GULF INTRACOASTAL WATERWAY: BRAZOS RIVER FLOODGATES AND COLORADO RIVER LOCKS SYSTEMS FEASIBILITY STUDY

Draft Report

U.S. Army Corps of Engineers
Southwestern Division
Galveston District
19 February 2018

US Army Corps of Engineers ®
Galveston District

Texas Department of Transportation

TABLE OF CONTENTS

TABLE OF CONTENTS

LIST OF APPENDICES

TABLE OF CONTENTS

THIS PAGE LEFT INTENTIONALLY BLANK

Executive Summary

The U.S. Army Corps of Engineers (USACE), Southwestern Division (SWD), Galveston District (CESWG), Regional Planning and Environmental Center (RPEC); with input provided by the study partner, the Texas Department of Transportation (TxDOT), and other Federal, State, and local resource agencies prepared this document as the Gulf Intracoastal Waterway (GIWW) Brazos River Floodgates (BRFG) and Colorado River Locks (CRL) System Draft Integrated Feasibility Study and Final Environmental Impacts Statement (FEIS), hereafter referred to as the GIWW BRFG/CRL Integrated Feasibility and DEIS Report. The GIWW – BRFG/CRL project follows a 2000 reconnaissance report entitled, *GIWW Modifications, Texas Section 905(b) Analysis.* It encompassed two locations on the GIWW along the Texas Coast. The BRFG is located about 7 miles southwest of Freeport, Texas, on the GIWW where it crosses the Brazos River in Brazoria County. The CRL are located near Matagorda, Texas, on the GIWW where it crosses the Colorado River in Matagorda County.

General Study Area

The Study Area encompasses the two project sites and adjacent lands and waters. There is a large amount of hydraulic connectivity to a variety of bodies of water, which expands the study area.

Navigation System Background and Use

The GIWW is a Federal shallow-draft navigation project. BRFG and CRL are in the western portion of the GIWW. The waterway was constructed starting prior to 1900 and ending with full extension or depth to Brownsville ending in 1949. Its path intersects many bodies of water including the Brazos and Colorado Rivers. These rivers have found the GIWW as an outlet for discharging their sediment-laden flows. In the 1940's, 75-foot wide gated structures aimed at controlling flows and silt into the GIWW at each river were completed. The closing of the gates allows the rivers to perform more naturally in allowing their sediments to continue downstream. The gates on both sides of the Colorado River crossing were upgraded to 1200-foot long locks in 1954 by adding gated structures and earthen lock chambers. The locks increase the navigability window at the crossing. Approximately 21M tons of commodities, average from 2010-2014, transit each project.

Problem Introduction

Although the structural improvements on both rivers helped to reduce shoaling, they created their own set of delays to navigation. Other than at higher flows, the gates are set to the open position allowing free flow of water and tows that are nearly constantly transiting the crossing (approximately 21M tons average from 2010-2014 at each project). The narrow opening of the gated structure creates an impedance to the flow of water causing the water to swell and rise locally, which accelerates the water through the structure creating hazardous navigation conditions. At a certain level of swell, or head differential, navigation is deemed too hazardous and the river crossing is closed to navigation either by policy or by physically closing the gates. Also, the 75-foot opening causes the tows that are assembled to two barges wide to break down to single wide and commonly a single barge for shuttling across the river in a process known as tripping. After all barges have been shuttled across the river, they are reassembled by cabling them back together into their original tow configuration. Additionally, the narrow gate opening and crossing geometry create hazardous cross currents and eddies, which when coupled with winds and other drivers are the cause for many vessel impacts (allisions) to the structures with many more at BRFG than CRL (65 versus 8 annually). In fact, the long history or allisions has driven many mariners and towing companies to adopt risk-averse policies that essentially increases single barge tripping thus increasing delays. Safety is held paramount to efficiency with such policies.

These problems combine to create massive average delays to navigation (12 hours at BRFG, 3 hours CRL) as well as contributing to hazards to mariners thus creating the need for the study of improvements that is documented herein. Delays to navigation became the single-most important economic benefit and decision

point for the study process, and safety was improved in the end. The study process includes an in-depth investigation of the existing practices and conditions for navigation as well as an extrapolation of these practices and conditions into the future to establish a baseline, or without-project condition, to which all improvements, meaures/alternatives, can be compared.

The without-project condition was dominated by the continuation of navigation delays. This report estimates the cost of continuing the current operation, policies, and practices. The quantification of delays as well as sediment management practices were found to be best appreciated by thinking about them in the following categories:

Delays

- base transit time for tows crossing the river
- the practices, frequency and timing, of tripping
- the downtime of vessel allisions – the allision and any subsequent closure for infrastructure repairs
- river crossing closures due to hydraulic conditions – head differential at the structure, gate closures resulting from high river levels, tidal impacts

Sediment Management

- Dredging frequency, volumes, disposal, and pending capacity exhaustion of current lower cost upland disposal areas.

Potential Problem Solutions and Process

Measures were generated aimed at targeting delay reduction in the categories above while being mindful of dredging and other impacts. Measures generally included non-structural and structural – both small-scale and large-scale. Non-structural measures generally includes the changing of existing or introducing new operation or management practices to reduce delays. Structural measure generally entail the construction of a variety of features that would improve navigation. Small-scale differs from large-scale in the construction cost, and degree of navigation improvement. Working with individual measures adds a great strength to the process as their individual contributions can be evaluated. Measures can be combined essentially creating new measures. The combination of measures for a project and the subsequent combination of project solutions become alternatives. It is the term “Alternative” that is used herein to describe the solutions to problems. Greater detail is contained herein on these concepts and other definitions as well as the overall plan formulation process including the tentatively selected plan (which at this writing is synonymous with the draft recommended plan).

The result of the plan formulation is a solution that reasonably maximizes NED, National Economic Development, benefits. This best plan is the draft recommended plan at this writing and has undergone various in-progress reviews in accord with USACE standard planning practices. The current level of completion includes a preliminary design that was evaluated with an emphasis on economic value and vetted with USACE Headquarters and subordinate levels. Preliminary coordination with some resource agency had been conducted. The subject of this process is termed the tentatively selected plan, which is deemed “tentative” as it yet must undergo review and scrutiny by peers, stakeholders, partners, special interests, and the general public. The comments from such reviews contribute to the process in that they help shape the recommendation ranging from full or partial validation to adjustment of features to future implementation considerations.

A draft recommended plan typically is not without impact to the natural and/or human environments. Even if there turns out not to be impacts, rigorous investigation is required and conducted. The process and procedures within NEPA and other policy and practices by USACE govern the evaluation of project impacts as well as the sharing or transparency of such evaluations including interactions with the public. The

relevant description of the existing environment and human environments and systems, and the impacts of the draft recommended plan are contained in Chapters 2 and 5, respectively. Any concepts or prescriptions for mitigation of impacts are in Chapter 5. Part of the process regulates that an EIS, Environmental Impact Statement, accompany the study, which herein is manifested by integration into this feasibility study.

The TSP Plan

The Brazos River crossing portion of the plan will be in the existing channel alignment with open channel on the west side and a gate structure (125' wide) on the east side that will be set back from the river. The setback reduces accidents. The open channel on the west side changes overall sediment deposit distribution compared to the without-project condition. Approximately an 8% increase in dredging volumes and costs. The current cost estimate for construction is approximately $147.8M including contingencies.

The Colorado River crossing portion of the plan will be in the existing channel alignment and include gate removal of the riverside gate structures while retaining the outer gates, creating a wider (125ft) and much longer forebay that will reduce accidents. Since gated structures will remain, minimal changes to existing sediment distribution patterns are expected. The current cost estimate for construction is approximately $36.9M including contingencies.

Economic Analysis and Justification.

To quantitatively analyze and compare alternatives resulting in the TSP, monetized benefits of the alternatives were estimated using a stand-alone model that was developed and approved for use in this study. Benefits were compared to costs to develop benefit-cost ratio (BCR) and net benefits estimates. The system BCR for the TSP is 2.5.

Comments: The comment period for the draft FR-EIS ends on March 25, 2018. Please send comments to the District Engineer, P.O. Box 1229, Galveston, TX 77553. Comments may also be sent to the District Engineer through Ms. Franchelle Craft, via email at Franchelle.E.Craft@usace.army.mil. For further information about this study please contact Ms. Craft, via email or telephone at (409) 766-3187

LIST OF ACRONYMS

Acronym or Abbreviation	Definition or Meaning
APE	Area of Potential Effect
BG	block group
BGEPA	Bald and Golden Eagle Protection Act
BMP	best management practice
BRFG	Brazos River Floodgates
CAA	Clean Air Act
CAP	Climate Action Plan
CBRA	Coastal Barrier Resources Act
CBRS	Coastal Barrier Resources System
CCC	Coastal Coordination Council
CEPRA	Coastal Erosion Planning & Response Act
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
CO	carbon monoxide
CRL	Colorado River Locks
CT	census tract
CWA	Clean Water Act
dB, dBA	Decibels, A-weighted decibels
DHHS	Department of Health and Human Services
DMPA	dredged material placement area
EFH	Essential Fish Habitat
EIS	Environmental Impact Statement
EO	Executive Order
EPA	Environmental Protection Agency (U.S.)
ESA	Endangered Species Act
FEMA	Federal Emergency Management Agency
FHWA	Federal Highway Administration
FIRM	Flood Insurance Rate Map
FMC	Fishery Management Council
FMP	Fishery Management Plan
FPPA	Farmland Protection Policy Act
FR	Feasibility Report
FTA	Federal Transit Authority
FWOP	Future Without Project
GHG	greenhouse gas
GIWW	Gulf Intracoastal Waterway
GLO	General Land Office (Texas)
GMFMC	Gulf of Mexico Fishery Management Council
GPM	gallons per minute
HAPC	Habitat Areas of Particular Concern
HEP	Habitat Evaluation Procedures
HGB	Houston-Galveston-Brazoria
H&H	hydrology & hydraulics
HRSR	historic resources survey report
HSI	habitat suitability index
HTRW	Hazardous, toxic, and radioactive waste
HUC	Hydrologic Unit Code

Acronym or Abbreviation	Definition or Meaning
MBTA	Migratory Bird Treaty Act
MHHW	Mean Higher High Water
MHW	Mean High Water
MLLW	Mean Lowest Low Water
MLW	Mean Low Water
MMPA	Marine Mammal Protection Act
MSL	mean sea level
MTL	mean tide level
NAAQS	National Ambient Air Quality Standards
NEPA	National Environmental Policy Act
NHPA	National Historic Preservation Act
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NO_x	nitrogen oxides
NO_2	nitrogen dioxide
NPS	National Park Service
NRCS	Natural Resources Conservation Service
NRHP	National Register of Historic Places
NWR	National Wildlife Refuge
ODMDS	ocean dredged material disposal site
O&M	operations & maintenance
OSHA	Occupational Safety and Health Administration
O_2	oxygen
Pb	lead
PCB	polychlorinated biphenyls
PM_{10}, $PM_{2.5}$	particulate matter
ppt	parts per thousand
RHA	Rivers and Harbors Act
RRC	Railroad Commission (Texas)
RSLC	relative sea level change
SAL	State Antiquities Landmark
SHPO	State Historic Preservation Office
SIP	State Implementation Plan
SO_2	sulfur dioxide
TASA	Texas Archeological Sites Atlas
TCEQ	Texas Commission on Environmental Quality
TCMP	Texas Coastal Management Plan
THC	Texas Historical Commission
TIPPC	Texas Invasive Plant and Pest Control
TPWD	Texas Parks and Wildlife Department
TSP	Tentatively Selected Plan
TWDB	Texas Water Development Board
TxDOT	Texas Department of Transportation
TXNDD	Texas Natural Diversity Database
U.S.	United States
USACE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture
USFWS	U.S. Fish and Wildlife Service

LIST OF ACRONYMS

Acronym or Abbreviation	Definition or Meaning
USGS	U.S. Geological Survey
U.S.C.	United States Code
VOC	volatile organic compounds
WMA	Wildlife Management Area
WWTP	wastewater treatment plant

1.0 Introduction

This document is the Gulf Intracoastal Waterway (GIWW) Brazos River Floodgates (BRFG) and Colorado River Locks (CRL) System Draft Integrated Feasibility Study and Final Environmental Impacts Statement (FEIS), hereafter referred to as the GIWW BRFG/CRL Integrated Feasibility and DEIS Report. This report was prepared by the U.S. Army Corps of Engineers (USACE) Southwest Division (SWD), Galveston District (SWG), and the Regional Planning and Environmental Center (RPEC); with input provided by the study partner, the Texas Department of Transportation (TXDOT), and other Federal, State, and local resource agencies.

The GIWW – BRFG/CRL project was recommended for feasibility level analysis after completion of a 2000 reconnaissance report entitled, *GIWW Modifications, Texas Section 905(b) Analysis*, to determine federal interest (sections incorporated by reference). It encompassed two locations on the GIWW along the Texas Coast. The BRFG are located about 7 miles southwest of Freeport, Texas, on the GIWW where it crosses the Brazos River and the GIWW in Brazoria County. The Colorado River Locks are located near Matagorda, Texas, on the GIWW where it crosses the Colorado River and the GIWW in Matagorda County.

1.1 Study Authority

This integrated Draft Feasibility Report and Environmental Impact Statement (DFR-EIS) has been prepared in response to the provision of funds in the Energy and Water Development Appropriations Act of 1998, under the authority of Section 216 of the 1970 Flood Control Act, which reads:

> *"The Secretary of the Army, acting through the Chief of Engineers, is authorized to review the operation of projects the construction of which has been completed and which were constructed by the Corps of Engineers in the interest of navigation, flood control, water supply, and related purposes, when found advisable due to significant changed physical or economic conditions, and to report thereon to Congress with recommendations on the advisability of modifying the structures or their operation, and for improving the quality of the environment in the overall public interest."*

Amendments to the WRDA 1986 (Section 229 amends 1899 River and Harbors Act (Sec. 14)) also state that "the Secretary of the Army can improve or alter navigation improvements in the public interest but doesn't impair usefulness of the constructed Federal Project." This report reassesses the alternatives proposed in the 2000 reconnaissance study and updates the results of the hydraulic, economic, and environmental analysis, and recommends design level solutions that are favorable improving navigability on the GIWW at the crossings of the Brazos and Colorado Rivers. Construction of any recommended projects will be cost-shared with the Inland Waterways Trust Fund per WRDA 1986 Section 223.

1.2 Federal Interest

Addressing the navigation issues in the region is not only significant to Texas residents and workers but the nation because of the various types of commodities that are shipped and transported along the GIWW to the country's interior. The top three commodities by tonnage are: petroleum / petroleum products; chemicals and related products; and crude materials. Petroleum/crude oil account for (60%), manufactured goods (5%), and agricultural products (2%). The value of goods exported from Texas ports in 2011 was $251 billion, more than that from all other states. The Port of Houston alone generated a statewide economic impact of

$178 billion with its 25-mile-long complex of public and private facilities. The Port handled 162.4 million in foreign tonnage in 2012 and its petrochemical complex has a total daily operable refining capacity of 351,776 barrels, one of the largest in the world.

The GIWW links the petrochemical industries, refineries and manufacturing facilities along Texas coast, all Texas deep draft ports, and other Gulf ports east of Texas; 80.1 million tons transited Texas portion of GIWW in 2016. Many of these commodities have to pass through the lock and floodgate structures. The Colorado River Lock (CRL) is unique because it is the oldest operating lock in Texas. The locks are operated 24 hours a day, 365 days a year by the USACE. The locks pass an approximate tonnage of 20,000,000 each year via 15,000 tows, and about 5,000 recreational vessel locks each year. The Brazos River Floodgates (BRFG) are significant because they pass approximately 23,000,000 tons of barged material each year. Both structures have a yearly project Operations and Maintenance budget of about $1.8 million. Traffic transits the Brazos and/or Colorado Rivers projects to Freeport and Matagorda respectively. Without modifications to the floodgate and lock structures, barges and tows will continue to experience costly navigation delays along this portion of the GIWW.

1.3 Study Partner

The study partner is the Texas Department of Transportation (TxDOT). The agency has provided the EIS and technical appendices per a Memorandum of Agreement (MOA) signed with the USACE in August 2016. The MOA outlines the scope of work and expected products developed by TxDOT that will undergo technical and policy review as outlined in the review plan. Sections from the EIS are integrated into this draft FR.

1.4 Study Area and Congressional District

The full characterization of alternatives and selection of a plan required the general study area be expanded beyond the immediate project area due to hydraulic connectivity of numerous types of bodies of water. The overall system study area (**Figure 1.1**) encompasses a very large area due to the hydraulic connectivity of the rivers, bays, GIWW, Gulf inlets and outlets and the Gulf of Mexico itself including all associated shoreline, bank line, and adjacent impacted lands. The system of structures includes flood gates on the GIWW where it intersects the Brazos River and Locks on the GIWW where it intersects the Colorado River. The hydraulic impact of the proposed recommendations also includes the evaluation of upstream and downstream impacts on the subject rivers. In general, the potential for changes to water levels, flows and velocities resulting in sediment redistribution, isolated scour, and altered hydrographs served to physically bind the study area. This is approximately 40 miles of the GIWW in Texas, the lands and waters towards the Gulf and inland up each subject river. These areas are contained in two counties, Brazoria and Matagorda. The floodgates are 7 miles southwest of Freeport, Texas and are accessible via Floodgate Road, 3.5 miles south of State Highway 36. The locks are located near Matagorda, Texas. The East Lock is located on Matagorda Street approximately 0.25 miles west of the FM 2031 Bridge over the GIWW. The West Lock is not accessible by road, but as its name suggest is west of the East lock.

The following Congressional representatives serve the project area: Senators John Cornyn and Ted Cruz, Representative Randy Weber (District 14), and Representative Randolph Farenthold (District 27).

Figure 1.1: Study Area Overview

1.5 Historical Background and General Navigation Use

The GIWW is a Federal shallow-draft navigation channel that extends from Brownsville, Texas, to the Okeechobee waterway at Fort Myers, Florida. It was proposed by Albert Gallatin, United States Secretary of the Treasury, in a report on *Public Roads and Canals*, and submitted to the United States Senate in 1808. In 1819 Secretary of War John C. Calhoun urged congress to develop a plan for an improved internal transportation system that included waterways. He proposed that the Army Corps of Engineers be used to develop and, if necessary, supervise construction of the internal improvements. By 1829 much of the route along the eastern portion of the proposed GIWW had been identified. A plan was not submitted for the western portion (Donaldsonville, Louisiana, to the Rio Grande) of the GIWW until 1875. (**Picture insert Figure 1.2:** GIWW opening at Port Bolivar, Texas 1999).

The state of Texas had already dredged a shallow channel through part of the West Bay inside Galveston Island and in 1892 Congress authorized enlargement and extension of the channel to Christmas Point in Oyster Bay, and in 1897 authorized purchase of the Brazos Navigation Company of an eleven-mile canal that connected Oyster Bay to the Brazos River. The purchase was completed in 1902. By 1905 Congress had provided authorization and funds to tie the various existing canal segments into a continuous channel nine

feet deep and 100 feet wide from New Orleans to Galveston Bay. By 1941 the canal had been extended to Corpus Christi Bay and by 1949 it had been enlarged to 12 feet deep and 125 feet wide and extended the Texas portion of the canal system for 423 miles, from Sabine Pass to the mouth of the to the Brownsville Ship Channel. (https://tshaonline.org/handbook/online/articles/rrg04).

The BRFG were authorized by the River and Harbor Act of 21 January 1927 as an integral part of the GIWW from the Mississippi River to Corpus Christi, Texas. Construction of the floodgates were completed in September 1943. The gates are located approximately 7 miles southwest of Freeport, Texas, on each side of the Brazos River on the Gulf Intracoastal Waterway. Each pair of floodgates consists of two structural steel sectors installed in concrete gate recesses and are operated by rack and pinion drive.

At the Colorado River crossing, similar floodgates were constructed under the same authorization as the BRFG in September 1943. They were converted to locks in April 1954. The locks are located on each side of the Colorado River on the GIWW. A pair of sector gates located at each end encloses a 1,200-feet lock chamber. The CRL is unique because they are the oldest operating locks in Texas and are operated 24 hours a day, 365 days a year by the USACE.

A reconnaissance study was completed in 2000 on the *GIWW Modification, Texas in a Section 905(b) Analysis* to determine the need and advisability of modifying the configurations of the crossings to reduce traffic accidents and delays where the GIWW crosses the Colorado and Brazos Rivers. It was determined that there was Federal interest in continuing the study into the feasibility phase. The feasibility for the Colorado River Locks was initiated in November 2001, with a scoping meeting held in December 2003. Tow simulations for several design alternatives were completed by ERDC in January 2004. The projects languished for a number of years thereafter until the Texas Department of Transportation began feasibility analysis on the Brazos River Floodgates in 2014. The two projects were recommended as a system combined study in 2015 and study kickoff occurred in March of 2016 after funds were appropriated.

1.6 Study Purpose, Need, and Scope

The study **purpose** is to develop alternatives to determine the feasibility of undertaking modifications to the BRFG and CRL river crossings. This study will identify changes that are structurally sustainable, economically justified, and environmentally acceptable. There is a **need** to reduce navigation impacts and costly waterborne traffic delays that are a result of permanently altered tow arrangements and barge sizes, changed transiting procedures, hazardous approaches and exits to structures, overall aging of infrastructure, narrow openings at structures, and complex hydraulic conditions.

The **scope** of the study is to:

- Update existing and future with/without project conditions from the 2000 study with focus on:
    - Hydraulics (currents, velocities, flows and stage frequency impacts to navigation at crossings)
    - Sedimentation, salinity, erosion, and dredging requirements
    - Assessment of riverine changes
    - Assessment of operational adequacy of the floodgates/locks dimensions and overall geometry of the projects
    - Economic analysis (delays, allisions, and shipping/tonnage values) to estimate National Economic Development (NED) benefits
    - Environmental impacts
- Evaluate and compare alternatives developed and select a recommended plan.

This report presents a collaboratively-developed plan prepared in accordance with the National Environmental Policy Act (NEPA) and Engineering Regulation (ER) 1105-2-100, the USACE Planning Guidance Notebook in accordance with SMART Planning principles and processes. It consists of an integrated feasibility report and EIS, together with associated appendices, and identifies the expected benefits, estimated cost and implementation responsibilities as well as adequate engineering, construction, and design details for the NED plan. The purpose of the economic analysis in this feasibility study is to estimate the net NED benefits associated with navigation improvements that are designed to reduce traffic delays and accidents at the floodgate and lock structures. The purpose of the environmental analysis in this study is to assess the environmental impacts of proposed actions. The appendices provide detailed supporting information for all of the investigations and tasks conducted for the project effort. The project considers a host of reasonable measures including:

- Measures and alternatives considered under previously initiated and existing projects and/or studies
- Recommendations from the PDT, including the study partner (TXDOT)
- Recommendation from other Federal and non-Federal stakeholders

1.7 Prior Studies, Reports, and Existing Water Projects

Listed below are the relevant reports and studies that were considered in the development of the 2000 reconnaissance report and current system feasibility study. New start and ongoing projects will also be considered as part of this studies existing conditions.

Table 1.1: Relevant Prior Reports and Studies

		Relevance to Brazos/Colorado Study			
Navigation Studies and Reports		**Data Source**	**Consistency**	**Measure Source**	**FWOP Conditions**
1939	Report on the Study of the Intracoastal Waterway Crossing of the Colorado River	X	X		X
1975	Final Environmental Statement, Maintenance Dredging, Gulf Intracoastal Waterway, Texas Section, Main Channel and Tributary Channels, Volumes 1-3	X	X		X
1977	Mouth of Colorado River, Texas, Phase I, General Design Memorandum (Navigation Features)	X	X		X
1981	Mouth of Colorado River, Texas, Phase I, General Design Memorandum and Environmental Impact Statement (Diversion Features)	X	X		X
1999	Colorado River/GIWW Intersection Draft Report	X	X		X
2000	GIWW Modifications, Texas Section 905(b) Analysis, U.S. Army Corps of Engineers	X	X	X	X
2009	Hydraulic Sediment Response Model Study for the Brazos River and Gulf Intracoastal Waterway Crossing Technical Report M45	X	X		X
2016	GIWW Mooring Basin Modification Study (Ongoing), U.S. Army Corps of Engineers	X	X	X	X
2016	Coastal Texas Protection and Restoration Study (Ongoing), U.S. Army Corps of Engineers	X	X		X
Federal & Local Significant Projects					
Gulf Intracoastal Waterway (GIWW)		X	X		
Freeport Ship Channel		X	X		
Matagorda and Freeport Levee Systems		X	X		

1.8 USACE Civil Works Guidance and Initiatives

USACE planning is grounded in the 1983 Economic and Environmental Principles and Guidelines for Water and Related Land Implementation Studies (Principles and Guidelines). The Principles and Guidelines provide for the formulation of reasonable plans responsive to National, state and local concerns. Within the framework of the Principles and Guidelines, the USACE seeks to balance economic development and environmental needs as it addresses water resources problems. The Federal objective of water and related land resources planning is to contribute to National Economic Development (NED) consistent with protecting the Nation's environment, in accordance with National environmental laws, Executive Orders and other Federal planning requirements. The Planning Guidance Notebook (ER 1105-2-100) provides the overall direction to formulate, evaluate and select projects for implementation. The study conforms to the USACE Campaign Plan goals, and the USACE Environmental Operating Principles by undertaking a proactive public and stakeholder involvement campaign, including a project website, regular stakeholder meetings, and targeted industry meetings. Active and responsive public involvement has informed the

development of solutions to the problems this study seeks to address, and has facilitated the sharing and distribution of data and knowledge between the USACE and its study partner TXDOT. The relationships that the study team has developed with stakeholders and navigation industry groups, local officials, and other special interest groups and agency partners has facilitated the consensus-building process to create a mutually supportable economic and environmentally suitable solution for the nation. The study was conducted under the USACE's Civil Works Planning modernization process by utilizing the SMART planning to effectively execute and deliver the study in a timely manner.

The tentatively selected plan (TSP) was approved by HQUSACE in accordance with the provisions and requirements of the Planning Guidance Notebook (Engineering Regulation ER 1105-2-100) and of Section 1001 of the Water Resources Reform and Development Act of 2014 (WRRDA 2014), as well as the implementation guidance for Section 1001 of WRRDA 2014, as set forth in the memorandum from the Chief, Planning and Policy Directorate of Civil Works, dated 09 April 2015 SUBJECT: "Implementation Guidance for Section 1001 of the Water Resources Reform and Development Act of 2014 (WRRDA 2014) – Vertical Integration and Acceleration of Studies".

1.9 Economic Analysis of USACE Inland/Shallow-Draft Navigation Projects

The purpose of a U. S. Army Corps of Engineers economic analysis is to estimate changes in national economic development that occur as a result of differences in project outputs with a plan, as opposed to national economic development without a plan. This is accomplished through a federally mandated National Economic Development (NED) analysis which is generally defined as an economic cost-benefit analysis for plan formulation, evaluation, and selection that is used to evaluate the federal interest in pursuing a prospective project plan. NED benefits are defined as increases in the net value of the national output of goods and services, expressed in monetary units.

For a navigation project investment, NED benefits are composed primarily of the reductions in transportation costs attributable to the improved waterway system. The reduction in transportation costs is achieved through increased efficiency of existing waterway movements, shifts of waterway and overland traffic to more efficient modes and routes, and shifts to more efficient origin destination combinations. Further benefits can accrue from induced (new output / production) traffic that is transported only because of the lower transportation cost deriving from an improved project, and from creating or enhancing the potential for other productive uses of the waterway, such as the generation of hydropower. National defense benefits can also be realized from regional and national growth, and from diversity in transportation modes. In many situations, lower emissions can be achieved by transporting goods on the waterway. The basic economic benefit of a navigation project is the reduction in the value of resources required to transport commodities remains the conceptual basis of NED benefits for inland navigation.

Traditionally, this primary benefit for barge transportation is calculated as the cost savings for barge shipment over the long-run least costly all-overland alternative routing. This benefit estimation is referred to as the waterway transportation rate-savings which also accounts for any difference in transportation costs arising from loading, unloading, trans-loading, demurrage, and other activities involved in the ultimate point to point transportation of goods. This analysis, for reasons discussed in detail later in this document, the benefit of barge transportation (rate savings) is not addressed, as the benefit for an alternative is calculated as the cost savings between waterway transportation costs for that alternative and waterway transportation costs for the baseline condition. In both cases, the benefit for federal investment in commercially-navigable waterways (benefits with a plan as opposed to benefits without a plan) ends up as a transportation cost reduction.

To accomplish an incremental analysis, all alternatives must be measured against a common base. The future condition at the project (and in the system) without the investment(s) is referred to as the Without-Project Condition (WOPC) and the future condition with investment is referred to as the With-Project Condition (WPC). Identifying these future scenarios or conditions is central to the analysis framework. An economic analysis of these competing future conditions (over a 50-year analysis period) estimates the stream of benefits and costs associated with each respective future. The temporal aggregation of these cash flows necessitates discounting to complete the CBA.

1.9.1 Analytic Framework

To understand the GIWW and inland navigation analysis framework, it is best to first understand the investment issues involved with inland navigation projects. The inland waterway transportation system is a mature transportation system and as a result, the investment options are typically focused on operational measures. The investment decisions are not whether to build a waterway transportation system, but whether and how to maintain and/or enhance the existing system (e.g. extended or new locks, channel improvements, replacement of key components, alternative maintenance policies, etc.). The objective is not to determine the value of the waterway transportation system, but to determine the value to changes in the waterway transportation system.

A typical inland navigation study focuses on the delta between waterborne transportation and the least-cost all-overland alternative, which is referred to as transportation rate savings. The basis of the adjustments to waterway infrastructure can increase or decrease the cost characteristics of waterborne transportation, resulting in an increase or decrease in transportation rate savings. This change results in either an NED benefit or NED cost, depending upon the nature of the change.

Given the system characteristics of the Brazos River Floodgates and Colorado River Locks, primarily the closed modal system, the relatively flat nature of the traffic forecasts, the presence of sufficient project capacity at both projects, and the lack of sustained long-duration closures projected into the future, the decision was made to evaluate the benefits derived from the delta in the costs of waterborne transportation between the existing condition and the proposed project alternatives. For this analysis, the NED benefit is the delta between the total costs of waterborne transportation between the without-project condition and the proposed alternatives.

Transportation rate analysis is typically ideal in an inland navigation study for evaluating projects that experience sustained long-duration closures, as they effectively cap the negative impact of these closures by providing the threshold at which movements will leave waterborne transportation for a now less costly overland mode. This cap reduces the potential benefits available to be claimed as a result of improvements made to a project by not allowing for waterborne costs to rise above the realistic threshold in the presence of a multi-modal system. Without these long-duration closures, this threshold is less important, as the analysis is solely devoted to waterborne movements which are currently operating and evaluating the reductions in these costs.

1.9.2 Modeling Framework

The WLCEN model estimates tow level transit times through a user defined navigation system, including incurred delay times due to service disruption events. The model uses a combination of user specified static inputs and probability distributions to define a project or projects within the system, traffic levels and composition, river conditions, operating policies, and probabilistic service disruptions.

The general theory underlying this model is that, given an environment in which modal shifts do not commonly occur in response to changes in transportation costs and thus system equilibrium traffic given a defined condition should generally mirror observed traffic under the existing condition, the vast majority

of existing condition traffic delay or disruption impacts and thus the degree to which an alternative can reduce these impacts (benefits) can be closely approximated by computing the total cost of vessel delays in the existing and alternative conditions, and taking the difference.

A more detailed discussion of the modeling concept and general framework is located in Appendix B: Economics. The WLCEN has received a single-use certification from the USACE Planning Center of Expertise for Inland Navigation and Risk-Informed Economics Division (PCXIN-RED) for use on this study.

1.10 National Environmental Policy Act Compliance Requirements

The National Environmental Policy Act (NEPA), 43 U.S.C. 4321 *et seq*., is the Nation's charter legislation for protection of the environment. The Federal regulations for implementing NEPA are found in Title 40, Code of Federal Regulations (CFR) Parts 1500-1508. Other regulations, at 33 CFR §230 *et seq*., describe how USACE is to implement NEPA. The intent of NEPA is to ensure that information is made available to the public regarding major actions taken by Federal agencies that significantly affect the quality of the human environment, and to identify and consider concerns and issues raised by the public. Any environmental document in compliance with NEPA may be combined with any other agency document to reduce duplication and paperwork. 40 CFR 1506.4. NEPA provides for an early and open process, called scoping, to determine the scope of issues to be addressed and identify the significant issues related to a proposed action. A Notice of Intent to prepare the EIS was published in the Federal Register in June of 2016. The scoping period ended in August 2016. Scoping identified concerns regarding the effect on the local community, navigation interruptions during construction, and safety. People are concerned about continued operations through the system, reducing navigation risk while traversing the locks and floodgates, construction times, noise, and impacts to access to the structures. The scoping report is provided in the Environmental Appendices.

This report documents the USACE study of navigation improvements for the BRFG and CRL in compliance with NEPA requirements. It employs three concepts to establish the CEQ NEPA regulations (integration, tiering, and adoption) that are appropriate to the planning and design process for this study.

Integration is based on the CEQ provision to combine documents, which states, *"any environmental document in compliance with NEPA may be combined with any other agency document to reduce duplication and paperwork"* (40 CFR 1506.4). The USACE regulations permit an EIS ("environmental document") to be either a self-standing document combined with and bound within a feasibility report ("agency document"), or an integration of NEPA-required discussions in the text of the report. In view of the ecosystem impact aspect of this study, to reduce paperwork and redundancies, and consolidate documentation into one consistent report, the USACE elected to integrate discussions that normally would appear in an EIS into this report. Sections in this "integrated report" that include NEPA- required discussions are marked "**(NEPA-Required)*" in both the table of contents and within the body of the document to assist readers in identifying such material.

Tiering was established by the CEQ to provide *"coverage of general matters in broader environmental impact statements (such as national program or policy statements) with subsequent narrower statements*

or environmental analyses (such as regional or basin-wide program statements or ultimately site-specific statements) … Agencies are encouraged to tier their environmental impact statements to eliminate repetitive discussions of the same issues and to focus on the actual issues ripe for decision at each level of environmental review" (40 CFR 1508.28 and 1502.20). This integrated report doesn't tier from any specific document or report.

Adoption is discussed in 40 CFR Section 1506.3. *"An agency may adopt a Federal draft or final environmental impact statement or portion thereof provided that the statement or portion thereof meets the standards for an adequate statement under these regulations."* In an effort to reduce paperwork, integrate NEPA requirements with the other environmental review and consultation requirements, and combine environmental documents with other documents, this report utilizes the concept of adoption and incorporation by reference. This report adopts in its entirety or portions thereof previous NEPA documents to take advantage of lessons learned from previous or ongoing Texas coastal preservation efforts.

This document integrates discussions that normally would appear in an EIS into the Feasibility Report. Sections in this document include NEPA-required discussions. Table 2 lists required EIS information and its location in this document.

Table 1.2: NEPA-Required EIS Information

EIS Requirement	Location in this Document
Cover sheet	Cover page
Table of Contents	Table of Contents
Executive Summary	Executive Summary
Affected Environment	Chapter 2
Purpose of and Need for Action	Chapter 1
Alternatives Including Proposed Action	Chapter 3
Environmental Consequences	Chapter 5
List of Report Recipients	Chapter 9
List of Preparers	Chapter 9
Literature Cited	Chapter 9
Appendices	Table of Contents

Finally, the Corps has requested the following agencies to be cooperating agencies (as defined under 40 CFR 1501.6) for this study: Texas Council on Environmental Quality (TCEQ), Texas Parks and Wildlife Department (TPWD), National Marine Fisheries Service (NMFS), National Resource Conservation Service (NRCS), United States Environmental Protection Agency (USEPA), United States Fish and Wildlife Service (USFWS,) and the United States Geological Survey (USGS).

THIS PAGE LEFT INTENTIONALLY BLANK

2.0 Affected Environment (NEPA Required)

Conditions described here focus on summarizing technical evaluations of the NEPA resources that drive the National Economic Development (NED) analysis for this navigation system feasibility study. The resource conditions in this chapter are discussed separately for Brazos and Colorado Rivers as appropriate. When not discussed separately it is assumed the existing conditions for each location and resources are similar. While all NEPA resources are significant to various institutions, this section discusses only those resources that would be directly impacted by the proposed alternatives. Additional details descriptions of the resources in the project area are provided in the Environmental appendices of this report.

2.1 General Environmental Setting of the Study Areas

2.1.1 Location

Both sites are located within the Mid-Coast Barrier Islands and Coastal Marshes region of the Texas coast. The areas surrounding the facilities are low-lying at elevations generally less than 10 feet above sea level, and are largely covered with wetlands and other water resources. For each facility, existing environmental conditions were evaluated within focused areas that encompasses the maximum disturbance area for the reasonable alternatives. The San Bernard River falls within the overall study area, however its influence on Navigation and contributions to the NED were limited impacts to it were determined to be outside of the critical areas experiencing significant navigation delays and recommended for specific environmental analysis for other study efforts. The BRFG project area encompasses roughly 600 acres and extends 1 mile east and west of the Brazos River crossing and up to 0.5 mile north and south of the river crossing (**Figure 2.1)**. The CRL NEPA project area encompasses roughly 400 acres and extends 1 mile east and west of the Colorado River crossing and up to 0.25 mile north and south of the river crossing (**Figure 2.2)**. Under the reasonable alternatives, all direct construction activities would occur within these focused areas. In addition, nearby resources were identified and evaluated on a case-by-case basis depending on their potential to be directly or indirectly affected by modifications to the BRFG and/or CRL facilities (e.g., salinity and sedimentation changes).

2.1.2 Geomorphic and Physiographic Setting

Brazoria and Matagorda Counties are within the West Gulf Coast subdivision of the Atlantic and Gulf Coastal Plains geomorphic province of the U.S. This region of Texas is underlain by rock and sediments that slope toward the Gulf of Mexico and date from the Pleistocene and Holocene epochs (Texas Water Development Board [TWDB] 1982, 1987). Surface geology in the BRFG and CRL project areas is of the late Pleistocene Beaumont Formation and younger deposits. The Beaumont Formation was deposited as a large alluvial plain, after which sea levels fell during a period of glacial advance. A period of erosion then **f**ollowed, with incision of stream channels. At the end of the last glacial period, as sea levels rose again, the area was flooded and a series of estuaries and bays formed. As sea levels stabilized, barrier islands developed (Aronow 1981, 2002). Modern barrier islands along the Gulf coast are characterized by subparallel to parallel beach and fore-dune ridges that are closely spaced. In Brazoria County, the action of wind, hurricanes, or other natural processes destroyed the ridged pattern of the barrier islands (Aronow 1981). Ridged barrier islands and reefs persist in Matagorda County (USGS 1952, Hyde 2001).

2.1.3. Land Use and Land Cover

Based on aerial photograph review and field reconnaissance, much of the project areas (BRFG/CRL) are largely undeveloped, with open water, emergent marsh, and upland shrub/woods being the major land cover types in both locations (**Figures 2.1 and 2.2**). Some livestock grazing occurs within these areas. Commercial navigation is a major land use in the overall study area, represented by the GIWW, BRFG and CRL facilities and access roads, and existing dredged material placement areas (DMPAs) along the GIWW. Developed areas near the BRFG facilities include Texas Boat and Barge, Inc., which is a barge storage,

cleaning, maintenance, and repair facility located adjacent to the east floodgate. Nearby, the Department of Energy's Bryan Mound Strategic Petroleum Reserve, which is one of two Federal strategic petroleum reserve sites in Texas, is located about 1 mile north of the east floodgate (**Figure 2.1**). At the CRL facility, residential areas lie just outside the study area to the northeast in the town of Matagorda and to the south along the east bank of the original Colorado River channel (**Figure 2.2**).

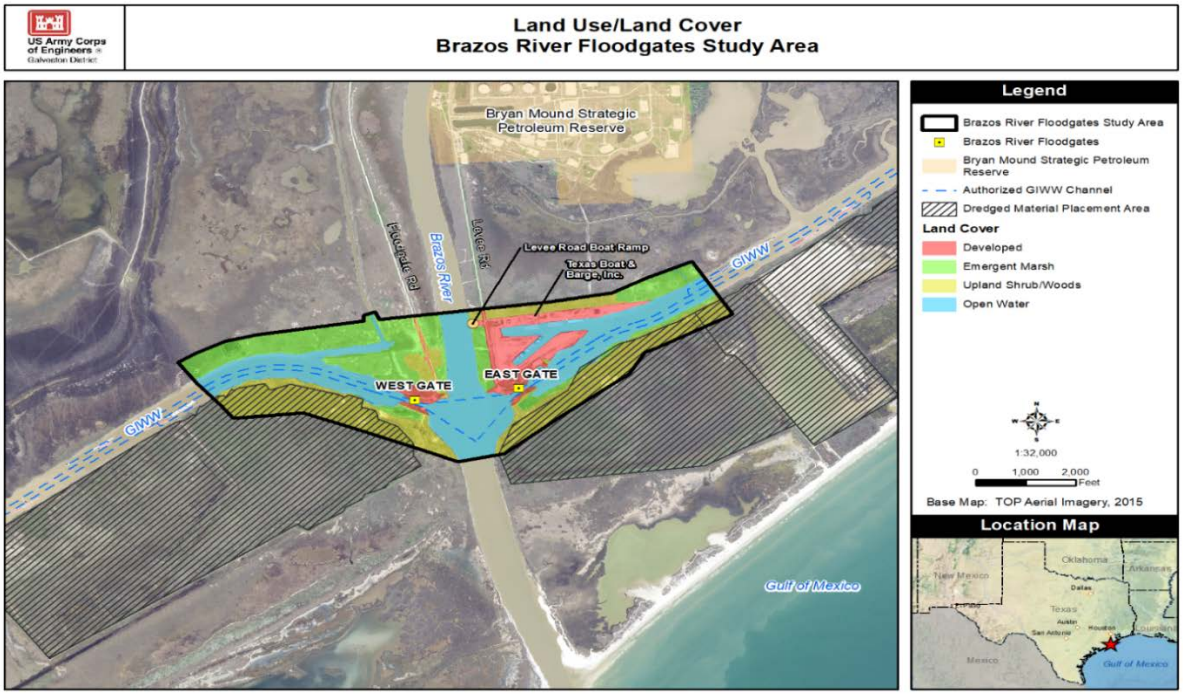


Figure 2.1 Brazos River Floodgates Study Area

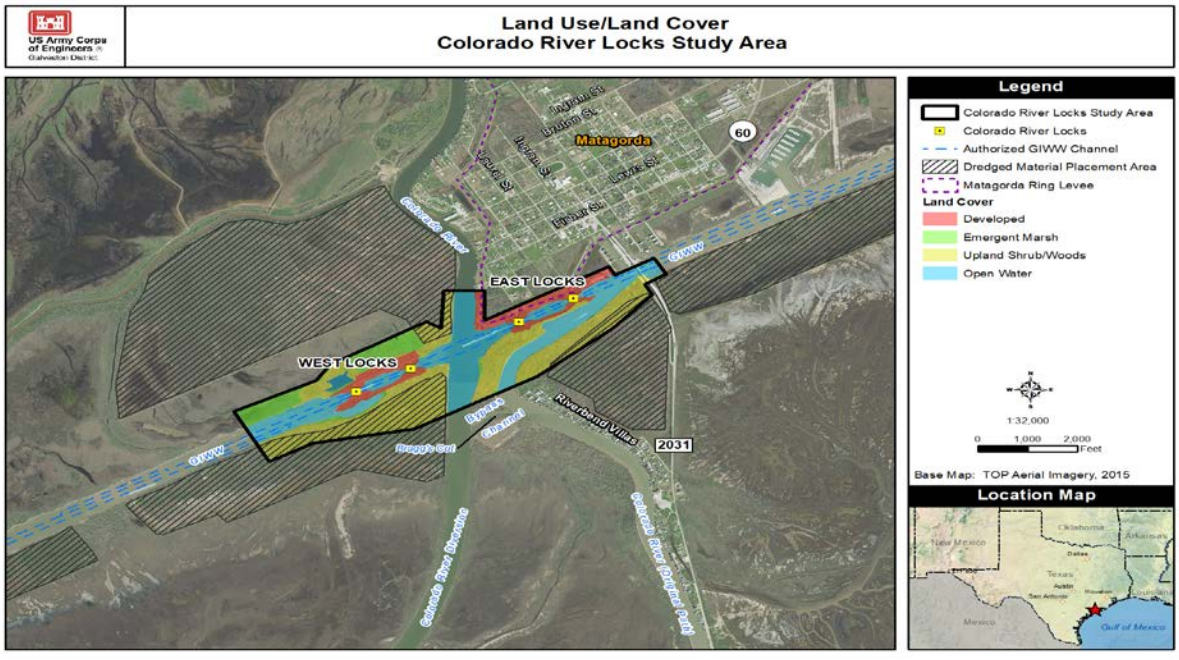


Figure 2.2 Colorado River Locks Study Area

2.1.4. Climate, Storms and Hurricanes

The climate of the region is sub-humid, with long, humid summers and short, warm winters. Annual rainfall in Brazoria and Matagorda Counties is about 52 and 48 inches, respectively, most of which falls from April through September (Crenwelge et al. 1981, Hyde 2001). The climate is influenced by the Gulf of Mexico, adjacent bays, and other major surface water features, cold fronts during the fall and winter, and tropical air masses during the spring and summer. The area experiences both periodic droughts, flooding, storms, and hurricanes

Tropical depressions, tropical storms, and hurricanes are relatively common occurrences in the Gulf of Mexico. Tropical storms typically produce the highest wind speeds and greatest rainfall events along the Gulf Coast. Hurricane season is from July through September (Hyde 2001) and, historically, the frequency of hurricanes making landfall along any 50-mile segment of the Texas coast is one hurricane about every six years (Roth 2010). From 1900 through 2009, 44 hurricanes and 44 tropical storms made landfall on the Texas Coast, with Hurricane Ike (2008) and Hurricane Rita (2005) being the largest recent hurricanes during that period, totaling over $29 billion in damages (Roth 2010). The Galveston Hurricane of 1900, which resulted in an estimated 8,000 deaths, is considered the worst natural disaster in U.S. history in terms of human lives lost (Roth 2010).

Most recently, Hurricane Harvey (2017), the first Category 4 hurricane to make landfall on the Texas Coast since Hurricane Carla in 1961, affected the Texas Coast from Corpus Christi to Port Arthur, causing record rainfall and flooding, as well as property damage and loss of human life. Once final damages are estimated, Hurricane Harvey will most likely be considered the most devastating hurricane in Texas history in terms of property damage. The storm surge from Harvey increased water and tide levels over most of the Texas Coast, with the highest storm tides observed at the Aransas National Wildlife Refuge (NWR), where the storm surge levels were more than 12 feet above ground level. Storm surge in Port Lavaca was also more than 10 feet and at least 6 feet in Port Aransas. Elsewhere across South Texas, storm tide levels were from near 3 feet to 6 feet above ground level at Seadrift, Port O'Connor, Holiday Beach, Copano Bay, Port Aransas, and Bob Hall Pier (National Weather Service 2017).

Instead of moving inland, Harvey stalled over South and Southeast Texas for days, producing catastrophic, deadly flash and river flooding. Southeast Texas bore the brunt of the heavy rainfall, with some areas receiving more than 40 inches of rain in less than 48 hours. Cedar Bayou in Houston received a storm total of 51.88 inches of rainfall, which is a new North American record (National Weather Service 2017).

2.1.5. Climate Change

Federal guidance and direction regarding climate change evaluation is currently in flux. Several Executive Orders (EOs) have been issued in recent years that direct federal agencies to address climate change and greenhouse gas (GHG) emissions with emission reductions and preparedness planning and implementation. President Obama issued EO 13653, preparing the U.S. for the Impacts of Climate Change in 2013, which was rescinded by President Trump's EO 13783, Promoting Energy Independence and Economic Growth in 2017. EO 13693, Planning for Federal Sustainability in the Next Decade (2015) requires federal agencies to meet emission-reducing goals associated with energy use, water use, building design and utilization, Fleet vehicles, and procurement and acquisition decisions.

Federal agencies are required to consider GHG emissions and climate change in environmental assessment in accordance with NEPA. On August 1, 2016, the Council on Environmental Quality (CEQ) issued final guidance on the consideration of GHG emissions and climate change in NEPA review; however, EO 13783 directed the CEQ to rescind that guidance. At the same time, case law in the Ninth Circuit still requires climate change analysis: "The impact of greenhouse gas emissions on climate change is precisely the kind

of cumulative impacts analysis that NEPA requires agencies to conduct" (Center for Biological Diversity v. National Highway Traffic Safety Administration, 538 F.3d 1172, 1217 [Ninth Circuit 2008]). Consistent with case law, an analysis of climate change impacts was conducted for the BRFG-CRL Feasibility Study. During construction at the proposed BRFG and CRL facilities, GHG emissions will be from heavy construction equipment such as bulldozers, tugboats, barges, and other equipment powered by internal combustion engines. The USACE will estimate the emissions based on projected equipment needs and coordinate the anticipated emissions with the Texas Commission on Environmental Quality (TCEQ) and/or U.S. Environmental Protection Agency (EPA).

Two EOs, EO 13514 and EO 13693, as well as the President's Climate Action Plan (CAP) set forth requirements to be met by federal agencies. These requirements range from preparing general preparedness plans to meeting specific goals to conserve energy and reduce GHG emissions. In response to the EOs and CAP, the USACE prepared an Adaptation Plan, which is still in effect. The Adaptation Plan includes the following USACE policy statement:

> It is the policy of USACE to integrate climate change preparedness and resilience planning and actions in all activities for the purpose of enhancing the resilience of our built and natural water-resource infrastructure and the effectiveness of our military support mission, and to reduce the potential vulnerabilities of that infrastructure and those missions to the effects of climate change and variability.

2.1.6. Sea Level Change and Relative Subsidence

Based on U.S. Geological Survey (USGS) topographic maps, elevations in the BRFG and CRL study areas range from sea level to approximately 22 feet above mean sea level (USGS 1952, 1963, 1964). Due to their low elevation and their proximity to the Gulf of Mexico, the study areas and surrounding areas will be impacted by rising sea levels resulting from climate change. Therefore, relative sea level change (RSLC) should be factored into coastal planning initiatives. Based on data calculated for the USACE's ongoing Coastal Texas Protection and Restoration Feasibility Study (Coastal Texas), the projected RSLC in the BRFG region for the 50-year period from 2035 to 2085 ranges from an increase of 1.05 feet (assuming the Low curve) to an increase of 3.57 feet (assuming the High curve) (**Table 2.1**). The projected RSLC for the CRL region over the same period ranges from an increase of 0.84 feet (assuming the Low curve) to an increase of 3.37 feet (assuming the High curve) (**Table 2.1**).

Table 2.1 Projected Relative Sea Level Change (RSLC), Years 2035 – 2135

Year	Coastal Texas Region 1 (includes BRFG Study Area)[1]			Coastal Texas Regions 2-3 (includes CRL Study Area)[2]		
	Low	Intermediate	High	Low	Intermediate	High
2035	0.90	1.07	1.59	0.73	0.89	1.41
2045	1.11	1.36	2.15	0.90	1.15	1.94
2055	1.32	1.67	2.79	1.07	1.42	2.54
2065	1.53	2.00	3.51	1.24	1.71	3.21
2075	1.74	2.35	4.29	1.41	2.02	3.96
2085	1.95	2.72	5.16	1.57	2.34	4.78
2095	2.16	3.10	6.09	1.74	2.69	5.68
2105	2.37	3.50	7.10	1.91	3.05	6.65
2115	2.58	3.92	8.19	2.08	3.43	7.69
2125	2.79	4.36	9.35	2.25	3.82	8.81
2135	3.00	4.82	10.58	2.42	4.24	10.00

[1] Region 1 calculations use data from National Oceanic and Atmospheric Administration (NOAA) Tide Gauge Station 8771450, Galveston Pier 21, TX. The published historical RSLC rate for Region 1 is +0.02096 feet/year. Elevations are in feet relative to LMSL. Datum conversion from LMSL to NAVD88 is +0.69 feet.

[2] Region 2-3 calculations use data from NOAA Tide Gauge Station 8774770, Rockport, TX. The published historical RSLC rate for Regions 2-3 is +0.01693 feet/year. Elevations are in feet relative to LMSL. Datum conversion from LMSL to NAVD88 is +1.13 feet.

2.1.6.1 Subsidence

Subsidence is the sinking of the land surface over time due to natural processes and/or man-made causes such as the withdrawal of groundwater, oil and gas, and/or mineral resources (Ratzlaff 1980, Neighbors 2003, Zilkoski et al. 2015). A 2013 NOAA report on estimating vertical land movement (subsidence) using long-term tide gage data estimates that the subsidence rate at the Freeport tide gage was -3.65 ± 0.41 mm/year between 1954 and 2006 (NOAA 2013). Subsidence in the Freeport vicinity has been attributed primarily to groundwater withdrawals for municipal and industrial use (Ratzlaff 1982). Localized subsidence attributable to subsurface sulfur mining over a salt dome has occurred in the Bryan Mound area, located less than 1 mile north of the BRFG study area. The elevation at Bryan Mound decreased from 23 feet in 1926, to 19 feet in 1980, to the current elevation of approximately 16 to 18 feet. Subsidence around the perimeter of Bryan Mound has resulted in the creation of Blue Lake to the north and Mud Pit (or "Mud Lake") to the southeast (Kirby and Lord 2015).

2.1.7. Tides, Currents, and River Stages

Tides, currents, and river stage/flows vary daily and seasonally, and continuously affect water levels in the study areas. Along the Texas Gulf coast, tides are considered *diurnal*, meaning that typically only a single high and low water level occur each tidal day (Hicks 2006). The *great diurnal range* or *diurnal tide range* is the difference between mean higher high water (MHHW) and mean lower low water (MLLW), while the mean tide range is the difference between mean high water (MHW) and mean low water (MLW). For perspective on the tidal ranges at the BRFG and CRL, **Table 2.2** summarizes the tide data from the National Oceanic and Atmospheric Administration (NOAA) tide gauge stations nearest to each facility (NOAA 2017a, 2017b). The diurnal tide range and mean tide range are 1.8 feet and 1.39 feet, respectively, in the BRFG vicinity, and 0.41 feet and 0.39 feet, respectively, in the CRL vicinity. Based on data from the TCEQ, the tidally influenced reaches of the Brazos and Colorado Rivers extend 24 to 25 miles upstream from the Gulf of Mexico (TCEQ 2016a).

Table 2.2 Tide Levels in BRFG and CRL Study Areas

Tidal Datum	Elevations Relative to Mean Lower Low Water (MLLW), in Feet	
	BRFG Study Area[1]	CRL Study Area[2]
Mean Higher High Water (MHHW)	1.80	0.41
Mean Sea Level (MSL)	0.97	0.23
Mean Lower Low Water (MLLW)	0.00	0.00
Mean Tide Range[4]	*1.39*	*0.39*

[1] BRFG tide data is from NOAA tide gauge station 8772447 (Freeport, TX), which is located at the Freeport Channel entrance, approximately 5.8 miles northeast of the BRFG (NOAA 2017a).
[2] CRL tide data from NOAA tide gauge station 8773146 (Matagorda City, TX), which is located on the GIWW approximately 3.8 miles northeast of the CRL (NOAA 2017b).
[3] *Mean tide range* is the difference in height between MHW and MLW.

Currents in the GIWW and the river crossings are created and influenced by the combination of tidal fluctuations and by non-tidal forces such as river flows and wind. Both the direction and velocity of currents depend on these factors and can affect navigation through the study area. In particular, high flows in the Brazos and Colorado Rivers create high-current situations that affect navigation. The San Bernard River also affects currents at the BRFG. The San Bernard River flows into the GIWW about 4 miles west of the BRFG, and the GIWW serves as the river's outlet through the west floodgate.

