Coastal Texas Protection and Restoration Feasibility Study

Final Feasibility Report

Appendix E-1:

Economics for the Coastal Storm Risk Management - Upper Texas Coast

August 2021

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PART 1: BACKGROUND INFORMATION

INTRODUCTION

General. This appendix presents an economic evaluation of the coastal storm risk management alternatives for Region 1 of the Coastal Texas Protection and Restoration (CTPS) Feasibility Study. The overflow area includes large portions of four counties (Brazoria, Chambers, Galveston and Harris) in the Galveston/South Houston area and several small communities located in Jefferson and Orange counties. The analysis was prepared in accordance with Engineering Regulation (ER) 1105-2-100, Planning Guidance Notebook, and ER 1105-2-101, Planning Guidance, Risk Analysis for Flood Damage Reduction Studies. The National Economic Development Procedures Manual for Flood Risk Management and Coastal Storm Risk Management, prepared by the Water Resources Support Center, Institute for Water Resources, was also used as a reference, along with the User's Manual for the Hydrologic Engineering Center Flood Damage Analysis Model (HEC-FDA).

The economic appendix consists of a description of the methodology used to determine the National Economic Development (NED) damages and benefits under existing and future conditions and the projects costs. The analysis prepared for the Tentatively Selected Plan (TSP) SMART planning milestone used FY 2018 (October 2017) price levels, the FY 2018 Federal discount rate of 2.5 percent and a 50-year period of analysis with the year 2035 as the base year.

For the Recommended Plan, the HEC-FDA modeling was conducted for the years 2035 and 2085, and the damages and benefits were calculated using FY 2021 (October 2020) price levels, the FY 2021 Federal discount rate of 2.5 percent for a 50-year period of analysis. However, the base year for the Recommended Plan was changed from the year 2035 to the year 2043 due to an eight-year increase in the construction period, and the analysis period was extended to the end of the year 2092. The equivalent annual damage and benefit estimates were compared to the annual construction costs and the associated Operation, Maintenance, Repair, Replacement and Rehabilitation (OMRR&R, or more commonly O&M) costs for each of the project alternatives.

NED Benefit Categories Considered. The NED procedure manuals for coastal and urban areas recognize four primary categories of benefits for flood risk management measures: inundation reduction, intensification, location, and employment benefits. The majority of the benefits attributable to a project alternative generally result from the reduction of actual or potential damages caused by inundation. Inundation reduction includes the reduction of physical damages to structures, contents, and vehicles and indirect losses to the national economy.

Physical Flood Damage Reduction. Physical flood damage reduction benefits include the decrease in potential damages to residential and commercial structures, their contents, and the privately owned vehicles associated with these structures. Two other categories of physical flood damage reduction benefits were also considered: the decrease in damages to transportation infrastructure (highways, streets and railroad tracks); and the decrease in damages to above ground storage tanks and their contents. While both existing and future conditions were considered in the economic analysis, future development was not included in the HEC-FDA modeling for the Recommended Plan

Indirect Losses to the National Economy. Indirect losses to the national economy result from disruptions in the production of goods and services by the industries affected by the storm. Normal business operations can be curtailed because workers are displaced, structures are inundated and flooded roads limit access to the facilities. The associated net losses in gross domestic product (GDP) for the national economy were also estimated for this evaluation.

Emergency Cost Reduction Benefits. Emergency costs are those costs incurred by a community during and immediately following a major storm. The cost of debris removal from inundated residential and non-residential structures was the only emergency cost reduction benefit considered for this analysis.

NED Benefit Categories Not Considered. The following NED benefit categories were not addressed in this economic appendix either because there was insufficient data to fully incorporate them in the analysis or because they would not provide a significant contribution to the total NED benefits attributable to the project alternative:

- costs associated with evacuation and reoccupation activities before, during and following a flood event incurred by property owners and governments;
- costs of cleanup of oil spills and restoration of petroleum storage tanks on industrial properties following a flood event;
- increased cost of operations for large industrial facilities, in particular the oil and gas industry, following a flood event relative to normal business operations;
- losses to agricultural crops.

Regional Economic Development. When the economic activity lost in a flooded region can be transferred to another area or region in the national economy, these losses cannot be included in the NED account. However, the impacts of the expenditures associated with the Recommended Plan on the employment, income, and output of the regional economy are considered part of the RED account. The input-output macroeconomic model RECONS was used to address the impacts of the construction spending associated with the project alternatives. The RED impacts associated with the Recommended Plan are shown in Appendix E-4.

DESCRIPTION OF THE STUDY AREA

Geographic Location. The Coastal Texas study area, which includes the entire Texas coastline from the mouth of the Sabine River at the Texas/Louisiana border to the mouth of the Rio Grande near Brownsville, Texas, was divided into four regions. Only the CSRM alternatives for Region 1 were analyzed in this part of the Economics Appendix. Region 1 includes portions of Brazoria County in the southern portion of the region, portions of Chambers, Galveston and Harris counties (Galveston/South Houston area) in the central portion of the region, and several small communities in Jefferson and Orange counties in the northeastern portion of the region. An inventory of residential and non-residential structures was developed for the portions of Region 1 impacted by storm surges associated with the future without project condition 0.001 (1,000 year) AEP event. The structures in Jefferson and Orange counties were not included in the overflow area because these counties will receive flood risk reduction from the proposed Sabine to Galveston project. Figure 1 shows the structure inventory and the boundaries of the counties along with the proposed alignment for the Recommended Plan.

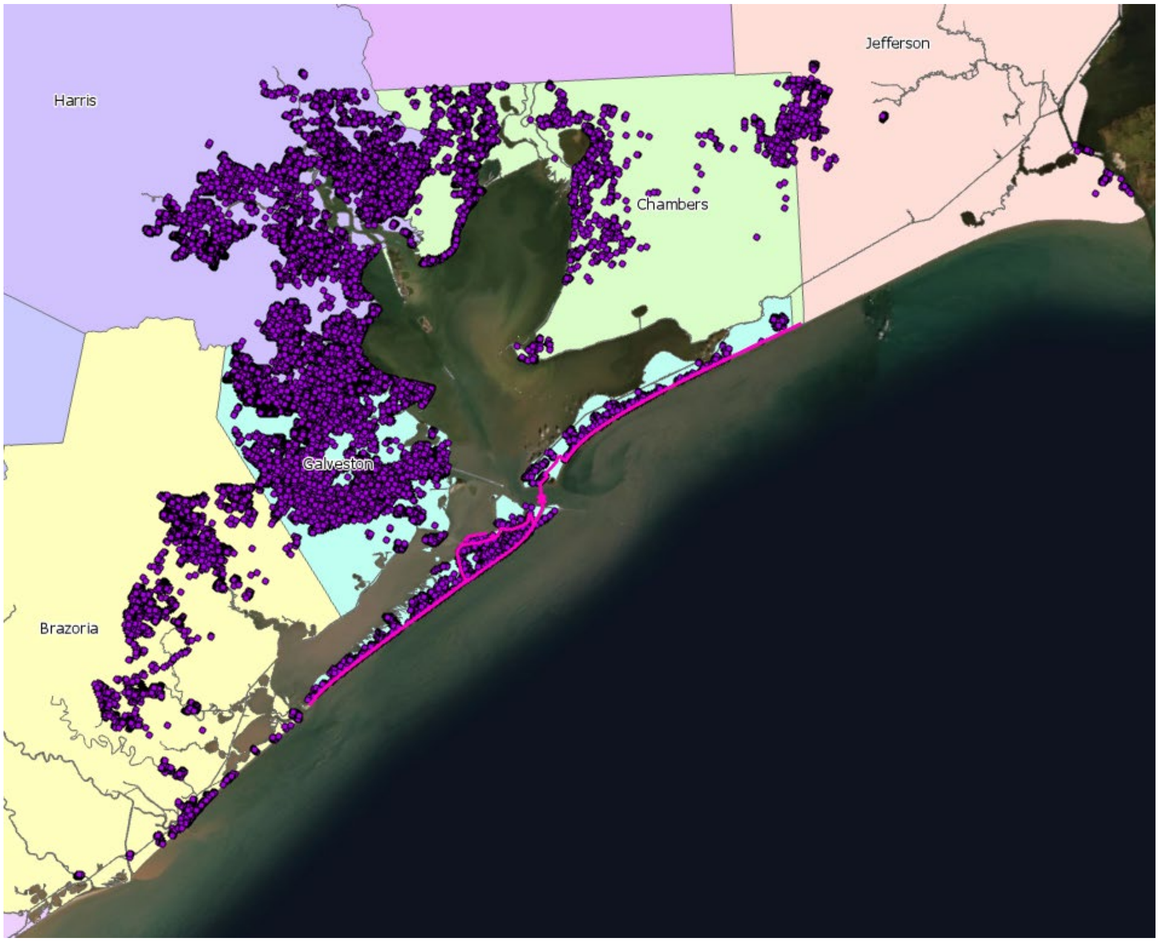


Figure 1 - County Boundaries, Structure Inventory, and Proposed Alignments

The overflow area was divided into 42 study area reaches containing 2,587 stations, or smaller geographic areas, with unique stage-probability relationships. These stations were used to calculate flood damages using Version 4.1.2 of the HEC-FDA certified model. Figure 2 shows the county boundaries in white and the study area reach boundaries in yellow.

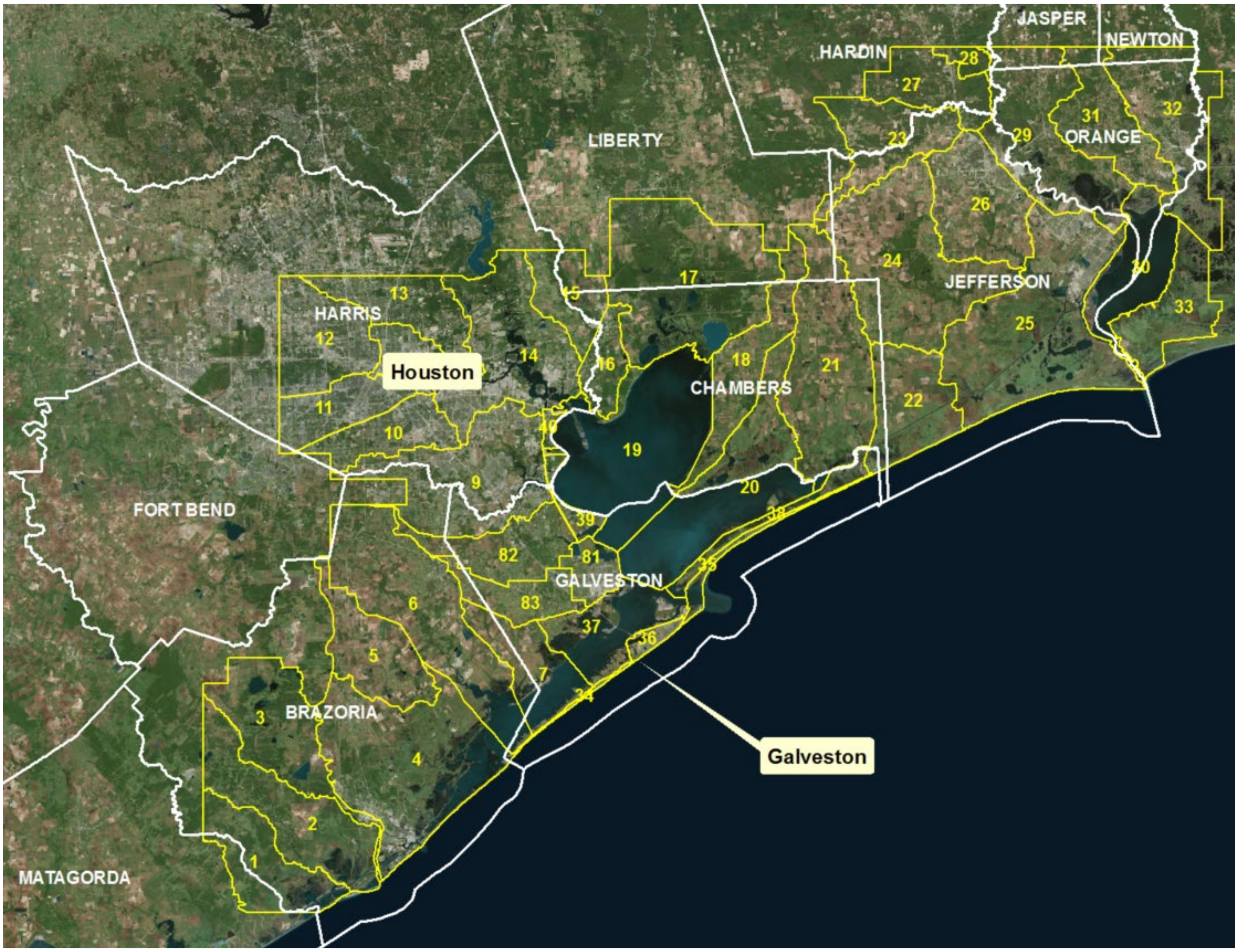


Figure 2 - Study Area Reaches for Region 1.

Land Use. The total number of acres of developed land, agricultural land and undeveloped land in the four major counties in Region 1 of the study area (Brazoria, Chambers, Galveston, and Harris) is displayed in Table 1. As shown in the table, 41 percent of the total acres in the study area are currently developed. Since there are slightly over 757,000 acres of agricultural land and 698,000 acres of undeveloped land, there is sufficient land available to accommodate the projected residential and non-residential development through the year 2084. This projected future development is expected to be located on parcels with relatively high ground elevation and relatively low exposure to flood risk.

Table 1
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
Land Use in the Region 1 Study Area

Land Class Name	Acres	Percentage of Total
Developed land	996,605	41%
Agricultural Land	757,472	31%
Undeveloped Land	698,412	28%
Total	2,452,488	100%

Source: Based on Land Use data developed by the Galveston Houston Regional Council for Brazoria, Chambers, Galveston, and Harris counties of Region 1.
Note: Rice is the dominant crop in the area.

SOCIOECONOMIC SETTING

Population, Number of Households, and Employment. Tables 2, 3, and 4 display the population, number of households, and the employment (number of jobs) for four counties in Region 1 for the year 2010, as well as projections for the years 2015, 2020, 2035 and 2045. The 2000 and 2015 population, number of households and employment were based on estimates from the 2010 U.S. Census, and the projections through the year 2045 were developed by the Houston-Galveston Area Regional Council Forecast.

Table 2
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
Historical and Projected Population by County
(Thousands)

County	2010	2015	2020	2035	2045
Brazoria	313,166	342,796	394,110	522,253	725,002
Chambers	35,096	35,995	38,671	65,117	110,057
Galveston	291,309	311,807	338,520	425,723	502,181
Harris	4,092,459	4,468,113	4,835,762	6,002,910	6,539,791
Total	4,732,030	5,158,711	5,607,063	7,016,003	7,877,031

Source: U.S. Census and Houston-Galveston Area Council Regional Growth Forecast

Table 3
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
Projected Number of Households by County
(Thousands)

County	2010	2015	2020	2035	2045
Brazoria	106,589	124,719	144,996	197,229	279,708
Chambers	12,967	13,234	14,580	25,008	44,515
Galveston	115,685	119,789	129,130	163,765	196,953
Harris	1,536,259	1,593,148	1,726,726	2,216,515	2,485,984
Total	1,771,500	1,850,890	2,015,432	2,602,517	3,007,160

Source: U.S. Census and Houston-Galveston Area Council Regional Growth Forecast

Table 4
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
Projected Employment by County
(Thousands)

County	2010	2015	2020	2035	2045
Brazoria	92,057	113,315	120,961	172,436	286,849
Chambers	10,268	16,433	21,672	31,270	36,882
Galveston	100,892	130,215	134,347	144,987	148,175
Harris	2,107,125	2,482,334	2,665,583	3,257,098	3,597,670
Total	2,310,342	2,742,297	2,942,563	3,605,791	4,069,576

Source: Bureau of Economic Analysis and Houston-Galveston Area Council Regional Growth Forecast

Note: 2010 employment based on Wage and Salary Employment

Table 5 displays the estimated population of the inventoried portion of Region 1 for the year 2015 and the projected population for the years 2035 and 2084. The 2015 population estimate was based on the inventory of residential single-family residential and multi-family units within the future condition 0.001 (1,000-year) AEP overflow geographic area. The number of residential structures and multi-family units was multiplied by 2.7, the average number of persons per household in the study area in 2015, to estimate the population. An average of 20 units was applied to the apartment buildings if the actual number of units was unavailable. The 2035 and 2084 projected population for the inventoried area of Region 1 includes the number of residents in the existing development and the additional number of residents for the announced, or planned, and projected development forecasted by the Houston-Galveston Area Regional Council between 2015 and 2045. The residents associated with the announced, or planned, development were included for the year 2035, and the projected development beyond the announced development was used to estimate the population in 2084.

Table 5
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
Existing Condition and Projected Population Within Inventoried Study Area
(Thousands)

2015	2035	2085
642	763	1,095

Note: Population estimates assume 2.7 residents based on average household size and 20 housing units within a multi-family structure.

Income. Table 6 shows the per capita personal income levels for four counties for the years 2010, 2015, 2016, 2017 and 2018, the year with the latest available data.

Table 6
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
Per Capita Income
($ Dollars)

County	2010	2015	2016	2017	2018
Brazoria	36,917	45,606	45,539	45,575	47,239
Chambers	39,167	51,055	51,304	52,075	53,673
Galveston	40,689	50,017	48,289	49,618	51,785
Harris	45,745	53,874	50,511	53,708	56,474

Source: Bureau of Economic Analysis

Compliance with Policy Guidance Letter (PGL) 25 and Executive Order 11988. Given the growth trends in employment and income, it is expected that development will continue to occur in the study area with or without the storm surge risk reduction system. The Recommended Plan will not conflict with PGL 25 and EO 11988, which state that the primary objective of a flood risk reduction project is to protect existing development rather than make undeveloped land available for more valuable uses. The project will not induce development, but it will reduce the risk of the population being displaced after a major storm event.

RECENT FLOOD HISTORY

Tropical Flood Events. While Coastal Texas has periodically experienced localized flooding from excessive rainfall events, including Hurricane Harvey in 2017, the primary cause of flood damages has been the tidal surges associated with hurricanes and tropical storms. Between 1851 and the present, over 120 tropical events have made landfall along the Texas Gulf Coast. The paths and intensities of these storms are shown in Figure 3.

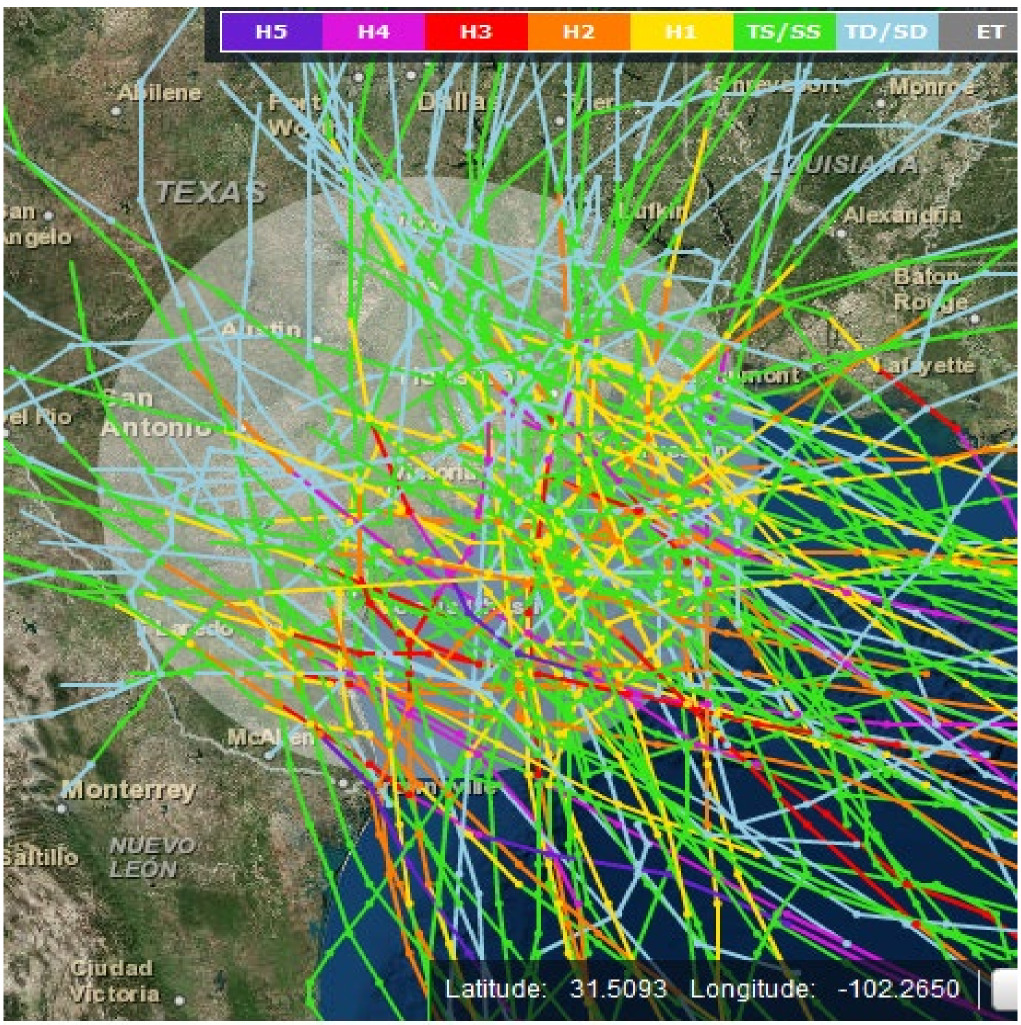


Figure 3 – Hurricane and Tropical Storm Paths Since 1851

FEMA Flood Claims. The two most recent tropical events to affect Region 1 of the Coastal Texas study area are Hurricane Ike in 2008 and Hurricane Harvey in 2017. Hurricane Ike brought storm surge damage mainly to the Galveston Bay area. Hurricane

Harvey in 2017 brought heavy tropical rains over an extended period to most of the Region 1 area, but relatively little storm surge damage to the area as compared to Hurricane Ike. The FEMA flood claims for Hurricane Ike in 2008 and Hurricane Harvey in 2017 are shown in Table 7. Table 8 shows the flood claims paid between 1978 and January 2018 (the most recent data available) for four counties in Region 1 of the Coastal Texas study area. The table includes the number of paid losses, the total amount paid, and the average amount paid on each loss in the dollar value at the time the claim was paid out to property owners. The table excludes losses that were not covered by flood insurance.

Table 7
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
Flood Insurance Claims

Event	Month/Year	Number of Paid Claims	Total Amount Paid
Hurricane Ike	Sep-08	46,683	$2.7 billion
Hurricane Harvey	Aug-17	Ongoing	Projected $11 Billion

Source: Federal Emergency Management Agency
Note: Price level used at time the claim was paid.

Table 8
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
FEMA Flood Claims by County
1978-31 January 2018
($ Dollars)

County	Number of Claims	Total Nominal Dollar Amount	Average Dollar Amount per Claim
Brazoria	7,961	$319,058,984	$40,078
Chambers	1,089	$59,688,763	$54,811
Galveston	15,503	$703,099,624	$45,352
Harris	39,062	$2,364,870,016	$60,541
Total	63,615	$3,446,717,387	$54,181

Source: Federal Emergency Management Agency
Note: Price level used at time the claim was paid.

SCOPE OF THE STUDY

Problem Description. The study area is characterized by low, flat terrain, which makes the area highly susceptible to flooding from the tidal surges of hurricanes and tropical storms. The apparent subsidence, or relative sea level rise, that has been taking place in the Coastal Texas study area is expected to magnify the flooding problems in the future.

The exposure of the Region 1 study area to coastal storm surge was made apparent by Hurricane Ike in September 2008, which made landfall just east of Galveston Island (see Figure 4). Approximately 80 percent of the structures were inundated with depths up to 6 feet, and the standing water allowed mold to invade the flooded structures. Transportation routes were impassable for several days after the storm, and this slowed emergency response times. The oil facility production between Galveston Bay and Houston was interrupted or shut down for several days. Storage tanks were separated from their foundations, and pipelines were ruptured. Oil spills occurred in the High Island area of Galveston County where storm surge rose over the low-lying oilfields. According to NOAA, 28 fatalities in Texas were related to Hurricane Ike. Figure 4 shows the satellite view of Hurricane Ike as it approached the Texas coast in 2008.

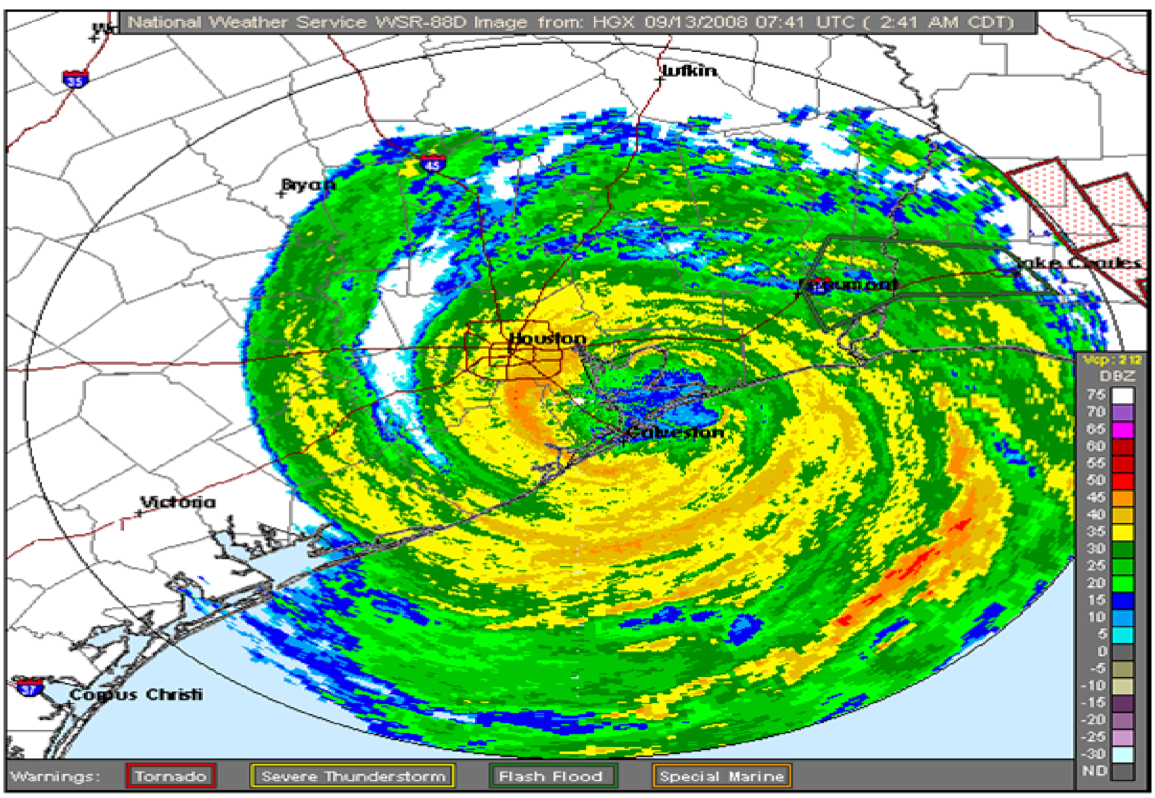


Figure 4 – Satellite View of Hurricane Ike

Project Alternatives (TSP Milestone). While several CSRM project alternatives were designed for Region 1 of the Coastal Texas study area, only Alternative A and Alternative D2 were considered as part of the economic evaluation for the TSP milestone. An economic analysis was also conducted for two nonstructural measures, which are independent of the two structural alternatives. These measures could also be used to reduce the residual risk associated with the structural alternatives.

Alternative A includes the construction of a coastal barrier system across Bolivar Peninsula, a closure at the pass at Bolivar Roads, improvements to the Galveston Seawall and a barrier along the western end of Galveston Island. These features are designed to reduce the impact of storm surges from the Gulf of Mexico. The alternative also includes the construction of a ring levee system surrounding Galveston Island, the construction of navigation gates and structures at Clear Lake and the construction of a ship channel structure near Galveston Bay. These features are designed to reduce the impact of wind-driven surges in Galveston Bay that could impact the backside of Galveston Island and the upper reaches of the bay. The alignment for Alternative A is shown in Figure 5.

Alternative D2 includes the construction of a levee system along Highway 146 on the west side of Galveston Bay from Texas City to the Hartman Bridge, which spans the Houston Ship Channel between Baytown and La Porte. The levee system ties into and improves the existing Texas City levee system and extends west into the communities of Hitchcock and Santa Fe. The plan also includes the construction of a surge gate at Clear Lake, a barrier at the Hartman Bridge and a ring levee surrounding Galveston Island. Impacts to navigation are minimized by this alternative. The alignment for Alternative D2 is shown in Figure 6.

Recommended Plan. After the TSP was released for agency technical review (ATR), independent technical review and public comments, two significant modifications were made to the feasibility design for the Recommended Plan. First, the levee/floodwall system across Bolivar Peninsula and Galveston Island was replaced with an engineered dune system to ensure compliance with existing policies and laws, specifically those related to the Coastal Barrier Resources Act (CBRA), and to minimize social and environmental impacts. . Second, due to policy concerns regarding the Ecosystem Restoration features, the out-year nourishment cycles were removed from the recommendation.

For Region 1 (Upper Texas Gulf Coast), the Galveston Bay surge barrier was formulated as a system with multiple lines of defense to reduce flood risk to communities, petrochemical and refinery complexes, federal navigation channels and the other existing infrastructure in the Galveston Bay area. The primary line of defense includes the following three components designed to reduce the volume of storm surge from the Gulf of Mexico entering Galveston Bay: a 2-mile storm surge gate at Bolivar Roads that crosses the entrance to the Houston Ship Channel between Bolivar Peninsula and Galveston Island; 43 miles of dune and berm segments located along Bolivar Peninsula and the western portion of Galveston Island; and improvements to a 10-mile seawall segment that provide an additional two to three feet of storm surge defense.

The interior line of defense enables the system to manage the residual risks of the primary defense alignment. Residual risks are driven by water already in Galveston Bay and any additional surge that could overtop the primary alignment. The interior features, which also provide resiliency against the variations in storm track and intensity, include each of the following: an 18-mile ring barrier designed to reduce the risk of bay water inundating neighborhoods, businesses and critical health facilities in Galveston; two surge gates on the western perimeter of Galveston Bay at Clear Creek and Dickinson Bayou designed to reduce storm surge volume from inundating homes and industrial facilities located along Galveston Bay; and nonstructural measures (acquisitions and structure elevations) designed to manage bay-surge risks along the west bank of Galveston Bay. Nonstructural measures were also proposed for the Channelview/West Point neighborhood on the north side of Galveston Island to mitigate the induced damages that could occur due to its location outside of the proposed ring barrier system.

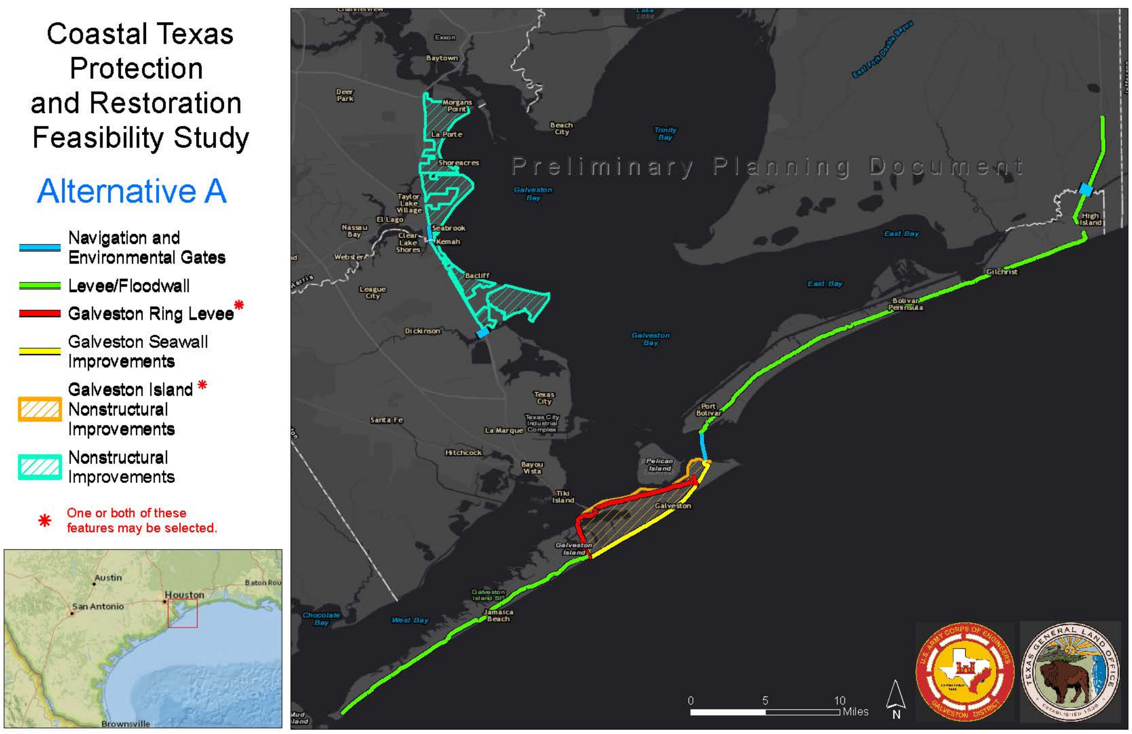


Figure 5 – Alignment for Alternative A

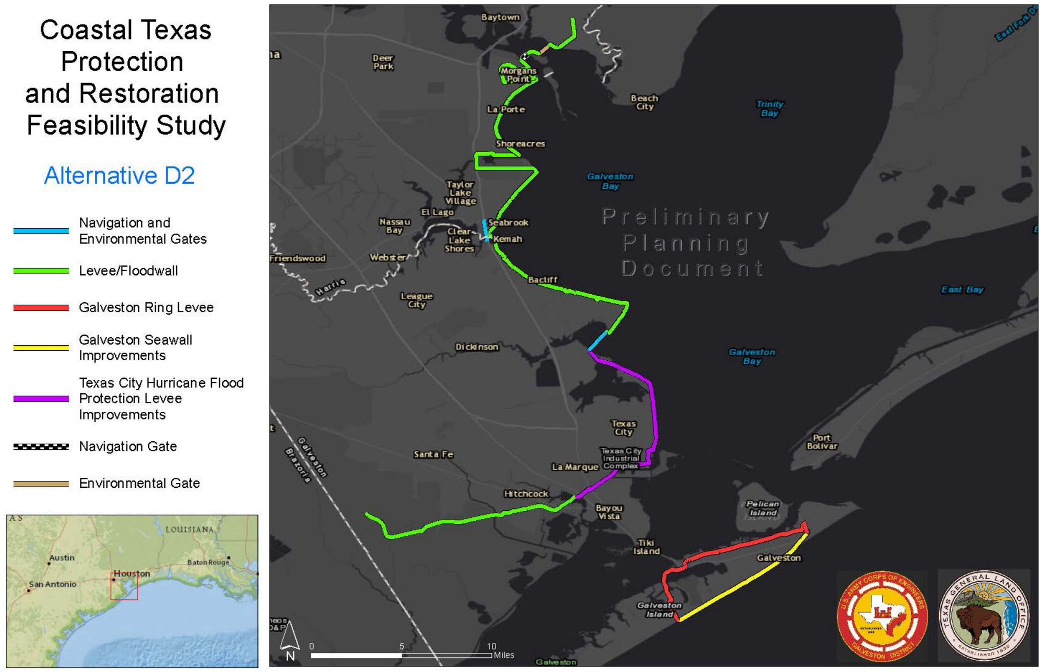


Figure 6 – Alignment for Alternative D2

PART 2: ECONOMIC AND ENGINEERING INPUTS TO THE HEC-FDA MODEL

HEC-FDA MODEL

Model Overview. The Hydrologic Engineering Center Flood Damage Analysis (HEC-FDA) Version 1.4.2 Corps-certified model was used to calculate the damages and benefits for the Coastal Texas CSRM evaluation. The economic and engineering inputs used by the model to calculate damages include the existing condition structure inventory, future development structure inventory, contents-to-structure value ratios, vehicles, first-floor and ground elevations, and depth-damage relationships, and without-project and with-project stage-probability relationships. For the TSP milestone and the initial analysis for the Recommended Plan, the model results were calculated using the year 2017 as the current year of analysis, the year 2035 as the project base year, the year 2084 as the final year in the period of analysis and FY 2021 (October 2020) price levels. In the final analysis for the Recommended Plan, the base year was changed from the year 2035 to the year 2043 to reflect an 8-year increase in the construction period. The HEC-FDA model results for the years 2035 and 2084 were used with straight-line interpolation in spreadsheet format to calculate damages using the new base year for the project.

The uncertainty surrounding each of the economic and engineering variables was also entered into the model. Either a normal probability distribution, with a mean value and a standard deviation, or a triangular probability distribution, with a most likely, a maximum and a minimum value, was entered into the model to quantify the uncertainty associated with the key economic variables. A normal probability distribution was entered into the model to quantify the uncertainty surrounding the ground elevations. The number of years that stages were recorded at a given gage was entered for each study area reach to quantify the hydrologic uncertainty or error surrounding the stage-probability relationships.

ECONOMIC INPUTS TO THE HEC-FDA MODEL

Structure Inventory. A structure inventory of residential and non-residential structures for the central (Chambers, Galveston and Harris counties) and southern portions (Brazoria County) of Region 1 of the Coastal Texas study area was obtained from a contractor working for the local sponsor and modified by Corps personnel. The structure inventory was based on county assessor databases reflecting development in the year 2014 for Brazoria, Chambers, Galveston, Harris, Jefferson and Orange counties and included the location, square footage and occupancy classification of each of the structures. After initial windshield surveys were conducted of the study area, the following modifications were made:

- Structures located outside of the overflow area, primarily in Jefferson and Orange counties, were removed from the structure inventory database;
- Ground elevations were assigned base on LiDAR data, and foundation heights were assigned based on Google Earth Street View and sampling techniques;
- Total depreciated structure values were calculated based on the 2017 RS Means Square Foot Catalog;
- Depth-damage functions were assigned to structure categories and structure occupancies;
- Stations (smaller geographic areas within a reach having consistent water surface profiles) and study area reaches (larger geographic area, containing stations, used to report damage results) were assigned to individual structures using GIS tools.

Table 9 shows the total number of residential, mobile homes, commercial, industrial and vehicles associated with residential units by study area reach representing the analysis year 2017.

Table 9
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
Number of Structures Under Existing Conditions (2017)

Reach Name	Residential	Mobile Homes	Commercial	Industrial	Vehicle	Total Structures
1	3	0	2	0	3	5
2	109	7	14	0	116	130
4	3,840	239	437	0	4,084	4,516
5	1,752	60	206	0	1,813	2,018
6	2,194	438	146	71	2,653	2,849
7	2,936	29	49	6	2,978	3,020
9	55,587	106	2,172	257	55,881	58,122
10	3,735	11	306	19	3,860	4,071
11	1,270	1	141	3	1,297	1,415
13	2,954	226	463	17	3,207	3,660
14	31,935	1,257	3,219	603	33,341	37,014
15	2,000	220	67	0	2,221	2,287
16	5,267	510	353	0	5,793	6,130
17	3,811	314	202	0	4,126	4,327
18	861	170	147	0	1,033	1,178
19	927	37	43	6	964	1,013
20	88	25	4	0	113	117
21	154	33	19	0	189	206
22	155	17	14	10	172	196
24	846	130	219	0	976	1,195
25	25	1	19	5	27	50
30	28	0	1	10	28	39
34	1,755	0	32	6	1,760	1,793
35	2,126	10	62	18	2,138	2,216
36	12,362	3	1,973	365	13,293	14,703
37	4,107	4	102	47	4,116	4,260
38	958	19	77	14	979	1,068
39	5,722	624	516	42	6,398	6,904
40	2,610	12	259	3	2,633	2,884
81	13,296	15	1,272	251	13,572	14,834
82	18,315	564	980	135	18,947	19,994
83	10,729	794	684	176	11,588	12,383
Total	192,457	5,876	14,200	2,064	200,299	214,597

Note: The table shows the number of structures inventoried within the estimated 0.001 (1000-year) annual chance exceedance overflow for the study area in 2017.

Structure Values. The 2017 RS Means Square Foot Costs Data catalog was used to assign a depreciated replacement cost to the residential and non-residential structures in the study area reaches. Residential replacement costs per square foot were provided for four exterior walls types (wood frame, brick veneer, stucco, or masonry) and three construction classes (economy, average, and luxury) reflecting the quality of the materials used in the construction of the buildings. An average replacement cost per square foot for the four exterior wall types was calculated for each construction class. Based on limited windshield surveys and a sampling of approximately 4,000 structures using Street View Google Maps, it was determined that the characteristics of the structures in the area were consistent with those of the average construction class, and as such were depreciated 15 percent. An additional regional adjustment factor (85 percent of the national square foot costs) for the Galveston/Houston area was then applied to the depreciated cost per square foot. The square footage for each of the individual residential structures was multiplied by the size-specific depreciated cost per square for the average construction class to obtain a total depreciated cost. Finally, the Marshall and Swift Valuation Service was used to calculate a depreciated replacement cost per square foot for the manufactured or mobile homes in the Coastal Texas area. These procedures are consistent with the guidelines provided in IWR 95-R-9.

Non-residential replacement costs per square foot were provided in the RS Means catalog for six exterior wall types: decorative concrete with steel frame and with bearing walls frame, face brick with concrete block back-up with steel frame and with bearing walls frame, metal sandwich panel with steel frame, and precast concrete panel with bearing walls frame. An average replacement cost per square foot was calculated for each of the six exterior wall types and for each non-residential occupancy. The RS Means depreciation schedule for non-residential structures provides depreciation percentages for three structure frames: wood frame exterior, masonry on wood frame, and masonry on steel frame. Based on windshield surveys, it was determined that the majority of the non-residential structures in the area reflected the masonry on wood exterior wall construction with an approximate observed age of 15 years. The masonry on wood depreciation percentage (20 percent) was applied to all of the non-residential structures in the structure inventory. An additional regional adjustment factor (85 percent of the national square foot costs) for the Galveston/Houston area was then applied to the depreciated cost per square foot. The square footage for each of the individual structures was multiplied by the size-specific depreciated cost per square foot for each non-residential occupancy to obtain a total depreciated cost.

Table 10 shows the average depreciated replacement cost for residential and non-residential structure categories for FY 2017, FY 2018, FY 2020 and FY 2021.

Table 10
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
Residential and Non-Residential Structure Inventory
Existing Conditions (2017)
($ Thousands)

Structure Category	Number	Average Depreciated Replacement Value			
		FY 2017	FY 2018	FY 2020	FY 2021
Residential					
One-Story Slab	95,298	$181	$183	$205	$208
One-Story Pier	43,774	$177	$179	$201	$204
Two-Story Slab	44,462	$190	$192	$215	$218
Two-Story Pier	8,923	$179	$181	$203	$206
Mobile Home	5,876	$38	$38	$43	$44
Total Residential	**198,333**				
Non-Residential					
Eatery Slab	5	$329	$332	$372	$378
Professional Slab	8	$4,070	$4,111	$4,606	$4,681
Public Slab	1,041	$1,446	$1,461	$1,637	$1,663
Public Pier	67	$735	$742	$832	$845
Repair Slab	5	$220	$223	$249	$253
Retail Slab	9,747	$1,189	$1,201	$1,347	$1,369
Retail Pier	478	$734	$741	$832	$845
Warehouse Slab	745	$103	$104	$116	$118
Warehouse Pier	138	$98	$99	$111	$113
Multi-Family Slab	1,895	$2,103	$2,124	$2,380	$2,419
Multi-Family Pier	71	$346	$350	$392	$398
Industrial Slab	2,064	$3,148	$3,179	$3,463	$3,620
Total Non-Residential	**16,264**				

Structure Value Uncertainty. The uncertainty surrounding the residential structure values includes two components: the range in the replacement cost per square foot for the three construction classes, and the depreciation percentage applied to the three construction classes. A triangular probability distribution based on the depreciated replacement costs derived for the three construction classes (economy, average, and luxury) was used to represent the uncertainty surrounding the residential structure values in each occupancy category. The most-likely depreciated value was based on the average construction class and a 15 percent depreciation rate (consistent with an observed age of a 15-year old structure in average condition), the minimum value was based on the economy construction class and a 25 percent depreciation rate (consistent with an observed age of a 25-year old structure in average condition), and the maximum value was based on the luxury construction class and a 6 percent depreciation rate (consistent with an observed age of a 5-year old structure in average condition). These values were then converted to a percentage of the most-likely value with the most-likely value equal to 100 percent of the average value for each occupancy category and the economy and luxury class values equal to a percentage of these values. The triangular probability distributions were entered into the HEC-FDA model to represent the uncertainty surrounding the structure values in each residential occupancy category.

The uncertainty surrounding the non-residential structure values was based on the depreciation percentage applied to the average replacement cost per square foot calculated from the six exterior wall types. A triangular probability distribution based on the depreciation percentage associated with the masonry on wood frame structures was used to represent the uncertainty surrounding the non-residential structure values in each occupancy category. The most-likely depreciated value was based on the depreciation percentage (20 percent) assigned to structures with an observed age of 15 years, the minimum depreciated value was based on the depreciation percentage (30 percent) assigned to structures with an observed age of 25 years, and the maximum depreciated value was based on the on the depreciation percentage (5 percent) assigned to structures with an observed age of 5 years. These values were then converted to a percentage of the most-likely value with the most-likely value being equal to 100 percent and the minimum and maximum values equal to percentages of the most-likely value. The triangular probability distributions were entered into the HEC-FDA model to represent the uncertainty surrounding the structure values for each non-residential occupancy category.

Table 11 shows the minimum and maximum proportions of the most-likely structure values assigned to the various structure categories.

Table 11
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
Structure Value Uncertainty Parameters by Structure Category

Structure Category		Min	Max
Residential	One-Story (1STY)	0.70	1.79
	Two-Story (2STY)	0.70	1.79
	Mobile Home (MOBHOM)	0.48	1.47
Automobiles	Automobiles (AUTO)	0.16	1.81
Non-Residential	Eating and Recreation (EAT)	0.88	1.19
	Professional Buildings (PROF)	0.88	1.19
	Public and Semi-Public Buildings (PUBL)	0.88	1.19
	Multi-Family Buildings (MULTI)	0.88	1.19
	Repair and Home Use (REPA)	0.88	1.19
	Industrial (IND)	0.88	1.19
	Retail and Personal Services (RETA)	0.88	1.19
	Warehouses and Contractor Services (WARE)	0.88	1.19

Source: Based on the report entitled *Depth-Damage Relationships for Structures, Contents, and Vehicles and Content-to-Structure Value Ratios (CSVR) in Support of the Lower Atchafalaya and Morganza to the Gulf, Louisiana, Jefferson and Orleans Parish, and Donaldsonville to the Gulf of Mexico Feasibility Studies.*

Future Development Inventory. Projections of population, number of households and employment for the years 2015 through 2045 prepared by the Houston-Galveston Regional Area Council (HGAC) were used to estimate the increase in the number of structures for the portions of Chambers, Galveston and Harris counties in Region 1. The projected population and economic activity in the area was used by HGAC to create future land-use parcels. The geographic location of the land-use parcels included the number of residential units, the square footage of the non-residential properties and the occupancy type of the structures (single-family, multi-family, retail and warehouse). HGAC created 5,989 residential land-use parcels and 640 non-residential land-use parcels containing 42,842 announced, or planned, residential units and 1,280 non-residential properties within the Coastal Texas study area. The announced, or planned, development includes currently on-going construction, while projected development is based on growth trends in population and employment. HGAC created 17,699 residential projected parcels and 6,743 non-residential projected parcels containing 81,127 residential structures and 6,743 non-residential properties.

Figure 7 shows the three inventories used for the TSP milestone: existing development (purple dots), development planned to be in place for 2035 (light blue dots) and development projected to be in place for 2084 (yellow dots).

While the future development inventory discussed above was included in the economic analysis for the TSP milestone, it was not included in the HEC-FDA modeling for the Recommended Plan. Since the projected development is expected to have a first-floor elevation above the stage associated with the existing condition 0.002 (500-year) AEP event based on the stricter local flood plain regulations put in place following Hurricane Harvey, the future development benefits attributable to the Recommended Plan would be insignificant.

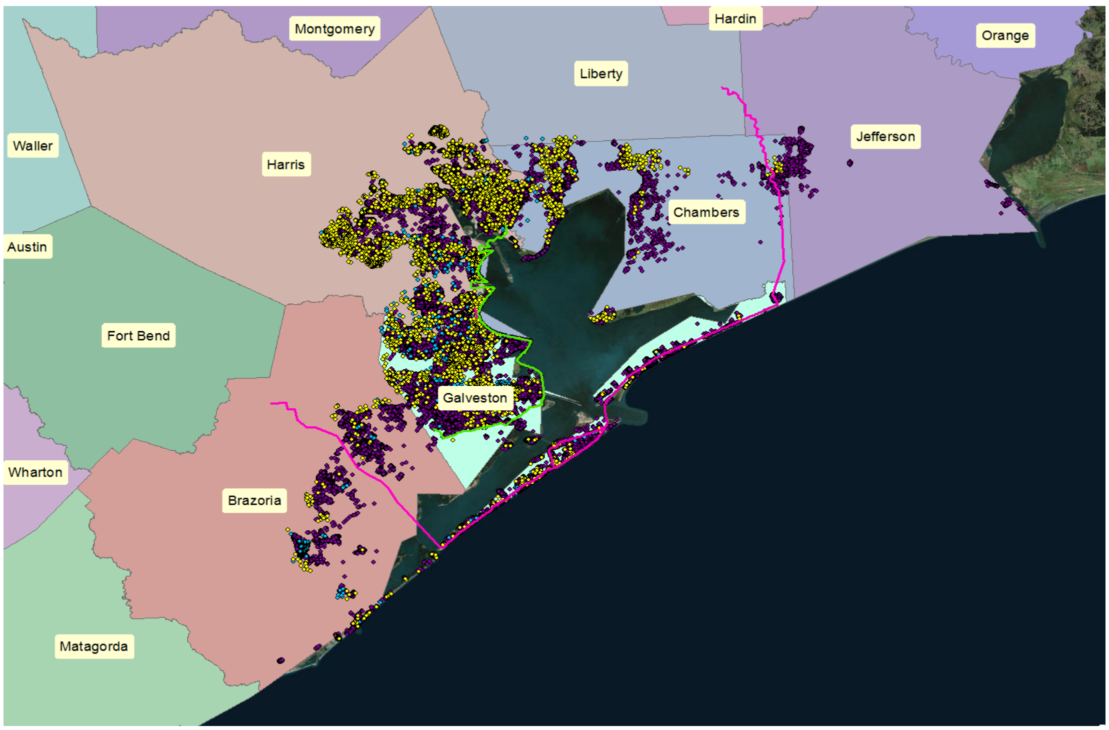


Figure 7 – Existing and Future Development

Residential and Non-Residential Content-to-Structure Value Ratios. The content-to-structure value ratios (CSVRs) applied to the residential and non-residential structure occupancies in Region 1 were obtained from extensive face-to-face interviews with business owners in coastal Louisiana for three large CSRM evaluations. These interviews included a sampling from the three residential content categories (single family one- and two-story structures and mobile homes) and the eight non-residential content categories (eating and recreation, groceries, multi-family, professional buildings, public buildings, repair buildings, retail buildings, and warehouses) from each of the three evaluation areas. It should be noted that structures with less than five housing units are classified as residential structures, and structures with more than five housing units are classified as non-residential (multi-family). A total of 96 residential structures and 210 non-residential structures were used to develop CSVRs for each of the residential and non-residential categories. The OMB approved survey forms developed for industrial facilities were used to facilitate the collection of information during the non-residential face-to-face interviews.

Since only a limited number of property owners participated in the interviews and the participants were not randomly selected, statistical bootstrapping was performed to address the potential sampling error in estimating the mean and standard deviation of the CSVR values. Statistical bootstrapping uses re-sampling with replacement to improve the estimate of a population statistic when the sample size is insufficient for straightforward statistical inference. The bootstrapping method has the effect of increasing the sample size and accounts for distortions caused by a specific sample that may not be fully representative of the population. It should be noted that industrial surveys were developed for the Coastal Texas area. However, due to the limited response, the completed surveys were used to determine if the surveyed values were within the uncertainty range of the CSVRs from the surveys conducted in coastal Louisiana.

Content-to-Structure Value Ratio Uncertainty. For each of the residential and non-residential categories, a mean CSVR and a standard deviation was calculated and entered into the HEC-FDA model. A normal probability density function was used to describe the uncertainty surrounding the CSVR for each content category. The expected CSVR and standard deviations percentage values for each of the five residential occupancies and twelve non-residential occupancies are shown in Table 12.

Table 12
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
Content-to-Structure Value Ratio (CSVR) Percentage and Uncertainty Standard Deviation (SD) Percentage by Structure Category

Structure Category		CSVR %	SD %
Residential	One-Story (1STY)	69	37
	Two-Story (2STY)	67	35
	Mobile Home (MOBHOM)	114	79
Non-Residential	Eating and Recreation (EAT)	170	293
	Professional Buildings (PROF)	54	54
	Public and Semi-Public Buildings (PUBL)	55	80
	Multi-Family Buildings (MULTI)	28	17
	Repair and Home Use (REPA)	236	295
	Industrial (IND)	207	325
	Retail and Personal Services (RETA)	119	105
	Warehouses and Contractor Services (WARE)	207	325

Note: CSVRs are a percentage of the structure value and SD represents the standard deviation percentage or uncertainty surrounding the CSVRs.

Source: CSVRS are based on the report entitled *Depth-Damage Relationships for Structures, Contents, and Vehicles and Content-to-Structure Value Ratios (CSVR) in Support of the Lower Atchafalaya and Morganza to the Gulf, Louisiana, Jefferson and Orleans Parish, and Donaldsonville to the Gulf of Mexico Feasibility Studies.*

Vehicle Inventory and Values. Based on 2010 Census information for the Galveston/Houston area, there is an average of 1.9 vehicles associated with each household (owner occupied housing or rental unit). According to the Southeast Louisiana Evacuation Behavioral Report published in 2006 following Hurricanes Katrina and Rita, approximately 70 percent of privately owned vehicles would be used for evacuation during storm events. The remaining 30 percent of the privately owned vehicles would remain parked at the residences and would be subject to flood damages. According to Edmunds.Com, the average value of a used car as of second quarter 2015 was $18,800. The Manheim Used Vehicle Value Index was used to adjust this average value to reflect FY 2021 price levels. Since only those vehicles not being used for evacuation can be included in the damage calculations, an adjusted average vehicle value of $13,823 ($24,250 x 1.9 x 0.30) was assigned to the individual residential automobile structure records in the HEC-FDA model. The adjusted vehicle value was also assigned to each housing unit in the multi-family residential structure categories. Vehicles associated with non-residential properties were not included in the evaluation.

Vehicle Value Uncertainty. The uncertainty surrounding the values assigned to the vehicles associated with residential structures was determined using a triangular probability distribution function. The average value of a used car, $24,250, was used as the most-likely value, the average value of a new vehicle before taxes, license, and shipping charges, $43,893, was used as the maximum value, and the average 10-year depreciated value of a vehicle, $3,880, was used as the minimum value. Percentages were developed for the most-likely, minimum, and maximum values with the most-likely equal to 100 percent of the most likely value, the minimum equal to 16 percent of the most-likely value and the maximum equal to 181 percent of the most-likely value. These percentages were entered into the HEC-FDA model to form a triangular probability distribution.

First-floor Elevations. Topographical data based on Light Detection and Ranging (LiDAR) data using NAVD 88 vertical datum were used to assign ground elevations to structures and vehicles in the study area. The assignment of ground elevations and the placement of structures were based on a digital elevation model (DEM) with a three-meter by three-meter grid resolution developed by the United States Geological Survey (USGS). The ground elevation was added to the height of the foundation of the structure above the ground in order to obtain the first-floor elevation of each structure in the study area. Vehicles were assigned to the ground elevation of the adjacent residential structures.

Sampling of Foundation Heights Above Ground. The foundation heights of the residential and non-residential structures above the ground were determined using statistical random sampling procedures. Sampling was necessary due to varying types of structure foundations (slab on grade, pier/pile, crawlspace and solid wall) and the large variation in the heights of these foundations above the ground elevation. A focused ATR was conducted in April 2017 to confirm the adequacy of the sampling techniques used to develop the results.

Initial windshield surveys were conducted in the study area to identify areas that had relative uniformity in foundation types and heights above ground. Based on this information, the study area was divided into 20 areas of interest (AOIs). The AOIs tended to have structures that were developed during a similar timeframe. Statistical formulas were used to account for the estimated variation, acceptable error, and level of confidence and to determine a statistically significant number of structures to be surveyed for each AOI in the study area.

A total of 4,258 residential and non-residential structures were randomly selected for the sample. If a selected structure had been demolished or razed, then an adjacent structure was surveyed in its place. The survey team used Google Earth to collect the required information including the height of the foundation above the ground (measured from the bottom of the front door to adjacent ground), the foundation type of foundation, (slab or pier) and the number of stories (1-story, and 2 or more stories). This information was recorded in a database using the GIS ARC_MAP software and used to develop the average height above ground elevation of slab on grade and pier/pile foundation structures in each AOI, the proportion of slab on grade foundation structures and pier/pile foundation structures in each AOI, and the proportion of 1-story and 2-story residential structures in each AOI.

The mean foundation height and proportions of sampled residential 1-story and 2-story pile foundation structures and residential 1-story and 2-story slab foundation structures were applied to all the unsampled residential structures in each AOI. The mean foundation height and proportions of the sampled commercial 1-story and 2-story pile foundation structures and commercial 1-story and 2-story slab foundation structures were randomly applied to the unsampled commercial structures in each AOI. Since the commercial depth-damage relationships are only provided for commercial one-story structures, all the commercial structures were treated as 1-story structures.

It should be noted that a sample of 20 industrial warehouse buildings was separately surveyed using Google Earth Street View to determine that the average foundation height of these structures was 1.5 feet above the ground. This foundation height was applied to all industrial and warehouse occupancies in the study area.

Uncertainty Surrounding Elevations. There are two sources of uncertainty surrounding the first-floor elevations: the use of the LiDAR data for the ground elevations, and the methodology used to determine the structure foundation heights above ground elevation. The error surrounding the LiDAR data was determined to be plus or minus 0.5895 feet at the 95 percent level of confidence. This uncertainty was normally distributed with a mean of zero and a standard deviation of 0.3 feet.

The uncertainty surrounding the foundation heights for the residential and commercial structures was estimated by calculating the standard deviations surrounding the sampled mean values. An overall weighted average standard deviation for the four structure groups was computed for each structure category. The standard deviation was calculated to be 2.35 feet for residential pier foundation structures and 0.3 feet for slab foundation structures. The standard deviation for commercial structures was calculated to be 1.85 feet for pier foundation structures and 0.3 feet for slab foundation structures. The standard deviation for industrial structures was calculated to be 0.86 feet. Table 13 shows the average foundation height and the first-floor elevation uncertainty calculated for the residential and non-residential structure categories.

Table 13
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
Average Foundation Height and First-Floor Stage Uncertainty Standard Deviation (SD)
by Structure Category
(Feet)

Structure Occupancy	Average Foundation Height	SD Ground Stage	SD Foundation Height	SD First Floor
Residential				
One-Story Slab (1STY-SLAB)	0.583	0.3007	0.3	0.42
One-Story Pier (1STY-PIER)	4.913	0.3007	2.35	2.37
Two-Story Slab (2STY-SLAB)	0.656	0.3007	0.3	0.42
Two-Story Pier (2STY-PIER)	7.299	0.3007	2.35	2.37
Mobile Home (MOBHOM)	3.169	0.3007	2.35	2.37
Non-Residential				
Eating and Recreation Slab (EAT-SLAB)	0.675	0.3007	0.33	0.45
Professional Buildings Slab (PROF-SLAB)	0.663	0.3007	0.33	0.45
Public and Semi-Public Buildings Slab (PUBL-SLAB)	0.699	0.3007	0.33	0.45
Public and Semi-Public Buildings Pier (PUBL-PIER)	5.039	0.3007	1.85	1.87
Repair and Home Use Slab (REPA-SLAB)	0.675	0.3007	0.33	0.45
Retail and Personal Services Slab (RETA-SLAB)	0.677	0.3007	0.33	0.45
Retail and Personal Services Pier (RETA-PIER)	5.850	0.3007	1.85	1.87
Warehouses and Contractor Services Slab (WARE-SLAB)	1.500	0.3007	0.86	0.91
Warehouses and Contractor Services Pier (WARE-PIER)	1.500	0.3007	0.86	0.91
Multi-Family Buildings Slab (MULTI-SLAB)	7.419	0.3007	0.33	0.45
Multi-Family Buildings Pier (MULTI-PIER)	0.716	0.3007	1.85	1.87
Industrial Slab (IND-SLAB)	1.500	0.3007	0.86	0.91

Source: Ground elevations are based on LiDAR data and foundation heights are based on a first floor elevation survey conducted in the study area. The average foundation heights were determined using statistical sampling techniques and a foundation height survey.

The standard deviations for the ground elevations and foundation heights were combined, which resulted in a 2.37 feet standard deviation for residential pier foundation structures and 0.42 for slab foundation structures. For commercial structures, the combined standard deviation was calculated to be 1.87 feet for pier structures and 0.45 feet for slab foundation structures. For industrial structures and warehouses, the combined standard deviation was 0.91 feet. Table 14 displays the calculations used to combine the uncertainty surrounding the ground elevations with uncertainty surrounding the foundation height to derive the uncertainty surrounding the first-floor elevations of residential, commercial and industrial structures.

Table 14
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
First-Floor Stage Uncertainty Standard Deviation (SD) Calculation

Ground - LiDAR	
(conversion cm to inches to feet))	
+/- 18 cm @ 95% confidence	18cm
	x 0.393
z = (x - u)/ std. dev.	7.074in
	÷ 12
1.96 = (0.5895 - 0)/ std.dev.	0.5895ft
0.3007 = std.dev.	

Foundation Height (shown in feet)				
Residential		Commercial		Industrial
Pier	Slab	Pier	Slab	Slab
2.35	0.3	1.85	0.33	0.86

Combined First Floor (shown in feet)					
Residential		Commercial		Industrial	
Pier	Slab	Pier	Slab	Slab	
0.30	0.30	0.30	0.30	0.30	ground std. dev.
0.09	0.09	0.09	0.09	0.09	ground std. dev. squared
2.35	0.30	1.85	0.33	0.86	1st floor std. dev.
5.52	0.09	3.42	0.11	0.74	1st floor std. dev. squared
5.61	0.18	3.51	0.20	0.83	Sum of squares
2.37	**0.42**	**1.87**	**0.45**	**0.91**	**Square Root of Sum of Squares = Combined Std. Dev.**

Note 1: Mobile Homes are assigned the same uncertainty as Residential Pier.
Note 2: Autos do not have foundations, so only ground uncertainty is used.
Note 3: Warehouse facilities were assigned the same uncertainty as Industrial.

Debris Removal Costs. Debris removal costs are typically discussed in the Other Benefit Categories section of the Economic Appendix. However, since debris removal costs were included as part of the HEC-FDA structure records for the individual residential and non-residential structures in the Coastal Texas study area, these costs are being treated as an economic input. The HEC-FDA model does not report debris removal costs separately from the total expected annual without-project and with-project damages.

Following Hurricanes Katrina and Rita, interviews were conducted with experts in the fields of debris collection, processing and disposal to estimate the cost of debris removal following a storm event. Information obtained from these interviews was used to assign debris removal costs for each residential and non-residential structure in the Coastal Texas structure inventory. The experts provided a minimum, most likely, and maximum estimate for the cleanup costs associated with the 2 feet, 5 feet, and 12 feet depths of flooding. A prototypical structure size in square feet was used for the residential occupancy categories and for the non-residential occupancy categories. The experts were asked to estimate the percentage of the total cleanup caused by floodwater and to exclude any cleanup that was required by high winds.

In order to account for the cost/damage surrounding debris cleanup, values for debris removal were incorporated into the structure inventory for each record according to its occupancy type. These values were then assigned a corresponding depth-damage function with uncertainty in the HEC-FDA model. For all structure occupancy types, 100% damage was reached at 12 feet of flooding. All values and depth-damage functions were selected according to the long-duration flooding data specified in a report titled "Development of Depth-Emergency Cost and Infrastructure Damage Relationships for Selected South Louisiana Parishes." The debris clean-up values provided in the report were expressed in 2010 price levels for the New Orleans area. These values were converted to 2021 price levels for the Galveston/Houston area using the indexes provided by the Gordian "Square Foot Costs with RS Means Data." The debris removal costs were included as the "other" category on the HEC-FDA structure records for the individual residential and non-residential structures and used to calculate the expected annual without-project and with-project debris removal and cleanup costs.

Debris Removal Costs Uncertainty. The uncertainty surrounding debris percentage values at 2 feet, 5 feet and 12 depths of flooding were based on range of values provided by the four experts in the fields of debris collection, processing, and disposal. The questionnaires used in the interview process were designed to elicit information from the experts regarding the cost of each stage of the debris cleanup process by structure occupancy type. The range of responses from the experts were used to calculate a mean value and standard deviation value for the cleanup costs percentages provided at 2 feet, 5 feet, and 12 feet depths of flooding. The mean values and the standard deviation values were entered into the HEC-FDA model as a normal probability distribution to represent the uncertainty surrounding the costs of debris removal for residential and non-residential structures. The depth-damage relationships containing the damage percentages at the various depths of flooding and the corresponding standard deviations representing the uncertainty are shown with in the depth–damage tables.

Depth-Damage Relationships. Depth-damage relationships indicate the percentage of the total structure value damaged at various depths of flooding. For residential (no basement) and non-residential structures, damage percentages were estimated for each one-half foot increment of flooding from one foot below first-floor elevation to two feet above first-floor elevation, and for each one-foot increment from two feet to 15 feet above the first-floor elevation. Damage percentages for vehicles were estimated for each one-half foot increment of flooding from one foot above the ground to two feet above the ground and for each one-foot increment above two feet. Damage percentages for residential and non-residential contents were estimated for each one-half foot increment from one-half foot above the first-floor elevation to two feet above the first-floor, and for each one-foot increment of flooding from two feet above the first-floor to fifteen feet above the first-floor.

