APPENDIX J

Scofield Offshore Borrow Area
Design Analysis

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SCOFIELD OFFSHORE BORROW AREA DESIGN ANALYSIS

1.0 INTRODUCTION

The Scofield Offshore Borrow Area Design Analysis was completed in support of the Preliminary Design Phase for the Riverine Sand Mining / Scofield Island Restoration Project (Project). The Project is sponsored by the Louisiana Department of Natural Resources (LDNR), State of Louisiana Office of Coastal Protection and Restoration (OCPR), and NOAA Fisheries. The Project design is funded and authorized in accordance with the provisions of the Coastal Wetlands Planning, Protection and Restoration Act (CWPPRA) (16 U.S.C.A., Sections 3951-3956) and has been approved by the Public Law 101-646 Task Force. The Project's CWPPRA designation is BA-40.

The scope of services included detailed review of prior surveys and analyses, evaluation of geophysical and geotechnical survey data, borrow area geometry refinement, and volume estimates. The design analysis was conducted by Coastal Engineering Consultants, Inc (CEC) and reviewed by SJB Group, LLC. (SJB).

1.1 Summary of Prior Work

The selection of the Project offshore borrow area was based on the review of prior surveys and analyses that identified multiple areas in the Gulf of Mexico as containing sufficient quantities of mixed sediments suitable for marsh creation. The primary sources of this information included prior work conducted by Coastal Planning and Engineering (CPE). Of the three areas investigated by CPE, the Scofield Study Area was of particular interest to the Project due to its close proximity to the island. CPE conducted offshore geotechnical and geophysical surveys to evaluate potential sediment sources; locate potential sources of borrow material; determine the suitability of the sediments in these potential areas; recommend borrow areas, sediment thickness, characteristics, and available quantities; and prepare sediment inventory plans. Magnetometer surveys were conducted to identify existing infrastructure, petroleum pipelines, and other obstructions that could affect usage of the recommended borrow areas (CPE, 2002 and 2003).

1.2 Project Area and Location

The location of the Scofield Study Area is to the south of Scofield Island and lies approximately three (3) miles from the Scofield Island Restoration Area (Figure 1). This close proximity allows for hydraulic cutterhead dredges to efficiently excavate and transport the sediment via the sediment pipeline to the island.

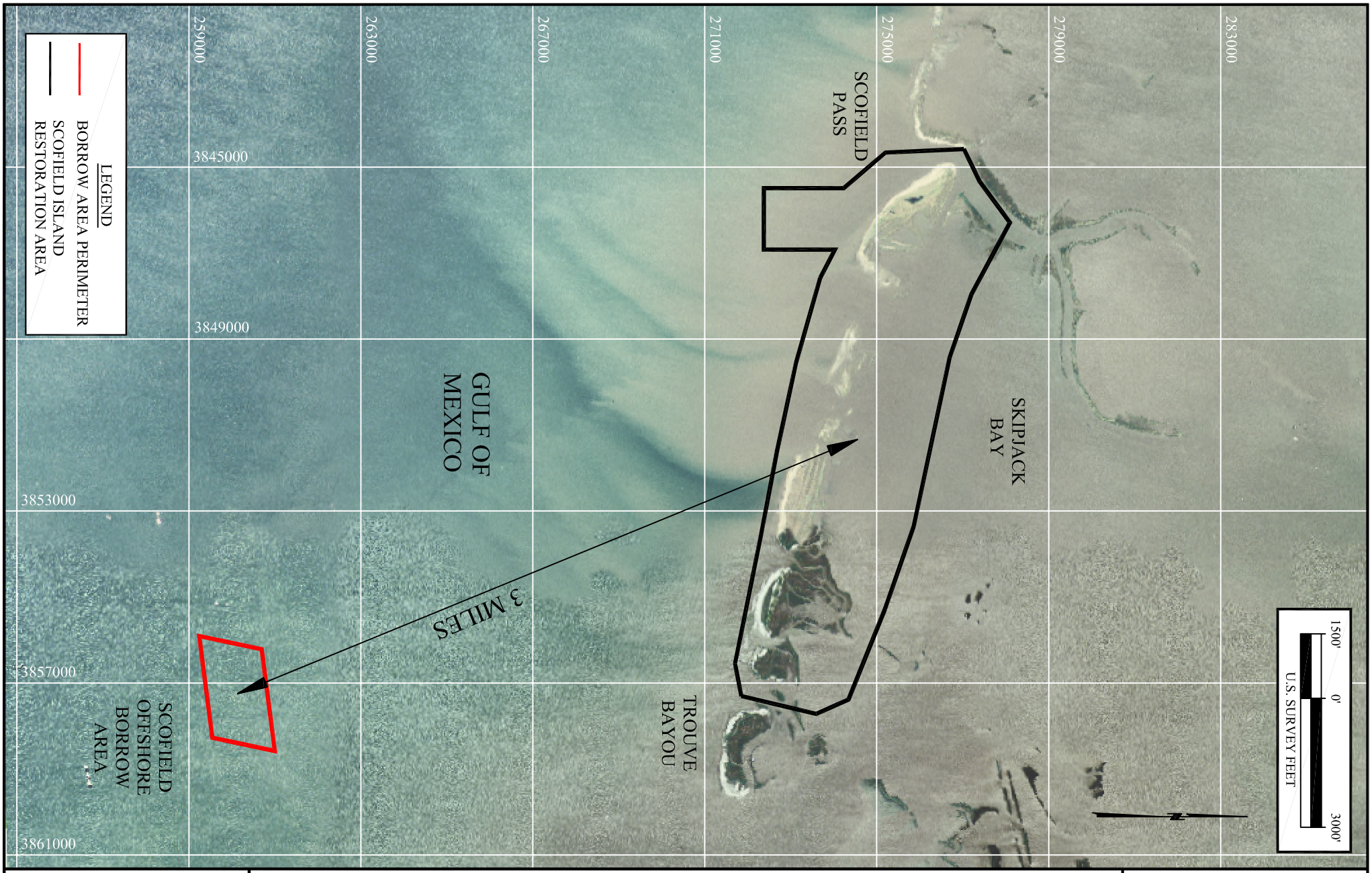

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FIGURE 1: SCOFIELD OFFSHORE BORROW AREA LOCATION

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2.0 GEOPHYSICAL AND GEOTECHNICAL ANALYSIS

The focus of the CPE study was to locate, qualify, and quantify beach compatible sand resources. The geotechnical report contains vibracore logs and split/sectioned-core photographs, tables and/or reports of gradation and grain-size data for composite samples, graphs of grain-size distribution for composite and individual sediment samples, penetrometer records, and seismic records. Since the report covers an investigation encompassing most of the Gulf shoreline adjacent to Barataria Bay, from Grande Terre Island (Quatre Bayou Pass) to the east end of Scofield Island (Bay Coquette), many of the data presented are relevant to potential borrow sites to the west of the one being provided for Scofield Island CPE (2003).

The geotechnical analysis noted the small size of the Scofield Study Area and the difficulties that would be encountered in obtaining its limited sand resources. The sand does not exist as a uniform stratum in the sediment, but rather as a series of distinct sand bodies/lenses averaging approximately 9.0 feet in thickness, lying beneath an average of 7.5 feet of overburden. The assessment of the Scofield Study Area was not positive with respect to a sand source for beach and dune restoration because of the low volume of beach compatible sand identified, logistic difficulties of disposing of the overburden, and presence of petroleum-extraction infrastructure.

Figure 2 shows a seismic transect across the borrow area, specifically one that intersects a sand body. The extent of the muddy overburden is evident. The CPE study suggested use of some of that volume of overburden for marsh creation, in lieu of offshore disposal, if it is removed to dredge the sand bodies beneath it. CPE obtained ten vibracore samples from the Scofield Study Area (Figure 3) including five from within their proposed borrow area (Figure 4). Seismic reflectors correlated to vibracore data are presented in Figure 5. The vibracore boring logs for the three borings illustrated in Figure 5 are shown in Figures 6 through 8.

Vibracore SFVC-02-04 is located along Seismic Survey Line 92, within the Scofield Study Area but just south of the delineated SOBA. Vibracores SFVC-02-07 and SFVC-02-09 are also located along the same survey line within the limits of SOBA. The nature of the sediment that led CPE to recommend against using the area as a borrow source for beach restoration is evident from a comparison of the three vibracore logs. Vibracore SFVC-02-04 shows an almost uniform layer of “strong brown” silt and clay from the surface to the end of the boring (19.5 feet). Between 12 to 13 feet, CPE found a thin stratum of fine to very fine “olive gray” quartz sand.

Vibracore SFVC-02-07 shows the upper half (approximately 9.7 feet) is predominantly “dark gray” silt and clay. The lower half of the vibracore is predominantly fine to very fine-grained “olive gray” sand and silty sand. The vibracore log for SFVC-02-09 indicates the upper one-third (approximately 6.0 feet) is predominantly “dark gray” silt and clay. The lower two-thirds of the vibracore is predominantly fine to very fine grained “olive gray” sand and silty sand.

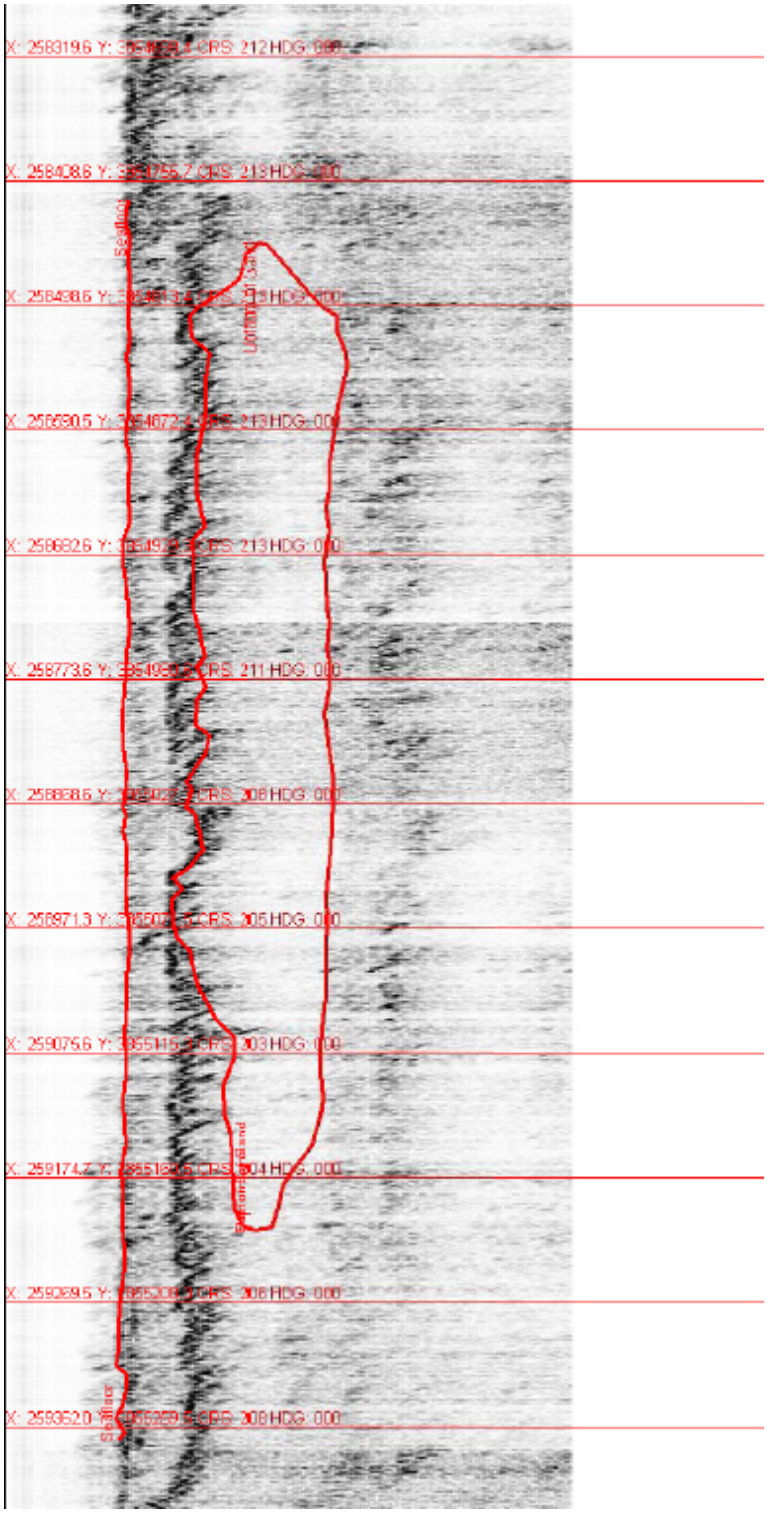

Figure 2: Scofield Study Area Sample Seismic Profile Segment (CPE, 2003, App. A, p. 1617, Scofield Profile Line 92, excerpt)