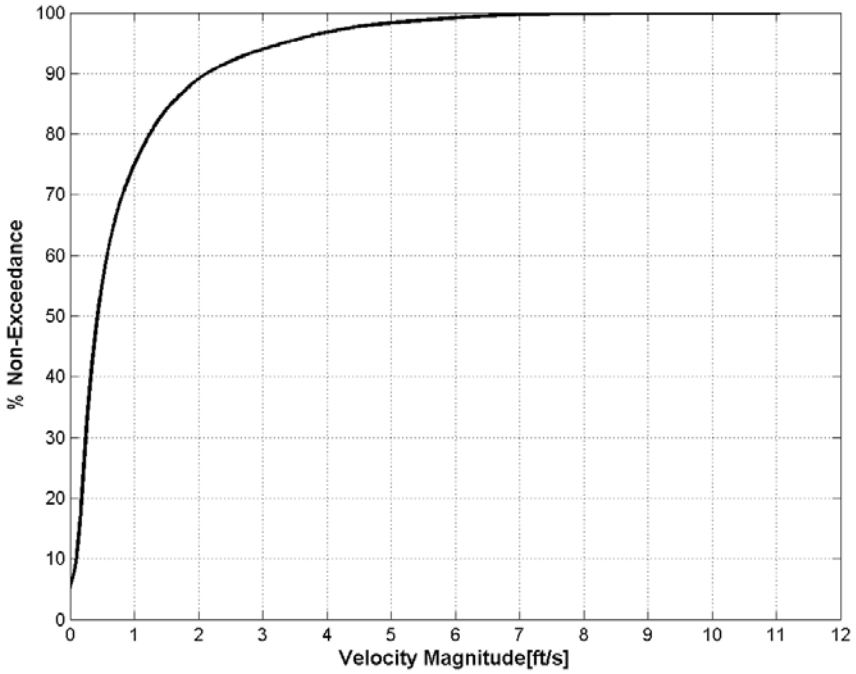


Figure 2.3 Probability of Non-Exceedance of Velocity in the Brazos River at the GIWW Crossing (1980-2017)

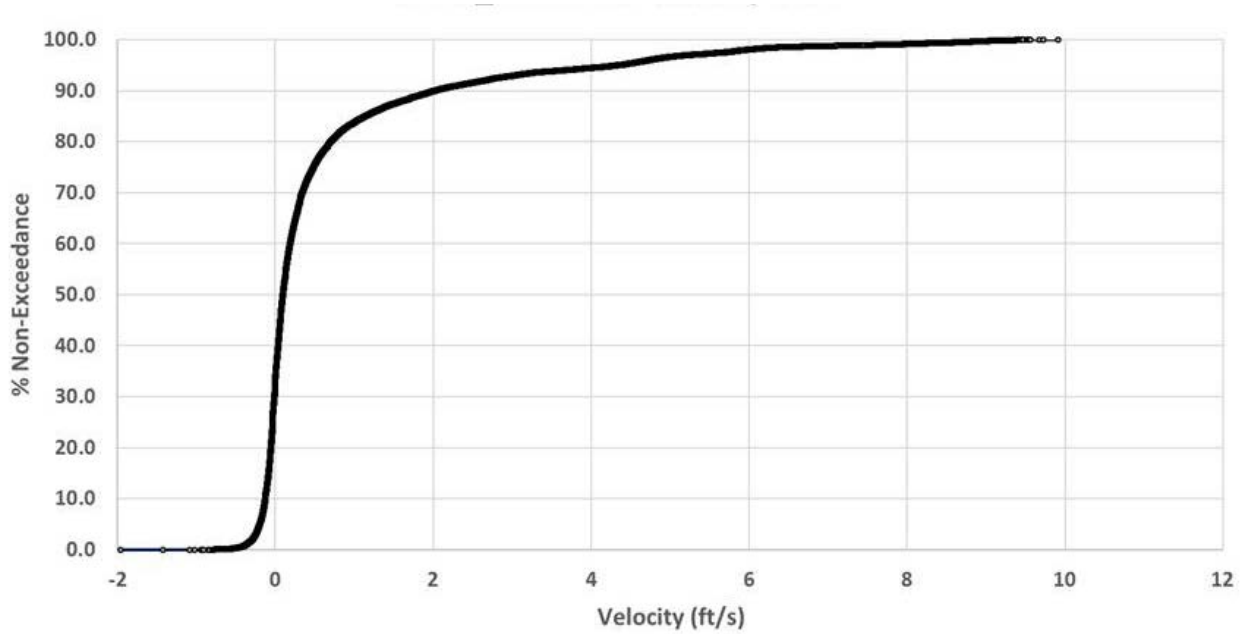


Figure 2.4 Probability of Non-Exceedance of Velocity in the Colorado River at the GIWW Crossing (1980-2017)

2.2 Floodplains, Water and River Resources

2.2.1 Floodplains and Flood Control

According to the Federal Emergency Management Agency (FEMA) Flood Insurance Rate Map (FIRM) database, the majority of the BRFG and CRL facilities are within the 100-year floodplain (FEMA 2017) (**Figure 2.5**). Flooding events are primarily due to high river flows after heavy rains upstream of the Lower Brazos and Lower Colorado watersheds, although occasional hurricanes and tropical storms from the Gulf cause severe flooding.

Flood-protection levees have been constructed in the vicinity of the BRFG and CRL facilities to protect the nearby towns and cities. In the BRFG vicinity, the Velasco Drainage District operates and maintains a hurricane-flood protection system around Freeport and the surrounding area that includes 60 miles of levees, 14 pump stations, 34 gravity drainage structures, a navigation control tidal gate structure, and 72.5 miles of outfall ditches. The system's West End Pump Station, capable of pumping 450,000 gallons per minute (GPM), and Clute-Lake Jackson Pump Station, capable of pumping 1.95 million GPM, discharge into the Brazos River approximately 3.5 miles and 10.5 miles upstream of the BRFG, respectively. The nearest levee to the BRFG is on East Floodgate Road approximately 1.2 miles north of the East Floodgate (**Figure 2.5**). According to USACE (2005), the flood control levees around the Freeport area are expected to provide protection from a 100-year storm plus tide event.

In the CRL vicinity, the USACE has constructed over 40 miles of flood protection levees along the Colorado River in Matagorda County, including a 7-mile ring levee around the town of Matagorda that is designed to provide 100-year flood protection (Matagorda County Flood Mitigation Planning Committee 2010). The East Locks and associated facility are located on and adjacent to the Matagorda ring levee (**Figure 2.6**).

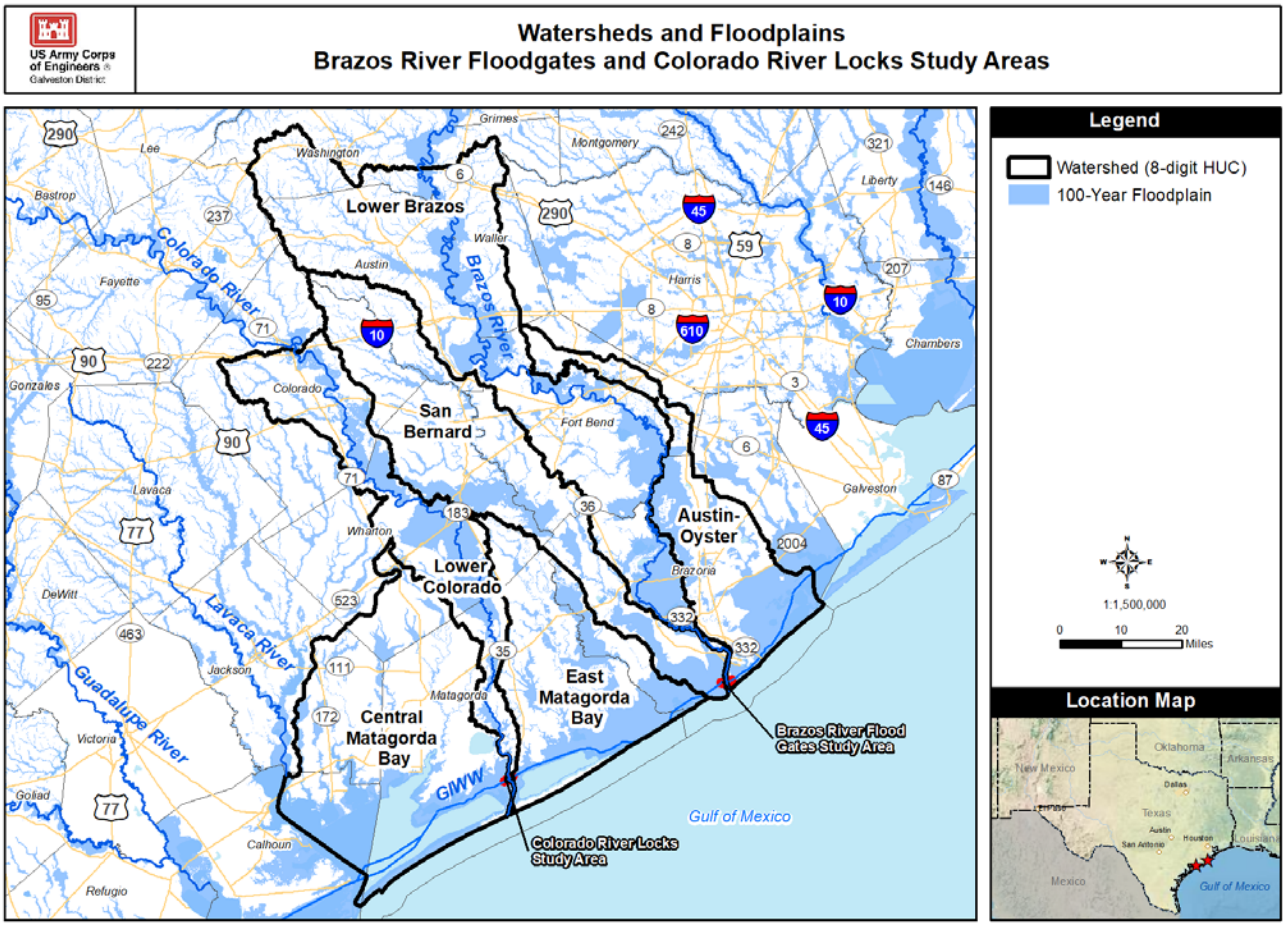


Figure 2.5 Watersheds and Floodplains in the Study Area

2.2.2 Water Resources

The BRFG study area includes portions of three sub-watersheds (**Figure 2.5**): (1) the Lower Brazos River watershed (Hydrologic Unit Code [HUC] 12070104) crosses the central part of the study area and includes the Brazos River and a narrow corridor on either side of the river; (2) the San Bernard watershed (HUC 12090401) covers the western part of the study area, west of the Lower Brazos; and (3) the Austin-Oyster watershed (HUC 12040205) covers the eastern part of the study area, east of the Lower Brazos (USGS 2017a, b). Based on aerial photography review and field reconnaissance, an estimated 60 percent of the BRFG study area contains water resources, including the GIWW, Brazos River, and adjacent marshes. The San Bernard River, Cedar Lakes, and various other sloughs, lakes, and marshes surround the study area.

Hydraulics in the BRFG area has been modified over the years by various activities such as excavation and maintenance of the GIWW and placement of dredged material; 1929 diversion of the Brazos River; 1943 construction of the BRFG; construction of levees, drainage ditches, pump stations, with a tidal gate structure for hurricane and flood protection; and natural migration and opening/closing of the San Bernard River.

The CRL area also contains portions of three sub-watersheds (**Figure 2.5**): (1) the Central Matagorda Bay watershed (HUC 12100401) in the western half, (2) the Lower Colorado River watershed (HUC 12090302) in the eastern half, and (3) the East Matagorda Bay watershed (HUC 12090402) in the extreme eastern end (USGS 2017a, b). Based on aerial photography review and field reconnaissance, an estimated 44 percent of the CRL study area contains water resources, including the GIWW, Colorado River and Colorado River

Diversion Channel, and adjacent marshes. West Matagorda Bay and East Matagorda Bay are to the southwest and east, respectively, and various other sloughs, lakes, and marshes occur in the surrounding low-elevation coastal plain. Hydrology in the CRL area has also been modified by activities such as excavation and maintenance of the GIWW and placement of dredged material; 1944 and 1951 construction of the CRL; levee construction for hurricane and flood protection; diversion of the Colorado River into West Matagorda Bay in the early 1990s; and 2012 excavation of Bragg's Cut between the Colorado River and Colorado River Diversion Channel.

The water resources in the BRFG and CRL areas are considered waters of the U.S. subject to regulation under Section 404 of the Clean Water Act (CWA), and the GIWW, Brazos and Colorado Rivers, and other tidal waters are also navigable waters subject to regulation under Section 10 of the Rivers and Harbors Act (RHA). These statutes are administered by the USACE and regulate the discharge of dredged and fill material and other work in regulated waters. Information on impacts to waters of the U.S. is provided in the 404(b)(1) analysis that has been prepared for the project (**Appendix D-1**).

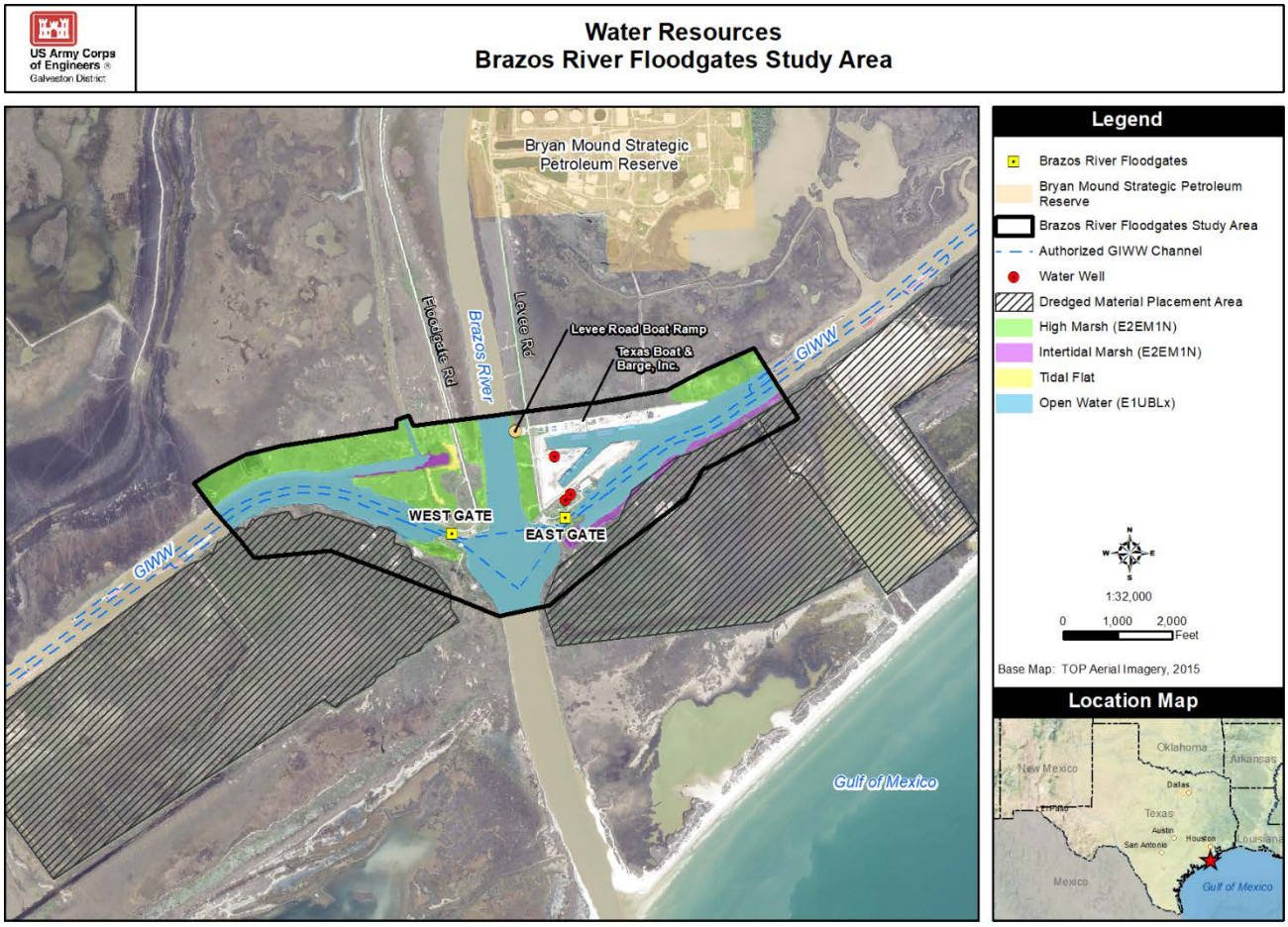


Figure 2.6 Water Resources in BRFG Study Area

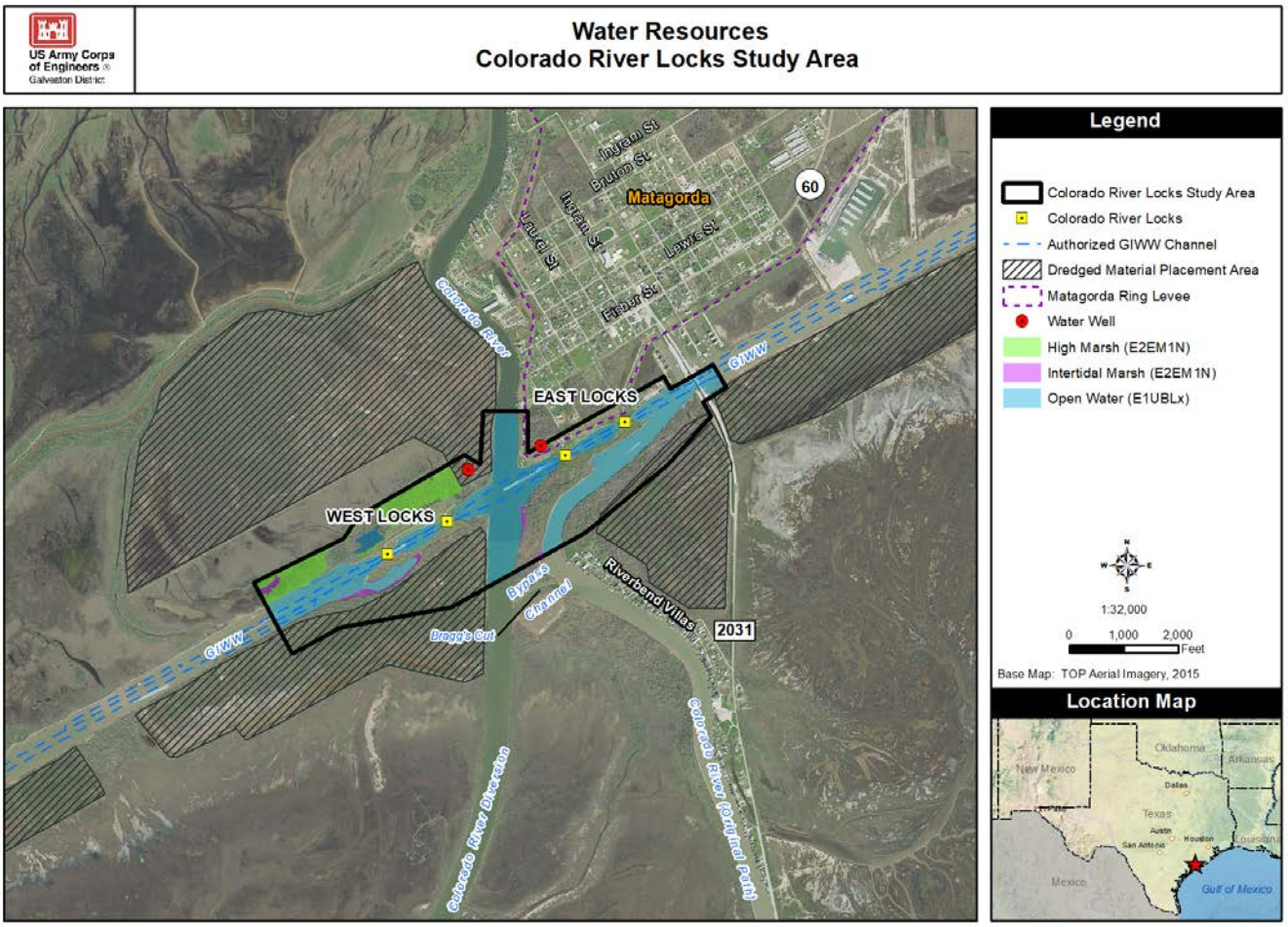


Figure 2.7 Water Resources in CRL Study Area

2.2.3 Water Supply and Use

2.2.3.1 Surface Water

The Brazos and Colorado Rivers are major water sources for irrigation, municipal water supply, manufacturing, electric power, livestock, and mining uses; there are over 40 water supply lakes/reservoirs in the Brazos River basin and over 30 water supply lakes/reservoirs in the Colorado River Basin (Lower Colorado Regional Water Planning Group 2015; Region H Regional Water Planning Group 2015; TWDB 2016a, 2016b, 2017b). However, there are no water supply lakes or reservoirs in or adjacent to the BRFG or CRL areas.

Based on TCEQ data, there are water intake/diversion points off the Brazos River at the Bryan Mound Strategic Petroleum Reserve (1 mile north of the BRFG) and at the Dow Chemical Plant (over 6 miles north of the BRFG). The nearest intake/diversion point to the CRL area is at the South Texas Electric Project generating station, located 8 miles to the north (TCEQ 2016b).

2.2.3.1 Groundwater

The BRFG and CRL study areas are underlain by the Gulf Coast Aquifer, a major aquifer system that parallels the Gulf of Mexico coastline from the Texas-Louisiana border to the Texas-Mexico border

(George et al. 2011, TWDB 2017c). The thickness, water quality, and productivity of the aquifer varies across its range (George et al. 2011, TWDB 2017c). The Gulf Coast Aquifer is comprised of, from shallowest to deepest, the Chicot Aquifer, the Evangeline Aquifer, the Burkeville Confining Unit, and the Jasper Aquifer, with parts of the Catahoula Formation acting as the Catahoula Confining System (Coastal Plains Groundwater Conservation District 2014). The Gulf Coast Aquifer system is used for municipal, industrial, and irrigation purposes (TWDB 2017b, 2017c). The main source of groundwater in Brazoria County is the Chicot Aquifer (Brazoria County Groundwater Conservation District 2012). All registered wells in Matagorda County are in either the Chicot Aquifer or the Evangeline Aquifer (Coastal Plains Groundwater Conservation District 2014). Water level declines in the Gulf Coast Aquifer underlying Harris, Galveston, Fort Bend, Jasper, and Wharton Counties have historically led to land subsidence in some areas outside of the BRFG and CRL study areas (George et al. 2011, TWDB 2017c).

According to the TWDB Groundwater Database and the Submitted Driller's Report Database, there are four groundwater wells within the BRFG area, and two groundwater wells located with the CRL area (**Table 2.3**). All but one of the wells are part of the BRFG and CRL facilities. The other well is associated with the Texas Boat and Barge, Inc. facility located adjacent to the BRFG east floodgate.

Table 2.3 Groundwater Wells Located Within the Study Area

State Well ID No. or Submitted Driller's Report No	Well Owner	Aquifer Formation	Well Type	Purpose of Use
BRFG Study Area				
8105901	USACE	Chicot Aquifer, Upper	Withdrawal	Plugged or Destroyed
8105902	USACE	Chicot Aquifer, Upper	Withdrawal	Domestic
8105903	USACE #3	Chicot Aquifer, Upper	Withdrawal	Public Supply
5586	Texas Boat and Barge	Not Identified	New Well	Domestic
CRL Study Area				
8117401	USACE	Chicot Aquifer	Withdrawal	Domestic
8117402	USACE	Chicot Aquifer	Withdrawal	Public Supply

Sources: TWDB 2017b

2.2.4 Water Quality

The Texas Integrated Report of Surface Water Quality is a requirement of the federal CWA Sections 305(b) and 303(d) and evaluates the quality of surface waters in Texas (TCEQ 2017a). Section 303(d) requires states to develop lists of impaired waters, which are waters where technology-based regulations and other required controls are not stringent enough to meet the state water quality standards. Based on a review of the Texas Integrated Report and 303(d) lists, there are no threatened or impaired surface waters in the BRFG or CRL study areas (TCEQ 2015). Within the BRFG study area, the Brazos River Tidal segment is designated as Segment 1201 and is in attainment for all water quality parameters. Within the CRL study area, the Colorado River Tidal segment is designated as Segment 1401 and is also in attainment for all water quality parameters. Near both study areas, the Gulf of Mexico is listed as threatened/impaired for mercury in edible tissue on the 2014 303(d) lists.

2.2.5 Salinity

Salinity in the bays, estuaries, and nearshore areas of the Gulf Coast of Texas is strongly influenced by the amount of freshwater inflow from surrounding streams and rivers. Salinity levels are typically reported in parts per thousand (ppt) and are categorized as follows: oligohaline (0.5-5 ppt), mesohaline (5-18 ppt), polyhaline (18-30 ppt), euhaline (30-40 ppt), and hyperhaline (>40 ppt). Salinity levels and fluctuations affect estuary characteristics such as nutrient cycling, benthic organism communities, and estuarine/wetland plant and animal communities, including juvenile fish and shellfish nursery stocks (Longley 1994).

Salinity in the study area ranges widely depending on river stages/flows in the Brazos, San Bernard, and Colorado Rivers. The Brazos River discharges directly into the Gulf of Mexico, so the amount of freshwater flows in the river greatly influences salinity in the study area and surrounding areas. In the BRFG study area, site-specific salinity data measured from late 2012 through mid-2017 at the east floodgate showed monthly salinity levels ranging from less than 0.5 part per thousand (ppt) (essentially freshwater) to 33 ppt, which is near the average seawater concentration of 35 ppt. These salinities coincide with periods when high river flows reduce salinity, and low river flows allow tidal waters from the Gulf to extend upstream in the river.

Although there is no salinity gauge at the CRL, the USACE collected site specific data within the CRL study area between May and October 2001, and salinity ranged from 8 to 27 ppt during that period. Based on the CRL modeling results, existing average salinities in the CRL study area range from 7 ppt in the GIWW-Colorado River intersection to 18 ppt in the original Colorado River channel. Average salinities in the Colorado River upstream and downstream of the study area are less than 1 ppt and 11 ppt, respectively. Existing salinities in West Matagorda Bay (outside the Colorado River delta) and East Matagorda Bay are 18 and 25 ppt, respectively. Most of the water in the Colorado River drains to West Matagorda Bay at the Colorado River delta, but when the CRL are open, some flow also enters the GIWW and reaches East Matagorda Bay reaches the Gulf through the original river channel and. East Matagorda Bay is considered by some sources to be a lagoon with limited freshwater input, resulting in relatively high average salinities (Palmer et al. 2011, Montagna 2001).

2.2.6 River Sediment Resources

The Brazos River has the highest water and sediment load discharge of all Texas rivers, and the second highest sediment load discharge to the entire Gulf of Mexico, behind the Mississippi River (Milliman and Meade 1983, Carlin 2013). The Colorado River has lower sediment load discharges than the Brazos River but still carries large loads of sediment. In the early 1990s, the mouth of the Colorado River was moved from the Gulf of Mexico to West Matagorda Bay[1] in an effort to enhance seafood productivity of the bay, reduce flood damage potential along the lower Colorado River, and to reduce navigation hazards as well as channel maintenance costs (USACE 1981). Since the relocation, the river deposits sediments in West Matagorda Bay, creating shallow-water wetlands along the delta.

The BRFG and CRL facilities were constructed on the GIWW to prevent excessive sedimentation in the navigation channel due to high sediment loads in the rivers. The USACE's primary objective for the BRFG and CRL continues to be minimizing sedimentation in the GIWW, as excessive sedimentation increases the need for maintenance dredging, which leads to increased maintenance costs and possible delays for commercial navigation. Even with the floodgates and locks, sediment does accumulate in the GIWW, resulting in the need for periodic maintenance dredging in the vicinity of the rivers.

[1] Note that the Colorado River currently drains to Matagorda Bay, which is often referred to as "West" Matagorda Bay to clearly differentiate it from East Matagorda Bay. Because both bays are referenced multiple times in this document, Matagorda Bay is referred to as West Matagorda Bay throughout the document.

2.2.7. Shoal Formation Concerns

At the BRFG, high sediment loads result in sediment deposits in the GIWW on the east and west sides of the river, creating shoals in areas where vessels pass. These shoals have caused periodic grounding of vessels, and dredging is required to remove the shoals. Shoaling has also occurred periodically at the CRL, particularly after major flooding events. Most recently, major flooding from Hurricane Harvey in August 2017 resulted in shoal formation near the west locks, making the GIWW impassable at this location.

2.2.8. Erosion

According to the Texas General Land Office's (GLO's) 2015 Coastal Erosion Planning & Response Act (CEPRA) Report, 84 percent of the Texas Gulf shoreline is retreating, averaging about 4 feet per year and resulting in 235 acres of lost land per year along the coastline, bays, estuaries, and navigation channels (GLO 2015). These land losses affect properties, extend saltwater intrusion, and affect wetlands and other habitats. Between the 1930s and 2012, the Gulf coastline extending from Quintana to Sargent Beach, which includes the BRFG study area, retreated an average of 9.5 feet per year. Land losses near the CRL study area were less than 5 feet per year during the same period (McKenna 2014, Paine et al. 2014, Bureau of Economic Geology 2016). Causes of coastal erosion include storm impacts, lack of sufficient sediment discharges, long-term sea level rises, and subsidence (McKenna 2014).

In September 2008, 3 years after Hurricane Rita damaged the upper Texas coast, Hurricane Ike made landfall with a 5- to 10-foot storm surge in Brazoria County and 15- to 20-foot storm surge in Chambers and Galveston Counties to the north, causing major erosion along the coastline. Following Hurricane Ike, the State of Texas required local governments along the Gulf to develop erosion response plans, with the intent of minimizing future public expenditures for erosion and storm damages. Through these plans, various restoration and stabilization projects have helped maintain the shoreline position (McKenna 2014). Brazoria and Matagorda Counties have implemented multiple restoration and stabilization projects with the help of CEPRA funding.

Within the BRFG and CRL study areas, local shoreline erosion on the south end of the Brazos and Colorado River crossings of the GIWW are ongoing problems. Along the GIWW, barge wakes are one of the biggest sources of erosion. Erosion also occurs along the GIWW banks where tows push into the GIWW banks while waiting for mooring buoys to become available.

2.3 Vegetation, Wildlife Habitat and Resources

The BRFG and CRL study areas are in the Mid-Coast Barrier Islands and Coastal Marshes portion of the Western Gulf Coastal Plain ecoregion, which stretches from Galveston Bay in the north to Corpus Christi Bay in the south (Griffith et al. 2007). This ecoregion is characterized as having salt marsh on the back side of barrier islands, with fresh or brackish marshes near river deltas. The region contains a matrix of wetland and upland habitats that support a variety of wildlife species.

Based on aerial photography review and field reconnaissance, six general vegetation communities/habitat types were observed within the BRFG and CRL study areas (**Figures 2.6 and 2.7**). **Table 2.4** lists the habitat types and the approximate percentage of each study area that contains the habitat. Descriptions of the habitat types follow the table.

Table 2.4 Estimated Habitat Types in the BRFG and CRL Study Areas

Habitat Type	Percentage of BRFG Study Area	Percentage of CRL Study Area
Open Water	36	35
Intertidal Marsh	2	1
High Marsh	21	8
Tidal Flat	0.5	0
Upland Shrub/Woods	30	43
Developed	11	13

Open Water

Open water is a major habitat type in both study areas and is present in the GIWW and Brazos and Colorado Rivers. The open water areas provide habitat for fish, shrimp, crabs, bottlenose dolphins (*Tursiops truncatus*), and other estuarine species. Most of the open water habitat experiences regular disturbances by barge tows and other vessels traveling through the GIWW, as well as periodic maintenance dredging.

High / Intertidal Marshes

High marsh habitat is the dominant wetland habitat in the study areas, occurring at low elevations but only infrequently inundated by very high tides. Common plant species observed in this habitat include turtleweed (*Batis maritima*), saltgrass (*Distichlis spicata*), saltworts (*Salicornia* spp.), Gulf cordgrass (*Spartina spartinae*), marshhay cordgrass (*S. patens*), sea-oxeye daisy (*Borrichia frutescens*), seepweed (*Suaeda linearis*), and marsh-elder (*Iva frutescens*). Scattered threesquare (*Schoenoplectus pungens*), wolfberry (*Lycium carolinianum*), saltcedar (*Tamarix ramosissima*), smooth cordgrass (*Spartina alterniflora*), and common reed (*Phragmites australis*) were also observed.

Within both study areas, there are relatively small patches of intertidal marsh, which are wetland areas that occur at elevations between the low and high tides (intertidal zone). These areas are dominated by smooth cordgrass (*Spartina alterniflora*), with species common to the high marsh habitat present along the edges.

Tidal Flat

One small area of unvegetated tidal flat is in the BRFG study area. This habitat is adjacent to an intertidal marsh and contained less than 5 percent plant cover (turtleweed, smooth cordgrass, saltwort, and saltgrass). Algal mats covered an estimated 50 percent of the flat during a February 2017 field investigation. The area also showed evidence of disturbance from cattle.

Upland Shrub/Woods

Higher elevations in the study areas, such as portions of the river banks and in DMPAs, support upland shrub/woods vegetation. Common plant species observed in this habitat include American elm (*Ulmus americana*), sugar hackberry (*Celtis laevigata*), honey mesquite (*Prosopis glandulosa*), Hercules'-club (*Zanthoxylum clava-herculis*), osage orange (*Melia azedarach*), roughleaf dogwood (*Cornus drummondii*), retama (*Parkinsonia aculeata*), elbowbush (*Forestiera angustifolia*), eastern baccharis (*Baccharis halimifolia*), saltcedar, Louisiana vetch (*Vicia ludoviciana*), rosettegrass (*Dichanthelium* sp.), catchweed (*Galium* sp.), crow-poison (*Nothoscordum bivalve*), hairyfruit chervil (*Chaerophyllum tainturieri*), giant ragweed (*Ambrosia trifida*), mustang grape (*Vitis mustangensis*), poison ivy (*Toxicodendron radicans*), southern dewberry (*Rubus trivialis*), Virginia creeper (*Parthenocissus quinquefolia*), and peppervine (*Ampelopsis arborea*).

Developed Areas

Developed areas include the floodgate and lock facilities and Texas Boat & Barge, Inc. (BRFG study area).

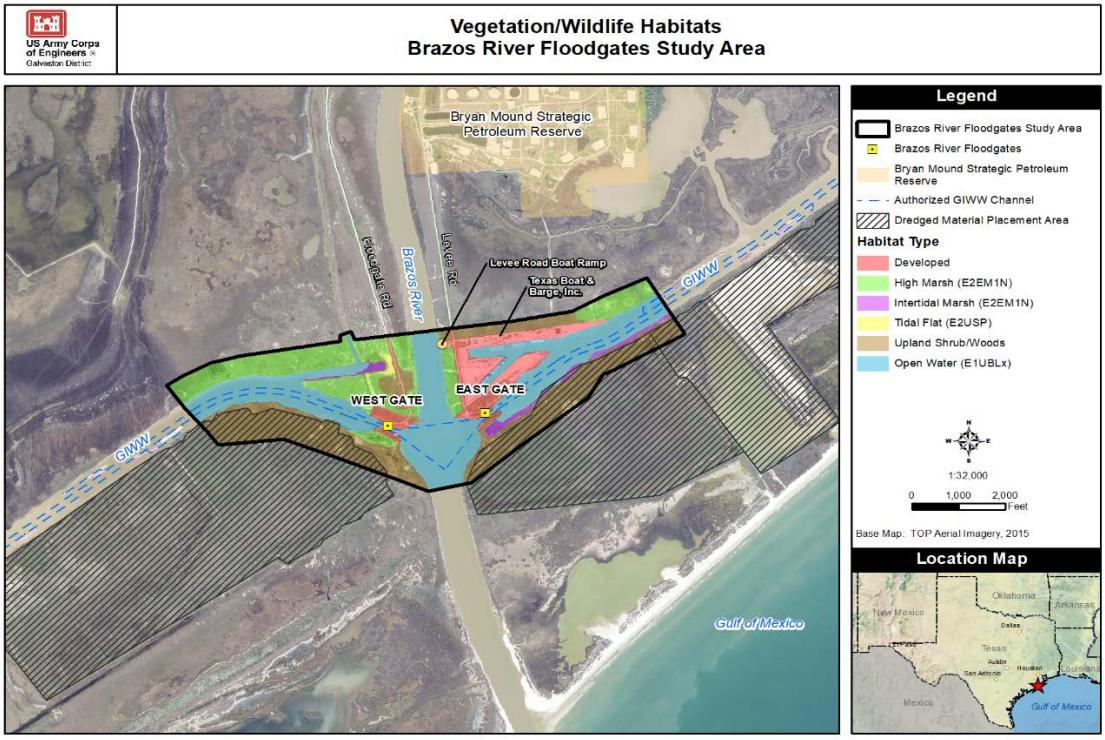


Figure 2.8 Vegetation & Wildlife Habitats in the BRFG Study Area

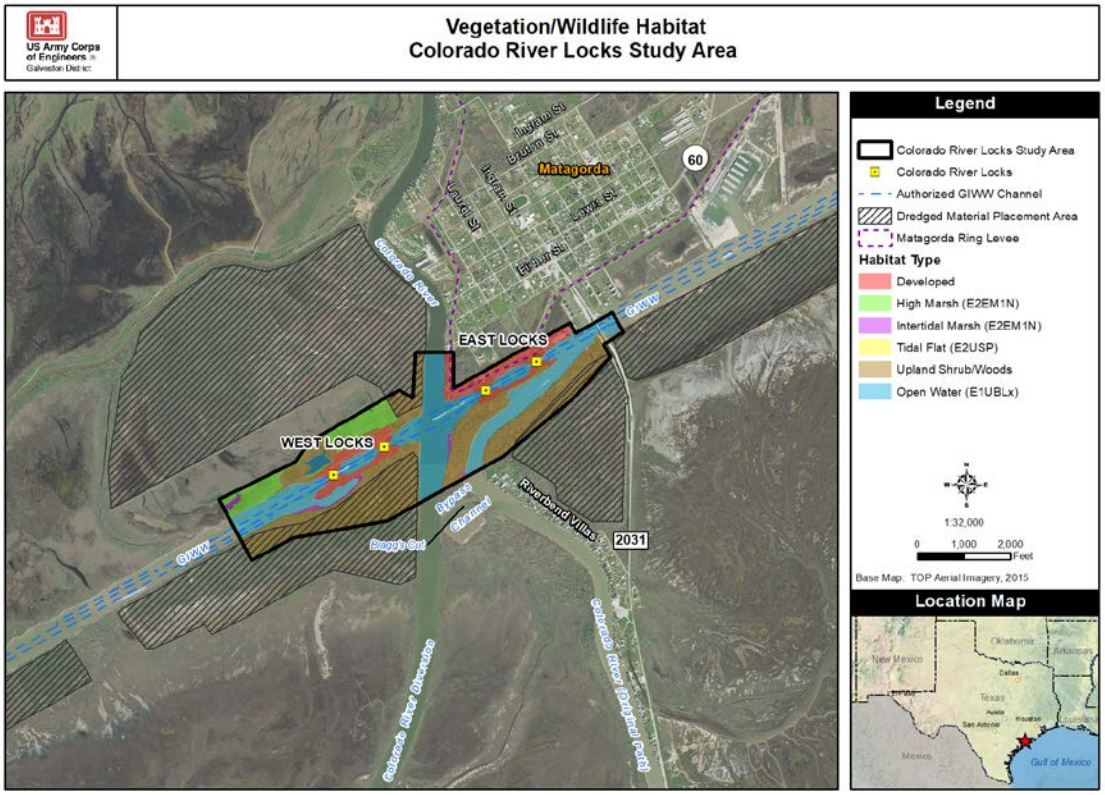


Figure 2.9 Vegetation & Wildlife Habitats in the CRL Study Area

2.3.1. Habitat Evaluations

The mix of open water, wetland, and upland habitats provide the opportunity for the study areas to support a variety of aquatic and terrestrial wildlife species. An interagency biological team, including USACE, TxDOT, USFWS, NMFS, and TPWD, conducted field visits to evaluate habitats in the study areas. Through these field visits, the team determined that none of the upland or open water habitats are considered significant because most are associated with the GIWW or DMPAs and do not contain significant resources.

The team conducted a habitat evaluation of the three wetland habitat types (high marsh, intertidal marsh, and tidal flat) in the study areas using Habitat Evaluation Procedures (HEP) methodology. HEP is a habitat-based assessment methodology developed by the USFWS to estimate habitat values for use in project planning and impact assessment (USFWS 1980). HEP requires the use of Habitat Suitability Index (HSI) models developed for wildlife indicator species that use the habitats. The HSI models evaluate structural habitat composition variables that are contained in optimum habitat, and these variables are measured in the field.

Modeled habitat conditions are expressed as a numeric function (HSI value) ranging from 0.0 to 1.0, where 0.0 represents no suitable habitat for an indicator species and 1.0 represents optimum conditions for the species. HSI values ranging from 0.01 to 0.24 are considered “poor” habitat, 0.25 to 0.49 are considered “below average” habitat, 0.50 to 0.69 are “average” habitat, 0.70 to 0.89 are “good” habitat, and 0.90 to 1.00 are considered “excellent” habitat. Habitat units (HU) are calculated by multiplying the HSI value for each habitat by the amount of acres of that specific habitat type present in the study area.

The interagency team met in February and March 2017 to (1) select wildlife indicator species that use each habitat in the BRFG and CRL study areas and (2) collect field data at representative locations within each habitat. The team selected seven wildlife indicator species for the wetland habitats: red drum, brown and white shrimp, and clapper rail for intertidal marsh; clapper rail, marsh wren, and mottled duck for high marsh; and least tern for tidal flats (**Table 2.5**). During the field visits, access to private properties in the study areas was limited, so data collection occurred on USACE property, in areas along the GIWW and Brazos and Colorado Rivers, and private properties where access was granted. Data were collected at six locations in wetland habitats in the BRFG study area and four locations in wetland habitats in the CRL study area (**Table 2.5**). Of the high marsh habitats sampled, the interagency team determined that only one site had the potential to be used by marsh wren and mottled duck.

Table 2.5 Wetland Habitats, Indicator Species, and HEP Data Sites for BRFG and CRL

Habitat Type	HEP Data Sites	Indicator Species					
		Red Drum	Brown/White Shrimp	Clapper Rail	Marsh Wren*	Mottled Duck*	Least Tern
BRFG							
High Marsh	1, 4, 5			x			
Intertidal Marsh	2, 6	x	x	x			
Tidal Flat	3						x
CRL							
High Marsh	1, 2, 3			x	x*	x*	
Intertidal Marsh	4	x	x	x			

* Marsh wren and mottled duck were evaluated only at one high marsh site in the CRL study area. During field investigations, the interagency team determined that the other high marsh habitats at BRFG and CRL were not suitable for these species.

Average HSI values and HUs for each habitat are summarized in **Table 2.6**. The habitats scored "average" to "excellent" with the exception of the high marsh habitat at CRL, which scored "poor". The limiting factor causing high marsh habitats in the CRL study area to score "poor" was the lack of tidally influenced waters adjacent to these habitats. The high marsh habitats in the CRL study area are mostly separated from the GIWW and Brazos River by upland habitats (see **Figure 2.9**).

Table 2.6 Average HSI Values and Habitat Units for Wetland Habitats in BRFG and CRL Study Areas

Habitat Type	Acreage	Indicator Species							HSI Average	Habitat Units
		Red Drum	Brown Shrimp	White Shrimp	Clapper Rail	Least Tern	Marsh Wren*	Mottled Duck*		
BRFG										
High Marsh	125.2				1.00				1.00	125.20
Intertidal Marsh	13.9	0.37	0.92	0.90	1.00				0.80	11.12
Tidal Flat	3.0					0.80			0.80	2.40
CRL										
High Marsh	32.0				0.15		0.85*	0.00*	0.25	8.0
Intertidal Marsh	4.5	0.45	0.97	0.91	0.98				0.83	3.74

* Marsh wren and mottled duck were evaluated only at one high marsh site in the CRL study area. During field investigations, the interagency team determined that the other high marsh habitats at BRFG and CRL were not suitable for these species.

2.3.2. Rare, Unique, and Imperiled Vegetation Communities and Wildlife Habitats

The vegetation communities/wildlife habitats present in the BRFG and CRL study areas are characteristic of the Texas Gulf coast, and, while they are important resources, none of the habitats are considered regionally rare, unique, or imperiled. Threatened and endangered plant and wildlife species that may occur in the study areas are discussed in the *Threatened and Endangered Species* section below.

2.3.3. Invasive Plant and Animal Species

Several invasive plant species occur in coastal Texas. In terrestrial areas, Chinese tallow (*Triadica sebifera*), Chinaberry (*Melia azedarach*), and Chinese privet (*Ligustrum sinense*) can become rapidly established in disturbed areas, including DMPAs (Texas Invasive Plant and Pest Council [TIPPC] 2017). Invasive aquatic plants include water hyacinth (*Eichhornia crassipes*) and common reed (*Phragmites australis*), both of which thrive in fresh to brackish water zones (USDA 2017e, Stutzenbaker 1999). Water hyacinth creates dense cover and root mats that block sunlight, reduce oxygen, and kill plants that provide food for fish and other aquatic life (TPWD 2017a). Common reed creates dense stands that choke out native wetland species. Some invasive wildlife species common in the region include feral hogs (*Sus scrofa*), nutria (*Myocastor coypus*), and red imported fire ant (*Solenopsis invicta*). Feral hogs compete with wildlife and livestock and damage crops and habitats by uprooting vegetation and disturbing the soil. Nutria burrow into wetland soils and eat aquatic vegetation, which creates disturbed, unvegetated areas that erode and become open water. Fire ants damage electrical wiring and some crops, as well as prey on ground-nesting birds, eggs, and other wildlife (TPWD 2017a). Recently, Asian tiger shrimp (*Penaeus monodon*) have been recorded off the Texas Gulf coast and in some Texas bays, and the red lionfish (*Pterois volitans*) has been reported in Tres Palacios Bay, approximately 11 miles west-northwest of the CRL study area (TIPPC 2017).

2.3.4. Protected/Managed Lands and Recreation Areas

The only public recreation facility in either study area is a public boat ramp that provides access to the Brazos River approximately 0.3 mile north of the GIWW crossing (**Figure 2.10**). Named the Levee Road Boat Ramp, it is owned and managed by Brazoria County (Atkins North America 2013). There are no other designated parks or recreation areas, national wildlife refuges, wildlife management areas, or other protected or managed lands within the BRFG or CRL study areas (**Figures 2.10 and 2.11**). Protected and managed lands and recreation areas that are near the study areas are listed in **Table 2.7**.

Table 2.7 Protected/Managed Lands and Recreational Areas near BRFG and CRL Study Areas

Property	Location from Study Area	Description
BRFG Study Area (Figure 2.8)		
Levee Road Boat Ramp	Within study area	Public boat ramp
Justin Hurst WMA	Less than 1 mile northwest of BRFG	Part of Central Coast Wetlands Ecosystem Project; develops/manages habitats for wildlife species with special emphasis on waterfowl
Bryan Beach State Recreation Area	Less than 1 mile south of BRFG study area	Public access for fishing in the Gulf of Mexico and the Brazos River, and for camping
Bryan Beach Park	1.5 mile east of study area	Public park maintained by City of Freeport
San Bernard NWR	3 miles west of study area	54,000-acre refuge that provides a habitat corridor for migrating and wintering birds
CRL Study Area (Figure 2.9)		
Mad Island WMA	1.5 miles west of study area	7,200 acres of fresh to brackish marsh with sparse brush and flat coastal prairie; preserve coastal wetland habitat for wintering waterfowl
Matagorda County Jetty Park	Matagorda Peninsula, 6 miles south of study area	Public park that is a popular birding location

Sources: TPWD 2017b, eBird 2017, The Go Travel Sites 2017

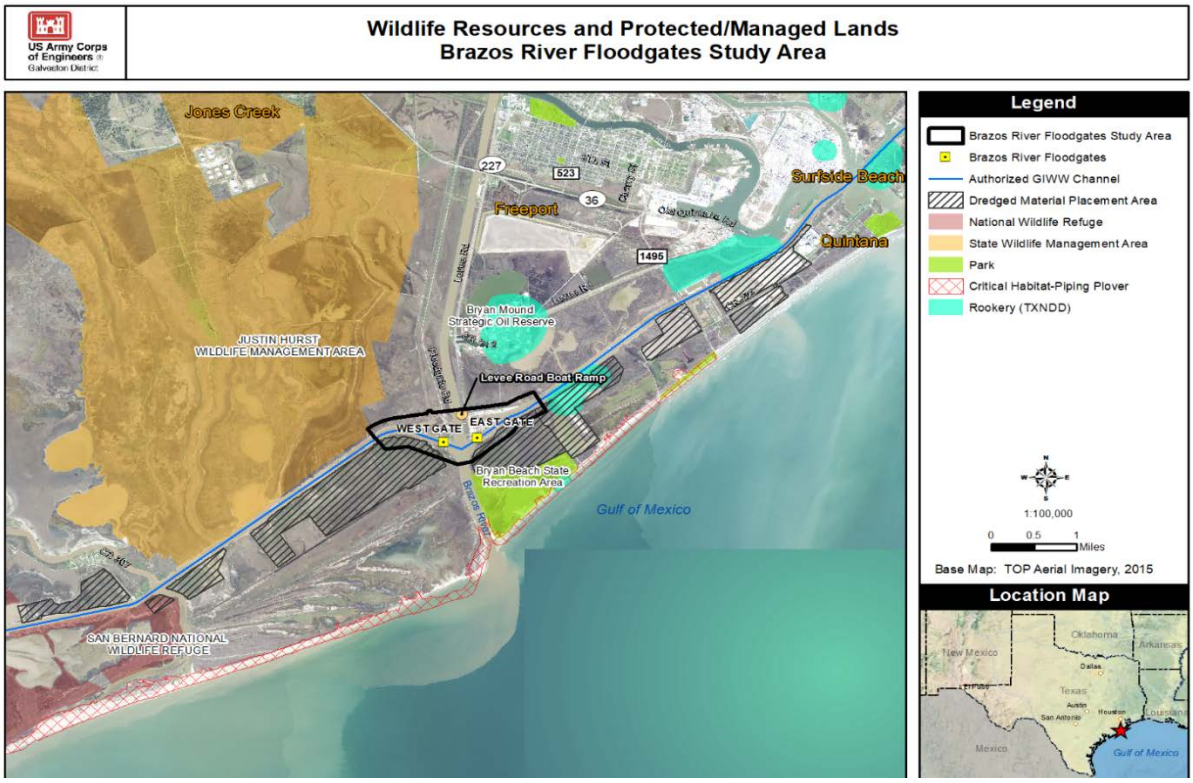


Figure 2.10 Wildlife Resources and Protected/Management Lands in BRFG Study Area

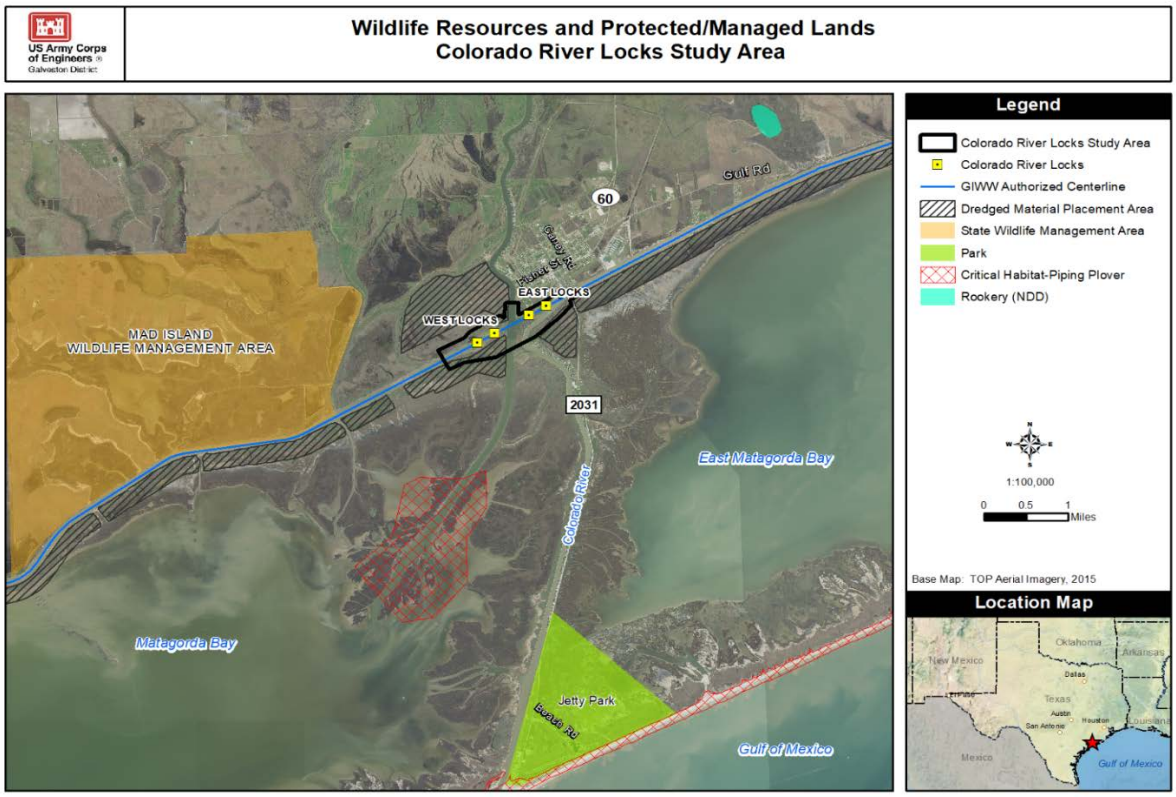


Figure 2.11 Wildlife Resources and Protected/Management Lands in CRL Study Area

2.3.5. Threatened and Endangered Species

According to the USFWS' threatened and endangered species lists for Brazoria and Matagorda Counties (USFWS 2017a, 2017b, 2017c) and NMFS' threatened and endangered species list for the Texas portion of the Gulf of Mexico (NMFS 2017), 18 federally listed threatened or endangered species and four candidates for federal listing may occur in Brazoria and Matagorda Counties (**Table 2.8**). In addition, the USFWS has designated critical habitat for the wintering piping plover (*Charadrius melodus*) along the entire Texas Gulf, including in Brazoria and Matagorda Counties (USFWS 2009, 2017c) and near the study areas. There is no designated or proposed critical habitat for other species in or near the study areas.

Table 2.8 Federally Listed and Candidate Species with Potential to Occur in Brazoria and Matagorda Counties, Texas

Listed Species		Listing Status	Jurisdiction	Potential to Occur in BRFG and CRL Study Areas?
Common Name	**Scientific Name**			
Birds				
Northern aplomado falcon	*Falco femoralis septentrionalis*	Endangered	USFWS	Yes
Piping plover	*Charadrius melodus*	Threatened	USFWS	Yes
Red knot	*Calidris canutus rufa*	Threatened	USFWS	Yes
Whooping crane	*Grus americana*	Endangered	USFWS	Yes
Mammals				
West Indian manatee	*Trichechus manatus*	Threatened	USFWS	Yes
Fin whale	*Balaenoptera physalus*	Endangered	NMFS	No
Humpback whale	*Megaptera novaeangliae*	Endangered	NMFS	No
Sei whale	*Balaenoptera borealis*	Endangered	NMFS	No
Sperm whale	*Physeter macrocephalus*	Endangered	NMFS	No
Reptiles				
Green sea turtle	*Chelonia mydas*	Threatened	NMFS	Yes
Hawksbill sea turtle	*Eretmochelys imbricata*	Endangered	USFWS; NMFS	Yes
Kemp's ridley sea turtle	*Lepidochelys kempii*	Endangered	USFWS; NMFS	Yes
Leatherback sea turtle	*Dermochelys coriacea*	Endangered	USFWS; NMFS	No
Loggerhead sea turtle	*Caretta caretta*	Threatened	USFWS; NMFS	Yes
Mollusks				
Golden Orb	*Quadrula aurea*	Candidate	USFWS	No
Smooth pimpleback	*Quadrula houstonensis*	Candidate	USFWS	No
Texas fawnsfoot	*Truncilla macrodon*	Candidate	USFWS	No
Texas pimpleback	*Quadrula petrina*	Candidate	USFWS	No
Corals				
Boulder star coral	*Orbicella franksi*	Threatened	NMFS	No
Elkhorn coral	*Acropora palmata*	Threatened	NMFS	No
Lobed star coral	*Orbicella annularis*	Threatened	NMFS	No
Mountainous star coral	*Orbicella faveolata*	Threatened	NMFS	No

Sources: NMFS 2017; USFWS 2017a, b, c

Based on habitat assessments and recorded sightings, nine of the federally listed threatened/endangered species have the potential to occur in the BRFG and CRL study areas (**Table 2.8**). The following bullets summarize the potential for each species to occur in the study areas. More detailed information is provided in the Biological Assessment prepared for the project (**Appendix D-3**).

- Northern aplomado falcon (*Falco femoralis septentrionalis*) – A breeding population of northern aplomado falcons exists on Matagorda Island, located 32 miles southwest of the CRL study area. Individual sightings of the species have been recorded within 5 miles of the BRFG and CRL study areas, at San Bernard NWR and Mad Island Wildlife Management Area (WMA) (eBird 2017). The study areas contain open habitats that could be used by aplomado falcons, but no nesting falcons are expected based on the current known nesting range.

