Mississippi River Valley Division,
Regional Planning and Environment Division South

Port of New Orleans Access Channel Deepening Feasibility Study

Appendix A: Engineering

March 2020

CONTENTS

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Section 1
General

This draft Engineering Appendix presents and documents the feasibility level engineering and design for the Port of New Orleans Access Channel Deepening Feasibility Study (PONO), Tentatively Selected Plan (TSP). The non-Federal sponsor (NFS) is the Port of New Orleans (PORT). Development of the Engineering Appendix was in accordance with Engineering Regulation (ER) 1110-2-1150, "Engineering and Design for Civil Works Projects," dated 31 August 1999. The comparative studies of alternatives, field investigations, designs, and costs estimates presented herein are in sufficient detail to substantiate the recommended plan and baseline estimate.

All elevations are referenced to North American Vertical Datum of 1988 (NAVD 88 (Epoch 2009.55)), unless otherwise noted.

Section 2
Hydraulics and Hydrology

2.1 PURPOSE OF STUDY

A model study was conducted to inform the study team on the possible shoaling increase as a result of deepening the maintenance depth at the PORT. The Delft3D model analysis included the construction of a two-dimensional (2D) model extending from the Inner Harbor Navigation Canal (IHNC) Lock to Baton Rouge, LA. The purpose of this 2D model was to ascertain the river discharge and sediment loads at Fairview Crossing River Mile (RM) 116 Above Head of Passes (AHP). This information was required to develop upstream boundary conditions for the 3D model. The 3D model extends from the IHNC Lock to Fairview Crossing and was used to develop shoaling estimates.

2.2 METHOLOGY

A depth-averaged sediment model from the IHNC Lock to Baton Rouge with a fixed bed was used to develop a time series of discharge and sediment load at the Fairview Crossing. The observed stage data at the IHNC lock was used as the 2D model tailwater condition, and the U.S. Geological Survey (USGS) measured discharge data at Baton Rouge, LA, defined the upstream inflow boundary. Additionally, the discharge was withdrawn from the model at the Bonnet Carre Spillway and Davis Pond as it occurred. The 2D model simulation was executed from 1 October 2017 through 8 July 2018.

The USGS measured suspended sediment at Baton Rouge was analyzed to build concentration-time series for the 2D model for five sand classes. A linear relationship was

developed between the measured suspended sand concentration and the Mississippi River discharge at Baton Rouge. This relationship is shown graphically in Figure A:2-1.

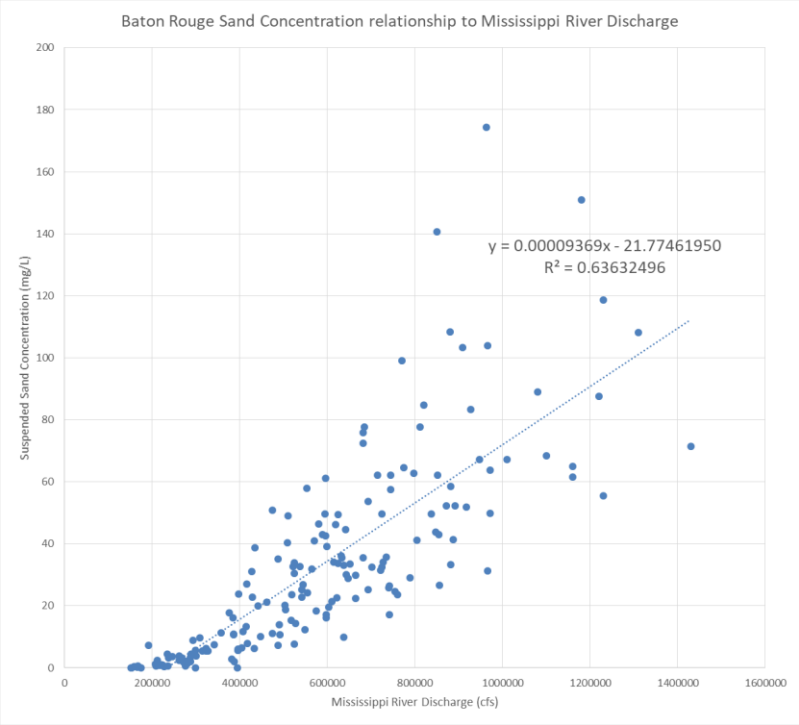

Figure A:2-1. Baton Rouge Sand Concentration

This linear relationship was then used to develop an hourly suspended sand concentration time series at Baton Rouge. This total sand concentration was further subdivided among five sand grain classes using the distribution shown in Table A:2-1. This distribution was designed to replenish the bed at the upstream end of the model in a similar ratio to that used in the 3D model bed, which is predominantly composed of fine sand. This distribution was also used as the initial bed configuration in the 2D model.

Table A:2-1. Baton Rouge Grain Class Distribution

Grain class	Size range (mm)	Percent of total concentration
Very Fine Sand	0.062 - 0.125	5
Fine Sand	0.125 - 0.25	81
Medium Sand	0.25 – 0.5	11
Coarse Sand	0.5 – 1	2
Very Coarse Sand	1 – 2	1

The resulting sand concentration time series are shown in Figure A:2-2. The silt concentration was held steady at 0.035 kg/m^3 at Baton Rouge, LA.

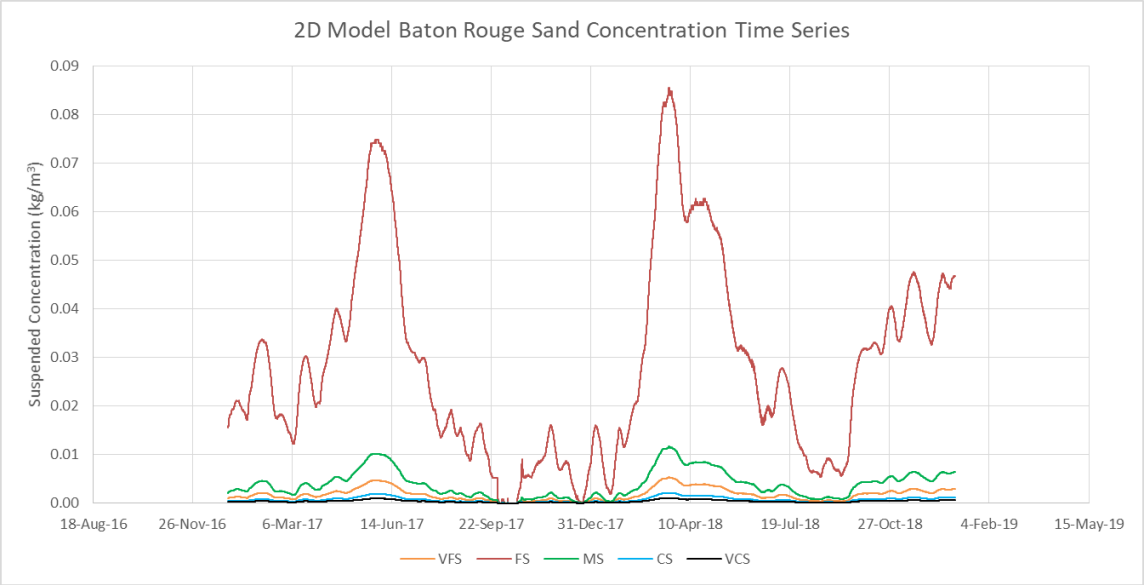

Figure A:2-2. Baton Rouge Sand Concentration Time Series

The bathymetry used for the 2D model was from a 2D Adaptive Hydraulics model developed by the U.S. Army Engineering Research and Development Center as used in the Mississippi River Ship Channel (MRSC) Gulf to Baton Rouge, LA Integrated General Reevaluation Study (December 2017).

The computed Mississippi River discharge and sediment concentration for each grain class are shown in Figures A:2-3 to A:2-5. This data was used at the upstream boundary of the 3D model.

