ANNEX B-1

GEOTECHNICAL DESIGN AND INVESTIGATIONS

Table B-1.1. Embankment materials quantity calculations for the C-18W reservoir.

LOX QUANTITIES					
C-18W RESERVOIR					
1) soil cement volume	crown/slope area (sf)	apron/key area (sf)	length of emb (ft)	Volume (cf)	Volume (cy)
	75	27	28740	2,931,480.00	108,573.33
2) sand filter under U/S soil cement	slope area (sf)	length of emb (ft)		Volume (cf)	Volume (cy)
	41.1	28740		1,181,214.00	43,748.67
3) geotextile fabric under U/S soil cement	slope length (ft)	length of emb (ft)		Area (sf)	
	43	28740		1,235,820.00	
4) chimney filter sand (C33, non-calcareous)	chimney area (sf)	length of emb (ft)		Volume (cf)	Volume (cy)
	28.5	28740		819,090.00	30,336.67
5) blanket drain sand (C33, non-calcareous)	blanket area (sf)	length of emb (ft)		Volume (cf)	Volume (cy)
	26	28740		747,240.00	27,675.56
6) drain sand around perforated pipe (C33, non-calcareous)	area (sf)	length of emb (ft)		Volume (cf)	Volume (cy)
	16	28740		459,840.00	17,031.11
7) drain gravel around perforated pipe (No 89, non-calcareous)	area (sf)	length of emb (ft)		Volume (cf)	Volume (cy)
	8	28740		229,920.00	8,515.56
8) internal, perforated drain pipe near D/S toe (12 inch dia, profile wall		length of emb (ft)			length of pipe required (ft)
corregated HDPE pipe with slotted perforations)		28740			28,740.00
9) lateral, drain pipe exiting the embankment near D/S toe (12 inch dia,	length of each pipe (ft)	length of emb (ft)	pipes spaced every 1000 ft		length of pipe required (ft)
profile wall corregated HDPE pipe - no perforations)	136	28740	28.74		3,908.64
10) internal, perforated drain pipe near U/S toe (6 inch dia, profile wall		length of emb (ft)			length of pipe required (ft)
corregated HDPE pipe with slotted perforations)		28740			28,740.00
11) lateral, drain pipe exiting the embankment near U/S toe (6 inch dia,	length of each pipe (ft)	length of emb (ft)	pipes spaced every 1000 ft		length of pipe required (ft)
profile wall corregated HDPE pipe - no perforations)	10	28740	28.74		287.40
12) embankment fill volume	internal area (sf)		length of emb (ft)	Volume (cf)	Volume (cy)
	1226		28740	35,235,240.00	1,305,008.89
13) exterior toe fill volume	area of fill (sf)	length of fill (ft)	No of fill locations	Volume (cf)	Volume (cy)
	300	9	28.74	77,598.00	2,874.00
14) piezometers	Number of PZs per every 2000 ft of embankment		total length of 2-in dia standpipe per PZ group (ft)	one RTU and telemetry per group?	
	4		76	yes	
15) geotextile fabric under riprap in seepage canal	coverage length (ft)	length of canal (ft)		Area (sf)	
	126	28740		3,621,240.00	
16) R-20 riprap in seepage canal (local stone)	area (sf)	length of canal (ft)		Volume (cf)	Volume (cy)
	110	28740		3,161,400.00	117,088.89
17) instrumentation cost per monitoring location		length of emb (ft)	No of monitoring locations	estimated cost for instrumentation per location	instrumentation cost for C-18W
		28740	14.37	$10,000.00	$143,700.00

Table B-1.2. Rip-Rap design calculations for LRWPR structures. Follows EM 1110-2-1601, *Hydraulic design of flood control channels.*

Structure	Riprap Size	Stone Type	D100 Max	1.5 D50 Max (ft)	Layer Thickness (ft)	Armored Area (ft^2)	Riprap Volume (ft^3)	Riprap Volume (yd^3)
S-101B	R-20	Local	0.86	0.985	0.985	5000	4925	182.4074074
S-102	R-20	Local	0.86	0.985	0.985	794	782.09	28.9662963
S-103E	R-20	Local	0.86	0.985	0.985	794	782.09	28.9662963
S-103W	R-20	Local	0.86	0.985	0.985	4960	4885.6	180.9481481
S-104	R-20	Local	0.86	0.985	0.985	4960	4885.6	180.9481481
S-105	R-20	Local	0.86	0.985	0.985	4501	4433.485	164.2031481
S-107	R-20	Local	0.86	0.985	0.985	5357	5276.645	195.4312963
S-111N	R-20	Local	0.86	0.985	0.985	3000	2955	109.4444444
S-111S	R-1500	Import	3.2625	3.88375	3.88375	2500	9709.375	359.6064815
S-111S(2)	R-20	Local	0.86	0.985	0.985	1000	985	36.48148148
S-112(10.8 to 8)	R-700	Import	2.589167	3.0125	3.0125	5670	17080.875	632.625
S-112(8 to 5)	R-150	Import	1.514167	1.8025	1.8025	5670	10220.175	378.525
S-112(5 to 3)	R-20	Local	0.86	0.985	0.985	5670	5584.95	206.85
S-113S	R-20	Local	0.86	0.985	0.985	1000	985	36.48148148
S-114A	R-20	Import	0.804167	0.92	0.92	1350	1242	46
S-114B	R-20	Import	0.804167	0.92	0.92	1350	1242	46
S-114C	R-60	Import	1.201667	1.325	1.325	1350	1788.75	66.25
S-116	R-60	Import	1.201667	1.325	1.325	1800	2385	88.33333333
S-117	R-60	Import	1.201667	1.325	1.325	2000	2650	98.14814815
S-100	R-20	Local	0.86	0.985	0.985	1000	985	36.48148148
S-101A	R-20	Local	0.86	0.985	0.985	1000	985	36.48148148
S-106	R-60	Import	1.201667	1.325	1.325	2000	2650	98.14814815
S-109	R-20	Local	0.86	0.985	0.985	1000	985	36.48148148

ANNEX B-1 (GEOTECHNICAL): Filter Design

References:

- EM 1110-2-2300 dated 30 July 2004 (General Design and Construction Considerations for Earth and Rock-Fill Dams), Appendix B (Filter Design)
- ASTM C33/C33M 2016 (Standard Specification for Concrete Aggregates)

A. Fine Filter Design Steps:

1) The gradation curves from 8 different soil samples were examined to determine a "base-soil" that will require the smallest D_{15} size. These samples were obtained from SPT borings drilled for the Project. The gradation curve from boring MFEBBH24 (sample depth 20ft) was selected for the "base soil" (see **Figure B-1.1**).

2) As the base soil did not contain particles larger than the No. 4 sieve, an adjusted gradation curve did not need to be prepared per paragraph "B-2c" of Appendix B in EM 1110-2-2300.

3) Based on the particle size determination in Step 2, the base soil falls into a "Category 4 soil" – according to Table B-1 in EM 1110-2-2300.

4) Therefore, per Step 3, the maximum D_{15} will be as follows per Table B-2 in EM 1110-2-2300:

   $D_{15(max)} \leq 4$ to $5 \times d_{85}$
   Using the gradation band from boring MFEBBH24 (sample depth 20 ft):
   $D_{15(max)} \leq (4 \times 0.16) = 0.64$mm to $(5 \times 0.16) = 0.8$mm
   -- use 0.8mm for $D_{15(max)}$

5) Next, the minimum $D_{15} \geq 3$ to $5 \times d_{15\,(max)}$ – per paragraph "f" in Appendix B in EM 1110-2-2300.

   $D_{15(min)} = 3 \times 0.075$mm = 0.22mmn to 5×0.075mm = 0.37mm
   -- use 0.22mm for $D_{15(min)}$ per paragraph "f".

6) Per paragraph "g" of Appendix B in EM 1110-2-2300, the maximum particle size must be less than or equal to 75mm and the maximum percentage passing the No. 200 sieve must be less than or equal to 5 percent – OK.

7) Considering standard ASTM C33 gradations, a C33 fine aggregate (sand) was selected for the fine filter. This fine aggregate meets the filter criteria discussed above and also falls within the D10 and D90 limits for preventing segregation per Table B-3 of EM 1110-2-2300.

8) The next check is for permeability per paragraph B-3 in EM 1110-2-2300.

   ((15% size of filter material)/(15% size of protected soil)) ≥ 3 to 5
   0.22mm/.075mm = 2.93, therefore OK.

Fine Filter Design Recommendations –

Fine Filter gradation: ASTM C33 fine aggregate (sand)
Fine Filter aggregate type: non-calcareous (to prevent dissolution/cementation of the filter material with time)

B. Coarse Filter Design Steps:

1) The fine aggregate selected in the previous design steps now becomes the "base soil" for the design of the coarse filter.

2) As the "minimum" gradation curve for the fine aggregate contains no material that could be retained on the No. 4 (4.75mm) sieve (and will also be used to determine D_{15} of the coarsefilter material), an adjusted gradation curve was not prepared for the fine aggregate "maximum" gradation curve.

3) Based on the particle size determination from Step 2, the C33 fine aggregate falls into a "Category 4 soil" – according to Table B-1 in EM 1110-2-2300.

4) Therefore, per Step 3, the maximum D_{15} will be as follows per Table B-2 in EM 1110-2-2300:

   $D_{15(max)} \leq 4$ to $5 \times d_{85}$
   Using the minimum gradation band from the fine aggregate:
   $D_{15(max)} \leq 4*1.2mm = 4.8mm$ to $5*1.2mm = 6mm$, use 6mm for $D_{15(max)}$

5) Next, the minimum $D_{15} \geq 3$ to $5 \times d_{15\,(max)}$ – per paragraph "f" of Appendix B in EM 1110-2-2300.

   $D_{15(min)} = 3x0.25mm = 0.75mm$ to $5x0.25mm = 1.25mm$
   Use 0.75mm for $D_{15(min)}$

6) Per paragraph "g" of Appendix B in EM 1110-2-2300, the maximum particle size must be less than or equal to 75mm and the maximum percentage passing the No. 200 sieve must be less than or equal to 5 percent – OK.

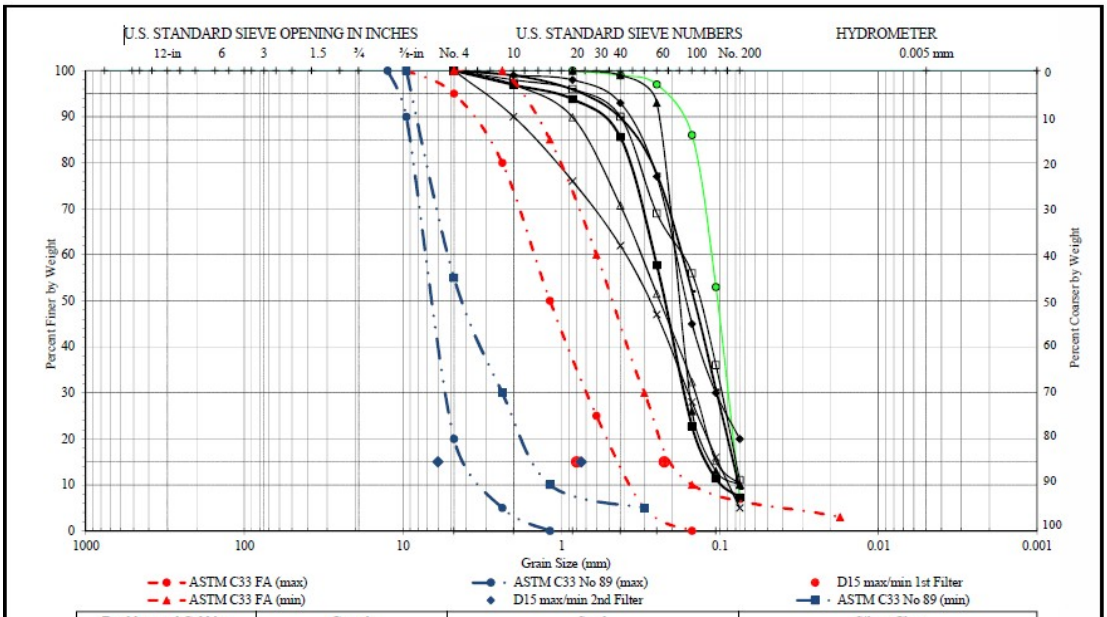
7) One coarse aggregate that will meet the filter criteria discussed above is a No. 89 stone per ASTM C33/C33M. The gradation band for this material is shown on Figure 2. This gradation also falls within the D10 and D90 limits for preventing segregation per Table B-3 of EM 1110-2-2300.

8) The next check is for permeability per paragraph B-3 in EM 1110-2-2300.

   ((15% size of filter material)/(15% size of protected soil)) ≥ 3 to 5
   1.6mm/0.22mm = 7.2, therefore OK.

Coarse Filter Design Recommendations –

Coarse Filter gradation: ASTM C33 No. 89 Stone
Coarse Filter aggregate type: non-calcareous (to prevent dissolution/cementation of the filter material with time)



Boulders and Cobbles		Gravel		Sand			Silt or Clay	
Boulder	Cobble	Coarse	Fine	Coarse	Medium	Fine	Silt?	Clay?

Sample No.	Depth (ft)	Classification	Nat w%	LL	PL	PI
● FEBBH24	20	(SP-SM)				
■ FEBBH01	8	(SP-SM)				
▲ FEBBH01	18	(SP-SM)				
□ FEBBH02	0	(SP-SM)				
♦ FEBBH05	10	(SM)				
– FEBBH10	8	(SP-SM)				
x FEBBH15	18	(SP)				
Δ FEBBH20	6	(SP-SM)				

Project	Loxahatchee River
	Filter Design
Boring No.	See Sample No.
Location	Project Limits
Date	6/27/2019

*Filter Bands as per EM 2300 Appendix B

US Army Corps of Engineers

Particle Size Distribution Analysis

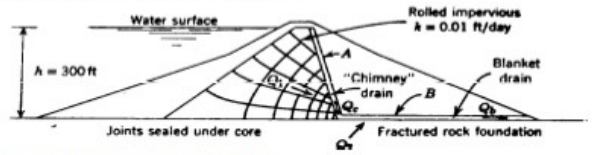
Figure B-1.1. Particle size distribution analysis for the internal filter design.

Seepage Control in Embankments
Chimney and Blanket Designs
EM 1110-2-1901

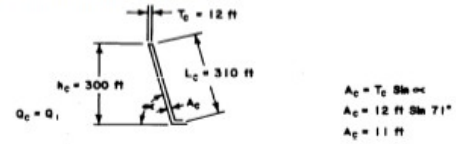
Project:	Loxahatchee River, C-18W Impoundment	**Name:**	M. Viessman
Location:	SEEP/W West Section	**Date:**	6/30/2019

Chimney and Blanket Design according to EM 1110-2-1901

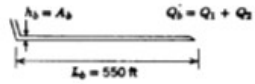
Cross Section and Flow Net of the Embankment



Dimensions of the Inclined (or Vertical) Drain



Dimensions of the Horizontal Drain



Formula Inputs

Input values in green fields; gray fields are calculated

Q1 =	1.86E-06	cfs	Q1 =	0.16	cu ft/day
Q2 =	7.58E-08	cfs	Q2 =	0.0	cu ft/day
Qc =	0.16	cu ft/day	Qb =	0.2	cu ft/day
hc =	10.5	ft	hb =	2	ft
Lc =	10.5	ft	Lb =	13	ft
ic =	1.00	ft/ft	ib =	0.15	ft/ft
Tc =	3	ft	Ab =	2	ft²
α =	90	°			
Ac =	3	ft²			
Design FS =	20				

Drainage Soil Characteristics

	Soil Type 1: ASTM C33 Fine Aggregate			(Only in blanket) Soil Type 2: ASTM C33 Fine Aggregate	
k soil type =	153	ft/day	k soil type =	153	ft/day
Max D10 Size =	0.4	mm	Max D10 Size =	0.4	mm
Min D10 Size =	0.2	mm	Min D10 Size =	0.2	mm
Min D50 Size =	0.5	mm	Min D50 Size =	0.5	mm
Max D85 Size =	3.0	mm	Max D85 Size =	3.0	mm
Min D85 Size =	1.2	mm	Min D85 Size =	1.2	mm

White = Input Value
Gray= Calculated Value

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Figure B-1.2. Chimney and blanket design for C-18W reservoir embankment (also see following sheets).

Seepage Control in Embankments
Chimney and Blanket Designs
EM 1110-2-1901

Project:	Loxahatchee River, C-18W Impoundment	**Name:**	M. Viessman
Location:	SEEP/W West Section	**Date:**	6/30/2019

Chimney Permeability, kc
kc = 0.1 ft/day
1.9E-05 cm/s

Blanket Permeability, kb
kb = 0.5 ft/day
1.9E-04 cm/s

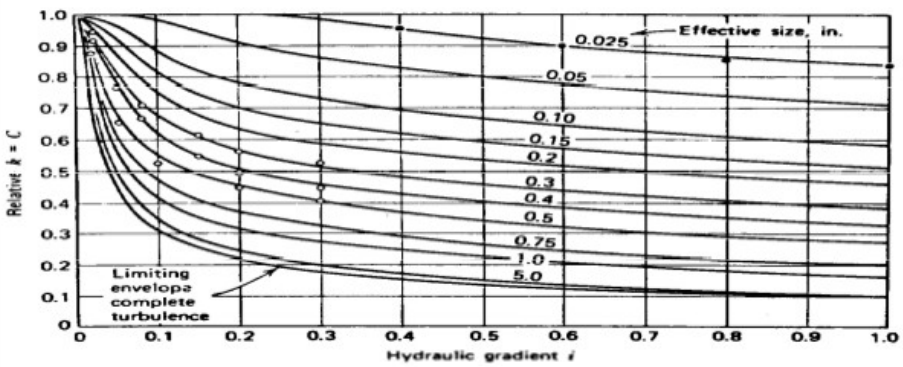
Permeability of Soil Required to Meet FS=20
kc design = 1.1 ft/day
3.8E-04 cm/s

kb design = 10.85640754 ft/day
0.00 cm/s

Calculate Adjusted Permeability for Drainage Soil
If the soil has an effective size greater than or equal to 0.025 in, a reduction in permeability must be applied using the graph below

ic = 1.00 ft/ft
Eff Grain Size = 0.011 in

ib = 0.154 ft/ft
Eff Grain Size = 0.011 in



Chimney Reduction = 1
Drainage Permeability = 153 ft/day
Adj Drainage Perm = 153 ft/day

Blanket Reduction = 1
Permeability = 153 ft/day
Adj Drainage Perm = 153 ft/day

Verify that the Drainage Soil is Acceptable

Chimney Drain Soil Type: ASTM C33 Fine Aggregate
Blanket Drain Soil Type: ASTM C33 Fine Aggregate

Chimney Design: Acceptable Drainage Soil
Blanket Design: Acceptable Drainage Soil

FS c = 2860
FS b = 282

White = Input Value
Gray= Calculated Value

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Seepage Control in Embankments
Chimney and Blanket Designs
EM 1110-2-1901

Project:	Loxahatchee River, C-18W Impoundment	**Name:**	M. Viessman
Location:	SEEP/W West Section	**Date:**	6/30/2019

Determine Pipe Perforation Size for Chosen Drainage Soil--EM 1110-2-2300 Appendix B

EM 1110-2-2300 Appendix B

Drainage Soil Type: ASTM C33 Fine Aggregate

Min D50 Size = 0.02 in
FS = 1 NOTE: FS has to be at least 1.0
Hole Diameter or Slot Width = 0.02 in

Bureau of Reclamation, Uniformly Graded Soil

Drainage Soil Type: ASTM C33 Fine Aggregate

D85 Size = 0.08 in
FS = 2 NOTE: FS has to be at least 2.0
Max Opening of Pipe Drain = 0.04 in

Max Opening of Pipe Drain = 0.02 in

*Must be AASHTO Class II Perforations

Additional Notes:
Drain pipe not needed for this design.

White = Input Value
Gray= Calculated Value

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Figure B-1.3. C-18W Reservoir west seepage section. The FOS against boiling was analyzed at different points in the seepage canal.

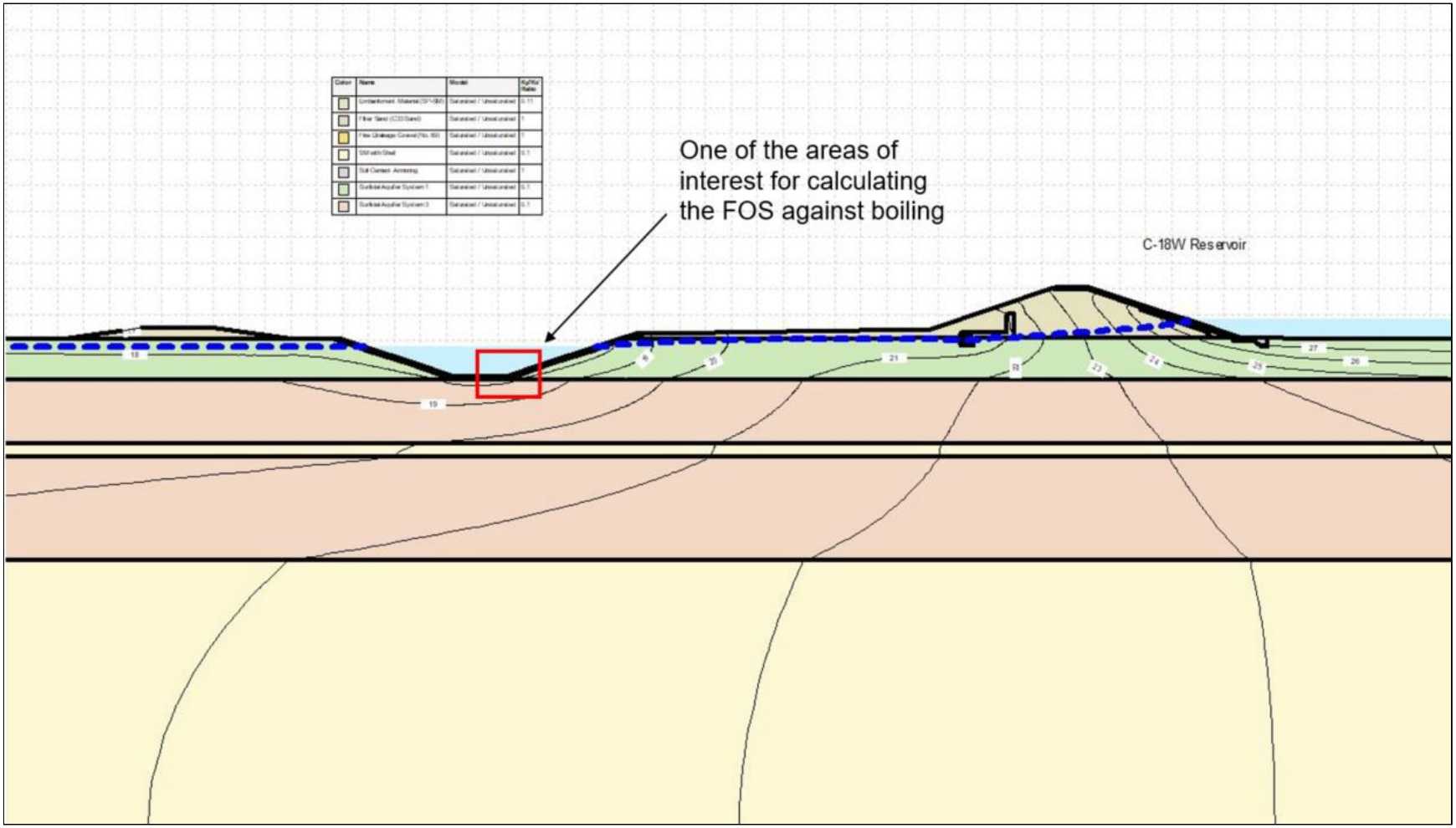


Figure B-1.4. Example calculation from the C-18W reservoir west seepage section.

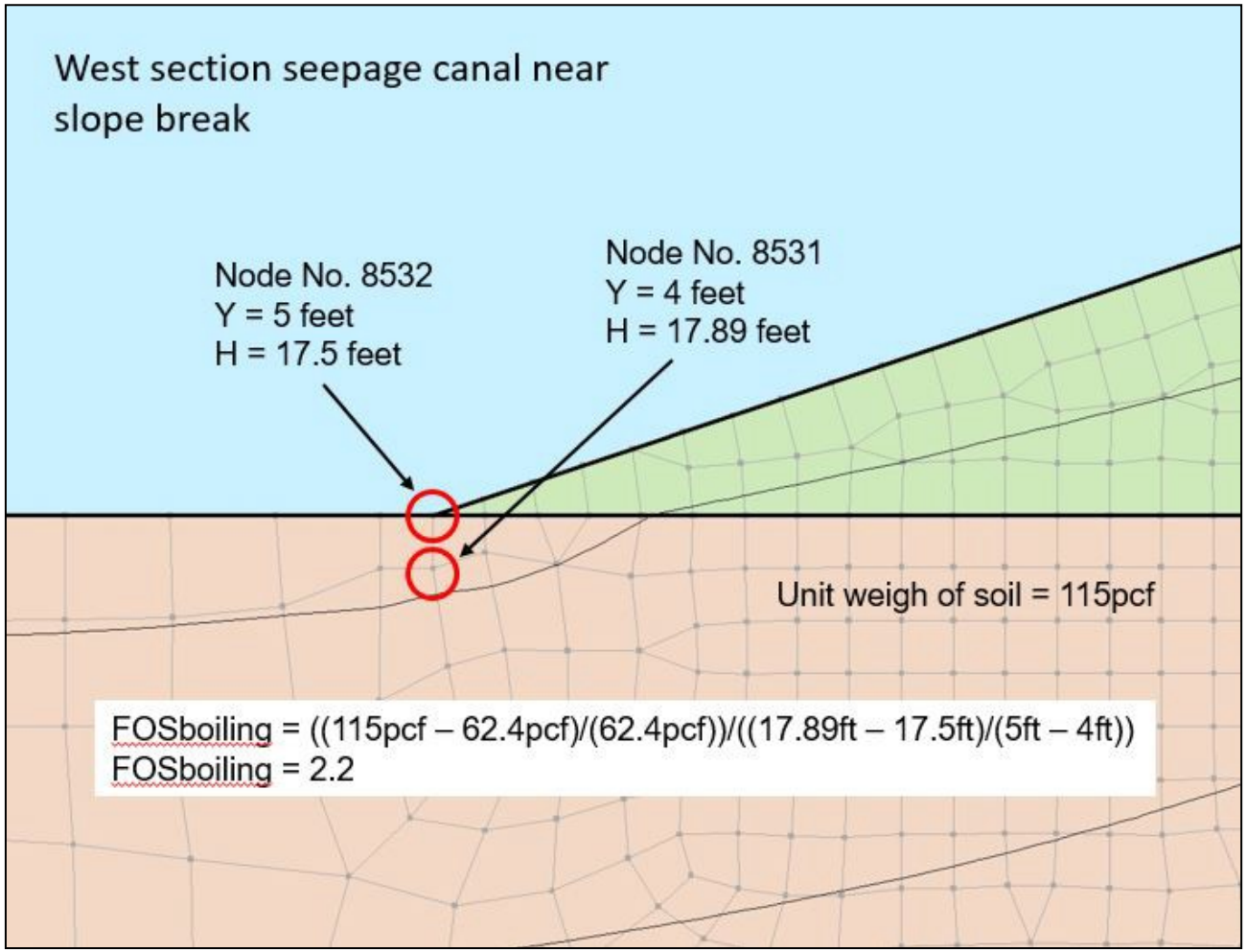


Figure B-1.5. C-18W reservoir west seepage section, steady-state seepage EOC condition with no pool.

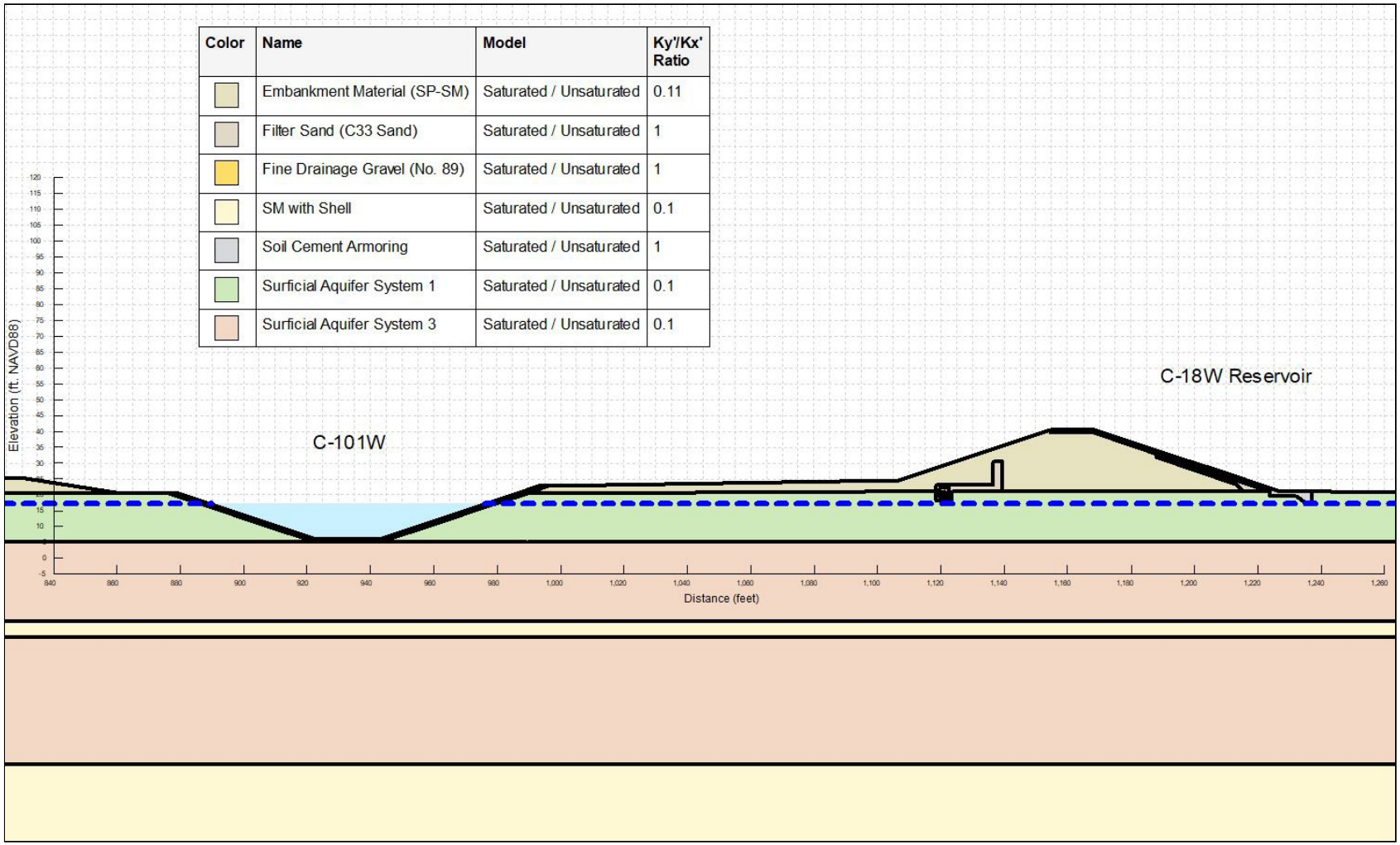


Figure B-1.6. C-18W reservoir west seepage section, steady-state seepage LT condition with normal pool.

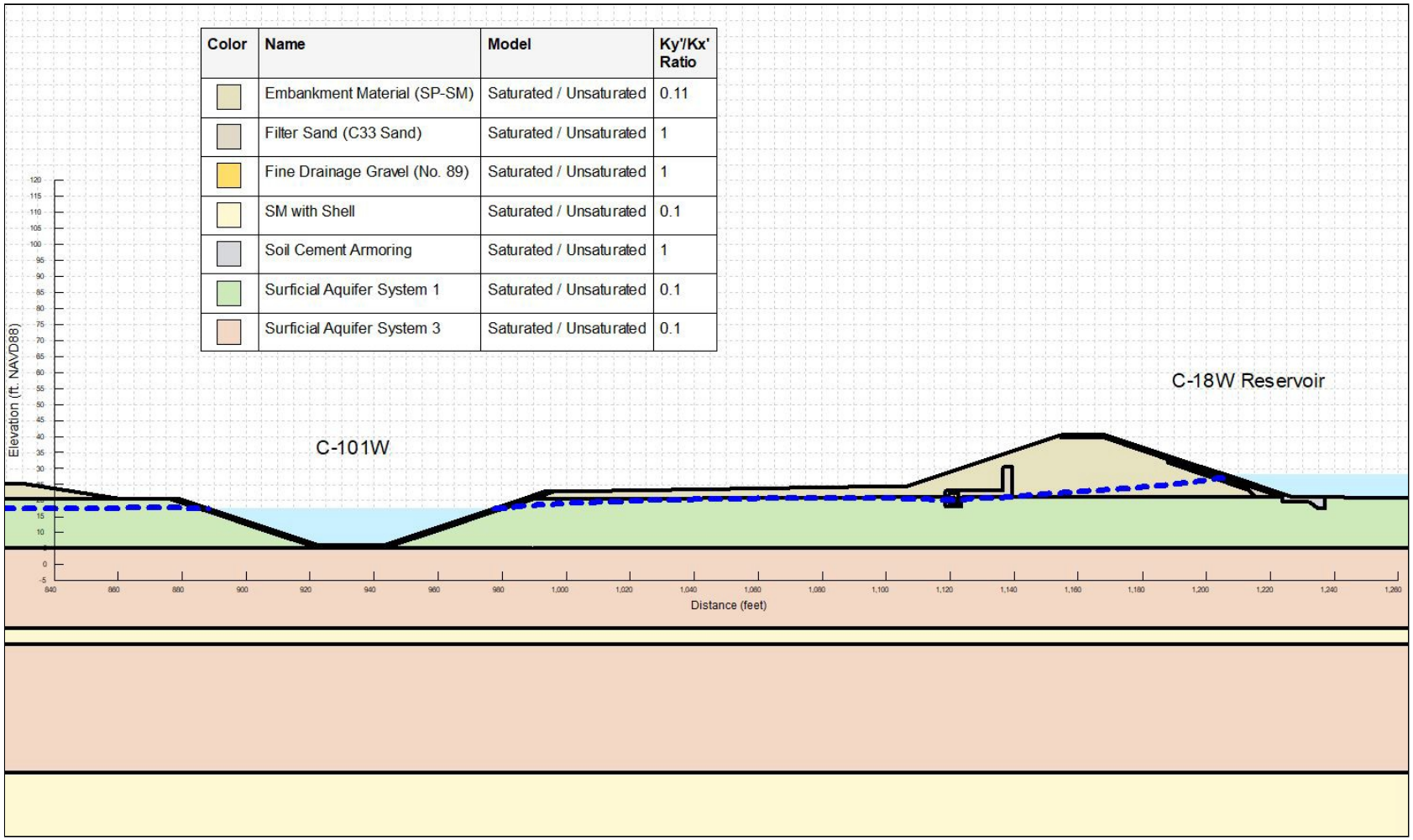


Figure B-1.7. C-18W reservoir west seepage section, steady-state seepage LT condition with maximum pool

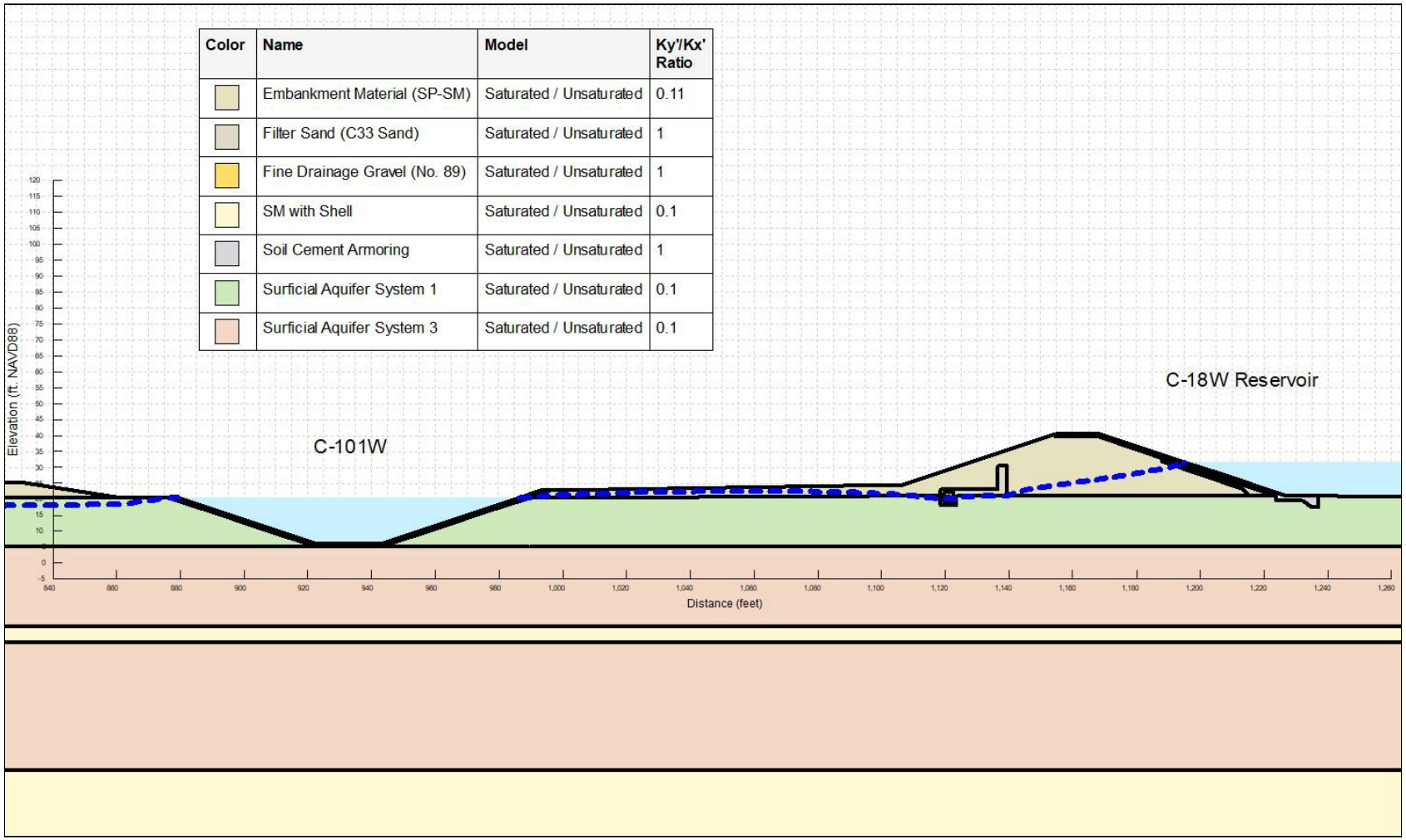
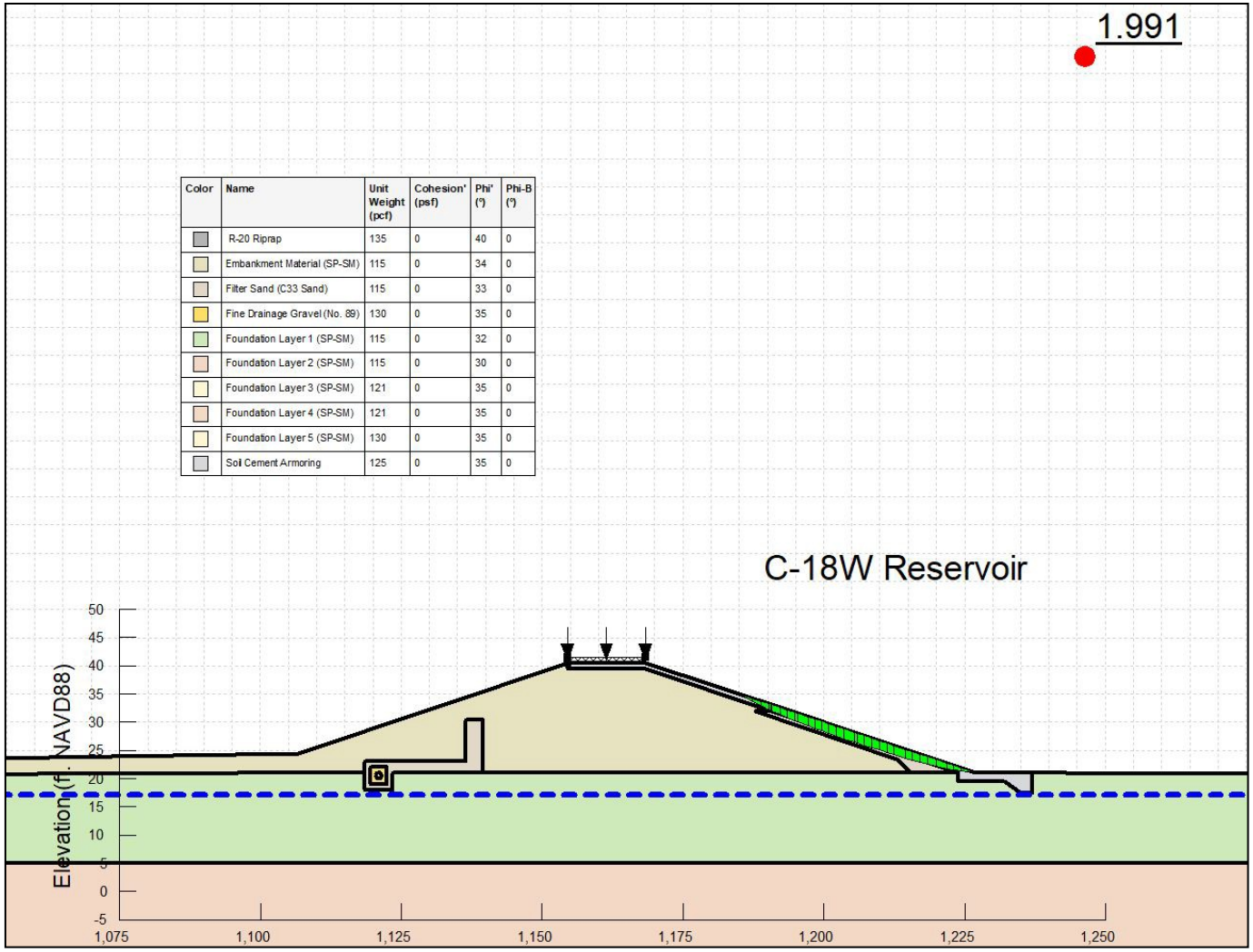
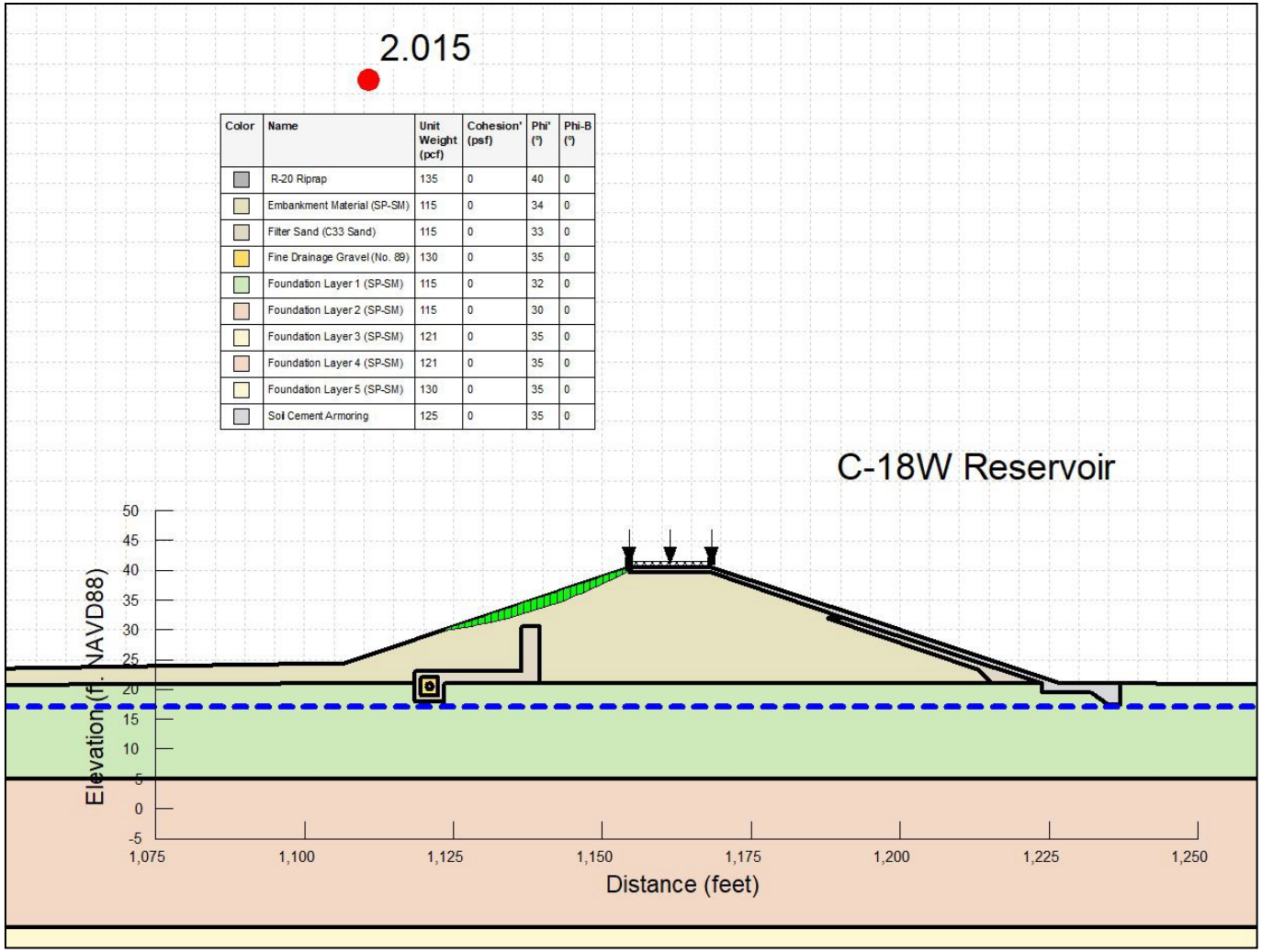


Figure B-1.8. C-18W reservoir west seepage section, slope stability analysis, EOC condition, embankment U/S slope.



Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)
	R-20 Riprap	135	0	40	0
	Embankment Material (SP-SM)	115	0	34	0
	Filter Sand (C33 Sand)	115	0	33	0
	Fine Drainage Gravel (No. 89)	130	0	35	0
	Foundation Layer 1 (SP-SM)	115	0	32	0
	Foundation Layer 2 (SP-SM)	115	0	30	0
	Foundation Layer 3 (SP-SM)	121	0	35	0
	Foundation Layer 4 (SP-SM)	121	0	35	0
	Foundation Layer 5 (SP-SM)	130	0	35	0
	Soil Cement Armoring	125	0	35	0

Figure B-1.9. C-18W Reservoir west seepage section, slope stability analysis, EOC condition, embankment D/S slope



Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)
	R-20 Riprap	135	0	40	0
	Embankment Material (SP-SM)	115	0	34	0
	Filter Sand (C33 Sand)	115	0	33	0
	Fine Drainage Gravel (No. 89)	130	0	35	0
	Foundation Layer 1 (SP-SM)	115	0	32	0
	Foundation Layer 2 (SP-SM)	115	0	30	0
	Foundation Layer 3 (SP-SM)	121	0	35	0
	Foundation Layer 4 (SP-SM)	121	0	35	0
	Foundation Layer 5 (SP-SM)	130	0	35	0
	Soil Cement Armoring	125	0	35	0

Figure B-1.10. C-18W Reservoir west seepage section, slope stability analysis, EOC condition, canal near slope

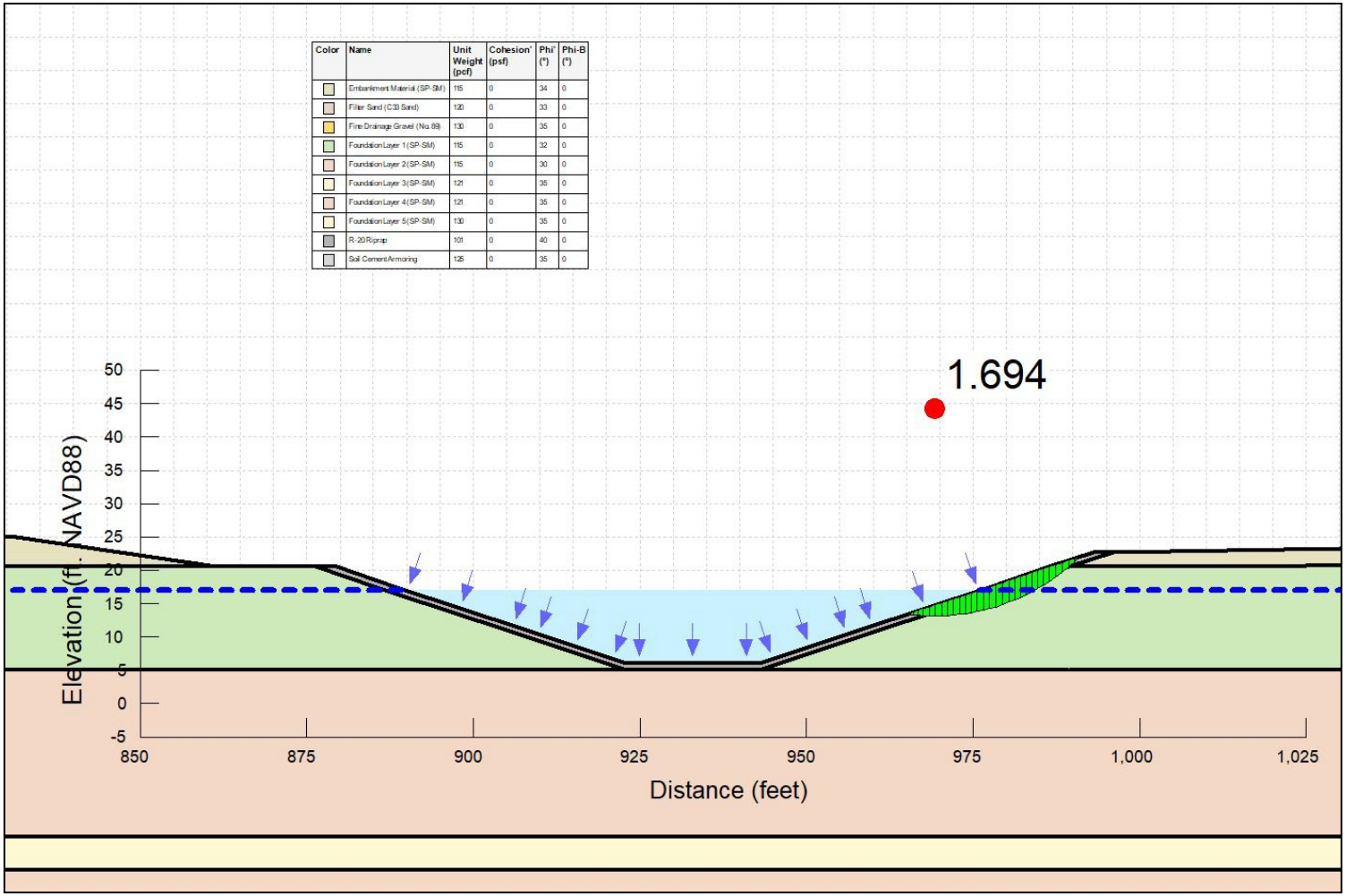
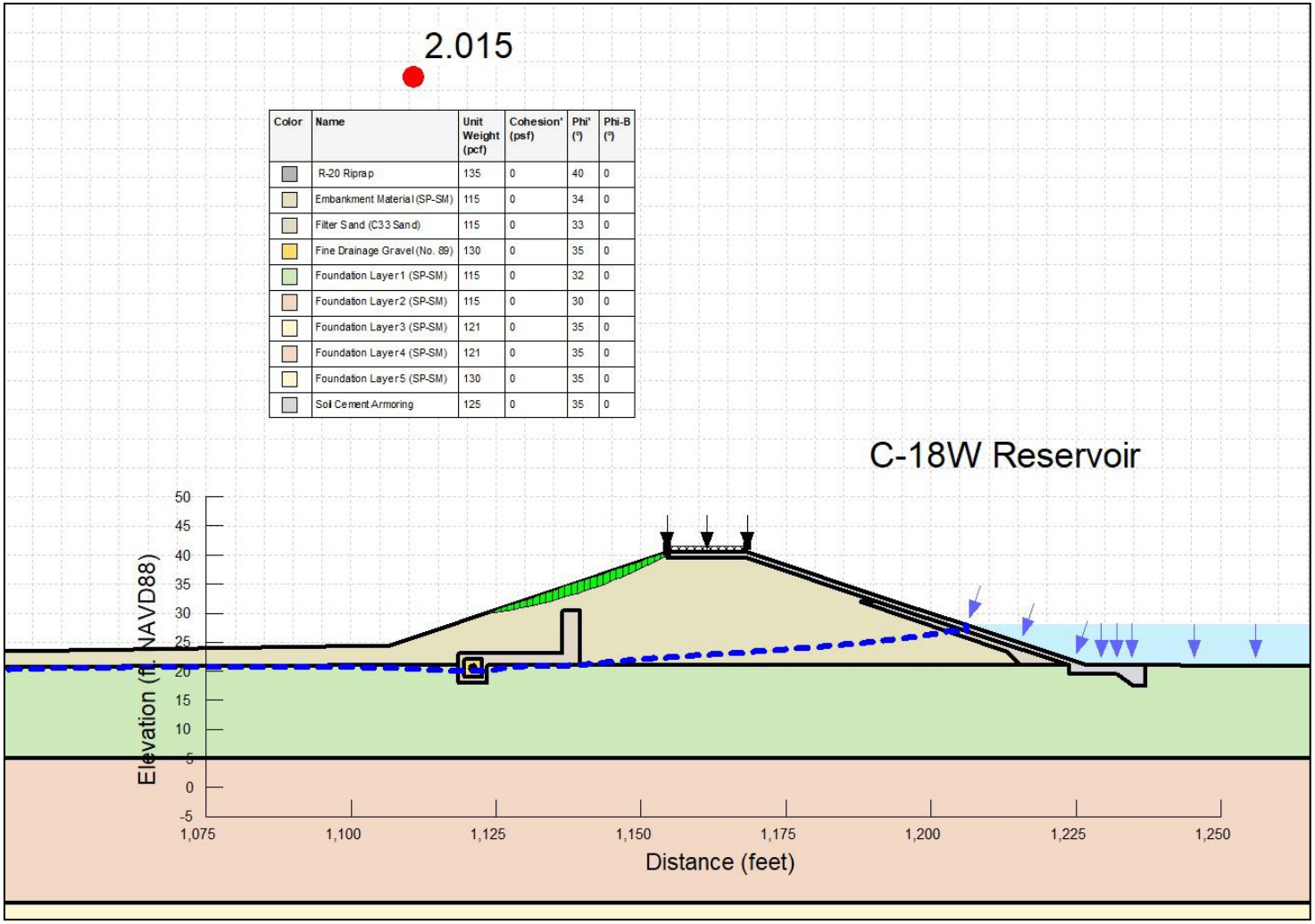


Figure B-1.11. C-18W reservoir west seepage section, slope stability analysis, LT condition, embankment D/S slope.



Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)
	R-20 Riprap	135	0	40	0
	Embankment Material (SP-SM)	115	0	34	0
	Filter Sand (C33 Sand)	115	0	33	0
	Fine Drainage Gravel (No. 89)	130	0	35	0
	Foundation Layer1 (SP-SM)	115	0	32	0
	Foundation Layer2 (SP-SM)	115	0	30	0
	Foundation Layer3 (SP-SM)	121	0	35	0
	Foundation Layer4 (SP-SM)	121	0	35	0
	Foundation Layer5 (SP-SM)	130	0	35	0
	Soil Cement Armoring	125	0	35	0

Figure B-1.12. C-18W reservoir west seepage section, slope stability analysis, LT condition, canal near slope.

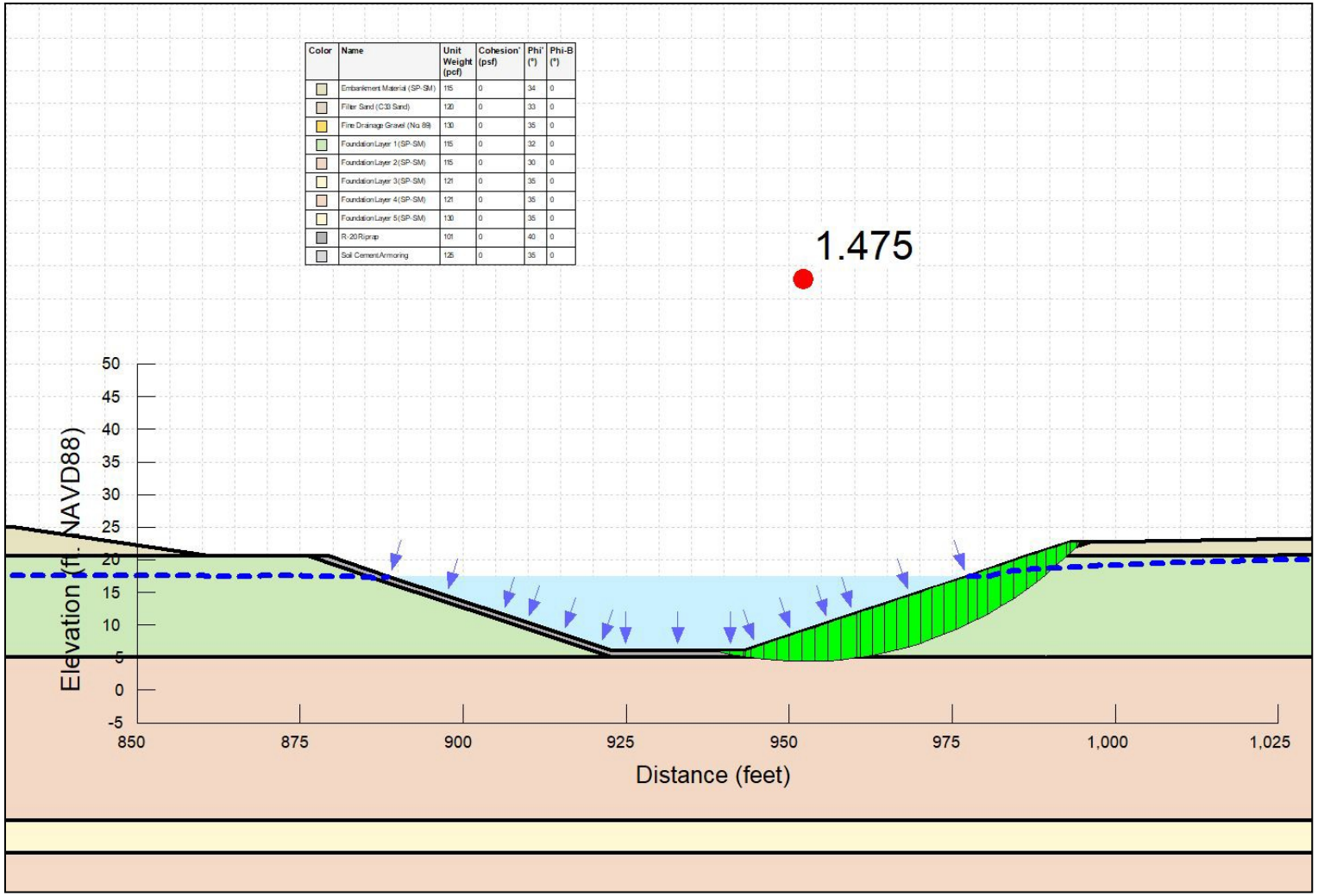
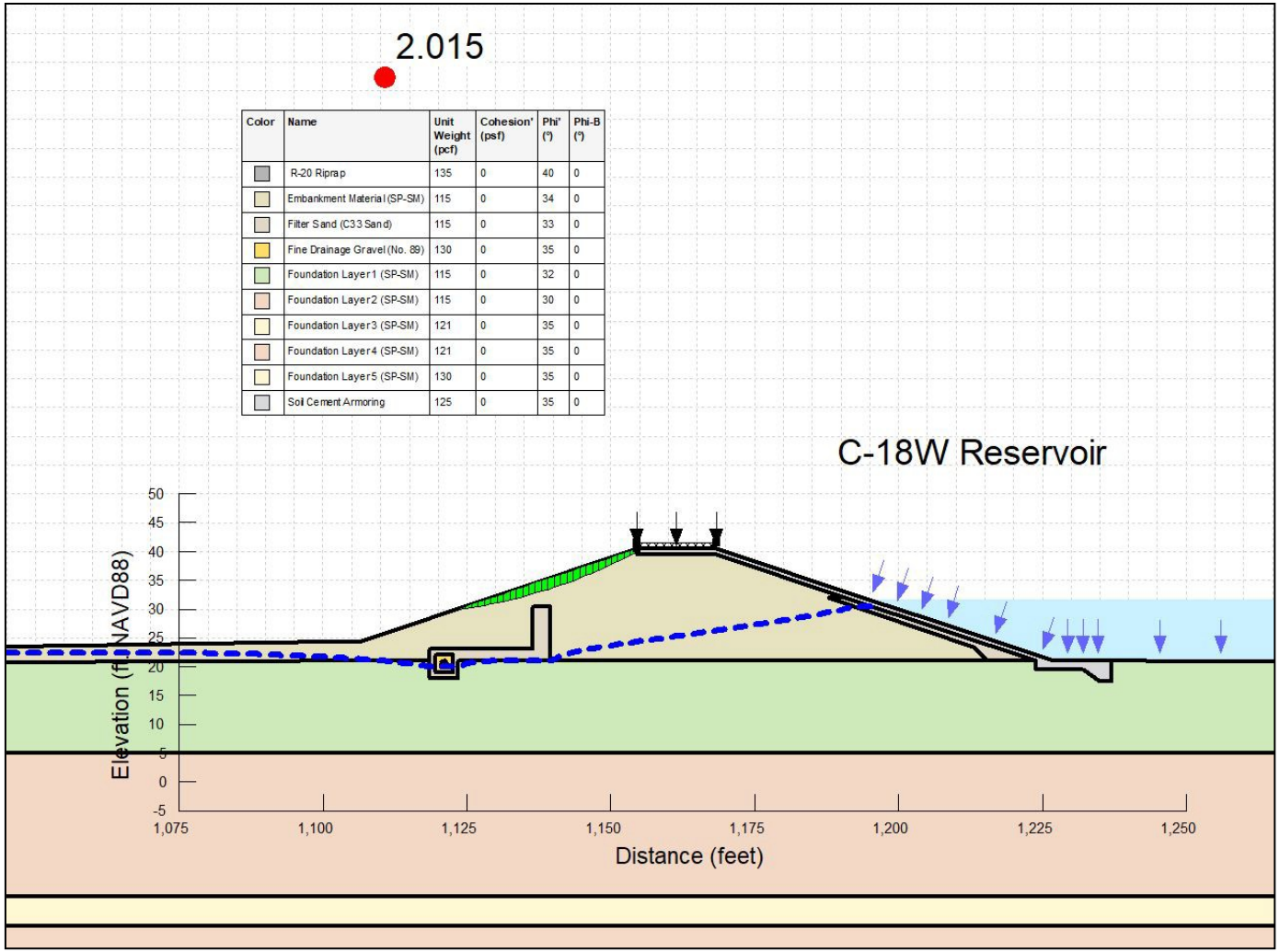


Figure B-1.13. C-18W reservoir west seepage section, slope stability analysis, max pool condition, embankment D/S slope.



Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)
	R-20 Riprap	135	0	40	0
	Embankment Material (SP-SM)	115	0	34	0
	Filter Sand (C33 Sand)	115	0	33	0
	Fine Drainage Gravel (No. 89)	130	0	35	0
	Foundation Layer1 (SP-SM)	115	0	32	0
	Foundation Layer2 (SP-SM)	115	0	30	0
	Foundation Layer3 (SP-SM)	121	0	35	0
	Foundation Layer4 (SP-SM)	121	0	35	0
	Foundation Layer5 (SP-SM)	130	0	35	0
	Soil Cement Armoring	125	0	35	0

Figure B-1.14. C-18W reservoir west seepage section, slope stability analysis, max pool condition, canal near slope.

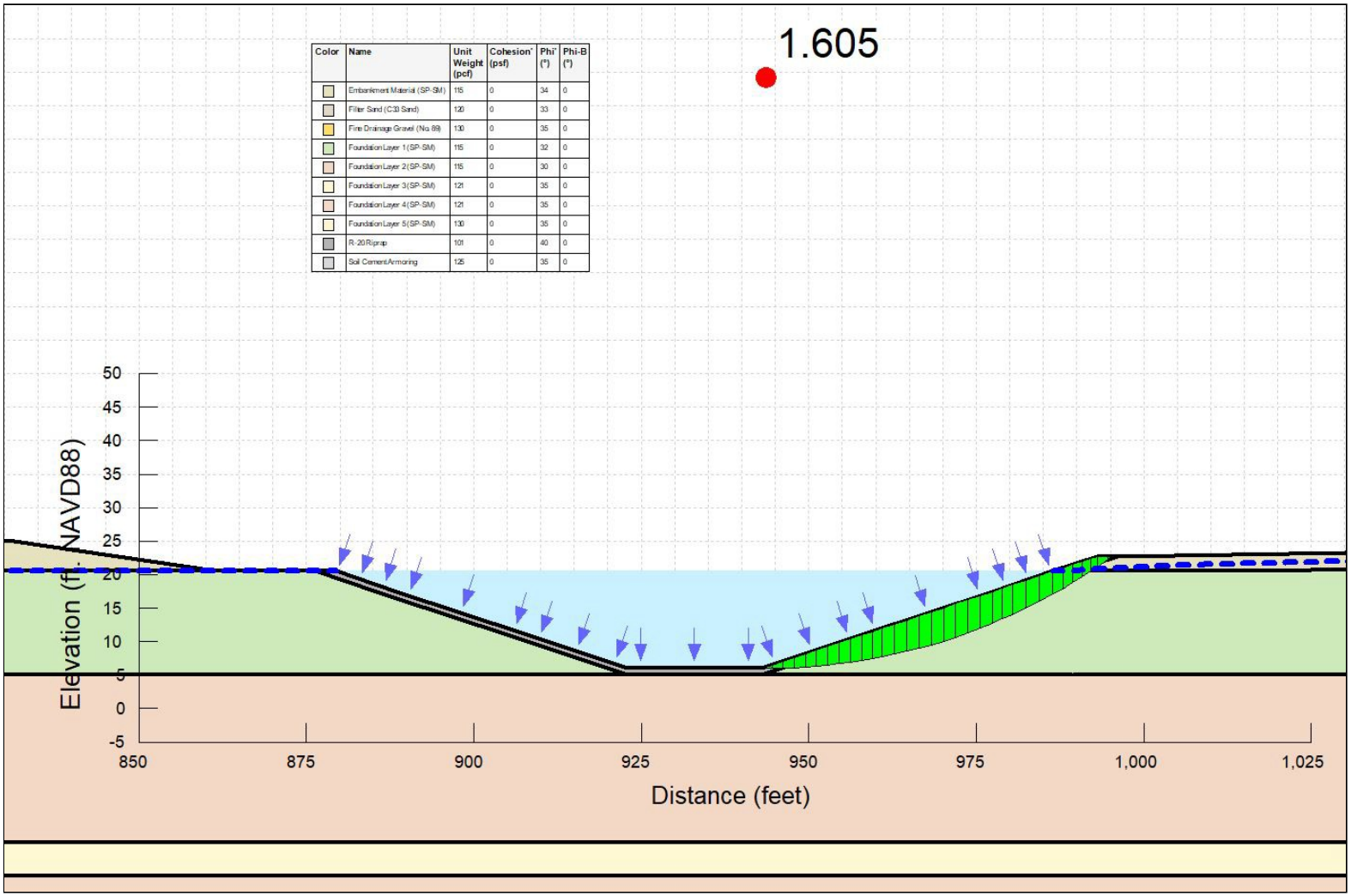
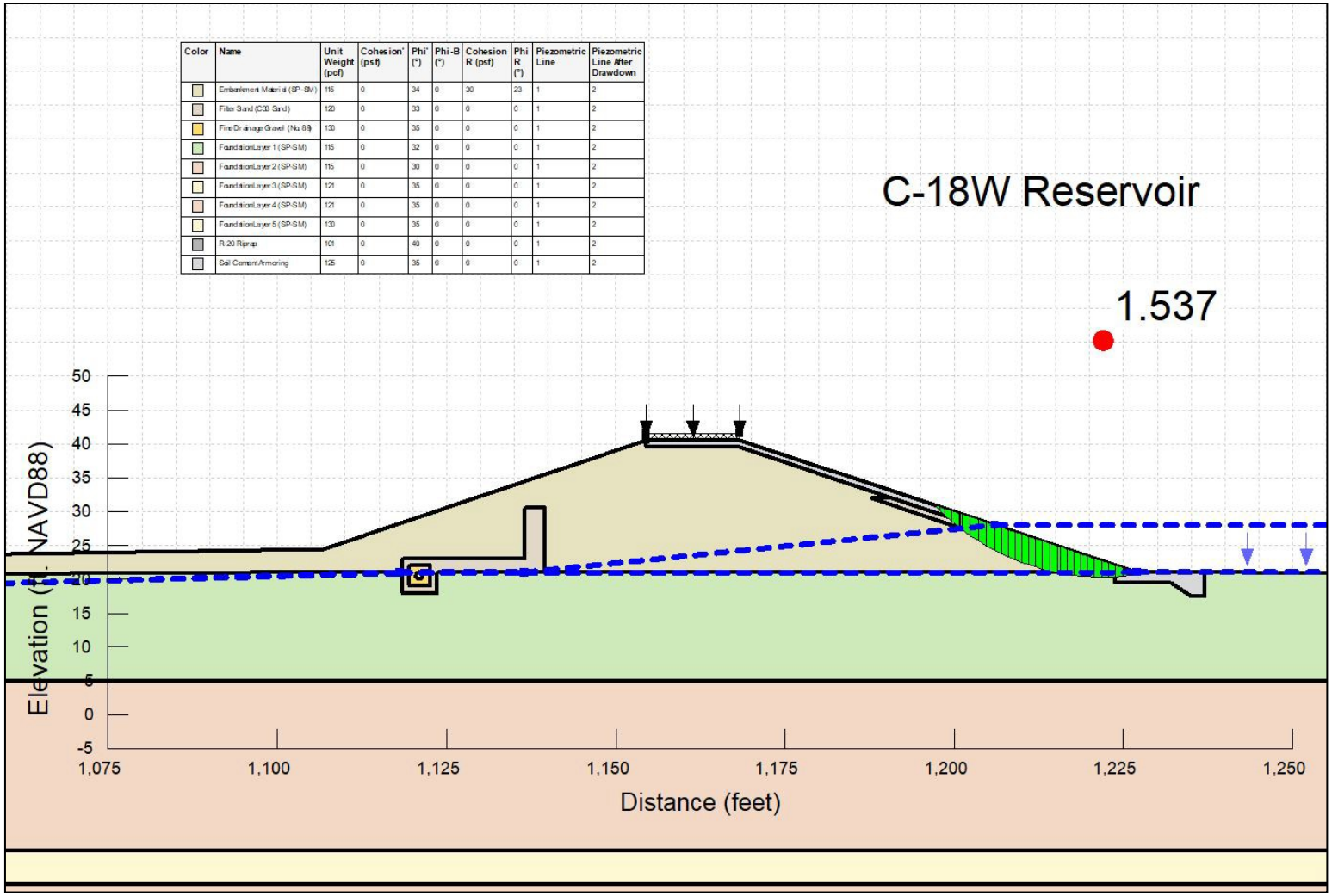


Figure B-1.15. C-18W reservoir west seepage section, slope stability analysis, rapid drawdown condition, embankment U/S slope.



Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)	Cohesion R (psf)	Phi R (°)	Piezometric Line	Piezometric Line After Drawdown
	Embankment Material (SP-SM)	115	0	34	0	30	23	1	2
	Filter Sand (C33 Sand)	120	0	33	0	0	0	1	2
	Fine Drainage Gravel (No. 89)	100	0	35	0	0	0	1	2
	FoundationLayer 1 (SP-SM)	115	0	32	0	0	0	1	2
	FoundationLayer 2 (SP-SM)	115	0	30	0	0	0	1	2
	FoundationLayer 3 (SP-SM)	121	0	35	0	0	0	1	2
	FoundationLayer 4 (SP-SM)	121	0	35	0	0	0	1	2
	FoundationLayer 5 (SP-SM)	100	0	35	0	0	0	1	2
	R-20 Riprap	101	0	40	0	0	0	1	2
	Soil Cement Armoring	125	0	35	0	0	0	1	2

Figure B-1.16. C-18W reservoir south seepage section, steady-state seepage end of construction condition with no pool.

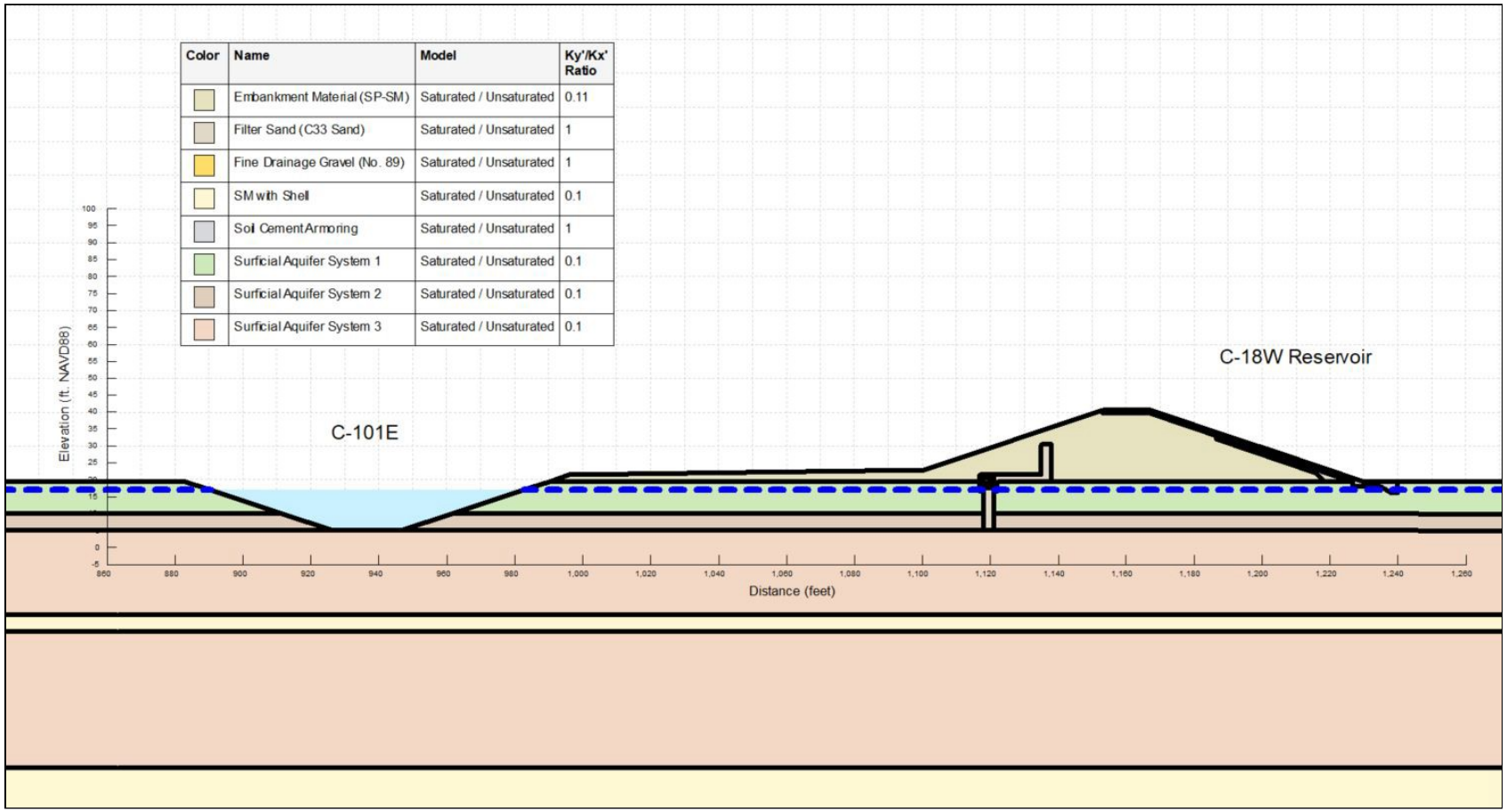


Figure B-1.17. C-18W reservoir south seepage section, steady-state seepage, long term condition with normal pool.

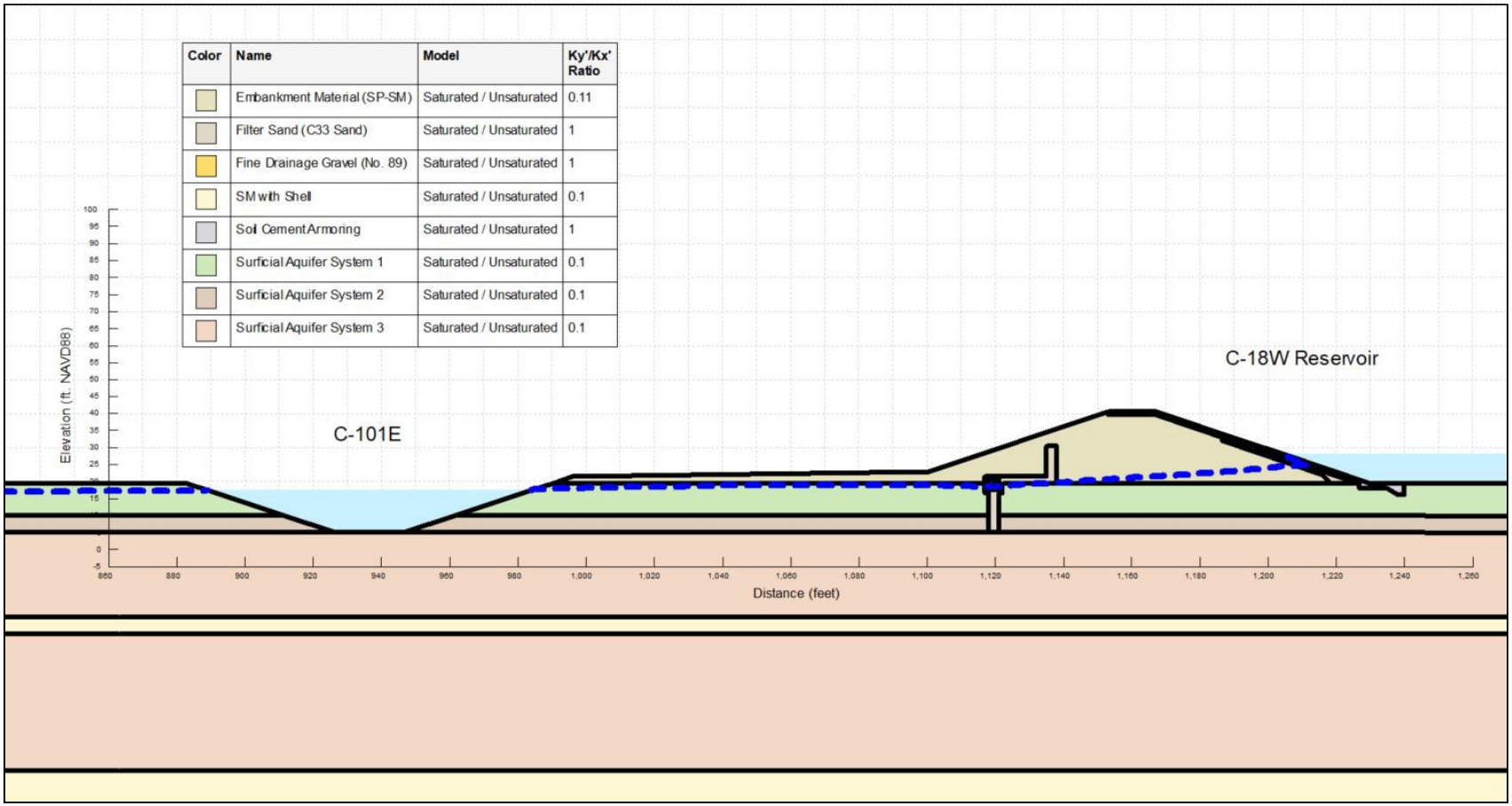


Figure B-1.18. C-18W reservoir south seepage section, steady-state seepage long-term condition with maximum pool.

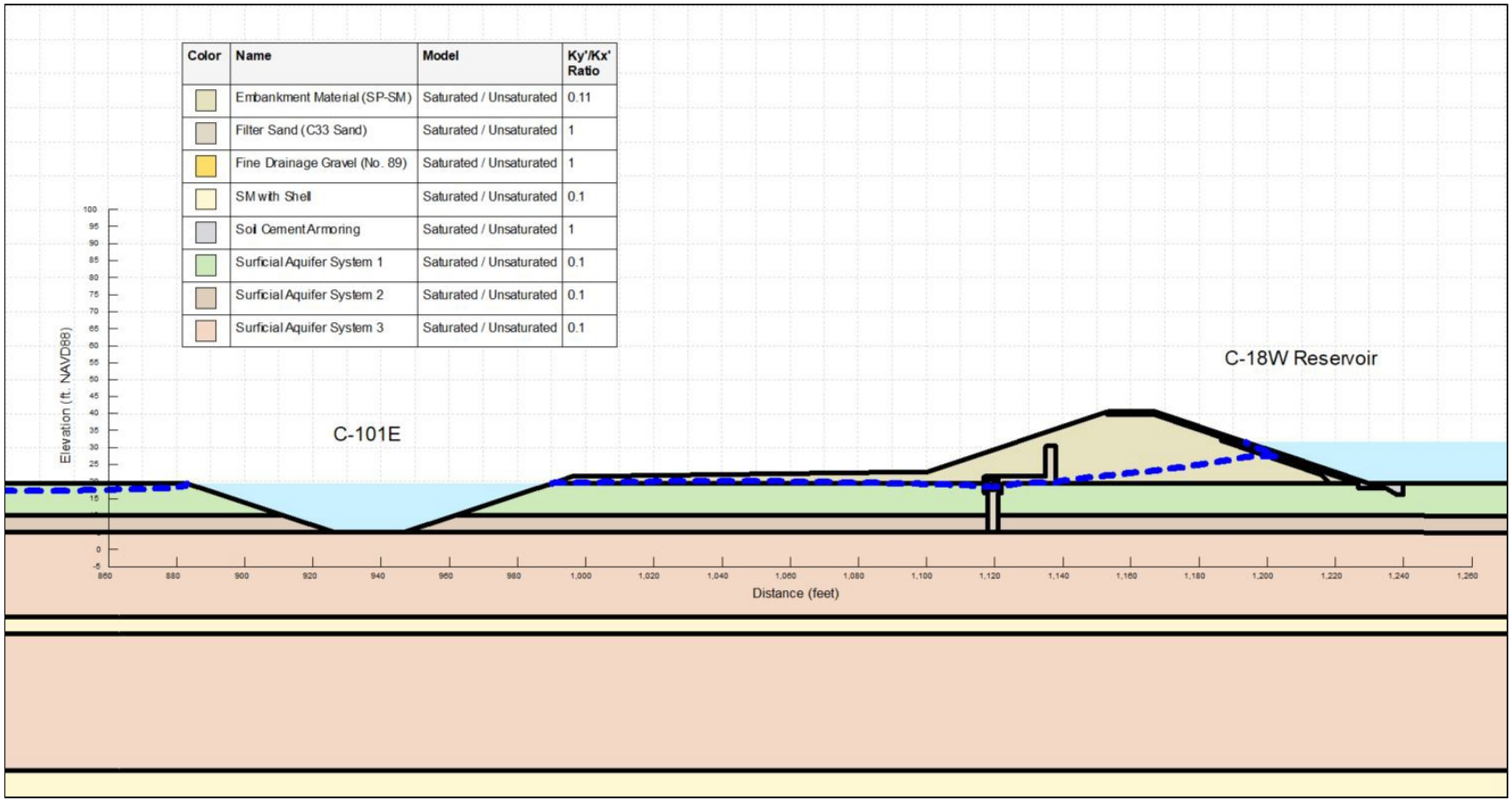
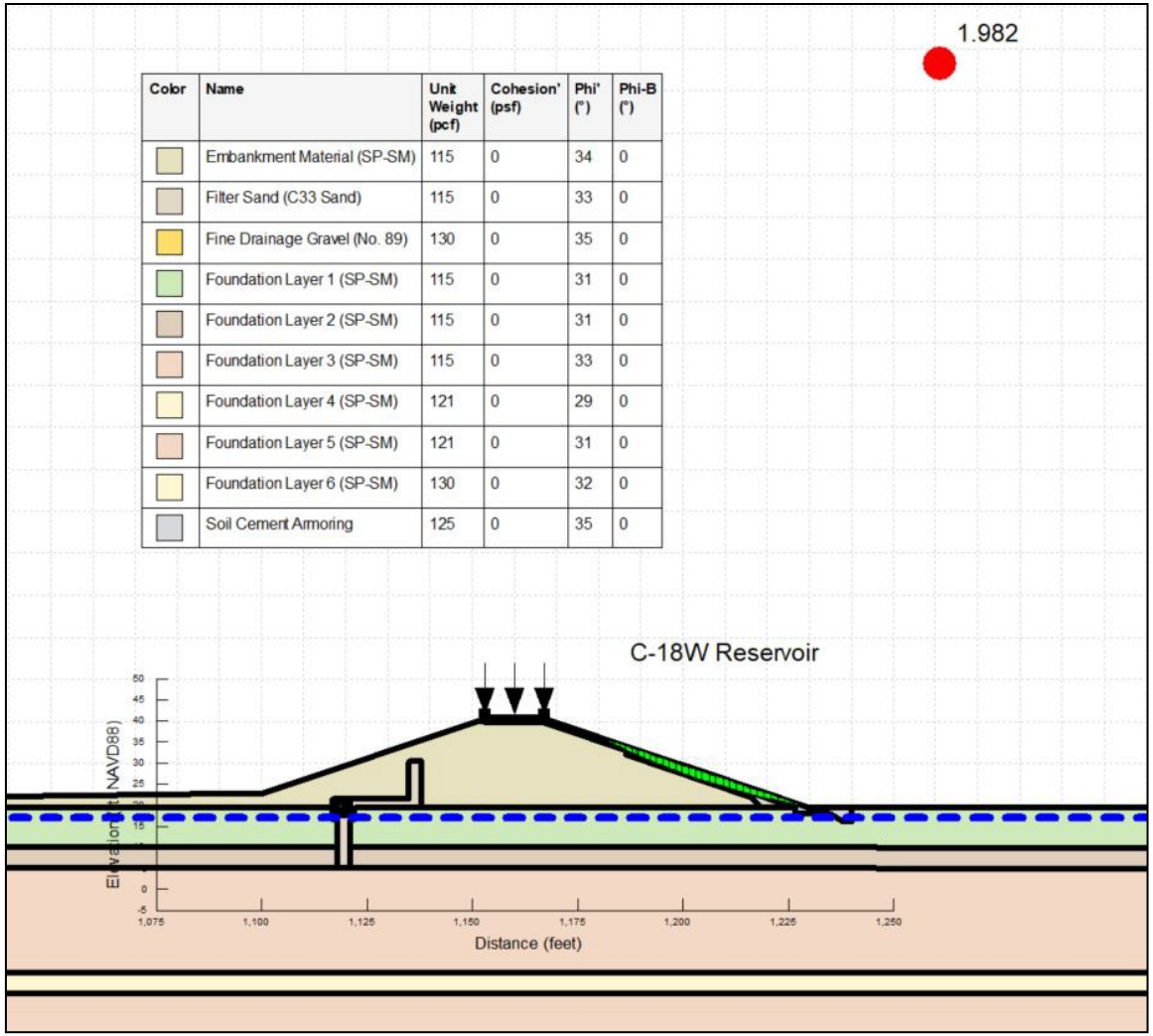
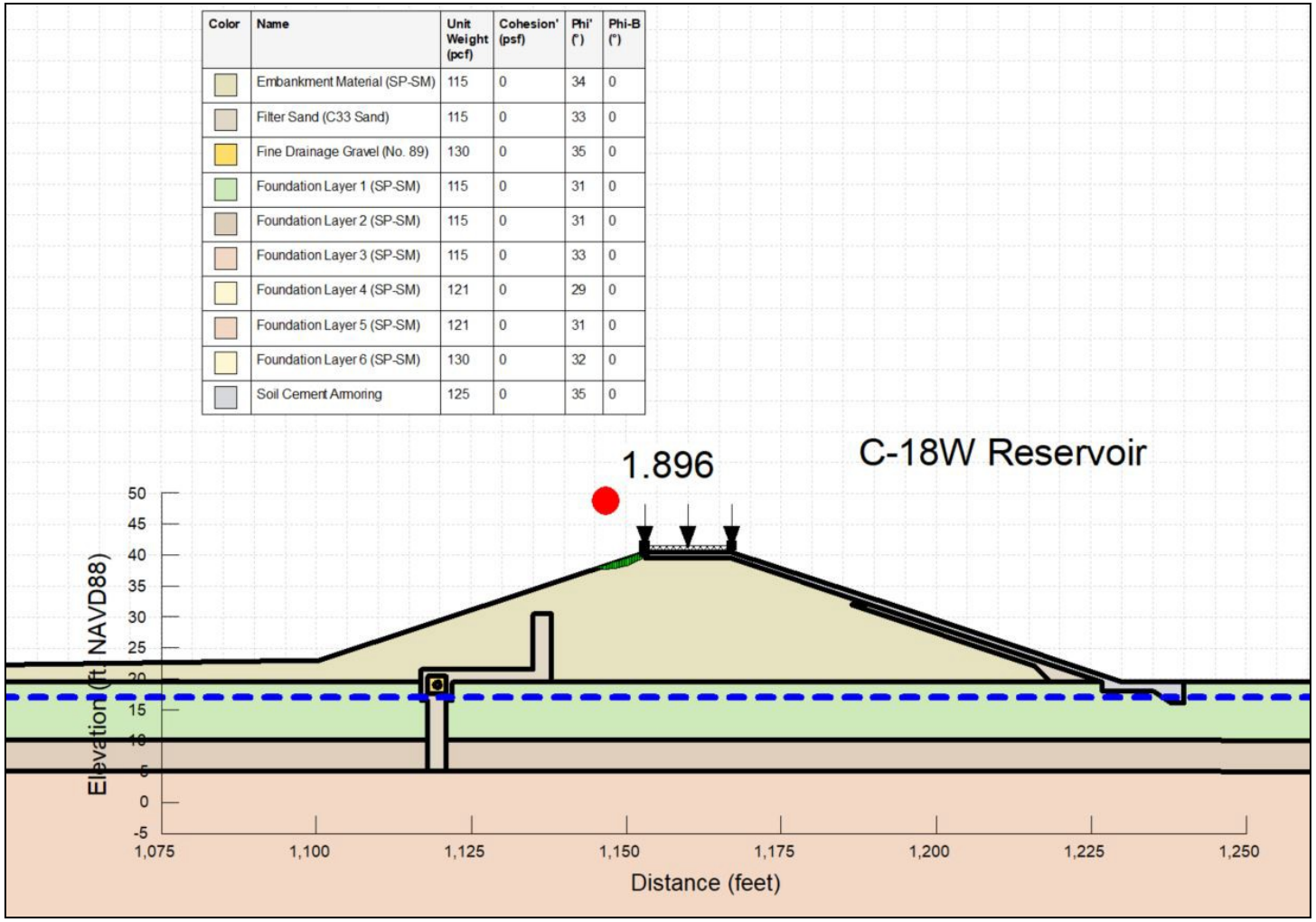


Figure B-1.19. C-18W reservoir south seepage section, slope stability analysis, end of construction condition, embankment U/S slope.



Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)
	Embankment Material (SP-SM)	115	0	34	0
	Filter Sand (C33 Sand)	115	0	33	0
	Fine Drainage Gravel (No. 89)	130	0	35	0
	Foundation Layer 1 (SP-SM)	115	0	31	0
	Foundation Layer 2 (SP-SM)	115	0	31	0
	Foundation Layer 3 (SP-SM)	115	0	33	0
	Foundation Layer 4 (SP-SM)	121	0	29	0
	Foundation Layer 5 (SP-SM)	121	0	31	0
	Foundation Layer 6 (SP-SM)	130	0	32	0
	Soil Cement Armoring	125	0	35	0

Figure B-1.20. C-18W reservoir south seepage section, slope stability analysis, end of construction condition, embankment D/S slope.



Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)
	Embankment Material (SP-SM)	115	0	34	0
	Filter Sand (C33 Sand)	115	0	33	0
	Fine Drainage Gravel (No. 89)	130	0	35	0
	Foundation Layer 1 (SP-SM)	115	0	31	0
	Foundation Layer 2 (SP-SM)	115	0	31	0
	Foundation Layer 3 (SP-SM)	115	0	33	0
	Foundation Layer 4 (SP-SM)	121	0	29	0
	Foundation Layer 5 (SP-SM)	121	0	31	0
	Foundation Layer 6 (SP-SM)	130	0	32	0
	Soil Cement Armoring	125	0	35	0

Figure B-1.21. C-18W reservoir south seepage section, slope stability analysis, end of construction condition, canal near slope.

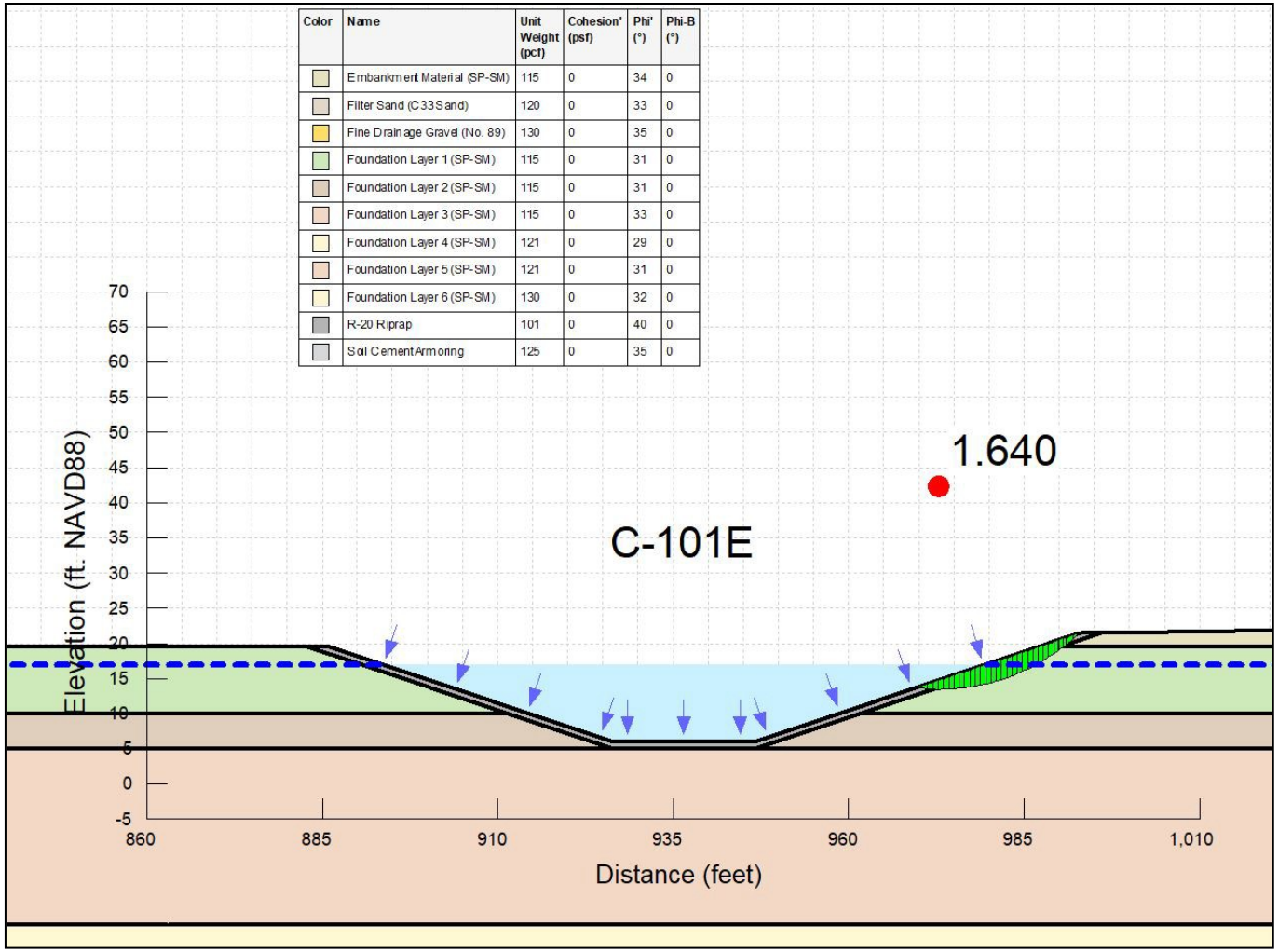
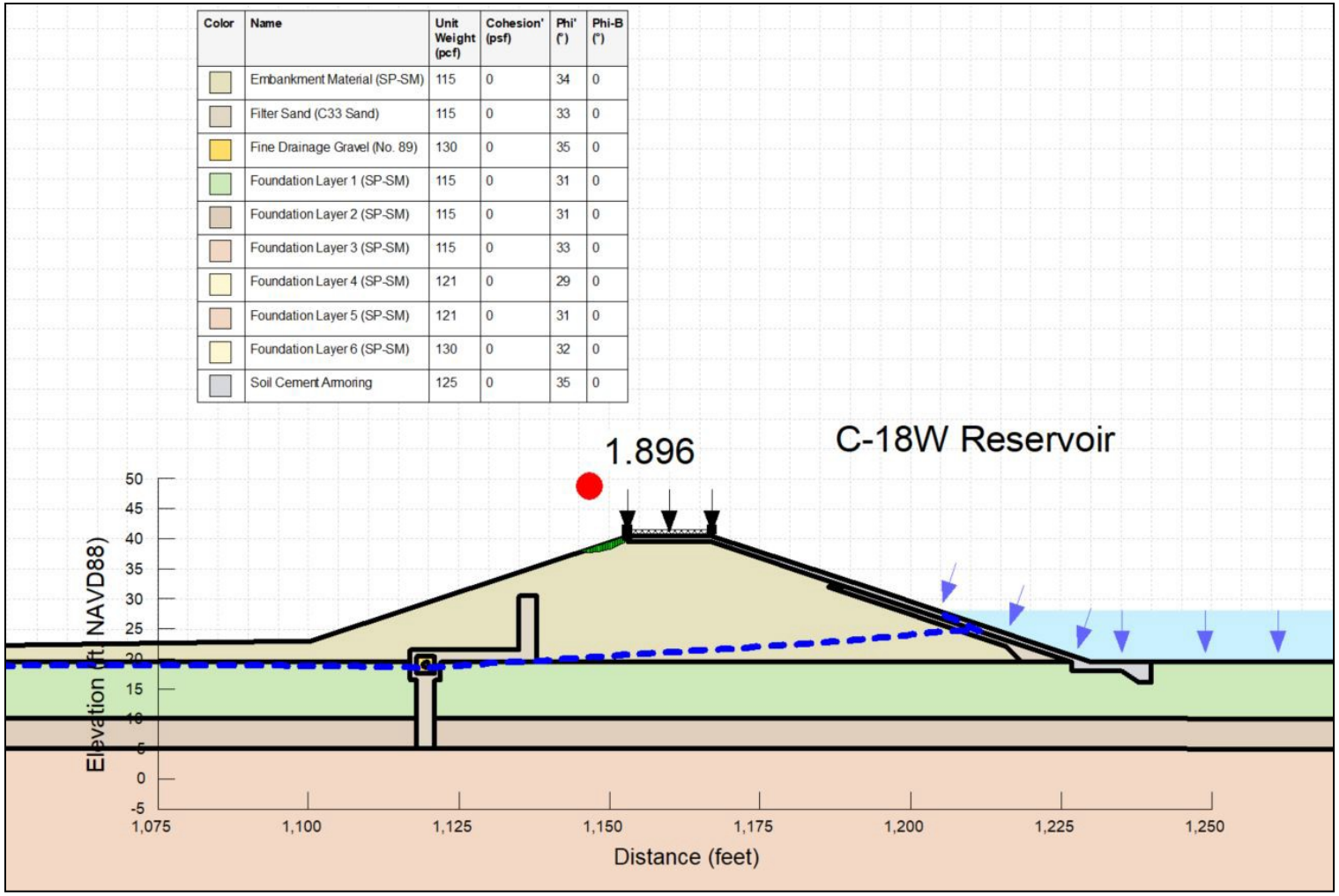


Figure B-1.22. C-18W reservoir south seepage section, slope stability analysis, long term condition, embankment D/S slope.



Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)
	Embankment Material (SP-SM)	115	0	34	0
	Filter Sand (C33 Sand)	115	0	33	0
	Fine Drainage Gravel (No. 89)	130	0	35	0
	Foundation Layer 1 (SP-SM)	115	0	31	0
	Foundation Layer 2 (SP-SM)	115	0	31	0
	Foundation Layer 3 (SP-SM)	115	0	33	0
	Foundation Layer 4 (SP-SM)	121	0	29	0
	Foundation Layer 5 (SP-SM)	121	0	31	0
	Foundation Layer 6 (SP-SM)	130	0	32	0
	Soil Cement Armoring	125	0	35	0

Figure B-1.23. C-18W reservoir south seepage section, slope stability analysis, long term condition, canal near slope.

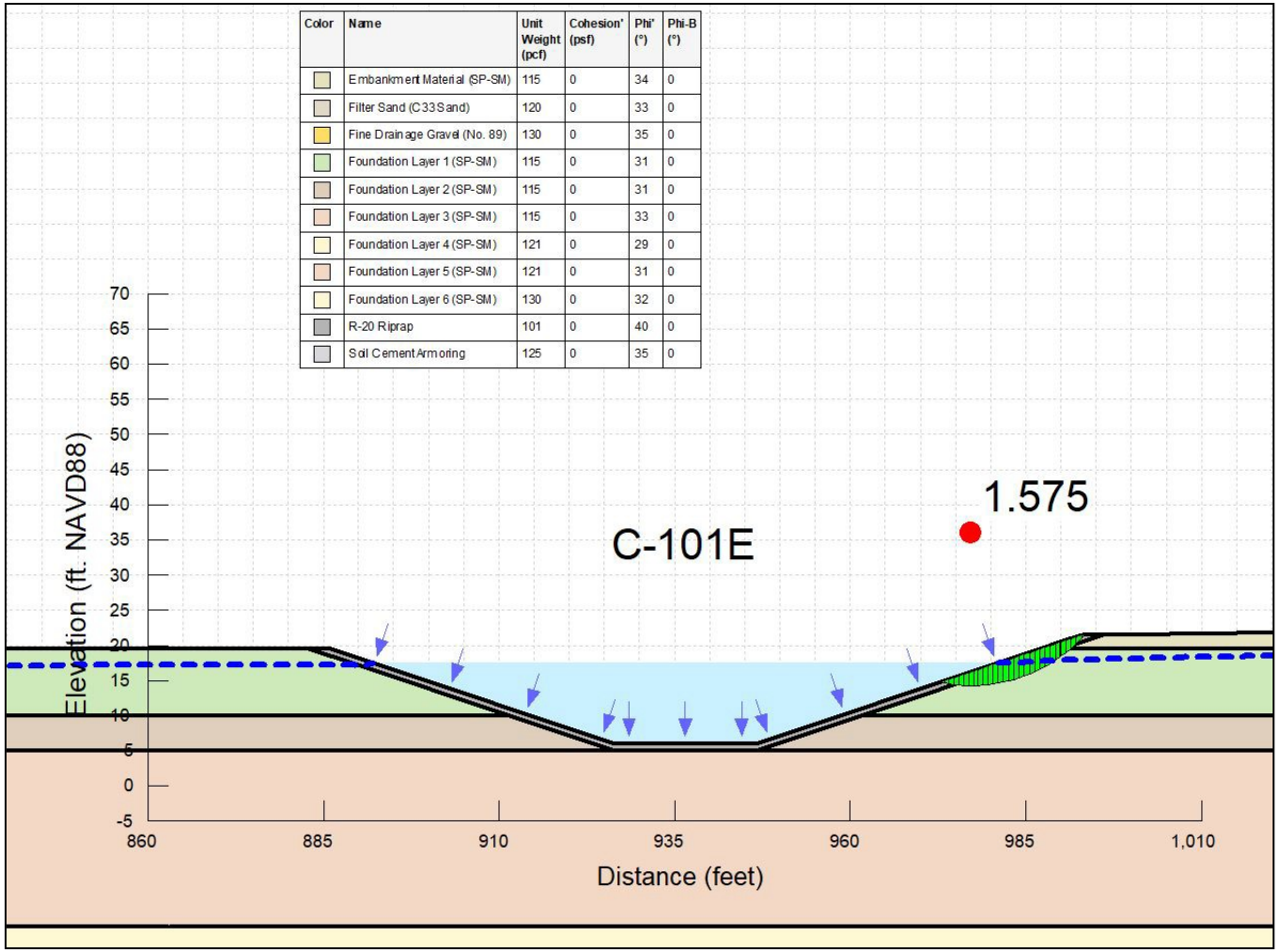
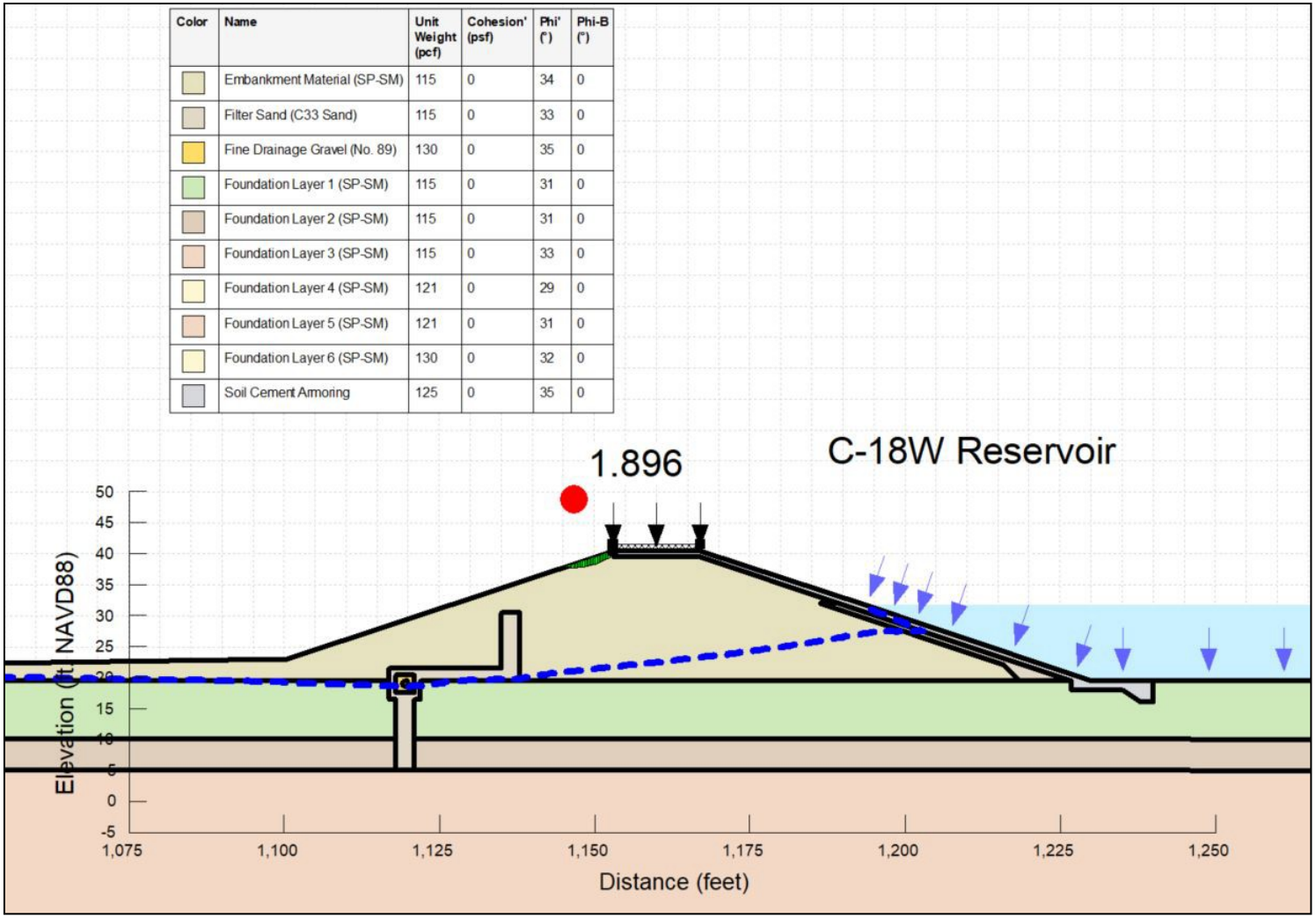


Figure B-1.24. C-18W reservoir south seepage section, slope stability analysis, max pool condition, embankment U/S slope.



Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)
	Embankment Material (SP-SM)	115	0	34	0
	Filter Sand (C33 Sand)	115	0	33	0
	Fine Drainage Gravel (No. 89)	130	0	35	0
	Foundation Layer 1 (SP-SM)	115	0	31	0
	Foundation Layer 2 (SP-SM)	115	0	31	0
	Foundation Layer 3 (SP-SM)	115	0	33	0
	Foundation Layer 4 (SP-SM)	121	0	29	0
	Foundation Layer 5 (SP-SM)	121	0	31	0
	Foundation Layer 6 (SP-SM)	130	0	32	0
	Soil Cement Armoring	125	0	35	0

Figure B-1.25. C-18W reservoir south seepage section, slope stability analysis, max pool condition, canal near slope.

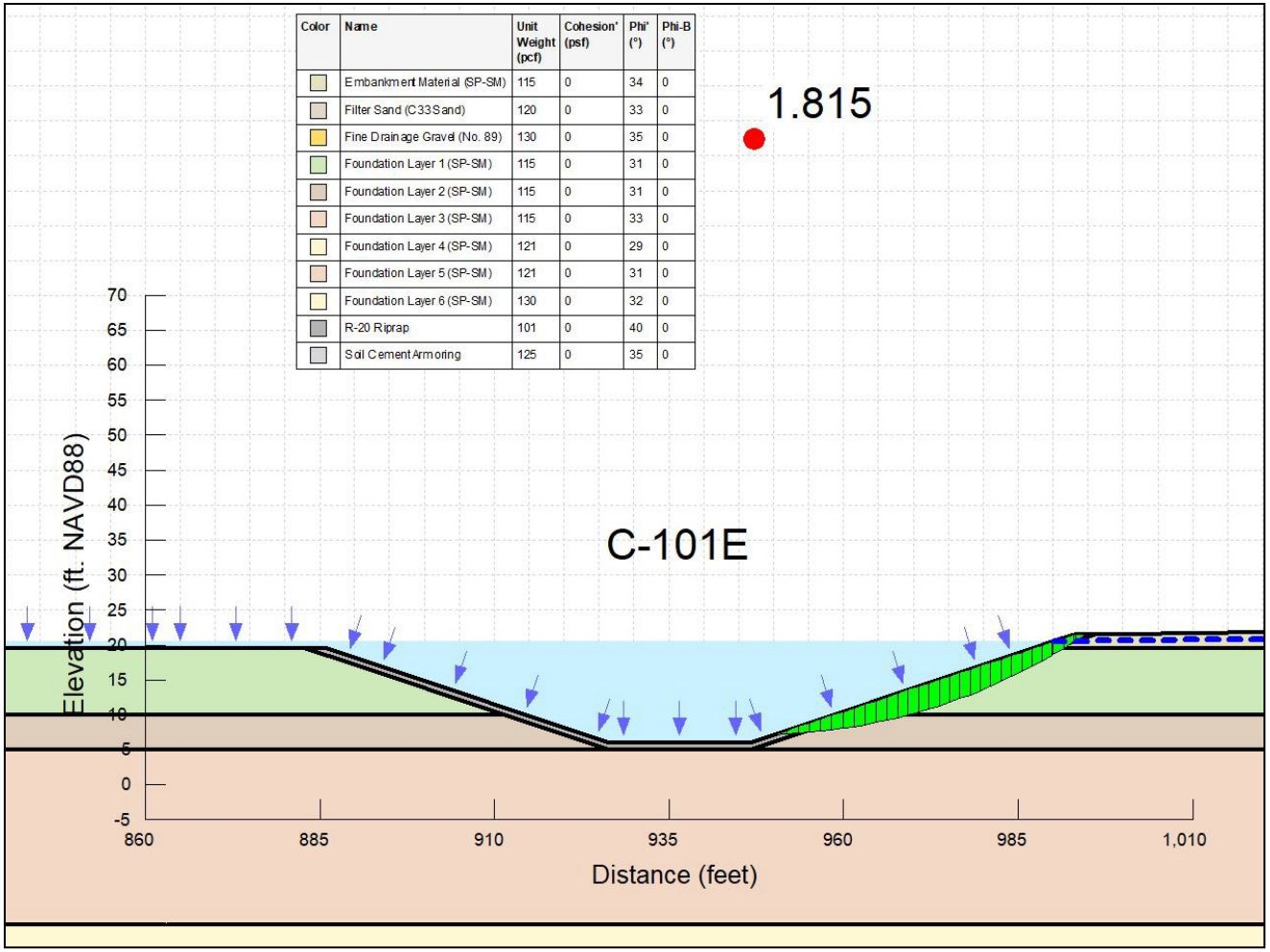
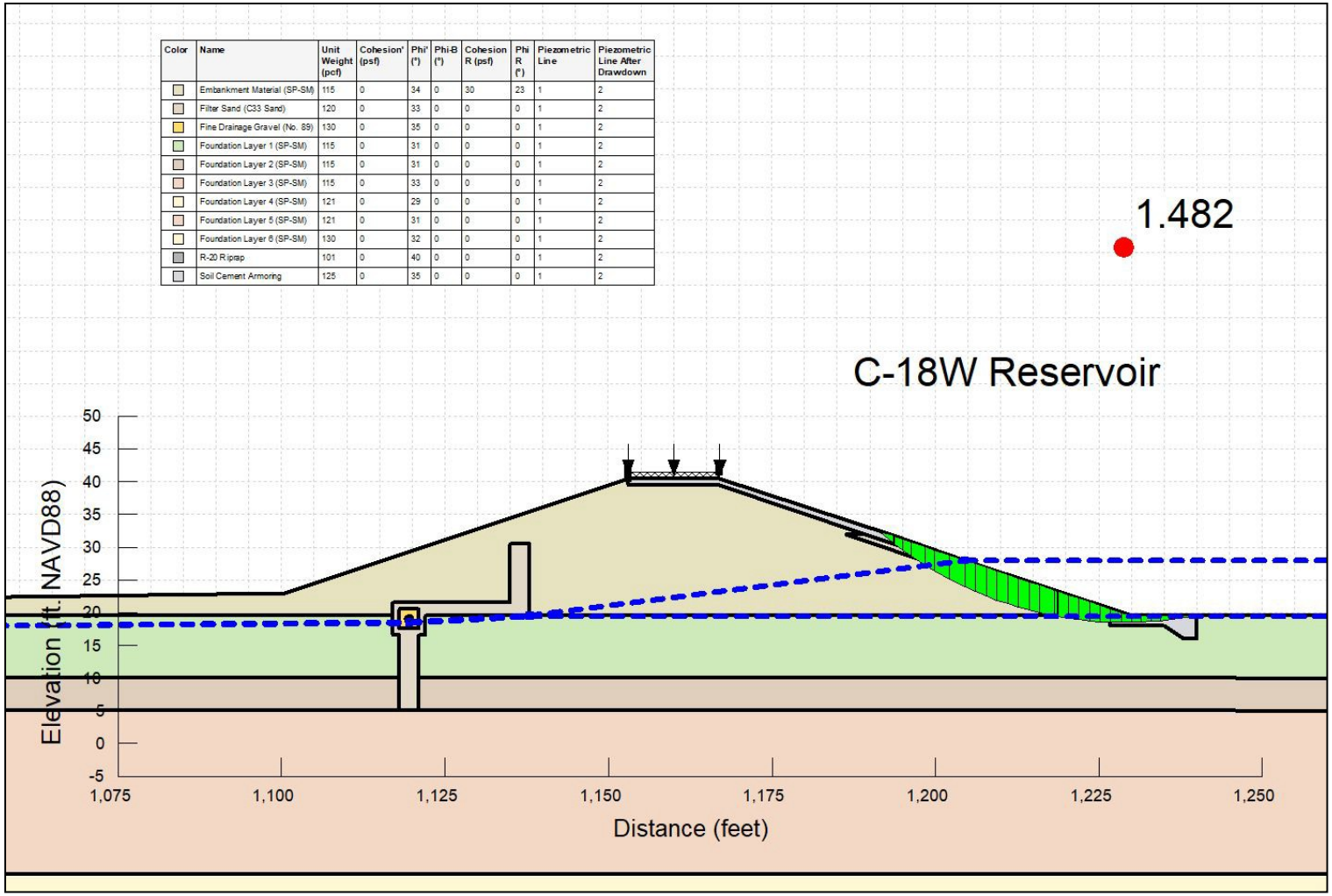


Figure B-1.26. C-18W reservoir south seepage section, slope stability analysis, rapid drawdown condition, embankment U/S slope.



Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)	Cohesion R (psf)	Phi R (°)	Piezometric Line	Piezometric Line After Drawdown
	Embankment Material (SP-SM)	115	0	34	0	30	23	1	2
	Filter Sand (C33 Sand)	120	0	33	0	0	0	1	2
	Fine Drainage Gravel (No. 89)	130	0	35	0	0	0	1	2
	Foundation Layer 1 (SP-SM)	115	0	31	0	0	0	1	2
	Foundation Layer 2 (SP-SM)	115	0	31	0	0	0	1	2
	Foundation Layer 3 (SP-SM)	115	0	33	0	0	0	1	2
	Foundation Layer 4 (SP-SM)	121	0	29	0	0	0	1	2
	Foundation Layer 5 (SP-SM)	121	0	31	0	0	0	1	2
	Foundation Layer 6 (SP-SM)	130	0	32	0	0	0	1	2
	R-20 Riprap	101	0	40	0	0	0	1	2
	Soil Cement Armoring	125	0	35	0	0	0	1	2

Figure B-1.27. C-18W reservoir east seepage section, steady-state seepage end of construction condition with no pool.

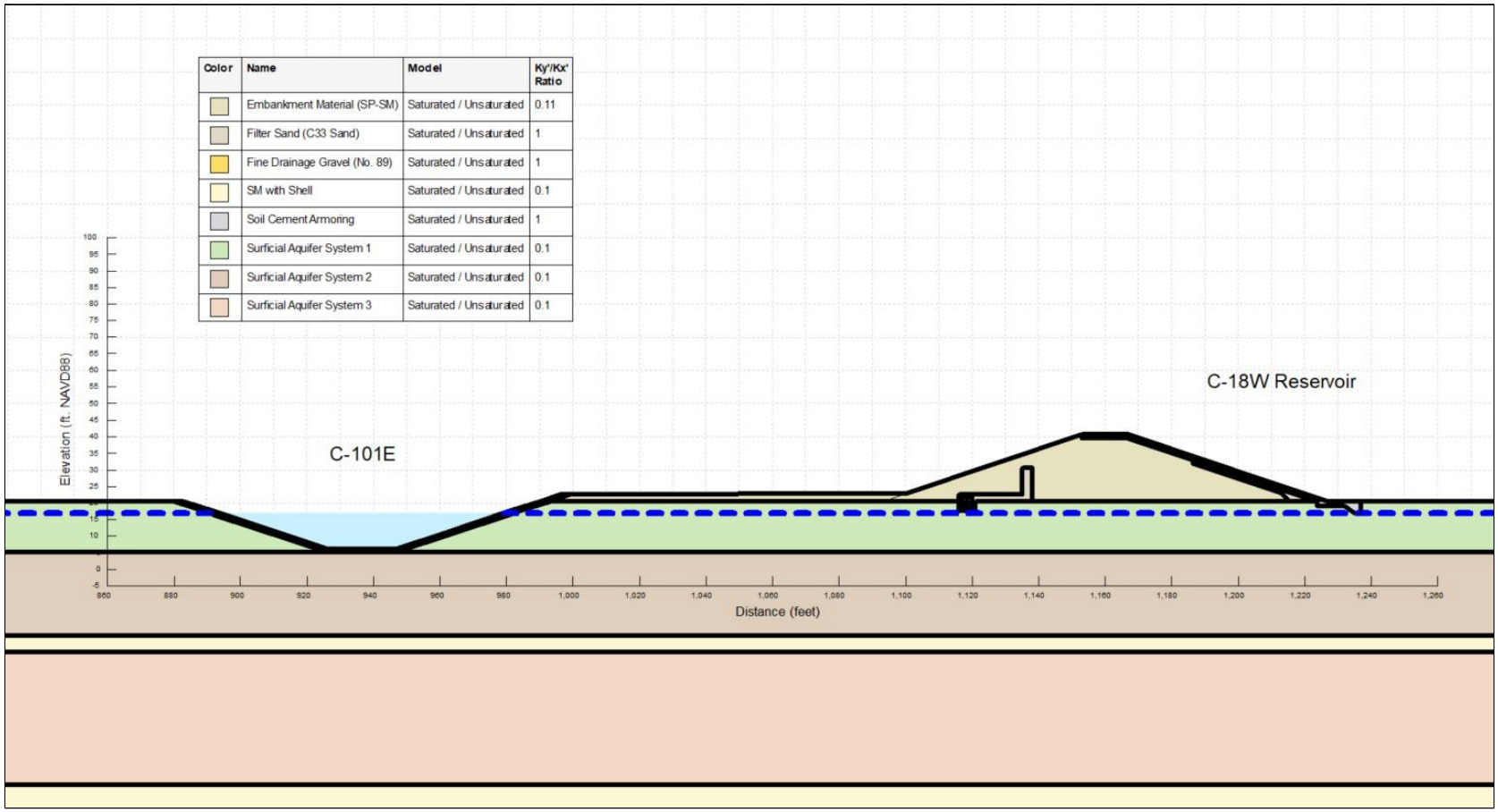


Figure B-1.28. C-18W reservoir east seepage section, steady-state seepage, long term condition with normal pool.

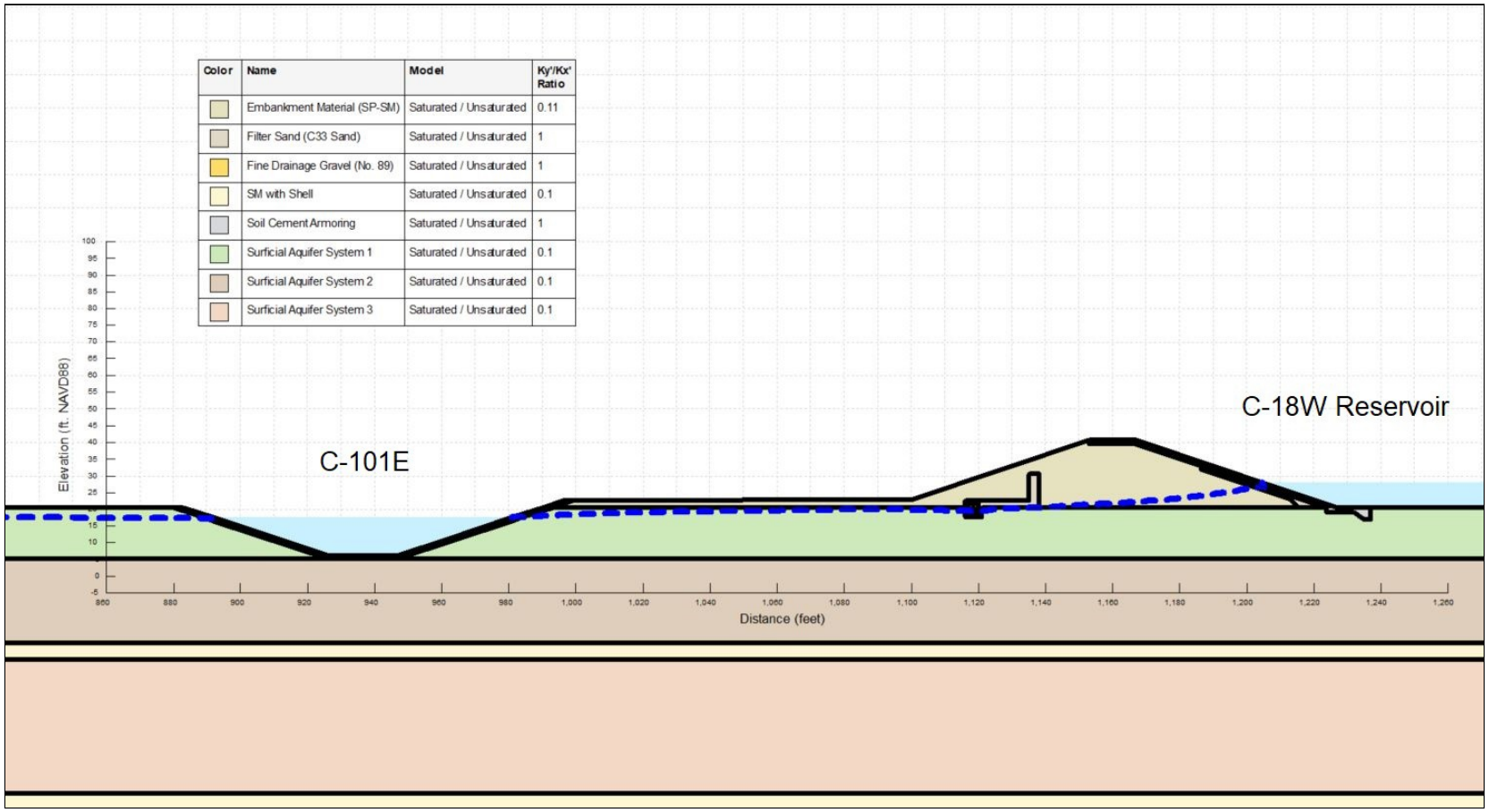


Figure B-1.29. C-18W reservoir east seepage section, steady-state seepage, long term condition with maximum pool.

