Mott MacDonald
650 Poydras Street
Suite 2025
New Orleans LA 70130
United States of America

T +1 (504) 529 7687
F +1 (504) 529 7688
mottmac.com

New Orleans Landbridge Shoreline Stabilization and Marsh Creation

April 11th, 2018

DRAFT

Issue and revision record

Revision	Date	Originator	Checker	Approver	Description
1	3/15/18	V. Curto	J. Carter	J. Carter	Memo 1 - Analytical wave heights
2	3/23/18	V. Curto	J. Carter	J. Carter	Memo 2 - Model wave heights
3	4/11/18	J. Todd	V. Curto	J. Carter	Memo 3 - Revisions

Document reference: 385576 | 3 | 0

Information class: Standard

Contents

1 Introduction

Data analysis and wave modeling at the New Orleans Landbridge project site was conducted to develop an understanding of the environmental forcing acting on the proposed containment dikes and to evaluate how the containment dikes should account for these processes. The project location is shown on Figure 1. The analysis included a review of water surface elevation, wind statistics, and numerical modeling of wind-generated waves at the project site.

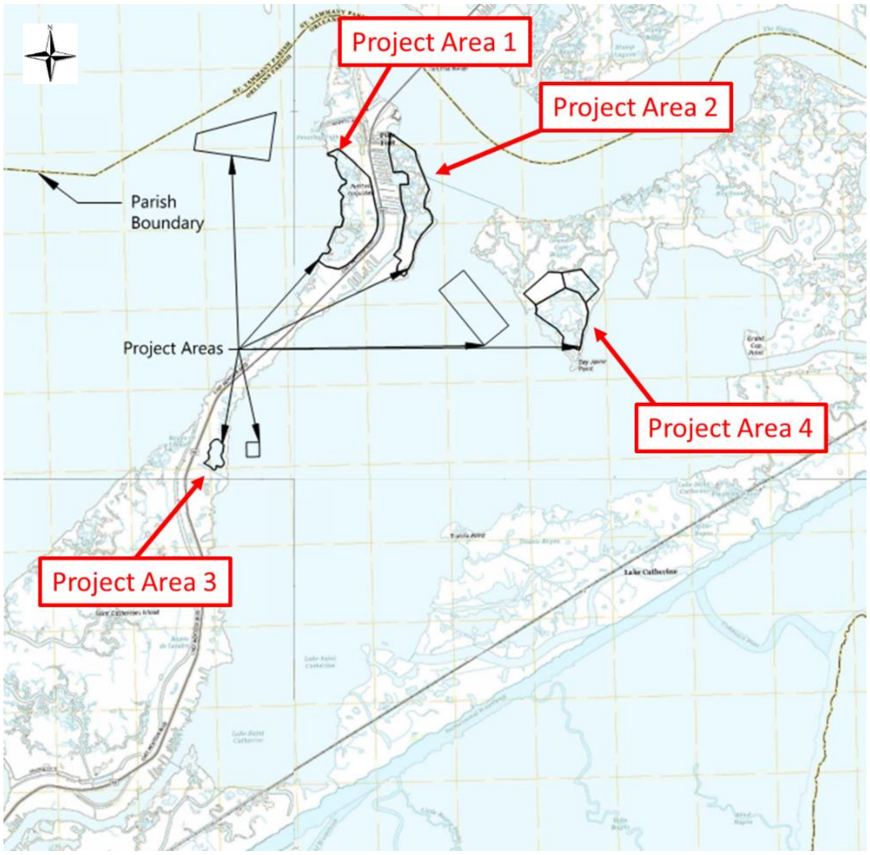

Figure 1 Project Location, Orleans Parish, Louisiana.

Wind and water surface elevation (WSE) data were obtained from several gages shown on Table 1 and Figure 2.

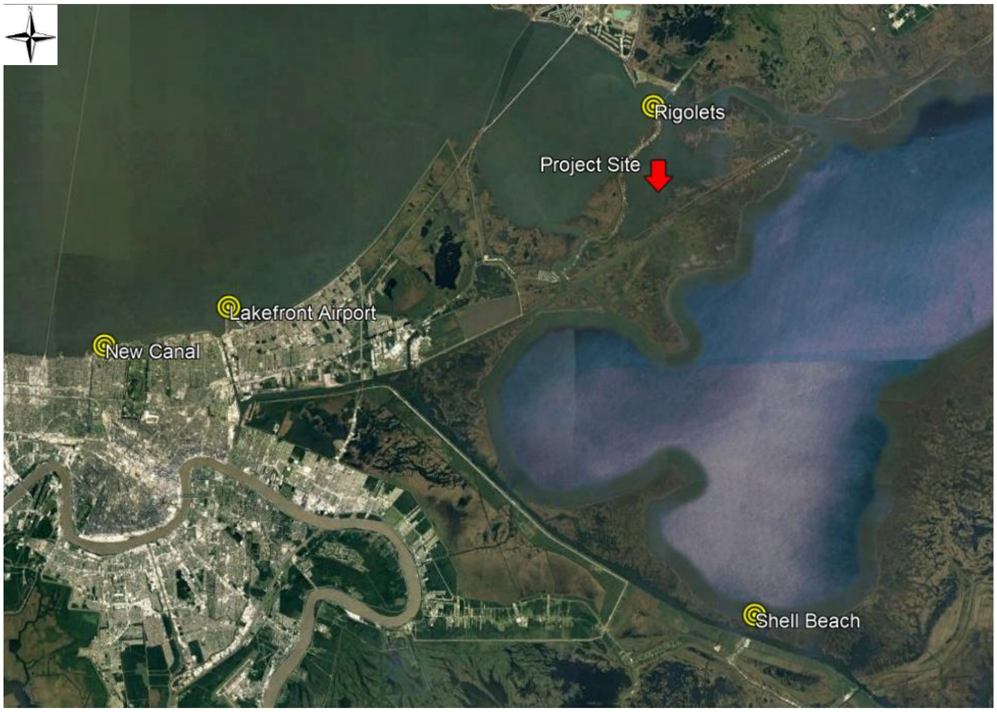

Figure 2 NOAA gaging stations and project location map.