- Piping plover and red knot (*Calidris canutus rufa*) – The piping plover and red knot are migratory species that overwinter on the Texas coast and utilize barrier island beaches, exposed tidal flats, washover passes, and mud flats. Designated critical habitat for the piping plover is present along

  the Gulf beach near both study areas, as well as in the Colorado River delta in West Matagorda Bay (USFWS 2017a, 2017b, 2017d) (**Figures 2.8 and 2.9**). Piping plovers have been recorded in the vicinity of both study areas (eBird 2017, Texas Natural Diversity Database [TXNDD] 2017).

- Whooping crane (*Grus americana*) – Whooping cranes also overwinter on the Texas coast, mostly in the area surrounding the Aransas NWR located about 30 miles southwest of the CRL study area. They utilize salt marshes and tidal flats on the mainland and barrier islands. Salt marsh habitat is present in both study areas, and whooping cranes have been recorded within 5 miles of both study areas at Justin Hurst WMA, San Bernard NWR, and Mad Island WMA (TXNDD 2017, eBird 2017).

- West Indian manatee (*Trichechus manatus*) – Manatee occurrences in Texas are extremely rare. The Texas Marine Mammal Standing Network has recovered fewer than 10 manatees along the Texas coast since 1980 (Houston Chronicle 2012). One historical manatee record is in the GIWW near Oyster Creek just north of Freeport. Historical records from Texas waters also include Cow Bayou, Sabine Lake, Copano Bay, the Bolivar Peninsula, and the mouth of the Rio Grande (Natural Science Research Laboratory 2017). In October 2012, live manatee sightings were recorded near Galveston and near Corpus Christi (Houston Chronicle 2012). A West Indian manatee could occur in the GIWW or rivers in the study areas; however, the likelihood of their occurrence is considered low due to their rare occurrence in Texas.

- Whales – Whales are generally restricted to offshore waters and are not expected to occur in the study areas.

- Sea turtles – The GIWW and Brazos and Colorado Rivers provide open water habitats that could be used by sea turtles. Four of the five sea turtle species are known to use Texas waters; the leatherback sea turtle (*Dermochelys coriacea*) is uncommon in Texas coastal waters and is not likely to occur in the study areas.

- Mollusks (mussels) – The mussel species that are candidates for federal listing are freshwater species and are not expected to occur in the tidal and brackish waters of the Brazos River, Colorado River, or other waters in the study areas due to salinity fluctuations.

- Corals – The listed corals are offshore species and do not occur in the study areas.

2.3.6. Other Protected Wildlife Species

In addition to species protected under the Endangered Species Act, other protected wildlife that may occur in the study areas include marine mammals, bald eagles, and general migratory birds. The following sections discuss the regulations protecting these species and their potential to occur in the study areas.

2.3.7. Marine Mammals

The Marine Mammal Protection Act (MMPA) was enacted in 1972 and prohibits the "take" of marine mammals in U.S. waters and by U.S. citizens on the high seas, as well as the importation of marine mammals and marine mammal products into the U.S. (NOAA 2017c). Take, as defined by the MMPA, means "to harass, hunt, capture, or kill, or attempt to harass, hunt, capture, or kill any marine mammal" (16 U.S.C. 1362). Although taking of marine mammals is prohibited, NMFS can issue incidental take authorizations for activities that may unintentionally take marine mammals, such as sonar and noise-producing activities (e.g., military sonar activities, oil/gas development, geophysical surveys, pile-driving, and demolition using explosives). The only marine mammal species that is likely to occur in the BRFG and CRL study areas is the bottlenose dolphin (*Tursiops truncatus*), which are common throughout the Texas Gulf coast.

2.3.8. Bald and Golden Eagles

The Bald and Golden Eagle Protection Act (BGEPA) (16 U.S.C. §§ 668-668d) prohibits the take of bald and golden eagles unless pursuant to regulations. The BGEPA defines the take of an eagle to include a broad range of actions, including to pursue, shoot, shoot at, poison, wound, kill, capture, trap, collect, molest, or disturb. Based on regulations found at 50 CFR 22.3, the term "disturb" means to "agitate or bother a bald or golden eagle to a degree that causes, or is likely to cause, based on the best scientific information available, (1) injury to an eagle, (2) a decrease in its productivity, by substantially interfering with normal breeding, feeding, or sheltering behavior, or (3) nest abandonment, by substantially interfering with normal breeding, feeding, or sheltering behavior."

Golden eagles are not expected to occur in the study areas except for the possibility of migrating individuals passing through. Bald eagles, however, are well known to occur and nest near major water bodies in the Texas coastal region, including Brazoria and Matagorda Counties (Ortego 2016). Recent records show that the number of reported bald eagle nests in Brazoria and Matagorda Counties is 16 and 13, respectively; Harris County has the most reported nests of the coastal counties, with 23 nests (Ortego 2016).

Bald eagles may forage in the Brazos, San Bernard, and Colorado Rivers, GIWW, East and West Matagorda Bays, and other large water bodies in and near the study areas. No known bald eagle nests are in or adjacent to the study areas. Trees in the study area are generally too small to support bald eagle nests, and no nesting habitat for bald eagles is present in or adjacent to the study areas.

2.3.9. Migratory Birds

The Migratory Bird Treaty Act (MBTA) prohibits the taking, killing, possession, transportation, and export of migratory birds, their eggs, parts, and nests without a USFWS permit or other regulatory authorization. The MBTA protects most native bird species occurring in the wild in the U.S. except for gallinaceous birds (upland game birds such as turkeys and quail) that are not considered migratory. In addition, the MBTA does not protect some non-native species such as the house sparrow (*Passer domesticus*), European starling (*Sturnus vulgaris*), rock pigeon (*Columba livia*), and any recently listed unprotected species in the Federal Register (70 FR 12710, March 15, 2005).

The habitats in the BRFG and CRL study areas are used by various migratory birds for nesting, foraging, loafing, and roosting. A number of rookeries that are used by colonial nesting birds are documented in the vicinity of the study areas (TXNDD 2017) (**Figure 2.8 and 2.9**). Species that have been documented nesting

in the rookeries include cattle egret (*Bubulcus ibis*), great egret (*Ardea alba*), tricolored heron (*Egretta tricolor*), great blue heron (*Ardea herodias*), olivaceous cormorant (*Phalacrocorax brasilianus*), snowy egret (*Egretta thula*), roseate spoonbill (*Platalea ajaja*), least tern (*Sternula antillarum*), laughing gull (*Leucophaeus atricilla*), white ibis (*Eudocimus albus*), reddish egret (*Egretta rufescens*), forester's tern (*Sterna forsteri*), and black skimmer (*Rynchops niger*) (TXNDD 2017).

The Texas coast also provides important stopover habitats for migratory birds crossing the Gulf of Mexico during spring migration. Once they reach the coast, migrating birds sometimes "fallout" in large numbers to seek shelter and food. Fallouts of migratory birds have been recorded in and around the BRFG and CRL study areas, primarily in wooded habitats along the rivers and in DMPAs (TXNDD 2017).

2.4 Archeological and Historic Resources

Cultural resources (archeological and historic resources) are protected by a number of laws and regulations, primarily the National Historic Preservation Act (NHPA) and, on lands owned by the State of Texas or political subdivisions of the State, the Antiquities Code of Texas. The following discusses existing conditions regarding archeological resources and non-archeological historic resources within the BRFG and CRL study areas.

2.4.1. Archeological Resources

An archeological background review was conducted for the two project areas (areas of potential effect – APE) around the BRFG and CRL as show in **Figures 2.1 and 2.2**. Examination of the online files and maps at the Texas Historical Commission's (THC) restricted-access online Texas Archeological Sites Atlas (TASA) were searched for previously recorded archeological sites, sites listed on the National Register of Historic Places (NRHP), historical markers, and State Antiquities Landmarks (SALs). Additional records affiliated with the National Park Service, the THC's Online Historical Sites Atlas, and the Texas Archeological Research Laboratory were also consulted.

The files and maps on the TASA show that portions of the BRFG study area and surrounding area have been subject to previous archeological survey by the Department of Energy in 1991; the USACE in 1987, 1991, 1992, and 1998; Prewitt & Associates in 1999; and PBS&J in 2008 and 2009. Based on the TASA, there are no previously recorded archeological sites within the BRFG study area, and the nearest recorded archeological site is in the Bryan Beach State Recreation Area, approximately 0.5 mile south of the BRFG study area. Site 41BO110 was recorded in 1978 as a historic site with ceramics and brick and is listed as a State SAL. It was not found during subsequent investigations in 1998, suggesting it has either been destroyed, buried, or the location was mapped erroneously.

In the CRL vicinity, the TASA shows that several archeological surveys were conducted between 1973 and 1980. There are no previously recorded archeological sites in the CRL study area, and the nearest recorded site is Site 41MG128, which is a historic wooden home built in 1833 that is located 0.2 mile north of the study area. Two shipwrecks and one NRHP-listed cemetery, the Matagorda Cemetery, are also located in the general vicinity but well outside the CRL study area.

Much of the BRFG and CRL study areas have been extensively disturbed by previous excavation of the GIWW, diversion of the Brazos and Colorado Rivers, construction of the BRFG and CRL facilities, and construction of roads, levees, and DMPAs. Therefore, the potential for encountering intact archeological sites is considered relatively low and limited to few undisturbed areas.

2.4.2. Historic Resources

Historic resources include buildings, structures, objects, and historic districts located above ground. In accordance with Section 106 of the NHPA and its associated regulations (36 CFR 800), the USACE established APE at BRFG and CRL for non-archeological historic resources in cooperation with the Texas State Historic Preservation Office (SHPO). Due to the insular nature of the study areas, the APE at each facility was established as 500 feet from the study area boundary. Per 36 CFR 800.4, non-archeological historic resource studies were completed to determine if historic-age resources within the APEs are eligible for or listed in the NRHP and may be affected by project alternatives.

A review of the THC's Texas Historic Sites Atlas revealed that there are no non-archeological historic resources listed in the NRHP within the BRFG and CRL APEs. In July and August 2017, a survey was conducted to determine if any non-archeological historic resources within the APEs were NRHP-eligible.

A survey cutoff date of 1975 was established based on an estimated date of construction of 2020. Although National Park Service (NPS) guidelines state that a property must generally be at least 50 years old to be NRHP eligible, an additional five years was subtracted to account for delays in project planning or funding. The identified pre-1975 historic resources in the study areas are also referred to as "historic-age" resources. As documented in the September 2017 historic resources survey report (HRSR) titled *Non-Archeological Historic Resources Survey Report for the Gulf Intracoastal Waterway Brazos River Floodgates and Colorado River Locks Systems Feasibility Study, Brazoria and Matagorda Counties, Texas*, a total of 25 historic-age resources within the APEs at BRFG and CRL were identified, inventoried, and evaluated for their NRHP eligibility per NPS criteria. Within the APE of the BRFG, 10 historic-age resources were identified and inventoried, which included the floodgates and other USACE-owned resources within the BRFG facility (e.g., control houses, power houses, pump house, boat house). Based on evaluations documented in the HRSR, none of the historic-age resources within the BRFG APE met the NPS criteria for NRHP eligibility.

Within the APE of the CRL, 15 historic-age resources identified and inventories; 11 of the resources were associated with the CRL facility and four of the resources were located outside the CRL facility. As outlined in the HRSR, none of the historic-age resources within the CRL APE met the NPS criteria for NRHP eligibility.

2.5 Economic, Socioeconomic, and Human Resources

2.5.1. Economics – Navigation (BRFG)

The Brazos River flows into the Gulf of Mexico, crossing the GIWW near Freeport, TX. Two 75 foot floodgates, one on each side of the Brazos River crossing of the GIWW, are provided to control flow and sediment into the GIWW. The authorized channel in the GIWW is 125 feet wide and is typically about 12 feet deep. Navigation between the floodgates across the Brazos River is difficult during high flows in the Brazos River. The floodgates were installed at a time when most tug boats pulled barges behind them instead using the modern pushing method. The current angled approaches to each floodgate is not conducive to the pushing method. The cross current and through gate flows cause eddies to form unstable approach conditions. Also, shoaling issues have occurred causing periodic grounding of vessels. This has increased the difficulties faced by pilots navigating between the floodgates.

Tidal effects are present at the project location. Combined with the Brazos River flood stage, this can cause flow both into and out of the GIWW. In addition, the flow velocities through the west floodgate are greatly affected by the San Bernard River. The outlet dredging for the San Bernard River within the last decade has silted in due to low flow and the GIWW has become its outlet partly through the west gate structure. This has increased the difficultly on pilots to navigate the structures.

Restrictions are placed on the tows allowed to cross the Brazos River during high flow events by the USACE. In accordance with 33CFR 207.187 (**Table 2.9**). Long periods of high flow through the Brazos River that require "tripping" barges through places a serious economic impact on operation of tows through the reach.

Table 2.9 Existing Navigation Restrictions – Brazos River Crossing

Condition	River Velocity	Head Differential	Restriction
1	Over 2 mph	0.7 to 1.8 ft	• Single vessel passage • Tows with single loaded barges • Tows with two empty barges • Velocity reaches 1.7 mph, tows with two empty barges only
2	-	Over 1.8 ft	Closed
3	Over 5 mph	-	• Single vessel passage • Tows with one barge only loaded or empty • Operation during daylight hours only
4	Over 7 mph	-	Closed

Due to the well-known navigation issues associated with these floodgates, individual companies have instituted additional self-imposed regulation on their pilots above and beyond the USACE restrictions in order to minimize risks.

2.5.2. Navigation (CRL)

The Colorado River flows into West Matagorda Bay, crossing the GIWW near Matagorda, TX. Two 1,200 foot by 75 foot locks, one on each side of the Colorado River crossing of the GIWW, are provided to control flow/sediment into the GIWW and improve navigation. The authorized channel in the GIWW is 125 feet wide and is typically about 12 feet deep. The original course of the Colorado River southward of the GIWW was south-southwesterly through the Matagorda Peninsula into the Gulf of Mexico. In the early 1990s, a diversion channel was dredged from the intersection of the Colorado River and GIWW southwest towards West Matagorda Bay. Diversion of flow into Matagorda Bay was performed to route the heavy sediment load into the bay to create shallow wetlands for environmental improvements of biologic productivity.

USACE restrictions are placed on the size of a tow that can cross the Colorado River when current speed in the river immediately upstream of the intersection exceeds 2.0 mph or 3.0 fps (Table 2.10). Long periods of high flow through the Colorado River that require "tripping" place a serious economic impact on operation of tows through the reach.

Table 2.10 Existing Navigation Restrictions – Colorado River Crossing

Condition	River Velocity	Restriction
1	2 mph (3.0 fps) or higher	• Single vessel passage • Tows with one loaded barge or two empty barges
2	Over 7mph	• Closed

2.5.3 Navigation System

The Brazos River Floodgates and Colorado River Locks System on the Gulf Intracoastal Waterway provides shallow-draft navigation between deep draft ports along the Texas coast and connects these ports to the inland navigation system comprised of the Mississippi River and its tributaries.

2.5.3.1 Traffic Commonality

The Brazos River Floodgates and Colorado River Locks are separated by 40 miles, with few commercial docks located between the projects. The authorized navigation channel has a width 125 feet and an authorized depth of 12 feet for GIWW system encompassing the Brazos and Colorado Rivers. Several streams and rivers flow into the GIWW along this route, with a few areas of minor open water navigation. Aerial imagery shows multiple fleeting/mooring locations in between, but no infrastructure for loading or unloading barges along the GIWW. The San Bernard River meets the GIWW at GIWW mile 405 and supports limited commercial navigation for approximately 26 miles. This route is highly congested due to bends, river crossings, and private docks. Approximately 500,000 tons of commercial navigation on average takes place along this waterway.

According to lock operators, less than 1% of traffic traverses one lock or gate and turns up the Brazos River, while approximately 1 million tons on average utilizes one Colorado Lock and travels up the Colorado River without crossing the other lock. **Table 2.11** shows the average annual tonnage at Brazos and Colorado from 2010 through 2014 demonstrates the high level of commonality between projects.

Table 2.11 Average Annual Tonnage Commonality

Project Name	Average Tonnage	Average Through All	Commonality
Brazos River Floodgates	22,497,593	21,038,012	97%
Colorado River Locks	21,607,965		99%

Source: Waterborne Commerce Statistics (WCS) 2010-2014

Table 2.12 Traffic Commonality between Brazos, Colorado Projects, and Other USACE Projects

Project	Average Tonnage	Average Through Colorado, Brazos, and Lock	Commonality
Algiers	23,029,425	1,750,659	8%
Bayou Boeuf	25,253,375	2,116,894	8%
Bayou Sorrel	18,832,450	1,852,975	10%
Calcasieu	38,127,544	4,568,180	12%
Inner Harbor	15,967,412	425,916	3%
Leland Bowman	37,984,467	4,473,239	12%
Port Allen	19,486,405	1,850,999	9%

Source: Waterborne Commerce Statistics (WCS) 2010-2014

As displayed in Table 2.12, the Brazos and Colorado River projects have a significantly high level of traffic commonality. This suggests any substantial change at one project has the potential to alter traffic patterns or operations at the other project. These alterations can be beneficial or detrimental. For example, while expanding a chamber at a project could be beneficial in reducing trip costs and delays, it could also mean larger tows may desire to call on other projects in the system less equipped to handle them. Table 1.4 shows the traffic commonality with other USACE lock projects within the geographical extent of the GIWW. The

relatively low level of commonality suggests that changes to Brazos or Colorado would have little relative impacts on the operational performance of other USACE Lock projects.

2.5.3.2 Historic Annual Commodity Tonnages

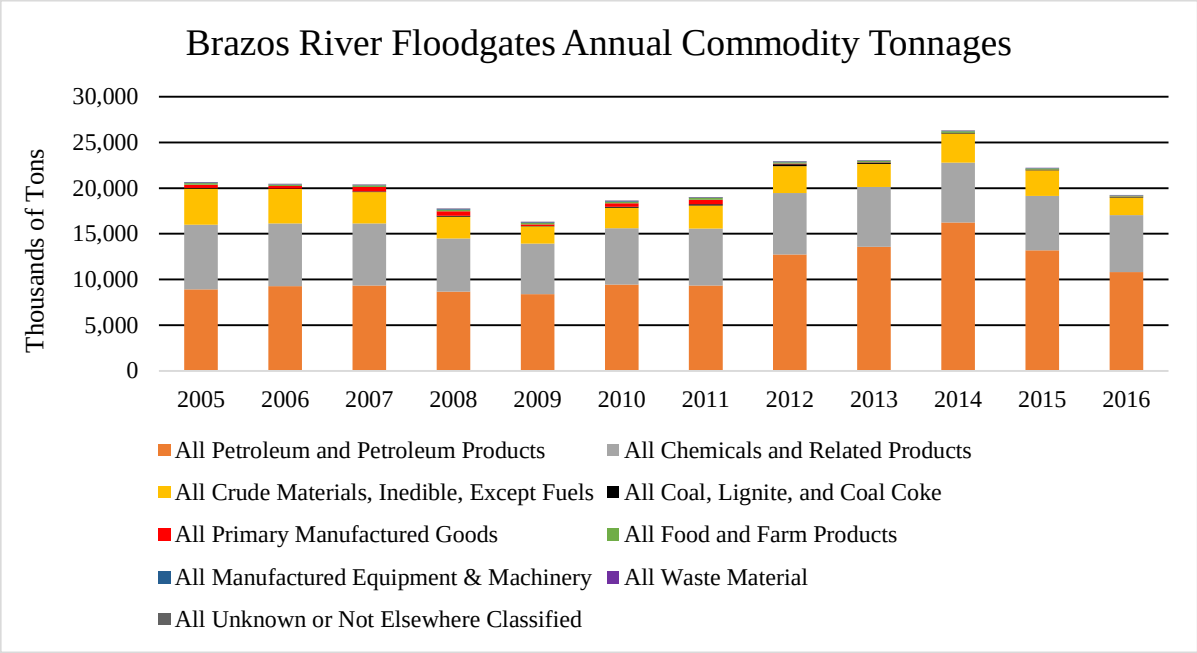
Table 2.13 displays the total annual commodity tons for the Brazos River Gates and Colorado River Locks, respectively. During the period of 2005-2016, the Brazos River Gates East, total annual commodity tons fluctuated slightly, decreasing throughout the middle years of 2008 to 2011. This decrease tracks with trends elsewhere on the inland waterways system in the years associated with the recession of the late 2000's. Traffic at both projects then grew beyond their pre-recession years through 2015, with traffic in 2016 dropping back closer to the historical average.

Table 2.13 Brazos and Colorado Rivers Annual Total Commodity Tons 2005 - 2016

Year	Brazos River East Gate	Brazos River West Gate	Colorado River East Lock	Colorado River West Lock
2005	20,640,084	20,644,753	20,088,737	19,477,873
2006	20,443,189	20,458,107	19,945,061	19,394,265
2007	20,372,677	20,233,632	19,806,747	19,160,974
2008	17,745,009	17,663,283	17,249,356	16,748,306
2009	16,283,167	16,188,812	16,031,834	15,496,657
2010	18,575,688	18,647,592	18,390,208	17,631,988
2011	18,996,720	18,994,027	18,671,598	17,514,619
2012	22,908,666	22,825,455	22,655,487	21,067,805
2013	23,010,205	23,198,631	22,926,748	21,690,325
2014	26,281,053	26,181,211	26,209,876	24,921,438
2015	22,216,148	22,248,305	22,032,787	21,051,805
2016	19,235,731	18,971,748	19,137,893	18,521,217

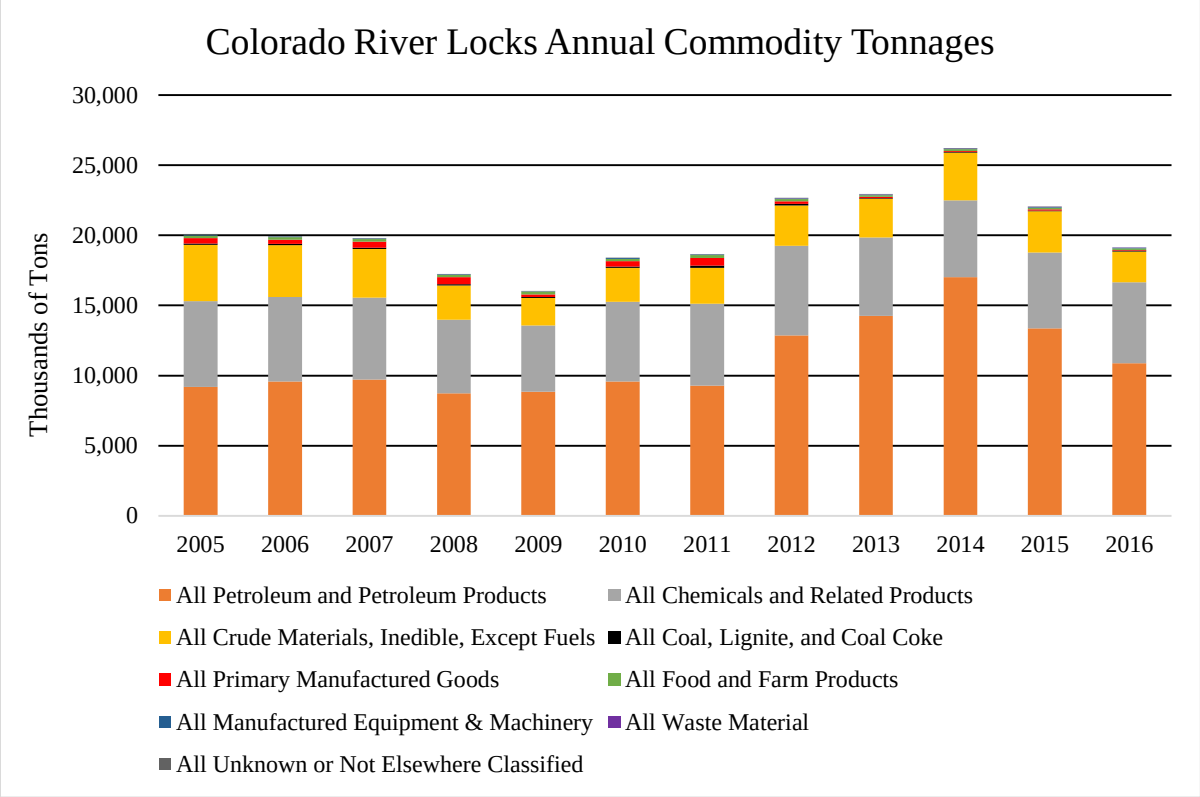
Source: Lock Performance Monitoring System

Figures 2.12 and 2.13, respectively, show the breakdown of annual tonnage by commodity from 2005 through 2016. As shown in the figures, while traffic has fluctuated up and down throughout the years, the proportion of that traffic by the three main commodity groups; petroleum and petroleum products, chemicals and related products, and crude materials and related products, has remained stable.



Source: Lock Performance Monitoring System (LPMS)

Figure 2.12 Brazos River Floodgates Annual Tonnage by Commodity



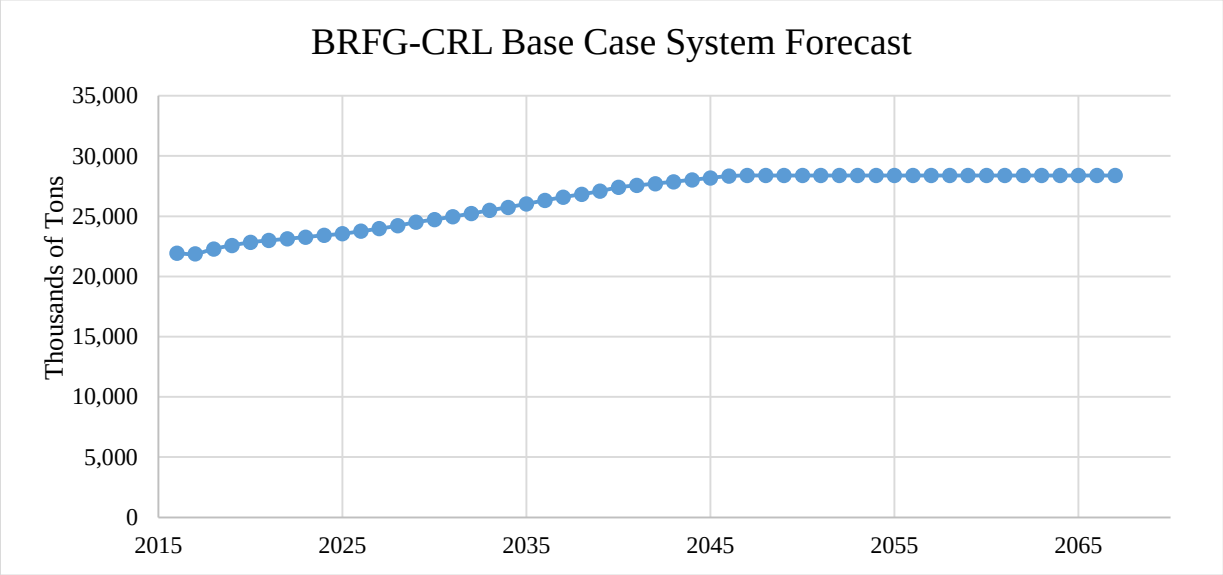
Source: Lock Performance Monitoring System (LPMS)

Figure 1.13 Colorado River Locks Annual Tonnage by Commodity

2.5.3.3 Commodity Forecasts

Martin Associates developed a series of traffic forecasts, the purpose of which is to project traffic throughout the 50 year planning horizon for multiple future scenarios. These detailed write-up accompanying these forecasts are attached to Appendix B of this document.

Given that approximately 90% of the commodities moved through these projects have consistently been the same three commodity groups, the forecasting effort by Martin Associates focused on these same three groups. The primary source for the forecasts was the U.S. Energy Information Association (EIA) for crude and refined petroleum products and Moody's.com forecast for domestic chemical production in the State of Texas. The graph in Figure 2.14 represents the base-case traffic total system traffic forecast provided by Martin Associates.



Source: Martin Associates – Final Cargo Forecasts

Figure 2.14 Brazos River Floodgates and Colorado River Locks Base-Case System Forecast

The base-case forecast has traffic growing gradually from approximately 22 million tons in 2016 to approximately 28 million tons in 2044, then remaining flat for the remainder of the planning horizon.

2.5.3.4 System Behavior

Historically, commodity traffic utilizing the GIWW within the study area has functioned as a relatively closed modal system. As Figures 1 and 2 show, the majority of traffic through the Brazos River Floodgates and Colorado River locks has been comprised mainly of bulk liquids, mainly petroleum and chemical products, which are barged up and down the Texas coast for use as an input by the multiple refineries located throughout the region. The products and byproducts of these refineries typically travel either by pipeline, rail, or barge to other facilities throughout the country for further refinement as an intermediate good. Facilities tend to construct their production model around this infrastructure pattern, with intakes tending towards waterborne delivery and refined products being dispersed around the multiple modes of transportation that most efficiently allow it to travel to the next step of the refining process.

The Brazos River Floodgates and Colorado River Locks have historically not been prone to sustained long-duration outages. While the projects do close relatively frequently due to issues discussed later in this report, the closures are usually stretched across multiple days or weeks with traffic being allowed to pass

intermittently during these events. As such, the industries that have developed in the region have not been forced to source their primary inputs via other transportation modes for sustained periods, and more typically will adjust their production to account for these delays rather than sourcing from land-based modes, which tend to be strained by the capacity of the unloading equipment at the respective facilities. This behavior is typical of petroleum-based industries located throughout the inland transportation system whose primary input is primarily received via water.

Martin Associates conducted interviews with shippers who utilize the shallow-draft transportation system provided by the GIWW in the economic study area of the Brazos River Floodgates and Colorado River Locks:

> *"It is to be noted that interviews with the key customers using the BRFG (Brazos River Floodgates) and CRL (Colorado River Locks) indicated that the delays under the without project case do not result in the use of surface modes, due to the fact that the waterborne movements are essentially a part of the production process of chemicals and petroleum products, and the shippers do not have the ability to use truck or rail as a substitute. The customers are notified when the barge shipment is within 4 hours of delivery, and at that time the process of berth availability at the shipper's facility is planned. Only in very isolated instances, such as a week or more delay, would inventory stocks be jeopardized, and since the average delay time is less than 6 hours, the impact on the logistics supply chain of delays is negligible. This suggests that a reduction in the delay times and the resulting savings in logistics costs will not likely result in a diversion of traffic from truck or rail to barge in the future. The flows will be driven by the production levels and economy as described in this report."*

2.5.4. Population, Housing, and Community Cohesion

The BRFG and CRL study areas are largely undeveloped, and there are no communities, residences, or other community-related facilities within either study area. Therefore, there are no populations that reside within the study areas, and no housing options are available within the study area boundaries.

The nearest residential areas to the BRFG study area are associated with the city of Freeport, approximately 2 to 3 miles east and north of the study area, and along the San Bernard River approximately 3.5 miles west of the study area. Freeport, with a population of just over 12,000, was estimated to have approximately 4,700 housing units (according to the 2010 U.S. Census) with approximately 54 percent of the housing units owner-occupied. Median gross rent of housing units available in the city of Freeport is approximately $613 (U.S. Census Bureau 2017a).

Community cohesion has been described as the force that bonds people together long enough to establish meaningful interactions, common institutions, and agreed ways of behavior. It is a dynamic process, changing as the physical and human environment changes. Conditions brought about by water resources development can impact community cohesion through changing a right-of-way or constructing a feature that can divide a community, cause the dislocations of a significant number of residents, or requiring the relocation of an important local institution, such as a church or community center. The basic objectives of water resources development have been to provide additional security through hurricane and storm damage risk reduction, improved navigation, environmental restoration, and recreation through civil works, as needed by the local area, region, and Nation.

In the CRL vicinity, residential communities associated with the town of Matagorda and along the east bank of the Colorado River are present immediately north and south of the study area. Matagorda is a small fishing and tourist township with a population of less than 500 people. Lodging for visitors to the area includes motels, bed and breakfasts, and lodges, as well as condo and beach house rentals.

2.5.5. Employment and Income

Most of the infrastructure located in the BRFG study area support the floodgate operations. Since the BRFG are owned and operated by the USACE, employment and income within the study area is dominated by government sector jobs associated with the maintenance, operation, and oversight of the BRFG. Texas Boat and Barge, Inc. is a commercial barge cleaning, maintenance, and repair facility and has been operating for approximately 26 years. Texas Barge & Boat is estimated to generate $8.2 million in annual revenues and employs approximately 60 people at this single location (Buzzfile 2017).

The BRFG are located near the cities of Freeport and Lake Jackson, an area with a large petrochemical industry. Lake Jackson is home to Dow Chemical, one of North America's largest petrochemical complexes, and the number one employer for the Freeport area. According to the City of Freeport business development website, other major employers in the Freeport area include contractor labor, Texas Department of Criminal Justice, Brazosport ISD, and other large petrochemical companies. Based on median household income data from the 2011-2015 U.S. Census American Community Survey, the median household income for areas surrounding the BRFG study area is above the U.S. Department of Health and Human Services (DHHS) 2017 threshold for low-income populations (U.S. Census Bureau 2017b, DHHS 2017).

Within the CRL study area, virtually all the infrastructure supports the lock operations, thus employment and income within the study area is dominated by government sector jobs associated with the maintenance, operation, and oversight of the CRL. According to the Matagorda County Economic Development Corporation, the top industry in Matagorda County is educational services and health care and social services, other major industries include manufacturing, agricultural, and the seafood and fishing industry. Based on median household income data from the 2011-2015 U.S. Census American Community Survey, the median household income for areas surrounding the CRL study area is above the DHHS 2017 threshold for low-income populations.

2.5.6. Environmental Justice

Executive Order (EO) 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations," signed by the president on February 11, 1994, directs Federal agencies to take the appropriate and necessary steps to identify and address disproportionately high and adverse effects of Federal projects on the health of the environment of minority and low-income populations to the greatest extent practicable and permitted by law. The EO requires that minority and low-income populations not receive disproportionately high adverse human health or environmental impacts, and requires that representatives of any low-income or minority populations that could be affected by the proposed project be involved in the community participation and public involvement process.

In compliance with EO 12898, data was collected from the 2010 U.S. Census and the 2011-2015 U.S. Census American Community Survey at the state, county, census tract (CT), block group (BG), and block level (when available). A review of U.S. Census Bureau data on population, race, ethnicity, income, and English proficiency was conducted to determine the potential for persons from minority populations and low-income populations to reside within the study area (U.S. Census Bureau 2017a, b, c).

Residents near Brazos River Floodgates

There are no residences located within the BRFG study area; therefore, there are no environmental justice populations living in the study area. The study area is located within a larger BG (BG 2) which is part of an even larger CT (CT 6644). CT 6644-BG 2 encompasses approximately 16,113 acres and has a total population of approximately 1,375. Based on the 2010 U.S. Census, CT 6644-BG 2 is composed of 657 Hispanic or Latino persons (approximately 48 percent of the population), which is lower than the CT (CT

6644) at 58 percent. However, based on review of aerial photography, the closest residence to the BRFG study area is over 2 miles to the northeast.

Residents near Colorado River Locks

No residences are located within the CRL study area, so no environmental justice populations live within the study area. The study area is located within three larger BGs which are part of two larger CTs 7305.01 and CT 7306. CT 7305.01-BG 1, CT 7305.01-BG 4, and CT 7306-BG 1 encompass a combined total of approximately 241,059 acres with a total population of approximately 2,869. Based on the 2010U.S. Census, all three BGs are composed primarily of non-Hispanic or Latino persons with a majority of residents identifying as White. The percentage of Hispanic or Latino populations within each BG is less than 31 percent, which is lower than the Matagorda County average (approximately 38 percent). Although no residences are located within the CRL study area, the city of Matagorda is located adjacent to the study area, with some residences located immediately north and south of the study area.

2.6 Air Quality

2.6.1. National Ambient Air Quality Standards

The Clean Air Act (CAA) of 1970, as amended in 1977 and 1990, regulates air emissions from stationary and mobile sources. The CAA requires the EPA to set National Ambient Air Quality Standards (NAAQS) for pollutants considered harmful to public health and the environment (40 CFR 50). The CAA establishes two types of NAAQS: primary and secondary. Primary standards define levels of air quality that the EPA judges necessary, with an adequate margin of safely, to protect the public health, particularly to "sensitive" populations such as children, elderly, and asthmatics. Secondary define levels of air quality that the EPA deems necessary to protect public welfare, including protection against decreased visibility and damage to animals, crops, vegetation, and buildings (40 CFR 50).

The EPA has established NAAQS for six principal pollutants, called "criteria" air pollutants: carbon monoxide (CO), lead (Pb), nitrogen dioxide (NO_2), ground-level ozone (O_3), particulate pollution or particulate matter (PM_{10} and $PM_{2.5}$), and sulfur dioxide (SO_2) (EPA 2017a). The CAA requires the EPA to monitor ambient air quality and assign a designation to each area based on its compliance with the NAAQS. Based on their NAAQS compliance level, the EPA designates areas as either:

- Attainment – area currently meets the NAAQS;
- Maintenance – area currently meets the NAAQS, but has previously been out of compliance;
- Non-attainment – area currently does not meet the NAAQS; or
- Unclassified – area that cannot be classified based on available data.

Ozone nonattainment areas are further classified as extreme, severe, serious, moderate, and marginal depending on the severity of NAAQS exceedance (EPA 2017b).

Under the CAA, if an area is designated as nonattainment, then state and local governments must develop a State Implementation Plan (SIP), which is a comprehensive plan for an area to meet federal air quality guidelines. The TCEQ has developed a SIP, with EPA's approval, that describes how Texas will comply with the CAA and how the compliance will be monitored (TCEQ 2017b).

The BRFG study area is located within the Houston-Galveston-Brazoria (HGB) Intrastate Air Quality Control Region, which is in attainment for all criteria pollutants except ozone (EPA 2017c, TCEQ 2017b). The HGB Ozone Nonattainment Area was classified as "severe" by the EPA in October 2008 under the 1997 eight-hour ozone NAAQS. As of July 2012, the EPA designated the HGB area as "marginal" for the

2008 ozone NAAQS based on major improvements in air quality for the area. In December 2016, the HGB area was reclassified as "moderate" ozone nonattainment for the 2008 ozone NAAQS, with an attainment deadline of July 2018 (81 FR 90207). The CRL area is located in Matagorda County, which is in attainment for all criteria pollutants.

2.6.2. Conformity of Federal Actions

As required by the CAA, the EPA has established rules to ensure that Federal actions conform to the appropriate SIP. The General Conformity Rule applies to all Federal actions within NAAQS nonattainment areas, except for Federal Highway Administration (FHWA)/Federal Transit Authority (FTA) actions, which are subject to the Transportation Conformity Rule.

The CAA prohibits Federal undertakings (including funding, permitting, constructing, or licensing) that do not comply with the applicable SIP. The General Conformity requirement ensures that Federal agencies consult with State and local air quality managers and allows State agencies to include expected emissions into the appropriate SIP.

Since the BRFG study area is in the HGB moderate ozone nonattainment area, the USACE will evaluate projected pollutant emissions from construction and, if needed, maintenance activities. If the projected emissions exceed 100 tons per year of either nitrogen oxides (NOx) or volatile organic compounds (VOCs), a General Conformity Determination will be required (TCEQ 2017c). Since the CRL study area is in an area that is in attainment for all criteria pollutants, no emissions analysis or conformity determination will be needed there.

2.7 Noise

The magnitude of noise is generally described by its sound pressure. The range of sound pressure varies greatly, and sound is generally measured on a logarithmic scale, measured in decibels (dB). Environmental measurements of sound are usually made on the A-weighted scale, as this is the frequency range detected by humans; this frequency is expressed as dBA. Common sound/noise levels that an individual may encounter, and the human response, are listed in **Table 2.14**. Included are noise levels of tugs and some common equipment that may be used for construction or maintenance in the BRFG and CRL study areas.

Table 2.14. Sound Levels and Human Response

Common Sound[1]	dBA	Human Response
Rocket launching pad (no ear protection)	180	Irreversible hearing loss
Carrier deck jet operation Air raid siren	140	Painfully loud
Thunderclap Shotgun blast	130	
Jet takeoff (200 feet) Auto horn (3 feet)	120	Uncomfortably loud; Maximum vocal effort
Pile driver Rock concert (20 feet)	110	Extremely loud
Garbage truck Firecrackers	100	Very loud
Heavy truck (50 feet) City traffic **Tug boat** (50 feet)[2]	90	Very annoying Hearing damage (8 hours)

Common Sound[1]	dBA	Human Response
High Solids Pump (3 feet)[2]		
Alarm clock (2 feet) Hair dryer **Excavator Clamshell Dredge** (50 feet)[2]	80	Annoying
Noisy restaurant Freeway traffic Business office **Work Boat** (50 feet)[2]	70	Telephone use difficult
Air conditioning unit Conversational speech	60	Intrusive
Light auto traffic (100 feet)	50	Quiet
Living room Bedroom Quiet office	40	
Library Soft whisper (15 feet)	30	Very quiet
Broadcast recording studio	20	
Whisper Light rainfall	10	Just audible
	0	Threshold of hearing

[1] Occupational Safety and Health Administration (OSHA) 2017
[2] Epsilon Associates, Inc. 2006

Noise generators are limited in the study areas, with tugs and other vessels being a primary source of noise. Operations at the floodgate/lock facilities and Texas Boat and Barge would also generate noise. Tug operators sometimes have to moor the tows along the bank while waiting to transit the BRFG or CRL. Normally, tugs leave their generators running and often leave their main engines running while waiting to transit, contributing to the overall noise environment. There are no sensitive receptors in the study areas, and limited residential or recreational (e.g., the Bryan Beach Recreation Area) near the study areas. As such, noise associated from the project is not expected to be a major concern.

2.8 Oil, Gas, and Minerals

Oil, gas, and mineral resources vary between the BRFG and CRL study areas. Near the BRFG, the Bryan Mound Strategic Petroleum Reserve is the closest major energy and mineral resource; it is located about 1 mile north of the East Floodgate (**Figure 2.1**). The site stores 245 million barrels of crude oil, or one-third of the nation's oil reserves, in a subterranean salt dome held by the Strategic Petroleum Reserve for use in national emergencies. It has 20 underground chambers and is connected to port facilities at Freeport. A number of other major facilities occur in the BRFG vicinity, including Dow Chemical, Freeport Liquefied Natural Gas, and facilities around the Port of Freeport and the GIWW.

There are no oil or gas pipelines in the BRFG study area (Texas Railroad Commission [RRC] 2017). There are four known oil wells in the study area. However, three locations are considered dry holes, and drilling was cancelled or abandoned at the fourth locations. There are no oil wells, pipelines, or other oil, gas, or mineral resources in the CRL study area (RRC 2017).

2.9 Hazardous, Toxic, and Radioactive Waste

The USACE identified potential hazardous, toxic, and radioactive waste (HTRW) issues that may affect the BRFG and CRL areas. The survey included 2-mile and 4-mile search radii. The results of the efforts are summarized here and documented in a report titled *Hazardous Toxic Radioactive Waste (HTRW) Survey for Gulf Intracoastal Waterway Brazos River Floodgates & Colorado River Lock Feasibility Study* (USACE 2017a).

2.9.1 Potential HTRW Impacts from Construction of the Structures

The BRFG and CRL were built in 1943 and 1944, respectively, when industrial marine facilities were coated in lead paint. Depending on the repairs and rehabilitation projects done at the facilities, there may still be lead paint on the structures.

2.9.2 Potential HTRW Impacts from Nearby Facilities

Two possible HTRW sites were identified within 2 miles of the BRFG facility: Texas Boat & Barge, Inc., located adjacent to the east floodgate, and Bryan Mound Strategic Petroleum Reserve, located about 1 mile to the north of the BRFG. Beyond 2 miles, there are a number of industrial and chemical facilities in and around the Freeport-Lake Jackson area.

Two possible HTRW sites were also identified within 2 miles of the CRL facility: Matagorda wastewater treatment plant (WWTP), located east of the CRL, and Beach Road Municipal Utility District WWTP located about 2 miles south of the CRL facility. According to database information, both of these facilities hold discharge permits that include polychlorinated biphenyls (PCBs) and heavy metals such as lead, nickel, zinc, cadmium, arsenic, mercury, and molybdenum. In addition to the two WWTPs, the South Texas Electric Project discharges into the Colorado River about 4 miles upstream of the CRL facility.

The EPA has records of two water quality testing locations near the CRL facility. Testing results from these locations indicate relatively high metals, microbes, and pesticides (USACE 2017a). In August 2017, Hurricane Harvey made landfall on the Texas Gulf coast, and flooding and power outages contributed to a high potential for chemical releases and other contamination from industrial operations, particularly upstream of the BRFG facility where large chemical and petrochemical plants occur.

THIS PAGE LEFT INTENTIONALLY BLANK

Plan formulation supports the USACE water resources development mission. A systematic and repeatable planning approach is used to ensure that sound decisions are made. The Principles and Guidelines describe the process for Federal water resource studies. It requires formulating alternative plans that contribute to Federal objectives. Sections 3.1 through 3.8 review the plan formulation process used to identify the tentatively selected plan (TSP) that is described in this document. The information presented in Sections 3.0 through 3.8 is to inform the reader of the planning process as it had been conducted up to publication of the Draft Report. After the release of the Draft Report, the team will refine the design of the TSP with additional engineering and environmental investigations. Based on feasibility level of design and based on comments received following publication of the Draft Report, portions of the TSP may be modified.

3.0 PROBLEMS, OPPORTUNITIES, OBJECTIVES AND CONSTRAINTS

Navigating through this portion of the inland system on the GIWW presents a unique challenge as it is essentially four structures at two separate locations along a 40 mile stretch of the waterway, with two river crossings in the middle of each location, that operate quite differently depending on direction of traffic and river conditions, which make the system atypical of more commonly assessed reaches along the GIWW (i.e. shipping channels/ports/etc.).

3.1 Study Problems

The primary **problems** in the study area are due to the configuration of the narrow channels and structure guidewalls (width), hazardous and periodic closed channel crossings, outdated floodgate and lock structures, which when combined with larger capacity vessels and high river flows, and evolution of mariner practices, increase the likelihood of accidents and reduce efficiency in navigation through this stretch of the GIWW. A number of overarching problems exist for both the floodgate and locks and include:

Study Problems

- Hydraulic flows and channel geometry present navigational hazards at river crossings.
- Outdated 75 foot width of floodgates at Brazos River and floodgates and lock chambers at Colorado River do not efficiently accommodate current tow configurations along the GIWW, which arrive at structures as wide as 104 feet resulting in multiple trips to transit the crossing.
- Aging and outdated lock components and equipment leads to structural, electrical and mechanical maintenance issues.
- Shutdown of operations during high river periods and accident repairs causes significant economic impacts to navigation industry.
- Vessels impact and damage to aging existing structure sheet pile guide walls.
- Sedimentation at the crossings and along the GIWW impacts the navigation industry.

Figure 3.1 (Top): Barge Traffic at CRL
Figure 3.2 (Bottom): Guidewall Damage Accident

To assess full breadth of problems in the study area it is also critical to understand the historic and existing traffic conditions that have contributed to navigation problems in the study area. As stated in Chapter 1, the structures were built in the 1940s as sediment control structures for the GIWW, when barging traffic utilized push/pull tug methods and when barges/containers were significantly smaller than those used today.

The locks/floodgates have been maintained for over a 75 year period but with aging system components and with navigation industry moving towards computer automated systems, the structures now contribute to significant traffic delays due to frequent system/gate failures during high river stages (see figure 3.3).

Figure 3.3: Colorado River Gate Closure due to high water

Specific problems to each of the structures address the structural configurations, operational conditions, traffic problems experienced at each location (includes transit times, allisions, delays, tripping), and river conditions within the waterway system.

3.1.1 Brazos River Floodgates Problems

Floodgate Configuration:

The narrow 75 foot gate opening and limited forebay (approximately 600 feet) coupled with the angled approaches to each floodgate is not conducive to modern barge navigation. The cross currents and through gate flows cause eddies to form unstable approach conditions. When crossing the river, towboat operators do not have enough time to recover their course after struggling with the river currents. The traffic through the project and impacts due to allusion risk and tripping are characterized in Chapter 2, with detailed information on timing and quantified delay cost provided in Section 2.2.3 of the Economics Appendices.

Operational Conditional Assessment:

Currently, the project has multiple documented maintenance/operational issues outlined in the 2017 Operational Condition Assessment (OCA). Because of the low elevation of the top of the wall of the gate structure, barges routinely hit the walls and gates damaging the steel railing, concrete walls and machinery pit. There are up to 8 feet deep scour holes along the steel sheet pile guide walls on the West and East gates which extend towards the middle of the channel, exceeding the design elevations of the guidewalls. The steel sheet piling for the guidewalls is exhibiting corrosion at the waterline and the bolts for the wale beams

are heavily corroded. The guidewall timber bumpers and steel tangent plates are missing or damaged from constant barge impact. Additionally, the existing design of the guidewall is not resilient to barge impact, requiring repairs to the guidewall for most barge impacts. The existing plumbing system (water and septic) and emergency generator/fuel systems are significantly deteriorated with no dependable backup power. The existing electrical power cables within the chamber crossovers are extremely deteriorated. The existing paint system has been ineffective preventing marine growth (particularly gulf oysters) on the structure. This growth has been substantial and adds significant weight causing damage to the hinges/machinery. Also, the gates have been binding during operation; this is speculated to be caused by the movement of the non-pile founded 2 feet thick slabs. The lock buildings continue to deteriorate with missing roof shingles, asbestos siding, leaking windows and doors, inadequate lighting, no GFI receptacles required by NEC, and panel boards that have deteriorated to the point of exposed wiring.

3.1.2 Colorado River Locks Problems

Lock Configuration:

The narrow 75 foot gate opening and limited forebay is not conducive to safe barge navigation. When crossing the river, towboat operators do not have enough time to recover their course after struggling with the river currents. The traffic through the project and impacts due to allusion risk and tripping are characterized in Chapter 2, with detailed information on timing and quantified delay cost provided in Section 2.2.3 of the Economics Appendices.

Operational Conditional Assessment:

Currently, the project has multiple documented maintenance/operational issues outlined in the 2017 Operational Condition Assessment (OCA). There are 5 feet deep scour holes along the tie-back sheet pile guide walls on both the East and West locks, exceeding the design elevations of the guidewalls. There are up to 15 feet deep scour holes along the steel sheet pile guide walls and concrete gravity walls on the West and East gates which extend towards the middle of the channel. Wall timbers are missing or damaged. Additionally, the existing design of the guidewall is not resilient to barge impact, requiring repairs to the guidewall for most barge impacts. The existing plumbing system (water and septic) and emergency generator/fuel systems are significantly deteriorated. The existing gate controls, switchgears and transformers are very old and show signs of significant deterioration. The controls houses are in poor condition and do not meet modern codes. The existing electrical conduit running underneath the lock structure is damaged and has rendered the West gates inoperable. The existing paint system has been ineffective preventing marine growth (particularly gulf oysters) on the structure. This growth has been substantial and adds significant weight causing damage to the hinges/machinery.

3.1.4 High River Flow Problems

Restrictions are placed on the tows allowed to cross the Brazos and Colorado Rivers during high flow events. In accordance with 33CFR 207.187, when the river current exceeds 2 mile per hour (mph); OR, “the head differential in either floodgate is between the limits of 0.7’ and 1.8’, passage shall be afforded only for single vessels or towboats with single loaded barges or two empty barges through gate flow reaches 1.7 mph, only two empty barges. The Brazos River Floodgates shall be closed to navigation when the head differential exceeds 1.8 feet” in either gate. In addition, when the river flow exceeds 5 mph, traffic is limited to one barge only (load or empty) and closed to navigation at night (daylight operation only). When the river flow exceeds 7 mph, all traffic is halted until the flow lowers (below 7 mph).

3.2 Study Opportunities

The **opportunities** are to reduce or eliminate costly commercial traffic delays and improve the national and regional economic conditions. The need to maintain the effectiveness of the floodgates and locks at this

location is critical not only from an economic standpoint but from a national security risk as well due to the types of commodities transported. Many of the products shipped along this stretch of the GIWW include oil, natural gas, and other chemicals used throughout various industries; maintaining safe, reliable, and efficient waterway systems for the movement of commerce, national security, and recreation is one of the primary function of the USACE.

3.3 Study Goals, Objectives, and Constraints

The **goals** of this study are to identify the NED Plan and to maximize the efficiency of the BRFG and CRL crossings to the greatest extent economically justified, thereby contributing to the improved efficiency of the GIWW as a nationally significant navigation system, while continuing to provide water management capability, sediment control, and navigation safety on the GIWW.

The **objectives** are what the alternative plans should achieve. To support accomplishment of the study goals and the Federal objectives, the project delivery team (PDT) developed the following planning objectives to apply to this stretch of the GIWW over the next 50 years. Four planning objectives include:

- Reduce navigation delays, tripping, allisions of vessels traveling through structures
- Improve channel alignments and hydraulic flows for vessels approaching structures traveling through crossings during high river periods
- Improve overall operations/functions of the floodgate/lock structures which experience frequent mechanical failures due to age and outdated systems
- Manage sediment in the GIWW

The planning **constraints** limit plan formulation. There are generally two types of planning constraints, universal and study specific constraints. The **universal** constraints are typically considered in every planning study and include the following for this study:

- Do not increase impacts to floodplain management
- Avoid impacts to existing Federal projects in the study area. If impacts are unavoidable, engineer solutions and incorporate revisions as part of the study
- Avoid or minimize adverse impacts to Threatened and Endangered (T&E) Species and wildlife habitat
- No use of public funds on private property without an overriding public benefit

The **study specific** constraints for this study were determined to fall within four categories:

Study Constraints

- **Impacts to Navigation Industry:** With limited alternative routes for bulk cargos being shipped through the floodgates and locks, excessive waterway closures that are unacceptable to the navigation industry are to be avoided.
- **General Infrastructure:** A state highway bridge and several local roads, as well as residences are located in the study area. Additionally there is a hurricane flood protection levee near the CRL. Adverse effects to the existing infrastructure will be minimized to the extent practicable and will adhere to the U.S. Coast Guard safety requirements.
- **Sediment Management:** Measures considered that result in a change to current and expected sediment deposition should be identified and addressed as necessary to reasonably minimize or avoid impacts.
- **Impacts to Wildlife Management Areas:** Wildlife management areas are found adjacent to the study area. Adverse impacts to those areas should be avoided where practicable and mitigated.

Legal constraints may include those associated with impacting existing federally constructed projects and expanding the study area beyond the scope of the approved authority, including project areas not previously approved by Southwestern Division (SWD) or Headquarters (HQ).

3.4 Plan Formulation

Alternative plans are a set of one or more **management measures** functioning together to address one or more planning objectives. A management measure is a feature or activity that can be implemented at a specific geographic site to address one or more planning objectives. For this study the team developed an array of measures and alternatives and screened them to identify a focused array of alternatives as standalone and within the navigation system. These were screened until an NED plan was identified and became the TSP (Figure 3.4 illustrates this iterative process). The team considered a systems based approach to assess the possible benefits that would be gained after construction.

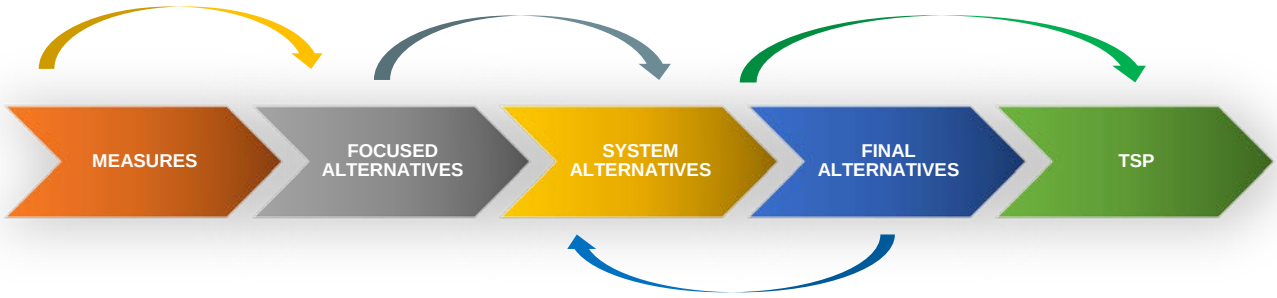


Figure 3.4 Alternative Development Process

3.4.1 Management Measures

To address the study problems and capitalize on the opportunities within the region, the team developed a strategy based on four problem categories found at each project location (BRFG and CRL) and within the overall system and river crossings between the structures. These categories focused on different components that were identified in previous studies as contributing to the problems in the study area. They include:

- *Floodgate/Lock Structures* → *Structural Component*
- *Channel Modifications* → *Channel Maintenance Component*
- *Water/Sediment Management* → *River Component (water/sediment)*
- *Navigation Efficiency Improvements* → *Navigation Component*

The measures include structural and non-structural measures and could be used at both locations if they shared commonality (i.e. guidewalls) as shown in Table 3.1, or as standalone solutions that addressed specific issues at each of the structural locations for Brazos (Table 3.2) and for Colorado (Table 3.3). Twenty-seven measures were identified and were derived from a variety of sources including the public scoping process, industry groups, and the team. The measures are briefly described to understand their performance contribution in support of screening and further alternative development after screening.

