2023 DRAFT COASTAL MASTER PLAN

HISTORIC STORM RUN – IKE

SUPPLEMENTAL MATERIAL H6.1

REPORT: VERSION 01

DATE: APRIL 2023

PREPARED BY: SCOTT A. HEMMERLING, PATRICK KANE, ABBY LITTMAN, ZACH COBELL, OVEL DIAZ, JORDAN R. FISCHBACH, DAVID R. JOHNSON, AND JINGYA WANG

COASTAL PROTECTION AND
RESTORATION AUTHORITY
150 TERRACE AVENUE
BATON ROUGE, LA 70802
WWW.COASTAL.LA.GOV

COASTAL PROTECTION AND RESTORATION AUTHORITY

This document was developed in support of the 2023 Coastal Master Plan being prepared by the Coastal Protection and Restoration Authority (CPRA). CPRA was established by the Louisiana Legislature in response to Hurricanes Katrina and Rita through Act 8 of the First Extraordinary Session of 2005. Act 8 of the First Extraordinary Session of 2005 expanded the membership, duties, and responsibilities of CPRA and charged the new authority to develop and implement a comprehensive coastal protection plan, consisting of a master plan (revised every six years) and annual plans. CPRA's mandate is to develop, implement, and enforce a comprehensive coastal protection and restoration master plan.

CITATION

Hemmerling, S. A., Kane, P., Littman, A., Cobell, Z., Diaz, O. Fischbach, J. R., Johnson, D. R., & Wang, J. (2023). 2023 Draft Coastal Master Plan: Supplemental Material H6.1: Historic Storm Run – Ike. Version 1. (p. 29). Baton Rouge, Louisiana: Coastal Protection and Restoration Authority.

ACKNOWLEDGEMENTS

This document was developed under the guidance of the Master Plan Development Team (MPDT):

- Coastal Protection and Restoration Authority (CPRA) of Louisiana – Stuart Brown, Ashley Cobb, Madeline LeBlanc Hatfield, Valencia Henderson, Krista Jankowski, David Lindquist, Sam Martin, and Eric White
- University of New Orleans – Denise Reed

The following experts were responsible for the preparation of this document:

- Scott A. Hemmerling – The Water Institute
- Patrick Kane – The Water Institute
- Abby Littman – The Water Institute

The following people assisted with access and summaries of data used in this report:

- Zach Cobell – The Water Institute
- Ovel Diaz – The Water Institute
- Jordan R. Fischbach – The Water Institute
- David R. Johnson – Purdue University
- Jingya Wang – Purdue University

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ADCIRC ... ADVANCED CIRCULATION (MODEL)
CLARA ... COASTAL LOUISIANA RISK ASSESSMENT (MODEL)
CPRA ... COASTAL PROTECTION AND RESTORATION AUTHORITY
FEMA ... FEDERAL EMERGENCY MANAGEMENT AGENCY
FWA ... FUTURE WITH ACTION
FWOA ... FUTURE WITHOUT ACTION
HSDRRS ... HURRICANE AND STORM DAMAGE RISK REDUCTION SYSTEM
SLR ... SEA LEVEL RISE
SWAN ... SIMULTAING WAVES NEARSHORE (MODEL)

1.0 INTRODUCTION

The historical storm analysis conducted for the 2023 Coastal Master Plan simulates and presents the potential coastal flood risk and damage that would result from five Atlantic tropical storms that directly impacted Louisiana from 2005 to 2021 were they to make landfall under current and future conditions. The simulated storms examined for this analysis include Hurricane Rita (2005), Hurricane Ike (2008), Hurricane Isaac (2012), Hurricane Barry (2019), and Hurricane Ida (2021). This document describes the current and future coastal flood risk and damage that would result from Hurricane Ike-like storm, a high Category 2 storm that made landfall along the upper Texas coast in September of 2008.

The Advanced Circulation (ADCIRC) and Simulating Waves Nearshore (SWAN) models were used to simulate surge and wave heights for each of the five historical hurricanes analyzed. The ADCIRC+SWAN model geometries used in this analysis and throughout Louisiana's 2023 Coastal Master Plan are derived from those used in both the 2012 and 2017 Coastal Master Plans, with incremental upgrades. As part of Louisiana's 2023 Coastal Master Plan, an extensive model validation and calibration study was conducted by Cobell and Roberts (2021) to ensure that the parameters used within these models were most appropriate from those currently found within the modeling community and available literature. ADCIRC+SWAN model version v55.00 was used in this work.

Flood depth and damage results from each of the storms described in this analysis were simulated with the Coastal Louisiana Risk Assessment (CLARA) model. An introduction to the CLARA model can be found in Johnson et al. (2021), Fischbach et al. (2012), and Johnson et al. (2013). The CLARA model uses high-resolution hydrodynamic storm surge and wave output from ADCIRC+SWAN. It estimates flood depth exceedances; direct economic damage exceedances across different asset types, including residential, commercial, and industrial structures; expected annual damage dollars; and expected annual structural damage in the Louisiana Coastal Zone. However, this analysis only considers a single storm run rather than a probabilistic storm suite, so the results are simply estimates of direct economic damage associated with the historical storm.

Results are presented for current conditions, a future without action (FWOA) in Year 50, as well as a future with action (FWA) in Year 50 that simulates the anticipated impacts of the 2023 Coastal Master Plan. Current conditions are represented with the initial conditions (Year 0) scenario assumptions. Projected future conditions, including sea level rise (SLR), were analyzed under the lower environmental scenario (S07) developed and used in the 2023 Coastal Master Plan. Both the FWOA and FWA represent a single projected future condition with changing environmental and population conditions. This scenario represents one of many possible futures for the Louisiana coast and should be interpreted as a plausible projection rather than a likely prediction for future flood risk outcomes.

2.0 DESCRIPTION

Hurricane Ike made landfall at Galveston Island, Texas on September 13, 2008, as a high Category 2 storm. The hurricane's center moved northward across Galveston Bay, just east of Houston, then northward across eastern Texas (Figure 1). Hurricane Ike and its associated storm surge caused extensive damage across the northwestern Gulf Coast, causing billions of dollars of property damage and fatalities. Official counts and media reports indicate that 21 people died in Texas, Louisiana, and Arkansas as a direct result of Hurricane Ike. Thirteen of these deaths happened in Galveston and Chambers counties, Texas, where the worst storm surge occurred.

The storm had an unusually long surge duration, resulting in damage levels beyond those typically seen with Category 2 storms. While storm surge and water levels typically rise over several hours during hurricane events, they can persist for several days in some cases, as was seen with Ike. The surge caused prolonged flooding of structures and allowed waves to reach far inland. Beaches and wetlands from southwest Louisiana to South Padre Island, TX, were damaged (Kraus & Lin, 2009). Storm surge levels on Galveston Island and on the west side of Galveston Bay are estimated to have been between 10 and 15 ft (Berg, 2009). Storm surge heights along the southwestern Louisiana coast and the upper Texas coast near Sabine Pass and Port Arthur ranged from 10 to 13 ft while the coast of southcentral Louisiana experienced surge heights between 5 and 10 ft (Berg, 2009).

While the highest storm surge levels occurred from southcentral Louisiana to Galveston, TX, higher-than-normal water levels were recorded across virtually the entire U.S. Gulf Coast (Berg, 2009). Maximum storm surge heights along the coasts of Alabama, Mississippi, and southeastern Louisiana ranged from 3 to 6 ft. Grand Isle, Louisiana recorded a surge of 3.84 ft while the New Canal Station near New Orleans recorded a surge of 5.24 ft. The greatest surge height measured east of the Mississippi River was 7.51 ft, recorded at Shell Beach, an unincorporated community in St. Bernard Parish, Louisiana (Berg, 2009).

