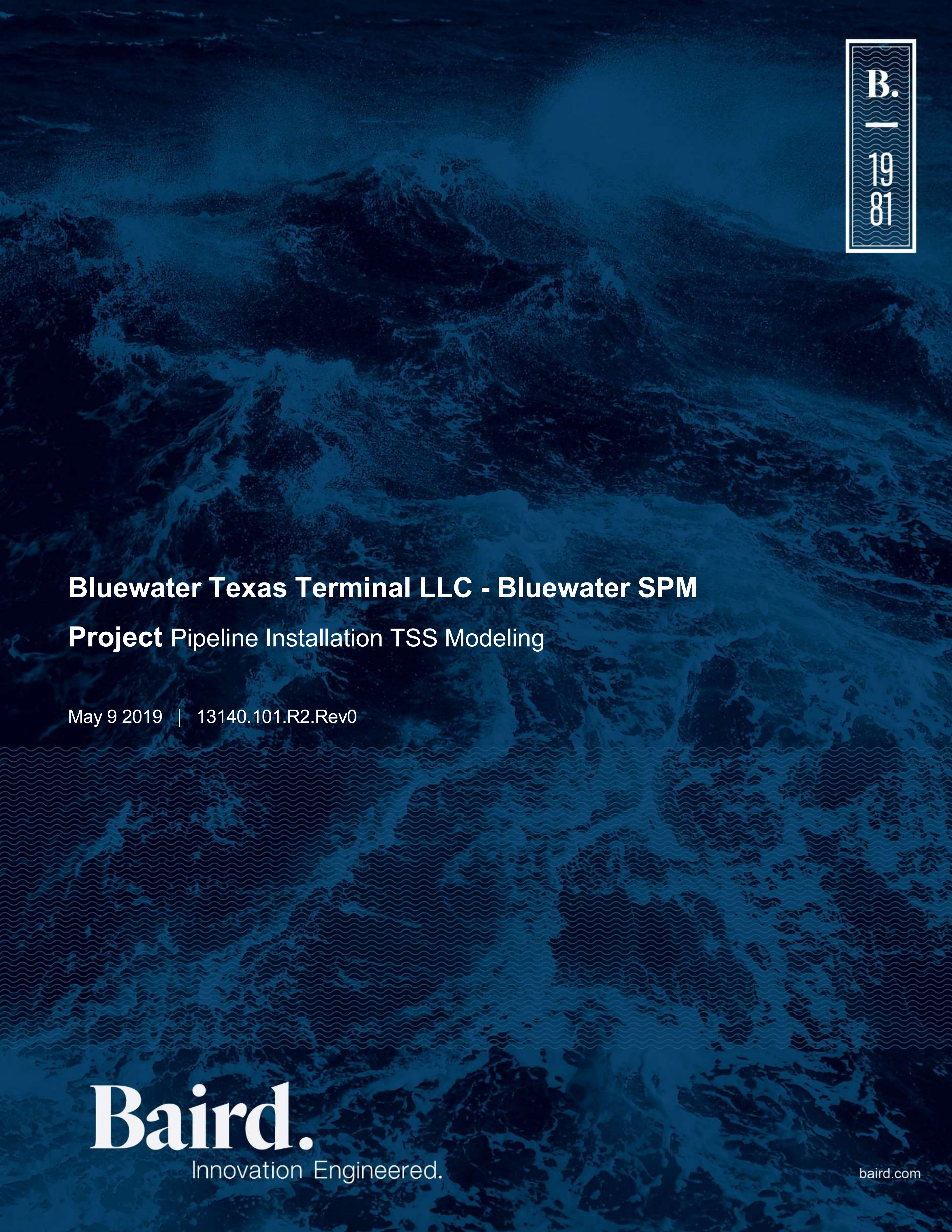
APPENDIX D

TEMPORARY SUSPENDED SOLIDS MODELING ANALYSIS



Bluewater Texas Terminal LLC - Bluewater SPM Project Pipeline Installation TSS Modeling

May 9 2019 | 13140.101.R2.Rev0

Baird.

Innovation Engineered.

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A	May 6, 2019	Draft	For review	MD	LAW	
0	May 9, 2019	Final	Lloyd comments incorporated	MD	LAW	LAW

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1. Introduction

Lloyd Engineering, Inc. (LEI), as part of permitting services for Bluewater SPM project, requires modeling to be performed to assess the impacts of suspended sediments (quantified as total suspended sediments, TSS) resulting from jet sled laying of a pipeline to the Bluewater SPM project, located in the Gulf of Mexico just offshore of Corpus Christi, Texas. The project will require the installation of approximately 26 miles (~42 km) of pipeline from the terminus of horizontal directional drilling (HDD) in 23 ft (~7 m) depth approximately 3,300 ft (~1 km) offshore to the offshore terminal location (Figure 1.1).

The proposed infrastructure consists of two 30-inch-diameter concrete coated pipelines extending from the shore approach HDD exit to SPM Buoy System 1 and continuing to SPM Buoy System 2. The pipeline installation will be conducted from a pipe lay barge using a jet sled. The objective it to quantify the extent of the dispersion plume created as well as anticipated thickness of potential sedimentation deposits around the construction area resulting from the jet sled trenching.

