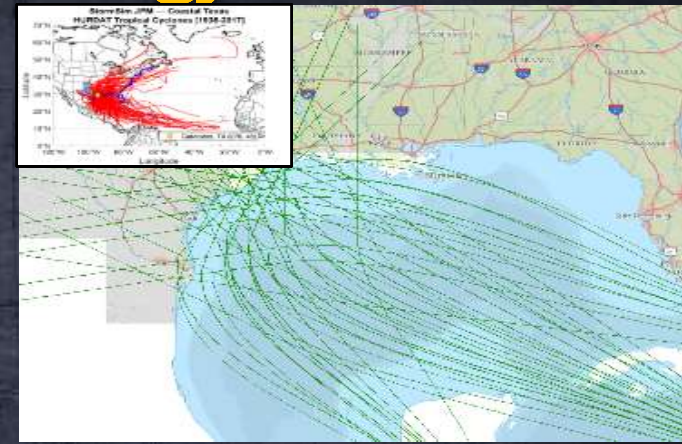
Track orientation has huge bearing on surge

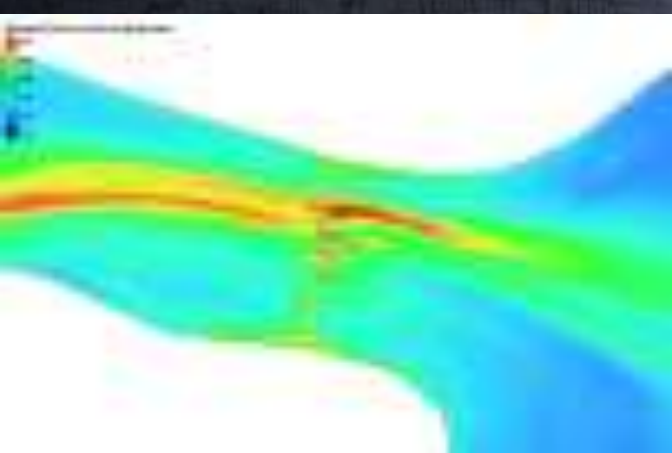


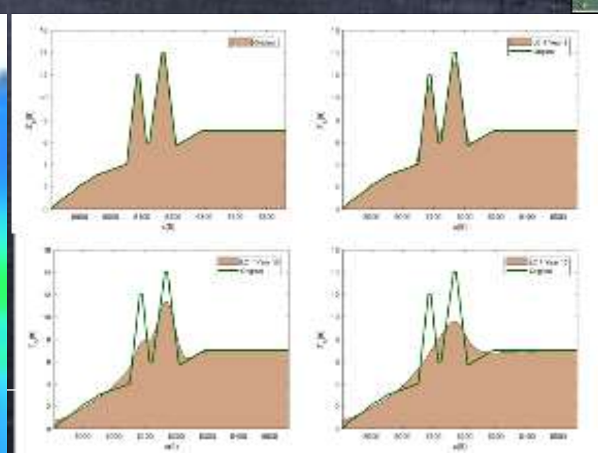


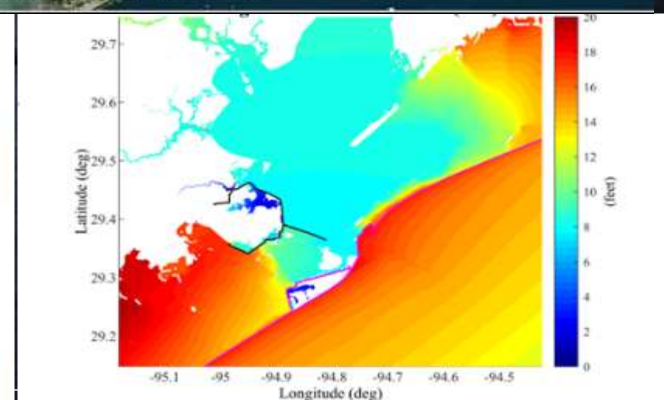
Coastal Texas : Evaluation Methodology

1. Coastal Modeling
    a. Over 2000 ADCIRC+STWAVE simulations using different SLC and multiple configurations (ERDC CSTORM)
    b. Protection level (Probabilistic)
2. Life cycle modeling of beach and dune features (CSHORE)
3. ADH modeling for hydrodynamic and salinity
4. Particle track modeling
5. Ship simulator studies for navigation gates
6. International collaboration for Gate design
7. BEACH-FX (SPI)



