Appendix A

Basis of Design Report
(Appendix A in Final Design Report)

Report

Basis of Design Report

Milwaukee Estuary AOC Dredged Material Management Facility

Project I.D.: 19W012

WEC Energy Group – Business Services
Milwaukee, Wisconsin

November 2020

Foth

Basis of Design Report
Milwaukee Estuary AOC Dredged Material Management Facility

Project ID: 19W012

Prepared for
WEC Energy Group – Business Services
Milwaukee, Wisconsin

Prepared by
Foth Infrastructure & Environment, LLC

November 2020

2121 Innovation Court, Ste. 300 • PO Box 5126 • De Pere, WI 54115-5126 • (920) 497-2500 • Fax: (920) 497-8516 • www.foth.com

Basis of Design Report

Table of Contents

Table of Contents *(continued)*

Tables

Illustrations

List of Abbreviations, Acronyms, and Symbols

AASHTO	American Association of State Highway and Transpiration Officials
AISC	American Institute of Steel Construction
ANSI	American National Standards Institute
AOC	area of concern
ASCE	American Society of Civil Engineers
ASTM	American Society for Testing and Materials
BODR	*Basis of Design Report*
CDF	Confined Disposal Facility
deg	degree
DMDF	Dredged Material Disposal Facility
DMMF	Dredged Material Management Facility
DMMP	Dredged Material Management Plan
EM	Engineering Manual
Foth	Foth Infrastructure & Environment, LLC
FHWA	Federal Highway Administration
FS	Factors of Safety
IGLD	International Great Lakes Datum
LRFD	Load and Resistance Factor Design
LWD	Low Water Datum
NAD	North American Datum
NAVD	North American Vertical Datum
NAVFAC	Naval Facilities Engineering Command
NHI	National Highway Institute
pcf	pounds per cubic foot
PGA	Peak Ground Acceleration
psf	pounds per square foot
UFC	Unified Facilities Criteria
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
WDNR	Wisconsin Department of Natural Resources
WPDES	Wisconsin Pollution Discharge Elimination System

1 Introduction

1.1 Project Introduction

Foth Infrastructure & Environment, LLC (Foth) is developing a design for a new Dredged Material Management Facility (DMMF) for dredged material from within the Milwaukee Estuary Area of Concern (AOC), on the behalf of WEC Business Services and Port Milwaukee. The DMMF will be located to the north of and adjacent to the existing Milwaukee Dredged Material Disposal Facility (DMDF) operated by the U.S. Army Corps of Engineers (USACE). This *Basis of Design Report (BODR)* documents the key parameters and assumptions upon which the DMMF design will be developed.

1.2 Project Scope

The scope of the project consists of the design of 3,250 feet of waterfront with the following applications:

- Enclose a portion of the Lake Michigan shoreline for the management of dredged material, within a Lake Bed Grant area via Chapter 238 of 1909, Chapter 285 of 1923, and Chapter 381 of 1931 for the management of dredged material.
- Create 3,250 linear feet of new cellular cofferdam structures to enclose the dredged material management area and to provide the Port with expanded facilities.
- Provide a rubble mound tie-back to the existing USACE rubble mound structure on the south east corner incorporating materials to limit hydraulic conductivity through the berm.

1.3 Project Location and Limits

The project is located on Lake Michigan in the outer harbor of the Milwaukee Harbor Federal Navigation project adjacent to Jones Island and the USACE DMDF.

1.4 General Project Description

The project consists of containing dredged material within an area established by new structures and existing structures. The new structures will be comprised of cellular cofferdam with a load support structure supported by steel piles. The cellular cofferdam structure will also serve as a vessel berthing facility with pile supported fender dolphins.

1.5 Existing Structures

Existing structures, which affect the Milwaukee AOC-DMMF, are the Milwaukee DMDF North Dike, the eastern Jones Island Bulkhead Wall, and the Liquid Cargo Pier.

2 General Analysis Criteria

2.1 Unit System

The unit system for this project will be the imperial system with Standard U.S. Foot.

2.2 Vessels (from Port Milwaukee)

- Ore carrier:
  - DWT: 90,000 tons
  - Length: 1,015 feet
  - Beam or width: 155 feet
  - Draft: 27 feet
  - Approach velocity: 0.2 ft/sec

- Alternate carrier:
  - DWT: 30,000 tons
  - Length: 730 ft
  - Beam or width: 76 ft
  - Draft: 26 ft
  - Approach velocity: 0.5 ft/sec

- Potential carriers:
  - https://en.wikipedia.org/wiki/MV_Indiana_Harbor (1,000 footer)
  - https://en.wikipedia.org/wiki/Baie_comeau (2013_ship) (750 footer)

2.3 Bollard (from Port Milwaukee)

120 kip pull capacity, every 60 feet.

