WATERTOWN, SOUTH DAKOTA
FLOOD RISK MANAGEMENT
GENERAL INVESTIGATIONS STUDY

FINAL INTEGRATED FEASIBILITY REPORT & ENVIRONMENTAL ASSESSMENT

APPENDIX D: STRUCTURAL ENGINEERING

OMAHA DISTRICT
NORTHWESTERN DIVISION

July 2026

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1 INTRODUCTION

The Watertown, SD area has experienced 11 major floods since 1943, averaging a major flood approximately once a decade. Watertown's susceptibility to flood damages has increased over time as the city has grown and development has increased around nearby Lake Kampeska and Pelican Lake. Major floods occurred in 1943, 1952, 1969, 1972, 1986, 1993, 1997, 2001, 2010, 2011, and 2019. The Watertown and Lake Kampeska area sustained flood damage to sewers, utilities, roads, rail spurs, life stations, boat docks, and more during all flood events. The 1997 flood event was the most severe flood on record for the Big Sioux River and Lake Kampeska.

The majority of floods occur in early spring during snowmelt and high amounts of rainfall. Due to the timing of the flood events, ice jams have occurred near Lake Kampeska and along the Big Sioux River by the bridges on 3rd Avenue, Kemp, and the railroad trussell which exacerbate the flood damages. The frequency of flood fights requires a lot of resources from the City of Watertown in terms of costs and manpower. During major flood events if there are impacts to the wastewater treatment plant, this can increase risks of releasing untreated water back into the Big Sioux River.

As a result of the flooding in 1969, a U.S. Army Corps of Engineers (USACE) Section 205 Flood Control Study (authorized by Section 205, 1948 Flood Control Act, as amended) for Watertown was completed in which multiple alternatives to reduce flood damages at Lake Kampeska and Watertown were screened. USACE also compiled a reconnaissance-level report on flood control for Watertown and the vicinity along the Big Sioux River in 1987 and FEMA investigated the existence and severity of flood hazards in Watertown. A USACE Feasibility Study on flood control for Watertown and vicinity was completed in 1994 and a USACE General Reevaluation Report was completed in 2000. As a result of information presented in these two reports, and a major flood event in 2001, USACE evaluated the Mahoney Creek Dry Dam control method.

Additionally, a Value Engineering (VE) Study and Economic Optimization Study were completed in 2012. USACE then started a Project Management Plan for a Feasibility Report Update & Environmental Assessment (FS/EA). Then RESPEC Company, LLC studied one-percent and 0.02-percent Annual Exceedance Probability (AEP) flood events in Watertown. This study, completed in 2019, determined Mahoney Creek Dry Dam would reduce peak flows as much as 95 percent. Due to strong public opposition in the basin, the Mahoney Creek Dry Dam never moved to the construction phase.

After a subsequent Letter of Request from the City of Watertown to re-study the area, Section 201(a)(62) of the Water Resources Development Act of 2022 authorized the funding for the Flood Risk Management (FRM) study on the Big Sioux River in Watertown and its vicinity. A Feasibility Cost Sharing Agreement was executed between USACE and the City (the Non-Federal Sponsor) on 19 August 2022 officially starting the feasibility study. The Watertown study area is shown in Figure 1. Existing flood fight measures are shown in Figure 2 below.