Since site-specific residential and non-residential depth-damage relationships were not available for the Coastal Texas study area, the saltwater, long duration (average of one-week) depth-damage relationships developed by a panel of building, construction, restoration and insurance experts for the Lower Atchafalaya and Morganza to the Gulf, Louisiana feasibility study were used in the economic analysis. These relationships were deemed appropriate because the two study areas have similar coastal topography and hydrology and similar structure categories and occupancies. Both study areas are characterized by low, flat terrain and are highly susceptible to flooding from the tidal surges associated with hurricanes and tropical storms due to their proximity to the Gulf of Mexico. The majority of the residential structures in the two areas are either wood frame construction with pier foundation or masonry construction with slab foundation. The areas have similar types of retail, eating and recreation non-residential structures and warehouse facilities related to the oil and gas industry.

Most tropical storms in coastal areas are multiple day events with heavy rainfall and storm surge. The water pushed into the area during a tropical event must flow over land features such as beaches, agricultural land, roads and highways, ridges along waterways and localized flood risk management systems. After the storm system moves through the area, there are no mechanisms to push the water back over these land features, and the saltwater could remain inside of inundated structures for several days. Evacuated residents may not be able to return to their homes until the roads are safely passable and electrical power has been restored.

According to the panel of experts, saltwater flooding leads to more damages to structures and contents in a shorter amount of time than freshwater flooding. Saltwater is more corrosive on both metal and wood frame structures than freshwater. Inundation of four feet or more above the first-floor elevation of one-story residential structures causes substantial or total damage to the following structural components: soffit and fascia, exterior walls, structural frame and the heating and cooling units. For metal frame non-residential buildings, the following structural items are damaged at four feet: windows, hardware, framing, flooring, electrical, plumbing, HVAC, and building structure façade.

The combination of saltwater and warm, humid climate promotes the growth of mold and allows the mold to spread rapidly throughout inundated structures and contents. As the floodwaters begin to evaporate, the salt becomes more concentrated in the remaining moisture in the room, and contents of the structure that were not touched by the saltwater can also incur damages. For this reason, large damage percentages occur to the contents of structures at relatively low depths of flooding.

The conclusions of the panel of experts were confirmed by the actual damages to structures and contents in the New Orleans area following the saltwater, long duration flooding at various depths caused by Hurricane Katrina. The saltwater remained in the inundated structures for several weeks following the storm. Since Coastal Texas has a similar climate to Southeast Louisiana, similar flood damages would be expected to occur due to the storm surge from tropical events.

The Coastal Texas team determined that the saltwater, long duration depth-damage relationships developed for the final report using the methodology discussed above provide a more accurate characterization of the potential flood damages in the study area than the depth-damage relationships used for the TSP milestone. For the TSP milestone, USACE generic depth-damage relationships for one-story and two-story residential structures (no basements) obtained from EGM, 01-03, dated 4 December 2000 were used for all residential structures, USACE generic depth-damage curves for sedans obtained from EGM, 09-04, dated 22 June 2009 were used for all vehicles associated with residential structures and saltwater, short-duration (average of one day) depth-damage relationships developed for the Morganza to the Gulf of Mexico, Louisiana evaluation were used for non-residential structures. Residential generic depth-damage relationships are based on both riverine (freshwater) and coastal (saltwater) events throughout the country, and the non-residential relationships are based on saltwater, short-duration (one-day) flood events. The TSP milestone results using these depth-damage relationships (and associated content-to-structure value ratios) are displayed in Addendum A and can be used to show the sensitivity of the results from the final report to changes in depth-damage relationships.

For industrial facilities in the Coastal Texas study area, OMB approved survey forms were used to collect information from managers regarding any past flooding that they experienced, estimates of the depreciated replacement cost of their facilities, and the value and percentage of the contents that could be damaged at various depths of flooding below and above the first-floor elevation. The managers were also asked to provide the dollar value of the damage to their vehicles. The information obtained from the surveys was found to closely correlate with the information received from the expert elicitation used to develop the saltwater, long-duration depth-damage functions for the Morganza to the Gulf feasibility study.

Uncertainty Surrounding Depth-Damage Relationships. A triangular probability density function was used to determine the uncertainty surrounding the damage percentage associated with each depth of flooding for residential, non-residential structures, mobile homes and the vehicles associated with the residential structures. A minimum, maximum and most-likely damage estimate was provided by a panel of experts for each depth of flooding. The specific range of values regarding probability distributions for the depth-damage curves can be found in the final report dated May 1997 entitled *Depth-Damage Relationships for Structures, Contents, and Vehicles and Content-to-Structure Value Ratios (CSVRs) in Support of the Lower Atchafalaya Reevaluation and Morganza to the Gulf, Louisiana Feasibility Studies.*

The specific range of values regarding probability distributions for the debris depth-damage curves can be found in the final report dated March 2012 entitled *Development of Depth-Emergency Cost and Infrastructure Damage Relationships for Selected South Louisiana Parishes.* This report was also used as the basis for the depth-damage relationships developed for transportation infrastructure, which will be discussed more fully in the Other Benefits section of the economic appendix.

Tables 15a through 15e show the damage relationships for structures, contents, vehicles, debris removal and damages to the transportation infrastructure. The tables contain the damage percentages at each depth of flooding along with the uncertainty surrounding the damage percentages. Depth-damage relationships for floodproofed structures in selected commercial categories were also included in the tables.

Table 15a
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
Depth-Damage Relationships for Structures, Contents, Vehicles, and Debris Removal

Residential — 1-Story on Pier (1STY-PIER)

Depth in Structure	Structure Percent Damage	Structure Lower Percent	Structure Higher Percent
-1.1	0.0	0.0	0.0
-1.0	1.1	1.0	1.7
-0.5	12.2	11.9	18.3
0.0	15.2	13.7	22.8
0.5	49.4	44.4	74.0
1.0	50.1	45.1	75.1
1.5	66.7	60.0	100.0
2.0	70.2	63.2	100.0
3.0	71.2	64.1	100.0
4.0	97.5	87.7	100.0
5.0	97.5	87.7	100.0
6.0	97.5	87.7	100.0
7.0	97.5	87.7	100.0
8.0	97.5	87.7	100.0
9.0	97.5	87.7	100.0
10.0	97.5	87.7	100.0
11.0	97.5	87.7	100.0
12.0	97.5	87.7	100.0
13.0	97.5	87.7	100.0
14.0	97.5	87.7	100.0
15.0	97.5	87.7	100.0

Depth in Structure	Contents Percent Damage	Contents Lower Percent	Contents Higher Percent
-1.0	0.0	0.0	0.0
-0.5	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.5	95.0	90.0	98.0
1.0	95.0	90.0	98.0
1.5	95.0	90.0	98.0
2.0	95.0	95.0	98.0
3.0	95.0	95.0	98.0
4.0	98.0	98.0	100.0
5.0	98.0	98.0	100.0
6.0	98.0	98.0	100.0
7.0	98.0	98.0	100.0
8.0	98.0	98.0	100.0
9.0	98.0	98.0	100.0
10.0	98.0	98.0	100.0
11.0	98.0	98.0	100.0
12.0	98.0	98.0	100.0
13.0	98.0	98.0	100.0
14.0	98.0	98.0	100.0
15.0	98.0	98.0	100.0

Debris Depth	Debris Percent Damage	Debris Standard Deviation
0.0	0.0	0.0
2.0	85.0	15.0
5.0	92.0	14.0
12.0	100.0	15.0

Residential — 1-Story on Slab (1STY-SLAB)

Depth in Structure	Structure Percent Damage	Structure Lower Percent	Structure Higher Percent
-1.0	0.0	0.0	0.0
-0.5	1.1	1.0	1.7
0.0	1.1	1.0	1.7
0.5	23.3	21.0	35.0
1.0	23.3	21.0	35.0
1.5	37.2	35.5	55.9
2.0	41.9	37.7	62.9
3.0	45.3	40.8	68.0
4.0	92.0	82.8	100.0
5.0	92.0	82.8	100.0
6.0	92.0	82.8	100.0
7.0	92.0	82.8	100.0
8.0	92.0	82.8	100.0
9.0	92.0	82.8	100.0
10.0	92.0	82.8	100.0
11.0	92.0	82.8	100.0
12.0	92.0	82.8	100.0
13.0	92.0	82.8	100.0
14.0	92.0	82.8	100.0
15.0	92.0	82.8	100.0

Depth in Structure	Contents Percent Damage	Contents Lower Percent	Contents Higher Percent
-1.0	0.0	0.0	0.0
-0.5	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.5	95.0	90.0	98.0
1.0	95.0	90.0	98.0
1.5	95.0	90.0	98.0
2.0	95.0	95.0	98.0
3.0	95.0	95.0	98.0
4.0	98.0	98.0	100.0
5.0	98.0	98.0	100.0
6.0	98.0	98.0	100.0
7.0	98.0	98.0	100.0
8.0	98.0	98.0	100.0
9.0	98.0	98.0	100.0
10.0	98.0	98.0	100.0
11.0	98.0	98.0	100.0
12.0	98.0	98.0	100.0
13.0	98.0	98.0	100.0
14.0	98.0	98.0	100.0
15.0	98.0	98.0	100.0

Debris Depth	Debris Percent Damage	Debris Standard Deviation
0.0	0.0	0.0
2.0	87.0	14.0
5.0	94.0	15.0
12.0	100.0	15.0

Residential — 2-Story on Pier (2STY-PIER)

Depth in Structure	Structure Percent Damage	Structure Lower Percent	Structure Higher Percent
-1.1	0.0	0.0	0.0
-1.0	1.4	1.2	2.1
-0.5	2.2	2.0	3.3
0.0	6.4	5.8	9.6
0.5	19.0	17.1	28.5
1.0	19.0	17.1	28.5
1.5	31.9	28.7	47.9
2.0	32.6	29.3	48.9
3.0	33.3	30.0	49.9
4.0	93.4	84.0	100.0
5.0	93.4	84.0	100.0
6.0	93.4	84.0	100.0
7.0	93.4	84.0	100.0
8.0	93.4	84.0	100.0
9.0	93.4	84.0	100.0
10.0	93.6	84.0	100.0
11.0	93.6	84.0	100.0
12.0	93.6	84.0	100.0
13.0	93.6	84.0	100.0
14.0	93.6	84.0	100.0
15.0	93.6	84.0	100.0

Depth in Structure	Contents Percent Damage	Contents Lower Percent	Contents Higher Percent
-1.0	0.0	0.0	0.0
-0.5	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.5	69.6	66.2	73.1
1.0	69.6	66.2	73.1
1.5	74.7	70.9	78.4
2.0	74.7	70.9	78.4
3.0	78.5	74.6	82.5
4.0	79.9	75.9	83.9
5.0	83.2	79.0	87.3
6.0	83.2	79.0	87.3
7.0	83.2	79.0	87.3
8.0	83.2	79.0	87.3
9.0	83.2	79.0	87.3
10.0	83.2	79.0	87.3
11.0	97.5	92.6	100.0
12.0	97.8	92.9	100.0
13.0	98.5	93.6	100.0
14.0	98.5	93.6	100.0
15.0	98.5	93.6	100.0

Debris Depth	Debris Percent Damage	Debris Standard Deviation
0.0	0.0	0.0
2.0	85.0	14.0
5.0	92.0	14.0
12.0	100.0	15.0

Residential — 2-Story on Slab (2STY-SLAB)

Depth in Structure	Structure Percent Damage	Structure Lower Percent	Structure Higher Percent
-1.0	0.0	0.0	0.0
-0.5	1.2	1.1	1.8
0.0	1.2	1.1	1.8
0.5	16.1	14.5	24.2
1.0	16.1	14.5	24.2
1.5	26.1	23.5	39.1
2.0	27.1	24.4	40.7
3.0	28.5	25.7	42.8
4.0	80.0	72.0	100.0
5.0	80.0	72.0	100.0
6.0	80.0	72.0	100.0
7.0	80.0	72.0	100.0
8.0	80.0	72.0	100.0
9.0	80.0	72.0	100.0
10.0	80.3	72.0	100.0
11.0	80.3	72.0	100.0
12.0	80.3	72.0	100.0
13.0	83.2	72.0	100.0
14.0	83.2	72.0	100.0
15.0	83.2	72.0	100.0

Depth in Structure	Contents Percent Damage	Contents Lower Percent	Contents Higher Percent
-1.0	0.0	0.0	0.0
-0.5	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.5	69.6	66.2	73.1
1.0	69.6	66.2	73.1
1.5	74.7	70.9	78.4
2.0	74.7	70.9	78.4
3.0	78.5	74.6	82.5
4.0	79.9	75.9	83.9
5.0	83.2	79.0	87.3
6.0	83.2	79.0	87.3
7.0	83.2	79.0	87.3
8.0	83.2	79.0	87.3
9.0	83.2	79.0	87.3
10.0	83.2	79.0	87.3
11.0	97.5	92.6	100.0
12.0	97.8	92.9	100.0
13.0	98.5	93.6	100.0
14.0	98.5	93.6	100.0
15.0	98.5	93.6	100.0

Debris Depth	Debris Percent Damage	Debris Standard Deviation
0.0	0.0	0.0
2.0	82.0	11.0
5.0	90.0	12.0
12.0	100.0	12.0

Table 15b
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
Depth-Damage Relationships for Structures, Contents, Vehicles, and Debris Removal

Mobile Home
Mobile Home (MOBHOME)

Depth in Structure	Structure Percent Damage	Structure Lower Percent	Structure Higher Percent
-1.1	0.0	0.0	0.0
-1.0	6.4	6.1	8.6
-0.5	7.3	6.9	9.8
0.0	9.9	9.4	13.4
0.5	43.4	41.2	58.6
1.0	44.7	42.5	60.3
2.0	97.6	92.7	100.0
3.0	97.6	92.7	100.0
4.0	97.6	92.7	100.0
5.0	97.6	92.7	100.0
6.0	97.6	92.7	100.0
7.0	97.6	92.7	100.0
8.0	97.6	92.7	100.0
9.0	97.6	92.7	100.0
10.0	97.6	92.7	100.0
11.0	97.6	92.7	100.0
12.0	97.6	92.7	100.0
13.0	97.6	92.7	100.0
14.0	97.6	92.7	100.0
15.0	97.6	92.7	100.0

Depth in Structure	Contents Percent Damage	Contents Lower Percent	Contents Higher Percent
-1.0	0.0	0.0	0.0
-0.5	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.5	95.0	90.0	100.0
1.0	96.0	92.0	100.0
1.5	97.0	94.0	100.0
2.0	98.0	96.0	100.0
3.0	99.0	98.0	100.0
4.0	100.0	100.0	100.0
5.0	100.0	100.0	100.0
6.0	100.0	100.0	100.0
7.0	100.0	100.0	100.0
8.0	100.0	100.0	100.0
9.0	100.0	100.0	100.0
10.0	100.0	100.0	100.0
11.0	100.0	100.0	100.0
12.0	100.0	100.0	100.0
13.0	100.0	100.0	100.0
14.0	100.0	100.0	100.0
15.0	100.0	100.0	100.0

Debris Depth	Debris Percent Damage	Debris Standard Deviation
0.0	0.0	0.0
2.0	82.0	14.0
5.0	90.0	14.0
12.0	100.0	15.0

Industrial
Industrial (IND)

Depth in Structure	Structure Percent Damage	Structure Lower Percent	Structure Higher Percent
-1.0	0.0	0.0	0.0
-0.5	0.0	0.0	0.0
0.0	1.1	1.1	1.3
0.5	22.3	20.8	25.7
1.0	23.7	22.1	27.3
1.5	25.8	24.0	29.7
2.0	32.7	29.5	39.3
3.0	34.4	31.0	43.0
4.0	79.1	71.2	100.0
5.0	79.1	71.2	100.0
6.0	79.1	71.2	100.0
7.0	79.1	71.2	100.0
8.0	79.1	71.2	100.0
9.0	79.1	71.2	100.0
10.0	79.1	71.2	100.0
11.0	79.1	71.2	100.0
12.0	80.5	72.4	100.0
13.0	80.5	72.4	100.0
14.0	80.5	72.4	100.0
15.0	80.5	72.4	100.0

Depth in Structure	Contents Percent Damage	Contents Lower Percent	Contents Higher Percent
-1.0	0.0	0.0	0.0
-0.5	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.5	17.6	16.8	22.0
1.0	22.1	21.0	27.7
1.5	22.1	21.0	27.7
2.0	29.2	27.8	36.6
3.0	34.0	32.3	42.5
4.0	42.8	40.7	53.6
5.0	50.8	48.3	63.5
6.0	58.7	55.8	73.4
7.0	66.7	63.4	83.4
8.0	74.6	70.9	93.3
9.0	79.7	75.7	99.6
10.0	79.7	75.7	99.6
11.0	79.7	75.7	99.6
12.0	79.7	75.7	99.6
13.0	79.7	75.7	99.6
14.0	79.7	75.7	99.6
15.0	79.7	75.7	99.6

Debris Depth	Debris Percent Damage	Debris Standard Deviation
0.0	0.0	0.0
2.0	76.0	13.0
5.0	87.0	14.0
12.0	100.0	14.0

Commercial
Warehouses & Contractors (WARE)

Depth in Structure	Structure Percent Damage	Structure Lower Percent	Structure Higher Percent
-1.0	0.0	0.0	0.0
-0.5	0.0	0.0	0.0
0.0	1.1	1.1	1.3
0.5	22.3	20.8	25.7
1.0	23.7	22.1	27.3
1.5	25.8	24.0	29.7
2.0	32.7	29.5	39.3
3.0	34.4	31.0	43.0
4.0	79.1	71.2	100.0
5.0	79.1	71.2	100.0
6.0	79.1	71.2	100.0
7.0	79.1	71.2	100.0
8.0	79.1	71.2	100.0
9.0	79.1	71.2	100.0
10.0	79.1	71.2	100.0
11.0	79.1	71.2	100.0
12.0	80.5	72.4	100.0
13.0	80.5	72.4	100.0
14.0	80.5	72.4	100.0
15.0	80.5	72.4	100.0

Depth in Structure	Contents Percent Damage	Contents Lower Percent	Contents Higher Percent
-1.0	0.0	0.0	0.0
-0.5	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.5	17.6	16.8	22.0
1.0	22.1	21.0	27.7
1.5	22.1	21.0	27.7
2.0	29.2	27.8	36.6
3.0	34.0	32.3	42.5
4.0	42.8	40.7	53.6
5.0	50.8	48.3	63.5
6.0	58.7	55.8	73.4
7.0	66.7	63.4	83.4
8.0	74.6	70.9	93.3
9.0	79.7	75.7	99.6
10.0	79.7	75.7	99.6
11.0	79.7	75.7	99.6
12.0	79.7	75.7	99.6
13.0	79.7	75.7	99.6
14.0	79.7	75.7	99.6
15.0	79.7	75.7	99.6

Debris Depth	Debris Percent Damage	Debris Standard Deviation
0.0	0.0	0.0
2.0	76.0	13.0
5.0	87.0	14.0
12.0	100.0	14.0

Floodproofed Commercial
Warehouses & Contractors

Depth in Structure	Structure Percent Damage	Structure Lower Percent	Structure Higher Percent
-1.0	0.0	0.0	0.0
-0.5	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.5	0.0	0.0	0.0
1.0	0.0	0.0	0.0
1.5	0.0	0.0	0.0
2.0	0.0	0.0	0.0
3.0	0.0	0.0	0.0
4.0	79.1	71.2	100.0
5.0	79.1	71.2	100.0
6.0	79.1	71.2	100.0
7.0	79.1	71.2	100.0
8.0	79.1	71.2	100.0
9.0	79.1	71.2	100.0
10.0	79.1	71.2	100.0
11.0	79.1	71.2	100.0
12.0	80.5	72.4	100.0
13.0	80.5	72.4	100.0
14.0	80.5	72.4	100.0
15.0	80.5	72.4	100.0

Depth in Structure	Contents Percent Damage	Contents Lower Percent	Contents Higher Percent
-1.0	0.0	0.0	0.0
-0.5	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.5	0.0	0.0	0.0
1.0	0.0	0.0	0.0
1.5	0.0	0.0	0.0
2.0	0.0	0.0	0.0
3.0	0.0	0.0	0.0
4.0	42.8	40.7	53.6
5.0	50.8	48.3	63.5
6.0	58.7	55.8	73.4
7.0	66.7	63.4	83.4
8.0	74.6	70.9	93.3
9.0	79.7	75.7	99.6
10.0	79.7	75.7	99.6
11.0	79.7	75.7	99.6
12.0	79.7	75.7	99.6
13.0	79.7	75.7	99.6
14.0	79.7	75.7	99.6
15.0	79.7	75.7	99.6

Debris Depth	Debris Percent Damage	Debris Standard Deviation
0.0	0.0	0.0
2.0	76.0	13.0
5.0	87.0	14.0
12.0	100.0	14.0

Table 15c
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
Depth-Damage Relationships for Structures, Contents, Vehicles, and Debris Removal

Commercial Repairs & Home Use (REPA)			
Depth in Structure	Structure Percent Damage	Structure Lower Percent	Structure Higher Percent
-1.0	0.0	0.0	0.0
-0.5	0.0	0.0	0.0
0.0	1.1	1.1	1.3
0.5	22.3	20.8	25.7
1.0	23.7	22.1	27.3
1.5	25.8	24.0	29.7
2.0	32.7	29.5	39.3
3.0	34.4	31.0	43.0
4.0	79.1	71.2	100.0
5.0	79.1	71.2	100.0
6.0	79.1	71.2	100.0
7.0	79.1	71.2	100.0
8.0	79.1	71.2	100.0
9.0	79.1	71.2	100.0
10.0	79.1	71.2	100.0
11.0	79.1	71.2	100.0
12.0	80.5	72.4	100.0
13.0	80.5	72.4	100.0
14.0	80.5	72.4	100.0
15.0	80.5	72.4	100.0
Depth in Structure	Contents Percent Damage	Contents Lower Percent	Contents Higher Percent
-1.0	0.0	0.0	0.0
-0.5	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.5	33.3	31.7	41.7
1.0	34.3	32.6	42.9
1.5	34.3	32.6	42.9
2.0	69.2	65.7	86.5
3.0	70.6	67.1	88.3
4.0	72.1	68.5	90.2
5.0	80.6	76.6	100.0
6.0	83.7	79.6	100.0
7.0	83.7	79.6	100.0
8.0	83.7	79.6	100.0
9.0	83.7	79.6	100.0
10.0	83.7	79.6	100.0
11.0	83.7	79.6	100.0
12.0	83.7	79.6	100.0
13.0	83.7	79.6	100.0
14.0	83.7	79.6	100.0
15.0	83.7	79.6	100.0
Debris Depth	Debris Percent Damage	Debris Standard Deviation	
0.0	0.0	0.0	
2.0	95.0	21.0	
5.0	97.0	21.0	
12.0	100.0	21.0	

Commercial Retail and Personal Services (RETA)			
Depth in Structure	Structure Percent Damage	Structure Lower Percent	Structure Higher Percent
-1.0	0.0	0.0	0.0
-0.5	0.0	0.0	0.0
0.0	1.1	1.1	1.3
0.5	22.3	20.8	25.7
1.0	23.7	22.1	27.3
1.5	25.8	24.0	29.7
2.0	32.7	29.5	39.3
3.0	34.4	31.0	43.0
4.0	79.1	71.2	100.0
5.0	79.1	71.2	100.0
6.0	79.1	71.2	100.0
7.0	79.1	71.2	100.0
8.0	79.1	71.2	100.0
9.0	79.1	71.2	100.0
10.0	79.1	71.2	100.0
11.0	79.1	71.2	100.0
12.0	80.5	72.4	100.0
13.0	80.5	72.4	100.0
14.0	80.5	72.4	100.0
15.0	80.5	72.4	100.0
Depth in Structure	Contents Percent Damage	Contents Lower Percent	Contents Higher Percent
-1.0	0.0	0.0	0.0
-0.5	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.5	36.6	34.8	45.7
1.0	60.5	57.5	75.7
1.5	60.5	57.5	75.7
2.0	75.4	71.6	94.2
3.0	85.1	80.8	100.0
4.0	94.5	89.7	100.0
5.0	100.0	95.0	100.0
6.0	100.0	95.0	100.0
7.0	100.0	95.0	100.0
8.0	100.0	95.0	100.0
9.0	100.0	95.0	100.0
10.0	100.0	95.0	100.0
11.0	100.0	95.0	100.0
12.0	100.0	95.0	100.0
13.0	100.0	95.0	100.0
14.0	100.0	95.0	100.0
15.0	100.0	95.0	100.0
Debris Depth	Debris Percent Damage	Debris Standard Deviation	
0.0	0.0	0.0	
2.0	95.0	22.0	
5.0	96.0	22.0	
12.0	100.0	22.0	

Floodproofed Commercial Retail and Personal Services			
Depth in Structure	Structure Percent Damage	Structure Lower Percent	Structure Higher Percent
-1.0	0.0	0.0	0.0
-0.5	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.5	0.0	0.0	0.0
1.0	0.0	0.0	0.0
1.5	0.0	0.0	0.0
2.0	0.0	0.0	0.0
3.0	0.0	0.0	0.0
4.0	79.1	71.2	100.0
5.0	79.1	71.2	100.0
6.0	79.1	71.2	100.0
7.0	79.1	71.2	100.0
8.0	79.1	71.2	100.0
9.0	79.1	71.2	100.0
10.0	79.1	71.2	100.0
11.0	79.1	71.2	100.0
12.0	80.5	72.4	100.0
13.0	80.5	72.4	100.0
14.0	80.5	72.4	100.0
15.0	80.5	72.4	100.0
Depth in Structure	Contents Percent Damage	Contents Lower Percent	Contents Higher Percent
-1.0	0.0	0.0	0.0
-0.5	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.5	0.0	0.0	0.0
1.0	0.0	0.0	0.0
1.5	0.0	0.0	0.0
2.0	0.0	0.0	0.0
3.0	0.0	0.0	0.0
4.0	94.5	89.7	100.0
5.0	100.0	95.0	100.0
6.0	100.0	95.0	100.0
7.0	100.0	95.0	100.0
8.0	100.0	95.0	100.0
9.0	100.0	95.0	100.0
10.0	100.0	95.0	100.0
11.0	100.0	95.0	100.0
12.0	100.0	95.0	100.0
13.0	100.0	95.0	100.0
14.0	100.0	95.0	100.0
15.0	100.0	95.0	100.0
Debris Depth	Debris Percent Damage	Debris Standard Deviation	
0.0	0.0	0.0	
2.0	95.0	22.0	
5.0	96.0	22.0	
12.0	100.0	22.0	

Commercial Professional Services (PROF)			
Depth in Structure	Structure Percent Damage	Structure Lower Percent	Structure Higher Percent
-1.0	0.0	0.0	0.0
-0.5	0.0	0.0	0.0
0.0	6.6	6.2	7.6
0.5	19.8	18.4	22.8
1.0	19.8	18.4	22.8
1.5	24.5	22.8	28.2
2.0	24.5	22.8	28.2
3.0	29.6	26.6	37.0
4.0	34.7	31.2	43.4
5.0	37.9	34.1	47.4
6.0	37.9	34.1	47.4
7.0	37.9	34.1	47.4
8.0	63.3	57.0	79.2
9.0	63.3	57.0	79.2
10.0	63.3	57.0	79.2
11.0	63.3	57.0	79.2
12.0	63.3	57.0	79.2
13.0	63.3	57.0	79.2
14.0	63.3	57.0	79.2
15.0	63.3	57.0	79.2
Depth in Structure	Contents Percent Damage	Contents Lower Percent	Contents Higher Percent
-1.0	0.0	0.0	0.0
-0.5	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.5	35.0	30.0	50.0
1.0	43.3	37.1	61.8
1.5	56.7	48.6	81.0
2.0	63.9	54.8	91.3
3.0	100.0	85.7	100.0
4.0	100.0	100.0	100.0
5.0	100.0	100.0	100.0
6.0	100.0	100.0	100.0
7.0	100.0	100.0	100.0
8.0	100.0	100.0	100.0
9.0	100.0	100.0	100.0
10.0	100.0	100.0	100.0
11.0	100.0	100.0	100.0
12.0	100.0	100.0	100.0
13.0	100.0	100.0	100.0
14.0	100.0	100.0	100.0
15.0	100.0	100.0	100.0
Debris Depth	Debris Percent Damage	Debris Standard Deviation	
0.0	0.0	0.0	
2.0	95.0	22.0	
5.0	96.0	22.0	
12.0	100.0	22.0	

Table 15d
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
Depth-Damage Relationships for Structures, Contents, Vehicles, and Debris Removal

Commercial Public Facilities (PUBL)			
Depth in Structure	Structure Percent Damage	Structure Lower Percent	Structure Higher Percent
-1.0	0.0	0.0	0.0
-0.5	0.0	0.0	0.0
0.0	1.1	1.1	1.3
0.5	22.3	20.8	25.7
1.0	23.7	22.1	27.3
1.5	25.8	24.0	29.7
2.0	32.7	29.5	39.3
3.0	34.4	31.0	43.0
4.0	79.1	71.2	100.0
5.0	79.1	71.2	100.0
6.0	79.1	71.2	100.0
7.0	79.1	71.2	100.0
8.0	79.1	71.2	100.0
9.0	79.1	71.2	100.0
10.0	79.1	71.2	100.0
11.0	79.1	71.2	100.0
12.0	80.5	72.4	100.0
13.0	80.5	72.4	100.0
14.0	80.5	72.4	100.0
15.0	80.5	72.4	100.0
Depth in Structure	Contents Percent Damage	Contents Lower Percent	Contents Higher Percent
-1.0	0.0	0.0	0.0
-0.5	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.5	80.0	60.0	88.0
1.0	85.0	63.8	93.5
1.5	85.7	64.3	94.2
2.0	86.6	65.0	95.3
3.0	100.0	75.0	100.0
4.0	100.0	75.0	100.0
5.0	100.0	75.0	100.0
6.0	100.0	75.0	100.0
7.0	100.0	75.0	100.0
8.0	100.0	75.0	100.0
9.0	100.0	75.0	100.0
10.0	100.0	75.0	100.0
11.0	100.0	75.0	100.0
12.0	100.0	75.0	100.0
13.0	100.0	75.0	100.0
14.0	100.0	75.0	100.0
15.0	100.0	75.0	100.0
Debris Depth	Debris Percent Damage	Debris Standard Deviation	
0.0	0.0	0.0	
2.0	95.0	22.0	
5.0	96.0	22.0	
12.0	100.0	22.0	

Floodproofed Commercial Public Facilities (PUBL_FP)			
Depth in Structure	Structure Percent Damage	Structure Lower Percent	Structure Higher Percent
-1.0	0.0	0.0	0.0
-0.5	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.5	0.0	0.0	0.0
1.0	0.0	0.0	0.0
1.5	0.0	0.0	0.0
2.0	0.0	0.0	0.0
3.0	0.0	0.0	0.0
4.0	79.1	71.2	100.0
5.0	79.1	71.2	100.0
6.0	79.1	71.2	100.0
7.0	79.1	71.2	100.0
8.0	79.1	71.2	100.0
9.0	79.1	71.2	100.0
10.0	79.1	71.2	100.0
11.0	79.1	71.2	100.0
12.0	80.5	72.4	100.0
13.0	80.5	72.4	100.0
14.0	80.5	72.4	100.0
15.0	80.5	72.4	100.0
Depth in Structure	Contents Percent Damage	Contents Lower Percent	Contents Higher Percent
-1.0	0.0	0.0	0.0
-0.5	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.5	0.0	0.0	0.0
1.0	0.0	0.0	0.0
1.5	0.0	0.0	0.0
2.0	0.0	0.0	0.0
3.0	0.0	0.0	0.0
4.0	100.0	75.0	100.0
5.0	100.0	75.0	100.0
6.0	100.0	75.0	100.0
7.0	100.0	75.0	100.0
8.0	100.0	75.0	100.0
9.0	100.0	75.0	100.0
10.0	100.0	75.0	100.0
11.0	100.0	75.0	100.0
12.0	100.0	75.0	100.0
13.0	100.0	75.0	100.0
14.0	100.0	75.0	100.0
15.0	100.0	75.0	100.0
Debris Depth	Debris Percent Damage	Debris Standard Deviation	
0.0	0.0	0.0	
2.0	95.0	22.0	
5.0	96.0	22.0	
12.0	100.0	22.0	

Commercial Multi-Family Residence (MULTI)			
Depth in Structure	Structure Percent Damage	Structure Lower Percent	Structure Higher Percent
-1.0	0.0	0.0	0.0
-0.5	0.0	0.0	0.0
0.0	6.6	6.2	7.6
0.5	19.8	18.4	22.8
1.0	19.8	18.4	22.8
1.5	24.5	22.8	28.2
2.0	24.5	22.8	28.2
3.0	29.6	26.6	37.0
4.0	34.7	31.2	43.4
5.0	37.9	34.1	47.4
6.0	37.9	34.1	47.4
7.0	37.9	34.1	47.4
8.0	63.3	57.0	79.2
9.0	63.3	57.0	79.2
10.0	63.3	57.0	79.2
11.0	63.3	57.0	79.2
12.0	63.3	57.0	79.2
13.0	63.3	57.0	79.2
14.0	63.3	57.0	79.2
15.0	63.3	57.0	79.2
Depth in Structure	Contents Percent Damage	Contents Lower Percent	Contents Higher Percent
-1.0	0.0	0.0	0.0
-0.5	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.5	20.1	15.8	22.2
1.0	26.2	22.4	28.7
1.5	33.5	31.2	35.2
2.0	42.4	40.5	46.2
3.0	49.8	46.6	51.4
4.0	51.7	50.3	53.0
5.0	51.7	50.3	53.1
6.0	51.7	50.3	54.6
7.0	51.7	50.3	54.6
8.0	51.7	50.3	54.6
9.0	51.7	50.3	54.6
10.0	71.8	56.4	79.3
11.0	85.2	79.6	89.5
12.0	100.0	93.5	100.0
13.0	100.0	97.1	100.0
14.0	100.0	97.1	100.0
15.0	100.0	97.1	100.0
Debris Depth	Debris Percent Damage	Debris Standard Deviation	
0.0	0.0	0.0	
2.0	77.0	7.0	
5.0	83.0	7.0	
12.0	100.0	10.0	

Floodproofed Commercial Multi-Family Residence (MULTI_FP)			
Depth in Structure	Structure Percent Damage	Structure Lower Percent	Structure Higher Percent
-1.0	0.0	0.0	0.0
-0.5	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.5	0.0	0.0	0.0
1.0	0.0	0.0	0.0
1.5	0.0	0.0	0.0
2.0	0.0	0.0	0.0
3.0	0.0	0.0	0.0
4.0	34.7	31.2	43.4
5.0	37.9	34.1	47.4
6.0	37.9	34.1	47.4
7.0	37.9	34.1	47.4
8.0	63.3	57.0	79.2
9.0	63.3	57.0	79.2
10.0	63.3	57.0	79.2
11.0	63.3	57.0	79.2
12.0	63.3	57.0	79.2
13.0	63.3	57.0	79.2
14.0	63.3	57.0	79.2
15.0	63.3	57.0	79.2
Depth in Structure	Contents Percent Damage	Contents Lower Percent	Contents Higher Percent
-1.0	0.0	0.0	0.0
-0.5	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.5	0.0	0.0	0.0
1.0	0.0	0.0	0.0
1.5	0.0	0.0	0.0
2.0	0.0	0.0	0.0
3.0	0.0	0.0	0.0
4.0	51.7	50.3	53.0
5.0	51.7	50.3	53.1
6.0	51.7	50.3	54.6
7.0	51.7	50.3	54.6
8.0	51.7	50.3	54.6
9.0	51.7	50.3	54.6
10.0	71.8	56.4	79.3
11.0	85.2	79.6	89.5
12.0	100.0	93.5	100.0
13.0	100.0	97.1	100.0
14.0	100.0	97.1	100.0
15.0	100.0	97.1	100.0
Debris Depth	Debris Percent Damage	Debris Standard Deviation	
0.0	0.0	0.0	
2.0	77.0	7.0	
5.0	83.0	7.0	
12.0	100.0	10.0	

Table 15e
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
Depth-Damage Relationships for Structures, Contents, Vehicles, and Debris Removal

Commercial			
Eating & Recreation (EAT)			
Depth in Structure	Structure Percent Damage	Structure Lower Percent	Structure Higher Percent
-1.0	0.0	0.0	0.0
-0.5	0.0	0.0	0.0
0.0	6.6	6.2	7.6
0.5	19.8	18.4	22.8
1.0	19.8	18.4	22.8
1.5	24.5	22.8	28.2
2.0	24.5	22.8	28.2
3.0	29.6	26.6	37.0
4.0	34.7	31.2	43.4
5.0	37.9	34.1	47.4
6.0	37.9	34.1	47.4
7.0	37.9	34.1	47.4
8.0	63.3	57.0	79.2
9.0	63.3	57.0	79.2
10.0	63.3	57.0	79.2
11.0	63.3	57.0	79.2
12.0	63.3	57.0	79.2
13.0	63.3	57.0	79.2
14.0	63.3	57.0	79.2
15.0	63.3	57.0	79.2

Depth in Structure	Contents Percent Damage	Contents Lower Percent	Contents Higher Percent
-1.0	0.0	0.0	0.0
-0.5	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.5	41.2	39.2	51.5
1.0	45.6	43.3	57.0
1.5	73.3	69.6	91.6
2.0	74.8	71.1	93.5
3.0	92.4	87.8	100.0
4.0	100.0	95.0	100.0
5.0	100.0	95.0	100.0
6.0	100.0	95.0	100.0
7.0	100.0	95.0	100.0
8.0	100.0	95.0	100.0
9.0	100.0	95.0	100.0
10.0	100.0	95.0	100.0
11.0	100.0	95.0	100.0
12.0	100.0	95.0	100.0
13.0	100.0	95.0	100.0
14.0	100.0	95.0	100.0
15.0	100.0	95.0	100.0

Debris Depth	Debris Percent Damage	Debris Standard Deviation
0.0	0.0	0.0
2.0	96.0	22.0
5.0	98.0	22.0
12.0	100.0	22.0

Autos			
Vehicles (AUTO)			
Depth in Structure	Structure Percent Damage	Structure Lower Percent	Structure Higher Percent
0.0	0.0	0.0	0.0
0.5	0.0	0.0	0.0
1.0	3.7	2.3	4.7
1.5	13.0	12.0	15.0
2.0	46.7	44.7	45.3
3.0	100.0	100.0	100.0
4.0	100.0	100.0	100.0
5.0	100.0	100.0	100.0
6.0	100.0	100.0	100.0
7.0	100.0	100.0	100.0
8.0	100.0	100.0	100.0
9.0	100.0	100.0	100.0
10.0	100.0	100.0	100.0
11.0	100.0	100.0	100.0
12.0	100.0	100.0	100.0
13.0	100.0	100.0	100.0
14.0	100.0	100.0	100.0
15.0	100.0	100.0	100.0
16.0	100.0	100.0	100.0
17.0	100.0	100.0	100.0

ENGINEERING INPUTS TO THE HEC-FDA MODEL

Stage-Probability Relationships. The Advanced Circulation model (ADCIRC) used a 100-storm suite for the without-project condition and a 20-storm suite for the with-project conditions as inputs for the TSP milestone. Revised ADCIRC modeling used a 660-storm suite for the without-project condition and a 170-storm suite for the with-project conditions for the Recommended Plan.

Stage-probability relationships were provided for the existing without-project condition (2017), future without-project conditions (2035 and 2084) and for future with-project conditions 0.01 AEP level of risk reduction (2035 and 2084). Water surface profiles were provided for eight annual probability exceedance (AEP) events: 0.99 (1-year), 0.10 (10-year), 0.02 (50-year), 0.01 (100-year), 0.005 (200-year), 0.002 (500-year), and 0.001 (1,000-year). The without-project water surface profiles were based on storm surge and incorporated heavy rainfall events. The with-project water surface profiles were based on rainfall and the residual storm surge damages with the Recommended Plan in place.

The 0.99 (1-year) AEP event and 0.10 (10-year) AEP event water surface profiles for the year 2017 were based on gage data for the without-project condition. For each of these AEP events, the water surface profiles for the years 2035 and 2084 were determined by adding relative sea level rise to the gage data. The water surface profiles for the 0.02 (50-year) AEP event through the 0.001 (1,000-year) AEP event were based on results from the ADCIRC model. The stage-probability relationships for the time period 2035 to 2084 were used as the 50-period of analysis for comparing equivalent annual damages to annual life cycle costs.

Uncertainty Surrounding the Stage-Probability Relationships. A 50-year equivalent record length was used to quantify the uncertainty surrounding the stage-probability relationships for each study area reach. The 50-year equivalent record length was selected after H&H viewed the HEC-FDA model uncertainty estimates for various equivalent record lengths. It was determined that the 50-year equivalent record length best represented the uncertainty surrounding the water surface elevations. Based on this equivalent record length, the HEC-FDA model calculated the confidence limits surrounding the stage-probability functions.

PART 3: NATIONAL ECONOMIC DEVELOPMENT (NED) FLOOD DAMAGE AND BENEFIT CALCULATIONS

STRUCTURES, CONTENTS, VEHICLES AND DEBRIS REMOVAL

HEC-FDA Model Calculations. The HEC-FDA model was utilized to evaluate flood damages using risk-based analysis. Damages were reported at the index location for each of the 42 study area reaches for which a structure inventory had been created. HEC-FDA model developer, Bob Carl, was consulted regarding the selection of index locations for each of the study area reaches. Mr. Carl also periodically reviewed the models throughout the planning process to ensure that the model results were consistent with the economic and engineering inputs.

A range of possible values, with a maximum and a minimum value for each economic variable (first-floor elevation, structure and content values, and depth-damage relationships), was entered into the HEC-FDA model to calculate the uncertainty or error surrounding the elevation-damage, or stage-damage, relationships. The model also used the number of years that stages were recorded at a given gage to determine the hydrologic uncertainty surrounding the stage-probability relationships.

The possible occurrences of each variable were derived through the use of Monte Carlo simulation, which used randomly selected numbers to simulate the values of the selected variables from within the established ranges and distributions. For each variable, a sampling technique was used to select from within the range of possible values. With each sample, or iteration, a different value was selected. The number of iterations performed affects the simulation execution time and the quality and accuracy of the results. This process was conducted simultaneously for each economic and hydrologic variable. The resulting mean value and probability distributions formed a comprehensive picture of all possible outcomes.

The initial HEC-FDA model calculations for the Recommended Plan used the year 2035 as the base year and the year 2084 as the last year in the 50-year period of analysis. Damages for the structures, contents, vehicles and debris removal categories were calculated using this period of analysis. However, in the final analysis for the Recommended Plan, the base year was changed to the year 2043 to reflect an 8-year increase in the construction period. The damage and benefit results reflecting this change are shown at the end of Part 3 of the Economic Appendix.

Stage-Damage Relationships with Uncertainty. The HEC-FDA model used the economic and engineering inputs to generate a stage-damage relationship for each structure category in each study area reach under existing (2017) and future (2035 and 2084) conditions. The possible occurrences of each economic variable were derived through the use of Monte Carlo simulation. A total of 1,000 iterations were executed in the model for the stage-damage relationships. The sum of all sampled values was divided by the total number of samples to yield the expected value for a specific simulation. A mean and standard deviation was automatically calculated for the damages at each stage.

Stage-Probability Relationships with Uncertainty. The HEC-FDA model used an equivalent record length (50 years) for each study area reach to generate a stage-probability relationship with uncertainty for the without-project condition under existing (2017) and future (2035 and 2084) conditions through the use of graphical analysis. The model used the eight stage-probability events together with the equivalent record length to define the full range of the stage-probability or stage-probability functions by interpolating between the data points. Confidence bands surrounding the stages for each of the probability events were also provided.

Without-Project Expected Annual Damages. The model used Monte Carlo simulation to sample from the stage-probability curve with uncertainty. For each of the iterations within the simulation, stages were simultaneously selected for the entire range of probability events. The sum of all damage values divided by the number of iterations run by the model yielded the expected value, or mean damage value, with confidence bands for each probability event. The probability-damage relationships are integrated by weighting the damages corresponding to each magnitude of flooding (stage) by the percentage chance of exceedance (probability). From these weighted damages, the model determined the expected annual damages (EAD) with confidence bands (uncertainty). For the without-project alternative, the expected annual damages (EAD) were totaled for each study area reach to obtain the total without-project EAD under existing (2017) and future (2035 and 2084) conditions.

Structure Inventory Adjustments for Severe-Flooding. Adjustments were made to the structure inventory to more accurately reflect the most-likely future without-project and with-project conditions. Under without-project and with-project conditions, residential and non-residential structures that were identified as severely flooded structures (greater than 50 percent damage to the structural components) from the 0.10 (10-year) AEP event were set equal to the stage associated with 0.002 (500-year) plus 1-foot for the year 2084 under the high sea-level rise scenario. This adjustment is consistent with the FEMA floodplain regulations that require residents to rebuild above the base flood elevation after a structure receives greater than 50 percent damage to the structural components as a result of a flood. The first-floor elevations of 213 structures in 2035 and 156 structures in 2084 were adjusted for severe flooding.

Table 16 shows the number and category of structures that are damaged by each of the annual exceedance probability (AEP) events for the years 2035 and 2084 under without-project conditions for the three sea-level rise scenarios. Table 17 shows the without-project damages for the residential, commercial, mobile home and industrial structure categories for each of the AEP events for the years 2035 and 2084 for the three sea-level rise scenarios.

Table 16
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
Residential, Non-Residential, Mobile Homes and Industrial Categories
Structures Damaged by Probability Event and Category in 2035 and 2084
Without Project

Annual Exceedance Probability (AEP)	Residential	Commercial	Mobile Home	Industrial	Total
Base Year 2035 Low Sea-Level Rise					
0.99 (1 yr)	0	0	0	0	0
0.10 (10 yr)	3,129	792	23	91	4,035
0.05 (20 yr)	6,976	1,321	122	224	8,643
0.02 (50 yr)	26,616	2,960	571	585	30,732
0.01 (100 yr)	53,302	4,480	1,070	908	59,760
0.005 (200 yr)	78,003	5,893	1,600	1,185	86,681
0.002 (500 yr)	99,236	7,364	2,177	1,346	110,123
0.001 (1000 yr)	107,645	8,163	2,462	1,415	119,685
Future Year 2084 Low Sea-Level Rise					
0.99 (1 yr)	0	0	0	0	0
0.10 (10 yr)	9,482	1,558	113	240	11,393
0.05 (20 yr)	17,252	2,286	286	369	20,193
0.02 (50 yr)	44,932	4,110	767	750	50,559
0.01 (100 yr)	69,684	5,404	1,424	1,051	77,563
0.005 (200 yr)	95,188	7,142	1,941	1,313	105,584
0.002 (500 yr)	117,315	8,828	2,576	1,458	130,177
0.001 (1000 yr)	124,519	9,522	2,799	1,568	138,408

Table 16 (continued)
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
Residential, Non-Residential, Mobile Homes and Industrial Categories
Structures Damaged by Probability Event and Category in 2035 and 2084
Without Project

Annual Exceedance Probability (AEP)	Residential	Commercial	Mobile Home	Industrial	Total
Base Year 2035 Intermediate Sea-Level Rise					
0.99 (1 yr)	0	0	0	0	0
0.10 (10 yr)	3,407	832	31	104	4,374
0.05 (20 yr)	7,391	1,368	134	232	9,125
0.02 (50 yr)	28,003	3,042	595	600	32,240
0.01 (100 yr)	54,499	4,529	1,099	926	61,053
0.005 (200 yr)	79,325	5,978	1,631	1,199	88,133
0.002 (500 yr)	100,321	7,443	2,206	1,351	111,321
0.001 (1000 yr)	108,338	8,219	2,489	1,423	120,469
Future Year 2084 Intermediate Sea-Level Rise					
0.99 (1 yr)	0	0	0	0	0
0.10 (10 yr)	17,531	2,552	275	398	20,756
0.05 (20 yr)	31,886	3,552	525	601	36,564
0.02 (50 yr)	60,100	4,995	982	916	66,993
0.01 (100 yr)	84,999	6,545	1,796	1,207	94,547
0.005 (200 yr)	111,669	8,248	2,248	1,451	123,616
0.002 (500 yr)	132,574	10,034	2,896	1,654	147,158
0.001 (1000 yr)	139,197	10,545	3,140	1,749	154,631

Table 16 (continued)
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
Residential, Non-Residential, Mobile Homes and Industrial Categories
Structures Damaged by Probability Event and Category in 2035 and 2084
Without Project

Annual Exceedance Probability (AEP)	Residential	Commercial	Mobile Home	Industrial	Total
Base Year 2035 High Sea-Level Rise					
0.99 (1 yr)	0	0	0	0	0
0.10 (10 yr)	3,779	890	49	128	4,846
0.05 (20 yr)	8,149	1,424	152	246	9,971
0.02 (50 yr)	30,177	3,131	627	619	34,554
0.01 (100 yr)	56,340	4,601	1,150	948	63,039
0.005 (200 yr)	81,345	6,094	1,689	1,226	90,354
0.002 (500 yr)	101,916	7,581	2,262	1,371	113,130
0.001 (1000 yr)	109,275	8,332	2,519	1,441	121,567
Future Year 2084 High Sea-Level Rise					
0.99 (1 yr)	0	0	0	0	0
0.10 (10 yr)	48,507	4,226	747	817	54,297
0.05 (20 yr)	63,938	5,173	1,081	1,032	71,224
0.02 (50 yr)	85,032	6,715	1,776	1,312	94,835
0.01 (100 yr)	112,109	8,559	2,542	1,517	124,727
0.005 (200 yr)	139,911	10,400	3,123	1,790	155,224
0.002 (500 yr)	153,148	11,284	3,666	1,916	170,014
0.001 (1000 yr)	155,827	11,525	3,777	1,937	173,066

Note: Damage count based on 2017 development inventory

Table 17
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
Residential, Non-Residential, Mobile Homes and Industrial
Damages by Probability Event and Category
(2021 Price Level; $ Thousands)

Annual Exceedance Probability (AEP)	Residential	Commercial	Mobile Home	Industrial	Total
Base Year 2035 Low Sea-Level Rise					
0.99 (1 yr)	$ -	$ -	$ -	$ -	$ -
0.10 (10 yr)	$ 346,100	$ 624,537	$ 386	$ 138,424	$ 1,109,448
0.05 (20 yr)	$ 967,486	$ 1,372,886	$ 3,097	$ 499,099	$ 2,842,567
0.02 (50 yr)	$ 4,584,073	$ 4,090,214	$ 32,521	$ 2,611,157	$ 11,317,967
0.01 (100 yr)	$ 12,390,690	$ 7,288,222	$ 80,216	$ 5,116,425	$ 24,875,553
0.005 (200 yr)	$ 20,182,004	$ 10,023,593	$ 120,120	$ 7,418,404	$ 37,744,120
0.002 (500 yr)	$ 27,939,885	$ 13,660,954	$ 185,441	$ 9,588,801	$ 51,375,081
0.001 (1000 yr)	$ 31,739,193	$ 15,500,999	$ 209,364	$ 10,721,865	$ 58,171,422
Future Year 2084 Low Sea-Level Rise					
0.99 (1 yr)	$ -	$ -	$ -	$ -	$ -
0.10 (10 yr)	$ 996,376	$ 1,249,206	$ 3,160	$ 561,765	$ 2,810,506
0.05 (20 yr)	$ 2,247,139	$ 2,190,811	$ 12,044	$ 1,201,803	$ 5,651,796
0.02 (50 yr)	$ 7,917,299	$ 5,488,380	$ 52,345	$ 3,669,753	$ 17,127,777
0.01 (100 yr)	$ 16,272,895	$ 8,562,462	$ 100,102	$ 6,180,569	$ 31,116,027
0.005 (200 yr)	$ 24,491,094	$ 12,001,907	$ 153,763	$ 8,585,458	$ 45,232,223
0.002 (500 yr)	$ 32,456,822	$ 16,082,342	$ 214,920	$ 10,698,068	$ 59,452,152
0.001 (1000 yr)	$ 36,086,443	$ 18,015,665	$ 241,915	$ 11,791,125	$ 66,135,149

Table 17 (continued)
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
Residential, Non-Residential, Mobile Homes and Industrial
Damages by Probability Event and Category
(2021 Price Level; $ Thousands)

Annual Exceedance Probability (AEP)	Residential	Commercial	Mobile Home	Industrial	Total
Base Year 2035 Intermediate Sea-Level Rise					
0.99 (1 yr)	$ -	$ -	$ -	$ -	$ -
0.10 (10 yr)	$ 384,449	$ 693,274	$ 553	$ 154,568	$ 1,232,844
0.05 (20 yr)	$ 1,051,396	$ 1,445,251	$ 3,915	$ 543,543	$ 3,044,104
0.02 (50 yr)	$ 4,900,335	$ 4,262,860	$ 34,612	$ 2,761,635	$ 11,959,442
0.01 (100 yr)	$ 12,868,107	$ 7,449,414	$ 83,036	$ 5,277,847	$ 25,678,404
0.005 (200 yr)	$ 20,736,619	$ 10,220,652	$ 124,368	$ 7,613,790	$ 38,695,429
0.002 (500 yr)	$ 28,447,984	$ 13,908,811	$ 188,875	$ 9,739,710	$ 52,285,379
0.001 (1000 yr)	$ 32,179,805	$ 15,737,682	$ 212,879	$ 10,860,579	$ 58,990,944
Future Year 2084 Intermediate Sea-Level Rise					
0.99 (1 yr)	$ -	$ -	$ -	$ -	$ -
0.10 (10 yr)	$ 2,278,944	$ 2,400,239	$ 10,763	$ 1,241,609	$ 5,931,554
0.05 (20 yr)	$ 4,516,725	$ 3,704,178	$ 27,766	$ 2,157,701	$ 10,406,370
0.02 (50 yr)	$ 12,224,546	$ 7,004,663	$ 71,132	$ 4,863,081	$ 24,163,423
0.01 (100 yr)	$ 20,708,043	$ 10,144,204	$ 128,990	$ 7,343,914	$ 38,325,151
0.005 (200 yr)	$ 29,172,984	$ 14,237,282	$ 186,264	$ 9,703,414	$ 53,299,944
0.002 (500 yr)	$ 37,581,568	$ 18,650,249	$ 246,871	$ 11,831,498	$ 68,310,187
0.001 (1000 yr)	$ 41,094,798	$ 20,653,405	$ 274,133	$ 12,979,370	$ 75,001,706

Table 17 (continued)
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
Residential, Non-Residential, Mobile Homes and Industrial
Damages by Probability Event and Category
(2021 Price Level; $ Thousands)

Annual Exceedance Probability (AEP)	Residential	Commercial	Mobile Home	Industrial	Total
Base Year 2035 High Sea-Level Rise					
0.99 (1 yr)	$ -	$ -	$ -	$ -	$ -
0.10 (10 yr)	$ 450,758	$ 804,750	$ 855	$ 193,615	$ 1,449,979
0.05 (20 yr)	$ 1,185,139	$ 1,561,273	$ 5,543	$ 621,993	$ 3,373,949
0.02 (50 yr)	$ 5,406,856	$ 4,505,943	$ 37,794	$ 2,990,160	$ 12,940,754
0.01 (100 yr)	$ 13,613,103	$ 7,688,964	$ 86,893	$ 5,531,460	$ 26,920,419
0.005 (200 yr)	$ 21,585,898	$ 10,529,021	$ 130,639	$ 7,917,029	$ 40,162,586
0.002 (500 yr)	$ 29,236,400	$ 14,311,718	$ 193,364	$ 9,971,578	$ 53,713,060
0.001 (1000 yr)	$ 32,826,180	$ 16,069,832	$ 218,364	$ 11,067,726	$ 60,182,101
Future Year 2084 High Sea-Level Rise					
0.99 (1 yr)	$ -	$ -	$ -	$ -	$ -
0.10 (10 yr)	$ 9,994,818	$ 6,097,270	$ 52,946	$ 4,084,433	$ 20,229,468
0.05 (20 yr)	$ 15,602,131	$ 7,780,642	$ 80,577	$ 5,756,159	$ 29,219,508
0.02 (50 yr)	$ 23,465,189	$ 10,958,947	$ 134,910	$ 8,272,729	$ 42,831,776
0.01 (100 yr)	$ 31,958,522	$ 15,316,478	$ 217,196	$ 10,505,956	$ 57,998,152
0.005 (200 yr)	$ 41,284,525	$ 20,565,903	$ 272,030	$ 12,849,704	$ 74,972,162
0.002 (500 yr)	$ 48,492,181	$ 24,410,024	$ 336,355	$ 14,761,082	$ 87,999,642
0.001 (1000 yr)	$ 50,824,052	$ 25,740,923	$ 356,050	$ 15,539,665	$ 92,460,690

Note: Damages based on 2017 development inventory

Table 18a shows the without-project expected annual damages for the analysis years 2017, 2035 and 2084. The increase in expected annual damages relative to the year 2017 is shown for all three sea-level rise scenarios. The future conditions do not include future development.

Table 18a
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
Structures, Contents, Vehicles, and Debris Removal
Expected Annual Damages
(2021 Price Level; $ Thousands)

Analysis Year	Without-Project Damages	Percent Increase from 2017
2017	$1,616,507	
Low Sea-Level Rise Scenario		
2035	$1,684,600	4%
2084	$2,816,040	74%
Intermediate Sea-Level Rise Scenario		
2035	$1,773,060	10%
2084	$4,584,560	184%
High Sea-Level Rise Scenario		
2035	$1,918,790	19%
2084	$12,438,600	669%

Note: Without-project damage increases are due to relative sea-level rise. Future development was not included in the damages.

Without-Project Equivalent Annual Damages. The HEC-FDA model used linear interpolation for the years between 2035 and 2084 to obtain the stream of expected annual damages over the 50-year period of analysis. The FY 2021 Federal interest rate of 2.5 percent was used to discount the stream of expected annual damages and benefits occurring after the base year (2035) to calculate the total present value of the damages over the period of analysis. The present value of the expected annual damages was then amortized over the period of analysis using the Federal interest rate to calculate the without-project equivalent annual damages.

Recommended Plan With Structural Measures Only. The structural components of the Recommended Plan include a primary line of defense (storm surge gate, dune and berm segments and raised seawall) and an interior line of defense (ring levee with pump stations). An incremental analysis was conducted in December 2019 to confirm the increasing effectiveness of the structural components. The HEC-FDA model was used to calculate the without-project damages and the with-project damages and benefits attributable to the storm surge gate by itself and then in conjunction with each of the other structural components included in the Recommended Plan. Since revisions were made to the H&H data in April 2020, the results of the incremental analysis using the December 2019 H&H data are provided in Addendum B to this economic analysis for informational purposes only. Table 18b shows the equivalent annual without-project and with-project damages and the reduction in damages attributable to the structural components of the Recommended Plan using the revised H&H data for the three sea-level rise scenarios.

Table 18b
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
Equivalent Annual Damages for Recommended Plan 2035-2084 Structural Components
Structures, Contents, Vehicles, and Debris Removal
(2021 Price Level; 2.5% Discount Rate; $ Thousands)

Plan Name	Total Without Project	Total With Project	Damage Reduced
Low Sea-Level Rise Scenario			
Recommended Plan - Structural Components	$2,125,500	$717,752	$1,407,750
Intermediate Sea-Level Rise Scenario			
Recommended Plan - Structural Components	$2,868,640	$1,148,330	$1,720,310
High Sea-Level Rise Scenario			
Recommended Plan - Structural Components	$6,018,120	$3,362,050	$2,656,070

Recommended Plan With Structural and Nonstructural Measures. In addition to the structural components, nonstructural measures (structure elevations, floodproofing and acquisitions) were included in the Recommended Plan to reduce residual surge risk and to mitigate induced damages. Elevations and floodproofing measures were formulated for four floodplains in Reaches 30 and 40 on the west bank of Galveston Bay, including the communities of San Leon Point and Kemah, to reduce the residual surge risk. Flooding could occur in these reaches if counterclockwise winds from tropical events push water toward the west bank of the bay.

Damages and benefits were calculated for the structures in the four floodplains with a first-floor elevation less than the stages associated with the 0.05 (20-year) AEP, the 0.02 (50-year) AEP, the 0.01 (100-year) AEP and the 0.005 (200-year) AEP events along with the preliminary costs for the implementation of the nonstructural measures. Net benefits were maximized by the 0.01 (100-year) AEP plan in which 1,737 residential structures and 18 commercial structures with pier foundations were elevated and 170 commercial structures with slab foundations were floodproofed. The structures were elevated to the stage associated with the future condition 0.01 (100-year) AEP event plus one foot under the intermediate sea-level rise scenario. The commercial structures with slab foundations were floodproofed to three feet above the ground elevation. As a result of these nonstructural measures, residual damages were reduced in study area reaches 39 and 40. The preliminary cost of elevating structures to the target elevation averaged approximately $218,000 per structure, while the cost of floodproofing averaged approximately $115,000 per structure.

Table 19 shows the net benefit analysis for the various nonstructural plans considered for the area. It should be noted that Cost Engineering refined the preliminary nonstructural cost estimates used in this analysis in the final cost estimate for the Recommended Plan.

It should be noted the nonstructural measures were optimized using the FY 2020 interest rate and price level.

Table 19
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
Recommended Plan
Nonstructural Optimization
(2020 Price Level; 2.75% Discount Rate; $ Thousands)

Plan	Nonstructural Floodplain			
	20 year	50 year	100 year	200 year
Total Project Costs				
First Cost	$73,954	$199,844	$402,140	$667,017
Interest During Construction	$251	$679	$1,366	$2,266
Total Investment Cost	$74,206	$200,522	$403,506	$669,283
Estimated Annual Costs				
Annualized Project Costs	$2,749	$7,428	$14,946	$24,791
Total Annual Costs	$2,749	$7,428	$14,946	$24,791
Average Annual Benefits				
Total Annual Incremental Benefits	$15,777	$28,115	$36,251	$40,668
Net Annual Benefits	$13,028	$20,687	$21,305	$15,877
Benefit to Cost Ratio	5.74	3.79	2.43	1.64

Note: Contingencies were not included in the preliminary costs used in this analysis

Acquisitions and elevations were also included in the Recommended Plan to mitigate the induced damages in the Channelview/West Point neighborhood (study area reach 37) located on the north side of Galveston Island outside of the proposed ring barrier system. The operation of the storm surge gate that crosses the entrance to the Houston Ship Channel at Bolivar Road leads to overall inducements in two of the 42 reaches in Region 1. While higher stages for various AEP storm events occur in the years 2035 and 2084 with the project in place, these inducements could be the result of limitations in the H&H modeling which does not consider the design and operation of the gate. Since the storm surge gate can become operational within a few hours both during and after a storm event, most of the inducements may not occur. These inducements are further detailed in the engineering appendix. The inducements in the Channelview/West Point neighborhood would require mitigation due to the unique location of the neighborhood outside of the ring barrier system and adjacent to the Interstate 45 bridge crossing Galveston Bay.

In the HEC-FDA model, 64 structures in the Channelview/West Point neighborhood were first elevated to the stage associated with the 0.01 (100-year) AEP event plus one foot under the intermediate sea-level rise scenario and were then removed from the inventory as part of an acquisition measure. Both measures were considered in the analysis because of the uncertainty as to which nonstructural measure would be more acceptable to the residents. Since the costs for acquisition are generally higher than the costs for elevation, the acquisition costs were used in the analysis. Conversely, the damages and benefits were based on structure elevation because the damage reduction was lower for elevation relative to acquisition. Table 20 shows the damages and benefits associated with the inducement mitigation plan options considered. It should be noted that Cost Engineering refined the preliminary acquisition cost estimates in the final cost estimate for the Recommended Plan.

Table 20
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
Equivalent Annual Damages for 2035-2084
Channelview Nonstructural Analysis
(2020 Price Level; 2.75% Discount Rate; $ Thousands)

Intermediate Sea-Level Rise Scenario			
Plan Name	Total Without Project	Total With Project	Damage Reduced
Recommended Plan - Structural Components	$2,902	$2,902	$0
Raising Channelview Neighborhood	$2,902	$140	$2,762
Buyout of Channelview Neighborhood	$2,902	$0	$2,902

Note: The models were run with an inventory limited to just the Channelview Neighborhood for this analysis

Equivalent Annual Damages and Benefits for the Recommended Plan. The HEC-FDA model was used to calculate the 2035 and 2084 expected annual without-project and with-project damages. For the Recommended Plan, the without-project and with-project damages were calculated using a base year of 2035, FY 2021 price level and interest rate. The HEC-FDA model then used linear interpolation for the years between 2035 and 2084 to obtain the stream of expected annual damages over the 50-year period of analysis. The present value of the expected annual damages was then amortized over the period of analysis using the Federal interest rate to calculate the equivalent annual damages.

Table 21 shows the equivalent annual damages by damage categories under the without-project condition, Recommended Plan – Structural Components, and Complete Recommended Plan by damage category for the projected three sea-level rise scenarios.

Table 21
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
Recommended Plan
Equivalent Annual Damages by Category 2035-2084
(2021 Price Level; 2.5% Discount Rate; $ Thousands)

Low Sea-Level Rise Scenario						
Plan	Auto	Commercial	Industrial	MobileHome	Residential	Total
Without Project	$83,673	$635,645	$549,891	$5,021	$851,270	$2,125,500
Recommended Plan - Structural Components	$50,725	$203,860	$200,125	$2,126	$260,916	$717,752
Complete Recommended Plan	$50,748	$200,013	$200,269	$2,036	$240,864	$693,929
Intermediate Sea-Level Rise Scenario						
Plan	Auto	Commercial	Industrial	MobileHome	Residential	Total
Without Project	$112,607	$851,805	$758,386	$6,559	$1,139,280	$2,868,640
Recommended Plan - Structural Components	$70,180	$317,565	$359,854	$2,866	$397,867	$1,148,330
Complete Recommended Plan	$70,251	$311,146	$360,573	$2,729	$368,199	$1,112,900
High Sea-Level Rise Scenario						
Plan	Auto	Commercial	Industrial	MobileHome	Residential	Total
Without Project	$219,507	$1,685,590	$1,621,080	$13,061	$2,478,890	$6,018,120
Recommended Plan - Structural Components	$146,138	$866,565	$1,043,720	$7,365	$1,298,270	$3,362,050
Complete Recommended Plan	$146,151	$848,219	$1,043,840	$6,958	$1,230,380	$3,275,550

Tables 22, 23 and 24 show the equivalent annual without-project, with-project, and damages reduced for the Recommended Plan – Structural Components and Complete Recommended Plan by study area reach for the three projected sea-level rise scenarios.

