2023 COASTAL MASTER PLAN

HISTORIC STORM RUN – IDA

SUPPLEMENTAL MATERIAL H6.4

REPORT: VERSION 02
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 Coastal Master Plan: Supplemental Material H6.4: Historic Storm Run – Ida. Version 2. (p. 28). Baton Rouge, Louisiana: Coastal Protection and Restoration Authority.

ACKNOWLEDGEMENTS

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

- 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)
AGL	ABOVE GROUND LEVEL
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	SIMULATING 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 a Hurricane Ida-like storm, a Category 4 storm that made landfall on August 29, 2021, to the west of Port Fourchon, a deep-draft port at the mouth of Bayou Lafourche on the Gulf of Mexico,

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) 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 Ida made landfall on August 29, 2021, as a Category 4 storm to the west of Port Fourchon, a deep-draft port at the mouth of Bayou Lafourche on the Gulf of Mexico, and Grand Isle, a barrier island community of 1,400 residents located in Jefferson Parish. Grand Isle is accessible only via Louisiana Highway 1 through Lafourche Parish (Figure 1). The highest reported sustained winds near the area of landfall were 116 mph, with gusts up to 131 mph reported at a National Oceanic and Atmospheric Administration (NOAA) Coastal Marine Automated Network Station (Beven II et al., 2021). The tropical storm system also produced 24 total tornadoes with 2 located in Louisiana.

Lower Terrebonne Parish and Lower Lafourche Parish experienced catastrophic damage, particularly within the communities of Grand Isle, Leeville, Dulac, and Montegut (National Weather Service, 2021). Hurricane Ida caused widespread flooding from both heavy rainfall and storm surge with up to 14 ft of flooding above ground level (AGL) experienced on the east bank of the Mississippi River in Plaquemines and St. Bernard parishes and up to 12 ft on the west bank of the river in Jefferson, Plaquemines, and St. Charles parishes. Similar levels of flooding occurred in the basins to the west of the Mississippi River Bird's Foot Delta in Lafourche and Terrebonne parishes. Inland areas to the west of Lake Pontchartrain experienced significant flooding as easterly winds pushed water from the Chandeleur Sound into the lake, with high water marks up to 9.9 ft AGL found near Frenier Landing at the edge of the Maurepas Swamp.

There were four reported deaths directly associated with Hurricane Ida in Louisiana while the parishes of southeast Louisiana reported thousands of instances of building damage caused by wind and surge. The coastal areas of Lafourche and Jefferson parishes in proximity to the location of landfall experienced the highest levels of structural damage, while the New Orleans metropolitan area, the River Parishes along the Mississippi River northwest of New Orleans, and areas of Point Coupee Parish within the storm's path experienced widespread electrical power failures (Beven II et al., 2021).

On August 22, 2021, Governor John Bel Edwards requested an expedited major disaster declaration, which preceded the joint preliminary damage assessment due to the severity and magnitude of the storm event and the need for immediate supplemental federal assistance. On August 29, 2021, President Joseph Biden declared Hurricane Ida a major disaster in the State of Louisiana. This declaration allowed for the provision of Individual Assistance for affected households in 25 of Louisiana's 64 parishes and made emergency protective measures, which include direct federal assistance, available statewide.

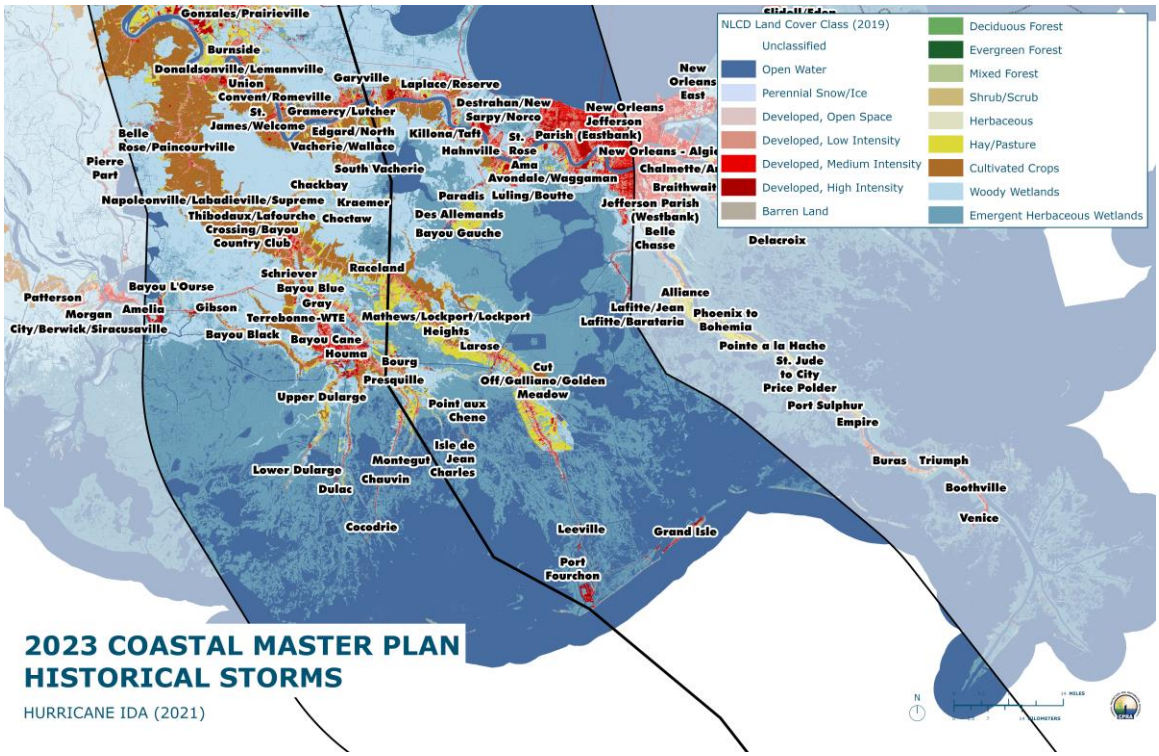

Figure 1. Storm track of Hurricane Ida and communities within a 50 km buffer of the storm's center.

3.0 STORM SURGE AND WAVES

The ADCIRC+SWAN model was used to simulate storm surge and wave height associated with Hurricane Ida 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 initial conditions. Under these conditions, ADCIRC+SWAN simulations show that if a Hurricane Ida-like storm were to make landfall in Year 0, which approximates current conditions, following the same track, the anticipated surge would be greatest in three primary locations: two to the west of the Mississippi River Bird's Foot Delta in the Barataria Region and one to the east in the Pontchartrain/Breton Region (Figure 2). Model simulations show that the two locations in the Barataria Region are adjacent to flood protection levees, where storm surge is expected to pile up, resulting in peak water surface elevations ranging from 10 to 12 ft. The first of these locations is to the southeast of the Larose to Golden Meadow levee system which surrounds the densely populated Lafourche Parish community of Cut Off/Galliano/Golden Meadow. The second location is at the eastern edge of the Barataria Region, where high peak water surface elevations are expected along the Mississippi River levees on the west bank of the river in Plaquemines Parish. Similar water surface elevations are projected for portions of Grand Isle, located directly east of the storm's landfall.

