Sabine Pass to Galveston Bay, Texas
Coastal Storm Risk Reduction and Ecosystem Restoration
Draft Integrated Feasibility Report and Environmental Impact Study

Draft Appendix O

Wetland Value Assessment Modeling

September 2015

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1 MODEL APPROVAL FOR USE

In the Review Plan for the Sabine Pass to Galveston Bay, Texas (S2G), Coastal Storm Risk Management (CSRM) and Ecosystem Restoration (ER) Study, Galveston District proposed to use the Wetland Value Assessment (WVA) coastal marsh, swamp and bottomland hardwood community models to evaluate ecosystem impacts. The U.S Army Corps of Engineers (USACE) National Ecosystem Restoration Planning Center of Expertise (ECO-PCX) agreed, noting that while the swamp and bottomland hardwood models are certified, use of the coastal marsh models would require approval by USACE Headquarters (HQUSACE) (Attachment A). By memo dated May 6, 2014 (Attachment B), the HQUSACE Model Certification Panel reported that it had reviewed the WVA marsh model in accordance with EC 1105-2-412 and determined that the model and its accompanying documentation are sufficient to approve the Coastal Marsh Community Model Version 1.0 for use on the S2G Feasibility Study. Since several unresolved issues exist with the form of suitability graphs for Variables 1, 2, and 3 and the aggregation methods used to combine marsh and open water habitat units, Galveston District was directed to conduct sensitivity analyses for application of the marsh models using a sensitivity spreadsheet prepared by the Engineering Research and Development Center's (ERDC) Environmental Lab. These analyses will be coordinated with the ECO-PCX and reported in a separate appendix to the Final Integrated Feasibility Report and EIS (FIFR-EIS).

2 STUDY OVERVIEW

The Sabine Pass to Galveston Bay study area encompasses six coastal counties of the upper Texas coast (Orange, Jefferson, Chambers, Galveston, Harris and Brazoria) (Figure 2-1). The study area consists of three watershed-based regions: the Sabine, Galveston, and Brazoria Regions. Although the S2G study addresses coastal storm risk management and ecosystem restoration problems and opportunities within the six-county region, the detailed evaluation of alternatives focuses on two regions outlined in Figure 2-1, the Sabine and Brazoria regions. The DIFR-EIS presents a programmatic overview of coastal storm risk problems and opportunities in the Galveston region and a programmatic overview of ER opportunities for the entire six-county study area. Using work already accomplished to date, this overview provides recommendations for future studies in the Galveston Region; no in-depth alternative analyses will be conducted and no recommendations for project construction will be made for this region. None of the ER proposals will be fully developed or recommended for construction in this report.

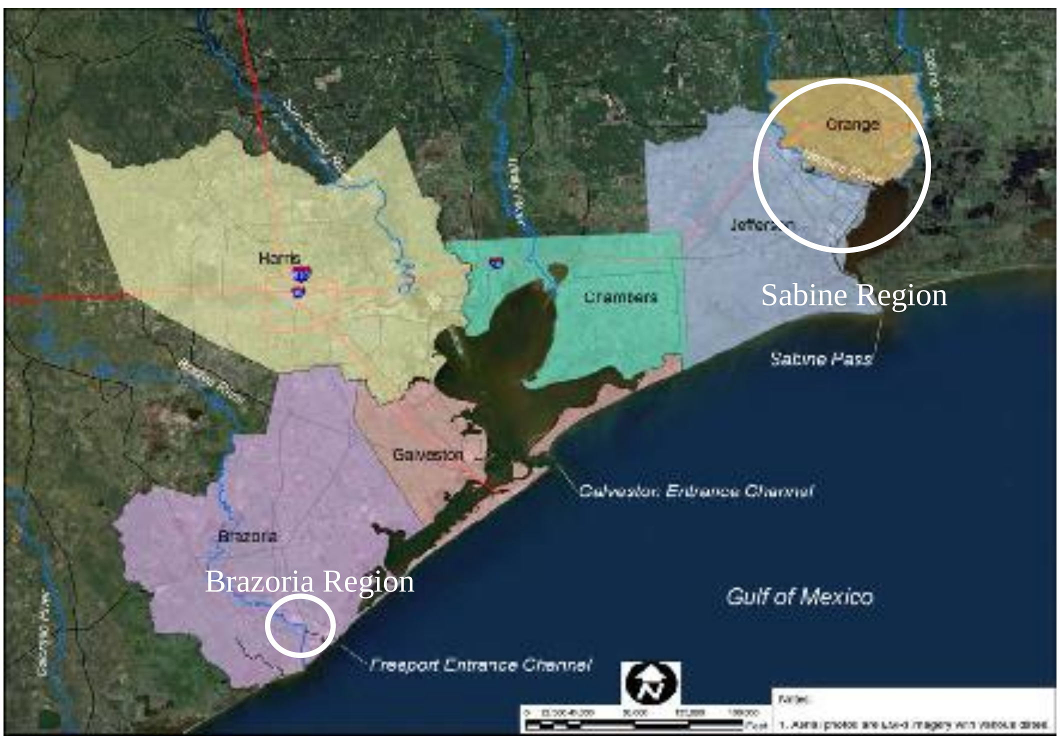

Figure 2-1. Six-County Study Area – Sabine and Brazoria Regions

The S2G study conducted a detailed evaluation of the following structural plans: 1) the Freeport and Vicinity CSRM Plan (Figure 2-2); 2) the Port Arthur and Vicinity CSRM Plan (Figure 2-3); and 3) the Orange-Jefferson CSRM Plan (Figure 2-4). The Port Arthur and Orange-Jefferson project areas are located in the Sabine region in the vicinity of Port Arthur, Beaumont, and

Orange, Texas, and the Freeport project area is located in the Brazoria region in the vicinity of Freeport, Clute, and Oyster Creek.

Figure 2-2. Existing Freeport HFP System

Figure 2-3. Existing Port Arthur HFP System

Figure 2-4. Orange-Jefferson County CSRM Alternative

This WVA modeling appendix focuses on an evaluation of the Orange-Jefferson CSRM project area in Orange and Northeast Jefferson Counties, Texas, and specifically on the plan that will be proposed as part of the Tentatively Selected Plan (TSP). The Orange-Jefferson CSRM Plan involves the construction of an entirely new CSRM system. The TSP includes only portions of the alignment illustrated in Figure 2-4. The alignment shown there is the full alignment evaluated by the study; the final TSP alignment is presented later in this report. The Freeport and Port Arthur plans involve improvements to existing Hurricane Flood Protection (HFP) projects. WVA evaluation of the Freeport and Port Arthur CSRM Plans was not needed because these projects would have no wetland impacts. Construction would be confined primarily to the existing project rights-of-way, and no wetland or other significant habitats would be affected. If future refinements to these plan result in potential impacts, the Freeport and Port Arthur project areas will be evaluated for impacts and WVA modeling will be conducted.

3 EXISTING CONDITIONS IN THE STUDY AREA

3.1 WETLAND VEGETATION COMMUNITIES

In the study area, coastal marshes occur in four types that are differentiated by salinity, elevation, and soil regimes. Information on indicator species, salinity regime, and lists of vegetation community species provided by marsh type below was completed from references cited here (The Nature Conservancy, 2006; USFWS, 1998; White et al., 1987).

Salt marsh is located primarily along the Gulf shoreline and the shores of Sabine Pass. Small areas of salt marsh can also be found north of Sabine Lake, primarily in areas regularly exposed to higher salinities in the deep draft navigation channels. Subjected to regular tidal inundation, low saline marsh is dominated by smooth cordgrass/oystergrass (*Spartina alterniflora*) and often accompanied by seashore saltgrass (*Distichlis spicata*), blackrush (*Juncus romerianus*), saline marsh aster (*Aster tenuifolius*), and marshhay cordgrass/wiregrass (*S. patens*). The dominant species in high salt marsh, which is subject to less-frequent tidal inundation, is glasswort (*Salicornia* spp.). Relative to other marsh types, salt marsh typically supports fewer terrestrial vertebrates although some shorebird species are common.

Brackish marshes in the study area are located primarily along the lower reaches of the Neches and Sabine Rivers, and the north shore of Sabine Lake. The dominant species in low brackish marsh is saltmarsh bulrush (*Scirpus robustus*); seashore saltgrass and marshhay cordgrass are co-dominant species in high brackish marsh. These species are often accompanied by marsh pea (*Vigna luteola*), waterhemp (*Amaranthus tamariscinus*), and dwarf spikerush (*Eleocharis parvula*). Brackish marshes are extremely important as nurseries for fish and shellfish. Other characteristic species include fur-bearers and shorebirds.

Intermediate marshes are subjected to periodic pulses of salt water and maintain a year-round salinity in the range of 3 to 4 parts per thousand (ppt). In the study area, they are the major marsh type along the Neches and Sabine Rivers. The diversity and density of plant species are relatively high with marshhay cordgrass the most dominant species in high marsh. Co-dominant species in low marsh are seashore paspalum (*Paspalum vaginatum*), Olney bulrush (*S. americanus*), California bulrush/giant bulrush (*S. californicus*), and common reedgrass/roseau cane (*Phragmites australis*); bulltongue (*Sagittari lancifolia*) and sand spikerush (*E. montevidensis*) are also frequent. Intermediate marshes are considered extremely important for many wildlife species, such as alligators and wading birds, and serve as important nursery areas for larval marine organisms.

Freshwater marshes are heterogeneous, with local species composition governed by frequency and duration of flooding, topography, substrate, hydrology, and salinity. Tidal fresh marsh is located in the riparian zone of the Neches and Sabine rivers. Co-dominant species in low marsh are maidencane (*P. hemitomen*), giant cutgrass (*Zizaniopsis milacea*), and bulltongue. Co-dominant species in high marsh are squarestem spikerush (*E. quadrangulata*) and marshhay cordgrass. Other characteristic species include American lotus (*Nelumbo lutea*), watershield (*Brasenia screben*), duckweed *(Lemna* spp.), and fanwort (*Cabomba caroliniana*). Salinity rarely increases above 2 ppt, with a year-round average of approximately 0.5 to 1 ppt. Tidal fresh marshes support extremely high densities of wildlife, such as migratory waterfowl.

Upstream of the coastal marshes in Sabine Lake estuary, the area north of Interstate 10 is dominated by dense bottomland hardwood forests and cypress-tupelo swamps. These wetland forests cover an intricate network of sloughs and sandy ridges formed within the rivers' relict meander belts. Bald cypress (*Taxodium distichum*) – tupelo-gum (*Nyssa aquatica*) swamps grow in the inundated areas between the ridges, and floodplain hardwood forest of oaks (*Quercus nigra, Q. phellos, Q. alba, Q. lyrata*), sweetgum (*Liquidambar styraciflua*), hickories (*Carya* spp.), American elm (*Ulmus americanus*), maple (*Acer rubrum*), green ash (*Fraxinus pennsylvanica*), American holly (*Ilex opaca*), and loblolly pine (*Pinus taeda*) grow atop the sandier ridges. In general, these are healthy, stable habitats. The hardwoods, and especially the cypress trees, have been logged repeatedly since the turn of the century and as recently, perhaps, as the 1950s (USACE, 1998). Pockets of bottomland hardwood forest remain in the uplands south of Interstate 10, and cypress swamp can still be found in low lying drainages such as Cow and Adams Bayous. Though much of the forest is secondary growth, the swamp and bottomland hardwood habitats have medium to high value for food and cover to resident and migratory fish and wildlife.

3.2 LOSS OF EMERGENT MARSH

Marshes in the study area are severely threatened, with the conversion of numerous large marshes to open water documented by various mapping studies (Barras et al., 2004). Immediately east of the study area in the Chenier Plain subregion of coastal Louisiana, a net land loss of 21 percent between 1978 and 2000 has been reported (USACE, 2004:MR 2-24; Appendix B). In Texas, the most-extensive losses of interior coastal wetlands in the state (12,632 acres between 1930 and 1978) have occurred in the Neches River delta. In total, over 90 percent of the emergent marshes in the Lower Neches River delta have been converted to open water (White et al., 1987; Morton and Paine, 1990), which is more than half of the total wetland loss in the State of Texas (Sutherlin, 1997). The breakup of previously intact emergent marsh is apparent, and shoreline erosion is occurring around larger lakes. In the conversion of marsh to open water, topsoils and nutrients have eroded, leaving dense clay substrates that do not support marsh vegetation. More recently, however, the rate of land loss in the Chenier Plain region appears to have ameliorated and interior marshes appear to have stabilized. Over the last 20-30 years, rates of loss have declined and marshes do not appear to be undergoing rapid conversion of large areas to open-water like areas to the east in Louisiana (LCWCR/WCRA, 1998; TPWD, 2003; USACE, 2004; USGS 2014). For example, 61 percent of the total land loss in the Chenier Plain region occurred between 1978 and 1990 as compared to 39 percent between 1990 and 2000 (Barras et al., 2004). A recent analysis of satellite images covering the period from 1984 and 2014 in Orange County documented much lower marsh loss rates, as well as documenting increases in areas with active marsh restoration projects (USGS 2014).

3.3 EFFECTS OF RECENT HURRICANES

Three large hurricanes have occurred in and near the study area within the last ten years. In 2005, Hurricane Katrina devastated areas to the east but did not affect this area. The same year, Hurricane Rita's storm surge at Louisiana Point was 10.6 feet as recorded by USGS sensors (Farris et al., 2007). The surged deposited 3.3 feet of new sediment on the Hackberry Beach chenier ridge and inundated thousands of acres of coastal marsh. Bar welding of nearshore sediments to the lower shore face was also evident (Guidroz et al., 2006). Immediately after the storm, hundreds of acres of marshhay cordgrass marsh in Cameron Parish appeared to have been severely impacted by extensive flooding of high-salinity waters. When the water finally subsided, the vegetation in some areas appeared dead, and the marsh had areas that were 30 to 50 percent devegetated. Over time, porewater salinity levels should decline as rainwater flushes salinity from the system (Farris et al., 2007).

In 2008, Hurricane Ike struck the north Texas Gulf Coast, with the eye passing over the city of Galveston, approximately 60 miles southwest of the study area. Ike's hurricane-force winds, record-breaking levels of storm surge, and extensive coastal and inland flooding had a direct impact on the coastal wetlands, including significant marsh loss, scouring, and compression (Federal Emergency Management Agency [FEMA], 2008). The secondary effects of saltwater intrusion, in which freshwater habitats and species are stressed by elevated soil salinities from the surge overwash and sediments, may not be fully realized for years to come.

Chenier plain marshes in the Sabine and Neches River floodplains are concave in shape, and under normal conditions, do not drain as rapidly as tidal fringe marshes. The normal drainage of these marshes is also impaired by numerous human-caused hydrologic modifications within and adjacent to these marshes, such as the GIWW, the Sabine-Neches Waterway, numerous roads and other infrastructure (FEMA 2009). In addition to inundating salt marshes near the coast, tidal surges resulted in significantly increased salinities in large areas of swamp and freshwater marsh in the Sabine system for months after the storms (Steyer et al. 2007; FEMA 2009). The marshes of Sabine Lake are comprised of generally brackish and intermediate vegetation communities which were not tolerant of the higher salinity of Ike's storm surge. Therefore, the high salinity water was either lethal to these plants or had sub-lethal effects ranging from reduced seed production, vegetative stress and increased vulnerability to disease (Smart and Barko 1980; Linthurst and Seneca 1981; Howard and Mendelssohn 1999). Further compounding the problem is the organic soils that are typical of these marshes, and when exposed to saline waters, can produce high amounts of hydrogen sulfide, which can lead to sulfide toxicity and death in marsh plants. Organic soils are also dependant on plant roots for cohesion; therefore, upon plant death, these soils are subject to rapid erosion and dissolution in normal marsh conditions (FEMA 2009).

4 FUTURE WITHOUT-PROJECT CONDITIONS

4.1 EXPECTED NAVIGATION CHANNEL IMPROVEMENTS

Deepening of the existing Sabine-Neches Waterway (SNWW) 40-foot deep-draft navigation channel to 48 feet was authorized by the Water Resources Reform and Development Act (WRDDA) 2014. Deepening of the channel will allow the saltwater wedge in the deep draft navigation channel to reach further inland and increase salinity in the lower Neches and Sabine River channels, as well as Sabine Lake (USACE 2011). Since project implementation is likely, projected future with-project (FWP) salinities from the SNWW feasibility study have been utilized as the future without-project (FWOP) salinities for this study.

4.2 PROJECTIONS OF FUTURE RELATIVE SEA-LEVEL CHANGE

Future rates of freshwater inflow and relative sea-level change (RSLC) are likely to result in significant changes in the FWOP condition for the study area (National Research Council [NRC], 1987; Intergovernmental Panel on Climate Change [IPCC], 2013; Milliken et al., 2008a). FWOP forecasts of salinity, marsh loss, and related impacts on plant and animal communities in the study area are important in establishing the baseline condition against which FWP impacts are measured. For the purpose of predicting FWOP salinities in the Orange-Jefferson study area, this modeling effort utilized the results of 3-dimensional TABS-MDS hydrodynamic salinity (HS) modeling conducted for the SNWW deepening feasibility study (USACE 2009). The HS model incorporated the effects of relative sea-level rise (RSLR) and forecasts of future freshwater inflows into the FWOP and FWP conditions through 2069. Salinities and tidal circulation through the environmental period of analysis for this study (2019-2080) are expected to be similar to those projected by the SNWW HS model.

The projected rate of RSLR at the Sabine-Neches estuary is very uncertain. The uncertainty inherent in the rates of eustatic sea level rise is evident in the wide range of various estimates from the NRC (1987) and the IPCC (2013). The confidence that any estimate will match actual future sea levels decreases over time, and significant deviations are possible. In order to incorporate a risk-based assessment given this uncertainty, Galveston District used current USACE guidance to assess the effects of changes in RSL over the period of analysis on economic benefits and engineering design considerations. USACE guidance (ER 1100-2-8162, December 2013 and ETL 1100-2-1, June 2014) specifies the procedures for incorporating climate change and relative sea level change into planning studies and engineering design projects. Projects must consider alternatives that are formulated and evaluated for a wide range of possible future rates of relative sea level change for both existing and proposed projects. The

USACE guidance requires that projects be evaluated using "low", "intermediate", and "high" rates of future sea level change, as defined below.

> 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.

Project impacts and costs of the Orange-Jefferson CSRM Plan have been assessed against 50-year projections of the three potential rates of RSLR calculated for Sabine Pass, Texas (Table 4-1). The computed future rates of RSLC given here give the predicted change between the years 2030 and 2080 for the Sabine Lake system. The SNWW HS modeling (2009) included an estimate of +1.1 feet of RSLR over a period of analysis ending in 2069. The estimated amount of historic RSLR applied for this study is 0.93 foot for the period of analysis ending in 2080. Use of the SNWW HS modeling for salinity estimates will provide a conservatively high estimate of salinities for this study.

Table 4-1. Rates of RSLR at Sabine Pass, Texas

Tidal Gage	Low RSLR (ft)	Intermediate RSLR (ft)	High RLSR (ft)
Sabine Pass, Texas	0.93	1.49	3.26

Recent wetland loss rates (1984-2014) have been calculated by USGS for 12 subunits of the study area by analyzing multiple dates of cloud free Landsat imagery from 1984-2014 (USGS 2014). The conversion of wetland acres to open water is assumed to have occurred under the low (or historic) rate of RSLR. For the low RSLR scenario, the historic marsh loss rates will be held constant and projected forward to provide yearly wetland acres through the period of analysis. This will be considered the baseline loss rate.

4.3 CLIMATE CHANGE AND CHANGES IN FRESHWATER INFLOWS

Future projections of freshwater inflows for the study area are also highly uncertain. These flows would be influenced by changes in the timing and amount of precipitation, temperature, water demand, and water supply strategies. The Texas State Climatologist concluded that it is impossible to predict with confidence what precipitation trends will be in Texas over the next half century (Nielsen-Gammon, 2009). Unlike precipitation, there is more consensus for a predicted temperature increase in Texas of close to 4 degrees Fahrenheit (°F) by 2060. Patterns of precipitation change are affecting coastal areas in complex ways. The Texas coast saw a 10 to 15 percent increase in annual precipitation for 1991-2012 compared to the 1901-1960 average. Texas coastal areas will see heavier runoff from inland areas, with the already observed trend toward more intense rainfall events continuing to increase the risk of extreme runoff and flooding.

Projections of future water demand and supply strategies are also very difficult to make and often involve controversial subjects such as interbasin transfer and new reservoirs. Freshwater inflows applied in the 2009 SNWW HS modeling were based upon the 2007 Texas State Water Plan and the associated regional plan for the study area (TWDB, 2007), and Run 8 of the Texas Commission on Environmental Quality (TCEQ) Water Availability Models (WAMs) for the lower Sabine and Neches Rivers.

The 2007 State Water Plan took into consideration existing flows in the Sabine River that are dedicated to the State of Louisiana as prescribed by the Sabine River Compact. The states of Texas and Louisiana are apportioned equal shares of the total Sabine River flow, and therefore freshwater inflows for Louisiana in the HS modeling were equivalent to Texas inflows. The plans were based upon evaluations of population projections, water demand projections, and existing water supplies available during drought. By 2060, population in the region encompassing the study area was projected to grow 36 percent. In the 2007 plan, water demands were projected to increase 41 percent but the region was assessed as having surplus water available beyond projected demands.

Texas updated its State Water Plan in 2012 (TWDB 2012). Projections still apply to a planning horizon ending in 2060, with the same projection of 36 percent growth in population. However, water demands are now projected to more than double, with the existing water supply projected to meet demands through 2040. Conservation, new water-supply reservoirs, and new diversion from existing reservoirs are recommended water management strategies.

The Texas Water Code requires that flow quantities adequate to support a sound ecological environment and to maintain the productivity, extent, and persistence of key aquatic habitats be maintained. Work on setting target inflows for the Sabine-Neches area was undertaken as part of the Texas Senate Bill (SB) 3 Environmental Flows Allocation Process (TCEQ 2014). The Texas Commission on Environmental Quality (TCEQ) adopted environmental flow standards for the Sabine-Neches region in 2011; however, there are some questions that the standards are adequate to support a sound ecological environment in the coastal estuarine system. To address this concern, the Stakeholder Committee developed a work plan for adaptive management which was approved. It requires additional monitoring and studies, with a review of the Sabine-Neches environmental flow standards on a 5-year cycle. The first review of the current standards may be completed by 2016.

4.4 FREQUENCY OF HURRICANES

Texas' entire Gulf Coast historically averages three tropical storms or hurricanes every four years, generating coastal storm surges and sometimes bringing heavy rainfall and damaging winds hundreds of miles inland. The expected rise in sea level will result in the potential for greater damage from storm surge along the Gulf Coast of Texas. Tropical storms have increased in intensity in the last few decades. Future projections suggest increases in hurricane rainfall and intensity (with a greater number of the strongest – Category 4 and 5 – hurricanes) (Melillo 2014).

Storm surge modeling conducted by ERDC for this study (USACE 2014) provided a predicted return interval of 10-15 years for storm surges high enough to threaten the areas targeted for protection in the Sabine Region. Upland areas in Orange and Jefferson Counties are generally 7-10 feet higher than the structure locations.

4.5 EMERGENT MARSH LOSS

For the WVA wetland change analysis for the Sabine region, trend line projections were made for three scenarios – low (historic), intermediate and high RSLR. These scenarios were based on the 50-year projections of RSLR calculated by SWG for Sabine Pass, Texas (see Table 4-1).

Recent wetland loss rates (1984-2014) have been calculated by USGS for 12 subunits of the Sabine study area by analyzing multiple dates of cloud free Landsat imagery from 1984-2014. The historic rate of conversion of wetland acres to open water is assumed to have occurred under the low (or historic) rate of RSLR. For the low RSLR scenario, the historic marsh loss rates was held constant and projected forward to provide yearly wetland acres through the period of analysis. This was considered the baseline loss rate.

For the intermediate and high RSLR scenarios, the annual FWOP wetland loss rates for each subunit of the study area were gradually increased (beginning at Target Year 1 or 2020) by adding an additional annual increment of loss in the landloss spreadsheet that is based on the projected annual RSLR increase for the intermediate and high scenarios. The annual wetland loss rate increases were based on the negative relationship that has been observed between wetland loss rates and RSLR from coastwide non-fresh marshes outside of active deltaic influences in Louisiana (USACE 2013). The percentage change per year from the Low to Intermediate RSLR rate and from the Low to High RSLR rate were computed as shown in Table 4-2. The annual percentage change from Low to Intermediate RSLR was .012 ft/year; and from Low to High RSLR was 0.05 ft/year. This additional RSLR related wetland loss was added to the baseline or historic wetland loss rate to obtain total annual loss rates for each year to project wetland loss over the period of analysis for the intermediate and high RSLR scenarios.

Table 4-2. RSLR Scenarios for Sabine Pass, Texas

Tidal Gage	Low RSLR (ft)	Intermediate RSLR (ft)	High RLSR (ft)
Sabine Pass, TX	0.93	1.49	3.26
Percent Total Change by Year 2080			
Low to Intermediate	0.6022		
Low to High	2.51		
Percent Change Per Year			
Low to Intermediate	0.012		
Low to High	0.05		

4.6 SALINITY

In the FWOP condition, RSLR would also increase salinity in the floodplain portions of the study area due open hydrologic connections to the Sabine and Neches Rivers. WVA impacts modeling for the historic or low RSLR scenario through year 2080 utilized outputs from the SNWW hydrodynamic salinity modeling as described above. The RSLR estimates for the intermediate and high scenarios would be expected to increase tidal flows, and this higher tidal energy would likely increase water surface elevation and salinity. Since these changes were not modeled for this study due to study scope and cost constraints, Year 2080 salinity projections for the three marsh types affected in this study area for the intermediate and high RSLR scenarios were estimated using modeled output from a similar study in the northwest Gulf of Mexico region.

ERDC hydrodynamic salinity modeling conducted for the Morganza to the Gulf of Mexico Project (USACE 2013) provided salinity projections for the three RSLR scenarios in accordance with the same guidance utilized for this study. Modeled outputs of salinities within ranges associated with fresh, intermediate and brackish marshes were averaged over the Morganza study area and used to calculate a percentage change in salinity between the baseline (or historic) rate and the intermediate and high rates of RSLR occurring over 75 years. Since the Morganza area has significantly higher rates of subsidence than this study area, the percentage changes calculated for the Morganza area were adjusted by reducing them by the percentage difference of the RSLR rates between Morganza and the Sabine region. The adjusted percentage change for the intermediate and high scenarios was applied to the baseline salinities to provide estimates of FWOP salinities in year 2080. The calculations described here are presented in Table 4-3.

Table 4-3. Method for Estimating FWOP Intermediate and High Salinities for Sabine Region

Morganza Average Modeled Salinities from RSLR Scenarios			
	Average Salinity (ppt)		
RSLR Scenario	Brackish	Intermediate	Fresh
Historic (Low)	9.1	4.4	0.5
Intermediate	10.7	4.9	0.5
High	12.1	5.0	0.7
Percentage Morganza Salinity Change for RSLR Scenarios			
Difference between	Brackish	Intermediate	Fresh
Historic – Intermediate RSLR	18.2%	10.4%	2.6%
Historic – High RSLR	33.5%	11.8%	32.1%
Percentage Change Adjusted for Difference in Subsidence Rates			
	RSLR (ft over 75 years)		
RSLR Scenario	Morganza	Sabine	% Difference
Historic (Low)	1.7	0.93	-45.3%
Intermediate	2.4	1.49	-37.9%
High	4.8	3.26	-32.1%
Percentage Change in Salinity Adjusted for Difference in RSLR for Sabine Region			
Difference between	Brackish	Intermediate	Fresh
Historic – Intermediate RSLR	11.3%	6.5%	1.6%
Historic – High RSLR	22.7%	8.0%	21.8%

5 WVA MODELING METHODOLOGY

This study applies WVA Coastal Marsh (Version [V] 1.0), Swamp (V 1.0) and Bottomland Hardwood (V 1.0) models to calculate impacts and develop mitigation for the Tentatively Selected Plan (USFWS 2002; 2010). Sensitivity analyses of WVA Coastal Marsh Versions 2.0 and 2.0B will be conducted after the plan has been finalized; the sensitivity analysis will be presented in an appendix to the Final IFP-EIS. Plan selection and mitigation utilized WVA Model V 1.0 outputs.

The WVA methodology is similar to the USFWS Habitat Evaluation Procedures (HEP), in that habitat quality and quantity are measured for baseline conditions and predicted for FWOP and FWP conditions. Instead of the species-based approach of HEP, the WVA models use an assemblage of variables considered important to the suitability of a given habitat type for supporting a diversity of fish and wildlife species. As with HEP, the WVA allows a numeric comparison of each future condition and provides a combined quantitative and qualitative estimate of project-related impacts on fish and wildlife resources.

WVA models operate under the assumption that optimal conditions for fish and wildlife habitat within a given coastal wetland type can be characterized, and that existing or predicted conditions can be compared to that optimum to provide an index of habitat quality. Habitat quality is estimated and expressed through the use of a mathematical model developed specifically for each habitat type. Each model consists of 1) a list of variables that are considered important in characterizing fish and wildlife habitat; 2) a Suitability Index graph for each variable, which defines the assumed relationship between habitat quality (Suitability Indices) and different variable values; and 3) a mathematical formula that combines the Suitability Indices for each variable into a single value for wetland habitat quality, termed the Habitat Suitability Index (HSI).

The habitat variable-habitat suitability relationships within these WVA models have not been verified by field experiments or validated through a rigorous scientific process. However, the variables were originally derived from HEP suitability indices taken from species models for species found in that habitat type. An independent external peer review of the WVA Models has been conducted by the USACE Eco-PCX (Battelle 2010). The reviewers agreed that the concept and application of the models are sound for planning efforts. The models seem to sufficiently capture the habitats being modeled and do not have any irreparable deficiencies. However, some aspects of the WVA Coastal Marsh Model concerning variables 1, 2, and 3 were found to have been defined primarily by policy and/or functional considerations of Coastal Wetlands Planning, Protection, and Restoration Act (CWPPRA). These concerns are being evaluated with a sensitivity analysis presented in DIFR-EIS Appendix Q. Plan formulation for this study will be based on V 1.0 of these models.

A new WVA spreadsheet has been developed by ERDC that allows for all three versions of the Marsh Model (V1.0, V2.0 and V2.0B) to be run simultaneously. The Swamp and Bottomland Hardwood models (V 1.0) are also included in the spreadsheet, as well as other WVA models not used for this study. The capability to handle risk and uncertainty was incorporated by the use of a Monte Carlo simulation and the ability of the user to either input High/Low or Standard Deviations for inputs. One hundred iterations were run each time the model was applied and results are reported for the 95 percent confidence level with standard deviations.

5.1 PERIOD OF ANALYSIS/TARGET YEARS

The environmental period of analysis for the Orange-Jefferson CSRM Plan is a total of 61 years based on the following assumptions. The construction period is assumed to begin in 2020 and end in 2030. All direct impacts are assumed to occur in the first year of construction (2020). This is conservative assumption since construction would not impact the entire project area in the first year of construction, and construction is not currently projected to be complete until 2030. Indirect impacts may begin later but all are assumed to begin by 2031. Mitigation area construction is assumed to be concurrent with levee system construction, beginning in 2020 and ending in 2030. The period for which mitigation benefits are analyzed is 2031-2080, which is the same as the 50-year economic period of analysis. A target year summary is provided in Table 5-1.

Table 5-1. Target Year Summary

TY0	2019 (the year before impacts begin)
TY1	2020 (all impacts occur)
TY11	2030 (levee and mitigation construction complete)
TY12	2031 (mitigation and economic benefits begin)
TY61	2080 (end of mitigation and economic period of analysis)

5.2 WETLAND VEGETATION MAPPING

Marsh vegetation and water acreages are based on a USGS classification using 2010 imagery (USGS 2014a). Forested wetland acreages are based on the 1992 National Wetland Inventory classification that were updated by referencing 2015 Google Earth imagery. As impacts are not projected to start until the year 2020, the relative percentage of emergent marsh and water acreage in each subunit were updated to reflect changes in emergent marsh acreage occurring between 2010 and 2020 due to the baseline emergent marsh loss rate. Preliminary wetland vegetation maps (prior to updating with Google Earth) are shown in Figures 5-1 through 5-5. These maps also show the preliminary alignment of the Orange-Jefferson CSMR system.

Marsh acreages provided by the USGS classification have been aggregated by type (fresh/intermediate/brackish) within each hydrounit; separate swamp and bottomland hardwood stands have also been aggregated. There may be one or more groups of any one marsh or forested wetland type within each hydrounit; groupings were based on proximity and similarity. Object ID's within the construction right-of-way were aggregated into groups of wetland vegetation and water within each hydrounit, subdivided by hydrologic unit.

Wetlands in the Orange-Jefferson CSRM project area that could potentially be affected by direct impacts of levee system construction are shown in Table 5-2. Incremental analysis of separate levee system reaches resulted in a reduction in the length of the alignment in Orange County and the elimination of two small alignments in the Beaumont area. This is discussed in greater detail below.

5.3 EMERGENT MARSH CHANGE ANALYSIS

Recent historic emergent marsh loss rates (1984-2014) have been calculated by USGS (2014b) for 12 subunits of the study area, and separately for Jefferson and Orange Counties, by analyzing multiple dates of cloud free Landsat imagery from 1984-2014. These change rates are shown in Table 5-3. Those shown in red are loss rates; those in black are accretion rates. They are uniformly very low and reflect lower subsidence rates that have resulted from decreased water and oil/gas withdrawals in the region in recent decades. The areas showing accretion are largely swamps or marsh areas with significant ongoing beneficial use projects which are constructing new marsh. Since none of the construction right-of-way is located in areas directly affected by the beneficial use projects, the applicable overall county change rate (which both show losses) was applied when evaluating marsh impacts. Marsh change rates are not directly applicable to the Swamp or Bottomland Hardwoods models.

The conversion of marsh acres to open water occurred under the low (or historic) rate of RSLR. For the low RSLR scenario, the historic marsh loss rates will be held constant and projected forward to provide yearly wetland acres through the period of analysis. This will be considered the baseline loss rate.