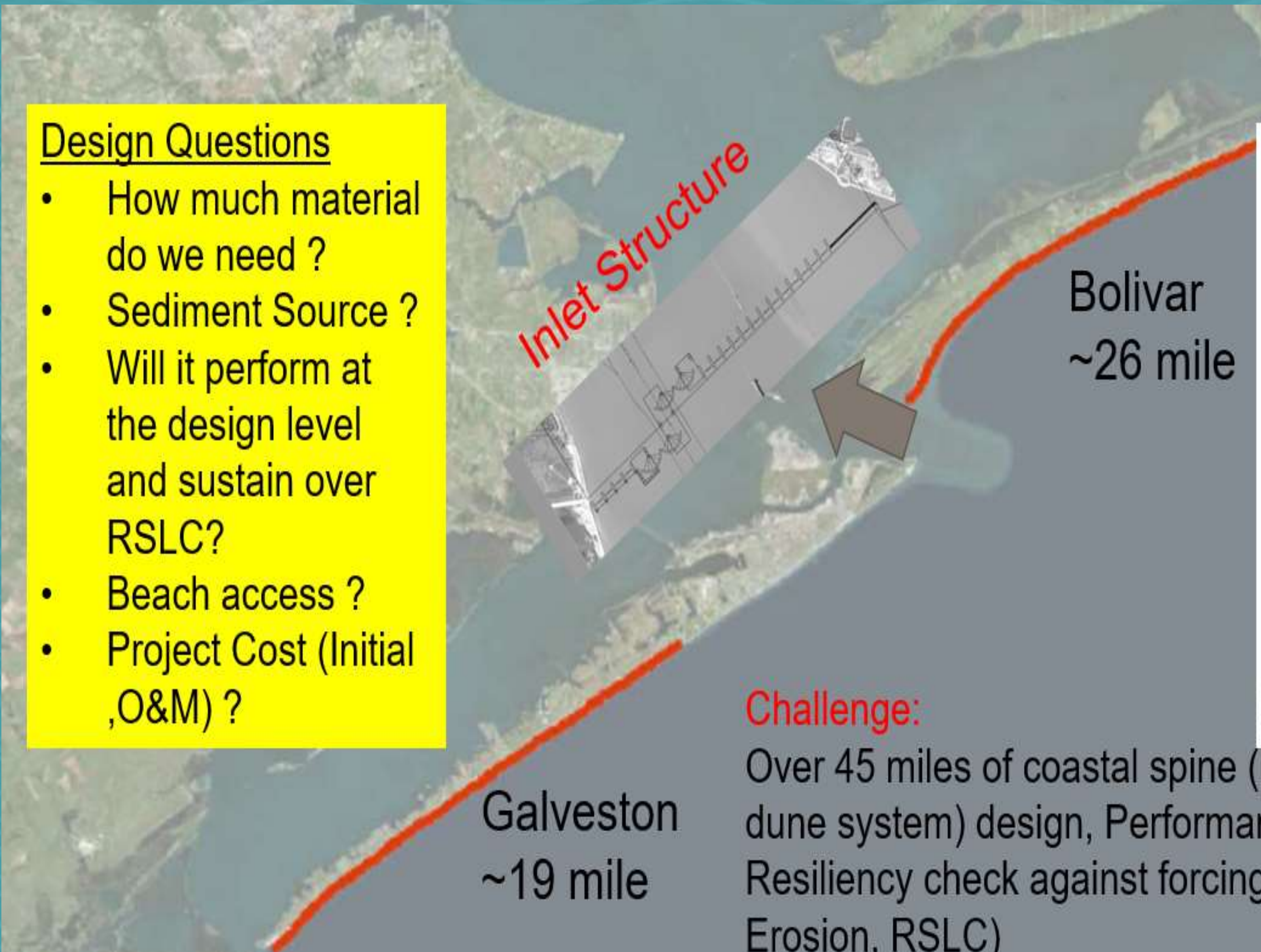






Change in Max. WSEs with alt6 project for storm #0342

Design of Beach and Dune System



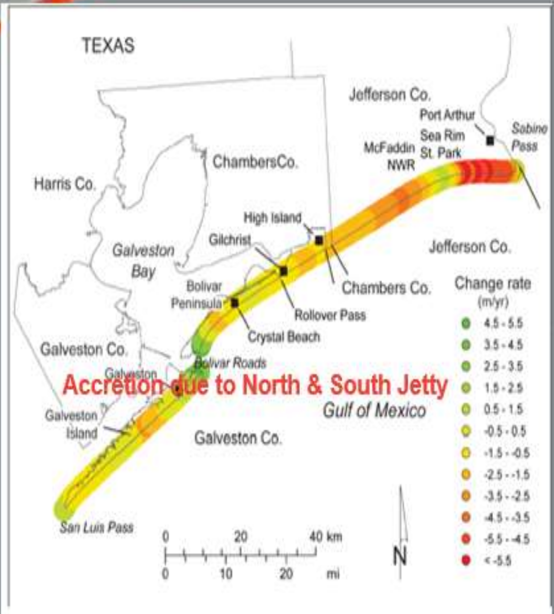


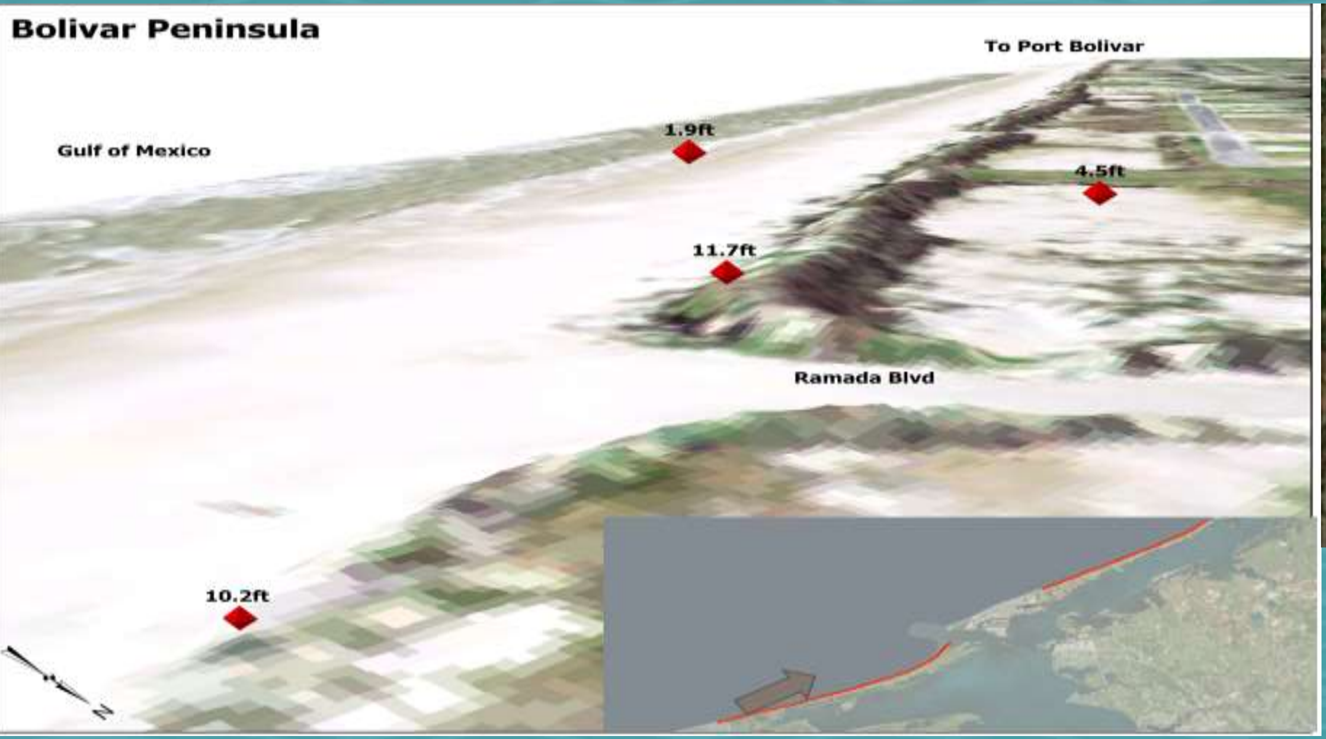
Figure 17. Net rates of long-term change for the upper Texas Gulf shoreline between Sabine Pass and San Luis Pass (Jefferson, Chambers, and Galveston counties) calculated from shoreline positions through 2007 (table 3).

Design Questions
- How much material do we need ?
- Sediment Source ?
- Will it perform at the design level and sustain over RSLC?
- Beach access ?
- Project Cost (Initial ,O&M) ?

Challenge:
Over 45 miles of coastal spine (beach & dune system) design, Performance & Resiliency check against forcing (Storm, Erosion, RSLC)