On September 12, 2008, following the completion of joint federal, state, and local preliminary damage assessments of the impacted areas in Louisiana, Governor Bobby Jindal requested a major disaster declaration beginning on September 11. On September 13, President George W. Bush declared a major disaster in the State of Louisiana. This declaration made individual assistance available to affected individuals in Acadia, Beauregard, Calcasieu, Cameron, Iberia, Jefferson Davis, Sabine, St. Mary, Vermilion, and Vernon parishes. This declaration also made public assistance for debris removal available to state and local governments and certain private nonprofit organizations on a cost-sharing basis in Acadia, Beauregard, Calcasieu, Cameron, Iberia, Jefferson Davis, Sabine, St. Mary, Vermilion, and Vernon parishes. Finally, this declaration made Hazard Mitigation Grant Program assistance requested by the Governor available for hazard mitigation measures statewide (FEMA, 2008). In total, insured damages (not including inland flooding or storm surge) from Hurricane Ike in Texas, Louisiana, and Arkansas were estimated at $12.5 billion. The National Flood Insurance Program estimates that insured losses from inland flooding and storm surge were approximately $2.26 billion in the same three states (Berg, 2009).

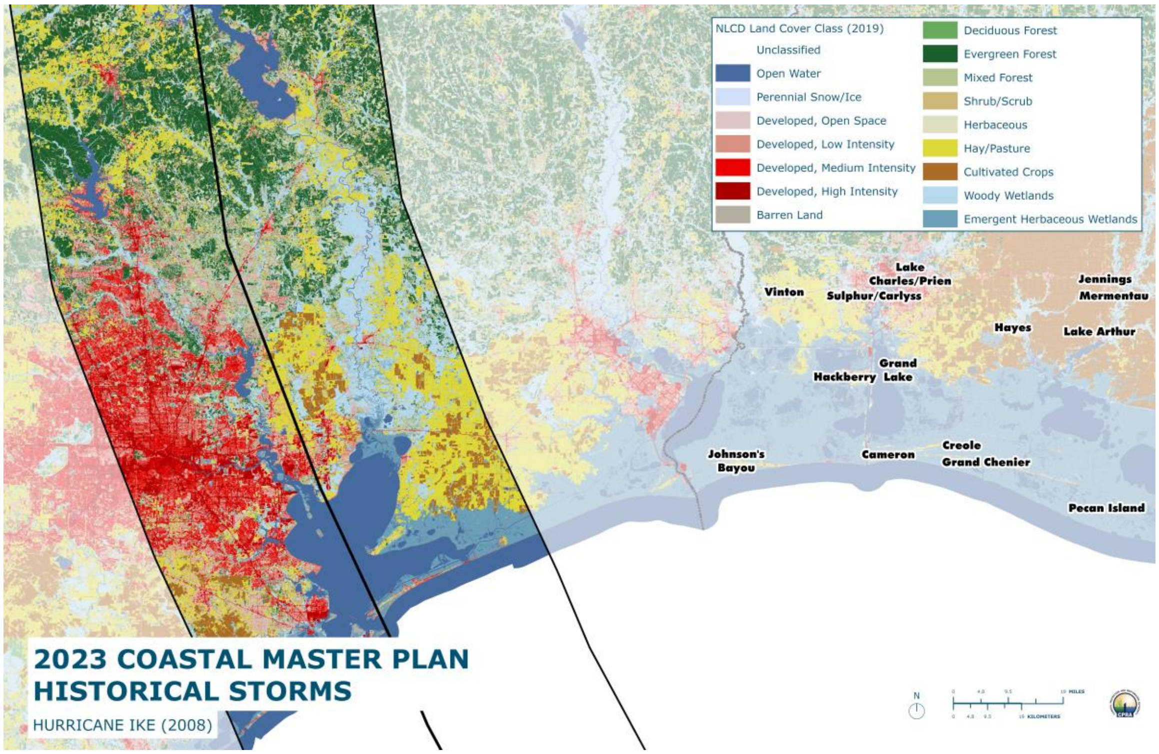

Figure 1. Storm track of Hurricane Ike and communities within a 50 km buffer of the storm's center.

3.0 STORM SURGE AND WAVES

The ADCIRC+SWAN model was used to simulate storm surge and wave height associated with Hurricane Ike for initial conditions, a FWOA, and a FWA, all of which assumed S07 conditions. Results for initial conditions (Year 0), a FWOA (Year 50), and a FWA (Year 50) are presented below along with localized results for several key communities/locations.

3.1 INITIAL CONDITIONS

Current sea level conditions were used to project storm impacts for Year 0 simulations. Under these conditions, ADCIRC+SWAN simulations show that if a Hurricane Ike-like storm were to make landfall in Year 0 following the same track, the anticipated peak water surface elevations would be greatest to the east of the storm track, in southeast Texas, with high elevated water levels exceeding 14 ft projected for most of Louisiana's Chenier Plain Region (Figure 2). In Sabine Lake and locations further north along the Sabine River (the boundary between Texas and Louisiana), model simulations project peak water surface elevations ranging from 10 to 12 ft in Year 0. Similar or slightly lower local peak water surface elevations are projected along the northern shore of Calcasieu Lake and on the western shore of Vermilion Bay, where the storm's counterclockwise motion is expected to push high water levels through Cote Blanche Bay into Vermilion Bay. East of the Chenier Plain Region, much of the Central Coast Region is projected to experience peak water surface elevation of 8 to 10 ft in locations adjacent to the Gulf of Mexico. ADCIRC+SWAN results also show isolated locations in the Atchafalaya Basin projected to approach these levels.

While the highest anticipated water surface elevations resulting from a Hurricane Ike-like storm are expected to occur in the Chenier Plain Region, ADCIRC+SWAN results show elevated water levels in two locations east of the Mississippi River in the Pontchartrain/Breton Region. The first is located in the wetlands between Lake Borgne and the Mississippi River, home to a number of small unincorporated fishing communities such as Delacroix and Yscloskey. ADCIRC+SWAN simulations show pronounced water surface elevations in this area due to hurricane winds that rotate counterclockwise, piling surge up against the Mississippi River levees in Plaquemines Parish and the Hurricane and Storm Damage Risk Reduction System (HSDRRS) levees in St. Bernard Parish, resulting in 8 to 10 ft of water above surface. Further north, a Hurricane Ike-like storm in Year 0 would be expected to generate similar but slightly lower water surface elevations in locations west of Lake Pontchartrain and north of Lake Maurepas.

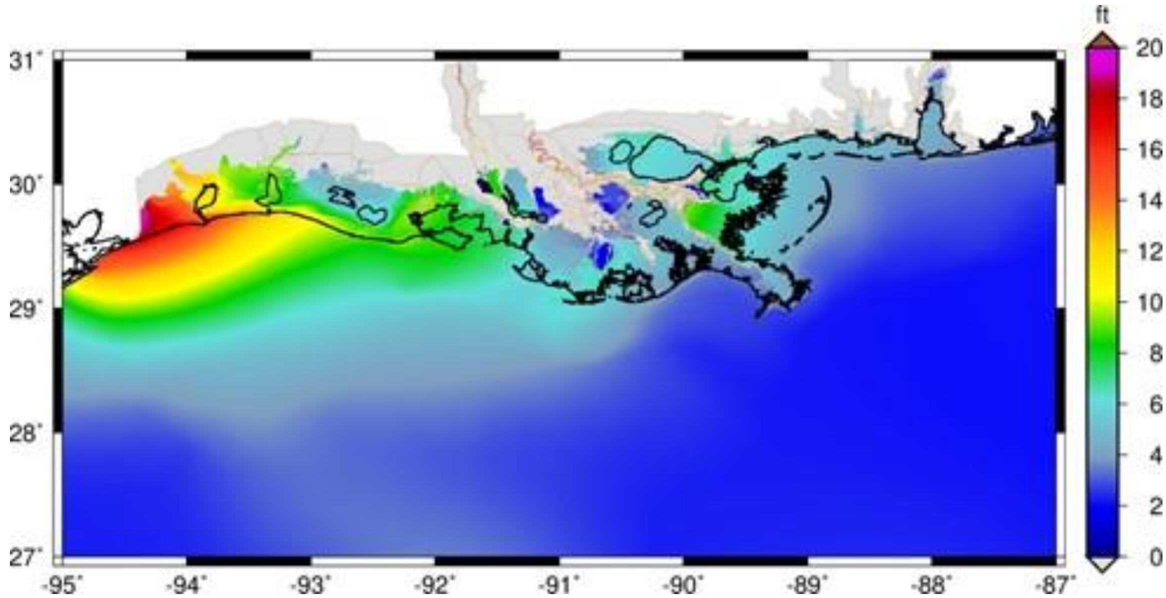

Figure 2. Peak water surface elevation (ft, NAVD88) for a Hurricane Ike-like storm simulated in Year 0.