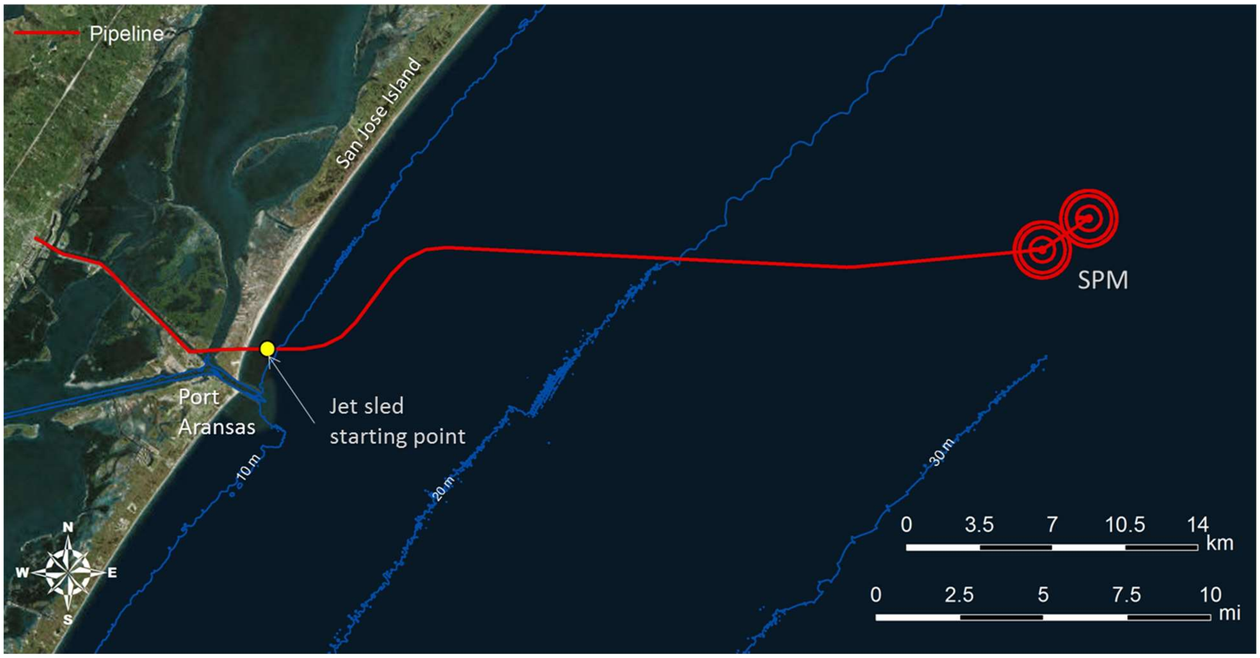

Figure 1.1: Project location relative to Aransas Pass

2. Project Description

2.1 Construction Methodology

The following construction methodology has been provided by LEI. Pipeline installation begins with the positioning of the pipelay barge at the eastern end of the shore approach HDD. The pipelay barge will then set four anchors along the pipeline ROW, two of which anchors will be from the stern (port stern and starboard stern) and two from the bow (port bow and starboard bow). The anchors set from the bow will be set and tensioned approximately 5,000 feet in front of the pipelay barge. When the anchors are set, a material transport barge loaded with line pipe will be towed from the nearby port and brought alongside the pipelay barge. The material transport barge will be secured with ropes to either the port or starboard side of the pipelay barge. Once positioning is confirmed, the pipelay barge will use the A&R winch to retrieve the tail sections of the HDD from the sea floor and will then guide the pipeline through the pipe alley and onboard the vessel. The pipelay barge bow will be facing eastward. A stinger will not be required for this portion of pipelaying due to the shallow water and proximity to shore. The laydown head that was installed on the HDD tail section will be removed, and the pipelay barge will commence to assemble the pipeline.

During the assembly of each new joint of pipe, the pipelay barge will move forward by tightening the bow anchor cables and slacking the stern anchor cables. Given that the pipe is connected to the end of the HDD, the pipe will begin to leave the stern of the pipelay barge and settle on the ocean floor. This process will repeat over and over until the total length of pipeline has been installed on the seafloor. When the last joint of pipe has been welded and inspected, it will be lowered to the seafloor using the A&R winch on the pipelay barge. This process will be performed once for each of the proposed offshore pipelines.

Upon completion of the assembly of the offshore pipelines, the pipelay vessel will return to the starting point (shore approach HDD) and will attach a jet sled (or similar pipe burial sled) to an A-Frame located at the stern of the vessel. The vessel will position the sled over one of the pipelines on the seafloor and begin the process of moving along the pipeline. The jet sled will utilize high pressure water jets to remove and discharge the earthen materials underneath the pipeline until the desired depth is reached. The hardness (or softness) of the soils will determine and influence the rate of travel along the route. This process will be repeated for the second pipeline. The pipelines will be covered by earthen subsea materials by natural currents and movements at the sea floor in addition to the jetted materials settling on top of the pipeline until a minimum depth of 3-feet below the seabed is reached. An approximate 56-ft workspace corridor is proposed for the installation of the offshore pipelines.

2.2 Displaced sediment volume

Trenching for each of the two pipelines will be completed in three passes. Trenching speed would be approximately 200 m/hr (~0.18 ft/s). It is expected that each pass would take approximately 210 hours to complete. One a pass is completed, approximately 24 hours is required to get ready for the subsequent pass. As such, trenching of one pipeline is expected to be completed in approximately 630 hours or 26.25 days. Two pipelines will thus require approximately 1,260 hours or 52.5 days. In summary, installation is likely to take approximately two months and is expected to occur between February and May 2020.

Figure 2.1 shows trench cross-sections for single and dual pipes. For the purpose of TSS modeling a trench cross-section (i.e., disturbance) area equal to twice of that for a single pipe was used to be on the conservative side. The volume of displaced bed material was thus estimated to be approximately 0.21 m^3/s (~7.4 cfs) per path based on a trenching speed of 200 m/hr. The dry density of seabed material was assumed to be 1,560 kg/m^3 (97 lb/ft^3).

