U.S. Army Corps
of Engineers

Galveston District
Southwestern Division

Houston Ship Channel Expansion Channel Improvement Project, Harris, Chambers, and Galveston Counties, Texas

Draft Integrated Feasibility Report–Environmental Impact Statement

APPENDIX G

ENVIRONMENTAL SUPPORTING DOCUMENT

August 2017

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FIGURES

TABLES

List of Acronyms

ACS	American Community Survey
ALU	Aquatic Life Use
AOC	Area of Concern
AST	Above Ground Storage Tank
AU	Assessment Units
AUL	Activity Use Limitations
BA	Biological Assessment
BCC	Barbours Cut Channel
BCCT	Barbours Cut Container Terminal
BSCCT	Bayport Ship Channel Container Terminal
BMP	Best Management Practice
BSC	Bayport Ship Channel
CAA	Clean Air Act
CDF	Confined Disposal Facility
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CERCLIS	Comprehensive Environmental Response, Compensation and Liability Information System
CWA	Clean Water Act
CY	Cubic Yards
D50	Median Grain Size
dB	Decibels
dBA	Decibels, A-Weighted
DEQ	Oregon Department of Environmental Quality
DIFR-EIS	Draft Integrated Feasibility Report and Environmental Impact Statement
DMPA	Dredged Material Placement Area
DMMP	Dredged Material Management Plan
DSHS	Texas Department of State Health Services
DO	Dissolved Oxygen
dw	Dry Weight
ECA	Emissions Control Area
ECIP	Expansion Channel Improvement Project
EFH	Essential fish habitat
EIS	Environmental Impact Statement

EJ	Environmental Justice
EO	Executive Order
EPA	U.S. Environmental Protection Agency
EQ	environmental quality
ER	Engineer Regulation
ERDC	U.S. Army Engineer Research and Development Center
ERL	Effects Range Low
ERM	Effects Range Medium
ERNS	Emergency Response Notification System
ESA	Endangered Species Act
ETL	Engineer Technical Letter
ºF	Degrees Fahrenheit
FCU	Fish Consumption Use
FEIS	Final Environmental Impact Statement
FMC	Fishery Management Councils
FMP	Fishery Management Plans
FUDS	Formerly Used Defense Site
FWOP	Future Without-Project
GBEP	Galveston Bay Estuary Program
GHG	Greenhouse Gases
GIWW	Gulf Intracoastal Waterway
GMFMC	Gulf of Mexico Fishery Management Council
GRBO	Gulf Regional Biological Opinion
GU	General Use
HFD	Houston Fire Department
HGAC	Houston-Galveston Area Council
HGB	Houston-Galveston-Brazoria
HGNC	Houston-Galveston Navigation Channel
HHS	U.S. Department of Health and Human Services
HPA	Houston Pilots Association
HSC	Houston Ship Channel
HTRW	Hazardous, Toxic and Radioactive Waste
HP	Horsepower
IC	Institutional Controls
IH	Interstate Highway
ITA	Incidental Take Authorization

Leq	Equivalent Continuous Sound Level
LQG	Large Quantity Generator
MBTA	Migratory Bird Treaty Act
MHI	Median Household Income
MLLW	Mean Lower Low Water
MSFCMA	Magnuson-Stevens Fishery Conservation and Management Act
MSL	Mean Sea Level
NAAQS	National Ambient Air Quality Standards
NCA	U.S. National Climate Assessment
NED	National Economic Development
NEPA	National Environmental Policy Act
NRHP	National Register of Historic Places
NFS	Non-Federal Sponsor
NMFS	National Marine Fisheries Service
NPL	National Priorities List
NOAA	National Oceanic and Atmospheric Administration
NO_x	nitrogen oxide
NC	No Concern
OCDD	Octachlorodibenzo-p-dioxin
OCDF	Octachlorodibenzofuran
ODMDS	Ocean Dredged Material Disposal Site
OGV	ocean-going vessels
P&G	Principles and Guidelines
OWU	Oysters Waters Use
PA	placement area
PAH	polycyclic aromatic hydrocarbons
PCB	polychlorinated biphenyl
PED	Preconstruction Engineering and Design
PHA	Port of Houston Authority
POA	Period of Analysis
ppm	parts per million
ppt	parts per trillion
ppth	parts per thousand
RCRA	Resource Conservation and Recovery Act
REC	recognized environmental conditions
RSLC	Relative Sea Level Change

RU	Recreation Use
SAV	submerged aquatic vegetation
SEMS	Superfund Enterprise Management System
SH	State Highway
SIP	State Implementation Plan
SLV	screening level values
SOx	Sulfur Oxides
SVOC	Semi Volatile Organic Compound
SWQM	Surface Water Quality Monitoring
T&E	Threatened and Endangered
TB	Turning Basin
TCEQ	Texas Commission on Environmental Quality
TDED	Texas Department of Economic Development
TEQ	Toxicity Equivalents
TMDL	Total Maximum Daily Load
TSDF	Treatment, Storage, Disposal Facility
TOC	Total Organic Carbon
TSP	Tentatively Selected Plan
TPH	Total Petroleum Hydrocarbon
TPWD	Texas Parks and Wildlife Department
TPY	Tons Per Year
TSWQS	Texas Water Quality Standards
TxGLO	Texas General Land Office
TxRRC	Texas Railroad Commission
TWDB	Texas Water Development Board
U.S.	United States of America
USACE	United States Army Corps of Engineers
USCG	U.S. Coast Guard
USFWS	U.S. Fish and Wildlife Service
UST	Underground Storage Tank
VCP	Voluntary Cleanup Program
VOC	Volatile Organic Compounds
WMA	Wildlife Management Area

1 EXISTING WITHOUT PROJECT CONDITIONS AND AFFECTED ENVIRONMENT

1.1 GENERAL

This appendix supplements and provides detail to the existing without project conditions information in Chapter 2 of the Main Report of the Draft Integrated Feasibility Report and Environmental Impact Statement (DIFR-EIS). That chapter carries out the inventorying part of Step 2 Inventorying and Forecasting Conditions of the required U.S. Army Corps of Engineers (USACE) planning process in Engineer Regulation (ER) 1105-2-100, *Planning Guidance Notebook*, and provides the Affected Environment chapter of an Environmental Impact Statement (EIS) for National Environmental Policy Act (NEPA) purposes.

1.2 PHYSICAL DESCRIPTION OF THE EXISTING PROJECT

The Houston Ship Channel (HSC) is a 50 mile-long deep draft navigation channel that is predominantly 46.5 feet deep through approximately 39 miles of its length from Bolivar Roads near Galveston Island and the Bolivar Peninsula to Boggy Bayou. Beyond Boggy Bayou to just downstream of the east part of the Beltway 8 in east Houston, the channel is 41.5 feet deep for the next 8 upstream miles, and 37.5 feet deep for the most upstream 5 miles. In Galveston Bay, the HSC is channel dredged out of shallow bay bottom that was typically 8.5 to 9.5 feet deep prior to its construction and today, is a deep channel surrounded by a wide expanse of shallow Bay. Above Galveston Bay, the HSC was dredged out of the lower part of Buffalo Bayou including its confluence with the San Jacinto River. Between Morgans Point and the San Jacinto Battleground, the HSC is a deep channel surrounded by the small bays formed at the confluence of Buffalo Bayou and the San Jacinto River, including Tabbs, Black Duck, Scott, San Jacinto, Crystal, and Burnet Bays. Above the San Jacinto Battleground, the HSC is a deep channel in Buffalo Bayou, which was widened up to the Main Turning Basin to create the earlier shallower draft versions of the channel, and is surrounded by mainland in this reach.

The side channels to the HSC being studied are the 4.1-mile-long Bayport Ship Channel (BSC) and the 1.5-mile long Barbours Cut Channel (BCC), which are both 46.5 feet deep draft navigation channels. The BSC is a deep channel that surrounded by the shallow Galveston Bay for approximately half of its length, and mainland for the other half, as it was originally excavated out of land forming a land cut. The BCC is deep channel surrounded by the Spilmans Island Placement Area (PA) to the north and mainland to the south.

1.3 PHYSICAL RESOURCES

This section provides general and detailed information on the non-living resources of the physical environment of the project area including the project area, climate, geology, topography, soils, physical oceanography, water and sediment quality, energy and mineral resources, hazardous, toxic, and radioactive waste (HTRW), air quality, and noise.

1.3.1 Project Area

The project area is located in southeast Texas and within Chambers, Harris, and Galveston Counties. Chambers County consists mostly of agriculture, open water, and wetlands. Harris County is mostly developed and includes agriculture, open space developments, forests, wetlands, grasslands, and open water. Most of Galveston County is open water but contains a mix of agriculture and development on land areas (NOAA 2017). The project area includes Galveston Bay and the greater Houston area along the Houston Ship Channel upstream of Galveston Bay. Galveston Bay is an estuary where freshwater flows mix with the salt water of the Gulf of Mexico. The surface area of Galveston Bay is approximately 600 square-miles. Galveston Bay is characterized by generally shallow water depths, generally ranging from 5 to 12 feet. Dredged navigation channels, with permitted or authorized depths ranging from -13.5 to -46.5 Mean Lower Low Water (MLLW) (-12 to -45 feet Mean Low Tide [MLT]) that with advanced maintenance and allowable overdepths have maximum depths ranging from -14.5 to -50.5 feet MLLW (-13 to -49 feet MLT), are located throughout the bay system. Galveston Bay consists of several subsystems: Trinity Bay, East Bay, San Jacinto Bay, upper Galveston Bay, and West Bay. The project area also includes the HSC above Morgans Point, within the most downstream segment of Buffalo Bayou that confluences with the mouth of the San Jacinto River to form several small bays just upstream of Galveston Bay.

1.3.2 Climate

The climate for the Greater Houston area is classified as humid subtropical. Temperatures on average range from a low of 43º Fahrenheit (F) in January to a high of 95º F in August with an average yearly precipitation of 50 inches (NOAA 2016). The prevailing wind in Galveston Bay is from the southeast. The Greater Houston area and Galveston Bay region in general are susceptible to tropical cyclones during hurricane season (June through November). Storm tide heights recorded near the City of Galveston have ranged from 6.29 to 15.69 feet above MLLW (5.7 to 15.1 feet above mean sea level [MSL]). The last major hurricane to impact the area was Hurricane Ike in 2008.

1.3.3 Topography, Soils, Geology and Groundwater

The majority (90 percent) of the project area is in open water. The topography of land adjacent to the general area of the project is relatively flat and is located on the Gulf Coastal Plain of Texas which consists of flat low-lands. Elevation in the vicinity of the project, according to a review of U.S. Geological Survey topographic maps, ranges from sea level within Galveston Bay to approximately 30 feet on the surrounding lands.

Soil survey data for Chambers County, Galveston County, and Harris County, Texas from Natural Resources Conservation Service (NRCS) were reviewed to determine the existing soils of land within the Counties adjacent to the project area (NRCS 2016). The project area located in Chambers and Galveston Counties does not have any soil classifications assigned and is classified as "Water" (W) since the land is submerged. The soils of the nearest mapped units on adjacent land in Harris County are listed and described below in **Table G1-1**. Galveston Bay was formed by some of the same geological processes and events as the adjacent coastal land; therefore, some of the same formations, most importantly, the Beaumont Clay, form the bottom of Galveston Bay.

Table G1-1: Soil Types and Characteristics (Harris County)

Soil Type	Soil Characteristics
Atasca Fine Sandy Loam (AtaC)	Slope ranges from 2 to 5 percent, moderately well drained, very high runoff.
Bacliff-Urban land complex (BadA)	Slope ranges from 0 to 1 percent, poorly drained soil, negligible runoff.
Dylan Clay (DylC)	Slope ranges from 3 to 5 percent, moderately well drained, very high runoff.
Harris Clay (HarA)	Slopes range from 0 to 1 percent, very poorly drained, high runoff.
Ijam Clay (IjmB)	Slopes range from 0 to 2 percent, poorly drained, very high runoff.
Kenney Loamy Fine Sand (Kn)	Slopes range from 0 to 2 percent, well drained, very low runoff.
Lake Charles Clay: 0 to 1 percent slopes (LcA)	Slopes range from 0 to 1 percent, moderately well drained, high runoff.
Lake Charles-Urban Land Complex (Lu)	Slopes range from 0 to 3 percent, moderately well drained, high runoff.
Texla Silt Loam (TelB)	Slopes range from 0 to 2 percent, somewhat poorly drained, high runoff.
Texla-Urban Land Complex (TeuB)	Slopes range from 0 to 2 percent, somewhat poorly drained, high runoff.
Urban Land (URLX)	Slopes range from 0 to 3 percent, very high runoff.
Vamont Clay (VamA)	Slopes range from 0 to 1 percent, somewhat poorly drained, high runoff.
Vamont-Urban Land Complex (VauA)	Slopes range from 0 to 1 percent, somewhat poorly drained, high runoff.
Verland-Urban Land Complex (Mu)	Slopes range from 0 to 1 percent, somewhat poorly drained, high runoff.

Source: NRCS 2016

The geology within the project area is of the Quaternary Period. The geology of the mainland adjacent to the proposed project is mapped as Beaumont formation. The Beaumont formation is the youngest formation of the Pleistocene age. The origin of the Beaumont formation is primarily fluvial and deltaic; however some small areas might have originated as coastal marsh and lagoonal deposits. In the project area, the Beaumont formation is dominantly clay and mud of low permeability, high water-holding capacity, high compressibility, high to very-high shrink-swell potential, poor drainage, low shear strength, and high plasticity. The top-most sediments of the bay bottom overlying the geologic formations in the project area are primarily the result of deposition from modern fluvial and coastal erosion processes, and sediment transport from currents and tides. Historic dredging of oyster shell for road construction in the 20th century has created voids filled in by this deposition, resulting in deeper pockets of unconsolidated sediment deposits in some parts of the bay bottom in the general project area, while other areas have less depth of unconsolidated sediments overlying the stiffer materials of the Beaumont formation.

The Gulf Coast Aquifer is the only major aquifer that underlies the project area. No minor aquifers are located in the project area. The Gulf Coast Aquifer consists of the Chicot, Evangeline, and Jasper aquifers that are composed of discontinuous sand, silt, clay and gravel beds (George, P.G. et al. July 2011). Groundwater withdrawals in the Chambers, Harris and Galveston Counties over the years have led to land subsidence. However, mandatory reductions in groundwater withdrawal beginning in 1975 have led to gradual recovery of aquifer levels and curtailment of subsidence since that time (Kasmarek et al. 2016). Withdrawal has largely been curtailed in the study area, and long term net changes in the aquifers indicate increases of 80 to 200 feet in water level. Subsidence monitoring at extensometers closest to the project area show subsidence generally leveling off by 1990, except for an abrupt short term increase between 2010 and 2013 associated with the 2010-2011 drought (Kasmarek et al. 2016).

1.3.4 Physical Oceanography

Galveston Bay is characterized as a relatively large shallow bay with an extensive interconnected system of deeper navigational ship channels. With the exception of ship navigation channels and the Mid Bay constriction caused by Redfish Bar, both natural and anthropogenic oyster reefs constitute the largest physiographic feature in Galveston Bay as remaining portions are comprised of shell, sand, mud, silt and clay particles with little bottom relief. A description of the Galveston Bay bathymetry is provided in **Section 1.3.1**. The physical oceanography in Galveston Bay is dominated by tidal mixing and, to a lesser degree, freshwater input and wind driven circulation.

1.3.4.1 Tides, Currents, and Water Level

The proposed project area experiences semi-diurnal tides encompassing two high and two low tidal periods each daily tidal cycle, with an average mean tidal range of approximately 1 feet. Elevated tidal surge is experienced in Galveston Bay during storm conditions and high spring tide events. From May to September the Galveston Bay experiences increased precipitation driven freshwater input from the two largest river drainages, the Trinity and San Jacinto Rivers, and Buffalo Bayou. These increased freshwater inputs typically result in the formation of a fresh/saltwater wedge concentrated in the deeper areas of the Galveston Bay as well as navigational channels such as the HSC and BSC.

Water circulation and currents in Galveston Bay can also be affected by prevailing wind conditions, especially within the relatively shallower areas. The prevailing south and southeastern winds, typically experienced from spring through fall, force water against the mainland and create countercurrent eddies within the nearshore areas while north and northwest winds in the winter months cause bay water to push against the barrier islands of Galveston and Bolivar. Due to the low capacity to inflow ratio and small tidal range, water entering Galveston Bay has a relatively long residence time, with flushing times ranging from 75 to 280 days for the entire bay and from 16 to 28 days in the HSC (Sparr et al. 2010).

Although Galveston Bay is typically a low energy environment protected on the seaward side by a chain of barrier islands with limited inlets, the area experiences a high level of storm activity. Multiple hurricanes and tropical storms in recent years have had a dramatic effect on the location, composition, and function of shorelines throughout the bay. Coastal flooding from hurricanes occurs when the effects of storm surge, driven by cyclonic winds and low pressure, cause water to pile up at levels higher than normal ocean water surface levels. Storm surge levels are highest when storm surge coincides with the astronomical high tide to result in storm tide. Storm surge effects are greatest in shallower offshore waters. Therefore, the bathymetry that tends to exacerbate storm surge effects are those that result in shallower water.

1.3.4.2 Salinity

The depth and width of the Houston Galvestion Navigation Channel (HGNC) Entrance Channel and Jetties generally control the saltwater inflows and outflows of the Galveston and Trinity Bay Systems. The BSC is a tributary channel to the HSC with a closed terminus that runs east-west essentially along the same isohaline (contour with the same salinity). Freshwater inflows are generally controlled by the San Jacinto and Trinity River as well as various local flood control district outflows and surface runoff. The salinity in Galveston Bay is highly variable with the diurnal tidal and seasonal changes in seawater and freshwater but average from near-ocean salinity (~35 parts per thousand [ppth]) in the lower part to much fresher values between 5 and 10 ppth in the upper parts of Galveston Bay.

Salinity impacts the habitat condition for Galveston Bay's marine fauna, most notably for oysters and oyster reef. Data from the Texas Commission on Environmental Quality (TCEQ) Surface Water Quality Monitoring (SWQM) Program, and from the Texas Water Development Board (TWDB) Bays and Estuaries monitoring program were obtained to support assessment of the potential for reef above the limits of reef mapping in Galveston Bay, and habitat modeling described in the TSP Oyster Reef Mitigation Plan provided in **Appendix P**. Data from the TCEQ SWQM contains many years' worth of monthly grab samples at many locations throughout Galveston Bay and upstream along the HSC above Morgans Point. The TWDB program operates continuously monitoring data sondes that covers 10 locations throughout Galveston Bay. This data is discussed in detail in **Section 3.2.2.3** under the subsection "Potential of Project Areas above Mapping to Contain Reef" and in the TSP Oyster Reef Habitat Mitigation Plan provided in **Appendix P**. Annual historical averages show decreasing salinity as one moves upstream toward the upper limit of the project area at the Main Turning Basin on the HSC where historical monthly averages from TCEQ data range between 3.7 ppth to 7.6 ppth.

1.3.4.3 Relative Sea Level Change

Rising sea levels due to changes induced by climate change are an impact of the environment on coastal project performance of increasing concern to the USACE. Relative Sea Level Change (RSLC) was evaluated using the current USACE guidance ER 1100-2-8162, *Incorporating Sea Level Change In Civil Works Programs*, dated December 2013, and Engineering Technical Letter (ETL) 1100-2-1, *Procedures To Evaluate Sea Level Change: Impacts, Responses, And Adaptation*, dated June 2014. 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.

ETL 1100-2-1 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 typically justified over a 50-year POA. 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. Given these factors and for consistency with ER 1110-2-8159, *Life Cycle Design And Performance*, the project planning horizon considered for analyzing RSLC is 100 years to better quantify RSLC.

Historic rates from the Center for Operational Oceanographic Products and Services (CO-OPS) at National Oceanic and Atmospheric Administration (NOAA), which has been measuring sea level for over 150 years, were used in the analysis, consistent with USACE guidance that changes in MSL should be computed using gages with a minimum 40-year span of observations.

The longest-running (from 1908 to present) tide gage in Galveston Bay is at Pier 21 (NOAA 8771450) in Galveston and is still active. 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 such as subsidence, 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.

As the nearest tide station with over 40 years of record, the Pier 21 tide gage data was utilized to determine the MSL trend from 1908 to 2013 which is estimated at 6.39 mm/yr with a 95% confidence interval of ± 0.24 mm/yr. NOAA estimates the mean sea level trend as 6.37 mm/yr. When compared to the USACE estimate of 6.39 mm/yr, this difference is presumably due to NOAA computation encompassing data through 2015, whereas the USACE calculations only encompass data through 2013. If the estimated historic eustatic rate equals that given for the modified NRC curves, the observed subsidence rate would be approximately 4.69 mm/yr (= 6.39 mm/yr - 1.70 mm/yr), but by utilizing NOAA and USACE calculations, subsidence in this area may be slowing down at the rate of 0.01 mm/yr (=(6.39mm/yr – 6.37mm/yr)/2yr). The RSLC trends derived from this tidal gage data were used to project future changes in sea level for the FWOP Condition discussed in **Section 2.2**

In addition to the project period of analysis of 50 years and the RSLC planning horizon of 100 years, RSLC for the 25-year period was calculated, per ETL 1100-2-1. The following paragraphs present the predicted rates for the 25, 50 and 100-year periods which are summarized in Table G1-5. A full discussion of RSLC can be found in Attachment 4 of the Engineering Appendix.

Predicted Future Rates of RSLC for 25-Year Period of Analysis

RSLC values for this 25-year period are summarized in Table G1-2.. For comparison, both NOAA and USACE curves are shown (for this first example only). The rate that will be used in this navigation project is the USACE and NOAA low curve, which should be identical, but in fact are slightly different, since the periods of analysis differ by two years. However, all the curve plots and data tables in this report use the USACE analysis of the Pier 21 tide gage.

Predicted Future Rates of RSLC for 50-Year (Project Design) Period of Analysis

The computed future RSLC for a 50-year period of analysis is based on the predicted change between the years 2023 and 2073 for Galveston Bay. Relative sea level change values for the 50-year period are shown in and Table G1-3.

Predicted Future Rates of RSLC – 100-year Sea Level Change (Planning Period)

The computed future RSLC for a 100-year period of analysis is based on the predicted change between the years 2023 and 2123 for Galveston Bay. Relative sea level change values for the 100-year period are shown in and Table G1-4.

Table G1-2: RSLC over the First 25 Years of the Project Life (2023 - 2048)

Galveston Bayside
8771450, Galveston Pier 21, TX
NOAA's Published Rate: 0.02096 feet/yr
All values are expressed in feet relative to LMSL

Year	USACE Low NOAA Low	USACE Int NOAA Int Low	NOAA Int High	USACE High	NOAA High
2023	0.65	0.74	0.93	1.01	1.14
2025	0.69	0.79	1.00	1.10	1.25
2030	0.80	0.93	1.21	1.33	1.53
2035	0.90	1.07	1.43	1.59	1.85
2040	1.01	1.21	1.67	1.86	2.18
2045	1.11	1.36	1.91	2.15	2.55
2048	1.17	1.45	2.07	2.34	2.78

Table G1-3: RSLC for the 50-Year Period of Analysis

Houston Ship Channel Expansion
8771450, Galveston Pier 21, TX
NOAA's Published Rate: 0.02096 feet/yr
All values are expressed in feet relative to LMSL

Year	USACE Low	USACE Int	USACE High
2023	0.65	0.74	1.01
2025	0.69	0.79	1.10
2030	0.80	0.93	1.33
2035	0.90	1.07	1.59
2040	1.01	1.21	1.86
2045	1.11	1.36	2.15
2050	1.22	1.52	2.46
2055	1.32	1.67	2.79
2060	1.43	1.84	3.14
2065	1.53	2.00	3.51
2070	1.64	2.18	3.89
2073	1.70	2.28	4.13

Table G1-4: RSLC for the 100-Year Period of Analysis

Galveston Bayside
8771450, Galveston Pier 21, TX
NOAA's Published Rate: 0.02096 feet/yr
All values are expressed in feet relative to LMSL

Year	USACE Low	USACE Int	USACE High
2023	0.65	0.74	1.01
2025	0.69	0.79	1.10
2030	0.80	0.93	1.33
2035	0.90	1.07	1.59
2040	1.01	1.21	1.86
2045	1.11	1.36	2.15
2050	1.22	1.52	2.46
2055	1.32	1.67	2.79
2060	1.43	1.84	3.14
2065	1.53	2.00	3.51
2070	1.64	2.18	3.89
2075	1.74	2.35	4.29
2080	1.85	2.53	4.72
2085	1.95	2.72	5.16
2090	2.06	2.91	5.62
2095	2.16	3.10	6.09
2100	2.26	3.30	6.59
2105	2.37	3.50	7.10
2110	2.47	3.71	7.64
2115	2.58	3.92	8.19
2120	2.68	4.14	8.76
2123	2.75	4.27	9.11

Table G1-5: Summary of Relative Sea Level Change Estimates

Year	Low (feet)	Intermediate (feet)	High (feet)
2013[1]	0.44	-	-
2017[2]	0.52	-	-
2023[3]	0.65	0.74	1.01
2048 (25 years)	1.17	1.45	2.34
2073 (50 years)	1.70	2.28	4.13
2123 (100 years)	2.75	4.27	9.11

[1] USACE end of year analysis for RSLC
[2] Year of economic modeling for project
[3] Anticipated year of project construction

1.3.5 Water and Sediment Quality

1.3.5.1 Water Quality

Section 303(c) of The Federal Clean Water Act (CWA) requires each state to establish, review and revise water quality standards for all surface waters within the state. States have a responsibility to accomplish this by designating uses (such as for aquatic life, recreation, and fish consumption) of a waterbody, or waterbody segment, adopting the water quality criteria necessary to protect those designated uses, and supporting the anti-degradation policy. In Texas, Surface waters of the State are classified by the TCEQ into segments for purposes of water quality management and for the designation of site-specific uses and criteria. Classification supports the operation of the State's programs to assure compliance with State and Federal requirements (TCEQ 2004)). Biennially, each state is also required under Section 305(b) of the CWA, to submit a report to the EPA describing the status of surface waters in the state. A use is said to be "impaired" when it is only partially supported or not supported at all. A list of waters that are impaired is required by Section 303(d) and included in the 305(b) Water Quality Inventory Reports. Regulation (40 CFR 130.7) requires that each 303(d) list be prioritized and identify waters targeted for Total Maximum Daily Load (TMDL) development, with the goal to restore the full use of the water body. The TMDL defines an environmental target by determining the extent to which a certain pollutant must be reduced in order to attain and maintain the affected use. Based on this environmental target, the State develops an implementation plan to mitigate sources of pollution within the watershed and restore full use of the water body (TCEQ 2007).

The Houston Ship Channel (HSC) encompasses three separate classified water quality segments within Basin 10 of the San Jacinto River Basin. These segments are identified as follows: HSC/San Jacinto River Tidal (Segment 1005), HSC Tidal (Segment 1006), and HSC/Buffalo Bayou Tidal (Segment 1007). These segments are divided into assessment units (AU) for purposes of water quality management by the TCEQ. The study limits for the HSC ECIP also includes several water quality Segments in Basin 24 of the Bays and Estuaries including; water quality Segments No. 2421, 2426, 2427, 2428, 2429, 2430, 2436, 2438, and 2439. These segments have multiple designated uses including High Aquatic Life Use (ALU), Recreation Use (RU), General Use (GU) and Fish Consumption Use (FCU). The follow subsection discusses the current designated uses and classification of how existing water quality is meeting those uses for the water quality segments and their associated assessment units.

For the most upstream study reaches 4, 5, and 6, and the upmost part of 1, the water quality Segment 1005, Segment 1006, and AU 1007_01 of Segment 1007 located within the project area, have the ALU, GU, and FCU designated uses. ALU is fully supported based on the minimum Dissolved Oxygen (DO) criteria and is listed as a No Concern (NC), GU is fully supported with the exception of nitrate for Segments 1005 and 1006, and total phosphorus, ammonia, and nitrate for 1007, which are listed as screening level concerns. Segment 1005 has RU designated, which it fully supports based on the geometric mean criteria for *Enterococcus* bacteria. The FCU in these segments is not supported due to Texas Department of State Health Services (DSHS) fish consumption advisories for specific contaminants in fish edible tissue.

For the small bays adjacent to Segment 1005 in the upper part of study reach 1, Segment 2426, Segment 2427, Segment 2428, Segment 2429, Segment 2430, and AU 2430A_01 within Segment 2430, fully support ALU based on the DO criteria with no concerns, RU based on the geometric mean for *enterococcus* bacteria, and GU, with the exception of total phosphorus, ammonia, and nitrate, and chlorophyll ɑ (in 2430), which are all listed as screening level concerns. FCU is not supported in these segments due to various contaminants in edible fish tissue while the DSHS has imposed restrictions and fish consumption advisories for this entire segment.

For the Barbours Cut and Bayport side channels of study reaches 2 and 3, Segment 2436, and Segment 2438 fully support RU based on the *enterococcus* bacteria geometric mean, and ALU based on DO grab minimum and toxic substances in water however; DO is also listed as a screening level concern based on number of exceedances for 2438. The GU is fully supported with the exception of nitrate, ammonia, total phosphorus, and chlorophyll ɑ (for 2438), which are listed as a screening level concern. FCU is not supported due to PCBs and dioxins in fish edible tissue and the DSHS has imposed fish consumption advisories in this segment.

For the upper part of Galveston Bay portion of study reach 1, Segment 2421, AU 2421_01 and AU 2421_02, the 2 AUs in the project area, have ALU, RU, GU, and FCU designated uses. ALU is fully supported with no concern listed for DO screening level. RU is also fully supported based on geometric mean data for *enterococcus* bacteria. The GU are also fully supported with the exception of nitrate, total phosphorus, and chlorophyll ɑ, which are all listed as screening level concerns. FCU is not supported due to DSHS fish consumption advisories for specific contaminants in fish edible tissue. AU 2421OW_ 01 has a designated use of Oyster Waters Use (OWU) which is not supported due to bacteria in shellfish where the DSHS imposes shellfishing restrictions.

For the lower part of Galveston Bay portion of study reach 1, Segment 2439, AU 2439_01 and AU 2439_02 fully support ALU and RU based on the DO criteria with no concerns, and *enterococcus* bacteria geometric mean, respectively. GU is fully supported with the exception of chlorophyll ɑ. FCU is not supported due to dioxins and PCBs in fish edible tissue, while the DSHS has imposed fish consumption advisories in this segment. AU 2439OW_01 located adjacent to the Texas City Channel and Moses Lake designated use for OWU is not supported due to bacteria and the DSHS has imposed shellfishing restrictions. AU 2439OW_2 which is defined as the main portion of the Lower Galveston Bay, fully supports its OWU based on bacteria assessments, although the DSHS has also imposed specific shellfishing restrictions in this area.

Table G1-6: Water Quality by Segment in Project Area

Basin Name	Water Quality Segment No. Assessment Unit No.	Designated Uses	Level of Support		
			Fully Supported	Concerns	Not Supported
Houston Ship Channel/San Jacinto River Tidal	1005	ALU, RU, GU, FCU	ALU, RU,	GU - Screening Level Concern for Nitrate	FCU – various contaminants in fish tissue
Houston Ship Channel Tidal	1006	ALU, GU, FCU	ALU	GU - Screening Level Concern for Nitrate	FCU – various contaminants in fish tissue
Houston Ship Channel Tidal/Buffalo Bayou Tidal	1007_01	ALU, GU, FCU	ALU	GU – Screening Level Concern for Ammonia, Total Phosphorus, and Nitrate	FCU – various contaminants in fish tissue
Upper Galveston Bay	2421_01	ALU, RU, GU, FCU	ALU, RU	GU – Screening Level Concern for Nitrate, Total Phosphorus & *Chlorophyll α*	FCU – various contaminants in fish tissue
Upper Galveston Bay	2421_02	ALU, RU, GU, FCU	ALU, RU	GU – Screening Level Concern for Nitrate, Total Phosphorus, and *Chlorophyll α*	FCU – various contaminants in fish tissue
Upper Galveston Bay	2421OW_01	OWU	–	–	OWU – Restrictions due to bacteria in shellfish
Tabbs Bay	2426	ALU, RU, GU, FCU	ALU, RU	GU – Screening Level Concern for Nitrate, Ammonia and Total Phosphorus	FCU – various contaminants in fish tissue
San Jacinto Bay	2427	ALU, RU, GU, FCU	ALU, RU	GU – Screening Level Concern for Nitrate, Ammonia and Total Phosphorus	FCU – various contaminants in fish tissue
Black Duck Bay	2428	ALU, RU, GU, FCU	ALU, RU	GU – Screening Level Concern for Nitrate, Total Phosphorus, and *Chlorophyll α*	FCU – various contaminants in fish tissue
Scott Bay	2429	ALU, RU, GU, FCU	ALU, RU	GU – Screening Level Concern for Nitrate, Ammonia and Total Phosphorus	FCU – various contaminants in fish tissue
Burnett Bay	2430	ALU, RU, GU, FCU	ALU, RU	GU – Screening Level Concern for Nitrate, Ammonia, Total Phosphorus and *Chlorophyll α*	FCU – various contaminants in fish tissue
Crystal Bay	2430A_01	ALU, RU, GU, FCU	ALU, RU	GU – Screening Level Concern for Nitrate, Ammonia and Total Phosphorus	FCU – various contaminants in fish tissue
Barbours Cut Channel	2436	ALU, RU, GU, FCU	ALU, RU	GU – Screening Level Concern for Nitrate, Ammonia and Total Phosphorus	FCU – various contaminants in fish tissue
Bayport Channel	2438	ALU, RU, GU, FCU	RU	ALU – Screening Level Concern for DO, and GU - Screening Level Concern for Nitrate, Ammonia, Total Phosphorus, and *Chlorophyll α*	FCU – various contaminants in fish tissue
Lower Galveston Bay	2439_01	ALU, RU, GU, FCU	ALU, RU	GU- Screening Level Concern for *Chlorophyll α*	FCU – various contaminants in fish tissue
Lower Galveston Bay	2439_02	ALU, RU, GU, FCU	ALU, RU	GU- Screening Level Concern for Chlorophyll α	FCU – various contaminants in fish tissue

Basin Name	Water Quality Segment No. Assessment Unit No.	Designated Uses	Level of Support		
			Fully Supported	Concerns	Not Supported
Lower Galveston Bay	2439OW_01	OWU	-	-	OWU – Restrictions due to bacteria in shellfish
Lower Galveston Bay	2439OW_02	OWU	OWU	OWU – specific restrictions imposed	_

*ALU – Aquatic Life Use, based on DO levels
RU – Recreational Use, based on geometric mean of bacteria concentration in water
GU – General Use, based on nutrient screening levels
FCU – Fish Consumption Use, based on State Health Department Advisories
OWU – Oyster Waters Use, based on bacteria levels in shellfish

In summary, all of the water quality segments discussed above with an Aquatic Life Use Designation, meet the use based on DO levels which meet the minimum DO requirements with no concerns. However, all the segments discussed above have a concern for nutrients whether it is nitrate-nitrite, ammonia, or phosphorus; which exceed state screening levels but do not meet the definition of "impaired" since the nutrient screening levels are not actual water quality standards and are just listed as "concerns". Seven of the twelve segments (2421, 2428, 2430, 2438, 2439) discussed above are listed as a concern for Chlorophyll a, while two of the segments (2421 and 2439) with a designation for Oyster Waters Use, do not meet this use and are impaired due to bacteria levels and the 3rd segment with this designation partially supports it with specific restrictions. Moreover, none of the segments discussed meet Fish Consumption Uses as the DSHS has imposed fish consumption advisories due to high levels of either; PCBs, and Dioxins, or a combination of both in edible fish tissue. In conclusion, the only "impairments" by definition are the Oyster Waters and Fish Consumption uses for the various segments discussed above. All other parameters used to assess the designated uses of each segment, particularly DO, meet the minimum levels established in the Texas Water Quality Standards (TSWQS).

1.3.5.2 Sediment Quality

Sediment quality has been characterized in various reaches of the HSC for nearly every dredging project on the waterway. Sampling has been conducted as part of research studies, as part of Federal maintenance dredging characterization in accordance with the joint EPA/USACE Inland Testing Manual, for new work dredging projects, and even private berth dredging. These sampling events have typically characterized both sediment chemistry and sediment elutriate, the latter of which simulates chemical leaching resulting when material is agitated, as it is during dredging. These events test for numerous metals, polychlorinated biphenyls (PCBs), volatile organic compounds (VOCs), polycyclic aromatic hydrocarbons (PAHs), among others.

The results of these sampling events are compared to several different standards and criteria, one of which is the Effects Range Low, or ERL (Buchman 2008). This is a method of statistical analysis of sediment chemical concentrations with biological responses using only effect data.

This method is essentially an estimation of probability of the sediment causing harm to benthic organisms. The ERL is the concentration below which negative impacts to these organisms is not expected, while the ERM is the concentration above which negative effects are predicted (Long, et. al. 1995). While uses of the ERL guidelines are useful in estimating sediment toxicity, they are not enforceable sediment quality standards, and do not represent hard and fast toxicity thresholds. Other standards are frequently employed as well, especially in evaluation of the elutriate, including the Texas State Water Quality Standards (TSWQS) and EPA Region 6 Marine benchmarks.

Galveston Harbor Channel and Bolivar Roads, to Redfish Reef

Shoaled sediment collected from the lower HSC shows varying physical characteristics in different parts of the lower reach. Maintenance material from the Galveston Harbor Channel has high fines content, as high as 88% silt/clay, along with 12-50% sand (USACE 1995). Historical median grain size (D50) has been measured at 0.026 mm (SOL Engineering Services 2012a). This is in contrast to the channel from Bolivar to Redfish Reef, which has been characterized as a high scour area with little to no fines, and 60-96% sand (USACE 1995).

Several interagency studies related to sediment quality were conducted in the lower reaches of the HSC in support of the 1995 Supplemental EIS for the HSC deepening. These studies found little to no organics in channel sediment, although channel values for all analytes were generally higher than reference values (USACE 1995). When compared to NOAA's 2008 Effects Range sediment values, only barium and manganese showed elevated potential for effects (USACE 1995). In general, most contaminant trends were found to be decreasing at that time, with the exception of areas in the vicinity of the Texas City Dike (Ward and Armstrong 1992). The interagency studies for the 1995 EIS also analyzed several years of elutriate data and found that no dilution of discharge would be needed to meet the acute TSWQS (USACE, 1995). Solid phase bioassays were also performed in 1991 and 1994, both concluding that "unreasonable acute or chronic toxicity" should not be expected from the discharge of sediment during dredging (USACE 1995). Bioaccumulation tests during this study also showed no indication of toxicity. Most of the material tested in these sampling events was therefore cleared for beneficial reuse placement in Galveston Bay.

The lower reaches of the HSC were sampled subsequently in 2011, and found that only copper exceeded the applicable ERL (SOL Engineering Services 2012a). This copper result of 49.8 mg/kg dry weight (dw) remained well below the ERM value of 270 mg/kg dw, showing a low likelihood of negative effects in benthic organisms. Elutriate samples were also taken, and showed a slight exceedance of the TSWQS for ammonia (SOL Engineering Services 2012a). However, available dilution would render this exceedance irrelevant. Most of the sediment dredged in this reach has historically been shown to be clean for placement offshore at the designated Offshore Dredged Material Disposal Site (ODMDS). In total, extensive historical sediment testing has shown ERL exceedances to be relatively rare, and concentration trends have been decreasing overall (GBEP 1994).

The 2011 samples were also analyzed for dioxin and furans, and the data normalized to total organic content. The range of values were considered not to "reflect significant point source contributions of dioxins/furans to the project area but rather reflect the low level dioxin/furan contamination that is ubiquitous in environmental media throughout the United States, including coastal areas" (USACE 2012). The 2011 level of dioxins and furans concentrations are generally less than those found in the Florida Panhandle Bays, Detroit/Rouge Rivers, Lake Ontario, and Newark Bay (Hemming et al. 2002).

Redfish Reef to Morgans Point, including the Bayport Ship Channel

Historical grain size data for shoaled material in this reach shows sand content to range from 2-57%, and generally decreasing farther up the channel (USACE 1995). An examination of the sediment quality in and around the Bayport Ship Channel (BSC) showed that new work areas contained Beaumont clay formations overlain with unconsolidated sediments deposited by more recent fluvial and coastal erosion processes (PHA 2014a). This clay formation underlies much of the western portion of Galveston Bay.

Sediment sampling for the 1995 EIS within the HSC from Redfish Reef to Morgan's Point showed the presence of methylene chloride, toluene, and dioxin (USACE 1995). Metals appear slightly elevated compared to reference stations, consistent with the lower reaches of the HSC. Both suspended particulate phase and solid phase bioassays were collected as well, and it was determined that adequate dilution exists to reduce concentrations to an acceptable level within one hour of discharge (USACE 1995). Maintenance material in this reach was sampled again in 2009 and 2011 with no exceedances of applicable ERLs in sediment, elutriate, or surface water (USACE 2015). The most recent sampling for maintenance material in this reach occurred in 2015. This sampling event showed marginal surface water exceedances for copper at all stations, and no exceedances for any analytes in the elutriate. Sediment samples showed only silver concentrations in excess of the ERL (USACE 2015). However, both the 2009/2011 and the 2015 data shows a significant decrease in sediment chemical concentrations from the concentrations found in 1995 for all analytes, and as a result, this material was all cleared for safe offshore disposal.

The BSC itself has been the subject of extensive sediment characterization efforts in the last 15-20 years. Past sediment testing data for the BSC from the Bayport Ship Channel Container Terminal Final EIS (BSCCT FEIS), and more from recent sampling by the Port of Houston Authority (PHA), were reviewed to summarize sediment quality in the BSC. This data involved a wide array of compounds in sediment and elutriate. Data from the BSSCT FEIS was collected primarily by the USACE and spanned from 1992-2001. Historically, copper and mercury were found to be below TSWQS; however, copper showed a possible increasing trend. Oil and grease were found to be above screening levels for an estuary but below those of a tidal stream. Sediment sampling from 1997 to 1998 showed some metals concentrations were elevated compared to TSWQS, but in 1999, all constituents, including metals and polycyclic aromatic hydrocarbons (PAHs), were below the screening levels. Elutriate analyses from 1997 to 2001 showed all parameters were below chronic criteria, except for copper in 2001, which was only slightly above the chronic criteria, but the maximum concentration was well below acute criteria (PHA 2014a). The decreasing trend of constituents of concern (COCs), which are the specific chemicals targeted for evaluation, is consistent with observations from studies conducted under the Galveston Bay Estuary Program (GBEP 1994).

February 2001 sediment and water sampling conducted for the BSCCT FEIS at six locations along the BSC where berths and the cruise terminal were planned, was analyzed for 11 target metals, PCBs, pesticides, PAHs, TPH, phenols, total volatile solids, total sulfides, ammonia, total organic carbon (TOC), percent solids, and grain size. No pesticides, PCBs, or PAHs were detected in any of the samples. TPH was detected in all samples, ranging from 47.4 mg/kg to 260 mg/kg, but with no olfactory or visual evidence of hydrocarbons or phase separated hydrocarbons in any samples. Metals concentrations were generally low and relatively uniform in all samples, suggesting concentrations were consistent with background levels. Water samples were analyzed for many of the same parameters as sediment, and indicated no detectable levels of pesticides, PCBs, PAHs, TPH, or phenols in any sample. Of the 11 metals analyzed, only barium and zinc were detected. Ammonia was detected in all samples. Elutriate testing indicated no detectable levels of pesticides, PCBs, PAHs, TPH, or phenols in any sample. Barium and zinc were consistently detected in all samples, while low levels of cadmium, chromium, copper, and nickel were detected in a portion of the samples. Ammonia was detected in all elutriate samples (PHA 2014a). However, no ERL exceedances were found for any of the samples in sediment or the elutriate.

PHA sediment core sampling conducted in August 6, 2004 at seven locations along the container and cruise terminals for the purpose of pre-dredging analysis were analyzed for 10 specific metals, TOC, total recoverable phenolics, acetone, 1,2-Dichloroethane and methylene chloride. At the terminal locations, Bis(2-ethylhexyl)phthalate, Di-n-butyl phthalate and carbon disulfide were also analyzed. At the cruise terminal locations, gamma-chlordane, total chlordane and 4,4-DDT were also analyzed. Most analytes were below detection limits. Barium was detected at all locations, with container terminal concentrations higher than cruise terminal concentrations. Total chlordane was detected in one sample, exceeding the ERL, but not the ERM, constituting the only ERL exceedance in the sampling event (PHA 2014a).

PHA sediment sampling was conducted in July 2010 at 10 container terminal locations, and at 8 cruise terminal locations (Benchmark Ecological Services, 2010). Parameters analyzed included 7 target metals, total dioxin/furan reported as toxicity equivalents (TEQ) in picograms per gram (or parts per trillion [ppt]), percent moisture, TOC, total solids, and total volatile solids. Specific sites were tested for heptachlor, benzoic acid, phenanthrene, pyrene, 4,4-DDT, total PCB, Aroclor 1260 PCB and gamma-BHC. No analytes were detected above their respective ERM values, but two samples exceeded ERL for phenanthrene, which is a PAH. Dioxin was detected in all of the samples, ranging from 2.18 ppt to 7.18 ppt, and most values around 6.5 ppt. However, no national marine sediment guidelines for dioxin exist, though some regional or state authorities have published their own thresholds. The Oregon Department of Environmental Quality's (DEQ) published screening level values (SLV) for the individual compounds that comprise dioxin for use in bioaccumulative risk assessment, including fish (Oregon DEQ, 2007). Dioxin concentrations are usually expressed in TEQ, which is a toxicity weighted average of all dioxin compounds, weighted relative to the most toxic dioxin compound 2,3,7,8-Tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD). However, the Oregon DEQ SLVs allow comparison for the individual compounds in the group. The SLVs are conservative generic screening-level risk values that indicate a need to determine a site-specific SLV and does not necessarily mean that the bioaccumulation risk is unacceptable. The marine fish SLVs vary widely, as the toxicity for compounds under this group vary from relatively innocuous to highly toxic, ranging from 0.56 ppt for 2,3,7,8-TCDD to 4,300,000 ppt for Octachlorodibenzo-p-dioxin (OCDD) and Octachlorodibenzofuran (OCDF). All but 2,3,7,8-TCDD and 2,3,4,7,8-Pentachlorodibenzofuran (2,3,4,7,8-PeCDF) have a threshold of 17 ppt or greater. Of the detected dioxin compounds in the PHA sampling, only 2,3,7,8-TCDD exceeded the SLV of 0.56 ppt, by 1.6 times to 2.3 times. Results for all other compounds were below the other SLVs (PHA 2014a).

The most recent PHA sediment core sampling at 5 locations along the container terminal berths adjacent to the channel, were analyzed for 7 target metals, PAHs, xylenes, percent moisture, TOC, total solids, total volatile solids, and dioxins/furans. Many analytes were below detections limits, and of those with NOAA sediment guidelines, all were below the ERL and ERM. The dioxins ranged from 2.02 ppt to 2.53 ppt expressed as TEQ, with no detection for many compounds, including TCDD. As discussed in the previous paragraph, no national marine sediment guidelines for dioxin exist, but for comparison, the values detected were all below the Oregon DEQ SLVs for all dioxin compounds (PHA 2014a).

Water and sediment samples were collected by USACE from the Federally-maintained Bayport navigation channel for the purpose of conducting testing to characterize the shoal material that would be excavated during routine maintenance dredging; this information was presented in the Bayport Assumption of Maintenance Environmental Assessment (EA) dated 2014 (Anacon and

Atkins 2011a, PHA 2014). The material was evaluated to determine whether unacceptable adverse impacts would result from dredging and dredged material placement operations. The evaluation consisted of chemical analyses of sediment, water, and elutriate samples, and grain-size analyses. Four composite sediment samples were taken along with surface water from the BSC to represent reaches between BSC Station 58+00 and BSC Station 234+00. Each composite sediment sample, water and elutriate were analyzed for metals, pesticides, PCBs, semivolatiles (including PAHs), gross parameters (ammonia, total petroleum hydrocarbons, etc.), and dioxins/furans. Sediment sample data was reported as dry weight. No organic chemicals were detected in the sediments, and none of the detected metals exceeded NOAA ERL screening guidelines (Anacon and Atkins 2011a).

The results of the 2012 elutriate tests for the Bayport EA showed that all organic chemicals (e.g., pesticides, PCBs, and PAHs) were below their respective detection limits. Of the 15 metals evaluated, only one sample of four exceeded the TSWQS saltwater chronic criteria for copper by a factor of 1.16. Surface water samples collected by USACE in the BSC during the sampling event were also above the TSWQS saltwater chronic criteria for copper by a factor of 1.48, indicating that ambient regional concentrations of copper in surface water exceed the TSWQS chronic criteria under certain flow conditions. .