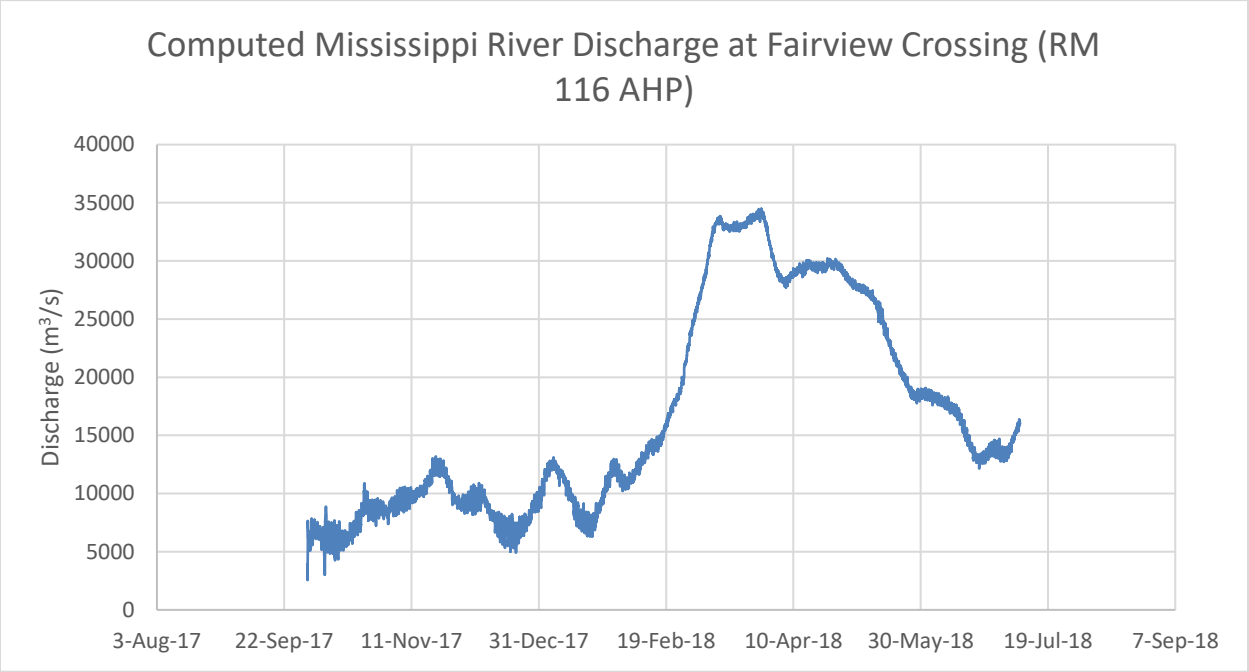

Figure A:1-3. Fairview Crossing Discharge

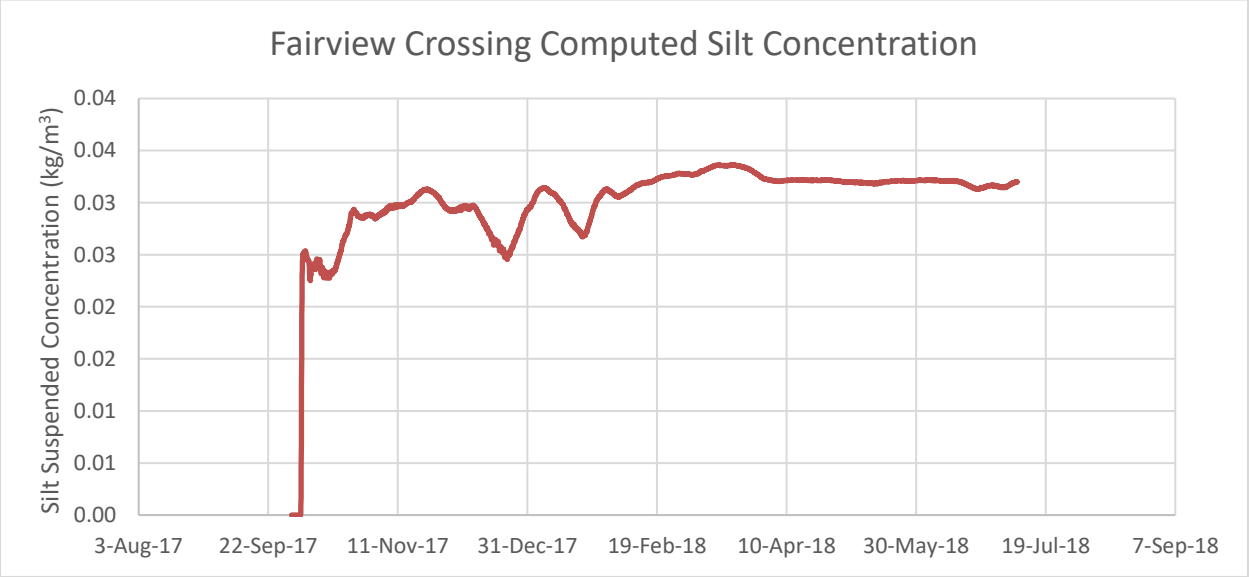

Figure A:2-4. Fairview Crossing Silt Concentration

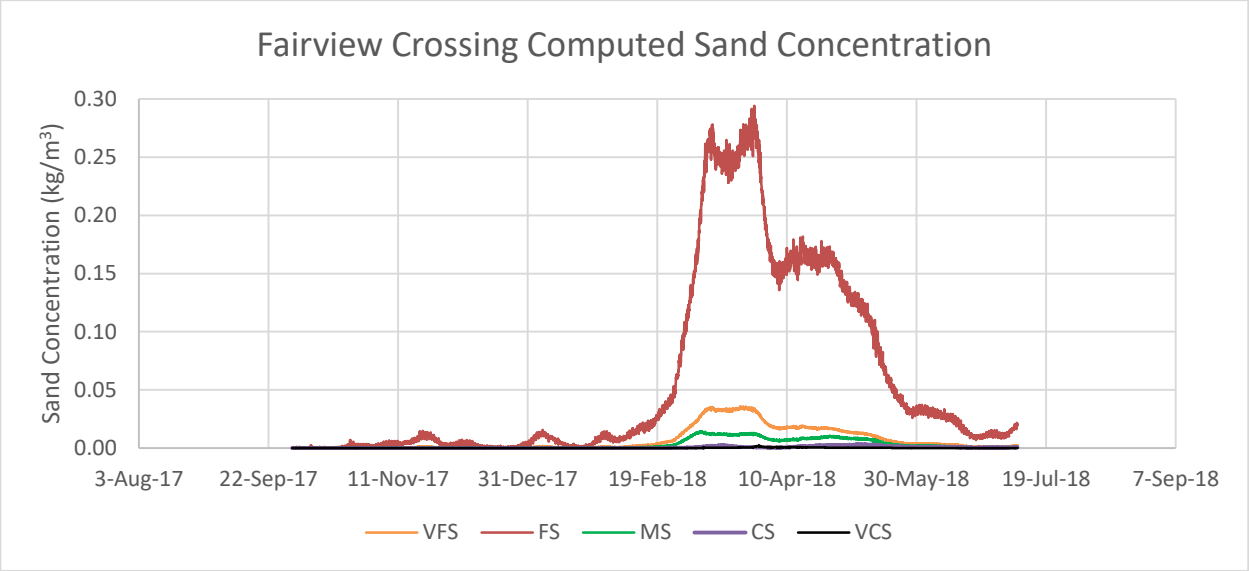

Figure A:2-5. Fairview Crossing Sand Concentration

The 3D model grid extends from the IHNC Lock at the downstream end to the Fairview Crossing at the upstream end. The model bathymetry was sourced from multi-beam sonar and Light Detection and Ranging (LiDAR) data and is as shown in Figure A:2-6. The multi-beam sonar data was collected in the period from September 2012 through September 2013. The LiDAR data was collected in March 2012 for the New Orleans Hurricane and Storm Damage Risk Reduction System project.

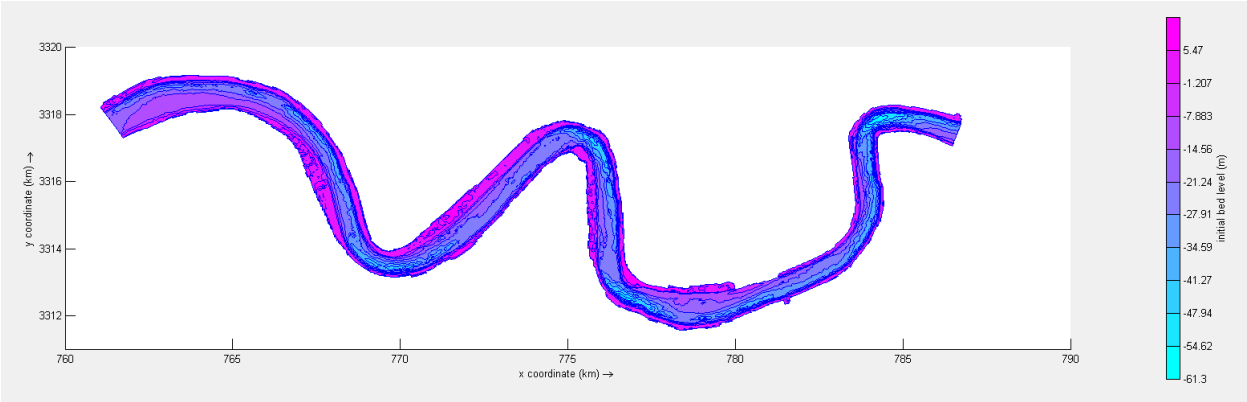

Figure A:2-6. 3D Model Bathymetry

A shapefile depicting the limits of the area of federal responsibility was provided to the U.S. Army Corps of Engineers (USACE), New Orleans District (MVN), Hydrology, Hydraulics, and Coastal Engineering Branch (HH&C) as shown in Figure A:2-7. This area was used to compare shoaling volumes between the numerical model and the shoaling accumulated volume, as measured from survey data.

Figure A:2-7. Area of Federal Dredging Responsibility

A difference analysis was performed between the 17 October 2017 post-dredge survey and the 5 July 2018 pre-dredge survey hydrographic survey data sets. The xyz survey data were mapped to the numerical model grid for consistent analyses when compared to numerical model differences. A difference volume of 250,583 m^3 between the two survey data sets was measured using ArcGIS.

The 17 October 2017 survey is the starting bathymetry in the area of interest for all base and alternative model runs. Three model runs were performed noted as the 35 ft, 45 ft, and 50 ft alternatives, referring to annual maintenance depths referenced to the Low Water Reference Plane (LWRP). For the 35 ft alternative, the 17 October 2017 survey was used as the starting condition, and the model bed was fixed for the first month of the simulation to initialize the bed gradation. For the 45 ft alternative, the bathymetry was lowered to 14.94 M (49 ft) in the federal area of interest to account for a 0.61 m (2 ft) advanced maintenance and 0.61 m (2 ft) over depth. For the 50 ft alternative, the bathymetry was lowered to 16.46 m (54 ft). These depths were converted to NAVD88 (2009.55) depths for consistency with the model datum. The model was then allowed to run for the duration of the period between the 2017 and 2018 dredge events.

The initial model results are presented in Table A:2-2.

Table A:2-2. Initial Model Results

Data set, zero initial bed depth	Depth used in model analysis	Depth used in model analysis	Difference	Difference	Increase	Percent increase over base (35-ft alternative)
	Feet below LWRP	Meters below LWRP	m^3	yd^3	yd^3	%
Survey data			250583	327750		
35 ft depth	39.00	11.89	124885	163343		
45 ft depth	49.00	14.94	142714	186663	23320	14.3
50 ft depth	54.00	16.46	230538	301532	138189	84.6

The volume of material in the initial run was about half of the observed volume; therefore, a boundary and parameter sensitivity analysis was performed to improve the model predictive ability. The fine sediment parameters were carried over from previous modeling efforts in the Mississippi River delta. The cohesive sediment characteristics vary with the makeup of the material, and the deposition environment and fine sediment are modeled using bulk material properties that can only be determined using direct measurement of in-situ material such as through flume testing. However, that testing was not available for this study; therefore, a trial and error process was utilized to improve model results.

A clay constituent was added to the model runs as a review of dredge bed grab samples showed a portion of the dredge material included clay. The fine sediment concentration at the boundary was changed to a steady concentration equivalent to the average measured at Baton Rouge. The clay and silt portions observed at Tarbert Landing were used to distribute the average fine sediment concentration. The clay concentration was set to 0.043 kg/m^3 or 35 percent of the total, and the silt concentration was set to 0.079 kg/m^3 or 65 percent of the total.

The parameters used to define the fine sediment transport formulation were adjusted and tested for sensitivity to the change in the shoaling volume. The parameter adjustments were also informed from previous flume tests conducted on the Atchafalaya River delta sediment. The model runs tested with associated parameters are summarized in Table A:2-3. A model run with the shear stress for erosion set to 1 Pa and the dry density set to 1200 kg/m^3, as highlighted in Table A:2-4, resulted in a shoaling volume close to the measured volume.

Table A:2-3. Fine Sediment Parameter Tests

	Critical shear stress for deposition, Pascals	Critical shear stress for erosion, Pascals	Erosion Parameter, $kg/m^2/s$	Dry bed bulk density, kg/m^3	Resultant shoaling volume, m^3
Initial run no clay	0.1	0.2	0.00001 (default)	500 (default)	124,885
w/Clay 3 (CL3)	1000 (default)	0.5 (default)	0.00012	500 (default)	199,135
w/Clay 4 (CL4)	1000 (default)	1.0	0.00012	1200	261,067
w/Clay 5 (CL5)	1000 (default)	2.0	0.00012	500 (default)	493,877
w/Clay 7 (CL7)	1000 (default)	2.0	0.00012	1000	393,324

The shoaling volume was analyzed for the 45 ft and 50 ft alternatives using the fine sediment parameters selected for simulation CL4. The 45 ft alternative resulted in accumulation of 265,381 m^3, and the 50 ft alternative resulted in accumulation of 316,540 m^3 during the same simulation period analyzed for the 35 ft base run. The results for the base and alternative simulations are summarized in Table A:2-4.

Table A:2-4. Summary of Model Results

Data set, zero initial bed depth	Depth used in model analysis	Depth used in model analysis	Cubic meter difference	Yd^3 difference	Increase Yd^3	Percent increase over base (35-ft alternative)
	ft	meters				
Survey data			250583	327750		
35 ft depth	39.00	11.89	261067	341463		
45 ft depth	49.00	14.94	265381	347105	5642	1.7
50 ft depth	54.00	16.46	316540	414019	72556	21.2

The accumulated material for each alternative, using these fine sediment parameters, are shown in Figure A:2-8 through A:2-10. In other words, these figures portray the difference in the final bed elevation and the starting bed elevation for each simulation.