Table 1 Wind and WSE data sources at the project site vicinity.

Gage ID	Agency	Data Type	Time Range
New Canal 8761927	NOAA	Wind WSE	2005 to 2018
Shell Beach 8761305	NOAA	Wind WSE	2008 to 2018
Lakefront Airport USW00053917	NOAA	Wind	1998 to 2018
Rigolets 301001089442600	USGS	WSE	2004 to 2018

2 Water Surface Elevation

2.1 Datum

The water surface elevations and tidal datums at the project site, shown in Table 2, were collected from the NOAA Station New Canal 8761927 (NOAA, 2013). All water surface elevations are shown in ft NAVD88 (epoch 1983-2001).

Table 2 Water Surface Elevations at New Canal.

Water Surface Elevations	NAVD88 ft*
Highest Observed Tide	6.31
Highest Astronomical Tide	0.38
Mean Higher-High Water	0.28
Mean Sea Level	0.03
Mean Lower-Low Water	-0.22
Lowest Astronomical Tide	-0.31
Lowest Observed Tide	-2.18

* Conversion between NAVD88 and MSL taken from Shell Beach

2.2 WSE Extreme Value Statistics

Extreme value WSE analyses were conducted on Shell Beach, New Canal, and Rigolets gaging stations by using the measured WSE, which includes the meteorological and astronomical components. Results are shown on Table 3. Results indicate good correlation between the gaging stations.

The analysis of the WSE data was used to provide surge values only up to the 5-year return period due to the unreliability of the instrumentation to record higher WSE, such as those that occur during an extreme tropical event (gages are often damaged and records are frequently incomplete); extreme values of WSE above approximately a 5-year event are better determined through evaluation of historical high water marks or comprehensive storm surge modeling. It is also assumed the containment dike will not be designed to withstand an event higher than 5-year return period.

Table 3 Extreme WSE values and corresponding return period

Return Period [yrs]	Shell Beach [ft NAVD]	New Canal [ft NAVD]	Rigolets [ft NAVD]
1	3.9	3.0	2.9
2	5.1	3.5	3.1
5	7.1	4.5	3.8

2.3 Surge Extreme Value Statistics

Extreme value surge analyses were conducted for both Shell Beach and New Canal NOAA gaging stations by subtracting the harmonic WSE from the measured WSE, which results in surge values (meteorological component only). Results are shown on Table 4.

Table 4 Extreme surge values and corresponding return period

Return Period [yrs]	Shell Beach Surge [ft]	New Canal Surge [ft]
1	3.7	2.8
2	5.0	3.3
5	7.1	4.1

For reference purposes, high water marks (HWM) near the project site were collected. HWM at the project site are shown on Figure 3 and Table 5.

Figure 3 High water marks in vicitiny of project area.

Table 5 Highest HWM for each hurricane at the project site.

Hurricane	HWM [ft]	Datum	Year	Long	Lat
Katrina	18.7	MSL	2005	-89.805	30.066
Isaac	10.1	NAVD	2012	-89.762	30.116
Rita	8.7	NGVD	2005	-90.082	30.360
6th Hurr FL	8.0	MSL	1947	-89.799	30.062
Flossy	7.6	MSL	1956	-89.888	30.054
Ike	6.7	NAVD	2008	-90.067	30.353
Carla	6.0	N/A	1961	-90.066	30.355
Gustav	4.8	NAVD	2008	-90.124	30.021
Audrey	3.4	MSL	1957	-90.069	30.346

3 Winds

To describe the wind characteristics at New Orleans Landbridge project site, wind roses were developed using the historical wind data for Shell Beach and New Canal stations. Wind roses illustrate the frequency of occurrence of wind events for 16 directional bins at 16 points of the compass for various wind speeds. Wind roses are shown on Figure 4. The highest wind speeds are observed coming from the northeast directions. Those wind speeds are associated with strong winter cold fronts that pass through the area.

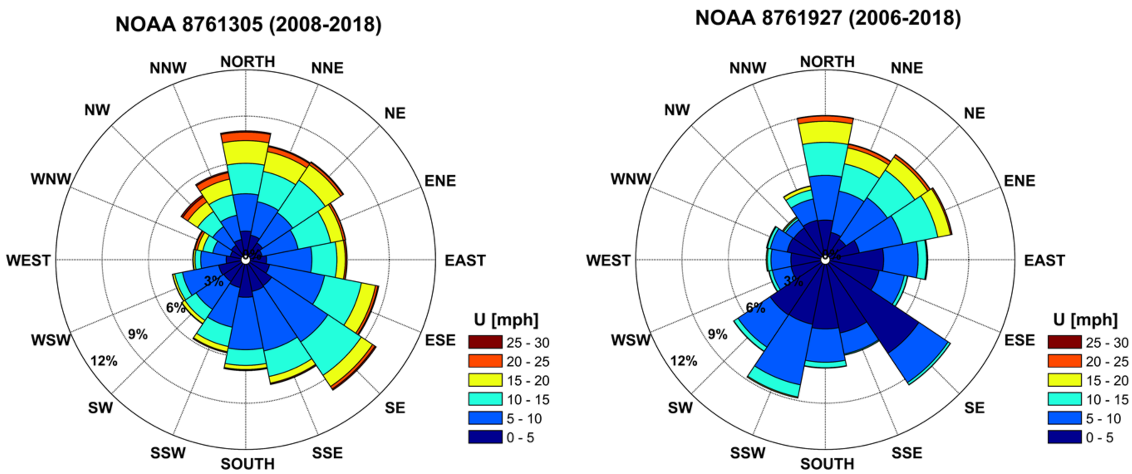

Figure 4 Wind roses, Shell Beach (NOAA 8761305) on the left and New Canal (NOAA 8761927) on the right.