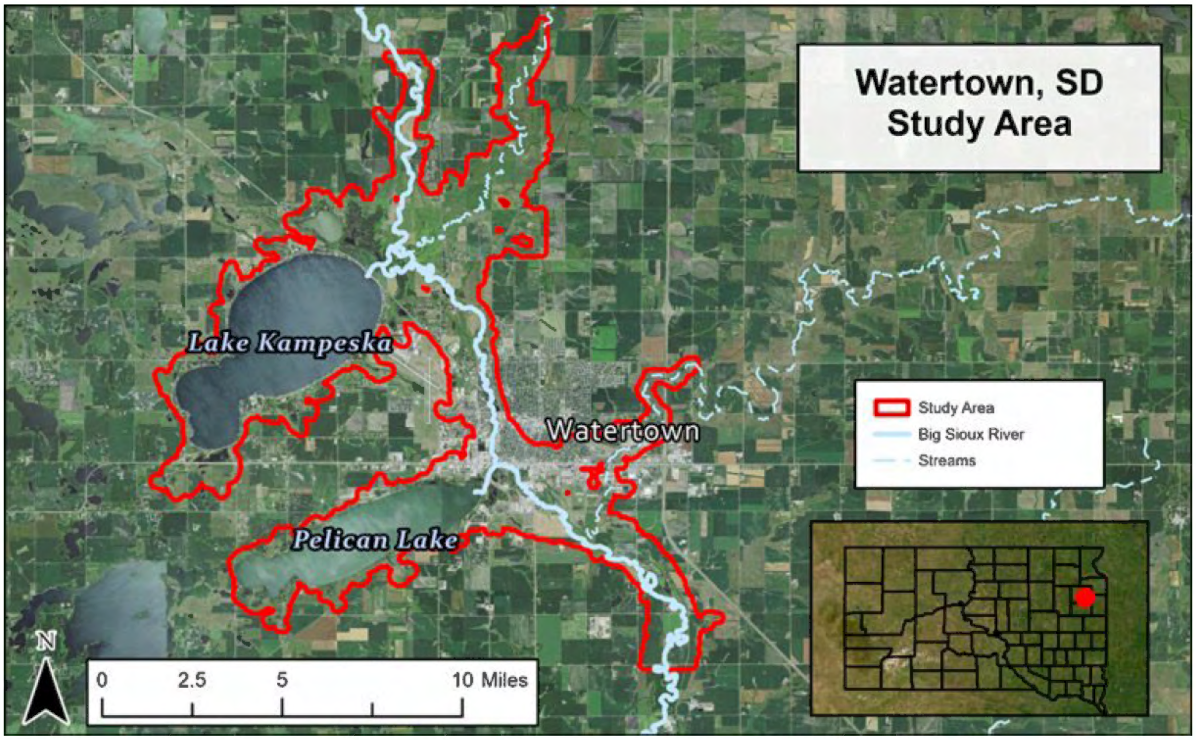


Figure 1. Watertown Study Area

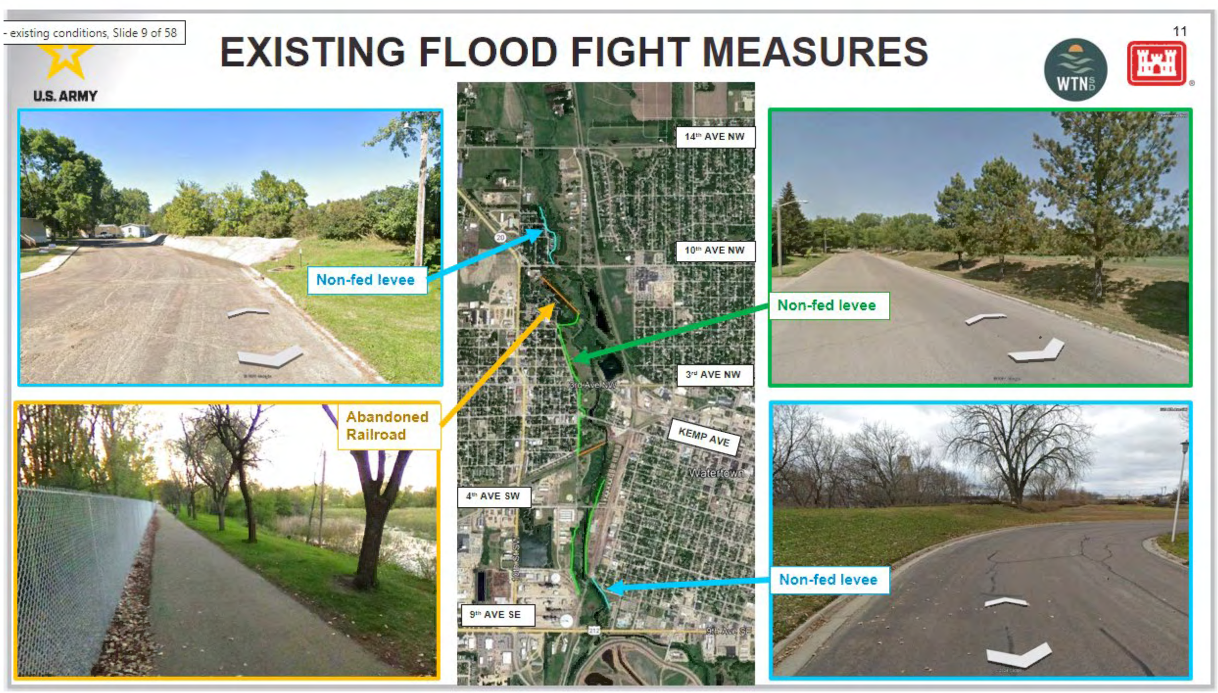


Figure 2. Watertown Existing Flood Fight Measures

2 ALTERNATIVES BEING CONSIDERED

The current study developed a comprehensive plan to address flood risk reduction in Watertown and vicinity; an array of structural and non-structural alternatives were formulated. Alternatives include measures such levee systems, floodwalls, channel widening, lowering Lake Kampeska, non-structural measures/ floodproofing non-residential buildings, or a combination of these. The following table shows the Final Array of Alternatives:

U.S. ARMY

24

FINAL ARRAY OF ALTERNATIVES

Initial Array of Alternatives

Alternative	Measures Included	Description
1	A	No Action
2	D, E	Channel widening + Levee Right/Left Banks
3	D, F	Channel widening + Levee Left Bank Only
4	D, G	Channel widening + Levee Right/Left Banks w/ Closure Structures.
5	B, D	Lowering Lake Kampeska + Channel Widening
6	B, E	Lowering Lake Kampeska + Levee Right/Left Banks
7	C, F	Lowering Lake Kampeska + Levee Left Bank Only
8	C, D, F	Lowering Lake Kampeska + Channel Widening + Levee Left Bank Only
9	C, D, E	Lowering Lake Kampeska + Channel Widening + Levee Right/Left Banks
10	C, D, G	Lowering Lake Kampeska + Channel Widening + Levee Right/Left Banks w/ Closure Structures
11	C, G	Lowering Lake Kampeska + Levee Right/Left Banks w/ Closure Structures
12	N	Nonstructural
13	C	Lowering Lake Kampeska