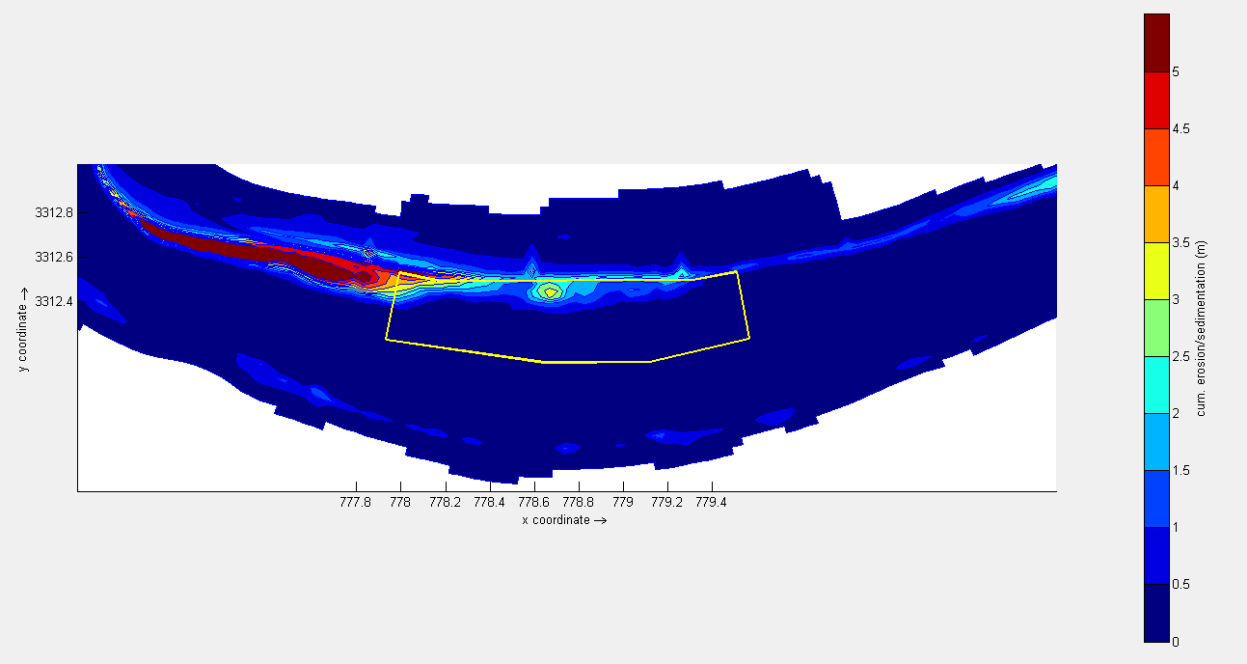

Figure A:2-8. 35 ft Alternative Accumulated Material

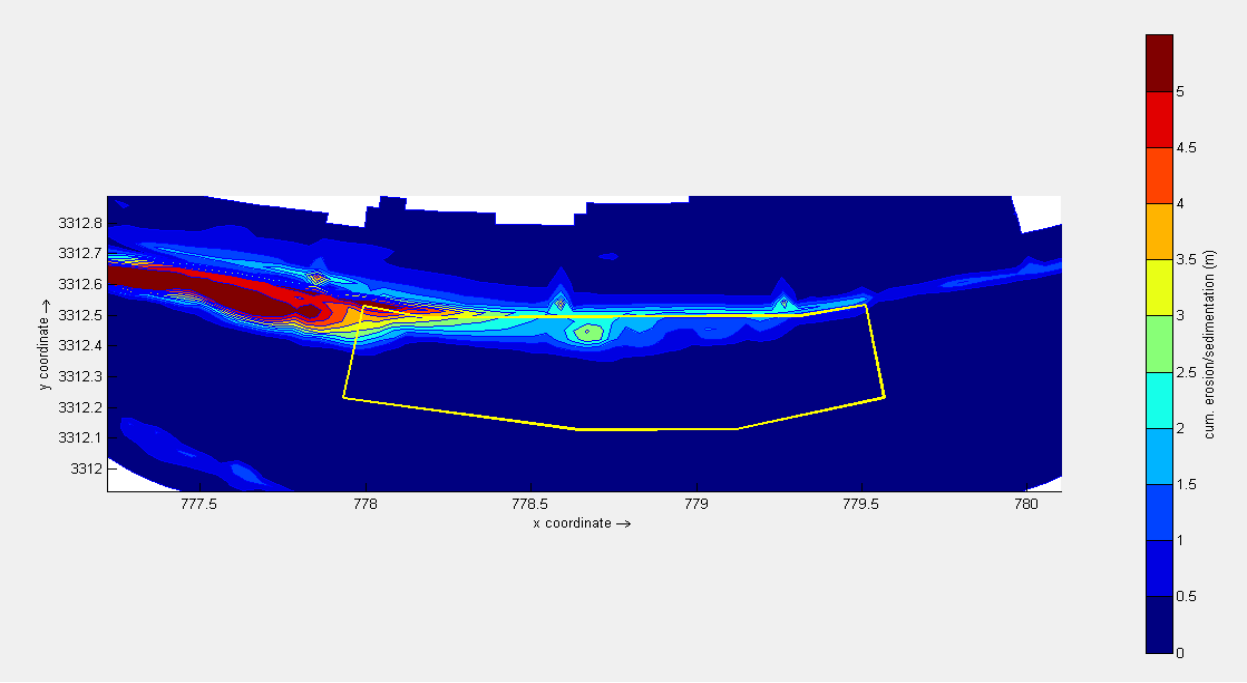

Figure A:2-9. 45 ft Alternative Accumulated Material

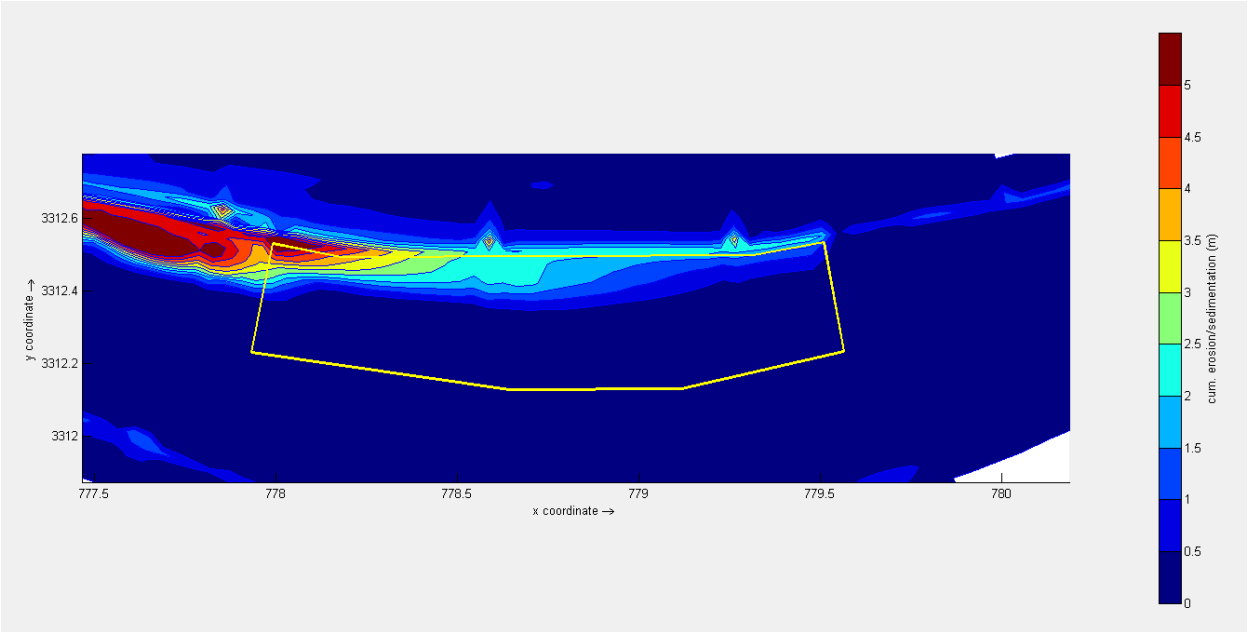

Figure A:2-10. 50 ft Alternative Accumulated Material

2.3 CONCLUSIONS

Adjustment of the fine sediment parameters gave the model the ability to closely approximate the observed shoaling volume within the area of interest polygon. Using these same parameters, additional analysis was performed on the two maintenance depth alternatives. The 45 ft alternative starting conditions were almost identical to the 35 ft base conditions due to current maintenance practices; these models computed a small increase in shoaling between the 45 ft and 35 ft simulations. The 50 ft alternative simulation predicted a 21.2 percent increase in shoaling volume over the base 35 ft simulation.

These results are considered the best estimate of expected additional maintenance, given the information available at the time of the study. Increased confidence in the model results could be obtained by analyzing additional time periods with the refined model sediment parameters. However, further refinement of sediment model parameters would most likely require in-situ material testing.

Section 3
Geotechnical Investigations and Design

This section includes the soils investigations and analyses for the channel deepening within the Mississippi River, PORT, between approximate RM 100.5 to RM 99.5.

3.1 GEOTECHNICAL DESIGN FOR CHANNEL DEEPENING

This portion of the report contains the initial feasibility level geotechnical design performed for the proposed channel deepening within the PORT site. This report covers the soils, geology, foundation investigation, and proposed dredging conditions.

3.1.1 Data Collection

No new borings were drilled for this project. Existing general type and undisturbed borings and dredged material grab samples are available throughout the entire project area.

3.1.2 Project Design Criteria

For this investigation, existing conditions (accretion under wharf), restoration to as-built conditions (existing riprap under the wharf), and proposed channel depth to elevation (-) 50 ft below the LWRP (plus 2 ft advanced maintenance, plus 2 ft over depth) (-) 54 ft were evaluated.

3.1.3 Field Investigation

3.1.3.1 Undisturbed Soil Borings

Several undisturbed soil borings exist throughout the project area. The soil borings were obtained by the USACE, Architect-Engineer (A/E) contract, and/or local sponsors. The boring locations may be found on Plate 1 in Annex 1. The boring plots are shown on Plates 2-4 in Annex 1.

3.1.3.2 General Type Soil Borings

Several general type borings exist throughout the project area. The soil borings were obtained by the USACE, A/E contract, and/or local sponsors. The boring locations may be found on Plate 1. The boring plots are shown on Plate 5 in Annex 1.

3.1.3.3 Dredged Material Samples

The dredged material grab sample data is available for portions of the project area. The sample locations may be found on Plate 1a in Annex 1. A spreadsheet of the data and grain size curves are located at the end of this section.

3.1.4 Geology

Geologic profiles have been developed for the project study area, refer to Plates 6 and 7 in Annex 1. The study area is located within a point bar deposit. Generally, from the existing ground surface to the approximate elevation (-) 20 ft, alternating layers of silt (ML), clay (CH-CL), and sands (SP-SM) were encountered. Below elevation (-) 20 ft, a stratum of fine sand (SP) extends approximately to elevation (-) 90 ft, where a stiff Pleistocene clay was found.

3.1.5 Laboratory Tests

3.1.5.1 Testing for Undisturbed Soil Borings

For the undisturbed soil borings, visual classifications were made on all samples obtained from the soil borings. Water content determinations were made on all cohesive soil samples. Unconfined Compression (UCT) tests and Unconsolidated-Undrained (Q) shear tests were performed on samples from the undisturbed borings. Liquid and plastic limits were determined for all samples on which UCTs and Q tests were performed.

3.1.5.2 Testing for General Type Soil Borings

For the general type soil borings, visual classifications were made on all samples obtained from the soil borings. Water content determinations were made on all cohesive soil samples. UCT tests were performed on samples from the general type borings. Liquid and plastic limits were determined for all samples on which UCTs were performed.

3.1.5.3 Testing for Dredged Material Samples

For the dredged material grab samples, classifications were made on all samples in accordance with the Unified Soil Classification System and as supplemented by “Guide for Moisture Contents Adapted to CEMVN-ED-F Soils.” Specific gravity, grain size, hydrometer, and sieve tests were performed on all samples. The reports were presented containing the grain-size curve and D85, D60, D50, D30, D15, Cc, and Cu values. The relative maximum and minimum density testing were performed on granular samples (American Society for Testing and Materials (ASTM) D-4253 and D-4254).

3.1.6 Foundation Design

3.1.6.1 General

Based on the interpretation of the soil and geologic profiles, it was determined that the study area is within one soils reach. See geologic profiles, Plates 6 and 7 in Annex 1.

3.1.6.2 Design Soil Parameters

Design shear strengths in the clays were based on the test data from the above-referenced borings and from the USACE soils report entitled, "Nashville-Napoleon Avenue Floodwall, Item M-100-L, Mississippi River Soils Report, Appendix A: 1975 Failure at Public Grain Elevator," dated February 1977. See Plate 8 in Annex 1 for design parameters.

The soil properties of the silt strata were assumed to be γ = 117 pcf, c = 200 psf, and ϕ = 15 degrees and for the sand, γ = 122 pcf, c = 0 psf, and ϕ = 30 degrees.

3.1.7 Geotechnical Analysis

Stability analyses using the USACE MVN program Stability with Uplift (Method of Planes) were performed for selected cross sections throughout the study area. Additional analyses using the program SLOPE/W (Spencer's Method) were also performed on selected cross sections. Evaluation of the stability indicates existing critical bank factors of safety for most of the study area. See Table A:3-1 for a summary of existing conditions and Plates 9 and 9a in Annex 1.

Table A:3-1. Factor of Safety (FS) – Existing Conditions

Baseline Station	Existing Bank Factor of Safety	
	Method of Planes	Spencer's Method
35+00	1.00	1.00
40+00	1.00	1.03
45+00	1.00	
50+00	1.05	1.10
65+00	1.00	1.04
70+00	1.00	1.02
80+00	1.00	
84+00	1.04	1.27

Note: See Drawing C-01 of Annex 2 for Baseline Stationing locations.

Preliminary analyses were performed to determine how much material would need to be removed under the wharves to bring the factors of safety up to acceptable values (1.30 or greater). Information provided by the PORT indicated that riprap exists beneath the wharves. Additional analyses were performed to examine removing the accreted material down to the existing riprap to improve the stability of the river bank. Then, analyses were performed to determine if the proposed channel deepening would be feasible with respect to the bank stability. The results of these analyses are:

Baseline Station (B/L) (STA) 35+00 to B/L STA 67+00: The material should be removed under the wharf, following the existing slope of the riprap. At the toe of the riprap, continue with a 1V on 2H slope down to the proposed elevation (-) 50 ft below the LWRP (plus 2 ft advanced maintenance, plus 2 ft over depth) ((-) 54 ft) dredge cut. This will result in a factor of safety (FS) of 1.43. See Plate 10 in Annex 1.

B/L STA 68+00 to B/L STA 70+00: The material should be removed under the wharf, following the existing slope of the riprap down to the design dredge elevation of (-) 45 ft below the LWRP (plus 2 ft advanced maintenance, plus 2 ft over depth) ((-) 49 ft). This will result in an FS of 1.22. Because the resulting safety factor is below our allowable level, deepening of the channel is not recommended at this location. See Plate 11 in Annex 1.

B/L STA 71+00 to B/L STA 79+00: The material should be removed under the wharf, following the existing slope of the riprap down to the design dredge elevation of (-) 45 ft below the LWRP (plus 2 ft advanced maintenance, plus 2 ft over depth) ((-) 49 ft). This will result in an FS of 1.21. Because the resulting safety factor is below our allowable level, deepening of the channel is not recommended at this location. See Plate 12 in Annex 1.

B/L STA 80+00 to B/L STA 85+00: Within this area, no apparent riprap exists under the wharf. From the face of the wharf, dredge at the proposed elevation (-) 50 ft below the LWRP (plus 2 ft advanced maintenance, plus 2 ft over depth) ((-) 54 ft), with a slope of 1V on 4H under the wharf. This will result in an FS of 1.34. See Plate 13 in Annex 1.