Sediment, water, and elutriate sampling was also conducted for new work dredging in the BSC in 2014. The material was characterized as mostly virgin Beaumont clay. The sampling showed intermittent exceedances of cyanide in surface water and elutriate, along with one marginal ERL exceedance for arsenic and 6 marginal ERL exceedances for nickel (USACE 2015). These results appeared to be in line with background concentrations of those contaminants in Galveston Bay (NOAA 2003).

Morgans Point to Exxon, including Barbours Cut

The HSC reach from Morgan’s Point to Exxon is primarily characterized by fine grained silt and clay, with a maximum sand/gravel content of 18.6% (SOL Engineering Services 2012b). Concentrations of organic contaminants have not historically been found downstream of Exxon, except sporadic detections of dioxin (USACE 1995). Historical investigations found increasing concentrations of metals in the form of chromium, copper, nickel, vanadium and zinc as one moves up-channel (USACE 1995). Historical data also includes a focused study looking at the dredged material effluent from Spilman Island, Alexander Island, Peggy Lake, and Lost Lake, which are placement areas located either within the Morgan’s to Exxon reach of the HSC, or in immediate proximity. This study concluded that although copper and zinc both exceeded TSWQS, dilution would occur within 30 min of discharge (USACE 1995). The Alexander Island investigation in particular found no observable trends with respect to organic compound or metal concentrations (USACE 1995).

The HSC in this stretch has undergone more recent sediment investigations as well, primarily in connection with the removal of maintenance material from the channel. A 2012 sampling event showed no exceedances of ERLs for sediment, and sporadic dioxin detections (SOL Engineering Services 2012b). These dioxin detections were normalized for total organic content, and were eventually determined to not “reflect significant point source contributions of dioxins/furans to the project area but rather reflect the low level dioxin/furan contamination that is ubiquitous in environmental media throughout the United States, including coastal areas” (USACE 2012).

Since 2012, two known sampling events for private berth dredging have occurred in the vicinity of the HSC near the Fred Hartman Bridge. Both events showed dioxins and furans in all samples, but no metal exceedances of ERLs, and no VOC, SVOC, PCB, or pesticide detections (CRA 2013, CRA 2014). The results from these sampling events likely represent the HSC sediments, due to proximity to the channel.

This reach of the HSC also includes the Barbour’s Cut channel, upon which the Barbour’s Cut Container Terminal (BCCT) is located. Historical elutriate data shows a wide variety of COCs in sediment in the area, predominantly chlorinated hydrocarbons such as chlordane, dieldrin, and dichlorodiphenyltrichloroethane (DDT), although none in concentrations exceeding 2010 TSWQS or EPA Water Quality criteria (PHA, 2014b). 2009 sediment sampling data detected a variety of polyaromatic hydrocarbons (PAHs) located in the channel near the confluence with the HSC, but none in concentrations exceeding the applicable ERL. The 2009 sampling also detected dioxin/furans ranging from 7.8 ppt to 14.6 ppt, reported as TEQs. These samples were primarily taken from the top 6 feet of unconsolidated material in the channel, potentially representing recently shoaled material rather than the underlying clay layers (PHA 2014b).

Another sampling event occurred in November 2012, as part of the Federal maintenance dredging in the Upper HSC and BCC. Elutriate sample concentrations were all below TSWQS except for cyanide, and all sediment concentrations were below the ERL (PHA 2014b). The cyanide exceedance was measured as free cyanide, and the ambient water quality sample also exceeded the TSWQS standard, leading to the conclusion that total cyanide concentrations in water will likely overestimate the actual cyanide toxicity to aquatic organisms. Dioxin/furans TEQ were slightly lower than the 2009 data, and USACE concluded that those concentrations reflected the low level ubiquitous concentrations found in many coastal areas across the country (USACE 2012).

The most recent known sampling event in the BCC occurred in April of 2013 as part of the PHA’s pre-dredge sampling program; seven cores were taken at a private berth adjacent to the Federal channel. Dioxin and furans were detected in all samples, but no other analytes were detected in concentrations exceeding the applicable ERL (Amistad 2013).

<u>Exxon to Carpenter's Bayou</u>

Historical grain size data for this reach of the HSC shows primarily fine grained silt and clay in the channel, with approximately 15% sand (USACE 1995). A review of maintenance material data shows a D50 of 0.030 mm. Chemical analytical data shows that metals such as chromium, copper, nickel, vanadium and zinc tend to increase up-channel from Morgan's Point (USACE 1995). Acetone, benzene, chloroform, and methylene chloride were found at sampling stations in the mid 1990's, with the acetone concentrations ranging from 1170 µg/kg to 67700 µg/kg (USACE 1995). No applicable criteria for acetone in sediment currently exist. A water quality investigation concerning dredged material effluent was conducted for this reach of the HSC, and is summarized in the preceding section.

More recent sediment testing occurred in June of 2011 as part of the regular maintenance dredging cycle. No exceedances of the ERL were found for any analytes except for nickel, with samples concentrations of 21 and 24 mg/kg. These values are well under the ERM of 51.6 mg/kg. (ARCADIS 2011).

Private berth sampling has occurred for over 20 years as part of the PHA sampling program, and much of the private sampling in this reach has been centered around the ExxonMobil Refinery at Mitchell Bay, which is immediately adjacent to the HSC. Sampling events as early as 2008 have detected concentrations of mercury, lead, and a suite of pesticides (DDD, DDE, DDT, and dieldrin) in shoaled sediment exceeding the applicable ERL, along with detected concentrations of dioxins and furans. The two most recent known sampling events in Mitchell Bay, which included elutriate samples as well as sediment samples, showed exceedances of ERLs for cyanide, selenium, DDT, dieldrin, mercury, and a variety of SVOCs such as acenaphthene and fluorine; however concentrations did not exceed the ERM (CRA 2015).

Much of the private sampling, as well as the Federal navigation sampling, has revealed concentrations of dioxin/furans in most if not all samples. While USACE has consistently found similar concentrations in estuaries across the country, this reach of the HSC is immediately downstream from the San Jacinto Waste Pits Superfund Site. Listed on EPA's National Priorities List (NPL) in 2008, the San Jacinto Waste Pits is a series of impoundments that served as a dumping ground for pulp waste material containing dioxin/furans and other chemicals of concern. The site was stabilized in 2011 to prevent the further input of dioxin into the San Jacinto River, approximately 2 miles upstream of the confluence with the HSC (EPA 2016). Due to the continued discovery of dioxin in the estuary as well as continuing cleanup efforts at the site, a public notice was released in 2009 establishing an Area of Concern (AOC) and requiring that certain sampling take place for any dredged material projects in that AOC (EPA et al. 2009). Much of the HSC reach between Exxon and Carpenter's Bayou is in this AOC, and the appropriate coordination and sampling will be conducted before dredging events.

Carpenter's Bayou to Green's Bayou

In the reach of the HSC between Carpenter's Bayou and Green's Bayou, shoaled sediment in the channel is predominantly fine grained silt, with a maximum of 20.3% sand/gravel (USACE, 1995). Historical chemical data has shown the presence of acetone, benzene, chloroform, and methylene chloride in most sample locations (USACE, 1995). More recent USACE maintenance material characterizations show a variety of contaminants in concentrations exceeding ERLs, including copper, mercury, acenaphthene, fluorine, and phenanthrene (SOL Engineering Services, 2012c). Dioxin and furans were found as well, although in concentrations that were lower than concurrent samples taken in the Exxon to Carpenter's Bayou reach. No ERMs were exceeded in these sampling events.

Due to the limited width of the waterway above Carpenter's Bayou, it's useful to look at private berth sampling results when characterizing the sediment quality of the HSC. Several terminals immediately upstream from the mouth of Carpenter's Bayou, including Houston Fuel Oil, Vopak, and Shell Deer Park, have been sampled frequently since 2006. In general these sampling events have shown dioxin and furan to be present, along with mercury in concentrations that exceeded the ERM in several instances. Private berth sampling results from this reach have also exceeded the ERM for nickel, zinc, and chromium. Besides metals, pesticides are relatively common in this reach of the HSC, with concentrations of DDD, DDE, DDT, and dieldrin that have exceeded ERLs in several cases in the last 10 years. VOCs and SVOCs are also relatively common in sediment in this reach, although not in concentrations exceeding the applicable ERM.

Green's Bayou to Turning Basin

Historical studies have shown the grain size in the reach of the HSC from Green's Bayou to the turning basin to be comparable to that of grain sizes found in the reach from Carpenter's Bayou to Green's Bayou. An examination of maintenance material data from USACE sampling from 2011-2014 showed a D50 of 0.021 mm with 17.1% sand from Green's to Sim's Bayou, and a D50 of 0.027 mm with 20.4% sand from Sim's Bayou to the turning Basin (Anacon and Atkins 2011b, SOL Engineering Services 2014). The underlying virgin material, similar to other reaches of the HSC, is characterized by Beaumont clay.

Sediment samples were taken as part of the USACE maintenance dredging program between 2011-2014. In the sub-reach from Green's Bayou to Sim's Bayou, both copper and zinc exceeded ERLs, and neither exceeded ERMs. However, from Sim's Bayou to the turning basin, a wide variety of COCs were found. Twelve COCs, including three pesticides, eight PAHs, and one metal, were found at concentrations marginally exceeding the ERM. Twenty-one COCs were found in concentrations exceeding ERLs, including mercury, silver, chlordane, total PCBs, and pyrene. In total, 51 organic compounds were detected, although not all in concentrations exceeding any standards. (SOL Engineering Services 2014).

Private berth sediment testing has occurred at various locations above Green's Bayou as well, at locations such as Manchester Terminals, the Southwest Shipyard at Brady Island, and Kinder Morgan, among others. Data from the pre-dredge sampling for these berths, spanning 2003 to 2015, shows the presence of a wide variety of COCs in shoaled material throughout the upper reach of the HSC to the turning basin. Some of the more common COCs found in concentrations exceeding the ERM include mercury, phenanthrene, zinc, arsenic, and copper. Pesticides such as DDD, DDT, and dieldrin were frequently detected in concentrations exceeding the ERL as well. Similar to the lower reaches, PAHs were common; indeno(1,2,3-cd)pyrene and dibenzo[a,h]anthracene in particular were found in concentrations not found in the lower reaches. The private berth sampling events during this span also showed ERL exceedances in virtually every metal found on the targeted COC list, most pesticides, and a large number of organic compounds. Like the lower reaches, dioxins and furans were found in almost all of the sampling events that tested for dioxin, although in one case, the upper bound TEQ reached 887 (CRA 2012).

Despite the presence of COCs in much of the shoaled sediment in the HSC, concentrations over time have largely been either decreasing (in the case of the Bay reaches) or have been static. None of the shoaled sediment data reviewed show sediment that will require special handling beyond what is already done to maintenance material as part of Corps maintenance dredging cycles. COCs in new work material, due to largely being composed of Beaumont clay, is typically found in concentrations lower than that of maintenance material, and will either be disposed of in upland confined disposal facilities (CDFs), as beneficial reuse material for the creation of biological habitat, or disposed of offshore. As a result, dredged material from the HSC ECIP project represents material upon which large amounts of data exists, and known processes for handling are well established.

1.3.6 Energy and Mineral Resources

The study area is home to the nation's and one of the world's largest centers of petroleum refining with numerous refining facilities served by the HSC, and product pipelines present throughout the area. Additionally, oil and gas field development and extraction continues on land and through shallow offshore drilling in various parts of the study area. No other major mineral resource extraction occurs in the vicinity of the HSC system.

Active shallow offshore drilling activity is mostly clustered around several major fields with the south-most major activity near the HSC occurring near Bolivar Peninsula and around Texas City in the North Point Bolivar Field. North of that, a major cluster of activity occurs in the Redfish

Reef Field on either side of HSC at Redfish Reef, and some active drilling to the west of the HSC just south of Mid Bay PA. Further north in Galveston Bay, all activity occurs east of the HSC between Mid Bay PA to the Fred Hartmann Bridge in the major fields of Cedar Point and Goose Creek, east of Atkinson Island and Hog Island, respectively. Upstream of the Fred Hartmann, not much active shallow offshore or land-based drilling takes place near the HSC.

1.3.7 Hazardous, Toxic and Radioactive Waste

In order to complete a feasibility level HTRW evaluation for the HSC ECIP, a report was completed following the rules and guidance of ER 1165-2-132: *HTRW Guidance for Civil Works Projects*, and ASTM E1527-13: *Standard Practice for Environmental Site Assessment: Phase 1 Environmental Site Assessment Process*. These two documents outline a process which has three main components (excluding the report itself): the records review, site reconnaissance, and interviews.

1.3.7.1 Records Review

Perhaps the most critical part of the feasibility level HTRW evaluation is the records review. In this, records, maps and other documents that provide environmental information about the project area are obtained and reviewed. To complete the records review, USACE used a commercially available vendor of environmental database searches called Environmental Data Resources, of Shelton, CT. This records review was completed using the proposed footprint of the project, and the standard ASTM environmental record sources, along with an approximate 1 mile search distance for each of the sources shown in the below **Table G1-7**. Due to the size of the record search results, the Environmental Data Resources report will not be included here. Once the database searches were complete, USACE analyzed the results for recognized environmental conditions (RECs) that could affect the proposed project or need further investigation, given the proposed project measures. Due to the conservative search distances and specifics of the proposed project, many of the record search results can be dismissed from further consideration in this study. The results of that analysis, specifics of the REC (where applicable), and justification for dismissal from further evaluation (where applicable) are discussed below.

Table G1-7: Standard ASTM Search Distances and Records Review Results

ASTM Source	ASTM Distance (miles)	Searched Distance (miles)	Number of Results
Federal National Priorities List (NPL) site list	1.0	1.0	2
Federal Delisted NPL site list	0.5	1.0	0
Federal CERCLIS (SEMS) list	0.5	1.0	9
Federal NFRAP (SEMS archive) site list	0.5	1.0	26
Federal RCRA Corrective Action facilities list	1.0	1.0	28
Federal RCRA TSD facilities list	0.5	1.0	20
Federal RCRA generators list	Property and adjacent properties only	1.0	48
Federal ICs/Engineering Control registry	Property only	1.0	10
Federal ERNS list	Property only	1.0	175
State and tribal equivalent NPL list	1.0	1.0	0
State and tribal equivalent CERCLIS	0.5	1.0	0
State and tribal landfill and/or solid waste disposal sites	0.5	1.0	4
State and tribal leaking AST/UST sites	0.5	1.0	63
State and tribal registered storage tank list	Property and adjacent properties only	1.0	102
State and tribal ICs/Engineering Control registry	Property only	1.0	4
State and tribal voluntary cleanup sites	0.5	1.0	18
Federal, State and tribal Brownfields site list	0.5	1.0	8

Federal NPL site list – The records search identified two sites on the Federal NPL site list. The first site is the Patrick Bayou Superfund site. The mouth of Patrick Bayou is located approximately 1.9 miles east of the Beltway 8 Bridge over the HSC, and the waterway extends to the south into Deer Park. Sediment and surface water within the bayou have been found to contain high levels of PAHs, metals, and PCBs, and the site was placed on the final NPL on September 5, 2002 due to the threat of sediment contamination to downstream fisheries (EPA 2015). The site is currently in the feasibility study phase of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) cleanup process. Because Patrick Bayou drains into the HSC, it is possible that contaminated sediment from the bayou may reach the proposed project area. Further investigation needs to occur to evaluate the potential of Patrick Bayou sediments being detected in the HSC during sediment quality testing for the proposed project. Depending on this evaluation, a recognition that sediment testing in the HSC potentially reflects discharge from Patrick Bayou may be warranted.

The second site found on the Federal NPL site list is the U.S. Oil Recovery Site. This site straddles Vince Bayou, approximately 0.5 miles south of its confluence with the HSC. The site consists of several abandoned ASTs and portable drums containing a variety of hazardous liquids, sludges, and solids. A removal action is ongoing to contain the migration of the contaminants, and the site will be undergoing further extensive investigation in the RI/FS phase. Despite the proximity of the site to the HSC, no interaction between the site and the proposed project are expected to occur due to the nature of the contaminated media at the site.

Although it was not identified in the records search, the San Jacinto Waste Pits site must be included for environmental consideration. Listed on EPA's National Priorities List (NPL) in 2008, the San Jacinto Waste Pits is a series of impoundments that served as a dumping ground for pulp waste material containing dioxin/furans and other chemicals of concern. The site was stabilized in 2011 to prevent the further input of dioxin into the San Jacinto River, approximately 2 miles upstream of the confluence with the HSC (EPA 2016). Due to the continued discovery of dioxin in the estuary as well as continuing cleanup efforts at the site, a public notice was released in 2009 establishing an Area of Concern (AOC) and requiring that certain sampling take place for any dredged material projects in that AOC (EPA et al. 2009). The USACE has and will continue to monitor the progress of this site, and conduct all sampling within the AOC according to the 2009 public notice.

Federal CERCLIS (SEMS) List – The Comprehensive Environmental Response, Compensation and Liability Information System (CERCLIS) (now called the SEMS) database tracks hazardous waste sites where remedial action has occurred under EPA's CERCLA program. This list also includes sites that are in the screening and assessment phase for possible inclusion on the NPL. The records search identified 9 sites on the CERCLIS (SEMS) database. Only one of the sites qualifies as a recognized environmental condition, based on the justification chart below:

Table G1-8: Federal CERCLIS (SEMS) List Sites

Site	Included in RECs?	Justification
Patrick Bayou NPL	No	Addressed as REC in NPL section
Mississippi Canyon 7	No	Spill/release, data failure
ExxonMobil Baytown	No	See discussion below
Agrifos Phosphoric Acid Release	No	Spill/release, outside ASTM search area
Pasadena Refining Fire	No	Spill/release, see discussion below
Rhodia Inc. Acid Release	No	Spill/release
MCC Recycling	No	Part of U.S. Oil Recovery NPL site, addressed in NPL section
U.S. Oil Recovery	No	Addressed in NPL section
Lyondell Petrochemical Spill	No	Spill/release

As noted above, the Patrick Bayou NPL, MCC Recycling, and U.S. Oil Recovery sites have been addressed in the NPL list section, so they will not be addressed here. Sites where spills or releases occurred will not be evaluated as a REC unless other data is found. In each case, the spill/release was presumably cleaned up as part of the CERCLA removal action, and no further site assessment work was needed. While there certainly remains a possibility that the spill has resulted in contamination that wasn't cleaned up, without specific site assessment data it is impossible to evaluate the threat posed by each spill site to the proposed project.

The ExxonMobil Chemical Plant site in Baytown can be found on several environmental databases, and is located adjacent to the HSC at Mitchell Bay. The Baytown refinery is the second largest refinery in the U.S. as of 2013, and produces a wide variety of products such as jet fuel, propane, oils, waxes, and gasoline. The plant is listed as a Treatment, Storage, Disposal Facility (TSDF) for hazardous wastes, as well as a Large Quantity Generator (LQG) of RCRA regulated hazardous materials. The plant suffered a large fire and release in August of 2009, a fire that triggered an emergency removal action that same month. Although the release is noted in the database as cleaned up, several RCRA corrective actions have been in place at various times at the facility, including a currently active groundwater corrective action. However, despite the documented environmental conditions at the refinery, there is no reason to believe that those conditions will affect the proposed action. All proposed work will be done within the confines of the HSC, and all sediment will be tested per the *Inland Testing Manual* before dredging and disposal.

Another site on the SEMS list that may show RECs is the Pasadena Refining System located on the HSC in Deer Park, approximately 1 mile upstream from Hunting Bayou. The subject property was once known as the Pasadena Paper Pulp Mill, and now is the location of a large refinery complex. The property has been the subject of several RCRA investigations and corrective actions, including both soil and groundwater actions, although records seem to indicate that all corrective action processes were terminated in 2012. Aerial photos and available documents show several registered ASTs and USTs on the property, and RCRA records show the facility to be a TSDF as well. The SEMS lists shows that a large fire occurred in 2011, although the details and results of the release are not included. Records also show that institutional controls (ICs) are in place on the property, in the form of groundwater controls, informational devices, and other measures. The existence of ICs indicates the continued onsite presence of contaminants in groundwater and other media. Despite these conditions, there is no reason to believe that the conditions noted will affect the proposed action, since the proposed action is occurring entirely in-water in the HSC. If the proposed action ends up widening the HSC in the vicinity of the Pasadena Refining System, then further investigation will be needed.

<u>Federal NFRAP (SEMS archive) List</u> – The Federal NFRAP list (now known as the SEMS archive list) tracks sites where no further remedial action is planned, based on available assessments and information. The list also represent sites that were not chosen for the NPL.

Further EPA assessment could possibly be ongoing, and hazardous environmental conditions may still exist; however, in the absence of remedial action and assessment data, no determination about environmental hazards can be made. The records search identified 26 sites on the CERCLIS NFRAP (SEMS archive) database. None of these sites are explicitly sediment sites, so these sites are not expected to impact the proposed project.

Federal RCRA Corrective Action List – The sites on the RCRA corrective action list are sites where corrective action is underway under the RCRA program. 28 sites were identified in the proposed project search area. The proposed project area is located in the largest petrochemical complex in the country. As such, 28 RCRA corrective actions are in progress in locations within the search area near the navigation channel. Because dredging is the only construction method to be employed in the proposed action, only those RCRA corrective actions with a sediment component in the search area will be included. However, no information was found linking any of the 28 sites to a sediment cleanup under RCRA. For this reason, none of the sites with RCRA corrective action are expected to impact the proposed project.

Federal RCRA TSDF List – The Federal RCRA TSDF list contains sites that are designated as Treatment, Storage, and Disposal facilities. These sites typically handle large amounts of hazardous waste, and are permitted under RCRA to do so. 20 TSDFs were found in the search area. The proposed channel expansion is entirely within the boundaries of an existing Federal project, the Houston Ship Channel. As such, no RCRA TSDFs are located on the subject property. Additionally, the presence of a TSDF is not sufficient to believe that contamination is likely to be generated, as long as the facility is permitted. As a result, none of the sites on the list will be carried forward as RECs.

Federal RCRA Generators List – Similar to the TSDF list, the RCRA generators list identifies sites that generate quantities of waste classified as hazardous under RCRA. 48 sites were identified within a one mile radius of the HSC, sorted by the quantity of waste they generate. 26 sites were classified as large quantity generators, 6 as small quantity generators, and 16 as conditionally exempt small quantity generators. Several of the sites are located adjacent to the HSC, such that any widening of the channel could potentially cause concerns. However, realignment or deepening of the channel is not expected to increase the possibility of impacts from these generator sites.

Federal Institutional Controls (IC)/Engineering Controls Registry – Engineering controls and ICs are both methods of preventing exposure to contaminants on a particular site. This database is a listing of sites where one or both of those controls are in place. 10 sites that have these measures in place were identified within a one mile radius of the HSC. However, the ASTM standard only requires that the proposed project property be searched for ICs or engineering controls. The proposed channel expansion is entirely within the boundaries of an existing Federal project, and therefore, no ICs or engineering controls exist in this area.

Federal ERNS List – The Federal Emergency Response Notification System (ERNS) records and stores information on reported releases of oil and hazardous substances. Due to the enormous amount of petrochemical activity on the HSC, many records were returned in this search. However, much of the information was incomplete, and did not give a specific location. Even if location information was recorded, it was often impossible to discern exactly what material or substance the release or spill consisted of. Therefore, from a sediment quality standpoint, the records returned from this search don't provide any meaningful data as to the risk to the proposed project, other than to say that increased activity on the channel may result in increased releases into the environment. The failure of this data set to provide enough information is called a data failure.

State and Tribal Solid Waste Facilities/Landfill Sites – This search is designed to check any state or tribal databases for solid waste handling facilities or landfills in the project vicinity. 4 sites were identified, and the databases indicated that all 4 sites had "closed" permits from the State of Texas. Upon further investigation, only one of these sites could be found at the listed address. That one site, Slay Transportation, appeared to be a solid waste trucking company, and therefore is not expected to impact the proposed project.

The State of Texas also has a Closed and Abandoned Landfill database, which is similar to the solid waste database. This database showed 5 sites in the project vicinity, although only two could be located. The first site is an old sand quarry site closed in 1989 approximately one mile north of the HSC on Carpenter's Bayou, now owned by the Houston Fuel Oil Terminal Co. The second site is located at 7100 J.W. Peavey Dr., immediately south of the turning basin in an area adjacent to the Port of Houston Docks # 1-7. Records show that the permitted landfill was verified to be closed in 1992, although historical aerial photographs don't show any areas of obvious landfill activity. Neither site is expected to impact the proposed project.

State and Tribal Leaking AST/UST Sites – This database is a list of leaking petroleum storage tank incidents, maintained by the State of Texas. A search of this database identified 63 sites within a one mile radius of the HSC. Despite the large number of sites near the HSC, none of the sites are expected to impact the proposed project due to the entirely in-water nature of the project. Several of the sites are located adjacent to the HSC, such that any widening of the channel could potentially cause concerns. However, realignment or deepening of the channel is not expected to increase the possibility of impacts from these generator sites.

State and Tribal Registered Storage Tanks – This list is a combination of the State of Texas registered UST and AST databases, representing sites with storage tanks registered with the State of Texas. 102 sites were identified. However, the existence of a registered storage tank (UST or AST) is not sufficient to believe that contamination is likely to be generated, and therefore none of these sites will be carried forward as RECs.

State and Tribal ICs/Engineering Control registry – The State of Texas maintains a database called the Activity Use Limitations (AUL) List, which functions as the State's IC list. 4 site were identified in a one mile radius from the HSC. All four of the sites are located adjacent to the HSC, and were contaminated sites certified as cleaned up under the Texas State Voluntary Cleanup Program (VCP). As a result, this site is not expected to affect the proposed project.

State and Tribal Voluntary Cleanup Sites – This database identifies sites where the responsible party chooses to clean up the site themselves with TCEQ oversight. 18 sites were identified from this database, although many of these sites had already completed their respective remedial actions. The sites of concern from this list are sites where active remediation or investigation is occurring, sites where the VCP application was withdrawn but the site shows up on other databases, or sites where the VCP application was denied. Several of these sites are adjacent to the HSC, and therefore could pose a hazard to the proposed project in certain circumstances. The sites of concern from this list are discussed below.

Table G1-9: State and Tribal VCP Sites

Site	Location	Distance From HSC (miles)	VCP Application Status, year	Included in RECs?
Targa Patriot Terminal	Pasadena	Adjacent	Withdrawn, 2008	No
Exxon Pipeline Co. (EPC)	Baytown	Adjacent	Rejected, 1997	No
BP Pipelines Tract B	Galena Park	0.6	Withdrawn, 1998	No
South Coast Terminals	Houston	Adjacent	Active Remediation	Yes
Lone Star Industries, Manchester	Houston	Adjacent	Investigation	Yes
Pasadena Terminal (Kinder Morgan)	Pasadena	0.45	Completed, 2005	No
Oxid, LP	Houston	Adjacent	Active Remediation	Yes

According to the TCEQ VCP database, the Targa Patriot Terminal, located on the HSC at the mouth of Hunting Bayou, submitted a VCP application that was subsequently withdrawn. Withdrawal of a VCP application does not necessarily mean there is contamination, although records show that groundwater at the site was affected by a leaking petroleum storage tank in 2007. Despite these records, the site is not expected to impact the proposed project, although the site should be kept in mind if sediment quality results taken during the project in the area show contamination.

The Exxon Pipeline Co. is a division of the ExxonMobil Company refinery located in Baytown. Records show that a VCP application was filed, then subsequently rejected by TCEQ in 1997. The rejection of a VCP application typically indicates that the contamination present, in this case petroleum hydrocarbons in soil and groundwater, was too severe to be cleaned up under the VCP program. This is confirmed by the presence of the ExxonMobil refinery on the Federal CERCLIS (SEMS) list. However, despite the documented environmental conditions at the refinery, there is no reason to believe that those conditions will affect the proposed action. All proposed work will be done within the confines of the HSC, and all sediment will be tested per the *Inland Testing Manual* before dredging and disposal.

The BP Pipelines Tract B is located approximately 0.6 miles north of the HSC in Galena Park, and is also known as the Seaway Crude Pipeline Co. site. A VCP application was filed and subsequently withdrawn in 1998. Withdrawal of a VCP application does not necessarily mean there is contamination, although records show a TCEQ Industrial Hazardous Waste corrective action active as of 2007. Despite these records, the site is not expected to impact the proposed project due to the distance of the site from the HSC.

The South Coast Terminals site is located on the south bank of the HSC approximately a tenth of a mile east of the 610 Bridge. The site is co-located with several other facilities, including the Westway Terminal and the Oxid LP chemical plant. According to VCP records, the site was accepted into the VCP program in 1997 for soil and groundwater contaminated with VOCs, BTEX, and PAHs. More recent records indicate that remediation under the VCP is still ongoing, although no details are provided. Records also indicate a recent NPDES permit issued for the site, as well as numerous State enforcement orders. Due to the active remediation occurring at the site, this site will be carried forward as a REC.

The Lone Star Industries (Manchester) site is located adjacent to the HSC approximately a tenth of a mile east of Brady Island. A VCP file was opened in 2007 under the site's previous owner, Lone Star Industries, although the VCP is currently listed as "under investigation" under the new owner, Texas Port Recycling LP. The site was used for bulk material storage, and records indicate that soil and groundwater have been verified to be contaminated with VOCs, SVOCs, metals, and petroleum hydrocarbons. Aerial photography seems to show very little current activity at the site. Even so, the current investigation under the VCP, and the verified contamination means that this site will be carried forward as a REC.

The Pasadena Terminal site is owned by Kinder Morgan, and is located about a half mile south of the HSC in Pasadena. The site is comprised primarily of storage tank facilities, and is adjacent to several other facilities owned by GATX Terminal Corp, which may have been an owner of the site at one point. The storage facilities at the Pasadena Terminal are also likely associated with the Pasadena Refining System site located immediately to the west. The Pasadena Terminal Site is listed in the VCP database as being cleaned up as 2005, although institutional controls remain active. The site also has been the subject of numerous TCEQ enforcement action under a variety of programs. The site is not likely to impact the proposed project, but if any widening occurs in this area, the hazard posed by the site must be revaluated.

The Oxid LP site is a chemical plant located on the HSC approximately a tenth of a mile east of the 610 bridge. The VCP database shows a VCP application filed in 1997, and active remediation ongoing for solvents and metal in soil and groundwater. Records indicate a major emergency response occurred at the site in 2008, where 600 gallons of an extremely hazardous (yet unidentified) substance entered the HSC. Records also indicate active activity use limitations on the site, to prevent exposure to soil and groundwater. Due to the active VCP remediation ongoing at the site, and its proximity to the HSC, this site will be carried forward as a REC.

Brownfields List – The Brownfields database is a list of sites where information has been reported back to EPA Brownfields Assessment office. This does not mean these sites were selected as Brownfields for redevelopment. 8 sites were found in the search area, but none of these sites pose any hazard to the proposed project.

Other Sites – One site did not appear on the ASTM required database searches, but is known and requires some assessment in relation to the proposed project. The former San Jacinto Ordnance Depot is a Formerly Used Defense Site (FUDS) located on the north bank of the HSC immediately east of the Beltway 8 Bridge. The 4,851 acre site was used between 1942 and 1960 for storing and out-loading of ammunition, producing anhydrous ammonia, and demilitarizing ammunition. The site was also potentially used for the burial of conventional munitions, and records indicate that chemical munitions may have been handled at the site as well. The land was decontaminated and sold in 1960, with the “surface use only” caveat. The site is now owned by several entities, with the Port of Houston owning the largest portion.

In 2005, the site underwent a FUDS investigation that concluded that the possibility of chemical munitions continuing to be present onsite could not be completely be ruled out, and the report recommended further investigation. The Port began to consider the site for dredged material placement around the same time, although this possibility did not immediately materialize. In 2012, the Port completed a response action to address mercury contamination in onsite groundwater, essentially confining groundwater to the site, and relying on monitored natural attenuation to reduce concentrations to below cleanup levels over time. However, concerns remained about the site, specifically that the placement of dredged material would alter the groundwater regime and reduce the effectiveness of groundwater containment, possibly allowing mercury to migrate offsite. The onsite contamination is not expected to impact the proposed project. However, in order for the site to be considered for dredged material placement as part of this project, the concerns about munitions and migration of groundwater due to material placement must be resolved.

1.3.7.2 Site Visit

The site visit in environmental investigations is designed to identify environmental conditions that would otherwise not be identified in the records search. The site visit also is used to look at indoor areas and area usages on the subject property. Due to the proposed action occurring entirely in-water in the Federal navigation channel, a site visit will not be conducted for this phase of the investigation.

1.3.7.3 Interviews

The objective of the interviews is to discover environmental conditions that could not be obtained in the records search, as well as to determine past uses of the subject property. Due to the nature of the proposed project and its constant Federal ownership, it is expected that the subjects and scope of the interviews for this project will be limited. Potential interviewees include EPA Remedial Project Managers, State regulators, and users of the channel. The subjects of the interviews will be determined at a later time, once the records search is completed and allows for the narrowing of potential interviewees.

1.3.7.4 Conclusion

In order to complete a feasibility level HTRW evaluation for the HSC ECIP, this report was completed following the rules and guidance of ER 1165-2-132: *HTRW Guidance for Civil Works Projects*, and ASTM E1527-13: *Standard Practice for Environmental Site Assessment: Phase 1 Environmental Site Assessment Process*. Several sites were found that had recognized environmental conditions; these sites are listed below in **Table G1-10**, along with the site location, details of the applicable RECs, and the action recommendation. **Figure G1-1** through **Figure G1-4** below also shows the location of these sites.

Table G1-10: Final Site List

Site	Location	REC	Action Recommendation
Patrick Bayou	1.8 mi E of Beltway 8 bridge, Harris County	NPL site, sediment contaminated with PAHs, metals, and PCBs	Further investigation needed to evaluate potential for contaminated sediments to enter HSC
San Jacinto Waste Pits	Immediately N of I10 bridge @ San Jacinto River, Channelview	NPL site, sediment contaminated with dioxin	Chemical sediment quality sampling within HSC portion of AOC, in accordance with 2009 EPA public notice
Pasadena Refining System	0.25 mi E of Washburn Tunnel, Pasadena	Past RCRA investigations and corrective actions, TSDF, active institutional controls	No action needed. However, further investigation will be needed if widening occurs in this reach of the HSC
South Coast Terminals	0.1 mi E of I610 bridge, Houston	Past state enforcement orders, active VCP remediation ongoing, soil and GW contaminated with VOCs, BTEX, and PAHs	Avoidance of widening measures in this area of HSC
Lone Star Industries	0.1 mi E of Brady Island, Houston	Active VCP investigation ongoing, soil and GW contaminated with VOCs, SVOCs, metals, and TPH	Avoidance of widening measures in this area of HSC
Pasadena Terminal	0.4 mi S of Hunting Bayou, Pasadena	Past state enforcement orders, active institutional controls	No action needed. However, further investigation will be needed if widening occurs in this reach of the HSC
Oxid, LP	0.1 mi E of I610 bridge, Houston	Active VCP remediation ongoing, soil and GW contaminated with solvents and metals	Avoidance of widening measures in this area of HSC
San Jacinto Ordnance Depot	Immediately E of Beltway 8 Bridge, Houston	Unresolved munitions and future use concerns, GW contaminated with mercury	No action needed. However, if the site is considered for dredged material placement, resolution of existing concerns is required.

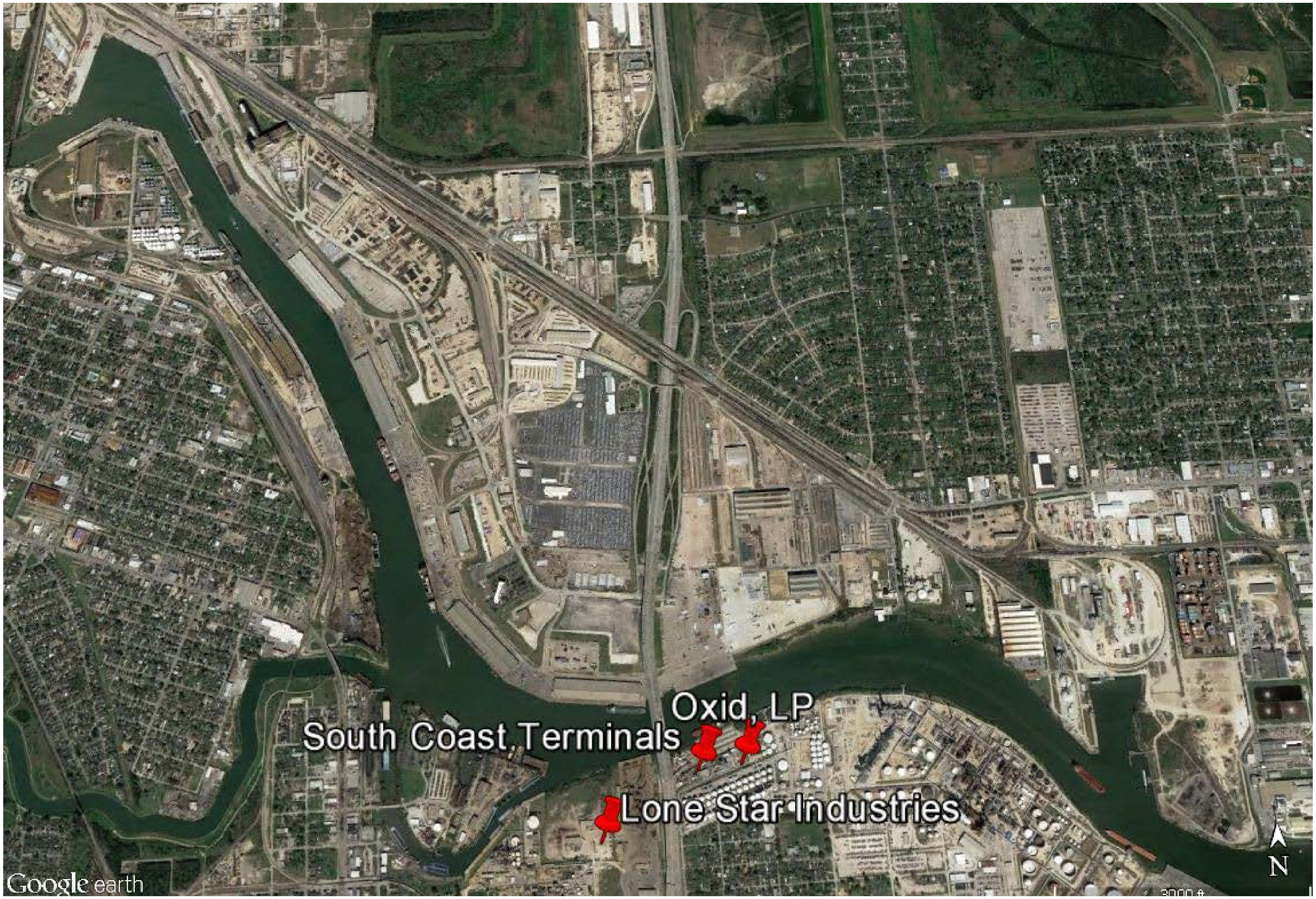

Figure G1-1: Identified HTRW REC Sites on the HSC

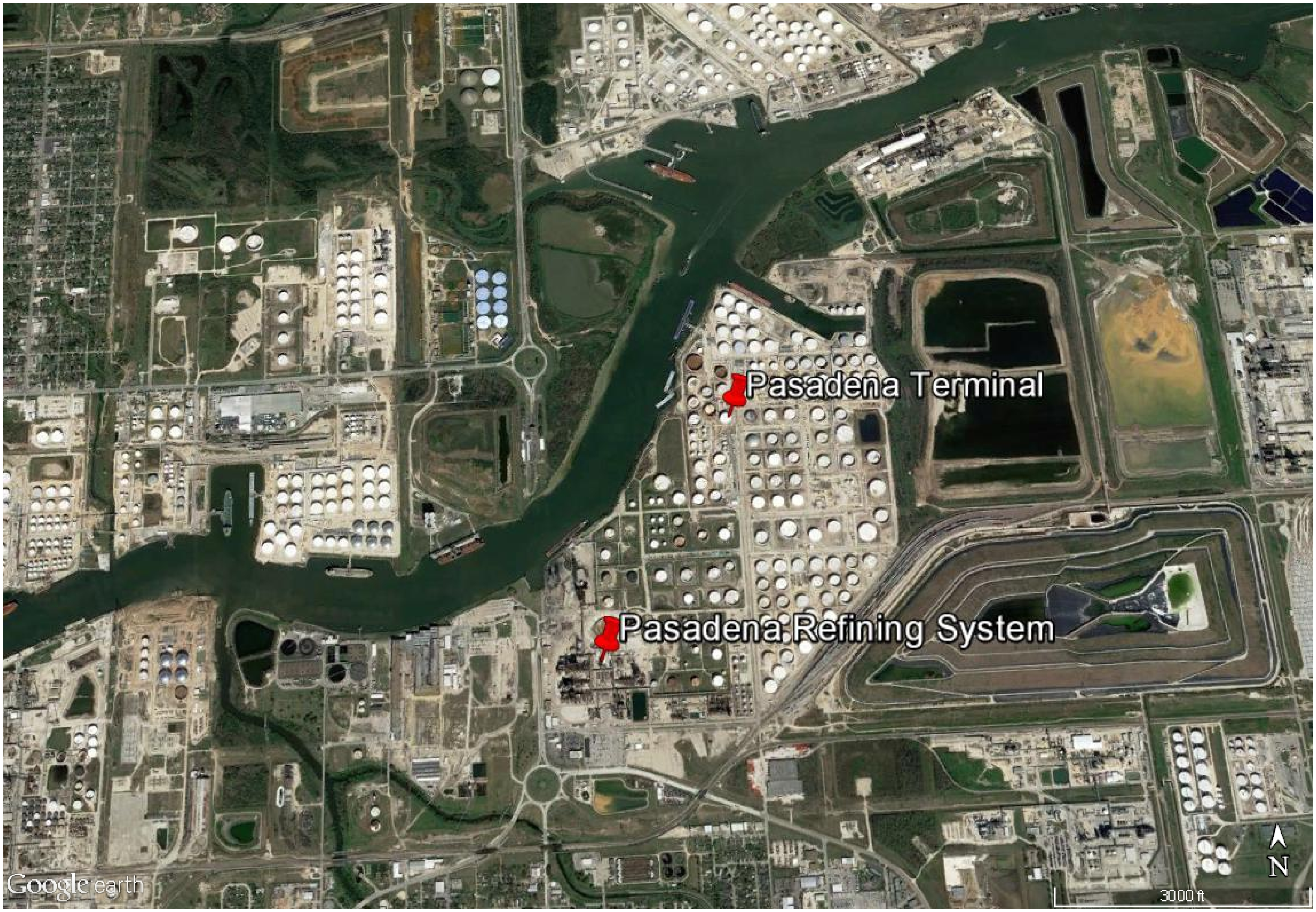

Figure G1-2: Identified HTRW REC Sites on the HSC

Figure G1-3: Identified HTRW REC Sites on the HSC

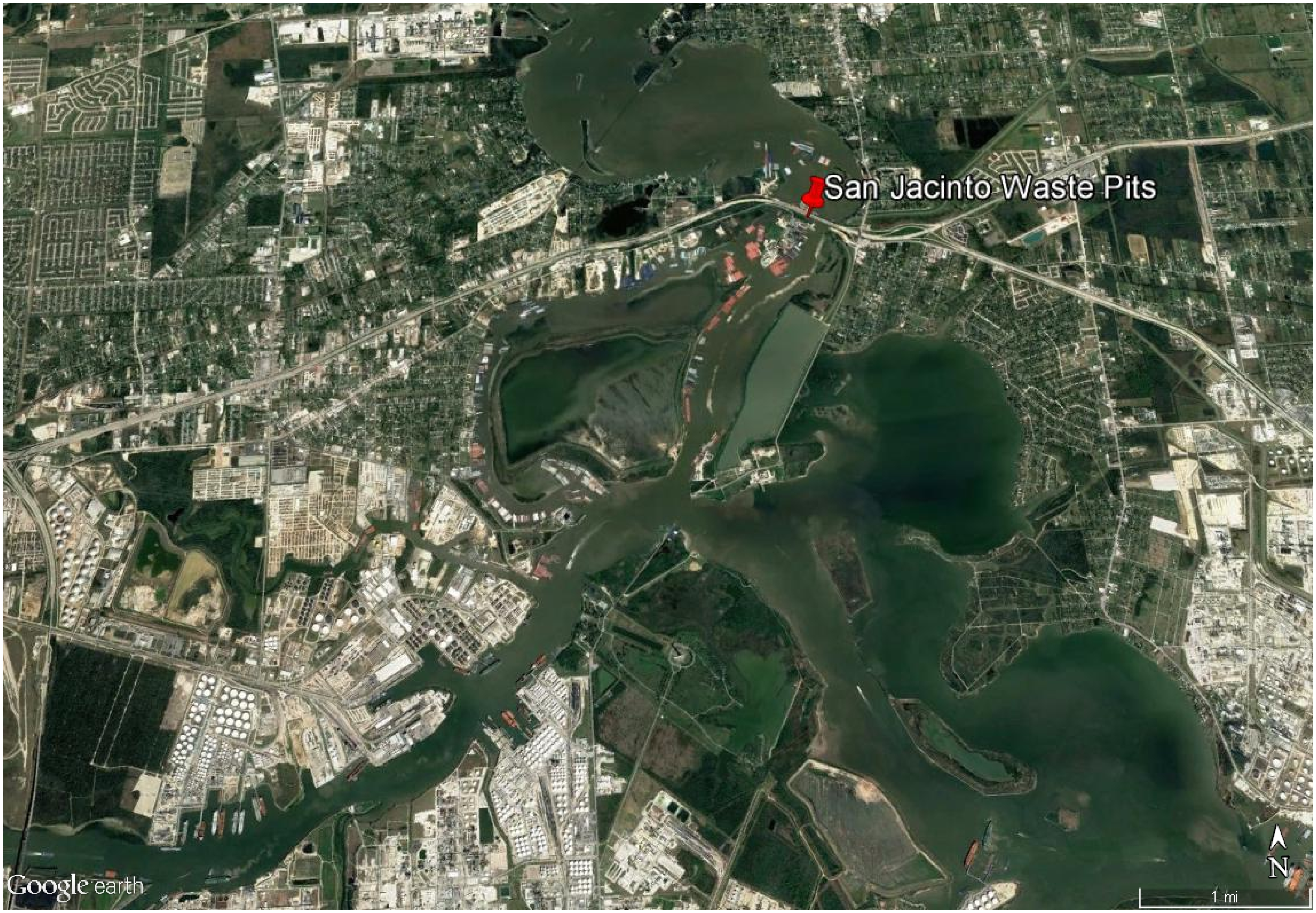

Figure G1-4: Identified HTRW REC Sites on the HSC

1.3.8 Air Quality

The Clean Air Act (CAA), as amended in 1990, regulates air emissions from area, stationary, and mobile sources, and requires the EPA to set National Ambient Air Quality Standards (NAAQS) for pollutants considered harmful to public health and the environment. Currently, there are air quality standards for six "criteria" pollutants designated by EPA; carbon monoxide, nitrogen dioxide, ozone, lead, sulfur oxides, and inhalable and fine airborne particulate matter (PM_{10} and $PM_{2.5}$ respectively) [EPA 2017]. A list of the standards is provided in **Table G1-11**. The HSC ECIP study area is located within the Houston-Galveston-Brazoria (HGB) nonattainment area (NAA) regulated under the CAA, consisting of Harris, Montgomery, Liberty, Chambers, Galveston, Brazoria, Fort Bend, and Waller Counties.

Table G1-11: National Ambient Air Quality Standards

Pollutant	Level	Averaging Time	Primary/Secondary
Carbon Monoxide	9 ppm	8-hour	Primary
	35 ppm	1-hour	
Lead	0.15 µg/m3	Rolling 3-Month Average	Prime and Secondary
Nitrogen Dioxide	53 ppb	Annual Mean	Primary and Secondary
	100 ppb	1-hour	Primary
Particulate Matter (PM_{10})	150 µg/m3	24-hour	Primary and Secondary
Particulate Matter ($PM_{2.5}$)	12.0 µg/m3	Annual	Primary
	15 µg/m3	24-hour	Secondary
	35 µg/m3	24-hour	Primary and Secondary
Ozone	0.075 ppm	8-hour	Primary and Secondary
Sulfur Dioxide	75 ppb	1-hour	Primary
	0.5 ppm	3-hour	Secondary

Source: EPA 2015c

The HGB NAA currently meets all of the EPA NAAQS, except for ozone. The attainment status of the HGB area is summarized in **Table G1-12**. Ozone is a reactive form of oxygen that can occur in two different levels of the atmosphere, the stratosphere and troposphere. Exposure to ground-level ozone (troposphere) in high concentrations can result in adverse effects to humans, plants and animals. Ground-level ozone is primarily formed by the reaction of sunlight with man-made emissions of nitrogen oxides (NO_x) and VOCs. Urban areas typically have high levels of ground level ozone. The current eight-hour ozone NAAQS of 0.075 parts per million (ppm) was passed in 2008 and became effective for the eight-county HGB area on July 20, 2012. The attainment deadline for the HGB moderate nonattainment area was July 20, 2015 (TCEQ 2017).

