Appendix A

Plan Formulation Supporting Documentation

U.S. Army Corps
of Engineers

Galveston District
Southwestern Division

Appendix A

Plan Formulation

Supporting Documentation

for the
Coastal Texas Protection and Restoration Study
Integrated Feasibility Report and
Environmental Impact Statement

October 2018

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Acronyms and Abbreviations

BD	Beach Dune
BEG	Bureau of Economic Geology
BI	Bird Island
BU	beneficial use
CE/ICA	Cost Effectiveness and Incremental Cost Analyses
CEM	Conceptual Ecological Model
CEPRA	Coastal Erosion Planning and Response Act
Coastal Texas Study	Coastal Texas Protection and Restoration Study
CSRM	coastal storm risk management
DIFR-EIS	Draft Integrated Feasibility Report and Environmental Impact Statement
EB	Estuarine Bay
EFH	essential fish habitat
EPA	U.S. Environmental Protection Agency
ER	ecosystem restoration
FEMA	Federal Emergency Management Agency
FWOP	Future Without-Project
GIWW	Gulf Intracoastal Waterway
GLO	Texas General Land Office
Gulf	Gulf of Mexico
HC	Hydrologic Connectivity
HEP	Habitat Evaluation Procedure
HFPS	Hurricane Flood Protection System
I-37	Interstate Highway 37
MB	Migratory Bird
NED	National Economic Development
NEPA	National Environmental Policy Act
NER	National Ecosystem Restoration
NFWF	National Fish and Wildlife Foundation
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPS	National Park Service
NRDA	Natural Resources Damage Assessment
NWR	National Wildlife Refuge
OR	Oyster Reef
PA	placement area
PDT	Project Development Team

RESTORE	Resources and Ecosystems Sustainability, Tourist Opportunities, and Revived Economies of the Gulf Coast States
RSLR	relative sea level rise
SAV	submerged aquatic vegetation
SC	screening criteria
SLR	sea level rise
SP	Shoreline Protection
T&E	threatened and endangered
TPWD	Texas Parks and Wildlife Department
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
WMA	Wildlife Management Area

1.0 REGION-SPECIFIC PROBLEMS AND OPPORTUNITIES

1.1 UPPER TEXAS COAST

Specific problems and specific opportunities reviewed in the upper Texas coast included:

Problems	Opportunities
Coastal Storm Risk Management (CRSM)	
• Populations are vulnerable to life safety from flooding due to their close proximity to the coast. This includes the fourth largest U.S. city (Houston), and other key metropolitan areas such as Beaumont/Port Arthur/ Orange, Galveston/Texas City, and Freeport/Surfside • Flood risk increase in the industrial section of the upper Galveston Bay system due to coastal storm surges. The area at risk includes nine of the largest oil refineries in the world, 40 percent of the Nation's petrochemical industry, 25 percent of the Nation's petroleum-refining capacity, 60 percent of the U.S. jet fuel production, and includes two of the nation's strategic petroleum reserves • Local existing hurricane risk reduction systems are increasingly at risk from coastal storms due to Relative Sea Level Rise (RSLR). Majority do not meet current design standards for resiliency and redundancy • Infrastructure associated with nationally important deep-draft seaport and shallow-draft channels is susceptible to flood and hurricane storm damages, particularly the Port of Houston, which is number one in importing fuel, and the Port of Beaumont, which is the number one military outload port in the world • Critical infrastructure throughout the region, including hurricane evacuation routes, nationally significant medical centers, government facilities, universities, and schools are at risk of damage due to storm events. Also, there is the potential for release of hazardous, toxic and radioactive waste to the sensitive environmental areas due to storm surge impacts on refineries and tank farms	• Reduce the susceptibility of residential, commercial, and public structures and infrastructure to hurricane-induced storm damages along Galveston Island, Bolivar Peninsula, and along the interior of the Galveston Bay system • Improve flood warnings for preparation and/or evacuation • Recommend future modifications to the roadway systems to maintain, as much as possible, emergency response vehicle access during and following hurricane and tropical storm events • Reduce region's population vulnerable to life safety issues from storm surge flooding
Ecosystem Restoration (ER)	
• Loss of fish and shellfish habitat in the Galveston Bay system due to navigation impacts and increased salinities • Gulf of Mexico (Gulf) shoreline erosion along the Texas-Louisiana Coastal Marshes due to loss of longshore sediment transportation particularly in areas near the Texas Point National Wildlife Refuge (NWR) and from the Clam Lake Road area to High Island in the McFaddin NWR area	• Restoration of marshes along the Gulf Intracoastal Waterway (GIWW) damaged by salinity intrusion and barge wake erosion, and protection of marsh shorelines to prevent further damage from erosion • Restoration of islands that protect navigation in the GIWW from wind fetch across large bay systems • Increase resiliency of barrier island systems

Problems	Opportunities
• Gulf shoreline erosion along the Mid-Coast Barrier Islands and Coastal Marshes near the Brazos River due to the redirection of riverine flows • Saltwater intrusion in the Galveston Bay estuary due to breaches in the Barrier Islands system resulting from coastal storms reduces the long-term sustainability of coastal wetland systems • Loss of coastal wetlands along GIWW due to wind and barge traffic wave impacts	• Benefit coastal and marine resources in the Galveston Bay system through marsh and oyster reef restoration • Maintain sediment within the system and use beneficially where feasible, particularly when dredging in the Galveston Bay system • Reduce saltwater intrusion associated with tropical systems within sensitive estuarine systems • Assist in the restoration and long-term sustainability of coastal wetlands that support important fish and wildlife resources within areas of national significance • Restore and protect endangered species habitat.

1.2 MID TO UPPER TEXAS COAST

Specific problems and specific opportunities reviewed in the mid to upper Texas coast included:

Problems	Opportunities
CSRM	
• Populations are vulnerable to life safety from flooding due to close proximity to the coast • Critical infrastructure including hurricane evacuation routes at risk of damage and closure due to storm events • Local existing hurricane risk reduction system systems are increasingly at risk from storm damages due to RSLR • Anthropogenic hydrologic alterations have reduced riverine inflows and overland flows, or adversely altered tidal flows and circulation	• Reduce economic damages from storm surge flooding to businesses, residents, and infrastructures in Matagorda and Calhoun County system • In the city of Matagorda, increase the resilience of existing Hurricane Flood Protection System (HFPS) from sea level rise (SLR) and storm surge impacts • Enhance and restore coastal geomorphology along Matagorda Island, Matagorda Peninsula, and the Sargent Beach Area that contributes to reducing the risk of storm surge damages • Reduce the susceptibility of public health and safety from storm surge impacts in the Matagorda and Calhoun County system
ER	
• Anthropogenic hydrologic alterations have resulted in a loss of connectivity in the Matagorda Bay system and the San Antonio Bay system • Storm surge erosion is degrading nationally significant migratory waterfowl and fisheries habitats in the Matagorda Bay system • The GIWW is creating shoreline erosion and impacts tidal flow entering interior marshes. Erosion of bay shorelines and islands caused by wind and wakes is destroying estuarine marsh habitat and rookery islands • Loss of coastal marshes and bay shorelines on Barrier Island system and estuarine systems. Oyster reefs are	• Restore hydrologic connectivity in the Matagorda Bay system and the San Antonio Bay system • In area of Matagorda Bay system, improve migratory bird habitat and critical threatened and endangered habitat • Along the GIWW, reduce the magnitude of shoreline erosion to marshes and also reduce the magnitude of tidal flow entering interior marshes to prevent continuing wetland loss • Improve sustainability of coastal marshes and bay shorelines on Barrier Island system and estuarine systems

Problems	Opportunities
at risk due to increasing salinities, predation, and disease in addition to the pressures of harvesting • Loss of beaches and dunes to erosion	• Restore size and quality of beaches and dunes focusing on areas with existing high erosion rates

1.3 MID TEXAS COAST

Specific problems and specific opportunities reviewed in the mid Texas coast included:

Problems	Opportunities
CSRM	
• Populations are vulnerable to life safety from flooding due to close proximity to the coast • Critical infrastructure including hurricane evacuation routes at risk of damage and closure due to storm events • Threat to energy security and economic impacts of petrochemical supply-related interruption due to storm surge impacts • Changes in coastal geomorphology contribute to risk of storm surge damages	• Reduce economic damage from storm surge flooding to business, residents and infrastructure in the Rockport/Fulton and surrounding area • Reduce risk to critical infrastructure and evacuation routes (e.g., Interstate Highway 37 [I-37], I-35, and US 361) from storm surge flooding the area of Corpus Christi, Rockport/ Fulton, and surrounding area • Reduce risk to public health and safety from storm surge impacts in the Rockport/Fulton and surrounding area • In the surrounding areas of Corpus Christi, enhance energy security and reduce economic impacts of petrochemical supply-related interruption due to storm surge impacts • Enhance and restore coastal geomorphology along Mustang and North Padre islands that contributes to reducing the risk of storm surge damages
ER	
• Loss of hydraulic connectivity between rivers, deltas, and bays due to construction of roadways, diversion canals, ship channels, and other manmade features • Loss of migratory bird and other threatened and endangered (T&E) species habitat due to storm surge and erosion • Loss of ecosystem function within coastal bays and estuaries • Loss of coastal marshes and bay shorelines on Barrier Island system and estuarine systems. Oyster reefs are at risk due to increasing salinities, predation, and disease in addition to the pressures of harvesting • The GIWW is causing shoreline erosion and impacting tidal flow entering interior marshes. Erosion of bay shorelines and islands caused by wind and wakes is destroying estuarine marsh habitat and rookery islands	• Maintain hydrologic connectivity in the Nueces Delta, Aransas Delta, and in the Mesquite Bay system • Regionwide improvement of migratory bird habitat and critical T&E habitat • Improve coastal bays and estuaries with restoration of marshes and oyster reefs • Improve/sustain coastal marshes and bay shorelines on Barrier Island system and estuarine systems • Along the GIWW, reduce the magnitude of shoreline erosion to marshes and also reduce the magnitude of tidal flow entering interior marshes to prevent continuing wetland loss

1.4 LOWER TEXAS COAST

Specific problems and specific opportunities reviewed in the lower Texas coast included:

Problems	Opportunities
CSRM	
• Populations are vulnerable to life safety from flooding due their close proximity to the coast • Critical infrastructure including hurricane evacuation routes at risk of damage and closure due to storm events • Public health and safety risks due to storm surge impacts • Loss of natural regional sediment movement contributes to increased storm surge risk • Loss of natural coastal geomorphology, such as dune systems, contributes to the risk of storm surge damages	• Reduce economic damage from storm surge flooding to business, residents, and infrastructure in Port Isabel, Port Mansfield, and South Padre Island and surrounding areas • Reduce risk to critical infrastructure and evacuation routes from storm surge flooding in Port Isabel, Port Mansfield, and South Padre Island and surrounding areas • Reduce risk to public health and safety from storm surge impacts in the areas of Port Isabel, Port Mansfield, and South Padre Island and surrounding areas • Manage regional sediment so that it contributes to storm surge attenuation where feasible • Enhance and restore coastal beach and dune systems along South Padre Island to reduce the risk of storm surge damages
ER	
• Loss of hydrologic connectivity to and within the Bahia Grande system • Loss of migratory bird habitat and critical T&E species habitat • Oyster reefs are at risk due to increasing salinities, predation, and disease in addition to the pressures of harvesting • Beaches and dunes experience high erosion rates; • Critical habitat for wintering populations of the piping plover and the whooping crane are damaged or destroyed due to storm surge • Loss of coastal marshes and bay shorelines on Barrier Island system and estuarine systems • Barge wakes in the GIWW are causing erosion of Laguna Madre shorelines and rookery islands	• Reduce salinity and restore hydrologic connectivity to and within the Bahia Grande system • Improve region wide migratory bird habitat, and critical threatened and endangered habitat • Improve water quality in coastal bays and estuaries with restoration of marshes • Restore size and quality of beaches and dunes focusing on areas with existing high erosion rates; improve/sustain coastal marshes and bay shorelines on Barrier Island system and estuarine systems • Along the GIWW, reduce the magnitude of shoreline erosion to rookery islands to prevent continued losses of habitats

2.0 REVIEW OF MANAGEMENT MEASURES AND REFINEMENTS OF REGION-SPECIFIC OBJECTIVES BASED ON INVENTORYING AND FORECASTING (STEP 1)

Section 4.2.1 of the Draft Integrated Feasibility Report and Environmental Impact Statement (DIFR-EIS) presents the initial list of measures and the subsequent refinement of the initial region-specific objectives since some of the apparent problems did not rise to a high enough significance to be addressed by the goals of study. For example, there was an anticipated problem with coastal storm damages in the area of Corpus Christi in the mid Texas coast. A detailed review of the structure inventory showed that many of the structures were outside of the 100-year Federal Emergency Management Agency (FEMA) floodplain. Also, when reviewing the historical shoreline erosion rates, there were mainly three areas with high erosion rates. Many of the other areas are stable. Information collected under the inventory and forecasting phase of the planning process was used to update the region-specific objectives.

Table 4-2 in the DIFR-EIS provided an overview of the updates to the region-specific objectives for upper Texas coast only. Table 2-1 presents the study objectives for the entire study area.

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Table 2-1
Upper Texas Coast Specific Objectives through 2085

ID	Title	Description	Changes to Description	Refinements
Objectives for CSRM (NED):				
NED_Reg_1_Obj1	Reduce Flood Damages	• Reduce economic damage from coastal storm surge flooding to business, residents, and infrastructure in the areas of the Galveston Bay system, Galveston Island, and in the area of Chocolate Bayou	• Reduce economic damage from coastal storm surge flooding to business, residents, and infrastructure in the areas of the Galveston Bay system and Galveston Island	Chocolate Bayou Area removed from considerations based on site visits (Limited Risk)
NED_Reg_1_Obj2	Life, Health, and Welfare (Facilities)	• Reduce risk to critical infrastructure (e.g., medical centers, government facilities, universities, and schools) from coastal storm surge flooding in the areas of Galveston Bay, Galveston Island, and in the area of Chocolate Bayou, to the maximum extent practical and also reduce emergency costs associated with the occurrence of storm-related events, specifically the Blue Water Highway, I-45, State Highway 87, and Highway 146 access routes	• Reduce risk to critical infrastructure (e.g. medical centers, government facilities, universities, and schools) from coastal storm surge flooding in the areas of Galveston Bay and Galveston Island to the maximum extent practical and also reduce emergency costs associated with the occurrence of storm-related events, specifically the Blue Water Highway, I-45, State Highway 87, and Highway 146 access routes	
NED_Reg_1_Obj3	Life, Health, and Welfare (Population)	• Reduce risk to public health and safety from storm surge impacts in the areas of Galveston Bay system, Galveston Island, and in the area of Chocolate Bayou	• Reduce risk to public health and safety from storm surge impacts in the areas of Galveston Bay system and Galveston Island	
NED_Reg_1_Obj4	Industrial Impacts	• In the areas of the Galveston Bay system, Galveston Island, and in the area of Chocolate Bayou, enhance energy security and reduce economic impacts of petrochemical supply-related interruption due to coastal storm surge impacts	• In the areas of the Galveston Bay system and Galveston Island, enhance energy security and reduce economic impacts of petrochemical supply-related interruption due to coastal storm surge impacts	
NED_Reg_1_Obj5	Existing CSRM	• In the areas of the Galveston Bay system and Galveston Island, increase the resilience of existing coastal storm risk reduction systems from SLR and coast storm surge impacts	• In the areas of the Galveston Bay system and Galveston Island, increase the resilience of existing coastal storm risk reduction systems from SLR and coast storm surge impacts	
NED_Reg_1_Obj6	Coastal Landforms	• Enhance and restore coastal landforms along Galveston island and Bolivar Peninsula that contribute to reducing the risk of coastal storm surge damages	• Enhance and restore coastal landforms along Galveston Island and Bolivar Peninsula that contribute to reducing the risk of coastal storm surge damages	
Objectives for ER (National Ecosystem Restoration [NER]):				
NER_Reg_1_Obj1	Marsh Improvements (Navigation Impacts)	• Along the GIWW reduce the magnitude of shoreline erosion to marshes and also reduce the magnitude of tidal flow entering interior marshes to prevent continuing wetland loss	No change	No change
NER_Reg_1_Obj2	Hydrologic Connectivity	• Improve hydrologic connectivity of area wetlands in the Texas-Louisiana Coastal Marshes, Mid-Coast Barrier Islands, and Coastal Marshes		
NER_Reg_1_Obj3	Beaches and Dunes	• Restore size and quality of beaches and dunes focusing on areas with existing high erosion rates		
NER_Reg_1_Obj4	Oyster Reefs	• Create, restore, and nourish oyster reefs to benefit coastal and marine resources		
NER_Reg_1_Obj5	Back Bay Systems	• Improve sustainability of coastal marshes and bay shorelines on Barrier Island system and estuarine systems		
NER_Reg_1_Obj6	Rookeries	• In the area of Galveston Bay, improve migratory bird habitat and threatened and endangered habitat		