An extreme value analysis was conducted for both Shell Beach and New Canal NOAA gaging stations. Using the 2-minute average wind speed, analysis of the wind data was used to provide wind speed values only up to the 5-year return period due to the unreliability of the instrumentation to record higher wind speeds, such as those that occur during an extreme tropical event (gages are often damaged and records are frequently incomplete).

Extreme value analysis was also conducted on Lakefront Airport wind gage. Upon data inspection and reconciliation of wind speed sampling frequency and adjustments to the data based on the height of the instrument, Lakefront Airport gage wind measurements appeared to be significantly higher than the Shell Beach and New Canal gages. Effort was made to reconcile the differences through evaluation of metadata and reconciliation of sample duration and instrument elevation. The extreme value analysis results yielded larger wind speeds that did not correlate to Shell Beach and New Canal gages; hence, Lakefront Airport gage has been excluded from this Memo.

To provide a more comprehensive analysis of wind speeds, an extreme value analysis on all hurricanes influencing the project site was conducted using methodology consistent with the National Hurricane Center (NHC) Risk Analysis Program (HURISK) (NOAA, 1987). Hurricane tracks, wind speed, and pressure data were obtained from the National Hurricane Center (NHC) database to perform this extreme wind analysis. The NHC storm database spans from 1842 to 2015. Maximum wind speeds were extracted for all storms passing within 75 nautical miles of the project site during the data record. Figure 5 shows all storms with an intensity of tropical storm level or greater that pass within 75 nautical miles of the project site. Extreme value wind analysis results are shown on Table 6.

Table 6. Extreme wind speed (2-min averaging U) values and corresponding return period.

Return Period [yr]	Shell Beach U [mph]	New Canal U [mph]	NHC U [mph]
1	37.3	32.4	-
2	40.7	36.3	38.3
5	45.8	42.1	86.4
7.5	-	-	100.2
10	-	-	109.2
25	-	-	134.7
50	-	-	151.9
100	-	-	167.9

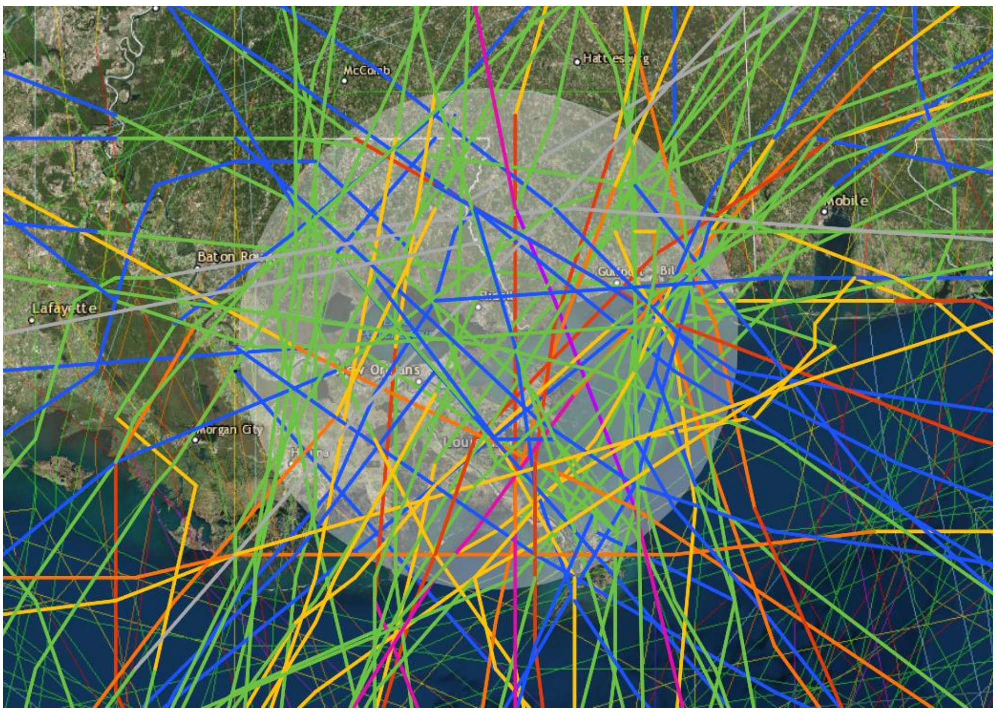

Figure 5 All Storms Passing within 75 Nautical Miles (shaded grey circle represents 75 nautical miles) of the Project Site.

For comparison purposes, Table 7 shows the Saffir-Simpson Hurricane Wind Scale, the corresponding averaged wind speed, and the return period at the project site.

Table 7 Saffir-Simpson Hurricane Wind Scale and return period at the project site.

Storm Category	Avg. Speed U [mph]	Return Period [yr]
Category 1	84	8
Category 2	103	18
Category 3	120	31
Category 4	143	65
Category 5	156	170

4 Waves

Wave modeling was conducted to transform waves from offshore to the project shoreline. Wave modeling was conducted using the SWAN model. SWAN (Delft University of Technology, 2012) is a 2-D, spectral (phase-averaged) wave transformation model that can be used to generate wind-waves and transform wave conditions to the nearshore project area. SWAN wave modeling was conducted in stationary mode.

The wave modeling grid is 48.5 mi (78.0 km) long and 25.9 mi (41.7 km) wide. On the x and y directions, the grid uses variable spacing where 500 m grid cells are used away from the Project Site, deeper water in Lake Pontchartrain, and on areas that do not influence waves. Resolution is increased to 15 m in the nearshore throughout Lake Catherine and Project Area 1.

The CPRA master plan (MP) mesh bathymetry (Arcadis, 2017) was used in the wave model. The overall bathymetric surface and grid extents are shown in Figure 6. The bathymetry at the project site is shown on Figure 7.

A sensitivity analysis of different bathymetry sources including the MP mesh, SL15 mesh (Dietrich, et al., 2010), NOAA Digital Elevation Model, and survey data provided by CPRA (Chustz Surveying, 2017) was conducted. After the necessary datum adjustments, disagreements were observed between SL15, Arcadis, NOAA, and MP bathymetric data sets by in some cases up to 3 ft in the vicinity of the project features and nearby water bottoms. The most conservative bathymetric data was found to be the MP mesh; hence, it was used in the analysis. Due to the shallow bathymetry at the project site, a more extensive bathymetric survey is recommended for more accurate results.