On October 26, 2015, EPA issued the final rule for the proposed revision to the 8-hour ozone standard, termed the 2015 NAAQS for Ozone. Nonattainment areas are required to comply with the 2015 8-hour ozone standard within 3 to 20 years of being designated as NAAs under the 2015 standard, depending on the severity of nonattainment. The EPA will designate NAAs by October 1, 2017, and attainment schedules vary from 3 years for marginal nonattainment to 20 years for extreme nonattainment following designation.

Table G1-12: Attainment Status of Houston-Galveston-Brazoria Area

Pollutant	Primary NAAQS	Averaging Period	Designation	Attainment Deadline
Ozone (O3)*	0.075 ppm (2008 standard)	8-hour	Moderate Nonattainment	July 20, 2018
Lead (Pb)	0.15 µg/m^3 (2008 standard)	Rolling 3-Month Avg.	Attainment/ Unclassifiable	
	1.5 µg/m^3 (1978 standard)	Quarterly Average	Attainment/ Unclassifiable	
Carbon Monoxide (CO)	9 ppm (10 mg/m^3)	8-hour	Attainment/ Unclassifiable	
	35 ppm (40 mg/m^3)	1-hour	Attainment/ Unclassifiable	
Nitrogen Dioxide (NO_2)	0.053 ppm (100 µg/m^3)	Annual	Attainment/ Unclassifiable	
	100 ppb	1-hour	Pending	
Particulate Matter (PM_{10})	150 µg/m^3	24-hour	Attainment/ Unclassifiable	
Particulate Matter ($PM_{2.5}$)	12.0 µg/m^3) (2012 Standard)	Annual (Arith. Mean)	Attainment/ Unclassifiable	
	15 µg/m^3 (1997 Standard)	Annual (Arith. Mean)	Attainment/ Unclassifiable	
	35 µg/m^3	24-hour	Attainment/Unclassifiable	
Sulfur Dioxide (SO_2)	0.03 ppm	Annual (Arith. Mean)	Attainment/ Unclassifiable	
	0.14 ppm	24-hour	Attainment/ Unclassifiable	
	75 ppb	1-hour	Governor's Recommendation Attainment (Harris and Galveston Counties)	

Source: TCEQ 2017

*The U.S. Environmental Protection Agency (EPA) revoked the one-hour ozone standard and the 1997 eight-hour ozone standard in all areas, although some areas have continuing obligations under these standards.

The existing air quality, although improving, is still impaired for ozone, for which NOx and VOC emissions that produce ozone, come from many different sources in an urban and industrial environment. These sources include vehicle traffic, power generation, construction activity, and transportation (i.e. aircraft, truck, rail, and marine cargo), oil and gas production, refining and industrial processes, recreational equipment, and lawn and garden equipment.

To comply with the CAA, the State of Texas develops State Implementation Plans (SIP) for the NAAs to outline how the NAAQS will be met for pollutants for which there is nonattainment. These SIPS contain emissions inventories for the pollutants to estimate the emissions from all sources in a NAA to comprehensively account for the regulated pollutant in order to demonstrate how compliance with the NAAQS will be achieved. The inventories estimate various categories of emissions under uncontrolled scenarios that simulate emissions with current or previous emissions standards with less air pollution controls required or in place, and controlled scenarios simulating impending or proposed standards requiring additional controls for a given year. The inventory of a given category (e.g. on-road mobile, marine) indicates the relative contribution to total emissions from those sources.

The latest proposed HGB SIP contains 2017 emissions estimates for all sources, on-road mobile sources (e.g. passenger vehicles, commercial trucks), point sources (e.g. power plants, refineries), and other major categories for the HGB NAA, and 2014 county-level and 2017 statewide commercial marine sources (TCEQ 2016). The growth and yearly emissions factors used to project 2017 statewide commercial marine emissions from 2014 county-level emissions was used to project the 2017 county-level emissions for the HGB coastal counties of Harris, Chambers, Brazoria, and Galveston which contain the commercial marine sources for HGB. This information indicates that commercial marine source NOx emissions (10,009 tons per year [TPY]) account for approximately 7 percent of the total HGB controlled scenario NOx emissions (143,536 TPY). By comparison, on-road mobile source emissions (35,825 TPY) comprise 25 percent, and point source emissions (46,143 TPY) comprise 32 percent of the total NOx emissions. Therefore, commercial marine sources comprise a small proportion of the existing NO_x emissions of the HGB NAA, which is the relevant air quality resource area for this study.

The commercial marine sources account for the full range of commercial vessel sizes ranging from smaller tugboats, fishing, and barge pushboats (Category 1, typically 700 horsepower (HP) to 11,000 HP) to the largest ocean-going container, oil tankers, cruise, and bulk carrier vessels (Category 3, typically 3,000 to 100,000 HP). The HGB commercial marine activity is dominated by the vessel activity associated with the HSC, BSC, and BCC being studied under the HSC ECIP, but also includes port activity from the Ports of Texas City, Galveston, and Freeport.

As a long-term trend, Texas air quality has improved markedly, especially in Houston. The Houston-area 8-hour ozone levels improved 29 percent between 2000 and 2014, even while the population increased over 34 percent (TCEQ 2015). The HGB NAA experienced an approximately 48% reduction in days exceeding the ozone standard from 2006 (64 total days) to 2009 (31 total days) (TCEQ 2011a, HGAC 2010a). A comparison of fourth highest ozone concentrations (a statistic used in determining standard attainment) for Houston indicates a downward linear trend for Houston for 2000-2010 (TCEQ 2011a, HGAC 2010a). The statewide trend may be attributable to several improvements resulting from better compliance with air quality regulations, including industry cutting production of NO_x over 80 percent in the last 10 years in Houston, tougher rules on compressor emissions in north and east Texas, tougher emissions rules on power plants, newer passenger cars and improved heavy-duty truck and gasoline standards (TCEQ 2015). Many of these improvements have taken place within the HGB NAA. The latest proposed HGB SIP discussed above lists the multi-tiered suite of controls required for the HGB NAA to continue future improvements towards achieving the NAAQS.

These include the phase-in of higher emissions standards for all major on-road and non-road sources (e.g. locomotive, marine), improved fuel formulations for several source categories (e.g. on-road, recreational marine, drilling rig), and improved vehicle inspection and maintenance.

In summary, the existing regional emissions of most concern (ozone precursors) are dominated by on-road mobile and point sources, and the commercial marine vessel emissions most directly associated with the HSC ECIP comprise a small proportion (7 percent) of these regional emissions. Collectively, air quality has improved significantly in the region due to improved emissions standards and controls implemented for the HGB NAA.

1.3.9 Noise

Noise is typically categorized as unwanted sound. Sound is characterized by a number of variables including frequency, duration, and intensity. Sound intensity is measured in decibels (dB), which is a logarithmic measure for which values cannot be simply added arithmetically to calculate the total levels. Environmental sound levels are often expressed in terms of averages over standard durations such as 1-hour, 8-hour, and 24-hour periods. These averages are expressed as an equivalent continuous sound level (L_{eq}) with the same duration. Normal speech has a typical sound level of approximately 60 dB. The human ear typically cannot detect variations of 3 dB or less (U.S. Department of Transportation 2010, Minnesota Pollution Control Agency 2008, Nevada Department of Transportation 2000). Human hearing is less sensitive to low frequencies and extremely high frequencies, and is most sensitive to mid-range frequencies. The most widely accepted method of quantifying sound for human receptors is to measure sound across a wide frequency spectrum and apply a weighting known as “A-weighting” to the individual decibel value of each frequency interval. The logarithmic sum of these values is known as the A-weighted sound level, expressed as dB A-weighted units, or dBA. Sound levels attenuate (decrease) with distance and dependent on important factors such as geometric spreading from point and line sources, ground absorption, atmospheric effects and refraction (bending), shielding by natural (e.g. trees) and manmade features (e.g. buildings), noise barriers, and diffraction (spreading) and reflection off of objects (Caltrans 2013). The simplest, most common type of attenuation is due to spherical geometric spreading from a point source, where sound level drops 6 dBA for each doubling of the distance. Other types of sources and spreading include cylindrical spreading from line sources such as a line or *row* of individual noise sources like trains or busy highways, and hemispherical spreading where the noise source is close to a reflective ground.

Noise-sensitive receivers are locations or areas where excessive noise may disrupt normal activity, or cause annoyance or loss of business. Land uses such as residential, religious, educational, recreational, and medical facilities are more sensitive to increased noise levels than are commercial and industrial land uses.

The navigation channels in all but Segment 2 (Bayport) of the HSC ECIP study area are directly lined with industrial development or open water. Segment 1 is surrounded by the wide expanse of Galveston Bay for most of its length, and open water of the wider segment of the San Jacinto River and associated bays upstream of Morgans Point to roughly the Battleship Texas around Mile 35. Upstream of that, industrial land use consisting of refineries and other industrial terminals directly line the HSC for distances of 0.5 mile or more away from the channel. Only in the most upstream Segments of 4, 5 and 6 upstream of Vince Bayou, does any nonindustrial development (consisting of residential) approach closer than 0.5 mile from the HSC. Segment 3 (Barbours Cut) is surrounded by the Barbours Cut Terminal to the south, petroleum terminals to the west, and Spilmans Island PA to the north. Segment 2 (Bayport) is the only study segment with nonindustrial development directly adjacent to the navigation channel with the Shoreacres residential community to the north of the BSC approximately 220 feet north of the channel within the land cut at its closest. Otherwise, the BSC has the existing Bayport container terminal and petroleum terminal facilities to the south and west in the land cut, or open waters of Galveston Bay outside of the land cut.

The closest church to the project area is Asbury Memorial Methodist Church, located approximately 990 ft southwest of the Brady Island Turning Basin on the HSC in Segment 6. The closest park to the project area is Hartman Park, located approximately 1,150 ft south of the HSC in Segment 5 near Interstate Highway (IH) 610. Apart from the San Jacinto Maritime Campus directly on the BSC, the closest school to the project area is JR Harris Elementary, which is located approximately 2,600 ft south of the Brady Island Turning Basin, and the closest cemetery is the Glendale Cemetery, located approximately 2,400 ft south of the Brady Island Turning Basin. Except for the San Jacinto Maritime Campus, all the other receptors have adjacent or surrounding industrial development between the navigation channel and the receptor.

The existing sound environment of the area surrounding the HSC ECIP study segments is influenced by numerous noise generating sources, many of which are transportation (e.g. waterways, roadways) or marine terminal-related (e.g. docks, cranes). Waterborne transportation includes the operation of ships, barges, commercial fishing vessels, and sport and recreational boats. Terminal activity consists of a wide variety of equipment used to load or transfer cargo such as cranes, pumps, trucks, or other equipment (e.g. loaders, forklifts). Typical maximum instantaneous sound levels, expressed in dBA, are shown in **Table G1-13**, with levels calculated for a few distances, assuming simple spherical spreading with no ground absorption or attenuation from trees, buildings etc. It should be noted that these types of sources can vary with make, model, equipment housing etc. For comparison, typical noise levels of common indoor and outdoor activities are shown in **Table G1-14**. Numerous surface roadways traverse the mainland portion of the study area adjacent to the channels, for which road traffic influences the existing sound environment. The more heavily traveled roads nearest the channels include the State Highway (SH) 416 (Fred Hartmann) in Segment 1, SH 146 and Port Road in Segment 2, Beltway 8 and Federal Road in Segment 4, IH 610 in Segment 5, and Clinton Drive and Navigation Boulevard in Segment 6.

Table G1-13: Typical Marine Source Noise Levels

Source	Sound level (dBA)			
	at source	at 100 ft	at 250 ft	at 500 ft
Dockside crane[1]	105	64	56	50
Rail mounted gantry crane[1]	102	61	53	47
Trucks (<12 mph)[1]	103.8	63	55	49
Forklift, 8-ton, diesel[1]	100.1	59	51	45
Motorboat (at 50 ft)[2]	85	50	38	31
Motorboat (loud)[2]	102	61	53	47
Ship (>60,000 tons)	107.7	67	59	53
Tugboat (at 50 ft)[3]	92.5	58	46	39
Commercial Fishing Vessel (deck)[4]	88-100	53-65	41-53	34-46

1. Source: DGMR 2006. IMAGINE noise database accessed through SourceDB. Average quality data used.
2. Source: 3M Noise Navigator 2015
3. Source: USACE Kansas City District. 2011. Missouri River Commercial Dredging FEIS, Avg. of 800-1200 HP tugs
4. Source: Workers Compensation Board of British Columbia 2009.

*Based on simple, spherical propagation, no ground absorption or attenuation from objects such as trees and buildings

Table G1-14: Typical Noise Levels

Common Outdoor Activities	Noise Level (dBA)	Common Indoor Activities
	110	Rock band
Jet flyover at 1,000 feet		
	100	
Gas lawnmower at 3 feet		
	90	
Diesel truck at 50 feet at 50 mph		Food blender at 3 feet
	80	Garbage disposal at 3 feet
Noisy urban area, daytime		
Gas lawnmower, 100 feet	**70**	Vacuum cleaner at 10 feet
Commercial area		Normal speech at 3 feet
Heavy traffic at 300 feet	**60**	
		Large business office
Quiet urban daytime	**50**	Dishwasher in next room
Quiet urban nighttime	**40**	Theater, large conference room (background)
Quiet suburban nighttime		
	30	Library
Quiet rural nighttime		Bedroom at night, concert hall (background)
	20	
		Broadcast/recording studio
	10	
	0	

Source: Caltrans 2013. Technical Noise Supplement to the Caltrans Traffic Noise Analysis Protocol

1.4 ECOLOGICAL AND BIOLOGICAL RESOURCES

The following subsections describe the biological resources within the study area, including habitats and wildlife.

1.4.1 Habitats

Habitat in the HSC ECIP study area is characterized by the confluence of Galveston Bay's shallow estuarine environment, and the terrestrial environment of the mainland, predominated by the urban development of metropolitan Houston in what previously was mainly coastal prairie and ribbons of woodlands along waterways. The confluence of these marine and coastal environments results in a variety of terrestrial and aquatic habitat types that remain to a limited degree, given the urban development. The following subsections describe the habitats of the study area, and those most closely associated with the navigation channels.

1.4.1.1 Terrestrial

The study area is located within the Gulf Coast Prairies and Marshes Natural Region as mapped by the Texas Parks and Wildlife Department (TPWD) [TPWD 2011]. This region is approximately 12,940,500 acres of flat to very gently rolling topography along the Gulf Coast from Louisiana to Mexico. It includes coastal features such as barrier islands, beaches, estuarine lagoons, and saline and brackish marshes as well as inland prairies and woodlands of various sorts (Poole et al. 2007).

Most of the area directly adjacent to the HSC, BSC, and BCC is heavily developed, primarily with industrial development. In order to define existing terrestrial conditions in the areas most likely to be within or closest to the footprints of potential project measures and alternatives, land cover classification within 500 feet of the existing HSC toes was reviewed using recent land cover classification data. Because of the broad state-wide scale of the mapping data, 2014 aerial photography was used to verify the classification. According to the TPWD Natural Resources Information System (Elliott 2009), almost 70 percent of landside portions within 500 feet of the channel toes of the existing HSC, the corridor used to define conditions for the project area, are mapped as urban (high and low intensity, **Table G1-15**). The great majority of land within the 500-foot review corridor occurs upstream of Morgans Point. The aerial photograph review divided the project area into three classes: Industrial of approximately 723 acres, Upland Vegetation of approximately 90 acres, and potential wetlands of approximately 5.7 acres. The aerial review indicated 88 percent of the landside portions to be industrial development, which is greater than the 70 percent of the similar TPWD category of urban development confirming the predominant land cover is developed. The potential wetlands comprise less than 1 percent and appear to be located in areas where sediment would normally accumulate along the channel such as the downstream side of where Sims Bayou joins the ship channel, downstream side of nonbulkhead areas just upstream and downstream of the Beltway 8 bridge, adjacent to the Lynchburg ferry landing, southwest section of Alexander Island PA and adjacent to the Fred Hartman Bridge.

Twenty-six existing PAs, one partially built PA, and one already-planned and approved PA that may receive new work and maintenance material future, renourishment, or levee repair if needed, have been identified as potential dredged material PAs listed in **Table G1-16** and shown in **Figure G1-5**. Most of these are historically used PAs that are periodically disturbed by deposition of dredged material during channel maintenance cycles or earthwork to de-water and manage these PAs, where pioneer herbaceous species continually re-vegetate areas of deposition in between these activities. The two that are partially built or already planned and approved are PAs already planned, approved, and mitigated for under the Expansion of Placement Areas 14 and 15 Project (USACE 2010). Previous site investigations of several of Galveston Bay segment PAs (Spilmans Island, PA 14, and PA 15) conducted during previous USACE and NFS projects indicate the typical nature of the vegetation as invasive with species such as salt cedar (*Tamarix chinensis*) and giant cane (*Arundinaria gigantea*) as well as typical marsh plants such as saltwater cordgrass (*Spartina alterniflora*) and salt-meadow cordgrass (*Spartina patens*) that readily colonize deposited material in between periods of disturbance. All of the upland disposal areas are periodically filled with additional material from current and future maintenance dredging activities. However, the PA areas that are designated beneficial use areas are currently under construction and need additional fill material to complete the marsh creation. Once filled to the correct level for marsh creation they will no longer be used for dredged material placement. However, if the designated beneficial use areas are impacted by future subsidence or sea level change, additional dredge material could be added to maintain quality marsh habitat. Similarly, currently filled marsh cells impacted by future subsidence or sea level change may also receive additional maintenance dredged material to renourish marsh habitat.

Table G1-15: TPWD Natural Resources Information System on Land within 500 Feet of the existing Houston Ship Channel

TPWD Common Name	Classification from Aerial Photographs	Sub-Total Acres by Classification	Percent
Urban High Intensity	Industrial	502.6	61.0%
Open Water	Industrial	133.2	16.2%
Urban Low Intensity	Industrial	36.6	4.4%
Pineywoods: Disturbance or Tame Grassland	Industrial	20.3	2.5%
Barren	Industrial	10.5	1.3%
Gulf Coast: Coastal Prairie	Industrial	9.5	1.2%
Chenier Plain: Fresh and Intermediate Tidal Marsh	Industrial	6.3	0.8%
Native Invasive: Deciduous Woodland	Industrial	4.3	0.5%
Gulf Coast: Coastal Prairie Pondshore	Industrial	1.8	0.2%
Marsh	Industrial	1.2	0.1%
Post Oak Savanna: Live Oak Motte and Woodland	Industrial	0.6	0.1%
Pineywoods: Bottomland Temporarily Flooded Hardwood Forest	Industrial	0.5	0.1%
Post Oak Savanna: Post Oak - Redcedar Motte and Woodland	Industrial	0.3	0.04%
Row Crops	Industrial	0.1	0.01%
Industrial Subtotal		**727.8**	**88.3%**
Open Water	Upland Vegetation	20.3	2.5%
Urban Low Intensity	Upland Vegetation	18.0	2.2%
Urban High Intensity	Upland Vegetation	14.1	1.7%
Gulf Coast: Coastal Prairie	Upland Vegetation	10.0	1.2%
Native Invasive: Deciduous Woodland	Upland Vegetation	8.1	1.0%
Pineywoods: Disturbance or Tame Grassland	Upland Vegetation	7.4	0.9%
Barren	Upland Vegetation	4.7	0.6%
Post Oak Savanna: Live Oak Motte and Woodland	Upland Vegetation	2.2	0.3%
Chenier Plain: Salt and Brackish High Tidal Marsh	Upland Vegetation	1.9	0.2%
Post Oak Savanna: Post Oak - Redcedar Motte and Woodland	Upland Vegetation	1.1	0.1%
Gulf Coast: Coastal Prairie Pondshore	Upland Vegetation	1.1	0.1%
Native Invasive: Juniper Woodland	Upland Vegetation	1.1	0.1%
Grass Farm	Upland Vegetation	0.3	0.04%
Marsh	Upland Vegetation	0.01	0.00%
Pine Plantation > 3 meters tall	Upland Vegetation	0.00	0.00%
Upland Vegetation Subtotal		**90.4**	**11.0%**
Open Water	Potential Wetland	2.70	0.3%
Native Invasive: Deciduous Woodland	Potential Wetland	1.13	0.1%
Urban Low Intensity	Potential Wetland	0.96	0.1%
Urban High Intensity	Potential Wetland	0.85	0.1%
Pineywoods: Disturbance or Tame Grassland	Potential Wetland	0.02	0.00%
Gulf Coast: Coastal Prairie	Potential Wetland	0.01	0.00%
Potential Wetland Subtotal		**5.68**	**0.7%**
	Total	**823.9**	**100%**

Table G1-16: Potential Dredged Material Placement Areas

Name	Placement Type Proposed
ODMDS No. 1	Ocean Disposal
Bolivar Marsh Cells 1 through 3	Renourishment Placement
Bolivar 288-acre marsh	Renourishment Placement
Redfish Island	Renourishment Placement
Mid Bay PA	Upland Placement
PA 14	Upland Placement
PA 14/15 Connection (partially built)	Upland Placement
PA 15	Upland Placement
Cell M5/M6	Beneficial Use Placement
M10	Beneficial Use Placement
M 7/8/9	Beneficial Use Placement
M11 (future)	Beneficial Use Placement
M1/M2	Renourishment Placement
NW	Renourishment Placement
M3	Renourishment Placement
M4	Renourishment Placement
Spilmans	Upland Placement
Alexander Island	Upland Placement
Goat Island	Renourishment Placement
Peggy Lake	Upland Placement
Lost Lake	Upland Placement
East Clinton	Upland Placement
West Clinton	Upland Placement
Rosa Allen	Upland Placement
House-Stimson	Upland Placement
Glendale	Upland Placement
Filter Bed	Upland Placement

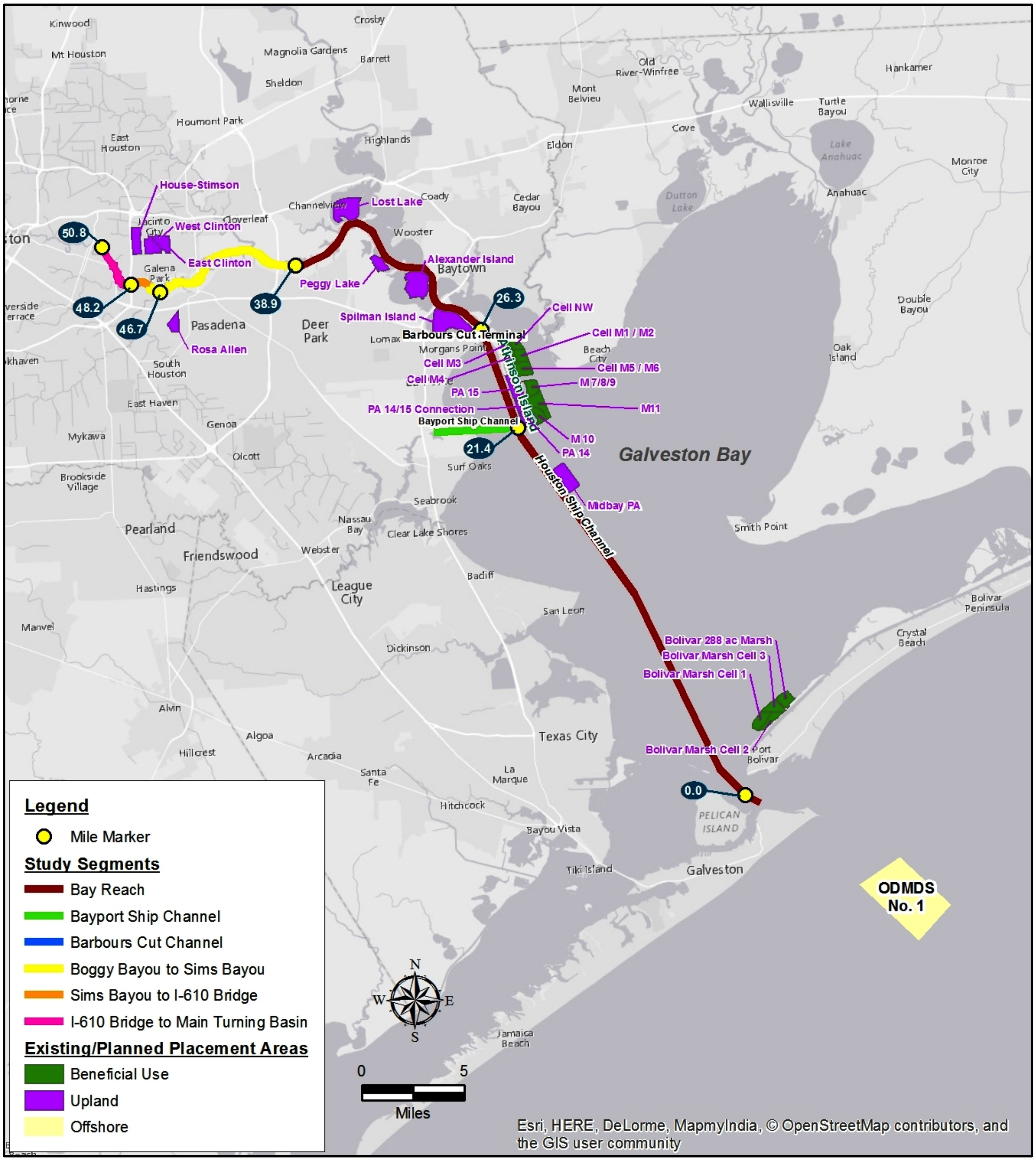

Figure G1-5: Existing Dredged Material Placement Areas

1.4.1.2 Wetlands

Two basic types of wetlands are common in the study area. The first type is a depressional wetland that occurs on the coastal prairie. The depressional wetlands typically occur in a depressed location on the landscape. Depressional wetlands usually receive moisture from rainfall and are poorly drained. The depressional wetlands typically support hydric soils caused by periods of inundation. Herbaceous vegetation typically is the dominate vegetation type within the depressional wetlands. Examples of common herbaceous wetland plants that typically grow in depressional wetlands include: spike rush (*Eleocharis* spp.), smartweed (*Polygonum hydropiperoides*), various sedges (*Carex* spp.), soft rush (*Juncus effusus*), and cattail (*Typha latifolia*). Some woody species have encroached on the depressional wetlands, examples of woody species found in depressional wetlands include: Chinese tallow (*Triadica sebifera*), black willow (*Salix nigra*), rattlebush (*Sesbania drummondii*), and eastern baccharis (*Baccharis halimifolia*).

The second type of wetland found in the study area is estuarine wetlands. These types of wetlands are typically saline and are located in a transitional area between freshwater and saltwater marshes. Common species that occur in the estuarine wetlands include glasswort, salt marsh bulrush (*Scirpus maritimus*), smooth cordgrass (*Spartina alterniflora*), seashore saltgrass (*Distichlis spicata*), and sea-oxeye (*Borrichia frutescens*).

Within 500 feet of the toes of the existing Houston Ship Channel is mostly open water used for the ship channel and turning basins, and the surrounding majority of the land is developed. Except where noted in **Section 1.4.1.1** for the limited areas of potential wetlands, the shoreline of the navigation channels are primarily either bulkheaded or have a steep transition and riprap erosion protection that is not conducive to shoreline marsh development. This was the condition observed during field visits conducted at the BCC on April 5, 2012 and to the BSC on February 17, 2011 during the NFS's BSC Improvements Project and BCC Improvement Project, and review of recent aerial photographs. The review of the recent aerial photographs discussed in **Section 1.4.1.1** indicate eight potential wetland areas totaling approximately 5.7 acres along the shoreline where sediment accumulates adjacent to the HSC in the few areas noted upstream of Morgans Point. No wetlands or vegetated shallows are located directly along the BCC or BSC channel margins. Scattered minor wetland areas are located on a low lying slope bench behind the rip rap and foreshore of the northern shore of the BSC in front of the San Jacinto College where an existing half-acre wetland was enhanced with herbaceous species during the 2002 BSC shore protection project, and eastward of that, approximately 0.3 acres of fragmented scrub shrub or forested wetlands adjacent to the slope along the northern shoreline in the land cut. Outside of the eastern containment dikes of PA 14 and 15, tidal marsh has developed on dredged material that migrated prior to the closure of the dikes in 2002.

1.4.1.3 Bays and Deepwater Habitats

The open-bay bottoms in Texas bay systems includes all unvegetated subtidal areas with various sediment types. They are open systems that greatly interact with the overlying waters and adjacent habitats (Armstrong et al., 1987; Tunnel and Judd, 2002). The Galveston-Houston area bay system includes the Galveston, Trinity, East, and West bays. Mud and sandy mud are the dominant sediment types in this system, with sand at bay margins. Sandy sediments are associated with flood-tidal deltas at Bolivar Roads and San Luis Pass and with modern barrier islands.

The study area contains the deep water (> 6 feet deep) habitat in Galveston Bay and the Buffalo Bayou/San Jacinto River tidal stream that characterizes the predominant habitat encountered in the project area where project features would be located. This estuarine habitat is comprised of the open water column of varying salinity, and estuarine bottom that is predominantly soft, unvegetated bay and tidal stream bottom, except where oyster reef has developed. The salinity is described in more detail in Section 1.3.4.2, and the oyster reef in Section 1.4.2.3. The function of this habitat as essential fish habitat is described in Section 1.4.3.

1.4.2 Wildlife

1.4.2.1 Terrestrial

The wildlife in the project area includes species typical of the Gulf Coast Plain and the Galveston Bay system. The following sections describe the terrestrial wildlife found in the project area.

<u>Birds</u>

The project area is located in a region along the GOM that is known for bird watching activities throughout the year. Observers have noted 139 bird species associated with Galveston Bay wetlands and open-bay habitats. These birds can be described in two main feeding groups, with the Ibis's, heron and egrets being wading birds who feed along the shoreline and marshes of Galveston Bay, and the terns, gulls skimmers and pelicans primarily depending on fish caught from the open water habitats of the bay (GBEP 2011). Examples of common resident species in the first feeding group include the black-crowned Night heron (*Nycticorax nycticorax*), great blue heron (*Ardea herodias*), roseate spoonbill (*Platalea ajaja*), snowy egret (*Egretta thula*), reddish egret (*Egretta rufescens*), and white faced ibis (*Plegadis chihi*). Examples of common resident species in the second feeding group include black skimmer (*Rynchops niger*), brown pelican (*Pelecanus occidentalis*), laughing gull (*Larus atricilla*), royal tern (*Sterna maxima*), and the sandwich tern (*Thalasseus sandvicensis*).

Many species of waterfowl use the coastal prairies of the upper Texas coast as a vital winter foraging area as they migrate along the Central Mississippi flyways each year. Species observed in the Galveston Bay system include the following: the blue winged teal (*Anas acuta*), American widgeon (*Anas americana*), northern shoveler (*Anas clypeata*), ruddy duck (*Oxyura jamaicensis*), Canada goose (*Branta canadensis*), and snow goose (*Chen caerulescens*) (GBEP 2011). The Galveston Bay system is also an important site for migrating shorebirds including the American avocet (*Recurvirostrata americana*), sanderling (*Calidris alba*), western sandpiper

(*Calidris mauri*), dowitchers (*Limnodromus sp*.), and the black-bellied plover (*Pluvialis squatarola*) (GBEP 2011).

Reptiles and Amphibians

Reptiles and amphibians that are known to occur in the counties adjacent to Galveston Bay including the Texas rat snake (*Elaphe obsolete*), ground skink (*Scincella lateralis*), western ribbon snake (*Thamnophis proximus*), Gulf Coast toad (*Bufo valliceps*), copperhead (*Agkistrodon contortrix*), western cottonmouth (*Agkistrodon piscivorus*), rough earth snake (*Virginia striatula*), marsh brown snake (*Storeria dekayi*), coachwhip (*Masticophis flagellum*), box turtle (*Terrepene carolinensis*), yellow-bellied racer (*Coluber constrictor*), gray tree frog (*Hyla versicolor*), green tree frog (*Hyla cinerea*), southern leopard frog (*Rana sphenocephala*), cricket frog (*Acris crepitans*), green anole (*Anolis carolinensis*), and five lined skink (*Eumeces fasciatus*).

The American alligator (*Alligator mississippiensis*) is known to inhabit the fresh and brackish waters and wetlands and can also be found in the bayous and rivers that flow into the bay. There are three threatened or endangered sea turtle species known to use the bay as a seasonal foraging area as they make their way along the coast, including the Kemp's ridley sea turtle (*Lepidochelys kempii*), the green sea turtle (*Chelonia mydas*), and the loggerhead sea turtle (*Caretta caretta*) (GBEP 2011, USACE Galveston District 2003a).

Mammals

Common terrestrial mammals that inhabit the general region include, but are not limited to, the swamp rabbit (*Sylvilagus aquaticus*), gray squirrel (*Sciurus carolinensis*), fox squirrel (*Sciurus niger*), Virginia opossum (*Didelphis virginiana*), nine-banded armadillo (*Dasypus novemcintus*), eastern cotton tail (*Sylvilagus floridanus*), roof rat (*Rattus rattus*), hispid cotton rat (*Sigmodon hispidus*), Norway rat (*Rattus norvegicus*), nutria (*Myocastor coypus*), raccoon (*Procyon lotor*), coyote (*Canis latrans*), striped skunk (*Memphitis memphitis*), white tailed deer (*Ordocoileus virginianus*), and feral domestic hogs (USACE Galveston District 2003a).

1.4.2.2 Aquatic

Fish and Nekton

The open bay habitat contains nekton species comprised mostly of crustaceans and finfish species. The diversity and distribution of the fish species can be affected at any time during the year by migrations and spawning cycles (Armstrong 1987). Newly spawned fish species begin migrating into Galveston Bay in winter and early spring, with the maximum biomass observed during the summer months (Armstrong et al. 1978, Parker 1965). Dominant finfish species inhabiting the open waters of Galveston Bay include Atlantic croaker (*Micropogonias* *undulates*), Gulf menhaden (*Brevoortia patronus*), bay anchovy (*Anchoa mitchilli*), sand seatrout (*Cynoscion arenarius*), gizzard shad (*Dorosoma cepedianum*), spot (*Leiostomus xanthurus*), and hardhead catfish (*Arius felis*). In San Jacinto Bay, a similar species assemblage is observed, including red drum, Atlantic croaker, black drum, and spotted seatrout. More detail on species catch rates is described for game fish in **Section 1.4.4**.

Benthos

The benthic (bottom) habitats within Galveston Bay have been previously surveyed, and common assemblages that occur within the areas of soft bottom (those areas comprised of sand, silt or clay) are described in Table G1-17. Common dominants include species of polychaetes, molluscs, and crustaceans. Silty clay (or muddy) sediments tend to support a community dominated by polychaetes, while more sandy (coarse grained) sediments are primarily dominated by crustaceans (GBEP 2002). The assemblages within the proposed project area are a combination of several of these, depending on channel extent and current depth of water.

Table G1-17: Common Benthic Species for Galveston Bay

Assemblage	Predominant Species
River Influenced, Low Salinity Assemblages (Salinity < 10 ppth)	*Rangia cuneata, Rangia flexuosa, Macoma mitchelli, Texadina, Vioscalba louisianea, Streblospio benedicti, Mediomastus ambista, Hobsonia florida, Tubificoides heterochaetus, Peloscolex gabriellae, Macrobrachium spp., Chironomidae*
Enclosed Bay or Inter-reef Assemblage (Salinity variable)	*Nuculana acuta, Nuculana concentrica, Mulinia lateralis, Tagelus pebius, Ensis minor, Acteocina caniculata, Streblospio benedicti, Mediomastus ambiseta, Microphiopholis atra*
Open Bay Assemblage (Salinity Range 10-35 ppth)	*Abra aequalis, Corbula contracta, Mulinia lateralis, Nuculana concentrica, Pandora trilineata, Periploma orbicularis, Acteocina canaliculata, Paraprionospio pinnata*
Bay Margin Assemblage	*Ensis minor, Heteromastus filiformis, Streblospio benedicti, Mediomastus ambiseta, Capitella capitata, Ampelisca abdita, Corophium louisianum, Hargeria rapax*
Inlet and Deep Channel Assemblage (Salinity Near-Gulf)	*Nassarius acutus, Tellina texana, Owenia fusiformis, Onuphis eremita oculata*

Source: Parker 1960 and White et al. 1985 as noted in GBEP 1992

Benthic invertebrate abundance generally increases north to south in Galveston Bay below Morgans Point, and seasonally peaking in spring, between February and May, and decreasing in October and November. Macrofaunal diversity within Galveston Bay is considered to be low or moderate compared to other estuaries in the Gulf of Mexico (GOM), with the highest diversity in areas with stable salinity regimes (e.g., near inlets such as Bolivar Roads and Rollover Pass).

The highest densities of oligochaetes (pollution tolerant species) are found in the HSC upstream of Morgans Point. All other areas in Galveston Bay have low densities of oligochaetes, including other tributaries.

Plankton

The benthic and nekton species depend on the food web provided by planktonic species. Phytoplankton in Galveston Bay is dominated by diatoms which constitute over 40 percent of all phytoplankton, and includes species such as *Skeletonema costatum*, *Thalassionema nitzschoides*, and *Navicula abunda*, all of which exhibit peak abundance in the early spring months. Blue-green algae *Oscillatoria* species dominate this community in the summer, while green algae *Ankistrodesmus* species dominate in the late summer and early fall months (Texas Department of Water Resources 1981). Zooplankton (not including meroplankton) in Galveston Bay is primarily comprised of copepods, cladocerans, and chaetognaths, with species such as *Acartia tonsa*, *Oithona* sp., *Labidocera aestiva*, and *Noctiluca scintillans*. Meroplankton are early planktonic life history stages (eggs and/or larvae) of organisms such as fish and benthic invertebrates. In Galveston Bay, zooplankton abundance is closely linked to water temperatures and inversely related to salinity levels (Armstrong 1987). Peaks in standing crop abundance have been identified in April and late summer, and are correlated with high freshwater input into the bay and elevated water temperatures, respectively. The increased zooplankton populations observed in the warmer summer months have the capacity to severely limit phytoplankton abundance through intensive grazing and leave the less palatable cyanobacteria (blue green algae) as the dominant phytoplankton group (Ornolfsdottir 2003).

1.4.2.3 Oyster Reef

Oyster reefs are present in many areas of the Galveston Bay system and provide ecologically important functions. Two species inhabit Texas coastal waters. Eastern oysters (*Crassostrea virginica*) are the dominant bivalve species in shallow saltwater bays, lagoons and estuaries, in water 8 to 25 ft (2.5 to 7.5 m) deep and between 28 and 90 degrees F. Crested oyster (*Ostrea equestris*) is less common in Texas and limited to higher salinity waters. Therefore, it is not expected to be abundant in the project area.

The proposed project encompasses a large portion of the HSC with varying degrees of salinity and dissolved oxygen. It is expected that live oysters will be limited to the areas of the channel with suitable habitat. While oysters can survive in salinities from 5 to 40 ppth (Cake 1983), they grow and spawn most successfully when salinity is between 10 and 30 ppth, and dissolved oxygen is greater than 5 ppm (NRCS 2011, Volety et al. 2009, Cake 1983, Butler 1954). With regard to depth, American oyster reef has been documented to occur as deep as anywhere between 40 feet and 100 feet (Cake 1983, SCDNR 2015), but are known to thrive in depths less than 15 feet (SCDNR 2015, NOAA Fisheries Eastern Oyster Biological Review Team 2007).

Most reef along the Gulf Coast occurs at 10 feet or less of depth with a preferred depth of approximately 13 feet or less (Kilgen and Dugas 1989, NOAA Fisheries Eastern Oyster Biological Review Team 2007).

However, 2011 side-scan imagery for reef surveillance around the BSC to 3 miles north along the HSC in support of the Non-Federal Sponsor's BSC Improvements and the HSC Project Deficiency Report (PDR) projects showed signature indicative of continuous reef at locations on the BSC and HSC side slopes. This imagery indicates reef signature on side slopes that would be at depths between 15 and 20 feet, and in the existing HSC barge lane bottom that would be at approximately 12 feet of depth, considering the NFS project or Galveston District channel hydrographic survey data. In isolated cases, the imagery along the HSC indicated signature in depths between 30-35 feet, but prevailingly reef appears in side slopes at less than 20 feet, and in no cases appears in navigation channel bottoms. This is mainly due to the periodic maintenance dredging of the channels that focuses on the deepest parts of the channel, including the bottom. However, other factors such as local DO and phytoplankton (oyster's food source) distribution in deeper water could limit growth deeper within the navigation channels. The presence of reef development from the 20-foot depth contour and out towards shallower depths along the HSC is consistent with observations of reef habitat extent along the channel margins contained in the Fish and Wildlife Coordination Act Report for the 1995 LRR (Appendix E, USACE 1995). The extent is also observed in more recent TPWD reef mapping data discussed in the next paragraph.

Reef within Galveston Bay was last mapped comprehensively on a Bay-wide basis during the surveys conducted by Texas A&M for the Galveston Bay National Estuary Program (now Galveston Bay Estuary Program), with field surveillance in 1991 and reported in 1997 (Powell et al. 1997). This mapping (reference **Figure G1-6**) shows that the largest extent of concern to the project occurs directly lining the HSC essentially from the Redfish Reef area between Eagle and Smith Points northward to Morgans Point and along the BSC. Very little to no reef is seen along the HSC south of that area to the southern end of the study. The historical solid growth lining the HSC was observed in the 2011 survey data around Bayport. Following Hurricane Ike in 2008, TPWD surveyed major reef complexes in Galveston Bay to assess damage from sedimentation produced by this event, targeting the broader Redfish Reef, Dollar Point, East Bay and Trinity Bay (e.g. Fisher's Reef) complexes, and the portion of the bay from roughly between Redfish and Mid Bay PA at the southern end, up to Morgans Point at the north end. Using sidescan sonar to help determine extent and sub-bottom acoustic profilers to determine depth of burial, they estimated between 50 percent of the oyster reef in Galveston Bay was damaged or destroyed, and categorized severity of burial into areas receiving between 0 to 6 inches of sedimentation and greater than 6 inches (Rohrer et al. 2010, Hons and Robinson 2010, Drake 2012). Most of the area along the HSC was less impacted (0-6 inches), and most areas of impact greater than 6 inches occurred in complexes away from the channel. This more recent TPWD mapping indicated a relatively solid extent along the HSC margin. The 2011 BSC and PDR project sidescan data discussed in the previous paragraph was acquired 3 years after Hurricane

Ike and also indicated solid reef coverage around the HSC margins that did not appear to have been significantly impacted by burial. Ground-truthing of some reef complexes lining the HSC indicated a higher density of live reef growth towards the channel confirming the solid reef coverage at the channel margin. It confirms the lighter or no damage (0 to 6 inches) generally observed along the HSC indicated in TPWD data and is consistent with the solid extent mapped along the HSC. The TPWD mapping is displayed in **Figure G1-6**. Surveys to determine detailed extent within specific proposed plan footprints where only older Powell mapping is available would be conducted after the TSP is approved.

Neither the Powell historical mapping nor the recent TPWD mapping included areas of the HSC above Morgans Point. The deepened navigation channel and adjacent deep draft berths, which are 36 to 45 feet or more deep, and receive periodic maintenance dredging, would not be expected to support reef development as sidescan sonar data supports. These deepened parts of the navigation system cover most of the open water area above Carpenter's Bayou. Between Morgans Point and Carpenter's however, Buffalo Bayou and the San Jacinto River is wider with a greater extent of shallower undredged bathymetry outside of the main channel that could support reef growth given the appropriate salinity. Sidescan sonar data and low tide observations in the shallow bay south of Alexander Island for a recent proposed liquid natural gas terminal project indicated reef growth on the shallow bottom (Ashley Judith, AECOM; personal communication 2016). Salinity data, channel bathymetry, and berth presence were reviewed in the footprint of the TSP to determine the likelihood that reef could develop or not, to identify areas that warrant local reef surveillance after the TSP is approved. This review is described in **Section 3.2.2.3** under the subsection "Potential of Project Areas above Mapping to Contain Reef " and detailed in the Mitigation Plan provided in **Appendix P**. The review indicated HSC salinity would have a higher probability to support growth between Morgans Point and the Battleship Texas, a medium probability of supporting growth between the Battleship and Greens Bayou, a lower probability between Vince Bayou and Greens Bayou, but would be too fresh above Vince Bayou to support reef development. TSP areas shallow enough to support growth below Vince Bayou totaled approximately 176 acres, but only 79 acres were in measures with broader expanses of shallow undisturbed bathymetry, with only 8 acres in salinity with a higher probability to support growth. Overall, the potential for acreage being impacted above Morgans Point would be small compared to the Bay.

While the extent of oyster reef depends on the presence and propagation of the inert material (hard substrate, dead shell etc.) to build the base for a living reef, the living portion depends on the repeated and seasonal spawning and settling of live oysters dependent on appropriate salinity to trigger spawning and sustain growth. As such, live oyster productivity and density is subject to the highly variable salinity fluctuations that occur with drought and flood cycles on land that influence salinity in an estuary. Prolonged salinity below 5 ppth (especially in warmer waters) results in mass oyster mortality, while too high a salinity that favors oyster predators, parasites, and diseases may also decimate populations (Cake 1983, Buzan et al. 2009, Rybovich 2014).

Droughts decrease freshwater inflow that can result in the higher salinities that allow oyster predators and pests to thrive. The last such event happened in Galveston Bay for several years following the severe 2011 drought, where infestation from the protozoan parasite *Perkinsus marinus* ("dermo") was seen to increase or infest previously unaffected reef areas (Plushnick-Masti 2011, Associated Press 2011, Brezosky 2014). Long term high freshwater inflows into estuaries from prolonged rain events ("freshets") periodically cause mass mortalities from depressed salinities, especially when conditions of less than 2 ppth persists for more than a month; however, they will normally recover to pre-flood productivity in 2-3 years (Cake 1983). The last such event occurred in Galveston Bay in 2016 with back-to-back years of high spring rainfall events in 2015 and 2016 resulting in high reef mortality and reef harvesting closures in 2016 (Rice 2016a and b).