Interim Screening of Alternatives

Alternative	Description
1	No Action
6	Lowering Lake Kampeska to Elev 1718 + Levee Right/Left Banks (no closures)
7	Lowering Lake Kampeska to Elev 1718 + Levee Left Bank (no closures)
8	Lowering Lake Kampeska to Elev 1718 + Channel Widening + Levee Left Bank (no closures)
9	Lowering Lake Kampeska to Elev 1718 + Channel Widening + Levee Right/Left Banks (no closures)
10	Lowering Lake Kampeska to Elev 1718 + Channel Widening + Levee Right/Left Banks (all 4ft closure structures)
11a	Lowering Lake Kampeska to Elev 1718 + Levee Right/Left Banks (all 4ft closure structures)
11b	Lowering Lake Kampeska to Elev 1718 + Levee Right/Left Banks (one 3ft closure structure)
11c	Lowering Lake Kampeska to Elev 1718 + Levee Right/Left Banks (two 3-4ft closure structures)
12	Nonstructural

Final Array of Alternatives

Alternative
1
7
8
11b
11c
12

Table 1. Final Array of Alternatives

2.1 Alternative 8

Lowering Lake Kampeska to Elevation 1718 + Channel Widening + Levee Left Bank (no closures): This is a combination of lowering Lake Kampeska, constructing a levee on the left bank, and widening the channel of the Big Sioux River. The left bank levee would start near West Kemp Avenue and extend south where it would tie off just north of US-212. A T-shaped floodwall would be constructed around Watertown Iron and Metal. Channel widening would start just north of the bridge at 14th Avenue and continue south past US-212, where it crosses both 5th Street and 20th Avenue and ends approximately 1,600 feet south of the 20th Avenue bridge. The channel would be expanded for a total width of approximately 150 feet. See Figure 3 for a depiction of Alternative 8.