3.2 FUTURE WITHOUT ACTION

ADCIRC+SWAN simulations under S07 show that were a Hurricane Ike-like storm to make landfall in a FWOA in Year 50, the overall floodplain footprint would look very similar to that observed in the Year 0 simulations (

Figure 3). Model results show that the greatest projected expansion of the floodplain compared to Year 0 would occur within the Atchafalaya Basin and the low elevation forested wetlands between the Atchafalaya Basin and Bayou Lafourche. Additional expansion of the floodplain from a Hurricane Ike-like event in Year 50 in a FWOA would be expected to occur across the broad expanse of forested wetlands containing Lac Des Allemands and the Lac Des Allemands Swamp.

While the overall floodplain footprint of a Hurricane Ike-like storm in a FWOA in Year 50 is similar to that projected for Year 0, ADCIRC+SWAN results project that peak water surface elevations generated by the storm are expected to increase across the coast, largely the result of predicted increases in eustatic SLR and higher base water levels in the Gulf of Mexico. In a FWOA in Year 50, the location of highest water surface elevation is projected to extend from southeast Texas to encompass much of the area around Sabine Lake and the Sabine River in southwest Louisiana. In addition, projected water surface elevations of 10 to 12 ft are expected to extend as far east as Marsh Island in Iberia

Parish. Similar peak water surface elevations are projected far inland across Calcasieu Lake as far north as Lake Charles/Prien and Sulphur/Carlyss. This also includes the smaller unincorporated communities along Calcasieu Lake such as Hackberry and Grand Lake. To the east, ADCIRC+SWAN results project 10 to 12 ft of peak water surface elevation inland of Vermilion Bay and in the Atchafalaya Basin.

In the Pontchartrain/Breton Region, ADCIRC+SWAN simulations show similar increases in water surface elevations as those observed in locations west of the Mississippi River, although the elevations are expected to be lower. Around Braithwaite, the Plaquemines Parish community located near the junction of the Mississippi River levees and the HSDRRS levees, water surface elevations resulting from a Hurricane Ike-like event in Year 50 in a FWOA are projected to be approximately 2 ft higher than in Year 0. Similar increases are projected for most of the Pontchartrain Basin, including the Pearl River Valley and lakes Borgne, Pontchartrain, and Maurepas and the forested wetlands surrounding these lakes. Surge and wave heights are projected to increase as much as 4 ft in some of these locations.

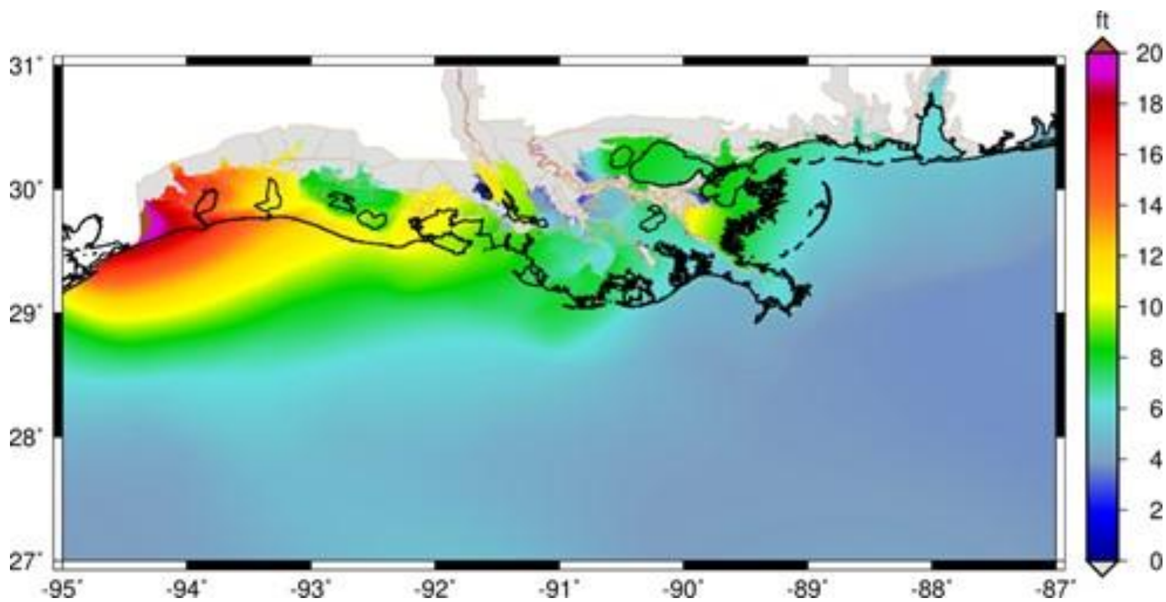

Figure 3. Peak water surface elevation (ft, NAVD88) for a Hurricane Ike-like storm simulated in the FWOA, S07, Year 50.

3.3 FUTURE WITH ACTION

ADCIRC+SWAN results for a FWA in Year 50 show few large-scale differences from the FWOA simulation to the east of the Mississippi River in the Pontchartrain/Breton Region (Figure 4). Projected water surface elevations in and around lakes Pontchartrain and Maurepas are expected to be reduced by approximately 2 ft in a FWA in Year 50 relative to a FWOA, resulting in peak water surface elevations close to those projected for Year 0. West of the Mississippi River, the greatest reductions in peak water surface elevations resulting from a Hurricane Ike-like storm are projected to occur in the Terrebonne Region in the vicinity of Houma and the bayou communities of lower Terrebonne Parish. In southwest Louisiana, ADCIRC+SWAN simulations project water surface elevation reductions similar to those seen around lakes Pontchartrain and Maurepas in a FWA in Year 50, relative to a FWOA at the same timestep. Notably, ADCIRC+SWAN results project increased water surface elevations at several locations west of the Mississippi River in a FWA in Year 50 relative to a FWOA (Figure 5). The locations expected to experience increased water surface elevations are largely linear and located seaward of elevated landscape feature such as U.S. Highway 90.

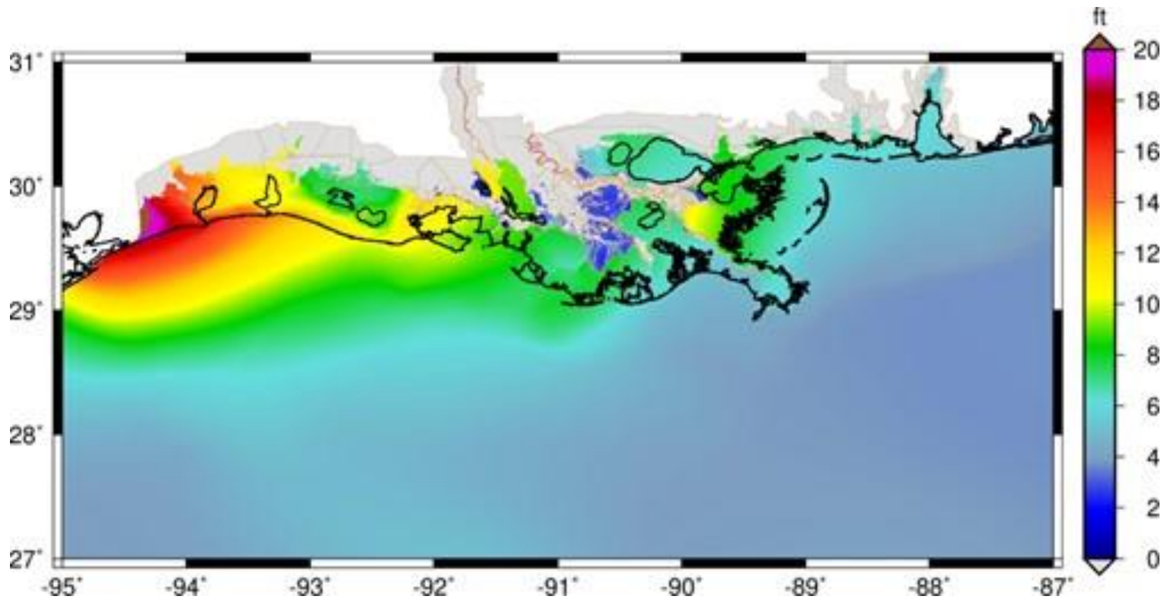

Figure 4. Peak water surface elevation (ft, NAVDD88) for a Hurricane Ike-like storm simulated in the FWA, S07, Year 50.