We stepped back from 17 ft Levee to Nature Based Solution

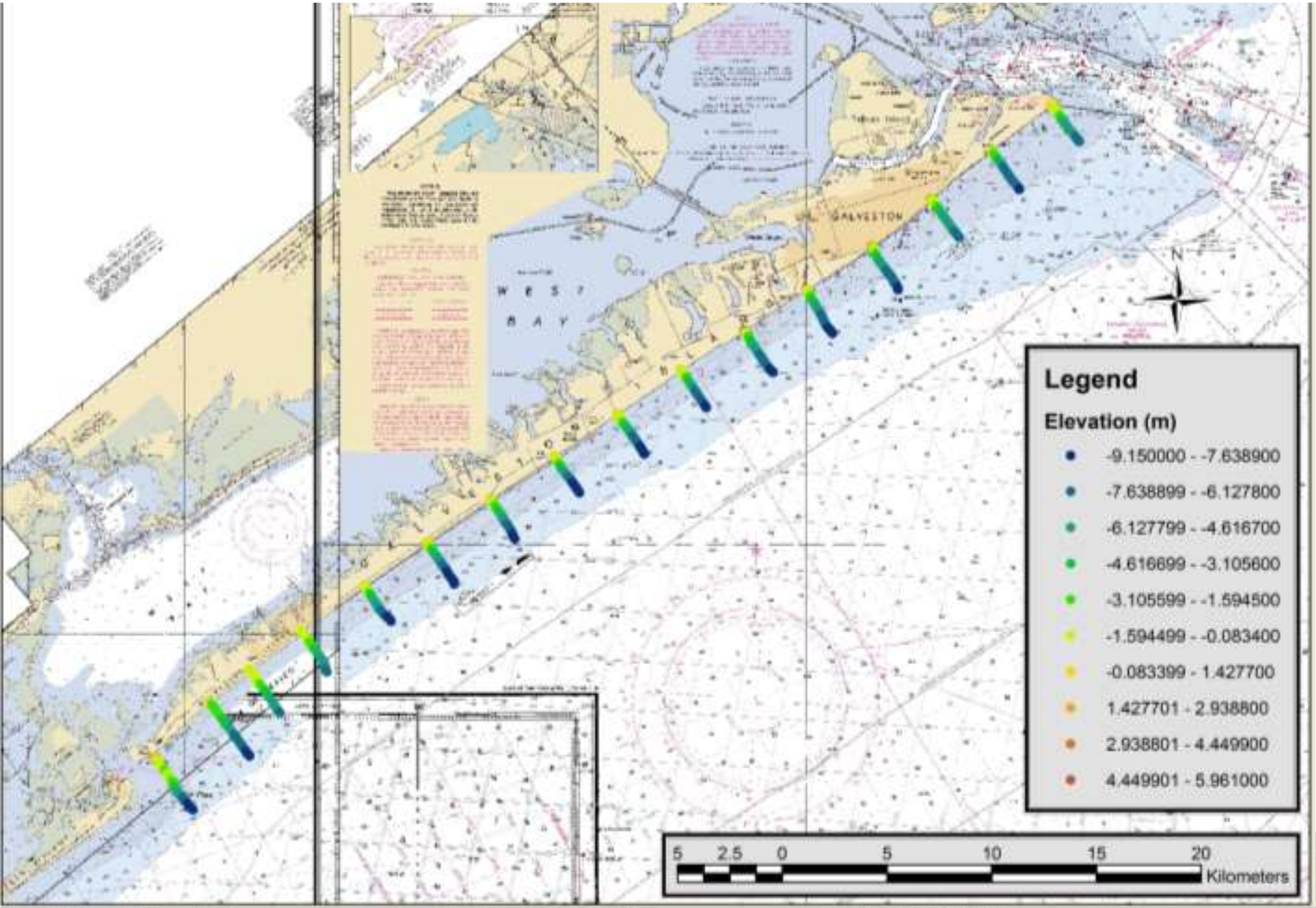
Design Philosophy : Mimic Natural Condition



State & Federal Regulation on Beach Access

Bolivar Peninsula Dune Line (~10 ft)