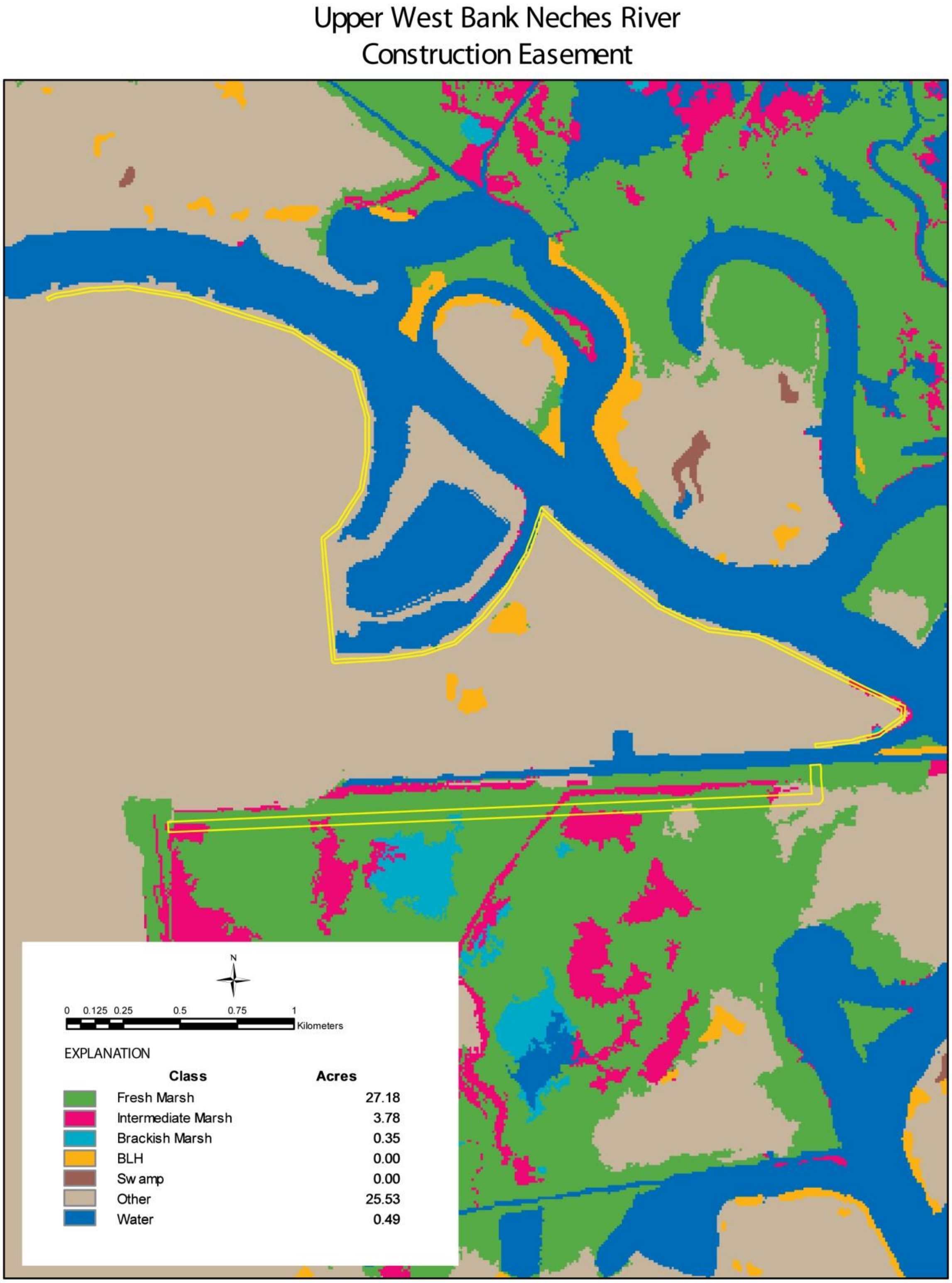

Figure 5-1. Upper West Bank, Neches River

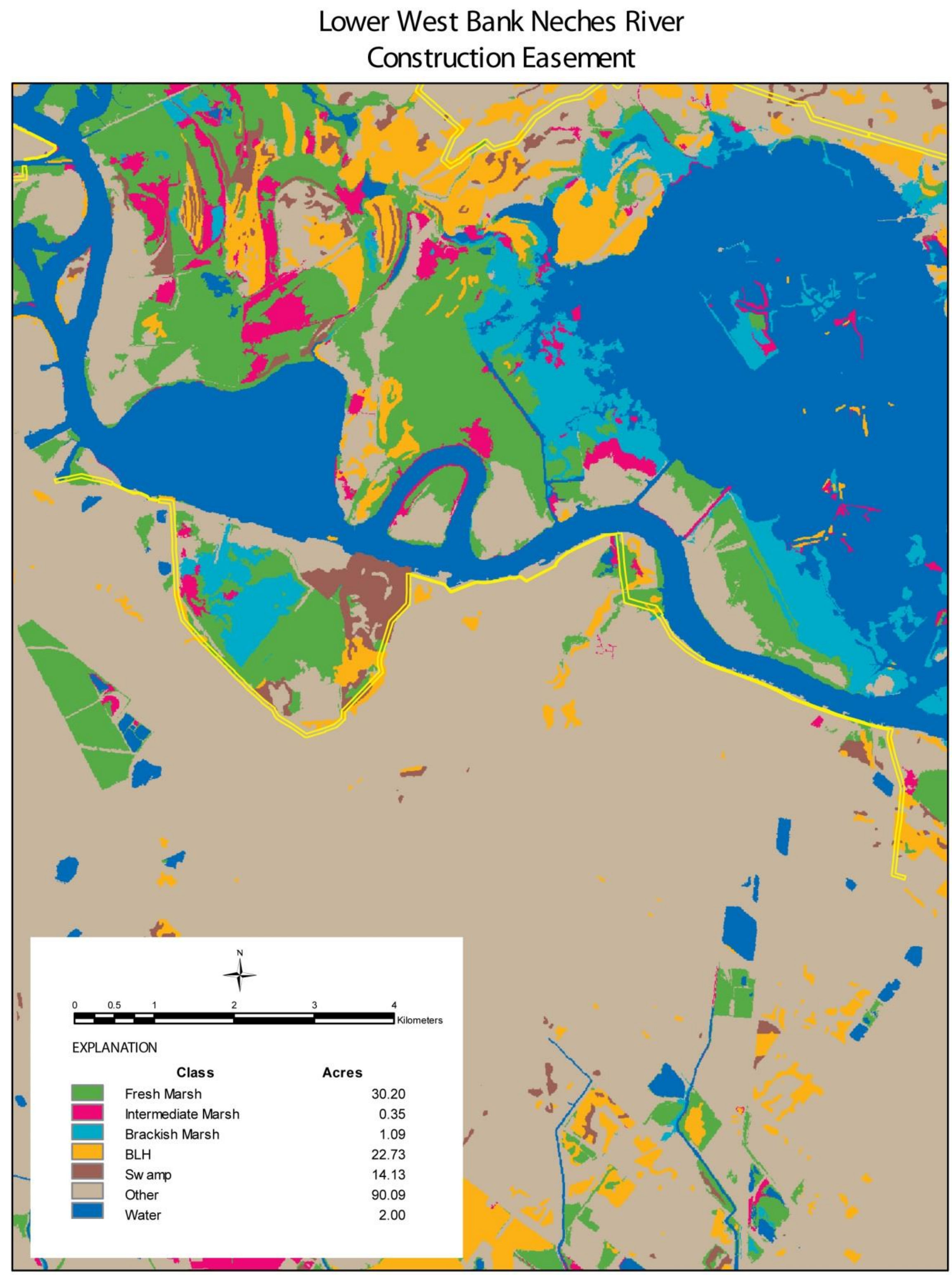

Figure 5-2. Lower West Bank, Neches River

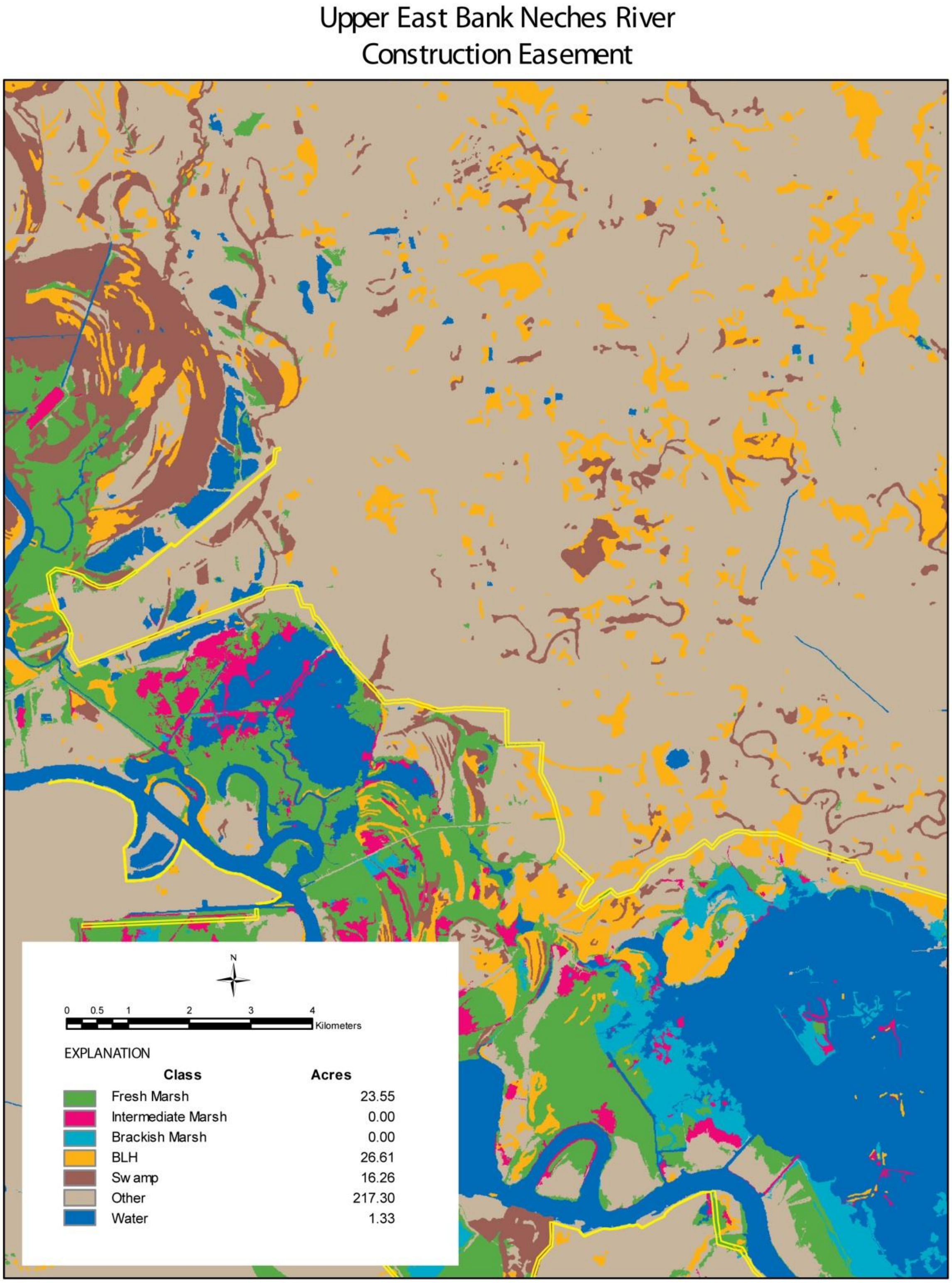

Figure 5-3. Upper East Bank, Neches River

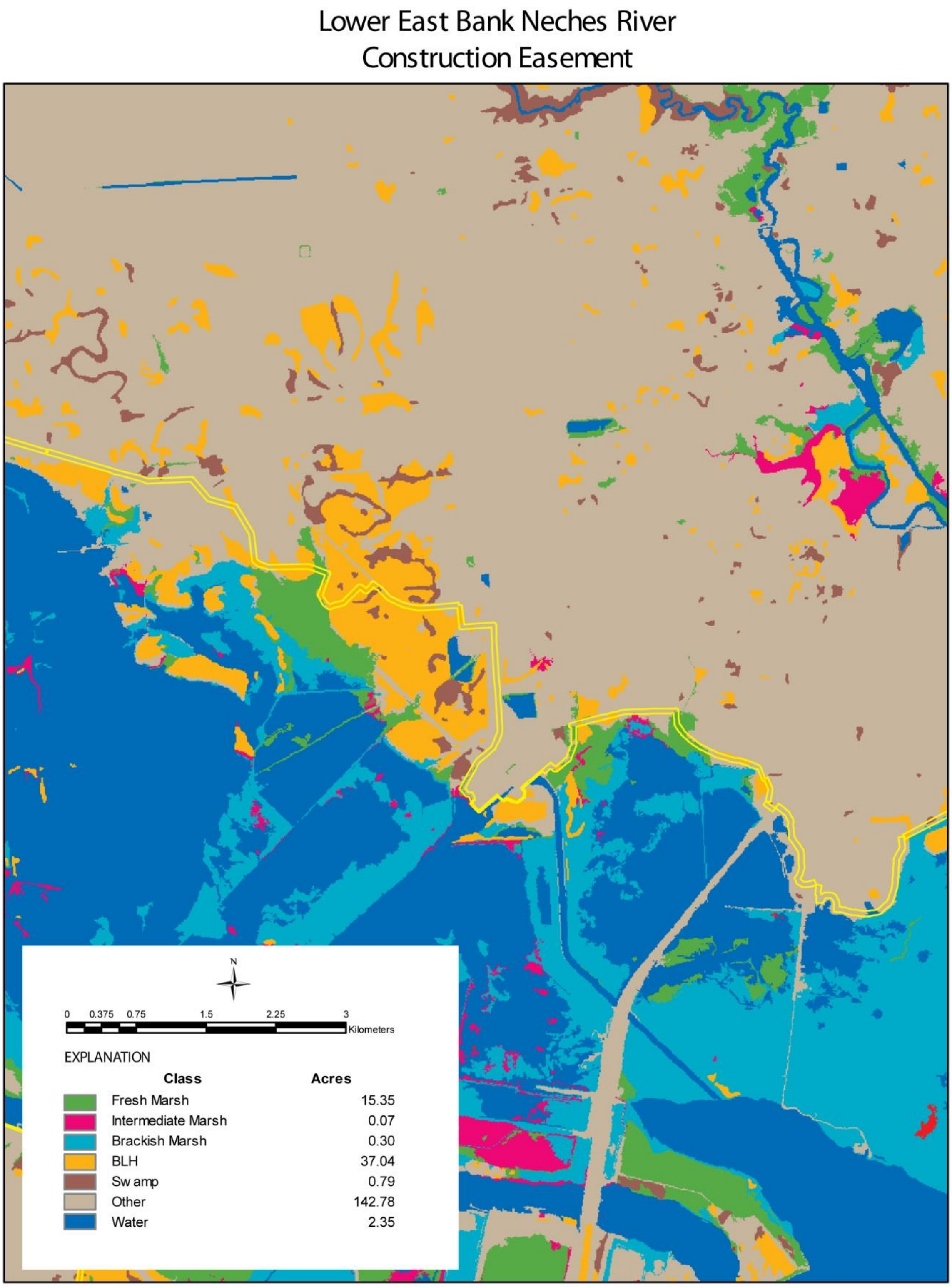

Figure 5-4. Lower East Bank, Neches River

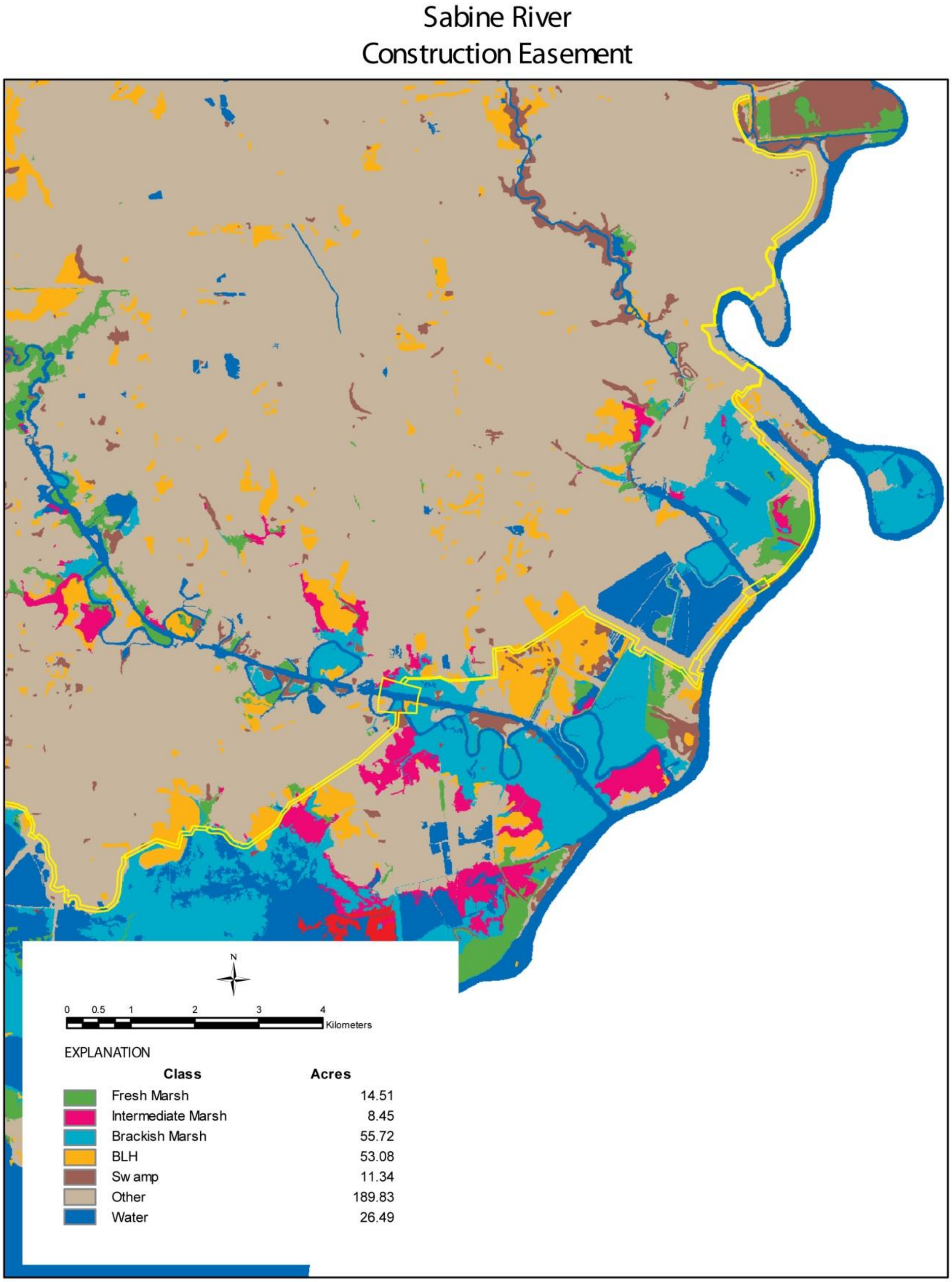

Figure 5-5. Sabine River

Table 5-2. Total Acres Potentially Affected by Direct Impacts in Orange-Jefferson CSRM Project Area

Hydrounit	Group ID	Group Wetland Acres	Group Water Acres	Group Total Acres	Hydrounit	Group ID	Group Wetland Acres	Group Water Acres	Group Total Acres
Swamp					**Fresh Marsh**				
TX 3	S-1	3.1		3.1	TX 3	F-1	19.0	0.7	19.7
TX 3	S-2	10.0		10.0	TX 3	F-2	7.8	0.3	8.1
TX 3	S-3	5.7	0.1	5.8	TX 5	F-3	6.4	0.5	6.9
TX 5	S-4	0.7		0.7	TX 6	F-4	17.8	0.8	18.6
TX 10	S-5	5.5		5.5	TX 10	F-5	1.5		1.5
TX 11	S-6	3.5		3.5	TX 4	F-6	2.6		2.6
TX 12	S-7	7.6	0.1	7.7	TX 4	F-7	6.9	1.1	8.0
TX 4	S-8	0.9		0.9	TX 13	F-8	4.3	1.2	5.4
TX-LA 2	S-9	21.6		21.6	TX11	F-9	10.5		10.5
TX 6	S-10	1.3		1.3		Subtotal			81.3
	Subtotal			60.1					
Bottomland Hardwood					**Intermediate Marsh**				
TX 3	BH-1	10.6		10.6	TX 6	I-1	2.2	0.1	2.3
TX 3	BH-2	4.8		4.8	TX 10	I-2	4.8		4.8
TX 5	BH-3	7.2		7.2	TX 11	I-3	3.7	0.1	3.8
TX 5	BH-4	36.2	0.2	36.4	TX 4	I-4	1.6	0.0	1.6
TX 6	BH-5	21.4		21.4	TX 4	I-5	0.4		0.4
TX 10	BH-6	21.6		21.6		Subtotal			12.9
TX 11	BH-7	21.3	0.5	21.8					
TX 12	BH-8	1.8		1.8	**Brackish Marsh**				
TX 4	BH-9	0.3		0.3	TX 6	B-1	18.8	2.2	21.0
TX 4	BH-10	12.4		12.4	TX 10	B-2	49.9	25.2	75.1
TX 13	BH-11	1.5		1.5	TX 11	B-3	5.0		5.0
TX-LA 2	BH-12	0.5		0.5	TX 13	B-4	7.6	2.3	9.9
	Subtotal			140.3		Subtotal			111.0
Total 405.6*									

* Totals may not add exactly due to rounding.

Table 5-3. USGS Aerial Photography Analysis of Marsh Change Rates

Hydrologic Unit	Name	Rate perc/yr	r^2
TX 1	North Neches River	0.0085%	0.15
TX 2	Neches River	-0.0567%	0.289
TX 3	Rose City	0.0543%	0.0201
TX 4	Beaumont South	0.0703%	0.165
TX 5	Bessie Heights	-0.0052%	0.000113
TX 6	Old River Cove	-0.0892%	0.0345
TX 10	Cow Bayou	-0.0203%	0.0424
TX 11	Adam Bayou	0.0032%	0.00106
TX 12	Blue Elbow South	0.0110%	0.0994
TX 13	Lower Neches	-0.0456%	0.0809
Texas/LA 1	Sabine Island	0.0036%	0.0115
Texas/LA 2	Blue Elbow North	0.0087%	0.0513
Jefferson County	Marshes county-wide	-0.0196%	0.00138
Orange County	Marshes county-wide	-0.0183%	0.217

The wetland loss rates were calculated separately for subdivisions of the Sabine Region study area called hydrounits. The hydrounits are subdivisions of the Sabine and Neches River floodplains that are distinguishable by topography and hydrology from surrounding areas. They were developed for WVA modeling of impacts of the proposed deepening of the Sabine-Neches Waterway (SNWW) (USACE 2011). Inasmuch as they cover the same geographic area affected by this study, the same units were adopted for this WVA modeling effort. The hydrologic areas included in the wetland change mapping for this study are shown in Figure 5-6.

5.4 DATA COLLECTION/GROUNDTRUTHING

Groundtruthing of wetland types and collection of data for WVA variable inputs were based upon field investigations and previous observations of the S2G study area by the Habitat Workgroup of the Interagency Coordination Team for the Sabine-Neches Waterway (SNWW) Channel Improvement Project (USACE 2011) and by the resource agency review team for this study. Data were collected from a total of 17 bottomland hardwood and swamp reference sites on the Neches and Sabine Rivers on August 24 and 25 and October 21, 2004, and January 23, 2015.

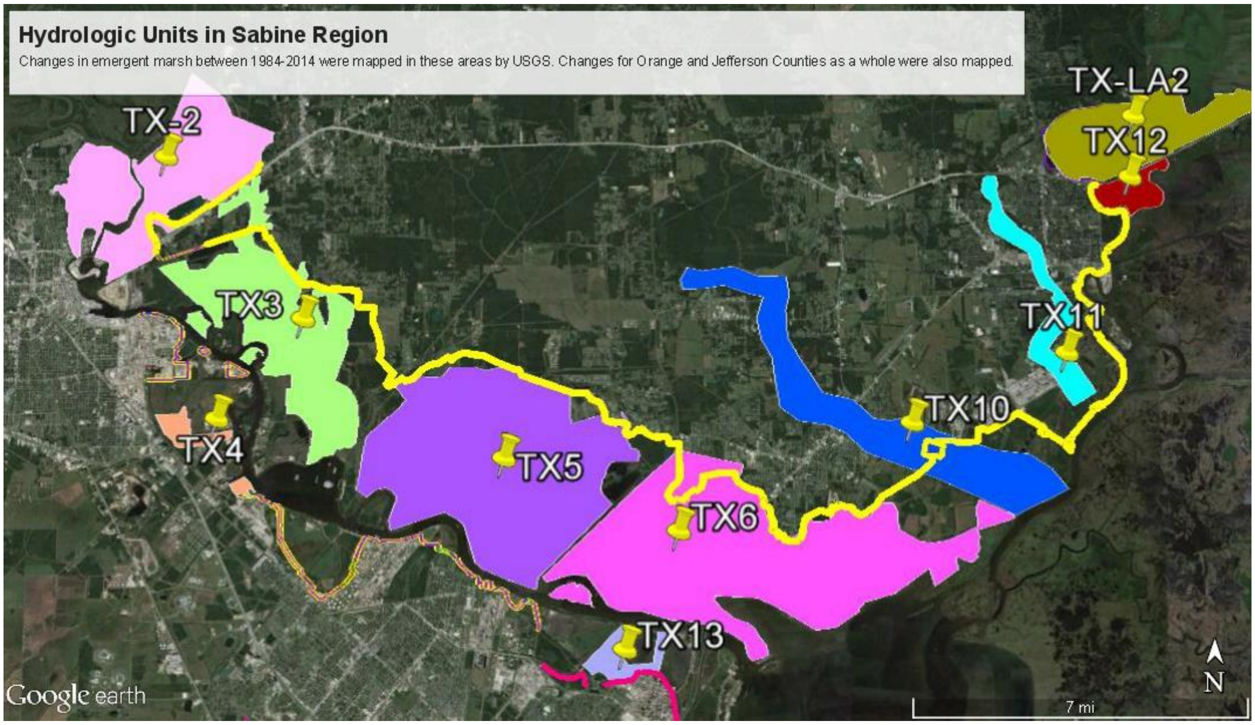

Figure 5-6. Hydrologic Units in Sabine Region

6 FWP ANALYSIS OF DIRECT IMPACTS

Direct impacts are those that would result from construction of the Orange-Jefferson CSRM Plan. A preliminary construction right-of-way containing all areas needed to construct the new levee system alternative was developed in GIS and applied to the USGS wetland vegetation files to identify all wetland vegetation and water areas that would be affected by levee construction. Conservative assumptions were applied in estimating the width of the construction right-of-way, and it is large enough to accommodate construction of a levee height for the intermediate RSLR scenario. The methodology described below applies to all of the RSLR scenarios; however there is greater uncertainty for TY 61 variable values under the intermediate and high RSLR scenarios. It is assumed that all wetland habitats within the rights-of-way would be lost through the end of the period of analysis.

Changes in the levee alignment and/or width may be recommended as a result of agency technical, peer and/or public review of the DIFR-EIS. Some refinement of the placement of levee alignments may be possible, which could reduce these impacts. However, in the event that impacts are increased significantly, a supplemental EIS disclosing these impacts will be prepared and released for public review.

6.1 MARSH MODELING – PROCEDURES AND ASSUMPTIONS

Since the marsh vegetation and water acreages are based on a classification conducted using 2010 imagery (USGS 2014), and impacts are not projected to start until the year 2020, the relative percentage of emergent marsh and water acreage in each subunit were updated to reflect changes occurring between 2010 and 2020 due to the baseline land loss rate. A Microsoft Excel spreadsheet was used to calculate this change, and to track changes in wetland/water acres associated with the USGS wetland change rates over the period of analysis.

6.1.1 V1 Emergent Marsh

Persistent emergent vegetation provides foraging, resting, and breeding habitat for a variety of coastal fish and wildlife species. Detritus from coastal marshes also provides a source of mineral and organic nourishment for organisms at the base of the food chain. In this model, an area that is 100 percent shallow water is assumed to have minimal habitat suitability (SI = 0.1). For all marsh types, optimal vegetative coverage is assumed to be 100 percent (SI = 1.0). This assumption diverges from the general biological understanding that optimum cover falls in the 60 to 80 percent range. Selection of 100 percent marsh cover as the optimal habitat condition is based upon several factors. Loss of emergent coastal marsh is a serious existing condition in the study area, and it is assumed that this loss will continue due to RSLR.

Existing Condition. Baseline total marsh and water acres of each affected wetland area are based on the acreages provided in Attachment C, adjusted using the baseline emergent marsh loss rate to reflect marsh and water acres in 2019 (TY0). As uncertainty associated with the baseline marsh/water acres is very low, a narrow range for the baseline percent emergent marsh was assumed; typically one percent higher and lower than the mapped acreage.

FWOP. The baseline acreage at TY0 will be reduced each year of the period of analysis by the USGS (2014b) percent loss per year for the specific hydrounit, using the landloss spreadsheet. It is assumed that the emergent marsh that is lost is converted to water, and therefore, the acres lost from the marsh are added to the water acres. The baseline rate of emergent marsh loss includes chronic, regional effects of subsidence, altered sediment delivery, historical rates of sea level rise, and tropical storms or hurricanes that occurred during the period of observation. The calculated historical rate of sea-level rise for the Sabine region is 0.93 feet over 50 years. The uncertainty of the estimation of the percent of emergent marsh coverage in TY1 is similar to that of TY0, and therefore the same narrow range (one percent higher and lower than the mapped acreage) was assumed. The uncertainty of projections of emergent marsh percentage for TY61 are higher given greater uncertainties associated with average temperatures, precipitation, freshwater inflows and RSLR. Therefore, for TY 61, a total range of 30 percent was assumed – 15 percent higher and lower than the emergent marsh percentage calculated by the spreadsheet as remaining in TY61.

FWP. It is assumed that construction impacts will begin in TY1, and that all wetlands within the construction right-of-way will be removed and replaced by levees, floodwalls or other project features. Wetland and water acres would fall to zero at TY1 and remain unchanged through TY61. There is no uncertainty associated with the projection of zero percent wetland coverage in TY61, and therefore a range of zero to 0.1 percent was assumed.

6.1.2 V2 Percent Submerged Aquatic Vegetation

For the purpose of this model, SAV is defined as any of the diverse array of floating-leaved and submerged aquatic plants that are typically found in the study area. Seagrasses, included in the SAV designation, are flowering plants that grow entirely underwater. SAV coverage is included as an important marsh variable because it provides important food and cover to a wide variety of fish and wildlife (Virnstein, 1987; Thomas et al., 1990; Castellanos and Rozas, 2001; Raz-Guzman and Huidobro, 2002; Wyda et al., 2002; Lazzari and Stone, 2006). SAV provides a refuge from predation, and because of this protection, densities of many invertebrates (infaunal and epifaunal) and small fishes are greater in SAV than in nearby unvegetated areas. SAV (including seagrasses) provide additional benefits by stabilizing sediments and filtering water. SAV (including seagrasses) tolerate or require a wide range of salinities.

The species composition and primary productivity of SAV communities corresponds to the salinity regime (Haller et al., 1974; Longstreth et al., 1984; Dunton, 1990; Bonis et al., 1993; Bortone, 2002; La Peyre and Rowe, 2003; Singh and Arora, 2003; Paresh and Freedman, 2006). Fresh and intermediate marshes, in particular, often support diverse communities of submerged and floating-leaved vegetation. Open water with no aquatics within a fresh or intermediate marsh is assumed to have low suitability (SI = 0.1). Optimal conditions are assumed when 100 percent of the open water is dominated by aquatic vegetation (SI = 1.0). Brackish marshes can also support aquatic plants that provide food and cover for several species of fish and wildlife. Although amounts are generally less than that which occurs in fresh or intermediate marshes, certain species such as widgeon-grass, coontail, and milfoil, can be abundant under some conditions, and widgeon grass, in particular, is an important food source for waterfowl. The SI graph for brackish marsh is identical to the fresh/intermediate model.

Existing Condition. Baseline values for this variable were based largely upon previous observations in the area by SNWW Habitat Workgroup members, the current review team's knowledge of SAV types and prevalence in the general area and examination of Google Earth's 2015 and earlier historic images. Since SAV cover and species can change rapidly in response to a complex interaction of environmental conditions, even TY0 values are fairly uncertain. Therefore, a total range of 20 percent (10 percent higher and lower than the projected percentage) was assumed for TY0.

FWOP. No change in percentage SAV cover was assumed through TY61. While the historic rate of RSLR would result in slightly higher salinities and a slightly larger tidal prism, it was assumed that salinity and water depth changes would not be great enough to result in a change in SAV coverage in TY1 through TY61. Therefore, the uncertainty of this projection for TY 1 was assumed to be the same as for TY0. However, greater uncertainty associated with climate change and RSLR exists for the period between TY1 and TY61, and therefore, a larger total range of 20 percent (10 percent higher and lower than the projected percentage) was assumed.

FWP. All water areas would be converted to levees, floodwalls or other project features in TY1 and remain unchanged through TY61. There is no uncertainty associated with the projection of zero percent wetland coverage in TY61, and therefore a range of zero to 0.1 percent was assumed.

6.1.3 V3 Interspersion

This variable takes into account the relative amount of marsh to open water, and the degree to which open water is dispersed throughout the marsh. Interspersion is an important characteristic for freshwater and estuarine fish and shellfish nursery and foraging habitat in all marsh types (Rakocinski et al., 1992; Baltz et al., 1993, 1998; Rozas and Reed, 1993; Minello et al., 1994; Peterson and Turner, 1994; Rozas and Zimmerman, 2000; Minello and Rozas, 2002; Whaley and Minello, 2002; Rozas and Minello, 2007). The marsh/open-water edge provides cover for postlarval and juvenile organisms. Smaller, isolated ponds are less turbid and contain more aquatic vegetation, thereby providing more suitable waterfowl habitat. Conversely, a large degree of interspersion is assumed indicative of marsh degradation, as solid marsh converts to ever-larger areas of open water. Areas with a high degree on interspersion in the form of tidal channels and small ponds, Class 1 interspersion was assigned (SI = 1.0). Large ponds (Class 3) and open water areas with little surrounding marsh (Class 4) offer lower interspersion values and indicate advanced stages of marsh loss. Class 3 was also assigned to areas of "carpet" marsh which contain no or relatively insignificant tidal channels, creeks, or ponds but may still provide aquatic organism habitat during tidal flooding. If the entire area is open water or contains a few small marsh islands, Class 5 interspersion was assigned (SI = 0.1).

Existing Condition. The degree of marsh/waterbody interspersion was assessed for each wetland group within the construction right-of-way using Google Earth 2015 imagery at the same scale as the photographs of class examples shown in the WVA marsh model (V1.1). Each wetland group was carefully examined and assigned interspersion classes by comparing them to the photographic examples. In some cases, the wetland groups contain wetlands of more than one interspersion class. The percentage of acreage exhibiting each class was entered in the spreadsheet, such that all added up to 100 percent.

FWOP. No change in interspersion was assumed for TY1. The greater the percentage loss of emergent wetland tracked with V1 was assumed to relate to changes in interspersion by TY61. Changes greater or equal to 1 percent were reflected in similar changes in interspersion classes.

FWP. All marsh and water areas within the construction right-of-way would be converted to levees, floodwalls or other project features in TY1 and remain unchanged through TY61. Therefore, all were assumed to convert to the class associated with conversion to a non-marsh area (Class 5).

There are no uncertainty ranges required for this variable in the sensitivity spreadsheet.

6.1.4 V4 Percent Open Water ≤ 1.5 Feet

Deeper water is assumed to be less biologically productive than shallow water because sunlight, oxygen, and temperature are reduced as depth increases. Shallow water also provides better bottom access for waterfowl, better foraging habitat for wading birds, and more-favorable conditions for the growth of aquatic vegetation. Certain species typically use shallow water for spawning, feeding, and/or shelter during various life stages (e.g., white/brown shrimp, Gulf flounder, red drum, roseate spoonbill, and mottled duck). SIs for shallow water are calculated differently for fresh/intermediate, brackish and saline marshes. Optimal shallow-water conditions in fresh/intermediate marsh are assumed when 80 to 90 percent of the open water is equal to or less than 1.5 feet deep. It is assumed that brackish marshes generally contain deeper open-water areas because of tidal scouring, and therefore lower percentages of shallow water receive a higher SI than in fresh/intermediate marsh.

Existing Condition. Baseline values for this variable were based largely upon previous observations in the area by SNWW Habitat Workgroup members, the current review team's knowledge of the area and examination of Google Earth imagery (2015 and earlier historic images). As uncertainty associated with the baseline V4 acres is low, a fairly narrow range for the baseline percent emergent marsh was assumed; typically five percent higher and lower than the estimated percentage.

FWOP. No change in V4 was assumed for TY1. RSLR of about 1 foot by TY61 is assumed to increase the depth of current shallow water, and to inundate new areas within 1 foot of the current water levels, resulting in no net change from existing conditions. The uncertainty range for TY1 was assumed to be the same as for TY0. The uncertainty range for TY61 would be higher, associated primarily with uncertainties in the historic rate RSLR. Uncertainties related to intermediate and high rates of RSLR will be evaluated under separate WVA model runs for those scenarios. For this scenario, calculation of the historic rate was developed in accordance with current USACE guidance, and therefore the range of historic rates is assumed to fairly narrow, thus the range of V4 percentage was also assumed to be fairly narrow, 10 percent higher and lower than the estimated percentage.

FWP. All shallow water areas would be converted to levees, floodwalls or other project features at TY1 and remain unchanged through TY61. There is no uncertainty associated with the projection of zero percent wetland and wetland coverage in TY61, and therefore a range of zero to 0.1 percent was assumed.

6.1.5 V5 Salinity

This variable may appear to duplicate or overlap with V1 (emergent marsh cover) because the functionality and potential land loss of the marsh vegetation are related to salinity. However, this variable was included as a separate variable in order to account for salinity impacts on fish and wildlife as well as on vegetation.

Salinity is one of the most important factors affecting coastal marsh loss. Salinity projections affect all of the other WVA variables with the exception of aquatic organism access. Small increases in mean salinity can adversely affect aquatic systems by reducing overall biological productivity. An extensive literature review (Visser et al., 2004) compiled information on the effect of salinity on the productivity of emergent tidal marsh. Productivity algorithms, based upon measurements of total biomass, stem/leaf elongation, and photosynthesis, were developed that predict changes in primary productivity for every ppt change in salinity. Salinity and primary productivity were found to be inversely related, as salinity increases, primary productivity decreases by different amounts dependent upon the salinity tolerance of the vegetation community.

For fresh/intermediate marshes, the mean high salinity (calculated as a roaming mean of the highest 33 percent consecutive salinity readings) during the growing season is used to assess impacts. For brackish and saline marshes, average annual salinity is recommended. Optimum salinity ranges assumed by the model for the various habitat types are as follows: swamp and bottomland hardwood (≤1 ppt), fresh marsh (≤2 ppt), intermediate marsh (≤4 ppt), brackish marsh (≤10 ppt), and saline marsh (≥9 and ≤ 1 ppt). For V5, salinity changes within the optimal salinity ranges of each marsh type are not considered an impact, and are assigned a maximum suitability index score of "1." But even a small salinity change outside of these optimal ranges, as shown in the formulas for the salinity variable, reduces the suitability index scores below "1."

Existing Condition. Baseline salinities for the wetland areas in the construction right-of-way were taken from baseline salinities reported by the 3-D hydrodynamic-salinity model for the SNWW navigation project (USACE 2009) and from Texas Parks and Wildlife data. Mean salinities associated with median flows during the growing season were used for all marsh types, assuming that the SNWW 48-foot deepening is in place. Model values were obtained from the nearest model output node, and in some cases, salinity values were adjusted for the salinity gradient observed on isohaline maps for swamps located upstream of the nearest node. The uncertainty range of the salinity projection was based on the standard deviation of the average of the surface and mid-depth salinity values at the nearest station at which salinity data was collected for validation of the HS model.

FWOP. It was assumed that salinity will also change with RSLR, based on the SNWW modeling which estimated 1.1 feet of RSLR by year 2069, which is very close to the 0.93 foot of RSLR now projected for S2G by year 2080. In general, the model predicted an increase of between 1.0 and 1.5 ppt in the Neches River near Bessie Heights and Old River, and on the lower Sabine River in the vicinity of Cow and Adams Bayous.

FWP. All water areas would be converted to levees, floodwalls or other project features at TY1 and remain unchanged through TY61. Using a value of zero for the salinity variable is not appropriate, since it would be interpreted by the model as an optimal condition for all marsh types, and inappropriately increase the quality of the FWP habitat units. Therefore, the salinity value utilized for TY1 through TY61 was the same as FWOP.

There are no uncertainty ranges required for this variable in the sensitivity spreadsheet.

6.1.6 V6 Aquatic Organism Access

Access by estuarine-dependent fishes and shellfishes, as well as other aquatic organisms, is important in assessing the quality of marsh systems. It is assumed that a high degree of surface hydrologic connectivity with adjacent systems provides high organism access, as well as providing greater nutrient exchange. The SI is calculated by determining an Access Value that is based on an interaction between the wetland area accessible to aquatic organisms during normal tidal fluctuations and the type of man-made structures (if any) blocking access channels (USFWS, 2002c: Appendix B). Access ratings for specific structures, developed by the Louisiana EnvWG, were adopted for the SNWW application. The installation and operation of water control structures has been shown to significantly impact marine fishery access to, use of, and production on wetlands behind those structures (Rogers and Herke, 1985; Herke et al., 1992; Rogers et al., 1992; Sanzone and McElroy, 1998); therefore, optimal conditions are assumed when the entire wetland area is accessible and access points are unobstructed. Brackish and saline marshes are assumed to be more important than fresh/intermediate marshes as habitat for estuarine-dependent fish and shellfish.

Existing Condition. Baseline values for this variable were based largely upon previous observations in the area by SNWW Habitat Workgroup members, the current review team's knowledge of the area and examination of Google Earth imagery (2015 and earlier historic images). Fisheries access is not blocked to any of the marshes in the construction right-of-way and therefore all were assigned a value of "1".

FWOP. The review group has no knowledge of planned water control structures, impoundments, or other impediments to fisheries access through the period of analysis. No changes to the fisheries access value is projected TY1 though TY61; all were assigned a value of “1”.

FWP. All water areas would be converted to levees, floodwalls or other project features at TY1 and remain unchanged through TY61. This would result in the complete blockage of access to the area within the construction right-of-way. Therefore, a value of “0” was applied for TY1 through TY61.

There are no uncertainty ranges required for this variable in the sensitivity spreadsheet.

6.2 SWAMP MODELING – PROCEDURES AND ASSUMPTIONS

6.2.1 V1 Stand Structure

Wildlife foods in swamp habitats consist predominantly of soft mast, other edible seeds, invertebrates, and vegetation. Since most swamp tree species produce soft mast or edible seeds, the actual tree species composition is not considered a limiting factor. However, a variety of stand structure should be present to provide appropriate habitat for resting, foraging, breeding, nesting, and nursery activities. Three structures are evaluated: (1) overstory closure, (2) scrub-shrub midstory cover, and (3) herbaceous cover. The variable assigns the lowest suitability to sites with a limited amount of all three stand structures, and the highest suitability to sites with significant amounts of all three stand structures.

Existing Condition. WVA input data for percentage overstory, midstory, and understory cover in swamp areas that would be directly impacted by construction were estimated using data from the most similar reference sites. These sites were selected based upon knowledge of the study area and close examination of Google Earth imagery. As reference sites were used as the basis for input data, uncertainty in the accuracy of the input is reflected in a 20 percent range (from low to high) around percentage overstory estimates, and a 10 percent range around mid- and understory coverage estimates.

FWOP. Predicted changes in percentage overstory, midstory, and understory cover were based on the existing overstory closure; higher overstory growth rates were assumed for moderately open areas and slower growth rates for moderately dense swamp areas. With steady maturation, an increase in percentage overstory coverage was generally associated with a decrease in percentage of understory coverage. Generally, no changes in midstory coverage were predicted, as it was assumed that trees growing into the overstory would be replaced by trees growing from the understory. Steady maturation was projected for all hydro-units, as changes related to historic rates of sea-level rise and changes in salinity would not be large enough to affect growth rates substantially. Greater uncertainty exists for TY61 projections, primarily related to changes in rainfall and RSLR; therefore, a 30 percent range was applied around overstory and midstory coverages, and a 20 percent range around understory.

FWP. A 10-year construction period is assumed, beginning TY1. No specifics are available at this time regarding construction contracts or timing. Therefore, all impacts are assumed to occur in TY1. It is assumed that all swamps within the construction right-of-way will be removed and replaced by levees, floodwalls or other project features through the period of analysis. There is little uncertainty associated with this projection, so a conservatively small range of zero to 0.1 was used for all percentage cover input.

6.2.2 V 2 Stand Maturity

Swamps with mature sizable trees are considered to be rare and ecologically important because of the historical loss of swamp habitat from timber harvesting, saltwater intrusion, and a reduced growth rate in the subsiding coastal zone. Two components, stand age and stand density, are combined in the SI for this variable. Stand age is included because older trees provide important wildlife requisites such as snags, nesting cavities, and the medium for invertebrate production. Additionally, as the older, stronger trees establish themselves in the canopy, weaker trees die and form additional snags that would not be present in younger stands. Stand age is determined by average trunk diameter measured at breast height (DBH). The optimal size for canopy-dominant and canopy co-dominant bald cypress is greater than 16 inches, and greater than 12 inches for tupelo-gum and other species. Stand density allows evaluation of mature swamp ecosystems that contain an overstory of a few widely scattered, mature bald cypresses but in which other stand characteristics important for nesting, foraging, and other habitat functions are absent. Basal area is used as a measure of stand density; it measures how much of the forest floor is covered by the area of standing tree trunks. Stand age and density are evaluated separately for cypress and tupelo-gum.

Existing Condition. Baseline values for the relative percentage of the canopy provided by baldcypress and tupelo, the average DBH of each of these species, and estimates of abundance of each species based on average basal area per acre were estimated using data from the most similar reference sites. These sites were selected based upon knowledge of the study area and close examination of Google Earth imagery. As reference sites were used as the basis for input data, uncertainty in the accuracy of the input is reflected in a 10 percent range around canopy coverage estimates and a 2-3 $inches^2$ range was used around the DHB estimates. Since basal area inputs were estimated based upon an association with percentage overstory cover (i.e., a moderate DBH range would be associated with a moderate overstory coverage), the full range of DBH for each density class as defined in the model was used as the low and high range for DBH values. For example, a swamp site with a moderately open overstory coverage was estimated to have a DBH range from 40 $feet^2$ to 80 $feet^2$.

FWOP. Rates of tree growth were based on data for relevant species from the USDA Silvics of North America (USDA, 2004), and other forest research literature (Brown and Montz, 1986) that generally reflect optimum growth conditions on managed lands. This is appropriate because swamps in the study area are generally not impounded and in relatively good condition. Steady growth throughout the period of analysis was assumed. For TY1, a 10 percent range around canopy coverage estimates and a 2-3 $inches^2$ range was used to bracket the DHB estimates. For TY61, a larger range was used to capture the uncertainties associated with climate change and RSLR. For the percentage of cypress and tupelo canopy coverage, a 20 percent range was assumed. For DBH growth projections, a range of 10 $inch^2$ was utilized.

FWP. It is assumed that all swamps within the construction right-of-way will be removed and replaced by levees, floodwalls or other project features through the period of analysis. There is little uncertainty associated with this projection, so a conservatively small range of zero to 0.1 was used for all percentage canopy cover by species and for DBH. For basal area, the range for TY1 through TY61 was entered as 5.0 to 5.1, based on ERDC instructions that the sensitivity spreadsheet being used for this modeling will not accept a value less than 5.

6.2.3 Water Regime

Seasonal flooding with periodic drying cycles increases nutrient cycling, vertical structure complexity, and recruitment of dominant overstory trees. The optimal water regime is assumed to be seasonal flooding with abundant and consistent riverine/tidal input and water flow-through. Optimal flow-through is assumed to be an abundant and consistent input, allowing maximum use as fish and wildlife habitat. Temporary or seasonal flooding is optimal because permanent flooding produces poor water quality during warm weather and reduces fish and invertebrate production.

Existing Condition. Baseline values for flooding duration and exchange were based on the review group's knowledge of the swamp impact areas and on careful review of Google Earth imagery.

FWOP. The FWOP values consider the effects of gradual RSLR on water surface elevation and tidal circulation. The increase in water surface elevation was forecast by the HS model, which in addition to RSLR, also incorporated forecasted changes in freshwater inflow. The effects of higher FWOP water surface elevations on hydrologic conditions were estimated by comparing FWOP water surface elevations over the period of analysis to existing land elevations within the swamp areas. The range of existing water surface elevations in the Sabine and Neches Rivers adjacent to these communities was determined by field sampling in 2001 (Fagerburg, 2003). Water surface elevations associated with diurnal tides and extremes associated with normal seasonal wind variations were measured at that time. The 1.1-foot increase in water surface elevation predicted by the HS model was added to existing average and extreme water surface elevations, and then compared to the land surface elevations taken from recent LIDAR survey data (CADGIS, 2009; NOAA Coastal Service Center, 2009). While some of the lower-lying areas could see a marginal increase in the depth and duration of tidal flooding by the end of the period of analysis, the gradual change in water surface elevation due to RSLR would not permanently inundate swamp substrate throughout the year, and therefore no change in flooding duration and exchange classes were forecast through TY61.

FWP. At TY1, it is assumed that all swamps within the construction right-of-way will be removed and replaced by levees, floodwalls or other project features through the period of analysis. Existing water regimes will be permanently disrupted. In order to capture the effect on water regime, the FWP assumed a change to classes with the lowest SI values for TY1 through TY61 (permanently flooded with no flows/exchange).

6.2.4 Mean High Salinity

Many swamp species, especially tupelo-gum and many herbaceous species, are salinity sensitive (Conner et al., 1997; Pezeshki et al., 1989). Swamp systems may be acutely affected by the sudden addition of only a few parts per thousand of salt during an intrusion event (Reid and Wood, 1976). Primary biological productivity is lowered 8.4 percent for each 1 ppt increase in salinity, slowing growth rates for dominant overstory species such as tupelo-gum (and, to a lesser degree, bald cypress since it is more salt tolerant), reducing the overstory coverage, and reducing the percentage cover and variety of fresh, herbaceous understory vegetation. These changes would result in lower wildlife values for forage, cover, and reproduction (Palmisano, 1972).

