I-95 Express Lanes – Opitz Boulevard Ramp (“Opitz”) Project

Exhibit C-6

Technical Requirements

Attachment 3.4a

Opitz Project Geotechnical Report

Interstate-95 Express Lanes

OPITZ BOULEVARD CONNECTION

PRINCE WILLIAMS COUNTY, VIRGINIA

STATE PROJECT # 0095-076-299, P101, C501
UPC# 116663

GEOTECHNICAL REPORT

WRA W/O # 045893.001
REVISION 3
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1. Introduction

The Interstate 95 reversible High Occupancy-Toll (HOT) facility is maintained and operated by Transurban in the median of interstate I-95. The facility stretches from south of Garrisonville Road in Stafford County to north of Edsall Road in Fairfax County. The proposed improvements consist of adding an access ramp to create direct access to the Express Lanes from Opitz Blvd. The project is in Woodbridge, Prince Williams County, Virginia. A site vicinity map is included in Appendix A.

Whitman, Requardt, and Associate, LLP. (WRA) was tasked to provide a geotechnical investigation program for the proposed spot improvement project. The project elements include: a retaining wall supporting T Ramp to I-95 Express Lanes from Opitz Boulevard, a new abutment at the bridge to connect to the new T-ramp and associated widening to the existing Opitz Boulevard bridge abutments and piers. This report provides a summary of the geotechnical investigation, subsequent study, and design recommendations.

The study includes the following: review and summary of available existing geotechnical data; summary and review of the subsurface investigation and laboratory test results; and geotechnical analysis and recommendations for the project, which elements include: back-to-back Mechanically Stabilized Earth (MSE) wall for the T-Ramp, deep foundations of abutment and pier expansions, a post and panel retaining wall, gravity retaining wall, and widened embankment to support the expansion along Opitz Blvd. As part of the recommendation development, a memo was developed earlier for review of available historic geotechnical data and as-built foundation elements of the existing bridge. This memo is included in Appendix B of this report.

2. Project Site and Proposed Construction

Improvements on Opitz Boulevard include a new eastbound right turn lane (requiring bridge widening) and new westbound left turn lane (to be built within the existing median), both of which would only be open during southbound operations, with access managed by gates. This new reversible ramp will be controlled by a new traffic signal on Opitz Boulevard between the existing signals at Telegraph Road and at River Rock Way. During northbound operations, the ramp will provide northbound 95 Express Lane users the opportunity to exit onto Opitz Boulevard near Potomac Mills mall and Sentara Northern Virginia Medical Center. During southbound operations, the ramp will provide a new entrance from Opitz Boulevard onto the southbound 95 Express Lanes. The proposed ramp will be located in the existing median between the southbound 95 General Purpose (GP) lanes and the 95 Express Lanes.

The following main elements were identified for the Geotechnical investigation.

Widening of the Opitz Boulevard Bridge on East Bound: Both Abutments and three piers will be expanded. Selected bridge drawings are attached in Appendix A.

Widening of East and West Approach to the Bridge: Two retaining walls are proposed for the widening: a soldier pile and lagging wall at the west approach; and a RW-3 type gravity wall on the east approach. Selected drawings and cross-sections are provided in Appendix A.

New T-Ramp and Associated MSE Walls: New abutment, Abutment C is proposed on the east side of the bridge to receive the T-Ramp to the south. Drawings detailing the ramp grade separation MSE walls; Wall-1, Wall 2, and Wall 3, are included in Appendix A.

Pavement Improvements: Pavement improvements include new pavement for the T-Ramp, slip ramp modifications, and Maintenance of Traffic (MOT) pavement sections during construction.

Attached drawings in Appendix A include the proposed construction and the and associated soil test boring locations.

3. Geology

WRA obtained information about the geologic setting of the Opitz Boulevard project from the Geologic Map of the Washington West 30- by 60-minute Quadrangle, Maryland, Virginia, and Washington D.C., which is U.S. Geological Survey Open-File Report OF-2017-1142 by P. T. Lyttle and several other authors.

The project is in the region of Virginia where layers of mostly non-lithified sediments of the coastal plain sequence rest on top of Piedmont crystalline bedrock. The surficial coastal plain material in the area belongs to the Potomac Formation. The Potomac Formation contains interbedded units of sand and clay that were originally deposited by streams in the Cretaceous Period of earth history. Underneath the Potomac Formation is bedrock and decomposed bedrock. The rock is obscured at the site by coastal plain sediment, however the bedrock mapped by the USGS nearest to the Opitz Boulevard project is metamorphic rock of Ordovician age. Data from several borings that penetrated decomposed graphitic schist in the project area. The reported occurrence of schist is generally consistent with the USGS map.

4. Review of Historic Data

We have reviewed the historic data available on existing Opitz Blvd as part of the study. A total of nine test boring results and as-built records of deep foundation consisted of driven HP 10x42 steel beam piles for bridge structures were available for the review from the following Virginia Department of Transportation (VDOT) reference.

- As Built Plans, Titled “Proposed Bridge on Opitz Blvd. over Tte.95, Ramp G & N.B.C.C RD., Prince William Co.-0.4 Mi N. Int. Rte 642, Proj. 0095-076-112, B636,” Commonwealth of Virginia, Department of Highway and Transportation, dated October 24, 1979

A total of nine (9) historic Standard Penetration Test (SPT) test borings were provided in the as-built plans. A summary of the borings is provided in the following table.

Table 4.1: Summary of Historic Test Borings

Structure	Traffic Lane [(1)]	Boring No.	Station & Offset	Boring Grades		Ground water EL (ft.)	Decomposed Rock [(2)] EL (ft.)
				Top EL (ft.)	Bottom EL (ft.)		
Abutment A	W.B.L.	1	Sta.65+44; 15’ LT	194.5	174.0	181.7	184.0
	E.B.L.	2	Sta.65+44; 15’ RT	193.1	172.2	179.9	182.6
Pier 1	W.B.L.	4	Sta.66+52; 10’ LT	193.1	172.9	180.0	178.1

Table 4.1: Summary of Historic Test Borings

Structure	Traffic Lane (1)	Boring No.	Station & Offset	Boring Grades		Ground water EL (ft.)	Decomposed Rock (2) EL (ft.)
				Top EL (ft.)	Bottom EL (ft.)		
Pier 2	W.B.L.	6	Sta.68+10; 10’ LT	178.4	157.7	170.0	167.9
	E.B.L.	5	Sta.68+10; 10’ RT	179.5	148.7	168.6	169.0
Pier 3	W.B.L.	8	Sta.69+78; 10’ LT	172.7	147.3	166.7	162.7
	E.B.L.	7	Sta.69+77; 20’ RT	172.7	151.7	166.7	163.7
Abutment B	W.B.L.	10	Sta.70+18; 13’ LT	169.8	144.7	167.0	165.3
	E.B.L.	9	Sta.70+18; 20’ RT	169.6	153.4	166.0	165.1

Notes:
(1) Abbreviations: W.B.L. – West Bound Lane; E.B.L.– East Bound Lane.
(2) Decomposed rock identified in the boring logs generally indicates an SPT blow-count (blows per foot) greater than 50.

The test boring logs and the review results are provided in a WRA memo dated September 22, 2021, and which is included as Appendix B.

5. Subsurface Investigation

A total of twenty-five (25) Standard Penetration Test (SPT) borings were performed for the current project, to supplement the historic geotechnical data. The borings were drilled for the design of bridge structures, retaining walls and pavements. The drilling was performed by Soil and Land Use Technology (SaLUT), Inc., from Glenburnie, Maryland, from September 2021 to November of 2021. Full time inspection and logging of the soil borings soil borings was provided by WRA.

The test boring locations were staked by H&B Surveyors. The borings were advanced using hollow-stem augers and soil samples were recovered from the borings at 2.5 feet interval for the top 20 feet and at 5 feet intervals thereafter. The soil samples were recovered by driving a Standard Penetration Test 1 3/8-inch ID (2-inch OD) split-spoon sampler in accordance with ASTM D-1586 specifications. The sampler was first seated about 6 inches to penetrate through the loose cuttings and then driven an additional 1 foot with blows of a 140-pound automatic hammer falling 30 inches. The number of hammer blows required to drive the sampler the final foot is typically designated as the Standard Penetration Resistance (N) value. The penetration resistance is an index of the soil’s strength, density, and behavior under applied loads. Soils obtained from the sampling device were sealed in glass sample jars and transported to our soils testing laboratory. The recovered soil samples were inspected and identified by the WRA Geotechnical Engineer per Unified Soil Classification System (USCS). Bulk samples were taken at selected boring locations. For borings taken in roadways, pavement cores were obtained in selected borings. One undisturbed sample was obtained via a Shelby tube at selected at Boring B-A3-4. In addition to test borings, four (4) Dynamic Cone Penetrometer (DCP) testing WRA personnel performed and logged DCP testing using Corp of Engineers DCP equipment.

Test holes were in two general areas: along Opitz boulevard and along High Occupancy-Toll (HOT) lane facility. Following are the boring numbers with boring identification (name) for each area of the site.

- 9 borings along Eastbound Opitz Boulevard, along the area to be widened. These borings are numbered as B-A1-1 to BA-A1-4, B-A1-6, and B-PE-1 to B-PE-2. The PE borings were to obtain pavement cores along with one SPT sample at the east end of the existing bridge. It is noted that a planned boring B-A1-5 was cancelled due to utility conflict and replaced with a DCP-SW hole. A summary of these borings is provided in Table 5.1.
- 16 borings were drilled within the Transurban managed High Occupancy-Toll (HOT) lane facility. The boring numbers are B-A2-1, B-A3-1 to B-A3-9, and B-A4-1 to B-A4-8. These borings were drilled for widening of Opitz Blvd, and Maintenance of Traffic (MOT) within HOT facility. Table 5.2 summarizes these borings.

The test location plans for test borings and DCP are included in Appendix A. SPT boring logs, DCP logs, and pictures of pavement core are included in Appendix C.

5.1. SPT Borings for Structures

The following is a summary of test borings drilled for the design and recommendations of bridge structures and retaining walls.

Table 5.1: Summary of Structural Test Borings

Structure	Boring ID	Boring Location [3]			Ground EL [3] (ft.)	Boring Depth (ft.)	Ground water Depth (ft.)	Notes
		Ref.	Station	Offset				
SPL Wall [2]	B-A1-3	Opitz Blvd	63+75	59 RT	209.4	30.0	N/E	---
	B-A1-4	Opitz Blvd	64+75	73 RT	203.9	28.8	23.5	---
Abut. A	B-A1-5	Opitz Blvd	64+75	55 RT	214.0	Note (1).		
Abut. B	B-A1-6	Opitz Blvd	70+30	46 RT	211.6	75.0	56.0	---
Abut. C	B-A2-1	T-Ramp	27+10	20 RT	188.0	59.0	23.5	---
T-Ramp MSE Wall & Roadway	B-A3-1	T-Ramp	26+00	20 RT	187.0	40.0	20.0	---
	B-A3-2	T-Ramp	25+00	12 LT	189.2	40.0	20.7	---
	B-A3-3	T-Ramp	24+00	23 RT	185.4	30.0	19.5	---
	B-A3-4	T-Ramp	23+50	6 LT	187.2	30.0	22.0	Shelby @14'
	B-A3-5	T-Ramp	22+00	35 RT	183.5	20.0	N/E	---
	B-A3-6	T-Ramp	21+00	2 LT	184.9	20.0	N/E	---
	B-A3-7	T-Ramp	19+99	33 RT	181.6	15.0	N/E	---
	B-A3-8	T-Ramp	19+00	4 LT	181.1	10.0	N/E	---
	B-A3-9	T-Ramp	17+99	29 RT	179.9	10.0	N/E	---

Notes
(1) Boring B-A1-5 was cancelled due to utility conflict. Results from Boring B-A1-4 and DCP-SW are utilized to verify existing historic boring results.
(2) SPL – Soldier Pile and Lagging wall at the south slope of the west approach behind Abutment A.
(3) Stationing and elevations are interpolated from the drawings. Borings were staked per drawing coordinates.

5.2. Pavement Area Test Borings

Summary of pavement borings are provided in the following table, Table 5.2. These borings are drilled for Opitz Boulevard widening and for Maintenance of Traffic (MOT). These boring include and pavement cores at each hole with at least one SPT sample. It is noted that the pavement thickness information included in the structural borings were also used for pavement recommendations.

Table 5.2: Summary of Pavement Test Borings

Area	Boring ID	Boring Location (1)			Ground EL (2)	Boring Depth	Pavement Core		
		Lane	Station (ft.)	Offset (ft.)			HMA Depth	Subbase	
						(ft.)	(inch)	Depth (inch)	Material
Opitz Blvd	B-A1-1	EB Decel Lane	63+25	41 RT	212.5	15.0	12.0	4	CRA
	B-A1-2		64+25	41 RT	214.2	20.0	11.0	7	CRA
	B-PE-1	EB Outside Shoulder	70+75	50 RT	209.8	3.2	4.5	10.5	CRA
	B-PE-2		71+25	52 RT	208.1	3.2	3.0	11	CRA
I-95 HOT Facility	B-A4-1	I-95 XBL East Shoulder	727+80	17 RT	186.1	8.0	14.0	10	CRA
	B-A4-2		724+55	17 LT	183.0	8.0	17.0	8	CRA
	B-A4-3	I-95 XBL	721+55	18 RT	180.2	8.0	17.0	8	CRA
	B-A4-4	I-95 XBL West Shoulder/ Gore to Gates	718+64	18 LT	179.0	8.0	15.0	9	CRA
	B-A4-5	I-95 XBL East Shoulder	686+81	18 LT	172.1	8.0	16.0	9	CRA
	B-A4-6		682+81	18 RT	168.3	8.0	15.0	10	CRA
	B-A4-7	I-95 XBL West Shoulder	672+06	18 LT	149.8	8.0	16.0	9	CRA
	B-A4-8		668+56	18 LT	140.3	8.0	15.0	33	CRA

Notes (1) Stationing and elevations are interpolated from the drawings. Borings were staked per drawing coordinates

(2) Groundwater was not encountered in pavement test borings listed herein...
CRA- Crushed Aggregate

Photographic logs of the pavement are included in Appendix C.

6. Soil Laboratory Testing

Soil samples recovered from the field explorations were transported to our soil laboratory and select soil samples were subjected to various testing to determine additional engineering characteristics of the existing on-site soils. Laboratory tests that were conducted on selected soil samples included natural moisture content tests, Atterberg Limits, consolidation, pH and resistivity, and sieve analysis tests. All tests were performed at SaLUT's AASHTO certified laboratory or a certified laboratory subcontracted by SaLUT. The results of the classification tests are summarized in the following table.

Table 6.1: Summary of Soil Classification Test Results

Boring ID	Sample No	Depth (ft.)	Moisture Content (%)	Liquid Limit (%)	Plasticity Index (%)	Percent Fines (%)	USCS
B-A1-1	S3	6.0 - 7.5	30.0	68	41	76	CH
B-A1-2	S5	11.0 - 12.5	26.6			76	
B-A1-3	Bulk	1.5 - 8.0	1.4	44	22	38	SC
B-A1-3	S3	5.0 - 6.5	13.9			25	
B-A1-6	Bulk	1.5 - 8.0	7.0	77	58	26	SC
B-A1-6	S6	13.5 - 15.0	15.6	35	11	23	SC
B-A1-6	S13	43.5 - 45.0	19.2	35	11	98	CL
B-A2-1	S4	8.5 - 10.0	12.7			22	
B-A2-1	S10	28.5 - 30.0	10.1			46	
B-A3-1	Bulk	1.5 - 8.0	13.1	41	18	28	SC
B-A3-2	Bulk	1.5 - 8.0	23.9	52	21	66	MH
B-A3-2	S5	11.0 - 12.5	14.5			21	
B-A3-3	S4	8.5 - 10.0	22.4	41	16	89	CL
B-A3-4	S5	11.0 - 12.5	19.7	55	27	45	SC
B-A3-4	ST-1	14.0 - 16.0	19.9	30	9	46	SC
B-A3-5	S-2	3.5 - 5.0	15.4			27	
B-A3-5	S-4	8.5 - 10.0	16.6	46	21	35	SC
B-A3-7	S3	6.0 - 7.5	14.8			20	
B-A3-8	S3	6.0 - 7.5	29.3			56	
B-A3-9	S2	3.5 - 5.0	19.1			24	
B-A4-2	S1	2.0 - 4.0	15.6			27	
B-A4-4	S1	2.0 - 4.0	12.9			32	
B-A4-6	S1	2.0 - 4.0	24.2			55	
B-A4-8	S1	2.0 - 4.0	16.2			59	

Note: NP – Non-plastic; USCS – Unified Soil Classification System

Moisture density relationship (Proctor) test and CBR results are included in the following table.

Table 6.2: Summary of Proctor and CBR Test Results

Boring ID	Sample No	Natural Moisture Content (%)	USCS Classification	Max. Dry Density (pcf) (2)	Optimum Moisture (%)	CBR (%)	Swelling (%)
B-A1-3	Bulk	1.4	SC	120.4	11.7	13.0	0.5
B-A1-6	Bulk	7.0	SC	120.1	11.8	10.9	0.2
B-A3-1	Bulk	13.1	SC	121.1	11.2	12.3	0.1
B-A3-2	Bulk	23.9	MH	105.2	17.9	4.0	3.8

Notes:
(1) Proctor Method per VDOT procedures (equivalent to ASTM Standard Proctor)
(2) Abbreviation: pcf – pounds per cubic foot.

A single one-dimensional consolidation test was performed on a Shelby Tube sample obtained from SPT boring B-A3-4. The results are summarized in the following table.

Table 6.3: Consolidation Test Results Summary

Boring ID	Sample No	Sample Depth (ft.)	USCS	Pre-Consolidation Pressure (tsf)	Virgin Compression Index (pcf)	Recompression Index (%)	Notes (%)
B-A1-4	ST-1	14.0-16.0	SC	0.893	0.124	0.017	Note (1)

Notes:
1. Specific gravity of the soil estimated at 2.65

In addition to samples listed in Tables 6.1 to 6.3, all other SPT samples were tested for natural moisture test per VDOT protocol. Complete results of the soil laboratory tests are included in Appendix D.

7. Description of Subsurface Conditions

7.1. General Stratigraphy

Based on the review finding of historic test borings, and the results of current subsurface investigations, findings of the subsurface investigations, project limit subsoils are generalized to following stratigraphy.

Topsoil

One test boring, which was drilled in an unpaved area, a 4-inch-thick layer of topsoil was encountered.

Stratum F: Existing Fill

Fill is visually identified during drilling. It is composed of material placed during previous site development. The encountered fill materials generally consisted of brown, loose to medium dense silty sands with gravel (SM/SP-SM). Uncorrected SPT blow counts ranged from 6 blows per foot to 9 blows per foot (bpf), with an average blow count of 6 bpf.

Stratum P: Possible Fill/Potomac

Below the fill stratum, soils identified as possible fill or Potomac formation soil generally consisted of gray and brown, medium to coarse, silty sand with a varying percentage of gravel. Occasional fine grain soil layers were also encountered within this layer. Uncorrected SPT N values ranged between 6 and 16 bpf, with an average blow count of 14 bpf.

Stratum R: Residual Soils

Upper residual soils generally consisted of gray and brown, medium to coarse, silty sand with varying percentage of gravel. Uncorrected SPT N values ranged between 10 and 44 bpf, with an average blow count of 30 bpf.

Stratum D: Decomposed Rock

Lithified weathered graphitic schist was encountered below the residual soil layer in most of the borings. Uncorrected SPT N values ranged between 55 bpf to 50 blows per 3” penetration. This layer extends to the maximum depth explored.

Core-able bedrock was not encountered in the depth drilled.

7.2. Groundwater Conditions

During the subsurface investigation programs, the deep borings encountered groundwater during drilling. The test borings were backfilled after completion and no long-term groundwater readings were taken. The following table summarizes the encountered groundwater levels during the investigations.

Table 7.1: Summary of Groundwater Readings

Boring ID	Location	Boring Ground Elevation (ft.)	Groundwater Depth	
			Depth (ft.)	Elevations (ft.)
B-A1-4	SPL Wall @ Abutment A Approach	203.9	23.5	180.4
B-A1-6	Abutment B Approach	211.6	58.5	153.1
B-A2-1	T-Ramp @ Bridge	188.0	23.5	164.5
B-A3-1	T Ramp MSE Wall	187.0	20.0	167.0
B-A3-2	T Ramp MSE Wall	189.2	20.7	168.5
B-A3-3	T Ramp MSE Wall	185.4	19.5	165.9
B-A3-4	T Ramp MSE Wall	187.2	22.0	165.2

Note: Readings listed corresponds to groundwater depths encountered during drilling.

Average groundwater elevation is estimated to be 167± ft. Fluctuations in groundwater depths should be anticipated along the project site since the depth to groundwater is influenced by water infiltration from rainfall and/or surface runoff, changes in surface topography, drainage systems and drought or wet time periods during the year. The groundwater depths and elevations are intended to provide a reference of measured groundwater levels during the subsurface explorations.

7.3. Design Soil Parameters

Design soil parameters were generally developed based on empirical relationships between corrected SPT blow counts (N60), the angle of internal friction, and unit weight of granular soils. A typical calculation of the friction angle is presented Appendix E, Section E1.2. Table 7.2 provides a summary of the design soil parameters used in analysis.

Table 7.2: Summary of Design Soil Parameters

Stratum	Unit Weight, γ (pcf)	Internal Friction Angle, ϕ (degree)	Cohesion, Intercept c (psf)
Existing Fill (Stratum-F)	120 pcf	30°	0
Possible Fill/Potomac (Stratum-P)	120 pcf	32°	0
Residual Soils (Stratum-RS)	125 pcf	34°	0
Decomposed Rock (Stratum-D)	130 pcf	38°	0

7.4. Seismic Site Classifications

Based on subsurface conditions defined by the preliminary engineering subsurface investigation borings, Seismic Site Class D may be utilized for seismic design considerations. This estimation is based on average SPT N values from the test borings and the methods described in Table 3.10.3.1-1 of AASHTO LRFD Bridge Design Specifications. Detailed calculations are included in Appendix E.

8. Recommendations for Retaining Walls and Modified Slopes

The grade separation for the proposed T-Ramp is achieved by three MSE walls, namely Wall-1, Wall-2 and Wall-3. Wall 2 is at the northern end at Abutment C, providing grade separation normal to the T-Ramp axis. Grade separation on the east and west side of the ramp is provided by MSE Walls 1 and 3.

The T-ramp will be constructed to a width of 36’-4” using back-to-back retaining walls. The top of the ramp wall will be at EL 212± ft at Abutment C. The wall extends from Station 20+00 at the south end to 27+09 at the bridge (Abutment C). At abutment C, the effective wall heights for design varies from 26 feet to 30 feet, end to end. Noted that the effective heights are estimated by adding 2 feet of embedment to the exposed height.

Table 8.1: Design Parameters for Retaining Walls

Item	Unit Weight, γ	Internal Friction Angle, ϕ
MSE Wall Reinforced Granular Backfill (1)	105 pcf	34°
SPL Wall Backfill (VDOT Select Type I, CBR 30) (2)	120 pcf	34°
Foundation Soils	120 pcf	30°

Notes: (1) External stability calculations are based on parameters provided herein.
(2) Select fill should be per VDOT Select Type I, CBR=30 per VDOT Spec Section 207.02

We recommend that for reinforced fill for the MSE consist of #57 stone.

8.1. MSE Wall 2 at Abutment C

The internal stability analysis, bearing check, and settlement estimations were performed for the wall using the average effective wall height of 28 feet. Due to expected additional horizontal loads, and overlapping of walls 1 and 3, the design strap length for wall 2 is set at 80% of the wall height, i.e. 23 feet. The external stability analyses bearing capacity checks are based on Load and Resistance Factor Design (LRFD) methods and AASHTO recommended load and resistance factors are used for the analyses. The LRFD analyses results indicate the Capacity Demand Ratio (CDR) is greater than one for Wall 2. The required maximum factored bearing pressure (demand) is 6.5 ksf (kips/sq.ft. Available factored bearing resistance (Capacity) is estimated at 13.6 ksf. Calculation details are included in Appendix E (Section E.2.1).

The settlement analysis was performed using the Modified Hough Method (FHWA, 2006a) with elastic stress distribution estimations. A uniform infinite loading settlement pressure due to exposed average wall height of 28 feet was considered in the analyses and the settlement is estimated at 0.3 inches. The details of the calculations are included in Appendix E. It is noted that the piles are not expected to develop negative skin frictions at this settlement levels and the piles may be installed prior to the construction of the MSE wall for the T-Ramp and friction isolating cans are not required.

8.2. MSE Walls for T-Ramp

The T-ramp will be constructed to a width of 36’-4”. The wall extends from Station 20+00 (south end) at the south end to Station 27+09 at Abutment C (north end). The effective height of the wall will be less than 10 feet beyond Sta.22+50 towards the south. The strap length in these stations should be the project recommended minimum of 8 feet. For back-to-back wall check, the reinforcement strap lengths are set at 70% of the wall height. A check for the wall classifications of Wall1 and Wall 3 was performed to verify whether they are of Back-to Back MSE (BBMSE) walls or standalone MSE walls. The check was performed in accordance with FHWA (2009) guidelines. The summary of the results is provided in the following table.

Table 8.2: Summary of Wall Conditions and Estimated Strap Lengths

Station	Effective Design Height (ft.)		Gap D (1) (ft.)	Wall Type (2)	Estimated Strap Length (ft.)	
	West Wall	East Wall			West Wall	East Wall
27+00	26.0	30.0	-2.9	BBMSE	20.7	23.5
26+50	24.0	28.0	-0.1	BBMSE	20.4	23.2
26+00	24.0	27.0	0.6	BBMSE	20.7	22.8
25+50	22.0	26.0	2.7	MSE	15.4	18.2
25+00	21.0	23.0	5.5	MSE	14.7	16.1
24+50	19.0	19.0	9.7	MSE	13.3	13.3
24+00	17.0	17.0	12.5	MSE	11.9	11.9
23+50	15.0	15.0	15.3	MSE	10.5	10.5
23+00	13.0	13.0	18.1	MSE	9.1	9.1
22+50	10.0	10.0	20.3	MSE	8.0	8.0

Notes:
(1) BBMSE is designated - when distance between the walls, D < 2 ft.
(2) BBMSE – Back-to-Back Mechanically Stabilized Earth wall

For constructability, we recommend that # 57 stone should be used behind the reinforced zone.

Back-to-Back Wall Configurations

The MSE walls from Sta.27+00 to Sta. 25+00 are classified as BBMSE walls and the straps lengths provided in the Table 8.2 include an overlap length per FHWA recommendations (30% of short wall height, $0.3H_2$). No external stability analyses are warranted for the walls, as both walls will act as a single gravity unit. For bearing capacity concern, the BBMSE configuration is compared to the Wall 2. The BBMSE configuration has lower loading and larger foundation width than Wall 2, therefore, Wall 2 recommendations can be conservatively used for this section. Assuming an infinite loading conditions similar to Wall 2 with 26 feet of fill the wall settlement in the middle station (Sta.26+00) of the configuration will be 0.6 inches.

Stand Alone MSE Wall Configurations

The MSE walls from Sta.25+00 to Sta. 20+00 are classified to be standalone MSE wall configurations with a maximum height of 19 feet. A strap length of 70% of the wall height is recommended. The effective wall heights south of Sta.22+50 (Sta.22+50 to Sta.20+00) are less than 10 feet and a minimum strap length of 8 feet should be used in these stations. The rest of wall strap length estimations (Sta. 22+50 to Sta. 25+00) are provided in the Table 8.2. Internal stability analyses and bearing resistance checks were performed at Sta.24+50 and Sta.22+50 for completeness.

Table 8.3: Summary of Global Stability and Bearing

Station	Maximum Wall Height	Factor of Safety against Deep Seated Failure	Factored Bearing Pressure	
			Demand	Capacity
STA 24+50 to 22+50	19 feet	1.62	4.13 ksf	8.29 ksf
STA 22+50 to End	10 feet	1.65	2.54 ksf	5.14 ksf

It is noted that a layer of soft fine soil was encountered in Boring B-A3-4, at Sta.23+50 (Wall height 15 feet). Additional settlement analyses were performed for this area, which include a consolidation settlement analysis for the soft layer, and elastic settlement estimations for granular layers (See Appendix D).

Settlement Review

The summary of settlements is included in the following Table. It is noted the wall settlement gradient is less than 2.0 inches per 100 feet.

Table 8.4: Summary of Settlement Calculations

Station	Effective T-Ramp Height (ft.)		Estimated Settlements
	At West Wall	At East Wall	
27+00	26.0	30.0	0.30 inch (1)
26+00	24.0	28.0	0.60 inch
24+50	19.0	19.0	0.35 inch
23+50	13.0	13.0	1.85 inch (2)
22+50	10.0	10.0	0.53 inch

Notes: (1) Settlement estimations corresponds to Abutment C, located at the edge of RT-Ramp fill.
(2) Value includes consolidated settlement due to 9 ft soft layer, encountered 9 feet below the subgrade.

The settlement calculation details for walls are included in Appendix E. Total settlement and differential settlement of the MSE walls are within VDOT acceptable tolerances (within 100 feet of the bridge and beyond). However, due to estimated inconsistent differential settlements, we recommend slip joints for both walls (Wall 1 and Wall 3) at Stations 23+00 and 22+00.

Preliminary Global Slope Stability Analysis

A global slope stability analysis was performed for a typical stand-alone MSE wall system. The results of the analysis are given in Appendix E.2. The retaining wall will be designed by the contractor's wall designer, with reinforcements strength and placement determined for internal stability concern. For this preliminary global stability analysis, the MSE wall is assumed to be a coherent gravity structure. A cohesion value of 3000 psf is assigned to the reinforced zone to ensure that the trial slip surfaces in a limit equilibrium slope stability analysis will not go through the reinforced zone (zone behave as a coherent gravity structure). Once the strength and vertical placement of the reinforcements are available a "final combined failure check – global stability analysis with reinforced #57 stone" can be performed by contractor's wall designer. A note will be added to the MSE wall drawing requiring this check be performed by the wall designer.

8.3. RW-3 Retaining Wall at Abutment B Approach (Southeast Quadrant)

The south end of the approach embankment slope behind Abutment B is proposed to be widened by approximately 4 feet. A VDOT RW-3 retaining wall is proposed from Sta.70+25 to Sta.71+50. The effective wall height (for bottom of the wall to top of retained soil/pavement) varies from 8 feet (Sta.70+25) to 4 feet (Sta.71+50). The effective wall height includes 3 feet (drawings indicated 2.5 ft approximated to 3 feet) of embedment at the toe. It is noted that the maximum effective height includes the exposed height plus the embedment.

The existing approach slope consist of structurally compacted granular soil, sloped approximately at 2H:1V. The soil conditions at this location are estimated using data from nearest test borings DCP test hole DCP-SE. The compactness of the soil at proposed foundation subgrade appears to be medium dense based on SPT $(N1)_{60}$ values (SPT N value corrected for overburden and hammer efficiency). The conversion calculations of DCP index values to SPT N are included in Appendix E. Allowable bearing pressures with wall height are based on VDOT RW-3 standard sheet. The values are listed in the following table.

Table 8.5: Compression Loads and Bearing Resistances for RW-3 Walls

Wall Height (ft.)	Foundation width (ft.)	Maximum Compression at Toe (1) (Demand, psf)	Allowable Bearing Capacity (2) (Capacity, psf)
4	2.4	1141	1200
5	3.0	1427	1500
6	3.6	1712	1800
7	4.2	1997	2000
8	4.8	2283	2300

Notes: (1) The values are based on VDOT Standard detail
(2) Allowable bearing capacity to exceed max compression for conservativeness.

The allowable bearing capacity calculations for the tallest wall (8') are provided based on the deduced friction angle of subgrade material. As part of subgrade preparation, we recommend that the foundation subgrade should be densified by 10 passes of ride on vibratory compaction equipment. Details of the bearing capacity calculations with AASHTO slope reduction are included in Appendix E.

It is noted that the retained wall height listed in the above table includes a wall embedment of 3 feet. a (retained soil height is 1 foot to 5 feet). The resulting average additional soil load (a soil prism of 3 feet height and 6 feet base) is estimated at 1 kip per linear foot of wall (equivalent or less than a vehicle load). For this light additional loads, no additional slope stability analyses are warranted for this well performing, heavily vegetated 2H:1V slope.

8.4. Soldier Pile and Lagging (SPL) Wall at West Approach (Southwest Quadrant)

A soldier pile and lagging wall is proposed along the south side slope of the Abutment A approach embankment. The wall is designed to a retain soil up to 12 feet. Proposed wall spans from Sta.63+22 to Sta.65+38. Cross sections of the wall are included in Appendix A.9

Design of the soldier pile and spacing is for the entire wall which is based on section at Sta.64+50, where the wall retention is at its maximum. The wall is analyzed per LRFD Simplified Cantilever Method (Teng Method) for the required section, spacing and embedment. Top deflection (Service conditions) is estimated using the DeepEx software. The results are summarized as follows:

- Pile spacing 6 feet, Required Z_x = 126 inch^3; Selected Pile HP 14x 89 with Z_x = 145 inch^3
- Embedment Tip Elevation EL 178. This includes a minimum embedment 24 feet with 10 feet into decomposed rock stratum.
- Anticipated top deflection: 1.0 inch upon initial backfilling.

The calculation details are included in Appendix E, Section E4. Granular backfill compacted to VDOT specifications is recommended for the new fill behind the SPL wall. The soldier piles can be installed within a drilled shaft or be driven using an impact hammer. For the Impact driving installation of the soldier piles, a hammer capable of driving these piles to the design tip should be selected by the contractor. In addition, we recommend location templates and a fixed lead rig should be utilized for the driven pile installation option for accuracy.

8.5. Sliver Fill at East Approach (Northeast Quadrant)

The approach embankment to Abutment B is proposed to be extended along the north face of the slope from Sta.70+25± ft to Sta. 70+75 as part of the current improvements. The finished grade after the fill will make the slope to 2H:1V, shallower than the existing configuration. For example, at Sta.70+25, where the embankment height is 35 ft, the sliver fill widths are 3 feet at the top and 15 feet at the bottom, making the slope to 2H:1V from an existing configuration of 1.65H: 1V. Since the existing slope performed well and current additional fill provides extra toe loading by shallowing the slope, it is determined that the proposed configuration will be more stable than the existing and is acceptable from a stability standpoint.

The sliver fill slope area is covered with vegetation. A few small, isolated pockets of soil erosion caused by overtopping of pavement surface water flow, were observed at the top of the slope. Existing soil conditions along the slope area were evaluated with two DCP test holes, DCP-NE-Upper and DCP-NE-Mid. Based on the test results and visual observations, the existing slope is in good condition with no visible stability issues and found to be suitable for the slope expansion. We recommend that the eroded areas be excavated as part of the benching requires as specified in Section 303.04 of the Standard Specifications as the fill is placed. Roadway drainage should be directed away from the slope or channelized using an armored flume.

The additional fill for the embankment expansion should be placed on a properly benched subgrade and compacted in lifts per VDOT standards. The fill soil should have a CBR of 5 or better, placed in 8-inch-thick loose lifts, and compacted in place to VDOT standards.

9. Foundation Recommendations

New foundations are required at six (6) locations for the widening of existing Opitz Boulevard along the south edge of the east bound right lane. New foundations are required for the widening of the two abutments (Abutment A at west end & Abutment B at east end) and three piers (Piers 1, 2, & 3). The new Abutment C will be added to the new bridge to receive the T-Ramp to the Express Lanes.

A steel HP 10x57 piles driven in to decomposed rock stratum are proposed for the support of new bridge elements. The geotechnical foundation recommendations are based on the results of historic borings drilled within the footprint of the bridge foundation elements, and adjacent test borings recently drilled as part of this effort. For proposed new Abutment C, the current boring (B-A2-1) was drilled within the footprint of Abutment C.

9.1. Validation of Historic Borings

The historic boring results are validated by comparing their results to the two adjacent boring logged by a WRA geotechnical engineer. The historic borings are within the footprint of the existing bridge elements. The key comparison is made on top grade of high blow count decomposed rock layer. The pile tip estimations are mainly based on the embedment into the decomposed rock stratum.

It is noted the current boring blow-counts corresponds to high-efficient (90%±) auto hammer testing (SPT blow count N_{90}) whereas, based on the year drilled and the results, the historic borings would have been performed using the donut or standard safety hammer with efficiency at 60%± (SPT blow count N_{60}. The decomposed rock stratum classification is, therefore, based on residual soils with SPT blow counts of N_{60} >50± for historic borings, and N_{90}>33± current borings. The validation summary is provided in the following table.

Table 9.1: Validation of Historic Borings for Foundation Design

Bridge Element	Pile Cap Subgrade EL (ft.)	Boring Type	Boring ID	Opitz Blvd Station (ft.)	Boring Top EL (ft.)	Top of DR Stratum $^{(1)}$ (ft.)	Notes
Abutment A	204.8	*Current*	*B-A1-4*	*64+75*	*203.9*	*184.9*	Compared well
		Historic	1	65+44	194.5	183.5	
		Historic	2	65+44	193.1	180.6	
Pier 1	189± $^{(2)}$	*Current*	B-A1-4	64+75	*203.9*	*184.9*	Compared OK to the interpolated DR stratum to EL 170.2
		Historic	4	66+52	193.1	178.1	
		Current	*B-A2-1*	*67+50* $^{(1)}$	*188.0*	*162.0*	

Table 9.1: Validation of Historic Borings for Foundation Design

Bridge Element	Pile Cap Subgrade EL (ft.)	Boring Type	Boring ID	Opitz Blvd Station (ft.)	Boring Top EL (ft.)	Top of DR Stratum (1) (ft.)	Notes
Pier 2.	170± (2)	*Current*	B-A2-1	67+50(1)	188.0	162.0	Compared OK. Variation noticed in Historic borings.
		Historic	5	68+10	179.5	169.0	
		Historic	6	68+10	178.4	167.2	
Pier 3	167± (2)	Historic	7	68+77	172.7	162.2	Compared OK Variation noticed in Historic borings.
		Historic	8	69+78	172.7	157.2	
		Current	B-A1-6	*70+30*	*211.6*	*163.1*	
Abutment B	201.1	Historic	9	70+10	169.9	165.1	Compared well
		Historic	10	70+18	169.8	165.3	
		Current	B-A1-6	*70+30*	*211.6*	*163.1*	

Notes: (1) Approximate value interpolated from drawings.
(2) Approximate values of existing pier pile cap subgrades.

A reasonable agreement / comparison of current borings and historic borings is achieved.

9.2. Design Recommendations for Driven Piles

Steel HP 10x57 beam piles are recommended for the support of expanding existing bridge elements and the new Abutment C for the T-Ramp connection to the bridge. The piles will be driven into Stratum D, the decomposed rock layer to a nominal (ultimate) resistance of 385 kips. This nominal value yields a factored geotechnical resistance of 250 kips when performing dynamic testing at each substructure and applying 0.65 as the appropriate resistance factor. The axial resistance is estimated using the DRIVEN program, and the complete results are included in Appendix E. A summary of estimated pile tip elevations and lengths are included in the following table.

Table 9.2: Summary of Estimated Pile Tips for Proposed Bridge Elements

Bridge Element	Pile Cap Subgrade EL (ft.)	Assumed Existing Grade EL (ft.)	Boring Type	Boring ID	Opitz Blvd Station (ft.)	Ground Water EL (ft.)	Top EL of DR Stratum (1) (ft.)	Estimated Pile Tip EL (ft.)
Abut A	205	205	Historic	1 & 2	65+44	182	180	150
Pier 1	189	191	Historic	4	66+52	182	178	144
Pier 2.	186	191	Historic	5 & 6	68+10	167	168	146
Pier 3	185	191	Historic	7 & 8	69+78	166	160	145
Abut B	201	191	Historic	9 & 10	70+15	167	165	151
Abut C	191	192	Current	B-A2-1	67+50(3)	185	162	141

Notes: (1) Bearing stratum of pile foundation, tip elevations for HP 10x57 driven to 385 kips nominal.

Based on the axial capacity results, we estimate that the piles can resist the anticipated a factored uplift load of 7 kips per pile. The DRIVEN results are included in Appendix E.

A lateral load analysis is performed for a pile in the typical group configuration. Based on the results, piles have the required lateral load resistance of 5 kips/pile (factored) in the weak axis direction with three rows of piles. LPILE results are included in Appendix E.

One of the 4 soil samples subject to corrosivity testing indicated potentially slightly aggressive soils within the existing abutment approach fill embankments according to Chapter 23 of the Structure and Bridge Manual by having a resistivity value of 2540 ohm-cm. Although not necessarily considered aggressive by FHWA guidelines the long-term axial structural capacity of the pile section was checked after a reduction of 0.05-inch loss of section at the flanges and web according to Chapter 23.

9.3. Pile Drivability and Dynamic Testing

The Wave Equation Analysis of Pile (WEAP) was performed for a pile in typical configuration in order to determine pile drivability and preliminary hammer energy range for pile installation. Based on the analyses, a pile hammer within the energy range of 40 ft-kips to 60 ft-kips is expected to install the piles to the required nominal resistance, without overstressing the pile. Contractor shall submit a preliminary WEAP analysis for the selected installation equipment, with driving resistance at the required nominal resistance range from 36 blow/ft to 96 blows/ft.

The pile nominal resistance should be verified by Pile Driving Analyzer (PDA) testing at each substructure location during construction (totaling 6 locations). The PDA testing should be performed during initial drive, or during a restrike on a test pile at each location. The test pile should be at least 10 feet longer than the production piles of the location. The pile installation criteria for the production pile should be developed based on the PDA results.

10. Pavement Recommendations

10.1. Opitz Boulevard Widening

The eastbound Opitz Boulevard will be widened to accommodate an additional traffic lane associated with the T ramp. Following are the summary of existing pavement sections encountered in the Opitz Boulevard test borings. Pavement widening should be in accordance with VDOT Standard WP-2.

Table 10.1: Existing Pavement Section at Opitz Boulevard

Location	Boring ID	Asphalt (inch)	Agg. Base (inch)	Concrete (inch)	Notes
East Bound Travel Lane West Approach	B-A1-1	12.0	4.0	---	---
	B-A1-2	11.0	7.0	---	---
East Bound Shoulder, East Approach	B-A1-6	5.0	12.0	---	---
	B-PE-1	4.5	10.5	---	---
	B-PE-2	3.0	11.0	---	---

We recommend that the new pavements for the widening area match the thickness of the existing pavements. In addition, new prepared subgrade and the aggregate base layer should ensure positive drainage towards the south edge of the pavement. Following are the recommended thickness for the new pavement.

Table 10.2: Opitz Boulevard – Recommended New Pavement

Layer Name	Layer Type	Thickness	Summary	
Asphalt Surface	SM-9.5 D	2.0 inch	Total HMA	12.0 inch
Asphalt Intermediate	IM-19.0A	2.0 inch		
Asphalt Base	BM-25 A	8.0 inch		
Aggregate Base	21B	6.0 inch	Aggregate Base	6.0 inch

Notes: (1) Standard UD-4 edge drains along all new pavement sections
(2) Standard Combination Underdrain (CD-2) shall be provided at grade sags, bridge approaches, and at the lower end of undercut areas.

. Aggregate base should extend 6 inches beyond the sides of the base.

10.2. Pavements for T-Ramp and Express Lanes

The eastbound Opitz Boulevard will be widened to accommodate an additional traffic lane associated with the T ramp. Following are the summary of existing pavement sections encountered in the Express Lane test borings.

Table 10.3: Existing Pavement Section - I-95 Express Lanes

Boring ID	Location	Existing Pavement Section				
		Pavement Core	Asphalt (ASPH) (inch)	Agg. Base (BASE) (inch)	Concrete (CONC) (inch)	Notes
B-A2-1	I-95 HOT T-Ramp		7.0	17.0	6.0	Note (1)
B-A3-1	I-95 HOT T-Ramp	---	15.0	4.0	---	
B-A3-2	I-95 HOT T-Ramp	---	18.0	18.0	---	
B-A3-3	I-95 HOT T-Ramp	---	15.0	5.0	4.0	Note (2)
B-A3-4	I-95 HOT T-Ramp	---	18.0	18.0	---	---
B-A3-5	I-95 HOT T-Ramp	---	19.0	9.0	---	---
B-A3-6	I-95 HOT T-Ramp	---	19.0	18.0	---	---
B-A3-7	I-95 HOT T-Ramp	---	15.0	9.0	---	---
B-A3-8	I-95 HOT T-Ramp	---	19.0	23.0	---	---
B-A3-9	Road south of T ramp	---	12.0	9.0	3.0	Note (3)
B-A4-1	I-95 XBL MOT	1	14.0	10.0	---	---
B-A4-2	I-95 XBL MOT	1	17.0	8.0	---	---

Table 10.3: Existing Pavement Section - I-95 Express Lanes

Boring ID	Location	Existing Pavement Section				
		Pavement Core	Asphalt (ASPH) (inch)	Agg. Base (BASE) (inch)	Concrete (CONC) (inch)	Notes
B-A4-3	I-95 XBL MOT	1	17.0	8.0	---	---
B-A4-4	I-95 XBL MOT	1	15.0	9.0	---	---
B-A4-5	I-95 XBL Slip Ramp	1	16.0	9.0	---	---
B-A4-6	I-95 XBL Slip Ramp	1	15.0	10.0	---	---
B-A4-7	I-95 XBL Slip Ramp	1	16.0	9.0	---	---
B-A4-8	I-95 XBL Slip Ramp	1	15.0	33.0	---	---

Notes:
(1) 7.0"**ASPH** + 6.0"**CONC** + 17.0"**Base**
(2) 15.0"**ASPH** + 5.0" **Base** + 4.0" **CONC**
(3) 9.0"**ASPH** + 3.0"**CONC** + 3.0"**ASPH** + 9.0"**Base**

The test borings drilled for the T-Ramp wall foundation (B-A3 – xx borings) encountered a small portion of concrete within the pavement section. The borings were drilled for the T-Ramp foundation design and located at the edge of the travel lanes. Cores were not obtained in these sections. The auger took several minutes to penetrate the concrete. The B-A4 borings were drilled for pavement design. Pavement cores were recovered from these borings. These borings were drilled within the full depth shoulder and considered to reflect the existing conditions of the pavements.

The areas where the pavement sections with concrete will be excavated for the preparation of the MSE wall foundations. It is noted that the section depicted by Notes (2) is acceptable to be left in place, (15” HMA and 5” Base section above concrete) as it is adequate for the Express Lane traffic levels.

We recommend that the new pavements for the widening area match the thickness of existing pavement in the area to maintain a consistent section within the project limits. In addition, new prepared subgrade and the aggregate base layer should ensure positive drainage towards the south edge of the pavement. Following are the recommended thickness for the new pavement.

Table 10.4: I-95 Express HOT Lanes – Recommended New Pavement

Layer Name	Layer Type	Thickness	Summary	
Asphalt Surface	SM-12.5E	2.0 inch	Total HMA	15 inches
Asphalt Intermediate	IM-19.0 D	2.0 inch		
Asphalt Base	BM-25.0 A	11.0 inch		
Aggregate Base	21B	15.0 inch	Aggregate Base	15 inches

Notes:
(1) Standard UD-4 edge drains along all new pavement sections
(2) Standard Combination Underdrain (CD-2) shall be provided at grade sags, bridge approaches, and at the lower end of undercut areas.

Table provided pavement section is recommended for new expressway pavements including the T-Ramp. A validation pavement thickness evaluation is performed for this section and the results are included in Appendix E.6. For the analysis I-95 traffic count is conservatively assumed with a subgrade resilient modulus (M_r) value of 5000 psi. As expressway does not carry trucks, 1% truck traffic volumes is assumed to account for occasional heavy load traffic.

During construction, the aggregate base should extend 6 inches beyond the sides of the base.

10.3. MOT Use of Shoulder Pavements

Current construction sequence requires use of existing shoulders for Maintenance of traffic during construction Following are the recommendations for the pavement section requirements for MOT.

HOT Lanes East Shoulder
Based on the results of current investigation, the shoulders have at least 14 inches of asphalt which is a sufficient section to support Express Lane traffic during construction.

Southbound I-95 Outside Shoulder
According to available record drawings the I-95 southbound outside shoulder has already been reconstructed to support Mainline traffic during the Express Lane work. Reviewed drawing indicating 10 inches of HMA thickness are included in Appendix E.6. A pavement thickness analysis performed to validate the existing thickness to support the MOT on a subgrade with M_r=5000 psi. The results of the analysis are included in the same appendix.

Opitz Blvd Northeast Quadrant
A new MOT section is required in a very short stretch along Opitz Blvd on the Northwest quadrant approaching the bridge. We recommend this portion should be fortified with the following section:

HMA:	2”- IM-19.0D
	4” BM-25.0A
Subbase:	6” Aggregate Base 21B

Mill and Overlay
Area where the lines are eradicated, a 2-inch depth mill and overlay with SM-12.5E HMA mix layer is recommended. For Opitz Boulevard, mill and overlay with SM-9.5D HMA mix layer is recommended.

10.4. Subgrade Preparation and Construction Considerations

The new pavement and retaining wall subgrades should be observed by the geotechnical engineer during construction. Any unsuitable soils such as wet, loose, or fine soils with high plasticity should be undercut to a maximum of 3 feet and replaced with controlled compacted fill. Additional measures such as use of a separation fabric on undercut subgrade before placing the fill may be employed as recommended by the geotechnical engineer.

Unsuitable subgrade materials consisting of CH and MH materials are anticipated to be encountered at subgrade levels in the vicinity of borings B-A1-1, B-A1-2 and B-A3-2 which is in the vicinity of the start of the soldier pile wall. These areas are identified on the cross sections as areas to be undercut (3 ft. max) and replaced with CBR 5 material. The undercut will be approximately 10 feet wide, and approximately span from Sta 62+50 to Sta.64+75.

10.5. Subgrade Preparation for Storm Drain at T-Ramp Sta. 23+10

A 48-inch diameter concrete storm drain is proposed across the T-Ramp at approximately Sta 23+10. The invert of the pipe is at EL168 feet while under the embankment footprint. Based on the results of boring B-A3-4 at Sta.23+50, pipe subgrades consist of competent natural soils. Following are noted:

The materials below pipe subgrades are anticipated to be medium stiff clays to very dense residual soils. An acceptable bedding material and thickness would be the Standard Detail (PB-1) for subgrade condition identified as “Normal Earth Foundation”, however the groundwater levels in this area expected vary between EL 165 and EL 169 which will result in pipe subgrades being wet during construction. To facilitate construction, we recommend 18 inches of undercut and backfill. The undercut should be backfilled with 12 inches of No.57 stone wrapped in separation fabric for groundwater control and subgrade preservation. The wrapped stone should be capped with a minimum 6” crusher run (Chapter 4 – Installation of Pipe Backfill and Testing, Page 10, VDOT Soils and Aggregate Compaction) or 6” of bedding material. Separation fabric is recommended to prevent fine particle migration through #57 stone and subsequent erosion/piping on surrounding native soils.

The calculated settlement due to embankment loading listed in Table 10.4 for this area is mainly due to the soft soils above the proposed storm drain. The materials below pipe subgrades are stiff clays and very dense residual soils, therefore, the settlement of the pipe due to embankment load are not a concern for the proposed concrete pipe.

11. References

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APPENDIX A

Figures

APPENDIX A.1

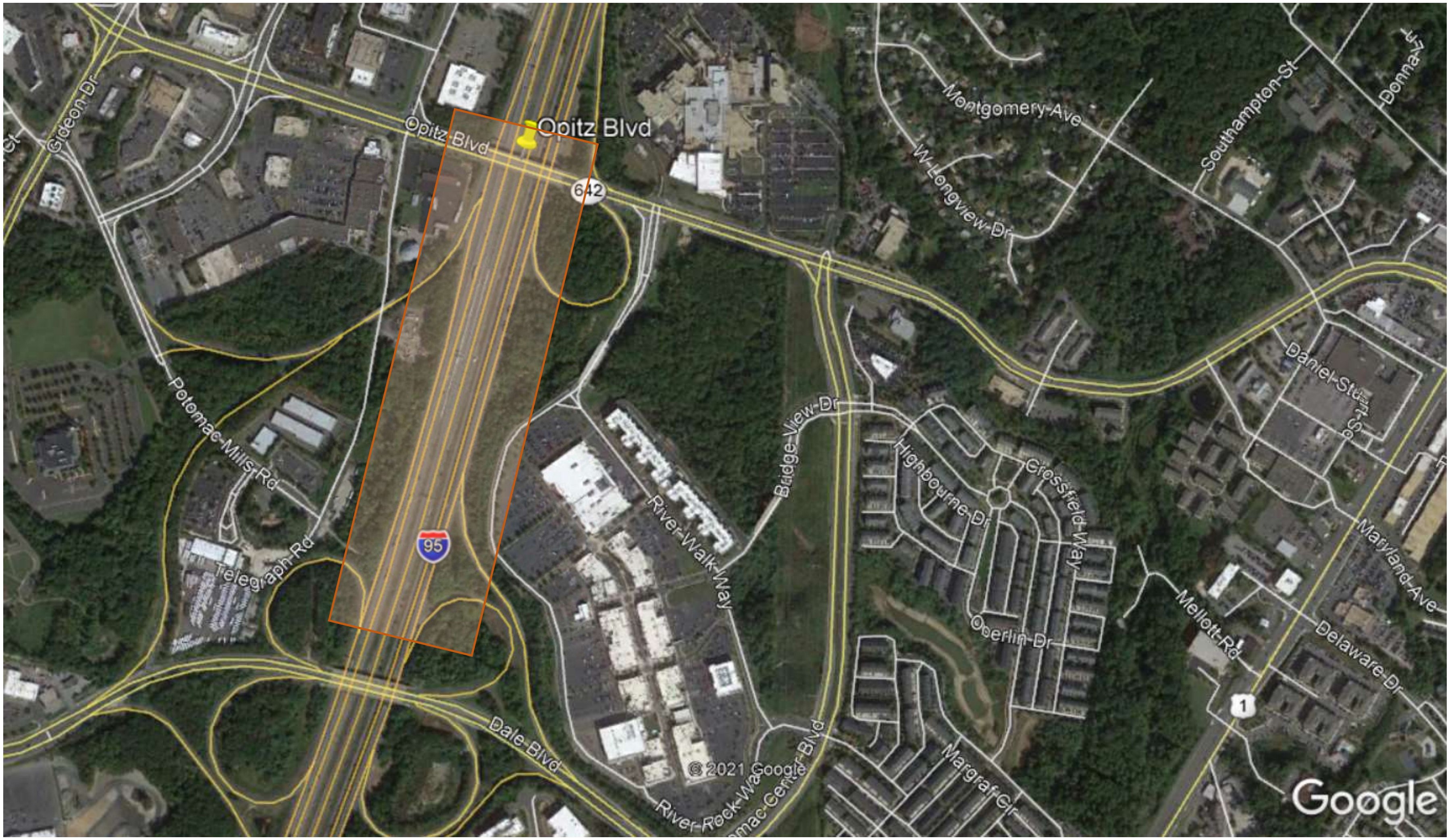
Site Vicinity Map

SITE VICINITY MAP

I-95 Expressway Spot Improvements at Opitz Blvd,
Prince Williams, County, Virginia

Project No. 0095-076-299, P101, C501, UPC 116663
Reference: Google

WRA W/O No. 45893.001



APPENDIX A.2

Test Hole Location Plan

12/16/2021 Sheet 9-Geo.dgn
10:58:54 AM Plotted By: jfauber

LIMITED ACCESS HIGHWAY

By Resolution of the Highway Commission dated October 4, 1956
By Resolution of the Highway Commission dated January 18, 1973
By Resolution of the Commonwealth Transportation Board dated January 18, 2001
By Resolution of the Commonwealth Transportation Board dated TBD (Anticipated February 2022)

REVISED	STATE	STATE ROUTE	STATE PROJECT	SHEET NO.
	VA.	95	0095-076-299, C-501	

Whitman, Requardt & Associates
Richmond, Virginia
ROADWAY ENGINEER

DESIGN FEATURES RELATING TO CONSTRUCTION
OR TO REGULATION AND CONTROL OF TRAFFIC
MAY BE SUBJECT TO CHANGE AS DEEMED
NECESSARY BY THE DEPARTMENT

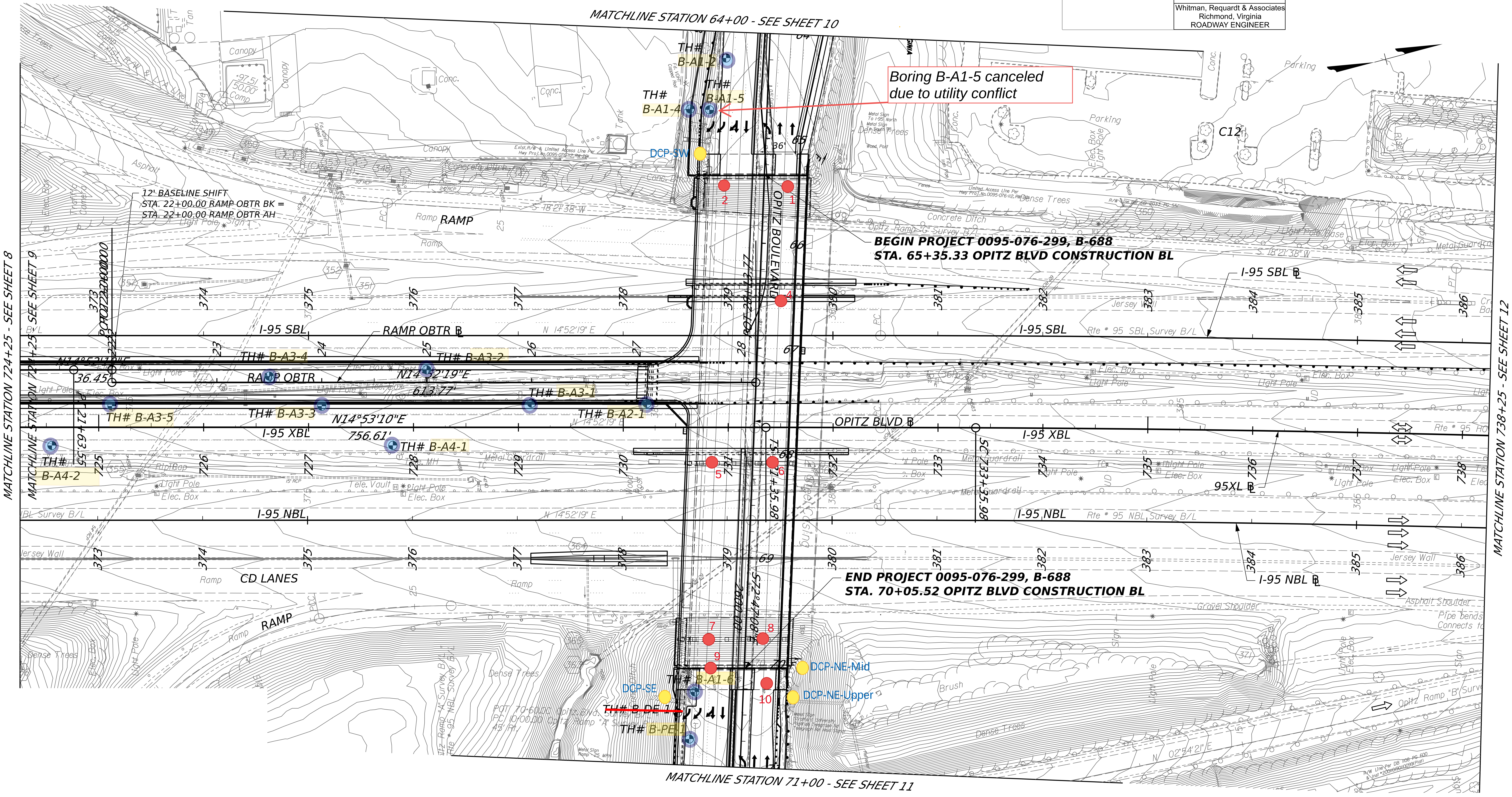
PROJECT MANAGER Rimpal Shah, P.E. (703) 259-2362 (NOVA District)
SURVEYED BY, DATE H&B Surveying and Mapping, LLC (804) 330-3781, 03/09/2021
DESIGN BY Whitman, Requardt, & Associates, LLP (804) 272-8700
SUBSURFACE UTILITY BY, DATE Accumark, Inc. (804) 550-7740, 07/07/2021

See Sheet 10 for Utility Owner's List

Test Hole Location Plan

Sheet 1 of 6

● Current Borings
● Historic Borings
● DCP Locations



REFERENCES
(PLAN AND DETAIL SHEETS)

SCALE
0 50' 100'

PROJECT	SHEET NO.
0095-076-299	

Cell Revised 12/11/12

12/16/2021 Sheet10-Geo.dgn
10:59:07 AM Plotted By: jfauber

LIMITED ACCESS HIGHWAY

By Resolution of the Highway Commission dated October 4, 1956
By Resolution of the Highway Commission dated January 18, 1973
By Resolution of the Commonwealth Transportation Board dated January 18, 2001
By Resolution of the Commonwealth Transportation Board dated TBD (Anticipated February 2022)

PROJECT MANAGER Rimpal Shah, P.E. (703) 259-2362 (NOVA District)
SURVEYED BY, DATE H&B Surveying and Mapping, LLC (804) 330-3781, 03/09/2021
DESIGN BY Whitman, Requardt, & Associates, LLP (804) 272-8700
SUBSURFACE UTILITY BY, DATE Accumark, Inc. (804) 550-7740, 07/07/2021

See Sheet 10 for Utility Owner's List

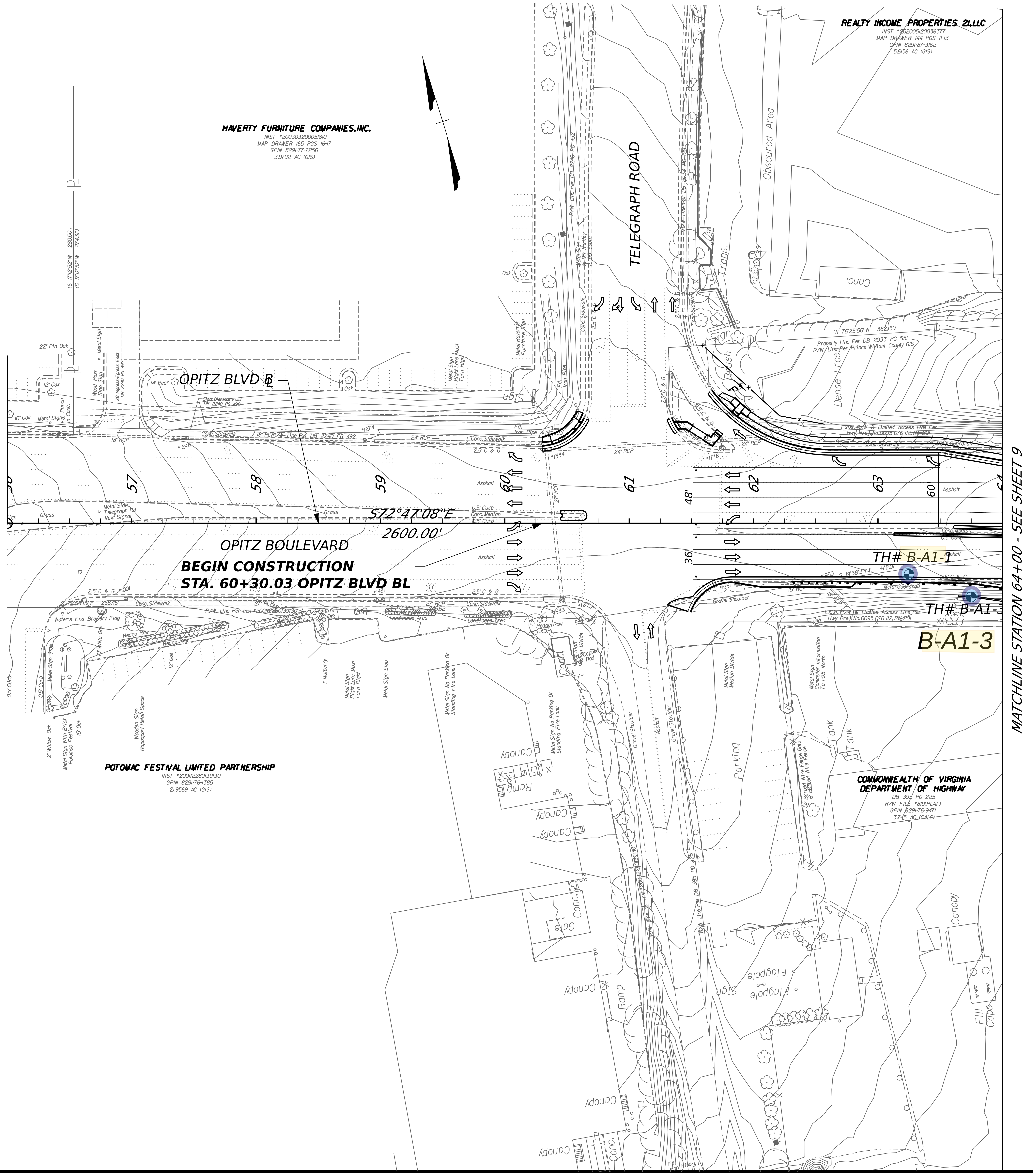
Test Hole Location Plan

Sheet 2 of 6

REVISED	STATE	STATE ROUTE	STATE PROJECT	SHEET NO.
	VA.	95	0095-076-299, C-501	

DESIGN FEATURES RELATING TO CONSTRUCTION
OR TO REGULATION AND CONTROL OF TRAFFIC
MAY BE SUBJECT TO CHANGE AS DEEMED
NECESSARY BY THE DEPARTMENT

Whitman, Requardt & Associates
Richmond, Virginia
ROADWAY ENGINEER



REFERENCES
(PLAN AND DETAIL SHEETS)

SCALE
0 50' 100'

PROJECT	SHEET NO.
0095-076-299	

Cell Revised 12/11/12

12/16/2021 Sheet11-Geo.dgn
10:59:21 AM Plotted By: jfauber

LIMITED ACCESS HIGHWAY

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SUBSURFACE UTILITY BY, DATE Accumark, Inc. (804) 550-7740, 07/07/2021

See Sheet 10 for Utility Owner's List

Test Hole Location Plan

Sheet 3 of 6

REVISED	STATE	STATE ROUTE	STATE PROJECT	SHEET NO.
	VA.	95	0095-076-299, C-501	

Whitman, Requardt & Associates
Richmond, Virginia
HYDRAULICS ENGINEER

Whitman, Requardt & Associates
Richmond, Virginia
ROADWAY ENGINEER

DESIGN FEATURES RELATING TO CONSTRUCTION
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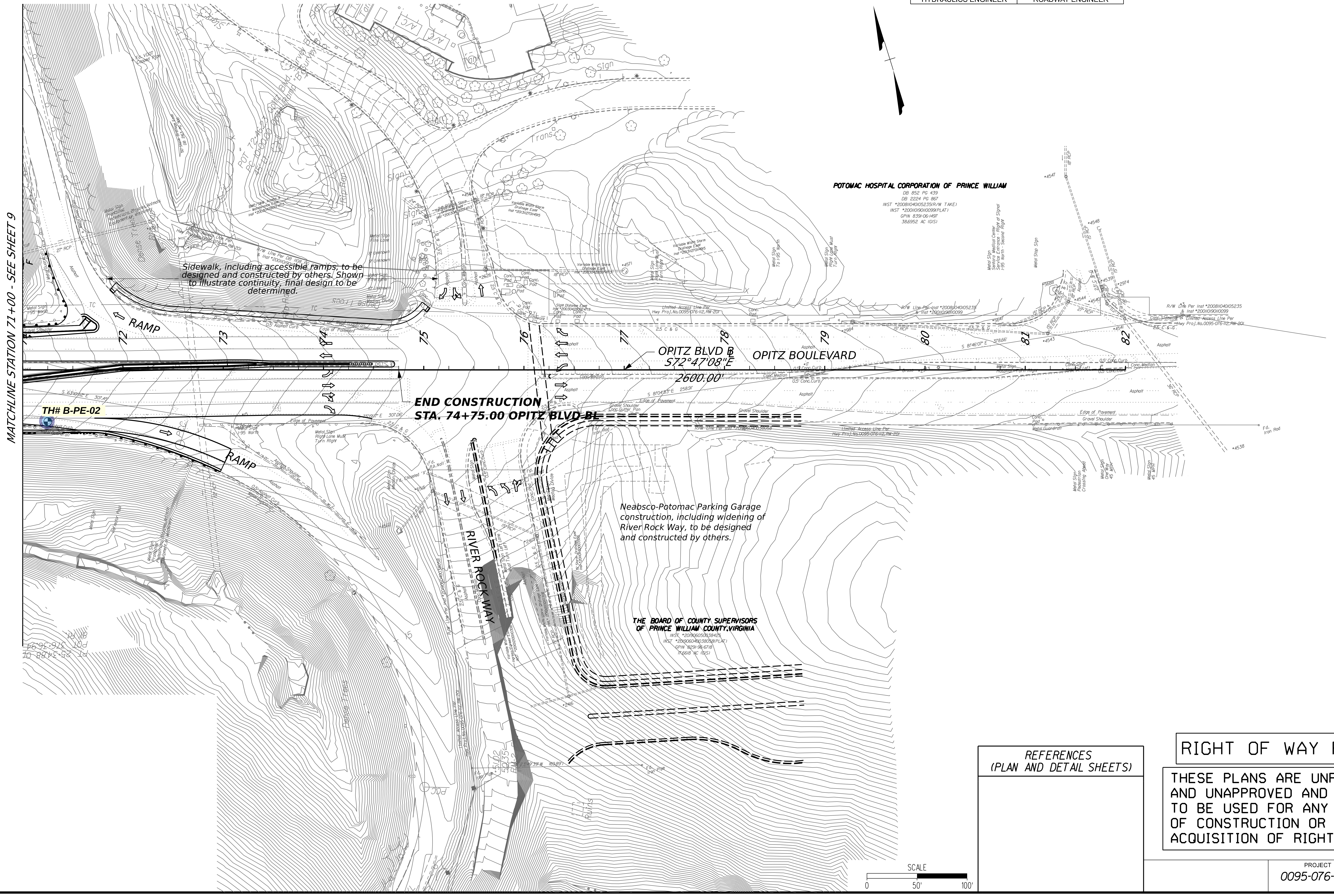

Sidewalk, including accessible ramps, to be designed and constructed by others. Shown to illustrate continuity, final design to be determined.