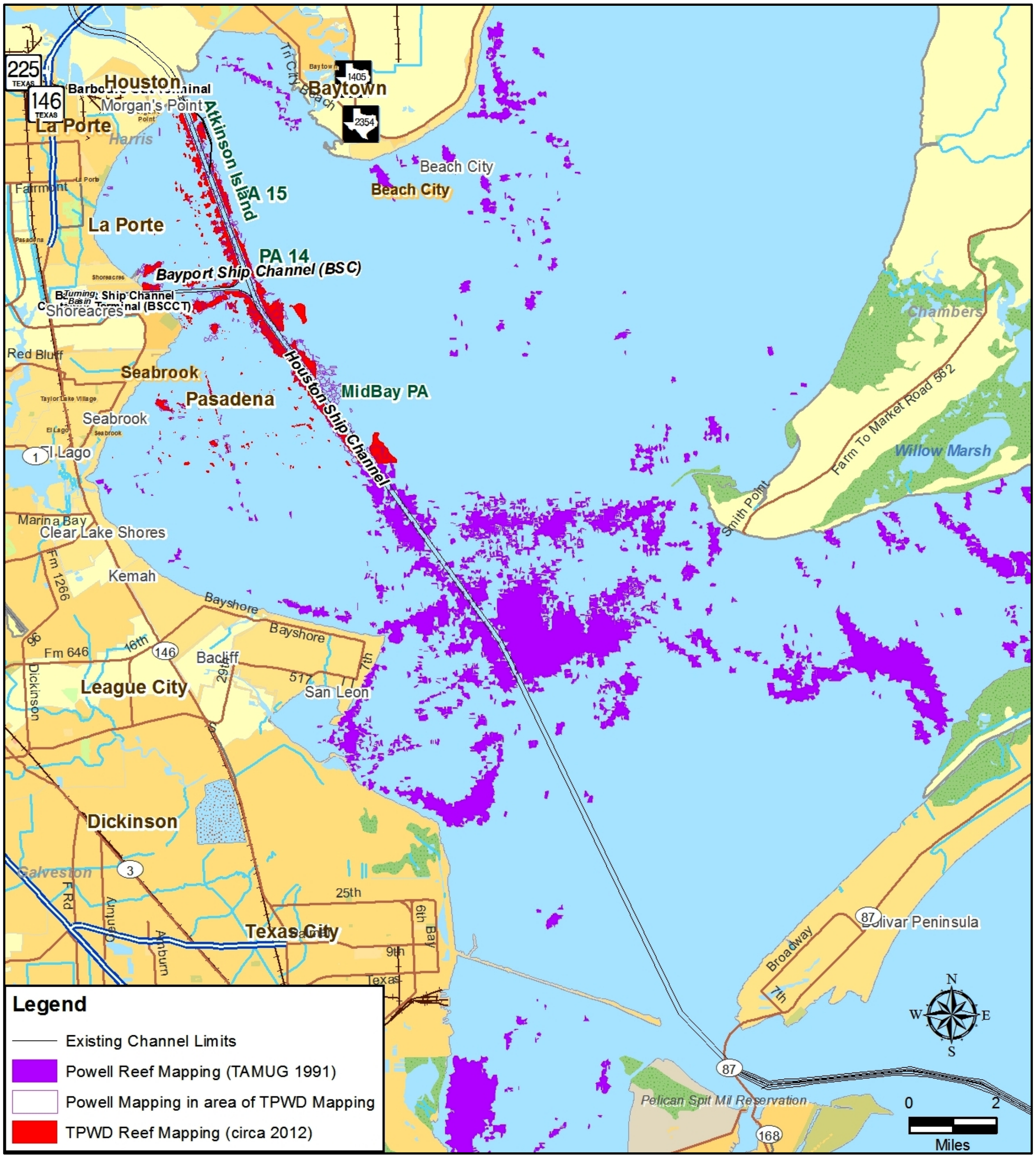

Figure G1-6: Reef Mapping in the Study Area.

1.4.3 Essential Fish Habitat

The 1996 amendments to the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA) set forth a new mandate for the National Marine Fisheries Service (NMFS), regional Fishery Management Councils (FMC), and other Federal agencies to identify and protect important marine and anadromous fisheries habitat, referred to as Essential Fish Habitat (EFH). To achieve this goal, it was recognized by NMFS that suitable marine fishery habitat needed to be maintained. The NMFS and the regional FMCs were required to delineate EFH in Fishery Management Plans (FMP) for all federally managed fisheries. The 1996 amendments to the MSFCMA also required that EFH consultation be conducted for any activity that may affect important habitats of federally managed marine and anadromous fish species.

EFH has been defined in MSFCMA § 3(10) as those waters and substrate necessary to fish for spawning, breeding, feeding or growth to maturity. The EFH interim final rule summarizing EFH regulations (62 CFR 66551) further specified the EFH definition as waters and their associated physical, chemical, and biological properties that are used by fish and may include aquatic areas historically used by fish where appropriate; substrate, including sediment, hard-bottom structures underlying the waters, and associated biological communities; 'necessary' means the habitat required to support a sustainable fishery and the managed species' contribution to a healthy ecosystem; and 'spawning, breeding, feeding, or growth to maturity' covers a species' full life cycle.

NOAA Fisheries Gulf of Mexico Fishery Management Council (GMFMC) is responsible for the creation of FMPs in Federal waters off Texas, Louisiana, Mississippi, Alabama, and Florida. GMFMC defines six FMPs for the Gulf of Mexico [GOM] (for shrimp [4 species], red drum [1 species], reef fish [43 species], coastal migratory pelagics [3 species managed, 4 not in the management group], corals [managed species are not listed under this FMP], and spiny lobster [1 species]). EFH consists of areas of higher species density, based on the NOAA Atlas (NOAA 1985) and functional relationships analysis for the Red Drum, Reef Fish, Coastal Migratory Pelagics, Shrimp, and Spiny Lobster FMPs; and on known distributions for the Coral FMP.

The MSFCMA established procedures for identifying EFH and required interagency coordination to further the conservation of federally managed fisheries. Any Federal agency that authorizes funds or undertakes, or proposes to authorize, fund, or undertake an activity that could adversely affect EFH is subject to the consultation provisions of the above-mentioned Act. This EIS serves to initiate EFH consultation under the MSFCMA.

In addition to the EFH information provided in **Section 3.2.3**, a separate EFH Assessment for this project will be prepared in the next planning phase that contains all of the elements outlined by the final rules for the MSFCMA under 50 CFR Part 600. The EFH assessment includes (1) a description of the proposed action; (2) an analysis of the effects, including cumulative effects, of the action on EFH, the managed species, and associated species by life history stage; (3) the Federal agency's views regarding the effects of the action on EFH; and (4) proposed mitigation, if applicable. The assessment includes the results of an on-site inspection, the views of recognized experts on the habitat or species affects, a literature review, an analysis of alternatives to the proposed action, and any other relevant information. Given the scale of the proposed action, the proportion and type of habitat being impacted and mitigated for, and the current presence of shipping activity, the assessment does not result in identifying further mitigation actions. The EFH Assessment is available upon request. The following paragraphs describe the general impacts that would occur to EFH and the managed species.

Project Area EFH Determination by FMPs

EFH for the Gulf of Mexico is identified by the GMFMC as Ecoregion 4 and determined as the composite of EFH for various species and life stages in the fishery management units (FMU) of the Gulf of Mexico. General EFH information presented was derived from the EFH mapping tool provided by NOAA. Details on EFH for specific species and life stages in each FMU are provided in Section 3 of the EFH FEIS (GMFMC 2004). Additionally, the Draft EFH Assessment is available upon request. A more detailed discussion of usage of habitat in the specific project area for the various individual or groups of species and their life stages is also included in the Draft EFH Assessment. This information is summarized in this section to provide a description of what EFH and managed species is defined for the project area. Additionally, informal consultation with NMFS has been initiated.

Information from the habitat descriptions from the GMFMC FMPs and the EFH FEIS were used to provide the following summary of what EFH and managed species (and associated life stages) are present in the project area (GMFMC 2004 and 2005).

Red Drum FMP EFH: All estuaries in the GOM, which would include Galveston Bay, are defined as EFH for the Red drum (*Sciaenops ocellatus*). The area of Galveston Bay where the proposed project is planned is considered to be EFH for all life stages of the Red drum.

Reef Fish and Coastal Migratory Pelagics FMPs EFH: All estuaries in the GOM, which would include Galveston Bay, are defined as EFH for Reef Fish and Coastal Migratory Pelagics. Of the species listed in the Reef Fish FMP, only the Gray snapper (*Lutjanus griseus*) has habitat descriptions associated with Galveston Bay. Of the species listed in the Coastal Migratory Pelagics FMP, only the Spanish mackerel (*Scomberomorus maculatus*) has habitat descriptions associated with Galveston Bay. The area of Galveston Bay where the proposed project is planned is considered to be EFH for post larval through adult life stages of the grey snapper, and for early to late juvenile and, occasionally, adult stages of the Spanish mackerel.

Shrimp FMP EFH: All estuaries in the GOM, which would include Galveston Bay, are defined as EFH for shrimp. Of the species listed in the Shrimp FMP, only brown shrimp (*Farfantepenaeus aztecus*), pink shrimp (*F. duorarum*), and white shrimp (*Litopenaeus setiferus*) have habitat descriptions associated with Galveston Bay. The area of Galveston Bay where the proposed project is planned is determined to be EFH for late post-larval to sub-adult life stages for brown, white and pink shrimp (GMFMC 2004).

Galveston Bay does not have habitat defined as EFH for the other GMFMC FMPs, which are the Spiny Lobster FMP and Coral FMP. The absence of EFH for the species not found in Galveston Bay is generally attributable to life stage requirements for oceanic salinity, continental shelf or reef structure, and seagrass, but also may be due to natural range, offshore spawning habits, and other causes.

In addition to the species discussed above, the highly migratory species are managed by the NOAA Fisheries Highly Migratory Species Management Unit, Office of Sustainable Fisheries and an FMP was developed for the Atlantic species of sharks, tunas, and swordfish, and Atlantic billfishes (NMFS 2006). EFH has been mapped for 39 of the species managed by this FMP, and are listed in and discussed in more detail in the Draft EFH Assessment which is available upon request. Of the 39 highly migratory species for which EFH has been mapped, only the following have EFH within the open water area in Galveston Bay at approximately the Bayport cut and points south (not applicable to the remainder of the project area): Atlantic sharpnose shark neonates and adults (*Rhizoprionodon terraenovae*), Blacktip shark neonates and juveniles (*Carcharinus limbatus*), Bonnethead shark neonates and juveniles (*Sphyrna tiburo*), Bull shark neonates and juveniles (*Carcharhinus leucas*), and the Scalloped hammerhead shark neonates only (*Sphyrna lewini*).

The proposed project area is located within Ecoregion 4 as identified by the GMFMC. The categories of EFH in the project area include estuarine emergent marsh, estuarine shell substrate, estuarine mud substrate, and estuarine water column. In addition to being designated as EFH, these habitats provide nursery, foraging, and refuge habitats that support various economically important marine fishery species, such as spotted seatrout (*Cynoscion nebulosus*), flounder (*Paralichthys spp.*), Atlantic croaker (*Micropogonias undulatus*), black drum (*Pogonias cromis*), gulf menhaden (*Brevoortia patronus*), striped mullet (*Mugil cephalus*), and blue crab (*Callinectes sapidus*). Such estuarine-dependent organisms serve as prey for other fisheries managed under the MSFCMA by the GMFMC (e.g., red drum, mackerels, snappers, and groupers) and highly migratory species managed by NMFS (e.g., billfishes and sharks). These habitats also provide other essential estuarine support functions, including: (1) providing a physically recognizable structure and substrate for refuge and attachment above and below the sediment surface; (2) binding sediments; (3) preventing erosion; (4) collecting organic and inorganic material by slowing currents; and (5) providing nutrients and detrital matter to the Galveston Bay estuary.

<u>Description of Project Area EFH Identified by the GMFMC</u>

Open Water Column: Zooplankton and phytoplankton are the dominant organisms in this habitat and serve as the foundation of the estuarine and marine food webs. Phytoplankton are major contributors to primary production, which is directly linked to production of biomass of species managed under the MSFCMA. In addition to supplying food for animals, phytoplankton plays a central role in nutrient cycling in Galveston Bay.

Open-Bay Bottom: The open-bay bottoms in the project area include flat areas consisting of mixtures of mud and mud/shell hash. Benthic epifauna and infauna are the primary organisms that utilize this habitat by adhering to the surface or burrowing into the sediment. These organisms feed by filtering particles from the water column or by ingesting sediments and extracting nutrients. Many of the epifauna and infauna feed on plankton, and are then directly fed upon by some of the species managed under the MSFCMA, such as shrimp and demersal fish species.

Submerged Aquatic Vegetation (SAV): Seagrass areas provide nursery grounds for many fish species, support a tremendously complex ecosystem and are extremely productive. Seagrass areas are considered EFH for many species of fish. According to seagrass mapping, there are no areas of seagrass present within or adjacent to the proposed project area (TPWD 2016b). Project site conditions are not conducive to seagrass growth.

Oyster Reefs: Oyster reefs provide structural complexity in soft sediment environments by increasing available surface area for use by other organisms. Oyster reefs serve as fish habitat by providing structure, protection and trophic support to juveniles and adults (SAFMC 1998). In the northern Gulf of Mexico (north of Galveston Bay, Texas, to northwestern Florida) spotted seatrout and red drum appear to favor oysters reefs as foraging areas in much the same way they use seagrass meadows in areas where seagrasses are abundant. Oyster reefs of various sizes are present in all Texas estuaries, but are best developed between Galveston Bay and Corpus Christi Bay (Diener 1975). In an effort to restore oyster reef habitats severely impacted by Hurricane Ike in 2008, the TPWD placed reef building materials (clutch) over 178 acres of six natural, publicly owned oyster reefs in Galveston Bay in 2011. The cultch was placed at Frenchy's Reef, Middle Reef and Hanna Reef in East Bay; and Dollar Reef, East Redfish Reef and South Redfish Reef in Galveston Bay. The cultch is expected to attract planktonic oyster larvae, which will settle on the cultch and grow to adult oysters (TPWD 2011).

Oyster reef habitat is found in the area of the project within the greater study area. The majority of the oyster fishery as well as the oyster reefs in Texas are located within the Galveston Bay area (80-90 percent) with some additional areas in the Corpus Christi-Aransas Bay area (Kilgen and Dugas 1989).

Estuarine Emergent Marsh: Estuarine wetlands exist in the Galveston Bay system across a salinity gradient and are classified into salt marshes and brackish marshes. In addition to the marshes found near the shoreline, several DMPAs are and have been beneficially used for creation of emergent marsh. This type of habitat is discussed further in **Sections 1.4.1.1** and **1.4.1.2**. Specifically within the proposed project footprint, no marsh is found within the area of the channel improvements.

Coral Areas: There are no coral areas within Galveston Bay.

1.4.4 State Managed, Commercial, and Recreational Fisheries

Texas recreational and commercial fishermen fishing less than 9 nautical miles off the coast of Texas are considered to be in State regulated waters, and must comply with the rules and regulations for each type of fishing that have been published by the TPWD. The TPWD provides electronic access to the rules and regulations for coastal fishing on its website (TPWD 2016c). The former Texas Parks and Wildlife Commission adopted management plans for only the shrimp, oyster and crab fisheries. The remaining species which are regulated by the State of Texas are regulated only through written rules and regulations, not through FMPs.

The finfish and shellfish resources in Galveston Bay support the most lucrative commercial and recreational fisheries of all the major ports in Texas and annually constitute approximately 33 percent of the total commercial revenue and 50 percent of the total recreational revenue for the entire State (Lester 2002). The annual commercial finfish catch within Galveston Bay between 1997 and 2001 averaged approximately 209,065 lbs, and the annual ex-value of finfish averaged $211,770 (GBEP 2011, Culbertson et al. 2004). While the majority of recreational revenue is generated through the collection of finfish, the commercial catch is predominantly comprised of shellfish. Large scale commercial fishing in Galveston Bay dates back to the 1870’s as a result of increasingly efficient processing and refrigerated shipping techniques. Since that time, considerable advancements in fishing gear has allowed the commercial fishing industry to flourish, as evidenced by 2009 landings in Galveston Bay worth approximately $35 million (all values given are in U.S. dollars (USD)) (NMFS 2011). From 1997 to 2001, landings of white shrimp (*Penaeus setiferus*) from Galveston Bay comprised 62 percent of the landings from Texas bay systems and were valued at $5.7 million in 1999, while brown (*Panaeus aztecus*) and pink (*Panaeus duorarum*) shrimp comprised the majority of landings (36 percent) for these species in Texas bays, with Galveston Bay landings worth an estimated $2.5 million in 1999 (Culbertson et al. 2004). In addition, Galveston Bay supports a robust live and dead bait shrimp fishery and is responsible for over 50 percent of coastal Texas landings worth $1.6 million in 2001 (Culbertson et al. 2004). Dominant finfish species caught in the open waters of Galveston Bay include

Atlantic croaker, black drum, sand seatrout, among others as shown in **Figure G1-7** (TPWD 2016a). In San Jacinto Bay, the species caught most frequently include red drum, Atlantic croaker, black drum, and spotted seatrout (*Cynoscion nebulosus*) **Figure G1-8** (TPWD 2016a).

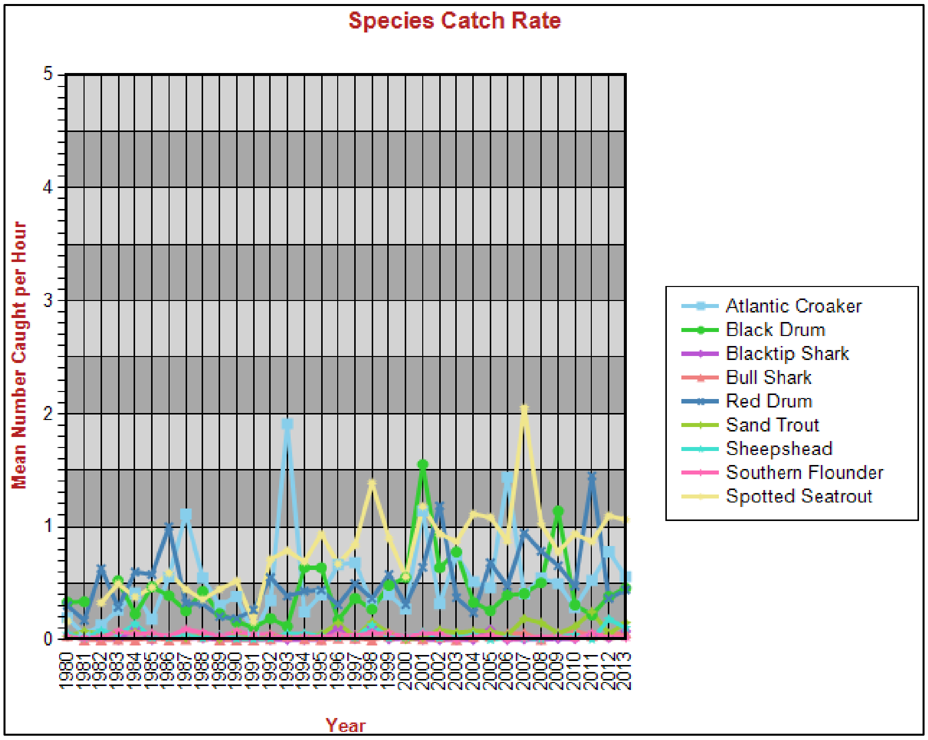

Figure G1-7: Species Catch Rates for Open Water Areas of Galveston Bay from 1990-2013 (TPWD 2016a)

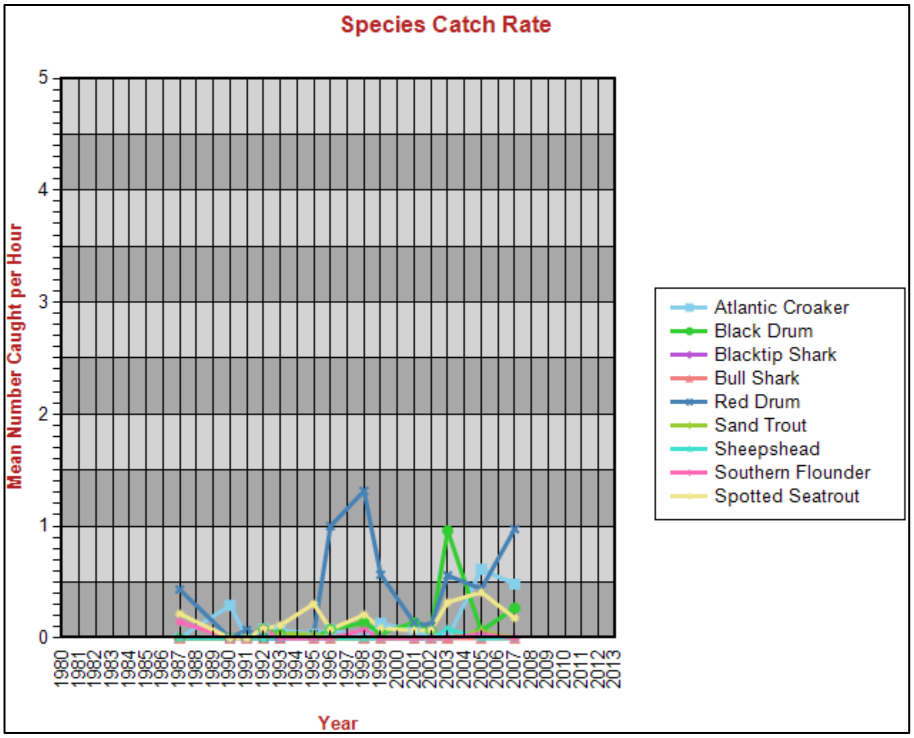

Figure G1-8: Species Catch Rates for San Jacinto Bay from 1987-2007 (TPWD 2016a).

Although trawl based shrimp landings account for nearly half of Galveston Bay's commercial harvest, other shellfish landed relatively frequently from the bay include blue crab (*Callinectes sapidus*), accounting for 28 percent of coastal Texas landings from 1997-2001 and worth $1.6 million in 1998, and eastern oyster (*Crassostrea virginica*), which accounts for 91 percent of Texas landings from 1997-2001 worth an estimated $13.2 million in 1999. The blue crab fishery in Texas went through a developing phase from 1960 – 1982, a mature phase from 1983 – 1991, and was senescent or declining from 1992 – 2005; with peak landings of 11.7 million pounds in 1987 to 3.1 million pounds (the lowest in 38 years) in 2005 with landings in Galveston Bay declining steadily since the late 1980s (Sutton and Wagner 2007). Galveston Bay commercial finfish landings ($234,000 in 1999) pale in comparison to shellfish landings and typically only account for about 7 percent of annual coastal Texas finfish landings (Robinson et al. 1998). Commercial finfish landings in the bay are primarily comprised of mullet (*Mugil cephalus*) at 26 percent, southern flounder (*Paralichthys lethostigma*) at 13 percent, black drum (*Pogonias cromis*) at 11 percent, and sheepshead (*Archosargus probatocephalus)* at 10 percent, in order of decreasing pounds landed from 1991 to 2001.

The Texas recreational fishery is an economically important segment of the total coastal fishery industry with resultant direct expenditures translating to over $2 billion annually to the State's economy (TWDB 1987). Recreational fishing in the Galveston Bay system accounts for almost 40 percent of this coastal fishing and 35 percent of the landings, and is accomplished through the issuance of over 262,000 fishing licenses and caught by anglers using primarily hook and line equipment (TPWD 2000). The primary species targeted and landed by recreational fisherman include Atlantic croaker, sand sea trout, southern flounder, red drum, and spotted seatrout. Galveston Bay yielded the most recreational marine fish landed (40% of the state total) when compared to other Texas Bays between 1993 and 2003 (GBEP 2011). Annual private-boat fishing pressure and landings average at least three times greater in Galveston Bay than in any other Texas bay system during the 1998-2008 timeframe (Green and Campbell 2010).

Although commercial and recreational fishing is important in the Galveston Bay area, much of the bay is subject to fishing restrictions and consumption advisories (DSHS 2016). The HSC northwest of Morgans Point is currently within an area prohibited for shellfishing. This designation means the area is closed to the harvesting of molluscan shellfish. The area from Morgans Point south to channel marker 72 is in an area designated as restricted (the area is closed to the harvesting of shellfish for direct marketing); while the HSC from marker 72 south to marker 33 is within a conditionally approved area (which means the status is subject to change based on meteorological or hydrological conditions).

The HSC and all contiguous waters north of the Fred Hartman Bridge, State Highway 146 including the San Jacinto River below the Lake Houston Dam are under restrictions due to dioxins and PCBs. It is recommended that adults should limit consumption of all species of fish and blue crabs from this area to no more than one (1) eight ounce (8 oz.) meal per month; and women of childbearing age and children under twelve (12) years old should not consume any fish or blue crabs from this area.

The Upper Galveston Bay area north of a line drawn from Red Bluff Point to Five-Mile cut marker to Houston Point is also within a consumption advisory area for blue crabs, catfish and spotted seatrout. It is recommended that adults limit consumption of blue crab, catfish and spotted seatrout from this area to no more than one (1) eight ounce (8 oz.) meal per month; and that women who are nursing, pregnant, or who may become pregnant and children under twelve (12) years old should not consume blue crab, catfish or spotted seatrout from this area. All of Galveston Bay is within a consumption advisory area by the TDSHS for all catfish species due to PCBs and dioxins in edible tissue.

1.4.5 Protected Species

The U.S. Fish and Wildlife Service (USFWS) and NMFS have responsibilities under the Endangered Species Act (ESA) of 1973 to protect species Federally-designated as threatened or endangered. Threatened and endangered (T&E) species are known to occur in the study area. However, actual occurrence of a species depends upon the availability of specific suitable habitat, the seasonal climate relative to a species' temperature tolerance, migratory habits, and other factors. Other Federal acts afford specific protection for species relevant to the study area. The following subsections describe the protected species in the study area.

1.4.5.1 Threatened and Endangered Species

Federal T&E designation information from USFWS and NMFS was consulted to develop a list of the T&E species present in the subject counties of the HSC ECIP study area. These are listed in **Table G1-18**. This list includes the federally-listed T&E species that could be present in the area based upon their geographic range. However, many species, such as most terrestrial and freshwater species do not have habitat relevant to areas near a potential project for this study, and some, such as the smalltooth sawfish are considered to be locally extirpated. To focus the description of T&E species on habitat most likely to be impacted by a potential project, the habitat types and critical habitat designations within 500 feet of the current HSC was reviewed. Additionally, existing PAs adjacent to the channel study segments were considered.

Of the Federal species listed in **Table G1-18**, only sea turtles are likely to occur within the project area. However, piping plover and red knot, may be found in the shoreline adjacent to the project area for this study, at the far southern end of the study. This habitat is more than a mile away from the TSP footprint. There is no designated critical habitat for any species located directly within the 500-foot buffer of the project area of the HSC or the BSC and BCC side channels. However, piping plover critical habitat is located near the southern end of HSC study Segment 1, on either side of the Bolivar Roads portion of the channel: approximately 2 miles away at Bolivar Beach on the southern end of Bolivar Peninsula, and approximately 1.5 miles away on Big Reef Nature Park on the northern Galveston Island. Loggerhead critical habitat (Sargassum habitat) was designated in offshore waters of the Gulf of Mexico, approximately 6 miles from the proposed TSP's southern limit. This is discussed in more detail in **Section 1.4.6.2**. Refer to the Biological Assessment (BA) in **Appendix K** for more details regarding the federally listed species that may be affected by the TSP.

In addition to the federally protected species, the TPWD maintains a separate county-specific list of threatened and endangered species that may potentially occur as a resident or migrant in the project area. The TPWD protected species is also listed in **Table G1-18**. Of the State-listed species that are not also listed on the Federal list of protected species, only the reddish egret and white-faced ibis are likely to occur in the areas around a potential project for this study.

A BA of the study area describing the federally-listed threatened and endangered species likely to occur and the potential impact associated with the proposed Federal actions has been prepared and is attached as **Appendix K**. The BA accounts for any species that have been added to or deleted from the USFWS and NMFS Federal lists of endangered and threatened species, presents any new information regarding the previously assessed species, and provides an effects determination based on habitats available that may be affected by the proposed action. The BA includes a list of federally-listed species under the jurisdiction of USFWS and/or NMFS. Of these species, only the bald eagle, piping plover, red knot, and sea turtles are likely to occur in areas adjacent to the project.

Only those species with a federally endangered or threatened status were considered in further detail in the attached BA. Those species with only a State-listed status were not considered in further detail in the BA. All species listed were compiled from USFWS and TPWD county-specific lists for Harris, Galveston, and Chambers County. State-listed species with “Species of Greatest Conservation Need” designation were also not considered due to their non-regulatory status under the ESA.

For the State-listed species that are not otherwise Federally-listed, only three wading bird species that use brackish marsh, could be expected to use habitat near the project area in the vicinity of existing PAs. Wood stork (*Mycteria americana*), Reddish egret (*Egretta rufescens*), and White-faced Ibis (*Plegadis chihi*) use shallow brackish or saltwater marsh habitat mainly for foraging. The existing BU marshes contain this type of habitat, created by the construction and maintenance of the previous improvements to the HSC. All other State-listed species are birds, fish, mammals, mollusks, turtles or reptiles that require terrestrial, freshwater, or other types of habitat not associated with the project area. For example, the Creek chubsucker (*Erimyzon oblongus*), is a freshwater fish that prefers headwaters of streams, far upstream of tidal portions of rivers, and the Sandbank pocketbook (*Lampsilis satura*) is a freshwater mussel inhabiting gravel and sand bottom rivers. Generally, these species are associated with freshwater, terrestrial, or shoreline habitats not present in the project area.

Table G1-18: Federally-Listed Threatened and Endangered Species in Chambers and Harris Counties

Common Name	Scientific Name	Listing Status		
		USFWS[1] IPaC List	TPWD[2]	NMFS[3] List for State of Texas
Amphibians				
Houston toad	*Anaxyrus houstonensis*	E[6], CH[4]	E	NA
Birds				
American peregrine falcon	*Falco peregrinus anatum*	NL	T	NA
Attwater's greater prairie-chicken	*Tympanuchus cupido attwateri*	E	E	NA
Bald eagle	*Haliaeetus leucocephalus*	NL	T	NA
Eskimo curlew	*Numenius borealis*	E[6]	E	NA
Peregrine falcon	*Falco peregrinus*	NL	T	NA
Piping plover[#]	*Charadrius melodus*	T, CH[4]	T	NA
Red Knot[#]	*Calidris canutus rufa*	T	NL	NA
Red-cockaded woodpecker	*Picoides borealis*	E[6]	E	NA
Reddish egret	*Egretta rufescens*	NL	T	NA
Swallow-tailed kite	*Elanoides forficatus*	NL	T	NA
White-faced Ibis	*Plegadis chihi*	NL	T	NA
White-tailed hawk	*Buteo albicaudatus*	NL	T	NA
Whooping crane	*Grus americana*	E[6], CH[4]	E	NA
Wood stork	*Mycteria americana*	NL	T	NA
Fishes				
Creek chubsucker	*Erimyzon oblongus*	NL	T	NL
Smalltooth sawfish	*Pristis pectinata*	NL	E	E
Invertebrates				
Lobed star coral	*Orbicella annularis*	NA	NL	T
Mountainous star coral	*Orbicella faveolata*	NA	NL	T
Boulder star coral	*Orbicella franksi*	NA	NL	T
Elkhorn coral	*Acropora palmata*	NA	NL	T, CH[4]
Mammals				
Finback whale	*Balaenoptera physalus*	NL	NL	E
Sei whale	*Balaenoptera borealis*	NL	NL	E
Sperm whale	*Physeter macrocephalus*	NL	NL	E
West Indian Manatee	*Trichechus manatus*	E, CH[4]	NL	NL
Louisiana black bear	*Ursus americanus luteolus*	NL	T	NL
Rafinesque's big-eared bat	*Corynorhinus rafinesquii*	NL	T	NL
Red wolf	*Canis rufus*	E[6]	E	NL
Mollusks				
Texas pigtoe	*Fusconaia askewi*	NL	T	NL
Sandbank pocketbook	*Lampsilis satura*	NL	T	NL
Louisiana pigtoe	*Pleurobema riddellii*	NL	T	NL
Reptiles				
Alligator snapping turtle	*Macrochelys temminckii*	NL	T	NA
Atlantic hawksbill sea turtle	*Eretmochelys imbricata*	E, CH[4]	E	E
Green sea turtle[#]	*Chelonia mydas*	T, CH[4]	T	T
Kemp's Ridley sea turtle[#]	*Lepidochelys kempii*	E	E	E
Leatherback sea turtle	*Dermochelys coriacea*	E, CH[4]	E	E
Loggerhead sea turtle[#]	*Caretta caretta*	T, CH[4]	T	T
Northern scarlet snake	*Cemophora coccinea copei*	NL	T	NL
Smooth green snake	*Liochlorophis vernalis*	NL	T	NL
Texas horned lizard	*Phrynosoma cornutum*	NL	T	NL
Timber/Canebrake rattlesnake	*Crotalus horridus*	NL	T	NL
Plants				
Texas prairie dawn	*Hymenoxys texana*	E	E	NA

[1] USFWS 2016,
[2] TPWD 2016; [3] NOAA/NMFS 2016; [4] Critical Habitat is listed, but not present within the project study area
[5] E = Endangered; T = Threatened; CH = Critical Habitat has been designated NL = Not Listed; NA = Not Applicable [6]Not listed by USFWS IPaC to be within the project area 2016
[#]Federal- listed species likely to be found in the project area.

1.4.5.2 Migratory Birds

The MBTA of 1918 states that it is unlawful to kill, capture, collect, possess, buy, sell, trade, or transport any migratory bird, nest, or egg in part or in whole, without a federal permit issued in accordance with the Act's policies and regulations.

The majority of the Project Area is located in a marine habitat, and the majority of the adjacent terrestrial area is industrially developed; therefore there are limited areas for nesting and rookeries that are directly near the channel Project Area. The TxGLO in cooperation with TPWD and USFWS mapped colonial waterbird rookeries including the Galveston Bay area using generalized boundaries. This mapping identified portions of several active dredged material PAs or other dredge material placement islands as supporting colonial waterbird rookeries. These include Atkinson Island, Alexander Island, and Goat Island. The USFWS has listed 41 migratory birds that may utilize other land areas or islands near the Project Area (USFWS 2017). Thirteen of the 41 are year-round residents and may utilize the PAs and the limited sand beaches, mud or sand flats that are adjacent to the Project Area such as the American oystercatcher (*Haematopus palliatus*) or Sandwich tern (*Thalasseus sandvicensis*). These same habitat areas may be utilized by the 17 over-wintering migrant species such as Long-billed Curlew (*Numenius americanus*) or Whimbrel (*Numenius phaeopus*). Nine species have been documented that breed in the area such as the Snowy plover (*Charadrius alexandrinus*) and may utilize the limited habitat adjacent to the Project Area. Two have been documented to migrate through the area: Hudsonian godwit (*Limosa haemastica*) and Worm eating warbler (*Hemitheros vermivorum*).

Table G1-19: Migratory Birds Listed by USFWS that may be in the Project Area

Common Name	Scientific Name	Season(s)
American Oystercatcher	*Haematopus palliatus*	Year-round
Bald Eagle	*Haliaeetus leucocephalus*	Year-round
Black Rail	*Laterallus jamaicensis*	Year-round
Black Skimmer	*Rynchops niger*	Year-round
Brown-headed Nuthatch	*Sitta pusilla*	Year-round
Buff-bellied Hummingbird	*Amazilia yucatanensis*	Year-round
Burrowing Owl	*Athene cunicularia*	Year-round
Dickcissel	*Spiza americana*	Breeding
Fox Sparrow	*Passerella iliaca*	Wintering
Gull-billed Tern	*Gelochelidon nilotica*	Year-round
Henslow's Sparrow	*Ammodramus henslowii*	Wintering
Hudsonian Godwit	*Limosa haemastica*	Migrating
Lark Bunting	*Calamospiza melanocorys*	Wintering
Le Conte's Sparrow	*Ammodramus leconteii*	Wintering
Least Bittern	*Ixobrychus exilis*	Breeding

Least Tern	*Sterna antillarum*	Breeding
Lesser Yellowlegs	*Tringa flavipes*	Wintering
Loggerhead Shrike	*Lanius ludovicianus*	Year-round
Long-billed Curlew	*Numenius americanus*	Wintering
Magnificent Frigatebird	*Fregata magnificens*	Wintering
Marbled Godwit	*Limosa fedoa*	Wintering
Mississippi Kite	*Ictinia mississippiensis*	Breeding
Nelson's Sparrow	*Ammodramus nelsoni*	Wintering
Painted Bunting	*Passerina ciris*	Breeding
Peregrine Falcon	*Falco peregrinus*	Wintering
Prothonotary Warbler	*Protonotaria citrea*	Breeding
Red Knot	*Calidris canutus rufa*	Wintering
Red-headed Woodpecker	*Melanerpes erythrocephalus*	Year-round
Reddish Egret	*Egretta rufescens*	Year-round
Rusty Blackbird	*Euphagus carolinus*	Wintering
Sandwich Tern	*Thalasseus sandvicensis*	Year-round
Seaside Sparrow	*Ammodramus maritimus*	Year-round
Sedge Wren	*Cistothorus platensis*	Wintering
Short-billed Dowitcher	*Limnodromus griseus*	Wintering
Short-eared Owl	*Asio flammeus*	Wintering
Snowy Plover	*Charadrius alexandrinus*	Breeding
Swainson's Warbler	*Limnothlypis swainsonii*	Breeding
Whimbrel	*Numenius phaeopus*	Wintering
Wilson's Plover	*Charadrius wilsonia*	Breeding
Worm Eating Warbler	*Helmitheros vermivorum*	Migrating
Yellow Rail	*Coturnicops noveboracensis*	Wintering

1.4.5.3 Marine Mammals

The Marine Mammal Protection Act (MMPA) was passed in 1972 and amended through 2007. It establishes a moratorium on the taking and importation of marine mammals and marine mammal products, with certain exceptions. It is intended to conserve and protect marine mammals and it established the Marine Mammal Commission, the International Dolphin Conservation Program, and a Marine Mammal Health and Stranding Response Program. Review and consultation for the MMPA is triggered via the ESA when actions involve marine mammals.

The only marine mammals covered under the MMPA expected to regularly be present in Galveston Bay are bottlenose dolphins (*Tursiops truncatus*). The West Indian manatee, (*Trichechus manatus*), is only rarely present as a transient when they wander or are displace from their normal range in Florida and northern Mexico.

1.4.6 Protected/Managed Lands

1.4.6.1 Wildlife Management Areas

Atkinson Island is located approximately 0.7 miles east of the proposed project area. The northern end of Atkinson Island just beyond PA 16 is listed as a wildlife management area (WMA) managed by the TPWD. The island has been used as a case study for a wetland restoration project using dredged materials. Wildlife on the island includes shore and wading birds, raccoons, and rattlesnakes. On the island is a 40-acre wooded lot composed mainly of hackberry and yaupon and a 90-acre area comprised of brackish marsh (TPWD 2012a). All other WMAs are located farther than 10 miles away around Galveston Bay.

1.4.6.2 Critical Habitat Areas

There are two piping plover critical habitat areas located on either side of Bolivar Roads near the southern end of the study Segment 1: Bolivar Beach on the southern end of Bolivar Peninsula approximately 2.0 miles east of the southern study limit, and on Big Reef Nature Park on the northern Galveston Island approximately 1.5 miles south of the southern study limit. Loggerhead critical habitat was designated in offshore waters at the 10 meter depth contour of the Gulf of Mexico, approximately 6 miles from the proposed TSP's southern limit. The designation was based on the waters providing Sargassum seaweed habitat, which harbors the majority of juvenile Loggerhead turtles. An existing Ocean Dredged Material Disposal Site (ODMDS No. 1) is located in the designated waters and is currently permitted for placement of maintenance material from of the lower segment of the HSC. More details on piping plover and Loggerhead turtle are discussed in threatened and endangered species section and within the BA in Appendix K.

1.5 Cultural Resources

The Houston Ship Channel is located along the upper Texas coast and has been occupied by humans since the Paleoindian period dating to around 11,500 BP. The study area is characterized by upland coastal prairies dissected by streams and rivers and an extensive bay and estuarine systems along the coast. The study area is primarily drained by the Trinity River, the San Jacinto River, and Buffalo Bayou. Sediments in the region are generally fluvial sandy and silty clays overlying Pleistocene aged clay. Prehistoric sites are commonly found within these upper sediments along streams and rivers and the along the shorelines of the bays and gulf coast, close to prime areas for resource exploitation. These sites include campsites, dense shell middens, and cemeteries, containing projectile points, stone, bone, and shell tools, aquatic and terrestrial faunal remains, hearth features, ceramics, and in some cases human remains and associated funerary objects. Historic aged resources in the region consist of farmsteads and ranches, houses, buildings, bridges, tunnels, oil industry structures, cemeteries, lighthouses, shipwrecks, and the ruins of these buildings and structures. Although historic resources can occur anywhere, these sites tend to be concentrated in small towns and urban areas, along roads, and within current and historic navigation paths. Shipwrecks may also occur in numerous locales due to the dynamic nature of the sea floor and bay bottoms and the lack of navigation improvements until the latter part of the 19th century. These dynamic conditions can result in shifting shoals and reefs that endanger ships as well as bury their wrecks as shorelines and bars migrate through time.

There are an estimated total of 194 cultural resources located within one mile of the Houston Ship Channel. These cultural resources include two National Historic Landmarks, four National Register of Historic Places listed properties, 143 archeological sites, 16 cemeteries, and 29 shipwrecks and submerged resources. The two National Historic Landmarks in the study area include the San Jacinto Battlefield and the Battleship Texas. The four National Register Properties are generally located in urban areas and consist of historic houses, commercial and government buildings, and structures represented by the Morgans Point Historic District, Pomeroy Homestead, Ross S. Sterling House, and the Washburn Tunnel.

The primary considerations concerning cultural resources are threats to submerged resources from dredging, wake-induced erosion of shoreline sites, and from construction of new DMPAs. A large portion of the study area, especially along the margins of the ship channels, has been altered for industrial and commercial use. As such, in upland areas, the probability for intact prehistoric archeological sites to occur is low. However, there is a moderate to high potential for encountering historic age archeological sites, as well as historic age structures and buildings. For the marine portions of the study area, the potential for encountering submerged cultural resources, such as shipwrecks, is moderate. Although much of the area has been dredged in years past, the very dynamic nature of the study area means that submerged resources may occur anywhere.

1.6 Socioeconomic Considerations

This section provides information on existing population, demographics, and community and recreational resources within the project area. For the population and demographic existing conditions were examined at the County, City, and Census tract levels for areas that encompass the proposed project improvements.

The existing conditions for community and recreational resources a half-mile buffer was placed around the main project channel. The proposed project is expected to have minimal impacts to the human environment because all construction activities will be located in the open water (Galveston Bay) and uninhabited man-made dredge sediment placement islands in Galveston Bay.

1.6.1 Population, Employment, and Income

The proposed project is located in Chambers, Galveston, and Harris counties, and is located within or adjacent to the city limits of Baytown, Deer Park, Galena Park, Galveston, Houston, La Porte, Morgans Point, Pasadena, Seabrook, Shore Acres, and Texas City. A majority of the proposed project is located within the open water of Buffalo Bayou and Galveston Bay; therefore, it is not located within City limits.

The 2000 and 2010 Census population and the 2010-2014 (2014) 5-year American Community Survey (ACS) population estimates for counties in the project area are shown in **Table G1-20**. Between 2000 and 2014, the population for Chambers, Galveston, and Harris counties is estimated to have increased by approximately 49, 29, and 33 percent, respectively.

Table G1-20: Population Statistics for Chambers, Galveston and Harris County

Geographic Area	Population		
	2000	2010	2014
Chambers County	26,031	35,096	38,863
Galveston County	250,158	291,304	322,225
Harris County	3,400,578	4,093,076	4,538,028

U.S. Census 2000, and 2010, and ACS 2014

According the Texas Workforce Commission (TWC), the civilian labor force in Chambers, Galveston, and Harris Counties is 18,244; 159,958; and 2,275,980 percent, as of August 2016, respectively (TWC 2016). The unemployment rate is 6.8, 5.9, and 5.8 percent (TWC 2016).

Median household income (MHI) at the Census tract and block group's levels are included in **Table G1-21** (ACS 2014) for Chambers, Galveston, and Harris counties, in addition to the cities/communities completely or partially within the study area. MHI is defined as the income of householders and all other individuals 15 years or older (U.S. Census 2014). The average MHI within the 20 Census Tract Area ranges from a low of $27,321 in Tract 7240.00 to a high of $77,470 in Tract 3416.00. One of the Census tracts has no data for average MHI due to not enough data being available for an estimate by the U.S. Census Bureau, likely because Tract 7106.00 is located in Galveston Bay.

Table G1-21: Median Household Income for Chambers, Galveston and Harris County

Geographic Area	Median Household Income
20 Census Tract Area	$48,874
Brazoria County	$68,008
Chambers County	$48,874
Galveston County	$61,555
Cities/Census Designated Place (CDP)	
Baytown	$45,638
Deer Park	$77,612
Galena Park	43,586
Galveston	$38,008
Houston	$45,728
La Porte	$67,806
Morgans Point	$74,583
Pasadena	$46,585
Seabrook	$79,308
Shore Acres	$103,352
Texas City	$102,811

Source: ACS 2014

1.6.2 Demographics

Area demographics are best represented through defining population, race, and ethnicity on a regional (i.e., by county and city designation) and more specific (i.e., the identified Census tracts that intersect or are within the study area) level. **Table G1-22** presents the area's population and racial/ethnic distribution. As shown, the percent minority within 11 cities/communities within or directly adjacent to the project area and three counties in the project area (U.S. Census 2010).

Table G1-22: Population and Demographic Statistics in the Study Area, Associated Counties, and Local Cities/Census Designated Place

	Population	Hispanic	White	Black or African American	American Indian and Alaska Native	Asian	Native Hawaiian and Other Pacific Islander	Some Other Race	Two or more races	Percent Minority
County										
Chambers County	35,096	18.9	70.6	8.0	0.4	0.9	0.0	0.1	1.1	29.4
Galveston County	291,309	22.4	59.3	13.5	0.4	2.9	0.0	0.1	1.4	40.7
Harris County	4,092,459	40.8	33.0	18.4	0.2	6.1	0.1	0.2	1.2	60.7
Cities and Census Designated Place (CDP)										
Baytown	71,802	43.4	38.7	15.0	0.3	1.4	0.0	0.2	1.0	61.3
Deer Park	32,010	26.3	69.5	1.3	0.3	1.4	0.1	0.1	1.0	30.5
Galena Park	10,887	81.4	11.4	6.6	0.1	0.1	0.0	0.2	0.2	88.6
Galveston	47,743	31.3	45.0	18.6	0.4	3.1	0.0	0.1	1.4	55.0
Houston	2,099,451	43.8	25.6	23.1	0.2	5.9	0.0	0.2	1.1	74.4
La Porte	33,800	29.4	61.5	5.9	0.4	1.1	0.1	0.1	1.4	38.5
Morgans Point	339	25.1	61.4	10.0	1.5	0.6	0.0	0.0	1.5	38.6
Pasadena	149,043	62.2	32.7	2.0	0.2	2.1	0.0	0.1	0.7	67.3
Seabrook	11,952	14.2	75.3	3.9	0.4	4.3	0.0	0.1	1.7	24.7
Shoreacres	1,493	17.4	78.6	1.5	0.5	0.5	0.0	0.2	1.2	21.4
Texas City	45,099	27.0	41.0	29.2	0.3	1.0	0.0	0.1	1.3	59.0
20 Tract area										
20 Total Census Tracts Average	3,555	52.0	32.0	9.1	0.4	0.7	0.0	0.1	0.7	68.0

Source: U.S. Census 2010 (Summary File 1, Table P9).

[a] Percent minority includes all non-white races and persons of Hispanic origin.

[b] The 20 Census tracts that intersect or are within the study area.

1.6.3 Community Resources and Facilities

The community resources within the half-mile buffer of the project area are discussed below, and shown in Figure G3-7 through Figure G3-9.

<u>Police, Fire Protection and Emergency Services</u>

Port of Houston Fire Department (HFD) provides emergency response along the ship channel, and the United States Coast Guard provides security and emergency response services for open water areas in the project area. Within the half-mile buffer of the project area there are two fire stations. Both of the fire stations also have special duties dealing with the Port of Houston such as rescue and evacuation boats and the HFD regional hazmat station.

Schools and Educational Facilities

As the area of a potential project is anticipated to be in the middle of open water of the HSC and Galveston Bay, there are no educational facilities within the project area. Two schools are located in in the communities on the mainland within the half-mile buffer of the project area and include De Zavala Elementary School, and J.R. Harris Elementary school.

Cemeteries, Historical Markers and Places of Worship

Since the planning area is primarily in open water of the HSC Galveston Bay, there are no cemeteries or places of worship within the project area. However, within the study area of the project in the communities on the mainland surrounding the project area, there are numerous places of worship and some cemeteries and historical markers.

Four cemeteries were identified within the half-mile buffer of the project area in the upper reach of the HSC and include Glendale Cemetery, Crow Hill Cemetery, De Zavalla Cemetery and Lynchburg Cemetery. Some of these cemeteries are historical cemeteries.

Eight historical markers identified as Thomas H. Ball, Jr.; Buffalo Bayou, Brazos & Colorado Railroad; San Jacinto Battle; Holy Cross Mission (Episcopal); De Zavala Plaza; Glendale Cemetery; Crown Hill Cemetery; and Galveston Quarantine Stations were all located within the half-mile buffer of the project area .

Thirty-eight places of worship were identified with within the half-mile buffer of the project area. A majority of the places of worship are located in neighborhoods adjacent to HSC from the Turning Basin to the Boggy Bayou.

1.6.4 Recreational Resources

Recreational activities in the project area of the include duck hunting, saltwater fishing, swimming, sailing, nature viewing, pleasure boating, camping, picnicking, and sightseeing. Ecotourism, or tourism that is based on nature rather than man-made attractions, is the tourist industry's most rapidly expanding sector.