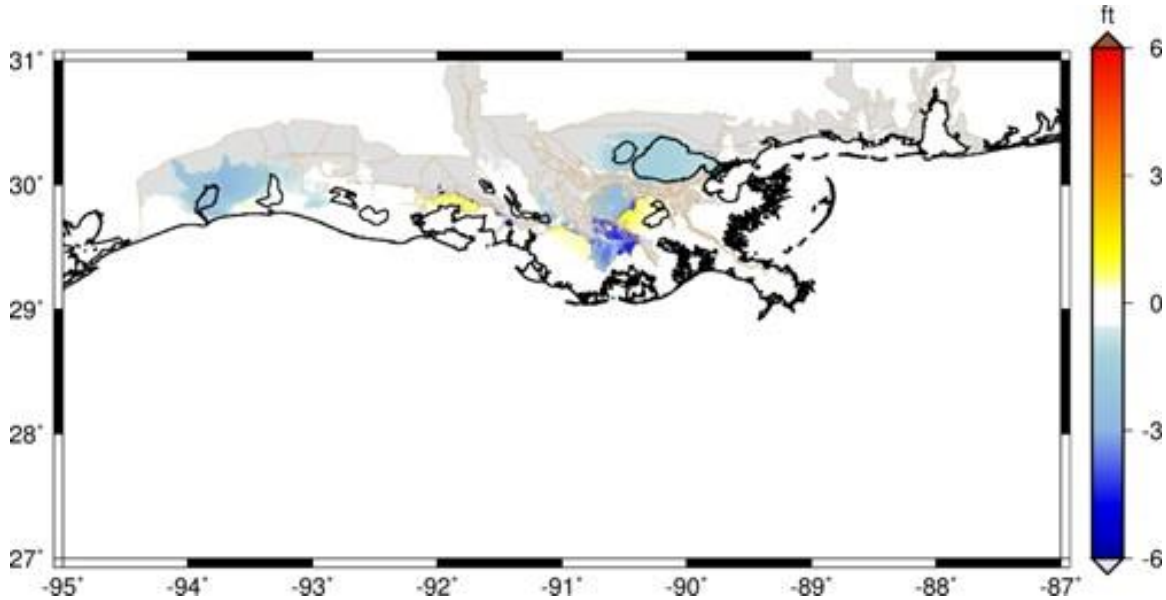

Figure 5. Change in peak water surface elevation (ft, NAVD88) between FWOA and FWA for a Hurricane Ike-like storm simulated in the lower scenario in Year 50.

3.4 LOCAL STORM SURGE AND WAVE IMPACTS

More granular analysis of the anticipated local impacts of a Hurricane Ike-like event in Year 50, both FWA and FWOA simulations, reveal the impacts of local landscape features on exacerbating or reducing the impacts of storm surge and waves. Several communities across coastal Louisiana were analyzed for high tide flooding impacts (see Attachment H3: High Tide Flooding). Within each community, a number of key locations of community importance were identified and verified by local stakeholders. To assess the local impacts of a Hurricane Ike-like storm, water surface elevations were projected under initial conditions as well as into the future under both FWOA and FWA.

On average, hurricane-force winds tend to extend forward and to the right about 50 to 100 km from the eye and 25 to 50 km to the left (Keim et al., 2007). Because the track of a Hurricane Ike-like storm would bring the storm onshore in Texas near Galveston Bay, no Louisiana communities fall within this zone of maximum wind impacts. However, ADCIRC+SWAN results show that the peak water surface elevations resulting from a Hurricane Ike-like storm are projected to extend far to the east of the storm track, encompassing much of the Louisiana coast. In the community of Cameron, located close to the Gulf of Mexico just to the east of the Louisiana-Texas border, projected water surface elevations exceeding 3 ft are expected in all locations examined in Year 0. This includes those located atop the elevated Chenier ridges, such as the local recreational facility (Table 1). By Year 50 in a

FWOA, ADCIRC+SWAN simulations show water surface elevations approaching or even exceeding 4 ft in height. In a FWA in Year 50, model simulations show that planned coastal protection and restoration activities would not be expected to result in any notable change in peak water surface elevations.

Table 1. Peak water surface elevation (ft, NAVD88) for a Hurricane Ike-like storm at key locations in Cameron, Louisiana

Community	Name	Initial Conditions (Year 0)	FWOA (Year 50)	FWA (Year 50)
Cameron	Cameron Clerk of Court	3.28	3.80	3.78
Cameron	Cameron Evacuation Link - LA27	3.25	3.89	3.89
Cameron	Cameron Ferry West Landing	3.27	3.78	3.73
Cameron	Cameron Parish Library	3.38	3.87	3.88
Cameron	Cameron Parish Recreation District No. 6 Facility	3.60	4.07	4.06

Further to the east, in the Central Coast Region, a Hurricane Ike-like storm is projected to result in similarly high peak water surface elevations. In the town of Delcambre, located on the Delcambre Canal (also known as Bayou Carlin) in Iberia and Vermilion parishes, projected water surface elevations from this storm in Year 0 are expected to exceed 2.5 ft in all locations examined. These impacts are not limited to locations along the Delcambre Canal. By Year 50 in a FWOA, ADCIRC+SWAN simulations project that peak water surface elevations will exceed 3 ft at each of these locations (Table 2). In a FWA, the projected peak water surface elevations would be greatly reduced or even eliminated by Year 50, with locations along the Delcambre Canal projected to experience less than 1 ft of water above surface.

Table 2. Peak water surface elevation (ft, NAVD88) for a Hurricane Ike-like storm at key locations in Delcambre, Louisiana

Community	Name	Initial Conditions (Year 0)	FWOA (Year 50)	FWA (Year 50)
Delcambre	Bayou Carlin Cove Boat Landing	2.63	3.27	0.89
Delcambre	Delcambre High School	2.61	3.23	N/A
Delcambre	Delcambre Local Road Link - E Main St and S President St	2.63	3.25	0.90
Delcambre	Vermilion Parish Library - Delcambre Branch	2.62	3.24	N/A

In Amelia, a census designated place located between Bayou Boeuf and Lake Palourde in St. Mary Parish, ADCIRD+SWAN results show lower projected peak water surface elevations than those observed in either Cameron or Delcambre. In Year 0, key locations such as the local library and elementary school are not expected to experience any water above surface from a Hurricane Ike-like storm, while low points in the road network are expected to have less than 0.5 ft of water above surface (Table 3). By Year 50 in a FWOA, simulations project peak water surface elevations approaching 2 ft at each of these areas. In a FWA in Year 50, notable reductions in peak water surface elevations are projected, but ADCIRC+SWAN results still show over 1 ft of water above surface at all locations analyzed.

Table 3. Peak water surface elevation (ft, NAVD88) for a Hurricane Ike-like storm at key locations in Amelia, Louisiana

Community	Name	Initial Conditions (Year 0)	FWOA (Year 50)	FWA (Year 50)
Amelia	Amelia Branch Library	N/A	1.95	1.38
Amelia	Amelia Local Road Link - Duhon Blvd	0.36	1.98	1.25
Amelia	J S Aucoin Elementary School	N/A	1.97	1.26

In coastal Terrebonne Parish, most of the communities, including Dulac, Dularge, Chauvin, and Montegut, are located atop a number of distributary ridges. A Hurricane Ike-like storm would be expected to generate water surface elevations for these communities like those expected in Amelia. ADCIRC+SWAN simulations project under 1 ft of water surface elevation in Year 0 with Grand Caillou Road not expected to have any water above surface during a Hurricane Ike-like event (Table 4). As seen in Amelia, by Year 50 in a FWOA, projected water surface elevations are expected to approach 2 ft at all locations examined, including Grand Caillou Road. However, ADCIRC+SWAN results show that the Morganza to the Gulf project and other restoration and protection measures implemented in a FWA would reduce water surface elevations for all the key location examined in Dulac in Year 50 to 1 ft or less.