Table 22
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
Recommended Plan
Equivalent Annual Damages and Benefits by Reach 2035-2084
Low Sea-Level Rise Scenario
(2021 Price Level; 2.5% Discount Rate; $ Thousands)

Damage Reach Name	Recommended Plan - Structural Components			Complete Recommended Plan		
	Total Without Project	Total With Project	Damage Reduced	Total Without Project	Total With Project	Damage Reduced
1	$ 217	$ 185	$ 31	$ 217	$ 185	$ 31
2	$ 2,080	$ 1,781	$ 299	$ 2,080	$ 1,781	$ 299
4	$ 199,959	$ 172,369	$ 27,590	$ 199,959	$ 172,369	$ 27,590
5	$ 8,523	$ 7,379	$ 1,144	$ 8,523	$ 7,379	$ 1,144
6	$ 25,407	$ 15,772	$ 9,634	$ 25,407	$ 15,772	$ 9,634
7	$ 36,165	$ 31,207	$ 4,958	$ 36,165	$ 31,207	$ 4,958
9	$ 424,812	$ 60,228	$ 364,584	$ 424,812	$ 60,228	$ 364,584
10	$ 4,323	$ 916	$ 3,407	$ 4,323	$ 916	$ 3,407
11	$ 15,179	$ 3,987	$ 11,193	$ 15,179	$ 3,987	$ 11,193
13	$ 34,179	$ 10,359	$ 23,819	$ 34,179	$ 10,359	$ 23,819
14	$ 168,186	$ 43,273	$ 124,913	$ 168,186	$ 43,273	$ 124,913
15	$ 237	$ 24	$ 213	$ 237	$ 24	$ 213
16	$ 15,246	$ 1,478	$ 13,768	$ 15,246	$ 1,478	$ 13,768
17	$ 3,536	$ 380	$ 3,156	$ 3,536	$ 380	$ 3,156
18	$ 7,444	$ 1,250	$ 6,194	$ 7,444	$ 1,250	$ 6,194
19	$ 10,081	$ 2,194	$ 7,887	$ 10,081	$ 1,035	$ 9,046
20	$ 437	$ 232	$ 206	$ 437	$ 232	$ 206
21	$ 295	$ 213	$ 82	$ 295	$ 213	$ 82
22	$ 973	$ 744	$ 229	$ 973	$ 744	$ 229
24	$ 7,058	$ 6,767	$ 291	$ 7,058	$ 6,767	$ 291
25	$ 7,173	$ 6,351	$ 822	$ 7,173	$ 6,351	$ 822
30	$ 5,955	$ 5,210	$ 746	$ 5,955	$ 5,210	$ 746
34	$ 13,289	$ 8,252	$ 5,037	$ 13,289	$ 8,252	$ 5,037
35	$ 17,188	$ 10,690	$ 6,498	$ 17,188	$ 10,690	$ 6,498
36	$ 559,305	$ 39,951	$ 519,354	$ 559,305	$ 39,951	$ 519,354
37	$ 116,283	$ 138,951	$ (22,668)	$ 116,283	$ 136,776	$ (20,493)
38	$ 13,309	$ 25,440	$ (12,131)	$ 13,309	$ 25,440	$ (12,131)
39	$ 137,366	$ 39,558	$ 97,808	$ 137,366	$ 22,492	$ 114,874
40	$ 28,896	$ 8,300	$ 20,596	$ 28,896	$ 4,876	$ 24,019
81	$ 83,400	$ 48,265	$ 35,135	$ 83,400	$ 48,265	$ 35,135
82	$ 122,299	$ 6,202	$ 116,098	$ 122,299	$ 6,202	$ 116,098
83	$ 56,702	$ 19,845	$ 36,857	$ 56,702	$ 19,845	$ 36,857
Total	**$ 2,125,500**	**$ 717,752**	**$ 1,407,750**	**$ 2,125,500**	**$ 693,929**	**$ 1,431,570**

Note: Reaches 3, 12, 23, 26, 27, 28, 29, 31, 32, and 33 do not have any damages

Table 23
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
Recommended Plan
Equivalent Annual Damages and Benefits by Reach 2035-2084
Intermediate Sea-Level Rise Scenario
(2021 Price Level; 2.5% Discount Rate; $ Thousands)

Damage Reach Name	Recommended Plan - Structural Components			Complete Recommended Plan		
	Total Without Project	Total With Project	Damage Reduced	Total Without Project	Total With Project	Damage Reduced
1	$ 274	$ 231	$ 43	$ 274	$ 231	$ 43
2	$ 2,729	$ 2,283	$ 445	$ 2,729	$ 2,283	$ 445
4	$ 257,463	$ 216,883	$ 40,580	$ 257,463	$ 216,883	$ 40,580
5	$ 9,696	$ 8,144	$ 1,553	$ 9,696	$ 8,144	$ 1,553
6	$ 30,815	$ 19,750	$ 11,065	$ 30,815	$ 19,750	$ 11,065
7	$ 49,569	$ 43,943	$ 5,626	$ 49,569	$ 43,943	$ 5,626
9	$ 542,406	$ 97,337	$ 445,069	$ 542,406	$ 97,337	$ 445,069
10	$ 5,163	$ 1,026	$ 4,137	$ 5,163	$ 1,026	$ 4,137
11	$ 17,817	$ 5,120	$ 12,697	$ 17,817	$ 5,120	$ 12,697
13	$ 42,460	$ 13,322	$ 29,138	$ 42,460	$ 13,322	$ 29,138
14	$ 216,206	$ 55,769	$ 160,437	$ 216,206	$ 55,769	$ 160,437
15	$ 385	$ 24	$ 361	$ 385	$ 24	$ 361
16	$ 18,767	$ 2,299	$ 16,468	$ 18,767	$ 2,299	$ 16,468
17	$ 4,331	$ 652	$ 3,679	$ 4,331	$ 652	$ 3,679
18	$ 10,088	$ 2,293	$ 7,795	$ 10,088	$ 2,293	$ 7,795
19	$ 13,237	$ 3,326	$ 9,911	$ 13,237	$ 1,713	$ 11,524
20	$ 589	$ 339	$ 250	$ 589	$ 339	$ 250
21	$ 320	$ 206	$ 114	$ 320	$ 206	$ 114
22	$ 1,231	$ 1,062	$ 169	$ 1,231	$ 1,062	$ 169
24	$ 7,765	$ 7,326	$ 439	$ 7,765	$ 7,326	$ 439
25	$ 8,529	$ 7,420	$ 1,108	$ 8,529	$ 7,420	$ 1,108
30	$ 7,248	$ 6,227	$ 1,021	$ 7,248	$ 6,227	$ 1,021
34	$ 17,951	$ 13,946	$ 4,005	$ 17,951	$ 13,946	$ 4,005
35	$ 20,411	$ 16,302	$ 4,108	$ 20,411	$ 16,302	$ 4,108
36	$ 786,219	$ 160,119	$ 626,100	$ 786,219	$ 160,119	$ 626,100
37	$ 173,600	$ 227,058	$ (53,458)	$ 173,600	$ 224,743	$ (51,143)
38	$ 18,460	$ 30,173	$ (11,713)	$ 18,460	$ 30,173	$ (11,713)
39	$ 176,561	$ 56,670	$ 119,891	$ 176,561	$ 29,775	$ 146,786
40	$ 41,353	$ 10,598	$ 30,755	$ 41,353	$ 5,988	$ 35,366
81	$ 166,569	$ 99,824	$ 66,744	$ 166,569	$ 99,824	$ 66,744
82	$ 147,833	$ 10,979	$ 136,854	$ 147,833	$ 10,979	$ 136,854
83	$ 72,598	$ 27,680	$ 44,919	$ 72,598	$ 27,680	$ 44,919
Total	**$ 2,868,640**	**$1,148,330**	**$ 1,720,310**	**$ 2,868,640**	**$1,112,900**	**$ 1,755,740**

Note: Reaches 3, 12, 23, 26, 27, 28, 29, 31, 32, and 33 do not have any damages

Table 24
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
Recommended Plan
Equivalent Annual Damages and Benefits by Reach 2035-2084
High Sea-Level Rise Scenario
(2021 Price Level; 2.5% Discount Rate; $ Thousands)

Damage Reach Name	Recommended Plan - Structural			Complete Recommended Plan		
	Total Without Project	Total With Project	Damage Reduced	Total Without Project	Total With Project	Damage Reduced
1	$ 433	$ 392	$ 41	$ 433	$ 392	$ 41
2	$ 5,046	$ 4,516	$ 530	$ 5,046	$ 4,516	$ 530
4	$ 406,613	$ 363,593	$ 43,020	$ 406,613	$ 363,593	$ 43,020
5	$ 14,005	$ 11,668	$ 2,337	$ 14,005	$ 11,668	$ 2,337
6	$ 66,202	$ 41,613	$ 24,589	$ 66,202	$ 41,613	$ 24,589
7	$ 102,932	$ 102,693	$ 239	$ 102,932	$ 102,693	$ 239
9	$1,091,030	$ 329,342	$ 761,689	$1,091,030	$ 329,342	$ 761,689
10	$ 8,326	$ 2,087	$ 6,240	$ 8,326	$ 2,087	$ 6,240
11	$ 26,464	$ 11,332	$ 15,132	$ 26,464	$ 11,332	$ 15,132
13	$ 67,631	$ 28,288	$ 39,344	$ 67,631	$ 28,288	$ 39,344
14	$ 381,770	$ 141,997	$ 239,773	$ 381,770	$ 141,997	$ 239,773
15	$ 1,126	$ 75	$ 1,050	$ 1,126	$ 75	$ 1,050
16	$ 34,710	$ 8,692	$ 26,019	$ 34,710	$ 8,692	$ 26,019
17	$ 7,884	$ 2,207	$ 5,676	$ 7,884	$ 2,207	$ 5,676
18	$ 18,358	$ 7,947	$ 10,411	$ 18,358	$ 7,947	$ 10,411
19	$ 28,538	$ 9,824	$ 18,714	$ 28,538	$ 5,947	$ 22,590
20	$ 1,377	$ 894	$ 483	$ 1,377	$ 894	$ 483
21	$ 454	$ 324	$ 130	$ 454	$ 324	$ 130
22	$ 2,283	$ 1,997	$ 286	$ 2,283	$ 1,997	$ 286
24	$ 10,388	$ 9,761	$ 627	$ 10,388	$ 9,761	$ 627
25	$ 11,910	$ 10,877	$ 1,033	$ 11,910	$ 10,877	$ 1,033
30	$ 10,946	$ 9,917	$ 1,029	$ 10,946	$ 9,917	$ 1,029
34	$ 43,789	$ 48,628	$ (4,839)	$ 43,789	$ 48,628	$ (4,839)
35	$ 41,660	$ 43,405	$ (1,745)	$ 41,660	$ 43,405	$ (1,745)
36	$1,749,770	$ 780,572	$ 969,197	$1,749,770	$ 780,572	$ 969,197
37	$ 366,013	$ 482,416	$ (116,402)	$ 366,013	$ 478,084	$ (112,071)
38	$ 33,445	$ 47,247	$ (13,802)	$ 33,445	$ 47,247	$ (13,802)
39	$ 320,541	$ 149,578	$ 170,963	$ 320,541	$ 83,533	$ 237,007
40	$ 95,316	$ 27,220	$ 68,096	$ 95,316	$ 14,967	$ 80,349
81	$ 669,648	$ 565,575	$ 104,073	$ 669,648	$ 565,575	$ 104,073
82	$ 241,720	$ 39,569	$ 202,151	$ 241,720	$ 39,569	$ 202,151
83	$ 157,797	$ 77,811	$ 79,987	$ 157,797	$ 77,811	$ 79,987
Total	**$6,018,120**	**$3,362,050**	**$ 2,656,070**	**$6,018,120**	**$3,275,550**	**$ 2,742,570**

Note: Reaches 3, 12, 23, 26, 27, 28, 29, 31, 32, and 33 do not have any damages

Table 25 shows the total equivalent annual without-project damages, with-project damages, and damages reduced for the Recommended Plan – Structural Components and Complete Recommended plan for the three projected sea-level rise scenarios and the probability damages reduced exceeds the 0.75, 0.50 and 0.25 confidence levels.

Table 25
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
Equivalent Annual Damages for Recommended Plan 2035-2084
Structures, Contents, Vehicles, and Debris Removal
(2021 Price Level; 2.5% Discount Rate; $ Thousands)

Low Sea-Level Rise Scenario						
Plan Name	Total Without Project	Total With Project	Damage Reduced	Prob Damg Reduced Exceeds Values 0.75	Prob Damg Reduced Exceeds Values 0.50	Prob Damg Reduced Exceeds Values 0.25
Recommended Plan - Structural Components	$2,125,500	$717,752	$1,407,750	$749,368	$1,269,050	$1,936,420
Complete Recommended Plan	$2,125,500	$693,929	$1,431,570	$766,356	$1,292,820	$1,967,180
Intermediate Sea-Level Rise Scenario						
Plan Name	Total Without Project	Total With Project	Damage Reduced	Prob Damg Reduced Exceeds Values 0.75	Prob Damg Reduced Exceeds Values 0.50	Prob Damg Reduced Exceeds Values 0.25
Recommended Plan - Structural Components	$2,868,640	$1,148,330	$1,720,310	$1,017,070	$1,595,180	$2,307,590
Complete Recommended Plan	$2,868,640	$1,112,900	$1,755,740	$1,043,920	$1,630,800	$2,351,370
High Sea-Level Rise Scenario						
Plan Name	Total Without Project	Total With Project	Damage Reduced	Prob Damg Reduced Exceeds Values 0.75	Prob Damg Reduced Exceeds Values 0.50	Prob Damg Reduced Exceeds Values 0.25
Recommended Plan - Structural Components	$6,018,120	$3,362,050	$2,656,070	$1,905,240	$2,552,260	$3,316,390
Complete Recommended Plan	$6,018,120	$3,275,550	$2,742,570	$1,982,060	$2,638,980	$3,412,970

Note: The Complete Recommended Plan is the full recommended plan with nonstructural implemented on the west bank and in the West Point neighborhood.

OTHER BENEFIT CATEGORIES

General. In addition to the physical damages to structures, contents, vehicles and debris removal costs, there are three other categories of NED benefits attributable to the Coastal Texas alternatives: physical damages to transportation infrastructure; physical damages to above ground storage tanks and their contents; and the reduction of indirect losses to the national economy. Equivalent annual benefits were calculated for each of these categories using the year 2035 as the base year and the year 2084 as the last year in the 50-year period of analysis. However, in the final analysis for the Recommended Plan, the base year was changed to the year 2043 to reflect an 8-year increase in the construction period. The damage and benefit results reflecting this change are shown at the end of Part 3 of the Economic Appendix.

Damages to Transportation Infrastructure. The reduction of potential flood damages to the transportation infrastructure (highways and streets, bridges, railroads, ports, airports, land-based pipelines, and petroleum wells) in an evaluation area can form a significant category of benefits attributable to a project alternative. For purposes of this analysis, only the damages to highways, streets and railroad tracks were considered. Major and secondary highways are defined as roadways with four lanes with relatively higher volumes of traffic and access, while streets are defined as roadways with two lanes with relatively lower volumes of traffic and access. Railroad tracks include both electrical and non-electrical components.

The Open Street Map GIS database was used to determine the number of miles of streets, highways and railroad tracks within each station of the study area reaches of the overflow area of Region 1. A center point of each segment of streets, highways and railroad tracks was determined, and an elevation was assigned to the segment using LiDAR data. A HEC-FDA structure record was created for each roadway or railroad segment within the station. The elevation and value per segment of roadway or railroad in each station were entered on the structure record for the HEC-FDA model. The value was based on the costs of replacing or repairing a roadway or railways segment on a per mile basis. It was estimated that there are slightly under $34 billion of roadways and railways in the study area.

The NED costs associated with transportation infrastructure were estimated based on data obtained during interviews with professionals familiar with infrastructure inundation impacts. The information compiled as part of the interview process can be found in the report entitled, *Development of Depth-Emergency Costs and Infrastructure Damage Relationships for Selected South Louisiana Parishes* dated March 2012. The depth-damage relationships for transportation infrastructure obtained from this report were recently applied to the adjacent Sabine to Galveston study area, which is located in Region 1 of the Coastal Texas study area.

The experts provided costs for three components of streets (street surface, street base, and street curb), three components of major and secondary highways (road surface, road base, and road shoulder, and three components of railroad tracks (electrical interlocking and grade crossings and non-electrical track structures). The experts also provided estimates of the depreciation of the roadways. The value of each mile of roadway and railway component was discounted by the estimated depreciation percentage. Finally, the experts estimated the percentage of the road components that would be damaged at the 2-feet, 5-feet, and 12-feet depths of flooding.

The damage to the highways, streets and railroad tracks per mile was calculated by multiplying the cost of the materials and labor to replace each infrastructural component by the inverse of the depreciation percentage by the percentage damage to each component. The minimum, most likely, and maximum damages for each roadway and railway component were used to develop a range of values for the total cost of the infrastructural damages per mile. Using a normal distribution, a mean value for the damages per mile and a standard deviation were calculated for each of the three depths of flooding. The mean value for the damages per mile in the report were updated from 2010 to 2020 values using the roads, railroads, and bridges index from the Civil Works Construction Cost Index System (CWCCIS) dated 30 September 2019. A damage value of approximately $3.37 million per mile for (4-lane) secondary and primary highways, $612,000 per mile for (2-lane) streets and $394,000 per mile for railroad tracks was used in the analysis.

The depth-damage relationships for major and secondary highways, streets and railroads were converted to percentages and entered into the HEC-FDA model, along with the major and secondary highways, streets and railroad track structure records. The damage value for each mile of highways, streets and railroads at 12 feet of flooding was used as the infrastructure value, and the stage-probability relationships for each station within the study area reaches was used to calculate the expected annual without-project and with-project damages to major and secondary highways, streets and railroad tracks for the base year (2035) and the final year of the 50-year period of analysis (2084). The expected annual damages were converted to equivalent annual values using the current Federal discount rate of 2.5 percent and a 50-year period of analysis. Table 26 shows the depth-damage relationships used in HEC-FDA for transportation infrastructure.

Table 26
Coastal Texas Protection and Restoration Study
Integrated Feasibility Report
Depth-Damage Relationships for Transportation Infrastructure

Streets		
Street Depth	Street Percent Damage	Street Standard Deviation
1.9	0.0	0.0
2.0	54.2	9.1
5.0	66.2	11.0
12.0	100.0	15.4

Highways		
Highway Depth	Highway Percent Damage	Highway Standard Deviation
1.9	0.0	0.0
2.0	32.7	3.6
5.0	72.3	7.1
12.0	100.0	9.9

Railroads		
Railroad Depth	Railroad Percent Damage	Railroad Standard Deviation
1.9	0.0	0.0
2.0	90.6	37.8
5.0	93.9	37.9
12.0	100.0	38.1

Table 27 shows the total equivalent annual without-project damages, with-project damages, and damages reduced for the Recommended Plan for the three projected sea-level rise scenarios and the probability damages reduced exceeds the 0.75, 0.50 and 0.25 confidence levels. It should be noted that 49 percent of the total transportation infrastructure damages are to highways, 45 percent to streets, and 6 percent to railroad tracks.

Table 27
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
Equivalent Annual Damages for Recommended Plan 2035-2084
Primary and Secondary Highways, Streets, and Railroad Tracks
(2021 Price Level; 2.5% Discount Rate; $ Thousands)

Low Sea-Level Rise Scenario						
Plan Name	Total Without Project	Total With Project	Damage Reduced	Prob Damg Reduced Exceeds Values 0.75	Prob Damg Reduced Exceeds Values 0.50	Prob Damg Reduced Exceeds Values 0.25
Recommended Plan	$351,327	$265,775	$85,552	$48,106	$80,423	$117,204
Intermediate Sea-Level Rise Scenario						
Plan Name	Total Without Project	Total With Project	Damage Reduced	Prob Damg Reduced Exceeds Values 0.75	Prob Damg Reduced Exceeds Values 0.50	Prob Damg Reduced Exceeds Values 0.25
Recommended Plan	$459,565	$341,976	$117,589	$77,661	$112,396	$151,329
High Sea-Level Rise Scenario						
Plan Name	Total Without Project	Total With Project	Damage Reduced	Prob Damg Reduced Exceeds Values 0.75	Prob Damg Reduced Exceeds Values 0.50	Prob Damg Reduced Exceeds Values 0.25
Recommended Plan	$819,930	$650,807	$169,123	$128,009	$164,580	$205,052

Note: Approximately 49 percent of the total transportation infrastructure damages are to highways, 45 percent to streets, and 6 percent to railroad tracks.

The uncertainty surrounding the damage percentages for each mile of secondary and primary highways, streets and railroad tracks at the three depths of flooding (2 feet, 5 feet and 12 feet) was represented by a normal probability distribution with mean values and standard deviations. The depth-damage relationships containing the damage percentages at the various depths of flooding and the corresponding standard deviations representing the uncertainty are shown with in the tables for depth–damage relationships. The uncertainty surrounding the use of LiDAR to estimate the elevation of each segment of roadway or railway was entered as a standard deviation, 0.3007 feet, on the HEC-FDA model structure records.

Addendum C reports modeling results with a 10-year levee in place for the transportation infrastructure.

Damages to Above Ground Storage Tanks. Approximately 13,000 above ground storage tanks are located in Region 1 (Galveston/Houston area) of the Coastal Texas evaluation area. These tanks are used by industrial facilities primarily in the oil and gas sector to store fuels and various other chemicals. Storm surges from tropical events could cause physical damages to these storage tanks and the loss or spillage of their contents. As an example, floodwaters from Hurricane Harvey in 2017 led to the floating of two large (30-meter diameter) storage tanks and 20 small storage tanks in the Houston Ship Channel area. The failure of the two large tanks led to the largest chemical spill during Hurricane Harvey. While the spillage of 1.75 million liters of gasoline from these storage tanks was mostly contained, a small portion of the spill reached the Houston Ship Channel. The spillage from the smaller tanks was reported to have reached nearby creeks and rivers. Damages to above ground storage tanks and the resulting content spillage contributed to the temporary closure of 18 refineries and a 20 to 25 percent reduction in the U.S. refining capacity. The excessive rain from the Hurricane Harvey caused floating roof failures in 16 other tanks. However, the recommended CSRM measures would not address this damage mechanism.

Dr. Jamie Padgett and Dr. Sabarethinam Kameshwar of the Department of Civil and Environmental Engineering at Rice University have conducted extensive research on the fragility of the above ground storage tanks in the Houston Ship Channel area. Data developed by the Rice team in their on-going research were used to develop generic depth-damage relationships for the storage tanks and their contents in Region 1 of the Coastal Texas evaluation area. The generic depth-damage relationships developed for this study include only the physical damages to the tanks and their contents and do not consider the cost of cleaning up the materials that spilled from the tanks.

In their research, Kameshwar and Padgett used Archimedes principle to evaluate the effects of floodwater, in one-foot increments up to a depth of 25 feet, on the 4,596 storage tanks located along the upper portion of the Houston Ship Channel. These tanks represent approximately 35 percent of the tanks in Region 1 of the Coastal Texas study area. The Rice research team compiled a database that assigned a unique identification number to each of the storage tanks in the area. The database included the GPS location, diameter, height, ground elevation, lower and upper bounds for content density, and the replacement cost of each tank. Tank replacement costs were obtained from the State of Michigan Tax Assessors Manual, which provided costs in 2003 U.S. dollars. The Rice team converted these costs to 2016 U.S. dollars using the Nelson-Farrar refinery construction index. (USACE later used the Engineering News Record (ENR) Construction Cost Index to update these costs to October 2019 price levels.)

Based on Archimedes principle, a storage tank is assumed to fail when the uplift created by the storm surge of a tropical event becomes greater than the self-weight of the tank. At that point, the surge of water will force the tank to float away from its original position and spill its contents. Kameshwar and Padgett provided an engineering evaluation of the probability of tank floatation based on a number of parameters. The buoyancy forces considered in the analysis included the density of seawater, the inundation level in feet, the acceleration of water due to gravity, and the height of the storage tanks. The buoyancy resistance forces considered included the thickness of the shell, base, and roof of the tank, the relative density of the steel used in its construction, the level of liquid stored in tank, and the relative density of the stored liquid.

The Rice research team made several assumptions in their evaluation of tank fragility (probability of failure) at each of the given inundation depths. Since the level of liquid inside each tank was uncertain, the content level was modeled as a uniformly distributed random variable between zero and 90 percent of the tank capacity. Similarly, since the contents of each tank was uncertain, the density of the contents was modeled as a uniformly distributed random variable within the lower and upper bounds for contents using Texas Commission on Environmental Quality (TCEQ) permits. All of the contents were assumed to spill out of the tank as soon as the tank failed. Damages to the pipelines attached to the tanks were not considered. And finally, based on observations of the tanks in the area, all tanks were assumed to be un-anchored.

Kameshwar and Padgett used regression analysis to predict the floatation of the storage tanks for the various parameters and inundation depths. Monte Carlo simulations were performed to reproduce the uncertainties in the liquid levels and densities to obtain the failure probability and the expected spill volume. The Rice analysis produced failure probabilities at various levels of inundation and the proportion of tank capacity spilled at various levels of inundation for each of the 4,598 individual tanks in the upper portion in the Houston Ship Channel area. The failure analysis only considered floatation failure and not other failure modes such as buckling, debris, and wave impact. Figure 8 shows the results for the lowest cost tank, an average cost tank, and the highest cost tank.

Specific Information by Individual Storage Tank

Tank ID	Latitude	Longitude	Tank diameter (m)	Tank height (m)	Content density lower bound (kg/m³)	Content density upper bound (kg/m³)	Capacity (m³)	Cost of tank (in 2016 $)
3053	29.682	-95.013	1.68	4.35	400	920	10	25,322
210	29.741	-95.128	14.63	17.88	600	950	3,004	281,689
850	29.751	-95.205	88.39	22.04	700	950	135,172	5,842,141

Failure Probability at Various Levels of Inundation

Tank ID	1 foot	2 feet	3 feet	4 feet	5 feet	6 feet	7 feet	8 feet	9 feet	10 feet
3053	0	12%	25%	37%	50%	62%	75%	83%	90%	95%
210	0	2%	4%	7%	9%	12%	14%	17%	19%	22%
850	0	0.2%	2%	4%	6%	8%	10%	12%	14%	16%

Proportion of Tank Capacity Spilled at Various Levels of Inundation

Tank ID	1 foot	2 feet	3 feet	4 feet	5 feet	6 feet	7 feet	8 feet	9 feet	10 feet
3053	0	0.7%	3%	7%	12%	19%	26%	32%	37%	41%
210	0	0.01%	0.08%	0.2%	0.4%	0. 7%	0.9%	1%	2%	3%
850	0	0.0001%	0.02%	0. 08%	0.2%	0.3%	0.4%	0.6%	0.9%	1%

Figure 8 – Results for lowest cost, highest cost, and average cost tanks

The results of the Rice research for the storage tanks in the Houston Ship Channel area were used by USACE to develop the following data for all of the storage tanks in Region 1 of the Coastal Texas evaluation area: a generic cost value for the tank structures; a generic contents to structure value ratio (CSVR); failure probabilities at each one-foot increment above the ground elevation to be used as damage percentages for the tank structures; and the proportion of tank capacity spilled at each one-foot increment to be used as damage percentages for the contents. Uncertainty ranges were developed for each of these values and damage percentages.

The mode of the distribution was used to represent the most likely cost value. In order to calculate the mode, the 4,596 tank cost observations were grouped from lowest cost to highest cost into 20 equal sized increments, or bins. The width of each bin was computed as the maximum tank cost value minus the minimum tank cost value divided by the number of bins. The top point of the first bin was calculated by adding the bin width to the minimum cost value in the distribution. This process was repeated so as to assign a minimum value and a maximum value, or top point, to each bin. A cumulative percentage, or percentile, was calculated for the top point of each bin. The midpoint (minimum value plus one half of the bin width) of the bin with the largest incremental percentage was identified as the mode, or most likely value. The 1st and 99th percentile values were used as the minimum and maximum values, and together with the most likely value, were used to form a triangular probability distribution for the cost value of a tank structure. The minimum, most likely and maximum tank cost values are displayed in Table 28. Also shown in the table are the cumulative percentages for the distribution of tank cost values.

Table 28
Coastal Texas Protection and Restoration Study
Integrated Feasibility Report
Above Ground Storage Tank Structure Value with Uncertainty
(2020 Price Level; $ Thousands)

Minimum Tank Value	Most Likely Tank Value	Maximum Tank Value
$41	$187	$3,140

While the content of the individual storage tanks was not specified as part of the Rice analysis, it was possible to estimate tank contents based on the type and volume of the fuels and other chemical products shipped into the area. Data obtained from the USACE Waterborne Commerce Statistics Center were used to identify the most common liquid commodities transported through the Houston Ship Channel area. The commodities with the highest tonnage included crude oil, residual fuel oil, distillate fuel oil, gasoline, benzene, and naphtha. It was assumed that these commodities were representative of the contents of the storage tanks located throughout Region 1 of the Coastal Texas area.

A price per gallon for each of these commodities was calculated based on the average commodity prices during the three-year period 2017 to 2019. A weighted average of these prices could be used to represent a point estimate for the value of the commodities. However, for purposes of risk and uncertainty, a uniform probability distribution was created using the price estimate for the commodity with the lowest price per gallon as the minimum value and the price estimate for the commodity with the highest price per gallon as the maximum value.

The contents to structure value ratio (CSVR) for the storage tanks relates the value of the tank contents to the value of the tank structure, and it was calculated by multiplying the tank capacity by the commodity value and then dividing the product by the tank cost. The modal value was used as the most likely value for the CSVR and was computed by completing four steps. First, the tank capacity of each of the 4,596 storage tanks was divided by its corresponding tank cost. Second, a distribution of the tank capacity to tank cost ratios was generated, and each of these 4,596 data points was grouped from smallest to largest into 20 equal sized increments, or bins. Third, a general probability distribution was created using the midpoints of the 20 increments and the associated frequencies. Finally, the @Risk program was used to produce a distribution of CSVRs by multiplying the uniform probability distribution for the commodity values by the tank capacity. The 1st and 99th percentile values were used as the minimum and maximum values, and together with the most likely value, were used to form a triangular probability distribution for the CSVRs. The minimum, most likely, and maximum CSVRs are displayed in Table 29. Also shown in the table are the cumulative percentages for the distribution of tank cost values.

Table 29
Coastal Texas Protection and Restoration Study
Integrated Feasibility Report
Above Ground Storage Tank CSVR with Uncertainty

Minimum CSVR	Most Likely CSVR	Maximum CSVR
0.59	4.11	13.55

In order to develop a generic depth-damage relationship for tank structures, the following four assumptions were made: the distribution of the 4,596 tank values is representative of the size and cost of the larger tank population in Region 1 of the Coastal Texas evaluation area; a storage tank does not incur any structural damage until it fails (floats off its base); there is a total loss of the structure value when the tank fails; and the distribution of the expected value failure probabilities of the 4,596 tanks for a given depth of flooding represents the uncertainty surrounding the tank failure at that depth of flooding. The Rice research team provided an expected failure probability for each of the 4,596 individual tanks at one-foot increments of flooding up to a depth of 25 feet. These expected value failure probabilities were used to represent the structure damage percentages at various depths of flooding. The individual expected tank failure values at each of the various depths of flooding were assigned to 20 equal sized increments, or bins. The midpoint of the increment with the greatest frequency was defined as the most likely expected tank failure value at each depth of flooding. The 1st and 99th percentile values were used as the minimum and maximum values, and together with the most likely value, were used to form a triangular probability distribution representing the tank failure uncertainty. The minimum, most likely, and maximum tank failure percentages are displayed in Table 30. The structure depth-damage percentages at various depths of flooding for various percentiles are shown in Figure 9.

Table 30
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
Above Ground Storage Tank Structure Depth-Damage Percentages

Flooding Depth (ft.)	Minimum Structure Damage Percentage	Most Likely Structure Damage Percentage	Maximum Structure Damage Percentage
1	0	0.2	1.7
5	6.4	12.7	39.3
10	15.6	28.4	84.5
15	25.1	39.2	100
20	34.4	59.4	100
25	43.6	97.6	100

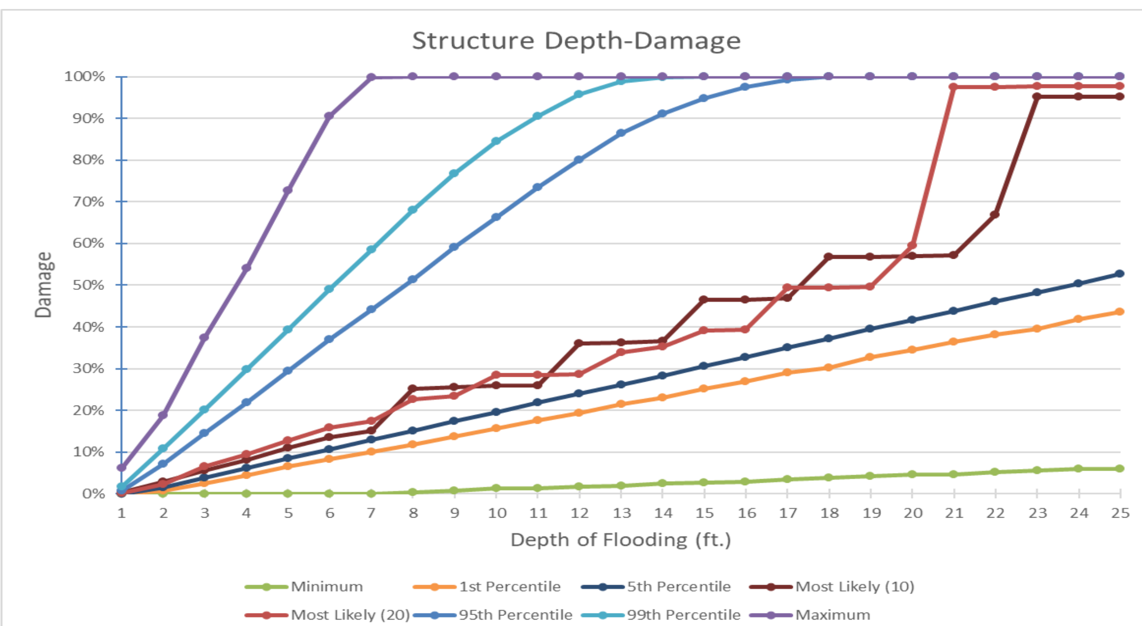


Figure 9 – Structure depth-damage percentages

A generic depth-damage relationship for tank contents was developed using the following five assumptions: the distribution of commodities used to compute contents value is representative of the larger population of tank commodity contents in Region 1 of the Coastal Texas evaluation area; the content value reflects a full tank; any tank failure results in spillage and a complete loss of contents; a three-year average price for the individual commodity value is used for contents value; and the distribution of the expected value spill proportion of the 4,596 tanks for a given depth of flooding represents the uncertainty surrounding the spill proportion for that depth of flooding. The 4,596 expected value spill proportions were assigned to 20 equal sized increments, or bins. The midpoint of the increment with the greatest frequency was defined as the most likely content value at each depth of flooding. The 1st and 99th percentile values were used as the minimum and maximum values, and together with the most likely value, were used to form a triangular probability distribution representing spill proportion uncertainty. The minimum, most likely, and maximum content damage percentages are displayed in Table 31. The content depth-damage percentages at various depths of flooding for various percentiles are shown in Figure 10.

Table 31
Coastal Texas Protection and Restoration Study Integrated
Feasibility Report
Above Ground Storage Tank Content Depth-Damage Percentages

Flooding Depth (ft.)	Minimum Content Damage Percentage	Most Likely Content Damage Percentage	Maximum Content Damage Percentage
1	0	0	0
5	0.2	0.6	7.4
10	1.1	3.4	32.6
15	2.9	5.7	45
20	5.4	12.7	45.3
25	8.8	44.7	45.4

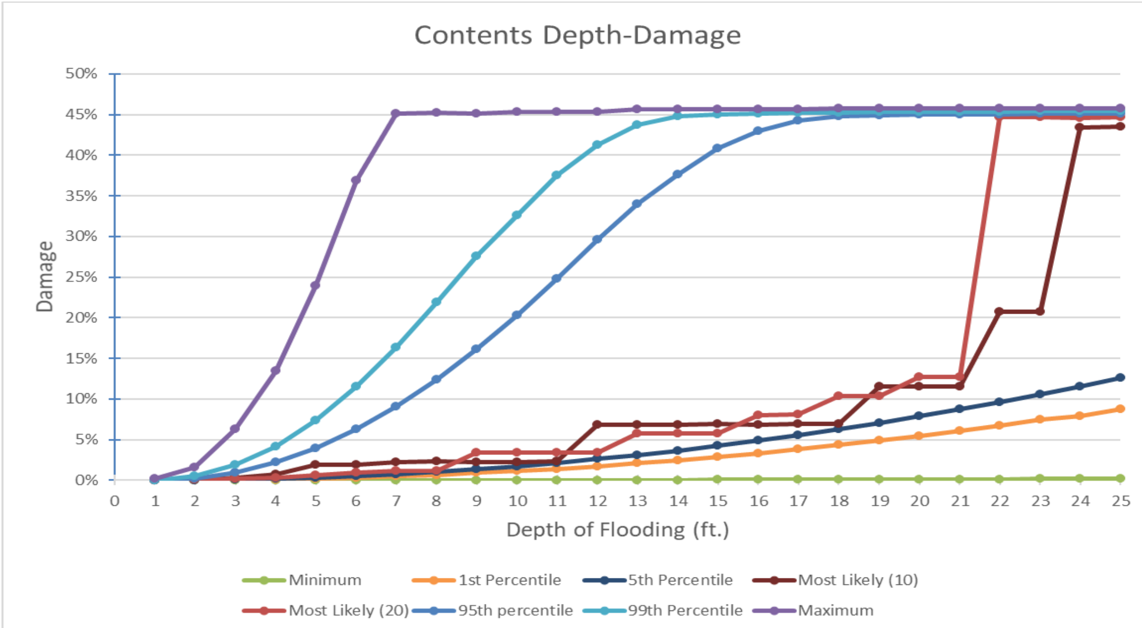


Figure 10 - Contents depth-damage percentages

The generic depth-damage relationships for storage tank structures and their contents, which were expressed as damage percentages, were entered into the HEC-FDA model along with the storage tank structure records (unique ground elevations, structure values and CSVRs) and engineering inputs (without-project and with-project stage-probability relationships). Due to the existence of containment levees, or berms, surrounding the tanks, top of levee elevations were also entered into the model by reach to mitigate the effects of frequent flooding events under both the without-project and with-project conditions. The top of levee elevations were equal to the stage of the 10-year event at the index station of each reach throughout the period of analysis.

Since the storage tank values provided by the Rice team represented tank replacement costs, adjustments were made to the structure values entered into the HEC-FDA model to reflect structure depreciation. A typical storage tank was estimated to have a useful life of approximately 20 years; however, this useful life could be extended to as long as 50 years if major repair and replacement actions had been taken. In the absence of specific storage tank performance data, the straight-line depreciation method was used with a depreciation factor of 0.5 based on the mid-point of the useful life of the structures. The most likely storage tank structure value, as well as the minimum and maximum values for the triangular probability distribution, were adjusted by the depreciation factor, while the minimum, maximum and most likely values for the CSVRs were adjusted by the inverse of the depreciation factor.

An example of the structure inventory records for storage tanks in the HEC-FDA format are shown in Figure 11. It should be noted the values are shown for a FY 2020 price level. Table 32 shows the number of storage tanks in each study area reach.

Struc_Name	Cat_Name	Stream_Name	Occ_Name	Station	Bank	Year	Struc_Val	Grnd_Stage	Mod_Name
10000	TANK	Gulf of Mexico	TANK	14054.44	Left	2020	93.531	22.405	Base
10001	TANK	Gulf of Mexico	TANK	14054.44	Left	2020	93.531	22.048	Base
10002	TANK	Gulf of Mexico	TANK	14054.44	Left	2020	93.531	20.259	Base
10003	TANK	Gulf of Mexico	TANK	14054.44	Left	2020	93.531	20.852	Base
10004	TANK	Gulf of Mexico	TANK	14054.44	Left	2020	93.531	21.208	Base

Figure 11 - Example HEC-FDA storage tank inventory

Table 32
Coastal Texas Protection and Restoration Study
Integrated Feasibility Report
Number of Above Ground Storage Tanks by Reach

Reach Name	Storage Tanks
4	276
6	304
9	1,713
10	289
13	334
14	6,735
15	457
16	709
17	6
18	6
19	385
20	5
21	74
22	10
24	49
25	48
30	3
36	10
37	463
38	13
39	58
40	40
81	777
82	62
83	75
Total	12,901

Probability distributions were used to represent the uncertainty surrounding the key economic and engineering inputs. The error associated with the first-floor elevations was equal to the uncertainty surrounding the LiDAR data (normal distribution with a standard deviation of 0.3 feet). The error associated with the structure values was expressed as a triangular probability distribution with the first percentile as the lower value (22 percent of the most likely value) and the 99th percentile as the upper value (1,679 percent of the most likely value). The CSVR was set to the most likely value (822 percent) based on the 20-increment breakdown. The error associated with the CSVR is a triangular probability distribution with the first percentile as the lower value (14 percent of the most likely value) and the 99th percentile as the upper value (330 percent of the most likely value). The economic inputs for structure value, content value, first-floor elevation, and their associated uncertainties for the HEC-FDA model are displayed in Table 33. The depth-damage relationships for the tank structures and their contents and their uncertainty ranges are displayed in Table 34. Table 35 shows the total equivalent annual without-project damages, with-project damages, and damages reduced for the Recommended Plan for the three projected sea-level rise scenarios and the probability damages reduced exceeds the 0.75, 0.50 and 0.25 confidence levels. The values are shown using a FY 2021 price level and interest rate.

Table 33
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
Above Ground Storage Tank HEC-FDA Data Inputs
(2021 Price Level; $ Thousands)

Number	Structure Value	Structure Value Uncertainty	
		Minimum Proportion	Maximum Proportion
12,901	$96	0.22	16.79
CSVR %	Content Value	CSVR Uncertainty	
		Minimum Proportion	Maximum Proportion
822	$790	0.14	3.30
Foundation Height (feet)	Foundation Height Uncertainty (feet)	Ground Stage Uncertainty (feet)	First Floor Uncertainty (feet)
0	0.00	0.30	0.30

Table 34
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
Above Ground Storage Tank Depth-Damage Relationship

Depth	Structure Percent Damage	Structure Lower Percent	Structure Upper Percent	Contents Percent Damage	Contents Lower Percent	Contents Upper Percent
0	0	0	0	0	0	0
1	0.15	0	1.67	0	0	0.01
2	2.34	0.63	10.7	0.04	0	0.53
3	6.54	2.54	20.08	0.16	0.03	1.87
4	9.46	4.46	29.9	0.34	0.09	4.12
5	12.72	6.44	39.27	0.6	0.19	7.39
6	15.85	8.18	48.97	0.92	0.31	11.54
7	17.48	9.94	58.47	1.13	0.46	16.35
8	22.71	11.84	68.03	1.14	0.65	21.88
9	23.34	13.79	76.78	3.39	0.88	27.62
10	28.36	15.63	84.45	3.41	1.12	32.59
11	28.37	17.53	90.6	3.43	1.42	37.51
12	28.72	19.32	95.83	3.43	1.73	41.3
13	33.82	21.43	98.85	5.73	2.08	43.73
14	35.2	22.95	99.95	5.76	2.42	44.79
15	39.17	25.13	100	5.76	2.9	45.01
16	39.26	26.91	100	7.98	3.31	45.1
17	49.34	29.06	100	8.08	3.85	45.21
18	49.47	30.27	100	10.34	4.31	45.23
19	49.65	32.64	100	10.36	4.87	45.28
20	59.42	34.45	100	12.66	5.44	45.32
21	97.62	36.36	100	12.68	6.09	45.35
22	97.63	38.08	100	44.68	6.7	45.35
23	97.64	39.59	100	44.68	7.44	45.42
24	97.65	41.81	100	44.68	7.91	45.42
25	97.65	43.6	100	44.68	8.77	45.43

Table 35
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
Equivalent Annual Damages for Recommended Plan 2035-2084
Above Ground Storage Tanks
(2021 Price Level; 2.5% Discount Rate; $ Thousands)

Low Sea-Level Rise Scenario						
Plan Name	Total Without Project	Total With Project	Damage Reduced	Prob Damg Reduced Exceeds Values 0.75	Prob Damg Reduced Exceeds Values 0.50	Prob Damg Reduced Exceeds Values 0.25
Recommended Plan	$53,608	$23,650	$29,958	$10,651	$23,673	$43,591
Intermediate Sea-Level Rise Scenario						
Plan Name	Total Without Project	Total With Project	Damage Reduced	Prob Damg Reduced Exceeds Values 0.75	Prob Damg Reduced Exceeds Values 0.50	Prob Damg Reduced Exceeds Values 0.25
Recommended Plan	$61,698	$28,064	$33,634	$13,131	$27,517	$48,466
High Sea-Level Rise Scenario						
Plan Name	Total Without Project	Total With Project	Damage Reduced	Prob Damg Reduced Exceeds Values 0.75	Prob Damg Reduced Exceeds Values 0.50	Prob Damg Reduced Exceeds Values 0.25
Recommended Plan	$89,556	$47,970	$41,586	$18,629	$36,052	$59,378

The above economic analysis for above ground storage tanks and their contents underwent a focused ATR in April 2020 and was approved by the CSRM-PCX in May 2020. The technical details of the analysis can be found in Addendum D in the report prepared for Galveston District U.S. Army Corps of Engineers entitled “Storage Tank Depth-Damage Functions,” dated 1 April 2020, which references the Excel spreadsheets used to perform the calculations.

Indirect Losses (Nonphysical Impacts) to the National Economy. Indirect losses, or nonphysical impacts, to the national economy are related to disruptions in the production of goods and services by industries affected by a tropical storm event. Business facilities could be forced to curtail their normal operations following a tropical event because workers are displaced, buildings are inundated and/or access to the facilities becomes limited by flooded roadways. While the geographic redistribution of production outputs following a storm event is typically considered an RED impact, the net change in national output associated with storm damages can be considered an NED loss. This is consistent with ER 1105-2-100, which states that the national economic development account displays changes in the economic value of the national output of goods and services and the regional account displays changes in the distribution of regional economic activity (income and employment).

The oil and gas refineries in Region 1 of the Coastal Texas evaluation area account for approximately 30 percent of the crude oil and 25 percent of the natural gas produced in the United States. The total refining capacity in the study area is approximately 5 million barrels per day, with approximately 2.5 million barrels per day produced in the Galveston Bay area. The majority of this fuel is sent to other parts of the country, primarily the East Coast, via pipelines, barges, and tankers. Thus, the disruption of oil and gas activities during and immediately following a storm event could have a significant impact on both the regional and national economy, as well as on the magnitude of the indirect losses in Region 1.

Regional Economic Models, Inc. developed a forecasting and policy analysis tool, known as the REMI model, that is a hybrid input-output, general equilibrium (supply and demand) and econometric model. The REMI model could be used to quantify the nonphysical impacts or indirect losses from a storm event. The input-output portion of the model incorporates the economic links and interdependencies between the different industries in the economy and accounts for regional production and trade between regions. The general equilibrium portion of the model considers economic changes over time and allows for individuals and businesses to adapt their behavior to the changing economic conditions. It accounts for the population shifts and migration flows that occur when the labor market responds to wage and job market opportunities. Finally, the REMI model is an econometric model that uses statistical techniques to forecast the future of a regional economy during the next 40 years (through the year 2060) and to predict the impact of any economic changes expected to occur during that period. The REMI model forecast was later extended through the year 2094 by the REMI modeler for the Coastal Texas evaluation based on data obtained from various Federal agencies including the U.S. Census Bureau, Bureau of Labor Statistics, Congressional Budget Office and the Department of Energy.

Figure 12 shows the conceptual relationship between the five economic and demographic activity measures that comprise each regional economy. As show in the diagram, these include output, labor and capital demand, population and labor supply, wages, prices and costs and market shares. The REMI model is constructed to show the response of the economic and demographic activity measures to changes in various policy variables such as a proposed coastal storm risk management system. Focusing on the impacts to the petrochemical industry, there are three types of indirect losses (avoided storm damages) to consider: the avoided loss of industrial output and the jobs linked to output losses; the avoided losses associated with non-residential contents (goods-in-process and/or inventory); and the avoided population shifts that accompany the loss of residential property. Together, these avoided losses constitute the nonphysical impacts of the proposed coastal storm risk management system.

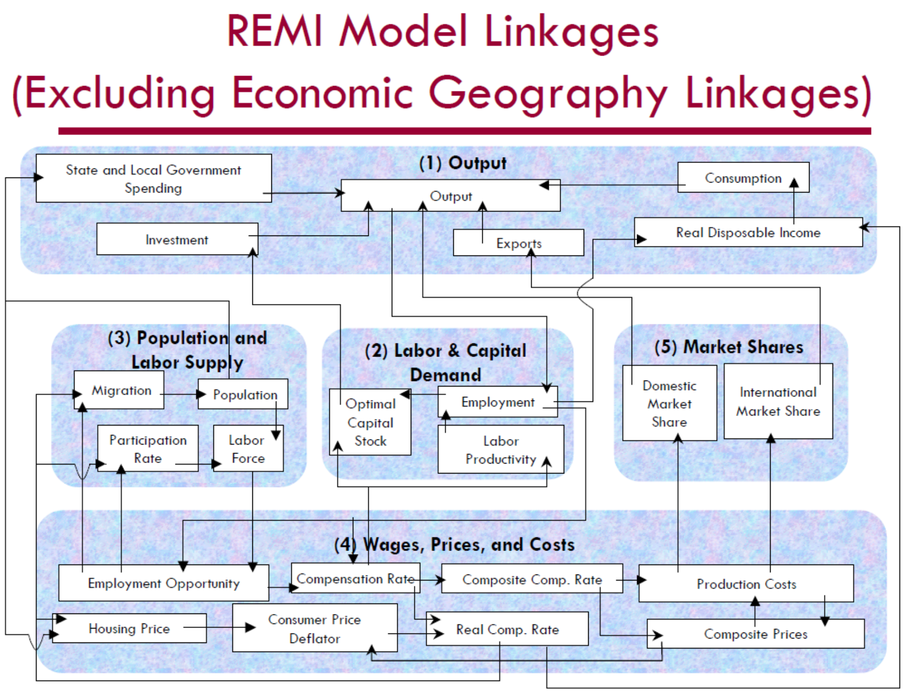


Figure 12 – REMI Model Linkages

In the economic analysis prepared for the TSP milestone, data developed by the Gulf Coast Community Protection and Recovery District (GCCPRD), the local sponsor of the surge suppression study for Region 1, were used as inputs to the REMI model to quantify the avoided production loss to the U.S. gross domestic product (GDP) during the period of analysis. The Corps study team applied the same proportion of REMI impacts calculated by GCCPRD for the central portion of Region 1 (Chambers, Galveston and Harris counties) to the HEC-FDA model benefits to estimate the REMI impacts for each of the CSRM focused array project alternatives for the years 2035 and 2084. For the recommended plan, the USACE team developed revised inputs for the REMI model based on guidance from the vertical team.

In October 2019, a meeting was held at USACE Headquarters to determine if REMI Model outputs could be included in the NED analysis for the Coastal Texas evaluation. Members of the Coastal Texas planning team from Galveston and New Orleans, the Southwest Division economist, planning representatives from IWR, HEC and Headquarters, and economist Dr. Nicolas Rockler of the Massachusetts Institute of Technology (MIT) Department of Urban Studies and Planning were in attendance. After significant discussion, the participants of the meeting agreed that REMI model outputs could be included in the NED calculations if the following guidelines were followed:

- HEC-FDA model outputs for the base year and future years would be limited to industrial categories, including storage tanks, and warehouse facilities. Residential categories would be included only to tract demographic changes in the

REMI modeling. Other commercial categories and transportation infrastructure would not be included.

- Only probability events equal to or less frequent than the 0.01 AEP event (100-year, 200-year, 500-year and 1,000-year events) would be used in the REMI analysis since these probability events are more likely to result in the extended loss of production for the industries in the evaluation area. The damages associated with these probability events would be used as inputs to the REMI model. The avoided production loss outputs from the REMI model would be annualized before being included in the NED calculations.

- The REMI model results would be divided by counties into three regions: the five counties in Region 1 that surround and include the cities of Galveston and Houston (Brazoria, Chambers, Galveston, Harris, and Jefferson); the remaining 249 counties in Texas (designated as the "rest of Texas"); and the counties located in the other 49 states and the District of Columbia (designated as the "rest of the United States"). Summary results would also be provided for the entire United States. Only the national net losses as measured by gross domestic product (GDP) could be included in the NED account for the recommended plan.

- A Focused ATR on the inputs and outputs of the REMI model would be conducted and approved by the CSRM-PCX before the results from the REMI model could be included in the NED account for the recommended plan. This would not be a review of the REMI model itself, but rather a review of the appropriateness of the model inputs and data transformations.

- The NED net benefits and BCR for the recommended plan would be displayed both with the REMI model results and without the REMI model results.

Based on these guidelines, USACE personnel provided HEC-FDA model outputs to Dr. Nicolas Rockler, the REMI modeler, to be used in the execution of the REMI model. A U.S. Department of Homeland Security database was used by USACE to identify the industrial facilities in Region 1 related to energy and chemical sectors and their location. A listing of the Homeland Infrastructure Foundation-Level Data (HIFLD) categories is shown in Figure 13. USACE personnel then used the structure inventory developed for the HEC-FDA model to provide the value and number of the industrial, storage tank and warehouse structure records tied to the relevant chemical and energy categories located within a one-mile radius of the Homeland Security locations. The damages associated with these structures and their contents were totaled for the 0.01 (100-year) AEP event, 200-year event, 500-year event, and the 1,000-year event under both the without-project and the with-project conditions for the years 2035 and 2084. The individual probability event damages, along with the number and value of the structures, were provided by county and used as inputs to the REMI model.

Homeland Infrastructure Foundation-Level Data (HIFLD) Layers
Biodiesel Plants
Chemical Manufacturing
EPA Emergency Response (ER) Toxic Release Inventory (TRI) Facilities
EPA Emergency Response (ER) Toxic Substances Control Act (TSCA) Facilities
Ethanol Plants
Ethanol Transloading Facilities
Liquified Natural Gas Import Exports and Terminals
Natural Gas Compressor Stations
Natural Gas Import and Export
Natural Gas Market Hubs
Natural Gas Processings and Plants
Natural Gas Receipt Delivery Points
Natural Gas Storage Facilities
Non Gasoline Alternative Fueling Stations (FOUO)
Oil and Gas Extraction
Oil and Natural Gas Interconnects
Oil Refineries
Petroleum and Coal Products Manufacturing
Petroleum Ports
Petroleum Terminals
Plastics and Rubber Products Manufacturing
POL Pumping Stations
Power Plants
Strategic and Petroleum Reserves
Warehousing and Storage

Figure 13 – Industry-specific HIFLD layers

A baseline forecast of various activity measures was developed by the REMI model for the five-county region, the rest of Texas and the rest of the U.S. for the 40-year period 2020 through 2060. A summary of the entire U.S., which includes all three regions, was also provided. The REMI modeler extended these baseline forecasts through the year 2094 based on data obtained from various Federal agencies including the U.S. Census Bureau, Bureau of Labor Statistics, Congressional Budget Office and the Department of Energy. The baseline forecasts were developed using a no flood assumption.

The REMI model used the physical flood losses provided by USACE to estimate the change in the regional and national economic (production and output) and demographic (population and labor supply) activity measures that would result from the storm damages to the industrial, storage tank and warehouse facilities for each of the four probability flood events. A database obtained from Dodge Data and Analytics, Inc., which provided the stock value of the structures and equipment per square foot for the industrial and manufacturing structure categories, was used with the HEC-FDA flood damages to quantify the effects of the flood losses on production and output. To determine the proportion of the total regional production and output losses associated with the flood damages, the damage estimates for the non-residential structures in the five-county area were linked to the total output value for those same structure types in the rest of Texas and in the rest of the U.S.

The residential structure damages were used to estimate the impact that a tropical storm event would have on the population and labor supply in the region. The total county residential stock was used to estimate relationships for the number of persons per dwelling unit and the number of dwelling units per structure. Both statistics were reported on a county basis. The county estimates were then applied to the number of damaged structures and their dwelling unit equivalents to determine the affected population. The loss of population impacts the labor supply in the regions, which in turn impacts the production and output in the regions.

Summary statistics for the baseline forecast of the economic and demographic activity measures (income, output and employment) for the years 2035 through 2044 and for the years 2050 through 2060 are displayed in Addendum E. The impacts that the changed policy variable (coastal storm risk management system) has on the forecasted activity measures as compared to those in the baseline forecast are also shown in Addendum E. An individual forecast was provided for the 100-year, 200-year, 500-year and 1,000-year events occurring in the years 2035 (base year) and 2085 (future year) for the five-county region, the rest of Texas, rest of the U.S. and the U.S. summary. The economy of each of the three regions rebounds from the production losses associated with the four probability storm events by the years 2044 and 2094, respectively. The activity measures are displayed for the years 2035 through 2044 and 2085 through 2094. As shown in the tables, the production losses resulting from three of the storm events are lower in the year 2085 than in the year 2035 due to the higher labor productivity forecast.

With the coastal storm risk management system in place, the production losses associated with each of the four storm events are considered avoided production losses and can be considered benefits attributable to the project. The avoided production losses were calculated as the net discounted value of the GDP statistics from the U.S. summary between the years 2035 and 2044 for each of the four events. It was assumed that there were no avoided production losses for events less frequent than the 0.01 (100-year) AEP event. These values were annualized in order to calculate the expected annual avoided production losses for 2035. The same procedure was used to estimate the expected annual avoided production losses resulting from the various frequency storm events occurring in the year 2084. Straight-line interpolation was then used to calculate the expected annual avoided production losses between the years 2035 and 2084. The FY 2020 interest rate was used with the 50-year period of analysis to calculate the equivalent annual avoided production losses for the recommended plan.

Table 36 shows the calculation of the net discounted value of the production losses for the U.S. economy between the years 2035 and 2044 and between the years 2085 and 2094, respectively. It should be noted that revisions were made to the hydraulics and hydrology (H&H) inputs after the HEC-FDA model outputs were given to the REMI modeler. To reflect these changes, the REMI model results, which were based on the intermediate sea-level rise scenario, were proportionately adjusted using the revised damages for the industrial structure category calculated by the HEC-FDA model. This adjustment factor is shown in Table 36.

Table 36
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
Economic Impact Summary Discounting and Adjusting
Intermediate Sea-Level Rise Scenario; Recommended Plan
(2.75% Discount Rate)

U.S. Summary-Change from Baseline Due to Flood Protection Measures; 0.01 Annual Exceedance Probability Event														
Category	Units	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	10-Year Total	Adjustment Factor	Adjusted 10-Year Total
GDP	$ Billions; Fixed (2019)	24.08	-5.71	-1.28	-1.58	-1.13	-0.80	-0.53	-0.33	-0.19	-0.10	12.43		
GDP	$ Billions; Fixed (2019) Discounted to 2085	24.08	-5.56	-1.21	-1.46	-1.02	-0.70	-0.45	-0.27	-0.15	-0.08	13.19	1.14	**15.04**
U.S. Summary-Change from Baseline Due to Flood Protection Measures; 0.005 Annual Exceedance Probability Event														
Category	Units	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	10-Year Total	Adjustment Factor	Adjusted 10-Year Total
GDP	$ Billions; Fixed (2019)	33.60	-7.90	-1.80	-2.20	-1.50	-1.10	-0.70	-0.50	-0.20	-0.20	17.50		
GDP	$ Billions; Fixed (2019) Discounted to 2085	33.60	-7.69	-1.70	-2.03	-1.35	-0.96	-0.59	-0.41	-0.16	-0.16	18.55	1.09	**20.22**
U.S. Summary-Change from Baseline Due to Flood Protection Measures; 0.002 Annual Exceedance Probability Event														
Category	Units	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	10-Year Total	Adjustment Factor	Adjusted 10-Year Total
GDP	$ Billions; Fixed (2019)	42.03	-9.93	-2.29	-2.83	-2.05	-1.47	-0.98	-0.63	-0.39	-0.23	21.24		
GDP	$ Billions; Fixed (2019) Discounted to 2085	42.03	-9.67	-2.17	-2.61	-1.84	-1.28	-0.84	-0.52	-0.31	-0.18	22.63	1.07	**24.21**
U.S. Summary-Change from Baseline Due to Flood Protection Measures; 0.001 Annual Exceedance Probability Event														
Category	Units	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	10-Year Total	Adjustment Factor	Adjusted 10-Year Total
GDP	$ Billions; Fixed (2019)	46.40	-10.90	-2.50	-3.10	-2.20	-1.60	-1.10	-0.60	-0.50	-0.20	23.70		
GDP	$ Billions; Fixed (2019) Discounted to 2085	46.40	-10.61	-2.37	-2.86	-1.97	-1.40	-0.93	-0.50	-0.40	-0.16	25.21	1.06	**26.72**
U.S. Summary-Change from Baseline Due to Flood Protection Measures; 0.01 Annual Exceedance Probability Event														
Category	Units	2085	2086	2087	2088	2089	2090	2091	2092	2093	2094	10-Year Total	Adjustment Factor	Adjusted 10-Year Total
GDP	$ Billions; Fixed (2019)	25.49	-4.75	-0.70	-0.92	-0.50	-0.27	-0.08	0.08	0.19	0.19	18.74		
GDP	$ Billions; Fixed (2019) Discounted to 2085	25.49	-4.63	-0.66	-0.85	-0.45	-0.23	-0.07	0.07	0.15	0.15	18.98	0.83	**15.76**
U.S. Summary-Change from Baseline Due to Flood Protection Measures; 0.005 Annual Exceedance Probability Event														
Category	Units	2085	2086	2087	2088	2089	2090	2091	2092	2093	2094	10-Year Total	Adjustment Factor	Adjusted 10-Year Total
GDP	$ Billions; Fixed (2019)	33.84	-9.48	-2.14	-2.37	-1.79	-1.28	-0.88	-0.66	-0.28	-0.20	14.75		
GDP	$ Billions; Fixed (2019) Discounted to 2085	33.84	-9.23	-2.03	-2.19	-1.61	-1.12	-0.75	-0.55	-0.23	-0.16	15.99	0.84	**13.43**
U.S. Summary-Change from Baseline Due to Flood Protection Measures; 0.002 Annual Exceedance Probability Event														
Category	Units	2085	2086	2087	2088	2089	2090	2091	2092	2093	2094	10-Year Total	Adjustment Factor	Adjusted 10-Year Total
GDP	$ Billions; Fixed (2019)	38.38	-10.59	-2.38	-2.81	-1.86	-1.32	-0.93	-0.53	-0.35	-0.25	17.37		
GDP	$ Billions; Fixed (2019) Discounted to 2085	38.38	-10.31	-2.26	-2.59	-1.67	-1.15	-0.79	-0.44	-0.28	-0.19	18.71	0.83	**15.53**
U.S. Summary-Change from Baseline Due to Flood Protection Measures; 0.001 Annual Exceedance Probability Event														
Category	Units	2085	2086	2087	2088	2089	2090	2091	2092	2093	2094	10-Year Total	Adjustment Factor	Adjusted 10-Year Total
GDP	$ Billions; Fixed (2019)	34.49	-9.48	-2.14	-2.50	-1.74	-1.22	-0.84	-0.60	-0.28	-0.18	15.51		
GDP	$ Billions; Fixed (2019) Discounted to 2085	34.49	-9.23	-2.02	-2.31	-1.56	-1.06	-0.72	-0.49	-0.22	-0.14	16.73	0.8	**13.38**

Note: "GDP" is Gross Domestic Product. Due to changes made after the REMI analysis was completed, an adjustment factor was applied to scale the results based on the differences in the FDA model outputs used in the REMI analysis and updated FDA model outputs

The calculation of the expected annual avoided production losses for the intermediate sea-level rise scenario in years 2035 and 2084 are shown in Table 37. The REMI model results were also adjusted to reflect the revised H&H data for the low sea-level rise and the high sea-level rise scenarios. The adjustment factor and expected annual damages for the low and high sea-level rise scenarios are also shown in Table 37.

Table 37
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
REMI Model NED Impacts from Change in GDP
Expected Annual Damage Calculation by Scenario
Recommended Plan
(2021 Price Level, $ Millions)

Intermediate Sea-Level Rise Scenario - 2035			
Return Interval	Annual Exceedance Probability	Event Damage	Expected Annual Damages
99	0.0101	$0	
100	0.0100	$15,287	$1
200	0.0050	$20,552	$90
500	0.0020	$24,620	$68
1000	0.0010	$27,167	$26
			$27
		Expected Annual Damages	$211
Intermediate Sea-Level Rise Scenario - 2084			
Return Interval	Annual Exceedance Probability	Event Damage	Expected Annual Damages
99	0.0101	$0	
100	0.0100	$16,020	$1
200	0.0050	$13,658	$74
500	0.0020	$15,793	$44
1000	0.0010	$13,614	$15
			$14
		Expected Annual Damages	$147
Low Sea-Level Rise Scenario - 2035			
Low Sea-Level Rise Adjustment Factor			0.942
		Expected Annual Damages	$199
Low Sea-Level Rise Scenario - 2084			
Low Sea-Level Rise Adjustment Factor			0.813
		Expected Annual Damages	$120
High Sea-Level Rise Scenario - 2035			
High Sea-Level Rise Adjustment Factor			1.065
		Expected Annual Damages	$225
Low Sea-Level Rise Scenario - 2084			
High Sea-Level Rise Adjustment Factor			1.832
		Expected Annual Damages	$270

Note: Since only FDA results for Intermediate Sea-Level Rise were used as inputs for the REMI analysis, a multiplication factor was used to adjust for changes in results based on sea-level rise

The revised equivalent annual avoided production losses for the intermediate, low and high sea-level rise scenarios in 2035 to 2084 are shown in Tables 38a-c. The values are shown using a FY 2021 price level and interest rate.