Within Galveston Bay, more than 20 percent of the region's population participates in saltwater fishing and the use of open space and about 15 percent enjoys saltwater boating (GBEP 2011). A 1993 study found that the proportion of area residents expected to annually participate in walking, saltwater swimming, and picnicking is well over 40 percent (GBEP 2011). Approximately 34 percent of Houston-Galveston Bay households were likely to use the bay at least once a year for recreational purposes including swimming, picnicking, shoreline walks, bird or wildlife watching, and fishing (GBNEP 1994b). A general recreational activity summary indicated that 27 percent of Texas travel destination in the Gulf Coast Region, defined by the

Texas Department of Economic Development (TDED) as the Houston, Galveston-Texas City, and Brazoria Metropolitan Statistical Areas, include nature or outdoor sports activities (TDED 1999).

Tourism in the Gulf Coast Region creates notable economic benefit to the community and provides employment. In 1999, overall recreation-related travel spending in the region contributed over $5 billion to the economy and grew at an average rate of 6.6 percent annually over 4 years. For the same year, TDED reported that recreation-related travel spending for Texas destinations was an estimated $700 million and generated 10,700 jobs (TDED 1999).

Table G1-23 below lists the parks, colonial waterbird rookeries, marinas and boat ramps and related recreational resources within 0.5 mile of the HSC. The colonial waterbird rookeries areas are discussed in this section because many nature and bird watchers have unique opportunities to view the colonial waterbird rookeries, defined as a large bird colony or large congregations of individual or more than one species of the bird that nest in area. Many species of birds seek out islands along the Texas coast to raise their young during summer (Audubon 2016).

Table G1-23: Recreational Resources in the Project Area

Recreational Resource	Address/Location
Parks	
Buffalo Bend Nature Park	POH turning basin
Hidalgo Park	7000 Avenue Q, Houston, Texas 77011
De Zavala Park and Swimming Pool	7520 Avenue H, Houston, Texas 77012
Peiser Park	8510 Manchester St., Houston, Texas 77012
Hartman Park and Community Center	9311 E, Avenue P, Houston, Texas 77012
San Jacinto Battleground State Historical Park, San Jacinto Monument, and Battleship Texas	3523 Independence Pkwy, LaPorte, Texas 77571
Baytown Nature Center and Park (undeveloped)	Baytown, Texas
Seawolf Park and USS Seawolf monument	Pelican Island
Bayland Park	Baytown, Texas
Colonial Waterbird Rookery Areas (CWRA)	
Atkinson Island Bird Colony	Galveston Bay
Alexander Island	Galveston Bay
Baytown Tunnel	Galveston Bay
Goat Island	Galveston Bay
Redfish Island	Galveston Bay
Pelican Island CWRA	Galveston Bay
Fort San Jacinto CWRA	Galveston Bay
Marina's and Boat Ramps	
Morgans Point	
The Galley (boat ramp)	Near SH 146
Tabb's Bay (boat ramp)	Near SH 146
Morgans Point (boat ramp)	Near Barbours Cut Channel
Mary's Bait Camp (boat ramp)	Near Barbours Cut Channel
Texas City Dike Marina	Texas City Dike

Source: H-GAC 2011, Texas General Land Office 2007 and 2009,

By law boats, sail boats, motorized boats, and U.S. Coast Guard (USCG) documented vessels, must be registered with TPWD when on Texas public water. About 90,000 pleasure boats are registered in Galveston Bay. Galveston Bay has the 3rd highest concentration of privately-owned marinas in the U. S. (TCEQ 2007). There are many popular boating and yacht clubs within the Galveston Bay area that utilize the bay for their boating activities, including but not limited to the Houston Yacht Club and Seabrook Sailing Club. The existing HSC also has three existing boaters cuts crossing the HSC Bay Reach study Segment 1 that were excavated as crossings for deeper-drafting recreational vessels across previous spoil banks at the margins of the current HSC. These are South Boaters Cut, North Boaters Cut located south and north of Mid Bay PA, and Five Mile Cut, just south of the BSC. These are used by the sailing community to access Trinity Bay coming from Galveston Bay west of the HSC, where the major recreational marinas are located.

2 NO ACTION/FUTURE WITHOUT-PROJECT CONDITIONS

This section provides the supporting detail and further discussion of the Future Without-Project (FWOP) conditions and No Action alternative where needed, to supplement Chapter 3, No Action/Future Without-Project Conditions, of the Main Report. Not all resources are discussed in this section for the No Action alternatives or for FWOP conditions, as they are sufficiently discussed in the Main Report, and do not need supporting detail in this appendix.

2.1 Climate

Climate change could impact the project area through precipitation, temperature, drought and sea level change. Predictions of changes to these climate factors under low and high global Greenhouse Gas (GHG) emissions scenarios during future periods are discussed. A variety of climate prediction tools and resources were used to assess potential climate change factors on the project area. NOAA's Climate Explorer Tool was used to assess county level impacts (temperature, precipitation) associated with climate change to year 2090. The U.S. National Climate Assessment (NCA) was reviewed to assess various changes to temperature, precipitation, extreme weather, and hurricanes at a regional scale from years 2041 to 2070 for low and high GHG emissions scenarios. The NCA provides summary forecasts from three sets of models, while NOAA's Climate Explorer focuses on results from one of those model sets (Melillo et al. 2014, NOAA 2016). The following discusses the predicted future climate changes relevant to the study area and this deep draft navigation study.

Climate change and GHG emissions are expected to alter future weather patterns including precipitation. Climate change mapping in the NCA for Texas (Great Plains Region) indicates there would be little change in the number of annual heavy precipitation days (defined as the seven wettest days of the year) over the period 2041-2070 in the Harris, Galveston, and Chambers County area. The change predicted is between 0 and 0.2 day under the low emissions scenario and between 0.2 and 0.6 day under the high emissions scenarios, approximately between a 0 and 9 percent change (Melillo et al. 2014). Precipitation in any given year is influenced by many local, regional and global factors such as seasonal cold fronts from Canada, tropical systems form the Gulf of Mexico, and multi-year weather patterns like El Niño; therefore, it varies widely from year to year (TWDB 2012).

Human-induced climate change impact on extreme weather events (hurricanes, tropical storms) has still not been determined and continues to be studied, but these events are generally expected to increase in intensity with a warming climate (Melillo et al. 2014). Whether and how much hurricanes impact a particular area depends on storm tracks, intensity during land fall, coincidence with tides, and other storm attributes. These are potentially influenced by many complex climate factors such as atmospheric and sea surface temperatures, and natural periodic climate oscillations that continue to be studied for their effect on tropical storm events (Melillo et al. 2014). Therefore, forecasting whether the frequency of hurricanes impacting a particular area due to climate change is not yet possible. Though the relative contributions of human and natural causes on changes in extreme weather events (e.g. hurricanes) is still uncertain, and projections from modeling to forecast changes still equivocal, one consistent indication from climate change models is an increase in hurricane rainfall rates predicted with increasing average temperatures (Melillo et al. 2014). These results generally indicate projected increases of about 20 percent averaged near the center of hurricanes.

Climate change mapping in the NCA for Texas (Great Plains Region) indicates that in the Harris and Galveston County area, there would be dramatic increase in the number of days with the hottest temperatures between 2041-2070. The mapping indicates a change in number of the annual hottest days (defined as the hottest two percent of days of the year [about 7 days] from the 1971-2000 historical data) would effectively double or quadruple depending on the emissions scenario. The annual hottest days from the 1971-2000 historical data generally range from 95° F to 105°F in Texas. The mean daily maximum temperature for Harris County would be expected to increase from approximately 80° F from year 2016 to approximately 88° F in 2099 (NOAA 2017). The mean daily maximum temperature for both Chambers and Galveston County would be expected to increase from nearly 79° F from year 2016 to approximately 87° F in 2099 (NOAA 2017).These data indicate an increase in the frequency and magnitude of the warm temperature extreme.

An increase in extreme heat events would generally be expected to increase drought and wildfire risk, though wildfire risk would not be very relevant in this project setting. The most relevant climate change measure for drought is the projected change in consecutive dry days. According to the NCA, during the period 2041-2070, a relatively small change in the number of consecutive dry days is projected. Under the low emissions scenario, one to three extra consecutive dry days are projected for the Harris County area, representing an approximate change of 4 to 15 percent over the 20 to 25 consecutive dry-day historical average. Under the high emissions scenario, two to three extra consecutive dry days are projected for the Harris County area representing an approximate change of 8 to 15 percent. Droughts occur during prolonged periods of no precipitation that are part of the multi-decadal weather pattern, such as the drought of record in Texas in 2011 through 2012, which has been attributed to the cooler-than-normal water temperatures in the Pacific Ocean or La Niña (NOAA 2012).

As discussed in ER 1100-2-8162, *Incorporating Sea Level Change in Civil Works Programs*, research by climate science experts predicts continued or accelerated climate change for the 21st Century and possibly beyond, which will cause a continued or accelerated rise in global mean sea-level. Therefore, impacts to coastal and estuarine zones caused by future sea-level change must be considered in Civil Works projects. **Sections 2.2** and **3.1.4.3** details the analysis of future relative sea-level change (RSLC) in accordance with the regulation, and consideration of impacts to the TSP.

2.2 Population, Employment, and Income

The *Social, Economic and Demographic Characteristics of Metro Houston Report with Projections to 2040 and 2050* prepared by the Greater Houston Partnership (GHP) in 2014 discussed over the next four decades that Houston’s racial and ethnic composition will shift dramatically (GHP 2014). Population growth will come from the natural increase (births minus deaths) and from “net immigration”, which is people moving into the region minus people moving out. Two growth scenarios were evaluated; the Fast and Moderate Growth scenarios. The growth scenarios were examined for the Houston-The Woodlands- Sugar Land, and Texas Metropolitan Statistical Area which includes the 10 counties in the Houston regional area. **Table G2-1** below lists the population, and racial and ethnic composition project changes by decade from 2010 to 2050 for the fast and moderate growth scenarios.

Table G2-1: Population and Racial Ethnic Composition Changes between 2010 and 2050

Growth scenarios/population and Race/Ethnicity Types	Population, Racial and Ethnic Projections				
	2010	2020	2030	2040	2050
Fast Growth Scenario					
Total Population	5.9 M	7.4 M	9.3 M	11.6 M	14.4 M
Anglo	39.5 %	32.6%	26.2%	20.7%	16.1%
Black	16.8%	16.2%	15.1%	13.6 %	12.1%
Hispanic	35.4%	41.0%	46.5%	51.3%	55.3%
Other	8.2%	10.2%	12.2%	14.4%	16.5%
Moderate Growth Scenario					
Total Population	5.9 M	6.9M	8.0M	9.M	10.2 M
Anglo	39.5%	34.7%	30.0%	25.7%	21.8%
Black	16.8%	16.4%	15.7%	14.9%	13.9%
Hispanic	35.4%	39.7%	44.2%	48.6%	52.8%
Other	8.2%	9.2%	10.0%	10.8%	11.5%

Note: M= Million
Other includes Asian, Native American, and the population of more than one race.
Source: GHP 2014

Anglo populations are projected to decrease between 23 and 18 percent for the Fast and Moderate growth scenarios, respectively. The percent black population is projected to decrease but population numbers are projected to stay relatively the same. The Hispanic population is projected to increase to be over 50 percent of the population for both growth scenarios. The Other population category will also increase but not at the rate of the Hispanic population.

2.3 Air Quality

As discussed in the **Existing Conditions**, air quality has improved markedly in the HGB NAA, as a result of SIP actions and improved national emissions standards. The 2015 NAAQS for Ozone continues the trend of improvement in standards, and as discussed, will begin taking effect in the near future. Considering this, it is expected that improvements to air emissions controls implemented as a result of these SIP requirements and improving national emission standards for on-road and non-road sources will continue resulting in gradual air quality improvements. Outside of regulated pollutants, other regional trends are also contributing to reduced emissions. Power generation (e.g. electric utilities), which is a major part of the point source category, is increasingly coming from renewable or non-fossil fuel sources (e.g. wind, nuclear, solar). The increasing percentage of non-combustion power reflects the significant increase in renewable energy, most notably, wind power in Texas, with the percent of Texas power generated by non-combustion sources increasing from approximately 6 percent to 17 percent between 1990 and 2013 (EIA 2015). The HGB region's power grid is interconnected and managed at the state-level by the Electric Reliability Council of Texas power management region, and therefore local power demands would also increasingly use State-wide additions of wind turbine and other renewable generation. This trend would also be expected to contribute to gradual air quality improvements.

With respect to vessel activity associated with the HSC system, recent changes in national and international marine emissions standards will help reduce future marine vessel emissions, as specific requirements become applicable, or vessel replacement of older vessels occurs. These changes include the following:

- **More Stringent EPA Emissions Standards**. EPA CAA regulations passed in 2010 required new U.S. flagged or manufactured ocean-going vessels (OGV) with Category 3 marine diesel engines (the largest category) to have engines meeting Tier 2 standards by 2011 which would reduce NO_x from current standards by 15 to 25 percent. Thereafter, new engines must have met Tier 3 standards by 2016 which would reduce NO_x 80 percent from pre-2011 standards. Also, since 2015, all fuel produced and sold here for Category 3 engines must have reduced fuel sulfur content that bring the content down from a typical 30,000 parts per million (ppm) to 1,000 ppm.

- **North American Emissions Control Area (ECA) Designation**. In 2010, most of the North American coastal area, including the Gulf Coast was designated by the United Nations International Maritime Organization, to be an ECA that requires all OGVs to meet fuel and emissions standards similar to the EPA standards discussed above. The ECA is managed in the U.S. by the USCG, and it applies to all OGVs calling or traveling through ECA. Starting August 1, 2012, the standards for this ECA required, that fuel sulfur content was to be reduced to 10,000 ppm, and to 1,000 ppm in 2015. Starting in 2016, new engines must use NO_x or other ozone precursor exhaust after-treatment systems, to achieve reduced emissions equivalent to the EPA Tier 3 standard. Such systems include seawater-based scrubbers, and combustion temperature controls to reduce NO_x and sulfur oxides (SO_x) formation (Chopra 2016, Scott 2011, Wirth, 2009).

The EPA reduced sulfur fuel applies to new and existing vessels, which reduces SO_x emissions directly, and increases the performance of NO_x-reducing catalytic pollution controls (Chopra 2016). EPA Tier 2 and 3 emissions standards applies to new engines, which would take effect as the fleet of older vessels that do not meet these standards are replaced due to age. Similarly, the reduced-sulfur fuel use of the ECA standards would result in reduced SO_x and NO_x emissions with existing or new vessels, and NO_x after-treatment applicable to new engines would take effect as the fleet of older vessels are replaced due to age. It is expected that these ongoing improved emissions controls would contribute to the continuing trend of regional air quality improvement in the FWOP Condition. It is not anticipated that FWOP conditions of air quality will affect the problems and opportunities being specifically addressed by this deep draft navigation study.

3 ENVIRONMENTAL CONSEQUENCES

This section provides the supporting detail and further discussion of the environmental consequences of the TSP to supplement Chapter 7, Environmental Consequences, of the Main Report.

3.1 PHYSICAL RESOURCES CONSEQUENCES

3.1.1 Project Area

The TSP will not alter the characteristic of the project area. The project area can be characterized as consisting of a navigation channel system flowing through a predominantly industrial land use and marine environment, with minor areas of residential land use adjacent or in proximity to short segments of the channel (mainly in Segments 2 and 6).

3.1.2 Climate

The impacts of future climate changes on the TSP will not be significantly different than the impacts of these changes on the existing navigation channels in the No Action alternative. Chapter 3 of the Main Report describes the changes predicted for the area in **Section 2.1** which consists of significantly increased temperatures, a slight increase in heavy precipitation days, and a slight increase in drought conditions, represented by extra consecutive dry days. These changes will not particularly alter the efficacy of either the existing or proposed navigation channel improvements under the TSP since they do not appreciably alter the deep water and navigability of these channels. The change is RSLC will have mostly beneficial impacts, and some negative impacts, to a navigation channel, under both the TSP and No Action, which are described in **Section 3.1.4.3** below.

3.1.3 Topography, Soils, Geology and Groundwater

The modifications to the navigation channels of the TSP would not impact surface topography, but would have minor bathymetric changes in the vicinity of existing navigation channels.

Like the FWOP/No Action Alternative, the TSP would continue to result in periodic changes in topography from regular channel maintenance of dredged material at the existing PAs that are proposed for use. While local changes would occur to topography during construction of the TSP, these changes would occur on PAs, which are islands located away from the mainland, and would not alter topography or drainage patterns surrounding the project area or water resources. The TSP would be expected to have no impacts on the regional physiography and topography of the study area.

Under the TSP, no impacts to native surface soils within the project area would occur. A large portion of the new work material removed from the bay bottom would be clay and some sand. However, this would represent a very small percentage of the bay bottom's clay, which is primarily the Beaumont Formation covering much of Galveston Bay. Considering this information, this plan would result in no significant impacts to topography or soils.

Dredging to construct the TSP modifications to the HSC would minimally impact the local geology by redistributing existing bay bottom clays and sediments, causing potential increases of local shoaling rates within the HSC. Net changes to the local or regional nature of the existing geology of the study area would be minimal. Additionally, there would be no impacts or changes to geologic hazards such as faults and subsidence.

The TSP would not be expected to have indirect effects on topographical, soils, geology, or groundwater, for several reasons. Navigation channel modifications to existing channels are not expected to induce landside population growth or development as other social and economic factors (e.g. economy, jobs) influence this, and the study area is already highly developed. Therefore, impacts to those resources from associated human activity (e.g. land excavation, water consumption) would not occur due to the TSP.

3.1.4 Physical Oceanography

Channel modifications can have effects on salinity, circulation, tidal variation, and storm surge. Different improvements, deepening or widening, can impact each of these areas differently. A hydrodynamic model is being developed by the U.S. Army Engineer Research and Development Center (ERDC) to evaluate those hydrodynamic effects as well as sediment transport in the next planning phase after the release of this DIFR-EIS, with results to be included in the Final IFR-EIS. Recent studies involving hydrodynamic modeling of these effects for similar channel modification projects found minimal increases to surge levels, tidal variation, and small changes to salinity as a result of channel modifications. Some of these results are discussed below.

3.1.4.1 Tides, Currents, and Water Level

Channel deepening has the potential to affect surge and tidal variations by lowering the bay bottom relative to existing conditions and reducing hydraulic resistance. Storm surge hydrodynamic modeling of modifications to existing channels in the U.S. in areas exposed to hurricanes shows more often than not, these effects are minimal, even during more adverse surge conditions. Studies conducted for the Charleston Harbor Post 45-Foot Deepening and Savannah Harbor Expansion Projects indicated no significant adverse impacts from a propagated storm surge as it travels upstream through the river system and navigation channel due to harbor and channel deepening. The results of the modeling analysis conducted for the Charleston Harbor Deepening, indicate that the Post 45-Foot Project, which would deepen the existing channel by 7 feet from the entrance in the Atlantic Ocean through the estuary, would cause insignificant increases in peak storm surge water levels in the estuary with the maximum increase to storm surge produced by the project at 0.1 feet or less (Water Environment Consultants 2016). The modeling was conducted with a more refined and accurate hydrodynamic model than one previously used to screen effects in order to ensure project effects would not affect floodplain mapping. These results indicated changes that were less than the uncertainty in analysis being used for coastal regulatory floodplain mapping and therefore did not indicate the project would affect floodplain mapping. Hydrodynamic modeling to assess water level changes from tidal variation for the Charleston project showed maximum changes of 0.07 feet, which is negligible (USACE Charleston District 2014).

In the case of Savannah Harbor Expansion, the results from the hurricane surge modeling show that the change in water surface elevation due to the deepening the inner harbor is not significant (USACE Savannah District 2012a). The project consists of extending the entrance channel in the Atlantic, deepening the 42-foot channel by 5 feet from the entrance through the length of the existing channel up the Savannah River, some bend easings, and a turning basin expansion. The difference in the water surface elevation between the existing and future project depths during three storm events were simulated at two different times in the tide cycle including at high tide (USACE Savannah District 2012b). The maximum difference in the water surface elevations determined by the model was 0.9 feet during a 15-foot surge at the peak of high tide and is due to the larger volumes of water being transported through the system during the tidal cycle and storm surge. These larger volumes cause a slight increase in peaks during high tide and surge and slight decrease in lows during low tide. In conclusion, the hurricane surge modeling showed no significant adverse impacts, due to harbor deepening, to a propagated storm surge as it travels upstream through the river system and navigation channel.

A 10-year monitoring study of the Wilmington Harbor Deepening Project on the Cape Fear River found no clear evidence of changes to tides and salinity following deepening of the ship channel (Queram 2012). The monitoring followed the deepening of the channel by 4 feet to 42 feet of depth where pre-project modeling had predicted a maximum tidal increase of 2 inches and small decreases in salinity. However, the post-project monitoring indicated no clear changes over 10 years among the naturally high variability of the system.

As part of the TSP, the deepening would occur at the upper reaches of the HSC and not in the sections through Galveston Bay. However, the existing channel in the upper reaches is already scoured to proposed depths throughout the centerline as evidenced in USACE hydrographic surveys which are collected on a regular basis. For example, channel depths range from -41 to -43 feet and -48 to -50 feet MLLW in areas near the I-610 and BW 8 bridges, respectively. The HSC ECIP Project would mostly be dredging the channel toes and slopes in these reaches. Therefore, effects to current tidal variations or surge conditions are not anticipated. As discussed before, hydrodynamic effects will be modeled in the next planning phase. The USACE Galveston District's Coastal Texas Protection and Restoration Feasibility Study includes evaluating hurricane and storm risks in Galveston Bay, with a hydrodynamic surge model being developed by ERDC to assess effects of plans. The District plans to use this model to assess the effects of the TSP, which are anticipated to be minimal. Considering the minimal impacts shown in recent hydrodynamic modeling for channel modification projects involving deepening, the limited deepening proposed in the TSP constrained to the upper reaches, and the existing deep bathymetry in those reaches, significant adverse effects would not occur due to the TSP. These conditions would be minimally changed compared to the No Action Alternative.

3.1.4.2 Salinity

Most salinity impacts from channel modifications are linked to deepening. With the proposed deepening, the saline water from the Gulf of Mexico has the potential to travel further upstream as a saltwater "wedge" along the bottom of the channel. The denser, saltier water is heavier than freshwater and, therefore, sinks to the bottom of the water column. Therefore, the salt wedge may shift farther inland but, would remain at or near the bottom of the deepened channel. In some occasion, a decreased mixing between layers is often observed as well.

Modeling studies from the Texas City Channel Deepening and Miami Harbor Projects, indicated that dredging would have little to no effect on salinity variations in areas upstream of proposed dredging activities. Modeling for the Texas City project, which proposed deepening the Texas City Channel that intersects the HSC in the southern part of Galveston Bay by 5 feet to 45 feet deep, showed peak changes of less than 0.5 ppth and prevailingly less than 0.25 ppth. The study concluded no significant impacts were expected. In Miami, The salinity comparisons yielded maximum salinity differences on the order of 1.0 part ppth which far exceeds the variability of the natural salinity in the existing bay system.

TWDB conducted a modeling study that examined the removal of the HSC, Galveston Ship Channel, Gulf Intracoastal Waterway (GIWW), and Texas City Channel to assess what salinity would be without the HSC, the Texas City dike, and other major structures affecting salinity in Galveston Bay (Matsumoto et al. 2005). Results indicated that without the HSC and associated system of channels, low salinity during wet periods would last longer and high salinity during dry periods would tend to get higher. The upper Galveston Bay and the upper reaches of the HSC would be mostly affected. During a wet period, salinity would be lower by as much as 4 ppth near the Fred Hartman Bridge/Baytown Tunnel and by 3 ppth near Morgans Point, and it would be 1 to 2 ppth lower in Galveston Bay and Trinity Bay. During a dry period, salinity would be 1 to 2 ppth higher in both Galveston Bay and Trinity Bay. With this range of effects for the bays without any existing HSC (essentially pre-20th century conditions), later incremental changes to the HSC and other Galveston Bay channels, such as those in the aforementioned Texas City study and the HGNC project, would be expected to have even less impact on salinity. The modeling for the 1995 HGNC LRR, which proposed deepening the HSC by 5 feet to its current depth, was performed before the TWDB study and indicated smaller effects, as would be expected. Results of the modeling mainly indicated a shifting of salinity contours further up channel & deeper into Trinity Bay mainly in the August-October seasonal period, and small increase in bottom salinities of less than 2.5 ppth.

As discussed in **Section 3.1.4.1** above, proposed HSC deepening for the TSP would be confined to the upper reach of the channel where part of the channel is already at proposed depths, and would not occur in Galveston Bay. Considering the modeling results discussed from previous studies with deepening of channels extending from oceanic to estuarine conditions, and the limited deepening for the TSP that does not extend into Galveston Bay or Gulf, the TSP would not result in significant adverse impacts to salinity. As discussed at the beginning of this section, hydrodynamic modeling to include impacts on salinity is planned for the next phase of this study to confirm the expectation of minimal effects.

3.1.4.3 Relative Sea Level Change

ER 1100-2-8162 requires formulating and evaluating alternatives for a range of possible future rates of SLC, represented by the “low,” “intermediate,” and “high” scenarios analyzed and discussed in **Section 2.2**, including comparison to the without project conditions. The water level component of RSLC is a regional phenomenon at its smallest scale, with land subsidence adding a local scale component. As discussed in **Section 1.3.4.3**, the water level component has trended upward due to the general increase in the global sea level, while the local subsidence, although appearing to have curtailed, has moved local land surfaces downward. Both of these would increase navigation water depths relatively uniformly across the project area. Future projections of subsidence from the Gulf Coast Community Protection and Recovery District (GCCPRD) Phase 2 report map the project area including all the study segments as projected to experience 0.5 ft between 2010 and 2050 (GCCPRD 2016). Therefore, the effects on water depth would be uniform throughout the study area for all alternatives, including the TSP. The existing channel would experience the same RSLC. As a result, the change in depth affects the TSP and the No Action Alternative equally. The change ranging from 1.7 feet to 4.1 feet at 50 years between the low and high rate scenarios, would range from being a small to appreciable benefit for shipping towards the end of the period of analysis. However, the change would be gradual and not immediate.

Other possible ways RSLC impacts navigation discussed in ETL 1100-2-1 are wave attack and erosion by changing the base elevation at which surface waves from weather or ships can propagate, since wave forces near the water surface are the strongest. However, other than the above-water portions of mooring dolphins, none of the navigation features of the TSP would be subject to these effects as they are all essentially underwater dredging of existing channels and adjacent bay bottom to deeper bathymetry. Mooring dolphins are designed for large vessel mooring forces, and therefore integrity would not be compromised by these types of surface waves anyways. All alternatives, including the TSP and the No Action Alternative, would be equally subject to the same changes in surface wave elevation. Therefore, any gradual adjustments in shore protection at dikes and channels necessary to raise the armored height would be required for any existing or planned DMPAs. Because design of containment dike heights to maximize capacity would take RSLC into account, new dredge material PAs for all action alternatives, including the TSP would take this into account and be determined during the Preconstruction Engineering and Design (PED) phase of the project. Existing upland PA capacity would not be anticipated to be impacted given the typical dike crown elevations and 1.7 feet to 4.1 feet or rise projected. Outlet structures would be adjusted for the gradual change. Containment dikes at existing marsh cells may have to be raised. However, impacts to any use of the existing PAs and marsh cells for the TSP would be equally experienced for maintaining the existing project under the No Action Alternative. Therefore, impacts to placement would not be a differentiator among alternatives. It would be anticipated that adjustments would be made to the gradual change under all alternatives.

Another possible way RSLC impacts navigation that is discussed in ETL 1100-2-1 is through changes in harbor, basin, and channel hydrodynamics through phenomena such as harbor resonance to waves, and increased vessel excursion (vertical movement into water), presumably due to reduced seabed friction from deeper seas. With respect to the TSP, no new enclosed basins are being proposed, and turning basins are either expansion of existing ones or if new, are underwater non-enclosed features. Any such effects would also occur to existing dead end channels and enclosed turning basins under the No Action Alternative.

3.1.5 Water and Sediment Quality

3.1.5.1 Water Quality

Dredging under the TSP, would result in minimal impacts, and would not be expected to degrade the long-term water quality within the project area. These effects would be consistent with those that would occur during normal maintenance dredging operations occurring within the project area. Physico-chemico parameters may be temporarily affected as a result of water column mixing during dredging and placement activities. These patterns would return to their previous condition following completion of dredging. Any impacts to the distribution patterns for these water quality parameters from dredging would be minimal.

Short-term changes in dissolved oxygen (DO), nutrients, turbidity, and contaminant levels could occur due to mixing and disturbance of sediments into the water column during dredging and dredged material placement. Temporary decreases in DO concentration may occur during and immediately after dredging due to the movement of anoxic water and sediments through the water column. Temporary DO decreases may occur due to the aerobic decomposition from short-term increases in organic matter suspended within the water column. These minimal impacts would be expected to be limited to the immediate vicinity of dredging and dredged material placement. Contaminants present in the surface sediments would be temporarily suspended during dredging and placement activity. However, once the dredging activities stop, disturbed material would settle, and the physico-chemico parameters temporarily affected would return to pre-disturbance levels. These impacts would be minimal and similar to impacts occurring during the periodic maintenance dredge activity and placement that currently takes place in Galveston Bay and the Houston Ship Channel. Therefore, the effects expected from dredging would be temporary.

Dredging could cause short-term increases in turbidity. However, numerous studies indicate that dredge-induced turbidity plumes are, more often than not, localized, spreading less than a thousand meters from their sources and dissipating to ambient water quality within several hours after dredging is completed (Higgins et al. 2004). A literature review of dredging operation effects on suspended sediments found that in almost all cases, the vast majority of re-suspended sediments resettle close to the dredge within an hour (Anchor Environmental CA L.P. 2003). The anticipated dredging technique for this project would be hydraulic cutterhead dredging, which generally produces small plumes that rapidly decay (ERDC 2002). Properly operated dredges can confine elevated suspended bottom sediments to several hundred meters from the cutterhead with levels dissipating exponentially towards the surface with little turbidity actually reaching surface waters, and in many cases, at concentrations no greater than those generated by commercial shipping operations or during severe storms (Higgins et al. 2004). Therefore, only temporary, minor effects are expected from dredging due to increased turbidity.

Channel deepening tends to be the type of modification that can more permanently alter DO, although these effects tend to be small and localized. To corroborate the expectation that effects would be temporary and negligible, long term DO monitoring data was examined at stations in the part of the HSC that was deepened by 5 feet from 40 to 45 feet of depth between 1999 and 2008 during construction of the HGNC project. The stations are within the channel in the upper part of study Segment 1, which is in the Bayou section of the HSC, and just downstream of where deepening is proposed under the TSP. **Table G3-1** below shows measured DO concentrations from TCEQ water quality station 11258 between the years 1970 and 2016. This station is located in the Upper HSC above Morgans Point just downstream of San Jacinto Battleground near Goat Island. **Figure G3-1**, which shows the data with a linear trend line, illustrates a slightly increasing trend in DO concentrations supporting the anticipated minimal effects on DO in the current TSP. **Table G3-2** shows measured DO concentrations from TCEQ water quality station 11264 between the years 1969 and 2016. This station is located in the Upper HSC near the Battleship Texas, approximately 3 miles upstream of station 11258. **Figure G3-2**, which shows the data with a linear trend line, also illustrates a slightly increasing trend in DO concentrations supporting the anticipated minimal effects on DO in the current TSP. These increases most likely reflect improving water quality in the watershed and discharges to Buffalo

Bayou/HSC. Considering the temporary nature of water quality effects that the TSP would have, those impacts would not be expected to be significant.

Table G3-1: Average Annual Dissolved Oxygen (Station 1158)

Year	Average DO (mg/L)
1973	4.99
1974	5.43
1975	6.03
1976	5.33
1977	6.35
1978	5.54
1979	6.45
1980	5.85
1981	5.56
1982	3.89
1983	6.92
1984	5.32
1985	6.87
1986	5.29
1987	6.81
1988	5.79
1989	6.23
1990	5.79
1991	5.96
1992	6.11
1993	5.69
1994	6.25
1995	6.63
1996	6.50
1997	6.20
1998	6.62
1999	5.57
2000	5.87
2001	6.97
2002	6.40
2003	7.11
2004	6.72
2005	5.96
2006	6.05
2007	5.63
2008	5.81
2009	6.54
2010	6.20
2011	6.99
2012	6.51
2013	6.03
2014	6.07
2015	5.32
2016	6.76

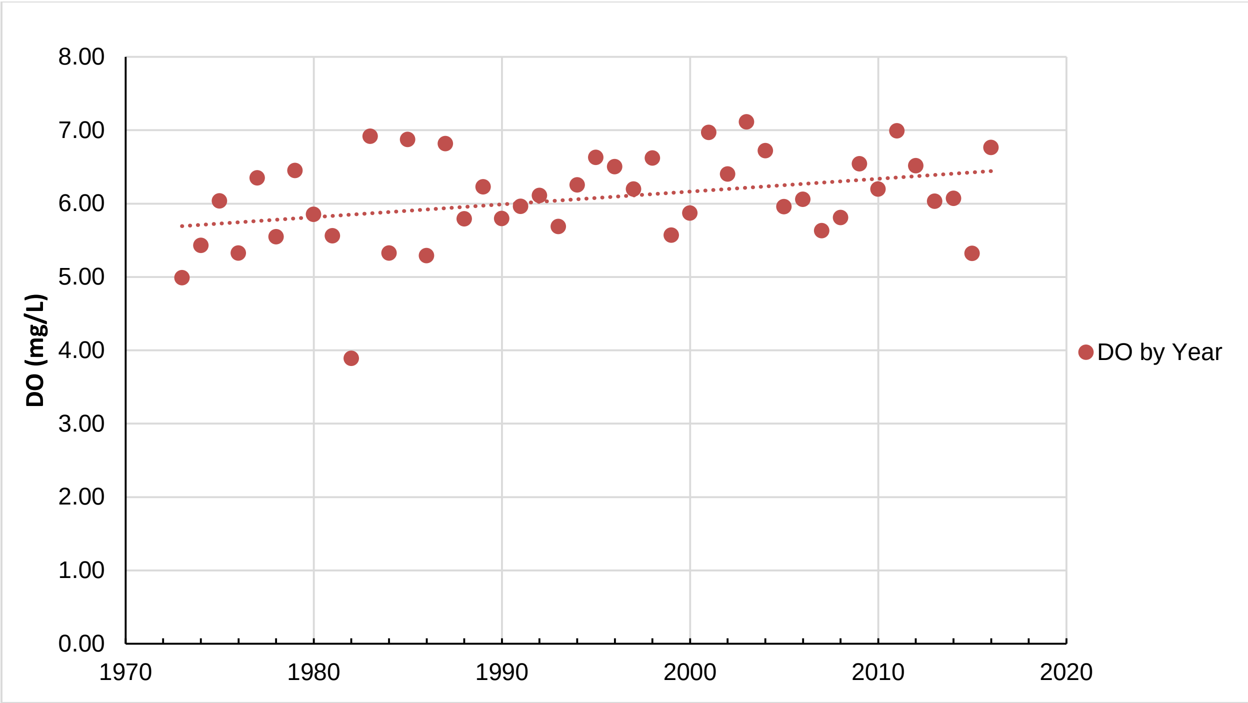

Figure G3-1: Average Annual Dissolved Oxygen (Station 1158)

Table G3-2: Average Annual Dissolved Oxygen (Station 1164)

Year	AvgOfmg/L
1969	0.71
1970	1.24
1971	1.68
1972	3.44
1973	2.73
1974	3.38
1975	4.01
1976	4.22
1977	4.52
1978	4.16
1979	4.91
1980	4.27
1981	3.37
1982	1.40
1983	3.68
1984	3.67
1985	5.09
1986	4.00
1987	5.34
1988	4.75
1988	4.75
1989	5.00
1990	4.51
1991	4.99
1992	4.71
1993	4.55
1994	5.04
1995	4.58
1996	5.32
1997	5.09
1998	5.65
1999	4.90
2000	5.44
2001	6.12
2002	5.97
2003	6.29
2004	6.17
2005	5.83
2006	5.34
2007	5.33
2008	5.96
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2010	5.76
2011	6.31
2012	5.98
2013	6.42
2014	6.32
2015	6.32
2016	7.02

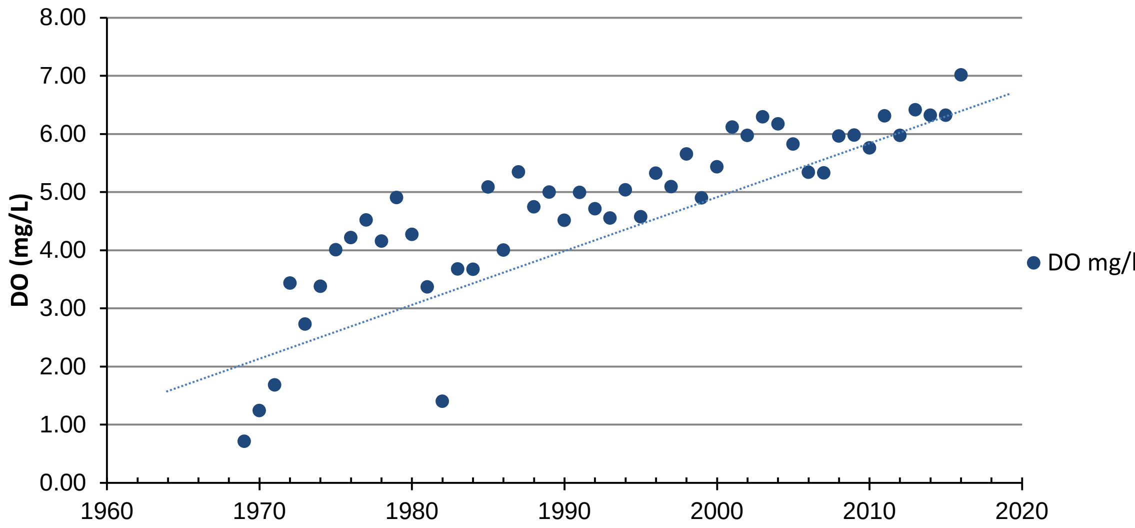

Figure G3-2: Average Annual Dissolved Oxygen (Station 1164)

3.1.5.2 Sediment Quality

Chemical concentrations in shoaled sediment within the HSC will not change as a result of the proposed alternative. The proposed actions will have no discernable effect on chemical concentrations in sediment.

3.1.6 Energy and Mineral Resources

The TSP will not have significant impacts on the availability or use of energy and mineral resources of the study area as it will not use or preclude access to them. To assess smaller potential impacts, geospatial data from the Texas Railroad Commission's (TxRRC) public data viewer for oil and gas exploration activity was used to search for listed active wells in the project footprint. Except for one gas well near Station 111+500 in the lowest segment of proposed widening between Bolivar Roads and Redfish, all other oil and gas activity mapped within the TSP footprint were abandoned, plugged, or dry wells. The one gas well not mapped as abandoned, plugged, or dry (API # 16730335), was verified to actually be plugged using more detailed TxRRC records available online (TxRRC 2017).

3.1.7 Hazardous, Toxic and Radioactive Waste Concerns

The proposed alternative has the potential to impact an existing EPA National Priorities List (NPL) site, known as the Patrick Bayou NPL site. The Patrick Bayou site is undergoing assessment and cleanup under the CERCLA, and is potentially a continuing source of sediment contaminated with PAHs, PCBs, and metals to the HSC. The channel widening measure from the San Jacinto Monument to Boggy Bayou would widen the existing Federal channel to include a small portion of land at the mouth of Patrick Bayou. Due to the verified contamination in sediment in the bayou, and the continuing discharge from the bayou into the HSC, the proposed alternative may encounter those sediments. Further evaluation is needed in order to assess the risk to the proposed project posed by the Patrick Bayou site. Additionally, widening the channel from Boggy Bayou to Greens Bayou would involve the acquisition of a small portion of land currently owned by the Texas Deepwater Terminal. If this land was to be acquired, the nonfederal sponsor must ensure that the land is clean and free of contaminants before inclusion into the federal project. All other measures in this alternative will have no effect in relation to known HTRW.

3.1.8 Air Quality

The following subsections describe the short term (i.e. construction) and long term (i.e. operation) impacts of the TSP on air quality.

3.1.8.1 Construction Emissions and General Conformity

General Conformity is a Federal/state program designed to ensure that actions taken by Federal entities do not hinder states' efforts to meet the NAAQS. Regulations in 40 CFR 93.152 define a Federal action to include "…a permit, license, or other approval for some aspect of a nonfederal undertaking, (and) the relevant activity is the part, portion, or phase of the nonfederal undertaking that required the federal permit, license, or approval." (EPA 2010a)

The Federal Action is the implementation of the TSP, and any activity that the Federal agency supports or finances (i.e. to implement) in a NAA is subject to General Conformity review. The General Conformity rules in 40 CFR 93.153 require determining if general conformity is applicable by estimating emissions and comparing them to *de minimis* limits set by the rules. For the moderate nonattainment designation for ozone of the HGB NAA, 100 tons of any ozone precursor pollutant (NO_x or VOC) in any one year is the *de minimis* limit. The TSP will require new work dredging in the HGB NAA, potentially up to 58.2 million cubic yards (CY). New work dredging will produce construction emissions from the dredge itself, including its main and auxiliary engines used to drive and control the cutterhead, main pumps, and ladders, and engines from associated booster pumps, tugs and tender vessels. At the placement end of the construction, emissions would be produced by earthmoving equipment such as marsh buggies, backhoes, and wheeled loaders, operating at dredged material PAs or marsh cells to shape material to build or raise containment dikes. The construction would take place over several years with actual phasing dependent on funding of pieces or separable elements of the TSP. The construction emissions are highly dependent on the details of final new work quantities, specific PAs, and selected or forecasted equipment assemblages (both dredge and placement). The determination of emissions for General Conformity compliance will depend on this detail, but will also depend on a specific construction schedule. A specific construction schedule has not been developed and will depend on detailed dredged material placement planning that will occur in the next planning phase after the release of this DIFR-EIS.

Based on the quantity of dredging, and past emissions rates in Federal feasibility studies, including those in the Galveston District, it is expected that construction emissions will exceed *de minimis* levels for one or both ozone precursors of NO_x and VOCs in a given construction year. Therefore, a formal General Conformity Determination is anticipated to be required. A detailed construction schedule, dredging and placement equipment identification, and an estimate of annual ozone precursor emissions, will be conducted in the post-TSP phase, and a GCD will be developed and coordinated with the TCEQ, the agency responsible for the SIP for Texas, to demonstrate and determine that the proposed Federal action will conform to the SIP. As required by the Conformity rules, the Draft GCD will be released through a public notice with a 30-day public comment period, and coordinated with EPA Region 6, Houston-Galveston Area Council (HGAC), the local MPO, and other local air quality agencies as appropriate. A Final GCD will be produced and provided with the Final IFR-EIS.

3.1.8.2 Operational Air Emissions

The purpose of this study is to improve deep draft navigation by reducing transportation costs, which is achieved by two primary ways. One way is by reducing transportation delays in the form of slower or delayed navigation, and waiting at docks and anchorages due to navigation restrictions. Another way is to reduce inefficient delivery of cargo imposed by draft restrictions by deepening the channel to alleviate light loading of vessels. Every measure formulated during the planning process, including those that formed the TSP, was aimed at reducing these restrictions in one form or another. Therefore, inherently, they would reduce fuel consumption spent in the delays and waiting, or more vessel trips to deliver the same amount of cargo, and as a result, reduce operational air emissions compared to the No Action Alternative. The next paragraphs describe the nature of how these measures reduce the delay, and accompanying air emissions.

Reduction in Vessel Calls and Tug Assists

Vessel calls are the individual instances that a vessel arrives or departs from a port. Modifications to existing deep draft navigation channels do not change terminal facilities or their ability to process cargo, which would be required to increase the numbers of vessels a port can process. The capacity of existing terminal facilities, the economics of commodities delivered, and external shipping market forces are what influence increases in vessel calls to a port. Typically, deepening existing navigation channels can reduce the numbers of vessel calls by reducing the numbers of vessels needed to deliver the forecasted goods, as several USACE deep draft navigation feasibility studies have concluded, such as those for Corpus Christi Ship Channel, Savannah Harbor, Sacramento Deep Water Ship Channel, and Miami Harbor (USACE

Galveston District 2003, USACE Jacksonville District 2004, USACE San Francisco District 2011, and USACE Savannah District 2012a). The economic analysis for this HSC ECIP study has also shown this expected reduction in vessel calls, discussed later in this section.

The TSP would involve modifications only to the existing channels and waterways, and would therefore not add or modify any landside facilities that process cargo, such as berths, cranes, docks, storage areas, (i.e. “backlands”) or related handling equipment (e.g. rubber tired gantry cranes, hustlers, stackers etc.). The TSP would not add or enhance any intermodal transfer facilities such as portside rail and truck yards. Therefore, the TSP cannot increase the cargo handling and throughput capacity of port facilities. As a result, the TSP cannot increase the numbers of vessels calling at the port. Increases in vessel traffic are projected to occur without the TSP, as documented in the navigation FWOP Conditions in **Section 3.4.2** and **Figure 3-3** of the Main Report of the DIFR-EIS.

However, the TSP can reduce the number of vessel calls from the future forecasted levels by alleviating light loading of vessels by deepening the existing channel as discussed previously. This allows ships of the current sizes calling at the port to come in more fully loaded and take advantage of their full shipping draft, or it allows fewer larger ships to carry the same cargo, both of which reduce fuel consumption and emissions to deliver the same cargo. The with-project economic analysis for the TSP indicates that with-project changes to vessel calls result in a reduction of between 110 and 142 non-container vessels per year, and 6 to 22 container vessels per year, as shown in **Table 4-10** and **Table 4-11**, respectively, of **Appendix B**. Therefore, this reduces emissions from those equivalent numbers of vessels calling at the Port of Houston over the distances from their commodity origins (for imports) and destinations (for exports). Because some of the major import and export trade routes for the Port involve Asian and European destinations, this type of emissions reduction has the potential to be substantial. The use of fewer, larger ships, does not incur greater emissions from larger engines to overcome the effect of reducing vessel numbers compared to smaller vessels. This is because of the basic marine engineering principle that water resistance on a ship's hull does not increase at the same rate as the volume of the hull; therefore, at any given speed, the horsepower needed to move a ship is less than proportional to ship size. (Cullinane and Khanna 1998). This is the principle behind the economies of scale that drive vessel sizes to get larger, as shipping companies seek to reduce fuel consumption, the major factor in shipping costs, to move a given amount of cargo. Therefore, the effect of reducing vessel calls, whether through using fewer more fully-loaded current-sized ships, or fewer larger ships, would reduce air emissions compared to the No Action alternatives.

The reduction of vessel calls would reduce the associated tug assists used to guide the large vessels into the BSC and BCC side channels, and tug assists needed in other more constrained parts of the HSC. The TSP modifications would also allow easier turning of future design vessels compared to the No Action alternative into the BSC BCC which could reduce tug assist needed for entrance.

The measures of the TSP most responsible for these types of air emissions reduction are those that do the following:

- Allow a larger design vessel than is currently used – Segment 1 Bay bend easings; Segments 2 and 3 side channel improvements at the BSC and BCC (Flares, widening, turning basins at side channel mouths); Segment 4 widening, deepening, and turning basins.
- Allow a more fully loaded vessel currently used – Segments 4, 5 and 6 deepening

Reductions in Delays within the Port

The other way the plan formulation that led to the TSP achieved the principle functional goal of reducing transportation costs was to reduce transportation delays, which occur in many forms at the Port of Houston. These delays occur due to the practical restrictions imposed by vessel Pilot rules for safe navigation, and timing and scheduling of vessel movements at docks and in port, with both causes interacting with the limitations imposed by the existing channel width and depth. Specific detail about the nature of these rules and delays is discussed in Chapter 4, Problems and Opportunities. The main ways the TSP reduces delays relevant to reducing air emissions is summarized as follows:

- Enabling two-way transit where one-way transit currently occurs
- Extending the potential hours of daylight navigation
- Reducing transits out to anchorage for vessels making stops at multiple terminals in port.

Enabling two-way transit where one-way transit currently occurs is provided by TSP widening to lift one-way transit Pilot rule restrictions due to the existing channel width and limitations on the width (beam) of vessels that can pass each other, often expressed as a rule based on the combined width or beam of both vessels. This varies by channel segment and geometry (i.e. how straight or curved) throughout the Port. One-way restrictions force docked ships wider than the restriction condition that are ready to depart to wait until inbound vessels pass through the part of the channel restricted, which can mean several hours of waiting at docks, and emissions of the waiting vessels. These emissions are usually the continued running of smaller auxiliary engines or generators for onboard electrical power, or indirect power plant emissions from direct electrical grid connection and consumption. The reverse situation is encountered for inbound ships anchored in the Gulf of Mexico or at Bolivar Roads waiting for outbound ships to clear the part of the channel restricted. Those emissions are usually the continued running of smaller auxiliary engines for electrical power and larger engine idling to be able to start up and move quickly. These types of delays can last for the several hours needed for transiting through Galveston Bay and through the HSC above Morgans Point, and are experienced daily.