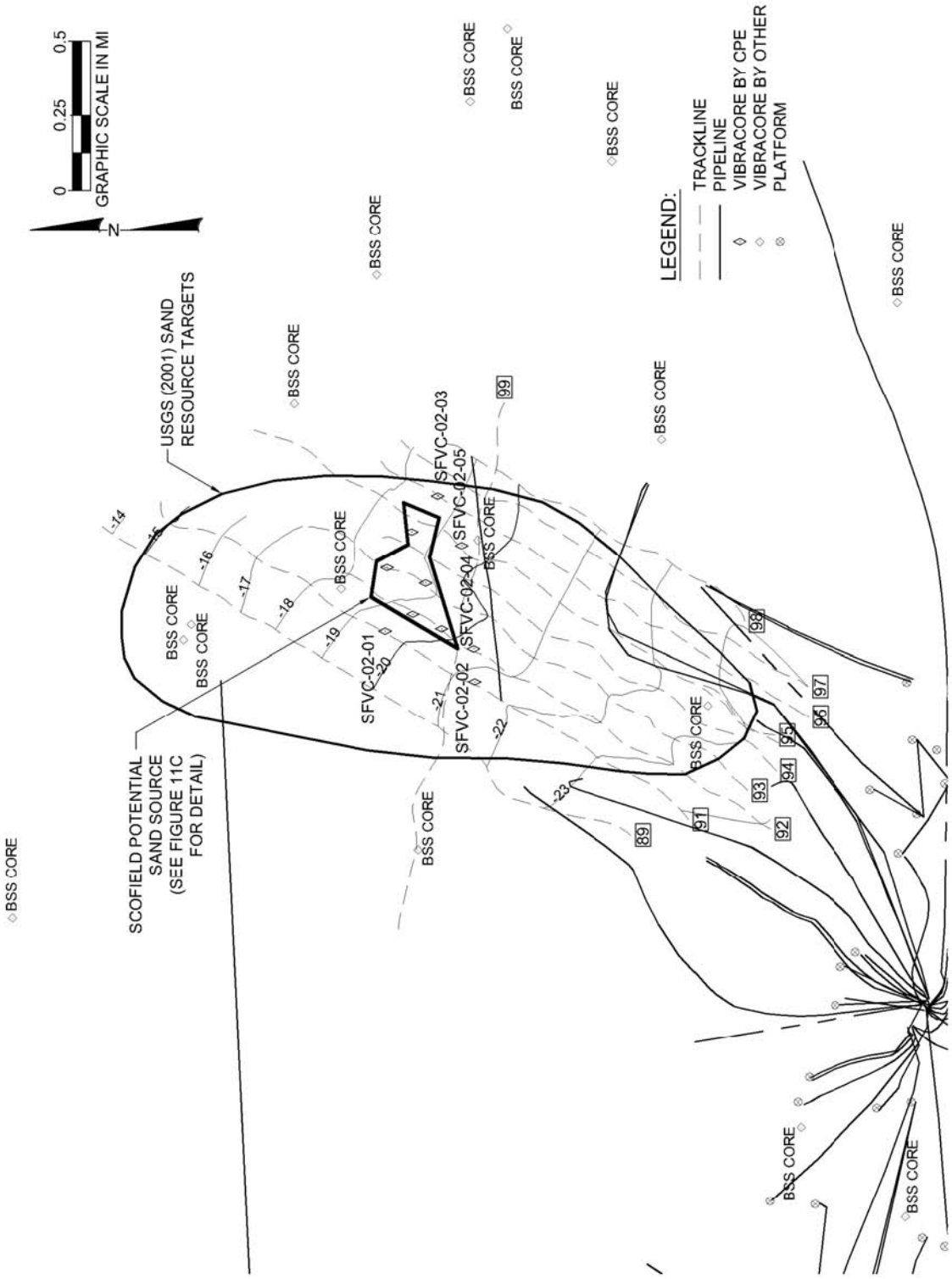

Figure 3: Scofield Study Area Location Map
(CPE, 2003, p. 41)

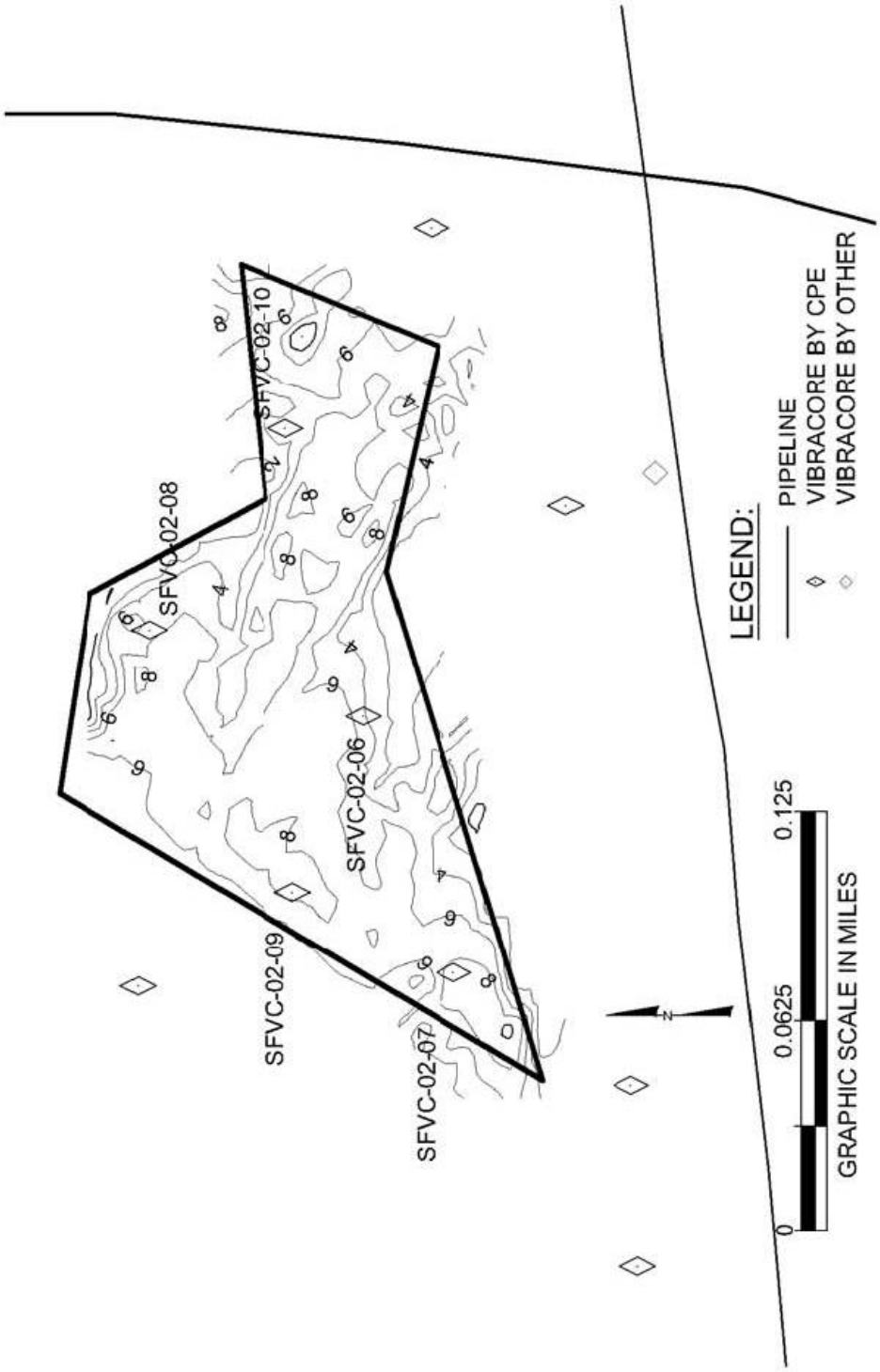

Figure 4: Scofield Study Area Details
(CPE, 2003, p. 43)

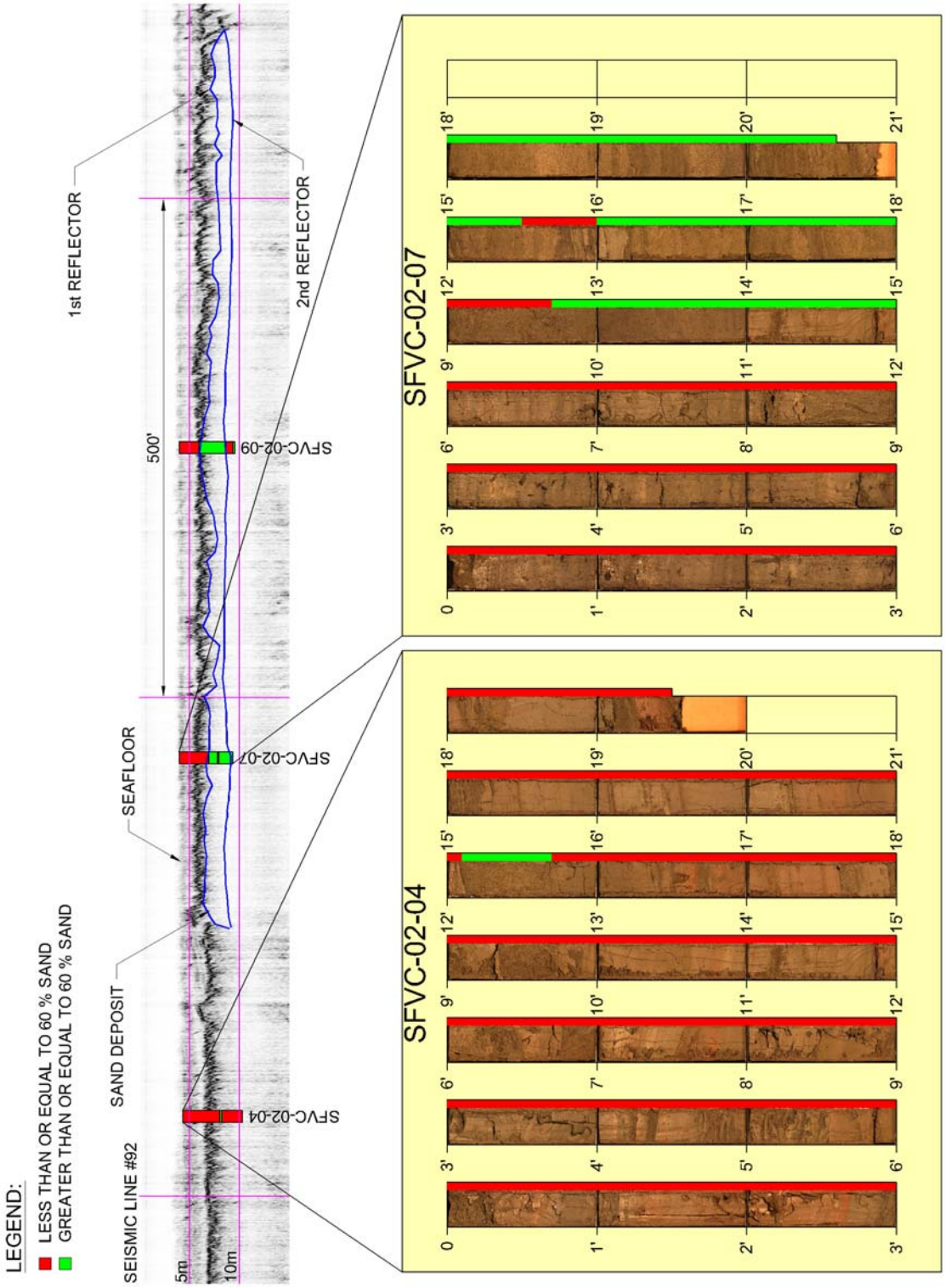

Figure 5: Seismic Reflectors Correlated with Vibracore Data (CPE, 2003, p. 42)

