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CPRA

Bayou De Cade Ridge & Marsh Creation (TE-0138) Wave Modeling

August 27, 2018

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Issue and revision record

Revision	Date	Originator	Checker	Approver	Description
1	8/27/18	T.Everett V.Curto	V.Curto	J.Carter	Submitted for first review

Document reference: 400468 | 1 | 1

Information class: Standard

Contents

1 Introduction

The Bayou De Cade Ridge and Marsh Creation project (TE-0138) located in Terrebonne Parish, Louisiana, is funded by the Coastal Wetlands Planning, Protection, and Restoration Act (CWPPRA) under Priority Project List 26 in partnership with the National Oceanic and Atmospheric Administration's (NOAA's) National Marine Fisheries Service (NMFS). The Coastal Protection and Restoration Authority (CPRA) is serving as the local sponsor and is also performing the engineering and design work. As proposed, the proposed marsh will restore 11,276 linear feet of ridge habitat along the northern bank of Bayou De Cade and create/nourish approximately 504 acres of marsh.

Approximately 504 acres of marsh will be created and nourished by hydraulically dredging material from Lake De Cade and pumping it to the designated fill sites. The hydraulically dredged material will be mined from a 350 acre borrow site located approximately 800 feet from the southern shoreline of Lake De Cade.

The goal of this study is to evaluate the potential changes to wave climate on Lake De Cade shoreline associated with the proposed borrow site (dredge pit). The analysis included a review of water surface elevation, wind statistics, and numerical modeling of wind-generated waves at the project site of existing and proposed conditions. The project location is shown on Figure 1.

Figure 1. Project Location, Lake De Cade in Terrebonne Parish, Louisiana. Borrow site (dredge pit) delimitated in red.

2 Data Collection

An analysis of water surface elevations, wind, and wave conditions via analytical methods at Bayou De Cade project site was conducted to select the environmental conditions to be modeled as part of the numerical analysis. Nearby gages collecting wind and water surface elevation data were gathered to assess the availability and quality of data. Table 1 lists the gages that were determined to have sufficient quality data, and Figure 2 displays the gage locations in relation to the project site.

Figure 2. Gaging stations and project location map.

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

Gage ID	Data Type	Time Range
NOAA 8764227	Wind WSE	2008 to 2018 2006 to 2018
CRMS 0398	WSE	2007 to 2017
NDBC LUML1	Wind	2004 to 2010
WIS 73123	Wind WSE	1982 to 2016 1982 to 2016

2.1 Water Surface Elevation

The water surface elevations and tidal datums at the project site from CRMS0398 gage are shown in Table 2.

Table 2. Water Surface Elevations at CRMS0398.

Water Surface Elevation	ft NAVD88
Mean High Water	0.76
Mean Low Water	0.37
Mean Sea Level	0.57

2.2 Wind

To describe the wind conditions at the Bayou De Cade project site, wind roses were developed using historical data from NOAA 8764227, NDBC LUML1, and WIS 73123. Wind roses, shown in Figure 3, illustrate the frequency of occurrence of wind events for 16 directional bins at 16 points of the compass for various wind speeds. Using the converted 10-minute averaged wind speed data, an extreme value analysis was performed up to the 5-yr return period; results are shown in Table 3. WIS data was deemed too far from the site and not evaluated for winds.

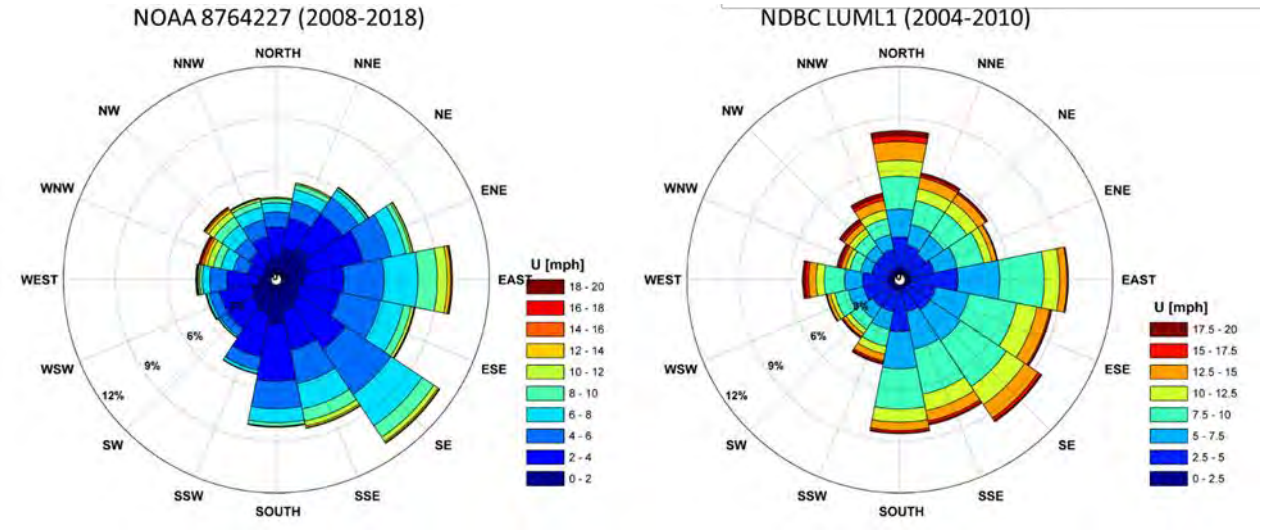

Figure 3. Wind roses, NOAA 8764227 on the left and NDBC LUML1 on the right.