See Table A:3-2 for a summary of these analyses.

Table A:3-2. Factor of Safety – Proposed Conditions

Stationing	Proposed grading and dredging	Resulting Safety Factor (Method of Planes)
35+00 to 67+00	Removal to riprap, 1V:2H to proposed (-)50 ft dredge cut	1.43
68+00 to 70+00	Removal to riprap, no deepening	1.22
71+00 to 79+00	Removal to riprap, no deepening	1.21

80+00 to 85+00	1V:4H slope under wharf, deepening to proposed (-)50 ft	1.34

Note: See Drawing C-01 of Annex 2 for Baseline Stationing locations.

3.1.8 Pile Capacity of Existing Structures

The existing 16-inch diameter steel pipe piles at the Nashville “B” wharf were evaluated to determine if they are adequate for the proposed channel deepening. Pile capacity curves were developed for the Q and S cases and provided to Structures Branch for their use. The results of this evaluation are presented in the Section 5.3. Also, see Plates 14 and 15 in Annex 1.

Section 4
Civil Design

4.1 CHANNEL DESIGN

4.1.1 General

To access the PORT, deep draft vessels have to transit the MRSC from the Gulf of Mexico to New Orleans Harbor. At the New Orleans Harbor, deep draft vessels transit from the MRSC through the New Orleans Harbor approach channels to access to the various ports and berthing areas. The USACE maintains the MRSC and the New Orleans Harbor approach channels. The ports and berthing areas are maintained by their respective owners and/or operators.

4.1.1.1 Mississippi River Ship Channel (MRSC)

The currently authorized and maintained MRSC Gulf to Baton Rouge project is located within the Mississippi River between the Gulf of Mexico, approximate RM 22.1 Below Head of Passes, and Baton Rouge, Louisiana, approximate RM 232.4 AHP. The MRSC project authorization was re-evaluated in 2016 and was re-authorized in 2019, to change from a 45 ft depth deep-draft channel to a 50 ft depth deep-draft channel from the Gulf of Mexico to RM 232.4 AHP (refer to Figure A:4-1). Construction of the new 50 ft MRSC deep-draft channel is expected to commence in 2020/2021. It should be noted that the Mississippi River is naturally below a 50 ft depth for the width of the channel from New Orleans Harbor to approximately RM 13 AHP. This reach of the MRSC will not require dredging to maintain the authorized 50 ft depth.

Figure A:4-1. Mississippi River Ship Channel

4.1.1.2 New Orleans Harbor

New Orleans Harbor is maintained between Mississippi RM 94.6 and RM 101.1 and is comprised of three adjacent harbors identified as Harbor 1, 2, and 3 (refer to Figure A:4-2). The PORT is located in the vicinity of Harbor 1. The New Orleans Harbor requires annual maintenance dredging between the MRSC to the berthing areas (100 ft riverward of the front of the wharves) along the left descending bank of the Mississippi River, although some reaches within the harbor are naturally deeper than the authorized depth and typically has not required maintenance dredging.

Figure A:4-2. Current New Orleans Harbor Authorization Limits

The present New Orleans Harbor authorization, The River and Harbor Act of 1938, “Mississippi River and New Orleans, LA,” authorizes a 35 ft depth by 1,500 ft approach channel through the PORT, currently maintained by USACE to the authorized depth. To permit deeper draft vessels to access the berthing between the Nashville Wharf “C” and the Napoleon Wharf “A” at Harbor 1, the PORT currently dredges these berthing areas, and part of the adjacent USACE maintained approach channel to the elevation (-) 47 ft National Geodetic Vertical Datum of 1929 (NGVD29). This feasibility study was authorized per the Water Resources Development ACT of 2016, Section 1202(d), to determine the feasibility of a new project authorization to deepen the channel approaches associated with the left descending bank of the Mississippi River between RM 100.6 to RM 98.3, within Harbor 1, to depths up to but not to exceed, the authorized depth of the MRSC, currently 50 ft. If this new authorization is approved, the new authorization will replace the current authorization within the limits for this study. The current authorization will remain as is, with the limits of this study removed from the current authorization (refer to Figure A:4-3).

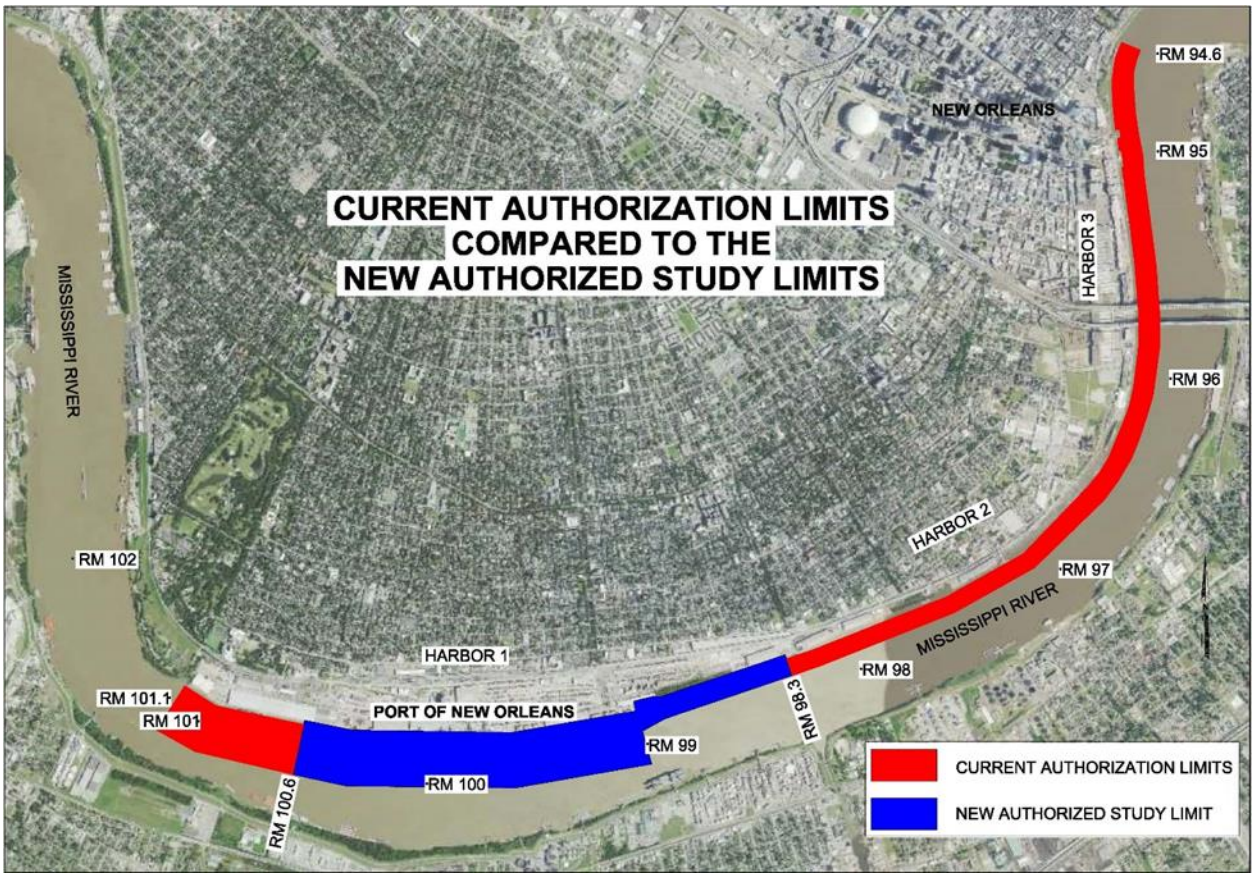

Figure A:4-3. Current Authorization Limits Compared to the New Authorized Study Limits

4.1.1.3 Project/Study Limits

The project limits for this study is between RM 100.6 to RM 98.3. Within these limits, the PORT requested that only the approach channel accessing the wharves Nashville "B," Nashville "C," and Napoleon "A" be deepened (refer to Figure A:4-4). These wharves are the main container loading and unloading wharves deeper draft vessels require a draft greater than 35 ft depth to access. The remaining area within these limits will stay at the current authorized depth of 35 ft. The current USACE Operations Division baseline used for maintenance dredging will be used to identify the study/project limits, and the deepened approach channel limits for the new project authorization as follows:

Upstream Project Limit: RM 100.6 – B/L STA 29+72.

Downstream Project Limit: RM 98.3 – B/L STA 145+13.64.

Upstream Deepened Approach Channel: B/L STA 41+22.67.

Downstream Deepened Approach Channel: B/L STA 78+49.49.

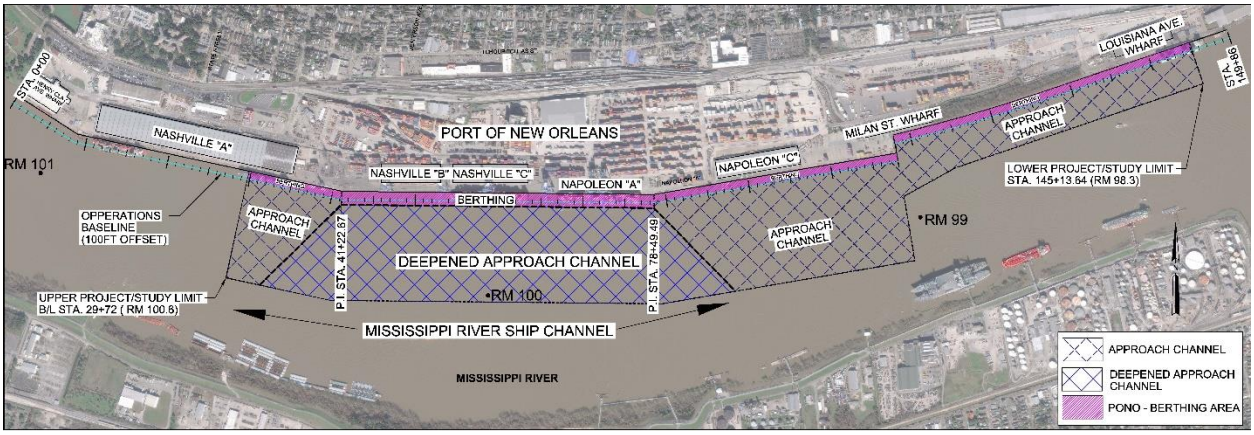

Figure A:4-4. Project/Study Limits

4.1.1.4 Limits of Responsibility

The USACE will be responsible for the project construction and maintenance of the approach channels, between the MRSC and the PORT ship berthing within the project limits. The PORT will be responsible for the project construction and maintenance of the ship berthing areas. The berthing area adjacent to the deepened approach channel (B/L STA 41+22.67 to B/L STA 78+49.49) will be 160 ft riverward from the front edge of the wharves. The remaining berthing areas, within the project limits, will remain at 100 ft riverward from the front edge of the wharves. The berthing adjacent to the deepened approach channel increased from 100 ft to a 160 ft width to account for the berth width of the larger vessels, which the deeper approach channel will accommodate.

4.1.1.5 Project Datum and Hydraulic Reference

The current authorized New Orleans Harbor project depth is 35 ft. In order to achieve this depth, the current project has historically been dredged to an elevation of (-) 35 ft Mean Low Gulf (MLG). The USACE has developed a 2007 LWRP, and proposed it be used as a reference for low water from the Mississippi River RM 320 to RM 13.4 AHP. The use of the 2007 LWRP was approved by the USACE Mississippi Valley Division on 10 Dec 2007. As a result, the current USACE maintenance dredging to elevation (-) 35 ft MLG will be changed to a 35 ft depth below the 2007 LWRP using the vertical datum NAVD88 (2009.55) in 2020/2021. Note that this will not be an MLG to NAVD88 (2009.55) datum conversion, as it will solely be a 35 ft depth below the LWRP at the NAVD88 (2009.55) datum. At this location, the 2007 LWRP is at elevation 0.6 ft; therefore, a 35 ft depth below the LWRP is elevation (-) 34.4 ft. The newly authorized project will be to the authorized depths below the 2007 LWRP using the vertical datum NAVD88 (2009.55). It should be noted the LWRP will be periodically updated due to

changes to river conditions, annual stage elevations, and any effects from sea level rise. If this new project is authorized, the LWRP will continuously be updated to the most current LWRP elevation developed by the USACE for the life of the project. See Figure A:4-5.