Data Collection : Beach profile



Ref.
Tim Dellapenna

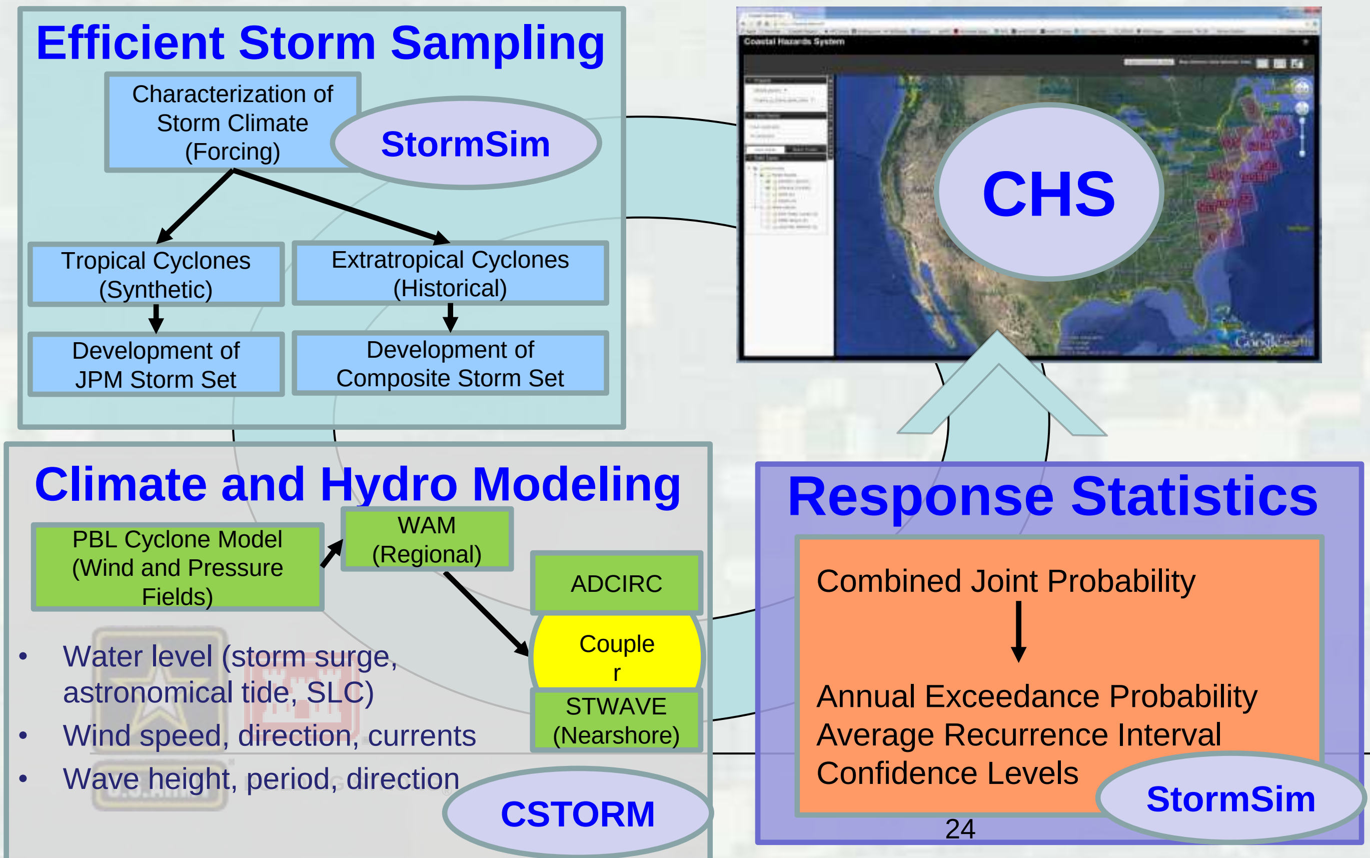
DOC, Equilibrium profile, volume

US Army Corps of Engineers ®

U.S.ARMY

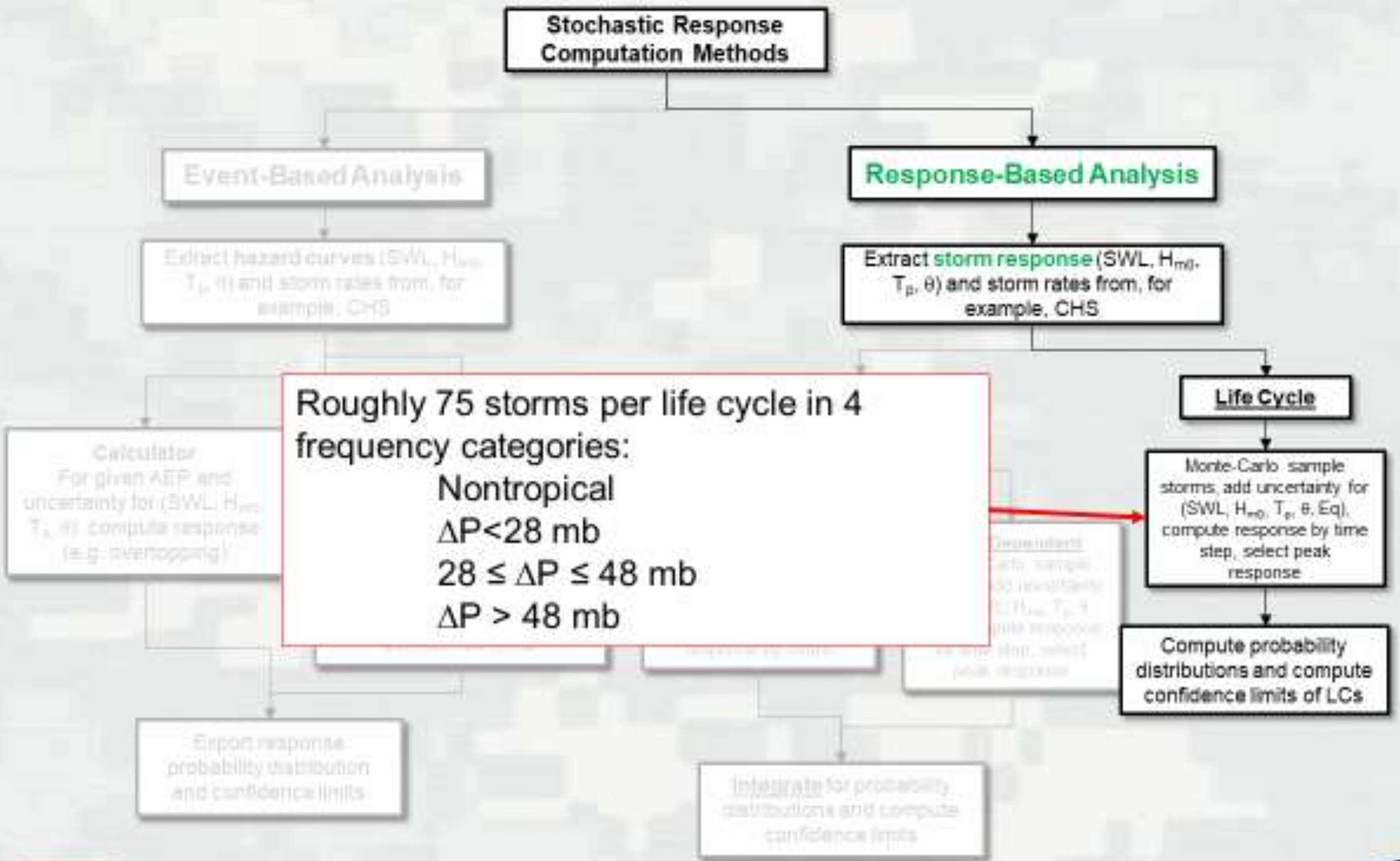
Design & Evaluation Method

Step 1: Coastal Hazards System



Design & Evaluation Method

Step2: Probabilistic Life Cycle Analyses



Design & Evaluation Method

1. CEDAS: BMAP, S-Beach

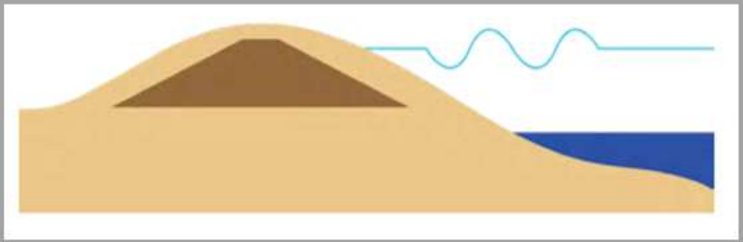
Storm Condition : Event Based
(Ike, Rita, Frances, Allison)

2. CSHORE

MonteCarlo Probabilistic Simulations
(170 Tropical Storms,
RSLC)

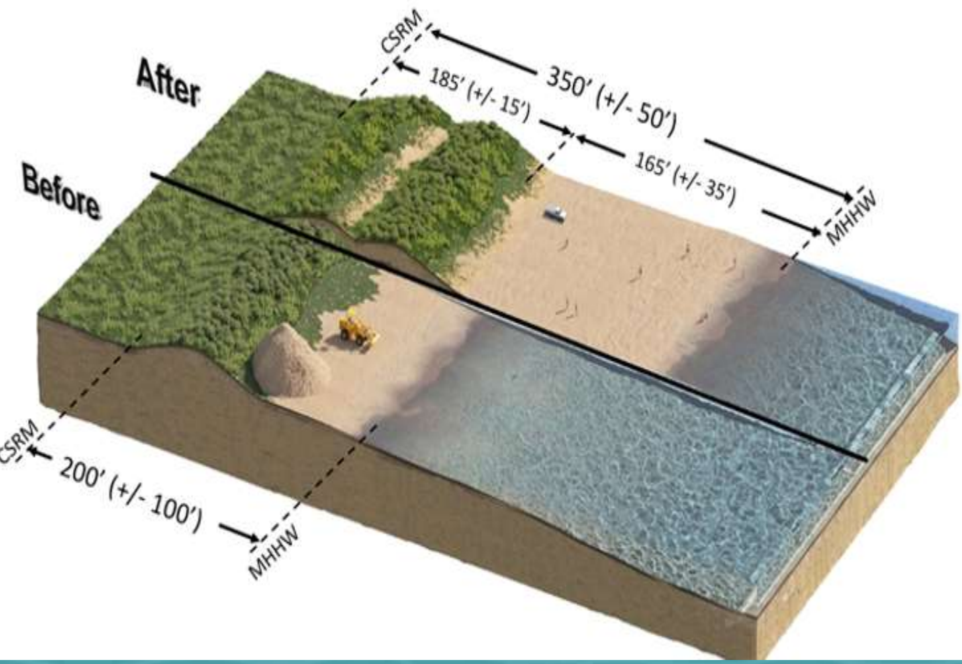
Design Cross Section : Many Cases

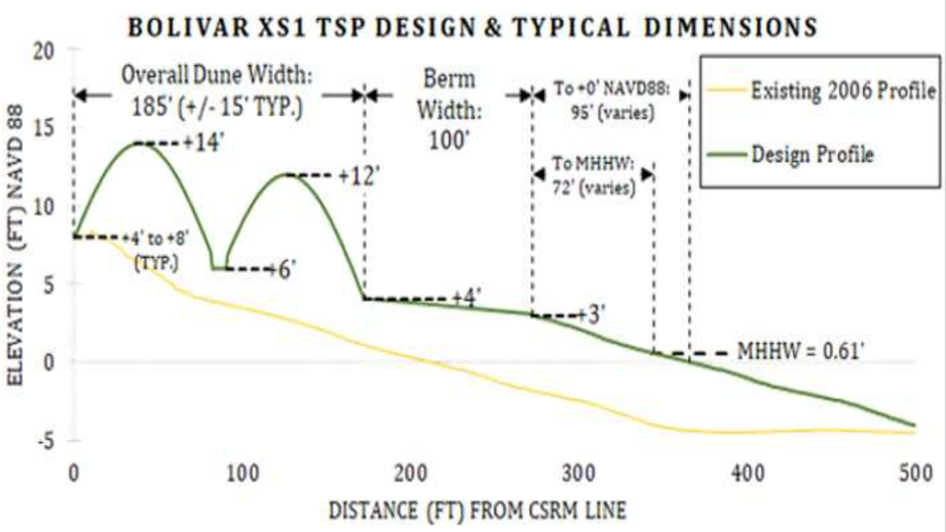
- Existing Condition
- Dune: Sand Only Option (12 ft, 14 ft Dune Height)
- Dune Field: Sand Only Option (12 ft, 14 ft Dune Height)
- Fortified Dune - Hard Core Inside (8 ft, 10 ft, 12 ft)