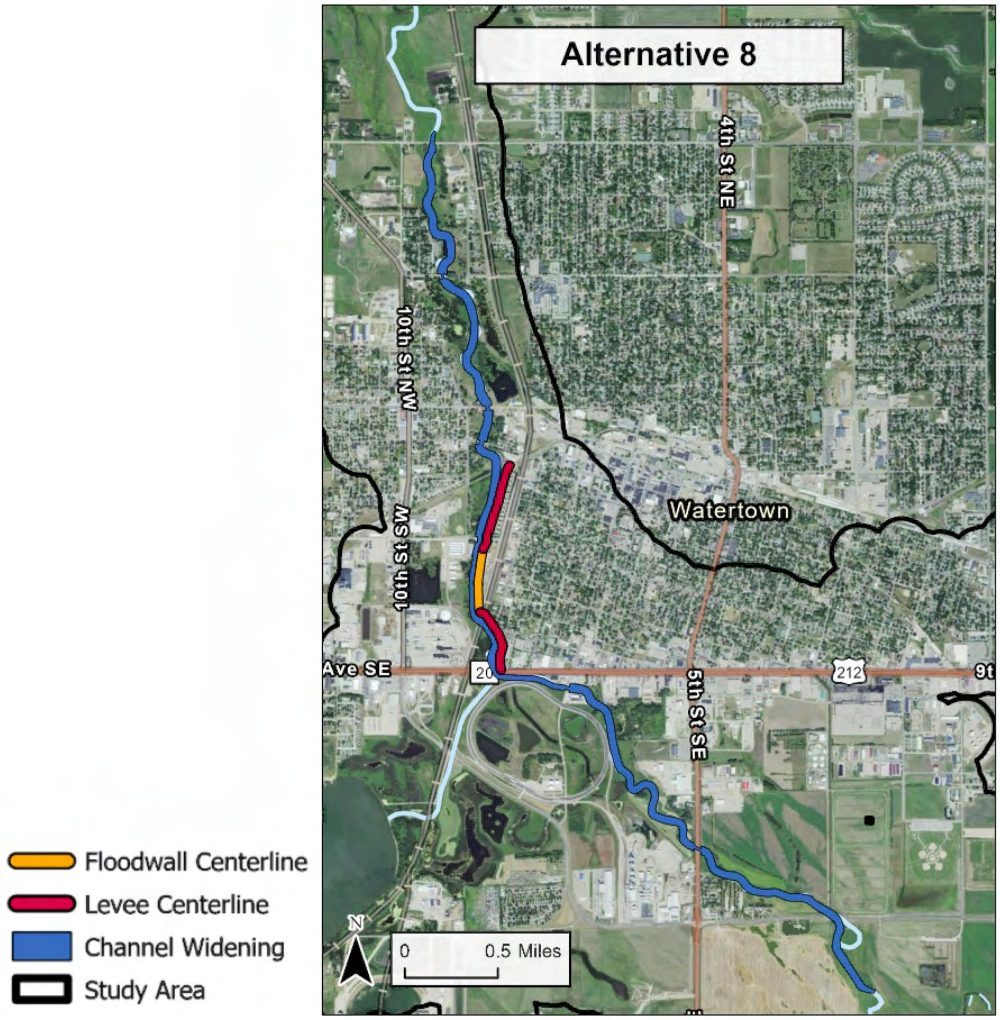


Figure 3. Alternative 8

2.2 Alternative 11B

Lowering Lake Kampeska to Elev 1718 + Levee Right/Left Bank (one 3-foot closure structure): This is a combination of lowering Lake Kampeska to elevation of 1718 and constructing levees along the left and right banks of the Big Sioux River. The right bank levee would start just north of 14th Avenue. and extend south until the railroad crossing. The left bank levee would start near West Kemp Avenue and extend south where it would tie off just north of US-212. A T-shaped floodwall would be constructed around Watertown Iron and Metal on the left bank and around a manufactured housing community on the right bank. On average, the embankment would be two-to-four feet tall with a twelve-foot-wide gravel-surfaced crest and 1:3 side slopes. Due to the height of the levees, there would be one three-foot closure structure required at 3rd Avenue along the right bank. The remaining crossings would utilize HESCO ® barriers (or similar) for closure structures during flood events. See Figure 4 below for a depiction of Alternative 11B.

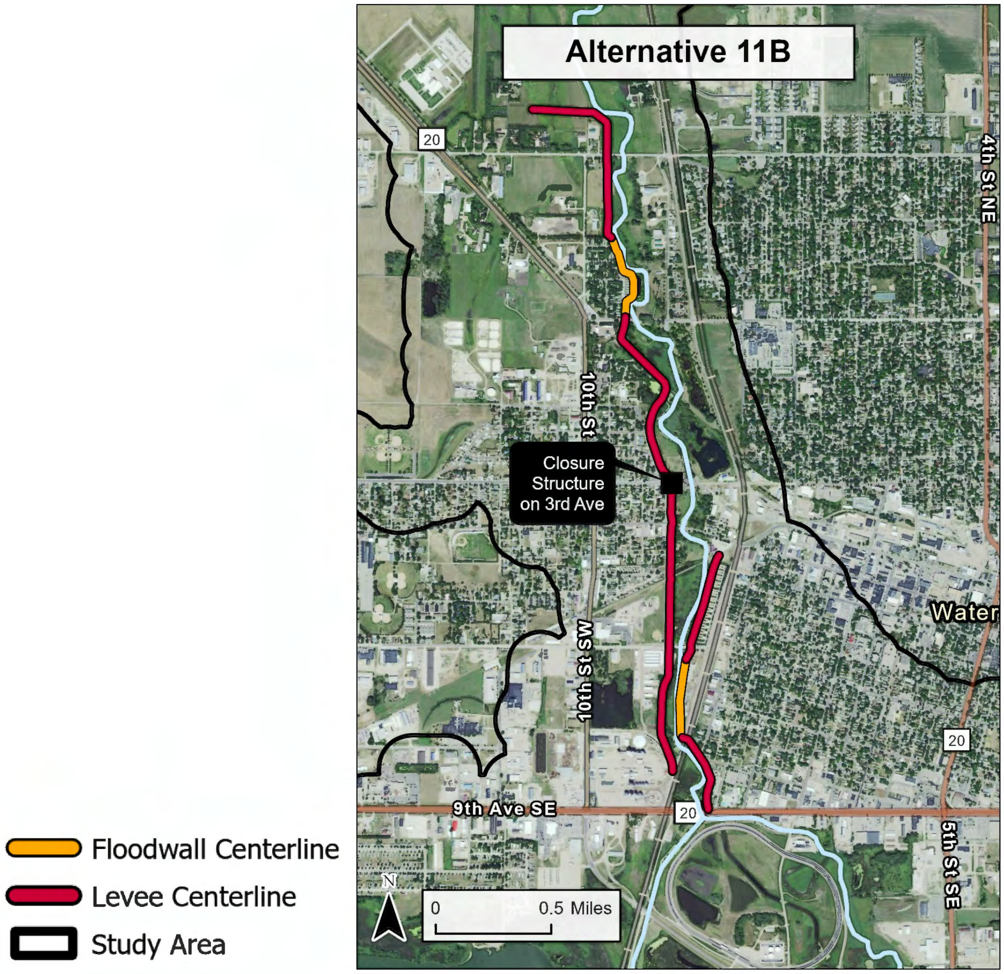


Figure 4. Alternative 11B

2.3 Alternative 11C

Lowering Lake Kampeska to Elev 1718 + Levee Right/Left Banks (two 3-4foot closure structures). This is a combination of lowering Lake Kampeska to elevation of 1718 and constructing levees along the left and right banks of the Big Sioux River. The right bank levee would start just north of 14th Avenue and extend south until the railroad crossing. The left bank levee would start near West Kemp Avenue and extend south where it would tie off just north of US-212. A T-shaped floodwall would be constructed around Watertown Iron and Metal on the left bank and around a manufactured housing community on the right bank. On average, the embankment would be 0.5 to 4 feet-tall with a twelve-foot-wide gravel surfaced crest and 1:3 sideslopes. Due to the height of the levees, there would be two closure structures required at 3rd Avenue and West Kemp Avenue along the right bank. The remaining crossings would utilize HESCO ® barriers (or similar) for closure structures during flood events. See Figure 5 below for a depiction of Alternative 11C.

