SRR-CWDA-2021-00026
Revision 0

March 8, 2021

TO: Brittany Brush, 705-1C

FROM: Steven P. Hommel, 705-1C Steven Hommel Digitally signed by Steven Hommel Date: 2021.03.08 07:50:51 -05'00'

REVIEWER: Bailey Arnett, 705-1C Bailey E. Arnett Digitally signed by Bailey E. Arnett Date: 2021.03.08 09:48:28 -05'00'

SUBJECT: Recommended Geometry Parameters for Selected Closure Caps

This memorandum uses designs for long-term closure caps for selected facilities to provide recommended side slope and surface geometry parameters to use in evaluating long-term slope stability.

The selected facilities considered herein are the F-Tank Farm (FTF), the H-Tank Farm (HTF), and the Saltstone Disposal Facility (SDF). Table 1 summarizes the references for the closure cap designs for these facilities.

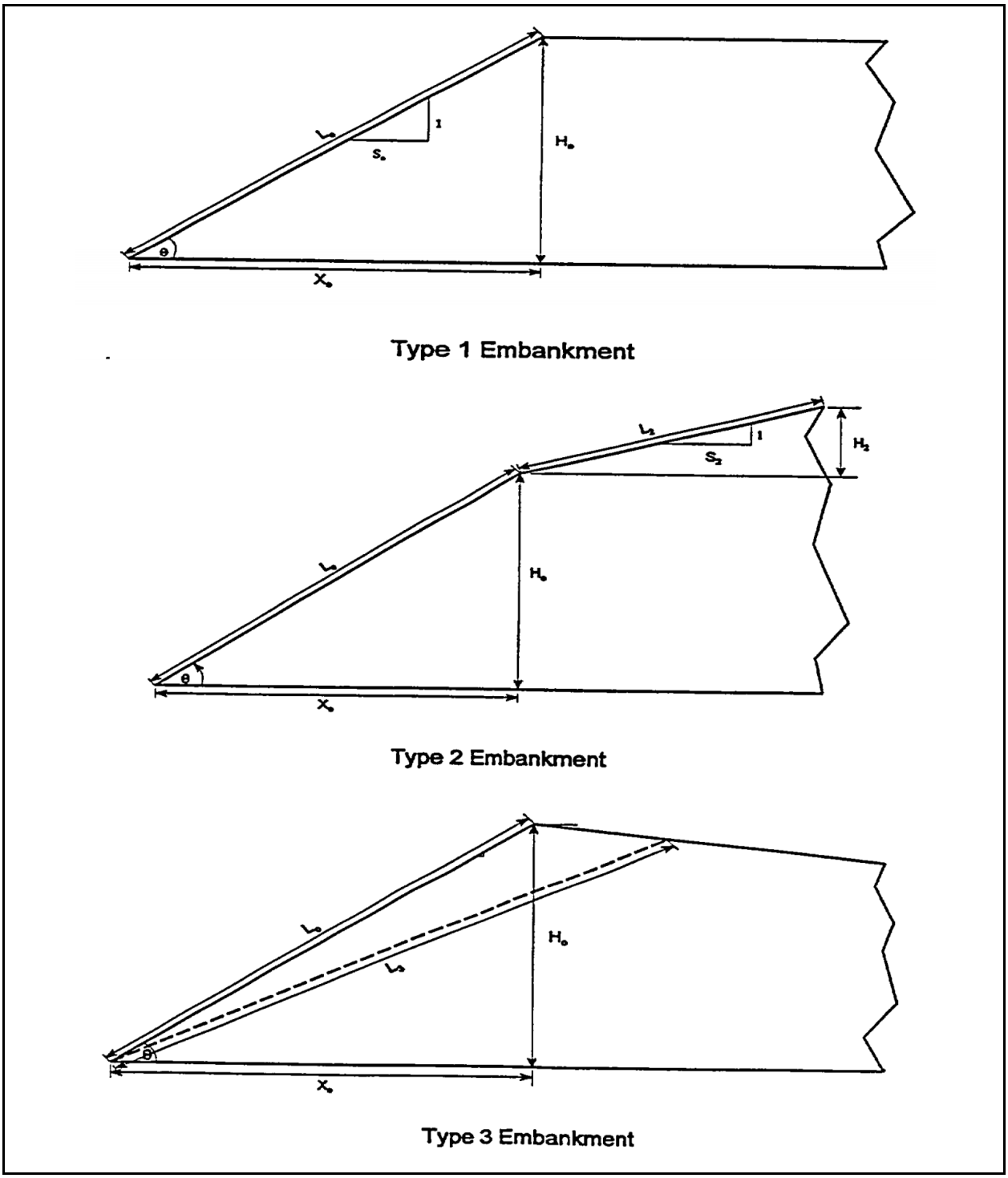
Table 1. References for Closure Cap Designs for Selected Facilities

Facility	Reference for Closure Cap Design
FTF	SRR-CWDA-2019-00081
HTF	SRR-CWDA-2019-00080
SDF	SRR-CWDA-2018-00087

The U.S. Nuclear Regulatory Commission (NRC) report, *Design of Erosion Protection for Long-Term Stabilization* (NUREG-1623 [ML022530043]), provides a number of analytical approaches for evaluating slope stability. To use these approaches, one of the first steps is determining the type of embankment geometry that best applies to the system. Figure 1 shows the three types of embankment geometries.

Based on the facility closure cap designs (as referenced per Table 1), all of the closure caps are best defined by the Type 2 embankment geometry.

Figure 1: Three Types of Embankment Geometries from NUREG-1623 [ML022530043]