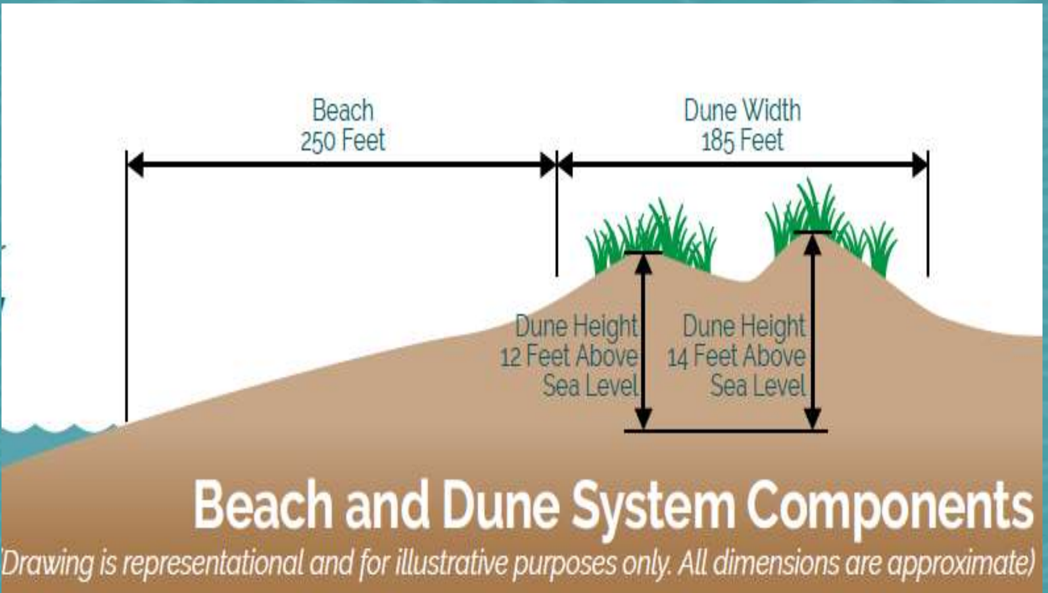


Question to Answer
(a) Initial Quantity (Construction Cost)
(b) Regular re-nourishment cycle (O&M)

Recommended Plan







Wide Beach (200 – 250 ft)
Dune Field (12, 14 ft)
Vegetated
Beach Access: Open Beaches Act

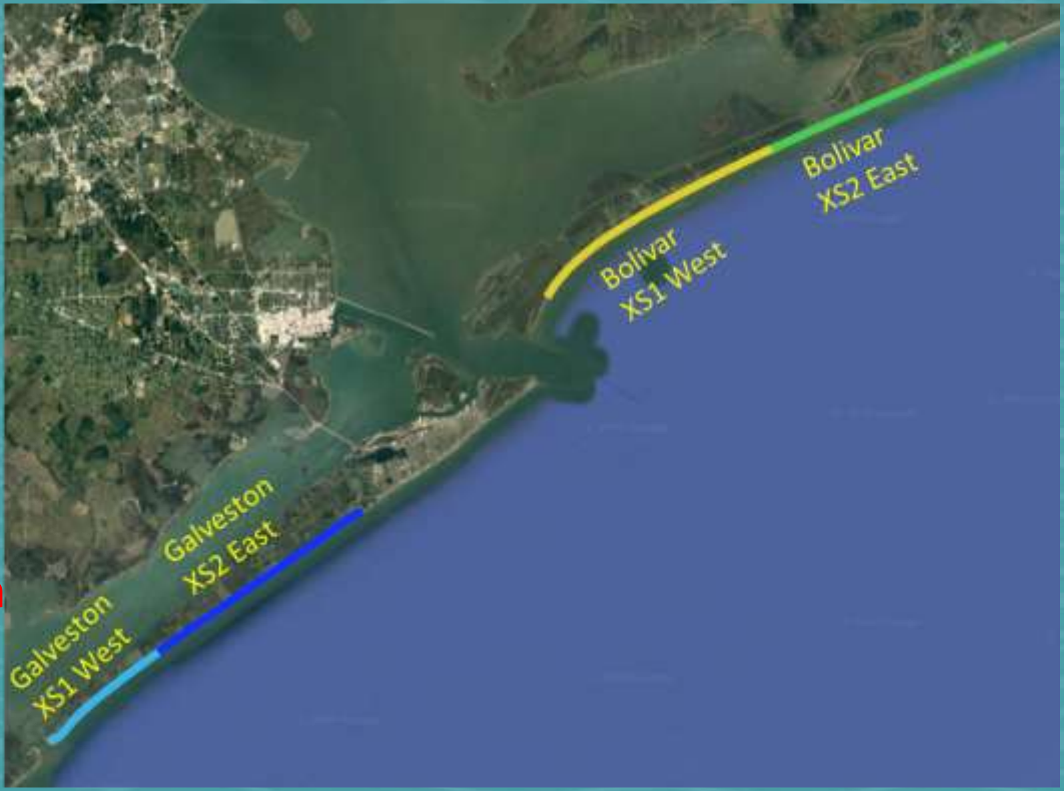
Sediment Needs (Initial Construction Quantity)

- Galveston Length: 18.35 mile
- Bolivar Length : 25.09 mile

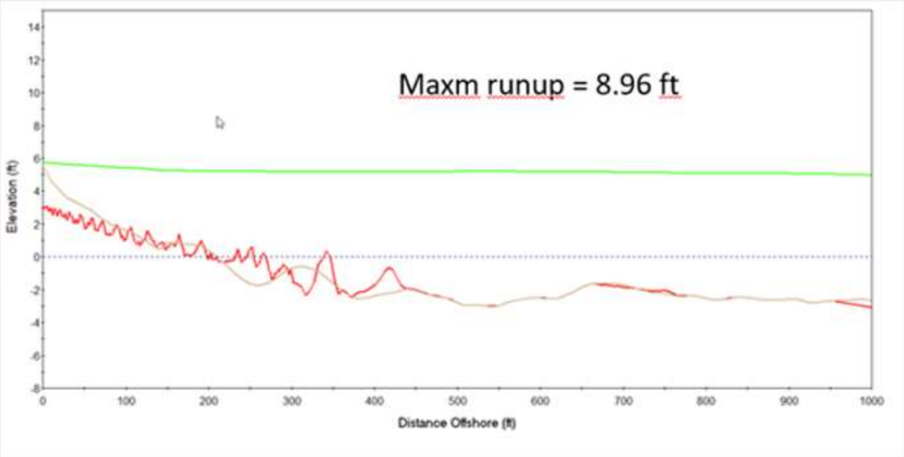
- Galveston initial construction volume
  17.19 MCYD (Avg. 177.43 CYD/ft)

- Bolivar Initial Construction Volume
  22.14 MCYD (Avg. 167.12 CYD/ft)