Table 4. Peak water surface elevation (ft, NAVD88) for a Hurricane Ike-like storm at key locations in Dulac, Louisiana

Community	Name	Initial Conditions (Year 0)	FWOA (Year 50)	FWA (Year 50)
Dulac	Dulac Community Center	0.75	1.82	1.00
Dulac	Dulac Evacuation Link - Grand Caillou Rd	N/A	1.95	0.94
Dulac	Dulac Local Road Link - Shrimpers Row and Bayou Guillaume Rd	0.75	1.86	0.85
Dulac	Holy Family Catholic Church	0.75	1.85	0.84

A Hurricane Ike-like storm is projected to result in high peak water surface elevations at all locations analyzed in Grand Isle, the only populated barrier island in Louisiana. In Year 0, over 1 ft of water above surface is projected at all key locations, including the transportation network, both on the island and on the mainland, across the causeway over Caminada Pass (Table 5). ADCIRC+SWAN simulations show that by Year 50 in a FWOA, these values are expected to increase by approximately 0.5 ft at all locations. In a FWA, the implementation of planned protection and restoration projects would not be expected to notably alter these peak water surface elevations.

Table 5. Peak water surface elevation (ft, NAVD88) for a Hurricane Ike-like storm at key locations in Grand Isle, Louisiana

Community	Name	Initial Conditions (Year 0)	FWOA (Year 50)	FWA (Year 50)
Grand Isle	Grand Isle Community Center	1.06	1.62	1.66
Grand Isle	Grand Isle Evacuation Link - LA1	1.29	1.75	1.82
Grand Isle	Grand Isle Local Road Link - Oak Ln at Louisiana Ave	1.08	1.66	1.69
Grand Isle	Grand Isle State Park	1.11	1.66	1.70

On the east side of the Mississippi River Bird's Foot Delta, ADCIRC+SWAN results for a Hurricane Ike-like event show that peak water surface elevations are projected to exceed those seen in the Terrebonne and Barataria regions. In the small fishing community of Delacroix, located in St. Bernard Parish along Bayou Terre-aux-Boeufs, model results project approximately 2.5 ft of water above surface at key locations in the community in Year 0 (Table 6). This includes high water elevations along the town's transportation network, including roadways and boat docks. In Year 50 in a FWOA, water surface elevations from a Hurricane Ike-like event are expected to approach 3 ft at each of these locations. In a FWA, the implementation of planned protection and restoration projects would not be expected to significantly alter these water surface elevations.

Table 6. Peak water surface elevation (ft, NAVD88) for a Hurricane Ike-like storm at key locations in Delacroix, Louisiana

Community	Name	Initial Conditions (Year 0)	FWOA (Year 50)	FWA (Year 50)
Delacroix	Delacroix Evacuation Link - Delacroix Hwy	2.46	2.92	2.94
Delacroix	Delacroix Island Pier	2.49	2.95	2.97
Delacroix	Delacroix Local Road Link - Delacroix Hwy	2.48	2.94	2.96

Finally, ADCIRD+SWAN results show that peak water surface elevations resulting from a Hurricane Ike-like storm event will be elevated in most of the communities located in St. Tammany Parish along the north shore of Lake Pontchartrain, including Slidell and Mandeville. In Year 0, model simulations show that if a Hurricane Ike-like storm were to make landfall today following the same track, many key locations in downtown Slidell including the local high school and one of the local churches, would not be expected to experience water above surface (Table 7). However, ADCIRC+SWAN results show that each of the key locations located to the west of the high density developed downtown, including the locations and roadways along bayous Bonfouca and Liberty, are projected to experience over 1.5 ft of water above surface in Year 0. By Year 50 in a FWOA simulation, projected peak water surface elevations at all locations, include those expected to remain dry in Year 0, will exceed 2 ft. In a FWA, these levels are expected to be reduced to less than 1 ft, and even eliminated at some locations by Year 50.

Table 7. Peak water surface elevation (ft, NAVD88) for a Hurricane Ike-like storm at key locations in Slidell, Louisiana

Community	Name	Initial Conditions (Year 0)	FWOA (Year 50)	FWA (Year 50)
Slidell	Bayou Liberty Marina	1.70	2.26	0.86
Slidell	Our Lady of Lourdes Church	N/A	2.14	N/A
Slidell	Salmen High School	N/A	2.14	N/A
Slidell	Slidell Local Road Link - Bayou Liberty Rd near Galatas Ln	1.70	2.25	0.88
Slidell	Slidell Municipal Marina at Heritage Park	1.67	2.23	N/A
Slidell	St Genevieve Church	1.71	2.26	0.86

ADCIRC+SWAN results for peak water surface elevations in Mandeville for a Hurricane Ike-like storm are similar to those observed in Slidell, with proximity to water being a key driver. In Mandeville, locations along Lake Pontchartrain are projected to experience nearly 2 ft of peak water surface elevation in Year 0 (Table 8). The Fontainebleau State Park Visitors Center is separated from the lake by an expanse of cypress swamp, resulting in similar peak water surface elevations to those observed in locations directly on the lakefront. By Year 50 in a FWOA, all of the locations projected to experience high peak water surface elevation in Year 0 are projected to see increases of over 0.5 ft. In a FWA in Year 50, ADCIRC+SWAN results project a reduction in peak water surface elevations to levels slightly higher than those projected for Year 0.

Table 8. Peak water surface elevation (ft, NAVD88) for a Hurricane Ike-like storm at key locations in Mandeville, Louisiana

Community	Name	Initial Conditions (Year 0)	FWOA (Year 50)	FWA (Year 50)
Mandeville	Fontainebleau State Park Visitors Center	1.84	2.40	2.08
Mandeville	Lakeshore Dr	1.86	2.41	2.08
Mandeville	Mandeville Evacuation Link - Florida St and Jackson Ave	N/A	N/A	N/A
Mandeville	Mandeville Local Road Link - Monroe St and Ramon St	1.89	2.43	2.11
Mandeville	West Lakefront Children's Park	1.86	2.42	2.08

4.0 FLOOD DEPTH

The CLARA model was used to estimate flood depths associated with a Hurricane Ike-like storm for initial conditions, a FWOA, and a FWA, all of which assumed S07 conditions. Results for initial conditions (Year 0), a FWOA (Year 50), and a FWA (Year 50) are presented below.

4.1 INITIAL CONDITIONS

CLARA simulations modeling the impacts of a Hurricane Ike-like storm across the Louisiana coast mirror many of the patterns observed in the storm surge and wave results (Figure 6). However, whereas storm surge and wave results show inundation and water levels over both land and water, the CLARA results focus on flood depth over land surfaces. In Year 0, CLARA results project that expected flood depths across the southwestern coast resulting from a Hurricane Ike-like event are expected to approach 12 ft along the coastline of Cameron Parish and further inland along the shores of Calcasieu Lake. Other areas projected to experience similar flood depths include locations along the northern and western shores of Vermilion Bay, a sparsely populated area of the Central Coast Region. Inland from these areas, expected flood depths are generally lower. However, all coastal regions see some flooding of approximately 5-10 ft. East of the Mississippi River, the projected flood depths resulting from a Hurricane Ike-like event are primarily limited to an area of Breton Sound bounded by the Mississippi River levees, the HSDRRS levees, and Lake Borgne.