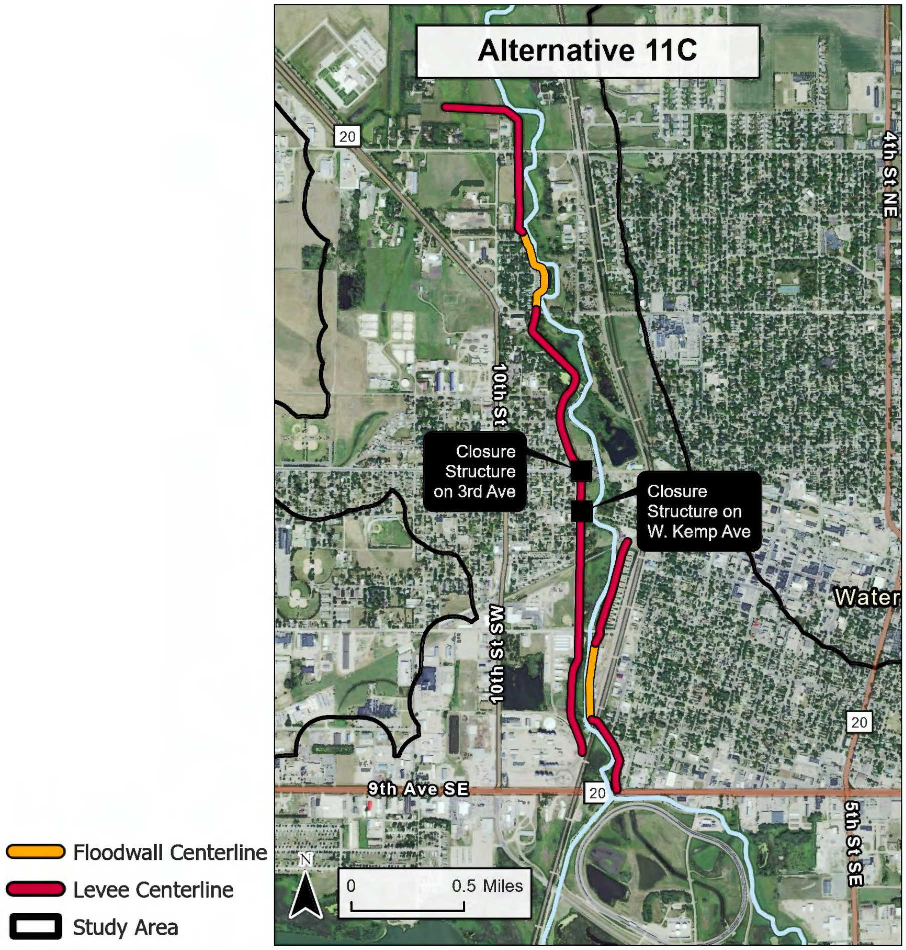


Figure 5. Alternative 11C

3 STRUCTURAL COMPONENTS

3.1 Floodwall

The flood wall will be a cast-in-place reinforced-concrete T-shaped wall, as shown in the structural drawing 6 on sheet S-301 (Attachment 1), and is designed to resist the hydrostatic and dynamic flood pressures. The wall's foundation will extend 4.5 feet below grade to protect against frost heave. Thirty-foot sheet piles have been incorporated to the design to prevent seepage, as recommended by the geotechnical engineer. Each wall monolith is 12 feet in length, with water stops provided between segments. The quantity, length, and height of the walls are detailed in Table 2.

Table 2: Floodwall Height and Length

LOCATION	WATERTOWN FLOODWALL QUANTITY (1 % AEP)			
	HEIGHT H (FT)	STRUCTURE LENGTH (FT)	CONCRETE (CUF)	SHHET PILE (SF)
LEFT BANK / 2 FT HEIGHT FLOODWALL	2	1,287	25,354	38,610
TOTAL		1,287	25,354	38,610

3.2 Design Criteria

The following references were used in preparing the structural design:

- American Association of State Highway and Transportation Officials (AASHTO) Publications
- AASHTO LRFD Bridge Design Specification (2015)
- American Concrete Institute (ACI) Publications
- Building Code Requirements for Reinforced Concrete
- American Society of Civil Engineers (ASCE) Publications
  - ASCE 7-16 Minimum Design Loads for Buildings and Other Structures
- The Unified Facilities Criteria (UFC)
  - UFC 3 301 01 Structural Engineering
- Engineering Manuals (EM)
  - EM 1110-2-1913 Design and Construction of Levees 2000
  - EM 1110-2-2100 Stability Analysis of Concrete Structures 2005
  - EM 1110-2-2104 Strength Design for Reinforced Concrete Hydraulic Structures 2016
  - EM 1110-2-2107 Design of Hydraulic Steel Structures 2022
  - EM 1110-2-2502 Flood Walls and Other Hydraulic Retaining Walls 2022
  - EM 1110-2-2902 Conduits, Pipes, and Culverts associated with Dams and Levee Systems 2020

3.3 Design Loads and Conditions

Seismic Loads:

- Site Class: D
- PGA: 0.08g
- Ss: 0.16g
- S1: 0.06g
- Fa: 1.6
- Fv: 2.4

Hydrostatic Loading: The floodwall is designed for hydrostatic and dynamic loading during flooding with saturated soil.

Embankment Loads: Soil loads from top and sides of the foundation.

Construction Loading: The construction loads include the weight of the equipment (including compactors).

Foundation Design Criteria:

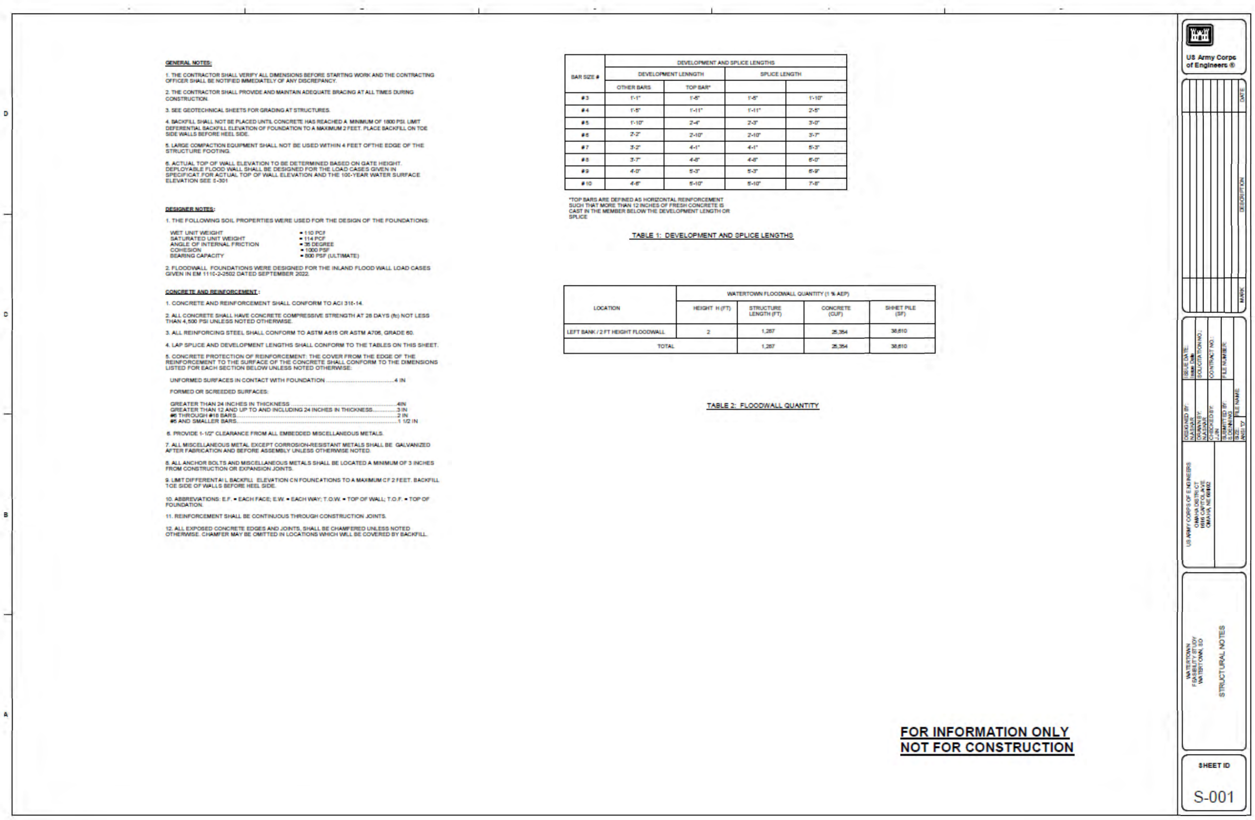
- Design frost depth = 4.5 ft. below finish grade
- Soil Bearing Capacity = 800 psf
- Lateral earth pressure coefficients:
- Ka = 0.32, Kp = 3.12, Ko = 0.48
- Effective Friction Angle = 20°
- Unit Weight of Soil (Saturated): 114 pcf
- Unit Weight of Soil (Wet): 110 pcf
- Sliding Coefficient (Soil vs. Concrete): 0.40

Strengths:

Structural materials of the following strengths were used for design:

- Concrete: f'c = 4,500 psi at 28 days.
- Reinforcing Steel: fy = 60,000 psi, Grade 60.