2.4 Fender (from Port Milwaukee)

Zalda Technology SC1450 or equivalent, every 60 feet.

2.5 Waterfront Elevation (from Port Milwaukee)

The waterfront elevation is determined relative to the lake water level and the existing port waterfront elevation. This level must not be so low as to flood by storm surge or seiche nor so high as to increase time and energy of loading and unloading of cargo.

The dikes of the existing Milwaukee DMDF are multi-tiered, as the original dikes were raised to accommodate more dredged material. The initial crest elevation of the dikes of the existing Milwaukee DMDF is at +10.0 feet above Low Water Datum (LWD) or 587.5 feet International Great Lakes Datum 1985 (IGLD85) (USACE, 1972), and a crest elevation of the secondary internal dike is at +17 LWD or 594.5 feet IGLD85.

The elevation of the Milwaukee DMMF cellular cofferdam structure will be at +12.0 feet above LWD or 589.5 feet IGLD85.

2.6 Analysis Methodology

Analysis of the waterfront will be performed based on the guidelines and standards outlined in Section 2.8. Two main design scenarios are:

2.6.1 Pre-Disposal:

The waterfront is constructed and partially operational. The disposal area is not yet filled. The waterfront is not subject to backfill pressures.

2.6.2 Post-Disposal

The waterfront is constructed and fully operational. The disposal area is filled and compacted. The waterfront is subject to backfill pressures.

2.6.3 Safety Factors

The safety factors for the waterfront structures are listed in Tables 2-1 and 2-2.

Table 2-1

Safety Factors for Cellular Cofferdam

Failure Mechanism	Targeted Safety Factor (USACE EM 2504)
Overturning	3.5
Interlock	2.5
Internal Friction	1.5
Tilting	1.5
Cell Fill	1.5
Horizontal Shear	1.5
Bearing Capacity	3
Pullout	2

Table 2-2

Safety Factors for Piles

Pile Demand and Testing Requirements	Targeted Safety Factor
Axial Capacity with PDA testing	2.5
Axial Capacity without PDA testing	3.0

Safety factors come from Table 2-3, Typical Factors of Safety (FS) for Foundations in Soils [UFC, 2012]).

2.7 Codes and Standards

- Dredging and Dredged Material Management, EM 1110-2-5025
- Specifications for Structural Steel Buildings by the American Institute of Steel Construction, ANSI/AISC 360-16.
- Minimum Design Loads and Associated Criteria for Buildings and Other Structures by the American Society of Civil Engineers, ASCE 7-16.
- Design: Piers and Wharves by the Unified Facilities Criteria, UFC 4-152-01. January 24, 2017.
- Design of Sheet Pile Walls, EM 1110-2-2504.
- Geotechnical Engineering Circular No. 5, FHWA-IF-02-034, April 2002 and FHWA-NHI-16-072, April 2017.
- Pile Buck Steel Sheet Piling Design Manual.
- Handbook of Port and Harbor Engineering, Geotechnical and Structural Aspects.
- ArcelorMittal Sheet Piling, Design & Execution Manual, AS 500 Straight web sheet piles.
- Design of Sheet Pile Cellular Structures, EM-1110-2-2503.
- Foundations & Earth Structures, Design Manual 7.02, NAVFAC.
- PIANC, Guidelines for the Design of Fender Systems: 2002.
- OCIMF, Mooring Equipment Guidelines (MEG4): 2018.
- ACI 318-14, Building Code Requirements for Structural Concrete.
- ACI 315, Details and Detailing of Concrete Reinforcement.
- API Recommended Practice for Planning, Designing and Constructing Fixed Offshore Platforms – WSD.
- USS Steel Sheet Pile Design Manual.
- United Facilities Criteria (UFC), Geotechnical Engineering, UFC 3-220-01. November 1, 2012.
- Arcelor Mittal Piling Handbook, 9th Edition.

2.8 Project Datum

2.8.1 Horizontal Datum

The horizontal datum for the structure is Wisconsin South State Plane North American Datum (NAD) 83.