Table 38a
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
Equivalent Annual Net GDP Losses Prevented Base Year 2035
Low Sea-Level Rise Scenario
Recommended Plan
(2021 Price Level, $ Millions)

Year	Analysis Year	National Net GDP Loss Prevented	Present Value Factor	Present Value
2035	1	$ 199	0.9756	$ 194
2036	2	$ 197	0.9518	$ 188
2037	3	$ 196	0.9286	$ 182
2038	4	$ 194	0.9060	$ 176
2039	5	$ 193	0.8839	$ 170
2040	6	$ 191	0.8623	$ 165
2041	7	$ 189	0.8413	$ 159
2042	8	$ 188	0.8207	$ 154
2043	9	$ 186	0.8007	$ 149
2044	10	$ 184	0.7812	$ 144
2045	11	$ 183	0.7621	$ 139
2046	12	$ 181	0.7436	$ 135
2047	13	$ 180	0.7254	$ 130
2048	14	$ 178	0.7077	$ 126
2049	15	$ 176	0.6905	$ 122
2050	16	$ 175	0.6736	$ 118
2051	17	$ 173	0.6572	$ 114
2052	18	$ 172	0.6412	$ 110
2053	19	$ 170	0.6255	$ 106
2054	20	$ 168	0.6103	$ 103
2055	21	$ 167	0.5954	$ 99
2056	22	$ 165	0.5809	$ 96
2057	23	$ 164	0.5667	$ 93
2058	24	$ 162	0.5529	$ 90
2059	25	$ 160	0.5394	$ 86
2060	26	$ 159	0.5262	$ 83
2061	27	$ 157	0.5134	$ 81
2062	28	$ 155	0.5009	$ 78
2063	29	$ 154	0.4887	$ 75
2064	30	$ 152	0.4767	$ 73
2065	31	$ 151	0.4651	$ 70
2066	32	$ 149	0.4538	$ 68
2067	33	$ 147	0.4427	$ 65
2068	34	$ 146	0.4319	$ 63
2069	35	$ 144	0.4214	$ 61
2070	36	$ 143	0.4111	$ 59
2071	37	$ 141	0.4011	$ 57
2072	38	$ 139	0.3913	$ 55
2073	39	$ 138	0.3817	$ 53
2074	40	$ 136	0.3724	$ 51
2075	41	$ 134	0.3633	$ 49
2076	42	$ 133	0.3545	$ 47
2077	43	$ 131	0.3458	$ 45
2078	44	$ 130	0.3374	$ 44
2079	45	$ 128	0.3292	$ 42
2080	46	$ 126	0.3211	$ 41
2081	47	$ 125	0.3133	$ 39
2082	48	$ 123	0.3057	$ 38
2083	49	$ 122	0.2982	$ 36
2084	50	$ 120	0.2909	$ 35
Total:		$ 7,973		$ 4,753
Federal Discount Rate:			2.50%	
Amortization Factor:			0.03526	
Equivalent Annual GDP Losses Prevented-Base Year 2035:				$ 168

Table 38b
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
Equivalent Annual Net GDP Losses Prevented Base Year 2035
Intermediate Sea-Level Rise Scenario
Recommended Plan
(2021 Price Level, $ Millions)

Year	Analysis Year	National Net GDP Loss Prevented	Present Value Factor	Present Value
2035	1	$ 211	0.9756	$ 206
2036	2	$ 210	0.9518	$ 200
2037	3	$ 209	0.9286	$ 194
2038	4	$ 207	0.9060	$ 188
2039	5	$ 206	0.8839	$ 182
2040	6	$ 205	0.8623	$ 177
2041	7	$ 203	0.8413	$ 171
2042	8	$ 202	0.8207	$ 166
2043	9	$ 201	0.8007	$ 161
2044	10	$ 199	0.7812	$ 156
2045	11	$ 198	0.7621	$ 151
2046	12	$ 197	0.7436	$ 146
2047	13	$ 196	0.7254	$ 142
2048	14	$ 194	0.7077	$ 138
2049	15	$ 193	0.6905	$ 133
2050	16	$ 192	0.6736	$ 129
2051	17	$ 190	0.6572	$ 125
2052	18	$ 189	0.6412	$ 121
2053	19	$ 188	0.6255	$ 117
2054	20	$ 186	0.6103	$ 114
2055	21	$ 185	0.5954	$ 110
2056	22	$ 184	0.5809	$ 107
2057	23	$ 183	0.5667	$ 103
2058	24	$ 181	0.5529	$ 100
2059	25	$ 180	0.5394	$ 97
2060	26	$ 179	0.5262	$ 94
2061	27	$ 177	0.5134	$ 91
2062	28	$ 176	0.5009	$ 88
2063	29	$ 175	0.4887	$ 85
2064	30	$ 173	0.4767	$ 83
2065	31	$ 172	0.4651	$ 80
2066	32	$ 171	0.4538	$ 78
2067	33	$ 170	0.4427	$ 75
2068	34	$ 168	0.4319	$ 73
2069	35	$ 167	0.4214	$ 70
2070	36	$ 166	0.4111	$ 68
2071	37	$ 164	0.4011	$ 66
2072	38	$ 163	0.3913	$ 64
2073	39	$ 162	0.3817	$ 62
2074	40	$ 160	0.3724	$ 60
2075	41	$ 159	0.3633	$ 58
2076	42	$ 158	0.3545	$ 56
2077	43	$ 157	0.3458	$ 54
2078	44	$ 155	0.3374	$ 52
2079	45	$ 154	0.3292	$ 51
2080	46	$ 153	0.3211	$ 49
2081	47	$ 151	0.3133	$ 47
2082	48	$ 150	0.3057	$ 46
2083	49	$ 149	0.2982	$ 44
2084	50	$ 147	0.2909	$ 43
Total:		$ 8,967		$ 5,272
Federal Discount Rate:			2.50%	
Amortization Factor:			0.03526	
Equivalent Annual GDP Losses Prevented-Base Year 2035:				$ 186

Table 38c
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
Equivalent Annual Net GDP Losses Prevented Base Year 2035
High Sea-Level Rise Scenario
Recommended Plan
(2021 Price Level; $ Millions)

Year	Analysis Year	National Net GDP Loss Prevented	Present Value Factor	Present Value
2035	1	$ 225	0.9756	$ 219
2036	2	$ 226	0.9518	$ 215
2037	3	$ 227	0.9286	$ 211
2038	4	$ 228	0.9060	$ 206
2039	5	$ 229	0.8839	$ 202
2040	6	$ 230	0.8623	$ 198
2041	7	$ 231	0.8413	$ 194
2042	8	$ 231	0.8207	$ 190
2043	9	$ 232	0.8007	$ 186
2044	10	$ 233	0.7812	$ 182
2045	11	$ 234	0.7621	$ 178
2046	12	$ 235	0.7436	$ 175
2047	13	$ 236	0.7254	$ 171
2048	14	$ 237	0.7077	$ 168
2049	15	$ 238	0.6905	$ 164
2050	16	$ 239	0.6736	$ 161
2051	17	$ 240	0.6572	$ 158
2052	18	$ 241	0.6412	$ 154
2053	19	$ 242	0.6255	$ 151
2054	20	$ 242	0.6103	$ 148
2055	21	$ 243	0.5954	$ 145
2056	22	$ 244	0.5809	$ 142
2057	23	$ 245	0.5667	$ 139
2058	24	$ 246	0.5529	$ 136
2059	25	$ 247	0.5394	$ 133
2060	26	$ 248	0.5262	$ 131
2061	27	$ 249	0.5134	$ 128
2062	28	$ 250	0.5009	$ 125
2063	29	$ 251	0.4887	$ 123
2064	30	$ 252	0.4767	$ 120
2065	31	$ 253	0.4651	$ 118
2066	32	$ 254	0.4538	$ 115
2067	33	$ 254	0.4427	$ 113
2068	34	$ 255	0.4319	$ 110
2069	35	$ 256	0.4214	$ 108
2070	36	$ 257	0.4111	$ 106
2071	37	$ 258	0.4011	$ 104
2072	38	$ 259	0.3913	$ 101
2073	39	$ 260	0.3817	$ 99
2074	40	$ 261	0.3724	$ 97
2075	41	$ 262	0.3633	$ 95
2076	42	$ 263	0.3545	$ 93
2077	43	$ 264	0.3458	$ 91
2078	44	$ 265	0.3374	$ 89
2079	45	$ 266	0.3292	$ 87
2080	46	$ 266	0.3211	$ 86
2081	47	$ 267	0.3133	$ 84
2082	48	$ 268	0.3057	$ 82
2083	49	$ 269	0.2982	$ 80
2084	50	$ 270	0.2909	$ 79
Total:		$ 12,379		$ 6,891
Federal Discount Rate:			2.50%	
Amortization Factor:			0.03526	
Equivalent Annual GDP Losses Prevented-Base Year 2035:				$ 243

The economic analysis for the REMI model analysis underwent a focused ATR in June 2020 and was approved by the CSRM-PCX in July 2020. The technical details of the REMI model analysis can be found in Addendum E in the report prepared for Galveston District U.S. Army Corps of Engineers entitled "Coastal Texas Flood Damage Losses and Regional Economic Impacts," dated 19 June 2020.

TOTAL EQUIVALENT ANNUAL NED FLOOD DAMAGES AND BENEFITS

Summary of Equivalent Annual NED Damages and Benefits for the Recommended Plan. The physical damages to structures, contents, vehicles and debris removal costs were combined with the physical damages to transportation infrastructure, physical damages to above ground storage tanks and their contents and the reduction of indirect losses to the national economy to show the total NED flood damages and benefits attributable to the Recommended Plan. The HEC-FDA model used linear interpolation for the years between 2035 and 2084 to obtain the stream of expected annual damages over the 50-year period of analysis. The damages and costs were calculated using FY 2021 (October 2020) price levels, the FY 2021 Federal discount rate of 2.5 percent and a period of analysis of 50 years with the year 2035 as the base year.

After the HEC-FDA model was executed for the years 2035 and 2084, the base year was changed from the year 2035 to the year 2043. The change in the base year was due to an 8-year increase in the construction period for the Recommended Plan. The damages in the year 2043 were used to represent the base year, and the damages in the year 2084 were held constant through the year 2092, the final year in the 50-year period of analysis. The FY 2021 Federal interest rate of 2.5 percent was used to discount the stream of expected annual damages and benefits occurring after the base year (2043) to calculate the total present value of the damages over the period of analysis. The expected annual damages were then amortized over the period of analysis using the Federal interest rate to calculate the equivalent annual without-project damages, with-project damages and benefits for the Recommended Plan. This process was conducted for each of the benefit categories. It should be noted that since the calculations using the new base year were performed in a spreadsheet format outside of the HEC-FDA model, the benefit results using the 2043 base year could not be shown in a risk-based format.

Table 39 shows the total equivalent annual damages under the without-project condition, the damages with the Recommended Plan in place and the damages reduced for each benefit category under the three sea-level rise scenarios. The table also shows the percentage of benefits attributable to each of the benefit categories.

Table 39
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
Recommended Plan
Total Equivalent Annual Damages and Benefits
(2021 Price Level; 2.5% Discount Rate; $ Millions)

Low Sea-Level Rise Scenario				
Item	Equiv Annual W/O Project Damages (2035-2084)	Equiv Annual With-Project Damages (2035-2084)	Equiv Annual Benefits (2035-2084)	Percent of Total Benefits (2035-2084)
Damage Category				
Residential & Commercial - Structure/Content/Vehicles	$2,126	$694	$1,432	83%
Transportation Infrastructure	$351	$266	$86	5%
Aboveground Storage Tanks	$54	$24	$30	2%
Indirect Business Losses			$168	10%
Total Benefits - 2035 Base Year			$1,715	
Item	Equiv Annual W/O Project Damages (2043-2092)	Equiv Annual With-Project Damages (2043-2092)	Equiv Annual Benefits (2043-2092)	Percent of Total Benefits (2043-2092)
Damage Category				
Residential & Commercial - Structure/Content/Vehicles	$2,310	$781	$1,529	85%
Transportation Infrastructure	$384	$290	$94	5%
Aboveground Storage Tanks	$56	$25	$31	2%
Indirect Business Losses			$155	9%
Total Benefits - 2043 Base Year			$1,809	

Table 39 (continued)
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
Recommended Plan
Total Equivalent Annual Damages and Benefits
(2021 Price Level; 2.5% Discount Rate; $ Millions)

Intermediate Sea-Level Rise Scenario				
Item	Equiv Annual W/O Project Damages (2035-2084)	Equiv Annual With-Project Damages (2035-2084)	Equiv Annual Benefits (2035-2084)	Percent of Total Benefits (2035-2084)
Damage Category				
Residential & Commercial - Structure/Content/Vehicles	$2,869	$1,113	$1,756	84%
Transportation Infrastructure	$460	$342	$118	6%
Aboveground Storage Tanks	$62	$28	$34	2%
Indirect Business Losses			$186	9%
Total Benefits - 2035 Base Year			$2,093	
Item	Equiv Annual W/O Project Damages (2043-2092)	Equiv Annual With-Project Damages (2043-2092)	Equiv Annual Benefits (2043-2092)	Percent of Total Benefits (2043-2092)
Damage Category				
Residential & Commercial - Structure/Content/Vehicles	$3,328	$1,369	$1,959	85%
Transportation Infrastructure	$531	$396	$135	6%
Aboveground Storage Tanks	$67	$31	$36	2%
Indirect Business Losses			$176	8%
Total Benefits - 2043 Base Year			$2,306	

Table 39 (continued)
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
Recommended Plan
Total Equivalent Annual Damages and Benefits
(2021 Price Level; 2.5% Discount Rate; $ Millions)

High Sea-Level Rise Scenario				
Item	Equiv Annual W/O Project Damages (2035-2084)	Equiv Annual With-Project Damages (2035-2084)	Equiv Annual Benefits (2035-2084)	Percent of Total Benefits (2035-2084)
Damage Category				
Residential & Commercial - Structure/Content/Vehicles	$6,018	$3,276	$2,743	86%
Transportation Infrastructure	$820	$651	$169	5%
Aboveground Storage Tanks	$90	$48	$42	1%
Indirect Business Losses			$243	8%
Total Benefits - 2035 Base Year			$3,196	
Item	Equiv Annual W/O Project Damages (2043-2092)	Equiv Annual With-Project Damages (2043-2092)	Equiv Annual Benefits (2043-2092)	Percent of Total Benefits (2043-2092)
Damage Category				
Residential & Commercial - Structure/Content/Vehicles	$7,735	$4,415	$3,320	87%
Transportation Infrastructure	$1,032	$825	$206	5%
Aboveground Storage Tanks	$105	$59	$47	1%
Indirect Business Losses			$250	7%
Total Benefits - 2043 Base Year			$3,823	

PART 4: PROJECT COSTS FOR THE RECOMMENDED PLAN

Construction Schedule. Construction of the Recommended Plan is expected to begin in the year 2025 and to continue through the year 2043, which was established as the base year for analysis. The operations, maintenance, relocations, rehabilitation, and repair (OMRR&R) activities will begin in the year 2043 and will continue throughout the 50-year period of analysis.

Annual Project Costs. Life cycle cost estimates were provided for the Recommended Plan in FY 2021 (October 2020) price levels. The initial construction costs (first costs) and the schedule of expenditures were used to determine the interest during construction and gross investment cost at the end of the installation period (2043). The FY 2021 Federal interest rate of 2.5 percent was used to discount the costs to the base year and then to amortize the costs over the 50-year period of analysis. The operations, maintenance, relocations, rehabilitation, and repair (OMRR&R) costs for the Recommended Plan during the period of analysis were also discounted to present value and annualized using the Federal discount rate of 2.5 percent for 50 years.

Table 40a displays a schedule of the total construction costs by year for the construction period (2025 through 2042) and the total construction costs during the 50-year period of analysis after the base year (2043 through 2092). Table 40b displays a schedule of the total OMRR&R costs by year between the years 2043 and 2092 along with the calculation of the average annual OMRR&R costs. Table 40c provides a summary of the total average annual project costs for the Recommended Plan. Tables providing more specific details regarding the schedule of the costs associated with each of the individual components of the Recommended Plan can be found in Addendum F. The addendum also shows the schedule of construction costs and OMRR&R costs for each of the individual components of the Recommended Plan along with the calculation of the total project costs for the Recommended Plan.

Table 40a
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
Construction Costs for Recommended Plan
(2021 Price Level, $ Millions)

Year	Analysis Year	Total Construction Costs	Present Value Factor	Present Value	Year	Analysis Year	Total Construction Costs	Present Value Factor	Present Value
2024	-18	$ -	1.5597	$ -	2059	17	$ 12	0.6572	$ 8
2025	-17	$ 326	1.5216	$ 496	2060	18	$ 86	0.6412	$ 55
2026	-16	$ 326	1.4845	$ 484	2061	19	$ -	0.6255	$ -
2027	-15	$ 1,217	1.4483	$ 1,763	2062	20	$ 8	0.6103	$ 5
2028	-14	$ 1,217	1.4130	$ 1,720	2063	21	$ 54	0.5954	$ 32
2029	-13	$ 1,217	1.3785	$ 1,678	2064	22	$ -	0.5809	$ -
2030	-12	$ 1,217	1.3449	$ 1,637	2065	23	$ 12	0.5667	$ 7
2031	-11	$ 1,101	1.3121	$ 1,444	2066	24	$ 86	0.5529	$ 48
2032	-10	$ 1,069	1.2801	$ 1,368	2067	25	$ -	0.5394	$ -
2033	-9	$ 1,382	1.2489	$ 1,726	2068	26	$ -	0.5262	$ -
2034	-8	$ 1,478	1.2184	$ 1,801	2069	27	$ 8	0.5134	$ 4
2035	-7	$ 1,730	1.1887	$ 2,057	2070	28	$ 54	0.5009	$ 27
2036	-6	$ 1,846	1.1597	$ 2,141	2071	29	$ 12	0.4887	$ 6
2037	-5	$ 1,807	1.1314	$ 2,044	2072	30	$ 86	0.4767	$ 41
2038	-4	$ 1,702	1.1038	$ 1,879	2073	31	$ -	0.4651	$ -
2039	-3	$ 1,827	1.0769	$ 1,968	2074	32	$ -	0.4538	$ -
2040	-2	$ 1,971	1.0506	$ 2,071	2075	33	$ -	0.4427	$ -
2041	-1	$ 1,952	1.0250	$ 2,001	2076	34	$ 8	0.4319	$ 3
2042	0	$ 1,653	1.0000	$ 1,653	2077	35	$ 66	0.4214	$ 28
2043	1	$ -	0.9756	$ -	2078	36	$ 86	0.4111	$ 35
2044	2	$ -	0.9518	$ -	2079	37	$ -	0.4011	$ -
2045	3	$ -	0.9286	$ -	2080	38	$ -	0.3913	$ -
2046	4	$ -	0.9060	$ -	2081	39	$ -	0.3817	$ -
2047	5	$ 12	0.8839	$ 11	2082	40	$ -	0.3724	$ -
2048	6	$ 94	0.8623	$ 81	2083	41	$ 24	0.3633	$ 9
2049	7	$ 54	0.8413	$ 45	2084	42	$ 167	0.3545	$ 59
2050	8	$ -	0.8207	$ -	2085	43	$ -	0.3458	$ -
2051	9	$ -	0.8007	$ -	2086	44	$ -	0.3374	$ -
2052	10	$ -	0.7812	$ -	2087	45	$ -	0.3292	$ -
2053	11	$ 12	0.7621	$ 9	2088	46	$ -	0.3211	$ -
2054	12	$ 86	0.7436	$ 64	2089	47	$ -	0.3133	$ -
2055	13	$ 8	0.7254	$ 6	2090	48	$ -	0.3057	$ -
2056	14	$ 54	0.7077	$ 38	2091	49	$ -	0.2982	$ -
2057	15	$ -	0.6905	$ -	2092	50	$ -	0.2909	$ -
2058	16	$ -	0.6736	$ -					

Total Construction Costs:	$ 26,128
Total Present Value:	$ 30,552
Federal Discount Rate:	2.50%
Amortization Factor:	0.03526
Interest During Construction:	$ 4,891
Average Annual Construction Costs:	$ 1,077

Table 40b
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
OMRR&R Costs for Recommended Plan
(2021 Price Level, $ Millions)

Year	Analysis Year	Total O&M Costs	Present Value Factor	Present Value	Year	Analysis Year	Total O&M Costs	Present Value Factor	Present Value
2042	0	$ -	1.0000	$ -	2067	25	$ 576	0.5394	$ 311
2043	1	$ 10	0.9756	$ 10	2068	26	$ 10	0.5262	$ 5
2044	2	$ 10	0.9518	$ 10	2069	27	$ 16	0.5134	$ 8
2045	3	$ 17	0.9286	$ 16	2070	28	$ 10	0.5009	$ 5
2046	4	$ 10	0.9060	$ 9	2071	29	$ 10	0.4887	$ 5
2047	5	$ 577	0.8839	$ 510	2072	30	$ 721	0.4767	$ 344
2048	6	$ 16	0.8623	$ 14	2073	31	$ 10	0.4651	$ 4
2049	7	$ 10	0.8413	$ 8	2074	32	$ 10	0.4538	$ 4
2050	8	$ 10	0.8207	$ 8	2075	33	$ 16	0.4427	$ 7
2051	9	$ 16	0.8007	$ 13	2076	34	$ 10	0.4319	$ 4
2052	10	$ 619	0.7812	$ 483	2077	35	$ 576	0.4214	$ 243
2053	11	$ 10	0.7621	$ 7	2078	36	$ 16	0.4111	$ 7
2054	12	$ 16	0.7436	$ 12	2079	37	$ 10	0.4011	$ 4
2055	13	$ 10	0.7254	$ 7	2080	38	$ 10	0.3913	$ 4
2056	14	$ 10	0.7077	$ 7	2081	39	$ 16	0.3817	$ 6
2057	15	$ 678	0.6905	$ 468	2082	40	$ 699	0.3724	$ 260
2058	16	$ 10	0.6736	$ 6	2083	41	$ 10	0.3633	$ 3
2059	17	$ 10	0.6572	$ 6	2084	42	$ 16	0.3545	$ 6
2060	18	$ 16	0.6412	$ 10	2085	43	$ 10	0.3458	$ 3
2061	19	$ 10	0.6255	$ 6	2086	44	$ 10	0.3374	$ 3
2062	20	$ 699	0.6103	$ 427	2087	45	$ 678	0.3292	$ 223
2063	21	$ 16	0.5954	$ 10	2088	46	$ 10	0.3211	$ 3
2064	22	$ 10	0.5809	$ 6	2089	47	$ 10	0.3133	$ 3
2065	23	$ 10	0.5667	$ 5	2090	48	$ 16	0.3057	$ 5
2066	24	$ 16	0.5529	$ 9	2091	49	$ 10	0.2982	$ 3
					2092	50	$ 624	0.2909	$ 181

Total Operations and Maintenance Costs:	$ 6,917
Total Present Value:	$ 3,721
Federal Discount Rate:	2.50%
Amortization Factor:	0.03526
Average Annual Operations and Maintenance Costs:	$ 131

Table 40c
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
Project Costs for Recommended Plan
(2021 Price Level; 2.5% Discount Rate; $ Millions)

Total Implementation Costs	$	26,128		
Total Interest During Contruction	$	4,891		
Total Construction Costs	$	30,552		
Average Annual Total Construction Costs			$	1,077
Total O&M Costs	$	3,721		
Average Annual Total O&M Costs			$	131
Total Average Annual Project Costs			$	1,208

It should be noted that the accuracy of the spreadsheet calculations used to annualize the project costs was confirmed using the IWR Planning Suite software. The project cost annualization spreadsheet calculations and the IWR Planning Suite software produced similar results.

PART 5: RESULTS OF THE NATIONAL ECONOMIC DEVELOPMENT (NED) ANALYSIS

NET BENEFIT ANALYSIS

Calculation of Net Benefits. The expected annual benefits attributable to the project alternatives were converted to an equivalent time frame by using the FY 2021 Federal discount rate of 2.5 percent. The base year for this conversion is the year 2043 when the Recommended Plan becomes fully operational. The equivalent annual benefits were compared to the annual costs to develop a benefit-to-cost ratio (BCR) for the Recommended Plan. The net benefits for the Recommended Plan were calculated by subtracting the annual costs from the equivalent annual benefits. The net benefits were used to determine the economic justification of the Recommended Plan.

Tables 41 and 42 show the equivalent annual net benefits for the Recommended Plan by benefit category without and with Indirect Business Losses for each of the three sea-level rise scenarios for the years 2043 (revised base year) through 2092.

Table 41
Coastal Texas Protection and Restoration Feasibility Study Integrated Feasibility Report
Recommended Plan
Total Equivalent Annual Net Benefit Scenarios without Indirect Business Losses
(2021 Price Level; 2.5% Discount Rate; $ Millions)

Low Sea-Level Rise Scenario			
Item	Equiv Annual W/O Project Damages (2043-2092)	Equiv Annual With-Project Damages (2043-2092)	Equiv Annual Benefits and Costs (2043-2092)
Damage Category			
Residential & Commercial - Structure/Content/Vehicles	$ 2,310	$ 781	$ 1,529
Transportation Infrastructure	$ 384	$ 290	$ 94
Aboveground Storage Tanks	$ 56	$ 25	$ 31
Total Benefits - 2043 Base Year			$ 1,654
First Costs			$ 26,128
Interest During Construction			$ 4,891
Average Annual Total Construction Costs			$ 1,077
Annual Operation & Maintenance Costs			$ 131
Total Average Annual Project Costs			$ 1,208
B/C Ratio			1.37
Equivalent Annual Net Benefits - 2043 Base Year			$ 446

Table 41 (continued)
Coastal Texas Protection and Restoration Feasibility Study Integrated Feasibility Report
Recommended Plan
Total Equivalent Annual Net Benefit Scenarios without Indirect Business Losses
(2021 Price Levels; 2.5% Discount Rate; $ Millions)

Intermediate Sea-Level Rise Scenario			
Item	Equiv Annual W/O Project Damages (2043-2092)	Equiv Annual With-Project Damages (2043-2092)	Equiv Annual Benefits and Costs (2043-2092)
Damage Category			
Residential & Commercial - Structure/Content/Vehicles	$ 3,328	$ 1,369	$ 1,959
Transportation Infrastructure	$ 531	$ 396	$ 135
Aboveground Storage Tanks	$ 67	$ 31	$ 36
Total Benefits - 2043 Base Year			$ 2,130
First Costs			$ 26,128
Interest During Construction			$ 4,891
Average Annual Total Construction Costs			$ 1,077
Annual Operation & Maintenance Costs			$ 131
Total Average Annual Project Costs			$ 1,208
B/C Ratio			1.76
Equivalent Annual Net Benefits - 2043 Base Year			$ 921

Table 41 (continued)
Coastal Texas Protection and Restoration Feasibility Study Integrated Feasibility Report
Recommended Plan
Total Equivalent Annual Net Benefit Scenarios without Indirect Business Losses
(2021 Price Levels; 2.5% Discount Rate; $ Millions)

High Sea-Level Rise Scenario			
Item	Equiv Annual W/O Project Damages (2043-2092)	Equiv Annual With-Project Damages (2043-2092)	Equiv Annual Benefits and Costs (2043-2092)
Damage Category			
Residential & Commercial - Structure/Content/Vehicles	$ 7,735	$ 4,415	$ 3,320
Transportation Infrastructure	$ 1,032	$ 825	$ 206
Aboveground Storage Tanks	$ 105	$ 59	$ 47
Total Benefits - 2043 Base Year			$ 3,573
First Costs			$ 26,128
Interest During Construction			$ 4,891
Average Annual Total Construction Costs			$ 1,077
Annual Operation & Maintenance Costs			$ 131
Total Average Annual Project Costs			$ 1,208
B/C Ratio			2.96
Equivalent Annual Net Benefits - 2043 Base Year			$ 2,365

Table 42

Coastal Texas Protection and Restoration Feasibility Study Integrated Feasibility Report

Recommended Plan

Total Equivalent Annual Net Benefit Scenarios with Indirect Business Losses

(2021 Price Level; 2.5% Discount Rate; $ Millions)

Low Sea-Level Rise Scenario			
Item	Equiv Annual W/O Project Damages (2043-2092)	Equiv Annual With-Project Damages (2043-2092)	Equiv Annual Benefits and Costs (2043-2092)
Damage Category			
Residential & Commercial - Structure/Content/Vehicles	$ 2,310	$ 781	$ 1,529
Transportation Infrastructure	$ 384	$ 290	$ 94
Aboveground Storage Tanks	$ 56	$ 25	$ 31
Indirect Business Losses			$ 155
Total Benefits - 2043 Base Year			$ 1,809
First Costs			$ 26,128
Interest During Construction			$ 4,891
Average Annual Total Construction Costs			$ 1,077
Annual Operation & Maintenance Costs			$ 131
Total Average Annual Project Costs			$ 1,208
B/C Ratio			1.50
Equivalent Annual Net Benefits - 2043 Base Year			$ 601

Table 42 (continued)
Coastal Texas Protection and Restoration Feasibility Study Integrated Feasibility Report
Recommended Plan
Total Equivalent Annual Net Benefit Scenarios with Indirect Business Losses
(2021 Price Levels; 2.5% Discount Rate; $ Millions)

Intermediate Sea-Level Rise Scenario			
Item	Equiv Annual W/O Project Damages (2043-2092)	Equiv Annual With-Project Damages (2043-2092)	Equiv Annual Benefits and Costs (2043-2092)
Damage Category			
Residential & Commercial - Structure/Content/Vehicles	$ 3,328	$ 1,369	$ 1,959
Transportation Infrastructure	$ 531	$ 396	$ 135
Aboveground Storage Tanks	$ 67	$ 31	$ 36
Indirect Business Losses			$ 176
Total Benefits - 2043 Base Year			$ 2,306
First Costs			$ 26,128
Interest During Construction			$ 4,891
Average Annual Total Construction Costs			$ 1,077
Annual Operation & Maintenance Costs			$ 131
Total Average Annual Project Costs			$ 1,208
B/C Ratio			1.91
Equivalent Annual Net Benefits - 2043 Base Year			$ 1,097

Table 42 (continued)
Coastal Texas Protection and Restoration Feasibility Study Integrated Feasibility Report
Recommended Plan
Total Equivalent Annual Net Benefit Scenarios with Indirect Business Losses
(2021 Price Levels; 2.5% Discount Rate; $ Millions)

High Sea-Level Rise Scenario			
Item	Equiv Annual W/O Project Damages (2043-2092)	Equiv Annual With-Project Damages (2043-2092)	Equiv Annual Benefits and Costs (2043-2092)
Damage Category			
Residential & Commercial - Structure/Content/Vehicles	$ 7,735	$ 4,415	$ 3,320
Transportation Infrastructure	$ 1,032	$ 825	$ 206
Aboveground Storage Tanks	$ 105	$ 59	$ 47
Indirect Business Losses			$ 250
Total Benefits - 2043 Base Year			$ 3,823
First Costs			$ 26,128
Interest During Construction			$ 4,891
Average Annual Total Construction Costs			$ 1,077
Annual Operation & Maintenance Costs			$ 131
Total Average Annual Project Costs			$ 1,208
B/C Ratio			3.16
Equivalent Annual Net Benefits - 2043 Base Year			$ 2,615

RISK ANALYSIS

Benefit Exceedance Probability Relationship. The HEC-FDA model incorporates the uncertainty surrounding the economic and engineering inputs to generate results that can be used to assess the performance of proposed plans. The HEC-FDA model was used to calculate equivalent annual without-project and with-project damages and the damages reduced for the Recommended Plan. Table 43a shows the mean equivalent annual benefits and the benefits at the 75, 50, and 25 percentiles for the Recommended Plan for the period 2035 through 2084 under the three sea-level rise scenarios.

Table 43a
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
Probability that Equivalent Annual Benefits Exceed Annual Costs
Recommended Plan 2035-2084
(2021 Price Level; 2.5% Discount Rate; $ Millions)

Low Sea-Level Rise Scenario				
Damage Category	Equivalent Annual Damages Reduced	Prob Damg Reduced Exceeds Values 0.75	Prob Damg Reduced Exceeds Values 0.50	Prob Damg Reduced Exceeds Values 0.25
Residential & Commercial - Structure/Content/Vehicles	$1,432	$766	$1,293	$1,967
Transportation Infrastructure	$86	$48	$80	$117
Aboveground Storage Tanks	$30	$11	$24	$44
Indirect Business Losses	$168	$90	$151	$230
Total Benefits	$1,715	$915	$1,548	$2,358
Intermediate Sea-Level Rise Scenario				
Damage Category	Equivalent Annual Damages Reduced	Prob Damg Reduced Exceeds Values 0.75	Prob Damg Reduced Exceeds Values 0.50	Prob Damg Reduced Exceeds Values 0.25
Residential & Commercial - Structure/Content/Vehicles	$1,756	$1,044	$1,631	$2,351
Transportation Infrastructure	$118	$78	$112	$151
Aboveground Storage Tanks	$34	$13	$28	$48
Indirect Business Losses	$186	$111	$173	$249
Total Benefits	$2,093	$1,245	$1,943	$2,800
High Sea-Level Rise Scenario				
Damage Category	Equivalent Annual Damages Reduced	Prob Damg Reduced Exceeds Values 0.75	Prob Damg Reduced Exceeds Values 0.50	Prob Damg Reduced Exceeds Values 0.25
Residential & Commercial - Structure/Content/Vehicles	$2,743	$1,982	$2,639	$3,413
Transportation Infrastructure	$169	$128	$165	$205
Aboveground Storage Tanks	$42	$19	$36	$59
Indirect Business Losses	$243	$176	$234	$302
Total Benefits	$3,196	$2,304	$3,073	$3,980

Table 43b displays each of these values proportioned to reflect a base year of 2043 and a 50-year period of analysis ending in the year 2092. The percentiles shown in the tables reflect the percentage chance that the benefits will be greater than or equal to the indicated values. Finally, the benefit exceedance probability relationships are compared to the point estimate of the annual costs to show the percentage chance that the equivalent annual benefits will exceed the annual costs under the three sea-level rise scenarios.

Table 43b
Coastal Texas Protection and Restoration Feasibility Study Integrated Feasibility Report
Probability that Equivalent Annual Benefits Exceed Annual Costs
Recommended Plan 2043-2092
(2021 Price Level; 2.5% Discount Rate; $ Millions)

Low Sea-Level Rise Scenario						
Damage Category	Equivalent Annual Damages Reduced	Prob Damg Reduced Exceeds Values 0.75	Prob Damg Reduced Exceeds Values 0.50	Prob Damg Reduced Exceeds Values 0.25	Annual Costs	Probabilty Benefits Exceed Costs
Residential & Commercial - Structure/Content/Vehicles	$1,529	$819	$1,381	$2,102	$1,208	50% to 75%
Transportation Infrastructure	$94	$53	$88	$128		
Aboveground Storage Tanks	$31	$11	$25	$45		
Indirect Business Losses	$155	$83	$140	$213		
Total Benefits	$1,809	$966	$1,634	$2,488		
Intermediate Sea-Level Rise Scenario						
Damage Category	Equivalent Annual Damages Reduced	Prob Damg Reduced Exceeds Values 0.75	Prob Damg Reduced Exceeds Values 0.50	Prob Damg Reduced Exceeds Values 0.25	Annual Costs	Probabilty Benefits Exceed Costs
Residential & Commercial - Structure/Content/Vehicles	$1,959	$1,165	$1,819	$2,623	$1,208	Over 75%
Transportation Infrastructure	$135	$89	$129	$174		
Aboveground Storage Tanks	$36	$14	$29	$52		
Indirect Business Losses	$176	$105	$163	$236		
Total Benefits	$2,306	$1,373	$2,141	$3,084		
High Sea-Level Rise Scenario						
Damage Category	Equivalent Annual Damages Reduced	Prob Damg Reduced Exceeds Values 0.75	Prob Damg Reduced Exceeds Values 0.50	Prob Damg Reduced Exceeds Values 0.25	Annual Costs	Probabilty Benefits Exceed Costs
Residential & Commercial - Structure/Content/Vehicles	$3,320	$2,400	$3,195	$4,132	$1,208	Over 75%
Transportation Infrastructure	$206	$156	$201	$250		
Aboveground Storage Tanks	$47	$21	$40	$67		
Indirect Business Losses	$250	$181	$241	$311		
Total Benefits	$3,823	$2,757	$3,677	$4,760		

In order to present the REMI results in a probabilistic framework, the reduction of indirect losses to the national economy was proportioned to the equivalent annual damage reductions for structures, contents, and vehicles calculated by the HEC-FDA model at the 75 percent, 50 percent and 25 percent exceedance values. These proportions were applied to the Recommended Plan for the three sea-level rise scenarios.

Project Performance by Reach for the Years of Analysis. The results from the HEC-FDA model were also used to calculate the long-term annual exceedance probability (AEP) and the conditional non-exceedance probability, or assurance, for various probability storm events. The model provided a target stage to assess project performance for each study area reach for the analysis years, 2035 and 2084, for the without-project condition and for the Recommended Plan under the intermediate sea-level rise scenario. For each study area reach, the target stage was set by default at the elevation where the model calculated five percent residual damages for the 0.01 AEP (100-year) event.

The HEC-FDA model calculated a target stage AEP with a median and expected value that reflected the likelihood that the target stages will be exceeded in a given year. The median value was calculated using point estimates, while the expected value was calculated using Monte Carlo simulation. The results also show the long-term risk or the probability of a target stage being exceeded over 10-year, 30-year, and 50-year periods. Finally, the model results show the conditional non-exceedance probability or the likelihood that a target stage will not be exceeded by the 0.10 (10 year) AEP, the 0.04 (25-year) AEP, the 0.02 (50-year) AEP, the 0.01 (100-year) AEP, the 0.004 (250-year) AEP and the 0.002 (500-year) AEP. Tables 44 and 45 display the project performance results for the structures, contents, vehicles, and debris HEC-FDA model for each study area reach for the analysis years 2035 and 2084 for both the without-project and with-project conditions under the intermediate sea-level rise scenario. It should be noted that the HEC-FDA model chose a target stage of 0.00 for reaches 3, 5, 12, 15, 21, 23, 24, 26, 27, 28, 29, 31, 32, and 33. As data pertaining to this target stage does not add any value and may be misleading, those reaches have been left off of the tables. It should also be noted that the HEC-FDA model normally will choose target stages associated with top of levee elevations in cases where levees are incorporated into the model. All levees in this study are incorporated into the water surface profiles, so target stages may not be associated with top of levee elevations.

Table 44
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
Project Performance by Study Area Reach for Structures, Contents, Vehicles, & Debris
Intermediate Sea-Level Rise Scenario
2035

Without Project													
Study Area Reach	Target Stage	Target Stage Annual Exceedance Probability		Long-Term Risk (years)			Conditional Non-Exceedance Probability by Events						
		Median	Expected	10	30	50	0.100	0.040	0.020	0.010	0.004	0.002
1	3.56	0.45	0.45	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
10	5.33	0.05	0.05	0.41	0.79	0.93	0.99	0.38	0.15	0.05	0.01	0.01
11	3.22	0.39	0.39	0.99	1.00	1.00	0.00	0.00	0.00	0.01	0.00	0.00
13	3.50	0.31	0.32	0.98	1.00	1.00	0.00	0.00	0.00	0.01	0.00	0.00
14	10.59	0.16	0.16	0.82	0.99	1.00	0.22	0.08	0.04	0.01	0.00	0.00
16	5.46	0.07	0.07	0.50	0.88	0.97	0.85	0.26	0.10	0.06	0.02	0.01
17	2.35	0.69	0.70	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
18	6.34	0.18	0.17	0.84	1.00	1.00	0.17	0.07	0.03	0.03	0.01	0.00
19	5.27	0.19	0.19	0.87	1.00	1.00	0.11	0.08	0.04	0.04	0.01	0.01
2	4.58	0.31	0.31	0.98	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
20	4.78	0.09	0.09	0.61	0.94	0.99	0.58	0.16	0.06	0.04	0.01	0.00
22	4.16	0.08	0.07	0.53	0.90	0.98	0.82	0.20	0.07	0.03	0.01	0.00
25	4.05	0.56	0.56	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
30	2.88	0.59	0.59	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
34	6.79	0.07	0.07	0.50	0.87	0.97	0.88	0.23	0.09	0.05	0.01	0.00
35	6.20	0.08	0.07	0.53	0.90	0.98	0.81	0.18	0.06	0.03	0.01	0.00
36	5.63	0.10	0.10	0.65	0.96	0.99	0.51	0.13	0.05	0.04	0.01	0.00
37	11.78	0.07	0.07	0.50	0.88	0.97	0.88	0.20	0.07	0.05	0.01	0.00
38	6.75	0.21	0.21	0.90	1.00	1.00	0.07	0.03	0.02	0.01	0.00	0.00
39	7.50	0.29	0.29	0.97	1.00	1.00	0.01	0.01	0.00	0.01	0.00	0.00
4	6.95	0.43	0.43	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
40	6.03	0.04	0.04	0.35	0.73	0.89	1.00	0.46	0.22	0.10	0.04	0.02
6	8.93	0.09	0.08	0.57	0.92	0.99	0.68	0.18	0.07	0.03	0.01	0.00
7	8.13	0.12	0.11	0.70	0.97	1.00	0.41	0.13	0.06	0.05	0.01	0.01
81	11.81	0.02	0.03	0.23	0.54	0.73	1.00	0.75	0.44	0.23	0.10	0.05
82	9.27	0.08	0.08	0.56	0.91	0.98	0.72	0.19	0.06	0.05	0.01	0.01
83	8.14	0.04	0.04	0.34	0.71	0.88	1.00	0.47	0.24	0.11	0.04	0.02
9	8.67	0.08	0.08	0.55	0.91	0.98	0.71	0.22	0.09	0.05	0.02	0.01

Table 44 (continued)
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
Project Performance by Study Area Reach for Structures, Contents, Vehicles, & Debris
Intermediate Sea-Level Rise Scenario
2035

With Project (Structural Alone)												
Study Area Reach	Target Stage	Target Stage Annual Exceedance Probability		Long-Term Risk (years)			Conditional Non-Exceedance Probability by Events					
		Median	Expected	10	30	50	0.100	0.040	0.020	0.010	0.004	0.002
1	3.56	0.37	0.37	0.99	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
10	5.33	0.02	0.02	0.18	0.45	0.63	1.00	0.85	0.55	0.30	0.15	0.09
11	3.22	0.04	0.04	0.36	0.74	0.89	1.00	0.44	0.22	0.12	0.06	0.04
13	3.50	0.05	0.05	0.37	0.75	0.90	1.00	0.43	0.20	0.09	0.02	0.01
14	10.59	0.07	0.07	0.52	0.89	0.97	0.87	0.15	0.04	0.04	0.01	0.00
16	5.46	0.01	0.01	0.10	0.28	0.42	1.00	1.00	0.85	0.56	0.22	0.09
17	2.35	0.08	0.07	0.54	0.90	0.98	0.79	0.16	0.05	0.05	0.00	0.00
18	6.34	0.01	0.02	0.14	0.37	0.54	1.00	0.94	0.70	0.45	0.16	0.04
19	5.27	0.09	0.09	0.59	0.93	0.99	0.66	0.09	0.02	0.02	0.00	0.00
2	4.58	0.26	0.26	0.95	1.00	1.00	0.02	0.02	0.01	0.00	0.00	0.00
20	4.78	0.66	0.66	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
22	4.16	0.07	0.07	0.50	0.88	0.97	0.88	0.23	0.08	0.04	0.01	0.00
25	4.05	0.51	0.51	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
30	2.88	0.51	0.51	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
34	6.79	0.08	0.08	0.55	0.91	0.98	0.78	0.11	0.03	0.01	0.00	0.00
35	6.20	0.46	0.46	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
36	5.63	0.00	0.00	0.01	0.04	0.06	1.00	1.00	1.00	1.00	0.97	0.87
37	11.78	0.19	0.19	0.88	1.00	1.00	0.04	0.00	0.00	0.00	0.00	0.00
38	6.75	0.55	0.55	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
39	7.50	0.18	0.18	0.86	1.00	1.00	0.13	0.05	0.01	0.00	0.00	0.00
4	6.95	0.39	0.39	0.99	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
40	6.03	0.02	0.03	0.24	0.55	0.74	1.00	0.78	0.47	0.25	0.07	0.02
6	8.93	0.05	0.05	0.42	0.81	0.93	0.97	0.36	0.16	0.08	0.03	0.01
7	8.13	0.30	0.30	0.97	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
81	11.81	0.00	0.00	0.01	0.04	0.07	1.00	1.00	1.00	1.00	1.00	0.93
82	9.27	0.00	0.00	0.03	0.08	0.13	1.00	1.00	1.00	1.00	1.00	0.00
83	8.14	0.02	0.03	0.23	0.55	0.74	1.00	0.74	0.43	0.23	0.05	0.01
9	8.67	0.01	0.01	0.13	0.33	0.49	1.00	0.99	0.74	0.44	0.15	0.07

Table 44 (continued)
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
Project Performance by Study Area Reach for Structures, Contents, Vehicles, & Debris
Intermediate Sea-Level Rise Scenario
2035

With Project (Structural and Nonstructural)												
Study Area Reach	Target Stage	Target Stage Annual Exceedance		Long-Term Risk (years)			Conditional Non-Exceedance Probability by Events					
		Median	Expected	10	30	50	0.100	0.040	0.020	0.010	0.004	0.002
1	3.56	0.37	0.37	0.99	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
10	5.33	0.02	0.02	0.18	0.45	0.63	1.00	0.85	0.55	0.30	0.15	0.09
11	3.22	0.04	0.04	0.36	0.74	0.89	1.00	0.44	0.22	0.12	0.06	0.04
13	3.50	0.05	0.05	0.37	0.75	0.90	1.00	0.43	0.20	0.09	0.02	0.01
14	10.59	0.07	0.07	0.52	0.89	0.97	0.87	0.15	0.04	0.04	0.01	0.00
16	5.46	0.01	0.01	0.10	0.28	0.42	1.00	1.00	0.85	0.56	0.22	0.09
17	2.35	0.08	0.07	0.54	0.90	0.98	0.79	0.16	0.05	0.05	0.00	0.00
18	6.34	0.01	0.02	0.14	0.37	0.54	1.00	0.94	0.70	0.45	0.16	0.04
19	5.27	0.09	0.09	0.59	0.93	0.99	0.66	0.09	0.02	0.02	0.00	0.00
2	4.58	0.26	0.26	0.95	1.00	1.00	0.02	0.02	0.01	0.00	0.00	0.00
20	4.78	0.66	0.66	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
22	4.16	0.07	0.07	0.50	0.88	0.97	0.88	0.23	0.08	0.04	0.01	0.00
25	4.05	0.51	0.51	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
30	2.88	0.51	0.51	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
34	6.79	0.08	0.08	0.55	0.91	0.98	0.78	0.11	0.03	0.01	0.00	0.00
35	6.20	0.46	0.46	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
36	5.63	0.00	0.00	0.01	0.04	0.06	1.00	1.00	1.00	1.00	0.97	0.87
37	11.78	0.19	0.19	0.88	1.00	1.00	0.04	0.00	0.00	0.00	0.00	0.00
38	6.75	0.55	0.55	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
39	7.50	0.18	0.18	0.86	1.00	1.00	0.13	0.05	0.01	0.00	0.00	0.00
4	6.95	0.39	0.39	0.99	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
40	6.03	0.02	0.03	0.23	0.55	0.73	1.00	0.79	0.47	0.25	0.07	0.02
6	8.93	0.05	0.05	0.42	0.81	0.93	0.97	0.36	0.16	0.08	0.03	0.01
7	8.13	0.30	0.30	0.97	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
81	11.81	0.00	0.00	0.01	0.04	0.07	1.00	1.00	1.00	1.00	1.00	0.93
82	9.27	0.00	0.00	0.03	0.08	0.13	1.00	1.00	1.00	1.00	1.00	0.00
83	8.14	0.02	0.03	0.23	0.55	0.74	1.00	0.74	0.43	0.23	0.05	0.01
9	8.67	0.01	0.01	0.13	0.33	0.49	1.00	0.99	0.74	0.44	0.15	0.07

Table 45
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
Project Performance by Study Area Reach for Structures, Contents, Vehicles, & Debris
Intermediate Sea-Level Rise Scenario
2084

Without Project													
Study Area Reach	Target Stage	Target Stage Annual Exceedance Probability		Long-Term Risk (years)			Conditional Non-Exceedance Probability by Events						
		Median	Expected	10	30	50	0.100	0.040	0.020	0.010	0.004	0.002
1	4.17	0.70	0.70	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
10	6.57	0.09	0.08	0.57	0.92	0.99	0.67	0.19	0.07	0.04	0.01	0.00
11	4.08	0.67	0.67	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
13	4.62	0.58	0.58	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
14	9.92	0.47	0.47	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
16	7.07	0.19	0.19	0.87	1.00	1.00	0.12	0.05	0.02	0.02	0.01	0.00
17	6.01	0.36	0.37	0.99	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
18	7.43	0.40	0.40	0.99	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
19	6.60	0.44	0.44	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
2	5.20	0.58	0.58	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
20	5.48	0.39	0.39	0.99	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
22	3.69	0.44	0.44	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
24	3.87	0.04	0.04	0.35	0.72	0.88	1.00	0.50	0.24	0.16	0.00	0.00
25	4.23	0.71	0.71	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
30	3.52	0.72	0.72	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
34	6.70	0.27	0.27	0.95	1.00	1.00	0.01	0.01	0.01	0.01	0.00	0.00
35	5.69	0.40	0.40	0.99	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
36	6.08	0.44	0.44	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
37	8.27	0.52	0.52	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
38	5.59	0.59	0.59	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
39	7.95	0.49	0.49	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
4	7.00	0.67	0.67	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
40	5.01	0.30	0.30	0.97	1.00	1.00	0.00	0.00	0.00	0.01	0.00	0.00
5	6.84	0.10	0.09	0.61	0.94	0.99	0.55	0.25	0.11	0.05	0.02	0.01
6	10.57	0.17	0.16	0.83	1.00	1.00	0.20	0.05	0.02	0.02	0.00	0.00
7	7.81	0.48	0.48	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
81	6.17	0.48	0.48	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
82	10.56	0.14	0.13	0.76	0.99	1.00	0.31	0.07	0.02	0.02	0.01	0.00
83	8.32	0.13	0.13	0.75	0.98	1.00	0.33	0.09	0.04	0.03	0.01	0.00
9	8.90	0.32	0.32	0.98	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 45 (continued)
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
Project Performance by Study Area Reach for Structures, Contents, Vehicles, & Debris
Intermediate Sea-Level Rise Scenario
2084

With Project (Structural Alone)												
Study	Target	Target Stage		Long-Term Risk			Conditional Non-Exceedance Probability by					
Area	Stage	Median	Expected	10	30	50	0.100	0.040	0.020	0.010	0.004	0.002
1	4.17	0.65	0.65	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
10	6.57	0.03	0.03	0.28	0.63	0.81	1.00	0.62	0.34	0.17	0.06	0.02
11	4.08	0.09	0.08	0.57	0.92	0.98	0.70	0.15	0.05	0.04	0.01	0.00
13	4.62	0.08	0.08	0.55	0.91	0.98	0.73	0.19	0.07	0.04	0.01	0.00
14	9.92	0.23	0.23	0.92	1.00	1.00	0.04	0.01	0.01	0.01	0.00	0.00
16	7.07	0.03	0.03	0.24	0.56	0.74	1.00	0.72	0.43	0.23	0.07	0.02
17	6.01	0.05	0.05	0.41	0.79	0.93	0.98	0.37	0.17	0.13	0.02	0.00
18	7.43	0.09	0.09	0.62	0.95	0.99	0.57	0.13	0.04	0.04	0.01	0.00
19	6.60	0.11	0.11	0.68	0.97	1.00	0.46	0.10	0.03	0.01	0.00	0.00
2	5.20	0.52	0.52	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
20	5.48	0.66	0.66	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
22	3.69	0.35	0.35	0.99	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
24	3.87	0.04	0.04	0.35	0.72	0.88	1.00	0.50	0.24	0.16	0.00	0.00
25	4.23	0.66	0.66	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
30	3.52	0.66	0.66	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
34	6.70	0.38	0.38	0.99	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
35	5.69	0.59	0.59	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
36	6.08	0.06	0.06	0.47	0.85	0.96	0.90	0.28	0.11	0.06	0.01	0.00
37	8.27	0.62	0.62	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
38	5.59	0.77	0.77	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
39	7.95	0.32	0.32	0.98	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
4	7.00	0.59	0.59	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
40	5.01	0.04	0.04	0.33	0.70	0.86	1.00	0.51	0.27	0.18	0.10	0.06
5	6.84	0.05	0.05	0.43	0.81	0.94	0.95	0.36	0.16	0.08	0.03	0.01
6	10.57	0.07	0.07	0.51	0.88	0.97	0.82	0.24	0.09	0.08	0.01	0.00
7	7.81	0.54	0.54	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
81	6.17	0.00	0.00	0.02	0.05	0.08	1.00	1.00	1.00	1.00	0.97	0.89
82	10.56	0.01	0.01	0.10	0.26	0.40	1.00	0.98	0.86	0.66	0.19	0.00
83	8.32	0.08	0.08	0.55	0.91	0.98	0.76	0.20	0.07	0.05	0.01	0.00
9	8.90	0.14	0.14	0.77	0.99	1.00	0.18	0.05	0.04	0.03	0.01	0.00

Table 45 (continued)
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
Project Performance by Study Area Reach for Structures, Contents, Vehicles, & Debris
Intermediate Sea-Level Rise Scenario
2084

With Project (Structural and Nonstructural)													
Study	Target	Target Stage		Long-Term Risk			Conditional Non-Exceedance Probability by						
Area	Stage	Median	Expected	10	30	50	0.100	0.040	0.020	0.010	0.004	0.002
1	4.17	0.65	0.65	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
10	6.57	0.03	0.03	0.28	0.63	0.81	1.00	0.62	0.34	0.17	0.06	0.02
11	4.08	0.09	0.08	0.57	0.92	0.98	0.70	0.15	0.05	0.04	0.01	0.00
13	4.62	0.08	0.08	0.55	0.91	0.98	0.73	0.19	0.07	0.04	0.01	0.00
14	9.92	0.23	0.23	0.92	1.00	1.00	0.04	0.01	0.01	0.01	0.00	0.00
16	7.07	0.03	0.03	0.24	0.56	0.74	1.00	0.72	0.43	0.23	0.07	0.02
17	6.01	0.05	0.05	0.41	0.79	0.93	0.98	0.37	0.17	0.13	0.02	0.00
18	7.43	0.09	0.09	0.62	0.95	0.99	0.57	0.13	0.04	0.04	0.01	0.00
19	6.60	0.11	0.11	0.68	0.97	1.00	0.46	0.10	0.03	0.01	0.00	0.00
2	5.20	0.52	0.52	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
20	5.48	0.66	0.66	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
22	3.69	0.35	0.35	0.99	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
24	3.87	0.04	0.04	0.35	0.72	0.88	1.00	0.50	0.24	0.16	0.00	0.00
25	4.23	0.66	0.66	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
30	3.52	0.66	0.66	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
34	6.70	0.38	0.38	0.99	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
35	5.69	0.59	0.59	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
36	6.08	0.06	0.06	0.47	0.85	0.96	0.90	0.28	0.11	0.06	0.01	0.00
37	8.27	0.62	0.62	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
38	5.59	0.77	0.77	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
39	7.95	0.32	0.32	0.98	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
4	7.00	0.59	0.59	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
40	5.01	0.04	0.04	0.33	0.70	0.86	1.00	0.51	0.27	0.18	0.10	0.06
5	6.84	0.05	0.05	0.43	0.81	0.94	0.95	0.36	0.16	0.08	0.03	0.01
6	10.57	0.07	0.07	0.51	0.88	0.97	0.82	0.24	0.09	0.08	0.01	0.00
7	7.81	0.54	0.54	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
81	6.17	0.00	0.00	0.02	0.05	0.08	1.00	1.00	1.00	1.00	0.97	0.89
82	10.56	0.01	0.01	0.10	0.26	0.40	1.00	0.98	0.86	0.66	0.19	0.00
83	8.32	0.08	0.08	0.55	0.91	0.98	0.76	0.20	0.07	0.05	0.01	0.00
9	8.90	0.14	0.14	0.77	0.99	1.00	0.18	0.05	0.04	0.03	0.01	0.00

Residual Risk. Any flood risk to either existing or future development that remains in the floodplain after the implementation of the Recommended Plan is considered residual risk. While future development was not included in the modeling of damages and benefits for the Recommended Plan, the projected residential and non-residential structures would increase the residual flood risk in the study area. The amount of this increase would depend on the adherence by local officials to the new stricter floodplain requirements and/or the occurrence of flooding from events greater than the design elevation of the Recommended Plan. Two nonstructural measures, elevations and floodproofing, were formulated for Reaches 39 and 40 on the west bank of Galveston Bay to reduce residual surge risk. The total equivalent annual residual damages by category are shown in Table 46 for each of the three sea-level rise scenarios. The values are shown using a FY 2021 price level and interest rate.

Table 46
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
Recommended Plan
Total Equivalent Annual Residual Damages
(2021 Price Level; 2.5% Discount Rate; $ Millions)

Low Sea-Level Rise Scenario	
Item	Equivalent Annual Residual Damages (2043-2092)
Residential & Commercial - Structure/Content/Vehicles	$781
Transportation Infrastructure	$290
Aboveground Storage Tanks	$25
Total Residual Damages	$1,096
Intermediate Sea-Level Rise Scenario	
Item	Equivalent Annual Residual Damages (2043-2092)
Residential & Commercial - Structure/Content/Vehicles	$1,369
Transportation Infrastructure	$396
Aboveground Storage Tanks	$31
Total Residual Damages	$1,796
High Sea-Level Rise Scenario	
Item	Equivalent Annual Residual Damages (2043-2092)
Residential & Commercial - Structure/Content/Vehicles	$4,415
Transportation Infrastructure	$825
Aboveground Storage Tanks	$59
Total Residual Damages	$5,299

Note: These equivalent annual residual damages do not inlcude future development and may be understating damages depending on future adherence to stricter floodplain requirements.

ADDENDUM A: DEPTH-DAMAGE FUNCTION SENSITIVITY

TSP Milestone depth-damage functions and content-to-structure value ratios. A sensitivity was conducted using the same depth-damage functions and content-to-structure value ratios (CSVRs) that were utilized at the time of the TSP milestone. At that milestone, residential structures were assigned generic depth-damage functions and a corresponding 100% CSVR. Vehicles were assigned generic depth-damage functions. Non-residential structures were assigned depth-damage functions and CSVRs reflecting short duration, saltwater flooding being the primary source of flooding. Table 1 displays the damages and benefits for the intermediate sea level rise scenario with both the modeled 2035 base year and the adjusted 2043 base year. Tables 2a and 2b display the net-benefit analysis without and with indirect business losses, respectively.

Addendum A: Table 1
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
Recommended Plan
Total Equivalent Annual Damages and Benefits
(2021 Price Level; 2.5% Discount Rate; $ Millions)

Intermediate Sea-Level Rise Scenario				
Item	Equiv Annual W/O Project Damages (2035-2084)	Equiv Annual With-Project Damages (2035-2084)	Equiv Annual Benefits (2035-2084)	Percent of Total Benefits (2035-2084)
Damage Category				
Residential & Commercial - Structure/Content/Vehicles	$1,906	$742	$1,164	79%
Transportation Infrastructure	$460	$342	$118	8%
Aboveground Storage Tanks	$62	$28	$34	2%
Indirect Business Losses			$153	10%
Total Benefits - 2035 Base Year			$1,468	
Item	Equiv Annual W/O Project Damages (2043-2092)	Equiv Annual With-Project Damages (2043-2092)	Equiv Annual Benefits (2043-2092)	Percent of Total Benefits (2043-2092)
Damage Category				
Residential & Commercial - Structure/Content/Vehicles	$2,203	$911	$1,291	80%
Transportation Infrastructure	$531	$396	$135	8%
Aboveground Storage Tanks	$67	$31	$36	2%
Indirect Business Losses			$146	9%
Total Benefits - 2043 Base Year			$1,608	

Addendum A: Table 2a
Coastal Texas Protection and Restoration Feasibility Study Integrated Feasibility Report
Recommended Plan
Total Equivalent Annual Net Benefit Scenarios without Indirect Business Losses
(2021 Price Levels; 2.5% Discount Rate; $ Millions)

Intermediate Sea-Level Rise Scenario			
Item	Equiv Annual W/O Project Damages (2043-2092)	Equiv Annual With-Project Damages (2043-2092)	Equiv Annual Benefits and Costs (2043-2092)
Damage Category			
Residential & Commercial - Structure/Content/Vehicles	$ 2,203	$ 911	$ 1,291
Transportation Infrastructure	$ 531	$ 396	$ 135
Aboveground Storage Tanks	$ 67	$ 31	$ 36
Total Benefits - 2043 Base Year			$ 1,462
First Costs			$ 26,128
Interest During Construction			$ 4,891
Average Annual Total Construction Costs			$ 1,077
Annual Operation & Maintenance Costs			$ 131
Total Average Annual Project Costs			$ 1,208
B/C Ratio			1.21
Equivalent Annual Net Benefits - 2043 Base Year			$ 254

Addendum A: Table 2b

Coastal Texas Protection and Restoration Feasibility Study Integrated Feasibility Report

Recommended Plan

Total Equivalent Annual Net Benefit Scenarios with Indirect Business Losses

(2021 Price Levels; 2.5% Discount Rate; $ Millions)

Intermediate Sea-Level Rise Scenario			
Item	Equiv Annual W/O Project Damages (2043-2092)	Equiv Annual With-Project Damages (2043-2092)	Equiv Annual Benefits and Costs (2043-2092)
Damage Category			
Residential & Commercial - Structure/Content/Vehicles	$ 2,203	$ 911	$ 1,291
Transportation Infrastructure	$ 531	$ 396	$ 135
Aboveground Storage Tanks	$ 67	$ 31	$ 36
Indirect Business Losses			$ 146
Total Benefits - 2043 Base Year			$ 1,608
First Costs			$ 26,128
Interest During Construction			$ 4,891
Average Annual Total Construction Costs			$ 1,077
Annual Operation & Maintenance Costs			$ 131
Total Average Annual Project Costs			$ 1,208
B/C Ratio			1.33
Equivalent Annual Net Benefits - 2043 Base Year			$ 400

ADDENDUM B: INCREMENTAL ANALYSIS

First line structural measures. The structural components of the Recommended Plan include a primary line of defense (storm surge gate, dune and berm segments and raised seawall) and an interior line of defense (ring levee with pump stations). An incremental analysis was conducted in December 2019 to confirm the increasing effectiveness of the structural components. The HEC-FDA model was used to calculate the without-project damages and the with-project damages and benefits attributable to the storm surge gate by itself and then in conjunction with each of the other structural components included in the Recommended Plan. It should be noted that revisions were made to the H&H data in April 2020, the results of this incremental analysis using the December 2019 H&H data are provided for informational purposes only. The results of this analysis are summarized in Table 1 below.

Addendum B: Table 1
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
Incremental Analysis of Components of Recommended Plan
Expected and Equivalent Annual Damages and Benefits
Intermediate Sea Level Rise Scenario
(2020 Price Level; 2.75% Discount Rate; $ Millions)

Structures, Contents, Vehicles, & Debris			
Recommended Plan-Structural			
Plan	Expected Annual		Equivalent Annual
	2035	2084	
Without	$2,159	$4,896	$3,200
With	$999	$2,118	$1,424
Benefits	$1,160	$2,778	$1,776
Surge Gate Only			
Plan	Expected Annual		Equivalent Annual
	2035	2084	
Without	$2,159	$4,896	$3,200
With	$1,695	$3,342	$2,321
Benefits	$464	$1,555	$879
Surge Gate with Galveston Ring			
Plan	Expected Annual		Equivalent Annual
	2035	2084	
Without	$2,159	$4,896	$3,200
With	$1,075	$2,539	$1,632
Benefits	$1,084	$2,358	$1,568
Surge Gate with Bolivar and Galveston Dunes			
Plan	Expected Annual		Equivalent Annual
	2035	2084	
Without	$2,159	$4,896	$3,200
With	$1,505	$3,071	$2,101
Benefits	$654	$1,825	$1,099
Surge Gate with Galveston Ring and Dunes			
Plan	Expected Annual		Equivalent Annual
	2035	2084	
Without	$2,159	$4,896	$3,200
With	$885	$2,268	$1,411
Benefits	$1,273	$2,628	$1,789

Storage Tanks			
Recommended Plan-Structural			
Plan	Expected Annual		Equivalent Annual
	2035	2084	
Without	$85	$150	$110
With	$36	$63	$46
Benefits	$50	$87	$64
Surge Gate Only			
Plan	Expected Annual		Equivalent Annual
	2035	2084	
Without	$85	$150	$110
With	$43	$75	$55
Benefits	$43	$75	$55
Surge Gate with Galveston Ring			
Plan	Expected Annual		Equivalent Annual
	2035	2084	
Without	$85	$150	$110
With	$43	$75	$55
Benefits	$43	$75	$55
Surge Gate with Bolivar and Galveston Dunes			
Plan	Expected Annual		Equivalent Annual
	2035	2084	
Without	$85	$150	$110
With	$36	$68	$49
Benefits	$49	$82	$62
Surge Gate with Galveston Ring and Dunes			
Plan	Expected Annual		Equivalent Annual
	2035	2084	
Without	$85	$150	$110
With	$36	$68	$49
Benefits	$49	$82	$62

Note: This analysis was completed prior to receiving final H&H.