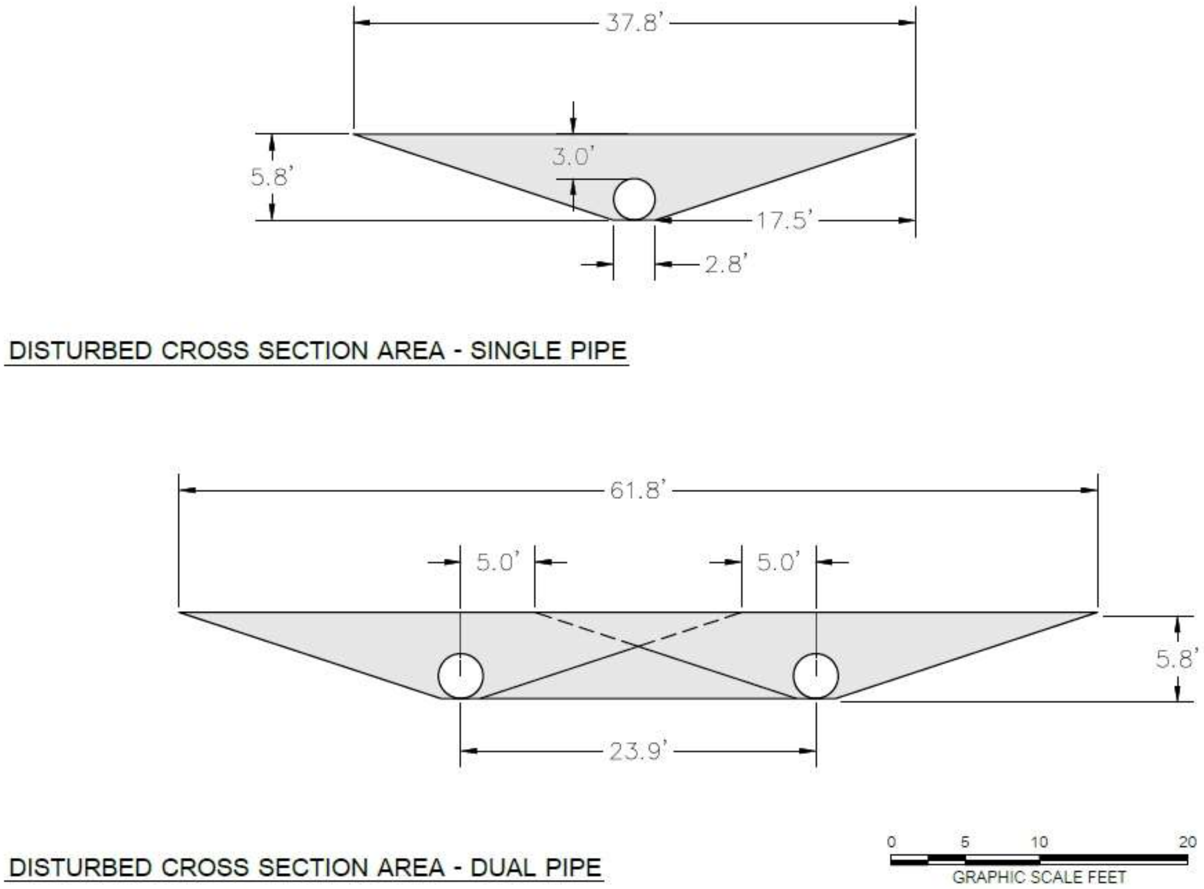

Figure 2.1: Disturbed cross-section for single (top) and dual (bottom) pipes

2.3 Grain Size Distribution of Displaced Sediment

Excavated sediment was released into the water column at 21 source points along the 42 km pipeline following the construction schedule discussed in previous section. Each source point thus represented approximately 2 km of pipeline. It was assumed that all material from the excavated trench is suspended into the water column (i.e., a conservative assumption). Sediment fractions of bed material were determined based on sediment sampling data provided by LEI as shown in Figure 2.2. Table 2.1 provides a summary of sediment fractions and corresponding release rates (i.e., discharges) at each source point.

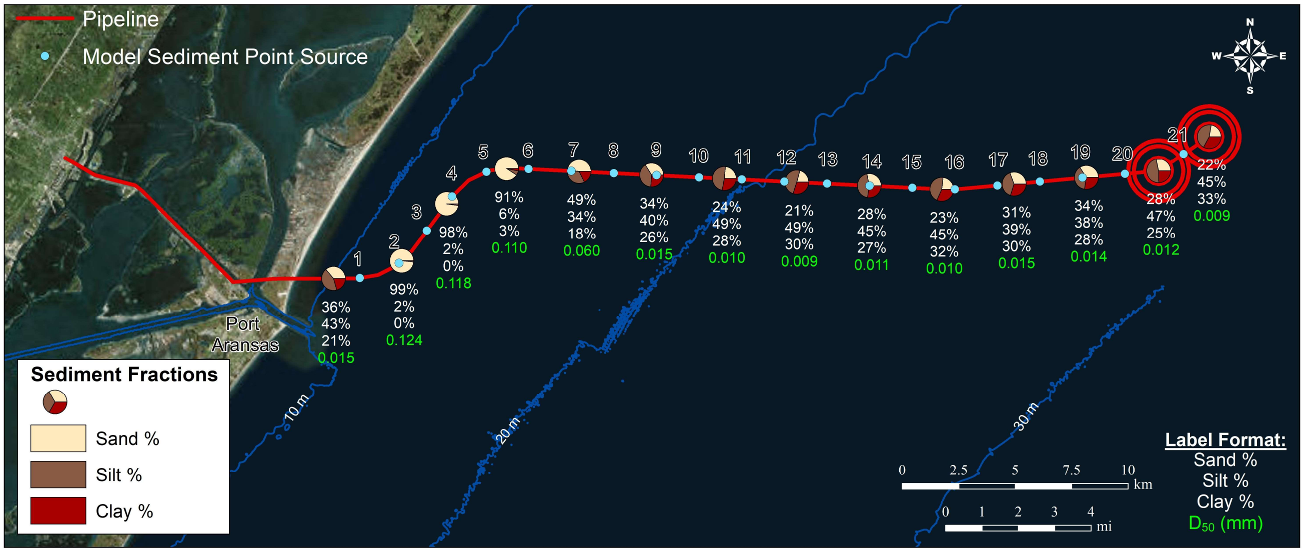

Figure 2.2: Sediment sampling results and model sediment source points

Table 2.1: Sediment fractions and discharges at each source point

	Sediment Fraction			Discharge (kg/s)		
Source #	Silt	Sand	Clay	Silt	Sand	Clay
1	27%	60%	13%	86	190	40
2	3%	96%	1%	10	303	3
3	2%	98%	0%	6	310	0
4	3%	97%	0%	8	307	1
5	5%	93%	2%	15	294	7
6	14%	78%	8%	45	247	24
7	31%	53%	16%	97	168	51
8	37%	42%	22%	116	131	69
9	41%	33%	26%	128	105	83
10	46%	27%	27%	144	86	86
11	49%	23%	28%	154	72	90
12	49%	21%	30%	155	67	94
13	47%	24%	29%	149	75	91
14	45%	28%	27%	141	89	86
15	45%	25%	30%	141	80	95
16	44%	25%	32%	139	78	100
17	41%	29%	30%	129	92	96
18	39%	32%	29%	123	101	92
19	38%	34%	28%	121	108	87
20	43%	31%	26%	135	98	83
21	46%	28%	26%	146	87	82

3. Numerical Modeling of TSS

The three-dimensional MIKE3 model and the Mud Transport (MT) model both developed by Danish Hydraulic Institute (DHI) were deemed appropriate for the present modeling exercise for simulation of hydrodynamics and dispersion and deposition of the excavated material/sediment, respectively.