HOLE NO. SFVC-02-04

DRILLING LOG | DIVISION: | INSTALLATION: | SHEET 1 of 1

1. PROJECT BARATARIA	10. SIZE AND TYPE OF BIT 3"
2. LOCATION (Coordinates or Station) X=3855637 Y=258894	11. DATUM FOR ELEVATION SHOWN (TBM or MSL) NAVD 88
3. DRILLING AGENCY: Eckerd College	12. MANUFACTURER'S DESIGNATION OF DRILL Rossfelder P-3 Electric Vibracorer
4. HOLE NO. (As shown on drawing title and file number) SFVC-02-04	13. TOT NO. OF OVERBURDEN SAMPLES TAKEN Disturbed: 0 Undisturbed: 0
5. NAME OF DRILLER Gregg Brooks, PhD	14. TOTAL NO. OF CORE BOXES 1
6. DIRECTION OF HOLE VERTICAL	15. ELEVATION GROUND WATER
7. THICKNESS OF BURDEN 0.0 FT	16. DATE HOLE Started Completed 09/12/02 08:17
8. DEPTH DRILLED INTO ROCK N/A	17. ELEVATION TOP OF HOLE -20.4 FT
9. TOTAL DEPTH OF HOLE 19.4 FT	18. TOTAL CORE RECOVERY FOR BORING 100 %
	19. SIGNATURE OF GEOLOGIST ML and JB

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS (Description)	CORE REC %	SAMPLE NUMBER	REMARKS
-20.4	0					
	1					
	2					
	3					
	4					
	5					
	6		CLAY, trace sand laminae/layers, strong brown (7.5YR-5/8) from 1.2' to 2.8' and 7.6' to 7.9', olive gray (5Y-4/2), (CL).		1	
	7					Sample #1 Depth = 7.9 *Mean (mm):0.005 , Phi Sorting: 1.8 *Sand 7.8%, Silt 46.3%, Clay 45.8%
	8					
	9					
	10					
	11					
-32.5	12					Sample #2 Depth = 12.4
-33.1			SAND, fine to very fine grained, quartz, trace silt, olive gray (5Y-5/2), (SW-SM).		2	Mean (mm): 0.11, Phi Sorting: 0.58 Silt: 12.61% (SM)
	13					
	14					
	15					
	16		CLAY, trace sand laminae/layers, strong brown (7.5YR-5/8) from 13.5' to 14.6' and 19.2' to 19.5', olive gray (5Y-4/2), (CL).		1	
	17					
	18					
	19					
-39.9						
	20		End of Boring			
	21		Expansion from 19.4'			* Data Analyzed by UNO
	22		Note: 1) Soils are field visually classified in accordance with the Unified Soil Classification System.			
	23					
	24					

PROJECT: BARATARIA | HOLE NUMBER: SFVC-02-04

Figure 6: Core Log for Vibracore SFVC-02-04 (CPE, 2003, App A, p. 131)

HOLE NO. SFVC-02-07

DRILLING LOG DIVISION: INSTALLATION: SHEET 1 of 1

1. PROJECT BARATARIA	10. SIZE AND TYPE OF BIT 3"
2. LOCATION (Coordinates or Station) X=3855992 Y=259453	11. DATUM FOR ELEVATION SHOWN (TBM or MSL) NAVD 88
3. DRILLING AGENCY: Eckerd College	12. MANUFACTURER'S DESIGNATION OF DRILL Rossfelder P-3 Electric Vibracorer
4. HOLE NO. (As shown on drawing title and file number) SFVC-02-07	13. TOT NO. OF OVERBURDEN SAMPLES TAKEN Disturbed: 0 Undisturbed: 0
5. NAME OF DRILLER Gregg Brooks, PhD	14. TOTAL NO. OF CORE BOXES 1
6. DIRECTION OF HOLE VERTICAL	15. ELEVATION GROUND WATER
7. THICKNESS OF BURDEN 0.0 FT	16. DATE HOLE Started 09/12/02 10:41 Completed
8. DEPTH DRILLED INTO ROCK N/A	17. ELEVATION TOP OF HOLE -19.6 FT
9. TOTAL DEPTH OF HOLE 19.0 FT	18. TOTAL CORE RECOVERY FOR BORING 93 %
	19. SIGNATURE OF GEOLOGIST ML and JB

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS (Description)	CORE REC %	SAMPLE NUMBER	REMARKS
-19.6	0					
	1, 2, 3, 4, 5, 6, 7		CLAY, trace organics, trace silty sand laminae, trace mottled yellow (5Y-7/6) clay (occasionally partially lithified), dark gray (5Y-4/1), (CL).		1	Sample #1 Depth = 3.5 *Mean (mm):0.007, Phi Sorting: 2.0 *Sand 8.7%, Silt 59.2%, Clay 32.0%
-27.8	8					Sample #2 Depth = 8.5 *Mean (mm):0.006 , Phi Sorting: 2.0 *Sand 6.2%, Silt 60.2%, Clay 33.7%
-28.3			soft, dark gray (5Y-4/1), (CL).		2	
-29.3	9		SILTY CLAY, dark gray (5Y-4/1), (CL).		3	Sample #3 Depth = 9.3 *Mean (mm):0.019 , Phi Sorting: 2.3 *Sand 26.6%, Silt 57.3%, Clay 16.1%
-30.7	10, 11		SILTY SAND, very fine grained, quartz, trace organics, yellow clay lamina @ 10.9', olive gray (5Y-5/2), (SM).		4	Sample #4 Depth = 10.5 Mean (mm): 0.08, Phi Sorting: 0.54 Silt: 48.64% (ML)
-32.1	12		SAND, very fine grained, quartz, little silt, 2" clay layer @ 11.7', olive gray (5Y-5/2), (SW-SM).		5	Sample #5 Depth = 12.0 Mean (mm): 0.08, Phi Sorting: 0.57 Silt: 31.26% (SM)
-32.6	13		CLAY, some sand layers/laminae, gray (5Y-5/1), (CL).		1	
-33.9	14		SAND, very fine grained, quartz, little silt, 0.5" clay layer @ 14.2', olive gray (5Y-/1), (SW-SM).		5	
-37.2	15, 16, 17		fine to very fine grained, quartz, trace silt, trace clay laminae, olive gray (5Y-5/2), (SW-SM).		6	Sample #6 Depth = 15.0 Mean (mm): 0.11, Phi Sorting: 0.59 Silt: 10.19% (SM)
-38.6	18		No Recovery			
	19		End of Boring			
	20, 21, 22, 23, 24		Note: 1) Soils are field visually classified in accordance with the Unified Soil Classification System.			* Data Analyzed by UNO

PROJECT: BARATARIA HOLE NUMBER: SFVC-02-07

Figure 7: Core Log for Vibracore SFVC-02-07 (CPE, 2003, App A, p. 134)

HOLE NO. SFVC-02-09

DRILLING LOG | DIVISION: | INSTALLATION: | SHEET 1 of 1

1. PROJECT BARATARIA	10. SIZE AND TYPE OF BIT 3"
2. LOCATION (Coordinates or Station) X=3856247 Y=259961	11. DATUM FOR ELEVATION SHOWN (TBM or MSL) NAVD 88
3. DRILLING AGENCY: Eckerd College	12. MANUFACTURER'S DESIGNATION OF DRILL Rossfelder P-3 Electric Vibracorer
4. HOLE NO. (As shown on drawing title and file number) SFVC-02-09	13. TOT NO. OF OVERBURDEN SAMPLES TAKEN Disturbed: 0 Undisturbed: 0
5. NAME OF DRILLER Gregg Brooks, PhD	14. TOTAL NO. OF CORE BOXES 1
6. DIRECTION OF HOLE VERTICAL	15. ELEVATION GROUND WATER
7. THICKNESS OF BURDEN 0.0 FT	16. DATE HOLE Started Completed 09/12/02 12:42
8. DEPTH DRILLED INTO ROCK N/A	17. ELEVATION TOP OF HOLE -19.3 FT
9. TOTAL DEPTH OF HOLE 19.0 FT	18. TOTAL CORE RECOVERY FOR BORING 96 %
	19. SIGNATURE OF GEOLOGIST ML and JB

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS (Description)	CORE REC %	SAMPLE NUMBER	REMARKS
-19.3	0					
-25.3	1, 2, 3, 4, 5, 6		CLAY, trace organics, trace silty sand laminae, trace mottled yellow (5Y-7/6) occasionally partially lithified clay, dark gray (5Y-4/1), (CL).		1	Sample #1 Depth = 3.0 *Mean (mm):0.009, Phi Sorting: 2.5 *Sand 14.7%, Silt 46.7%, Clay 38.7%
-25.8			SILTY CLAY, dark gray (5Y-4/1), (CL).		2	Sample #2 Depth = 6.2 *Mean (mm):0.018, Phi Sorting: 2.2 *Sand 21.5%, Silt 62.5%, Clay 16.0%
-27.7	7, 8		SILTY SAND, trace clay, dark gray (5Y-4/1), (SM).		3	Sample #3 Depth = 7.0 Mean (mm):0.09, Phi Sorting: 0.60 Silt: 21.87% (SM)
-29.1	9		Alternating CLAY and SILTY SAND layers, dark gray (5Y-4/1), (SM-SC).		4	Sample #4 Depth = 9.0 *Mean (mm):0.018, Phi Sorting: 3.1 *Sand 41.3%, Silt 32.5%, Clay 26.1
-31.8	10, 11, 12		SAND, very fine grained, trace silt, gray (5Y-5/1), (SW-SM).		5	Sample #5 Depth = 10.7 Mean (mm): 0.09, Phi Sorting: 0.64 Silt: 29.78% (SM)
-34.6	13, 14, 15		SAND, very fine grained, trace silt, two clay laminae @ 13.7', gray (5Y-5/1), (SW-SM).		6	Sample #6 Depth = 14.3 Mean (mm): 0.15, Phi Sorting: 0.74 Silt: 4.72% (SW-SM)
-36.9	16, 17		SAND, fine grained, trace silt, some clay laminae, dark gray (5Y-5/1), (SC).		7	Sample #7 Depth = 16.3 *Mean (mm):0.019, Phi Sorting:2.6 *Sand 29.7%, Silt 51.3%, Clay 18.9%
-37.5	18		SAND, fine grained, quartz, trace silt, olive gray (5Y-5/1), (SP).		8	Sample #8 Depth = 17.8 Mean (mm): 0.13, Phi Sorting: 0.44 Silt: 3.06% (SP)
-38.3	19		No Recovery			
			End of Boring			
	20, 21, 22, 23, 24		Note: 1) Soils are field visually classified in accordance with the Unified Soil Classification System.			* Data Analyzed by UNO

PROJECT: BARATARIA | HOLE NUMBER: SFVC-02-09

Figure 8: Core Log for Vibracore SFVC-02-09 (CPE, 2003, App A, p. 136)

The composite sample data collected from the vibracores within the SOBA delineation had a mean grain size of 0.10 mm, which is fine sand, according to ASTM D2487-92. While this soil description is classified sand, the vibracores encompass the range from fine sand to clay materials within the soil sample. The percent of silt ranged from 18.3 to 43.4% with a composite mean of 27.7% (CPE, 2003).