Bald cypress is able to tolerate higher salinities than the other species. Optimal conditions are assumed to occur at salinities less than 1 ppt, and habitat suitability is assumed to decrease rapidly as mean high salinities exceed that mark. Mean high salinity during the growing season (March 1 through October 31) is defined as the average of the highest 33 percent consecutive salinity readings.

Existing Condition. Baseline salinity values were based upon SNWW HS model (USACE 2009) output or empirical data provided by resource agencies, if available. The HS model salinities are the mean of the highest consecutive 33 percent of values, median flow scenario during the growing season, with the SNWW 48-foot deepening in place. Model values were obtained from the nearest model output node, and in some cases, salinity values were adjusted for the salinity gradient observed on isohaline maps for swamps located upstream of the nearest node. The uncertainty range of the salinity projection was based on the standard deviation of the average of the surface and mid-depth salinity values at the nearest station at which salinity data was collected for validation of the HS model. Inasmuch as prevailing salinities in the swamp areas are generally fresh, the uncertainty range for the existing condition was zero to zero.

FWOP. FWP salinities values were obtained from the authorized SNWW 48-foot channel deepening model runs. FWP TY1 salinities were expected to be the same as TY0 salinities because the deepening of the inland portions of the SNWW channels would not be expected to occur by 2020 (TY1). The HS model incorporates the most likely effects of RSLR and future freshwater inflows for the period of analysis. On average, the uncertainty range for was very small, with the low being zero and the high range less than or equal to 1.2 ppt for most areas. However, swamps on the Sabine River near Interstate 10 are an exception. The high range for salinity at TY61 was 2.1 ppt in these areas because of salinities introduced by the 30-foot-deep Channel to Orange in the lower Sabine River, and higher salinity waters entering through the GIWW from the Calcasieu Ship Channel in Louisiana.

FWP. Destruction of swamps within the construction right-of-way would not affect salinities in the area generally. To avoid the model interpreting any change as a move toward optimal conditions, the FWP salinity range was equal to the FWOP salinity range for TY61.

6.3 BOTTOMLAND HARDWOOD MODELING – PROCEDURES AND ASSUMPTIONS

6.3.1 V1 Tree Species Composition

Bottomland hardwood wildlife depends heavily on mast, other edible seeds, and tree buds as primary sources of food. The model assumes that more production of mast and other edible seeds is better than less, and that hard mast is more critical than soft mast because it is available during late fall and winter and has high energy content. Typical hard mast producers in the SNWW study area are oaks, pecan, and other hickories. Soft mast and other edible seeds are produced by red maple, sugarberry, green ash, boxelder, common persimmon, sweetgum, honeylocust, red mulberry, bald cypress, tupelo-gum, American elm, and cedar elm. Nonmast/inedible seed producers are eastern cottonwood, black willow, and American sycamore. The model defines five classes based upon the percentage of the overstory that contains mast-producing trees, and the percentage of hard mast producers in the canopy.

Existing Condition. WVA input data for the percentages of mast-producing trees and hard mast producers in the overstory were estimated using data from the most similar reference sites. The reference sites were selected based upon knowledge of the study area and close examination of Google Earth imagery. As reference sites were used as the basis for input data, uncertainty in the accuracy of the input is reflected in a 20 percent range (from low to high) around percentage overstory estimates, and a 10 percent range around mid- and understory coverage estimates.

FWOP. It was assumed that the bottomland hardwood sites would remain intact and mature at a steady rate. All bottomland hardwoods in the study area appear to have some hard mast producers in them and, therefore, there were no Class 1 sites. For Classes 2-4, it was assumed that the percentage of hard mast producers would steadily increase over the period of analysis, such that Class 2 sites become Class 3, and Class 4 sites become Class 5 by TY61. Class 5 sites were assumed to remain Class 5 through TY61, as changes in climate and RSLR are not expected to significantly affect the health and growth of these forested wetlands.

FWP. It was assumed that all bottomland hardwoods within the construction right-of-way will be removed and replaced by levees, floodwalls, or other project features through TY61. To best capture this effect, the classification was changed to Class 1 from TY1 through TY61, as it has the lowest SI value for this variable.

6.3.2 V2 Stand Maturity

Mature stands of bottomland hardwood are rare in the study area and ecologically important. Historical and ongoing timber harvesting has reduced the number of mature stands and increased the ecological importance of those that remain. These stands provide more hard and soft mast, other edible seeds, and buds than younger stands. They provide important wildlife requisites such as snags, nesting cavities, and medium for invertebrate production. Older, stronger trees in the canopy outcompete understory trees and stimulate the production of additional snags and downed treetops as younger trees die. The model allows for either the average age of stands, or the average DBH to be entered for this variable. As we do not have reliable data on age, DBH was utilized.

Existing Condition. WVA input data for the stand maturity, as reflected in DBH, were estimated using data from the most similar reference sites. The reference sites were selected based upon knowledge of the study area and close examination of Google Earth imagery. As reference sites were used as the basis for input data, uncertainty in the accuracy of the input is reflected in a 2-inch^2 range for smaller average sizes, and a 3-inch^2 range for larger average sizes.

FWOP. An average rate of growth was developed based on data for species prevalent in the study area from the USDA Silvics of North America (USDA, 2004). These growth rates generally reflect optimum growth conditions on managed lands. This is appropriate because bottomland hardwood stands in the study area are generally not impounded and in relatively good condition. Steady growth throughout the period of analysis was assumed. For TY61, a larger range was used to capture the uncertainties associated with climate change and RSLR. For DBH growth projections, a range of 10 inch^2 was utilized.

FWP. At TY1, it is assumed that all bottomland hardwoods within the construction right-of-way will be removed and replaced by levees, floodwalls or other project features through the period of analysis. Since there is little uncertainty in this projection, a range of zero to 0.1 was entered for TY1 through TY61.

6.3.3 V3 Understory/Midstory

Midstory and understory plants also provide important food sources for bottomland hardwood wildlife, and also are preferable habitat for breeding, nesting, and feeding activities. The percentage coverage of understory and midstory is the variable input. Highest SIs apply to a mid-range coverage. The optimal range for understory is between 30 and 60 percent, while for midstory, it is between 20 and 50 percent.

Existing Condition. WVA input data for understory/midstory percentage coverage were estimated using data from the most similar reference sites. The reference sites were selected based upon knowledge of the study area and close examination of Google Earth imagery. As reference sites were used as the basis for input data, uncertainty in the accuracy of the input is reflected in a 20 percent range.

FWOP. Changes over the period of analysis are assumed to be associated with canopy growth. It was assumed that the steady growth of BH stands will result in greater closure of the canopy. As the canopy closes, it is assumed that the percentage midstory coverage would decrease by 27 percent and understory coverage would decrease by 33 percent by TY61.

FWP. At TY1, it is assumed that all bottomland hardwoods within the construction right-of-way will be removed and replaced by levees, floodwalls or other project features through the period of analysis. Since there is little uncertainty in this projection, a range of zero to 0.1 was entered for TY1 through TY61.

6.3.4 V4 Hydrology

The model assumes that the optimum hydrology for stands of bottomland hardwood is one that is essentially unaltered from natural conditions, allowing natural wetting and drying cycles that are beneficial to vegetation and associated fish and wildlife species. The variable utilizes two sets of classes to evaluate and compare flooding duration and flow/exchange. The highest SI value is applied to temporary flooding with high flow/exchange, and the lowest is permanent flooding or dewatering and no flow/exchange.

Existing Condition. WVA input data for understory/midstory percentage coverage were estimated using the review team's knowledge of the study area and elevation data for specific areas.

FWOP. The bottomland hardwoods are generally located in elevations high enough that they would not be affected by changes in water surface elevation associated with RSLR. Changes in precipitation and freshwater inflows could affect them, but the uncertainty associated with current predictions is very large. Therefore no change in flooding duration and exchange classes were forecast through TY61.

FWP. At TY1, it is assumed that all bottomland hardwoods within the construction right-of-way will be removed and replaced by levees, floodwalls or other project features through the period of analysis. In order to capture the effect on water regime, the FWP assumed a change to classes with the lowest SI values for TY1 through TY61 (permanently flooded with no flows/exchange).

6.3.5 V5 Size of Contiguous Forest Area

The model assumes that larger forested tracts are less common and offer higher-quality habitat than smaller tracts, and that species in greatest need of conservation are specialists in habitat use requiring large forested tracts. It is recognized that forest edge and diversity are important, but the model assumes that species that thrive in edge habitat are highly mobile and occur in substantial numbers because of the increase in forest fragmentation. Species found in "edge" habitat are generalists in habitat use but are capable of existing in larger tracts. For this model, tracts greater than 500 acres in size are considered optimal.

Existing Condition. For the direct impacts of the construction corridor, small parcels of bottomland hardwood have been aggregated into groups within hydrounits. For this reason, it was not appropriate to consider the total acreage of each group as the forest size. Since the construction right-of-way is a linear corridor that crosses forest areas, the size of the encompassing contiguous forest area was used to identify the class size for each bottomland hardwood group. The measurement was made using Google Earth.

FWOP. It was assumed that the size of the encompassing forested area would not change by TY61.

FWP. In order to capture the effect on contiguous forest size, the FWP assumed a change from TY 1 through TY61 to the class representing the size of smallest forest area left after bisection by the levee alignment.

6.3.6 V6 Surrounding Land Use

The model assumes that surrounding land uses affect the wildlife value of specific bottomland hardwood tracts. Many wildlife species commonly use adjacent areas as temporary escape or resting cover, as seasonal or diurnal food sources, or as connecting corridors to other desirable habitats. Surrounding areas that meet these needs can make a specific bottomland hardwood area more valuable. Furthermore, some types of surrounding land use are more valuable than others in providing food sources or encouraging wildlife movement. The model defines five types of surrounding land use that are typically found in the study area, and assigns weighting factors that reflect their estimated potential in meeting specific needs. The effect of surrounding land use is measured within a 0.5-mile perimeter of the bottomland hardwood tract. The percent of this area occupied by each of the land use types is calculated and summed.

Existing Condition. Since bottomland hardwood parcels that would be impacted by the construction right-of-way have been aggregated within each hydrounit, the 0.5-mile perimeter was drawn around the aggregated of the individual stands. The existing condition was assessed using Google Earth imagery dated January 2015. Uncertainty associated with the assessment for TY1 in 2020 was assumed to be a range of 10 percent.

FWOP. The review group had no specific information regarding future land use or development changes in the areas surrounding the construction right-of-way. Land use types identified in the study area were predominantly nonhabitat (linear, residential, commercial, and industrial development) and natural habitats such as forested wetlands and marsh. In areas with existing industrial development, professional judgment was used to estimate the likely percentage increase in developed areas. Between 5 and 10 percent of forested or marsh areas in some of the bottomland hardwood groups were assumed to convert to developed areas by TY61. It was assumed that no changes would occur in state lands managed for fish and wildlife conservation purposes, and that navigation project placement areas would not change in use over the period of analysis. Significant uncertainty is associated with any prediction of land use change over 60 years from now. For those areas where no change was projected, a range of 20 percent was assumed. For those areas where a change was projected, a larger range of uncertainty (30 percent) was assumed.

FWP. Development is occurring now in the absence of storm surge protection, and the majority of the alignment would protect areas that are already developed. For those areas that are currently undeveloped, it was assumed that changes in surrounding land use would occur with or without the project, and therefore, the projected change was the same as the FWOP. However, significant uncertainty is associated with any prediction of land use change over 60 years from now. Therefore, a 20 percent uncertainty range at TY61 was assumed for those areas where no change was predicted and a 30 percent range was assumed for those areas where change was predicted.

6.3.7 V7 Disturbance

The model assumes that human-induced disturbance can displace individuals, modify home ranges, interfere with reproduction, cause stress, and force animals to use important energy reserves. The model measures the effect of disturbance using two components: (1) type of disturbance, and (2) distance from disturbance. The magnitude of the effect of each type of disturbance is a factor of the distance to that disturbance.

Existing Condition. Since bottomland hardwood parcels that would be impacted by the construction right-of-way have been aggregated within each hydrounit, the distance to disturbance was measured in Google Earth from the edge of the right-of-way to the nearest disturbance type. Disturbance classes are predominantly frequent/moderate due to roads and industry or seasonal/intermittent due to distance from disturbances. Since the construction right-of-way follows the transition between the floodplain and the upland terrace margin to the greatest extent possible, distance to disturbance was often quite close, primarily in the 50- to 500-foot range.

FWOP. The review group had no specific information regarding future land use or development changes in the areas surrounding the construction right-of-way. Therefore, TY-1 through TY61 projections on type and distance to disturbance were the same as TY 0.

FWP. Since the source of the disturbance would be within the bottomland hardwood stands in the construction right-of-way, the FWP assumed a change from TY 1 through TY61 to the class representing constant/major disturbance, and distance was changed to the closest range (zero to 50 feet).

6.4 SUMMARY OF DIRECT IMPACTS – INTERMEDIATE RSLR SCENARIO

An incremental analysis of levee reaches was conducted which compared the economic and social benefits to estimated construction and mitigation costs to determine which reaches would be recommended for inclusion in the Tentatively Selected Plan (TSP). Reaches that did not meet planning objectives were dropped from further consideration. The analyzed reaches are shown in Figure 6-1. The TSP plan includes Orange-Jefferson Reach 3, Beaumont Reach A, and the Jefferson Main Reach. Orange-Jefferson Reaches 1 and 2, and Beaumont Reaches B and C were dropped from further consideration. The direct impacts reflect the assumed loss of all forested and marsh wetlands within the construction right-of-way of the TSP plan due to construction impacts in the first year of construction. Detailed tables of WVA model output of direct impacts for the intermediate RSLR scenario are presented in Attachment C.

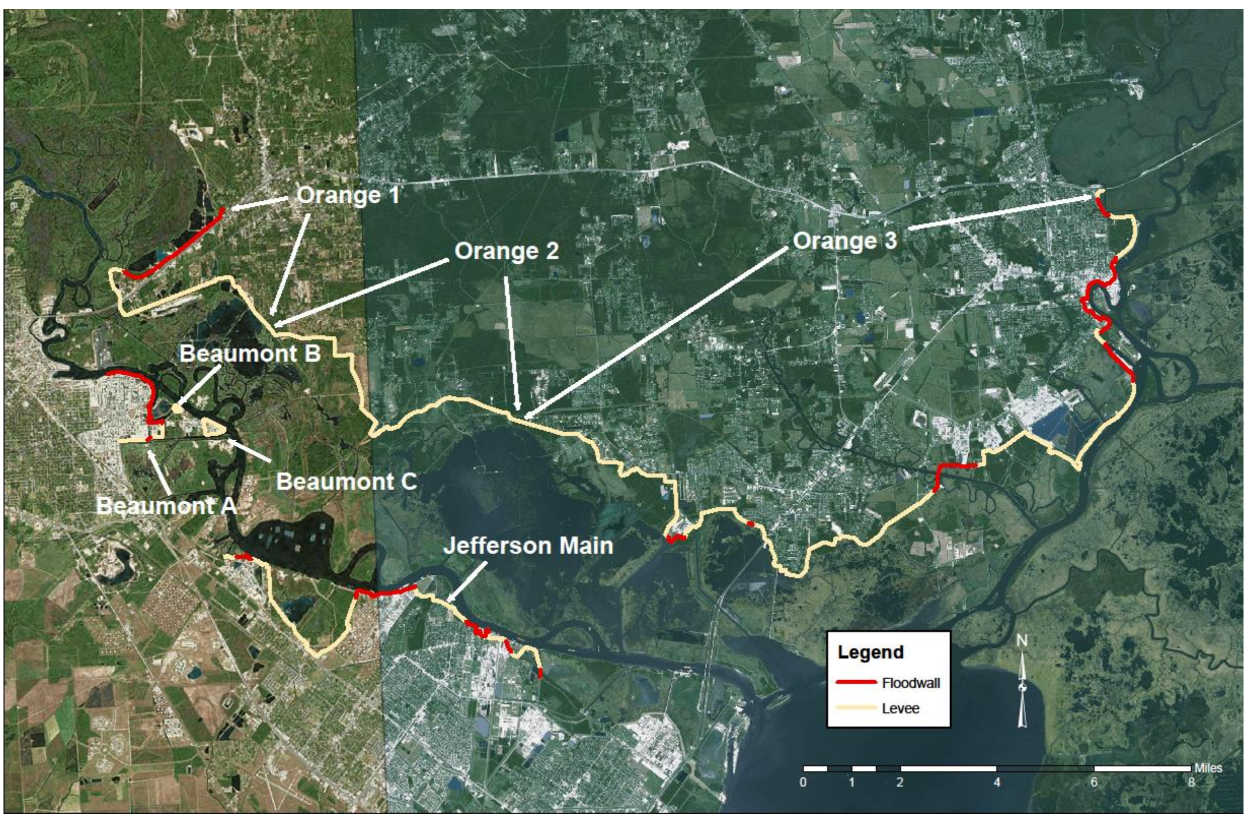

Figure 6-1. Orange-Jefferson CSRM Reaches Evaluated in Incremental Analysis

Direct impacts that would occur under the low and high RSLR scenarios were not modeled, as they are expected to be similar for the three conditions, and the differences in mitigation costs would not be large enough to affect plan selection. The width of the right-of-way might be slightly narrower under the low RSLR scenario; the right-of-way width for the intermediate scenario (for which impacts have been modeled) is believed to be sufficient to construct a system under the high scenario and thus additional impacts would be minor.

Table 6-1 provides a summary of the results of the WVA modeling of direct and indirect (discussed below) impacts on bottomland hardwood, swamp, and tidal marsh for the Orange-Jefferson CSRM Plan (intermediate RSLR scenario). Total direct impacts would affect 300.5 acres of wetlands and result in the loss of 161.8 AAHUs over the period of analysis. Impacts will be refined in consultation with resource agencies during development of the final plan; any revisions will be presented in the Final IFR-EIS.

Table 6-1. Direct and Indirect Impacts (Intermediate RSLR) – Orange-Jefferson CSRM Plan

DIRECT IMPACTS								
	Orange Reach 3		Beaumont Reach A		Jefferson Reach		Totals	
Wetland Type	**Acres**	**AAHUs**	**Acres**	**AAHUs**	**Acres**	**AAHUs**	**Acres**	**AAHUs**
Forested Wetlands								
Swamp	18.0	-10.6			0.9	-0.4	18.9	-11.0
Bottomland Hardwood	94.1	-57.3	0.3	-0.2	13.9	-6.4	108.3	-63.9
Subtotal	112.1	-67.9	0.3	-0.2	14.8	-6.8	127.2	-74.9
Coastal Marsh								
Fresh Marsh	34.4	-18.8	2.6	-1.6	13.4	-6.1	50.4	-26.5
Intermediate Marsh	10.9	-6.2	0.6	-0.3	0.4	-0.2	11.9	-6.7
Brackish Marsh	101.1	-48.8			9.9	-4.9	111.0	-53.7
Subtotal	146.4	-73.8	3.2	-1.9	23.7	-11.2	173.3	-86.9
Total Direct Impacts*	**258.5**	**-141.7**	**3.5**	**-2.1**	**38.5**	**-18.0**	**300.5**	**-161.8**
INDIRECT IMPACTS								
Forested Wetlands								
Swamp	0.0	-0.1					0.0	-0.1
Bottomland Hardwood	12.7	-5.1					12.7	-5.1
Subtotal	12.7	-5.2					12.7	-5.2
Coastal Marsh								
Fresh Marsh	785.2	-18.8					785.2	-18.8
Intermediate Marsh	322.5	-12.6					322.5	-12.6
Brackish Marsh	1130.4	-63.4					1130.4	-63.4
Subtotal	2238.1	-94.8					2238.1	-94.8
Total Indirect Impacts*	**2250.8**	**-100.0**					**2250.8**	**-100.0**
TOTAL IMPACTS BY REACH								
Total Forested Wetlands	124.8	-73.1	0.3	-0.2	14.8	-6.8	139.9	-80.1
Total Coastal Marsh	2384.5	-168.6	3.2	-1.9	23.7	-11.2	2411.4	-181.7
Total Impacts by Reach*	**2509.3**	**-241.7**	**3.5**	**-2.1**	**38.5**	**-18.0**	**2551.3**	**-261.8**

* Totals may not add exactly due to rounding.

7 FWP ANALYSIS OF INDIRECT IMPACTS OF ORANGE-JEFFERSON CSRM PLAN

Indirect impacts of the Orange-Jefferson CSRM Plan are related to two primary project effects – those associated with fisheries access impacts on the extensive marshes in the lower Cow and Adams Bayous floodplains and indirect impacts related to changes in hydrologic connectivity caused by the new levee system and the Cow Bayou structure.

The potential for hydrologic impacts of the Adams and Cow Bayou surge gate structures on the Adams and Cow Bayou watersheds was evaluated using desktop hydrologic modeling as presented below. It is assumed that normal flows would be constricted by the presence of surge gates in the bayous in their normal open condition, and that this constriction would result in fisheries access impacts. An analysis of the location of the levee system alignment identified small, localized areas that would be impounded between the new levee and terrace bluff. Construction of the Cow Bayou gate structure and levee system would indirectly affect a few areas both inside and outside the levee system by permanently disrupting tidal connections. Tidal access to one bottomland hardwood area outside of the levee would also be permanently disrupted by levee construction.

WVA models were used to quantify the indirect impacts of these effects; methods and assumptions used in this modeling are presented below. Wetland areas affected by the indirect impacts of the levee system would change in type and extent due to different levels of tidal flooding under the three RSLR scenarios, and therefore impacts were modeled for each scenario. For example, it was assumed that some swamp would convert to brackish marsh under the Intermediate and High RSLR, because of changes to the salinity regime and higher water elevations. Likewise, some marsh areas switched from intermediate to brackish or brackish to saline due to the changing salinity regime. At other locations, former uplands were assumed to convert to marsh as tides pushed into new areas due to intermediate and high RSLR. These wetland switches were assumed to occur at the midpoint of the period of analysis (TY 31). Indirect fisheries impacts on marsh function associated with the surge gates in Adams and Cow Bayous were modeled for the low RSLR scenario, and these impacts were applied to the intermediate and high scenarios. Higher tidal inundation would improve fisheries access even with the structures in place; the low RSLR condition thus provides a conservatively high impact assessment. Table 6-1 displays all of the indirect impacts described here. All of the indirect impacts are associated with the Orange Reach 3; none were identified for Beaumont Reach A or Jefferson Main.

Indirect fisheries impacts associated with the surge gates in Adams and Cow Bayous would affect about 2,137 marsh acres in those watersheds under all RSLR scenarios, resulting in the loss of about 50 AAHUs. All other indirect impacts would affect about 247.5 acres with the loss of about 50 AAHUs. Modeling assumptions for all of these impact evaluations are described in more detail below. Tables of WVA model output of indirect impacts are presented in Attachment D.

7.1 ANALYSIS OF SURGE GATE IMPACTS ON ADAMS AND COW BAYOUS

7.1.1 Hydrologic Modeling of the Surge Gates

ERDC's DOWSMM modeling (USACE 2015) indicates negligible impacts on the water surface elevation and salinity within Adams and Cow Bayous from potential constrictions to the channel cross-section with the proposed surge gates in their normal open condition. This was determined by a sensitivity analysis conducted on the inlet size for each bayou, based on the assumption that construction of the gates would result in some reduction of the cross-section in their normal, open condition. In the analysis, bayou cross-sections were reduced by a wide range of estimated parameters, up to a maximum 75 percent constriction. It was determined that the limited tidal prism associated with the bayous results in minimal energy loss across the connection between the bayous and the Sabine River, and therefore constriction of this access point results in little change in the tidal energy passing into the bayou. The insensitivity of the water surface elevation and the salinity impacts gives high confidence that the general conclusion associated with this study is robust; constriction of the inlet, even significant constriction, results in minimal impacts on water surface elevation and salinity within the bayous.

The extent to which these constrictions would impound storm water within the bayous was also examined by evaluating the effects of a significant rainfall event (Tropical Storm Allison) that had been captured in the median flow simulation. Once again, this analysis applies to the normal, open condition of the gate and evaluated the impacts of rainfall not associated with a significant storm surge event. Given the type of structures currently being evaluated (sector gates on the navigation channels with one or more flanking vertical lift gates to maintain flows on one or both sides of the navigation gates), it is estimated that existing flows may be reduced by a maximum of 50 percent. An aerial view of this type of structure is shown in Figure 7-1. The DOWSMM analysis showed that, even for a 50 percent constriction, the volume of water resulting from such a storm could still pass through the constriction with little impact on upstream stage. There was no attempt made to determine if this storm event represented a project flood, and hence a larger storm could have a more significant impact.

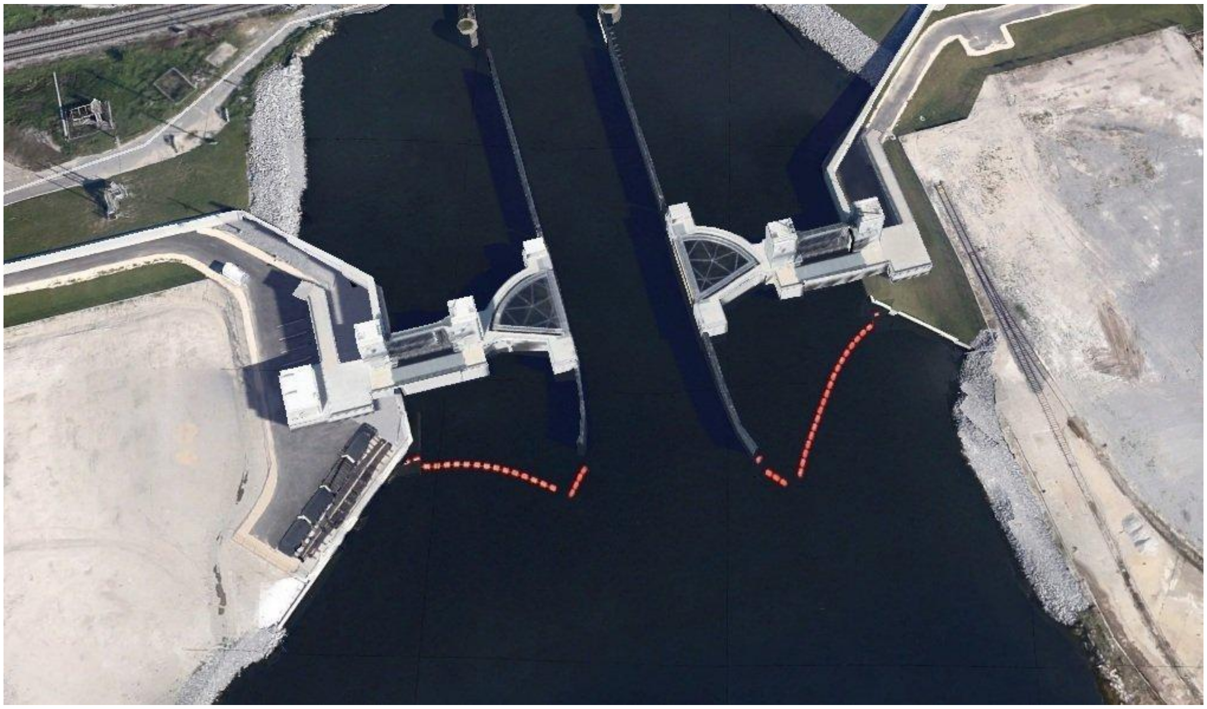

Figure 7-1. Conceptual Plan View of Adams and Cow Bayou Structures

7.1.2 Indirect Impacts on Coastal Marsh and Aquatic Organisms

Impacts related to the temporary closure of the gates were also considered to determine whether fisheries migration would be impacted with temporary surge-related gate closures. The degree of impact would be influenced by the timing and duration of a structure closure relative to peak migration seasons. However, given the predicted return interval of 10 to15 years for storm surges high enough to threaten the areas targeted for protection by this study (which are generally 7 to 10 feet higher than the structure locations), interruption of fishery migrations would be rare. In addition, it is not anticipated that the gates, once closed, would remain closed for an extended period. The operating plan for the gates has not yet been developed, but even a worst case estimate of closure time (5 to7 days every 10 to15 years) would result in only minor and temporary impacts to fisheries access. The project design includes a pump system that would significantly reduce the flood duration upstream of the structures after the gates have been closed to protect against storm surge impacts. It must be noted, however, that should the final structure design reduce the cross section by more than 50 percent, additional modeling and environmental analysis would be needed to more thoroughly characterize potential hydrologic impacts of the gate structures.

Based on all of the above analyses and assumptions, it appears that the only significant impact of the Cow and Adam Bayous structures would be fisheries access impacts associated with the day-to-day operation in the open condition. For the historic RSLR scenario, indirect impacts on swamps and bottomland forests upstream of the gated structures are expected to be negligible because changes in water surface elevation and salinity are expected to be negligible (USACE 2015). Therefore, no WVA impact modeling was needed for the Adams and Cow Bayou forested wetlands. However, indirect impacts associated with fisheries access through the gated structures would be expected for extensive marshes in the bayou floodplains upstream of the gated structures (Figures 7-2 and 7-3). These impacts could be expected to affect approximately 1,235 and 900 acres of coastal marsh in the Cow and Adams Bayou floodplains, respectively. The upstream limit of the affected areas, defined to include all upstream marshes in the bayou floodplains, is approximately 7.7 stream miles upstream of the Cow Bayou structure and 4.4 stream miles upstream of the Adams Bayou structure.

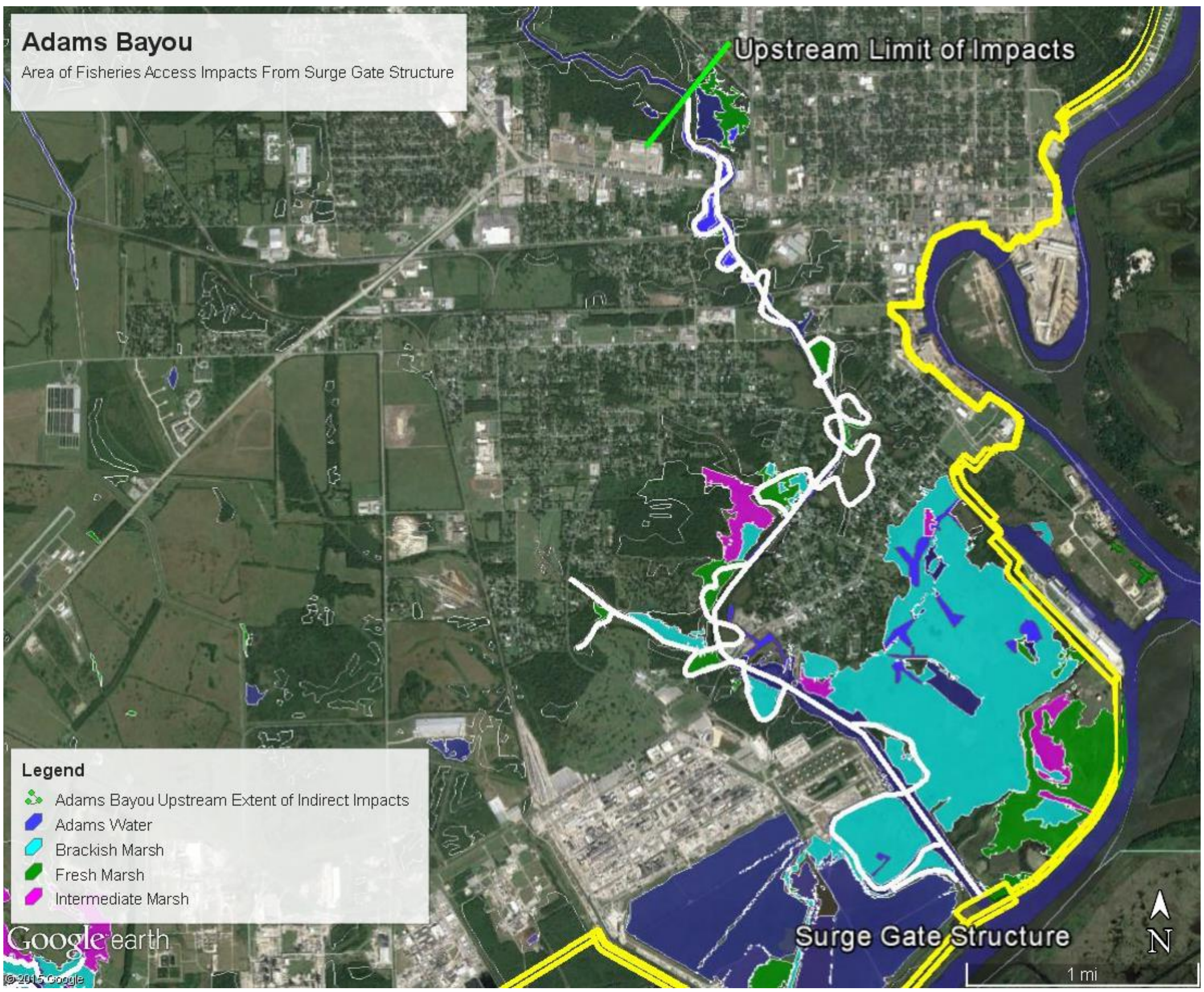

Figure 7-2. Adams Bayou Indirect Impact Area of Surge Gate Structure

According to the NMFS (2008), the ability of estuarine dependent marine fishery organisms to migrate to and from coastal habitats decreases as structural restrictions increase, thereby reducing fishery production (Hartman et al. 1987; Rogers et al. 1992; Rozas and Minello 1999). The physical ability (i.e., swimming speed) to navigate through a structure is not the only factor influencing fish passage. Both behavioral and physical responses govern migration and affect passage of fishery organisms through structures. These responses may vary by species and life stage. In addition, most marine fishery species are relatively planktonic in early life stages and are dependent on tidal movement to access coastal marsh nursery areas. For this reason, in general, the greater the flow through a structure into a hydrologically affected wetland area, the greater the marine fishery production functions provided by that area. It should not be assumed that structures that have been determined to provide sufficient drainage capacity also optimize or provide adequate fishery passage. More investigation is warranted to refine and adaptively manage water control structure design and operations to minimize adverse impacts to fishery passage. Structures constructed along the sides of Cow and Adams Bayou would interfere with organism movement into and out of the bayou, but this impact could be minimized by following specific NMFS design recommendations.

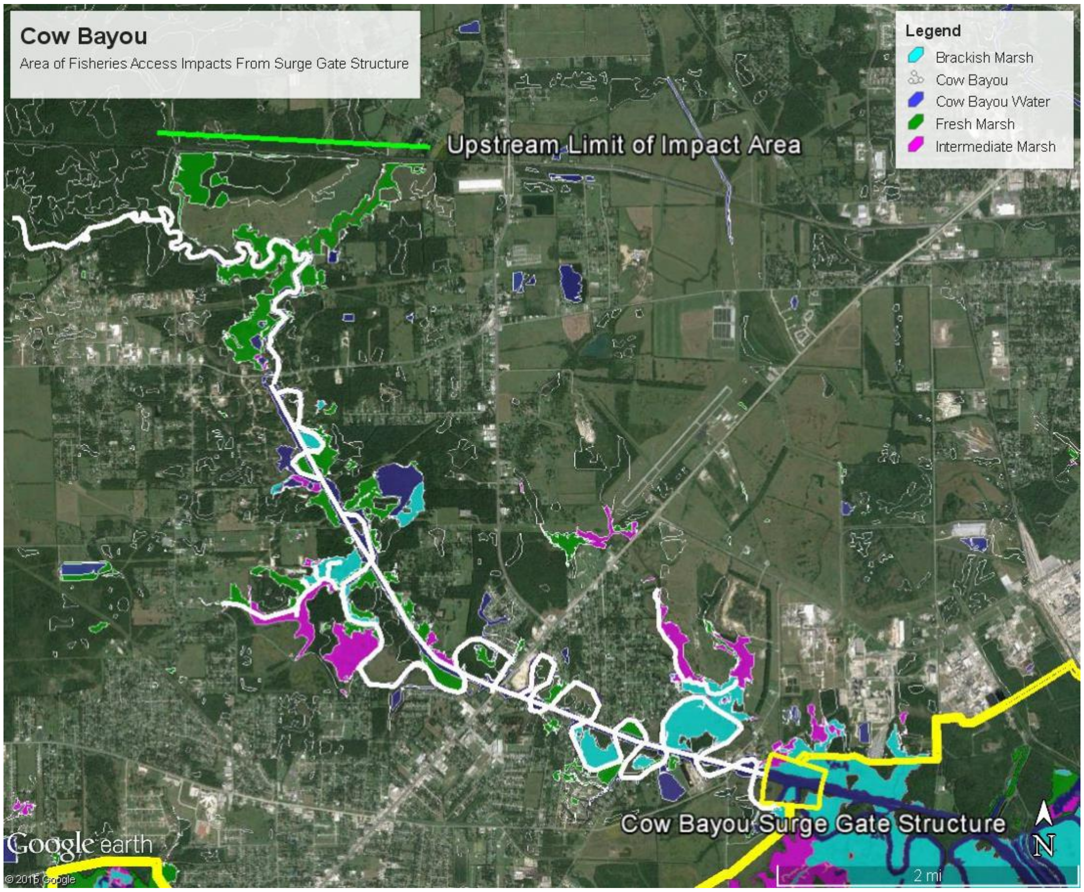

Figure 7-3. Cow Bayou Indirect Impact Area of Surge Gate Structure

Since only preliminary information on the Cow and Adams gate structures is available at this time, the WVA indirect impacts analysis assumed that the structures would reduce the cross-sectional area of the inlets by 50 percent. Final structural designs will incorporate fisheries-friendly considerations recommended by USFWS (2008) to the greatest extent possible. If it is determined that the final feasibility design would reduce the cross-sectional area of the bayou inlets by more than 50 percent, impacts will be reevaluated and reported in the FIFR-EIS.

7.1.3 WVA Coastal Marsh Modeling of Indirect Impacts

The following method was used to develop input for the WVA Coastal Marsh variables 1 through 6 to capture the indirect effects described above, particularly the fisheries access affects. The WVA marsh models include a variable (V6) that can evaluate impacts on fisheries access. Persistent emergent marsh vegetation and associated open water play an important role in coastal wetlands by providing foraging, resting, and breeding habitat for a variety of fish and wildlife species; and by providing a source of detritus and energy for lower trophic organisms that form the basis of the food chain. Access to these marsh and water systems by aquatic organisms, particularly estuarine-dependent fishes and shellfishes, is considered to be a critical component in assessing the quality of a given marsh system. Additionally, a marsh with a relatively high degree of access by default also exhibits a relatively high degree of hydrologic connectivity with adjacent systems, and therefore may be considered to contribute more to nutrient exchange than would a marsh exhibiting a lesser degree of access.

For V1 input (Percent Emergent Marsh and Water), emergent marsh and water acres within the Cow and Adams floodplains upstream of the gates was taken from the USGS wetland vegetation classification of the Cow and Adam water basins (USACE 2014). These are the only basins for which surge gate structures are proposed; large marsh areas are located upstream of the levee right-of-way on both bayous. Marsh polygons were lumped within each basin for each marsh type - brackish, intermediate, and fresh (no saline marsh is present in these areas). Lumping all polygons of one marsh type for the WVA modeling of each basin is appropriate because of the general uniformity of the marshes in these basins.

Two areas on Adams Bayou were investigated to determine if they should be modeled separately. An area of impounded fresh and intermediate marsh within a former dredged material placement area at the mouth of Adams Bayou (the TPWD Adams Bayou Unit) was found to be hydrologically isolated from the adjacent Sabine River and Adams Bayou. Dredged material placement has raised the elevation of the area to between 7 and 10 feet, and there is no tidal access from the Sabine River or Adams Bayou. Since the proposed surge gate would have no additional impact on fisheries access to this area, the Adams Bayou Unit was excluded from the impact analysis. Separate WVA modeling of the 475-acre marsh west of the Adams Bayou Unit was considered but it was ultimately lumped together with the other Adams Bayou marshes. Primary access is provided by Adams Bayou on its southwestern side, although up to an estimated 40 percent of the flows enter the area near its northernmost point through a bridge-culvert under the road leading into the Port of Orange. An old levee, which bisects the area from northwest to southeast, is degraded in many areas, allowing flows to pass unencumbered to both sides of the levee. Since the Adams Bayou hydrologic openings are capable by themselves of providing full access to the entire area, the separate marsh types in this area were lumped with the rest of the marshes in the impact area, and all were assigned a structure rating of 1.0 since no impediments to access are known.

The total amount of the classified water in each basin, including the channelized bayou reaches and the natural oxbows within the tidal segment, is included in the V1 water acres since all are important avenues for fisheries access, and all would be affected in some way by the structures. Water acres were subdivided and associated with each of the three marsh types in accordance with the total relative percentages of the marsh types themselves. All of the polygons for each marsh type within each basin were added together, and the relative percentages of fresh, intermediate, and brackish marsh were calculated. If, for example, 30 percent of the marsh in the basin was brackish, then 30 percent of the water in the affected reach of the bayou was associated with brackish marsh.

The percent of aquatic vegetation cover (V2) was estimated based upon observations documented for these areas for the SNWW Channel Improvement Project Feasibility Study and Environmental Impact Statement (USACE 2011), review of Google Earth 2015 imagery and best professional judgment.

The degree of marsh/waterbody interspersion (V3) was assessed for each marsh type over each drainage using Google Earth 2015 imagery at the same scale as the examples shown in the WVA marsh model V 1.0

The percent shallow water (V4) of total water in each drainage was calculated by apportioning the shallow water percentage across the marsh types in accordance with their relative percentages. The percent shallow water was estimated using a weighted average based on length of the dredged channel, natural oxbow channels, and small shallow streams with the assumptions that the dredged channel has 10 percent shallow water along its edges, the natural oxbows have 30 percent shallow water along their edges, and the shallow tributaries have 40 percent shallow water along their edges. The breakdown of the three water body types is shown in Table 7-1 for each bayou. Calculations to estimate the percentage of shallow water in the affected areas of for Adams and Cow Bayous are shown in Tables 7-2 and 7-3 below.