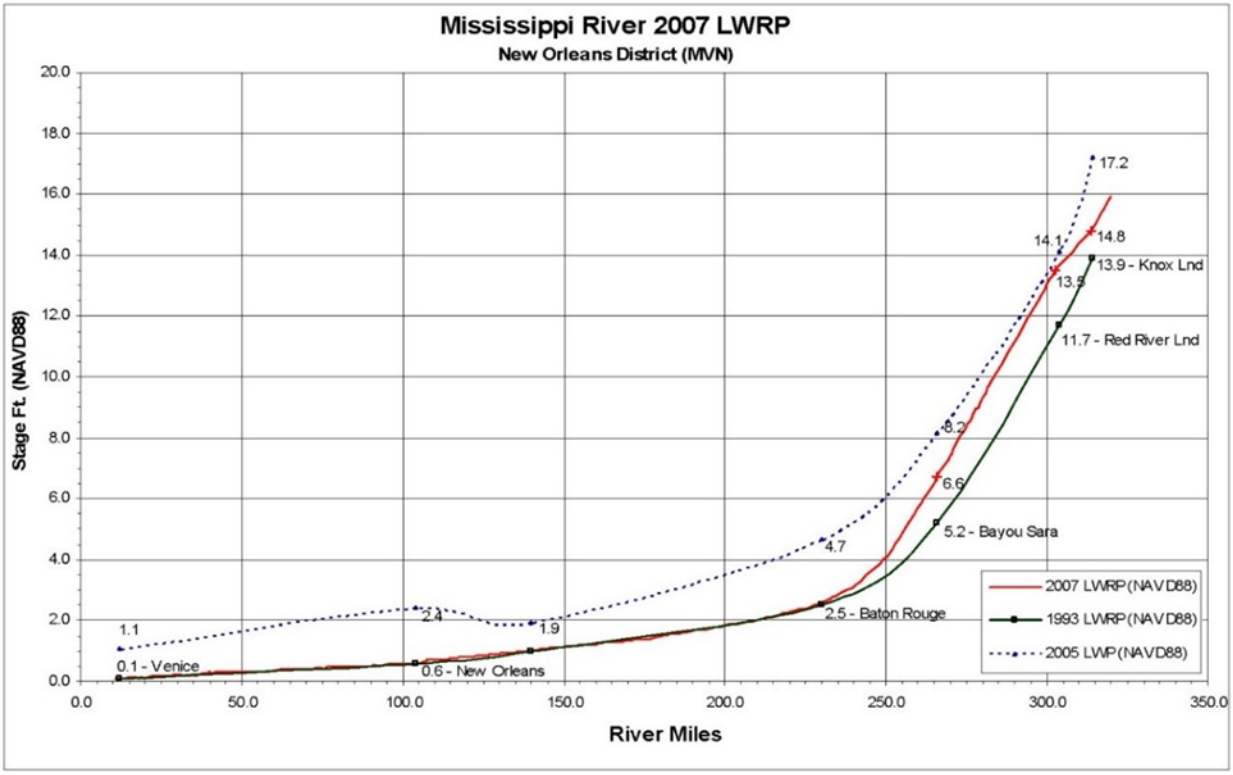

Figure A:4-5. 2007 LWRP Elevations – NAVD88 (2009.55)

4.1.1.6 Project Advance Maintenance & Over Depth

Advanced maintenance is performed to avoid frequent re-dredging and to ensure the least overall cost of maintaining the project by allowing post-dredging shoaling to occur without initially impacting the project depth. Advance maintenance of 2 ft below the authorized depth has been historically determined suitable for this project location.

An allowable over depth will account for inaccuracies in the dredging process as well as shoaling during construction and maintenance dredging events, and facilitate obtaining the full advance maintenance prism. The current authorization allows for 1 ft of over depth but historically has been determined inadequate due to the dynamic conditions of the river stages and/or shoaling. The allowable over depth of 2 ft below the advance maintenance depth has been determined suitable for this project location and the proposed depths.

4.1.2 Alternative Design Criteria

Four alternatives, with two sub alternatives, have been evaluated for this study. The two sub alternatives, 2a and 3a, were developed to assist in the evaluation of the benefit-cost ratio analysis. Each alternative includes a deepened approach channel to the depths below the NAVD88 (LWRP) between B/L STA 41+22.67 and B/L STA 78+49.49, in front of the Nashville "B," Nashville "C," and Napoleon "A" wharves. The remainder of the study limits will remain at a depth of 35 ft below the NAVD88 (LWRP). These alternatives are:

Alternative 1: No action, the limits of the study remain in the current authorization at a 35 ft depth.

Alternative 2: A 40 ft Deepened Approach Channel/35 ft Approach Channels.

Alternative 2a: A 43 ft Deepened Approach Channel/35 ft Approach Channels.

Alternative 3: A 45 ft Deepened Approach Channel/35 ft Approach Channels.

Alternative 3a: A 48 ft Deepened Approach Channel/35 ft Approach Channels.

Alternative 4: A 50 ft Deepened Approach Channel/35 ft Approach Channels.

The deepened approach channel is designed with an upstream and downstream 45-degree approach angle to assist in safely navigating vessels to and from the PORT berthing.

4.1.2.1 Alternative Design Elevations

The design of the alternatives is based on depths below the 2007 LWRP using the NAVD88 (2009.55) datum. The current LWRP elevation at New Orleans Harbor, as of 2019, is elevation 0.6 ft. The design elevations for the evaluated alternative depths for this study are as shown in Table A:4-1 below.

Table A:4-1. Design Elevations

40 FT ALTERNATIVE	45 FT ALTERNATIVE	50 FT ALTERNATIVE
40 ft depth: **EL (-)39.4 ft NAVD88 (LWRP)**	**45 ft depth:** **EL (-)44.4 ft NAVD88 (LWRP)**	**50 ft depth:** **EL (-)49.4 ft NAVD88 (LWRP)**
40 ft depth plus 2 ft Advance: EL (-)41.4 ft NAVD88 (LWRP)	45 ft depth plus 2 ft Advance: EL (-)46.4 ft NAVD88 (LWRP)	50 ft depth plus 2 ft Advance: el (-)51.4 ft NAVD88 (LWRP)
40 ft depth plus 2 ft Advance plus 2 ft Over Depth: EL (-)43.4 ft NAVD88 (LWRP)	45ft depth plus 2 ft Advance plus 2 ft Over Depth: EL (-)48.4 ft NAVD88 (LWRP)	50 ft depth plus 2 ft Advance plus 2 ft Over Depth: EL (-)53.4 ft NAVD88 (LWRP)
35 ft depth: **EL (-)34.4 ft NAVD88 (LWRP)**	**35 ft depth:** **EL (-)34.4 ft NAVD88 (LWRP)**	**35 ft depth:** **EL (-)34.4 ft NAVD88 (LWRP)**
35 ft depth plus 2 ft Advance: EL (-)36.4 ft NAVD88 (LWRP)	35 ft depth plus 2 ft Advance: EL (-)36.4 ft NAVD88 (LWRP)	35 ft depth plus 2 ft Advance: EL (-)36.4 ft NAVD88 (LWRP)
35 ft depth plus 2 ft Advance plus 2 ft Over Depth: EL (-)38.4 ft NAVD88 (LWRP)	35 ft depth plus 2 ft Advance plus 2 ft Over Depth: EL (-)38.4 ft NAVD88 (LWRP)	35 ft depth plus 2 ft Advance plus 2 ft Over Depth: EL (-)38.4 ft NAVD88 (LWRP)

4.1.2.2 Dredge Template

The dredge template for the approach channels will have a required dredge cut to the proposed alternative depths plus an additional 2 ft depth for advance maintenance. A 2 ft over depth will be permitted, but not measured for payment. Along the left descending riverside, adjacent to the berthing areas limits, will have a side slope to the natural angle of repose, approximately 1V to 2H. This side slope, which will be within the berthing limits, will be dredged by the PORT during their maintenance dredging of the berthing areas, to achieve the required depths. Termination for dredging along the MRSC will end at the naturally occurring contour elevation at the required dredge cut depth (refer to the “Dredge Template” drawings within the alternative drawings attached in Annexes 2 - 4).

4.1.2.3 Dredge Disposal

The disposal of dredged material for construction and maintenance will be discharged at the naturally occurring (-) 55.5 ft contour in the river. The disposal elevation was determined at an elevation below the MRSC 50 ft authorized depth and the additional 6 ft depth of advance maintenance, elevation (-) 49.4 ft NAVD88 (LWRP) and elevation (-) 55.4 ft NAVD88 (LWRP) respectively. At the discharge point, the dredge slurry will be carried off downstream by the river current. This is the standard practice for the New Orleans Harbor maintenance dredging.

4.1.3 40 ft Alternative

This alternative is to provide an authorized depth of 40 ft below the NAVD88 (LWRP) for the deepened approach channel and berthing area between B/L STA 41+22.67 and B/L STA 78+49.49, including the upstream and downstream approach angles. The remaining areas within the study limits will remain at the current authorized depth of 35 ft below the NAVD88 (LWRP). Additional depth of 2 ft for advance maintenance and an additional depth of 2 ft for over depth will be included in the authorization for each depth. The PORT has identified the Nashville "B" wharf as not having the structural integrity to accommodate a berthing depth below 39 ft. Until structural remediation from the wharf is completed, the berthing area in front of the wharf (identified as "Reach 2" in the attached Annex 2 drawings) will require this alternative to be phased. The scopes for Phase I and Phase II are:

4.1.3.1 40 ft Alternative Phase I

Phase I PORT Construction:

a. Dredge the 160 ft wide berthing area (between B/L STA 41+22.67 and B/L STA 78+49.49) identified as Reach 1 (Nashville "C" and Napoleon "A") to a depth of 40 ft below the LWRP, with 2 ft advance dredging and an additional 2 ft for over depth permitted.
b. Dredge the 160 ft wide berthing area (between B/L STA 41+22.67 and B/L STA 78+49.49) identified as Reach 2 (Nashville "B") to a depth of 35 ft below the LWRP, with 2 ft advance dredging and an additional 2 ft for over depth permitted.
c. Dredge the 100 ft wide berthing areas within the remainder of the study limits to a depth of 35 ft below the LWRP with 2 ft advance dredging and an additional 2 ft for over depth permitted.

Phase I PORT Operation & Maintenance (O&M): Maintain the 100 ft and 160 ft berthing areas within the study limits in accordance with the depths, advance dredging, over depths, and limits for the Phase I PORT Construction.

USACE Construction:

a. Dredge to deepen the approach channel between B/L STA 41+22.67 and B/L STA 78+49.49, including the interior of the upstream and downstream approach angles, to a depth of 40 ft below the LWRP, with 2 ft advance dredging, and an additional 2 ft for over depth permitted.
b. Dredge the approach channels in the remainder of the study limits to a depth of 35 ft below the LWRP, with 2 ft advance dredging, and an additional 2 ft for over depth permitted.

USACE O&M: Maintain the approach channel between B/L STA 41+22.67 and B/L STA 78+49.49, including the interior of the upstream and downstream approach angles, to a depth of 40 ft below the LWRP. The remainder of the study limits will be maintained to a depth of 35 ft below the LWRP. Both depths will be authorized to have an additional 2 ft depth for advance maintenance and an additional 2 ft depth for over depth permitted.

4.1.3.2 40 ft Alternative Phase II

Assume Phase II initial construction and O&M will commence 5 years after the completion of Phase I as follows:

Phase II PORT Construction**:** Dredge the 160 ft wide berthing area identified as Reach 2 (Nashville "B") to a depth of 40 ft below the LWRP, with 2 ft advance dredging and an additional 2 ft for over depth permitted.

Phase II PORT O&M**:** Maintain the 160 ft wide berthing area (between B/L STA 41+22.67 and B/L STA 78+49.49), to a depth of 40 ft below the LWRP and the remainder of the study area, with 100 ft wide berthing to a depth for 35 ft below the LWRP. Both depths will be authorized to have an additional 2 ft depth for advance maintenance and an additional 2 ft depth for over depth permitted.

USACE Construction**:** No additional construction required for Phase II.

USACE O&M**:** Remains the same as Phase I.

4.1.4 45 ft Alternative

This alternative is to provide an authorized depth of 45 ft below the NAVD88 (LWRP) for the approach channel and berthing area between B/L STA 41+22.67 and B/L STA 78+49.49, including the upstream and downstream approach angles. The remaining areas within the study limits will continue at the current authorized depth of 35 ft below the NAVD88 (LWRP). An additional depth of 2 ft for advance maintenance and an additional depth of 2 ft for over depth will be included in the authorization for each depth. The PORT has identified the Nashville "B" wharf as not having the structural integrity to accommodate a berthing depth below 39 ft. Until structural remediation from the wharf is completed, the berthing area in front of the wharf (identified as "Reach 2" in the attached Annex 3 drawings) will require this alternative to be phased. The scopes for Phase I and Phase II are:

4.1.4.1 45 ft Alternative Phase I

Phase I PORT Construction:

a. Dredge the 160 ft wide berthing area (between B/L STA 41+22.67 and B/L STA 78+49.49) identified as Reach 1 (Nashville "C" and Napoleon

"A") to a depth of 45 ft below the LWRP, with 2 ft advance dredging and an additional 2 ft for over depth permitted.

b. Dredge the 160 ft wide berthing area (between B/L STA 41+22.67 and B/L STA 78+49.49) identified as Reach 2 (Nashville "B") to a depth of 35 ft below the LWRP, with 2 ft advance dredging and an additional 2 ft for over depth permitted.
c. Dredge the 100 ft wide berthing areas within the remainder of the study limits to a depth of 35 ft below the LWRP with 2 ft advance dredging and an additional 2 ft for over depth permitted.