3.1 Model Domain and Bathymetry

This model domain should be large enough to capture important regional oceanographic processes while remaining computationally effective and feasible within study scope and schedule. A set of preliminary particle tracking runs were completed to define the required model extents. Figure 3.1 shows the final model domain which extents approximately 50 km (~31 miles) on either side of the pipeline.

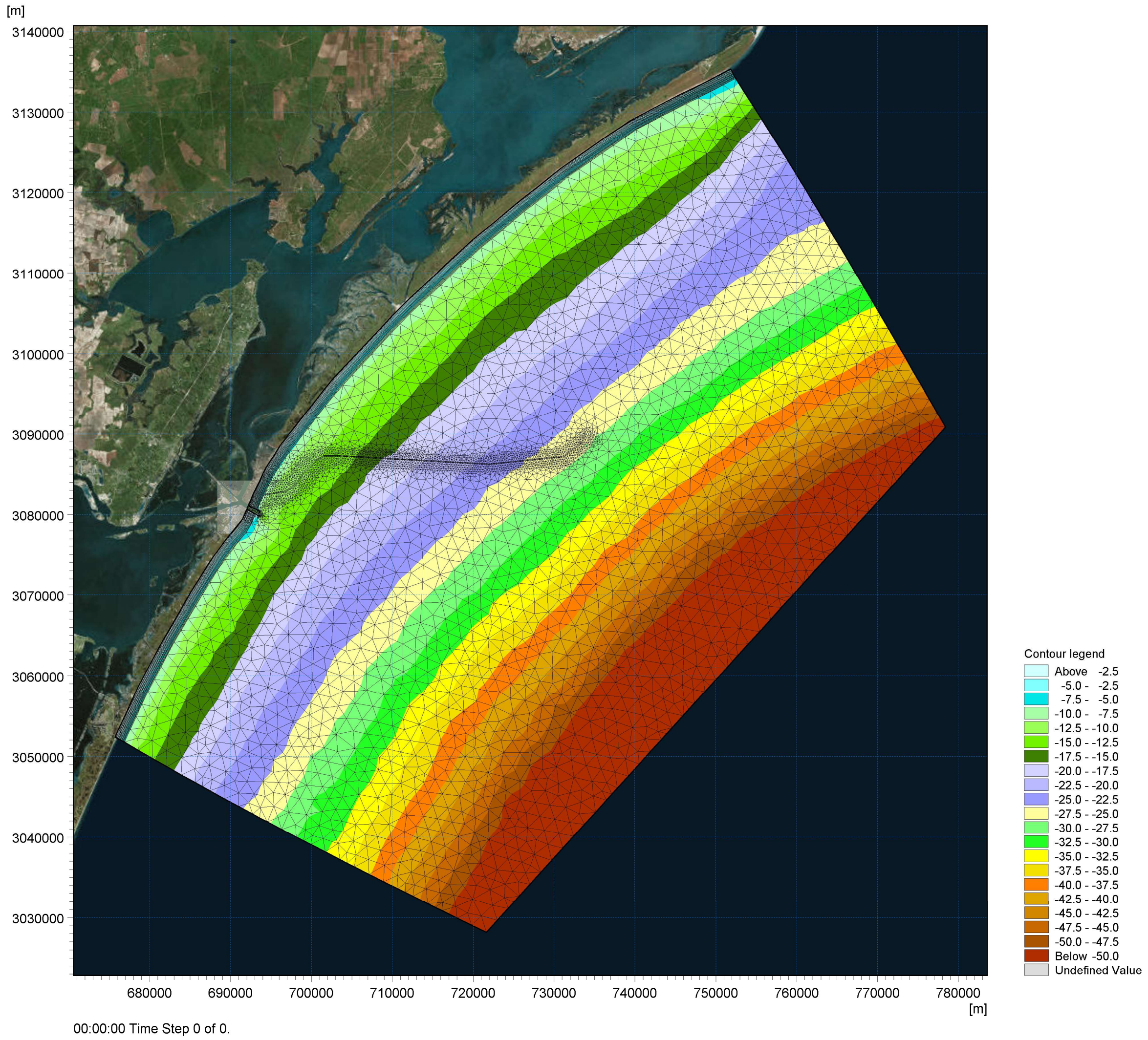

Figure 3.1: Model domain, grid, and bathymetry

The MIKE3 model uses a flexible mesh that allows for sufficient grid resolution to describe the local shoreline as well as the pipeline to properly simulate the currents and other coastal processes around the project site. Model grid details in the vicinity of the pipeline are shown in Figure 3.2. Model bathymetry was obtained from LEI's pipeline route survey provided to Baird, NOAA's Corpus Christi, Texas 1/3 arc second grid, and NOAA's Western Gulf Coastal Relief model.