Table 3. Extreme wind speed values and corresponding return period.

Return Period (yr)	NOAA 8764227 U [mph]	NDBC LUML1 U [mph]
1	27.4	26.2
2	30.6	30.1
5	35.9	37.8

2.3 Environmental Conditions

Impacts on wave climate due to the borrow pit have been assessed by means of numerical wave modeling. Based on the Selection of Environmental Conditions at Bayou De Cade Technical Note (Mott MacDonald, 2018), the environmental conditions forcing the wave model were set as the 2-yr wind speed at mean low water (MLW) for varying wind directions since wind direction is expected to be the most sensitive parameter to wave height. The environmental conditions used in this analysis are listed in Table 4.

Increasing the water level is only expected to increase the wave heights; wave refracting patterns are expected to be more prominent under low water conditions and therefore, the MLW has been chosen for this study. The 2-yr return period wind speeds were selected because these are representative of a cold front; lower wind speeds, such as the average wind speed, would yield lower wave heights.

Table 4. Environmental conditions for numerical wave modeling.

Environmental Condition	MLW [ft NAVD88] CRMS0398	2-yr U [mph] NDBC LUML1	U direction [deg from TN]	Description
A	0.37	30.1	60	Longest fetch
B	0.37	30.1	240	Longest fetch
C	0.37	30.1	90	Predominant wind
D	0.37	30.1	135	Predominant wind
E	0.37	30.1	180	Predominant wind
F	0.37	30.1	315	Northwesterly wind

2.4 Bathymetry

A bathymetric surface that covers Lake De Cade and the marsh surrounding it was developed to obtain a consistent bathymetry set required for circulation and wave modeling. Two different bathymetry sets used in this study include bathymetry data collected and provided by CPRA (Byland (a), 2018) shown on Figure 4 and the CPRA Master Plan mesh (CPRA, 2017).

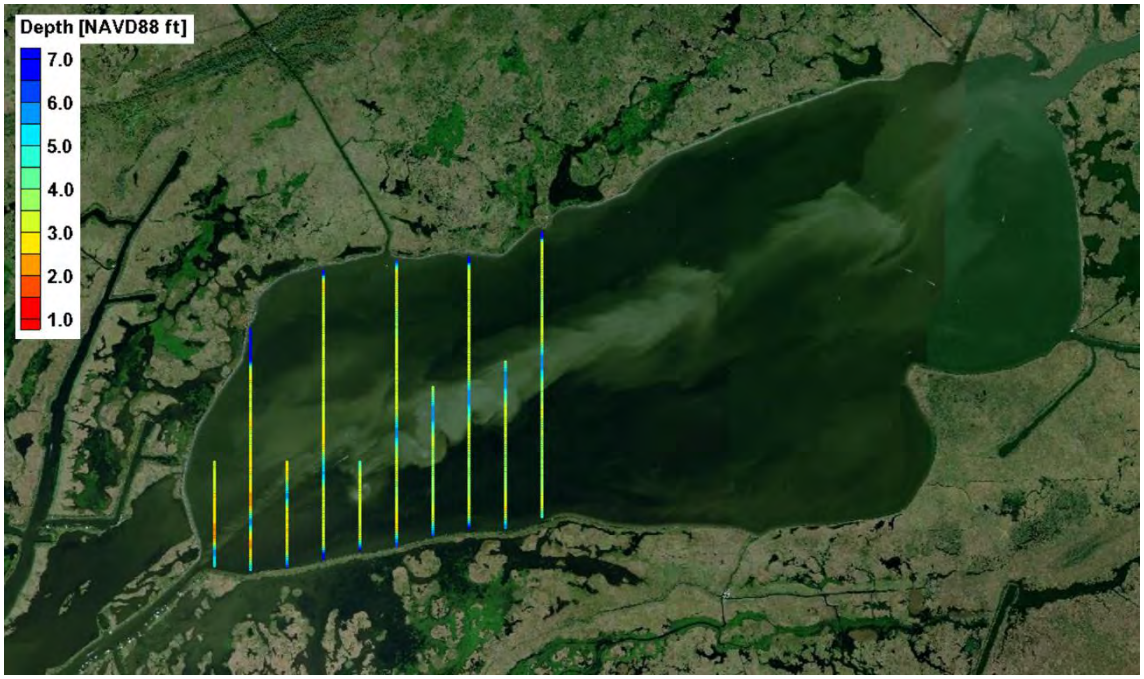

Figure 4. Lake De Cade bathymetry collected by CPRA.