Table 2-2
Mid to Upper Texas Coast Specific Objectives through 2085

ID	Title	Description	Changes to Description	Refinements
Objectives for CSRM (National Economic Development [NED]):				
NED_Reg_2_Obj1	Reduce Flood Damages	• Reduce economic damage from storm surge flooding to business, residents and infrastructure in the Matagorda and Calhoun County systems	• Reduce economic damage from storm surge flooding to business, residents, and infrastructure in the Matagorda and Calhoun County systems	Limited Risk. Areas not included in final considerations
NED_Reg_2_Obj2	Life, Health, and Welfare (Facilities)	• Reduce risk to critical infrastructure and evacuation routes from storm surge flooding in Matagorda and Calhoun counties	• Reduce risk to critical infrastructure and evacuation routes from storm surge flooding in Matagorda and Calhoun counties	
NED_Reg_2_Obj3	Life, Health, and Welfare (Population)	• Reduce risk to public health and safety from storm surge impacts in the areas of Matagorda and Calhoun counties	• Reduce risk to public health and safety from storm surge impacts in the areas of Matagorda and Calhoun counties	
NED_Reg_2_Obj4	Life, Health, and Welfare (Population)	• In the city of Matagorda, increase the resilience of the existing coastal storm risk reduction systems from SLR and storm surge impacts	• In the city of Matagorda, increase the resilience of the existing coastal storm risk reduction systems from SLR and storm surge impacts	
NED_Reg_2_Obj5	Coastal Geomorphology	• Enhance and restore coastal landforms along Matagorda Island, Matagorda Peninsula, and the Sargent Beach area that contribute to reducing the risk of storm surge damages	• Enhance and restore coastal landforms along ~~Matagorda Island, Matagorda Peninsula, and~~ the Sargent Beach area that contribute to reducing the risk of storm surge damages	Limited Risk Areas, only Sargent Beach has a high erosion rate
Objectives for ER (NER):				
NER_Reg_2_Obj1	Hydrologic Connectivity	• Reduce salinity and restore hydrologic connectivity in the Matagorda Bay system and the San Antonio Bay system	No change	No change
NER_Reg_2_Obj2	Bird Habitat/Rookery	• In area of the Matagorda Bay system, improve migratory bird habitat and critical T&E habitat		
NER_Reg_2_Obj3	Estuary and Marsh Habitat	• Improve habitat quality in coastal bays and estuaries with restoration of marshes and oyster reefs		
NER_Reg_2_Obj4	Beaches and Dunes	• Restore size and quality of beaches and dunes focusing on areas with existing high erosion rates		
NER_Reg_2_Obj5	Sustainability of Barrier Islands and Estuaries	• Improve sustainability of coastal marshes and bay shorelines on the Barrier Island and estuarine systems		
NER_Reg_2_Obj6	Wetlands	• Along the GIWW reduce the magnitude of shoreline erosion to marshes and also reduce the magnitude of tidal flow entering interior marshes to prevent continuing wetland loss		
NER_Reg_2_Obj7	Sediment Connectivity	• Restore historical sediments inputs from the Guadalupe River into the Guadalupe Delta		

Table 2-3
Mid Texas Coast Specific Objectives through 2085

ID	Title	Description	Changes to Description	Refinements
Objectives for CSRM (NED):				
NED_Reg_3_Obj1	Reduce Flood Damages	• Reduce economic damage from storm surge flooding to business, residents, and infrastructure in the area of Rockport/Fulton and surrounding area	• Reduce economic damage from storm surge flooding to business, residents, and infrastructure in the area of Rockport/Fulton and surrounding area	Limited Risk. Areas not included in final considerations
NED_Reg_3_Obj2	Life, Health, and Welfare (Facilities)	• Reduce risk to critical infrastructure and evacuation routes (e.g., I-37, I-35, and US 361) from storm surge flooding of Corpus Christi, Rockport/Fulton, and surrounding areas	• Reduce risk to critical infrastructure and evacuation routes (e.g., I-37, I-35, and US 361) from storm surge flooding of Corpus Christi, Rockport/Fulton, and surrounding areas	
NED_Reg_3_Obj3	Life, Health, and Welfare (Population)	• Reduce risk to public health and safety from storm surge impacts in the area of Rockport/Fulton and surrounding area	• Reduce risk to public health and safety from storm surge impacts in the area of Rockport/Fulton and surrounding area	
NED_Reg_3_Obj4	Life, Health, and Welfare (Population/Facilities)	• In the surrounding areas of Corpus Christi, enhance energy security and reduce economic impacts of petrochemical supply-related interruption due to storm surge impacts	• In the surrounding areas of Corpus Christi, enhance energy security and reduce economic impacts of petrochemical supply-related interruption due to storm surge impacts	
NED_Reg_3_Obj5	Coastal Geomorphology	• Enhance and restore coastal landforms along Mustang and North Padre islands that contribute to reducing the risk of storm surge damages	• Enhance and restore coastal landforms along Mustang and North Padre islands that contribute to reducing the risk of storm surge damages	
Objectives for ER (NER):				
NER_Reg_3_Obj1	Hydraulic Connectivity	• Restore hydrologic connectivity in the Nueces Delta, Aransas Delta, and in the Mesquite Bay system	• Restore hydrologic connectivity in the Nueces Delta, Aransas Delta, and in the Mesquite Bay system	
NER_Reg_3_Obj2	Migratory Birds/Rookery	• Region-wide improvement to migratory bird habitat, and critical T&E habitat	• Regionwide improvement to migratory bird habitat and critical T&E habitat	
NER_Reg_3_Obj3	Estuary and Bay Habitat	• Improve habitat quality in coastal bays and estuaries with restoration of marshes and oyster reefs	• Improve habitat quality in coastal bays and estuaries with restoration of marshes and oyster reefs	
NER_Reg_3_Obj4	Beaches and Dunes	• Restore size and quality of beaches and dunes focusing on areas with existing high erosion rates	• Restore size and quality of beaches and dunes focusing on areas with existing high erosion rates	Limited Areas of High Erosion
NER_Reg_3_Obj5	Sustainability of Barrier Islands and Estuaries	• Improve/sustain sustainability coastal marshes and bay shorelines on Barrier Island system and estuarine systems	• Improve/sustain sustainability of coastal marshes and bay shorelines on Barrier Island system and estuarine systems	
NER_Reg_3_Obj6	Marshes	• Along the GIWW, reduce the magnitude of shoreline erosion to marshes and also reduce the magnitude of tidal flow entering interior marshes to prevent continuing wetland loss	• Along the GIWW, reduce the magnitude of shoreline erosion to marshes and also reduce the magnitude of tidal flow entering interior marshes to prevent continuing wetland loss	

Table 2-4
Lower Texas Coast Specific Objectives through 2085

ID:	Title	Description	Changes to Description	Refinements
Objectives for CSRM (NED):				
NED_Reg_4_Obj1	Reduce Flood Damages	• Reduce economic damage from storm surge flooding to business, residents, and infrastructure in Port Isabel, Port Mansfield and South Padre and surrounding areas	• Reduce economic damage from storm surge flooding to business, residents, and infrastructure in ~~Port Isabel, Port Mansfield and~~ South Padre and surrounding areas	Limited Risk. Areas not included in final considerations
NED_Reg_4_Obj2	Life, Health, and Welfare (Facilities)	• Reduce risk to critical infrastructure and evacuation routes from storm surge flooding in Port Isabel, Port Mansfield, and South Padre Island and surrounding areas	• Reduce risk to critical infrastructure and evacuation routes from storm surge flooding ~~in Port Isabel, Port Mansfield, and~~ in South Padre Island and surrounding areas	
NED_Reg_4_Obj3	Life, Health, and Welfare (Population)	• Reduce risk to public health and safety from storm surge impacts in the areas of Port Isabel, Port Mansfield, and South Padre Island and surrounding areas	• Reduce risk to public health and safety from storm surge impacts in ~~the areas of Port Isabel, Port Mansfield, and~~ South Padre Island and surrounding areas	
NED_Reg_4_Obj4	Reduce Storm Surge	• Manage regional sediment so it contributes to storm surge attenuation where feasible	• Manage regional sediment so it contributes to storm surge attenuation where feasible	
NED_Reg_4_Obj5	Coastal Geomorphology	• Enhance and restore coastal geomorphology along South Padre Island so that it contributes to reducing the risk of storm surge damages	• Enhance and restore coastal geomorphology along South Padre Island so that it contributes to reducing the risk of storm surge damages	
Objectives for ER (NER):				
NER_Reg_4_Obj1	Hydrologic Connectivity	• Reduce salinity and restore hydrologic connectivity to and within the Bahia Grande System	No change	No change
NER_Reg_4_Obj2	Migratory Birds and T&E	• Regionwide improvement of migratory bird habitat and critical T&E habitat		
NER_Reg_4_Obj3	Estuary and Bay Habitat	• Improve habitat quality in coastal bays and estuaries		
NER_Reg_4_Obj4	Beaches and Dunes	• Restore size and quality of beaches and dunes focusing on areas with existing high erosion rate		
NER_Reg_4_Obj5	Sustainability of Barrier Islands and Estuaries	• Improve/sustain coastal marshes and bay shorelines on Barrier Island and estuarine systems		
NER_Reg_4_Obj6	Rookery	• Along the GIWW, reduce the magnitude of shoreline erosion to rookery islands to prevent continued loss of habitats		

3.0 ECOSYSTEM RESTORATION MEASURE SCREENING

Table 4-4 in Section 4.0 of the DIFR-EIS presents the initial array of measures proposed for the study area. The list includes structural and nonstructural approaches to reduce risk of coastal storms to property and contents and habitat restoration features to reduce damage to ecosystem features and habitat necessary to support diverse species along the Texas coast. These habitat restoration features are part of a comprehensive system of interrelated approaches to comprehensive risk reduction and resiliency building. The first screening assessed the viability of the measures with professional judgement and current plans of other agencies. Many were viable and already proposed for implementation by others. Measures screened from this list are presented in Table 3-1. Table 4.6 in the DIFR-EIS presents the measures that were carried forward.

The measures carried forward were presented at the Alternatives Milestone Meeting to demonstrate that conceptual plans with a combination of habitat restoration, structural and nonstructural measures will succeed in providing comprehensive risk reduction along the coast. Further iterations, however, required more-thorough assessment of measure performance and benefit quantification to confirm cost effectiveness and performance of each of the measures. This analysis required separate evaluation and comparison of the project features with approved models, which separated the individual plan components by benefits stream. For these screening steps, the measures were compared as separate CSRM measures and ER measures. Also due to the hydrologic separability of the CSRM features in the Galveston area, the city of Matagorda and South Padre Island were evaluated independently. Section 4.0 of the DIFR-EIS presents the detailed screening of the CSRM measures. Section 4 of this supplementary information appendix provides the many screening steps of the ER measures.

The ecosystem restoration evaluation advanced in multiple steps during technical meetings of the study team and meetings or workshops including the interagency working group. Members refined the measures to eliminate or combine them. Table 3-2 provides a quick visual summary of the screening steps provided in Section 4.0 of this supplementary information. Green cells indicate the measure was carried forward from each interagency meeting. Grey cells indicate when the measure was eliminated and the reason. Combined measures are noted as equations in light blue cells. Reasons for elimination included low score in performance against other measures, already adopted by another agency, infeasibility, or deferred for another study due to the complexity of the hydrological modeling and benefit quantification process.

Table 3-1
Measures Screened from List

Measure	Justification for Screening
B-3 Gulf Beach and Dune (CSRM)	Limited CSRM benefit stream. Structures in the area show that they are currently elevated above the more frequent flood elevation (1–50 year)
B-4 Gulf Beach and Dune Restoration (ER)	Infeasible since most of the area is dominated by dredge disposal sites
B-7 GIWW Island Restoration (ER)	Limited benefit stream attributed to the acres created
B-8 Follets Island Road Raising (CSRM)	Project could work together with B-2
B-9 Galveston Bay Estuary Program (ER)	Conceptual only; no feasible action or benefits noted
B-10 Oyster Reef Restoration, Galveston County (ER)	No specific measure identified. Will be discussed as a future effort by others
C-1 East Galveston Bay Shoreline Restoration (ER)	Primarily roadway benefits. These areas should not be considered for ER measures and would likely have limited benefits.
G-1 Closure of Rollover Pass (CSRM)	Will be accomplished sooner under other effort
O-3 Neches River Marsh Restoration (ER)	Under the most reasonably foreseeable future, this measure will be constructed under other authorizations
J-2 Marsh Restoration, Jefferson County (ER)	Will be undertaken under cooperative beneficial use project with the U.S. Fish and Wildlife Service (USFWS) and local industry.
J-3 GIWW Siphons (ER)	Will be construction under the Resources and Ecosystems Sustainability, Tourist Opportunities, and Revived Economies of the Gulf Coast States (RESTORE) Act
RI-1 Smith Point Island Rookery Island Restoration (ER)	Site has secured Phase IV Early Restoration Project Funding
RI-2 Vingt-et-un Islands (ER)	Site has secured Phase IV Early Restoration Project Funding
RI-3 Rollover Pass (ER)	Site has secured Phase IV Early Restoration Project Funding
RI-4 Alligator Point (ER)	Site has secured Phase IV Early Restoration Project Funding
RI-5 West Bay Bird Island Old (ER)	Site has secured Phase IV Early Restoration Project Funding
RI-6 Syndey Island (ER)	Site has secured Phase IV Early Restoration Project Funding
RI-7 Dooms Island (ER)	Site has secured Phase IV Early Restoration Project Funding

Table 3-2
ER Measures Screening

Screening Date	Nov-16	Jan-17	Jan-17	Feb-17	Apr-17	May-17	May-17
1st Line Defense							
B-11	Unsustainable nourishment requirements						
B-2							
B-4		Did not receive a high enough score					
CM-6		Did not receive a high enough score					
G-5 E							G-5E+G-5W
G-5 W							G-5E+G-5W
G-12 E							G12+G13=G28
G-12 W		Low Score					
G-15		Low Score					
M-1		Low Score					Unnecessary
M-10		Low Score					
M-8		Low Score					
N-6		Low Score					
N-7	Already Completed						
N-8							
W-2		Combined with W-1 to create W-3					
Z-1	Already Completed						
2nd Line Defense							
B-5				Combined with B-6 to create B-12			
B-6				Combined with B-5 to create B-12			
CA-4		Low Score					
CA-5		Low Score					
CA-6							
G-11							
G-12 W		Low Score					
G-13		Low Score					G12+G13=G28
M-7		Low Score					
N-3			Combined with N-5 to create N-11				
O-1		Low Score					
O-2		Low Score					
SP-1		Low Score					
W-1		Combined with W-2 to create W-3					
3rd Line Defense							
CA-7					Complexity		
CM-2		Captured in other study					
N-5			Combined with N-3 to create N-11				
N-9					Low Score		
Newly Named Measures							
W-3							
N-11					Complexity		
B-12							
G-28							
G-5							

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4.0 ECOSYSTEM RESTORATION SCREENING SUMMARY

4.1 INTRODUCTION

The Texas coast is a complex and dynamic system that serves to protect the mainland as well as nourish a rich diversity of aquatic, bird, and land-based species — including the human population. Through years of anthropogenic alterations along the coast (including industrial uses, residential development, etc.), delicate ecosystems are degrading and losing their structure and function. At the base of this loss are changes in the geomorphological and hydrological dynamics of the region.