The most notable location to the east of the delta is in the Breton Sound Basin at the junction of the Hurricane and Storm Damage Risk Reduction System (HSDRRS) levees on the south side of St. Bernard Parish and the Mississippi River levees in Plaquemines Parish, where the expected surge is greatest in the area from the fishing villages of Delacroix and Yscloskey toward the unincorporated community of Braithwaite. One notable location east of the delta where ADCIRC+SWAN simulations show peak water surface elevations of 8 to 10 ft is on the north shore of Lake Pontchartrain near Mandeville/Covington/Madisonville/Abita Springs, part of the New Orleans–Metairie metropolitan statistical area.

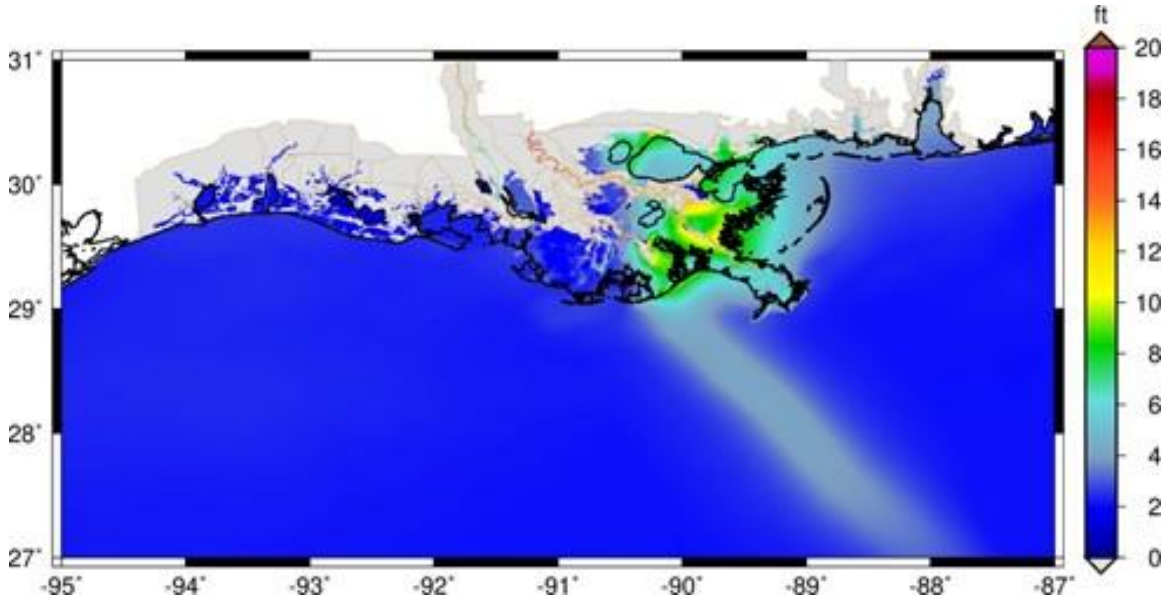

Figure 2. Peak water surface elevation (ft, NAVD88) for a Hurricane Ida-like storm simulated in Year 0.

3.2 FUTURE WITHOUT ACTION

Storm surge and wave simulations under S07 show that were a Hurricane Ida-like storm to make landfall in a FWOA, the greatest expansion of the floodplain in Year 50 (compared to initial conditions) would be expected to occur in the upper Barataria Basin north of the fisheries-dependent communities of Chackbay, Choctaw, Kraemer, and South Vacherie (Figure 3). In a FWOA simulation, floodplain expansion is also anticipated in areas to the west of the storm track. Most notably, this includes several locations throughout the lower Atchafalaya Basin. While this location is projected to see some increase in water surface elevations from a Hurricane Ida-like storm in Year 0, by Year 50 in a FWOA, these levels are expected to reach upwards of 10 ft in some locations in the Atchafalaya Basin. Further to the west, ADCIRC+SWAN results show that many areas of the Chenier Plain Region located atop the chenier ridges that are not projected to see notable water surface elevations in Year 0 will experience increased water surface levels in Year 50.

Many areas in which ADCIRC+SWAN simulations anticipate high peak water surface elevations from an Ida-like storm in a FWOA in Year 0 are expected to see large increases in water heights in a FWOA in Year 50. The most notable location is near Braithwaite at the junction of the HSDRRS levees in St. Bernard Parish and the Mississippi River levees in Plaquemines Parish. By Year 50 in a FWOA, this area is expected to see water heights exceeding 14 ft. Similar increases in projected water height are observed along the Mississippi River levees on the west bank of the river in Plaquemines Parish at the

eastern edge of the Barataria Region. ADCIRC+SWAN results additionally show increasing water heights reaching from this location along the Mississippi River westward across many of the lakes, bays, and marshes of the Barataria Basin by Year 50 in a FWOA. The other locations with notable high peak water elevations seen in the ADCIRC+SWAN projections for Year 0, the Atchafalaya Basin and the north shore of Lake Pontchartrain, are projected to see increases in peak water surface elevations from a Hurricane Ida-like storm in Year 50 in a FWOA, with levels potentially exceeding 10 ft.

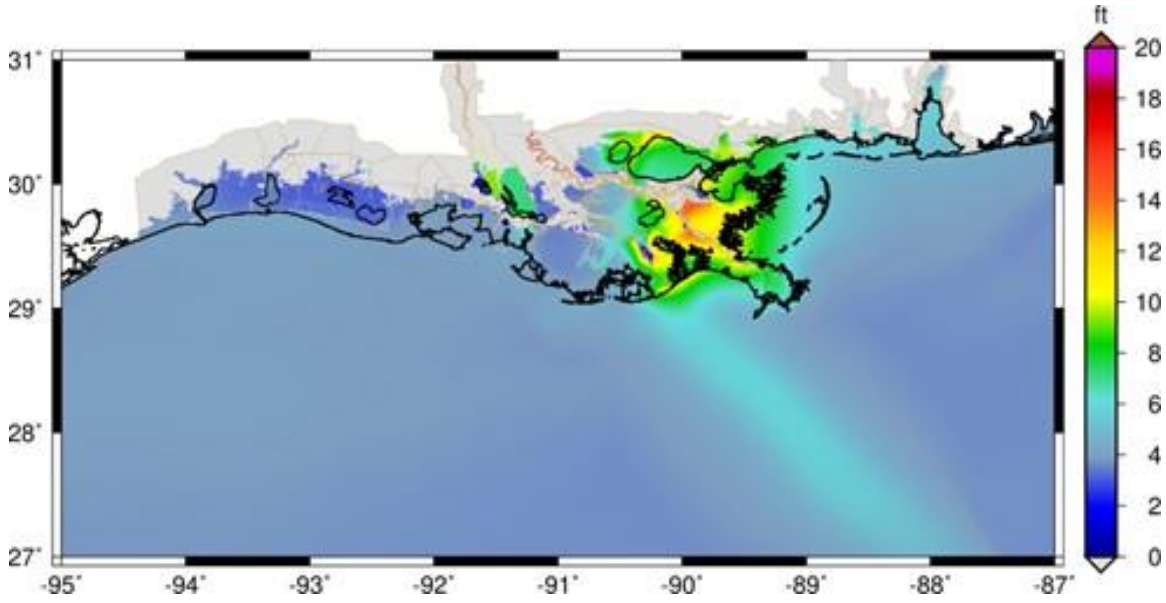

Figure 3. Peak water surface elevation (ft, NAVD88) for a Hurricane Ida-like storm simulated in the FWOA, S07, Year 50.