Phase I PORT O&M: Maintain the 100 ft and 160 ft berthing areas within the study limits in accordance with the depths, advance dredging, over depths, and limits for the Phase I PORT Construction.

USACE Construction:

a. Dredge to deepen the approach channel between B/L STA 41+22.67 and B/L STA 78+49.49, including the interior of the upstream and downstream approach angles, to a depth of 45 ft below the LWRP, with 2 ft advance dredging an additional 2 ft for over depth permitted.
b. Dredge the approach channels in the remainder of the study limits to a depth of 35 ft below the LWRP, with 2 ft advance dredging and an additional 2 ft for over depth permitted.

USACE O&M: Maintain the approach channel between B/L STA 41+22.67 and B/L STA 78+49.49, including the interior of the upstream and downstream approach angles, to a depth of 45 ft below the LWRP. The remainder of the study limits will be maintained to a depth of 35 ft below the LWRP. Both depths will be authorized to have an additional 2 ft depth for advance maintenance and an additional 2 ft depth for over depth permitted.

4.1.4.2 45 ft Alternative Phase II

Assume Phase II initial construction and O&M will commence 5 years after the completion of Phase I as follows:

Phase II PORT Construction**:** Dredge the 160 ft wide berthing area identified as Reach 2 (Nashville "B") to a depth of 45 ft below the LWRP, with 2 ft advance dredging and an additional 2 ft for over depth permitted.

Phase II PORT O&M**:** Maintain the 160 ft wide berthing area (between B/L STA 41+22.67 and B/L STA 78+49.49, to a depth of 45 ft below the LWRP and the remainder of the study area with 100 ft wide berthing to a depth for 35 ft below the

LWRP. Both depths will be authorized to have an additional 2 ft depth for advance maintenance and an additional 2 ft depth for over depth permitted.

USACE Construction**:** No additional construction required for Phase II.

USACE O&M**:** Remains the same as Phase I.

4.1.5 50 ft Alternative

This alternative is to provide an authorized depth of 50 ft below the NAVD88 (LWRP) for the approach channel and berthing area between B/L STA 41+22.67 and B/L STA 78+49.49, including the upstream and downstream approach angles. The remaining areas within the study limits will remain at the current authorized depth of 35 ft, below the NAVD88 (LWRP). An additional depth of 2 ft for advance maintenance and an additional depth of 2 ft for over depth will be included in the authorization for each depth. Because the PORT has identified that the structural integrity of the Nashville "B" wharf cannot accommodate a berthing depth below a depth of 39 ft until structural remediation of the wharf is complete, the berthing area in front of the wharfs (identified as Reach 2 on the alternative drawings attached in Annex 4) will require this alternative to be a phased alternative. The scopes for Phase I and Phase II are:

4.1.5.1 50 ft Alternative Phase I

Phase I PORT Construction:

a. Dredge the 160 ft wide berthing area (between B/L STA 41+22.67 and B/L STA 78+49.49) identified as Reach 1 (Nashville "C" and Napoleon "A") to a depth of 50 ft below the LWRP, with 2 ft advance dredging and an additional 2 ft for over depth permitted.
b. Dredge the 160ft wide berthing area (between B/L STA 41+22.67 and B/L STA 78+49.49) identified as Reach 2 (Nashville "B") to a depth of 35 ft below the LWRP, with 2 ft advance dredging and an additional 2 ft for over depth permitted.
c. Dredge the 100 ft wide berthing areas within the remainder of the study limits to a depth of 35 ft below the LWRP with 2 ft advance dredging and an additional 2 ft for over depth permitted.

Phase I PORT O&M: Maintain the 100 ft and 160 ft berthing areas within the study limits in accordance with the depths, advance dredging, over depths, and limits for the Phase I PORT Construction.

USACE Construction:

a. Dredge to deepen the approach channel between B/L STA 41+22.67 and B/L STA 78+49.49, including the interior of the upstream and

downstream approach angles, to a depth of 50 ft below the LWRP, with 2ft advance dredging an additional 2 ft for over depth permitted.

b. Dredge the approach channels in the remainder of the study limits to a depth of 35 ft below the LWRP, with 2 ft advance dredging and an additional 2 ft for over depth permitted.

USACE O&M: Maintain the approach channel between B/L STA 41+22.67 and B/L STA 78+49.49, including the interior of the upstream and downstream approach angles, to a depth of 50 ft below the LWRP. The remainder of the study limits will be maintained to a depth of 35 ft below the LWRP. Both depths will be authorized to have an additional 2 ft depth for advance maintenance and an additional 2 ft depth for over depth permitted.

4.1.5.2 50 ft Alternative Phase II

Assume Phase II initial construction and O&M will commence 5 years after the completion of Phase I as follows:

Phase II PORT Construction**:** Dredge the 160 ft wide berthing area identified as Reach 2 (Nashville "B") to a depth of 50ft below the LWRP, with 2 ft advance dredging and an additional 2ft for over depth permitted.

Phase II PORT O&M**:** Annually maintain the 160 ft wide berthing area (between B/L STA 41+22.67 and B/L STA 78+49.49, to a depth of 50 ft below the LWRP and the remainder of the study area with 100 ft wide berthing to a depth for 35 ft below the LWRP. Both depths will be authorized to have an additional 2 ft depth for advance maintenance and an additional 2 ft depth for over depth permitted.

USACE Construction**:** No additional construction required for Phase II.

USACE O&M**:** Remains the same as Phase I.

4.1.6 USACE Construction Dredging Quantities

Surveys conducted by the USACE Operations Division on 6 September 2019 were used to develop dredge quantities for the approach channels of the evaluated alternative depths. The datum for the survey data was provided in NAVD88 (2009.55), and the surveys represent the 2019 high river and shoaling conditions prior to maintenance dredging of that year. The construction of the deepened approach channel will take place after the current authorized project's maintenance dredging is completed for that year when the initial construction for the new project begins. The maintenance dredging conducted prior to initial construction will not be cost-shared as it will be maintenance of shoaled material of the subsequent maintenance dredging of the current authorized project. The maintenance dredging will be dredged down to elevation (-) 37.4 ft NAVD88 (LWRP); therefore, any dredge cut quantity above elevation (-) 37.4 ft

NAVD88 (LWRP) will not be included in the evaluated deepened approach channel dredge quantities. The approach channel limits will remain at a 35 ft depth below the NAVD88 (LWRP), and will also be covered by the maintenance dredging to elevation (-) 37.4 ft NAVD88 (LWRP). Therefore, no construction will be required for the 35 ft depth approach channel limits for any of the evaluated alternatives. It is assumed that additional dredging of the approach channel conducted by the PORT to elevation (-) 47.0 NGVD29 ((-) 47.83 ft NAVD88) will not be conducted once construction is initiated, and therefore will not be considered in the dredging quantities for the evaluated alternatives. Construction quantities in cubic yards (CY) for the deepened approach channel at each alternative depth are as shown on Table A:4-2.

Table A:4-2. Construction Dredge Quantities

Alternative (Alt.)	**Alt. Depth + 2 ft Advance Quantities**	**Additional 2 ft Over Depth* Quantities**
40 ft Alternative	125,000 CY (to EL (-) 41.4 ft NAVD88)	109,000 CY (EL (-) 41.4 ft to (-) 43.4 ft NAVD88)
43 ft Alternative	321,500 CY (to EL (-) 44.4 ft NAVD88)	155,000 CY (EL (-) 44.4 ft to (-) 46.4 ft NAVD88)
45 ft Alternative	500,000 CY (to EL (-) 46.4 ft NAVD88)	177,000 CY (EL (-) 46.4 ft to (-) 48.4 ft NAVD88)
48 ft Alternative	784,500 CY (to EL (-) 49.4 ft NAVD88)	220,000 CY (EL (-) 49.4 ft to (-) 51.4 ft NAVD88)
50 ft Alternative	1,000,000 CY (to EL (-) 51.4 ft NAVD88)	240,000 CY (EL (-) 51.4 ft to (-) 53.4 ft NAVD 88)

*Over depth not included in dredge quantities, but considered to time production rate and cubic yard unit cost for estimates.

Note: Dredge quantities do not include dredge quantities above elevation (-) 37.4 ft NAVD88 as this material will be dredged to that depth during maintenance dredging prior to the initial construction for the new project.

Spread sheets developed for estimating quantities are attached in Annex 5.

4.1.7 USACE Maintenance Dredging Quantities

Maintenance dredging quantities were estimated based on a model study that was conducted by USACE, MVN, HH&C Branch to determine the annual shoaling increase as a result of the deeper depths of the deepened approach channel, refer to Section 2 for in depth details of the modeling. The model considers the depths of 39 ft, 49 ft, and 54 ft. These model depths include an additional depth of 2 ft for advance maintenance, and the additional depth for the 2 ft for over depth. Therefore the model depths of 49 ft and 54 ft are suitable for shoaling estimates of the 45 ft alternative and 50 ft alternative respectively. The model results of the 49 ft depth was used for maintenance dredging quantities of the 45 ft alternative. The model results of the 54 ft depth were used for maintenance dredging quantities of the 50 ft alternative. Because the model did not include a 44 ft depth, the estimated maintenance quantities for the 40 ft alternative were developed by interpolating the results between the 39 ft depth and 49 ft depths of the model. Alternatives 2a (43 ft) and 3a (48 ft) were also develop by interpolation. The estimated shoaling quantities are as shown in Table A:4-3.

Table A:4-3. Estimated Shoaling Quantities

Alternative	Estimated Annual Shoaling Quantity
40 ft Alternative	344,000 CY
43 ft Alternative	345,500 CY
45 ft Alternative	347,000 CY
48 ft Alternative	381,000 CY
50 ft Alternative	414,000 CY

Estimated shoaling quantities include both the deepened approach channel and the 35 ft depth approach channels within the study limits. The current maintenance dredging conducted by USACE within the limits of work is approximately 300,000 to 310,000 cubic yards. This quantity represents Alternative 1, No Action, and the project to remain at a 35 ft depth

4.1.8 PORT Construction Quantities

Surveys conducted by the USACE Operations Division on 15 September 2019 were used to develop dredge quantities for the PORT's 160 ft wide berthing area for all evaluated alternative depths. These surveys also included the existing conditions under the wharves. The datum for the survey data was provided in NAVD88 (2009.55) and represents the 2019 high river and shoaling conditions prior to maintenance dredging of that year. Because the PORT already maintains the 100 ft wide berthing areas to a depth of 35 ft below the LWRP, there will be no construction cost for the 100 ft wide berthing areas. The new 160 ft wide berthing area will be constructed in two phases, Phase I and Phase II, as stated in Sections 4.1.3, 4.1.4, and 4.1.5.

4.1.8.1 PORT Phase I Construction Quantities

For the PORT Phase I construction, identified as "Reach 1" (refer to alternative drawings in Annexes 2 - 4), is currently dredged to a depth of 48.5 ft to 50 ft below the NAVD88 (LWRP). It was determined by the Project Delivery Team (PDT) that there will not be a construction cost for the PORT in Phase I.

4.1.8.2 PORT Phase II Construction Quantities

For the PORT Phase II construction, identified as "Reach 2" (refer to alternative drawings in Annexes 2 - 4), quantities are shown in Table A:4-4. Quantities include the alternative depth plus 2 ft of advance maintenance dredging.

Table A:4-4. Estimated PONO Phase II Construction Quantities

Alternative (Alt.)	Estimated "Reach 2" Dredge Quantity
40 ft Alternative	1,600 CY
43 ft Alternative	7,600 CY
45 ft Alternative	13,000 CY
48 ft Alternative	21,500 CY
50 ft Alternative	27,500 CY

Quantities were not estimated by the USACE for the pile bracing of the Nashville "B" wharf since the cost estimate for the pile bracing was provided by the PORT. The cost for the pile bracing is included in the study cost, and will be the PORT's cost and construction responsibility. The Spreadsheets developed for estimating quantities are attached in Annex 5.

4.1.9 PORT Maintenance Quantities

The PORTmaintenance quantities and costs were provided by the PORT.

4.2 FOCUSED ARRAY OF ALTERNATIVES COST ESTIMATES

4.2.1 General

Dredging and disposal in this study are based on the existing dredging and disposal operations of New Orleans Harbor and will result in the least-cost and environmentally acceptable plan. Dredging and dredged material disposal for construction and maintenance will be accomplished by the same type of dredging equipment similar to that utilized for the current maintenance dredging of the current 35 ft authorized project.