2.8.2 Vertical Datum

The vertical datum for this project shall be the IGLD85. LWD for Lake Michigan is 577.7 feet above IGLD85. North American Vertical Datum of 1988 (NAVD88) is 0.41 feet higher than the IGLD85.

2.9 Service Life

The design service life is to be 100 years with an operation and maintenance plan developed by others to prevent contaminant release into perpetuity.

2.10 Loss of Thickness (EN 1993-5 [2007])

Considering the 100-year design life of the structure, the estimated loss of sheet pile web thickness is 0.03 inches (ArcelorMittal, 2016) for faces in contact with water and 0.02 inches for faces in contact with non-aggressive and compacted soil.

2.11 Sealant

Sheet pile interlocks on the side of the cofferdam cells facing away from Lake Michigan and adjacent to the interior where dredged material will be disposed either welded or sealed with interlock injected sealant to prevent the seepage through the sheets. The sealant shall reduce hydraulic conductivity to 1×10^{-9} cm/sec or less.

3 Geotechnical Design Criteria

3.1 Existing Geotechnical Data

Site-specific geotechnical data was collected in June 2020 and was used to develop the soil layers and properties. The data are presented in Appendix L of the *Final Design Report* (Foth 2020b).

3.2 Fill Material Properties

Cells should be filled with free draining granular material, with less than 5% of the particles by weight passing the No. 200 sieve and 15% passing the No. 100 sieve.

Table 3-1

Fill Material Properties

Description	ϕ	δ	C	ɣ	ɣ sub
	Deg.	Deg.	psf	pcf	pcf
Cell Fill	35	18.9	0	125	70

3.3 Sediment Properties in DMMF Footprint

Soil properties "behind the wall," the Milwaukee Harbor bed sediments into which the piles will be driven, are extracted from site specific geotechnical boring data collected in June 2020. After review of boring descriptions and tests, a soft clay with the following properties extracted from Table 3-4, of *Design of Sheet Pile Walls* (USACE, 1994), is considered in the design.

Table 3-2

Soil Condition Behind the Wall

Description	ϕ	δ	C	ɣ	ɣ sub
	Deg.	Deg.	psf	pcf	pcf
Un-improved	30	16.2	750	110	70
Improved	30	16.2	375	125	80

4 Metocean Design Criteria

4.1 Site Bathymetry

Site multi-beam bathymetry was collected in September 2019 by FreshWater Engineering. It has been added to the project base map.

4.2 Design Water Levels

Based upon input from project stakeholders and the water level analysis documented in the *Metocean Report* (Foth, 2020a), which is Appendix D of the *Final Design Report* (Foth, 2020b), the following water levels are to be utilized for the design.

- Design High Still Water Level: +5 ft LWD or 582.5 ft IGLD85
- Design Low Still Water Level: -1.5 ft LWD or 576.0 ft IGLD85

5 Mooring and Berthing Design Criteria

Mooring requirements have been provided by Port Milwaukee.

5.1 Mooring and Berthing Analysis

See Section 2.2.

5.2 Passing Vessel

Passing vessel is considered inconsequential for the project based on the level of activities within the nearby facilities.

6 Structural Design Criteria

6.1 Design Loads (from Port Milwaukee)

6.1.1 Vertical Loads

6.1.1.1 Dead Loads

Live Load (L)

A uniform surcharge live load of 1,000 pounds per square foot (psf) is considered on the yard starting 30 feet behind the bulkhead (i.e., 30 feet away from the back face of the cell wall).

A uniform surcharge live load of 500 psf is considered on the yard immediately behind the back face of the cells for a width of 30 feet.

A uniform surcharge live load of 500 psf is considered on top of the cells where concrete platform has been constructed.

A uniform surcharge live load of 250 psf is considered on top of the cells without concrete platform.