Extending the potential hours of daylight navigation also is provided by TSP widening to lift one-way transit restrictions. Certain sizes of vessels can only sail within the HSC during daylight hours due to channel size restrictions and visual requirements, and have to get past a certain point by a certain cutoff time that accounts for transit time through Galveston Bay to safely navigate. Otherwise, the vessel must wait either at dock (for outbound ships) or at anchorage in the Gulf (for inbound ships) essentially overnight, until daylight hours resume. The allowance of two-way transit helps vessels to get underway sooner by reducing the waiting at docks or anchorage, which in turn allows later sail times. This type of delay reduction also avoids the auxiliary and idling engine emissions described in the previous paragraph, but would involve a longer reduction (potentially up to 18 hours) that is also expected to be a frequent, if not daily, occurrence.

Reducing transits out to anchorage for vessels making stops at multiple terminals in port is provided by the TSP mooring measure. As described in Chapter 4, some vessels, typically chemical tankers and sometimes bulk liquid tankers, must stop at multiple terminals to pick up individual shipments of chemical or petroleum products from different shipping service customers. When product at a customer's terminal is not ready for loading or their loading berths are all occupied by other vessels, the shipping vessel often must transit back out to either Bolivar Roads or to the offshore anchorage to wait until they are ready. This type of delay in the Port of Houston was examined and described in detail in a Texas Transportation Institute (TTI) report (Kruse 2015). This report used detailed vessel tracking and destination data to analyze statistics for this type of transit, indicating the average number of berthings, that is the number of times it docks to load or unload, to be about 3.4, and the number of transits out to Bolivar Roads or to the offshore anchorage to be approximately 1,000 annually. The average round trip out and back into Port from these locations is approximately 7.5 hours from the upper channel region where many of these extra transits originate from. Given the number of transits and duration, the emissions reduction to address these delays would be substantial if they could be reduced significantly. TTI estimated the additional emissions imposed by these transits using California Air Resources Board emissions factors for the average size vessel involved to calculate ship transit and waiting ("hoteling") emissions. The annual tons of NO_x (the pollutant driving CAA nonattainment in the region) estimated for transits to Bolivar Roads and to the offshore anchorage were 356 tons and 1,280 tons, respectively. These emissions could be greatly reduced if moorings in the upper channel provide a much closer place to temporarily anchor to wait for the next receiving terminals to be ready. The TSP mooring would be in the same area that the TTI report used as a starting point for analyzing the 7.5 hour trip, and would therefore effectively eliminate the extra distance traveled. Even reducing half of the annual transits would reduce NO_x emissions by hundreds of tons.

A final more minor way the TSP reduces delays or extra transit that result in air emissions, is through reducing extra transit and wait times to sufficiently sized turning basins for various design vessels. Typically, inbound vessels use the closest upstream turning basin to reorient themselves outbound prior to loading a dock downstream of the basin. If that turning basin is not large enough for that vessel or is not available, a vessel must transit further upstream to one that is large enough or available. Several TSP turning basin measures ensure that future larger design vessels do not have to travel farther than necessary, or address availability issues caused by space restrictions and adjacent docking activity. The transit and wait reductions are expected to be relatively minor compared to the other ways the TSP reduces air emissions.

Conclusion

Considering the effects on operational air emissions, compared to the No Action alternative, the TSP will reduce air emissions over the long term (e.g. 50-year period of analysis). Therefore, no significant adverse impacts to air quality would occur due to implementation of the TSP. Because marine category emissions are a minor percent (about 7%) of regional emissions, the air emission reductions would be relatively minor on the scale of the regional HGB NAA zone, but would be important in efforts of the region to improve air quality achieve CAA standards.

3.1.9 Noise

Short term impacts of the TSP would primarily involve the construction sound during dredging. The effects of channel improvements on ship transit, terminal activity, and related rail and roadway sound within portions of the Federal channel with nearby nonindustrial or noncommercial development would primarily account for the potential long-term noise impacts of a proposed action. This is limited to very few areas such as the BSC land cut. These long-term impacts would be indirect effects. DMPAs do not involve permanent noise activity, and would therefore have no potential for long-term impacts.

The TSP would result in temporary impacts due to the dredging activities required for construction of the channel improvements. The maximum sound levels expected would be similar to those produced during periodic maintenance dredging that occurs on the HSC, BCC and BSC in sound level and duration. Because the construction noise impacts would be temporary and similar to noise already generated periodically by maintenance dredging, they are considered minor. The TSP channel improvements would not result in any adverse long term indirect impacts from changes in ship transit, terminal activity, and related rail and roadway sound, for the same reasons discussed for operational air quality in **Section 3.1.8.2**. The TSP will reduce vessel calls, will not alter any terminal facilities, and as a result, will not alter landside terminal activity.

3.2 BIOLOGICAL CONSEQUENCES

The following sections describe the anticipated impact to biological resources within the TSP alternative area and the mainland surrounding the project area. Placement would occur in the 27 PAs identified and the associated wetland impacts within these PAs have already been accounted for and mitigated. The following sections describe the anticipated impact to biological resources within the project area and the mainland surrounding the project area.

3.2.1 Habitats

The following subsections describe TSP impacts to the various habitats in the project area.

3.2.1.1 Terrestrial

TSP channel improvements would impact approximately 2 acres of terrestrial habitat in two areas, the proposed expansion to the existing turning basin adjacent to Brady Island and the eastern end of Barbours Cut Terminal, near Morgans Point. The Brady Island impact is approximately 0.4 acre of mowed grass and tree landscaping for Brady's Landing Restaurant and similar impacts to vegetated, armored shoreline at a scrap yard to the north. The alignment of the proposed basin expansion is preliminary and will be optimized in the next planning phase to reduce impacts to both properties as much as possible. The impacted area of Morgans Point is approximately 1.5 acres. This area is existing parking and boat launch on NFS property with maintained vegetation. Both are areas where the revised toe of proposed project features will have slight impacts to land. Sheet piling would be used to minimize land impacts by allowing steeper slopes. There are several areas along the HSC above Morgans Point (north shore approximately 1097+80, and three areas associated with the proposed turning basin near station 775+00 [TB4_775+00]), and areas along the northern shores of the BSC, and the BCC that are within the footprint of the projected channel side sloping used for preliminary planning. Those terrestrial areas would be avoided by either more detailed geotechnical information and design during PED that would indicate an allowable steeper channel slope, or by adding sheet piling to allow more vertical slopes than the 3 horizontal:1 vertical side slopes used in the preliminary planning for the TSP. At the BSC, if indicated by more detailed geotechnical design and analysis during the PED phase, sheet piling would be placed along the northern shore to maintain the existing shoreline and adjacent wetlands. No significant adverse impacts on terrestrial vegetation of the 14 upland Pas listed in Table G1-16: Potential Dredged Material Placement Areas from anticipated construction or maintenance of TSP alternative over the next 50 years is expected. The approximately 2 acres of terrestrial area that would be impacted are upland vegetation and located in industrialized or urban locations. No mitigation is anticipated for these impacts.

3.2.1.2 Wetlands

Few wetlands exist along the shoreline surrounding the proposed channel improvements. The three wetlands that are adjacent to BSC northern shore would be avoided by sheet piling of the shore at the existing water line. The approximately 5.7 acres of potential tidal marsh north and west of Morgans Point and within 500 feet of the centerline of the existing HSC would be avoided by the TSP alternative.

No wetland impacts would occur from the construction or the associated maintenance over the next 50 years.

3.2.1.3 Bays and Deepwater Habitats

Aquatic habitat within the project area and vicinity includes open-bay water, open-bay bottom, intertidal (e.g., marsh, mudflat), wetlands (salt marsh), and oyster habitat. There are no special aquatic sites regulated under 40 CFR 230 such as sanctuaries and refuges, coral reefs, mudflats, vegetated shallows, or riffle and pool complexes present within the project footprint. Portions of the aquatic habitat in the project area would be directly impacted by the proposed modifications to the channel, including impacts to oyster habitat, presented below. Temporary and minimal impacts to aquatic life in the project area and immediate project vicinity similar to what occurs during existing channel maintenance dredging could occur as a result of increased turbidity, sedimentation, noise, light, and vessel activity during the construction period. Turbidity may temporarily affect the respiration, foraging, and/or reproductive capability of some species. Construction vessel traffic could increase wave activity and water uptake/discharge, while construction activity may also result in temporary avoidance of the construction area and a temporary and very localized reduction in marine life productivity. Dredging activities would be intermittent and localized causing only temporary impacts.

Benthic Habitat

The benthic habitat in the project area and adjacent areas is comprised primarily of featureless soft-bottom substrates likely dominated by benthic infauna, such as polychaetes and amphipods. It can be assumed that dredging would result in 100 percent mortality to benthic infaunal communities present in the dredged material footprint, but would be expected to recover sometime after dredging ceases. **Table G4-2** in the cumulative impact analysis in **Section 4.7.4** identifies the approximate acreage and characteristic of channel and bay bottom that would be dredged for the TSP. The resultant turbidity and settling from dredging has the potential for smothering sessile benthic organisms and/or inhibiting filtration functions required by some organisms for respiration and nutrition. The temporary lower DO concentrations that could result from temporary suspension of organic material during dredging could cause a temporary displacement of mobile organisms and may stress or cause mortality to sessile organisms. As discussed in **Section 3.1.5.1**, these effects would be temporary and minor given the nature of hydraulic dredging, as suspended sediments would return to background levels within a short time frame, and would be similar to what occurs during existing channel maintenance dredging. This would also apply to the periodic maintenance dredging over 50 years. Furthermore, it is assumed that marine organisms present in upper Galveston Bay have adapted to the naturally occurring yet highly variable turbidity levels caused by dynamic freshwater and tidal inputs compounded by strong wind driven currents which are typically observed.

As the HSC is already an existing active navigational channel which undergoes routine maintenance dredging, the benthic community that is present is likely adapted to frequent dredging disturbance. Studies conducted for the 1995 HGNC LRR noted that recovery of benthic infauna has been observed as quickly as 18 months following disturbance in experimental dredge plots in upper Galveston Bay (USACE 1995). As such, the impact to benthic infauna would be considered a temporary, short-term impact.

In summary, the dominant infaunal species within Galveston Bay are opportunistic species expected to rapidly recolonize the area following disturbance. Therefore, only temporary impacts to the soft-bottom open-bay community from constructing the proposed modifications to the channel and placing new work and maintenance material under the TSP would occur.

Mitigation of oyster habitat may replace some soft-bottom benthic habitat with new oyster reef construction. Placement of cultch over previous soft-bottom habitat would cause mortality to the infauna and sessile megafauna, but would create a new bottom habitat beneficial to pelagic species. Mitigation would range from 427 acres for the 650 ft wide option and 487 acres for the 820 ft option at the most optimal sites in Galveston Bay currently identified while mitigation at the least optimal site would require 551 acres for the 650 ft option and 632 acres for the 820 ft option. This would be a permanent impact, but would be minor as it would only affect a relatively small portion (less than 0.2 percent at most) of Galveston Bay bottom.

3.2.2 Wildlife

3.2.2.1 Terrestrial

The minor impacts to upland urban and industrial habitat described in **Section 1.4.1.1** anticipated as a result of the TSP would not impact native habitat. The paved, disturbed and urban landscaping nature at the Brady Island turning basin and Barbours Cut Terminal have limited wildlife habitat value. At existing PAs, wildlife that are tolerant to the urban and industrial areas (e.g., foraging or nesting avian species, raccoons) may be temporarily displaced during dike modification and PA use. Noise and light associated with the construction and maintenance activities would be expected to temporarily affect wildlife behavior, as would the general increase in human activity. Construction impacts would be considered minimal in these areas that are subjected to routine maintenance activity disturbances, which also occur in the No Action Alternative. No significant adverse impacts to terrestrial wildlife would occur.

3.2.2.2 Aquatic

Fish and Other Pelagic Fauna

During construction, only temporary disturbances and minor, temporary impacts associated with dredging would occur. Disturbances to finfish such as from noise and light during construction dredging would be temporary. Given their high mobility, finfish juveniles and adults would be able to readily avoid impacts of the dredging activity. Impacts to free-floating or limited-mobility pelagic fauna, such as fish eggs and larvae, would be temporary and minor. These impacts, such as entrainment into cutterheads or vessel cooling water intakes and discharges would be temporary during construction, and minor because the amount of water exchange involved is volumetrically insignificant compared to Galveston Bay, and because of the ubiquity and high abundances of these types of fauna. These temporary impacts are the same that occur during maintenance dredging under the No Action Alternative. No permanent or long term impacts on finfish and other pelagic fauna would result from implementing the TSP. Considering this, impacts on fish and other pelagic fauna would be temporary and minor.

Plankton

Impacts to other free-floating or limited-mobility pelagic fauna, such as phytoplankton, macroalgae, and zooplankton would be temporary during construction, and minor. These impacts, such as entrainment into cutterheads or vessel cooling water intakes and discharges would be temporary and minor, because the amount of water exchange involved is volumetrically insignificant compared to Galveston Bay, and the ubiquity and high turnover in populations of these types of fauna would quickly replace any impacted organisms. These temporary impacts are the same that occur during maintenance dredging under the No Action Alternative. No permanent or long term impacts on plankton would result from implementing the TSP. Considering this, impacts on plankton would be temporary and minor.

3.2.2.3 Oyster Reef

The dredging to implement modifications to the channel for the TSP would result in removal of oyster reef and shell hash habitat that have been mapped within the project footprint. If not mitigated for, this would be a permanent impact to the local oyster reef habitat; however mitigation of these impacts will include restoration of healthy oyster reefs damaged by Hurricane Ike through construction of reef pads in Galveston Bay. Further detail regarding oyster mitigation is described in **Section 3.5**.

Impacts to Mapped Reef

The area of impact to reef was assessed using the TPWD and Powell reef mapping discussed in **Section 1.4.2.3**, the TSP geospatial extent data and a geographic information system (GIS) to determine acreages of direct impact within the footprint of the TSP to the extent of proposed channel top-of-banks. Estimates of directly impacted oyster reef within the TSP footprint total 469.4 acres with the 650 ft. channel option and 538.4 acres with the 820 ft. channel option, and are summarized in **Table G3-3** below and shown in Figure G3-3 through Figure G3-6 below. Impacts were adjusted to exclude portions that were already impacted by and mitigated for under the HGNC project (which is reef in the existing channel footprint), the BSC Improvements Assumption of Maintenance, and the HSC PDR project, shown in hatched lines. For clarity, the entire HSC is not hatched in the figures, even though it is a previous Federal project impact. This constitutes a significant adverse impact to a significant resource and would be fully mitigated if the project is constructed.

Table G3-3: Direct Impacts of TSP Measures with Mapped Reef

MEASURE/INCREMENT		Acres	Previous HGNC Barge Lane Mitigation	Net Acres	AAHUS
CW1_BSC-BCC_820 [1]	BSC to BCC HSC Widening 820' wide channel	210	20	190	151.6
CW1_BSC-BCC_650 [1]	BSC to BCC HSC Widening 650' wide channel	171	20	151	121.2
CW1_Redfish-BSC_820 [1,3]	Redfish to BSC HSC Widening 820' wide channel	329	34	295	238.2
CW1_Redfish-BSC_650 [1,2]	Redfish to BSC HSC Widening 650' wide channel	305	34	271	218.2
CW1_BR-Redfish_820 [3]	Bolivar Roads to Redfish HSC Widening 650' wide channel	34	0	34	31.0
CW1_BR-Redfish_650 [2]	Bolivar Roads to Redfish HSC Widening 820' wide channel	28	0	28	25.5
BE1_028+605 [4]	Bend easing near Bayport	16	-	16	11.2
BE1_078+844 [4]	Bend easing near Redfish Reef	24	-	24	22.1
BE2_BSCFlare	Bayport Flare Easing	14	-	14	9.8
CW2_BSC	BSC Widening to 455' wide channel	5	-	5	3.5
TB2_BSC_RORO	Turning basin at Bayport Auto Terminal	0.1	-	0.1	0.1
Total Impact Acres (net) [5]	820' HSC Option			**538.4**	**434.0**
	650' HSC Option			**469.4**	**378.2**

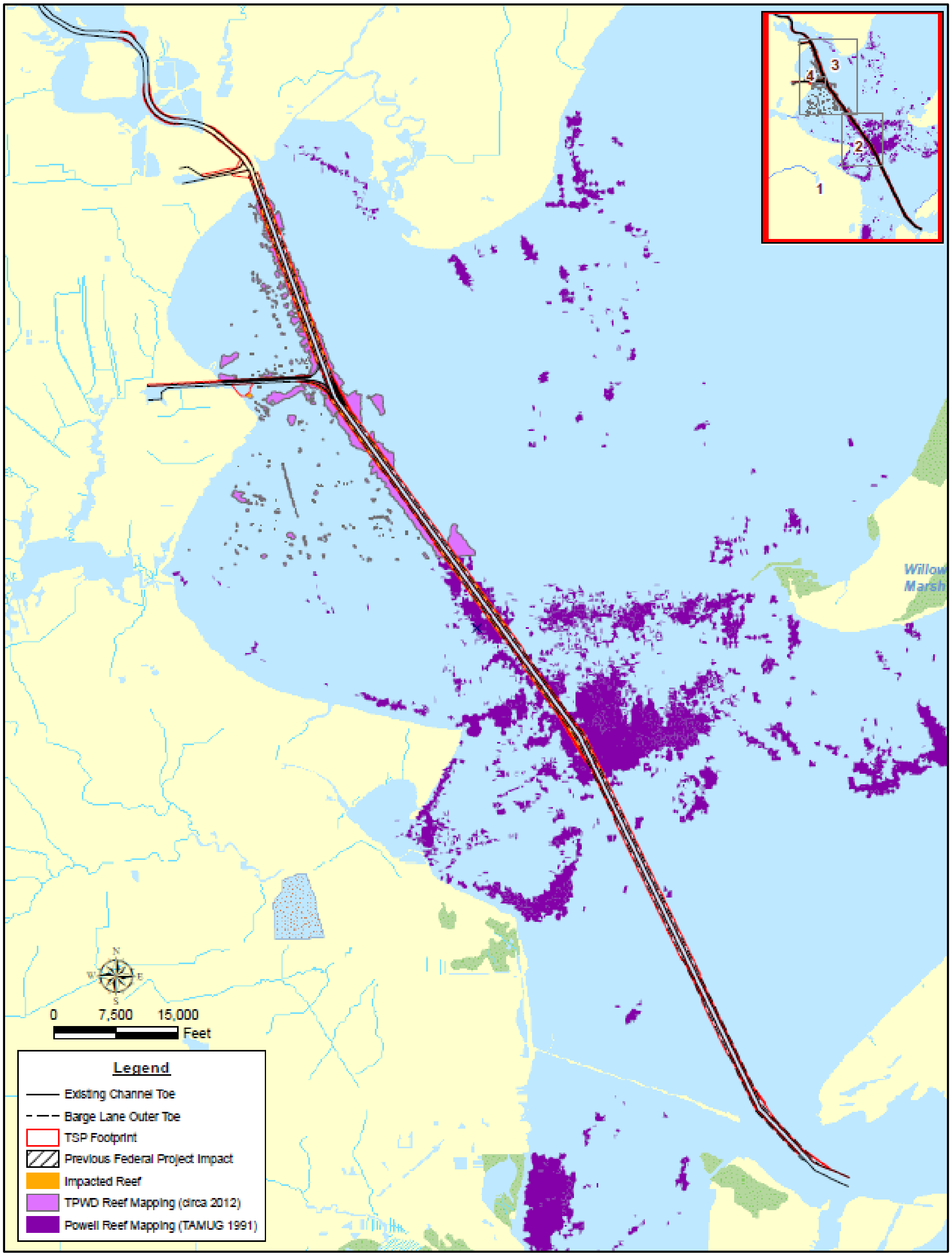

Figure G3-3: Oyster Reef Impacts of the TSP – Overview

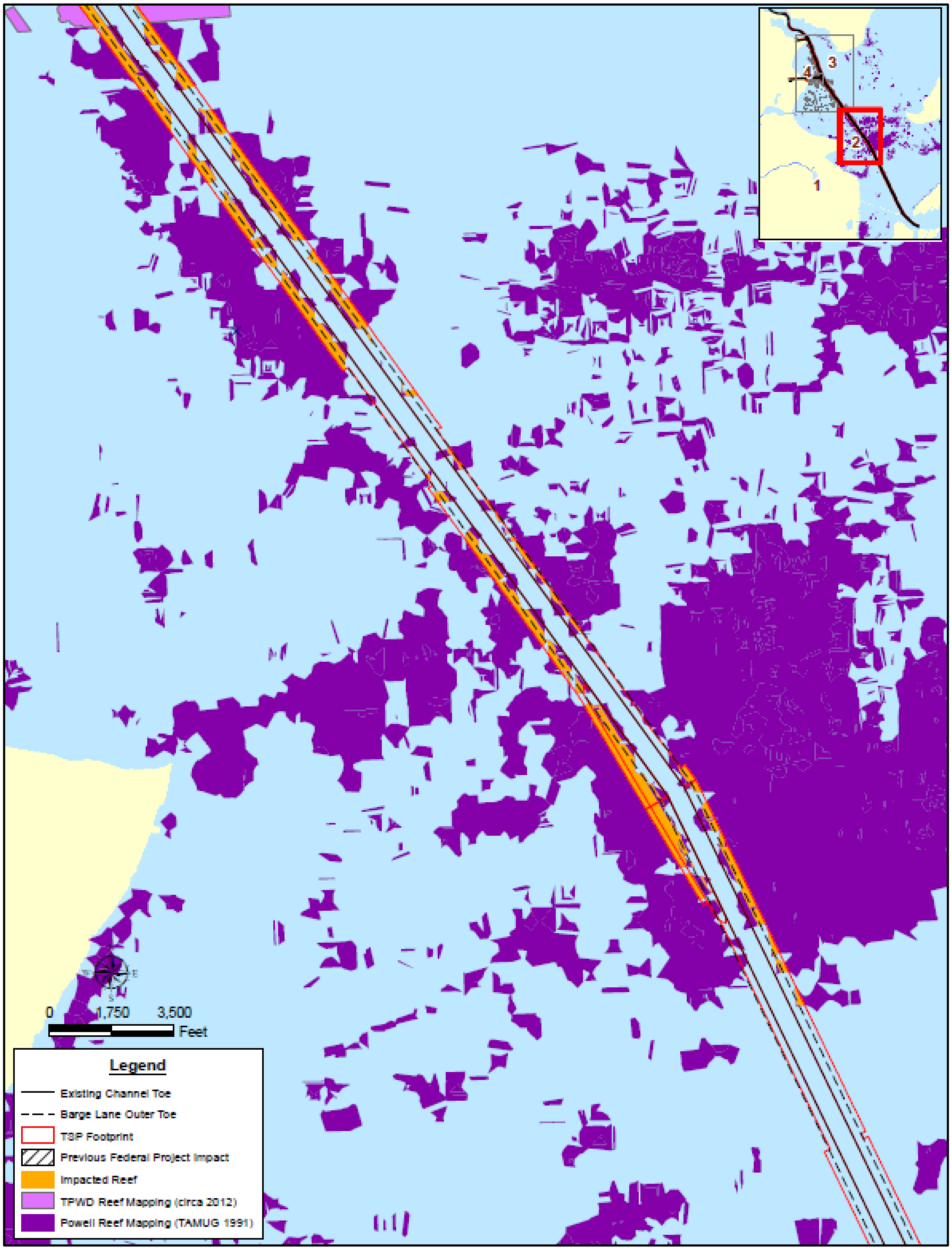

Figure G3-4: Oyster Reef Impacts of the TSP – Lower Bay

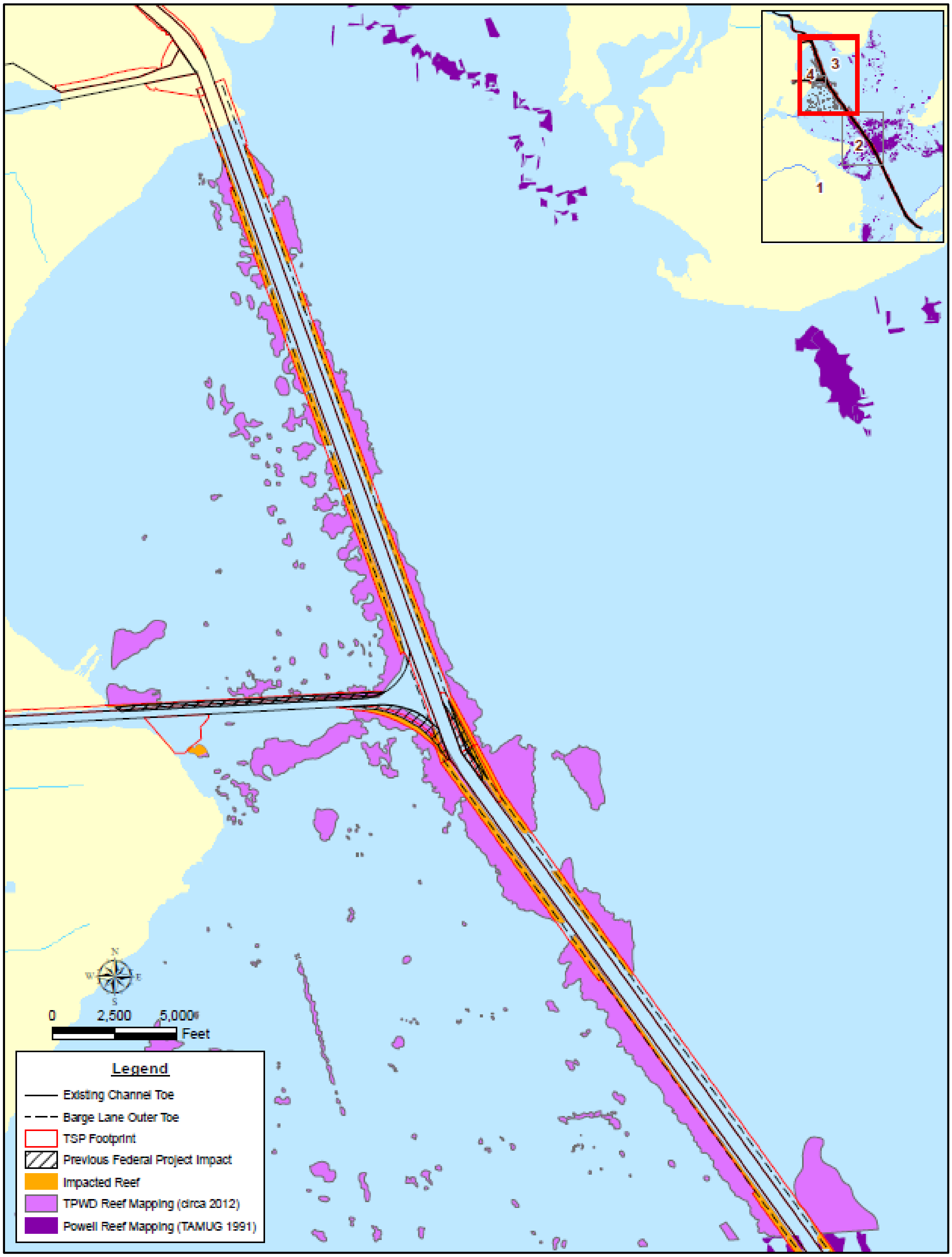

Figure G3-5: Oyster Reef Impacts of the TSP – Upper Bay

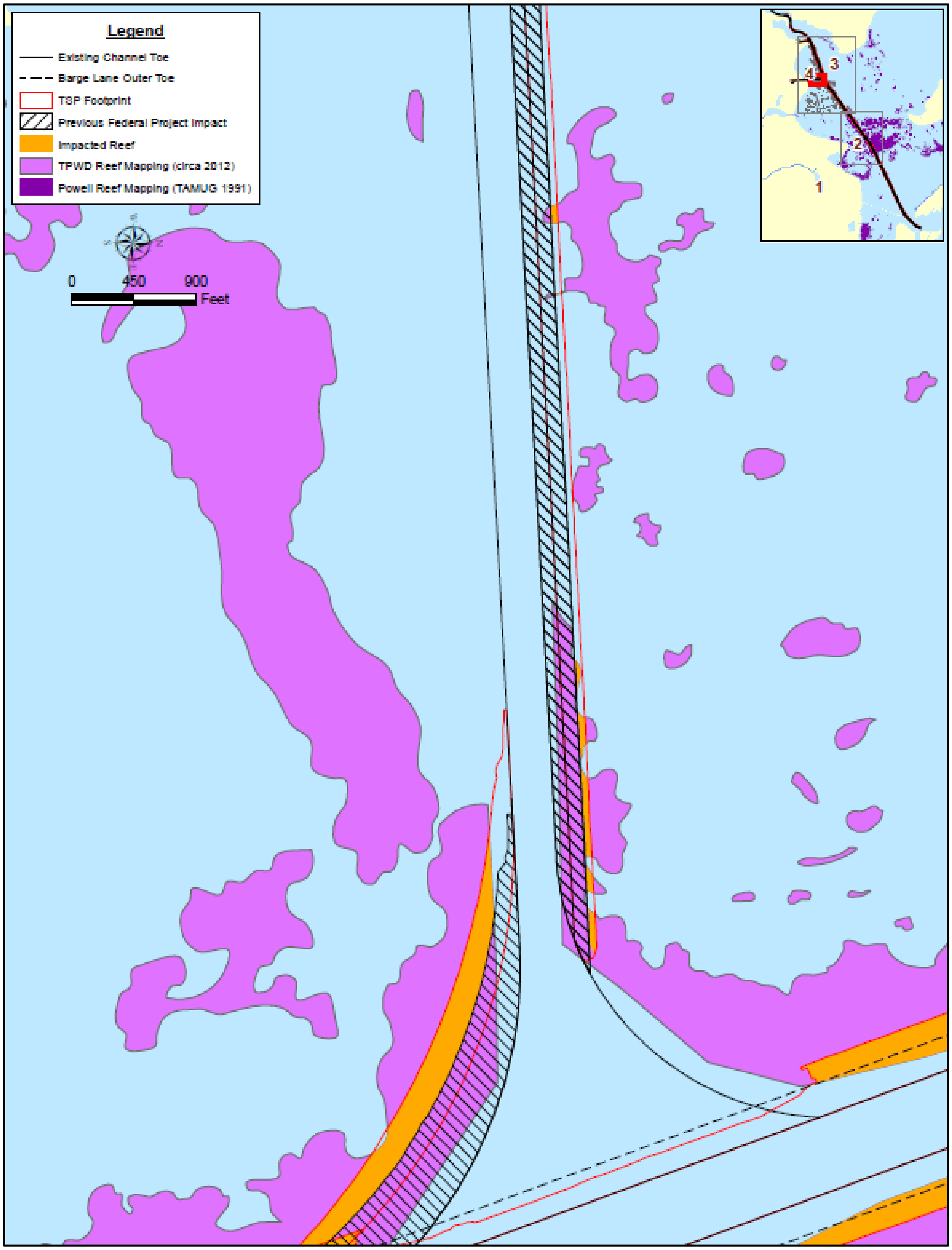

Figure G3-6: Oyster Reef Impacts of the TSP – Bayport

Potential of Project Areas above Mapping to Contain Reef

Reef mapping is not available above Morgans Point. Therefore, to determine potential reef impacts of measures upstream of Galveston Bay, various information and data for salinity, depth, and disturbance were used to indicate conditions conducive (or not) to reef development. This data were reviewed to identify areas in the TSP footprint that would have the potential to support growth. This was done to prioritize areas for reef surveillance in the next planning phase rather than to ascribe reef presence in those areas, or to completely rule out the presence of reef. The scope, extent, and methods to further detail the areas to be surveyed will be coordinated with the resource agencies in the next planning phase. The details of this review are discussed in the Mitigation Plan provided in **Appendix P**.

As discussed in **Section 1.4.2.3**, oyster reef needs average salinities greater than 5 ppth to survive, and in the range of 10 to 30 ppth to thrive. Data from the TCEQ SWQM Program, and from the TWDB's Bays and Estuaries monitoring program were examined. The TCEQ data contains many years' worth of grab samples that typically reflect monthly sampling at many locations throughout Galveston Bay and upstream along the HSC. The TWDB program operates continuously monitoring data sondes in Galveston Bay that was used to validate the usefulness of grab sample data to indicate average salinities by comparing averages at locations common in the Bay. The comparison showed the difference in average salinity to be within 1.5 ppth. Therefore, TCEQ salinity data upstream of Morgans Point was deemed useful for assessing average and prevailing conditions for supporting reef growth. Key stations between Morgans Point and the upstream study limit at the Main Turning Basin with long periods of record were selected along the HSC to observe the expected downward average salinity trend moving upstream. Stations above Alexander Island were focused on, given the sufficient salinity apparent in oyster reef found in the shallow bay south of the island for a recent proposed liquid natural gas terminal project discussed in **Section 1.4.2.3**. **Table G3-4** summarizes the monthly salinities at the key stations, ordered from downstream to upstream, left to right.

Table G3-4: Average Monthly Salinity at Key Locations Upstream of Morgans Point

Month	Average Salinity (ppth) at Indicated Station			
	HSC at Battleship	HSC at Greens Bayou	HSC at Vince Bayou	HSC at Main Turning Basin
	11264	11271	11299	11292
Jan	11.7	9.8	5.2	6.6
Feb	11.7	9.8	7.1	6.8
Mar	8.5	8.9	7.5	5.2
Apr	8.2	6.4	3.9	4.0
May	8.4	5.9	4.2	3.7
Jun	8.5	5.9	8.9	3.7
Jul	10.2	9.0	5.3	5.2
Aug	12.4	10.2	7.6	6.4
Sep	13.6	11.0	12.1	6.2
Oct	13.7	11.4	8.0	7.6
Nov	13.0	11.1	5.1	6.5
Dec	13.7	12.0	4.3	7.6

Typically, there are two major spawning/spat set peak periods in the year in in Galveston Bay: the greatest peak from April to June, and a smaller one around August. Salinity at the Battleship, while not optimal in both spat set periods, approaches optimal during the first peak, and is optimal during the second August peak, with average values well above 5 ppth. At Greens Bayou, the values are lower during the first peak and approach but are above 5 ppth; however, they are in the optimal range during the second August peak. Once at Vince Bayou however, average salinity is below 5 ppth for most of the first peak spawning months, and approach or are below 5 ppth in several later months. The upmost station at the Main Turning Basin is even fresher. With an average below lethal levels for two or more months, this salinity would cause mortality, especially during the key spawning period. Considering this, HSC salinity above Vince Bayou is too fresh to sustain any appreciable reef growth, and no reef is expected above there. Between Greens Bayou and Vince Bayou, the average salinity, although not optimal during peak spawning, is not lethal; it was assigned a low probability of developing reef. Between the Battleship and Greens Bayou, salinity during peak spawning is well above lethal, and although not optimal, approaches the preferred range during the first peak, and was qualitatively assigned a medium probability with respect to salinity. Below the Battleship, salinity would be expected to reach the preferred range during the first and second spawning peaks, and therefore the probability to support growth would be higher. In summary, the HSC salinity condition for reef growth above Morgans Point can be summarized as follows:

- Morgans Point to the Battleship – higher probability for growth
- Battleship to Greens Bayou – medium probability for growth
- Greens Bayou to Vince Bayou – low probability for growth
- Vince Bayou to Main Turning Basin – too fresh; growth not expected

Besides salinity, both depth and disturbance affect the likelihood for reef development. As discussed in **Section 1.4.2.3**, most reef in the Gulf Coast has a preferred depth of 13 feet, but locally has been found at depths of 20 feet and less, with a strong line of demarcation at 20 feet indicated in the HGNC study and in modern mapping. Most of the measures are in portions of the existing HSC, turning basins, or adjacent to berths where waters are deepened and periodically maintained by dredging, which would not support growth. Using the 20-foot depth as the practical limit for supporting reef, the most current NOAA bathymetric charts, 2015-2016 aerials, and TSP measures geospatial footprints, the potential to support growth was assessed for measures below Vince Bayou. Areas within the TSP measure footprints with less than 20 feet of depth and no sign of active vessel berthing were identified as having more potential to support growth to prioritize for surveillance in the next planning phases through probings, sidescan sonar, or other exploratory means. The acreage was roughly estimated for survey planning and prioritization, and not to infer that all of this area could contain reef or that lower priority areas would not receive some level of survey to verify absence. Indeed, though the most current NOAA bathymetry was used, given the typical frequency with which surveys are conducted to update the charts, this data may not fully reflect all deepened portions, and areas directly adjacent the HSC may be deeper. **Table G3-5** summarizes the measures with sufficient salinity and shallow enough bathymetry. Most of the areas identified are where a majority of the measure does not have shallow depth, and the shallow portions primarily are at the margins of the deepened HSC in the side slopes of the current channel. Those measures where a majority of the footprint has shallower bathymetry would be of higher interest for surveying. As shown, those areas total 79 acres with only 8 acres in higher quality salinity. Overall, the potential reef acreage that could possibly exist is small compared to the potential impacts in Galveston Bay. The scope, extent, and methods to further detail all areas to be surveyed will be coordinated with the resource agencies in the next planning phase.

Table G3-5: Potential Areas to Assess Oyster Reef Presence Above Reef Mapping

Measure	Significant areas <20’ Bathymetry	Existing Docks? Y/N	Acres of potential areas	Higher interest area?	Oyster Salinity Quality*
CW3_BSC	Y	N	3.6	N	Higher
BETB3_BCCFlare	Y	N	8.1	Y	Higher
CW1_820	Y	N	24.5	N	Higher
CW1_HOG	Y	N	17.0	N	Higher
BE1_153+06	Y	N	17.2	N	Higher
BE1_246+54	Y	N	8.3	N	Higher
MM1_520+00	Y	N	40.7	Y	Medium
CW1_SJM_BB	Y	N	17.4	N	Medium
CW4_BB_GB	Y	N	9.1	N	Medium
TB4_775+00	Y	N	30.0	Y	Medium
		Total	175.8		
	Total High Interest Areas	**Salinity Qual.**	**Acres**		
		High	8.1		
		Medium	70.7		
		Total	78.8		

Reef Accretion and Regrowth in the HSC

It has been well observed in studies for the historical Powell reef mapping, the previous HGNC project, from more modern surveys and mapping conducted for the NFS’s BSC Improvements Project, and from observing the modern TPWD mapping and current bathymetry, that regrowth of oyster reef will occur into the HSC after the channel has been dredged for modification. There are no specific, robust studies to determine the exact reasons, but those that have been suggested in the Powell mapping report and the 1995 HGNC LRR include extending the zone of favorable salinity further up Galveston Bay due to localized increases, increased local currents favorable to filter feeders, the side casting of dredged stiff clays from previous HSC modification, and the presence of extensive old subsurface reef deposits along the channel presumably exposed during previous dredging (Powell 1997, USACE Galveston District 1995).

During the last time the channel was widened by 130 feet and deepened by 5 feet in the Bay, 118 acres in the main channel footprint and 54 acres in the barge lanes were mitigated for. The current modern bathymetry and TPWD and historical Powell mapping were used to estimate acreages in the horizons of the existing main channel and barge lanes. Recognizing that the Powell mapping was done before the construction of the HGNC, the acreage indicated by the TPWD mapping could shed some light about regrowth since the HGNC construction. In the length of the HSC covered by TPWD mapping, approximately 57 acres is within the estimated margin of the main channel between the 20-foot depth contour and the estimated top of bank. So regrowth has clearly occurred. This TPWD-mapped portion covers approximately 65 percent of the Redfish to Morgans Point length that contains the vast portion of channel-side reef. If one were to assume the rest of the channel below the modern mapping has the same relative density and extent of coverage, then proportionally, the entire length would contain about 88 acres, or approximately 75 percent of the 118 acres in the original main channel. Within the existing barge lanes, in the TPWD mapped portion alone, 113 acres are mapped today, considerably more than the 54 acres previously mitigated in that barge lane footprint over the whole length with reef. It should be noted that the barge lane amounts were determined by a more detailed survey separate from the Powell mapping. Because the TSP will again widen right alongside the current HSC where regrowth has clearly occurred, re-accretion of reef inside of the main channel and relocated barge lanes would be expected. However, because the responsible factors are complex and not yet well-studied, a specific amount of regrowth expected cannot be predicted.

<u>Indirect Effects</u>

Indirect impacts from turbidity and sedimentation could occur to the oyster habitat down-current from the directly impacted areas, but are expected to be minimal, considering literature reviewed and the extensive presence of reef directly adjacent to the HSC system. Turbidity can inhibit successful filter-feeding and spawning activity while excess sedimentation can prevent efficient settlement and recruitment over existing consolidated reef and shell hash substrates. However, these effects from hydraulic dredge induced turbidity are expected to be minimal, considering the literature discussed in **Section 3.1.5.1**. The vast majority of suspended particles would be expected to resettle close to the dredge area and turbidity would be concentrated at the bottom of the water column. In another study of total suspended solid (TSS) around a hydraulic dredge in the vicinity of oyster beds in Calcasieu Lake during maintenance dredging of a navigation channel, results showed no discernible differences in concentrations upstream, parallel to, and downstream of the dredge, indicating the dredging operation had no influence on TSS (USACE New Orleans District 2007). Results of earlier densitometry surveys from this study indicated silt suspension during maintenance dredging was confined to the deep parts of the channel. These results are expected because hydraulic cutterhead blades are designed to direct loosened material efficiently toward the suction intake. Wilbur and Clarke (2001) found no effect to Eastern oyster larvae from turbidity concentrations up to 300 mg/L over a duration of 12-days. A 10% mortality was reported from a 400 mg/L concentration for 12 days, increasing to 18% mortality from concentrations of 500 mg/L after 12 days. Adult Eastern oysters showed no effect from turbidity concentrations of 500 mg/L after 21 days, or 710 mg/L after 20 days. Reduced pumping (feeding) was reported after 2 days of exposure from concentrations of 1,000 mg/L. In a review of more than 20 measurement studies, the 90th percentile of total suspended sediment concentrations above background was approximately 500 mg/L, and the 75th percentile was approximately 100 mg/L for hydraulic dredging, the type of dredging that would be primarily used (Anchor Environmental CA L.P. 2003). Considering this information, it is unlikely that turbidity concentrations will be high enough for a length of time to significantly affect oysters adjacent to the area of dredging.

With the exception of a few smaller complexes, reef in Upper Galveston Bay north of Redfish Island, is primarily located directly adjacent to the navigation channels of the BSC and HSC. This is clearly observed in the 1991 historical mapping of reef by Texas A&M University at Galveston, and newer reef mapping conducted by TPWD to assess post-Hurricane Ike damage. The HSC was widened and deepened under the HGNC Project between 1998 and 2008, and extensive HSC adjacent reef was still observed in the sidescan sonar data for the Bayport Ship Channel Improvements Project collected in 2011, and in the aforementioned TPWD mapping. Considering the extensive reef coverage directly adjacent to the channels, and considering that these channels are periodically dredged for maintenance (which would involve higher percentages of unconsolidated fines), the new work dredging required for construction of the TSP and subsequent maintenance dredging would not be expected to result in reef losses due to turbidity effects, and only minimal impacts would occur.

3.2.3 Essential Fish Habitat

Channel improvements proposed for the TSP by necessity would have to be located adjacent to the current channel. EFH has been described over broad spatial scales throughout the coastal Gulf of Mexico region; therefore it is difficult to propose any large scale project without impacting EFH for some species.

The majority of impacts to managed species and their associated EFH would be limited to the estuarine benthic environment where the actual dredging would take place, as well as temporary impacts to the water column as a result of increased turbidity. The life stages of fish anticipated to be most impacted are the eggs and larval stages, with those utilizing benthic habitats within the dredged footprint expected to have 100 percent mortality. The majority of the juvenile and adult life stages present in the project footprint are primarily forage and pelagic species capable of detection and avoidance behavior when exposed to unfavorable conditions. It is expected that construction of the TSP would have only temporary direct impacts to juvenile and adult fish by way of displacement, and individuals would re-inhabit temporarily affected areas upon dredging completion. No aquatic vegetation has been identified in the project area for the TSP, and so no impacts to seagrass or the nursery habitat it provides to juvenile fish would occur. Therefore, only impacts to benthic EFH are expected to occur.

The dredging would occur in the estuary of Galveston Bay, which is a nursery area for some species known to inhabit the GOM. The degradation of coastal and estuarine EFH habitats is associated with the following:

- Temporary disturbance and displacement of fish species;

- Temporary increases in sediment loads and turbidity in the water column;
- Temporary loss of benthic food items to fisheries;
- Loss of oyster habitats; and
- Limited sediment transport and re-deposition.

For the purposes of this project, most of the above effects are temporary and likely either offset by environmental protection guidelines, or are negligible considering the localized effect of the actions compared to the proportional area of the Gulf that would be unaffected. In this sense, the coastal and marine environmental degradation from the proposed action would have minor effects on designated EFH or commercial fisheries.

Turbidity generated by the project could affect the foraging behavior of visual predators and the efficiency of filter feeders. As discussed in **Section 3.1.5.1**, the turbidity plume would be expected to migrate only a short distance and cover a small area relative to the total pelagic habitat area available to managed species, and dissipate quickly due to prevailing water circulation and the nature of hydraulic dredging proposed to be used for the TSP. The impact to the water column EFH would be considered minor and short-term.

Deposition of suspended sediments could partially or entirely bury shellfish and other sessile organisms. Although existing oyster reefs within the footprint of the dredged areas would be lost, mitigation is proposed as described in **Section 3.5**. If not mitigated for, this would be a permanent impact. Oyster reefs near the project area may be indirectly affected by the temporary increased turbidity during the dredging operations, but long-term effects to oyster reefs are not expected from the proposed project. In fact, accretion of oyster reefs is probable considering the high occurrence of this habitat within close proximity of other anthropogenic activity in Galveston Bay, and extensive reef mapped by TPWD adjacent to the channel and observed along the current channel side slope margins in 2011 side scan imagery. Regrowth of reef was discussed in more detail in **Section 3.2.2.3**, in the subsection “Reef Accretion and Regrowth in the HSC“ and would be expected to reoccur in the channel margins and relocated barge lanes. The details of oyster habitat impacted for TSP are also discussed in **Section 3.2.2.3** above.

The TSP nor existing PAs are not in or near any of the areas identified as habitat areas of particular concern HAPC. These areas are all located offshore. Therefore, no impacts to HAPC are anticipated through the completion or maintenance of the proposed project.

3.2.4 State Managed, Commercial, and Recreational Fisheries

No commercial or recreational fishing would be allowed to occur within and near the dredging operations. The commercial fishing widely done in Galveston Bay is trawling for shrimp. The trawlers typically avoid active shipping lanes and would be required to avoid the areas of dredging and placement operations. Other shellfish species frequently landed include blue crab and eastern oyster. The footpring of the TSP spans areas that are prohibited, restricted, and conditionally approved as well as approved areas for shellfishing. Therefore, the actual dredge operation would have temporary and minor impacts on commercial fishing that might be done in the project area, but could resume upon completion of dredge operations within approved areas.

The entire HSC and upper Galveston Bay is within a consumption advisory area for blue crabs, and the entire Galveston Bay is within a consumption advisory area for all catfish species as well as spotted seatrout. The HSC system already supports extensive vessel traffic and is a focal point for commercial marine transport in the Galveston Bay system. While the recreational landings associated with Galveston Bay account for 35 percent of the State total, it is unclear how much of this fishing is actually done within or near the active channels. The HSC above the Battleship Texas, the BSC south of its centerline within the landcut, and the BCC are USCG security zones restricted from recreational use. The remaining unrestricted areas in the TSP footprint are right near the active channels. Given the high existing large commercial vessel activity, these areas are likely not routinely used for recreational fishing. Any recreational fishing could resume upon completion of dredge operations. Therefore, no significant disruption to recreational fishing is expected to occur during the initial construction or periodic maintenance dredging events over the 50-year maintenance period.