No utilities have been identified to be relocated; therefore, no utility relocations will be required prior to construction activities, refer to Section 4.5.

4.2.1.1 Dredging

Dredging for construction and maintenance will utilize hydraulic cutterhead dredges. In order to achieve the depths of the entire approach channel limits, dredging operations will be permitted to perform a box cut beyond the delineated approach channel limits into the PORT's berthing limits. The approximate length of 10 ft to 20 ft beyond the theoretical width of the delineated approach channel will be required to achieve the required depth for the entire approach channel limits.

4.2.1.2 Dredge Disposal

The disposal of dredged material for construction and maintenance will be discharged at the naturally occurring (-) 55.5 ft NAVD88 contour in the river via floating and/or submerged pipelines. The disposal elevation is determined at the elevation below the MRSC 50 ft authorized depth and the additional 6 ft depth of advance maintenance, elevation (-) 49.4 ft NAVD88 (LWRP) and elevation (-) 55.4 ft NAVD88 (LWRP) respectively.

4.2.2 USACE - Deepened Approach Channel

The construction of the deepened approach channel will commence at the start of Phase I. The construction of the approach channels for the authorized depths will commence after the USACE annual maintenance is completed during low water river conditions. Because the O&M dredging will be completed to a depth of 35 ft below the LWRP, with 2 ft advance maintenance and an additional 1 ft for over depth as currently authorized, it is assumed that the conditions of the approach channels within the project area will be at or below elevation (-) 37.4 ft NAVD88 (LWRP) at the time of construction. The 35 ft depth below the LWRP approach channels would not require construction effort. The deepened approach channel will, however, require dredging from elevation

(-) 37.4 ft NAVD88 (LWRP) to the authorized depth of the deepened approach channel. The deepened approach channel will be dredged to the authorized depth plus the additional 2 ft depth for advance maintenance. An over depth of 2 ft below the advance maintenance depth will be permitted.

4.2.3 PORT – "Reach 1" 160 ft Berthing Phase I

The construction of the deepened berthing area identified as "Reach 1" (refer to alternative drawings attached in Annex 2) would commence at the start of Phase I after the USACE has completed the deepened approach channel dredging**.** Because the PORT already conducts additional dredging from 48.5 ft to 50 ft depth below the LWRP at the "Reach 1" berthing area, the construction of "Reach 1" will not be required, but will have to be maintained to the authorized depth of the adjacent approach channel.

4.2.4 PORT – "Reach 2" 160 ft Berthing Phase II

The construction of the deepened berthing area identified as "Reach 2" (refer to the alternative drawings attached in Annex 2) will commence at the start of Phase II by the PORT. Phase II is assumed to be 5 years after the commencement of Phase I. The PORT would be completed bracing the piles of the wharf at the Nashville "B" wharf, and able to provide suitable structural integrity of the facility to deepen the "Reach 2" berthing area up to a depth of 50 ft below the LWRP. Construction will be completed by the PORT utilizing the PORT's dredging Contractor.

4.3 OPERATIONS AND MAINTENANCE DREDGING

4.3.1 USACE Maintenance Dredging

The USACE will maintain the approach channels to the authorized depths once the initial project construction is completed. Annual maintenance dredging, plus the additional 2 ft of advance maintenance, will be typically required to maintain the authorized depths.

4.3.2 PORT Maintenance Dredging

The PORT will maintain the berthing areas to the authorized depths by the PORT's current means and methods for maintaining the required depths. The PORT will typically maintenance dredge the berthing areas after the USACE maintenance dredging is completed, and as required throughout the year based on shoaling conditions adjacent to the wharves. Because the PORT dredging contract dredges year-round, and as needed, the PORT will typically not conduct advance maintenance dredging.

4.4 TENTATIVELY SELECTED PLAN (TSP) – 50 FT ALTERNATIVE

The TSP has been identified as the 50 ft alternative. Table A:4-5 through Table A:4-7 provide a summary of the construction phases, elevations, and dredge quantities for the initial construction and maintenance of the 50 ft alternative TSP.

Table A:4-5. 50 ft TSP Phase I Construction Summary

PHASE I CONSTRUCTION – 50 FT DEEPENED APPROACH CHANNEL/35 FT APPROACH CHANNELS			
Work Description	**Authorized Depth (Elevation)**	**Required Dredge Depth Elevation** (Authorized Depth plus 2 ft Advanced Maintenance)	**Estimated Dredge Quantity (CY)**
USACE Deepened 50 ft Depth Approach Channel	(-)49.4 ft NAVD88 (LWRP)	(-)51.4 ft NAVD88 (LWRP)	1,000,000 CY
USACE 35 ft Depth Approach Channels	(-)34.4 ft NAVD88 (LWRP)	(-)36.4 ft NAVD88 (LWRP)	0.0 CY
PORT 50 ft Depth Berthing Area, "Reach 1"	(-)49.4 ft NAVD88 (LWRP)	(-)51.4 ft NAVD88 (LWRP)*	0.0 CY
PORT 35 ft Depth Berthing Areas	(-)34.4 ft NAVD88 (LWRP)	(-)36.4 ft NAVD88 (LWRP)*	0.0 CY
*PORT dredging contract dredges all year and as needed, the PONO may not conduct advance dredging, and will not go below -50.0 ft NAVD88 (LWRP) for wharf structural integrity.			

Table A:4-6. 50 ft TSP PONO Phase II Construction Summary

PORT PHASE II CONSTRUCTION – 50 FT "REACH 2" DEEPENED BERTHING AREA			
Work Description	**Authorized Depth (Elevation)**	**Required Dredge Depth Elevation** (Authorized Depth plus 2 ft Advanced Maintenance)	**Estimated Dredge Quantity (CY)**
PORT 50 ft Depth Berthing Area, "Reach 2"	(-)49.4 ft NAVD88 (LWRP)	(-)51.4 ft NAVD88 (LWRP)*	27,500 CY
*PORT dredging contract dredges all year and as needed, the PORT may not conduct advance dredging and will not go below -50.0 ft NAVD88 (LWRP) for wharf structural integrity, however quantities include over depth for Phase II cost estimates to be consistent with shallower alternative depth estimates.			

Table A:4-7. 50 ft TSP USACE Maintenance Dredging Summary

USACE MAINTENANCE DREDGING – 50 FT DEEPENED APPROACH CHANNEL/35 FT APPROACH CHANNELS			
Work Description	**Authorized Depth (Elevation)**	**Required Dredge Depth Elevation** (Authorized Depth plus 2 ft Advanced Maintenance)	**Estimated Annual Dredge Quantity (CY)**
USACE Deepened 50 ft Approach Channel	(-)49.4 ft NAVD88 (LWRP)	(-)51.4 ft NAVD88 (LWRP)	414,000 CY (Combined)
USACE 35 ft Approach Channels	(-)34.4 ft NAVD88 (LWRP)	(-)36.4 ft NAVD88 (LWRP)	

4.5 RELOCATIONS

4.5.1 Purpose

Relocation data were collected, tabulated, and detailed in this appendix by the USACE, MVN, Engineering Division, Relocations and Studies Team, to a feasibility level of design, prior to the selection of the TSP. The Relocations and Studies Team reviewed proposed designs against pipeline databases to obtain information and locations of existing facilities. Historical project documents, correspondence, and permits were also reviewed against the scope of this effort. For the purpose of this feasibility study, facility crossings are referenced by RM AHP along the Mississippi River.

The Relocations and Studies Team then made assumptions based on the proposed feasibility level project design and project location to determine project relocation requirements. These requirements are based on the latest relocation methods and means previously used by facility owners on USACE projects.

4.5.2 Scope

Improvements for the Mississippi River will involve dredging to bottom depths of 50 ft LWRP for the approach channel and berthing area between B/L 41+22.67 and B/L 78+49.49, including the upstream and downstream approach angles. The facilities located within project study limits, from RM 98.3 to RM 100.6, are listed in Table A:4-8.

4.5.3 Process

The USACE pipeline permits for the Mississippi River crossings between RM 98.3 and RM 100.6 were provided by the Operations Division, Regulatory Branch, and were used as a preliminary reference. Pipeline ownership information was compiled from the pipeline databases, including Hild Technological Services, Inc., National Pipeline Mapping System, and Louisiana Department of Natural Resources. Drawings were prepared showing the proposed limits of dredging and pipelines identified therein. The pipeline owners were contacted to confirm ownership, identify additional pipelines, and provide depth information to determine potential conflicts. No relocations are required by the TSP. The utility crossings in the project area, summarized in Table A:4-8, are located outside of the limits of the proposed deepening area.

4.5.4 Estimated Relocations Costs

The pipeline, power line, and communication line crossings in the project area are summarized in Table A:4-8 and shown on Figure A:4-6.

Table A:4-8. River Deepening Facilities Relocation Costs

Owner	RM (AHP)	Description	Total Estimated Relocation Cost
AT&T	98.3	Telephone Line	$0.00
Entergy (abandoned)	99.2	Electric Lines	$0.00
AT&T	99.2	Telephone Line	$0.00
Total Expected Pipeline Relocation Costs			**$0.00**

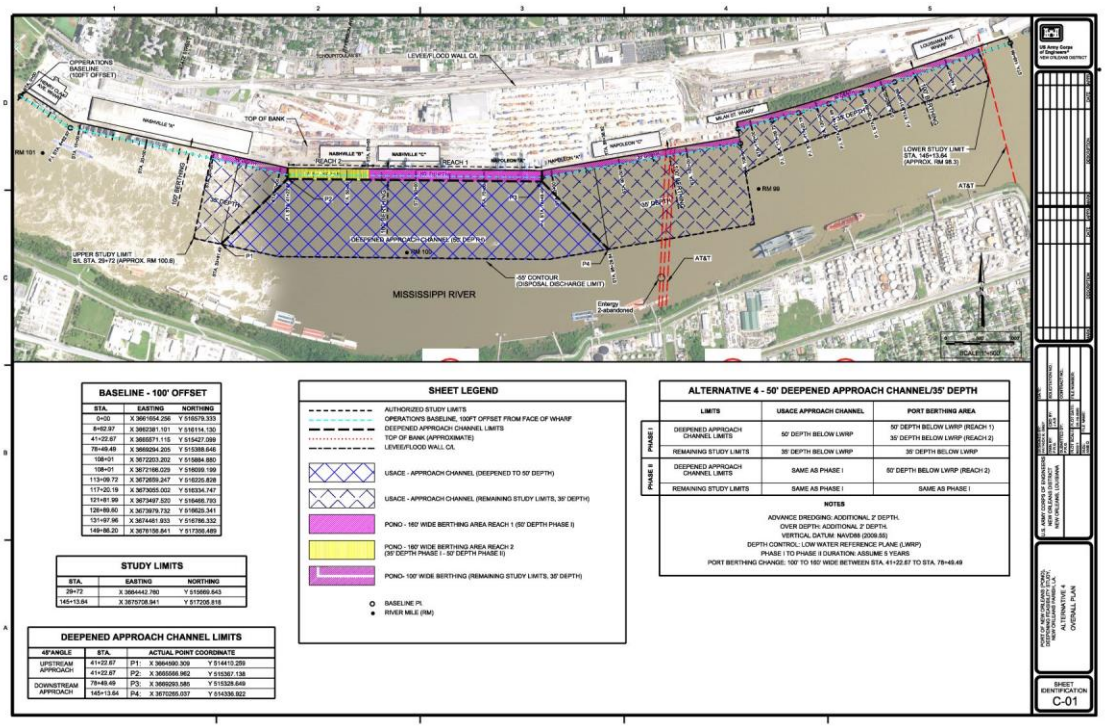

Figure A:4-6. River Deepening Facilities Relocation Costs

Section 5
Structure Design

5.1 STRUCTURAL PROJECT FEATURES

Initially, the scope of the structural analysis for the deepening study considered both the existing flood protection and the PORT wharves. The geotechnical analysis determined that the channel-deepening dredging activities for both the PORT and the USACE have sufficient distance from the flood control structures as not to have any influence on their stability. Therefore, structural analysis for the existing USACE flood control structures was not performed. However, the pile capacities under the PORT wharves would be influenced by PORT dredging activities, and structural analysis of these piles was performed.

Within the vicinity of the PORT reach that could service the target ship class that the feasibility study is based upon (Henry Clay Avenue Wharf to Harmony Street Wharf), only the wharves at Nashville Avenue and Napoleon Avenue have the crane capacity for loading/unloading the target ship class. The PORT currently has an engineering consultant analyzing the dredging effects on the Nashville “C” and Napoleon “A” wharves. The USACE structural analysis will include dredging effects on the Nashville “B” wharf.

5.2 GENERAL STRUCTURAL DESIGN CRITERIA

5.2.1 References

Copies of the drawings received from the PORT for the Nashville Avenue Terminal Complex Wharf and Shed “B” in the MR3-13005-W sheet series provided wharf geometry and original design criteria.