Of the 367 miles of shoreline, more than 60 percent has been identified by the Texas General Land Office (GLO) as subject to high rates of erosion. Wetlands, barrier islands, beaches, and dunes protect the Texas coast and inland areas from hurricanes and storm surge. These natural defenses are threatened by alarming erosion rates, demands of a rapidly growing population, and rising sea levels, which will continue to expose inland communities to increasing risks.

The marshes, prairies, and tidal flats over the entire coastal zone are a major wintering area for waterfowl of the Central Flyway, while primary routes for both the Central and Mississippi flyways converge in the Sabine River area. Coastal scrub/shrub habitat and forests are critically important for the Nation's neotropical migratory songbirds as many utilize this habitat during their trans- and circum-Gulf migrations.

Loss of transitional estuarine marsh and coastal prairie habitats would directly reduce habitat for T&E species. As interior marshes are lost, shoreline retreat rates increase. The continued erosion of the Gulf coast shoreline would reduce sea turtle nesting habitat and lead to additional saltwater intrusion into the interior wetlands resulting in additional marsh loss. Without action, degradation and loss of emergent wetland habitats used by many different fish and wildlife species for shelter, nesting, feeding, roosting, cover, nursery, and other life requirements would continue.

4.2 OVERVIEW OF ECOSYSTEM RESTORATION

The Coastal Texas Protection and Restoration Study (Coastal Texas Study) focus is on the protection, conservation, and restoration of wetlands, barrier islands, shorelines, and related lands and features that protect critical resources, habitat, and infrastructure from the impacts of coastal storms, hurricanes, erosion, and subsidence. The complexity and interrelatedness of the abiotic, biotic, and human systems along the Texas coast require the coastal ecosystem to be restored and managed.

4.3 ECOSYSTEM RESTORATION – GOALS AND OBJECTIVES

ER and management will be based on holistic, landscape-scale, and science-based planning not only at the local and regional levels, but also at a national level (which is especially important for a U.S. Army Corps of Engineers [USACE] National Ecosystem Restoration [NER] study). This approach to ER and management of the Texas coastal ecosystems includes collaboration with stakeholders, monitoring, and adaptive management that sustains

the health, resilience, and diversity of those ecosystems tempered with sustainable management of coastal ecosystem goods and services.

4.3.1 Coastal Texas Study Goals

The Coastal Texas Study ER and management goals include:

- Goal #1: Promote a resilient and sustainable coastal ecosystem by reducing future land loss and restoring, creating, and enhancing coastal wetlands to achieve and sustain a coastal ecosystem that can support and protect the environment, economy, and culture of the Texas coast.

- Goal #2: Restore natural landscape features and hydrologic processes that are critical to sustainable ecosystem structure and function and that provide diverse fish and wildlife habitats.

4.3.2 Coastal Texas Study Objectives

The Coastal Texas Study ER objectives include:

- Objective 1: Shoreline Protection (SP) – Reduce/prevent shoreline erosion of barrier system shorelines, estuarine bay shorelines, and channel shorelines.

- Objective 2: Hydrologic Connectivity (HC) – Restore and/or create hydrologic connectivity of sensitive estuarine systems.

- Objective 3: Estuarine Bay Systems Restoration (EB) – Restore, create, and/or protect critical estuarine wetlands, tidal flats, etc.

- Objective 4: Barrier Beach, Dune, and Back Marsh Restoration (BD) – Nourish and protect barrier beach, dune, and back marsh.

- Objective 5: Oyster Reef Restoration (OR) – Restore and/or create important oyster reefs.

- Objective 6: Neotropical Migratory Bird Habitat Restoration (MB) – Restore and/or create important habitat used by migratory birds.

- Objective 7: Bird Island Rookeries Restoration (BI) – Restore and/or create important islands used as bird rookeries.

- Objective 8: Restore Habitat Used by Species of Concern – Restore and/or create habitat (important, critical, essential, and other habitat types) used by species of concern, such as Federally listed species, shorebirds, Federally managed aquatic species (e.g., essential fish habitat [EFH]), and others.

4.4 ECOSYSTEM RESTORATION STRATEGY

4.4.1 Ecosystem Restoration Strategy Components

The ER Strategy consists of four parts:

1. Identification of conceptual lines of defense and critical geomorphic or key landscape features, and vital hydrologic features;
2. Selection of ER measures and alternatives;
3. Consideration of recent stakeholder and agency comments, and programmatic approaches; and
4. Identification of ER measures and alternatives for critical near-term implementation.

The existing coastal barrier systems (barrier islands, shorelines, and headlands) and estuarine bay shorelines and marsh across the Texas coast, while still relatively intact, are critical geomorphic or key landscape features that are experiencing substantial land loss. According to Paine et al. (2014), the Texas coast shoreline has averaged 4.1 feet per year of retreat from 1930 through 2012 with net shoreline retreat along 80 percent of the shoreline. The annual rate of land loss along the Texas Gulf shoreline (through 2007) is 178 acres per year. Average rates of retreat are higher (5.5 feet per year) along the upper Texas coast than on the central and lower coast (3.2 feet per year).

Similarly, critical bayhead deltas, such as the Nueces and the Guadalupe deltas, provide important, essential, and critical fish and wildlife habitat, migratory bird habitat, and nursery habitat necessary for a healthy and functioning coastal bayhead deltaic system. However, the long-term prognosis for these critical bayhead deltas under present conditions is poor and the vulnerability of the delta systems is high. For example, Hodges et al.'s (2012) *Nueces Delta Restoration Study* for the Coastal Bend Bays and Estuaries Program determined freshwater inundation over the past 30 years has been insufficient in volume and distribution to maintain a healthy marsh, so the delta front is eroding into Nueces Bay, the marsh plants are under stress, and the connectivity of aquatic habitat is threatened.

Targeted ER and management actions now, can help prevent widespread Texas coastal barrier system degradation, fragmentation, and eventual loss (which in turn would expose interior bay shorelines and marshes to Gulf forces resulting in land loss on scales comparable to losses experienced in coastal Louisiana). The strategy described in this document outlines ER, which supports the long-term functional geomorphic and ecosystem integrity of the entire Texas coast.

4.4.2 Identification of Conceptual Lines of Defense and Ecosystem Restoration

This portion of the strategy is based on the concept that the primary threat to estuarine ecosystems is increased exchange with and exposure to Gulf waters and forces. Increased exchange and exposure with the Gulf will change the tidal prism and salinity regime, impacting marsh vegetation and erosion. The concept of lines of defense relates to protection of coastal ecosystems and human infrastructure from storm damage caused by hurricanes and tropical storms coming ashore from the Gulf. The lines of defense provided first by the barrier

islands, then by living shorelines, and finally coastal marshes, can reduce the physical impacts of storm surges and winds that enter the bays. This combination of lines of defense and ER is intended to provide redundant and resilient levels of protection and restoration for both humans and Texas coastal ecosystems. Each of these lines of defense and restoration are individually discussed below:

- *1st Line of Defense and Ecosystem Restoration – Barrier Systems* (includes barrier shorelines, islands, and headlands as well as barrier beach, dune, and back marsh). Restoration of this line of defense includes consideration of barrier system ecological and geomorphic functions.

- *2nd Line of Defense and Ecosystem Restoration – Estuarine Bay System* (includes geomorphic bay features and estuarine habitats including bay shorelines and estuarine marsh, bird rookery islands, oyster reefs, and seagrass beds). Restoration of this line of defense includes consideration of estuarine and bay ecological and geomorphic functions.

- *3rd Line of Defense and Ecosystem Restoration – Bayhead Deltas* (includes bayhead deltaic features and associated habitats including adjacent bird rookery islands, reefs, subaquatic vegetation, and marsh). Restoration of this line of defense includes consideration of bayhead delta ecological and geomorphic functions.

4.4.2.1 1st Line of Defense and Ecosystem Restoration – Barrier Systems

Barrier islands, shorelines, and headlands, as well as tidal inlets, form the 1st line of defense for the major estuarine bays and the residential, industrial, and recreational structures therein. Barrier systems are the boundary between the Gulf and estuarine and terrestrial ecosystems. These features include barrier beach, dune, back marsh, and shallow open-water areas along the inland side of barrier islands. Natural and man-influenced tidal passes (including navigation channels and associated structures, e.g., jetties, etc.), influence exchange of Gulf and riverine waters and sediments providing important habitats for many estuaries.

Coastal barriers also provide habitat for various marine, estuarine, and terrestrial organisms as well as stopover habitat for migrating neotropic birds. Coastal barrier systems provide protection to the wetlands, bays, and estuaries located behind the barrier systems. These features influence tidal prism, limit storm surge heights, retard saltwater intrusion, and limit mechanical erosion by reducing wave energy at the margins of coastal wetlands. Coastal barrier systems and other features of the coastal landscape (e.g., shoals, marshes, and forested wetlands) can provide a considerable and potentially sustainable buffer from wind-wave action and storm surge generated by tropical storms and hurricanes.

Associated with barrier systems are adjacent bird rookery islands, marsh complexes, oyster reefs, and submerged aquatic vegetation (SAV). Each of these habitat features can be limited in size and have intrinsic ecological functionality, as in the case of bird rookery islands. However, when considered from a cumulative perspective, the combination of these features along a barrier system can have considerable local, regional, and national ecological implications, especially important to the NER requirements for the Coastal Texas Study. In addition, strategic placement and numbers of bird rookery islands, oyster reefs, marsh complexes, SAV, and other various living shorelines can also attenuate waves and erosion, reduce fetch, and create EFH.

4.4.2.2 2nd Line of Defense and Ecosystem Restoration – Estuarine Bay System

Bay shorelines, inlets, and bordering estuarine marshes form the 2nd line of defense. Like barrier systems, these features buffer wind and wave attack and help maintain hydrology within bays. These features protect coastal ecosystems and human communities farther inland. In addition to forming a secondary storm buffer, estuaries provide habitat for ecologically, commercially, and recreationally important fish and wildlife. Estuaries are particularly important nursery habitat for many organisms with early life stages dependent on salinities below Gulf salinities. Shrub and woody habitats along estuarine shorelines provide important habitat for neotropical migrating birds.

Associated with estuarine bay systems are bird rookery islands, marsh complexes, oyster reefs, and SAV. Each of these habitat features can be limited in size and have intrinsic ecological functionality, as in the case of bird rookery islands. However, when considered from a cumulative perspective, the combination of these features along a barrier system can have valuable local, regional, and national ecological implications, especially important to the NER requirements for the Coastal Texas Study. In addition, strategic placement and numbers of bird rookery islands, oyster reefs, marsh complexes, SAV, and other various living shorelines can also function as wave and sediment attenuation, reduce fetch, and create EFH.

4.4.2.3 3rd Line of Defense and Ecosystem Restoration – Bayhead Deltas

The 3rd line of defense and ER involves restoring, enhancing, and protecting bayhead deltas. Managing freshwater inflows to optimize salinity, sediment, and nutrient regimes helps sustain deltas and their associated habitats. Opportunities to manage hydrologic connectivity and development of sediment management strategies would maximize delta accretion and sustain important wetland habitats dependent on deltaic ecogeomorphic function. Deltas function as the 3rd line of defense that further protects human infrastructure and estuarine ecosystems. Similar to barrier and estuarine bay systems, there are adjacent bird rookery islands, reefs, marsh complexes, and SAV, which provide benefits similar to those previously described for barrier systems and bay systems.

4.4.3 Conceptual Ecological Model

To assist in the Alternative Plan Formulation process, a Conceptual Ecological Model (CEM) was prepared to initiate development of ER concepts, goals, and objectives (Figure 4-1). A CEM serves as a logical starting point in the planning process for any ER project and provides support throughout the process (Fischenich and Barnes, 2014). The CEM attempts to identify and describe (Fischenich and Barnes, 2014):

- functional relationships within an ecosystem,
- illustrates important system processes, attributes, and cause-effect relationships;
- synthesize current understanding of system functions;

- isolate and help diagnose environmental challenges; and
- provide insight into potential outcomes of restoration actions within the project area.

CEMs foster and establish a common understanding of system functionality, degradation, and potential solutions or restoration actions. CEMs facilitate communication among the Project Delivery Team (PDT), other stakeholders, and the public. Development of CEMs has been recommended for all USACE ER projects (Fischenich and Barnes, 2014). Figure 4-1 depicts this study's CEM.

4.5 ECOSYSTEM RESTORATION MEASURES

An ER measure is a structural element or feature that requires construction, a nonstructural action, or activity that can be combined with other measures to form alternative plans. ER measures were specifically developed to capitalize upon opportunities that best address the problems related to the current trend of ecosystem degradation throughout the Texas coast. During subsequent planning phases, optimization of ER measures will be conducted to account for sustainability in the face of SLR, subsidence, design considerations, need for additional ecological benefits, and other factors.

ER measures were developed and derived from a variety of sources including the National Environmental Policy Act (NEPA) public scoping process; consideration of the existing and future without-project conditions; development of a CEM; previously executed restoration projects; analysis of reports and projects with similar problems, needs, and opportunities; coordination with other resource management agencies, private, local governmental, or landowner groups; information and scientific data from prior studies; as well as the professional judgment of the interdisciplinary and interagency PDT. Those ER measures that are anticipated to be studied or constructed under another authority or program were removed from further consideration.

Table 4-1 displays the initial 33 Coastal Texas Study ER measures that were screened.