3 Wave Analysis

Wave modeling was performed to analyze wave transformation across Lake De Cade. Wave modeling was conducted using the SWAN model (Delft University of Technology, 2012). SWAN is a 2D, spectral (phase-averaged) wave transformation model that can be used to generate wind-waves and transform wave conditions to the nearshore project area. In this analysis, SWAN wave modeling was conducted in stationary mode.

The wave modeling grid is 32.9 mi (53.0 km) long and 59.0 mi (95.0 km) wide. The grid uses equal and constant spacing throughout the x- and y-axis of 32.8 ft (10 m). The new bathymetric data set provided by CPRA (Byland (a), 2018), in combination with the CPRA master plan mesh bathymetry (see Section 2.4), was used to create the existing conditions bathymetry for the wave model. The CPRA master plan mesh was almost exclusively used outside of the project area, primarily on the east side of Lake De Cade and the marshlands. The proposed condition bathymetry was created by numerically cutting the existing bathymetry with the dredge template provided by CPRA where the bottom elevation was set to a depth of 12.5 ft NAVD88 and the sides slopes equal 2H:1V (Byland (b), 2018). The bathymetric surface and grid extents for existing and proposed conditions are shown in Figure 5 and Figure 6, respectively.

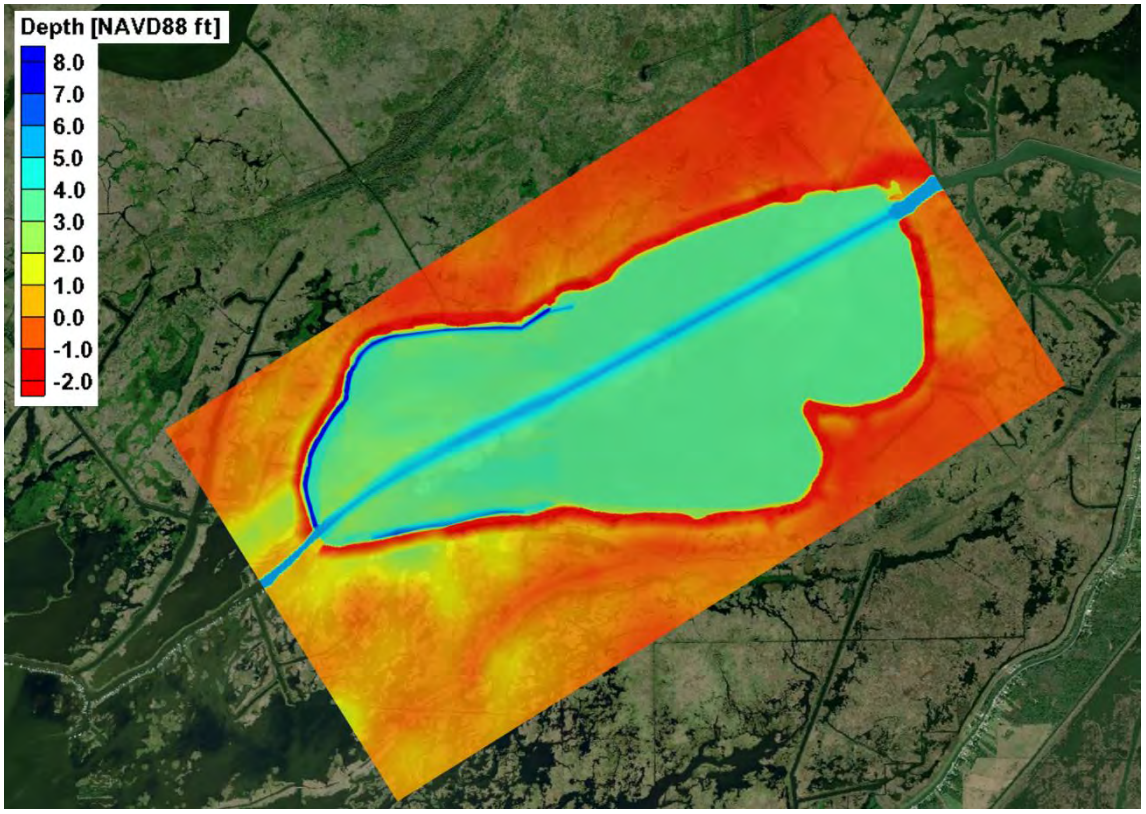

Figure 5. Existing conditions model bathymetry.