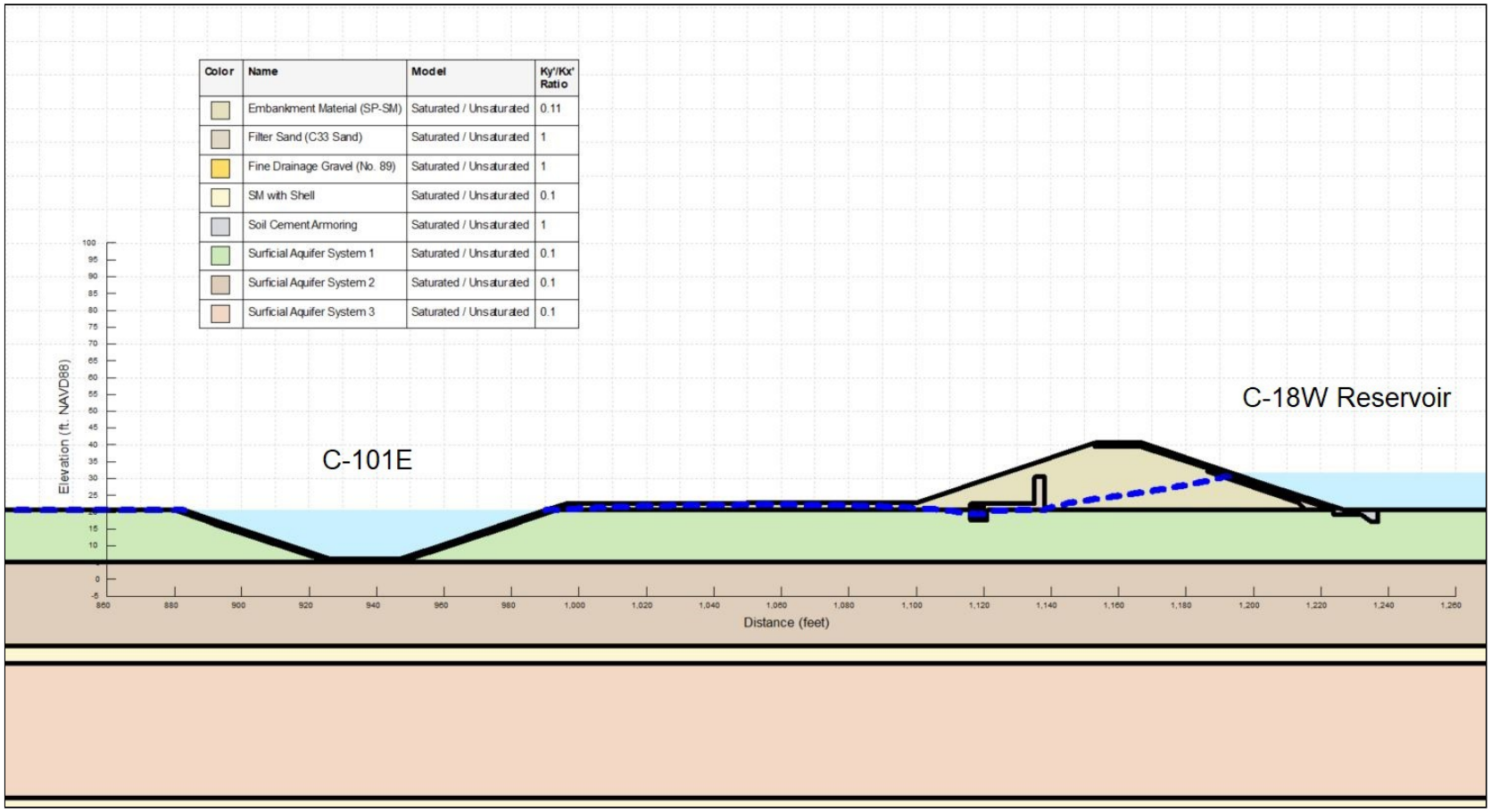
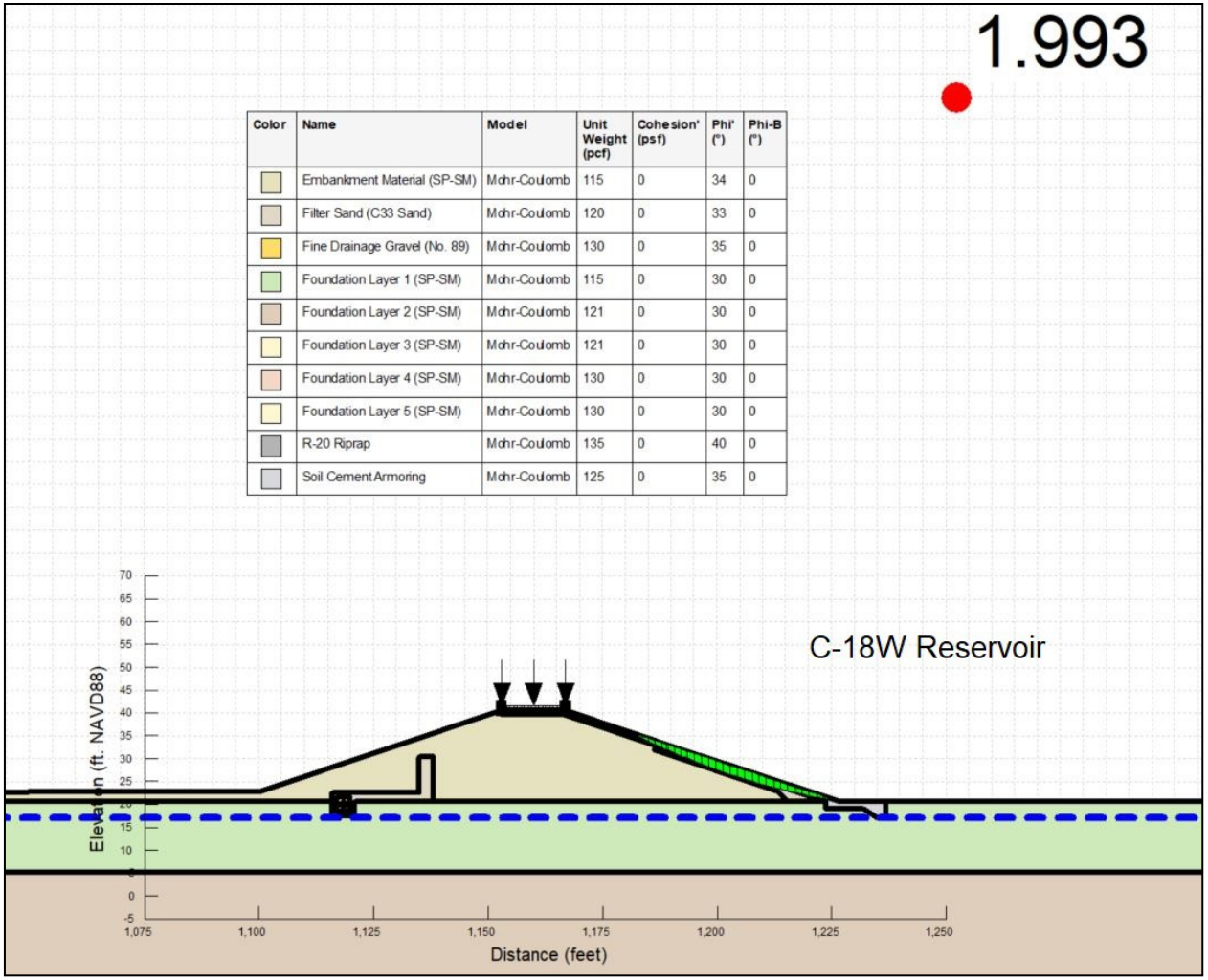
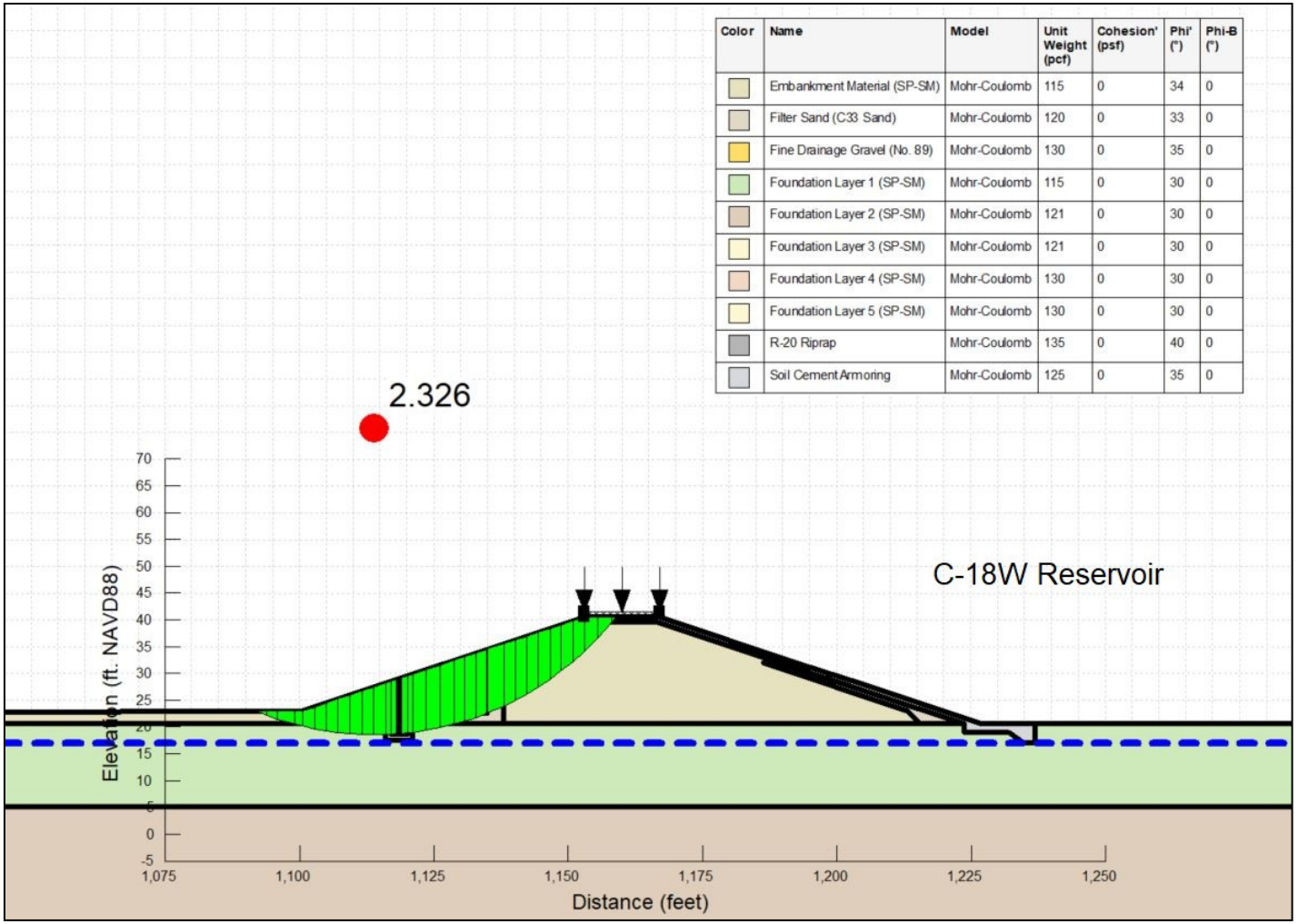


Figure B-1.30. C-18W reservoir east seepage section, slope stability analysis, end of construction condition, embankment U/S slope.



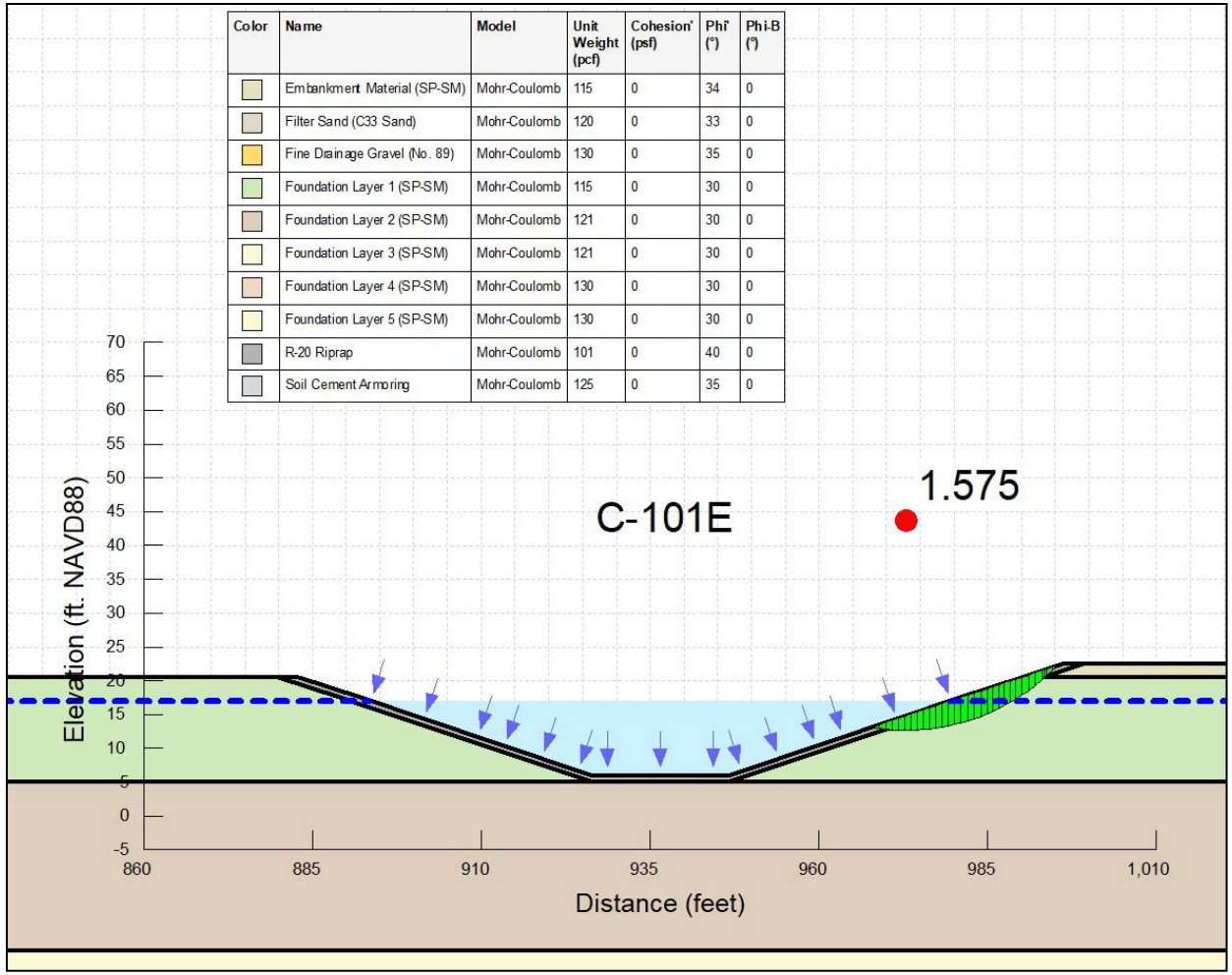
Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)
	Embankment Material (SP-SM)	Mohr-Coulomb	115	0	34	0
	Filter Sand (C33 Sand)	Mohr-Coulomb	120	0	33	0
	Fine Drainage Gravel (No. 89)	Mohr-Coulomb	130	0	35	0
	Foundation Layer 1 (SP-SM)	Mohr-Coulomb	115	0	30	0
	Foundation Layer 2 (SP-SM)	Mohr-Coulomb	121	0	30	0
	Foundation Layer 3 (SP-SM)	Mohr-Coulomb	121	0	30	0
	Foundation Layer 4 (SP-SM)	Mohr-Coulomb	130	0	30	0
	Foundation Layer 5 (SP-SM)	Mohr-Coulomb	130	0	30	0
	R-20 Riprap	Mohr-Coulomb	135	0	40	0
	Soil Cement Armoring	Mohr-Coulomb	125	0	35	0

Figure B-1.31. C-18W reservoir east seepage section, slope stability analysis, end of construction condition, embankment D/S slope.



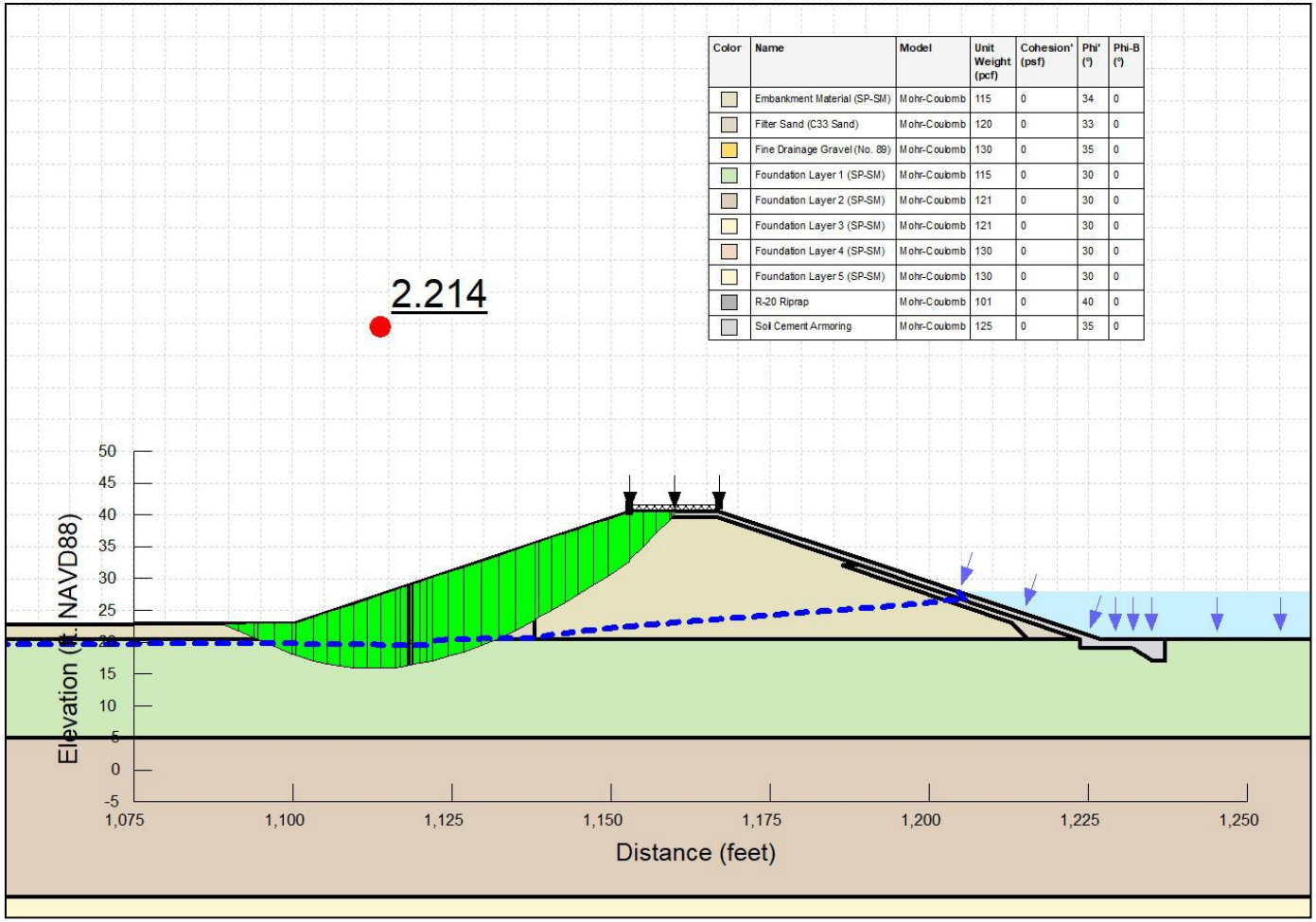
Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)
	Embankment Material (SP-SM)	Mohr-Coulomb	115	0	34	0
	Filter Sand (C33 Sand)	Mohr-Coulomb	120	0	33	0
	Fine Drainage Gravel (No. 89)	Mohr-Coulomb	130	0	35	0
	Foundation Layer 1 (SP-SM)	Mohr-Coulomb	115	0	30	0
	Foundation Layer 2 (SP-SM)	Mohr-Coulomb	121	0	30	0
	Foundation Layer 3 (SP-SM)	Mohr-Coulomb	121	0	30	0
	Foundation Layer 4 (SP-SM)	Mohr-Coulomb	130	0	30	0
	Foundation Layer 5 (SP-SM)	Mohr-Coulomb	130	0	30	0
	R-20 Riprap	Mohr-Coulomb	135	0	40	0
	Soil Cement Armoring	Mohr-Coulomb	125	0	35	0

Figure B-1.32. C-18W reservoir east seepage section, slope stability analysis, end of construction condition, canal near slope.



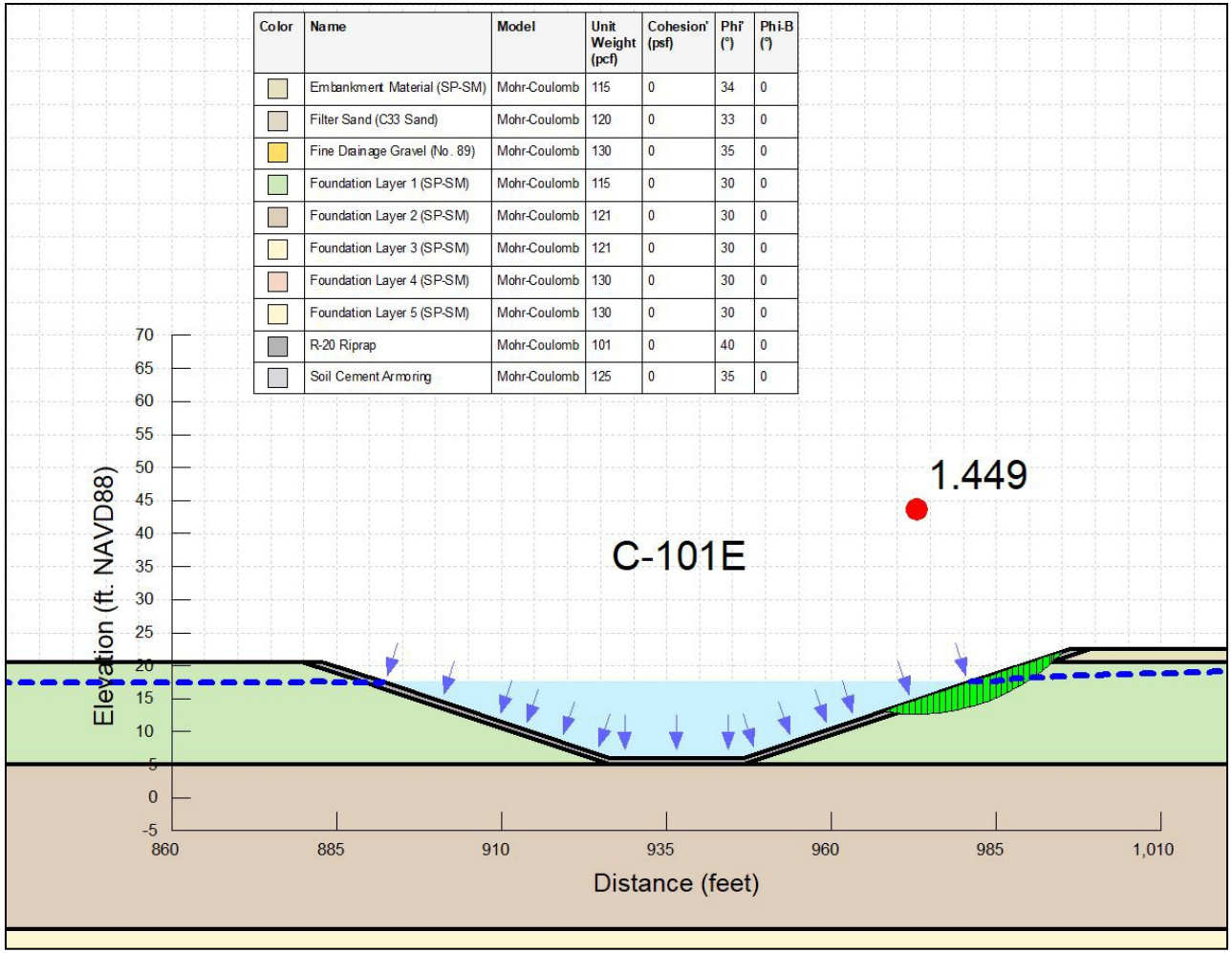
Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)
	Embankment Material (SP-SM)	Mohr-Coulomb	115	0	34	0
	Filter Sand (C33 Sand)	Mohr-Coulomb	120	0	33	0
	Fine Drainage Gravel (No. 89)	Mohr-Coulomb	130	0	35	0
	Foundation Layer 1 (SP-SM)	Mohr-Coulomb	115	0	30	0
	Foundation Layer 2 (SP-SM)	Mohr-Coulomb	121	0	30	0
	Foundation Layer 3 (SP-SM)	Mohr-Coulomb	121	0	30	0
	Foundation Layer 4 (SP-SM)	Mohr-Coulomb	130	0	30	0
	Foundation Layer 5 (SP-SM)	Mohr-Coulomb	130	0	30	0
	R-20 Riprap	Mohr-Coulomb	101	0	40	0
	Soil Cement Armoring	Mohr-Coulomb	125	0	35	0

Figure B-1.33. C-18W reservoir east seepage section, slope stability analysis, long term condition, embankment D/S slope.



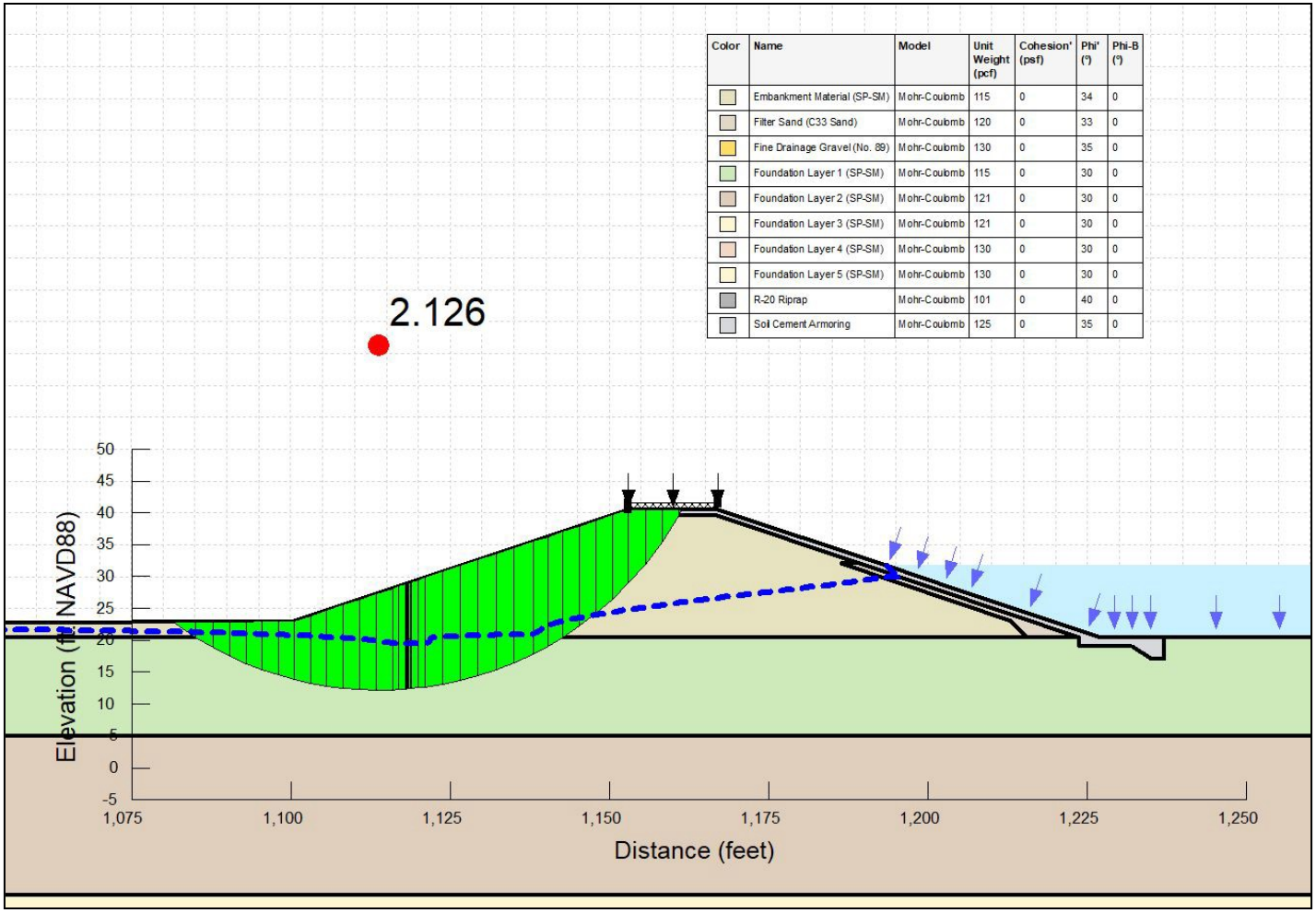
Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)
	Embankment Material (SP-SM)	Mohr-Coulomb	115	0	34	0
	Filter Sand (C33 Sand)	Mohr-Coulomb	120	0	33	0
	Fine Drainage Gravel (No. 89)	Mohr-Coulomb	130	0	35	0
	Foundation Layer 1 (SP-SM)	Mohr-Coulomb	115	0	30	0
	Foundation Layer 2 (SP-SM)	Mohr-Coulomb	121	0	30	0
	Foundation Layer 3 (SP-SM)	Mohr-Coulomb	121	0	30	0
	Foundation Layer 4 (SP-SM)	Mohr-Coulomb	130	0	30	0
	Foundation Layer 5 (SP-SM)	Mohr-Coulomb	130	0	30	0
	R-20 Riprap	Mohr-Coulomb	101	0	40	0
	Soil Cement Armoring	Mohr-Coulomb	125	0	35	0

Figure B-1.34. C-18W reservoir east seepage section, slope stability analysis, long term condition, canal near slope.



Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)
	Embankment Material (SP-SM)	Mohr-Coulomb	115	0	34	0
	Filter Sand (C33 Sand)	Mohr-Coulomb	120	0	33	0
	Fine Drainage Gravel (No. 89)	Mohr-Coulomb	130	0	35	0
	Foundation Layer 1 (SP-SM)	Mohr-Coulomb	115	0	30	0
	Foundation Layer 2 (SP-SM)	Mohr-Coulomb	121	0	30	0
	Foundation Layer 3 (SP-SM)	Mohr-Coulomb	121	0	30	0
	Foundation Layer 4 (SP-SM)	Mohr-Coulomb	130	0	30	0
	Foundation Layer 5 (SP-SM)	Mohr-Coulomb	130	0	30	0
	R-20 Riprap	Mohr-Coulomb	101	0	40	0
	Soil Cement Armoring	Mohr-Coulomb	125	0	35	0

Figure B-1.35. C-18W reservoir east seepage section, slope stability analysis, max pool condition, embankment D/S slope.



Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)
	Embankment Material (SP-SM)	Mohr-Coulomb	115	0	34	0
	Filter Sand (C33 Sand)	Mohr-Coulomb	120	0	33	0
	Fine Drainage Gravel (No. 89)	Mohr-Coulomb	130	0	35	0
	Foundation Layer 1 (SP-SM)	Mohr-Coulomb	115	0	30	0
	Foundation Layer 2 (SP-SM)	Mohr-Coulomb	121	0	30	0
	Foundation Layer 3 (SP-SM)	Mohr-Coulomb	121	0	30	0
	Foundation Layer 4 (SP-SM)	Mohr-Coulomb	130	0	30	0
	Foundation Layer 5 (SP-SM)	Mohr-Coulomb	130	0	30	0
	R-20 Riprap	Mohr-Coulomb	101	0	40	0
	Soil Cement Armoring	Mohr-Coulomb	125	0	35	0

Figure B-1.36. C-18W reservoir east seepage section, slope stability analysis, max pool condition, canal near slope.

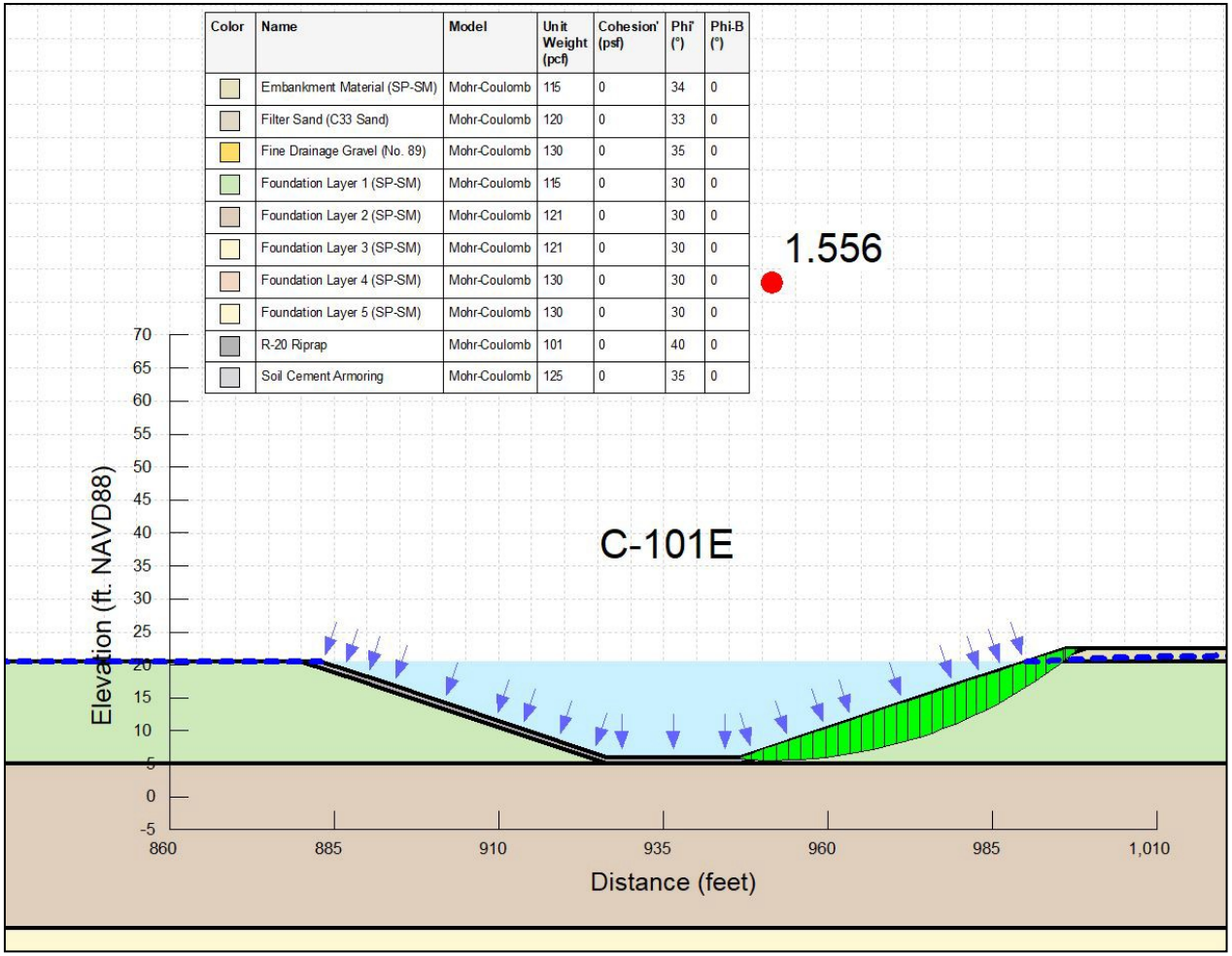
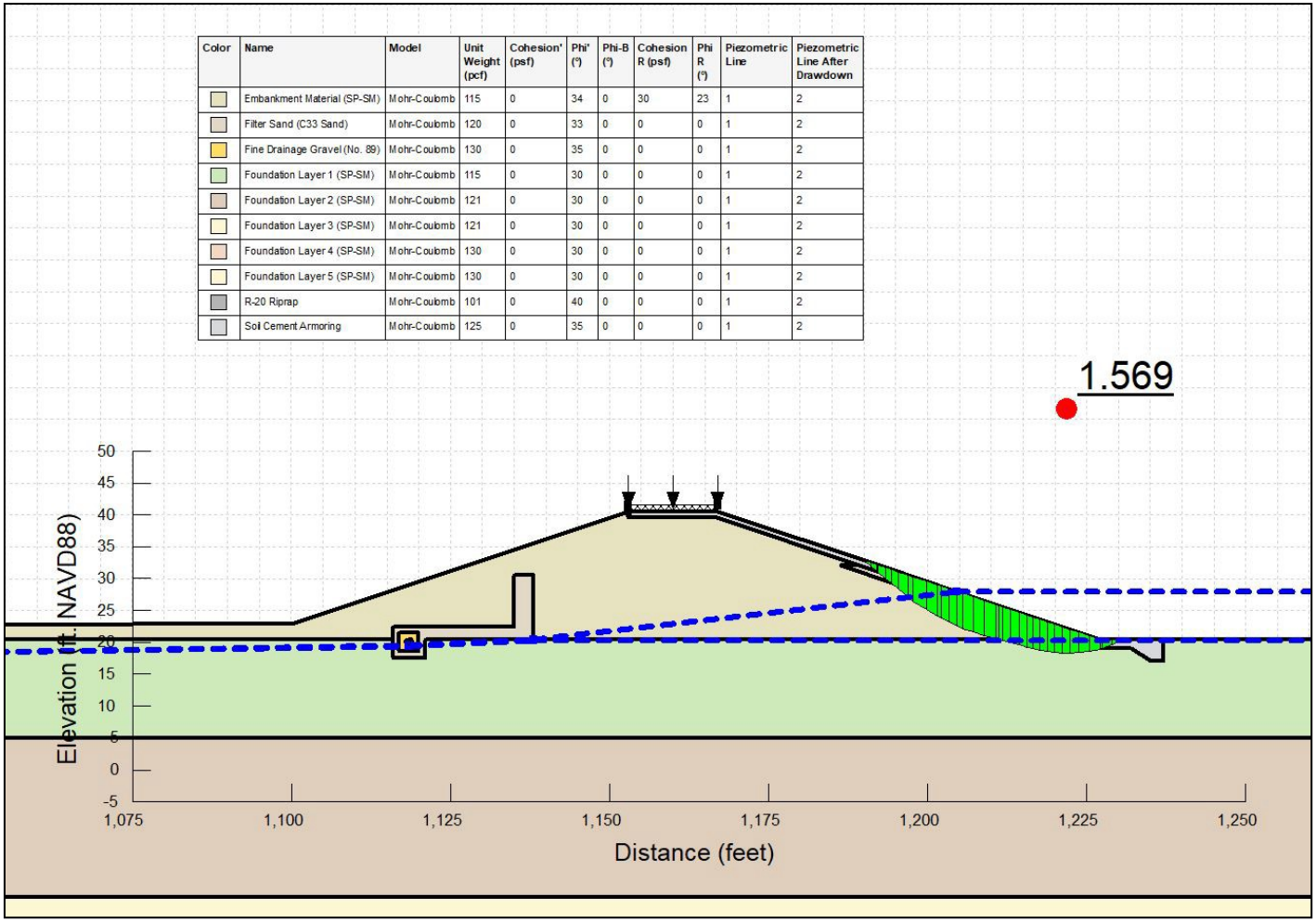


Figure B-1.37. C-18W reservoir east seepage section, slope stability analysis, rapid drawdown condition, embankment U/S slope.



Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)	Cohesion R (psf)	Phi R (°)	Piezometric Line	Piezometric Line After Drawdown
	Embankment Material (SP-SM)	Mohr-Coulomb	115	0	34	0	30	23	1	2
	Filter Sand (C33 Sand)	Mohr-Coulomb	120	0	33	0	0	0	1	2
	Fine Drainage Gravel (No. 89)	Mohr-Coulomb	130	0	35	0	0	0	1	2
	Foundation Layer 1 (SP-SM)	Mohr-Coulomb	115	0	30	0	0	0	1	2
	Foundation Layer 2 (SP-SM)	Mohr-Coulomb	121	0	30	0	0	0	1	2
	Foundation Layer 3 (SP-SM)	Mohr-Coulomb	121	0	30	0	0	0	1	2
	Foundation Layer 4 (SP-SM)	Mohr-Coulomb	130	0	30	0	0	0	1	2
	Foundation Layer 5 (SP-SM)	Mohr-Coulomb	130	0	30	0	0	0	1	2
	R-20 Riprap	Mohr-Coulomb	101	0	40	0	0	0	1	2
	Soil Cement Armoring	Mohr-Coulomb	125	0	35	0	0	0	1	2

Table B-1.3. C-18W reservoir west seepage section, seepage calculations.

Model Run	U/S - D/S Head Δ (ft)	Critical Gradient, i_c (1)	SEEP/W - Vertical Hydraulic Gradient, i_y (2)	i_y Location	FOS against Boiling, i_c/i_y	Water Rate through Embankment (cfs/lf)	Water Rate from Toe Drain (cfs/lf)	Water Rate into Seepage Canal (cfs/lf)	Percentage of Seepage Loss recharging the SAS
West Section - Pool at El. 28 ft, Seepage Canal wse at 17.5ft, Nat area wse at 17ft.	10.50	0.84	0.36	Bottom of seepage canal at far slope break - no canal lining	2.3	1.76E-04	1.85E-05	5.09E-05	60.57%
West Section - Pool at El. 28 ft, Seepage Canal wse at 17.5ft, Nat area wse at 17ft.	10.50	0.84	0.39	Bottom of seepage canal at near slope break - no canal lining	2.2	1.76E-04	1.85E-05	5.09E-05	60.57%
West Section - Pool at El. 28 ft, Seepage Canal wse at 17.5ft, Nat area wse at 17ft.	10.50	0.84	0.27	Seepage Canal near slope just below the wse - no canal lining in canal	3.1	1.76E-04	1.85E-05	5.09E-05	60.57%
West Section - Pool at El. 31.7 ft, Seepage Canal wse at 20.5ft, Nat area wse at 20.5ft.	11.20	0.84	0.20	Seepage Canal near slope just below the wse - no canal lining	4.2	2.07E-04	4.75E-05	5.62E-05	49.90%
West Section - Pool at El. 31.7 ft, Seepage Canal wse at 20.5ft, Nat area wse at 20.5ft.	11.20	0.84	0.39	Bottom of seepage canal at near slope break - no canal lining	2.2	2.07E-04	4.75E-05	5.62E-05	49.90%
West Section - Pool at El. 31.7 ft, Seepage Canal wse at 20.5ft, Nat area wse at 20.5ft.	11.20	0.84	0.37	Bottom of seepage canal at far slope break - no canal lining	2.3	2.07E-04	4.75E-05	5.62E-05	49.90%

Table B-1.4. C-18W reservoir west seepage section, seepage calculations.

						FOS Boiling (vertical)								Exit Gradient (horizontal)						
Model Run	Case	Unit Wt	Y'	Yw	Icv	Node #	Total Head 1	Elev. 1	Node #	Total Head 2	Elev. 2	Iev	FS	Node #	Total Head 1	X1	Node #	Total Head 2	X2	Ieh
West Section - Pool at El. 28 ft, Seepage Canal wse at 17.5ft, Nat area wse at 17ft.	2	115	52.6	62.4	0.84	8255	17.5	5	8254	17.86	4	0.36	2.3	8255	17.5	922.9	8241	17.65	921.9	0.15
West Section - Pool at El. 28 ft, Seepage Canal wse at 17.5ft, Nat area wse at 17ft.	2	115	52.6	62.4	0.84	8532	17.5	5	8531	17.89	4	0.39	2.2	8532	17.5	942.9	8540	17.68	943.89	0.18
West Section - Pool at El. 28 ft, Seepage Canal wse at 17.5ft, Nat area wse at 17ft.	2	115	52.6	62.4	0.84	9331	17.5	17.17	9347	17.77	16.17	0.27	3.1	9331	17.5	979.4	9407	17.85	981.7	0.15
West Section - Pool at El. 31.7 ft, Seepage Canal wse at 20.5ft, Nat area wse at 20.5ft.	3	115	52.6	62.4	0.84	9595	20.5	20.17	9615	20.68	19.27	0.2000	4.2	9530	20.5	986.4	9615	20.68	988.48	0.0865
West Section - Pool at El. 31.7 ft, Seepage Canal wse at 20.5ft, Nat area wse at 20.5ft.	3	115	52.6	62.4	0.84	8532	20.5	5	8531	20.89	4	0.3900	2.2	8532	20.5	942.9	8540	20.68	943.88	0.1837
West Section - Pool at El. 31.7 ft, Seepage Canal wse at 20.5ft, Nat area wse at 20.5ft.	3	115	52.6	62.4	0.84	8255	20.5	5	8254	20.87	4	0.3700	2.3	8255	20.5	922.9	8241	20.66	921.91	0.1616

Table B-1.5. C-18W reservoir south seepage section, seepage calculations.

Model Run	U/S - D/S Head Δ (ft)	Critical Gradient, i_c (1)	SEEP/W - Vertical Hydraulic Gradient, i_y (2)	i_y Location	FOS against Boiling, i_c/i_y	Water Rate through Embankment (cfs/lf)	Water Rate from Toe Drain (cfs/lf)	Water Rate into Seepage Canal (cfs/lf)	Percentage of Seepage Loss recharging the SAS
South Section - Pool at El. 28 ft, Seepage Canal wse at 17.5ft, Subdivision wse at 17ft. No canal treatment, no trench.	10.50	0.84	0.13	Seepage Canal near slope just below the wse - no canal lining	6.3	8.29E-04	2.36E-04	1.87E-04	48.97%
South Section - Pool at El. 28 ft, Seepage Canal wse at 17.5ft, Subdivision wse at 17ft. No canal treatment, no trench.	10.50	0.84	0.15	Bottom of seepage canal at near slope break - no canal lining	5.6	8.29E-04	2.36E-04	1.87E-04	48.97%
South Section - Pool at El. 28 ft, Seepage Canal wse at 17.5ft, Subdivision wse at 17ft. No canal treatment, no trench.	10.50	0.84	0.11	Bottom of seepage canal at far slope break - no canal lining	7.7	8.29E-04	2.36E-04	1.87E-04	48.97%
South Section - Pool at El. 28 ft, Seepage Canal wse at 17.5ft, Subdivision wse at 17ft. No canal treatment, trench.	10.50	0.84	0.10	Seepage Canal near slope just below the wse - no canal lining in canal	8.2	8.78E-04	3.38E-04	1.49E-04	44.53%
South Section - Pool at El. 28 ft, Seepage Canal wse at 17.5ft, Subdivision wse at 17ft. No canal treatment, trench.	10.50	0.84	0.13	Bottom of seepage canal at near slope break - no canal lining	6.5	8.78E-04	3.38E-04	1.49E-04	44.53%
South Section - Pool at El. 28 ft, Seepage Canal wse at 17.5ft, Subdivision wse at 17ft. No canal treatment, trench.	10.50	0.84	0.10	Bottom of seepage canal at far slope break - no canal lining	8.4	8.78E-04	3.38E-04	1.49E-04	44.53%
South Section - Pool at El. 31.7 ft, SCanal wse at 20.5ft, Subdivision wse at 20.5ft. No canal treatment, trench.	11.20	0.84	0.04	Seepage Canal near slope just below the wse - no canal lining in canal	23.2	1.06E-03	6.37E-04	1.52E-04	25.57%
South Section - Pool at El. 31.7 ft, SCanal wse at 20.5ft, Subdivision wse at 20.5ft. No canal treatment, trench.	11.20	0.84	0.11	Bottom of seepage canal at near slope break - no canal lining	7.7	1.06E-03	6.37E-04	1.52E-04	25.57%
South Section - Pool at El. 31.7 ft, SCanal wse at 20.5ft, Subdivision wse at 20.5ft. No canal treatment, trench.	11.20	0.84	0.09	Bottom of seepage canal at far slope break - no canal lining	9.4	1.06E-03	6.37E-04	1.52E-04	25.57%

(1) Critical gradient = buoyant unit weight of material through which seepage occurs / unit weight of water

(2) Determined by using two different nodes

Table B-1.6. C-18W reservoir south seepage section, seepage calculations.