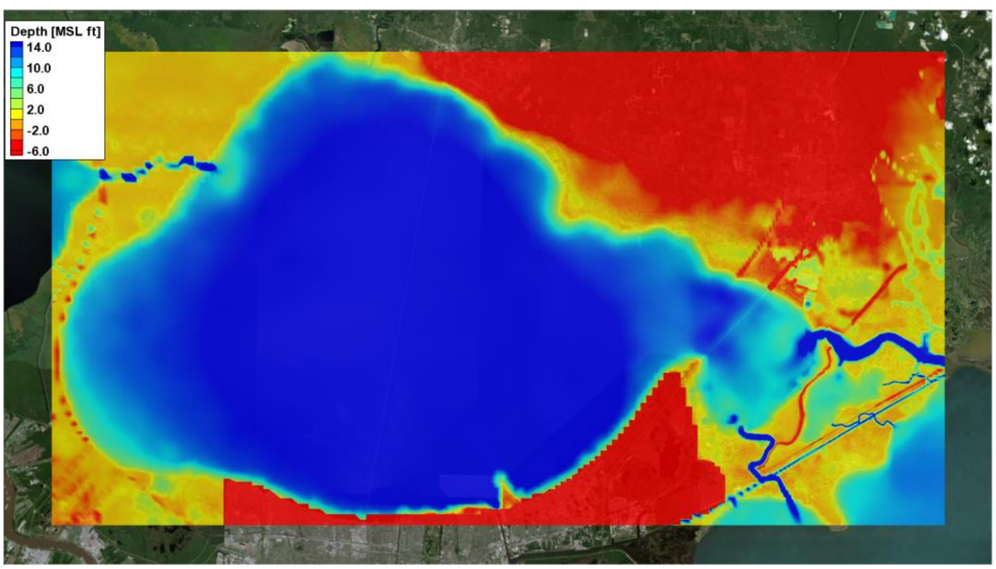

Figure 6 Overall wave model grid extents and bathymetric surface

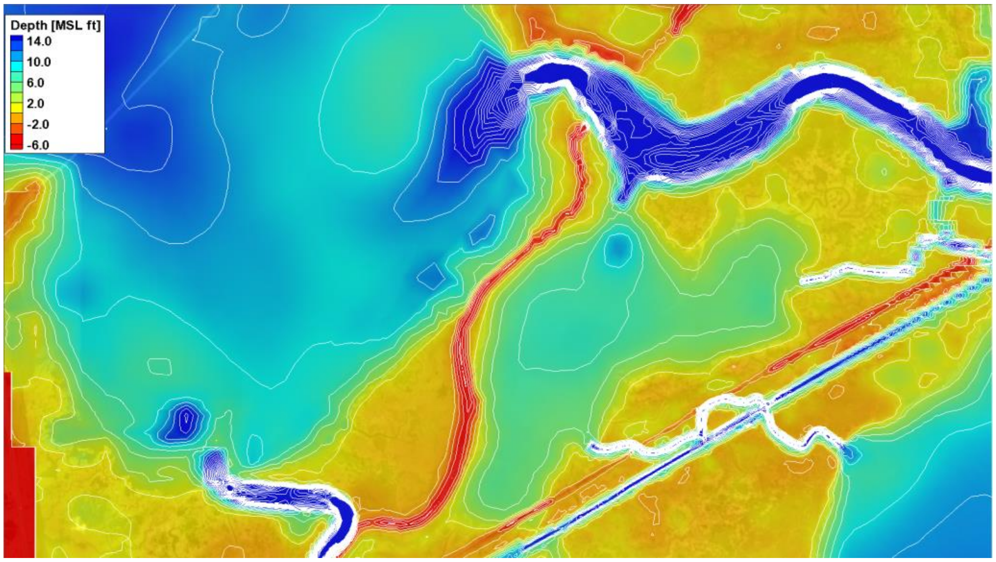

Figure 7 Project site wave model bathymetric surface

Nearshore waves were modeled for 1-yr, 2-yr, 5-yr return period events. A summary of design conditions for wave modeling are shown in Table 8. The wind speed values correspond to the extremal waves for New Canal NOAA gage station. The storm tide values for Project Area 1 in Lake Pontchartrain correspond to New Canal NOAA gage station, where storm tide data is the sum of extreme values provided in Table 4 and mean higher high water level. The storm tide values for Project Areas 2, 3, and 4 correspond to Rigolets USGS gage station where storm tide data are extreme values calculated form the raw data (meteorological and astronomical components are included). The design conditions are provided on Table 8.

To assess the nearshore wave climate variability associated with wind direction, each wind speed was modeled from all direction associated with a 16-point compass: N (0°), NNE (22.5°), NE (45°), ENE (67.5°), E (90°), ESE (112.5°), SE (135°), SSE (157.5°), S (180°), SSW (202.5°), SW (225°), WSW (247.5°), W (270°), WNW (292.5°), NW (315°), and NNW (337.5°).

Table 8 Wave model inputs for design conditions

Return Period [years]	Wind Speed [mph]*	Project Area 1 Storm Tide [ft NAVD]	Project Area 2, 3, 4 Storm Tide [ft NAVD]
1	32.4	3.1	2.9
2	36.2	3.6	3.1
5	42.1	4.4	3.8

* All wind speeds were modeled from 16-point-compass directions

Design condition maximum significant wave height results, using the water surface elevation from the New Canal gage at the project site are shown in Figure 8, Figure 9, and Figure 10. Design condition maximum significant wave height results, using the water surface elevation from the Rigolets gage, at the project site are shown in Figure 11, Figure 12, and Figure 13. The figures represent the overall max at each location encompassing all wind directions. For comparison purposes, the significant wave height scales have been maintained equal for all figures. For each design condition (1-yr, 2-yr, and 5-yr), maximum significant wave heights were extracted from the 16 wind direction modeling results at each point in the computational grid.