Addendum B: Table 1 (continued)
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
Incremental Analysis of Components of Recommended Plan
Expected and Equivalent Annual Damages and Benefits
Intermediate Sea Level Rise Scenario
(2020 Price Level; 2.75% Discount Rate; $ Millions)

Transportation Infrastructure				**Total**			
Recommended Plan-Structural				**Recommended Plan-Structural**			
Plan	Expected Annual		Equivalent Annual	Plan	Expected Annual		Equivalent Annual
	2035	2084			2035	2084	
Without	$367	$884	$564	Without	$2,611	$5,931	$3,874
With	$269	$610	$399	With	$1,304	$2,791	$1,869
Benefits	$98	$274	$165	Benefits	$1,308	$3,140	$2,004
Surge Gate Only				**Surge Gate Only**			
Plan	Expected Annual		Equivalent Annual	Plan	Expected Annual		Equivalent Annual
	2035	2084			2035	2084	
Without	$367	$884	$564	Without	$2,611	$5,931	$3,874
With	$309	$677	$449	With	$2,046	$4,094	$2,825
Benefits	$58	$207	$115	Benefits	$565	$1,837	$1,049
Surge Gate with Galveston Ring				**Surge Gate with Galveston Ring**			
Plan	Expected Annual		Equivalent Annual	Plan	Expected Annual		Equivalent Annual
	2035	2084			2035	2084	
Without	$367	$884	$564	Without	$2,611	$5,931	$3,874
With	$283	$644	$421	With	$1,401	$3,258	$2,107
Benefits	$84	$240	$143	Benefits	$1,210	$2,673	$1,767
Surge Gate with Bolivar and Galveston Dunes				**Surge Gate with Bolivar and Galveston Dunes**			
Plan	Expected Annual		Equivalent Annual	Plan	Expected Annual		Equivalent Annual
	2035	2084			2035	2084	
Without	$367	$884	$564	Without	$2,611	$5,931	$3,874
With	$294	$659	$433	With	$1,835	$3,799	$2,582
Benefits	$73	$225	$131	Benefits	$776	$2,132	$1,292
Surge Gate with Galveston Ring and Dunes				**Surge Gate with Galveston Ring and Dunes**			
Plan	Expected Annual		Equivalent Annual	Plan	Expected Annual		Equivalent Annual
	2035	2084			2035	2084	
Without	$367	$884	$564	Without	$2,611	$5,931	$3,874
With	$268	$626	$405	With	$1,190	$2,963	$1,864
Benefits	$98	$258	$159	Benefits	$1,421	$2,968	$2,009

Note: This analysis was completed prior to receiving final H&H.

ADDENDUM C: INFRASTRUCTURE SENSITIVITY

Incorporation of 10-year levees in HEC-FDA model. A sensitivity analysis was conducted incorporating 10-year levees into the HEC-FDA transportation infrastructure model to not allow damages at or below the 10% AEP event. Table 1 displays the damages and benefits for the intermediate sea level rise scenario with both the modeled 2035 base year and the adjusted 2043 base year. Tables 2a and 2b display the net-benefit analysis without and with indirect business losses, respectively.

Addendum C: Table 1
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
Recommended Plan
Total Equivalent Annual Damages and Benefits
(2021 Price Level; 2.5% Discount Rate; $ Millions)

Intermediate Sea-Level Rise Scenario				
Item	Equiv Annual W/O Project Damages (2035-2084)	Equiv Annual With-Project Damages (2035-2084)	Equiv Annual Benefits (2035-2084)	Percent of Total Benefits (2035-2084)
Damage Category				
Residential & Commercial - Structure/Content/Vehicles	$2,869	$1,113	$1,756	86%
Transportation Infrastructure	$250	$179	$71	3%
Aboveground Storage Tanks	$62	$28	$34	2%
Indirect Business Losses			$186	9%
Total Benefits - 2035 Base Year			$2,046	
Item	Equiv Annual W/O Project Damages (2043-2092)	Equiv Annual With-Project Damages (2043-2092)	Equiv Annual Benefits (2043-2092)	Percent of Total Benefits (2043-2092)
Damage Category				
Residential & Commercial - Structure/Content/Vehicles	$3,328	$1,369	$1,959	87%
Transportation Infrastructure	$274	$198	$76	3%
Aboveground Storage Tanks	$67	$31	$36	2%
Indirect Business Losses			$176	8%
Total Benefits - 2043 Base Year			$2,246	

Addendum C: Table 2a
Coastal Texas Protection and Restoration Feasibility Study Integrated Feasibility Report
Recommended Plan
Total Equivalent Annual Net Benefit Scenarios without Indirect Business Losses
(2021 Price Levels; 2.5% Discount Rate; $ Millions)

Intermediate Sea-Level Rise Scenario			
Item	Equiv Annual W/O Project Damages (2043-2092)	Equiv Annual With-Project Damages (2043-2092)	Equiv Annual Benefits and Costs (2043-2092)
Damage Category			
Residential & Commercial - Structure/Content/Vehicles	$ 3,328	$ 1,369	$ 1,959
Transportation Infrastructure	$ 274	$ 198	$ 76
Aboveground Storage Tanks	$ 67	$ 31	$ 36
Total Benefits - 2043 Base Year			$ 2,070
First Costs			$ 26,128
Interest During Construction			$ 4,891
Average Annual Total Construction Costs			$ 1,077
Annual Operation & Maintenance Costs			$ 131
Total Average Annual Project Costs			$ 1,208
B/C Ratio			1.71
Equivalent Annual Net Benefits - 2043 Base Year			$ 862

Addendum C: Table 2b

Coastal Texas Protection and Restoration Feasibility Study Integrated Feasibility Report

Recommended Plan

Total Equivalent Annual Net Benefit Scenarios with Indirect Business Losses

(2021 Price Levels; 2.5% Discount Rate; $ Millions)

Intermediate Sea-Level Rise Scenario			
Item	Equiv Annual W/O Project Damages (2043-2092)	Equiv Annual With-Project Damages (2043-2092)	Equiv Annual Benefits and Costs (2043-2092)
Damage Category			
Residential & Commercial - Structure/Content/Vehicles	$ 3,328	$ 1,369	$ 1,959
Transportation Infrastructure	$ 274	$ 198	$ 76
Aboveground Storage Tanks	$ 67	$ 31	$ 36
Indirect Business Losses			$ 176
Total Benefits - 2043 Base Year			$ 2,246
First Costs			$ 26,128
Interest During Construction			$ 4,891
Average Annual Total Construction Costs			$ 1,077
Annual Operation & Maintenance Costs			$ 131
Total Average Annual Project Costs			$ 1,208
B/C Ratio			1.86
Equivalent Annual Net Benefits - 2043 Base Year			$ 1,038

ADDENDUM D: ABOVE GROUND STORAGE TANKS

Report. The following report entitled "Storage Tank Depth-Damage Functions," was prepared for Galveston District U.S. Army Corps of Engineers dated 1 April 2020

STORAGE TANK DEPTH-DAMAGE FUNCTIONS

April 1, 2020

Contract No: W912HY-00060W912HY19F0033
Task Order W912HY-19-F-0033

Prepared for

US Army Corps of Engineers, Galveston District

Table of Contents

1 Introduction

The following documentation describes the procedures used to develop generic depth-damage functions for the physical damage to storage tanks and the loss of the tank contents. The procedures employ data developed by Dr. Jamie Padgett and Sabarethinam Kameshwar of the Department of Civil and Environmental Engineering at Rice University. Padgett and Sabarethinam individually evaluated how 4,596 storage tanks in the vicinity of the Houston Ship Channel would withstand the effects of flood waters in one-foot increments up to depths of 25 feet. The 4,596 tanks evaluated by the Rice analysts are located along the upper portion of the Houston Ship Channel. These tanks are all situated within the Texas Coastal study area and represent approximately 35 percent of all study area tanks. The Rice analysis is an engineering evaluation of the prospects for tank floatation given a number of parameters such as tank weight, percentage of tank capacity in use, commodity density, and depth of flooding. The analysis does not evaluate tank floatation for historical storm events. This work is presented in, Kameshwar, S. and Padgett, J. E. (in review) “Storm surge fragility assessment of above ground storage tanks” Structural Safety, and Kameshwar, S. and Padgett, J. E. (in review) “Assessment of fragility and resilience indicators for portfolio of oil storage tanks subjected to hurricanes” Journal of Infrastructure Systems.

This documentation also describes the procedures to represent tank structure value and content-to-structure value ratio (CSVR.) Depth-damage functions, structure value, and CSVRs have been developed in a manner consistent for use with the Hydrologic Engineering Center – Flood Damage Analysis (HEC-FDA) model, including requirements to address risk and uncertainty.

The referenced works by Padgett and Sabarethinam also include estimates of cleanup costs associated with the spilled contents of damaged storage tanks. Cleanup costs are not included in the work covered by this documentation.

Data and calculations for the damage functions, structure value, and CSVR are contained in a single Excel workbook, Storage Tank DD Functions.

2 Workbook Structure

2.1 Rice Results

The first three worksheets, Failure Probability, Spill Volume, and Normalized Spill Volume contain the data generated by the Rice analysts. The first seven columns in each worksheet are the same and are described below:

Lat.: Latitude of the tank’s location (coordinate system: NAD 1983)

Long.: Longitude of the tank’s location (coordinate system: NAD 1983)

Tank diameter: Diameter of the tank, in meters. The tank diameters are obtained by measuring the diameter from aerial imagery.

Tank height: Height of the tank, in meters. Tank height is obtained by taking the difference of the DSM (digital surface model) and DEM (digital elevation model) at tank’s location. For tanks installed after

2008, tank height is evaluated using trends in heights for tanks of different diameters since DSMs are unavailable for year 2014.

Content density lower bound: Lower bound for the density of contents stored in the tank. Exact contents of the tanks are unknown. However, lower and upper bounds for possible contents were determined using Texas Commission on Environment Quality (TCEQ) permit data.

Content density upper bound: Upper bound for the density of contents stored in the tank. Exact contents of the tanks are unknown. However, lower and upper bounds for possible contents were determined using TCEQ permit data.

Cost of tank: Cost to construct the tank in 2016 US dollars. The costs are obtained from Michigan's tax assessors manual, volume 2 Section UIP 11. The tax assessor's manual provides costs in 2003 US dollars. The cost was converted to 2016 costs using Nelson-Farrar refinery construction index. Reference: Michigan Department of Treasury 2003. Assessor's manual volume II.

For each of the three worksheets, the next 25 columns, Excel columns H thru AF, represent expected value results from Monte Carlo simulations for flooding depths of 1 foot to 25 feet. In worksheet Failure Probability, the expected values represent the probabilities of tank floatation (see Attachment 1 – Fragility Assessment.) In worksheet Spill Volume, the expected values represent volumes of spilled contents measured cubic meters. In worksheet Normalized Spill Volumes, the expected values represent spilled contents as a proportion of tank capacity.

The values computed by the Rice analysts in the Failure Probability worksheet represent the expected value failure probabilities for individual tanks at various depths of flooding. An underlying assumption of the analysis is that the full value of the tank is lost once it fails (floats.) With this information we can establish that (expected failure probability for a given depth of flooding) x (tank value) = expected value of tank damage. For example, a tank valued at $187,000 with an expected value failure of 2.3% at two feet of flooding has an expected value of damage of $4,301 (187,000 x .023.) Expressing the expected value damage as a proportion of tank value (4301/187,000) is equivalent to the expected value failure probability. In this manner, the expected value failure probabilities generated by the Rice analysts can be used to represent structure damage percentages. In a similar manner, the spill volume percentages in the Normalized Spill Volume worksheet represent content damage percentages.

2.2 Damage Functions, Structure Value and CSVR

The next five worksheets, Failure Probability (2), Contents Value, CSVR, CSVR (Value Uncertainty), and Normalized Spill Volume (2) contain the computations to produce the generic depth-damage functions for physical damage to storage tanks and the loss of the tank contents, along with storage tank value and CSVRs.

The worksheet Update is designed to facilitate price level updates. It contains inputs used for calculating current price level tank values, current price level commodity values, and CSVR displays. The initial input values in the Update worksheet are for 2019 tank value prices and the 3-year average 2019-2016 for commodity prices. These represent a Fiscal Year 2020 price level..

2.2.1 Failure Probability (2)

The worksheet Failure Probability (2), uses the Rice data to generate the structure damage percentages for the depth-damage function and the damage percentage uncertainty parameters for a triangular probability distribution. This worksheet also generates the Cost of Tank (structure value) and uncertainty parameters for a triangular distribution, as well as the CSVR and the uncertainty parameters for a triangular probability distribution. The CSVR computed in column H of the Failure Probability (2) worksheet uses a point estimate for commodity contents value. This estimate of CSVR is presented to identify the CSVR distribution without the additional variability that is introduced when commodity value uncertainty is included. (CSVR with commodity value variability is presented in the CSVR (Value Uncertainty) worksheet.

Failure Probability (2) adds to the Rice worksheet structure by adding a column for tank Reference Number, CSVR, and Tank Capacity (computed as the volume of a cylinder using the Rice-provided data on tank diameter and height.) The formula for capacity (the formula for cylinder volume) is: volume = Pi * radius squared * height. The formula for the first tank in sheet Normalized Spill Volume ='spill volume'!I3/(3.14*$C3*$C3*$D3/4), where3.14 is the value of Pi, C3 equals tank diameter and D4 equals tank height. The denominator is divided by 4 to account for use of diameter vs radius. The computed tank capacity proportion values in sheet Normalized Spill Volumes are copied to sheet Normalized Spill Volume (2). CSVR is computed for each of the 4,596 tanks and is calculated as (tank capacity x commodity value / tank cost. The CSVR reflects prices of the current analysis year. (Tank costs are updated from the initial 2016 price levels presented by the Rice analysts.)

The triangular probability distribution requires specification of minimum, most likely, and maximum values. The bulk of the computations performed in Failure Probability (2) are geared to generating these three parameters. In columns H thru AI, rows 4600 and 4601, display the minimum and maximum values for CSVR, Capacity, Cost of Tank, and Failure Probability for each flooding depth. Columns H thru AI, rows 4607 thru 4708, compute percentile values ranging from 0.1 to 100.

Percentile values were computed to facilitate computation of the mode (most likely value.) To compute the mode, it was necessary to group the 4,596 observations into increments and to identify the increment with the largest number of observations. The mid-point value of the increment with the largest number of observations was specified as the point estimate for the mode. The width of an increment was computed as (maximum value - minimum value)/number of increments. With increment width identified, the top point of each increment could be computed. The cumulative percentage of observations for each increment was computed using the previously calculated percentile values and the Excel vertical lookup function (VLOOKUP.) With the cumulative percentage calculated for each increment, the incremental percentage for each increment was readily calculated. The increment with the largest incremental percentage was identified as the most probable.

Mode calculations take place in columns AK to EU over rows 4606 to 4645. To identify the sensitivity of the number of increments used in computing the mode, the mode was computed using both 10 and 20 increments. Results of the mode calculations are graphically displayed in columns AK to EU over rows 4648 to 4677.

The worksheet Failure Probability (2) also includes intermediate calculations used in generation of a CSVR distribution that incorporates commodity value uncertainty. The intermediate calculation generates Capacity/Tank Cost expressed in current prices. These calculations take place in columns FC to FH and are computationally equivalent to the percentile and mode computations described earlier. Use of these calculations is described in the CSVR (Value Uncertainty) worksheet.

2.2.2 Contents Value

The worksheet Contents Value provides the basis for computing the value of tank contents. The worksheet contains historical price data for likely storage tank commodities, along with data source references. USACE Waterborne Commerce Statistics Center data was used to help identify likely storage tank commodities. The more prominent, in terms of tonnage, liquid commodities moving over the Houston Ship Channel were assumed to be reflective of the range of commodities held by storage tanks. The representative commodities include, crude oil, residual fuel oil, distillate fuel oil, gasoline, benzene, and naphtha. While not an exhaustive list of the numerous commodities held in storage tanks, the identified commodities capture a reasonable range of likely commodity values.

The current analysis year is referenced in cell C3. Commodity labels and values are referenced in columns B thru C, over rows 4 to 12. Commodity values reflect dollars per US gallon and are transformed to reflect dollars per cubic meter, the units used to express tank capacity. Links to commodity prices are included in the worksheet. The data are further organized to display the parameters necessary to define a point estimate and a uniform probability distribution.

2.2.3 CSVR

The worksheet CSVR summarizes the results of the CSVR computations expressed in current prices assuming a point estimate for commodity value computed as an average of the six representative commodities. Consequently, the variability in CSVR values is limited to the variation in individual tank capacity and cost.

The worksheet contains the price level update procedure for tank cost necessary to place tank cost on the same price level basis as commodity value. Tank price level updating is based on the Engineering News Record (ENR) construction cost index.

The CSVR for storage tanks may require a periodic price level adjustment. Because the value of tank contents is potentially more volatile than the cost of the tank itself, tank cost and commodity value must be separately updated in order to maintain current CSVR estimations.

2.2.4 CSVR (Value Uncertainty)

The worksheet CSVR (Value Uncertainty) summarizes the results of the CSVR computations expressed in current prices assuming a uniform probability distribution for commodity value. The uniform distribution for commodity value is specified using the minimum and maximum values of the representative six commodities. Incorporation of a commodity value uniform probability distribution into the CSVR calculation was accomplished with the Palisade Corporation add-in to Excel, @Risk.

CSVR is a measure of total contents value divided by structure value. Equivalently defined, CSVR is equal to (tank capacity x commodity value) / tank cost. The steps to compute the CSVR were as follows. 1) for each of the 4,596 tanks, divide tank capacity by tank cost. 2) generate a distribution of tank capacity / tank cost by assigning each of the 4,596 data points into 20 equally sized increments or bins. 3) create an @Risk General probability distribution using the mid-points of the 20 increments and the associated frequencies. 4) using @Risk, multiply the commodity value uniform probability distribution and the tank capacity / tank cost general probability distribution to produce a distribution of CSVRs.

The formula for specifying the uniform distribution of commodity value is as follows: =@RiskUniform('Contents Value'!C42,'Contents Value'!C43), where the two cell references are the minimum and maximum commodity values, respectively, from the Contents Value worksheet.

The formula for specifying the general distribution for tank cost divided by capacity is as follows: =@RiskGeneral('failure probability (2)'!FC4600,'failure probability (2)'!FC4601,A17:A36,C17:C36), where cell references FC4600 and FC4601 are the minimum and maximum values, respectively, for capacity/tank cost from the Failure Probability (2) worksheet; the range A17:A36 contains the mid-points of the 20 bins from the CSVR (Value Uncertainty) worksheet; and the range C17:C36 contains the proportion of each bin from the CSVR (Value Uncertainty) worksheet.

The multiplication of the uniform and general distributions is accomplished with the following: =@RiskOutput("CSVR")+C41*C40, where cell C41 is the location of the uniform distribution and cell C40 is the location of the general distribution from the CSVR (Value Uncertainty) worksheet.

The mode as calculated by @Risk in the procedure described above accurately reflects the most frequently occurring individual CSVR value generated by the @Risk Monte Carlo simulation. However, for purposes of identifying the mostly likely value to be used in specifying a triangular distribution for the CSVR, it is more appropriate to identify the mid-point of the increment containing the largest number of simulation iterations as the triangular distribution most likely value. As can be seen from the graphic captured from the @Risk simulation, the tenth increment displays the greatest frequency as indicated by bar height. The mode displayed in the @Risk summary, reflecting the unique value that occurs most often, also falls in the tenth increment but at a slightly lower value (3.98 vs 4.11.)

2.2.5 Normalized Spill Volume (2)

The worksheet Normalized Spill Volume (2) uses the Rice data to generate the damage percentages for the contents depth-damage function and the damage percentage uncertainty parameters for a triangular probability distribution. The individual Rice values for each tank by depth of flooding represent the expected value spill proportion of a full tank.

The triangular probability distribution requires specification of minimum, most likely, and maximum values. The bulk of the computations performed in Normalized Spill Volume (2) are geared to generating these three parameters. In columns K thru AI, rows 4600 and 4601, display the minimum and maximum values for spill proportion for each flooding depth. Columns K thru AI, rows 4607 thru 4708, compute various percentile values ranging from 0.1 to 100.

Percentile values were computed to facilitate computation of the mode (most likely value.) To compute the mode, it was necessary to group the 4,596 observations into increments and to identify the increment with the largest number of observations. The mid-point value of the increment with the largest number of observations was specified as the point estimate for the mode. The width of an increment was computed as (maximum value - minimum value)/number of increments. With increment width identified, the top point of each increment could be computed. The cumulative percentage of observations for each increment was computed using the previously calculated percentile values and the Excel vertical lookup function (VLOOKUP.) With the cumulative percentage calculated for each increment, the incremental percentage for each increment was readily calculated. The increment with the largest incremental percentage was identified as the most probable.

Mode calculations take place in columns AK to EF over rows 4606 to 4645. To identify the sensitivity of the number of increments used in computing the mode, the mode was computed using both 10 and 20 increments. Results of the mode calculations are graphically displayed in columns AK to EF over rows 4648 to 4677.

2.2.6 Update

The structure of the Update worksheet is designed to facilitate price level updates. The worksheet contains the ENR index factor used for calculating current price level tank values, along with commodity values for the updated price level. The worksheet also contains summary results from CSVR with commodity value uncertainty computations that are used in the Results Summary worksheet displays.

2.3 Results Summary

The worksheet, Results Summary, summarizes the results for the depth damage functions for structure and contents, tank value, and CSVR. Tank value reflects the current analysis year price levels. The CSVR reflects the current analysis year price levels for both with and without contents value uncertainty.

Some minor adjustments to structure and contents damage percentages were necessary for specific depths flooding depth. These adjustments were required to conform to the HEC-FDA requirement of non-decreasing damage percentages as depth of flooding increases. For structure damage with the 20-increment formulation, mode (most likely) damage percentage adjustments were made for flooding depths of 13 ft. (a reduction of 4.9 percentage points) and 18 ft. (a reduction of 4.8 percentage points.) No structure damage adjustments were necessary for the 10-increment formulation.

In addition to the content damage percentage adjustments described above, several lesser smoothing adjustments were necessary to conform to HEC-FDA requirements. For the contents damage percentages ultimately recommended for use (see Section 5.2) the 20-increment formulation for the mode (most likely) damage percentage was adjusted by 0.1 percentage points for both the 14-ft. and 24 ft. flooding depths.

For contents damage with the 20-increment formulation, a mode (most likely) damage percentage adjustment was made for the 16-ft. flooding depth (a reduction of 2.3 percentage points.) For contents damage with the 10-increment formulation, a mode (most likely) damage percentage adjustment was made for the 23-ft. flooding depth (a decrease of 4.6 percentage points.)

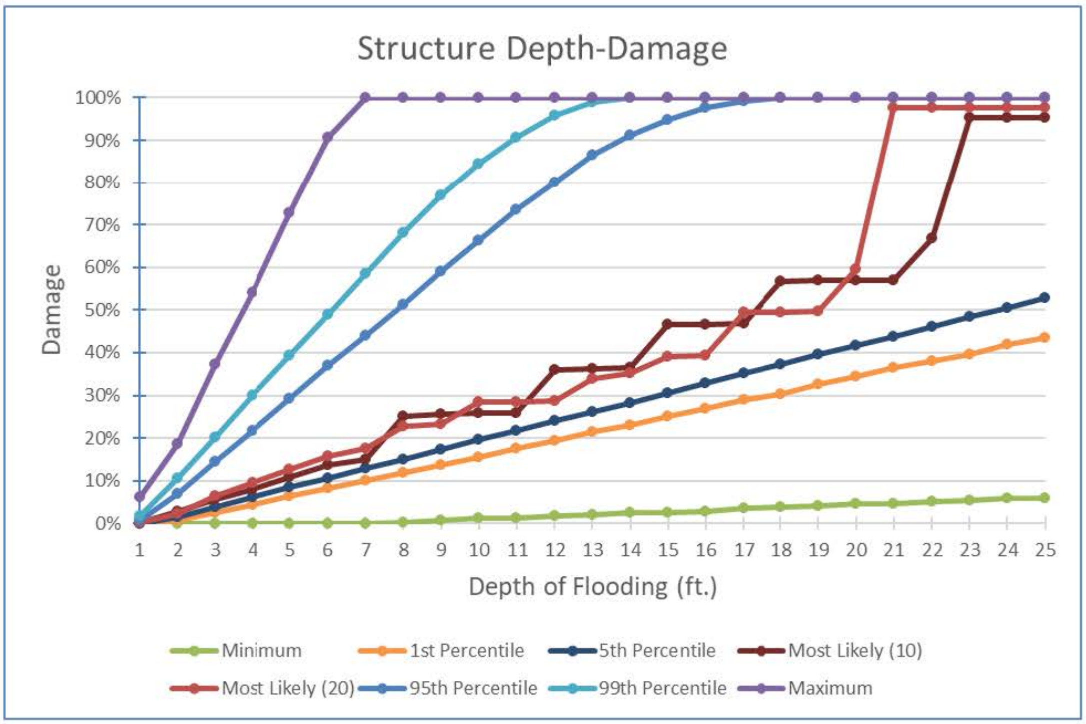
Mode values for failure probability, spill proportions, and tank cost were computed using increments of 10 and 20 when aggregating the 4,596 individual tank values. The selection of 10 or 20 increments had only modest impact on results for failure probability and spill proportions. However, the impact on tank value was much more significant. For both the 10-increment and 20-increment calculations, the first increment clearly contains the largest number of observations. By having fewer groupings than the 20-increment calculation, the 10-increment calculation reflects a larger range of values and therefore also a larger mid-point. The observations within the first increment of the 10-increment calculation are not evenly distributed; they are clustered to the lower end of the range. This clustering is, in large measure, captured in the first increment of 20-increment calculation.

Structure depth-damage percentages for the minimum, 1st percentile, 5th percentile, most likely (20 increments), most likely (10 increments), 95th percentile, 99th percentile, and maximum are displayed in Table 1. These damage percentages are displayed graphicly in Figure 1.

Table 1 – Structure Depth-Damage Percentages

Flooding Depth (ft.)	Min	1st Pctl.	5th Pctl.	Most Likely (20 Inc)	Most Likely (10 Inc)	95th Pctl.	99th Pctl.	Max
1	0.0	0.0	0.0	0.2	0.3	0.6	1.7	6.1
2	0.0	0.6	1.5	2.3	2.8	7.1	10.7	18.7
3	0.0	2.5	3.9	6.5	5.6	14.5	20.1	37.4
4	0.0	4.5	6.2	9.5	8.1	21.8	29.9	54.1
5	0.0	6.4	8.5	12.7	10.9	29.3	39.3	72.7
6	0.0	8.2	10.7	15.8	13.6	36.9	49.0	90.6
7	0.0	9.9	12.9	17.5	15.0	44.1	58.5	99.9
8	0.3	11.8	15.1	22.7	25.2	51.3	68.0	100.0
9	0.7	13.8	17.3	23.3	25.5	59.1	76.8	100.0
10	1.2	15.6	19.5	28.4	25.9	66.2	84.5	100.0
11	1.2	17.5	21.8	28.4	25.9	73.4	90.6	100.0
12	1.7	19.3	23.9	28.7	36.1	80.1	95.8	100.0
13	2.0	21.4	26.2	33.8	36.3	86.5	98.9	100.0
14	2.5	22.9	28.3	35.2	36.6	91.1	100.0	100.0
15	2.7	25.1	30.6	39.2	46.5	94.8	100.0	100.0
16	2.8	26.9	32.7	39.3	46.6	97.5	100.0	100.0
17	3.5	29.1	35.1	49.3	46.9	99.3	100.0	100.0
18	3.8	30.3	37.2	49.5	56.7	100.0	100.0	100.0
19	4.1	32.6	39.5	49.7	56.8	100.0	100.0	100.0
20	4.5	34.4	41.6	59.4	57.0	100.0	100.0	100.0
21	4.6	36.4	43.9	97.6	57.1	100.0	100.0	100.0
22	5.1	38.1	46.2	97.6	66.8	100.0	100.0	100.0
23	5.5	39.6	48.3	97.6	95.3	100.0	100.0	100.0
24	5.9	41.8	50.4	97.6	95.3	100.0	100.0	100.0
25	5.9	43.6	52.7	97.6	95.3	100.0	100.0	100.0

Figure 1 – Structure Depth-Damage Percentages

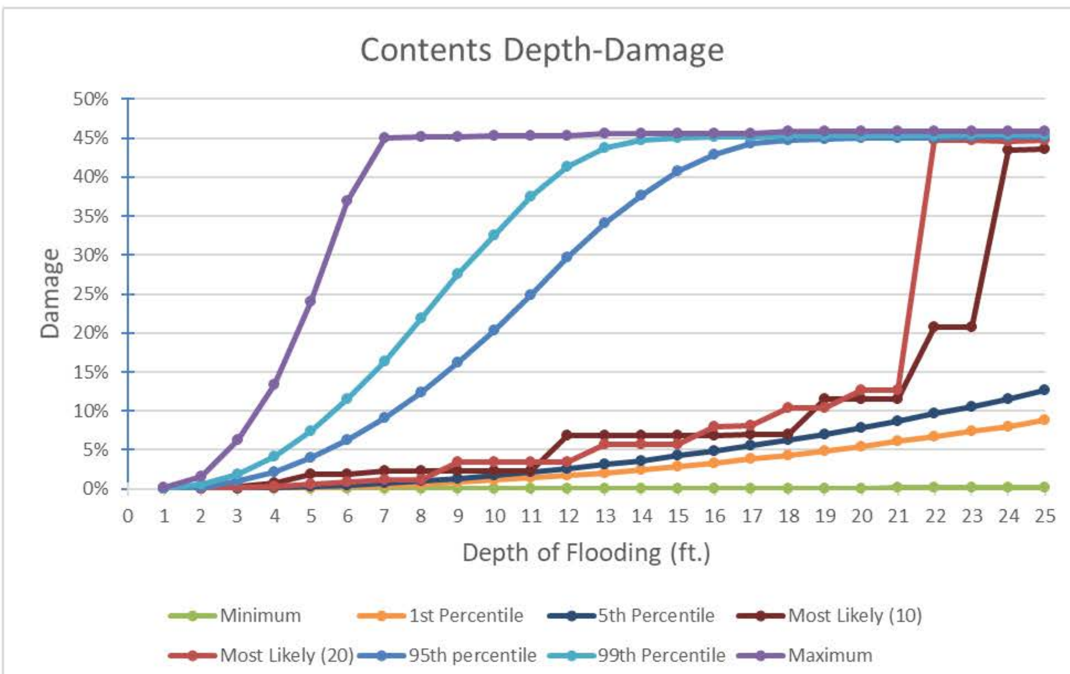


Contents depth-damage percentages for the minimum, 1st percentile, 5th percentile, most likely (20 increments), most likely (10 increments), 95th percentile, 99th percentile, and maximum are displayed in Table 2. These damage percentages are displayed graphically in Figure 2.

Table 2 - Contents Depth-Damage Percentages

Flooding Depth (ft.)	Min	1st Pctl.	5th Pctl.	Most Likely (20 Inc)	Most Likely (10 Inc)	95th Pctl.	99th Pctl.	Max
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
2	0.0	0.0	0.0	0.0	0.1	0.2	0.5	1.6
3	0.0	0.0	0.1	0.2	0.3	1.0	1.9	6.3
4	0.0	0.1	0.2	0.3	0.7	2.2	4.1	13.4
5	0.0	0.2	0.3	0.6	1.8	4.0	7.4	23.9
6	0.0	0.3	0.5	0.9	1.8	6.3	11.5	36.9
7	0.0	0.5	0.8	1.1	2.3	9.1	16.3	45.1
8	0.0	0.7	1.0	1.1	2.3	12.4	21.9	45.2
9	0.0	0.9	1.4	3.4	2.3	16.1	27.6	45.2
10	0.0	1.1	1.7	3.4	2.3	20.3	32.6	45.3
11	0.0	1.4	2.1	3.4	2.3	24.8	37.5	45.3
12	0.0	1.7	2.6	3.4	6.8	29.6	41.3	45.3
13	0.0	2.1	3.1	5.7	6.9	34.0	43.7	45.6
14	0.0	2.4	3.6	5.7	6.9	37.7	44.8	45.6
15	0.0	2.9	4.2	5.7	6.9	40.8	45.0	45.6
16	0.0	3.3	4.9	8.0	6.9	42.9	45.1	45.6
17	0.1	3.9	5.6	8.1	6.9	44.3	45.2	45.6
18	0.1	4.3	6.3	10.3	6.9	44.8	45.2	45.8
19	0.1	4.9	7.0	10.4	11.5	44.9	45.3	45.8
20	0.1	5.4	7.9	12.7	11.5	45.0	45.3	45.8
21	0.1	6.1	8.7	12.7	11.5	45.0	45.3	45.8
22	0.1	6.7	9.6	44.7	20.7	45.0	45.4	45.8
23	0.1	7.4	10.6	44.7	20.7	45.1	45.4	45.8
24	0.2	7.9	11.6	44.6	43.5	45.1	45.4	45.8
25	0.2	8.8	12.6	44.7	43.5	45.1	45.4	45.8

Figure 2 – Contents Depth Damage Percentages

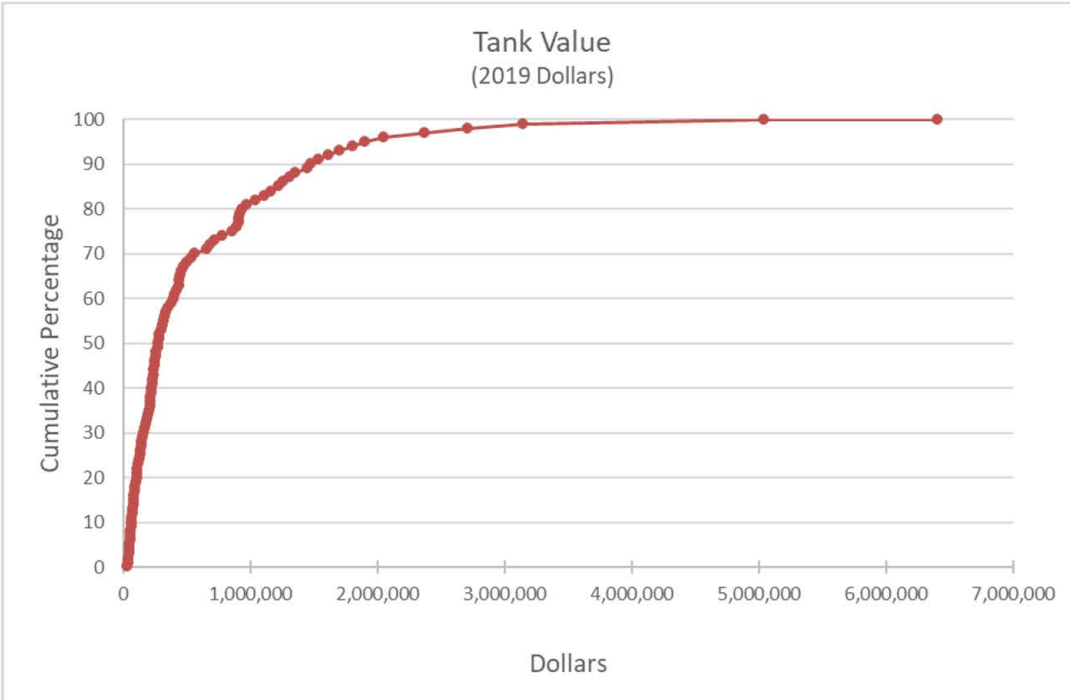


Minimum, 1st percentile, 5th percentile, most likely (20 increments), most likely (10 increments), 95th percentile, 99th percentile, and maximum tank values are displayed in Table 3. Tank value percentiles are displayed graphically in Figure 3.

Table 3 – Tank Values

Condition	Tank Value (2019 Prices)
Min	28,000
1st percentile	41,000
5th percentile	53,000
Most Likely (20 Inc)	187,000
Most Likely (10 Inc)	346,000
95th percentile	1,904,000
99th percentile	3,140,000
Max	6,400,000

Figure 3 – Tank Value Percentiles

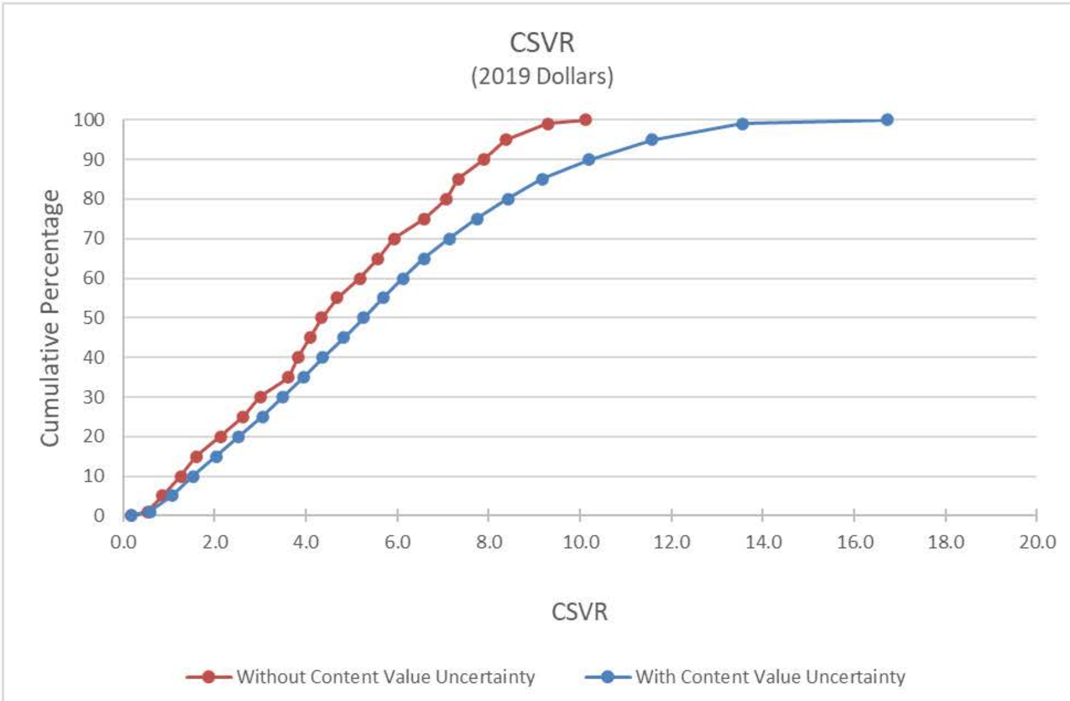


Minimum, 1st percentile, 5th percentile, most likely (20 increments), most likely (10 increments), 95th percentile, 99th percentile, and maximum CSVRs are displayed in Table 4 for both with and without content value uncertainty. (Most likely for 10 increments not calculated with content value uncertainty.) CSVR value percentiles are displayed graphically in Figure 4.

Table 4 – Content-to-Structure Value Ratios

Condition	CSVR (without content value uncertainty) (2019 Prices)	CSVR (with content value uncertainty) (2019 Prices)
Min	0.17	0.18
1st percentile	0.54	0.59
5th percentile	0.86	1.07
Most Likely (20 Inc)	3.90	4.11
Most Likely (10 Inc)	3.65	-
95th percentile	8.37	11.58
99th percentile	9.29	13.55
Max	10.12	16.73

Figure 4 – Content-to-Structure Value Ratio Percentiles



3 Assumptions and Limitations

The distribution of the 4,596 tank values are representative of the larger tank population with respect to size and cost.

There is no structure damage to a tank until the tank fails (floats.)

If the tank fails, there is total loss of tank structure value.

The distribution of the expected value failure probabilities of the 4,596 tanks for a given depth of flooding represents the uncertainty around tank failure for that depth of flooding. However, this does not reflect the true uncertainty because the variation in individual tank failure probabilities is a distribution of expected values. By using the variation in expected values to represent failure uncertainty, the uncertainty range is restricted compared to the true uncertainty. This restriction is potentially more significant on the upper end (the maximum value) of the damage percentage range because the lower end (the minimum value) of the damage percentage range results using expected values are closer to zero percent than the upper end results are to 100 percent.

The distribution of commodities used to compute contents value is representative of the larger population of likely tank commodity contents.

If the tank fails, there is total loss of tank contents. There is no contents loss without tank failure.

Content value = tank capacity x cost per cubic meter of commodity. Content value is reflected as content value of a full tank. This representation is necessary because the damage percentages of the contents depth-damage function reflect spill quantity percentages of a full tank.

A future refinement could disaggregate the 4,596 tanks into classes by tank capacity. Disaggregation by class could potentially produce more precise damage estimation with smaller uncertainty ranges but would require the ability to identify the tank inventory by the disaggregated classes.

4 Variable Uncertainty Summary

Failure Probability: The distributions, by depth of flooding, of expected values for the 4,596 individual tanks.

Spill Volume: The distributions, by depth of flooding, of expected values for the 4,596 individual tanks.

Capacity: The distribution of values for the 4,596 individual tanks.

Content Value: Uniform distribution of value per cubic meter for a user specified commodity mix.

Tank Cost: The distribution of values for the 4,596 individual tanks.

CSVR (without value contents uncertainty): The distribution of the 4,596 individual tank capacities divided by tank cost, multiplied by a point estimate of content value measured in dollars per cubic ft. The resulting CSVR distribution specified as triangular.

CSVR (with value contents uncertainty): The distribution of the 4,956 individual tank capacities divided by tank cost, multiplied by a uniform distribution of contents value measured in dollar per cubic ft. The resulting CSVR distribution specified as triangular.

5 Recommendations

5.1 Mode Calculations

Results based on 20 increments should be used for failure probability, spill proportions, tank cost and CSVR. As previously mentioned in Section 2.3, the selection of 10 or 20 increments had only modest impact on results for failure probability and spill proportions. However, the impact on tank value was much more significant with the 20-increment calculation producing a more accurate result. For consistency the 20-increment calculation is recommended for all parameters.

5.2 Triangular Distribution Minimum and Maximum Values

Minimum and maximum values of a triangular distribution are not typically specified to represent the most extreme values that can be envisioned. Rather, the minimum and maximum values are intended to capture a range that represents the vast majority of possible distribution values. In various analytical settings this range is defined as the 5^{th} and 95^{th} percentile of conceivable values.

A relevant consideration applies in the current case with respect to defining the minimum and maximum values. The distribution of 4,596 data points is a distribution of expected values derived from Monte Carlo simulation. Each of the 4,596 expected values has an associated distribution. As such, the variability reflected by the 4,596 data points is understated to some degree. This argues for using the absolute minimum and absolute maximum, or values close to these like the 1st percentile and 99th percentile values, to represent the minimum and maximum values used in the triangular distribution specification.

5.3 Commodity Value

Price volatility year-to-year, and even over shorter periods, is a characteristic of the typical commodities held by storage tanks. To mitigate the impact of such wide price swings in a planning setting, the use of multiple-year averages is common practice. A 3-year average price for commodities is recommended for the current setting.

The inability to know the contents of an individual storage tank at a given point in time argues for use of a probability distribution to specify contents value as opposed to a single value point estimate. A uniform probability is recommended to reflect commodity value uncertainty.

Attachment 1

Fragility Assessment

Fragility assessment

Assumptions

The following assumptions are made to evaluate the fragility of tanks – probability of tank failure for given inundation depths:

- The level of liquid inside the tank is assumed to be uncertain and therefore, it is considered as a random variable. For each tank, the liquid level is assumed to be uniformly distributed random variable ranging from zero to 90% of tank height.
- The contents of the tanks are also unknown. However, the lower and upper bound values for density of possible contents are determined from TCEQ permits. Within the lower and upper bound values, the density of contents is modeled using a uniformly distributed random variable – i.e. within the lower and upper bounds all values of density are equally likely.
- As soon as a tank starts to float, it is assumed to fail. In reality, flotation of a tank does not necessarily lead to spills. However, in view of the consequences of a spill, flotation of a tank is conservatively considered a failure.
- If a tanks floats, all the contents of the tanks are assumed to be spilled out.
- Effects of pipelines attached to the tanks are neglected.
- All tanks are assumed to be un-anchored since it is commonly observed.

Methodology

Flotation failures are caused when the uplift created by the surge, due to buoyancy forces, is greater than the self-weight of the tank. A buoyant tank may float away from its position and spill its contents as it settles at a different place or hits other tanks nearby. The buoyancy forces exerted on the tank due to storm surge are evaluated using the Archimedes principle; i.e., the buoyancy force equals the weight of the water displaced. Therefore, the buoyancy force on a tank prior to flotation is evaluated as:

$$F_f = \frac{\rho_w g \pi D^2 S}{4}; S < H \quad (1a)$$

$$F_f = \frac{\rho_w g \pi D^2 H}{4}; S > H \quad (1b)$$

where ρ_w is the density of sea water, D is tank diameter, S is the inundation level, g is acceleration due to gravity, and H is the height of the tank. Self-weight of tanks provides resistance against the buoyancy forces; therefore, net resistance against flotation (R_f) is evaluated as:

$$R_f = \pi\left(DHt_s + \frac{D^2 t_b}{4} + \frac{D^2 t_r}{4}\right)\rho_s g + \frac{\rho_l \pi D^2 L g}{4} \tag{2}$$

In the above equation, t_s refers to the thickness of the tank's shell, t_b is shell thickness of the tank's base, t_r is the thickness of roof shell, ρ_s is the relative density of steel, L is the level of the liquid stored in the tank, and the relative density of the stored liquid is ρ_l. Taking the difference of of Eq. 2 and 1, the limit state equation can be obtained:

$$g_{float} = 1000\left[\pi\left(DHt_s + \frac{D^2 t_b}{4} + \frac{D^2 t_r}{4}\right)\rho_s g + \frac{\pi D^2 L \rho_l g}{4} - \min\left\{\frac{\rho_w g \pi D^2 S}{4}, \frac{\rho_w g \pi D^2 H}{4}\right\}\right] \tag{3}$$

A logistic regression model is trained on the limit state function shown above. The trained logistic regression model can accurately predict flotation of tanks, for given parameters and inundation depth. The accuracy of the trained logistic regression model was observed to be 99.9%.

For each tank in the inventory, Monte Carlo simulations are performed on the trained logistic regression model to propagate the uncertainties in the liquid level and liquid densities to obtain the failure probability and expected spill volume. This procedure is repeated for each inundation level.

Limitations

- Failure analysis only focuses on flotation failure of tanks. Other failure modes such as buckling, debris and wave impact have not been considered.

Citations

For the methodology, please cite the following paper:

Kameshwar, S. and Padgett, J. E. 2016 (in review). Storm surge fragility assessment of above ground storage tanks. Structural Safety.

Attachment 2

Tank Cost

WELDED STEEL TANKS

(API)

Costs are averages for tanks erected on sand or gravel with steel ring curb, and include cone roofs with supports as needed, outside ladder, roof and shell manholes, threaded and/or flanged openings as needed for operation, roof vents, and paint. Catwalks, stairways, and platforms are not included.

CAPAC. (barrels)	SIZE (feet)	TANK COST	CAPAC. (barrels)	SIZE (feet)	TANK COST
2,000	30 x 16	$ 58,500	75,000	120 x 36	$ 504,000
3,000	30 x 24	66,000	100,000	140 x 37	648,500
4,000	30 x 32	75,000	125,000	160 x 35	788,500
5,000	38 x 24	85,000	150,000	180 x 33	924,000
7,500	38 x 36	98,500	200,000	200 x 36	1,127,750
10,000	55 x 24	124,000	250,000	220 x 36	1,288,000
15,000	55 x 36	155,750	300,000	240 x 37	1,512,000
20,000	60 x 40	189,250	350,000	260 x 37	1,680,000
30,000	80 x 34	252,000	400,000	260 x 42	1,876,000
50,000	90 x 44	360,750	500,000	280 x 46	2,236,750

Add $975 to $1,775 per foot of diameter for pontoon floating roof.
Add $1,075 to $1,325 per foot of diameter for double-deck roof.

ADDENDUM E: INDIRECT LOSSES (NONPHYSICAL IMPACTS) TO THE NATIONAL ECONOMY

REMI model. Summary statistics for the baseline forecast of the economic and demographic activity measures (income, output and employment) for the years 2035 through 2044 and for the years 2050 through 2060 are displayed in the tables below. The impacts that the changed policy variable (coastal storm risk management system) has on the forecasted activity measures as compared to those in the baseline forecast are also shown in these tables. An individual forecast was provided for the 100-year, 200-year, 500-year and 1,000-year events occurring in the years 2035 (base year) and 2085 (final year in the 50-year period of analysis) for the five-county region, the rest of Texas, rest of the U.S. and the U.S. summary. The economy of each of the three regions rebounds from the production losses associated with the four probability storm events by the years 2044 and 2094, respectively. The activity measures are displayed for the years 2035 through 2044 and 2085 through 2094. As shown in the tables, the production losses resulting from three of the storm events are lower in the year 2085 than in the year 2035 due to the higher labor productivity forecast. This data is presented in Tables 1-18 below.

Addendum E: Table 1
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
Baseline Forecast for 2035-2044, U.S. and Three Regions
Intermediate Sea-Level Rise Scenario

U.S. Summary-Baseline											
Category	Units	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044
Total Employment	Thousands (Jobs)	212,965.9	213,787.2	214,610.7	215,433.4	216,263.0	217,094.0	217,930.8	218,773.2	219,625.9	220,492.2
Private Non-Farm Employment	Thousands (Jobs)	186,327.2	187,235.2	188,149.5	189,064.2	189,985.8	190,908.7	191,837.3	192,771.3	193,715.4	194,671.7
Residence Adjusted Employment	Thousands	210,540.5	211,362.2	212,186.3	213,009.6	213,839.8	214,671.7	215,509.2	216,352.4	217,205.8	218,072.8
Population	Thousands	365,149.9	366,950.0	368,697.5	370,394.9	372,044.6	373,649.8	375,213.9	376,741.1	378,235.7	379,702.1
Labor Force	Thousands	175,393.4	176,064.0	176,756.5	177,485.5	178,200.3	178,858.1	179,557.9	180,251.6	180,972.3	181,680.8
Gross Domestic Product	**$ Billions; Fixed (2019)**	**27,281.7**	**27,745.0**	**28,217.8**	**28,698.4**	**29,187.7**	**29,684.9**	**30,190.8**	**30,705.2**	**31,229.1**	**31,761.7**
Output	$ Billions; Fixed (2019)	45,963.8	46,898.7	47,864.9	48,854.8	49,866.4	50,898.7	51,953.2	53,030.0	54,130.9	55,255.1
Value-Added	$ Billions; Fixed (2019)	27,286.0	27,749.6	28,222.7	28,703.7	29,193.3	29,690.9	30,197.1	30,711.9	31,236.2	31,769.1
Personal Income	$ Billions; Fixed (2019)	25,401.8	25,876.0	26,360.4	26,854.0	27,357.2	27,869.5	28,391.6	28,923.5	29,466.0	30,018.5
Disposable Personal Income	$ Billions; Fixed (2019)	22,112.5	22,525.7	22,947.8	23,378.0	23,816.5	24,263.0	24,718.0	25,181.6	25,654.4	26,135.9
Real Disposable Personal Income	$ Billions; Fixed (2012)	20,114.5	20,490.4	20,874.4	21,265.7	21,664.7	22,070.8	22,484.7	22,906.4	23,336.5	23,774.5
Real Disposable Personal Income per Capita	$ Thousands; Fixed (2012)	55.1	55.8	56.6	57.4	58.2	59.1	59.9	60.8	61.7	62.6
PCE-Price Index	2012=100 (Nation)	151.5	154.5	157.6	160.7	164.0	167.2	170.6	174.0	177.5	181.1

Addendum E: Table 1 (continued)
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
Baseline Forecast for 2035-2044, U.S. and Three Regions
Intermediate Sea-Level Rise Scenario

5-County Region-Baseline											
Category	Units	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044
Total Employment	Thousands (Jobs)	4,014.7	4,045.1	4,077.9	4,112.7	4,148.3	4,184.4	4,221.0	4,257.8	4,294.7	4,332.5
Private Non-Farm Employment	Thousands (Jobs)	3,642.6	3,673.6	3,706.8	3,741.8	3,777.7	3,813.9	3,850.6	3,887.4	3,924.3	3,962.1
Residence Adjusted Employment	Thousands	3,280.4	3,304.3	3,330.1	3,357.5	3,385.6	3,414.2	3,443.3	3,472.4	3,501.7	3,531.7
Population	Thousands	6,496.7	6,542.7	6,591.2	6,642.2	6,695.4	6,750.6	6,807.7	6,866.4	6,926.5	6,987.9
Labor Force	Thousands	3,053.8	3,072.5	3,092.9	3,115.1	3,138.4	3,161.5	3,185.9	3,210.8	3,236.7	3,262.9
Gross Domestic Product	$ Billions; Fixed (2019)	731.4	747.1	763.4	780.4	797.8	815.7	833.9	852.5	871.5	890.9
Output	$ Billions; Fixed (2019)	1,256.9	1,287.2	1,319.3	1,352.8	1,387.3	1,422.8	1,459.2	1,496.5	1,534.8	1,574.1
Value-Added	$ Billions; Fixed (2019)	731.4	747.1	763.4	780.4	797.8	815.7	833.9	852.5	871.5	890.9
Personal Income	$ Billions; Fixed (2019)	498.1	509.0	520.5	532.4	544.8	557.5	570.6	583.9	597.6	611.7
Disposable Personal Income	$ Billions; Fixed (2019)	447.0	456.7	467.0	477.7	488.7	500.1	511.7	523.7	535.9	548.6
Real Disposable Personal Income	$ Billions; Fixed (2012)	406.6	415.5	424.8	434.5	444.6	454.9	465.5	476.4	487.5	499.0
Real Disposable Personal Income per Capita	$ Thousands; Fixed (2012)	62.6	63.5	64.4	65.4	66.4	67.4	68.4	69.4	70.4	71.4
PCE-Price Index	2012=100 (Nation)	136.2	139.0	141.7	144.6	147.5	150.4	153.4	156.5	159.7	162.9

Addendum E: Table 1 (continued)
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
Baseline Forecast for 2035-2044, U.S. and Three Regions
Intermediate Sea-Level Rise Scenario

Rest of Texas-Baseline											
Category	Units	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044
Total Employment	Thousands (Jobs)	15,381.3	15,488.6	15,598.0	15,708.3	15,819.9	15,931.4	16,042.8	16,152.9	16,263.4	16,373.9
Private Non-Farm Employment	Thousands (Jobs)	13,352.3	13,461.2	13,572.4	13,684.6	13,798.2	13,911.8	14,025.4	14,137.8	14,250.6	14,363.6
Residence Adjusted Employment	Thousands	15,353.2	15,463.4	15,575.9	15,689.5	15,804.5	15,919.5	16,034.5	16,148.2	16,262.1	16,376.4
Population	Thousands	27,579.0	27,808.8	28,036.5	28,262.2	28,485.6	28,706.2	28,924.1	29,139.1	29,351.3	29,560.5
Labor Force	Thousands	12,823.2	12,913.0	13,004.6	13,100.1	13,196.0	13,288.8	13,384.6	13,479.4	13,576.2	13,672.4
Gross Domestic Product	$ Billions; Fixed (2019)	1,922.7	1,962.3	2,003.1	2,044.8	2,087.3	2,130.6	2,174.6	2,219.2	2,264.5	2,310.6
Output	$ Billions; Fixed (2019)	3,184.9	3,260.6	3,339.3	3,420.1	3,503.0	3,587.6	3,674.1	3,762.1	3,852.1	3,943.8
Value-Added	$ Billions; Fixed (2019)	1,922.7	1,962.3	2,003.1	2,044.8	2,087.3	2,130.6	2,174.6	2,219.2	2,264.5	2,310.6
Personal Income	$ Billions; Fixed (2019)	1,760.4	1,799.2	1,839.3	1,880.6	1,922.9	1,966.1	2,010.2	2,054.9	2,100.4	2,146.7
Disposable Personal Income	$ Billions; Fixed (2019)	1,581.7	1,616.6	1,652.7	1,689.8	1,727.8	1,766.5	1,806.2	1,846.3	1,887.3	1,928.9
Real Disposable Personal Income	$ Billions; Fixed (2012)	1,438.8	1,470.5	1,503.3	1,537.1	1,571.7	1,606.9	1,643.0	1,679.5	1,716.7	1,754.6
Real Disposable Personal Income per Capita	$ Thousands; Fixed (2012)	52.2	52.9	53.6	54.4	55.2	56.0	56.8	57.6	58.5	59.4
PCE-Price Index	2012=100 (Nation)	145.0	148.0	151.0	154.1	157.2	160.5	163.7	167.1	170.5	174.0

Addendum E: Table 1 (continued)
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
Baseline Forecast for 2035-2044, U.S. and Three Regions
Intermediate Sea-Level Rise Scenario

Rest of U.S.-Baseline											
Category	Units	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044
Total Employment	Thousands (Jobs)	193,569.9	194,253.5	194,934.8	195,612.4	196,294.8	196,978.3	197,666.9	198,362.5	199,067.9	199,785.8
Private Non-Farm Employment	Thousands (Jobs)	169,332.2	170,100.5	170,870.3	171,637.8	172,409.9	173,183.1	173,961.3	174,746.2	175,540.5	176,346.0
Residence Adjusted Employment	Thousands	191,906.9	192,594.5	193,280.2	193,962.6	194,649.7	195,337.9	196,031.4	196,731.8	197,442.0	198,164.7
Population	Thousands	331,074.2	332,598.5	334,069.8	335,490.5	336,863.6	338,193.0	339,482.1	340,735.5	341,957.9	343,153.8
Labor Force	Thousands	159,516.4	160,078.5	160,659.0	161,270.3	161,865.9	162,407.8	162,987.4	163,561.4	164,159.5	164,745.5
Gross Domestic Product	$ Billions; Fixed (2019)	24,631.9	25,040.2	25,456.1	25,878.5	26,308.2	26,744.6	27,188.5	27,640.2	28,100.1	28,567.6
Output	$ Billions; Fixed (2019)	41,522.0	42,350.8	43,206.3	44,082.0	44,976.2	45,888.4	46,819.9	47,771.4	48,744.1	49,737.2
Value-Added	$ Billions; Fixed (2019)	24,631.9	25,040.2	25,456.1	25,878.5	26,308.2	26,744.6	27,188.5	27,640.2	28,100.1	28,567.6
Personal Income	$ Billions; Fixed (2019)	23,143.3	23,567.9	24,000.6	24,440.9	24,889.5	25,345.9	25,810.8	26,284.7	26,768.0	27,260.0
Disposable Personal Income	$ Billions; Fixed (2019)	20,083.7	20,452.4	20,828.2	21,210.5	21,600.0	21,996.4	22,400.1	22,811.6	23,231.2	23,658.5
Real Disposable Personal Income	$ Billions; Fixed (2012)	18,269.1	18,604.5	18,946.3	19,294.1	19,648.4	20,009.0	20,376.2	20,750.5	21,132.2	21,520.9
Real Disposable Personal Income per Capita	$ Thousands; Fixed (2012)	55.2	55.9	56.7	57.5	58.3	59.2	60.0	60.9	61.8	62.7
PCE-Price Index	2012=100 (Nation)	152.3	155.3	158.4	161.6	164.8	168.1	171.5	174.9	178.4	182.0

Source: Kavet, Rockler & Associates (KRA) using the REMI PI+ Model
Note: Only the US Summary Gross Domestic Product was used in the benefit analysis

Addendum E: Table 2
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
Economic Impact Summary for 2035-2044 for 0.01 Annual Exceedance Probability Event Occuring in 2035, U.S. and Three Regions
Intermediate Sea-Level Rise Scenario
Recommended Plan

U.S. Summary-Change from Baseline Due to Flood Protection Measures											
Category	Units	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044
Total Employment	Thousands (Jobs)	115.8	-42.0	-8.0	-10.1	-6.8	-4.5	-2.7	-1.5	-0.7	-0.2
Private Non-Farm Employment	Thousands (Jobs)	112.9	-42.4	-7.9	-9.8	-6.4	-4.2	-2.5	-1.3	-0.5	-0.1
Residence Adjusted Employment	Thousands	110.9	-42.5	-8.2	-10.1	-6.8	-4.5	-2.7	-1.4	-0.6	-0.2
Population	Thousands	0.1	0.3	0.5	0.6	0.7	0.8	0.9	0.9	1.0	1.0
Labor Force	Thousands	11.5	3.1	1.5	0.3	-0.1	-0.2	-0.2	0.0	0.1	0.2
Gross Domestic Product	**$ Billions; Fixed (2019)**	**24.1**	**-5.7**	**-1.3**	**-1.6**	**-1.1**	**-0.8**	**-0.5**	**-0.3**	**-0.2**	**-0.1**
Output	$ Billions; Fixed (2019)	48.8	-9.9	-2.4	-2.9	-2.1	-1.5	-1.0	-0.7	-0.4	-0.2
Value-Added	$ Billions; Fixed (2019)	24.1	-5.7	-1.3	-1.6	-1.1	-0.8	-0.5	-0.3	-0.2	-0.1
Personal Income	$ Billions; Fixed (2019)	10.4	-7.6	-0.4	-1.0	-0.5	-0.3	-0.2	-0.1	0.0	0.0
Disposable Personal Income	$ Billions; Fixed (2019)	8.9	-6.6	-0.3	-0.8	-0.5	-0.3	-0.1	0.0	0.0	0.0
Real Disposable Personal Income	$ Billions; Fixed (2012)	8.1	-6.0	-0.3	-0.7	-0.4	-0.2	-0.1	0.0	0.0	0.0
Real Disposable Personal Income per Capita	$ Thousands; Fixed (2012)	0.2	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.0	0.0	0.0
PCE-Price Index	2012=100 (Nation)	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Addendum E: Table 2 (continued)

Coastal Texas Protection and Restoration Study Integrated Feasibility Report

Economic Impact Summary for 2035-2044 for 0.01 Annual Exceedance Probability Event Occuring in 2035, U.S. and Three Regions

Intermediate Sea-Level Rise Scenario

Recommended Plan

5-County Region-Change from Baseline Due to Flood Protection Measures											
Category	Units	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044
Total Employment	Thousands (Jobs)	79.6	4.4	5.0	3.1	2.4	2.1	2.1	2.2	2.3	2.4
Private Non-Farm Employment	Thousands (Jobs)	75.6	2.1	3.6	2.2	1.7	1.6	1.6	1.8	1.9	2.0
Residence Adjusted Employment	Thousands	62.3	2.8	4.5	3.2	2.7	2.6	2.5	2.5	2.6	2.6
Population	Thousands	50.2	39.3	33.2	28.3	24.5	21.6	19.2	17.4	15.8	14.6
Labor Force	Thousands	31.1	20.2	15.6	11.9	9.4	7.5	6.2	5.3	4.6	4.1
Gross Domestic Product	$ Billions; Fixed (2019)	19.4	0.5	0.6	0.3	0.2	0.2	0.2	0.2	0.3	0.3
Output	$ Billions; Fixed (2019)	40.8	0.7	0.9	0.5	0.3	0.3	0.3	0.4	0.4	0.5
Value-Added	$ Billions; Fixed (2019)	19.4	0.5	0.6	0.3	0.2	0.2	0.2	0.2	0.3	0.3
Personal Income	$ Billions; Fixed (2019)	7.8	0.1	1.0	0.8	0.7	0.6	0.6	0.6	0.6	0.6
Disposable Personal Income	$ Billions; Fixed (2019)	6.9	0.1	0.9	0.7	0.6	0.6	0.6	0.6	0.6	0.6
Real Disposable Personal Income	$ Billions; Fixed (2012)	6.3	0.1	0.8	0.6	0.6	0.6	0.5	0.5	0.5	0.5
Real Disposable Personal Income per Capita	$ Thousands; Fixed (2012)	0.5	-0.4	-0.2	-0.2	-0.2	-0.1	-0.1	-0.1	-0.1	-0.1
PCE-Price Index	2012=100 (Nation)	0.1	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Addendum E: Table 2 (continued)
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
Economic Impact Summary for 2035-2044 for 0.01 Annual Exceedance Probability Event Occuring in 2035, U.S. and Three Regions
Intermediate Sea-Level Rise Scenario
Recommended Plan

Rest of Texas-Change from Baseline Due to Flood Protection Measures											
Category	Units	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044
Total Employment	Thousands (Jobs)	16.7	-5.9	-3.2	-3.9	-3.8	-3.6	-3.3	-2.9	-2.6	-2.3
Private Non-Farm Employment	Thousands (Jobs)	17.1	-5.4	-2.7	-3.4	-3.4	-3.2	-2.8	-2.5	-2.2	-2.0
Residence Adjusted Employment	Thousands	28.5	-4.9	-2.8	-4.0	-4.1	-3.9	-3.6	-3.2	-2.8	-2.5
Population	Thousands	-20.6	-18.4	-16.3	-15.0	-13.9	-13.0	-12.2	-11.4	-10.7	-9.9
Labor Force	Thousands	-5.6	-5.6	-4.8	-4.5	-4.3	-4.0	-3.8	-3.5	-3.2	-2.9
Gross Domestic Product	$ Billions; Fixed (2019)	2.1	-0.7	-0.4	-0.5	-0.5	-0.4	-0.4	-0.4	-0.3	-0.3
Output	$ Billions; Fixed (2019)	3.4	-1.2	-0.6	-0.8	-0.8	-0.7	-0.7	-0.6	-0.5	-0.5
Value-Added	$ Billions; Fixed (2019)	2.1	-0.7	-0.4	-0.5	-0.5	-0.4	-0.4	-0.4	-0.3	-0.3
Personal Income	$ Billions; Fixed (2019)	2.3	-1.1	-0.5	-0.6	-0.6	-0.6	-0.5	-0.5	-0.5	-0.5
Disposable Personal Income	$ Billions; Fixed (2019)	1.9	-1.0	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.4
Real Disposable Personal Income	$ Billions; Fixed (2012)	1.8	-1.0	-0.4	-0.5	-0.5	-0.5	-0.5	-0.4	-0.4	-0.4
Real Disposable Personal Income per Capita	$ Thousands; Fixed (2012)	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCE-Price Index	2012=100 (Nation)	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Addendum E: Table 2 (continued)

Coastal Texas Protection and Restoration Study Integrated Feasibility Report

Economic Impact Summary for 2035-2044 for 0.01 Annual Exceedance Probability Event Occuring in 2035, U.S. and Three Regions