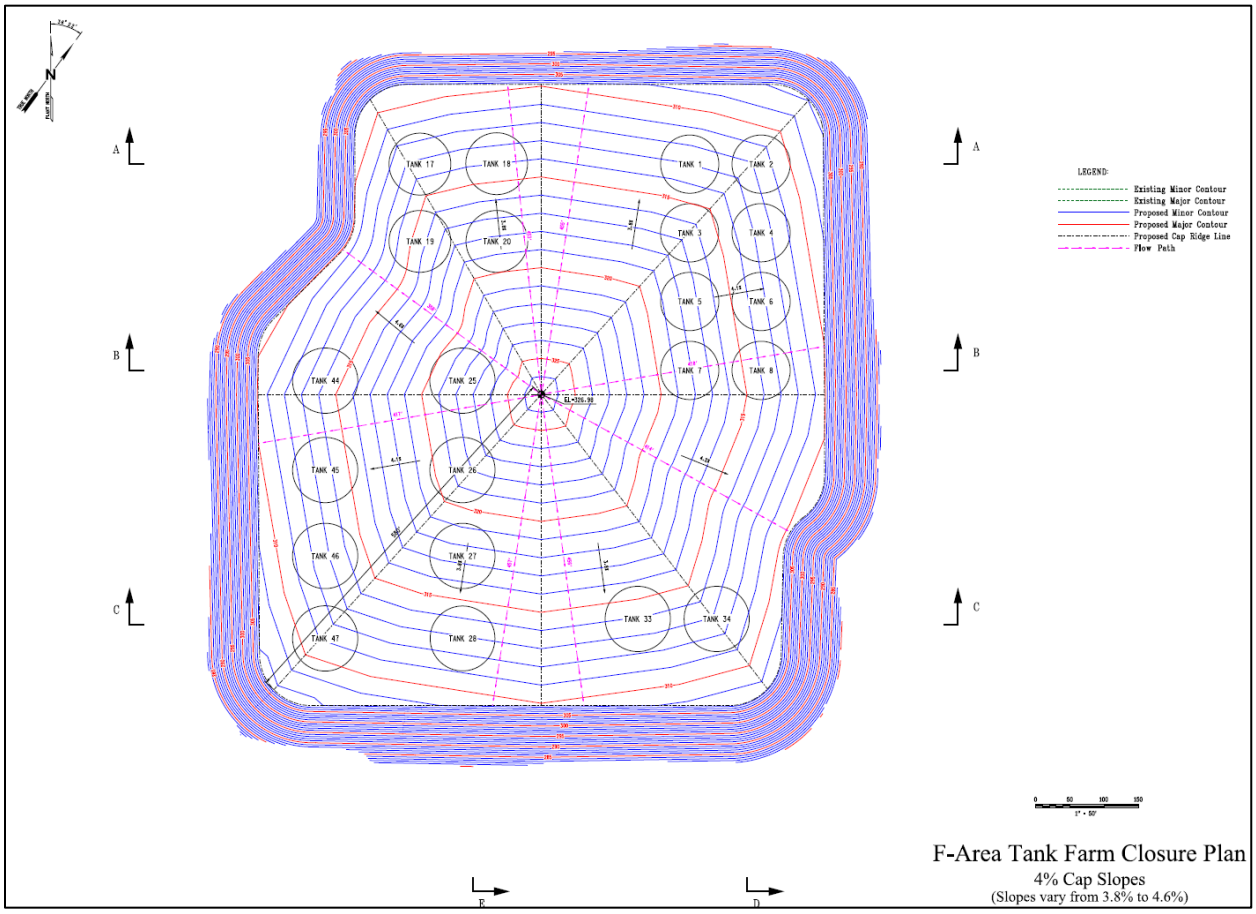
Note: Figure copied from best available copy of reference. Reference: Fig. B-4 from NUREG-1623 [ML022530043]

Using the selected Type 2 embankment geometry, a minimum of eight inputs are needed to assess the slope stability according to various formulas discussed in NUREG-1623. These inputs are:

1. The angle (θ) of the embankment (or side slope) in degrees,
2. The length (L_0) of the surface of the embankment (or side slope) in feet,
3. The length (L_2) of the top surface of the closure cap in feet,
4. The height (H_0) of the embankment (or side slope) in feet,
5. The height (H_2) of the top surface of the closure cap in feet (starting from the top of the embankment),
6. The horizontal distance (X_0) of the embankment (or side slope) in feet,
7. The horizontal distance (X_2) of the top surface of the closure cap in feet, and
8. The slope (S_2) of the top surface of the closure cap (given as rise over run).

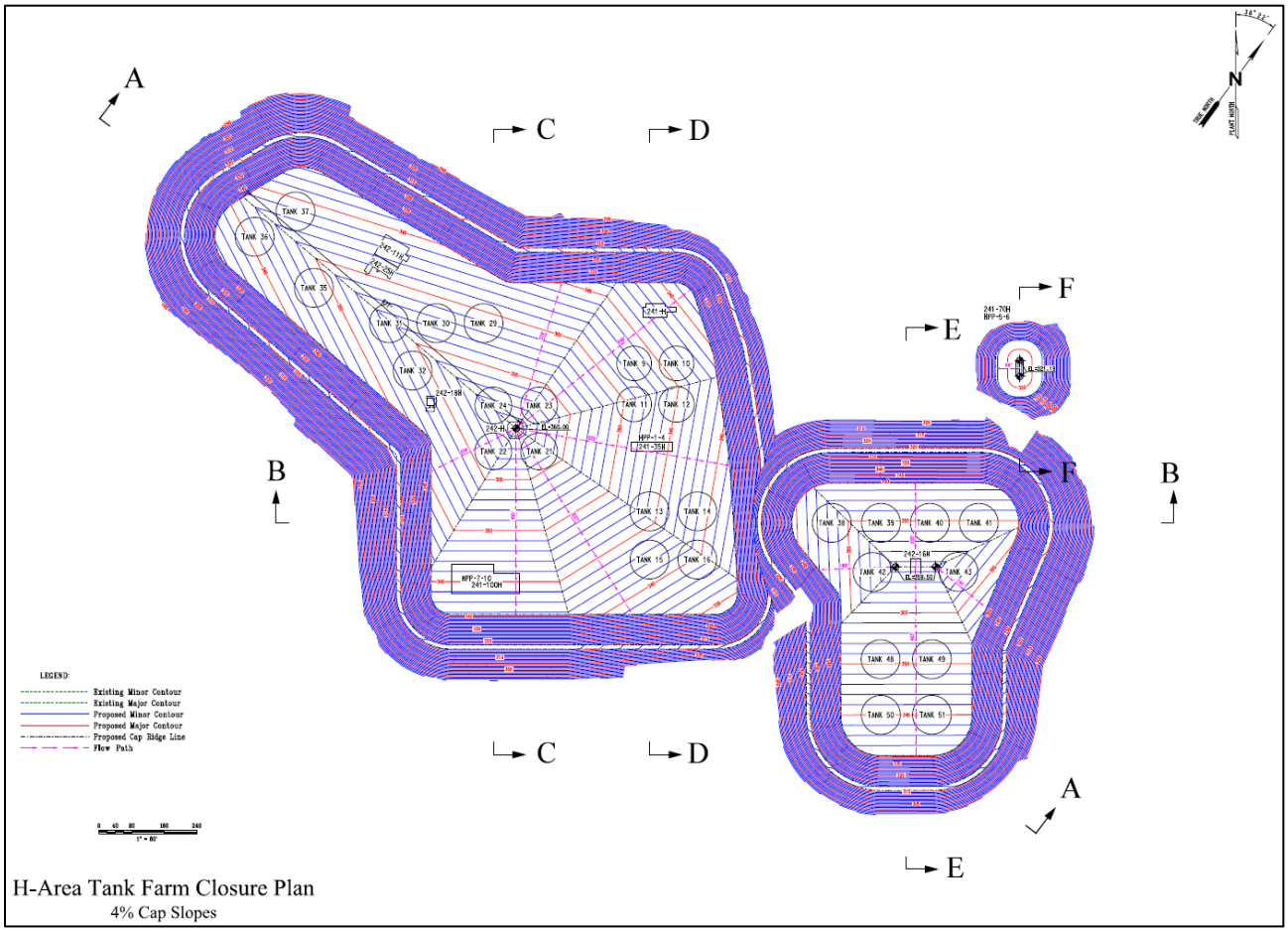
To determine Item 5 (height of the top surface, H_2) and Item 3 (the length of the top surface, L_2), the first step was to determine the values for Item 8 (slope of the top surface of the closure cap, S_2). These were provided on the layout views of each of the closure cap designs. These are depicted here as Figures 2, 3, and 4 for FTF, HTF, and SDF, respectively. It is noted that the resolution of the values for these slopes is not clear in this memorandum, so the references from which these figures were taken should be consulted.