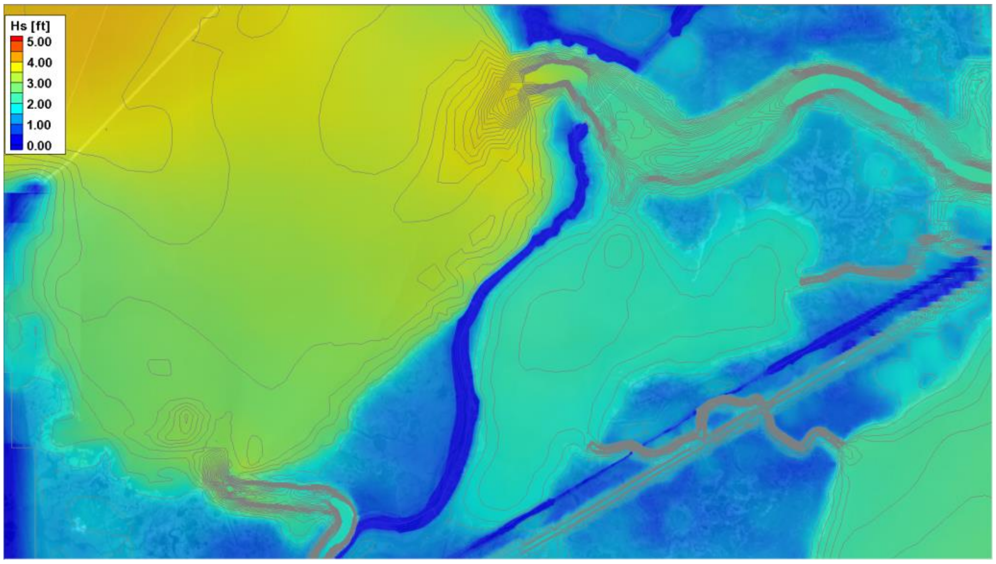

Figure 8 Maximum significant wave height for 1-yr conditions at project site using WSE data from the New Canal gage. Bathymetry shown on grey 2-ft contour lines.

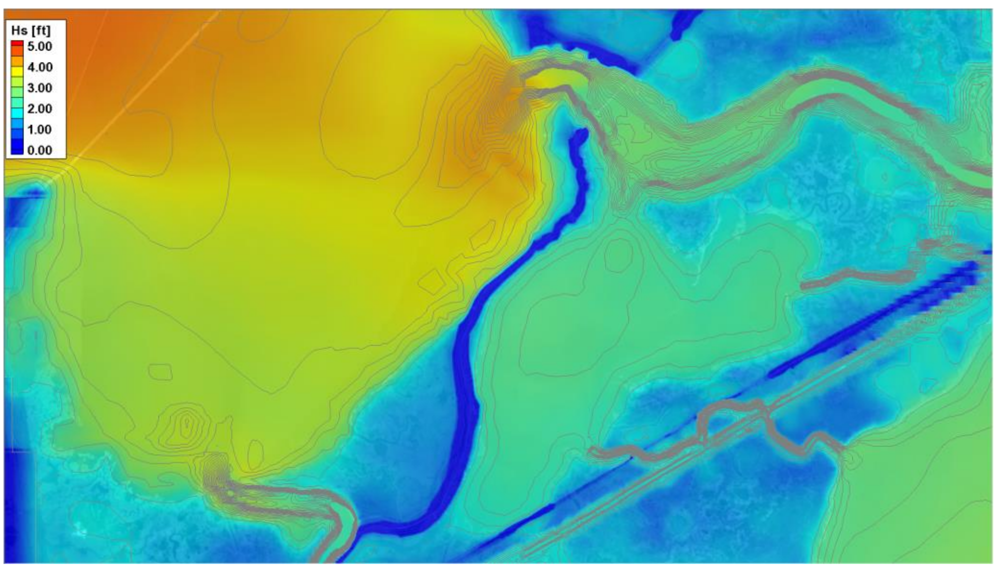

Figure 9 Maximum significant wave height for 2-yr conditions at project site using WSE data from the New Canal gage. Bathymetry shown on grey 2-ft contour lines.

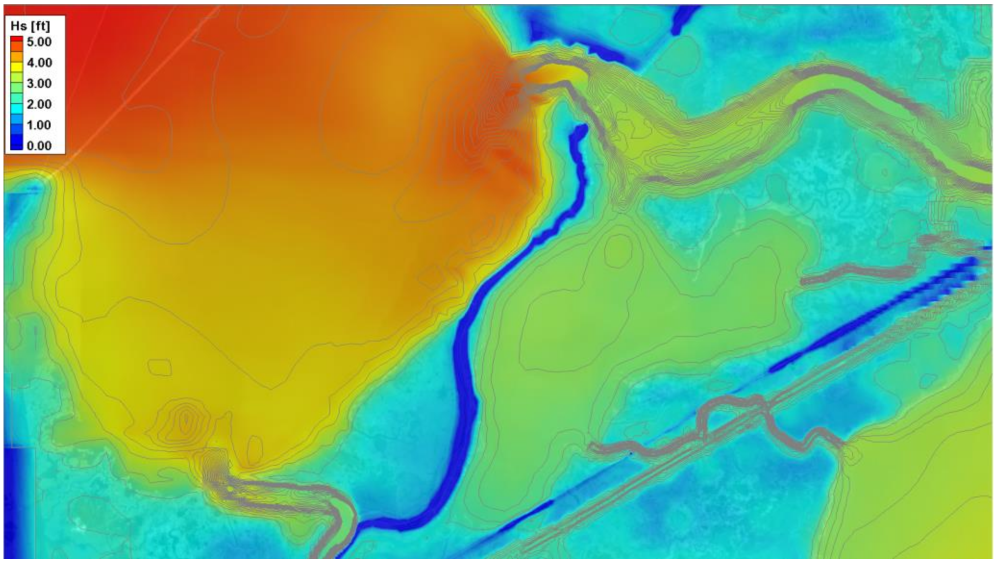

Figure 10 Maximum significant wave height for 5-yr conditions at project site using WSE data from the New Canal gage. Bathymetry shown on grey 2-ft contour lines.