Table 3.1: Proposed Measures for Brazos and Colorado

Major Rehabilitation of Floodgates (MR): Major rehabilitation of the floodgates would restore the reliability of the steel floodgates, concrete gatebay monolith and machinery. This could potentially include new gates, machinery, electrical power, and controls. This measure would improve navigation efficiency through the reduction of closures of the floodgates due to unscheduled maintenance of structural, mechanical or electrical component failures.

Channel Improvement Structures (CS): Channel improvement structures would consist of training and side channel enhancement structures such as above and/or below water weirs, dikes and other structures to improve hydrodynamic conditions and sediment transport. The improvement to the hydrodynamic conditions at the crossing would improve navigation efficiency by reducing delays.

Dredging at Crossings (DC) – Non-structural: Dredging at crossings would consist of modification of the river crossings utilizing conventional dredging techniques to improve hydrodynamic conditions and sediment transport. The improvement to the hydrodynamic conditions at the crossing would improve navigation efficiency by increasing channel availability.

Dredging Maintenance (DM) – Non-structural: Increased scheduled maintenance dredging of the Colorado River and Brazos River. Would improve navigation efficiency by managing sandbar buildup, and maintain required depths/width of rivers.

Modify/Construct Guidewalls (MG): Modification or construction of new approach guidewalls would provide a safer approach to the structures, improve transit times, and reduce accidents that cause unscheduled repairs on the structures.

Structure Removal (SR): Structure removal involves the complete removal of the floodgate/lock structures.

Table 3.2: Measures Specific to the Brazos River Floodgates

Floodgate Maintenance (FM): Floodgate maintenance would involve the continued maintenance of the current steel floodgates, concrete gatebay monolith and machinery without any major rehabilitation of the structure.
Raise/Relocate Gate Operator Buildings (RO): This measure would Raise/relocate the gate operator building out of the way of navigation to prevent unscheduled repairs on the buildings and improve visibility.
Modify Gate Machinery Pit Location (MP): The low elevation of the gate structure puts the machinery pit at risk of being struck by vessels during high river events. Modifying the gate machinery pit would reduce accidents that result in unscheduled repairs on the gate machinery.
Channel Realignment (CR): This measure would permanently relocate the river crossings of the GIWW to improve efficiency. A range of alternative realignments would be considered and could include bypass channels as needed.
Relocate/Setback Gate Structures (RG): This measure would involve the relocation of the gate structure to either a new alignment or setback along the existing alignment.
Construct Temporary Bypass Channel (CB): Construction of a temporary bypass channel involves the temporary realignment or bypass of the GIWW in order to accomplish the permanent construction.
Construct Lock/Earthen Chamber (CL): Construction of the lock/earthen chamber involves the replacement of the existing gate structures with a lock structure at existing or new alignments. It includes two new sets of gates with an earthen chamber or reuse of the existing gates as the river side gate bay.

Table 3.3: Measures Specific to the Colorado River Locks

Lock Maintenance (LM): Lock maintenance would involve the continued maintenance of the current steel floodgates, concrete gatebay monoliths and machinery without any major rehabilitation of the structure.

Relocate Locks South (RS): This measure involves the construction of a new set of locks south of the existing locks.

Modify Dam (MD): This measure would involve the construction of a flow control structure such as sluice gates in the existing diversion channel dam. The gates would be operated to improve approaches impacted by the effects of river flow.

Modify Scheduled Maintenance of Locks (MS) – Non-structural: This measure would entail the modification of the maintenance of the lock to reduce delays due to lock shutdown.

Construct Mooring Facilities (CM) – Non-structural: This measure would involve the construction of additional mooring buoys on the east and/or west sides of the lock to provide adequate mooring facilities. It would prevent navigation delays by facilitating the breaking and remaking of tows when tripping is required. Also environmental impacts can be reduced as fewer tows would need to nose into the bankline as they await turn for a mooring facility.

Construct Sluice Gates (SG): This measure would involve the construction of sluice gates on an alternative channel alignment to reduce the velocities through the existing lock structure or a proposed new structural alternative.

Construct Southwest Cut to Matagorda (SC): This measure would involve the construction of an outlet for the old Colorado Diversion Channel into East Matargorda Bay. The outlet would consist of a gate/culvert system that would reduce currents at the intersection of the bypass channel and the GIWW on the east side of the east locks.

Construct Chevron in West Matagorda Bay (CC): This measure would involve the construction of a chevron at the mouth of the Colorado in West Matagorda Bay, creating a more effective flood discharge channel and reducing sedimentation upstream in the river.

After the development of the measures, the team combined them into an initial array of alternatives by checking them against the study objectives and constraints. For the initial screening analysis a rudimentary ranking tool was used to determine which alternatives could act as standalone alternatives and which ones would need to be combined to form complete plans. The measures were combined based on their capability not only address objectives and avoid constraints, but for engineering, environmental and economic feasibility, and for the level of navigation impact reduction provided before/after construction. **Table 3.4** illustrates how the alternatives were ranked and compared. Detailed discussion about how this combining tool was used follows.

Table 3.4: Measure Combining/Comparison Table

	Meets Objectives (3=High, 2=Medium, 1=Low)			Avoids Constraints (3=High, 2= Medium, 1=Low)		
Measures	**Obj. 1 – Reduce Operational Delays (Tripping)**	**Obj. 2 – Maintain Nav. on GIWW/COR**	**Obj. 3 – Manage Sedimentation into GIWW**	**Const. 1 – Reduce Impacts to Navigation (Time)**	**Const. 2 – Minimize Environmental Impacts**	**Const. 3 – Avoid Existing Fed Projects**
Brazos Measures						
FM	1	3	3	1	3	3
MR	2	3	1	1	3	3
CS	3	3	3	3	3	2
DC	2	2	2	2	2	3
MG	2	3	2	3	3	2
SR	3	2	1	2	2	1
RO	1	1	1	3	3	3
MP	1	1	1	2	3	3
CR	3	3	2	3	2	2
RG	2	2	1	2	2	2
CB	3	3	2	3	3	3
CL	3	3	3	3	3	3
WG	2	2	2	2	2	1
DM	3	3	3	3	2	3
Colorado Measures						
LM	2	2	1	2	3	3
MR	2	3	1	1	3	3
CS	3	3	3	3	3	2
DC	2	2	2	2	2	3
MG	2	3	2	3	3	2
SR	1	1	1	3	2	3
RS	3	2	2	3	2	3
MD	1	1	1	1	1	1
MS	2	2	1	2	2	1
CM	1	1	1	1	1	1
SG	2	2	2	3	2	3
SC	1	1	1	3	2	3
CC	1	1	1	1	1	1
DM	3	3	3	3	2	3

3.4.2 Combining Measures into Initial Array of Alternatives

Combining, modifying, and screening measures is an ongoing and iterative part of the planning process and is considered from alternative formulation through TSP selection, and during the PED phase of a study. Specific criteria are developed and used to help reduce or eliminate those measures or plans that cannot act as standalone plans. The criteria used for this phase of the study were strictly based on the measures ability to meet the study objectives and avoid constraints. The outcome of this process can result in specific measures or alternatives being dropped from further consideration. Reasons for elimination of specific measures can include consideration of whether a measure or alternative was implementable from an engineering, economic, environmental, or legal perspective.

To determine if the measures listed above would qualify for further evaluation, the PDT ranked them in the table above from 1 (high) to 3 (low) with those measures not meeting objectives or avoiding constraints receiving a 3 (low) and those meeting both objectives and/or avoiding constraints receiving a score of 1 (high), those measures that fell in minimally met objectives and mostly avoided the constraints were ranked as 2 (medium). Some of the measures are listed in both the BRFG and CRL and have different performance numbers because it is expected that at each location (roughly 40 miles between them) they could perform different in how it would meet objectives and/or avoid constraints. Those measures with high scores (2-3) and could act as standalone alternatives were retained. Standalone alternatives include those measures that were of enough complexity to act as a complete plan to address one of the study objectives on its own. Some measures ranked lower than others and could not be considered as standalone options, consequently they risked being screened from consideration altogether. To avoid removing a viable option the team put those that ranked low aside to be combined into viable alternatives as they could address one or more of the four problem categories listed in Section 3.4.1.

One example of this combining process in action considered improvements to current lock structures in the existing channel. A major concern was the impacts barges and boats have on the wooden guidewalls of the structure. A measure was to add guidewalls designed for impact loads and to better align tows for entry. This measure doesn't rank high enough as a standalone option, but when combined with other measures it could be used on the existing lock structures so this became a part of Alternative 1, under the floodgate/lock structure category. Each category was considered with different configurations until the team had an initial array of approximately 12 alternatives (including non-structural). With each alternative created we discussed its ability to meet the study objectives, avoid constraints, potential benefits, and if it were being implemented as part of standard navigation practices.

The non-structural measures for this study includes improvements to scheduled maintenance of the locks, improvements to towing schedules, enhanced use of AIS, or similar scheduling techniques, and adding mooring buoys and additional navigation lights to help guide barges. After several discussions it was determined that while these measures were beneficial, they were currently being implemented as standard navigation practices to address the ongoing issues (i.e. towing schedules), could be implemented by other federal agencies (i.e. U.S. Coast Guard); or are currently a part of other ongoing Federal studies (i.e. Mooring Basin Study). It is assumed that these non-structural measures would continue to be used in future actions to reduce accidents and are currently being used to increase safety as needed. Consequently, the team decided to focus on the structural measures. The non-structural alternative is listed in **Table 3.5** to show that the team considered it under the navigation efficiency improvements category, but it will not be discussed further beyond this section.

Table 3.5 illustrates how each of the measures were combined under each category to form an initial array of 11 alternative plans (excluding non-structural). Where applicable the floodgate and/or lock location are listed (abbreviated use: B = Brazos and C = Colorado) by alternative number. Specific scales and benefits for each plan were refined after the alternatives milestone.

Table 3.5: Categories for Initial Array of Alternative Plans

Floodgate/Lock Structures	Channel Alignments	Sediment/Water Management	Navigation Efficiency/Safety Improvements (Non-Structural/Small Scale)
No Action: Maintain Existing Floodgate/Locks in current condition with existing structures. Would also maintain current dredge cycles, no additional work to control flow or erosion, and no additional safety measures to reduce accidents/delays.			
B/C-Alt. 1: Minimal improvements to Existing Floodgate/Lock (modify schedule maintenance, modify gate machinery pit, improve guidewalls)	**B/C-Alt. 7:** Maintain Existing Channel Alignment (no structures) – Open Channel Alt. 3	**Alt. 10:** Open System (no structures) on existing alignment construct weirs, trail dike, or wingdams	**Reference Alt. for B/C:** Add additional mooring structures, buoys, improve AIS or other tow scheduling systems, and aids to navigation (i.e. guide lights)
B/C-Alt. 2: Major Rehab of existing Floodgate/Lock (All of Alt. 1 plus raise/relocate gate operator buildings, new guidewalls)	**B/C-Alt. 8:** Widen existing channel alignment (150ft.) *Includes bypass channel to maintain navigation during construction that can be closed or remain open for recreation access after construction.	**C-Alt. 11:** With Structures- where applicable (construct sluice gates, cuts near Matagorada (control flows), chevrons (sediment control), or modify channel dam to control flow)	
B/C-Alt. 3: Open Channel -Remove Floodgate/Lock Structures (include sediment/water management alternatives plus bypass channel)	**B-Alt. 9:** Move channel alignment north/south of existing alignment (5 options)		
B-Alt. 4: Convert Floodgate into Locks/Locks to Floodgates -retain riverside gates in existing alignment at Brazos -widen existing alignment to 150ft for Colorado			
C-Alt. 5: Relocate locks south of existing locks			
C-Alt. 6: Rebuild locks in same location and include a temporary bypass			

At this phase the team once again checked the plans to see if they met study objectives, avoided constraints, were constructible, had environmental impacts, and if they were economically justified. Preliminary cost were developed based on similar inland navigation and lock studies and used to help screen the initial array of plans to a focused array of alternatives that would be presented at the Alternatives Milestone Meeting (AMM).

3.4.3 Initial Array Screening Justification

The initial array of alternatives were compared to one another to see if they were similar in physical properties (i.e. channel width 75 feet), composition (i.e. guidewall improvements), location (i.e. channel realignments in same area), and how they would impact navigation down time during construction. Plans that failed to meet the objectives or avoid constraints were tentatively eliminated and where they were similar but with slight differences in potential benefits, they were combined as appropriate or left as standalone plans and retained for further screening.

Preliminary cost estimates and benefits were also used to help screen the alternatives further. Rough alternative cost estimates were developed using data from other similar projects. Four categories of economic benefits were identified for comparison to these costs; allision induced delay cost avoidance, allision repair cost avoidance, tripping delay cost reduction, and other delay cost reduction. These benefit categories were individually assigned to alternatives that would potentially achieve them, and the sum of these weighed against that alternatives cost. Alternatives 3 and 9 are expected to provide benefits in both the reduction of allision related costs (repair costs and delay reduction) and tripping reduction (tripping costs and delay reduction). Alternatives 4 and 6 are expected to provide benefits in tripping reduction only. Additional benefits in terms of environmental benefits and safety risk reductions were qualitatively considered as well.

Alternative 1 was tentatively eliminated from both locations because it did not maximize the planning objectives, primarily to improve navigation efficiency as it utilizes the existing gate and channel alignment with minimal changes.

Alternative 2 was retained for baseline comparison purposes for both locations. While it falls within the existing alignment it would produce slightly more benefits than those under alternative 1 by having minimum impacts due to large construction modifications. It would also have very few environmental impacts.

Alternative 3 was retained. Removing the floodgates/locks could potentially increase sedimentation, however upstream sediment loads have not greatly increased into this portion of the GIWW over the years as dredging is not used often in this location. Additional sediment modeling is recommended to confirm sediment loads.

Alternative 4 was combined and retained as a viable option (conversion from lock to floodgate or vice versa) to address bank to bank differences between the gate structures. For Brazos it was combined with proposed channel realignments (some considered structure conversion with new alignment), however for use at existing alignment it wouldn't reduce tripping delays. On Colorado it was retained as it would allow for a wider alignment (125 foot) which would eliminate tripping but it may have an impact on bridges/utilities.

Alternative 5 was eliminated under Colorado as it would have impacts to the environment and existing infrastructure. It would require a new channel alignment which would require new bridge construction, impacts to pipelines, and impacts to wildlife management areas.

Alternative 6 was retained for Colorado as it would allow for a temporary bypass, thus no interruptions to navigation and would impact fewer utilities.

Alternative 7 was combined with alternative 3 (removal of structures) to solve floodgate/lock structure problems. It was conditionally retained as it could be used as a baseline when considering various alternatives on the existing channel alignment.

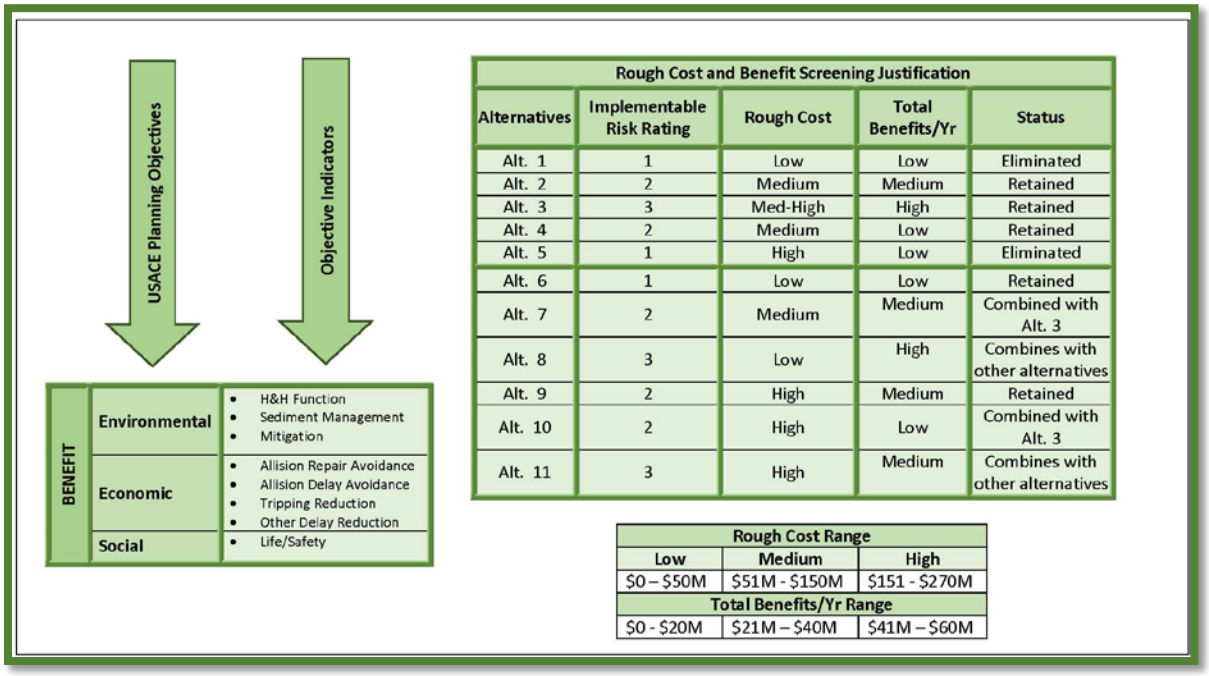
Alternative 8 was retained because of its similarities and combinability with other alternatives (Alts. 4, 6 and 9). It would allow for the widening of the existing channel from its current width of 75 feet up to 150 feet. As a standalone with would cause impacts to sediment and flows, especially during high river stages.

Alternative 9 was retained. It includes new locks in a potentially new alignment. As the team evaluated further, it was determined that there are approximately 5 different channel alignment configurations (A-E) that could take place in the area. Upon further inspection of existing data, it was determined that some alignments (B-D-E) would not avoid study constraints as they would increase potential real estate cost, would impact critical infrastructure, and would impact wildlife management areas in the vicinity. Consequently, the team settled on use of two alignments (existing alignment (A) and the use of new alignment (C)).

Alternative 10 this plan was combined with Alt. 3 as it is an array of options that can apply to the open channel alternatives at either the Brazos or Colorado locations.

Alternative 11 this plan applies primarily to the Colorado location. It would allow a cut (East Matagorda Bay) to reduce adverse currents in the east approach to the east lock. The chevrons may be used in conjunction with channel maintenance structures and will be determined as the study progresses. It can be combined with structural alternatives.

The team then conducted a final round of screening using construction cost from similar navigation and lock studies to develop some preliminary cost estimates as a comparison tool. Figure 3.5 provides a comparison of estimated NED benefits focused on four benefit categories for economics, the estimated implementation risk of the various alternatives (1 doesn't buy down risk, 2 undetermined or minimally buys down risk, and 3 buys down risk), and options for achieving these benefit to provide a proportional estimate of NED benefits captured through implementation of project alternatives, details for this initial justification are included in the Economic Appendix B.



Rough Cost and Benefit Screening Justification

Alternatives	Implementable Risk Rating	Rough Cost	Total Benefits/Yr	Status
Alt. 1	1	Low	Low	Eliminated
Alt. 2	2	Medium	Medium	Retained
Alt. 3	3	Med-High	High	Retained
Alt. 4	2	Medium	Low	Retained
Alt. 5	1	High	Low	Eliminated
Alt. 6	1	Low	Low	Retained
Alt. 7	2	Medium	Medium	Combined with Alt. 3
Alt. 8	3	Low	High	Combines with other alternatives
Alt. 9	2	High	Medium	Retained
Alt. 10	2	High	Low	Combined with Alt. 3
Alt. 11	3	High	Medium	Combines with other alternatives

Rough Cost Range		
Low	Medium	High
$0 – $50M	$51M - $150M	$151 - $270M
Total Benefits/Yr Range		
$0 - $20M	$21M – $40M	$41M – $60M

Figure 3.5: Rough Cost Estimate and Benefit Screening Justification

Based on the above considerations the PDT eliminated those alternatives that did not meet study objectives, avoid constraints, or where estimated preliminary costs significantly exceeded estimated potential benefits. Those that provided a medium to high benefit and whose preliminary estimated cost, while high, provides a maximum level view of all potential cost for comparison screening and could yield a favorable benefit to cost ratio, were retained.

Six alternative plans, including the No-Action alternative, were identified as the focused array that could be constructed at either location as part of the system (similar plans applied at both locations) or as a standalone alternative plans that addresses specific problems at each structure (BRFG or CRL), individually. The plans at each structure could be constructed individually if a phased approach was needed, or as part of the navigation system to improve navigation efficiency. These were presented during the Alternative Milestone Meeting on September 14, 2016 and approved by HQ for further evaluation and comparison. The evaluation alternatives include:

Table 3.6: Focused Array of Alternative Plans

Alternative	Location	Description
No Action Alt.	BRFG and CRL	Existing condition, no change in operation and maintenance of current structures
Alt. 2	BRFG and CRL	Major rehab of existing floodgates/locks
Alt. 3	BRFG and CRL	**BRFG:** Remove existing gates. Install 125 feet minimum width gates each side of river, located further from river. Include temporary bypass channel. **CRL:** Remove existing structures for open channel. Includes bypass channel.
Alt. 4	BRFG and CRL	**BRFG:** Convert floodgates to locks. Retain existing gates and install additional 75 feet width gates to form the locks. **CRL:** Convert locks to floodgates. Remove existing gates and locks. New channel with 125 feet bottom minimum width, with new 125 feet minimum width gates.
Alt. 6	CRL	Rebuild locks at same location and on existing alignment with wider gates and channel. Remove existing gates, install new 125 feet minimum gates. Create 125 feet bottom minimum width channel. Includes temporary bypass channel.
Alt. 9	BRFG	Construct new alignment north of the existing alignment which is along the existing barge mooring facility. There are four configurations: no gates, gate each side of river, gate each side of river with sediment/flow control features in the existing alignment, and locks each side of the river.

After the AMM the team also looked at all possible combinations of the five alternatives that could be modeled and identified approximately 23 different system combinations that would each have to undergo an additional round of screening by compiling current available data to define the existing condition, problems and opportunities by category and defined the alternative conditions as expected changes vs existing condition. These were evaluated based on cost, hydrographic data, benefits, environmental impact, and best professional judgement. These system combined alternatives are listed in Table 3.7 below and are color coded only for organizational purposes in tracking each of the potential combinations.

The combined alternatives were then screened using a tool developed by the Planning Center of Expertise for Inland Navigation (PCXIN). The existing conditions, problems, and opportunities by category (tripping, outages, and miscellaneous (repair, dredging, disposal or other related cost) were refined and identified the alternative conditions as expected changes vs existing conditions. These benefits were evaluated using the above categories and screened out infeasible alternatives and rank the remaining using traditional benefit/cost metrics. For details see Economic Appendix B.

Table 3.7: System Combinations Based On Focused Array of Alternatives

Open Channel (B)+ Rehab existing (C) (9a/2b)	Open Channel (B)+ Convert locks to floodgates (C) ((9a/4b)	Open Channel (B)+ Rebuild New locks (C) (9a/6)	Open Channel (C)+ Convert floodgates to locks (B) (3b/4a)	Open Channel (C)+ Rebuild New floodgates (B) (3b/3a)	Open Channel (C) + New Alignment (B) (3b/9b)	Open Channel (B) + (C) (3b/9a)	Rehab existing (C)+ Convert (B) (2b/4a)	Rehab existing (C) +New gates (B) (2b/3a)
Rehab existing (C) + New alignment (B) (2b/9b)	Convert (B)+ Convert (C) (4a/4b)	Convert (B)+ Rebuild locks (C) (4a/6)	New gate (B)+ Convert to lock (C) (3a/4b)	New gates (B)+ Rebuild locks (C) (3a/6)	New alignment (B)+ Rebuild locks (C) (9b/6)	New alignment (B)+ Convert (C) (9b/4b)	New alignment (B) + Open Channel (C) (9c/3b)	New alignment (B)+ Rebuild(C) (9c/4b)
New alignment (B)+ Convert floodgates (C) (9c/6)	New alignment (B)+ Rebuild locks (C) (9d/6)	New alignment (B)+ Convert (C) (9d/4b)	New alignment (B) + Open River (C) (9d/3b)	New alignment (B)+ Rehab (C) (9d/2b)				

The planning tool further helped to define the existing and alternative navigation impacts as a function of series of input parameters, and computes navigation impacts dynamically based on those inputs. The tool attributes existing delays to different impact categories using available data and roughly calibrates existing condition impacts against other available estimates obtained by TXDOT, the Texas Transportation Institute (GIWW Master Plan), and site operations personnel. The cost and benefits of each alternative were compared against one another and those alternatives where the benefit to cost ratio was significantly less than one were screened out. An example of how the input parameters were used for BRFG is shown in Table 3.8.

The alternative screening began with sub-division of identified problems/opportunities in the existing condition at both project into individual impact categories. These categories, including tripping delays, outage delays, and other impact costs, were further sub-divided by cause of delay/cost. Tripping delays are incurred by traffic transiting one or both projects when multi-barge tows must break up to transit in more than one cut or trip. Tripping delay sub-categories represent various reasons why multi-barge tows would be required to trip; either because the arriving tow as configured could not pass through the project due to width restrictions, because of adverse river conditions, or for other reasons. Outage delays are incurred by traffic during closures of a project to navigation. These closures can occur because of allisions and related repairs, as well as adverse river conditions. The final category of impacts includes project repair costs resulting from allisions, as well as annual maintenance and dredging costs. Once done, a spreadsheet was developed which defined the impacts within each category as a function of a series of input parameters. For the existing condition these parameters were drawn from existing data; namely time series hydraulic data at both river crossings, Lock Performance Monitoring System (LPMS) data on tow arrivals, tripping, and processing times, LPMS data on recording project closures from the Stall/Stoppage dataset, and notices to navigation for traffic disruptions. For the alternative conditions, changes in parameters were elicited from the team. The screening spreadsheet model was then used to recompute delays, their associated costs, and other impact costs in both the existing and alternative conditions, and from the delta estimate a rough benefit-cost ratio. In characterizing the existing and alternative conditions, conservative input assumptions were made in all cases, such that these benefit-cost ratios could be used to screen out alternatives with a

low probability of type 1 error (i.e. screening out viable alternatives), but with a reasonable probability of type 2 error (retaining non-viable alternatives)."

Table 3.8: Sample Input Parameters for BRFG

BRFG	Rehab existing + guidewalls (2a/2b)	Rebuild New floodgates (3a)	Open Channel (9a)	New Alignment - Gates (9b)	New Alignment - Gates + Control (9c)	New Alignment - Locks (9d)
Change in Base Transit Time	100%	80%	50%	80%	80%	110%
"Chamber" Length	1000	1000	1000	1000	1000	1000
"Chamber" Width	75	125	125	125	125	125
Lock?	No	No	No	No	No	Yes
Reduction in other tripping	10%	60%	100%	80%	80%	90%
Velocity Threshold (mph)	2	3	5	5	5	5
Head Differential Threshold (ft)	0.7	1.2	1.8	1.8	1.8	1.8
Accident % Reduction	50%	80%	100%	90%	90%	90%
% Reduction in Velocity Related Closures	0%	50%	75%	50%	75%	75%
% Reduction in Head Diff Related Closures	0%	50%	95%	50%	100%	100%
Changing Dredging Cost	0	0	+2M	0	0	0
WOPC Maint/Rehab Costs	2.6M	2.6M	2.6M	2.6M	2.6M	2.6M
WPC Maint/Rehab Costs	2.6M	2M	0	2M	2M	2.3M
Total Cost ($000)	**$42,000**	**$130,000**	**$95,000**	**$190,000**	**$190,000**	**$326,000**

A preliminary benefit cost analysis was conducted on each of the remaining system combined alternatives and determined the net annual benefits. The remaining alternatives underwent an additional round of screening and further refinement as the team analyzed the data from field and survey analysis and other modeling. While the open channel had the highest BCR in this second round of screening, further assessment and design of the rehab of the existing facility remained an option for both locations and would have fewer environmental impacts which are also considered in the final decision. At a May 2017 meeting the Vertical Team concurred with the methodology presented and requested that the model used should be certified for single use (approved in December 2017).

3.4.4 Final Array of Alternative Plans (NEPA required)

The final array of alternatives that were evaluated and compared include the following: No Action, Open Channel, Rebuild 125ft Floodgates, New Channel Alignment with new Gates, and Rehabilitation of Existing Structures. The economics model inputs the alternatives for each location and combines/compares them to assess system functionality (i.e. Open Channel at BRFG and Open Channel at CRL, or Open Channel at BRFG and Convert Locks to Floodgates at CRL), they included:

- Plan 1 - No Action on BRFG and CRL
- Plan 2 - Open Channel at BRFG and CRL (9a and 3b)
- Plan 3 - Open Channel at BRFG and No Action at CRL (9a and No Action)

- Plan 4 - Rebuild 125 foot Floodgate at BRFG and Open Channel at CRL (3a and 3b)
- Plan 5 - Rebuild 125 foot Floodgate at BRFG and No Action at CRL (3a and No Action)
- Plan 6- New alignment (C) and new gates with control structure at BRFG and Open Channel at CRL (9c and 3b)
- Plan 7 - New alignment (C) and new gates with control structure at BRFG and No Action at CRL (9c and No Action)
- Plan 8 - Rehab Existing Structures at BRFG and No Action at CRL (2a and No Action)
- Plan 9 - Rehab Existing Structures at CRL and No Action at BRFG (2a and No Action)

3.5 Engineering Analysis of Final Array of Alternative Plans

Hydraulic analysis of the final array of alternatives was necessary to evaluate how the alternatives affect the salinity, sedimentation volumes and patterns along the GIWW and velocities at the river crossings. The sedimentation analysis was particularly critical to identify whether a particular alternative generates unacceptable maintenance costs or poses risk of the inability to maintain the GIWW.

3.5.1 Hydraulic Analysis

A numerical modeling study was performed to evaluate proposed project alternatives using the AdH Adaptive Hydraulics model. The purpose of the numerical model study was to evaluate the impacts to navigation and the environment associated with a set proposed alternatives, including removal or reconfiguration of the lock system. To develop the AdH model, bathymetric surveys and sediment samples were collected in the project area. The models were validated against observed water levels, velocities, salinities, sedimentation. Once a sufficient validation was achieved for existing conditions, the models were altered to represent the proposed alternatives. Comparison of modeled alternatives provided useful information in terms of TSP selection.

The changes in sedimentation in various areas at the river crossings were used to develop O&M dredging estimates for the various alternatives. **Tables 3.9 and 3.10** show the changes in sedimentation volumes relative to FWOP at Colorado River and Brazos River. For the Colorado open channel alternative, a significant increase in sedimentation in the GIWW was noted compared to the FWOP. For the Brazos Alternative 9a, significant increases in sedimentation are noted for the Freeport Channel. The 3a.1 Brazos Alternative shows slight increases in sedimentation along the GIWW west of the crossing compared to the FWOP.

Table 3.9: Average Annual Sediment Deposition at CRL

Area of Interest	Results Based on 2016 Simulation Regression Analysis		
	Average Annual Deposition Existing FWOP (cubic yards)	Average Annual Deposition Open Channel –Alt. 3b (cubic yards)	% Difference
GIWW East	88,921	476,787	436
GIWW West	212,956	834,907	292
Bypass Channel	70,519	171,101	143
Intersection	11,789	30,017	155
Delta 1	2,432,825	2,206,549	-9
Delta 2	651,095	791,945	22
Delta 3	1,450,778	765,962	-47
Offshore	360,739	799,477	122

Table 3.10: Average Annual Sediment Deposition at BRFG

Alternative	West GIWW	Brazos Basin	East GIWW	Freeport Channel	Brazos Delta	Freeport Offshore	Total in Zones Requiring Maintenance
Existing/2a	554,769	48,000	890,769	295,385	44,382,462	208,726	1,788,923
3a	493,846	59,077	902,769	316,615	44,332,615	190,864	1,772,307
	(-11%)	23%	1%	7%	0%	(-8%)	(-0.1%)
3a.1	653,130	58,332	902,653	326,420	44,000,887	196,239	1,940,535
	18%	22%	1%	11%	(-1%)	(-6%)	8%
9a	781,846	92,308	1,079,077	978,462	42,026,769	854,614	2,931,693
	41%	92%	21%	231%	(-5%)	309%	64%
9b	780,923	96,923	1,044,000	550,154	43,232,308	396,989	2,472,000
	41%	102%	17%	86%	(-3%)	90%	38%
9c	781,846	107,077	1,044,000	550,154	43,218,462	395,887	2,483,077
	41%	123%	17%	86%	(-3%)	90%	39%

Velocity and stage data for the various alternatives was provided to the economic teams to determine the delays associated with each alternative due to the river conditions.

3.5.2 Structural Analysis for BRFG and CRL

Rehabilitation of the existing projects was assessed without the use of detailed engineering reliability or economic risk analysis. These analysis are typically used to estimate the expected navigation impacts and other economic impacts due to operating old and unreliable equipment and structures. Detailed reliability risk analysis was not performed because the focus of the feasibility study was accident risk and navigation delays, not a major rehabilitation report. Rehabilitation of the project was based on past practices and expert elicitation from the operating personnel on what components needed to be rehabilitated to ensure continued reliability of the existing projects. The key issues of the existing structures were location and function of gate operating machinery, damage to guide wall approaches particularly on the river side, damage to existing gates to due normal operation of vessel pass through, and large amount of crustacean life accumulation on gates over time which has led to substantial weight increases. The structural rehabilitation alternatives focused on providing updated gate operating machinery that can operate submerged if necessary and appropriate new housing for specific components. Updated electrical systems featuring new wiring and controls would be integrated with the machinery. The gates would be removed, repaired as necessary, sandblasted, and coated with a paint system best suited for saltwater environment of close proximity to the Gulf. The existing sheet pile approach guide walls would be replaced as necessary with a new composite panel system that can resist impacts to alleviate damage to the guide walls.

The alternatives consisting of structure replacement at the Brazos River floodgate would consist of new 125 foot wide sector gates that match the authorized GIWW channel width. The existing gates/locks at both sites are 75 foot wide. The new sector gates features would also include guide walls, channel rip rap, dewatering equipment, and dewatering storage. The dewatering system would be designed to allow for continued passage through the GIWW while gate recess can be dewatered, gates serviced, and put back into operation. The structures would also feature new control houses for both personnel and operating machinery.

Quantity take-offs for alternatives involving structures were performed to generate costs estimates. Original drawings were used to estimate concrete wall demolition, gate removal, guide wall removal and gate rehabilitation/painting. For new structures, slab/wall thicknesses were estimated based on similar sector gates in the Louisiana hurricane protection system. Gate member sizes were similarly based on known structures. This along with typical guide wall design, dewatering systems, machinery sizes, electrical, pre-engineered control houses, and channel rip rap were quantified for the cost estimate.

3.5.3 Cost Estimates

The project cost estimate for the GIWW BRFG and CRL Systems Feasibility Study was developed in the MCACES MII cost estimating software and used the standard approaches for a feasibility estimate structure. An analysis of each line item evaluating quantity, production rate, and time, together with the appropriate labor, equipment, materials, crews, unit prices, quotes, sub- and prime contractor markups. The estimate assumes a typical application of tiering subcontractors. The cost estimate was prepared based on readily available New Orleans District (MVN) and Galveston District (SWG) data and quantities provided for CRL by MVN Structures Branch and for BRFG by TXDOT. This philosophy was taken wherever practical and supplemented with estimating information from other sources where necessary such as the previous contracts for the same type work on these same structures, quotes, bid data, and A-E estimates. The intent was to provide or convey a "fair and reasonable" estimate which depicts the local market conditions.

All of the construction work (e.g., sector gate structures, dredging, excavation, dewatering, pilings, rock, etc.) is common to the Gulf coast region. The construction sites are accessible from land and water. Access is easily provided from the Gulf of Mexico, GIWW, or various local highways. Contingencies were also developed using the USACE Abbreviated Cost Risk Analysis (ARA) program based on cost risks determined by the PDT. A separate ARA was prepared for each alternative to help differentiate between the different alternatives. Access is easily provided from the Gulf of Mexico, GIWW, or various local highways. See **Table 3.11** below for summary of first construction cost:

Table 3.11: Alternative First Construction Costs ($000)

Colorado River Locks	
Alternative	**First Construction Cost**
Existing Condition	$0.00
2B - Major Rehab	$48,409,000.00
4a - Remove R/S Gates	$36,862,000.00
Open Channel	$21,592,000.00
Brazos River Floodgates	
Alternative	**First Construction Cost**
Existing Condition	$0.00
2a Rehab	$44,940,000.00
3a	$266,819,000.00
3a.1	$147,818,000.00
9a	$29,303,000.00
9b	$258,087,000.00
9c	$272,226,000.00

3.5.4 Operations and Maintenance (O&M) Costs:

Anecdotal O&M data was supplied by SWG Operations Division personnel based on historical data including yearly maintenance costs on the structures, major maintenance cost and frequency on the structures, average yearly dredge quantities along the GIWW, estimated dredging costs based on recent dredging contracts, and remaining capacity of the existing disposal sites.

A comparison of the historical dredge quantities was made versus the sediment deposition predicted by the AdH models. Because the AdH models output total of channel deposition included quantities from top of bank to top of bank and does not account for the consolidation that may occur in the deposited material, the yearly historical dredge quantities were less than those predicted by the AdH model. Therefore, the O&M dredging costs for the various alternatives was developed by pro-rating the quantities predicted by the AdH model by the ratio of the AdH predicted sediment values for the existing condition to the actual historical dredge quantities.

3.6 Hurricane Harvey

3.6.1 Hurricane Harvey Impacts to Study Analysis:

As the team was nearing completion of evaluation and comparison of the above alternatives, Hurricane Harvey struck the region from August 24-28, 2017. The team was asked to assess potential impacts (increased sediment or damage to the structures) as a result of the storm and determine if it would impact our capability to meet the planned TSP deadline. The storm did not directly impact the structures themselves, however flows/velocities were increased in the channels and increased sediment deposition in the system, especially at CRL.

Analysis of Hurricane Harvey allowed the modelers to recalibrate the AdH models to get a better representation of the hydrodynamics, especially the sedimentation rates that occur during extreme flooding, increasing confidence in the model's ability to predict the effects of proposed project alternatives. While some sediment material may have already built up around the locks since the last dredge cycle, the AdH models show that the channel configuration contributed significantly to the increase sediment build up at the gates and in the fore-bays at CRL. This configuration would continue to be an issue with more frequent storm events pushing sediment material through the area, causing the locks to become inoperable, and contributing to shipping delays as sediment is removed by dredging.

3.6.2 Development of Hybrid Alternatives (Stakeholder Engagement):

At an October 2017 meeting with navigation industry groups, concerns were raised about the open channel crossing and the effects of the increased currents and sedimentation on the Freeport Harbor. A hybrid alternative (3a.1) was developed which provided an open channel along the existing alignment on the west side, where deposition of sediment is not as severe as the east side, and a replacement 125 foot flood gate on the east side. At the same time of the development of the hybrid alternative for the Brazos River crossing, the team recommended that removal of the river side flood gates be investigated for the Colorado River crossing. This decision was made as result of initial O&M dredging costs for the open channel alternative appearing high. The removal of the river side gates would reduce allisions and tripping frequency due to the longer forebay. The Adh models were re-run for the hybrid alternatives and cost estimates developed.

3.7 Comparison of Alternatives

The team then compared the alternatives to the decision criteria. Criteria used to evaluate the remaining alternatives include a comparison to see if objectives have been met, improvements to system functionality, environmental impacts, and evaluation of costs and benefits of the proposed modifications. At each stage of the process the team looked at the measures, the initial alternatives, the focused alternatives and cross checked them to ensure we were meeting the intent of each objective which also address the study problems; and to determine what the environmental impacts would be.

While rehabilitation of the structures would be a least cost option, it did little in the way of meeting the objectives or improving the navigation functions. The "hybrid" plan(s) for Brazos/Colorado would improve the navigation on the system by creating bigger forebays for navigation traffic, thus reducing accidents and allowing for continued sediment management in the GIWW. The open channel would reduce the cost of maintenance and accidents that happen at the structures, however there is considerable uncertainty in the sediment modeling to determine in any given year the sediment transport through the system or where it would cause shoaling and potential grounding of vessels, as well as shipping delays due to dredging activities. Additionally, the open channel would have increased impacts to downstream navigation operations by transporting sediment down into areas such as Freeport as well as critical environmental habitats near Matagorda Bay which are a part of ongoing studies in the region.

3.7.1 Economic Analysis of the Final Array of Plans

To quantitatively analyze and compare alternatives, monetized benefits of the above alternatives were estimated using a stand-alone model developed for the study, and compared to estimated costs to develop benefit-cost ratios and net benefits estimates. These metrics were used to select the NED plan, the plan which reasonably maximizes net benefits. Costs were developed by the engineering team. The economic analysis was primarily focused on the estimation of baseline FWOP and alternative transportation costs.

These benefits were calculated utilizing the Waterway Limited Cost Estimator for Navigation (WLCEN) model. This custom model was developed to estimate these benefits in lieu of the traditional equilibrium modeling approach. Early in the study process, several unique characteristics of the projects analyzed were identified which necessitated this non-standard modeling approach. These characteristics are as follows:

1) Nature of significant problems/opportunities – The primary identified existing condition issue impacting traffic on this stretch of the GIWW is the frequency of allisions (vessels colliding with gate or lock structures) and the resultant closures of these projects to affect repairs. In particular at the Brazos River Floodgates, a significant number of accidents occur yearly, and result in periodic closures for repairs. These closures cause direct delays, as well as indirect delays resulting from queuing following the service disruption event. These service disruption events are scheduled closures, occurring Monday through Friday, 7:00 to 17:00, for the duration of the repair. As such these closures do not result in significant, long duration outages, but rather frequent short duration closures which significantly slow the processing of traffic.

2) Lack of alternate overland modes – Interviews conducted by Martin and Associates (by contract with TXDOT) with shippers using the analyzed stretch of the GIWW (Texas Lehigh Cement, Formosa, Philips 66, Oil Tanking, Dow Seadrift, Citgo Refinery, Nustar Energy, and Valero Refinery) have indicated that existing condition delays do not generally result in the use of overland routes, as they do not have the ability to use truck or rail as a substitute mode given waterway service disruptions. Interviewed shippers stated that only in very rare cases in which a week or more of contiguous service disruption occurred would inventory stocks be jeopardized. As the

majority of service disruption events are scheduled (resulting from accidents) they do not resulting more than 10 hours of contiguous closure.

3) Traffic Commonality – The Brazos River Floodgates and Colorado River Locks are separated by 40 miles, with few commercial docks located between the projects. The average width of the GIWW between the Brazos and Colorado Rivers is estimated between 300-450 feet with the narrowest point being a 130 feet wide bridge underpass located at approximately mile 418 on the GIWW. Several streams and rivers flow into the GIWW along this route, with a few areas of minor open water navigation. Aerial imagery shows multiple fleeting/mooring locations in between, but no infrastructure for loading or unloading barges along the GIWW. The San Bernard River meets the GIWW at GIWW mile 405 and supports limited commercial navigation for approximately 26 miles. This route is highly congested due to bends, river crossings, and private docks. Approximately 500,000 tons of commercial navigation on average takes place along this waterway.

   According to lock operators, less than 1% of traffic traverses one lock or gate and turns up the Brazos River, while approximately 1 million tons on average utilizes one Colorado Lock and travels up the Colorado River without crossing the other lock. **Table 3.12** shows the average annual tonnage at Brazos and Colorado from 2010 through 2014 demonstrates the high level of commonality between projects.

Table 3.12: Average Annual Tonnage Commonality

Project Name	Average Tonnage	Average Through All	Commonality
Brazos Floodgates	22,497,593	21,038,012	97%
Colorado Locks	21,607,965		99%

Source: Waterborne Commerce Statistics 2010-2014

The general theory underlying the model is that, due to the nature of service disruptions and the lack of available alternate overland modes, the vast majority of existing condition traffic delay or disruption impacts and thus the degree to which an alternative can reduce these impacts (benefits) can be closely approximated by computing the total cost of vessel delays in the existing and alternative conditions and taking the difference.

An equilibrium analysis would quantify the consumer surplus, or willingness-to-pay for barge transportation in the existing condition and equilibrium traffic levels, and again in each analyzed alternative condition, and subtract the latter from the former to estimate benefits in terms of rate savings. This is depicted in 3 below. A system improvement shifts the supply curve from S1 to S2, reflecting a reduced price to provide any given quantity of barge transportation. At the new equilibrium the area A + B+ C represents the with-project willingness-to-pay, and the difference, B + C, represents the benefit. The area B represents the increase in consumer surplus for traffic already using the waterway, while the area C represents the added consumer surplus for traffic which shifts from other transportation modes onto the waterway in response to the system improvement.

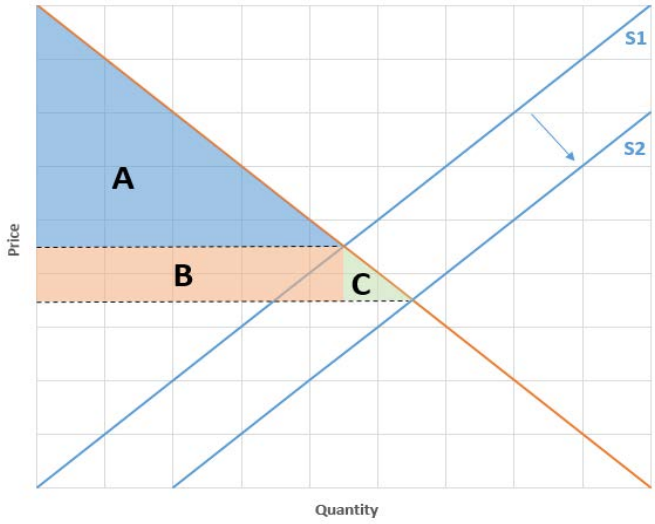


Figure 3.6: Willingness-to-Pay Visualization

Given however a sharply inelastic demand curve, as would represent the unavailability or high relative cost of alternate overland modes, the relative size of the area C will shrink to a very small contribution to the total benefit of any alternative. Put another way, if the amount of traffic on the system, as indicated by shippers, is very insensitive to the price of moving commodities on that system, reductions in that price will almost entirely be enjoyed by current users of the system. If the system is in effect a closed one, the vast majority of benefits will accrue to current users of the waterway, and can be accurately captured by just the area B in the figure above.

Extending from this premise, if the total equilibrium cost of waterway transportation for a given movement involves all transportation rates between origin and destination, so long as demand is very inelastic and under analyzed alternatives these origin-destination movements remain essentially unchanged, knowing or quantifying this total linehaul cost is not necessary to evaluate alternative benefits (the area B in the figure above) as all components of this linehaul cost other than delay costs will be the same in both the existing condition and alternative condition. As such the benefits of a given alternative can be defined as the reduction in total vessel delay in hours multiplied by the hourly operating cost. The model is designed to estimate this total vessel delay.

This vessel delay time can be further broken down into four categories; processing time, which is the time tows spend processing through project non-inclusive of delay; queuing time, which is the time tows spend waiting in queue to begin processing; tripping time, which is the time tows spend breaking, reassembling, and performing other tasks necessary to trip multiple barges; and finally closure delay time, which is the time tows spend delayed due to river or accident related closures. These delay categories are the primary output of the WLCEN model.

The model performs Monte Carlo uncertainty analysis, by sampling uncertain input parameters from probability distributions. Uncertain inputs include accident probabilities, ranges of river condition, tow size and other characteristics, and others. This results in a distribution of possible outputs (total transit time), which is representative of output uncertainty. The following figures illustrate the distribution of baseline FWOP condition outputs (total annual transit cost for all traffic, in dollars) for the Brazos River Floodgates and Colorado River Locks, respectively.

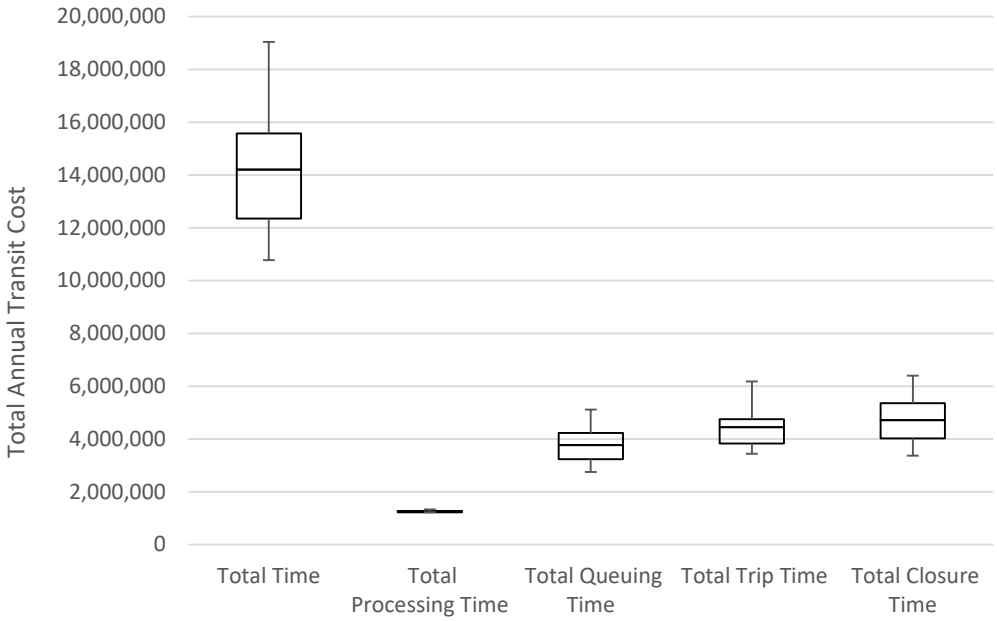


Figure 3.7: Baseline Total Transit Cost, BRFG

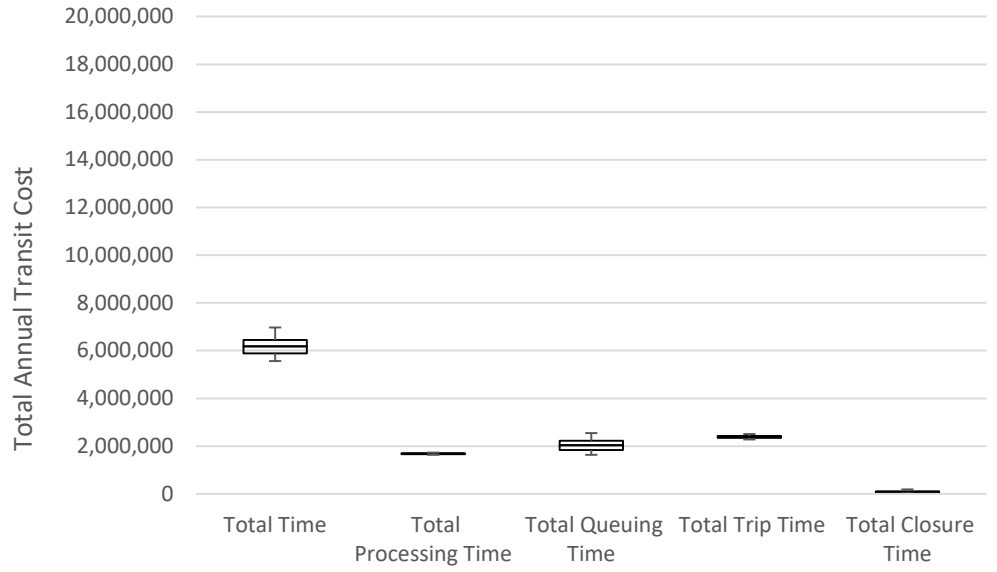


Figure 3.8: Baseline Total Transit Time, CRL

Delays are estimated in the FWOP and with project conditions and the net reductions translated into benefits. Delay times were monetized using average hourly vessel operating cost for various activities. Avoided FWOP accident repair costs represent an additional benefit category. First Cost of Construction, as well as incremental (increase or decrease in) Operation and Maintenance (O&M), Operations, Maintenance Rehabilitation (OMRR&R), Upland/Off Shore Disposal, Bank Realignment, Accident and

Tripping Reductions, Real Estate (LERRDS), and mitigation and monitoring costs are all included in as alternative costs. Due to the significant relative value of both baseline and alternative O&M costs, benefit-cost ratios shown below are computed as benefit to incremental costs.

As the system analyzed includes two projects, alternatives at both projects were analyzed separately (the project specific alternative analyzed in combination with the baseline condition at the other), and together in all possible permutations. Because the project operates as a system, changes at one project can have significant impacts at the other. If for example accident frequency is reduced at the Brazos River Floodgates, the size and frequency of large queues at that project will reduce, which will in turn reduce the frequency of large clusters of down bound tows arriving consecutively at the Colorado River Locks, where they will incur additional queuing delay. **Table 3.13** illustrates the annualized cost of each permutation alternatives and their net benefits as well as their benefit-to-cost ratio. The Alternative name in the first column represents the alternative at Brazos first, followed by the alternative at Colorado, with "EC" denoting the existing condition.

Table 3.13: System Benefit Analysis for Alternatives
October 2017 Price Levels and 2.75% Interest Rate

Alt ID	Brazos River Floodgates	Colorado River Locks	Total Annual Cost	Total Annual Benefit	Net Benefit	Benefit-Cost Ratio
EC-EC	Existing	Existing	-	-	-	-
EC-3b	Existing	Open Channel	5,956,000	7,737,000	1,781,000	1.3
EC-4b.1	Existing	River Side Gate Removal	1,412,000	8,219,000	6,807,000	5.8
9a-EC	Open Channel	Existing	11,467,000	18,569,000	7,102,000	1.6
9a-3b	Open Channel	Open Channel	17,423,000	24,390,000	6,967,000	1.4
9a-4b.1	**Open Channel**	**River Side Gate Removal**	**10,860,000**	**22,321,000**	**11,461,000**	**2.1**
3a-EC	125' Gates Existing Align	Existing	10,505,000	11,432,000	927,000	1.1
3a-3b	125' Gates Existing Align	Open Channel	16,358,000	17,421,000	1,063,000	1.1
3a-4b.1	125' Gates Existing Align	River Side Gate Removal	11,918,000	17,289,000	5,371,000	1.5
9c-EC	125' Gates Align C	Existing	20,470,000	9,715,000	(10,756,000)	0.5
9c-3b	125' Gates Align C	Open Channel	26,426,000	15,205,000	(11,221,000)	0.6
9c-4b.1	125' Gates Align C	River Side Gate Removal	19,863,000	13,194,000	(6,669,000)	0.7
3a.1-EC	125' Gate East/Open West	Existing	7,782,000	14,600,000	6,817,000	1.9
3a.1-3b	125' Gate East/Open West	Open Channel	13,738,000	20,376,000	6,638,000	1.5
3a.1-4b.1	**125' Gate East/Open West**	**River Side Gate Removal**	**7,175,000**	**18,252,000**	**11,077,000**	**2.5**

As detailed in the above table, Alternative 9a (open channel) at the Brazos River and 4b.1 (river side gate removal) for Colorado yield the highest net benefits at $11,461,000 with a BCR of 2.1. There is significant uncertainty however with regards to the rate of sedimentation in an open system and how it would impact future navigation functionality and what environmental impacts may be associated with increased sediment loads into areas that are currently important habitats for fishery/aquatic resources.

Additional uncertainty exists as to the logistics of executing the dredging activities costed in the cost/benefit analysis, in particular if sedimentation volumes exceed those modeled. How frequently dredging would need to occur, whether or not multiple mobilization and demobilization costs for dredge contracts within one year could be incurred, whether or not the capability exists to dredge as necessary to maintain a navigable channel without impacts to traffic are uncertainties that have not been sufficiently captured in the analysis to date.

Finally industry representatives of the Port of Freeport have indicated that during periods in which the existing east gate at Brazos River is open increased cross currents are observed in Freeport Channel.

It was expected that given an open channel condition would increase velocities that could impede traffic in and out of the Freeport Channel. With these considerations in mind the team determined that, while the highest Net Benefits are found in the open channel (9a) at Brazos and Gate Removal (4b.1) at Colorado plan, the potential risk and uncertainty of environmental, navigation, and system impacts may have significant impacts over time. The next best alternative that avoids these critical uncertainties in continued system function would be open channel on the west side and a new 125 foot gate on the east side (3a.1) at Brazos and Gate Removal (4b.1) at Colorado. The following tables break out the benefits and cost for the 3a.1 – 4b.1 alternatives. These are presented for both projects in the system, and together as the system total benefit and cost for comparison purposes.