Figure 2: FTF Closure Cap Design, Plan Layout



Reference: SRR-CWDA-2019-00081

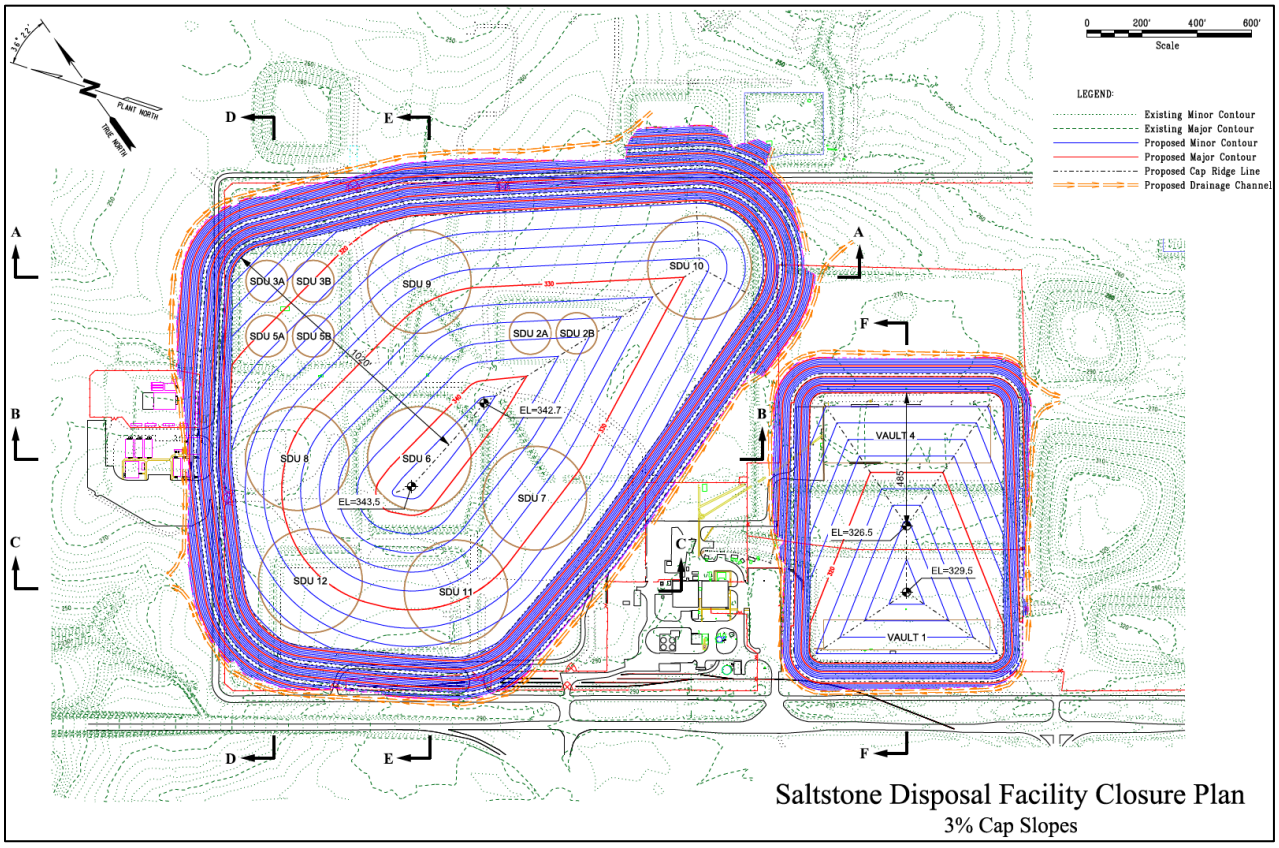
Figure 3: HTF Closure Cap Design, Plan Layout



H-Area Tank Farm Closure Plan
4% Cap Slopes

Reference: SRR-CWDA-2019-00080

Figure 4: SDF Closure Cap Design, Plan Layout



Reference: SRR-CWDA-2018-00087

On these layout figures, the slopes (S_2) of the top surfaces of the closure caps are shown (as percentages) in either the lower left or lower right of each figure.

- FTF = 4% slope (or a rise-over-run of 4 ft for every 100 ft),
- HTF = 4% slope (or a rise-over-run of 4 ft for every 100 ft), and
- SDF = 3% slope (or a rise-over-run of 3 ft for every 100 ft).

For FTF and HTF, pink dashed lines show various slope lengths for slopes perpendicular to the directions of flow. The highest of these values indicates the maximum horizontal length of the respective top surface slopes. For the SDF, black arrows show the maximum slope lengths for slopes perpendicular to the directions of flow. These are the values for Item 7 (horizontal distance of the top surface of the closure cap, X_2):

- FTF = 457 ft of horizontal distance,
- HTF = 546 ft of horizontal distance, and
- SDF = 1,020 ft of horizontal distance.

Using these slopes (S_2) and the respective horizontal distances (X_2), Item 5 (height of the top surface, H_2), can then be estimated as:

$$H_2 = S_2 \times X_2$$

Such that the tops of the closure caps have the following heights (H_2):

- FTF = 18.3 ft,
- HTF = 21.8 ft, and
- SDF = 30.6 ft.

With horizontal distances (X_2) and heights (H_2) of the top surfaces of the closure caps defined, the length of the top surface (L_2) may be estimated using the Pythagorean theorem and solving for the hypotenuse of a right triangle:

$$L_2 = \sqrt{((H_2)^2 + (X_2)^2)}$$

Such that the lengths of the top surfaces (L_2) of the closure caps are:

- FTF = 457.4 ft,
- HTF = 546.4 ft, and
- SDF = 1,020.5 ft.