Crane Load (C)

A Manitowoc 2250 Series 3 crawling crane with following characteristics are considered for the design:

- Machine counterweight: 249,200 lb. + 120,000 lb.
- Crawler: Fixed with gantry up position
- Primary boom length: 200 feet
- Lifting load: 68,000 lbs @ 35 feet radius

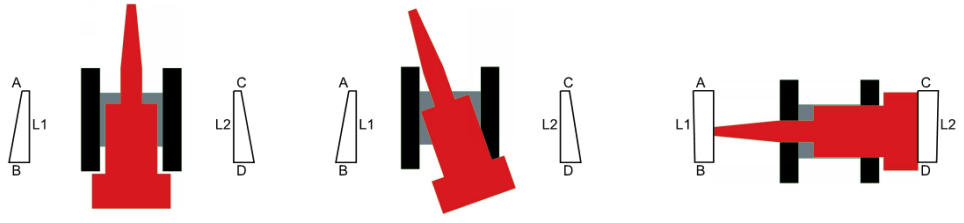
Manitowoc

Ground Bearing Pressure Estimator

GBPressure ver: 1.0.6.0
12/4/2019 6:43 AM

Project: Milwaukee DMMF	Operating Surface: Soft - Tread Contact Width 47.3 Inches
Model: 2250 Series 3	Primary: 200FT (61M) #44 HL BOOM
Machine Counterweight: 249,200-LB (113,040-KG) + 120,000-LB (54,430-KG)	Secondary: 0FT (0M) No Attachment
Crawler:Fixed, Position: Gantry Up	Load: From Boom 68,000 LBS @ 35 ft radius

Imperial Pressure Conversion Factor: 1 PSI = 144 PSF



Boom Over Front or Rear | **Boom at Critical 23 degree Swing** | **Boom Over Side**

Center of Rotation to Fulcrum: 164.4375 inch		Center of Rotation to Fulcrum: 164.4375 inch	Center of Rotation to Fulcrum: 164.4375 inch
A	12.9 psi	11.9 psi	20.2 psi
B	35.9 psi	32.9 psi	18.2 psi
L1	328.9 inch	328.9 inch	328.9 inch
C	12.9 psi	15.9 psi	30.6 psi
D	35.9 psi	36.9 psi	28.6 psi
L2	328.9 inch	328.9 inch	328.9 inch

Illustration 6-1: Ground Bearing Pressure Estimator

6.1.2 Horizontal Loads

Earth Load (H)

The earth pressure acting on the structure shall be calculated in correspondence to various conditions such as cohesionless and cohesive soils.

Hydrostatic Load (HY)

A hydrostatic pressure of 29.8 feet above mudline is considered during high water level.

Berthing Load (Be) Berthing forces should evaluate the following:

- Impact:
  - Ore Carrier: 16 kips/ft uniform over 40 feet impact length
  - Alternate Carrier: 22 kips/ft uniform over 30 feet impact length

Earthquake Load (EQ)

Based on the ASCE 7-16, the PGA (Peak Ground Acceleration) and Site amplification factor at PGA for the site are 0.059g and 1.6g, respectively.

Bray et al. (2010) and Lew et al. (2010) indicate that "lateral earth pressure increases due to seismic ground motion are likely insignificant for peak ground accelerations of 0.3g to 0.4g or less" - taken from Appendix A11, Seismic Design of Retaining Structures, AASHTO LRFD 2014. Additionally, FHWA-NHI-11-032 (Section 11.2.2) states that seismic analysis is not necessary for structures when the site-adjusted peak ground acceleration (i.e., F_PGA X PGA) is less than 0.3g unless the foundation is susceptible to liquefaction.

Wind or Wave Load (W)

A horizontal wave load of 12.4 kips/ft will be considered at elevation +2.0 feet LWD.

Mooring Load (M)

- Bollard: 120 kips with following arrangement.