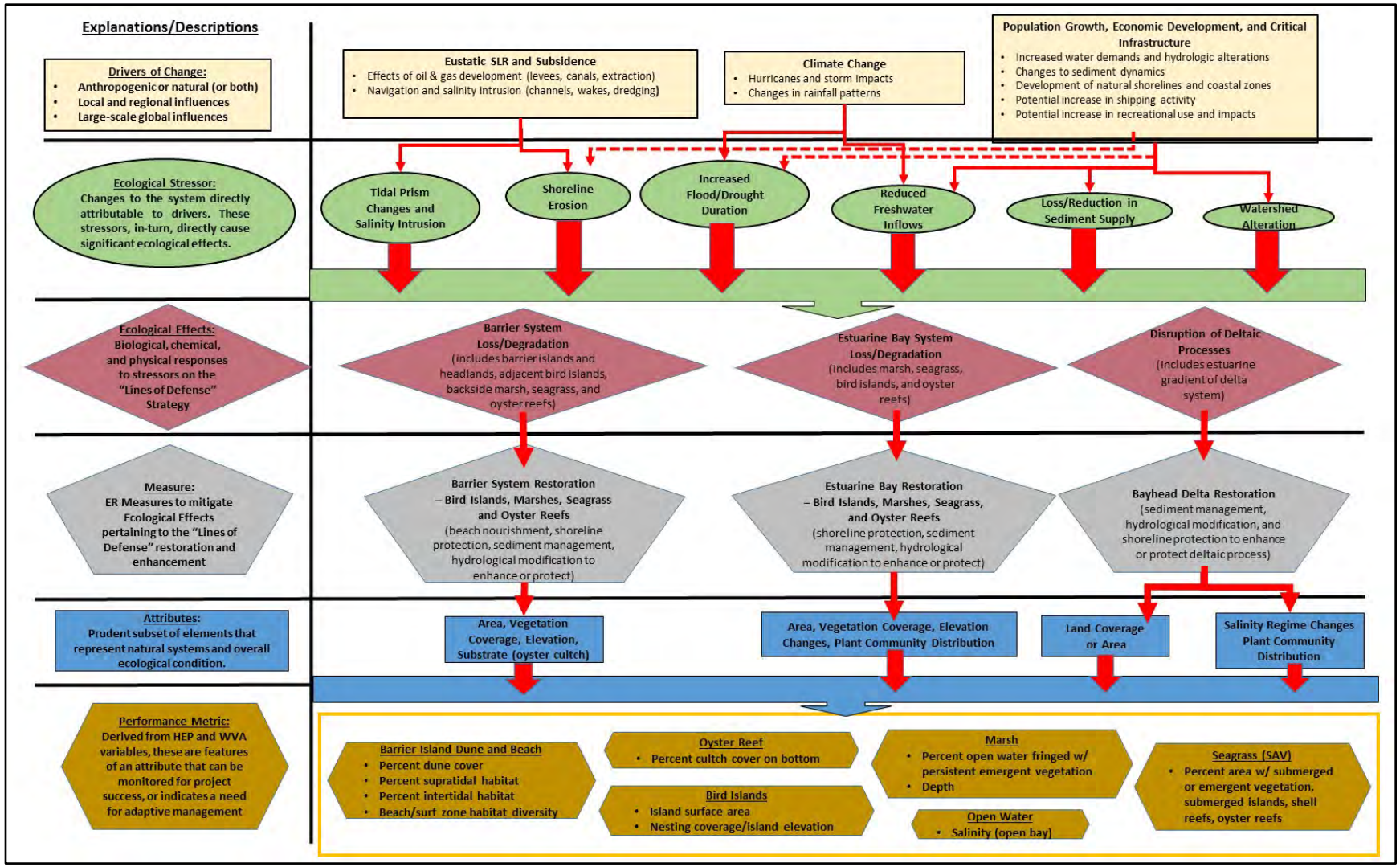

Figure 4-1: Ecosystem Restoration Conceptual Ecological Model

Table 4-1
Initial Coastal Texas Study ER Management Measures

ER Measure	Description
1st Line of Defense – Barrier System Restoration	
G-12 East	GIWW Shoreline Protection and Restoration
G-5 East	Galveston County Gulf Beach and Dune Restoration (Bolivar Peninsula)
G-12 West	Galveston County Gulf Beach and Dune Restoration (West Galveston Island)
G-15	Sediment Management – Galveston Entrance Channel
B-2	Gulf Beach and Dune Restoration – Follets Island
B-4	Gulf Beach and Dune Restoration – Cedar Lakes to Quintana
B-11	Sediment Management – Freeport Harbor Channel
M-1	Dune/Beach Restoration Sargent Beach
M-8	GIWW Mainland Shoreline Protection and Restoration at Chinquapin BU* Site
M-10	Sediment Management – Matagorda Ship Channel
N-6	Sediment Management – Corpus Christi Ship Channel
N-7	Sediment Management – Packery Channel
W-2	Sediment Management – Port Mansfield Channel
CM-6	Sediment Management – Brazos Island Harbor Channel
Z-1	Sediment Management – Mouth of Old Colorado River
2nd Line of Defense – Bay Shorelines, Islands, Estuarine Marsh, and Other Habitats	
O-1	GIWW Shoreline Protection and Restoration
O-2	GIWW Island Restoration
G-11	West Bay Marsh Restoration
G-12 West	GIWW Shoreline Protection and Restoration
G-13	GIWW Island Restoration
B-5	Bastrop Bay Shoreline Protection and Restoration
B-6	GIWW Shoreline Protection and Restoration
M-7	Shamrock Island Rookery Restoration
CA-4	Redfish Lake Restoration
CA-5	Keller Bay Restoration
CA-6	Magnolia to Port O'Connor Shoreline Protection and Beach/Dune Restoration
SP-1	Dagger and Ransom Islands Shoreline Protection and Restoration
N-3	Nueces Delta Restoration – Shoreline Protection and Restoration
W-1	Mansfield Island Rookery Restoration
3rd Line of Defense – Bayhead Deltas	
CA-7	Guadalupe River Delta Hydrologic Restoration/ Shoreline Protection
N-5	Nueces Delta Hydrological Restoration
N-9	Lake Corpus Christi Sediment Bypass
CM-2	Bahia Grande Hydrologic Restoration

*BU = beneficial use

The GLO is comprehensively analyzing ecological restoration projects, which may contribute to coastal ecosystems resiliency in their Coastal Resiliency Master Plan. The list of the GLO Coastal Resiliency Master Plan projects will be provided to the 2017 Texas legislature to guide funding priorities for coastal restoration during the legislative session. The Coastal Texas Study measures, which are the same as the GLO Coastal Resiliency Master Plan projects, may be eliminated from further consideration if it appears the corresponding GLO Coastal Resiliency Master Plan projects have a high probability of being constructed in the near future. Comparison of Coastal Texas Study measures to the GLO Coastal Resiliency Master Plan projects maximizes synergy and minimizes duplication among restoration programs.

4.5.1 Comparison to Goals and Objectives

As the Nation's environmental engineer, the USACE manages one of the largest Federal environmental missions in the United States. The focus of the USACE's ER program is on water-related ecosystem projects, including restoration of wetland, riparian, and aquatic systems. The USACE's goal for its environmental mission is to restore ecosystem structure and processes, manage our land, resources, and construction activities in a sustainable manner, and support cleanup and protection activities efficiently and effectively, all while leaving the smallest footprint behind. The Coastal Texas Study goals and objectives were developed with the USACE's environmental mission goal as its basis.

Screening of ER measures was conducted, in accordance with USACE (2000), Planning Guidance Notebook, by a multidisciplinary PDT consisting of experts from State and Federal agencies. The selected measures were developed and screened based upon experience with previous restoration efforts along the Texas coast, knowledge of the Texas coast, conventional scientific theory, best professional judgment, and consideration of the Coastal Texas Study goals and objectives.

ER measures being considered or constructed under another authority or program were removed from further consideration. Consequently, the first step in the screening process is a comparison of ER measures for consistency with study goals and objectives (Table 4-2). For an ER measure to be carried forward, it must be consistent with both study goals and at least two or more study objectives. All ER measures met the goals and objectives and were therefore carried forward for further consideration (see Table 4-2).

4.6 ECOSYSTEM RESTORATION MEASURE SCREENING

4.6.1 ER Measure Screening Criteria

ER measures were subjected to additional screening conducted by the interagency team during three meetings, the results of which are discussed in Section 4.7. The following factors were considered in this screening process:

- Each ER measure was evaluated on its ability to meet screening criteria (SC) independent of other measures.
- ER measures that are initially screened out but could accomplish Coastal Texas Study goals and objectives when modified or combined with another measure may be reevaluated.

Table 4-2
Screening of ER Measures for Consistency with Study Goals and Objectives

ER Measure		Goal 1	Goal 2	Obj 1 SP	Obj 2 HC	Obj 3 EB	Obj 4 BD	Obj 5 OR	Obj 6 MB	Obj 7 BI	Obj 8 TE	Carried Forward
1st Line of Defense/Barrier System Restoration												
G-12 East	GIWW Shoreline Protection and Restoration	X	X	X	0	X	0	0	X	0	X	yes
G-5 East	Galveston County Gulf Beach and Dune Restoration (Bolivar Peninsula)	X	X	X	0	0	X	0	X	0	X	yes
G-12 West	Galveston County Gulf Beach and Dune Restoration (West Galveston Island)	X	X	X	0	0	X	0	X	0	X	yes
G-15	Sediment Management -Galveston Entrance Channel	X	X	X	0	0	X	0	X	0	X	yes
B-2	Gulf Beach and Dune Restoration – Follets Island	X	X	X	0	0	X	0	X	0	X	yes
B-4	Gulf Beach and Dune Restoration – Cedar Lakes to Quintana	X	X	X	0	0	X	0	X	0	X	yes
B-11	Sediment Management – Freeport Harbor Channel	X	X	X	0	0	X	0	X	0	X	yes
M-1	Dune/Beach Restoration Sargent Beach	X	X	X	0	0	X	0	X	0	X	yes
M-8	GIWW Mainland Shoreline Protection and Restoration at Chinquapin BU Site	X	X	X	0	X	0	0	X	0	X	yes
M-10	Sediment Management – Matagorda Ship Channel	X	X	X	0	0	X	0	X	0	X	yes
N-6	Sediment Management – Corpus Christi Ship Channel	X	X	X	0	0	X	0	X	0	X	yes
N-7	Sediment Management – Packery Channel	X	X	X	0	0	X	0	X	0	X	yes
W-2	Sediment Management – Port Mansfield Channel	X	X	X	0	0	X	0	X	0	X	yes
CM-6	Sediment Management – Brazos Island Harbor Channel	X	X	X	0	0	X	0	X	0	X	yes
Z-1	Sediment Management – Mouth of Old Colorado River	X	X	X	0	0	X	0	X	0	X	yes
2nd Line of Defense – Bay Shorelines, Islands, Estuarine Marsh and Other Habitats												
O-1	GIWW Shoreline Protection and Restoration	X	X	X	0	X	0	0	X	0	X	yes
O-2	GIWW Island Restoration	X	X	X	0	X	0	0	X	X	X	yes
G-11	West Bay Marsh Restoration	X	X	0	0	X	0	0	X	0	X	yes
G-12 West	GIWW Shoreline Protection and Restoration	X	X	X	0	X	0	0	X	0	X	yes
G-13	GIWW Island Restoration	X	X	X	0	X	0	0	X	0	X	yes
B-5	Bastrop Bay Shoreline Protection and Restoration	X	X	X	0	X	0	0	X	0	X	yes

ER Measure		Goal 1	Goal 2	Obj 1 SP	Obj 2 HC	Obj 3 EB	Obj 4 BD	Obj 5 OR	Obj 6 MB	Obj 7 BI	Obj 8 TE	Carried Forward
B-6	GIWW Shoreline Protection and Restoration	X	X	X	0	X	0	0	X	0	X	yes
M-7	Shamrock Island Rookery Restoration	X	X	X	0	X	0	0	X	X	X	yes
CA-4	Redfish Lake Restoration	X	X	X	0	X	0	0	X	0	X	yes
CA-5	Keller Bay Restoration	X	X	X	0	X	0	0	X	0	X	yes
CA-6	Magnolia to Port O'Connor Shoreline Protection and Beach/Dune Restoration	X	X	X	0	0	X	0	X	0	X	yes
SP-1	Dagger and Ransom Islands Shoreline Protection and Restoration	X	X	X	0	X	0	0	X	X	X	yes
N-3	Nueces Delta Restoration – Shoreline Protection and Restoration	X	X	X	X	X	0	0	X	0	X	yes
W-1	Mansfield Island Rookery Restoration	X	X	0	0	X	0	0	X	X	X	yes
3rd Line of Defense – Bayhead Deltas												
CA-7	Guadalupe River Delta Hydrologic Restoration/ Shoreline Protection	X	X	X	X	X	0	0	X	0	X	yes
N-5	Nueces Delta Hydrological Restoration	X	X	X	X	X	0	0	X	0	X	yes
N-9	Lake Corpus Christi Sediment Management	X	X	X	X	X	0	0	X	0	X	yes
CM-2	Bahia Grande Hydrologic Restoration	X	X	X	X	X	0	0	X	0	X	yes

To determine the total score for a proposed ER measure, the scores for each criterion are summed with the maximum possible points equaling 100. Table 4-3 shows the SC and maximum points associated with each. Screening criteria are discussed in detail below.

Table 4-3
ER Measures Screening Criteria and Points

	Screening Criteria	Maximum Points
1	Restores and/or Protects Critical Geomorphic or Key Landscape Structural Features	20
2	Restores and/or Protects Fundamentally Impaired Hydrologic Connections	20
3	Wetland Elevation – Sustainability	14
4	Ecosystem Influence Area	10
5	Area of Protection	10
6	Organism and Materials Linkages	10
7	Infrastructure	8
8	ER Measure Synergy	8

4.6.2 Screening Criteria Definitions

The following define criteria that consider hydrological connections, sediment transport, wetland sustainability, ecosystem influence, and amount of area protected (SC 2 through 5). These criteria require consideration of ER effects on a spatial scale to score or rank the ER measure. These spatial scales pertain to bay systems along the Texas coast, but also include the coastal watersheds and basins that influence each spatial scale.

- Multiple Bay Scale: Direct and indirect effects of a measure that encompass more than one major bay system. An example may include a measure whose effects encompass parts of both the Matagorda Bay System (i.e., Matagorda Bay, East Matagorda Bay, and all minor bays like Keller Bay) and the Galveston Bay System (i.e., Galveston Bay, and all minor bays such as East Galveston, Drum Bay, Bastrop Bay, etc.). Please note that the interagency team did not identify a measure that is considered to have effects or impacts at a multiple bay scale (although it is acknowledged that sediment management actions may affect downdrift bay systems – this is not considered a multiple bay scale effect).

    1. Bay Scale: Direct and indirect effects of a measure that encompass most (>50 percent) of a major bay system, or an ecologically substantive portion (use professional judgment) of a major bay system, such as encompassing several minor bays, or estuarine complexes.

- An example may include a hydrological modification of the Nueces Delta, which may result in ecological, hydrological, and geomorphological effects to Nueces Bay and Corpus Christi Bay, which is a large portion of the Corpus Christi Bay System.

    2. Sub-Bay Scale: Direct and indirect effects of a measure that encompass part of a major bay system, or may affect minor bays and estuaries within the larger major bay system.

- An example may include a measure that affects Jones Bay, Greens Lake, and Pierce Marsh within West Galveston Bay. Another example may include a barrier restoration measure along Bolivar Peninsula, which mostly affects East Galveston Bay.

3. Measure Footprint Only: Direct and indirect effects of a measure are limited to the footprint and immediately adjacent areas.

- An example may include a dune restoration measure from the Brazos River to Quintana Beach, which may not affect adjacent bays due to its position as a headland barrier with no back bay.

- Note that the terms bay, sub-bay, and multiple bay include all terrestrial and aquatic habitats associated with that scale.

SC 1. Restores and/or Protects Critical Geomorphic Feature

To help in scoring this criterion, the following questions were asked:

- Does the ER measure create, restore, and/or protect critical geomorphic features of the coastal ecosystem, such as the barrier system (including barrier islands, shorelines, headlands and back barrier marsh, or sustain vegetated wetlands)?

- How would the measure affect existing or eminent breeches of shoreline protection?

Vegetative planting and marsh creation is not considered a structural component unless the planting or created marsh maintains or protects the integrity of a barrier island, back barrier marsh, estuarine wetlands, or other key geomorphic structures such as a landbridge, etc. If hard structures are used to restore or maintain a geomorphic feature, the duration and extent of benefits may be greater than 50 years.

The score of this criterion is the total of the two sub-criterion values. Note that for sub-criterion 2, breeches can include barrier islands, marsh shorelines, and erosion of island chains (that protect seagrass or marsh complexes).

Sub-Criterion 1 Value	Critical Geomorphic Landscape Feature
10	Barrier system (barrier islands, shorelines, headlands, back barrier marsh)
8	Delta, bay shorelines, and estuarine marsh
6	Migratory bird habitat, oyster reef, bird island, seagrass beds
Sub-Criterion 2 Value	**Extent**
10	Necessary to restore existing breech
8	Necessary to prevent eminent a breech
6	Reduces erosion/fragmentation

SC 2. Restore and/or Protect Fundamentally Impaired Hydrologic Connections

To help in scoring this criterion, the following questions were asked:

- Does this ER measure restore and/or protect critical, fundamentally impaired hydrologic and sediment connectivity?

- Are the introductions of waters and sediment into the impaired system in the local or immediate area, the sub-bay level, or multiple bay areas surrounding the ER measure?

The score of this criterion is the total of the two sub-criterion values.

Sub-Criterion 1 Value	Area of Hydrologic Connectivity
10	Multiple bay scale
8	Bay scale
6	Sub-bay scale
4	Measure footprint only
0	Not applicable
Sub-Criterion 2 Value	**Area of Sediment Connectivity**
10	Multiple bay scale
8	Bay scale
6	Sub-bay scale
4	Measure footprint only
0	Not applicable

SC 3. Wetland Elevation-Sustainability

Wetland Elevation-Sustainability is the net acres of emergent wetlands at the end of the period of analysis (target year 50), which compares the future with-project acreage to the future without-project acreage.

To help in scoring this criterion, the following question was asked: Once constructed, does the ER measure maintain and/or achieve an elevation that is conducive to sustaining vegetated wetlands?

Criterion Value	Net Acres of Wetlands Sustained Over the Period of Analysis
14	Multiple bay scale
12	Bay basin scale
10	Sub-bay scale
4	Measure footprint only

SC 4. Ecosystem Influence Area

To help in scoring this criterion, the following question was asked: How much total area would the measure affect beneficially (both directly and indirectly)? This encompasses the area of direct measurable impacts and the predicted indirect impacts area that would be positively influenced/benefited by the measure (e.g., storm surge protection, flood water retention, factors that extend ER measure impacts beyond the direct impact area).