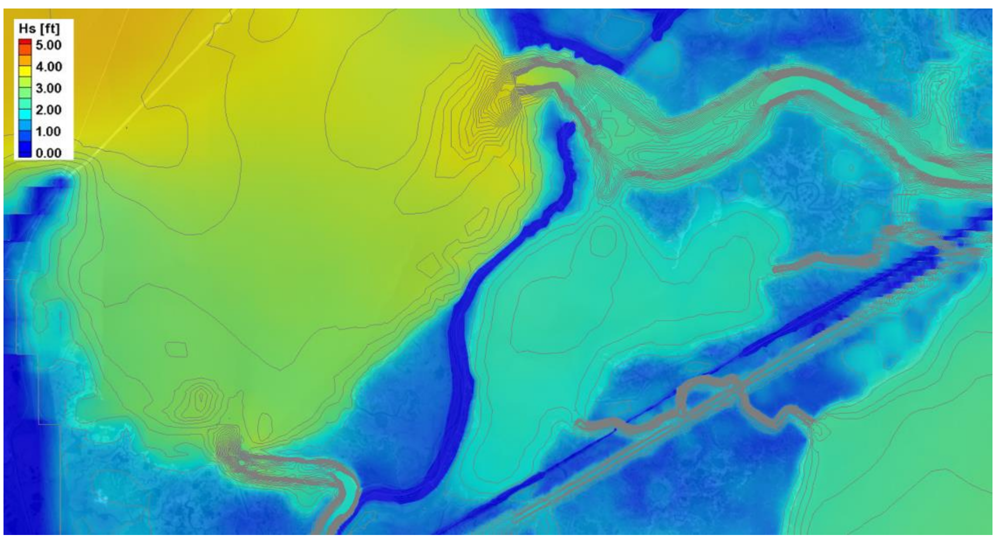

Figure 11 Maximum significant wave height for 1-yr conditions at project site using WSE data from the Rigolets gage. Bathymetry shown on grey 2-ft contour lines.

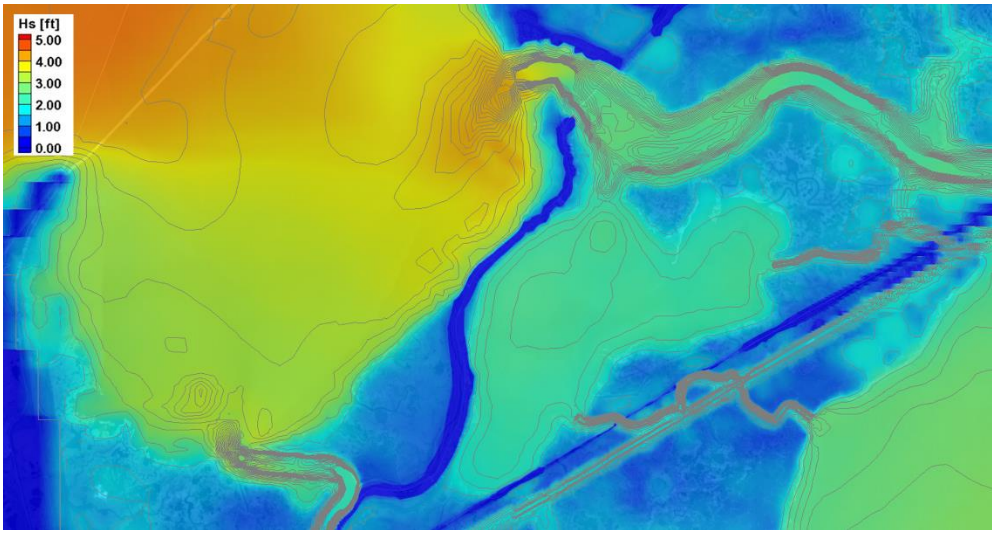

Figure 12 Maximum significant wave height for 2-yr conditions at project site using WSE data from the Rigolets gage. Bathymetry shown on grey 2-ft contour lines.

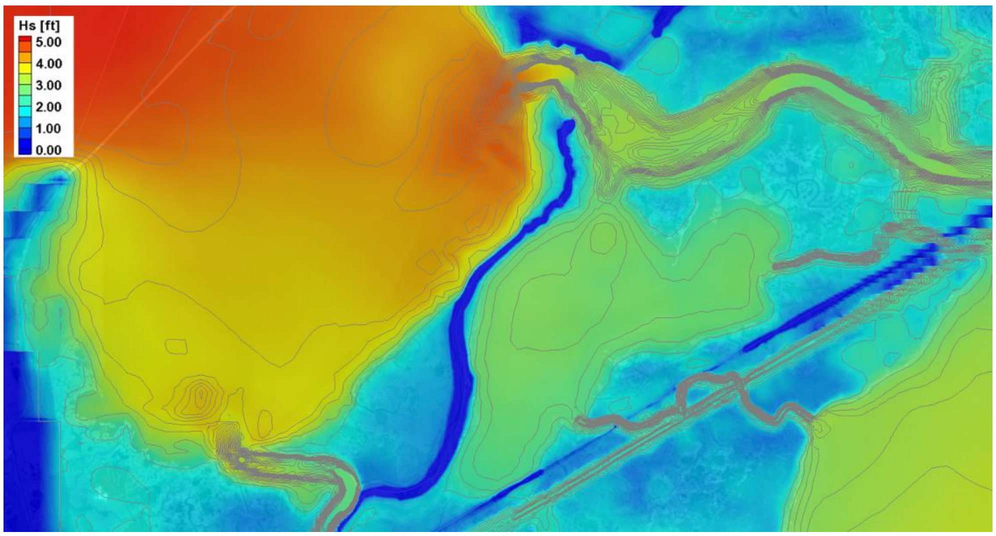

Figure 13 Maximum significant wave height for 5-yr conditions at project site using WSE data from the Rigolets gage. Bathymetry shown on grey 2-ft contour lines.