						FOS Boiling (vertical)								Exit Gradient (horizontal)						
Model Run	Case	Unit Wt	Y'	Yw	Icv	Node #	Total Head 1	Elev. 1	Node #	Total Head 2	Elev. 2	Iev	FS	Node #	Total Head 1	X1	Node #	Total Head 2	X2	Ieh
South Section - Pool at El. 28 ft, Seepage Canal wse at 17.5ft, Subdivision wse at 17ft. No canal treatment, no trench.	2	115	52.6	62.4	0.84	9900	17.5	17.19	9907	17.63	16.22	0.13	6.3	9900	17.5	983.06	9987	17.74	986.33	0.07
South Section - Pool at El. 28 ft, Seepage Canal wse at 17.5ft, Subdivision wse at 17ft. No canal treatment, no trench.	2	115	52.6	62.4	0.84	9088	17.5	5	9086	17.65	4	0.15	5.6	9088	17.5	946.5	9111	17.54	947.5	0.04
South Section - Pool at El. 28 ft, Seepage Canal wse at 17.5ft, Subdivision wse at 17ft. No canal treatment, no trench.	2	115	52.6	62.4	0.84	8765	17.5	5	8769	17.61	4	0.11	7.7	8765	17.5	926.5	8757	17.52	925.5	0.02
South Section - Pool at El. 28 ft, Seepage Canal wse at 17.5ft, Subdivision wse at 17ft. No canal treatment, trench.	2	115	52.6	62.4	0.84	9900	17.5	17.19	9907	17.6	16.22	0.10	8.2	9900	17.5	983.1	9987	17.69	986.33	0.06
South Section - Pool at El. 28 ft, Seepage Canal wse at 17.5ft, Subdivision wse at 17ft. No canal treatment, trench.	2	115	52.6	62.4	0.84	9088	17.5	5	9086	17.63	4	0.13	6.5	9088	17.5	946.5	9111	17.53	947.5	0.03
South Section - Pool at El. 28 ft, Seepage Canal wse at 17.5ft, Subdivision wse at 17ft. No canal treatment, trench.	2	115	52.6	62.4	0.84	8765	17.5	5	8769	17.6	4	0.10	8.4	8765	17.5	926.5	8757	17.52	925.5	0.02
South Section - Pool at El. 31.7 ft, SCanal wse at 20.5ft, Subdivision wse at 20.5ft. No canal treatment, trench.	2	115	52.6	62.4	0.84	10099	20.5	19.5	10100	20.54	18.4	0.04	23.2	10099	20.5	990	10137	20.52	991	0.02
South Section - Pool at El. 31.7 ft, SCanal wse at 20.5ft, Subdivision wse at 20.5ft. No canal treatment, trench.	2	115	52.6	62.4	0.84	9088	20.5	5	9086	20.61	4	0.11	7.7	9088	20.5	946.5	9111	20.52	947.5	0.02
South Section - Pool at El. 31.7 ft, SCanal wse at 20.5ft, Subdivision wse at 20.5ft. No canal treatment, trench.	2	115	52.6	62.4	0.84	8765	20.5	5	8769	20.59	4	0.09	9.4	8765	20.5	926.5	8757	20.52	925.5	0.0200

Table B-1.7. C-18W reservoir east seepage section, seepage calculations.

Model Run	U/S - D/S Head Δ (ft)	Critical Gradient, i_c (1)	SEEP/W - Vertical Hydraulic Gradient, i_y (2)	i_y Location	FOS against Boiling, i_c/i_y	Water Rate through Embankment (cfs/lf)	Water Rate from Toe Drain (cfs/lf)	Water Rate into Seepage Canal (cfs/lf)	Percentage of Seepage Loss recharging the SAS
East Section - Pool at El. 28 ft, Seepage Canal wse at 17.5ft, Nat area wse at 17ft	10.50	0.84	0.24	Seepage Canal near slope just below the wse - no canal lining	3.5	3.49E-04	1.43E-05	2.12E-04	35.16%
East Section - Pool at El. 28 ft, Seepage Canal wse at 17.5ft, Nat area wse at 17ft	10.50	0.84	0.28	Bottom of seepage canal at near slope break - no canal lining	3.0	3.49E-04	1.43E-05	2.12E-04	35.16%
East Section - Pool at El. 28 ft, Seepage Canal wse at 17.5ft, Nat area wse at 17ft	10.50	0.84	0.23	Bottom of seepage canal at far slope break - no canal lining	3.7	3.49E-04	1.43E-05	2.12E-04	35.16%
East Section - Pool at El. 31.7 ft, Seepage Canal wse at 20.5ft, Nat area wse at 20.5ft.	11.20	0.84	0.19	Seepage Canal near slope just below the wse - no canal lining	4.5	3.88E-04	4.40E-05	2.32E-04	28.87%
East Section - Pool at El. 31.7 ft, Seepage Canal wse at 20.5ft, Nat area wse at 20.5ft.	11.20	0.84	0.30	Bottom of seepage canal at near slope break - no canal lining	2.8	3.88E-04	4.40E-05	2.32E-04	28.87%
East Section - Pool at El. 31.7 ft, Seepage Canal wse at 20.5ft, Nat area wse at 20.5ft.	11.20	0.84	0.25	Bottom of seepage canal at far slope break - no canal lining	3.4	3.88E-04	4.40E-05	2.32E-04	28.87%

(1) Critical gradient = buoyant unit weight of material through which seepage occurs / unit weight of water

(2) Determined by using two different nodes

Table B-1.8. C-18W reservoir east seepage section, seepage calculations.

						FOS Boiling (vertical)								Exit Gradient (horizontal)						
Model Run	Case	Unit Wt	Y'	Yw	Icv	Node #	Total Head 1	Elev. 1	Node #	Total Head 2	Elev. 2	Iev	FS	Node #	Total Head 1	X1	Node #	Total Head 2	X2	Ieh
East Section - Pool at El. 28 ft, Seepage Canal wse at 17.5ft, Nat area wse at 17ft	2	115	52.6	62.4	0.84	10902	17.5	17.33	10905	17.62	16.83	0.2400	3.5	10902	17.5	983.5	10953	17.66	984.63	0.1416
East Section - Pool at El. 28 ft, Seepage Canal wse at 17.5ft, Nat area wse at 17ft	2	115	52.6	62.4	0.84	9598	17.5	5	9600	17.78	4	0.28	3.0	9598	17.5	946.5	9614	17.66	947.49	0.1616
East Section - Pool at El. 28 ft, Seepage Canal wse at 17.5ft, Nat area wse at 17ft	2	115	52.6	62.4	0.84	9099	17.5	5	9098	17.73	4	0.23	3.7	9099	17.5	926.5	9084	17.62	925.51	0.121
East Section - Pool at El. 31.7 ft, Seepage Canal wse at 20.5ft, Nat area wse at 20.5ft.	3	115	52.6	62.4	0.84	11360	20.5	20.34	11361	20.59	19.86	0.1875	4.5	11284	20.5	991.1	11361	20.59	992.69	0.0566
East Section - Pool at El. 31.7 ft, Seepage Canal wse at 20.5ft, Nat area wse at 20.5ft.	3	115	52.6	62.4	0.84	9598	20.5	5	9600	20.8	4	0.30	2.8	9598	20.5	946.5	9614	20.67	947.5	0.1700
East Section - Pool at El. 31.7 ft, Seepage Canal wse at 20.5ft, Nat area wse at 20.5ft.	3	115	52.6	62.4	0.84	9099	20.5	5	9098	20.75	4	0.25	3.4	9099	20.5	926.5	9084	20.64	925.51	0.1414

Table B-1.9. Table 4 from Task 2.8 geotechnical report (Arcadis, 2016).

Table 4. Unit Weight and Shear Strength Parameters

Embankment	Elevation (feet)		Unit Weight (pcf)[1]	Φ (degree)
	Top	Bottom		
Dam Fill	N/A	N/A	115	30
Northern	30	10	115	29
	10	0	115	30
	0	-5	115	28
	-5	-15	121	28
	-15	-45	121	30
	-45	-50	130	30
	-50	-70	130	33
Southern	20	-10	115	31
	-10	-15	115	33
	-15	-20	121	33
	-20	-45	121	29
	-45	-55	121	31
	-55	-75	130	32
Eastern	30	-5	115	30
	-5	-45	121	30
	-45	-75	130	30
Western	20	-5	115	32
	-5	-15	115	28
	-15	-20	121	30
	-20	-55	121	35
	-55	-75	130	35

(1) pcf – pounds per cubic foot

Figure B-1.38. Representative FDOT borings for Gulfstream West FTM embankment for seepage analysis. Boring locations are from the Florida Turnpike alignment at Cypress Creek Canal.

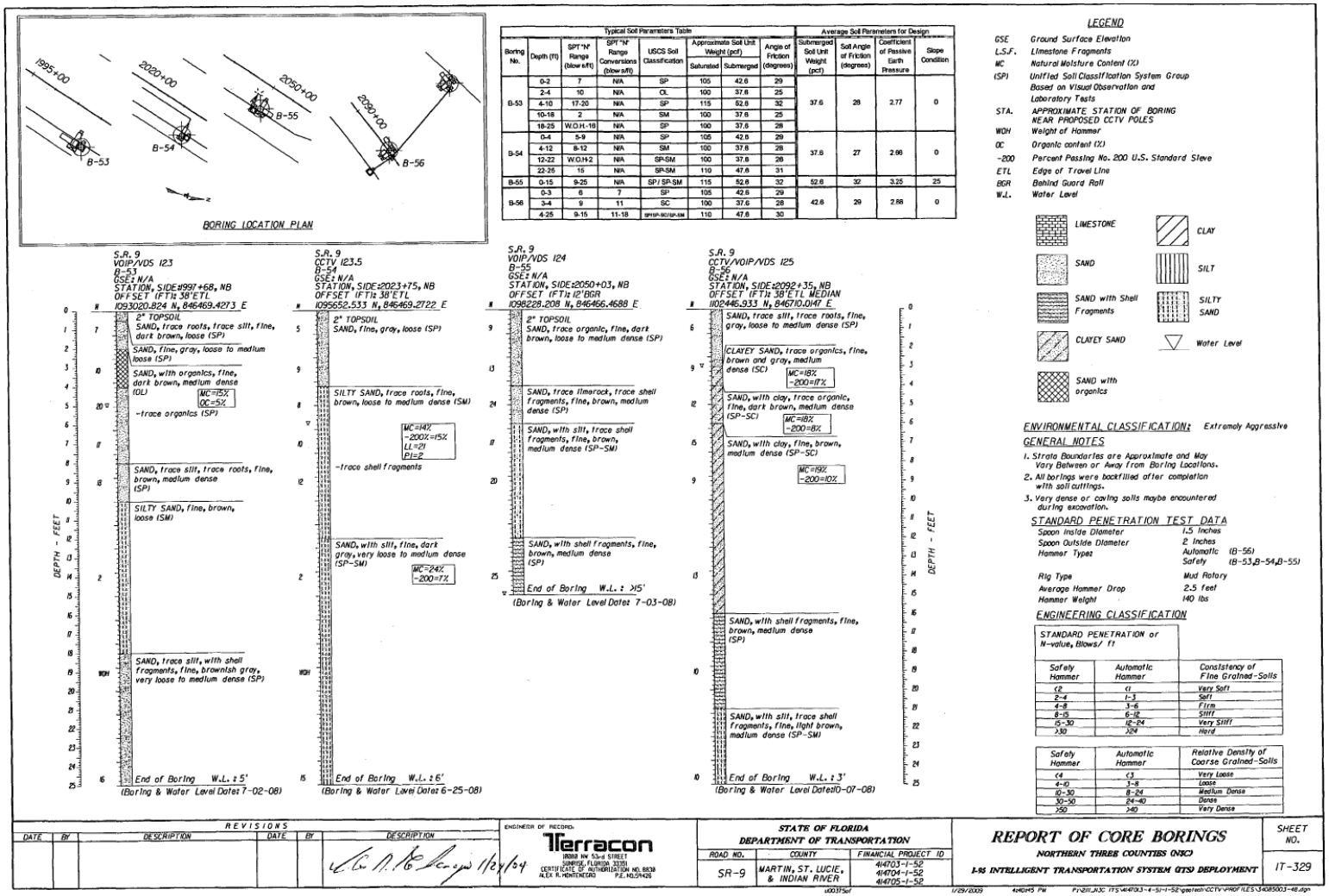


Figure B-1.39. Representative FDOT borings for Gulfstream West FTM embankment for seepage analysis. Boring locations are from I-95 over Cypress Creek Canal.

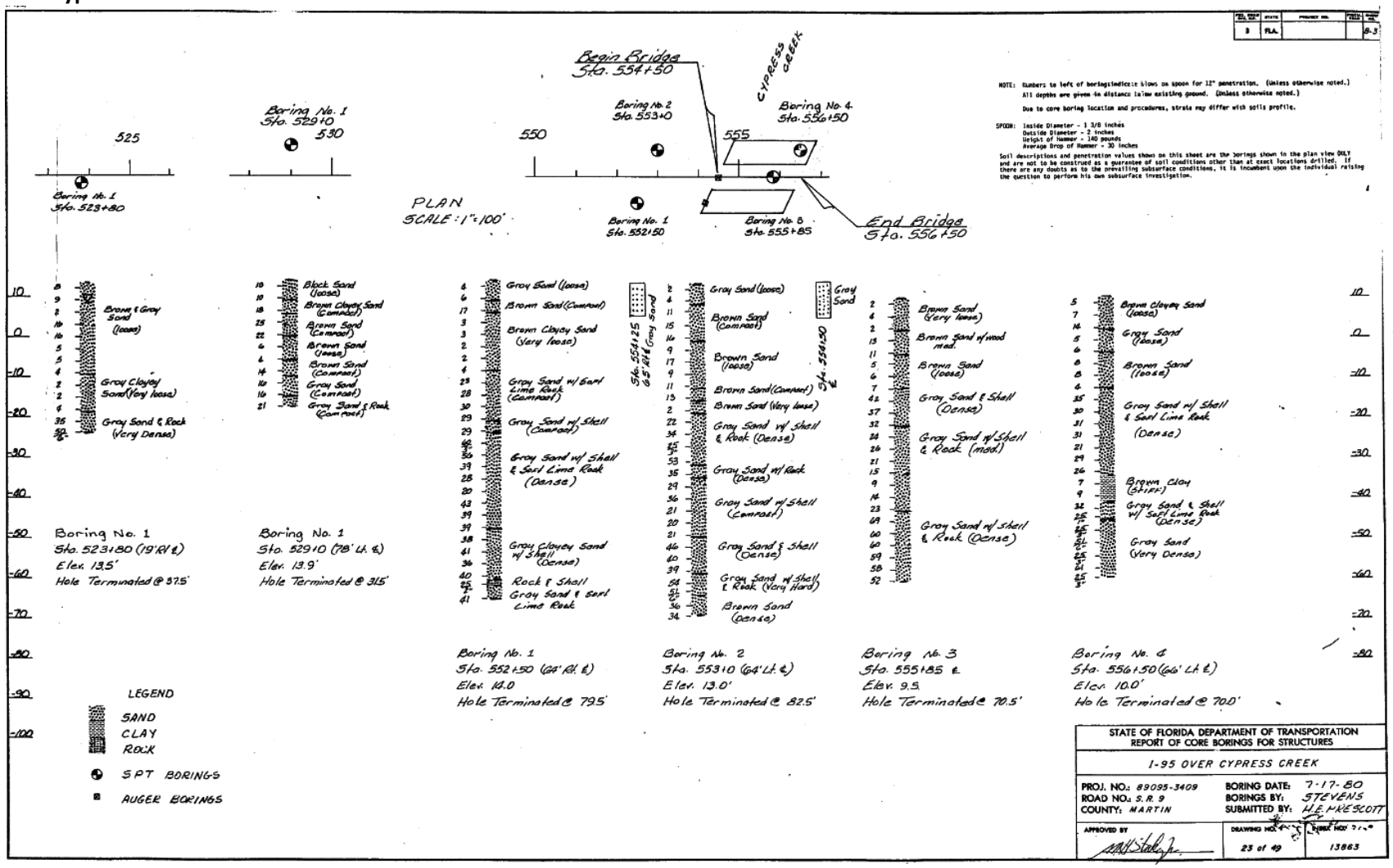


Figure B-1.40. Representative FDOT borings for Gulfstream West FTM embankment for seepage analysis. Boring locations are from I-95 Weigh-in-Motion Station.

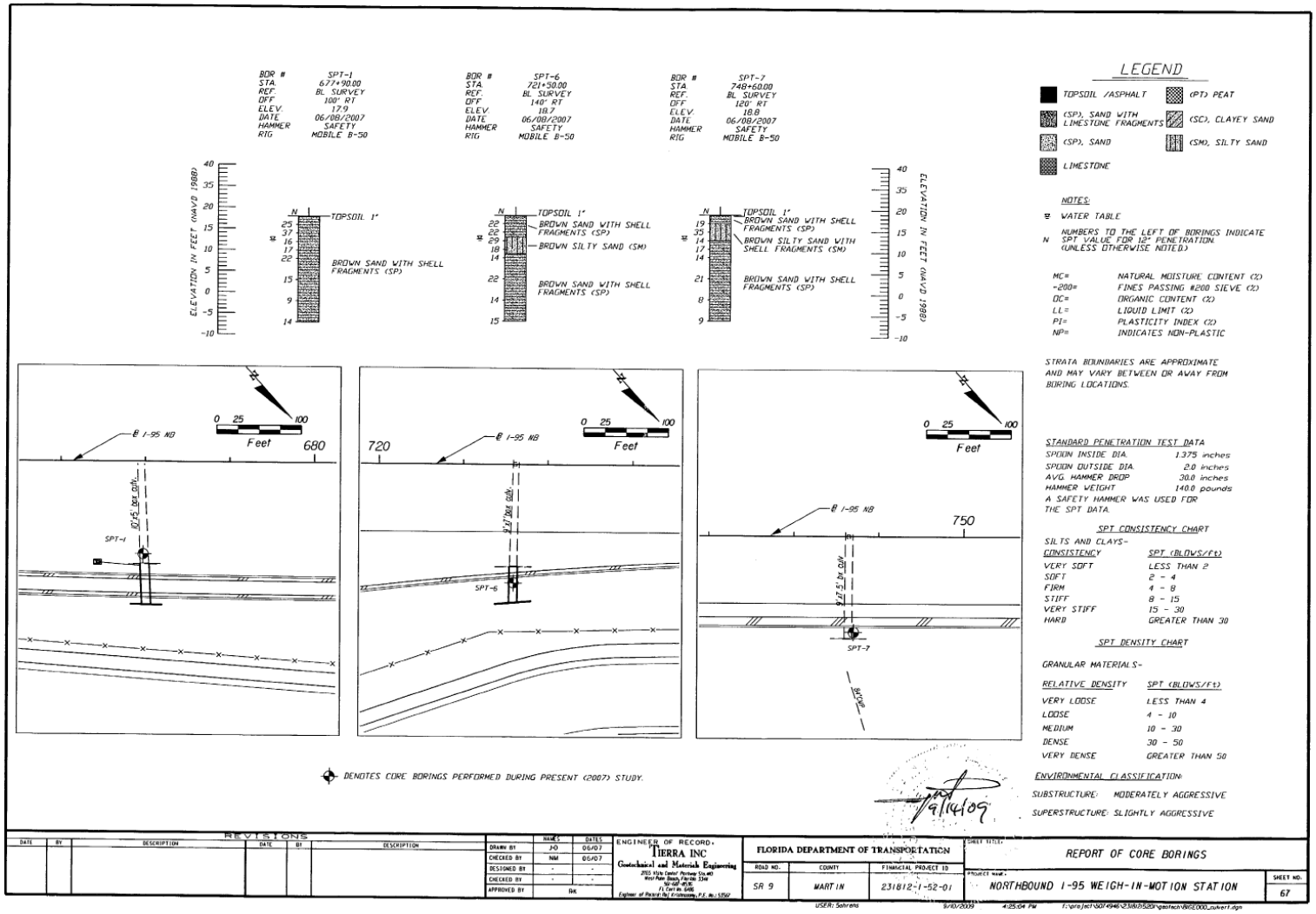


Figure B-1.41. Representative FDOT borings for Gulfstream West FTM embankment for seepage analysis. Boring locations are from I-95 Weigh-in-Motion Station.

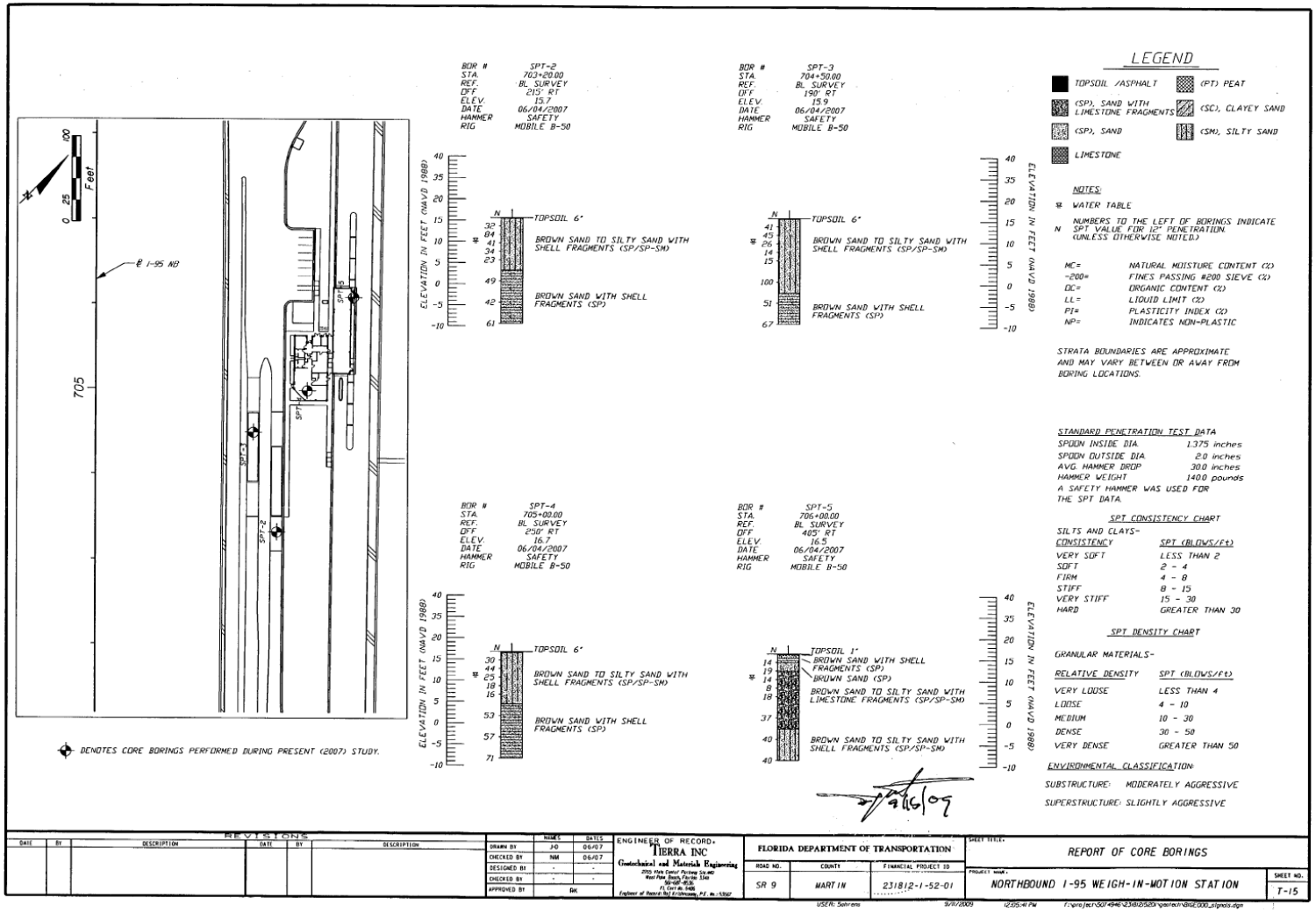
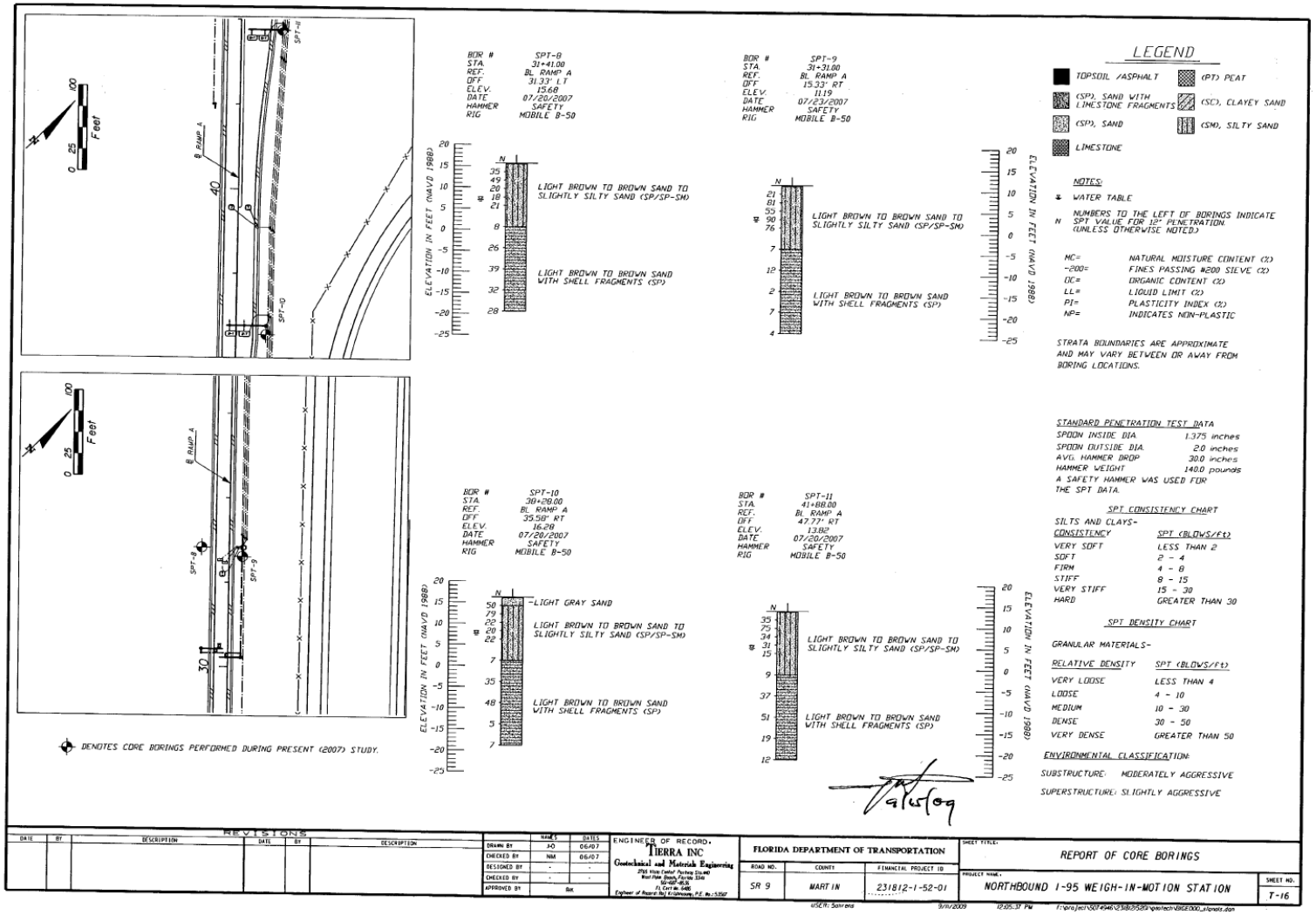


Figure B-1.42. Representative FDOT borings for Gulfstream West FTM embankment for seepage analysis. Boring locations are from I-95 Weigh-in-Motion Station.



Permeability k_H of Unconsolidated Natural Soils (k_H inversely related to % finer grains)

Soil	k_H Range (ft/yr or 10^{-6} cm/s)
Gravel, open-work	>2,000,000
Gravel (GP)	200,000 to 2,000,000
Gravel (GW)	10,000 to 1,000,000
Sand, coarse (SP)	10,000 to 500,000
Sand, medium (SP)	1,000 to 100,000
Sand, fine (SP)	500 to 50,000
Sand (SW)	100 to 50,000
Sand, silty (SM)	100 to 10,000
Sand, clayey (SC)	1 to 1,000
Silt (ML)	1 to 1,000
Clay (CL)	~0 to 3

References: [15], [18], [22-29], [32-36]

Permeability k_H of Unfractured Rock (k_H increases with pore size)

Rock	k_H Range (ft/yr or 10^{-6} cm/s)
Sandstone, medium	100 to 200,000
Sandstone, silty	~0 to 5,000
Limestone	~0 to 15,000
Granite, weathered	200 to 10,000
Schist	~0 to 2,000
Tuff	~0 to 1,000
Gabbro, weathered	50 to 500
Basalt	~0 to 50
Dolomite	~0 to 5
Gneiss	~0 to 2

References: [15], [25], [27-28], [34], [36]

Anisotropy of Natural Soil and Rock

Formation	k_H/k_V	Remarks
Stratified deposits	10 to 1,000	k_H/k_V depends on grain size of substrata
Massive soil or rock	1 to 3	Depends on particle shape and orientation
Fractured rock	0.1 to 10	Depends on aperture arrangement
Eolian soil (loess and dune)	0.02 to 2	Depends on consolidation

References: [3], [15], [17], [19-21], [24], [30-32], [35-42]

Table B-1.10. Table of permeability values of natural soil and rock. From USBR DS-13(8).

Permeability (k_V) of Embankment Core Materials (k_V inversely related to % fines)

Unified Soil Classification	k_V Range (ft/yr or x10^{-6} cm/s)*
GM-SM	0.0 to 10.0
GM or GC	0.0 to 10.0
SP-SM	0.0 to 10.0
SM	0.0 to 10.0
SM-SC	0.0 to 3.0
SM-ML	0.0 to 10.0
SC	0.0 to 3.0
ML	0.0 to 10.0
ML-CL	0.0 to 1.0
CL	0.0 to 1.0
MH	0.0 to 0.1

References: [31-32], [34], [44-45]
* Based primarily on Reclamation laboratory test data

Permeability (k_V) of Embankment Shell Materials (k_V inversely related to % fines)

Unified Soil Classification	k_V Range (ft/yr or x10^{-6} cm/s)
GP	2,000 to 1,000,000
GW	1,000 to 100,000
GP-SP	1,000 to 50,000
GW-SW	500 to 5,000
GM	10 to 500
SP (medium to coarse)	10,000 to 20,000
SP (fine to medium)	5,000 to 10,000
SP (very fine to fine)	500 to 5,000
SW	300 to 5,000
SP-SM	10 to 1,000
SM	10 to 500

References: [18], [26], [33], [36], [44-45]

Permeability (k_V) of Washed Embankment Drain Materials (k_V increases with grain size)

Material	k_V Range (ft/yr or x10^{-6} cm/s)
Coarse sand and gravel	150,000 to 500,000
Medium to coarse sand	50,000 to 150,000
Fine to medium sand	10,000 to 50,000

References: [18], [26], [33], [36], [45]

Anisotropy (k_H/k_V) of embankment materials (k_H/k_V increases with placement water content)

Material	k_H/k_V Range
Embankment core Reclamation standard placement	4 to 9
Nonstandard placement	9 to 36
Hydraulic fill	64 to 225
Embankment shell Reclamation standard	4 to 9
Embankment drains Reclamation standard	1 to 4

References: [3], [17], [21], [31], [37]

Table B-1.11. Table of permeability values of embankment materials. From USBR DS-13(8).

TABLE 3.39

Typical Properties of Compacted Soils[a]

				Typical Value of Compression		Typical Strength Characteristics						
				Percent of Original Height								
Group Symbol	Soil Type	Range of Maximum Dry Unit Weight (pcf)	Range of Optimum Moisture (%)	At 1.4 tsf (20 psi)	At 3.6 tsf (50 psi)	Cohesion as Compacted (psf)	Cohesion (Saturated) (psf)	Effective Stress Envelope ϕ (deg)	tan ϕ	Typical Coefficient of Permeability (ft/min)	Range of CBR Values	Range of Subgrade Modulus k_s (lb/in.^{3})
GW	Well-graded clean gravels, gravel–sand mixtures	125–135	11–8	0.3	0.6	0	0	>38	>0.79	5×10^{-2x}	40–80	300–500
GP	Poorly graded clean gravels, gravel–sand mix	115–125	14–11	0.4	0.9	0	0	>37	>0.74	10^{-1}	30–60	250–400
GM	Silty gravels, poorly graded gravel–sand silt	120–135	12–8	0.5	1.1	–	–	>34	>0.67	$>10^{-6}$	20–60	100–400
GC	Clayey gravels, poorly graded gravel-sand–clay	115–130	14–9	0.7	1.6	–	–	>31	>0.60	$>10^{-7}$	20–40	100–300
SW	Well-graded clean sands, gravelly sands	110–130	18–9	0.6	1.2	0	0	38	0.79	$>10^{-3}$	20–40	200–300
SP	Poorly-graded clean sands, sand–gravel mix	100–120	21–12	0.8	1.4	0	0	37	0.74	$>10^{-3}$	10–40	200–300
SM	Silty sands, poorly graded sand–silt mix	110–125	16–11	0.8	1.6	1050	420	34	0.67	5×10^{-5}	10–40	100–300
SM-SC	Sand–silt clay mix with slightly plastic fines	110–130	15–11	0.8	1.4	1050	300	33	0.66	2×10^{-6}	–	

(*Continued*)

TABLE 3.39

Continued

				Typical Value of Compression		Typical Strength Characteristics						
				Percent of Original Height								
Group Symbol	Soil Type	Range of Maximum Dry Unit Weight (pcf)	Range of Optimum Moisture (%)	At 1.4 tsf (20 psi)	At 3.6 tsf (50 psi)	Cohesion as Compacted (psf)	Cohesion (Saturated) (psf)	Effective Stress Envelope ϕ (deg)	tan ϕ	Typical Coefficient of Permeability (ft/min)	Range of CBR Values	Range of Subgrade Modulus k_s (lb/in.^{3})
SC	Clayey sands, poorly graded sand–clay mix	105–125	19–11	1.1	2.2	1550	230	31	0.60	5×10^{-7}	5–20	100–300
ML	Inorganic silts and clayey silts	95–120	24–12	0.9	1.7	1400	190	32	0.62	10^{-5}	15 or less	100–200
ML-CL	Mixture of inorganic silt and day	100–120	22–12	1.0	2.2	1350	480	32	0.62	5×10^{-7}	...	
CL	Inorganic clays of low to medium plasticity	95–120	24–12	1.3	2.5	1800	270	28	0.54	10^{-7}	15 or less	50–200
OL	Organic silts and silt-days, low plasticity	80–100	33–21	–	–	–	–	–	–	–	5 or less	50–100
MH	Inorganic clayey silts, elastic silts	70–95	40–24	2.0	3.8	1500	420	25	0.47	5×10^{-7}	10 or less	50–100
CH	Inorganic clays of high plasticity	75–105	38–19	2.6	3.9	2150	230	19	0.35	10^{-7}	15 or less	50–150
OH	Organic clays and silty clays	65–100	45–21	–	–	–	–	–	–	–	5 or less	25–100

[a] From NAVFAC Manual DM 7 (1971). All properties are for condition of "standard Proctor" maximum density, except values of k and CBR which are for "modified Proctor" maximum density. Typical strength characteristics are for effective strength envelopes are obtained from USBR data. Compression values are for vertical loading with complete lateral confinement. (–) Indicates Inefficient data available for an estimate.

Table B-1.12. Typical properties of compacted soil. From Hunt (2005).

$$C_B = \frac{X_1 + L_2 + X}{h} \quad (9\text{-}21)$$

where

C_B = Bligh's creep ratio

X_1 = effective length of upstream blanket

L_2 = length of dam base

X = width of downstream seepage berm

h = net head on dam

Table 9-10. Minimum Bligh's Creep Ratios for Dams Founded on Pervious Foundations [a]

Material	Minimum Bligh's Creep Ratio
Very fine sand or silt	18
Fine to medium sand	15
Coarse sand	12
Fine gravel or sand and gravel	9
Coarse gravel including cobbles	

[a] From U. S. Army Engineer Waterways Experiment Station[120]

Table B-1.13. Bligh's creep ratio equation and values. Source is Table 9-10 from EM-1110-2-1901.

Color	Name	Model	Sat Kx (ft/sec)	Vol WC. Function	K-Function	Ky'/Kx' Ratio	Rotation (°)	Volumetric Water Content	Compressibility (/psf)
	C33Sand	Saturated / Unsaturated		Mat. & Filter Sand (C33) (2)	Mat. & Filter Sand (2)	1	0		
	Fill	Saturated / Unsaturated		Fill	Fill	0.11	0		
	Sand (0-5)	Saturated / Unsaturated		Sand (0-5)	Sand (0-5)	0.1	0		
	Sand (25-60)	Saturated Only	0.00075282			0.1	0	0.3	2.5e-06
	Sand (5-25)	Saturated Only	0.00075282			0.1	0	0.3	2.5e-06
	Sand (60-100)	Saturated Only	0.00075282			0.1	0	0.3	2.5e-06

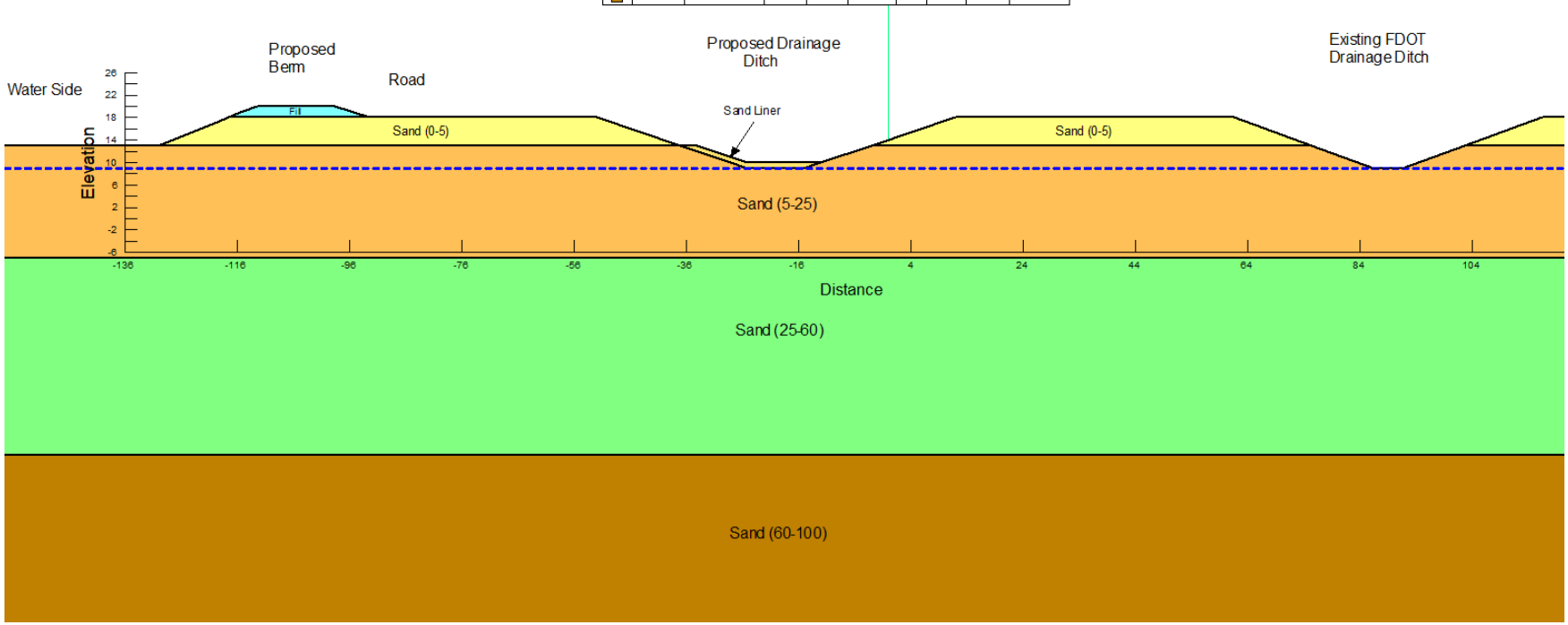
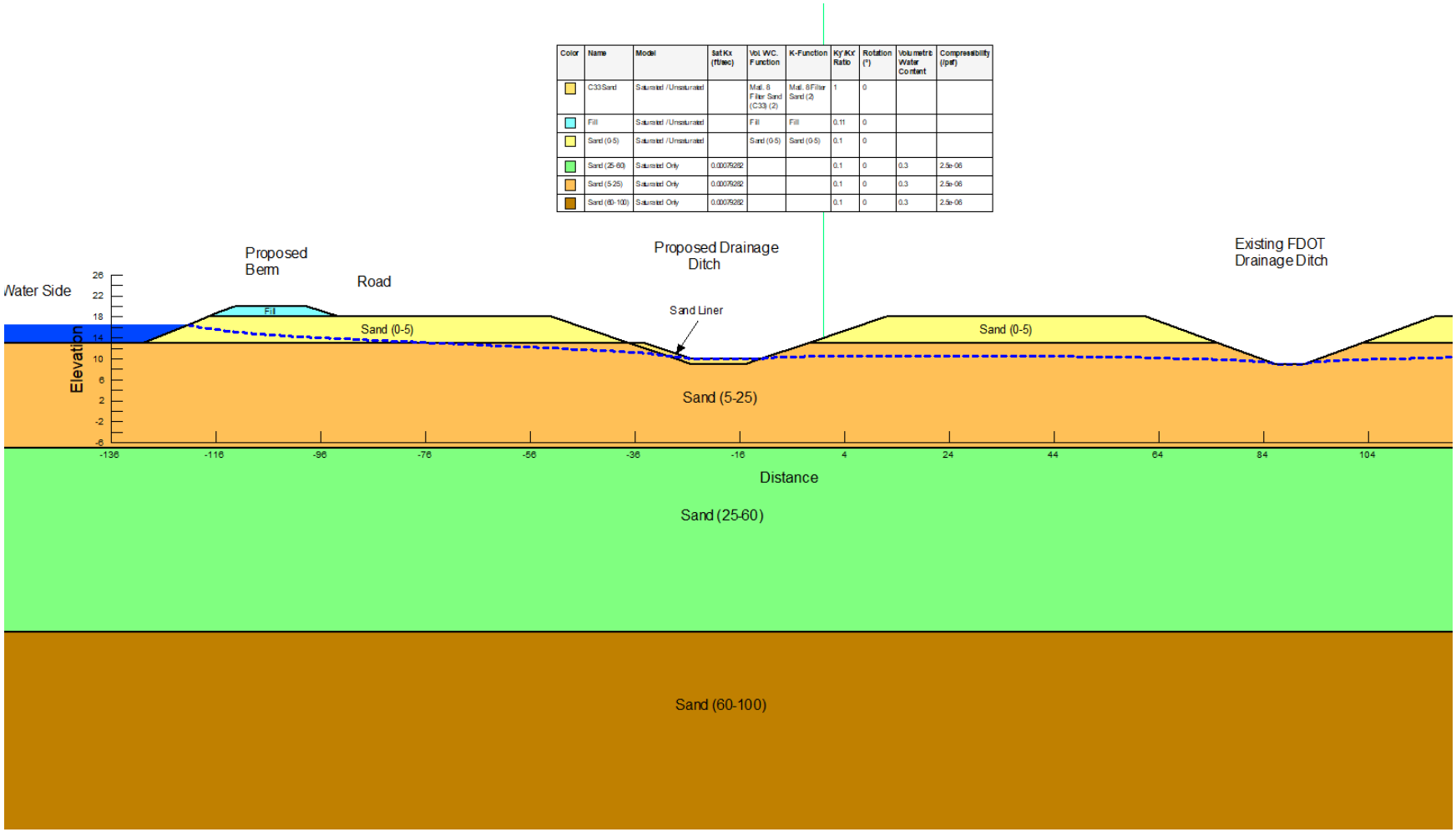


Figure B-1.43. Gulfstream West, east section, end of construction condition, no pool.