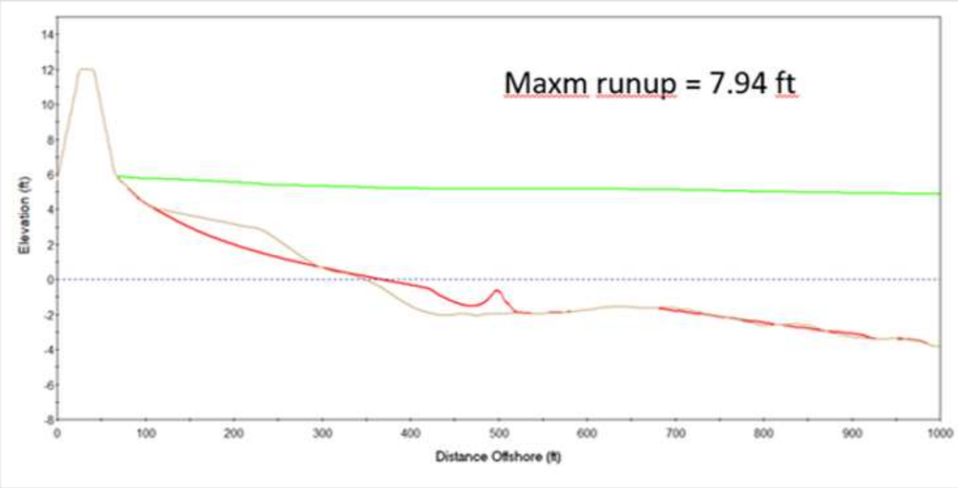
- Total initial construction volume with advanced nourishment
  39.33 MCYD



Evaluation of O&M
10 year Storm (~Reta)

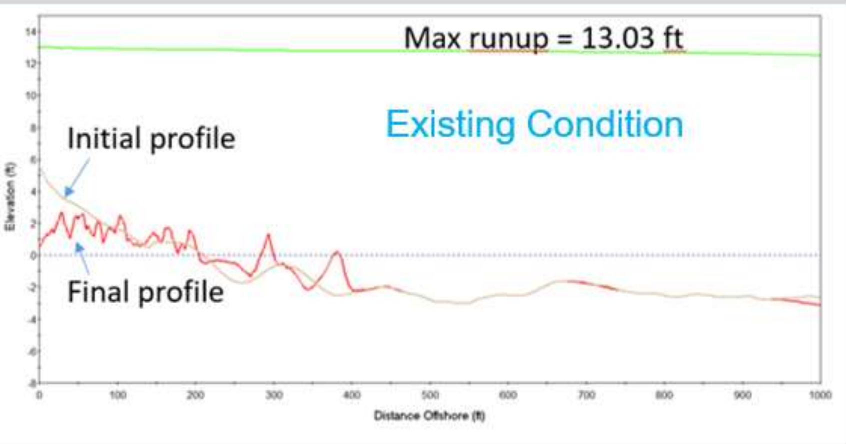


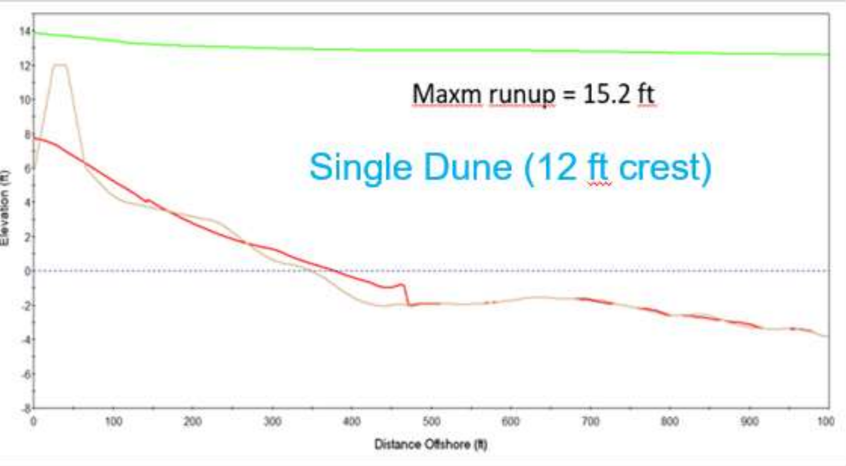
Existing Condition

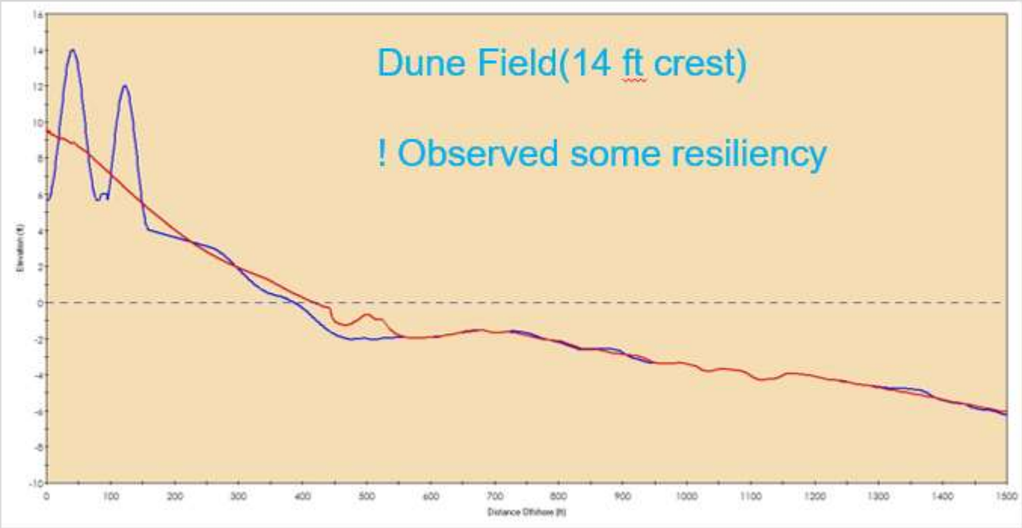


Dunes appears to be intact

Evaluation of O&M
100 year Storm (> Ike)