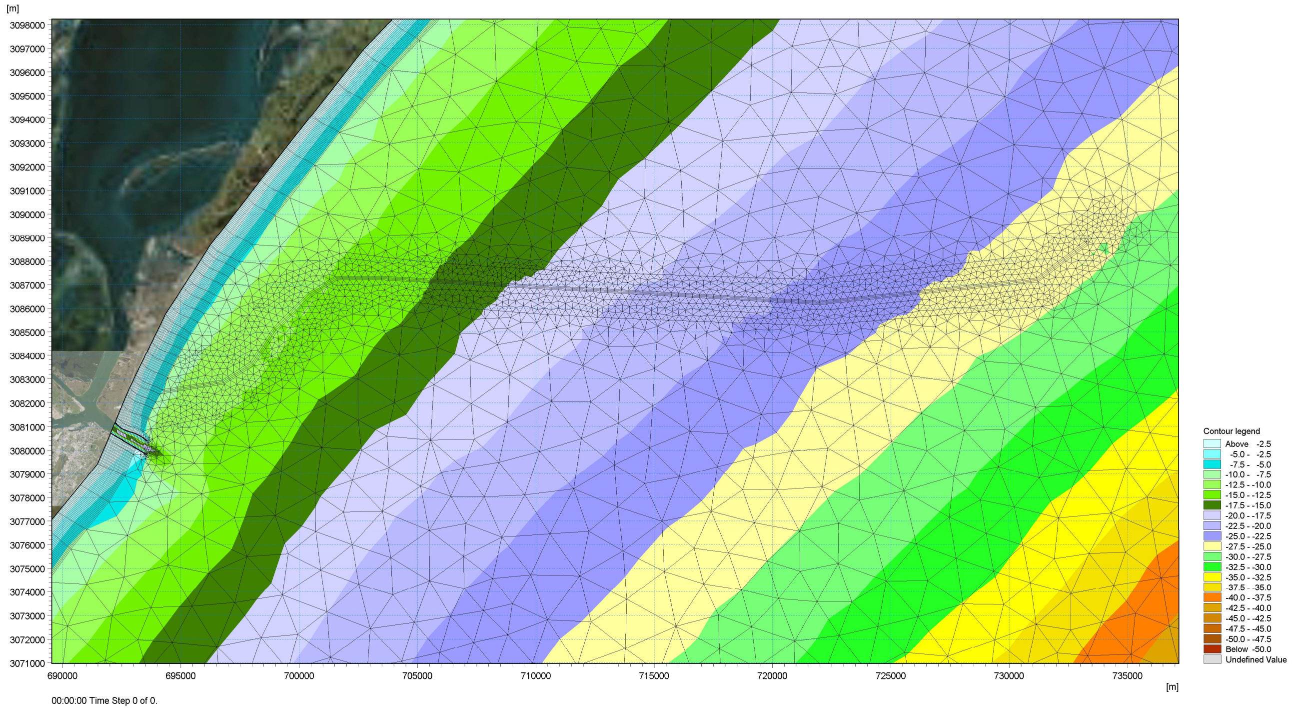

Figure 3.2: Model grid and bathymetry details in the vicinity of the pipeline

3.2 Boundary Conditions

The main hydrodynamic forces impacting sediment transport at the study site are as follows:

- Oceanic circulation in the Gulf of Mexico (including tides);
- Wind-driven currents;
- Wave-driven bottom shear stresses and nearshore currents.

The HYCOM model data was used to characterize oceanographic currents along the boundaries of the local MIKE3 hydrodynamic model. The HYCOM model provides hourly water level and current data at a spatial resolution of 0.04 degree (~2.2 miles) across the Gulf of Mexico and is publicly available. The model was also forced by overwater winds as well as wave radiation stresses. Waves and winds at the location of proposed SPM were predicted by Oceanweather for the 1980-2017 period and provided to Baird by LEI. Wave radiation stresses were calculated using the MIKE21 SW spectral wave model by DHI.

3.3 Model Parameters

Default model parameters as recommended by DHI were used in the calculations. Typical values were assumed for fall velocity of sand, silt, and clay, i.e., 14, 0.45, and 0.014 mm/s, respectively.

3.4 Modeling Scenarios

A review of Oceanweather 1980-2017 wave hindcast indicated that wind and wave energies were lowest in 2015 since 1980 as shown in Figure 3.3. Less sediment dispersion and more sediment deposition are expected during low energy years. Therefore, hydrodynamics in 2015 were used as driving force for the simulations as it would provide worst case scenario results from an environmental assessment perspective.

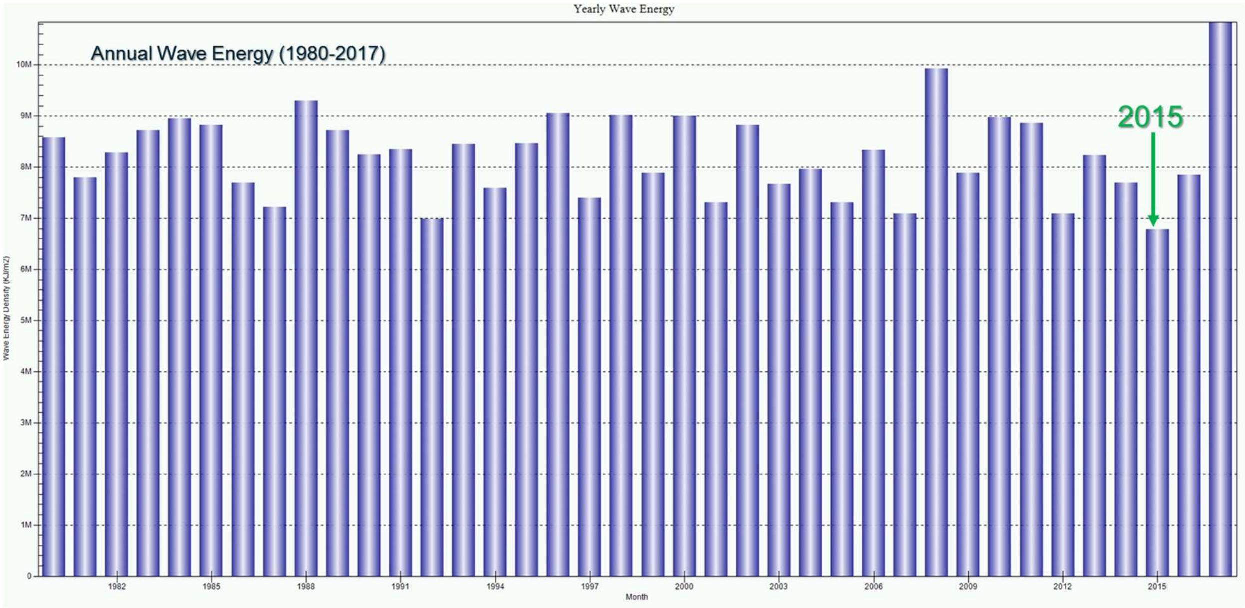

Figure 3.3: Distribution of annual wave energy between 1980 and 2017

Two construction periods were considered to incorporate potential delays in construction schedule:

1. February and March, 2015, and
2. March and April, 2015.

A 10-day warm-up period as well as a one-month settling allowance period were added to the beginning and end of each simulation period, respectively, resulting in approximately 100 days total simulation period.

4. Model Results

The model outputs included water level, currents, suspended sediment concentration (SSC), and accumulated sediment. The outputs were three-dimensional at an hourly output frequency. The model results are presented through the following types of plots:

- map of maximum sedimentation thickness experienced during the entire simulation period
- maps of maximum hourly SSC experienced during the entire simulation period
- animations of mud plumes (not included in this report).