To determine the other recommended values for each of these inputs, cross-section figures from each of the closure cap references (in Table 1) were closely examined. These cross-section figures are provided (at a smaller scale) in Appendix A. As described in Appendix A, blue rectangles were superimposed over each of the figures. These rectangles were used as guides during the development of the recommended input values.

For each facility (FTF, HTF, and SDF) multiple cross-sections were used. Two simplifying assumptions were used during the development of the input values. First, for cross-sections that included terraces (i.e., benches at intermediate heights along the side slopes), the terraces were ignored; only the top and bottom elevations of each of the side slopes were used. Second, even though there are multiple cross-sections, only the maximum values across all the cross-sections for a given facility are recommended as inputs. For complete details of each of the cross-sectional geometries, refer to Appendix B.

Table 2 provides the recommended slope geometry inputs for FTF, HTF, and SDF based on the evaluations of the geometries.

Table 2. Summary of Closure Cap Geometry Inputs

Input #	Symbol	Input Description	FTF	HTF	SDF
1	θ	Angle of the embankment (or side slope) in degrees	19.7	19.0	18.1
2	L_0	Length of the surface of the embankment (or side slope) in feet	92.9	206.6	219.7
3	L_2	Length of the top surface of the closure cap in feet	457.4	546.4	1,020.5
4	H_0	Height of the embankment (or side slope) in feet	29.5	58.0	61.8
5	H_2	Height of the top surface of the closure cap in feet (starting from the top of the embankment)	18.3	21.8	30.6
6	X_0	Horizontal distance of the embankment (or side slope) in feet	88.0	201.5	210.8
7	X_2	Horizontal distance of the top surface of the closure cap in feet	457.0	546.0	1,020.0
8	S_2	Slope of the top surface of the closure cap (given as rise over run).	0.04 (4%)	0.04 (4%)	0.03 (3%)

References

NUREG-1623 [ML022530043], Johnson, T. L., *Design of Erosion Protection for Long-Term Stabilization*, Final Report, U.S. Nuclear Regulatory Commission, Office of Nuclear Regulatory Material Safety and Safeguards, Washington, DC, August 2002.

SRR-CWDA-2018-00087, Coffield, T.W., *Saltstone Disposal Facility Closure Cap Concept Update for Large-Scale Disposal Units* [Attachments], Savannah River Site, Aiken, SC, Rev. 1, April 2019.

SRR-CWDA-2019-00080, Coffield, T.W., *2019 PA HTF Tank Farm Closure Cap Concepts*, [Attachments], Savannah River Site, Aiken, SC, Rev. 0, September 2019.

SRR-CWDA-2019-00081, Coffield, T.W., *2019 PA FTF Tank Farm Closure Cap Concepts*, [Attachments], Savannah River Site, Aiken, SC, Rev. 0, September 2019.

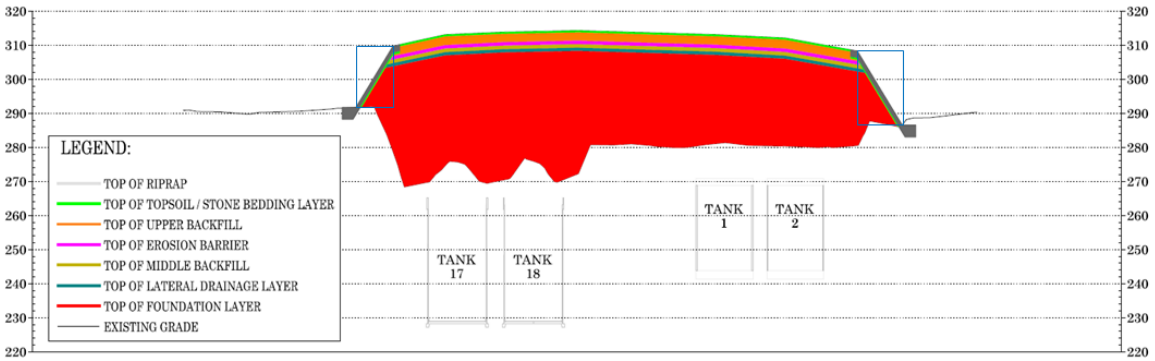
Appendix A

This appendix provides copies of each of the closure cap cross-sections that were used to develop the inputs discussed herein.

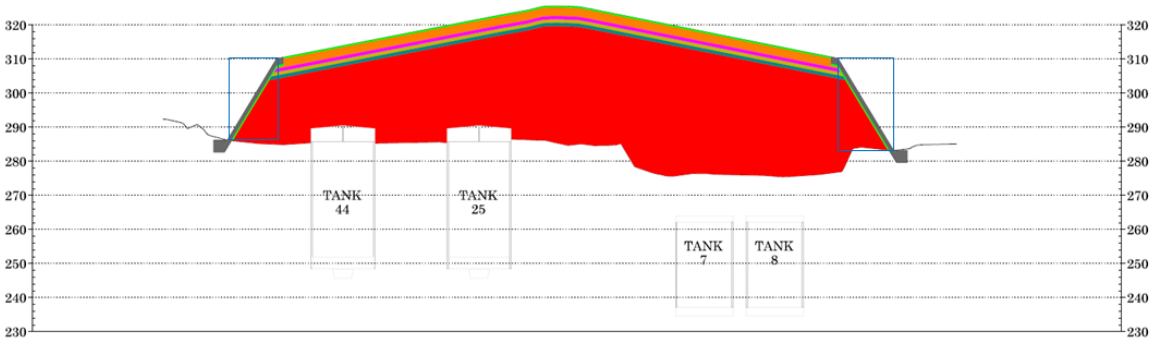
Measurements were done by copying these figures from the original references (Table 1) and pasting them into Microsoft PowerPoint, then zooming in to each figure to ensure better precision in the estimated values. Blue rectangles have been superimposed over each of these cross-section figures; these rectangles were used as guides during the development of the measurements and/or they were used to assist in the conversions of scales.

Note that for HTF, the cross-section F-F was not evaluated because it was clear that this portion of the HTF closure cap would not represent any of the maximum values.