Table 3.14: Benefit-Cost Detail, Tentatively Selected Plan, Brazos River Floodgates
October 2017 Price Levels and 2.75% Interest Rate

Benefit - BRAZOS RIVER FLOODGATES

	FWOP	FWP	Benefit
Transit Time			
Processing Time	$1,279,965	$870,375	$409,590
Queuing Time	$3,768,769	$648,048	$3,120,720
Tripping Time	$4,449,567	$1,256,168	$3,193,399
Closure Delay Time	$4,712,640	$453,599	$4,259,041
Total	**$14,210,940**	**$3,228,190**	**$10,982,750**
O&M			
Normal O&M	$1,750,000	$1,750,000	$0
Maintenance Dredging	$17,904,989	$20,023,182	$0
Periodic Major Maintenance	$1,200,000	$600,000	$600,000
Maintenance Closure Impact Costs	$0	$0	$0
Total	**$20,854,989**	**$22,373,182**	**$600,000**
Accidents			
Accident Repair Cost	**$984,417**	**$184,578**	**$799,839**
Total Annual Benefit			**$12,382,589**

Incremental Cost - BRAZOS RIVER FLOODGATES

	FWOP	FWP	Cost
Investment Cost			
Annualized Construction Cost w/ IDC	**$0**	**$5,664,171**	**$5,664,171**
O&M			
Normal O&M	$1,750,000	$1,750,000	$0
Maintenance Dredging	$17,904,989	$20,023,182	$2,118,193
Periodic Major Maintenance	$1,200,000	$600,000	$0
Maintenance Closure Impact Costs	$0	$0	$0
Total	**$20,854,989**	**$22,373,182**	**$2,118,193**
Total Annual Cost			**$7,782,364**
NET BENEFIT			**$4,600,225**
BENEFIT-COST RATIO			**1.59**

Table 3.15: Benefit-Cost Detail, Tentatively Selected Plan, Colorado River Locks
October 2017 Price Levels and 2.75% Interest Rate

Benefit - COLORADO RIVER LOCKS

	FWOP	FWP	Benefit
Transit Time			
Processing Time	$1,679,180	$835,351	$843,829
Queuing Time	$2,039,660	$284,763	$1,754,898
Tripping Time	$2,390,826	$650,968	$1,739,858
Closure Delay Time	$75,074	$60,730	$14,344
Total	**$6,184,740**	**$1,831,811**	**$4,352,929**
O&M			
Normal O&M	$1,750,000	$1,750,000	$0
Maintenance Dredging	$4,424,376	$2,404,705	$2,019,671
Periodic Major Maintenance	$2,400,000	$1,200,000	$1,200,000
Maintenance Closure Impact Costs	$0	$0	$0
Total	**$8,574,376**	**$5,354,705**	**$3,219,671**
Accidents			
Accident Repair Cost	**$316,832**	**$0**	**$316,832**
Total Annual Benefit			**$7,889,432**

Incremental Cost - COLORADO RIVER LOCKS

	FWOP	FWP	Cost
Investment Cost			
Annualized Construction Cost w/ IDC	**$0**	**$1,412,498**	**$1,412,498**
O&M			
Normal O&M	$1,750,000	$1,750,000	$0
Maintenance Dredging	$4,424,376	$2,404,705	$0
Periodic Major Maintenance	$2,400,000	$1,200,000	$0
Maintenance Closure Impact Costs	$0	$0	$0
Total	**$8,574,376**	**$5,354,705**	**$0**
Total Annual Cost			**$1,412,498**
NET BENEFIT			**$6,476,934**
BENEFIT-COST RATIO			**5.59**

Table 3.16: Benefit-Cost Detail, Tentatively Selected Plan, System Total
October 2017 Price Levels and 2.75% Interest Rate

Benefit - SYSTEM TOTAL

	FWOP	FWP	Benefit
Transit Time			
Processing Time	$2,959,145	$1,705,726	$1,253,419
Queuing Time	$5,808,429	$932,811	$4,875,618
Tripping Time	$6,840,393	$1,907,136	$4,933,256
Closure Delay Time	$4,787,714	$514,329	$4,273,385
Total	**$20,395,680**	**$5,060,001**	**$15,335,679**
O&M			
Normal O&M	$3,500,000	$3,500,000	$0
Maintenance Dredging	$22,329,365	$22,427,887	$0
Periodic Major Maintenance	$3,600,000	$1,800,000	$1,800,000
Maintenance Closure Impact Costs	$0	$0	$0
Total	**$29,429,365**	**$27,727,887**	**$1,800,000**
Accidents			
Accident Repair Cost	**$1,301,249**	**$184,578**	**$1,116,671**
Total Annual Benefit			**$18,252,350**

Incremental Cost - SYSTEM TOTAL

	FWOP	FWP	Cost
Investment Cost			
Annualized Construction Cost w/ IDC	**$0**	**$7,076,669**	**$7,076,669**
O&M			
Normal O&M	$3,500,000	$3,500,000	$0
Maintenance Dredging	$22,329,365	$22,427,887	$98,522
Periodic Major Maintenance	$3,600,000	$1,800,000	$0
Maintenance Closure Impact Costs	$0	$0	$0
Total	**$29,429,365**	**$27,727,887**	**$98,522**
Total Annual Cost			**$7,175,192**
NET BENEFIT			**$11,077,158**
BENEFIT-COST RATIO			**2.54**

Given the similarity in net NED benefits between the above alternative and Alternative 3a.1 (125' gate on the east side, open channel on the west, both along existing alignment) for BRFG and 4b.1 (river side gate removal) for CRL, this latter alternative is assumed to reasonably maximize net benefits, as it minimizes the risk posed by these uncertainties. The presence of the gate on the east side of the Brazos River eliminates the vast majority of expected increase in sedimentation as well as likely minimizes potential velocity impacts to traffic in the Freeport Channel, as well as some flood relief on the San Bernard River.

3.8 Identification of the NED Plan (TSP)

The recommended system NED plan for this study is a hybrid alternative (3a.1) for BRFG and a refined alternative (4b.1) for CRL. The BRFG alternative will be in the existing channel alignment with open channel on the west side and a gate structure (125') on the east side. While the selected alternative maintains the existing alignment, the widening of the channel and placement of the east gate structure further away from the river crossing would significantly reduce allisions based on expert elicitation from the navigation industry.

The CRL would also be in the existing channel alignment and include gate removal of the riverside locks (west) with retainment of the outer gates (east), creating a wider channel (125ft) and forebay at Colorado, reducing barge strikes against the guidewalls.

The system plan yields a Net Benefit of $11,077,687 with a BCR of 2.54, and reasonably maximizes the net benefits, has fewer environmental impacts; and unlike the open channel, it reduces uncertainty with sedimentation impacts throughout the wider navigation system, and ensures continued function and movement of commerce along the GIWW. The table below demonstrates the project first cost comparison for the navigation system, at Brazos, and at Colorado.

Table 3.17: Project First Cost Comparison Summary ($000)
October 2017 Price Levels

Cost Account and Feature	Project First Cost Total	BRFG First Cost Total	CRL First Cost Total
Construction	$140,351	$112,343	$28,008
Lands and Damages	$53	$33	$20
Preconstruction Engineering and Design	$28,566	$22,865	$5,701
Construction Management	$15,711	$12,577	$3,134
Total Project First Cost	$184,680	$147,818	$36,862

3.9 Planning and Guidance Criteria

Alternative plans, including the NED plan, should be formulated in consideration of four criteria: Completeness; effectiveness; efficiency; and acceptability.

(1) Completeness is the extent to which a given alternative plan provides and accounts for all investments or other actions to ensure the realization of the planned effects. This may require relating the plan to other types of public or private plans if the other plans are crucial to realization of the contributions to the objective.

(2) Effectiveness is the extent to which an alternative plan alleviates the specified problems and achieves the specified opportunities.

(3) Efficiency is the extent to which an alternative is the most cost effective means of alleviating the specified problems and realizing the specified opportunities, consistent with protecting the Nation's environment.

(4) Acceptability is 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.

Table 3.18: Criteria Comparison of the NED Plan and No-Action Plan

Alternative	Completeness	Effectiveness	Efficiency	Acceptability
Plan 1: No-Action	The plan is complete and allows for navigation and sediment management but would not address any problems or opportunities.	This plan provides no benefits beyond the existing condition.	No cost for this project, continued maintenance on the existing structures would continue with continued shipping delays, cross current challenges, and frequent closures.	This plan is the existing condition and is not supported by the navigation industry (shippers) or the project partners.
NED Plan: 3a.1 – 4b.1	The NED plan is implementable, provides benefits, and addresses most of the study problems and objectives and navigation improvements in the GIWW.	This plan reduces average transit time from 3.84hrs to .83 at Brazos and 1.48hrs to .43 at Colorado. The NED is expected to reduce transit time by approximately 78.3% Reduces allisions (accidents) with structures by an estimated 81% (Brazos)	This plan reasonability maximizes Net Benefits and shows a strong BCR.	This plan was developed in partnership with TXDOT, uses input from navigation industry, has agency buy-in on the NED plan, and is NEPA compliant.

3.10 Summary of Accounts and Comparison of the NED Plan

3.10.1 Summary of Accounts

To facilitate evaluation and comparison of the alternatives, the 1983 Principles and Guidelines lay out four Federal Accounts that are used to assess the effects of alternatives. The accounts are National Economic Development (NED), Environmental Quality (EQ), Other Social Effects (OSE), and Regional Economic Development (RED).

- The NED account displays changes in the economic value of the national output of goods and services. The 1983 Principles and Guidelines require the identification of an NED plan from among the alternatives.
- The EQ account displays non-monetary effects on significant natural and cultural resources.
- The RED account registers changes in the distribution of economic activity that result from each alternative plan. Evaluations of regional effects are to be carried out using nationally consistent projections of income, employment, output, and population.
- The OSE account registers plan effects from perspectives that are relevant to the planning process, but are not reflected in the other three accounts.

3.10.2 Comparison of the NED Plan and the No-Action Plan

No-action Plan: There would be no benefits attributable to the no-action plan. The EQ and OSE accounts would remain unchanged. The NED and RED accounts would be adversely impacted as current transit times of waterborne commerce traffic that utilize the existing structures to continue to increase as traffic increases and the frequency of maintenance events increase. The recommended plan reasonably maximizes the net NED benefits with a BCR greater than 1. Impacts to EQ account would be minimal, and there would be negligible impacts to OSE. The RED account would benefit because new and reliable floodgates/locks

would increase efficiency of cargo transiting on the GIWW and the reliability of the structures would be increased.

3.11 Assumptions/Risks/Uncertainties of the NED Plan

USACE guidelines, as presented in the Principles and Guidelines and in the Planning Guidance Notebook, ER 1165-02-100, Appendix E-4, have long recognized that risk and uncertainty is inherent in all phases of the analysis of waterway investments. The study assumptions, risks, and uncertainties have been identified in the Risk Register and will be made available to the ATR and IEPR teams. Those items ranked as high and medium risks are summarized below:

Plan Formulation Assumptions/Risks/Uncertainties:

After release of the draft report, the team will refine the design of the TSP with additional engineering and environmental analysis as necessary. These investigations are to support the feasibility design of the TSP. Items that may be investigated include optimization of the measures within the TSP, additional navigation modeling (SHIPSIM) to confirm TSP, with respect to the channel alignment at BRFG, the development of a detailed mitigation plan, and further assessment of the river crossings and by-pass channels to maintain navigation during construction activities, and any sediment impacts of reopening and maintaining those channels for that duration. The investigations may be adjusted after the conclusion of the public review and comment period to address significant public and agency concerns. These additional updates will be included in the Final Feasibility Report.

Economic Assumptions/Risks/Uncertainties:

Existing conditions for navigation and shipping cost nationally/regionally have not been well documented through the floodgates and locks. Tracking systems in place include outdated paper documentation and computerized tracking systems that have inconsistent readings. This may lead to inaccurate data analysis of the economic benefits. Risk management options include using existing data to extrapolate missing pieces and optimization of said data to determine NED benefits. A new model has been developed to account for these discrepancies by the PCXIN, it is currently being certified for this project and will be used for other inland water projects. The PDT has determined that the risk is acceptable and that TSP selection of the NED plan will not be greatly impacted with our assumption (documented in Economic Appendix B).

SHIPSIM Assumptions/Risks/Uncertainties:

The risk to selecting a plan without using SHIPSIM is the selection of a TSP that could have long term impacts to the navigation system. Without SHIPSIM modeling the chosen TSP may require significant modification during the PED phase to provide acceptable navigable conditions and may also increase study cost. From discussions with ERDC, previous ERDC SHIPSIM work during PED on other projects has resulted in major modifications to the TSP 50 percent of the time when no SHIPSIM was conducted during Feasibility design. The TSP at Brazos maintains the current alignment, which in its current state with a narrow 75 foot gate opening and limited forebays is not conducive to safe navigation. The TSP alternative improves upon the current FWOP conditions with 125 foot wide approach channels, an 125 foot open channel on the west side, and the east gate widened to 125 foot and moved further away from the river crossing. Expert elicitation from the navigation industry indicated that this proposed TSP configuration would significantly reduce alisions at the crossing and be a significant improvement over FWOP conditions. The navigation industry has stated that they would like to investigate the slight straightening of the channel alignment similar to that shown in **Figure 3.9** to facilitate a smoother crossing and further reduce potential alisions at the river crossing. While SHIPSIM would provide greater refinement of navigation performance, it would be unlikely to change the identification of the draft recommended plan. The revisions to the TSP alignment are minor in nature and would be considered a normal part of PED. Based on the expert elicitation from industry, it is recommended that SHIPSIM be performed during PED to validate these assumptions.

However, while not probable, it is possible that SHIPSIM conducted during PED could result in major alignment change at the Brazos River crossing.

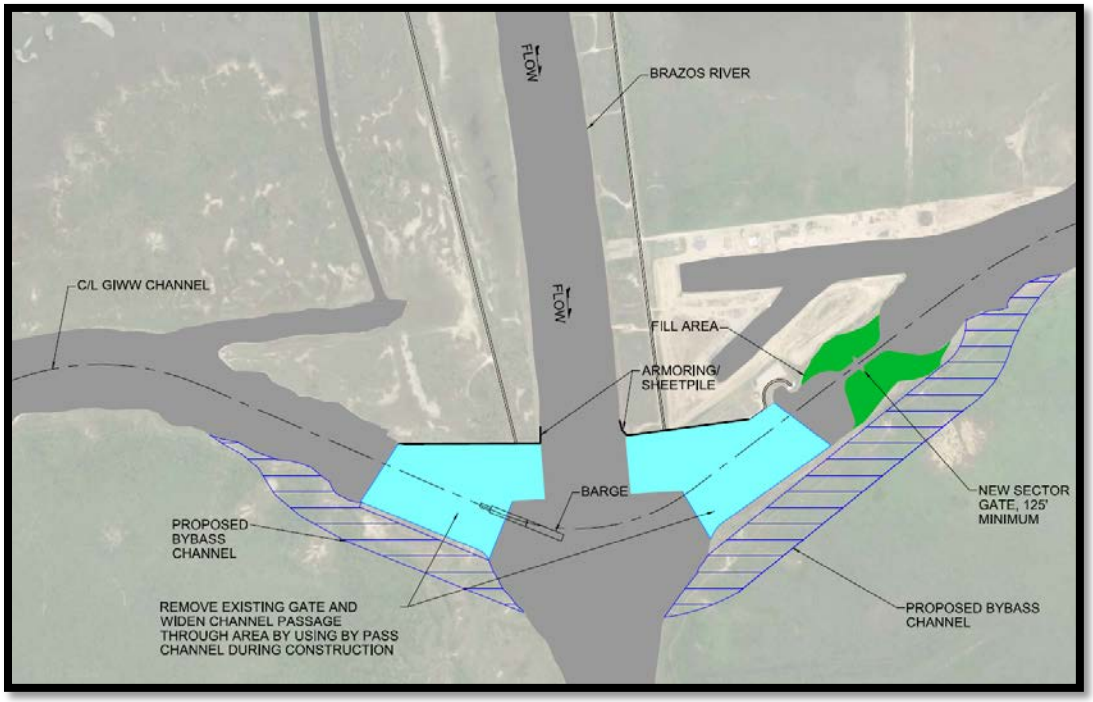


Figure 3.9: Industry Recommended Refinement to BRFG Plan – Alternative 3a.1

Real Estate Assumptions/Risks/Uncertainties:

The assumption is that USACE-SWG has current, valid perpetual easements on all of the lands within the foot print area. These perpetual easements cover the entire section of Texas Boat and Barge, Inc. as well as a portion that the Port of Freeport has interest, however these easements have revisionary clauses. The risk is if the perpetual easements have been revoked by the land owners or have been released by the Government then the current real estate interest is invalid and the portions of the foot print the fall within two (2) potential alternatives would require acquisition.

Maintenance Dredging Funding Assumptions/Risks/Uncertainties:

Some alternatives allow more deposition of material into the GIWW that would otherwise continue out into the delta for both rivers. These deposits will accumulate in areas that will require dredging to maintain the channel comparable to unaffected parts of the GIWW. This will require additional dredging funding in the annual O&M budget. If such an alternative is the best solution, then study guidelines require that we assume the budget will be increased adequately to support the dredging need. Currently, the dredging budget for the relevant portions of the GIWW is inadequate to fully meet the mission requirements. The budget is managed by prioritizing the most efficient way to operate the navigation system. First, the authorized channel depth is not met. Second, the delta for the Colorado River needs dredged to restore the hydraulic capacity of the river. It follows, that additional future dredging needs would fall onto a budget history that has proven not to be able to meet full needs. In addition to the budget uncertainty, the quantity of dredge material predicted by the hydraulic models is also high. There is a high degree of uncertainty in the suspended sediment rating curves, potentially increasing sedimentation rates in higher flow events than what is predicted in the models. The Harvey event provided an opportunity to calibrate the sediment rating curves based on the level of sedimentation and the composition of the material deposited, but some uncertainty still exists.

Dredging Disposal Cost Assumptions/Risks/Uncertainties:
A fully developed Dredge Material Management Plan (DMMP) is not available for the portions of the GIWW affected by increased sedimentation associated with some of the alternatives evaluated. Utilizing existing data, remaining capacities in the placement areas along the GIWW were evaluated. The team assumed that once those capacities were met, dredge disposal would occur offshore, at a significantly higher cost than the cost for disposal in nearby placement areas. A fully developed DMMP could result in more cost effective dredge disposal options, potentially changing the TSP selection due to reduced O&M dredging costs.

Environmental Assumptions/Risks/Uncertainties:
A mitigation plan is currently being drafted (detailed in Chapter 5) and further consultation and coordination with state and federal agencies is ongoing and expected to conclude before a Chief's Report is finalized.

THIS PAGE LEFT INTENTIONALLY BLANK

4.0 National Economic Development (TSP) Plan

Per ER 1105-2-100 Appendix G.3.b. For this navigation study, the systems models used in the estimates of navigation benefits are fully described and their strengths and limitations presented in the **Economics Appendix B**. Identification of the NED plan is based on consideration of the most effective plans for providing different levels of output or service. The TSP for this study is described below.

4.1 Plan Description

The recommended system TSP for this study is alternative (3a.1) for BRFG and alternative (4b.1) for CRL. At BRFG, the TSP consists of construction of a new 125 foot flood gates along the existing alignment, set back approximately 1000 feet from the river on the east side, and a minimum 125 foot open channel on the west side of the river crossing (Figure 4.1).

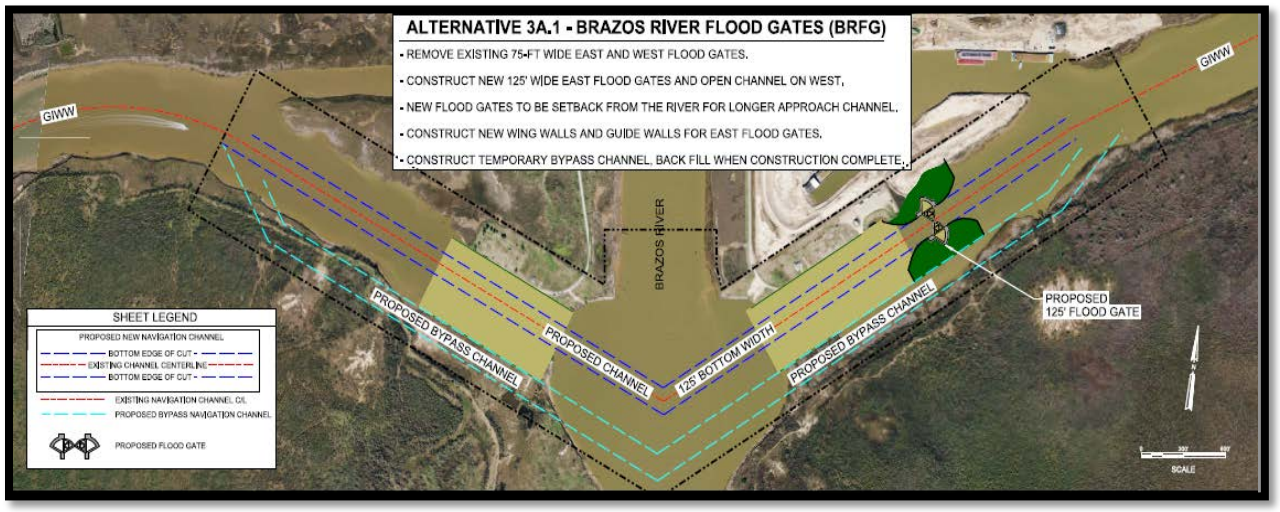


Figure 4.1: Recommended BRFG Plan – Alternative 3a.1

At CRL, the TSP consists of the removal of the existing river side sector gate structures and rehabilitation of the existing GIWW side sector gate structures (Figure 4.2).

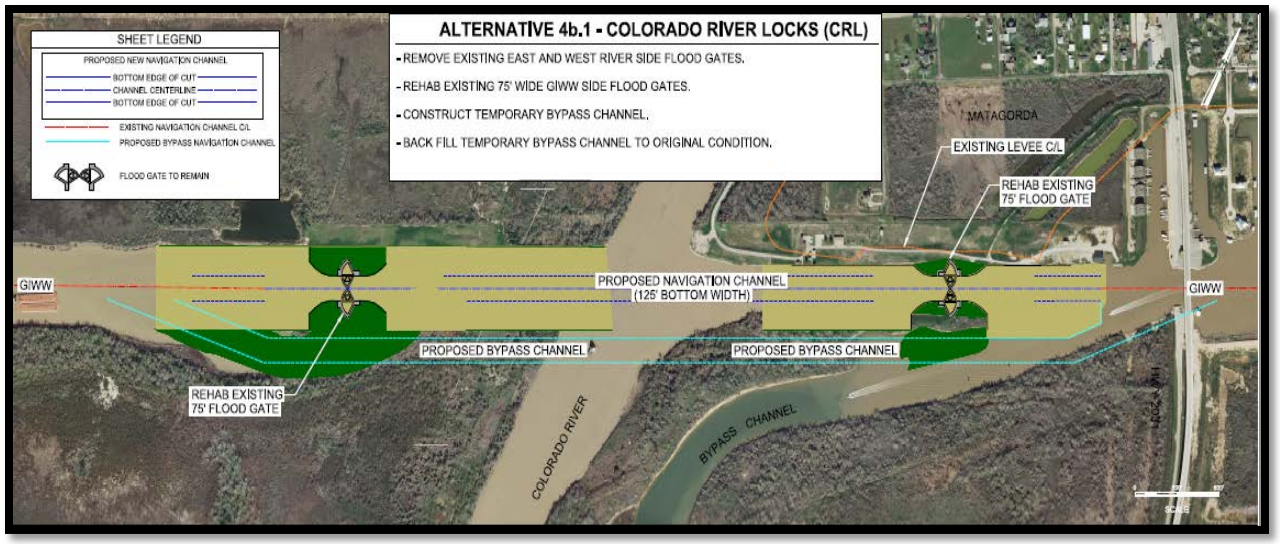


Figure 4.2: Recommended CRL Plan – Alternative 4b.1

The system plan yields a Net Benefit of $11,077,687 with a BCR of 2.54, and reasonably maximizes the net benefits, has fewer environmental impacts; and unlike the open channel, it reduces our uncertainty with sedimentation impacts throughout the wider navigation system, and ensures continued function and movement of commerce along the GIWW. The table below demonstrates the project first cost comparison for the navigation system, at Brazos, and at Colorado.

Table 4.1: Project First Cost Comparison Summary ($000)
October 2017 Price Levels

Cost Account and Feature	Project First Cost Total	BRFG First Cost Total	CRL First Cost Total
Construction	$140,351	$112,343	$28,008
Lands and Damages	$53	$33	$20
Preconstruction Engineering and Design	$28,566	$22,865	$5,701
Construction Management	$15,711	$12,577	$3,134
Total Project First Cost	$184,680	$147,818	$36,862

At BRFG, the main features of the TSP are the removal of the existing gates on both sides of the river crossing, the construction of a 125 feet wide open channel on the west side and a new 125 feet wide sector gate structure on the east side. The open channel will have a bottom depth of -12 ft NAVD88 and a bank-to-bank width of approximately 500 feet. The new sector gate on the east side is set back approximately 1,300 feet from the existing gate structure, providing increased safety and efficient vessel operation through the system, reducing allisions. The gate will be constructed to a top El. 16 ft NAVD88 with a sill at El. -16 ft NAVD88. Construction of the open channel and new sector gate would take approximately two years to complete, if adequate funding is provided. Assuming one contract, construction would be sequenced as follows:

- A temporary bypass channel with a bottom width of 125 feet wide at El. -12 ft NAVD88 would be constructed to the south of the existing alignment. The bypass will be designed to minimize impacts to the adjacent placement areas and their retention dikes. Disposal of excavated material from the bypass will be placed in the adjacent placement areas. Suitable material will be re-used for backfill for the new 125 foot sector gate.

- Following construction of the temporary bypass, demolition of the existing gates will be concurrent with the start of construction of the new 125 foot sector gate on the east side of the Brazos River. Demolition will include removal of sector gates, vertical masonry walls, buildings, and anchored sheet pile guide walls. The existing base slab of the sector gate is to remain in place. Once the guide walls are removed, the remaining fill is to be excavated and sloped to accommodate the new 125 foot channel through the gate footprint.

- Once demolition is complete on the west side, final excavation will be performed to create the full 125 foot wide open channel.

- Prior to cofferdam construction, the guidewalls would be installed and fill placed in the wet to create the land adjacent to the gates, serving as a portion of the cofferdam to limit length of temporary cofferdam construction. The temporary cofferdam will then be installed between the permanent guidewalls, and then dewatered to perform the gate construction.

- Foundation pilings would be driven within the un-watered cofferdam to support the concrete pours of the sector gate monolith. Foundation pilings would consist of approximately 275, 30 inch steel pipe piles, driven to a depth of 150 feet below grade. Concrete pours for the sector gate monolith would then occur. Machinery, electrical, and mechanical connections would all be installed after completion of concrete placement.

- Following completion of the sector gate monolith, the cofferdam would be removed and the area re-watered. Final site work would be accomplished including, grading, parking and support building facilities.

- The sector gate would then be open to navigation and the temporary construction bypass would have an earthen plug placed on the river end on both east and west sides. The bypass channel would be turned into a mooring facility.

At CRL, the main features of the TSP are the removal of the existing river side sector gate structures and rehabilitation of the GIWW side sector gate. The removal would include the removal of the anchored sheet pile guide walls, vertical structure walls, sector gates, control houses, and equipment buildings. The land area behind the anchored sheet pile retaining walls would be excavated in order to accommodate a new 125 foot wide channel at El. -12 ft NAVD up to the remaining sector gate structure on the GIWW side of the lock. The interior guide wall in the lock chamber would also be removed. New control houses, offices and equipment buildings would be constructed if removed due to the channel widening. Rehabilitation would consist of improvements to the existing guide walls, replacement of outdated machinery with new hydraulically operated motors, modernization of electrical equipment, and rehabilitation of sector gates including coating system capable of reducing crustacean growth. Demolition of the river side gate and rehabilitation of the GIWW side sector gates would take approximately 15 months to complete, if adequate funding is provided. Assuming one contract, construction would be sequenced as follows:

- A temporary bypass channel with a bottom width of 125 feet wide at El. -12 ft NAVD88 would be constructed to the south of the existing alignment. The bypass will be designed to minimize impacts to the adjacent placement areas and their retention dikes. Disposal of excavated material from the bypass will be placed in the adjacent placement areas.

- Following construction of the temporary bypass, demolition of the existing river side sector gates will be concurrent with the start of rehabilitation of the existing GIWW side sector gates. Demolition will include removal of sector gates, vertical masonry walls, buildings, and anchored sheet pile guide walls. The existing base slab of the sector gate is to remain in place. Once the guide walls are removed, the remaining fill is to be excavated and sloped to accommodate the new 125 foot channel through the river side gate footprint.

- Construction of new buildings and rehabilitation of gate structure would occur simultaneously.

- Once rehabilitation of the sector gates is complete, they would then be open to navigation and the temporary construction bypass would have an earthen plug placed on the river end on both east and west sides. Note that rehabilitation work can progress without impacts to navigation due to the bypass navigation traffic.

4.2 Hazardous, Toxic, and Radioactive Waste

The USACE is obligated under Engineer Regulation (ER) 1165-2-132 to assume responsibility for the reasonable identification and evaluation of all Hazardous, Toxic, and Radioactive Waste (HTRW) contamination within the vicinity of the proposed actions during the feasibility phase ER 1165-2-132 identified the HTRW policy is to avoid the use of project funds for HTRW removal and remediation activities. An ASTME 1527-05 Phase I Environmental Site Assessment (ESA), HTRW 14-02 has been completed for the project area and can be found in the Environmental Appendix D. The provability of encountering HTRW for the proposed action is low based on the initial site assessment. If no recognized environmental conditions are identified in relation to the project site, the probability of encountering HTRW for the project will be considered low. If a recognized environmental condition is identified in relation to the project site, the USACE Galveston District would take the necessary measures to avoid the recognized environmental condition so that the probability of encountering or disturbing HTRW would continue to be low. Any further investigations or HTRW that occur after the feasibility phase are the responsibility of the study partner.

4.3 Real Estate Requirements

A Real Estate Plan (REP) describing the real estate requirements and cost for the project can be found in Appendix C. The REP describes the lands, easements, and rights-of-way (LERR) required for the construction, operation and maintenance of the proposed project, including those required for relocations, borrow material, and dredge or excavated material disposal.

The majority of the real estate needed for construction of the BRFG and CRL Projects are within current perpetual easements conveyed to the United States. Any borrow material needed for the project will be obtained within the project footprint. There is an assumption that four (4) staging areas will be required for BRFG and two (2) staging areas for CRL. There will not be any displaced persons and businesses entitled to Public Law 91-646, title Relocation Assistance. Real estate costs are minimal for administration costs associated with staging areas and project related administration. The estimated cost of real estate for this project will be the sole responsibility of USACE.

4.4 Operation and Maintenance, Repair, Rehabilitation and Replacement

The purpose of operation and maintenance, repair, rehabilitation and replacement (OMRR&R) is to sustain the constructed project. O&M cost estimates for maintenance of the structures was based off of existing expenditures for normal O&M ($1,750,000 annually) and periodic major maintenance ($1,200,000 annualized) at each river crossing. The USACE is responsible for these cost as federally maintained structures. For more detailed information, refer to the Engineering Appendix (A).

4.5 Relative Sea Level Change

The Brazos and Colorado River crossings are located in the coastal zone. The performance of the system has potential to be affected by sea level change and other climate changes. The Climate Preparedness and Resilience Register (CPRR) documents the robustness of the project alternative selections to climate change, how the selected plan's performance might be expected to change over time, and how the plan might be adapted to continue to deliver performance in a changing climate. Future conditions were modeled by adjusting the boundary conditions and re-running the AdH simulations for the open channel and existing alternatives. Given the uncertainty in projected sea level rise and subsidence, a range of relative sea-level rise (RSLR) scenarios was evaluated. For this project, a 1.0ft and 2.0ft RSLR were evaluated. The overall effects of SLC on the recommended plan are relatively minor. The modeling shows that sedimentation rates are not highly sensitive to sea level rise. Furthermore, with higher Gulf water levels, navigability is expected to improve, since a higher tailwater will slow velocities at the crossing, and increase channel depths. Finally, modest changes to average salinity occur as a result of SLC. Refer to the Engineering Appendix A for further details on the impact of RSLC on the recommended plan.

4.6 PED Design

The first order of PED design would be to run Ship Simulation to validate the alignment of the draft recommended plan developed as part of this study. Minor revisions may be made to the alignment to reduce allisions and difficulty in navigating the crossings if Ship Simulation indicates problems with the draft recommended plan, and a full scale sedimentation and model validation study will be conducted based on 2 years of live data. The BRFG will be placed in the proposed gate settings and an emergency dredge contract will be on standby to prevent GIWW interruptions.

A foundation investigation program involving borings and CPTs would be initiated to better define the foundation beneath the new 125' sector gate proposed to be constructed on the east side of the Brazos River Crossing. A Value Engineering (VE) Study should be initiated to evaluate potential savings and innovation in design items such as the guidewalls, pile foundation, and steel sector gate. Following the VE Study, P&S development would ensue. The number of construction contracts would depend on available funding and selected acquisition strategy.

4.7 Acquisition Strategy

The construction of the draft recommended plan at the Brazos River Crossing and the Colorado River Crossing involves a variety of work including demolition, dredging and heavy civil works construction, but some of the work is less complex with the 125-foot gate structure at Brazos East driving the complexity. This variety supports dividing the construction into small parts that are achievable by specialty contractors like those that dredge or those that work in salvage/demolition. This approach should be considered during the PED phase. Alternatively, the use of a single construction contract at each river crossing with fairly significant dollar values might attract highly skilled contractors and drive competition and lower bids.

It is assumed that the contracts would be fully funded allowing for such contractor acquisition. The method of delivery for each project would likely be Design-Bid-Build. The contract could be an invitation for bid (IFB) or request for proposal (RFP). The benefit of an IFB is the lowest price will be selected, which is good if the successful offeror is a highly qualified contractor. The RFP will provide the government with the opportunity to generate key criteria upon which to select highly qualified contractors. Alternatively, a best-value approach could be utilized if the design team decides that particular aspects of the project foster innovative solutions by the contractor and allows the government to pay for any added value. Another option for an RFP is technically acceptable low price which blends some of the characteristics of the aforementioned acquisition methods. It allows an acceptable (measured against establish criteria) contractors to offer bids where the low bid is chosen among the pool of acceptable contractors. There really is not one single acquisition method that stands out for this project. One fairly strong consideration is that if dredging of the bypass canals were a standalone contract, then dredging companies would likely bid and there would be no potential for markup by a general contractor.

4.8 Funding

Construction of the TSP is dependent on funds made available by Congress. In the case of this TSP, an inland waterway navigation project, funding is provided from two separate sources. One source of funds is what Congress appropriates out of general Treasury funds for the USACE to expend as directed. The other source of funds is from the IWWTF which are collected from a per gallon tax levied on fuels purchased by inland waterway users. The IWWTF is overseen by the Inland Waterways Users Board (IWWUB), but appropriation of funds from the IWWTF can only be made by Congress, based on the recommendations of the IWWUB. To conclude, Treasury funds are made available via the Congressional appropriations process; IWWTF funds are also made available via the Congressional appropriations process, but is subject to the availability of the balance of funds in the IWWTF, unless any deficit in the IWWTF is remedied by additional Congressional action.

THIS PAGE LEFT INTENTIONALLY BLANK

5.0 Environmental Consequences for Comparative Analysis

This chapter discusses the environmental consequences of the reasonable Action Alternatives for the BRFG and CRL sites, as required under NEPA. The information used to determine environmental consequences of the Action Alternatives is derived from initial descriptions and draft engineering drawings of the alternatives, field reconnaissance and desktop analysis, and engineering reports such as the "Brazos River Floodgates Hydraulic Engineering Appendix" (TxDOT 2017a) and the "Hydrodynamic Evaluation of Proposed Navigation Improvements at the Colorado River Intersection with the Gulf Intra-Coastal Waterway" (USACE 2017b).

The anticipated environmental consequences of each Action Alternative, including the Recommended Plan, are provided below. Exceptions include BRFG Alternative 2a and CRL Alternative 2A, both of which entail rehabilitating the existing gates, guide walls, and other infrastructure within the existing footprint. These alternatives would result in minor, if any, changes to the overall footprint, orientation, operations, or bathymetry. Therefore, H&H modeling, sedimentation, salinity, and other conditions were assumed to be the same as the FWOP Condition (No Action Alternative), and no additional discussion of environmental consequences of these two Action Alternatives are provided here.

For the Action Alternatives that are discussed below, environmental consequences to a particular resource may be the same among alternatives; however, in this report the alternatives are listed and discussed separately for each resource, noting where the consequences are expected to be the same as other alternatives. Those alternatives that have similar impacts may be discussed together in the FR/EIS. For reference, the Action Alternatives considered for each site include:

- **BRFG**
  - Alternative 2a: Rehab Existing Facilities – impacts assumed to be same as the FWOP Condition
  - Alternative 3a: Gate Relocation on Existing Alignment
  - Alternative 3a.1: Open Channel West/East Gate Relocation (existing alignment)
  - Alternative 9: Open Channel (new alignment to the north to straighten this section of the GIWW)
  - Alternative 9b/c: New Alignment/Gates with Control Structures

- **CRL**
  - Alternative 2a: Rehab Existing Facilities – impacts assumed to be same as the FWOP Condition
  - Alternative 3b: Open Channel
  - Alternative 4b.1: Removal of Riverside Gates

5.1 General Environmental Setting of the NEPA Study Area

No Action

Under the FWOP Condition, there will be no changes to the overall location, physiography, or land use resulting from the project. However, the Texas Gulf coast is a dynamic environment, and the NEPA study areas will continue to be exposed to environmental factors that will change the landscape. Hurricanes and other storms will periodically affect both of the NEPA study areas, and projected sea level rises in the study areas resulting from climate change range from roughly 1 foot to as much 3.6 feet between 2035 and 2085, which will gradually inundate low-elevation areas.

Both of the NEPA study areas are expected to remain largely undeveloped due to their low elevations; however, development could occur in topographically high points along the rivers based on potential increases in shipping on the GIWW. Local wildlife refuges/management areas could expand their boundaries to incorporate more of the surrounding coastal wetland habitats. Some wetland areas may gradually disappear either by inundation due to erosion and sea level rises, or by filling by continued disposal of maintenance dredged material from the GIWW and other navigation channels.

All Alternatives

None of the Action Alternatives would affect the overall location, physiography, or climate of the NEPA study areas; however, the NEPA study areas would continue to be exposed to environmental factors that will affect the area, including hurricanes, climate change and projected sea level rises, local subsidence, and periodic disposal of dredged material from maintenance dredging. These effects are expected to be similar to the FWOP Condition, or No Action Alternative. Other changes to the general environmental setting are discussed below for each Action Alternative.

BRFG Alternative 3a

This alternative would impact an estimated 83 acres of land, primarily due to excavation of a temporary bypass channel to maintain navigation through the area during construction. The land alteration would not change the general setting. Consistent with the FWOP Condition, the area is expected to remain undeveloped due to the low elevation of the area, and portions of the NEPA study area may be gradually inundated due to projected sea level rises. Existing land uses in the NEPA study area would remain.

BRFG Alternative 3a.1 (Recommended Plan)

This alternative would impact an estimated 73 acres of land, primarily due to excavation of a temporary bypass channel to maintain navigation through the area during construction. The land alteration would not change the general setting. Consistent with the FWOP Condition, the area is expected to remain undeveloped due to the low elevation of the area, and portions of the NEPA study area may be gradually inundated due to projected rises in sea level. Existing land uses in the NEPA study area would remain.

BRFG Alternative 9a

This alternative would impact approximately 75 acres of land; however, the general setting would not change and would be consistent with the FWOP Condition. One commercial facility, Texas Boat & Barge, Inc. would be removed by this alternative.

BRFG Alternative 9b/c

This alternative would impact approximately 87 acres of land; however, the general setting would not change and would be consistent with the FWOP Condition. One commercial facility, Texas Boat & Barge, Inc. would be removed by this alternative.

CRL Alternative 3b

This alternative would impact an estimated 71 acres of land, primarily due to excavation of a temporary bypass channel to maintain navigation through the area during construction. The general setting would remain the same as the FWOP Condition, and low-elevation portions of the NEPA study area may be gradually inundated due to projected rises in sea level. Without the locks in place, sediment from the Colorado River would be diverted into the GIWW, which would reduce the amount of sediment that reaches the delta in West Matagorda Bay. Over time, this may slow development of the delta and affect resources in the bay.

CRL Alternative 4b.1 (Recommended Plan)
This alternative would impact an estimated 71 acres of land, primarily due to excavation of a temporary bypass channel to maintain navigation through the area during construction. The general setting would remain the same as the FWOP Condition.

5.2 Relative Sea Level Change

This document uses current USACE guidance to assess relative sea level change (RSLC). Current USACE guidance - ER 1100-2-8162, December 2013, and ETL 1100-2-1, June 2014, specifies the procedures for incorporating climate change and RSLC into planning studies and engineering design projects. Projects must consider alternatives that are formulated and evaluated for the entire range of possible future rates of RSLC for both existing and proposed projects. USACE guidance specifies evaluating alternatives using "low," "intermediate," and "high" rates of future sea level change.

- Low - Use the historic rate of local mean sea-level change as the "low" rate. The guidance further states that historic rates of sea level change are best determined by local tide records (preferably with at least a 40-year data record).
- Intermediate - Estimate the "intermediate" rate of local mean sea-level change using the modified NRC Curve I. It is corrected for the local rate of vertical land movement.
- High - Estimate the "high" rate of local mean sea-level change using the modified NRC Curve III. It is corrected for the local rate of vertical land movement.

USACE (ETL 1100-2-1, 2014) recommends an expansive approach to considering and incorporating RSLC into civil works projects. It is important to understand the difference between the period of analysis (POA) and planning horizon. Initially, USACE projects are justified over a period of analysis, typically 50 years. However, USACE projects can remain in service much longer than the POA. The climate for which the project was designed can change over the full lifetime of a project to the extent that stability, maintenance, and operations may be impacted, possibly with serious consequences, but also potentially with beneficial consequences. Given these factors, the project planning horizon (not to be confused with the economic period of analysis) should be 100 years, consistent with ER 1110-2-8159. Current guidance considers both short- and long-term planning horizons and helps to better quantify RSLC. RSLC must be included in plan formulation and the economic analysis, along with USACE expectations of climate change and RSLC, and their impacts. Some key expectations include:

- At minimum 20-, 50-, and 100-year planning horizons should be considered in the analysis.
- Reinforces the concept that a thorough physical understanding of the project area and purpose is required to effectively assess the projects sensitivity to RSLC.
- Sea level changes should be incorporated into models at the mean and extreme events.
- Identification of thresholds by the project delivery team and tipping points within the impacted project area will inform both the selection of anticipatory, adaptive, and reactive options selected and the decision/timing strategies.

5.2.1 Historical RSLC

Historical rates are taken from the Center for Operational Oceanographic Products and Services (CO-OPS) at NOAA, which has been measuring sea level for over 150 years. Changes in MSL have been computed using a minimum 30-year span of observations at each location. These measurements have been averaged by month to eliminate the effect of higher frequency phenomena such as storm surge, in order to compute an accurate linear sea-level trend.

The MSL trends presented are local relative trends as opposed to the global (eustatic) sea-level trend. Tide gauge measurements are made with respect to a local fixed reference level on land; therefore, if there is some long-term vertical land motion occurring at that location, the relative MSL trend measured there is a combination of the global sea-level rate and the local vertical land motion, also known as RSLC.

Historical rates of local RSLC can be obtained from local tide records. The tide gage with sea level trend information nearest to the Brazos and Colorado River systems, with over 40 years of record, is located at Freeport, TX Island (NOAA Gage 8772440). The NOAA MSL trend at this site (from 1954 to 20016) is equal to 4.35 mm/yr with a 95 percent confidence interval of ± 1.12 mm/yr. If the estimated historic eustatic rate equals that given for the modified NRC curves, the observed subsidence rate would be 2.65 mm/yr (4.35 mm/yr - 1.70 mm/yr). A vicinity map for NOAA gage 8772440 is shown in **Figure 5.1**.

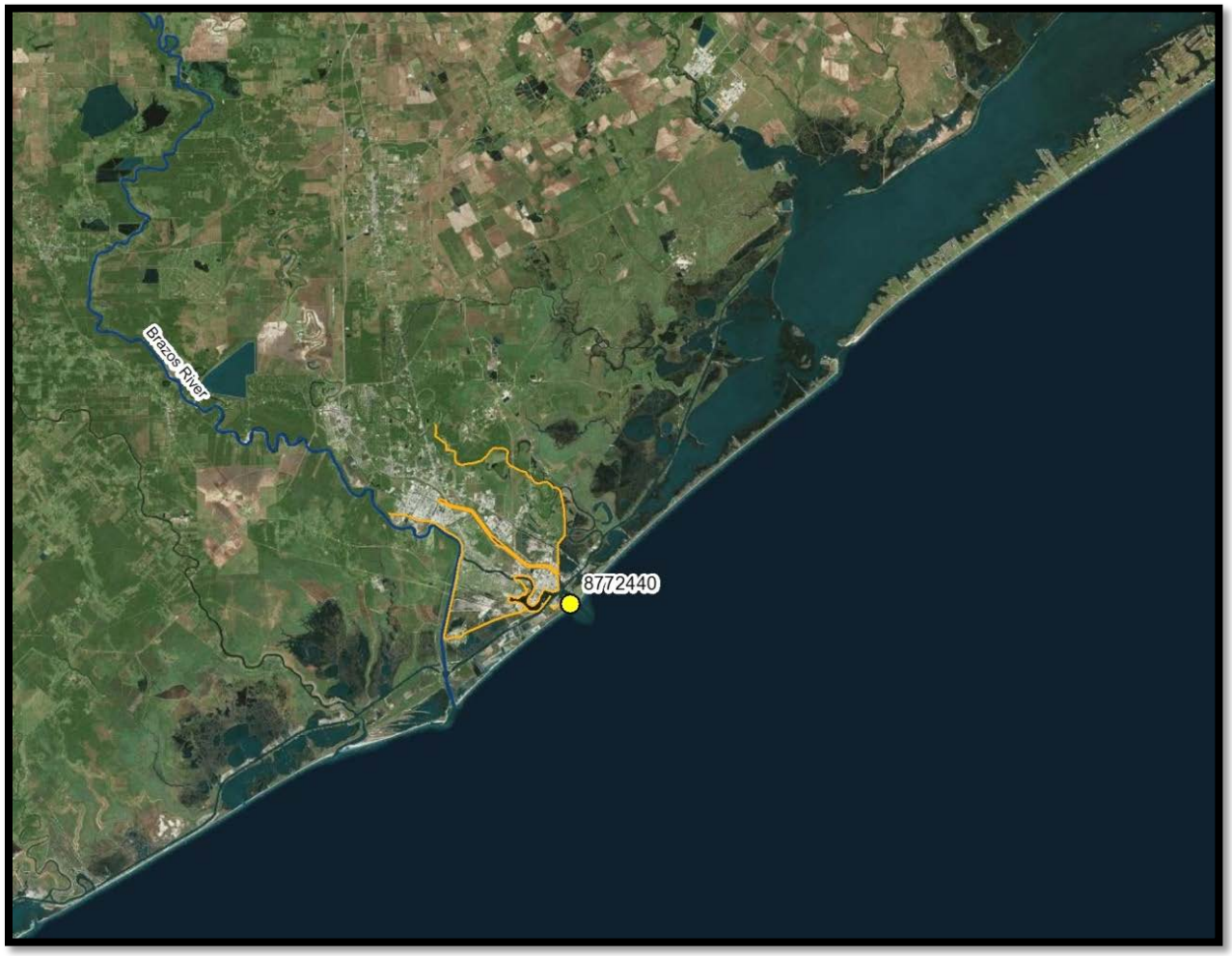


Figure 5.1 NOAA Gage 8772440 Vicinity Map

5.2.2 Predicted Future Rates of RSLC for 20-Year Period of Analysis

The computed future rates of RSLC in this section give the predicted change between the years 2030 and 2050 for the Brazos and Colorado River systems. RSLC values for this 20-year period are summarized in **Table 5.1** and plotted for in **Figure 5.2**.

Table 5.1 Estimated Impacts to Wetlands and Other Special Aquatic Sites (acres)

Tide Gage	Measured Relative SLR Rate (NOAA)	Low (ft)	Intermediate (ft)	High (ft)
Freeport, TX	4.35 mm/yr	0.83	1.13	2.07

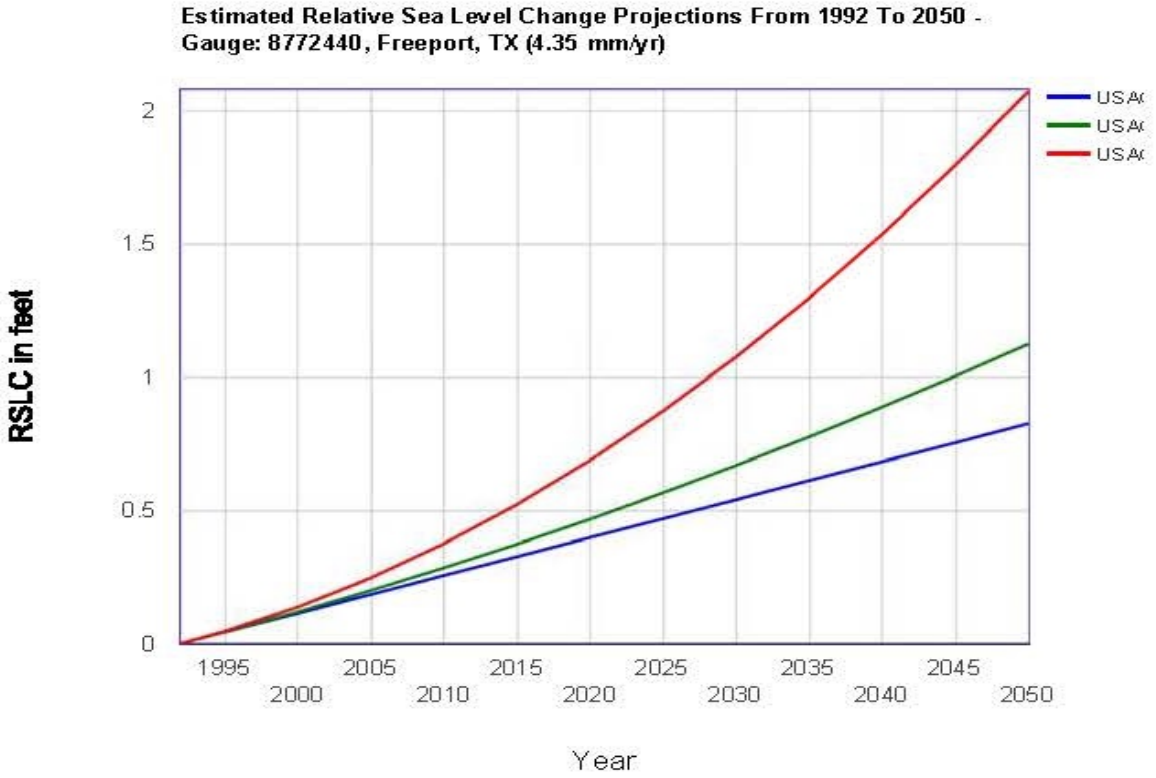


Figure 5.2 RSLC at Freeport, Texas over 20-Year Period of Analysis

5.2.3 Predicted Future Rates of RSLC for 50-Year Period of Analysis

The computed future rates of RSLC in this section give the predicted change between the years 2030 and 2080 for the Brazos and Colorado River systems. RSLC values for this 50-year period are summarized in **Table 5.2**.

Table 5.2 Estimated RSLC over the First 50 Year of the Project Life (2030-2080)

Tide Gage	Measured Relative SLR Rate (NOAA)	Low (ft)	Intermediate (ft)	High (ft)
Freeport, TX	4.35 mm/yr	1.26	1.94	4.13

Figure 5.3 shows the computed sea level change for the Brazos River system based on the current USACE guidance for "low," "intermediate," and "high" rates of change.

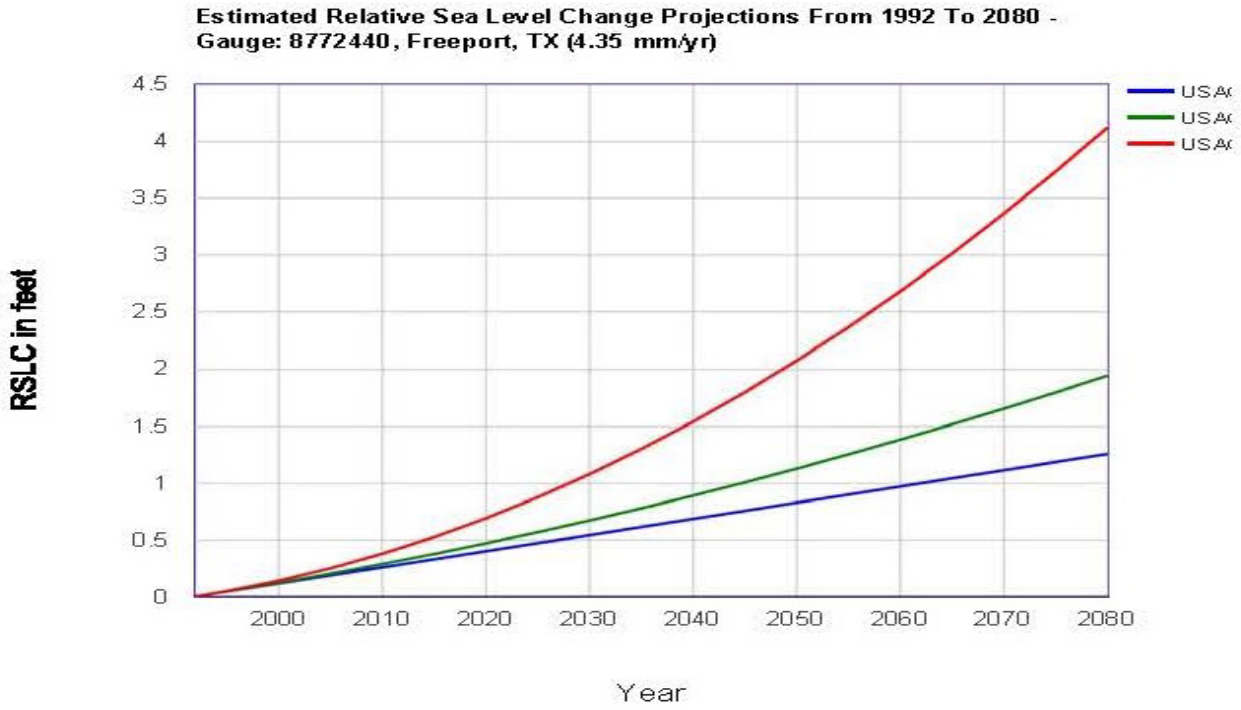


Figure 1 RSLC at Freeport, Texas over 50-Year Period of Analysis

Much of the area in the Freeport vicinity is low-lying. The majority of these low-lying areas are undeveloped, consisting of empty plots of land, some including marshes and wetlands. At 1 foot of sea level rise, several of these plots are inundated. It is important to note that water has begun to impact the Surfside Beach community just east of the Freeport Entrance Channel under this sea level rise scenario. At 2 feet, water begins to flood some central parts of Surfside Beach, inundating dozens of homes. For all considered sea level rise scenarios, safety from storm surge and wave attack for low-lying areas consistently decreases (**Figure 5.4**).