3.3 FUTURE WITH ACTION

In a FWA simulation under the S07, ADCIRC+SWAN results for Year 50 show similar spatial patterns to those observed for Year 50 in a FWOA, with projected water surface elevations in excess of 14 ft observed near Braithwaite at the junction of the HSDRRS levees and the Mississippi River levees and to the east of the Larose to Golden Meadow levee system (Figure 4). While the overall spatial pattern of peak water surface elevations from a Hurricane Ida-like storm in a FWA in Year 50 is similar to that observed in a FWOA in Year 50, an examination of the differences in projected water height reveals a clear delineation between areas expected to experience increases and those expected to experience decreases (Figure 5). Within the Terrebonne and Barataria regions, ADCIRC+SWAN results show that the Morganza to the Gulf project is projected to reduce peak water surface elevations likely to result from a Hurricane Ida-like storm in a FWA in Year 50. However, on the outside of this levee system, water heights are projected to increase as storm water piles against the levees. A similar broad

pattern is observed in the Pontchartrain Basin, where Lake Borgne and the lower Pearl River Valley are projected to see slight increases in water heights from a Hurricane Ida-like storm in Year 50, while the areas to the west, including Lake Pontchartrain and the North Shore communities from Slidell/Eden Isle/Pearl River to Mandeville/Covington/Madisonville/Abita Springs and Ponchatoula/Springfield, are projected to see slight decreases.

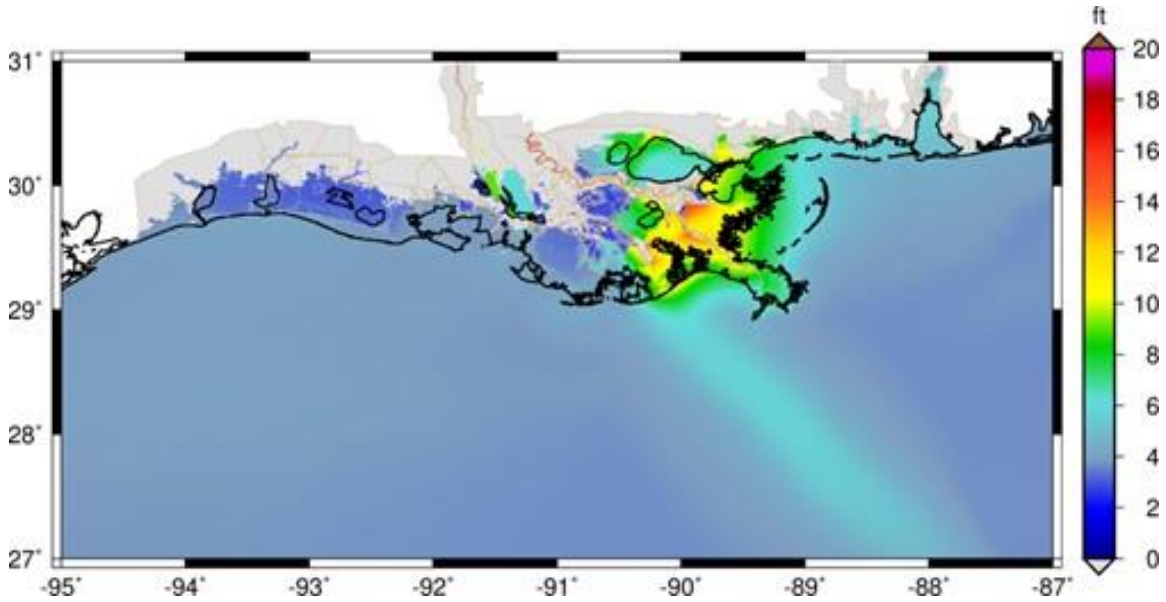

Figure 4. Peak water surface elevation (ft, NAVD88) for a Hurricane Ida-like storm simulated in the FWA, S07, Year 50.

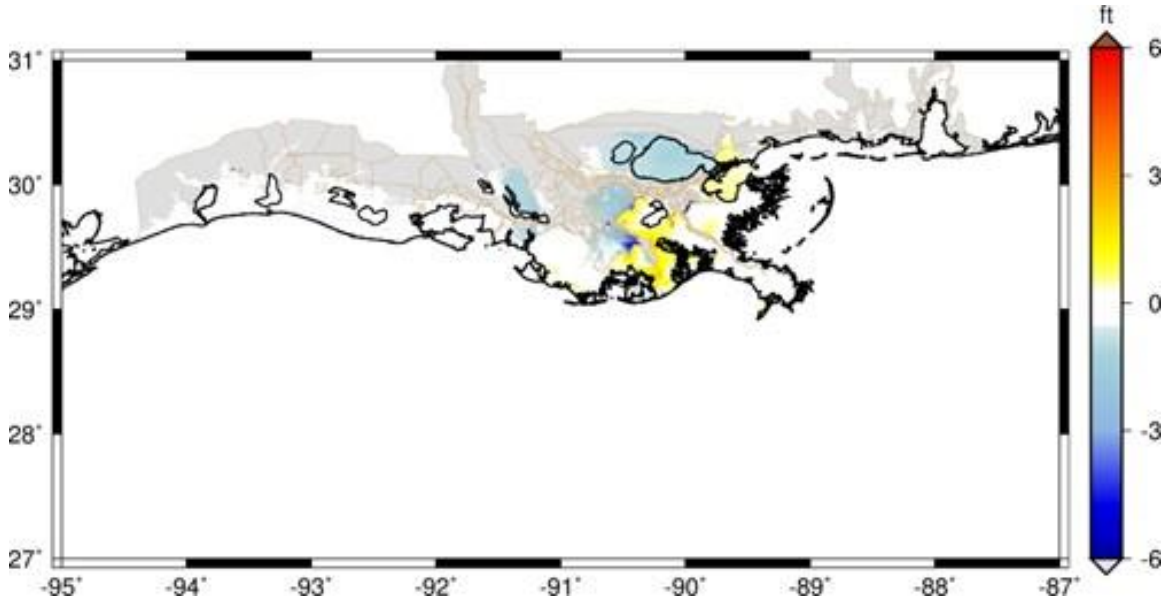

Figure 5. Change in peak water surface elevation (feet, NAVD88) between FWOA and FWA for a Hurricane Ida-like storm simulated in S07, Year 50.