Criterion Value	Ecosystem Influence Area
10	Multiple bay scale
8	Bay scale
6	Sub-bay scale
1	Measure footprint only

SC 5. Area of Protection

To help in scoring this criterion, the following question was asked: How much total area of wetlands, shoreline (barrier beach shoreline and bay shorelines), etc. is protected?

Criterion Value	Hydrologic Level Protected
10	Multiple bay scale
8	Bay scale
6	Sub-bay scale
1	Measure footprint only

SC 6. Organism and Materials Linkages

To help in scoring this criterion, the following question was asked: Does this ER measure mimic or allow natural level of exchange of organisms and materials, such as detritus, nutrients, water, and sediments consistent with the sustainability of the ecosystem?

NOTE: By definition, shoreline protection measures do not allow a natural level of exchange. Even when well designed with fish dips, etc., the level of organism and material linkage is less than the natural system.

Criterion Value	Description
10	Mimics (50 to 100 percent) or allows a natural level of organism and material exchange
8	Mimics or allows moderately less (25 to 50 percent) than a natural level of organism and material exchange
6	Mimics or allows noticeably less (5 to 25 percent) than a natural level of organism and material exchange
4	Mimics or allow only a very limited level (<5 percent) of organism and material exchange

SC 7. Infrastructure

To help in scoring this criterion, the following question was asked: What is the net impact of the ER measure on coastal infrastructure within the ecosystem influence area?

The following definitions apply to SC 7:

- Critical infrastructure includes any structures relating to communities (cities, towns, or villages), major oil and gas facilities (such as those where people go to work every day), flood

protection/hurricane protection levees, hurricane protection routes, major roads/highways, major navigation channels (e.g., GIWW, etc.), and ports.

- Noncritical infrastructure includes any secondary roads, minor roads, minor navigation channels/canals, minor oil and gas facilities (small wellheads, tank batteries, compressor stations, and pipelines), and camps.

Criterion Value	Description
8	Substantial (>50 percent immediate surrounding area) net positive impact on critical infrastructure
7	Moderate (25 to 50 percent immediate surrounding area) net positive impact on critical infrastructure
4	Marginal (5 to 25 percent of immediate surrounding area) net positive impact on critical infrastructure
2	Net positive (1 to 5 percent of immediate surrounding area) impact on critical infrastructure
1	ER measure has no positive impact on critical infrastructure
0	ER measure has a negative impact on critical infrastructure

SC 8. ER Measure Synergy

ER Measure Synergy is meant to capture ecosystem-level benefits of ongoing or multiphased projects or those ER measures that provide a synergistic effect with other existing, authorized for construction, or under construction ER measures or projects. Conservation and management efforts of adjacent National Wildlife Refuges, Wildlife Management Areas (WMA), and mitigation projects should be included in considering ER Measure Synergy.

Criterion Value	Description
8	High degree of synergy (>50 percent in the immediate surrounding area) with other existing/authorized for construction/under construction ER measures or projects
6	Moderate degree of synergy (25 to 50 percent in the immediate surrounding area) with other existing/authorized for construction/under construction approved ER measures or projects
4	Marginal degree of synergy (5 to 25 percent in the immediate surrounding area) with other existing/authorized for construction/under construction approved ER measures or projects
2	Very limited degree of synergy (<5 percent in the immediate surrounding area with other existing/authorized for construction/under construction approved ER measures or ER projects
0	ER measure provides no synergistic effects with other existing or authorized for construction, or under construction ER measures or ER projects

4.6.3 Interagency Workgroup Meetings

Interagency meetings were held at the USACE Galveston District on October 11, 17, and November 8, 2016, to discuss and score proposed ER measures using the screening criteria described above. These meetings resulted in 30 ER measures carried forward for further consideration.

The interagency meetings resulted in further revisions to the screening criteria (that are reflected above in this document) and further refining of ER measures. Table 4-4 lists results of the interagency ER measures screening, and thus, the ER measures that are being carried forward for further consideration. Measures with an asterisk (*) are those for which the name has been modified following the interagency meetings. Table 4-4 is sorted by total score.

Three measures were screened out during the interagency meetings: B-11, N-7, and Z-1. B-11 was screened out because there is not enough sand in the area to support this measure. N-7 was screened out because there is already a sand bypass system in place at this location. B-11 was screened out because there is already an authorized sediment management process set up at that location.

For ER measures where no agency consensus for a screening criteria was reached, agency scores were mathematically averaged.

These ER measures being carried forward for further consideration have two fundamental characteristics:

- Each measure is intended to protect and/or restore desired ecological structure and function of coastal ecosystems; and
- Project partners acknowledge that construction/adaptive management may continue over the 50-year life of each measure to ensure measure objectives are achieved despite ongoing SLR, erosion, and other factors affecting measures. Adaptive management may include adding or adjusting shoreline protection structures and managing sediment additions (to account for relative SLR and erosive forces).

Table 4-4
Interagency Meeting ER Screening Measures Outcome and Measures Carried Forward for Further Analysis

ER Measure		SC 1		SC 2		SC 3	SC 4	SC 5	SC 6	SC 7	SC 8	Total
		SC 1-1	SC 1-2	SC 2-1	SC 2-2							
1st Line of Defense – Barrier System Restoration												
B-4	Bryan Beach to Quintana Gulf Beach and Dune Restoration*	10	6	4	4	4	1	1	10	7	4	51.0
M-10	Matagorda Ship Channel Entrance Channel*	10	6	4	6	4	6	6	6	2	2	52.0
G-22	Galveston Entrance Channel	8	6	4	8	4	6	6	8	2	6	58.0
CM-6	Brazos Island Harbor Entrance Channel*	10	6	4	6	4	6	6	8	4	6	60.0
M-1	San Bernard River Mouth to Sargent Beach Dune/Beach Restoration*	10	6	0	6	10	6	6	10	2	4	60.0
G-12 East	Bolivar Peninsula GIWW Shoreline Protection*	10	6	4	4	10	6	6	6	7	6	65.0
G-5 West	West Galveston Island Gulf Beach and Dune Restoration*	10	6	4	6	4	6	6	10	7	6	65.0
N-8	Corpus Christi Ship Channel Entrance Channel*	10	6	4	6	10	8	6	8	7	2	67.0
G-5 East	Bolivar Peninsula Gulf Beach and Dune Restoration*	10	8	4	6	4	6	6	10	7	8	69.0
W-2	Port Mansfield Channel Entrance Channel*	10	8	8	**6.57**	10	8	**7.71**	8	1	2	69.3
B-2	Follets Island Gulf Beach and Dune Restoration*	10	8	4	6	10	6	6	10	8	6	74.0
~~*B-11*~~	~~*Sediment Management – Freeport Harbor Channel*~~	–	–	–	–	–	–	–	–	–	–	–
~~*N-7*~~	~~*Sediment Management – Packery Channel*~~	–	–	–	–	–	–	–	–	–	–	–
~~*Z-1*~~	~~*Sediment Management – Mouth of Old Colorado River*~~	–	–	–	–	–	–	–	–	–	–	–
2nd Line of Defense – Bay Shorelines, Islands, Estuarine Marsh and Other Habitats												
W-1	Mansfield Island Rookery Restoration	6	6	0	0	4	8	1	**9.71**	1	6	41.7
O-2	Upper Sabine Lake GIWW Island Restoration*	8	6	0	0	4	6	1	10	2	6	43.0
M-7	Sundown Island Restoration*	6	6	4	0	4	10	1	10	1	6	48.0

ER Measure		SC 1		SC 2		SC 3	SC 4	SC 5	SC 6	SC 7	SC 8	Total
		SC 1-1	SC 1-2	SC 2-1	SC 2-2							
O-1	Lower Neches WMA, Old River Unit Shoreline Protection*	8	8	4	4	4	6	6	6	**3.75**	**5.75**	55.5
CA-5	Keller Bay Restoration	8	8	0	**1.71**	10	8	6	10	2	2	55.7
G-13	West Bay GIWW Island Restoration*	8	**9.50**	**3.50**	**3.50**	4	6	1	10	**7.25**	4	56.8
M-8	East Matagorda Bay Shoreline Protection*	8	6	4	6	10	6	6	8	2	6	62.0
SP-1	Dagger and Ransom Islands Protection and Restoration*	**6.86**	**8.29**	6	**5.14**	4	8	6	**8.29**	4	6	62.6
G-12 West	West Bay GIWW Shoreline Protection*	8	6	4	**3.50**	**9.25**	6	6	8	4	8	62.8
CA-4	Redfish Lake Restoration	8	10	6	6	**6.57**	6	6	10	1	4	63.6
N-3	Nueces Delta Shoreline Protection*	8	6	6	**5.71**	**9.14**	6	**5.29**	8	**2.29**	8	64.4
B-5	Bastrop Bay, Oyster Lake, and West Bay Shoreline Protection*	8	10	6	**5.71**	**9.14**	**6.29**	**6.29**	8	2	8	69.4
G-11	West Bay Marsh Restoration	8	6	6	6	10	6	**4.75**	10	7	8	71.8
B-6	Brazoria County GIWW Shoreline Protection	8	10	6	6	10	**8.75**	**7.25**	**7.25**	**6.25**	6	75.5
CA-6	Magnolia to Port O'Connor Shoreline Protection and Restoration*	8	10	6	**5.71**	10	**6.29**	6	8	8	8	76.0
3rd Line of Defense – Bayhead Deltas												
CM-2	Bahia Grande Hydrologic Restoration	**7.71**	**4.29**	**5.43**	**2.29**	4	6	**5.29**	10	1	8	54.0
CA-7	Guadalupe River Delta Hydrologic Restoration*	8	**9.14**	6	6	10	6	6	10	2	2	65.1
N-5	Nueces Delta Hydrological Restoration	8	6	6	6	10	6	6	10	1	8	67.0
N-9	Lake Corpus Christi Sediment Bypass	8	6	6	6	10	6	6	10	1	8	67.0

* Name of measure was changed.

Bold numbers indicate agency consensus was not reached for that measure and scores were mathematically averaged.

~~*Text*~~ = Measure was removed from consideration.

4.7 ECOSYSTEM RESTORATION ALTERNATIVE SCREENING

The screening discussed above identified an initial focused array of measures. Since the Coastal Texas Study has limited time and resources, this screening ensured the Coastal Texas Study resources for ecosystem modeling are focused on measures with the greatest likelihood of long-term ecological benefit. Some measures may be eliminated from consideration after this analysis if it appears there is little ecological benefit to be derived relative to the cost of implementing the measure. The following section describes the second level alternative screening.

4.7.1 Ecosystem Restoration Alternative Formulation Strategies

The ER strategies, derived from the study ER goals and objectives, provided the basis for developing the initial ER alternative array.

Consistent with the ER goals and objectives, the ER alternatives focus on those key coastwide geomorphic or landscape features and hydrologic processes presently experiencing substantial degradation, fragmentation, and loss, and pertain to the three lines of defense ER strategy:

- 1st Line of Defense – Barrier Systems (barrier beach, dune, and back marsh);
- 2nd Line of Defense – Estuarine Bay System (bay shorelines and estuarine marsh, bird rookery islands, seagrass beds, oyster reefs, and marsh, etc.); and
- 3rd Line of Defense – Bayhead Deltas (sediment management, shoreline protections, hydrological).

4.7.2 Initial Ecosystem Restoration Alternative Array Development

Formulating NER alternative plans, as described in the *Planning Guidance Notebook* (Engineer Regulation 1105-2-100), is Step 3 of the USACE planning process. The ER alternatives were formulated to maximize ecosystem restoration benefits within the context of the four qualitative criteria from the USACE's Principles and Guidelines, (Paragraph 1.6.2(c)) (USACE, 2000):

> *Completeness*: The extent to which an alternative plan provides and accounts for all necessary investments or other actions to ensure the realization of the planned effects.
>
> *Effectiveness*: The extent to which an alternative plan alleviates the specified problems and achieves the specified opportunities.
>
> *Efficiency*: The extent to which an alternative plan is the most cost-effective way to alleviate the specified problems and realize the specified opportunities, consistent with protecting the Nation's environment.
>
> *Acceptability*: The workability and viability of the alternative plan with respect to acceptance by State and local entities and the public and compatibility with existing laws, regulations, and public policies.

4.7.3 Ecosystem Restoration Alternatives

The proposed initial ER alternative array consisted of the following:

- **ER No-Action Alternative:** Required by NEPA; alternative of not implementing proposed ER alternatives.

- **ER Alternative 1: Coastwide All-inclusive Restoration Alternative**: Based on addressing all three lines of defense, this alternative includes all ER measures carried forward from screening that pertain to critical and essential barrier system, estuarine bay system, bayhead deltas, bird island rookery, seagrass beds, and oyster reef restoration measures that best restore and protect critical geomorphic key landscape features, and watershed hydrologic processes.

- **ER Alternative 2: Coastwide Restoration of Near-term, Critical Geomorphic or Landscape Features Alternative**: This alternative includes restoration of the most critical geomorphic or landscape barrier and estuarine bay systems features that, without implementation, would likely result in severe ecological degradation or irreversible negative trends. This alternative was formed by using ER measures that had a combined scored ≥28 for SC 1 (*Restores and/or Protects Critical Geomorphic Feature or Framework*) and SC 2 (*Restore and/or Protects Fundamentally Impaired Hydrologic Connections*), without consideration of the total ER score.

- **ER Alternative 3: Coastwide Barrier System Restoration Alternative**: Based on the 1st line of defense ER strategy, this alternative includes all ER measures that pertain to restoration of the barrier system (barrier beach, dune, and back marsh).

- **ER Alternative 4: Coastwide Bay System Restoration Alternative**: Based on the 2nd line of defense ER strategy, this alternative includes all ER measures that pertain to restoration of estuarine bay shorelines and estuarine marsh features. ER measures include living shorelines, marsh fills, potentially bird islands, and SAV protection.

- **ER Alternative 5: Coastwide Hydrologic Restoration Alternative**: Based on the 3rd line of defense ER strategy, this alternative includes all ER measures that pertain to coastwide restoration of hydrologic processes and hydrologic connectivity, particularly at deltas.

- **ER Alternative 6: Coastwide ER Contributing to Infrastructure Protection Alternative**: This alternative is based on ER measures that contribute to the protection of critical infrastructure. ER measures included for this alternative scored relatively high for SC 7 (*Infrastructure Protection*) and ≥65 as a total score.

- **ER Alternative 7: Coastwide Shoreline Protection and Stabilization Alternative**: This alternative includes all ER measures that pertain to protection and stabilization of barrier system shorelines, estuarine bay system shorelines, and bayhead delta shorelines that are undergoing relatively high rates of erosion.

Based on the proposed alternatives descriptions, the screened ER measures were formulated into proposed alternative project plans (Tables 4-5 through 4-11).