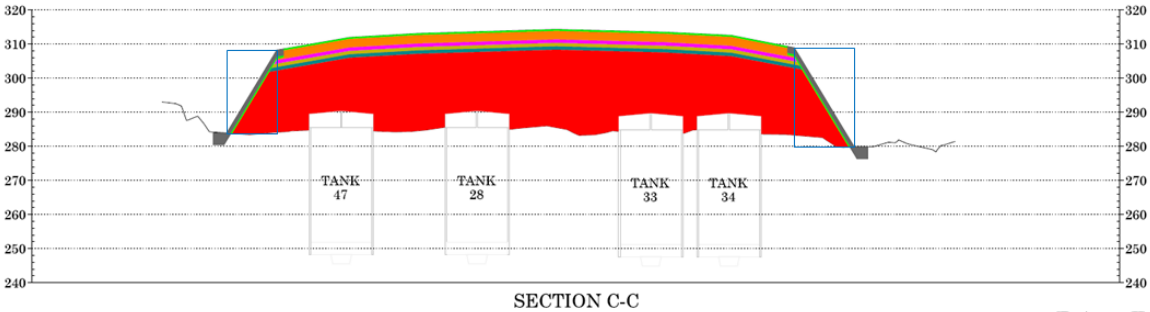
Figure A1: FTF Closure Cap Cross-Sections A-A, B-B, and C-C