Table 7-1. Affected Bayou and Stream Miles in Cow and Adams Bayous

	Adams Bayou		Cow Bayou	
Water Body Types	Total Length (miles)	Water Body Type (%)	Total Length (miles)	Water Body Type (%)
Channelized Bayou	4.1	33.0%	4.4	19%
Natural Bayou	7.12	57.3%	14.8	65%
Shallow Streams	1.2	9.7%	3.6	16%
Total	12.42	100.0%	22.8	100%

Table 7-2. Estimation of Percentage Shallow Water for Adams Bayou

Adams Bayou						
Calculations to Estimate Percent Shallow Water (V4)						
	Marsh Type Percentage	Emergent Marsh by Type (acres)	Water Acres Proportioned by Relative Percentage of Water Body Type	Assumed Percentage Shallow Water*	Calculated Shallow Water (Acres)	Total Marsh & Water (Acres)
Fresh Marsh (F Indirect-3)	21.2%	63.1	47.5			110.6
Channelized Water (19%)			9.0	10%	0.9	
Natural Channels (65%)			30.9	30%	9.3	
Shallow Streams (16%)			7.6	40%	3.0	
Subtotal					13.2	
Intermediate Marsh (I Indirect-4)	7.3%	35.8	16.4			52.2
Channelized Water (19%)			3.1	10%	0.3	
Natural Channels (65%)			10.6	30%	3.2	
Shallow Streams (16%)			2.6	40%	1.0	
Subtotal					4.6	
Brackish Marsh (B Indirect-5)	71.5%	578.7	160.3			739.0
Channelized Water (19%)			30.5	10%	3.0	
Natural Channels (65%)			104.2	30%	31.3	
Shallow Streams (16%)			25.7	40%	10.3	
Subtotal					44.6	
Totals		677.6	224.3		62.3	901.9
Percentage Shallow Water Associated with All Marsh Types					**35.7%**	

*Weighting based on following assumptions:
Channelized bayou has 10 percent shallow water along edges.
Natural bayou and oxbows have 30 percent shallow water along edges.
Small shallow streams have 40 percent shallow water along edges.

Table 7-3. Estimation of Percentage Shallow Water for Cow Bayou

Cow Bayou Calculations to Estimate Percent Shallow Water (V4)	Marsh Type Percentage	Emergent Marsh by Type (acres)	Water Acres Proportioned by Relative Percentage of Water Body Type	Assumed Percentage Shallow Water*	Calculated Shallow Water (Acres)	Total Marsh & Water (Acres)
Fresh Marsh (F Indirect-2)	54.6%	421.0	253.6			674.6
Channelized Water (19%)			48.2	10%	4.8	
Natural Channels (65%)			164.8	30%	49.4	
Shallow Streams (16%)			40.6	40%	16.2	
Subtotal					70.5	
Intermediate Marsh (I Indirect-3)	21.9%	168.7	101.6			270.3
Channelized Water (19%)			19.3	10%	1.9	
Natural Channels (65%)			66.0	30%	19.8	
Shallow Streams (16%)			16.3	40%	6.5	
Subtotal					28.2	
Brackish Marsh (B-Indirect-4)	23.5%	181.3	109.2			290.5
Channelized Water (19%)			20.7	10%	2.1	
Natural Channels (65%)			71.0	30%	21.3	
Shallow Streams (16%)			17.5	40%	7.0	
Subtotal					30.4	
Totals		771.0	464.4		129.1	1,235.4
Percentage Shallow Water Associated with All Marsh Types					**27.8%**	

*Weighting based on following assumptions:
Channelized bayou has 10 percent shallow water along edges.
Natural bayou and oxbows have 30 percent shallow water along edges.
Small shallow streams have 40 percent shallow water along edges.

Salinity (V5) for the existing condition (historic RSLR) was based on salinity projections developed for the SNWW 48-foot channel improvement project as described for WVA modeling of S2G direct impacts.

Impacts to fisheries access (V6) were assessed based on limited, preliminary information on the type of surge prevention structure planned for Cow and Adams Bayous. Fisheries access impacts for the affected tidal areas are primarily associated with the proposed surge gate structures. The final design will attempt to minimize impacts on the existing flow and cross-sectional area of the bayous, and will utilize fisheries-friendly design concepts as discussed above. However, to provide a conservatively high estimate of potential impacts, the WVA modeling assumed a 50 percent reduction in the cross-section of the channel. Based on a curve developed with data from Rogers et al. (1992) for the "Percent Open Channel Method" for calculating fisheries access impacts, this equates to a structure rating of 0.7 for the type of open structure planned (Figure 7-4). This method has been used by NOAA-NMFS and USACE on recent projects in Louisiana (NMFS 2012).

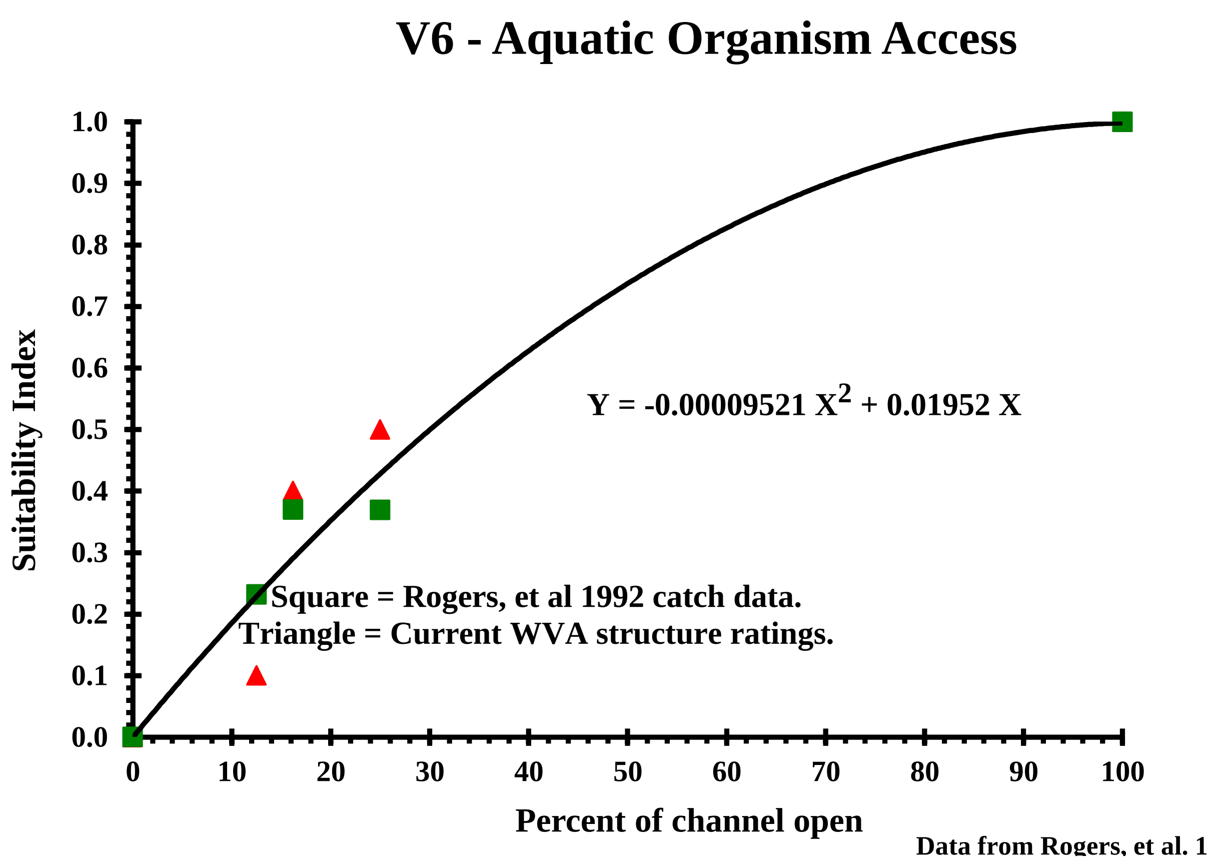

Figure 7-4. Percent Open Channel Curve

7.1.4 Intermediate and High RSLR Scenarios

Indirect impacts related to the Cow and Adams gated structures were modeled for the historic RSLR scenario. Surge gate structures on Cow and Adams Bayou would be open the vast majority of the time, allowing sea levels to rise upstream of the structure as they would in the FWOP condition. In Cow and Adams Bayous, water levels under intermediate RSLR should remain largely within the existing channels; with high RSLR, water elevations would encroach into some developed areas of Bridge City which are adjacent to the bayou and tidal inundation of all wetland areas would be deeper. Large areas of brackish marsh in the floodplains downstream of the Cow Bayou gate and around the mouth of Adams Bayou on the Sabine River would experience much deeper daily tidal inundation with high RSLR, with some areas possibly converting to open water. Higher tidal inundation would improve fisheries access even with the structures in place. However, the degree of improvement is difficult to estimate, and therefore indirect fisheries impacts were not modeled for the intermediate and high RSLR scenarios; impacts quantified for the historic scenario were applied, providing a conservatively-high impact assessment.

Indirect fisheries impacts of the Adams and Cow Bayous structures would affect about 2,137 acres, resulting in the loss of 50 AAHUs. Inasmuch as impacts of the three RSLR scenarios are assumed to similar, differences in mitigation costs would not affect plan selection.

7.2 ANALYSIS OF INDIRECT IMPACTS OF THE LEVEE SYSTEM

7.2.1 Historic RSLR Scenario

7.2.1.1 FWOP Condition

A desktop analysis of interior drainage requirements has been performed by Galveston District as required using current USACE guidance contained in ER 1100-2-8162 and ETL 1100-2-1. This analysis identified all of the sub-drainage basins behind the proposed new levee alignment and the primary small drainage in each sub-basin for which existing flow will need to be maintained. Figure 7-5 shows the sub-basins outlined in white, the primary drainage in each sub-basin in red, and the major rivers in blue. The proposed levee alignment is shown in yellow. The analysis calculated the amount of both overland and channelized flow from each basin.

7.2.1.2 FWP Condition

Sluice gate culverts are planned for use everywhere there are tidal flows (Figure 7-6); flap gate culverts may be utilized in upstream areas above tidal influence (Figure 7-7). Gated culverts would be placed everywhere the red drainage lines intersect the yellow levee alignment. The sluice gates would remain open except when surge protection is needed; they would be closed temporarily for a short period before and after a storm occurs. Flap gate culverts would provide for one-way flow downstream from the levee system.

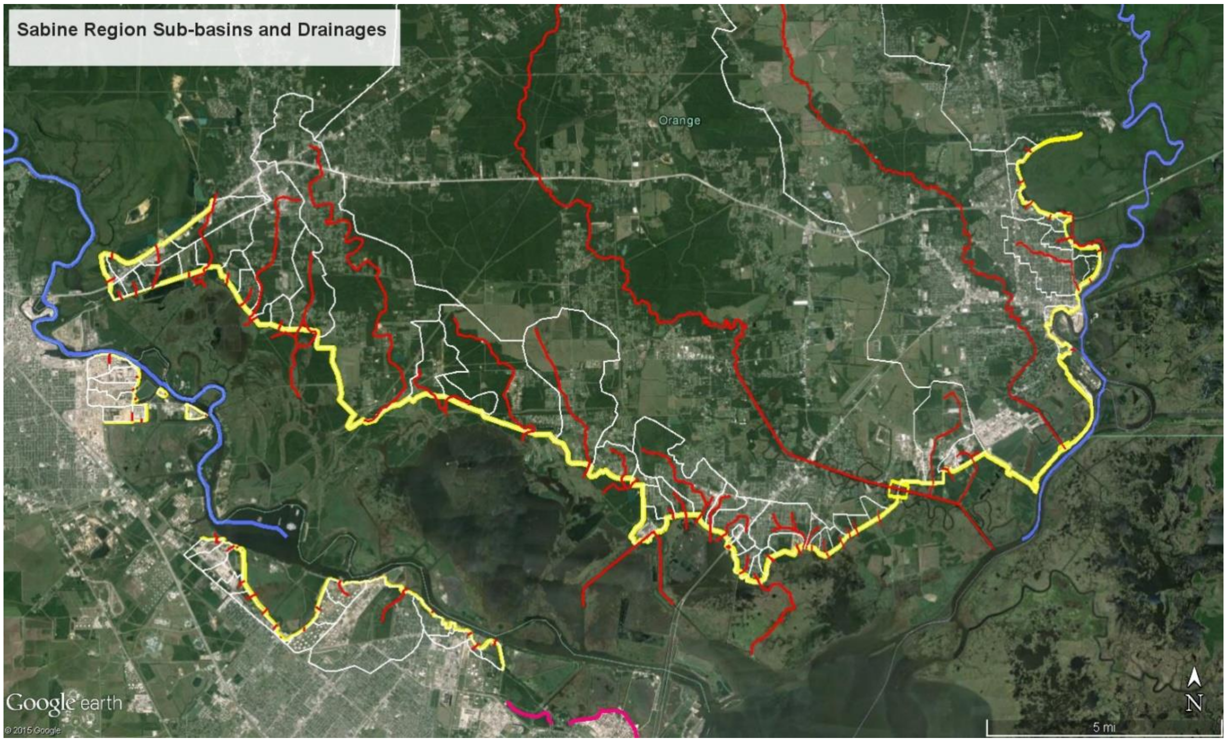

Figure 7-5. Sabine Region Sub-basins and Drainages

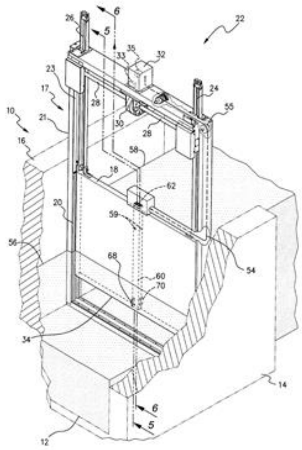

Figure 7-6. Sluice Gate Example

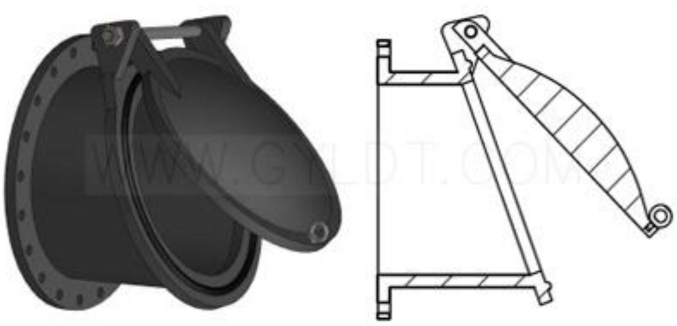

Figure 7-7. Flap Gate Example

Impacts on the floodplain, both upstream and downstream of the levee system, would be minimized to the greatest extent possible. Culverts have been designed to maintain existing flows for a 100-year rainfall event, with an additional 10 percent to account for the predicted increase in rainfall due to climate change over the period of analysis. In addition, they will be designed with longer spans and lesser heights than would typically be used in an attempt to replicate the natural openings. In the existing condition, freshwater inflows from the upland areas to marshes and forested wetlands in the floodplain are being conveyed primarily through existing stream channels. The majority of the time, flows are directed toward channels and ditches that discharge into the floodplain through existing drainages. Water flows into the major rivers through those channels which have an incised bed, and in some cases flows spread out directly into wetland areas. Overland sheet flow is temporary, occurring during intense or long duration rain events, as the majority of the area upstream of the levee is undeveloped and permeable. The degree to which shallow groundwater aquifers may contribute flows to the floodplain is unknown, but they are assumed to be a minor contributor. It is believed that marshes in the floodplain rely primarily on rainfall and tidal push for inundation.

During a surge event the sluice gates would be closed, pumps would be used to pump rainfall runoff from the interior to the exterior. The pumps are being conservatively sized to avoid floodplain impacts to the interior of the levee system, and to allow overbank flooding in the streams in the floodplain outside of the levee during high flow events. Hydrologic flows in the FWP condition would thus be very similar to FWOP flows and in location, duration and magnitude, both inside and outside of the levee system. Like the Cow and Adams Bayou structures, it is assumed that these gates would be closed for an estimated two weeks every 10-15 years. The operating plan for the gates has not yet been developed, but even a worst case estimate of closure time would result in only minor and temporary impacts on fisheries access for gates with tidal flows. Groundwater flow from shallow aquifers may be affected by compaction of aquifer sediments due to the weight of the overlying levee, or by construction of seepage barriers beneath the levee. The location and extent of these will not be known until final levee design.

Based on these assumptions, it was determined that the levee would have minor impacts on the hydrology of the floodplain both inside and outside of the levee system. Because this determination rests heavily on these assumptions, resource agencies have requested to be involved in the development of Operating Manuals during the PED Phase and during subsequent periodic reviews when operating plans are reevaluated to determine project performance under future conditions, including potentially higher than anticipated rates of RSLR. In addition, the monitoring and adaptive management plan for this project must include periodic monitoring of the extent and quality of wetlands in the floodplain to determine if the assumptions regarding freshwater flows appear valid.

The levee alignment, drainage basins and proposed culvert locations were evaluated in detail using Google Earth 2015 imagery to check for smaller, secondary drainages where culverts would also be needed to maintain flows to adjacent wetlands. Approximately 13 new culverts, recommended as a result of this analysis, have been incorporated into the project design where additional connectivity appeared to be needed. With the exception of the Cow and Adams Bayou basins discussed above, the majority of the wetlands in the uplands behind the levee alignment are swamp or bottomland hardwoods. A few small areas of marsh are scattered inside of the levee alignment. Since drainage and tidal connections would be maintained in essentially the FWOP condition as described above, no indirect impacts were identified on most of the marshes, bottomland hardwoods and swamps located inside and outside the levee system.

The potential for indirect impacts related to induced development was also considered. The general area is vulnerable to storm surge impacts, and construction of this alternative would reduce the risk of storm surge damages in the future. Development has been occurring in the area because of the concentration of petro-chemical industries and the Port of Beaumont, and this development is expected to occur with or without the project. A study of the potential for induced development in coastal areas due to shoreline protection projects found that the existence of such projects is not statistically significant in generating changes in the pattern and growth of development (Cordes and Yezer 1995). For this study, therefore, it is assumed that the existing patterns of employment and income would persist, and that the pattern and extent of development would be similar in both the FWOP and FWP conditions.

However, impacts were identified for wetland areas immediately adjacent to the levee that would be impounded between the levee and the higher elevation upland terrace margin. In many areas, the transition between the floodplain and the upland is an abrupt bluff, averaging from 4 to 8 feet high. Marsh or forested wetlands caught between the new levee and bluff would be cut-off from daily tidal inundation, denied nutrients and sediments; the health of the wetlands would decline and they would eventually die. For the marshes, it was assumed that this process would occur quickly with emergent marsh converting to open water by TY 1; for swamps, it was assumed that the disrupted hydrology and impounded rainwater would result in a slow decline in the health of cypress and tupelo, with eventual loss of the entire stand by TY61. For bottomland hardwoods, however, the soil would become saturated due to the impoundment of rainfall and it was assumed that the trees would die off quickly, with a complete loss by TY2.

In addition, the construction zone impacts for the Cow Bayou gate and one levee segment would block the flow of small channels feeding adjacent marsh or swamp. For these areas, it was assumed that tidal connectivity would be disrupted permanently and that wetland vegetation would no longer be supported in the FWP condition. Similar to the impoundment impacts, it was assumed that marsh would be lost by TY1. Bottomland hardwoods and swamps would survive longer under these conditions because the soils would not be saturated; however, lower water availability would create stress and increase susceptibility to pests and diseases. These stands were assumed to be totally lost by TY25.

The indirect impact areas and the acres of impacts are listed in Table 7-4 and shown on Figures 7-8 through 7-12.

Table 7-4. Indirect Impact Areas for Orange Jefferson CSRM Plan

Hydrounit	Indirect Area ID	Swamp	Bottomland Hardwood	Fresh Marsh	Intermediate Marsh	Brackish Marsh	Water in Wetland	Total Wetland Acres	Impact Description
TX 3	F Indirect-1			1.1			0.3	1.4	Impounded between bluff and levee
TX 3	S Indirect-1	4.4						4.4	Impounded between bluff and levee
TX 3	BH Indirect-1		0.7					0.7	Impounded between bluff and levee
TX 6	B Indirect-1					0.9		0.9	Impounded between sandpit and levee
TX 10	F Indirect-2			421.0			253.6	674.6	Fishery access primarily controlled by Cow Bayou surge gate
TX 10	I Indirect-1				5.7		1.2	6.9	Hydrologic access permanently disrupted
TX 10	I Indirect-2				11.4		1.3	12.7	Hydrologic access permanently disrupted
TX 10	I Indirect-3				168.7		101.6	270.3	Fishery access primarily controlled by Cow Bayou surge gate
TX 10	B Indirect-2					18.9	7.2	26.1	Hydrologic access permanently disrupted
TX 10	B Indirect-3					14.1	4.3	18.4	Hydrologic access permanently disrupted
TX 10	B Indirect-4					181.3	109.2	290.5	Fishery access primarily controlled by Cow Bayou surge gate
TX 10	S Indirect-2	1.9						1.9	Hydrologic access permanently disrupted
TX 11	F Indirect-3			63.1			47.5	110.6	Fishery access primarily controlled by Adams Bayou surge gate
TX 11	I Indirect-4				35.8		16.4	52.2	Fishery access primarily controlled by Adams Bayou surge gate
TX 11	B Indirect 5					578.7	160.3	739.0	Fishery access primarily controlled by Adams Bayou surge gate
TX 11	BH Indirect-2		12.7					12.7	Hydrologic access permanently disrupted
TX-LA2	S Indirect-3	2.0						2.0	Impounded between bluff and levee
TX-LA2	S Indirect-4	11.0						11.0	Impounded between bluff and levee
	Totals*	19.3	13.4	485.2	221.6	793.9	702.9	2236.3	
*Numbers may not add to totals because of rounding.									

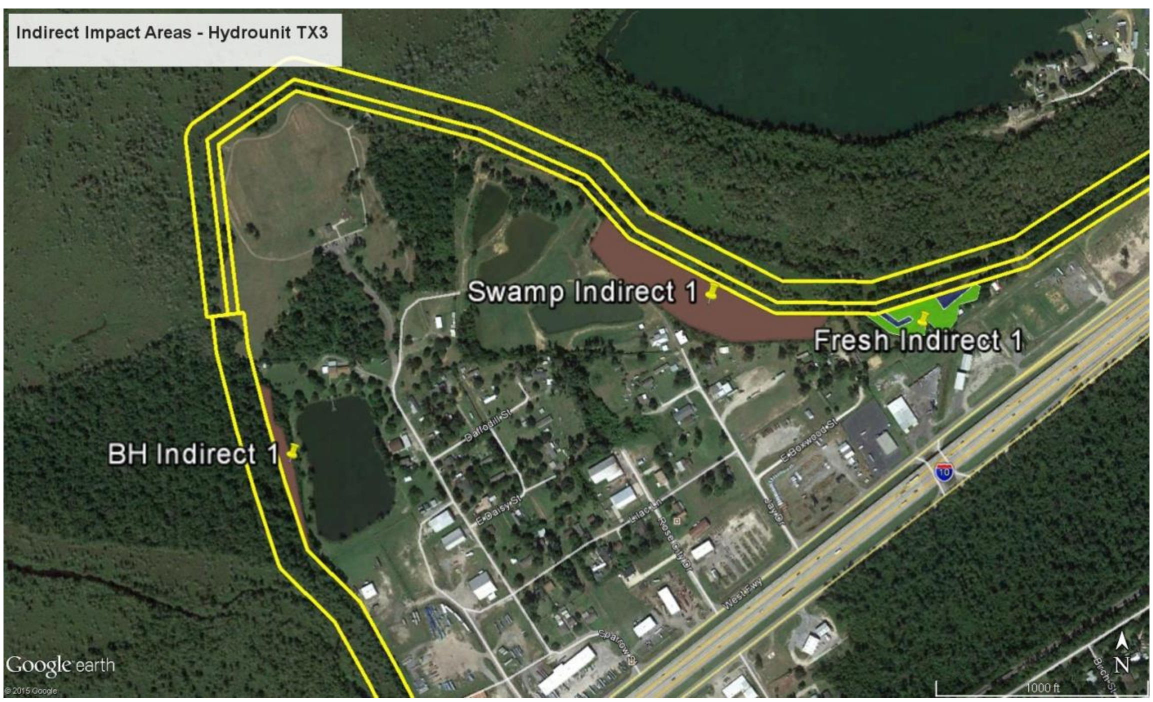

Figure 7-8. Indirect Impact Areas in Hydrounit TX3 (Historic RSLR Scenario)

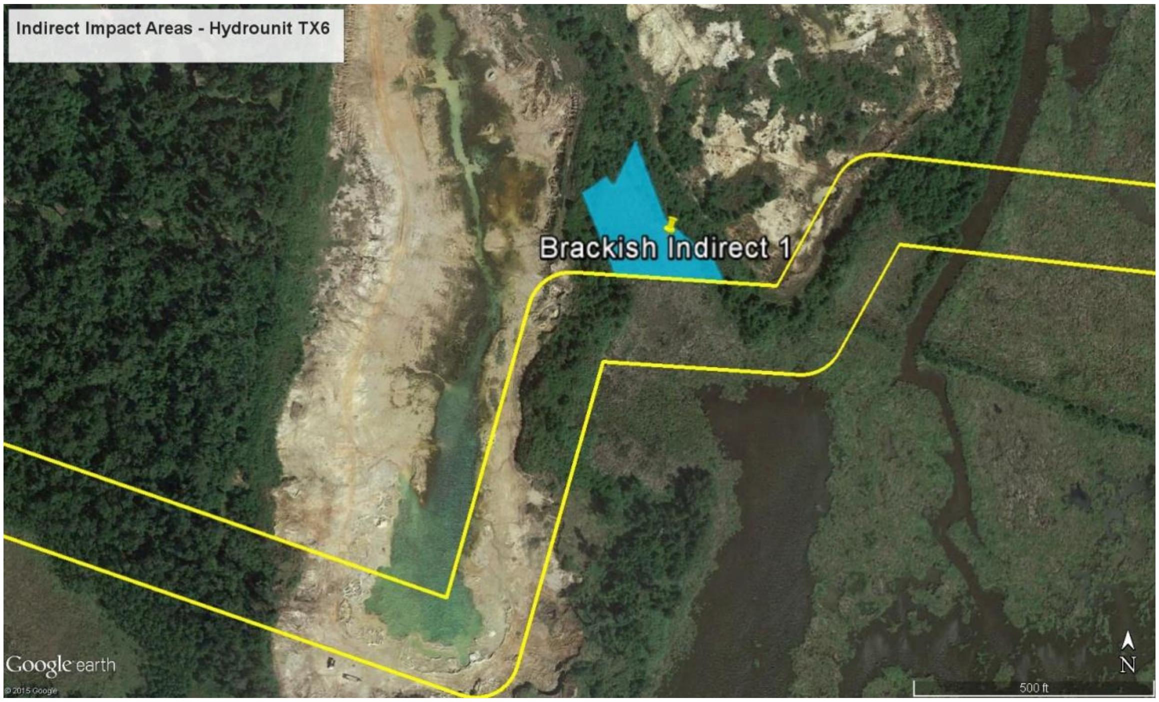

Figure 7-9. Indirect Impact Area in Hydrounit TX6 (Historic RSLR Scenario)

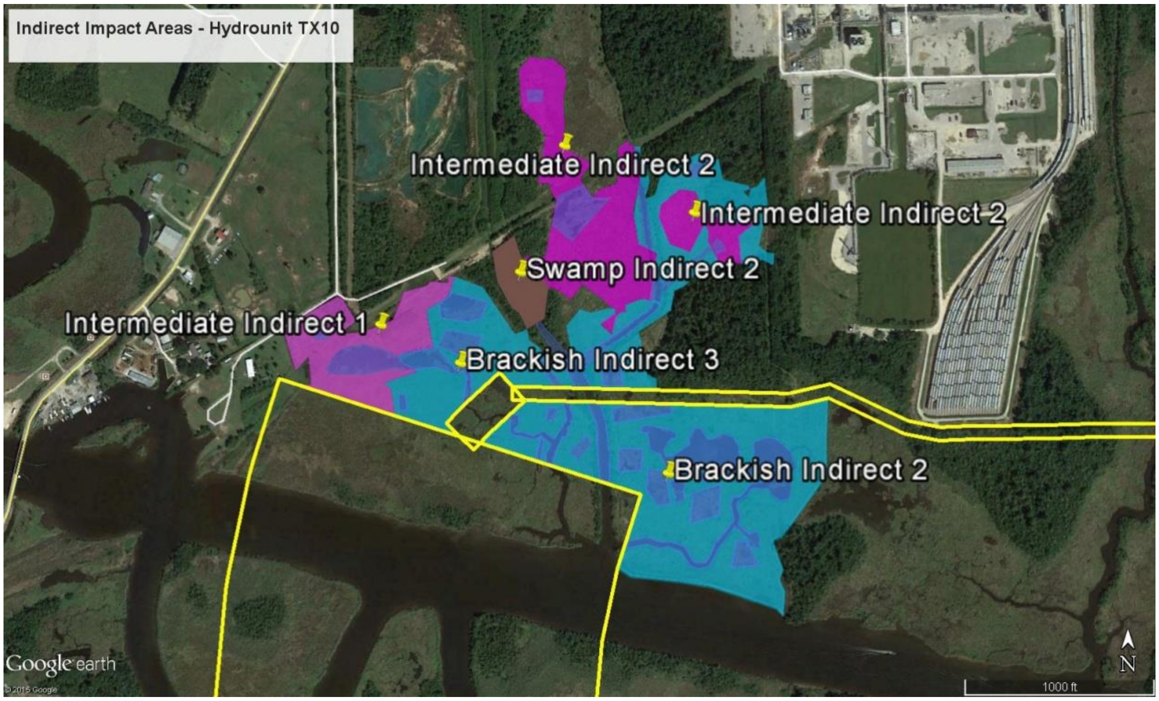

Figure 7-10. Indirect Impact Area in Hydrounit TX10 (Historic RSLR Scenario)

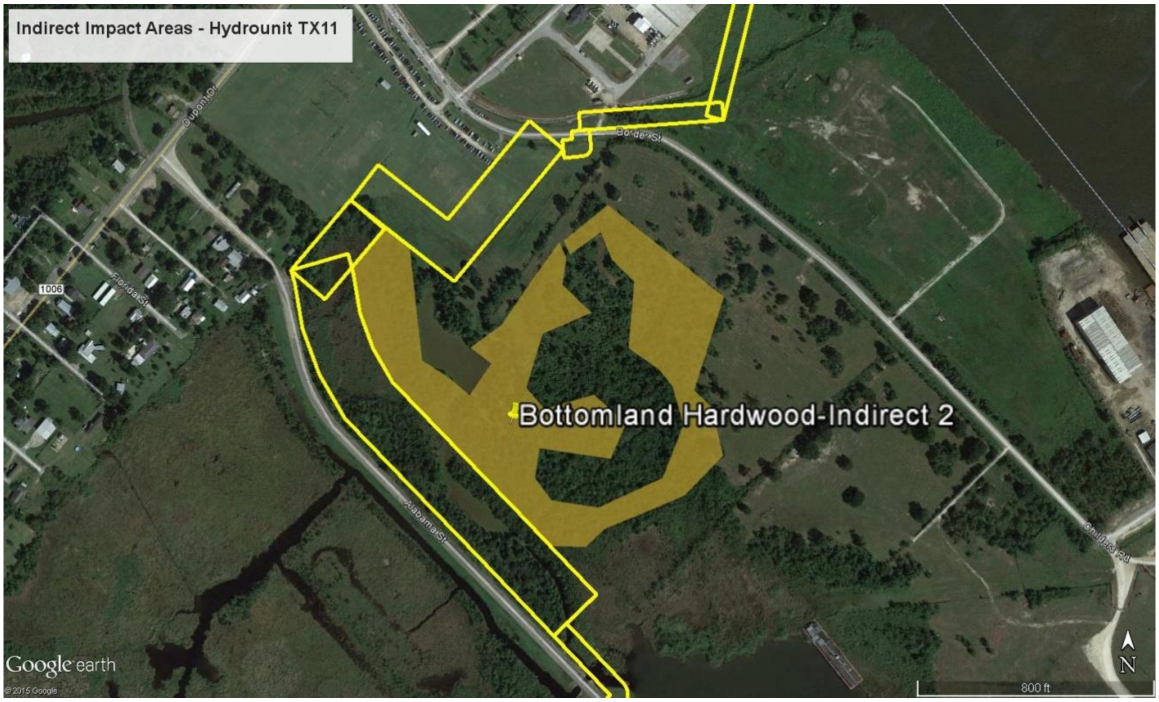

Figure 7-11. Indirect Impact Area in Hydrounit TX11 (Historic RSLR Scenario)

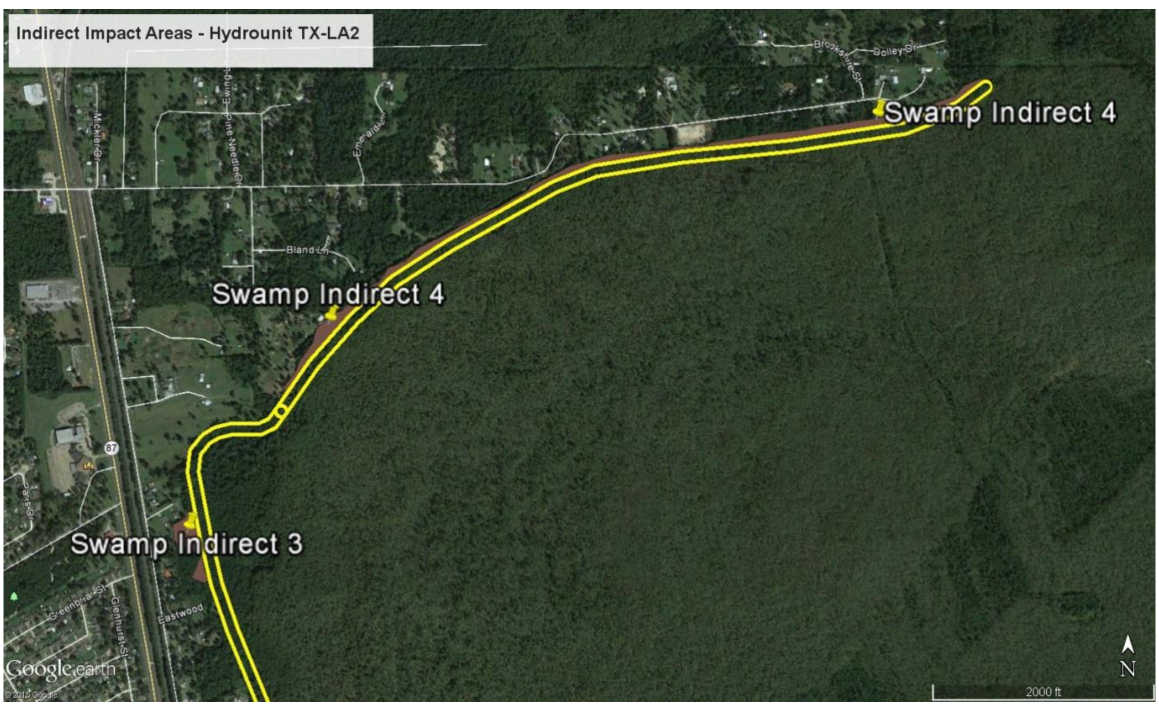

Figure 7-12. Indirect Impact Areas in Hydrounit TX-LA2 (Historic RSLR Scenario)

Changes in the levee alignment may be recommended as a result of agency technical, peer and/or public review of the DIFR-EIS. Some refinement of the placement of the levee alignment may be possible, which could reduce impacts. However, changes in the location of the levee alignment could also result in significant additional impacts. In that event, a supplemental EIS disclosing these impacts will be prepared and released for public review.

7.2.2 Intermediate and High RSLR Scenarios

7.2.2.1 Method for Evaluating Impacts

The general area of the levee alignment was carefully evaluated to identify areas into which wetlands would have migrated under the intermediate or high RSLR scenarios in the FWOP condition. The NOAA Sea-Level Rise Viewer (NOAA 2015) was used to identify new tidally-influenced areas and the NOAA marsh impacts/migration viewer was used to map changes in marsh type and extent. The data and maps in this NOAA tool illustrate the scale of potential flooding and a general location, and do not account for erosion, subsidence, or future construction. Water levels are shown as they would appear during the highest high tides or MHHW, and do not include wind driven tides.

The NOAA method for mapping marsh migration due to RSLR assumes that specific wetland types exist within an established tidal elevation range, based on an accepted understanding of what types of vegetation can exist given varying frequency and time of inundation, as well as salinity impacts from such inundation (NOAA 2012). The viewer maps changes associated with sea-level rise from the current MHHW up to 6 feet, in 1-foot increments. The potential changes associated with intermediate and high RSLR by TY61 in the Sabine region (+1.49 feet and +3.26 feet, respectively) were evaluated using the 2- and 4-foot Sea Level Rise and Marsh Impacts views. Marsh impacts were evaluated with no accretion rate, as data for this is unavailable, and this will provide a conservatively high impact evaluation.

7.2.2.2 FWOP Condition

Natural areas vulnerable to sea level rise and marsh migration in the FWOP condition were mapped in Google Earth and are shown relative to the Orange-Jefferson CSRM Plan alignment in Figures 7-13 through 7-17. Developed areas and leveed areas were excluded from this analysis, as the purpose was identify wetland impacts. RSLR migration of wetlands into formerly upland zones would be expected to occur with increasing RSLR where the migration is not blocked by existing hard structures, natural bluffs or development. The significant elevation difference between the floodplain and the uplands in this study area (approximately 7 to 10 feet) would block this migration is most areas. However, increasing sea levels would also increase the tidal prism in the smaller bayous and streams which cut from the upland to the floodplain. The higher water levels would flood low lying areas adjacent to these bayous and streams, creating new wetlands in the areas shown in the following figures.