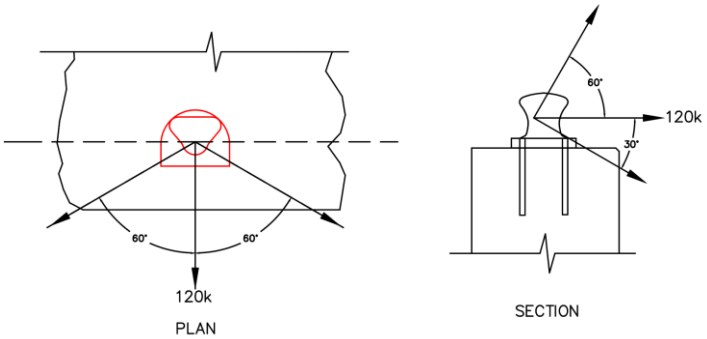


Illustration 6-2: Bollard Loads

Ice Load (ICE) Port Criteria

- Horizontal 10 kips/ft at El 0.0 and for Piles equal to 38 kips/ft at El +4.0

- Vertical on Piles is 160 kips Upward and 135 kips downward

6.2 Load Combinations (UFC 4-152-01)

6.2.1 Load and Resistance Factor Design

Table 6-1

Load and Resistance Factor Design

	U0	U1	U2	U3	U4	U5	U6	U7	U8	U9
D[a]	1.4	1.2	1.2	1.2	1.2	1.2	1.0+k	1.0-k	1.2	1.2
(Lc+I)|Lu	-	1.6[b]	-	1.6[b]	-	1.6[b]	0.1	-	1.6[b]	1.0
B	1.4	1.2	1.2	1.2	1.2	1.2	1.2	0.9	1.2	1.2
Be	-	-	1.6[c]	-	-	-	-	-	-	-
C	-	-	1.2	1.2	1.2	1.2	-	-	-	1.2
H[d]	-	1.6	1.6	1.6	1.6	1.6	1.0	1.0	1.6	1.6
Eq	-	-	-	-	-	-	1.0	1.0	-	-
W	-	-	-	-	1.0	-	-	-	-	1.0
M	-	-	-	-	-	1.6	-	-	-	-
R+S+T	-	-	-	1.2	-	-	-	-	-	-
Ice		-	-	0.5	-	-	-	-	1.0	1.0

6.2.2 Allowable Stress Design

Table 6-2

Allowable Stress Design

	S0	S1	S2	S3	S4	S5	S6	S7	S8	S9
D[a]	1.0	1.0	1.0	1.0	1.0	1.0	1+k'	1-k'	1.0	1.0
(Lc+I)|Lu	-	1.0	-	1.0	-	1.0	0.1	-	1.0	0.75
B	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.6	1.0	1.0
Be	-	-	1.0	-	-	-	-	-	-	-
C	-	-	1.0	1.0	1.0	1.0	-	-	1.0	1.0
H[d]	-	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Eq	-	-	-	-	-	-	0.7	0.7	-	-
W	-	-	-	-	0.6	-	-	-	-	0.6
M	-	-	-	-	-	1.0	-	-	-	-
R+S+T	-	-	-	1.0	-	-	-	-	-	-
Ice	-	-	-	0.2	-	-	-	-	0.7	0.7

6.3 Corrosion Protection

6.3.1 Protective Coating

All steel in contact with water, cell fill, or dredged material shall be coated. Other steel elements may not be coated at the discretion of the Engineer.

6.3.2 Cathodic Protection

Cathodic protection with sacrificial anode will be considered.

6.4 Materials

6.4.1 Concrete

Concrete shall be normal weight with a minimum comprehensive strength of 4,000 pounds per square inch (psi) at 28 days.

6.4.2 Reinforcing Steel

Reinforcing steel shall conform to the requirements of ASTM A615, Grade 60 or 75.

6.4.3 Structural Steel

Structural steel sheets and pipe piles shall conform to ASTM A572, Grade 50.

6.5 Regulatory Work

6.5.1 Wisconsin Department of Natural Resources

Wisconsin Department of Natural Resources (WDNR) is a delegated permitting authority, completing permitting reviews based on both state and federal regulations.

6.5.1.1 Chapter 30 and NR 200 Water Quality Certification

Wisconsin statute Chapter 30 lists regulations that apply to navigable waters, harbors, and navigation in waters of the state. However, Chapter 30 does not apply to areas that are within a lake bed grant area because it was granted from the State to a municipality, as stated in Chapter 30.05. The dredging of rivers in the Milwaukee Estuary AOC will be permitted under a Chapter 30 permit. Wisconsin Natural Resource Code Chapter 299 requires a Water Quality Certification that reviews if the placement of material within the Lake Bed Grant area is consistent with the public interest.

6.5.1.2 WPDES

Wisconsin Statutes and regulations require a WPDES permit for discharge into waters of the state. The WPDES permit is issued by the WDNR consistent with applicable federal and state requirements, and contains requirements that include discharge limitations, monitoring and reporting requirements, best management practices to minimize or remove risk to impacting human health and the environment. WDNR has determined that one WPDES permit will be issued covering all of the dredging projects discharging into the DMMF and not the DMMF facility as a whole.

6.5.2 U.S. Army Corps of Engineers

6.5.2.1 Section 404

A Section 404 review will be completed as part of the Individual Permit process by USACE to evaluate the facility due to the placement of fill and anticipated placement of dredged material within the DMMF.