The USACE geotechnical analysis utilizing the soil boring logs found in the previously mentioned sheet series were able to produce pile capacity curves for the Nashville “B” wharf. (Reference Figure A:5-1)

5.2.2 General Design Criteria

The live load descriptions on drawing no. MR3-13005-W6 include an open wharf design value of 1,000 psf.

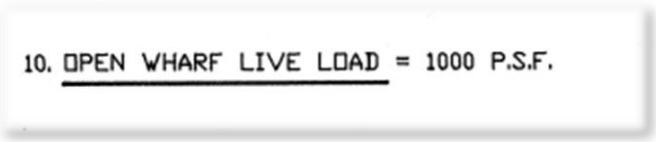

Figure A:5-1. Wharf Live Load

A representative partial plan taken from drawing MR3-13005-W15 illustrates the river edge piles under the wharf as open circles (Figure A:5-2).

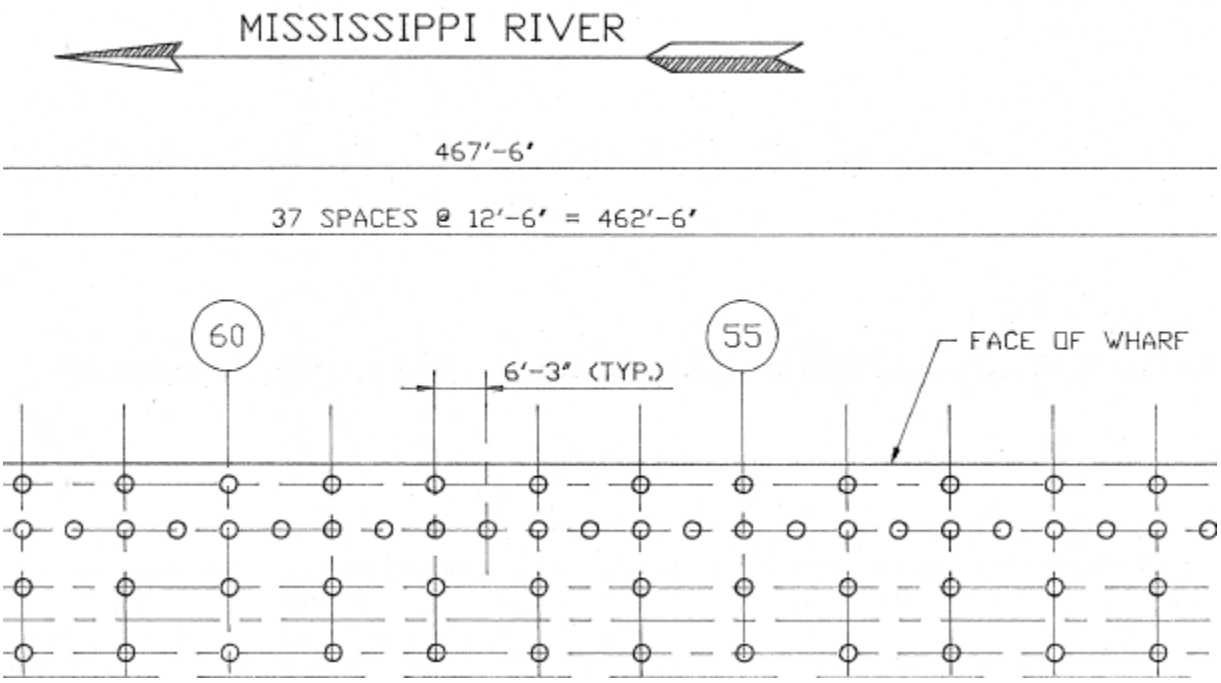

Figure A:5-2. Wharf Partial Plan

The legend on this drawing (Figure A:5-3) identifies the open circles as 16-inch diameter steel piles.

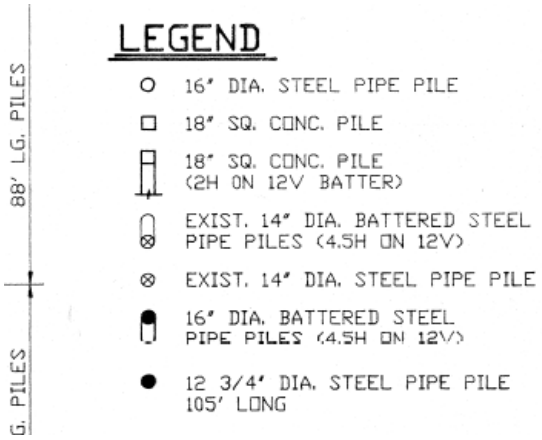

Figure A:5-3. Wharf Plan Legend

Also from drawing W15, the plan identifies the leading pile rows as having lengths of 150 ft (Figure A:5-4).

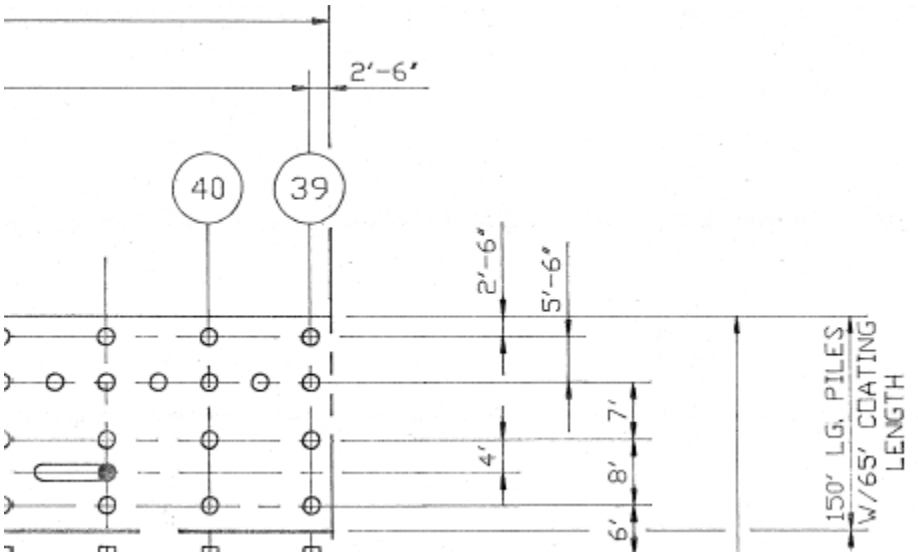

Figure A:5-4. Wharf Pile Length

A partial wharf cross section from Section 3 on drawing MR3-13005-W7 (Figure A:5-5) illustrates an underlying riprap layer and a design mudline at EL (-) 35.00 ft.

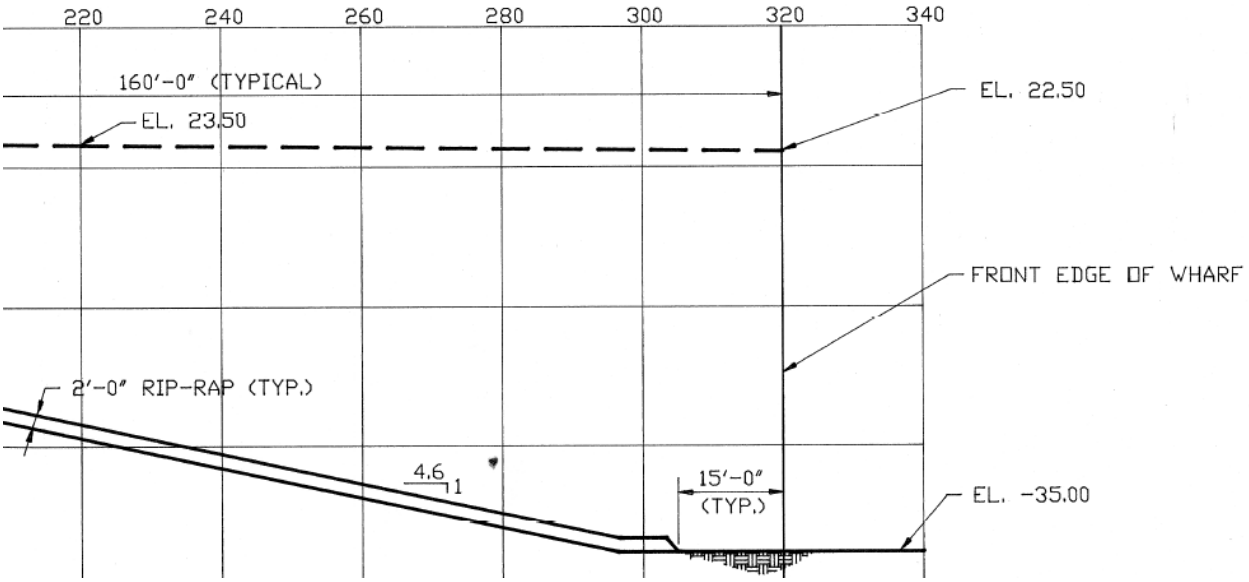

Figure A:5-5. Wharf Cross Section

5.3 NASHVILLE "B" WHARF PILE ANALYSIS

With the understanding that maintenance dredging underneath the wharf would be limited to the removal of the materials above the riprap layer, the pile analysis focused on piles within 15 ft of the wharf edge, i.e., the 16-inch diameter steel pipe piles. With no field inspection for dive reports, the piles in analysis were considered as pristine, with no section loss from corrosion and no damage from allision.

From a review of the wharf plan drawings, the largest tributary area for the target piles is 93.8 square ft. Adding a dead load of the concrete deck structure to the area live load along with pile self-weight yields a total pile load of 136.2 kips.

Values from 1960 for an ASTM A53 pile show a yield strength of 35 ksi with a nominal wall thickness of 0.375 inch and a design wall thickness of 0.349 inches.

From recent LIDAR data, the top of concrete deck at the front edge of wharf is at elevation 22 ft. Reducing the elevation with deck structure dimensions gives a top of pile elevation of 17.5 ft.

For a proposed dredging depth of (-) 45 ft with a 2-ft over depth tolerance yields a mudline elevation of (-) 47 ft. Utilizing a depth of fixity of 12D below the mudline, the piles would have an unbraced length (L_b) of 80.5 ft. This L_b reduces the steel pile axial load capacity to 132.2 kips, which is less than the total pile load of 136.2 kips. Thus, the piles would need lateral bracing to reduce the L_b. With the remaining length of 62 ft in the soil, and utilizing the pile curves provided with FS = 2.0, the pile skin friction could resist approximately 144 kips.

For a proposed dredging depth of (-) 50 ft with a 2-ft over depth tolerance yields a mudline elevation of (-) 52 ft. Utilizing a depth of fixity of 12D below the mudline, the piles would have an unbraced length (L_b) of 85.5 ft. This L_b reduces the steel pile axial load capacity to 117.2 kips, which is less than the total pile load of 136.2 kips. Thus, the piles would need lateral bracing to reduce the L_b. With the remaining length of 57 ft in the soil, and utilizing the pile curves provided with FS = 2.0, the pile skin friction could resist approximately 130 kips. This represents approximately a 1.05 percent overstress in the soil resistance.

During the course of this study, the PORT's consultant reviewing dredging effects on the wharves recommended bracing of the underlying piles. The bracing installation effort is currently underway.

Section 6
Cost Estimates

6.1 BASIS OF COST ESTIMATE

The initial construction cost estimate for the TSP was finalized utilizing the Micro-Computer Aided Cost Estimating System (M-CACES) and is included in Annex 6. The cost estimate reflects current and applicable pricing and addresses specific construction procedures for the various line items in the estimate.

The estimated costs for the PONO were based upon an analysis of each line item evaluating quantity, production rate, and time, together with the appropriate equipment, labor, and material costs. Cost was developed using actual in-house knowledge and experience by MVN cost engineers who either personally designed or estimated similar projects.

All the construction and maintenance work is common to MVN.

6.2 CONTINGENCIES

Contingencies for the cost estimates were based upon similar cost estimates that had a risk analysis performed using the Cost and Schedule Risk Analysis Abbreviated Version. The PDT assessed project management and scope growth, contract strategy, construction elements, specialty construction or fabrication, technical design and quantities, Cost, Schedule, and Construction. See Annex 6.

Contingencies for engineering and design are based on uncertainties involved in the preparation of plans and specifications, and in engineering during construction. These include the cost of field data collection, unanticipated design problems, change in design based on the review of the report, changes in the design criteria, and changes in overhead rates.

Contingencies for construction management are based on using a historical average of time growth for similar type contracts in the area. The time growth includes additional duration for unusually severe weather and unknown changes to the contracts.

6.3 DETAILED ESTIMATE

The project cost estimate for the TSP in M-CACES format is included in Annex 6. The project estimate of first cost, which included costs for lands and damages, and real estate costs during construction, as well as construction cost is included in Annex 6.