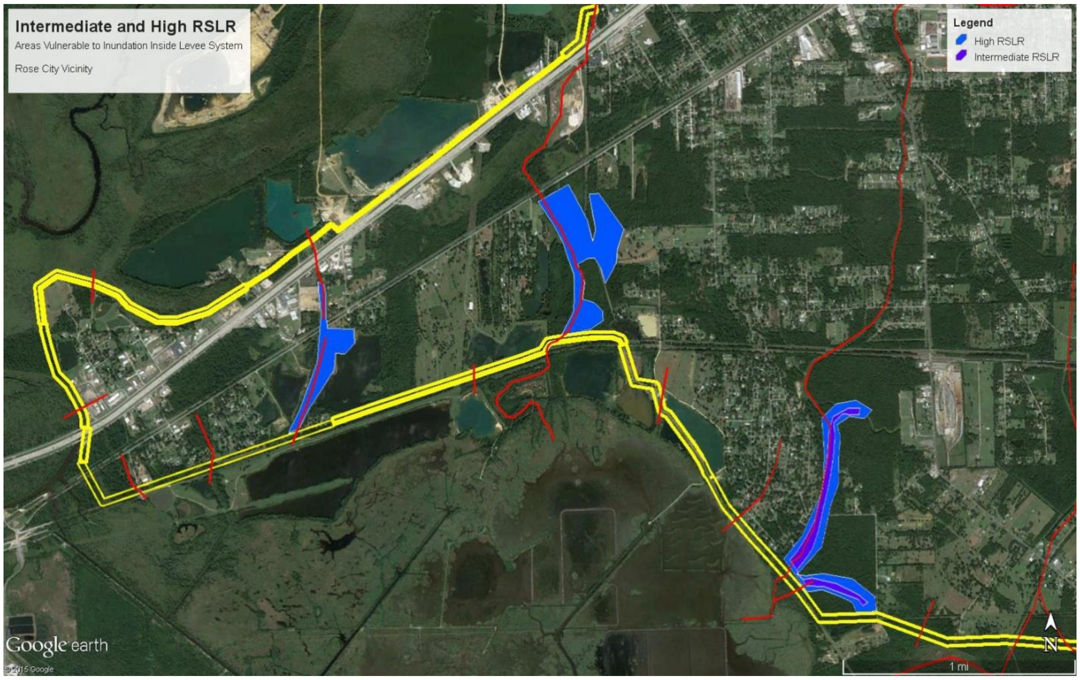

Figure 7-13. Rose City Vicinity-Areas Vulnerable to RSLR and Wetland Change/Migration

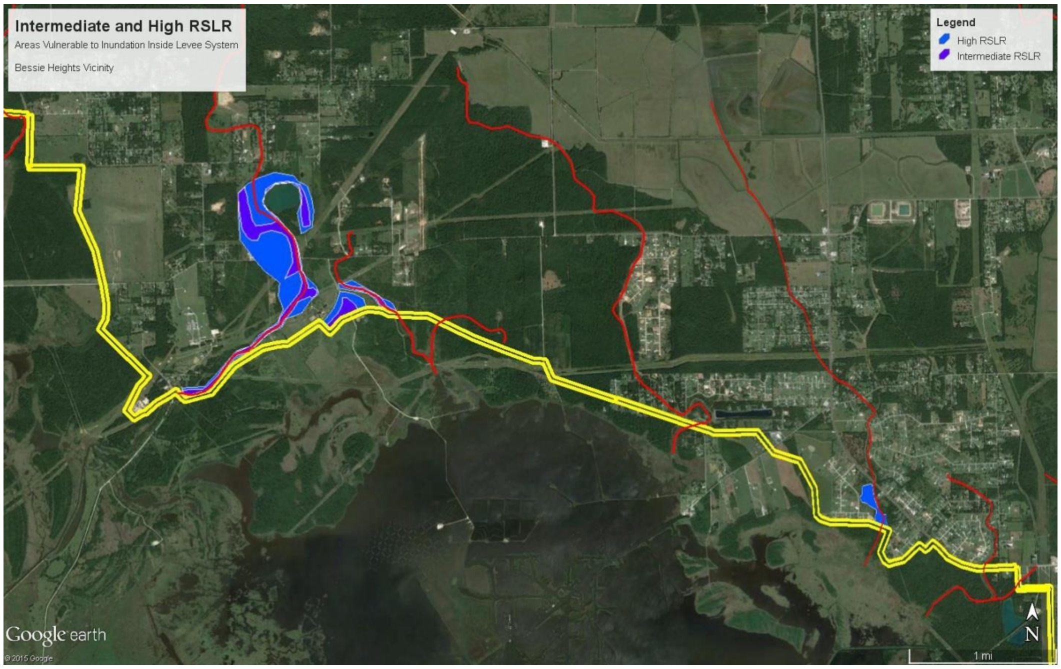

Figure 7-14. Bessie Heights–Areas Vulnerable to RSLR and Wetland Change/Migration

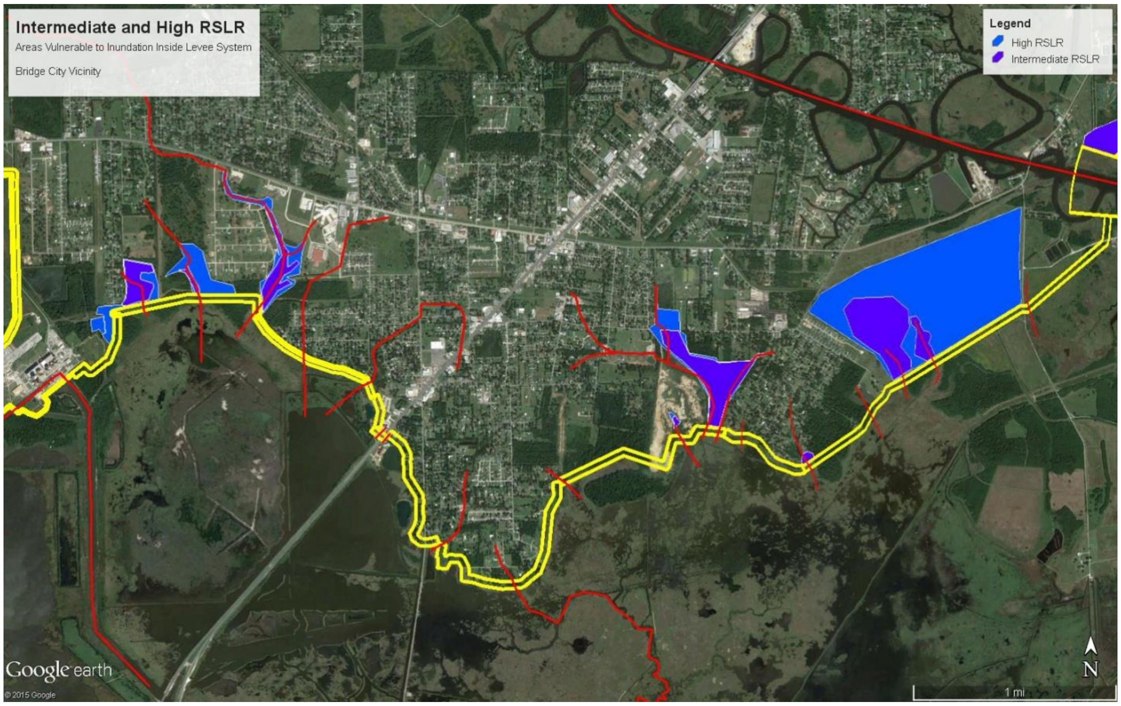

Figure 7-15. Bridge City Vicinity–Areas Vulnerable to RSLR and Wetland Change/Migration

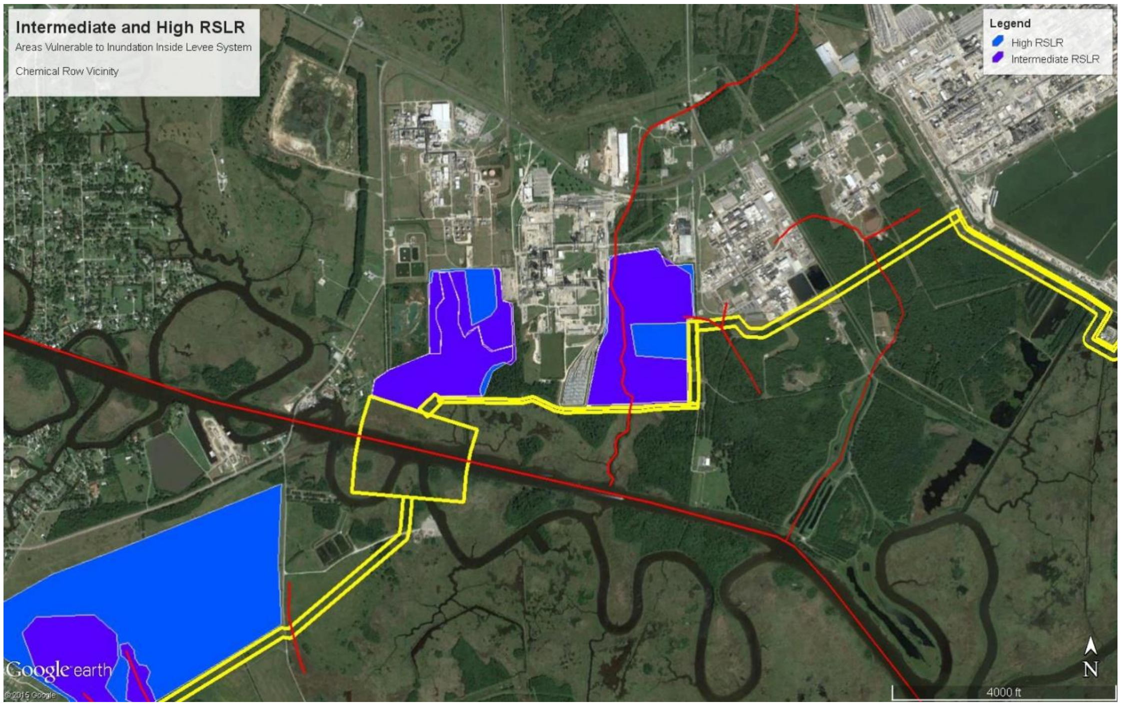

Figure 7-16. Chemical Row Vicinity–Areas Vulnerable to RSLR and Wetland Change/Migration

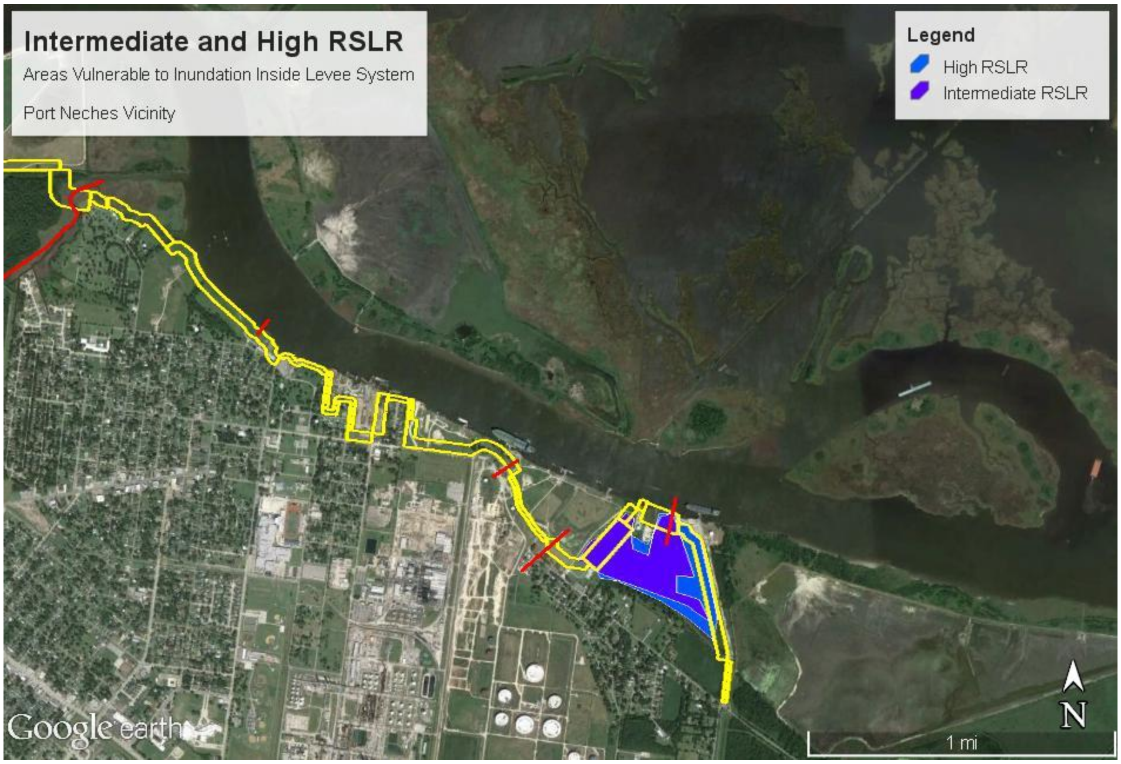

Figure 7-17. Port Neches Vicinity–Areas Vulnerable to RSLR and Wetland Change/Migration

In general, bluffs on the upland terraces of the Sabine and Neches River prevent large-scale overland flooding over the period of analysis. Only one natural area in Jefferson County, near Port Neches, was identified as vulnerable to RSLR. The most vulnerable areas are located within the lower reaches of bayous and streams that would be flooded to greater depths and inland extent with RSLR. As sea level rises, higher elevations will become more frequently inundated, allowing for marsh migration landward. At the same time, some lower-lying areas will be so often inundated that the marshes will no longer be able to thrive, becoming lost to open water. Depending upon elevation and projected salinities, in the intermediate RSLR scenario wetlands would switch from swamps to intermediate scrub-shrub marshes, or from fresh/intermediate to brackish/saline marshes. Significant areas of open-water would develop only in the high RSLR scenario, and these were located primarily in the Bridge City and Chemical Row vicinities. With high RSLR, swamps and intermediate marshes would switch to brackish or saline marshes. Because of generally higher elevations, bottomland hardwoods would generally persist in their existing locations through the period of analysis.

WVA modeling of the FWOP condition assumed that the conversion from one wetland type to another occurred at the midpoint of the period of analysis (TY31). The existing wetland was assumed to persist through TY30, with increased loss rates for emergent marsh and gradually increasing salinities. The annual FWOP wetland loss rate was gradually increased by a percentage change of 0.012 ft/year and 0.05 ft/year for intermediate and high RSLR, respectively, based on the negative relationship that has been observed between wetland loss rates and RSLR in Louisiana. For intermediate RSLR, salinity was increased by 6.5 percent and 11.3 percent for intermediate and brackish marsh, respectively, over the period of analysis based upon a modeled relationship between RSLR and salinity. For high RSLR, salinity was increased by 8.0 percent for intermediate and 22.7 percent for brackish marsh. Methods and calculations for these projections were described in Sections 3.5 and 3.6 above.

7.2.2.3 FWP Condition

Indirect impacts associated with construction of this alternative in the intermediate and high RSLR scenarios would be minimized by maintaining flows in tidal bayous and streams equivalent to the FWOP condition. New levees would be constructed incrementally to provide protection from storm surges up to heights required to reduce risks under the intermediate RSLR scenario. The construction right-of-way used to determine direct impacts was drawn using conservative assumptions and is large enough to encompass the construction right-of-way width required for Intermediate RSLR. However, any proposed modifications in the future must be evaluated to determine if the additional NEPA environmental impact review and public coordination is required.

Culverts would be modified as described for indirect impacts in the historic RSLR scenario to provide for increased tidal flows. Daily flooding of natural areas and wetland creation would occur as they would have under the FWOP condition. With tidal access maintained at FWOP flows, RSLR-related landscape and wetland changes to areas within the levee system would occur for FWP as they would have occurred in the FWOP condition with only minimal differences. Most of the areas vulnerable to RLSR inundation are currently undeveloped but are located immediately adjacent to ongoing current development. It is assumed that this development would continue in the FWOP condition, and therefore the alternative would cause no impacts related to induced development.

One exception to the negligible impacts described above was identified in the vicinity of the Cow Bayou surge gate structure (Figure 7-18). It is assumed that extensive construction in the gate area would permanently disrupt tidal streams and prevent daily flooding of areas in which marsh migration would have occurred under the intermediate and high RSLR scenarios. Under the Intermediate RSLR scenario, existing intermediate marsh and a small area of swamp would convert to brackish marsh and existing brackish marsh would persist and expand inland, adding 34.0 acres that was not impacted under the Historic RSLR scenario. Under the high RSLR scenario with a moderate accretion rate, existing intermediate and brackish marsh, and the same small area of swamp, would convert to saline marsh, and the same 34 acres of brackish marsh would be added as it migrates inland. In addition, 11.7 acres of new saline marsh would be created from inundated upland areas. Table 7-5 describes the indirect impact areas and impact assumptions for the Orange-Jefferson CSRM Plan under the intermediate and high RSLR scenarios.

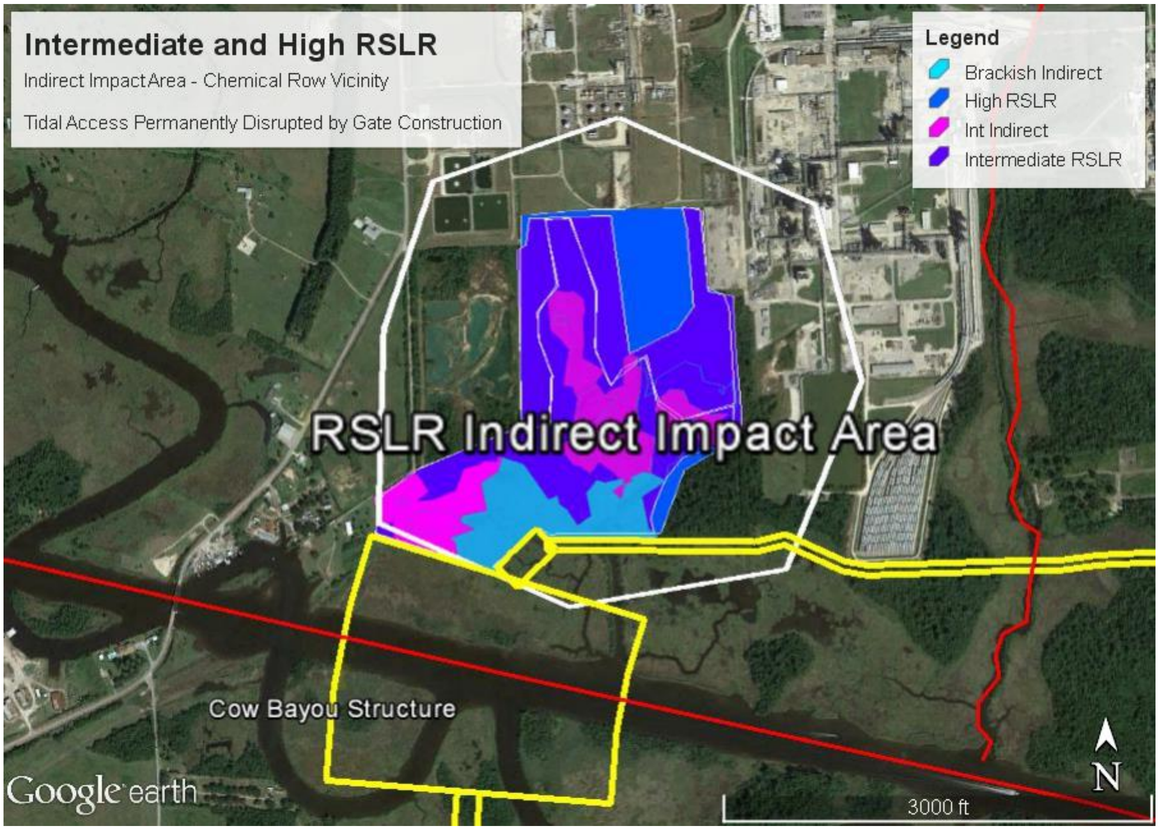

Figure 7-18. Chemical Row Indirect Impact Area, Intermediate and High RSLR

The indirect impact areas described above would be affected as tidal elevations rise under the intermediate and high RSLR scenarios, as they would remain open to the effects of RSLR. For the other indirect impact areas, impacts under the intermediate and high RSLR scenarios would be the same as those under the low RSLR scenario because tidal access would be permanently altered by construction of the Orange-Jefferson CSRM Plan, and thus the effects would be the same across all RSLR scenarios. Table 7-1, above, includes all of the areas permanently removed from tidal access in all three scenarios, as well as the area near Chemical Row that will remain open and be affected differently under the three scenarios. Fisheries access impacts in the Cow and Adams Bayou watershed are also included. Total indirect impacts could range from about 2230 acres and a loss of 94.4 AAHUs for the low RSLR scenario, to about 2276 acres and a loss of 133.3 AAHUs for the high RSLR scenario. Mitigation will be calculated using the impacts from the Intermediate RSLR scenario which would impact about 2264 acres and result in the loss of 105.1 AAHUs.

Table 7-5. Description of Indirect Impact Areas – Intermediate and High RSLR Scenarios

		Wetland Type - TY0						
Hydrounit	Indirect Impact Area ID	Upland	Swamp	Intermd Marsh	Brackish Marsh	Water in Wetland	Group Total Acres	Impact Assumptions
Intermediate RSLR Indirect Impact Areas								
TX10	I Indirect-1 and 2			17.1		2.5	19.6	Persists as intermediate through TY30; switches to brackish TY 31-61
	B Indirect 3				14.9	3.5	18.4	Persists as brackish TY0-TY61
	New Brackish Migration	34.0					34.0	Brackish marsh gradually migrates into former upland TY0-61
	S-Indirect 2		1.9			0.0	1.9	Persists as swamp through TY30; switches to brackish scrub-shrub TY31-61
Totals			1.9	17.1	14.9	6.0	73.9	
High RSLR Indirect Impact Areas								
TX10	I Indirect-1 and 2			17.1		2.5	19.6	Persists as intermediate through TY30; converts to saline TY31-61
	B Indirect 3				14.9	3.5	18.4	Persists as brackish thru TY30; converts to saline TY31-61
	New Brackish Migration	34.0					34.0	Brackish marsh gradually migrates into former upland TY0-61
	New Saline Migration	11.7					11.7	Saline marsh gradually migrates into former uplands TY0-61
	S-Indirect 2		1.9			0.0	1.9	Persists as swamp through TY30; switches to brackish scrub-shrub TY31-61
Totals		45.7	1.9	17.1	14.9	6.0	85.6	

8 MITIGATION PLANNING

8.1 SUMMARY OF TSP IMPACTS AND MITIGATION NEEDS

The WVA modeling evaluated and quantified direct and indirect impacts of the Orange Jefferson CSRM Plan. A map of this plan is shown in Figure 8-1. Direct and indirect impacts for each reach are summarized in Table 6-1 above.

Under the Intermediate RSLC scenario, the new levee system would negatively impact approximately 2,551.3 acres in Orange and Jefferson Counties. Total direct impacts, affecting approximately 300.5 acres, would result from construction of the levee system, and indirect impacts to about 2250.8 acres would be associated with fisheries access and hydrologic impacts. In total, approximately 139.9 acres of forested wetland and 2,411.4 acres of coastal marsh would be impacted.

Mitigation would be needed to compensate for a loss of 80.1 AAHUs from forested wetlands and 181.7 AAHUs from coastal wetlands. Planning for the avoidance and minimization of impacts began with the initial selection of the Orange-Jefferson levee alignment. The levee was located as close to the upland-wetland margin as possible to minimize wetland impacts, while also minimizing social effects and maximizing economic impacts. Opportunities to further avoid and minimize environmental impacts will be evaluated during final feasibility planning.

Since the alignment may change as a result of public, technical, and policy review, conceptual mitigation plans and estimates have been developed for the DIFR-EIS. These conceptual plans are described below. Preliminary mitigation cost estimates were developed based on these conceptual plans for use in the incremental analysis of levee reaches. Mitigation costs are small in relation to overall project construction costs, and therefore a final mitigation plan and more developed mitigation cost estimates are not needed to support plan selection. Final mitigation plans and cost estimates will be prepared during final feasibility planning for the Agency Decision Milestone.

8.2 DESCRIPTION OF POTENTIAL MITIGATION SITES AND CONCEPTUAL MITIGATION PLANS

Adverse impacts on ecological resources resulting from construction of the TSP have been avoided or minimized to the extent practicable at this phase of planning. Further refinements to the plan will occur during preparation of the FIFR-EIS, and efforts will be made to avoid and reduce impacts. Remaining unavoidable impacts will be fully compensated with in-kind mitigation. WVA modeling will be conducted to quantify benefits (AAHUs) of mitigation measures. Selection of potential mitigation sites and modeling of benefits will be conducted in coordination with resource agencies. Feasibility-level costs of selected mitigation measures will be developed, and the costs and benefits will be used to identify a best buy mitigation plan using Cost-Effectiveness/Incremental Cost Analysis that will fully compensate for all impacts.

Figure 8-1. Orange-Jefferson CSRM Plan

Large areas in the floodplains of the Neches and Sabine Rivers within and adjacent to the study area, such as those shown in Figures 8-2 through 8-4, will be reviewed to identify potential mitigation sites. Additional sites may be identified during final feasibility planning or suggested by resource agencies. Areas actually needed for the final mitigation plan would probably be a fraction of the areas shown. The areas will be evaluated during final feasibility planning to identify the most appropriate sites for in-kind mitigation. Possible mitigation measures and the determination of mitigation benefits will be developed in coordination with resource agencies. Conceptual mitigation measures used to estimate mitigation costs for use in alternative comparisons included coastal marsh restoration, the acquisition and long-term conservation of bottomland hardwoods and/or swamps, and possible improvements to the forested wetland areas targeted for conservation.

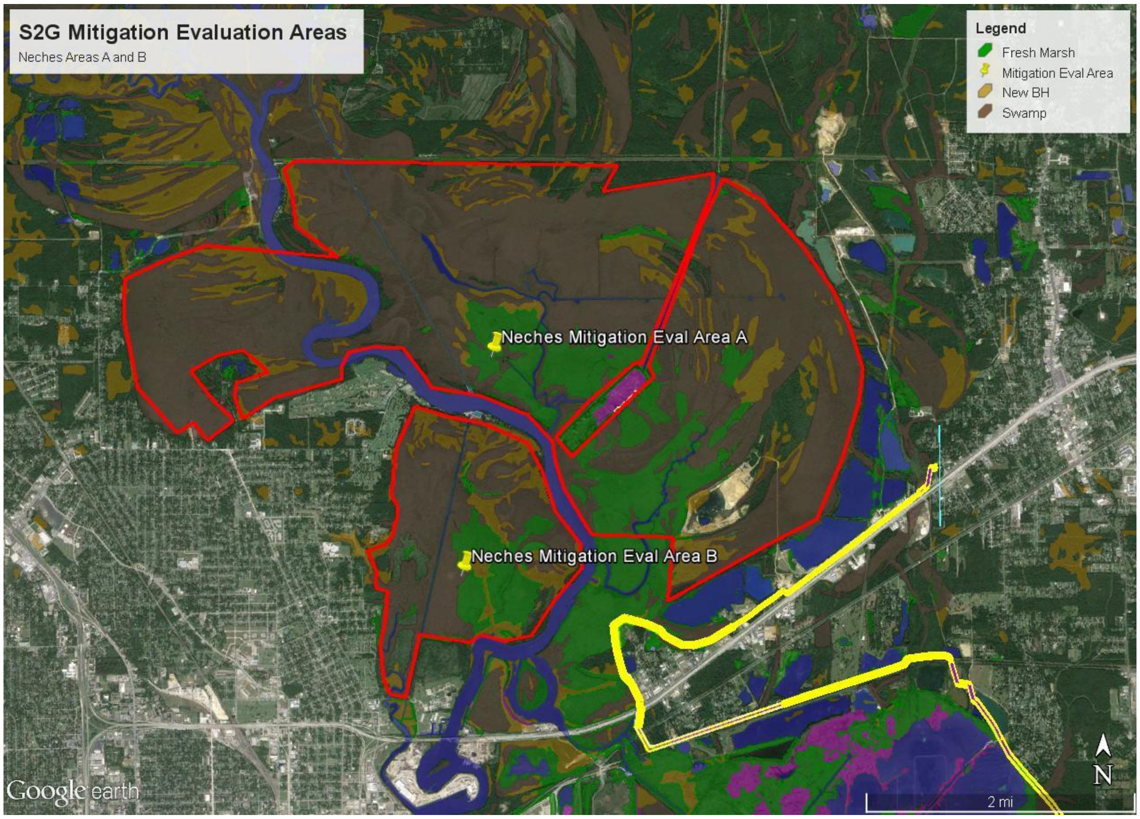

Figure 8-2. Mitigation Evaluation Areas on the Neches River

Figure 8-3. Mitigation Evaluation Areas - Lower Neches River and Old River Cove

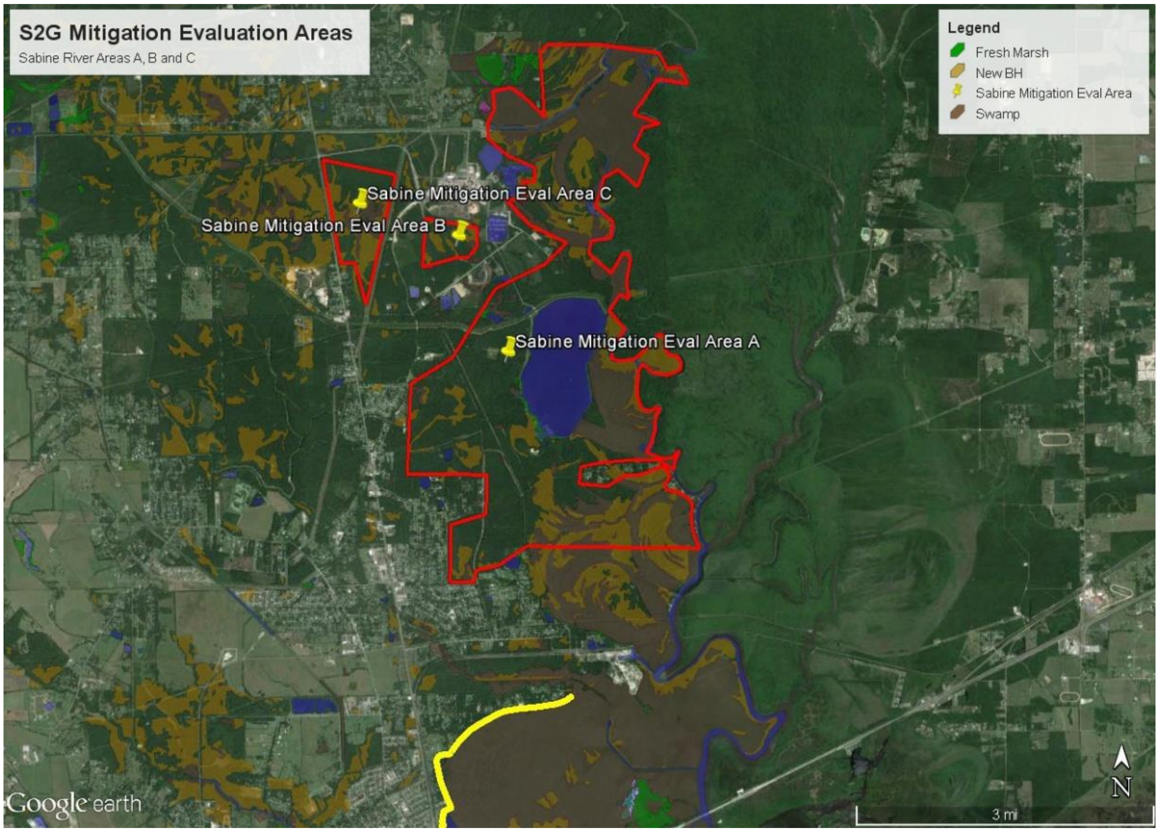

Figure 8-4. Mitigation Evaluation Areas - Sabine River

Areas on the Neches and Sabine Rivers north of Interstate 10 contain large undeveloped tracts of low-lying swamps in the floodplains, interspersed with floodplain ridges covered by bottomland hardwoods. Some areas on the Sabine River are immediately adjacent to the Blue Elbow Wildlife Management Area, which is managed by TPWD. Existing silviculture and borrow area practices in both floodplains are likely to result in unregulated losses of some of these forested wetlands during the period of analysis. Therefore, acquisition and long-term conservation of forested wetland areas could provide compensatory mitigation benefits. Other benefits could be earned by making improvements to the forested wetland conservation areas, such as improvements to hydrology (i.e., improving flows from impounded areas) or the removal and control of invasive species such as Chinese tallow (*Triadica sebifera*). Some additional study of targeted areas, needed to identify and quantify these opportunities, would be conducted during final feasibility planning.

High levels of marsh loss have occurred on the lower Neches River where large areas of open water have developed within former marsh and swamp lands due a combination of many factors, including subsidence, logging, saltwater intrusion and sea level rise. Marsh restoration evaluation areas have been identified in the Bessie Heights and Old River Cove vicinities. Areas targeted for evaluation exclude areas already identified for beneficial use or mitigation in conjunction with other projects. Specifically, authorized improvements to the SNWW navigation project include the restoration of large areas within both Bessie Heights and Old River Cove marshes with the beneficial use of dredged material. In addition, areas targeted for restoration by TPWD have also been excluded. Any mitigation sites selected for this project would augment, not replace, these other proposals.

Sediments from regular maintenance dredging of the adjacent Sabine-Neches could be used to restore elevation in areas of open water. Temporary containment dikes would be constructed to hold dredged material slurry while it decants and consolidates to form new marsh platforms in open water areas. Long term erosion control measures (such as concrete mats or riprap) would be installed where needed. In addition to restoring marsh in open water areas, sediment would also improve large expanses of shallow water by creating shallower ponds and interconnecting channels, and existing fringing marsh would be nourished by winnowing fine-grained material from unconfined flows of hydraulic dredged material. Containment dikes would be breached after the material consolidates and small channels would be excavated to improve edge and provide access routes for aquatic organisms to utilize interior marsh areas.

During final feasibility planning, fully-realized mitigation plans will be developed in consultation with the resource agencies and presented in the FIFR-EIS. Impacts of the TSP will be fully compensated in accordance with specific impacts and benefits quantified by the WVA modeling. An appendix to the FIFR-EIS will be prepared that presents a sensitivity analyses of the WVA marsh models using a sensitivity spreadsheet prepared by the ERDC Environmental Lab. These sensitivity analyses will provide additional information to assist in the investigation of several unresolved issues related to the suitability graphs for Variables 1, 2, and 3 and the aggregation methods used to combine the marsh habitat units and open water habitat units for each sub-model. These analyses will be coordinated with the ECO-PCX and reported in a separate appendix to the FIFR-EIS.

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ATTACHMENT A
ECOPCX MEMO – APPROVAL TO USE WVA MODELS

DEPARTMENT OF THE ARMY
MISSISSIPPI VALLEY DIVISION, CORPS OF ENGINEERS
P.O. BOX 80
VICKSBURG, MISSISSIPPI 39181-0080

REPLY TO
ATTENTION OF:

CEMVD-PD-N 07 April 2014

MEMORAMDUM FOR CECW-SWD (Gore)

SUBJECT: Wetland Value Assessment Models – Marsh Model, Recommendation for Single-use Approval on Sabine Pass to Galveston Bay, Texas, Coastal Storm Damage Risk Management and Ecosystem Restoration Feasibility Study

1. References

a. Engineering Circular 1105-2-412: Assuring Quality of Planning Models, dated 31 March 2011.

b. Coastal Marsh Community Models, CWPRRA Wetland Value Assessment Methodology, 19 March 2010 (Encl 1)

c. Final Model Review Report for the Wetland Value Assessment Models, dated 31 August 2010, Battelle Memorial Institute (Encl 2)

d. CECW-P Memorandum dated 28 Feb 2012 Subject: Wetland Value Assessment Models – Costal Marsh Model Version 1.0- Approval for Use (Encl 3)

e. Sample output of sensitivity analyses, Analysis of the WVA Model Outputs for the Mitigation of Lake Pontchartrain and Vicinity (LPV) and West Bank and Vicinity (WBV) projects of the Hurricane Storm Damage Risk Reduction System. ERDC Environmental Lab, dated 28 August 2011 (ftp://ftp.usace.army.mil/usace/mvd/ECO-PCX/Model Certification/WVA/WVA_Mitigation_Sensitivity082911.pdf)

2. The National Ecosystem Planning Center of Expertise (ECO-PCX) recommends single-use approval of the Wetland Value Assessment (WVA) Coastal Marsh Community Models 1.0 on the Sabine Pass to Galveston Bay, Texas, Coastal Storm Damage Risk Management and Ecosystem Restoration Feasibility Study. The Coastal Marsh Community model is one of seven WVA community models that were developed by the Coastal Wetlands Planning, Protection and Restoration Act (CWPPRA) Environmental Work Group, an interagency team including US Fish and Wildlife Service, National Marine Fisheries Services, US Environmental Protection Agency, Natural Resources Conservation Service, USACE, and Louisiana Office of Coastal Protection and Restoration. The WVA Community model point of contact is Mr. Kevin Roy, US Fish and Wildlife Service, Lafayette Ecological Services Field Office.

3. The Coastal Marsh Community Models consist of sub-models for fresh marsh, brackish marsh/intermediate and saline marsh. The three sub-models have the same variables, but there are variations in the form of the suitability graphs and aggregation formulas. Model documentation consists of the Coastal Marsh Community Models (Encl 1) and 3 Excel spreadsheets (one for each sub-community). The Coastal Marsh Models were approved for use on a specific list of New Orleans District studies by CECW-P

memorandum dated 28 February 2012 (Encl 2). The subject project was not included in this list of projects as the ECO-PCX not coordinate with the Galveston District regarding anticipated use of the WVA Marsh Models in SWG.

4. Battelle Memorial Institute conducted a review of all the WVA community models and associated spreadsheets to assess the technical quality and usability of the model. Review results are found in the Final Model Review Report for the Wetland Value Assessment Models dated 31 August 2010 (Enclosure 3). The models were reviewed in accordance with EC 1105-2-412 Assuring Quality of Planning Models. The model review panel included 6 individuals with expertise in Habitat Evaluation Procedures, planning, hydraulic engineering, coastal wetland ecology, coastal ecosystems, and software programming/spreadsheet auditing. All panel members had PhDs in relevant fields of study.

5. Technical Quality. The recommended models meet the technical quality criterion. The models are based on the well-established contemporary theory that habitat quality can be estimated using key physical parameters. The model represents the key critical components of the system and properly incorporates key analytical requirements with the exception of Sea Level Rise. The model can be used to assess impacts of Sea Level Rise through separate model runs for each sea-level rise scenario. The model documentation has been revised to include literature citations and assumptions to support the selection, form and aggregation of the model variables. The model is in line with USACE policies and accepted procedures. It doesn't include any non-compliant components. The spreadsheet formulas were thoroughly checked for accuracy.

6. There are a few of unresolved issues related to the technical quality of the model. The unresolved issues are related to the form of suitability graphs for Variables 1, 2 and 3 and the aggregation methods used to combine the marsh habitat units and open water habitat units for each sub-model. The interagency user group and the ECO-PCX are working together to increase understanding of the sensitivity of the model to the unresolved issues and the impact the model differences may have on decision-making.

The PDT is directed to conduct sensitivity analyses for application of the marsh models to the subject project using the sample sensitivity analysis and spreadsheets prepared by ERDC Environmental Lab (Reference e). A summary of the sensitivity analyses should be presented in the project report or appendices. The Agency Technical Review team will be charged with reviewing the adequacy and findings of the sensitivity analysis.

7. The ECO-PCX planned to work with the users group and ERDC to compile findings of multiple sensitivity analyses and describe the impact the unresolved issues have on decision-making and facilitate resolution of issues. Progress on this effort has been slow due to inactivity on numerous studies that planned to use these models.

8. System Quality. Excel spreadsheets are used to run the model. Significant improvements were made to the spreadsheets in response to the model review. All spreadsheets are computationally correct, have a notes sheet with instructions, cue users for input including units, have data validation for input cells, and all non-input cells are locked for editing.

9. Usability. The model meets the usability criteria. The model inputs are readily available and model outputs are easily understandable and useful in supporting USACE civil works planning activities. The model is transparent – calculations and outputs can be easily verified. The user documentation is available and user friendly. The spreadsheets are also user-friendly. While formal training is not currently available, members of the CWPPRA Environmental Work Group provide on-the-job training to new and junior staff, as needed.

10. In summary, the ECO-PCX recommends single use approval of Wetland Value Assessment Coastal Marsh Community Model 1.0 on the Sabine Pass to Galveston Bay, Texas, Coastal Storm Damage Risk Management and Ecosystem Restoration Feasibility Study. Model application shall address model sensitivity associated with Variables 1-3 and the marsh/open water aggregation methods. Please notify the ECO-PCX of the findings of the Model Certification Panel.

Encls (3)

Jodi K. Creswell
Operational Director, Ecosystem Restoration
Planning Center of Expertise

CF:
CF (without enclosures):
CECW-PC (Coleman, Matusiak, Bee, Ware)
CECW-CP (Kitch, Hughes)
CECW-PB (Carlson)
CECW-SWD (Haberer, Brown)
CESWD-PDP (Clay, Conley, Johanning, Kelly, Varghese)
CESWF-PEC (Verwers)
CESWF-PEC-T (Davee)
CESWF-PEC-P (Laird)
CESWF-PEC-PF (Willey, Heinly)
CESWF-PEC-TN (Stokes, Murphy, Sims)
CEMVD-PD-N (Wilbanks, Lachney, Creswell)
CENAD-PD-X (Cocchieri)
CEERD-EE-E (Fischenich)
CEMVN-PDN-CEP (Dayan)
CEMVP-PD-P (Richards)

ATTACHMENT B
HQUSACE MEMO – SINGLE USE APPROVAL FOR WVA MARSH MODEL

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS
441 G STREET, NW
WASHINGTON, DC 20314-1000

REPLY TO
ATTENTION OF

CECW-P 6 May 2014

MEMORANDUM FOR MEMORANDUM FOR Director, National Ecosystem Restoration Planning Center of Expertise (ECO-PCX)

SUBJECT: Recommendation for Single-use Approval of the Wetland Value Assessment (WVA) Coastal Marsh Community Models for the Sabine Pass to Galveston Bay, Texas, Coastal Storm Damage Risk Management and Ecosystem Restoration Feasibility Study

1. The HQUSACE Model Certification Panel has reviewed the WVA marsh model in accordance with EC 1105-2-412 and has determined that the model and its accompanying documentation are sufficient to approve the model for use on the Sabine Pass to Galveston Bay, Texas, Coastal Storm Damage Risk Management and Ecosystem Restoration Feasibility Study. Adequate technical reviews have been accomplished and the HQUSACE panel has considered the assessments of the technical reviews and the recommendations of the ECO-PCX in making this determination.

2. The Coastal Marsh Community Models consist of sub-models for fresh marsh, brackish marsh/intermediate and saline marsh. The three sub-models have the same variables, but there are variations in the form of the suitability graphs and aggregation formulas. Model documentation consists of the Marsh Community Models and three Excel spreadsheets (one for each sub-community). Several unresolved issues exist related to the suitability graphs for Variables 1, 2 and 3 and the aggregation methods used to combine the marsh habitat units and open water habitat units for each sub-model. The model developers and the ECO-PCX are working together to resolve these issues and to evaluate the potential effects of the model outputs on the planning process.

3. In response to the unresolved issues discussed in paragraph 2 above, the Sabine to Galveston study is directed to conduct sensitivity analyses for application of the marsh models project using the sample sensitivity analysis and spreadsheets prepared by ERDC Environmental Lab. These sensitivity analyses shall be coordinated with the ECO-PCX. In addition, a summary of the sensitivity analyses should be presented in the Sabine to Galveston project report. The Agency Technical Review team will be charged with reviewing the adequacy and findings of the sensitivity analyses.

APPLICABILITY: This approval for use of the WVA is limited to the subject study.