3.4 LOCAL STORM SURGE AND WAVE IMPACTS

In a more granular analysis of the anticipated local impacts of a Hurricane Ida-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, several key locations of community importance were identified and verified by local stakeholders. To assess the local impacts of a Hurricane Ida-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). Of the communities examined for this analysis, three were located within 50 km of the center line of the storm, one on the eastern side (Grand Isle) and two on the west (Amelia and Dulac). ADCIRC+SWAN results for the future impacts of a Hurricane Ida-like storm for Grand Isle, the community closest to the eye of the storm at landfall, shows an increase of over 2.5 ft at all key locations examined in a FWOA. This is with the exception of one key local road link, which is still projected to experience over 2 ft of water (Table 1), and includes flooding along the transportation network on the mainland, across the causeway over Caminada Pass. ADCIRC+SWAN results show that in a FWA, the projected water heights from Hurricane Ida at one key location (the Grand Isle Community Center) and along the primary evacuation route across the

causeway would be eliminated, while the other locations on the island are expected to see no notable change in water surface elevation, or even a slight increase.

Table 1. Peak water surface elevation (ft, NAVD88) for a Hurricane Ida-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	2.14	2.55	2.61
GRAND ISLE	GRAND ISLE EVACUATION LINK - LA1	2.29	2.63	2.86
GRAND ISLE	GRAND ISLE LOCAL ROAD LINK - OAK LN AT LOUISIANA AVE	1.68	2.17	2.14
GRAND ISLE	GRAND ISLE STATE PARK	2.11	2.75	2.85

ADCIRC+SWAN simulations for a Hurricane Ida-like storm show that the surge and wave impacts of the storm are projected to extend far beyond the 50 km range where hurricane force winds are anticipated. To the east of Hurricane Ida's storm track, the local impacts of flooding are more pronounced in locations along Lake Pontchartrain. For communities located on the north shore of Lake Pontchartrain, including Slidell and Mandeville, the projected water surface elevations from a Hurricane Ida-like storm are expected to be extremely high. This is especially true for areas immediately adjacent to Lake Pontchartrain and any connected, tidally influenced waterways.

ADCIRC+SWAN simulations show that if a Hurricane Ida-like storm were to make landfall in Year 0, key locations in the densely populated core of Slidell would not be expected to experience any flooding. Much of the area of Slidell located to the west of the high-density, developed downtown area may experience over 2 ft of water height in Year 0 (Table 2). This includes the locations and roadways along Bayou Bonfouca and Bayou Liberty proximate to the wide expanses of brackish marsh fringing the Lake Pontchartrain shoreline. Simulations for a FWOA in Year 50 show these values increasing by approximately 0.5 ft for each of these areas. In addition, each of the key locations not expected to experience any water above surface in Year 0 are projected to experience water surface elevations exceeding 2 ft in Year 50 in a FWOA. In a FWA, ADCIRC+SWAN simulations show major reductions or eliminations in water above surface in each of the key locations examined in Slidell.

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

COMMUNITY	NAME	INITIAL CONDITIONS (YEAR 0)	FWOA (YEAR 50)	FWA (YEAR 50)
SLIDELL	BAYOU LIBERTY MARINA	2.02	2.58	0.97
SLIDELL	OUR LADY OF LOURDES CHURCH	N/A	2.53	N/A
SLIDELL	SALMEN HIGH SCHOOL	N/A	2.52	N/A
SLIDELL	SLIDELL LOCAL ROAD LINK - BAYOU LIBERTY RD NEAR GALATAS LN	2.05	2.60	0.99
SLIDELL	SLIDELL MUNICIPAL MARINA AT HERITAGE PARK	2.10	2.64	N/A
SLIDELL	ST GENEVIEVE CHURCH	2.04	2.60	1.02

As with Slidell, the anticipated flood risk in Mandeville from a future Hurricane Ida-like storm is limited to locations immediately adjacent to water bodies. In both a FWOA and FWA, a Hurricane Ida-like storm is expected to result in 2 to 2.5 ft of water above surface along the shores of Lake Pontchartrain with the more inland locations along Florida Street and Jackson Avenue not expected to flood (Table 3). The Fontainebleau State Park Visitors Center, largely separated from Lake Pontchartrain by large tracts of cypress swamp, is projected to experience increases in water surface elevation during future storm events like Hurricane Ida, both with and without action. Despite being located inland from the shoreline of Lake Pontchartrain, the water surface elevation at the visitor center is projected to be only slightly less than that seen in locations immediately adjacent to the lake.

Table 3. Peak water surface elevation (ft, NAVD88) for a Hurricane Ida-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	2.21	2.73	2.40
MANDEVILLE	LAKESHORE DR	2.29	2.80	2.48
MANDEVILLE	MANDEVILLE EVACUATION LINK - FLORIDA ST AND JACKSON AVE	N/A	2.98	N/A
MANDEVILLE	MANDEVILLE LOCAL ROAD LINK - MONROE ST AND RAMON ST	2.41	2.91	2.58
MANDEVILLE	WEST LAKEFRONT CHILDREN'S PARK	2.33	2.84	2.52

East of lakes Pontchartrain and Borgne and the Mississippi River are a number of small unincorporated fishing communities including Delacroix, a small Isleño census-designated place located in St. Bernard Parish along Bayou Terre aux Bouefs that is surrounded on all sides by bayous and wetlands. ADCIRC+SWAN simulations of a Hurricane Ida-like storm for Delacroix projects nearly 3 ft of water elevation along some local road segments in Year 0 with levels approaching 4 ft in Year 50 in a FWOA (Table 4). In a FWA scenario, the implementation of planned protection and restoration

projects would not be expected to significantly alter these water surface elevations.

Table 4. Peak water surface elevation (ft, NAVD88) for a Hurricane Ida-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	2.97	3.72	3.75
DELACROIX	DELACROIX ISLAND PIER	2.87	3.69	3.73
DELACROIX	DELACROIX LOCAL ROAD LINK - DELACROIX HWY	2.93	3.73	3.77

The two communities located to the west of the storm track within the 50 km buffer are each expected to experience increases in peak water surface elevations from a Hurricane Ida-like storm in Year 50 in a FWOA. Dulac, located Terrebonne Parish, is located atop a distributary ridge. In Year 0, a Hurricane Ida-like storm would be expected to generate just over 1 ft of water surface elevation at most of the key locations examined, including the Dulac Community Center (Table 5). Similar water surface levels would be expected to occur along Shrimpers Row, while no expected flooding is projected for locations along Grand Caillou Road. In Year 50 in a FWOA, these levels are projected to increase by 0.5 ft with Grand Caillou Road projected to experience over 1.2 ft of water elevation. However, model results show that the Morganza to the Gulf project and other restoration and protection measures would reduce hurricane storm surge levels for all key locations examined in Dulac. With the master plan in place, each of the key locations is expected to experience a reduction in water elevation above surface from a Hurricane Ida-like storm in Year 50. Most of these differences are projected to be slight.