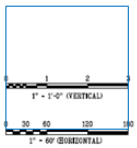
SECTION A-A



SECTION B-B



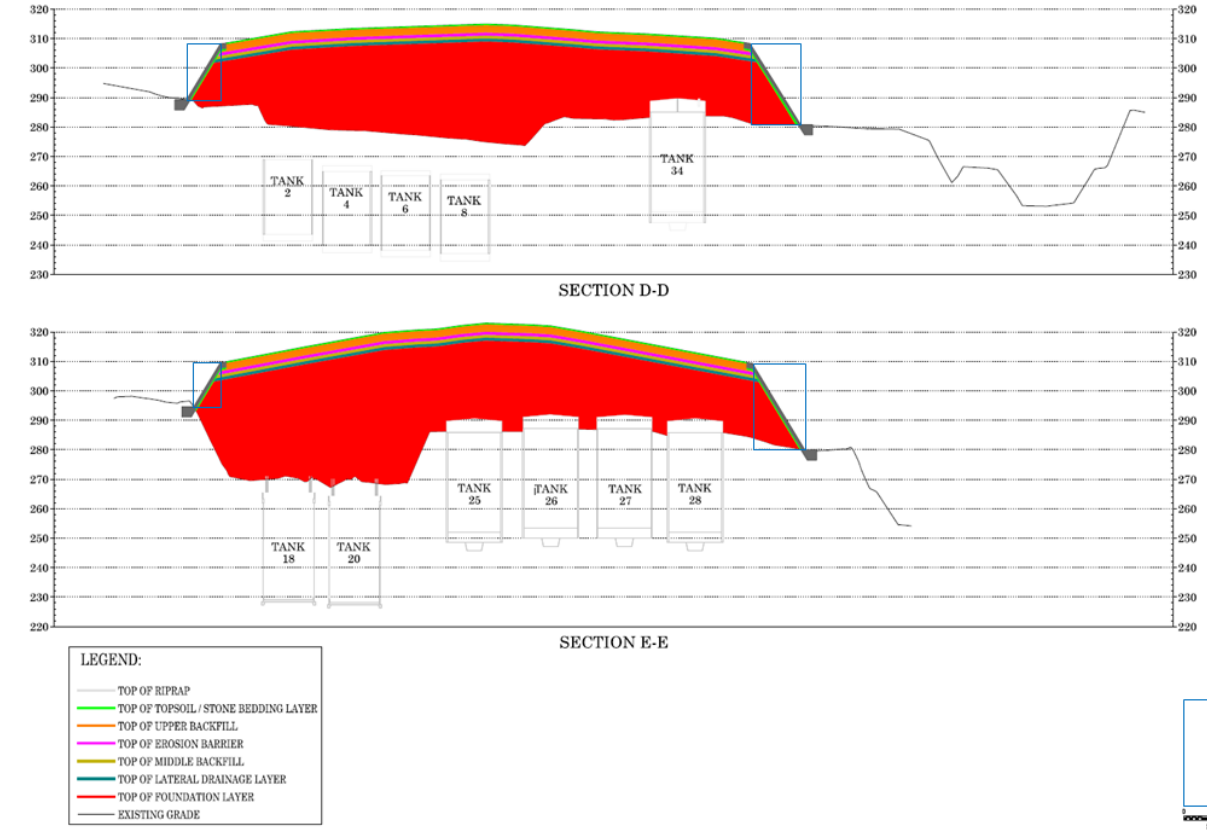
SECTION C-C



F-Area Tank Farm Closure Plan

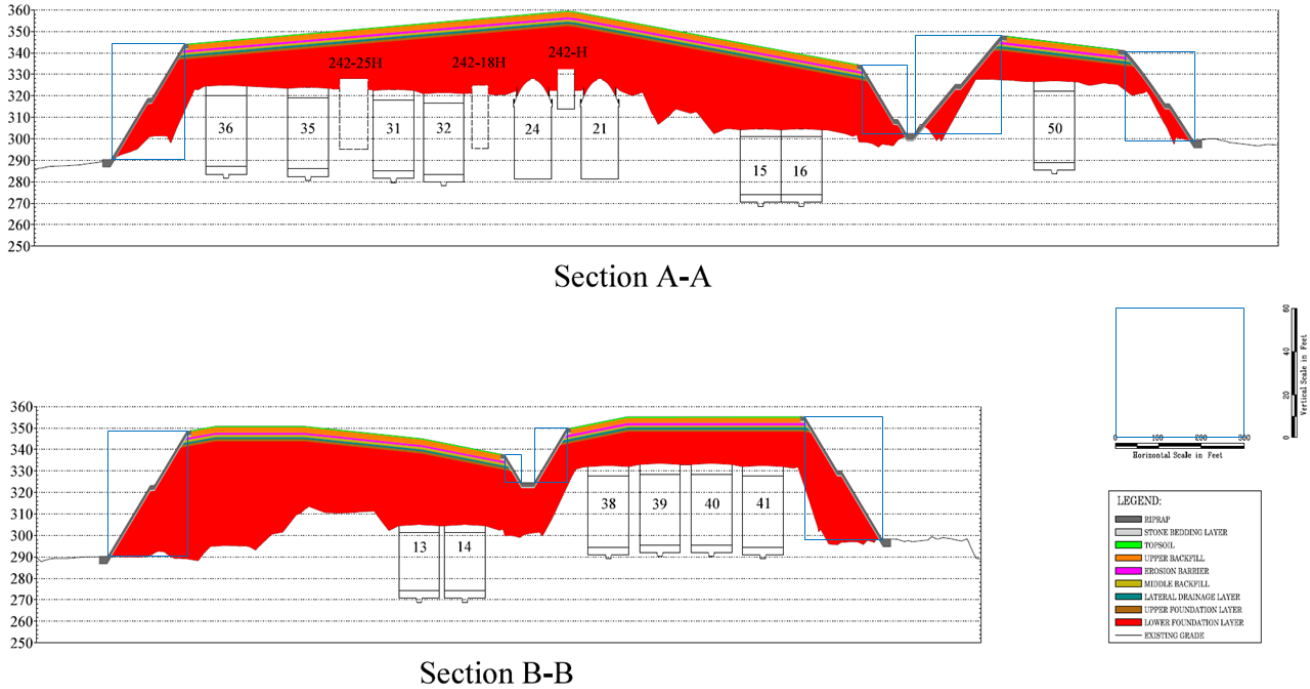
Source: SRR-CWDA-2019-00081

Figure A2: FTF Closure Cap Cross-Sections D-D and E-E



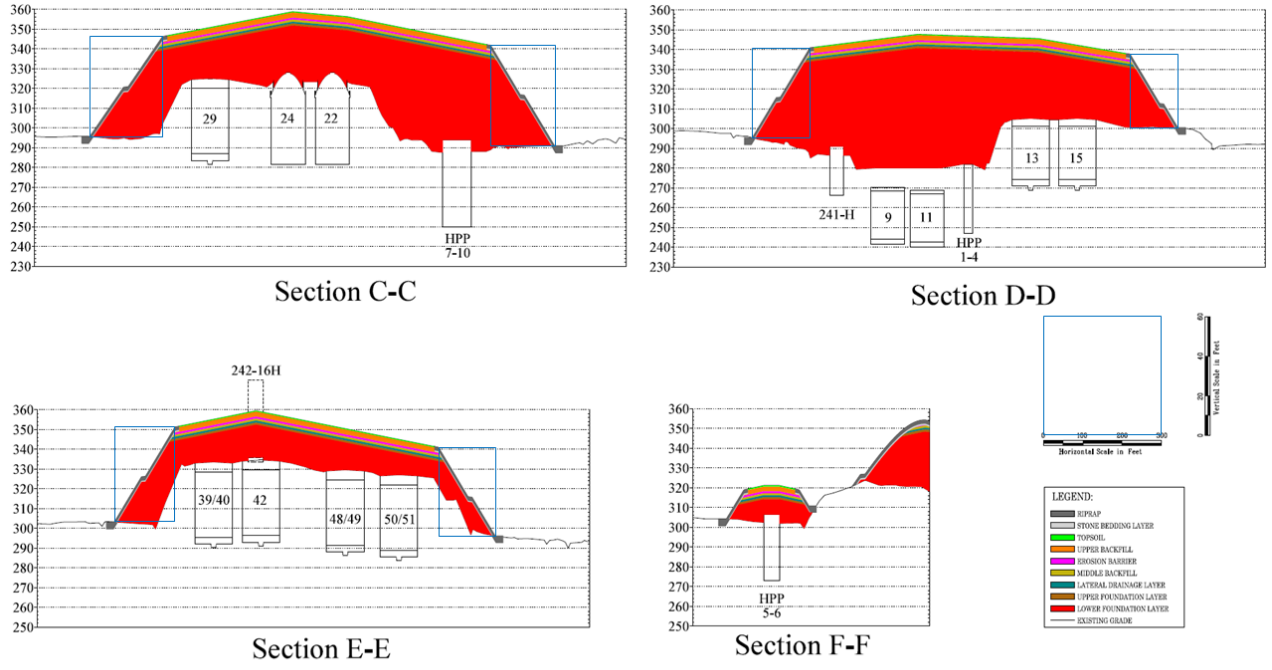
Source: SRR-CWDA-2019-00081

Figure A3: HTF Closure Cap Cross-Sections A-A and B-B



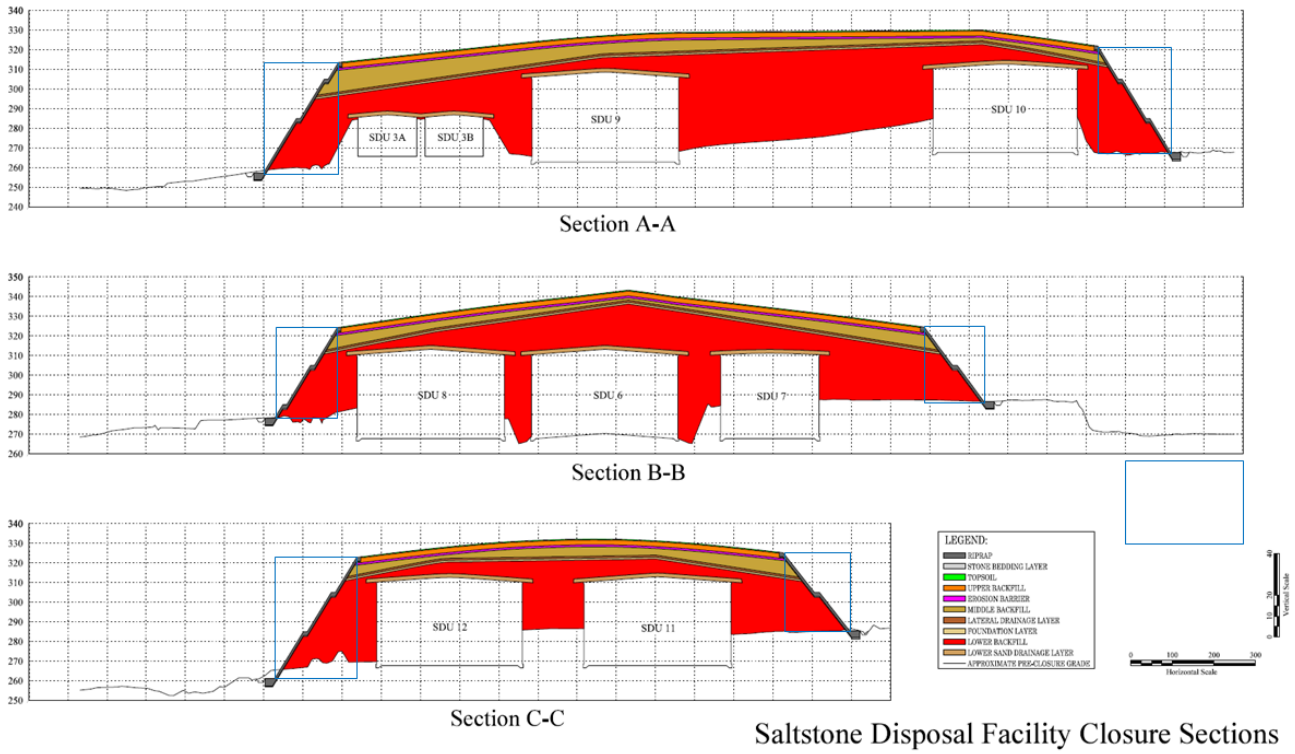
Source: SRR-CWDA-2019-00080

Figure A4: HTF Closure Cap Cross-Sections C-C, D-D, E-E, and F-F



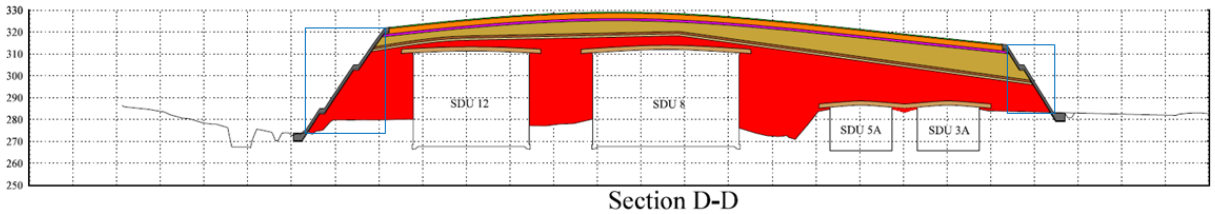
Source: SRR-CWDA-2019-00080

Figure A5: SDF Closure Cap Cross-Sections A-A, B-B, and C-C

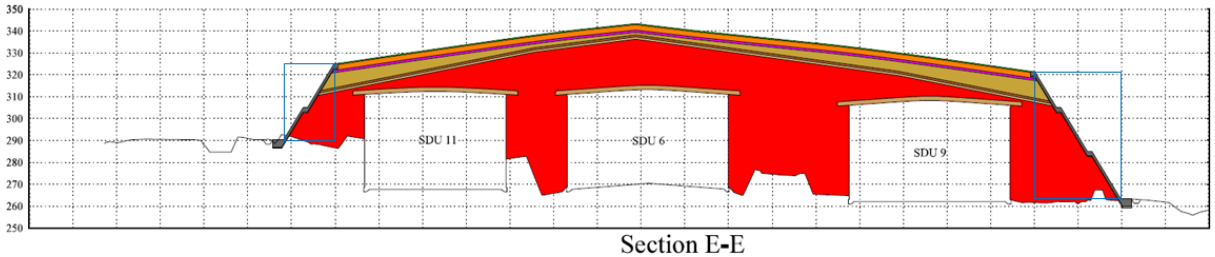


Source: SRR-CWDA-2018-00087

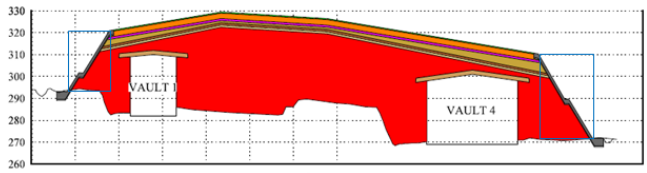
Figure A6: SDF Closure Cap Cross-Sections D-D, E-E, and F-F

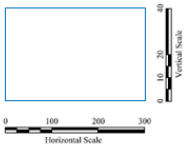


Section D-D



Section E-E





Source: SRR-CWDA-2018-00087 Section F-F

Appendix B

This appendix provides side slope geometry estimates based on each of the cross-sections (from Appendix A). Many of the values provided in Table 2 were based on the maximum values taken from each facility.

Table B.1: FTF Section A-A

Parameter	Left Side Slope (near Tank 17)	Right Side Slope (near Tank 2)
Top Elevation (in ft above mean sea level) of Side Slope	309.9	308.5
Bottom Elevation (in ft above mean sea level) of Side Slope	291.9	286.5
Height (ft) of Side Slope	18	22
Width (ft) of Side Slope	53.8	67.7
Slope (grade) (rise-over-run)	0.33	0.33
Slope (angle in degrees)	19.2	18.6
Surface Slope Length (ft)	56.8	71.2

Table B.2: FTF Section B-B

Parameter	Left Side Slope (near Tank 44)	Right Side Slope (near Tank 8)
Top Elevation (in ft above mean sea level) of Side Slope	310.2	310.2
Bottom Elevation (in ft above mean sea level) of Side Slope	286.2	283.5
Height (ft) of Side Slope	24	26.7