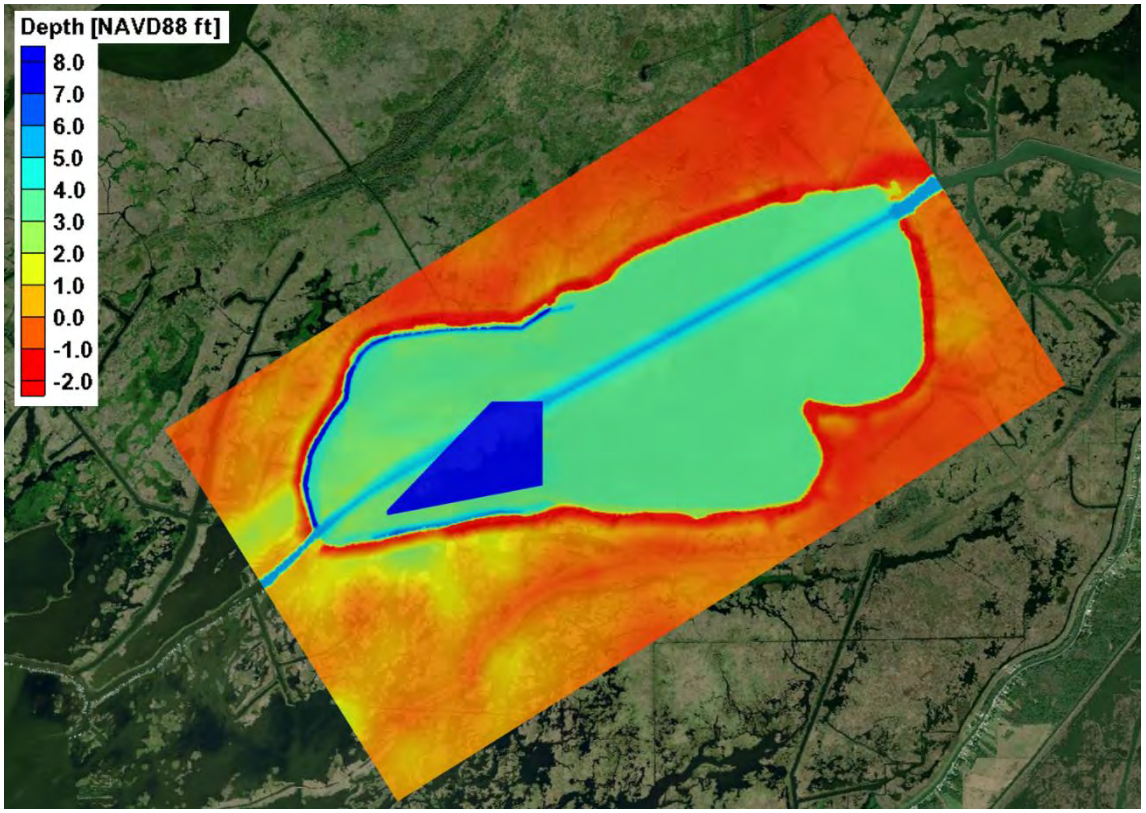

Figure 6. Proposed conditions model bathymetry. Bottom of dredge pit is set to 12.5 ft NAVD88 deep with sides slopes equal to 1V:2H.

Wave modeling was conducted for the environmental conditions shown on Table 4 using the existing and proposed bathymetry. The difference in wave height between proposed and existing conditions was calculated to assess the impact of the dredge pit in the wave climate at Lake De Cade shoreline. The results are shown on Figure 7, Figure 8, and Figure 9 where the top, middle, and bottom windows represent the significant wave height (Hs) for existing conditions, proposed conditions, and their difference (proposed minus existing), respectively. For comparison purposes, the Hs scales have been maintained equal for all figures.

Since the goal of this analysis is to evaluate the impacts the dredge pit has on wave climate, particularly at the Lake De Cade shoreline, this study focusses on differences in wave height observed between proposed and existing conditions.