6.5.2.2 Section 408

A Section 408 review will be completed by USACE to evaluate the impact to existing USACE facilities, in this case the Milwaukee DMDF and Milwaukee Harbor Federal channel. The 408 review will look at the impacts to hydraulics, operations, and if the intended use of the DMMF will negatively impact the structures owned by the USACE, including the authorized federal navigation channel. This review is being done as the new DMMF will rely on the North wall of the DMDF to provide containment, as well as to provide access to the Eastern wall of the DMMF.

6.5.3 U.S. Environmental Protection Agency

The U.S. Environmental Protection (USEPA) may choose to exercise their authority under Section 401 of the Clean Water Act to evaluate the proposed facility for impacts after the review by the WDNR. It is unknown at this time if they would choose to perform that review.

7 References

American Concrete Institute, 1999. *Details and Detailing of Concrete Reinforcement*, ACI 315-99. August 31, 1999.

American Concrete Institute, 2014. *Building Code Requirements for Structural Concrete*, ACI 318-14.

American Institute of Steel Construction (AISC). *Specifications for Structural Steel Buildings,* ANSI/AISC 360-16.

American Petroleum Institute, 2000. *Recommended Practice for Planning, Designing and Constructing Fixed Offshore Platforms – Working Stress Design*. December 2000.

American Society for Testing and Materials. ASTM Standard Practice A572 – Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel.

American Society for Testing and Materials. ASTM A615 – Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.

American Society of Civil Engineers. *Minimum Design Loads and Associated Criteria for Buildings and Other Structures*, ASCE 7-16.

ArcelorMittal, 2016. *Piling Handbook*, 9th edition, ISBN 978-99959-0-194-3.

ArcelorMittal, 2017. *Sheet Piling, Design & Execution Manual*, AS 500® Straight web steel sheet piles. August 2017.

Bray, Jonathan, T. Travasarou, & J. Zupan, 2010. Seismic Displacement Design of Earth Retaining Structures. Geotechnical Special Publication. 384. 638-655. 10.1061/41128 (384)65.

Foth Infrastructure & Environment, LLC, 2020a. *Metocean Report* – Milwaukee Estuary DMMF. June 2020.

Foth Infrastructure & Environment, LLC, 2020b. *Final Design Report* – Milwaukee Estuary DMMF. November 2020.

International Navigation Association (PIANC), 1984. *Guidelines for the Design of Fender Systems: 2002*, ISBN 2-87223-125-0.

Lew, Marshall, N. Sitar, & L. Atik, 2010. Seismic Earth Pressures: Fact or Fiction?. Geotechnical Special Publication. 384. 656-673. 10.1061/41128(384)66.

Naval Facilities Engineering Command, 2012. *Foundations and Earth Structures: NAVFAC Design Manual* 7.02.

Oil Companies International Marine Forum (OCIMF), 2018. *Mooring Equipment Guidelines (MEG4)*. June 2018.

Pile Buck, 1986. *Pile Buck® Steel Sheet Piling Design Manual*.

Tsinker, Gregory, 1997. *Handbook of Port and Harbor Engineering, Geotechnical and Structural Aspects.*

United Facilities Criteria, 2012. *Geotechnical Engineering*, UFC 3-220-01. November 1, 2012.

Unified Facilities Criteria, 2017. *Design: Piers and Wharves*, UFC 4-152-01. January 24, 2017.

U.S. Army Corps of Engineers, 1972. Milwaukee Harbor Drawings. May 15, 1972.

U.S. Army Corps of Engineers, 1989. *Design of Sheet Pile Cellular Structures Cofferdams and Retaining Structures*, EM-1110-2-2503. September 29, 1989.

U.S. Army Corps of Engineers, 1994. *Design of Sheet Pile Walls*, EM 1110-2-2504. March 31, 1994.

U.S. Army Corps of Engineers, 2008. *Phase II Report, Dredged Material Management Plan Study*. January 2008.

U.S. Army Corps of Engineers, 2015. *Dredging and Dredged Material Management*, EM 1110-2-5025. July 31, 2015.

U.S. Department of Transportation-Federal Highway Administration, 2002. *Geotechnical Engineering Circular No. 5 – Evaluation of Soil and Rock Properties*, FHWA-IF-02-034. April 2002.

U.S. Department of Transportation-Federal Highway Administration, 2017. *Geotechnical Engineering Circular No. 5 – Geotechnical Site Characterization*, FHWA-NHI-16-072. April 2017.

United States Steel, 1984. *Steel Sheet Piling Design Manual*. July 1984.