In all maps, the impact zone is highlighted using distinct colors. The impact of sedimentation is defined as the area where sediment deposition exceeds 0.04 in (~1 mm). The impact zone of maximum SSC is defined as the area where the SSC exceeds 50 mg/L.

4.1 Suspended Sediment Concentrations

Distributions of predicted maximum SSC levels experienced over the Feb-March simulation period near the seabed (or near bottom) and near the water surface are presented in Figure 4.1. Distribution of maximum SSC around the pipeline is shown in Figure 4.2 in more detail. The modeling of dispersion showed that the maximum suspended sediment concentration throughout the 100 day simulation impacted a distance of approximately ±8,000 ft (~±2,500 m) from the pipeline. The model predicted similar results for the Mar-Apr construction period. Those results are provided in Appendix A.

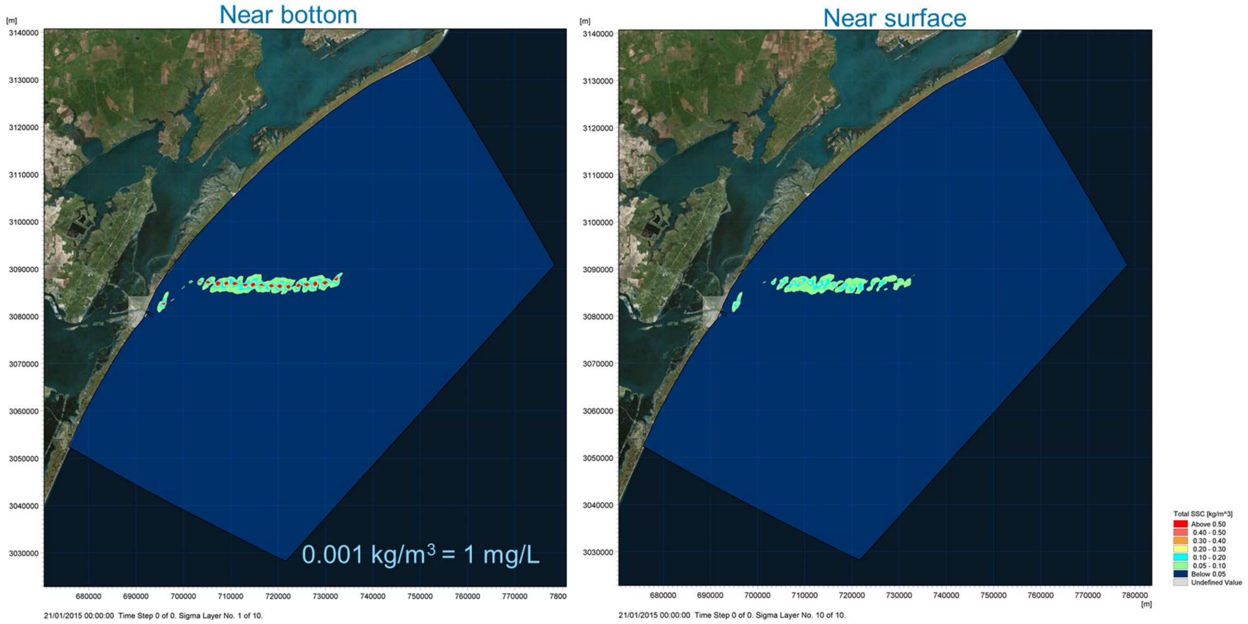

Figure 4.1: Distribution of maximum SSC levels experienced over the Feb-March simulation period

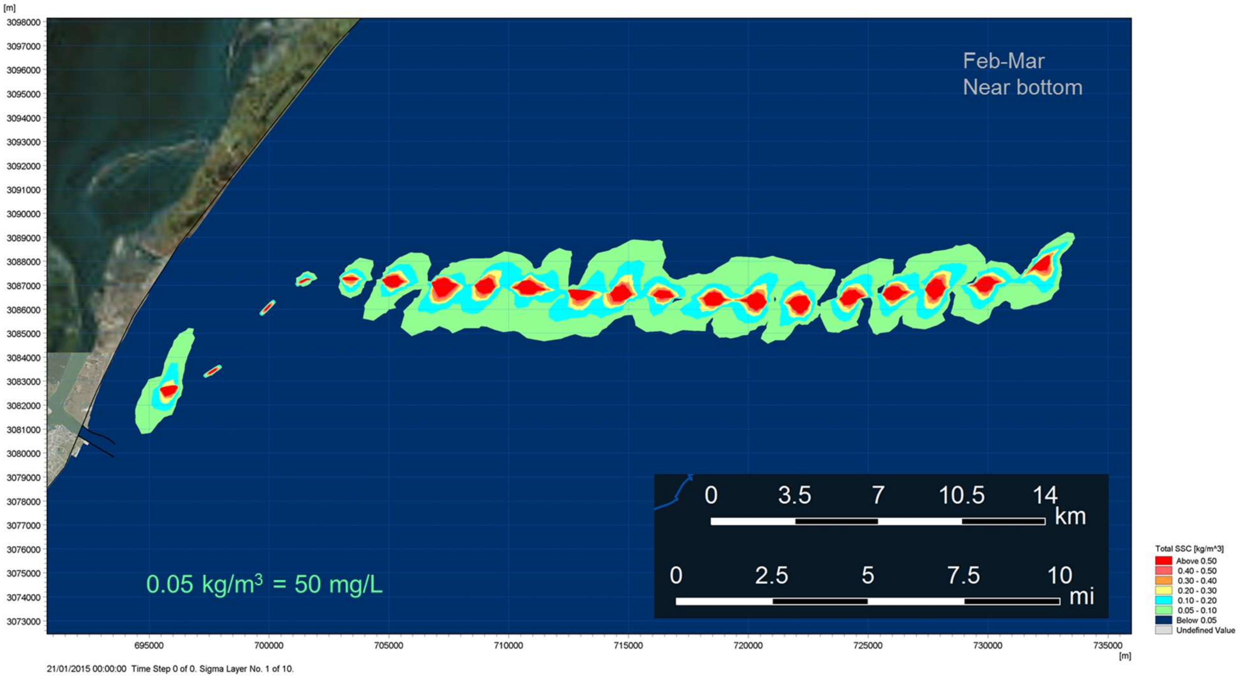

Figure 4.2: Distribution of maximum SSC levels experienced over the Feb-Mar simulation period

4.2 Sediment Deposition Thickness

Predicted maximum sediment deposition thickness experienced during the Feb-Mar period is mapped and shown in Figure 4.3. Sediment deposition exceeding 0.04 inches was estimated to occur within a distance of ±250 ft (~75 m) feet from the pipeline. The model predicted similar results for the Mar-Apr construction period. Those results are provided in Appendix A.