Width (ft) of Side Slope	72.3	81.5
Slope (grade) (rise-over-run)	0.33	0.33
Slope (angle in degrees)	19.0	18.8
Surface Slope Length (ft)	76.2	85.8

Table B.3: FTF Section C-C

Parameter	Left Side Slope (near Tank 47)	Right Side Slope (near Tank 34)
Top Elevation (in ft above mean sea level) of Side Slope	308.2	309
Bottom Elevation (in ft above mean sea level) of Side Slope	284	279.9
Height (ft) of Side Slope	24.2	29.1
Width (ft) of Side Slope	73.8	87.7
Slope (grade) (rise-over-run)	0.33	0.33
Slope (angle in degrees)	18.8	19.0
Surface Slope Length (ft)	77.7	92.4

Table B.4: FTF Section D-D

Parameter	Left Side Slope (near Tank 2)	Right Side Slope (near Tank 34)
Top Elevation (in ft above mean sea level) of Side Slope	308.2	308.5
Bottom Elevation (in ft above mean sea level) of Side Slope	289.5	281.1
Height (ft) of Side Slope	18.7	27.4
Width (ft) of Side Slope	56.7	84.1
Slope (grade) (rise-over-run)	0.33	0.33
Slope (angle in degrees)	18.9	18.7
Surface Slope Length (ft)	59.7	88.5

Table B.5: FTF Section E-E

Parameter	Left Side Slope (near Tank 18)	Right Side Slope (near Tank 28)
Top Elevation (in ft above mean sea level) of Side Slope	309.5	309.5
Bottom Elevation (in ft above mean sea level) of Side Slope	294	280
Height (ft) of Side Slope	15.5	29.5
Width (ft) of Side Slope	45.0	88.0
Slope (grade) (rise-over-run)	0.34	0.34
Slope (angle in degrees)	19.7	19.2
Surface Slope Length (ft)	47.6	92.9

Table B.6: HTF Section A-A (Main Section)

Parameter	Left Side Slope (near Tank 36)	Right Side Slope (near Tank 16)
Top Elevation (in ft above mean sea level) of Side Slope	344	334
Bottom Elevation (in ft above mean sea level) of Side Slope	290.2	302.2
Height (ft) of Side Slope	53.8	31.8
Width (ft) of Side Slope	169.5	105.3
Slope (grade) (rise-over-run)	0.32	0.30
Slope (angle in degrees)	18.2	17.3
Surface Slope Length (ft)	177.8	110.0