Neabsco-Potomac Parking Garage construction, including widening of River Rock Way, to be designed and constructed by others.

REFERENCES
(PLAN AND DETAIL SHEETS)

RIGHT OF WAY PLANS

THESE PLANS ARE UNFINISHED
AND UNAPPROVED AND ARE NOT
TO BE USED FOR ANY TYPE
OF CONSTRUCTION OR THE
ACQUISITION OF RIGHT OF WAY.

PROJECT	SHEET NO.
0095-076-299	

Cell Revised 12/11/12

12/16/2021 Sheet 8-Geo.dgn
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LIMITED ACCESS HIGHWAY

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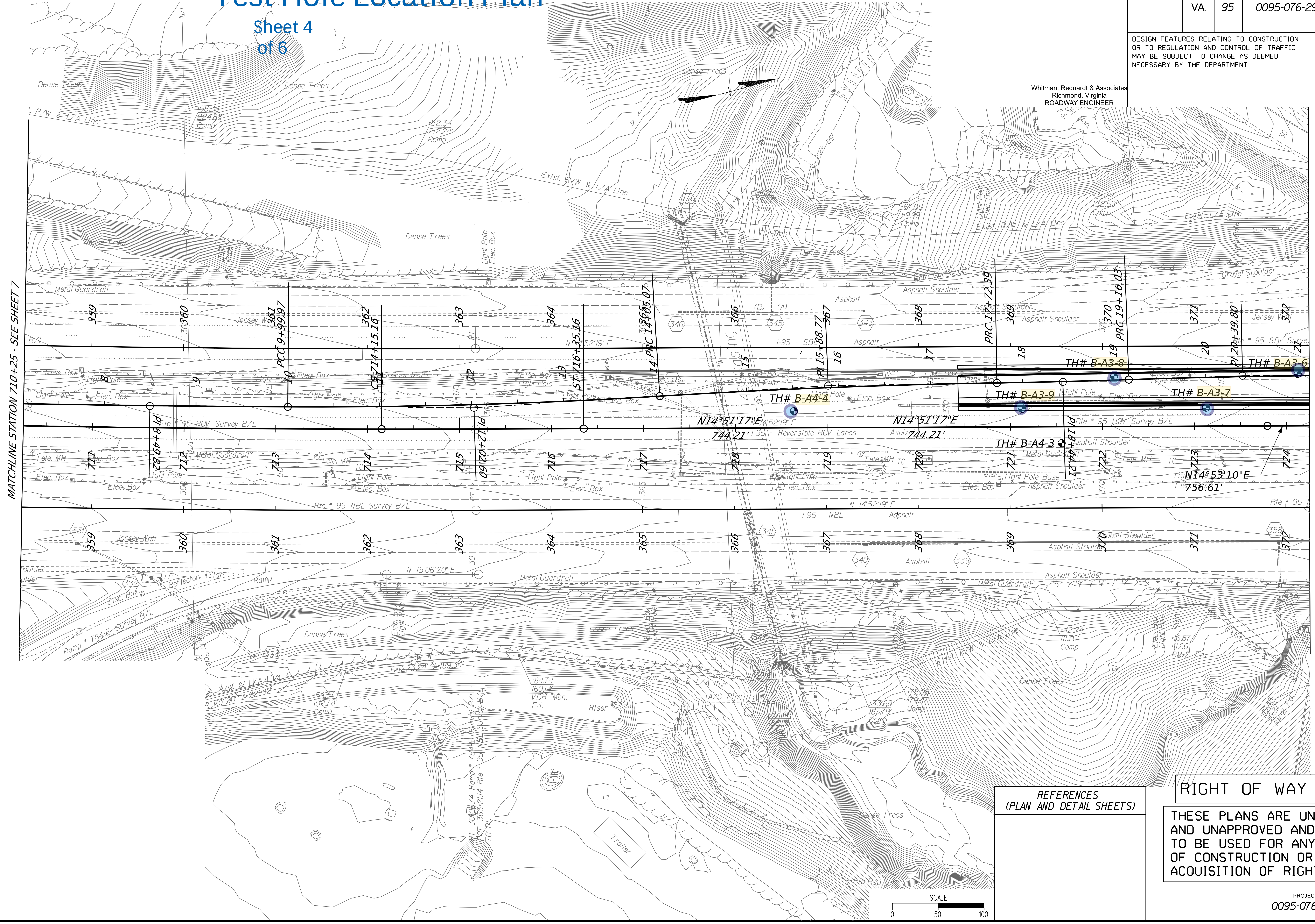
REVISED	STATE	STATE ROUTE	STATE PROJECT	SHEET NO.
	VA.	95	0095-076-299, C-501	

Whitman, Requardt & Associates
Richmond, Virginia
ROADWAY ENGINEER

DESIGN FEATURES RELATING TO CONSTRUCTION OR TO REGULATION AND CONTROL OF TRAFFIC MAY BE SUBJECT TO CHANGE AS DEEMED NECESSARY BY THE DEPARTMENT

Test Hole Location Plan

Sheet 4 of 6



SCALE
0 50' 100'

REFERENCES
(PLAN AND DETAIL SHEETS)

RIGHT OF WAY PLANS

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PROJECT	SHEET NO.
0095-076-299	

Cell Revised 12/11/12

12/16/2021 Sheet 6-Geo.dgn
10:58:14 AM Plotted By: jfauber

LIMITED ACCESS HIGHWAY

By Resolution of the Highway Commission dated October 4, 1956
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Test Hole Location Plan

Sheet 5 of 6

REVISED	STATE	STATE ROUTE	STATE PROJECT	SHEET NO.
	VA.	95	0095-076-299, C-501	

Whitman, Requardt & Associates
Richmond, Virginia
ROADWAY ENGINEER

DESIGN FEATURES RELATING TO CONSTRUCTION
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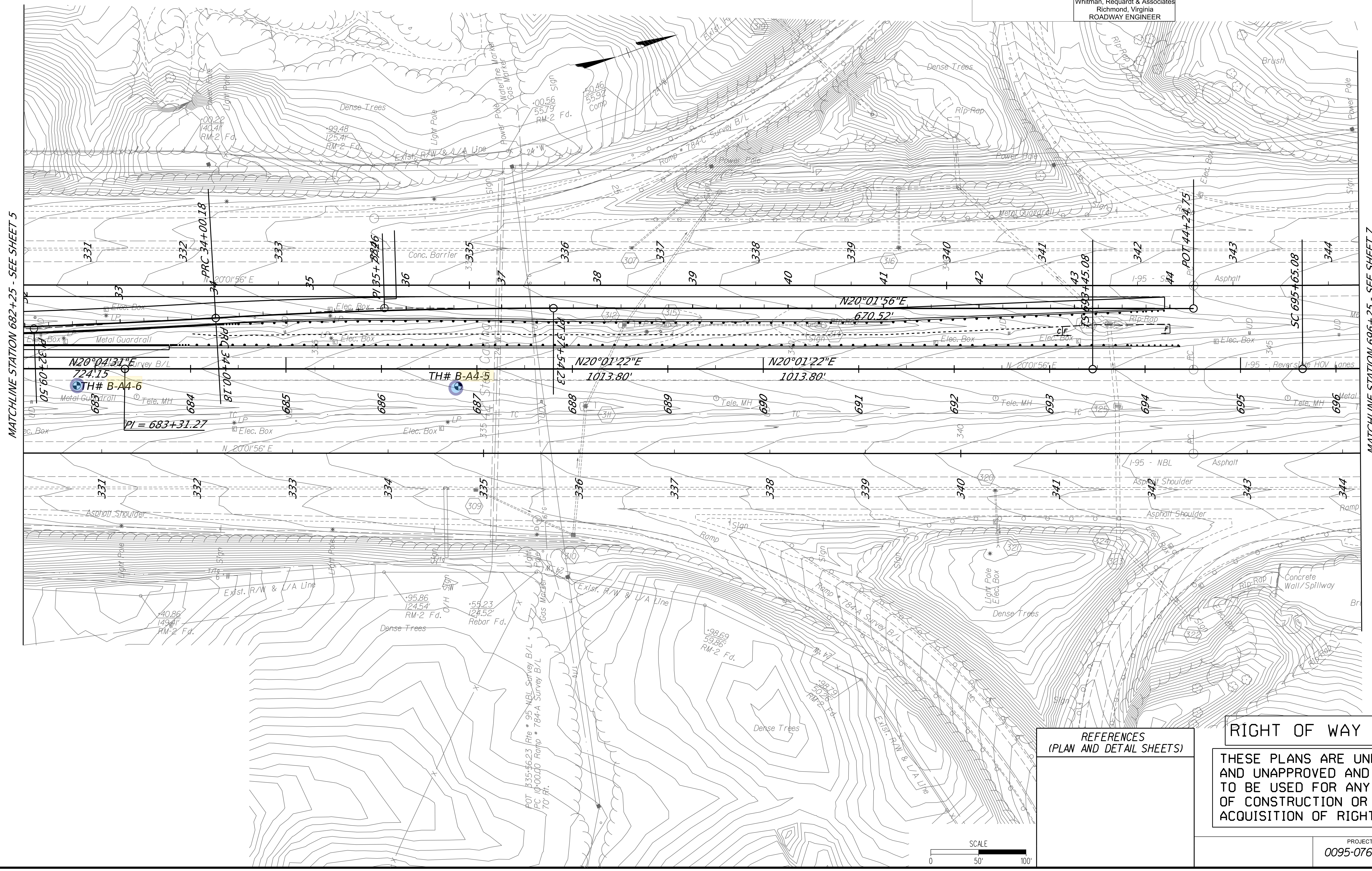

REFERENCES
(PLAN AND DETAIL SHEETS)

RIGHT OF WAY PLANS

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PROJECT	SHEET NO.
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SUBSURFACE UTILITY BY, DATE Accumark, Inc. (804) 550-7740, 07/07/2021

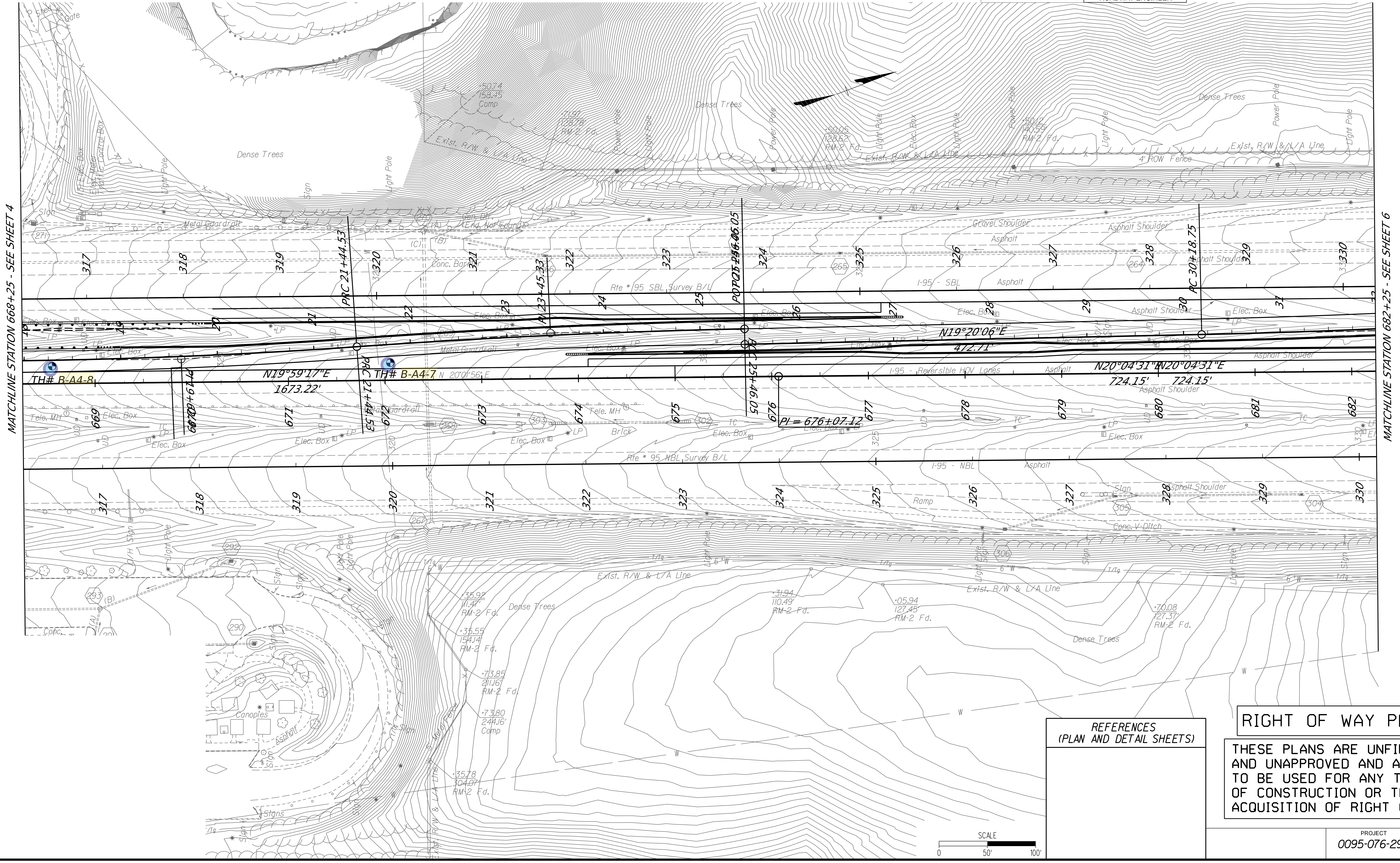
Test Hole Location Plan

Sheet 6 of 6

REVISED	STATE	STATE ROUTE	STATE PROJECT	SHEET NO.
	VA.	95	0095-076-299, C-501	

DESIGN FEATURES RELATING TO CONSTRUCTION OR TO REGULATION AND CONTROL OF TRAFFIC MAY BE SUBJECT TO CHANGE AS DEEMED NECESSARY BY THE DEPARTMENT

Whitman, Requardt & Associates
Richmond, Virginia
ROADWAY ENGINEER



REFERENCES
(PLAN AND DETAIL SHEETS)

RIGHT OF WAY PLANS

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PROJECT	SHEET NO.
0095-076-299	

APPENDIX A.3

Selected Plans – Bridge Elements

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<tr><td>VA.</td><td>—</td><td></td><td>2000</td><td>0095-076-299, B688</td><td>I</td></tr>
<tr><td colspan="3">Federal Structure No. 000000000014334</td><td colspan="3">FHWA Construction and Scour Code: X771-SN</td></tr>
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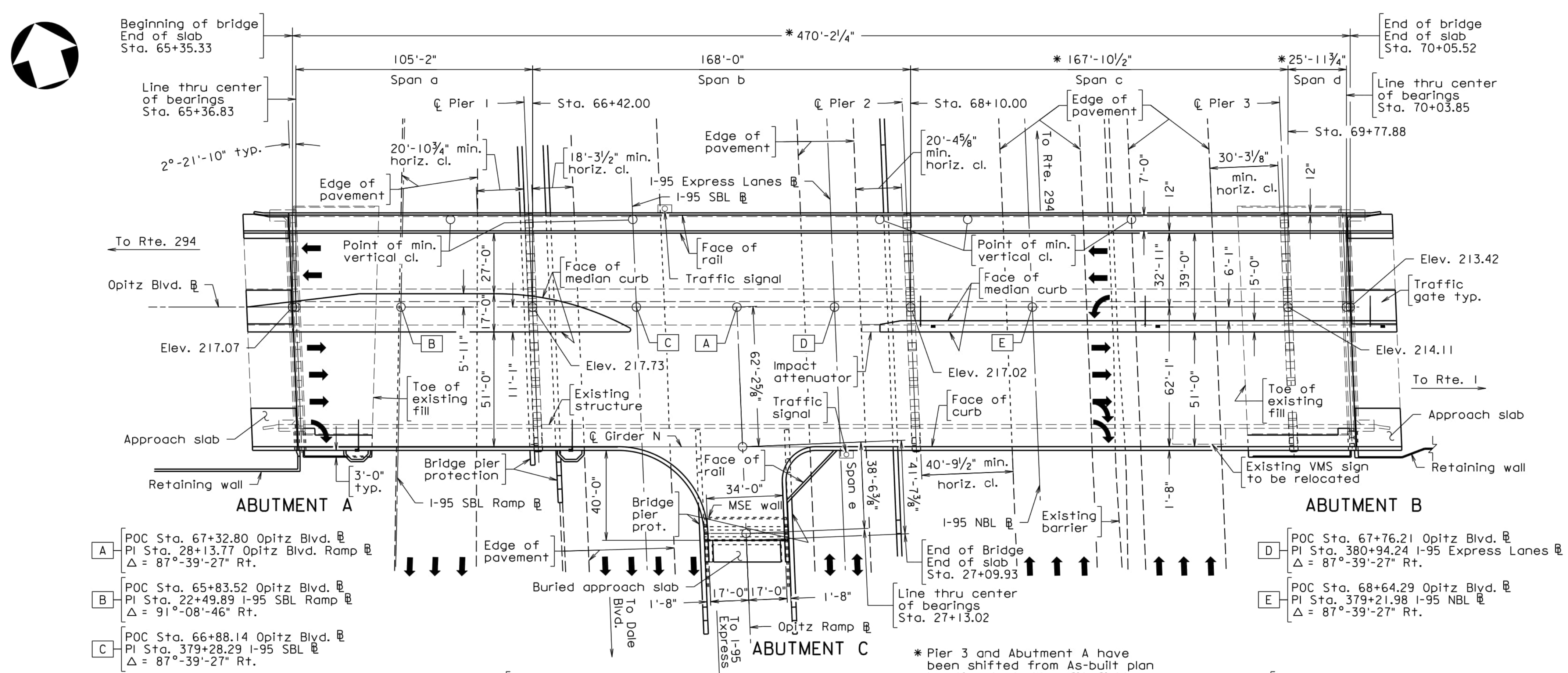


A POC Sta. 67+32.80 Opitz Blvd. ℄
PI Sta. 28+13.77 Opitz Blvd. Ramp ℄
Δ = 87°-39'-27" Rt.

B POC Sta. 65+83.52 Opitz Blvd. ℄
PI Sta. 22+49.89 I-95 SBL Ramp ℄
Δ = 91°-08'-46" Rt.

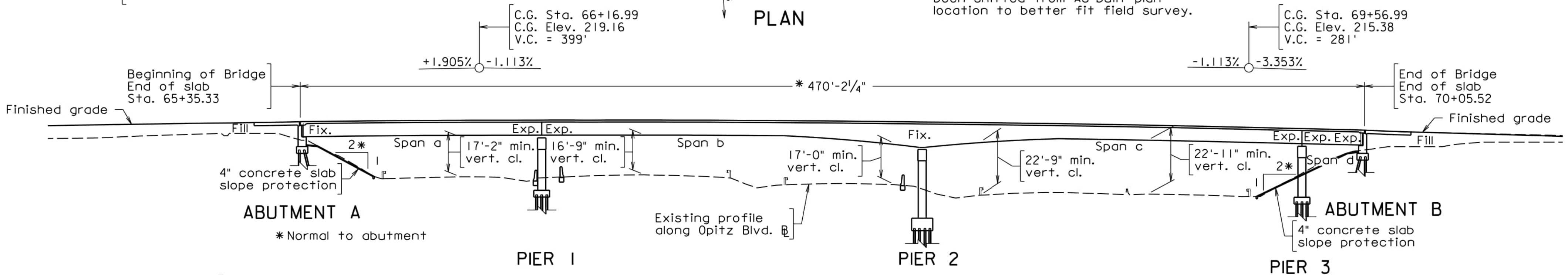
C POC Sta. 66+88.14 Opitz Blvd. ℄
PI Sta. 379+28.29 I-95 SBL ℄
Δ = 87°-39'-27" Rt.

D POC Sta. 67+76.21 Opitz Blvd. ℄
PI Sta. 380+94.24 I-95 Express Lanes ℄
Δ = 87°-39'-27" Rt.

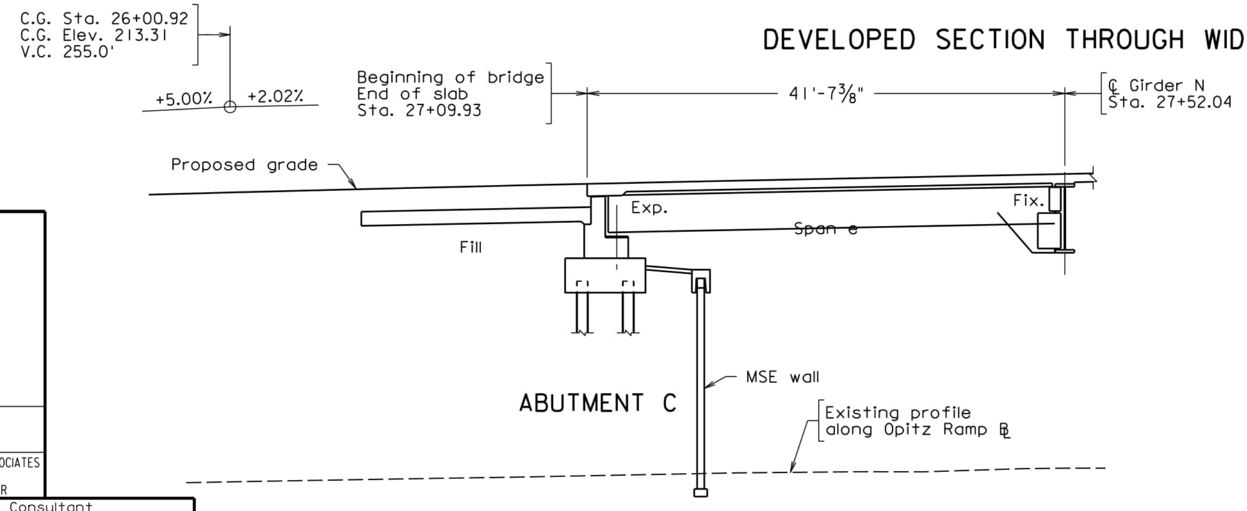
E POC Sta. 68+64.29 Opitz Blvd. ℄
PI Sta. 379+21.98 I-95 NBL ℄
Δ = 87°-39'-27" Rt.

* Pier 3 and Abutment A have been shifted from As-built plan location to better fit field survey.

PLAN



DEVELOPED SECTION THROUGH WIDENING



DEVELOPED SECTION ALONG OPITZ RAMP ℄

Scale: ⅛" = 1'-0"

Progress Print / provided to address Stage 1 comments for Stage 1 approval

WHITMAN REQUARDT & ASSOCIATES
RICHMOND, VA
STRUCTURAL ENGINEER

PLANS BY:	Consultant
COORDINATED:	Brian Morrison
SUPERVISED:	Jeremy Schlussel
DESIGNED:	Michelle Defreese
DRAWN:	Charlie Reagle
CHECKED:	Gary Shelor

PRELIMINARY PLANS

THESE PLANS NOT TO BE USED FOR CONSTRUCTION

Scale: 1" = 30', unless otherwise noted.

No.	Description	Date

REVISIONS

For Table of Revisions, see Sheet 3.

DESIGN EXCEPTION(S):

None.

GENERAL NOTES:

The original approved sheet, including original signatures, is filed in the VDOT Central Office. Any misuse of electronic files, including scanned signatures is illegal. Violators will be prosecuted to the full extent of the applicable laws.

Width: Opitz Blvd. - 7'-0" sidewalk, 12" rail, 39'-0" WBL roadway, variable median, 51'-0" EBL roadway. Overall width 103'-0" face-to-face of rails.
Ramp - Varies face-to-face of curbs

Span layout: Opitz Blvd. - 105'-2", 168'-0" - 167'-10½" continuous, and one 25'-11¾" steel plate girder spans
Ramp - 39'-0⅜" steel plate girder span

Capacity: HS20-44 loading and alternate military loading (original); HL-93 loading (new)

Specifications:

Construction: Virginia Department of Transportation Road and Bridge Specifications, 2020.

Design: AASHTO Standard Specifications for Highway Bridges, 16th Edition, 1996; 1997 and 1998 Interim Specifications; and VDOT Modifications.

AASHTO LRFD Bridge Design Specifications, 8th Edition, 2017; and VDOT Modifications.

Standards: Virginia Department of Transportation Road and Bridge Standards, 2016; including all current revisions.

These plans are incomplete unless accompanied by the Supplemental Specifications and Special Provisions included in the contract documents.

This project is to be constructed in accordance with the Virginia Department of Transportation Work Area Protection Manual, August 2011 and latest revisions.

Design loading includes 20 psf allowance for construction tolerances and construction methods for new deck, beams and substructure.

Design loading includes 15 psf allowance for future wearing surface for new deck, beams and substructure.

Stay-in-place forms to be supported by existing girders shall have their corregations filled with foam inserts.

All structural steel, including bearings, shall be ASTM A709 Grade 50W and shall be painted.

Finish paint color shall be brown, 595-30045

Zone coating of beams for 9'-0" from end of beam including bearings and end crossframes and diaphragms shall be in accordance with Section 411.05 (c5) of the Specifications.

Concrete in superstructure shall be Low Shrinkage Class A4 Modified and in rails, parapets, terminal walls and medians shall be Low Shrinkage Class A4 Modified (Lightweight) in accordance with Section 217.12(a); in substructure, Class A3.

VDOT

COMMONWEALTH OF VIRGINIA
DEPARTMENT OF TRANSPORTATION

PROPOSED WIDENING ON OPITZ BLVD OVER I-95, I-95 EXPRESS LANES PRINCE WILLIAM CO. PROJ. 0095-076-299, B688

VDOT to verify

Recommended for Approval: ______________________ ______
District Project Development Engineer Date

Approved: ______________________ ______
District Administrator Date

257-38A

Date: November 17, 2021 © 2021, Commonwealth of Virginia Sheet 1 of 93

PROGRESS PRINT 2021-11-17

STATE	FEDERAL AID ROUTE	FEDERAL AID PROJECT	STATE ROUTE	STATE PROJECT	SHEET NO.
VA.	—		2000	0095-076-299, B688	4

A ⊢ POC Sta. 67+32.80 Opitz Blvd. ℄
PI Sta. 28+13.77 Opitz Blvd. Ramp ℄
△ = 87°-39'-27" Rt.

B ⊢ POC Sta. 65+83.52 Opitz Blvd. ℄
PI Sta. 22+49.89 I-95 SBL Ramp ℄
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C ⊢ POC Sta. 66+88.14 Opitz Blvd. ℄
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△ = 87°-39'-27" Rt.

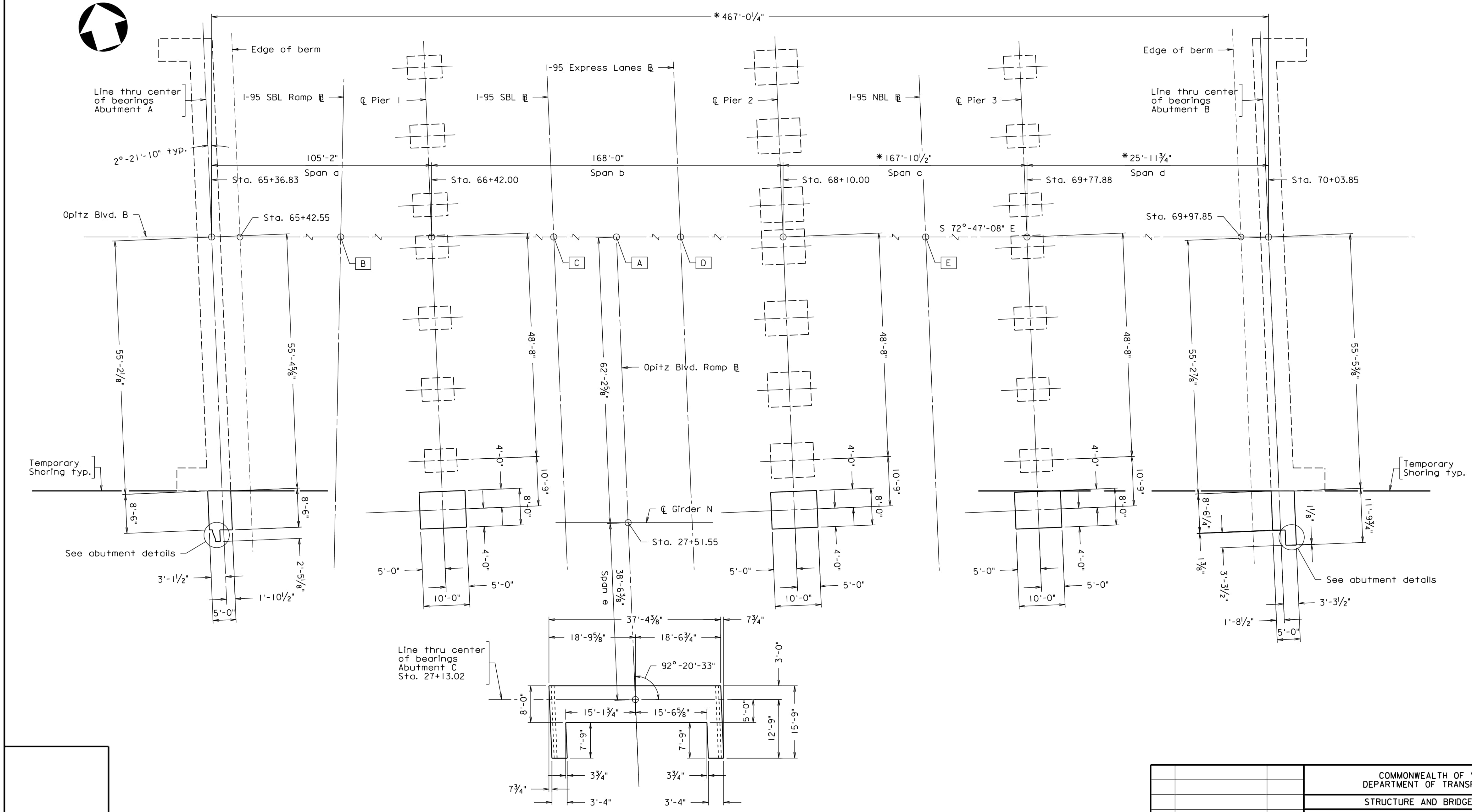
E ⊢ POC Sta. 68+64.29 Opitz Blvd. ℄
PI Sta. 379+21.98 I-95 NBL ℄
△ = 87°-39'-27" Rt.

* Pier 3 and Abutment A have been shifted from As-built plan location to better fit field survey.

◐ = Boring locations, for details, see sheets X thru X.

Notes:

This layout is to be used only for the purpose of locating fill slopes and footings. For details not shown see abutment and pier details.



SUBSTRUCTURE LAYOUT

Scale: $\frac{3}{32}$ " = 1'-0" unless otherwise noted.

WHITMAN REQUARDT & ASSOCIATES
RICHMOND, VA
STRUCTURAL ENGINEER

PRELIMINARY PLANS

THESE PLANS NOT TO BE USED FOR CONSTRUCTION

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No.	Description	Date
Revisions		

COMMONWEALTH OF VIRGINIA
DEPARTMENT OF TRANSPORTATION

STRUCTURE AND BRIDGE DIVISION

SUBSTRUCTURE
LAYOUT

Designed: WRA Drawn: WRA Checked: WRA	Date	Plan No.	Sheet No.
	Nov. 2021	257-38A	4 of 93

PROGRESS PRINT 2021-11-17

STATE	FEDERAL AID		STATE		SHEET NO.
	ROUTE	PROJECT	ROUTE	PROJECT	
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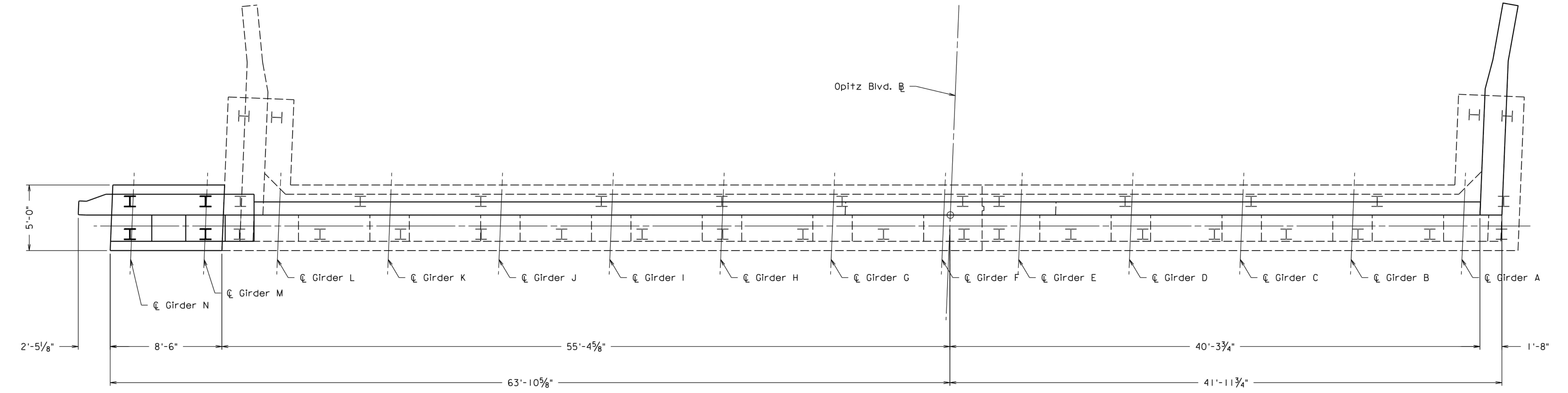
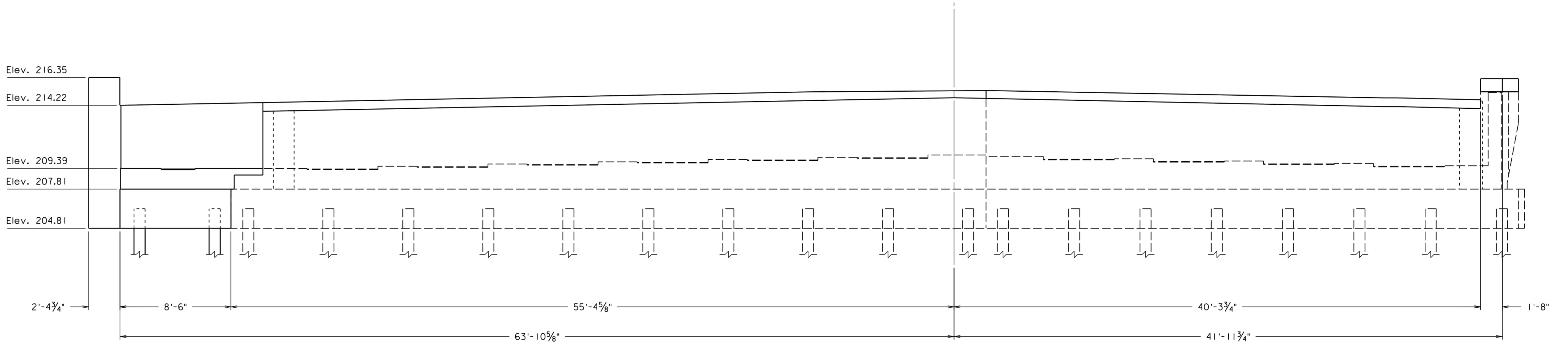


PLAN



ELEVATION

WHITMAN REQUARDT & ASSOCIATES
RICHMOND, VA
STRUCTURAL ENGINEER

Scale: ¼" = 1'-0" unless otherwise noted.

PRELIMINARY PLANS

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No.	Description	Date
	Revisions	

COMMONWEALTH OF VIRGINIA
DEPARTMENT OF TRANSPORTATION

STRUCTURE AND BRIDGE DIVISION

ABUTMENT A
PLAN & ELEVATION

	Date	Plan No.	Sheet No.
Designed: WRA Drawn: WRA Checked: WRA	Nov. 2021	257-38A	10 of 93

PROGRESS PRINT 2021-11-17

STATE	FEDERAL AID		STATE		SHEET NO.
	ROUTE	PROJECT	ROUTE	PROJECT	
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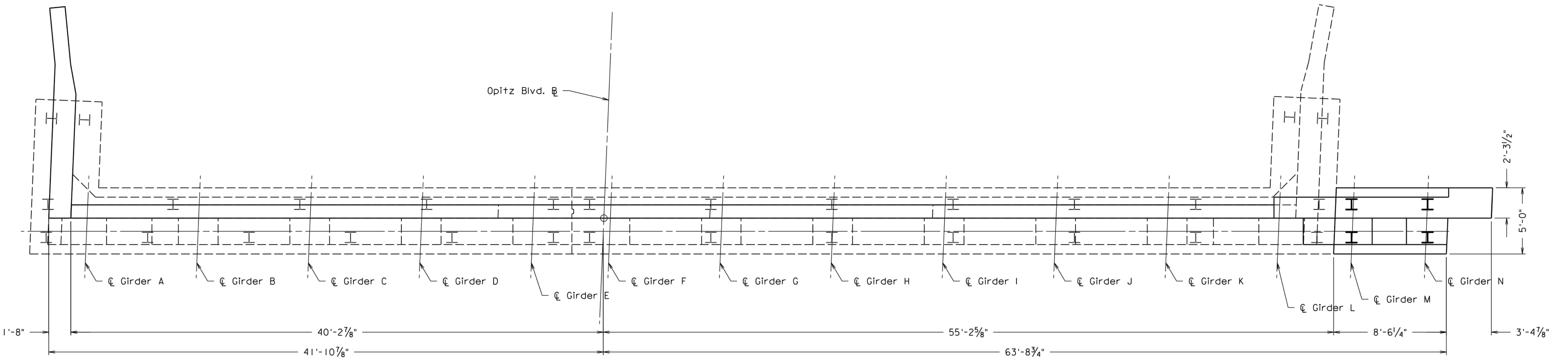
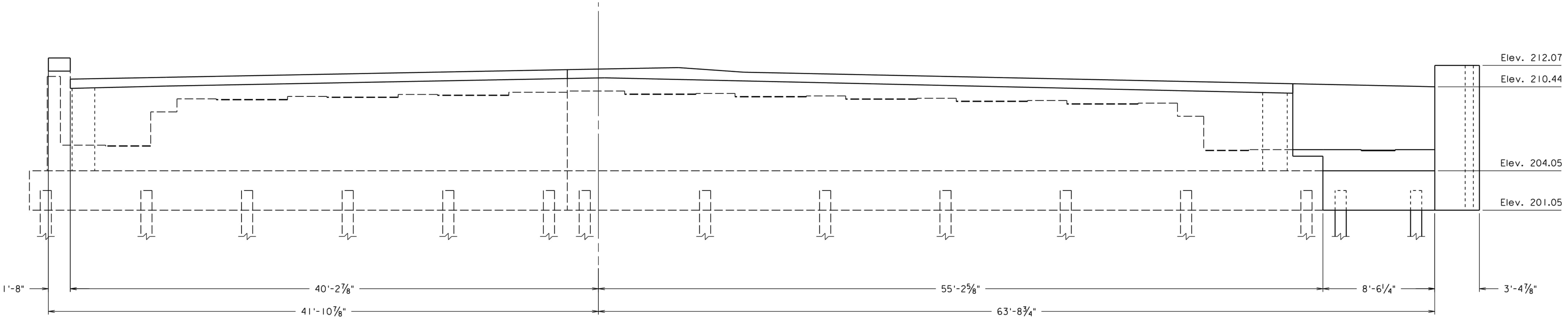


PLAN



ELEVATION

WHITMAN REQUARDT & ASSOCIATES
RICHMOND, VA
STRUCTURAL ENGINEER

Scale: ¼" = 1'-0" unless otherwise noted.

PRELIMINARY PLANS

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No.	Description	Date
	Revisions	

COMMONWEALTH OF VIRGINIA
DEPARTMENT OF TRANSPORTATION

STRUCTURE AND BRIDGE DIVISION

ABUTMENT B
PLAN & ELEVATION

	Date	Plan No.	Sheet No.
Designed: WRA Drawn: WRA Checked: WRA	Nov. 2021	257-38A	16 of 93

PROGRESS PRINT 2021-11-17

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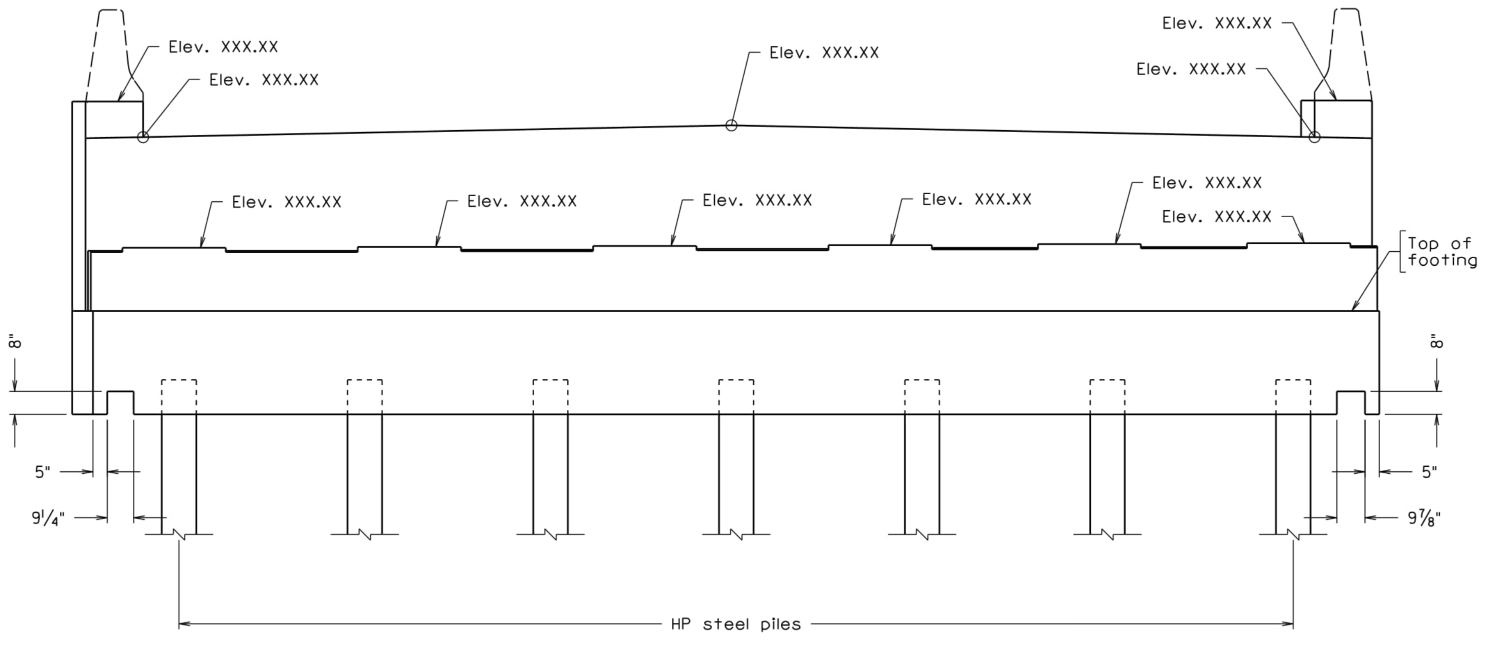

ELEVATION

PRELIMINARY PLANS

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No.	Description	Date
	Revisions	

COMMONWEALTH OF VIRGINIA
DEPARTMENT OF TRANSPORTATION

STRUCTURE AND BRIDGE DIVISION

ABUTMENT C
ELEVATION

Designed: WRA
Drawn: WRA
Checked: WRA

Date	Plan No.	Sheet No.
Nov. 2021	257-38A	22 of 93

WHITMAN REQUARDT & ASSOCIATES
RICHMOND, VA
STRUCTURAL ENGINEER

PROGRESS PRINT 2021-11-17

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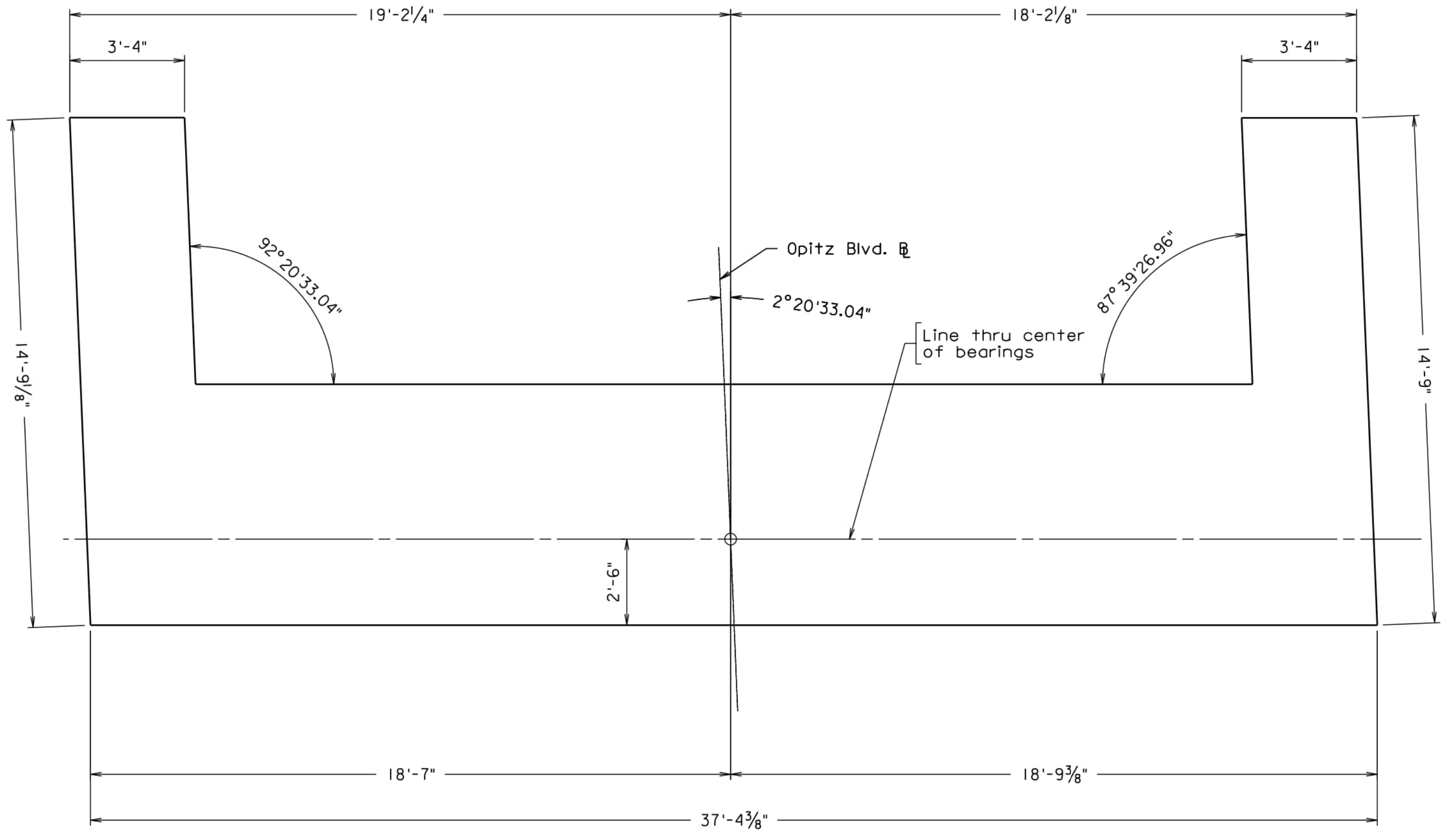
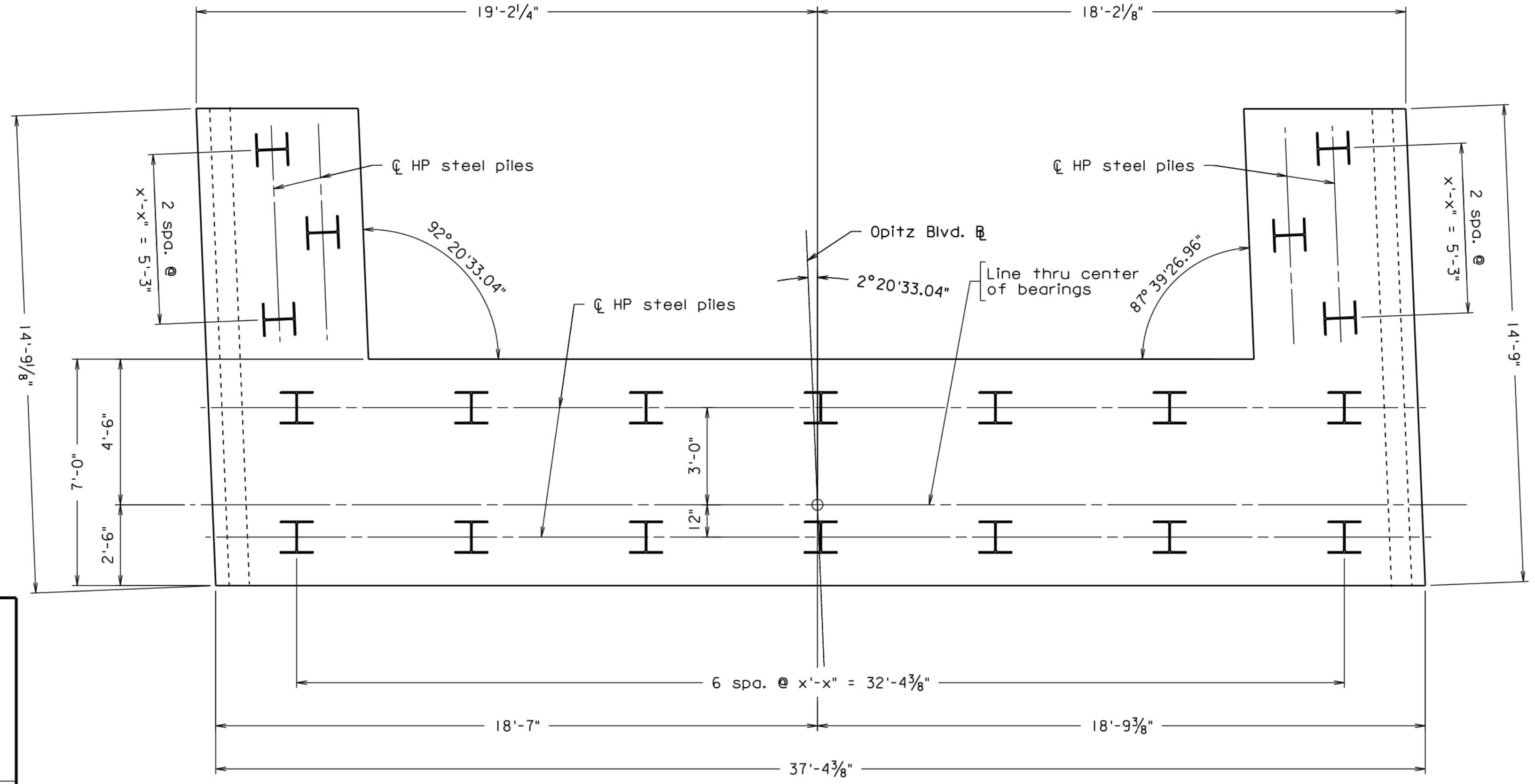


FOOTING PLAN



PILE LAYOUT

Scale: ¼" = 1'-0" unless otherwise noted.