Color	Name	Model	Sat Kx (ft/sec)	Vol WC. Function	K-Function	Ky/Kx Ratio	Rotation (°)	Volumetric Water Content	Compressibility (/psf)
	C33 Sand	Saturated / Unsaturated		Mat. 6 Filter Sand (C33) (2)	Mat. 6 Filter Sand (2)	1	0		
	Fill	Saturated / Unsaturated		Fill	Fill	0.11	0		
	Sand (0-5)	Saturated / Unsaturated		Sand (0-5)	Sand (0-5)	0.1	0		
	Sand (25-60)	Saturated Only	0.00075282			0.1	0	0.3	2.5e-06
	Sand (5-25)	Saturated Only	0.00075282			0.1	0	0.3	2.5e-06
	Sand (60-100)	Saturated Only	0.00075282			0.1	0	0.3	2.5e-06

Figure B-1.44. Gulfstream West, east section, long term condition, normal pool.

Color	Name	Model	Sat Kx (ft/sec)	Vol. WC. Function	K-Function	Ky/Kx Ratio	Rotation (°)	Volumetric Water Content	Compressibility (i/psf)
	C33 Sand	Saturated / Unsaturated		Mat. 6 Filter Sand (C33) (2)	Mat. 6 Filter Sand (2)	1	0		
	Fill	Saturated / Unsaturated		Fill	Fill	0.11	0		
	Sand (0-5)	Saturated / Unsaturated		Sand (0-5)	Sand (0-5)	0.1	0		
	Sand (25-60)	Saturated Only	0.0075282			0.1	0	0.3	2.5e-06
	Sand (5-25)	Saturated Only	0.0075282			0.1	0	0.3	2.5e-06
	Sand (60-100)	Saturated Only	0.0075282			0.1	0	0.3	2.5e-06

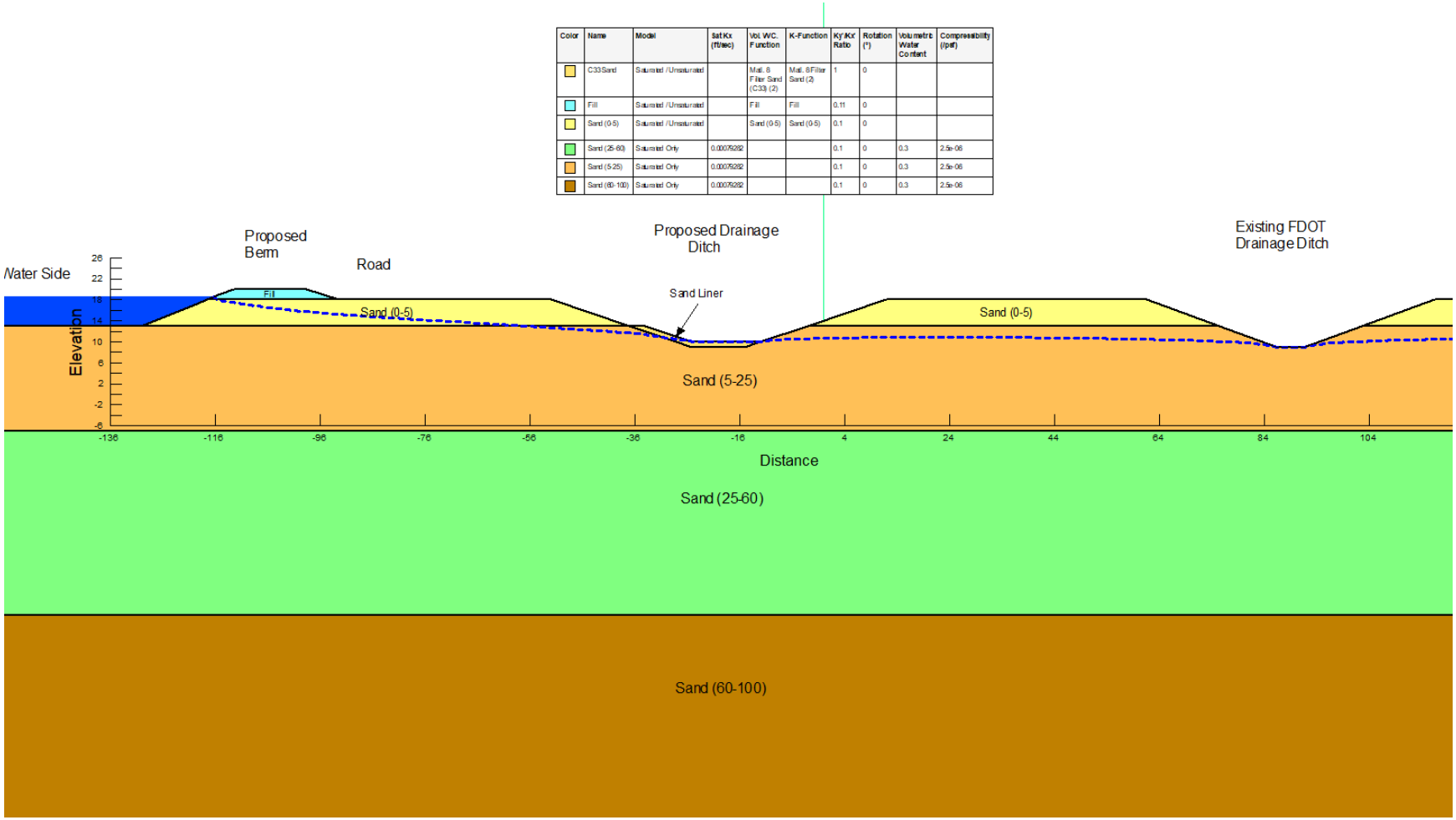
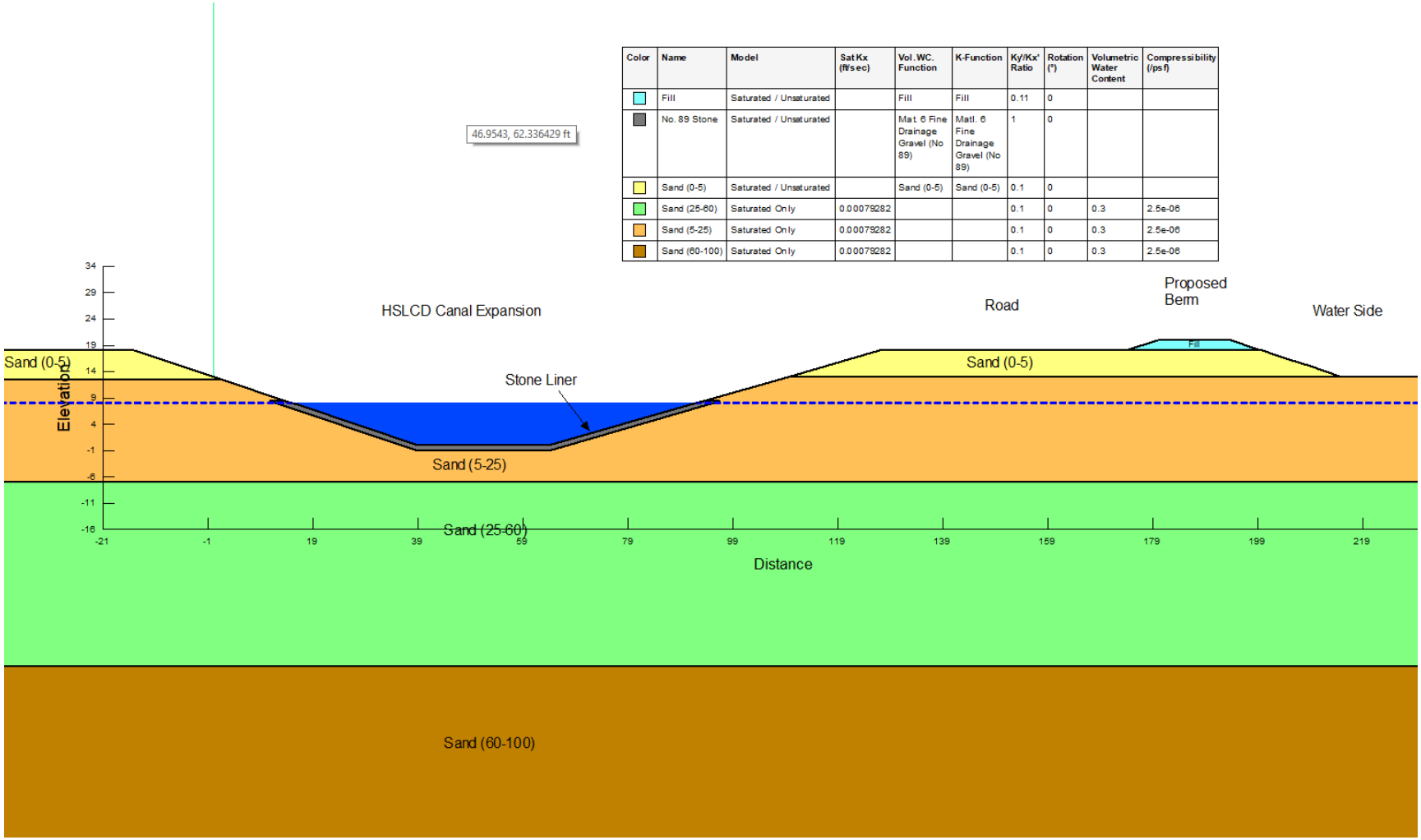
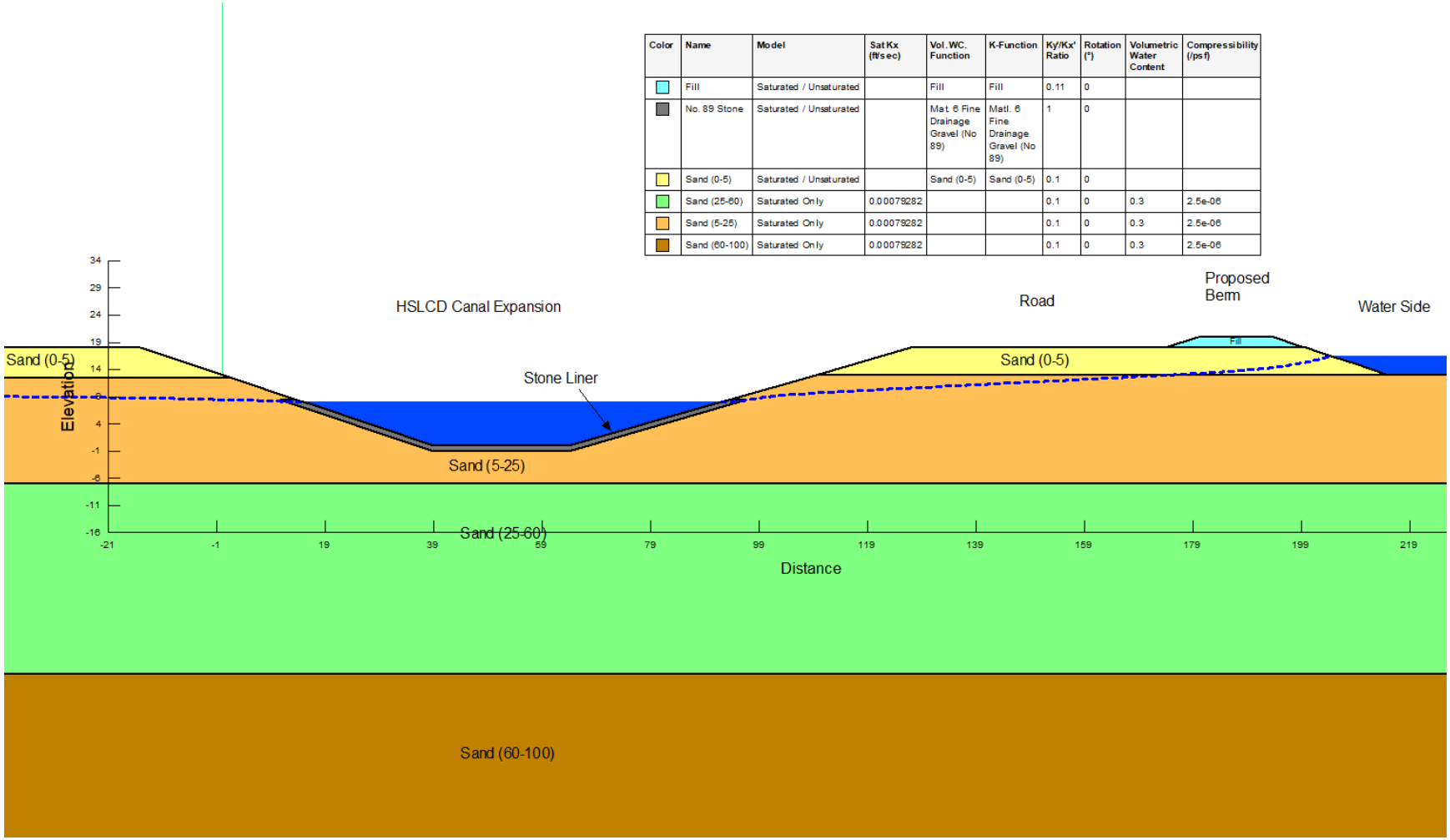


Figure B-1.45. Gulfstream West, east section, long term condition, max surcharge pool.



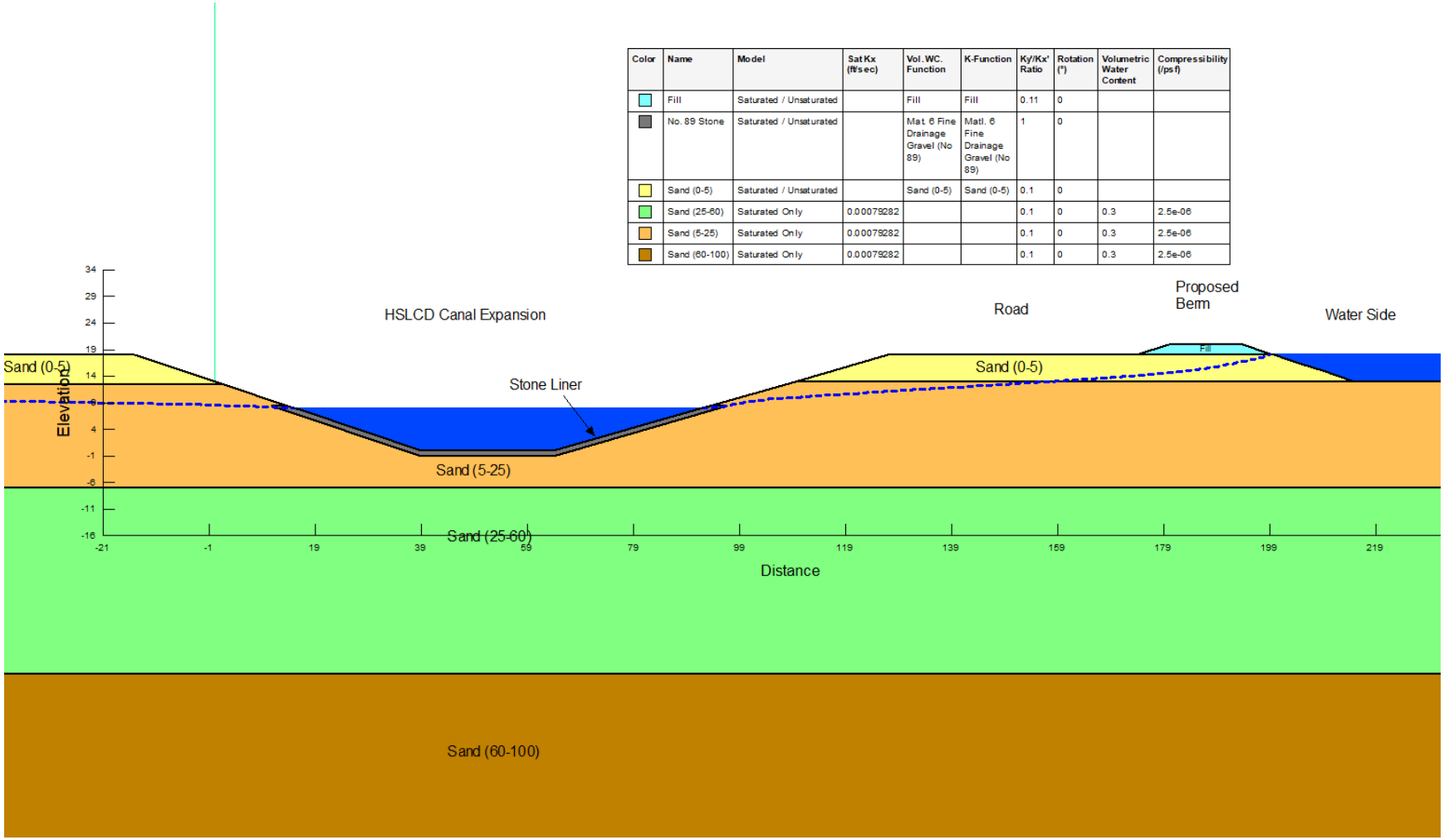
Color	Name	Model	Sat Kx (ft/sec)	Vol. WC. Function	K-Function	Ky/Kx' Ratio	Rotation (°)	Volumetric Water Content	Compressibility (/psf)
	Fill	Saturated / Unsaturated		Fill	Fill	0.11	0		
	No. 89 Stone	Saturated / Unsaturated		Mat. 6 Fine Drainage Gravel (No 89)	Matl. 6 Fine Drainage Gravel (No 89)	1	0		
	Sand (0-5)	Saturated / Unsaturated		Sand (0-5)	Sand (0-5)	0.1	0		
	Sand (25-60)	Saturated Only	0.00079282			0.1	0	0.3	2.5e-06
	Sand (5-25)	Saturated Only	0.00079282			0.1	0	0.3	2.5e-06
	Sand (60-100)	Saturated Only	0.00079282			0.1	0	0.3	2.5e-06

Figure B-1.46. Gulfstream West, south section, end of construction condition, no pool.



Color	Name	Model	Sat Kx (ft/sec)	Vol. WC. Function	K-Function	Ky'/Kx' Ratio	Rotation (°)	Volumetric Water Content	Compressibility (/psf)
	Fill	Saturated / Unsaturated		Fill	Fill	0.11	0		
	No. 89 Stone	Saturated / Unsaturated		Mat. 6 Fine Drainage Gravel (No 89)	Matl. 6 Fine Drainage Gravel (No 89)	1	0		
	Sand (0-5)	Saturated / Unsaturated		Sand (0-5)	Sand (0-5)	0.1	0		
	Sand (25-60)	Saturated Only	0.00079282			0.1	0	0.3	2.5e-06
	Sand (5-25)	Saturated Only	0.00079282			0.1	0	0.3	2.5e-06
	Sand (60-100)	Saturated Only	0.00079282			0.1	0	0.3	2.5e-06

Figure B-1.46. Gulfstream West, south section, long term condition, normal pool.



Color	Name	Model	Sat Kx (ft/sec)	Vol. WC. Function	K-Function	Ky'/Kx' Ratio	Rotation (°)	Volumetric Water Content	Compressibility (/psf)
	Fill	Saturated / Unsaturated		Fill	Fill	0.11	0		
	No. 89 Stone	Saturated / Unsaturated		Mat. 6 Fine Drainage Gravel (No 89)	Matl. 6 Fine Drainage Gravel (No 89)	1	0		
	Sand (0-5)	Saturated / Unsaturated		Sand (0-5)	Sand (0-5)	0.1	0		
	Sand (25-60)	Saturated Only	0.00079282			0.1	0	0.3	2.5e-06
	Sand (5-25)	Saturated Only	0.00079282			0.1	0	0.3	2.5e-06
	Sand (60-100)	Saturated Only	0.00079282			0.1	0	0.3	2.5e-06

Figure B-1.47. Gulfstream West, south section, long term condition, max surcharge pool.

Color	Name	Model	Sat Kx (ft/sec)	Vol. WC. Function	K-Function	Ky/Kx' Ratio	Rotation (°)	Volumetric Water Content	Compressibility (/psf)
	Fill	Saturated / Unsaturated		Fill	Fill	0.11	0		
	No. 89 Stone	Saturated / Unsaturated		Mat. 6 Fine Drainage Gravel (No 89)	Matl. 6 Fine Drainage Gravel (No 89)	1	0		
	Sand (0-5)	Saturated / Unsaturated		Sand (0-5)	Sand (0-5)	0.1	0		
	Sand (25-60)	Saturated Only	0.00079282			0.1	0	0.3	2.5e-06
	Sand (5-25)	Saturated Only	0.00079282			0.1	0	0.3	2.5e-06
	Sand (60-100)	Saturated Only	0.00079282			0.1	0	0.3	2.5e-06

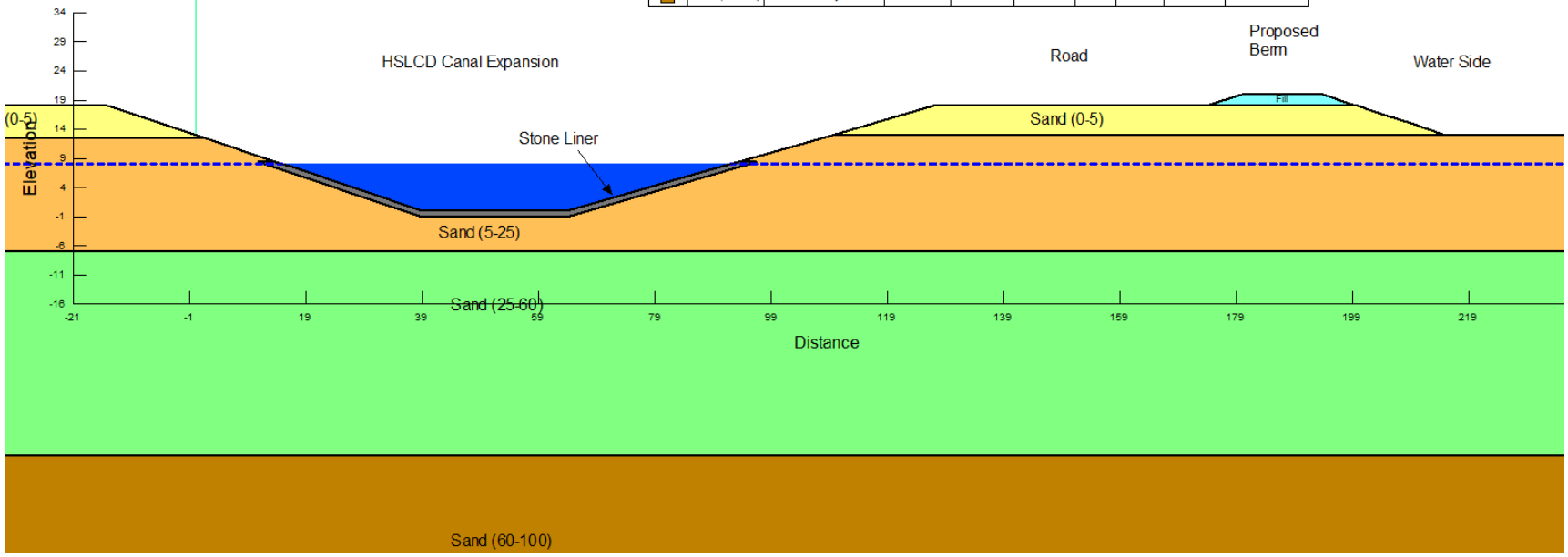
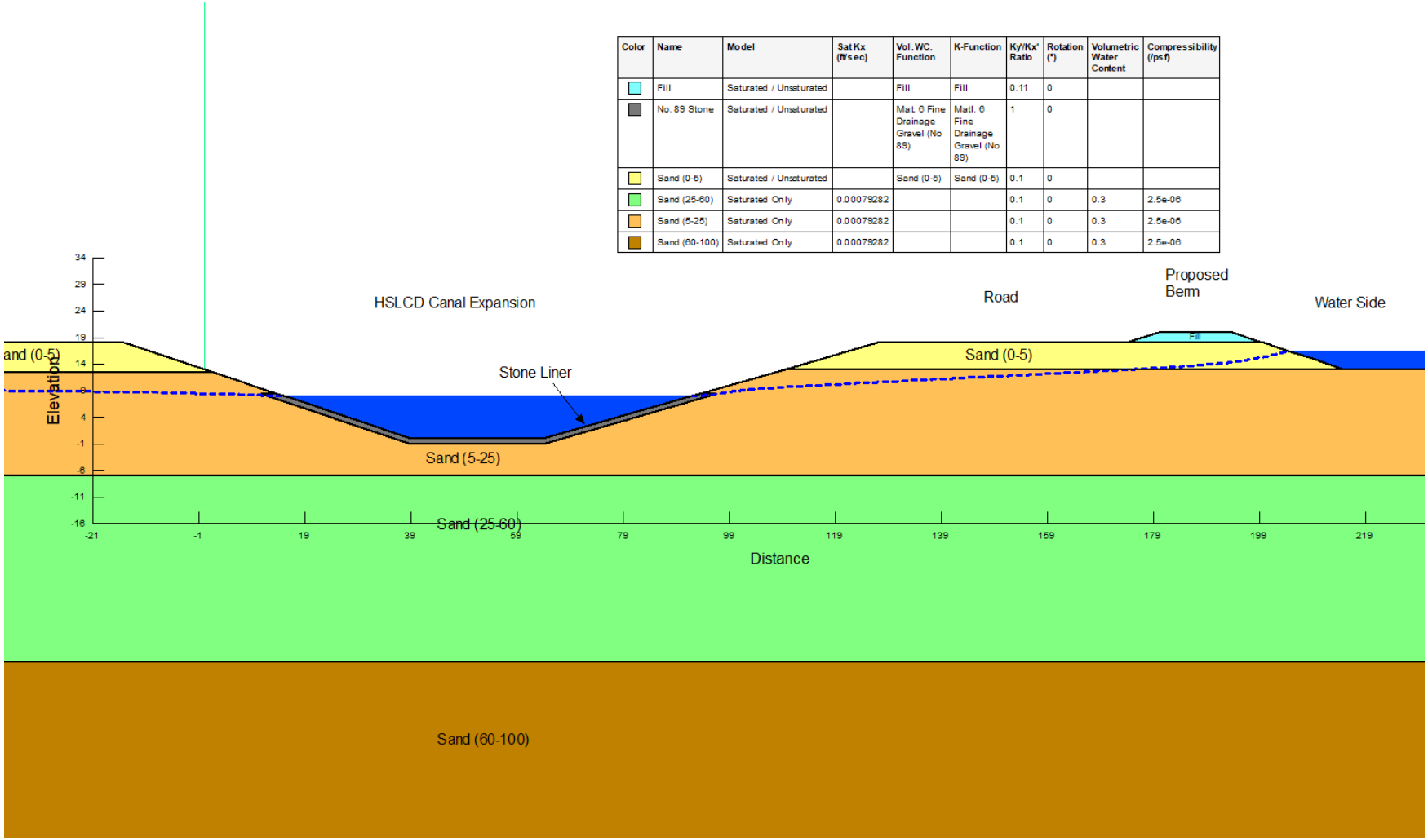
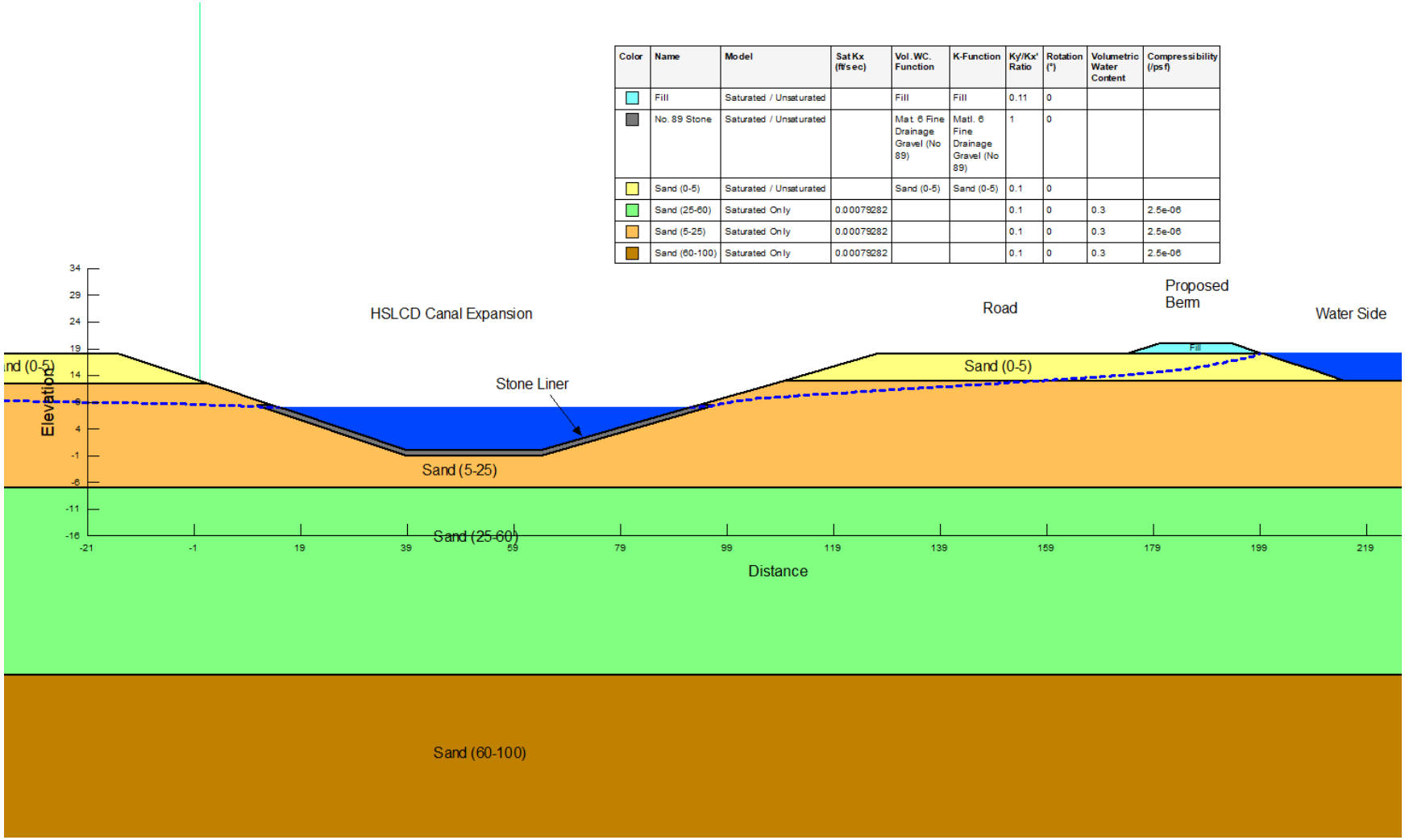


Figure B-1.48. Gulfstream West, west section, end of construction condition, no pool.



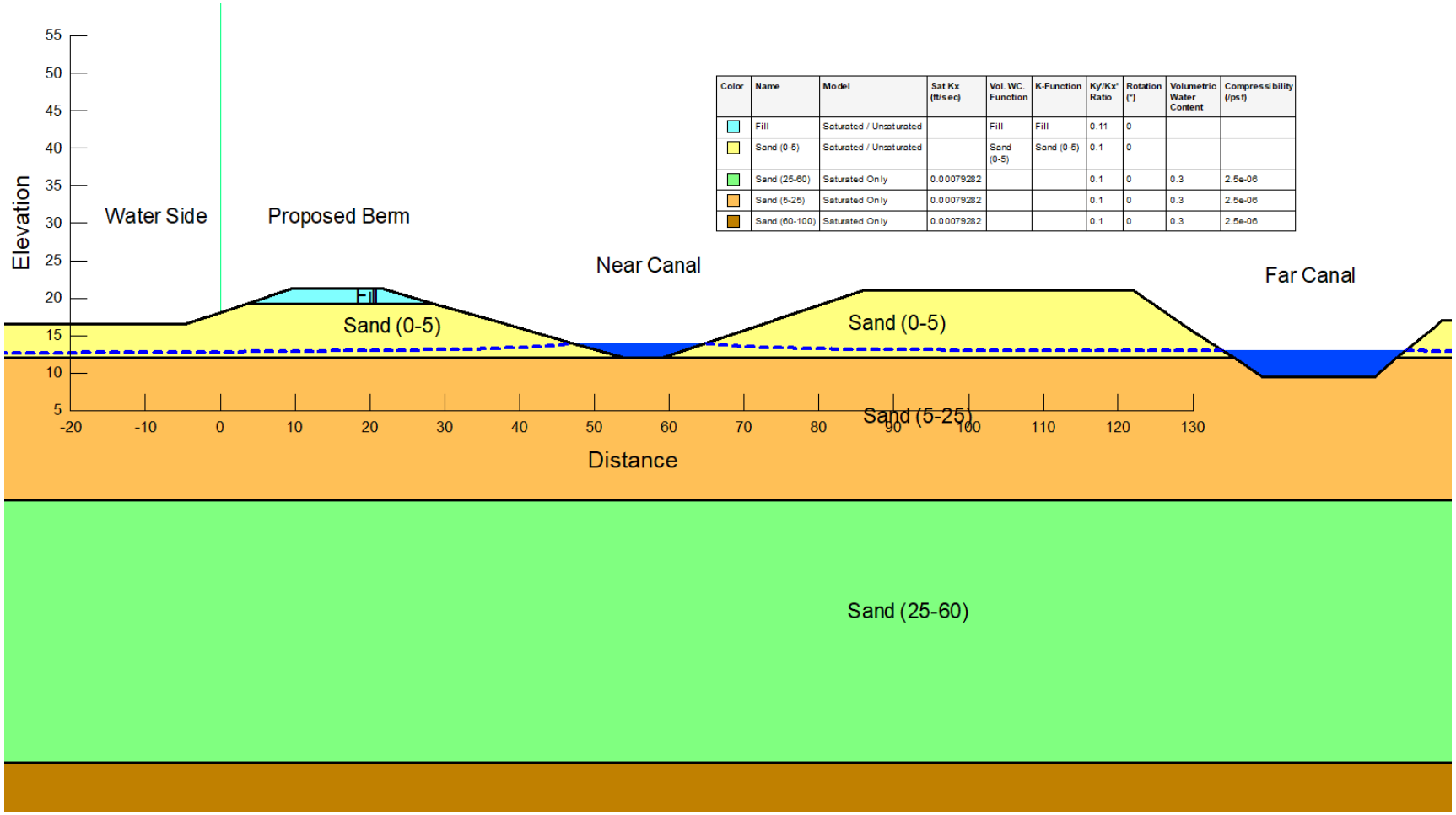
Color	Name	Model	Sat Kx (ft/sec)	Vol. WC. Function	K-Function	Ky/Kx' Ratio	Rotation (°)	Volumetric Water Content	Compressibility (/psf)
	Fill	Saturated / Unsaturated		Fill	Fill	0.11	0		
	No. 89 Stone	Saturated / Unsaturated		Mat. 6 Fine Drainage Gravel (No 89)	Matl. 6 Fine Drainage Gravel (No 89)	1	0		
	Sand (0-5)	Saturated / Unsaturated		Sand (0-5)	Sand (0-5)	0.1	0		
	Sand (25-60)	Saturated Only	0.00079282			0.1	0	0.3	2.5e-06
	Sand (5-25)	Saturated Only	0.00079282			0.1	0	0.3	2.5e-06
	Sand (60-100)	Saturated Only	0.00079282			0.1	0	0.3	2.5e-06

Figure B-1.48. Gulfstream West, west section, long term condition, normal pool.



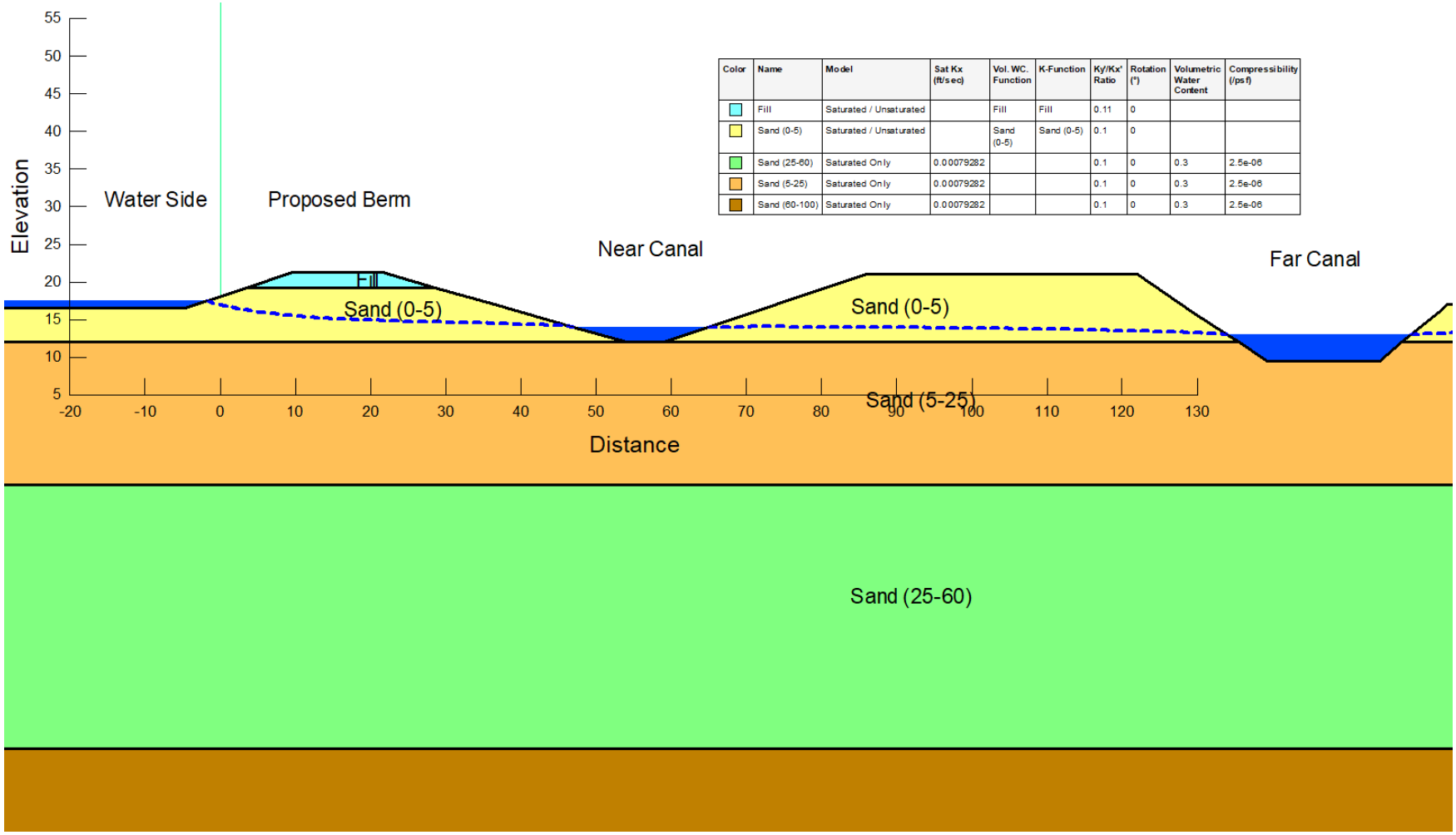
Color	Name	Model	Sat Kx (ft/sec)	Vol. WC. Function	K-Function	Ky'/Kx' Ratio	Rotation (°)	Volumetric Water Content	Compressibility (/psf)
	Fill	Saturated / Unsaturated		Fill	Fill	0.11	0		
	No. 89 Stone	Saturated / Unsaturated		Mat. 6 Fine Drainage Gravel (No 89)	Matl. 6 Fine Drainage Gravel (No 89)	1	0		
	Sand (0-5)	Saturated / Unsaturated		Sand (0-5)	Sand (0-5)	0.1	0		
	Sand (25-60)	Saturated Only	0.00079282			0.1	0	0.3	2.5e-06
	Sand (5-25)	Saturated Only	0.00079282			0.1	0	0.3	2.5e-06
	Sand (60-100)	Saturated Only	0.00079282			0.1	0	0.3	2.5e-06

Figure B-1.49. Gulfstream West, west section, long term condition, max surcharge pool.