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

COMMUNITY	NAME	INITIAL CONDITIONS (YEAR 0)	FWOA (YEAR 50)	FWA (YEAR 50)
DULAC	DULAC COMMUNITY CENTER	1.10	1.69	1.57
DULAC	DULAC EVACUATION LINK - GRAND CAILLOU RD	N/A	1.21	1.05
DULAC	DULAC LOCAL ROAD LINK - SHRIMPERS ROW AND BAYOU GUILLAUME RD	1.06	1.45	1.34
DULAC	HOLY FAMILY CATHOLIC CHURCH	1.07	1.54	1.43

Amelia, a census designated place in St. Mary Parish, is located at the western edge of the 50 km buffer around the track of Hurricane Ida. Despite its location in the Atchafalaya Basin surrounded by Lake Palourde and a number of canals, bayous, and rivers, Amelia is projected to experience relatively low water surface elevations from a Hurricane Ida-like storm in Years 0 and 50, with flooding only projected to occur along one of the local road links in the community. In Year 0, ADCIRC+SWAN results project no water above surface at either the local library or elementary school (Table 6). In a FWOA, this pattern is not projected to change, although peak water elevations along Duhon Boulevard are

expected to increase. In a FWA, ADCIRC+SWAN simulations show that master plan actions would only slightly reduce the projected water surface elevations at this location from their FWOA levels.

Table 6. Peak water surface elevation (ft, NAVD88) for a Hurricane Ida-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	N/A	N/A
AMELIA	AMELIA LOCAL ROAD LINK - DUHON BLVD	0.37	1.01	0.86
AMELIA	J S AUCOIN ELEMENTARY SCHOOL	N/A	N/A	N/A

Despite being further west of storm's center, Delcambre, a town located on the border of Vermilion and Iberia parishes at the head of the Delcambre Canal, is expected to experience slightly higher water surface elevations from a Hurricane Ida-like storm to those seen in Amelia. Water surface elevations of less than 1 ft are expected at Bayou Carlin Cove in Year 0, with this value climbing by about 0.5 ft in Year 50 in a FWOA (Table 7). Under this simulation, one new location—East Main Street—is expected to experience water above surface elevation. ADCIRC+SWAN results show decreased water surface elevations in a FWA compared to a FWOA for Bayou Carlin Cove, an area located directly on the Delcambre Canal. Under this simulation, the expected water surface elevations along the local roadways observed in a FWOA are expected to be eliminated in a FWA.

Table 7. Peak water surface elevation (ft, NAVD88) for a Hurricane Ida-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	0.67	1.16	0.88
DELCAMBRE	DELCAMBRE HIGH SCHOOL	N/A	N/A	N/A
DELCAMBRE	DELCAMBRE LOCAL ROAD LINK - E MAIN ST AND S PRESIDENT ST	N/A	1.16	N/A
DELCAMBRE	VERMILION PARISH LIBRARY - DELCAMBRE BRANCH	N/A	N/A	N/A

Further to the west of the storm track, in the community of Cameron, areas located atop the elevated chenier ridges, such as the local recreational facility, are not expected to experience any flooding in Year 0, with the exception of the local ferry landing (Table 8).

Locations off the chenier ridges and along the local waterways are expected to experience approximately 1 ft of water elevation from a Hurricane Ida-like storm in Year 50 in a FWOA. ADCIRC+SWAN simulations show that planned protection and restoration actions in a FWA are not projected to alter the expected water surface elevations in any of these locations.

Table 8. Peak water surface elevation (ft, NAVD88) for a Hurricane Ida-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	N/A	N/A	N/A
CAMERON	CAMERON EVACUATION LINK - LA27	N/A	0.91	0.91
CAMERON	CAMERON FERRY WEST LANDING	0.68	1.15	1.15
CAMERON	CAMERON PARISH LIBRARY	N/A	1.17	1.18
CAMERON	CAMERON PARISH RECREATION DISTRICT NO. 6 FACILITY	N/A	N/A	N/A

4.0 FLOOD DEPTH

The CLARA model was used to estimate flood depths associated with a Hurricane Ida-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

While the 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. CLARA simulations modeling the impacts of a Hurricane Ida-like storm across the Louisiana coast in Year 0 demonstrate effects centered along the lower section of the Mississippi River. Simulations indicate the greatest flood depths affecting areas along Bayou Lafourche in Lafourche Parish, within the lower Barataria Basin in Jefferson Parish, and an area that includes the barrier island community of Grand Isle. Other notable impacts are projected for locations within Breton Sound in Plaquemines and St. Bernard parishes (Figure 6). These parishes are projected to experience flood depths greater than 10 ft in an Ida-like storm. Flood depths taper off further down the coastline to the west, with Terrebonne Parish projected for depths of approximately 4 ft, while Iberia and more westerly parishes are projected to experience depths in the 1 to 2 ft range. On the eastern side of the Mississippi River in Bird's Foot Delta, elevated flood depths are projected for most of the Pontchartrain/Breton Region, with the New Orleans Landbridge area, located outside the HSDRRS system, projected to see flood depths greater than 10 ft, though depths fall off to less than 5 ft further inland around Lake Pontchartrain.