PRELIMINARY PLANS

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WHITMAN REQUARDT & ASSOCIATES
RICHMOND, VA
STRUCTURAL ENGINEER

No.	Description	Date

Revisions

COMMONWEALTH OF VIRGINIA
DEPARTMENT OF TRANSPORTATION

STRUCTURE AND BRIDGE DIVISION

ABUTMENT C
FOOTING PLAN AND PILE LAYOUT

	Date	Plan No.	Sheet No.
Designed: WRA Drawn: WRA Checked: WRA	Nov. 2021	257-38A	23 of 93

PROGRESS PRINT 2021-11-17

STATE	FEDERAL AID		STATE		SHEET NO.
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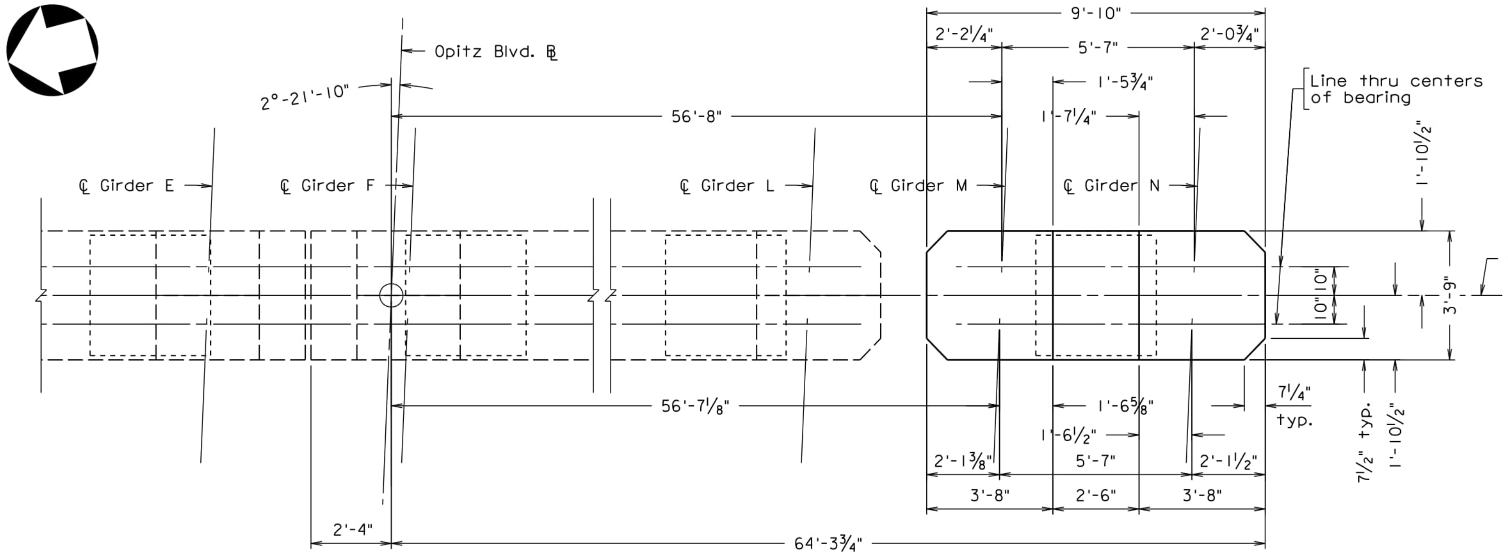

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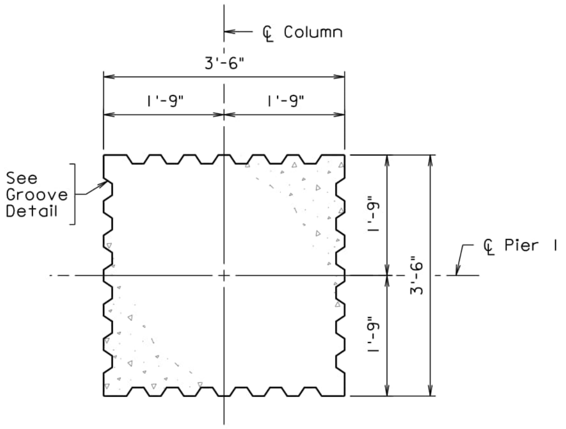

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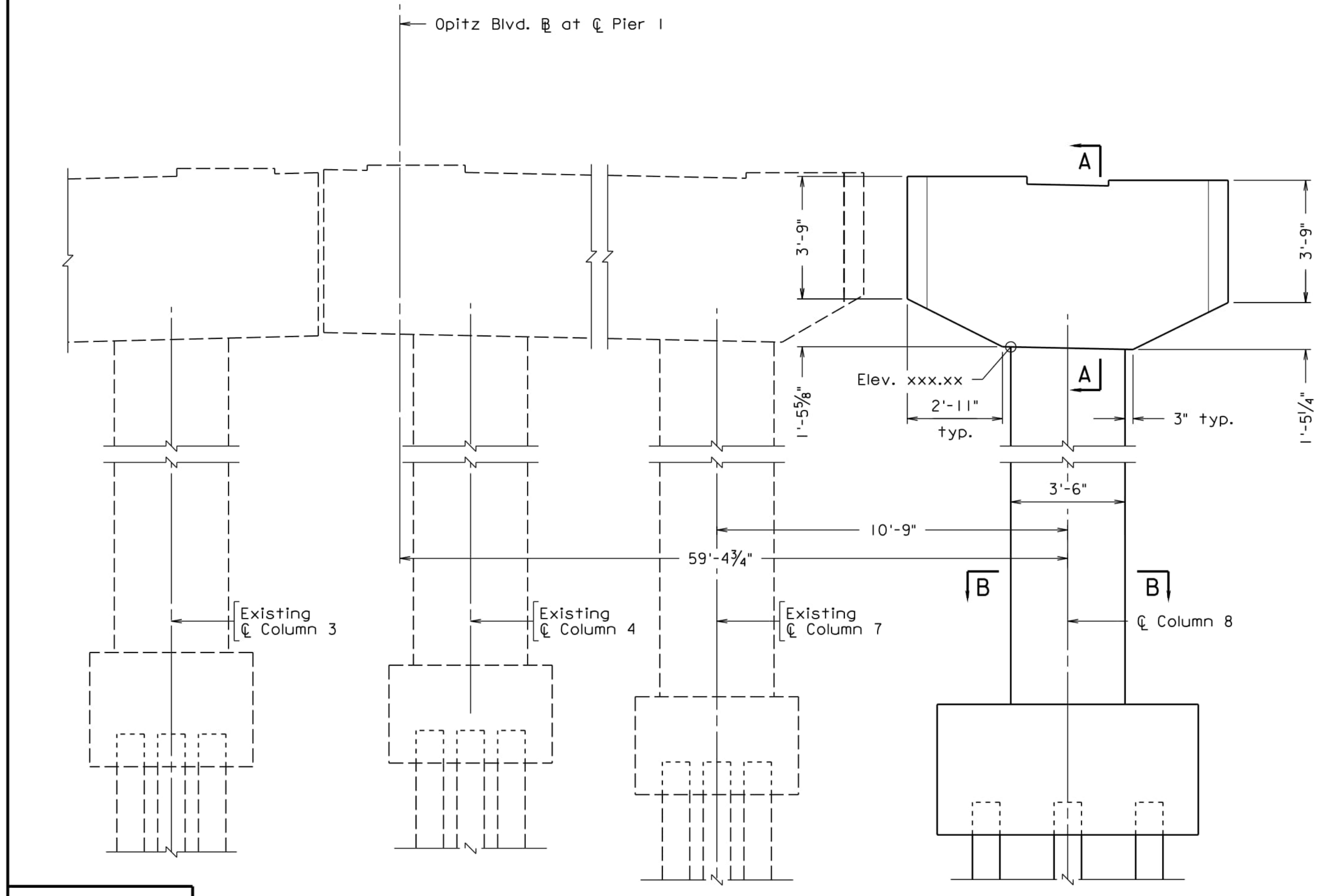

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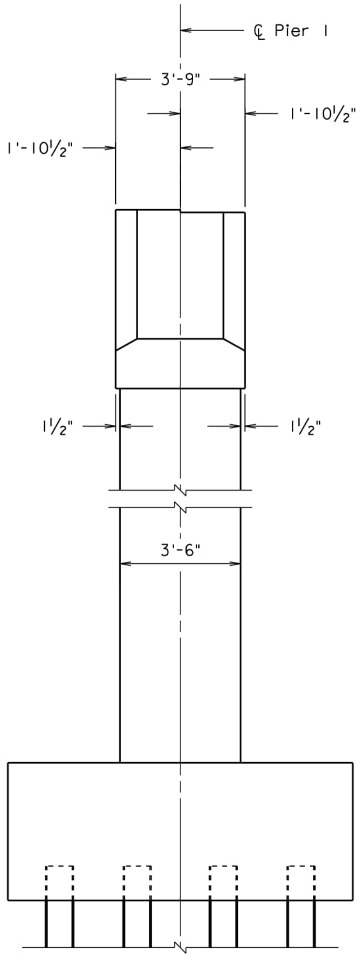

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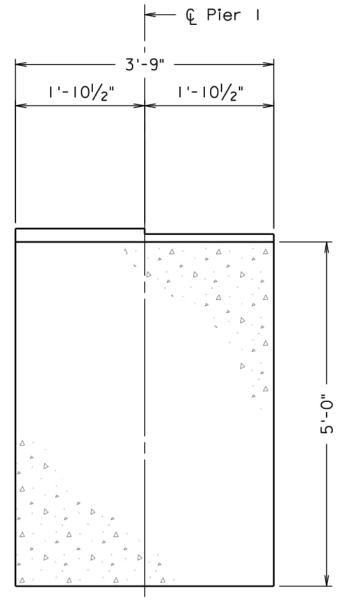

SECTION A-A

WHITMAN REQUARDT & ASSOCIATES
RICHMOND, VA
STRUCTURAL ENGINEER

Scale: $\frac{3}{16}$" = 1'-0"

PRELIMINARY PLANS
THESE PLANS NOT TO BE USED FOR CONSTRUCTION

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No.	Description	Date
	Revisions	

COMMONWEALTH OF VIRGINIA
DEPARTMENT OF TRANSPORTATION

STRUCTURE AND BRIDGE DIVISION

PIER 1 WIDENING
DETAILS

Designed: WRA Drawn: WRA Checked: WRA	Date	Plan No.	Sheet No.
	Nov. 2021	257-38A	26 of 93

PROGRESS PRINT 2021-11-17

STATE	FEDERAL AID		STATE		SHEET NO.
	ROUTE	PROJECT	ROUTE	PROJECT	
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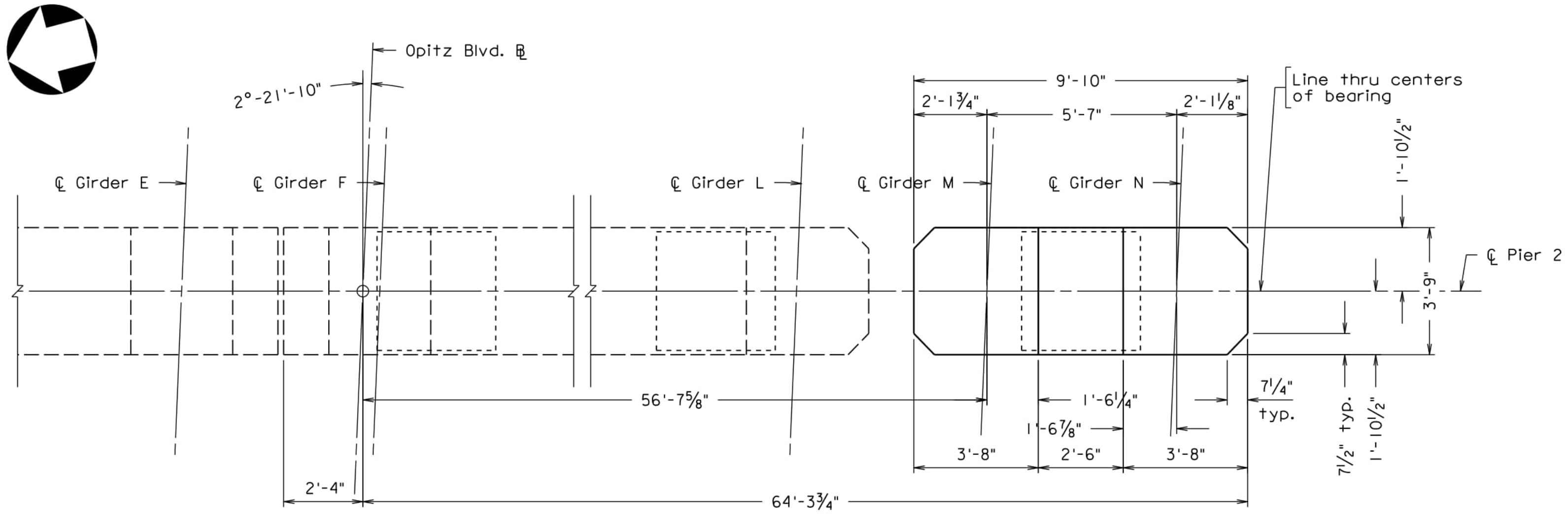
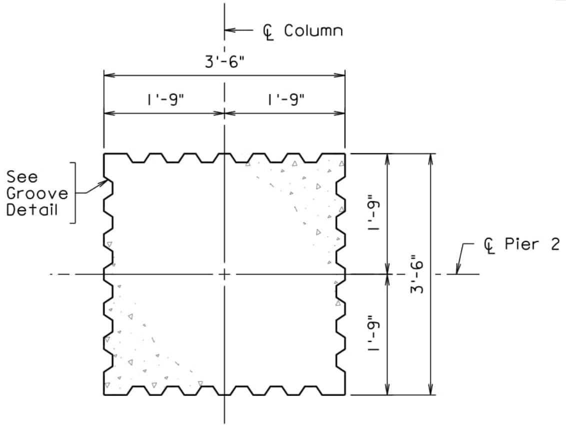
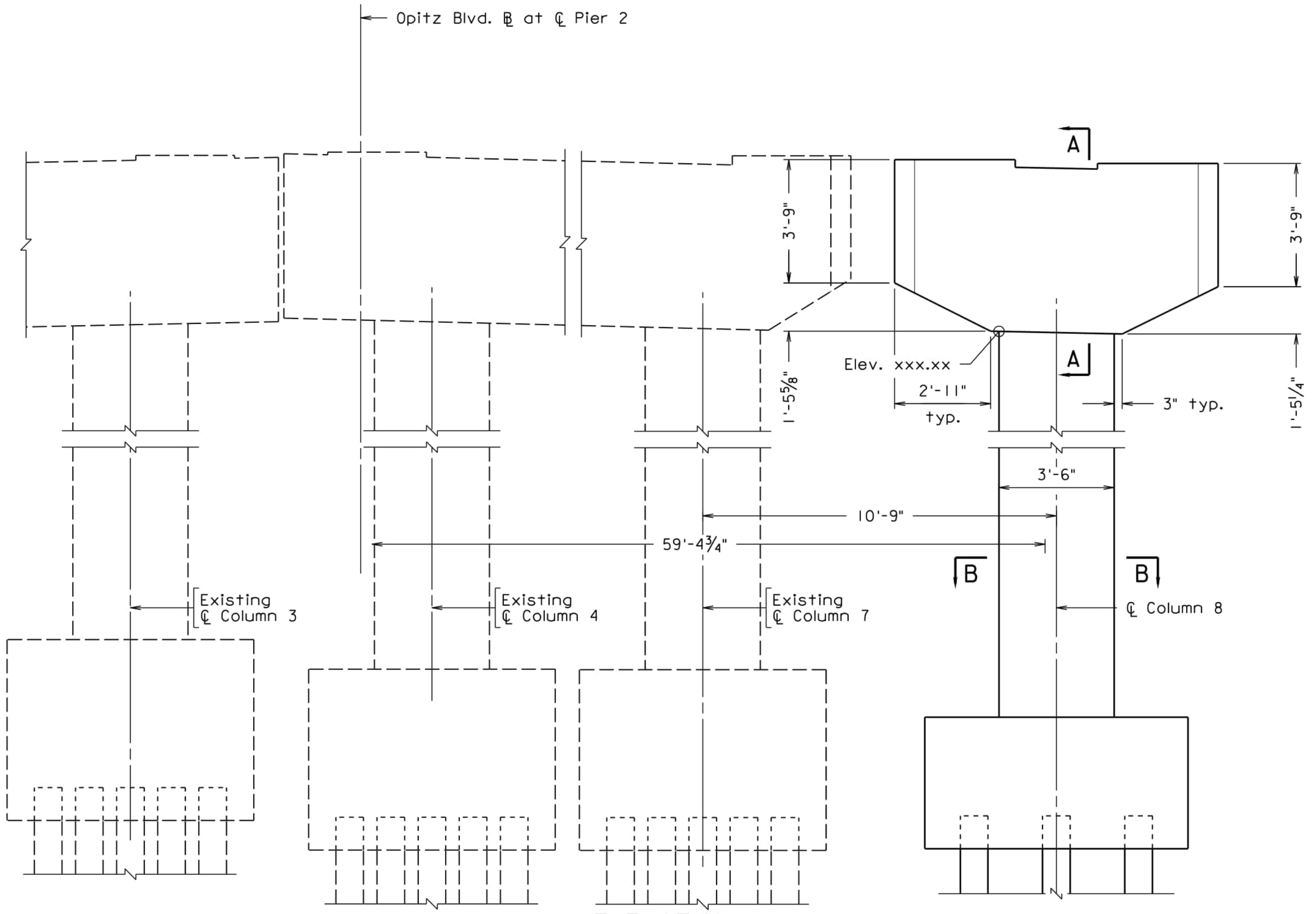


PLAN



SECTION B-B



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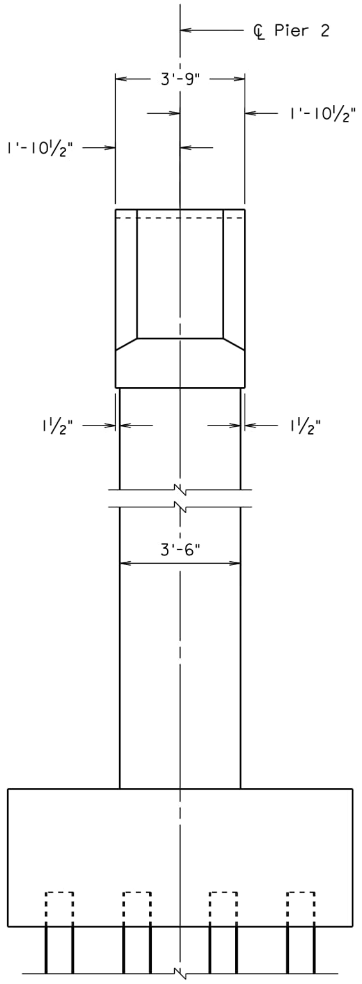
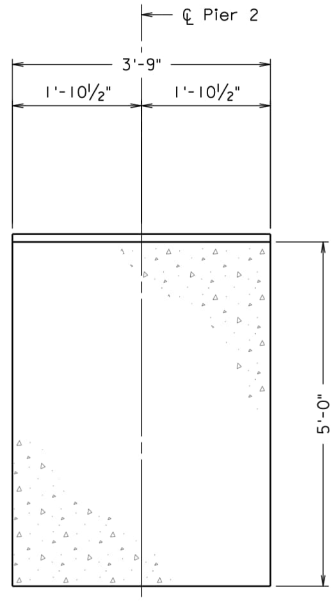


END VIEW



SECTION A-A

Scale: $\frac{3}{16}$" = 1'-0"

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PIER 2 WIDENING DETAILS

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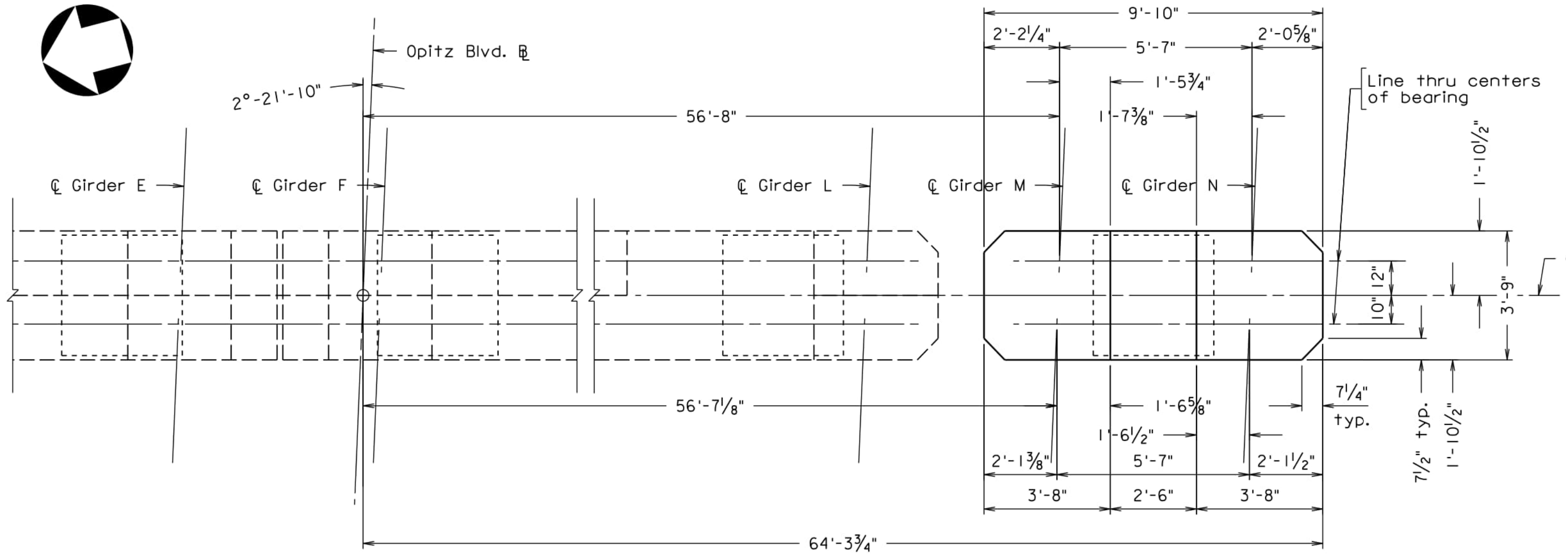

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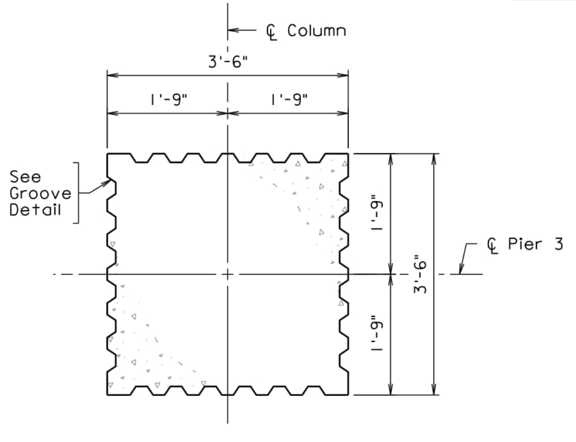

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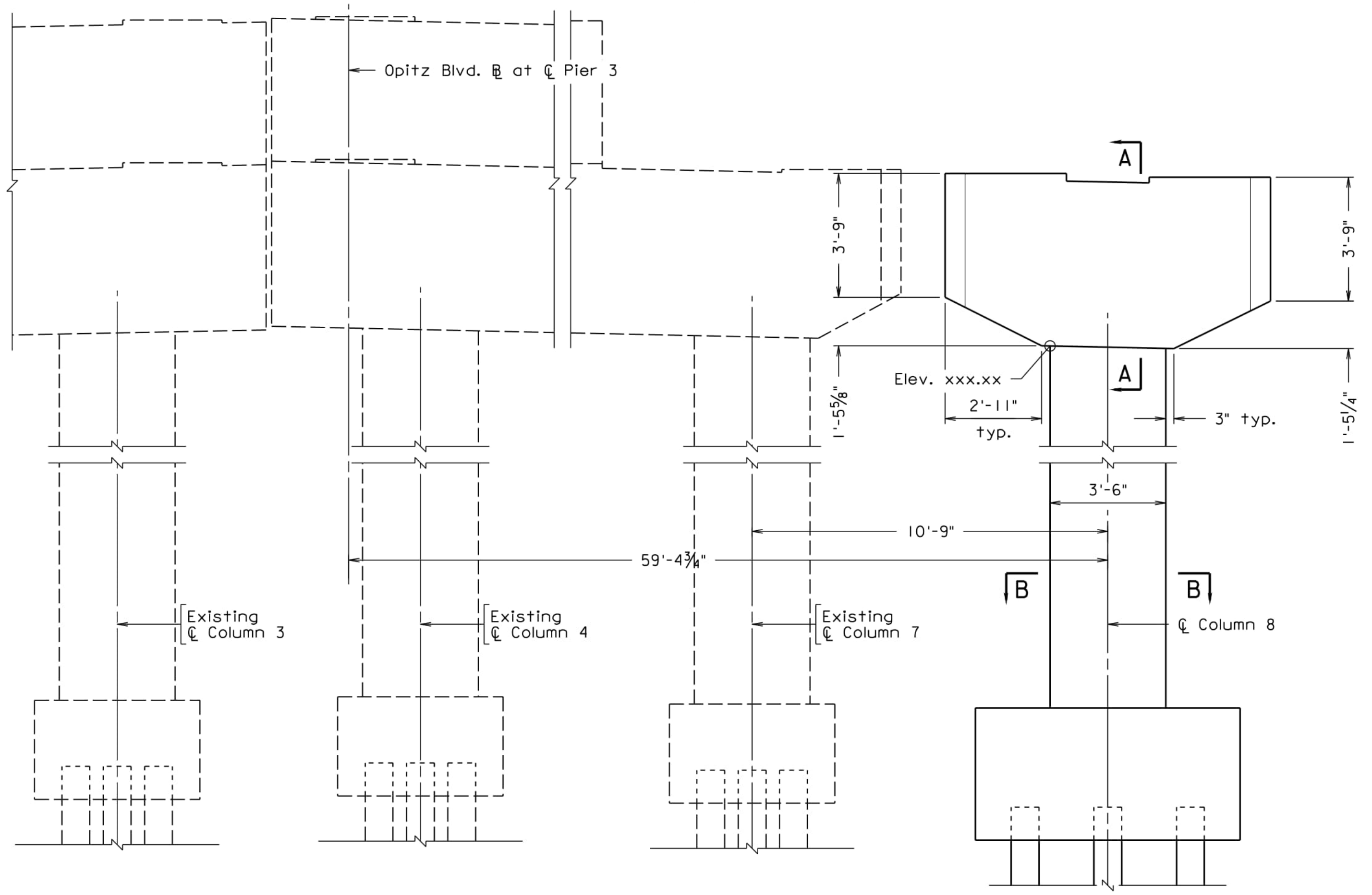

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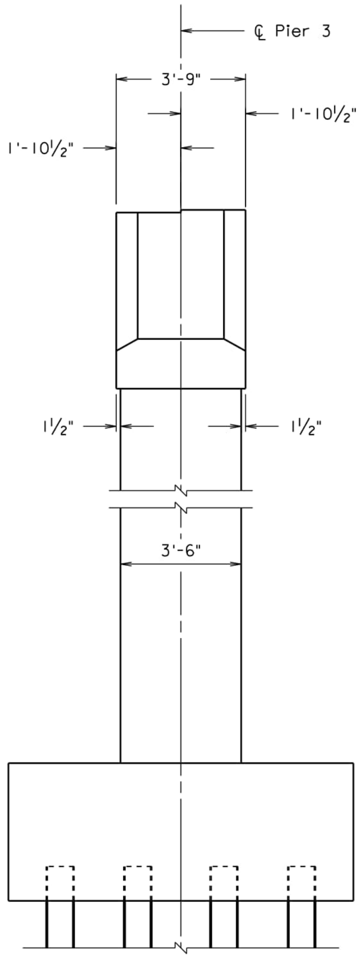

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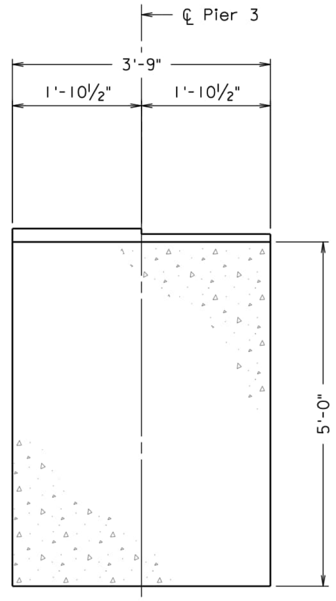

SECTION A-A

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Scale: $\frac{3}{16}$" = 1'-0"

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PIER 3 WIDENING DETAILS

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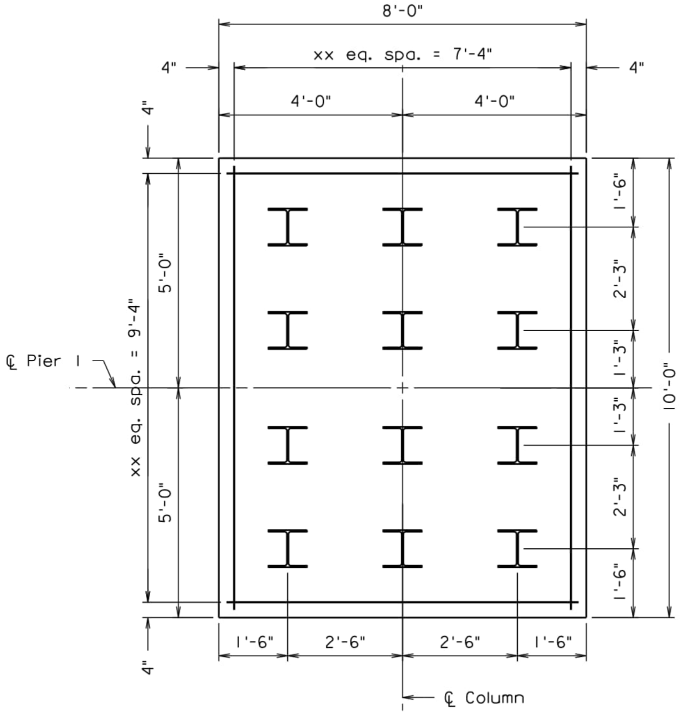
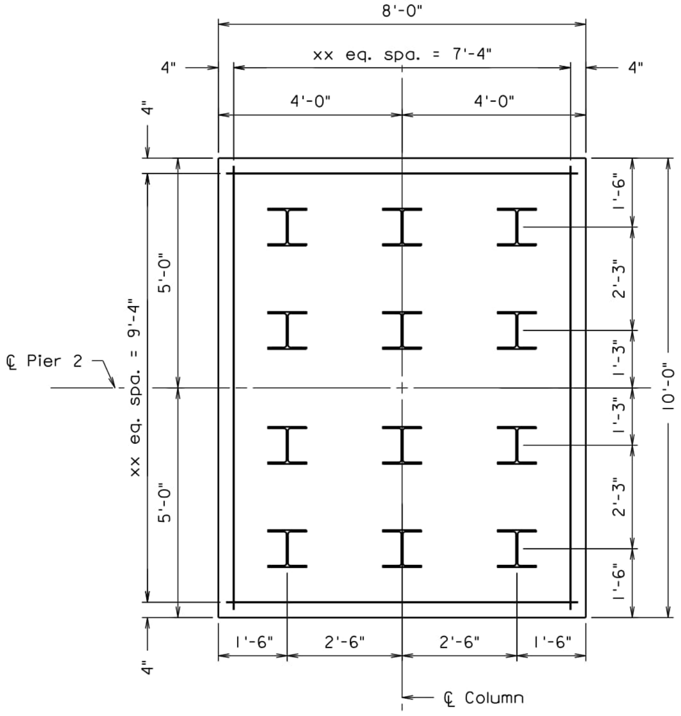
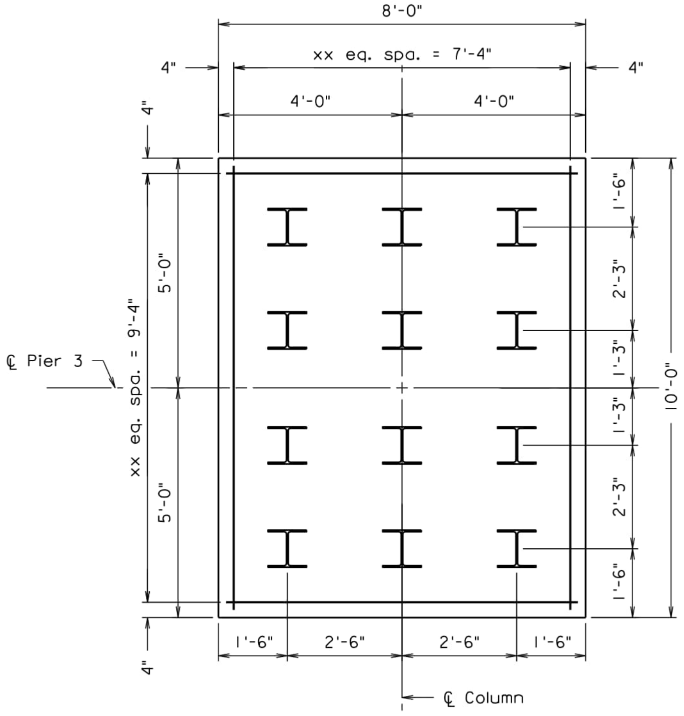
VA.	—		2000	0095-076-299, B688	29



PIER 1
FOOTING PLAN



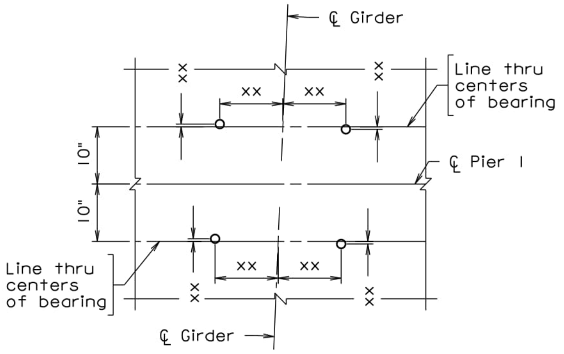
PIER 2
FOOTING PLAN



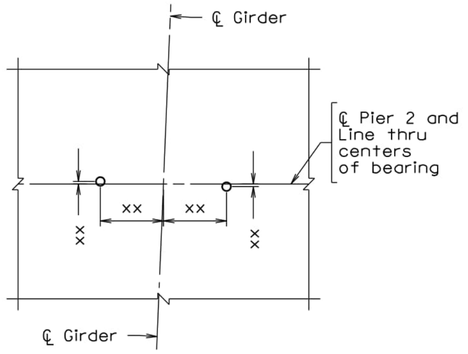
PIER 3
FOOTING PLAN

Notes:

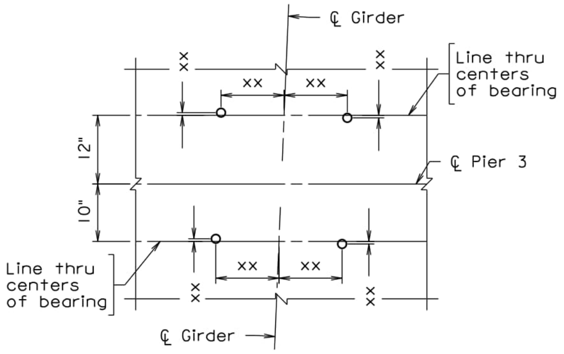
xxx



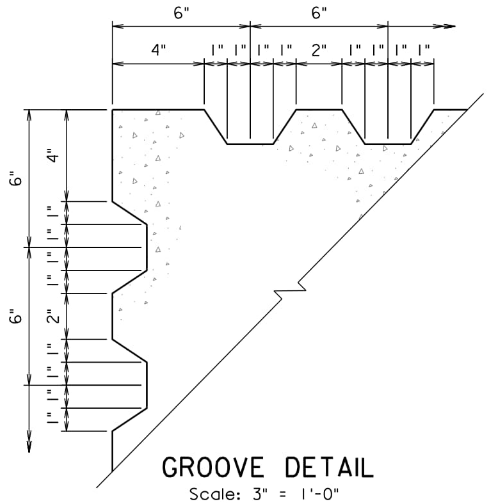
PIER 1 ANCHOR BOLT LAYOUT
Scale: ¾" = 1'-0"



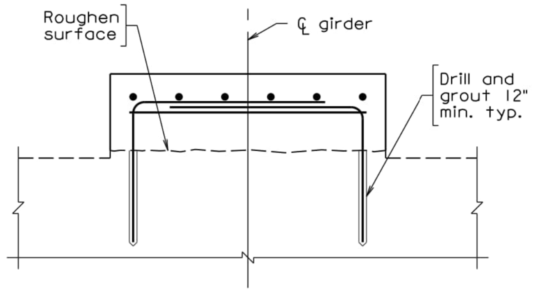
PIER 2 ANCHOR BOLT LAYOUT
Scale: ¾" = 1'-0"



PIER 3 ANCHOR BOLT LAYOUT
Scale: ¾" = 1'-0"



GROOVE DETAIL
Scale: 3" = 1'-0"



TYPICAL SEAT BUILDUP DETAIL
Not to scale

Scale: ½" = 1'-0" unless otherwise noted.

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MISCELLANEOUS PIER DETAILS

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APPENDIX A.4

Selected Plans – MSE & SPL Walls

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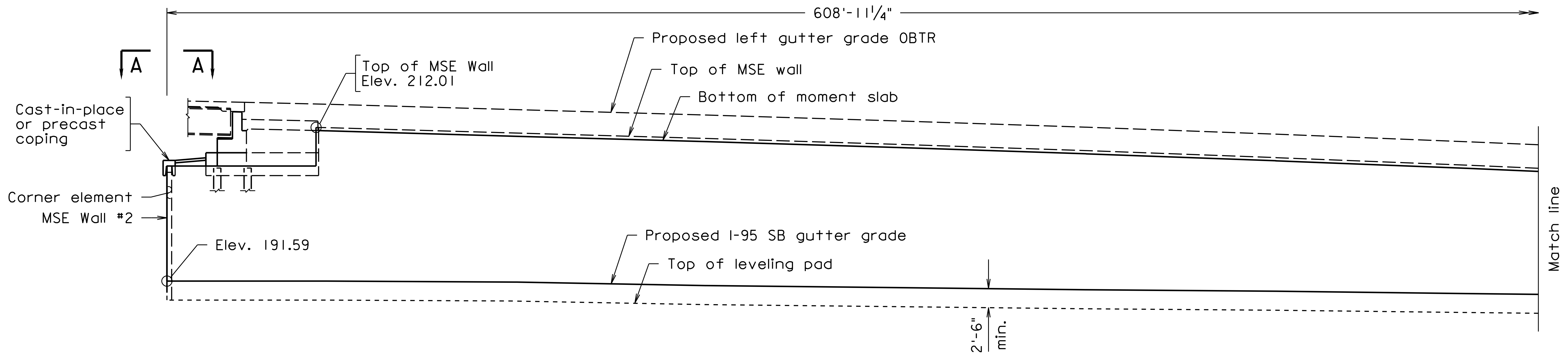
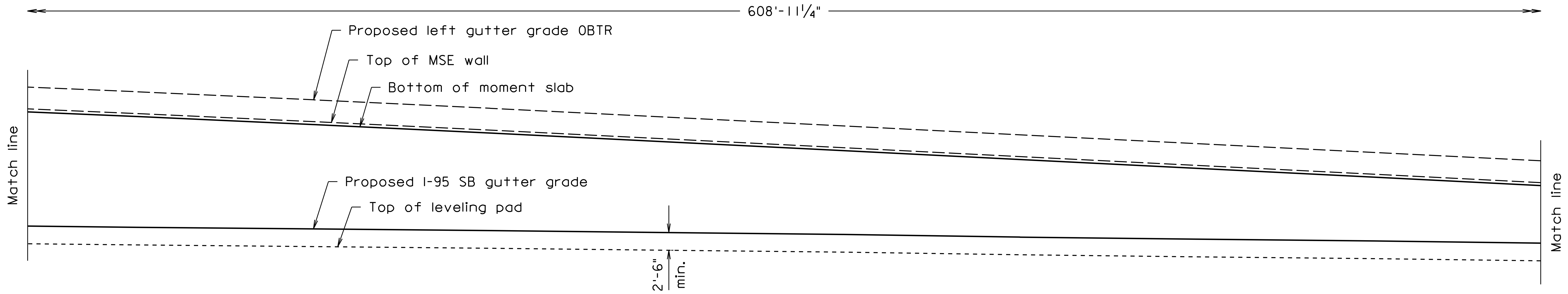
	ROUTE	PROJECT	ROUTE	PROJECT	
VA.	—		2000	0095-076-299, B688	00



MSE WALL #1 ELEVATION
Barriers not shown for clarity



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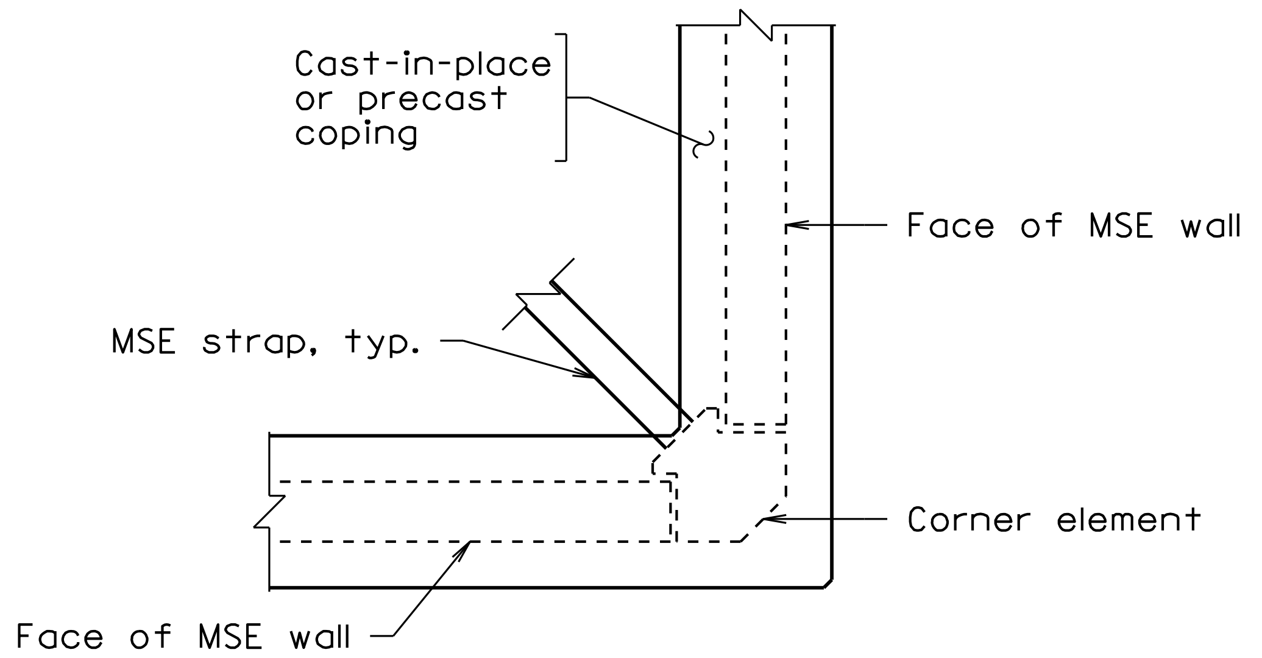
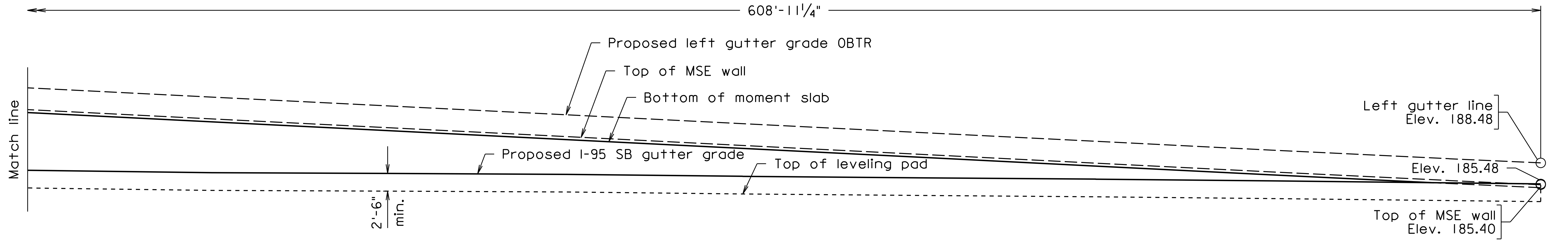


VIEW A-A
Scale: ½" = 1'-0"



MSE WALL #1 ELEVATION
Barriers not shown for clarity

MSE Wall Detail 1 of 2.dgn

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MSE WALL ELEVATIONS
WALL #1

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STATE	FEDERAL AID		STATE		SHEET NO.
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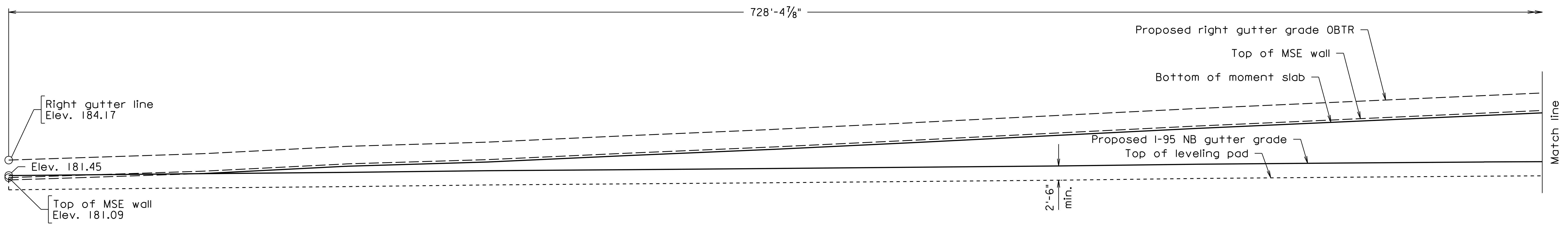
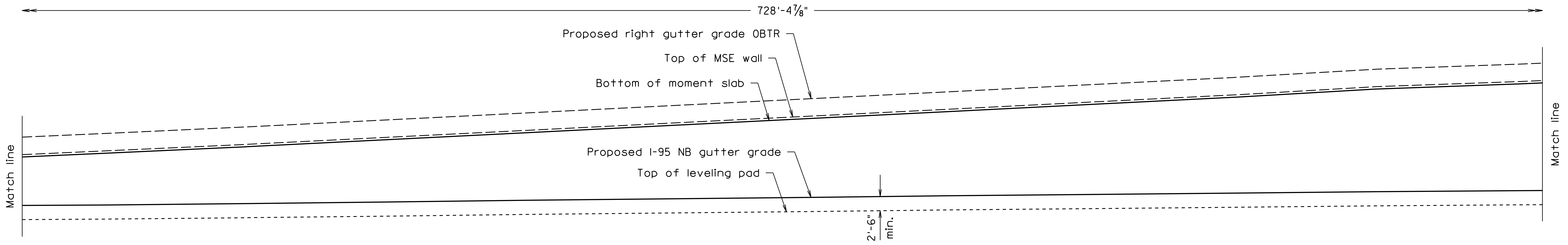
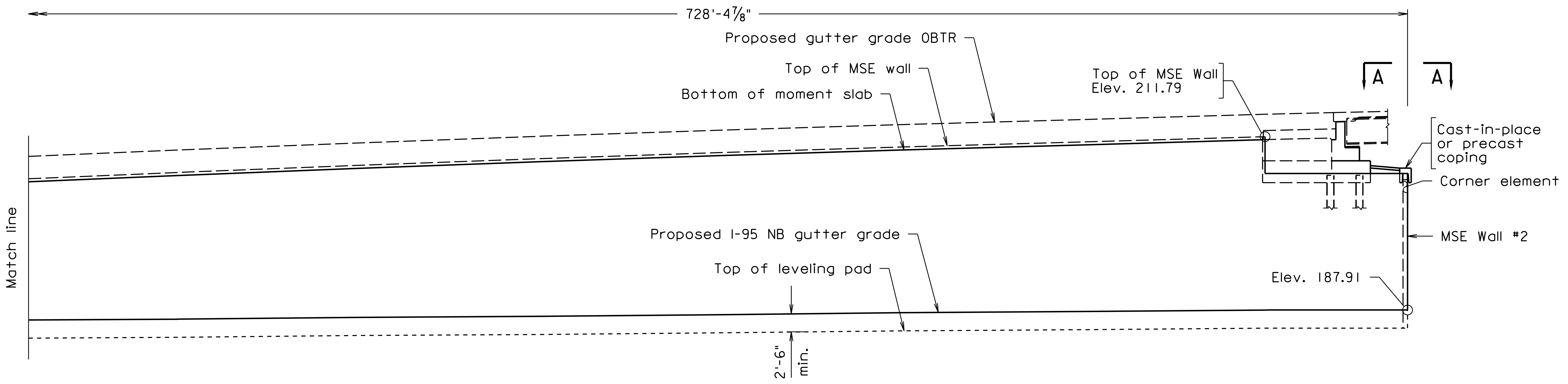
VA.	—		2000	0095-076-299, B688	00



MSE WALL #3 ELEVATION
Barriers not shown for clarity



MSE WALL #3 ELEVATION
Barriers not shown for clarity



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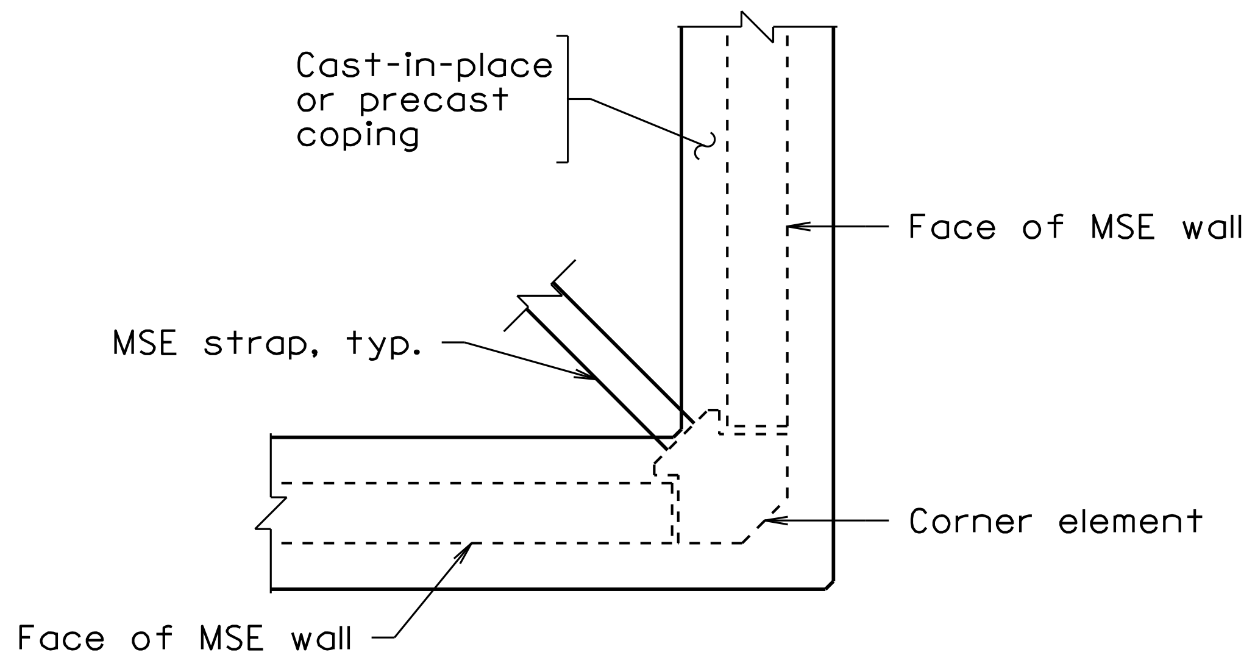

VIEW A-A
Scale: ½" = 1'-0"

MSE Wall Detail 2 of 2.dgn

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MSE WALL ELEVATIONS
WALL #3

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Checked: X.X.X.

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VA.	—		2000	0095-076-299, B688	00

Notes:

The minimum design life of MSE wall shall be (100-year).

The anticipated MSE wall total settlement is _X_ inches and differential settlement is _X_.

For bearing resistance requirements, see the MSE Wall Bearing Resistance Data Table.

For settlement requirements, see the Estimated Wall Settlement Table.

Vertical slip joints shall be placed in the wall at intervals not to exceed _X_ ft. between Sta XX+XX.XX and Sta XX+XX.XX

Prior to wall construction, the foundation shall be compacted with a smooth wheel vibratory roller weighting 10 tons minimum. The drums of the roller should be ballasted, and each pass of the roller should overlap one half the width of the previous pass. The roller shall make at least ten passes over the proposed wall foundation zone. No density test will be required. Any foundation soils found to be unsuitable and/or unstable shall be removed and replaced with select material Type I minimum CBR of 30. Compact the foundation area according to the VDOT Specifications.

Remove unsuitable or unstable foundation material below the bottom of the wall and replace with select material prior to wall construction. Compact the foundation area according to the VDOT Specifications.

The minimum required depth of undercut shall be _X_ ft. between Sta XX+XX.XX and Sta XX+XX.XX

The estimated required depth of unsuitable material to be removed is shown on the plans. The lateral limits of excavation are dependent on the depth at a particular location below the wall. Additional localized excavation may be required depending on the site conditions at the time of construction.

Minimum panel design thickness is 5.5 inches. Thickness of concrete must increase to accommodate any architectural surface finish that may be specified.

Concrete in moment slabs and parapet/railing shall be Low Shrinkage Class A4 Modified.

Corrosion Resistant Reinforcing (CRR) steel shall be used in moment slab and shall be the same type of corrosion resistant reinforcing steel specified for parapet/railing.

Class I CRR steel shall be used in copings.

Class I CRR steel shall be used in portions of MSE Wall panels within splash zone as shown on plans.

An impervious membrane shall be placed below the pavement and just above the first row of reinforcement. The membrane shall be sloped to drain away from the facing to an intercepting longitudinal drain outlet beyond the reinforced zone.

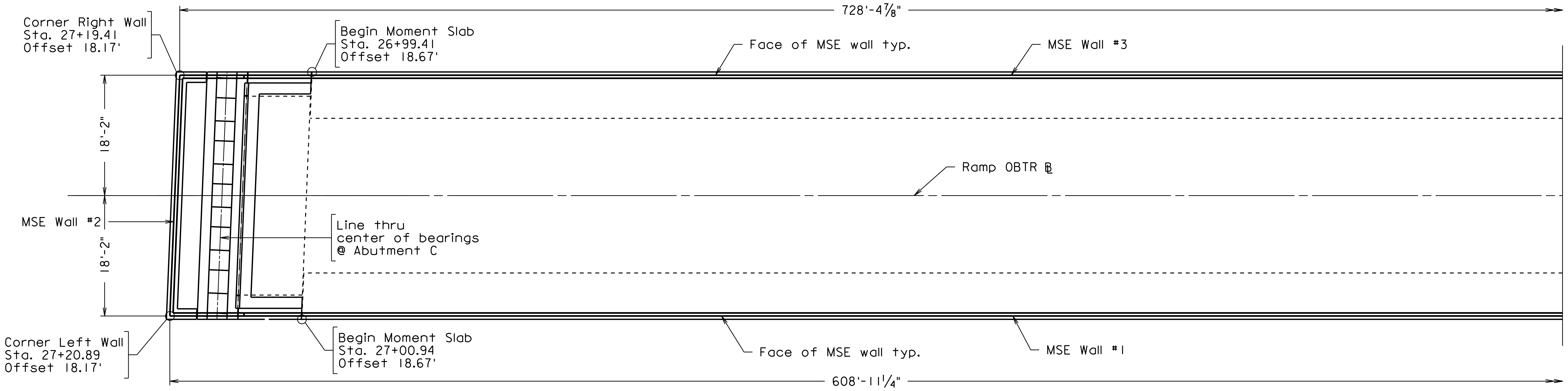
A non-woven geotextile shall be used as a separator between the mechanically stabilized earth mass and the subbase.

(Coping) (parapet) (moment slab) shall not be placed until _X_ days after wall completion have elapsed.

The selected wall supplier will submit a detailed design and shop drawings for approval.

Provide drainage details such as perforated pipe underdrain and/or drainage blanket based upon field conditions. For wall installation at stream crossing, provide adequate drainage so the difference between streambed and saturated backfill is not greater than what is considered in the design.

All panel types and other related elements shall be detailed on shop drawings.



MSE WALL LAYOUT - ABUTMENT AND APPROACH RAMP

MSE Wall Layout 1 of 2.dgn

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MSE WALL LAYOUT (1 OF 2)
ABUTMENT C AND APPROACH

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	ROUTE	PROJECT	ROUTE	PROJECT	
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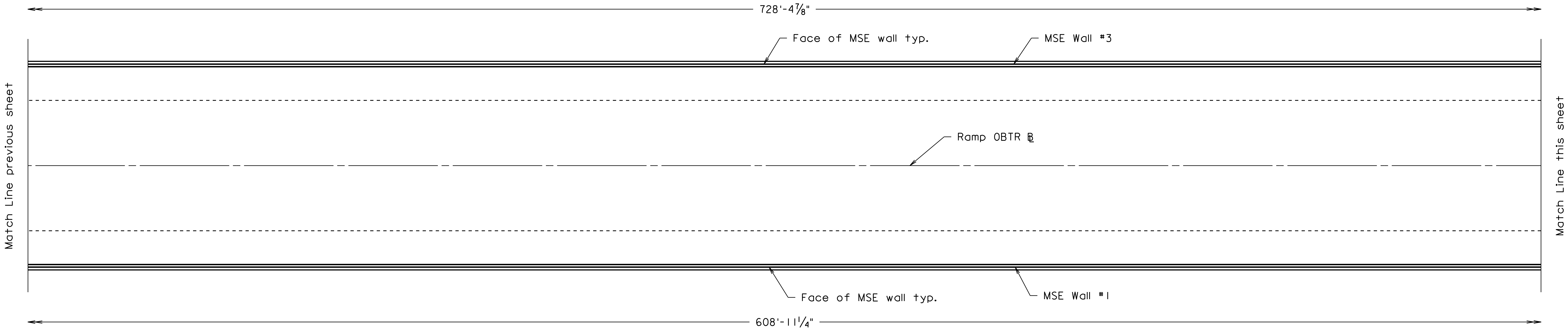
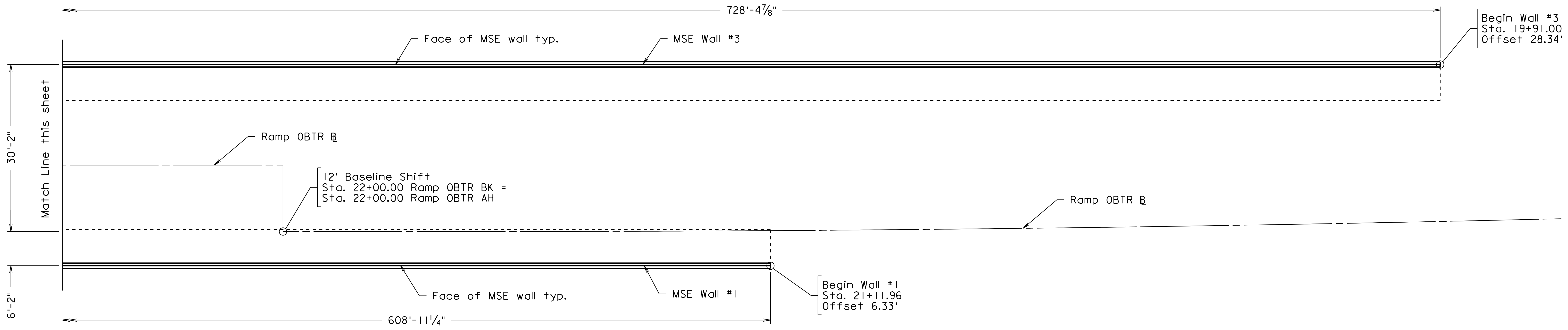


MSE WALL LAYOUT - ABUTMENT AND APPROACH RAMP



MSE WALL LAYOUT - ABUTMENT AND APPROACH RAMP

MSE Wall Layout 2 of 2.dgn

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MSE WALL LAYOUT (2 OF 2)
ABUTMENT C AND APPROACH

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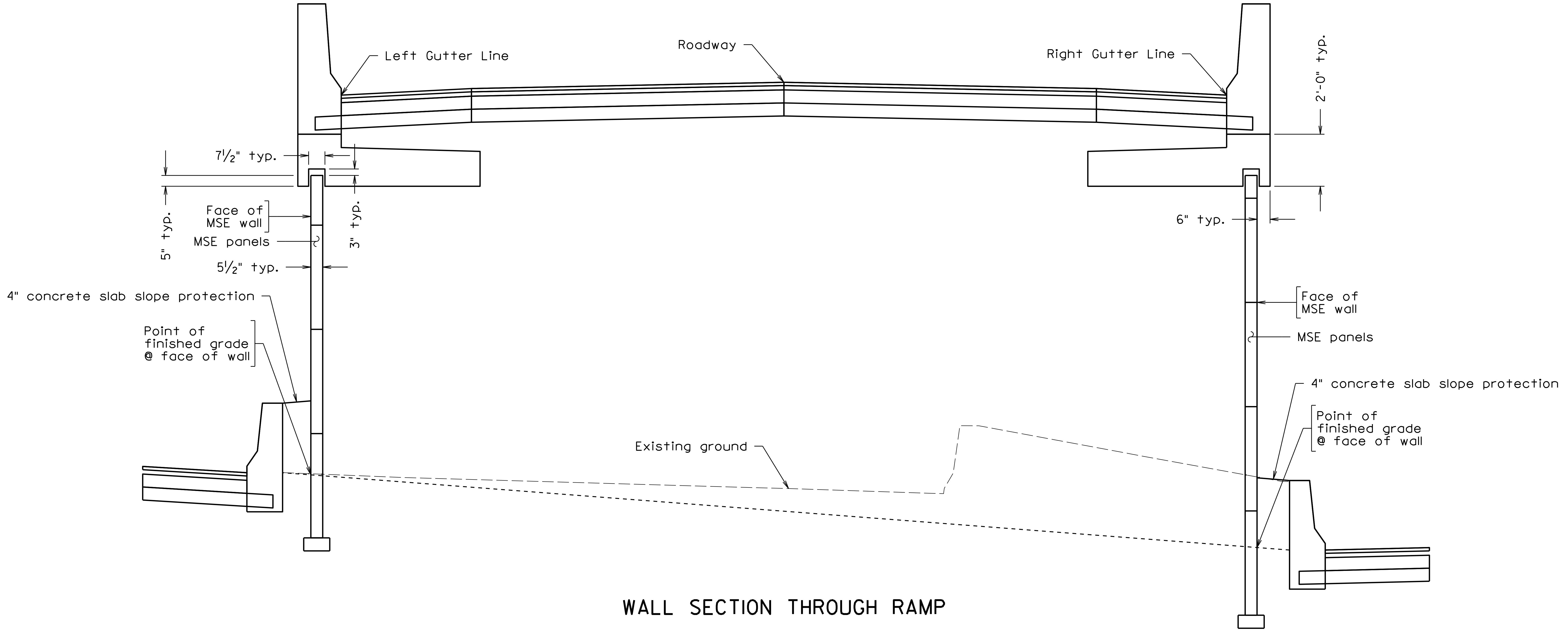
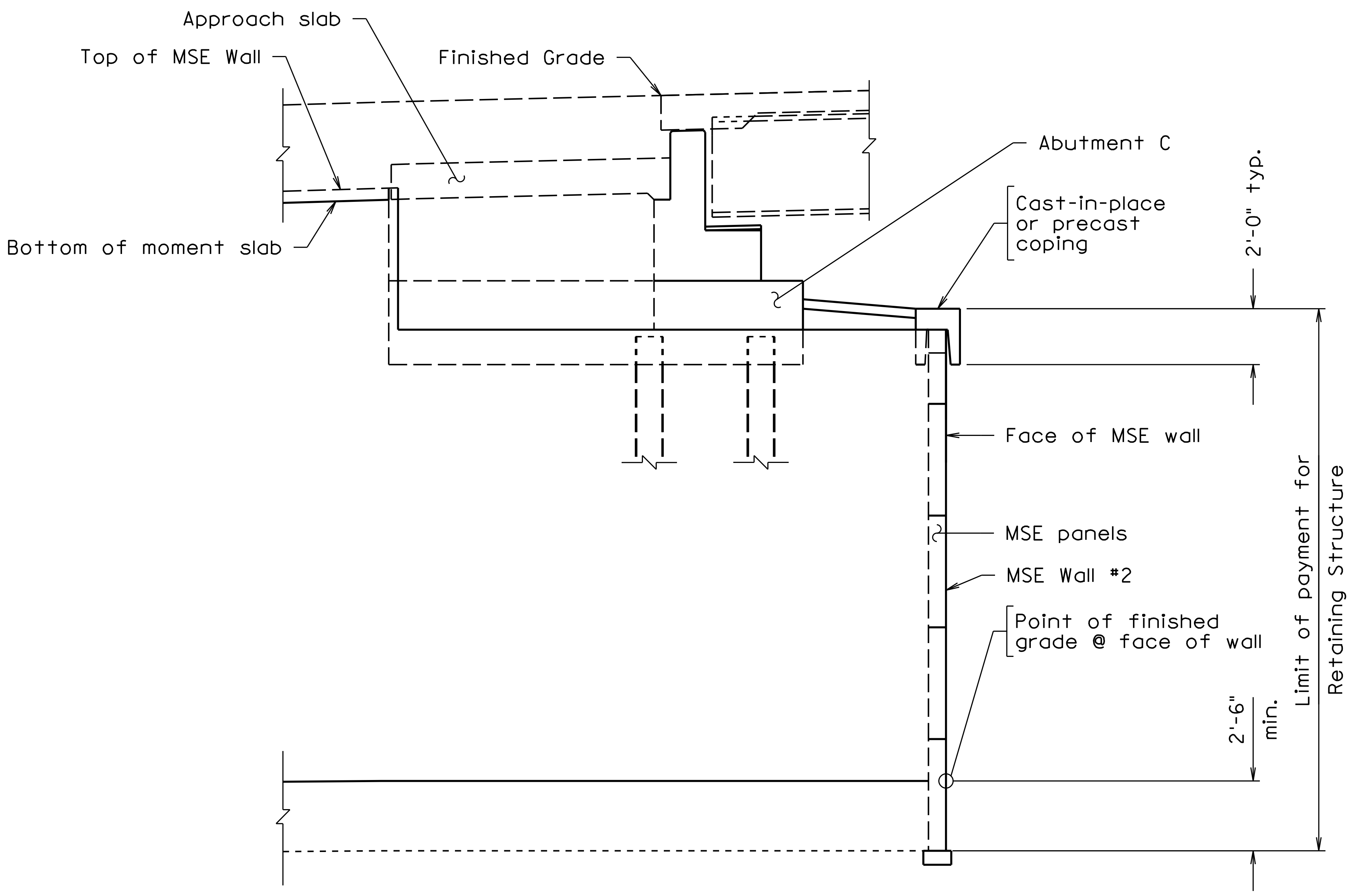


WALL SECTION THROUGH RAMP



ABUTMENT WALL SECTION

Scale: ¼" = 1'-0"

Scale: ⅜ " = 1'-0" unless otherwise noted.

MSE Wall Sections.dgn

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MSE WALL SECTIONS

	Date	Plan No.	Sheet No.
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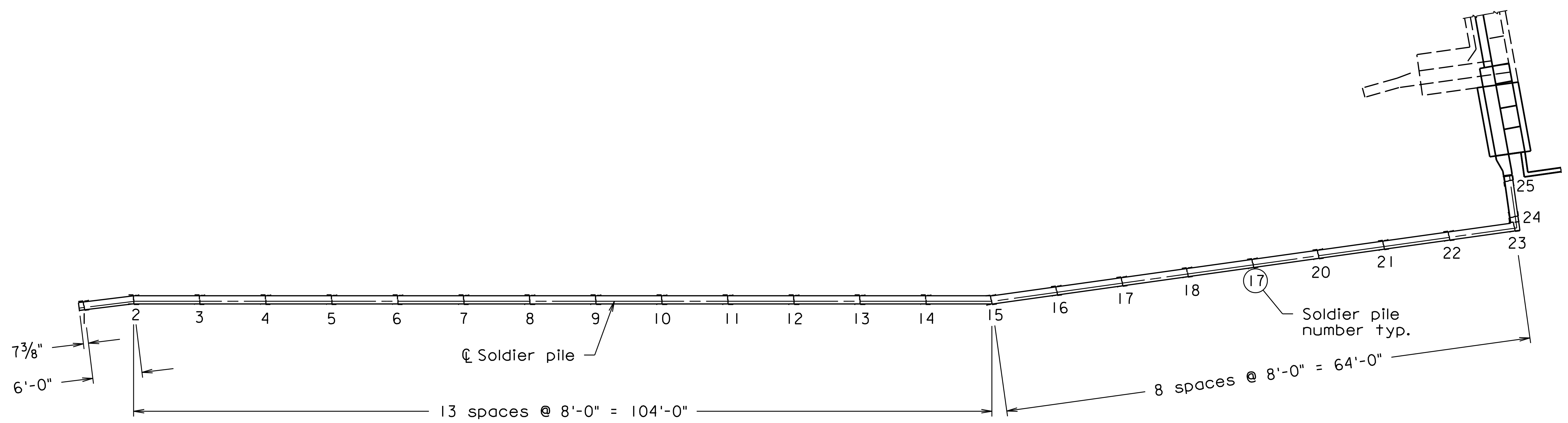
VA.	—		2000	0095-076-299, B688	XXb

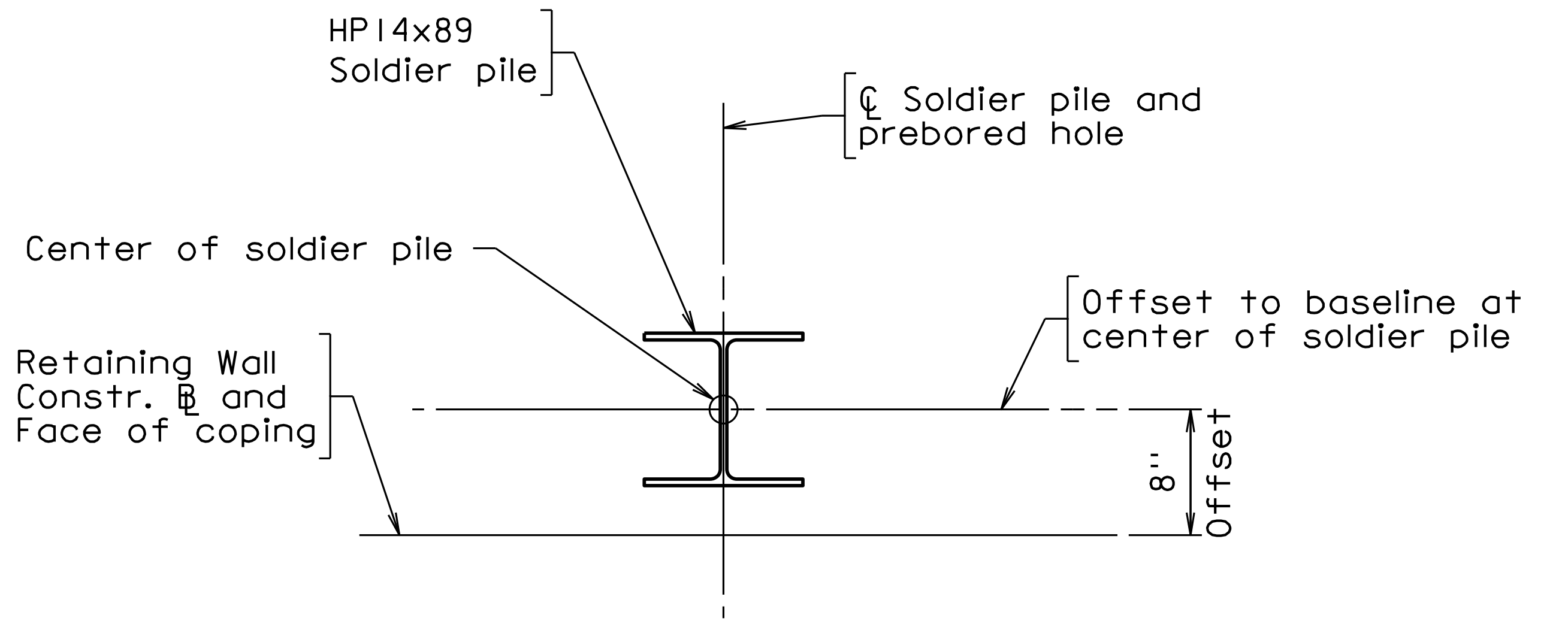
Notes:

For abutment details, including connection to wingwall see bridge plans.

Soldier piles shall be driven to or below the minimum tip elevation. A template and pile driving equipment with a fixed lead shall be used for the installation accuracy. The driving hammer shall be powerful enough to drive HP14x89 piles to the required depths into stiff residual soils and decomposed rock.



SOLDIER PILE LOCATION PLAN



SOLDIER PILE SECTION

Scale: 1" = 1'-0'

SOLDIER PILE LOCATION DATA

Soldier pile no.	Station	Offset	Min. tip elev.
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			
21			
22			

SUGGESTED SEQUENCE OF CONSTRCTION AND GENERAL REQUIREMENTS:

1. Clear and grub the area for the wall construction.

2. Place all erosion and sediment perimeter controls in accordance with the approved erosion and sediment control plan. These controls shall remain in place and be continuously maintained during all construction.