Table B.7: HTF Section A-A (Tank 50 Section)

Parameter	Left Side Slope (Left of Tank 50)	Right Side Slope (Right of Tank 50)
Top Elevation (in ft above mean sea level) of Side Slope	347.8	340.3
Bottom Elevation (in ft above mean sea level) of Side Slope	302.2	299
Height (ft) of Side Slope	45.6	41.3
Width (ft) of Side Slope	201.5	162.6
Slope (grade) (rise-over-run)	0.23	0.25
Slope (angle in degrees)	13.0	14.6
Surface Slope Length (ft)	206.6	167.8

Table B.8: HTF Section B-B (Left Portion)

Parameter	Left Side Slope (Far Left)	Right Side Slope (near Tank 14)
Top Elevation (in ft above mean sea level) of Side Slope	348.2	337.5
Bottom Elevation (in ft above mean sea level) of Side Slope	290.2	324.8
Height (ft) of Side Slope	58	12.7
Width (ft) of Side Slope	185.5	38.9
Slope (grade) (rise-over-run)	0.31	0.33
Slope (angle in degrees)	17.9	18.7
Surface Slope Length (ft)	194.4	41.0

Table B.9: HTF Section B-B (Right Portion)

Parameter	Left Side Slope (near Tank 38)	Right Side Slope (near Tank 41)
Top Elevation (in ft above mean sea level) of Side Slope	350	355.2
Bottom Elevation (in ft above mean sea level) of Side Slope	325	298.2
Height (ft) of Side Slope	25	57
Width (ft) of Side Slope	75.6	180.9
Slope (grade) (rise-over-run)	0.33	0.32
Slope (angle in degrees)	19.0	18.1
Surface Slope Length (ft)	79.6	189.7

Table B.10: HTF Section C-C

Parameter	Left Side Slope (near Tank 29)	Right Side Slope (near HPP 7-10)
Top Elevation (in ft above mean sea level) of Side Slope	346.2	342
Bottom Elevation (in ft above mean sea level) of Side Slope	295.8	291.5
Height (ft) of Side Slope	50.4	50.5
Width (ft) of Side Slope	185.4	163.4
Slope (grade) (rise-over-run)	0.27	0.31
Slope (angle in degrees)	15.6	17.7
Surface Slope Length (ft)	192.1	171.0

Table B.11: HTF Section D-D

Parameter	Left Side Slope (Near 241-H)	Right Side Slope (near Tank 15)
Top Elevation (in ft above mean sea level) of Side Slope	341	338.8
Bottom Elevation (in ft above mean sea level) of Side Slope	296	300.2
Height (ft) of Side Slope	45	38.6
Width (ft) of Side Slope	146.3	122.0
Slope (grade) (rise-over-run)	0.31	0.32
Slope (angle in degrees)	17.6	18.1
Surface Slope Length (ft)	153.1	127.9

Table B.12: HTF Section E-E

Parameter	Left Side Slope (Near Tanks 39/40)	Right Side Slope (near Tanks 50/51)
Top Elevation (in ft above mean sea level) of Side Slope	351	341
Bottom Elevation (in ft above mean sea level) of Side Slope	303	296
Height (ft) of Side Slope	48	45
Width (ft) of Side Slope	156.1	143.9
Slope (grade) (rise-over-run)	0.31	0.31
Slope (angle in degrees)	17.6	17.9
Surface Slope Length (ft)	163.3	150.8

Table B.13: SDF Section A-A

Parameter	Left Side Slope (near SDU 3A)	Right Side Slope (near SDU 10)
Top Elevation (in ft above mean sea level) of Side Slope	313	322
Bottom Elevation (in ft above mean sea level) of Side Slope	257	268
Height (ft) of Side Slope	56	54
Width (ft) of Side Slope	192.9	187.5
Slope (grade) (rise-over-run)	0.29	0.29
Slope (angle in degrees)	16.6	16.5
Surface Slope Length (ft)	200.8	195.1

Table B.14: SDF Section B-B

Parameter	Left Side Slope (near SDU 8)	Right Side Slope (near SDU 7)
Top Elevation (in ft above mean sea level) of Side Slope	324.2	324.8
Bottom Elevation (in ft above mean sea level) of Side Slope	278	286.2
Height (ft) of Side Slope	46.2	38.6
Width (ft) of Side Slope	156.6	152.7
Slope (grade) (rise-over-run)	0.29	0.25
Slope (angle in degrees)	16.9	14.5
Surface Slope Length (ft)	163.3	157.5

Table B.15: SDF Section C-C

Parameter	Left Side Slope (near SDU 12)	Right Side Slope (near SDU 11)
Top Elevation (in ft above mean sea level) of Side Slope	323	325.5
Bottom Elevation (in ft above mean sea level) of Side Slope	261.2	285.5
Height (ft) of Side Slope	61.8	40
Width (ft) of Side Slope	210.8	170.3
Slope (grade) (rise-over-run)	0.29	0.23
Slope (angle in degrees)	16.8	13.5
Surface Slope Length (ft)	219.7	174.9

Table B.16: SDF Section D-D

Parameter	Left Side Slope (near SDU 12)	Right Side Slope (near SDU 3A)
Top Elevation (in ft above mean sea level) of Side Slope	322	314
Bottom Elevation (in ft above mean sea level) of Side Slope	274	283
Height (ft) of Side Slope	48	31
Width (ft) of Side Slope	182.3	106.2
Slope (grade) (rise-over-run)	0.26	0.29
Slope (angle in degrees)	15.1	16.7
Surface Slope Length (ft)	188.5	110.6

Table B.17: SDF Section E-E

Parameter	Left Side Slope (near SDU 11)	Right Side Slope (near SDU 9)
Top Elevation (in ft above mean sea level) of Side Slope	324.8	321.5
Bottom Elevation (in ft above mean sea level) of Side Slope	290	263.5
Height (ft) of Side Slope	34.8	58
Width (ft) of Side Slope	115.4	198.5
Slope (grade) (rise-over-run)	0.30	0.29
Slope (angle in degrees)	17.3	16.7
Surface Slope Length (ft)	120.5	206.8

Table B.18: SDF Section F-F

Parameter	Left Side Slope (near SDU 1 [Vault 1])	Right Side Slope (near SDU 4 [Vault 4])
Top Elevation (in ft above mean sea level) of Side Slope	321	310.2
Bottom Elevation (in ft above mean sea level) of Side Slope	293	271.5
Height (ft) of Side Slope	28	38.7
Width (ft) of Side Slope	94.6	122.3
Slope (grade) (rise-over-run)	0.30	0.32
Slope (angle in degrees)	17.0	18.1
Surface Slope Length (ft)	98.7	128.3