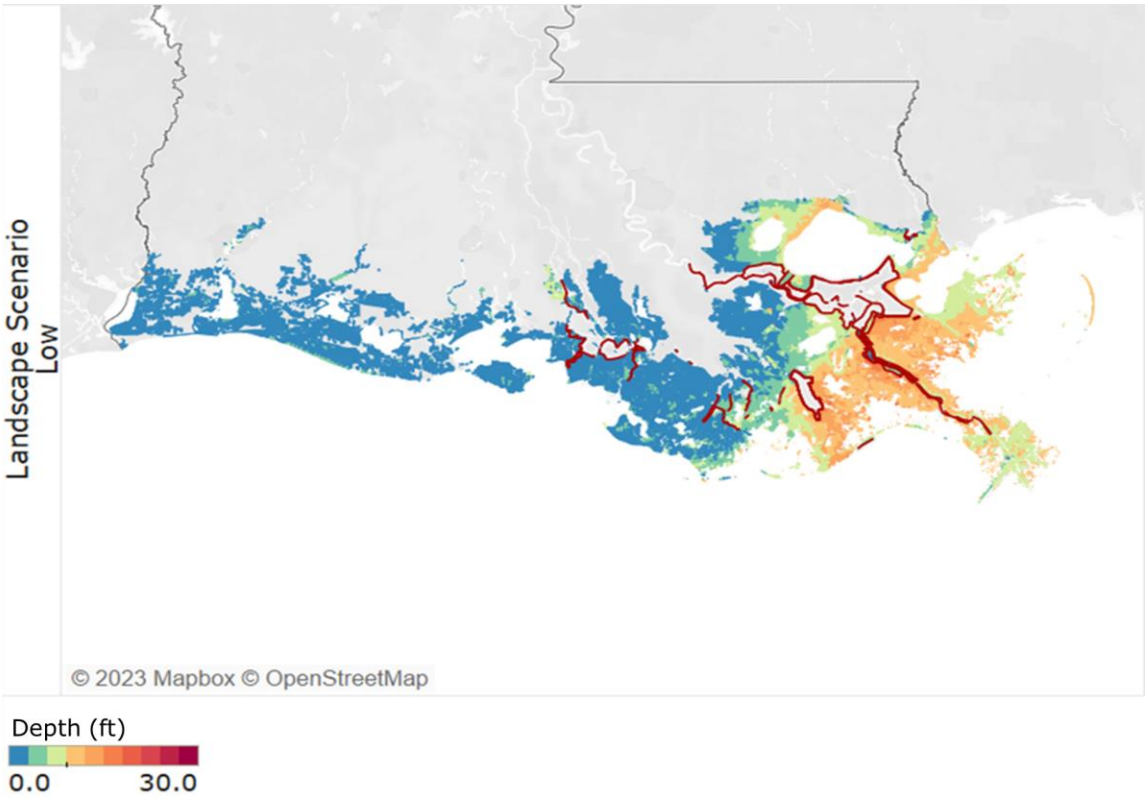

Figure 6. Modeled maximum flood depth for a Hurricane Ida-like storm simulated under initial conditions.

4.2 FUTURE WITHOUT ACTION

By Year 50, water elevation patterns from a Hurricane Ida-like storm are expected to intensify in a FWOA, as observed in the storm surge and wave analysis (Figure 7). This includes both an increase in flood depths for affected regions and an expansion of the flood plain into areas that were projected to have minimal flooding in Year 0. CLARA simulations show that the most heavily impacted areas around the Mississippi River are projected to experience an increase of more than 2 ft in flooding (or more in areas directly adjacent to the levee protection system). Projections show that locations far from the point of landfall in Lafourche Parish, as well as those further inland, are expected to experience between 6 in and 2 ft of flooding. However, locations in northern St. Martin Parish around Bayou Chene are projected to see a more than 6 ft increase in flood depths.

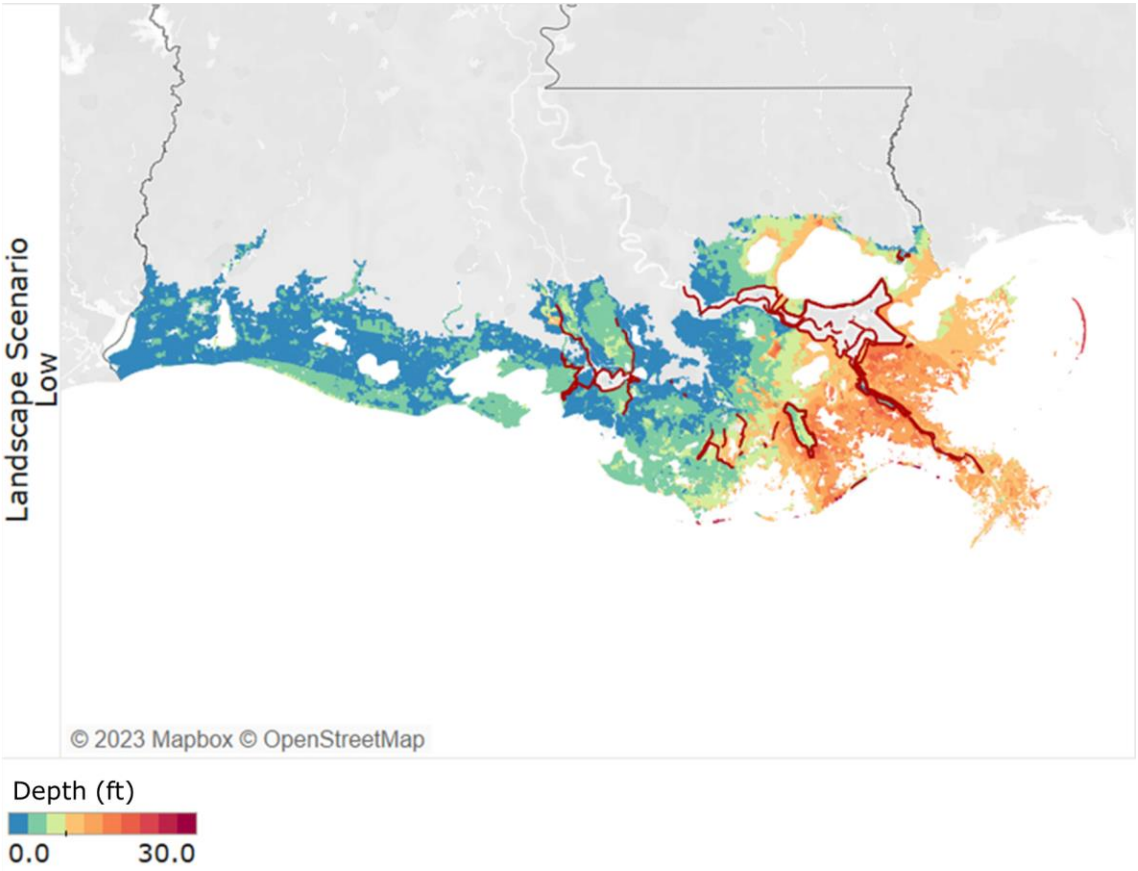

Figure 7. Modeled maximum future flood depth for a Hurricane Ida-like storm simulated in the FWOA, S07, Year 50 with current levee alignments.

4.3 FUTURE WITH ACTION

With planned protection and restoration actions, flood depths from a Hurricane Ida-like storm in Year 50 in St. Charles Parish and more inland parts of Lafourche Parish can be somewhat ameliorated (Figure 8). CLARA simulations found that that communities in this region such as Luling/Boutte and Houma are expected to see flood depths reduced by 1 to 2 ft under FWA conditions. A similar reduction in flood depths is expected further to the north along the northern shore of Lake Pontchartrain, as well as to the east in the Bayou Chene region of St. Martin Parish. The expected reduction in depths comes at the cost of a potential increase in projected depths on the coastal side of the Morganza to the Gulf project in Jefferson and Lafourche parishes. The more western parts of the state are largely unaffected by the planned protection and restoration actions.