3.0 PRIOR STUDY BORROW AREA PLAN

The bathymetry of the borrow area indicates that the ocean floor has low relief with minor changes in water depths of -18 to -20 feet NAVD88 as revealed in the contours shown in Figure 9. The sidescan sonar survey in this area revealed a featureless surface providing reasonable assurance that there are no surface areas of environmental concern or other man-made obstructions that might be adversely impacted by the dredging activities from the area. Water depth is reasonable for cutter-head dredge operation. Based on the geophysical, geotechnical, and laboratory data analysis, CPE delineated the location, depth, breadth, and length of a borrow area (CPE, 2003) comprised of approximately 1.35 million cubic yards of sand, silt and clay. Review of the geophysical and geotechnical data in the vicinity of the proposed borrow area led to the conclusion that the mixed sediment blend identified within the Scofield Study Area is ideal for marsh creation, therefore it was selected as the Project borrow area for marsh creation denoted as the Scofield Offshore Borrow Area (SOBA).

4.0 PRELIMINARY SCOFIELD OFFSHORE BORROW AREA PLAN

Seismic surveys, as represented in Figure 2, were utilized to evaluate subsurface geometry. By examining the seismic data in concert with vibracore logs, penetrometer data, and individual grain size analyses, a revised shape, length, width, and depth of a structural basin offshore was developed and used to refine the geometry and develop the preliminary borrow area design plan.

Review of magnetometer data revealed a number of anomalies that were linearly correlated in the vicinity of the SOBA (CPE, 2003). Further, the LDNR pipeline database indicated a petroleum pipeline in this approximate location. Therefore, the boundary of SOBA was refined to provide a minimum 500-foot buffer relative to the top of cut from the anomalies.

The preliminary borrow area design plan view (Figure 9) present the bathymetry, seismic survey tracks, preliminary design profile and section lines locations, and vibracore locations. The proposed SOBA footprint is a polygonal expansion of the CPE borrow area delineation (Figure 4). Figure 10 presents the approximate east-west preliminary design profile A – A'. Figure 11 presents two approximate north-south preliminary design sections B – B' and C – C'. It is anticipated that the entire volume will be dredged as a single cut, with all of the sediment blended during the excavation process.

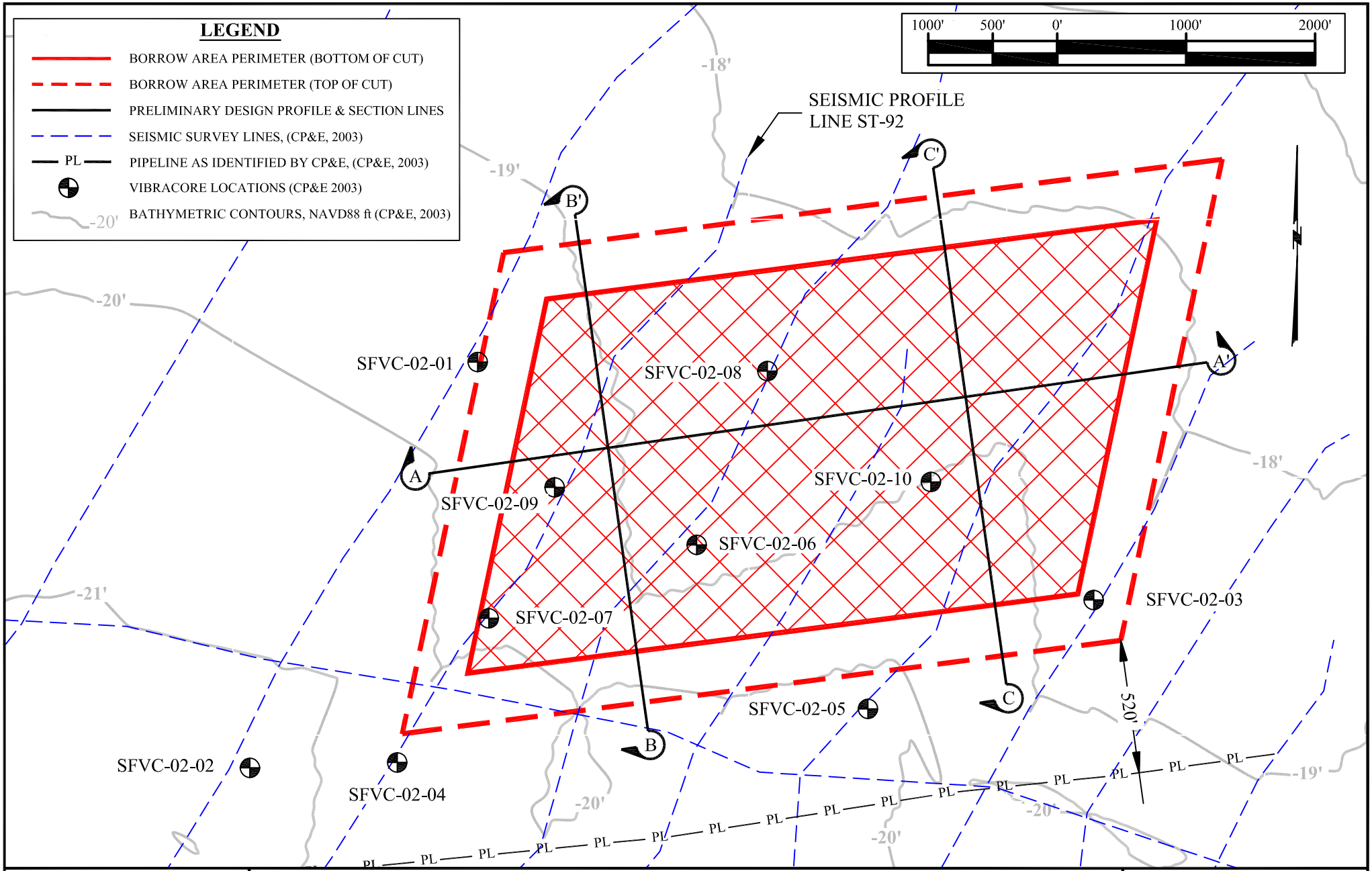

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FIGURE 9: PRELIMINARY SCOFIELD OFFSHORE BORROW AREA PLAN VIEW

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NOTES:

1. BATHYMETRY AND VIBRACORE DATA FROM BARATARIA/PLAQUEMINES BARRIER SHORELINE RESTORATION, COASTAL PLANNING & ENGINEERING, 2003

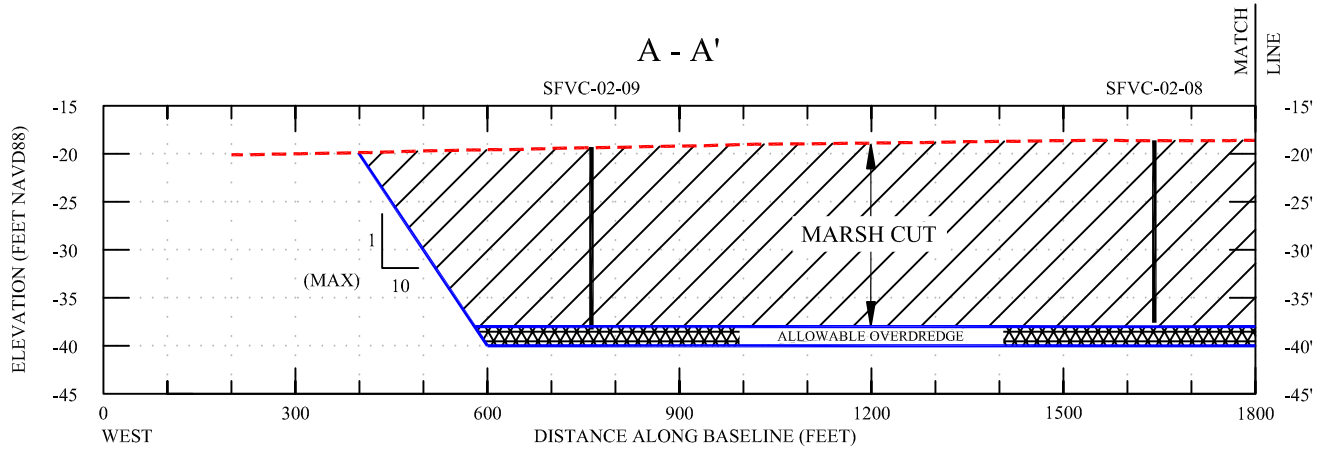
SCALE:

H: 1" = 300'

V: 1" = 10'

LEGEND:

- MARSH CUT
- ALLOWABLE OVERDREDGE
- JULY 2003
- DESIGN
- VIBRACORE SFVC-02-## (CP&E, 2002)



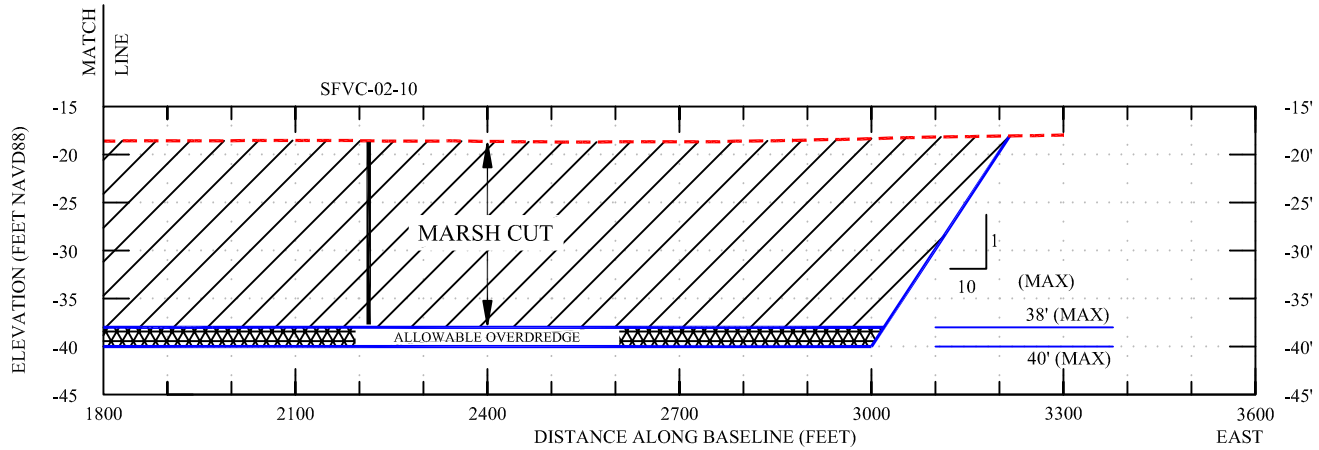


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FIGURE 10: PRELIMINARY SCOFIELD OFFSHORE BORROW AREA DESIGN SECTION

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NOTES:

1. BATHYMETRY AND VIBRACORE DATA FROM BARATARIA/PLAQUEMINES BARRIER SHORELINE RESTORATION, COASTAL PLANNING & ENGINEERING, 2003

SCALE:

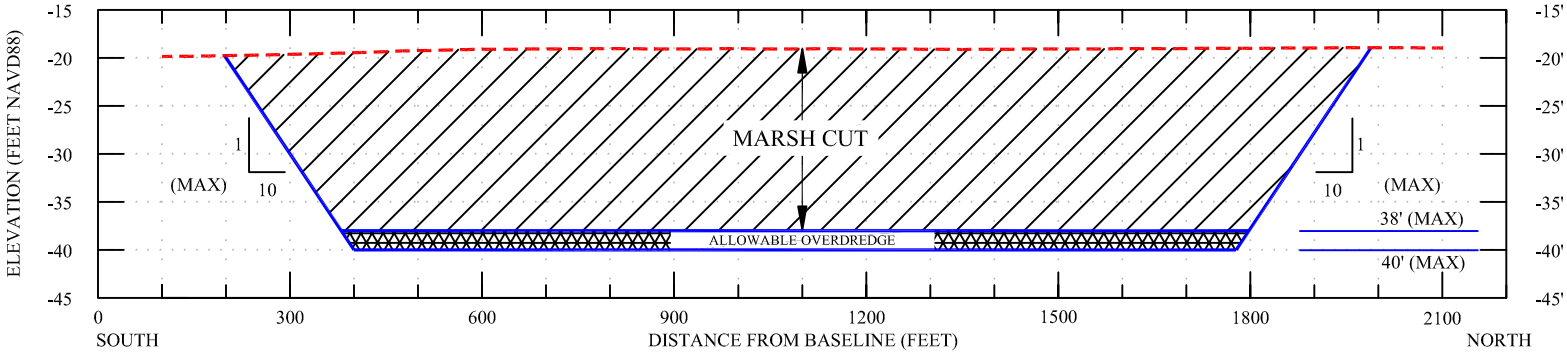
H: 1" = 300'

V: 1" = 10'

LEGEND:

- MARSH CUT
- ALLOWABLE OVERDREDGE
- JULY 2003
- DESIGN

B - B'



C - C'

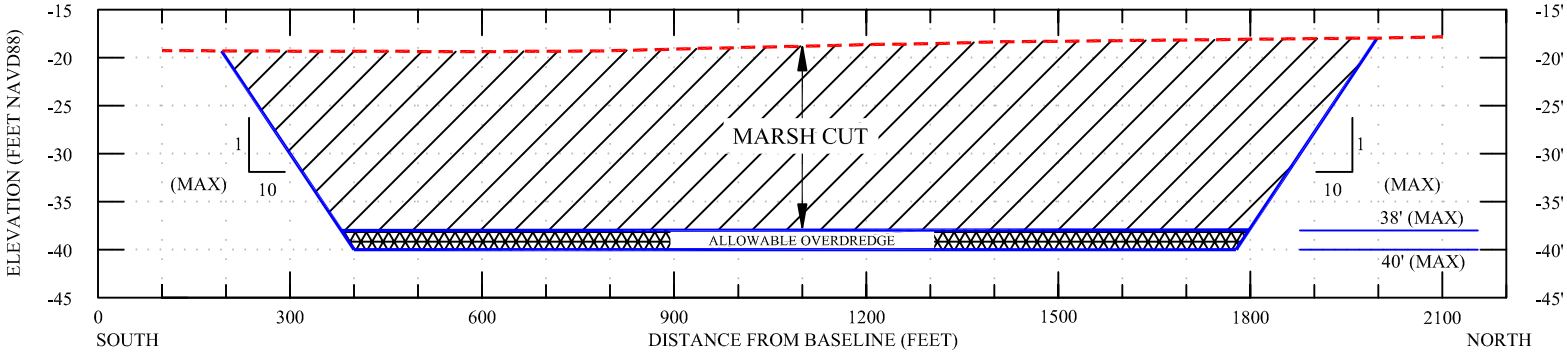


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FIGURE 11: PRELIMINARY SCOFIELD OFFSHORE BORROW AREA DESIGN SECTION

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5.0 FILL MATERIAL ANALYSIS

The composite samples for the preliminary offshore borrow area were determined to be fine sand per ASTM D2487-92. The grain size data for the samples from the cores within the expanded borrow area were also determined to be fine sand, based on their percent-by-weight histograms. Examination of the individual core logs and analyses of discrete samples indicates that the vibracores vary in number of discernible strata from three to twelve, with the commonest being clay and fine- to very fine grained sand. The uppermost (overburden) stratum is always clay. The other, less dominant strata were described as silt, silty sand, sandy silt, silty clay, clayey sand, and alternating mixtures. In the strata described as "sand" the silt content of the grain size samples varies from 3.1% to greater than 50%. This stratigraphic variability, reinforced by the presence of the clay overburden, is argument against attempting to exploit the limited sand resource for beach fill, however it supports the proposed use as marsh fill.

6.0 VOLUMES

The total estimated volume in the SOBA is approximately 3.3 million cubic yards. The cut is approximately 2,800 feet long, 1,900 feet wide at the top of cut, and the thickness ranges from 20 to 22 feet. The required excavation volume for marsh creation on Scofield Island as fully described in the Main Report and the Scofield Island Restoration Area Design Analysis (Appendix M) ranges from 2.79 to 3.01 million cubic yards. Thus, the proposed offshore borrow area contains sufficient volume of suitable mixed sediments for Project construction.

7.0 WAVE REFRACTION MODEL RESULTS

In order to predict impacts that excavation of a borrow area seaward of the depth of active sediment transport may have on wave and sediment transport patterns; a wave refraction analysis was performed.

7.1 Wave Model Description

The Steady-State Spectral Wave Model (STWAVE) was used to evaluate changes to wave refraction and sediment transport patterns resulting from the proposed borrow area excavation.

STWAVE is a steady-state finite difference model (Smith et al., 2001). It simulates depth-induced wave refraction and shoaling, current-induced refraction and shoaling, depth and steepness induced wave breaking, diffraction, wind driven wave growth, and wave-wave interaction and whitecapping that redistribute and dissipate energy in a growing wave field. The version of STWAVE chosen is part of the SMS model, Version 10.0, developed by Environmental Modeling System, Inc. and provided by Veri-Tech, Inc.

7.2 Grid Design

A rectangular grid design with evenly spaced grid cells was implemented in this study. The grid was rotated 14.5º clockwise to align with the existing average shoreline orientation. Each grid cell was 300 feet long by 300 feet wide.

7.3 Data Analysis

In order to investigate how wave refraction pattern might be affected by the offshore borrow area, a series of simulations using various wave conditions were performed. These conditions covered a wide range, from mild/regular to severe/storm conditions based on the statistical analysis of wave and wind data analyzed for the Scofield Island Restoration Preliminary Design (CEC, 2009). The analysis illustrates that there are three dominant directions (22.5°directional bands) that the waves enter the computational domain from: 135.0°, 157.5° and 180.0° (clockwise from true North), which occur in 17.7%, 16.7% and 10.8% of all cases, respectively. The average wave heights and periods for the three directions are 2.2 feet and 4.1 seconds, 3.0 feet and 4.6 seconds, and 3.6 feet and 4.9 seconds, respectively. The corresponding wind speeds are 20.1, 20.7, and 19.7 feet/second for the 135.0°, 157.5° and 180.0° directions, respectively.

The wave and wind directions are based on the standard meteorological convention, i.e., a wind direction of 0º corresponds to a wind that is blowing from due north. A wind direction of 90º corresponds to a wind that is blowing from due east. A wind direction of 180º corresponds to a wind blowing from due south and 270º corresponds to a wind blowing from due west.

Tables 1 presents average wave and wind conditions for the three dominant wave directions at WIS-132 which were used in the STWAVE simulations.

Table 1: Average Wave Heights and Periods at WIS-132

Case #	Wave Dir.* (deg)	Wave Height (feet)	Wave Period (sec)	Wind Speed (feet/sec)	Wind Dir.* (deg)
1	135.0	2.2	4.1	20	135.0
2	157.5	3.3	4.6	21	157.5
3	180.0	3.6	4.9	20	180.0

* wave and wind directions are based on the standard meteorological convention

The analysis of extreme sea conditions estimated extreme wave heights for 1-, 5-, 10-, 20-, 50-, and 100-year return periods (CEC, 2009). The 1-year and 20-year waves were used to simulate borrow area impacts during severe/storm conditions.

All input parameters used in STWAVE simulations for the Scofield Island offshore borrow area impact study, which included three statistically dominant "average" conditions and 1- and 20-year storm events, are summarized in Table 2. The water stage values listed in the table indicate corresponding storm surge elevations. Storm surge is a rise of water level above astronomical tide level due to wind stress and atmospheric pressure gradient. Due to unavailability of measured water elevation in the vicinity of Scofield Island, the water stage values for the area are based on observed water levels at Grand Isle. For average wave conditions, water stage was assumed to be 0 feet relative to MSL (=1.0 feet NAVD). For simplicity, water stage values were constant throughout the computational domain in each simulation case.

Table 2: Input Wave Parameters of STWAVE Simulation Cases

Case #	Description	Offshore Wave Height (feet)	Offshore Wave Period (sec)	Real World Angle (deg)	Wind Speed (feet/s)	Water Stage (feet, NAVD)	Γ	nn
1*	SE average	2.2	4.1	135.0	20	1.0	3.3	4
2*	SSE average	3.3	4.6	157.5	21	1.0	3.3	4
3*	S average	3.6	4.9	180.0	20	1.0	3.3	4
4**	1-yr storm	8.9	8.0	194.0	46	2.0	3.3	4
5**	20-yr storm	22.5	12.0	194.0	82	4.3	4.0	10

* based on WIS statistics
** based on extreme wave height analysis for various return periods

7.4 Wave Refraction Analysis Results

STWAVE simulations were run for all five (5) cases listed in Table 2 for both the existing pre-excavated bathymetry and the alternative post-excavated bathymetry representing the excavated borrow area. A total of ten (10) simulations were performed. For each case, the pre-excavated calculated wave heights and directions were subtracted from the post-excavated calculated wave heights and directions to compute corresponding differences that the proposed borrow area excavation caused. These differences are shown in Figures 12 through 16.

All simulation cases predicted that the proposed borrow area reduced wave heights in the lee of the borrow area, however, east and west of the wave height reduction area, the wave height increased. The area of impact correlated with the angle of the offshore wave direction.