Table 4-5
ER Alternative 1 – Coastwide All-Inclusive Restoration

ER Measure	Name	Region	LOD	Score
CA-6	Magnolia to Port O'Connor Shoreline Protection and Restoration	mid to upper	2	76.0
B-6	Brazoria County GIWW Shoreline Protection	upper	2	75.5
B-2	Follets Island Gulf Beach and Dune Restoration	upper	1	74.0
G-11	West Bay Marsh Restoration	upper	2	71.8
B-5	Bastrop Bay, Oyster Lake, and West Bay Shoreline Protection	upper	2	69.4
W-2	Port Mansfield Channel	Lower	1	69.3
G-5 East	Bolivar Peninsula Gulf Beach and Dune Restoration	upper	1	69.0
N-8	Corpus Christi Ship Channel	mid	1	67.0
N-5	Nueces Delta Hydrological Restoration	mid	3	67.0
N-9	Lake Corpus Christi Sediment Bypass	mid	3	67.0
CA-7	Guadalupe River Delta Restoration	mid	3	65.1
G-5 West	West Galveston Island Gulf Beach and Dune Restoration	upper	1	65.0
G-12 East	East GIWW Shoreline Protection	upper	1	65.0
N-3	Nueces Delta Shoreline Protection	mid	2	64.4
CA-4	Redfish Lake Restoration	mid to upper	2	63.6
G-12 West	West GIWW Shoreline Protection	upper	2	62.8
SP-1	Dagger and Ransom Islands Protection and Restoration	mid	2	62.6
M-8	East Matagorda Bay Shoreline Protection	mid to upper	2	62.0
M-1	San Bernard River Mouth to Sargent Beach Dune/Beach Restoration	mid to upper	1	60.0
CM-6	Brazos Island Harbor Channel	lower	1	60.0
G-22	Galveston Entrance Channel	upper	1	58.0
G-13	GIWW Island Restoration	upper	2	56.8
CA-5	Keller Bay Restoration	mid to upper	2	55.7
O-1	Lower Neches WMA, Old River Unit Shoreline Protection	upper	2	55.5
CM-2	Bahia Grande Hydrologic Restoration	lower	3	54.0
M-10	Matagorda Ship Channel	mid to upper	1	52.0
B-4	Bryan Beach to Quintana Gulf Beach and Dune Restoration	upper	1	51.0
M-7	Sundown Island Restoration	mid to upper	2	48.0
O-2	GIWW Islands Restoration	upper	2	43.0
W-1	Mansfield Island Rookery Restoration	lower	2	41.7

LOD = lines of defense

Table 4-6
ER Alternative 2 – Coastwide Restoration of Near-term, Critical Geomorphic or Landscape Features

ER Measure	Name	Region	LOD	SC1+ SC2	Score
B-2	Follets Island Gulf Beach and Dune Restoration	upper	1	28	74.0
G-5 East	Bolivar Peninsula Gulf Beach and Dune Restoration	upper	1	28	69.0
B-5	Bastrop Bay, Oyster Lake, and West Bay Shoreline Protection	upper	2	**29.71**	69.4
B-6	Brazoria County GIWW Shoreline Protection	upper	2	30	75.5
CA-6	Magnolia to Port O'Connor Shoreline Protection and Restoration	mid to upper	2	**29.71**	76.0
CA-4	Redfish Lake Restoration	mid to upper	2	30	63.6
CA-7	Guadalupe River Delta Restoration	mid	3	**29.14**	65.1
W-2	Port Mansfield Channel	lower	1	**32.57**	69.3

* Bold numbers indicate no agency consensus on the SC value, scores were averaged.

Table 4-7
ER Alternative 3 – Coastwide Barrier System Restoration

ER Measure	Name	Region	LOD	Score
B-2	Follets Island Gulf Beach and Dune Restoration	upper	1	74.0
G-5 West	West Galveston Island Gulf Beach and Dune Restoration	upper	1	65.0
G-5 East	Bolivar Peninsula Gulf Beach and Dune Restoration	upper	1	69.0
B-4	Bryan Beach to Quintana Gulf Beach and Dune Restoration	upper	1	51.0
G-22	Galveston Entrance Channel	upper	1	58.0
G-12 East	East GIWW Shoreline Protection	upper	1	65.0
M-1	San Bernard River Mouth to Sargent Beach Dune/Beach Restoration	mid to upper	1	60.0
M-10	Matagorda Ship Channel	mid to upper	1	52.0
N-8	Corpus Christi Ship Channel	mid	1	67.0
W-2	Port Mansfield Channel	lower	1	69.3
CM-6	Brazos Island Harbor Channel	lower	1	60.0

Table 4-8
ER Alternative 4 – Coastwide Bay System Restoration

ER Measure	Name	Region	LOD	Score
O-2	GIWW Islands Restoration	upper	2	43.0
G-13	GIWW Island Restoration	upper	2	56.8
G-11	West Bay Marsh Restoration	upper	2	71.8
B-5	Bastrop Bay, Oyster Lake, and West Bay Shoreline Protection	upper	2	69.4
B-6	Brazoria County GIWW Shoreline Protection	upper	2	75.5
O-1	Lower Neches WMA, Old River Unit Shoreline Protection	upper	2	55.5
G-12 West	West GIWW Shoreline Protection	upper	2	62.8
M-7	Sundown Island Restoration	mid to upper	2	48.0
CA-6	Magnolia to Port O'Connor Shoreline Protection and Restoration	mid to upper	2	76.0
CA-4	Redfish Lake Restoration	mid to upper	2	63.6
CA-5	Keller Bay Restoration	mid to upper	2	55.7
M-8	East Matagorda Bay Shoreline Protection	mid to upper	2	62.0
SP-1	Dagger and Ransom Islands Protection and Restoration	mid	2	62.6
N-3	Nueces Delta Shoreline Protection	mid	2	64.4
W-1	Mansfield Island Rookery Restoration	lower	2	41.7

Table 4-9
ER Alternative 5 – Coastwide Hydrologic Restoration

ER Measure	Name	Region	LOD	Score
N-5	Nueces Delta Hydrological Restoration	mid	3	67.0
N-9	Lake Corpus Christi Sediment Bypass	mid	3	67.0
CA-7	Guadalupe River Delta Restoration	mid	3	65.1
CM-2	Bahia Grande Hydrologic Restoration	lower	3	54.0

Table 4-10
ER Alternative 6 – Coastwide ER Contributing to Infrastructure Protection

ER Measure	Name	Region	LOD	SC 7	Score
G-5 West	West Galveston Island Gulf Beach and Dune Restoration	upper	1	7	65.0
B-2	Follets Island Gulf Beach and Dune Restoration	upper	1	8	74.0
G-5 East	Bolivar Peninsula Gulf Beach and Dune Restoration	upper	1	7	69.0
G-12 East	East GIWW Shoreline Protection	upper	1	7	65.0
B-6	Brazoria County GIWW Shoreline Protection	upper	2	6.25	75.5
G-11	West Bay Marsh Restoration	upper	2	7	71.8
CA-6	Magnolia to Port O'Connor Shoreline Protection and Restoration	mid to upper	2	8	76.0
N-8	Corpus Christi Ship Channel	mid	1	7	67.0

* Bold numbers indicate no agency consensus on the SC value, scores were averaged.

Table 4-11
ER Alternative 7 – Coastwide Shoreline Protection and Stabilization

ER Measure	Name	Region	LOD	Score
G-12 East	East GIWW Shoreline Protection	upper	1	65.0
O-1	Lower Neches WMA, Old River Unit Shoreline Protection	upper	2	55.5
B-5	Bastrop Bay, Oyster Lake, and West Bay Shoreline Protection	upper	2	69.4
B-6	Brazoria County GIWW Shoreline Protection	upper	2	75.5
G-12 West	West GIWW Shoreline Protection	upper	2	62.8
CA-5	Keller Bay Restoration	mid to upper	2	55.7
M-8	East Matagorda Bay Shoreline Protection	mid to upper	2	62.0
CA-6	Magnolia to Port O'Connor Shoreline Protection and Restoration	mid to upper	2	76.0
CA-4	Redfish Lake Restoration	mid to upper	2	63.6
SP-1	Dagger and Ransom Islands Protection and Restoration	mid	2	62.6
N-3	Nueces Delta Shoreline Protection	mid	2	64.4
CA-7	Guadalupe River Delta Restoration	mid	3	65.1
W-1	Mansfield Island Rookery Restoration	lower	2	41.7

4.7.4 Interagency Workgroup Meeting

An interagency meeting was held January 17, 2017, to discuss the proposed alternative plans and how to optimize and screen the ER measures further. The proposed alternative project plans (ER Alternatives 1–7) were presented to the agencies for further discussion. The following describes the results of this interagency meeting.

It was suggested by the National Park Service (NPS) that ER measures W-1 (Mansfield Island Rookery Restoration) and W-2 (Port Mansfield Channel) should be combined into one measure because all the work that would take place at this location would fall under the same contract and be using the same material. The USACE,

GLO, and all agencies agreed. This measure was reformulated to W-3 Port Mansfield Channel and Island Rookery Restoration (Sediment Management, Shoreline Protection, and Restoration).

During the discussion of ER Alternative 5 (Coastwide Hydrologic Restoration), it was decided that this alternative requires a separate long-term study (specifically ER measures N-5, N-9, and CA-7). Hydrological restoration is difficult in these areas and the cost and time of performing the Hydrologic and Hydraulic modeling is beyond the capabilities of the Coastal Texas Study, therefore, this alternative was removed. It was also decided that ER measure CM-2 (Bahia Grande Hydrologic Restoration) is being comprehensively covered under other efforts and can be removed from the Coastal Texas Study. The USACE, GLO, and all agencies agreed to remove ER Alternative 5 from further consideration.

The interagency team looked at the scores for all ER measures looking for obvious breakpoints in the numbers. The most obvious breakpoint occurred around 60 to 65, therefore, this number was used as the cutoff and all measures that scored below a value of 65 were removed from further consideration. The interagency team then looked at the measures that fell just below a score of 65 to determine if any of those measures should be included. ER measure N-3 (Nueces Delta Shoreline Protection) fell on the margin with a score of 64.4, the U.S. Environmental Protection Agency (EPA) wanted to include this ER measure because it is on their priority list. It was agreed that this ER measure was ecologically important and that it should be included and that any ER measure that scored below 64.4 would be removed. The interagency team felt that many of the measures that scored low were small-scale projects and not as important as the measures that scored higher. The USACE, GLO, and all agencies agreed.

After looking at all the remaining proposed alternative project plans, it was noted that several ER measures were included in multiple alternative plans. It was suggested by the National Marine Fisheries Service (NMFS) that we combine those into an additional alternative that represented our “top gun” alternative. The interagency team decided to create ER Alternative which included all ER measures that appeared four or more times in an alternative.

4.7.5 Initial Array of ER Alternatives Plans

A total of 14 ER measures were carried forward. Various combinations of these ER measures make up each ER alternative plan. The initial array of ER alternative plans is shown in Table 4-12.

Table 4-12
Initial Array of ER Alternatives

ER Measure	Name	LOD	Score
Alternative 1 – Coastwide All-Inclusive Restoration Alternative			
CA-6	Magnolia to Port O'Connor Shoreline Protection and Restoration	2	76.0
B-6	Brazoria County GIWW Shoreline Protection	2	75.5
B-2	Follets Island Gulf Beach and Dune Restoration	1	74.0
G-11	West Bay Marsh Restoration	2	71.8
B-5	Bastrop Bay, Oyster Lake, and West Bay Shoreline Protection	2	69.4
W-3*	Port Mansfield Channel and Island Rookery Restoration	1	69.3
G-5 East	Bolivar Peninsula Gulf Beach and Dune Restoration	1	69.0
N-8	Corpus Christi Ship Channel	1	67.0
N-5	Nueces Delta Hydrological Restoration	3	67.0
N-9	Lake Corpus Christi Sediment Bypass	3	67.0
CA-7	Guadalupe River Delta Restoration	3	65.1
G-5 West	West Galveston Island Gulf Beach and Dune Restoration	1	65.0
G-12 East	East GIWW Shoreline Protection	1	65.0
N-3	Nueces Delta Shoreline Protection	2	64.4
Alternative 2 – Coastwide Restoration of Near-term, Critical Geomorphic, or Landscape Features			
CA-6	Magnolia to Port O'Connor Shoreline Protection and Restoration	2	76.0
B-6	Brazoria County GIWW Shoreline Protection	2	75.5
B-2	Follets Island Gulf Beach and Dune Restoration	1	74.0
B-5	Bastrop Bay, Oyster Lake, and West Bay Shoreline Protection	2	69.4
W-3*	Port Mansfield Channel and Island Rookery Restoration	1	69.3
G-5 East	Bolivar Peninsula Gulf Beach and Dune Restoration	1	69.0
CA-7	Guadalupe River Delta Restoration	3	65.1
Alternative 3 – Coastwide Barrier System Restoration Alternative			
B-2	Follets Island Gulf Beach and Dune Restoration	1	74.0
W-3*	Port Mansfield Channel and Island Rookery Restoration	1	69.3
G-5 East	Bolivar Peninsula Gulf Beach and Dune Restoration	1	69.0
N-8	Corpus Christi Ship Channel	1	67.0
G-5 West	West Galveston Island Gulf Beach and Dune Restoration	1	65.0
G-12 East	East GIWW Shoreline Protection	1	65.0
Alternative 4 – Coastwide Bay System Restoration Alternative			
CA-6	Magnolia to Port O'Connor Shoreline Protection and Restoration	2	76.0
B-6	Brazoria County GIWW Shoreline Protection	2	75.5
G-11	West Bay Marsh Restoration	2	71.8
B-5	Bastrop Bay, Oyster Lake, and West Bay Shoreline Protection	2	69.4
N-3	Nueces Delta Shoreline Protection	2	64.4

ER Measure	Name	LOD	Score
Alternative 5 – Coastwide ER Contributing to Infrastructure Protection			
CA-6	Magnolia to Port O'Connor Shoreline Protection and Restoration	2	76.0
B-6	Brazoria County GIWW Shoreline Protection	2	75.5
B-2	Follets Island Gulf Beach and Dune Restoration	1	74.0
G-11	West Bay Marsh Restoration	2	71.8
G-5 East	Bolivar Peninsula Gulf Beach and Dune Restoration	1	69.0
N-8	Corpus Christi Ship Channel	1	67.0
G-5 West	West Galveston Island Gulf Beach and Dune Restoration	1	65.0
G-12 East	East GIWW Shoreline Protection	1	65.0
Alternative 6 – Coastwide Shoreline Protection and Stabilization Alternative			
CA-6	Magnolia to Port O'Connor Shoreline Protection and Restoration	2	76.0
B-6	Brazoria County GIWW Shoreline Protection	2	75.5
B-5	Bastrop Bay, Oyster Lake, and West Bay Shoreline Protection	2	69.4
CA-7	Guadalupe River Delta Restoration	3	65.1
G-12 East	East GIWW Shoreline Protection	1	65.0
N-3	Nueces Delta Shoreline Protection	2	64.4
Alternative 7 – Top Gun (later changed to Top Performers)			
CA-6	Magnolia to Port O'Connor Shoreline Protection and Restoration	2	76.0
B-2	Follets Island Gulf Beach and Dune Restoration	1	74.0
B-6	Brazoria County GIWW Shoreline Protection	2	75.5
B-5	Bastrop Bay, Oyster Lake, and West Bay Shoreline Protection	2	69.4
G-5 East	Bolivar Peninsula Gulf Beach and Dune Restoration	1	69.0
G-12 East	East GIWW Shoreline Protection	1	65.0

* W-1 and W-2 were combined into one measure, W-3. The combined measure was not rescored, the score shown is from measure W-2.

Finally, the interagency team was asked to pick their top 3 alternatives. Note that the Texas Parks and Wildlife Department (TPWD) abstained from this exercise as prioritizing habitats is not something they want to do. These results are shown in Table 4-13. ER Alternative 4 was selected more times (five) among the top three choices of agencies than any other alternative, followed by ER alternative 2, which was selected four times. ER alternatives 3, 7, and 8 were also selected among the top three alternatives by agencies. This agency prioritization was not used any further; however, it provides an indication of what seems most important to the agencies.

Table 4-13
Initial Array of ER Alternatives – Agency Top Picks

Agency	1st	2nd	3rd
EPA	2	4	3
GLO	2	8	7
NMFS	8	4	7
NPS	2	3	4
NRCS	4	7	8
TPWD	Abstained	Abstained	Abstained
USACE	2	3	4

ER Alternative	Count
4	5
2	4
3	3
7	3
8	3
6	0

4.8 FURTHER SCREENING OF ECOSYSTEM RESTORATION MEASURES

During the PDT meeting on April 6, 2017, the USACE decided that there was not enough information on the two delta measures (CA-7 and N-11), and they would require additional hydrological modeling that the Coastal Texas Study was not able to fund. Therefore, these measures are being recommended for further study under the comprehensive plan and are not being carried forward for further evaluation under the Coastal Texas Study. Measure N-9 (Lake Corpus Christi Sediment Bypass), which was associated with measure N-3, was also removed as it would not stand alone without the delta associated with it.