3.2.5 Protected Species

3.2.5.1 Threatened and Endangered Species

Species with a Federal status of threatened or endangered that may be present within the project area in the vicinity of the TSP include the Kemp’s ridley sea turtle, loggerhead sea turtle, green sea turtle, Piping plover, and Rufa Red knot. Other species listed are not likely to occur in the project area due to lack of suitable habitat or the area is beyond their known range limits. There is no designated critical habitat for any of the listed species within the TSP channel modification footprint. However, the ODMDS No. 1 is located within the loggerhead turtle Sargassum critical habitat area. The project area does not involve habitat required for other non-sea turtle oceanic species (e.g. fin, sei, or sperm whales, coral). For species using habitats potentially present in estuaries, the specific habitat required for regular use by most of those species is not present within the TSP footprint, including those for the Piping plover, Rufa Red knot, and West Indian manatee. The current known range of the Smalltooth sawfish is limited to the Florida peninsula. The effects of the project on Federally-listed species are considered in detail in the BA provided in **Appendix K**. Though it is not likely that the listed marine and shorebird species would be encountered within the project area, their presence in the area is possible. USACE contract specifications for this project would contain advisory language for construction contractors to be aware of the possible presence and contact numbers for the USFWS's Houston Coastal Ecological Services Field Office, or the Marine Mammal Stranding Network to call immediately in the event of encountering the species. This is discussed in more detail in **Section 6.9.4**, ESA, in the main report of the DIFR-EIS. Of the Texas State listed species that are not also listed on the Federal list of protected species, the reddish egret and white-faced ibis may also occur within areas in the vicinity of some existing PAs. The TSP and existing PAs do not include any nesting habitat for any of the species and all of the species are highly mobile and can easily avoid construction activities.

The HSC is an active commercial shipping channel that has a high frequency of large, deep draft vessel activity. Hydraulic cutterhead dredges (non-hopper) would be anticipated to be primarily used on this project for both construction and maintenance. A Gulf of Mexico Regional Biological Opinion (GRBO), dated November 19, 2003, by the NMFS for the Galveston, New Orleans, Mobile, and Jacksonville Districts of the USACE concluded that non-hopper dredges are not known to take sea turtles (NMFS 2016). As such, construction of the TSP would have no direct effects on any listed sea turtle species within the area when dredged by hydraulic cutterhead. Avoidance of use of transient forage habitat in Galveston Bay by sea turtles due to dredging noise and light would be the same as currently occurs during periodic maintenance dredging. This may affect but not adversely affect sea turtle species using Galveston Bay for transient foraging habitat as plenty of directly adjacent habitat would be available during the temporary construction. Given the transient use and the temporary nature of the construction, occurrence of the effect would be unlikely but possible. Hopper dredging may be used for some sections where the material and placement method is more suitable to this type, which is anticipated to be limited to softer material and locations lower in the Bay. A 2016 NMFS memo (NMFS 2016) clarifying previous opinions on various activities with respect to the new critical habitat found for offshore ocean disposal within the boundaries of the Sargassum critical habitat:

> “The placement of the dredged material may create temporary turbidity plumes that could potentially extend to the surface and interact with the Sargassum and its associated community, creating the potential to impact the following PCE: " available prey and other material associated with Sargassum habitat such as, but not limited to, plants and cyanobacteria and animals endemic to the Sargassum community such as hydroids and copepods." However, the sediments would be expected to settle quickly, and therefore interaction time with the Sargassum and materials associated with its habitat would be of very short duration and any effects would be insignificant. Thus, offshore ocean disposal is not likely to adversely affect the Sargassum critical habitat.”

Based on the March 4, 2016 GRBO, the use of ODMDS No. 1 as a disposal site may affect but would not likely adversely affect the Sargassum critical habitat area.

If hopper dredging is used, the dredging will follow the Best Management Practices (BMP) outlined in the revised Gulf of Mexico hopper dredging regional GRBO from NMFS, dated January 9, 2007 (NMFS 2007). Such measures include a dedicated protected species observers, inflow and outflow screening as well as turtle deflection devices installed on dragheads, implementing strategic use of dredge pumps at the start and end of dredging operations to minimize suction from dragheads to avoid sea turtles, trawling and relocation of endangered species as necessary, and training for personnel on dredging operations that will minimize takes of sea turtles. With use of hydraulic cutterhead dredges (non-hopper) for the construction of the TSP may affect but would not adversely affect any listed sea turtle species within the TSP area. With the use of hopper dredges for construction and maintenance dredging, placement at the offshore disposal site, ODMDS No. 1, may have an effect, but would not adversely affect sea turtles and the Loggerhead turtle Sargassum critical habitat.

3.2.5.2 Migratory Birds

The channel modifications of the TSP would not have direct impacts on migratory bird habitat and would therefore not be expected to cause significant adverse effects to migratory birds. The TSP channel improvements are not expected to have significant indirect effects on migratory birds that use Galveston Bay's fisheries as a food source, since the impact to fisheries would be less than a significant adverse effect, as discussed in **Section 3.2.4**. Some of the PAs in the area have been mapped by TxGLO geospatial data to host colonial waterbird rookeries (TxGLO 2009), and several of migratory species on the USFWS's 2008 Birds of Conservation Concern for the Gulf Coast Bird Conservation Region (BCR) 37 have been recorded at PAs 14 and 15. These include Reddish Egret (*Egretta rufescens*), Sandwich Tern (*Sterna sandvicensis*) and Black Skimmers (*Rynchops niger*) (USFWS 2008). The most recent Birds of Conservation Concern defines the species of concern for the purposes of Executive Order (EO) 13186. Three colonial waterbird rookies are mapped to be directly adjacent to the TSP footprint where the rookeries are also located on PAs used for maintaining the existing HSC, shown in Figure G3-8. The geospatial data for these bird rookeries are generalized boundaries that resulted from small-scale mapping efforts over State-wide coastal areas; as such, some boundaries overlap the open water of Galveston Bay including where the TSP channel modification footprint is located. However, open waters do not function as bird rookery habitat, and therefore rookery habitat is not located within the TSP construction area; except in areas where the colonial bird rookeries are located on portions of the existing PAs used for maintaining the existing HSC. These areas are currently impacted daily by large vessel traffic, and many of the colonial waterbird rookies created are also placement sites that created habitat for waterbirds in Galveston Bay. While migratory birds commonly have been observed on these PAs foraging, nesting, and roosting, they are active PAs, and the timing of construction would be coordinated to avoid impacts to migratory and nesting birds. Options to avoid migratory and nesting bird impacts may include adjusting the construction timeline to accommodate the nesting season or re-sequencing construction activities to work in areas where no active nests are present. Maintenance dredged material placement cycles in these and other PAs have been conducted successfully with minimal disturbance to migratory species. Similar construction practices and timing would be implemented for the proposed action if the existing PAs are used for dredged material placement.

3.2.5.3 Marine Mammals

The only marine mammals expected to regularly be present in Galveston Bay are bottlenose dolphins (*Tursiops truncatus*). These are highly mobile species that would be able to readily avoid dredging activities and vessels. The TSP would not have significant impacts on the fish food source or remove open water column habitat used by bottlenose dolphins. Considering this, the TSP would not be expected to cause significant adverse effects to marine mammals. Avoidance of the area by bottlenose dolphins would occur only during construction, and there is an abundance of similar habitat within Galveston Bay for dolphins to temporarily move to. Therefore, the proposed action would have minimal and temporary impacts, by way of disturbance, to individuals present. Previous USACE project determinations coordinated with NMFS have not indicated dredging to result in incidental takes of cetaceans. This includes a 2012 Incidental Take Authorization (ITA) for blasting operations in Miami Harbor that stated in response to public comments that "Neither the ACOE, nor NMFS, has determined that dredging operations, in previously dredged and maintained navigation channels, has the potential to result in the incidental take of cetaceans" (Department of Commerce, NOAA 2012). Therefore, dredging for construction and routine maintenance would not be expected to result in incidental takes of bottlenose dolphins that would require ITA under the MMPA.

3.2.6 Protected/Managed Lands

3.2.6.1 Wildlife Management Areas

The TSP channel improvements will not directly impact any TPWD WMAs or USFWS wildlife refuges. The Atkinson Island WMA is approximately 1,400 feet north of Marsh Cell M3, one of the existing DMPAs proposed for continued maintenance of the HSC, and for the TSP. Marsh Cell M3 and other adjacent ones have been used for periodic maintenance for many years with no impacts to the WMA, and would be continued to be used under the No Action Alternative, and for the TSP. No USFWS wildlife refuges are in the vicinity of the TSP. No significant impacts to WMAs or wildlife refuges would occur.

3.2.6.2 Critical Habitat Areas

The only critical habitat for piping plover is more than a mile away from the TSP as described in **Section 1.4.6.2**. Direct impacts would therefore not occur, and it would be too far to have any disturbance effects on nesting Piping plover. Therefore no significant impacts would occur to Piping plover critical habitat. The existing offshore placement site ODMDS 1 that would be used for any hopper dredging used for construction or maintenance of the TSP is located in Gulf waters designated as Loggerhead turtle critical habitat. The effect determination on the critical habitat resulting from the BA provided in **Appendix K** is that the TSP may effect but not adversely affect the critical habitat. As discussed in **Section 3.2.5.1**, the determination follows the recent clarification to the 2007 GRBO on hopper dredging, detailed in **Appendix K**. No significant adverse effects are expected on critical habitat.

Similar to WMAs, critical habitat are set aside lands that would not be subject to development, and the TSP channel changes would not induce landside development or offshore placement. The TSP channel modifications would not change the character of the beach habitat of Piping Plover nor the offshore nature of sea turtle Gulf of Mexico habitat. Therefore no significant indirect effects are expected to critical habitat from the TSP channel modifications.

3.3 CULTURAL RESOURCES

The TSP will include deepening and widening selected portions of the HSC as well improvements to the BCC and the BSC. The TSP will also include the construction or improvement of mooring areas and turning basins. All of the areas of potential impact within the TSP are located in a marine setting and therefore there is a potential for impacts to submerged cultural resources and sites that may be located on the shoreline adjacent to the ship channel. While this project will eventually include DMPAs for new construction and maintenance, as well as potential mitigation sites that could potentially impact terrestrial cultural resources, these areas have not yet been identified.

There are 12 previously recorded archeological sites, one National Register property (Washburn Tunnel), and one National Historic Landmark (San Jacinto Battlefield) that occur within or adjacent to the proposed project area. Seven of these sites (41HR680, 685, 831, 832, 1168, 1169, and 41CH372) have been previously investigated and determined to be not eligible for inclusion in the National Register of Historic Places (NRHP). Another site, 41GV151, the wreck of USS Westfield, was determined eligible for inclusion in the NRHP, but the site was investigated and mitigated for impacts as part of the Texas City Channel Improvement project. The remaining four sites are all terrestrial sites located on the shoreline and include prehistoric open campsites (41HR140 and 808), a possible historic age town site (41HR526), and the potential site of the Harrisburg Depot (41HR623). None of these four sites have been evaluated for NRHP eligibility.

The San Jacinto Battlefield is located just to the south of the project area and there are no direct impacts proposed within the boundaries of the battlefield. Additionally, the shoreline of the battlefield has been reinforced with bulkheads or armoring to control shoreline erosion. The Washburn Tunnel is the only NRHP property within the TSP and is located win the reach between Boggy Bayou and Sims Bayou. The tunnel was constructed in 1950 and listed on the NRHP in April 2008. The TSP proposes deepening the channel along this reach from 41.5 feet to a depth of 46.5 feet. While the as-built plans of the tunnel indicate that the top of the tunnel is only 45 feet below the water surface, hydrographic surveys by the USACE indicate that natural scouring of the channel bottom extends to 49 feet and have not exposed the tunnel. Therefore, no impacts are anticipated for the Washburn Tunnel. Finally, there are over 30 anomalies, representing shipwrecks or obstructions, identified by the NOAA within or adjacent to the proposed project area.

Based on the current information for the proposed construction and improvements, there is a potential to affect historic properties. Direct effects would consist of direct impacts from dredging activities related to channel deepening and widening that would occur if resources are not surveyed and recovered. If eligible terrestrial cultural resources are identified at sites near the channel shoreline where TSP improvements are planned, indirect effects such as the potential for erosion of shorelines from ship wakes to impact the resources would have to be evaluated, especially where widening or other improvements moves the shoreline closer to identified resources. The USACE recommends intensive cultural resources investigations to identify and evaluate any historic properties within proposed construction areas that have not been previously investigated. The scope of these investigations will be determined in concert with the Texas State Historic Preservation Officer and Native American Tribes and in accordance with the Programmatic Agreement for this project (Appendix N).

3.4 SOCIOECONOMIC CONSIDERATIONS

The TSP would have minimal direct impacts to human environment because work will primarily be located in open water (Galveston Bay) and uninhabited man-made islands or DMPAs, in Galveston Bay. The only impacts to land, described in **Section 3.2.1.1**, are minimal, and do not involve any displacement of occupied structure, residences, facilities, or businesses.

3.4.1.1 Population, Employment, and Income

The TSP channel improvements would have a negligible direct effect on population growth or employment trends within surrounding communities, cities, and counties located in the project area since it does not directly affect landside resources that encourage or discourage development. It would have a negligible effect on direct employment in the region during construction of the project because most of the project involves large scale dredging which involves a relatively limited industry and population of workers. There will be direct economic benefits to the nation in terms of reduced transportation costs, as detailed in the economic analysis for this study. Shipping and shipping-related industry has far-reaching direct and indirect economic benefits to the Houston region and the State, and the TSP channel improvements would help preserve the efficiency and competitiveness of the Port of Houston, which has been the first and second-ranked port in the nation in terms of total, import and foreign import/export tonnage in recent years. In that regard, the indirect effect of the TSP would be a positive one. No human environment impacts would be expected as a result of maintenance dredging events over the 50-year maintenance period.

3.4.1.2 Demographics and Environmental Justice

EO 12898, Federal Actions to Address EJ in Minority Populations and Low-Income Populations requires each Federal Agency to “make achieving EJ part of its mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority and low income populations.”

As provided in the April 1998 EPA guidance, Defining Minority and/or Low-Income Population, minority, and low income populations are defined by a numeric measure. A minority population is defined as a group of people and/or a community experiencing common conditions of exposure or impact that consists of persons classified by the U.S. Census Bureau as Black, Asian, American Indian or Alaska Native, Hispanic, or other non-white persons, including those persons of two or more races. Due to the size of the project area, and due to the fact that the TSP footprint is primarily located within open water, Census Tract level data was used for initial screening, but in areas where the TSP impacts near or on the shoreline closest to populated areas, Census block group data was examined, as shown in **Table G3-6**.

Table G3-6: Data for Census Tracts within or adjacent to the TSP and Census Block Groups near shoreline impacts within the TSP Footprint

Census Area	Population	Hispanic	White	Black or African American	American Indian and Alaska Native	Asian	Native Hawaiian and Other Pacific Islander	Some Other Race	Two or more races	Percent Minority	Median Household Income
Chambers County											
Tract 7106	0	0	0	0	0	0	0	0	0	0	0
Galveston County											
Tract 7239	2,417	14.6	81.2	0.7	1.4	0.7	0	0.1	1.3	18.8	$61,393
Tract 7240	2,393	18.5	57.8	20.6	0.6	1.0	0	0	1.4	42.2	$42,941
Harris County											
Tract 2115	6,907	92.1	3.9	3.5	0.1	0.2	0	0.1	0.1	96.1	$36,023
Tract 2125	3,610	28.1	1.1	69.4	0.1	0.2	0	0.2	0.9	98.9	$31,176
Tract 2333	4,818	89.7	8.9	0.7	0.3	0.2	0	0.1	0.1	91.1	$43,513
Tract 2337.01	5,245	75.1	11.1	13.1	0.1	0.1	0	0.1	0.3	88.9	$42,955
Tract 2337.03	2,656	83.9	14.8	0.6	0.3	0	0	0.2	0.3	85.2	$44,875
Tract 2525	4,325	65.8	31.7	1.3	0.2	0.2	0	0.1	0.7	68.3	$37,188
Tract 2533	3,428	23.2	69.9	5.4	0.3	0.5	0.1	0.1	0.5	30.1	$76,554
Tract 2545	2,356	66.4	8.8	23.4	0.5	0.2	0	0	0.7	91.2	$43,125
Tract 2546	4,067	71.6	15.4	11.7	0.4	0.2	0	0	0.6	84.6	$40,302
Tract 2547	2,029	29.2	53.4	12.7	0.3	3.5	0	0	0.8	46.6	$63,203
Tract 3110	7,111	97.2	1.9	0.5	0.1	0.1	0	0.1	0.1	98.1	$26,992
Tract 3111	5,886	96.7	2.2	0.5	0.1	0.2	0	0.1	0.2	97.8	$36,321
Tract 3114	1,496	85.2	3.2	11.2	0.1	0.2	0	0	0.1	96.8	$48,221
Tract 3241	5,540	85.3	12.2	1.1	0.1	0.8	0.1	0.1	0.3	87.8	$28,484
Tract 3242	1,647	94.1	3.5	1.5	0.4	0.4	0	0	0.1	96.5	$26,950
Tract 3416	5,463	15.0	76.4	2.8	0.4	3.3	0.2	0.2	1.7	23.6	$75,990
Block Group 3*	1,226	13.2	80.1	2.7	0.3	0.8	0.7	0.3	1.8	19.9	$65,906
Tract 3417	2,455	14.3	78.2	5.0	1.0	0.2	0	0.2	1.0	21.8	$64,122
Block Group 1*	711	14.9	79.2	2.7	1.1	0.3	0	0.4	1.4	20.8	$74,250
Block Group 2*	1,332	14.6	77.9	5.4	1.1	0.2	0	0.2	0.8	22.1	$50,893

Census Area	Population	Hispanic	White	Black or African American	American Indian and Alaska Native	Asian	Native Hawaiian and Other Pacific Islander	Some Other Race	Two or more races	Percent Minority	Median Household Income
Tract 3418	1,843	20.1	74.3	3.0	0.3	0.9	0	0.1	1.2	25.7	$74,297
Tract 3436	3,317	33.6	55.0	7.7	0.6	0.6	0	0.2	2.3	45.0	$49.417
Block Group 1*	1,395	31.9	57.1	8.2	0.7	0.4	0	0.3	1.4	42.9	$56,971
22 Census Tract Average	**79,009**	**63.5**	**26.7**	**8.1**	**0.3**	**0.6**	**0.1**	**0.1**	**0.6**	**73.3**	**$48,639**
4 Census Block Group Average*	**4,664**	**19.5**	**72.4**	**5.1**	**0.8**	**0.4**	**0.2**	**0.3**	**1.3**	**27.6**	**$62,005**

*Includes Census block groups where land and near shore impacts are anticipated. Source: U.S. Census Bureau 2010, ACS 2015

For the evaluation of the potential for EJ issues, the low-income population was defined as a group of people and/or a community that, as a whole, lives below the national poverty level. The average poverty level threshold for a family of four people in 2017, as defined by the U.S. Department of Health and Human Services (HHS) thresholds, was a total annual household income of $24,600. For purposes of determining low-income populations, median household was examined, using the U.S. Census poverty estimates for 2009 to 2014 (a 5-year average), as reported in the ACS. Geographies with a majority percentage of minority population was also considered in the screening for potential issues.

As shown in **Table G3-6**, the 22-Tract Census area that encompasses our project area is 73.3 percent minority and the average median household income is $48,639, which is almost double the 2017 HHS poverty level ($24,600) for a family of four. However, with respect to percent minority populations in the areas closest to the TSP where direct effects would be expected to be greatest, the Census block group data with land nearest to the TSP indicate the population is 26.7 percent minority, and the average median household income in $62,005. Therefore, EJ issues are not anticipated from implementing the TSP.

Minimal impacts to the human environment are expected, because a majority of the project construction will be located in open water (Galveston Bay) and an uninhabited man-made islands, or DMPAs, in Galveston Bay. Therefore, impacts to minority and low-income individuals and communities living within the project area would experience no adverse changes to the economic, or community cohesion characteristics. No residential displacements would occur, adverse impacts due to increased traffic noise and air quality degradation are not anticipated; and areas with shoreline impacts are not located in areas with high minority or low-income populations; therefore, disproportionately high and adverse impacts on minority and low-income populations are not anticipated.

3.4.1.3 Community Resources and Facilities

The TSP is not expected to have any direct physical impact to land-based community resources and facilities as the alternative would primarily be located in open water and man-made dredged material PAs. Potential impacts to parks and recreational areas which are also considered community resources are discussed in **Section 3.4.1.4**. None of these facilities would be directly impacted by the TSP; therefore, not impacts to community resources and facilities are anticipated. The resources in the vicinity of the TSP are shown in Figure G3-7 through Figure G3-9.

Channel improvements would impact approximately 2 acres of land in two areas, the proposed turning basin expansion adjacent to Brady Island and the eastern end of Barbours Cut Terminal at Morgans Point. On Brady Island, 0.4 acre of land would potentially be impacted which includes undeveloped land and shoreline at a scrap yard, part of a pavilion with a ship channel viewing area and a boat landing at the Brady’s Landing restaurant. The alignment of the proposed basin expansion is preliminary and will be optimized in the next planning phase to further reduce impacts to both properties as much as possible. The impacted area of Morgans Point is approximately 1.5 acres located on Port of Houston land, which has a parking area and boat dock not currently in use. Other areas impacted near land would be avoided by placing sheet piling along the existing water line to maintain the existing shoreline. The Shore Acres community and the San Jacinto Maritime campus are located north of the BSC, where sheet piling is proposed to avoid impacts to land.

3.4.1.4 Recreational Resources

As discussed in **Section 1.6.4**, boat ramps, marinas, parks, colonial waterbird rookeries are located within the recreational study area, which includes the TSP footprint. The resources in the vicinity of the TSP are shown in Figure G3-7 through Figure G3-9. As part of the project improvements, the outer extent of a proposed mooring basin is located less than 75 feet from the armored shoreline of the San Jacinto Battleground State Historic Site park but does not impact the upland portion. Three colonial waterbird rookeries are mapped by TxGLO geospatial data to (TxGLO 2009) be directly adjacent to the TSP footprint where the rookeries are also located on PAs used for maintaining the existing HSC, shown in. The rookery mapping and impact is described further in **Section 3-36** .The proposed project is expected to have minimal impact to the current activities that occur in close proximity to these recreational resources.

The TSP channel improvements will not have significant impacts on recreational use of waters. The proposed improvements are directly adjacent to the existing navigation channels and will not obstruct passage in recreational waters in Galveston Bay. Passage through the 3 boaters cut in Galveston Bay will not be obstructed. The max width of Galveston Bay widening (widening by 290 feet to achieve an 820 foot channel) would add less than 1.5 minutes to cross the revised HSC under a slow sailing speed of 2 knots and for crossing the revised BSC would add less than 20 seconds. Other measures of the TSP are in waters where use is restricted to commercial navigation or with limited recreational boating traffic.

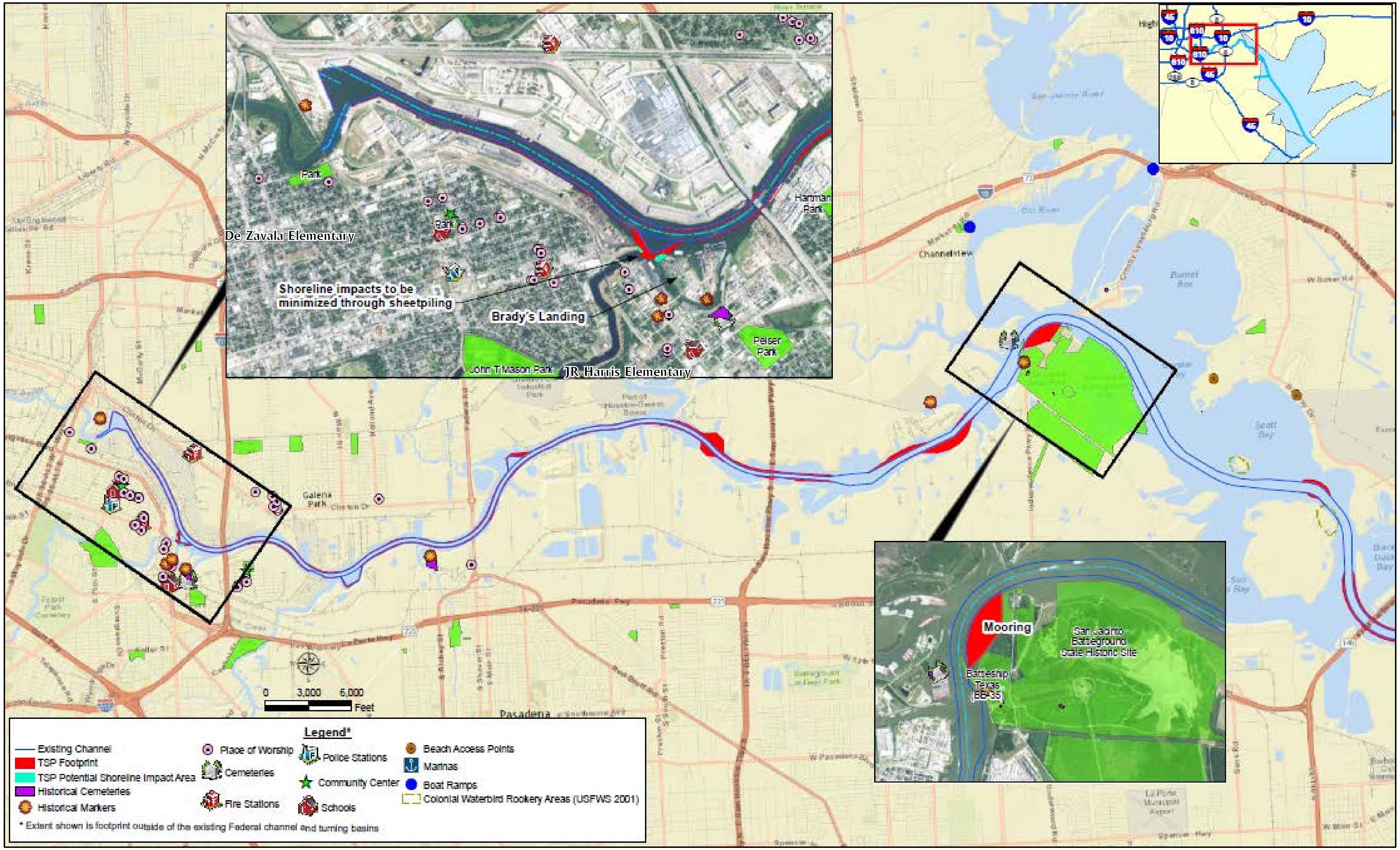

Figure G3-7: Community and Recreational Resources

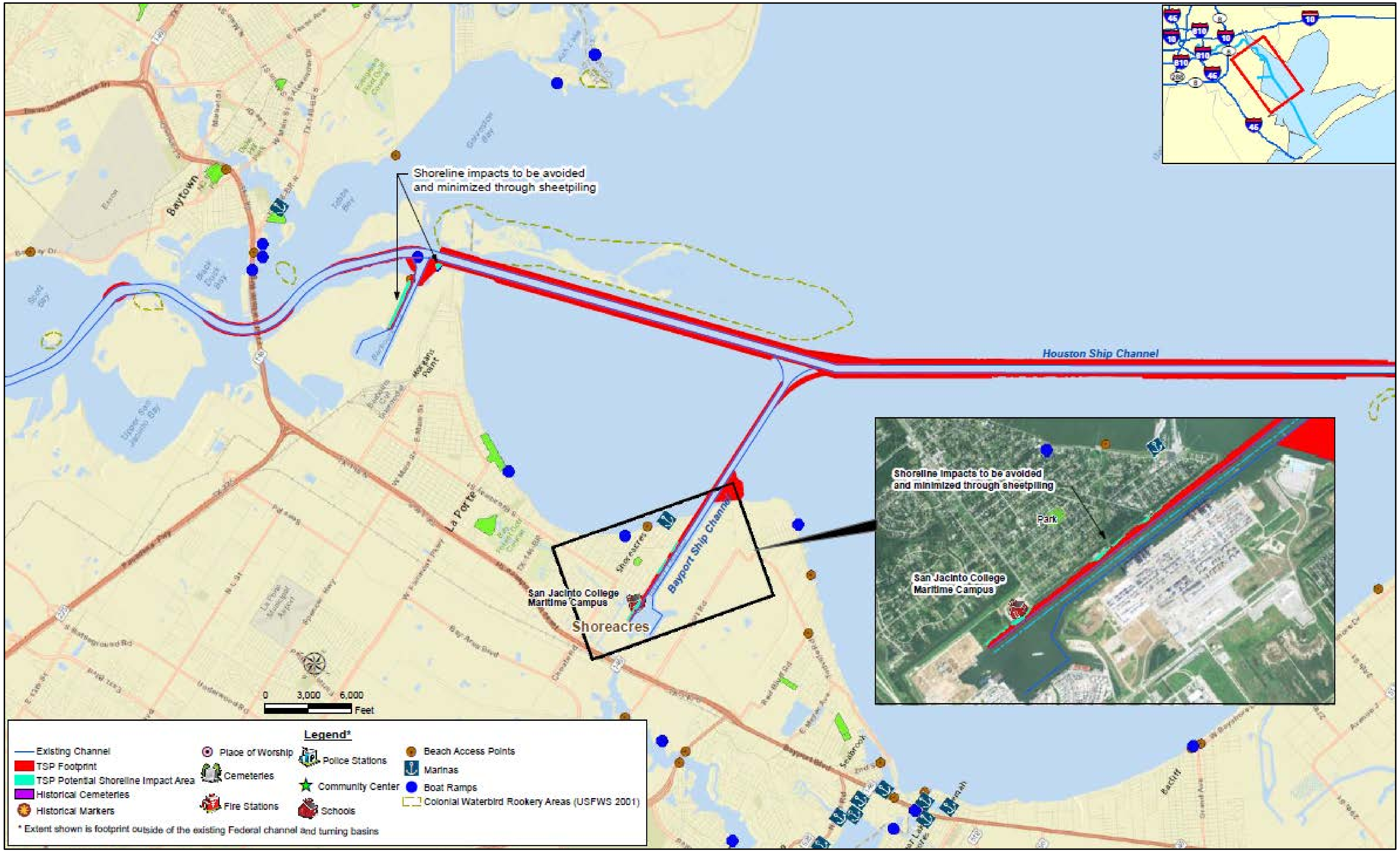

Figure G3-8: Community and Recreational Resources

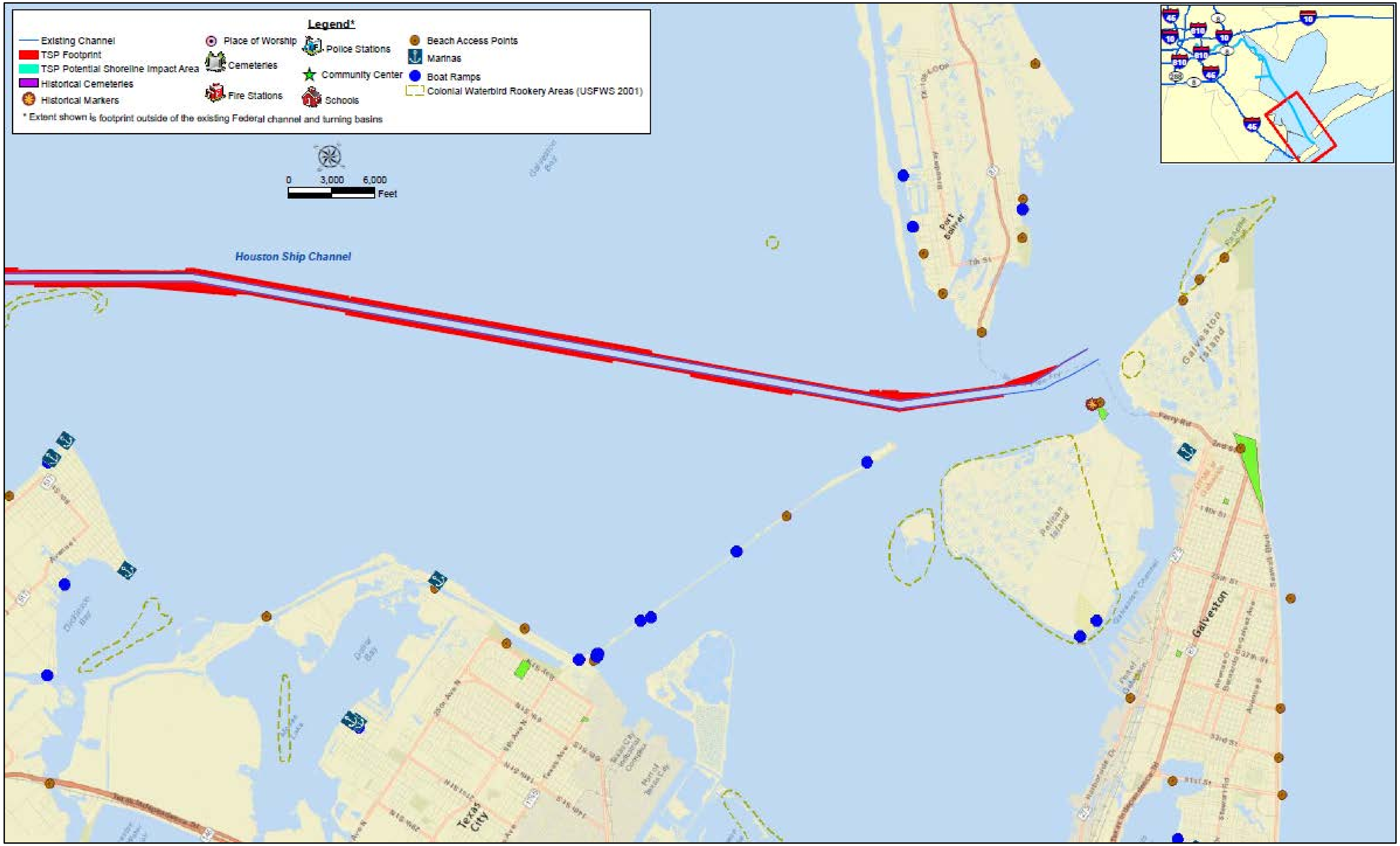

Figure G3-9: Community and Recreational Resources

3.5 MITIGATION

The PGN requires mitigation of significant unavoidable losses to significant ecological resources. ER 1105-2-100 and the Water Resources Council *Principles and Guidelines* (P&G) describe the procedures for determining the significance of resources that will be impacted by a project alternative. The Institute for Water Resources' (IWR) Publication IWR Report 97-R-4, *Resource Significance Protocol for Environmental Project Planning*, provides more specific guidance for determining significance. Under these criteria, oyster reef is a significant ecological resource since it has institutional significance from national and regional perspectives due to the various Federal and State laws and statutes that protect oyster reef. This includes the MSFCMA for which implementing regulations define oyster reefs as EFH within the regulated boundaries in the Gulf of Mexico, which includes bays and tidal waters, and require performing an EFH Assessment, including proposed mitigation if applicable. All natural oyster reefs are considered public resources in the State of Texas, managed by the Texas Parks and Wildlife Department (TPWD), who has broad authority under the Restitution and Restoration Rule, Chapter 69 of Title 31 of the Texas Administrative Code (TAC) to seek restoration of fish, wildlife and habitat loss occurring as a result of human activities, pursuant to enforcement powers in the Parks and Wildlife Code and Water Code. Oyster reefs are also designated as coastal natural resource areas (CNRA) and "critical areas" under the Texas Coastal Management Program managed by the Texas General Land Office (TxGLO) pursuant to the Coastal Zone Management Act, requiring compensatory mitigation for adverse impacts. Oyster reefs also have technical significance due to the number of research papers that document their importance to water quality, biodiversity and ecological productivity. Therefore, oyster reefs are significant ecological resources as defined by the PGN and the P&G criteria.

As discussed in **Section 3.2.1.3**, benthic fauna in the portion of the project comprised of soft, featureless bay bottom would be temporarily impacted following dredging, expected to recover and recolonize fairly quickly, becoming deeper water benthic habitat, as previous projects' studies have shown. Considering the ubiquity of the habitat and the temporary impact, the impact by the TSP would not be considered as a significant impact to a significant ecological resource.

To compensate for the loss of oyster reef from constructing the channel modifications of the TSP, mitigation is proposed by restoring oyster reef in Galveston Bay. Currently, several desirable sites shown in **Figure G3-10** have been identified in conjunction with the resource agencies, including the TPWD, the primary managing agency of oyster reef in Galveston Bay. Most of these are sites where Hurricane Ike impacted reef by sedimentation, and have been the focus of TPWD efforts to restore reef in the Bay.

Currently, the HSC-ECIP has completed the TSP milestone phase of the USACE Specific, Measurable, Attainable, Risk Informed, Timely (SMART) Civil Works planning process, where a plan has been tentatively selected for agency, technical, and public review, and vertical chain of command approval. At this stage, the major components of the plan have been identified and evaluated at a higher level of analysis, and will be analyzed in greater detail and refined in the next planning phase, following approval during the Agency Decision Milestone (ADM) meeting. Consistent with USACE policy in Planning Bulletin PB 2017-01, some uncertainty is expected in the size and make-up of the TSP, and other plans identified from the suite of alternatives analyzed in this initial phase, including the National Economic Development (NED) Plan, or a variant preferred by the Non-Federal Sponsor (the Locally Preferred Plan). As such, the final size of the measures (width, length etc.), and inclusion or exclusion of some of them in the TSP presented in this Draft Mitigation Plan may change in the next planning phase. These changes can affect the reef impacted.

Figure G3-10: Candidate Mitigation Sites

The proposed HSC channel widening through Galveston Bay would result in the majority of TSP impacts, and a range of revised channel widths from 650 feet to 820 feet has been conservatively proposed for further analysis and refinement in the post-ADM planning phase. Sufficient width to realize the economic benefits necessary to justify the plan depends on having enough width for safe two-way traffic meeting of design vessels. This is to be determined by ship simulation under a variety of sailing conditions to be conducted with participation from, and coordination with the Houston Pilots Association (HPA) in the next planning phase. The upper limit of 820 feet was assumed considering HPA input and experience, and a width narrower than this could result from the simulations, which would reduce reef impacts. The Bay widening is also divided lengthwise into the 3 straight segments of the existing HSC alignment, and one of those segments may not be justified for widening, or may be justified only to a narrower width than other segments, following refined economic analysis and ship simulation. This would also reduce reef impacts.

The need to replace the existing shallow draft barge lanes directly adjacent to the main channel of the HSC and shift them outward of the revised channel also accounts for a majority of potential reef impact. The NFS is coordinating with the shallow draft waterways users groups, to investigate whether the full current width is needed in the replacement lanes, or whether the lanes can share part of their footprint with the revised deeper HSC main channel to provide adequate barge navigation alongside the deep draft ship navigation. If they can share footprint, replacement barge lanes would reduce the overall width needed, and reduce reef impacts.

Modeling using a USACE-certified habitat model for the American oyster was used to calculate functional losses in accordance with USACE policy. The resultant average annual habitat units impacted and range of calculated mitigation amounts is summarized in **Table G3-7** below. The results and mitigation are described in detail in the Mitigation Plan provided in **Appendix P**.

Table G3-7: Calculated Mitigation for TSP Impacts

TSP Version	Impacts		Most Optimal Site (San Leon or Dollar Reef)			Least Optimal Site (Bayport)		
			Mitigation Required		Mitigation Ratio (mitigated/ impacted)	Mitigation Required		Mitigation Ratio (mitigated/ impacted)
	Acres (Net)	AAHUS	Acres	AAHUS		Acres	AAHUS	
820' Channel Option	538.4	434.0	486.6	434.0	0.904	631.9	434.0	1.17
650' Channel Option	469.4	378.2	427.0	378.2	0.910	550.7	378.2	1.17

The mitigation method proposed would be to beneficially use dredged new work material to build bottom relief berms capped with a thin veneer of suitable cultch such as crushed limestone or clean crushed concrete, and rely on natural recruitment to propagate growth. This method has been successful in previous projects in Chesapeake Bay and elsewhere, including Slaughter Creek, Maryland. The type of cultch material has been successfully used in local mitigation projects, including the mitigation at Fisher's Reef for the NFS's BSC Improvements Project.

Monitoring of the restoration sites would be conducted pre- and post-restoration to assess the success of the mitigation. Criteria for restoration success would include one structural and one functional endpoint. The structural endpoint would be the number of hard-bottom acres restored. The functional endpoint will be a measure of the live oyster density or recruitment onto the cultch that will be determined in coordination with TPWD. The specific method and techniques will be adapted to the scale of mitigation required and may follow TPWD monitoring methods suitable for large acreages of restoration. Monitoring would be conducted yearly to ensure the selected success criteria are met following the spat set season. When the success criteria are met, the monitoring would cease and the mitigation project would be determined to be successful.

The full details and required content for the Mitigation Plan are provided in **Appendix P**.

4 CUMULATIVE IMPACTS

This section discusses the cumulative impacts expected to result from the channel modifications of the TSP, in addition to impacts that have already occurred or are expected to occur in the project area due to other projects and development relevant to the impacts being considered. Following the development of a specific dredged material management plan (DMMP) for the TSP in the next planning phase, the cumulative impact analysis will be updated to include evaluation of new placement features. This section provides the following information:

- The definition of cumulative impacts and an introduction to cumulative impact analysis
- A discussion of the methodology used, a summary of direct and indirect impacts, and a description of the types of impacts that were included in the cumulative impact assessment
- A description of past, present, and reasonably foreseeable future projects and activities that may have cumulative impacts to the project area and the surrounding region
- A discussion of cumulative effects of those projects and activities relevant to the impacts included in the cumulative impact assessment.

4.1 Introduction and Methodology

For purposes of this analysis, cumulative impacts were discussed in further detail if the indirect and direct impacts have more than insubstantial temporary adverse or positive impacts to the particular resource. In addition, the health of the resource was taken into consideration.

The President's Council on Environmental Quality (CEQ) regulations defines cumulative impacts as "*…the impact on the environment which result from the incremental impact of the action (project) when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time*" (40 CFR 1508.7). Impacts of the other actions include both direct effects (caused by the actions and occurring at the same time and place as the proposed action), and indirect effects (caused by the action but removed in distance and later in time, and reasonably foreseeable).

The cumulative effects analysis considers the magnitude of the cumulative effect on the resource health. Health refers to the general overall condition, stability, or vitality of the resource and the trend of that condition. Laws, regulations, policies, or other factors that may change or sustain the resource trend were considered to determine if more or less stress on the resource is likely in the foreseeable future. Cumulative impacts may also occur when the occurrence of disturbances are so close that the effects of one are not dissipated before the next occurs, or when the timings of disturbances are so close that their effects overlap.

The general approach provided in the CEQ's 1997 publication, *Considering Cumulative Effects Under the National Environmental Policy Act* was used to conduct the analysis (CEQ 1997). Where the suggested analytical techniques in this publication were useful and appropriate, they were employed in the analysis. The following three steps in the general approach were accomplished, and explained further in the next sections:

1. Scope for the cumulative effects by 1) identifying the primary cumulative effects issues associated with the proposed action and define the assessment goals, 2) establishing the geographic scope for the analysis, 3) establishing the time frame for the analysis, and 4) identifying other actions affecting the resources, ecosystems, and human communities of concern. This was accomplished and is described in the next **Section 4.2**.

2. Describe the affected environment by 1) characterizing the resources, ecosystems, and human communities identified in scoping in terms of their response to change and capacity to withstand stresses, 2) characterizing the stresses affecting these resources, ecosystems, and human communities and their relation to regulatory thresholds, and 3) defining a baseline condition for the resources, ecosystems, and human communities.

    a. Part 1 was done implicitly in describing the Existing Conditions in Chapter 1, but a general discussion is provided in Chapter 4 for the cumulative impacts analysis.

    b. Part 2 was carried out in the Existing Conditions in Chapter 1, by discussing the pertinent regulatory thresholds and statuses for the various resources, where applicable.

    c. Parts 1 and 2 were also partially addressed in the discussion of trends for the resources in the cumulative impact analysis.

    d. Part 3 was explicitly carried out for all resources in the Existing Conditions in Chapter 1, by discussing the existing conditions of the physical, biological, and human environmental resources of the project area. The baseline condition and general health of the resource, where appropriate are summarized in **Section 4.2**.

3. Determine the environmental consequences by 1) identifying the important cause-and-effect relationships between human activities and resources, ecosystems, and human communities, and 2) determining the magnitude and significance of cumulative effects, and 3) modify or add alternatives to mitigate significant cumulative effects, 4) monitor the cumulative effects of the selected alternative and adapt management.

a. Parts 1 and 2 were carried out in the cumulative impact analysis. Where quantitative data was practical, and reasonably available or estimable for the past, present, and reasonably foreseeable actions, it was used. Otherwise, the discussion of the magnitude and significance of the effects was qualitative, employing knowledge of the scale of projects, resources, and impacting agents (e.g. air or water emitters, size of development) to provide perspective the effects against the resources impacted.

b. Parts 3 and 4 were discussed for the significant cumulative impact to oyster reef determined in Part 2.

4.2 Cumulative Effects Scoping and Summary of Direct and Indirect Impacts

The first part of the first step to scope cumulative effects was to identify the significant cumulative effects issues associated with the TSP and define the assessment goals. This involves defining the direct and indirect effects of the proposed action, which resources are affected, and which effects are important from a cumulative perspective. This is done to focus the analysis on meaningful impacts relevant to the effects of the proposed action, and not include those effects that are irrelevant or inconsequential to decisions about the TSP and alternatives.

To accomplish this, the direct and indirect effects discussed in Chapter 7 are summarized here to identify which of those effects were carried forward in the cumulative impact analysis. The second part of scoping is to identify the geographic scope for the analysis. This is discussed in this section for the effects carried forward in the cumulative impact analysis. Generally, if a more than an insubstantial temporary adverse direct or indirect impact was identified, considering the status or health of the resource, then the resource discussion was carried forward to the cumulative impact analysis section. The subsections below synopsize the reasoning for focusing on the effects carried forward in the cumulative impact analysis relative to the direct and indirect impacts to the physical, biological, and socioeconomic environments.

Regarding, the potential for indirect effects, no indirect changes to land features would occur since the TSP is not expected to induce any substantial changes in land use patterns, such as the facilitation of agriculture, mining, or urbanization. The surrounding terrestrial area is already highly developed with residential, industrial, and port terminal land uses, and further development of remaining nearby developable land would occur due to the normal population and commercial growth that already occurs in metropolitan Houston.

4.2.1 Physical Impacts Summary and Scoping

Topography, Soils, Geology, and Bathymetry

Status/Health of Resource – None of these resources is particularly listed or regulated as a threatened resource. The study area is a flat, largely urbanized land scape that has undergone extensive local modification of topography, conversion from farmland to development, and a relatively small percentage of Galveston Bay has had bathymetry altered for navigation channels.

Summary of TSP Effects for Scoping – Lack of terrestrial impacts, a small proportion of the resource affected, and regional nature of these resources, would result in a minor direct impact. TSP channel improvements would not impact prime agricultural soils. For the reasons stated at the beginning of **Section 4.2**, indirect impacts are not expected. Therefore effects to topography, soils, geology, and bathymetry are not carried forward in the cumulative impacts analysis.

Physical Oceanography

Status/Health of Resource – Galveston Bay has been historically modified by the dredging of several navigation channels including the HSC in 1914, and construction of several structural features such as the Texas City Dike and several dredge material placement islands. The TWDB modeling study discussed in **Section 3.1.4.2** assessed effects of channels and such structures on circulation and salinity. Effects on the general circulation pattern of Galveston Bay tended to be localized to the modifications, based on the residual flow patterns modeled. The effects on salinity of these modifications being in place were variable with mixtures of increases and decreases depending on wet or dry period flows and location in the Bay. The largest change was a maximum increase of about 4 ppth with the HSC in place vs without it. Galveston Bay's marine environment has adapted to these changes, with the higher salinity around the HSC likely helping to induce the reef accretion around it, as discussed in **Section 3.2.2.3**. With Galveston Bay providing a robust fish and shellfish fisheries, the hydrodynamic state of the bay would not be in a particularly critical state with respect to supporting marine life functions.

Summary of TSP Effects for Scoping – Significant effects on the hydrodynamics of Galveston Bay are not expected from the TSP given the results of previous studies on other channel modifications, and the proposed modifications for the TSP. This will be confirmed by modeling in the next planning phase. Therefore effects to physical oceanography are not carried forward in the cumulative impacts analysis.

Water and Sediment Quality

Status/Health of Resource **–** The water quality segments in the project area are impaired for fish consumption due to contaminants sampled in fish and shellfish tissue, bacteria in oyster waters, and have some segments where screening levels for nutrients or DO have been listed as of concern, but not impaired. However, other uses, such as aquatic life use, and other general quality parameters such as turbidity, are not listed as impaired. Water quality, although much improved from past decades, continues to have some impairment in the project area.

Summary of TSP Effects for Scoping – Indirect impacts to water quality from terrestrial land use changes are not expected to result from implementing the TSP. Though only temporary impacts to water quality, primarily from turbidity, would occur during dredging of the TSP, these temporary effects could overlap temporally or spatially with other foreseeable dredging projects. Therefore, water quality effects to turbidity are carried forward in the cumulative impact analysis.