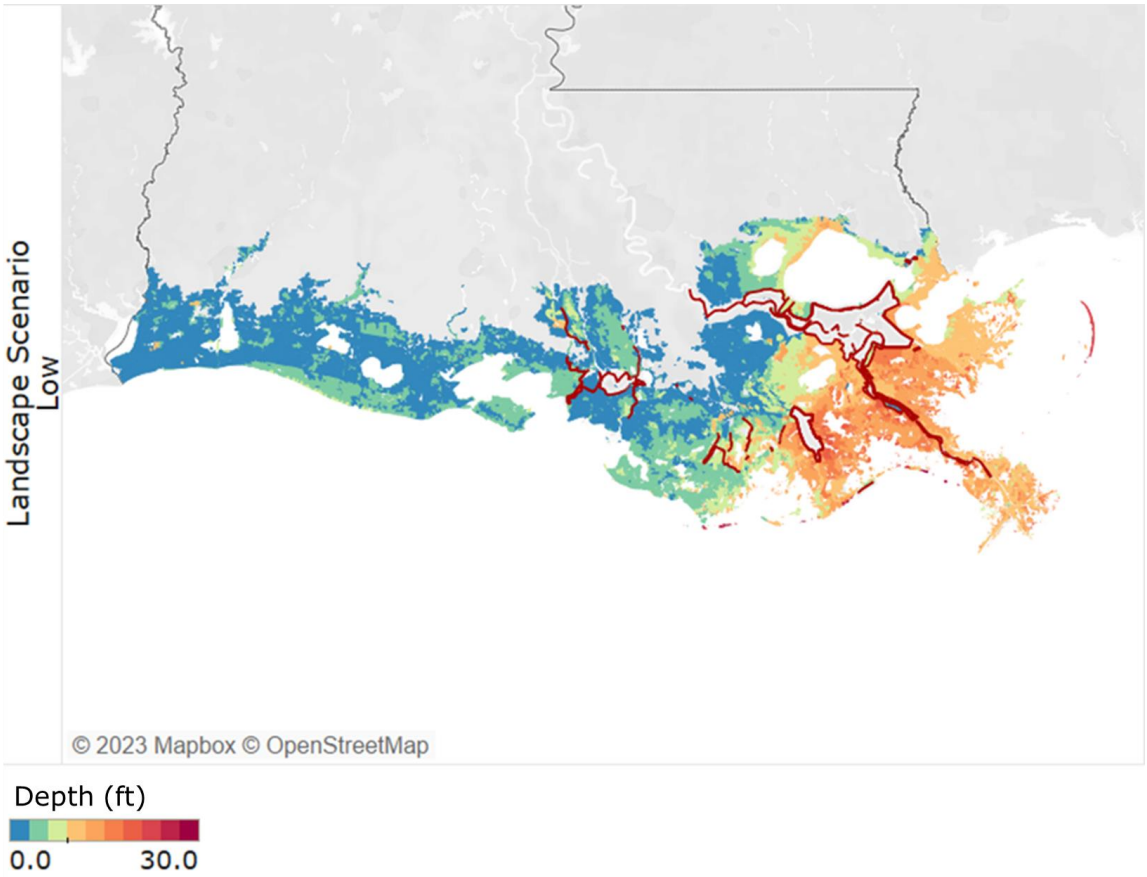

Figure 8. Modeled maximum future flood depth for a Hurricane Ida-like storm simulated in the FWA, S07, Year 50.

5.0 DAMAGES

The CLARA model was used to estimate direct economic damage associated with a Hurricane Ida-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 Ida-like storm show that the distribution of economic damage in Year 0 is tied to the density of population and residential structures, as well as the flood depths themselves. In Year 50 in a FWOA, the majority of the projected direct economic damage resulting from a Hurricane Ida-like storm is concentrated in the more densely populated communities directly in the path of the storm. Houma, Luling/Boutte, and Cut Off/Galliano/Golden Meadow all have projected damage values in the billions of dollars. These expected damage values are comparable to the expected damage in the communities along the north shore of Lake Pontchartrain, such as Mandeville and Slidell. While the storm track veered to the west, somewhat avoiding these communities, they nevertheless see high expected damage due to high levels of development and relatively light flood protection under FWOA conditions. Damage across the rest of the coast is more minimal, especially in the western portions of the state.

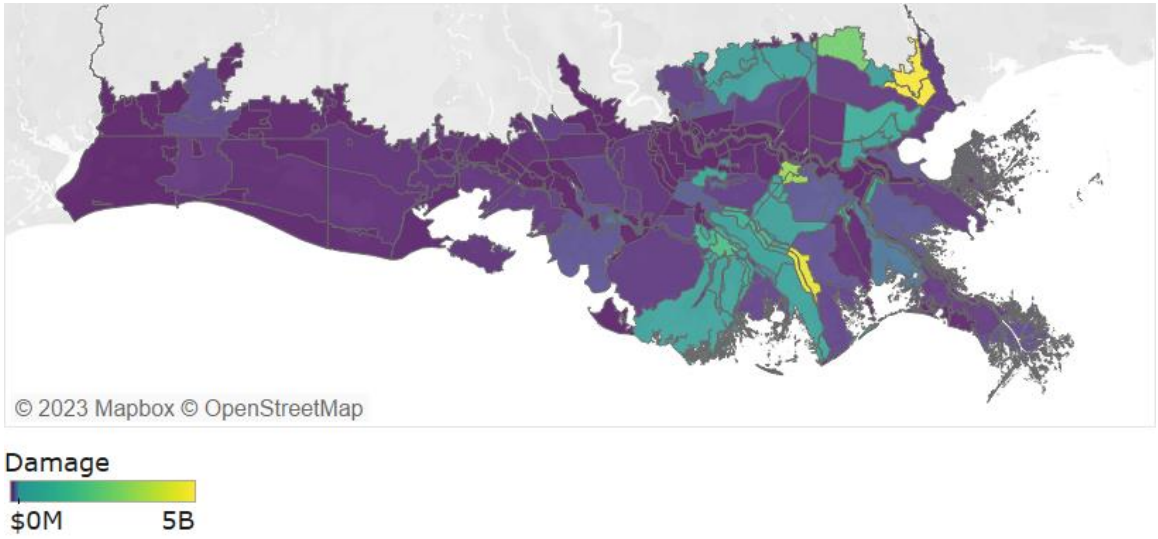

Figure 9. Modeled future economic damage for a Hurricane Ida-like storm simulated in the FWOA, S07, Year 50.

5.2 FUTURE WITH ACTION

CLARA simulations suggest that planned protection and restoration actions will not substantively alter which communities are facing the highest expected damage in Year 50 (Figure 10). Houma, Luling/Boutte, Mandeville, and Slidell all are still projected to experience relatively high expected damage values, though the damage in Lulling/Boutte is less than a billion dollars and more comparable to the damage projected for locations within Orleans Parish. Although Slidell is still projected to experience more than $2 billion in damage, CLARA simulations show that this site will see the greatest reduction in expected damage (Figure 11). The only other comparable reduction in damage is expected to occur within the Larose to Golden Meadow levee system, where damage values drop from more than $4 billion under FWOA conditions to less than $20 million under FWA conditions in the community of Cut Off/Galliano/Golden Meadow.