3. Grade a bench along the proposed wall alignment wide enough to accommodate the pile driving equipment required to install the soldier piles for the retaining wall.

4. The wall shall be constructed in a top down manner to continually support the earth and roadway adjacent to the wall. For no reason shall an open unsupported excavation face be left unprotected.

5. Once the permanent concrete lagging panels are in place the Contractor shall place the #68 stone backfill between the temporary wood lagging and the permanent concrete lagging panels. This shall be done at the end of each working day. The stone backfill shall be protected at the surface by a geotextile fabric to prevent mud and silt from fouling the stone.

6. All excavation material shall be removed to an approved stockpile or disposal site.

7. The top coping and pile encasement shall be placed once the precast panels have been placed.

8. Once the precast panels have been placed the Contractor may grade the areas behind the top of the wall. Extreme care shall be taken so as not to damage the concrete wall construction.

Soldier_Pile_Layout-Plan.dgn

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SOLDIER PILE WALL PLAN
AND PILE SECTION

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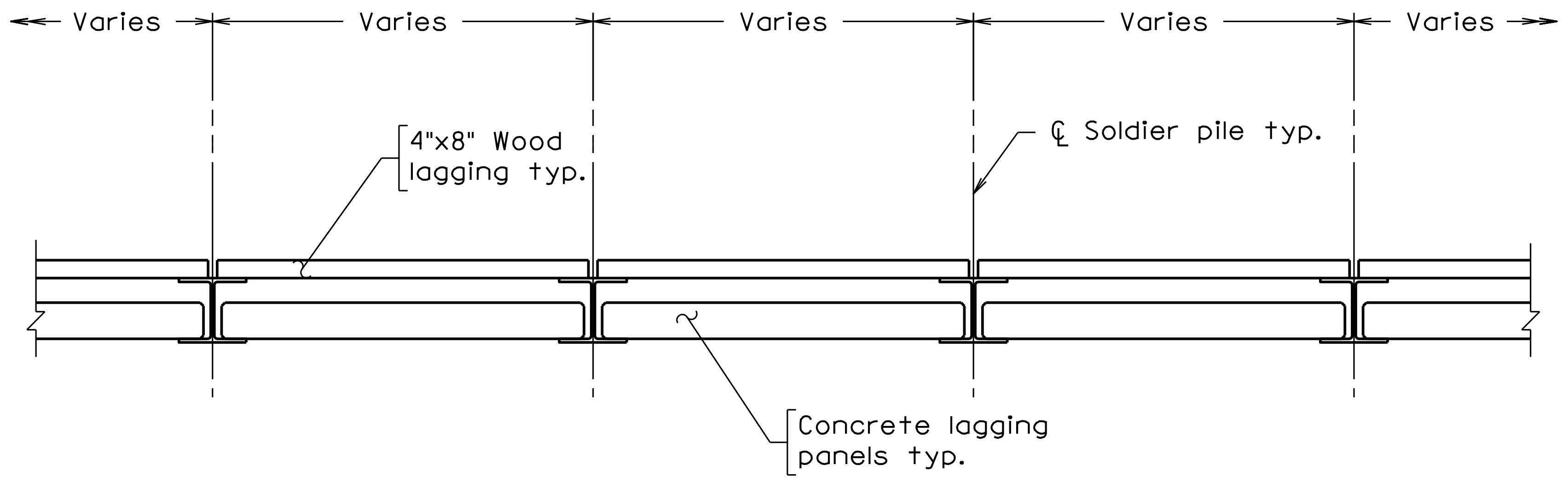
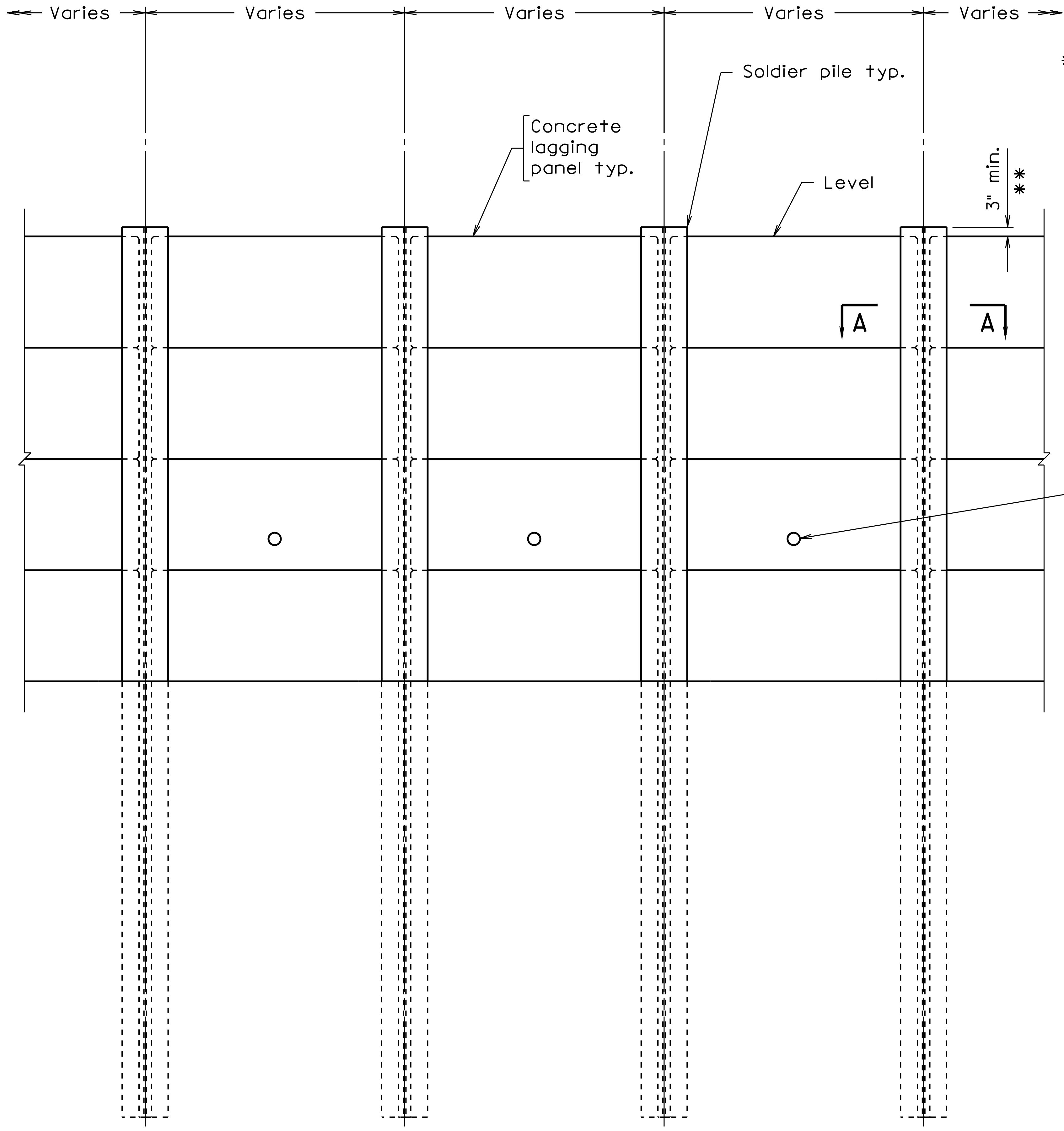
VA.	—		2000	0095-076-299, B688	26c



PART PLAN - LAGGING AND SOLDIER PILES

Scale: 3/8" = 1'-0"



**Contractor may vary this dimension to accommodate top of level lagging panel

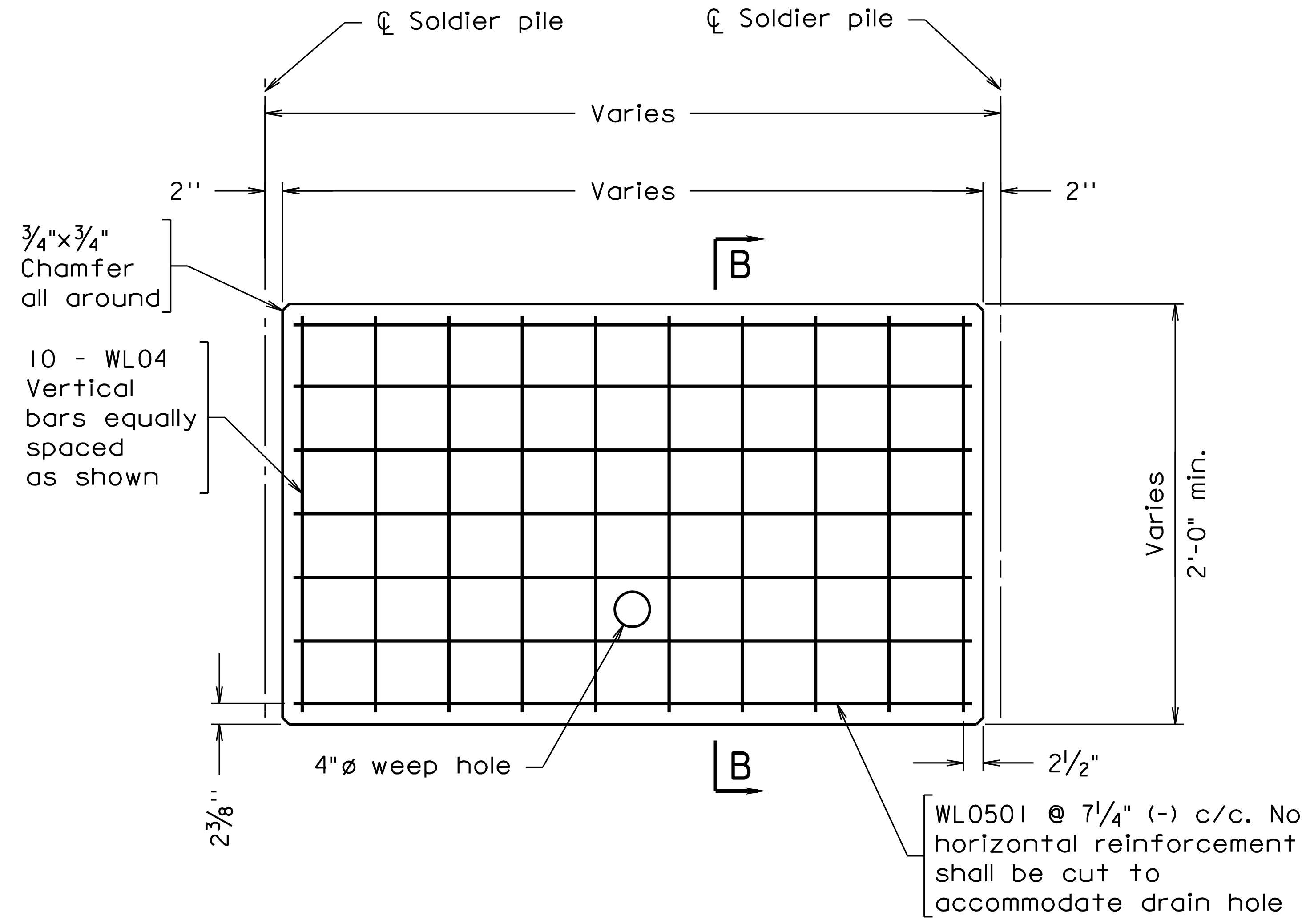
Note:

Concrete coping not shown for clarity

4"ø weep holes, one per bay loacted approximated 12" above finished grade

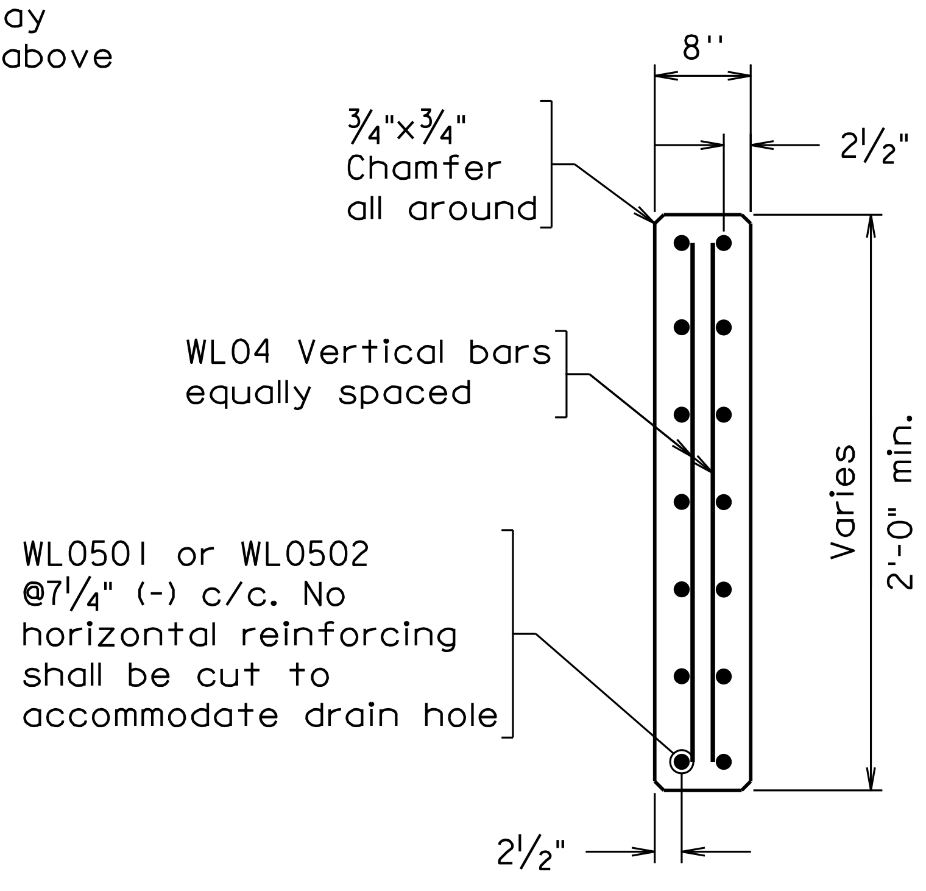
PART ELEVATION - LAGGING AND SOLDIER PILES

Scale: 3/8" = 1'-0"



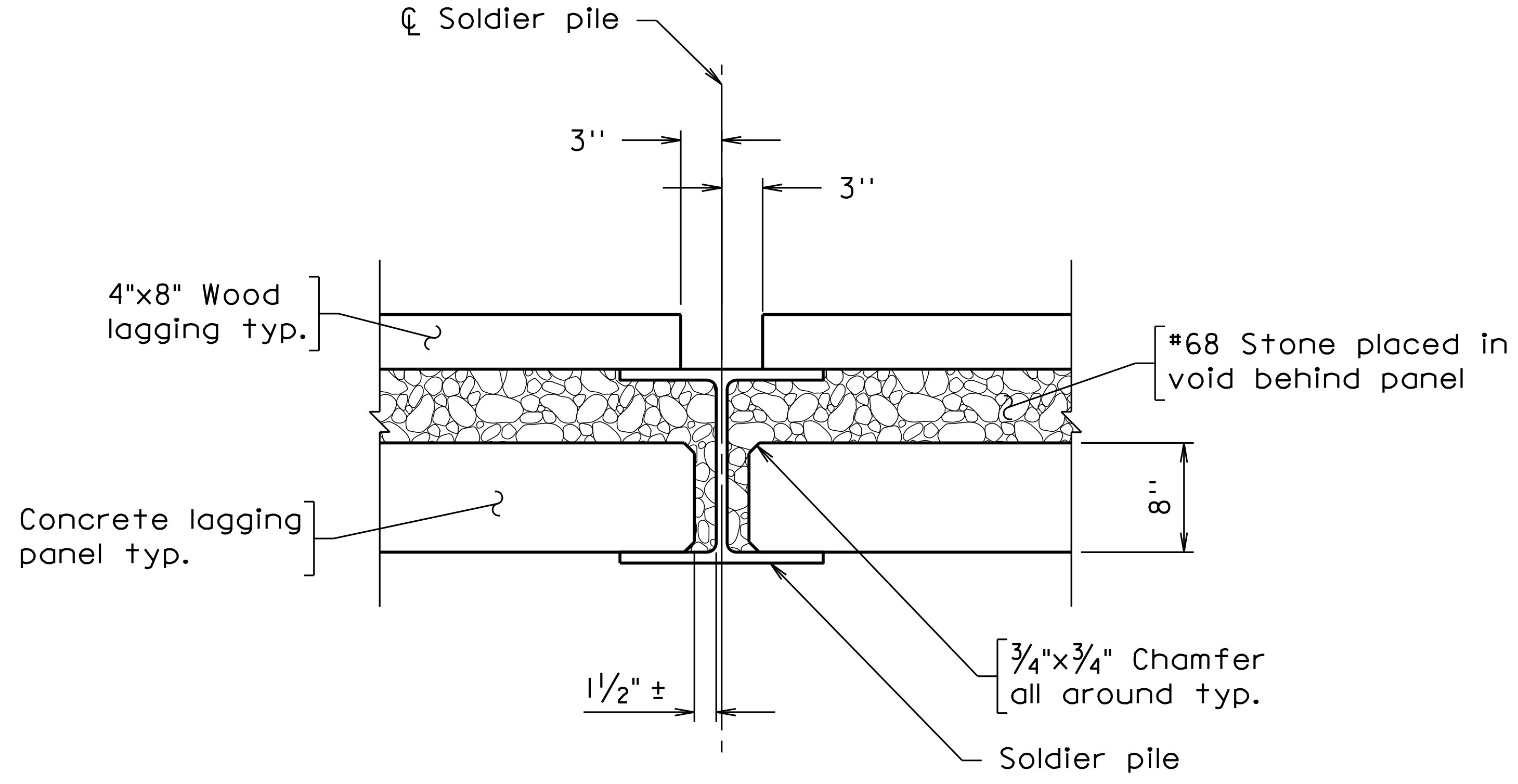
PRECAST CONCRETE LAGGING PANEL DETAILS

Scale: 3/4" = 1'-0"



SECTION B-B

Scale: 3/4" = 1'-0"



SECTION A-A

Scale: 1" = 1'-0"

Soldier_Pile_Wall_Details.dgn

WHITMAN REQUARDT & ASSOCIATES
RICHMOND, VA
STRUCTURAL ENGINEER

PRELIMINARY PLANS

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No.	Description	Date
Revisions		

COMMONWEALTH OF VIRGINIA
DEPARTMENT OF TRANSPORTATION

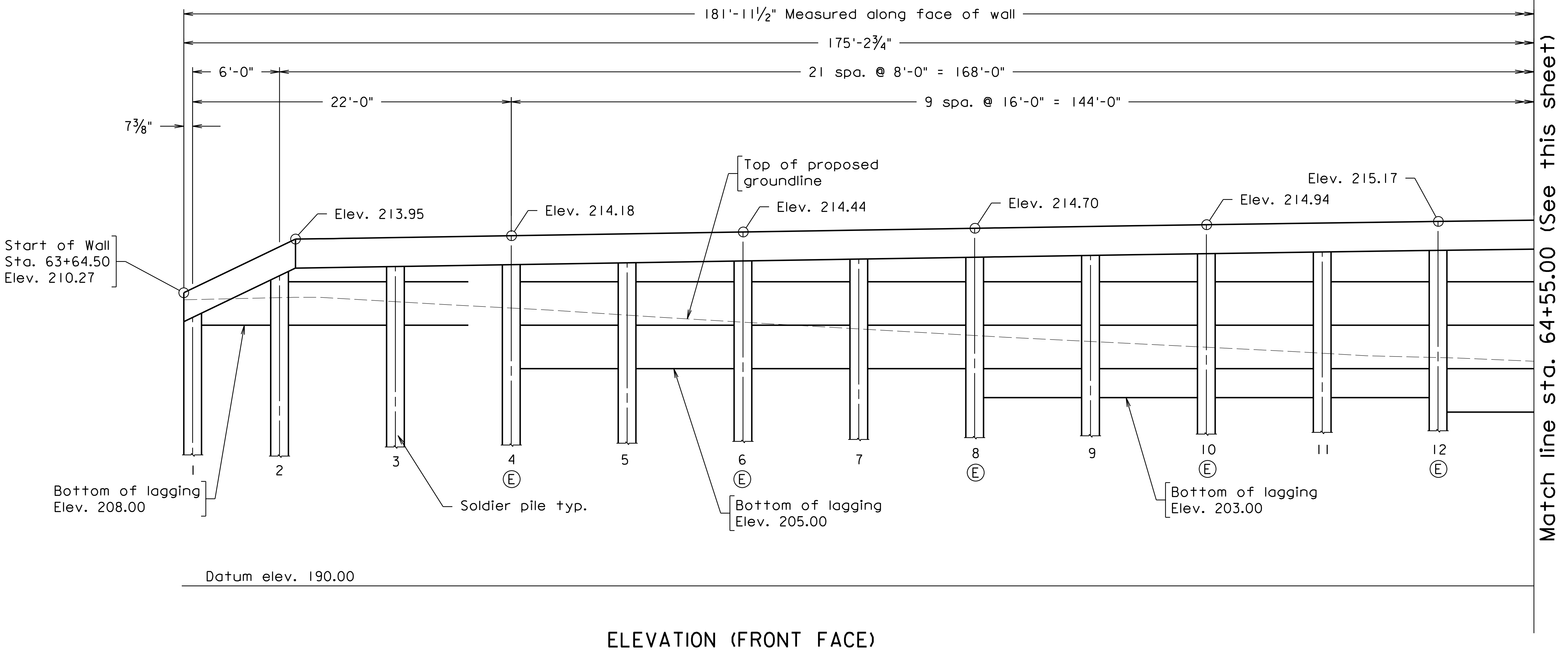
STRUCTURE AND BRIDGE DIVISION

SOLDIER PILE AND
LAGGING DETAILS

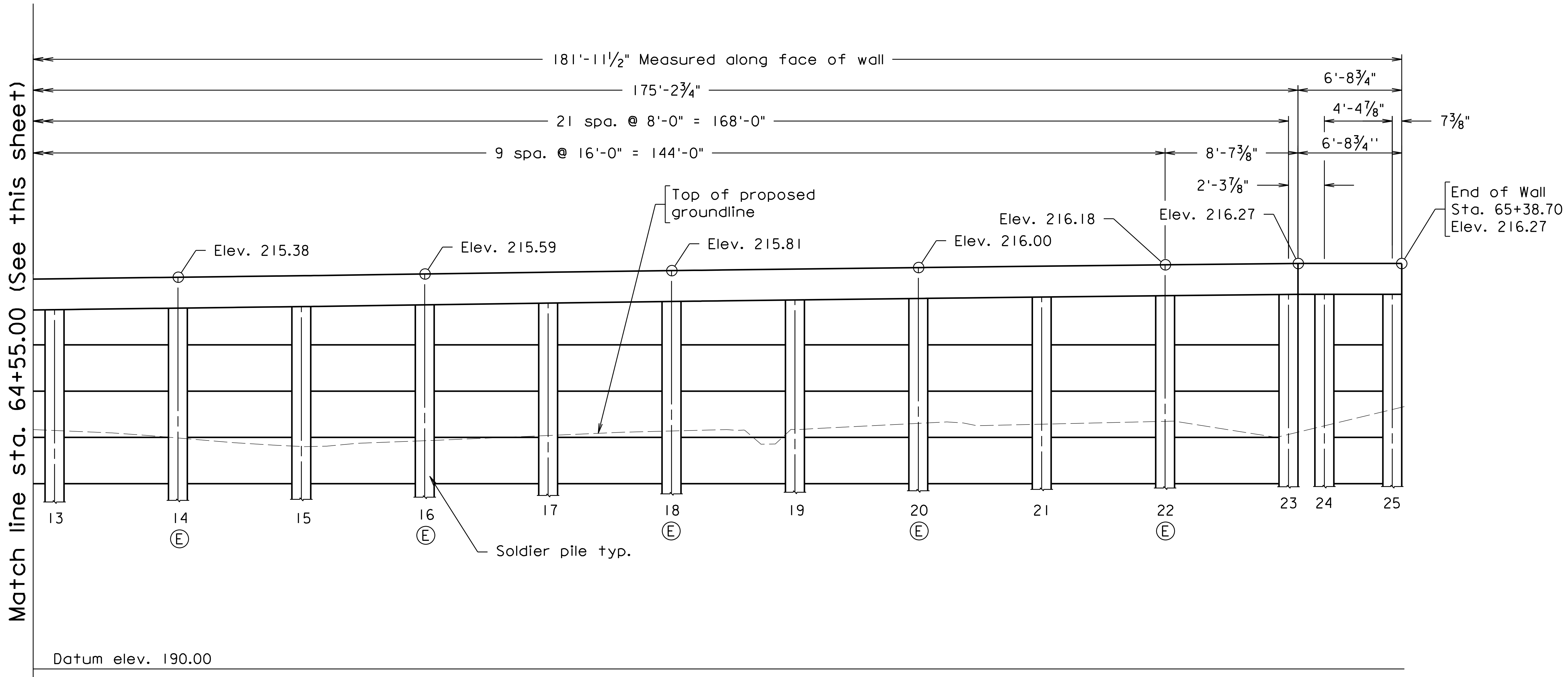
Designed: X.R.M. Drawn: X.R.M. Checked: X.A.B.	Date	Plan No.	Sheet No.
	Nov. 2021	251-38A	26c of 98

PROGRESS PRINT 2021-11-17

STATE	FEDERAL AID ROUTE	FEDERAL AID PROJECT	STATE ROUTE	STATE PROJECT	SHEET NO.
VA.	—		2000	0095-076-299, B688	XXa



ELEVATION (FRONT FACE)



ELEVATION (FRONT FACE)

GENERAL NOTES:

Specifications:

Construction: Virginia Department of Transportation Road and Bridge Specifications, 2020

Design: AASHTO LRFD Bridge Design Specification, 8th Edition, 2017 and VDOT Modifications

Standards: Virginia Department of Transportation Road and Bridge Standards, 2016, including all current revisions

These plans are incomplete unless accompanied by the Supplemental Specifications and Special Provisions included in the contract documents.

For additional requirements, refer to the Special Provision titled "Soldier Pile Precast Panel Retaining Wall."

All structural steel shall be ASTM A709 Grade 50 and shall be galvanized in accordance with the Special Provision.

All concrete shall be Class A4.

All reinforcing steel shall be deformed and shall conform to ASTM A615, Grade 60 except for reinforcing steels noted as CRR (corrosion resistant reinforcement) which shall conform to the applicable specifications noted in the special provision. All reinforcing bar dimensions on the detailed drawings are to centers of bars except where otherwise noted and are subject to fabrication and construction tolerances.

Corrosion resistant reinforcing (CRR) steels shall conform to one or more of the three types (low carbon/chromium, stainless clad and solid stainless) listed in the special provision. The minimum yield strength shall be: 100 ksi for low carbon/chromium and 60 ksi for stainless clad steel and solid stainless steel.

LEGEND:

Ⓔ = Expansion joint

Soldier_Pile_Wall_Elevation.dgn

WHITMAN REQUARDT & ASSOCIATES
RICHMOND, VA
STRUCTURAL ENGINEER

Scale: $\frac{3}{16}$" = 1'-0" unless otherwise noted.

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No.	Description	Date

Revisions

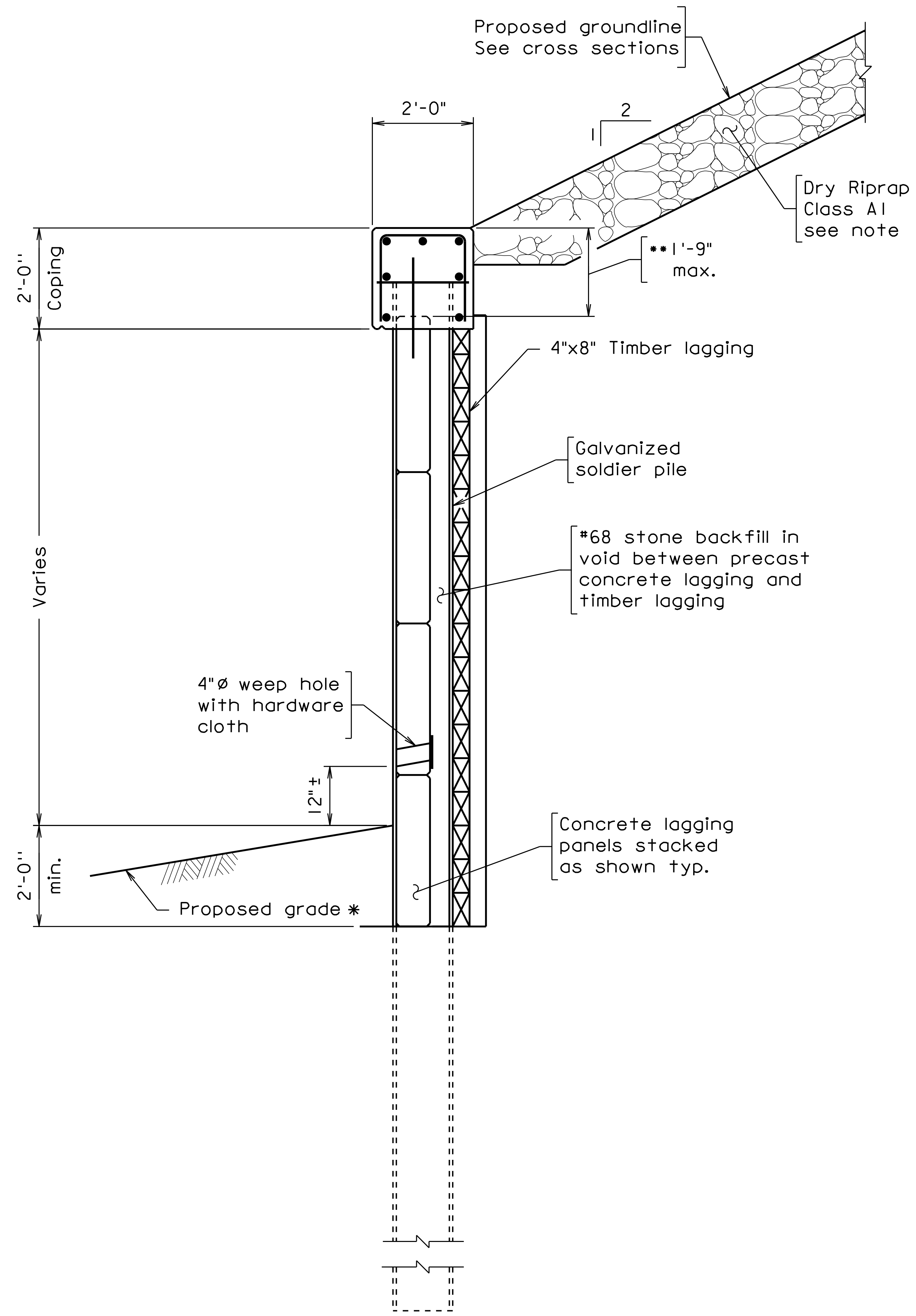
COMMONWEALTH OF VIRGINIA
DEPARTMENT OF TRANSPORTATION
STRUCTURE AND BRIDGE DIVISION

SOLDIER PILE WALL
ELEVATION AND
GENERAL NOTES

Designed: X.X.X. Drawn: X.X.X. Checked: X.X.X.	Date	Plan No.	Sheet No.
	Nov. 2021	257-38A	of 93

PROGRESS PRINT 2021-11-17

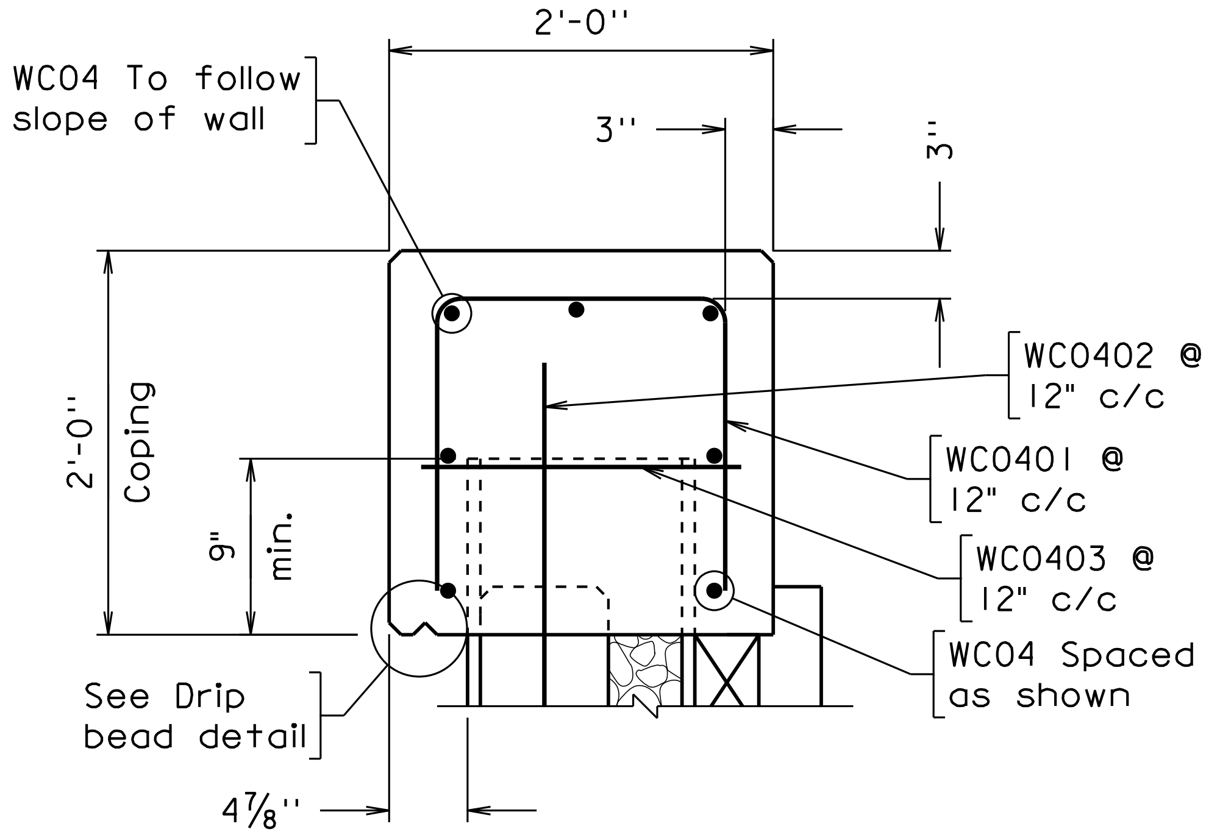
STATE	FEDERAL AID		STATE		SHEET NO.
	ROUTE	PROJECT	ROUTE	PROJECT	
VA.	——		2000	0095-076-299, B688	XXx



TYPICAL WALL SECTION

Scale: $\frac{1}{2}$" = 1'-0"

∗ See sheet X for details



COPING REINFORCEMENT DETAIL

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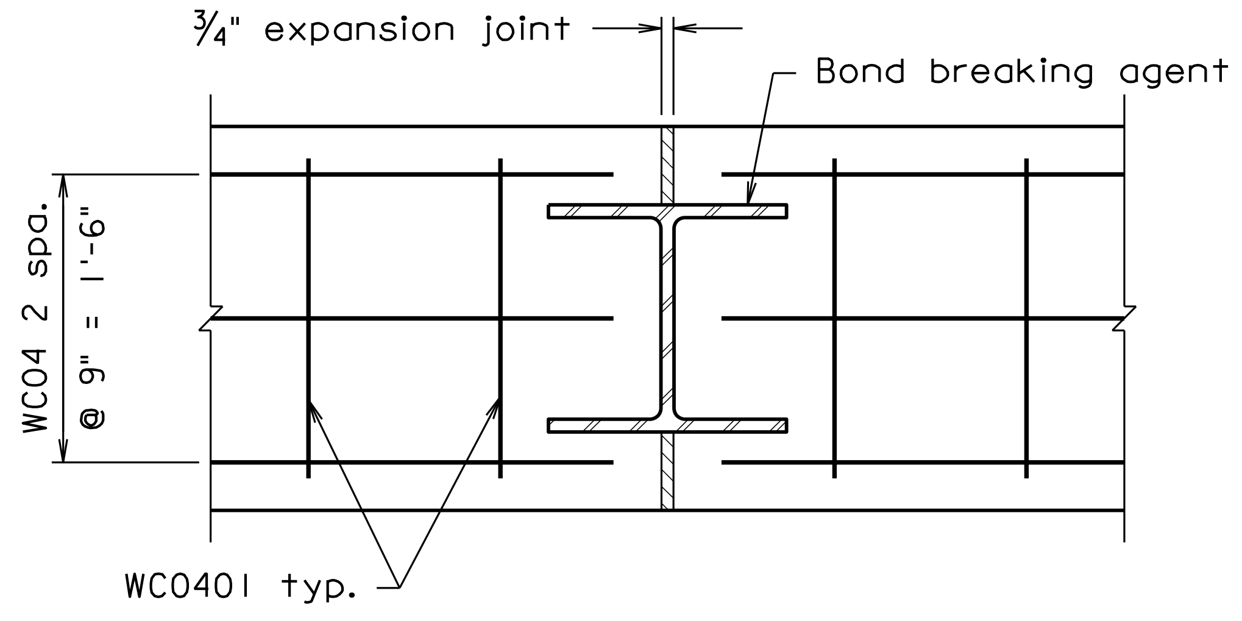
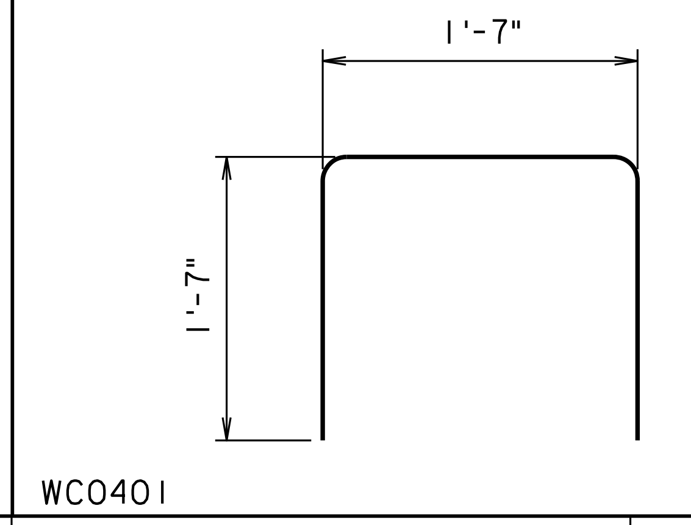


EXPANSION JOINT DETAIL

Scale: 1" = 1'-0"

REINFORCING STEEL SCHEDULE



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WC0402		#4	——	2'-0"	Cap
WC0403		#4	——	1'-8"	Cap
WC04		#4	——		Cap
WL0501		#5	——	6'-3$\frac{1}{2}$"	Lagging
WL04		#4	——		Lagging

PRELIMINARY PLANS

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No.	Description	Date

Revisions

COMMONWEALTH OF VIRGINIA
DEPARTMENT OF TRANSPORTATION

STRUCTURE AND BRIDGE DIVISION

SOLDIER PILE WALL TYPICAL SECTION AND COPING DETAILS

Designed: X.X.X. Drawn: X.X.X. Checked: X.X.X.	Date	Plan No.	Sheet No.
	Nov. 2021	257-38A	of 93

WHITMAN REQUARDT & ASSOCIATES
RICHMOND, VA
STRUCTURAL ENGINEER

Soldier_Pile_Wall_Typ_Section.dgn

PROGRESS PRINT 2021-11-17

APPENDIX A.5

Cross Sections – MSE Walls

11/17/2021
3:06:40 PM

LIMITED ACCESS HIGHWAY

By Resolution of the Highway Commission dated October 4, 1956
By Resolution of the Highway Commission dated January 18, 1973
By Resolution of the Commonwealth Transportation Board dated January 18, 2001
By Resolution of the Commonwealth Transportation Board dated TBD (Anticipated February 2022)

PROJECT MANAGER Rimpal Shah, P.E. (703) 259-2362 (NOVA District)
SURVEYED BY, DATE H&B Surveying and Mapping, LLC (804) 330-3781, 03/09/2021
DESIGN BY Whitman, Requardt, & Associates, LLP (804) 272-8700
SUBSURFACE UTILITY BY, DATE Accumark, Inc. (804) 550-7740, 07/07/2021

CROSS SECTIONS

SCALE 1 IN. = 10 FT (H)
1 IN. = 10 FT (V)

REVISED	STATE	STATE ROUTE	STATE PROJECT	SHEET NO.
	VA.	95	0095-076-299, C-501	53

DESIGN FEATURES RELATING TO CONSTRUCTION
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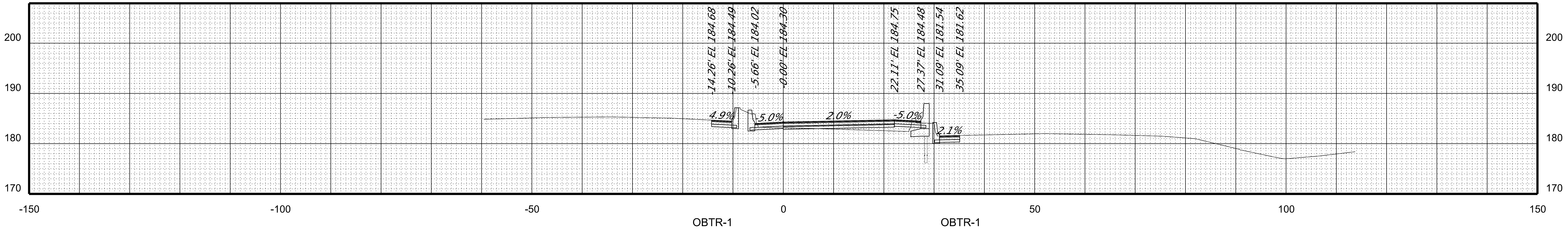
NECESSARY BY THE DEPARTMENT



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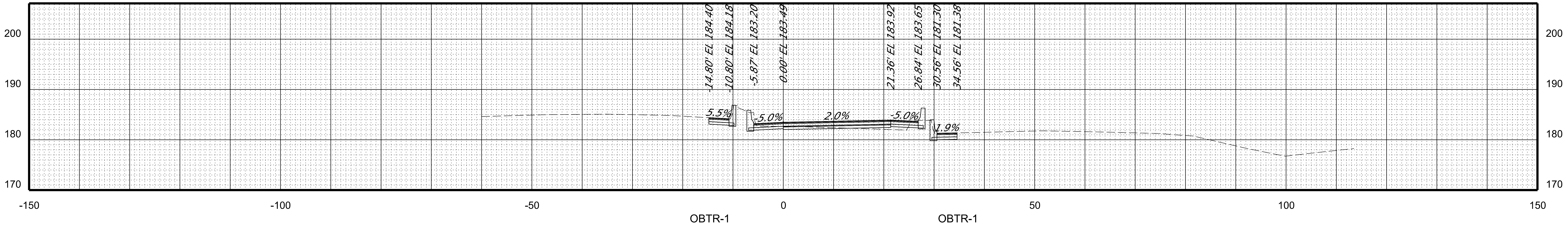

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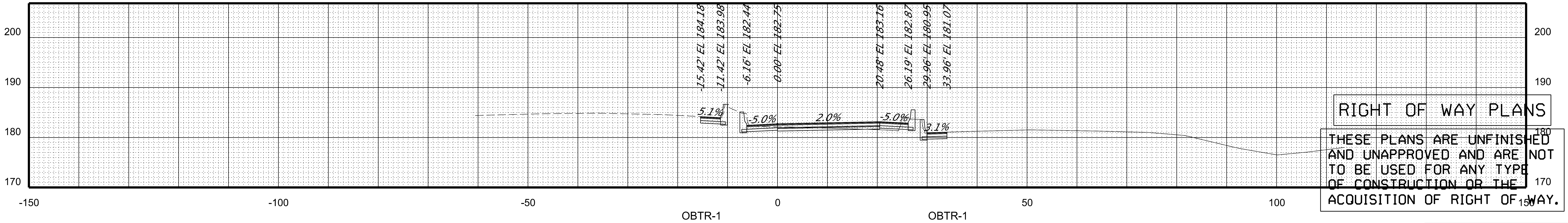

STA 19+50.00

RIGHT OF WAY PLANS

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CROSS SECTIONS

SCALE 1 IN. = 10 FT (H)
1 IN. = 10 FT (V)

REVISED	STATE	STATE ROUTE	STATE PROJECT	SHEET NO.
	VA.	95	0095-076-299, C-501	54

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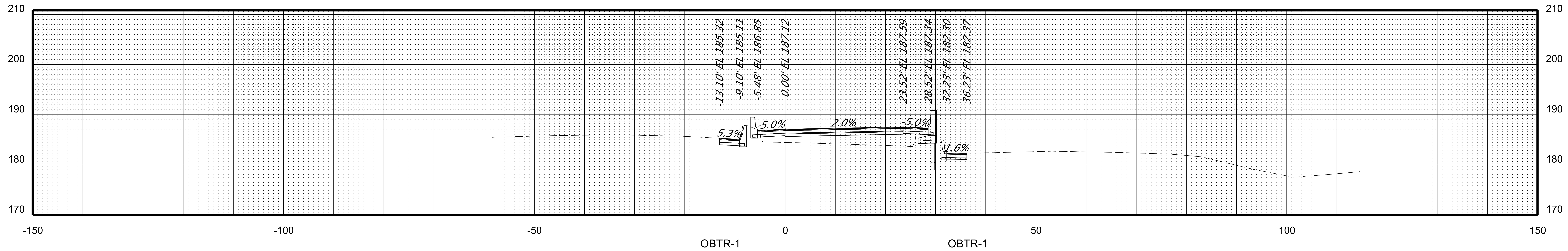

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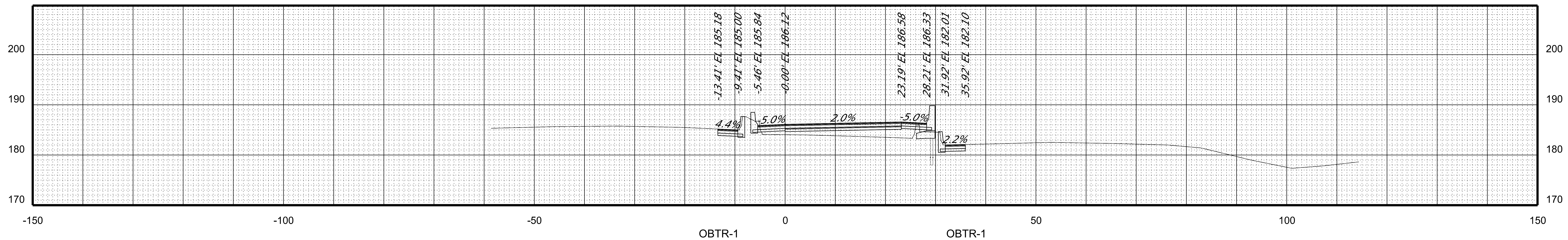

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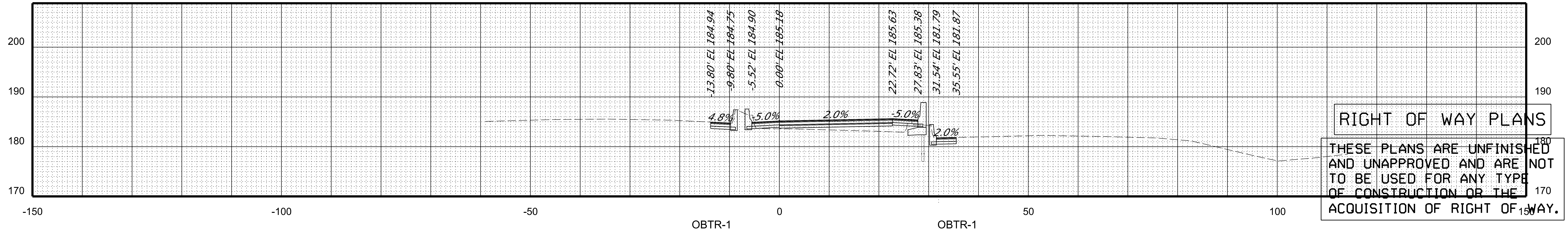

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3:06:44 PM

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CROSS SECTIONS

SCALE 1 IN. = 10 FT (H)
1 IN. = 10 FT (V)

REVISED	STATE	STATE ROUTE	STATE PROJECT	SHEET NO.
	VA.	95	0095-076-299, C-501	55

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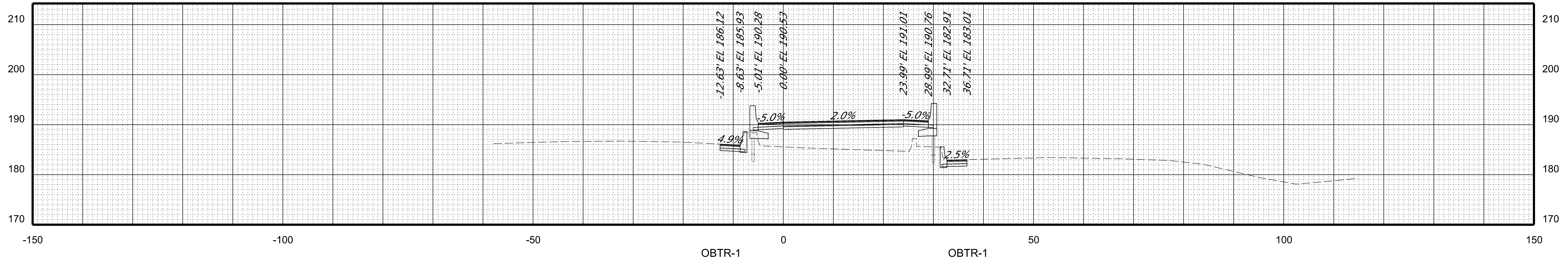

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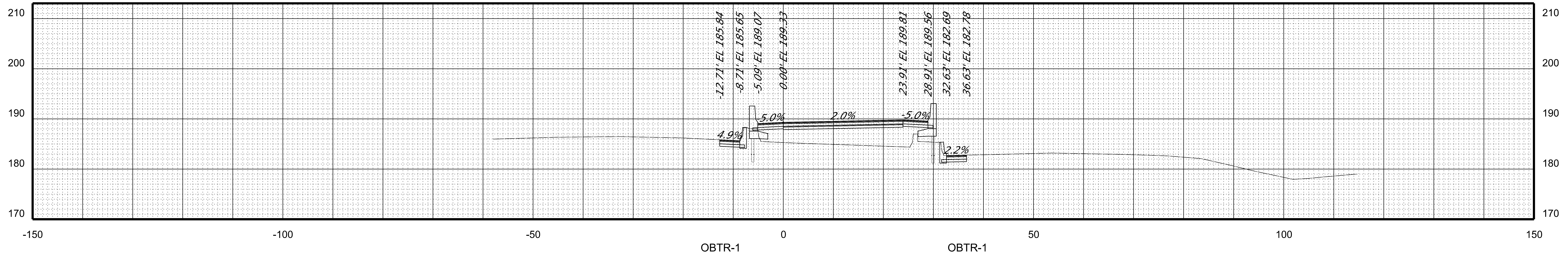

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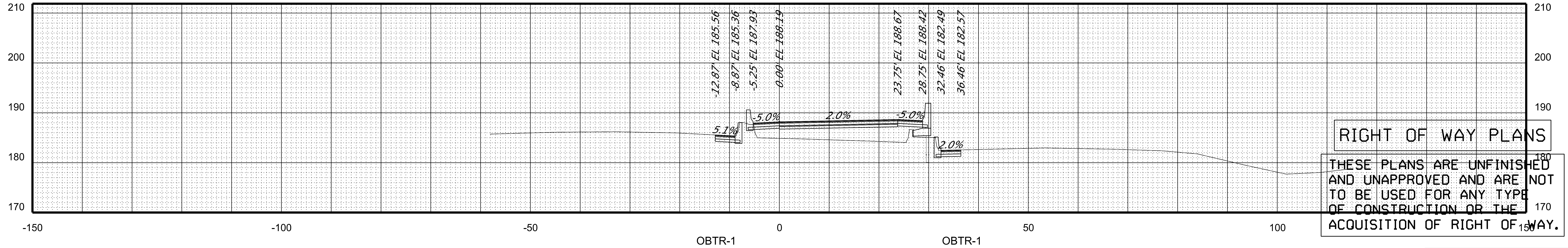

STA 21+00.00

RIGHT OF WAY PLANS

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11/17/2021
3:06:46 PM

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REVISED	STATE	STATE		SHEET NO.
		ROUTE	PROJECT	
	VA.	95	0095-076-299, C-501	56

PROJECT MANAGER Rimpal Shah, P.E. (703) 259-2362 (NOVA District)
SURVEYED BY, DATE H&B Surveying and Mapping, LLC (804) 330-3781, 03/09/2021
DESIGN BY Whitman, Requardt, & Associates, LLP (804) 272-8700
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CROSS SECTIONS

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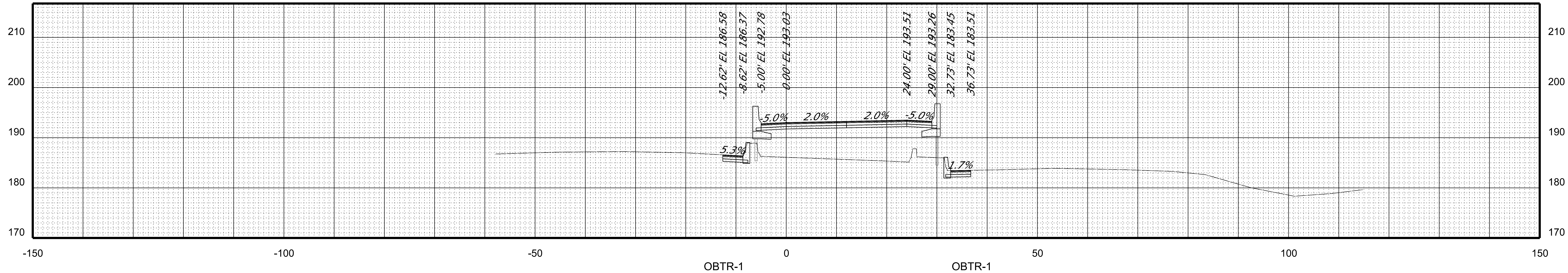

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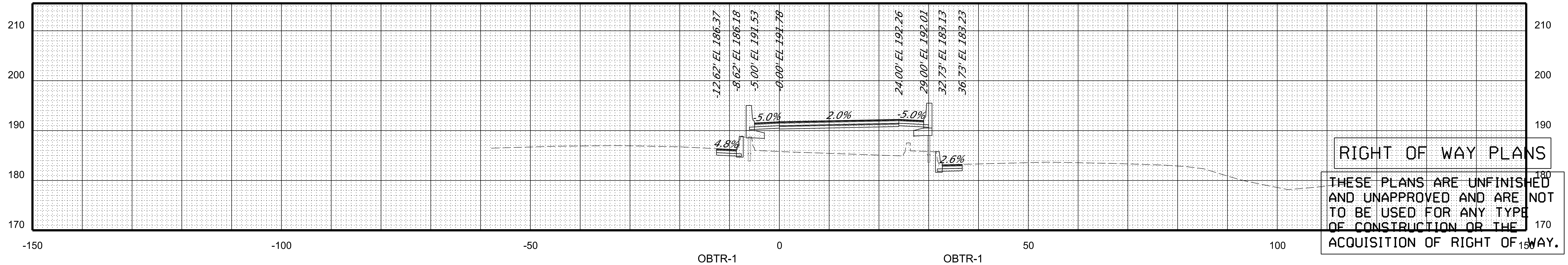

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RIGHT OF WAY PLANS

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11/17/2021
3:06:48 PM

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REVISED	STATE	STATE ROUTE	STATE PROJECT	SHEET NO.
	VA.	95	0095-076-299, C-501	57

PROJECT MANAGER Rimpal Shah, P.E. (703) 259-2362 (NOVA District)
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CROSS SECTIONS

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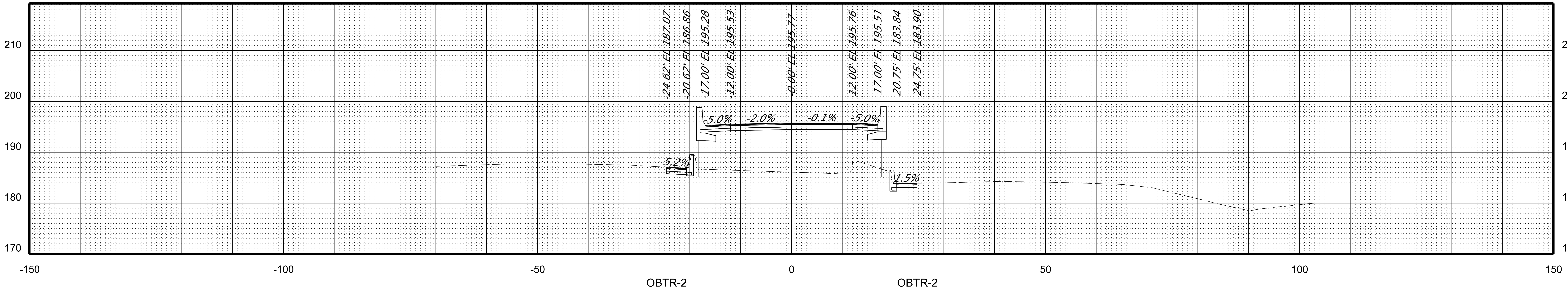

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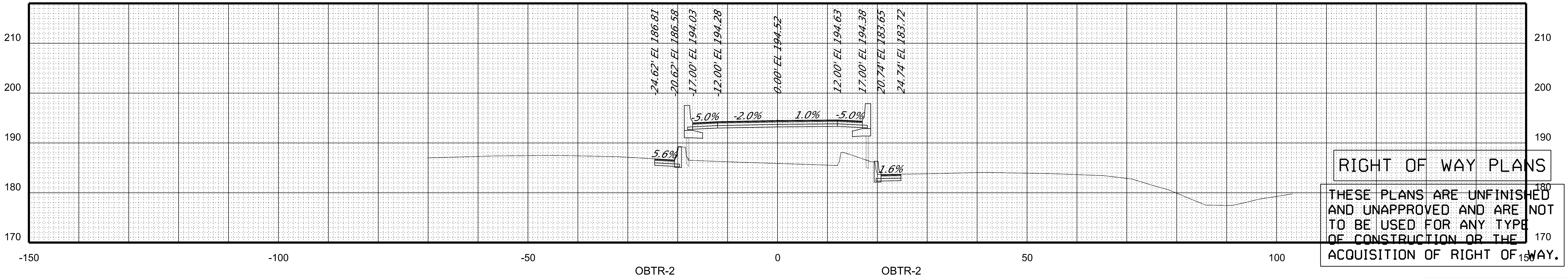

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3:06:50 PM

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SUBSURFACE UTILITY BY, DATE Accumark, Inc. (804) 550-7740, 07/07/2021

CROSS SECTIONS

SCALE 1 IN. = 10 FT (H)
1 IN. = 10 FT (V)

REVISED	STATE	STATE ROUTE	STATE PROJECT	SHEET NO.
	VA.	95	0095-076-299, C-501	58

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OR TO REGULATION AND CONTROL OF TRAFFIC
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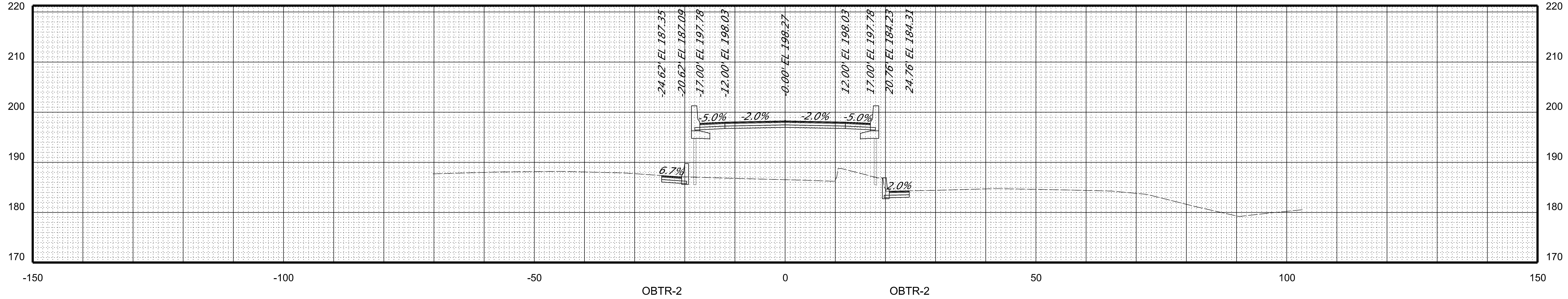

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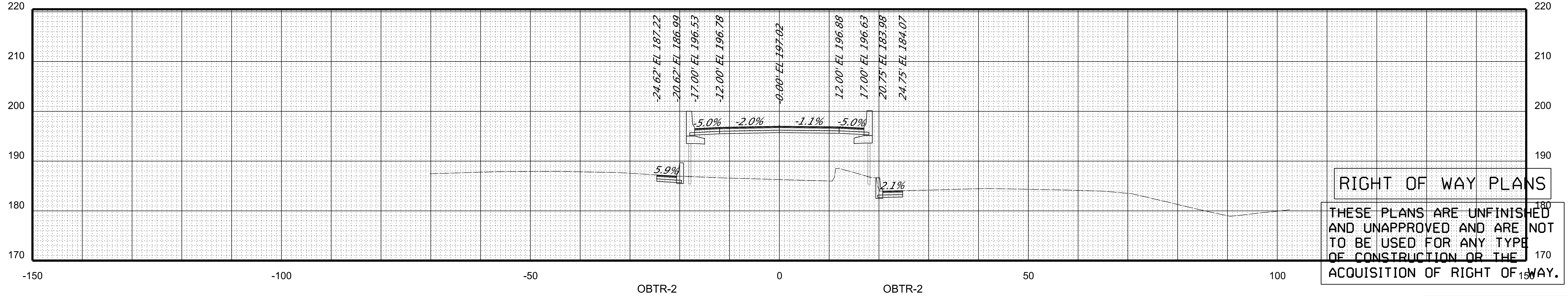

STA 22+75.00

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REVISED	STATE	STATE ROUTE	STATE PROJECT	SHEET NO.
	VA.	95	0095-076-299, C-501	59

PROJECT MANAGER Rimpal Shah, P.E. (703) 259-2362 (NOVA District)
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SUBSURFACE UTILITY BY, DATE Accumark, Inc. (804) 550-7740, 07/07/2021

CROSS SECTIONS

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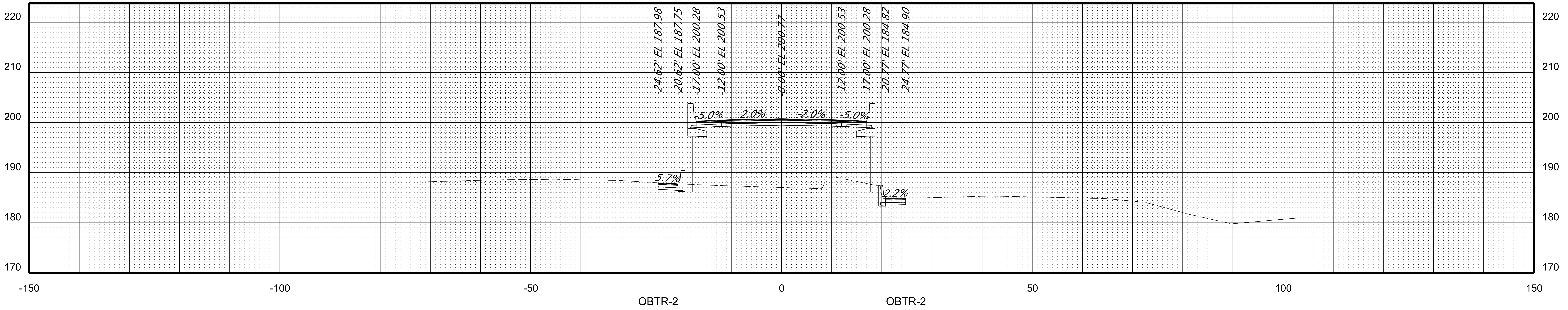

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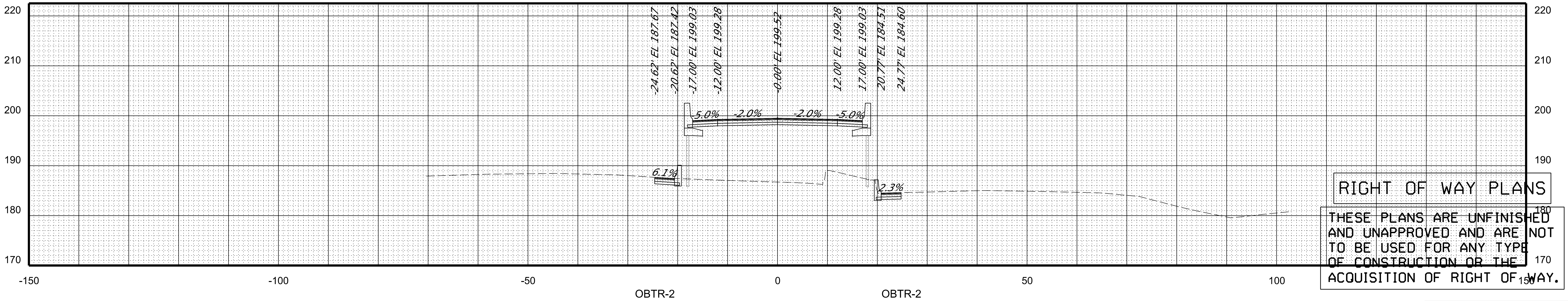