Maximum significant wave heights, shown on Table 9, were extracted at each Project Area, (see Figure 14). Extraction points were chosen at the point seaward of the majority of wave breaking, with depths of 3.0 ft MSL and 6.6 ft MSL for Lake Catherine and Lake Pontchartrain, respectively. Overall, higher wave heights are observed on Lake Pontchartrain Project Area 1 compare to Lake Catherine Project Areas 2, 3, and 4. Higher wave heights are associated with Lake Pontchartrain long fetch. Maximum wave heights are observed to be fairly uniform throughout Lake Catherine.

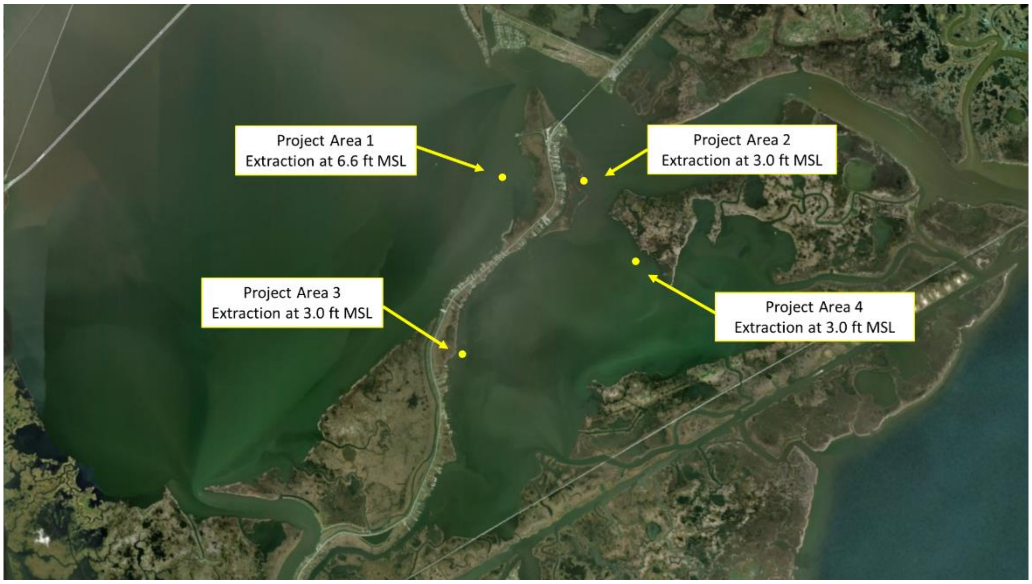

Figure 14 Extraction points at each Project Area.

Table 9 Maximum significant wave height at each Project Area.

	Project Area 1 Max Hs [ft]	Project Area 2 Max Hs [ft]	Project Area 3 Max Hs [ft]	Project Area 4 Max Hs [ft]
1yr	3.5	1.8	1.8	1.7
2yr	3.9	2.1	2.1	2.0
5yr	4.4	2.6	2.5	2.5

Significant wave heights and peak periods at each Project Area for all 16 wind directions for 1-, 2-, and 5-yr wind speeds are shown on Table 10, Table 11, and Table 12. For a given wind speed, peak wave periods vary slightly when looking at the Lake Catherine project areas; peak wave periods on Lake Pontchartrain have a wider range. The largest variation in wave height for a given wind speed was observed on Project Area 1; different wind directions are associated with different fetches leading to different wave heights. Lake Pontchartrain provides a 41 mi long fetch compared to 4.4 mi long fetch at Lake Catherine; hence more variation in wave heights and periods is observed on Lake Pontchartrain.

Table 10 Significant wave height and peak period at each Project Area for 1-yr wind speed and all 16 directions where the wind comes from. Maximum Hs underlined in bold.

1-yr	Project Area 1		Project Area 2		Project Area 3		Project Area 4	
Wind Dir. [from TN]	Hs [ft]	Tp [sec]	Hs [ft]	Tp [sec]	Hs [ft]	Tp [sec]	Hs [ft]	Tp [sec]
0°	2.2	3.3	1.4	2.6	1.3	2.9	1.5	2.6
22.5°	1.7	2.6	1.6	2.6	1.5	3.3	1.5	2.4
45°	1.4	2.4	1.7	2.6	1.6	3.3	1.4	2.1
67.5°	1.3	1.9	**1.8**	2.9	1.7	2.9	1.4	2.4
90°	1.2	1.8	**1.8**	2.9	**1.8**	2.9	1.4	2.4
112.5°	1.1	1.8	**1.8**	2.9	1.8	2.6	1.5	2.6
135°	1.1	1.9	1.7	2.9	1.6	2.6	1.5	2.6
157.5°	1.3	1.9	1.6	2.6	1.5	2.6	1.6	2.6
180°	1.6	2.9	1.4	2.4	1.3	2.4	**1.7**	2.6
202.5°	2.0	3.6	1.3	2.6	1.1	2.4	**1.7**	2.6
225°	2.6	4.0	1.1	2.4	1.0	2.1	**1.7**	2.6
247.5°	3.1	4.0	1.0	1.9	0.8	1.5	1.6	2.9
270°	**3.5**	4.0	0.9	1.5	0.7	1.4	1.6	2.6
292.5°	3.4	4.5	0.9	1.7	0.7	1.5	1.5	2.4
315°	3.1	4.5	1.0	1.9	0.8	1.5	1.4	2.1
337.5°	2.7	4.0	1.2	2.1	1.1	2.3	1.5	2.6

Table 11 Significant wave height and peak period at each Project Area for 2-yr wind speed and all 16 directions where the wind comes from. Maximum Hs underlined in bold.