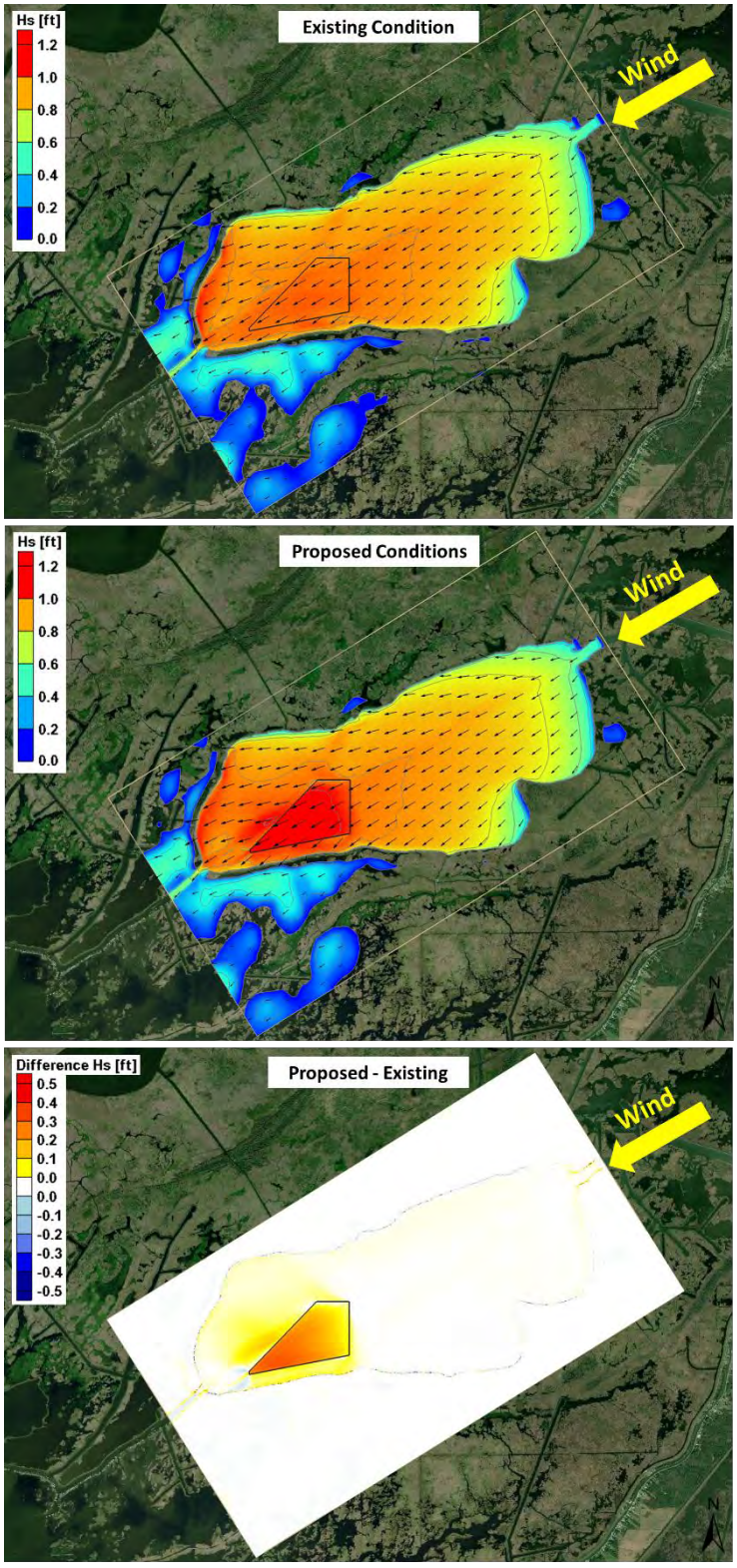

Figure 7. Wave heights for Condition A (longest fetch, 60° TN wind) for existing (top), proposed (middle), and their difference (bottom). Dredge pit shown in black.