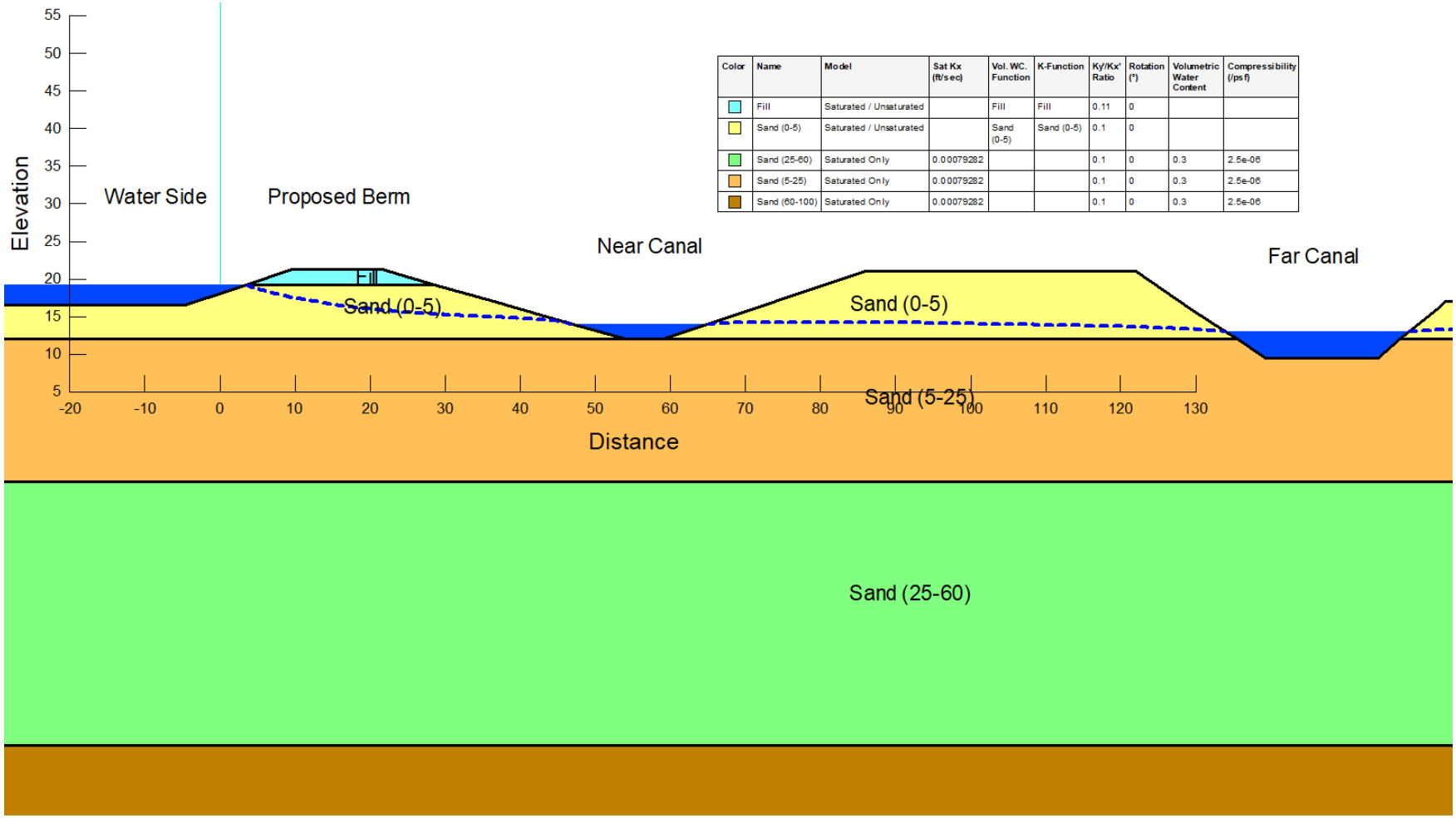
Color	Name	Model	Sat Kx (ft/sec)	Vol. WC. Function	K-Function	Ky/Kx' Ratio	Rotation (°)	Volumetric Water Content	Compressibility (/psf)
	Fill	Saturated / Unsaturated		Fill	Fill	0.11	0		
	Sand (0-5)	Saturated / Unsaturated		Sand (0-5)	Sand (0-5)	0.1	0		
	Sand (25-60)	Saturated Only	0.00079282			0.1	0	0.3	2.5e-06
	Sand (5-25)	Saturated Only	0.00079282			0.1	0	0.3	2.5e-06
	Sand (60-100)	Saturated Only	0.00079282			0.1	0	0.3	2.5e-06

Figure B-1.50. Nine Gems embankment, end of construction condition, no pool.



Color	Name	Model	Sat Kx (ft/sec)	Vol. WC. Function	K-Function	Ky/Kx' Ratio	Rotation (°)	Volumetric Water Content	Compressibility (/psf)
	Fill	Saturated / Unsaturated		Fill	Fill	0.11	0		
	Sand (0-5)	Saturated / Unsaturated		Sand (0-5)	Sand (0-5)	0.1	0		
	Sand (25-60)	Saturated Only	0.00079282			0.1	0	0.3	2.5e-06
	Sand (5-25)	Saturated Only	0.00079282			0.1	0	0.3	2.5e-06
	Sand (60-100)	Saturated Only	0.00079282			0.1	0	0.3	2.5e-06

Figure B-1.51. Nine Gems embankment, long term condition, normal pool.



Color	Name	Model	Sat Kx (ft/sec)	Vol. WC. Function	K-Function	Ky/Kx' Ratio	Rotation (°)	Volumetric Water Content	Compressibility (/psf)
	Fill	Saturated / Unsaturated		Fill	Fill	0.11	0		
	Sand (0-5)	Saturated / Unsaturated		Sand (0-5)	Sand (0-5)	0.1	0		
	Sand (25-60)	Saturated Only	0.00079282			0.1	0	0.3	2.5e-06
	Sand (5-25)	Saturated Only	0.00079282			0.1	0	0.3	2.5e-06
	Sand (60-100)	Saturated Only	0.00079282			0.1	0	0.3	2.5e-06

Figure B-1.52. Nine Gems embankment, long term condition, max surcharge pool.

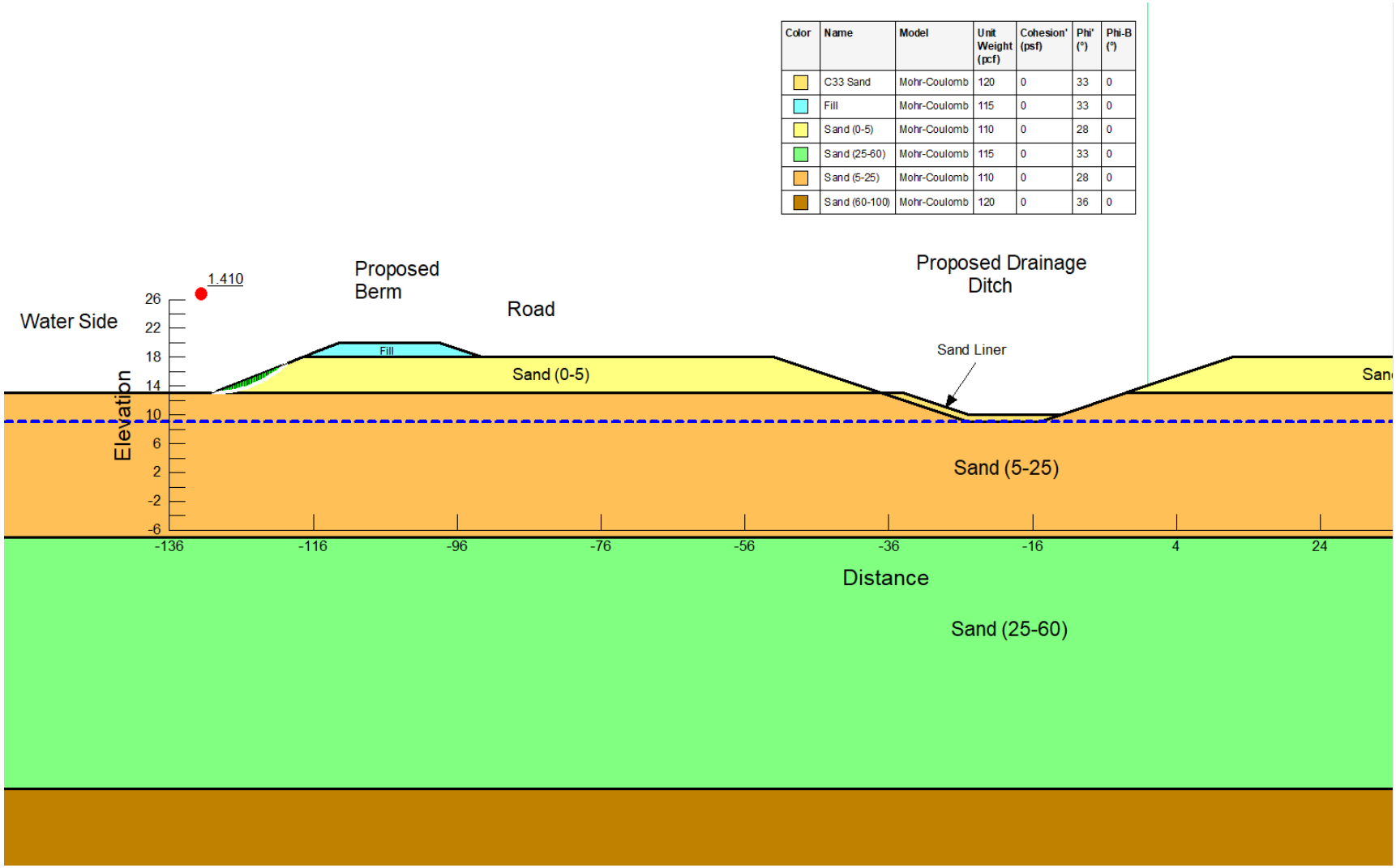


Figure B-1.53. Gulfstream West, east section, end of construction condition, U/S slope, no pool.

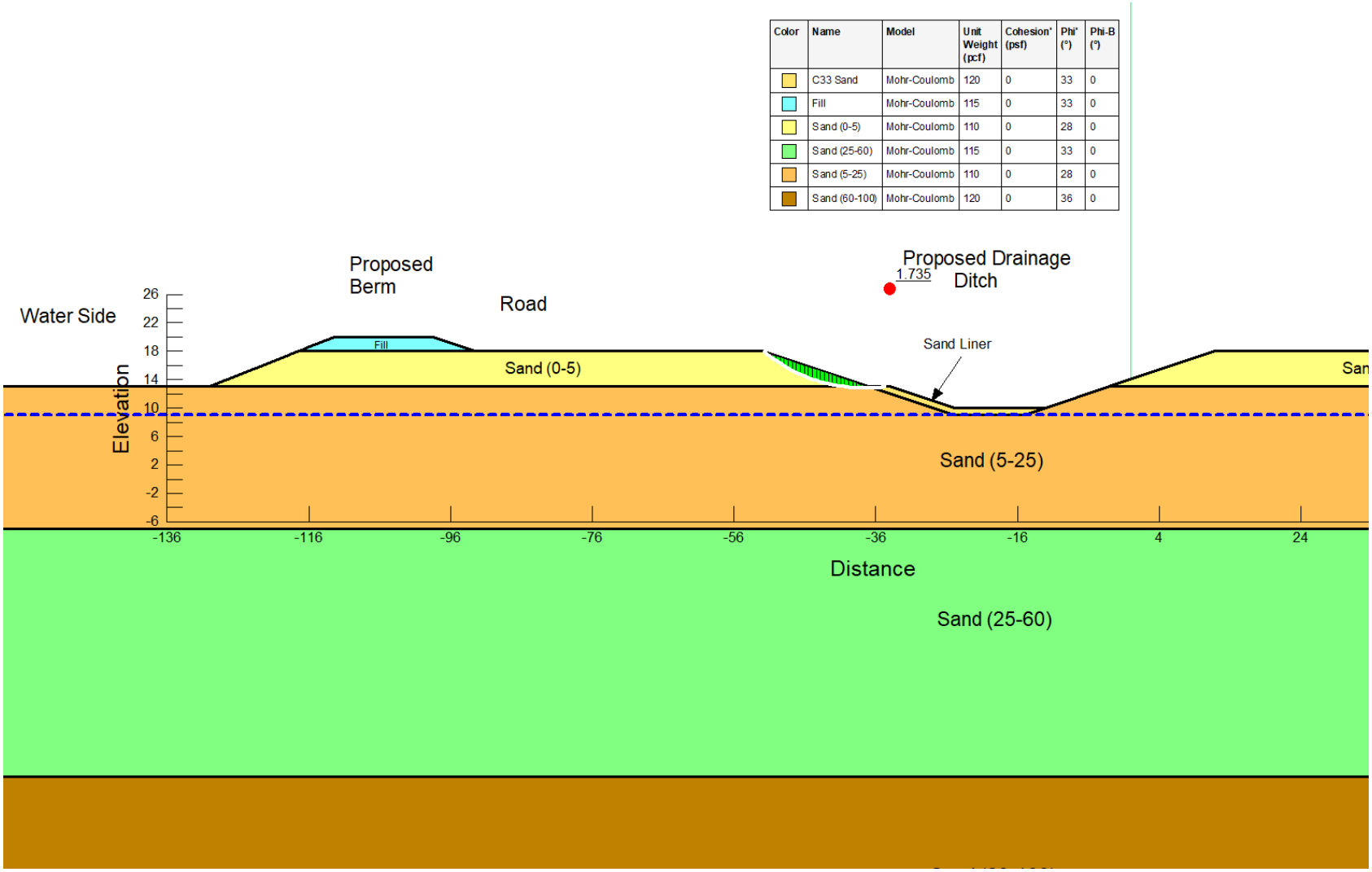


Figure B-1.54. Gulfstream West, east section, end of construction condition, D/S slope, no pool.

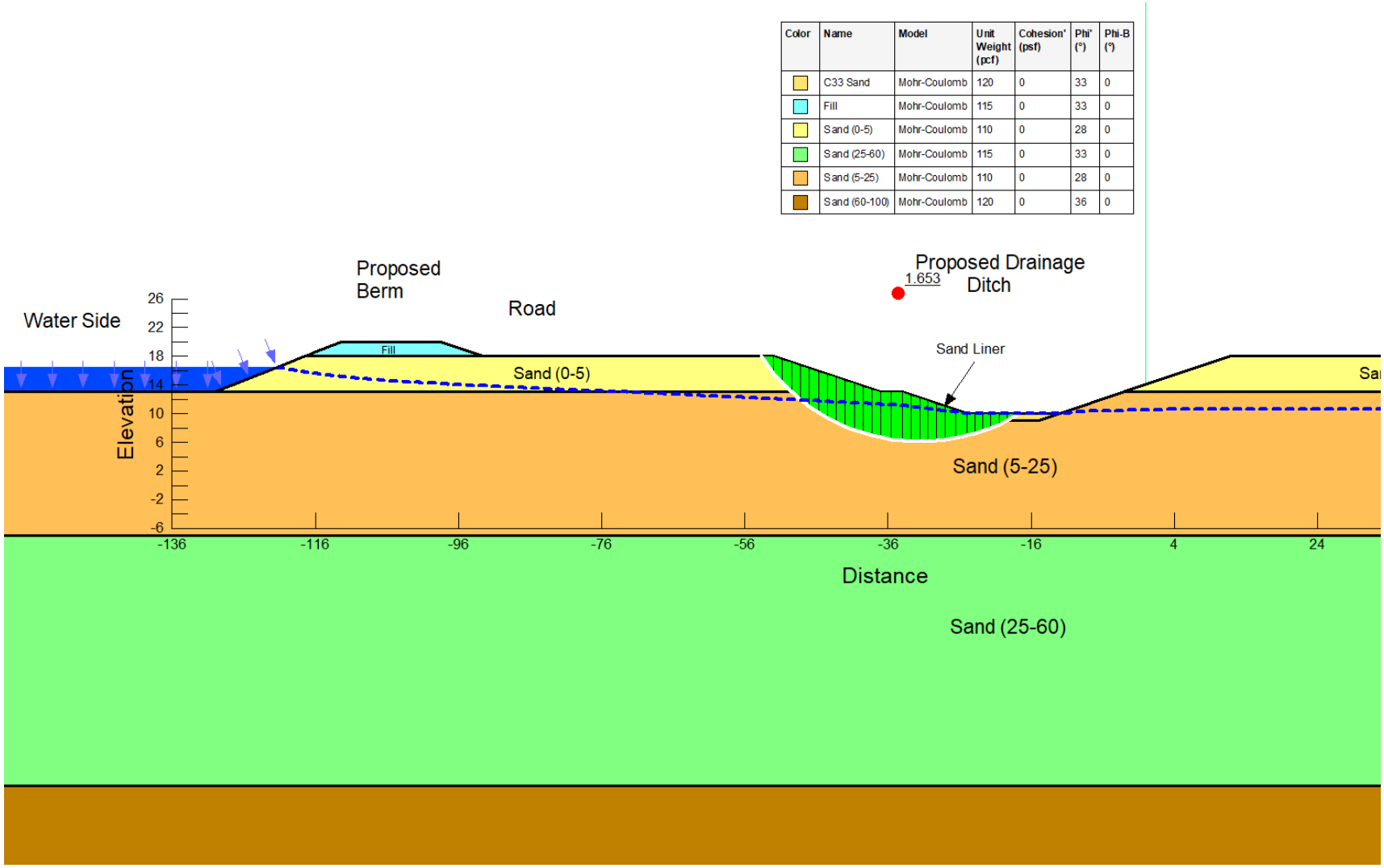
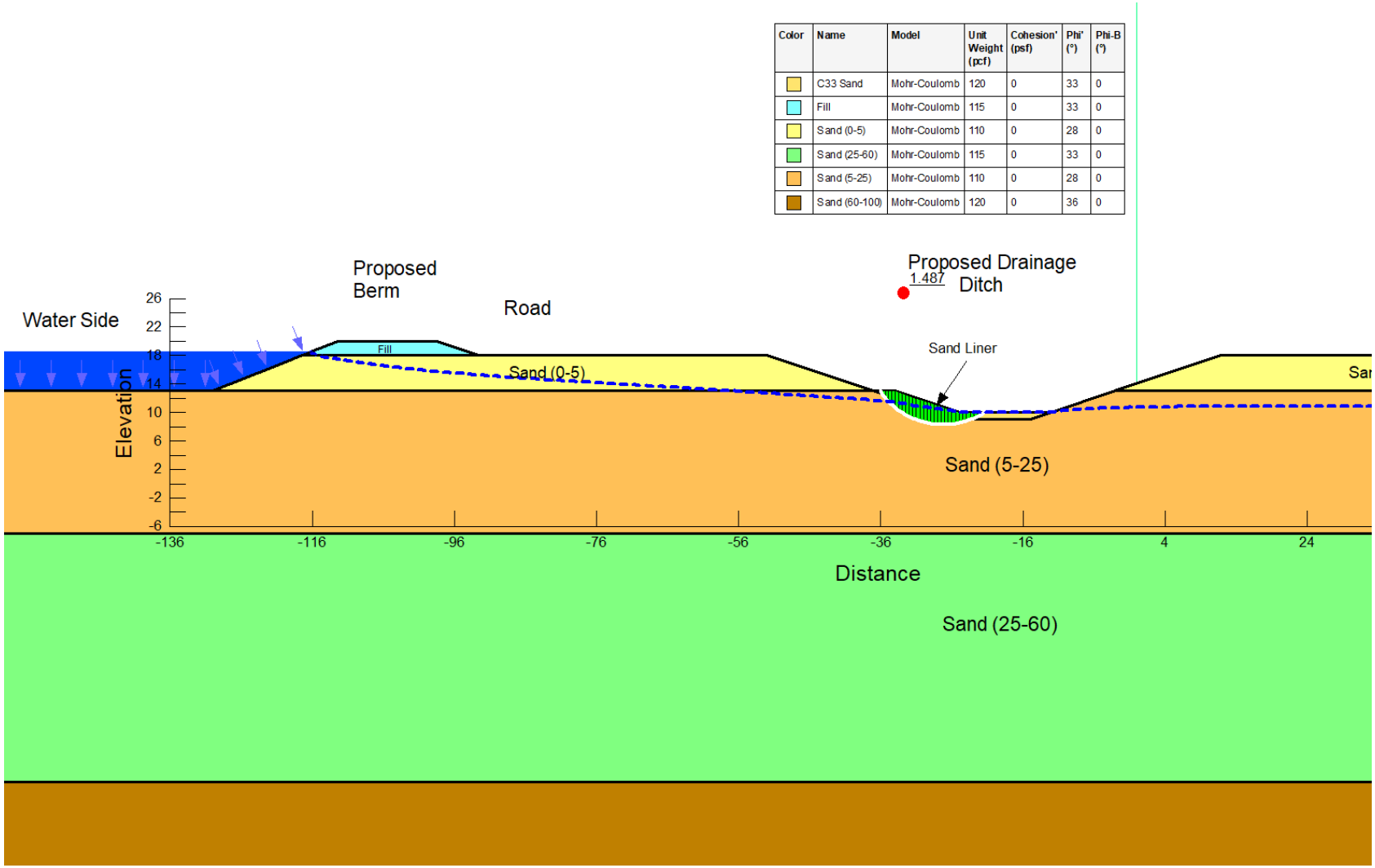


Figure B-1.55. Gulfstream West, east section, long term condition, D/S slope, normal pool.



Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)
	C33 Sand	Mohr-Coulomb	120	0	33	0
	Fill	Mohr-Coulomb	115	0	33	0
	Sand (0-5)	Mohr-Coulomb	110	0	28	0
	Sand (25-60)	Mohr-Coulomb	115	0	33	0
	Sand (5-25)	Mohr-Coulomb	110	0	28	0
	Sand (60-100)	Mohr-Coulomb	120	0	36	0

Figure B-1.56. Gulfstream West, east section, long term condition, D/S slope, max surcharge pool.

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)	Cohesion R (psf)	Phi R (°)	Piezometric Line	Piezometric Line After Drawdown
	C33 Sand	Mohr-Coulomb	120	0	33	0	0	0	1	2
	Fill	Mohr-Coulomb	115	0	33	0	420	0	1	2
	Sand (0-5)	Mohr-Coulomb	110	0	28	0	420	0	1	2
	Sand (25-60)	Mohr-Coulomb	115	0	33	0	0	0	1	2
	Sand (5-25)	Mohr-Coulomb	110	0	28	0	420	0	1	2
	Sand (60-100)	Mohr-Coulomb	120	0	36	0	0	0	1	2

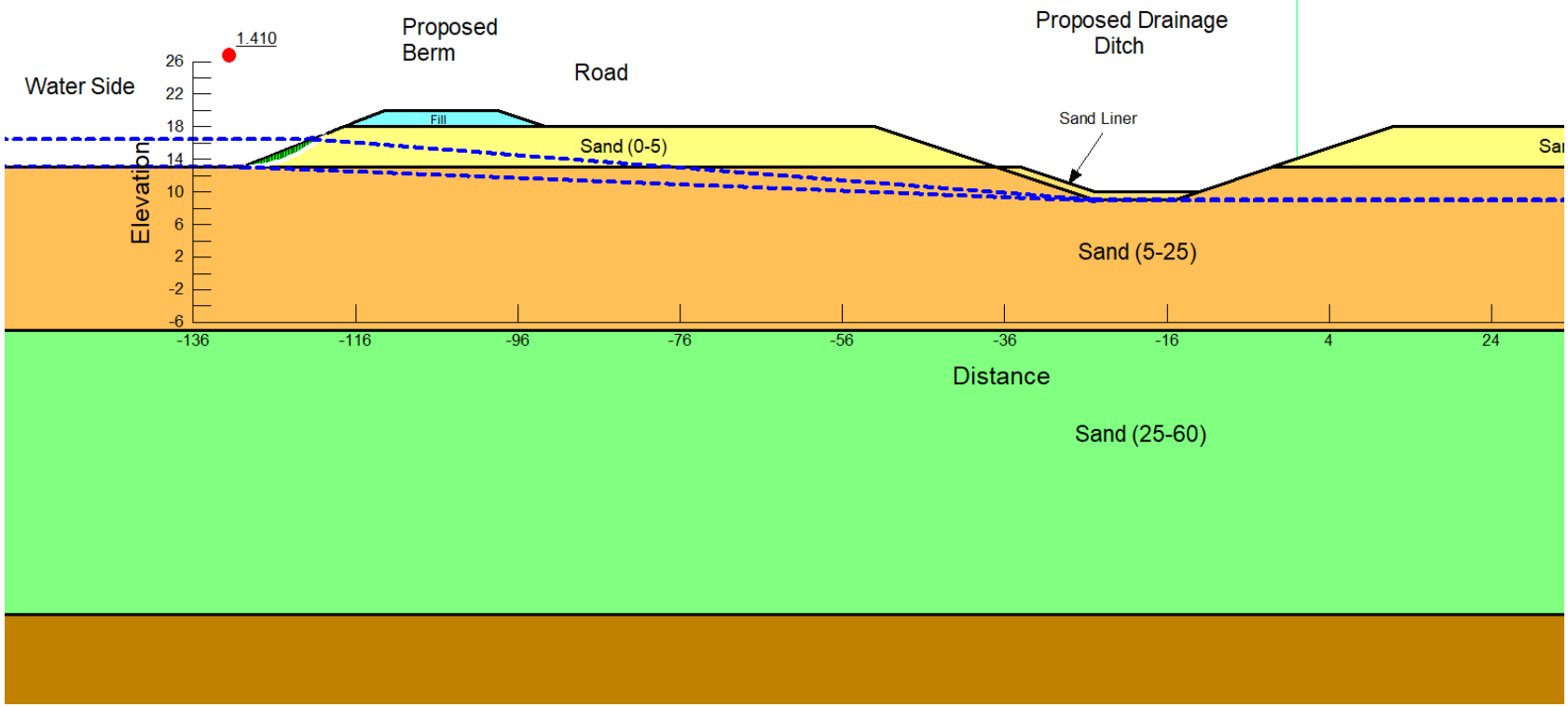


Figure B-1.56. Gulfstream West, east section, rapid draw down condition, U/S slope.

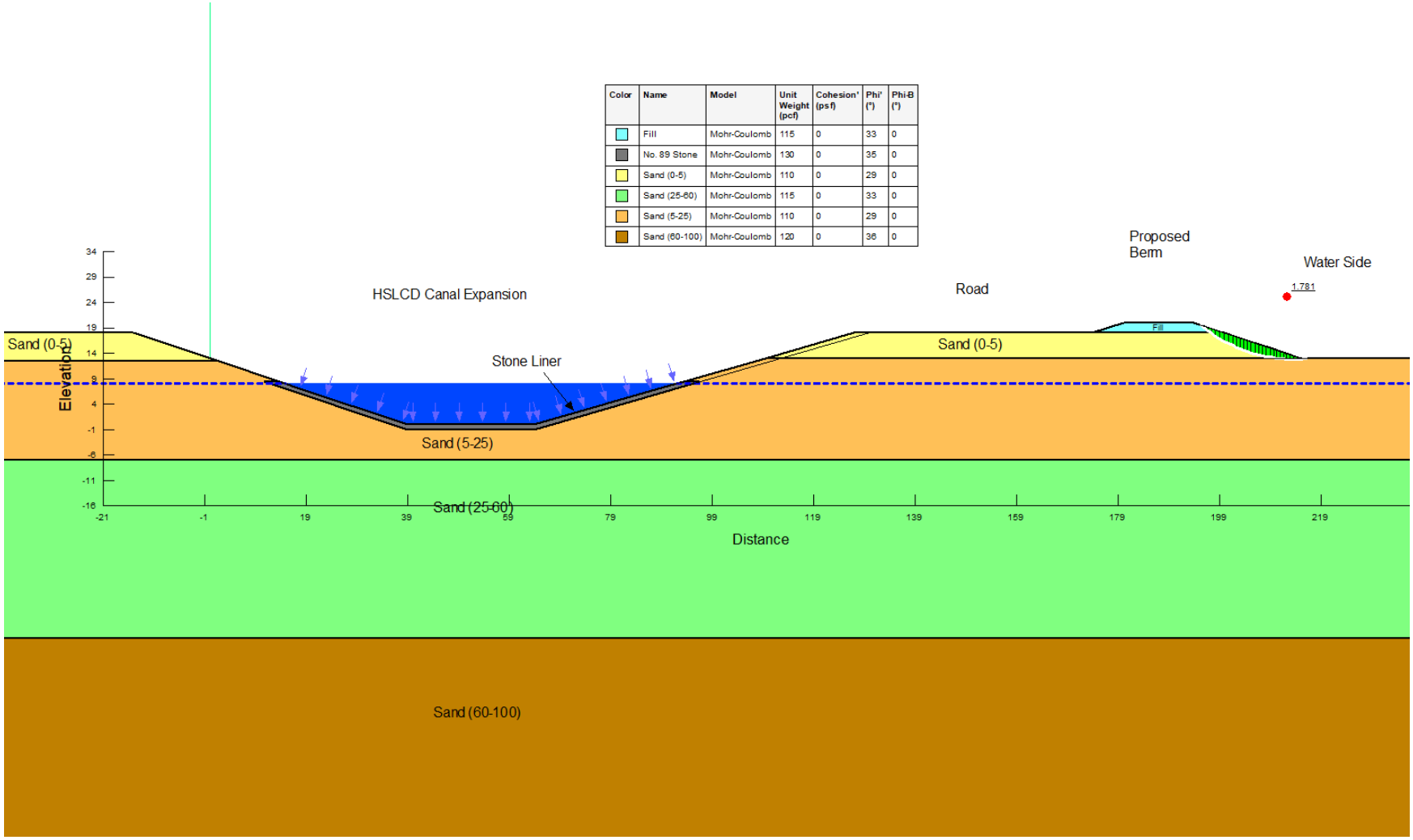


Figure B-1.57. Gulfstream West, south section, end of construction condition, U/S slope, no pool.

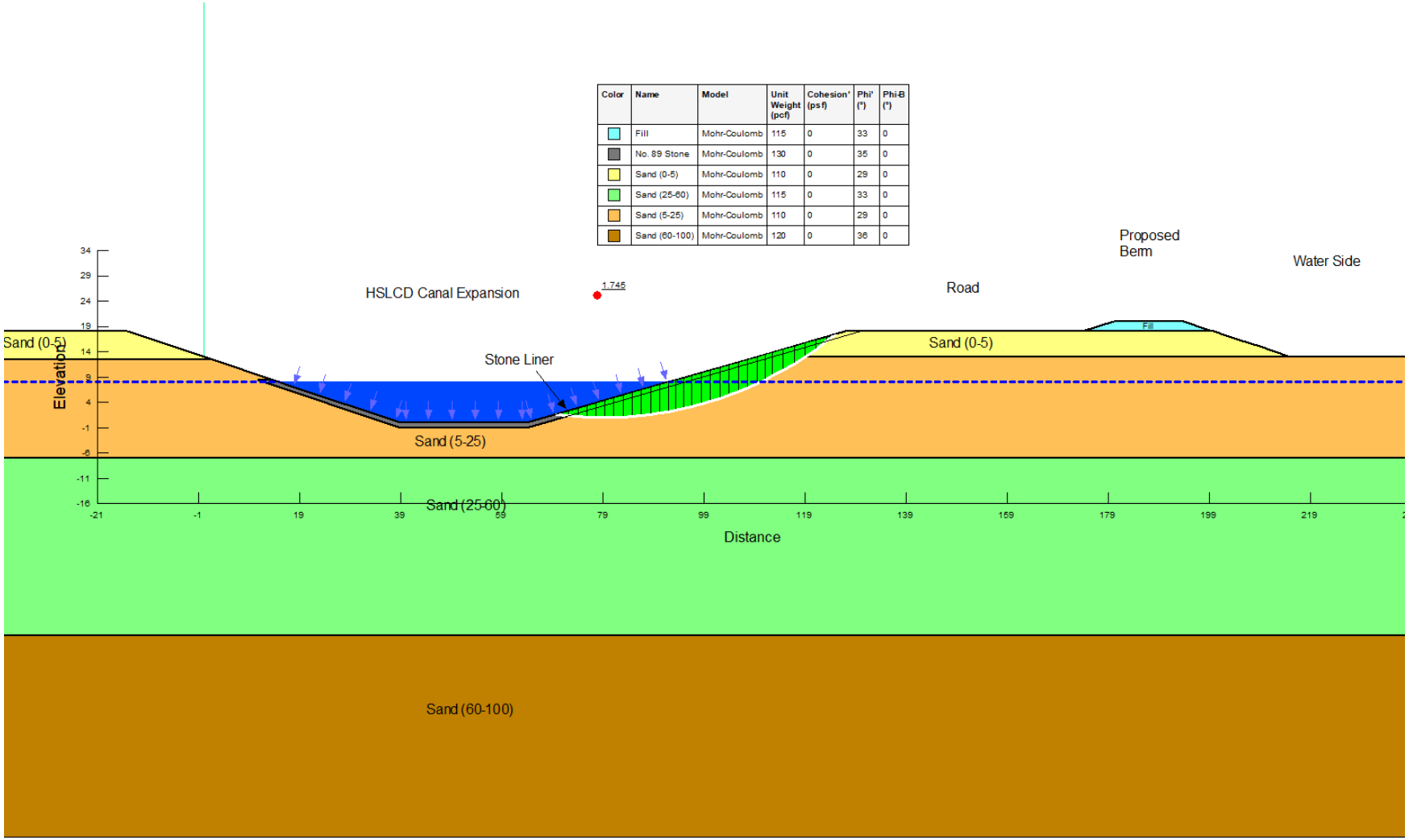


Figure B-1.58. Gulfstream West, south section, end of construction condition, D/S slope, no pool.

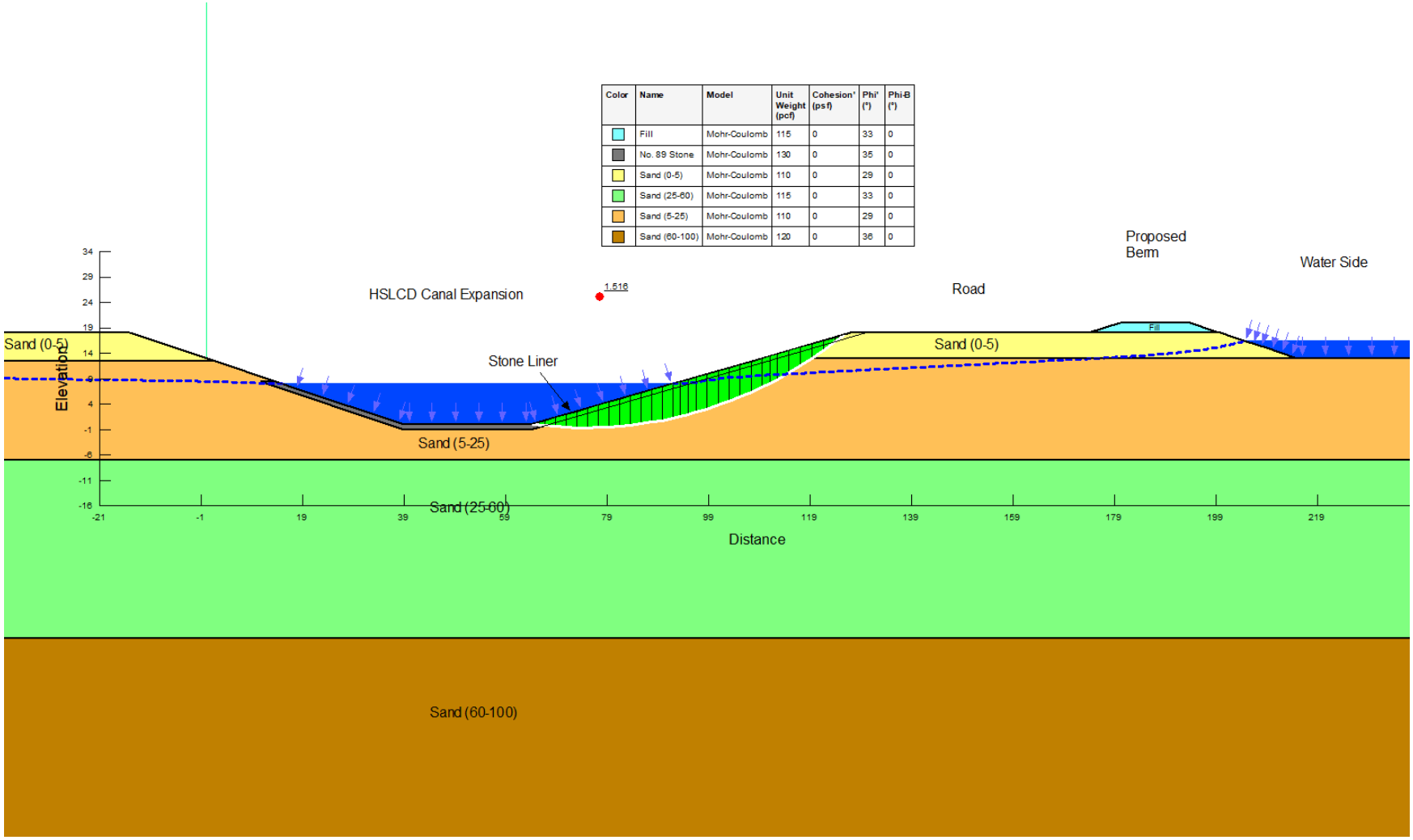


Figure B-1.58. Gulfstream West, south section, long term condition condition, D/S slope, normal pool.

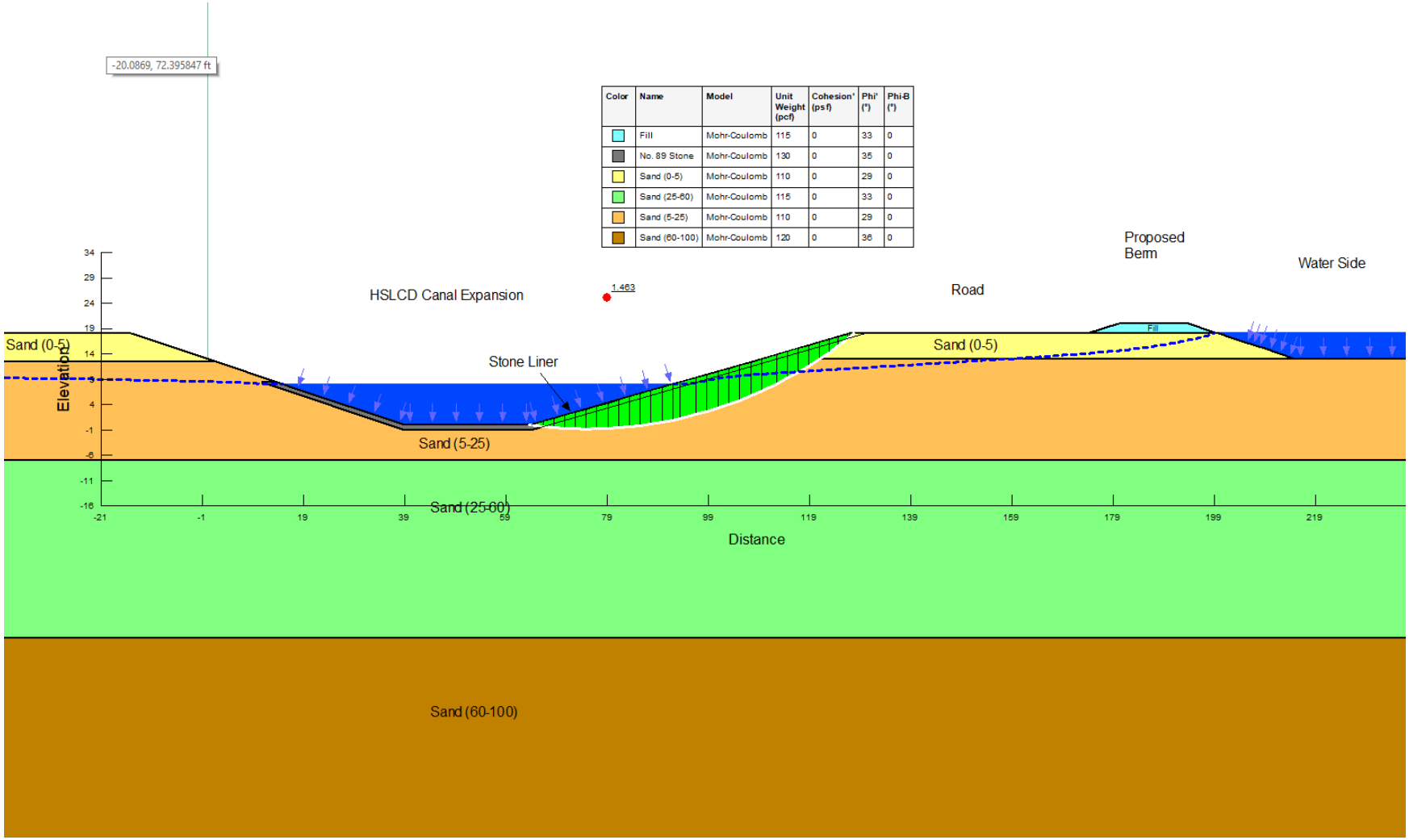
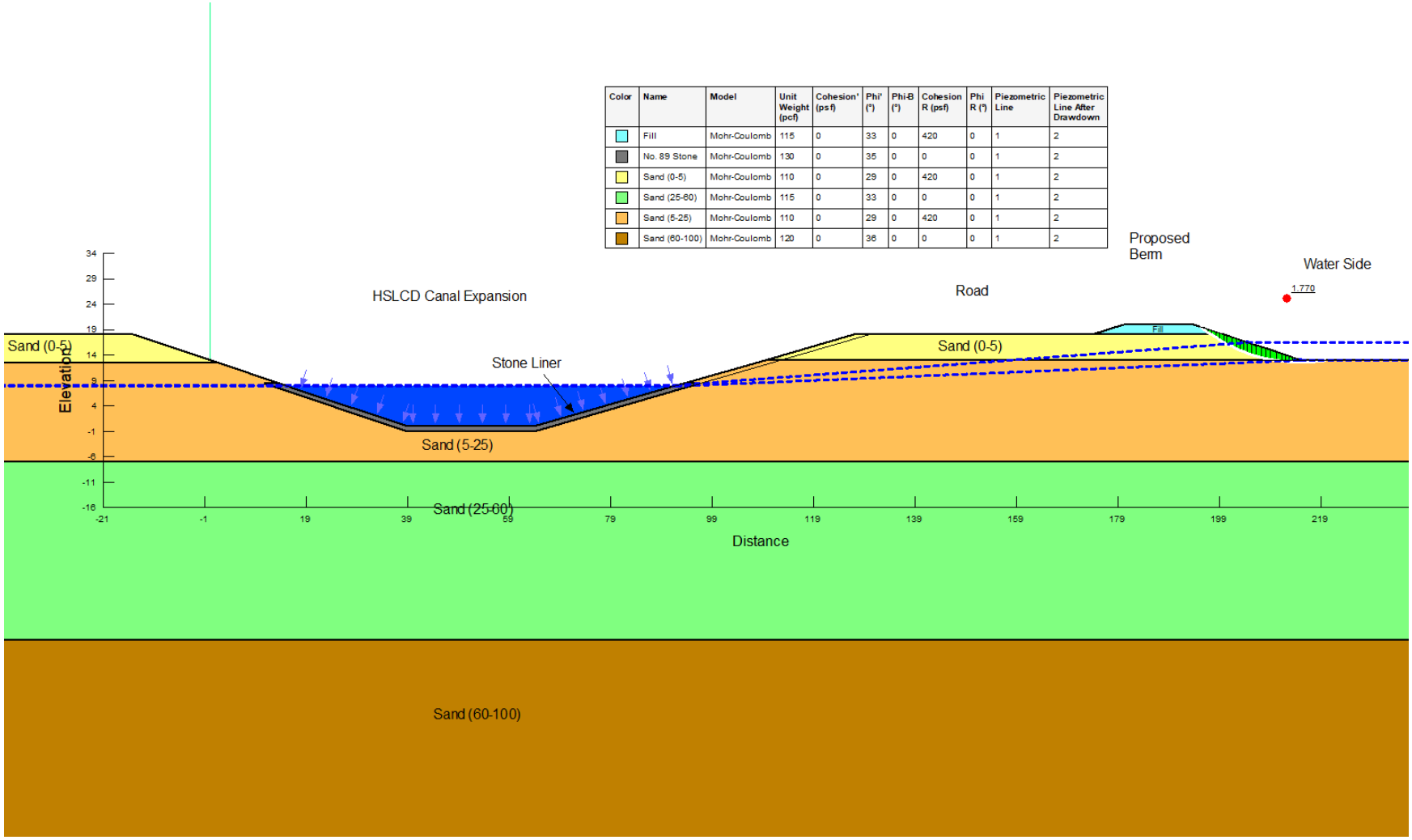
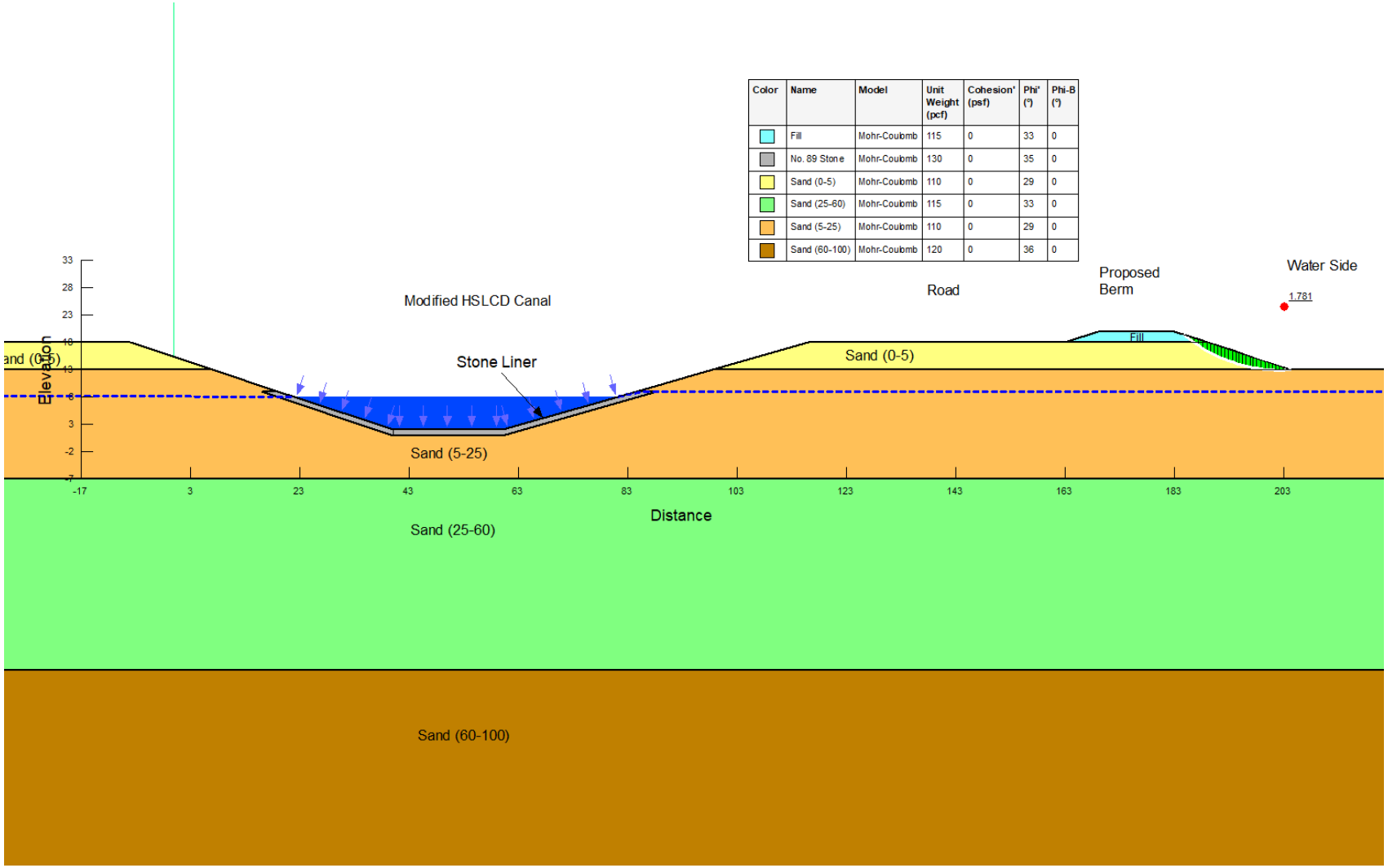


Figure B-1.59. Gulfstream West, south section, long term condition, D/S slope, maximum surcharge pool (U/S and D/S).



Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)	Cohesion R (psf)	Phi R (°)	Piezometric Line	Piezometric Line After Drawdown
	Fill	Mohr-Coulomb	115	0	33	0	420	0	1	2
	No. 89 Stone	Mohr-Coulomb	130	0	35	0	0	0	1	2
	Sand (0-5)	Mohr-Coulomb	110	0	29	0	420	0	1	2
	Sand (25-60)	Mohr-Coulomb	115	0	33	0	0	0	1	2
	Sand (5-25)	Mohr-Coulomb	110	0	29	0	420	0	1	2
	Sand (60-100)	Mohr-Coulomb	120	0	36	0	0	0	1	2

Figure B-1.60. Gulfstream West, south section, rapid draw down condition, U/S slope.



Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)
	Fill	Mohr-Coulomb	115	0	33	0
	No. 89 Stone	Mohr-Coulomb	130	0	35	0
	Sand (0-5)	Mohr-Coulomb	110	0	29	0
	Sand (25-60)	Mohr-Coulomb	115	0	33	0
	Sand (5-25)	Mohr-Coulomb	110	0	29	0
	Sand (60-100)	Mohr-Coulomb	120	0	36	0

Figure B-1.60. Gulfstream West, west section, end of construction condition, U/S slope, no pool.

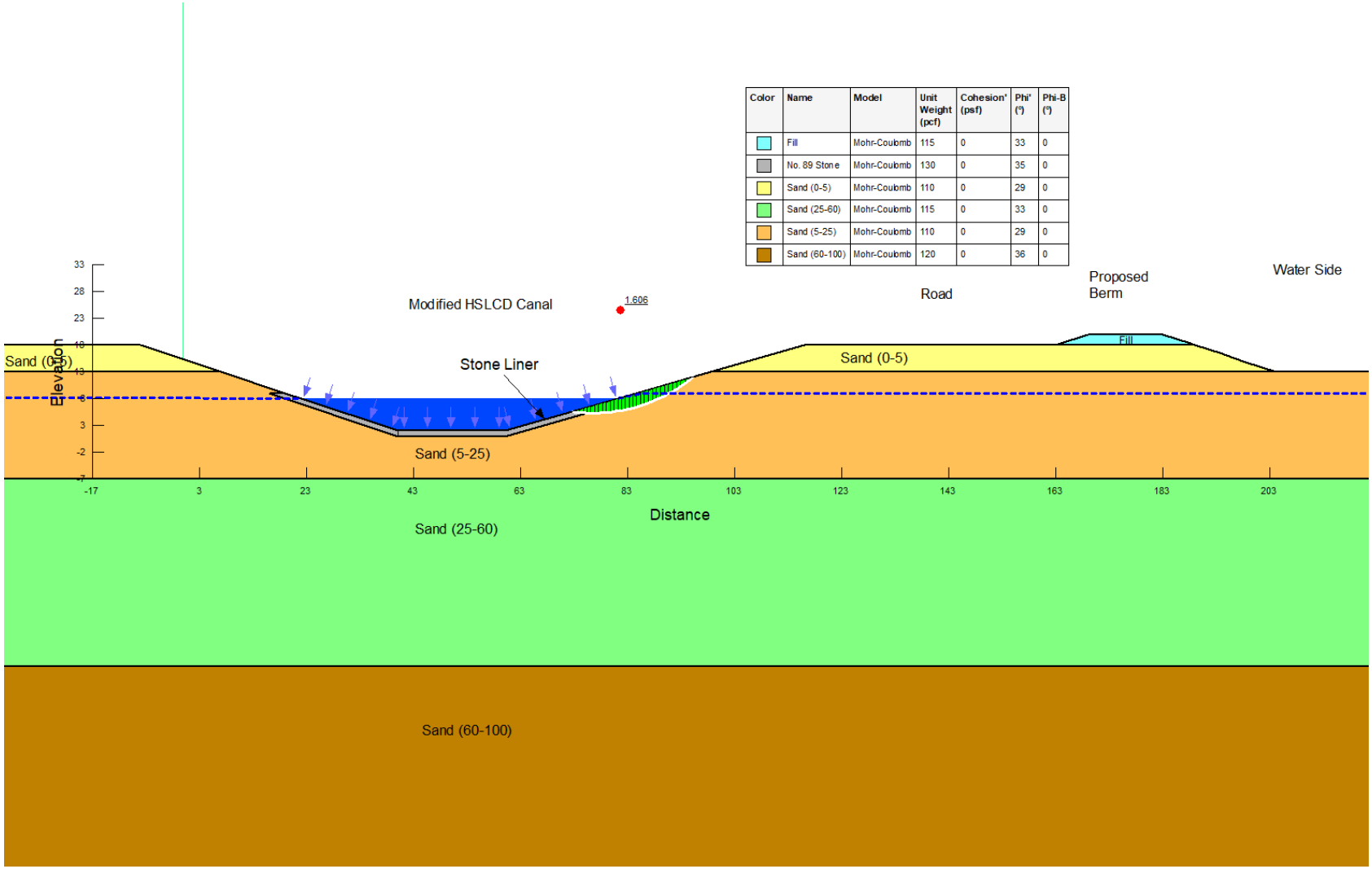


Figure B-1.61. Gulfstream West, west section, end of construction condition, D/S slope, no pool.

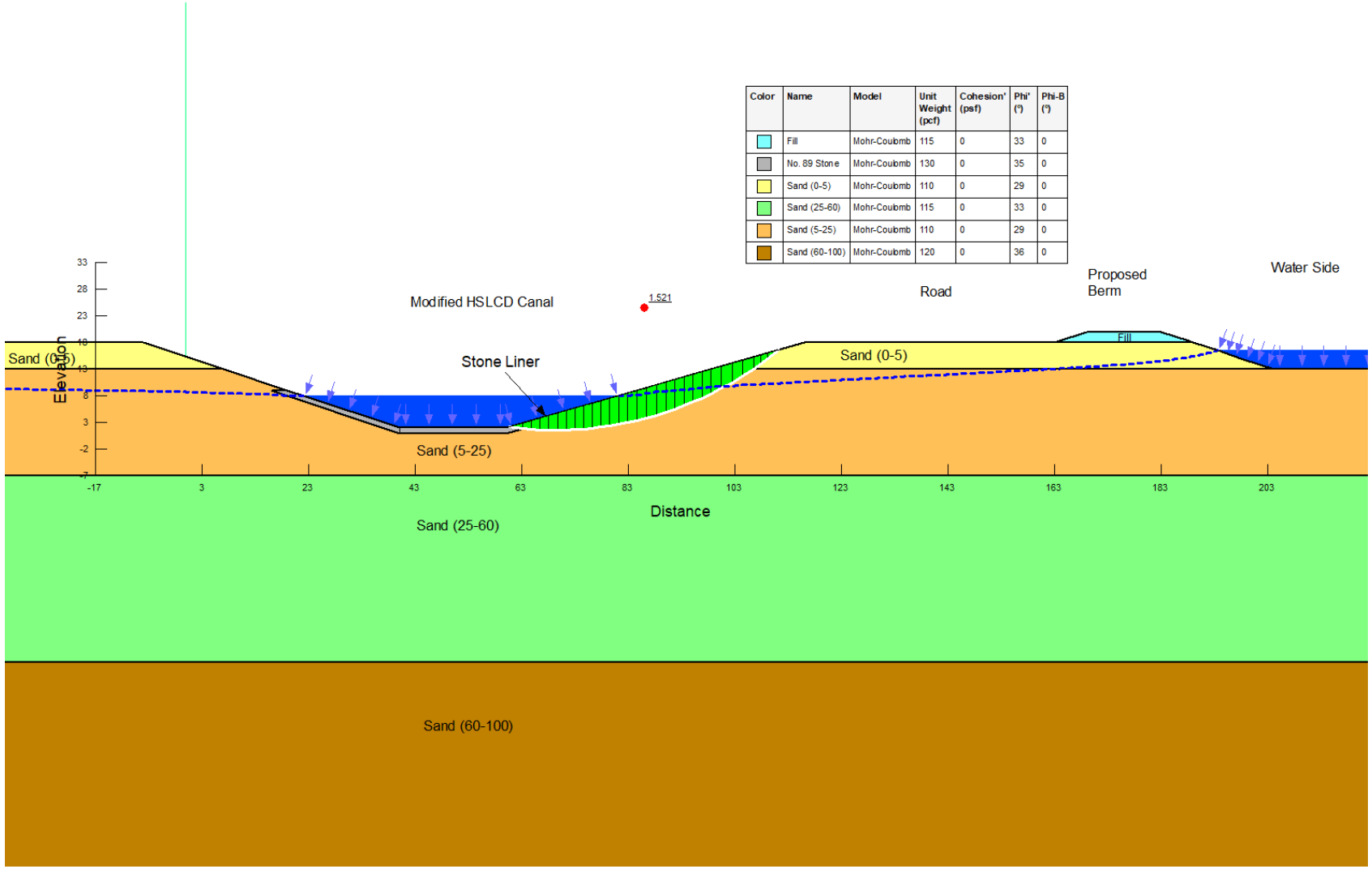


Figure B-1.61. Gulfstream West, west section, long term condition, D/S slope, normal pool (U/S and D/S).

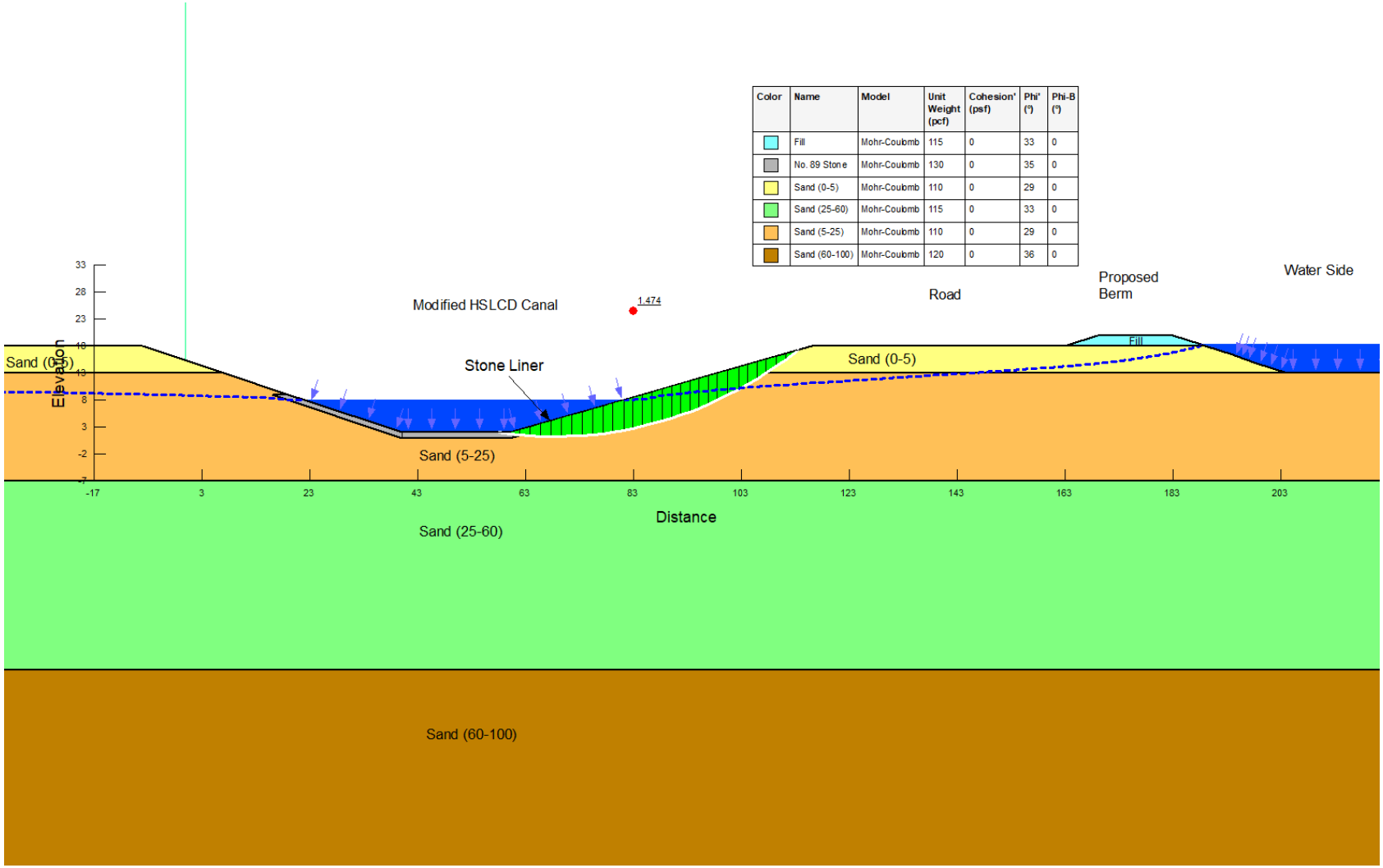
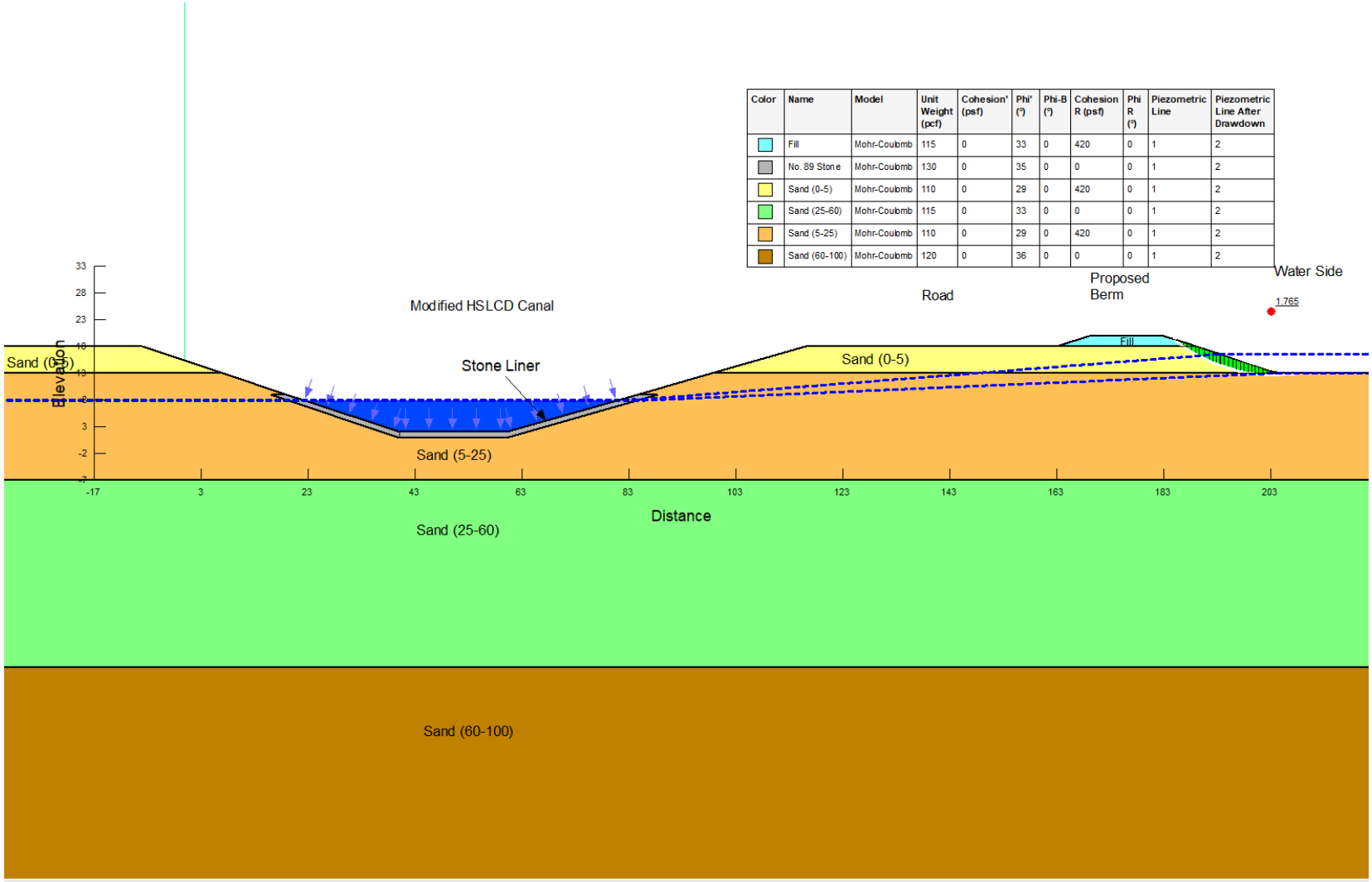
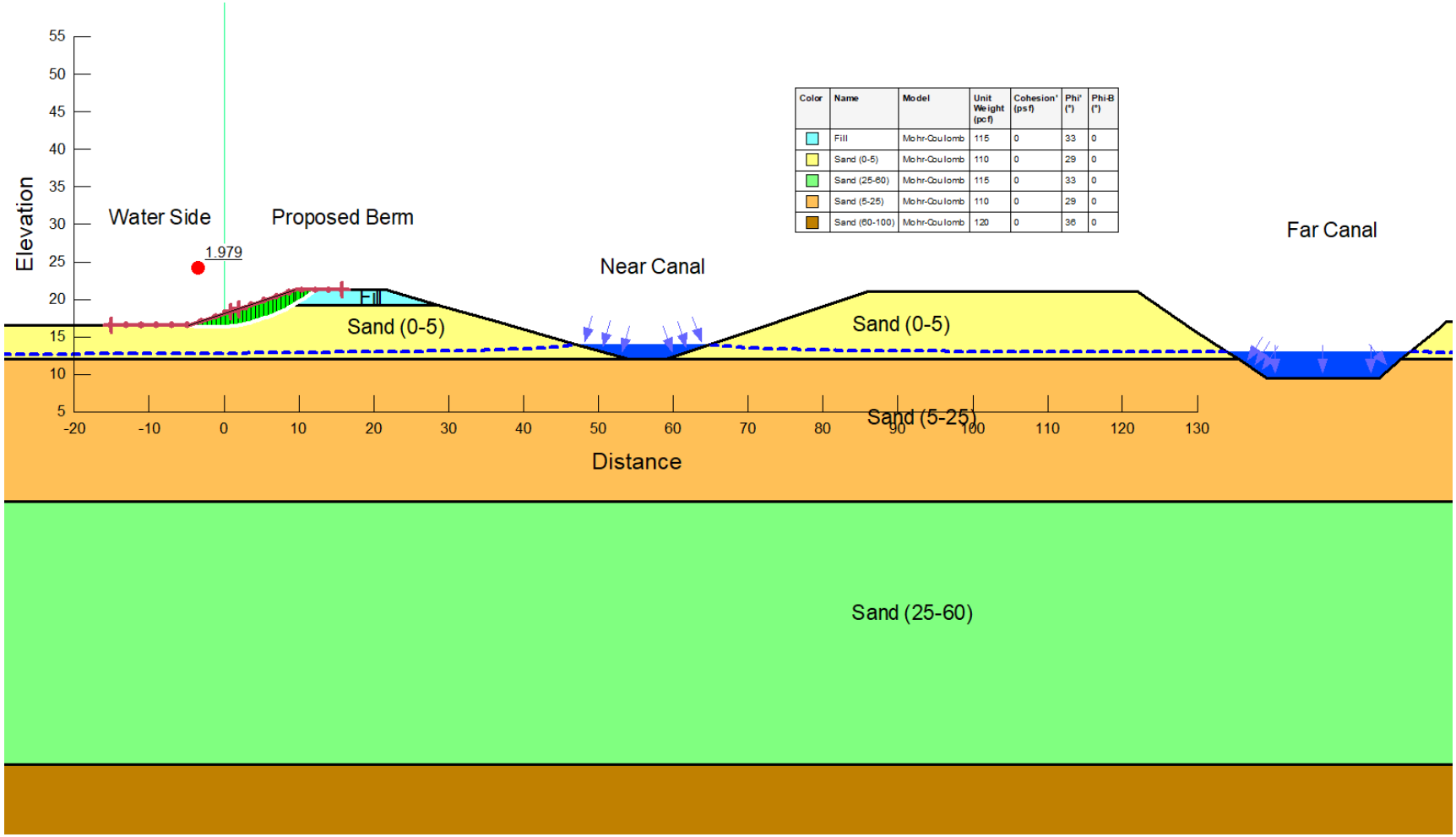


Figure B-1.62. Gulfstream West, west section, long term condition, D/S slope, max surcharge pool.



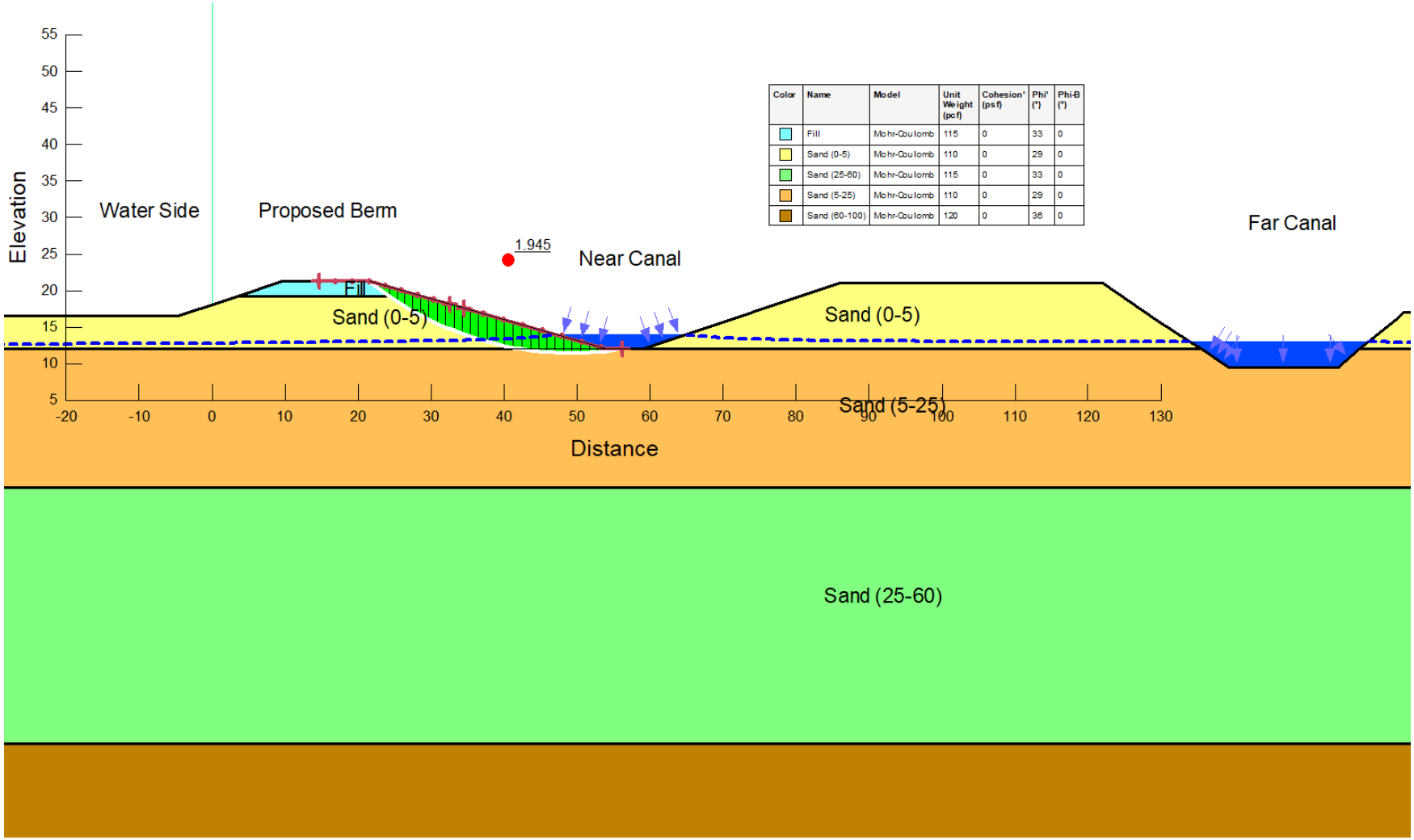
Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)	Cohesion R (psf)	Phi R (°)	Piezometric Line	Piezometric Line After Drawdown
	Fill	Mohr-Coulomb	115	0	33	0	420	0	1	2
	No. 89 Stone	Mohr-Coulomb	130	0	35	0	0	0	1	2
	Sand (0-5)	Mohr-Coulomb	110	0	29	0	420	0	1	2
	Sand (25-60)	Mohr-Coulomb	115	0	33	0	0	0	1	2
	Sand (5-25)	Mohr-Coulomb	110	0	29	0	420	0	1	2
	Sand (60-100)	Mohr-Coulomb	120	0	36	0	0	0	1	2

Figure B-1.63. Gulfstream West, west section, rapid drawdown condition, U/S slope.



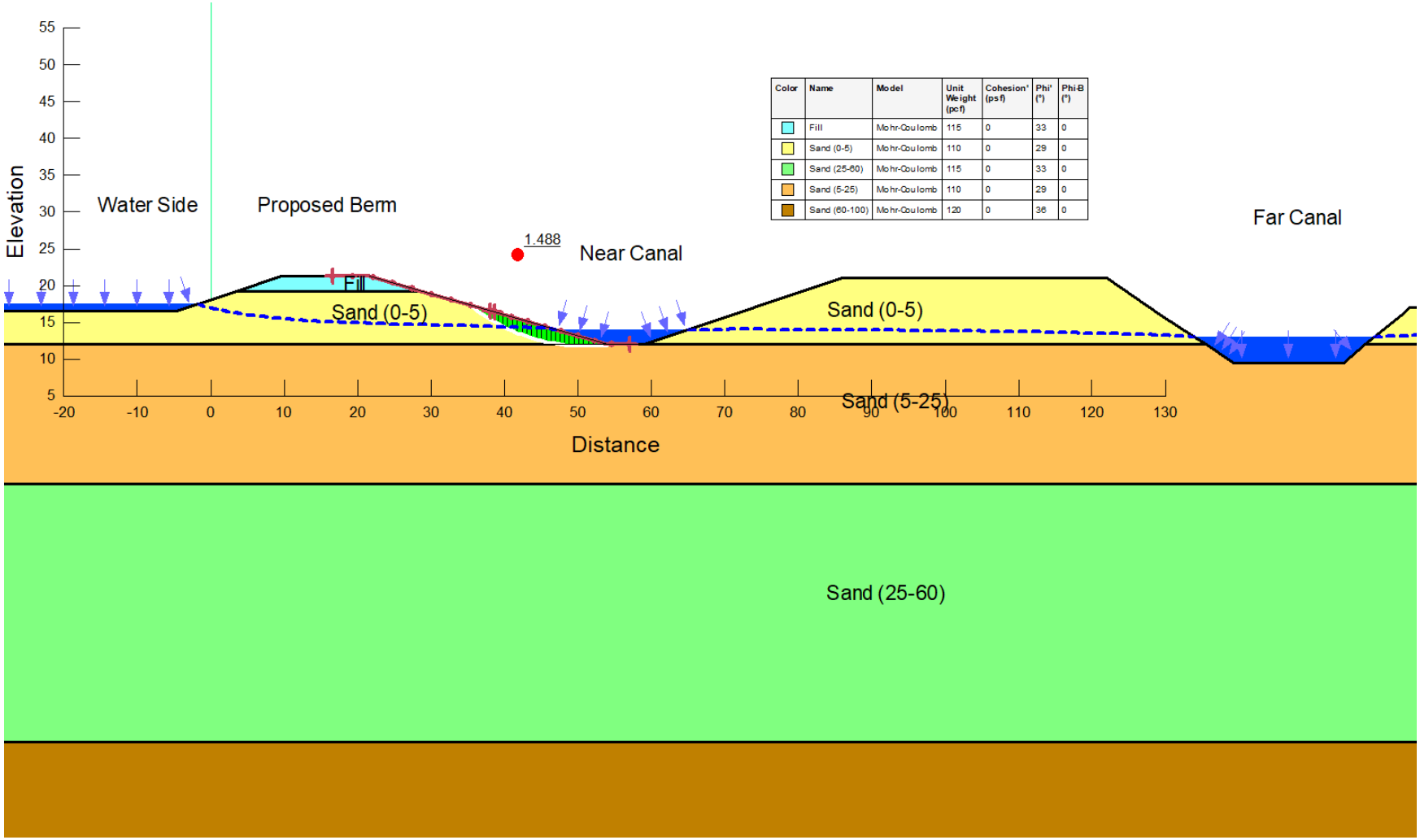
Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)
	Fill	Mohr-Coulomb	115	0	33	0
	Sand (0-5)	Mohr-Coulomb	110	0	29	0
	Sand (25-60)	Mohr-Coulomb	115	0	33	0
	Sand (5-25)	Mohr-Coulomb	110	0	29	0
	Sand (60-100)	Mohr-Coulomb	120	0	36	0

Figure B-1.64. Nine Gems embankment, end of construction condition, U/S slope, no pool.



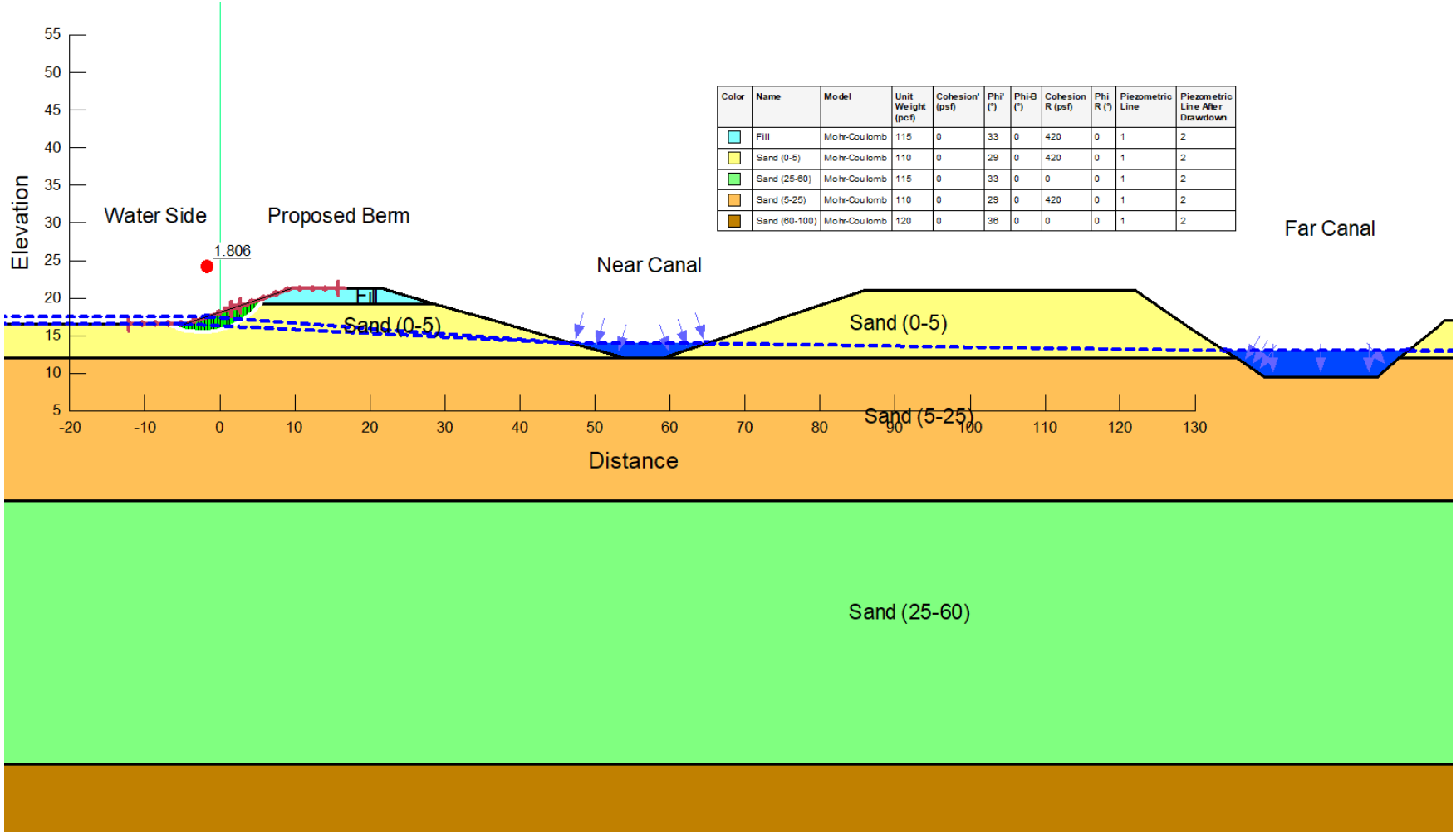
Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)
	Fill	Mohr-Coulomb	115	0	33	0
	Sand (0-5)	Mohr-Coulomb	110	0	29	0
	Sand (25-60)	Mohr-Coulomb	115	0	33	0
	Sand (5-25)	Mohr-Coulomb	110	0	29	0
	Sand (60-100)	Mohr-Coulomb	120	0	36	0

Figure B-1.65. Nine Gems embankment, end of construction condition, D/S slope, no pool.



Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)
	Fill	Mohr-Coulomb	115	0	33	0
	Sand (0-5)	Mohr-Coulomb	110	0	29	0
	Sand (25-60)	Mohr-Coulomb	115	0	33	0
	Sand (5-25)	Mohr-Coulomb	110	0	29	0
	Sand (60-100)	Mohr-Coulomb	120	0	36	0

Figure B-1.66. Nine Gems embankment, long term condition, D/S slope, normal pool (US).



Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)	Cohesion R (psf)	Phi R (°)	Piezometric Line	Piezometric Line After Drawdown
	Fill	Mohr-Coulomb	115	0	33	0	420	0	1	2
	Sand (0-5)	Mohr-Coulomb	110	0	29	0	420	0	1	2
	Sand (25-60)	Mohr-Coulomb	115	0	33	0	0	0	1	2
	Sand (5-25)	Mohr-Coulomb	110	0	29	0	420	0	1	2
	Sand (60-100)	Mohr-Coulomb	120	0	36	0	0	0	1	2

Figure B-1.67. Nine Gems embankment, rapid draw down condition, U/S slope.

Table B-1.14. Gulfstream West SEEP/W results.

Gulfstream West
SEEP/W Results

Model Run	U/S - D/S Head Δ (ft)	Length of Base (ft)	Critical Gradient, i_c (1)	SEEP/W - Vertical Hydraulic Gradient, i_y (2)	i_y Location	FOS against Boiling, i_c/i_y	Flow rate through Embankment (cfs/lf)	Flow rate into FDOT Ditch/Canal (cfs/lf)	Flow Into Drainage Canal (cfs/lf)	Percentage of Flow rate not captured by Seepage Canal	Bligh's Creep Ratio
East Section - Ditch at 10', FDOT Ditch at 9'	1.00	100.00	0.76	0.31	Lower left corner of FDOT drainage ditch	2.5	1.81E-03	7.54E-04	1.06E-03	41.63%	100.00
East Section - Ditch at 10', FDOT Ditch at 9"	1.00	100.00	0.76	0.25	Lower left corner of FDOT drainage ditch	3.0	1.40E-03	6.17E-04	7.78E-04	44.22%	100.00
West Section - Basin El at 18.25' Canal at 8'	10.25	120.00	0.76	0.12	Where water level meets berm in canal	6.3	2.17E-03	2.17E-03	NA	0.00%	11.71
West Section - Basin El at 16.5' Canal at 8'	8.50	120.00	0.76	0.02	Where water level meets berm in canal	41.8	1.79E-03	1.79E-03	NA	0.00%	14.12
South Section - Basin El at 18.25', Canal at 8'	10.25	125.00	0.76	0.01	Where water level meets berm in canal	107.0	2.23E-03	2.23E-03	NA	0.00%	12.20
South Section - Basin El at 16.5' Canal at 8'	8.50	125.00	0.76	0.01	Where water level meets berm in canal	124.8	1.84E-03	1.84E-03	NA	0.00%	14.71
West Section - Basin El at 18.25' Canal at 8'	10.25		0.76	0.00	Lower right Corner of Canal	224.4					
West Section - Basin El at 16.5' Canal at 8'	8.50		0.76	0.00	Lower right Corner of Canal	254.3					
South Section - Basin El at 18.25', Canal at 8'	10.25		0.76	0.00	Lower right Corner of Canal	238.4					
South Section - Basin El at 16.5' Canal at 8'	8.50		0.76	0.00	Lower right Corner of Canal	282.5					
East Section - Basin El at 18.25', Ditch at 10'	8.25	105.00	0.76	0.12	Lower left Corner of Drainage Canal	6.3					12.73
East Section - Basin El at 16.5', Ditch at 10'	6.50	105.00	0.76	0.09	Lower left Corner of Drainage Canal	8.6					16.15

(1) Critical gradient = buoyant unit weight of material through which seepage occurs / unit weight of water
(2) Determined by using two different nodes

Table B-1.4. Nine Gems SEEP/W results.

Nine Gems
SEEP/W Results

Model Run	U/S - D/S Head Δ (ft)	Critical Gradient, i_c (1)	SEEP/W - Vertical Hydraulic Gradient, i_v (2)	i_v Location	FOS against Boiling, i_c/i_v	Flow rate through Embankment (cfs/lf)	Flow rate into Near Canal (cfs/lf)	Flow rate into Far Canal (cfs/lf)	Percentage of Flow rate not captured by Near Canal
Basin El at 19.25', Canals at 14'	5.25	0.76	0.28	Lower left corner of near canal	2.8	7.39E-04	2.11E-04	5.28E-04	71.46%
Basin El at 17.5', Canals at 14'	3.50	0.76	0.14	Lower left corner of near canal	5.3	5.10E-04	1.04E-04	4.06E-04	79.56%
Basin El at 19.25', Canals at 14'	5.25	0.76	0.31	Water Level meets near Canal on left side	2.5				
Basin El at 17.5', Canals at 14'	3.50	0.76	0.17	Water Level meets near Canal on left side	4.5				
Basin El at 19.25', Canals at 13'	6.25	0.76	0.18	Lower left corner of far canal	4.2				
Basin El at 17.5', Canals at 13'	4.50	0.76	0.14	Lower left corner of far canal	5.4				
Basin El at 19.25', Canals at 13'	6.25	0.76	0.14	Water Level meets far Canal on left side	5.4				
Basin El at 17.5', Canals at 13'	4.50	0.76	0.11	Water Level meets far Canal on left side	6.9				

(1) Critical gradient = buoyant unit weight of material through which seepage occurs / unit weight of water
(2) Determined by using two different nodes

Case	Unit Wt	Y'	Yw	Icv	Node #	Head 1	Elev. 1	Node #	Head 2	Elev. 2	Iev	FS
S	110	47.6	62.4	0.76	9823	14	12	9822	14.27	11.026	0.28	2.8
LT	110	47.6	62.4	0.76	9823	14	12	9822	14.14	11.026	0.14	5.3
S	110	47.6	62.4	0.76	9779	14	14	9776	14.307	13.008	0.31	2.5
LT	110	47.6	62.4	0.76	9779	14	14	9776	14.167	13.008	0.17	4.5
S	110	47.6	62.4	0.76	10754	13	9.5	10753	13.2557	8.088	0.18	4.2
LT	110	47.6	62.4	0.76	10754	13	9.5	10753	13.198	8.088	0.14	5.4
S	110	47.6	62.4	0.76	10736	13	13	10735	13.142	12	0.14	5.4
LT	110	47.6	62.4	0.76	10736	13	13	10735	13.111	12	0.11	6.9

S - Surcharge
LT - Long Term
EOC - End of Construction

Horizontal Gradient

X 1	Node #	Head 2	X 2	Iev
54.0	9820	14.153	53.000	0.15
54.0	9820	14.082	53.000	0.08
47.0	9755	14.486	43.952	0.16
47.0	9755	14.257	43.952	0.08
139.3	10749	13.230	136.125	0.07
139.3	10749	13.179	136.125	0.06
134.0	10731	13.149	132.522	0.10
134.0	10731	13.116	132.522	0.08