Note that the model does not support simulation of a mobile source of sediment. Trenching was thus simulated using 21 sediment sources at approximately 2 km intervals along the pipeline resulting in a discontinuous deposition pattern. In reality, predicted deposition in the vicinity of the pipeline will be distributed over 6 to 7 neighboring cells along the pipeline (Figure 4.4). In other words, actual deposition will be continuous, and the corresponding deposition thickness would be less than 1/6 of the predicted figures.

Also, the model scale does not allow for simulation of backfilling of the excavated trench. It is expected that predicted deposition thickness around the pipeline would eventually be worked out by ongoing hydrodynamic forces to cover the pipeline and backfill the trench.

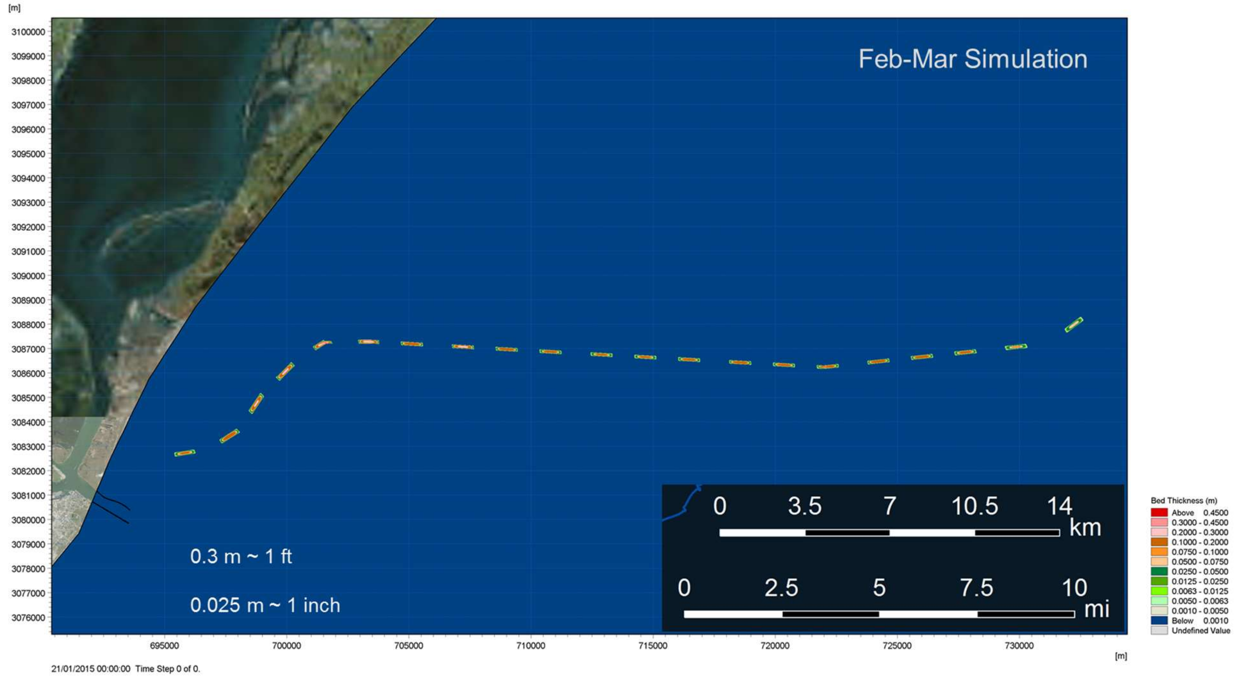

Figure 4.3: Maximum sediment deposition thickness experienced over the Feb-Mar simulation period

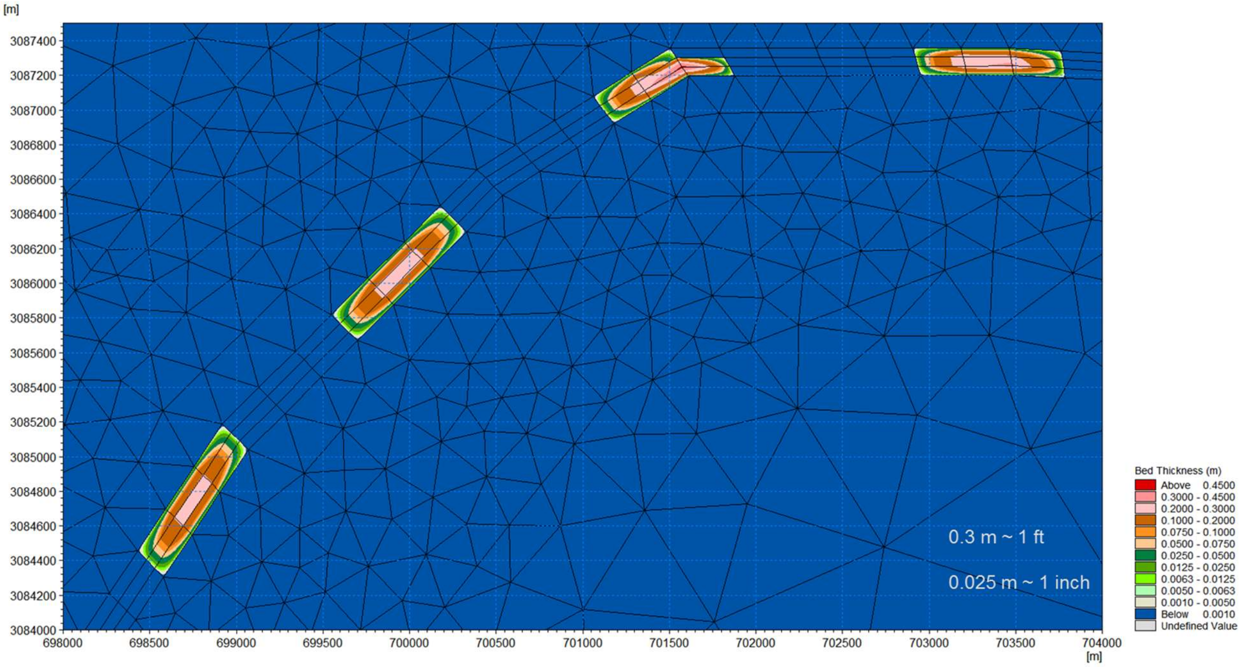

Figure 4.4: Discontinuity of the predicted deposition thickness relative to the model grid