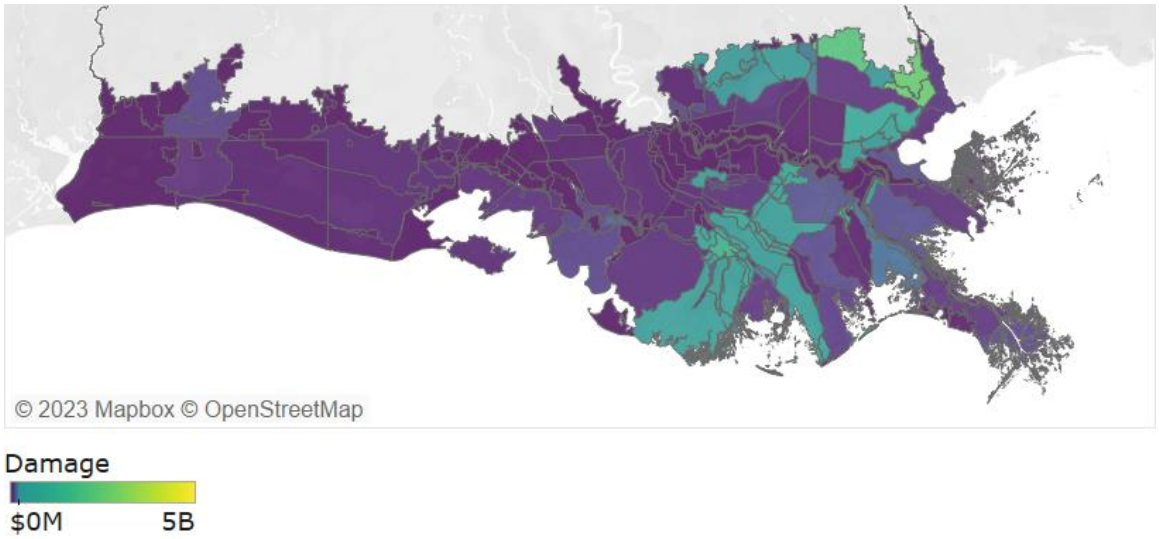

Figure 10. Modeled future economic damage for a Hurricane Ida-like storm simulated in the FWA, S07, Year 50.

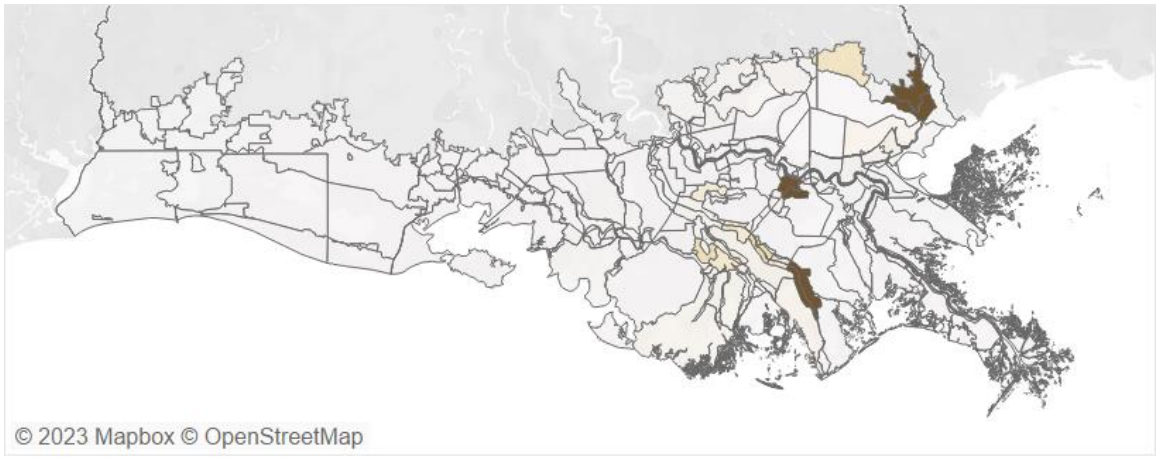

Figure 11. Change in modeled future economic damage between FWOA and FWA for a Hurricane Ida-like storm simulated in S07, Year 50.

Coastwide, CLARA results show that planned protection and restoration actions would effectively reduce the total amount of future economic damage from a Hurricane Ida-like storm by almost $18 billion 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 Ida-like storm in S07, Year 50

	SMALL RESIDENTIAL	LARGE RESIDENTIAL	COMMERCIAL AND INDUSTRIAL	PUBLIC AND EDUCATIONAL	GRAND TOTAL
FWOA (YEAR 50)	$27,821M	$504M	$9,452M	$1,592M	$39,370M
FWA (YEAR 50)	$14,614M	$222M	$5,823M	$809M	$21,468M
REDUCTION IN DAMAGE BETWEEN FWOA AND FWA (YEAR 50)	$13,207M	$282M	$3,630M	$784M	$17,902M

As found in the surge and wave analyses, flood depth and damage resulting from an Ida-like storm event show a large amount of spatial variation in communities across the coast (Table 10). Unlike the surge and wave results, however, the amount of expected economic damage is not purely a function of biogeophysical factors. The exposure of assets and associated economic damage is directly tied to the degree of human development and population exposed to flood impacts. Because the track of

Hurricane Ida brings the storm onshore near Grand Isle, the damage there is particularly pronounced relative to other communities of its size.

However, 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 more 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, the moderate flood depths of an Ida-like storm would nevertheless result in flood damage greater than a billion dollars in each community. These values grow to more than $7 billion in Year 50 of FWOA. Similarly, planned protection and restoration actions implemented in this area would be expected to result in significant damage reduction, although damages are still projected to exceed $2 billion in a FWA.

Table 10. Modeled total damage and change in damage to select coastal communities from a Hurricane Ida-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	$6M	$6M	2%
CAMERON	$43M	$48M	$47M	-2%
DELACROIX	$25M	$8M	$8M	0%
DELCAMBRE	$0M	$20M	$4M	-82%
DULAC	$123M	$200M	$193M	-4%
GRAND ISLE	$501M	$321M	$323M	1%
MANDEVILLE/COVINGTON/ MADISONVILLE/ABITA SPRINGS	$1,929M	$7,307M	$2,211M	-70%
SLIDELL/EDEN ISLE/PEARL RIVER	$1,254M	$7,469M	$2,547M	-66%

6.0 REFERENCES

Beven II, J. L., Hagen, A. B., & Berg, R. (2021). *Tropical cyclone report Hurricane Ida (AL092021) 26 August–1 September 2021* (p. 163) [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. (2021). *Preliminary damage assessment Louisiana – Hurricane Ida – FEMA-4611-DR Declared August 29, 2021* (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

National Weather Service. (2021, August 29). *Catastrophic Hurricane Ida strikes southeast Louisiana*. Weather.Gov. https://www.weather.gov/lix/hurricaneida2021