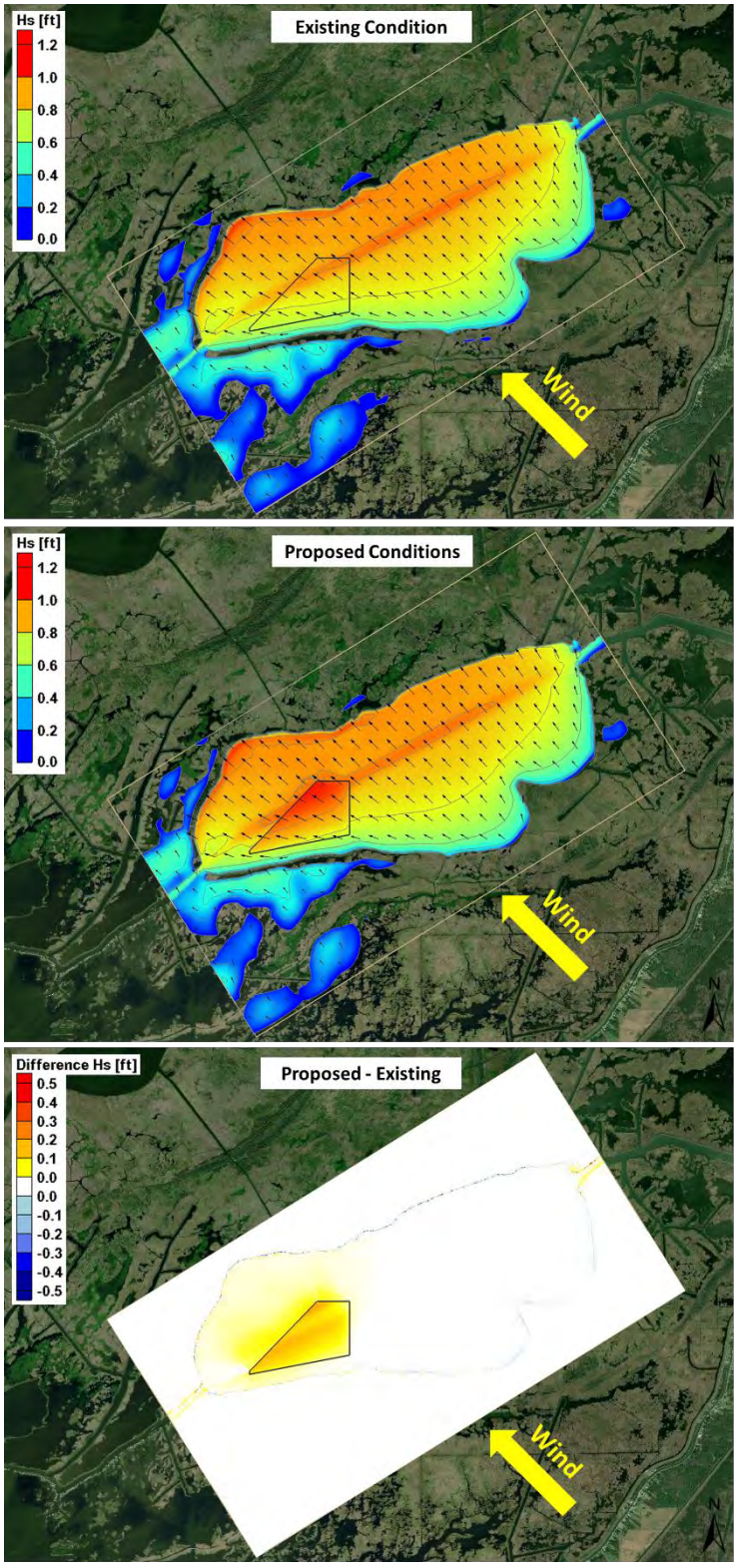

Figure 8. Wave heights for Condition D (predominant 135° TN wind) for existing (top), proposed (middle), and their difference (bottom). Dredge pit shown in black.

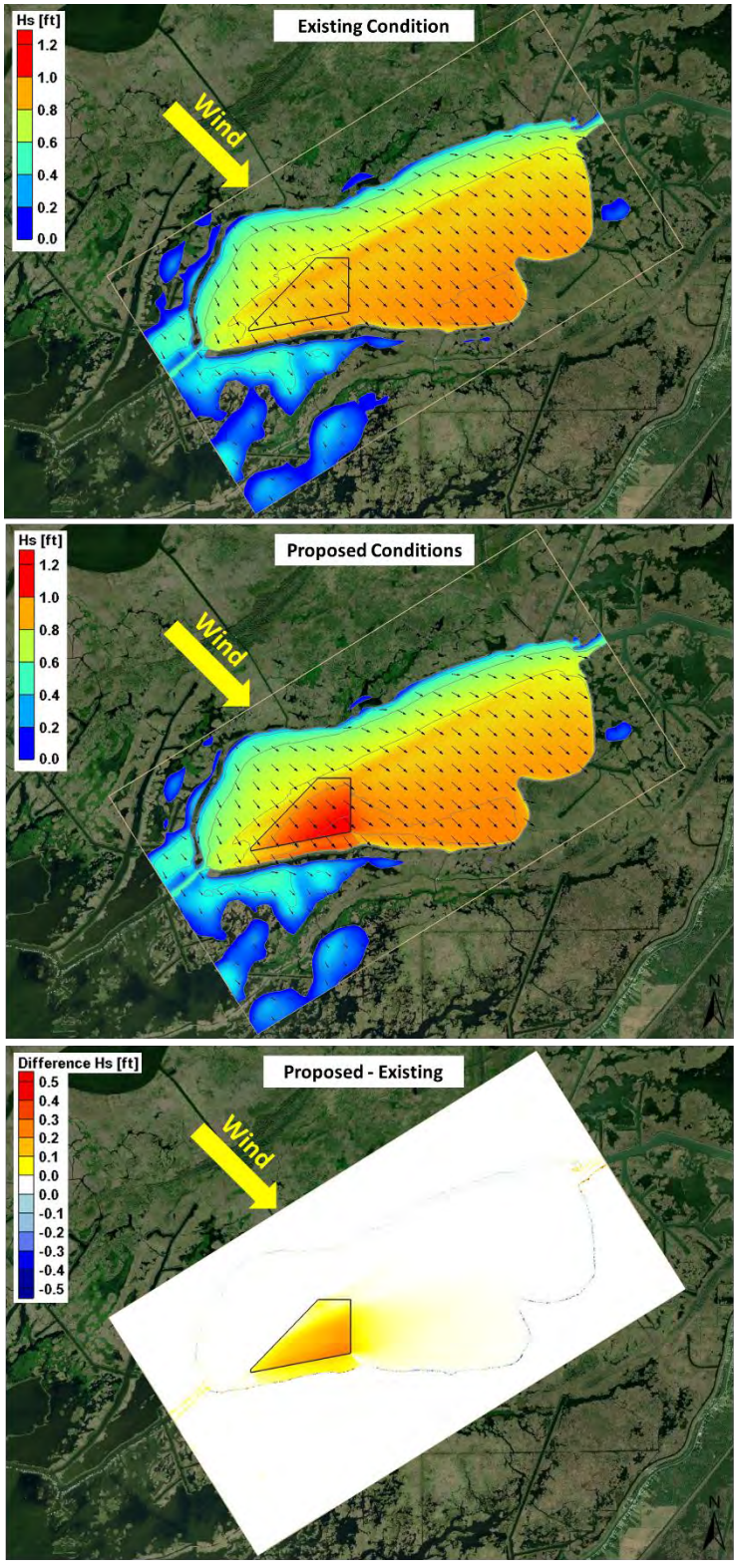

Figure 9. Wave heights for Condition F (predominant 315° TN wind) for existing (top), proposed (middle), and their difference (bottom). Dredge pit shown in black.