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3:06:53 PM

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SUBSURFACE UTILITY BY, DATE Accumark, Inc. (804) 550-7740, 07/07/2021

CROSS SECTIONS

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1 IN. = 10 FT (V)

REVISED	STATE	STATE ROUTE	STATE PROJECT	SHEET NO.
	VA.	95	0095-076-299, C-501	60

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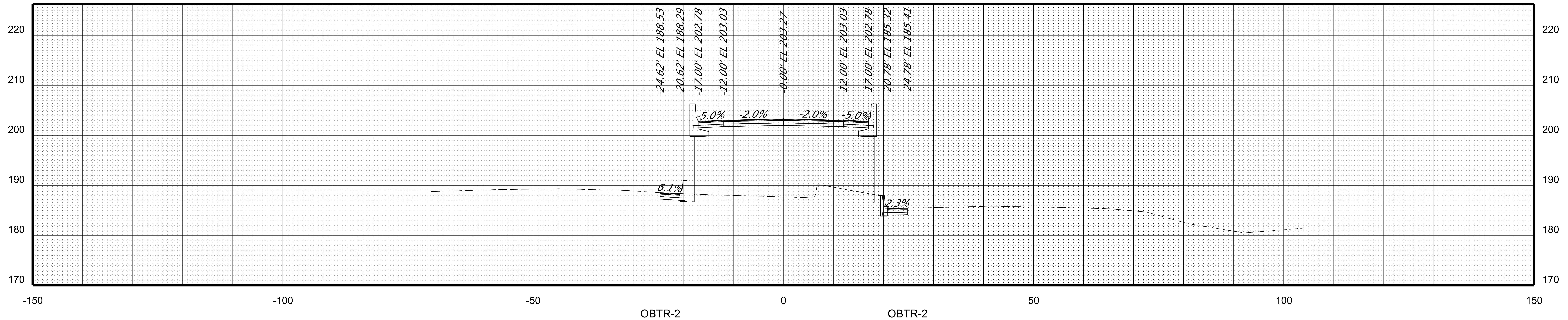

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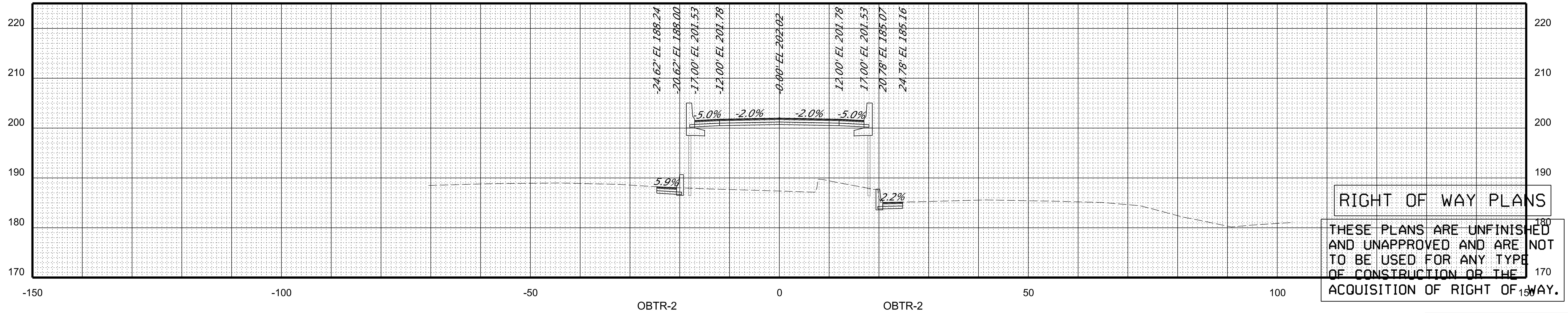

STA 23+75.00

RIGHT OF WAY PLANS

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CROSS SECTIONS

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REVISED	STATE	STATE ROUTE	PROJECT	SHEET NO.
	VA.	95	0095-076-299, C-501	61

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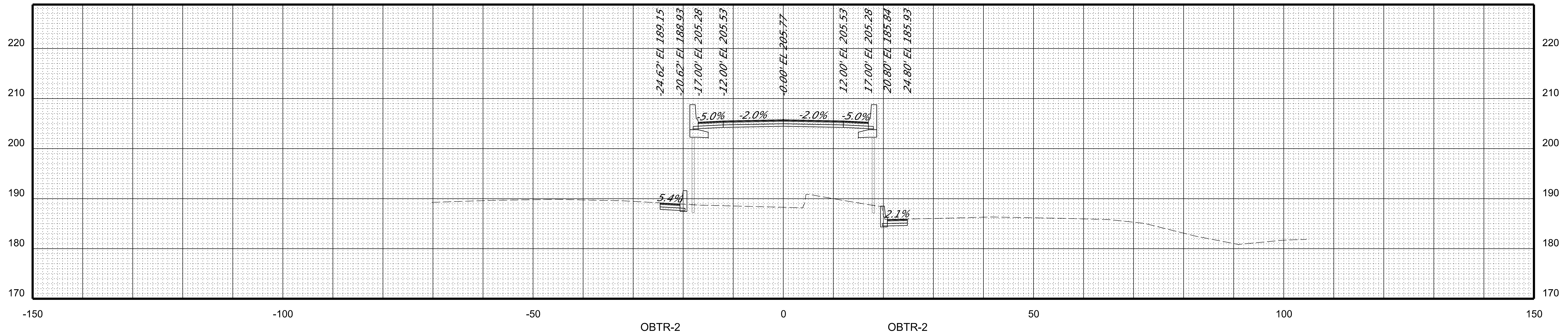

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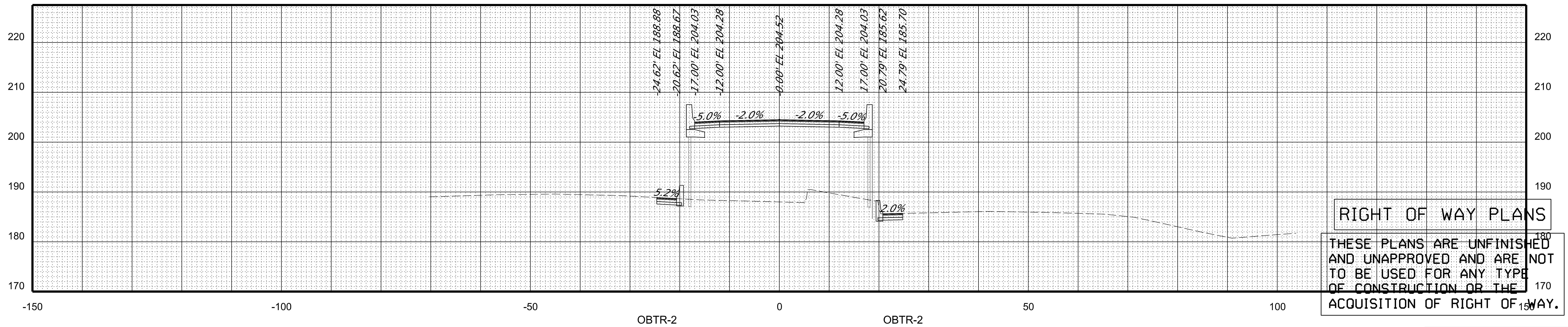

STA 24+25.00

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DESIGN BY Whitman, Requardt, & Associates, LLP (804) 272-8700
SUBSURFACE UTILITY BY, DATE Accumark, Inc. (804) 550-7740, 07/07/2021

CROSS SECTIONS

SCALE 1 IN. = 10 FT (H)
1 IN. = 10 FT (V)

REVISED	STATE	STATE ROUTE	STATE PROJECT	SHEET NO.
	VA.	95	0095-076-299, C-501	62

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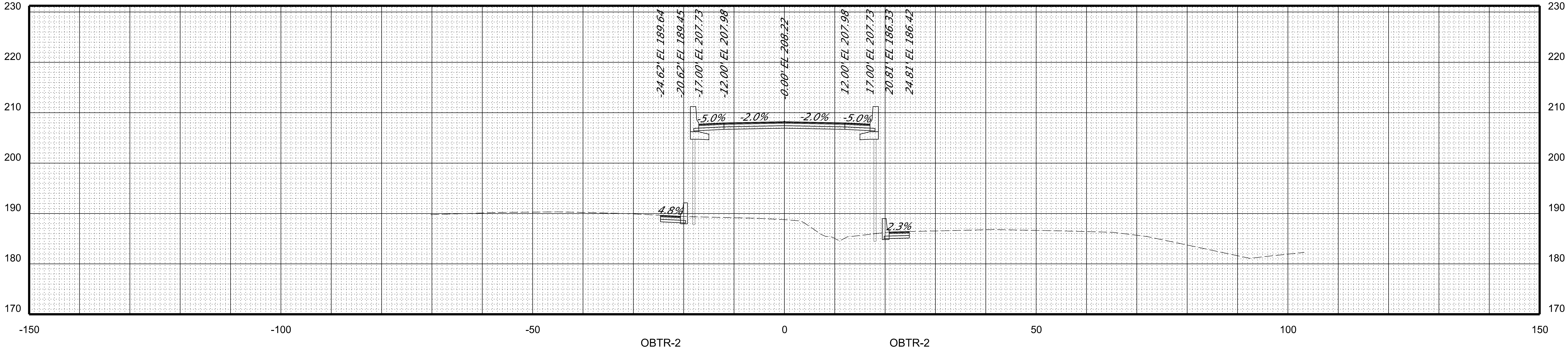
NECESSARY BY THE DEPARTMENT



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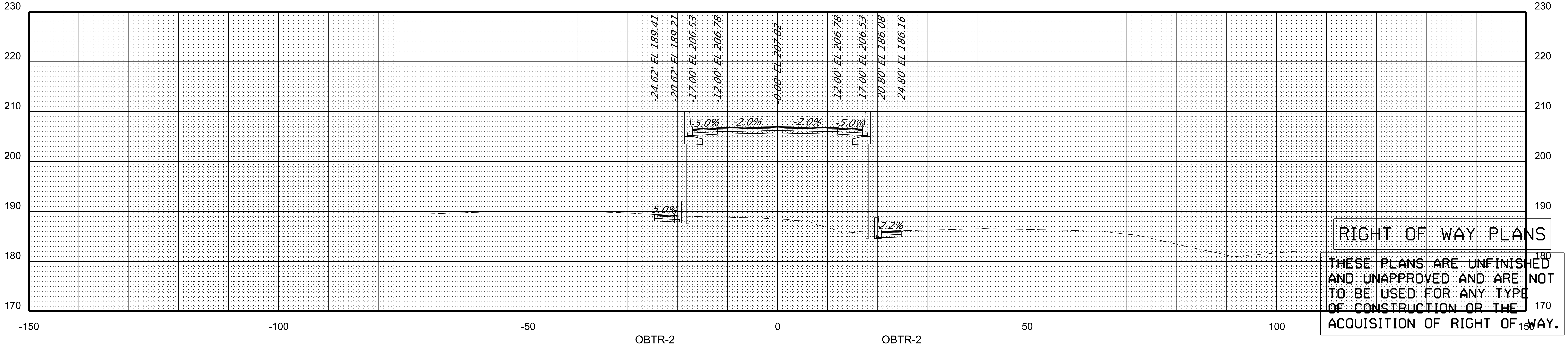

STA 24+75.00

RIGHT OF WAY PLANS

THESE PLANS ARE UNFINISHED AND UNAPPROVED AND ARE NOT TO BE USED FOR ANY TYPE OF CONSTRUCTION OR THE ACQUISITION OF RIGHT OF WAY.

LIMITED ACCESS HIGHWAY

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SUBSURFACE UTILITY BY, DATE Accumark, Inc. (804) 550-7740, 07/07/2021

CROSS SECTIONS

SCALE 1 IN. = 10 FT (H)
1 IN. = 10 FT (V)

REVISED	STATE	STATE ROUTE	STATE PROJECT	SHEET NO.
	VA.	95	0095-076-299, C-501	63

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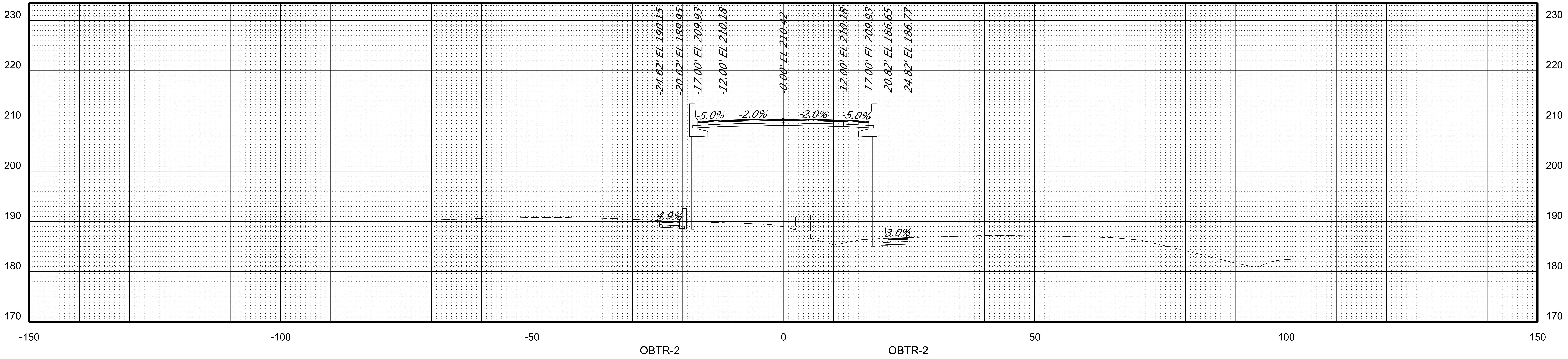

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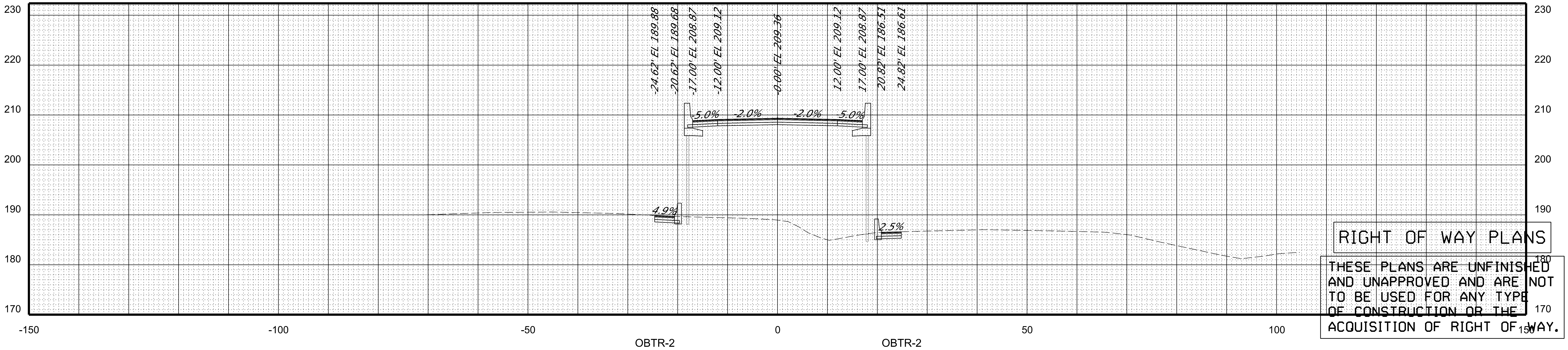

STA 25+25.00

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CROSS SECTIONS

SCALE 1 IN. = 10 FT (H)
1 IN. = 10 FT (V)

REVISED	STATE	STATE		SHEET NO.
		ROUTE	PROJECT	
	VA.	95	0095-076-299, C-501	64

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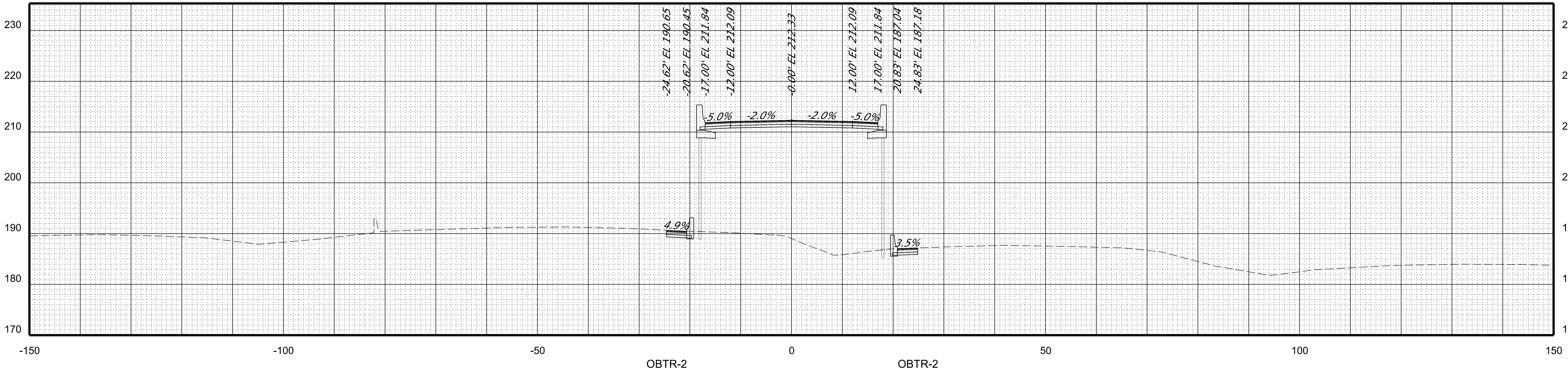

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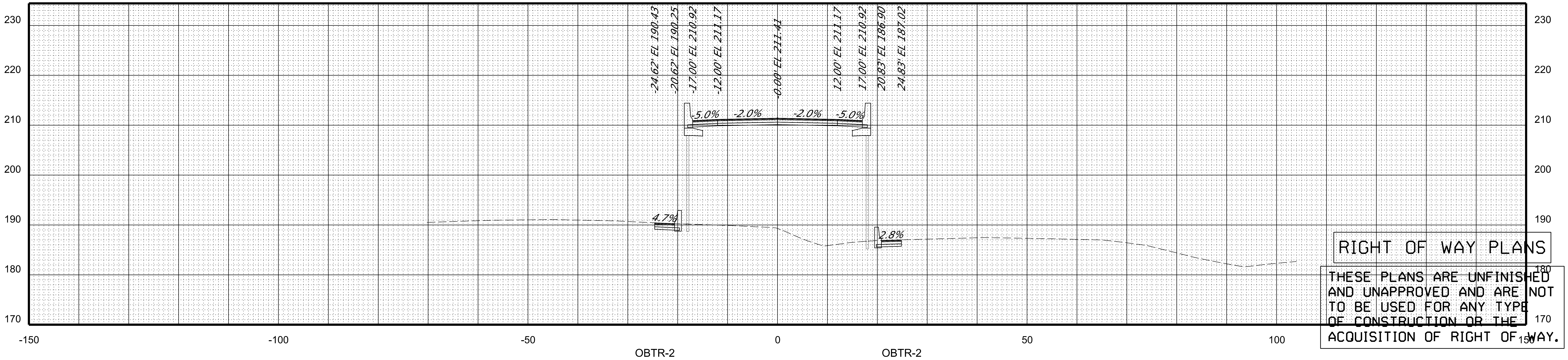

STA 25+75.00

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11/17/2021
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CROSS SECTIONS

SCALE 1 IN. = 10 FT (H)
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REVISED	STATE	STATE ROUTE	STATE PROJECT	SHEET NO.
	VA.	95	0095-076-299, C-501	65

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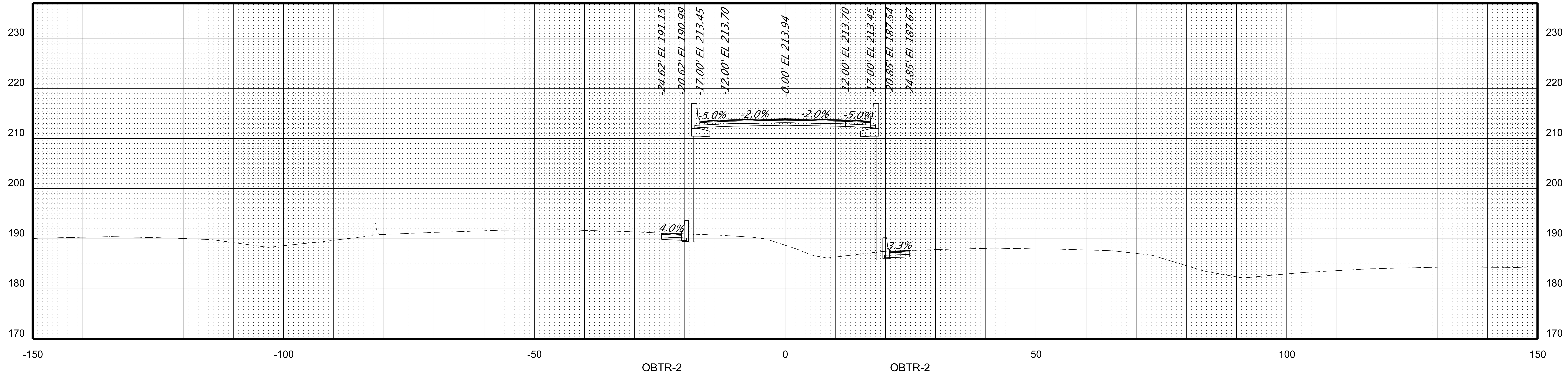

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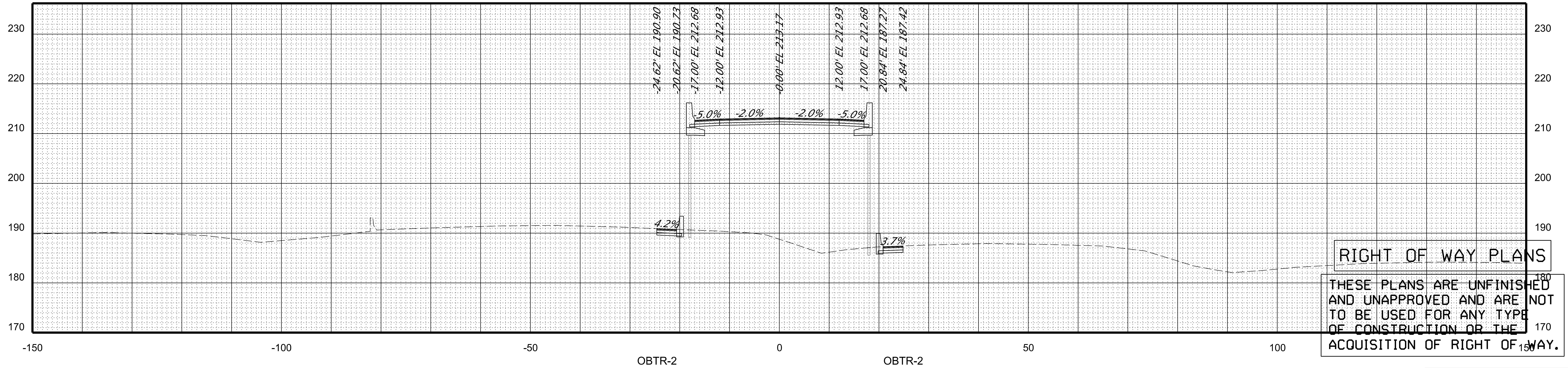

STA 26+25.00

RIGHT OF WAY PLANS

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PROJECT	SHEET NO.
0095-076-299	65

11/17/2021
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LIMITED ACCESS HIGHWAY

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CROSS SECTIONS

SCALE 1 IN. = 10 FT (H)
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REVISED	STATE	STATE		SHEET NO.
		ROUTE	PROJECT	
	VA.	95	0095-076-299, C-501	66

DESIGN FEATURES RELATING TO CONSTRUCTION
OR TO REGULATION AND CONTROL OF TRAFFIC
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NECESSARY BY THE DEPARTMENT

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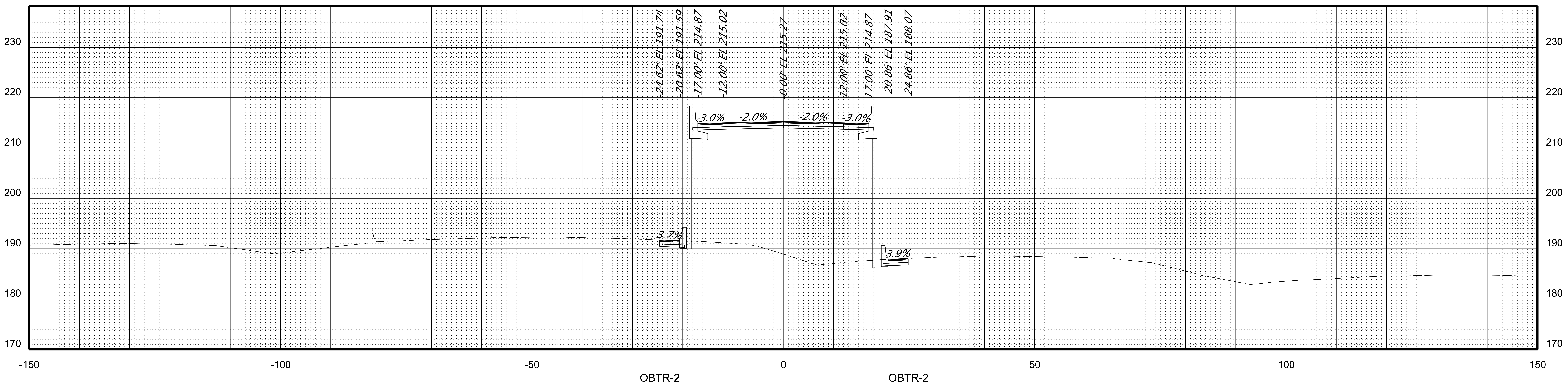

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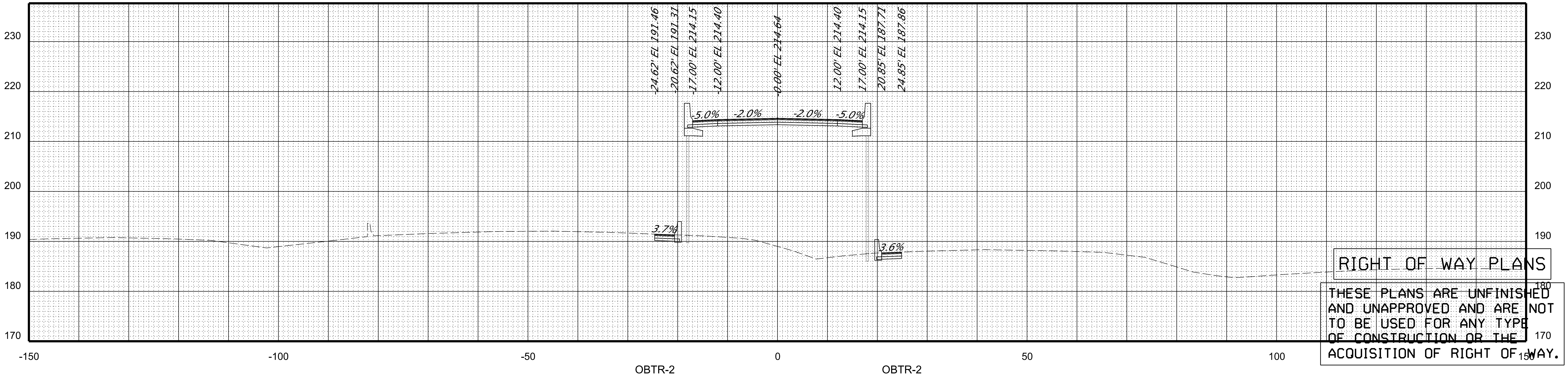

RIGHT OF WAY PLANS

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STA 26+75.00

APPENDIX A.6

Cross Sections – Slivcer Fill & RW3 Wall

11/17/2021
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LIMITED ACCESS HIGHWAY

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SUBSURFACE UTILITY BY, DATE Accumark, Inc. (804) 550-7740, 07/07/2021

CROSS SECTIONS

SCALE 1 IN. = 10 FT (H)
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REVISED	STATE	STATE ROUTE	STATE PROJECT	SHEET NO.
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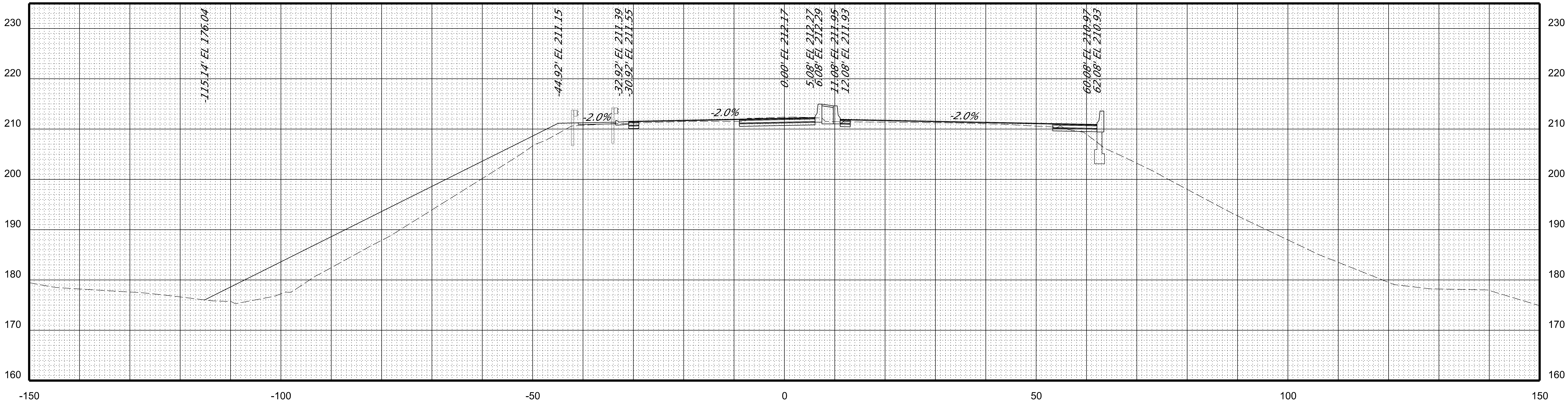

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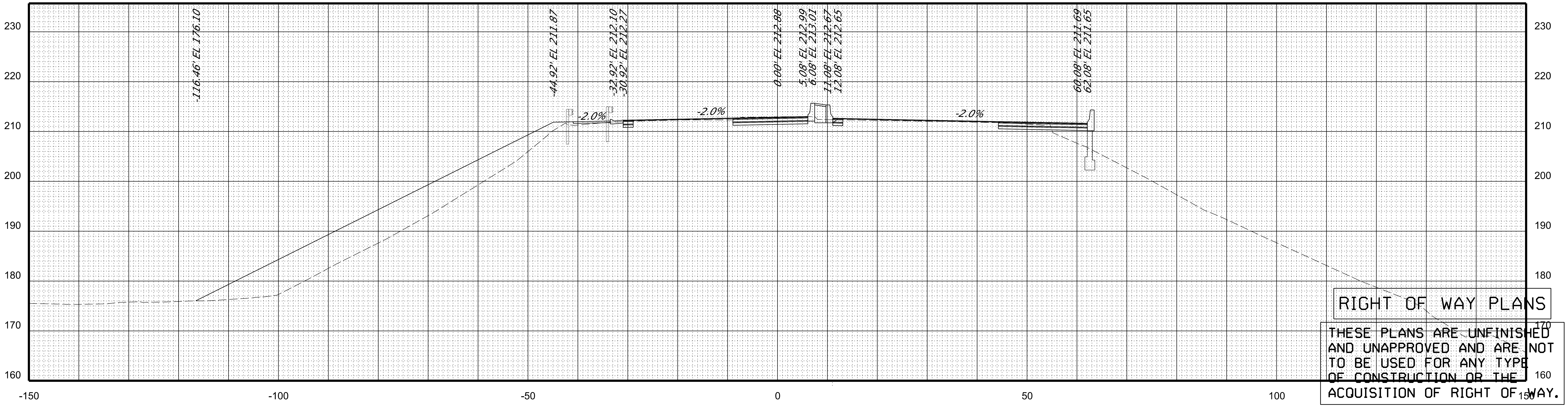

RIGHT OF WAY PLANS

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STA 70+25.00

11/17/2021
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LIMITED ACCESS HIGHWAY

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SUBSURFACE UTILITY BY, DATE Accumark, Inc. (804) 550-7740, 07/07/2021

CROSS SECTIONS

SCALE 1 IN. = 10 FT (H)
1 IN. = 10 FT (V)

REVISED	STATE	STATE		SHEET NO.
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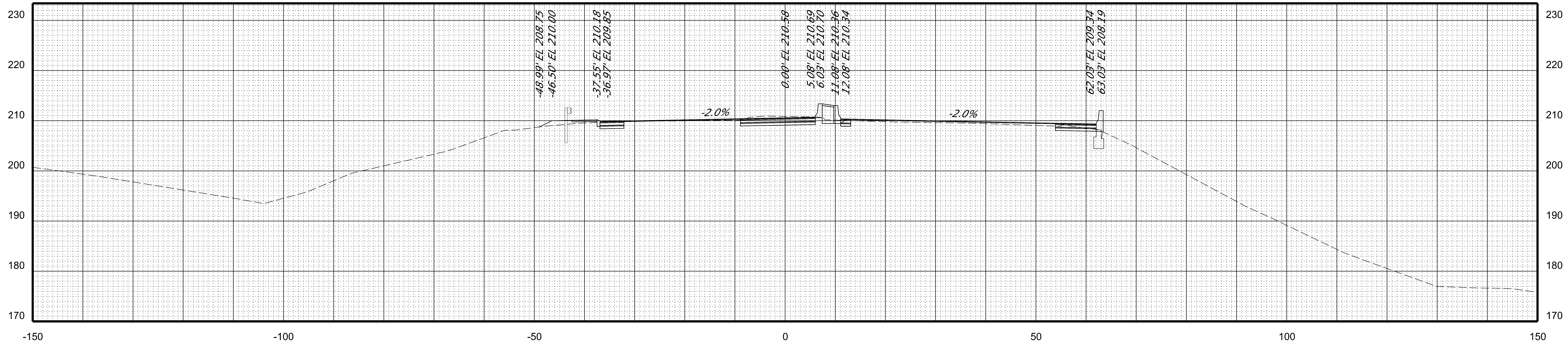

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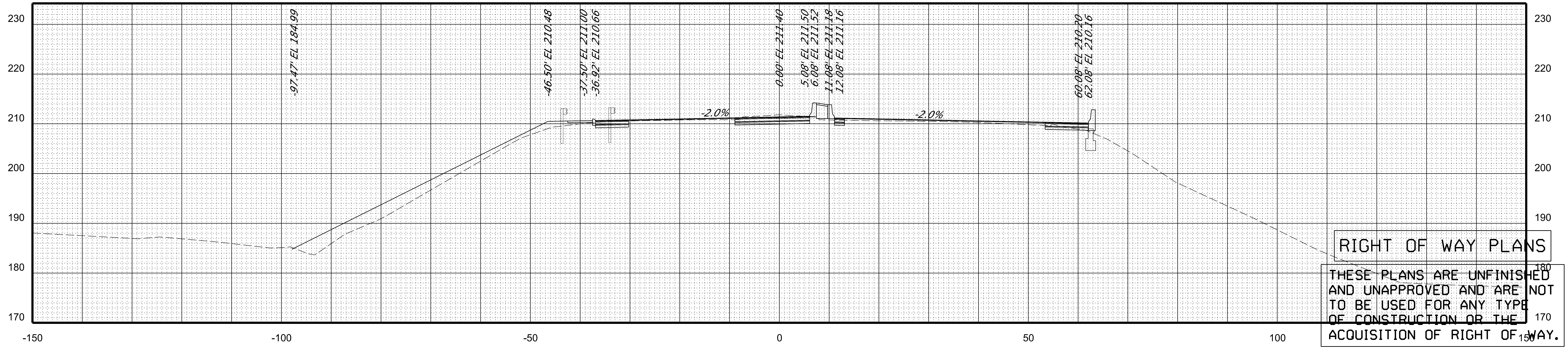

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STA 70+75.00

11/17/2021
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SUBSURFACE UTILITY BY, DATE Accumark, Inc. (804) 550-7740, 07/07/2021

CROSS SECTIONS

SCALE 1 IN. = 10 FT (H)
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REVISED	STATE	STATE ROUTE	PROJECT	SHEET NO.
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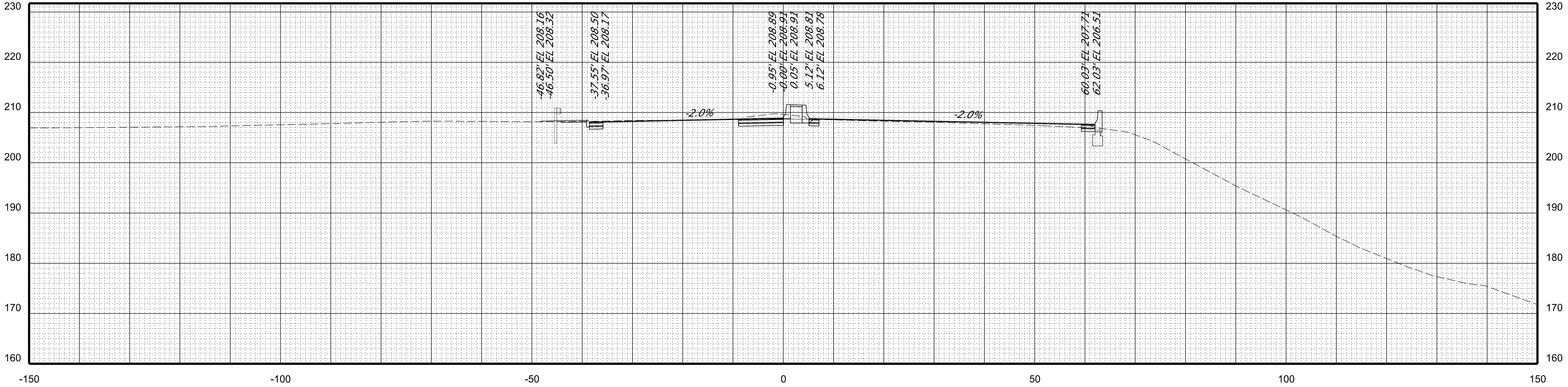

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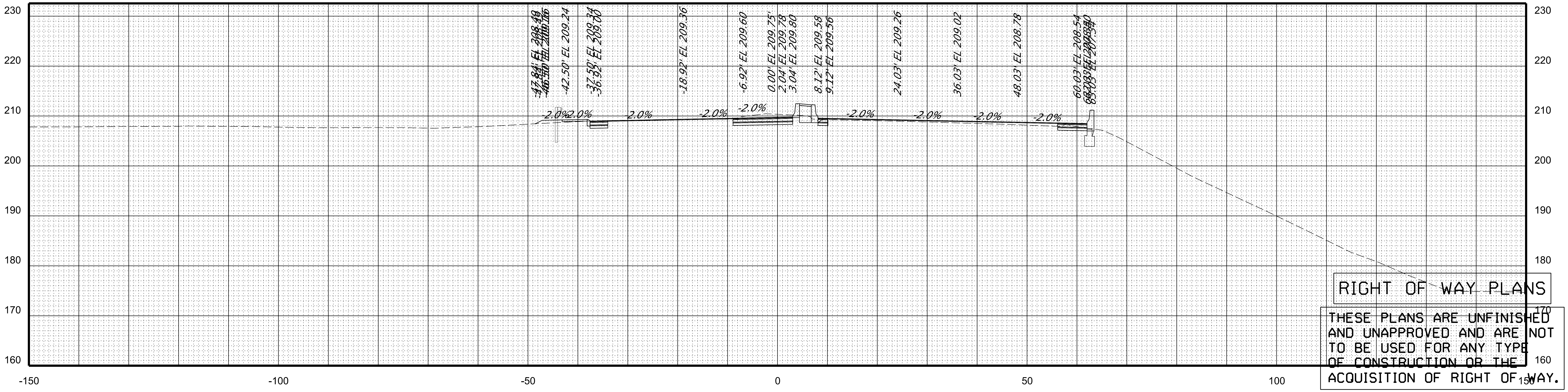

STA 71+25.00

RIGHT OF WAY PLANS

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APPENDIX A.7

Cross Sections – SPL Walls

LIMITED ACCESS HIGHWAY

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PROJECT MANAGER *Rimpal Shah, P.E. (703) 259-2362 (NOVA District)*
SURVEYED BY, DATE *H&B Surveying and Mapping, LLC (804) 330-3781, 03/09/2021*
DESIGN BY *Whitman, Requardt, & Associates, LLP (804) 272-8700*
SUBSURFACE UTILITY BY, DATE *Accumark, Inc. (804) 550-7740, 07/07/2021*

REVISED	STATE	STATE ROUTE	STATE PROJECT	SHEET NO.
	VA.	95	0095-076-299, C-501	74

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CROSS SECTIONS

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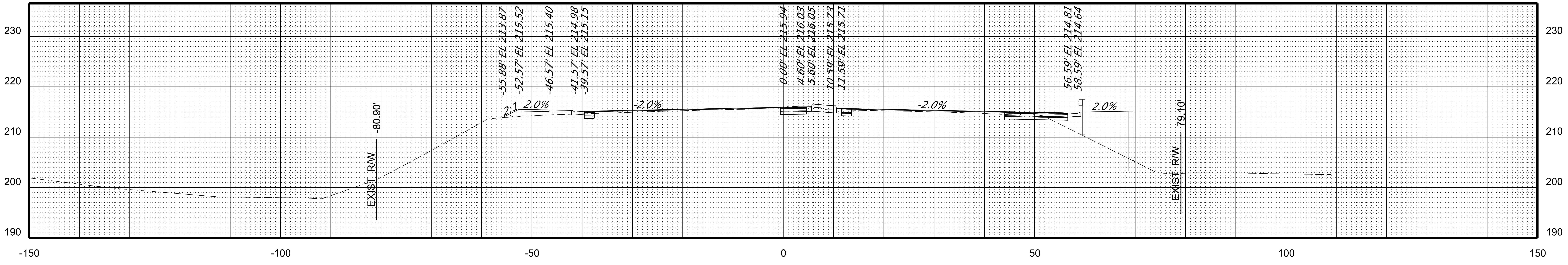

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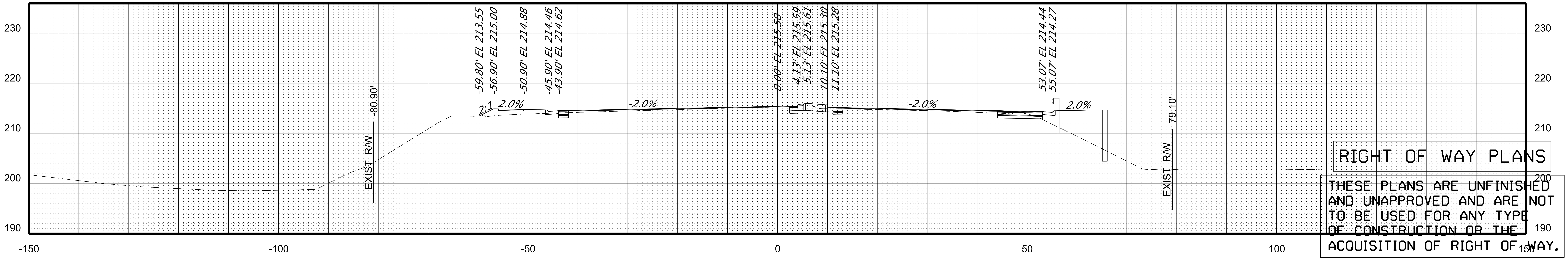

STA 64+25.00

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REVISED	STATE	STATE ROUTE	STATE PROJECT	SHEET NO.
	VA.	95	0095-076-299, C-501	75

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SUBSURFACE UTILITY BY, DATE *Accumark, Inc. (804) 550-7740, 07/07/2021*

CROSS SECTIONS

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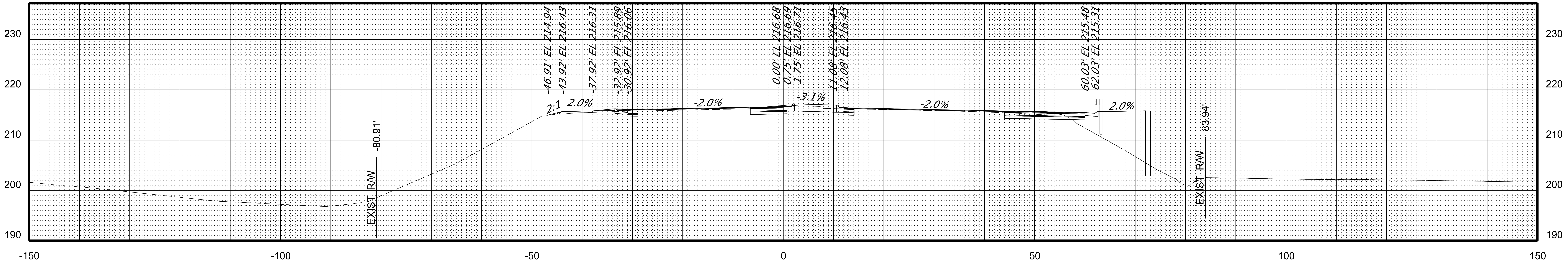

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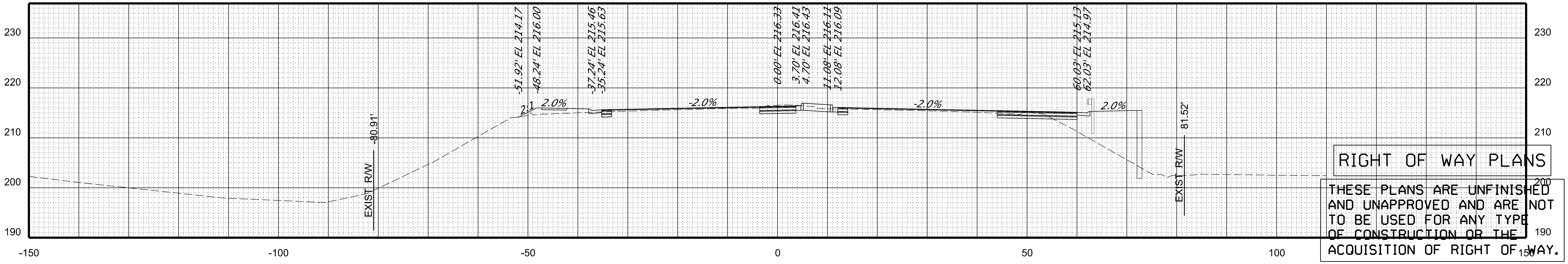

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CROSS SECTIONS

SCALE 1 IN. = 10 FT (H)
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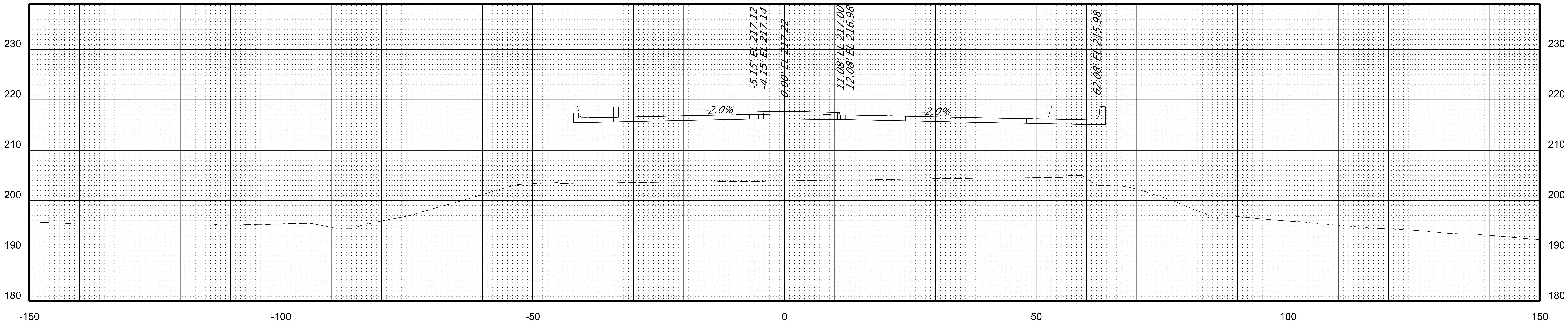
REVISED	STATE	STATE ROUTE	STATE PROJECT	SHEET NO.
	VA.	95	0095-076-299, C-501	76

DESIGN FEATURES RELATING TO CONSTRUCTION OR TO REGULATION AND CONTROL OF TRAFFIC MAY BE SUBJECT TO CHANGE AS DEEMED NECESSARY BY THE DEPARTMENT



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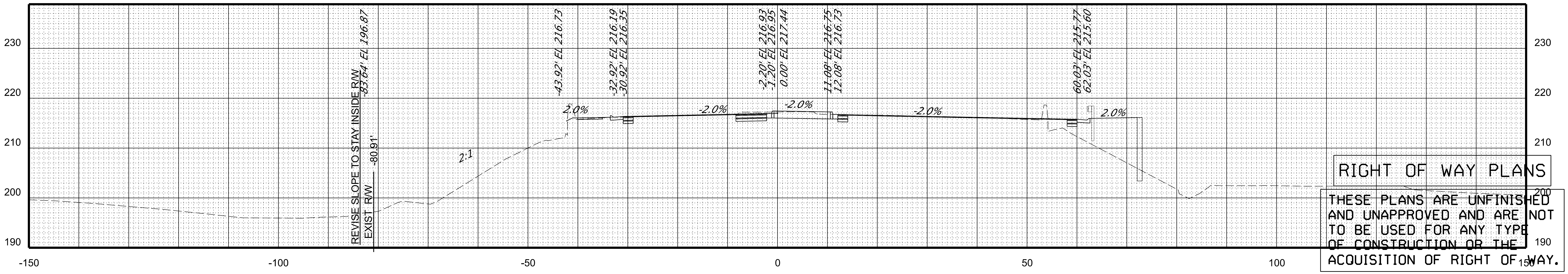

RIGHT OF WAY PLANS

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STA 65+25.00

APPENDIX B

Historic Data Review Memo

Whitman, Requardt & Associates, LLP
Engineers · Architects · Environmental Planners
Est. 1915

MEMORANDUM

Date: September 22, 2021

To: David Shiells

From: Siva Kesavan / Jeff Basford

Subject: Review of Existing Borings and Proposed Validation Borings

CC: Mitch Johnson

Work Order Number: 45893-001

Contract Number:

Project: I-95 Express Spot Improvement at Opitz Blvd., Prince William Co, VA

Introduction

This memo presents our review of available historic test borings in the vicinity of Opitz Boulevard. The review was performed during the development of a subsurface investigation program for the proposed project of ramp down from existing Opitz Blvd bridge. We reviewed the following as-built plans:

- VDOT(1979), As Built Plans, Titled “Proposed Bridge on Opitz Blvd. over I-95, Ramp G & N.B.C.C RD., Prince William Co.-0.4 Mi N. Int. Rte 642, Proj. 0095-076-112, B636,” Commonwealth of Virginia, Department of Highway and Transportation, dated October 24, 1979.

The plan view and elevations are enclosed as Figure 1 and Figure 2 in the enclosure. The structural elements of the bridge include the following: Abutment A, Pier 1, Pier 2, Pier 3, and Abutment B, from west to east. Figure 4 shows a Google street view looking north, where the express lanes are located between Pier 1 and Pier 2.

Historic Borings

A total of nine (9) SPT test borings were depicted in the as-built plans. A summary of the borings is provided in the following table.

Table 1. Summary of Historic Test Borings

Structure	Traffic Lane[1]	Boring No.	Station & Offset	Boring Grades		Ground water EL (ft.)	Decomposed[2] Rock EL (ft.)
				Top EL (ft.)	Bottom EL (ft.)		
Abutment A	W.B.L	1	Sta.65+44; 15’ LT	194.5	174.0	181.7	184.0
	E.B.L	2	Sta.65+44; 15’ RT	193.1	172.2	179.9	182.6
Pier 1	W.B.L	4	Sta.66+52; 10’ LT	193.1	172.9	180.0	178.1
Pier 2	W.B.L	6	Sta.68+10; 10’ LT	178.4	157.7	170.0	167.9
	E.B.L	5	Sta.68+10; 10’ RT	179.5	148.7	168.6	169.0
Pier 3	W.B.L	8	Sta.69+78; 10’ LT	172.7	147.3	166.7	162.7
	E.B.L	7	Sta.69+77; 20’ RT	172.7	151.7	166.7	163.7
Abutment B	W.B.L	10	Sta.70+18; 13’ LT	169.8	144.7	167.0	165.3
	E.B.L	9	Sta.70+18; 20’ RT	169.6	153.4	166.0	165.1

Table 1. Summary of Historic Test Borings

Structure	Traffic Lane(1)	Boring No.	Station & Offset	Boring Grades		Ground water EL (ft.)	Decomposed(2) Rock EL (ft.)
				Top EL (ft.)	Bottom EL (ft.)		

Notes: (1) Abbreviations: W.B.L – West Bound Lane; E.B.L – East Bound Lane.

(2) Decomposed rock identified in the boring logs generally indicates an SPT blow-count (blows per foot) greater than 50.

The test boring logs from the as-built plans are enclosed with this memorandum. The depth of borings ranged from 16.2 feet to 30.8 feet from the existing ground before the construction of the bridge. The top of decomposed rock sloped eastward from EL 184 feet at the west end (Abutment A) to EL 165 feet to the east (Abutment B).

Existing Bridge Foundation

The bridge structural elements are supported on HP10x42 piles, driven into the decomposed layer. The as-built plans list each driven pile length for the piers, and averaged pile lengths for the east bound lane and west bound lane abutments. Details about pile tip estimations for the bridge elements are enclosed. Only average pile driven lengths are provided for the abutment locations. Table 2 is a summary of pile data.

Table 2. Summary of Pile Tip Elevations and Pile Penetration in Decomposed Rock

Structure	Traffic Lane	Boring No.(1)	Boring Bottom EL (ft.)	Estimated Pile Tip EL (ft.)			Average Penetration into Decomposed Rock	
				Max. (Shallow)	Min. (Deep)	Ave.	DR Top EL (ft.)	Average Pile Penetration (ft.)
Abutment A	W.B.L	1	174.0	---	---	179.6	184.0	4.4
	E.B.L	2	172.2	---	---	176.9	182.6	5.7
Pier 1	W.B.L	4	172.9	176.5	160.0	170.8	178.1	7.3
	E.B.L		172.9	175.0	170.0	172.5	178.1	5.6
Pier 2	W.B.L	6	157.7	159.7	149.1	153.4	167.9	14.5
	E.B.L	5	148.7	160.0	150.8	156.3	169.0	12.7
Pier 3	W.B.L	8	147.3	158.4	151.3	155.3	162.7	7.4
	E.B.L	7	151.7	163.2	152.0	158.5	163.7	5.2
Abutment B	W.B.L	10	144.7	---	---	160.5	165.3	4.8
	E.B.L	9	153.4	---	---	159.6	165.1	5.5

Notes: (1) Boring No. 4 is located at Pier-2 W.B.L area and assumed for Pier-2 E. B.L calculations.

Based on review of the as-built plans, the test borings terminated at auger refusal, and the piles were driven to a refusal penetration criterion. The average depth of pile penetration into the bearing layer (decomposed rock) ranged from 4.4 feet to 14.5 feet. *The historic borings consistently encountered a layer of decomposed rock, the top of which became deeper from west to east.*

Proposed Validation Borings

Following are noted during the development of current test boring plans.

a) The modification to the foundation elements proposed for the current project is expected to be similar to the existing foundation type - a deep foundation consist of driven HP 10x42 piles, bearing in the decomposed rock layer .

b) The design will be based on the results of existing borings and proposed deep verification borings. The . verification borings will be for the validation of the subsurface profile in historic borings.

c) The borings will be drilled on the south side of existing bridge at the following locations: Abutment A (Boring B-A1-5), middle of the bridge (Boring B-A2-1 in the vicinity of proposed T-Ramp location closer to Pier-1), and Abutment B (Boring B-A1-6).

The locations of three borings are included in the in the attached test boring plan. The validation soil borings will be extended to EL 140 or to auger refusal, whichever occurs first. If the auger refusal occurs first, a 10 feet of rock coring will be performed, with coring depth extending beyond the soil auger refusal depth.

Siva Kesavan.

Siva K. Kesavan

Enclosures : Figure 1: Existing Bridge Plan
Figure 2: Existing Bridge Elevation
Figure 3: Historic Boring Location Plan
Picture 1: View of Existing Bridge – Looking North
Historic Boring Logs (1 sheet)
Existing Pile tip Estimations (4 sheets)
Project (current) Boring Locations (5 Sheets)

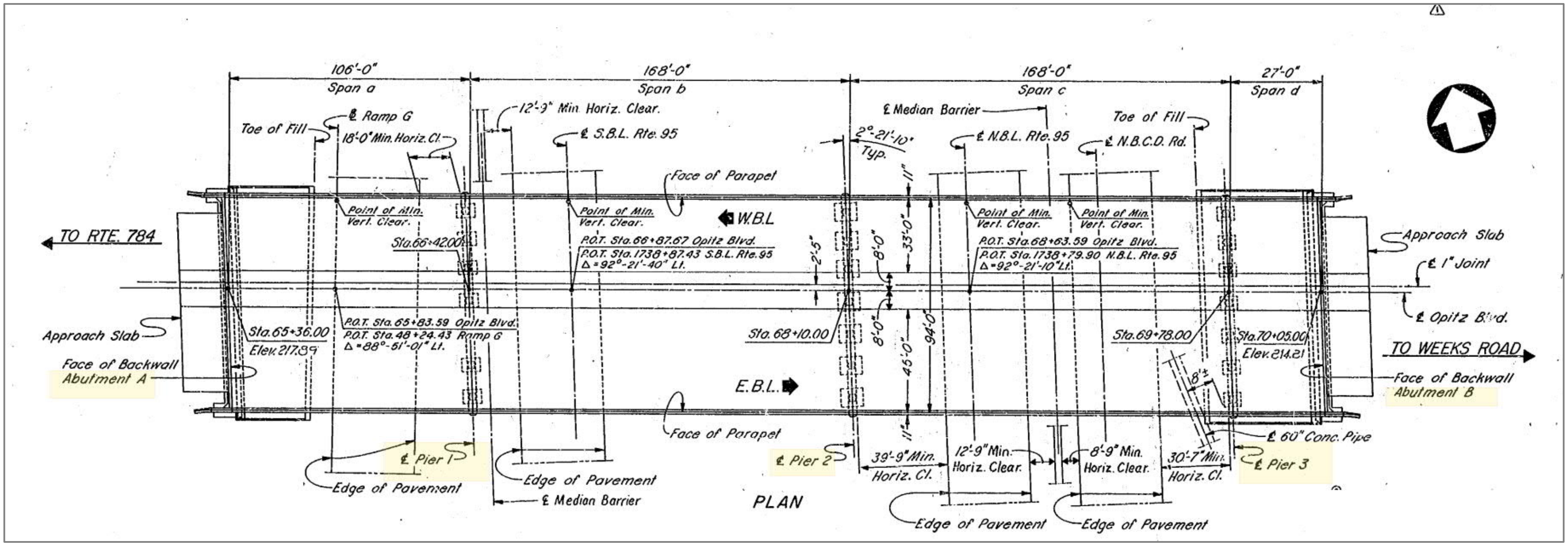


Figure 1: Existing Bridge Plan (Reference: VDOT, 1979, Sheet 1 of 47)

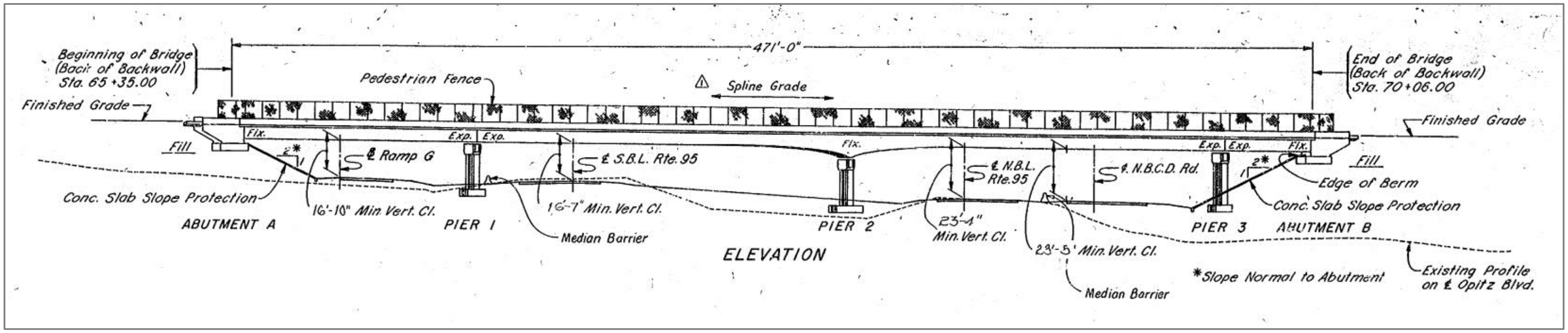


Figure 2: Existing Bridge Elevation (Reference: VDOT, 1979, Sheet 2 of 47)

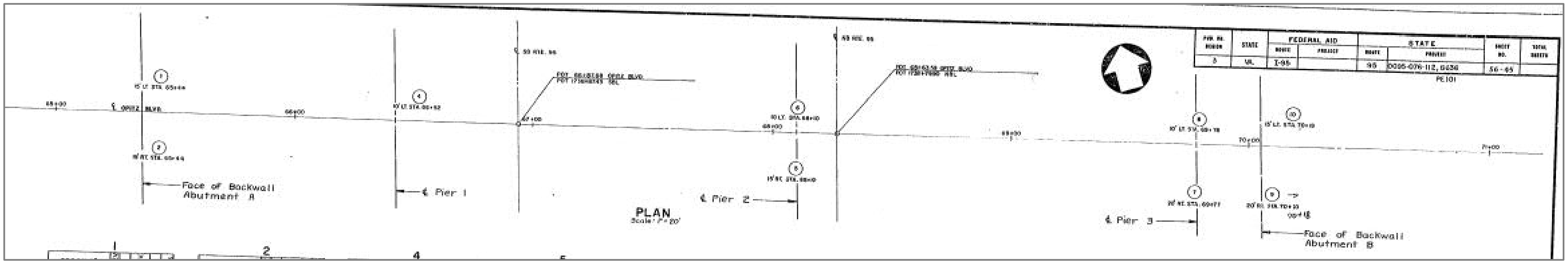
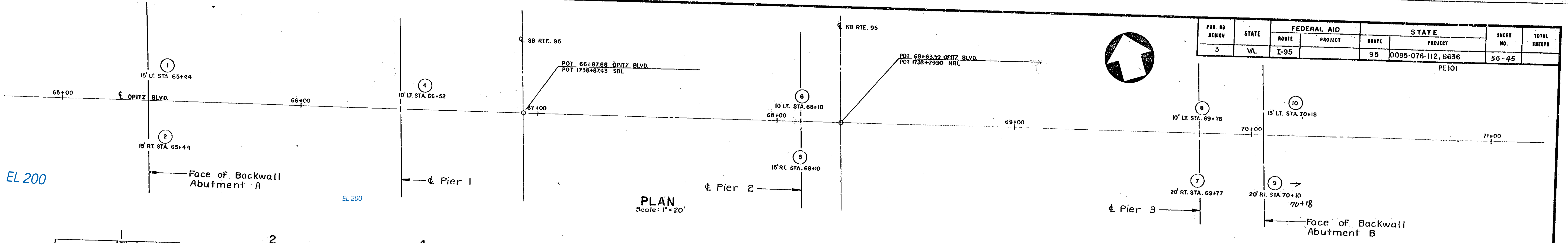


Figure 3: Historic Borings – Location Plan (Reference: VDOT, 1979, Sheet 45 of 47)

Picture 1: View of Existing Bridge -Looking North, Express Lanes Between Pier-1 and Pier 2 (Photo: Google Earth -Street View)

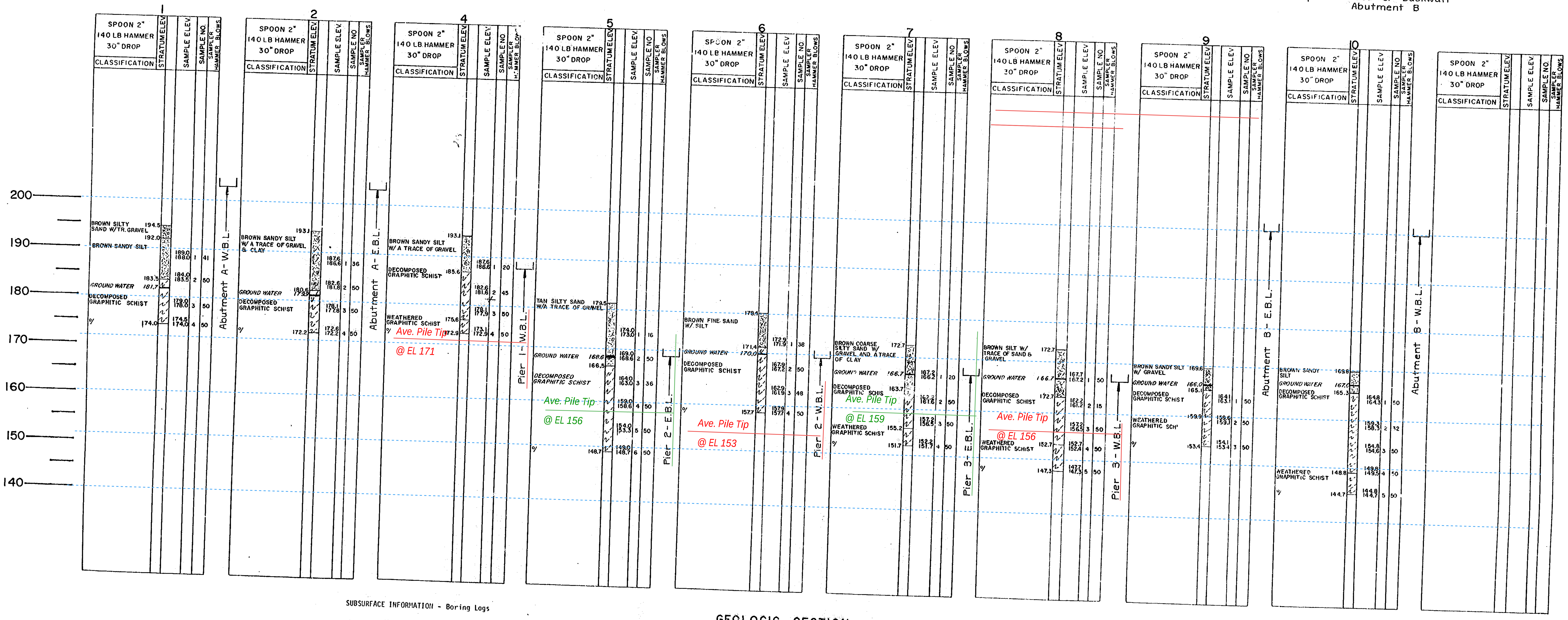
PUB. RD. REGION	STATE	FEDERAL AID ROUTE	FEDERAL AID PROJECT	STATE ROUTE	STATE PROJECT	SHEET NO.	TOTAL SHEETS
3	VA.	I-95		95	0095-076-112, B636	56-45	

PE101



PLAN

Scale: 1" = 20'



GEOLOGIC SECTION

SCALE: 1" = 10'

SUBSURFACE INFORMATION - Boring Logs

This subsurface information shown on the boring logs in these plans was obtained with reasonable care and recorded in good faith solely for use by the Department in establishing design controls for the project. The Department has no reason to suspect that such information is not reasonably accurate as an approximate indication of the subsurface conditions at the sites where the borings were taken. The Department does not in any way warrant or guarantee that such data can be projected as indicative of conditions beyond the limits of the borings shown; and any such projections by bidders are purely interpretive and altogether speculative. Further, the Department does not in any way guarantee, either expressly or by implication, the sufficiency of the information for bid purposes.