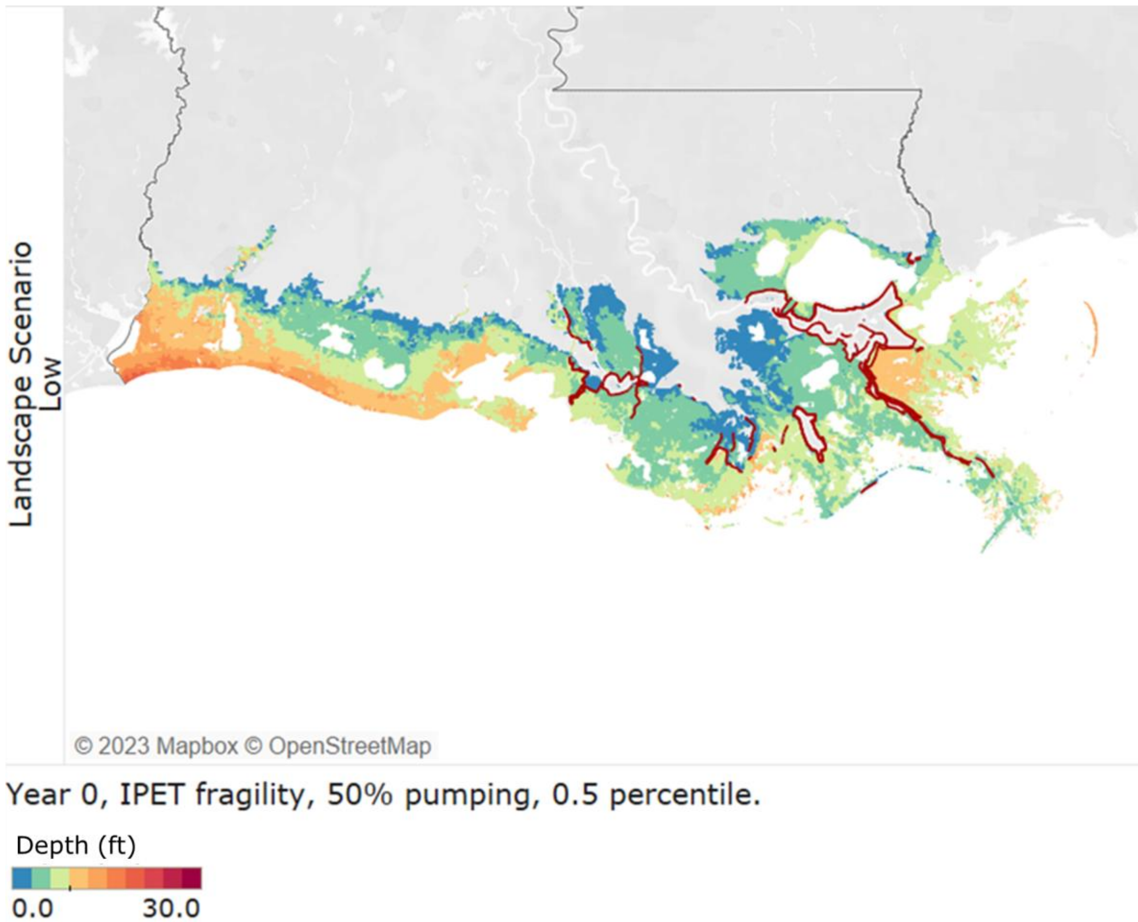

Figure 6. Modeled maximum flood depth for a Hurricane Ike-like storm simulated under initial conditions.

4.2 FUTURE WITHOUT ACTION

CLARA results show that many of the flood depth patterns resulting from a Hurricane Ike-like storm in Year 0 are projected to intensify by Year 50 in a FWOA. The highest projected flood depths are expected to occur along the coast of Cameron Parish, the location in Louisiana closest to where a Hurricane Ike-like storm would make landfall. However, CLARA results show that the greatest increase in flood depths in Year 50 relative to Year 0 are projected to occur further east, with projected flood depths increasing by more than 2 ft in Vermilion Bay. Similar increases are projected for much of the land surrounding Terrebonne Bay in Terrebonne and Lafourche parishes (Figure 7).

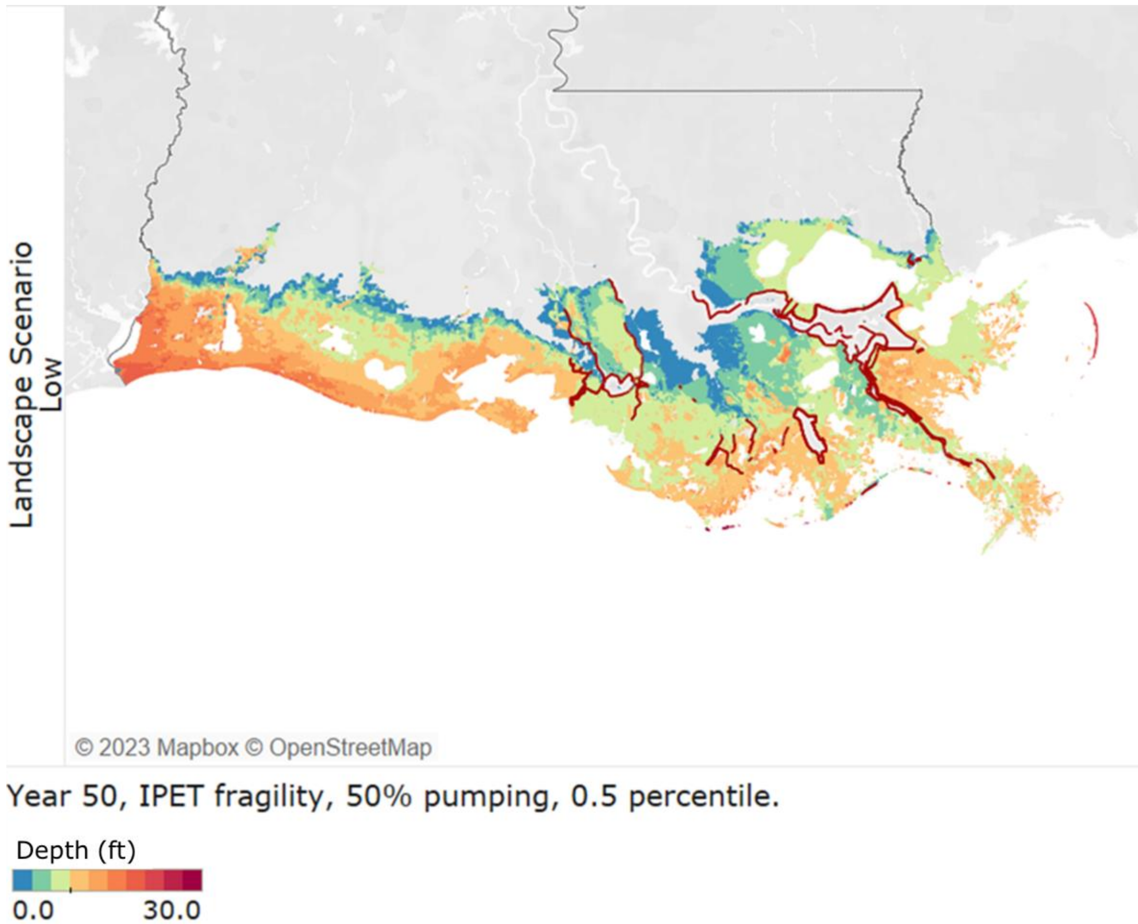

Figure 7. Modeled maximum future flood depth for a Hurricane Ike-like storm simulated in the FWOA, S07, Year 50 with current levee alignments.

4.3 FUTURE WITH ACTION

In a FWA, CLARA results show that the projected flood depths resulting from planned protection and restoration actions along the western part of the state are largely limited to locations along Sabine Lake and the Sabine River near the Texas-Louisiana border. In these locations, projected flood depths may be reduced by as much as 4 ft from a Hurricane Ike-like storm in a FWA relative to a FWOA (Figure 8). Further to the east in the Terrebonne Region, locations in and around the city of Houma are projected to experience more substantial reductions in depth than those observed in southwest Louisiana in a FWA (as much as 8 ft in some cases). CLARA simulations show similar depth reductions in the upper Barataria Basin around the River Parish community of Luling/Boutte. To the east of the Mississippi River in the Pontchartrain/Breton Region, depth reductions in a FWA are not as large or widespread. In this simulation, CLARA results project flood depth reductions of approximately 1.5 ft along the northwest shore of Lake Pontchartrain in a FWA compared to a FWOA.