HARRY E. KITCH, P.E.
Deputy Chief, Planning and Policy Division
Directorate of Civil Works

ATTACHMENT C
WVA MODEL OUTPUT OF DIRECT IMPACTS

Orange- Jefferson CSRM Project Area - All Potential Impacts
Bottomland Hardwoods Direct Impacts - Intermediate RSLR Scenario
WVA Model Output

Wetland Impact Subunit ID	Acres		AAHUs	Statistics			Net Mean AAHUs
					95% C.I.		
			Mean	SD	Lower	Upper	
BH 1	10.6	Future With Project =	1.08	0.00	1.08	1.08	
		Future Without Project =	5.46	0.07	5.45	5.47	
		Net (FWP - FWOP)=	-4.38	0.07	-4.39	-4.37	-4.4
			Mean	SD	Lower	Upper	
BH 2	4.8	Future With Project =	0.49	0.00	0.49	0.49	
		Future Without Project =	2.68	0.03	2.67	2.68	
		Net (FWP - FWOP)=	-2.18	0.03	-2.19	-2.18	-2.2
			Mean	SD	Lower	Upper	
BH 3	7.2	Future With Project =	0.76	0.00	0.76	0.76	
		Future Without Project =	4.45	0.05	4.44	4.46	
		Net (FWP - FWOP)=	-3.69	0.05	-3.70	-3.67	-3.7
			Mean	SD	Lower	Upper	
BH 4	36.4	Future With Project =	3.84	0.01	3.84	3.84	
		Future Without Project =	26.19	0.11	26.17	26.21	
		Net (FWP - FWOP)=	-22.35	0.11	-22.37	-22.32	-22.3
			Mean	SD	Lower	Upper	
BH 5	21.4	Future With Project =	2.31	0.00	2.31	2.31	
		Future Without Project =	18.86	0.04	18.85	18.86	
		Net (FWP - FWOP)=	-16.55	0.04	-16.56	-16.54	-16.5
			Mean	SD	Lower	Upper	
BH 6	21.6	Future With Project =	2.32	0.00	2.32	2.32	
		Future Without Project =	15.80	0.05	15.79	15.81	
		Net (FWP - FWOP)=	-13.48	0.05	-13.49	-13.47	-13.5
			Mean	SD	Lower	Upper	
BH7	21.8	Future With Project =	2.13	0.01	2.12	2.13	
		Future Without Project =	11.48	0.15	11.45	11.51	
		Net (FWP - FWOP)=	-9.35	0.15	-9.38	-9.32	-9.4

Wetland Impact Subunit ID	Acres		AAHUs	Statistics			Net Mean AAHUs
					95% C.I.		
			Mean	SD	Lower	Upper	
BH8	1.8	Future With Project =	0.19	0.00	0.19	0.19	
		Future Without Project =	1.19	0.01	1.19	1.20	
		Net (FWP - FWOP)=	-1.00	0.01	-1.00	-1.00	-1.0
			Mean	SD	Lower	Upper	
BH 9	0.3	Future With Project =	0.03	0.00	0.03	0.03	
		Future Without Project =	0.20	0.00	0.20	0.20	
		Net (FWP - FWOP)=	-0.17	0.00	-0.17	-0.17	-0.2
			Mean	SD	Lower	Upper	
BH 10	12.4	Future With Project =	1.23	0.00	1.23	1.23	
		Future Without Project =	6.98	0.09	6.96	6.99	
		Net (FWP - FWOP)=	-5.75	0.09	-5.77	-5.73	-5.7
			Mean	SD	Lower	Upper	
BH 11	1.5	Future With Project =	0.15	0.00	0.15	0.15	
		Future Without Project =	0.87	0.01	0.87	0.88	
		Net (FWP - FWOP)=	-0.72	0.01	-0.73	-0.72	-0.7
			Mean	SD	Lower	Upper	
BH 12	0.5	Future With Project =	0.05	0.00	0.05	0.05	
		Future Without Project =	0.36	0.00	0.36	0.36	
		Net (FWP - FWOP)=	-0.30	0.00	-0.31	-0.30	-0.3
Total Acres	**140.3**	**Total Bottomland Hardwood Direct Impacts (AAHUs)**					**-79.9**

Orange- Jefferson CSRM Project Area - All Potential Impacts
Swamp Direct Impacts -Intermediate RSLR Scenario
WVA Model Output

Wetland Impact Subunit ID	Acres		Statistics				Net Mean AAHUs
			AAHUs		95% Confidence Interval		
			Mean	S.D.	Lower	Upper	
S 1	3.1	Future With Projects=	0.02	0.00	0.02	0.02	
		Future Without Project=	1.70	0.02	1.70	1.71	
		Net (FWP - FWOP)=	-1.68	0.02	-1.68	-1.68	-1.7
					Lower	Upper	
S 2	10.0	Future With Projects=	0.11	0.00	0.11	0.11	
		Future Without Project=	3.05	0.04	3.04	3.05	
		Net (FWP - FWOP)=	-2.94	0.04	-2.95	-2.93	-2.9
					Lower	Upper	
S 3	5.9	Future With Projects=	0.09	0.00	0.09	0.09	
		Future Without Project=	3.20	0.03	3.20	3.21	
		Net (FWP - FWOP)=	-3.12	0.03	-3.12	-3.11	-3.1
					Lower	Upper	
S 4	0.7	Future With Projects=	0.01	0.00	0.01	0.01	
		Future Without Project=	0.39	0.00	0.39	0.39	
		Net (FWP - FWOP)=	-0.38	0.00	-0.38	-0.38	-0.4
					Lower	Upper	
S 5	5.5	Future With Projects=	0.07	0.00	0.07	0.07	
		Future Without Project=	2.94	0.04	2.93	2.95	
		Net (FWP - FWOP)=	-2.87	0.04	-2.88	-2.86	-2.9
					Lower	Upper	
S 6	3.5	Future With Projects=	0.05	0.00	0.05	0.05	
		Future Without Project=	1.91	0.02	1.91	1.92	
		Net (FWP - FWOP)=	-1.86	0.02	-1.86	-1.86	-1.9
					Lower	Upper	
S 7	7.7	Future With Projects=	0.13	0.00	0.13	0.13	
		Future Without Project=	5.26	0.05	5.25	5.27	
		Net (FWP - FWOP)=	-5.13	0.05	-5.14	-5.12	-5.1

Swamp Direct Impacts -Intermediate RSLR Scenario
WVA Model Output

Wetland Impact Subunit ID	Acres		Statistics				Net Mean AAHUs
			AAHUs		95% Confidence Interval		
S 8	0.9	Future With Projects=	0.01	0.00	0.01	0.01	
		Future Without Project=	0.44	0.00	0.44	0.44	
		Net (FWP - FWOP)=	-0.43	0.00	-0.43	-0.43	-0.4
					Lower	Upper	
S 9	21.6	Future With Projects=	0.36	0.00	0.36	0.37	
		Future Without Project=	14.80	0.08	14.78	14.81	
		Net (FWP - FWOP)=	-14.43	0.08	-14.45	-14.41	-14.4
					Lower	Upper	
S 10	1.3	Future With Projects=	0.02	0.00	0.02	0.02	
		Future Without Project=	0.72	0.01	0.72	0.72	
		Net (FWP - FWOP)=	-0.70	0.01	-0.70	-0.70	-0.7
Total Acres	**60.2**	**Total Swamp Direct Impacts (AAHUs)**					**-33.5**

Orange- Jefferson CSRM Project Area - All Potential Impacts
Marsh Direct Impacts - Intermediate RSLR Scenario
WVA Model Output

Wetland Impact Subunit	Acres		Statistics				Net Mean AAHUs
			AAHUs		95% Confidence Interval		
F-1	19.7		**Mean**	**SD**	**95% C.I.**		
		Marsh			**Lower**	**Upper**	
		Future With Project Emergent Marsh =	0.24	0.00	0.24	0.24	
		Future Without Project Emergent Marsh=	17.23	0.05	17.22	17.24	
		Net (FWP - FWOP)=	-16.99	0.05	-17.00	-16.98	
		Open Water					
		Future With Project Open Water=	0.00	0.00	0.00	0.00	
		Future Without Project Open Water=	0.35	0.00	0.35	0.35	
		Net (FWP - FWOP)=	-0.35	0.00	-0.35	-0.35	
		Total					
		Emergent Marsh Habitat Net AAHUs=	-16.99	0.05	-17.00	-16.98	
		Open Water Habitat Net AAHUs=	-0.35	0.00	-0.35	-0.35	
		Net Impacts=	-11.62	0.03	-11.63	-11.61	-11.6
F-2	8.1		**Mean**	**SD**	**95% C.I.**		
		Marsh			**Lower**	**Upper**	
		Future With Project Emergent Marsh =	0.10	0.00	0.10	0.10	
		Future Without Project Emergent Marsh=	7.07	0.02	7.06	7.07	
		Net (FWP - FWOP)=	-6.97	0.02	-6.97	-6.96	
		Open Water					
		Future With Project Open Water=	0.00	0.00	0.00	0.00	
		Future Without Project Open Water=	0.23	0.00	0.23	0.23	
		Net (FWP - FWOP)=	-0.23	0.00	-0.23	-0.23	
		Total					
		Emergent Marsh Habitat Net AAHUs=	-6.97	0.02	-6.97	-6.96	
		Open Water Habitat Net AAHUs=	-0.23	0.00	-0.23	-0.23	
		Net Impacts=	-4.79	0.01	-4.79	-4.79	-4.8

Marsh Direct Impacts - Intermediate RSLR Scenario
WVA Model Output

Wetland Impact Subunit	Acres		Statistics				Net Mean AAHUs
			AAHUs		95% Confidence Interval		
F-3	6.9		**Mean**	**SD**	**95% C.I.**		
		Marsh			**Lower**	**Upper**	
		Future With Project Emergent Marsh =	0.08	0.00	0.08	0.08	
		Future Without Project Emergent Marsh=	5.60	0.02	5.59	5.60	
		Net (FWP - FWOP)=	-5.52	0.02	-5.52	-5.51	
		Open Water					
		Future With Project Open Water=	0.00	0.00	0.00	0.00	
		Future Without Project Open Water=	0.18	0.00	0.18	0.18	
		Net (FWP - FWOP)=	-0.18	0.00	-0.18	-0.18	
		Total					
		Emergent Marsh Habitat Net AAHUs=	-5.52	0.02	-5.52	-5.51	
		Open Water Habitat Net AAHUs=	-0.18	0.00	-0.18	-0.18	
		Net Impacts=	-3.79	0.02	-3.80	-3.79	-3.8
F-4	18.6		**Mean**	**SD**	**95% C.I.**		
		Marsh			**Lower**	**Upper**	
		Future With Project Emergent Marsh =	0.22	0.00	0.22	0.22	
		Future Without Project Emergent Marsh=	14.49	0.07	14.47	14.50	
		Net (FWP - FWOP)=	-14.27	0.07	-14.29	-14.26	
		Open Water					
		Future With Project Open Water=	0.01	0.00	0.01	0.01	
		Future Without Project Open Water=	0.96	0.01	0.96	0.96	
		Net (FWP - FWOP)=	-0.95	0.01	-0.95	-0.95	
		Total					
		Emergent Marsh Habitat Net AAHUs=	-14.27	0.07	-14.29	-14.26	
		Open Water Habitat Net AAHUs=	-0.95	0.01	-0.95	-0.95	
		Net Impacts=	-9.98	0.05	-9.98	-9.97	-10.0

Marsh Direct Impacts - Intermediate RSLR Scenario
WVA Model Output

Wetland Impact Subunit	Acres		Statistics				Net Mean AAHUs
			AAHUs		95% Confidence Interval		
F-5	1.5		**Mean**	**SD**	**95% C.I.**		
		Marsh			**Lower**	**Upper**	
		Future With Project Emergent Marsh =	0.22	0.00	0.22	0.22	
		Future Without Project Emergent Marsh=	1.24	0.00	1.24	1.24	
		Net (FWP - FWOP)=	-1.01	0.00	-1.01	-1.01	
		Open Water					
		Future With Project Open Water=	0.21	0.00	0.21	0.21	
		Future Without Project Open Water=	0.00	0.00	0.00	0.00	
		Net (FWP - FWOP)=	0.21	0.00	0.21	0.21	
		Total					
		Emergent Marsh Habitat Net AAHUs=	-1.01	0.00	-1.01	-1.01	
		Open Water Habitat Net AAHUs=	0.21	0.00	0.21	0.21	
		Net Impacts=	-0.62	0.00	-0.62	-0.62	-0.6
F-6	2.6		**Mean**	**SD**	**95% C.I.**		
		Marsh			**Lower**	**Upper**	
		Future With Project Emergent Marsh =	0.03	0.00	0.03	0.03	
		Future Without Project Emergent Marsh=	2.34	0.01	2.34	2.34	
		Net (FWP - FWOP)=	-2.31	0.01	-2.31	-2.31	
		Open Water					
		Future With Project Open Water=	0.00	0.00	0.00	0.00	
		Future Without Project Open Water=	0.01	0.00	0.01	0.01	
		Net (FWP - FWOP)=	-0.01	0.00	-0.01	-0.01	
		Total					
		Emergent Marsh Habitat Net AAHUs=	-2.31	0.01	-2.31	-2.31	
		Open Water Habitat Net AAHUs=	-0.01	0.00	-0.01	-0.01	
		Net Impacts=	-1.57	0.00	-1.57	-1.57	-1.6

Marsh Direct Impacts - Intermediate RSLR Scenario
WVA Model Output

Wetland Impact Subunit	Acres		Statistics				Net Mean AAHUs
			AAHUs		95% Confidence Interval		
F-7	8.0		**Mean**	**SD**	**95% C.I.**		
		Marsh			**Lower**	**Upper**	
		Future With Project Emergent Marsh =	0.08	0.00	0.08	0.08	
		Future Without Project Emergent Marsh=	5.48	0.03	5.47	5.48	
		Net (FWP - FWOP)=	-5.40	0.03	-5.41	-5.40	
		Open Water					
		Future With Project Open Water=	0.01	0.00	0.01	0.01	
		Future Without Project Open Water=	0.60	0.00	0.60	0.60	
		Net (FWP - FWOP)=	-0.60	0.00	-0.60	-0.59	
		Total					
		Emergent Marsh Habitat Net AAHUs=	-5.40	0.03	-5.41	-5.40	
		Open Water Habitat Net AAHUs=	-0.60	0.00	-0.60	-0.59	
		Net Impacts=	-3.85	0.02	-3.85	-3.85	-3.9
F-8	5.4		**Mean**	**SD**	**95% C.I.**		
		Marsh			**Lower**	**Upper**	
		Future With Project Emergent Marsh =	0.05	0.00	0.05	0.05	
		Future Without Project Emergent Marsh=	3.16	0.02	3.16	3.16	
		Net (FWP - FWOP)=	-3.12	0.02	-3.12	-3.11	
		Open Water					
		Future With Project Open Water=	0.00	0.00	0.00	0.00	
		Future Without Project Open Water=	0.33	0.00	0.33	0.33	
		Net (FWP - FWOP)=	-0.32	0.00	-0.32	-0.32	
		Total					
		Emergent Marsh Habitat Net AAHUs=	-3.12	0.02	-3.12	-3.11	
		Open Water Habitat Net AAHUs=	-0.32	0.00	-0.32	-0.32	
		Net Impacts=	-2.21	0.01	-2.22	-2.21	-2.2

Marsh Direct Impacts - Intermediate RSLR Scenario
WVA Model Output

Wetland Impact Subunit	Acres		Statistics				Net Mean AAHUs
			AAHUs		95% Confidence Interval		
F-9	10.5		**Mean**	**SD**	**95% C.I.**		
		Marsh			**Lower**	**Upper**	
		Future With Project Emergent Marsh =	0.13	0.00	0.13	0.13	
		Future Without Project Emergent Marsh=	9.14	0.03	9.13	9.14	
		Net (FWP - FWOP)=	-9.00	0.03	-9.01	-9.00	
		Open Water					
		Future With Project Open Water=	0.00	0.00	0.00	0.00	
		Future Without Project Open Water=	0.03	0.00	0.03	0.03	
		Net (FWP - FWOP)=	-0.03	0.00	-0.03	-0.03	
		Total					
		Emergent Marsh Habitat Net AAHUs=	-9.00	0.03	-9.01	-9.00	
		Open Water Habitat Net AAHUs=	-0.03	0.00	-0.03	-0.03	
		Net Impacts=	-6.11	0.02	-6.11	-6.11	-6.1
I-1	2.3		**Mean**	**SD**	**95% C.I.**		
		Marsh			**Lower**	**Upper**	
		Future With Project Emergent Marsh =	0.03	0.00	0.03	0.03	
		Future Without Project Emergent Marsh=	1.80	0.01	1.80	1.80	
		Net (FWP - FWOP)=	-1.78	0.01	-1.78	-1.78	
		Open Water					
		Future With Project Open Water=	0.00	0.00	0.00	0.00	
		Future Without Project Open Water=	0.05	0.00	0.05	0.06	
		Net (FWP - FWOP)=	-0.05	0.00	-0.05	-0.05	
		Total					
		Emergent Marsh Habitat Net AAHUs=	-1.78	0.01	-1.78	-1.78	
		Open Water Habitat Net AAHUs=	-0.05	0.00	-0.05	-0.05	
		Net Impacts=	-1.22	0.00	-1.22	-1.22	-1.2

Marsh Direct Impacts - Intermediate RSLR Scenario
WVA Model Output

Wetland Impact Subunit	Acres		Statistics				Net Mean AAHUs
			AAHUs		95% Confidence Interval		
I-2	4.8		**Mean**	**SD**	**95% C.I.**		
		Marsh			**Lower**	**Upper**	
		Future With Project Emergent Marsh =	0.06	0.00	0.06	0.06	
		Future Without Project Emergent Marsh=	4.17	0.01	4.16	4.17	
		Net (FWP - FWOP)=	-4.11	0.01	-4.11	-4.10	
		Open Water					
		Future With Project Open Water=	0.00	0.00	0.00	0.00	
		Future Without Project Open Water=	0.02	0.00	0.02	0.02	
		Net (FWP - FWOP)=	-0.02	0.00	-0.02	-0.02	
		Total					
		Emergent Marsh Habitat Net AAHUs=	-4.11	0.01	-4.11	-4.10	
		Open Water Habitat Net AAHUs=	-0.02	0.00	-0.02	-0.02	
		Net Impacts=	-2.79	0.01	-2.79	-2.79	-2.8
I-3	3.8		**Mean**	**SD**	**95% C.I.**		
		Marsh			**Lower**	**Upper**	
		Future With Project Emergent Marsh =	0.05	0.00	0.05	0.05	
		Future Without Project Emergent Marsh=	3.28	0.01	3.28	3.28	
		Net (FWP - FWOP)=	-3.23	0.01	-3.23	-3.23	
		Open Water					
		Future With Project Open Water=	0.00	0.00	0.00	0.00	
		Future Without Project Open Water=	0.05	0.00	0.05	0.05	
		Net (FWP - FWOP)=	-0.05	0.00	-0.05	-0.05	
		Total					
		Emergent Marsh Habitat Net AAHUs=	-3.23	0.01	-3.23	-3.23	
		Open Water Habitat Net AAHUs=	-0.05	0.00	-0.05	-0.05	
		Net Impacts=	-2.20	0.01	-2.21	-2.20	-2.2

Marsh Direct Impacts - Intermediate RSLR Scenario
WVA Model Output

Wetland Impact Subunit	Acres		Statistics: AAHUs		Statistics: 95% Confidence Interval		Net Mean AAHUs
I-4	1.6		**Mean**	**SD**	**95% C.I.**		
		Marsh			**Lower**	**Upper**	
		Future With Project Emergent Marsh =	0.02	0.00	0.02	0.02	
		Future Without Project Emergent Marsh=	1.39	0.00	1.39	1.39	
		Net (FWP - FWOP)=	-1.37	0.00	-1.37	-1.37	
		Open Water					
		Future With Project Open Water=	0.00	0.00	0.00	0.00	
		Future Without Project Open Water=	0.02	0.00	0.02	0.02	
		Net (FWP - FWOP)=	-0.02	0.00	-0.02	-0.02	
		Total					
		Emergent Marsh Habitat Net AAHUs=	-1.37	0.00	-1.37	-1.37	
		Open Water Habitat Net AAHUs=	-0.02	0.00	-0.02	-0.02	
		Net Impacts=	-0.94	0.00	-0.94	-0.93	-0.9
I-5	0.4		**Mean**	**SD**	**95% C.I.**		
		Marsh			**Lower**	**Upper**	
		Future With Project Emergent Marsh =	0.01	0.00	0.01	0.01	
		Future Without Project Emergent Marsh=	0.36	0.00	0.36	0.36	
		Net (FWP - FWOP)=	-0.35	0.00	-0.35	-0.35	
		Open Water					
		Future With Project Open Water=	0.00	0.00	0.00	0.00	
		Future Without Project Open Water=	0.00	0.00	0.00	0.00	
		Net (FWP - FWOP)=	0.00	0.00	0.00	0.00	
		Total					
		Emergent Marsh Habitat Net AAHUs=	-0.35	0.00	-0.35	-0.35	
		Open Water Habitat Net AAHUs=	0.00	0.00	0.00	0.00	
		Net Impacts=	-0.24	0.00	-0.24	-0.24	-0.2

Marsh Direct Impacts - Intermediate RSLR Scenario
WVA Model Output

Wetland Impact Subunit	Acres		Statistics				Net Mean AAHUs
			AAHUs		95% Confidence Interval		
B-1	21.0		**Mean**	**SD**	**95% C.I.**		
		Marsh			**Lower**	**Upper**	
		Future With Project Emergent Marsh =	0.23	0.00	0.23	0.23	
		Future Without Project Emergent Marsh=	15.30	0.08	15.29	15.32	
		Net (FWP - FWOP)=	-15.07	0.08	-15.09	-15.06	
		Open Water					
		Future With Project Open Water=	0.02	0.00	0.02	0.02	
		Future Without Project Open Water=	1.45	0.01	1.44	1.45	
		Net (FWP - FWOP)=	-1.43	0.01	-1.43	-1.43	
		Total					
		Emergent Marsh Habitat Net AAHUs=	-15.07	0.08	-15.09	-15.06	
		Open Water Habitat Net AAHUs=	-1.43	0.01	-1.43	-1.43	
		Net Impacts=	-12.04	0.06	-12.05	-12.03	-12.0
B-2	75.1		**Mean**	**SD**	**95% C.I.**		
		Marsh			**Lower**	**Upper**	
		Future With Project Emergent Marsh =	0.55	0.00	0.55	0.55	
		Future Without Project Emergent Marsh=	39.87	0.25	39.82	39.92	
		Net (FWP - FWOP)=	-39.32	0.25	-39.37	-39.27	
		Open Water					
		Future With Project Open Water=	0.17	0.01	0.17	0.17	
		Future Without Project Open Water=	12.64	0.10	12.62	12.66	
		Net (FWP - FWOP)=	-12.47	0.10	-12.49	-12.45	
		Total					
		Emergent Marsh Habitat Net AAHUs=	-39.32	0.25	-39.37	-39.27	
		Open Water Habitat Net AAHUs=	-12.47	0.10	-12.49	-12.45	
		Net Impacts=	-33.35	0.20	-33.39	-33.31	-33.4

Marsh Direct Impacts - Intermediate RSLR Scenario
WVA Model Output

Wetland Impact Subunit	Acres		Statistics				Net Mean AAHUs
			AAHUs		95% Confidence Interval		
B-3	5.0		**Mean**	**SD**	**95% C.I.**		
		Marsh			**Lower**	**Upper**	
		Future With Project Emergent Marsh =	0.06	0.00	0.06	0.06	
		Future Without Project Emergent Marsh=	4.49	0.01	4.49	4.49	
		Net (FWP - FWOP)=	-4.42	0.01	-4.43	-4.42	
		Open Water					
		Future With Project Open Water=	0.00	0.00	0.00	0.00	
		Future Without Project Open Water=	0.02	0.00	0.02	0.02	
		Net (FWP - FWOP)=	-0.02	0.00	-0.02	-0.02	
		Total					
		Emergent Marsh Habitat Net AAHUs=	-4.42	0.01	-4.43	-4.42	
		Open Water Habitat Net AAHUs=	-0.02	0.00	-0.02	-0.02	
		Net Impacts=	-3.44	0.01	-3.45	-3.44	-3.4
B-4	9.9		**Mean**	**SD**	**95% C.I.**		
		Marsh			**Lower**	**Upper**	
		Future With Project Emergent Marsh =	0.09	0.00	0.09	0.09	
		Future Without Project Emergent Marsh=	6.12	0.00	6.12	6.12	
		Net (FWP - FWOP)=	-6.03	0.00	-6.04	-6.03	
		Open Water					
		Future With Project Open Water=	0.01	0.00	0.01	0.01	
		Future Without Project Open Water=	1.02	0.01	1.02	1.02	
		Net (FWP - FWOP)=	-1.01	0.01	-1.01	-1.01	
		Total					
		Emergent Marsh Habitat Net AAHUs=	-6.03	0.00	-6.04	-6.03	
		Open Water Habitat Net AAHUs=	-1.01	0.01	-1.01	-1.01	
		Net Impacts=	-4.92	0.00	-4.92	-4.92	-4.9

ATTACHMENT D
WVA MODEL OUTPUT OF INDIRECT IMPACTS

Orange- Jefferson CSRM Project Area - All Potential Impacts
Bottomland Hardwoods Indirect Impacts- Low RSLR Scenario
WVA Model Output (V1.0)

Wetland Impact	Acres		AAHUs	Statistics			Net Mean AAHUs
					95% C.I.		
			Mean	SD	Lower	Upper	
BH Indirect-1	0.7	Future With Project =	0.07	0.00	0.07	0.07	
		Future Without Project =	0.37	0.00	0.36	0.37	
		Net Benefit (FWP - FWOP)=	-0.29	0.00	-0.29	-0.29	-0.29
BH Indirect-2	12.7	Future With Project =	1.57	0.01	1.57	1.57	
		Future Without Project =	6.69	0.10	6.67	6.71	
		Net Benefit (FWP - FWOP)=	-5.12	0.10	-5.14	-5.11	-5.12
Total Acres	**13.4**	**Total Bottomland Hardwood Indirect Impacts (AAHUs)**					**-5.4**

Orange- Jefferson CSRM Project Area - All Potential Impacts
Swamp Indirect Impacts - Low RSLR Scenario
WVA Model Output (V1.0)

Wetland Impact Subunit ID	Acres		Statistics				Net Mean AAHUs
			AAHUs		95% Confidence Interval		
			Mean	S.D.	Lower	Upper	
S Indirect-1	4.4	Future With Projects=	0.57	0.01	0.57	0.57	
		Future Without Project=	1.34	0.02	1.34	1.34	
		Net (FWP - FWOP)=	-0.77	0.02	-0.77	-0.77	-0.8
			Mean	S.D.	Lower	Upper	
S Indirect-2	1.9	Future With Projects=	0.17	0.00	0.17	0.17	
		Future Without Project=	1.02	0.01	1.01	1.02	
		Net (FWP - FWOP)=	-0.85	0.01	-0.85	-0.85	-0.8
			Mean	S.D.	Lower	Upper	
S Indirect-3	2.0	Future With Projects=	0.59	0.01	0.59	0.60	
		Future Without Project=	1.37	0.01	1.37	1.37	
		Net (FWP - FWOP)=	-0.77	0.01	-0.78	-0.77	-0.8
			Mean	S.D.	Lower	Upper	
S Indirect-4	11.0	Future With Projects=	3.28	0.04	3.27	3.29	
		Future Without Project=	7.53	0.03	7.53	7.54	
		Net (FWP - FWOP)=	-4.25	0.05	-4.26	-4.24	-4.3
Total Acres	**19.3**	**Total Swamp Indirect Impacts (AAHUs)**					**-6.6**

Orange- Jefferson CSRM Project Area - All Potential Impacts
Marsh Indirect Impacts - Low RSLR Scenario
WVA Model Output (V1.0)

Wetland Impact Subunit	Acres		Statistics				Net Mean AAHUs
			AAHUs		95% Confidence Interval		
F Indirect-1	1.4		**Mean**	**SD**	**95% C.I.**		
		Marsh			**Lower**	**Upper**	
		Future With Project Emergent Marsh	0.02	0.00	0.02	0.02	
		Future Without Project Emergent Mar	0.91	0.01	0.91	0.91	
		Net (FWP - FWOP)=	-0.89	0.01	-0.89	-0.89	
		Open Water					
		Future With Project Open Water=	0.01	0.00	0.01	0.01	
		Future Without Project Open Water=	0.22	0.00	0.22	0.22	
		Net (FWP - FWOP)=	-0.21	0.00	-0.21	-0.21	
		Total					
		Emergent Marsh Habitat Net AAHUs	-0.89	0.01	-0.89	-0.89	
		Open Water Habitat Net AAHUs=	-0.21	0.00	-0.21	-0.21	
		Net Impacts=	-0.67	0.00	-0.67	-0.67	-0.67
F Indirect-2	674.6		**Mean**	**SD**	**95% C.I.**		
		Marsh			**Lower**	**Upper**	
		Future With Project Emergent Marsh	291.05	1.75	290.71	291.40	
		Future Without Project Emergent Mar	299.07	1.73	298.73	299.41	
		Net (FWP - FWOP)=	-8.02	2.38	-8.48	-7.55	
		Open Water					
		Future With Project Open Water=	125.61	1.58	125.30	125.92	
		Future Without Project Open Water=	130.78	1.48	130.49	131.07	
		Net (FWP - FWOP)=	-5.18	2.25	-5.62	-4.74	
		Total					
		Emergent Marsh Habitat Net AAHUs	-8.02	2.38	-8.48	-7.55	
		Open Water Habitat Net AAHUs=	-5.18	2.25	-5.62	-4.74	
		Net Impacts=	-7.10	1.78	-7.45	-6.75	-7.10

F Indirect-3	110.6		**Mean**	**SD**	**95% C.I.**		
		Marsh			**Lower**	**Upper**	
		Future With Project Emergent Marsh	37.27	0.23	37.22	37.31	
		Future Without Project Emergent Mar	43.02	0.25	42.97	43.07	
		Net (FWP - FWOP)=	-5.76	0.31	-5.82	-5.69	
		Open Water					
		Future With Project Open Water=	0.63	0.03	0.62	0.63	
		Future Without Project Open Water=	24.94	0.30	24.89	25.00	
		Net (FWP - FWOP)=	-24.32	0.30	-24.38	-24.26	
		Total					
		Emergent Marsh Habitat Net AAHUs	-5.76	0.31	-5.82	-5.69	
		Open Water Habitat Net AAHUs=	-24.32	0.30	-24.38	-24.26	
		Net Impacts=	-11.74	0.25	-11.79	-11.69	-11.74
I Indirect 1	6.9		**Mean**	**SD**	**95% C.I.**		
		Marsh			**Lower**	**Upper**	
		Future With Project Emergent Marsh	0.07	0.00	0.07	0.07	
		Future Without Project Emergent Mar	4.71	0.02	4.71	4.72	
		Net (FWP - FWOP)=	-4.65	0.02	-4.65	-4.64	
		Open Water					
		Future With Project Open Water=	0.01	0.00	0.01	0.01	
		Future Without Project Open Water=	0.92	0.01	0.92	0.93	
		Net (FWP - FWOP)=	-0.91	0.01	-0.91	-0.91	
		Total					
		Emergent Marsh Habitat Net AAHUs	-4.65	0.02	-4.65	-4.64	
		Open Water Habitat Net AAHUs=	-0.91	0.01	-0.91	-0.91	
		Net Impacts=	-3.44	0.01	-3.44	-3.44	-3.44

			Mean	SD	95% C.I.		
I Indirect-2	12.7		**Mean**	**SD**	**95% C.I.**		
		Marsh			**Lower**	**Upper**	
		Future With Project Emergent Marsh	0.14	0.00	0.14	0.14	
		Future Without Project Emergent Mar	9.72	0.03	9.71	9.73	
		Net (FWP - FWOP)=	-9.58	0.03	-9.59	-9.57	
		Open Water					
		Future With Project Open Water=	0.01	0.00	0.01	0.01	
		Future Without Project Open Water=	0.69	0.01	0.69	0.69	
		Net (FWP - FWOP)=	-0.68	0.01	-0.68	-0.68	
		Total					
		Emergent Marsh Habitat Net AAHUs	-9.58	0.03	-9.59	-9.57	
		Open Water Habitat Net AAHUs=	-0.68	0.01	-0.68	-0.68	
		Net Impacts=	-6.71	0.02	-6.71	-6.71	-6.71
I Indirect-3	270.3		**Mean**	**SD**	**95% C.I.**		
		Marsh			**Lower**	**Upper**	
		Future With Project Emergent Marsh	123.23	0.70	123.09	123.37	
		Future Without Project Emergent Mar	127.03	0.69	126.89	127.17	
		Net (FWP - FWOP)=	-3.80	0.95	-3.99	-3.61	
		Open Water					
		Future With Project Open Water=	52.92	0.63	52.79	53.04	
		Future Without Project Open Water=	55.35	0.59	55.23	55.46	
		Net (FWP - FWOP)=	-2.43	0.89	-2.60	-2.25	
		Total					
		Emergent Marsh Habitat Net AAHUs	-3.80	0.95	-3.99	-3.61	
		Open Water Habitat Net AAHUs=	-2.43	0.89	-2.60	-2.25	
		Net Impacts=	-3.36	0.71	-3.50	-3.22	-3.36

I Indirect-4	52.2		**Mean**	**SD**	**95% C.I.**		
		Marsh			**Lower**	**Upper**	
		Future With Project Emergent Marsh	26.91	0.16	26.88	26.94	
		Future Without Project Emergent Ma	27.76	0.15	27.73	27.79	
		Net (FWP - FWOP)=	-0.85	0.20	-0.89	-0.81	
		Open Water					
		Future With Project Open Water=	8.51	0.10	8.49	8.53	
		Future Without Project Open Water=	8.90	0.09	8.88	8.92	
		Net (FWP - FWOP)=	-0.39	0.15	-0.42	-0.36	
		Total					
		Emergent Marsh Habitat Net AAHUs	-0.85	0.20	-0.89	-0.81	
		Open Water Habitat Net AAHUs=	-0.39	0.15	-0.42	-0.36	
		Net Impacts=	-0.70	0.14	-0.73	-0.68	-0.70
B Indirect-1	0.9		**Mean**	**SD**	**95% C.I.**		
		Marsh			**Lower**	**Upper**	
		Future With Project Emergent Marsh	0.04	0.27	-0.01	0.09	
		Future Without Project Emergent Ma	0.78	0.25	0.73	0.83	
		Net (FWP - FWOP)=	-0.74	0.01	-0.74	-0.74	
		Open Water					
		Future With Project Open Water=	0.00	0.05	0.00	0.01	
		Future Without Project Open Water=	0.02	0.05	0.01	0.03	
		Net (FWP - FWOP)=	-0.02	0.00	-0.02	-0.02	
		Total					
		Emergent Marsh Habitat Net AAHUs	-0.74	0.01	-0.74	-0.74	
		Open Water Habitat Net AAHUs=	-0.02	0.00	-0.02	-0.02	
		Net Impacts=	-0.58	0.01	-0.58	-0.58	-0.58

			Mean	SD	95% C.I.		
B Indirect-2	26.1	Marsh			Lower	Upper	
		Future With Project Emergent Marsh	0.21	0.01	0.21	0.21	
		Future Without Project Emergent Mar	14.49	0.07	14.47	14.50	
		Net (FWP - FWOP)=	-14.28	0.07	-14.30	-14.27	
		Open Water					
		Future With Project Open Water=	0.08	0.01	0.08	0.08	
		Future Without Project Open Water=	5.80	0.04	5.79	5.81	
		Net (FWP - FWOP)=	-5.72	0.04	-5.73	-5.71	
		Total					
		Emergent Marsh Habitat Net AAHUs	-14.28	0.07	-14.30	-14.27	
		Open Water Habitat Net AAHUs=	-5.72	0.04	-5.73	-5.71	
		Net Impacts=	-12.38	0.06	-12.39	-12.37	-12.38
B Indirect-3	18.4		Mean	SD	95% C.I.		
		Marsh			Lower	Upper	
		Future With Project Emergent Marsh	0.17	0.01	0.17	0.17	
		Future Without Project Emergent Mar	11.76	0.05	11.75	11.77	
		Net (FWP - FWOP)=	-11.59	0.05	-11.60	-11.58	
		Open Water					
		Future With Project Open Water=	0.05	0.01	0.05	0.05	
		Future Without Project Open Water=	3.61	0.02	3.61	3.62	
		Net (FWP - FWOP)=	-3.57	0.02	-3.57	-3.56	
		Total					
		Emergent Marsh Habitat Net AAHUs	-11.59	0.05	-11.60	-11.58	
		Open Water Habitat Net AAHUs=	-3.57	0.02	-3.57	-3.56	
		Net Impacts=	-9.81	0.04	-9.82	-9.80	-9.81

B Indirect-4	290.5		**Mean**	**SD**	**95% C.I.**		
		Marsh			**Lower**	**Upper**	
		Future With Project Emergent Marsh	129.21	0.70	129.07	129.35	
		Future Without Project Emergent Mar	135.85	0.67	135.72	135.99	
		Net (FWP - FWOP)=	-6.64	0.89	-6.82	-6.47	
		Open Water					
		Future With Project Open Water=	55.64	0.85	55.47	55.81	
		Future Without Project Open Water=	60.53	0.85	60.36	60.70	
		Net (FWP - FWOP)=	-4.89	1.22	-5.13	-4.65	
		Total					
		Emergent Marsh Habitat Net AAHUs	-6.64	0.89	-6.82	-6.47	
		Open Water Habitat Net AAHUs=	-4.89	1.22	-5.13	-4.65	
		Net Impacts=	-6.25	0.78	-6.41	-6.10	-6.25
B Indirect-5	739.0		**Mean**	**SD**	**95% C.I.**		
		Marsh			**Lower**	**Upper**	
		Future With Project Emergent Marsh	478.19	2.14	477.77	478.61	
		Future Without Project Emergent Mar	503.45	2.17	503.03	503.88	
		Net (FWP - FWOP)=	-25.27	2.93	-25.84	-24.69	
		Open Water					
		Future With Project Open Water=	88.39	0.94	88.21	88.58	
		Future Without Project Open Water=	95.88	0.94	95.70	96.07	
		Net (FWP - FWOP)=	-7.49	1.38	-7.76	-7.22	
		Total					
		Emergent Marsh Habitat Net AAHUs	-25.27	2.93	-25.84	-24.69	
		Open Water Habitat Net AAHUs=	-7.49	1.38	-7.76	-7.22	
		Net Impacts=	-21.32	2.31	-21.77	-20.86	-21.32

Orange- Jefferson CSRM Project Area - All Potential Impacts
Marsh Indirect Impacts - Intermediate RSLR Scenario *
WVA Model Output (V1.0)

Wetland Impact Subunit	Acres		Statistics: AAHUs		Statistics: 95% Confidence Interval		Net Mean AAHUs
B Indirect Converted from I-1 and 2 TY31-61	19.6		Mean	SD	95% C.I.		
		Marsh			**Lower**	**Upper**	
		Future With Project Emergent Marsh =	0.00	0.00	0.00	0.00	
		Future Without Project Emergent Marsh=	6.10	0.06	6.09	6.12	
		Net (FWP - FWOP)=	-6.10	0.06	-6.12	-6.09	
		Open Water					
		Future With Project Open Water=	0.00	0.00	0.00	0.00	
		Future Without Project Open Water=	1.35	0.02	1.34	1.35	
		Net (FWP - FWOP)=	-1.35	0.02	-1.35	-1.34	
		Total					
		Emergent Marsh Habitat Net AAHUs=	-6.10	0.06	-6.12	-6.09	
		Open Water Habitat Net AAHUs=	-1.35	0.02	-1.35	-1.34	
		Net Impacts=	-5.05	0.05	-5.06	-5.04	-5.0

I Indirect 1 and 2 to TY30	**	Marsh			**Lower**	**Upper**	
		Future With Project Emergent Marsh =	0.34	0.00	0.34	0.34	
		Future Without Project Emergent Marsh=	11.92	0.11	11.90	11.94	
		Net (FWP - FWOP)=	-11.58	0.11	-11.61	-11.56	
		Open Water					
		Future With Project Open Water=	0.06	0.00	0.06	0.06	
		Future Without Project Open Water=	2.20	0.03	2.20	2.21	
		Net (FWP - FWOP)=	-2.14	0.03	-2.15	-2.14	
		Total					
		Emergent Marsh Habitat Net AAHUs=	-11.58	0.11	-11.61	-11.56	
		Open Water Habitat Net AAHUs=	-2.14	0.03	-2.15	-2.14	
		Net Impacts=	-8.54	0.08	-8.55	-8.52	-8.5

Orange- Jefferson CSRM Project Area - All Potential Impacts
Marsh Indirect Impacts - Intermediate RSLR Scenario *
WVA Model Output (V1.0)

B Indirect 3	18.4		Mean	SD	95% C.I.		
		Marsh			**Lower**	**Upper**	
		Future With Project Emergent Marsh =	0.17	0.00	0.17	0.17	
		Future Without Project Emergent Marsh=	11.79	0.07	11.77	11.80	
		Net (FWP - FWOP)=	-11.62	0.07	-11.63	-11.60	
		Open Water					
		Future With Project Open Water=	0.04	0.00	0.04	0.04	
		Future Without Project Open Water=	2.81	0.02	2.81	2.82	
		Net (FWP - FWOP)=	-2.78	0.02	-2.78	-2.77	
		Total					
		Emergent Marsh Habitat Net AAHUs=	-11.62	0.07	-11.63	-11.60	
		Open Water Habitat Net AAHUs=	-2.78	0.02	-2.78	-2.77	
		Net Impacts=	-9.65	0.06	-9.66	-9.64	-9.7

B Indirect 3	34.0		Mean	SD	95% C.I.		
		Marsh			**Lower**	**Upper**	
		Future With Project Emergent Marsh =	0.00	0.00	0.00	0.00	
		Future Without Project Emergent Marsh=	9.53	0.12	9.51	9.56	
		Net (FWP - FWOP)=	-9.53	0.12	-9.56	-9.51	
		Open Water					
		Future With Project Open Water=	0.00	0.00	0.00	0.00	
		Future Without Project Open Water=	0.21	0.00	0.21	0.21	
		Net (FWP - FWOP)=	-0.21	0.00	-0.21	-0.21	
		Total					
		Emergent Marsh Habitat Net AAHUs=	-9.53	0.12	-9.56	-9.51	
		Open Water Habitat Net AAHUs=	-0.21	0.00	-0.21	-0.21	
		Net Impacts=	-7.46	0.10	-7.48	-7.44	-7.5

Orange- Jefferson CSRM Project Area - All Potential Impacts
Marsh Indirect Impacts - Intermediate RSLR Scenario *
WVA Model Output (V1.0)

B Indirect S-2 Switch TY31-61	1.9		Mean	SD	95% C.I.		
		Marsh			**Lower**	**Upper**	
		Future With Project Emergent Marsh =	0.00	0.01	0.00	0.00	
		Future Without Project Emergent Marsh=	0.74	0.02	0.74	0.74	
		Net (FWP - FWOP)=	-0.74	0.01	-0.74	-0.74	
		Open Water					
		Future With Project Open Water=	0.00	0.01	0.00	0.00	
		Future Without Project Open Water=	0.01	0.01	0.01	0.02	
		Net (FWP - FWOP)=	-0.01	0.01	-0.01	-0.01	
		Total					
		Emergent Marsh Habitat Net AAHUs=	-0.74	0.01	-0.74	-0.74	
		Open Water Habitat Net AAHUs=	-0.01	0.01	-0.01	-0.01	
		Net Impacts=	-0.58	0.01	-0.58	-0.58	-0.6

to TY30	***		Mean	S.D.	Lower	Upper	
		Swamp					
		Future With Projects=	0.30	0.01	0.30	0.30	
		Future Without Project=	0.39	0.01	0.39	0.39	
		Net (FWP - FWOP)=	-0.09	0.01	-0.09	-0.09	-0.1

*Only areas with new or different impacts due to the Intermediate RSLR condition were modeled. Most of the indirect impact areas were assumed lost in the historic RSLR condition and thus were not modeled for this condition.