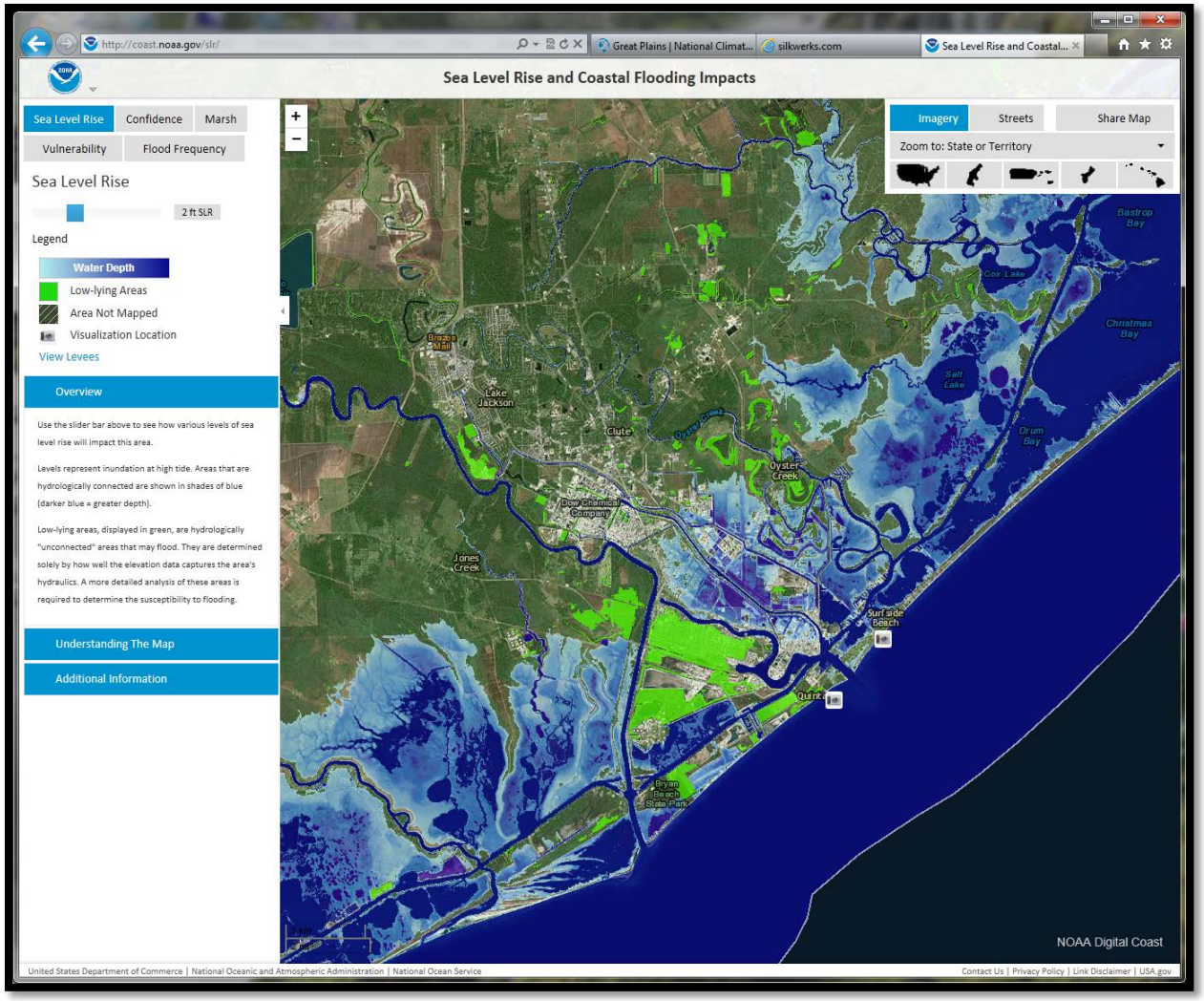


Figure 5.4 Extent of Inundation at Freeport, Texas with 2-foot Sea Level Rise

5.2.4 Predicted Future Rates of RSLC for 100-Year Period of Analysis

The planning, design, and construction of a large water resources infrastructure project can take decades. Though initially justified over a 50-year economic period of analysis, USACE projects often remain in service much longer. The climate for which the project was designed can change over the full lifetime of the project to the extent that stability, maintenance, and operations may be affected. These changes can cause detrimental or beneficial consequences. Given these factors, the project planning horizon (not to be confused with the economic period of analysis) should be 100 years, consistent with ETL-1110-2-1.

The period of economic analysis for USACE projects has generally been limited to 50 years because economic forecasts beyond that time frame were not considered reliable. However, the potential impacts of SLC over a 100-year period can be used in the formulation of alternatives and for robustness and resiliency comparisons. ETL 1100-2-1 recommends that predictions of how the project or system might perform, as well as its ability to adapt beyond the typical 50-year economic analysis period, be considered in the decision-making process.

The initial assessment that evaluates the exposure and vulnerability of the project area over the 100-year planning horizon was used in assisting planners and engineers in determining the long-term approach that best balances risks for the project. The three (3) general approaches are anticipatory, adaptive, and reactive strategies. These strategies can be combined or they can change over the life cycle of the project. Key factors in determining the approach include consequences, the cost, and risk. This consideration is of particular importance under a climate change condition where loading and response mechanisms are likely to transition over the life of the project.

Using the high SLC curve elevation at 100 years, the potential future affected area has been approximately defined. This includes both the vertical and the horizontal extents of potential SLC impacts. Since this feasibility level, detailed modeling has not occurred yet. This basic approach will provide a first-level assessment of how the project and project area might be impacted, and follows the guidance in ETL-2-1. More detailed engineering analyses will be conducted during PED.

The future affected areas, as defined by the 100-year high rate of RSLC, can impact resources, including economics. These resources can be identified and quantified, such as critical infrastructure (schools, roads, water supply, community buildings, etc.), impacted property, life-safety concerns, and environment and ecosystems. The consideration of the potentially larger area of impact facilitates discussion of what actions may need to be considered at certain trigger points. Community, as well as other stakeholder expectations will be better defined. Evaluation of coastal storm-damage risk reduction in the context of RSLC may also involve societal thresholds. Potential system and cumulative effects should be explored qualitatively when formulating plans.

An essential element of developing a good understanding of the project area's exposure and vulnerability is assessing how quickly the individual scenarios might necessitate an action due to thresholds and tipping points. It is important to identify key milestones in the project timeline when impacts are expected. This involves inputs from all members of the PDT as the threshold or tipping point could be a vast variety of different items or combinations of items.

Response strategies for the project planning horizon range from a conservative anticipatory approach, which constructs a resilient project at the beginning to last the entire life cycle (and possibly beyond), to a reactive approach, which would simply be to do nothing until impacts are experienced. Between these extremes is an adaptive management strategy, which incorporates new assessments and actions throughout the project life based on timeframes, thresholds and triggers. A plan may include multiple measures

Table 5.3 Estimated RSLC over the First 100 Year of the Project Life (2030-2130)

Tide Gage	Measured Relative SLR Rate (NOAA)	Low (ft)	Intermediate (ft)	High (ft)
Freeport, TX	4.35 mm/yr	1.97	3.66	9.03

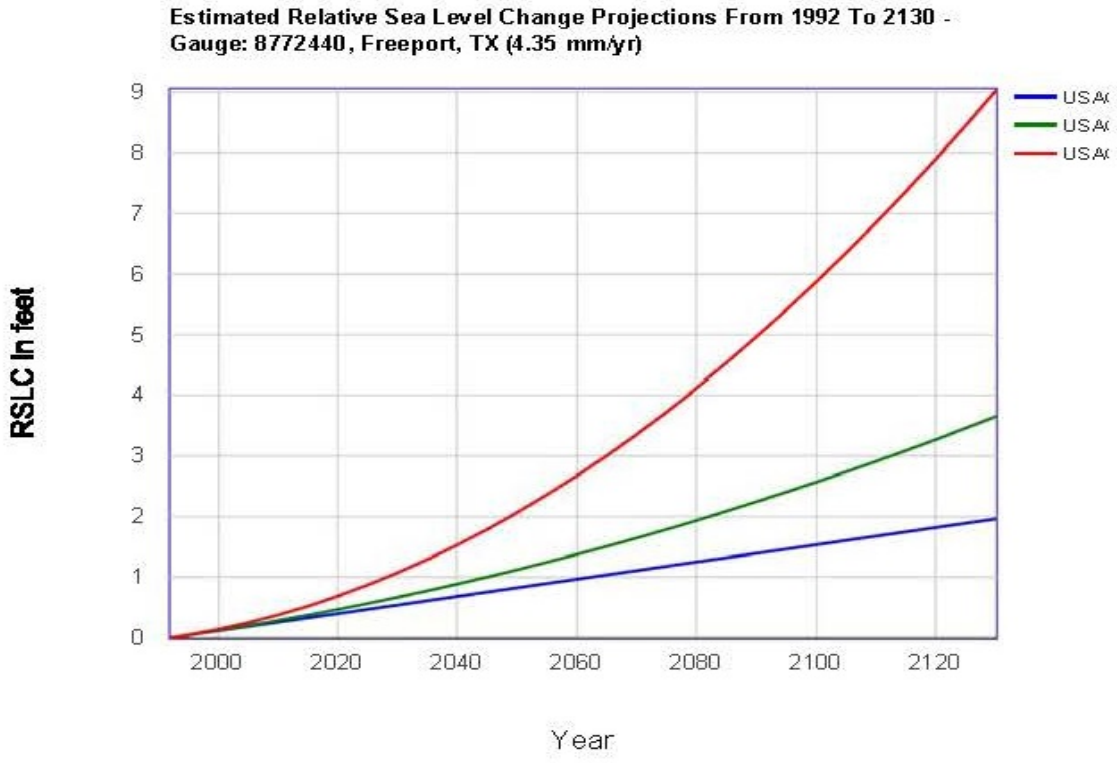


Figure 5.52 RSLC at Freeport, Texas over 100-Year Period of Analysis

5.3 Floodplain, Water and River Resources

5.3.1 Floodplains and Flood Control

No-Action

Under the FWOP Condition, existing river flooding trends will continue, although flooding may increase as the project region and areas further inland in the major watersheds (such as Brazos, San Bernard, and Colorado Rivers) are developed and impervious cover increases, resulting in more runoff during storms. In addition, flooding may increase due to projected climate change, sea level rises, and subsidence in the region. The Velasco Drainage District and Matagorda hurricane/flood protection systems may also need to expand in the future to accommodate development, resulting in more water being pumped outside the levee system during and after storm events.

BRFG Alternative 3a

Under this alternative, flooding and flood control conditions in the BRFG NEPA study area are expected to be similar to the FWOP Condition. Flooding in the area would continue to occur after storms upstream, causing localized flooding, and to a lesser extent, flooding from tropical storms and hurricanes would occur. Existing levees and flood control structures would not be altered by this alternative.

BRFG Alternative 3a.1 (Recommended Plan)

Impacts to floodplains and flood control would be similar to Alternative 3a and the FWOP Condition.

BRFG Alternative 9a
Impacts to floodplains and flood control would be similar to Alternative 3a and the FWOP Condition.

BRFG Alternative 9b/c
Impacts to floodplains and flood control would be similar to Alternative 3a and the FWOP Condition.

CRL Alternative 3b
If the locks are removed, water levels in the Colorado River channel during high-flow events would be lower compared to existing and FWOP conditions. This reduction in water level is not expected to have a substantial effect on floodplains or cause additional impacts to existing flood control structures. The lower water level may be considered favorable in comparison to the FWOP Condition, particularly during flooding conditions. This alternative would not affect flood control levees/structures.

CRL Alternative 4b.1 (Recommended Plan)
Under this alternative, flooding conditions and flood protection in the CRL NEPA study area are expected to be similar to the FWOP Condition. Flooding in the area would continue to occur after storms upstream, causing localized flooding, and to a lesser extent, flooding from tropical storms and hurricanes would occur. Existing levees and flood control structures would not be altered by this alternative.

5.3.2 Water Resources

No Action
Under the FWOP Condition, no impacts to wetlands or other waters will occur because of the project itself. Some wetland areas in the NEPA study areas may be converted gradually to open water habitats as sea levels rise; disposal of maintenance dredged material may also convert wetland areas to uplands. Water use and supply will not be affected by the FWOP Condition, although sea level rise may increase salinities further upstream in the rivers during low-flow periods.

All Alternatives
For each action alternative, the direct impacts of the alternative on wetlands and other special aquatic sites (e.g., tidal flats) are provided below and summarized in **Table 5.4**. Under all Action Alternatives, other wetland areas in the area may be converted gradually to open water habitats over time as sea levels rise, but this impact is similar to the FWOP Condition. Since existing DMPAs and ODMDS would be used, none of the alternatives are expected to impact wetlands due to dredged material placement. There would be no change to water supply or water use under any of the alternatives.

Table 5.4 Estimated Impacts to Wetlands and Other Special Aquatic Sites (acres)

Alternative	High Marsh	Intertidal Marsh	Tidal Flat	Total
BRFG Action Alternatives				
2a	0	0	0	**0**
3a	3.8	2.3	0	**6.1**
3a.1 (Recommended Plan)	3.7	2.3	0	**6.0**
9a	25.2	3.2	2.1	**30.5**
9b/c	24.9	2.6	1.0	**28.5**
CRL Action Alternatives				

Alternative	High Marsh	Intertidal Marsh	Tidal Flat	Total
2a	0	0	0	**0**
3b	0	0.7	0	**0.7**
4b.1 (Recommended Plan)	0	0.7	0	**0.7**

BRFG Alternative 3a
This alternative is expected to remove approximately 6.1 acres of wetlands, primarily due to excavation of a temporary bypass channel to maintain navigation through the area during construction. After construction, the temporary channel would be backfilled and the wetlands restored and/or mitigated.

BRFG Alternative 3a.1 (Recommended Plan)
Under this alternative, impacts to wetlands would be similar to Alternative 3a, with approximately 6.0 acres of wetlands being removed, primarily due to excavation of a temporary bypass channel. After construction, the temporary channel would be backfilled and the wetlands restored and/or mitigated.

BRFG Alternative 9a
Under this alternative, excavation of a new open channel would remove an estimated 30.5 acres of wetlands consisting mostly of high salt marsh. Due to higher impacts, this alternative would require higher amounts of mitigation than Alternatives 3a and 3a.1.

BRFG Alternative 9b/c
Impacts to wetlands, as well as mitigation needs, would be similar to Alternative 9a, with an estimated 28.5 acres of wetland habitats (mostly high salt marsh) being impacted by the new channel and floodgates.

CRL Alternative 3b
This alternative would result in minor changes to the physical and hydrological characteristics of the Colorado River and GIWW including the conversion of adjacent uplands into open water during construction of a temporary bypass channel. An estimated 0.7 acre of intertidal marsh would be impacted by the temporary bypass channel. After construction, the temporary channel would be backfilled and the wetlands restored and/or mitigated.

CRL Alternative 4b.1 (Recommended Plan)
This alternative would also require construction of a temporary bypass channel, which would impact an estimated 0.7 acre of intertidal marsh. After construction, the temporary channel would be backfilled and the wetlands restored and/or mitigated.

The Recommended Plan (BRFG Alternative 3a.1 and CRL Alternative 4b.1) will impact an estimated total of 6.7 acres of wetland habitats due primarily to the excavation of temporary bypass channels at each facility. After construction, these bypass channels will be backfilled, and the wetlands will be restored and/or mitigation. Additional information on impacts to waters of the U.S. resulting from the Recommended Plan is provided in the 404(b)(1) analysis that has been prepared for the project (Attachment D-1). The USACE is developing a mitigation plan for wetland habitats in coordination with the USFWS, NMFS, and TPWD (Attachment D-2).

5.3.3 Water Quality

No Action

Under the FWOP Condition, continued implementation of pollutant protection programs by the EPA and TCEQ and use of best management practices will benefit water quality. Periodic disturbance of sediments and suspension of sediments in the water column will continue because of maintenance dredging operations, barge traffic, and flooding. However, as the BRFG and CRL facilities continue to age, and/or if waterborne vessel traffic on the GIWW increases, the potential for accidents resulting in a contaminant spill may increase and may affect water quality.

Under the FWOP Condition, the project would not affect salinities in or near the NEPA study areas. Salinities are projected to increase due to anticipated sea level rises; however, in the NEPA study areas, freshwater inflows from the Brazos, San Bernard, and Colorado Rivers should help minimize the effects of salinity rises, except during low-flow periods.

All Alternatives

In general, during high flows in the Brazos and Colorado Rivers, salinities in the NEPA study areas would decrease due to higher influx of freshwater. Salinities would gradually increase as river levels and freshwater inflow decrease to normal flows and low flows. Modifying the BRFG and CRL facilities has the potential to change salinity in the NEPA study areas, the Brazos and Colorado Rivers upstream and downstream of the rivers, and nearby waters such as Cedar Lakes at BRFG and East and West Matagorda Bays at CRL. Salinity modeling at BRFG indicates the alternatives would alter average salinities by a decrease of up to 6 percent to and an increase of as much as 16 percent. However, under the existing and FWOP conditions, the area experiences large fluctuations in salinities, from near freshwater (0 ppt) to near seawater (35 ppt), and overall, projected average salinities under the various alternatives are expected to follow this trend.

BRFG Alternative 3a

Water-based construction activities would increase turbidity in the GIWW and Brazos River as a result of maintenance dredging. During land-based construction activities adjacent to the GIWW, runoff from exposed earth would result in localized, temporary increases in suspended sediment in adjacent water. The increase in turbidity is temporary and local, and water quality is expected to return to existing conditions after dredging and construction activities are completed. BRFG Alternative 3a: Hydraulic modeling predicted that during typically low-flow months (June through August), salinity would remain approximately the same as under the FWOP Condition.

Best management practices (BMPs) would be used to reduce suspended solids from land runoff, including installation of silt fences. Similarly, turbidity screens or silt collection curtains around construction equipment would reduce the amount of sediment entrained in the water. As under the FWOP Condition, periodic disturbance of sediments and suspension of sediments in the water column would continue as a result of maintenance dredging operations, barge traffic, and flooding.

BRFG Alternative 3a.1 (Recommended Plan)

Water quality impacts from this alternative, including turbidity increases from dredging activities, would be similar to Alternative 3a. Changes to salinity under this alternative would be similar to Alternative 3a and the FWOP Condition.

BRFG Alternative 9a
Temporary turbidity increases from this alternative would be more frequent due to the need for more maintenance dredging that would be needed if no gates were present. In addition, compared to Alternatives 3a and 3a.1, this alternative has a higher potential to affect water quality due to potential HTRW concerns associated with Texas Boat & Barge, Inc., which would be removed by this alternative. Under this alternative, hydraulic modeling projects that the mean salinity throughout the NEPA study area would be reduced due to the absence of floodgates, which leads to a greater exchange between the Brazos River and the GIWW; however, there would not be a substantial reduction in salinity compared to the FWOP Condition

BRFG Alternative 9b/c
Temporary turbidity impacts under this alternative would be similar to Alternative 3a; however, this alternative has a higher potential to affect water quality due to the removal of Texas Boat & Barge, Inc., which has HTRW concerns. Under this alternative, salinity changes would be similar to Alternative 9a, with only minor changes in salinity.

CRL Alternative 3b
The increased frequency of maintenance dredging under this alternative would result in increased temporary turbidity compared to the FWOP Condition. Under this alternative, the average salinity decreases slightly in West Matagorda Bay and increases in East Matagorda Bay. However, freshwater inflows from the Colorado River would be expected to limit salinity increases to periods of low river flows. This alternative is not anticipated to result in a substantial change in salinity compared to the FWOP Condition.

CRL Alternative 4b.1 (Recommended Plan)
Under this alternative, there would be an increase in turbidity that would occur at dredging locations during construction and maintenance dredging. Impacts from maintenance dredging are expected to be similar to the FWOP Condition. Salinity conditions in the NEPA study area under this alternative are expected to be similar to the FWOP Condition.

5.3.4 Sediment

No Action
Continued sedimentation in the GIWW will result in the need for regular maintenance dredging and dredged material disposal. River flooding trends will also continue and may change as inland areas within the major watersheds (such as Brazos, San Bernard, and Colorado Rivers) are developed and impervious cover increases, resulting in more storm water runoff.

BRFG Alternative 3a
Under this alternative, there is an overall small projected change in sedimentation that would require maintenance dredging, with a small decrease in sedimentation to the GIWW west of the BRFG and a small increase to the GIWW east of the BRFG. Project increases in sedimentation would occur in the Brazos Basin (23%), East GIWW (1%), and Freeport Channel (7%). Maintenance dredging would prevent or reduce the shoaling that would occur under natural sediment deposition processes, as under the FWOP Condition.

BRFG Alternative 3a.1 (Recommended Plan)
Under this alternative, a net 8 percent increase in sedimentation requiring maintenance is projected. Areas where increased sedimentation is expected include the West GIWW (18%), Brazos Basin (22%), East GIWW (15%), and Freeport Channel (11%).

BRFG Alternative 9a
The GIWW alignment would be altered, and there would be an open channel without any floodgates. Modeling indicates this Action Alternative would have the largest effects on sedimentation to the GIWW both west and east of the BRFG, and the increased sedimentation would require a substantial increase in maintenance dredging in the NEPA study area, with a projected 231 percent of increased sedimentation in the Freeport Harbor and Channel to the east. The additional sediment load would cause shoaling, which in turn would reduce navigational passages, increasing overall transportation costs. Maintenance dredging would prevent or reduce the shoaling that would occur under natural sediment deposition processes, as under the FWOP Condition, although more maintenance dredging would be needed compared to the FWOP Condition.

BRFG Alternative 9b/c
The GIWW alignment would be altered, there would be 125-foot-wide floodgates installed on new alignment, and a flood control structure may be installed at the existing west gate location. Under this alternative, there would be an increase in sedimentation, but not to the same magnitude as Alternative 9a. More sediment would be deposited in the Brazos River between the floodgates, and less sediment would be deposited in the GIWW both west and east of the BRFG than for Alternative 9a. Overall, less maintenance dredging would be required for this alternative than for Alternative 9a. Maintenance dredging would prevent or reduce the shoaling that would occur under natural sediment deposition processes, as under the FWOP Condition.

CRL Alternative 3b
Removing the locks and maintaining an open channel at the CRL would increase the existing sediment budget in the GIWW. Sedimentation rates might increase by approximately 436 percent in the East GIWW and increase by approximately 292 percent in the West GIWW. This deposition would require additional significant maintenance dredging. Further, this alternative would substantially reduce the amount of sediment that reaches the delta in West Matagorda Bay. Maintenance dredging would prevent or reduce the shoaling that would occur under natural sediment deposition processes, as under the FWOP Condition.

CRL Alternative 4b.1 (Recommended Plan)
Under this alternative, modeling indicates that sedimentation trends in the GIWW, Colorado River, West Matagorda Bay, and other areas would be similar to the FWOP Condition.

5.4 Vegetation, Wildlife Habitat, Land Resources, and Threatened and Endangered Species

5.4.1 Vegetation and Wildlife Habitat

No Action
Due to their low-lying position and proximity to the Gulf of Mexico, wetlands and other habitats in the BRFG and CRL areas are susceptible to being lost to rising sea levels resulting from climate change under the FWOP Condition. Wetlands and other habitats will also be lost to development and continued disposal of dredged material from the GIWW. Habitat losses would result in reduced habitat diversity, particularly for aquatic and semi-aquatic animals, waterfowl, and wading birds.

Large wetland areas in the BRFG and CRL regions will continue to be protected by the San Bernard NWR, Justin Hurst WMA, and Mad Island WMA, and future wetland losses may be reduced by restoration and shoreline stabilization projects and possible use of dredged material for those projects. Impacts to coastal habitats and resources would also be managed and mitigated to some extent by regulations such as the CWA, ESA, CBRA, Coastal Zone Management Act, and TCMP, as well as by continued funding of programs to purchase, preserve, and manage coastal areas.

All Alternatives

For each action alternative, the acreages of vegetation/wildlife habitats that are present within the anticipated disturbance footprint are provided below and summarized in **Table 5.5.** Under all Action Alternatives, other habitats in the area may be converted gradually to open water habitats over time as sea levels rise, but this impact is similar to the FWOP Condition. Since existing DMPAs and ODMDS would be used, none of the alternatives are expected to impact new vegetation/wildlife habitats due to dredged material placement.

Table 5.5 Impacts to Vegetation and Wildlife Habitats (acres)

Alternative	Developed	High Marsh	Intertidal Marsh	Tidal Flat	Upland Shrub/Woods	Open Water	Total
BRFG Action Alternatives							
2a	0	0	0	0	0	0	**0**
3a	6.1	3.8	2.3	0	49.7	21.4	**83.3**
3a.1 (TSP)	6.1	3.7	2.3	0	45.1	21.4	**78.6**
9a	12.9	25.2	3.2	2.1	2.7	29.1	**75.2**
9b/c	17.7	24.9	2.6	1.0	4.4	36.0	**86.6**
CRL Action Alternatives							
2a	0	0	0	0	0	0	**0**
3b	10.8	0	0.7	0	14.7	45.2	**71.4**
4b.1 (TSP)	10.8	0	0.7	0	14.7	45.2	**71.4**

While some vegetation/wildlife habitats would be lost due to construction of most alternatives, none of the vegetation communities are considered regionally rare, unique, or imperiled. BMPs will be used during construction activities to prevent the establishment and spread of invasive plant species.

With the exception of the two rehabilitation alternatives (which do not meet the purpose and need of the project), the Recommended Plan (BRFG Alternative 3a.1 and CRL Alternative 4b.1) have the lowest impacts to wetland habitats compared to other alternatives. Impacted wetland habitats in the temporary bypass channels would be restored and/or mitigated, resulting in no net loss due to any of the Action Alternatives. The restoration/ mitigation plan is being prepared in coordination with the USFWS, NMFS, and TPWD.

5.4.2 Land Resources (Protected/Managed) and Recreation Areas

No Action

Under the FWOP Condition, the Levee Road Boat Ramp, located in the BRFG NEPA study area, is expected to continue to be open to the public and maintained by Brazoria County. The San Bernard NWR, Justin Hurst WMA, Mad Island WMA, and other parks and recreation areas near the BRFG and CRL NEPA study areas will continue to operate.

All Alternatives
None of the Action Alternatives would impact designated parks, recreation areas, national wildlife refuges, wildlife management areas, or other protected or managed lands, as none are in the NEPA study areas. The Levee Road Boat Ramp, which is a public boat ramp owned and managed by Brazoria County and located on the Brazos River approximately 0.3 mile north of the GIWW crossing, would be impacted by some of the BRFG alternatives, as outlined below.

BRFG Alternative 3a
The Levee Road Boat Ramp would not be impacted by this alternative.

BRFG Alternative 3a.1 (TSP)
The Levee Road Boat Ramp would not be impacted by this alternative.

BRFG Alternative 9a
The Levee Road Boat Ramp would be removed by this alternative. Relocation of the ramp would need to be discussed with Brazoria County.

BRFG Alternative 9b/c
The Levee Road Boat Ramp would be removed by this alternative. Relocation of the ramp would need to be discussed with Brazoria County.

CRL Alternative 3b
Under this alternative, no changes to Mad Island WMA, Jetty Park, Big Boggy NWR, or other protected lands or recreational areas near the NEPA study area are expected to occur. There would be no change in impacts compared to the FWOP Condition.

CRL Alternative 4b.1 (TSP)
Like Alternative 3b, this alternative is not expected to impact protected lands or recreational areas.

5.4.3 Threatened and Endangered Species

No Action
Under the FWOP Condition, future losses of wetlands and beaches in the region due to sea level rises or other effects could have an impact on wintering whooping cranes, piping plovers, and red knots, while future restoration and stabilization efforts in coastal habitats could, in contrast, benefit these species. Sea turtles may be affected by increased vessel traffic, industrial development, and dredging operations in the GIWW and other waterways. Potential impacts of various activities would be managed by continued execution of the ESA, including development of conservation plans and measures.

All Alternatives
Table 5.6 identifies the federally listed threatened and endangered species that may occur in Brazoria and Matagorda Counties and provides the anticipated effect determination for the Recommended Plan (BRFG Alternative 3a.1 and CRL Alternative 4b.1). The Recommended Plan is expected to have no effect on most of the listed species because those species have low potential of occurring in the NEPA study areas and/or proposed improvements could be constructed in a way that would avoid impact. The Recommended Plan may affect, but is not likely to adversely affect the following six species:

- piping plover

- red knot
- green sea turtle
- hawksbill sea turtle
- Kemp's ridley sea turtle
- loggerhead sea turtle

Discussions of the effect determinations are provided by species below. More detailed information on impacts to threatened and endangered species resulting from the Recommended Plan is provided in the Biological Assessment prepared for the project in the Environmental Appendix.

Table 5.6 Anticipated Effects of Project on Threatened and Endangered Species

Listed Species		Listing Status	Jurisdiction	Potential to Occur in NEPA Study Areas?	Recommended Plan Effect Determination[1]
Common Name	**Scientific Name**				
Birds					
Northern aplomado falcon	*Falco femoralis septentrionalis*	Endangered	USFWS	Yes	No Effect
Piping plover	*Charadrius melodus*	Threatened	USFWS	Yes	May Affect, Not Likely to Adversely Affect
Red knot	*Calidris canutus rufa*	Threatened	USFWS	Yes	May Affect, Not Likely to Adversely Affect
Whooping crane	*Grus americana*	Endangered	USFWS	Yes	No Effect
Mammals					
West Indian manatee	*Trichechus manatus*	Threatened	USFWS	Yes	No Effect
Fin whale	*Balaenoptera physalus*	Endangered	NMFS	No	No Effect
Humpback whale	*Megaptera novaeangliae*	Endangered	NMFS	No	No Effect
Sei whale	*Balaenoptera borealis*	Endangered	NMFS	No	No Effect
Sperm whale	*Physeter macrocephalus*	Endangered	NMFS	No	No Effect
Reptiles					
Green sea turtle	*Chelonia mydas*	Threatened	NMFS	Yes	May Affect, Not Likely to Adversely Affect
Hawksbill sea turtle	*Eretmochelys imbricata*	Endangered	USFWS; NMFS	Yes	May Affect, Not Likely to Adversely Affect
Kemp's ridley sea turtle	*Lepidochelys kempii*	Endangered	USFWS; NMFS	Yes	May Affect, Not Likely to Adversely Affect

Listed Species		Listing Status	Jurisdiction	Potential to Occur in NEPA Study Areas?	Recommended Plan Effect Determination[1]
Common Name	**Scientific Name**				
Leatherback sea turtle	*Dermochelys coriacea*	Endangered	USFWS; NMFS	No	No Effect
Loggerhead sea turtle	*Caretta caretta*	Threatened	USFWS; NMFS	Yes	May Affect, Not Likely to Adversely Affect
Mollusks					
Golden Orb	*Quadrula aurea*	Candidate	USFWS	No	No Effect
Smooth pimpleback	*Quadrula houstonensis*	Candidate	USFWS	No	No Effect
Texas fawnsfoot	*Truncilla macrodon*	Candidate	USFWS	No	No Effect
Texas pimpleback	*Quadrula petrina*	Candidate	USFWS	No	No Effect
Corals					
Boulder star coral	*Orbicella franksi*	Threatened	NMFS	No	No Effect
Elkhorn coral	*Acropora palmata*	Threatened	NMFS	No	No Effect
Lobed star coral	*Orbicella annularis*	Threatened	NMFS	No	No Effect
Mountainous star coral	*Orbicella faveolata*	Threatened	NMFS	No	No Effect

[1] The Recommended Plan is BRFG Alternative 3a.1 and CRL Alternative 4b.1.
Sources: NMFS 2017; USFWS 2017a, b, c

• ***Northern aplomado falcon*** – The nearest population of northern aplomado falcon, which includes approximately 14 territorial pairs, is over 30 miles south of the CRL NEPA study area along the length of Matagorda Island and adjacent San Jose Island. Individual sightings have been recorded within 5 miles of the NEPA study areas, and the NEPA study areas contain open habitats that could be used by aplomado falcons. None of the Action Alternatives would remove preferred habitat, and none have the potential to affect aplomado falcon nesting; therefore, the Recommended Plan and other Action Alternatives are expected to have no effect on the northern aplomado falcon.

• ***Piping plover and red knot*** – The piping plover and red knot are migratory species that overwinter on the Texas coast and utilize barrier island beaches, exposed tidal flats, washover passes, and mud flats. Although no substantial habitat is located within the NEPA study areas, designated critical habitat for the piping plover is present along the Gulf beach near both NEPA study areas, as well as in the Colorado River delta in West Matagorda Bay. The Action Alternatives, including the Recommended Plan, could affect sediment budget to those areas; however, this change is not expected to modify the critical habitat or adversely affect the species. As a result, the Recommended Plan and other Action Alternatives may affect, but are not likely to adversely affect piping plovers and red knots.

• ***Whooping crane*** – Whooping cranes also overwinter on the Texas coast, mostly in the area surrounding the Aransas NWR located about 30 miles southwest of the CRL NEPA study area. They have been recorded within 5 miles of both NEPA study areas and could utilize salt marsh habitat in the NEPA study areas. The Action Alternatives will have varying levels of impacts to salt marshes, all of which are considered low compared to the availability of salt marshes in the region. Since most whooping crane wintering occurs well south of the NEPA study areas, the Recommended Plan and other Action Alternatives are expected to have no effect on whooping cranes.

• ***West Indian manatee*** – Texas is the extreme western edge of the West Indian manatee's current distribution, and occurrences in Texas are occasional to rare. Thus, it is unlikely that this species will occur in the NEPA study areas and be exposed to construction activities. As a result, the Recommended Plan and other Action Alternatives are expected to have no effect on the West Indian manatee.

• ***Whales*** – Whales are generally restricted to offshore waters and are not expected to occur in the NEPA study areas. Therefore, the Recommended Plan and other Action Alternatives are expected to have no effect on the listed whale species.

• ***Sea turtles*** – Green, hawksbill, Kemp's ridley, loggerhead, and leatherback sea turtles are known to occur off the Texas coast, although leatherback sea turtles are uncommon in Texas coastal waters and are not expected to occur in the NEPA study areas. The GIWW and Brazos and Colorado Rivers provide open water habitats that could be used by sea turtles. However, it is anticipated that hopper dredges would not be used for this project, thereby avoiding the potential of killing sea turtles. Activities in the GIWW and river channels could have some minor effect on sea turtles; therefore, the Recommended Plan and other Action Alternatives may affect, but are not likely to adversely affect green, hawksbill, Kemp's ridley, and loggerhead sea turtles and would have no effect on leatherback sea turtles.

• ***Mollusks (mussels)*** – The mussel species that are candidates for federal listing are freshwater species and are not expected to occur in the tidal and brackish waters of the Brazos River, Colorado River, or other waters in the NEPA study areas due to salinity fluctuations. Therefore, the Recommended Plan and other Action Alternatives would have no effect on the candidate mussel species.

• ***Corals*** – The listed corals are offshore species and do not occur in the NEPA study areas. Therefore, the Recommended Plan and other Action Alternatives would have no effect on corals.

5.4.4 Other Protected Wildlife Species

No Action

Under the FWOP Condition, overall habitat conditions in the NEPA study areas are expected to be similar to existing conditions, although sea level rises would increase open water areas and decrease wetland areas, which could affect some wildlife species. Bottlenose dolphins may be affected by increased vessel traffic, industrial development, and dredging operations in the GIWW and other waterways. Natural changes to vegetation/wildlife habitats would alter use of the habitats by migratory birds, but overall the NEPA study areas are expected to remain largely undeveloped and existing wildlife refuges/management areas are expected to continue protecting valuable coastal habitats for migratory birds.

All Alternatives

Marine Mammals – Bottlenose dolphins are common on the Texas coast and are known to occur in the BRFG and CRL NEPA study areas. The proposed construction activities associated with the Recommended Plan and other Action Alternatives are not expected to include blasting or SONAR. However, pile driving of sheet pile or other structures for the proposed new guide walls at the BRFG has the potential to impact bottlenose dolphins. The Recommended Plan would minimize impacts to bottlenose dolphins by minimizing activities that could affect dolphins, incorporating BMPs to minimize impacts, and adhering to the MMPA.

Bald and Golden Eagles – Golden eagles are not expected to occur in the NEPA study areas except for the possibility of migrating individuals passing through the area. Bald eagles may forage in the Brazos, San Bernard, and Colorado Rivers, GIWW, East and West Matagorda Bays, and other large water bodies in and near the NEPA study areas, but no bald eagle nests are in or adjacent to the NEPA study areas. Therefore, the Recommended Plan and other Action Alternatives are not expected to adversely affect bald or golden eagles.

Migratory Birds – The Recommended Plan and other Action Alternatives will remove wetland and upland habitats that could be used by migratory birds for various activities including nesting, foraging, loafing, and roosting. The Recommended Plan would minimize impacts to migratory birds by minimizing habitat removal, backfilling the proposed temporary bypass channel and restoring habitats there, and incorporating BMPs, if needed, to avoid removing active nests.

5.5 Aquatic Resources

No Action

Under the FWOP Condition, plankton and benthic resources will continue to be temporarily impacted by activities such as maintenance dredging. Maintenance dredging will affect benthic communities, primarily through removal; however, benthic organisms, particularly the infauna, are expected to re-colonize the dredged area within a relatively short period of time, perhaps as little as 18 months (Texas Water Resources Institute 1995).

BRFG Alternative 3a: Construction of this alternative would result in temporary disruption of benthic habitats within the channel, and impacts associated with maintenance dredging would continue. Dredging operations would alter benthic habitats through evacuation of bay bottom and dredged material placement in ODMDS (Montagna et al. 1998). The impact to benthic organisms is likely to be confined to the immediate vicinity of the area dredged (Newell et al. 1998), and recovery of benthic macroinvertebrates following burial is typically rapid (recovering within months rather than years) (Van Der Wal et al. 2011, Wilber et al. 2006, Wilber and Clarke 2001). Benthic communities that may be present in the submerged sediment on the edge of the current channel would be destroyed, but they would rapidly recolonize. Overall, changes to benthic communities are expected to be minor, localized, and similar to the FWOP Condition, which also includes bottom disturbances from maintenance dredging and barge traffic. No substantial changes to zooplankton species are anticipated, as the alternatives would result in only slight changes in salinity.

BRFG Alternative 3a.1 (Recommended Plan)

Impacts to benthic and plankton resources would be similar to Alternative 3a.

BRFG Alternative 9a
Impacts to benthic and plankton resources would be similar to Alternative 3a.

BRFG Alternative 9b/c
Impacts to benthic and plankton resources would be similar to Alternative 3a.

CRL Alternative 3b
Impacts to benthic and zooplankton resources from construction at the CRL facility would be similar to the anticipated impacts for the BRFG alternatives: temporary disruption of benthic communities that are expected to recover quickly after the disturbance is removed. Overall, changes to benthic communities are expected to be minor, localized, and similar to the FWOP Condition, which also includes bottom disturbances from maintenance dredging and barge traffic. No substantial changes to zooplankton species are anticipated, as the alternatives would result in only slight changes in salinity.

CRL Alternative 4b.1 (Recommended Plan)
Impacts to benthic resources would be similar to Alternative 3b.

5.6 Commercial and Recreational Fisheries

No Action
Under the FWOP Condition, expected land and wetland losses from erosion and sea level rise would result in the loss of important habitat for estuarine and marine fishery species. Erosion and sea level rise are expected to increase open water habitat but decrease wetland habitat that provides nursery grounds for important fishery species. As open water replaces marshes, fishery production is expected to decrease.

BRFG Alternative 3a
This alternative is not expected to have a substantial effect on commercial or recreational fisheries or fishery species. Temporary, localized disturbances and turbidity increases would affect fishery habitats and juvenile fish in the immediate vicinity of the construction, but there are large amounts of habitat in the surrounding area that support fisheries. Wetland losses from the alternative (approximately 6.1 acres) would be mitigated, and only slight changes in salinity are expected. The GIWW would remain open during construction via a bypass channel, so area waterbodies would remain accessible for recreational and commercial fishing.

BRFG Alternative 3a.1 (Recommended Plan)
Impacts to fisheries would be similar to Alternative 3a and would impact approximately 6.0 acres of wetland habitats

BRFG Alternative 9a
Impacts to fisheries would be similar to Alternative 3a, although this alternative would affect more wetland habitats (approximately 30.5 acres).

BRFG Alternative 9b/c
Impacts to fisheries would be similar to Alternative 3a, although this alternative would affect more wetland habitats (approximately 28.5 acres).

CRL Alternative 3b
Like the BRFG alternatives, this CRL alternative is not expected to have a substantial effect on commercial or recreational fisheries or fishery species. Wetland habitat loss would be minor (approximately 0.7 acre) and would be mitigated. Other habitat disturbances would be temporary, and only slight changes in salinity are expected. The GIWW would remain open during construction via a bypass channel, so area waterbodies would remain accessible for recreational and commercial fishing.

CRL Alternative 4b.1 (Recommended Plan)
Impacts to fisheries would be similar to Alternative 3b.

5.7 Essential Fish Habitat

No Action
Under the FWOP Condition, erosion could lead to existing shallow waters deepening, causing salinity gradients to be less estuarine. In addition, sea level rises are projected to result in marsh losses, which provide important nursery habitats. As loss of land and nursery habitat continues, it can be anticipated that there would be a reduction in fishery production.

All Alternatives
The NEPA study areas contain EFH for various species but are already partially developed with navigation-related structures and do not provide high-quality EFH. Additionally, marine water column and marine non-vegetated bottoms occur in abundance in the surrounding areas and are, therefore, not a unique resource. No HAPCs are located in the NEPA study areas. Coordination with NMFS is ongoing, and the EFH Assessment Report that has been prepared for the Recommended Plan (Attachment D-4) will be submitted to the NMFS for review.

BRFG Alternative 3a
Under this alternative, water column turbidity would increase during and immediately after construction activities, and displacement of water column food sources for finfish would be expected; however, recovery is expected to be rapid after construction activities are complete. During maintenance dredging activities, mobile finfish are expected to move away from the equipment; therefore, impacts would be considered short-term and not dissimilar to the FWOP Condition.

BRFG Alternative 3a.1 (Recommended Plan)
Impacts to EFH would be similar to Alternative 3a.

BRFG Alternative 9a
Impacts to EFH would be similar to Alternative 3a, although this alternative would affect more wetland habitats.

BRFG Alternative 9b/c
The impacts would be similar to Alternative 3a, although this alternative would affect more wetland habitats.

CRL Alternative 3b
The impacts would be similar to BRFG Alternative 3a, although fewer wetland losses would occur.

CRL Alternative 4b.1 (Recommended Plan)
The impacts would be similar to BRFG Alternative 3a, although fewer wetland losses would occur. Wetland impacts under this alternative would be the same as CRL Alternative 3b.

5.8 Coastal Barrier Resources and Coastal Natural Resources

No Action
Under the FWOP Condition, development within the Texas coastal zone is expected to continue at current rates and would continue to affect coastal barriers and natural resources. Impacts to coastal resources would be managed to some extent by regulations such as the CBRA, Coastal Zone Management Act, TCMP, and

CWA, as well as by continued allocation of funding to purchase, preserve, and manage coastal areas through Federal, state, and non-governmental resource agencies.

All Alternatives
The Recommended Plan and other Action Alternatives would affect coastal barrier resources and coastal natural resource areas; however, they would not substantially change the overall coastal environment. The alternatives are expected to be exempt from the prohibitions identified in the CBRA because they are associated with constructed improvements to an existing Federal navigation channel. However, consistent with the CBRA, the project is not expected to change development rates or patterns or induce growth on barrier islands. Compliance with the CBRA will be coordinated with the USFWS.

The Recommended Plan and other Action Alternatives would affect coastal natural resource areas protected by the TCMP, including coastal barriers, shore areas, wetlands, and special hazard areas (floodplains). The primary difference among the alternatives is the amount of coastal wetlands that would be removed. Under all alternatives, commensurate mitigation would be provided for wetland losses. The USACE has determined that the Recommended Plan is consistent with the TCMP policies and will submit the Coastal Consistency Determination that has been prepared for the Recommended Plan (Attachment D-5) to the Coastal Coordination Council for review.

5.9 Historic and Cultural Resources

No Action
Under the FWOP Condition, the BRFG and CRL facilities will continue to be operated and maintained as they have been for the last several decades. It is anticipated that the USACE will continue to repair steel members within the sector gates, replace portions of the timber guide walls, maintain the USACE support buildings, and maintenance dredge the GIWW as needed. Since there are no NRHP-listed or NRHP-eligible non-archeological historic resources within the BRFG and CRL APEs, none of these activities would affect any non-archeological historic resources under Section 106 of the NHPA.

Cultural resources may be impacted by continued shoreline erosion and by development. For projects where Federal and/or State land, funding, or permitting are involved, impacts to cultural resources would be addressed by avoidance, minimization, or mitigation.

All Alternatives
Much of the BRFG and CRL project areas have been extensively disturbed by previous excavation of the GIWW, diversion of the Brazos and Colorado Rivers, construction of the BRFG and CRL facilities, and

construction of roads, levees, and DMPAs. Therefore, the potential for encountering intact archeological sites is considered relatively low for any of the action alternatives.

A non-archeological historic resources survey was conducted in the APE for the BRFG and CRL facilities. Ten historic-age resources were inventoried in the BRFG APE and 15 historic-age resources were inventoried in the CRL APE. Most of the resources consisted of the floodgates, locks, and other USACE-owned resources within the BRFG and CRL facilities (e.g., control houses, power houses, pump house, boat house). None of the historic-age resources met the NPS criteria for NRHP eligibility. As a result, none of the action alternatives would affect historic resources.

5.10 Economic, Socioeconomic, and Human Resources

No Action
Populations in both NEPA study areas have been stable over the past decade, so rapid increases in growth and expansion are not expected under the FWOP Condition. Some expansion at ports and increased shipping on the GIWW may occur to support future growth and commerce in other portions of Texas. In addition, residential or industrial development may occur along the Brazos, Colorado, and San Bernard Rivers or other high points in the area. Likewise, existing wildlife refuges/management areas may expand to incorporate more coastal wetland habitats. Distribution of minority and low-income populations in the BRFG and CRL areas is expected to follow current trends. The existing aesthetics of the NEPA study area will not be altered.

BRFG Alternative 3a
This alternative would not impact minority or low-income populations in the BRFG vicinity. The duration of the construction would be relatively short, and therefore, it is not expected that workers will temporarily relocate to the project area; however, some expansion at ports and increased shipping on the GIWW may occur to support future growth and commerce leading to residential or industrial development along the Brazos or San Bernard Rivers. This alternative would allow for transit through the GIWW throughout construction, and would provide a long-term economic benefit to the shipping industry by making it more efficient to travel through the BRFG area. This alternative may be considered beneficial compared to the FWOP Condition.

BRFG Alternative 3a.1 (Recommended Plan)
Socioeconomic and human resource impacts would be similar to Alternative 3a.

BRFG Alternative 9a
Overall, socioeconomic and human resource impacts would be similar to Alternative 3a. This alternative would require relocation of one business, Texas Boat & Barge, Inc., which may temporarily affect the business and its employees.

BRFG Alternative 9b/c
Socioeconomic and human resource impacts would be similar to Alternative 9a.

CRL Alternative 3b
This alternative would not impact minority or low-income populations in the CRL vicinity. The duration of the construction would be relatively short, and therefore, it is not expected that workers will temporarily relocate to the project area; however, some expansion at nearby ports and increased shipping on the GIWW may occur to support future growth and commerce. This alternative would allow for transit through the GIWW throughout construction, and would provide a long-term economic benefit to the shipping industry by making it more efficient to travel through the CRL area. This alternative may be considered beneficial compared to the FWOP Condition.

CRL Alternative 4b.1 (Recommended Plan)
Socioeconomic and human resource impacts would be similar to Alternative 3b.

5.11 Air Quality

No Action
Future population growth within the Brazos, Colorado, and/or San Bernard River watersheds and within the HGB ozone nonattainment area will result in the potential for more contaminants to affect air quality under the FWOP Condition. Maintenance dredging in the GIWW will also continue to result in emissions, although it is expected that emissions would be minor. Continued implementation of pollutant protection programs by the EPA and TCEQ and use of best management practices will benefit air quality.

All Alternatives
Under the Recommended Plan and other Action Alternatives, air emissions would be from construction equipment associated with the project (dredging equipment, land-based construction equipment), and from personal vehicles for workers traveling to the project sites. Air emissions from the equipment will emit air pollutants and GHG. The air emissions from new construction would not occur at the same time as maintenance dredging. Air emissions are generally dispersed with distance and time, and a relatively slight increase in emissions during construction would correspond to a slight increase in ambient air quality concentrations for that air contaminant. These small increases in ambient air quality concentrations are not expected to cause exceedances of NAAQS.

The Recommended Plan and other Action Alternatives are expected to have similar effects on air quality, although alternatives that require longer construction durations and longer or more frequent maintenance cycles would result in higher overall emissions. None of the Action Alternatives are expected to result in emission levels that would have a large impact on air quality, and anticipated emissions from the BRFG alternatives are expected to be consistent with allowable emissions for the HGB moderate ozone nonattainment area. The USACE will evaluate projected emissions from construction and maintenance activities associated with the Recommended Plan and coordinate the results with the TCEQ and/or EPA.

5.12 Noise

No Action
Under the FWOP Condition, noise patterns in the BRFG and CRL vicinities would follow current trends, but increases in vessel traffic at the BRFG and CRL along the GIWW may increase noise levels in the areas, particularly during river flood-stage when the BRFG and CRL are closed or under restriction. Increased noise levels may affect residences at the CRL because of their proximity (within 0.25 mile); however, increased noise levels are expected to be periodic and temporary.

BRFG Alternative 3a
Noise sensitive receptors would be limited to recreational users of nearby parks such as San Bernard NWR, Justin Hurst WMA, Bryan Beach State Recreation Area, Bryan Beach Park, Quintana Beach County Park, Surfside Beach, or Brazoria NWR. No permanent noise sources would be installed as part of this alternative. Construction activities would create short-term noise level increases similar to increases during maintenance dredging currently occurring in the project area. Therefore, this alternative would have no adverse noise impacts. The noise generated by the existing maintenance dredging regime would continue as under the FWOP.

BRFG Alternative 3a.1 (Recommended Plan)
Noise impacts would be similar to Alternative 3a.

BRFG Alternative 9a
Noise impacts would be similar to Alternative 3a.

BRFG Alternative 9b/c
Noise impacts would be similar to Alternative 3a.

CRL Alternative 3b
Noise sensitive receptors would be limited to recreational users of nearby parks such as Mad Island WMA, Jetty Park, or Big Boggy NWR, as well as residences located near the CRL NEPA study area. Construction activities would create short-term noise level increases similar to increases during maintenance dredging currently occurring in the project area. Therefore, this alternative would have no adverse noise impacts. The noise generated by the existing maintenance dredging regime would continue as under the FWOP.

CRL Alternative 4b.1 (Recommended Plan)
Noise impacts would be similar to Alternative 3b.

5.13 Oil, Gas, and Minerals

No Action
Under the FWOP Condition, the Bryan Mound Strategic Petroleum Reserve and other existing oil and gas facilities in the NEPA study areas are expected to continue operations as at present. Any additional oil wells that would be drilled in the NEPA study area would not be impacted by the No Action Alternative.

BRFG Alternative 3a
This alternative would not affect existing, or induce new, oil and gas wells or pipelines in the BRFG vicinity. It would also not affect the Bryan Mound Strategic Petroleum Reserve. This alternative would be similar to the FWOP Condition in terms of oil, gas, and mineral resources.

BRFG Alternative 3a.1 (Recommended Plan)
Impacts to oil, gas, and mineral resources would be similar to Alternative 3a.

BRFG Alternative 9a
Impacts to oil, gas, and mineral resources would be similar to Alternative 3a.

BRFG Alternative 9b/c
Impacts to oil, gas, and mineral resources would be similar to Alternative 3a.

CRL Alternative 3b
This alternative would not affect existing, or induce new, oil and gas wells or pipelines in the CRL vicinity. This alternative would be similar to the FWOP Condition in terms of oil, gas, and mineral resources.

CRL Alternative 4b.1 (Recommended Plan)
Impacts to oil, gas, and mineral resources would be similar to Alternative 3b.

5.14 Hazardous, Toxic, and Radioactive Waste

No Action
Under the FWOP Condition, HTRW concerns are expected be similar to existing concerns. Lead paint would continue to be a potential concern at the BRFG and CRL facilities themselves, and contamination from permitted discharges or inadvertent releases from nearby facilities would continue to be a possibility.

All Alternatives
The BRFG and CRL were built in 1943 and 1944, respectively, when industrial marine facilities were coated in lead paint. Depending on the repairs and rehabilitation projects done at the facilities, there may still be lead paint on the structures. Other than the potential for lead paint, another HTRW concern in the immediate vicinity of the projects is Texas Boat & Barge, Inc., which is a barge cleaning and repair facility located adjacent to the east BRFG floodgate.

Sediment deposits around the BRFG are likely to contain HTRW from upstream chemical and petroleum manufacturing and processing facilities including Superfund sites. The EPA has characterized this area as having high sediment contaminants. It is likely that the unusually high flooding in the area in 2017 will have caused contaminated surface soil from upstream petroleum refineries, chemical plants and plastic manufacturing facilities to erode into the river, depositing in the sediments. At a minimum, sediment samples to characterize the contaminants present will be required for alternatives that result in disturbance of the riverbed. Potential contaminants from upstream operations include, but are not limited to, polychlorinated biphenyls [PCBs], heavy metals such as lead, nickel, mercury, zinc, cadmium, chromium, and arsenic, and organic compounds that include known carcinogens. Depending on the sediment sample results, there may be additional costs for disposal, treatment, or additional health and safety requirements during construction.

Sediment deposits near the CRL may also prove likely to contain HTRW material. EPA records of water quality testing near the CRL indicate fairly high metal, microbiology, and pesticide results. While there are not currently many industrial facilities visible upstream, there are several industrial wastewater discharge points that have had known past releases of hazardous materials. Depending on the sediment sample results, there may be additional costs for disposal, treatment, or additional health and safety requirements during construction.

BRFG Alternative 3a
Under this alternative, removal of the existing floodgates would require testing for lead paint and handling if present. Sediment sampling may be required to characterize the contaminants present; depending on the sediment sample results, there may be additional costs for disposal, treatment, or additional health and safety requirements during construction.

BRFG Alternative 3a.1 (Recommended Plan)
HTRW concerns would be similar to Alternative 3a.

BRFG Alternative 9a
Under this alternative, removal of the existing gates would require testing for lead paint and handling if present. Sediment sampling may be required to characterize the contaminants present; depending on the sediment sample results, there may be additional costs for disposal, treatment, or additional health and safety requirements during construction. Also, additional HTRW investigations would be needed to determine if there are contamination issues in the Texas Boat & Barge facility.

BRFG Alternative 9b/c
HTRW concerns would be similar to Alternative 9a.

CRL Alternative 3b
Under this alternative, removal of the existing lock gates would require testing for lead paint and handling if present. Sediment sampling may be required to characterize the contaminants present; depending on the sediment sample results, there may be additional costs for disposal, treatment, or additional health and safety requirements during construction.

CRL Alternative 4b.1 (Recommended Plan)
HTRW concerns under the Recommended Plan would be similar to Alternative 3b.

5.15 Indirect Impacts of Recommended Plan

This section describes the anticipated indirect impacts associated with the Recommended Plan (BRFG Alternative 3a.1 and CRL Alternative 4b.1). Indirect impacts are those impacts that are expected to be caused by the Recommended Plan, but "are later in time or farther removed in distance, but are still reasonably foreseeable. Indirect effects may include growth inducing effects and other effects related to induced changes in the pattern of land use, population density or growth rate, and related effects on air and water and other natural systems, including ecosystems." (40 CFR Section 1508.8). Indirect impacts are also known as secondary or induced impacts.

Overall, the Recommended Plan is expected to benefit the regional and national economy by improving navigation through the BRFG and CRL facilities, reducing navigation delays at the facilities, and reducing the risk of accidents at the facilities. The Recommended Plan would be constructed largely within the existing GIWW and BRFG/CRL facilities, temporary bypass channels are expected to be backfilled and restored after construction, and no induced growth is expected as a result of the Recommended Plan. Overall, the Recommended Plan is not expected to have major indirect effects.

Potential indirect effects of the Recommended Plan include the following:

• Changes in salinity – Major changes in salinity could result in long-term effects to habitats and wildlife communities. However, the Recommended Plan is not expected to result in major salinity changes. Minor salinity changes resulting from the Recommended Plan are expected to have commensurate small effects on wetlands, vegetation, and wildlife communities.

• Changes in sediment budget – Major changes in sediment budget and increased sedimentation in navigation channels could adversely affect navigation and result in large increases in maintenance dredging requirements. Changes in sediment budget could have long-term effects on beach habitats, the Colorado River delta development, piping plover critical habitat, and wetland habitats. At the CRL, the Recommended Plan would result in sedimentation trends that are similar to the FWOP Condition.

At the BRFG, the Recommended Plan would increase sedimentation up to 22 percent in the Brazos Basin and up to 18 percent in the GIWW; however, maintenance dredging would prevent or reduce shoaling and provide for continued navigation through these areas. The Recommended Plan is expected to result in a 1-percent reduction in sediment reaching the Brazos delta, which is expected to result in no more than minor effect on beach habitat, including piping plover critical habitat.

• Additional Maintenance Dredging – Increased maintenance dredging requirements could result in multiple indirect effects, including impacts from establishment of new DMPAs or ODMDS, increases in noise and air emissions, and disruptions to the water column and benthic communities. Under the Recommended Plan, maintenance dredging requirements at the CRL are expected to be similar to the FWOP Condition. At the BRFG, the Recommended Plan is projected to result in an 8-percent increase in sedimentation in zones that require maintenance (e.g., the GIWW, Brazos Basin, and Freeport Channel). The increased maintenance dredging needs would result in increases in noise, air emissions, and disturbances of the water column and benthic communities; however, these impacts are expected to be temporary and short-term. Based on current engineering analysis, no additional DMPAs or ODMDS are anticipated for the Recommended Plan.