The boring logs are made available to bidders in order that they may have access to subsurface data identical to that which is possessed by the Department, and are not intended as a substitute for personal investigation, interpretation and judgment by the bidders.

NOTE

℣ ELEVATION AT BOTTOM OF DRILL HOLE
EQUIPMENT - HOLLOW STEM AUGER

FIELD LOG - EGA
Drawn by: RS
Traced by:
Checked by: RCR

78-57-15
SHEET 1 OF 1

VIRGINIA DEPARTMENT OF HIGHWAYS
ROUTE NO. 95 STA. 1738+80
PROJ. NO. 0095-076-112, B636
ENGINEERING GEOLOGY
MATERIALS DIVISION
OPITZ BLVD. OVER RTE. 95
PRINCE WILLIAM COUNTY
DECEMBER 13, 1978

257-38
Sheet 45 of 47

Estimation of Pile Tip Elevations

Project: I-95 Express Spot Improvement at Opitz Blvd.
Prince Williams Co. VA
WRA # 45893-001

Prep by: skk
Chk by:

Sheet No. 1 of 4
Date: 9/20/2021

Pier 1 -W.B.S

Cap	Bottom	Data: Pile Depth (ft)						Ref.	Calculated Pile Tip Elevation (ft)					
No.	EL (ft)	Raw - 1	Raw - 2	Raw - 3	Raw - 4	Raw - 5	Raw - 6	EL (ft)	Raw - 1	Raw - 2	Raw - 3	Raw - 4	Raw - 5	Raw - 6
I	*186.5*	*11.0*	*12.6*	*16.0*	*13.0*	*16.0*	*14.8*	187.51	176.5	174.9	171.5	174.5	171.5	172.7
II	*186.9*	*15.0*	*15.1*	*16.0*	*15.1*	*12.7*	*13.0*	187.85	172.9	172.8	171.9	172.8	175.2	174.9
III	*187.1*	*24.3*	*21.3*	*20.3*	*23.2*	*18.2*	*28.1*	188.12	163.8	166.8	167.8	164.9	169.9	160.0

Stastical Results: Pile Tip EL (ft.)	
Max	176.5
Min	160.0
Mean, μ	170.8
Std.Dev σ	4.3
μ - βσ	160.9
β = 2.33	

Pier 1 -E.B.S

Cap	Bottom	Data: Pile Depth (ft)					Ref.	Calculated Pile Tip Elevation (ft)				
No.	EL (ft)	Raw - 1	Raw - 2	Raw - 3	Raw - 4	Raw - 5	EL (ft)	Raw - 1	Raw - 2	Raw - 3	Raw - 4	Raw - 5
IV	*187.3*	*16.3*	*18.3*	*14.3*	*13.3*	*15.3*	188.33	172.0	170.0	174.0	175.0	173.0
V	*187.0*	*15.2*	*15.2*	*16.5*	*14.3*	*17.1*	187.95	172.8	172.8	171.5	173.7	170.9
VI	*186.6*	*14.1*	*14.0*	*14.1*	*13.1*	*16.1*	187.60	173.5	173.6	173.5	174.5	171.5
VII	*186.3*	*14.4*	*16.3*	*16.3*	*16.4*	*16.3*	187.30	172.9	171.0	171.0	170.9	171.0

Stastical Results: Pile Tip Elev.	
Max	175.0
Min	170.0
Mean, μ	172.5
Std.Dev σ	6.0
μ - βσ	158.5
β = 2.33	

WRA

Estimation of Pile Tip Elevations

Project: I-95 Express Spot Improvement at Opitz Blvd.
Prince Williams Co. VA
WRA # 45893-001

Prep by: skk
Chk by:

Sheet No. 2 of 4
Date: 9/20/2021

Pier 2 -W.B.S												Stastical Results:	
Cap	Bottom	Data: Pile Depth (ft)										Pile Tip EL (ft.)	
No.	EL (ft)	Raw - 1	Raw - 2	Raw - 3	Raw - 4	Raw - 5	Raw - 6	Raw - 7	Raw - 8	Raw - 9	Raw - 10	Max	159.7
I	168.99	15.5	10.5	11.2	11.0	10.3	13.3	12.6	20.9	16.5	15.5	Min	149.1
II	169.29	20.7	16.6	15.7	19.4	15.7	20.6	17.5	18.6	17.6	18.7	Mean, μ	153.4
III	170.66	20.6	18.4	19.6	19.2	18.4	20.5	19.5	21.2	22.5	20.6	Std.Dev σ	3.1
Cap	Ref.	Calculated Pile Tip Elevation (ft)										μ - βσ	146.2
No.	EL (ft)	Raw - 1	Raw - 2	Raw - 3	Raw - 4	Raw - 5	Raw - 6	Raw - 7	Raw - 8	Raw - 9	Raw - 10	β = 2.33	
I	169.99	154.5	159.5	158.8	159.0	159.7	156.7	157.4	149.1	153.5	154.5		
II	170.29	149.6	153.7	154.6	150.9	154.6	149.7	152.8	151.7	152.7	151.6		
III	171.66	151.1	153.3	152.1	152.5	153.3	151.2	152.2	150.5	149.2	151.1		

Pier 2 -E.B.S												Stastical Results	
Cap	Bottom	Data: Pile Depth (ft)										Pile Tip EL (ft.)	
No.	EL (ft)	Raw - 1	Raw - 2	Raw - 3	Raw - 4	Raw - 5	Raw - 6	Raw - 7	Raw - 8	Raw - 9	Raw - 10	Max	160.0
IV	169.70	18.6	18.7	18.8	18.8	13.2	18.8	19.9	17.8	18.7	17.7	Max	150.8
V	169.39	10.9	10.4	11.6	10.6	11.0	10.7	10.8	13.9	13.7	11.6	Mean, μ	156.3
VI	169.05	10.7	10.9	10.7	12.1	11.8	12.0	11.8	15.8	14.3	14.8	Std.Dev σ	2.8
VII	168.73	11.8	12.0	12.0	13.5	12.8	13.8	14.3	14.9	15.9	14.7	μ - βσ	149.7
Cap	Ref.	Calculated Pile Tip Elevations										β = 2.33	
No.	EL (ft)	Raw - 1	Raw - 2	Raw - 3	Raw - 4	Raw - 5	Raw - 6	Raw - 7	Raw - 8	Raw - 9	Raw - 10		
IV	170.7	152.1	152.0	151.9	151.9	157.5	151.9	150.8	152.9	152.0	153.0		
V	170.4	159.5	160.0	158.8	159.8	159.4	159.7	159.6	156.5	156.7	158.8		
VI	170.1	159.4	159.2	159.4	158.0	158.3	158.1	158.3	154.3	155.8	155.3		
VII	169.7	157.9	157.7	157.7	156.2	156.9	155.9	155.4	154.8	153.8	155.0		

Estimation of Pile Tip Elevations	Project: I-95 Express Spot Improvement at Opitz Blvd. Prince Williams Co. VA WRA # 45893-001	Prep by: skk Chk by:	Sheet No. 3 of 4 Date: 9/20/2021

Pier 3 -W.B.S													Stastical Results:	
Cap	Bottom	Data: Pile Depth (ft)					Ref.	Calculated Pile Tip Elevation (ft)					Pile Tip EL (ft.)	
No.	EL (ft)	Raw - 1	Raw - 2	Raw - 3	Raw - 4	Raw - 5	EL (ft)	Raw - 1	Raw - 2	Raw - 3	Raw - 4	Raw - 5	Max	158.4
I	180.9	28.1	28.1	26.8	30.6	30.5	181.92	153.8	153.8	155.1	151.3	151.4	Min	151.3
II	181.9	24.4	24.6	24.5	24.7	24.5	182.92	158.5	158.3	158.4	158.2	158.4	Mean, μ	155.3
III	181.5	21.0	28.2	27.8	27.0	28.0	182.52	161.5	154.3	154.7	155.5	154.5	Std.Dev σ	2.9
													μ - $\beta\sigma$	148.6
													β = 2.33	

Pier 3 -E.B.S													Stastical Results:	
Cap	Bottom	Data: Pile Depth (ft)					Ref.	Calculated Pile Tip Elevation (ft)					Pile Tip EL (ft.)	
No.	EL (ft)	Raw - 1	Raw - 2	Raw - 3	Raw - 4	Raw - 5	EL (ft)	Raw - 1	Raw - 2	Raw - 3	Raw - 4	Raw - 5	Max	163.2
IV	181.3	29.9	28.0	20.0	30.3	30.3	182.26	152.4	154.3	162.3	152.0	152.0	Min	152.0
V	181.3	20.0	22.1	20.3	21.8	25.3	182.28	162.3	160.2	162.0	160.5	157.0	Mean, μ	158.5
VI	180.9	21.0	22.0	21.1	21.4	23.2	181.94	160.9	159.9	160.8	160.5	158.7	Std.Dev σ	3.8
VII	180.6	20.7	27.9	20.6	18.4	26.3	181.61	160.9	153.7	161.0	163.2	155.3	μ - $\beta\sigma$	149.6
													β = 2.33	

WRA

Estimation of Pile Tip Elevations

Project: I-95 Express Spot Improvement at Opitz Blvd.
Prince Williams Co. VA
WRA # 45893-001

Prep by: skk
Chk by:

Sheet No. 4 of 4
Date: 9/20/2021

		Pile Cap Bottom EL (ft)	Ref. EL (ft)	Pile Length L (ft.)	Pile Tip EL (ft.)
Abutment A	*WBL*	*205.64*	206.64	*27.0*	179.6
	EBL	*205.64*	206.64	*29.7*	176.9
Abutment B	*WBL*	*201.88*	202.88	*42.4*	160.5
	EBL	*201.88*	202.88	*43.3*	159.6

Stur.	Traffic Lane	Boring No.	Boring Bott. EL (ft.)	Pile Tip EL (ft.)			Elev. Of DR Top (ft.)	Pile Penet. (ft.)
				Max. (Shallow)	Min. (Deep)	Ave.		
Abut.A	W.B.L	1	174.0	---	---	179.6	184.0	4.4
	E.B.L	2	172.2	---	---	176.9	182.6	5.7
Pier 1	W.B.L	4	172.9	176.5	160.0	170.8	178.1	7.3
	E.B.L		172.9	175.0	170.0	172.5	178.1	5.6
Pier 2	W.B.L	6	157.7	159.7	149.1	153.4	167.9	14.5
	E.B.L	5	148.7	160.0	150.8	156.3	169.0	12.7
Pier 3	W.B.L	8	147.3	158.4	151.3	155.3	162.7	7.4
	E.B.L	7	151.7	163.2	152.0	158.5	163.7	5.2
Abut.B	W.B.L	10	144.7	---	---	160.5	165.3	4.8
	E.B.L	9	153.4	---	---	159.6	165.1	5.5

7/27/2021
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Plotted By: jlopez-ornelas

PROJECT MANAGER
SURVEYED BY, DATE
DESIGN BY
SUBSURFACE UTILITY BY, DATE

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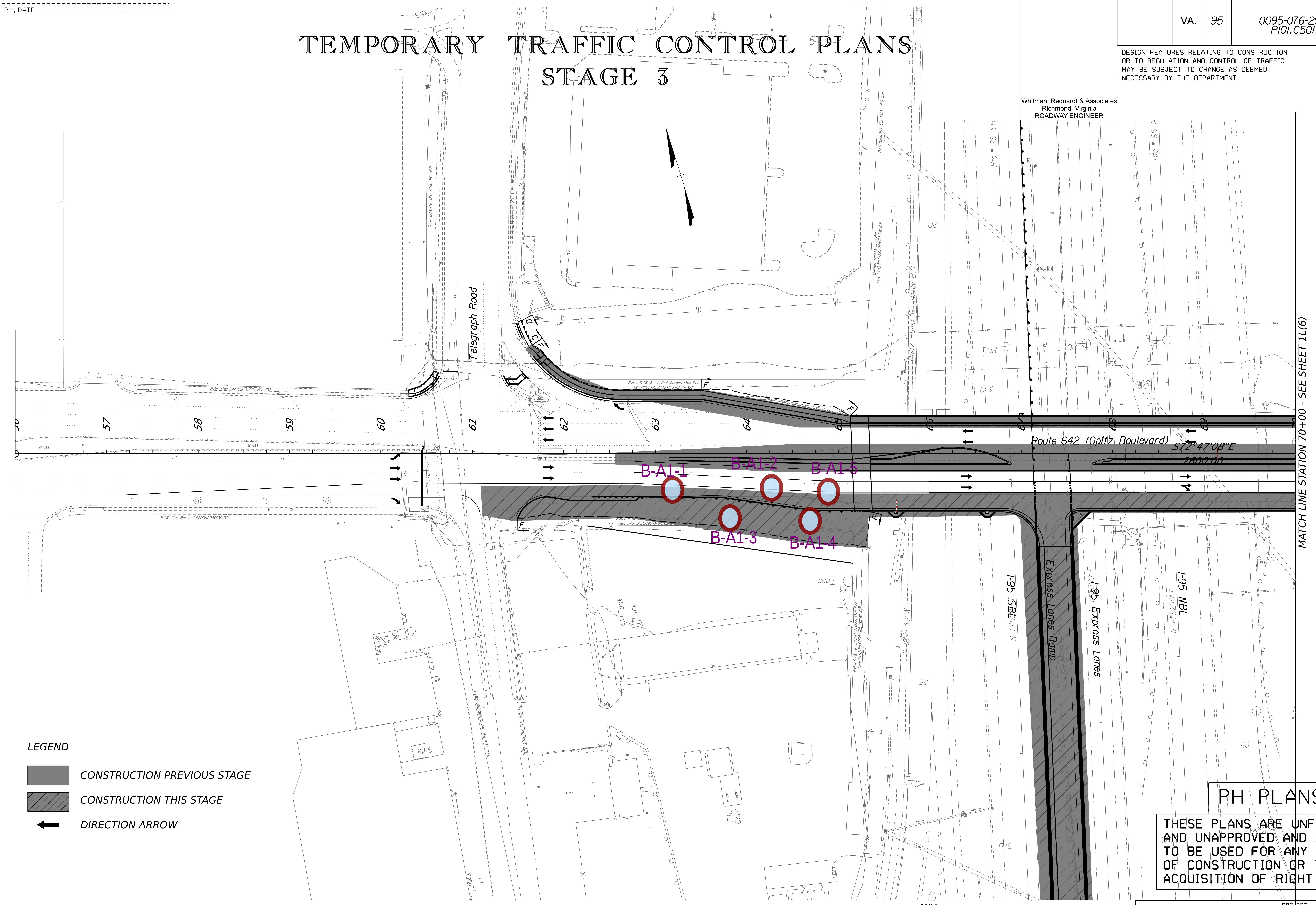
	VA.	95	0095-076-299 P101,C501	1L(5)

DESIGN FEATURES RELATING TO CONSTRUCTION
OR TO REGULATION AND CONTROL OF TRAFFIC
MAY BE SUBJECT TO CHANGE AS DEEMED
NECESSARY BY THE DEPARTMENT

Whitman, Requardt & Associates
Richmond, Virginia
ROADWAY ENGINEER

TEMPORARY TRAFFIC CONTROL PLANS
STAGE 3



LEGEND

▨ CONSTRUCTION PREVIOUS STAGE

▨ CONSTRUCTION THIS STAGE

← DIRECTION ARROW

PH PLANS

THESE PLANS ARE UNFINISHED
AND UNAPPROVED AND ARE NOT
TO BE USED FOR ANY TYPE
OF CONSTRUCTION OR THE
ACQUISITION OF RIGHT OF WAY.

SCALE
0 50' 100'

PROJECT	SHEET NO.
0095-076-299	1L(5)

Cell Revised 12/11/12

7/27/2021
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Plotted By: jlopez-ornelas

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DESIGN BY <Designer Name (000) 000-0000 (District)>
SUBSURFACE UTILITY BY, DATE <Surveyor Name (000) 000-0000 (District)>

Whitman, Requardt & Associates Richmond, Virginia HYDRAULICS ENGINEER	Whitman, Requardt & Associates Richmond, Virginia ROADWAY ENGINEER

REVISED	STATE	STATE ROUTE	STATE PROJECT	SHEET NO.
	VA.	95	0095-076-299 P101,C501	9

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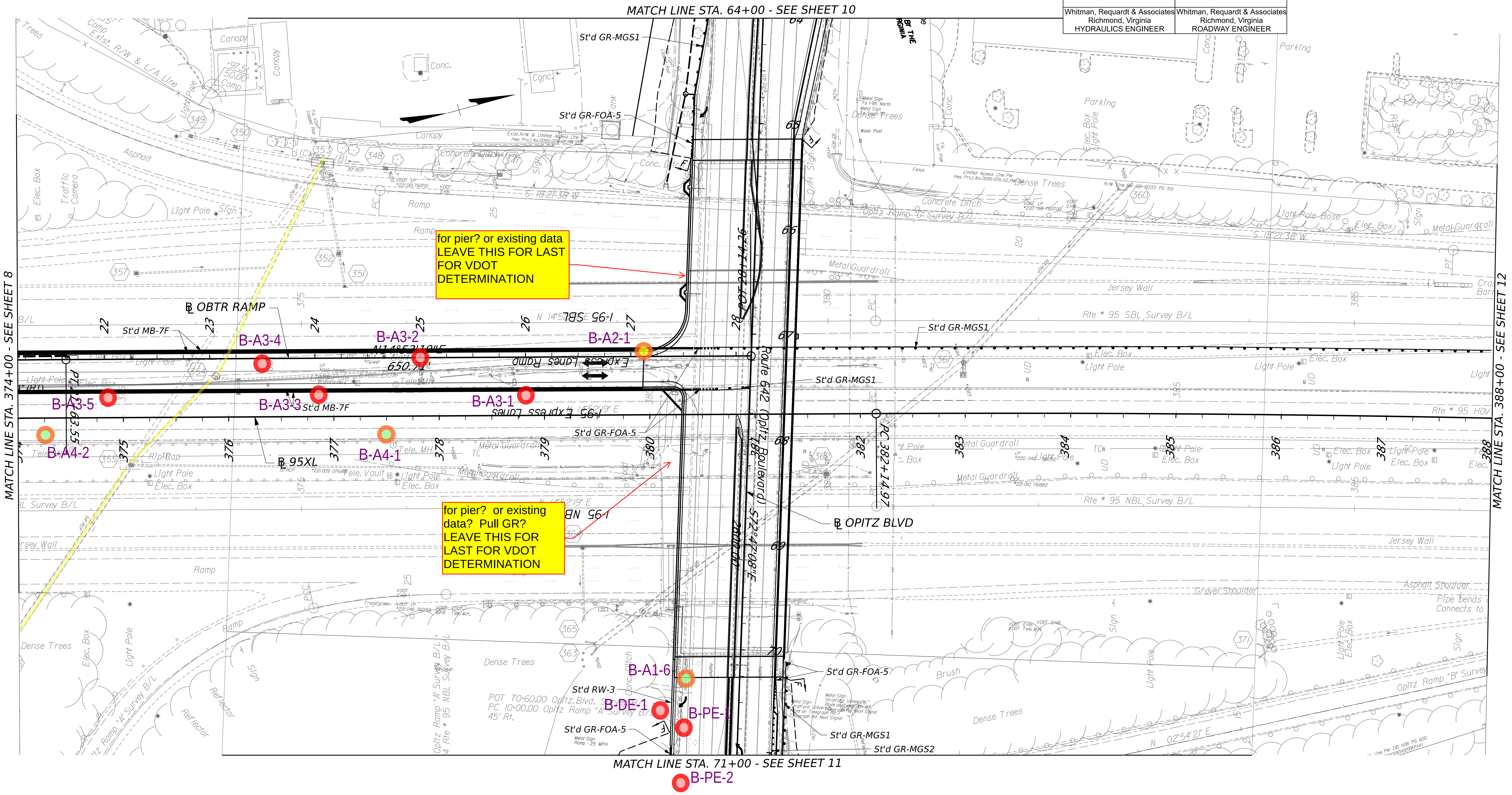

for pier? or existing data
LEAVE THIS FOR LAST
FOR VDOT
DETERMINATION

for pier? or existing
data? Pull GR?
LEAVE THIS FOR
LAST FOR VDOT
DETERMINATION

REFERENCES
(PROFILES, DETAIL & DRAINAGE
DESCRIPTION SHEETS, ETC.)

RAMP OBTR PROFILE	8A
OPITZ BLVD PROFILE	9A

SCALE
0 50' 100'

PH PLANS

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PROJECT	SHEET NO.
0095-076-299	9

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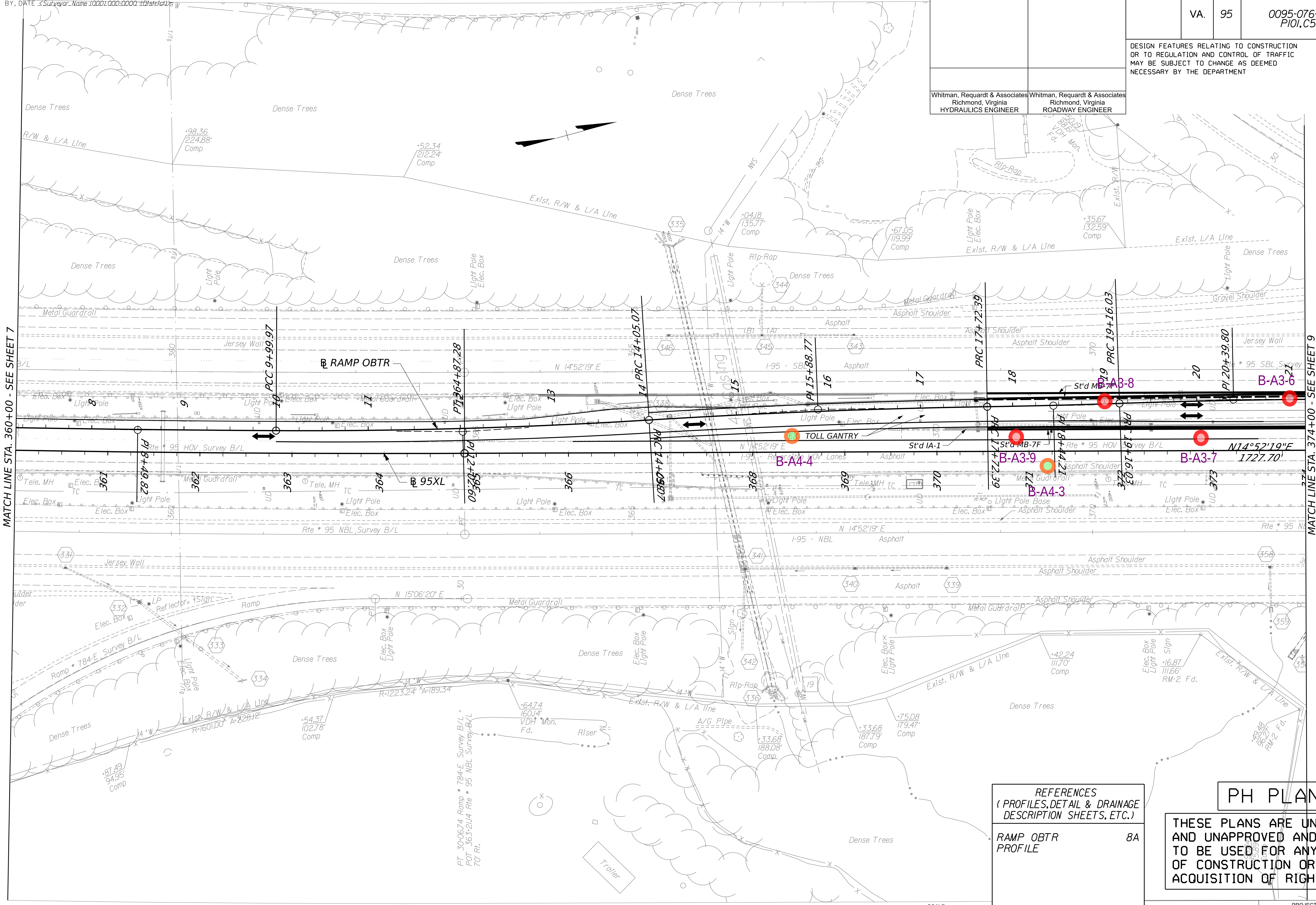
DESIGN BY <Designer Name (000) 000-0000 (District)>
SUBSURFACE UTILITY BY, DATE <Surveyor Name (000) 000-0000 (District)>

REVISED	STATE	STATE ROUTE	STATE PROJECT	SHEET NO.
	VA.	95	0095-076-299 P101, C501	8

DESIGN FEATURES RELATING TO CONSTRUCTION OR TO REGULATION AND CONTROL OF TRAFFIC MAY BE SUBJECT TO CHANGE AS DEEMED NECESSARY BY THE DEPARTMENT

Whitman, Requardt & Associates
Richmond, Virginia
HYDRAULICS ENGINEER

Whitman, Requardt & Associates
Richmond, Virginia
ROADWAY ENGINEER



REFERENCES
(PROFILES, DETAIL & DRAINAGE DESCRIPTION SHEETS, ETC.)

RAMP OBTR PROFILE	8A

SCALE
0 50' 100'

PH PLANS

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PROJECT	SHEET NO.
0095-076-299	8

Cell Revised 12/11/12

PROJECT MANAGER<Project Mgr Name (000) 000-0000 (District)>_______
SURVEYED BY, DATE <Surveyor Name (000) 000-0000 (District)>________
DESIGN BY <Designer Name (000) 000-0000 (District)>_______________
SUBSURFACE UTILITY BY, DATE <Surveyor Name (000) 000-0000 (District)>

REVISED	STATE	STATE ROUTE	STATE PROJECT	SHEET NO.
	VA.	95	0095-076-299 PE-101, C-501	6

DESIGN FEATURES RELATING TO CONSTRUCTION
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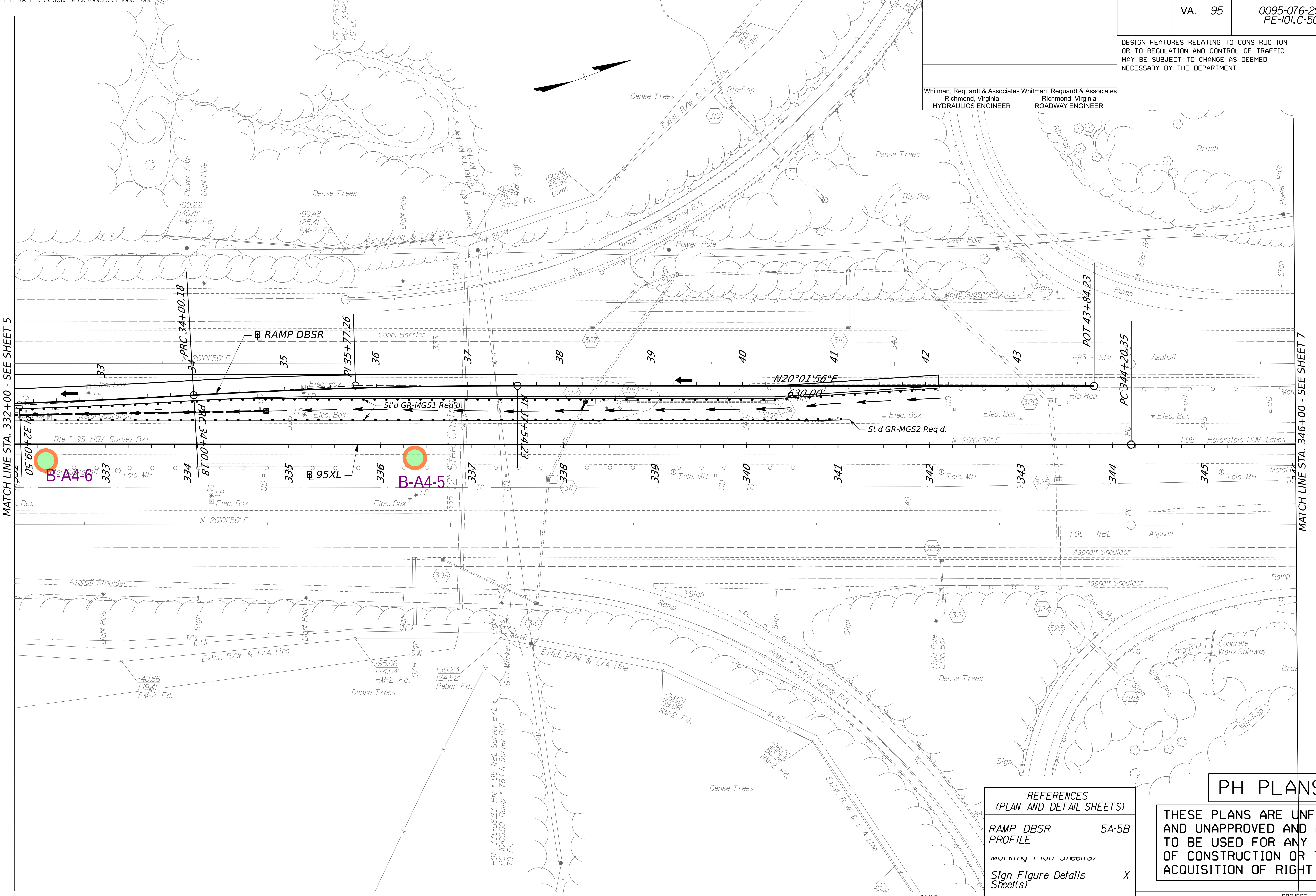
Whitman, Requardt & Associates Richmond, Virginia HYDRAULICS ENGINEER	Whitman, Requardt & Associates Richmond, Virginia ROADWAY ENGINEER



REFERENCES
(PLAN AND DETAIL SHEETS)

RAMP DBSR PROFILE	5A-5B
Marking Plan Sheet(s)	
Sign Figure Details Sheet(s)	X

PH PLANS

THESE PLANS ARE UNFINISHED
AND UNAPPROVED AND ARE NOT
TO BE USED FOR ANY TYPE
OF CONSTRUCTION OR THE
ACQUISITION OF RIGHT OF WAY.

PROJECT	SHEET NO.
0095-076-299	6

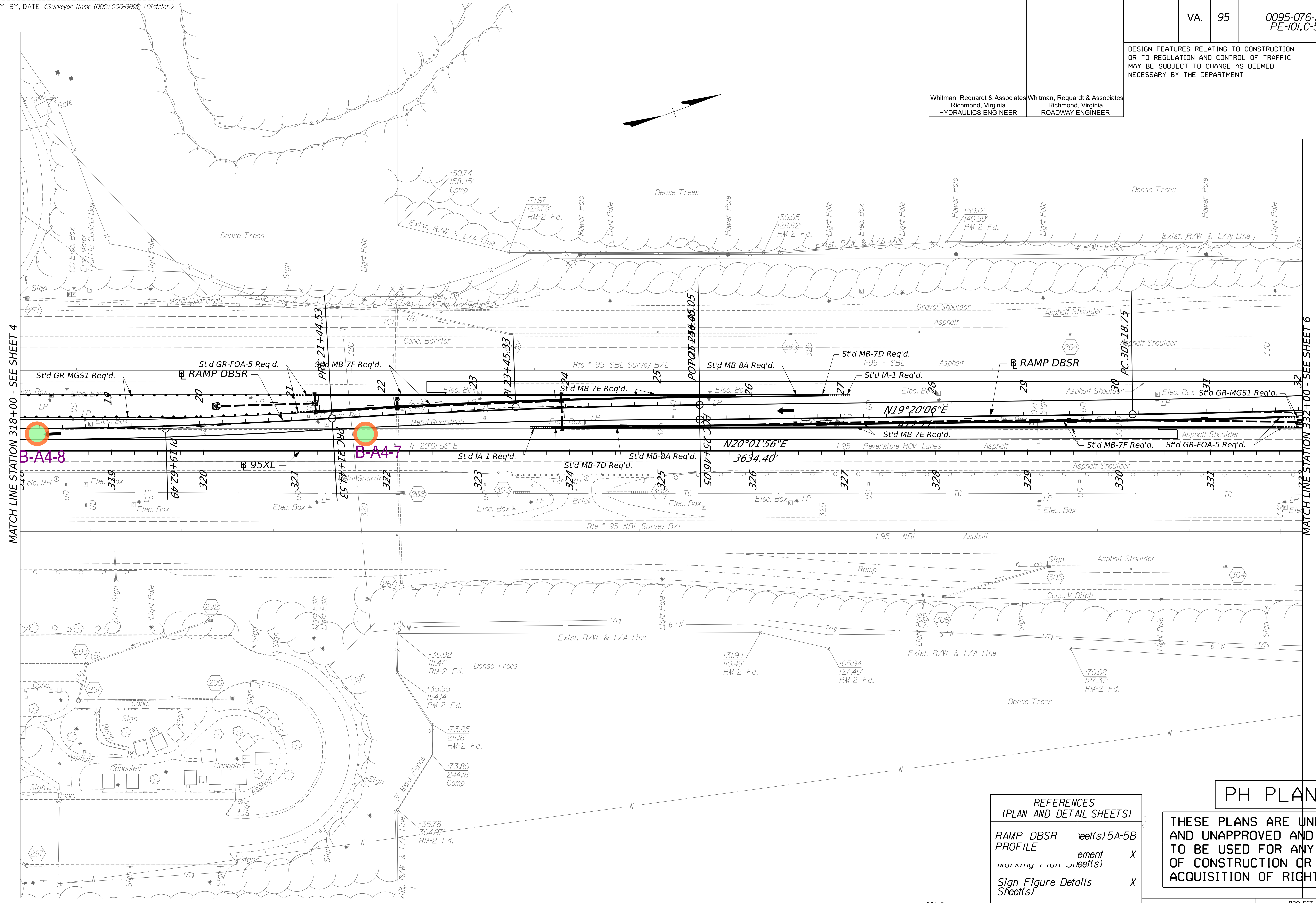
PROJECT MANAGER <Project Mgr Name (000) 000-0000 (District)>
SURVEYED BY, DATE <Surveyor Name (000) 000-0000 (District)>
DESIGN BY <Designer Name (000) 000-0000 (District)>
SUBSURFACE UTILITY BY, DATE <Surveyor Name (000) 000-0000 (District)>

REVISED	STATE	STATE ROUTE	STATE PROJECT	SHEET NO.
	VA.	95	0095-076-299 PE-101, C-501	5

DESIGN FEATURES RELATING TO CONSTRUCTION OR TO REGULATION AND CONTROL OF TRAFFIC MAY BE SUBJECT TO CHANGE AS DEEMED NECESSARY BY THE DEPARTMENT

Whitman, Requardt & Associates
Richmond, Virginia
HYDRAULICS ENGINEER

Whitman, Requardt & Associates
Richmond, Virginia
ROADWAY ENGINEER



REFERENCES
(PLAN AND DETAIL SHEETS)

RAMP DBSR PROFILE Sheet(s)	5A-5B
Pavement Marking Plan Sheet(s)	X
Sign Figure Details Sheet(s)	X

PH PLANS

THESE PLANS ARE UNFINISHED AND UNAPPROVED AND ARE NOT TO BE USED FOR ANY TYPE OF CONSTRUCTION OR THE ACQUISITION OF RIGHT OF WAY.

APPENDIX C

Subsurface Investigation Records

APPENDIX C.1

Test Boring Summary

Test Boring - Complete Summary

			Coordinates		Boring Stations							Pavement				
Ref.	Test Hole ID	Purpose & Location	Northing (ft.)	Easting (ft.)	Ref (ft.)	Sta (ft.)	Offset (ft.)	Ground EL (ft.)	Boring Depth (ft.)	Ground Water Depth (ft.)	Ground Water EL (inch)	Pavement Core	Asphalt (inch)	Base (inch)	Concrete (inch)	Notes
1	B-A1-1	East Bound Opitz Blvd	355465.6391	3626202.7403	Opitz Blvd	63+25	41 RT	212.5	15.0	N/E	---	1	12.0	4.0	---	---
2	B-A1-2	East Bound Opitz Blvd	355436.0442	3626298.2607	Opitz Blvd	64+25	41 RT	214.2	20.0	N/E	---	1	11.0	7.0	---	---
3	B-A1-3	Retaining wall design	355433.4805	3626245.1215	Opitz Blvd	63+75	59 RT	209.4	30.0	N/E	---	---	---	---	---	---
4	B-A1-4	Retaining wall design	355390.5715	3626336.5168	Opitz Blvd	64+75	73 RT	203.9	28.8	23.5	180.4	---	---	---	---	---
	B-A1-5	Abut A Opitz Br.	355408.0699	3626341.9383	Opitz Blvd	64+75	55 RT	214.0								Not drilled
5	B-A1-6	Abut B Opitz Vr.	355252.1568	3626874.5973	Opitz Blvd	70+30	46 RT	211.6	75.0	56.0	155.6	---	5.0	12.0	---	
6	B-PE-1	Opitz Blvd shoulders	355235.5276	3626916.6181	Opitz Blvd	70+75	50 RT	209.8	3.2	N/E	---	1	4.5	10.5	---	
7	B-PE-2	Opitz Blvd shoulders	355218.8102	3626963.7834	Opitz Blvd	71+25	52 RT	208.1	3.2	N/E	---	1	3.0	11.0	---	
8	B-A2-1	Abut.C for T-Ramp	355278.6864	3626597.1158	T-Ramp	27+10	20 RT	188.0	59.0	23.5	164.5		7.0	17.0	6.0	Note (1)
9	B-A3-1	T-Ramp MSE Wall	355172.3987	3626568.6573	T-Ramp	26+00	20 RT	187.0	40.0	20.0	167.0	---	15.0	4.0	---	
10	B-A3-2	T-Ramp MSE Wall	355083.9063	3626512.2718	T-Ramp	25+00	12 LT	189.2	40.0	20.7	168.5	---	18.0	18.0	---	
11	B-A3-3	T-Ramp MSE Wall	354978.3553	3626520.1235	T-Ramp	24+00	23 RT	185.4	30.0	19.5	165.9	---	15.0	5.0	4.0	Note (2)
12	B-A3-4	T-Ramp MSE Wall	354937.3133	3626479.5403	T-Ramp	23+50	6 LT	187.2	30.0	22.0	165.2	---	18.0	18.0	---	---
13	B-A3-5	T-Ramp MSE Wall	354785.0818	3626468.6903	T-Ramp	22+00	35 RT	183.5	20.0	N/E	---	---	19.0	9.0	---	---
14	B-A3-6	T-Ramp MSE Wall	354697.7435	3626407.9003	T-Ramp	21+00	2 LT	184.9	20.0	N/E	---	---	19.0	18.0	---	---
15	B-A3-7	T-Ramp MSE Wall	354591.7507	3626417.4743	T-Ramp	19+99	33 RT	181.6	15.0	N/E	---	---	15.0	9.0	---	---
16	B-A3-8	T-Ramp MSE Wall	354503.8875	3626358.4498	T-Ramp	19+00	4 LT	181.1	10.0	N/E	---	---	19.0	23.0	---	---
17	B-A3-9	Roadway south of T ramp	354398.3209	3626366.6296	T-Ramp	17+99	29 RT	179.9	10.0	N/E	---	---	12.0	9.0	3.0	Note (3)
18	B-A4-1	I-95 XBL MOT	355034.2590	3626573.5922	I-95 XBL	727+80	17 RT	186.1	8.0	N/E	---	1	14.0	10.0	---	---
19	B-A4-2	I-95 XBL MOT	354720.1225	3626490.2662	I-95 XBL	724+55	17 LT	183.0	8.0	N/E	---	1	17.0	8.0	---	---
20	B-A4-3	I-95 XBL MOT	354430.0292	3626413.7890	I-95 XBL	721+55	18 RT	180.2	8.0	N/E	---	1	17.0	8.0	---	---
21	B-A4-4	I-95 XBL MOT	354157.6633	3626304.2854	I-95 XBL	718+64	18 LT	179.0	8.0	N/E	---	1	15.0	9.0	---	---
22	B-A4-5	I-95 XBL Slip Ramp	351117.2654	3625366.6140	I-95 XBL	686+81	18 LT	172.1	8.0	N/E	---	1	16.0	9.0	---	---
23	B-A4-6	I-95 XBL Slip Ramp	350741.8477	3625229.2087	I-95 XBL	682+81	18 RT	168.3	8.0	N/E	---	1	15.0	10.0	---	---
24	B-A4-7	I-95 XBL Slip Ramp	349743.9644	3624827.1230	I-95 XBL	672+06	18 LT	149.8	8.0	N/E	---	1	16.0	9.0	---	---
25	B-A4-8	I-95 XBL Slip Ramp	349415.1818	3624707.6334	I-95 XBL	668+56	18 LT	140.3	8.0	N/E	---	1	15.0	33.0	---	---

Note(1) 7.0"**ASPH** + 6.0"**CONC** + 17.0"**Base**

Note(2) 15.0"**ASPH** + 5.0" **Base** + 4.0" **CONC**

Note(3) 9.0"**ASPH** + 3.0"**CONC** + 3.0"**ASPH** + 9.0"**Base**

APPENDIX C.2

Test Boring Logs

VDOT
Virginia Department of Transportation

PROJECT #: 45893-001
LOCATION: I-95 Express way/Opitz Blvd.
STRUCTURE: PAVEMENT

B-A1-1

PAGE 1 OF 1

STATION: 63+25
OFFSET: 41 RT
NORTHING: 355465.6391 ft
Easting: 3626202.7403 ft
SURFACE ELEVATION: 212.5 ft
COORD. DATUM: VA South

Date(s) Drilled: 11/9/2021 - 11/9/2021
Drilling Method(s): HSA
SPT Method: Automatic Hammer
Other Test(s):
Driller: SaLUT, Inc.
Logger: J. Yadeta

GROUND WATER
NOT ENCOUNTERED DURING DRILLING

FIELD DATA

DEPTH (ft)	ELEVATION (ft)	SOIL: STANDARD PENETRATION TEST HAMMER BLOWS	SOIL: SOIL RECOVERY (%)	SAMPLE LEGEND	SAMPLE INTERVAL	ROCK: CORE RECOVERY (%)	ROCK: ROCK QUALITY DESIGNATION	ROCK: DIP ° STRATA	ROCK: DIP ° JOINTS	STRATA LEGEND
2	210	8 4 3	33	⊠	1.5 3					
4		2 3 4	0	⊠	3.5 5					
6		2 2 4	100	⊠	6 7.5					
8	205									
10		3 6 10	67	⊠	8.5 10					
12	200	5 6 8	100	⊠	11 12.5					
14		5 11 11	87	⊠	13.5 15					

FIELD DESCRIPTION OF STRATA

FIELD DESCRIPTION OF STRATA	LIQUID LIMIT LL	PLASTICITY INDEX PI	MOISTURE CONTENT (%)	FINES CONTENT -#200 (%)
0.0 / 212.5 12" Asphalt **ASPH**				
1.0 / 211.5 *4" Subbase material*, Light gray, medium to coarse, SAND AND GRAVEL, trace Silt, dry **CRA**			8.3	
1.33 / 211.17 *Fill*, Tan-gray, FAT CLAY WITH SAND, trace wood, medium stiff, moist. Wood stuck at spoon tip and there were no sample recovered. sample was later retrived with 3" spoon **CH**			35.2	
	68	41	30.0	76.0
8.5 / 204.0 *Fill*, Tan, fine to medium, SILTY SAND, medium dense, moist **SM**			24.1	
			21.3	
			13.8	
15.0 / 197.5 Boring trerminated at 15ft				

REMARKS: Rig Type: Acker XLS.
Boring was offset 5' towards east due to undergroun utility. Hole backfilled with soil cutting and patched with cold asphalt at the surface.

PAGE 1 OF 1

B-A1-1

SPT_LOGB:I-95 EXPRESS LANE- OPITZ BLVD BORINGS.GPJ:SPT7.GDT:gINT_version 10.02.00.04:1/20/22:WRA

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VDOT Virginia Department of Transportation

PROJECT #: 45893-001
LOCATION: I-95 Express way/Opitz Blvd.
STRUCTURE: PAVEMENT

B-A1-2

PAGE 1 OF 1

STATION: 64+25
OFFSET: 41 RT
NORTHING: 355436.0442 ft
Easting: 3626298.2607 ft
SURFACE ELEVATION: 214.2 ft
COORD. DATUM: VA South

Date(s) Drilled: 11/9/2021 - 11/9/2021
Drilling Method(s): HSA
SPT Method: Automatic Hammer
Other Test(s):
Driller: SaLUT, Inc.
Logger: J. Yadeta

GROUND WATER
NOT ENCOUNTERED DURING DRILLING

FIELD DATA / LAB DATA

DEPTH (ft)	ELEVATION (ft)	STANDARD PENETRATION TEST HAMMER BLOWS	SOIL RECOVERY (%)	SAMPLE INTERVAL	CORE RECOVERY (%)	ROCK QUALITY DESIGNATION	DIP ° STRATA	DIP ° JOINTS	LIQUID LIMIT LL	PLASTICITY INDEX PI	MOISTURE CONTENT (%)	FINES CONTENT -#200 (%)
2		3 3 3	33	1.5 - 3							21.7	
4	210	3 3 2	67	3.5 - 5							33.7	
6		2 4 4	80	6 - 7.5							21.4	
8												
10	205	3 4 5	20	8.5 - 10							29.8	
12		3 7 11	100	11 - 12.5							26.6	76.0
14	200	3 5 6	100	13.5 - 15							16.4	
16		4 10 8	100	16 - 17.5							14.8	
18												
20	195	5 11 11	100	18.5 - 20							13.0	

FIELD DESCRIPTION OF STRATA

0.0 / 214.2
11" Asphalt **ASPH**

0.92 / 213.28
7" Subbase material, Light gray, medium to coarse, SAND AND GRAVEL, trace Silt, dry **CRA**

1.5 / 212.7
Fill, Tan-gray, FAT CLAY WITH SAND, trace to some Gravel, medium stiff, moist. **CH**

11.0 / 203.2
Fill, Red, tan, multi color, SANDY LEAN CLAY, very stiff, moist **CL**

14.0 / 200.2
Possible Fill, Tan, fine to medium, SILTY SAND, trace elastic fine, medium dense, moist **SM**

17.5 / 196.7
Brown, tan, fine to medium, POORLY GRADED SAND WITH SILT, medium dense, moist **SP-SM**

20.0 / 194.2
Boring trerminated at 20ft

REMARKS: Rig Type: Acker XLS.
Boring was offset 5' towards west due to undergroun utility. Hole backfilled with soil cutting and patched with cold asphalt at the surface.

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B-A1-2

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PROJECT #: 45893-001
LOCATION: I-95 Express way/Opitz Blvd.
STRUCTURE: RETAINING WALL

B-A1-3

PAGE 1 OF 1

STATION: 63+75
OFFSET: 59 RT
NORTHING: 355433.4805 ft
Easting: 3626245.1215 ft
SURFACE ELEVATION: 209.4 ft
COORD. DATUM: VA South

Date(s) Drilled: 10/11/2021 - 10/11/2021
Drilling Method(s): HSA
SPT Method: Automatic Hammer
Other Test(s):
Driller: SaLUT, Inc.
Logger: J. Yadeta

GROUND WATER
NOT ENCOUNTERED DURING DRILLING

FIELD DATA / LAB DATA

SAMPLE INTERVAL	STANDARD PENETRATION TEST HAMMER BLOWS	SOIL RECOVERY (%)	CORE RECOVERY (%)	ROCK QUALITY DESIGNATION	DIP ° STRATA	DIP ° JOINTS	LIQUID LIMIT LL	PLASTICITY INDEX PI	MOISTURE CONTENT (%)	FINES CONTENT -#200 (%)
0 - 1.5	1 3 3	33							18.7	
1.5 - 3	5 4 5	93							15.2	
5 - 6.5	3 10 6	80							13.9	25.0
7.5 - 9	5 8 7	100							17.5	
10 - 11.5	4 7 7	100							16.0	
12.5 - 14	7 16 21	100							17.8	
15 - 16.5	18 20 27	100							19.6	
17.5 - 19	29 26 39	100							11.5	
23.5 - 25	11 26 27	80							11.7	
28.5 - 30	39 50/3"	60							9.1	

DEPTH (ft): 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28, 30
ELEVATION (ft): 205, 200, 195, 190, 185, 180

FIELD DESCRIPTION OF STRATA

0.0 / 209.4
4" Topsoil **TOPS**

0.2 / 209.2
Fill, Light brown, fine to medium, SILTY SAND FILL, trace roots, loose, moist **SM**

3.0 / 206.4
Possible fill, Tan, fine to medium, SILTY SAND, medium dense, moist **SM**

13.0 / 196.4
Residual, Light gray, fine to medium, POORLY GRADED SAND WITH SILT, dense, moist **SP-SM**

15.0 / 194.4
Decomposed Rock, Gray, black, medium to coarse, highly weathered, DECOMPOSED GRAPHITIC SCHIST, lithified, very dense, dry **MST**

30.0 / 179.4
Boring trerminated at 30ft

REMARKS: Rig Type: Acker XLS.
Boring was offset 20' west and 5' south. As drilled boring elevatoin is 3' lower than the original location. Bulk sample collected from 0'-8'. Hole backfilled with soil cutting and patched with cold asphalt at the surface.

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B-A1-3

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PROJECT #: **45893-001**
LOCATION: **I-95 Express way/Opitz Blvd.**
STRUCTURE: **RETAINING WALL**

B-A1-4

PAGE 1 OF 1

STATION: 64+75
OFFSET: 73 RT
NORTHING: 355390.5715 ft
Easting: 3626336.5168 ft
SURFACE ELEVATION: 203.9 ft
COORD. DATUM: VA South

Date(s) Drilled: 10/12/2021 - 10/12/2021
Drilling Method(s): HSA
SPT Method: Automatic Hammer
Other Test(s):
Driller: SaLUT, Inc.
Logger: J. Yadeta

GROUND WATER

▽ FIRST ENCOUNTERED AT 23.5 ft DEPTH

FIELD DATA

SAMPLE INTERVAL	STANDARD PENETRATION TEST HAMMER BLOWS	SOIL RECOVERY (%)	MOISTURE CONTENT (%)
1 - 2.5	10 14 5	67	19.9
3.5 - 5	3 4 6	100	20.8
6 - 7.5	3 6 7	100	13.6
8.5 - 10	2 4 7	100	18.6
11 - 12.5	4 6 5	100	16.6
13.5 - 15	5 7 8	100	15.6
16 - 17.5	20 23 17	100	15.7
18.5 - 20	7 10 14	93	24.4
21 - 21.3	50/3"	1000	11.1
23.5 - 23.9	50/4"	1000	11.1
28.5 - 28.8	50/3"	1000	13.5

DEPTH (ft)	ELEVATION (ft)
4	200
9	195
14	190
19	185
24	180

ROCK: CORE RECOVERY (%) | ROCK QUALITY DESIGNATION | DIP ° STRATA | JOINTS — no entries

LAB DATA: LIQUID LIMIT LL | PLASTICITY INDEX PI — no entries

FIELD DESCRIPTION OF STRATA

0.0 / 203.9
12" Asphlat **ASPH**

1.0 / 202.9
12" Subbase material, Light gray, medium to coarse, SAND AND GRAVEL, trace Silt, dry **CRA**

2.0 / 201.9
Possible fill, Tan-brown, fine to medium, SILTY SAND, some elastic fine, loose, moist **SM**

6.5 / 197.4
Brown-tan, medium to coarse, SILTY SAND WITH FINE GRAVEL, medium dense, moist **SM/GM**

9.0 / 194.9
Light brown-light gray, fine to medium, POORLY GRADED SAND WITH SILT, medium dense, moist **SP-SM**

16.0 / 187.9
Brown-red, medium to coarse, SILTY SAND, trace fine gravel, dense, moist **SM**

19.0 / 184.9
Residual, Gray, black, highly weathered, DECOMPOSED GRAPHITIC SCHIST, lithified, very stiff, damp **MST**

21.0 / 182.9
Decomposed Rock, Gray, DECOMPOSED GRAPHITIC SCHIST, very dense, dry. Water was noted between rock layers near 25ft. **MST**

28.8 / 175.1
Boring trerminated at 28.8ft

REMARKS: Rig Type: Acker XLS.
Boring was offset 15' south. As drilled boring elevatoin is 1' lower than the original location. Hole backfilled with soil cutting and patched with cold asphalt at the surface.

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B-A1-4

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PROJECT #: 45893-001
LOCATION: I-95 Express way/Opitz Blvd.
STRUCTURE: BRIDGE

B-A1-6

PAGE 1 OF 3

STATION: 70+30
OFFSET: 46 RT
NORTHING: 355252.1568 ft
Easting: 3626874.5973 ft
SURFACE ELEVATION: 211.6 ft
COORD. DATUM: VA South

Date(s) Drilled: 11/8/2021 - 11/8/2021
Drilling Method(s): HSA
SPT Method: Automatic Hammer
Other Test(s):
Driller: SaLUT, Inc.
Logger: J. Yadeta

GROUND WATER

⊻ FIRST ENCOUNTERED AT 58.5 ft DEPTH

FIELD DATA / LAB DATA

SAMPLE INTERVAL (ft)	STANDARD PENETRATION TEST HAMMER BLOWS	SOIL RECOVERY (%)	LIQUID LIMIT (LL)	PLASTICITY INDEX (PI)	MOISTURE CONTENT (%)	FINES CONTENT -#200 (%)
0.5 - 2	6 7 5	33			6.6	
3.5 - 5	2 3 2	67			19.3	
6 - 7.5	WOH/4" 2/8" 17	100			18.9	
8.5 - 10	2 3 4	80			13.3	
11 - 12.5	2 3 4	100			18.7	
13.5 - 15	3 3 3	100	35	11	15.6	23.0
16 - 17.5	3 4 4	100			15.8	
18.5 - 20	3 6 4	100			15.6	
23.5 - 25	3 4 3	100			16.1	
28.5 - 30	3 6 9	67			26.6	
33.5 - 35	5 9 8	47			16.5	

FIELD DESCRIPTION OF STRATA

0.0 / 211.6
5" Asphlat **ASPH**

0.42 / 211.18
12" Subbase material, Light gray, medium to coarse, SAND AND GRAVEL, trace Silt, dry **CCA**

1.42 / 210.18
Fill, Light brown, fine to medium SILTY SAND FILL, trace elastic fine, loose, moist
Layer of 6" thick, mottled, tan-gray, FAT CLAY binder exists from 6'-6.5' **SM**

7.5 / 204.1
Fill, Light gray, light brown, fine to medium, CLAYEY SAND, loose, moist **SC**

20.0 / 191.6
Fill, Tan, light brown, fine to coarse, SAND WITH GRAVEL, trace Clay, loose, damp **SP/GP**

25.0 / 186.6
Fill, Tan, gray, fine to medium, SILTY, CLAYEY SAND, trace root, medium dense, moist **SC-SM**

30.0 / 181.6
Fill, Light brown, fine to coarse, SILTY SAND WITH GRAVEL, medium dense, moist **SM/GM**

REMARKS: Rig Type: Acker XLS.
Boring was offset 20' towards east due to undergroun utility. As drilled boring elevatoin is the same as the original location. Bulk sample collected from 0' - 8'. Hole backfilled with soil cutting and patched with cold asphalt at the surface.

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PROJECT #: 45893-001
LOCATION: I-95 Express way/Opitz Blvd.
STRUCTURE: BRIDGE

B-A1-6

PAGE 2 OF 3

STATION: 70+30
OFFSET: 46 RT
NORTHING: 355252.1568 ft
Easting: 3626874.5973 ft
SURFACE ELEVATION: 211.6 ft
COORD. DATUM: VA South

Date(s) Drilled: 11/8/2021 - 11/8/2021
Drilling Method(s): HSA
SPT Method: Automatic Hammer
Other Test(s):
Driller: SaLUT, Inc.
Logger: J. Yadeta

GROUND WATER

∇ FIRST ENCOUNTERED AT 58.5 ft DEPTH

FIELD DATA / LAB DATA

STANDARD PENETRATION TEST HAMMER BLOWS	SOIL RECOVERY (%)	SAMPLE INTERVAL	LIQUID LIMIT (LL)	PLASTICITY INDEX (PI)	MOISTURE CONTENT (%)	FINES CONTENT -#200 (%)
3 3 4	87	38.5 - 40			18.3	
2 4 8	20	43.5 - 45	35	11	19.2	98.0
8 20 19	80	48.5 - 50			17.2	
50/4"	20	53.5 - 55			12.1	
26 20 50	100	58.5 - 60			11.9	
15 50/1"	40	63.5 - 65			14.9	
50/2"	13	68.5 - 70			19.7	

FIELD DESCRIPTION OF STRATA

38.0 / 173.6
Residual, Gray, fine to medium, SILTY SAND, loose, moist
SM

43.5 / 168.1
Gray, LEAN CLAY, stiff, damp **CL**

48.5 / 163.1
Black, SILT, highly weathered, DECOMPOSED GRAPHITIC SCHIST, lithified, some rock fragments, very stiff to hard, dry to wet below 58.5'
Hard augering below 68.5' **MST**

REMARKS: Rig Type: Acker XLS.
Boring was offset 20' towards east due to undergroun utility. As drilled boring elevatoin is the same as the original location. Bulk sample collected from 0' - 8'. Hole backfilled with soil cutting and patched with cold asphalt at the surface.

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B-A1-6

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PROJECT #: 45893-001
LOCATION: I-95 Express way/Opitz Blvd.
STRUCTURE: BRIDGE

B-A1-6

PAGE 3 OF 3

STATION: 70+30
OFFSET: 46 RT
NORTHING: 355252.1568 ft
Easting: 3626874.5973 ft
SURFACE ELEVATION: 211.6 ft
COORD. DATUM: VA South

Date(s) Drilled: 11/8/2021 - 11/8/2021
Drilling Method(s): HSA
SPT Method: Automatic Hammer
Other Test(s):
Driller: SaLUT, Inc.
Logger: J. Yadeta

GROUND WATER
⊻ FIRST ENCOUNTERED AT 58.5 ft DEPTH

FIELD DATA											FIELD DESCRIPTION OF STRATA	LAB DATA			
		SOIL				ROCK									
								DIP °							
DEPTH (ft)	ELEVATION (ft)	STANDARD PENETRATION TEST HAMMER BLOWS	SOIL RECOVERY (%)	SAMPLE LEGEND	SAMPLE INTERVAL	CORE RECOVERY (%)	ROCK QUALITY DESIGNATION	STRATA	JOINTS	STRATA LEGEND		LIQUID LIMIT LL	PLASTICITY INDEX PI	MOISTURE CONTENT (%)	FINES CONTENT -#200 (%)
74		15 50/2"	40	☒	73.5 75					▤				16.2	
											75.0 / 136.6 Boring terminated at 75ft				

REMARKS: Rig Type: Acker XLS.
Boring was offset 20' towards east due to undergroun utility. As drilled boring elevatoin is the same as the original location. Bulk sample collected from 0' - 8'. Hole backfilled with soil cutting and patched with cold asphalt at the surface.

PAGE 3 OF 3

B-A1-6

SPT_LOGB:I-95 EXPRESS LANE- OPITZ BLVD BORINGS.GPJ:SPT7.GDT:gINT_version 10.02.00.04:1/20/22:WRA

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Virginia Department of Transportation

PROJECT #: **45893-001**
LOCATION: **I-95 Express way/Opitz Blvd.**
STRUCTURE: **MSE WALL**

B-A2-1

PAGE 1 OF 2

STATION: 27+10
OFFSET: 20 RT
NORTHING: 355278.6864 ft
Easting: 3626597.1158 ft
SURFACE ELEVATION: 188.0 ft
COORD. DATUM: VA South

Date(s) Drilled: 11/22/2021 - 11/23/2021
Drilling Method(s): HSA
SPT Method: Automatic Hammer
Other Test(s):
Driller: SaLUT, Inc.
Logger: J. Yadeta

GROUND WATER
⊻ FIRST ENCOUNTERED AT 23.5 ft DEPTH

FIELD DATA / **LAB DATA**

SAMPLE INTERVAL	STANDARD PENETRATION TEST HAMMER BLOWS	SOIL RECOVERY (%)	LIQUID LIMIT LL	PLASTICITY INDEX PI	MOISTURE CONTENT (%)	FINES CONTENT -#200 (%)
1.5 3	45 11 6	60			10.1	
3.5 5	2 3 4	93			18.1	
6 7.5	2 3 4	67			14.4	
8.5 10	4 3 3	80			12.7	22.0
11 12.5	4 6 8	80			10.8	
13.5 15	4 8 8	100			14.3	
16 17.5	5 8 7	100			16.2	
18.5 20	4 7 8	87			20.7	
23.5 25	4 5 9	100			23.1	
28.5 30	15 20 53	87			10.1	46.0
33.5 35	27 50/3" 24	53			10.0	

FIELD DESCRIPTION OF STRATA

0.0 / 188.0
7" Asphalt **ASPH**

0.6 / 187.4
6" Concrete **CONC**

1.1 / 186.9
17" Subbase material, Gray, medium to coarse, SAND AND GRAVEL, trace Silt, very dense, dry **CRA**

2.5 / 185.5
Fill, Black, brown shadding, fine to medium, SILTY SAND, some elastic fine, loose, moist **SM**

6.5 / 181.5
Possible fill, Tan, *black spotting at 13.5'-15'*, fine to medium, POORLY GRADED SAND WITH SILT, trace Gravel, loose to medium dense, moist **SP-SM**

23.5 / 164.5
Residual, Gray, black, lithified, SILT derived from decomposition of parent rock, trace rock fragments, hard, moist **ML**

REMARKS: Rig Type: Acker XLS.
Boring was offset 35' towards east, drilled on western shoulder of I-95 express lane. Cave-in at 55.3'. Hole backfilled with soil cutting and patched with cold asphalt at the surface.