5. References

DOC/NOAA/NESDIS/NGDC National Geophysical Data Center, NESDIS, NOAA, U.S. Department of Commerce

National Geophysical Data Center, 2001. U.S. Coastal Relief Model - Western Gulf of Mexico. National Geophysical Data Center, NOAA. doi:10.7289/V5QJ7F79

Appendix A

Model Prediction Results for the Mar-Apr Period

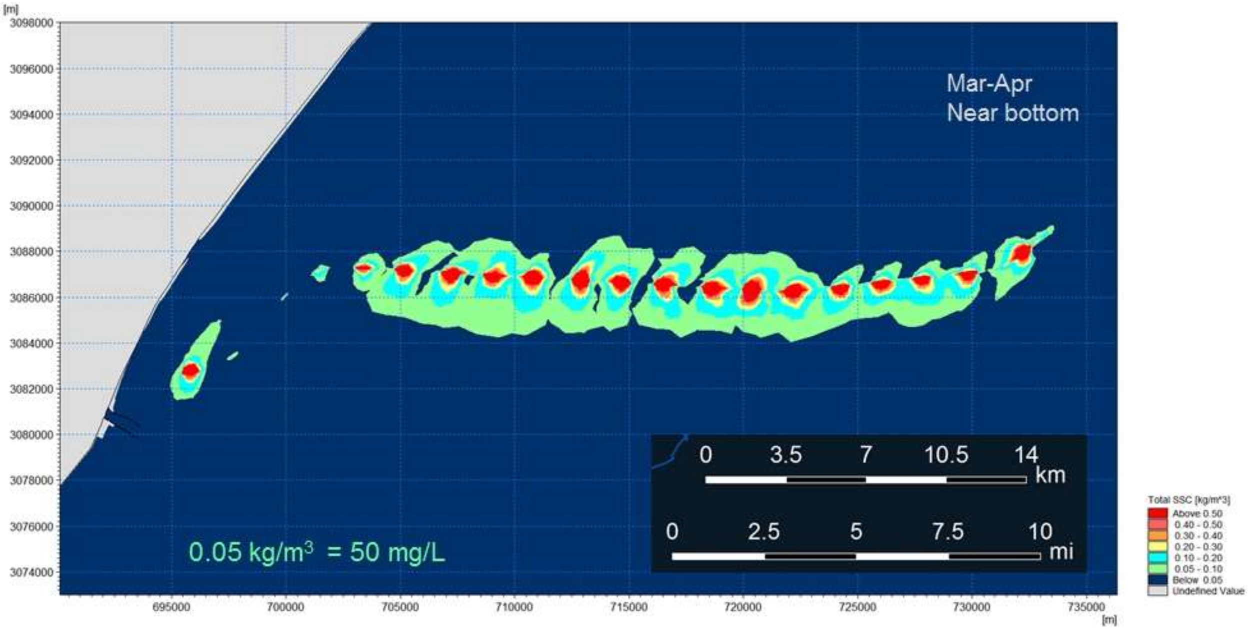

Figure A.1: Distribution of maximum SSC levels experienced over the Mar-Apr simulation period

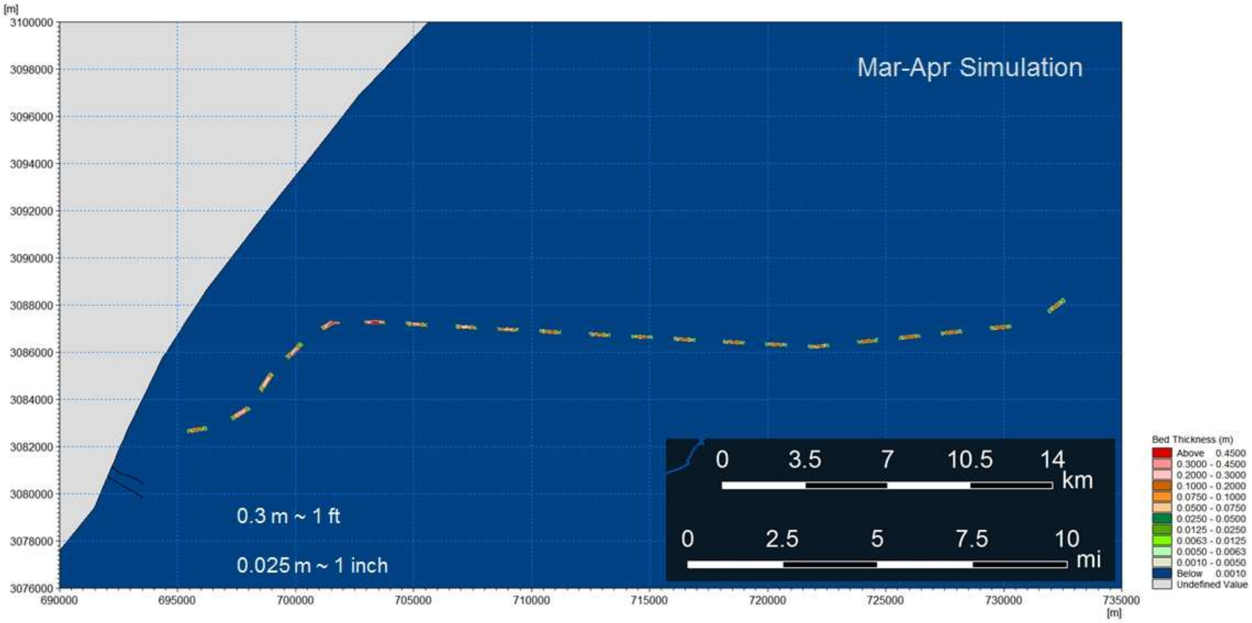

Figure A.2: Maximum sediment deposition thickness experienced over the Mar-Apr simulation period