Intermediate Sea-Level Rise Scenario

Recommended Plan

Rest of U.S.-Change from Baseline Due to Flood Protection Measures											
Category	Units	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044
Total Employment	Thousands (Jobs)	19.5	-40.5	-9.8	-9.4	-5.4	-3.1	-1.5	-0.7	-0.4	-0.3
Private Non-Farm Employment	Thousands (Jobs)	20.2	-39.1	-8.7	-8.5	-4.8	-2.6	-1.2	-0.5	-0.2	-0.1
Residence Adjusted Employment	Thousands	20.1	-40.4	-9.8	-9.4	-5.4	-3.1	-1.6	-0.8	-0.4	-0.3
Population	Thousands	-29.5	-20.5	-16.4	-12.7	-9.9	-7.7	-6.1	-5.0	-4.2	-3.7
Labor Force	Thousands	-14.0	-11.5	-9.3	-7.1	-5.2	-3.7	-2.6	-1.8	-1.3	-1.0
Gross Domestic Product	$ Billions; Fixed (2019)	2.6	-5.5	-1.5	-1.4	-0.9	-0.6	-0.3	-0.2	-0.1	-0.1
Output	$ Billions; Fixed (2019)	4.6	-9.4	-2.7	-2.6	-1.7	-1.1	-0.7	-0.4	-0.3	-0.3
Value-Added	$ Billions; Fixed (2019)	2.6	-5.5	-1.5	-1.4	-0.9	-0.6	-0.3	-0.2	-0.1	-0.1
Personal Income	$ Billions; Fixed (2019)	0.2	-6.5	-0.9	-1.1	-0.6	-0.4	-0.2	-0.2	-0.1	-0.1
Disposable Personal Income	$ Billions; Fixed (2019)	0.1	-5.6	-0.7	-1.0	-0.5	-0.3	-0.2	-0.2	-0.1	-0.1
Real Disposable Personal Income	$ Billions; Fixed (2012)	0.1	-5.1	-0.7	-0.9	-0.5	-0.3	-0.2	-0.1	-0.1	-0.1
Real Disposable Personal Income per Capita	$ Thousands; Fixed (2012)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCE-Price Index	2012=100 (Nation)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Source: KRA using the REMI PI+ Model

Note: Only the US Summary Gross Domestic Product was used in the benefit analysis

Addendum E: Table 3

Coastal Texas Protection and Restoration Study Integrated Feasibility Report

Economic Impact Summary for 2035-2044 for 0.005 Annual Exceedance Probability Event Occuring in 2035, U.S. and Three Regions

Intermediate Sea-Level Rise Scenario

Recommended Plan

U.S. Summary-Change from Baseline Due to Flood Protection Measures											
Category	Units	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044
Total Employment	Thousands (Jobs)	161.6	-58.4	-11.2	-14.2	-9.6	-6.4	-3.9	-2.0	-1.0	-0.4
Private Non-Farm Employment	Thousands (Jobs)	157.7	-58.9	-11.2	-13.6	-9.1	-6.0	-3.6	-1.8	-0.8	-0.2
Residence Adjusted Employment	Thousands	154.8	-59.0	-11.5	-14.2	-9.6	-6.3	-3.8	-2.0	-0.9	-0.4
Population	Thousands	0.3	0.5	0.7	0.8	1.0	1.0	1.2	1.3	1.3	1.3
Labor Force	Thousands	16.0	4.2	2.1	0.4	-0.2	-0.4	-0.3	-0.1	0.0	0.1
Gross Domestic Product	**$ Billions; Fixed (2019)**	**33.6**	**-7.9**	**-1.8**	**-2.2**	**-1.5**	**-1.1**	**-0.7**	**-0.5**	**-0.2**	**-0.2**
Output	$ Billions; Fixed (2019)	68.1	-13.7	-3.5	-4.1	-3.0	-2.1	-1.5	-0.9	-0.6	-0.4
Value-Added	$ Billions; Fixed (2019)	33.6	-7.9	-1.8	-2.2	-1.5	-1.1	-0.7	-0.5	-0.2	-0.2
Personal Income	$ Billions; Fixed (2019)	14.4	-10.7	-0.5	-1.4	-0.8	-0.5	-0.3	-0.1	-0.1	0.0
Disposable Personal Income	$ Billions; Fixed (2019)	12.4	-9.1	-0.4	-1.2	-0.6	-0.4	-0.2	0.0	0.0	0.0
Real Disposable Personal Income	$ Billions; Fixed (2012)	11.3	-8.3	-0.4	-1.0	-0.6	-0.4	-0.2	-0.1	-0.1	0.1
Real Disposable Personal Income per Capita	$ Thousands; Fixed (2012)	0.3	-0.2	-0.1	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0
PCE-Price Index	2012=100 (Nation)	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Addendum E: Table 3 (continued)
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
Economic Impact Summary for 2035-2044 for 0.005 Annual Exceedance Probability Event Occuring in 2035, U.S. and Three Regions
Intermediate Sea-Level Rise Scenario
Recommended Plan

5-County Region-Change from Baseline Due to Flood Protection Measures											
Category	Units	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044
Total Employment	Thousands (Jobs)	110.9	5.9	6.8	4.2	3.1	2.8	2.7	2.9	3.0	3.1
Private Non-Farm Employment	Thousands (Jobs)	105.4	2.8	4.8	2.9	2.2	2.0	2.1	2.3	2.5	2.7
Residence Adjusted Employment	Thousands	86.7	3.8	6.1	4.3	3.6	3.4	3.3	3.4	3.4	3.4
Population	Thousands	68.7	53.6	45.3	38.5	33.3	29.2	26.1	23.5	21.4	19.7
Labor Force	Thousands	42.7	27.6	21.3	16.3	12.7	10.2	8.4	7.1	6.2	5.5
Gross Domestic Product	$ Billions; Fixed (2019)	27.0	0.7	0.8	0.4	0.3	0.3	0.3	0.3	0.4	0.4
Output	$ Billions; Fixed (2019)	56.8	1.0	1.2	0.6	0.4	0.4	0.4	0.5	0.6	0.6
Value-Added	$ Billions; Fixed (2019)	27.0	0.7	0.8	0.4	0.3	0.3	0.3	0.3	0.4	0.4
Personal Income	$ Billions; Fixed (2019)	10.9	0.0	1.3	1.0	0.9	0.9	0.8	0.8	0.8	0.8
Disposable Personal Income	$ Billions; Fixed (2019)	9.6	0.1	1.2	0.9	0.9	0.8	0.8	0.8	0.8	0.8
Real Disposable Personal Income	$ Billions; Fixed (2012)	8.7	0.1	1.1	0.9	0.8	0.7	0.7	0.7	0.7	0.7
Real Disposable Personal Income per Capita	$ Thousands; Fixed (2012)	0.7	-0.5	-0.3	-0.2	-0.2	-0.2	-0.2	-0.1	-0.1	-0.1
PCE-Price Index	2012=100 (Nation)	0.1	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Addendum E: Table 3 (continued)

Coastal Texas Protection and Restoration Study Integrated Feasibility Report

Economic Impact Summary for 2035-2044 for 0.005 Annual Exceedance Probability Event Occuring in 2035, U.S. and Three Regions

Intermediate Sea-Level Rise Scenario

Recommended Plan

Rest of Texas-Change from Baseline Due to Flood Protection Measures											
Category	Units	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044
Total Employment	Thousands (Jobs)	23.5	-8.0	-4.3	-5.3	-5.2	-4.9	-4.4	-3.9	-3.5	-3.1
Private Non-Farm Employment	Thousands (Jobs)	24.1	-7.3	-3.7	-4.6	-4.6	-4.3	-3.9	-3.4	-3.0	-2.7
Residence Adjusted Employment	Thousands	40.0	-6.6	-3.8	-5.4	-5.6	-5.3	-4.9	-4.3	-3.8	-3.4
Population	Thousands	-27.4	-24.6	-21.8	-20.0	-18.6	-17.5	-16.4	-15.3	-14.3	-13.4
Labor Force	Thousands	-7.2	-7.4	-6.3	-6.0	-5.7	-5.4	-5.1	-4.7	-4.4	-4.0
Gross Domestic Product	$ Billions; Fixed (2019)	2.9	-1.0	-0.5	-0.6	-0.6	-0.6	-0.5	-0.5	-0.4	-0.4
Output	$ Billions; Fixed (2019)	4.8	-1.6	-0.9	-1.1	-1.1	-1.0	-0.9	-0.8	-0.7	-0.6
Value-Added	$ Billions; Fixed (2019)	2.9	-1.0	-0.5	-0.6	-0.6	-0.6	-0.5	-0.5	-0.4	-0.4
Personal Income	$ Billions; Fixed (2019)	3.2	-1.6	-0.6	-0.8	-0.8	-0.8	-0.7	-0.7	-0.7	-0.6
Disposable Personal Income	$ Billions; Fixed (2019)	2.7	-1.4	-0.6	-0.7	-0.7	-0.7	-0.7	-0.6	-0.6	-0.6
Real Disposable Personal Income	$ Billions; Fixed (2012)	2.5	-1.3	-0.6	-0.7	-0.7	-0.7	-0.6	-0.6	-0.6	-0.5
Real Disposable Personal Income per Capita	$ Thousands; Fixed (2012)	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCE-Price Index	2012=100 (Nation)	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Addendum E: Table 3 (continued)

Coastal Texas Protection and Restoration Study Integrated Feasibility Report

Economic Impact Summary for 2035-2044 for 0.005 Annual Exceedance Probability Event Occuring in 2035, U.S. and Three Regions

Intermediate Sea-Level Rise Scenario

Recommended Plan

Rest of U.S.-Change from Baseline Due to Flood Protection Measures											
Category	Units	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044
Total Employment	Thousands (Jobs)	27.2	-56.3	-13.7	-13.1	-7.5	-4.3	-2.2	-1.0	-0.5	-0.4
Private Non-Farm Employment	Thousands (Jobs)	28.2	-54.4	-12.3	-11.9	-6.7	-3.7	-1.8	-0.7	-0.3	-0.2
Residence Adjusted Employment	Thousands	28.1	-56.2	-13.8	-13.1	-7.6	-4.4	-2.2	-1.1	-0.5	-0.4
Population	Thousands	-41.0	-28.5	-22.8	-17.7	-13.7	-10.7	-8.5	-6.9	-5.8	-5.0
Labor Force	Thousands	-19.5	-16.0	-12.9	-9.9	-7.2	-5.2	-3.6	-2.5	-1.8	-1.4
Gross Domestic Product	$ Billions; Fixed (2019)	3.7	-7.6	-2.1	-2.0	-1.2	-0.8	-0.5	-0.3	-0.2	-0.2
Output	$ Billions; Fixed (2019)	6.5	-13.1	-3.8	-3.6	-2.3	-1.5	-1.0	-0.6	-0.5	-0.4
Value-Added	$ Billions; Fixed (2019)	3.7	-7.6	-2.1	-2.0	-1.2	-0.8	-0.5	-0.3	-0.2	-0.2
Personal Income	$ Billions; Fixed (2019)	0.3	-9.1	-1.2	-1.6	-0.9	-0.6	-0.4	-0.2	-0.2	-0.2
Disposable Personal Income	$ Billions; Fixed (2019)	0.1	-7.8	-1.0	-1.4	-0.8	-0.5	-0.3	-0.2	-0.2	-0.2
Real Disposable Personal Income	$ Billions; Fixed (2012)	0.1	-7.1	-0.9	-1.2	-0.7	-0.4	-0.3	-0.2	-0.2	-0.1
Real Disposable Personal Income per Capita	$ Thousands; Fixed (2012)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCE-Price Index	2012=100 (Nation)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Source: KRA using the REMI PI+ Model

Note: Only the US Summary Gross Domestic Product was used in the benefit analysis

Addendum E: Table 4

Coastal Texas Protection and Restoration Study Integrated Feasibility Report

Economic Impact Summary for 2035-2044 for 0.002 Annual Exceedance Probability Event Occuring in 2035, U.S. and Three Regions

Intermediate Sea-Level Rise Scenario

Recommended Plan

U.S. Summary-Change from Baseline Due to Flood Protection Measures											
Category	Units	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044
Total Employment	Thousands (Jobs)	202.4	-72.9	-14.1	-17.9	-12.2	-8.2	-5.0	-2.8	-1.3	-0.5
Private Non-Farm Employment	Thousands (Jobs)	197.4	-73.6	-14.0	-17.3	-11.5	-7.6	-4.5	-2.4	-1.1	-0.3
Residence Adjusted Employment	Thousands	193.9	-73.6	-14.4	-17.9	-12.0	-8.0	-4.9	-2.7	-1.3	-0.5
Population	Thousands	0.2	0.5	0.8	1.0	1.1	1.2	1.3	1.4	1.5	1.5
Labor Force	Thousands	20.0	5.3	2.5	0.4	-0.4	-0.6	-0.5	-0.2	0.0	0.1
Gross Domestic Product	**$ Billions; Fixed (2019)**	**42.0**	**-9.9**	**-2.3**	**-2.8**	**-2.0**	**-1.5**	**-1.0**	**-0.6**	**-0.4**	**-0.2**
Output	$ Billions; Fixed (2019)	85.2	-17.1	-4.4	-5.2	-3.8	-2.8	-1.9	-1.3	-0.8	-0.5
Value-Added	$ Billions; Fixed (2019)	42.0	-9.9	-2.3	-2.8	-2.0	-1.5	-1.0	-0.6	-0.4	-0.2
Personal Income	$ Billions; Fixed (2019)	18.1	-13.3	-0.8	-1.8	-1.0	-0.6	-0.4	-0.2	0.0	0.0
Disposable Personal Income	$ Billions; Fixed (2019)	15.6	-11.4	-0.6	-1.5	-0.8	-0.5	-0.3	-0.1	0.0	0.0
Real Disposable Personal Income	$ Billions; Fixed (2012)	14.2	-10.4	-0.5	-1.3	-0.8	-0.5	-0.3	-0.1	0.0	0.0
Real Disposable Personal Income per Capita	$ Thousands; Fixed (2012)	0.4	-0.2	-0.1	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0
PCE-Price Index	2012=100 (Nation)	0.1	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Addendum E: Table 4 (continued)
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
Economic Impact Summary for 2035-2044 for 0.002 Annual Exceedance Probability Event Occuring in 2035, U.S. and Three Regions
Intermediate Sea-Level Rise Scenario
Recommended Plan

5-County Region-Change from Baseline Due to Flood Protection Measures											
Category	Units	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044
Total Employment	Thousands (Jobs)	137.7	6.4	7.6	4.3	3.1	2.7	2.7	2.9	3.1	3.3
Private Non-Farm Employment	Thousands (Jobs)	131.1	2.8	5.3	2.8	2.0	1.8	2.0	2.2	2.5	2.8
Residence Adjusted Employment	Thousands	107.7	4.0	6.8	4.6	3.7	3.5	3.4	3.5	3.6	3.6
Population	Thousands	79.1	61.2	51.6	43.7	37.6	32.9	29.2	26.2	23.9	21.9
Labor Force	Thousands	50.2	32.1	24.6	18.7	14.5	11.5	9.4	7.9	6.8	6.1
Gross Domestic Product	$ Billions; Fixed (2019)	33.7	0.7	0.9	0.4	0.2	0.2	0.2	0.3	0.3	0.4
Output	$ Billions; Fixed (2019)	70.9	1.0	1.3	0.5	0.3	0.2	0.3	0.4	0.5	0.6
Value-Added	$ Billions; Fixed (2019)	33.7	0.7	0.9	0.4	0.2	0.2	0.2	0.3	0.3	0.4
Personal Income	$ Billions; Fixed (2019)	13.4	-0.1	1.4	1.1	1.0	0.9	0.9	0.9	0.9	0.9
Disposable Personal Income	$ Billions; Fixed (2019)	11.8	-0.1	1.3	1.0	0.9	0.9	0.9	0.8	0.8	0.8
Real Disposable Personal Income	$ Billions; Fixed (2012)	10.8	-0.1	1.2	0.9	0.8	0.8	0.8	0.8	0.8	0.8
Real Disposable Personal Income per Capita	$ Thousands; Fixed (2012)	0.9	-0.6	-0.3	-0.3	-0.2	-0.2	-0.2	-0.2	-0.1	-0.1
PCE-Price Index	2012=100 (Nation)	0.1	0.5	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Addendum E: Table 4 (continued)

Coastal Texas Protection and Restoration Study Integrated Feasibility Report

Economic Impact Summary for 2035-2044 for 0.002 Annual Exceedance Probability Event Occuring in 2035, U.S. and Three Regions

Intermediate Sea-Level Rise Scenario

Recommended Plan

Rest of Texas-Change from Baseline Due to Flood Protection Measures											
Category	Units	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044
Total Employment	Thousands (Jobs)	30.6	-9.0	-4.4	-5.7	-5.7	-5.4	-4.8	-4.3	-3.8	-3.3
Private Non-Farm Employment	Thousands (Jobs)	31.0	-8.3	-3.8	-5.1	-5.0	-4.7	-4.2	-3.7	-3.3	-2.8
Residence Adjusted Employment	Thousands	51.1	-7.4	-3.9	-5.9	-6.2	-5.9	-5.4	-4.8	-4.2	-3.6
Population	Thousands	-27.6	-25.0	-22.3	-20.5	-19.3	-18.2	-17.1	-16.1	-15.1	-14.0
Labor Force	Thousands	-5.9	-6.8	-6.0	-5.9	-5.8	-5.6	-5.4	-5.0	-4.6	-4.2
Gross Domestic Product	$ Billions; Fixed (2019)	3.8	-1.1	-0.5	-0.7	-0.7	-0.7	-0.6	-0.5	-0.5	-0.4
Output	$ Billions; Fixed (2019)	6.2	-1.8	-0.9	-1.2	-1.2	-1.1	-1.0	-0.9	-0.8	-0.7
Value-Added	$ Billions; Fixed (2019)	3.8	-1.1	-0.5	-0.7	-0.7	-0.7	-0.6	-0.5	-0.5	-0.4
Personal Income	$ Billions; Fixed (2019)	4.2	-1.8	-0.7	-0.9	-0.9	-0.8	-0.8	-0.8	-0.7	-0.7
Disposable Personal Income	$ Billions; Fixed (2019)	3.6	-1.6	-0.6	-0.8	-0.8	-0.8	-0.7	-0.7	-0.7	-0.6
Real Disposable Personal Income	$ Billions; Fixed (2012)	3.3	-1.5	-0.6	-0.7	-0.7	-0.7	-0.7	-0.6	-0.6	-0.6
Real Disposable Personal Income per Capita	$ Thousands; Fixed (2012)	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCE-Price Index	2012=100 (Nation)	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Addendum E: Table 4 (continued)

Coastal Texas Protection and Restoration Study Integrated Feasibility Report

Economic Impact Summary for 2035-2044 for 0.002 Annual Exceedance Probability Event Occuring in 2035, U.S. and Three Regions

Intermediate Sea-Level Rise Scenario

Recommended Plan

Rest of U.S.-Change from Baseline Due to Flood Protection Measures											
Category	Units	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044
Total Employment	Thousands (Jobs)	34.1	-70.4	-17.2	-16.5	-9.5	-5.5	-2.8	-1.3	-0.7	-0.5
Private Non-Farm Employment	Thousands (Jobs)	35.3	-68.0	-15.4	-15.0	-8.5	-4.7	-2.2	-0.9	-0.4	-0.2
Residence Adjusted Employment	Thousands	35.1	-70.2	-17.4	-16.5	-9.6	-5.5	-2.9	-1.4	-0.7	-0.5
Population	Thousands	-51.3	-35.7	-28.5	-22.2	-17.2	-13.5	-10.7	-8.7	-7.3	-6.4
Labor Force	Thousands	-24.3	-19.9	-16.1	-12.4	-9.1	-6.5	-4.5	-3.2	-2.3	-1.7
Gross Domestic Product	$ Billions; Fixed (2019)	4.6	-9.5	-2.6	-2.5	-1.6	-1.0	-0.6	-0.4	-0.3	-0.2
Output	$ Billions; Fixed (2019)	8.1	-16.3	-4.7	-4.5	-2.9	-1.9	-1.2	-0.8	-0.6	-0.5
Value-Added	$ Billions; Fixed (2019)	4.6	-9.5	-2.6	-2.5	-1.6	-1.0	-0.6	-0.4	-0.3	-0.2
Personal Income	$ Billions; Fixed (2019)	0.4	-11.4	-1.5	-2.0	-1.1	-0.7	-0.5	-0.3	-0.2	-0.2
Disposable Personal Income	$ Billions; Fixed (2019)	0.2	-9.7	-1.3	-1.7	-1.0	-0.6	-0.4	-0.3	-0.2	-0.2
Real Disposable Personal Income	$ Billions; Fixed (2012)	0.2	-8.8	-1.2	-1.6	-0.9	-0.6	-0.4	-0.3	-0.2	-0.2
Real Disposable Personal Income per Capita	$ Thousands; Fixed (2012)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCE-Price Index	2012=100 (Nation)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Source: KRA using the REMI PI+ Model

Note: Only the US Summary Gross Domestic Product was used in the benefit analysis

Addendum E: Table 5

Coastal Texas Protection and Restoration Study Integrated Feasibility Report

Economic Impact Summary for 2035-2044 for 0.001 Annual Exceedance Probability Event Occuring in 2035, U.S. and Three Regions

Intermediate Sea Level Rise Scenario

Recommended Plan

U.S. Summary-Change from Baseline Due to Flood Protection Measures											
Category	Units	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044
Total Employment	Thousands (Jobs)	223.5	-80.3	-15.6	-19.8	-13.5	-9.1	-5.5	-3.1	-1.5	-0.6
Private Non-Farm Employment	Thousands (Jobs)	217.8	-81.0	-15.5	-19.2	-12.8	-8.4	-5.1	-2.6	-1.2	-0.4
Residence Adjusted Employment	Thousands	214.0	-81.1	-16.0	-19.8	-13.3	-9.0	-5.4	-3.0	-1.5	-0.6
Population	Thousands	0.2	0.5	0.8	1.0	1.2	1.3	1.5	1.5	1.6	1.6
Labor Force	Thousands	22.0	5.8	2.7	0.4	-0.5	-0.7	-0.6	-0.4	-0.1	0.1
Gross Domestic Product	**$ Billions; Fixed (2019)**	**46.4**	**-10.9**	**-2.5**	**-3.1**	**-2.2**	**-1.6**	**-1.1**	**-0.6**	**-0.5**	**-0.2**
Output	$ Billions; Fixed (2019)	94.0	-18.9	-4.8	-5.7	-4.2	-3.1	-2.2	-1.4	-0.9	-0.6
Value-Added	$ Billions; Fixed (2019)	46.4	-10.9	-2.5	-3.1	-2.2	-1.6	-1.1	-0.6	-0.5	-0.2
Personal Income	$ Billions; Fixed (2019)	19.9	-14.6	-0.9	-2.0	-1.2	-0.8	-0.4	-0.2	-0.1	0.0
Disposable Personal Income	$ Billions; Fixed (2019)	17.2	-12.5	-0.7	-1.6	-1.0	-0.6	-0.3	-0.1	0.0	0.1
Real Disposable Personal Income	$ Billions; Fixed (2012)	15.7	-11.4	-0.6	-1.4	-0.8	-0.5	-0.3	-0.1	0.0	0.0
Real Disposable Personal Income per Capita	$ Thousands; Fixed (2012)	0.4	-0.2	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	0.0	0.0
PCE-Price Index	2012=100 (Nation)	0.1	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Addendum E: Table 5 (continued)

Coastal Texas Protection and Restoration Study Integrated Feasibility Report

Economic Impact Summary for 2035-2044 for 0.001 Annual Exceedance Probability Event Occuring in 2035, U.S. and Three Regions

Intermediate Sea Level Rise Scenario

Recommended Plan

5-County Region-Change from Baseline Due to Flood Protection Measures											
Category	Units	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044
Total Employment	Thousands (Jobs)	152	6.6	7.9	4.3	3	2.6	2.6	2.8	3.1	3.3
Private Non-Farm Employment	Thousands (Jobs)	144	2.7	5.4	2.7	1.8	1.7	1.8	2.2	2.5	2.8
Residence Adjusted Employment	Thousands	118	4	7.1	4.6	3.7	3.4	3.4	3.5	3.6	3.7
Population	Thousands	83.9	64.7	54.4	46	39.5	34.4	30.5	27.4	24.9	22.8
Labor Force	Thousands	53.8	34.2	26.2	19.8	15.3	12.1	9.8	8.2	7.1	6.3
Gross Domestic Product	$ Billions; Fixed (2019)	37.1	0.7	0.9	0.4	0.2	0.2	0.2	0.3	0.3	0.4
Output	$ Billions; Fixed (2019)	78.1	1	1.3	0.5	0.2	0.2	0.2	0.4	0.5	0.6
Value-Added	$ Billions; Fixed (2019)	37.1	0.7	0.9	0.4	0.2	0.2	0.2	0.3	0.3	0.4
Personal Income	$ Billions; Fixed (2019)	14.7	-0.2	1.5	1.1	1	0.9	0.9	0.9	0.9	0.9
Disposable Personal Income	$ Billions; Fixed (2019)	13	-0.1	1.4	1.1	0.9	0.9	0.9	0.9	0.9	0.9
Real Disposable Personal Income	$ Billions; Fixed (2012)	11.8	-0.1	1.3	1	0.9	0.8	0.8	0.8	0.8	0.8
Real Disposable Personal Income per Capita	$ Thousands; Fixed (2012)	1	-0.6	-0.3	-0.3	-0.3	-0.2	-0.2	-0.2	-0.1	-0.1
PCE-Price Index	2012=100 (Nation)	0.2	0.6	0.1	0	0	0	0	0	0	0

Addendum E: Table 5 (continued)

Coastal Texas Protection and Restoration Study Integrated Feasibility Report

Economic Impact Summary for 2035-2044 for 0.001 Annual Exceedance Probability Event Occuring in 2035, U.S. and Three Regions

Intermediate Sea Level Rise Scenario

Recommended Plan

Rest of Texas-Change from Baseline Due to Flood Protection Measures											
Category	Units	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044
Total Employment	Thousands (Jobs)	34.4	-9.4	-4.4	-5.9	-5.9	-5.6	-5	-4.4	-3.9	-3.4
Private Non-Farm Employment	Thousands (Jobs)	34.6	-8.8	-3.8	-5.3	-5.2	-4.9	-4.4	-3.8	-3.3	-2.9
Residence Adjusted Employment	Thousands	56.8	-7.8	-3.9	-6.1	-6.4	-6.2	-5.6	-5	-4.3	-3.7
Population	Thousands	-27.2	-25	-22	-21	-19	-18	-17	-16	-15	-14
Labor Force	Thousands	-5	-6.4	-5.7	-5.7	-5.7	-5.6	-5.4	-5.1	-4.7	-4.3
Gross Domestic Product	$ Billions; Fixed (2019)	4.2	-1.1	-0.5	-0.7	-0.7	-0.7	-0.6	-0.5	-0.5	-0.4
Output	$ Billions; Fixed (2019)	7	-1.9	-0.9	-1.2	-1.2	-1.2	-1	-0.9	-0.8	-0.7
Value-Added	$ Billions; Fixed (2019)	4.2	-1.1	-0.5	-0.7	-0.7	-0.7	-0.6	-0.5	-0.5	-0.4
Personal Income	$ Billions; Fixed (2019)	4.7	-1.9	-0.7	-0.9	-0.9	-0.9	-0.8	-0.8	-0.7	-0.7
Disposable Personal Income	$ Billions; Fixed (2019)	4	-1.7	-0.6	-0.8	-0.8	-0.8	-0.8	-0.7	-0.7	-0.6
Real Disposable Personal Income	$ Billions; Fixed (2012)	3.7	-1.6	-0.6	-0.7	-0.7	-0.7	-0.7	-0.6	-0.6	-0.6
Real Disposable Personal Income per Capita	$ Thousands; Fixed (2012)	0.2	0	0	0	0	0	0	0	0	0
PCE-Price Index	2012=100 (Nation)	0	0.1	0	0	0	0	0	0	0	0

Addendum E: Table 5 (continued)

Coastal Texas Protection and Restoration Study Integrated Feasibility Report

Economic Impact Summary for 2035-2044 for 0.001 Annual Exceedance Probability Event Occuring in 2035, U.S. and Three Regions

Intermediate Sea Level Rise Scenario

Recommended Plan

Rest of U.S.-Change from Baseline Due to Flood Protection Measures											
Category	Units	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044
Total Employment	Thousands (Jobs)	37.6	-78	-19	-18	-11	-6.1	-3.1	-1.5	-0.7	-0.5
Private Non-Farm Employment	Thousands (Jobs)	38.9	-75	-17	-17	-9.4	-5.2	-2.5	-1	-0.4	-0.3
Residence Adjusted Employment	Thousands	38.8	-77	-19	-18	-11	-6.2	-3.2	-1.5	-0.8	-0.6
Population	Thousands	-56.5	-39	-32	-25	-19	-15	-12	-9.7	-8.1	-7
Labor Force	Thousands	-26.8	-22	-18	-14	-10	-7.2	-5	-3.5	-2.5	-1.9
Gross Domestic Product	$ Billions; Fixed (2019)	5.1	-11	-2.9	-2.8	-1.7	-1.1	-0.7	-0.4	-0.3	-0.2
Output	$ Billions; Fixed (2019)	8.9	-18	-5.2	-5	-3.2	-2.1	-1.4	-0.9	-0.6	-0.5
Value-Added	$ Billions; Fixed (2019)	5.1	-11	-2.9	-2.8	-1.7	-1.1	-0.7	-0.4	-0.3	-0.2
Personal Income	$ Billions; Fixed (2019)	0.5	-13	-1.7	-2.2	-1.3	-0.8	-0.5	-0.3	-0.3	-0.2
Disposable Personal Income	$ Billions; Fixed (2019)	0.2	-11	-1.5	-1.9	-1.1	-0.7	-0.4	-0.3	-0.2	-0.2
Real Disposable Personal Income	$ Billions; Fixed (2012)	0.2	-9.7	-1.3	-1.7	-1	-0.6	-0.4	-0.3	-0.2	-0.2
Real Disposable Personal Income per Capita	$ Thousands; Fixed (2012)	0	0	0	0	0	0	0	0	0	0
PCE-Price Index	2012=100 (Nation)	0	0	0	0	0	0	0	0	0	0

Source: KRA using the REMI PI+ Model

Note: Only the US Summary Gross Domestic Product was used in the benefit analysis

Addendum E: Table 6
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
Baseline Forecast for 2050-2060, U.S. and Three Regions
Intermediate Sea-Level Rise Scenario

U.S. Summary-Baseline												
Category	Units	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060
Total Employment	Millions (Jobs)	225.6	226.4	227.1	227.8	228.5	229.1	229.7	230.4	231.2	231.9	232.5
Private Non-Farm Employment	Millions (Jobs)	200.4	201.2	202.1	202.9	203.7	204.4	205.2	206.0	206.8	207.6	208.3
Residence Adjusted Employment	Millions	223.2	224.0	224.7	225.4	226.1	226.7	227.3	228.1	228.8	229.5	230.1
Population	Millions	388.2	389.6	391.0	392.4	393.8	395.3	396.7	398.2	399.7	401.1	402.6
Labor Force	Millions	185.7	186.2	186.8	187.4	187.9	188.4	188.8	189.3	189.9	190.3	190.8
Gross Domestic Product	**$ Trillions; Fixed (2019)**	**35.1**	**35.7**	**36.3**	**37.0**	**37.6**	**38.2**	**38.9**	**39.6**	**40.3**	**41.0**	**41.7**
Output	$ Trillions; Fixed (2019)	62.5	63.8	65.1	66.5	67.9	69.3	70.8	72.3	73.9	75.5	77.2
Value-Added	$ Trillions; Fixed (2019)	35.2	35.7	36.4	37.0	37.6	38.2	38.9	39.6	40.3	41.0	41.7
Personal Income	$ Trillions; Fixed (2019)	33.6	34.2	34.8	35.5	36.1	36.8	37.5	38.2	39.0	39.7	40.5
Disposable Personal Income	$ Trillions; Fixed (2019)	29.2	29.8	30.3	30.9	31.5	32.1	32.7	33.3	33.9	34.6	35.3
Real Disposable Personal Income	$ Trillions; Fixed (2012)	26.6	27.1	27.6	28.1	28.6	29.2	29.7	30.3	30.9	31.5	32.1
Real Disposable Personal Income per Capita	$ Thousands; Fixed (2012)	68.5	69.5	70.6	71.6	72.7	73.8	74.9	76.1	77.3	78.5	79.7
PCE-Price Index	2012=100 (Nation)	203.9	208.0	212.1	216.4	220.7	225.1	229.6	234.1	238.7	243.5	248.3

Addendum E: Table 6 (continued)
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
Baseline Forecast for 2050-2060, U.S. and Three Regions
Intermediate Sea-Level Rise Scenario

5-County Region-Baseline												
Category	Units	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060
Total Employment	Thousands (Jobs)	4,560.6	4,596.5	4,632.2	4,667.4	4,702.2	4,735.2	4,768.6	4,803.8	4,839.1	4,874.0	4,907.6
Private Non-Farm Employment	Thousands (Jobs)	4,190.3	4,226.6	4,262.7	4,298.4	4,333.9	4,367.7	4,401.7	4,436.8	4,472.2	4,507.1	4,540.9
Residence Adjusted Employment	Thousands	3,714.3	3,743.3	3,772.2	3,800.7	3,829.0	3,856.0	3,883.3	3,912.1	3,941.3	3,970.1	3,997.9
Population	Thousands	7,375.8	7,441.7	7,507.7	7,573.4	7,638.6	7,703.4	7,767.1	7,829.8	7,891.3	7,951.7	8,010.9
Labor Force	Thousands	3,425.4	3,452.8	3,480.2	3,507.9	3,535.6	3,562.5	3,590.2	3,618.5	3,647.4	3,676.3	3,704.4
Gross Domestic Product	$ Billions; Fixed (2019)	1,015.4	1,037.4	1,060.0	1,083.1	1,106.8	1,131.0	1,155.8	1,181.5	1,207.9	1,235.0	1,262.7
Output	$ Billions; Fixed (2019)	1,830.2	1,876.3	1,923.8	1,972.6	2,022.9	2,074.6	2,127.8	2,183.2	2,240.3	2,299.2	2,359.9
Value-Added	$ Billions; Fixed (2019)	1,015.4	1,037.4	1,060.0	1,083.1	1,106.8	1,131.0	1,155.8	1,181.5	1,207.9	1,235.0	1,262.7
Personal Income	$ Billions; Fixed (2019)	703.5	719.9	736.7	753.6	770.9	788.4	806.1	824.5	843.0	861.6	880.3
Disposable Personal Income	$ Billions; Fixed (2019)	630.7	645.4	660.4	675.6	691.0	706.7	722.5	738.9	755.5	772.0	788.7
Real Disposable Personal Income	$ Billions; Fixed (2012)	573.7	587.1	600.8	614.6	628.6	642.8	657.3	672.2	687.2	702.3	717.5
Real Disposable Personal Income per Capita	$ Thousands; Fixed (2012)	77.8	78.9	80.0	81.1	82.3	83.4	84.6	85.8	87.1	88.3	89.6
PCE-Price Index	2012=100 (Nation)	183.4	187.0	190.7	194.5	198.4	202.3	206.3	210.3	214.4	218.6	222.8

Addendum E: Table 6 (continued)
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
Baseline Forecast for 2050-2060, U.S. and Three Regions
Intermediate Sea-Level Rise Scenario

Rest of Texas-Baseline												
Category	Units	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060
Total Employment	Millions (Jobs)	17.0	17.1	17.2	17.3	17.4	17.5	17.6	17.7	17.8	17.9	18.0
Private Non-Farm Employment	Millions (Jobs)	15.0	15.1	15.2	15.3	15.4	15.5	15.6	15.7	15.8	16.0	16.1
Residence Adjusted Employment	Millions	17.1	17.2	17.3	17.4	17.5	17.5	17.6	17.7	17.9	18.0	18.1
Population	Millions	30.8	31.0	31.2	31.4	31.6	31.8	31.9	32.1	32.3	32.5	32.7
Labor Force	Millions	14.2	14.3	14.4	14.5	14.6	14.6	14.7	14.8	14.9	14.9	15.0
Gross Domestic Product	$ Trillions; Fixed (2019)	2.6	2.7	2.7	2.8	2.8	2.9	2.9	3.0	3.1	3.1	3.2
Output	$ Trillions; Fixed (2019)	4.5	4.6	4.8	4.9	5.0	5.1	5.2	5.3	5.5	5.6	5.7
Value-Added	$ Trillions; Fixed (2019)	2.6	2.7	2.7	2.8	2.8	2.9	2.9	3.0	3.1	3.1	3.2
Personal Income	$ Trillions; Fixed (2019)	2.4	2.5	2.5	2.6	2.7	2.7	2.8	2.8	2.9	3.0	3.0
Disposable Personal Income	$ Trillions; Fixed (2019)	2.2	2.2	2.3	2.3	2.4	2.4	2.5	2.5	2.6	2.7	2.7
Real Disposable Personal Income	$ Trillions; Fixed (2012)	2.0	2.0	2.1	2.1	2.2	2.2	2.3	2.3	2.4	2.4	2.5
Real Disposable Personal Income per Capita	$ Thousands; Fixed (2012)	64.9	65.9	66.9	67.9	68.9	69.9	70.9	72.0	73.1	74.3	75.4
PCE-Price Index	2012=100 (Nation)	196.4	200.4	204.5	208.6	212.9	217.2	221.6	226.0	230.5	235.2	239.9

Addendum E: Table 6 (continued)
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
Baseline Forecast for 2050-2060, U.S. and Three Regions
Intermediate Sea-Level Rise Scenario

Rest of U.S.-Baseline												
Category	Units	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060
Total Employment	Millions (Jobs)	204.0	204.6	205.2	205.8	206.4	206.9	207.4	207.9	208.5	209.1	209.6
Private Non-Farm Employment	Millions (Jobs)	181.1	181.8	182.5	183.2	183.9	184.5	185.1	185.8	186.5	187.1	187.7
Residence Adjusted Employment	Millions	202.4	203.1	203.7	204.2	204.8	205.3	205.8	206.4	207.0	207.6	208.1
Population	Millions	350.0	351.2	352.3	353.5	354.6	355.8	357.0	358.2	359.4	360.6	361.9
Labor Force	Millions	168.0	168.5	168.9	169.4	169.8	170.2	170.6	170.9	171.3	171.7	172.1
Gross Domestic Product	$ Trillions; Fixed (2019)	31.5	32.1	32.6	33.1	33.7	34.2	34.8	35.4	36.0	36.7	37.3
Output	$ Trillions; Fixed (2019)	56.1	57.3	58.5	59.7	60.9	62.2	63.5	64.8	66.2	67.6	69.1
Value-Added	$ Trillions; Fixed (2019)	31.5	32.1	32.6	33.1	33.7	34.2	34.8	35.4	36.0	36.7	37.3
Personal Income	$ Trillions; Fixed (2019)	30.4	31.0	31.5	32.1	32.7	33.3	33.9	34.6	35.2	35.9	36.6
Disposable Personal Income	$ Trillions; Fixed (2019)	26.4	26.9	27.4	27.9	28.4	28.9	29.5	30.0	30.6	31.2	31.8
Real Disposable Personal Income	$ Trillions; Fixed (2012)	24.0	24.4	24.9	25.4	25.8	26.3	26.8	27.3	27.8	28.4	28.9
Real Disposable Personal Income per Capita	$ Thousands; Fixed (2012)	68.6	69.6	70.7	71.7	72.8	73.9	75.1	76.2	77.4	78.6	79.8
PCE-Price Index	2012=100 (Nation)	204.9	209.0	213.2	217.4	221.8	226.2	230.7	235.2	239.9	244.6	249.4

Source: KRA using the REMI PI+ Model
Note: Only the US Summary Gross Domestic Product was used in the benefit analysis

Addendum E: Table 7
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
Economic Impact Summary for 2050-2060 for 0.01 AEP Event Occuring in 2085, U.S. and Three Regions
Intermediate Sea-Level Rise Scenario
Recommended Plan

U.S. Summary-Change from Baseline; 2085 Values Run in 2050												
Category	Units	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060
Total Employment	Thousands (Jobs)	110.5	-40.1	-7.4	-9.1	-6.2	-4.2	-2.6	-1.5	-0.9	-0.3	-0.1
Private Non-Farm Employment	Thousands (Jobs)	108.3	-40.4	-7.3	-8.8	-5.9	-3.9	-2.4	-1.4	-0.6	-0.3	0.0
Residence Adjusted Employment	Thousands	105.8	-40.6	-7.6	-9.2	-6.1	-4.2	-2.6	-1.5	-0.9	-0.4	-0.1
Population	Thousands	0.3	0.6	0.8	1.1	1.3	1.4	1.6	1.8	1.8	1.9	1.9
Labor Force	Thousands	10.6	3.2	1.9	0.8	0.4	0.2	0.2	0.2	0.3	0.3	0.3
Gross Domestic Product	**$ Billions; Fixed (2019)**	**28.6**	**-6.8**	**-1.5**	**-1.8**	**-1.2**	**-0.9**	**-0.6**	**-0.4**	**-0.2**	**-0.2**	**-0.1**
Output	$ Billions; Fixed (2019)	61.7	-12.5	-3.1	-3.5	-2.6	-1.9	-1.3	-0.9	-0.6	-0.4	-0.3
Value-Added	$ Billions; Fixed (2019)	28.6	-6.8	-1.5	-1.8	-1.2	-0.9	-0.6	-0.4	-0.2	-0.2	-0.1
Personal Income	$ Billions; Fixed (2019)	12.0	-9.3	-0.4	-1.0	-0.6	-0.3	-0.1	0.0	0.1	0.1	0.2
Disposable Personal Income	$ Billions; Fixed (2019)	10.2	-8.0	-0.3	-0.8	-0.4	-0.3	0.0	0.0	0.2	0.1	0.1
Real Disposable Personal Income	$ Billions; Fixed (2012)	9.4	-7.3	-0.3	-0.7	-0.4	-0.2	0.0	0.1	0.1	0.1	0.1
Real Disposable Personal Income per Capita	$ Thousands; Fixed (2012)	0.2	-0.1	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.0	0.0
PCE-Price Index	2012=100 (Nation)	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5-County Region-Change from Baseline; 2085 Values Run in 2050												
Category	Units	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060
Total Employment	Thousands (Jobs)	78.7	5.5	6.4	4.9	4.3	4.0	3.9	3.8	3.7	3.7	3.6
Private Non-Farm Employment	Thousands (Jobs)	75.0	3.3	5.0	3.9	3.5	3.4	3.3	3.3	3.3	3.2	3.2
Residence Adjusted Employment	Thousands	61.3	3.8	5.8	4.8	4.5	4.3	4.2	4.1	3.9	3.8	3.7
Population	Thousands	59.4	47.5	40.6	35.1	30.9	27.6	25.0	22.9	21.1	19.6	18.2
Labor Force	Thousands	34.8	23.5	18.4	14.5	11.7	9.7	8.3	7.1	6.3	5.6	5.1
Gross Domestic Product	$ Billions; Fixed (2019)	23.4	0.7	0.9	0.7	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Output	$ Billions; Fixed (2019)	52.2	1.1	1.5	1.1	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Value-Added	$ Billions; Fixed (2019)	23.4	0.7	0.9	0.7	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Personal Income	$ Billions; Fixed (2019)	9.7	0.5	1.6	1.4	1.3	1.3	1.3	1.3	1.2	1.2	1.2
Disposable Personal Income	$ Billions; Fixed (2019)	8.5	0.5	1.5	1.3	1.3	1.2	1.2	1.2	1.2	1.1	1.1
Real Disposable Personal Income	$ Billions; Fixed (2012)	7.8	0.5	1.4	1.2	1.1	1.1	1.1	1.1	1.1	1.0	1.0
Real Disposable Personal Income per Capita	$ Thousands; Fixed (2012)	0.4	-0.4	-0.3	-0.2	-0.2	-0.2	-0.1	-0.1	-0.1	-0.1	-0.1
PCE-Price Index	2012=100 (Nation)	0.1	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Addendum E: Table 7 (continued)
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
Economic Impact Summary for 2050-2060 for 0.01 AEP Event Occuring in 2085, U.S. and Three Regions
Intermediate Sea-Level Rise Scenario
Recommended Plan

Rest of Texas-Change from Baseline; 2085 Values Run in 2050												
Category	Units	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060
Total Employment	Thousands (Jobs)	12.9	-7.8	-4.9	-5.2	-5.0	-4.6	-4.2	-3.8	-3.5	-3.1	-2.9
Private Non-Farm Employment	Thousands (Jobs)	13.8	-7.0	-4.2	-4.6	-4.4	-4.1	-3.7	-3.4	-3.0	-2.8	-2.5
Residence Adjusted Employment	Thousands	25.0	-6.6	-4.4	-5.2	-5.1	-4.9	-4.5	-4.1	-3.7	-3.3	-3.0
Population	Thousands	-31.4	-27.7	-24.5	-22.1	-20.3	-18.8	-17.4	-16.2	-15.1	-14.1	-13.1
Labor Force	Thousands	-10.7	-9.5	-7.9	-7.0	-6.3	-5.8	-5.3	-4.8	-4.4	-4.0	-3.7
Gross Domestic Product	$ Billions; Fixed (2019)	2.0	-1.1	-0.7	-0.8	-0.7	-0.7	-0.6	-0.6	-0.5	-0.5	-0.4
Output	$ Billions; Fixed (2019)	3.6	-2.0	-1.2	-1.3	-1.3	-1.2	-1.1	-1.0	-0.9	-0.8	-0.7
Value-Added	$ Billions; Fixed (2019)	2.0	-1.1	-0.7	-0.8	-0.7	-0.7	-0.6	-0.6	-0.5	-0.5	-0.4
Personal Income	$ Billions; Fixed (2019)	2.1	-1.9	-1.0	-1.1	-1.1	-1.0	-1.0	-1.0	-0.9	-0.9	-0.8
Disposable Personal Income	$ Billions; Fixed (2019)	1.7	-1.7	-1.0	-1.0	-1.0	-1.0	-0.9	-0.9	-0.8	-0.8	-0.8
Real Disposable Personal Income	$ Billions; Fixed (2012)	1.6	-1.6	-0.9	-0.9	-0.9	-0.9	-0.8	-0.8	-0.8	-0.7	-0.7
Real Disposable Personal Income per Capita	$ Thousands; Fixed (2012)	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCE-Price Index	2012=100 (Nation)	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rest of U.S.-Change from Baseline; 2085 Values Run in 2050												
Category	Units	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060
Total Employment	Thousands (Jobs)	18.9	-37.8	-8.9	-8.8	-5.5	-3.6	-2.3	-1.5	-1.1	-0.9	-0.8
Private Non-Farm Employment	Thousands (Jobs)	19.5	-36.7	-8.1	-8.1	-5.0	-3.2	-2.0	-1.3	-0.9	-0.7	-0.7
Residence Adjusted Employment	Thousands	19.5	-37.8	-9.0	-8.8	-5.5	-3.6	-2.3	-1.5	-1.1	-0.9	-0.8
Population	Thousands	-27.7	-19.2	-15.3	-11.9	-9.3	-7.4	-6.0	-4.9	-4.2	-3.6	-3.2
Labor Force	Thousands	-13.5	-10.8	-8.6	-6.7	-5.0	-3.7	-2.8	-2.1	-1.6	-1.3	-1.1
Gross Domestic Product	$ Billions; Fixed (2019)	3.2	-6.4	-1.7	-1.7	-1.1	-0.8	-0.6	-0.4	-0.3	-0.3	-0.3
Output	$ Billions; Fixed (2019)	5.9	-11.6	-3.4	-3.3	-2.3	-1.7	-1.2	-0.9	-0.7	-0.6	-0.6
Value-Added	$ Billions; Fixed (2019)	3.2	-6.4	-1.7	-1.7	-1.1	-0.8	-0.6	-0.4	-0.3	-0.3	-0.3
Personal Income	$ Billions; Fixed (2019)	0.2	-7.9	-1.0	-1.3	-0.8	-0.6	-0.4	-0.3	-0.2	-0.2	-0.2
Disposable Personal Income	$ Billions; Fixed (2019)	0.0	-6.8	-0.8	-1.1	-0.7	-0.5	-0.3	-0.3	-0.2	-0.2	-0.2
Real Disposable Personal Income	$ Billions; Fixed (2012)	0.0	-6.2	-0.8	-1.0	-0.6	-0.4	-0.3	-0.2	-0.2	-0.2	-0.2
Real Disposable Personal Income per Capita	$ Thousands; Fixed (2012)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCE-Price Index	2012=100 (Nation)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Source: KRA using the REMI PI+ Model
Note: Only the US Summary Gross Domestic Product was used in the benefit analysis

Addendum E: Table 8
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
Values and Growth Rates for Conversion from 2050-2060 to 2085-2094 for 0.01 AEP Event
Intermediate Sea-Level Rise Scenario
Recommended Plan

2085 Values Run in 2060 and Growth Rate 2050-2060			
Category	Units	2060	Growth Rate 2050-2060 (%)
Total Employment	Thousands (Jobs)	92.3	0.9822
Private Non-Farm Employment	Thousands (Jobs)	90.6	0.9823
Residence Adjusted Employment	Thousands	88.3	0.9821
Population	Thousands	2.1	1.2148
Labor Force	Thousands	8.9	0.9827
Gross Domestic Product	**$ Billions; Fixed (2019)**	**27.5**	**0.9961**
Output	$ Billions; Fixed (2019)	61.9	1.0003
Value-Added	$ Billions; Fixed (2019)	27.5	0.9961
Personal Income	$ Billions; Fixed (2019)	11.6	0.9966
Disposable Personal Income	$ Billions; Fixed (2019)	10.0	0.9980
Real Disposable Personal Income	$ Billions; Fixed (2012)	9.1	0.9968
Real Disposable Personal Income per Capita	$ Thousands; Fixed (2012)	0.1	0.9779
PCE-Price Index	2012=100 (Nation)	0.0	0.0152
2085 Values Run in 2060 and Growth Rate 2050-2060			
Category	Units	2060	Growth Rate 2050-2060 (%)
Total Employment	Thousands (Jobs)	70.1	0.9885
Private Non-Farm Employment	Thousands (Jobs)	66.6	0.9882
Residence Adjusted Employment	Thousands	55.4	0.9899
Population	Thousands	74.5	1.0229
Labor Force	Thousands	37.1	1.0064
Gross Domestic Product	$ Billions; Fixed (2019)	23.1	0.9987
Output	$ Billions; Fixed (2019)	53.7	1.0028
Value-Added	$ Billions; Fixed (2019)	23.1	0.9987
Personal Income	$ Billions; Fixed (2019)	10.8	1.0108
Disposable Personal Income	$ Billions; Fixed (2019)	9.6	1.0122
Real Disposable Personal Income	$ Billions; Fixed (2012)	8.7	1.0110
Real Disposable Personal Income per Capita	$ Thousands; Fixed (2012)	0.3	0.9716
PCE-Price Index	2012=100 (Nation)	0.1	0.0364

Addendum E: Table 8 (continued)
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
Values and Growth Rates for Conversion from 2050-2060 to 2085-2094 for 0.01 AEP Event
Intermediate Sea-Level Rise Scenario
Recommended Plan

2085 Values Run in 2060 and Growth Rate 2050-2060			
Category	Units	2060	Growth Rate 2050-2060 (%)
Total Employment	Thousands (Jobs)	6.8	0.9380
Private Non-Farm Employment	Thousands (Jobs)	8.0	0.9469
Residence Adjusted Employment	Thousands	17.0	0.9622
Population	Thousands	-45.6	1.0380
Labor Force	Thousands	-15.6	1.0384
Gross Domestic Product	$ Billions; Fixed (2019)	1.4	0.9650
Output	$ Billions; Fixed (2019)	2.6	0.9680
Value-Added	$ Billions; Fixed (2019)	1.4	0.9650
Personal Income	$ Billions; Fixed (2019)	0.9	0.9188
Disposable Personal Income	$ Billions; Fixed (2019)	0.6	0.9011
Real Disposable Personal Income	$ Billions; Fixed (2012)	0.6	0.9066
Real Disposable Personal Income per Capita	$ Thousands; Fixed (2012)	0.1	1.0000
PCE-Price Index	2012=100 (Nation)	0.0	0.0091
2085 Values Run in 2060 and Growth Rate 2050-2060			
Category	Units	2060	Growth Rate 2050-2060 (%)
Total Employment	Thousands (Jobs)	15.4	0.9797
Private Non-Farm Employment	Thousands (Jobs)	16.0	0.9804
Residence Adjusted Employment	Thousands	15.9	0.9798
Population	Thousands	-26.8	0.9967
Labor Force	Thousands	-12.6	0.9931
Gross Domestic Product	$ Billions; Fixed (2019)	3.0	0.9936
Output	$ Billions; Fixed (2019)	5.6	0.9948
Value-Added	$ Billions; Fixed (2019)	3.0	0.9936
Personal Income	$ Billions; Fixed (2019)	-0.1	0.0000
Disposable Personal Income	$ Billions; Fixed (2019)	-0.2	0.0000
Real Disposable Personal Income	$ Billions; Fixed (2012)	-0.2	0.0000
Real Disposable Personal Income per Capita	$ Thousands; Fixed (2012)	0.0	0.0000
PCE-Price Index	2012=100 (Nation)	0.0	0.0000

Source: KRA using the REMI PI+ Model
Note: Only the US Summary Gross Domestic Product was used in the benefit analysis

Addendum E: Table 9
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
Economic Impact Summary for 2085-2094 for 0.01 AEP Event Occuring in 2085, U.S. and Three Regions
Intermediate Sea-Level Rise Scenario
Recommended Plan

U.S. Summary-Change from Baseline Due to Flood Protection Measures											
Category	Units	2085	2086	2087	2088	2089	2090	2091	2092	2093	2094
Total Employment	Thousands (Jobs)	63.1	-15.6	-0.6	-1.6	-0.3	0.4	1.0	1.4	1.6	1.7
Private Non-Farm Employment	Thousands (Jobs)	61.3	-17.2	-1.4	-2.2	-0.8	0.0	0.6	1.0	1.3	1.3
Residence Adjusted Employment	Thousands	59.0	-17.5	-1.5	-2.3	-0.9	0.0	0.7	1.1	1.2	1.4
Population	Thousands	-9.3	-14.4	-14.3	-14.6	-14.9	-15.0	-14.3	-13.6	-12.9	-11.9
Labor Force	Thousands	-7.1	-14.6	-13.3	-13.3	-12.9	-12.5	-11.6	-10.7	-9.8	-9.0
Gross Domestic Product	**$ Billions; Fixed (2019)**	**25.5**	**-4.8**	**-0.7**	**-0.9**	**-0.5**	**-0.3**	**-0.1**	**0.1**	**0.2**	**0.2**
Output	$ Billions; Fixed (2019)	63.7	-9.1	-1.6	-2.0	-1.2	-0.7	-0.2	0.0	0.2	0.3
Value-Added	$ Billions; Fixed (2019)	25.5	-4.8	-0.7	-0.9	-0.5	-0.3	-0.1	0.1	0.2	0.2
Personal Income	$ Billions; Fixed (2019)	14.2	0.6	2.3	2.0	1.8	1.8	1.8	1.8	1.7	1.7
Disposable Personal Income	$ Billions; Fixed (2019)	13.1	0.7	2.3	2.0	2.0	1.8	1.8	1.8	1.8	1.7
Real Disposable Personal Income	$ Billions; Fixed (2012)	11.5	0.7	2.0	1.7	1.6	1.6	1.6	1.6	1.6	1.4
Real Disposable Personal Income per Capita	$ Thousands; Fixed (2012)	0.8	0.0	-0.5	-0.4	-0.4	-0.4	-0.2	-0.2	-0.2	-0.2
PCE-Price Index	2012=100 (Nation)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5-County Region-Change from Baseline Due to Flood Protection Measures											
Category	Units	2085	2086	2087	2088	2089	2090	2091	2092	2093	2094
Total Employment	Thousands (Jobs)	52.5	3.7	4.3	3.3	2.9	2.7	2.6	2.5	2.5	2.5
Private Non-Farm Employment	Thousands (Jobs)	49.5	2.2	3.3	2.6	2.3	2.2	2.2	2.2	2.2	2.1
Residence Adjusted Employment	Thousands	43.0	2.7	4.1	3.4	3.2	3.0	2.9	2.9	2.7	2.7
Population	Thousands	131.2	105.0	89.7	77.6	68.3	61.0	55.2	50.6	46.6	43.3
Labor Force	Thousands	43.5	29.4	23.0	18.1	14.6	12.1	10.4	8.9	7.9	7.0
Gross Domestic Product	$ Billions; Fixed (2019)	22.4	0.7	0.9	0.7	0.6	0.6	0.6	0.6	0.6	0.6
Output	$ Billions; Fixed (2019)	57.6	1.2	1.7	1.2	1.1	1.1	1.1	1.1	1.1	1.1
Value-Added	$ Billions; Fixed (2019)	22.4	0.7	0.9	0.7	0.6	0.6	0.6	0.6	0.6	0.6
Personal Income	$ Billions; Fixed (2019)	14.1	0.7	2.3	2.0	1.9	1.9	1.9	1.9	1.7	1.7
Disposable Personal Income	$ Billions; Fixed (2019)	13.0	0.8	2.3	2.0	2.0	1.8	1.8	1.8	1.8	1.7
Real Disposable Personal Income	$ Billions; Fixed (2012)	11.4	0.7	2.1	1.8	1.6	1.6	1.6	1.6	1.6	1.5
Real Disposable Personal Income per Capita	$ Thousands; Fixed (2012)	0.7	-0.7	-0.5	-0.4	-0.4	-0.4	-0.2	-0.2	-0.2	-0.2
PCE-Price Index	2012=100 (Nation)	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Addendum E: Table 9 (continued)
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
Economic Impact Summary for 2085-2094 for 0.01 AEP Event Occuring in 2085, U.S. and Three Regions
Intermediate Sea-Level Rise Scenario
Recommended Plan

Rest of Texas-Change from Baseline Due to Flood Protection Measures											
Category	Units	2085	2086	2087	2088	2089	2090	2091	2092	2093	2094
Total Employment	Thousands (Jobs)	1.4	-0.8	-0.5	-0.6	-0.5	-0.5	-0.4	-0.4	-0.4	-0.3
Private Non-Farm Employment	Thousands (Jobs)	2.0	-1.0	-0.6	-0.7	-0.7	-0.6	-0.5	-0.5	-0.4	-0.4
Residence Adjusted Employment	Thousands	6.5	-1.7	-1.1	-1.3	-1.3	-1.3	-1.2	-1.1	-1.0	-0.9
Population	Thousands	-115.9	-102.2	-90.4	-81.6	-74.9	-69.4	-64.2	-59.8	-55.7	-52.0
Labor Force	Thousands	-40.0	-35.5	-29.6	-26.2	-23.6	-21.7	-19.8	-18.0	-16.5	-15.0
Gross Domestic Product	$ Billions; Fixed (2019)	0.6	-0.3	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.1	-0.1
Output	$ Billions; Fixed (2019)	1.2	-0.6	-0.4	-0.4	-0.4	-0.4	-0.4	-0.3	-0.3	-0.3
Value-Added	$ Billions; Fixed (2019)	0.6	-0.3	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.1	-0.1
Personal Income	$ Billions; Fixed (2019)	0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	0.0	0.0
Disposable Personal Income	$ Billions; Fixed (2019)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Real Disposable Personal Income	$ Billions; Fixed (2012)	0.1	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Real Disposable Personal Income per Capita	$ Thousands; Fixed (2012)	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCE-Price Index	2012=100 (Nation)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rest of U.S.-Change from Baseline Due to Flood Protection Measures											
Category	Units	2085	2086	2087	2088	2089	2090	2091	2092	2093	2094
Total Employment	Thousands (Jobs)	9.2	-18.5	-4.3	-4.3	-2.7	-1.8	-1.1	-0.7	-0.5	-0.4
Private Non-Farm Employment	Thousands (Jobs)	9.8	-18.4	-4.1	-4.1	-2.5	-1.6	-1.0	-0.7	-0.5	-0.4
Residence Adjusted Employment	Thousands	9.5	-18.5	-4.4	-4.3	-2.7	-1.8	-1.1	-0.7	-0.5	-0.4
Population	Thousands	-24.7	-17.1	-13.6	-10.6	-8.3	-6.6	-5.3	-4.4	-3.7	-3.2
Labor Force	Thousands	-10.6	-8.5	-6.8	-5.3	-3.9	-2.9	-2.2	-1.6	-1.3	-1.0
Gross Domestic Product	$ Billions; Fixed (2019)	2.6	-5.1	-1.4	-1.4	-0.9	-0.6	-0.5	-0.3	-0.2	-0.2
Output	$ Billions; Fixed (2019)	4.9	-9.7	-2.8	-2.7	-1.9	-1.4	-1.0	-0.7	-0.6	-0.5
Value-Added	$ Billions; Fixed (2019)	2.6	-5.1	-1.4	-1.4	-0.9	-0.6	-0.5	-0.3	-0.2	-0.2
Personal Income	$ Billions; Fixed (2019)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Disposable Personal Income	$ Billions; Fixed (2019)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Real Disposable Personal Income	$ Billions; Fixed (2012)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Real Disposable Personal Income per Capita	$ Thousands; Fixed (2012)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCE-Price Index	2012=100 (Nation)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Source: KRA using the REMI PI+ Model
Note: Only the US Summary Gross Domestic Product was used in the benefit analysis

Addendum E: Table 10

Coastal Texas Protection and Restoration Study Integrated Feasibility Report

Economic Impact Summary for 2050-2060 for 0.005 AEP Event Occuring in 2085, U.S. and Three Regions

Intermediate Sea-Level Rise Scenario

Recommended Plan

U.S. Summary-Change from Baseline; 2085 Values Run in 2050												
Category	Units	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060
Total Employment	Thousands (Jobs)	146.1	-52.9	-9.9	-12.1	-8.2	-5.6	-3.6	-2.2	-1.1	-0.6	-0.2
Private Non-Farm Employment	Thousands (Jobs)	143.0	-53.2	-9.6	-11.8	-7.8	-5.2	-3.4	-1.9	-0.9	-0.5	-0.1
Residence Adjusted Employment	Thousands	139.9	-53.4	-10.0	-12.2	-8.3	-5.6	-3.6	-2.1	-1.2	-0.6	-0.3
Population	Thousands	0.2	0.7	0.9	1.2	1.5	1.7	1.9	2.0	2.1	2.3	2.4
Labor Force	Thousands	13.9	4.2	2.3	0.9	0.3	0.1	0.1	0.2	0.3	0.4	0.3
Gross Domestic Product	**$ Billions; Fixed (2019)**	**37.8**	**-9.0**	**-2.0**	**-2.3**	**-1.8**	**-1.3**	**-0.9**	**-0.7**	**-0.3**	**-0.2**	**-0.1**
Output	$ Billions; Fixed (2019)	81.5	-16.4	-4.2	-4.8	-3.5	-2.6	-1.9	-1.3	-0.8	-0.5	-0.5
Value-Added	$ Billions; Fixed (2019)	37.8	-9.0	-2.0	-2.3	-1.8	-1.3	-0.9	-0.7	-0.3	-0.2	-0.1
Personal Income	$ Billions; Fixed (2019)	15.8	-12.3	-0.6	-1.4	-0.8	-0.5	-0.2	0.0	0.1	0.1	0.2
Disposable Personal Income	$ Billions; Fixed (2019)	13.5	-10.5	-0.4	-1.1	-0.6	-0.4	-0.2	0.0	0.1	0.1	0.1
Real Disposable Personal Income	$ Billions; Fixed (2012)	12.2	-9.6	-0.4	-1.1	-0.6	-0.3	-0.1	0.0	0.0	0.2	0.2
Real Disposable Personal Income per Capita	$ Thousands; Fixed (2012)	0.2	-0.2	-0.1	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.0
PCE-Price Index	2012=100 (Nation)	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5-County Region-Change from Baseline; 2085 Values Run in 2050												
Category	Units	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060
Total Employment	Thousands (Jobs)	103.0	6.4	7.6	5.7	4.9	4.6	4.4	4.3	4.3	4.2	4.2
Private Non-Farm Employment	Thousands (Jobs)	98.3	3.7	5.9	4.4	3.9	3.8	3.7	3.7	3.8	3.7	3.7
Residence Adjusted Employment	Thousands	80.2	4.4	6.9	5.6	5.2	5.0	4.8	4.7	4.6	4.5	4.3
Population	Thousands	72.3	57.5	49.0	42.3	37.2	33.1	29.9	27.3	25.1	23.3	21.7
Labor Force	Thousands	43.1	28.8	22.5	17.7	14.2	11.7	9.9	8.5	7.5	6.7	6.0
Gross Domestic Product	$ Billions; Fixed (2019)	30.7	0.8	1.1	0.8	0.6	0.6	0.6	0.6	0.7	0.7	0.7
Output	$ Billions; Fixed (2019)	68.7	1.3	1.7	1.2	1.0	1.0	1.0	1.1	1.2	1.2	1.2
Value-Added	$ Billions; Fixed (2019)	30.7	0.8	1.1	0.8	0.6	0.6	0.6	0.6	0.7	0.7	0.7
Personal Income	$ Billions; Fixed (2019)	12.6	0.5	1.9	1.7	1.6	1.5	1.5	1.5	1.4	1.4	1.4
Disposable Personal Income	$ Billions; Fixed (2019)	11.0	0.5	1.8	1.6	1.5	1.4	1.4	1.4	1.4	1.3	1.3
Real Disposable Personal Income	$ Billions; Fixed (2012)	10.0	0.4	1.6	1.4	1.3	1.3	1.3	1.2	1.2	1.2	1.2
Real Disposable Personal Income per Capita	$ Thousands; Fixed (2012)	0.6	-0.5	-0.3	-0.3	-0.2	-0.2	-0.2	-0.1	-0.1	-0.1	-0.1
PCE-Price Index	2012=100 (Nation)	0.1	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Addendum E: Table 10 (continued)
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Rest of Texas-Change from Baseline; 2085 Values Run in 2050												
Category	Units	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060
Total Employment	Thousands (Jobs)	18.1	-9.4	-5.6	-6.1	-5.8	-5.4	-4.9	-4.5	-4.0	-3.6	-3.3
Private Non-Farm Employment	Thousands (Jobs)	19.0	-8.5	-4.8	-5.4	-5.1	-4.8	-4.4	-3.9	-3.5	-3.2	-2.9
Residence Adjusted Employment	Thousands	33.9	-8.0	-5.0	-6.1	-6.1	-5.8	-5.3	-4.8	-4.3	-3.9	-3.5
Population	Thousands	-35.5	-31.4	-27.8	-25.2	-23.2	-21.5	-20.0	-18.6	-17.3	-16.1	-15.0
Labor Force	Thousands	-11.4	-10.4	-8.8	-7.9	-7.2	-6.6	-6.1	-5.5	-5.1	-4.6	-4.2
Gross Domestic Product	$ Billions; Fixed (2019)	2.8	-1.4	-0.8	-0.9	-0.9	-0.8	-0.7	-0.7	-0.6	-0.5	-0.5
Output	$ Billions; Fixed (2019)	5.0	-2.4	-1.4	-1.6	-1.5	-1.4	-1.3	-1.2	-1.0	-0.9	-0.9
Value-Added	$ Billions; Fixed (2019)	2.8	-1.4	-0.8	-0.9	-0.9	-0.8	-0.7	-0.7	-0.6	-0.5	-0.5
Personal Income	$ Billions; Fixed (2019)	3.0	-2.3	-1.2	-1.3	-1.3	-1.2	-1.2	-1.1	-1.0	-1.0	-0.9
Disposable Personal Income	$ Billions; Fixed (2019)	2.5	-2.1	-1.1	-1.2	-1.2	-1.1	-1.1	-1.0	-1.0	-0.9	-0.9
Real Disposable Personal Income	$ Billions; Fixed (2012)	2.2	-1.9	-1.0	-1.1	-1.1	-1.0	-1.0	-0.9	-0.9	-0.8	-0.8
Real Disposable Personal Income per Capita	$ Thousands; Fixed (2012)	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCE-Price Index	2012=100 (Nation)	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rest of U.S.-Change from Baseline; 2085 Values Run in 2050												
Category	Units	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060
Total Employment	Thousands (Jobs)	25.0	-49.9	-11.9	-11.7	-7.3	-4.8	-3.1	-2.0	-1.4	-1.2	-1.1
Private Non-Farm Employment	Thousands (Jobs)	25.7	-48.4	-10.7	-10.8	-6.6	-4.2	-2.7	-1.7	-1.2	-1.0	-0.9
Residence Adjusted Employment	Thousands	25.8	-49.8	-11.9	-11.7	-7.4	-4.8	-3.1	-2.0	-1.5	-1.2	-1.1
Population	Thousands	-36.6	-25.4	-20.3	-15.9	-12.5	-9.9	-8.0	-6.7	-5.7	-4.9	-4.3
Labor Force	Thousands	-17.8	-14.2	-11.4	-8.9	-6.7	-5.0	-3.7	-2.8	-2.1	-1.7	-1.5
Gross Domestic Product	$ Billions; Fixed (2019)	4.3	-8.4	-2.3	-2.2	-1.5	-1.1	-0.8	-0.6	-0.4	-0.4	-0.3
Output	$ Billions; Fixed (2019)	7.8	-15.3	-4.5	-4.4	-3.0	-2.2	-1.6	-1.2	-1.0	-0.8	-0.8
Value-Added	$ Billions; Fixed (2019)	4.3	-8.4	-2.3	-2.2	-1.5	-1.1	-0.8	-0.6	-0.4	-0.4	-0.3
Personal Income	$ Billions; Fixed (2019)	0.2	-10.5	-1.3	-1.8	-1.1	-0.8	-0.5	-0.4	-0.3	-0.3	-0.3
Disposable Personal Income	$ Billions; Fixed (2019)	0.0	-8.9	-1.1	-1.5	-0.9	-0.7	-0.5	-0.4	-0.3	-0.3	-0.3
Real Disposable Personal Income	$ Billions; Fixed (2012)	0.0	-8.1	-1.0	-1.4	-0.8	-0.6	-0.4	-0.3	-0.3	-0.2	-0.2
Real Disposable Personal Income per Capita	$ Thousands; Fixed (2012)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCE-Price Index	2012=100 (Nation)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Source: KRA using the REMI PI+ Model
Note: Only the US Summary Gross Domestic Product was used in the benefit analysis