• Changes at San Bernard River – The proposed open channel on the west side of the BRFG is expected to have indirect effects on the San Bernard River in that it will allow increased drainage of San Bernard flows, thereby reducing water surface elevations along the river. This may reduce the amount of water that flows south of the GIWW to the San Bernard River's mouth at the Gulf of Mexico, which may contribute to silting in of the river's mouth. Silting in of the river's mouth has occurred repeatedly, and the mouth has been reopened multiple times. Another project to reopen the mouth is included in a list of RESTORE Act projects.

5.16 Cumulative Impacts

The CEQ defines cumulative impacts as those impacts "which result from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or persons undertake such actions." Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time. Impacts include both direct and indirect effects.

Cumulative effects can result from a wide range of activities including the addition of materials to the affected environment, repeated removal of materials from the affected environment, and repeated environmental changes over large areas and long periods. Cumulative impacts may also occur when individual disturbances are clustered, creating conditions where effects of one episode have not dispersed before the next occurs (timing) or are so close that their effects overlap (distance). In assessing cumulative impacts, consideration is given to the following:

- the degree to which the proposed action affects public health or safety;
- unique characteristics (physical, biological, and socioeconomic factors) of the geographic area;
- the degree to which effects on the quality of the human environment may be highly controversial;
- the degree to which possible effects on the human environment are highly uncertain or involve unique or unknown risks; and
- whether the action is related to other actions with individually insignificant, but cumulatively significant, impacts on the environment.

5.16.1 Assessment Method

The cumulative impacts analysis followed similar methods as recent analyses conducted by the USACE for Freeport Channel improvements, addressing impacts for a set of criteria and comparing other past, present, and reasonably foreseeable projects in the general vicinity of the BRFG and CRL areas to the Recommended Plan. For the purposes of this analysis, cumulative impacts were assessed within an area that included the BRFG and CRL NEPA study areas and surrounding areas generally bounded by West Matagorda Bay to the west, Freeport Channel and Harbor to the east, the Gulf of Mexico to the south, and north to the limits of Federal navigation channels in the Colorado, San Bernard, and Old Brazos Rivers (cumulative impact study area).

5.16.2 Evaluation Criteria

Evaluation criteria that were considered included key resources that the BRFG-CRL Recommended Plan would impact and that are discussed in NEPA documents and project reports. These include the following attributes:

- Biological/Ecological Environment – the Recommended Plan will affect the following key biological resources:
  - Wetlands
  - Threatened and Endangered Species
  - Essential Fish Habitat

- Physical/Chemical Environment – the Recommended Plan will affect the following physical and chemical elements:
  - Water Quality
  - Air Quality

- Human Environment – the Recommended Plan will affect the following human environment resources:
  - Socioeconomic and Human Resources

5.16.3 Individual Project Evaluation

Table 5.7 lists the past, present, and reasonably foreseeable projects/activities that were identified in the general cumulative impact study area based on previous reports and available planning documents. The projects were compared to the BRFG and CRL Recommended Plan Alternatives presented in this report.

Table 5.7 Past, Present, and Reasonably Foreseeable Future Actions - Cumulative Impacts

Project/Activity	Approximate Location
Past or Present Projects/Activities	
Freeport Harbor Jetties	Freeport
Brazos River Diversion Channel	Freeport
Freeport Harbor Channel 45-foot Project	Freeport
GIWW Maintenance	GIWW in Brazoria and Matagorda Counties
Freeport Hurricane Flood Protection Levees	Freeport
Bryan Mound Strategic Petroleum Reserve	East side of Brazos River about 1 mile north of BRFG
CenterPoint Energy 69-kV electric transmission line	Freeport and vicinity
Petrocom Fiber Optic Network	Brazoria County
Freeport Area Industrial Complex(es)	Freeport and vicinity
Freeport Harbor Channel Outer Bar and Jetty Channels Widening (Widening Project)	Freeport
Freeport LNG Phase I	Quintana Island
Velasco Terminal	Freeport
Tenaris Bay City Pipe Mill	Bay City
Schulman's Movie Bowl and Grille	Bay City
Henderson Fabrication Expansion	Bay City
Reasonably Foreseeable Future Projects/Activities	
BP Exploration Gulf of Mexico Fiber Optic Network	Brazoria County
Freeport LNG Phase II	Brazoria County
Port Freeport Modifications	Freeport
Freeport Harbor Channel Improvement Project	Freeport
Parcel 14 Developments	Freeport
OXEA Chemicals Bay City Plant Expansion	Bay City
STP Nuclear Operating Company Expansion	Approx. 9 miles northwest of CRL
Chocolate Bayou Wind Project	Brazoria County
Peyton Creek Wind Farm	Matagorda County
Various Roadway Improvement Projects	Various

Sources: Brazoria County 2016; Caswell 2016; Matagorda County Economic Development Corporation (EDC) 2016; Reddell 2017; TxDOT 2017b, 2017c; USACE 2012

5.16.4 Resource Impact Evaluation

Biological/ecological, physical/chemical, and human resource impacts were evaluated based on individual project reviews. Acreages and rankings for the past, present, and reasonably foreseeable projects, compared to qualitative and quantitative impacts of the BRFG-CRL Recommended Plan, are presented in Table 5.5. Impacts for the BRFG-CRL Recommended Plan considered in this cumulative analysis are summarized in the analysis table. Direct impacts to specific habitats that could be quantified (e.g., acreages) from existing project documents were considered. Where relevant information is not quantifiable, impacts were evaluated qualitatively. Cumulative impact conclusions follow the project descriptions and summary table. Table 5.5 includes those projects that had some impact information available. Although not included in Table 5.5, other projects were considered in the cumulative impacts analysis.

5.16.5 Past or Present Projects/Activities

Freeport Harbor Jetties
The Freeport Harbor Jetties were originally constructed in the early to mid-1880s, and repaired and strengthened by the USACE in 1908. Currently, the jetties extend on the north and south sides of the channel. The North Jetty was relocated north of its original location as part of 45-foot channel improvements. The South Jetty was also rehabilitated concurrent with the North Jetty improvements. Sand moving southwest along the beach at Surfside is carried out along the North Jetty and deposited in the channel, where it is regularly removed and deposited in ODMDS. No quantifiable environmental impacts from this project could be located for inclusion in Table 5.5 as it was constructed in the distant past.

Brazos River Diversion Channel
Due to excessive siltation problems at Freeport, the Brazos River was diverted in 1929, through the location of the current BRFG facility. Today, the Brazos River still outfalls into the Gulf of Mexico through the diversion channel, and the old Brazos River channel is developed and serves as the Freeport Channel and Harbor. No quantifiable environmental impacts from the diversion project are available for inclusion in **Table 5.8** as it was constructed in the distant past.

Table 5.8 Comparison of Environmental Impacts of Past, Present, and Reasonably Foreseeable Future Projects/Activities and TSP

Resource	Existing SH-45	GIWW	Bryan Mound SPR	CenterPoint Energy Transmission Line (Route 4)	Freeport LNG Phase I	Freeport Channel Widening
Past and Present Projects/Activities						
Wetlands	NA ("some water filled low areas and ponds")	Dredge: NO Disposal: 4,464 ac	20 acres impacted (brackish marsh and creek/river)	8 acres impacted	68 acres impacted	NO
Threatened or Endangered Species	NA	NO	NO	NO	NO	May affect, not likely to adversely affect, piping plover, 2 injury or mortality sea turtle takes, 32 noninjurious sea turtle takes allowed per NMFS BO
EFH	NA	NA	NA	NA	NI	NA
Water Quality	NO	Dredge turbidity: NO Disposal turbidity: NO Dredge pollutants: NA Disposal pollutants: NO	Possible toxic releases and increase in groundwater salinity: NA	NO	Groundwater: NI Surface water: NO	Groundwater: NO Surface water: NO
Air Quality	Odors	Dredge: NO Disposal: NI	Hydrocarbon emissions periodically exceed stds: NA	NA	NO	NO_X exceedances; coordinating regarding compliance with SIP is ongoing
Historic and Cultural Resources	Historic USCG building relocation	Dredge: NO Disposal: NA	NA	NO	NO	NO
Socioeconomic and Human Resources	NA	NA	NA	NA	NA	NO

Reasonably Foreseeable Future Projects/Activities and BRFG-CRL Recommended Plan						
Resource	**BP Fiber Optic Network**	**Freeport LNG Phase II**	**Freeport Harbor Channel Improvement**	**Port Freeport Modifications (Berth 7)**	**BRFG Recommended Plan (Alternative 3a.1)**	**CRL Recommended Plan (Alternative 4b.1)**
Wetlands	NO	NI	39 acres impacted	2 acres impacted	Removal of approximately 6.0 acres of wetlands, primarily due to excavation of a temporary bypass channel.	Removal of approximately 0.7 acre of wetlands, due to excavation of a temporary bypass channel.
Threatened or Endangered Species	NO	NO	Likely to affect sea turtles during dredging; may affect, not likely to adversely affect piping plover	NA	Project may affect, but is not likely to adversely affect, the piping plover, red knot, and four sea turtle species. The project would have no effect on other threatened or endangered species.	Project may affect, but is not likely to adversely affect, the piping plover and red knot. The project would have no effect on other threatened or endangered species.
EFH	NO	NI	NO	NA	Impacts to EFH during construction and maintenance dredging expected to be minor, short-term, and similar to the FWOP Condition.	Impacts to EFH during construction and maintenance dredging expected to be minor, short-term, and similar to the FWOP Condition.
Water Quality	NO	Groundwater: NI Surface water: NO	Groundwater: NO Surface water: NO	NA	Increase in turbidity during construction and maintenance dredging.	Increase in turbidity during construction and maintenance dredging.
Air Quality	NO	NO	NOx exceedances	NA	Air emissions from construction equipment and maintenance dredging, but no large impact on air quality. Anticipated emissions are expected to be consistent with allowable emissions for the non-attainment area.	Air emissions from construction equipment and maintenance dredging, but no large impact on air quality.

Historic and Cultural Resources	NI: 3 anomalies, buffered to avoid	NO	NI: 3 anomalies will require diving, and additional investigation of site 41BO226 in PA 9 will be needed	NA	Potential for encountering intact archeological sites is considered relatively low. No effects to historic resources.	Potential for encountering intact archeological sites is considered relatively low. No effects to historic resources.
Socioeconomic and Human Resources	NA	NA	NO	NA	Long-term economic benefit to the shipping industry. May be considered beneficial compared to the FWOP Condition.	Long-term economic benefit to the shipping industry. May be considered beneficial compared to the FWOP Condition.

Impacts in this table are derived from publicly available project impact documents. These impacts are presented as they were in the documents, at the time of the document production. Note: Acreages have been rounded to nearest whole number.
"NO" = No adverse effect from project; limited in duration or extent such that the resource is not adversely affected, according to project document(s). "NI" = Impact mitigated by compensatory or protective measures, as stated in project document(s). "NA" = No impact information is available for the resource in project document.

Freeport Harbor Channel Deepening 45-Foot Project (Past and Current Condition)
The 45-foot Freeport Harbor Channel project was constructed in 1978. The Freeport Harbor Channel Jetty and Outer Bar channels are currently maintained by the USACE to a depth of -47 feet MLT at a width of 400 feet. These existing channels are approximately 6.3 miles long. Ongoing routine maintenance requires the removal of material per maintenance cycle for placement in the ODMDS at a roughly 10-month interval. Maintenance impacts are included in Table 5.5.

GIWW Maintenance Activities
As discussed above, the GIWW is routinely dredged to maintain the navigation channel. In 1975, approval was provided for maintenance dredging. The current authorized maintenance dimensions of the GIWW are 12 feet by 125 feet, maintained using a hydraulic pipeline dredge. Dredged material from the GIWW in the vicinity of the project area is placed in DMPAs designated for GIWW maintenance dredging. In Table 5.5, potential impacts for the GIWW segment(s) within the cumulative impact study area have been generally estimated from the 1975 EIS, although the maintenance segments are not exactly correlated to cumulative impact study area boundaries.

Freeport Hurricane Flood Protection Levees
Galveston District led studies in 1958 for hurricane-flood protection projects at Freeport and Port Arthur. Both areas had local levee systems at the time, challenged by Hurricane Carla; the newer Federal projects were designed to improve and augment existing protection. At Freeport, approximately 42 square miles (including areas of Freeport, Velasco, Lake Jackson, Clute, Lake Barbara, and Oyster Creek) were protected by approximately 56 miles of levees, wave barriers, floodwalls, drainage structures, pumping plants, and a vertical-lift tide gate with a navigation opening. In 1982, approximately 43 miles of the existing levee system and 2 miles of new levee were constructed, with two pumping stations. The Freeport Harbor levee system is projected to be able to protect the city and port from a 200-year hurricane; therefore, it is not likely that any additional construction would be required for the levee system. No documentation could be located about the construction impacts of the Freeport Hurricane Flood Protection Levee system, either from the 1970s or 1980s. Because previous project impact information was not readily available and no new construction is anticipated, the Freeport Hurricane Flood Protection Levees are not included Table 5.5.

Bryan Mound Strategic Petroleum Reserve
The Bryan Mound Strategic Petroleum Preserve occupies 500 acres on the east side of the Brazos River about 1 mile north of the BRFG facility. The site has a total authorized storage capacity of approximately 232 million barrels. The site was operational by 1979 and was expanded under two supplemental NEPA documents. A Finding of No Significant Impact was issued in 1993 on a brine pipeline replacement. A new commercial potable water line was permitted by USACE, and the installation was completed in 1985.

Bryan Mound Strategic Petroleum Preserve operations have contributed to three documented large brine spills: two spills totaled 606,000 barrels at Bryan Mound and West Hackberry in 1985; one 825,000-barrel spill at Bryan Mound in 1989; and one 74,000-barrel spill at Bryan Mound in 1990. The 1989 brine spill removed vegetation in a limited area and resulted in subacute toxicity over a wider area; eventual recovery was achieved over time in some areas through natural flushing and succession, but revegetation and/or drainage enhancement was required to restore completely any poorly drained areas. Construction and operational impacts from Bryan Mound are included to the extent available in Table 5.5.

CenterPoint Energy, Inc.
Construction and operation of the Freeport LNG Project required that new, dedicated electrical service be brought to the LNG Terminal site. Freeport LNG requested CenterPoint Energy to provide a new 69-kV electric transmission line from an existing CenterPoint Energy substation to the Freeport LNG substation,

located near the storage and vaporization facility on Quintana Island. An Environmental Assessment (EA) was approved in March 2006. Construction on the facility ended in June 2007. Impacts from this transmission line are included in Table 5.5.

Petrocom Fiber Optic Network
Petrocom, a Gulf cellular and microwave communications provider, created a fiber optic ring in a rough oval, starting in Texas from Freeport north to Houston, crossing into Louisiana to New Orleans and south to Fourchon, then offshore south and westward to return to Freeport. Cable installation began in June 1999. No environmental impacts from this project could be located for inclusion in Table 5.5.

Freeport Area Industrial Developments
The Freeport area and surrounding communities within the cumulative impact study area support a wide variety of private industrial uses. These industrial developments include various private companies, such as BASF, Dow, Cyanco, INEOS and Shin-Etsu. Operations, materials storage and transport, and discharges are generally regulated under EPA and TCEQ guidelines and requirements. As construction and operational impact information is not uniformly available on all of these sites, impacts from industrial facilities within the project area are not included in Table 5.5.

Freeport Harbor Channel Widening Project (Widening Project)
The Brazos River Harbor Navigation District (BRHND) of Brazoria County, Texas (now Port Freeport) applied to USACE, Galveston District, for a CWA Clean Air Act Section 404 permit and Rivers and Harbors Act Section 10 permit for dredge and fill activities related to the widening of portions of the Freeport Harbor Channel on April 14, 2005. Activities subject to the jurisdiction of USACE would include dredging in navigable waters to widen portions of the Jetty Channel and all of the Outer Bar Channel, and placement of fill in waters of the U.S. Based on the Section 10/404 permit application submitted by Port Freeport to USACE in April 2005, USACE determined that the permitting action for the proposed dredge and fill activities constitutes a major Federal action. Impacts to resources are included in Table 5.5.

Freeport LNG Phase I
Freeport LNG Development, LP was permitted to construct the new Freeport LNG Import Terminal Project on Quintana Island, Brazoria County, Texas, and providing infrastructure to shippers at the Stratton Ridge Meter Station. This first phase of the Freeport LNG Project was completed in April 2008 and is currently operational. Potential impacts associated with this first phase are included in Table 5.5.

Velasco Terminal
The Velasco Terminal is one of the larger port improvements in the last 40 years. Although it is planned to total 2,400 linear feet of berth, Phase I has completed 800 feet of berth thus far. The terminal would handle containerized and break-bulk cargo, with 90 acres of developable land with 22 acres of a general cargo area. No environmental impacts from this project could be located for inclusion in Table 5.5.

Tenaris Bay City
Construction began in August 2013 on this $1.8 billion seamless steel pipe mill that is capable of producing 600,000 tons of pipe per year on an 1,800-acre site east of Bay City on Hwy 35 (Matagorda County EDC 2016). This project will create 600 new direct manufacturing jobs with an average salary of $66,000. During the first six years of operation, the facility's projected economic impact in Matagorda County shall be more than $19 billion. The pipe mill was unveiled in December 2017 (Tenaris 2017). No environmental impacts from this project could be located for inclusion in Table 5.5.

Schulman's Movie Bowl and Grille
Waco-based Schulman Amusement, together in a public/private partnership with the City of Bay City, broke ground on a 54,000 sq. ft. entertainment center in June 2016. The center was scheduled to open in summary 2017 and features 12 bowling lanes, eight movie screens, an arcade, and a full-service restaurant (Matagorda County EDC 2016). No environmental impacts from this project could be located for inclusion in Table 5.5.

Henderson Fabrication Expansion
This metal fabrication company, founded in Bay City in the late 1980s, doubled its operation with a $1+ million expansion, adding 10 new employees, partly due to a contract they secured with Tenaris Bay City. Construction was completed in 2016 (Matagorda County EDC 2016). No environmental impacts from this project could be located for inclusion in Table 5.5.

5.16.6 Reasonably Foreseeable Future Projects/Activities

BP Fiber Optic Cable Network
BP Exploration and Production, Inc. has proposed installation of a 725-mile fiber optic cable network extending across the Gulf from Pascagoula, Mississippi, to Freeport, Texas. The proposed network will provide offshore oil and gas facilities in the Gulf with updated telecommunications service. Onshore construction in Freeport has been designed to avoid all wetland impacts. This location is on Quintana Beach. The proposed fiber optic cable network project is subject to Section 404(b)(1) evaluation, Texas Coastal Zone consistency certification, and Section 401 water quality certification from TCEQ. To avoid potential impacts to three previously identified potential cultural resource sites (anomalies), construction will not occur within a 164-foot radius avoidance zone around each anomaly. Preliminary indications are that no known threatened or endangered species or their critical habitat will be affected by the proposed project, and no substantial adverse impacts to EFH or federally managed Gulf fisheries are anticipated. An EA and Statement of Findings was issued August 16, 2007. This project is included in Table 5.5.

Freeport Harbor Channel Improvement Project
The USACE and Port Freeport plans to deepen the Freeport Harbor Channel from approximately 45 feet to approximately 55 feet. The project proposes to deepen and selectively widen the Freeport Harbor Channel and associated turning basins. This project is included in Table 5.5.

Freeport LNG Phase II
In July 2005, Freeport LNG Development, LP submitted environmental documentation to FERC to increase the diameter of the previously authorized 9.6-mile send-out pipeline from 36 inches to 42 inches. As a result, the LNG terminal would also require expansion. The environmental effects for the LNG terminal expansion are presented in an EA approved in 2006. A FEIS was approved in June 2014 to modify its previously approved Phase II facilities discussed in the 2006 EA, as well as, authorization to export up to 13.2 million tons of LNG per year from its proposed Liquefaction Plant and associated facilities in Brazoria County. Impacts associated with Phase II for the Freeport LNG development are presented in Table 5.5.

Port Freeport Modifications
Several projects were identified by Port Freeport as reasonably foreseeable in the Freeport area. Some of these projects include: Dock 5 Expansion; Cool Storage Facility; Construction of Berth 7; and BASF Polycaprolactam Facility. Because many of these projects are still in the planning stages, there is little information available regarding their potential impacts, therefore impacts are not included in Table 5.5.

Parcel 14 Developments (Warehouse and Rail Multimodal Facility)
Parcel 14 is an environmentally mitigated tract immediately south of SH 36. The location would be developed as a multimodal facility with on-site warehousing and rail access. With a grade separation at FM 1495 and SH 36, connectivity with other port parcels is contiguous, with non-port traffic separated from port traffic. Preliminary studies are proposed in the near future, but at this time no information regarding the environmental impacts are available, thus not included in Table 5.5.

OXEA Chemicals Bay City Plant Expansion
OXEA, a chemical manufacturer, began construction of a new world-scale propanol unit at its production site in Bay City in 2017; the unit is expected to come on stream in 2018 (BusinessWire 2017). This expansion project will create 19 new full-time, permanent jobs and will be an initial investment of $90 million with a total maximum investment of $250 million (Matagorda County EDC 2016). No environmental impacts from this project could be located for inclusion in Table 5.5.

STP Nuclear Operating Company Expansion
This electric generating company and Matagorda County's largest employer was granted license to build two new units in late 2015. Expansion plans are ongoing (Matagorda County EDC 2016). No environmental impacts from this project could be located for inclusion in Table 5.5.

Chocolate Bayou Wind Generation Project
The Chocolate Bayou Wind Generation Project is a proposed wind energy project to be located in Brazoria County (Cassell 2016). The project would include 65 wind turbines with a total net rating of 149.5 megawatts (MW). There is no firm commercial operation target date for the project. No environmental impacts from this project could be located for inclusion in Table 5.5.

Peyton Creek Wind Farm
The Peyton Creek Wind Farm is a proposed wind energy project to be located in southern Matagorda County (Reddell 2017). The project would include between 44 and 75 wind turbines on 12,000 to 15,000 leased acres south of Bay City that are currently used primarily for cattle and grazing. Construction of the project is expected to start in late 2018 and take 10 to 14 months. Up to 300 workers would be hired during construction; an estimated 10 full-time technical and mechanical jobs would be created by the project. No environmental impacts from this project could be located for inclusion in Table 5.5.

Various Roadway Improvement Projects
Several roadway improvement projects are planned for the area (Brazoria County 2016, TxDOT 2017a, 2017b, USACE 2012). However, because many of these projects are still in the planning stages, minimal information is available regarding their potential impacts; since no environmental impacts for these projects could be located, they are not included in Table 5.5.

5.16.7 Cumulative Impacts Discussion

This section provides a discussion of the potential cumulative impacts of the past, present, and reasonably foreseeable projects, combined with the BRFG and CRL Recommended Plan Alternatives. Each of the seven evaluation criteria are addressed.

Biological and Ecological Environment

Wetlands
The Recommended Plan would would impact approximately 6.0 acres of wetlands at BRFG and 0.7 acre of wetlands at CRL. Most of these impacts would occur in the temporary bypass channels, which would be

backfilled after construction and the wetlands restores and/or mitigated. Additional wetland habitat impacts over time are related to the Bryan Mound Strategic Petroleum Preserve, CenterPoint Energy electric transmission line, 45-foot Freeport Channel project, Freeport LNG, and Port Freeport modifications. From the 1950s to 2002, the Brazos Delta and surrounding area have shown a significant estuarine marsh loss trend. Losses can be attributed to erosion at the mouth of the diverted Brazos River, conversion to uplands due to early placement of dredged materials (e.g., the GIWW), agricultural land conversion, and residential and industrial development. Similar losses have occurred at the Colorado River and in Matagorda Bay and East Matagorda Bay. The BRFG and CRL projects, and the other projects identified in this analysis, are subject to Section 404 of the CWA and would therefore be required to avoid, minimize, and mitigate impacts to wetlands. As a result, no significant cumulative impacts to wetlands are anticipated as a result of the BRFG-CRL project.

Threatened and Endangered Species

None of the proposed projects included in this analysis are expected to adversely affect federally protected species, with the exception of some dredging activities associated with some of the projects that may affect sea turtles. Coordination with NMFS is required for these projects to avoid or minimize potential impacts to sea turtles during dredging operations; specific protective measures are engaged to prevent adverse impacts to the extent practicable. Any unavoidable impacts will be to individuals, within thresholds established by NMFS; therefore, the overall potential cumulative impacts are not expected to adversely impact sustainable populations. Furthermore, the BRFG-CRL project is not expected to have a significant contribution to impacts to these species.

Essential Fish Habitat

In general, placement of dredged material into open-water areas may affect food sources, increase turbidity, and release contaminants in EFH. Several projects compared in this analysis use ODMDS in construction and/or maintenance, potentially affecting EFH, albeit temporarily. Recovery of some benthic organisms would likely occur relatively quickly, although the assemblage in the dredged material might differ from the assemblage that existed prior to construction. Impacts to EFH from turbidity associated with ocean placement are not significant. If the material to be dredged is not contaminated, there would be no contamination issues with respect to EFH. Placement of dredged material associated with the projects included in this analysis would occur over time and would be subject to USACE and EPA permitting; therefore, it is reasonable to expect that dredged material placed into open-water sites would not contain contaminants. No significant cumulative impacts to EFH are anticipated.

Physical and Chemical Environment

Water Quality

For those projects that include dredging activities, dredging and placement operations are expected to temporarily degrade water quality in the project vicinity through increased turbidity and the release of nutrients from the sediment. No projects reviewed showed concerns with sediment contamination. Dredging and placement at proposed DMPAs and ODMDS may increase suspended solids, release contaminants and bound nutrients, and deplete oxygen. This impact is temporary and, except for turbidity, insignificant. If temporary degradation occurs, the cumulative impact study area should rapidly return to ambient conditions upon completion of dredging. Although ship traffic in the cumulative impact study area may increase over time and due to some projects, this increase is expected to be offset by efficiency increases derived from those proposed.

Groundwater impacts may occur in two of the projects considered in this analysis; however, no groundwater impacts are foreseeable or expected from implementation of the BRFG-CRL Recommended Plan. With implementation of BMPs and other permitting requirements, no significant cumulative impacts to surface water quality or groundwater quality are expected.

Air Quality

Objectionable odors (e.g., hydrogen sulfide) may result from the dredging of maintenance sediments containing high concentrations of organic matter in those reviewed projects requiring dredging or digging into aquatic sediments. Current maintenance dredging activities (such as GIWW and Freeport Harbor Channel) and proposed projects that include dredging activities for construction would emit NOX, CO, particulates, sulfur dioxides, and hydrocarbons. Part of the cumulative impact study area occurs within the HGB nonattainment area for ozone; therefore, all applicable projects in the cumulative impact study area with the potential to affect air quality must coordinate with TCEQ in regards to the SIP. This coordination should ensure compliance with the SIP, and thus the NAAQS, resulting in no significant cumulative impact to air quality.

The cause of global climate change is generally accepted to be the increased production of GHG emissions worldwide. Unlike criteria pollutant impacts, which are local and regional, climate change impacts occur at a global level. In addition, the relatively long lifespan and persistence of GHGs require that climate change be considered a cumulative and global impact. It is unlikely that an increase in global temperature or sea level could be directly attributed to the emissions resulting from a single project or combination of a few local projects. Rather, it is more appropriate to conclude that the GHG emissions associated with the BRFG-CRL Recommended Plan Alternatives, as well as the other projects considered herein, would combine with emissions across the U.S. and the globe to cumulatively contribute to global climate change.

Human Environment

Socioeconomic and Human Resources

The EO on Environmental Justice was instituted in 1994; therefore, several of the projects presented for evaluation in the cumulative impacts analysis did not include this as a criterion. The BRFG-CRL project is expected to have an overall economic benefit, and many of the other projects discussed herein are intended to provide economic benefits as well. Projects that are considered Federal actions are required to follow the EO on Environmental Justice. Therefore, no cumulative impacts to Environmental Justice communities are expected.

5.16.8 Cumulative Impacts Conclusions

Cumulative impacts due to past, existing, and reasonably foreseeable future projects, along with the proposed BRFG-CRL improvements, are not expected to have significant adverse effects in the cumulative impact study area. Most of the resources considered in this analysis are not affected by any or are affected by very few of the projects, in minor (small areas, mitigated) and/or temporary (short-term, recoverable with conditions) ways: threatened or endangered species, EFH, water quality, and air quality. Impacts associated with the BRFG-CRL project would be offset by mitigation measures.

5.17 Mitigation

The CEQ and NEPA guidelines state that damages to fish and wildlife resources should be prevented to the extent practicable through planning, design, and incorporating mitigation measures. For USACE projects, mitigation plans should be the most efficient and least costly measures appropriate to reduce fish and wildlife resource losses. If project lands cannot fulfill mitigation requirements, then separable public lands adjacent to project lands, to the extent possible, should be considered for acquisition. Subsection 906(a) of

the Water Resource Development Act (WRDA) of 1986 requires that the USACE maintain the power of eminent domain, which is the right to take private property for public use. The intent is to maintain the integrity and viability of significant natural resources and their contributions to local or regional ecosystems by applying sound ecosystem management techniques.

Average Annual Habitat Units (AAHUs) were calculated for each wetland habitat type under the FWOP Condition, or "No Action" Alternative. Under the FWOP Condition, no improvements would be made to the BRFG or CRL facilities, although the USACE will continue to perform normal O&M activities and natural ecological processes will continue to occur in the NEPA study areas. For the FWOP analysis, existing wetland habitats were assumed to maintain, and not degrade, over the 50-year analysis period. Although climate change, sea level rises, and periodic major storm events may affect wetland habitats over the analysis period, these effects are expected to be similar under the FWOP Condition and the Future With Project Condition. Based on this assumption, the HUs were calculated for the FWOP Condition over the 50-year analysis period and annualized using the annualizer in the IWR Planning Suite to determine AAHUs.

Future habitat values with the implementation of mitigation were projected to ensure that a mitigation plan would adequately compensate for wetland losses. To predict future habitat values of a potential mitigation site, the interagency team met to discuss the anticipated progression of a created wetland in terms of the habitat variables in the HSI models for the wildlife indicator species for each of the wetland habitats that would be impacted by the Recommended Plan and thus created by a mitigation plan: high marsh and intertidal marsh. These data were input into the HSI models and future HSIs were calculated for each created habitat type at each project site (BRFG and CRL). The HSIs were annualized over the 50-year analysis period using the annualizer in the IWR Planning Suite.

Based on predicted habitat values of created high marsh and intertidal marsh in the NEPA study areas, 6.76 acres of marsh creation is needed to sufficiently offset the 6.7 acres of marsh habitats that would be impacted by the Recommended Plan. The 6.76 acres of created marsh would provide an estimated 6.13 AAHUs, which would replace the AAHUs that would be lost as a result of the project (**Table 5.9**).

Table 5.9 Wetland Habitats Impacted by the Recommended Plan and Mitigation Needs

Habitat Type	Average Baseline HSI (Annualized)	Acres Lost	AAHUs Lost	Projected Mitigation HSI (Annualized)	AAHU Needed	Acres Needed
BRFG						
High Marsh	1.00	3.7	3.70	0.98	3.70	**3.78**
Intertidal Marsh	0.80	2.3	1.84	0.82	1.84	**2.24**
CRL						
Intertidal Marsh	0.83	0.7	0.58	0.80	0.58	**0.74**
Total for Both Project Sites	--	***6.7***	***6.12***	--	***6.12***	***6.76***

The USACE considered three alternatives for meeting the identified mitigation needs, two of which had three different planting options/scales. The mitigation alternatives considered included:

1. Purchase mitigation bank credits
2. Establish wetlands off-site with the following planting scales:

- Plugs purchased
- Plugs collected on site
- Seeded pots of marsh vegetation

3. Establish wetlands on-site with the following planting scales
   - Plugs purchased
   - Plugs collected on site
   - Seeded pots of marsh vegetation

The mitigation alternatives were screened based on high-level constraints and comparisons. Purchasing mitigation bank credits was screened out because, based on the USACE's Regulatory In-lieu Fee and Bank Information Tracking Information System (RIBITS) website (USACE 2017c), the BRFG and CRL project sites are not within the service area of any active or pending mitigation bank or in lieu fee program that has tidal marsh credits. Therefore, wetland mitigation cannot be accomplished through mitigation bank or in lieu fee program credits. In addition, a sensitivity analysis was conducted, and mitigation bank costs are expected to be an order of magnitude more costly than the on-site mitigation alternative.

Establishing wetlands off-site was also screened out because the projected benefits would be the same as establishing wetlands on site, but the off-site mitigation alternative would result in the addition of real estate costs.

Based on the initial screening, one mitigation alternative was evaluated in further detail: establish wetlands on-site with three planting scales. As noted above, the three planting scales include (1) plugs purchased, (2) plugs collected on site, and (3) seeded pots of marsh vegetation. Leaving the created wetlands to vegetate on their own was not considered because interagency coordination indicated that, if left unplanted, the mitigation areas would establish vegetation very slowly, with a projected 10 percent coverage in 5 years compared to an expected 75 to 100 percent coverage if planted. The analysis of the on-site mitigation alternative assumes that the three planting scales would produce the same habitat benefits (AAHUs); however, the planting scales would affect mitigation cost. As a result, the on-site mitigation options were evaluated using cost effective/incremental cost analysis using the IWR Planning Suite (version 1.0.11). **Table 5.10** provides the preliminary cost estimates for each planting scale.

Table 5.10 Preliminary Cost Estimates for On-site Planting at Three Scales

Planting Scale	Cost per Plug	# Plugs/ Acre	Plug Cost/ Acre	Planting Cost/ Acre	OMRRR Cost/ Acre[1]	Total Cost/ Acre[2]	Total Mitigation Cost[3]	Average Annual Cost/Acre
Plugs purchased	$3.00	12,575	$37,725	$20,000	$2,500	$60,225	$407,121	$2,685
Plugs on-site	$1.00	12,575	$12,575	$20,000	$2,500	$35,075	$237,107	$1,676
Seeded nursery	$10.00	12,575	$125,750	$20,000	$2,500	$148,250	$1,002,170	$6,215

[1] OMRR&R = Operations, Maintenance, Repair, Replacement, and Rehabilitation. Because the mitigation sites should be self-sustaining after the success criteria are met, OMRR&R costs should be minimal.
[2] Note that these costs assume that site prep would be done through the dredged material placement.
[3] Total mitigation cost is based on a total mitigation acreage of 6.76 acres.

Collecting plugs on-site was identified as the Best Buy mitigation plan, as it incurs the lowest average annual cost per acre. An uncaptured ancillary benefit of the on-site plug option is that it promotes the establishment of other native marsh species in addition to the target species because other species or their seeds may be included in the collected plugs.

5.18 Mitigation, Monitoring, and Adaptive Management

The WRDA of 2007, Section 2039 states, "Monitoring includes the systematic collection and analysis of data that provides information useful for assessing project performance, determining whether ecological success has been achieved, or whether adaptive management may be needed to attain project benefits." This section discusses the preliminary feasibility-level monitoring and adaptive management strategies for the anticipated wetland mitigation efforts at the BRFG and CRL facilities. The primary intent of this preliminary Monitoring and Adaptive Management Plan (MAMP) is to identify monitoring and adaptive management actions appropriate for the project's mitigation goals and objectives. The MAMP, including costs, is based on currently available data and information developed during plan formulation of the mitigation plan. Uncertainties remain regarding the project design and construction details, extents of the mitigation areas and associated features, monitoring elements, and adaptive management opportunities. During the PED phase of the project, the PDT will develop a more detailed MAMP that will address uncertainties, provide a detailed cost breakdown, and further assess the establishment and success of the mitigation features proposed in the mitigation plan.

5.18.1 Authority and Purpose

Mitigation plans must include a strategy for monitoring the success of the mitigation [Section 2039, WRDA 2007]: "Monitoring includes the systematic collection and analysis of data that provides information useful for assessing project performance, determining whether ecological success has been achieved, or whether adaptive management may be needed to attain project benefits." Section 2039 also directs that a Contingency Plan (Adaptive Management Plan) be developed for all ecological mitigation projects.

5.18.2 Implementation

Pre-construction, during construction, and post-construction monitoring shall be conducted by utilizing a MAMP Team consisting of representatives of the USACE, TxDOT, and contracted personnel. Monitoring will focus on evaluating mitigation success and guiding adaptive management actions by determining if the project has met Performance Standards. Monitoring will be carried out until the project has been determined to be successful (performance standards have been met), as required by Section 2039 of WRDA 2007. Monitoring objectives are summarized in **Table 5.11** and discussed below.

Table 5.11 Monitoring Criteria, Performance Standards, and Adaptive Management Strategies

Measurement	Performance Standard	Adaptive Management Measures
Herbaceous Plant Cover	70 percent cover by target marsh species	Replanting and/or re-contouring as needed Changing species composition Collecting plugs from different locations
Non-native Vegetation	< 10 percent cover by non-native or invasive species	Mechanical removal Local herbicide application Replanting as needed
Water Depth	Target water depth for specific habitat	Re-contouring as needed
Erosion Control	Minimal erosion observed	Install breakwaters or other controls Re-contouring as needed

The mitigation areas will be assessed prior to construction, then monitored initially at 6 months after construction and initial planting is completed. Afterward, the mitigation areas will be monitored annually for up to 3 years or until the mitigation success criteria are achieved. The mitigation areas will be considered successful when:

1) herbaceous cover of target plant species is at least 70 percent;
2) cover of non-native or invasive plant species is less than 10 percent; and
3) target water depths are present.

After any monitoring period, if it is determined that the mitigation areas are not progressing as planned, adaptive management actions outlined in **Table 5.11** will be implemented as appropriate.

5.18.3 Reporting

After each monitoring period, a report will be prepared and submitted to the USFWS, NMFS, TPWD, and other interested parties. Permanent locations for photographic documentation will be established to provide a visual record of habitat development over time. The photograph locations will be identified in the pre-construction monitoring report. Photographs taken at each location will be included in monitoring reports.

5.18.4 Monitoring and Adaptive Management Costs

Costs to be incurred during PED and construction phases include drafting of the detailed MAMP. Cost calculations for post-construction monitoring are displayed as a 3-year (maximum) total. If ecological success is determined earlier (prior to 3 years post-construction), then the monitoring program will cease and costs will decrease accordingly.

It is intended that monitoring conducted for the wetland mitigation will utilize centralized data management, data analysis, and reporting functions associated at the USACE Fort Worth District office. All data collection activities will follow consistent and standardized processes established in the detailed MAMP. Cost estimates include monitoring equipment, photograph point establishment, data collection, quality assurance/quality control, data analysis, assessment, and reporting for the proposed monitoring elements (**Table 5.12**). The current total estimate for implementing the MAMP is $66,000. Unless otherwise noted, costs will begin at the onset of the PED phase and will be budgeted as construction costs. With the addition of these MAMP costs to the anticipated constriction and OMRR&R costs, the total cost to construct, maintain, and monitor the proposed mitigation is $303,108.

Table 5.12 Preliminary Cost Estimates for Implementation of the Monitoring and Adaptive Management Plan (MAMP)

Category	Activities	PED Set-up & Data Acquisition	1-year Post-construction	2-year Post-construction	3-year Post-construction	Total
Monitoring: Planning and Management	Monitoring workgroup, drafting detailed monitoring plan, working with PDT on performance measures	$4,000	$1,000	$1,000	$1,000	$7,000
Monitoring: Data Collection	Vegetation	$6,000	$6,000	$6,000	$6,000	$24,000
Data Analysis	Assess monitoring data and performance standards	$2,000	$2,000	$2,000	$2,000	$8,000
Adaptive Management Program	Detailed Adaptive Management Plan and Program Establishment	$10,000	--	--	--	$10,000
	Management of Adaptive Management Program	--	$4,000	$4,000	$4,000	$12,000
Database Management	Database development, management, maintenance	$2,000	$1,000	$1,000	$1,000	$5,000
	Total MAMP Costs	**$24,000**	**$14,000**	**$14,000**	**$14,000**	**$66,000**
	Total Construction and OMRRR Cost					**$237,108**
	TOTAL MITIGATION COST					***$303,108***

THIS PAGE LEFT INTENTIONALLY BLANK

6.0 Applicable Laws and Executive Orders

There are many Federal and state laws pertaining to the enhancement, management and protection of the environment. Federal projects must comply with the environmental laws, regulations, policies, rules and guidance in Appendix A, among others. Corps personnel coordinated with Federal and state resource agencies during planning and will continue to coordinate. Compliance with laws will be accomplished upon review of this report by appropriate agencies and the public, and with the signing of a Record of Decision by the Assistant Secretary of the Army for Civil Works.

A summary of the compliance of the project with environmental laws and executive orders is include in **Table 6.1**.

Table 6.1 Compliance of the Project with Environmental Laws and Executive Orders

Policies	Compliance of Recommended Plan
Public Laws	
Clean Air Act, 1970, as amended	Compliant
Clean Water Act, 1972, as amended	Compliant
Coastal Zone Management Act, 1972, as amended	Compliant
Endangered Species Act, 1973, as amended	In Progress
Fish and Wildlife Coordination Act, 1958, as amended	In Progress
Magnuson-Stevens Fishery Conservation and Management Act	In Progress
Marine Mammal Protection Act of 1972	Compliant
Migratory Bird Treaty Act, 1918, as amended	Compliant
National Historic Preservation Act, 1966, as amended	In Progress
Executive Orders	
Protection Environmental Quality (EO 11514)	Compliant
Consultation with Indian Tribes (EO 13175)	Compliant
Floodplain Management (EO 11988)	Compliant
Protection of Wetlands (EO 11990)	Compliant
Environmental Justice (EO 12898)	Compliant
Invasive Species (EO 13112)	Compliant
Migratory Birds (EO 13186)	Compliant
Protection of Children (EO 13045)	Compliant

6.1 Federal laws

6.1.1 Clean Air Act of 1970 (Air Quality)

The Clean Air Act (CAA) sets goals and standards for the quality and purity of air. It requires the Environmental Protection Agency to set National Ambient Air Quality Standards (NAAQS) for certain pollutants considered harmful to public health and the environment and requires federal agencies to act in conformity with an applicable State Implementation Plan (SIP). The BRFG study area is located within the Houston-Galveston-Brazoria (HGB) Intrastate Air Quality Control Region, which is in attainment for all criteria pollutants except ozone (EPA 2017c, TCEQ 2017b). The HGB Ozone Nonattainment Area was classified as “severe” by the EPA in October 2008 under the 1997 eight-hour ozone NAAQS. As of July 2012, the EPA designated the HGB area as “marginal” for the 2008 ozone NAAQS based on major improvements in air quality for the area. In December 2016, the HGB area was reclassified as “moderate” ozone nonattainment for the 2008 ozone NAAQS, with an attainment deadline of July 2018 (81 FR 90207). The CRL area is located in Matagorda County, which is in attainment for all criteria pollutants.

6.1.2 Clean Water Act of 1972 – Section 401 (Water Quality)

The Clean Water Act (CWA) sets and maintains goals and standards for water quality and purity. Section 401 requires a Water Quality Certification from the Texas Council on Environmental Quality that a proposed project does not violate established effluent limitations and water quality standards. Section 401 compliance will be documented in the final report.

6.1.3 Clean Water Act of 1972 – Section 404(b)(1) (Disposal Sites for Dredged or Fill Material)

The USACE administers regulations under Section 404(b)(1) of the CWA, which establishes a program to regulate the discharge of dredged and fill material into waters of the U.S. Potential project-induced impacts subject to these regulations were evaluated during feasibility level design; results are contained in Appendix A. A Section 404 public Notice will be prepared and distributed for public and agency review, and a final 404(b)(1) evaluation will be included in the final report.

6.1.4 Coastal Zone Management Act of 1972 (Coastal Zone Development)

The Coastal Zone Management Act establishes a partnership structure allowing states and the Federal government to work together for the protection of U.S. coastal zones from environmentally harmful over-development. Potential project-induced impacts will be evaluated during feasibility level design and will be described in a Consistency Determination that was submitted to the Texas General Land Office. The determination and findings will be provided in the final report.

6.1.5 Endangered Species Act of 1973 (Threatened and Endangered Species)

The Endangered Species Act (ESA) is designed to protect and recover threatened and endangered (T&E) species of fish, wildlife and plants. The Galveston District is coordinating with the United States Fish and Wildlife Service (USFWS) and the National Marine Fisheries Service (NMFS) to ensure the protection of those T&E species under their respective jurisdictions. The USFWS has previously identified several T&E species that are either known to or may possibly occur in the project area; piping plover and least tern. No plants were identified as being threatened or endangered in the project area. Based on review of existing data and initial informal consultation with the USFWS, the Galveston District finds that implementation of the TSP may affect, but would not likely adversely affect any listed species or their critical habitat.

6.1.6 Fish and Wildlife Coordination Act of 1934 (Fish & Wildlife)

The Fish and Wildlife Coordination Act (FWCA) provides authority for the USFWS involvement in evaluating impacts to fish and wildlife from proposed water resource development projects. It requires that fish and wildlife resources receive the same consideration as other project features. It requires Federal agencies that construct, license or permit water resource development projects to first consult with the USFWS, NMFS and state resource agencies regarding the impacts on fish and wildlife resources and measures to mitigate these impacts. Section 2(b) requires the USFWS to produce a Coordination Act Report (CAR) that details existing fish and wildlife resources in the project area, potential impacts due to the proposed project and recommendations for the project. A draft CAR will be submitted by the USFWS and include the USFWS positions and recommendations.

6.1.7 Magnuson-Stevens Fishery Conservation and Management Act of 1976 and The Magnuson-Stevens Act Reauthorization of 2006 (Essential Fish Habitat)

The law and its reauthorization govern marine fisheries management in the U.S. Specific categories of Essential Fish Habitat (EFH) occurring in the project area include estuarine emergent wetlands, estuarine water column and estuarine mud substrate (bottom). These habitats provide EFH to three Federally-managed estuarine/marine species that are commonly to abundantly found in the project area; brown shrimp, white shrimp, and red drum. Waterbodies and wetlands provide nursery and foraging habitats for a variety of fish species, some of which may serve as prey for other fish species designated as EFH species

(e.g., mackerel, snapper, and grouper) and highly migratory fishes (e.g., billfish and sharks). The Galveston District has determined that the recommended plan would have minimal impacts to EFH due to the presence of the existing BRFG/CRL facilities.

6.1.8 Marine Mammal Protection Act of 1972 (Marine Mammals)

The Marine Mammal Protection Act (MMPA) protects whales, dolphins, sea lions, seals, manatees and other species of marine mammals. Whales, sea lions, and seals do not occur in the project area. Dolphins occur in the general vicinity, but are unlikely at the proposed BRFG/CRL. Manatees may rarely be found in the project area. To avoid "takings" of the West Indian manatee and ensure compliance with the MMPA, the Galveston District commits that all construction personnel working where manatees may occur will be educated about the MMPA, the ESA and the West Indian manatee, and implementation of appropriate best management practices to avoid or minimize potential entrapment or adverse impacts to manatees during construction.

6.1.9 Migratory Bird Treaty Act of 1918 and Migratory Bird Conservation Act of 1929 (Migratory Birds)

The Migratory Bird Treaty Act (MBTA) and the Migratory Bird Conservation Act (MBCA) protect migratory birds and their habitat. The marsh and tidal flats within the study area provide habitat for migratory birds. The BRFG/CRL will be monitored for nesting and feeding migratory birds and activities would be temporally be modified to avoid take of migratory birds.

The USFWS has previously indicated that areas near the project area may support colonial-nesting water birds (e.g., herons, egrets, ibis, night-herons, anhingas, and roseate spoonbills). The Galveston District would conduct preconstruction surveys for colonial nesting birds, and if colonies are found, would adjust the timing of construction activities so that impacts to the nesting birds are avoided.

6.1.10 National Historic Preservation Act of 1966 (Cultural and Historic Resources)

In compliance with Section 106 of the National Historic Preservation Act (NHPA) and 36 CFR §800, Federal agencies are required to identify and consider the potential effects that their undertakings might have on significant historic properties, districts, sites, buildings, structures, or objects that are included in or eligible for inclusion in the National Register. Additionally, a Federal agency shall consult with any federally-recognized tribe that attaches religious and cultural significance to such properties. Agencies shall afford the State Historic Preservation Officer (SHPO) and tribes a reasonable opportunity to comment before decisions are made.

Although several archeological surveys have been conducted in the BRFG and CRL areas, no previously recorded archeological sites are within the project area. The nearest recorded sites are 0.5 miles from the BRFG and 0.2 miles from the CRL. Much of the BRFG/CRL study areas have been previously disturbed by previous excavations of the GIWW, diversion of the Brazos and Colorado Rivers, and construction of the BRFG and CRL. Therefore potential for discovering cultural or archeological resources is low.

6.2 Executive orders

6.2.1 Executive Order 11514, Protection and Enhancement of Environmental Quality

EO 11514 directs Federal agencies to "initiate measures needed to direct their policies, plans and programs so as to meet national environmental goals." The recommended plan TSP complies with EO 11514.

6.2.2 Executive Order 13175 - Consultation and Coordination with Indian Tribal Governments (Tribal Interests)

In partial fulfillment of Executive Order (EO) 13175, in addition to NEPA and NHPA Section 106, consultation will be initiated with the following Federally-recognized Tribes: Alabama-Coushatta Tribe of Texas, Comanche Nation of Oklahoma, Kiowa Tribe of Oklahoma, Tonkawa Tribe of Oklahoma, Caddo Nation of Oklahoma, Coushatta Tribe of Louisiana. Correspondence is included in appendix to this report.

6.2.3 Executive Order 11988, Floodplain Management

EO 11988 directs agencies to avoid development in floodplains to the maximum extent feasible. All alternatives considered, including alternatives eliminated from detailed consideration in this EIS would be located at existing facilities within the base floodplain. No non-floodplain alternatives exist. The recommended plan is not expected to alter base flood elevations, and complies EO 11988.

6.2.4 Executive Order 11990, Protection of Wetlands

EO 11990 directs Federal agencies to avoid to the extent possible the long and short term adverse impacts associated with the destruction or modification of wetlands, and to avoid direct or indirect support of new construction in wetlands wherever there is a practicable alternative. Mitigation planning was integrated into the planning by considering, individually and collectively, each of the CWA mitigation actions of avoiding, minimizing, reducing and rectifying potential adverse impacts to wetlands to the extent practicable. The recommended plan would completely involve compensatory mitigation for wetland impacts and complies with EO 11990.

6.2.5 Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations

EO 12898 requires agencies to make achieving environmental justice (EJ) part of their missions by identifying and addressing disproportionately high and adverse human health or environmental effects of programs, policies and activities on minority populations and low-income populations. The BRFG and CRL are located outside of city limits and no population centers or residences are located within the study area. The proposed action complies with EO 1289.

6.2.6 Executive Order 13112, Invasive Species

EO 13112 directs Federal agencies to prevent the introduction of invasive species; provide for their control; and minimize the economic, ecological and human health impacts that invasive species cause. The recommended plan is consistent with EO 13112 to the extent practicable and permitted by law. Efforts will be made to ensure that invasive species do not spread by cleaning earth moving equipment before soil disturbance activities and planting native species for the restoration of BRFG/CRL project lands and mitigation areas.

6.2.7 Executive Order 13186, Responsibilities of Federal Agencies to Protect Migratory Birds

EO 13186 directs Federal agencies to take actions to further implement the MBTA. The recommended plan has been evaluated for potential effects on migratory birds, with emphasis on species of concern. The

BRFG/CRL will be monitored for nesting and feeding migratory birds and activities would be temporally be modified to avoid take of migratory birds.

6.2.8 Executive Order 13045, Protection of Children from Environmental Health Risks and Safety Risks, as amended by EO 13229 and EO 13296.

These EOs require each Federal agency to ensure that its policies, programs, activities, and standards address disproportionate risks to children that result from environmental health risks or safety risks. No disproportionate environmental health risks or safety risks to children, as defined in EO 13045, are expected from implementation of the TSP.

THIS PAGE LEFT INTENTIONALLY BLANK

7.0 Public Involvement

As part of this feasibility, the USACE has conducted public involvement activities that include issuance of a Notice of Intent (NOI) and other notices, Public Scoping Meeting, interagency meetings, and industry/stakeholder meetings. These activities are summarized below. The Draft FR/EIS will be submitted for public comment, and a Notice of Availability will be published in the Federal Register informing the public that the draft report is available for comment. The comment period for the draft report will be at least 45 days long, during which a public meeting will be conducted in the project vicinity. Comments from Federal, State, Tribal, and local agencies will also be requested during this time. The Draft FR/EIS comment period will provide an opportunity for the USACE to gain public input on the alternatives analyzed and proposed plan.

7.1 Notice of Intent

The USACE published an NOI for the feasibility study in the Federal Register on June 22, 2016 (Vol. 81, No. 120, page 40681). In the NOI, the USACE provided background for the feasibility study, summarized ongoing study activities, identified possible alternatives, advertised the July 12, 2016 Public Scoping Meeting, and solicited public comments and concerns on the opportunities to improve navigation along the GIWW at the BRFG and CRL, identification of resources that may occur in the study areas, and other social, economic, and environmental concerns.

7.2 Other Notices

The USACE issued a news release on June 29, 2016, which was made available on the USACE Galveston District website and distributed by the Galveston District Public Affairs Office. The news release provided information on the July 12, 2016 Public Scoping Meeting, gave a project overview, and solicited public input.

7.3 Public Scoping Meeting

The USACE held a Public Scoping Meeting from 6:00 p.m. to 8:00 p.m. on July 12, 2016, at the West Columbia Civic Center in West Columbia, Texas. The purpose of the meeting was to inform the public and stakeholders about the feasibility study and to obtain public comments and concerns. The meeting was conducted in an open house format, with USACE staff providing an introduction and overview of the project. Attendees were provided a project pamphlet and a written comment form upon arriving at the meeting. The pamphlet described the project and existing BRFG and CRL facilities, provided information about the NEPA and feasibility study process and instructions on how to submit written comments, and encouraged attendees to offer comments. Attendees were invited to view an informational slideshow that was played on a loop during the open house, as well as view informational display stations around the room that provided project background and information about the NEPA and feasibility study process. USACE and TxDOT representatives were available to answer questions. Attendees were invited to submit comments in writing at the scoping meeting or at any time during the comment period via mail or e-mail.
A total of 56 people attended the meeting, including 14 project team members and 42 members of the public/media. Comments received at the scoping meeting and throughout the commenting period were considered during project development. The scoping commenting period ended August 11, 2016.

7.4 Interagency Meetings

In compliance with the Fish and Wildlife Coordination Act (FWCA), USACE and TxDOT representatives held an initial agency scoping meeting with the U.S. Fish and Wildlife Service (USFWS), National Marine Fisheries Service (NMFS), and Texas Parks and Wildlife Department on February 13, 2017. The purpose of the meeting was to introduce the project to the agencies and discuss methods of evaluating habitats in the study areas. Following the initial meeting, the interagency team conducted field visits to the BRFG and CRL study areas on February 15 and March 22, 2017, respectively, to collect field data for assessing the habitat types and quality present. Subsequent meetings with the agencies were held on September 12, October 10, and November 1, 2017, and January 9, 2018, to update the team, review alternatives, discuss mitigation possibilities, and predict future habitat values provided by mitigation activities.

7.5 Navigation Industry/Stakeholder Meetings

A number of navigation industry/stakeholder specific web-meetings and in-person meetings were held during the course of this study (February 2017 and October 2017) to determine specific concerns with Blue and Brown water navigation industry pilots and crews. Their feedback and experiences in navigating the BRFG and CRL crossings during various river conditions was invaluable in determining the appropriate measures and alternatives to consider. The teams continue to engage these groups in the refinement of the TSP.