ATTACHMENT 1: STRUCTURAL DRAWINGS



GENERAL NOTES:

1. THE CONTRACTOR SHALL VERIFY ALL DIMENSIONS BEFORE STARTING WORK AND THE CONTRACTING OFFICER SHALL BE NOTIFIED IMMEDIATELY OF ANY DISCREPANCY.

2. THE CONTRACTOR SHALL PROVIDE AND MAINTAIN ADEQUATE BRACING AT ALL TIMES DURING CONSTRUCTION.

3. SEE GEOTECHNICAL SHEETS FOR GRADING AT STRUCTURES.

4. BACKFILL SHALL NOT BE PLACED UNTIL CONCRETE HAS REACHED A MINIMUM OF 1800 PSI. LIMIT DEFERENTIAL BACKFILL ELEVATION OF FOUNDATION TO A MAXIMUM 2 FEET. PLACE BACKFILL ON TOE SIDE WALLS BEFORE HEEL SIDE.

5. LARGE COMPACTION EQUIPMENT SHALL NOT BE USED WITHIN 4 FEET OFTHE EDGE OF THE STRUCTURE FOOTING.

6. ACTUAL TOP OF WALL ELEVATION TO BE DETERMINED BASED ON GATE HEIGHT. DEPLOYABLE FLOOD WALL SHALL BE DESIGNED FOR THE LOAD CASES GIVEN IN SPECIFICAT. FOR ACTUAL TOP OF WALL ELEVATION AND THE 100-YEAR WATER SURFACE ELEVATION SEE S-301

DESIGNER NOTES:

1. THE FOLLOWING SOIL PROPERTIES WERE USED FOR THE DESIGN OF THE FOUNDATIONS:

WET UNIT WEIGHT = 110 PCF
SATURATED UNIT WEIGHT = 114 PCF
ANGLE OF INTERNAL FRICTION = 35 DEGREE
COHESION = 1000 PSF
BEARING CAPACITY = 800 PSF (ULTIMATE)

2. FLOODWALL FOUNDATIONS WERE DESIGNED FOR THE INLAND FLOOD WALL LOAD CASES GIVEN IN EM 1110-2-2502 DATED SEPTEMBER 2022.

CONCRETE AND REINFORCEMENT :

1. CONCRETE AND REINFORCEMENT SHALL CONFORM TO ACI 318-14.

2. ALL CONCRETE SHALL HAVE CONCRETE COMPRESSIVE STRENGTH AT 28 DAYS (f'c) NOT LESS THAN 4,500 PSI UNLESS NOTED OTHERWISE.

3. ALL REINFORCING STEEL SHALL CONFORM TO ASTM A615 OR ASTM A706, GRADE 60.

4. LAP SPLICE AND DEVELOPMENT LENGTHS SHALL CONFORM TO THE TABLES ON THIS SHEET.

5. CONCRETE PROTECTION OF REINFORCEMENT: THE COVER FROM THE EDGE OF THE REINFORCEMENT TO THE SURFACE OF THE CONCRETE SHALL CONFORM TO THE DIMENSIONS LISTED FOR EACH SECTION BELOW UNLESS NOTED OTHERWISE:

UNFORMED SURFACES IN CONTACT WITH FOUNDATION .... 4 IN

FORMED OR SCREEDED SURFACES:

GREATER THAN 24 INCHES IN THICKNESS 4IN
GREATER THAN 12 AND UP TO AND INCLUDING 24 INCHES IN THICKNESS .... 3 IN
#6 THROUGH #18 BARS .... 2 IN
#5 AND SMALLER BARS .... 1 1/2 IN

6. PROVIDE 1-1/2" CLEARANCE FROM ALL EMBEDDED MISCELLANEOUS METALS.

7. ALL MISCELLANEOUS METAL EXCEPT CORROSION-RESISTANT METALS SHALL BE GALVANIZED AFTER FABRICATION AND BEFORE ASSEMBLY UNLESS OTHERWISE NOTED.

8. ALL ANCHOR BOLTS AND MISCELLANEOUS METALS SHALL BE LOCATED A MINIMUM OF 3 INCHES FROM CONSTRUCTION OR EXPANSION JOINTS.

9. LIMIT DIFFERENTAIL BACKFILL ELEVATION ON FOUNDATIONS TO A MAXIMUM OF 2 FEET. BACKFILL TOE SIDE OF WALLS BEFORE HEEL SIDE.

10. ABBREVIATIONS: E.F. = EACH FACE; E.W. = EACH WAY; T.O.W. = TOP OF WALL; T.O.F. = TOP OF FOUNDATION.

11. REINFORCEMENT SHALL BE CONTINUOUS THROUGH CONSTRUCTION JOINTS.

12. ALL EXPOSED CONCRETE EDGES AND JOINTS, SHALL BE CHAMFERED UNLESS NOTED OTHERWISE. CHAMFER MAY BE OMITTED IN LOCATIONS WHICH WILL BE COVERED BY BACKFILL.