The largest changes in wave height within the dredge pit are observed under the longest fetch scenario (Condition A shown on Figure 7), where the difference in wave height reaches +0.4 ft. In addition, the dredge pit results in increased wave heights in the west side of Lake De Cade surrounding the dredge pit, uniformly to the north and south of the pit, and in the order of +0.1 ft (1.2 in). Because the proposed conditions only result in a minor wave height increase of +0.1 ft, the effects of the dredge pit under the longest fetch condition are considered negligible.

The predominant wind condition (Condition D shown on Figure 8) yields changes in wave height within the dredge pit in the order of +0.2 ft. Outside the dredge pit as expected, the changes in wave height occur in the north west side of Lake De Cade. Similar to the long fetch condition, minor changes of approximately +0.1 ft are observed on Lake De Cade shoreline and are considered negligible.

Lastly, the dredge pit leads to wave height changes of approximately +0.3 ft within its perimeter under the influence of a northwesterly wind (Condition F). The bottom plot on Figure 9 indicates the most noticeable and extensive change in wave height on the lake shoreline south of the dredge pit. Even though the change in wave height covers a longer distance, the difference is still in the order of +0.15 ft (1.8 in) which is also considered a negligible change in wave height.

For more detailed discussion, the difference in wave height between proposed and existing conditions for all the environmental conditions were calculated along an extraction arc approximately 820 ft (250 m) from the shoreline along the entire perimeter of Lake De Cade. The extraction points location and the associated results are shown on Figure 10 and Figure 11, respectively.

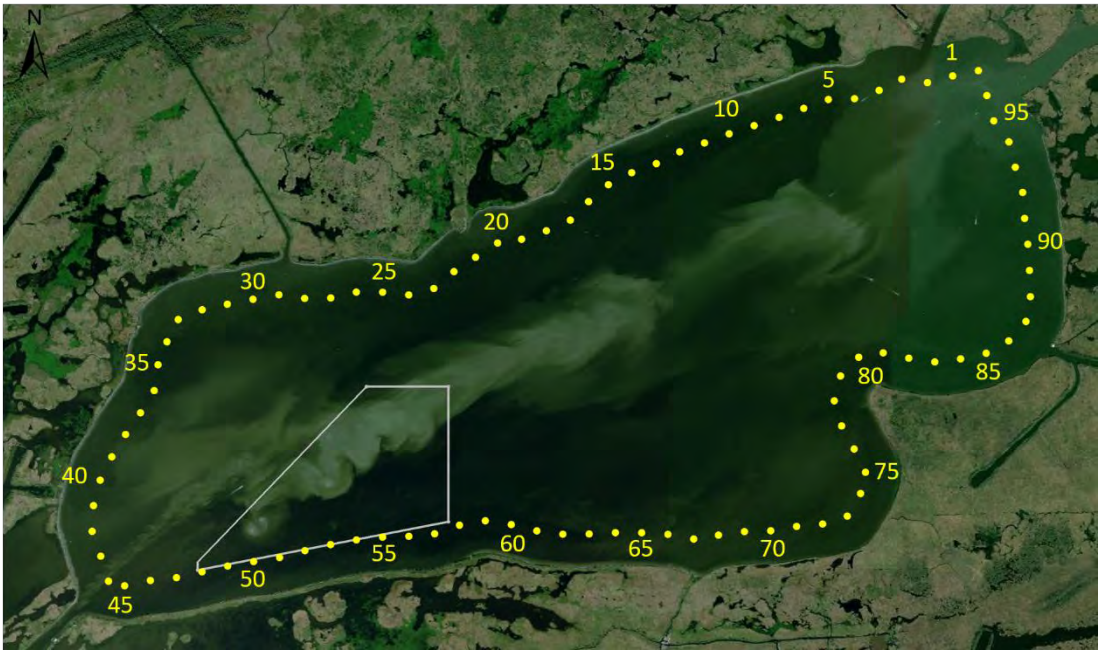

Figure 10. Extraction points along Lake De Cade perimeter. Grey line delineates the dredge pit.