During a USACE/GLO team discussion on May 22, 2017, the GLO brought up the concern that some of the ER measures being carried forward have a good chance of being completed before the Coastal Texas Study is finished. The GLO reviewed the initial 33 ER measures and identified those with a high likelihood of being completed by other authorities (see Table 4-1). A follow up meeting was held May 24, 2017, to discuss the results of the GLO review. The GLO determined that the following 16 measures were determined to have a high likelihood of being completed by other authorities before the completion of the Coastal Texas Study: G-15, B-4, B-11, M-10, N-6 (later renamed to N-8), N-7, CM-6, Z-1, G-11, M-7, CA-4, N-3/N5 (later combined and renamed to N-11), CA-7, N-9, and CM-2 (refer to Table 4-1).

All sediment management measures (G-15, B-11, M-10, N-6, N-7, CM-6, and Z-1), except W-2, were removed from the list as it was decided these were already being handled appropriately by other authorities, and they were not needed in the Coastal Texas Study. Programs are already in place for handling sediments at these locations.

Table 4-14 describes the authorities that are handling the sediment management measures. ER measure W-2 (Sediment Management – Port Mansfield Channel), which was earlier combined with W-1 (Mansfield Island Rookery Restoration) to form measure W-3, remained on the list due to the hydrological connection with the Gulf and the Laguna Madre and the benefit this would provide the estuary all the way to Brownsville. Reasoning why the sediment management measures and others were removed are described in Table 4-14.

Table 4-14
Remaining Removed ER Measures Actions

Measure		Authority/Reason
G-15	Sediment Management – Galveston Entrance Channel	GLO, Galveston County, and County Parks Board regularly fund use of sandy maintenance material for beach nourishment, also Galveston Bay Foundation, National Fish and Wildlife Foundation (NFWF), and TPWD
B-11	Sediment Management – Freeport Harbor Channel	Little sediment available updrift of jetties, and little difference between updrift and downdrift sides of channel – Freeport LNG, Port Freeport, and Coastal Erosion Planning and Response Act (CEPRA)
M-10	Matagorda Ship Channel Entrance Channel	No maintenance material is available adjacent to the island due to scoring in Jetty Channel; peninsula downdrift of channel is stable and not in need of sediment
N-8	Corpus Christi Ship Channel Entrance Channel	Material is placed regularly on San Jose Island during maintenance dredging
N-7	Sediment Management – Packery Channel	Beneficial use of dredge material required by City of Corpus Christi lease and USACE EIS
CM-6	Brazos Island Harbor Entrance Channel	Maintenance material regularly placed north of north jetty by USACE maintenance dredging; GLO and the City of South Padre redistribute sediment as needed
Z-1	Sediment Management – Mouth of Old Colorado River	USACE sediment trap
B-4	Bryan Beach to Quintana Gulf Beach and Dune Restoration	Not needed south of Brazos River – CEPRA project Bryan Beach to the Freeport Ship Channel – Freeport LNG
G-11	West Bay Marsh Restoration	Multiple restoration projects completed, underway or planned under Natural Resource Damage Assessment (NRDA), NFWF, Ducks Unlimited, and Galveston Bay Foundation
M-7	Sundown Island Restoration	Regularly nourished by USACE maintenance dredging projects and managed by the Audubon Society, The Nature Conservancy, and Coastal Bend Bay and Estuary Foundation
CA-4	Redfish Lake Restoration	Proposed NFWF project
N-11, N-9, CA-7	Nueces and Guadalupe Deltas Hydrologic Restoration	Recommended for separate studies under the Coastal Texas comprehensive plan
CM-2	Bahia Grande Hydrologic Restoration	Covered by several RESTORE and USFWS restoration efforts

The team referred to the ER measure SC that was conducted with the interagency team in October/November 2016. Originally any measure that scored below a 65 was removed from the list. The team decided a score of 50 and above would be established as the cut off for this rescreening effort. The only remaining ER measure that fell within this SC that was not included was measure O-1 (Lower Neches WMA, Old River Unit Shoreline Protection), because this measure is already being done by the TPWD.

The team had a follow-up discussion on May 30, 2017, and it was decided that measure G-13 should be combined with G-12 as it is not a separable measure; this measure was renamed to G-28. Additionally, measure M-1 was removed once more, because revetment in that area can be there on its own, it is not as sediment starved as initially thought, and past beach nourishment has occurred.

4.9 FINAL ARRAY OF ECOSYSTEM RESTORATION MEASURES CARRIED FORWARD

Table 4-15 presents the final array of ER measures being carried forward. Table 4-16 presents the updated ER alternatives array.

Table 4-15
ER Measures Being Carried Forward

ER Measure	Name
G-5[a]	Bolivar Peninsula/Galveston Island Gulf Beach and Dune Restoration
G-28[b]	Bolivar Peninsula and West Bay GIWW Shoreline and Island Protection
B-2	Follets Island Gulf Beach and Dune Restoration
B-12[c]	Bastrop Bay, Oyster Lake, West Bay, and GIWW Shoreline Protection
CA-5	Keller Bay Restoration
CA-6	Magnolia to Port O'Connor Shoreline Protection and Restoration
M-8	East Matagorda Bay Shoreline Protection
SP-1[d]	Redfish Bay Protection and Enhancement
W-3[e]	Port Mansfield Channel and Island Rookery Restoration

[a] Measure G-5 is measures G-5 East (Bolivar Peninsula Gulf Beach and Dune Restoration) and G-5 West (Galveston Island Gulf Beach and Dune Restoration) combined.

[b] Measure G-28 is measures G-12 East (Bolivar Peninsula GIWW Shoreline Restoration), G-12 West (West Bay GIWW Shoreline Restoration), and G-13 (West Bay GIWW Island Restoration) combined.

[c] Measure B-12 is measures B-5 (Bastrop Bay, Oyster Lake, and West Bay Shoreline Protection) and B-6 (Brazoria County GIWW Shoreline Protection) combined.

[d] Measure SP-1 (Dagger and Ransom Islands Protection and Restoration) was renamed to Redfish Bay Protection and Enhancement

[e] Measure W-3 is measures W-1 (Mansfield Island Rookery Restoration) and W-2 (Port Mansfield Channel) combined.

Table 4-16
ER Alternatives Array

ER Measure	Name	LOD
Alternative 1 – Coastwide All-Inclusive Restoration Alternative		
G-5	Bolivar Peninsula/Galveston Island Gulf Beach and Dune Restoration	1
G-28	Bolivar Peninsula and West Bay GIWW Shoreline and Island Protection	1, 2
B-2	Follets Island Gulf Beach and Dune Restoration	1
B-12	West Bay and Brazoria GIWW Shoreline Protection	2
M-8	East Matagorda Bay Shoreline Protection	1
CA-5	Keller Bay Restoration	2
CA-6	Powderhorn Shoreline Protection and Wetland Restoration	2
SP-1	Redfish Bay Protection and Enhancement	2
W-3	Port Mansfield Channel, Island Rookery, and Hydrologic Restoration	1, 2
Alternative 2 – Coastwide Restoration of Critical Geomorphic or Landscape Features Alternative *		
G-5	Bolivar Peninsula/Galveston Island Gulf Beach and Dune Restoration	1
B-2	Follets Island Gulf Beach and Dune Restoration	1
B-12	West Bay and Brazoria GIWW Shoreline Protection	2
CA-6	Powderhorn Shoreline Protection and Wetland Restoration	2
W-3	Port Mansfield Channel, Island Rookery, and Hydrologic Restoration	1
Alternative 3 – Coastwide Barrier System Restoration Alternative		
G-5	Bolivar Peninsula/Galveston Island Gulf Beach and Dune Restoration	1
G-28	Bolivar Peninsula and West Bay GIWW Shoreline and Island Protection	1, 2
B-2	Follets Island Gulf Beach and Dune Restoration	1
W-3	Port Mansfield Channel, Island Rookery, and Hydrologic Restoration	1
Alternative 4 – Coastwide Bay System Restoration Alternative		
G-28	Bolivar Peninsula and West Bay GIWW Shoreline and Island Protection	1, 2
B-12	West Bay and Brazoria GIWW Shoreline Protection	2
M-8	East Matagorda Bay Shoreline Protection	1
CA-5	Keller Bay Restoration	2
CA-6	Powderhorn Shoreline Protection and Wetland Restoration	2
SP-1	Redfish Bay Protection and Enhancement	2
Alternative 5 – Coastwide ER Contributing to Infrastructure Risk Reduction Alternative*		
G-5	Bolivar Peninsula/Galveston Island Gulf Beach and Dune Restoration	1
G-28	Bolivar Peninsula and West Bay GIWW Shoreline and Island Protection	1, 2
B-2	Follets Island Gulf Beach and Dune Restoration	1
B-12	West Bay and Brazoria GIWW Shoreline Protection	2
Alternative 6 – Top Performers		
G-5	Bolivar Peninsula/Galveston Island Gulf Beach and Dune Restoration	1
G-28	Bolivar Peninsula and West Bay GIWW Shoreline and Island Protection	1, 2
B-2	Follets Island Gulf Beach and Dune Restoration	1
B-12	West Bay and Brazoria GIWW Shoreline Protection	2
CA-6	Powderhorn Shoreline Protection and Wetland Restoration	2

* Alternative name revised

To further provide resiliency for the ER measures, on June 1, 2017, and June 7, 2017, the team identified the most critical areas along the measures that National Oceanic and Atmospheric Administration (NOAA, 2017) marsh migration layer identified as unconsolidated shore at 3-foot SLR. Based on the USACE SLR curves, 3-foot SLR is predicted to occur in the year 2080. These locations would receive a one-time out-year marsh nourishment in 2080. Nourishment in 2080 features occur in ER measures G-28, B-12, M-8, and W-3.

In addition, during these meetings, it was determined that the footprints of the beach/dune restoration features of measures G-5, B-2, and W-3 should be expanded slightly to encompass more of the features.

Following numerous team discussions, additional minor revisions occurred to the ER measure footprint features to better fit the purpose and need. In addition, the team discovered some issues with the NOAA (2017) marsh migration online tool that was being used to identify the out-year marsh nourishments. The team contacted Nate Herold at NOAA and obtained the correct GIS layers that were used to create the online tool. The NOAA marsh migration GIS layers that corresponded with the USACE SLR curves for the appropriate target years and coastal locations were then used to identify the most critical area along the ER measures.

Out-year marsh nourishments that would occur in 2055 and 2065 were identified at ER measures G-28, B-12, and M-8 in areas that would convert to open water or unconsolidated shoreline over the period of analysis due to RSLR. The locations of these out-year marsh nourishments were identified using the NOAA (2017) marsh migration RSLR layers of 2.0 feet for year 2055 and 2.5 feet for year 2065.

ER measures are described below and include the description, project need, Future Without-Project (FWOP), and similarity to the GLO's Texas Coastal Resiliency Master Plan (GLO, 2017). To provide a brief FWOP description for all the ER measures, the NOAA (2017) 3-foot SLR for the upper coast, 2.5 feet for the central coast, and 2 feet for the lower coast was used to provide a general acreage of habitat that would be impacted for that ER measure. The NOAA (2017) data does not consider natural processes such as erosion or marsh migration that would be affected by future SLR. ER measures were also cross-referenced to potential projects on the GLO Texas Coastal Resiliency Master Plan. Projects similar to the Coastal Texas ER measures are listed with their project subtype.

G-5 –Bolivar Peninsula/Galveston Island Gulf Beach and Dune Restoration

- Category: Beach nourishment and dune restoration
- Features: 5,057.1 acres/45.2 miles – dune/beach restoration
- Description: Restore 26.6 miles of Gulf shoreline from High Island to the Galveston North Jetty. Restore 18.6 miles of Galveston Island shoreline west of the Galveston seawall. Provides coastal surge risk reduction for several communities including Pirate's Beach, Jamaica Beach, the Silverleaf Seaside Resort, Vista Del Mar, Terramar, and Baywater.
- Need: Protect beaches and dunes along the shoreline from breaches and erosion caused by storm surge and SLR. Protect inland wetlands and habitat, which would be harmed if the Gulf shoreline

and dune system were breached. This project also protects State Highway 87, which is the only road accessing and providing evacuation capability on Bolivar Peninsula and Farm-to-Market Road 3005, which is the only road accessing and providing evacuation capability to the west from Galveston Island.

- FWOP: The Gulf shoreline is eroding at a rate of up to 5.7 feet per year along the Bolivar east portion of the reach, on Galveston Island 8.2 feet per year in the eastern reach of this area, and accreting 10 feet/year just east of San Luis Pass (Bureau of Economic Geology [BEG], 2016). The west end of Bolivar is gaining beach at a rate of 24 feet per year. Much of the existing 5,000 acres of Gulf beach and dunes in this area would be lost in 50 years. SLR may accelerate loss of beach and dune habitat. Loss of existing dunes will increase susceptibility of inland habitat and infrastructure to damage during storms.

- GLO Texas Coastal Resiliency Master Plan Resiliency Strategies: Bolivar Peninsula Beach and Dune Restoration (R1-1). Eroded beaches and dunes along a 10-mile reach from High Island in the east to Caplen in the west would be reconstructed. Galveston Island West of Seawall to 8 Mile Road Beach Nourishment (R1-22). This project would stabilize 1 mile of beach along Galveston Island's west end and create a feeder beach to nourish the beach west of 8 Mile Road.

G-28 – Bolivar Peninsula and West Bay GIWW Shoreline and Island Protection

- Category: Shoreline protection and restoration (breakwaters, etc.) and island restoration

- Features:

  - 36 miles – breakwaters
  - 326.0 acres/5.0 miles long – island restoration
  - 664.0 acres – estuarine marsh restoration
  - 26,280 linear feet/18.0 acres – oyster reef creation
  - 6,891.0 acres – out-year marsh nourishment at year at 2065

- Description: Construct rock breakwaters to reduce erosion of unprotected segments of shoreline along 27 miles of the GIWW on Bolivar Peninsula and 9 miles of shoreline along the north shore of West Bay along the GIWW. No breakwaters would be constructed where portions of the GIWW shoreline are stabilized by adjacent dredged material placement areas (PAs). Sediment would be used to restore a 326.0-acre (footprint) island that once protected 5 miles of the GIWW and the mainland in West Bay. Additional protection for restored island by adding 26,280 linear feet (18.0 acres) of oyster cultch to encourage the creation of oyster reef.

- Out-year marsh nourishment would occur in 2065 in areas that would convert to open water or unconsolidated shoreline over the period of analysis due to RSLR. The location of the out-year marsh nourishment was identified using the NOAA (2017) marsh migration RSLR layer of 2.5 feet for year 2065. A total out-year marsh nourishment of 6,891.0 acres will occur in 2065.

- Need: Reduce erosion of shoreline and adjacent marshes associated with GIWW vessel traffic and from submersion and erosion resulting from RSLR. Maintain marsh complexes on the south side

of the GIWW on the Bolivar Peninsula and on the mainland in West Bay to provide a buffer for storm surge impacts. Protect shallow-draft vessels and barges from wind-induced waves and reduce shoaling in the GIWW.

- FWOP: Without any shoreline protection, more than 18,000 acres of existing intertidal to high marsh, primarily along the south shore of the GIWW through Bolivar Peninsula, would be inundated at a SLR of 3 feet (NOAA, 2017). Loss of large areas of marsh along the south shore of the GIWW through Bolivar Peninsula would expose infrastructure along Bolivar Peninsula to increased risk of storm impacts by loss of the existing wetland buffer. Marshes along the south shoreline of the GIWW are eroding at an average rate of 3.9 feet per year. Much of the north shore of the GIWW is lined with leveed, upland PAs for GIWW dredged material. It is assumed that these levees will be maintained through the period of analysis. Small areas between the PAs would also be lost to erosion. Over the last 45 years, the width of the GIWW has increased by an average of 4.6 feet per year. Increased width of open water along the GIWW may affect navigation through the GIWW as the wave and current environment changes, and shoaling rates increase. Increased fetch with winds from the southeast may contribute to more-erosive wave forces impacting the marshes on upland areas along the north shore of West Bay. Sediments lost as marsh is submerged and eroded will tend to accumulate in the GIWW and may increase shoaling and maintenance dredging frequency. Without existing marshes, there may be increased likelihood Bolivar Peninsula will breach to the Gulf. At 3 feet of SLR, portions of the peninsula near High Island would narrow to less than 2,000 feet wide by the end of the period of analysis.