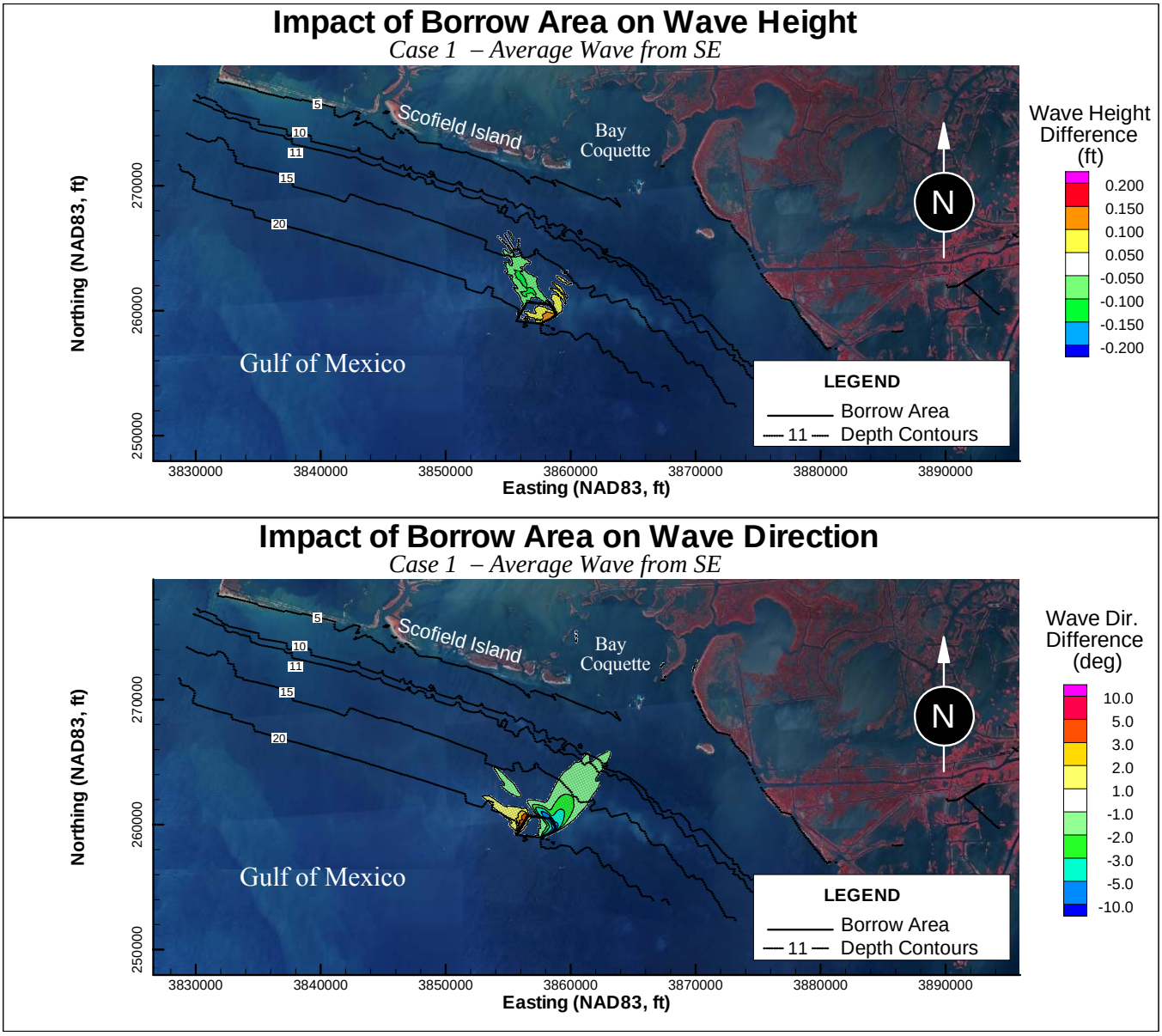

Figure 12: Impact of Wave Height and Direction on Borrow Area, Case 1

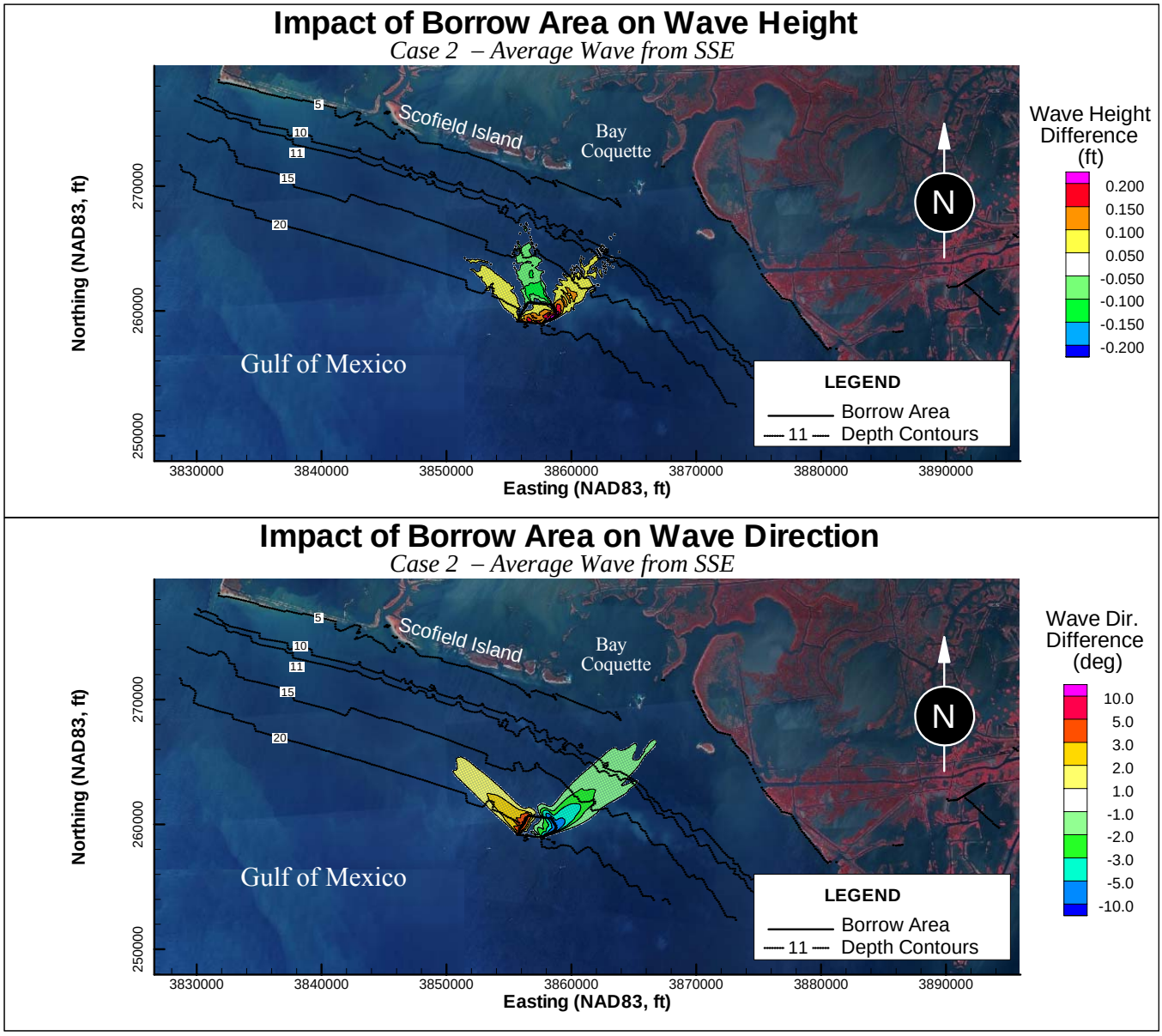

Figure 13: Impact of Wave Height and Direction on Borrow Area, Case 2

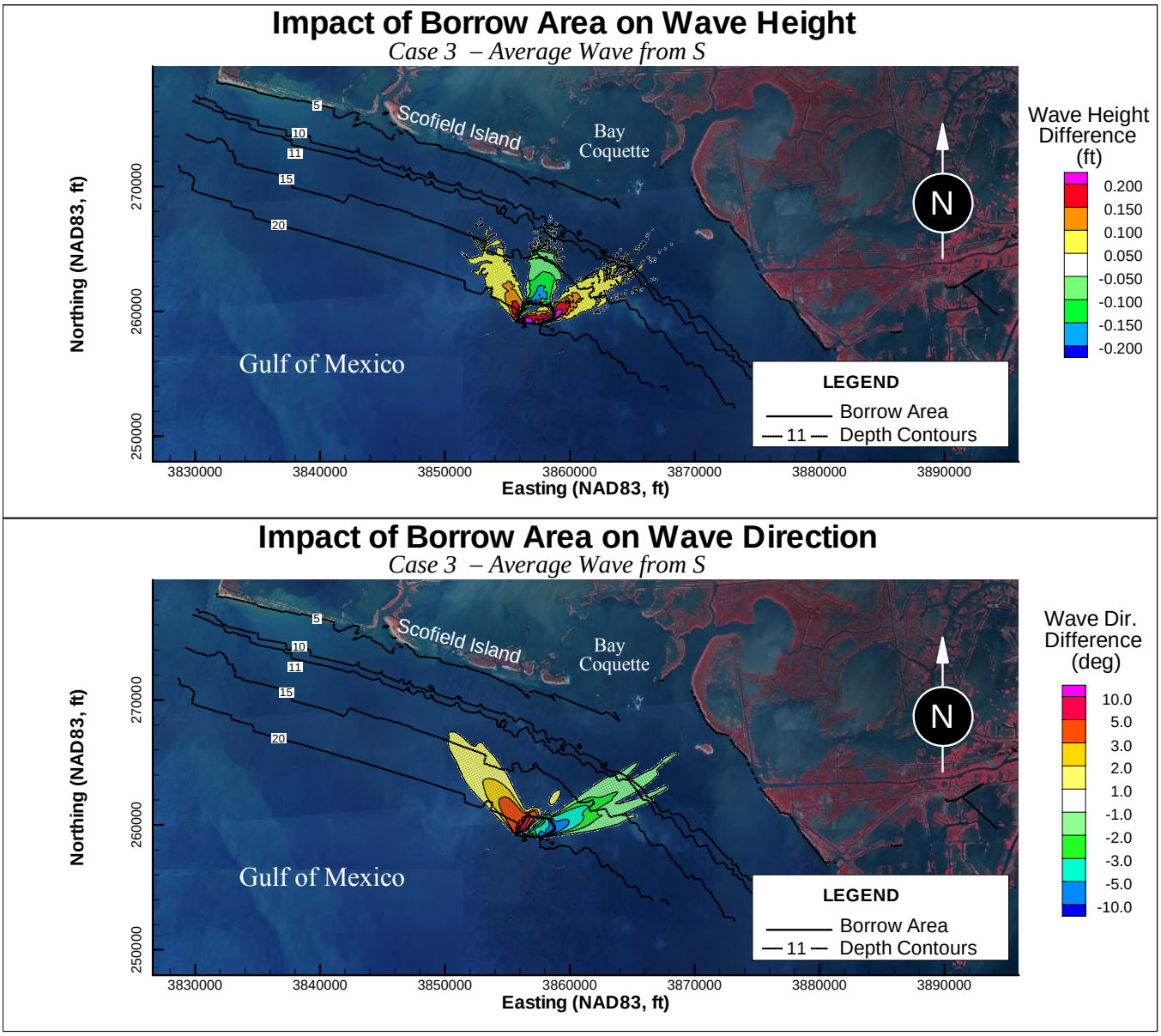

Figure 14: Impact of Wave Height and Direction on Borrow Area, Case 3

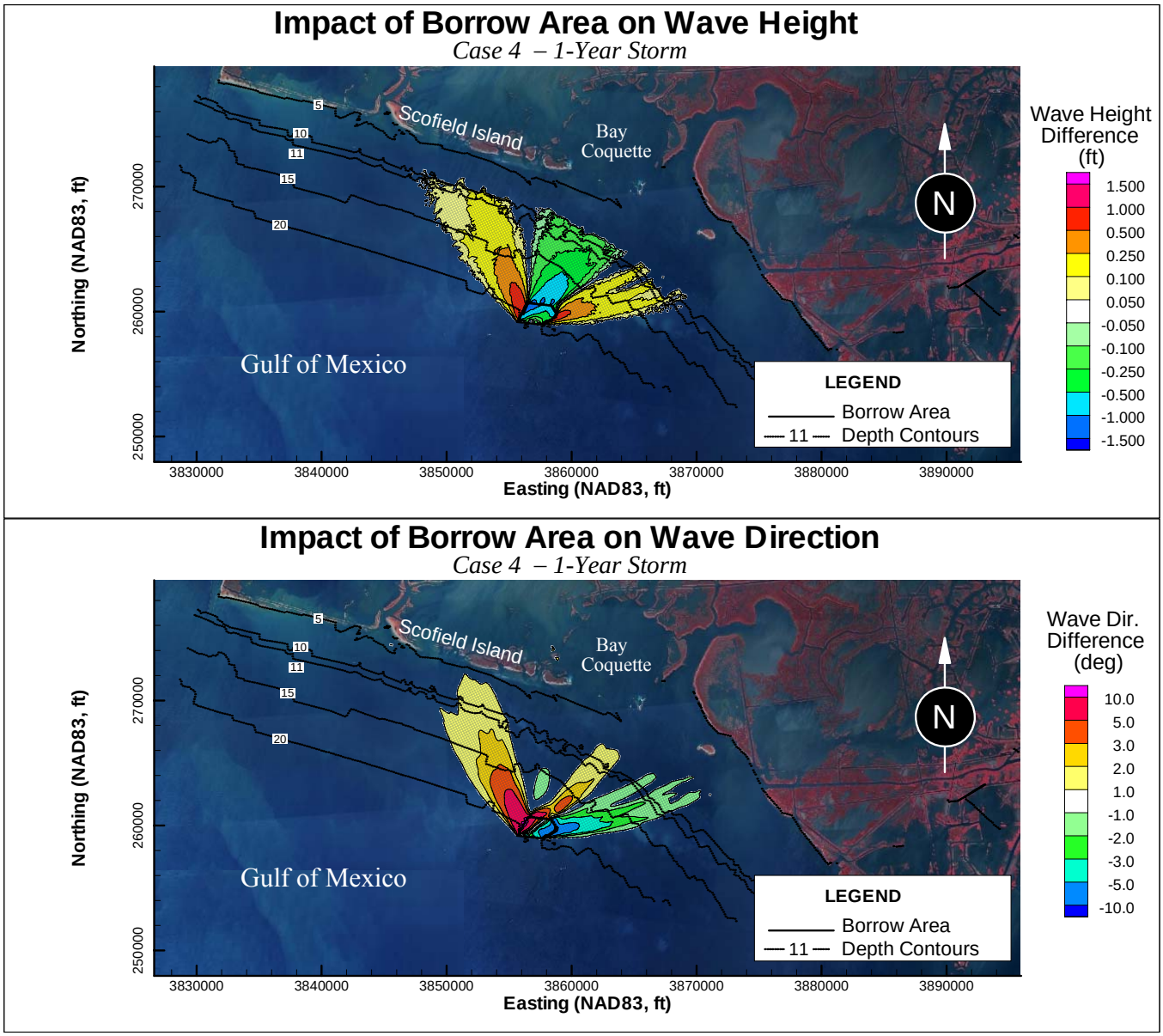

Figure 15: Impact of Wave Height and Direction on Borrow Area, Case 4

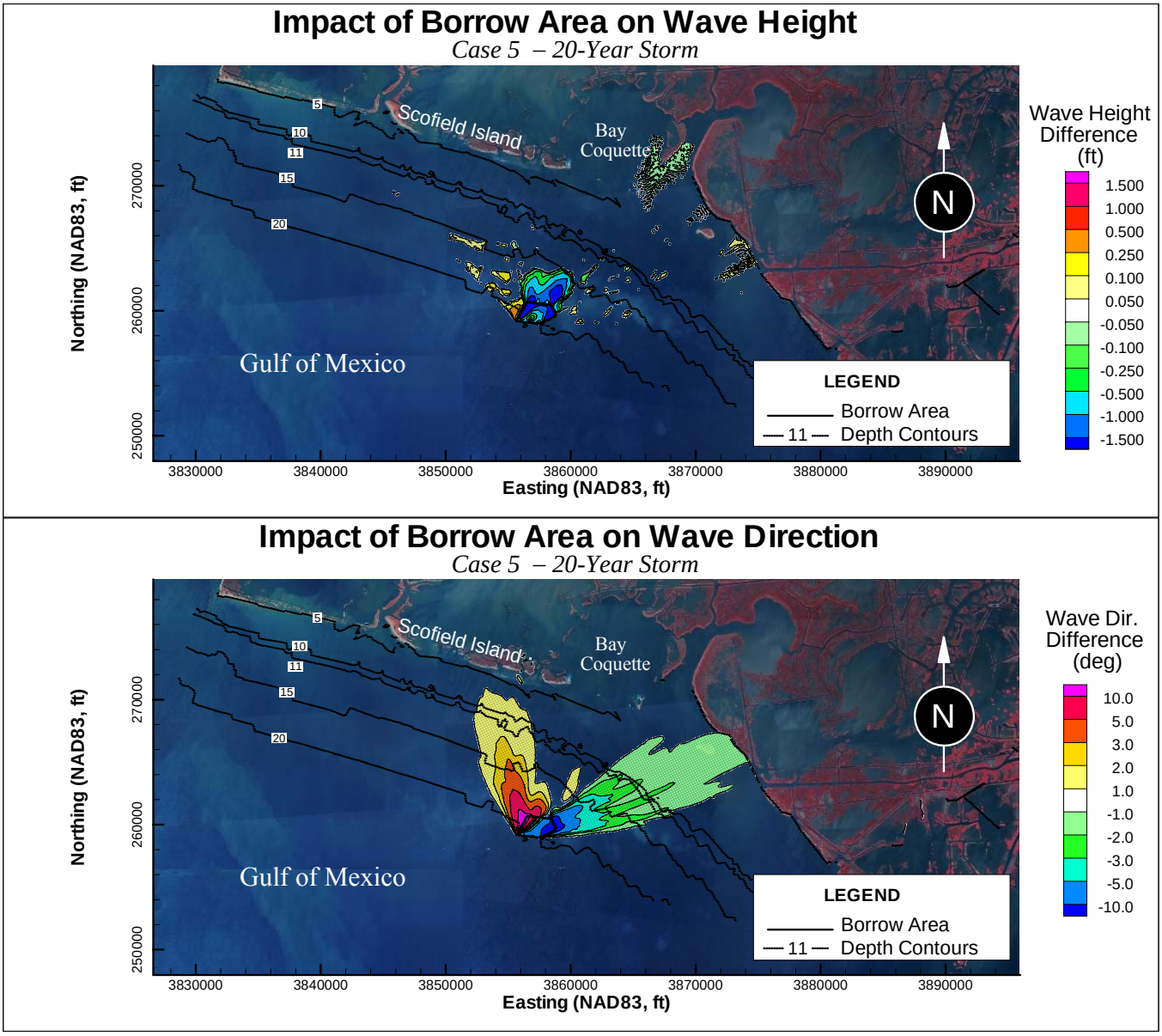

Figure 16: Impact of Wave Height and Direction on Borrow Area, Case 5

Table 3 summarizes the impacts of the borrow area for all five cases expressed in terms of the maximum wave height increase/decrease along the 11-foot depth contour line, maximum wave height increase/decrease along the shoreline, and minimum distance from the shoreline to the 0.025-foot wave height difference contour line.

Table 3: Summary of Borrow Area Impacts on Wave Height

Case #	[1]Max. Wave Height Increase(+)/Decrease(-) inside 11-ft Depth Contour, ft	[1]Max. Wave Height Increase(+)/Decrease(-) near Shoreline, ft	[2]Min. Distance from Shoreline to 0.05-ft Wave Height Difference Contour, ft
1	+0.03/-0.04	+0.0/-0.0	5,650
2	+0.04/-0.03	+0.0/-0.0	4,600
3	+0.07/-0.05	+0.0/-0.0	4,800
4	+0.13/-0.25	+0.0/-0.0	2,800
5	+0.00/-0.00	+0.0/-0.0	6,700

[1] smaller increase/decrease implies lesser impact
[2] longer distance implies lesser impact

Based on the quantitative analysis of impacts on wave height presented in Table 3, the borrow area is not expected to result in any effect on wave height along the shoreline. Overall, the borrow area impacted the wave heights, however, the area of influence was limited and no changes in wave heights are anticipated within at least 2,800 feet seaward of the shoreline. Wave height differences on the order of 0.05 feet depicted in Figure 16 along the shoreline east of Scofield Island across Bay Coquette are believed to be numerical errors that occurred during the 20-year storm simulation. Despite more significant overall impact caused by the 1- year and 20-year storms in the vicinity of the borrow area, their impact on wave height along the shoreline is minor. This is a result of, first, much stronger winds regenerating waves affected by the borrow area within a short fetch and, second, a wider surf zone due to larger waves which start to break further offshore compared to the average wave conditions. Once broken, waves heights became depth limited and thus not affected near the shoreline during major storms.

The borrow area caused the waves to change direction and refract. The changes in wave direction ranged, in general, between approximately -16º and +18º. Table 4 summarizes the impacts of the borrow area on wave direction expressed in terms of the maximum wave direction change along the 11-foot depth contour line, maximum wave direction change along the shoreline, and minimum distance from the shoreline to the 1º wave direction difference contour line.