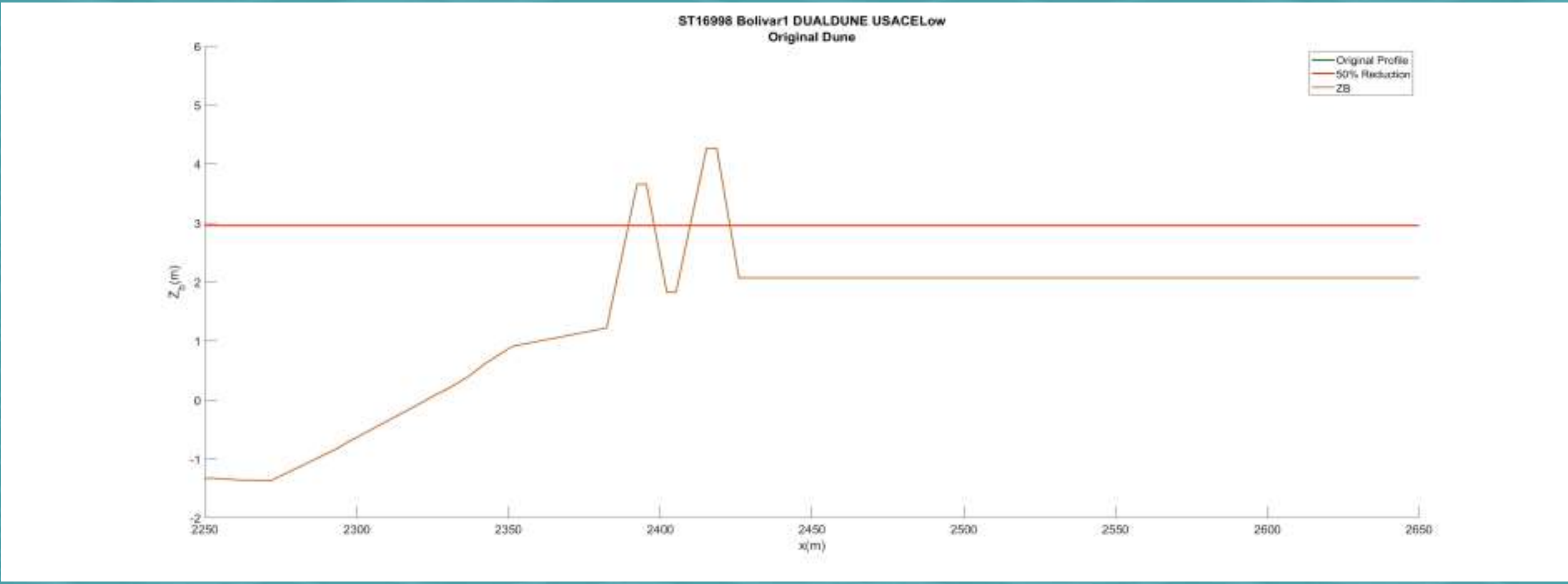




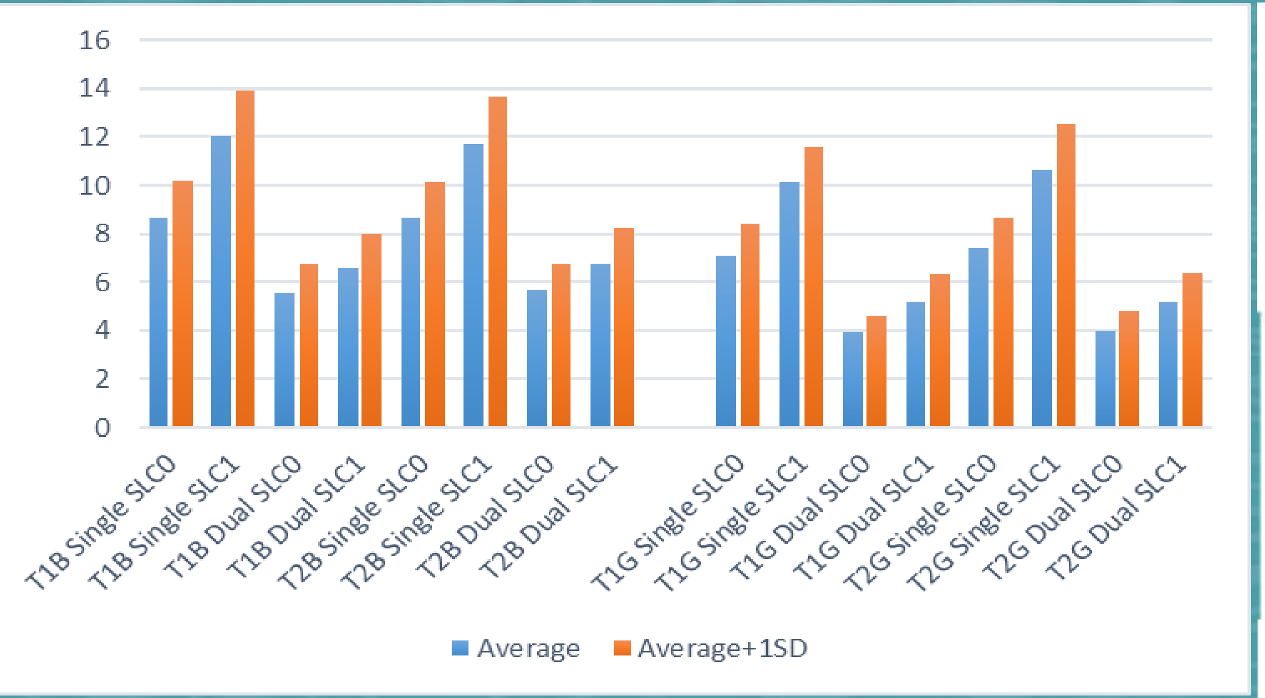


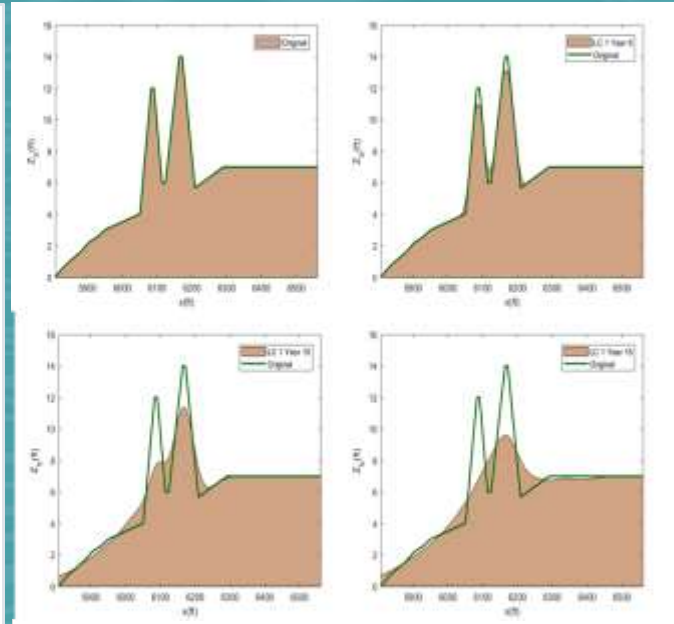
Dunes appear to be compromised

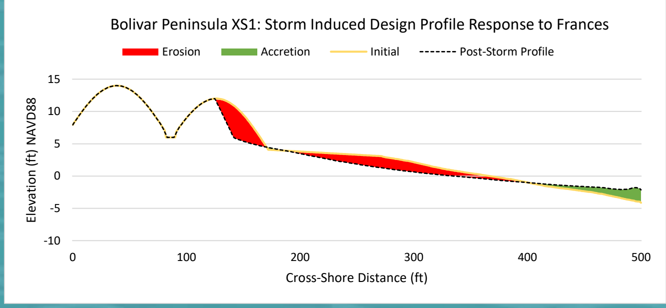
Evaluation of O&M Probabilistic Life Cycle Cost



Life Cycle Cost (O&M)







Rebuild Cycle : Single Dune @ 5 years
Dune Field @ 7 years

Life Cycle Cost (Renourish Volume)