** Same area as B Indirect I-1 and 2 Switch TY31-61

*** Same area as B Indirect S-2 Switch TY31-61

Orange- Jefferson CSRM Project Area - All Potential Impacts
Marsh Indirect Impacts - High RSLR Scenario *
WVA Model Output (V1.0)

Wetland Impact Subunit	Acres		Statistics				Net Mean AAHU s
			AAHUs		95% Confidence Interval		
Saline Switch from Upland Near B-3 TY31-61	11.7		Mean	SD	95% C.I.		
		Marsh			**Lower**	**Upper**	
		Future With Project Emergent Marsh =	0.00	0.00	0.00	0.00	
		Future Without Project Emergent Marsh=	3.57	0.27	3.52	3.63	
		Net (FWP - FWOP)=	-3.57	0.27	-3.63	-3.52	
		Open Water					
		Future With Project Open Water=	0.00	0.00	0.00	0.00	
		Future Without Project Open Water=	0.21	0.00	0.21	0.21	
		Net (FWP - FWOP)=	-0.21	0.00	-0.21	-0.21	
		Total					
		Emergent Marsh Habitat Net AAHUs=	-3.57	0.27	-3.63	-3.52	
		Open Water Habitat Net AAHUs=	-0.21	0.00	-0.21	-0.21	
		Net Impacts=	-2.83	0.21	-2.87	-2.79	-2.8
Saline Switch B-3 TY31-61	18.4		Mean	SD	95% C.I.		
		Marsh			**Lower**	**Upper**	
		Future With Project Emergent Marsh =	3.69	0.00	3.69	3.69	
		Future Without Project Emergent Marsh=	6.33	0.30	6.28	6.39	
		Net (FWP - FWOP)=	-2.64	0.30	-2.70	-2.58	
		Open Water					
		Future With Project Open Water=	3.66	0.00	3.66	3.66	
		Future Without Project Open Water=	5.47	0.03	5.46	5.47	
		Net (FWP - FWOP)=	-1.81	0.03	-1.81	-1.80	
		Total					
		Emergent Marsh Habitat Net AAHUs=	-2.64	0.30	-2.70	-2.58	
		Open Water Habitat Net AAHUs=	-1.81	0.03	-1.81	-1.80	
		Net Impacts=	-2.46	0.23	-2.50	-2.41	-2.5

Orange- Jefferson CSRM Project Area - All Potential Impacts
Marsh Indirect Impacts - High RSLR Scenario *
WVA Model Output (V1.0)

B Indirect-3 thru TY30	**		Mean	SD	95% C.I.		
		Marsh			**Lower**	**Upper**	
		Future With Project Emergent Marsh =	0.34	0.00	0.34	0.34	
		Future Without Project Emergent Marsh=	11.64	0.10	11.62	11.66	
		Net (FWP - FWOP)=	-11.30	0.10	-11.32	-11.28	
		Open Water					
		Future With Project Open Water=	0.08	0.00	0.08	0.08	
		Future Without Project Open Water=	2.76	0.03	2.75	2.76	
		Net (FWP - FWOP)=	-2.68	0.03	-2.69	-2.67	
		Total					
		Emergent Marsh Habitat Net AAHUs=	-11.30	0.10	-11.32	-11.28	
		Open Water Habitat Net AAHUs=	-2.68	0.03	-2.69	-2.67	
		Net Impacts=	-9.38	0.08	-9.40	-9.37	-9.4

Saline Switch I 1 and 2 TY31-61	19.6		Mean	SD	95% C.I.		
		Marsh			**Lower**	**Upper**	
		Future With Project Emergent Marsh =	0.00	0.00	0.00	0.00	
		Future Without Project Emergent Marsh=	5.33	0.39	5.26	5.41	
		Net (FWP - FWOP)=	-5.33	0.39	-5.41	-5.26	
		Open Water					
		Future With Project Open Water=	0.00	0.00	0.00	0.00	
		Future Without Project Open Water=	1.27	0.02	1.26	1.27	
		Net (FWP - FWOP)=	-1.27	0.02	-1.27	-1.26	
		Total					
		Emergent Marsh Habitat Net AAHUs=	-5.33	0.39	-5.41	-5.26	
		Open Water Habitat Net AAHUs=	-1.27	0.02	-1.27	-1.26	
		Net Impacts=	-4.43	0.30	-4.49	-4.37	-4.4

Orange- Jefferson CSRM Project Area - All Potential Impacts
Marsh Indirect Impacts - High RSLR Scenario *
WVA Model Output (V1.0)

I Indirect-I 1 and 2 thru TY 30	***		Mean	SD	95% C.I.		
		Marsh			**Lower**	**Upper**	
		Future With Project Emergent Marsh =	0.42	0.03	0.41	0.42	
		Future Without Project Emergent Marsh=	14.11	0.13	14.08	14.13	
		Net (FWP - FWOP)=	-13.69	0.13	-13.71	-13.66	
		Open Water					
		Future With Project Open Water=	0.04	0.01	0.03	0.04	
		Future Without Project Open Water=	1.32	0.02	1.31	1.32	
		Net (FWP - FWOP)=	-1.28	0.02	-1.28	-1.28	
		Total					
		Emergent Marsh Habitat Net AAHUs=	-13.69	0.13	-13.71	-13.66	
		Open Water Habitat Net AAHUs=	-1.28	0.02	-1.28	-1.28	
		Net Impacts=	-9.69	0.09	-9.70	-9.67	-9.7

B Indirect 3 Migration	34.0		Mean	SD	95% C.I.		
		Marsh			**Lower**	**Upper**	
		Future With Project Emergent Marsh =	0.00	0.00	0.00	0.00	
		Future Without Project Emergent Marsh=	12.83	0.14	12.80	12.85	
		Net (FWP - FWOP)=	-12.83	0.14	-12.85	-12.80	
		Open Water					
		Future With Project Open Water=	0.00	0.00	0.00	0.00	
		Future Without Project Open Water=	0.64	0.01	0.64	0.64	
		Net (FWP - FWOP)=	-0.64	0.01	-0.64	-0.64	
		Total					
		Emergent Marsh Habitat Net AAHUs=	-12.83	0.14	-12.85	-12.80	
		Open Water Habitat Net AAHUs=	-0.64	0.01	-0.64	-0.64	
		Net Impacts=	-10.12	0.11	-10.14	-10.10	-10.1

Orange- Jefferson CSRM Project Area - All Potential Impacts
Marsh Indirect Impacts - High RSLR Scenario *
WVA Model Output (V1.0)

B Indirect Switch S-2 TY31-61	1.9		Mean	SD	95% C.I.		
		Marsh			**Lower**	**Upper**	
		Future With Project Emergent Marsh =	0.00	0.00	0.00	0.00	
		Future Without Project Emergent Marsh=	0.70	0.01	0.70	0.70	
		Net (FWP - FWOP)=	-0.70	0.01	-0.70	-0.70	
		Open Water					
		Future With Project Open Water=	0.00	0.00	0.00	0.00	
		Future Without Project Open Water=	0.03	0.00	0.03	0.03	
		Net (FWP - FWOP)=	-0.03	0.00	-0.03	-0.03	
		Total					
		Emergent Marsh Habitat Net AAHUs=	-0.70	0.01	-0.70	-0.70	
		Open Water Habitat Net AAHUs=	-0.03	0.00	-0.03	-0.03	
		Net Impacts=	-0.55	0.01	-0.55	-0.55	-0.6

S Indirect-2 to TY30	****		Mean	S.D.	Lower	Upper	
		Swamp					
		Future With Projects=	0.30	0.01	0.30	0.30	
		Future Without Project=	0.39	0.01	0.39	0.39	
		Net (FWP - FWOP)=	-0.09	0.01	-0.09	-0.09	-0.1

*Only areas with new or different impacts due to the Intermediate RSLR condition were modeled.
Most of the indirect impact areas were assumed lost in the historic RSLR condition and thus were not modeled for this condition.

**Same area as Saline Switch B-3 TY31-61

***Same area as Saline Switch I 1 and 2 TY31-61

****Same area as B Indirect Switch S-2 TY31-61

Sabine Pass to Galveston Bay, Texas

Coastal Storm Risk Reduction and Ecosystem Restoration

Draft Integrated Feasibility Report and Environmental Impact Study

DRAFT APPENDIX P

MITIGATION PLAN
AND
INCREMENTAL ANALYSIS AND MONITORING PLAN

September 2015

PLACEHOLDER

The mitigation plan will be developed during final feasibility planning. It will be presented in the Final Integrated Feasibility Report and Environmental Impact Statement. A conceptual mitigation plan is presented in Appendix O of this draft report.

Sabine Pass to Galveston Bay, Texas
Coastal Storm Risk Reduction and Ecosystem Restoration
Draft Integrated Feasibility Report and Environmental Impact Study

DRAFT APPENDIX Q

WETLANDS VALUE ASSESSMENT SENSITIVITY ANALYSIS

September 2015

PLACEHOLDER

The Wetlands Value Assessment sensitivity analysis will be developed during final feasibility planning. It will be presented in the Final Integrated Feasibility Report and Environmental Impact Statement.

Sabine Pass to Galveston Bay, Texas
Coastal Storm Risk Reduction and Ecosystem Restoration
Draft Integrated Feasibility Report and Environmental Impact Study

Draft Appendix R

Study Area Demographics

September 2015

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1 STUDY AREA DEMOGRAPHICS

The socioeconomic characteristics of the study area are important to understand in the process of alternative formulation and making choices among the alternatives. This section provides data that describe the socioeconomic makeup of the study area and surrounding county.

1.1 RACE AND ETHNICITY

Table 1 breaks down the total population, as well as the racial and ethnic makeup, for Brazoria, Jefferson, and Orange counties and the study areas within each of these counties for the years 2000 and 2010.

Table 1. County and Study Area Racial Composition

	Brazoria County				Study Area			
	2000		2010		2000		2010	
Population	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Total	241,767	100%	313,166	100%	24,195	100%	46,208	100%
Male	124,837	51.6%	159,000	50.8%	12,382	51.2%	23,733	51.4%
Female	116,930	48.4%	154,166	49.2%	11,813	48.8%	22,475	48.6%
White*	131,320	54.3%	166,674	53.2%	11,442	47.3%	28,203	61.0%
Hispanic	55,063	22.8%	86,643	27.7%	7,393	30.6%	12,415	26.9%
Black	20,540	8.5%	36,880	11.8%	1,465	6.1%	3,589	7.8%
Asian	4,842	2.0%	17,013	5.4%	88	0.4%	514	1.1%
Am. Indian	1,280	0.5%	1,013	0.3%	137	0.6%	314	0.7%
Hawaiian, PI	73	0.0%	105	0.0%	5	0.0%	7	0.0%
Other	28,649	11.8%	4,838	1.5%	3,665	15.1%	1,166	2.5%
*White, Not Hispanic								
	Jefferson County				Study Area			
	2000		2010		2000		2010	
Population	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Total	252,051	100%	252,273	100%	41,486	100%	40,576	100%
Male	126,689	50.3%	128,946	51.1%	26,285	63.4%	24,435	60.2%
Female	125,362	49.7%	123,327	48.9%	15,201	36.6%	16,141	39.8%
White	117,738	46.7%	112,503	44.6%	18,524	44.7%	18,136	44.7%
Hispanic	26,536	10.5%	42,899	17.0%	6,078	14.7%	7,069	17.4%
Black	85,046	33.7%	84,500	33.5%	13,278	32.0%	13,394	33.0%
Asian	7,274	2.9%	8,525	3.4%	1,204	2.9%	975	2.4%
Am. Indian	857	0.3%	747	0.3%	205	0.5%	207	0.5%
Other	14,600	5.8%	3,099	1.2%	2,197	5.3%	795	2.0%

Table 1, continued

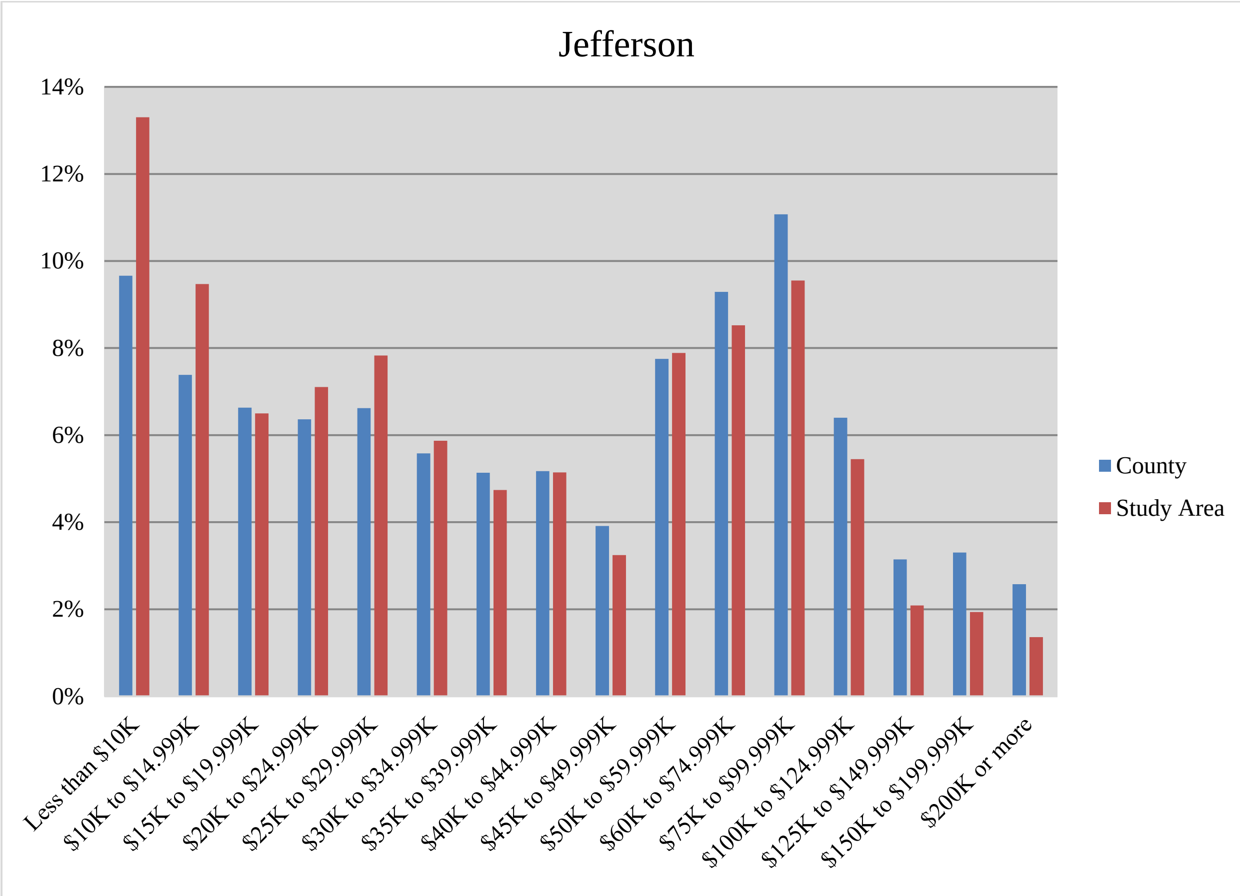
	Orange County				Study Area			
	2000		2010		2000		2010	
Population	**Number**	**Percent**	**Number**	**Percent**	**Number**	**Percent**	**Number**	**Percent**
Total	84,966	100%	81,837	100%	46,684	100%	45,195	100%
Male	41,696	49.1%	40,708	49.7%	22,944	49.1%	22,488	49.8%
Female	43,270	50.9%	41,129	50.3%	23,740	50.9%	22,707	50.2%
White	71,676	84.4%	67,895	83.0%	37,699	80.8%	35,770	79.1%
Hispanic	3,073	3.6%	4,766	5.8%	1,802	3.9%	2,700	6.0%
Black	7,124	8.4%	6,922	8.5%	5,292	11.3%	5,110	11.3%
Asian	664	0.8%	797	1.0%	479	1.0%	514	1.1%
Am. Indian	473	0.6%	340	0.4%	259	0.6%	224	0.5%
Other	1,956	2.3%	1,117	1.4%	1,153	2.5%	877	1.9%

Source: U.S. Bureau of the Census, 2010

Brazoria County's population increased by almost 30 percent between 2000 and 2010. Jefferson County increased by only 0.1 percent while Orange decreased almost four percent for the same period. The study area in Brazoria County, by contrast, increased by almost 91 percent from 2000 to 2010. The study area in Jefferson County decreased by 2.2 percent, while the study area in Orange County decreased by 3.2 percent. The study areas in the three counties represented 19.4 percent of the total population of the three counties in the year 2000 and around 20 percent in 2010. Minority population comprised 45.7 percent of the population for Brazoria County in 2000 and 46.8 percent in 2010. Minorities made up 53.3 percent of the population in Jefferson County in 2000 and 55.4 percent in 2010. Minorities made up 15.6 percent of the population in Orange County in 2000 and 17 percent in 2010. The study area minority population in Brazoria County was almost 53 percent in 2000 but decreased to 39 percent in 2010. The minority population in the study area of Jefferson County was 53.3 percent in both 2000 and 2010, while the minority population for the study area in Orange County was 19.2 percent in 2000 and 20.9 in 2010.

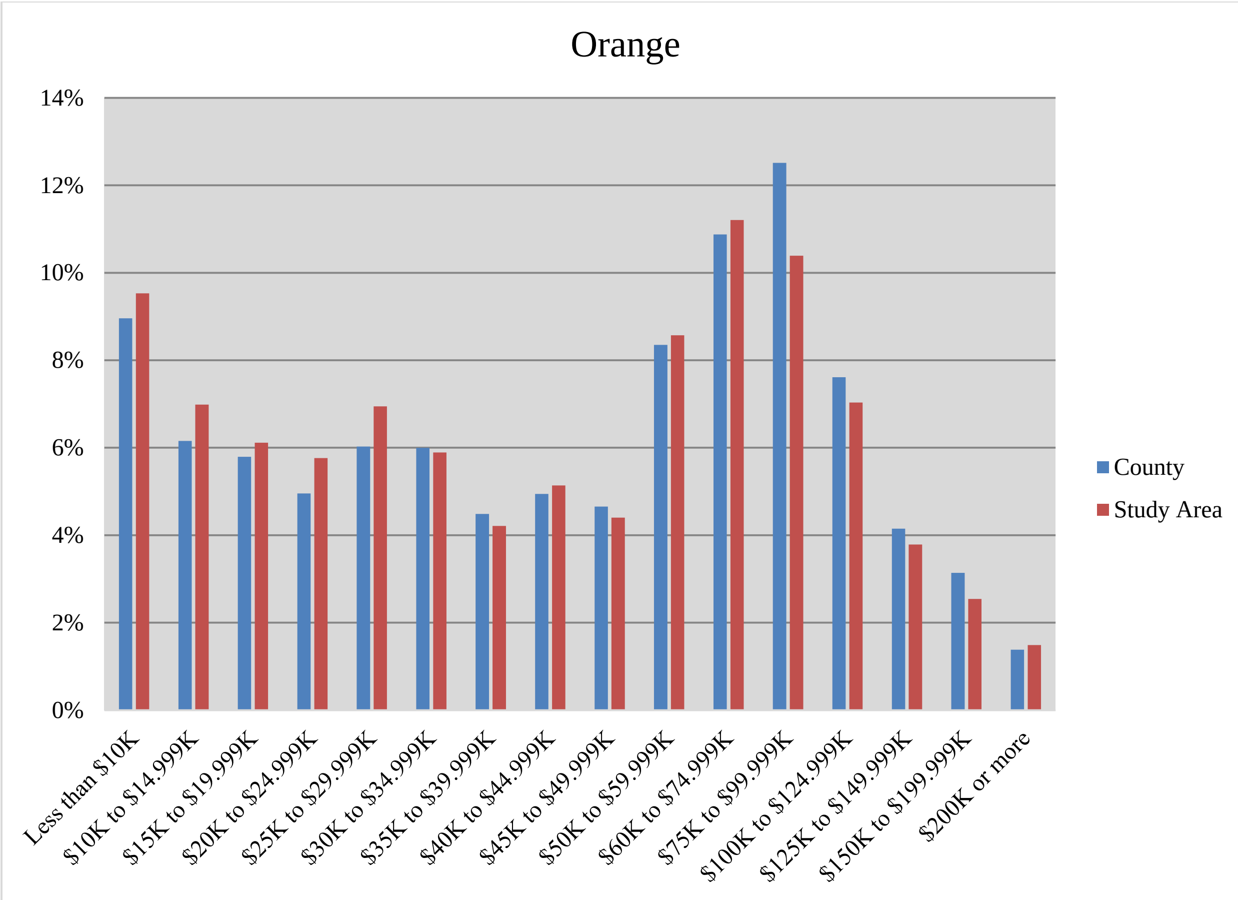
1.2 INCOME

On the next page, Figures 1, 2, and 3 illustrate the income distribution based on household income for the three counties, as well as the study areas within the three counties in 2010. As the charts illustrate, the distribution of income of the Counties as a whole are similar to the income distribution of the study areas within the three counties. Brazoria has relatively higher percentages of households with incomes ranging from $50K up to $125K. Jefferson has more relatively low levels of income but incomes increase between the levels of $50K to $125K. Orange County, like the other two counties, has relatively substantial high percentages of incomes between $50K up to $125K, but also has nearly 10 percent of its population that have household incomes of less than $10K.



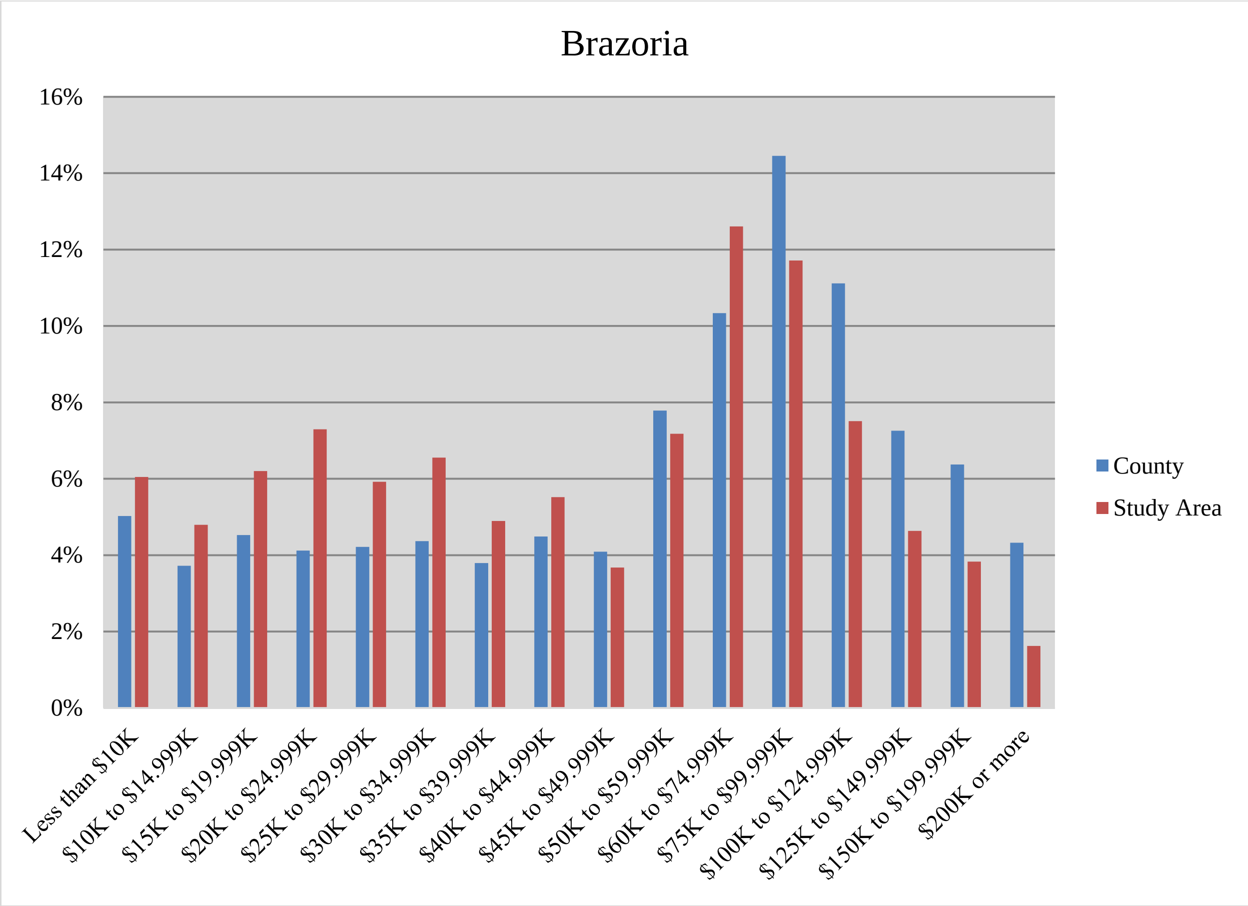
Source: U.S. Bureau of the Census, 2010

Figure 1. 2010 Income Distribution for Jefferson County



Source: U.S. Bureau of the Census, 2010

Figure 2. 2010 Income Distribution for Orange County



Source: U.S. Bureau of the Census, 2010

Figure 3. 2010 Income Distribution for Brazoria County

As the charts illustrate, the distribution of income of the study areas of each county is similar to that of the counties as a whole. All have relatively higher percentages of households with incomes in the range of $50K to $125K, with the exception of Orange, which has fairly large segment of the population with incomes below $10K.

Table 2 displays the number of households, aggregate household income, and average household income for counties and the study areas in 2010.

Table 2. 2010 Household Income

Household Characteristic	Brazoria County	Study Area
Total Households	101,656	15,398
Aggregate Income	$8,131,315,866	$941,129,375
Average Income	$79,989	$61,120
	Jefferson County	**Study Area**
Total Households	90,671	16,833
Aggregate Income	$5,316,131,170	$814,135,843
Average Income	$58,631	$48,365
	Orange County	**Study Area**
Total Households	31,271	21,553
Aggregate Income	$1,868,247,406	$1,235,127,500
Average Income	$59,744	$57,307

Source: U.S. Bureau of the Census, 2010

While the pattern of the income distribution between the study areas within the counties and the income distribution of the counties as a whole is similar, slightly higher percentages of households in the study areas have lower incomes than those of the entire counties. This is evident when examining the average household income for the study areas and the counties. Average household income for the study area in Brazoria County is approximately 76 percent of the average income for the entire county. In Jefferson County, the study area household income is approximately 82.5 percent of the county, while the study area in Orange County is 96 percent of the household income of the entire county. The study area in Jefferson County also has the lowest average household income of the three counties.

Table 3 describes the poverty status for the three counties and the study areas within the three counties. Brazoria and Orange counties have relatively low poverty levels, while Jefferson

County has a higher percentage of its population below the poverty level; 23.4 percent for the study area and 18.8 percent for the entire county.

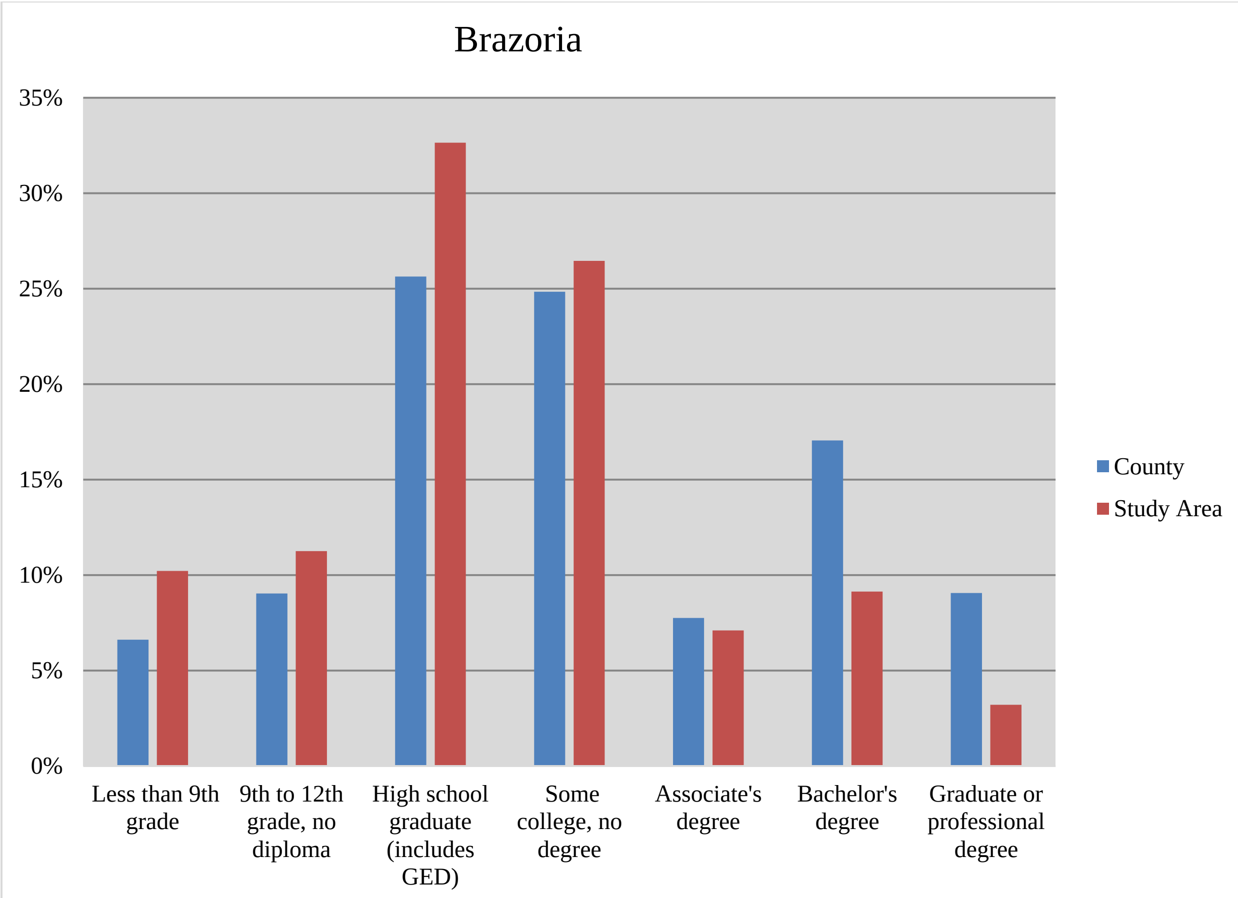
Table 3. Poverty Status

Population Characteristic	Brazoria County	Study Area
Total for Poverty Determination	287,910	42,357
Total Above Poverty Level	257,324	36,265
Total Below Poverty Level	30,586	6,092
Percent Above Poverty Level	89.4%	85.6%
Percent Below Poverty Level	10.6%	14.4%
	Jefferson County	**Study Area**
Total for Poverty Determination	233,086	44,806
Total Above Poverty Level	189,366	34,300
Total Below Poverty Level	43,720	10,506
Percent Above Poverty Level	81.2%	76.6%
Percent Below Poverty Level	18.8%	23.4%
	Orange County	**Study Area**
Total for Poverty Determination	80,925	54,734
Total Above Poverty Level	69,694	46,450
Total Below Poverty Level	11,231	8,284
Percent Above Poverty Level	86.1%	84.9%
Percent Below Poverty Level	13.9%	15.1%

Source: U.S. Bureau of the Census, 2010

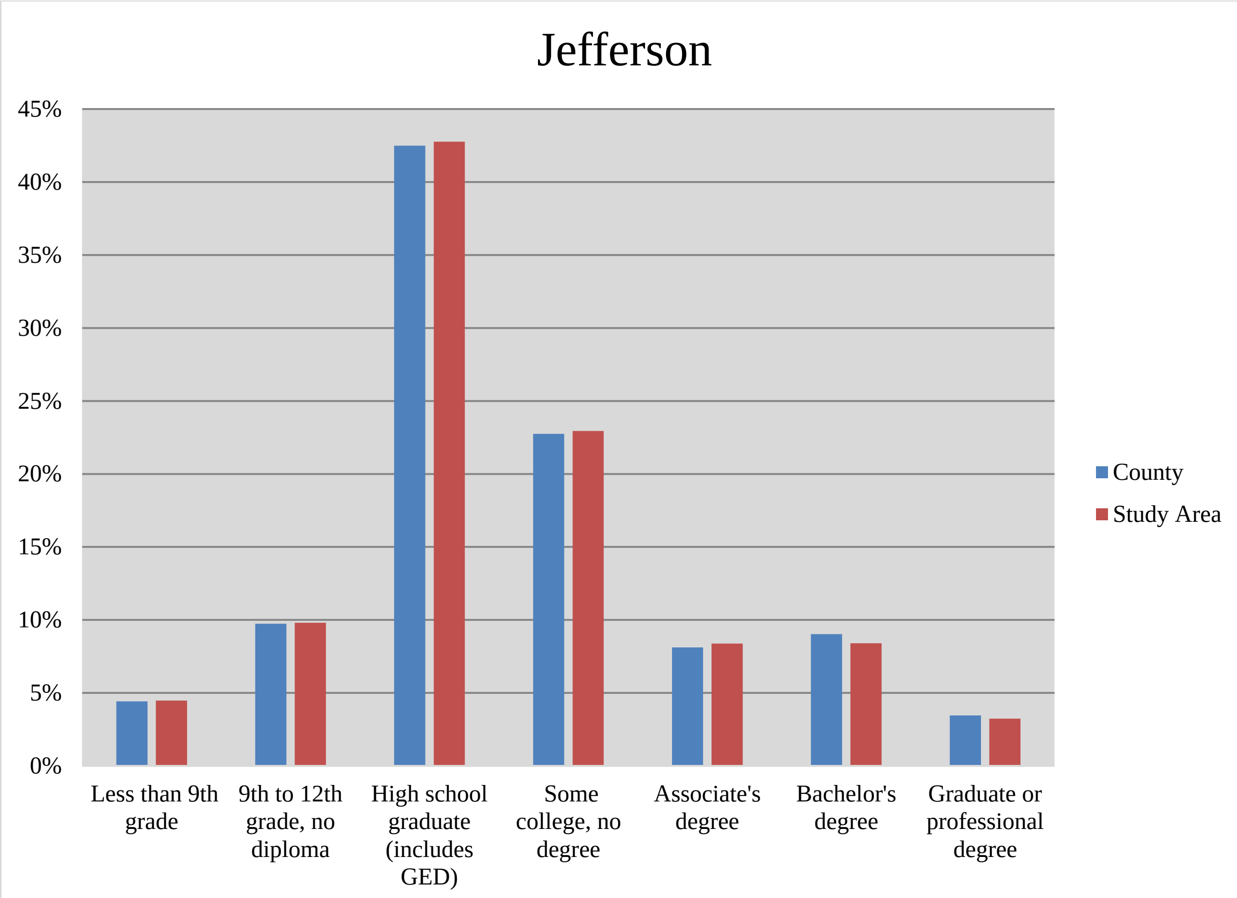
1.3 EDUCATION

Figures 4, 5, and 6 depict educational attainment for Brazoria, Jefferson, and Orange counties, as well as the study areas within those counties for 2010. The study area in Brazoria County has higher percentages of lower levels of educational attainment than the county as a whole. Educational attainment for the study area in Jefferson County closely mirrors that of the county. Orange County exhibits a pattern similar to that of Brazoria County.



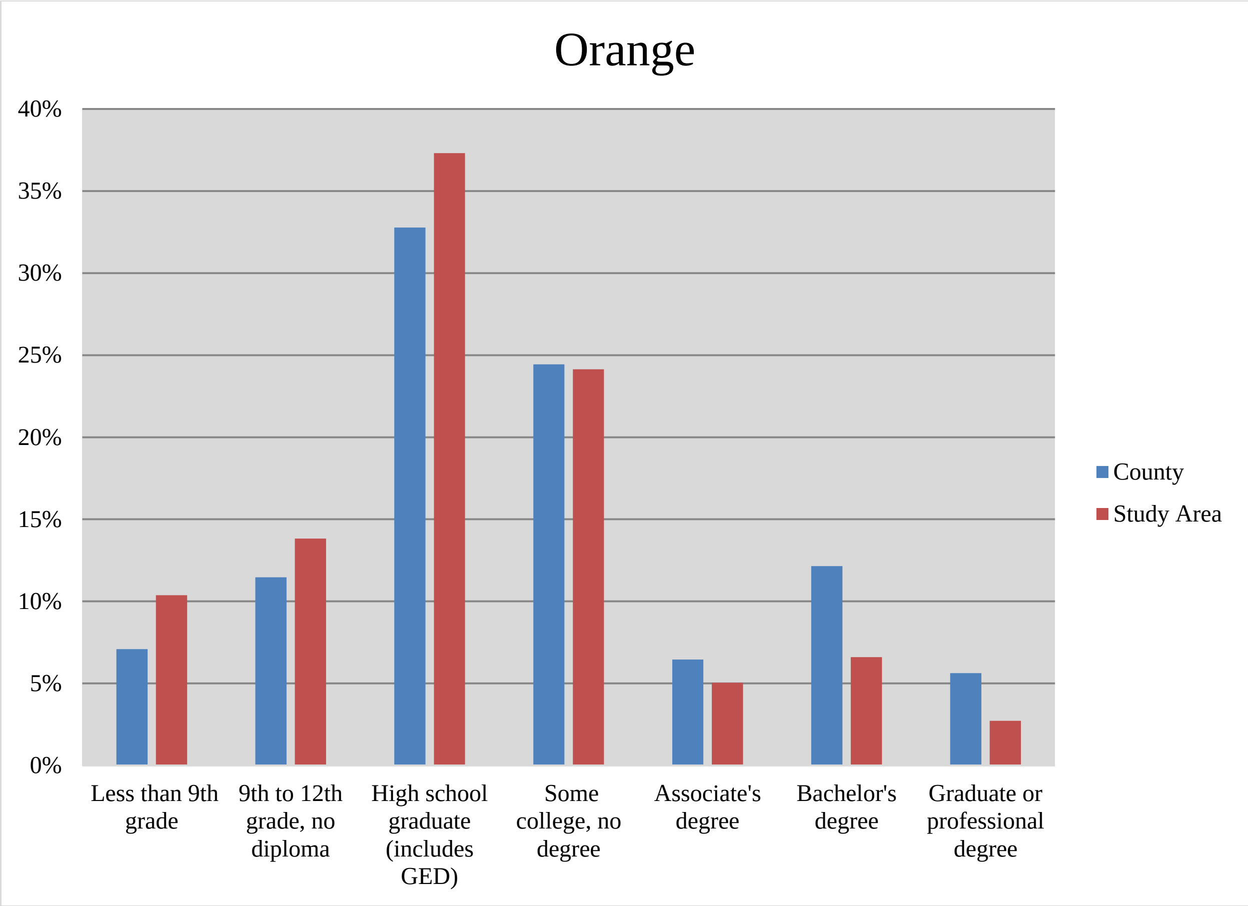
Source: U.S. Bureau of the Census, 2010

Figure 4. Educational Attainment for Brazoria County and Study Area



Source: U.S. Bureau of the Census, 2010

Figure 5. Educational Attainment for Jefferson County and Study Area



Source: U.S. Bureau of the Census, 2010

Figure 6. Educational Attainment for Orange County and Study Area

1.4 EMPLOYMENT

Table 4 displays the unemployment rates for Brazoria, Jefferson, and Orange counties, as well as the study areas within those counties for 2010. Unemployment rates are lowest for Brazoria County but highest for Jefferson County, both for the study area and the entire county.

Table 4. County and Study Area Unemployment Rates

Labor Force Characteristic	Brazoria County	Study Area
Total Civilian Labor Force	147,009	20,310
Employed	138,962	19,002
Unemployed	8,047	1,308
Unemployment Rate	5.5%	6.4%
	Jefferson County	**Study Area**
Total Civilian Labor Force	113,225	19,471
Employed	103,135	17,552
Unemployed	10,090	1,919
Unemployment Rate	8.9%	9.9%
	Orange County	**Study Area**
Total Civilian Labor Force	36,743	24,998
Employed	34,012	23,074
Unemployed	2,731	1,924
Unemployment Rate	7.4%	7.7%

Source: U.S. Bureau of the Census, 2010

1.5 HOUSING

Table 5 describes the occupancy status, vacancy rates, and the percentages of home ownership and rentals for Brazoria, Jefferson, and Orange counties, as well as the study areas within those counties, for 2010. Vacancy rates for all three of the study areas within the three counties are higher than the vacancy rates for the three counties as a whole, with Brazoria County being the highest at 20.7 percent. Vacancy rates for the three counties range from 9.9 percent in Brazoria County to 12.1 percent in Orange County. Home ownership is highest in Orange County with a rate of 76.7 percent, and lowest in Jefferson County with rate of 63.2 percent. However, among the study areas, home ownership was lowest in Brazoria County with a rate of 66.7 percent.