Addendum E: Table 11
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
Values and Growth Rates for Conversion from 2050-2060 to 2085-2094 for 0.005 AEP Event
Intermediate Sea-Level Rise Scenario
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2085 Values Run in 2060 and Growth Rate 2050-2060			
Category	Units	2060	Growth Rate 2050-2060 (%)
Total Employment	Thousands (Jobs)	122.2	0.9823
Private Non-Farm Employment	Thousands (Jobs)	119.8	0.9825
Residence Adjusted Employment	Thousands	117.0	0.9823
Population	Thousands	0.2	1.0000
Labor Force	Thousands	11.2	0.9786
Gross Domestic Product	**$ Billions; Fixed (2019)**	**36.6**	**0.9968**
Output	$ Billions; Fixed (2019)	82.2	1.0009
Value-Added	$ Billions; Fixed (2019)	36.6	0.9968
Personal Income	$ Billions; Fixed (2019)	15.2	0.9961
Disposable Personal Income	$ Billions; Fixed (2019)	13.0	0.9962
Real Disposable Personal Income	$ Billions; Fixed (2012)	11.8	0.9967
Real Disposable Personal Income per Capita	$ Thousands; Fixed (2012)	0.2	0.9847
PCE-Price Index	2012=100 (Nation)	0.0	0.0182
2085 Values Run in 2060 and Growth Rate 2050-2060			
Category	Units	2060	Growth Rate 2050-2060 (%)
Total Employment	Thousands (Jobs)	86.9	0.9831
Private Non-Farm Employment	Thousands (Jobs)	83.1	0.9833
Residence Adjusted Employment	Thousands	67.6	0.9831
Population	Thousands	67.9	0.9937
Labor Force	Thousands	39.3	0.9908
Gross Domestic Product	$ Billions; Fixed (2019)	29.6	0.9964
Output	$ Billions; Fixed (2019)	69.2	1.0007
Value-Added	$ Billions; Fixed (2019)	29.6	0.9964
Personal Income	$ Billions; Fixed (2019)	12.4	0.9984
Disposable Personal Income	$ Billions; Fixed (2019)	10.9	0.9991
Real Disposable Personal Income	$ Billions; Fixed (2012)	9.9	0.9990
Real Disposable Personal Income per Capita	$ Thousands; Fixed (2012)	0.5	0.9819
PCE-Price Index	2012=100 (Nation)	0.1	0.0455

Addendum E: Table 11 (continued)
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Values and Growth Rates for Conversion from 2050-2060 to 2085-2094 for 0.005 AEP Event
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2085 Values Run in 2060 and Growth Rate 2050-2060			
Category	Units	2060	Growth Rate 2050-2060 (%)
Total Employment	Thousands (Jobs)	13.7	0.9725
Private Non-Farm Employment	Thousands (Jobs)	14.6	0.9740
Residence Adjusted Employment	Thousands	27.2	0.9782
Population	Thousands	-37.2	1.0047
Labor Force	Thousands	-13.1	1.0140
Gross Domestic Product	$ Billions; Fixed (2019)	2.6	0.9926
Output	$ Billions; Fixed (2019)	4.7	0.9938
Value-Added	$ Billions; Fixed (2019)	2.6	0.9926
Personal Income	$ Billions; Fixed (2019)	2.6	0.9858
Disposable Personal Income	$ Billions; Fixed (2019)	2.1	0.9827
Real Disposable Personal Income	$ Billions; Fixed (2012)	1.9	0.9854
Real Disposable Personal Income per Capita	$ Thousands; Fixed (2012)	0.1	1.0000
PCE-Price Index	2012=100 (Nation)	0.0	0.0091
2085 Values Run in 2060 and Growth Rate 2050-2060			
Category	Units	2060	Growth Rate 2050-2060 (%)
Total Employment	Thousands (Jobs)	21.6	0.9855
Private Non-Farm Employment	Thousands (Jobs)	22.1	0.9850
Residence Adjusted Employment	Thousands	22.2	0.9851
Population	Thousands	-30.5	0.9819
Labor Force	Thousands	-15.0	0.9830
Gross Domestic Product	$ Billions; Fixed (2019)	4.4	1.0023
Output	$ Billions; Fixed (2019)	8.3	1.0062
Value-Added	$ Billions; Fixed (2019)	4.4	1.0023
Personal Income	$ Billions; Fixed (2019)	0.2	1.0000
Disposable Personal Income	$ Billions; Fixed (2019)	0.0	0.0000
Real Disposable Personal Income	$ Billions; Fixed (2012)	0.0	0.0000
Real Disposable Personal Income per Capita	$ Thousands; Fixed (2012)	0.0	0.0000
PCE-Price Index	2012=100 (Nation)	0.0	0.0000

Source: KRA using the REMI PI+ Model
Note: Only the US Summary Gross Domestic Product was used in the benefit analysis

Addendum E: Table 12

Coastal Texas Protection and Restoration Study Integrated Feasibility Report

Economic Impact Summary for 2085-2094 for 0.005 AEP Event Occuring in 2085, U.S. and Three Regions

Intermediate Sea-Level Rise Scenario

Recommended Plan

U.S. Summary-Change from Baseline Due to Flood Protection Measures											
Category	Units	2085	2086	2087	2088	2089	2090	2091	2092	2093	2094
Total Employment	Thousands (Jobs)	78.6	-29.9	-5.1	-6.2	-3.9	-2.4	-1.3	-0.5	0.0	0.2
Private Non-Farm Employment	Thousands (Jobs)	77.3	-29.9	-4.9	-6.1	-3.8	-2.3	-1.3	-0.5	0.0	0.2
Residence Adjusted Employment	Thousands	75.0	-30.7	-5.6	-6.7	-4.3	-2.8	-1.6	-0.8	-0.3	0.0
Population	Thousands	-3.1	-4.2	-4.1	-4.1	-4.1	-4.0	-3.8	-3.5	-3.2	-2.8
Labor Force	Thousands	2.9	-3.9	-4.3	-4.9	-5.1	-5.0	-4.8	-4.3	-4.0	-3.6
Gross Domestic Product	**$ Billions; Fixed (2019)**	**33.8**	**-9.5**	**-2.1**	**-2.4**	**-1.8**	**-1.3**	**-0.9**	**-0.7**	**-0.3**	**-0.2**
Output	$ Billions; Fixed (2019)	84.2	-19.6	-5.0	-5.5	-3.9	-2.8	-2.0	-1.3	-0.8	-0.5
Value-Added	$ Billions; Fixed (2019)	33.8	-9.5	-2.1	-2.4	-1.8	-1.3	-0.9	-0.7	-0.3	-0.2
Personal Income	$ Billions; Fixed (2019)	13.9	-11.4	-0.2	-1.0	-0.4	-0.1	0.2	0.4	0.4	0.4
Disposable Personal Income	$ Billions; Fixed (2019)	12.0	-0.7	1.1	0.9	0.8	0.8	0.8	0.8	0.8	0.8
Real Disposable Personal Income	$ Billions; Fixed (2012)	11.0	-0.8	0.9	0.7	0.6	0.7	0.7	0.6	0.6	0.7
Real Disposable Personal Income per Capita	$ Thousands; Fixed (2012)	1.8	-0.7	-0.4	-0.4	-0.3	-0.3	-0.3	-0.1	-0.1	-0.1
PCE-Price Index	2012=100 (Nation)	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5-County Region-Change from Baseline Due to Flood Protection Measures											
Category	Units	2085	2086	2087	2088	2089	2090	2091	2092	2093	2094
Total Employment	Thousands (Jobs)	56.8	3.5	4.2	3.1	2.7	2.5	2.4	2.4	2.4	2.3
Private Non-Farm Employment	Thousands (Jobs)	54.6	2.1	3.3	2.4	2.2	2.1	2.1	2.1	2.1	2.1
Residence Adjusted Employment	Thousands	44.1	2.4	3.8	3.1	2.9	2.7	2.6	2.6	2.5	2.5
Population	Thousands	58.0	46.2	39.3	34.0	29.9	26.6	24.0	21.9	20.1	18.7
Labor Force	Thousands	31.2	20.8	16.3	12.8	10.3	8.5	7.2	6.2	5.4	4.9
Gross Domestic Product	$ Billions; Fixed (2019)	27.0	0.7	1.0	0.7	0.5	0.5	0.5	0.5	0.6	0.6
Output	$ Billions; Fixed (2019)	70.5	1.3	1.7	1.2	1.0	1.0	1.0	1.1	1.2	1.2
Value-Added	$ Billions; Fixed (2019)	27.0	0.7	1.0	0.7	0.5	0.5	0.5	0.5	0.6	0.6
Personal Income	$ Billions; Fixed (2019)	11.9	0.5	1.8	1.6	1.5	1.4	1.4	1.4	1.3	1.3
Disposable Personal Income	$ Billions; Fixed (2019)	10.7	0.5	1.7	1.5	1.5	1.4	1.4	1.4	1.4	1.3
Real Disposable Personal Income	$ Billions; Fixed (2012)	9.7	0.4	1.5	1.4	1.3	1.3	1.3	1.2	1.2	1.2
Real Disposable Personal Income per Capita	$ Thousands; Fixed (2012)	0.8	-0.7	-0.4	-0.4	-0.3	-0.3	-0.3	-0.1	-0.1	-0.1
PCE-Price Index	2012=100 (Nation)	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Addendum E: Table 12 (continued)

Coastal Texas Protection and Restoration Study Integrated Feasibility Report

Economic Impact Summary for 2085-2094 for 0.005 AEP Event Occuring in 2085, U.S. and Three Regions

Intermediate Sea-Level Rise Scenario

Recommended Plan

Rest of Texas-Change from Baseline Due to Flood Protection Measures											
Category	Units	2085	2086	2087	2088	2089	2090	2091	2092	2093	2094
Total Employment	Thousands (Jobs)	6.8	-3.5	-2.1	-2.3	-2.2	-2.0	-1.8	-1.7	-1.5	-1.4
Private Non-Farm Employment	Thousands (Jobs)	7.6	-3.4	-1.9	-2.1	-2.0	-1.9	-1.8	-1.6	-1.4	-1.3
Residence Adjusted Employment	Thousands	15.7	-3.7	-2.3	-2.8	-2.8	-2.7	-2.5	-2.2	-2.0	-1.8
Population	Thousands	-41.8	-37.0	-32.7	-29.7	-27.3	-25.3	-23.6	-21.9	-20.4	-19.0
Labor Force	Thousands	-18.5	-16.9	-14.3	-12.9	-11.7	-10.7	-9.9	-8.9	-8.3	-7.5
Gross Domestic Product	$ Billions; Fixed (2019)	2.2	-1.1	-0.6	-0.7	-0.7	-0.6	-0.5	-0.5	-0.5	-0.4
Output	$ Billions; Fixed (2019)	4.0	-1.9	-1.1	-1.3	-1.2	-1.1	-1.0	-1.0	-0.8	-0.7
Value-Added	$ Billions; Fixed (2019)	2.2	-1.1	-0.6	-0.7	-0.7	-0.6	-0.5	-0.5	-0.5	-0.4
Personal Income	$ Billions; Fixed (2019)	1.8	-1.4	-0.7	-0.8	-0.8	-0.7	-0.7	-0.7	-0.6	-0.6
Disposable Personal Income	$ Billions; Fixed (2019)	1.4	-1.1	-0.6	-0.7	-0.7	-0.6	-0.6	-0.5	-0.5	-0.5
Real Disposable Personal Income	$ Billions; Fixed (2012)	1.3	-1.1	-0.6	-0.7	-0.7	-0.6	-0.6	-0.5	-0.5	-0.5
Real Disposable Personal Income per Capita	$ Thousands; Fixed (2012)	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCE-Price Index	2012=100 (Nation)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rest of U.S.-Change from Baseline Due to Flood Protection Measures											
Category	Units	2085	2086	2087	2088	2089	2090	2091	2092	2093	2094
Total Employment	Thousands (Jobs)	15.0	-29.9	-7.1	-7.0	-4.4	-2.9	-1.9	-1.2	-0.8	-0.7
Private Non-Farm Employment	Thousands (Jobs)	15.2	-28.5	-6.3	-6.4	-3.9	-2.5	-1.6	-1.0	-0.7	-0.6
Residence Adjusted Employment	Thousands	15.2	-29.4	-7.0	-6.9	-4.4	-2.8	-1.8	-1.2	-0.9	-0.7
Population	Thousands	-19.3	-13.4	-10.7	-8.4	-6.6	-5.2	-4.2	-3.5	-3.0	-2.6
Labor Force	Thousands	-9.8	-7.8	-6.3	-4.9	-3.7	-2.7	-2.0	-1.5	-1.2	-0.9
Gross Domestic Product	$ Billions; Fixed (2019)	4.7	-9.1	-2.5	-2.4	-1.6	-1.2	-0.9	-0.7	-0.4	-0.4
Output	$ Billions; Fixed (2019)	9.7	-19.0	-5.6	-5.5	-3.7	-2.7	-2.0	-1.5	-1.2	-1.0
Value-Added	$ Billions; Fixed (2019)	4.7	-9.1	-2.5	-2.4	-1.6	-1.2	-0.9	-0.7	-0.4	-0.4
Personal Income	$ Billions; Fixed (2019)	0.2	-10.5	-1.3	-1.8	-1.1	-0.8	-0.5	-0.4	-0.3	-0.3
Disposable Personal Income	$ Billions; Fixed (2019)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Real Disposable Personal Income	$ Billions; Fixed (2012)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Real Disposable Personal Income per Capita	$ Thousands; Fixed (2012)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCE-Price Index	2012=100 (Nation)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Source: KRA using the REMI PI+ Model

Note: Only the US Summary Gross Domestic Product was used in the benefit analysis

Addendum E: Table 13
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
Economic Impact Summary for 2050-2060 for 0.002 AEP Event Occuring in 2085, U.S. and Three Regions
Intermediate Sea-Level Rise Scenario
Recommended Plan

U.S. Summary-Change from Baseline; 2085 Values Run in 2050												
Category	Units	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060
Total Employment	Thousands (Jobs)	167.3	-60.5	-11.3	-13.9	-9.5	-6.5	-4.1	-2.5	-1.4	-0.7	-0.3
Private Non-Farm Employment	Thousands (Jobs)	163.7	-60.8	-11.2	-13.4	-9.0	-6.1	-3.9	-2.3	-1.2	-0.5	-0.2
Residence Adjusted Employment	Thousands	160.2	-61.0	-11.6	-14.0	-9.6	-6.4	-4.2	-2.6	-1.4	-0.8	-0.3
Population	Thousands	0.3	0.8	1.1	1.4	1.6	1.9	2.1	2.2	2.3	2.4	2.5
Labor Force	Thousands	16.0	4.6	2.6	0.9	0.2	0.1	0.1	0.2	0.3	0.3	0.3
Gross Domestic Product	**$ Billions; Fixed (2019)**	**43.3**	**-10.2**	**-2.3**	**-2.8**	**-1.9**	**-1.4**	**-1.0**	**-0.6**	**-0.4**	**-0.3**	**-0.2**
Output	$ Billions; Fixed (2019)	93.2	-18.8	-4.7	-5.4	-4.1	-2.9	-2.1	-1.5	-1.0	-0.7	-0.5
Value-Added	$ Billions; Fixed (2019)	43.3	-10.2	-2.3	-2.8	-1.9	-1.4	-1.0	-0.6	-0.4	-0.3	-0.2
Personal Income	$ Billions; Fixed (2019)	18.1	-14.0	-0.7	-1.7	-1.0	-0.5	-0.3	-0.1	0.1	0.2	0.3
Disposable Personal Income	$ Billions; Fixed (2019)	15.5	-12.0	-0.5	-1.4	-0.8	-0.4	-0.2	0.0	0.1	0.2	0.1
Real Disposable Personal Income	$ Billions; Fixed (2012)	14.0	-11.0	-0.5	-1.3	-0.7	-0.4	-0.2	0.0	0.1	0.1	0.1
Real Disposable Personal Income per Capita	$ Thousands; Fixed (2012)	0.3	-0.2	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0
PCE-Price Index	2012=100 (Nation)	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5-County Region-Change from Baseline; 2085 Values Run in 2050												
Category	Units	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060
Total Employment	Thousands (Jobs)	117.6	7.0	8.4	6.2	5.3	4.9	4.8	4.7	4.7	4.6	4.5
Private Non-Farm Employment	Thousands (Jobs)	112.3	4.0	6.4	4.8	4.2	4.1	4.0	4.0	4.1	4.1	4.0
Residence Adjusted Employment	Thousands	91.6	4.7	7.6	6.1	5.6	5.4	5.2	5.1	5.0	4.9	4.7
Population	Thousands	80.5	63.9	54.4	46.9	41.1	36.6	33.0	30.1	27.7	25.7	23.9
Labor Force	Thousands	48.3	32.1	25.1	19.6	15.7	12.9	10.9	9.4	8.3	7.3	6.6
Gross Domestic Product	$ Billions; Fixed (2019)	35.1	0.9	1.2	0.8	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Output	$ Billions; Fixed (2019)	78.5	1.4	1.9	1.3	1.1	1.1	1.1	1.2	1.2	1.3	1.3
Value-Added	$ Billions; Fixed (2019)	35.1	0.9	1.2	0.8	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Personal Income	$ Billions; Fixed (2019)	14.3	0.5	2.1	1.8	1.7	1.7	1.6	1.6	1.6	1.6	1.6
Disposable Personal Income	$ Billions; Fixed (2019)	12.6	0.5	2.0	1.7	1.6	1.6	1.5	1.5	1.5	1.5	1.4
Real Disposable Personal Income	$ Billions; Fixed (2012)	11.4	0.4	1.8	1.5	1.5	1.4	1.4	1.4	1.4	1.3	1.3
Real Disposable Personal Income per Capita	$ Thousands; Fixed (2012)	0.7	-0.6	-0.3	-0.3	-0.2	-0.2	-0.2	-0.2	-0.1	-0.1	-0.1
PCE-Price Index	2012=100 (Nation)	0.1	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Addendum E: Table 13 (continued)
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
Economic Impact Summary for 2050-2060 for 0.002 AEP Event Occuring in 2085, U.S. and Three Regions
Intermediate Sea-Level Rise Scenario
Recommended Plan

Rest of Texas-Change from Baseline; 2085 Values Run in 2050												
Category	Units	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060
Total Employment	Thousands (Jobs)	21.1	-10.4	-6.1	-6.7	-6.4	-5.9	-5.4	-4.9	-4.4	-4.0	-3.6
Private Non-Farm Employment	Thousands (Jobs)	22.0	-9.4	-5.3	-5.9	-5.6	-5.3	-4.8	-4.3	-3.9	-3.5	-3.2
Residence Adjusted Employment	Thousands	39.1	-8.8	-5.5	-6.7	-6.7	-6.3	-5.8	-5.3	-4.7	-4.3	-3.8
Population	Thousands	-38.3	-34.0	-30.1	-27.3	-25.2	-23.3	-21.7	-20.2	-18.9	-17.6	-16.4
Labor Force	Thousands	-12.0	-11.2	-9.4	-8.5	-7.8	-7.1	-6.6	-6.0	-5.5	-5.0	-4.6
Gross Domestic Product	$ Billions; Fixed (2019)	3.3	-1.5	-0.9	-1.0	-0.9	-0.9	-0.8	-0.7	-0.6	-0.6	-0.5
Output	$ Billions; Fixed (2019)	5.8	-2.7	-1.5	-1.7	-1.7	-1.5	-1.4	-1.3	-1.1	-1.0	-0.9
Value-Added	$ Billions; Fixed (2019)	3.3	-1.5	-0.9	-1.0	-0.9	-0.9	-0.8	-0.7	-0.6	-0.6	-0.5
Personal Income	$ Billions; Fixed (2019)	3.5	-2.5	-1.3	-1.4	-1.4	-1.3	-1.3	-1.2	-1.1	-1.1	-1.0
Disposable Personal Income	$ Billions; Fixed (2019)	2.9	-2.3	-1.2	-1.3	-1.3	-1.2	-1.2	-1.1	-1.1	-1.0	-1.0
Real Disposable Personal Income	$ Billions; Fixed (2012)	2.6	-2.1	-1.1	-1.2	-1.2	-1.1	-1.1	-1.0	-1.0	-0.9	-0.9
Real Disposable Personal Income per Capita	$ Thousands; Fixed (2012)	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCE-Price Index	2012=100 (Nation)	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rest of U.S.-Change from Baseline; 2085 Values Run in 2050												
Category	Units	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060
Total Employment	Thousands (Jobs)	28.6	-57.1	-13.6	-13.4	-8.4	-5.5	-3.5	-2.3	-1.7	-1.3	-1.2
Private Non-Farm Employment	Thousands (Jobs)	29.4	-55.4	-12.3	-12.3	-7.6	-4.9	-3.1	-2.0	-1.4	-1.1	-1.0
Residence Adjusted Employment	Thousands	29.5	-56.9	-13.7	-13.4	-8.5	-5.5	-3.6	-2.4	-1.7	-1.4	-1.2
Population	Thousands	-41.9	-29.1	-23.2	-18.2	-14.3	-11.4	-9.2	-7.7	-6.5	-5.7	-5.0
Labor Force	Thousands	-20.3	-16.3	-13.1	-10.2	-7.7	-5.7	-4.2	-3.2	-2.5	-2.0	-1.7
Gross Domestic Product	$ Billions; Fixed (2019)	4.9	-9.6	-2.6	-2.6	-1.7	-1.2	-0.9	-0.6	-0.5	-0.4	-0.4
Output	$ Billions; Fixed (2019)	8.9	-17.5	-5.1	-5.0	-3.5	-2.5	-1.8	-1.4	-1.1	-1.0	-0.9
Value-Added	$ Billions; Fixed (2019)	4.9	-9.6	-2.6	-2.6	-1.7	-1.2	-0.9	-0.6	-0.5	-0.4	-0.4
Personal Income	$ Billions; Fixed (2019)	0.3	-12.0	-1.5	-2.1	-1.3	-0.9	-0.6	-0.5	-0.4	-0.3	-0.3
Disposable Personal Income	$ Billions; Fixed (2019)	0.0	-10.2	-1.3	-1.8	-1.1	-0.8	-0.5	-0.4	-0.3	-0.3	-0.3
Real Disposable Personal Income	$ Billions; Fixed (2012)	0.0	-9.3	-1.2	-1.6	-1.0	-0.7	-0.5	-0.4	-0.3	-0.3	-0.3
Real Disposable Personal Income per Capita	$ Thousands; Fixed (2012)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCE-Price Index	2012=100 (Nation)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Source: KRA using the REMI PI+ Model
Note: Only the US Summary Gross Domestic Product was used in the benefit analysis

Addendum E: Table 14
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
Values and Growth Rates for Conversion from 2050-2060 to 2085-2094 for 0.002 AEP Event
Intermediate Sea-Level Rise Scenario
Recommended Plan

2085 Values Run in 2060 and Growth Rate 2050-2060			
Category	Units	2060	Growth Rate 2050-2060 (%)
Total Employment	Thousands (Jobs)	139.9	0.9823
Private Non-Farm Employment	Thousands (Jobs)	137.1	0.9824
Residence Adjusted Employment	Thousands	134.0	0.9823
Population	Thousands	0.3	1.0000
Labor Force	Thousands	12.8	0.9779
Gross Domestic Product	**$ Billions; Fixed (2019)**	**41.8**	**0.9965**
Output	$ Billions; Fixed (2019)	93.8	1.0006
Value-Added	$ Billions; Fixed (2019)	41.8	0.9965
Personal Income	$ Billions; Fixed (2019)	17.4	0.9961
Disposable Personal Income	$ Billions; Fixed (2019)	14.9	0.9961
Real Disposable Personal Income	$ Billions; Fixed (2012)	13.4	0.9956
Real Disposable Personal Income per Capita	$ Thousands; Fixed (2012)	0.3	0.9883
PCE-Price Index	2012=100 (Nation)	0.0	0.0212
2085 Values Run in 2060 and Growth Rate 2050-2060			
Category	Units	2060	Growth Rate 2050-2060 (%)
Total Employment	Thousands (Jobs)	99.1	0.9830
Private Non-Farm Employment	Thousands (Jobs)	94.8	0.9832
Residence Adjusted Employment	Thousands	77.1	0.9829
Population	Thousands	75.5	0.9936
Labor Force	Thousands	43.9	0.9905
Gross Domestic Product	$ Billions; Fixed (2019)	33.8	0.9962
Output	$ Billions; Fixed (2019)	79.0	1.0006
Value-Added	$ Billions; Fixed (2019)	33.8	0.9962
Personal Income	$ Billions; Fixed (2019)	14.1	0.9986
Disposable Personal Income	$ Billions; Fixed (2019)	12.4	0.9984
Real Disposable Personal Income	$ Billions; Fixed (2012)	11.2	0.9982
Real Disposable Personal Income per Capita	$ Thousands; Fixed (2012)	0.6	0.9847
PCE-Price Index	2012=100 (Nation)	0.1	0.0545

Addendum E: Table 14 (continued)
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
Values and Growth Rates for Conversion from 2050-2060 to 2085-2094 for 0.002 AEP Event
Intermediate Sea-Level Rise Scenario
Recommended Plan

2085 Values Run in 2060 and Growth Rate 2050-2060			
Category	Units	2060	Growth Rate 2050-2060 (%)
Total Employment	Thousands (Jobs)	16.1	0.9733
Private Non-Farm Employment	Thousands (Jobs)	17.0	0.9745
Residence Adjusted Employment	Thousands	31.5	0.9786
Population	Thousands	-40.3	1.0051
Labor Force	Thousands	-14.0	1.0155
Gross Domestic Product	$ Billions; Fixed (2019)	3.0	0.9905
Output	$ Billions; Fixed (2019)	5.4	0.9929
Value-Added	$ Billions; Fixed (2019)	3.0	0.9905
Personal Income	$ Billions; Fixed (2019)	3.0	0.9847
Disposable Personal Income	$ Billions; Fixed (2019)	2.5	0.9853
Real Disposable Personal Income	$ Billions; Fixed (2012)	2.2	0.9834
Real Disposable Personal Income per Capita	$ Thousands; Fixed (2012)	0.2	1.0000
PCE-Price Index	2012=100 (Nation)	0.0	0.0091
2085 Values Run in 2060 and Growth Rate 2050-2060			
Category	Units	2060	Growth Rate 2050-2060 (%)
Total Employment	Thousands (Jobs)	24.7	0.9854
Private Non-Farm Employment	Thousands (Jobs)	25.3	0.9851
Residence Adjusted Employment	Thousands	25.4	0.9851
Population	Thousands	-34.9	0.9819
Labor Force	Thousands	-17.1	0.9830
Gross Domestic Product	$ Billions; Fixed (2019)	5.0	1.0020
Output	$ Billions; Fixed (2019)	9.4	1.0055
Value-Added	$ Billions; Fixed (2019)	5.0	1.0020
Personal Income	$ Billions; Fixed (2019)	0.3	1.0000
Disposable Personal Income	$ Billions; Fixed (2019)	0.0	0.0000
Real Disposable Personal Income	$ Billions; Fixed (2012)	0.0	0.0000
Real Disposable Personal Income per Capita	$ Thousands; Fixed (2012)	0.0	0.0000
PCE-Price Index	2012=100 (Nation)	0.0	0.0000

Source: KRA using the REMI PI+ Model
Note: Only the US Summary Gross Domestic Product was used in the benefit analysis

Addendum E: Table 15

Coastal Texas Protection and Restoration Study Integrated Feasibility Report

Economic Impact Summary for 2085-2094 for 0.002 AEP Event Occuring in 2085, U.S. and Three Regions

Intermediate Sea-Level Rise Scenario

Recommended Plan

U.S. Summary-Change from Baseline Due to Flood Protection Measures											
Category	Units	2085	2086	2087	2088	2089	2090	2091	2092	2093	2094
Total Employment	Thousands (Jobs)	89.9	-34.4	-5.9	-7.2	-4.6	-2.9	-1.6	-0.7	-0.1	0.2
Private Non-Farm Employment	Thousands (Jobs)	88.4	-34.4	-5.9	-7.0	-4.4	-2.8	-1.6	-0.7	-0.1	0.2
Residence Adjusted Employment	Thousands	85.9	-35.3	-6.5	-7.7	-5.1	-3.3	-2.0	-1.1	-0.5	-0.2
Population	Thousands	-3.6	-4.9	-4.7	-4.8	-4.8	-4.6	-4.4	-4.2	-3.9	-3.5
Labor Force	Thousands	2.9	-5.2	-5.3	-6.1	-6.4	-6.1	-5.8	-5.3	-4.9	-4.4
Gross Domestic Product	**$ Billions; Fixed (2019)**	**38.4**	**-10.6**	**-2.4**	**-2.8**	**-1.9**	**-1.3**	**-0.9**	**-0.5**	**-0.4**	**-0.2**
Output	$ Billions; Fixed (2019)	95.6	-21.9	-5.4	-6.0	-4.4	-3.1	-2.1	-1.5	-1.0	-0.7
Value-Added	$ Billions; Fixed (2019)	38.4	-10.6	-2.4	-2.8	-1.9	-1.3	-0.9	-0.5	-0.4	-0.2
Personal Income	$ Billions; Fixed (2019)	16.0	-13.0	-0.3	-1.2	-0.5	0.0	0.2	0.3	0.5	0.6
Disposable Personal Income	$ Billions; Fixed (2019)	13.6	-0.9	1.2	0.8	0.7	0.8	0.7	0.8	0.8	0.8
Real Disposable Personal Income	$ Billions; Fixed (2012)	12.2	-0.8	1.1	0.7	0.7	0.7	0.7	0.8	0.8	0.7
Real Disposable Personal Income per Capita	$ Thousands; Fixed (2012)	1.8	-0.7	-0.4	-0.4	-0.2	-0.2	-0.2	-0.2	-0.1	-0.1
PCE-Price Index	2012=100 (Nation)	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5-County Region-Change from Baseline Due to Flood Protection Measures											
Category	Units	2085	2086	2087	2088	2089	2090	2091	2092	2093	2094
Total Employment	Thousands (Jobs)	64.6	3.8	4.6	3.4	2.9	2.7	2.6	2.6	2.6	2.5
Private Non-Farm Employment	Thousands (Jobs)	62.1	2.2	3.5	2.7	2.3	2.3	2.2	2.2	2.3	2.3
Residence Adjusted Employment	Thousands	50.1	2.6	4.2	3.3	3.1	3.0	2.8	2.8	2.7	2.7
Population	Thousands	64.3	51.1	43.5	37.5	32.8	29.2	26.4	24.0	22.1	20.5
Labor Force	Thousands	34.6	23.0	18.0	14.0	11.2	9.2	7.8	6.7	5.9	5.2
Gross Domestic Product	$ Billions; Fixed (2019)	30.8	0.8	1.1	0.7	0.6	0.6	0.6	0.6	0.6	0.6
Output	$ Billions; Fixed (2019)	80.3	1.4	1.9	1.3	1.1	1.1	1.1	1.2	1.2	1.3
Value-Added	$ Billions; Fixed (2019)	30.8	0.8	1.1	0.7	0.6	0.6	0.6	0.6	0.6	0.6
Personal Income	$ Billions; Fixed (2019)	13.6	0.5	2.0	1.7	1.6	1.6	1.5	1.5	1.5	1.5
Disposable Personal Income	$ Billions; Fixed (2019)	11.9	0.5	1.9	1.6	1.5	1.5	1.4	1.4	1.4	1.4
Real Disposable Personal Income	$ Billions; Fixed (2012)	10.7	0.4	1.7	1.4	1.4	1.3	1.3	1.3	1.3	1.2
Real Disposable Personal Income per Capita	$ Thousands; Fixed (2012)	0.8	-0.7	-0.4	-0.4	-0.2	-0.2	-0.2	-0.2	-0.1	-0.1
PCE-Price Index	2012=100 (Nation)	0.1	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Addendum E: Table 15 (continued)
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
Economic Impact Summary for 2085-2094 for 0.002 AEP Event Occuring in 2085, U.S. and Three Regions
Intermediate Sea-Level Rise Scenario
Recommended Plan

Rest of Texas-Change from Baseline Due to Flood Protection Measures											
Category	Units	2085	2086	2087	2088	2089	2090	2091	2092	2093	2094
Total Employment	Thousands (Jobs)	8.2	-4.0	-2.4	-2.6	-2.5	-2.3	-2.1	-1.9	-1.7	-1.6
Private Non-Farm Employment	Thousands (Jobs)	8.9	-3.8	-2.1	-2.4	-2.3	-2.1	-1.9	-1.7	-1.6	-1.4
Residence Adjusted Employment	Thousands	18.4	-4.1	-2.6	-3.1	-3.1	-3.0	-2.7	-2.5	-2.2	-2.0
Population	Thousands	-45.8	-40.6	-36.0	-32.6	-30.1	-27.8	-25.9	-24.1	-22.6	-21.0
Labor Force	Thousands	-20.6	-19.2	-16.1	-14.6	-13.4	-12.2	-11.3	-10.3	-9.4	-8.6
Gross Domestic Product	$ Billions; Fixed (2019)	2.4	-1.1	-0.6	-0.7	-0.6	-0.6	-0.6	-0.5	-0.4	-0.4
Output	$ Billions; Fixed (2019)	4.5	-2.1	-1.2	-1.3	-1.3	-1.2	-1.1	-1.0	-0.9	-0.8
Value-Added	$ Billions; Fixed (2019)	2.4	-1.1	-0.6	-0.7	-0.6	-0.6	-0.6	-0.5	-0.4	-0.4
Personal Income	$ Billions; Fixed (2019)	2.0	-1.5	-0.8	-0.8	-0.8	-0.8	-0.8	-0.7	-0.6	-0.6
Disposable Personal Income	$ Billions; Fixed (2019)	1.7	-1.4	-0.7	-0.8	-0.8	-0.7	-0.7	-0.7	-0.7	-0.6
Real Disposable Personal Income	$ Billions; Fixed (2012)	1.4	-1.2	-0.6	-0.7	-0.7	-0.6	-0.6	-0.6	-0.6	-0.5
Real Disposable Personal Income per Capita	$ Thousands; Fixed (2012)	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCE-Price Index	2012=100 (Nation)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rest of U.S.-Change from Baseline Due to Flood Protection Measures											
Category	Units	2085	2086	2087	2088	2089	2090	2091	2092	2093	2094
Total Employment	Thousands (Jobs)	17.1	-34.2	-8.1	-8.0	-5.0	-3.3	-2.1	-1.4	-1.0	-0.8
Private Non-Farm Employment	Thousands (Jobs)	17.4	-32.8	-7.3	-7.3	-4.5	-2.9	-1.8	-1.2	-0.8	-0.7
Residence Adjusted Employment	Thousands	17.5	-33.7	-8.1	-7.9	-5.0	-3.3	-2.1	-1.4	-1.0	-0.8
Population	Thousands	-22.1	-15.3	-12.2	-9.6	-7.5	-6.0	-4.9	-4.1	-3.4	-3.0
Labor Force	Thousands	-11.1	-8.9	-7.2	-5.6	-4.2	-3.1	-2.3	-1.8	-1.4	-1.1
Gross Domestic Product	$ Billions; Fixed (2019)	5.3	-10.3	-2.8	-2.8	-1.8	-1.3	-1.0	-0.6	-0.5	-0.4
Output	$ Billions; Fixed (2019)	10.8	-21.2	-6.2	-6.1	-4.2	-3.0	-2.2	-1.7	-1.3	-1.2
Value-Added	$ Billions; Fixed (2019)	5.3	-10.3	-2.8	-2.8	-1.8	-1.3	-1.0	-0.6	-0.5	-0.4
Personal Income	$ Billions; Fixed (2019)	0.3	-12.0	-1.5	-2.1	-1.3	-0.9	-0.6	-0.5	-0.4	-0.3
Disposable Personal Income	$ Billions; Fixed (2019)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Real Disposable Personal Income	$ Billions; Fixed (2012)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Real Disposable Personal Income per Capita	$ Thousands; Fixed (2012)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCE-Price Index	2012=100 (Nation)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Source: KRA using the REMI PI+ Model
Note: Only the US Summary Gross Domestic Product was used in the benefit analysis

Addendum E: Table 16
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
Economic Impact Summary for 2050-2060 for 0.001 AEP Event Occuring in 2085, U.S. and Three Regions
Intermediate Sea-Level Rise Scenario
Recommended Plan

U.S. Summary-Change from Baseline; 2085 Values Run in 2050												
Category	Units	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060
Total Employment	Thousands (Jobs)	173.0	-62.4	-11.7	-14.4	-9.8	-6.8	-4.3	-2.6	-1.4	-0.8	-0.3
Private Non-Farm Employment	Thousands (Jobs)	169.1	-62.9	-11.6	-14.0	-9.3	-6.4	-4.0	-2.3	-1.2	-0.5	-0.2
Residence Adjusted Employment	Thousands	165.6	-63.0	-12.0	-14.4	-9.9	-6.8	-4.3	-2.6	-1.5	-0.8	-0.4
Population	Thousands	0.2	0.7	1.0	1.4	1.6	1.8	2.0	2.2	2.3	2.4	2.4
Labor Force	Thousands	16.4	4.8	2.7	0.9	0.2	0.0	0.1	0.2	0.2	0.2	0.3
Gross Domestic Product	**$ Billions; Fixed (2019)**	**44.6**	**-10.6**	**-2.4**	**-2.9**	**-2.1**	**-1.5**	**-1.1**	**-0.8**	**-0.4**	**-0.3**	**-0.2**
Output	$ Billions; Fixed (2019)	96.2	-19.5	-5.0	-5.7	-4.2	-3.1	-2.3	-1.5	-1.0	-0.8	-0.6
Value-Added	$ Billions; Fixed (2019)	44.6	-10.6	-2.4	-2.9	-2.1	-1.5	-1.1	-0.8	-0.4	-0.3	-0.2
Personal Income	$ Billions; Fixed (2019)	18.6	-14.5	-0.7	-1.6	-0.9	-0.6	-0.2	-0.2	0.0	0.1	0.2
Disposable Personal Income	$ Billions; Fixed (2019)	15.9	-12.5	-0.6	-1.5	-0.7	-0.5	-0.2	-0.1	0.0	0.1	0.2
Real Disposable Personal Income	$ Billions; Fixed (2012)	14.5	-11.3	-0.5	-1.3	-0.7	-0.4	-0.2	-0.1	0.1	0.1	0.2
Real Disposable Personal Income per Capita	$ Thousands; Fixed (2012)	0.3	-0.2	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0
PCE-Price Index	2012=100 (Nation)	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5-County Region-Change from Baseline; 2085 Values Run in 2050												
Category	Units	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060
Total Employment	Thousands (Jobs)	121.0	6.7	8.2	5.9	5.0	4.6	4.5	4.5	4.5	4.4	4.4
Private Non-Farm Employment	Thousands (Jobs)	115.6	3.6	6.2	4.5	4.0	3.8	3.8	3.8	3.9	3.9	3.9
Residence Adjusted Employment	Thousands	94.2	4.4	7.4	5.9	5.4	5.1	5.0	4.9	4.8	4.7	4.5
Population	Thousands	79.5	62.9	53.5	46.1	40.3	35.8	32.3	29.4	27.0	25.0	23.2
Labor Force	Thousands	48.2	31.9	24.9	19.4	15.5	12.7	10.7	9.2	8.0	7.1	6.4
Gross Domestic Product	$ Billions; Fixed (2019)	36.1	0.8	1.1	0.7	0.6	0.6	0.6	0.6	0.7	0.7	0.7
Output	$ Billions; Fixed (2019)	80.9	1.2	1.8	1.2	1.0	1.0	1.0	1.1	1.2	1.2	1.2
Value-Added	$ Billions; Fixed (2019)	36.1	0.8	1.1	0.7	0.6	0.6	0.6	0.6	0.7	0.7	0.7
Personal Income	$ Billions; Fixed (2019)	14.6	0.4	2.1	1.8	1.7	1.6	1.6	1.5	1.5	1.5	1.5
Disposable Personal Income	$ Billions; Fixed (2019)	12.8	0.4	1.9	1.6	1.6	1.5	1.5	1.4	1.4	1.4	1.4
Real Disposable Personal Income	$ Billions; Fixed (2012)	11.7	0.4	1.7	1.5	1.4	1.4	1.3	1.3	1.3	1.3	1.3
Real Disposable Personal Income per Capita	$ Thousands; Fixed (2012)	0.7	-0.6	-0.3	-0.3	-0.2	-0.2	-0.2	-0.2	-0.1	-0.1	-0.1
PCE-Price Index	2012=100 (Nation)	0.1	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Addendum E: Table 16 (continued)
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
Economic Impact Summary for 2050-2060 for 0.001 AEP Event Occuring in 2085, U.S. and Three Regions
Intermediate Sea-Level Rise Scenario
Recommended Plan

Rest of Texas-Change from Baseline; 2085 Values Run in 2050												
Category	Units	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060
Total Employment	Thousands (Jobs)	22.5	-10.1	-5.8	-6.4	-6.1	-5.7	-5.2	-4.7	-4.2	-3.8	-3.4
Private Non-Farm Employment	Thousands (Jobs)	23.2	-9.3	-5.0	-5.7	-5.4	-5.1	-4.6	-4.1	-3.7	-3.3	-3.0
Residence Adjusted Employment	Thousands	41.0	-8.6	-5.2	-6.4	-6.5	-6.1	-5.6	-5.1	-4.6	-4.1	-3.6
Population	Thousands	-36.0	-32.0	-28.4	-25.8	-23.8	-22.1	-20.6	-19.2	-17.9	-16.7	-15.5
Labor Force	Thousands	-10.8	-10.3	-8.7	-7.9	-7.3	-6.7	-6.2	-5.7	-5.2	-4.8	-4.4
Gross Domestic Product	$ Billions; Fixed (2019)	3.5	-1.5	-0.8	-0.9	-0.9	-0.8	-0.8	-0.7	-0.6	-0.6	-0.5
Output	$ Billions; Fixed (2019)	6.1	-2.6	-1.5	-1.7	-1.6	-1.5	-1.4	-1.2	-1.1	-1.0	-0.9
Value-Added	$ Billions; Fixed (2019)	3.5	-1.5	-0.8	-0.9	-0.9	-0.8	-0.8	-0.7	-0.6	-0.6	-0.5
Personal Income	$ Billions; Fixed (2019)	3.7	-2.5	-1.2	-1.3	-1.3	-1.3	-1.2	-1.2	-1.1	-1.0	-1.0
Disposable Personal Income	$ Billions; Fixed (2019)	3.1	-2.3	-1.1	-1.3	-1.2	-1.2	-1.1	-1.1	-1.0	-1.0	-0.9
Real Disposable Personal Income	$ Billions; Fixed (2012)	2.8	-2.1	-1.0	-1.1	-1.1	-1.1	-1.0	-1.0	-0.9	-0.9	-0.8
Real Disposable Personal Income per Capita	$ Thousands; Fixed (2012)	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCE-Price Index	2012=100 (Nation)	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rest of U.S.-Change from Baseline; 2085 Values Run in 2050												
Category	Units	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060
Total Employment	Thousands (Jobs)	29.5	-59.0	-14.1	-13.9	-8.7	-5.7	-3.6	-2.4	-1.7	-1.4	-1.3
Private Non-Farm Employment	Thousands (Jobs)	30.3	-57.2	-12.8	-12.8	-7.9	-5.1	-3.2	-2.0	-1.4	-1.1	-1.1
Residence Adjusted Employment	Thousands	30.4	-58.8	-14.2	-13.9	-8.8	-5.8	-3.7	-2.4	-1.7	-1.4	-1.3
Population	Thousands	-43.3	-30.2	-24.1	-18.9	-14.9	-11.9	-9.7	-8.0	-6.8	-5.9	-5.3
Labor Force	Thousands	-21.0	-16.8	-13.5	-10.6	-8.0	-6.0	-4.4	-3.3	-2.6	-2.1	-1.7
Gross Domestic Product	$ Billions; Fixed (2019)	5.0	-9.9	-2.7	-2.7	-1.8	-1.3	-0.9	-0.7	-0.5	-0.4	-0.4
Output	$ Billions; Fixed (2019)	9.2	-18.1	-5.3	-5.2	-3.6	-2.6	-1.9	-1.4	-1.1	-1.0	-0.9
Value-Added	$ Billions; Fixed (2019)	5.0	-9.9	-2.7	-2.7	-1.8	-1.3	-0.9	-0.7	-0.5	-0.4	-0.4
Personal Income	$ Billions; Fixed (2019)	0.3	-12.4	-1.6	-2.1	-1.3	-0.9	-0.6	-0.5	-0.4	-0.4	-0.3
Disposable Personal Income	$ Billions; Fixed (2019)	0.0	-10.6	-1.4	-1.8	-1.1	-0.8	-0.6	-0.4	-0.4	-0.3	-0.3
Real Disposable Personal Income	$ Billions; Fixed (2012)	0.0	-9.6	-1.2	-1.7	-1.0	-0.7	-0.5	-0.4	-0.3	-0.3	-0.3
Real Disposable Personal Income per Capita	$ Thousands; Fixed (2012)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCE-Price Index	2012=100 (Nation)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Source: KRA using the REMI PI+ Model
Note: Only the US Summary Gross Domestic Product was used in the benefit analysis

Addendum E: Table 17

Coastal Texas Protection and Restoration Study Integrated Feasibility Report

Values and Growth Rates for Conversion from 2050-2060 to 2085-2094 for 0.001 AEP Event

Intermediate Sea-Level Rise Scenario

Recommended Plan

2085 Values Run in 2060 and Growth Rate 2050-2060			
Category	Units	2060	Growth Rate 2050-2060 (%)
Total Employment	Thousands (Jobs)	138.7	0.9781
Private Non-Farm Employment	Thousands (Jobs)	136.0	0.9785
Residence Adjusted Employment	Thousands	132.9	0.9782
Population	Thousands	0.1	0.9330
Labor Force	Thousands	12.6	0.9740
Gross Domestic Product	**$ Billions; Fixed (2019)**	**41.4**	**0.9926**
Output	$ Billions; Fixed (2019)	92.9	0.9965
Value-Added	$ Billions; Fixed (2019)	41.4	0.9926
Personal Income	$ Billions; Fixed (2019)	17.2	0.9922
Disposable Personal Income	$ Billions; Fixed (2019)	14.6	0.9915
Real Disposable Personal Income	$ Billions; Fixed (2012)	13.3	0.9914
Real Disposable Personal Income per Capita	$ Thousands; Fixed (2012)	0.3	0.9883
PCE-Price Index	2012=100 (Nation)	0.0	0.0212
2085 Values Run in 2060 and Growth Rate 2050-2060			
Category	Units	2060	Growth Rate 2050-2060 (%)
Total Employment	Thousands (Jobs)	98.4	0.9795
Private Non-Farm Employment	Thousands (Jobs)	94.2	0.9797
Residence Adjusted Employment	Thousands	76.6	0.9795
Population	Thousands	73.3	0.9919
Labor Force	Thousands	42.8	0.9882
Gross Domestic Product	$ Billions; Fixed (2019)	33.5	0.9926
Output	$ Billions; Fixed (2019)	78.3	0.9967
Value-Added	$ Billions; Fixed (2019)	33.5	0.9926
Personal Income	$ Billions; Fixed (2019)	13.9	0.9951
Disposable Personal Income	$ Billions; Fixed (2019)	12.2	0.9952
Real Disposable Personal Income	$ Billions; Fixed (2012)	11.1	0.9947
Real Disposable Personal Income per Capita	$ Thousands; Fixed (2012)	0.6	0.9847
PCE-Price Index	2012=100 (Nation)	0.1	0.0545

Addendum E: Table 17 (continued)
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
Values and Growth Rates for Conversion from 2050-2060 to 2085-2094 for 0.001 AEP Event
Intermediate Sea-Level Rise Scenario
Recommended Plan

2085 Values Run in 2060 and Growth Rate 2050-2060			
Category	Units	2060	Growth Rate 2050-2060 (%)
Total Employment	Thousands (Jobs)	16.1	0.9671
Private Non-Farm Employment	Thousands (Jobs)	17.0	0.9694
Residence Adjusted Employment	Thousands	31.4	0.9737
Population	Thousands	-38.4	1.0065
Labor Force	Thousands	-13.1	1.0195
Gross Domestic Product	$ Billions; Fixed (2019)	3.0	0.9847
Output	$ Billions; Fixed (2019)	5.4	0.9879
Value-Added	$ Billions; Fixed (2019)	3.0	0.9847
Personal Income	$ Billions; Fixed (2019)	3.1	0.9825
Disposable Personal Income	$ Billions; Fixed (2019)	2.5	0.9787
Real Disposable Personal Income	$ Billions; Fixed (2012)	2.3	0.9805
Real Disposable Personal Income per Capita	$ Thousands; Fixed (2012)	0.2	1.0000
PCE-Price Index	2012=100 (Nation)	0.0	0.0091
2085 Values Run in 2060 and Growth Rate 2050-2060			
Category	Units	2060	Growth Rate 2050-2060 (%)
Total Employment	Thousands (Jobs)	24.2	0.9804
Private Non-Farm Employment	Thousands (Jobs)	24.8	0.9802
Residence Adjusted Employment	Thousands	24.9	0.9802
Population	Thousands	-34.8	0.9784
Labor Force	Thousands	-17.1	0.9797
Gross Domestic Product	$ Billions; Fixed (2019)	4.9	0.9980
Output	$ Billions; Fixed (2019)	9.2	1.0000
Value-Added	$ Billions; Fixed (2019)	4.9	0.9980
Personal Income	$ Billions; Fixed (2019)	0.2	0.9603
Disposable Personal Income	$ Billions; Fixed (2019)	-0.1	0.0000
Real Disposable Personal Income	$ Billions; Fixed (2012)	-0.1	0.0000
Real Disposable Personal Income per Capita	$ Thousands; Fixed (2012)	0.0	0.0000
PCE-Price Index	2012=100 (Nation)	0.0	0.0000

Source: KRA using the REMI PI+ Model
Note: Only the US Summary Gross Domestic Product was used in the benefit analysis

Addendum E: Table 18

Coastal Texas Protection and Restoration Study Integrated Feasibility Report

Economic Impact Summary for 2085-2094 for 0.001 AEP Event Occuring in 2085, U.S. and Three Regions

Intermediate Sea-Level Rise Scenario

Recommended Plan

U.S. Summary-Change from Baseline Due to Flood Protection Measures											
Category	Units	2085	2086	2087	2088	2089	2090	2091	2092	2093	2094
Total Employment	Thousands (Jobs)	80.4	-29.4	-4.9	-6.1	-3.8	-2.4	-1.2	-0.5	0.0	0.3
Private Non-Farm Employment	Thousands (Jobs)	79.3	-29.7	-5.0	-6.1	-3.8	-2.4	-1.3	-0.5	0.0	0.2
Residence Adjusted Employment	Thousands	76.9	-30.5	-5.5	-6.6	-4.3	-2.8	-1.6	-0.8	-0.3	0.0
Population	Thousands	-5.4	-6.8	-6.5	-6.4	-6.4	-6.3	-6.0	-5.7	-5.3	-4.9
Labor Force	Thousands	0.3	-7.4	-7.2	-7.9	-8.0	-7.7	-7.3	-6.7	-6.2	-5.8
Gross Domestic Product	**$ Billions; Fixed (2019)**	**34.5**	**-9.5**	**-2.1**	**-2.5**	**-1.7**	**-1.2**	**-0.8**	**-0.6**	**-0.3**	**-0.2**
Output	$ Billions; Fixed (2019)	85.3	-18.7	-4.7	-5.2	-3.8	-2.7	-1.9	-1.2	-0.7	-0.6
Value-Added	$ Billions; Fixed (2019)	34.5	-9.5	-2.1	-2.5	-1.7	-1.2	-0.8	-0.6	-0.3	-0.2
Personal Income	$ Billions; Fixed (2019)	14.4	-4.0	0.7	0.3	0.4	0.4	0.6	0.5	0.6	0.6
Disposable Personal Income	$ Billions; Fixed (2019)	12.3	-0.7	1.1	0.7	0.8	0.7	0.7	0.7	0.7	0.7
Real Disposable Personal Income	$ Billions; Fixed (2012)	11.1	-0.7	0.9	0.7	0.6	0.6	0.6	0.6	0.6	0.6
Real Disposable Personal Income per Capita	$ Thousands; Fixed (2012)	0.6	-0.3	-0.2	-0.2	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1
PCE-Price Index	2012=100 (Nation)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5-County Region-Change from Baseline Due to Flood Protection Measures											
Category	Units	2085	2086	2087	2088	2089	2090	2091	2092	2093	2094
Total Employment	Thousands (Jobs)	58.7	3.2	4.0	2.9	2.4	2.2	2.2	2.2	2.2	2.1
Private Non-Farm Employment	Thousands (Jobs)	56.5	1.8	3.0	2.2	2.0	1.9	1.9	1.9	1.9	1.9
Residence Adjusted Employment	Thousands	45.7	2.1	3.6	2.9	2.6	2.5	2.4	2.4	2.3	2.3
Population	Thousands	59.8	47.3	40.3	34.7	30.3	26.9	24.3	22.1	20.3	18.8
Labor Force	Thousands	31.8	21.0	16.4	12.8	10.2	8.4	7.1	6.1	5.3	4.7
Gross Domestic Product	$ Billions; Fixed (2019)	27.8	0.6	0.8	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Output	$ Billions; Fixed (2019)	72.2	1.1	1.6	1.1	0.9	0.9	0.9	1.0	1.1	1.1
Value-Added	$ Billions; Fixed (2019)	27.8	0.6	0.8	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Personal Income	$ Billions; Fixed (2019)	12.3	0.3	1.8	1.5	1.4	1.3	1.3	1.3	1.3	1.3
Disposable Personal Income	$ Billions; Fixed (2019)	10.8	0.3	1.6	1.4	1.4	1.3	1.3	1.2	1.2	1.2
Real Disposable Personal Income	$ Billions; Fixed (2012)	9.7	0.3	1.4	1.2	1.2	1.2	1.1	1.1	1.1	1.1
Real Disposable Personal Income per Capita	$ Thousands; Fixed (2012)	0.4	-0.3	-0.2	-0.2	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1
PCE-Price Index	2012=100 (Nation)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Addendum E: Table 18 (continued)
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
Economic Impact Summary for 2085-2094 for 0.001 AEP Event Occuring in 2085, U.S. and Three Regions
Intermediate Sea-Level Rise Scenario
Recommended Plan

Rest of Texas-Change from Baseline Due to Flood Protection Measures											
Category	Units	2085	2086	2087	2088	2089	2090	2091	2092	2093	2094
Total Employment	Thousands (Jobs)	7.0	-3.1	-1.8	-2.0	-1.9	-1.8	-1.6	-1.5	-1.3	-1.2
Private Non-Farm Employment	Thousands (Jobs)	7.8	-3.1	-1.7	-1.9	-1.8	-1.7	-1.5	-1.4	-1.2	-1.1
Residence Adjusted Employment	Thousands	16.1	-3.4	-2.0	-2.5	-2.6	-2.4	-2.2	-2.0	-1.8	-1.6
Population	Thousands	-45.1	-40.1	-35.6	-32.3	-29.8	-27.7	-25.8	-24.1	-22.4	-20.9
Labor Force	Thousands	-21.2	-20.2	-17.1	-15.5	-14.3	-13.2	-12.2	-11.2	-10.2	-9.4
Gross Domestic Product	$ Billions; Fixed (2019)	2.0	-0.9	-0.5	-0.5	-0.5	-0.5	-0.5	-0.4	-0.3	-0.3
Output	$ Billions; Fixed (2019)	4.0	-1.7	-1.0	-1.1	-1.0	-1.0	-0.9	-0.8	-0.7	-0.7
Value-Added	$ Billions; Fixed (2019)	2.0	-0.9	-0.5	-0.5	-0.5	-0.5	-0.5	-0.4	-0.3	-0.3
Personal Income	$ Billions; Fixed (2019)	2.0	-1.3	-0.6	-0.7	-0.7	-0.7	-0.6	-0.6	-0.6	-0.5
Disposable Personal Income	$ Billions; Fixed (2019)	1.5	-1.1	-0.5	-0.6	-0.6	-0.6	-0.5	-0.5	-0.5	-0.5
Real Disposable Personal Income	$ Billions; Fixed (2012)	1.4	-1.1	-0.5	-0.6	-0.6	-0.6	-0.5	-0.5	-0.5	-0.5
Real Disposable Personal Income per Capita	$ Thousands; Fixed (2012)	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCE-Price Index	2012=100 (Nation)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rest of U.S.-Change from Baseline Due to Flood Protection Measures											
Category	Units	2085	2086	2087	2088	2089	2090	2091	2092	2093	2094
Total Employment	Thousands (Jobs)	14.8	-29.5	-7.1	-7.0	-4.4	-2.9	-1.8	-1.2	-0.9	-0.7
Private Non-Farm Employment	Thousands (Jobs)	15.0	-28.4	-6.3	-6.3	-3.9	-2.5	-1.6	-1.0	-0.7	-0.5
Residence Adjusted Employment	Thousands	15.1	-29.2	-7.1	-6.9	-4.4	-2.9	-1.8	-1.2	-0.8	-0.7
Population	Thousands	-20.2	-14.1	-11.2	-8.8	-6.9	-5.5	-4.5	-3.7	-3.2	-2.7
Labor Force	Thousands	-10.2	-8.2	-6.6	-5.2	-3.9	-2.9	-2.1	-1.6	-1.3	-1.0
Gross Domestic Product	$ Billions; Fixed (2019)	4.7	-9.2	-2.5	-2.5	-1.7	-1.2	-0.8	-0.7	-0.5	-0.4
Output	$ Billions; Fixed (2019)	9.2	-18.1	-5.3	-5.2	-3.6	-2.6	-1.9	-1.4	-1.1	-1.0
Value-Added	$ Billions; Fixed (2019)	4.7	-9.2	-2.5	-2.5	-1.7	-1.2	-0.8	-0.7	-0.5	-0.4
Personal Income	$ Billions; Fixed (2019)	0.1	-3.0	-0.4	-0.5	-0.3	-0.2	-0.1	-0.1	-0.1	-0.1
Disposable Personal Income	$ Billions; Fixed (2019)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Real Disposable Personal Income	$ Billions; Fixed (2012)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Real Disposable Personal Income per Capita	$ Thousands; Fixed (2012)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCE-Price Index	2012=100 (Nation)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Source: KRA using the REMI PI+ Model
Note: Only the US Summary Gross Domestic Product was used in the benefit analysis

REMI report. The economic analysis for the REMI model analysis underwent a Focused ATR in June 2020 and was approved by the CSRM-PCX in July 2020. The technical details of the REMI model analysis can be found in the following report prepared for Galveston District U.S. Army Corps of Engineers entitled "Coastal Texas Flood Damage Losses and Regional Economic Impacts," dated 19 June 2020.

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COASTAL TEXAS FLOOD DAMAGE LOSSES AND REGIONAL ECONOMIC IMPACT

PREPARED FOR ARCADIS, INC.

By
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June 19, 2020

Coastal Texas Flood Damage Losses and Regional Economic Impact

INTRODUCTION

We estimated the avoided storm-surge damage losses linked to flood protection measures for two Texas regions and a third region that covers the rest of the United States. We used a hybrid input-output/econometric model developed by Regional Economic Models, Inc. This model uses the industry structure of regions, their factor markets, trade flows of goods and services both within and between the regions, and their demographic characteristics to determine the economic impact linked to storm damage protection. The model, known as the REMI PI+ model, was calibrated for three regions which are defined as: 1. A five-county southeastern Texas region surrounding the cities of Houston and Galveston which includes Brazoria, Chambers, Galveston, Harris, and Jefferson counties (shown in estimates as "5 Counties".) 2. The remaining 249 Texas counties, which were combined to form a region shown as the "Rest of Texas". 3. The other 49 states and District of Columbia were combined and shown as the "Rest of U.S.".

In this report, we describe the methods and assumptions used to estimate the economic impact of flood protection measures on the three regions for the 2035 and 2085 reference years. These estimates will support cost-benefit analyses related to flood control management and infrastructure provision, and help determine whether such provision will generate a sufficient economic development benefits to the nation to merit federal funding for the 2035 and 2085 timeframes. The report is presented in four sections: In the first, we describe the avoided loss estimates (or "avoided damage") to structures and their contents. Further, we describe how these are used to form the direct impact estimates that are entered into the REMI model from which we estimate total economic impacts. We show the direct impact values for 2035 and 2085 as transformed for use with the REMI model. In the second section, we present our methodology for quantifying total impacts with the model. In the third section, we present illustrative summary tables of the total economic impact of avoided losses in which the immediate total impact and those that follow in subsequent years are given. Tables for a 100-year event for 2035 and 2085 are presented here. A complete set is found in the two Excel workbooks that accompany this report, one for each reference year. (See **Summary Impact Estimates-2035.xlsx** and **Summary Impact Estimates-2085.xlsx**.) Each workbook presents the estimated impact for flooding conditions that depict 100-, 200-, 500-, and 1000-year flood depths. Finally, in the last section we provide an appendix in which we provide an overview of the REMI model structure and detail regarding how the Dodge building stock data were used in preparing the direct impact estimates for nonresidential structures.

I. AVOIDED LOSS ESTIMATES

The starting point for our impact modeling is the loss estimates provided by the US Army Corps of Engineers (USACE) for structures and their contents. These figures were developed by USACE using the Hydrologic Engineering Center-Flood Damage Analysis model. The damage model estimates the water depth of flood damage to structures and their contents based on hydrological and topographical features of the natural and human-made environment for the study region. These estimates were prepared for four different levels of storm-related flooding that correspond to water depths associated with 100-, 200-, 500-, and 1000-year events. For each flood-stage scenario, estimates of water damage with and without flood control were made. The difference between the two represents avoided losses due to new flood control measures.

The USACE estimates were provided in constant ($2019) dollars for two industries of interest, for two reference years in the future, and include figures for the number of structures damaged, damage value, and losses of structure contents. The industries of interest were selected by USACE as being consequential to national economic development. These included manufacturing and warehouse structures, industries that include the petroleum and chemical product sectors which dominate the 5-county regional economy and which are of critical national economic importance. USACE also separately estimated damage to chemical and petroleum storage tanks, a distinct subset of the manufacturing capital stock and not otherwise included as manufacturing structures.