Based on the quantitative analysis of impacts on wave direction presented in Table 4, the borrow area is not expected to result in any effect on wave direction along the shoreline under average wave conditions of influence was limited and no change in wave directions was predicted within at least 5,800 feet seaward of the shoreline. For the 1-year and 20-year storms (Cases 4 and 5),

wave direction along the Scofield Island shoreline was affected by approximately 0.7º. The 20-year storm also caused a 1.0º difference in wave direction along the shoreline east of Scofield Island across Bay Coquette. This suggests that a storm event is expected to result in a minor effect in wave direction near the shoreline.

Table 4: Summary of Borrow Area Impacts on Wave Direction

Case #	[1]Max. Wave Direction Change inside 11-ft Depth Contour, º	[1]Max. Wave Direction Change near Shoreline, º	[2]Min. Distance from Shoreline to 1º Wave Direction Difference Contour, ft
1	1.2	0.0	5,850
2	1.6	0.0	6,300
3	1.6	0.0	5,800
4	1.7	0.7	900
5	2.3	1.0	0

[1] smaller change implies lesser impact
[2] longer distance implies lesser impact

To further estimate the impacts of changes in wave height and direction caused by the borrow area on the longshore sediment transport under storm conditions, analyses of wave energy flux ratios and differences were performed. According to Dean and Dalrymple (2002), alongshore wave energy flux is responsible for the longshore sediment transport. The flux per unit length of beach is:

$$F = \frac{1}{16}\rho g H^2 C_g \sin 2\theta = \frac{1}{16}\rho g H^2 \sqrt{gh} \sin 2\theta$$

where ρ = acceleration due to gravity

H = wave height

C_g = wave celerity

h = water depth

θ = angle between wave ray and onshore direction (perpendicular to shore = 0º)

Figures 17 and 18 present alongshore wave energy flux ratios computed between the existing bathymetric conditions and bathymetric conditions with the offshore borrow area for the 1-year and 20-year storm events. The wave energy flux ratio values are non-dimensional. Ratio values greater than 1.0 indicate an increase in wave energy resulted from the borrow area and ratio values less than 1.0 indicate a decrease in wave energy, e.g., a ratio of 0.9 infers a 10% decrease in wave energy responsible for the longshore sediment transport. The results depicted in Figures 17 and 18 were analyzed for wave energy flux ratios of 10% or greater which were observed

along the shoreline in both storm cases. This prompted a further look at the wave energy flux magnitude differences between pre- and post-excavated conditions.