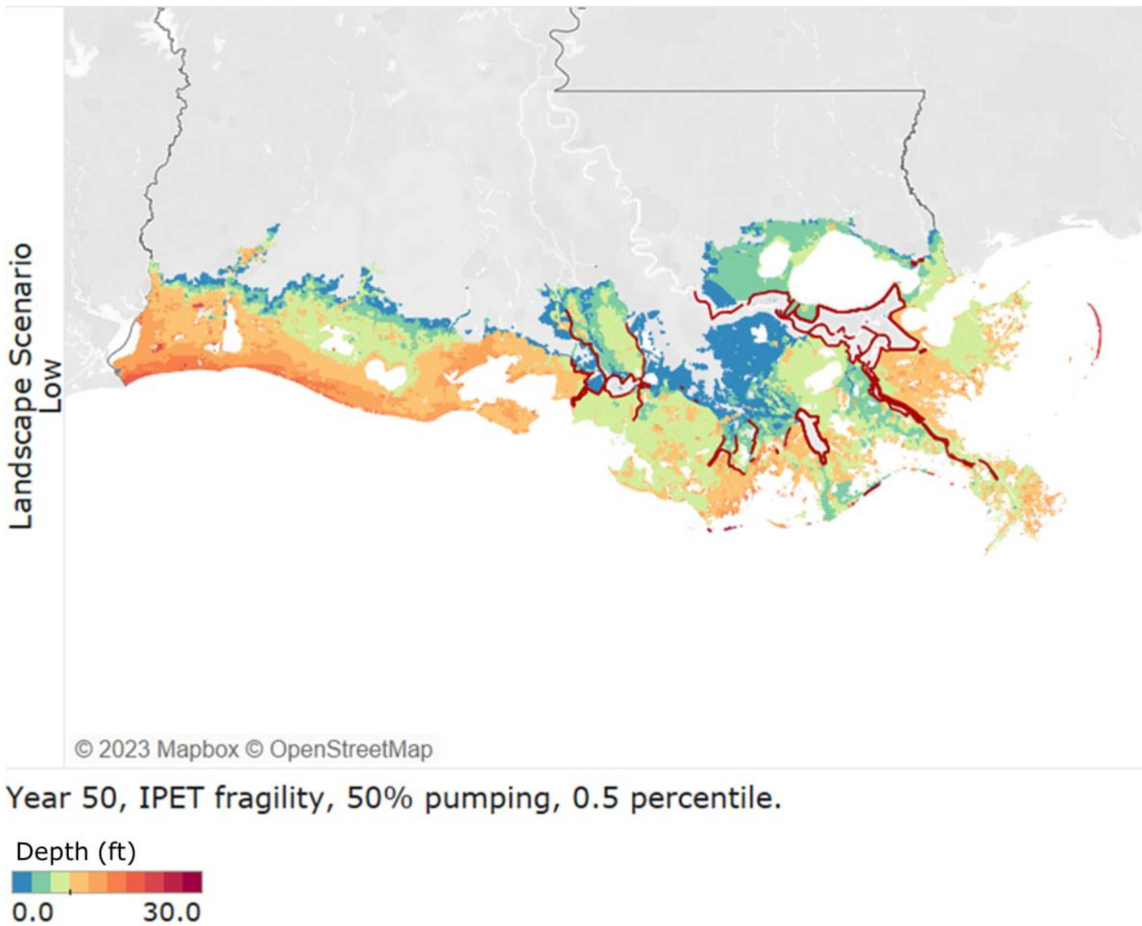

Figure 8. Modeled maximum future flood depth for a Hurricane Ike-like storm simulated in the FWA, S07, Year 50.

5.0 DAMAGES

The CLARA model was used to estimate direct economic damage associated with a Hurricane Ike-like storm for a FWOA and a FWA under S07 conditions. Results for Year 50 are presented below.

5.1 FUTURE WITHOUT ACTION

CLARA simulations for a Hurricane Ike-like storm generally show that the distribution of economic damage is tied to the density of population and residential structures. While CLARA results found that flood depths resulting from a Hurricane Ike-like storm in Years 0 and 50 were highest in Cameron Parish, the level of expected economic damage in this parish is expected to be relatively low due to the sparse population and the relatively undeveloped nature of the area (Table 9). Expected flood damage would be highest in many of the more populous locations east of the storm's landfall in Vermilion Parish, including communities in the Acadiana region to the west of Lafayette and the communities that comprise the Houma–Bayou Cane–Thibodaux metropolitan statistical area in the Terrebonne Region. CLARA results also project relatively high damage levels in most of the communities located along Bayou Lafourche, as well as in the vicinity of Port Fourchon. Finally, many locations in the New Orleans metropolitan region are expected to experience relatively high levels of damage from a Hurricane Ike-like event in Year 50 in a FWOA. This is due, in large part, to high population density and development, and includes New Orleans East, Mandeville, and Slidell. Overall, the CLARA results show that three areas are projected to have notably high levels of damage. The highest expected damages are projected in Slidell, followed by the city of Houma and the River Parish community of Luling/Boutte.

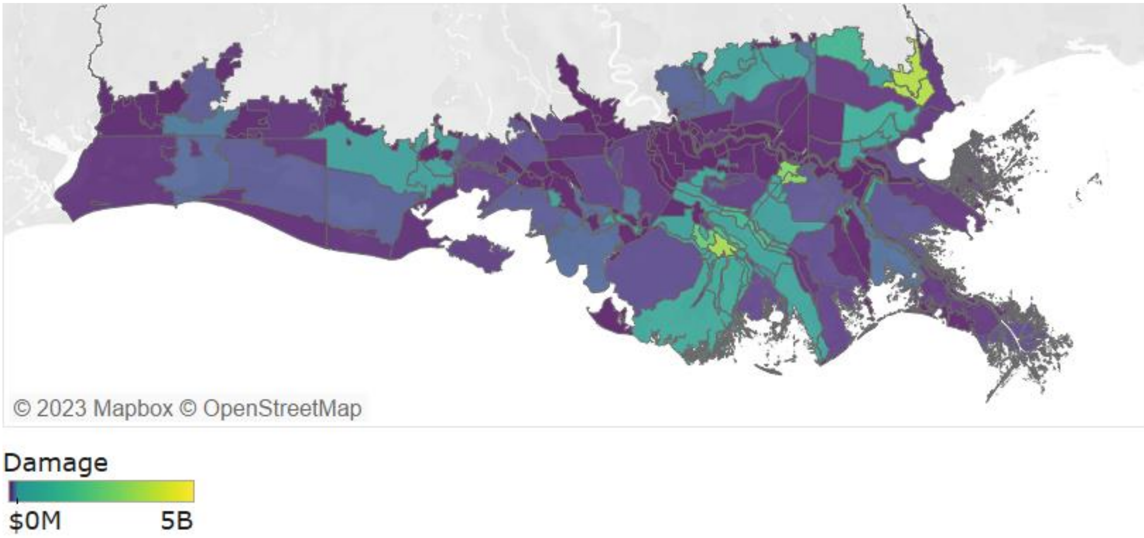

Figure 9. Modeled future economic damage for a Hurricane Ike-like storm simulated in the FWOA, S07, Year 50.

5.2 FUTURE WITH ACTION

In a FWA simulated in Year 50, CLARA results show that planned protection and restoration actions would have minimal impact on changing the overall coastwide damage footprint of a Hurricane Ike-like storm. However, significant reductions in damage are projected in Houma and the surrounding communities, as well as in Luling and Boutte, two census designated places located in St. Charles Parish that comprise a portion of the New Orleans metropolitan area (Table 10). When the difference between damage dollars in a FWOA and a FWA are directly compared, Houma, Slidell, and Luling/Boutte, the locations with the highest projected damages in a FWOA, show the highest level of anticipated damage reduction (Figure 11).

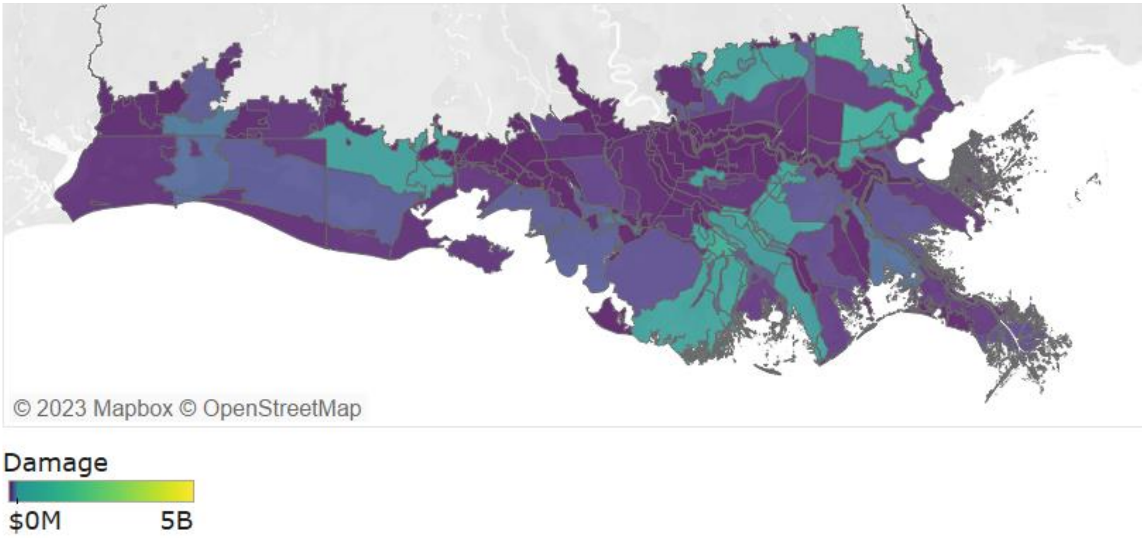

Figure 10. Modeled future economic damage for a Hurricane Ike-like storm simulated in the FWA, S07, Year 50.