- Islands created during GIWW construction helped protect about 7,000 acres of marsh north of the GIWW in West Bay and shelter barge traffic in the GIWW. Over time, most of the islands have been destroyed by erosion but some island fragments remain today. These islands are eroding at an average of 2.7 feet per year. Fringe marsh and sea grass meadows have developed around these island fragments, particularly along their south shores. Loss of these islands would contribute to reduced protection from wave and current erosion for intertidal and fresh marsh along with loss of seagrass meadows in West Bay. Increased fetch with winds from the southeast may contribute to more-erosive wave forces impacting the marshes and upland areas along the north shore of West Bay. Increased open water with changed wave and current environments may also affect navigation in the GIWW through that reach.

- GLO Texas Coastal Resiliency Master Plan Resiliency Strategies: Anahuac NWR Living Shoreline (R1-5). Nine miles of living shoreline would be constructed along the GIWW adjacent to the Anahuac NWR.

B-2 – Follets Island Gulf Beach and Dune Restoration

- Category: Beach nourishment and dune restoration

- Features: 1,113.8 acres/10.1 miles – dune/beach restoration

- Description: Restore beach and dune complex on 10.1 miles of Gulf shoreline on Follets Island in Brazoria County.

- Need: Protect beaches and dunes from breaches and erosion caused by storm surge and SLR. Protect inland wetlands, seagrass meadows, and habitat along with back-bay marshes which would be harmed if the Gulf shoreline and dune system were breached. This project also protects State Highway 257, which is the only road accessing and providing evacuation capability to the east towards Galveston Island and to the west towards Freeport. Follets Island protects Bastrop, Christmas, and Drum bays and the Brazoria NWR on the mainland behind this bay system. It also protects seagrasses in Christmas Bay, extensive marshes throughout the bay complex, and scattered residential developments. Christmas Bay is a designated Gulf Ecological Management Site because of its relatively undeveloped shorelines, high water quality, and unique mix of seagrass meadows, oyster reefs, and smooth cordgrass marsh; it is also a TPWD Coastal Preserve.

- FWOP: Gulf beaches in this reach are eroding at a rate of 13 feet per year in the eastern reach of this area adjacent to San Luis Pass (BEG, 2016). The western end of the project has experienced accretion at a rate of 0.7 foot per year. Over 50 years, over 200 acres of existing shoreline and dunes may be washed away. Homes, infrastructure, and habitat would be lost during severe storms. State Highway 257 would be substantially threatened because of its proximity to the beach. Along some reaches of the highway, it is within 180 feet of the current shoreline. Opening Christmas Bay to Gulf waters would substantially affect the unique ecological features it demonstrates.

- GLO Texas Coastal Resiliency Master Plan Resiliency Strategies: Follets Island Nourishment and Erosion Control (R1-2). This project would create two stone groins on the Gulf beach combined with beach nourishment and is intended to protect State Highway 257 and Christmas Bay, and reduce erosion at Surfside Beach.

B-12 –West Bay and Brazoria GIWW Shoreline Protection

- Category: Shoreline protection and restoration (breakwaters, etc.) and oyster reef creation

- Features:

  - 551.0 acres – estuarine marsh restoration
  - 43.2 miles – breakwaters
  - 19,794.0 acres – out-year marsh nourishment at year 2065
  - 3,708 linear feet – oyster reef creation

- Description: Construct rock breakwaters to reduce erosion of critical reaches of shorelines on the western side of West Bay and Cow Trap Lake, and along selected segments of the GIWW in Brazoria County. Protect critical reaches in Oyster Lake from breaching into West Bay by adding about 0.7 mile of oyster cultch to encourage the creation of oyster reef.

- Out-year marsh nourishment would occur in 2065 in areas that would convert to open water or unconsolidated shoreline over the period of analysis due to RSLR. The location of the out-year marsh nourishment was identified using the NOAA (2017) marsh migration RSLR layer of 2.5 feet for year 2065. A total out-year marsh nourishment of 19,794.0 acres will occur in 2065.

- Need: Protect critical reaches of shoreline in this bay complex from breaching and impacting marsh, oysters, colonial waterbird rookeries, and other habitats in the complex through erosion and changes in circulation. Reduce shoreline breaches and marsh erosion during storm events and erosive effects of vessel wakes. Create the capability for marsh to be sustained during RSLR.

- FWOP: 10 miles of shoreline throughout this complex, used by a wide variety of coastal birds, may be inundated with SLR of 3 feet (NOAA, 2017). More than 6,000 acres of intertidal marsh and freshwater wetland along the north side of the GIWW may be submerged under 3 feet of RSLR without this measure. Bastrop Bay and Oyster Lake have oyster reefs that may be impacted by changed patterns of sedimentation and flow. Converting large expanses of wetlands to open water through RSLR and erosion will increase fetch and wave-generated erosion along newly exposed shores. Portions of this area are in the Brazoria NWR, which will lose valuable wetland habitat. Expanded open water with increased fetch may also threaten marshes and shores of Drum Bay south of the GIWW. There has been colonial waterbird use of islands in Drum Bay, and integrity of those islands may be threatened by increased erosive forces. Changes in wave environment and currents may affect navigation in the GIWW.

- GLO Texas Coastal Resiliency Master Plan Resiliency Strategies: Brazoria NWR GIWW Shoreline Protection (R1-17). This project will reinforce shores on the bayside of the south side of the GIWW along certain reaches, create emergent marsh, and monitor shoreline erosion for future adaptive management.

M-8 – East Matagorda Bay Shoreline Protection

- Category: Shoreline protection and restoration (breakwaters, etc.), island restoration, and oyster reef creation

- Features:

  - 8.9 miles – breakwater
  - 239.0 acres – estuarine marsh restoration
  - 92.7 acres/3.5 miles – island restoration
  - 31,355.0 linear feet – oyster reef creation
  - 6,034.0 acres – out-year marsh nourishment at year 2065

- Description: Construct rock breakwaters to reduce erosion along unprotected segments of the GIWW shoreline and associated marsh along the Big Boggy NWR shoreline and eastward to the end of East Matagorda Bay. No breakwaters would be constructed where portions of the GIWW shoreline are stabilized by adjacent dredged material PAs. Sediment would be used to restore a 92.7-acre island that once protected about 3.5 miles of shoreline directly in front of Big Boggy NWR and place oyster cultch on the bayside of the island.

- Out-year marsh nourishment would occur in 2065 in areas that would convert to open water or unconsolidated shoreline over the period of analysis due to RSLR. The location of the out-year marsh nourishment was identified using the NOAA (2017) marsh migration RSLR layer of 2.5 feet for year 2065. A total out-year marsh nourishment of 6,034.0 acres will occur in 2065.

- Need: Protect shoreline and marshes from breaches and erosion resulting from RSLR, storm events, and erosive effects of vessel wakes.

- FWOP: More than 2,000 acres of intertidal marsh and wetlands around the Pelton, Kilbride, and Boggy lakes complex in the Big Boggy NWR along the north shore of the GIWW and west of the Chinquapin community may convert to open water at SLR of 3 feet (NOAA, 2017). And more than 7,000 acres of intertidal marsh and wetlands to the east of Big Boggy NWR towards Bay City at the east end of Matagorda Bay may convert to open water. Conversion of this area to open water will increase wave erosion along the north shore and on marsh, reefs, and islands in East Matagorda Bay south of the GIWW.

- GLO Texas Coastal Resiliency Master Plan Resiliency Strategies: Boggy Cut GIWW Stabilization (R2-2). Wind and wave-generated erosion of the GIWW and the mainland combined with navigation hazards would be eased through barrier island restoration, breakwater construction, and marsh restoration adjacent to the GIWW.

CA-5 – Keller Bay Restoration

- Category: Shoreline protection and restoration (breakwaters, etc.), island restoration, and oyster reef creation

- Features:

  - 3.8 miles – breakwaters
  - 12,213 linear feet – oyster reef creation
  - 623.0 acres – out-year marsh nourishment at year 2065

- Description: Construct rock breakwaters to reduce erosion of about 5 miles of Matagorda Bay shoreline adjacent to Keller Bay. This would help protect 295.8 acres of SAV that occurs along the shoreline of Keller Bay. Construct oyster reef along 2.3 miles of western shoreline along Sand Point in Lavaca Bay by installing oyster reef balls in nearshore waters.

- Out-year marsh nourishment would occur in 2065 in areas that would convert to open water or unconsolidated shoreline over the period of analysis due to RSLR. The location of the out-year marsh nourishment was identified using the NOAA (2017) marsh migration RSLR layer of 2.5 feet for year 2065. A total out-year marsh nourishment of 623.0 acres will occur in 2065.

- Need: Prevent the southern Keller Bay shoreline from breaching into Keller Bay with subsequent loss of intertidal marsh, SAV beds, and oyster reef in Keller Bay. Including protection of area north of Sand Point.

- FWOP: Over 250 acres of intertidal marsh in Keller Bay along the Matagorda/Keller Bay shoreline, about 330 acres of SAV and 7.0 acres of oyster reef would be lost with SLR of 2.5 feet (NOAA, 2017) and breaching of the shoreline. Increasing the extent of open water is expected to increase erosion from waves and modified currents.

- GLO Texas Coastal Resiliency Master Plan Resiliency Strategies: None

CA-6 – Powderhorn Shoreline Protection and Wetland Restoration

- Category: Shoreline protection and restoration (breakwaters, etc.) and wetland restoration
- Features:
  - 5.0 miles – breakwater
  - 531.0 acres – estuarine marsh restoration
- Description: Restore and reduce erosion of about 6.7 miles of Matagorda Bay shoreline fronting portions of the community of Indianola, the Powderhorn Lake estuary, and TPWD's Powderhorn Ranch by restoring marsh at three areas protecting estuarine bays and bayous between Powderhorn Lake and Port O'Connor. The shoreline in the northern part of this area is mainly crushed shell with a little sand, becoming more of a sandy shoreline moving south to Port O'Connor. The shoreline is heavily used for recreation. Shoreline stabilization to include breakwaters, maintaining circulation.
- Need: Protect intertidal marsh and ecological integrity of Powderhorn Lake estuary and several minor estuaries occurring along the Powderhorn Ranch shoreline. At present, the shoreline and various inlets have been eroding relatively rapidly.
- FWOP: Some areas of intertidal marsh/open-water complex may be eroded and submerged at a 2.5-foot RSLR combined with higher potential for breaches along the shoreline (NOAA, 2017). The mouths of Powderhorn Lake and Huckleberry, Bid Dam, Broad, and Big Boggy bayous will widen noticeably with subsequent changes in salinity regime, wave-generated erosion combined with possible losses of oysters and marsh. The ecological nature of Powderhorn Lake and the other estuarine bayous would be changed substantially. Potential navigation improvements within Matagorda Bay would also exacerbate erosion and estuarine resource loss.
- GLO Texas Coastal Resiliency Master Plan Resiliency Strategies: None

SP-1 – Redfish Bay Protection and Enhancement

- Category: Shoreline protection and restoration (breakwaters), island restoration, and oyster reef creation
- Features:
  - 7.4 miles – breakwater
  - 391.4 acres – island restoration
  - 7,392 feet – oyster reef creation
- Description: Restore the island complex of Dagger, Ransom, and Stedman islands in Redfish Bay. Construct breakwaters along unprotected GIWW shorelines along the backside of Redfish Bay and on the bayside of the restored islands. Add additional protection to island complex by adding oyster reef balls between the breakwater and island complex. Breakwater and islands would protect SAV

within Redfish Bay, and it is assumed about 200 acres of additional SAV will form between the breakwaters and islands.

- Need: Prevent loss of islands which protect extensive seagrass meadows and support coastal water birds.

- FWOP: Sizes of islands in the complex would shrink because of 2.5 feet SLR (NOAA, 2017) and continued erosion would open the area to greater wave action from increased fetch and deep-draft navigation in the Corpus Christi Ship Channel. Two thousand acres of seagrass meadows would be threatened as existing islands are eroded, opening the bay to increased wave energy and turbidity. Coastal waterbirds using the islands would be affected by reduced area and shoreline distance.

- GLO Texas Coastal Resiliency Master Plan Resiliency Strategies: Dagger Island Living Shoreline (R3-14). Up to 1 mile of nearshore breakwaters would be constructed, and 30 acres of island would be reconstructed with dredged material.

W-3 – Port Mansfield Channel, Island Rookery, and Hydrologic Restoration

- Category: Beach nourishment, island restoration, sediment management, shoreline protection and restoration (breakwaters, etc.), and hydrologic restoration

- Features:

  - Borrow Source: 6.9-mile channel to be dredged
  - Gulf Shoreline: 9.5 miles – beach nourishment
  - Bird Island Restoration: 0.7 mile – breakwater and 27.8 acres – island restoration
  - Hydrologic Restoration: 112,864.1 acres in Lower Laguna Madre

- Description: This measure has three elements: 1) recurring nourishment of the Gulf shoreline north of the Port Mansfield Channel; 2) protect and restore Mansfield Island with 3,696 feet of rock breakwater and 27.8-acre (footprint) island restoration; and 3) restore and maintain the hydrologic connection between Brazos Santiago Pass and the Port Mansfield Channel with dedicated dredging of a portion of the Port Mansfield ship channel, which will provide hydrologic restoration of the Lower Laguna Madre.

- Need: 1) Restore sediment transport across the Mansfield navigation channel to the Gulf shoreline north of the Port Mansfield Channel jetties. The jetties block the prevailing south to north longshore current. Sediment bypass is needed to move sediment trapped on the Gulf shoreline south of the south jetty, restore beaches/dunes north of the jetties, and prevent the imminent breach of the island, which would deny access to visitors and NPS staff. In addition, sandy shoaled sediment, available in the Port Mansfield Channel, would be used for beach nourishment of the island shoreline up to 9.5 miles north of the channel. Without this action, the north jetty for the Port Mansfield Channel will be undercut on the western end. Restoration of sediment transport would support dune development and help control erosion along the Gulf shore. The beach north and south of the entrance channel is designated critical habitat for wintering piping plovers and the primary U.S. nesting beach for the endangered Kemp's ridley sea turtles; 2) Protect Mansfield Island from

erosion resulting from RSLR, storms, and vessel wakes and increase the size and elevation of the island; and 3) Reduce hyper-salinity in the Laguna Madre caused by a reduction of water flow into the system through the Port Mansfield Channel related to channel shoaling restricting the flow (King et al., 2016).

- FWOP: Interruption of longshore sediment transport increases Gulf beach and dune erosion north of the entrance channel. Erosion is 14 feet per year on the north side of the pass, and it gradually decreases to 2 to 4 feet per year with distance north from the pass (BEG, 2016). The beach is accreting at a rate of 6 feet per year immediately south of the pass; however, the beach exhibits increasing rates of erosion with distance south of the pass. The beach and dune system will erode toward washovers, which may increase the likelihood of system breaches. Increased water exchange with the Gulf would result in salinity, circulation, and habitat changes in the Laguna. Two-foot RSLR by 2085 would result in the transition of dune areas to brackish intertidal wetlands on the back side of South Padre Island and increase the possibility of breaches in the barrier. Two feet of RSLR combined with ongoing erosion would cause the 3-acre island Mansfield island, used by colonial waterbirds, to completely convert to unconsolidated tidal flats (NOAA, 2017).

- GLO Texas Coastal Resiliency Master Plan Resiliency Strategies: None

ER measure and alternative screening resulted in nine ER measures remaining for alternative formulation. Habitat Evaluation Procedure (HEP) ecosystem modeling and analysis was conducted on these alternatives (Appendix C-8). Outputs from the HEP modeling efforts were incorporated into the Institute for Water Resources Planning Suite's Cost Effectiveness and Incremental Cost Analyses (CE/ICA). The CE/ICA utilized cost components and ecological outputs to identify Best Buy ER plans, which provided the greatest increase in ecological productivity for the least increase in cost (Appendix E-3). The USACE, Galveston District and its non-Federal sponsor recommended Alternative 1 as the Tentatively Selected Plan.

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