BAR SIZE #	DEVELOPMENT AND SPLICE LENGTHS			
	DEVELOPMENT LENNGTH		SPLICE LENGTH	
	OTHER BARS	TOP BAR*		
# 3	1'-1"	1'-8"	1'-8"	1'-10"
# 4	1'-5"	1'-11"	1'-11"	2'-5"
# 5	1'-10"	2'-4"	2'-3"	3'-0"
# 6	2'-2"	2'-10"	2'-10"	3'-7"
# 7	3'-2"	4'-1"	4'-1"	5'-3"
# 8	3'-7"	4'-8"	4'-8"	6'-0"
# 9	4'-0"	5'-3"	5'-3"	6'-9"
# 10	4'-6"	5'-10"	5'-10"	7'-8"

*TOP BARS ARE DEFINED AS HORIZONTAL REINFORCEMENT SUCH THAT MORE THAN 12 INCHES OF FRESH CONCRETE IS CAST IN THE MEMBER BELOW THE DEVELOPMENT LENGTH OR SPLICE

TABLE 1: DEVELOPMENT AND SPLICE LENGTHS

LOCATION	WATERTOWN FLOODWALL QUANTITY (1 % AEP)			
	HEIGHT H (FT)	STRUCTURE LENGTH (FT)	CONCRETE (CUF)	SHHET PILE (SF)
LEFT BANK / 2 FT HEIGHT FLOODWALL	2	1,287	25,354	38,610
TOTAL		1,287	25,354	38,610

TABLE 2: FLOODWALL QUANTITY

Figure 6. Structural Sheet S-001, Structural Notes

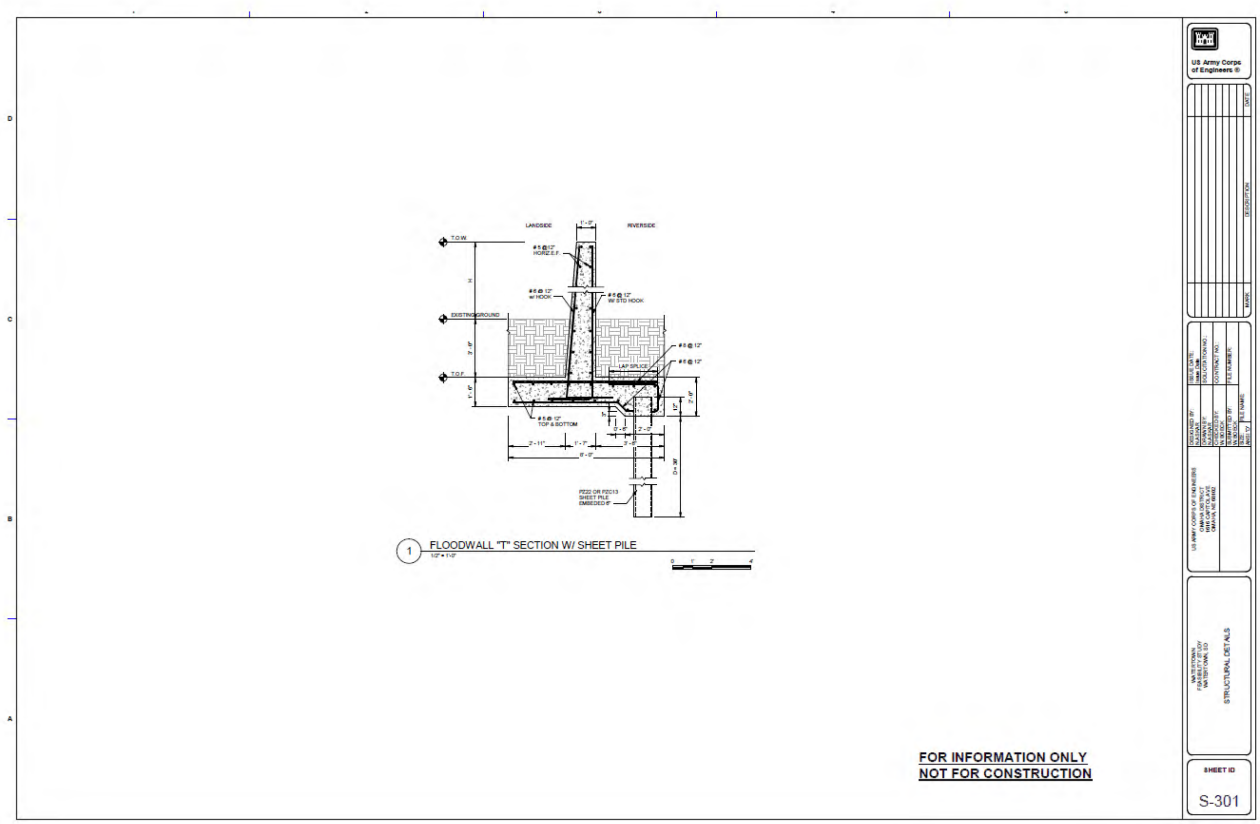


Figure 7. Structural Sheet S-301, Structural Details