PAGE 1 OF 2

B-A2-1

SPT_LOGB:I-95 EXPRESS LANE- OPITZ BLVD BORINGS.GPJ:SPT7.GDT:gINT_version 10.02.00.04:1/20/22:WRA

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PROJECT #: 45893-001
LOCATION: I-95 Express way/Opitz Blvd.
STRUCTURE: MSE WALL

B-A2-1

PAGE 2 OF 2

STATION: 27+10
OFFSET: 20 RT
NORTHING: 355278.6864 ft
Easting: 3626597.1158 ft
SURFACE ELEVATION: 188.0 ft
COORD. DATUM: VA South

Date(s) Drilled: 11/22/2021 - 11/23/2021
Drilling Method(s): HSA
SPT Method: Automatic Hammer
Other Test(s):
Driller: SaLUT, Inc.
Logger: J. Yadeta

GROUND WATER

⊻ FIRST ENCOUNTERED AT 23.5 ft DEPTH

FIELD DATA

LAB DATA

DEPTH (ft)	ELEVATION (ft)	STANDARD PENETRATION TEST HAMMER BLOWS	SOIL RECOVERY (%)	SAMPLE LEGEND	SAMPLE INTERVAL	CORE RECOVERY (%)	ROCK QUALITY DESIGNATION	STRATA	JOINTS	STRATA LEGEND	FIELD DESCRIPTION OF STRATA	LIQUID LIMIT LL	PLASTICITY INDEX PI	MOISTURE CONTENT (%)	FINES CONTENT -#200 (%)
38	150														
		14 19 26	67	☒	38.5 40									10.0	
40															
42															
	145														
44		10 29 50/5"	93	☒	43.5 45									12.5	
46															
48	140														
		15 29	80	☒	48.5 50									12.4	
50															
52															
	135														
54		50/3"	27	☒	53.5 55									9.8	
56															
58	130	50/4"	60	☒	58.5 59									14.8	
											59.0 / 129.0 Boring terminated at 59ft				

REMARKS: Rig Type: Acker XLS.
Boring was offset 35' towards east, drilled on western shoulder of I-95 express lane. Cave-in at 55.3'. Hole backfilled with soil cutting and patched with cold asphalt at the surface.

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PROJECT #: **45893-001**
LOCATION: **I-95 Express way/Opitz Blvd.**
STRUCTURE: **MSE WALL**

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PAGE 1 OF 2

STATION: 26+00
NORTHING: 355172.3987 ft
SURFACE ELEVATION: 187.0 ft
OFFSET: 20 RT
Easting: 3626568.6573 ft
COORD. DATUM: VA South

Date(s) Drilled: 11/22/2021 - 11/22/2021
Drilling Method(s): HSA
SPT Method: Automatic Hammer
Other Test(s):
Driller: SaLUT, Inc.
Logger: J. Yadeta

GROUND WATER
▽ FIRST ENCOUNTERED AT 20.0 ft DEPTH

FIELD DATA

DEPTH (ft)	ELEVATION (ft)
2	185
4	
6	
7	180
8	
10	
12	175
14	
16	
17	170
18	
20 ▽	
22	165
24	
26	
27	160
28	
30	
32	155
34	
36	

SAMPLE INTERVAL	STANDARD PENETRATION TEST HAMMER BLOWS	SOIL RECOVERY (%)	CORE RECOVERY (%)	ROCK QUALITY DESIGNATION	STRATA	JOINTS	LL	PI	MOISTURE CONTENT (%)
1.5 – 3	60/4"	22							6.1
3.5 – 5	2 6 6	53							15.7
6 – 7.5	3 5 6	100							13.9
8.5 – 10	5 8 9	87							13.6
11 – 12.5	6 6 7	100							14.3
13.5 – 15	6 8 8	87							13.3
16 – 17.5	4 6 5	100							18.7
18.5 – 20	6 7 10	87							16.8
23.5 – 25	7 19 24	87							29.7
28.5 – 30	4 21 50/4"	100							11.8
33.5 – 35	13 21 41	80							17.4

FIELD DESCRIPTION OF STRATA

0.0 / 187.0
15" Asphalt **ASPH**

1.25 / 185.75
9" Subbase material, Gray, medium to coarse, SAND AND GRAVEL, trace Silt, very dense, dry **CRA**

2.0 / 185.0
Possible fill, Tan, fine to medium, POORLY GRADED SAND WITH SILT, medium dense, moist **SP-SM**

18.5 / 168.5
Tan-brown, fine to coarse, SILTY SAND AND GRAVEL, layer of purple Silt from 23.5' to 24.2', medium dense to dense, moist to wet below 20ft. **SM/GM**

28.5 / 158.5
Residual, Gray, black, lithified, SILT derived from decomposition of parent rock, trace rock fragments, hard, moist **ML**

REMARKS: Rig Type: Acker XLS.
Cave-in at 16.7'. Bulk sample collected from 2' - 8'. Hole backfilled with soil cutting and patched with cold asphalt at the surface.

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PROJECT #: **45893-001**
LOCATION: **I-95 Express way/Opitz Blvd.**
STRUCTURE: **MSE WALL**

B-A3-1

PAGE 2 OF 2

STATION: 26+00
NORTHING: 355172.3987 ft
SURFACE ELEVATION: 187.0 ft
OFFSET: 20 RT
Easting: 3626568.6573 ft
COORD. DATUM: VA South

Date(s) Drilled: 11/22/2021 - 11/22/2021
Drilling Method(s): HSA
SPT Method: Automatic Hammer
Other Test(s):
Driller: SaLUT, Inc.
Logger: J. Yadeta

GROUND WATER

⊻ FIRST ENCOUNTERED AT 20.0 ft DEPTH

FIELD DATA													LAB DATA		
		SOIL				ROCK									
								DIP °							
DEPTH (ft)	ELEVATION (ft)	STANDARD PENETRATION TEST HAMMER BLOWS	SOIL RECOVERY (%)	SAMPLE LEGEND	SAMPLE INTERVAL	CORE RECOVERY (%)	ROCK QUALITY DESIGNATION	STRATA	JOINTS	STRATA LEGEND	FIELD DESCRIPTION OF STRATA	LIQUID LIMIT LL	PLASTICITY INDEX PI	MOISTURE CONTENT (%)
	150													
38		31 50/5"	47	☒	38.5 40					▥				18.1
40											40.0 / 147.0 Boring terminated at 40ft			

REMARKS: Rig Type: Acker XLS.
Cave-in at 16.7'. Bulk sample collected from 2' - 8'. Hole backfilled with soil cutting and patched with cold asphalt at the surface.

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PROJECT #: 45893-001
LOCATION: I-95 Express way/Opitz Blvd.
STRUCTURE: MSE WALL

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PAGE 1 OF 2

STATION: 25+00
OFFSET: 12 LT
NORTHING: 355083.9063 ft
Easting: 3626512.2718 ft
SURFACE ELEVATION: 189.2 ft
COORD. DATUM: VA South

Date(s) Drilled: 11/17/2021 - 11/18/2021
Drilling Method(s): HSA
SPT Method: Automatic Hammer
Other Test(s):
Driller: SaLUT, Inc.
Logger: J. Yadeta

GROUND WATER

▽ FIRST ENCOUNTERED AT 20.7 ft DEPTH

FIELD DATA										LAB DATA			
	SOIL			ROCK		DIP °							
ELEVATION (ft)	STANDARD PENETRATION TEST HAMMER BLOWS	SOIL RECOVERY (%)	SAMPLE INTERVAL	CORE RECOVERY (%)	ROCK QUALITY DESIGNATION	STRATA	JOINTS	STRATA LEGEND	FIELD DESCRIPTION OF STRATA	LIQUID LIMIT LL	PLASTICITY INDEX PI	MOISTURE CONTENT (%)	FINES CONTENT -#200 (%)
									0.0 / 189.2 18" Asphalt **ASPH**				
	25 34 25	100	1.5 3						1.5 / 187.7 *18" Subbase material*, Gray, medium to coarse, SAND AND GRAVEL, trace Silt, very dense, dry **CRA**			4.3	
185	2 3 5	100	3.5 5						3.0 / 186.2 Gray-brown mix, ELASTIC SILT, medium stiff to stiff, moist **MH**			40.8	
	2 5 8	100	6 7.5									42.4	
180	5 7 8	60	8.5 10						8.5 / 180.7 Brown, tan, fine to medium, POORLY GRADED SAND WITH SILT, medium dense, moist **SP-SM**			14.3	
	4 5 6	87	11 12.5									14.5	21.0
175	6 7 10	80	13.5 15									13.9	
	5 8 10	100	16 17.5									15.3	
170	6 12 25	87	18.5 20						18.5 / 170.7 Gray, black, fine to coarse, POORLY GRADE SAND, trace Silt, dense, moist to wet below 20.5ft **SP**			14.7	
165	24 50/2"	40	23.5 25						23.5 / 165.7 *Residual*, Gray, SILT DRIVED FROM DECOMPOSITION OF BED ROCK, hard, dry **ML**			20.4	
160	60/3"	20	28.5 30						28.5 / 160.7 Gray, fine to coarse, SILTY AND GRAVEL SIZE DECOMPOSED ROCK FRAGMENTS, little elastic fine, exteremely dense to dense to extremely dense, dry to moist **SM**			15.6	
155	4 13 20	40	33.5 35									15.2	

REMARKS: Rig Type: Acker XLS.
Cave-in at 34.5'. Boring was offset 5' towards south due to undergroun utility. As drilled boring elevatoin is the same as the original location. Bulk sample collected from 1.5' - 8'. Hole backfilled with soil cutting and patched with cold asphalt at the surface.

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PROJECT #: **45893-001**
LOCATION: **I-95 Express way/Opitz Blvd.**
STRUCTURE: **MSE WALL**

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PAGE 2 OF 2

STATION: 25+00
NORTHING: 355083.9063 ft
SURFACE ELEVATION: 189.2 ft

OFFSET: 12 LT
Easting: 3626512.2718 ft
COORD. DATUM: VA South

Date(s) Drilled: 11/17/2021 - 11/18/2021
Drilling Method(s): HSA
SPT Method: Automatic Hammer
Other Test(s):
Driller: SaLUT, Inc.
Logger: J. Yadeta

GROUND WATER

▽ FIRST ENCOUNTERED AT 20.7 ft DEPTH

FIELD DATA												LAB DATA			
		SOIL				ROCK									
								DIP °							
DEPTH (ft)	ELEVATION (ft)	STANDARD PENETRATION TEST HAMMER BLOWS	SOIL RECOVERY (%)	SAMPLE LEGEND	SAMPLE INTERVAL	CORE RECOVERY (%)	ROCK QUALITY DESIGNATION	STRATA	JOINTS	STRATA LEGEND	FIELD DESCRIPTION OF STRATA	LIQUID LIMIT LL	PLASTICITY INDEX PI	MOISTURE CONTENT (%)	FINES CONTENT -#200 (%)
38 40	150	53/2"	13	☒	38.5 40					▨	Gray, fine to coarse, SILTY AND GRAVEL SIZE DECOMPOSED ROCK FRAGMENTS, little elastic fine, exteremely dense to dense to extremely dense, dry to moist			8.6	
											40.0 / 149.2 Boring terminated at 40ft				

REMARKS: Rig Type: Acker XLS.
Cave-in at 34.5'. Boring was offset 5' towards south due to undergroun utility. As drilled boring elevatoin is the same as the original location. Bulk sample collected from 1.5' - 8'. Hole backfilled with soil cutting and patched with cold asphalt at the surface.

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PROJECT #: 45893-001
LOCATION: I-95 Express way/Opitz Blvd.
STRUCTURE: MSE WALL

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PAGE 1 OF 1

STATION: 24+00
OFFSET: 23 RT
NORTHING: 354978.3553 ft
Easting: 3626520.1235 ft
SURFACE ELEVATION: 185.4 ft
COORD. DATUM: VA South

Date(s) Drilled: 11/29/2021 - 11/29/2021
Drilling Method(s): HSA
SPT Method: Automatic Hammer
Other Test(s):
Driller: SaLUT, Inc.
Logger: J. Yadeta

GROUND WATER

⊻ FIRST ENCOUNTERED AT 19.5 ft DEPTH

FIELD DATA / LAB DATA

SAMPLE INTERVAL	STANDARD PENETRATION TEST HAMMER BLOWS	SOIL RECOVERY (%)	CORE RECOVERY (%)	ROCK QUALITY DESIGNATION	DIP ° STRATA	DIP ° JOINTS	LIQUID LIMIT LL	PLASTICITY INDEX PI	MOISTURE CONTENT (%)	FINES CONTENT -#200 (%)
2 - 3.5	3 6 8	67							16.1	
3.5 - 5	2 6 6	80							18.0	
6 - 7.5	2 4 6	100							13.5	
8.5 - 10	3 3 7	100					41	16	22.4	89.0
11 - 12.5	4 6 8	100							12.7	
13.5 - 15	4 6 6	67							16.8	
16 - 17.5	4 8 9	100							17.6	
18.5 - 20	5 8 16	100							24.8	
23.5 - 25	6 10 18	80							19.1	
28.5 - 30	14 34 41	87							15.4	

FIELD DESCRIPTION OF STRATA

DEPTH (ft) / ELEVATION (ft)	DESCRIPTION
0.0 / 185.4	15" Asphalt **ASPH**
1.25 / 184.15	*5" Subbase material over 4" concrete*, Gray, medium to coarse, SAND AND GRAVEL, dry **CRA**
2.0 / 183.4	*Fill*, Tan-gray, fine to medium, POORLY GRADED SAND WITH SILT, medium dense, moist **SP-SM**
6.5 / 178.9	*Fill*, Gray, fine to medium, CLAYEY, SILTY SAND, some woods, loose, moist **SC-SM**
8.5 / 176.9	*Fill*, Brown, LEAN CLAY, stiff, moist **CL**
11.0 / 174.4	*Fill*, Brown, fine to medium, POORLY GRADED, SAND WITH SILT, medium dense, moist **SP-SM**
13.0 / 172.4	*Residual*, Brown-light brown, fine to medium, POORLY GRADED SAND WITH SILT, medium dense, moist to wet below 19ft. **SP-SM**
23.5 / 161.9	*Residual*, Gray, black, lithified, SILT derived from decomposition of parent rock, trace rock fragments, very stiff to hard, moist **ML**
30.0 / 155.4	Boring terminated at 30ft.

REMARKS: Rig Type: Acker XLS.
Boring was offset 6' towards north due to underground utility. Cave-in at 25.2'. Hole backfilled with soil cutting and patched with cold asphalt at the surface. Shelby tube sample was taken from an offset boring from 14' - 16'

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PROJECT #: 45893-001
LOCATION: I-95 Express way/Opitz Blvd.
STRUCTURE: MSE WALL

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PAGE 1 OF 1

STATION: 23+50
NORTHING: 354937.3133 ft
SURFACE ELEVATION: 187.2 ft
OFFSET: 6 LT
Easting: 3626479.5403 ft
COORD. DATUM: VA South

Date(s) Drilled: 11/16/2021 - 11/16/2021
Drilling Method(s): HSA
SPT Method: Automatic Hammer
Other Test(s): Shelby Tube Sample
Driller: SaLUT, Inc.
Logger: J. Yadeta

GROUND WATER
FIRST ENCOUNTERED AT 22.0 ft DEPTH

FIELD DATA / LAB DATA

SAMPLE INTERVAL	STANDARD PENETRATION TEST HAMMER BLOWS	SOIL RECOVERY (%)	LIQUID LIMIT LL	PLASTICITY INDEX PI	MOISTURE CONTENT (%)	FINES CONTENT -#200 (%)
1.5 - 3	25 40 30	73			4.2	
3.5 - 5	7 6 6	60			14.8	
6 - 7.5	3 5 6	87			19.4	
8.5 - 10	2 4 4	93			20.8	
11 - 12.5	4 2 3	87	55	27	19.7	45.0
13.5 - 15	WOH WOH 1	53			20.9	
14 - 16		75	30	9	19.9	46.0
16 - 17.5	WOH 1 1	100			21.0	
18.5 - 20	WOH 2 3	100			22.5	
23.5 - 25	7 37 50/4"	87			14.9	
28.5 - 30	52/6"	33			19.4	

FIELD DESCRIPTION OF STRATA

0.0 / 187.2
18" Asphalt **ASPH**

1.5 / 185.7
18" Subbase material, Light gray, medium to coarse, SAND AND GRAVEL, trace Silt, very dense, dry **CRA**

3.0 / 184.2
Gray, fine to coarse, SILTY SAND AND GRAVEL, medium dense, moist **SM**

5.0 / 182.2
Light brown, fine to medium, SILTY SAND, some Gravel, medium dense, moist **SM**

8.5 / 178.7
Gray, fine to medium, CLAYEY SAND, trace Gravel, trace root, loose to very loose, moist **SC**

Shelby tube sample was taken from an offset boring from 14' - 16'

18.5 / 168.7
Dark gray, FAT CLAY, medium stiff, damp to wet below 23.5FT **CH**

24.0 / 163.2
Residual, Light brown-gray, SILT DRIVED FROM DECOMPOSITION OF BED ROCK, hard, dry. HARD AUGERING BELOW 27.5FT **ML**

30.0 / 157.2
Boring terminated at 30ft

REMARKS: Rig Type: Acker XLS.
Cave-in at 23.8'. Hole backfilled with soil cutting and patched with cold asphalt at the surface.

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SPT_LOGB:I-95 EXPRESS LANE- OPITZ BLVD BORINGS.GPJ:SPT7.GDT:gINT_version 10.02.00.04:1/20/22:WRA

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PAGE 1 OF 1

PROJECT #: **45893-001**
LOCATION: **I-95 Express way/Opitz Blvd.**
STRUCTURE: **MSE WALL**

STATION: 22+00
OFFSET: 35 RT
NORTHING: 354785.0818 ft
Easting: 3626468.6903 ft
SURFACE ELEVATION: 183.5 ft
COORD. DATUM: VA South

Date(s) Drilled: 11/29/2021 - 11/29/2021
Drilling Method(s): HSA
SPT Method: Automatic Hammer
Other Test(s):
Driller: SaLUT, Inc.
Logger: J. Yadeta

GROUND WATER
NOT ENCOUNTERED DURING DRILLING

FIELD DATA / LAB DATA

SAMPLE INTERVAL (ft)	STANDARD PENETRATION TEST HAMMER BLOWS	SOIL RECOVERY (%)	LIQUID LIMIT (LL)	PLASTICITY INDEX (PI)	MOISTURE CONTENT (%)	FINES CONTENT -#200 (%)
2 - 3.5	4 - 7 - 5	67			17.4	
3.5 - 5	4 - 7 - 6	73			15.4	27.0
6 - 7.5	3 - 3 - 3	87			22.2	
8.5 - 10	4 - 3 - 4	80	46	21	16.6	35.0
11 - 12.5	2 - 4 - 4	87			14.5	
13.5 - 15	3 - 2 - 3	33			16.9	
16 - 17.5	2 - 2 - 2	100			17.8	
18.5 - 20	3 - 3 - 4	67			25.9	

DEPTH (ft): 2, 4, 6, 8, 10, 12, 14, 16, 18, 20
ELEVATION (ft): 180, 175, 170, 165

FIELD DESCRIPTION OF STRATA

0.0 / 183.5
15" Asphalt **ASPH**

1.3 / 182.2
9" Subbase material, Gray, medium to coarse, SAND AND GRAVEL, dry **CRA**

2.0 / 181.5
Fill, Tan-light brown, fine to medium, POORLY GRADED SAND WITH SILT, trace Gravel, medium dense, moist
SP-SM

7.0 / 176.5
Fill, Gray, fine to medium, CLAYEY, SILTY SAND, seam of clay at 7ft to 7.3ft, trace Gravel, trace to some woods, loose, moist **SC**

16.0 / 167.5
Residual, Brown-light gray, fine to medium, POORLY GRADED SAND WITH SILT, clay seam, very loose, moist
SP-SM

19.0 / 164.5
Residual, Gray, black, lithified, SILT derived from decomposition of parent rock, trace rock fragments, medium stiff, moist **ML**

20.0 / 163.5
Boring terminated at 20ft.

REMARKS: Rig Type: Acker XLS.
Cave-in at 15.7'. Hole backfilled with soil cutting and patched with cold asphalt at the surface.

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PROJECT #: 45893-001
LOCATION: I-95 Express way/Opitz Blvd.
STRUCTURE: MSE WALL

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STATION: 21+00
OFFSET: 2 LT
NORTHING: 354697.7435 ft
Easting: 3626407.9003 ft
SURFACE ELEVATION: 184.9 ft
COORD. DATUM: VA South

Date(s) Drilled: 11/15/2021 - 11/15/2021
Drilling Method(s): HSA
SPT Method: Automatic Hammer
Other Test(s):
Driller: SaLUT, Inc.
Logger: J. Yadeta

GROUND WATER
NOT ENCOUNTERED DURING DRILLING

FIELD DATA

DEPTH (ft)	ELEVATION (ft)	SOIL: STANDARD PENETRATION TEST HAMMER BLOWS	SOIL: SOIL RECOVERY (%)	SAMPLE LEGEND	SAMPLE INTERVAL	ROCK: CORE RECOVERY (%)	ROCK: ROCK QUALITY DESIGNATION	ROCK: DIP °: STRATA	ROCK: DIP °: JOINTS	STRATA LEGEND	LAB DATA: LIQUID LIMIT LL	LAB DATA: PLASTICITY INDEX PI	LAB DATA: MOISTURE CONTENT (%)
2		14 14 6	53	☒	1.5 3								4.1
4	180	3 5 6	53	☒	3.5 5								22.4
6		2 5 6	87	☒	6 7.5								31.6
8 10	175	4 7 8	100	☒	8.5 10								16.0
12		5 8 8	93	☒	11 12.5								15.1
14	170	4 6 7	100	☒	13.5 15								17.1
16		5 8 11	100	☒	16 17.5								14.8
18 20	165	6 9 10	100	☒	18.5 20								17.2

FIELD DESCRIPTION OF STRATA

0.0 / 184.9
19" Asphalt **ASPH**

1.58 / 183.32
17" Subbase material, Light gray, medium to coarse, SILTY SAND AND GRAVEL, medium dense, moist **CRA**

3.0 / 181.9
Possible fill, Light brown, medium to coarse, SILTY SAND WITH SOME FINE GRAVEL, layer of elastic SILT binder from 6' to 6.5', medium dense, moist **SM**

7.0 / 177.9
Residual, Light brown, light gray, medium to coarse, POORLY GRADED SAND WITH SILT, trace Gravel, medium dense, moist **SP**

20.0 / 164.9
Boring terminated at 20ft

REMARKS: Rig Type: Acker XLS.
Cave-in at 13.9'. Hole backfilled with soil cutting and patched with cold asphalt at the surface.

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PROJECT #: 45893-001
LOCATION: I-95 Express way/Opitz Blvd.
STRUCTURE: MSE WALL

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PAGE 1 OF 1

STATION: 19+99
OFFSET: 33 RT
NORTHING: 354591.7507 ft
Easting: 3626417.4743 ft
SURFACE ELEVATION: 181.6 ft
COORD. DATUM: VA South

Date(s) Drilled: 11/30/2021 - 11/30/2021
Drilling Method(s): HSA
SPT Method: Automatic Hammer
Other Test(s):
Driller: SaLUT, Inc.
Logger: J. Yadeta

GROUND WATER
NOT ENCOUNTERED DURING DRILLING

FIELD DATA / LAB DATA

SAMPLE INTERVAL	STANDARD PENETRATION TEST HAMMER BLOWS	SOIL RECOVERY (%)	LIQUID LIMIT LL	PLASTICITY INDEX PI	MOISTURE CONTENT (%)	FINES CONTENT -#200 (%)
2 - 3.5	63 11 6	67			7.8	
3.5 - 5	2 3 4	67			29.0	
6 - 7.5	3 5 5	87			14.8	20.0
8.5 - 10	4 5 7	80			20.0	
11 - 12.5	2 4 5	100			35.3	
13.5 - 15	4 7 7	87			15.5	

DEPTH (ft): 2, 4, 6, 8, 10, 12, 14
ELEVATION (ft): 180, 175, 170

FIELD DESCRIPTION OF STRATA

0.0 / 181.6
15" Asphalt **ASPH**

1.25 / 180.35
9" Subbase material, Gray, medium to coarse, SAND AND GRAVEL, dry **CRA**

2.0 / 179.6
Fill, Tan-light gray, fine to medium, POORLY GRADED SAND WITH SILT, trace elastic fine, medium dense to loose, moist **SP-SM**

6.0 / 175.6
Fill, Tan, black spotting, fine to medium, POORLY GRADED SAND, trace Silt, loose to medium dense, moist **SP**

11.0 / 170.6
Possible fill, Brown, fine to medium, CLAYEY, SILTY SAND, trace Gravel, loose, moist **SC-SM**

13.5 / 168.1
Light gray, fine to medium, POORLY GRADED SAND WITH SILT, medium dense, moist **SP-SM**

15.0 / 166.6
Boring terminated at 15ft.

REMARKS: Rig Type: Acker XLS.
Cave-in at 11.8'. Hole backfilled with soil cutting and patched with cold asphalt at the surface.

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PROJECT #: **45893-001**
LOCATION: **I-95 Express way/Opitz Blvd.**
STRUCTURE: **MSE WALL**

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STATION: 19+00
NORTHING: 354503.8875 ft
SURFACE ELEVATION: 181.1 ft

OFFSET: 4 LT
Easting: 3626358.4498 ft
COORD. DATUM: VA South

Date(s) Drilled: 11/18/2021 - 11/18/2021
Drilling Method(s): HSA
SPT Method: Automatic Hammer
Other Test(s):
Driller: SaLUT, Inc.
Logger: J. Yadeta

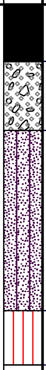
GROUND WATER
NOT ENCOUNTERED DURING DRILLING

FIELD DATA

DEPTH (ft)	ELEVATION (ft)
0.5	
1.0	180
1.5	
2.0	
2.5	
3.0	178
3.5	
4.0	
4.5	
5.0	176
5.5	
6.0	
6.5	
7.0	174
7.5	
8.0	
8.5	
9.0	172
9.5	
10.0	

SAMPLE INTERVAL	STANDARD PENETRATION TEST HAMMER BLOWS	SOIL RECOVERY (%)	CORE RECOVERY (%)	ROCK QUALITY DESIGNATION	DIP ° STRATA	DIP ° JOINTS	LIQUID LIMIT LL	PLASTICITY INDEX PI	MOISTURE CONTENT (%)	FINES CONTENT -#200 (%)
1.5 – 3	15 24 19	93							3.5	
3.5 – 5	6 5 5	33							12.2	
6 – 7.5	2 3 3	87							29.3	56.0
8.5 – 10	3 6 7	87							29.2	

STRATA LEGEND



FIELD DESCRIPTION OF STRATA

0.0 / 181.1
19" Asphalt **ASPH**

1.58 / 179.52
23" Subbase material, Light gray, medium to coarse, SAND AND GRAVEL, trace Silt, dense, dry **CRA**

3.5 / 177.6
Tan, black mix, fine to coarse, SILTY SAND, trace Gravel, none to trace elastic fine, loose, moist **SM**

8.5 / 172.6
Tan , gray, SILT, stiff, moist **ML**

10.0 / 171.1
Boring terminated at 10ft

REMARKS: Rig Type: Acker XLS.
Cave-in at 6.5'. Hole backfilled with soil cutting and patched with cold asphalt at the surface.

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SPT_LOGB:I-95 EXPRESS LANE- OPITZ BLVD BORINGS.GPJ:SPT7.GDT:gINT_version 10.02.00.04:1/20/22:WRA

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PROJECT #: **45893-001**
LOCATION: **I-95 Express way/Opitz Blvd.**
STRUCTURE: **MSE WALL**

B-A3-9

PAGE 1 OF 1

STATION: 17+99
OFFSET: 29 RT
NORTHING: 354398.3209 ft
Easting: 3626366.6296 ft
SURFACE ELEVATION: 179.9 ft
COORD. DATUM: VA South

Date(s) Drilled: 11/30/2021 - 11/30/2021
Drilling Method(s): HSA
SPT Method: Automatic Hammer
Other Test(s):
Driller: SaLUT, Inc.
Logger: J. Yadeta

GROUND WATER
NOT ENCOUNTERED DURING DRILLING

FIELD DATA

DEPTH (ft): 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5.0, 5.5, 6.0, 6.5, 7.0, 7.5, 8.0, 8.5, 9.0, 9.5, 10.0

DEPTH (ft)	ELEVATION (ft)	SOIL: STANDARD PENETRATION TEST HAMMER BLOWS	SOIL: SOIL RECOVERY (%)	SAMPLE LEGEND	SAMPLE INTERVAL	ROCK: CORE RECOVERY (%)	ROCK: ROCK QUALITY DESIGNATION	ROCK: DIP °: STRATA	ROCK: DIP °: JOINTS	STRATA LEGEND	LAB DATA: LIQUID LIMIT (LL)	LAB DATA: PLASTICITY INDEX (PI)	LAB DATA: MOISTURE CONTENT (%)	LAB DATA: FINES CONTENT -#200 (%)
2.0	178	8 9 8	60	☒	1.5 3								17.9	
4.0	176	4 7 6	87	☒	3.5 5								19.1	24.0
6.0	174	7 8 7	67	☒	6 7.5								19.2	
8.0	172													
9.0		3 5 7	100	☒	8.5 10								20.7	
10.0	170													

FIELD DESCRIPTION OF STRATA

0.0 / 179.9
9" Asphalt **ASPH**

0.75 / 179.15
3" Concrete **CONC**

1.0 / 178.9
3" Asphalt **ASPH**

1.25 / 178.65
9" Subbase material, Gray, medium to coarse, SAND AND GRAVEL, dry **CRA**

2.0 / 177.9
Fill, Brown, fine to medium, POORLY GRADED SAND WITH SILT, Clayey Silt layer at 8.8'-9.5', medium dense, moist **SP-SM**

10.0 / 169.9
Boring terminated at 10ft.

REMARKS: Rig Type: Acker XLS.
Cave-in at 6.8'. Hole backfilled with soil cutting and patched with cold asphalt at the surface.

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PROJECT #: **45893-001**
LOCATION: **I-95 Express way/Opitz Blvd.**
STRUCTURE: **PAVEMENT**

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PAGE 1 OF 1

STATION: 727+80
NORTHING: 355034.259 ft
SURFACE ELEVATION: 186.1 ft

OFFSET: 17 RT
Easting: 3626573.5922 ft
COORD. DATUM: VA South

Date(s) Drilled: 12/1/2021 - 12/1/2021
Drilling Method(s): HSA
SPT Method: Automatic Hammer
Other Test(s):
Driller: SaLUT, Inc.
Logger: J. Yadeta

GROUND WATER
NOT ENCOUNTERED DURING DRILLING

FIELD DATA

DEPTH (ft)	ELEVATION (ft)	SOIL: STANDARD PENETRATION TEST HAMMER BLOWS	SOIL: SOIL RECOVERY (%)	SAMPLE LEGEND	SAMPLE INTERVAL	ROCK: CORE RECOVERY (%)	ROCK: ROCK QUALITY DESIGNATION	ROCK: DIP °: STRATA	ROCK: DIP °: JOINTS	STRATA LEGEND	LAB DATA: LIQUID LIMIT LL	LAB DATA: PLASTICITY INDEX PI	LAB DATA: MOISTURE CONTENT (%)
0.5													
1.0													
1.5													
2.0	184	4			2								
2.5		4											
3.0		8	45										25.2
3.5		6											
4.0	182	4			4								
4.5		4											
5.0		4	85										16.3
5.5		4											
6.0	180	6			6								
6.5		6											
7.0		7	75										16.9
7.5		8											
8.0					8								

FIELD DESCRIPTION OF STRATA

0.0 / 186.1
14" Asphalt **ASPH**

1.2 / 184.9
10" Subbase materila Gray, medium to coarse SAND AND GRAVEL, dry **CCA**

2.0 / 184.1
Fill, Brown, hint of black, fine to medium, SILTY SAND, trace to none elastic fine, medium dense to loose to medium dense, moist
SM

8.0 / 178.1
Boring terminated at 8ft.

REMARKS: Rig Type: Acker XLS.
Boring was offset 3' towards south due to undergroun utility. Hole backfilled with soil cutting and patched with cold asphalt at the surface. Cave-in at 4.8'

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PROJECT #: 45893-001
LOCATION: I-95 Express way/Opitz Blvd.
STRUCTURE: PAVEMENT

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PAGE 1 OF 1

STATION: 724+55
NORTHING: 354720.1225 ft
SURFACE ELEVATION: 183.0 ft
OFFSET: 17 LT
Easting: 3626490.2662 ft
COORD. DATUM: VA South

Date(s) Drilled: 12/1/2021 - 12/1/2021
Drilling Method(s): HSA
SPT Method: Automatic Hammer
Other Test(s):
Driller: SaLUT, Inc.
Logger: J. Yadeta

GROUND WATER
NOT ENCOUNTERED DURING DRILLING

FIELD DATA / LAB DATA

DEPTH (ft)	ELEVATION (ft)	SOIL: STANDARD PENETRATION TEST HAMMER BLOWS	SOIL: SOIL RECOVERY (%)	SAMPLE LEGEND	SAMPLE INTERVAL	ROCK: CORE RECOVERY (%)	ROCK: ROCK QUALITY DESIGNATION	ROCK: DIP °: STRATA	ROCK: DIP °: JOINTS	STRATA LEGEND	LIQUID LIMIT LL	PLASTICITY INDEX PI	MOISTURE CONTENT (%)	FINES CONTENT -#200 (%)
0.5														
1.0	182													
1.5														
2.0					2									
2.5		4 5												
3.0	180	7	65										15.6	27.0
3.5		9												
4.0					4									
4.5		3 6												
5.0	178	6	65										14.8	
5.5		5												
6.0					6									
6.5		2 4												
7.0	176	6	75										15.8	
7.5		7												
8.0					8									

FIELD DESCRIPTION OF STRATA

0.0 / 183.0
17" Asphalt **ASPH**

1.42 / 181.58
8" Subbase materila Gray, medium to coarse SAND AND GRAVEL, dry **CCA**

2.08 / 180.92
Fill, Brown, fine to medium, SILTY SAND, trace to some to none Gravel, medium dense to loose, moist **SM**

8.0 / 175.0
Boring terminated at 8ft.

REMARKS: Rig Type: Acker XLS.
Boring was offset 7' towards south due to undergroun utility. Hole backfilled with soil cutting and patched with cold asphalt at the surface. Cave-in at 5.0'

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B-A4-2

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PROJECT #: 45893-001
LOCATION: I-95 Express way/Opitz Blvd.
STRUCTURE: PAVEMENT

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PAGE 1 OF 1

STATION: 721+55
NORTHING: 354430.0292 ft
SURFACE ELEVATION: 180.2 ft
OFFSET: 18 RT
Easting: 3626413.789 ft
COORD. DATUM: VA South

Date(s) Drilled: 12/1/2021 - 12/1/2021
Drilling Method(s): HSA
SPT Method: Automatic Hammer
Other Test(s):
Driller: SaLUT, Inc.
Logger: J. Yadeta

GROUND WATER
NOT ENCOUNTERED DURING DRILLING

FIELD DATA / LAB DATA

DEPTH (ft)	ELEVATION (ft)	SOIL: STANDARD PENETRATION TEST HAMMER BLOWS	SOIL: SOIL RECOVERY (%)	SAMPLE LEGEND	SAMPLE INTERVAL	ROCK: CORE RECOVERY (%)	ROCK: ROCK QUALITY DESIGNATION	ROCK: DIP ° STRATA	ROCK: DIP ° JOINTS	STRATA LEGEND	LIQUID LIMIT LL	PLASTICITY INDEX PI	MOISTURE CONTENT (%)
0.5													
1.0													
1.5													
2.0	178	4			2								
2.5		5											
3.0		5	65										17.8
3.5		6											
4.0	176	3			4								
4.5		6											
5.0		6	50										16.8
5.5		6											
6.0	174	4			6								
6.5		4											
7.0		5	85										16.1
7.5		6											
8.0					8								

FIELD DESCRIPTION OF STRATA

0.0 / 180.2
17" Asphalt **ASPH**

1.42 / 178.78
8" Subbase materila Gray, medium to coarse SAND AND GRAVEL, dry **CCA**

2.08 / 178.12
Fill, Brown, fine to medium, SILTY SAND, trace Gravel, loose to medium dense to loose, moist **SM**

8.0 / 172.2
Boring terminated at 8ft.

REMARKS: Rig Type: Acker XLS.
Hole backfilled with soil cutting and patched with cold asphalt at the surface. Cave-in at 4.9'

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B-A4-3

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PROJECT #: **45893-001**
LOCATION: **I-95 Express way/Opitz Blvd.**
STRUCTURE: **PAVEMENT**

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PAGE 1 OF 1

STATION: 718+64
NORTHING: 354157.6633 ft
SURFACE ELEVATION: 179.0 ft

OFFSET: 18 LT
Easting: 3626304.2854 ft
COORD. DATUM: VA South

Date(s) Drilled: 11/30/2021 - 11/30/2021
Drilling Method(s): HSA
SPT Method: Automatic Hammer
Other Test(s):
Driller: SaLUT, Inc.
Logger: J. Yadeta

GROUND WATER
NOT ENCOUNTERED DURING DRILLING

FIELD DATA												LAB DATA			
		SOIL				ROCK		DIP °							
DEPTH (ft)	ELEVATION (ft)	STANDARD PENETRATION TEST HAMMER BLOWS	SOIL RECOVERY (%)	SAMPLE LEGEND	SAMPLE INTERVAL	CORE RECOVERY (%)	ROCK QUALITY DESIGNATION	STRATA	JOINTS	STRATA LEGEND	FIELD DESCRIPTION OF STRATA	LIQUID LIMIT LL	PLASTICITY INDEX PI	MOISTURE CONTENT (%)	FINES CONTENT -#200 (%)
0.5										■	0.0 / 179.0 15" Asphalt **ASPH**				
1.0	178									■					
1.5											1.25 / 177.75 *9" Subbase materila* Gray, medium to coarse SAND AND GRAVEL, dry **CCA**				
2.0				⊠	2					▨	2.0 / 177.0 *Fill*, Tan, fine to medium, POORLY GRADED SAND WITH SILT, medium dense to loose, moist **SP-SM**				
2.5		18 12		⊠						▨					
3.0	176	5	50	⊠						▨				12.9	32.0
3.5		6		⊠						▨					
4.0		3		⊠	4					▨					
4.5		3		⊠						▨					
5.0	174	4	75	⊠						▨				15.4	
5.5		6		⊠						▨					
6.0					6						6.0 / 173.0 Boring terminated at 6ft.				

REMARKS: Rig Type: Acker XLS.
Boring was offset 4' towards west due to underground utility. Hole backfilled with soil cutting and patched with cold asphalt at the surface. Cave-in at 3.2'

SPT_LOGB:I-95 EXPRESS LANE- OPITZ BLVD BORINGS.GPJ:SPT7.GDT:gINT_version 10.02.00.04:1/20/22:WRA

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PROJECT #: **45893-001**
LOCATION: **I-95 Express way/Opitz Blvd.**
STRUCTURE: **PAVEMENT**

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PAGE 1 OF 1

STATION: 686+81
NORTHING: 351117.2654 ft
SURFACE ELEVATION: 172.1 ft
OFFSET: 18 LT
Easting: 3625366.614 ft
COORD. DATUM: VA South

Date(s) Drilled: 12/2/2021 - 12/2/2021
Drilling Method(s): HSA
SPT Method: Automatic Hammer
Other Test(s):
Driller: SaLUT, Inc.
Logger: J. Yadeta

GROUND WATER
NOT ENCOUNTERED DURING DRILLING

FIELD DATA

DEPTH (ft)	ELEVATION (ft)	SOIL: STANDARD PENETRATION TEST HAMMER BLOWS	SOIL: SOIL RECOVERY (%)	SAMPLE INTERVAL	ROCK: CORE RECOVERY (%)	ROCK: ROCK QUALITY DESIGNATION	ROCK: DIP °: STRATA	ROCK: DIP °: JOINTS	LAB DATA: LIQUID LIMIT LL	LAB DATA: PLASTICITY INDEX PI	LAB DATA: MOISTURE CONTENT (%)
0.5											
1.0											
1.5											
2.0	170	3		2							
2.5		7									
3.0		6	85								15.6
3.5		8									
4.0	168	4		4							
4.5		6									
5.0		6	65								17.4
5.5		7									
6.0	166	3		6							
6.5		3									
7.0		3	90								13.0
7.5		3									
8.0				8							

FIELD DESCRIPTION OF STRATA

0.0 / 172.1
16" Asphalt **ASPH**

1.33 / 170.77
9" Subbase materila Gray, medium to coarse SAND AND GRAVEL, dry **CCA**

2.08 / 170.02
Fill, Brown-tan, fine to medium, SILTY SAND, trace elastic fine, medium dense to loose, moist **SM**

8.0 / 164.1
Boring terminated at 8ft.

REMARKS: Rig Type: Acker XLS.
Hole backfilled with soil cutting and patched with cold asphalt at the surface. Cave-in at 4.7'

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PROJECT #: **45893-001**
LOCATION: **I-95 Express way/Opitz Blvd.**
STRUCTURE: **PAVEMENT**

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PAGE 1 OF 1

STATION: 682+81
NORTHING: 350741.8477 ft
SURFACE ELEVATION: 168.3 ft

OFFSET: 18 RT
Easting: 3625229.2087 ft
COORD. DATUM: VA South

Date(s) Drilled: 12/2/2021 - 12/2/2021
Drilling Method(s): HSA
SPT Method: Automatic Hammer
Other Test(s):
Driller: SaLUT, Inc.
Logger: J. Yadeta

GROUND WATER
NOT ENCOUNTERED DURING DRILLING

FIELD DATA / LAB DATA

DEPTH (ft)	ELEVATION (ft)	SOIL: STANDARD PENETRATION TEST HAMMER BLOWS	SOIL: SOIL RECOVERY (%)	SAMPLE LEGEND	SAMPLE INTERVAL	ROCK: CORE RECOVERY (%)	ROCK: ROCK QUALITY DESIGNATION	ROCK: DIP °: STRATA	ROCK: DIP °: JOINTS	STRATA LEGEND	LIQUID LIMIT LL	PLASTICITY INDEX PI	MOISTURE CONTENT (%)	FINES CONTENT -#200 (%)
0.5	168													
1.0														
1.5														
2.0		7			2									
2.5	166	4												
3.0		3	65										24.2	55.0
3.5		7												
4.0		2			4									
4.5	164	3												
5.0		3	35										15.6	
5.5		5												
6.0		2			6									
6.5	162	3												
7.0		3	90										15.9	
7.5		4												
8.0					8									

FIELD DESCRIPTION OF STRATA

0.0 / 168.3
15" Asphalt **ASPH**

1.25 / 167.05
10" Subbase materila Gray, medium to coarse SAND AND GRAVEL, dry **CCA**

2.08 / 166.22
Fill, Brown-tan, fine to medium, SILTY SAND, layer of mottled Clay from 2.5'-3.0', loose, moist **SM**

8.0 / 160.3
Boring terminated at 8ft.

REMARKS: Rig Type: Acker XLS.
Hole backfilled with soil cutting and patched with cold asphalt at the surface. Cave-in at 5.1'

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Virginia Department of Transportation

PROJECT #: 45893-001
LOCATION: I-95 Express way/Opitz Blvd.
STRUCTURE: PAVEMENT

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PAGE 1 OF 1

STATION: 672+06
NORTHING: 349743.9644 ft
SURFACE ELEVATION: 149.8 ft

OFFSET: 18 LT
Easting: 3624827.123 ft
COORD. DATUM: VA South

Date(s) Drilled: 12/2/2021 - 12/2/2021
Drilling Method(s): HSA
SPT Method: Automatic Hammer
Other Test(s):
Driller: SaLUT, Inc.
Logger: J. Yadeta

GROUND WATER

NOT ENCOUNTERED DURING DRILLING

FIELD DATA										FIELD DESCRIPTION OF STRATA	LAB DATA		
		SOIL				ROCK							
								DIP °					
DEPTH (ft)	ELEVATION (ft)	STANDARD PENETRATION TEST HAMMER BLOWS	SOIL RECOVERY (%)	SAMPLE LEGEND	SAMPLE INTERVAL	CORE RECOVERY (%)	ROCK QUALITY DESIGNATION	STRATA	JOINTS	STRATA LEGEND	LIQUID LIMIT LL	PLASTICITY INDEX PI	MOISTURE CONTENT (%)
0.0										0.0 / 149.8 15" Asphalt **ASPH**			
1.25										1.25 / 148.55 *10" Subbase materila* Gray, medium to coarse SAND AND GRAVEL, dry **CCA**			
2.0	148	7	65		2								
2.08		18								2.08 / 147.72 *Fill*, Brown/gray, fine to medium, CLAYEY, SILTY SAND, medium dense to loose, moist **SC-SM**			
3.0		15											5.9
3.5		13											
4.0	146	8	75		4								
4.5		6											
5.0		4											18.3
5.5		3											
6.0	144	1	60		6					6.0 / 143.8 Brown, fine to medium, POORLY GRADED SAND, trace Silt, medium dense, moist **SP**			
6.5		2											
7.0		3											14.7
7.5		5											
8.0	142				8					8.0 / 141.8 Boring terminated at 8ft.			

REMARKS: Rig Type: Acker XLS.
Hole backfilled with soil cutting and patched with cold asphalt at the surface. Cave-in at 4.7'

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PROJECT #: 45893-001
LOCATION: I-95 Express way/Opitz Blvd.
STRUCTURE: PAVEMENT

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PAGE 1 OF 1

STATION: 668+56
OFFSET: 18 LT
NORTHING: 349415.1818 ft
Easting: 3624707.6334 ft
SURFACE ELEVATION: 140.3 ft
COORD. DATUM: VA South

Date(s) Drilled: 12/2/2021 - 12/2/2021
Drilling Method(s): HSA
SPT Method: Automatic Hammer
Other Test(s):
Driller: SaLUT, Inc.
Logger: J. Yadeta

GROUND WATER
NOT ENCOUNTERED DURING DRILLING

FIELD DATA											LAB DATA			
		SOIL				ROCK		DIP °						
DEPTH (ft)	ELEVATION (ft)	STANDARD PENETRATION TEST HAMMER BLOWS	SOIL RECOVERY (%)	SAMPLE LEGEND	SAMPLE INTERVAL	CORE RECOVERY (%)	ROCK QUALITY DESIGNATION	STRATA	JOINTS	STRATA LEGEND	LIQUID LIMIT LL	PLASTICITY INDEX PI	MOISTURE CONTENT (%)	FINES CONTENT -#200 (%)
0.5	140													
1.0														
1.5														
2.0		7			2									
2.5	138	18												
3.0		15	65										16.2	59.0
3.5		13												
4.0		8			4									
4.5	136	6												
5.0		4	75										21.0	
5.5		3												
6.0		1			6									
6.5	134	2												
7.0		3	60										12.4	
7.5		5												
8.0					8									

FIELD DESCRIPTION OF STRATA

0.0 / 140.3
15" Asphalt **ASPH**

1.25 / 139.05
33" Subbase materila Gray, medium to coarse SAND AND GRAVEL, dry **CCA**

4.0 / 136.3
Fill, Dark gray-brown, fine to medium, CLAYEY, SILTY SAND, loose, moist **SM**

8.0 / 132.3
Boring terminated at 8ft.

SPT_LOGB:I-95 EXPRESS LANE- OPITZ BLVD BORINGS.GPJ:SPT7.GDT:gINT_version 10.02.00.04:1/20/22:WRA

REMARKS: Rig Type: Acker XLS.
Hole backfilled with soil cutting and patched with cold asphalt at the surface. Cave-in at 4.5'

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PROJECT #: **45893-001**
LOCATION: **I-95 Express way/Opitz Blvd**
STRUCTURE: **PAVEMENT**

B-PE-1

PAGE 1 OF 1

STATION: 70+75
NORTHING: 355235.5276 ft
SURFACE ELEVATION: 209.8 ft
OFFSET: 50 RT
Easting: 3626916.6181 ft
COORD. DATUM: VA South

Date(s) Drilled: 11/9/2021 - 11/9/2021
Drilling Method(s): HSA
SPT Method: Automatic Hammer
Other Test(s):
Driller: SaLUT, Inc.
Logger: J. Yadeta

GROUND WATER
NOT ENCOUNTERED DURING DRILLING

FIELD DATA

		SOIL				ROCK		DIP °		
DEPTH (ft)	ELEVATION (ft)	STANDARD PENETRATION TEST HAMMER BLOWS	SOIL RECOVERY (%)	SAMPLE LEGEND	SAMPLE INTERVAL	CORE RECOVERY (%)	ROCK QUALITY DESIGNATION	STRATA	JOINTS	STRATA LEGEND
0.2 0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0 2.2 2.4 2.6 2.8 3.0 3.2	209 208 207	4 3 3 3	75	☒	1.25 3.25					▨

LAB DATA

LIQUID LIMIT	PLASTICITY INDEX	MOISTURE CONTENT (%)
LL	PI	

FIELD DESCRIPTION OF STRATA

0.0 / 209.8
4.5" Asphalt **ASPH**

0.38 / 209.42
10.5" Subbase material, Light gray, medium to coarse, SAND AND GRAVEL, trace Silt, dry **CRA**

1.25 / 208.55
Fill, Light brown, fine to medium, SILTY SAND, some Gravel, some elastic fine, loose, moist. **SM**

3.25 / 206.55
Boring trerminated at 3.25ft

REMARKS: Rig Type: Acker XLS.
Boring was offset 5' towards west due to undergroun utility. Hole backfilled with soil cutting and patched with cold asphalt at the surface.

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SPT_LOG:I-95 EXPRESS LANE- OPITZ BLVD BORINGS.GPJ:SPT7.GDT:gINT_version 10.02.00.04:3/24/22:Whitman, Raquardt, and Associates

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PROJECT #: **45893-001**
LOCATION: **I-95 Express way/Opitz Blvd**
STRUCTURE: **PAVEMENT**

B-PE-2

PAGE 1 OF 1

STATION: 71+25
NORTHING: 355218.8102 ft
SURFACE ELEVATION: 208.1 ft
OFFSET: 52 RT
Easting: 3626963.7834 ft
COORD. DATUM: VA South

Date(s) Drilled: 11/9/2021 - 11/9/2021
Drilling Method(s): HSA
SPT Method: Automatic Hammer
Other Test(s):
Driller: SaLUT, Inc.
Logger: J. Yadeta

GROUND WATER
NOT ENCOUNTERED DURING DRILLING

FIELD DATA

		SOIL				ROCK		DIP °		
DEPTH (ft)	ELEVATION (ft)	STANDARD PENETRATION TEST HAMMER BLOWS	SOIL RECOVERY (%)	SAMPLE LEGEND	SAMPLE INTERVAL	CORE RECOVERY (%)	ROCK QUALITY DESIGNATION	STRATA	JOINTS	STRATA LEGEND
0.2 0.4 0.6 0.8 1.0	207	4		☒	1.3					
1.2 1.4 1.6 1.8 2.0	206	5 4	60							
2.2 2.4 2.6 2.8 3.0 3.2	205	4			3.3					

LAB DATA

LIQUID LIMIT	PLASTICITY INDEX	MOISTURE CONTENT (%)
LL	PI	

FIELD DESCRIPTION OF STRATA

0.0 / 208.1
3.0" Asphalt **ASPH**

0.25 / 207.85
11" Subbase material, Light gray, medium to coarse, SAND AND GRAVEL, trace Silt, dry **CCA**

1.17 / 206.93
Fill, Light gray, fine to medium, SILTY SAND, some Gravel, loose, moist. (Possible Subbase) **SM**

2.0 / 206.1
Fill,Tan, fine to coarse, SAND WITH GRAVEL, loose, damp. **SP/GP**

3.2 / 204.9
Boring trerminated at 3.2ft

REMARKS: Rig Type: Acker XLS.
Boring was offset 4' towards west due to undergroun utility. Hole backfilled with soil cutting and patched with cold asphalt at the surface.

PAGE 1 OF 1

B-PE-2

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APPENDIX C.3

DCP Logs

Virginia Department of Transportation

PROJECT #: **45893-001**
LOCATION: **Prince William County, VA**
STRUCTURE:

DCP-NE Mid

PAGE 1 OF 1

STATION:
NORTHING: 6917016 ft
SURFACE ELEVATION: 192.0 ft

OFFSET:
Easting: 11828718.8 ft
COORD. DATUM: VA North

Date(s) Drilled: 11/29/2021 - 11/29/2021
Drilling Method(s): Hand Auger
SPT Method:
Other Test(s): Hand-Held DCP
Driller: WRA
Logger: Burtis / Burroughs

GROUND WATER
NOT ENCOUNTERED DURING DRILLING
NO LONG TERM MEASUREMENTS TAKEN

FIELD DATA													
		SOIL				ROCK					LAB DATA		
								DIP °					
DEPTH (ft)	ELEVATION (ft)	STANDARD PENETRATION TEST HAMMER BLOWS	SOIL RECOVERY (%)	SAMPLE LEGEND	SAMPLE INTERVAL	CORE RECOVERY (%)	ROCK QUALITY DESIGNATION	STRATA	JOINTS	STRATA LEGEND	**FIELD DESCRIPTION OF STRATA**	LIQUID LIMIT LL	PLASTICITY INDEX PI	MOISTURE CONTENT (%)
		3 4 5									0.0 / 192.0 *FILL*, Brown, orange-brown, fine-grained SILTY SAND with fine, rounded quartz gravel, contains roots, dry to moist (SM) **SM**			
0.5					0.5									
1.0		5 5 4			1									
1.5					1.5									
2.0	190	5 6 5			2						2.0 / 190.0 *FILL*, Orange-brown, fine- to medium-grained CLAYEY SAND with coarse, quartz gravel, moist (SC) **SC**			
2.5		6 6 6			2.5									
3.0					3									
3.5														
4.0	188	7 6 6			4						4.0 / 188.0 *FILL*, Orange-brown, fine- to medium-grained SILTY SAND with rounded quartz gravel, clay, dry to moist (SM) **SM**			
4.5					4.5									
5.0		5 5 7			5									
5.5					5.5									
6.0	186	6 9 7			6									
6.5		7 6 7			6.5									
7.0					7						Boring terminated at 7 ft.			

REMARKS: DCP test conducted at 1-ft. intervals. Recorded blows are blows per 2-inches; Boring location and elevation estimated using Google Earth

PAGE 1 OF 1

DCP-NE Mid

SPT_LOG:OPITZ BLVD. DCP.GPJ:SPT7.GDT:gINT_version 10.02.00.04:12/1/21:WRA

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Virginia Department of Transportation

PROJECT #: **45893-001**
LOCATION: **Prince William County, VA**
STRUCTURE:

DCP-NE Upper

PAGE 1 OF 1

STATION:
NORTHING: 6916998.2 ft
SURFACE ELEVATION: 203.0 ft
OFFSET:
Easting: 11828744.7 ft
COORD. DATUM: VA North

Date(s) Drilled: 11/29/2021 - 11/29/2021
Drilling Method(s): Hand Auger
SPT Method:
Other Test(s): Hand-Held DCP
Driller: WRA
Logger: Burtis / Burroughs

GROUND WATER
NOT ENCOUNTERED DURING DRILLING
NO LONG TERM MEASUREMENTS TAKEN

FIELD DATA

DEPTH (ft)	ELEVATION (ft)
0.5	
1.0	202
1.5	
2.0	
2.5	
3.0	200
3.5	
4.0	
4.5	
5.0	198
5.5	
6.0	
6.5	
7.0	196

SAMPLE INTERVAL	STANDARD PENETRATION TEST HAMMER BLOWS	SOIL RECOVERY (%)	CORE RECOVERY (%)	ROCK QUALITY DESIGNATION	STRATA	JOINTS	LL	PI	MOISTURE CONTENT (%)
0.5	4 3 2								
1 – 1.5	2 2 2								
2 – 2.5	3 3 3								
3.25 – 3.75	2 2 2								
4 – 4.5	2 2 2								
5.25 – 5.75	1 1 2								
6 – 6.5	3 2 2								
6.5 – 7	2 3 4								

FIELD DESCRIPTION OF STRATA

0.0 / 203.0
1-inch Topsoil **TOPS**

0.1 / 202.9
FILL, Brown, fine- to medium-grained SILTY SAND with gravel, contains rock fragments, dry (SM) **SM**

1.0 / 202.0
FILL, Orange-brown, fine- to medium-grained SILTY SAND with clay and gravel, dry to moist (SM) **SM**

3.25 ft: Contains rounded quartz gravel

5.25 / 197.75
FILL, Orange-brown, fine- to medium-grained CLAYEY SAND, contains organics, moist to wet (SC) **SC**

Boring terminated at 7 ft.

REMARKS: DCP test conducted at 1-ft. intervals. Recorded blows are blows per 2-inches;
Boring location and elevation estimated using Google Earth

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Virginia Department of Transportation

PROJECT #: **45893-001**
LOCATION: **Prince William County, VA**
STRUCTURE:

DCP-SE

PAGE 1 OF 1

STATION:
NORTHING: 6916895.8 ft
SURFACE ELEVATION: 207.0 ft

OFFSET:
Easting: 11828717.5 ft
COORD. DATUM: VA North

Date(s) Drilled: 11/29/2021 - 11/29/2021
Drilling Method(s): Hand Auger
SPT Method:
Other Test(s): Hand-Held DCP
Driller: WRA
Logger: Burtis / Burroughs

GROUND WATER

NOT ENCOUNTERED DURING DRILLING
NO LONG TERM MEASUREMENTS TAKEN

FIELD DATA												**FIELD DESCRIPTION OF STRATA**	**LAB DATA**		
		SOIL				**ROCK**									
									DIP °						
DEPTH (ft)	ELEVATION (ft)	STANDARD PENETRATION TEST HAMMER BLOWS	SOIL RECOVERY (%)	SAMPLE LEGEND	SAMPLE INTERVAL	CORE RECOVERY (%)	ROCK QUALITY DESIGNATION	STRATA	JOINTS	STRATA LEGEND			LIQUID LIMIT LL	PLASTICITY INDEX PI	MOISTURE CONTENT (%)
		1 0 1										0.0 / 207.0 1-inch Topsoil **TOPS** 0.1 / 206.9 *FILL*, Orange-brown, CLAYEY SAND, contains rock fragments, moist to wet (SC) **SC**			
0.5					0.5										
1.0	206	1 1 1			1										
1.5					1.5										
2.0		1 1 1			2										
2.5					2.5										
3.0	204	1 1 1			3							3.0 / 204.0 *FILL*, Light brown and gray, fine- to medium-grained CLAYEY SAND, contains trace organic material, moist (SC) **SC**			
3.5					3.5										
4.0		1 1 1			4										
4.5					4.5										
5.0	202	1 1 2			5										
5.5					5.5										
6.0		2 3 2			6										
6.5		2 2 2			6.5										
7.0	200				7							Boring terminated at 7 ft.			

REMARKS: DCP test conducted at 1-ft. intervals. Recorded blows are blows per 2-inches;
Boring location and elevation estimated using Google Earth

PAGE 1 OF 1

DCP-SE

SPT_LOG:OPITZ BLVD. DCP.GPJ:SPT7.GDT:gINT_version 10.02.00.04:12/1/21:WRA

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Virginia Department of Transportation

PROJECT #: **45893-001**
LOCATION: **Prince William County, VA**
STRUCTURE:

DCP-SW

PAGE 1 OF 1

STATION:
NORTHING: 6917039.1 ft
SURFACE ELEVATION: 211.0 ft

OFFSET:
Easting: 11828255.7 ft
COORD. DATUM: VA North

Date(s) Drilled: 11/29/2021 - 11/29/2021
Drilling Method(s): Hand Auger
SPT Method:
Other Test(s): Hand-Held DCP
Driller: WRA
Logger: Burtis / Burroughs

GROUND WATER

NOT ENCOUNTERED DURING DRILLING
NO LONG TERM MEASUREMENTS TAKEN

FIELD DATA

DEPTH (ft)	ELEVATION (ft)	SOIL: STANDARD PENETRATION TEST HAMMER BLOWS	SOIL: SOIL RECOVERY (%)	SAMPLE LEGEND	SAMPLE INTERVAL	ROCK: CORE RECOVERY (%)	ROCK: ROCK QUALITY DESIGNATION	ROCK: DIP °: STRATA	ROCK: DIP °: JOINTS	STRATA LEGEND
		1 3 3								
0.5					0.5					
1.0	210	3 4 4			1					
1.5					1.5					
2.0		2 2 3			2					
2.5					2.5					
3.0	208	2 5 4			3					
3.5					3.5					
4.0										
4.5		3 3 3			4.5					
5.0	206				5					
5.5		3 3 2			5.5					
6.0					6					
6.5		3 2 2			6.5					
7.0	204				7					

FIELD DESCRIPTION OF STRATA

0.0 / 211.0
4-inch Topsoil **TOPS**

0.3 / 210.7
FILL, Orange-brown, fine- to medium-grained SANDY CLAY, moist to wet (SC) **SC**

1.0 / 210.0
FILL, Orange-brown, fine- to medium-grained SILTY SAND, contains rock fragments, rounded gravel, trace clay, moist (SM) **SM**

3.0 / 208.0
FILL, Light brown, fine- to medium-grained SILTY SAND, contains organic material, moist (SM) **SM**

4.5 / 206.5
FILL, Brown to orange-brown, fine- to medium-grained SILTY SAND, contains lenses to pockets of silty clay, organic material (SM) **SM**

Boring terminated at 7 ft.

LAB DATA

LIQUID LIMIT	PLASTICITY INDEX	MOISTURE CONTENT (%)
LL	PI	

REMARKS: DCP test conducted at 1-ft. intervals. Recorded blows are blows per 2-inches; Boring location and elevation estimated using Google Earth

PAGE 1 OF 1

DCP-SW

SPT_LOG:OPITZ BLVD. DCP.GPJ:SPT7.GDT:gINT_version 10.02.00.04:12/1/21:WRA

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APPENDIX C.4

Pavement Core Records

B-A4-1

Proposed Pavement Core Location

As drilled Pavement Core Location

Pavement Core Sample

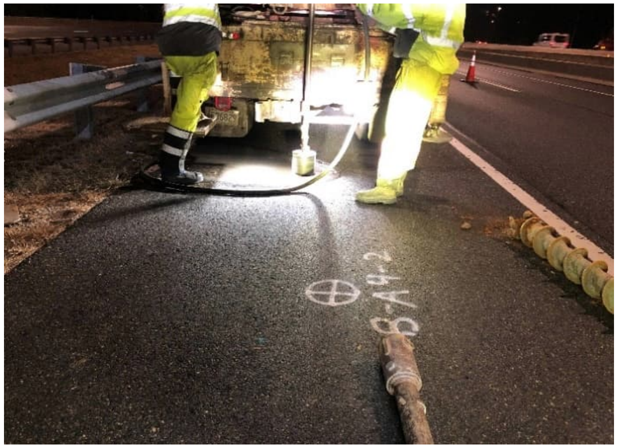
Material Description	Depth (in.)		Thickness (in.)	Total Thickness (in.)	Condition
	From	To			
Asphalt -Surface Mix	0.0	2.5	2.5		
Asphalt-Intermediate Mix	2.5	7.0	4.5	14.0	
Asphalt-Base Mix	7.0	14.0	7.0		
Concrete	-	-	-		
Aggregate Base	14.0	24.0	10.0	10.0	

Additional Notes:

Delineation between intermediate and base mix layers are approximate.

B-A4-2

Proposed Pavement Core Location



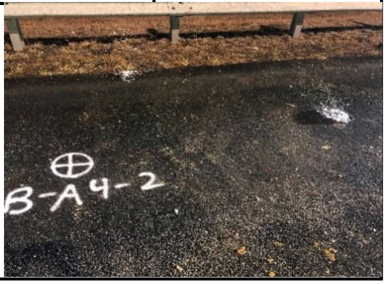
As drilled Pavement Core Location

Pavement Core Sample

Material Description	Depth (in.)		Thickness (in.)	Total Thickness (in.)	Condition
	From	To			
Asphalt -Surface Mix	0.0	2.5	2.5		
Asphalt-Intermediate Mix	2.5	7.0	4.5	17.0	
Asphalt-Base Mix	7.0	17.0	10.0		
Concrete	-	-	-		
Aggregate Base	17.0	25.0	8.0	8.0	

Additional Notes:

Delineation between intermediate and base mix layers are approximate.