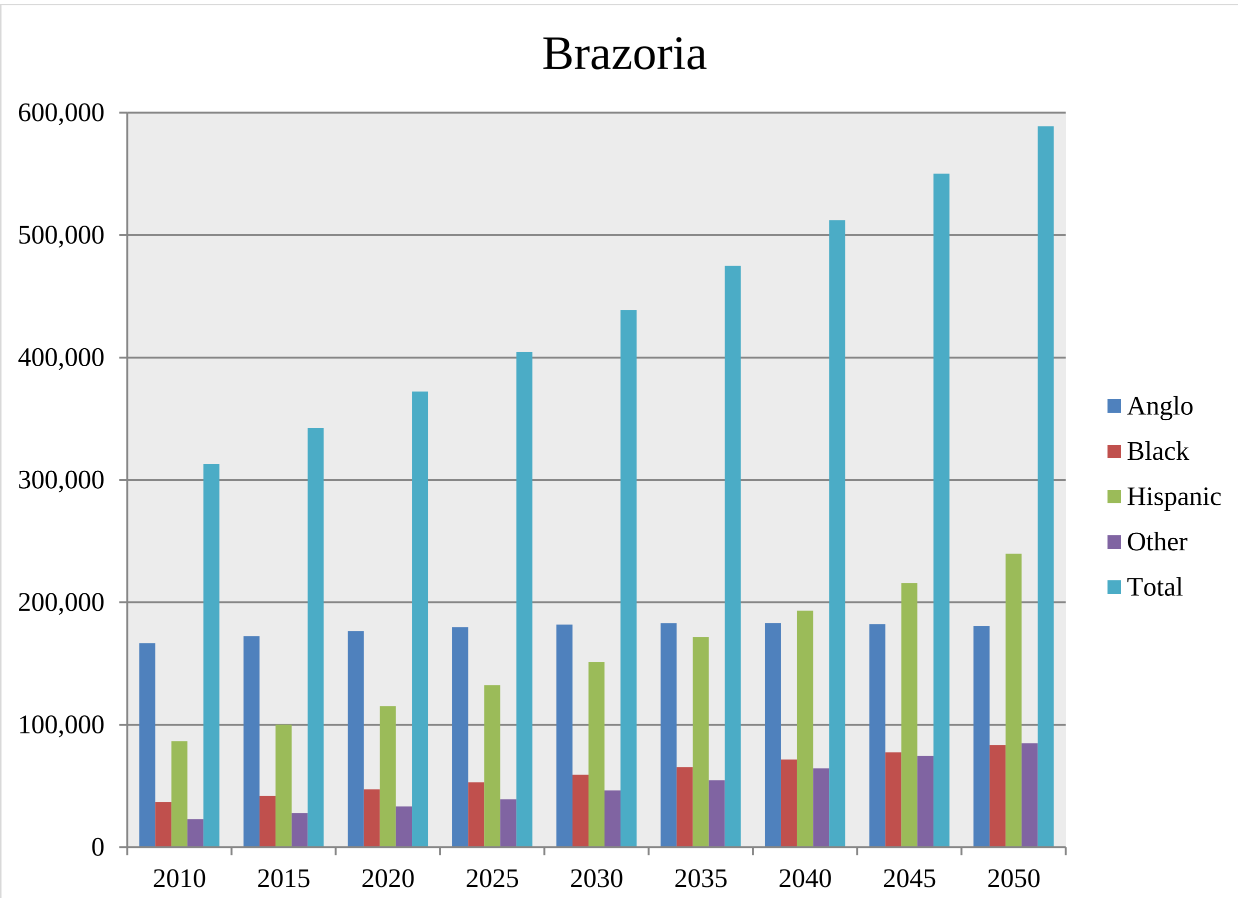
Table 5. County and Study Area Housing Statistics

Housing Characteristic	Brazoria County	Study Area
Total Units	118,336	19,952
Occupied Units	106,589	15,816
Vacant Units	11,747	4,136
Owner Occupied	79,477	10,557
Renter Occupied	27,112	5,259
Owner Occupied (Percent of Total Occupied)	74.6%	66.7%
Renter Occupied (Percent of Total Occupied)	25.4%	33.3%
Vacancy Rate	9.9%	20.7%
	Jefferson County	**Study Area**
Total Units	104,424	19,833
Occupied Units	93,441	16,998
Vacant Units	10,983	2,835
Owner Occupied	59,066	11,407
Renter Occupied	34,375	5,591
Owner Occupied (Percent of Total Occupied)	63.2%	67.1%
Renter Occupied (Percent of Total Occupied)	36.8%	32.9%
Vacancy Rate	10.5%	14.3%
	Orange County	**Study Area**
Total Units	35,313	24,747
Occupied Units	31,031	21,303
Vacant Units	4,282	3,444
Owner Occupied	23,808	15,694
Renter Occupied	7,223	5,609
Owner Occupied (Percent of Total Occupied)	76.7%	73.7%
Renter Occupied (Percent of Total Occupied)	23.3%	26.3%
Vacancy Rate	12.1%	13.9%

Source: U.S. Bureau of the Census, 2010

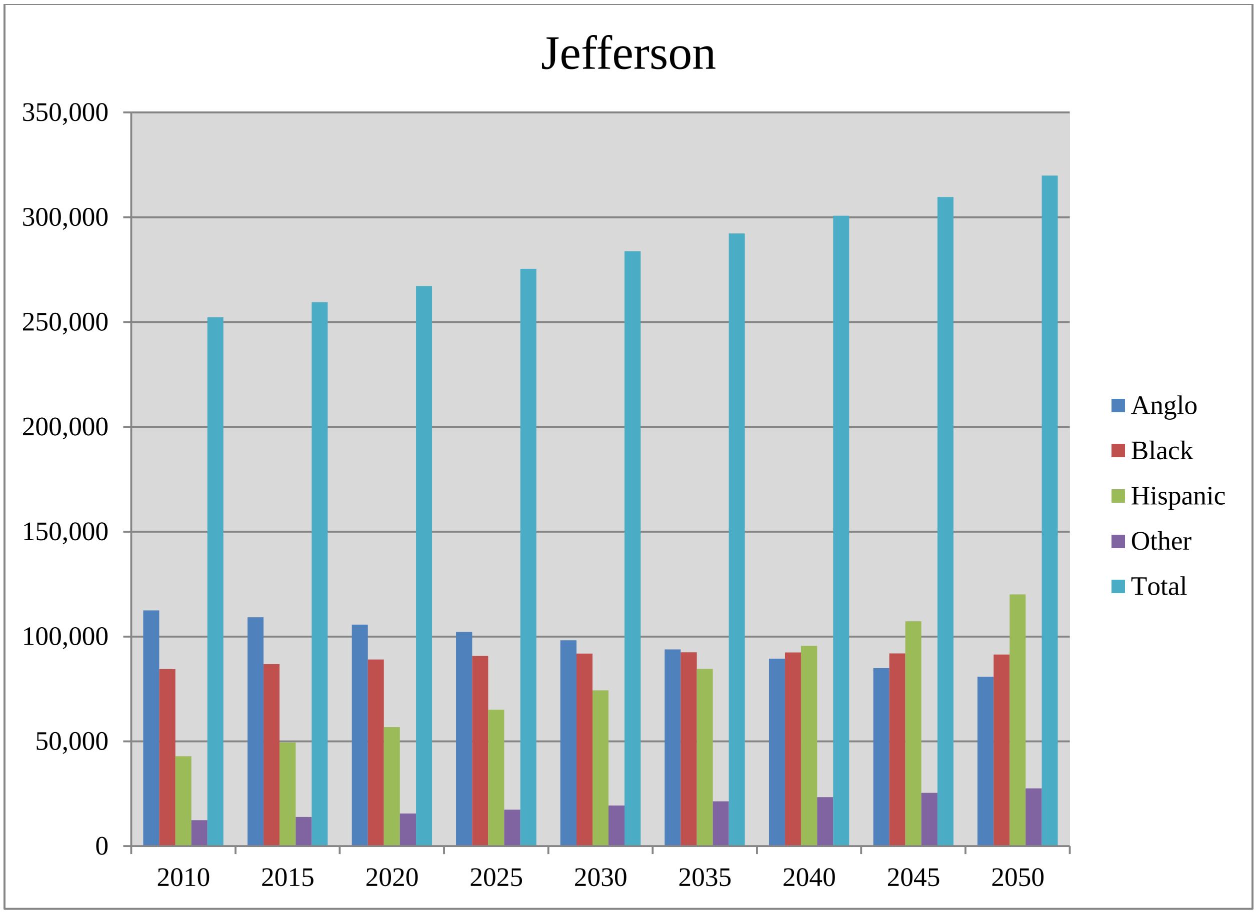
1.6 POPULATION PROJECTIONS

The following population projections for Brazoria, Jefferson, and Orange counties come from the Texas State Data Center and reflect the projections based on its 2000–2010 migration scenario, which takes into account post-2000 population trends for age, sex, race, and ethnicity. Based on these projections, the total population for Brazoria, Jefferson, and Orange counties is expected to grow by 88, 27, and 18 percent, respectively, between 2010 and 2050. This compares with a growth rate for the State of Texas of 61 percent for the same period under the same scenario. For Brazoria County, virtually all of the growth is through the non-white population. Growth in Jefferson and Orange counties is dependent on the Hispanic populations, which are projected to increase by 180 percent in Jefferson County and 211 percent in Orange County by 2050, and by Other populations. Alternately, Anglo populations will actually decrease in Jefferson County by 28 percent and just under 2 percent in Orange County. Black populations will stay fairly steady in Jefferson County and increase moderately in Orange County. Figures 7, 8, and 9 reflect the population growth of the three counties themselves, and Figure 10 and the growth rates of the State and the counties in comparison.



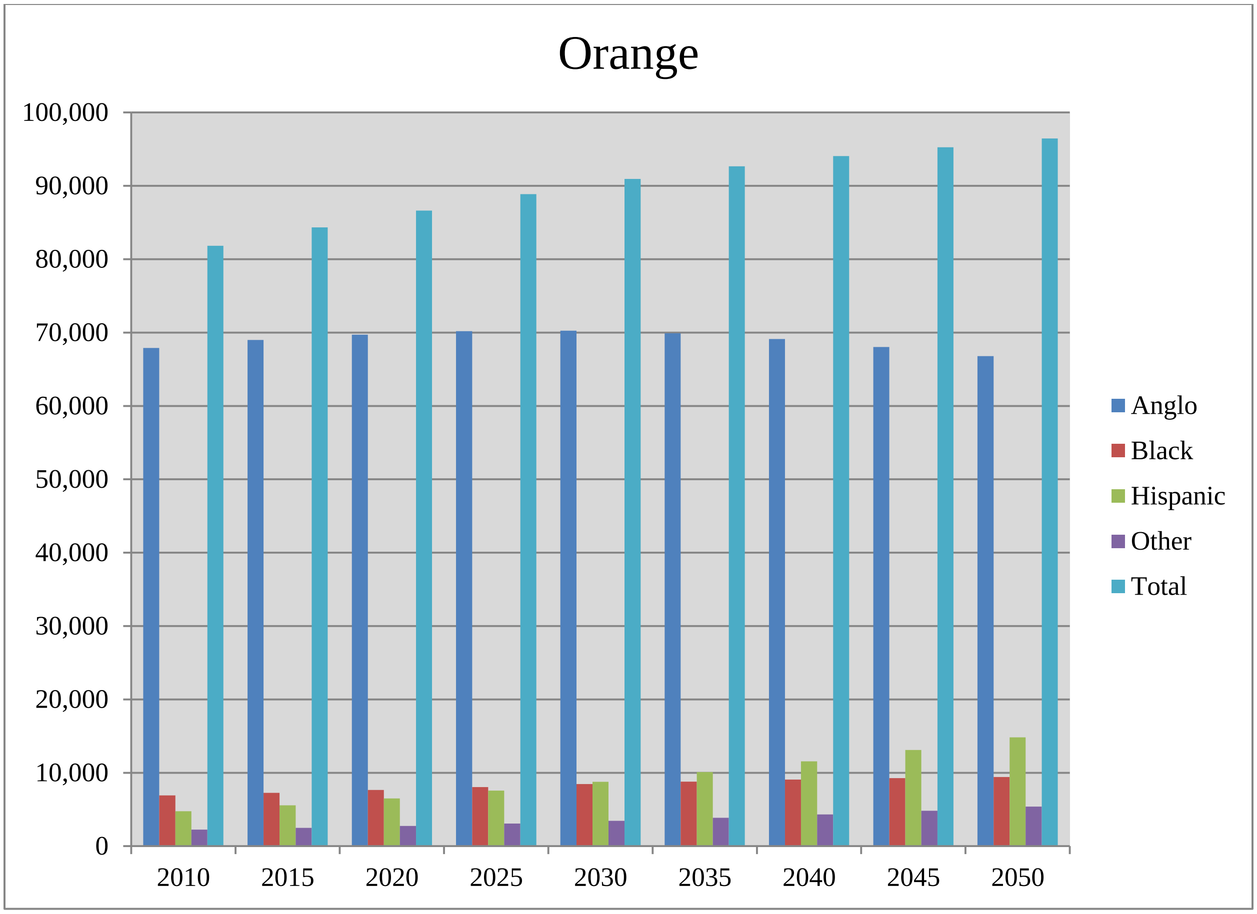
Source: Texas State Data Center

Figure 7. Brazoria County Population Growth by Race



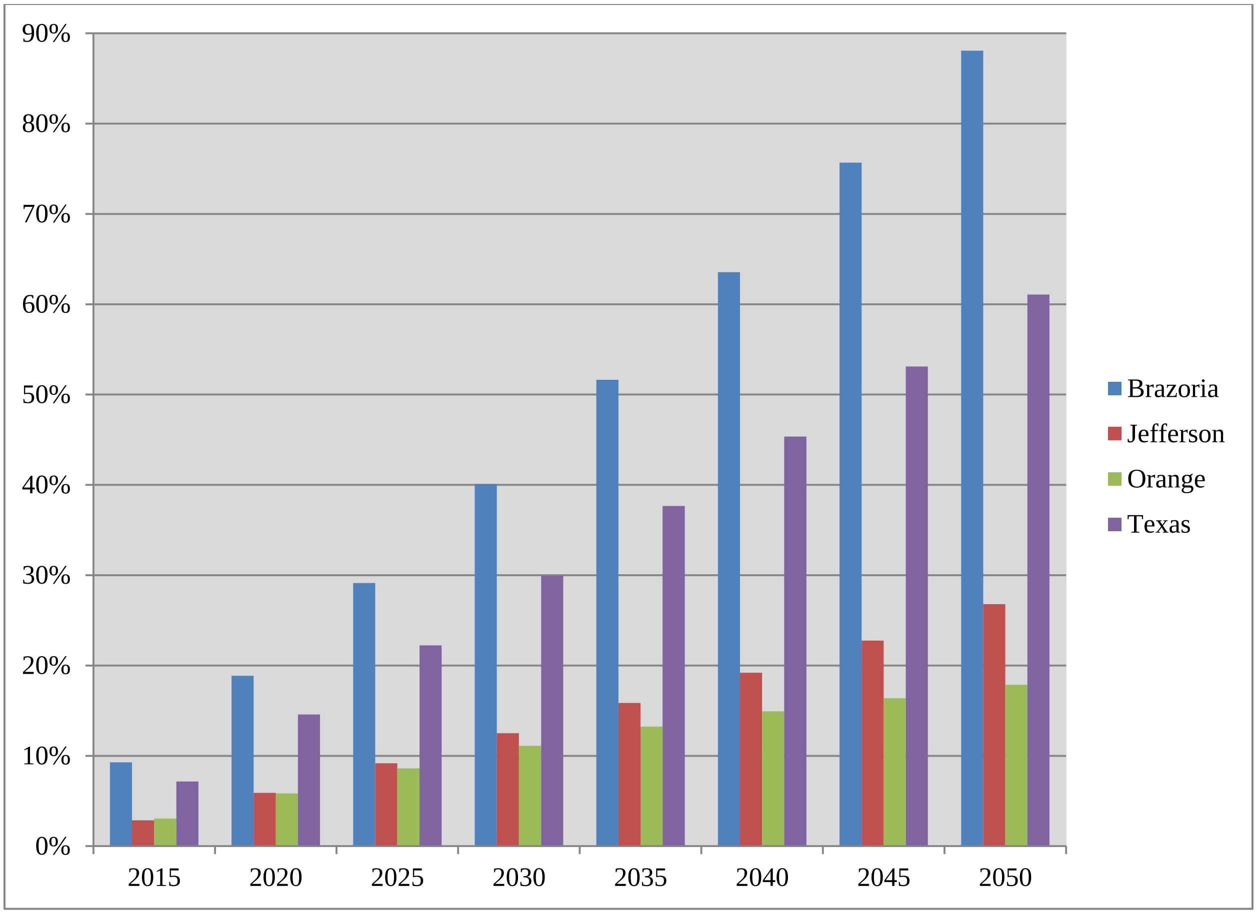
Source: Texas State Data Center

Figure 8. Jefferson County Population Growth by Race



Source: Texas State Data Center

Figure 9. Orange County Population Growth by Race



Source: Texas State Data Center

Figure 10. Population Growth in Texas vs. Brazoria, Jefferson, Orange Counties

1.7 AFFECTED POPULATIONS

In accordance with Executive Order 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low Income Populations," data were compiled to help assess the potential impacts on minority and low-income populations within the study area. This information indicates that 10 of the 39 2010 Census tracts in the Brazoria County study area, 20 of the 33 tracts in the Jefferson County study area, and 7 of the 40 tracts in the Orange County study area have minority populations higher than 50 percent. Table 6 shows the racial makeup percentages of each census block that intersects the study area. Those with minority populations above 50 percent are highlighted in red.

Table 6. Distribution of Population by Race/Ethnicity per Census Tract

Brazoria							
Census Tract	**White***	**Hispanic**	**Black**	**Asian**	**Am. Indian**	**Hawaiian / PI**	**Other**
6617.1	71.2%	22.8%	3.0%	0.1%	0.3%	0.0%	2.5%
6617.2	72.7%	20.0%	3.1%	0.0%	0.9%	0.0%	3.3%
6617.3	76.6%	20.6%	0.0%	0.0%	1.1%	0.0%	1.7%
6620.4	78.4%	13.4%	3.2%	0.8%	1.2%	0.0%	3.0%
6621.1	50.4%	38.9%	7.8%	0.3%	0.9%	0.2%	1.6%
6624.3	79.5%	15.5%	1.5%	0.4%	0.7%	0.0%	2.4%
6624.4	80.0%	15.7%	0.1%	0.5%	0.4%	0.0%	3.3%
6625.1	79.8%	12.8%	4.2%	0.6%	0.8%	0.0%	1.8%
6626.3	75.1%	17.3%	5.4%	0.3%	0.7%	0.0%	1.2%
6628.1	65.8%	11.7%	17.8%	0.7%	1.2%	0.0%	2.8%
6628.6	74.1%	10.5%	11.6%	0.3%	0.6%	0.0%	2.9%
6629.1	63.5%	19.7%	13.3%	0.5%	0.8%	0.0%	2.3%
6629.3	64.7%	25.0%	6.6%	0.6%	1.0%	0.0%	2.1%
6629.4	78.2%	12.6%	5.2%	1.7%	0.5%	0.0%	1.8%
6630.2	77.0%	16.3%	5.3%	0.0%	0.3%	0.0%	1.1%
6630.3	21.6%	37.0%	39.8%	0.7%	0.3%	0.0%	0.8%
6630.4	64.1%	11.5%	22.4%	0.2%	0.2%	0.1%	1.7%
6631.4	82.2%	10.4%	1.9%	3.9%	0.4%	0.0%	1.2%
6634.1	67.6%	15.6%	5.1%	9.3%	0.2%	0.0%	2.2%
6640.2	58.7%	35.9%	2.3%	0.4%	0.2%	0.0%	2.5%
6641.4	46.6%	45.6%	4.0%	0.6%	1.1%	0.0%	2.1%
6641.5	72.5%	22.8%	1.7%	0.9%	0.3%	0.0%	1.9%
6642.1	76.3%	15.5%	3.6%	0.6%	1.2%	0.0%	2.8%
6642.2	67.1%	24.6%	2.9%	0.1%	1.9%	0.0%	3.4%
6642.3	89.2%	5.8%	1.7%	0.9%	1.1%	0.0%	1.3%
6643.2	24.2%	59.7%	13.2%	0.7%	0.3%	0.0%	1.9%
6643.3	24.4%	62.4%	7.0%	0.2%	1.2%	0.0%	4.8%
6644.1	12.9%	68.5%	14.9%	0.3%	0.8%	0.0%	2.5%
6644.2	36.6%	43.9%	13.5%	0.3%	0.7%	0.0%	5.0%
6644.3	22.2%	69.5%	5.0%	0.5%	0.1%	0.0%	2.6%
6644.4	23.8%	58.5%	9.8%	0.3%	1.6%	0.0%	5.9%
6644.5	38.4%	42.0%	10.5%	0.8%	1.7%	0.0%	6.6%
6644.6	36.0%	52.2%	8.5%	0.4%	0.5%	0.1%	2.3%
6616.02.1	73.1%	20.9%	2.4%	1.8%	0.1%	0.0%	1.7%
6645.01.1	56.3%	38.2%	3.2%	0.1%	0.2%	0.0%	2.0%
6645.01.2	80.6%	10.3%	4.2%	0.6%	0.9%	0.0%	3.3%
6645.01.3	82.8%	8.1%	7.4%	0.3%	0.1%	0.0%	1.4%
6645.01.4	60.7%	13.7%	22.1%	0.1%	0.3%	0.0%	3.1%

Table 6, continued

6645.01.5	77.7%	16.6%	2.6%	1.0%	0.6%	0.0%	1.6%
9900.0	-	-	-	-	-	-	-
Jefferson							
Census Tract	**White**	**Hispanic**	**Black**	**Am. Indian**	**Asian**	**Other**	
7.4	4.2%	1.6%	92.8%	0.0%	0.0%	1.4%	
17.1	13.6%	7.5%	76.2%	1.9%	0.1%	0.6%	
51.1	13.3%	3.2%	82.8%	0.2%	0.0%	0.5%	
55.1	4.8%	19.6%	38.1%	34.3%	0.0%	3.2%	
55.2	9.7%	30.8%	42.5%	11.1%	1.8%	4.1%	
55.3	9.8%	25.4%	59.3%	1.5%	1.2%	2.8%	
56.1	8.2%	46.7%	35.5%	4.3%	0.5%	4.8%	
61.3	7.9%	7.2%	81.9%	0.2%	0.6%	2.3%	
66.1	77.8%	17.0%	1.4%	2.5%	0.9%	0.5%	
66.2	12.2%	14.0%	57.3%	14.1%	0.1%	2.3%	
69.1	28.9%	3.8%	59.4%	5.7%	0.3%	2.0%	
69.2	37.9%	5.9%	53.7%	0.7%	0.1%	1.7%	
71.1	67.7%	24.0%	4.5%	1.3%	0.6%	1.9%	
71.3	77.6%	17.8%	2.6%	0.2%	0.4%	1.4%	
101.1	12.5%	50.6%	28.9%	4.3%	1.4%	2.3%	
108.1	88.4%	8.3%	1.0%	0.5%	0.9%	0.9%	
108.2	84.5%	8.5%	1.9%	1.3%	0.9%	2.9%	
116.1	86.7%	8.2%	3.7%	0.4%	0.3%	0.8%	
116.2	78.9%	19.2%	0.5%	0.2%	0.0%	1.2%	
117.1	6.8%	15.2%	72.5%	0.7%	0.7%	4.2%	
117.2	23.2%	46.6%	26.0%	0.8%	0.2%	3.1%	
118.2	3.0%	10.1%	84.3%	0.3%	0.0%	2.3%	
1.03.2	8.5%	2.9%	86.3%	0.2%	0.3%	1.8%	
112.01.1	61.7%	7.0%	27.6%	1.0%	0.6%	2.1%	
112.01.2	81.7%	14.3%	0.6%	0.6%	0.3%	2.5%	
112.01.5	90.2%	6.7%	0.1%	1.1%	0.3%	1.6%	
112.03.1	10.9%	39.1%	49.4%	0.0%	0.6%	0.0%	
113.02.1	24.1%	31.4%	39.4%	0.8%	1.3%	2.9%	
113.03.1	89.3%	8.7%	0.4%	0.2%	0.4%	1.1%	
113.03.2	89.5%	7.8%	0.7%	0.5%	0.5%	1.0%	
113.04.1	48.1%	18.5%	32.4%	0.3%	0.1%	0.5%	
113.04.2	75.5%	7.5%	12.6%	2.0%	0.3%	2.0%	
13.03.2	21.3%	14.1%	62.2%	0.3%	0.4%	1.7%	
Orange							
Census Tract	**White**	**Hispanic**	**Black**	**Asian**	**Am. Indian**	**Other**	
202.1	44.1%	4.2%	49.3%	0.1%	0.0%	2.3%	

Table 6, continued

202.2	14.6%	4.6%	78.7%	0.7%	0.1%	1.3%	
202.3	38.8%	8.2%	51.1%	0.1%	0.2%	1.6%	
202.4	7.3%	2.3%	88.9%	0.0%	0.0%	1.5%	
203.1	87.8%	3.6%	6.2%	0.6%	0.1%	1.6%	
203.2	75.5%	10.4%	10.6%	1.1%	0.5%	2.0%	
203.3	74.0%	7.3%	15.9%	0.5%	0.6%	1.6%	
205.1	81.6%	9.4%	4.6%	0.6%	0.3%	3.5%	
205.2	79.9%	11.9%	5.4%	0.5%	0.9%	1.3%	
205.3	78.2%	7.8%	9.3%	0.7%	1.1%	2.9%	
205.4	70.3%	20.1%	6.5%	0.5%	0.4%	2.1%	
207.1	86.9%	4.4%	1.5%	4.9%	0.5%	1.8%	
208.1	81.0%	3.8%	12.4%	0.0%	1.1%	1.7%	
208.2	68.8%	5.8%	21.2%	1.0%	0.7%	2.5%	
209.1	46.2%	5.4%	44.1%	1.2%	0.3%	2.8%	
209.2	30.1%	7.8%	57.7%	2.0%	1.0%	1.4%	
209.3	57.0%	4.8%	33.2%	3.6%	0.1%	1.3%	
209.4	40.2%	2.9%	53.2%	1.0%	0.3%	2.4%	
210.1	88.4%	3.7%	3.9%	0.7%	0.7%	2.5%	
211.1	92.1%	3.7%	0.8%	0.5%	0.2%	2.6%	
216.1	92.6%	5.0%	0.1%	0.1%	1.3%	0.9%	
216.3	95.1%	2.8%	0.0%	0.2%	0.4%	1.6%	
217.1	92.6%	3.8%	0.1%	1.6%	0.9%	1.0%	
217.2	90.9%	6.7%	0.1%	0.4%	0.4%	1.5%	
219.5	92.1%	4.9%	0.3%	0.3%	0.5%	1.9%	
219.6	92.2%	3.8%	0.1%	1.0%	0.6%	2.3%	
220.2	91.9%	5.1%	0.6%	0.2%	0.1%	2.1%	
220.3	91.7%	5.9%	0.1%	0.2%	0.7%	1.4%	
222.1	97.5%	1.5%	0.2%	0.0%	0.3%	0.5%	
222.2	88.4%	6.7%	0.7%	1.1%	1.1%	1.9%	
223.1	69.8%	23.4%	0.1%	2.9%	0.5%	3.3%	
223.2	92.1%	4.1%	0.6%	1.6%	0.1%	1.6%	
223.3	88.5%	6.3%	0.1%	2.3%	1.0%	1.7%	
223.4	92.0%	4.3%	0.0%	1.9%	0.2%	1.6%	
223.5	92.4%	4.8%	0.0%	0.8%	0.5%	1.4%	
224.1	89.8%	6.1%	0.1%	1.6%	0.1%	2.3%	
224.2	87.7%	6.0%	0.8%	2.8%	0.5%	2.1%	
224.3	92.1%	5.0%	0.1%	1.7%	0.0%	1.2%	
224.4	84.0%	9.4%	0.4%	2.3%	0.4%	3.4%	
224.5	86.3%	7.6%	0.2%	3.0%	0.2%	2.7%	

Source: U.S. Bureau of the Census, 2010

In assessing the existence of low-income populations for the study area, mean household incomes were examined for all of the study area Census tracts. Based on a poverty threshold for a family size of three (considering that average number of persons per household for each county ranged from 2.53 to 2.85), an income of $17,373 was used for comparison. None of the census blocks fall below this poverty threshold. Table 7 presents the median income for each census block in the study area and the amount by which the median income per block is above the poverty threshold.

Table 7. Comparison of Median Household Income to Poverty Threshold

Brazoria		
Census Tract	**Mean Income ($)**	**Amount Above Threshold ($)**
6617	$69,081	$51,708
6624	$71,093	$53,720
6634	$79,836	$62,463
6640	$43,502	$26,129
6641	$69,890	$52,517
6642	$52,756	$35,383
6643	$45,711	$28,338
6644	$51,619	$34,246
6645.01	$58,736	$41,363
Jefferson		
Census Tract	**Mean Income ($)**	**Amount Above Threshold ($)**
1.03	$24,042	$6,669
7	$32,178	$14,805
51	$36,852	$19,479
55	$37,200	$19,827
56	$38,209	$20,836
61	$35,204	$17,831
66	$46,176	$28,803
69	$55,319	$37,946
71	$52,409	$35,036
101	$42,027	$24,654
108	$57,895	$40,522
113.02	-	-
113.03	$58,886	$41,513
113.04	$91,518	$74,145
116	$65,128	$47,755
117	$31,085	$13,712

Table 7, continued

118	$35,397	$18,024
Orange		
Census Tract	**Mean Income ($)**	**Amount Above Threshold ($)**
202	$35,156	$17,783
203	$46,024	$28,651
205	$44,221	$26,848
207	$55,514	$38,141
208	$56,216	$38,843
209	$53,690	$36,317
210	$79,447	$62,074
211	$68,920	$51,547
216	$54,361	$36,988
217	$51,534	$34,161
219	$49,657	$32,284
220	$46,415	$29,042
222	$89,753	$72,380
223	$76,427	$59,054
224	$62,656	$45,283

Source: U.S. Bureau of the Census, 2010

1.9 ASSESSMENT OF PROTECTED POPULATIONS AND POTENTIAL IMPACTS

1.9.1 Orange-Jefferson CSRM

The potential for impacts from the Tentatively Selected Plan on protected populations exists primarily at the Orange-Jefferson CSRM since it encompasses the construction of new levees and floodwalls. Both Freeport and Port Arthur have systems that are being proposed for improvements over their existing conditions. For the purposes of making a determination on the potential for impacts on potentially protected populations, the racial makeup of the Census block groups that intersect the footprint of the proposed features of the Orange-Jefferson portion of the TSP were examined. Of the eleven Census block groups, only one displayed a population where more than 50 percent of the population was non-white. Census block 202.1 has a white population of 44.1 percent with the remaining belonging to historically identified minority groups. There is no indication that populations may be protected on the basis of existing income among these Census block groups. Census block 202.1, however, resides at the very end of the Orange 3 reach of the proposed TSP in Orange County where impacts would not be expected to be as great as the potential impacts in other areas. Regardless, there should be no disproportionate impacts on the populations in this Census block.

1.9.1.1 County Economic Profile

To compare economic sectors of the three counties with those of the study areas within those three counties, information in Table 8 was obtained from the 2007 County Business Patterns, which outlines the number of employees and establishments for the major North American Industry Classification System (NAICS) classifications. The table gives the total number of employees per broad NAICS category for the three counties and for the zip codes that intersect the study areas within the three counties.

Table 8. 2010 County and Study Area Civilian Employment by NAICS Sector

	Brazoria County		Study Area	
Sector	**Number**	**Percent**	**Number**	**Percent**
Total Employees	142,798	100%	44,289	100%
Agriculture, Forestry, Fishing and Hunting, and Mining	3,588	2.5%	1,341	3.0%
Construction	13,429	9.4%	0	0.0%
Manufacturing	19,645	13.8%	7,069	16.0%
Wholesale Trade	4,598	3.2%	1,118	2.5%
Retail Trade	14,176	9.9%	5,755	13.0%
Transportation and Warehousing, and Utilities	7,485	5.2%	2,616	5.9%
Information	2,449	1.7%	726	1.6%
Finance and Insurance, and Real Estate and Rental and Leasing	7,106	5.0%	2,150	4.9%
Professional, Scientific, and Management, and Administrative and Waste Management Services	15,207	10.6%	4,344	9.8%
Educational Services, and Health Care and Social Assistance	32,421	22.7%	9,624	21.7%
Arts, Entertainment, and Recreation, and Accommodation and Food Services	9,164	6.4%	4,177	9.4%
Other Services, except Public Administration	6,777	4.7%	2,947	6.7%
Public Administration	6,753	4.7%	2,422	5.5%
	Jefferson County		**Study Area**	
Sector	**Number**	**Percent**	**Number**	**Percent**
Total Employees	102,898	100%	67,201	100%
Agriculture, Forestry, Fishing and Hunting, and Mining	1,289	1.3%	973	1.4%
Construction	10,321	10.0%	7,767	11.6%
Manufacturing	11,433	11.1%	7,643	11.4%
Wholesale Trade	2,236	2.2%	1,307	1.9%
Retail Trade	11,913	11.6%	7,950	11.8%
Transportation and Warehousing, and Utilities	5,399	5.2%	3,358	5.0%
Information	1,465	1.4%	906	1.3%
Finance and Insurance, and Real Estate and Rental and Leasing	4,461	4.3%	2,866	4.3%

Table 8, continued

Professional, Scientific, and Management, and Administrative and Waste Management Services	9,573	9.3%	5,978	8.9%
Educational Services, and Health Care and Social Assistance	24,852	24.2%	15,638	23.3%
Arts, Entertainment, and Recreation, and Accommodation and Food Services	8,267	8.0%	5,643	8.4%
Other Services, except Public Administration	5,788	5.6%	3,705	5.5%
Public Administration	5,901	5.7%	3,467	5.2%
	Orange County		**Study Area**	
Sector	**Number**	**Percent**	**Number**	**Percent**
Total Employees	34,026	100%	34,026	100%
Agriculture, Forestry, Fishing and Hunting, and Mining	389	1.1%	389	1.1%
Construction	4,257	12.5%	4,257	12.5%
Manufacturing	6,338	18.6%	6,338	18.6%
Wholesale Trade	659	1.9%	659	1.9%
Retail Trade	4,226	12.4%	4,226	12.4%
Transportation and Warehousing, and Utilities	1,700	5.0%	1,700	5.0%
Information	332	1.0%	332	1.0%
Finance and Insurance, and Real Estate and Rental and Leasing	1,283	3.8%	1,283	3.8%
Professional, Scientific, and Management, and Administrative and Waste Management Services	2,433	7.2%	2,433	7.2%
Educational Services, and Health Care and Social Assistance	6,877	20.2%	6,877	20.2%
Arts, Entertainment, and Recreation, and Accommodation and Food Services	2,142	6.3%	2,142	6.3%
Other Services, except Public Administration	2,435	7.2%	2,435	7.2%
Public Administration	955	2.8%	955	2.8%

Source: U.S. Bureau of the Census, 2010

In terms of total employment, both Brazoria County and the study area within Brazoria County have more Educational Services and Health Care and Social Assistance employees than any other business sector. This also true for Jefferson County and Orange County.

Sabine Pass to Galveston Bay, Texas
Coastal Storm Risk Reduction and Ecosystem Restoration
Draft Integrated Feasibility Report and Environmental Impact Study

Draft Appendix S

List of Preparers

September 2015

LIST OF PREPARERS

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Distribution List

September 2015

Appendix T - Study Distribution List

The following is a list of agencies, organizations, and persons to whom copies of the Notice of Availability for the Draft Integrated Feasibility Report/ Environmental Impact Statement with be sent. The document will be available for review on the Galveston District website (www.swg.usace.army.mil/) and compact disc copies of the report will be available on request.

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2C3	V.I.T., Inc.
Vastar Resources, Inc	Western Seafood
Wetland Technologies Corporation	Williams Gas Pipeline - Transco
Younger & Associates	
Individuals	
Abbott, James R.	Acrey, Rose Mary
Adams, Stacy	Anderson, Thomas & Patricia
Andrews, Serena	Anene, Darlene
Arnaud, Eddie	Austin, Michael
Bailey, Lisa	Bailey, James & Charlotte
Barker, Glen	Baker, Curtis
Barras, Leslie	Barksdale, Woody T. & Leta W.
Barth, Kathleen	Barrington, Ray
Batty, Barbara	Baughman, Michael
Becker, Al & Sandra	Bell, Regina
Bellard, Mary Ellen	Bellmyer, Larry
Benavides, Sarah	Benner, Tricia & Steve
Benoit, Dick	Benoit, Katie
Berlitz, Richard	Bevill, Anna
Bissel, Alice	Black, Clifton
Blake, Frank	Blansit , Frankie and Max
Bludworth, Richard	Blumentritt, David
Bolcar, Blinn S.	Bourg, John
Boyce, Judith	Boykin, Cecil
Breeland , Joanne	Brennan, Ron & Mary Ellen
Brennan, Jeff	Brizendine, Kim
Broussard, Dwight J. & Ann	Brown, James Jr.
Brown, Colleen & Delbert	Browne, Richard
Bryan, JP & Cassie Perry	Buckman, Steve & Kelly
Burch, Ralph	Burgess, Selmer Ray
Burkett, Winnie	Burns, Don & Millicent
Boudreaux, Lowell	Burns, Kevin
Butler, George	Caldwell, Mary C.
Cacioppo, James	Casey, Terry
Carraway, Rosemary	Charvoz, David
Chimenti, Katie	Chand, Dan
Christensen, Scott	Chang, Nelson
Clark, Ken	Christen, Barry & Elizabeth
Coleman, Steven	Christensen,J anice & Marc
Cornelison, Theresa	Clinton, Russell
Coward, Alfred Jr.	Cooley, James
Crist, James & Wanda	Cortney, Dennis
Crouch, Billy	Crawford, John
Cuclis, E.J. (Tery) & Velda	Crocker, Glen
Cunningham, Peter and Marilyn	Cruse, Leonard
Cunningham, Luther	Damon, John
Davenport, Tobey	Daigre, JoAnne
Deshotel, Russell	Danz, Suzanne

Federal, State and Local Government Representatives and Agencies	
Dodson, Mary	Davis, Roger
Dolan, Garrett Ph.D.	Dickenson, Richard
Dunlap, Sherri	Dudney, Newton E. & R. Fay
Durand, Eugene E.	Dupaquier, Lauri
Durham, Bob	Edwards, James
Edwards, Roy	Ehlers, Louis
Eichhorn, Greg	Eisen, Bill
Erickson, Jon	Evans,Troy
Farmer, Stuart	Flaniken, Greg
Ferguson, Cecil & Kay	Flickinger, David
Fitzgerald , Tyler	Flickinger, Marie
Flannigan, Michael	Flowers, Jim & Caty
Fowkes, Wayne	Frankie, Edward
Fratila, Nick P.E.	Freeman, Steven
Fuka, Lisa	Gallagher, Andrew
Garner, B.J. & Laura	Gardner, George
Gatten, Kenneth & Glenda	Garst, Jean
Gilmore, Ira & Carolyn	Germany, Garvin
Goodman, Teri	Glanton, Theo
Graham, James C. & Wanda L.	Goodwin, Theresa
Green, James	Gratzfeld, George & Norma
Gupta, Rohan	Greer, Faye & Lewis
Guthery, Lemuel & Jo	Guth, Sandra
Halbach, Joe	Hahn, Oscar
Hambright, Betty & Rhea	Halle, Roy &Carole
Hanks, Wayne	Hammond, Mark
Harder, James	Hannah, John
Harris, Gary	Hargrove, John
Harrison, Ray	Harris, Jack & Mary Ellen
Hawkins, Charles	Hatchett, Thomas &Lou Ellen
Heckendorn, Rob	Hays, Jack
Heinly, Joanie	Hesley, Susan
Hill, Carl & Connie	Hodge, Mike
Holbrook, Ray	Hodgson, Charles
Horecky, Carl	Hood, Jeremy & Janet Grobe
Howard, Spencer	Horn, Dennis & Mary
Hudson, Wade & Nancy	Hughes, James & Shirley
Dusek, Imogene (Jean)	Illerich, Daniel & Mary
Iyer, Aishwarya	Island, Gordon
Jalowy, David	Jackson, Kathleen
Jenkins, Mike	James, George & Sonia
Jess, Raymond	Jenkins,Mabelee
Johnson, Don	Johnson, Cheryl
Jones, Scott	Johnson, Mark
Keeney, Jon	Keele, Betty & Bevard
Keschinger, Richard	Kelly, Carol
Kie, Bruce & Jean	Key, Lonnie
Kirby, Meta	King, Craig
Knight, Phillip	Kneupper, Doug
Kocurek, David	Kobayashi, Herbert
Kologinczak, Teresa	Kouches, J

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Lang, L.G.	Larsen, Ivar
Ledkins, Thomas	Leech, Ted
Legendre, Abel & Audrey	Leheny, Lisa
Lelsz, David	Lenamon, Ben
Lester, Phil	Lloyd, Lila
Lotz, Frank & Tricia	Luce, Jay
Luycx, Susan	Machol, John
Mallios, Laura	Maloney, Donna
Mannchen, Brandt	Marcott, Larry
Marlow, Marie	Martin, Jacqueline
Martin, Betty	Martin, Trent
Masters, Jerry	Mastrofrancesco, Nancy
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McAlister, Gay	McCloskey, Meghan
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McGaughy, Belinda	McKay, Scott
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Miley, Joyce	Miller, David
Miller, Frederic	Mills, Stephen
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Mitchell, Julea	Moon, Ronald
Moon, Dennis	Mooney, Sonny
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Morrison, W.J.	Mowery, Curt
Mullins, Erin	Murphy, Jack
Nealy, Jimmy	Nelson, Oscar
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Nikolis, William	O'Brien, Catherine
O'Donell, Alice Anne	O'Kane, Ramona
O'Keeffe, Dennis	Oldham, Melanie
O'Neill, Natalie	Ong, Natalie
Orsak, Charles	Osburn, Richard
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Oxford, Hubert III	Parker, Robin
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Perkowski, Edward & Trudi	Phillips, John
Pirtle, Shane	Polah, Victor
Pool, Tom	Poor, Barry
Porter, Brooks W.	Powell, Darrell
Ramey, T.B. Jr.	Randall, Charlie & Paula
Rasch, Hans and Ann	Ratcliff, Jeremy
Reed, Christine	Reeves, Rose
Reisert, Donald	Reitan, Leo
Reixach, A.J.	Reynolds, Jeffery M.

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Roberts, Joseph & Josephine	Robinson, John & Bertha Lee
Roark, Karen	Roberts, Joseph Wayne
Roder, Charles	Rodriguez, Angela
Roesler, Doug	Rosen, Judy
Ryan, Barbara	Ryder, Drew
Saccomanno, Jim	Salatkowski, Ken
Salmen, Fred	Sawyer, Ralph
Schoellkopf, F.C.	Schroeder, Bert
Schenke, Diane	Schubert, Jamie
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Seidule, Frank	Seymour, Chris
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Smith, Ron	Smith, Barbara
Smith, David	Smith, Edward
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Stevens, Chris	Stevens, Frank W.
Stevens, Elizabeth & Guy	Stewart, Sharron
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Strate, K.C.	Strube, Kim
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Taylor, Larry	Taylor, Joel
Taylor, Charles & Susan	Taylor, Christie Walne
Tobin, Laurence	Thompson, James
Treiman, Allan and Diane Humes	Trapman, August & Jeanie
Turberville, Mary	Troxell, Robert
Underwood, David	Tully, John
Van Dussen, Neal	Valek, Millicent
Vaughan, Scott & Helen	Vargas, Karen
Walden, Louis	Wagner, Liz
Wallace, Bernice	Walker, George
Wang, Richard	Ward, Rex
Warren, Al	Warren, Mary B.
Weisiger, Craig & Sheri	Webb, Pat
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Whitaker, Harold	Whitcomb, J.
Whiteley, Linda	Whitworth, Mary Ellen
Whynott, Virginia	Wiesenborn, Robert
Wilcox, Charles	Williams, Kenneth
Williams, Jim	Williams, Donald

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Ethel & Erwin Wind	Yandell, Sandra
Dan Yarberry	Yarnall, Ann
Yost, Mike	Zeigler, Ila & John
Zolandz, Julia	