Energy and Mineral Resources

Status/Health of Resource – Energy resources are adequate in the region and access to oil and gas resources is not limited.

Summary of TSP Effects for Scoping – The TSP will have no significant effects on energy usage or access to oil and gas mineral resources.

HTRW Concerns

Status/Health of Resource – The project area has several HTRW sites adjacent to the footprint of the TSP resulting from past industrial practices. These legacy sites continue to undergo site investigation and cleanup. Generally, land contamination is expected to go down since the advent of more stringent regulations under CERCLA, RCRA, and the Oil Pollution Act.

Summary of TSP Effects for Scoping – The types of projects representing the cumulative projects and the TSP are dredging actions that would not inherently result in creating more HTRW sites. Required due diligence procedures during property acquisition of those cumulative projects would result in avoiding impacting legacy sites and exacerbating their conditions. The TSP would similarly avoid impacting these sites by continuing the HTRW due diligence process described in **Section 3.1.7**. A cumulative impact to HTRW sites would not be expected as a result, and therefore, is not carried forward in the cumulative impact analysis.

Air Quality

Status/Health of Resource – The air quality in the HGB NAA, although significantly improved in the last decade as discussed in **Section 1.3.8**, still does not meet applicable ozone standards. The HGB NAA currently meets all other NAAQS. The regional plan of improvement, the HGB SIP, has addressed the main sources of nonattainment, contributing to the improvement, despite the HGB region's growth. However, further improvement is needed to meet the 2008 ozone standard, and will likely be needed to meet the 2015 standard, once nonattainment designations are made in 2018.

Summary of TSP Effects for Scoping – The TSP will reduce long term emissions compared to the No Action Alternative due to the reduction of navigation delays and inefficiencies in the delivery of cargo that would have occurred without the channel improvements. Therefore significant adverse effects to air quality would not result from the TSP. The TSP will result in temporary construction emissions that will have to be evaluated for general conformity regulation compliance in the next planning phase. This evaluation will determine if a formal conformity determination is required, which would be coordinated with the TCEQ to ensure the temporary emissions would not jeopardize efforts to attain air quality standards (demonstration of conformity to the SIP). The cumulative projects are also subject to conformity regulations, since USACE Regulatory permits were required for them. The conformity process is the mechanism to ensure these construction actions would not jeopardize efforts to attain the ozone NAAQS. Inherent in this process is required implementation of measures to reduce temporary emissions if the estimated emissions constitute significant portions of the SIP emissions budgets and the emissions were deemed to not conform to the SIP. Considering the positive long term effect of the TSP and the conformity process to address temporary emissions, a significant cumulative impact would not be expected from TSP implementation. Therefore, air quality is not carried forward in the cumulative impact analysis.

Noise

Status/Health of Resource – The project area has a mixture of existing industrial, commercial, and residential development in the land adjacent to the TSP, and existing commercial vessel activity, in the existing channels, with a variety of existing noise sources typical for these types of development and activity.

Summary of TSP Effects for Scoping – The TSP will not result in any new permanent noise sources. Temporary construction noise from dredging would occur, similar to the noise from periodic maintenance dredging that occurs in the existing conditions for the existing channel. No significant adverse effects are expected. Therefore, noise is not carried forward in the cumulative impact analysis.

4.2.2 Biological Impacts Summary and Scoping

Habitats

Status/Health of Resource – The following summarize the status of the various habitats relevant to the project area:

- The project area is highly developed with little existing natural terrestrial habitat, and the study area in general has few areas of undeveloped land cover, with even fewer in natural condition. Those that are not part of parks and nature centers would continue to be subject to development.

- Similar for terrestrial habitat, the study area is highly developed with little existing natural terrestrial habitat, and as a consequence, wetlands have been greatly reduced in area. Development and subsidence along the shoreline of Galveston Bay has resulted in the loss of thousands of acres of tidal marsh. The remaining expanses of tidal wetlands are protected by CWA regulation and much of it is concentrated in the Trinity and East Bays portion of the Galveston Bay system

- The unvegetated shallow bay bottom benthic habitat that characterizes much of the bay/deepwater habitat in the project area is relatively ubiquitous, despite construction of various navigation channels and incremental improvements to them, in Galveston Bay. See the discussion for oyster reef in the Wildlife subsection below.

Summary of TSP Effects for Scoping – A summary of habitat effects of the TSP channel improvements for scoping is as follows:

- The TSP channel improvements will have no significant adverse impacts to terrestrial habitats, limited to a few acres of disturbed, urbanized land cover. No inducement of significant indirect effects, such as changing land development patterns that would result in terrestrial habitat loss, would occur due to the TSP for the reasons discussed at the beginning of **Section 4.2**. Therefore, impacts to terrestrial habitat are not carried forward in the cumulative impact analysis.

- The TSP channel improvements will have no significant adverse impacts to wetlands or tidal marsh. No inducement of significant indirect effects, such as changing land development patterns that would result in wetland loss, would occur due to the TSP for the reasons discussed at the beginning of **Section 4.2**. Therefore, impacts to wetlands are not carried forward in the cumulative impact analysis.

- The TSP channel improvements will impact approximately 740 acres of undredged shallow bay bottom. Though this is a relatively small proportion of the 600 square miles of Galveston Bay, the other cumulative projects involve dredging in the marine environment of the study area and could constitute a greater impact cumulatively with the TSP. Therefore, impacts to bay/deepwater habitat were carried forward in the cumulative impact analysis.

Wildlife

Status/Health of Resource – The following summarize the status of the various types of wildlife relevant to the project area, other than the T&E species discussed later in this section:

- Mammals typical of terrestrial areas adjacent to the project area are mainly limited to common species such as raccoons, and coyotes. Most reptiles and amphibians using the aquatic portions on land and water in the vicinity of the project area are common species, and the American alligator has currently recovered from protected status. Migratory birds that use the study area as a flyway are still subjects of conservation efforts for the various groups of birds protected under the MBTA.

- The primary aquatic wildlife in the project area are common and ubiquitous fish and benthic species. Fish typically consist of many game and commercial species such as croaker and black drum. Some, such as species like red drum, were the subject of stricter size and number fishing limits and tagging requirements following overfishing concerns. Overall, Galveston Bay supports a healthy population of fish and shellfish that supports a commercial and recreational fishery. Benthic species in the project area are widespread and ubiquitous within Galveston Bay.

- Oyster reef has accreted along the HSC in the last half of the 20th century and apparently expanded in area from its early 20th Century extent as observations in the Powell mapping report indicate (Powell et al. 1997). This mapping totaled approximately 28,000 thousand acres. However, as discussed in **Section 1.4.2.3**, TPWD estimated that between 50 percent and 60 percent of reef in Galveston Bay were impacted by Hurricane Ike-induced sedimentation. Therefore, restoration efforts were initiated and are ongoing.

Summary of TSP Effects for Scoping – A summary of the TSP channel impacts to wildlife for scoping is as follows:

- The TSP channel improvements would not have significant impacts on terrestrial wildlife, given its insignificant impacts on terrestrial habitat. Similarly, the lack of impacts on wetlands and other aquatic habitat types near or on land would not result in significant impacts on amphibians and reptiles. Dredging in the open water environment to construct the TSP would not result in significant direct impacts on migratory birds. No significant indirect effects such as inducing land use changes, are expected for the reasons discussed at the beginning of this section. Therefore, impacts to terrestrial wildlife were not carried forward in the cumulative impact analysis.

- For aquatic wildlife other than oysters, temporary impacts from dredging to construct or maintain the TSP channel improvements would not have significant direct impacts on populations of the fish and benthic species due to either the mobility or ubiquity of the species in Galveston Bay. Indirect effects would not be expected as a result of changes in salinity for reasons discussed in **Section 3.1.4.2** for physical oceanography. These species are tolerant of much wider variability in salinity due to the natural range of salinity conditions in wet and dry seasons. Therefore, impacts to aquatic wildlife were not carried forward in the cumulative impact analysis.

- The TSP would have a significant impact on oyster reef given the range of potential acreages directly impacted. Also, since more than 50 percent of oyster reef in Galveston Bay was estimated to have been impacted by Hurricane Ike with ongoing restoration efforts by TPWD, the TSP impacts would be significant to a resource in recovery. Also, two recent high spring season flow years in 2015 and 2016 resulted in significant oyster mortality Bay-wide from depressed salinity impactful to oyster harvesting. Therefore, impacts to oyster reef were carried forward in the cumulative impact analysis.

EFH and Fisheries

Status/Health of Resource – Some components of EFH such as the water column and soft benthic habitat, have been maintained sufficiently intact to continue supporting the fisheries in Galveston Bay. Other components such as tidal marsh and oyster reef have been impacted historically or recently, and are addressed by regulatory or restoration efforts, to recover or improve the state of these habitats. Other than recent impacts to oyster reef, the commercial and recreational fishery itself is still productive, though some fish and shellfish consumption advisories remain.

Summary of TSP Effects for Scoping – The TSP channel modifications would have significant impacts to oyster reef and result in conversion of hundreds of acres of undisturbed shallow bay bottom to deeper bay bottom. Therefore, impacts to EFH were carried forward in the cumulative impact analysis. An expanded evaluation of cumulative impacts to EFH will be provided in the EFH Assessment being developed as part of the consultation process for the MSFCMA to be initiated with the release of the Draft IFR-EIS. The TSP would not be expected to have significant impacts to populations of commercial and recreational fish species, or indirect effects to them from salinity changes, as discussed for aquatic wildlife.

Protected Species and Protected/Managed Lands

Status/Health of Resource – T&E species are by definition those whose populations have been in decline, and are therefore targeted for specific protection and recovery. Of the Federally-listed species most likely to use habitat directly related to the TSP channel modifications are sea turtles which are listed as either threatened or endangered. The rufa red knot and Piping plover do not use the deep water environment of the TSP channel modifications but may be found in beach habitat towards the southern limit of the study area, approximately a mile or more from the project area. Many migratory birds that frequently use the region's flyways are commonly observed. Although not rare or endangered, are still targeted for protection under the MBTA. Likewise, bottlenose dolphins are not rare or listed as threatened or endangered, but are still targeted for protection under the MMPA. The Piping plover critical habitat located more than 1 mile away at the lowest end of the project area are designated areas managed by the City of Galveston and the Houston Audubon Society. The Loggerhead critical habitat would be affected but not adversely affected by use of the existing ODMDS 1 as discussed in **Section 3.2.6.2**.

Summary of TSP Effects for Scoping – The TSP channel modifications would not have any significant adverse impacts on the T&E sea turtles, rufa red knot or Piping plover. The TSP channel modifications would not have significant adverse impacts to migratory birds or bottlenose dolphins. Only temporary effects that do not result in adverse effect determinations or incidental takes. Therefore effects to T&E are not carried forward in the analysis. However, the potential for overlap of water quality effects to exacerbate disturbance and avoidance of use of Galveston Bay is explained in the cumulative analysis for water quality in **Section 4.7.3**

4.2.3 Socioeconomic Impacts Summary and Scoping

Status/Health of Resource – The following describes the status of the various socioeconomic resources.

- Houston is the fourth largest city in the nation with a diverse population. Neither population nor diversity scarcity are issues in the study area.

- Community resources – The study area has numerous community resources including schools, libraries, cemeteries, and places of worship, as it is a highly urbanized area.

- Recreation – The study area has numerous terrestrial parks, and a wide variety of waterborne recreation, including, sailing, boating, and fishing, takes place on Galveston Bay, with boating and fishing also taking place in the small bays above Galveston Bay.

Summary of TSP Effects for Scoping –

- The TSP channel modifications will not have significant direct or indirect impacts on population or demographics. Demographics for the census tracts where the TSP footprint has the closest proximity to mainland do not indicate a significant potential for EJ issues to arise.

- The TSP channel modifications would have no direct impacts to community resources and would not have any significant indirect effects.

- The TSP channel modifications would not directly impact terrestrial parks, and would not have any significant impact to recreational use of Galveston Bay or other recreational waters. No significant indirect effects from the TSP would occur to these resources.

Considering that there would not be significant direct or indirect impacts from the TSP channel modifications, socioeconomic resource impacts were not carried forward in the cumulative impact analysis.

4.3 Cumulative Projects Considered

The next step in the cumulative impact analysis was to identify the reasonably foreseeable actions that could have cumulative effects together with the TSP actions for the resources carried forward in the analysis. The following subsections discuss the cumulative projects considered.

4.3.1 Past or Present Actions

The third and fourth sub-steps of the scoping step are to identify the timeframe for the analysis, and other actions affecting the resources, ecosystems, and human communities of concern. The relevant past and present actions are those that have had or continue to have effects on the resources carried forward in the analysis, and within the geographic scope identified for those effects. These represent the other actions that affect the resources, ecosystems, and human communities of concern. For purposes of these past or present impacts, a timeframe of 50 years from the present to the past was selected, which is the assumed lifespan of USACE navigation/dredging project. This is also a timeframe for which sufficient impact information is reasonably and readily available.

The analysis focused on projects with a more substantial impact to Galveston Bay and bay bottom through dredging or dredged material placement. Channel dredging projects that were for changes to existing channel geometry were selected. Commercial and private docks and berthing areas were considered for past projects. However, with the exception of the Clear Lake Channel and the BSC and BCC side channels to the HSC, private berthing facilities on Galveston Bay are all small piers and docks for recreational or small fishing shallow draft vessels that would only require small-scale dredging to maintain depths near the docks and shoreline to the relatively shallow drafts of Galveston Bay (6 to 8 ft). Upstream of Morgans Point, the commercial berths, where most of the large vessel berthing activity takes place are larger than private berths in the Bay. However, not much information on their past construction and dredging is readily available, and the majority of the larger berths appear to be excavation of uplands converted to deep water. Most of the other berths appear to be deepening in the section of Buffalo Bayou upstream of the San Jacinto Battleground that was widened to create the modern HSC. So most of these past actions above Morgans Point were in a section that expanded the estuarine water column and bottom. The area of small bays downstream of San Jacinto Battleground had a few large areas that were historically emergent land or swamp that subsided and were eventually supplanted by the Lost Lake PA, Lynchburg Reservoir, and the Black Duck Bay placement feature. So the net change in estuarine bottom from these features appears somewhat limited. The largest past changes to natural bay bottom appear to occur in Galveston Bay. Therefore the past and present projects focus on that part of the study area.

The following descriptions summarize the projects constituting the past and present actions. Data from publicly available environmental documents (i.e. EAs, EISs), Federal feasibility studies, and related documents were used. These projects have been constructed, except for the Bayport Ship Channel Container Terminal, which has been partially constructed and will continue to expand as the projected container cargo demand grows. For the most part, these projects would only pose future impacts from maintenance dredging and placement for the effect being analyzed.

- Houston and Galveston Navigation Channels (HGNC) – This project involves deepening and widening the 53-mile long HSC and deepening the 2-mile long Galveston Ship Channel (GSC), which have already been completed as of 2010. Placement of dredged material was planned for 50 years to go to existing and future upland and BU marsh PAs and ocean disposal sites along these channels from the lower reach of the Buffalo Bayou/HSC before it enters Galveston Bay to just outside of Galveston Bay in the Gulf of Mexico (GOM). The project had 118 acres in the main channel and 54 acres in the barge lanes of oyster reef impact which were mitigated.

- Cedar Bayou Federal Navigation Channel – This project involved the deepening of the Federal navigation barge channel in 1975, and is completed. The channel is located approximately 4.5 miles northeast of the BSC starting near Atkinson Island and extending into Cedar Bayou, to approximately Mile 3, near the City of Baytown in Chambers and Harris Counties, Texas. It joins the HSC between the north tip of Atkinson Island and Hog Island.

- Barbours Cut Terminal and Channel – This project involved the deepening of the Barbours Cut turning basin and side channel to the HSC, and constructing a container terminal along the channel in the 1970's. Barbours Cut Terminal and Barbours Cut Channel (BCC) are located near Morgans Point, which is at the mouth of the HSC/Buffalo Bayou leading into Galveston Bay.

- BCC Improvements – This project involved improving the BCC by deepening by 5 feet and shifting northward by 75 feet to allow a wider modern crane span and an increased safety setback required by vessel pilots to pass berthed ships. It was completed in 2016.

- Bayport Ship Channel Container Terminal (BSCCT) – This is an ongoing project to build a container and cruise ship terminals with the first phase completed in 2007 providing three berths. The terminal is located on the south shore of the BSC within the land cut.

- Bayport Ship Channel – This project involved the dredging of the original BSC, dredged in the mid 1960's and deepened in the 1970's.

- BSC Improvements – This project involves the recently completed (2017) modifications to the BSC to deepen it by 5 feet and widen it by 50 feet within the land cut and by 100 feet outside of the land cut. The project provided levee construction material for raising the levees at PA 15 to increase its capacity. The 4.6 acres of oyster reef impacted were mitigated.

- Odfjell Bulk Liquid Terminal – This project involved the construction of 2 large vessel wharves and 3 smaller barge docks to service bulk petrochemical liquid vessels on the BSC TB, west of the BSCCT.

- LBC Bulk Liquid Terminal – This project involved the construction of 3 large vessel wharves and 5 smaller barge slips to service bulk petrochemical liquid vessels on the BSC TB, west of the BSCCT. Some of these facilities were originally built by Celanese and sold to LBC in 2000.

- Enterprise Ethane Terminal – This was a recently completed (2016) project turn an existing wharf (Wharf No. 8) into an ethane export terminal by constructing new docks, mooring structures, pipe racks, gangways, and other structures, and dredging the berth to match the depths of the HSC. Approximately 0.8 acres of oysters were impacted and assumed mitigated.

- Texas City Channel Deepening – This project involves deepening the Federal navigation channel, which was completed in 2011. The Texas City Channel is located in the lower part of Galveston Bay near its outlet to the GOM.

- Clear Lake Channel – An approximate 7-ft deep channel running the length of Clear Lake and emptying to Galveston Bay at a draft of 10 to 12 ft. It receives periodic maintenance to maintain this draft for recreational users.

- Expansion of PAs 14 and 15 – This project involved expanding the existing PAs 14 and 15 by filling the gap between them with an upland PA connection and creating adjacent BU marsh cells M10 and a future cell M11. Mitigation for impacts to the saline marsh and tidal flats in the connection were achieved by construction of 88 acres of marsh at the Bolivar BU Marsh site, which is reflected under the HGNC project. PAs 14 and 15 are just to the east and north of the HSC-BSC confluence.

4.3.2 Reasonably Foreseeable Future Actions

The screening process in **Section 4.2** resulted in only a few marine environment-related effects being carried forward in the cumulative impact analysis. Because of this, the foreseeable projects were focused on those that had effect in the marine or estuarine environment of the study area, defined by the HSC, its side channels, and Galveston Bay. Because any project with substantial actions that could impact the HSC or Bay waters, which are navigable waters, would require a USACE CWA Section 404 and Section 10 permit, information from the Department of the Army (DA) permit system was researched. This ensured projects that were being planned, which would have to obtain a DA permit, were captured in the search for reasonably foreseeable future actions. Issued permits from the last 3 years from 2014 to the first quarter of 2017, and the pending permit applications which typically cover permits submitted within the last year that have not been yet issued. The permits were first screened using the project location coordinates and GIS to capture an area consisting of Galveston Bay and a 1 mile buffer around the existing HSC, BSC, and BCC. Duplicate actions representing resubmissions of other selected permits were removed. Project description and application information were then obtained from the USACE Galveston District Regulatory Branch for these permit numbers to help filter out smaller actions with little potential to impact Galveston Bay through dredging. The following filtering process was used:

- Projects consisting solely of constructing or modifying dock structures, piers, mooring piles, and shore protection were not included because their construction requires no dredging, and only minimal bottom disturbance to drive piles, place shore protection etc.
- Similarly, permits to construct small well pads were not included.
- Permits consisting solely of extending routine berth maintenance dredging permits or to modify the conditions of their maintenance that do not require new areas of dredging were not included because these projects represent routine maintenance dredging over an existing deepened berth footprint. These would not further modify the estuarine bottom, but remove new periodically shoaled material.
- Ensure permits did not list dredging in addition to the other actions.

The remaining projects consisted of dredging projects that would have the similar types of impacts carried forward in the analysis. In addition to the regulatory permits, the USACE Galveston District's Civil Works studies in Galveston Bay for which planning was completed or in progress were considered for inclusion in the reasonably foreseeable projects. Finally, some known previously planned and permitted projects in Galveston Bay that had not been constructed were not included, because information indicated that project implementation was not moving forward. These were the Shoal Point Container Terminal in Texas City, and the Cedar Bayou Federal Navigation Channel Extension. **Table G4-1** lists the reasonably foreseeable future actions, based on this process. Where information was available to quantify the size of project impacts, this information was extracted and summarized in the table.

Currently, the Coastal Texas Protection and Restoration Feasibility Study is in the alternatives planning phase (the “TSP” phase) and has no potential project formulated yet. This study will identify and evaluate the feasibility of a comprehensive plan for flood, hurricane and storm risk management and ecosystem restoration for Texas coastal areas including the Houston-Galveston region. The study is focusing on structural and nonstructural measures for coastal storm risk management such as surge barriers and structure evacuation, respectively, and providing for the protection, conservation, and restoration of wetlands, barrier islands, shorelines, and related lands and features that protect critical resources, habitat, and infrastructure from the impacts of coastal storms, hurricanes, erosion and subsidence. At this stage, only a general discussion of the types of impacts relevant to the Galveston Bay environment and the TSP’s impacts can be provided. Therefore, a general discussion of the consideration of the types of impacts that would be considered cumulatively is provided in **Section 4.7.6**.

Table G4-1: Reasonable and Foreseeable Future Actions

Project (with permit #)	Proponent	Project Description	Impacts Listed	In-Water Dredge Area		
Issued Permits				**Acres**	**Footprint Type**	**Location**
Galveston Shipbuilding/Extension of Time [EOT] (SWG-1994-02067)	West Gulf Marine, Inc.	Add 2 mooring dolphins, relocate existing structures and rip-rap, dredge to -18' MLT, extend maintenance dredging period, & install concrete slab and 560' bulkhead to existing barge shipyard.	• 100K CY dredging • No oyster impact listed • 0.1 ac. WOUS (non-wetland)	6	Existing	Galveston
GIWW Barge Fleeting & EOT (SWG-2001-00874)	Port Bolivar Marine Services, Inc.	Expand commercial barge fleeting area on the GIWW by mechanically dredging 11.07 acres to -13' MLT, and installing eleven 36-inch steel pilings in fleeting area along 1,581' of GIWW southern shore	• 167K CY dredging • No oyster impact listed • 8.75 ac. Bay bottom • 2.32 ac. estuarine emergent wetlands	8.8	New	GIWW
Texas Deepwater Industrial Port & EOT (SWG-2007-01694-RN)	Pinto-Lion Jacintoport, LLC	Construct bulk products loading/unloading facility on the HSC, by dredging 72-acres to -45'MLT with 2' overdredge, stabilizing new shoreline with sheet pile bulkhead, install four 100'x100' concrete ship docks extending from shoreline, and mooring and breasting dolphins.	• 5.34M CY dredging • No oyster impact listed • 3.9 ac. tidally influenced wetlands	45	New	Upper HSC
Oiltanking Houston, New Docks and Dolphins (SWG-2008-00073)	Enterprise Products LLC	Expand existing terminal by constructing ship dock by installing 85'X45' pile dock platform, approach trestle & pipe rack, 4 breasting dolphins, 1,250' of bulkhead, and combination of mechanical and hydraulic dredging; 2 barge docks by installing two 80'X40' pile dock platforms, fenders, approach trestle & pipe racks, 16 breasting dolphins, and 1,500' of bulkhead and combination of mechanical and hydraulic dredging	• 774K CY dredging ship berth • 525K CY dredging barge docks • No oyster impact listed	17.3	Existing	Upper HSC
Vopak Deer Park West Ship/Barge Facility (SWG-2013-00136)	Vopak Terminal Deer Park	Construct ship and barge terminal for liquefied hazardous gas and atmospheric liquids on the HSC by dredging 49-acre area to -45' MLT, constructing dock terminal for two 920' or three 620' vessels, internal docking area for four 300' barges or two 490' articulated barges, and 7 outfall structures and a retaining wall	• 2.09M CY dredging • No oyster impact listed • 0.036 ac. wetlands	49	New	Upper HSC
Powell Electrical Systems Barge Berth (SWG-2000-03009)	Powell Electrical Systems, Inc.	Application to amend permit SWG-2000-03009, issued 23 April 2012. Construct a 1,692 ft. long bulkhead and dredge approximately 75,000 cubic yards to a depth of 12 feet below mean low tide. The purpose of this project is to expand operations at an existing facility	• 30K CY dredging barge berthing area • Fill in and grade 3.53 ac. water inlet • No oyster impact listed	1.5	New	Upper HSC
LBC Dock Reconfiguration in BSC Turning Basin (SWG-2002-01382)	LBC Houston, LP	Request to hydraulically or mechanically dredge approximately 35,500 cubic yards of material from 150 ft. wide by 335 ft. long area. The dredged material will be placed in a previously authorized area during the dredging of the existing newly contabld docks.	• 1.15 ac. of TNW • No oyster impact listed • 35.5 K CY dredging ship docks	1.2	Existing	BSC
Enterprise Products Operating LLC. (SWG-2014-00905)	Dock Rehabilitation and Dredging	Replace existing Wharf #8 with new barge/ship dock which includes a 20 ft. X 120 ft. access trestle, a 12 ft. wide X 106 ft. long pipe rack, a 125 ft. long X 60 ft. wide dock, two 8 ft. wide X 45 ft. long lower barge access platforms, a 15 ft. wide X 30 ft. long gangway support structure, five mooring dolphins, and four breasting dolphins to support new Ethane export terminal. 387 linear foot bulkhead installed in uplands. Replacement of exiting boat house with a 1,000 sq. ft. boat house and 15 ft. wide X 100 ft. long boat ramp, discharging 56 CY of concrete slab.	• 12.6 ac. dredge area to a depth of -45 ft. MLT plus -2 ft. of over dredge. • .48 ac. estuarine emergent wetlands • .84 ac. of live oyster reef • 421K CY dredge material	12.6	Existing Mostly	BCC
Stolthaven Barge Dock J Dredging & Dock Construction (SWG-2014-00165)	Stolthaven Houston	Expand terminal facility with a barge dock and two ship docks. Dredge barge dock to a depth of -16 ft. and two ship docks to -42 ft. Construct a 42 X 60 ft. concrete barge dock with a concrete approach. Concrete ship docks would be 60 X 90 ft. with 20 ft. approaches. Installation of mooring and breasting structures would be required.	• 1,334,250 CY dredge material • 6.65 ac. open water habitat • 0.01 ac. estuarine wetlands • 0.16 ac. scrub-shrub wetlands • 0.17 forest wetlands impacted by grading. • No oyster impact listed	6.7	New	Upper HSC
Kinder Morgan Upgrade Export Terminal on Buffalo Bayou (SWG-2013-00801)	Kinder Morgan Liquid Terminals	Construct a bulkhead, ship dock, barge dock, install mooring and breasting dolphins, and perform dredging during construction of a gasoline, ULSD, Naphtha, and gasoline blend stocks import/export facility. 100 ft. X 80 ft. ship dock with a 20 ft. X 55 ft. pier in Buffalo Bayou. 15 ft. wide driveway and 17 ft. wide pipe rack. Install two 48 in. diameter mooring and breasting dolphins, four 72 in. diameter breasting and mooring dolphins, and two 48 in. diameter mooring dolphins. Natural ground in front of installed bulkhead to be excavated to create ship dock area with bottom lined with	• 12.14 ac. dredge areas • 389,963 CY dredge materials • No oyster impact listed	12.1	New	Upper HSC

Project (with permit #)	Proponent	Project Description	Impacts Listed	In-Water Dredge Area		
		6,267 CY of articulated concrete mat				
Miramar Shoreline Restoration (SWG-2015-00063)00165	City of Shoreacres	Restore approximately 2,885 linear ft. by 65 ft. wide of shoreline. The project would include the construction of a temporary barge access channel, the removal of existing concrete riprap, the construction of stone riprap revetments, beach establishment, and the construction of two super-step structures. Barge access channel would be 800 ft. long, 100 ft. wide and 3 ft. deep.	• No mitigation proposed. • No oyster impact listed. • 40,505 CY excavated shoreline.	1.84	New	Galveston Bay
Amerada Hess Corp. Platform Dock & Dredge (SWG-1997-00788)	Amerada Hess Corp. Magellan Terminals	Widen existing ship basin from 369.75 ft. to approximately 438 ft., deepen the basin from -42 ft. to -45 ft. MLT, dredge a turning basin with a 440-ft. radius to -45 ft. MLT, demolish and remove existing east side ship dock on the basin, construct 2 new ship docks, install new breasting and mooring dolphins.	• 525K CY dredged material • No oyster impact listed. • 17 acres of non-wetland waters in review area.	17	Existing	Upper HSC
Targa Resources (SWG-2015-00725)	Targa Resources/NWP and LOP/Houston Ship Channel	Excavate 0.9 ac. of uplands; install 1,215 linear feet of upland bulkhead for bank stabilization. Construct a 90 ft. long X 45 ft. wide ship dock supported by twenty four 24 in. square driven concrete piles. Construct a 100 ft. long by 45 ft. wide barge dock interior of the new bulkhead wall supported by twenty one 24 in. square driven concrete piles. Construct 235 ft. long X 10 ft. wide ship dock pipe rack and a 410 ft. long by 10 ft. wide access road in the uplands. Dredge 5.1 ac. to -45 ft. MLT and dredge 0.9 ac. area to -16.44 ft. MLT.	• 245K CY dredge material • No oyster impact listed	6	Existing	Upper HSC
Pending Permits						
Contanda Jacintoport Terminal, LLC (SWG-2016-00973	Contanda Jacintoport Terminal/Houston Ship Channel	Dredge existing barge dock slip to install a sheet pile bulkhead, two barge dolphins, and construct a new bard dock. Creation of two 300'x54' barge slips; install two new mooring dolphins; 790 LF bulkhead and toe wall. No proposed mitigation.	• 200K CY dredging • No oyster impact listed • 0.79 upland ac. converted to open water	4.9	Existing	Upper HSC
Magellan Terminals Holdings, L.P. (SWG-2016-00635)	Magellan Terminals Holdings, LP/Houston Ship Channel	Construct new 188-acre petroleum hydrocarbon bulk storage marine terminal facility and 86 bulk storage units. Dredge for 4 ship berths, one 1,020 ft. diameter turning basin, one barge berth; breasting and mooring dolphins; bulkheads and riprap shoreline protection; 2 dock platforms and support piers, and approach trestles and support piers with pipe, racks, marine loading arms, and docking fenders.	• 5.5M CY dredging mud, silt, sand, and shell. • 1.21M CY dry dredging • No oyster impact listed • 17.5 ac. jurisdictional wetlands. • Mitigate with purchase of 55.92 credits	32	New	Upper HSC
Houston Fuel Oil Terminal Company, LLC (HFOTCO) (SWG-2016-00164)	Houston Fuel Oil Terminal Company/Houston Ship Channel	Construction of a new ship dock; which includes a trestle, pipe rack, dock, access platform, gangway support structure, seven fender piles, four mooring dolphins and four breasting dolphins. Dredging 1,000 LF trench for pipeline crossing norther end of proposed bulkhead to the HFOTC facility across channel.	• 615K CY dredging • No oyster impact listed • 65K CY dredging for pipeline. • No proposed mitigation	9	Existing Jacintoport Channel	Upper HSC
Odfjell Terminals Adding of disposal areas (SWG-2002-02976)	Odfjell Terminals (Houston) Inc.	Hydraulically dredge a 9.06 ac. area within existing facility. Deepen facility from -40 ft. MLLW to -47 ft. Dredged material will be placed in DMPAs within the Spillman Island or Port of Houston. Deepen existing channel to accommodate deeper vessels.	• 110K CY dredging • No oyster impact listed • No mitigation proposed	9.1	Existing	Upper HSC
Odfjell Terminals: Dredge, Docks, Bulkhead, Fill (SWG-0000-15383)	Larsen Tankers	Modify existing permit to add authorization to relocate existing drainage structure, construct a wing wall parallel to shoreline, and install four new mooring dolphins and a high capacity fender on the bulkhead. Dredged docks #3&4 to a new depth.	• 150K CY dredged material • Fill in and raid 3.53 ac. water inlet • No oyster impact listed	9.3	Existing	Upper HSC
Targa Resources (SWG-2015-00274)	Targa Resources	Construction of new dock at existing facility. Removal of exiting turning dolphin, mechanical excavation of 8.8 ac. of dry land, dredging of 15.76 ac. to a depth of -42 ft. Expansion of existing dock facilities, installation of twelve 72-in. diameter dolphins, and installation of 4-17pprox.. 1,232 ft. of sheet pile bulkhead.	• 700K CY dredged material • 8.8 ac. dry land excavated • 15.76 ac. dredged area • 0.16 ac. wetlands	15.8	New	Upper HSC
Other Foreseeable Projects			•			
HSC Project Deficiency Report Modifications, Flare at the Intersection of the HSC and BSC	USACE Galveston District	Expansion of existing southern turning flare to 4,000 ft radius, and construction of a 325 ft widener at the HSC bend just south of the flare to correct a design deficiency in the geometry of the existing channels	• 1.94M CY dredging • 29.9 ac oyster reef	56.7	Existing and New	Galveston Bay
Coastal Texas Protection and Restoration Feasibility Study	USACE Galveston District	Study to identify and evaluate flood, hurricane and storm risk management and ecosystem restoration for Texas coastal areas including Houston-Galveston region. Study will focus on structural and nonstructural measures such as surge barriers and structure evacuation, and providing for the protection, conservation, and restoration of wetlands, barrier islands, shorelines, and related lands and features of coastal environment	No project yet – study is in planning phase	n/a	n/a	n/a

4.4 Cumulative Effects Analysis

The next step was to evaluate the cumulative effects of the proposed action together with the past, present and reasonably foreseeable future projects. Information from permit application material obtained from the USACE-SWG Regulatory Branch was tabulated and used to estimate quantities that portray the size of the relevant impacts. These were project quantities such as dredge quantities, acreage of dredged areas in water/bay bottom, and impacts to oyster reef. Where not directly given, areas of dredging in existing water and bay bottom were estimated from project plans using aerial photography and geospatial software or otherwise confirming that stated dredged areas were for existing areas of water. The impacts for each project are summarized in **Table G4-1**.

4.4.1 Water Quality

For water quality, the effects of the cumulative projects will be the same temporary effects that the dredging to construct the TSP will have, described in **Section 3.1.5.1**. Though temporary, these effects were carried forward to assess if their overlap would be of concern when considered cumulatively. The temporary effects of turbidity, decrease in DO, and short term changes in contaminant levels would occur from the disturbance of sediments during dredging. The past actions would not continue to have these effects from construction dredging, but would during periodic maintenance dredging, which would occur in the No Action Alternative. The present projects that still have berths to construct would have effects from construction dredging, and all would have effects from maintenance dredging which would occur in the No Action Alternative. The reasonably foreseeable projects would have effects from construction of dredging berths and access channels.

As previously discussed in **Section 3.1.5.1**, the temporary effect from dredging lasts a few hours and spreads less than a thousand meters, typically a few hundred meters (a few thousand feet). Therefore, the most important relationship of concern to turbidity and its associated effects from these projects is the timing and spacing of the projects and whether their effects would spatially or temporally overlap. Except for three projects, all of the foreseeable future projects are located at two ends of the HSC system: the first two are at the southern end of the HSC on the Galveston Channel or GIWW, and the rest are above the Fred Hartmann Bridge (SH 146) in the upper HSC. Therefore, effects from the construction of the HSC through Galveston Bay would not overlap with these projects as Galveston Bay section of the project is more than 3,000 meters from SH 146 and over 2,000 meters from the locations on the GIWW and Galveston Channel.

For the three projects in Galveston Bay portion of the study, the HSC PDR, which is located right near the BSC and HSC confluence, two things would preclude overlapping of effects. First, given the timeline for the HSC ECIP and the nature of the HSC PDR project, which addresses a deficiency that would have a quicker implementation, it is very likely that the HSC PDR would be constructed ahead of the HSC ECIP. Second, if it was not built yet and construction anticipated to occur around the same time, the HSC PDR, a USACE project, would likely be implemented under the same dredging effort as the HSC ECIP to eliminate extra mobilization costs, and would then be sequentially performed rather than simultaneously. The LBC project located at the end of the existing BSC TB, would likely be implemented earlier. Also, vessel pilot and USCG safety spacing, explained in the next paragraph, would likely preclude simultaneous dredging in close enough proximity for spatial overlap. The Miramar Shoreline Restoration project is the dredging of a small access channel for a rock barge, and would be located approximately 1,300 meters away along the shortest path on water between the nearest TSP feature (BSC widening) and the shoreline project site.

For the remaining projects above SH 146, several factors would likely preclude turbidity effects from overlapping. First is the constriction and limited water of the HSC above SH 146, the density of terminals (the majority in the Port of Houston system are located here), and the resulting existing vessel traffic. These constraints would limit the practicality of staging two simultaneous dredging operations so closely since they would likely impose temporary obstructions to local berth and terminal access for which accommodations or detours would have to be planned. Second, vessel pilot and USCG safety spacing restrictions typically require 3 to 5 miles between dredges, related to the navigation constraints just discussed. Execution of these projects would have to be coordinated with USCG Vessel Traffic Service (VTS) as they would involve dredging within or directly adjacent to a highly active navigation channel. Third is project timing. Given that the HSC ECIP is a Federal project whose implementation would be dependent on Congressional appropriation and would likely be done in phases, many of these smaller private projects may proceed to implementation and be constructed sooner. The limited population and availability of suitable dredges also makes it unlikely these projects would be dredged simultaneously.

The improbable likelihood of turbidity effects overlapping would also preclude these effects adversely impacting the occasional or transient foraging use of Galveston Bay by the protected species. Even if there were to be projects dredged simultaneously nearby each other, it would not preclude movement to or use of the rest of the expanse of Galveston Bay given the magnitude and temporary nature of the turbidity effects from dredging. However, overlap of effects is not expected. Also, consider that only three foreseeable projects were identified in the Bay reach as most of the foreseeable projects are above Morgans Point where these protected species would not likely use the heavily trafficked and narrower tidal river environment.

For the effects of maintenance dredging of the existing channels of the past and present actions, the same factors of safety spacing restrictions and dredge availability would make simultaneously dredging in sufficiently close proximity unlikely. The last deepening and widening of the HSC under the HGNC Federal project was constructed primarily between 1998 and 2005. Given that other private berth construction projects and ongoing existing channel maintenance would have also been performed during that period, the similar situation for cumulative effects would have been present. No long term water quality concerns have arisen as discussed in **Section 3.1.5.1**, and no adverse impacts from these temporary effects cumulatively resulted either. Considering the information discussed, the TSP's temporary localized effects from turbidity would likely not have cumulative effects with the past, present, or reasonably foreseeable actions since their effects would not overlap due to either timing or distance.

4.4.2 Bays and Deepwater Habitats and EFH

The TSP would involve impacts to estuarine bottom in two main areas: Galveston Bay, and the Buffalo Bayou/San Jacinto River tidal channel, in which the HSC above Galveston Bay is located. **Table G4-2** below summarizes the impact acreage and location with respect to these two areas of the estuary system. Bay bottom conversion would involve between 1,711 and 2,396 acres although between 469 and 538 acres of it is oyster reef which will be directly mitigated. The remainder of between 1,242 and 1,858 acres is unvegetated bay bottom. Of the total bay bottom, approximately between 1,002 (671+331) and 1,416 (989+427) acres of this is the previously deepened main channel side slope and existing barge lane, and between 475 and 746 acres of existing previously undredged bay bottom. Of the total bay bottom, approximately between 389 and 609 acres of this is undredged shallow bay bottom that would mainly become relocated shallow draft barge lanes. Much of this acreage would be conducive to allowing recovery of reef, as the existing shallow draft barge lanes did. The top side slope portion of the future main channel from a 20-foot depth and shallower, of about 63 to 90 acres, would also be expected to allow reef to recover, as was observed during the previous deepening and widening under the HGNC project.

As discussed in the Water Quality section above, the cumulative projects primarily propose dredging berths in the upper HSC above Galveston bay. Of the three foreseeable projects in the Bay reach, the LBC project is actually inside of the BSC land cut, and proposed to take place in an existing deepened berth. The Miramar Shoreline Restoration would involve a small temporary barge access channel. The HSC PDR will be in Galveston Bay near the confluence of the HSC and BSC with approximately half of the footprint covered in oyster reef that is being mitigated. The 59 acres that these projects impact in the bay would contribute cumulatively little to the TSP impact on unvegetated bay bottom of between 1,242 and 1,858 acres. Cumulatively, this acreage at maximum would be 1,917 acres or approximately 0.5 percent of the approximately 600 square miles of Galveston Bay, a relatively small amount. If the full acreage with oyster reef is considered, a total maximum of 2,455 acres or 0.6 percent would be impacted, still less than 1 percent. As discussed in **Section 3.2.1.3**, fairly quick recovery of benthic infauna would be expected relatively quickly according to the test plots done during the HGNC study. More modern benthic recovery monitoring efforts corroborate this expectation, where recolonization was rapid and the assemblage of species eventually recovered to pre-disturbance conditions within 2.5 years (USACE New York District 2013).

In the Buffalo Bayou/San Jacinto River, the 372 acres of the TSP dredging would have 205 acres that would become new deepened channel within the toe. This acreage is typically in the side slope margin of the existing channel. The remaining 167 acres would be side slope that would be typically located in shallow bayou bottom. The cumulative projects total approximately 479 acres of estuarine bottom dredged. However, 351 acres is within an existing deepened berth or channel footprint, leaving approximately 128 acres in shallower areas. Cumulatively, this would represent about 295 acres of shallow area or about 3 percent of the approximate 17 square miles of open water along the HSC and in the small bays above Galveston Bay up to the Main Turning Basin. Similar to Galveston Bay, benthic infauna would also be expected to recover some time after disturbance from dredging.

Considering the temporary effect with eventual recovery, and the relatively small percentages involved of existing Bay and estuarine channel bottom involved, a cumulatively significant effect would not be anticipated. However, the impact is to part of the EFH defined for the area. Given the size of the impact, this effect will be evaluated in detail in the EFH assessment being prepared for this study.

Table G4-2: Estimate of Estuarine Bottom Impact of the TSP

			Acres for Indicated Channel Width Option	
TSP Component	**Current Condition**	**TSP Dredged Condition**	**650'**	**820'**
HSC Bay Widening	Deepened navigation channel	Deepened main channel	671	989
	Existing side slopes and shallow draft barge lanes	Deepened main channel	331	427
	Shallow undredged bottom	Deepened main channel >20' depth	23	47
		Deepened main channel <20' depth side slope	63	90
		Shallow draft barge lane	389	609
		Total	**1,477**	**2,162**
TSP Component	**Acres for Dredged Footprint**		**Total**	
	New Toe Area	**New Side Slope Area**		
Other Bay Measures	144.5	89.4	**234.0**	
Upper HSC Measures	204.8	167.4	**372.2**	
			650' Channel	**820' Channel**
		Total in Galveston Bay	**1,711**	**2,396**
		Total Buffalo/San Jacinto River	**372.2**	**372.2**

4.4.3 Oyster Reef

Only a few of the cumulative projects listed oyster reef impacts. Most reef impacts were associated with past actions, and only one of the reasonably foreseeable projects had reef impacts identified. This is likely due to the vast majority of permits occurring in areas of the highly modified segment of the upper HSC above the San Jacinto Monument within existing berths and basin cuts. The TSP would impact between 469 acres and 538 acres of mapped reef. The past and present cumulative projects have impacted approximately 177 acres. All but 0.8 acres were known to have been mitigated by replacement reef in Galveston Bay, and 0.8 acres would be assumed to have been mitigated as it was part of a USACE-permitted project. The foreseeable project impact of 29.9 acres is a USACE project that will also have mitigation in the Bay. Therefore, these losses would be replaced in the Bay.

The historical Powell mapping had delineated approximately 28,000 acres of reef throughout the Galveston Bay system. As discussed in **Section 1.4.2.3**, TPWD estimated between 50 and 60 percent of the reef in Galveston Bay was impacted by Hurricane Ike sedimentation. A relatively minor percentage has been restored by TPWD projects including at Dollar Bay and San Leon reefs. Conservatively assuming that 40 percent remained unaffected (11,200 acres), if the TSP and cumulative projects that have not yet been mitigated, were considered, up to approximately 568 acres would be impacted, which is approximately 5 percent of the reef assumed unaffected.

If not mitigated for, this impact would be significant because it is permanent. Even though the other projects do not cumulatively add much since most of the acreage impact is from the TSP, the effect with or without the cumulative projects would be considered adverse and significant. Therefore, mitigation would be required. Mitigation for the TSP reef impact is already proposed for its direct significant adverse impact to a significant ecological resource per USACE planning guidance.

4.4.4 Cumulative Impact Considerations for Coastal Texas Protection and Restoration Feasibility Study

As previously discussed, the Coastal Texas Protection and Restoration Feasibility Study will focus on planning for measures that reduce coastal storm and flood risks, and engage in ecosystem restoration related to coastal natural features that can help protect against this risk. A major portion of this study which covers the entire Texas coast, will be in the Houston Galveston region, including Galveston Bay. A variety of separate studies to reduce coastal storm risk have been ongoing by entities such as Rice University, Texas A&M at Galveston, and a local 6-county planning entity GCCPRD. The Coastal Texas study is reviewing the results of these studies to inform the planning and alternatives, which may be adapted or considered in formulating original alternatives.

Some of the alternatives are likely to involve structural measures such as storm surge barriers like seawalls or ring levees around Galveston Island and surge gates that prevent surge entry into Galveston Bay through the inlet. Other options that provide barriers may be evaluated. By necessity, these features will have to consider the presence of the HSC and preserving navigability in the system. Therefore, the results of the HSC ECIP study will affect the ultimate configuration and accommodations these measures make for navigability. Such barriers may have the potential to alter flows, currents, and other hydrodynamic attributes in Galveston Bay during non-storm conditions that would be considered in the planning, design, and hydraulic modeling supporting those activities. The design to minimize impacts of these features could include sufficient pre-barrier deployment inlets to reduce impediments to normal tidal circulation. Though the hydrodynamic impacts are expected to be small, the HSC ECIP study will use the general hydrodynamic model being developed for the Coastal Texas Study to assess the hydrodynamic effects of the TSP. Later, when specific coastal storm risk management (CSRM) alternatives are being evaluated, the TSP will be included in the without and with project conditions. Effectively, this would model the cumulative hydrodynamic effects of both projects.

The CSRM features will require construction materials that may include dredged stiff clays to build parts of barriers. The Coastal Texas Study will also evaluate ecosystem restoration alternatives that involve coastal environment resources such as tidal marsh, oyster reef, barrier islands, and dunes. These needs may have synergy for beneficial use of materials from the TSP that will be coordinated with and considered in the TSP DMMP planning in the quest to meet BU objectives of this study.

4.5 Mitigation and Monitoring of Significant Cumulative Effects

The last steps in the cumulative impact analysis are to modify or add alternatives to mitigate significant cumulative effects, and to monitor the cumulative effects of the selected alternative and adaptive management. The cumulate effects evaluation in the previous section resulted in identifying impacts to oyster reef as a significant adverse cumulative impact if not mitigated for, mostly due to the direct impact of the TSP itself. Mitigation is proposed for the TSP as discussed in **Section 4.8**, and detailed in the Mitigation Plan provided in **Appendix P**. The mitigation is part of the TSP alternative and would consist of beneficially using dredged materials to build elevated relief above the bay bottom, capped with a veneer of suitable cultch. This method has been previously used successfully to restore reef as discussed in the Mitigation Plan. The Mitigation Plan also contains a monitoring and adaptive management plan to ensure success criteria will be met, and that the mitigation effort can respond to changes that prevent achieving success. This would be actions to ensure the restored reef is relatively vertically stable and that natural oyster recruitment has taken place to establish the reef.

4.6 Conclusions

The cumulative impact analysis resulted in identifying a significant cumulative adverse impact due to oyster reef impacts of the TSP, for which mitigation has been proposed. The impact to bay bottom, although expected to be a temporary one as benthic fauna would eventually recover to inhabit modified portions of the channel, is an impact to EFH that will be evaluated in detail in the EFH Assessment to be developed in the next planning phase. The cumulative impact analysis for this Draft IFR-EIS will be updated with consideration of the effects from the specific DMMP developed for the TSP in the next planning phase.

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