The 5-county region's petroleum and chemical industries national importance is evidenced by their share of national output. Based on 2017 data, the 5-county area generated 18 percent of the total U.S. petroleum and related products output and 34 percent of the U.S. chemical and related product manufacturing output.[1] Given the size and spatial dispersion of the underlying petroleum and natural gas resources, these are high concentration levels. Together, these two industries form the nucleus of a petrochemical complex in the 5-County region. Other industries, such as plastics and rubber, have collocated in the region to take advantage of access to petrochemical products, enhancing the importance of these two industries.

For purposes of this study, the reference years for damage estimation with and without flood control measures are 2035 and 2085. Damage related losses were estimated for flooding events both with and without new control measures. Losses related to structures were expressed as losses in property value for structures and contents, as well as the number of structures. Structure value losses were estimated using unit-construction costs estimates from R.S. Means, Inc. We note that figures for total value, total content value, and total number of structures refer only to the county subareas that will be affected by flood damage protection infrastructure. To determine the proportion of total regional economic losses associated with flood damage, we link the subarea estimates of nonresidential structure losses to the entire region's total output value for those same structure types. These figures give us the proportional losses by nonresidential structure. For residential structures, we estimate the affected population directly from the structures subject to flood damage. The total county residential stock was used to estimate relationships for the number of persons per dwelling unit and number of dwelling units per structure, both statistics reported on a county basis. These county figures were applied to the number of lost structures (and their dwelling unit equivalents) to determine affected population.

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[1]The 2017 output data are from the IMPLAN Texas model. These data include estimates for otherwise suppressed entries in the U.S. Bureau of the Census economic census databases.

We have not undertaken any estimates of avoided loss impact associated with debris removal. Although USACE develops estimates of such costs, we have not modeled the associated economic effects of debris removal because this activity is not considered critical to national economic development. It could be argued that its removal is critical to restoring output of a nationally important activity; however, we have restricted ourselves to the impact of the activity itself, and not to activities indirectly related to it.

II. AVOIDED LOSS DIRECT IMPACT ESTIMATION

Nonresidential Direct Impact

In the absence of empirical enterprise-level production statistics for the affected establishments, we use our estimate of the proportion of structural damage as a proxy for output losses that will result. We assume a linear relationship between structural losses and output reduction. From this, we estimate the loss of annual industry output based on the proportion of structural value loss. We do this for industry output and for in regional losses estimated from data for the individual counties. The former are estimated historically (and projected) within the REMI model[2]. REMI uses output changes to calibrate various transformations that affect labor income, employment, and other production relationships. These, in turn, affect a diverse set of economic variables including production cost, population migration, labor market participation, and wage rates that are used to estimate regional impact effects. For the estimates of pre-flood damaged total regional structure stock-value by industry, we relied on building stock estimates prepared by Dodge Data and Analytics, Inc. (Dodge). These estimates measure annual stock of floorspace by industry for a benchmark year to which empirical construction activity data are added. These gross stock estimates are adjusted for floorspace removals based on age of structures.[3,4]

[2] REMI uses estimated output by industry in each region as the basis for estimating interindustry production and trade volumes. For industries with few regional producers, REMI provides estimates output because the actual data are suppressed by the U.S. Bureau of the Census to prevent identification of firm-level operating statistics.

[3] The REMI model includes total nonresidential capital stock estimates that are based on national data from the Bureau of Economic Analysis and distributed to regions. However, REMI's distribution lacks industry detail and does not employ any empirical capital

Using the annual observations for 2019, we estimated the REMI-based regional industry output value per unit of Dodge-based regional industry structure value. This figure was then applied to the avoided structural damage losses provide by USACE to estimate avoided regional output losses by industry. We note that Dodge-based regional structure value was developed from floor square-footage stock estimates and construction value and that these specifically do not include the value of "outdoor" process equipment that is not enclosed in a structure, a feature characteristic of many petroleum refineries and petrochemical plants. However, the value of process equipment output is included in the REMI output figures. This apparent imbalance is not a cause for concern but does result in relatively high output value figures per unit of structure value. We assume that the structures found on those production sites are essential to the production process and that their avoided loss is critical for controlling the operation of the plants and resulting output. Affected output in correctly scaled to regional total output (i.e., including the value created from outdoor processes) when it comes to entering the REMI model. Using the Dodge warehouse and industrial floorspace estimates for the 5-County Region for 2019, we computed the proportion of total stock loss that would be avoided with the relevant flood control measures in place for the event year. This proportion was then applied to the REMI estimate of the total value of 5-County regional avoided output loss to provide a one-year avoided loss estimate. For damage that would reduce output beyond one year, an extended period of avoided loss value would have to be added to the simulation.[5] In order to distinguish avoided output losses of petroleum refining and chemical plant products that represent inventory held in aboveground storage tanks, we adjusted the storage tank contents value figures to account average utilization of tank capacity. This adjustment values total tank as 45% of the total capacity value. The impact of its avoided loss is estimated as a current-account item, although it could be argued that as inventory, it is

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stock measures. The Dodge data, in contrast, are based on county-level perpetual inventory estimates that use actual monthly construction data beginning in 1967. These have been assembled from project-level reports with detailed construction characteristics for industry classification, size, and value.

[4] For further information on the estimation of regional building values that we developed using the Dodge data, see Appendix B.

[5] This can be approximated by scaling the one-year loss with the appropriate factor to represent the avoided loss duration.

not really a current-account loss from a national economic and product perspective.[6] As a practical matter, and in terms of economic impacts, it differs from normal lost manufacturing output by only the deflator used for petroleum and chemical products as opposed to that of all manufactured goods when we converted the value from constant 2019 dollars to the constant 2017 dollars as used in REMI.[7]

We show the direct impact estimates after spatial adjustments and rebasing currency to the REMI basis of $2017 in Table 1.[8] We show the warehouse and industrial estimated output losses in Table 2. Note that in Table 2, no output losses are estimated separately for storage tanks. Output effects stemming from storage tank structure losses are already included under output losses for petroleum refining and chemical production. In both Tables 1 and 2, we note that losses of structures, contents, and output are significantly greater that those for warehouses. Much of the difference is attributable to the outsized importance of petroleum and chemical industries in the region. In general, these industries rely on storage tanks and/or direct shipment of intermediate and finished products by pipeline, railcar, tanker truck, or maritime vessel. Together, they employ almost no warehousing or storage services whatsoever. This can be seen in the 2012 U.S. Bureau of Economic Analysis Input-Output accounts of the U.S. that shows that together, the two sectors use $118 million of warehousing and storage services relative to their total intermediate use of goods

[6] "Current-account" as used in the present context refers to intermediate goods and services transactions used up in the reference period, in this case, one year. Inventory accumulation, however, is often treated as a capital-account transaction, consistent with other forms of investment. For further discussion of these conventions, see Bureau of Economic Analysis, Concepts and Methods of the U.S. Input-Output Accounts, https://www.bea.gov/resources/methodologies/concepts-methods-io-accounts.

[7] We converted 2019 output values to a 2017 basis using price indices given in the Bureau of Economic Analysis National Income and Product Accounts. See: https://apps.bea.gov/iTable/iTable.cfm?reqid=51&step=51&isuri=1&table_list=18&series=a for deflator values by industry.

[8] REMI offers a choice of 2012, 2017, and current dollar for entering most income and product account-type data. In this case, we selected 2017 and converted USACE and other data to that year.

and services amounting to $870 billion, or 0.01% of total intermediate inputs.[9]

Table 1

Avoided Losses: Nonresidential Structure and Contents After Flood Control Measures, 5-County Region

STRUCTURE TYPE/EVENT	Avoided Structure Losses ($2017, million)				Avoided Content Losses ($2017, million)			
	100 Year	200 Year	500 Year	1000 Year	100 Year	200 Year	500 Year	1000 Year
2035								
Warehouse	1.4	2.0	2.6	2.9	1.8	2.6	3.5	3.8
Industrial	991.9	1,376.4	1,719.0	1,895.3	1,183.0	1,836.3	2,350.1	2,585.4
Storage Tanks	89.8	143.8	204.7	241.2	16.1	32.7	58.5	78.0
2085								
Warehouse	2.1	3.2	3.7	3.9	2.8	4.1	4.7	5.2
Industrial	1,268.9	1,673.0	1,908.1	1,965.3	1,682.1	2,258.6	2,687.6	2,873.7
Storage Tanks	134.0	198.5	266.9	311.1	29.1	53.4	86.1	110.6

Sources: KRA, Inc. using data from USACE

Table 2
Avoided Losses: Nonresidential Output After Flood Control Measures, 5-County Region

STRUCTURE TYPE/EVENT	Avoided Output Losses ($2017, million)			
	100 Year	200 Year	500 Year	1000 Year
2035				
Warehouse	0.1	0.1	0.1	0.2
Industrial	18,194.2	25,247.0	31,532.2	34,765.7
2085				
Warehouse	0.1	0.2	0.2	0.2
Industrial	23,275.6	30,688.5	35,001.3	36,050.0

Sources: KRA, Inc. using data from USACE

Residential Direct Impact

We estimate the economic consequences of residential property damage through its affect on population levels. When sufficient damage makes dwelling units uninhabitable, there is a possibility that residents in heavily damaged units will be forced to relocate permanently from the region or for a protracted period as reconstruction

[9] See https://apps.bea.gov/iTable/iTable.cfm?reqid=52&step=100&isuri=1&table_list=4

occurs. While not all levels of flooding will do so, flood depths of only several feet may result in the need for demolition of the structure and relocation of its residents. [10]

The literature documenting empirical population behavior in the face of significant damage remains very limited. One study by Groen and Polivka (2009)[11] offers estimates of how the residents of the New Orleans metropolitan statistical area responded to damages caused by Hurricane Katrina. In that event, nearly 85 percent were forced to relocate for a multi-year period, and by 2014 (nine years later), the New Orleans metropolitan area had regained all but 5 percent of its pre-Katrina population, with the city itself having recovered to approximately 80 percent of its 2000 population by 2014.[12] More relevant to this study, however, are estimates regarding 2017's Hurricane Harvey. This storm caused flooding at a 500-year level, forcing 10 percent of Texas residents affected by the storm to move elsewhere for more than one year. Based on these figures, we adopted a population loss assumption of 10 percent tied to housing damages, and further assumed that of those displaced from the 5-county study area will relocate elsewhere within Texas. This assumption means that 10% of the housing sector's avoided losses also represent population losses that would have otherwise occurred in the 5-county region. We have further assumed that avoided population losses in the one region become avoided population gains in others. In this case, we have assumed the rest of Texas "avoids" a population inflow that stems from flooding of a size equal to the 5-county outflow.[13] Such population shifts affect migration streams in the REMI model, which, in turn, have linkages to consumer demand and ultimately, all parts of the economy, both regionally and nationally. The REMI migration streams are divided into economic- and retirement-related groups, based on population age groupings of 0 to 64 years and 65 years and greater. We

[10] This is not the only means of estimating the economic effects of residential damage. Another method would be to derive the value of housing services lost by means of estimating the rental income losses from uninhabitable or destroyed housing. For housing rentals, these data are given in the Census' Annual Housing Survey estimates. For owner-occupied portion of the housing supply, rental equivalence estimation should be possible. This method entails using rental rates to serve as a basis for determining the equivalent rental rates for owner-occupied units. This is the means by which owner-occupied housing services are entered into the BEA Personal Income estimates, both nationally and for states and smaller areas.

[11] Jeffrey Groen and Polivka, A. E. 2009. "Going Home After Hurricane Katrina: Determinant of Return Migration and Changes in Affected Areas." United States Bureau of Labor Statistics, Working Paper 428.

[12] Plyer, Allison. 2015. "Facts for Features: Katrina Recovery." http://www.datacenterresearch.org/data-resoures/katrina/facts-for-features-katrina-recovery/

[13] The inflow of population to unaffected regions could also include the Rest of the U.S. region. For our purposes, the destination is less importance than is keeping the regional outflow to areas within the U.S. so that estimates of the national economic impact of the local flood control measures reflects no net national population change.

applied the 10 percent relocation to both groups equally, in the absence of empirical data indicating otherwise. We show the direct impact residential population relocation figures in Table 3.

Table 3
Avoided Poulation Relocation After Flood Control Measures by Region in 2035 and 2085: Number of Persons

Scenario/Structure	100 Year Event	200 Year Event	500 Year Event	1000 Year Event
5-County Region				
With Project 2035				
Economic Migration	12,320	16,625	17,889	18,315
Retirement-Aged Migration	2,452	3,308	3,560	3,645
With Project 2085				
Economic Migration	16,194	18,864	20,641	19,799
Retirement-Aged Migration	4,550	5,300	5,799	5,563
Rest of Texas				
With Project 2035				
Economic Migration	-12,320	-16,625	-17,889	-18,315
Retirement-Aged Migration	-2,452	-3,308	-3,560	-3,645
With Project 2085				
Economic Migration	-16,194	-18,864	-20,641	-19,799
Retirement-Aged Migration	-4,550	-5,300	-5,799	-5,563
Rest of U.S.				
With Project 2035				
Economic Migration **Retirement-Aged Migration**	No Direct Impact			
With Project 2085				
Economic Migration **Retirement-Aged Migration**	No Direct Impact			

Sources: KRA, Inc. using data from USACE

III. ESTIMATED IMPACT EXAMPLE FOR 100-YEAR EVENT IN 2035 AND 2085

We show the results for a 100-year event for 2035 and 2085 in Tables 4 and 5. For each year, we show the initial year of the impact and the nine following years' response to the flood damage shock. We have estimated the effects of "avoided losses" in the case of the 5-county region's higher level of flood resilience. These have been entered as marginal increases in economic activity, which stimulate indirect and induced economic responses to that protection. In the case of avoided population relocation, we show the 5-county region "gaining" employment in the simulation and the adjacent Rest of Texas region "losing" population that would have otherwise likely relocated to that region in the absence of greater flood protection.

The spreadsheet tables that accompany this report show tables similar to Tables 4 and 5 that present simulations for each of the event years, i.e., 100-, 200-, 500-, and 1000-year events. Because the REMI model has a "partial-equilibrium" structure, a single annual impact estimate is not a complete reflection of all that takes place. Some events have impacts that span multiple years. For example, with a change in employment in one year, population migration or investment may be result in the following year or years. Generally, the effects of one event will diminish after several years.

In these tables, we show the basic income and product account summary measures as well as demographic, employment, and price-level summary effects. Some of the economic measures, particularly the personal income levels and personal consumption expenditure (PCE) price indexes, show small or no changes stemming from the event avoided losses, particularly for the Rest of Texas or the Rest of the U.S. This is to be expected because not all impacts (at the aggregate level shown in these summaries) are transmitted to relatively distant places. In general, the most sizeable affects are experienced within the region of direct impact.[14]

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[14] In general, the national totals given in the summary tables like Table 4 or 5 are the sum of constituent regions, in this case the 5-County Region, the Rest of Texas, and the Rest of the U.S. In the case of a relative measure such as a price index, the U.S. value is the weighed average of the component regions' index values. In the special case of population where we do not posit a change in international migration in any of the regions, we would expect the sum of the regions to have no effect (i.e., 0-values) on the U.S.

We show three employment impact measures in the tables which are total employment, private nonfarm employment, and residence adjusted employment. The first two are familiar measures, with total employment being the most comprehensive measure available, including both payroll and estimated self- and proprietor-employment. Nonfarm private employment excludes public employment that consists of federal, state, and local governments, as well as military and publicly owned enterprises. Residence adjusted employment represents estimated employment by place of residence to make it conform to the basis of personal income estimates, which are also done on a place of residence basis. For reference, employment statistics reported by the U.S. Bureau of Labor Statistics are normally given on a place of work basis. The difference between the two is almost entirely due to commuting that occurs over the county boundaries that are the reporting unit for those data.

A comparison of the 2035 and 2085 simulations shows that the employment impact (number of jobs) is forecast to decline significantly by 2085. The reason for this derives from the sizeable labor productivity increases that are part of the baseline forecast (+2.7% per year) which drives down employment relative to 2035. In this instance, productivity improvements reduce job numbers by nearly one-third when measured over 50 years. The lowered employment impact for 2035-2085, in turn, has a sizeable affect on personal income, value added, and gross regional product[15] growth, sees only small increases between 2035 and 2085.

In general, after an initial drastic change in output as is the case with flood damage, employment and labor income all reach reasonably stable levels of change after 10 years have passed. Demographic changes, however, persist over a longer period. There are three important assumptions that affect the simulation results that

population. As is seen in Table 4, the U.S. population shows small net population changes. This is the result of economic migration that implicitly allows for different age and gender characteristics of the affected regions. When there are fertility differences in the origin and destination populations, it is possible for migration to alter the number of births and the resulting population over time in a region beyond just that attributable to migration. This accounts for a change in the U.S. population derived from the sum of the constituent regions versus the baseline (or "control") figure that we use to show the impact of the event. For the 2085 figures, we see this figure starts with an initial difference of -9,300 persons that reaches -11,900 by 2094. This discrepancy is the product of extending the fertility differential from the 2060 REMI endpoint to 2085. This should not be cause for concern and is not a critical impact of the avoided losses.

[15] Shown in the tables as "Gross Domestic Product."

have been made to identify the national economic development affects of increased flood protection:

1. Demand for regional output of goods and services is unaltered except for the population relocation that is assumed to occur. Population change affects consumer demand for goods and services, but industrial demand, especially that from exogenous national sources, remains unaltered.
2. The only reconstruction activity that is relevant to national economic development in this instance is assumed to be the avoided loss of structures for manufacturing, warehousing, and storage tanks.
3. Debris removal expenditures are not included in these impact estimates. In general, these are highly localized and not of consequence for the national economy apart from drawing national disaster relief funding not considered here.

In the accompanying Excel workbooks, we show both the baseline forecast and the impact of the flood events. The baseline figures are the levels for the economic measures viewed over the forecast period. The flood event impact estimates shown in Tables 4 and 5 are displayed as differences from the baseline.

Table 4

Economic Impact Summary for 2035-2044 for 100 Year Event Occuring in 2035, U.S. and Three Regions

U.S. Summary-Change from Baseline Due to Flood Protection Measures											
Category	Units	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044
Total Employment	Thousands (Jobs)	115.8	-42.0	-8.0	-10.1	-6.8	-4.5	-2.7	-1.5	-0.7	-0.2
Private Non-Farm Employment	Thousands (Jobs)	112.9	-42.4	-7.9	-9.8	-6.4	-4.2	-2.5	-1.3	-0.5	-0.1
Residence Adjusted Employment	Thousands	110.9	-42.5	-8.2	-10.1	-6.8	-4.5	-2.7	-1.4	-0.6	-0.2
Population	Thousands	0.1	0.3	0.5	0.6	0.7	0.8	0.9	0.9	1.0	1.0
Labor Force	Thousands	11.5	3.1	1.5	0.3	-0.1	-0.2	-0.2	0.0	0.1	0.2
Gross Domestic Product	Billions of Fixed (2019) Dollars	24.1	-5.7	-1.3	-1.6	-1.1	-0.8	-0.5	-0.3	-0.2	-0.1
Output	Billions of Fixed (2019) Dollars	48.8	-9.9	-2.4	-2.9	-2.1	-1.5	-1.0	-0.7	-0.4	-0.2
Value-Added	Billions of Fixed (2019) Dollars	24.1	-5.7	-1.3	-1.6	-1.1	-0.8	-0.5	-0.3	-0.2	-0.1
Personal Income	Billions of Fixed (2019) Dollars	10.4	-7.6	-0.4	-1.0	-0.5	-0.3	-0.2	-0.1	0.0	0.0
Disposable Personal Income	Billions of Fixed (2019) Dollars	8.9	-6.6	-0.3	-0.8	-0.5	-0.3	-0.1	0.0	0.0	0.0
Real Disposable Personal Income	Billions of Fixed (2012) Dollars	8.1	-6.0	-0.3	-0.7	-0.4	-0.2	-0.1	0.0	0.0	0.0
Real Disposable Personal Income per Capita	Thousands of Fixed (2012) Dollars	0.2	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.0	0.0	0.0
PCE-Price Index	2012=100 (Nation)	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5-County Region-Change from Baseline Due to Flood Protection Measures											
Category	Units	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044
Total Employment	Thousands (Jobs)	79.6	4.4	5.0	3.1	2.4	2.1	2.1	2.2	2.3	2.4
Private Non-Farm Employment	Thousands (Jobs)	75.6	2.1	3.6	2.2	1.7	1.6	1.6	1.8	1.9	2.0
Residence Adjusted Employment	Thousands	62.3	2.8	4.5	3.2	2.7	2.6	2.5	2.5	2.6	2.6
Population	Thousands	50.2	39.3	33.2	28.3	24.5	21.6	19.2	17.4	15.8	14.6
Labor Force	Thousands	31.1	20.2	15.6	11.9	9.4	7.5	6.2	5.3	4.6	4.1
Gross Domestic Product	Billions of Fixed (2019) Dollars	19.4	0.5	0.6	0.3	0.2	0.2	0.2	0.2	0.3	0.3
Output	Billions of Fixed (2019) Dollars	40.8	0.7	0.9	0.5	0.3	0.3	0.3	0.4	0.4	0.5
Value-Added	Billions of Fixed (2019) Dollars	19.4	0.5	0.6	0.3	0.2	0.2	0.2	0.2	0.3	0.3
Personal Income	Billions of Fixed (2019) Dollars	7.8	0.1	1.0	0.8	0.7	0.6	0.6	0.6	0.6	0.6
Disposable Personal Income	Billions of Fixed (2019) Dollars	6.9	0.1	0.9	0.7	0.6	0.6	0.6	0.6	0.6	0.6
Real Disposable Personal Income	Billions of Fixed (2012) Dollars	6.3	0.1	0.8	0.6	0.6	0.6	0.5	0.5	0.5	0.5
Real Disposable Personal Income per Capita	Thousands of Fixed (2012) Dollars	0.5	-0.4	-0.2	-0.2	-0.2	-0.1	-0.1	-0.1	-0.1	-0.1
PCE-Price Index	2012=100 (Nation)	0.077	0.292	0.026	0.013	-0.001	-0.008	-0.01	-0.01	-0.01	-0.008
Rest of Texas-Change from Baseline Due to Flood Protection Measures											
Category	Units	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044
Total Employment	Thousands (Jobs)	16.7	-5.9	-3.2	-3.9	-3.8	-3.6	-3.3	-2.9	-2.6	-2.3
Private Non-Farm Employment	Thousands (Jobs)	17.1	-5.4	-2.7	-3.4	-3.4	-3.2	-2.8	-2.5	-2.2	-2.0
Residence Adjusted Employment	Thousands	28.5	-4.9	-2.8	-4.0	-4.1	-3.9	-3.6	-3.2	-2.8	-2.5
Population	Thousands	-20.6	-18.4	-16.3	-15.0	-13.9	-13.0	-12.2	-11.4	-10.7	-9.9
Labor Force	Thousands	-5.6	-5.6	-4.8	-4.5	-4.3	-4.0	-3.8	-3.5	-3.2	-2.9
Gross Domestic Product	Billions of Fixed (2019) Dollars	2.1	-0.7	-0.4	-0.5	-0.5	-0.4	-0.4	-0.4	-0.3	-0.3
Output	Billions of Fixed (2019) Dollars	3.4	-1.2	-0.6	-0.8	-0.8	-0.7	-0.7	-0.6	-0.5	-0.5
Value-Added	Billions of Fixed (2019) Dollars	2.1	-0.7	-0.4	-0.5	-0.5	-0.4	-0.4	-0.4	-0.3	-0.3
Personal Income	Billions of Fixed (2019) Dollars	2.3	-1.1	-0.5	-0.6	-0.6	-0.6	-0.5	-0.5	-0.5	-0.5
Disposable Personal Income	Billions of Fixed (2019) Dollars	1.9	-1.0	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.4
Real Disposable Personal Income	Billions of Fixed (2012) Dollars	1.8	-1.0	-0.4	-0.5	-0.5	-0.5	-0.5	-0.4	-0.4	-0.4
Real Disposable Personal Income per Capita	Thousands of Fixed (2012) Dollars	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCE-Price Index	2012=100 (Nation)	0.02	0.054	0.004	0.004	0.001	-0.001	-0	-0	-0.002	-0.002
Rest of U.S.-Change from Baseline Due to Flood Protection Measures											
Category	Units	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044
Total Employment	Thousands (Jobs)	19.5	-40.5	-9.8	-9.4	-5.4	-3.1	-1.5	-0.7	-0.4	-0.3
Private Non-Farm Employment	Thousands (Jobs)	20.2	-39.1	-8.7	-8.5	-4.8	-2.6	-1.2	-0.5	-0.2	-0.1
Residence Adjusted Employment	Thousands	20.1	-40.4	-9.8	-9.4	-5.4	-3.1	-1.6	-0.8	-0.4	-0.3
Population	Thousands	-29.5	-20.5	-16.4	-12.7	-9.9	-7.7	-6.1	-5.0	-4.2	-3.7
Labor Force	Thousands	-14.0	-11.5	-9.3	-7.1	-5.2	-3.7	-2.6	-1.8	-1.3	-1.0
Gross Domestic Product	Billions of Fixed (2019) Dollars	2.6	-5.5	-1.5	-1.4	-0.9	-0.6	-0.3	-0.2	-0.1	-0.1
Output	Billions of Fixed (2019) Dollars	4.6	-9.4	-2.7	-2.6	-1.7	-1.1	-0.7	-0.4	-0.3	-0.3
Value-Added	Billions of Fixed (2019) Dollars	2.6	-5.5	-1.5	-1.4	-0.9	-0.6	-0.3	-0.2	-0.1	-0.1
Personal Income	Billions of Fixed (2019) Dollars	0.2	-6.5	-0.9	-1.1	-0.6	-0.4	-0.2	-0.2	-0.1	-0.1
Disposable Personal Income	Billions of Fixed (2019) Dollars	0.1	-5.6	-0.7	-1.0	-0.5	-0.3	-0.2	-0.2	-0.1	-0.1
Real Disposable Personal Income	Billions of Fixed (2012) Dollars	0.1	-5.1	-0.7	-0.9	-0.5	-0.3	-0.2	-0.1	-0.1	-0.1
Real Disposable Personal Income per Capita	Thousands of Fixed (2012) Dollars	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCE-Price Index	2012=100 (Nation)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Source: KRA using the REMI PI+ Model

Table 5

Economic Impact Summary for 2085-2094 for 100 Year Event Occuring in 2085, U.S. and Three Regions

U.S. Summary-Change from Baseline Due to Flood Protection Measures											
Category	Units	**2085**	**2086**	**2087**	**2088**	**2089**	**2090**	**2091**	**2092**	**2093**	**2094**
Total Employment	Thousands (Jobs)	63.1	-15.6	-0.6	-1.6	-0.3	0.4	1.0	1.4	1.6	1.7
Private Non-Farm Employment	Thousands (Jobs)	61.3	-17.2	-1.4	-2.2	-0.8	0.0	0.6	1.0	1.3	1.3
Residence Adjusted Employment	Thousands	59.0	-17.5	-1.5	-2.3	-0.9	0.0	0.7	1.1	1.2	1.4
Population	Thousands	-9.3	-14.4	-14.3	-14.6	-14.9	-15.0	-14.3	-13.6	-12.9	-11.9
Labor Force	Thousands	-7.1	-14.6	-13.3	-13.3	-12.9	-12.5	-11.6	-10.7	-9.8	-9.0
Gross Domestic Product	Billions of Fixed (2019) Dollars	25.5	-4.8	-0.7	-0.9	-0.5	-0.3	-0.1	0.1	0.2	0.2
Output	Billions of Fixed (2019) Dollars	63.7	-9.1	-1.6	-2.0	-1.2	-0.7	-0.2	0.0	0.2	0.3
Value-Added	Billions of Fixed (2019) Dollars	25.5	-4.8	-0.7	-0.9	-0.5	-0.3	-0.1	0.1	0.2	0.2
Personal Income	Billions of Fixed (2019) Dollars	14.2	0.6	2.3	2.0	1.8	1.8	1.8	1.8	1.7	1.7
Disposable Personal Income	Billions of Fixed (2019) Dollars	13.1	0.7	2.3	2.0	2.0	1.8	1.8	1.8	1.8	1.7
Real Disposable Personal Income	Billions of Fixed (2012) Dollars	11.5	0.7	2.0	1.7	1.6	1.6	1.6	1.6	1.6	1.4
Real Disposable Personal Income per Capita	Thousands of Fixed (2012) Dollars	0.8	0.0	-0.5	-0.4	-0.4	-0.4	-0.2	-0.2	-0.2	-0.2
PCE-Price Index	2012=100 (Nation)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5-County Region-Change from Baseline Due to Flood Protection Measures											
Category	Units	**2085**	**2086**	**2087**	**2088**	**2089**	**2090**	**2091**	**2092**	**2093**	**2094**
Total Employment	Thousands (Jobs)	52.5	3.7	4.3	3.3	2.9	2.7	2.6	2.5	2.5	2.5
Private Non-Farm Employment	Thousands (Jobs)	49.5	2.2	3.3	2.6	2.3	2.2	2.2	2.2	2.2	2.1
Residence Adjusted Employment	Thousands	43.0	2.7	4.1	3.4	3.2	3.0	2.9	2.9	2.7	2.7
Population	Thousands	131.2	105.0	89.7	77.6	68.3	61.0	55.2	50.6	46.6	43.3
Labor Force	Thousands	43.5	29.4	23.0	18.1	14.6	12.1	10.4	8.9	7.9	7.0
Gross Domestic Product	Billions of Fixed (2019) Dollars	22.4	0.7	0.9	0.7	0.6	0.6	0.6	0.6	0.6	0.6
Output	Billions of Fixed (2019) Dollars	57.6	1.2	1.7	1.2	1.1	1.1	1.1	1.1	1.1	1.1
Value-Added	Billions of Fixed (2019) Dollars	22.4	0.7	0.9	0.7	0.6	0.6	0.6	0.6	0.6	0.6
Personal Income	Billions of Fixed (2019) Dollars	14.1	0.7	2.3	2.0	1.9	1.9	1.9	1.9	1.7	1.7
Disposable Personal Income	Billions of Fixed (2019) Dollars	13.0	0.8	2.3	2.0	2.0	1.8	1.8	1.8	1.8	1.7
Real Disposable Personal Income	Billions of Fixed (2012) Dollars	11.4	0.7	2.1	1.8	1.6	1.6	1.6	1.6	1.6	1.5
Real Disposable Personal Income per Capita	Thousands of Fixed (2012) Dollars	0.7	-0.7	-0.5	-0.4	-0.4	-0.4	-0.2	-0.2	-0.2	-0.2
PCE-Price Index	2012=100 (Nation)	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rest of Texas-Change from Baseline Due to Flood Protection Measures											
Category	Units	**2085**	**2086**	**2087**	**2088**	**2089**	**2090**	**2091**	**2092**	**2093**	**2094**
Total Employment	Thousands (Jobs)	1.4	-0.8	-0.5	-0.6	-0.5	-0.5	-0.4	-0.4	-0.4	-0.3
Private Non-Farm Employment	Thousands (Jobs)	2.0	-1.0	-0.6	-0.7	-0.7	-0.6	-0.5	-0.5	-0.4	-0.4
Residence Adjusted Employment	Thousands	6.5	-1.7	-1.1	-1.3	-1.3	-1.3	-1.2	-1.1	-1.0	-0.9
Population	Thousands	-115.9	-102.2	-90.4	-81.6	-74.9	-69.4	-64.2	-59.8	-55.7	-52.0
Labor Force	Thousands	-40.0	-35.5	-29.6	-26.2	-23.6	-21.7	-19.8	-18.0	-16.5	-15.0
Gross Domestic Product	Billions of Fixed (2019) Dollars	0.6	-0.3	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.1	-0.1
Output	Billions of Fixed (2019) Dollars	1.2	-0.6	-0.4	-0.4	-0.4	-0.4	-0.4	-0.3	-0.3	-0.3
Value-Added	Billions of Fixed (2019) Dollars	0.6	-0.3	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.1	-0.1
Personal Income	Billions of Fixed (2019) Dollars	0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	0.0	0.0
Disposable Personal Income	Billions of Fixed (2019) Dollars	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Real Disposable Personal Income	Billions of Fixed (2012) Dollars	0.1	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Real Disposable Personal Income per Capita	Thousands of Fixed (2012) Dollars	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCE-Price Index	2012=100 (Nation)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rest of U.S.-Change from Baseline Due to Flood Protection Measures											
Category	Units	**2085**	**2086**	**2087**	**2088**	**2089**	**2090**	**2091**	**2092**	**2093**	**2094**
Total Employment	Thousands (Jobs)	9.2	-18.5	-4.3	-4.3	-2.7	-1.8	-1.1	-0.7	-0.5	-0.4
Private Non-Farm Employment	Thousands (Jobs)	9.8	-18.4	-4.1	-4.1	-2.5	-1.6	-1.0	-0.7	-0.5	-0.4
Residence Adjusted Employment	Thousands	9.5	-18.5	-4.4	-4.3	-2.7	-1.8	-1.1	-0.7	-0.5	-0.4
Population	Thousands	-24.7	-17.1	-13.6	-10.6	-8.3	-6.6	-5.3	-4.4	-3.7	-3.2
Labor Force	Thousands	-10.6	-8.5	-6.8	-5.3	-3.9	-2.9	-2.2	-1.6	-1.3	-1.0
Gross Domestic Product	Billions of Fixed (2019) Dollars	2.6	-5.1	-1.4	-1.4	-0.9	-0.6	-0.5	-0.3	-0.2	-0.2
Output	Billions of Fixed (2019) Dollars	4.9	-9.7	-2.8	-2.7	-1.9	-1.4	-1.0	-0.7	-0.6	-0.5
Value-Added	Billions of Fixed (2019) Dollars	2.6	-5.1	-1.4	-1.4	-0.9	-0.6	-0.5	-0.3	-0.2	-0.2
Personal Income	Billions of Fixed (2019) Dollars	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Disposable Personal Income	Billions of Fixed (2019) Dollars	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Real Disposable Personal Income	Billions of Fixed (2012) Dollars	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Real Disposable Personal Income per Capita	Thousands of Fixed (2012) Dollars	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PCE-Price Index	2012=100 (Nation)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Source: KRA using the REMI PI+ Model

APPENDIX A

THE REMI MODEL IMPACT ESTIMATES FOR AVOIDED LOSSES

The REMI model is a hybrid economic model that combines an input-output model and a partial equilibrium regional econometric model that has a forecast horizon as long as 40 years. The input-output model depicts the initial production structure that is coupled through trade and transportation to form linkages between all other regions' production. The model accounts for current regional production and interregional trade of goods and services based on geographic commodity transportation data and assumed services flows that are derived from data on the relative concentration of different services activity of the regions in question. In addition to accounting for the geographic distribution of production, the REMI model incorporates a demographic model for each region that accounts for natural population changes and population migration flows. The latter come about through conventional economic processes that reflect labor market responses to wage and job opportunity differentials, with workers moving towards higher relative wages and additional labor needed to fulfill regional demand for goods and services. They can also altered by the analyst to reflect extraordinary conditions that arise with population shifts due to abnormal circumstances, such as occur with natural disasters or ones that are the product of public policy, such as changes in the immigration policy.

In Figure 1 below, we show the conceptual relationship between various economic and demographic activity measures that comprise each regional economy. There are five basic "blocks" of economic measures that are related by the directional flows shown as arrows between different concepts. These consist of output, productive factor markets (labor and capital), population, markets that determine wages, prices, incomes, etc. and factors that determine geographic location activity. As we noted, population migration is a contributing factor to population levels, shown in the third block, and is itself "driven" by economic opportunity and income differentials that are calculated in the 4th block of variables. (The diagram does not show exogenous shocks to migration as in this study's treatment of population movements that result from housing losses.)

The model is constructed to respond to changes in various "policy variables." In the case of avoided storm damage losses that result from proposed coastal flood control systems, there are several types of losses to consider. First, we consider avoided losses of industrial output (and the jobs that linked to any such output losses) for warehousing and manufacturing. Next, we include avoided losses of nonresidential contents, i.e., goods in process and/or inventory. Third, we include avoided population shifts that accompany the loss of residential property. Together, these avoided losses constitute the direct impact of flood control systems.

Extending the REMI Model Estimates to 2085

The current REMI model is capable of estimating impacts to 2060. The forecast portion of the model for the baseline or "control" forecast incorporates several different topical forecasts, such as those from the U.S. Bureau of the Census' population projection, the Bureau of Labor Statistics "Employment Outlook" projections, the Congressional Budget Office's federal spending forecast, the Research Seminar in Quantitative Economics Group's consumer spending forecasts ("RSQE", University of Michigan), and the Department of Energy's Energy Information Administration's annual energy outlook forecasts for energy prices. These different sources are assembled for the short-to-midterm forecasts, ranging at present from 2018 (REMI's current first forecast year) through 2026. For the longer-run forecast, i.e., beyond 2026, employment and output growth trends become the basis for the control forecast. This feature allows us to estimate economic impacts for 2061 to 2085 by estimating the same economic impacts for two different time-periods (using identical levels of avoided losses) and finding the annual rate of change over the interval. The difference between the intervals reflects the changes in productivity, employment, and output growth implicit in the model. We calculated rates for both 2050 and 2060 intervals. We separately applied the annual rate growth figures to the 2060 level, compounding over 25 years, to reach 2085. From these estimates, we see that the increasing labor productivity projected for the 2050-2060 interval reduces the employment impact over time when avoided output losses are applied to the model. The effect of this is that fewer employees are required for equivalent levels of output beyond 2060. We implicitly assume that such productivity growth will continue at the same rate for the 2060-2085 period as observed in the 2050 to 2060 period.

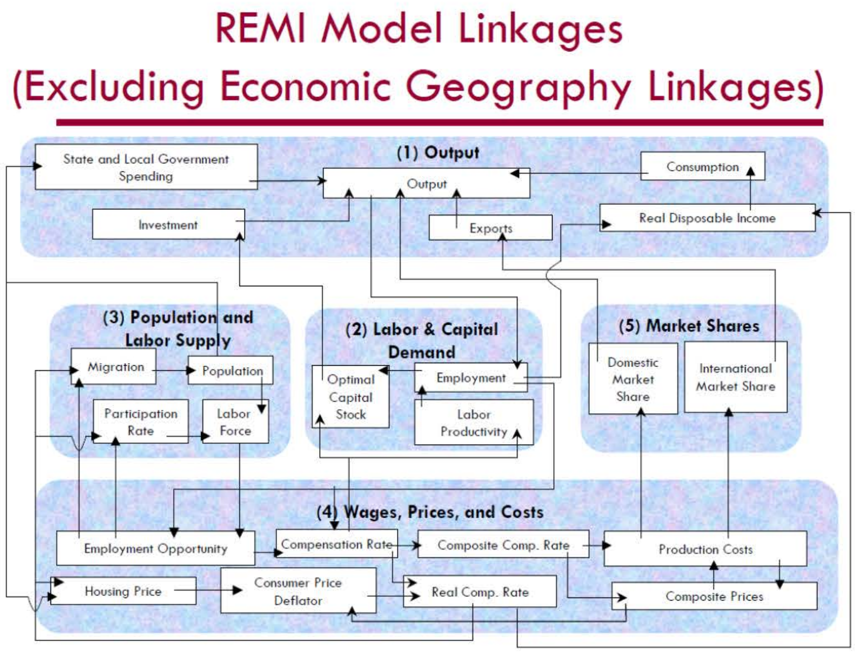

Figure 1: REMI Model Linkages

APPENDIX B-TRANSFORMATION OF DODGE ANALYTICS BUILDING STOCK FLOOR AREA DATA TO ESTIMATED VALUE

For this analysis, we required an estimate of the value of manufacturing and warehouse structures found in each of the five counties of the study area. With these, we can calculate the value of industry output relative to the stock-value for those structures. Based on the value of industry output generated within those structures (industry output being a REMI model concept), we apply this ratio as the means to estimate the avoided industry output loss associated with the flood damage avoided estimates prepared by USACE. The county manufacturing and warehouse stock value estimates were based on data provided by Dodge Analytics, Inc. Their proprietary building stock floor-area database offers county detail for those structures for the 1967-2020 period. Their stock estimates are constructed from empirical observations of monthly data for new and additions construction projects for 15 structure types, including manufacturing and warehouse buildings. A timeseries of each structure's stock is developed using a benchmark value for the total square footage for each type of structure at a point in time to which new construction and additions are added and building removals are subtracted, going both backward and forward in time (the "perpetual inventory" method. In preparing these estimates, the Dodge Analytics annual (year-end) square-footage stock estimates were transformed to $2019 value estimates using cost-per square-foot construction cost estimates from R.S. Means, Inc. provided by USACE and Bureau of Economic Analysis (BEA) deflator data.[16]

The Dodge manufacturing stock estimates used here include space only in enclosed structures, not the "outdoor" portion of a manufacturing facility. In the cases of the region's most important manufacturing activities, notably petroleum refining and chemical product manufacturing, the overwhelming value of these facilities is produced

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[16] These estimates were prepared through to 2016 from our earlier estimates prepared for a nearly identical region connected to this project. For this analysis, Dodge provided the necessary data to update the stock figures for 2017-2019. These were then used to update the stock value estimates employed here to estimate the value of avoided output losses through the different flood protection scenarios. The original 2016 dollar values were updated using BEA GDP deflators for 2019 relative to 2016.

in the outdoor portion of the facility.[17] For us, this is not a problem, because the floor area on which the value-to-stock ratios are estimated use the indoor-only values. This means that our ratios are based on total output value to indoor plant stock value. In so much as these indoor facilities house the critical controls for operating and managing these plants, our ratios will evidence high output value relative to floorspace value. The avoided losses of seemingly minor quantities of floorspace for these structures accurately reflect their importance in supporting the outdoor plant output.

[17] Data from Dodge Analytics indicate that more that 90% of expenditures on new and addition manufacturing construction in the region is for projects classified as "outdoor."

ADDENDUM F: COST ANNUALIZATION

Cost by plan measure. Table 1 below provides more specific details regarding the schedule of the costs associated with each of the individual components of the Recommended Plan. Tables 2a and 2b also show the schedule of construction costs and OMRR&R costs for each of the individual components of the Recommended Plan along with the calculation of the total project costs for the Recommended Plan.

Addendum F: Table 1
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
Construction Cost Schedule for Recommended Plan

Year	Analysis Year	Surge Gate	Bolivar Dune	Galveston Dune	Mitigation	Galveston Ring*	Clear Creek	Dickenson	Nonstructural
2024	-18								
2025	-17	PED							
2026	-16	PED							
2027	-15	PED/ Construction + Management / RE Cost							
2028	-14	PED/ Construction + Management / RE Cost							
2029	-13	PED/ Construction + Management / RE Cost							
2030	-12	PED/ Construction + Management / RE Cost							
2031	-11	Construction + Management/ RE Cost			PED	PED			
2032	-10	Construction + Management			PED	PED			
2033	-9	Construction + Management	PED	PED	Mitigation	RE/ Relocations/ Cultural/ Construction Management/ Construction			
2034	-8	Construction + Management	PED	PED	Mitigation	RE/ Relocations/ Cultural/ Construction Management/ Construction	PED		
2035	-7	Construction + Management	RE/ Const Man/ Relocations/ Cult/ Bolivar Dune Costruction	RE/ Const Man/ Relocations/ Galv Dune Costruction	Mitigation	RE/ Relocations/ Cultural/ Construction Management/ Construction	PED		
2036	-6	Construction + Management	RE/ Const Man/Relocations/ Cult/ Bolivar Dune Costruction	RE/ Const Man/ Relocations/ Galv Dune Costruction	Mitigation	RE/ Relocations/ Cultural/ Construction Management/ Construction	RE/ Relocations/ Cultural/ Construction Management/ Construction		

Addendum F: Table 1 (continued)
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
Construction Cost Schedule for Recommended Plan

Year	Analysis Year	Surge Gate	Bolivar Dune	Galveston Dune	Mitigation	Galveston Ring*	Clear Creek	Dickenson	Nonstructural
2037	-5	Construction + Management	RE/Const Man/Relocations/ Cult/Bolivar Dune Costruction	RE/Const Man/Relocations/ Galv Dune Costruction		Construction Management/ Construction	RE/Relocations/ Cultural/ Construction Management/ Construction	PED	
2038	-4	Construction + Management	Const Man/Bolivar Dune Costruction	Const Man/Galv Dune Costruction		Construction Management/ Construction	RE/Relocations/ Cultural/ Construction Management/ Construction	PED	PED
2039	-3	Construction + Management	Const Man/Bolivar Dune Costruction	Const Man/Galv Dune Costruction		Construction Management/ Construction	Construction	RE/ Relocations/ Cultural/ Construction Management/ Construction	PED
2040	-2	Construction + Management	Const Man/Bolivar Dune Costruction	Const Man/Galv Dune Costruction		Construction Management/ Construction	Construction	RE/ Relocations/ Cultural/ Construction Management/ Construction	RE/ Relocations/ Cultural/ Construction Management/ Construction
2041	-1	Construction + Management	Const Man/Bolivar Dune Costruction	Const Man/Galv Dune Costruction		Construction Management/ Construction	Construction	Construction	RE/ Relocations/ Cultural/ Construction Management/ Construction
2042	0	Construction + Management	Const Man/Bolivar Dune Costruction			Construction Management/ Construction	Construction	Construction	
2043	1								
2044	2								
2045	3								
2046	4								
2047	5		PED						
2048	6		Periodic nourishment	PED					
2049	7			Periodic nourishment					
2050	8								
2051	9								
2052	10								
2053	11		PED						
2054	12		Periodic nourishment						

Addendum F: Table 1 (continued)
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
Construction Cost Schedule for Recommended Plan

Year	Analysis Year	Surge Gate	Bolivar Dune	Galveston Dune	Mitigation	Galveston Ring*	Clear Creek	Dickenson	Nonstructural
2055	13			PED					
2056	14			Periodic nourishment					
2057	15								
2058	16								
2059	17		PED						
2060	18		Periodic nourishment						
2061	19								
2062	20			PED					
2063	21			Periodic nourishment					
2064	22								
2065	23		PED						
2066	24		Periodic nourishment						
2067	25								
2068	26								
2069	27			PED					
2070	28			Periodic nourishment					
2071	29		PED						
2072	30		Periodic nourishment						
2073	31								
2074	32								
2075	33								
2076	34			PED					
2077	35		PED	Periodic nourishment					
2078	36		Periodic nourishment						
2079	37								
2080	38								
2081	39								
2082	40								
2083	41		PED	PED					
2084	42		Periodic nourishment	Periodic nourishment					
2085	43								
2086	44								
2087	45								
2088	46								
2089	47								
2090	48								
2091	49								
2092	50								

*Note: The Galveston Ring cost includes costs for both the sea wall and the buyout of the West Point/Channelview neighborhood

Addendum F: Table 2a
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
Construction Costs for Recommended Plan
(2021 Price Level; $ Millions)

Year	Analysis Year	Surge Gate	Bolivar Dune	Galveston Dune	Mitigation	Galveston Ring	Clear Creek	Dickenson	Nonstructural	Total Construction Costs	Present Value Factor	Present Value
2024	-18	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	1.5597	$ -
2025	-17	$ 326	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 326	1.5216	$ 496
2026	-16	$ 326	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 326	1.4845	$ 484
2027	-15	$ 1,217	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 1,217	1.4483	$ 1,763
2028	-14	$ 1,217	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 1,217	1.4130	$ 1,720
2029	-13	$ 1,217	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 1,217	1.3785	$ 1,678
2030	-12	$ 1,217	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 1,217	1.3449	$ 1,637
2031	-11	$ 891	$ -	$ -	$ 6	$ 203	$ -	$ -	$ -	$ 1,101	1.3121	$ 1,444
2032	-10	$ 859	$ -	$ -	$ 6	$ 203	$ -	$ -	$ -	$ 1,069	1.2801	$ 1,368
2033	-9	$ 859	$ 84	$ 66	$ 25	$ 347	$ -	$ -	$ -	$ 1,382	1.2489	$ 1,726
2034	-8	$ 859	$ 84	$ 66	$ 25	$ 347	$ 96	$ -	$ -	$ 1,478	1.2184	$ 1,801
2035	-7	$ 859	$ 193	$ 210	$ 25	$ 347	$ 96	$ -	$ -	$ 1,730	1.1887	$ 2,057
2036	-6	$ 859	$ 193	$ 210	$ 25	$ 347	$ 212	$ -	$ -	$ 1,846	1.1597	$ 2,141
2037	-5	$ 859	$ 193	$ 210	$ -	$ 280	$ 212	$ 54	$ -	$ 1,807	1.1314	$ 2,044
2038	-4	$ 859	$ 143	$ 130	$ -	$ 280	$ 212	$ 54	$ 26	$ 1,702	1.1038	$ 1,879
2039	-3	$ 859	$ 143	$ 130	$ -	$ 280	$ 184	$ 207	$ 26	$ 1,827	1.0769	$ 1,968
2040	-2	$ 859	$ 143	$ 130	$ -	$ 280	$ 184	$ 207	$ 169	$ 1,971	1.0506	$ 2,071
2041	-1	$ 859	$ 143	$ 130	$ -	$ 280	$ 184	$ 188	$ 169	$ 1,952	1.0250	$ 2,001
2042	0	$ 859	$ 143	$ -	$ -	$ 280	$ 184	$ 188	$ -	$ 1,653	1.0000	$ 1,653
2043	1	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	0.9756	$ -
2044	2	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	0.9518	$ -
2045	3	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	0.9286	$ -
2046	4	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	0.9060	$ -
2047	5	$ -	$ 12	$ -	$ -	$ -	$ -	$ -	$ -	$ 12	0.8839	$ 11
2048	6	$ -	$ 86	$ 8	$ -	$ -	$ -	$ -	$ -	$ 94	0.8623	$ 81
2049	7	$ -	$ -	$ 54	$ -	$ -	$ -	$ -	$ -	$ 54	0.8413	$ 45
2050	8	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	0.8207	$ -

Addendum F: Table 2a (continued)
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
Construction Costs for Recommended Plan
(2021 Price Level; $ Millions)

Year	Analysis Year	Surge Gate	Bolivar Dune	Galveston Dune	Mitigation	Galveston Ring	Clear Creek	Dickenson	Nonstructural	Total Construction Costs	Present Value Factor	Present Value
2051	9	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	0.8007	$ -
2052	10	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	0.7812	$ -
2053	11	$ -	$ 12	$ -	$ -	$ -	$ -	$ -	$ -	$ 12	0.7621	$ 9
2054	12	$ -	$ 86	$ -	$ -	$ -	$ -	$ -	$ -	$ 86	0.7436	$ 64
2055	13	$ -	$ -	$ 8	$ -	$ -	$ -	$ -	$ -	$ 8	0.7254	$ 6
2056	14	$ -	$ -	$ 54	$ -	$ -	$ -	$ -	$ -	$ 54	0.7077	$ 38
2057	15	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	0.6905	$ -
2058	16	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	0.6736	$ -
2059	17	$ -	$ 12	$ -	$ -	$ -	$ -	$ -	$ -	$ 12	0.6572	$ 8
2060	18	$ -	$ 86	$ -	$ -	$ -	$ -	$ -	$ -	$ 86	0.6412	$ 55
2061	19	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	0.6255	$ -
2062	20	$ -	$ -	$ 8	$ -	$ -	$ -	$ -	$ -	$ 8	0.6103	$ 5
2063	21	$ -	$ -	$ 54	$ -	$ -	$ -	$ -	$ -	$ 54	0.5954	$ 32
2064	22	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	0.5809	$ -
2065	23	$ -	$ 12	$ -	$ -	$ -	$ -	$ -	$ -	$ 12	0.5667	$ 7
2066	24	$ -	$ 86	$ -	$ -	$ -	$ -	$ -	$ -	$ 86	0.5529	$ 48
2067	25	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	0.5394	$ -
2068	26	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	0.5262	$ -
2069	27	$ -	$ -	$ 8	$ -	$ -	$ -	$ -	$ -	$ 8	0.5134	$ 4
2070	28	$ -	$ -	$ 54	$ -	$ -	$ -	$ -	$ -	$ 54	0.5009	$ 27
2071	29	$ -	$ 12	$ -	$ -	$ -	$ -	$ -	$ -	$ 12	0.4887	$ 6
2072	30	$ -	$ 86	$ -	$ -	$ -	$ -	$ -	$ -	$ 86	0.4767	$ 41
2073	31	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	0.4651	$ -
2074	32	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	0.4538	$ -
2075	33	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	0.4427	$ -
2076	34	$ -	$ -	$ 8	$ -	$ -	$ -	$ -	$ -	$ 8	0.4319	$ 3
2077	35	$ -	$ 12	$ 54	$ -	$ -	$ -	$ -	$ -	$ 66	0.4214	$ 28

Addendum F: Table 2a (continued)
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
Construction Costs for Recommended Plan
(2021 Price Level; $ Millions)

Year	Analysis Year	Surge Gate	Bolivar Dune	Galveston Dune	Mitigation	Galveston Ring	Clear Creek	Dickenson	Nonstructural	Total Construction Costs	Present Value Factor	Present Value
2078	36	$ -	$ 86	$ -	$ -	$ -	$ -	$ -	$ -	$ 86	0.4111	$ 35
2079	37	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	0.4011	$ -
2080	38	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	0.3913	$ -
2081	39	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	0.3817	$ -
2082	40	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	0.3724	$ -
2083	41	$ -	$ 15	$ 9	$ -	$ -	$ -	$ -	$ -	$ 24	0.3633	$ 9
2084	42	$ -	$ 106	$ 61	$ -	$ -	$ -	$ -	$ -	$ 167	0.3545	$ 59
2085	43	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	0.3458	$ -
2086	44	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	0.3374	$ -
2087	45	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	0.3292	$ -
2088	46	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	0.3211	$ -
2089	47	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	0.3133	$ -
2090	48	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	0.3057	$ -
2091	49	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	0.2982	$ -
2092	50	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	0.2909	$ -
								Total:		$ 26,128		$30,552
								Federal Discount Rate:			2.50%	
								Amortization Factor:			0.03526	
								Interest During Construction			$ 4,891	
									Average Annual Construction Costs:			$ 1,077

Addendum F: Table 2b
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
OMRR&R Costs for Recommended Plan
(2021 Price Level; $ Thousands)

Year	Analysis Year	Bolivar Is Ancillary	Anchorage Basin	Bolivar Rd Gates	Galveston Ring Barrier	Offatts Bayou	West Galveston Is Ancillary	Clear Lake Gate	Dickenson Gate	Mitigation - Esturaine Wetland	Mitigation - Freshwater Wetland	Mitigation - Oyster Reef
2042	0	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
2043	1	$ 206	$ 825	$ 3,385	$ 1,496	$ 1,894	$ 168	$ 988	$ 850	$ 34	$ 79	$ 73
2044	2	$ 206	$ 825	$ 3,385	$ 1,496	$ 1,894	$ 168	$ 988	$ 850	$ 34	$ 79	$ 73
2045	3	$ 5,252	$ 825	$ 3,385	$ 1,496	$ 1,894	$ 1,955	$ 988	$ 850	$ 34	$ 9	$ 73
2046	4	$ 206	$ 825	$ 3,385	$ 1,496	$ 1,894	$ 168	$ 988	$ 850	$ -	$ -	$ -
2047	5	$ 326	$ 825	$534,530	$12,811	$20,076	$ 663	$ 4,493	$ 2,875	$ 34	$ 9	$ -
2048	6	$ 5,061	$ 825	$ 3,378	$ 1,494	$ 1,894	$ 1,851	$ 988	$ 850	$ -	$ -	$ -
2049	7	$ 15	$ 825	$ 3,378	$ 1,494	$ 1,894	$ 64	$ 988	$ 850	$ -	$ -	$ -
2050	8	$ 15	$ 825	$ 3,378	$ 1,494	$ 1,894	$ 64	$ 988	$ 850	$ -	$ -	$ -
2051	9	$ 5,061	$ 825	$ 3,378	$ 1,494	$ 1,894	$ 1,851	$ 988	$ 850	$ -	$ -	$ -
2052	10	$ 185	$ 7,215	$554,585	$18,186	$24,826	$ 753	$ 8,449	$ 4,644	$ 34	$ 9	$ -
2053	11	$ 15	$ 825	$ 3,378	$ 1,494	$ 1,894	$ 64	$ 988	$ 850	$ -	$ -	$ -
2054	12	$ 5,061	$ 825	$ 3,378	$ 1,494	$ 1,894	$ 1,851	$ 988	$ 850	$ -	$ -	$ -
2055	13	$ 15	$ 825	$ 3,378	$ 1,494	$ 1,894	$ 64	$ 988	$ 850	$ -	$ -	$ -
2056	14	$ 15	$ 825	$ 3,378	$ 1,494	$ 1,894	$ 64	$ 988	$ 850	$ -	$ -	$ -
2057	15	$ 5,181	$ 825	$534,523	$51,059	$20,076	$ 2,346	$ 32,827	$ 31,209	$ -	$ -	$ -
2058	16	$ 15	$ 825	$ 3,378	$ 1,494	$ 1,894	$ 64	$ 988	$ 850	$ -	$ -	$ -
2059	17	$ 15	$ 825	$ 3,378	$ 1,494	$ 1,894	$ 64	$ 988	$ 850	$ -	$ -	$ -
2060	18	$ 5,061	$ 825	$ 3,378	$ 1,494	$ 1,894	$ 1,851	$ 988	$ 850	$ -	$ -	$ -
2061	19	$ 15	$ 825	$ 3,378	$ 1,494	$ 1,894	$ 64	$ 988	$ 850	$ -	$ -	$ -
2062	20	$ 185	$ 7,215	$625,835	$18,186	$33,576	$ 753	$ 8,449	$ 4,644	$ 34	$ 9	$ -
2063	21	$ 5,061	$ 825	$ 3,378	$ 1,494	$ 1,894	$ 1,851	$ 988	$ 850	$ -	$ -	$ -
2064	22	$ 15	$ 825	$ 3,378	$ 1,494	$ 1,894	$ 64	$ 988	$ 850	$ -	$ -	$ -
2065	23	$ 15	$ 825	$ 3,378	$ 1,494	$ 1,894	$ 64	$ 988	$ 850	$ -	$ -	$ -
2066	24	$ 5,061	$ 825	$ 3,378	$ 1,494	$ 1,894	$ 1,851	$ 988	$ 850	$ -	$ -	$ -
2067	25	$ 135	$ 825	$534,523	$12,811	$20,076	$ 559	$ 4,556	$ 2,938	$ -	$ -	$ -
2068	26	$ 15	$ 825	$ 3,378	$ 1,494	$ 1,894	$ 64	$ 988	$ 850	$ -	$ -	$ -
2069	27	$ 5,061	$ 825	$ 3,378	$ 1,494	$ 1,894	$ 1,851	$ 988	$ 850	$ -	$ -	$ -

Addendum F: Table 2b (continued)
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
OMRR&R Costs for Recommended Plan
(2021 Price Level; $ Thousands)

Year	Analysis Year	Bolivar Is Ancillary	Anchorage Basin	Bolivar Rd Gates	Galveston Ring Barrier	Offatts Bayou	West Galveston Is Ancillary	Clear Lake Gate	Dickenson Gate	Mitigation - Esturaine Wetland	Mitigation - Freshwater Wetland	Mitigation - Oyster Reef
2070	28	$ 15	$ 825	$ 3,378	$ 1,494	$ 1,894	$ 64	$ 988	$ 850	$ -	$ -	$ -
2071	29	$ 15	$ 825	$ 3,378	$ 1,494	$ 1,894	$ 64	$ 988	$ 850	$ -	$ -	$ -
2072	30	$ 5,231	$ 7,215	$554,585	$56,436	$24,826	$ 2,540	$ 36,783	$ 32,978	$ -	$ -	$ -
2073	31	$ 15	$ 825	$ 3,378	$ 1,494	$ 1,894	$ 64	$ 988	$ 850	$ -	$ -	$ -
2074	32	$ 15	$ 825	$ 3,378	$ 1,494	$ 1,894	$ 64	$ 988	$ 850	$ -	$ -	$ -
2075	33	$ 5,061	$ 825	$ 3,378	$ 1,494	$ 1,894	$ 1,851	$ 988	$ 850	$ -	$ -	$ -
2076	34	$ 15	$ 825	$ 3,378	$ 1,494	$ 1,894	$ 64	$ 988	$ 850	$ -	$ -	$ -
2077	35	$ 135	$ 825	$534,523	$12,811	$20,076	$ 559	$ 4,493	$ 2,875	$ -	$ -	$ -
2078	36	$ 5,061	$ 825	$ 3,378	$ 1,494	$ 1,894	$ 1,851	$ 988	$ 850	$ -	$ -	$ -
2079	37	$ 15	$ 825	$ 3,378	$ 1,494	$ 1,894	$ 64	$ 988	$ 850	$ -	$ -	$ -
2080	38	$ 15	$ 825	$ 3,378	$ 1,494	$ 1,894	$ 64	$ 988	$ 850	$ -	$ -	$ -
2081	39	$ 5,061	$ 825	$ 3,378	$ 1,494	$ 1,894	$ 1,851	$ 988	$ 850	$ -	$ -	$ -
2082	40	$ 185	$ 7,215	$625,835	$18,186	$33,576	$ 753	$ 8,449	$ 4,644	$ -	$ -	$ -
2083	41	$ 15	$ 825	$ 3,378	$ 1,494	$ 1,894	$ 64	$ 988	$ 850	$ -	$ -	$ -
2084	42	$ 5,061	$ 825	$ 3,378	$ 1,494	$ 1,894	$ 1,851	$ 988	$ 850	$ -	$ -	$ -
2085	43	$ 15	$ 825	$ 3,378	$ 1,494	$ 1,894	$ 64	$ 988	$ 850	$ -	$ -	$ -
2086	44	$ 15	$ 825	$ 3,378	$ 1,494	$ 1,894	$ 64	$ 988	$ 850	$ -	$ -	$ -
2087	45	$ 5,181	$ 825	$534,523	$51,059	$20,076	$ 2,346	$ 32,827	$ 31,209	$ -	$ -	$ -
2088	46	$ 15	$ 825	$ 3,378	$ 1,494	$ 1,894	$ 64	$ 988	$ 850	$ -	$ -	$ -
2089	47	$ 15	$ 825	$ 3,378	$ 1,494	$ 1,894	$ 64	$ 988	$ 850	$ -	$ -	$ -
2090	48	$ 5,061	$ 825	$ 3,378	$ 1,494	$ 1,894	$ 1,851	$ 988	$ 850	$ -	$ -	$ -
2091	49	$ 15	$ 825	$ 3,378	$ 1,494	$ 1,894	$ 64	$ 988	$ 850	$ -	$ -	$ -
2092	50	$ 185	$ 7,215	$554,585	$18,186	$24,826	$ 753	$ 10,824	$ 7,019	$ -	$ -	$ -

Addendum F: Table 2b (continued)
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
OMRR&R Costs for Recommended Plan
(2021 Price Level; $ Thousands)

Year	Analysis Year	Total O&M Costs	Present Value Factor	Present Value
2042	0	$ -	1.0000	$ -
2043	1	$ 9,997	0.9756	$ 9,753
2044	2	$ 9,997	0.9518	$ 9,516
2045	3	$ 16,761	0.9286	$ 15,564
2046	4	$ 9,811	0.9060	$ 8,888
2047	5	$ 576,642	0.8839	$ 509,668
2048	6	$ 16,340	0.8623	$ 14,090
2049	7	$ 9,507	0.8413	$ 7,998
2050	8	$ 9,507	0.8207	$ 7,802
2051	9	$ 16,340	0.8007	$ 13,084
2052	10	$ 618,886	0.7812	$ 483,473
2053	11	$ 9,507	0.7621	$ 7,245
2054	12	$ 16,340	0.7436	$ 12,150
2055	13	$ 9,507	0.7254	$ 6,896
2056	14	$ 9,507	0.7077	$ 6,728
2057	15	$ 678,045	0.6905	$ 468,167
2058	16	$ 9,507	0.6736	$ 6,404
2059	17	$ 9,507	0.6572	$ 6,248
2060	18	$ 16,340	0.6412	$ 10,477
2061	19	$ 9,507	0.6255	$ 5,947
2062	20	$ 698,886	0.6103	$ 426,510
2063	21	$ 16,340	0.5954	$ 9,729
2064	22	$ 9,507	0.5809	$ 5,522
2065	23	$ 9,507	0.5667	$ 5,387
2066	24	$ 16,340	0.5529	$ 9,034
2067	25	$ 576,421	0.5394	$ 310,916
2068	26	$ 9,507	0.5262	$ 5,003
2069	27	$ 16,340	0.5134	$ 8,389

Addendum F: Table 2b (continued)
Coastal Texas Protection and Restoration Study Integrated Feasibility Report
OMRR&R Costs for Recommended Plan
(2021 Price Level; $ Thousands)

Year	Analysis Year	Total O&M Costs	Present Value Factor	Present Value
2070	28	$ 9,507	0.5009	$ 4,762
2071	29	$ 9,507	0.4887	$ 4,645
2072	30	$ 720,593	0.4767	$ 343,538
2073	31	$ 9,507	0.4651	$ 4,422
2074	32	$ 9,507	0.4538	$ 4,314
2075	33	$ 16,340	0.4427	$ 7,234
2076	34	$ 9,507	0.4319	$ 4,106
2077	35	$ 576,296	0.4214	$ 242,835
2078	36	$ 16,340	0.4111	$ 6,717
2079	37	$ 9,507	0.4011	$ 3,813
2080	38	$ 9,507	0.3913	$ 3,720
2081	39	$ 16,340	0.3817	$ 6,238
2082	40	$ 698,842	0.3724	$ 260,270
2083	41	$ 9,507	0.3633	$ 3,454
2084	42	$ 16,340	0.3545	$ 5,792
2085	43	$ 9,507	0.3458	$ 3,288
2086	44	$ 9,507	0.3374	$ 3,208
2087	45	$ 678,045	0.3292	$ 223,195
2088	46	$ 9,507	0.3211	$ 3,053
2089	47	$ 9,507	0.3133	$ 2,979
2090	48	$ 16,340	0.3057	$ 4,995
2091	49	$ 9,507	0.2982	$ 2,835
2092	50	$ 623,592	0.2909	$ 181,429
Total:		$ 6,917,054		$3,721,426
		Federal Discount Rate:	2.50%	
		Amortization Factor:	0.03526	
		Average Annual O&M Costs:		$ 131,210