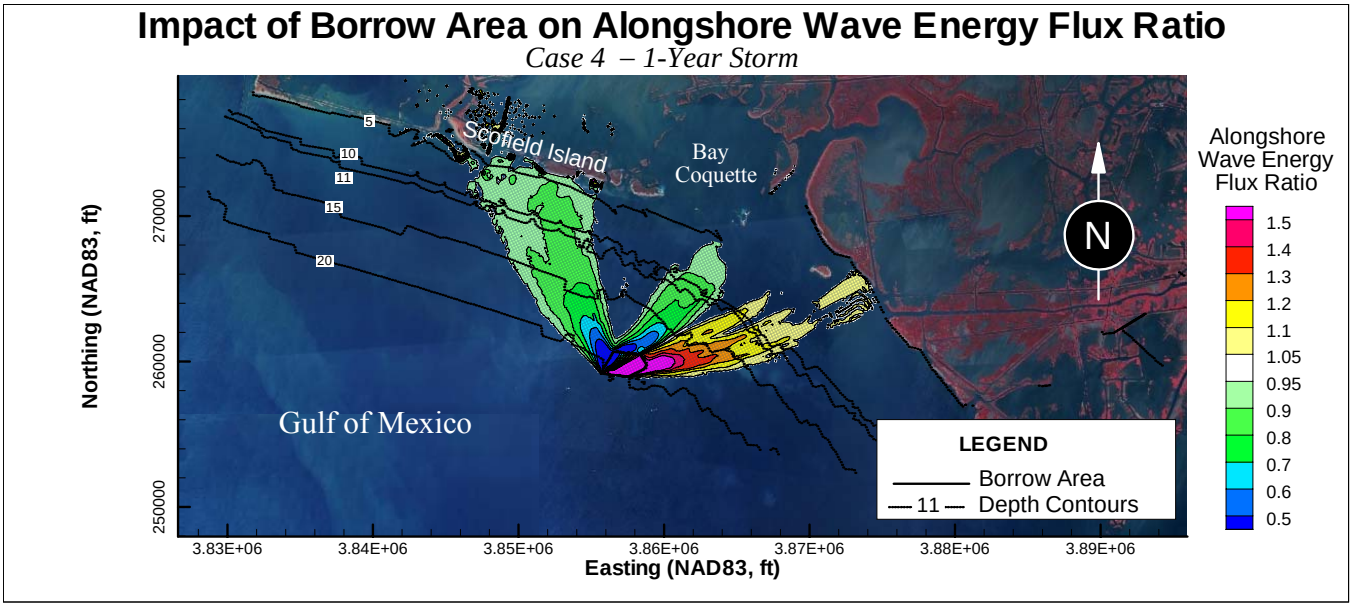

Figure 17: Alongshore Wave Energy Flux Ratios, Case 4

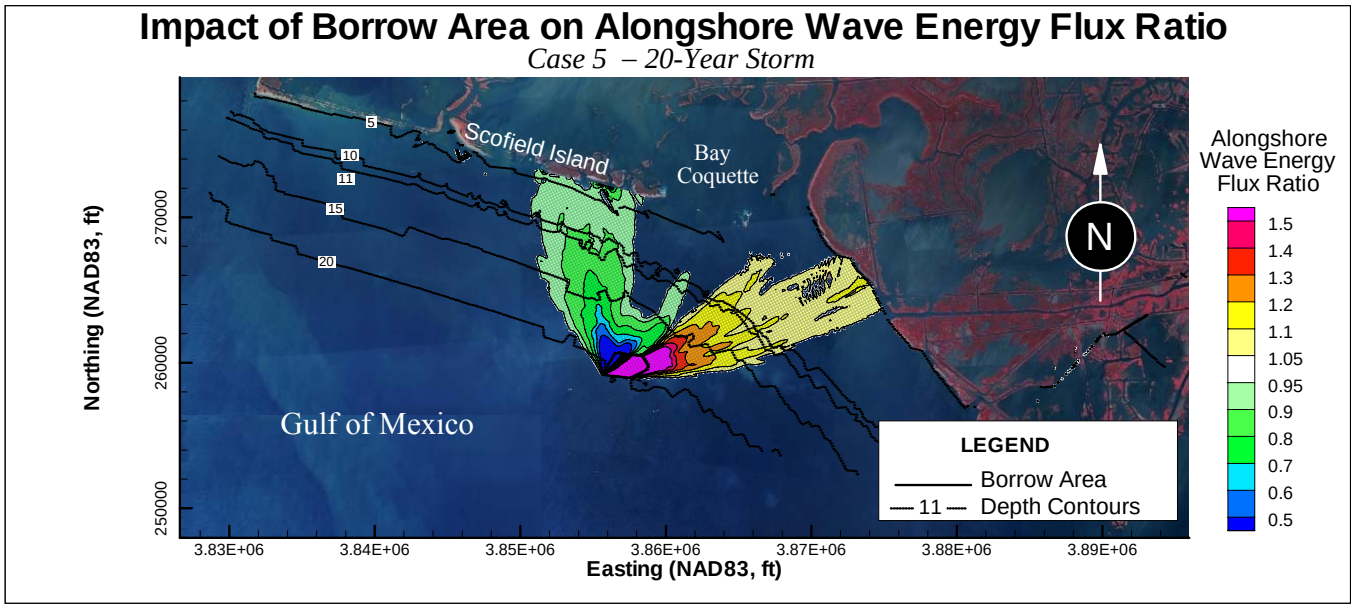

Figure 18: Alongshore Wave Energy Flux Ratios, Case 5

Figures 19 and 20 present alongshore wave energy flux differences computed between the existing bathymetric conditions and bathymetric conditions with the offshore borrow area for the 1-year and 20-year storm events. The wave flux differences are expressed in terms of pdl/ft*(ft/s). Positive flux differences imply that the borrow area caused an increase in wave energy and negative flux differences indicate that the wave energy decreased. The 11-foot depth contour was considered as the seaward limit of active sediment transport and was used as a benchmark for evaluating wave flux differences. Changes on the order of tens of thousands pdl/ft*(ft/s) inside the 11-foot depth contour were defined as significant impacts on sediment transport, whereas changes on the order of thousands pdl/ft*(ft/s) were defined as insignificant. Table 5 presents a summary of wave flux ratios and differences calculated for each case.

Table 5: Summary of Borrow Area Impacts on Wave Energy Flux

Case #	[1]Flux Ratio > 10%	[1]Max. Flux Difference, pdl/ft*(ft/s)	[2]Depth Contour, ft	[3]Frequency	Impact
4	Yes	6,900	11.9	Intermediate	Insignificant
5	Yes	9,500	11.2	Low	Insignificant

[1]Inside 11-foot depth contour, accounts for magnitude regardless of positive or negative change.
[2]Shallowest contour experiencing a flux difference magnitude of 10,000 or greater; N/A was assigned if flux magnitude difference did not exceed 10,000.
[3]Cases 1-3 are average conditions which occur regularly; Case 4 is a 1-year storm which occurred 8 times in the 20 year (1980-1999) period; Case 5 is a 20-year storm which occurred once in the 20 year (1980-1999) period.

Based on the criteria shown in Table 5, the 1-year and 20-year storms are predicted to have insignificant impacts on the longshore sediment transport inside the 11-foot depth contour which is designated as the zone of active sediment transport.

7.5 Wave Refraction Analysis Conclusions

The STWAVE model was applied to evaluate changes to wave refraction and sediment transport patterns resulting from excavation of the offshore borrow area. Five simulation cases were performed including three “average” condition simulations and two storm condition simulations. Based on the evaluation of impacts of the borrow area on wave height and direction, it was predicted that under “average” wave climate, changes in wave height and wave angle in the vicinity of Scofield Island would be negligible. During storm events, however, minor changes in wave direction at the shoreline, up to 1.0º, may have minor impacts on sediment transport. Further analysis of wave energy flux ratios and differences between the pre- and post-excavated conditions predicted that the 1-year and 20-year storm conditions would results in insignificant

impacts on the longshore sediment transport inside the 11-foot depth contour which was designated as the zone of active sediment transport.

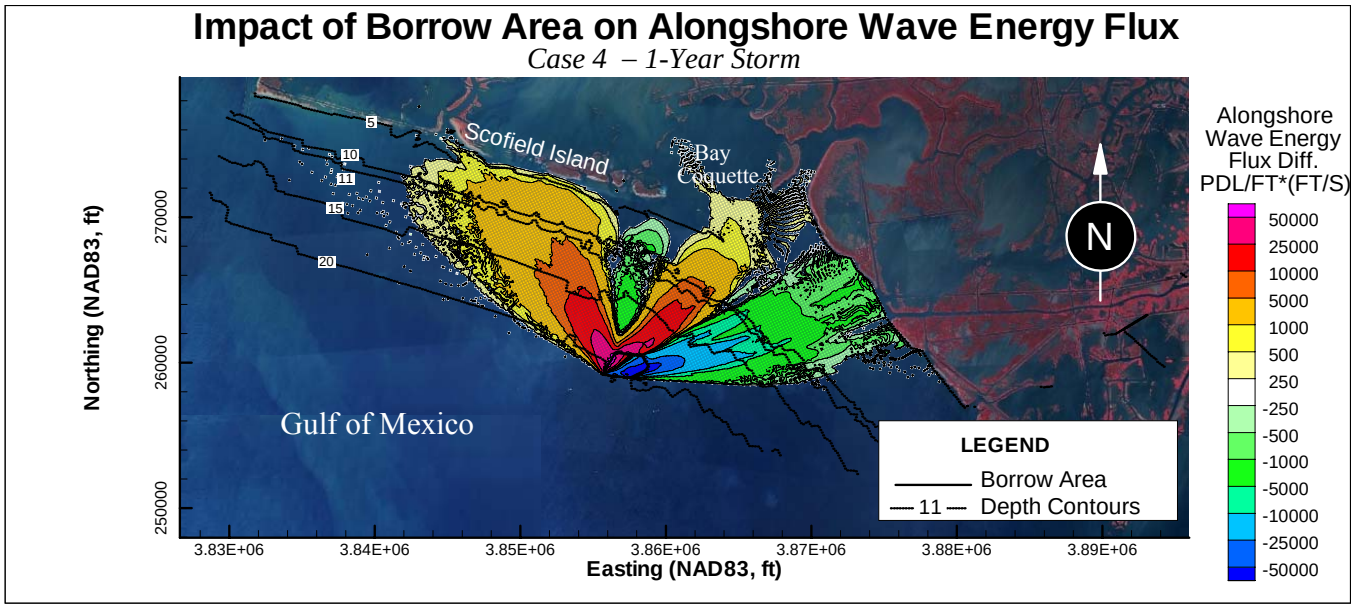

Figure 19: Alongshore Wave Energy Flux, Case 4

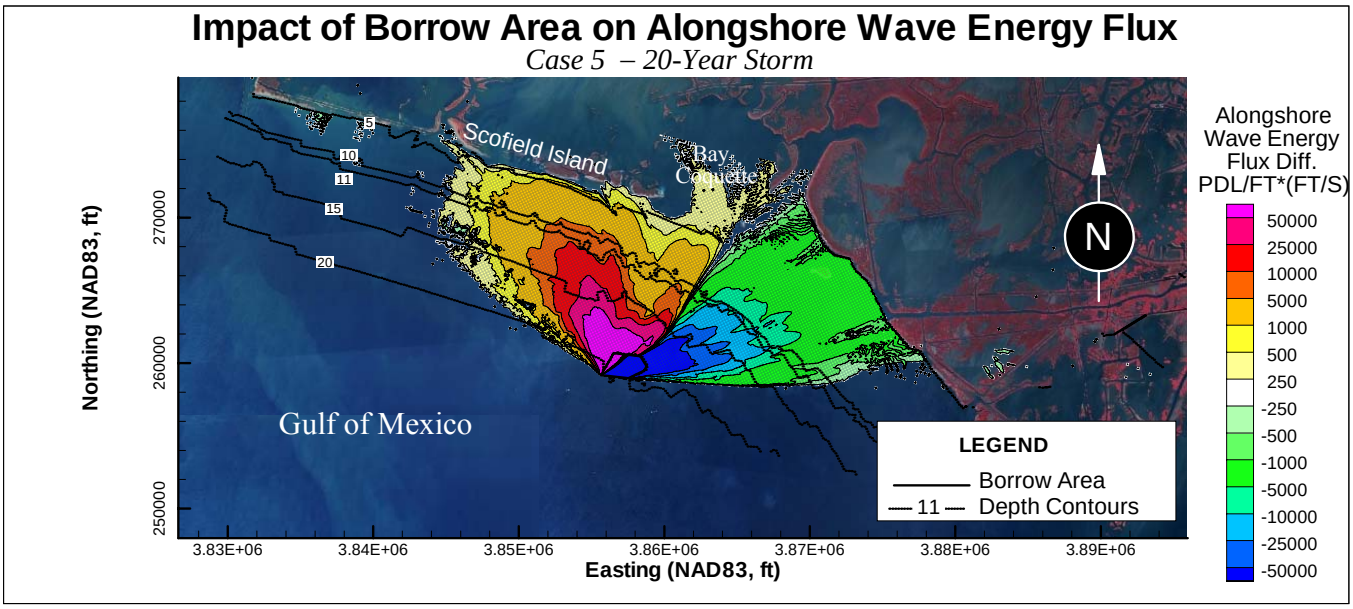

Figure 20: Alongshore Wave Energy Flux, Case 5

8.0 CONCLUSIONS

The goal of obtaining sediments for marsh restoration purposes is to provide stable sediment that imitates the natural soil. In addition to optimal elevation of the marsh surface for rapid vegetation colonization, the marsh supports a diverse range of aquatic organisms that live in and breed or feed in/on marsh sediment. It is important to have initial soil stability to support plant installation and growth, along with soil compatible with the organisms. The SOBA analysis computed the available sediment has a mean grain size of 0.097 mm; is composed of mixed fine sand, silts, and clays; and recommended for use to provide suitable stable material to construct the marsh fill at Scofield Island.

9.0 REFERENCES

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