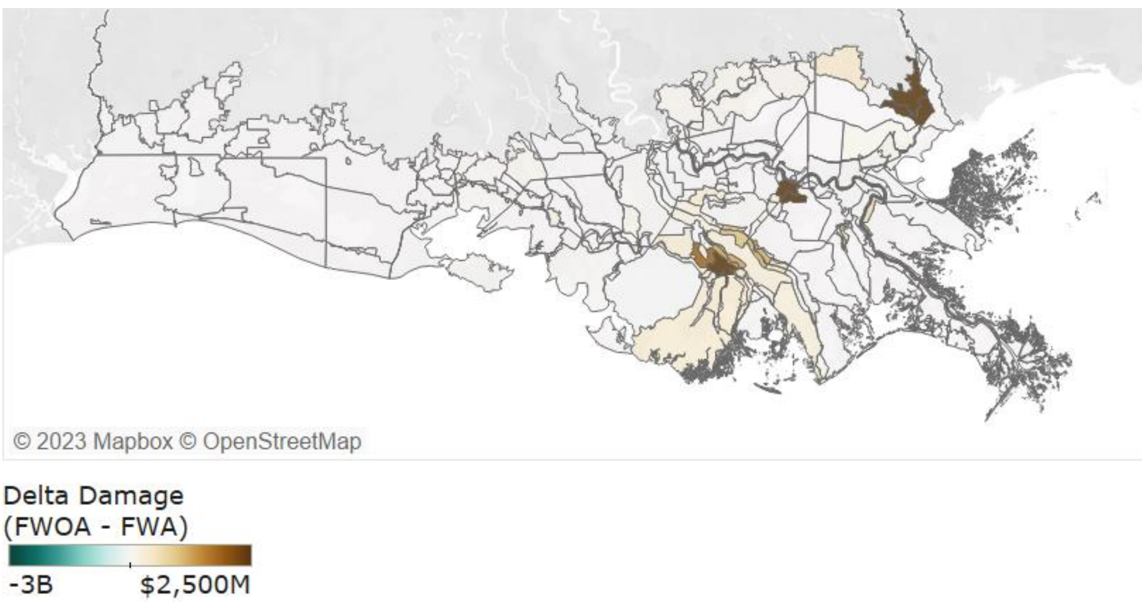

Figure 11. Change in modeled future economic damage between FWOA and FWA for a Hurricane Ike-like storm simulated in S07, Year 50.

Coastwide, CLARA results show that in a FWA, planned protection and restoration actions would effectively reduce the total amount of future economic damage from a Hurricane Ike-like storm by over $21.3 billion from a FWOA were the storm to make landfall in Year 50 (Table 9). Reflecting the social and economic profile of the potentially impacted areas, the highest level of both damage and damage reduction is expected to be in single family and other small residential units (e.g., manufactured homes and duplexes), followed by commercial and industrial structures.

Table 9. Modeled future asset damage and damage reduction from a Hurricane Ike-like storm in S07, Year 50

	Small Residential	Large Residential	Commercial and Industrial	Public and Educational	Grand Total
FWOA (Year 50)	$23,997M	$335M	$10,101M	$1,343M	$35,775 M
FWA (Year 50)	$9,135M	$94M	$4,974M	$236M	$14,440 M
Reduction in Damage Between FWOA and FWA (Year 50)	$14,861M	$240M	$5,127M	$1,106M	$21,335 M

Mirroring the results of the ADCIRC+SWAN simulations, the CLARA results show that the flood depth and damage resulting from a Hurricane Ike-like storm show a large amount of spatial variation in communities across the coast (Table 10). Unlike the ADCIRC+SWAN results, however, the amount of expected economic damage projected by CLARA is not purely a function of biogeophysical factors. The exposure of assets and associated economic damage is directly related to the degree of human development and the total population exposed to flood impacts. Because the track of a Hurricane Ike-like storm will bring it onshore near Galveston, Texas, the projected damage to individual structures in the town of Cameron, which is the master plan coastal community located nearest to the Texas border, is expected to be relatively high. CLARA results project lower, but still notable levels of damage in other communities with higher populations located farther from landfall, such as Delcambre and Dulac (Table 10). The expected damage under FWOA conditions for all these communities located in the Chenier Plain and Central Coast regions is expected to increase sharply under FWOA conditions. However, CLARA simulations show that unlike Cameron, Delcambre and Dulac are projected to experience notable reductions in damage from a Hurricane Ike-like storm in Year 50 under FWA conditions.

In terms of total coastwide damage dollars, damage levels in the sparsely populated portions of the coast are more than offset by those experienced in the most densely populated areas facing higher levels of flood exposure. For example, given the high population density of Lake Pontchartrain's North Shore communities in St. Tammany Parish, including Mandeville and Slidell, CLARA results project that a Hurricane Ike-like storm making landfall in Year 0 or in Year 50 will result in significant increases in flood damage relative to the expected surge and wave levels. In a FWA, planned protection and restoration actions implemented in these communities would be expected to result in significant damage reductions.

Table 10. Modeled total damage and change in damage to select coastal communities from a Hurricane Ike-like storm in S07

Community	Initial Conditions (Year 0)	FWOA (Year 50)	FWA (Year 50)	CHANGE IN Damage Between FWOA and FWA (Year 50)
Amelia	$6M	$7M	$6M	-14%
Cameron	$174M	$335M	$339M	1%
Delacroix	$16M	$5M	$6M	2%
Delcambre	$14M	$106M	$4M	-96%
Dulac	$53M	$211M	$117M	-45%
Grand Isle	$76M	$72M	$68M	-5%
Mandeville/Covington/ Madisonville/Abita Springs	$479M	$1,323M	$887M	-33%
Slidell/Eden Isle/Pearl River	$600M	$3,833M	$1,178M	-69%

6.0 REFERENCES

Berg, R. (2009). *Tropical Cyclone Report Hurricane Ike (AL092008) 1-14 September 2008* (p. 55) [Tropical Cyclone Report]. National Hurricane Center.

Cobell, Z., & Roberts, H. J. (2021). *2023 Coastal Master Plan: Model Improvement Plan, Storm Surge and Waves (Subtask 8).* (p. 56). CPRA.

FEMA. (2008). *Preliminary Damage Assessment Louisiana – Hurricane Ike – FEMA-1792-DR Declared September 13, 2008* (p. 2). Federal Emergency Management Agency.

Fischbach, J. R., Johnson, D. R., Ortiz, D. S., Bryant, B. P., Hoover, M., & Ostwald, J. (2012). *Coastal Louisiana Risk Assessment model: Technical description and 2012 Coastal Master Plan analysis results* (Technical Report TR-1259-CPRA; p. 146). Rand Gulf States Policy Institute. https://www.rand.org/pubs/technical_reports/TR1259.html

Johnson, D. R., Fischbach, J. R., Geldner, N. B., Wilson, M. T., & Stelzner, C. (2021). *2023 Coastal Master Plan: CLARA Model Summary.* Louisiana Coastal Protection and Restoration Authority.

Johnson, D. R., Fischbach, J. R., & Ortiz, D. S. (2013). Estimating surge-based flood risk with the Coastal Louisiana Risk Assessment Model. *Journal of Coastal Research*, *67*, 109–126. https://doi.org/10.2112/SI_67_8

Keim, B. D., Muller, R. A., & Stone, G. W. (2007). Spatiotemporal patterns and return periods of tropical storm and hurricane strikes from Texas to Maine. *Journal of Climate*, *20*(14), 3498–3509. https://doi.org/10.1175/JCLI4187.1

Kraus, N. C., & Lin, L. (2009). Hurricane Ike along the upper Texas coast: An introduction. *Shore & Beach*, *77*(2), 3–8.