2-yr	Project Area 1		Project Area 2		Project Area 3		Project Area 4	
Wind Dir. [from TN]	Hs [ft]	Tp [sec]	Hs [ft]	Tp [sec]	Hs [ft]	Tp [sec]	Hs [ft]	Tp [sec]
0°	2.5	3.3	1.6	2.6	1.5	2.9	1.7	2.6
22.5°	2.0	2.9	1.8	2.9	1.7	3.3	1.7	2.6
45°	1.7	2.6	1.9	2.9	1.8	3.3	1.6	2.4
67.5°	1.5	2.4	2.0	3.3	2.0	3.3	1.5	2.4
90°	1.4	1.9	2.1	3.3	**2.1**	2.9	1.6	2.6
112.5°	1.3	1.9	**2.1**	2.9	2.0	2.9	1.6	2.6
135°	1.3	1.9	2.0	2.9	1.9	2.9	1.8	2.6
157.5°	1.6	2.1	1.8	2.6	1.7	2.6	1.9	2.9
180°	1.9	3.3	1.6	2.4	1.5	2.6	1.9	2.9
202.5°	2.3	3.6	1.5	2.6	1.3	2.4	**2.0**	2.9
225°	3.0	4.0	1.3	2.4	1.1	1.7	2.0	2.6
247.5°	3.6	4.5	1.2	2.1	1.0	1.5	1.9	2.9
270°	3.9	4.0	1.1	1.7	0.9	1.5	1.8	2.6
292.5°	**3.9**	4.5	1.1	1.7	0.9	1.5	1.7	2.4
315°	3.6	4.5	1.2	1.9	1.0	1.7	1.6	2.4
337.5°	3.1	4.5	1.4	2.4	1.2	1.9	1.7	2.6

Table 12 Significant wave height and peak period at each Project Area for 5-yr wind speed and all 16 directions where the wind comes from. Maximum Hs underlined in bold.

5-yr	Project Area 1		Project Area 2		Project Area 3		Project Area 4	
Wind Dir. [from TN]	Hs [ft]	Tp [sec]	Hs [ft]	Tp [sec]	Hs [ft]	Tp [sec]	Hs [ft]	Tp [sec]
0°	3.1	3.6	2.0	2.9	1.8	3.3	2.2	2.9
22.5°	2.4	3.3	2.2	3.3	2.0	3.6	2.2	2.9
45°	2.1	2.9	2.4	2.9	2.3	3.6	2.0	2.6
67.5°	1.9	2.6	2.5	3.6	**2.5**	3.3	1.9	2.6
90°	1.7	2.1	**2.6**	3.6	**2.5**	3.3	2.0	2.9
112.5°	1.6	2.1	2.6	3.3	**2.5**	3.3	2.1	2.9
135°	1.6	2.1	2.5	3.3	2.3	3.3	2.2	2.9
157.5°	1.9	2.4	2.3	2.9	2.1	2.9	2.3	3.3
180°	2.3	3.6	2.0	2.9	1.9	2.9	2.4	3.3
202.5°	2.9	4.0	1.8	3.3	1.7	2.8	**2.5**	3.3
225°	3.6	4.5	1.6	2.9	1.4	2.4	2.5	3.2
247.5°	4.2	5.0	1.5	2.1	1.2	1.7	2.3	3.3
270°	**4.4**	4.5	1.4	1.7	1.1	1.7	2.2	2.9
292.5°	**4.4**	4.5	1.3	1.9	1.1	1.7	2.0	2.6
315°	4.2	4.5	1.4	2.1	1.2	1.9	2.0	2.6
337.5°	3.8	4.5	1.7	2.6	1.5	2.1	2.2	2.9

5 Conclusions and Recommendations

The work undertaken has concluded the following:

- Due to the proximity to the project and similar conditions, the wind data associated with NOAA New Canal gaging station was used as basis of design. NOAA New Canal gage WSE was applied to Project Area 1 while USGS Rigolets WSE was applied to Project Areas 2, 3, and 4.
- The most conservative available bathymetric data set, Arcadis CPRA master plan mesh bathymetry, was used in the analysis. For more accurate results, an updated and more extensive bathymetric survey data collection is recommended.
- At Project Area 1, a 5-year return period storm tide corresponding to 4.4 ft would produce greenwater overtopping over the proposed +3.5 ft top of dike elevation.
- When considering the contribution of a 5-year event at Lake Catherine including the 5-year wave height and 5-year storm tide at Project Area 2 equal to 2.6 ft and 3.8 ft, respectively, the proposed dike elevation of +3.5 ft is expected to be overtopped with unbroken waves.
- Because different wave heights are observed at different Project Areas, particularly between Lake Pontchartrain and Lake Catherine, a single containment dike design for all sites may not be the optimum solution. It is recommended to tailor the containment dike design using the pertinent wave height and wave period for the given Project Area.

6 References

Chustz Surveying. (2017). *New Orleans Landbridge Shoreline Stabilization & Marsh Creation Project (PO-169) Additional Sureys (Borrow Areas).* New Roads, LA: Chustz Surveying.

Delft University of Technology. (2012). *SWAN - User Manual, Version 40.91.* Delft: Environmental Fluid Mechanic Section.

Dietrich, J., Bunya, S., Westerink, J., Ebersole, B., Smith, J., & Atkinson, J. (2010). A high resolution coupled riverine flow, tide, wind, wind wave and storm surge model for southern Louisiana and Mississippi: Part II — synoptic description and analyses of Hurricanes Katrina and Rita. *Monthly Weather Review 138*, 378–404.

NOAA. (1987). *The National Hurricane Center Risk Analysis Program. NOAA Technical Memorandum NWS NHC 38.* Coral Gables, FL: National Hurricane Center.

NOAA. (2013). *NOAA Tides and Currents*. Retrieved from http://tidesandcurrents.noaa.gov/datums.html?id=8761724

USACE. (2002). *Coastal Engineering Manual 1110-2-1100 (in 6 volumes).* Washington, DC: USACE.

Western Carolina University. (n.d.). *Storm Surge Viewer*. Retrieved from http://stormsurge.wcu.edu/

mottmac.com