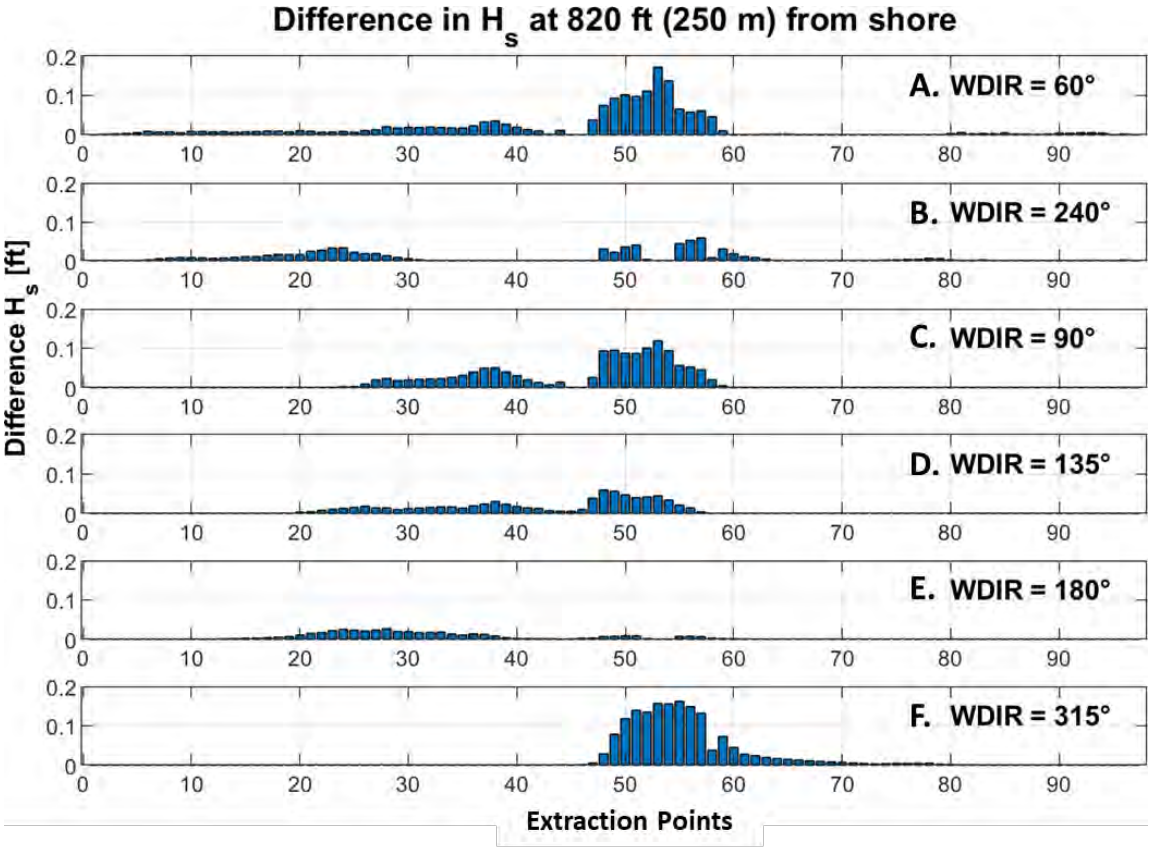

Figure 11. Difference in significant wave height at each extraction point for environmental condition A through F.

There is a noticeable change in wave height near the dredge pit, between extraction points 48 through 58, for all environmental conditions (Figure 11). Further, Condition F (northwesterly wind) yields the largest and most extensive changes in wave height. Condition F exhibits the larges changes in wave height when compared to the other environmental conditions because its fetch aligns in the direction of the dredge pit having the closest proximity to the shoreline. Generally, the dredge pit results in very slightly larger wave heights. The primary mechanism of this change is thought to be a result of the deepened bottom over fetch which allows for larger wind wave growth, as winds blowing over deeper water create larger waves than the same winds blowing over shallower water. The depth influence on wave growth is generally weak and with a relatively limited fetch at this site, results in very small changes in wave heights with differences ranging between 0.1 to 0.2 ft (1.2 to 2.4 inches) and therefore are considered negligible.

4 Conclusion

Based on the analysis shown in this report, the conclusions go as follows:

- Wave modeling was conducted using the existing and proposed bathymetry data sets to analyze the changes in wave height on Lake De Cade with an emphasis on its shoreline under several environmental conditions including longest fetch, dominant wind direction, and northwesterly winds.
- The largest changes in wave height within the dredge pit are observed under the longest fetch scenario (Condition A) in the order of 0.4 ft. The changes in wave height along the lake shoreline are minor with a slight wave height increase of 0.1 ft, which is considered negligible. Similarly, the predominant wind condition (Condition D) yields a negligible change also in the order of 0.1 ft.
- The most noticeable and extensive change in wave climate is observed under the northwesterly wind (Condition F) yielding an increase in wave height on the shoreline south of the dredge pit between 0.1 and 0.2 ft. Nonetheless, such a change in wave height is also considered negligible.

5 References

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Byland (b), T. (2018, 08 23). Dredging Template Geometry Email Correspondance. (V. Curto, Interviewer)

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