7.6 Federal Agencies – Consultation letters to be provided after Public Review

U.S. Advisory Council on Historic Preservation
U.S. Environmental Protection Agency, Region VI
U.S. Department of Energy, Office of Environmental Compliance
U.S. Department of the Interior, Fish and Wildlife Service
U.S. Department of Commerce, National Marine Fisheries Service
U.S. Department of Agriculture, Natural Resources Conservation Service
U.S. Department of Transportation, Federal Aviation Administration

7.7 State Agencies – Consultation letters to be provided after Public Review

Texas Department of Transportation – Study Partner
State Historic Preservation Office

7.8 Distribution and Public Engagement List for Feasibility Draft Report and EIS

Table 7.1: Distribution List

Texas Congressional	***Texas State Senators & Representatives***	
Senator John Cornyn 5300 Memorial Drive, Suite 980 Houston, TX 77007	Senator Joan Huffman P.O Box 541774 Houston TX 77254	
Senator Ted Cruz 808 Travis Street, Suite 1420 Houston, TX 77002	Senator Lois W. Kolkhorst 2000 S. Market St. #101 Brenham TX 77833	
Congressman Randy Weber 122 West Way, Suite 301 Lake Jackson, TX 77566	Representative Dennis Bonnen 122 East Myrtle Angleton TX 77515	
Congressman Randolph (Blake) Farenthold 5606 North Navarro Street, Suite 203 Victoria, TX 77904	Representative Geanie W. Morrison 1908 North Laurent, Ste. 500 Victoria TX 77901	
	Local Government	
Donald "Dude" Payne Brazoria County Commissioner 1432 Highland Park Drive P.O. Box 998 Clute, TX 77531	Matagorda County Judge Nate McDonald 1700 7th St., Room 301 Bay City, TX 77414	Amber Helbert Town of Quintana 814 N. Lamar Quintana, TX 77541
Ryan Cade Brazoria County Commissioner 21017 CR 171 Angleton, TX 77515	Lisa Krobot Director, Matagorda County Environmental Health 2200 7th St., First Floor Bay City, TX 77414	Mayor Larry Davison Village of Surfside Beach 1304 Monument Dr. Surfside Beach, TX 77541-9522
Stacy L. Adams Brazoria County Commissioner 2508 North Gordon St. P.O. Box 548 Alvin, TX 77512	Brian Moudy Floodplain Management, Matagorda County Environmental Health 2200 7th St., First Floor Bay City, TX 77414	Amanda Davenport City Secretary, Village of Surfside Beach 1304 Monument Dr. Surfside Beach, TX 77541-9522
David Linder Brazoria County Commissioner 121 North 10th St. West Columbia, TX 77486	Mayor Troy Brimage City of Freeport 200 W. 2nd St. Freeport, TX 77541	Mayor Mark A. Bricker City of Bay City 1901 Fifth St. Bay City, TX 77414
Brazoria County Judge L. M. "Matt" Sebesta, Jr. 111 East Locust St., Suite 102A Angleton, TX 77515	Bob Welch City Manager – Interim City of Freeport 200 W. 2nd St. Freeport, TX 77541	David Holuber City Secretary, City of Bay City 1901 Fifth St. Bay City, TX 77414
Joe K. Ripple Brazoria County Floodplain Administrator 451 North Velasco St., Suite 210 Angleton, TX 77515	Mayor Joe Rinehart City of Lake Jackson 25 Oak Drive Lake Jackson, TX 77566	Mayor Glen Smith City of Palacios 311 Henderson Palacios, TX 77465
Karen Carroll Director, Brazoria County Environmental Health Department 111 East Locust, A-29 Suite 270 Angleton, TX 77515	William P. Yenne City Manager, City of Lake Jackson 25 Oak Drive Lake Jackson, TX 77566	David Kocurek City Manager, City of Palacios 311 Henderson Palacios, TX 77465

Bryan Frazier Director, Brazoria County Parks Department 313 West Mulberry St. Angleton, TX 77515	Mayor Calvin Shiflet City of Clute 108 E Main St. Clute, TX 77531	Phil Ford General Manager, Brazos River Authority P.O. Box 7555 Waco, TX 76714
Gary Graham Matagorda County Commissioner 2604 Nichols Bay City, TX 77414	Gary Beverly City Manager, City of Clute 108 E Main St. Clute, TX 77531	Phil Wilson General Manager, Lower Colorado River Authority P.O. Box 220 Austin, TX 78767
Kent Pollard Matagorda County Commissioner P.O. Box 571 Matagorda, TX 77457	Mayor Steve Alongis Town of Quintana 814 N. Lamar Quintana, TX 77541	Chris Gallion Superintendent, Velasco Drainage District 915 Stratton Ridge Rd. P.O. Box 7 Clute, TX 77531
James A. Gibson Matagorda County Commissioner 25,000 Highway 35 South Palacios, TX 77465	Debbie Alongis Town of Quintana, Parks and Recreation 814 N. Lamar Quintana, TX 77541	West Brazoria County Drainage District No. 11 P.O. Box 1329 Brazoria, TX 77422
Charles “Bubba” Frick Matagorda County Commissioner P.O. Box 99 El Maton, TX 77440	Tonya McCaghren Town of Quintana 814 N. Lamar Quintana, TX 77541	Honorable Craig Estlinbaum 130th District Court 1700 7th Street Room 317 Bay City, TX 77414-5094
Federal Agencies		
Advisory Council on Historic Preservation 401 F Street NW, Suite 308 Washington, DC 20001	Donna Anderson Clear Lake Ecological Services Field Office U.S. Fish and Wildlife Service 17629 El Camino Real, Ste. 211 Houston, TX 77058	Robert Houston Chief, Special Projects Section Compliance Assurance and Enforcement Division U.S. Environmental Protection Agency Region 6 1455 Ross Avenue, Suite 1200 Dallas, Texas 75202-2733
Gary Zimmerer Mitigation Deputy Division Director FEMA Region VI FRC 800 North Loop 288 Denton, TX 76209	Edith Erfling Project Leader, Clear Lake Ecological Services Field Office U.S. Fish and Wildlife Service 17629 El Camino Real, Ste. 211 Houston, TX 77058	U.S. Environmental Protection Agency Office of Federal Activities – Room 7241 EIS Filing – Mail Code 2252A Ariel Rios Building, South Oval Lobby 1200 Pennsylvania Avenue, NW Washington, DC 20460

Rusty Swafford NMFS Habitat Conservation Division 4700 Avenue U, Bldg. 307 Galveston, TX 77551-5997	Jennifer Sanchez Texas Midcoast Refuges Complex 2547 CR 316 Brazoria, TX 77422	Michael Jansky Office of Planning and Coordination U.S. Environmental Protection Agency Region 6 1445 Ross Ave., Suite 1200, Mail Code 6 ENXP Dallas, TX 75202-2733
Virginia Fay Assistant Regional Administrator NMFS Habitat Conservation Division 263 13th Avenue South St. Petersburg, FL 33701-5505	Curtis Jones San Bernard National Wildlife Refuge 6801 County Road 306 Brazoria, TX 77422	Jeff Riley U.S. Environmental Protection Agency Region 6 1445 Ross Ave., Suite 1200, Mail Code 6PD Dallas, TX 75202-2733
Dr. Roy E. Crabtree Regional Administrator National Marine Fisheries Service 263 13th Avenue South St. Petersburg, FL 33701-5505	Don Gohmert Natural Resources Conservation Service 101 S. Main Temple, TX 76501	Karen McCormick Ocean Dumping Coordinator U.S. Environmental Protection Agency Region 6 1445 Ross Ave., Suite 1200, Mail Code 6WQ-EC Dallas, TX 75202-2733
David Bernhart Assistant Regional Administrator NMFS Protected Resources Division 263 13th Avenue South St. Petersburg, FL 33701-5505	Lisa Taylor U.S. Coast Guard 823 Coast Guard Dr. Freeport, TX 77541-9451	Robert Lawrence U.S. Environmental Protection Agency Region 6 1445 Ross Ave., Suite 1200, Mail Code 6MM-A Dallas, TX 75202-2733
Noah Silverman NEPA Coordinator National Marine Fisheries Service 263 13th Avenue South St. Petersburg, FL 33701-5505	Miles Aguinaga U.S. DOE – Bryan Mound P.O. Box 2276 Freeport, TX 77542-2276	Barbara Keeler U.S. Environmental Protection Agency Region 6 1445 Ross Ave., Suite 1200, Mail Code 6WQ-EC Dallas, TX 75202-2733
Director Office of ENV Policy & Compliance Department of the Interior Main Interior Bldg., MS 2342 1849 C Str., NW Washington, DC 20240	Jim Salinas U.S. DOE – Bryan Mound P.O. Box 2276 Freeport, TX 77542-2276	Aimee Wilson U.S. Environmental Protection Agency Region 6 1445 Ross Ave., Suite 1200, Mail Code 6MM-AP Dallas, TX 75202-2733
Stephen Spencer Regional Environmental Office U.S. DOI, Office of Environmental Policy and Compliance 1001 Indian School Rd. NW, Suite 348 Albuquerque, NM 87104	Dr. Pamela T. Plotkin Director, Texas Sea Grant College Program Texas A&M University TAES Annex Building 730 Lamar St., 4115 TAMU College Station, TX 77843-4115	
State of Texas (TX) Agencies and Offices		

Office of the Governor P.O. Box 12428 Austin, TX 78711-2428	Tammy Brooks Coastal Management Division Texas General Land Office P.O. Box 12873 Austin, TX 78701-2873	Cherie O'Brien Texas Parks and Wildlife Department 1502 FM 517 East Dickinson, TX 77539
Office of the Attorney General P.O. Box 12548 Austin, TX 78711-2548	Mark Wolfe Texas State Historic Preservation Officer Texas Historical Commission P.O. Box 12276 Austin, TX 78711	Colleen Roco Texas Parks and Wildlife Department 1502 FM 517 East Dickinson, TX 77539
Richard A. Hyde, P.E. Executive Director Texas Commission on Environmental Quality P.O. Box 13087, Mail Code 109 Austin, TX 78711-3087	Amy Borgens State Marine Archeologist Texas Historical Commission P.O. Box 12276 Austin, TX 78711	David Butler Justin Hurst Wildlife Management Area 6233 TX-36 Freeport, TX 77541
David W. Galindo Director, Water Quality Division Texas Commission on Environmental Quality P.O. Box 13087, Mail Code 145 Austin, TX 78711-3087	Justin Kockritz Historian, Federal Programs Texas Historical Commission P.O. Box 12276 Austin, TX 78711	Lang Alford Mad Island Wildlife Management Area 2200 7th St., 3rd Floor Bay City, TX 77414
Ashley K. Wadick Regional Director Texas Commission on Environmental Quality 5425 Polk St., Suite H Houston, TX 77023-1452	Jeff Durst Texas Historical Commission P.O. Box 12276 Austin, TX 78711	Carla Guthrie, Ph.D. Director, Surface Water Division Texas Water Development Board 1700 North Congress Avenue P.O. Box 13231 Austin, TX 78711-3231
Kate Zultner Coastal Management Division Texas General Land Office P.O. Box 12873 Austin, TX 78701-2873		
Native American Tribes		
Willie Nelson Chairman, Comanche Nation of Oklahoma P.O. Box 908, Lawton, OK, 73502 584 NW Bingo Road, Elgin, OK, 73538	Susan Nahwooksy Comanche Nation of Oklahoma P.O. Box 908 Lawton, OK 73502	Russell Martin President, Tonkawa Tribe of Oklahoma 1 Rush Buffalo Rd. Tonkawa, OK 74653-4449
JoAnn Battise Chairperson, Alabama-Coushatta Tribe of Texas 571 State Park Rd. 56 Livingston, TX 77351	Bryant J. Celestine Historical Preservation Clerk Alabama-Coushatta Tribe of Texas 571 State Park Road 56 Livingston, TX 77351	Tarpie Yargee Chief, Alabama-Quassarte Tribal Town P.O. Box 187 Wetumka, OK 74883
Bobby Komardley Chairman, Apache Tribe of Oklahoma 511 E Colorado Anadarko, OK 73005	Tamara Michele Francis Four-killer Chairperson, Caddo Nation of Oklahoma P.O. Box 487 Binger, OK 73047	Phil Cross THPO, Caddo Nation of Oklahoma P.O. Box 487 Binger, OK 73009

Michael Attocknie Tribal Administrator, Caddo Nation of Oklahoma P.O. Box 487 Binger, OK 73047	Bill John Baker Principal Chief and THPO Cherokee Nation of Oklahoma P.O. Box 984 Tahlequah, OK 74465-0948	Lovelin Poncho Chairman, Coushatta Tribe of Louisiana P.O. Box 818 Elton, LA 70532 1940 C.C. Bel Road, Elton, LA, 7053
Linda Langley THPO, Coushatta Tribe of Louisiana P.O. Box 818 Elton, LA 70532	Kerry Holton President, The Delaware Nation P.O. Box 825 Anadarko, OK 73005	Mekko-Tiger Hobia Kialegee Tribal Town P.O. Box 332 Wetumka, OK 74883
Estavio Elizondo Chairman, Kickapoo Traditional Tribe of Texas 2212 Rosita Valley Road Eagle Pass, TX 78852	David Pacheco Chairperson, Kickapoo Tribe of Oklahoma P.O. Box 70 McLoud, OK 74851	Matthew Komalty Chairperson, Kiowa Tribe of Oklahoma P.O. Box 369 Carnegie, OK 73015 100 Kiowa Way, Carnegie, OK, 73015
Danny H. Breuninger Sr., President, Mescalero Apache Tribe P.O. Box 227 Mescalero, NM 88340 101 Central Avenue, Mescalero, NM, 8834	Holly Houghten Tribal Historic Preservation Officer Mescalero Apache Tribe P.O. Box 227 Mescalero, NM 88340	Stephanie Bryan Chairwoman, Poarch Band of Creek Indians 5811 Jack Springs Rd. Atmore, AL 36502
Robert Thrower THPO, Poarch Band of Creek Indians 5811 Jack Springs Rd. Atmore, AL 36502	John L. Berrey Chairman, Quapaw Tribe of Oklahoma P.O. Box 765 Quapaw, OK 7435681 South 630 Road, Quapaw, OK, 7436463	Everett Bandy Tribal Historic Preservation Officer Quapaw Tribe of Oklahoma P.O. Box 765 Quapaw, OK 74363-0765
Leonard M. Harjo Principal Chief, Seminole Nation of Oklahoma P.O. Box 1498 Wewoka, OK 74884	Ryan Morrow Town King, Thlopthlocco Tribal Town P.O. Box 188 Okemah, OK 74859	Emman Spain THPO, Thlopthlocco Tribal Town PO Box 188 Okemah, OK 74859
Marshall Sampson, Sr; Beverly Chapman-Rachal, Co-Administrators Tunica-Biloxi Tribe of Louisiana P.O. Box 1589 Marksville, LA 71351 151 Melacon Drive, Marksville, LA, 71351	Tunica-Biloxi Tribal Historic Preservation Office PO Box 1589 Marksville, LA 71351	Joe Bunch Chief, United Keetoowah Band of Cherokee Indians P.O. Box 746 Tahlequah, OK 74465
Terri Parton President, Wichita and Affiliated Tribes P.O. Box 729 Anadarko, OK 73005		
Organizations		
Brazosport Area Chamber of Commerce 300 Abner Jackson Parkway Lake Jackson, TX 77566	Donnie Belote Dow Chemical 2301 N. Brazosport Blvd., BM-54 Freeport, TX 77541	Friends of the River San Bernard P.O. Box 93 Brazoria, TX 77422
Matagorda Area Chamber of Commerce P.O. Box 103 Matagorda, TX 77457	Lucy McGregor Dow Chemical 2301 N. Brazosport Blvd., A2813 Building Freeport, TX 77541	Matagorda Bay Pilots P.O. Box 836 Port Lavaca, TX 77979

Brazoria County Groundwater Conservation District 111 E. Locust Street Building A-29, Suite 140 Angleton, Texas 77515	James Prazak Dow Chemical 2301 N. Brazosport Blvd., B-122 Freeport, TX 77541	Phyllis Saathoff Executive Director, Port Freeport 1100 Cherry St. Freeport, TX 77541
Neil Hudgins General Manager, Coastal Plains Groundwater Conservation District 2200 7th Street Bay City, TX 77414	Julie Woodward Dow Chemical 2301 N. Brazosport Blvd., B-122 Freeport, TX 77541	Port of Bay City Authority P.O. Box 1426 Bay City, Texas 77404
Alan C. Clark Director of Transportation Planning Houston-Galveston Area Council P.O. Box 22777 Houston, TX 77227-2777	Steve Hazelwood Dow Chemical 2301 N. Brazosport Blvd., Building APB-2019 Freeport, TX 77541	STPNOC P.O. Box 289 Wadsworth, TX 77483
Keith Gray American Rice, Inc. P.O. Box 2490 Freeport, TX 77542	Jim Stark Gulf Intracoastal Canal Association P.O. Box 6846 New Orleans, LA 70174	Manufacturing Site OXEA Corporation P.O. Box 1141 Bay City, TX 77404-1141
Bob Smith Dole Fresh Fruit Company P.O. Box 2676 Freeport, TX 77542	LyondellBasell Matagorda Complex 17042 State Highway 60 South Bay City, TX 77414	Matagorda County SWCD 1006 Avenue F Ste A1 Bay City, TX 77414-4230
John Gunning Brazos Pilots Association 2502 Deep Sea Dr. Freeport, TX 77541	Tammy Moss Brazos Pilots Association P.O. Box 2246 Freeport, TX 77541	Charles Beckman Chiquita Brands International, Inc. P.O. Box 3146 Freeport, TX 77542
Kevin Parrish Kirby Inland Marine 18350 Market St. Channelview, TX 77530	Pat Studdert Texas Waterway Operators Association c/o Buffalo Marine Service P.O. Box 5006 Houston, TX 77262	Matagorda County Navigation District #1 Port of Palacios P.O. Box 551 Palacios, TX 77465
Individuals (from Public Scoping Meeting)		
Adalia Maudlin *address on file*	Mike Goodson President, Friends of the River San Bernard *address on file*	Mike Griffith Chairman, Port of Bay City Authority *address on file*
Valray Maudlin *address on file*	Mason Roylen (Roy) Edwards *address on file*	Captain Joe Kent *address on file*
Claudia Pechacek *address on file*	Alma Marches *address on file*	Lou Rossitto King Fabrication L.L.C. *address on file*
[no name provided] *address on file*		
Libraries		
Catherine H. Threadgill County Librarian Brazoria County Library System 451 N. Velasco Angleton, TX 77515	Marge Janke Librarian, Freeport Library 410 Brazosport Blvd. Freeport, TX 77541	Samantha Denbow Director, Bay City Public Library 1100 7th St. Bay City, TX 77414

Caroline Weatherly Clute Branch Library 215 N. Shanks St. Clute, TX 77531	Nancy Hackney Lake Jackson Library 250 Circle Way Lake Jackson, TX 77566	Matagorda Branch Library 800 Fisher St Matagorda, TX 77457
	West Columbia Public Library 518 E. Brazos West Columbia, TX 77486	Palacios Library 326 Main St. Palacios, TX 77465
Media Outlets		
The Bulletin of Brazoria County P.O. Box 2426 Angleton, TX 77516	Bay City Sentinel 3769 FM 2668 Bay City, Texas 77414	KTRK TV 3310 Bissonnet Houston, TX 77005
The Facts 720 S. Main St. Clute, TX 77531	The Bay City Tribune 2901 Carey Smith Blvd. Bay City, TX 77414	KHOU-TV Channel 11 1945 Allen Parkway Houston, TX 77019
The Source Weekly 223 Parking Way Lake Jackson, TX 77566	Palacios Beacon 809 First Street P. O. Box 817 Palacios, Texas 77465	

THIS PAGE LEFT INTENTIONALLY BLANK

8.0 Areas of Controversy and Recommendations

Information found in this document may be subject to change and further development during final feasibility analysis, to include refinement of relocation and real estate requirements, as well as from review and resolution of comments received from both the public and other agencies; the Agency Technical Review (ATR); and Independent External Peer Review (IEPR), all of which will help refine the TSP. The information provided in this chapter is based on the TSP, as currently defined and may be refined and/or changed prior to publication of the final report.

8.1 Areas of Controversy and Unresolved Issues

There are currently no areas of controversy or unresolved issues associated with this project. These may be updated after concurrent review and included in the final report.

8.2 Recommendations

The TSP for this study is alternative (3a.1) for BRFG and alternative (4b.1) for CRL. At BRFG, the TSP consists of construction of a new 125 foot flood gates along the existing alignment, set back approximately 1000 feet from the river on the east side, and a minimum 125 foot open channel on the west side of the river crossing. At CRL, the TSP consists of the removal of the existing river side sector gate structures and rehabilitation of the existing GIWW side sector gate structures. Further TSP Plan refinement and recommendations will be included in the final report.

8.3 Implementation Requirements

Study Partner PED Efforts

The study partner is the TXDOT, who has actively participated in the development of the scope, alternative formulation, and analysis of alternatives as they pertain to BRFG, and conducted the Environmental Impact Statement (EIS) for the study area. They fully support the tentatively selected plan which allows for channel modifications and wider gates at Brazos. Their work is included in this feasibility report and has undergone appropriate level peer review. The sponsor cost contribution to this study is estimated to be valued at approximately $1.5 million. They will contribute additional data for PED efforts as needed but will not receive WIK.

Key Social and Environmental Factors

There are currently no social or environmental factors that would prevent this project from being constructed. Work in the region would improve economic development by creating temporary jobs during construction and would contribute overall to the navigation industry in the region as it relates to system improvements and future development in the region.

Stakeholder Perspectives and Differences

Stakeholders/pilots in the region have expressed concern with having an open channel system as it would make navigation in the crossings more challenging during high river stages. They have also expressed concern with the 60 degree angle in the channel configuration at BRFG as it is at a sharp angle which makes navigation more difficult, especially if river velocities are increased. The sediment models have shown that these angles contribute to more shoaling and requires dredging in these areas as they catch most sediment that otherwise flow into the Gulf of Mexico. They have also expressed concern with increased sediment in the GIWW and the amount of time necessary to dredge the channel after major storm events. While each group has operational protocol that they follow to reduce accidents or need to shifting modes of transportation of goods, the concern is that with more dredging/delays that it will cost more money/time to the industry. As with any plan, they will adjust according to river conditions, however, there may be some

safety concerns due to those conditions as well as operational error if flows are increased and if sediment/shoaling occurs.

Environmental Compliance
Environmental consultation and coordination are ongoing for this study. A Coordination Act Report is anticipated prior to release of the final report and will be included in the Environmental Appendix. Section 106 Compliance is also ongoing, however neither State Historic Preservation Office (SHPO) nor Tribes have expressed concern for the areas surrounding the structures, nor has the Advisory Council prohibited modification of the operational structures or if necessary decommissioning of the structures. Ongoing coordination based on the final decision will be conducted with these groups as necessary. There are no anticipated impacts to the environment with placement of dredged material. Some material may be used to mitigate areas of disturbance if the channel is modified at Brazos or if old channels are reopened as bypass channels to maintain navigation during construction.

Navigation Systems Context
The BRFG-CRL study is a navigation focused study whose primary purpose when constructed was to reduce sediment input into the GIWW and consequently further downstream impacts. The Freeport General Revaluation Report is proposing modification to the Federal Channel in the area of the DOW Chemical Thumb, and focuses on harbor maintenance). The projects are independent of one another but operate within the same waterway system. The Freeport Harbor is approximately 10 miles upstream from the BRFG which could potentially increase sediment and consequently increase O&M/Dredging cost in the GIWW channel or to the port. These cost increases are included in the current study cost for BRFG-CRL. The TSP has been designed to have minimal environmental impacts and does not adversely affect the Freeport area based on modeling results.

Environmental Operating Principles. The USACE Environmental Operating Principles (EOPs) ensure our missions include totally integrated sustainable environmental practices. The seven re-energized EOP principles (July 2012) are available at the following webpage:
http://www.usace.army.mil/Missions/Environmental/Environmental-Operating-Principles/.

Environmental consequences of construction and operation of the TSP have been considered in avoiding and minimizing impacts. Sustainability was an integral consideration in the development of design of the channel modifications and development of the dredged material management plan. USACE Risk Management Center will be involved with determination of an appropriate risk management approach when modifying the locks or floodgates. Coordination with stakeholders has been conducted in developing the TSP and the Draft FR-EIS will be circulated for public review and additional resource agency comment. Resource agency knowledge and evaluation methods developed for the previous report on the Brazos River Floodgate and CRL and other similar projects were applied in the impact analysis. A thorough NEPA and engineering analysis has ensured that we will meet our corporate responsibility and accountability for actions that may impact human and natural environments in the study area. This analysis will be transparent and communicated to all individuals and groups interested in USACE activities.

8.4 Federal and Non-Federal Cost-Sharing

According to Sec. 844 of the WRDA ’86, for construction of a shallow draft (inland waterway) navigation lock/floodgate, one-half of the federal costs shall be paid from the Inland Waterways Trust Fund and one-half of the federal costs shall be paid from the general fund of the Treasury. OMRR&R will be the responsibility of the USACE. Total costs share will be split 50/50 and shared as follows:

US Army Corps of Engineers: $92,340
TXDOT via Inland Waterway Trust Fund: $92,340
Total Project First Cost: $184,680

8.4.1 Federal Responsibilities

The federal government will be responsible for 100 per cent of OMRR&R upon completion of the lock and floodgates.

8.4.2 Non-Federal Partner Responsibilities

There are no non-federal partner responsibilities for the TSP. OMRR&R of all items will be addressed in the final version of the plan.

8.5 Preconstruction Engineering and Design

Detailed design of the BRFG and CRL project will be shared between TXDOT and the USACE contingent upon the execution of a Design Agreement in accordance with the provisions of ER 1165-2-208. All detailed design will be in accordance with USACE's regulations and standards.

8.6 Construction and LERRD

Construction would be in accordance with USACE's regulations and standards. LERRD would be the responsibility of TXDOT. Since this is a 100 percent Federally Funded project, there are no anticipated WIK associated with the construction of this project. Any other cost sharing requirements or agreements between the USACE and the IUWB would be negotiated and contingent upon approval at the Assistant Secretary of the Army or Civil Works (ASACW) or appropriate level in accordance with applicable guidance and regulations.

8.7 District Engineers Recommendation

The District Engineers recommendations will be updated after the public comment period is over and included in the final report.

The recommendations herein reflect the information available at the time and current Department of the Army policies governing the formulation of individual projects. They do not reflect programming and budgeting priorities inherent in the formulation of national Civil Works construction program nor the perspective of higher review levels within the Executive Branch. Consequently the recommendations may be modified before they are transmitted to Congress as proposals for implementing funding. However, prior to the transmission to Congress, the state, Federal agencies and other parties will be advised of any modifications and afforded the opportunity to comment.

Lars N. Zetterstrom
Colonel, U.S. Army
District Engineer

THIS PAGE LEFT INTENTIONALLY BLANK

9.0 References

This chapter details the project delivery team members, literature cited, figures and tables.

9.1 Project Delivery Team Members

Name	Position	Location
USACE PDT		
Franchelle Craft	Project Manager	CE-SWG
Jerica Richardson	Lead Planner	CE-SWF-RPEC
Robert Needham	Economist	CE-SWG-RPEC
Daniel Allen	Biologist	CE-SWF-RPEC
Mark Peterson	Engineer - Structural	CE-SWG
Eric Russek	Operations Manager	CE-SWG
David Lovett	Engineer- Structural	CE-MVN
Mark Middleton	Engineer - Geotech	CE-SWG
John Petitbon	Engineer – Cost	CE-MVN
Chad Rachel	Engineer - Geotech	CE-MVN
Max Agnew	Engineer – Coastal Hydrologic	CE-MVN
Patrick Grey	Engineer - Civil	CE-MVN
Denis Hoerner	Engineer - Structural	CE-MVN
Victor Otero	Real Estate	CE-SWG
Clark Bartee	Office of Council	CE-SWG
John Campbell	Cultural Resources	CE-SWG-RPEC
TXDOT PDT		
Matthew Mahoney	TXDOT Project Manager	TXDOT
Hugo Bermudez	Project Manager	Mott MacDonald Assn.
Patrick McLaughlin	Project Controls	Mott MacDonald Assn.
Matthew Campbell	Assistant Project Manager	Mott MacDonald Assn.
Jason Schindler	Environmental Task Lead	Blanton Assn.
Joshua Carter	Engineering Task Lead	Mott MacDonald Assn.
Portia Osborne	Environmental Support	Blanton Assn.
John Martin	Economic Task Lead	John-Martin Assn.
PCXIN-RED PDT		
Beth Cade	Assistant Chief	CE-LRD-PCX
Patrick Donovan	Chief – PCXIN-RED	CE-LRD-PCX
Mark Hammond	Regional Economist	CE-LRD-PCX
Justin Carlson	Chief Statistics Review Branch	CE-LRD-PCX
James Nowlin	DA Intern	CE-LRD-PCX
INDC-MCX		
Andy Harkness	Deputy Director	CE-MVS
Jeff Stamper	Technical Manager	CE-MVS

9.2 Literature Cited

Aronow, S. 1981. Surface geology. In: Soil survey of Brazoria County, Texas. U.S. Department of Agriculture, Soil Conservation Service in cooperation with the Brazoria County Commissioners Court and Texas Agricultural Experiment Station. <https://www.nrcs.usda.gov/Internet/FSE_MANUSCRIPTS/texas/TX039/0/brazoria.pdf>. Accessed June 2017.

_____. 2002. Surface geology. In: Soil survey of Matagorda County, Texas. U.S. Department of Agriculture, Natural Resources Conservation Service. USDA in cooperation with the Texas Agricultural Experiment Station.

Armstrong, N. E., M. Brody, and N. Funicelli. 1987. The ecology of open-bay bottoms of Texas: a community profile. U.S. Department of the Interior Fish and Wildlife Service. Biological Report 85(7.12). 104 pp.

Atkins North America. 2013. Brazoria County regional plan for public parks and sustainable development: a case study. http://www.ourregion.org/documents/Brazoria_Final_Copy.pdf. Accessed July 2016.

Brazoria County. 2016. Road bridge capital projects, FY 2016. March 23, 2016. http://brazoriacountytx.gov/home/showdocument?id=1364. Accessed December 2017.

Brazoria County Groundwater Conservation District. 2012. Brazoria County Groundwater Conservation District groundwater management plan. <https://www.bcgroundwater.org/images/bcg/documents/BCGCD_Groundwater_Management_Plan_20121213.pdf>. Accessed July 2017.

Bureau of Economic Geology. 2016. Texas Gulf shoreline change rates through 2012. http://coastal.beg.utexas.edu/shorelinechange/. Accessed July 2016.

BusinessWire. 2017. Oxea builds second propanol unit at Bay City, Texas. March 16, 2017. https://www.businesswire.com/news/home/20170316005792/en/Oxea-Builds-Propanol-Unit-Bay-City-Texas. Accessed December 2017.

Buzzfile. 2017. Texas Barge & Boat, Inc. http://www.buzzfile.com/business/Texas-Barge.And.Boat,-Inc.-979-233-5539. Accessed September 2017.

Carlin, J. A. 2013. Sedimentation of the Brazos River system: Storage in the lower river, transport to the shelf and evolution of a modern subaqueous delta. Dissertation submitted to the Office of Graduate Studies, Texas A&M University, College Station, Texas, USA.

Cassell, B. 2016. CenterPoint files interconnect for 149-MW Chocolate Bayou Wind project." August 16, 2016. https://www.hubs.com/explore/2016/08/centerpoint-files-interconnect-for-149-mw-chocolate-bayou-wind-project. Accessed December 2017.

Coastal Barrier Resources System (CBRA). 2017. Coastal Barrier Resources System Mapper. https://www.fws.gov/cbra/Maps/Mapper.html. Accessed September 2017.

Coastal Plains Groundwater Conservation District. 2014. Coastal Plains Groundwater Conservation District groundwater management plan. <http://www.twdb.texas.gov/groundwater/docs/GCD/cpgcd/cpgcd_mgmt_plan2015.pdf?d=10280.181265359644>. Accessed July 2017.

Crenwelge, G. W., J. D. Crout, E. L. Griffin, M. L. Golden, and J. K. Baker. 1981. Soil survey of Brazoria County, Texas. United States Department of Agriculture, Soil Conservation Service, in cooperation with Brazoria County Commissioners Court and Texas Agricultural Experiment Station. 140 pp. https://www.nrcs.usda.gov/Internet/FSE_MANUSCRIPTS/texas/TX039/0/brazoria.pdf. Accessed August 2016.

Day, J. W. Jr., C. A. S. Hall, W. M. Kemp, and A. Yanez-Arancibia. 1989. Estuarine ecology. John Wiley and Sons, New York. 558 pp.

eBird. 2017. Range and point maps. http://ebird.org/ebird/map. Accessed April 2017.

Epsilon Associates Inc. 2006. Hudson River PCBs Superfund Site. Phase I Final Design Report. Attachment J – Noise Impact Assessment. Prepared for General Electric Company. https://www3.epa.gov/hudson/df_designreport/2006_3_21_attachment_J_noise_report.pdf

Federal Emergency Management Agency (FEMA). 2017. FEMA flood map service center. https://msc.fema.gov/portal/advanceSearch. Accessed April 2017.

George, P. G., R. E. Mace, and R. Petrossian. 2011. Aquifers of Texas. Texas Water Development Board Report 380. Austin, Texas, USA.

Green, A., M. Osborn, P. Chai, J. Lin, C. Loeffler, A. Morgan, P. Rubec, S. Spanyers, A. Walton, R.D. Slack, D. Gawlik, D. Harpole, J. Thomas, E. Buskey, K. Schmidt, R. Zimmerman, D. Harper, D. Hinkley, T. Sager, and A. Walton. 1992. Status and trends of selected living resources in the Galveston Bay system. Galveston Bay National Estuary Program Publication GBNEP-19. Webster, Texas

Griffith, G., S. Bryce, J. Omernik, and A. Rogers. 2007. Ecoregions of Texas. Project report to Texas Commission on Environmental Quality. Austin Texas, USA.

Gulf of Mexico Fishery Management Council (GMFMC). 1998. Generic amendment for addressing essential fish habitat requirements in the following fishery management plans of the Gulf of Mexico: Shrimp fishery of the Gulf of Mexico, United States waters; Red drum fishery of the Gulf of Mexico;

Reef fish fishery of the Gulf of Mexico; Coastal migratory pelagic resources (mackerels) in the Gulf of Mexico and South Atlantic; Stone crab fishery of the Gulf of Mexico; Spiny lobster in the Gulf of Mexico and South Atlantic; Coral and coral reefs of the Gulf of Mexico; Gulf of Mexico FMC, Tampa, FL, USA. https://gulfcouncil.org/wp-content/uploads/Oct-1998-FINAL-EFH-Amendment-1-no-appendices.pdf. Accessed July 2017.

_____. 2004. Final Environmental Impact Statement for the generic essential fish habitat amendment to the following fishery management plans of the Gulf of Mexico (GOM): Shrimp fishery of the Gulf of Mexico; Red drum fishery of the Gulf of Mexico; Reef fish fishery of the Gulf of Mexico; Stone crab fishery of the Gulf of Mexico; Coral and coral reef fishery of the Gulf of Mexico; Spiny lobster fishery of the Gulf of Mexico and South Atlantic; Coastal migratory pelagic resources of the Gulf of Mexico and South Atlantic. http://gulfcouncil.org/fishery-management/implemented-plans/essential-fish-habitat/.

Harris-Galveston Subsidence District. 2013. Subsidence 1906-2000. <http://hgsubsidence.org/wp-content/ uploads/2013/07/SubsidenceMap1906-2000.pdf>. Accessed August 2017.

Hicks, S. D. 2006. Understanding tides. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Ocean Service. 66 pp.

Houston Chronicle. 2012. Rare manatee sighting in Galveston. October 15, 2012. http://www.chron.com/news/houston-texas/article/Rare-manatee-sighting-in-Galveston-3924028.php. Accessed May 2016.

Hyde, H. W. 2001. Soil survey of Matagorda County, Texas. United States Department of Agriculture, Natural Resources Conservation Service, in cooperation with Texas Agriculture Experiment Station. 171 pp. https://www.nrcs.usda.gov/Internet/FSE_MANUSCRIPTS/texas/TX321/0/ Matagorda.pdf. Accessed July 2017.

INTERA Geosciences & Engineering. 2013. Predictions of potential Impacts on water Levels and land subsidence caused by well fields near Brazosport Water Authority plant in Brazoria County – final report. Prepared for CDM Smith and Texas Water Development Board. Included as Appendix H in Brazoria County Regional Water Facility Study Final Report. <http://www.twdb.texas.gov/publications/reports/contracted_reports/doc/1248321449_Appendices/Appendix%20H.pdf>. Accessed August 2017.

Kirby, C. L., and A. S. Lord. 2015. Sulphur extraction at Bryan Mound. Sandia Report SAND2015-6827. Sandia National Laboratories, Albuquerque, New Mexico, and Livermore, California, USA.

Knox, G. A. 2001. The ecology of seashores. CRC Press LLC, Boca Rotan, Florida. 557 pp.

Lower Colorado Regional Water Planning Group. 2015. 2016 Region K water plan for the Lower Colorado Regional Water Planning Group, Volume 1 of 2. <http://www.twdb.texas.gov/waterplanning/rwp/ plans/2016/K/Region_K_2016_RWPV1.pdf.>.

Longley, W. I., editor. 1994. Freshwater inflows to Texas bays and estuaries: ecological relationships and methods for determination of needs. Texas Water Development Board and Texas Parks and Wildlife Department, Austin. <http://www.twdb.texas.gov/publications/reports/other_reports/doc/ FreshwaterInflowstoTexasBays.pdf>.

Matagorda County Economic Development Corporation (EDC). 2016. Current and future development projects in Matagorda County, TX. July 2016. <http://www.mcedc.net/site/assets/files/1317/ current_and _ future _projects_list_-_july_2016.pdf>. Accessed December 2017.

Matagorda County Flood Mitigation Plan. 2010. Flood mitigation plan for Matagorda County, City of Bay City, and City of Palacios. <http://www.twdb.texas.gov/publications/reports/contracted_reports/doc/ 0904830905_Matagorda_wcover.pdf>. Accessed July 2017.

McKenna, K. K. 2014. Texas coastwide erosion response plan: 2013 update. Final report to the Texas General Land Office. <http://www.glo.texas.gov/coast/coastal-management/forms/files/coastwide-erosion-response-plan.pdf>. Accessed July 2016.

Mid-Atlantic Fishery Management Council. 2016. Regional use of the Habitat Area of Particular Concern (HAPC) designation. Prepared by the Fisheries Leadership & Sustainability Forum for the Mid-Atlantic Fishery Management Council. http://www.habitat.noaa.gov/pdf/Regional-HAPC-Report-May-2016.pdf. Accessed July 2017.

Milliman, J. D., and R. H. Meade. 1983. World-wide delivery of river sediment to the oceans. The Journal of Geology:1-21. The University of Chicago Press, Chicago, Illinois, USA.

Montagna, P. A. 2001. Effect of freshwater inflow on macrobenthos; productivity in minor bay and river-dominated estuaries. FY01. Report to Texas Water Development Board, Contract No. 2001-483-362. University of Texas at Austin, Marine Science Institute, Port Aransas, Texas. http://www.twdb.texas.gov/publications/reports/contracted_reports/doc/2001483362.pdf?d=4398.2.

Montagna, P. A., S. A. Holt, and K. H. Dunton. 1998. Characterization of anthropogenic and natural disturbance on vegetated and unvegetated bay bottom habitats in the Corpus Christi Bay National

Estuary Program study area. Final Project Report, Corpus Christi Bay National Estuary Program, Corpus Christi, Texas. http://cbbep.org/publications/virtuallibrary/cc25a.pdf. Accessed April 2017.

Montagna, P. A., T. A. Palmer, and J. B. Pollack. 2008. Effect of freshwater inflow on macrobenthos productivity in minor bay and river-dominated estuaries—synthesis. Final Report to Texas Water Development Board, Contract No. 2006-483-026, Texas A&M University-Corpus Christi. http://www.twdb.texas.gov/publications/reports/contracted_reports/doc/20064830026_MinorBays.pdf ?d=3494.2300000000005. Accessed July 2017.

National Marine Fisheries Service (NMFS). 2010. Essential fish habitat: A marine fish habitat conservation mandate for federal agencies. Gulf of Mexico Region. NMFS, Habitat Conservation Division, Southeast Regional Office, St. Petersburg, FL, USA. <http://sero.nmfs.noaa.gov/sustainable_fisheries/gulf_fisheries/generic/documents/pdfs/ 2013/gom_efh_guide_2010.pdf>. Accessed June 2016.

_____. 2015. Essential fish habitat – Gulf of Mexico. NOAA, National Marine Fisheries Service, Southeast Region, Habitat Conservation Division. VER: 082015.

_____. 2017. Texas' Threatened and endangered species and critical habitat designations. NMFS Southeast Region Protected Resources Division. <http://sero.nmfs.noaa.gov/protected_resources/ section_7/threatened_endangered/Documents/texas.pdf>. Accessed May 2017.

National Oceanic and Atmospheric Administration (NOAA). 2017a. Datums for 8772447, Freeport TX. <https://tidesandcurrents.noaa.gov/datums.html?id= 8772447>. Accessed August 2017.

_____. 2017b. Datums for 8773146, Matagorda City TX. <https://tidesandcurrents.noaa.gov/datums.html? id=8773146>. Accessed August 2017.

_____. 2017c. Marine Mammal Protection Act. http://www.nmfs.noaa.gov/pr/laws/mmpa/. Accessed June 2017.

_____. 2017d. Commercial fishing statistics. NMFS Fisheries Statistics Division, Office of Science and Technology. https://www.st.nmfs.noaa.gov/commercial-fisheries/commercial-landings/annual-landings/index. Accessed August 2017.

_____. 2017e. Recreational fisheries. NMFS Fisheries Statistics Division, Office of Science and Technology. http://www.st.nmfs.noaa.gov/recreational-fisheries/index. Accessed August 2017.

National Weather Service. 2017. Major Hurricane Harvey – August 25-29, 2017. http://www.weather.gov/crp/hurricane_harvey

Natural Science Research Laboratory. 2017. West Indian Manatee. In *The Mammals of Texas – Online Edition*. Museum of Texas Tech University, Lubbock, Texas, USA. <http://www.nsrl.ttu.edu/tmot1/ tricmana.htm>. Accessed April 2017.

Neighbors, R. J. 2003. Subsidence in the greater Houston area – past, present and future. University of Houston Center for Innovative Grouting Materials and Technology (CIGMAT). Part 1: Presentations. Houston, Texas, USA. http://www2.egr.uh.edu/~civeb1/CIGMAT/03_present/5.pdf.htm. Accessed August 2017.

Newell, R. C., L. J. Seiderer, and D. R. Hitchcock. 1998. The impact of dredging works in coastal waters: a review of the sensitivity to disturbance and subsequent recovery of biological resources on the sea bed. Oceanography and marine biology: an annual review, Vol. 36, pp. 127-78.

Occupational Safety and Health Administration (OSHA). 2017. Occupational Noise Exposure. https://www.osha.gov/SLTC/noisehearingconservation/. Accessed September 2017.

Ortego, B. The bald eagle in coastal Texas. In Roundtop magazine. https://roundtop.com/round-top-texas-bald-eagle/. Accessed July 2017.

Paine, J. G., T. L. Caudle, and J. L. Andrews. 2014. Shoreline movement along the Texas Gulf Coast, 1930's to 2012. Final Report to the Texas General Land Office. Bureau of Economic Geology, University of Texas at Austin, Austin, Texas, USA.

Palmer, T. A., R. A. Montagna, J. B. Pollack, R. D. Kalke, and H. R. DeYoe. 2011. The role of freshwater inflow in lagoons, Rivers, and bays. Hydrobiologia 667:49-67.

Ratzlaff, K. W. 1980. Land-surface subsidence in the Texas coastal region. Open-File Report 80-969. U.S. Geological Survey and Texas Department of Water Resources. Austin, Texas, USA.

Reddell, M. 2017. County begins review of wind farm. Bay City Sentinel. August 3, 2017. https://www.baycitysentinel.com/articles/2017/08/03/county-begins-review-wind-farm-mike-reddell. Accessed December 2017.

Region H Regional Water Planning Group. 2015. 2016 Region H Regional Water Plan. http://www.twdb.texas.gov/waterplanning/rwp/plans/2016/H/Region_H_2016_RWP.pdf>. Accessed June 2017.

Roth, D. 2010. Texas hurricane history. National Weather Service. Camp Springs, MD. 141 pp. https://www.weather.gov/media/lch/events/txhurricanehistory.pdf. Accessed July 2017.

Stutzenbaker, C. D. 1999. Aquatic and wetland plants of the western Gulf Coast. Texas Parks and Wildlife Department Wildlife Division. Austin, Texas, USA.

Tenaris. 2017. Tenaris unveils seamless pipe mill in Bay City, Texas. December 11, 2017. http://www.tenaris.com/en/MediaAndPublications/News/2017/December/TBCInauguration.aspx. Accessed December 2017.

Texas Commission on Environmental Quality (TCEQ). 2015. 2014 Texas 303(d) list (November 19, 2015). https://www.tceq.texas.gov/assets/public/waterquality/swqm/assess/14txir/2014_303d.pdf. Accessed April 2017.

_____. 2016a. Download TCEQ GIS data: water, TCEQ segments. <https://www.tceq.texas.gov/gis/download-tceq-gis-data/>. Metadata dated 12/7/2016. Accessed August 2017.

_____. 2016b. Download TCEQ GIS data: water, public water system wells & surface water intakes. https://www.tceq.texas.gov/gis/ download-tceq-gis-data/. Metadata dated 07/06/2016. Accessed August 2017.

_____. 2017a. Texas integrated report of surface water quality. https://www.tceq.texas.gov/water quality/assessment/305_303.html. Accessed August 2017.

_____. 2017b. Texas State Implementation Plan. https://www.tceq.texas.gov/airquality/sip. Accessed September 2017.

_____. 2017c. Understanding general conformity in Texas. http://tceq.texas.gov/airquality/mobilesource/gc.html. Accessed September 2017.

Texas Department of Transportation (TxDOT). 2013. Texas Department of Transportation, Gulf Intracoastal Waterway. Legislative Report – 83rd Legislature. <https://static.tti.tamu.edu/tti.tamu.edu/documents/ TTI-2013-12.pdf>. Accessed June 2016.

_____. 2016. 2016 Gulf Intracoastal Waterway Legislative Report – 85th Legislature. http://ftp.dot.state.tx.us/pub/txdot-info/tpp/giww/legislative-report-85.pdf. Accessed June 2017.

_____. 2017a. Hydraulic engineering appendix, Brazos River Floodgates. Prepared by Mott MacDonald. September 2017.

Texas Department of Transportation (TxDOT). 2017b. FM 457 bridge replacement project. https://www.txdot.gov/inside-txdot/projects/studies/yoakum/fm457-bridge-replacement.html. Accessed December 2017.

_____. 2017c. Projects and studies: Houston district. <https://www.txdot.gov/inside-txdot/projects/studies/houston.html>. Accessed December 2017.

Texas General Land Office (GLO). 2015. Coastal Erosion Planning & Response Act: a report to the 84th Texas Legislature (2015 Report). <http://www.glo.texas.gov/coast/coastal-management/forms/files/CEPRA-Report-2015.pdf>. Accessed July 2016.

Texas Invasive Plant and Pest Council (TIPPC). 2017. Invasives database. http://www.texasinvasives.org/invasives_database/index.php. Accessed April 2017.

Texas Natural Diversity Database (TXNDD). 2017. Texas Parks and Wildlife Department. Database search included 5-mile radius of the Project area. Received June 2017.

Texas Parks and Wildlife Department (TPWD). 2017a. Texas most unwanted plants and animals. https://tpwd.texas.gov/education/resources/keep-texas-wild/alien-invaders/texas-most-unwanted-plants-and-animals. Accessed August 2017.

_____. 2017b. Justin Hurst WMA. https://tpwd.texas.gov/huntwild/hunt/wma/find_a_wma/list/?id=41. Accessed April 2017.

Texas Railroad Commission (RRC), 2017. Public GIS viewer (map) for oil, gas, and pipeline data. http://www.rrc.state.tx.us/about-us/resource-center/research/gis-viewers/. Accessed April 2016.

Texas Water Development Board (TWDB). 1969. Ground-water resources of Matagorda County, Texas. Report 91, TWDB in cooperation with the Lower Colorado River Authority and Matagorda County Commissioners Court. 163 pp. https://www.twdb.texas.gov/publications/reports/numbered_reports/doc/R91/R91.pdf. Accessed July 2017.

_____. 1973. Ground-water resources of Brazoria County, Texas. Report 163, TWDB in cooperation with the U.S. Geological Survey. 64 pp. <https://www.twdb.texas.gov/publications/reports/numbered_reports/doc/R163/R163_text.pdf>. Accessed July 2017.

_____. 1982. Geologic atlas of Texas, Houston sheet. <https://www.twdb.texas.gov/groundwater/aquifer/GAT/houston.htm>. Accessed June 2017.

_____. 1987. Geologic atlas of Texas, Beeville-Bay City sheet. <https://www.twdb.texas.gov/groundwater/aquifer/GAT/beeville-bay-city.htm.> Accessed June 2017.

_____. 2016a. Summary of the 2016 Lower Colorado (K) regional water plan. http://www.twdb.texas.gov/waterplanning/swp/2017/doc/2016_RegionalSummary_K.pdf. Accessed June 2017.

_____. 2016b. Summary of the 2016 Region H regional water plan. <http://www.twdb.texas.gov/waterplanning/swp/2017/doc/2016_RegionalSummary_H.pdf>. Accessed June 2017.

_____. 2017a. Gulf coast aquifer. <http://www.twdb.texas.gov/groundwater/aquifer/majors/gulf-coast.asp>. Accessed May 2017.

_____. 2017b. River basins. http://www.twdb.texas.gov/surfacewater/Rivers/River_basins/index.asp. Accessed June 2017.

_____. 2017c. Submitted driller's reports database (SDRDB) Shapefile. <http://www.twdb.texas.gov/groundwater/data/drillersdb.asp>. Accessed August 2017.

Texas Water Resources Institute. 1995. Texas water resources. Spring 1995. Volume 21, No. 1. http://twri.tamu.edu/newsletters/texaswaterresources/twr-v21n1.pdf.

The Go Travel Sites. 2017. Matagorda County Jetty Park. <https://www.go-texas.com/Matagorda-County-Jetty-Park/#>. Accessed April 2017.

U.S. Army Corps of Engineers (USACE). 2017a. Hazardous toxic radioactive waste (HTRW) survey for Gulf Intracoastal Waterway Brazos River Floodgates & Colorado River Lock Feasibility Study. 6 October 2017.

_____. 2017b. Hydrodynamic evaluation of proposed navigation improvements at the Colorado River intersection with the Gulf Intra-Coastal Waterway. Prepared by Maxwell E. Agnew, USACE New Orleans District. September 2017.

_____. 2017c. Regulatory In-lieu Fee and Bank Information Tracking System (RIBITS). https://ribits.usace.army.mil/ribits_apex/f?p=107:2). Accessed December 2017.

_____. 2016. Alternative Milestone, Gulf Intracoastal Waterway Brazos River Floodgates and Colorado River Locks System Feasibility Study. Prepared by USACE Southwest Division, September 2016.

_____. 2012. Final Freeport Harbor, Texas Channel Improvement Project Feasibility Report. http://www.swg.usace.army.mil/Portals/26/docs/Planning/FHCIP%20Final%20Feasibility%20Report%20Vol%20I%20August%202012.pdf. Accessed April 2017.

_____. 2005. Freeport and vicinity, Texas. Hurricane-flood protection draft feasibility report. U.S. Army Engineer District, Galveston, Southwestern Division. May 2005. http://www.velascodrainagedistrict.com/Freeport_HFP_Draft_Final.pdf. Accessed June 2016.

_____. 1981. Mouth of the Colorado River, Texas, Phase I: general design memorandum and Environmental Impact Statement (diversion features).

U.S. Census Bureau. 2017a. 2011-2015 U.S. census American community survey. <https://factfinder.census.gov/faces/nav/jsf/pages/searchresults.xhtml?refresh=t>. Accessed April 2017.

_____. 2017b. *Median household income in the past 12 Months (In 2015 inflation-adjusted dollars) American community survey 5-year estimates (2011-2015).* <https://censusreporter.org/tables/B19013/>. Accessed April 2017.

_____. 2017c. *Age by language spoken at home by ability to speak English for the population 5 years and over American community survey 5-year estimates (2011-2015).* <https://censusreporter.org/tables/B16004/>. Accessed April 2017.

U.S. Department of Agriculture (USDA). 2017a. National soil survey handbook part 622, interpretative groups. USDA NRCS. <http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/tools/?cid=nrcs142p2_054226. Accessed August 2017.

_____. 2017b. Hydric soils - introduction. USDA NRCS. <https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/use/hydric/?cid=nrcs142p2_053961>. Accessed August 2017.

_____. 2017c. Web soil survey. USDA NRCS. http://websoilsurvey.nrcs.usda.gov/. Accessed April 2017.

_____. 2017d. Official soil series descriptions (OSDs). USDA NRCS. <https://soilseries.sc.egov.usda.gov/osdname.aspx>. Accessed April 2017.

_____. 2017e. National Invasive Species Information Center: Aquatic species. https://www.invasivespeciesinfo.gov/aquatics/main.shtml. Accessed July 2017.

_____. 2017f. Farmland Protection Policy Act. <https://www.nrcs.usda.gov/wps/portal/nrcs/detail/?cid=nrcs143_008275>. Accessed November 2017.

U.S. Department of Health and Human Services. 2017. Annual update of the HHS poverty guidelines. https://www.federalregister.gov/documents/2017/01/31/2017-02076/annual-update-of-the-hhs-poverty-guidelines. Accessed April 2017.

U.S. Environmental Protection Agency (EPA). 1974. Information on levels of environmental noise requisite to protect public health and welfare with an adequate margin of safety. EPA 550/9-74-004. March 1974.

_____. 2017a. NAAQS tables. https://www.epa.gov/criteria-air-pollutants/naaqs-table. Accessed September 2017.

_____. 2017b. Nonattainment areas for criteria pollutants (Green Book). Nonattainment areas for criteria pollutants (Green Book). https://www.epa.gov/green-book. Accessed September 2017.

_____. 2017c. Region 6 Federal Air Quality Control Regions. Designation of areas of air quality planning purposes 40 CFR Part 81. Current as of September 2017. https://www.epa.gov/air-quality-implementation-plans/region-6-federal-air-quality-control-regions-aqcrs. Accessed September 2017.

U.S. Fish and Wildlife Service (USFWS). 1980. Habitat evaluation procedures (HEP). https://www.fws.gov/policy/ESMindex.html. Accessed February 2017.

_____. 2009. Endangered and threatened wildlife and plants; revised designation of critical habitat for the wintering population of the piping plover (*Charadrius melodus*) in Texas. May 19, 2009. Federal Register 74(95): 23476-23600.

_____. 2017a. ECOS species by county report for Brazoria County, Texas. https://ecos.fws.gov/ecp0/reports/species-by-current-range-county?fips=48039. Accessed June 2017.

_____. 2017b. ECOS species by county report for Matagorda County, Texas. https://ecos.fws.gov/ecp0/reports/species-by-current-range-county?fips=48321. Accessed June 2017.

_____. 2017c. IPaC trust resources report official species list for Brazoria and Matagorda Counties, Texas. https://ecos.fws.gov/ipac/. Accessed June 2017.

_____. 2017d. ECOS threatened and endangered species active critical habitat report. https://ecos.fws.gov/ecp/report/table/critical-habitat.html. Accessed June 2017.

_____. 2017e. Coastal Barrier Resources System: Overview of Federal project consistency consultations. https://www.fws.gov/cbra/Consultations.html. Accessed September 2017.

U.S. Geological Survey (USGS). 1952. (Photorevised 1972). 7.5-minute series topographic map (1:24,000 scale), Matagorda, Texas. USGS. Denver, Colorado, and Reston, Virginia, USA.

_____. 1963 (Photorevised 1974). 7.5-minute series topographic map (1:24,000 scale), Jones Creek, Texas. USGS. Denver, Colorado, and Reston, Virginia, USA.

_____. 1964 (Photorevised 1974). 7.5-minute series topographic map (1:24,000 scale), Freeport, Texas. USGS. Denver, Colorado, USA.

_____. 2017a. Science in your watershed. http://water.usgs.gov/wsc/map_index.html. Accessed April 2017.

_____. 2017b. Lower Brazos watershed. U.S. Geological Survey watershed mapper. https://water.usgs.gov/wsc/cat/12070104.html. Accessed July 2017.

Van Der Wal, D., R. M. Forster, F. Rossi, H. Hummel, T. Ysebaert, F. Roose, and P. M. Herman. 2011. Ecological evaluation of an experimental beneficial use scheme for dredged sediment disposal in shallow tidal waters. Marine Pollution Bulletin 62(1):99-108.

Wilber, D. H., and D. G. Clarke. 2001. Biological effects of suspended sediments: a review of suspended sediment impacts on fish and shellfish with relation to dredging activities in estuaries. North American Journal of Fisheries Management 21:855-875.

Wilber, D. H., D. G. Clarke, and S. I. Rees. 2006. Responses of benthic macroinvertebrates to thin layer disposal of dredged material in Mississippi Sound, USA. Marine Pollution Bulletin. doi:10.1016/j.marpolbul.2006.08.042.

Zilkoski, D. B., L. W. Hall, G. J. Mitchell, V. Kammula, A. Singh, W. M. Chrismer, and R. J. Neighbors. 2017. The Harris-Galveston Coastal Subsidence District/national geodetic survey automated global positioning system subsidence monitoring project. Undated report prepared for the Harris-Galveston Subsidence District. http://hgsubsidence.org/subsidence-data/. Accessed August 2017.

9.3 Figures and Tables

THIS PAGE LEFT INTENTIONALLY BLANK