Total maintenance volume
over 50 year life cycle

Low RSLC
Bolivar: 12.751 MCYD
Galveston: 6.569 MCYD
Total : 19.32 MCYD

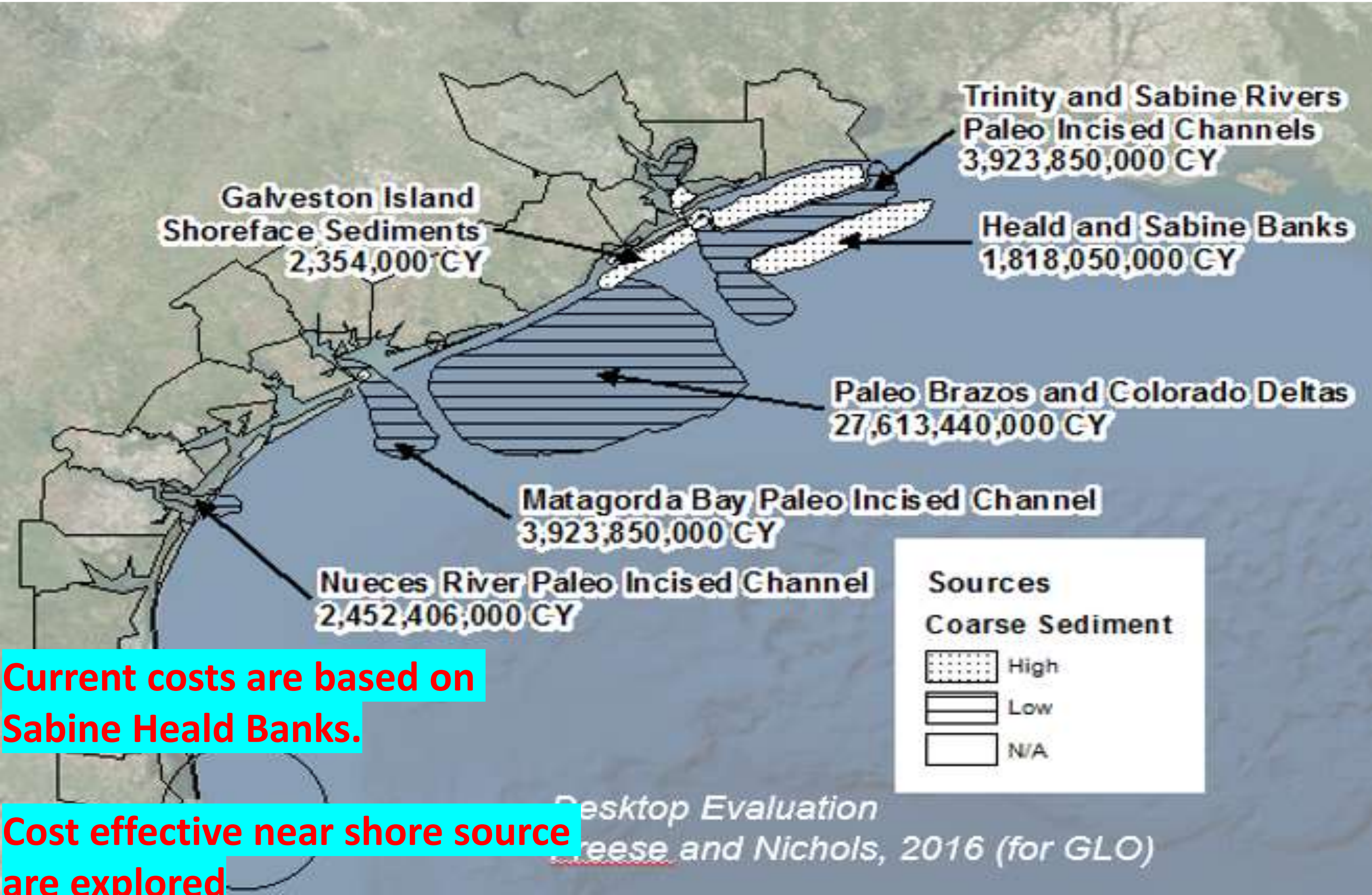
High RSLC (including Std. dev)
Bolivar: 15.813 MCYD
Galveston: 9.135 MCYD
Total : 24.948 MCYD

Int. RSLC (including Std. dev)
Bolivar: 14.28 MCYD
Galveston: 7.85 MCYD
Total : 22.13 MCYD

Bolivar: re-nourish cycle every 6 years @ 1.785 MCYD per rebuild

West Galveston: re-nourish cycle every 7 years @ 1.04 MCYD per rebuild

Sediment Source (> 60 MCY)



Current costs are based on Sabine Heald Banks.

Cost effective near shore source are explored

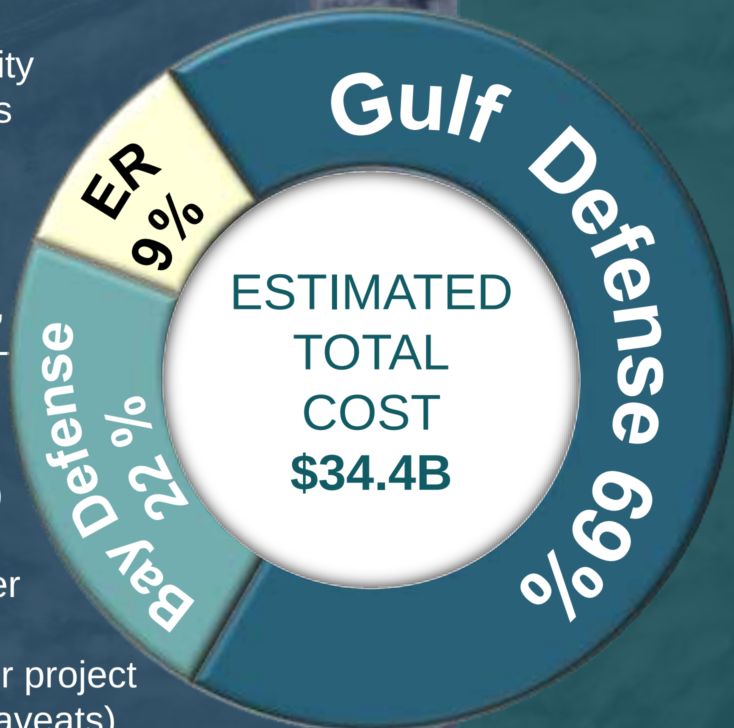
Desktop Evaluation
Freese and Nichols, 2016 (for GLO)

PROJECT COSTS
IS IT WORTH IT?

The NED/NER Plan must balance:

- ✓ Engineering soundness
- ✓ Environmental acceptability
- ✓ Economically justifications

- Unity: Benefits Equal Cost
- Benefits include quantitative, qualitative, monetized & non-monetized units
- Locally Preferred Plan (LPP) is a plan that is preferred by the non-Federal sponsor over the NED/NER plan, and is sometimes recommended for project authorization instead (with caveats)
- LPPs must be evaluated just as the Federal Plan (costs, impacts, benefits)



Project First Cost

Projected Costs

Gulf Defense: **$23.6B**
(Bolivar Roads Gate System + Bolivar/West Galveston Beach & Dune Systems + SPI + Mitigation)

Bay Defense: **$ 7.7B**
(Galveston Ring Barrier + Seawall Improvements + Clear Lake + Dickinson Bay + Non-Structural Improvements)

Ecosystem Restoration: **$ 3.1B**

TOTAL: $34.4B

Recovery Costs for Storms of the Past:

Hurricane Ike (2008): **$38B**
Hurricane Harvey (2017): **$125B**

Coastal Texas Project: What's Next

Web: http:CoastalStudy.Texas.gov

Coastal TX Story Maps

Questions/Comments

Thank you

Acknowledgments:

Kelly Burks-Copes
Chris Massey
Norberto Nadal
Jeff Melby
Tony Williams
I-STORM

US Army Corps of Engineers
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