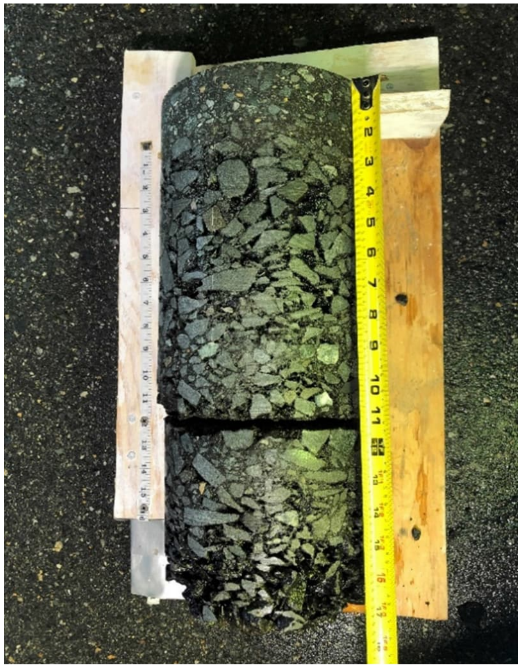


B-A4-3

Proposed Pavement Core Location

As drilled Pavement Core Location

Pavement Core Sample



Material Description	Depth (in.)		Thickness (in.)	Total Thickness (in.)	Condition
	From	To			
Asphalt -Surface Mix	0.0	3.0	3.0		
Asphalt-Intermediate Mix	3.0	8.0	5.0	17.0	
Asphalt-Base Mix	8.0	17.0	9.0		
Concrete	-	-	-		
Aggregate Base	17.0	25.0	8.0	8.0	

Additional Notes:

B-A4-4

Proposed Pavement Core Location

As drilled Pavement Core Location

Pavement Core Sample

Material Description	Depth (in.)		Thickness (in.)	Total Thickness (in.)	Condition
	From	To			
Asphalt -Surface Mix	0.0	3.0	3.0		
Asphalt-Intermediate Mix	3.0	7.0	4.0	15.0	
Asphalt-Base Mix	7.0	15.0	8.0		
Concrete	-	-	-		
Aggregate Base	15.0	24.0	9.0	9.0	

Additional Notes:

1.5" Pavement overlay

B-A4-5


Proposed Pavement Core Location


As drilled Pavement Core Location

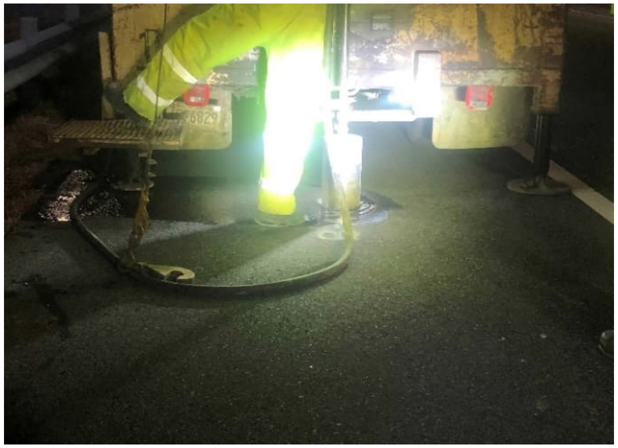

Pavement Core Sample

Material Description	Depth (in.)		Thickness (in.)	Total Thickness (in.)	Condition
	From	To			
Asphalt -Surface Mix	0.0	2.5	2.5		
Asphalt-Intermediate Mix	2.5	8.0	5.5	16.0	
Asphalt-Base Mix	8.0	16.0	8.0		
Concrete	-	-	-		
Aggregate Base	16.0	25.0	9.0	9.0	

Additional Notes:

B-A4-6

Proposed Pavement Core Location



As drilled Pavement Core Location

Pavement Core Sample

Material Description	Depth (in.)		Thickness (in.)	Total Thickness (in.)	Condition
	From	To			
Asphalt -Surface Mix	0.0	2.5	2.5		
Asphalt-Intermediate Mix	2.5	7.0	4.5	15.0	
Asphalt-Base Mix	7.0	15.0	8.0		
Concrete	-	-	-		
Aggregate Base	15.0	25.0	10.0	10.0	

Additional Notes:

Thicknesses based on picture.

Delineation between intermediate and base mix layers are approximate.

B-A4-7

Proposed Pavement Core Location

As drilled Pavement Core Location

Pavement Core Sample

Material Description	Depth (in.)		Thickness (in.)	Total Thickness (in.)	Condition
	From	To			
Asphalt -Surface Mix	0.0	2.5	2.5		
Asphalt-Intermediate Mix	2.5	7.0	4.5	16.0	
Asphalt-Base Mix	7.0	16.0	9.0		
Concrete	-	-	-		
Aggregate Base	16.0	25.0	9.0	9.0	

Additional Notes:

B-A4-8

Proposed Pavement Core Location

As drilled Pavement Core Location

Pavement Core Sample

Material Description	Depth (in.)		Thickness (in.)	Total Thickness (in.)	Condition
	From	To			
Asphalt -Surface Mix	0.0	2.5	2.5		
Asphalt-Intermediate & Base Mix	2.5	15.0	12.5	15.0	
Concrete	-	-	-		
Aggregate Base	15.0	48.0	33.0	33.0	

Additional Notes:

Unable to differentiate between intermediate and base asphalt layers.

B-A1-1

Proposed and as drilled pavement core location

Material Description	Depth (in.)		Thickness (in.)	Total Thickness (in.)	Condition
	From	To			
Asphalt -Surface Mix	0.0	1.5	1.5		
Asphalt-Intermediate Mix	1.5	5.5	4.0	12.0	
Asphalt-Base Mix	5.5	12.0	6.5		
Concrete	-	-	-		
Aggregate Base	12.0	16.0	4.0	4.0	

Additional Notes:

Pavement Core Sample

B-A1-2

Proposed and as drilled pavement core location

Material Description	Depth (in.)		Thickness (in.)	Total Thickness (in.)	Condition
	From	To			
Asphalt -Surface Mix	0.0	1.5	1.5		
Asphalt-Intermediate & Base Mix	1.5	11.0	9.5	11.0	
Concrete	-	-	-		
Aggregate Base	11.0	18.0	7.0	7.0	

Additional Notes:

Unable to differentiate between intermediate and base asphalt layers.

Pavement Core Sample

B-PE-1

Material Description	Depth (in.)		Thickness (in.)	Total Thickness (in.)	Condition
	From	To			
Asphalt -Surface Mix	0.0	1.5	1.5		
Asphalt-Intermediate Base Mix	1.5	4.5	3.0	4.5	
Concrete	-	-	-		
Aggregate Base	4.5	15.0	10.5	10.5	

Additional Notes:

Pavement Core Sample

B-PE-2

Proposed Pavement Core Location

As drilled Pavement Core Location

Pavement Core Sample

Material Description	Depth (in.)		Thickness (in.)	Total Thickness (in.)	Condition
	From	To			
Asphalt -Surface Mix	0.0	1.5	1.5		
Asphalt-Intermediate Mix	1.5	3.0	1.5	3.0	
Concrete	-	-	-		
Aggregate Base	3.0	14.0	11.0	11.0	

Additional Notes:

B-A1-1

Proposed and as drilled pavement core location

Material Description	Depth (in.)		Thickness (in.)	Total Thickness (in.)	Condition
	From	To			
Asphalt -Surface Mix	0.0	1.5	1.5		
Asphalt-Intermediate & Base Mix	1.5	12.0	10.5	12.0	
	-	-	-		
Concrete	-	-	-		
Aggregare Base	12.0	16.0	4.0	4.0	

Additional Notes:

Pavement Core Sample

B-A1-2

Proposed and as drilled pavement core location

Material Description	Depth (in.)		Thickness (in.)	Total Thickness (in.)	Condition
	From	To			
Asphalt -Surface Mix	0.0	1.5	1.5		
Asphalt-Intermediate & Base Mix	1.5	11.0	9.5	11.0	
	-	-	-		
Concrete	-	-	-		
Aggregare Base	11.0	18.0	7.0	7.0	

Additional Notes:

Pavement Core Sample

APPENDIX D

Laboratory Test Results

Boring	S No.	Depth (ft)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	% < #4 Sieve	% < #200 Sieve	Classification	AASHTO	Water Content (%)
B-A1-1	S1	1.5 - 3.0								8.3
B-A1-1	S2	3.5 - 5.0								35.2
B-A1-1	S3	6.0 - 7.5	68	27	41	100	76	CH	A-7-6	30.0
B-A1-1	S4	8.5 - 10.0								24.1
B-A1-1	S5	11.0 - 12.5								21.3
B-A1-1	S6	13.5 - 15.0								13.8
B-A1-2	S1	1.5 - 3.0								21.7
B-A1-2	S2	3.5 - 5.0								33.7
B-A1-2	S3	6.0 - 7.5								21.4
B-A1-2	S4	8.5 - 10.0								29.8
B-A1-2	S5	11.0 - 12.5				100	76			26.6
B-A1-2	S6	13.5 - 15.0								16.4
B-A1-2	S7	16.0 - 17.5								14.8
B-A1-2	S8	18.5 - 20.0								13.0
B-A1-3	S1	0.0 - 1.5								18.7
B-A1-3	S2	1.5 - 3.0								15.2
B-A1-3	S3	5.0 - 6.5				99	25			13.9
B-A1-3	S4	7.5 - 9.0								17.5
B-A1-3	S5	10.0 - 11.5								16.0
B-A1-3	S6	12.5 - 14.0								17.8
B-A1-3	S7	15.0 - 16.5								19.6
B-A1-3	S8	17.5 - 19.0								11.5
B-A1-3	S9	23.5 - 25.0								11.7
B-A1-3	S10	28.5 - 30.0								9.1
B-A1-4	S1	1.0 - 2.5								19.9
B-A1-4	S2	3.5 - 5.0								20.8
B-A1-4	S3	6.0 - 7.5								13.6

TLB_LAB_SUMMARY_BASIC OPITZ BLVD.GPJ PROJECT.GDT 1/3/22

Summary of Laboratory Results

Opitz Blvd

Woodbridge, VA

Project Number: 21-0038

Boring	S No.	Depth (ft)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	% < #4 Sieve	% < #200 Sieve	Classification	AASHTO	Water Content (%)
B-A1-4	S4	8.5 - 10.0								18.6
B-A1-4	S5	11.0 - 12.5								16.6
B-A1-4	S6	13.5 - 15.0								15.6
B-A1-4	S7	16.0 - 17.5								15.7
B-A1-4	S8	18.5 - 20.0								24.4
B-A1-4	S9	21.0 - 21.3								11.1
B-A1-4	S10	23.5 - 23.9								11.1
B-A1-4	S11	28.5 - 28.8								13.5
B-A1-6	S1	0.5 - 2.0								6.6
B-A1-6	S2	3.5 - 5.0								19.3
B-A1-6	S3	6.0 - 7.5								18.9
B-A1-6	S4	8.5 - 10.0								13.3
B-A1-6	S5	11.0 - 12.5								18.7
B-A1-6	S6	13.5 - 15.0	35	24	11	100	23	SC	A-2-6	15.6
B-A1-6	S7	16.0 - 17.5								15.8
B-A1-6	S8	18.5 - 20.0								15.6
B-A1-6	S9	23.5 - 25.0								16.1
B-A1-6	S10	28.5 - 30.0								26.6
B-A1-6	S11	33.5 - 35.0								16.5
B-A1-6	S12	38.5 - 40.0								18.3
B-A1-6	S13	43.5 - 45.0	35	24	11	100	98	CL	A-6	19.2
B-A1-6	S14	48.5 - 50.0								17.2
B-A1-6	S15	53.5 - 55.0								12.1
B-A1-6	S16	58.5 - 60.0								11.9
B-A1-6	S17	63.5 - 65.0								14.9
B-A1-6	S18	68.5 - 70.0								19.7
B-A1-6	S19	73.5 - 75.0								16.2

Summary of Laboratory Results
Opitz Blvd

Woodbridge, VA
Project Number: 21-0038

Boring	S No.	Depth (ft)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	% < #4 Sieve	% < #200 Sieve	Classification	AASHTO	Water Content (%)
B-A2-1	S1	1.5 - 3.0								10.1
B-A2-1	S2	3.5 - 5.0								18.1
B-A2-1	S3	6.0 - 7.5								14.4
B-A2-1	S4	8.5 - 10.0				99	22			12.7
B-A2-1	S5	11.0 - 12.5								10.8
B-A2-1	S6	13.5 - 15.0								14.3
B-A2-1	S7	16.0 - 17.5								16.2
B-A2-1	S8	18.5 - 20.0								20.7
B-A2-1	S9	23.5 - 25.0								23.1
B-A2-1	S10	28.5 - 30.0				94	46			10.1
B-A2-1	S11	33.5 - 35.0								10.0
B-A2-1	S12	38.5 - 40.0								10.0
B-A2-1	S13	43.5 - 45.0								12.5
B-A2-1	S14	48.5 - 50.0								12.4
B-A2-1	S15	53.5 - 55.0								9.8
B-A2-1	S16	58.5 - 60.0								14.8
B-A3-1	S1	1.5 - 3.0								6.1
B-A3-1	S2	3.5 - 5.0								15.7
B-A3-1	S3	6.0 - 7.5								13.9
B-A3-1	S4	8.5 - 10.0								13.6
B-A3-1	S5	11.0 - 12.5								14.3
B-A3-1	S6	13.5 - 15.0								13.3
B-A3-1	S7	16.0 - 17.5								18.7
B-A3-1	S8	18.5 - 20.0								16.8
B-A3-1	S9	23.5 - 25.0								29.7
B-A3-1	S10	28.5 - 30.0								11.8
B-A3-1	S11	33.5 - 35.0								17.4

Summary of Laboratory Results

Opitz Blvd

Woodbridge, VA

Project Number: 21-0038

TLB_LAB_SUMMARY_BASIC OPITZ BLVD.GPJ PROJECT.GDT 1/3/22

Boring	S No.	Depth (ft)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	% < #4 Sieve	% < #200 Sieve	Classification	AASHTO	Water Content (%)
B-A3-1	S12	38.5 - 40.0								18.1
B-A3-2	S1	1.5 - 3.0								4.3
B-A3-2	S2	3.5 - 5.0								40.8
B-A3-2	S3	6.0 - 7.5								42.4
B-A3-2	S4	8.5 - 10.0								14.3
B-A3-2	S5	11.0 - 12.5				98	21			14.5
B-A3-2	S6	13.5 - 15.0								13.9
B-A3-2	S7	16.0 - 17.5								15.3
B-A3-2	S8	18.5 - 20.0								14.7
B-A3-2	S9	23.5 - 25.0								20.4
B-A3-2	S10	28.5 - 30.0								15.6
B-A3-2	S11	33.5 - 35.0								15.2
B-A3-2	S12	38.5 - 40.0								8.6
B-A3-3	S1	2.0 - 3.5								16.1
B-A3-3	S2	3.5 - 5.0								18.0
B-A3-3	S3	6.0 - 7.5								13.5
B-A3-3	S4	8.5 - 10.0	41	25	16	100	89	CL	A-7-6	22.4
B-A3-3	S5	11.0 - 12.5								12.7
B-A3-3	S6	13.5 - 15.0								16.8
B-A3-3	S7	16.0 - 17.5								17.6
B-A3-3	S8	18.5 - 20.0								24.8
B-A3-3	S9	23.5 - 25.0								19.1
B-A3-3	S10	28.5 - 30.0								15.4
B-A3-4	S1	1.5 - 3.0								4.2
B-A3-4	S2	3.5 - 5.0								14.8
B-A3-4	S3	6.0 - 7.5								19.4
B-A3-4	S4	8.5 - 10.0								20.8

Summary of Laboratory Results

Opitz Blvd

Woodbridge, VA

Project Number: 21-0038

Boring	S No.	Depth (ft)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	% < #4 Sieve	% < #200 Sieve	Classification	AASHTO	Water Content (%)
B-A3-4	S5	11.0 - 12.5	55	28	27	97	45	SC	A-7-6	19.7
B-A3-4	S6	13.5 - 14.0								20.9
B-A3-4	ST-1	14.0 - 16.0	30	21	9	99	46	SC	A-4	19.9
B-A3-4	S7	16.0 - 17.5								21.0
B-A3-4	S8	18.5 - 20.0								22.5
B-A3-4	S9	23.5 - 25.0								14.9
B-A3-4	S10	28.5 - 30.0								19.4
B-A3-5	S1	2.0 - 3.5								17.4
B-A3-5	S2	3.5 - 5.0				91	27			15.4
B-A3-5	S3	6.0 - 7.5								22.2
B-A3-5	S4	8.5 - 10.0	46	25	21	100	35	SC	A-2-7	16.6
B-A3-5	S5	11.0 - 12.5								14.5
B-A3-5	S6	13.5 - 15.0								16.9
B-A3-5	S7	16.0 - 17.5								17.8
B-A3-5	S8	18.5 - 20.0								25.9
B-A3-6	S1	1.5 - 3.0								4.1
B-A3-6	S2	3.5 - 5.0								22.4
B-A3-6	S3	6.0 - 7.5								31.6
B-A3-6	S4	8.5 - 10.0								16.0
B-A3-6	S5	11.0 - 12.5								15.1
B-A3-6	S6	13.5 - 15.0								17.1
B-A3-6	S7	16.0 - 17.5								14.8
B-A3-6	S8	18.5 - 20.0								17.2
B-A3-7	S1	2.0 - 3.5								7.8
B-A3-7	S2	3.5 - 5.0								29.0
B-A3-7	S3	6.0 - 7.5				100	20			14.8
B-A3-7	S4	8.5 - 10.0								20.0

Summary of Laboratory Results

Opitz Blvd

Woodbridge, VA

Project Number: 21-0038

Boring	S No.	Depth (ft)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	% < #4 Sieve	% < #200 Sieve	Classification	AASHTO	Water Content (%)
B-A3-7	S5	11.0 - 12.5								35.3
B-A3-7	S6	13.5 - 15.0								15.5
B-A3-8	S1	1.5 - 3.0								3.5
B-A3-8	S2	3.5 - 5.0								12.2
B-A3-8	S3	6.0 - 7.5				100	56			29.3
B-A3-8	S4	8.5 - 10.0								29.2
B-A3-9	S1	1.5 - 3.0								17.9
B-A3-9	S2	3.5 - 5.0				100	24			19.1
B-A3-9	S3	6.0 - 7.5								19.2
B-A3-9	S4	8.5 - 10.0								20.7
B-A4-1	S-1	2.0 - 4.0								25.2
B-A4-1	S-2	4.0 - 6.0								16.3
B-A4-1	S-3	6.0 - 8.0								16.9
B-A4-2	S-1	2.0 - 4.0				100	27			15.6
B-A4-2	S-2	4.0 - 6.0								14.8
B-A4-2	S-3	6.0 - 8.0								15.8
B-A4-3	S-1	2.0 - 4.0								17.8
B-A4-3	S-2	4.0 - 6.0								16.8
B-A4-3	S-3	6.0 - 8.0								16.1
B-A4-4	S-1	2.0 - 4.0				92	32			12.9
B-A4-4	S-2	4.0 - 6.0								15.4
B-A4-4	S-3	6.0 - 8.0								37.0
B-A4-5	S-1	2.0 - 4.0								15.6
B-A4-5	S-2	4.0 - 6.0								17.4
B-A4-5	S-3	6.0 - 8.0								13.0
B-A4-6	S-1	2.0 - 4.0				94	55			24.2
B-A4-6	S-2	4.0 - 6.0								15.6

Summary of Laboratory Results

Opitz Blvd

Woodbridge, VA

Project Number: 21-0038

Sheet 7 of 7

Boring	S No.	Depth (ft)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	% < #4 Sieve	% < #200 Sieve	Classification	AASHTO	Water Content (%)
B-A4-6	S-3	6.0 - 8.0								15.9
B-A4-7	S-1	2.0 - 4.0								5.9
B-A4-7	S-2	4.0 - 6.0								18.3
B-A4-7	S-3	6.0 - 8.0								14.7
B-A4-8	S-1	2.0 - 4.0				100	59			16.2
B-A4-8	S-2	4.0 - 6.0								21.0
B-A4-8	S-3	6.0 - 8.0								12.4

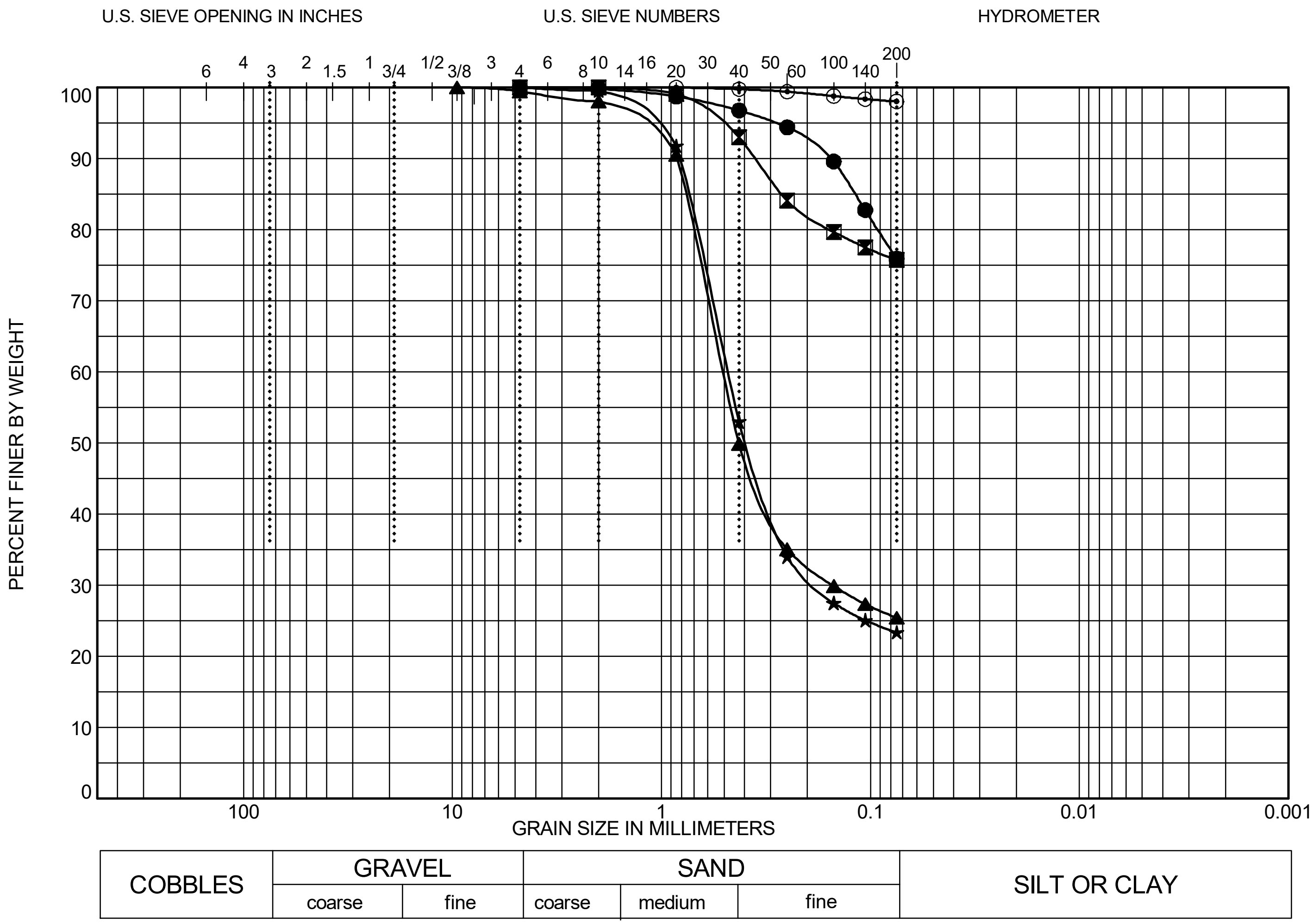
TLB_LAB_SUMMARY_BASIC OPITZ BLVD.GPJ PROJECT.GDT 1/3/22

Summary of Laboratory Results

Opitz Blvd

Woodbridge, VA

Project Number: 21-0038



	D10	D30	D60	D100
●				4.76
☒				4.76
▲		0.152	0.505	9.5
★		0.183	0.482	4.76
⊙				4.76

Test Method: VTM-25

Tested By: CL, KZ, SM

Date: 12/21/2021

	Boring	S No.	Depth	%Gravel	%Sand	%Silt	%Clay	LL	PI	MC(%)	Classification	AASHTO
●	B-A1-1	S3	6.0 - 7.5	0.0	24.1	75.9		68	41	30.0	FAT CLAY with SAND(CH)	A-7-6
☒	B-A1-2	S5	11.0 - 12.5	0.0	24.3	75.7				26.6		
▲	B-A1-3	S3	5.0 - 6.5	0.5	74.0	25.4				13.9		
★	B-A1-6	S6	13.5 - 15.0	0.0	76.6	23.4		35	11	15.6	CLAYEY SAND(SC)	A-2-6
⊙	B-A1-6	S13	43.5 - 45.0	0.0	2.0	98.0		35	11	19.2	LEAN CLAY(CL)	A-6

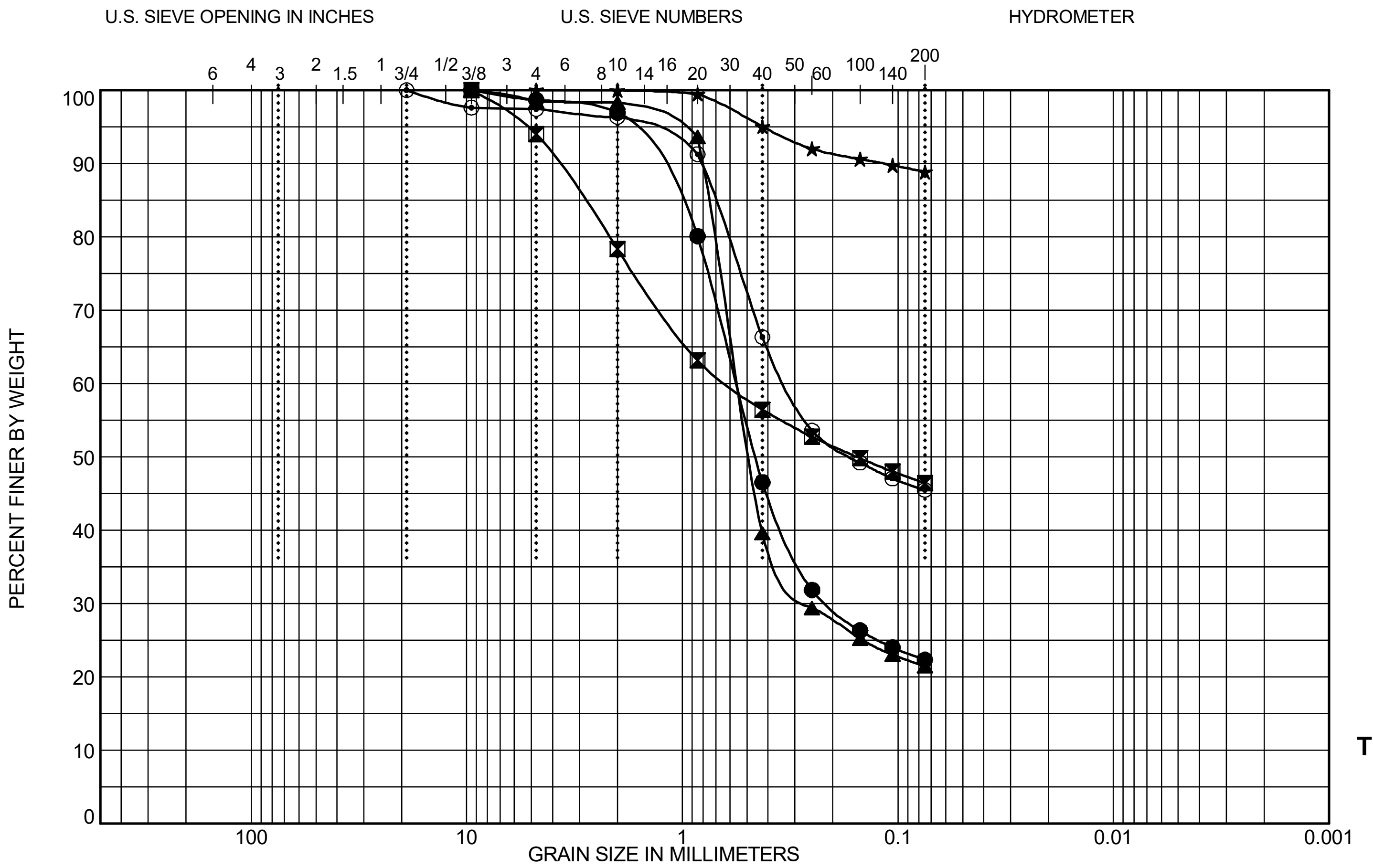
GRAIN SIZE DISTRIBUTION

Opitz Blvd

Woodbridge, VA

Project Number: 21-0038

Sheet 1 of 4



	D10	D30	D60	D100
●		0.211	0.561	9.5
☒			0.614	9.5
▲		0.258	0.552	9.5
★				4.76
⊙			0.327	19

Test Method: VTM-25

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Tested By: CL, KZ, SM Date: 12/22/2021

	Boring	S No.	Depth	%Gravel	%Sand	%Silt	%Clay	LL	PI	MC(%)	Classification	AASHTO
●	B-A2-1	S4	8.5 - 10.0	1.3	76.3	22.3				12.7		
☒	B-A2-1	S10	28.5 - 30.0	6.0	47.5	46.4				10.1		
▲	B-A3-2	S5	11.0 - 12.5	1.6	77.0	21.4				14.5		
★	B-A3-3	S4	8.5 - 10.0	0.0	11.1	88.9		41	16	22.4	LEAN CLAY(CL)	A-7-6
⊙	B-A3-4	S5	11.0 - 12.5	2.6	51.9	45.5		55	27	19.7	CLAYEY SAND(SC)	A-7-6

GRAIN SIZE DISTRIBUTION

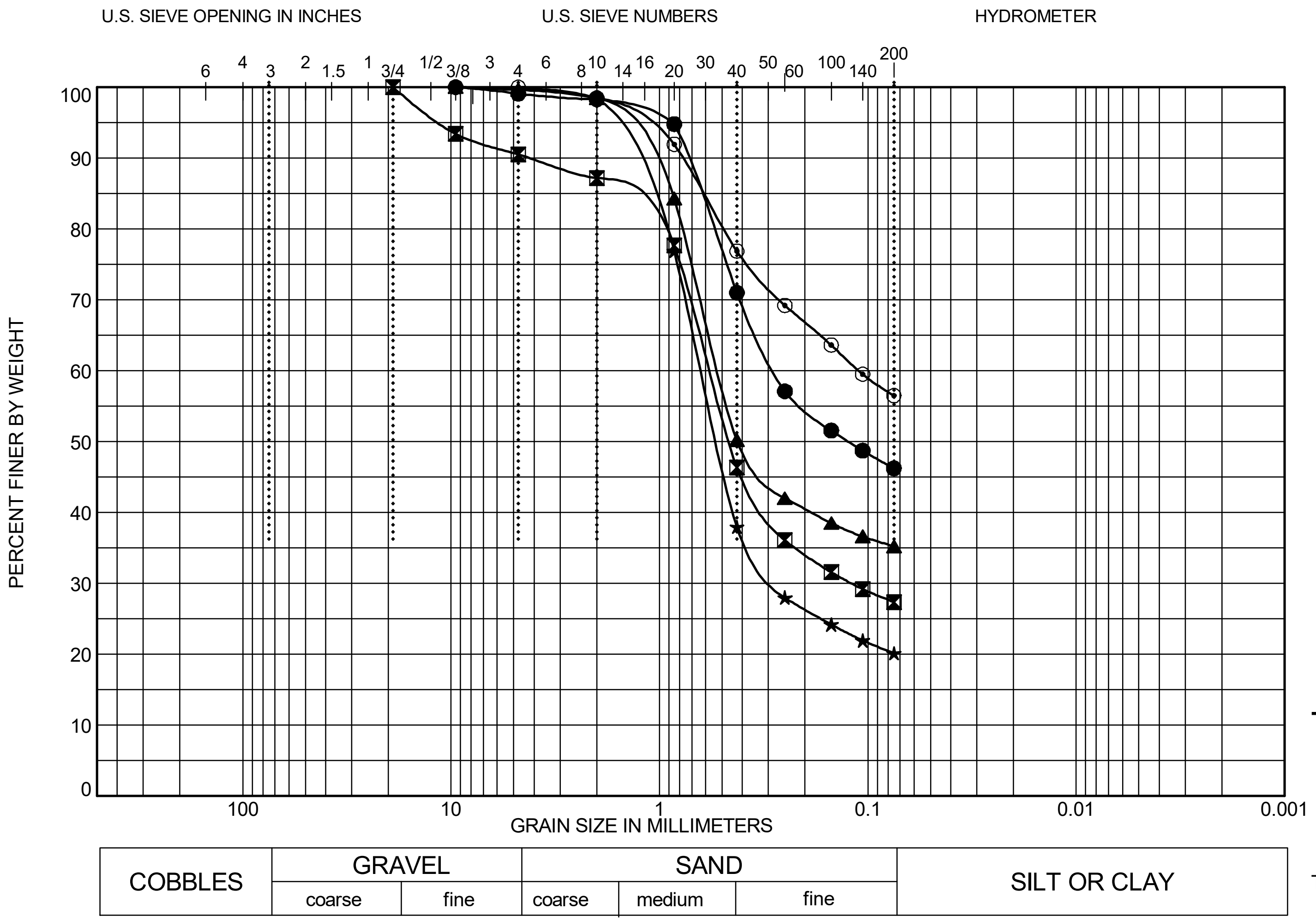
Opitz Blvd

Woodbridge, VA

Project Number: 21-0038

Sheet 2 of 4

TLB_GRAIN_SIZE_LANDSCAPE_USCS OPITZ BLVD.GPJ SALUT2014.GDT 1/3/22



	D10	D30	D60	D100
●			0.279	9.5
⧗		0.119	0.575	19
▲			0.519	9.5
★		0.278	0.629	9.5
⦿			0.111	4.76

Test Method: VTM-25

Tested By: CL, KZ, SM

Date: 12/22/2021

	Boring	S No.	Depth	%Gravel	%Sand	%Silt	%Clay	LL	PI	MC(%)	Classification	AASHTO
●	B-A3-4	ST-1	14.0 - 16.0	0.9	52.8	46.2		30	9	19.9	CLAYEY SAND(SC)	A-4
⧗	B-A3-5	S2	3.5 - 5.0	9.5	63.1	27.4				15.4		
▲	B-A3-5	S4	8.5 - 10.0	0.4	64.4	35.2		46	21	16.6	CLAYEY SAND(SC)	A-2-7
★	B-A3-7	S3	6.0 - 7.5	0.1	79.7	20.1				14.8		
⦿	B-A3-8	S3	6.0 - 7.5	0.0	43.5	56.5				29.3		

GRAIN SIZE DISTRIBUTION

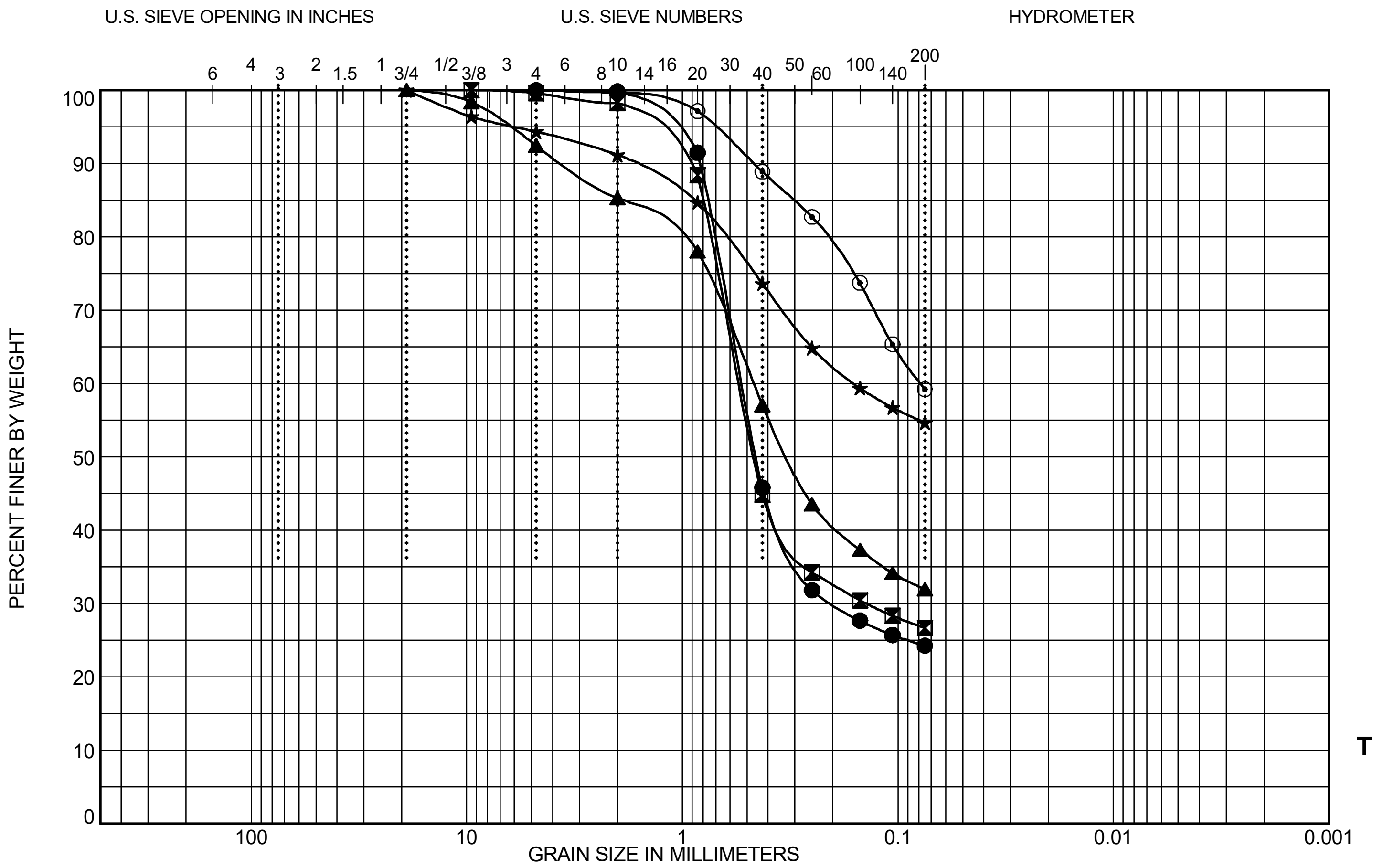
Opitz Blvd

Woodbridge, VA

Project Number: 21-0038

Sheet 3 of 4

TLB GRAIN SIZE LANDSCAPE USCS OPITZ BLVD.GPJ SALUT2014.GDT 1/3/22



	D10	D30	D60	D100
●		0.2	0.527	4.76
☒		0.139	0.541	9.5
▲			0.468	19
★			0.159	19
⊙			0.078	4.76

Test Method: VTM-25

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Tested By: CL, KZ, SM

Date: 12/28/2021

	Boring	S No.	Depth	%Gravel	%Sand	%Silt	%Clay	LL	PI	MC(%)	Classification	AASHTO
●	B-A3-9	S2	3.5 - 5.0	0.0	75.7	24.3				19.1		
☒	B-A4-2	S-1	2.0 - 4.0	0.4	72.9	26.7				15.6		
▲	B-A4-4	S-1	2.0 - 4.0	7.6	60.5	31.9				12.9		
★	B-A4-6	S-1	2.0 - 4.0	5.7	39.7	54.6				24.2		
⊙	B-A4-8	S-1	2.0 - 4.0	0.0	40.8	59.2				16.2		

GRAIN SIZE DISTRIBUTION

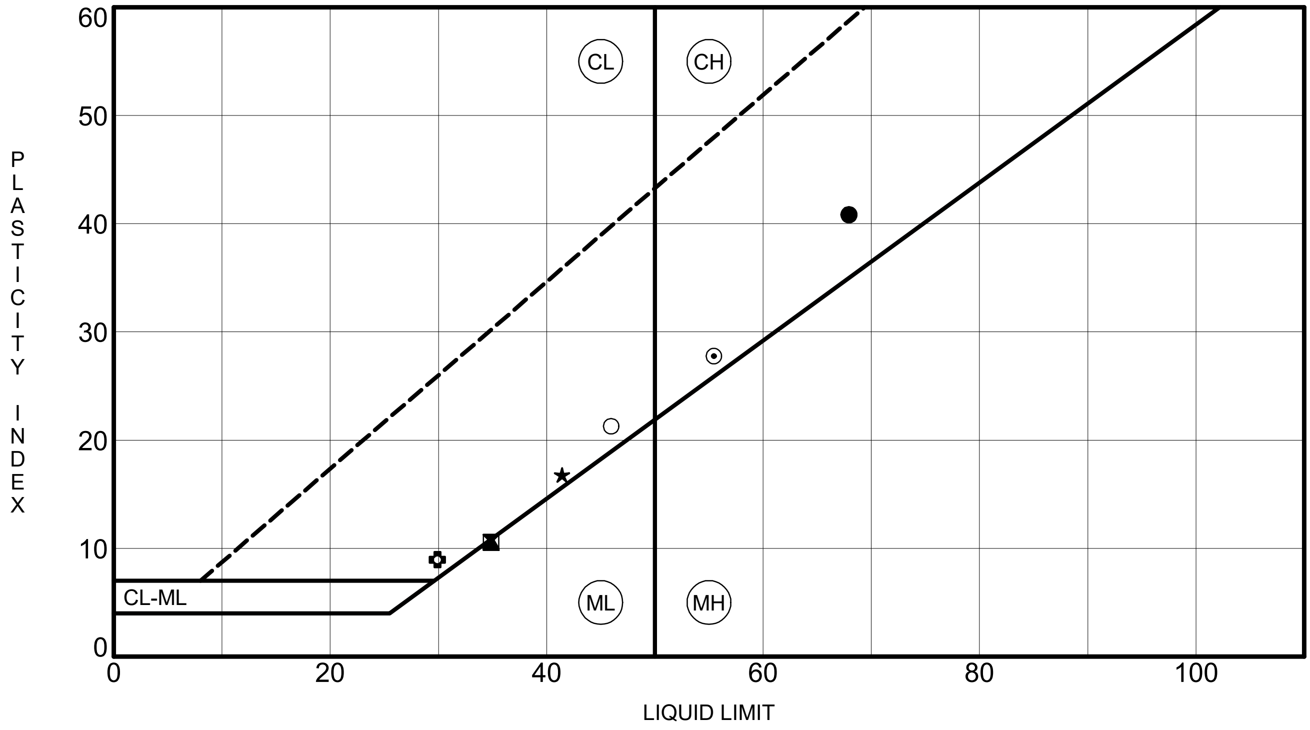
Opitz Blvd

Woodbridge, VA

Project Number: 21-0038

Sheet 4 of 4

TLB GRAIN SIZE LANDSCAPE USCS OPITZ BLVD.GPJ SALUT2014.GDT 1/3/22



	Boring	Depth	LL	PL	PI	Fines	Classification	AASHTO
●	B-A1-1	6.0 - 7.5	68	27	41	76	FAT CLAY with SAND(CH)	A-7-6
⧗	B-A1-6	13.5 - 15.0	35	24	11	23	CLAYEY SAND(SC)	A-2-6
▲	B-A1-6	43.5 - 45.0	35	24	11	98	LEAN CLAY(CL)	A-6
★	B-A3-3	8.5 - 10.0	41	25	16	89	LEAN CLAY(CL)	A-7-6
⊙	B-A3-4	11.0 - 12.5	55	28	27	45	CLAYEY SAND(SC)	A-7-6
✿	B-A3-4	14.0 - 16.0	30	21	9	46	CLAYEY SAND(SC)	A-4
○	B-A3-5	8.5 - 10.0	46	25	21	35	CLAYEY SAND(SC)	A-2-7

Test Method: VTM-7

Tested By: KZN, SM

Date: 12/21/2021

ATTERBERG LIMITS' RESULTS

Project: Opitz Blvd

Location: Woodbridge, VA

Project Number: 21-0038

Laboratory Testing - pH of Soil

Project Name: Opitz Blvd.
Project No.: 21-0038
Boring No.: B-A1-6
Sample No: S6
Depth: 13.5' - 15.0'

Date: 12/20/2021
Tested By: SM
Method: ASTM D4972

Calibration Data

	Buffer used for Calibration			Re-check
	pH 4.0	pH 7.00	pH 10.0	pH 7.00
Reading	4.00	7.00	10.00	7.01
Temperature C	20.1	20.1	20.1	20.1

pH reading for Soil

	pH	T(^{o}C)
Trial 1	5.33	20.3
Trial 2	5.26	20.3
Trial 3	5.33	20.3
Average	**5.31**	

Laboratory Testing - Resistivity of Soil

Project Name: Opitz Blvd.
Project No.: 21-0038
Boring No.: B-A1-6
Sample No: S6
Depth: 13.5' - 15.0'

Date: 12/20/2021
Tested By: SM
Method: ASTM G57

	In situ condition		Saturated condition	
Resistance reading	2.54	kΩ	0.845	kΩ
Sample resisitivity	2540	Ω-cm	845	Ω-cm

Laboratory Testing - pH of Soil

Project Name: Opitz Blvd.
Project No.: 21-0038
Boring No.: B-A1-6
Sample No: S13
Depth: 43.5' - 45.0'

Date: 12/20/2021
Tested By: SM
Method: ASTM D4972

Calibration Data

	Buffer used for Calibration			Re-check
	pH 4.0	pH 7.00	pH 10.0	pH 7.00
Reading	4.00	7.00	10.00	7.01
Temperature C	20.1	20.1	20.1	20.1

pH reading for Soil

	pH	T(^{o}C)
Trial 1	5.95	20.3
Trial 2	5.95	20.3
Trial 3	5.97	20.3
Average	**5.96**	

Laboratory Testing - Resistivity of Soil

Project Name: Opitz Blvd.
Project No.: 21-0038
Boring No.: B-A1-6
Sample No: S13
Depth: 43.5' - 45.0'

Date: 12/20/2021
Tested By: SM
Method: ASTM G57

	In situ condition	Saturated condition
Resistance reading	3.2 kΩ	1.4 kΩ
Sample resisitivity	3200 Ω-cm	1400 Ω-cm

Laboratory Testing - pH of Soil

Project Name: Opitz Blvd.
Project No.: 21-0038
Boring No.: B-A2-1
Sample No: S4
Depth: 8.5' - 10.0'

Date: 12/20/2021
Tested By: SM
Method: ASTM D4972

Calibration Data

	Buffer used for Calibration			Re-check
	pH 4.0	pH 7.00	pH 10.0	pH 7.00
Reading	4.00	7.00	10.00	7.01
Temperature C	20.1	20.1	20.1	20.1

pH reading for Soil

	pH	T(^{o}C)
Trial 1	4.30	20.3
Trial 2	4.26	20.3
Trial 3	4.34	20.3
Average	**4.30**	

Laboratory Testing - Resistivity of Soil

Project Name: Opitz Blvd.
Project No.: 21-0038
Boring No.: B-A2-1
Sample No: S4
Depth: 8.5' - 10.0'

Date: 12/20/2021
Tested By: SM
Method: ASTM G57

	In situ condition		Saturated condition	
Resistance reading	9.18	kΩ	3.17	kΩ
Sample resisitivity	9180	Ω-cm	3170	Ω-cm

Laboratory Testing - pH of Soil

Project Name:	Opitz Blvd.	Date:	12/20/2021
Project No.:	21-0038	Tested By:	SM
Boring No.:	B-A2-1	Method:	ASTM D4972
Sample No:	S10		
Depth:	28.5' - 30.0'		

Calibration Data

	Buffer used for Calibration			Re-check
	pH 4.0	pH 7.00	pH 10.0	pH 7.00
Reading	4.00	7.00	10.00	7.01
Temperature C	20.1	20.1	20.1	20.1

pH reading for Soil

	pH	T(^{o}C)
Trial 1	5.04	20.3
Trial 2	5.09	20.3
Trial 3	5.10	20.3
Average	**5.08**	

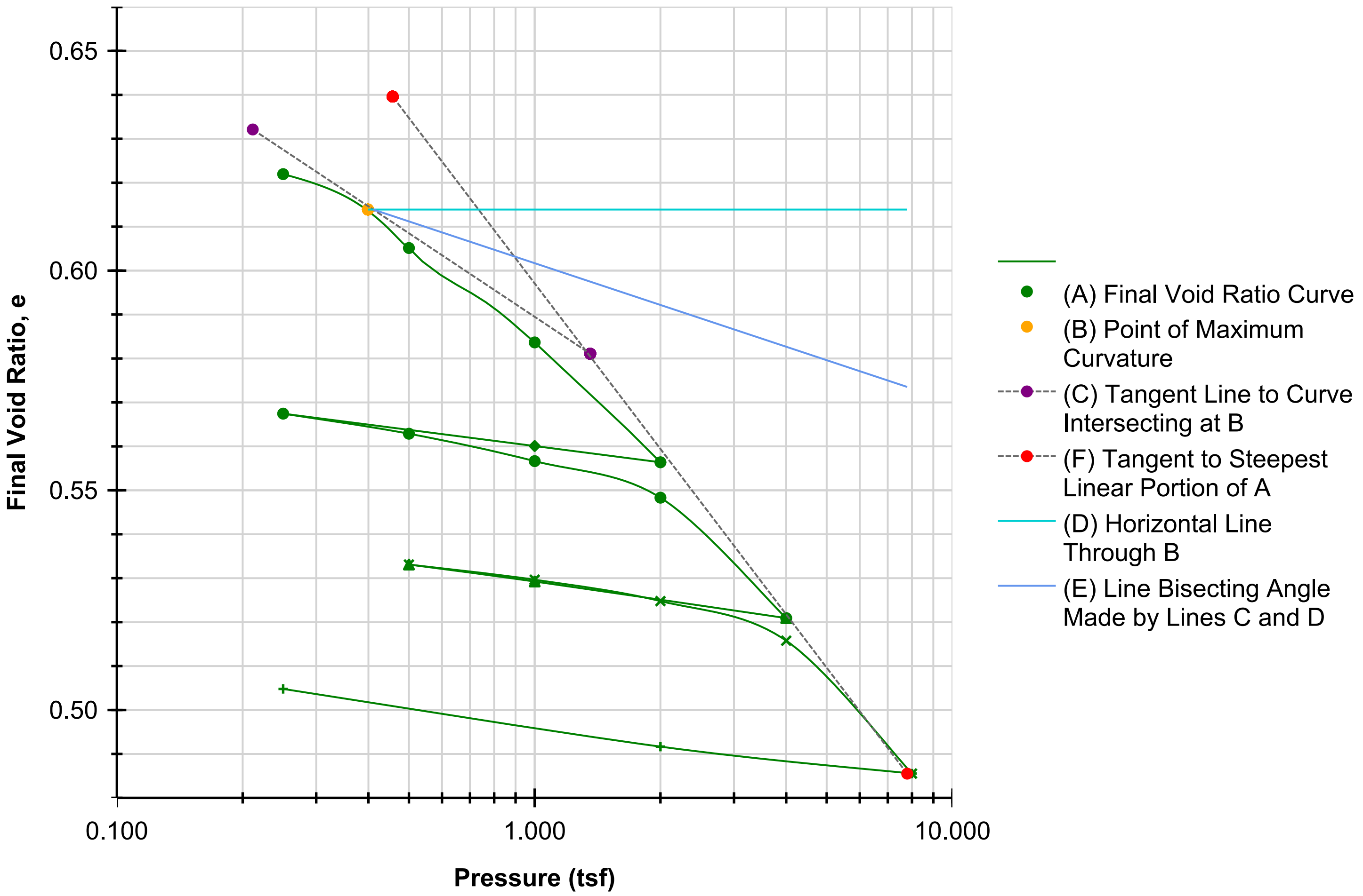
Laboratory Testing - Resistivity of Soil

Project Name:	Opitz Blvd.	Date:	12/20/2021
Project No.:	21-0038	Tested By:	SM
Boring No.:	B-A2-1	Method:	ASTM G57
Sample No:	S10		
Depth:	28.5' - 30.0'		

	In situ condition	Saturated condition
Resistance reading	28.7 kΩ	11.8 kΩ
Sample resisitivity	28700 Ω-cm	11800 Ω-cm

Final Voids [Log]

ASTM D2435



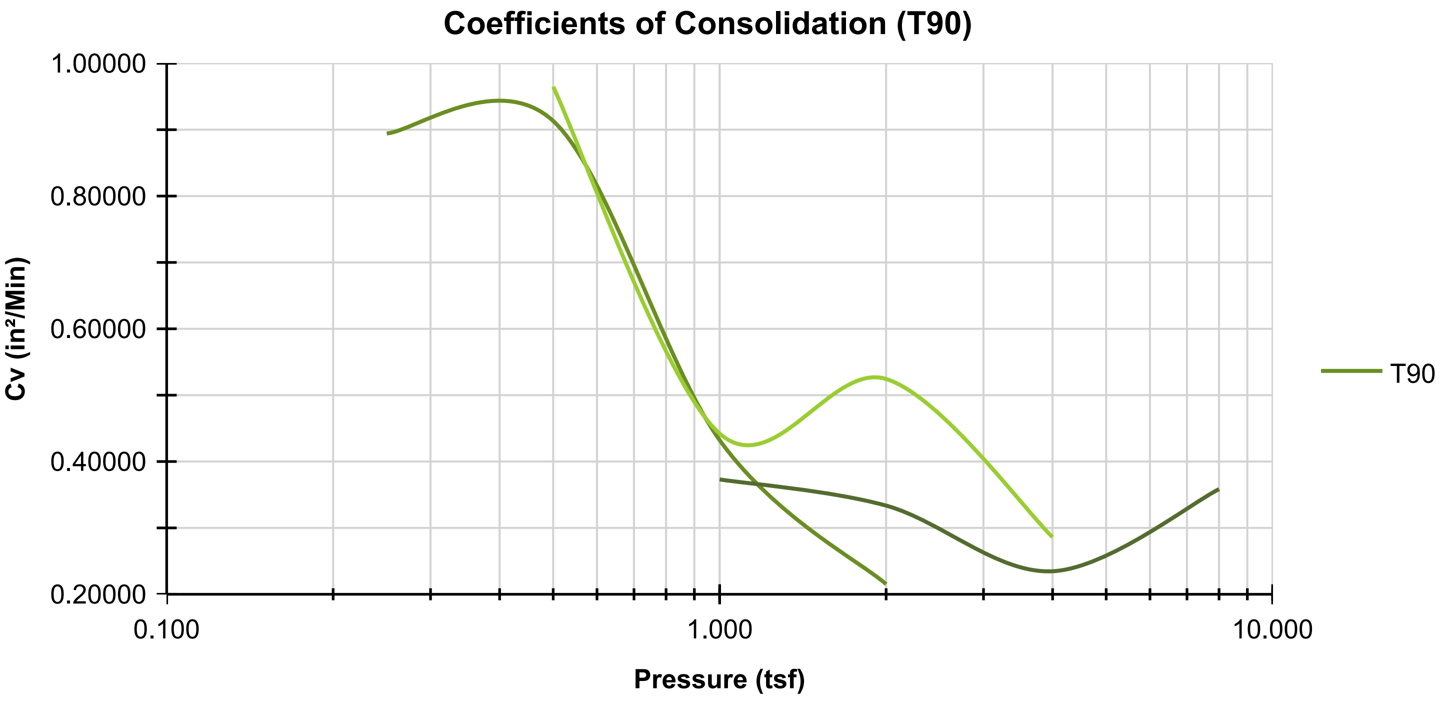
Preconsolidation Stress (tsf)	0.893	**Cc**	0.124	**Cr**	0.017

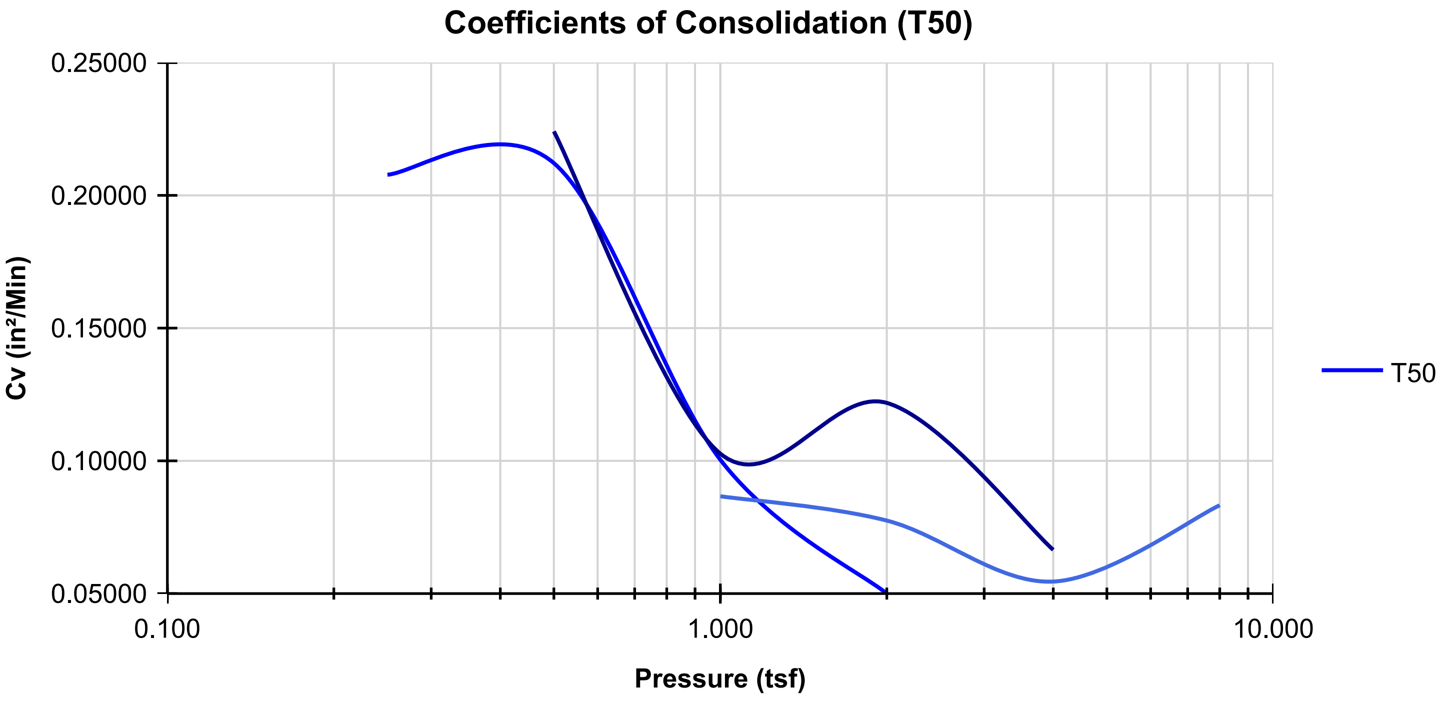
	BEFORE	AFTER			
			Liquid Limits	30	**Test Date** 12/20/2021
Moisture (%)	19.9	20.7	**Plastic Limits**	21	
Dry Density (pcf)	100.5	106.7			
Saturation (%)	81.4	99.9			
Void Ratio	0.65	0.55	**Specific Gravity**	2.65	ASSUMED

Sample Description	Clayey SAND (SC), contains roots & decay pieces of wood in tubes				
Project Number	21-0038 (WRA#45893-001)	**Depth (ft)**	15.5	**Remarks**	PP=2.2 tsf
Sample Number	ST-1	**Boring Number**	B-A3-4		
Project	Opitz Blvd				
Client	Whitman, Requardt & Associates, LLP (WR&A)				
Location	Woodbridge, VA				

Coefficients of Consolidation

ASTM D2435





Consolidation Test - Results

Summary

ASTM D2435

Sample Description	Clayey SAND (SC), contains roots & decay pieces of wood in tubes			
Project Number	21-0038 (WRA#45893-001)	**Depth (ft)**	15.5	**Remarks**
Sample Number	ST-1	**Boring Number**	B-A3-4	
Project	Opitz Blvd			
Client	Whitman, Requardt & Associates, LLP (WR&A)			
Location	Woodbridge, VA			

Index	Loading Sequence (tsf)	Cummulative Change in Height (in)	Specimen Height (in)	Height of Voids (in)	Vertical Strain (%)	Void Ratio	T90 Fitting Time (Hr)	T50 Fitting Time (Hr)	T90 Cv (in²/Min)	T50 Cv (in²/Min)	Sequence Status
0	0.000	0.0000	1.0000	0.0000	0.0	0.647	0.000	0.000	0.00000	0.00000	ENABLED
1	0.250	0.0132	0.9868	0.3784	1.3	0.622	0.016	0.004	0.89438	0.20778	ENABLED
2	0.500	0.0234	0.9766	0.3682	2.3	0.605	0.015	0.004	0.91317	0.21214	ENABLED
3	1.000	0.0365	0.9635	0.3551	3.7	0.584	0.031	0.007	0.43222	0.10041	ENABLED
4	2.000	0.0531	0.9469	0.3385	5.3	0.556	0.059	0.013	0.21528	0.05001	ENABLED
5	1.000	0.0508	0.9492	0.3408	5.1	0.560	0.000	0.000	0.00000	0.00000	ENABLED
6	0.250	0.0464	0.9536	0.3452	4.6	0.567	0.000	0.000	0.00000	0.00000	ENABLED
7	0.500	0.0491	0.9509	0.3425	4.9	0.563	0.013	0.003	0.96466	0.22410	ENABLED
8	1.000	0.0529	0.9471	0.3387	5.3	0.557	0.042	0.006	0.44211	0.10271	ENABLED
9	2.000	0.0580	0.9420	0.3336	5.8	0.548	0.028	0.005	0.52438	0.12182	ENABLED
10	4.000	0.0747	0.9253	0.3169	7.5	0.521	0.051	0.009	0.28608	0.06646	ENABLED
11	1.000	0.0696	0.9304	0.3220	7.0	0.529	0.000	0.000	0.00000	0.00000	ENABLED
12	0.500	0.0673	0.9327	0.3243	6.7	0.533	0.000	0.000	0.00000	0.00000	ENABLED
13	1.000	0.0694	0.9306	0.3222	6.9	0.530	0.041	0.007	0.37304	0.08666	ENABLED
14	2.000	0.0723	0.9277	0.3193	7.2	0.525	0.038	0.008	0.33359	0.07750	ENABLED
15	4.000	0.0778	0.9222	0.3138	7.8	0.516	0.048	0.011	0.23470	0.05452	ENABLED
16	8.000	0.0962	0.9038	0.2954	9.6	0.486	0.028	0.007	0.35842	0.08327	ENABLED

Project Name: Opitz Blvd Project Number: 21-0038 (WRA#45893-001), B-A3-4, ST-1

Technician: B.Aung

Test Date:
12/20/2021

Checked By: OE

Date: 12/23/2021

Consolidation Test - Results

Summary

ASTM D2435

Index	Loading Sequence (tsf)	Cummulative Change in Height (in)	Specimen Height (in)	Height of Voids (in)	Vertical Strain (%)	Void Ratio	T90 Fitting Time (Hr)	T50 Fitting Time (Hr)	T90 Cv (in²/Min)	T50 Cv (in²/Min)	Sequence Status
17	2.000	0.0925	0.9075	0.2991	9.2	0.492	0.000	0.000	0.00000	0.00000	ENABLED
18	0.250	0.0845	0.9155	0.3071	8.4	0.505	0.000	0.000	0.00000	0.00000	ENABLED

Project Name: Opitz Blvd Project Number: 21-0038 (WRA#45893-001), B-A3-4, ST-1

Technician: B.Aung

Test Date:
12/20/2021

Checked By: OE

Date: 12/23/2021

Consolidated Test Results

ASTM D2435

Project:	Opitz Blvd
Project Number:	21-0038 (WRA#45893-001)
Job Number:	
Test Date:	12/20/2021

Sampling Date:	11/30/2021
Sample Number:	ST-1
Depth (ft)	15.5
Boring Number:	B-A3-4
Location:	Woodbridge, VA
Client Name:	Whitman, Requardt & Associates, LLP (WR&A)
Remarks:	

Specific Gravity:	2.65	Plastic Limit:	21	Liquid Limit:	30
Specific Gravity Method:	ASSUMED			Weight of Ring (g)	109.1
Sampling Method:	Undisturbed	Soil Classification:			
Specimen Description:	Clayey SAND (SC), contains roots & decay pieces of wood in tubes				

Parameters	Initial	Final
Height (in)	1.0000	0.9155
Height Source	NA	TEST RESULTS
Diameter (in)	2.5000	NA
Area (in^2)	4.909	NA
Volume (in^3)	4.9087	4.4941
Weight of Container (g)	51.0	78.8
Weight of Wet Soil + Container (g)	204.8	230.6
Weight of Dry Soil + Container (g)	179.3	204.6
Moisture Content (%)	19.9	20.7
Moist Weight + Ring Weight (g)	264.3	261.1
Dry Density (pcf)	100.5	106.7
Wet Density (pcf)	120.4	128.9
Saturation (%)	81.4	99.9
Void Ratio	0.6	0.5

Technician: B.Aung
Test Date: 12/20/2021
Checked By: OE
Date: 12/23/2021

Consolidation Test Results

ASTM D2435

Specimen 1

Test Description: Maximum Loading to 8tsf, unloading cycle at 2 & 4 tsf.
Other Associated Tests:
Device Details: Humboldt IPC5470 (CON-2)
Test Specification:
Test Time: 12/20/2021 12:00:00 AM

Technician: B.Aung
Sampling Method: Undisturbed
Specimen Code:
Specimen Lab #:

Specimen Description: Clayey SAND (SC), contains roots & decay pieces of wood in tubes
Specimen Preparation: Cutting Shoe
Large Particle:

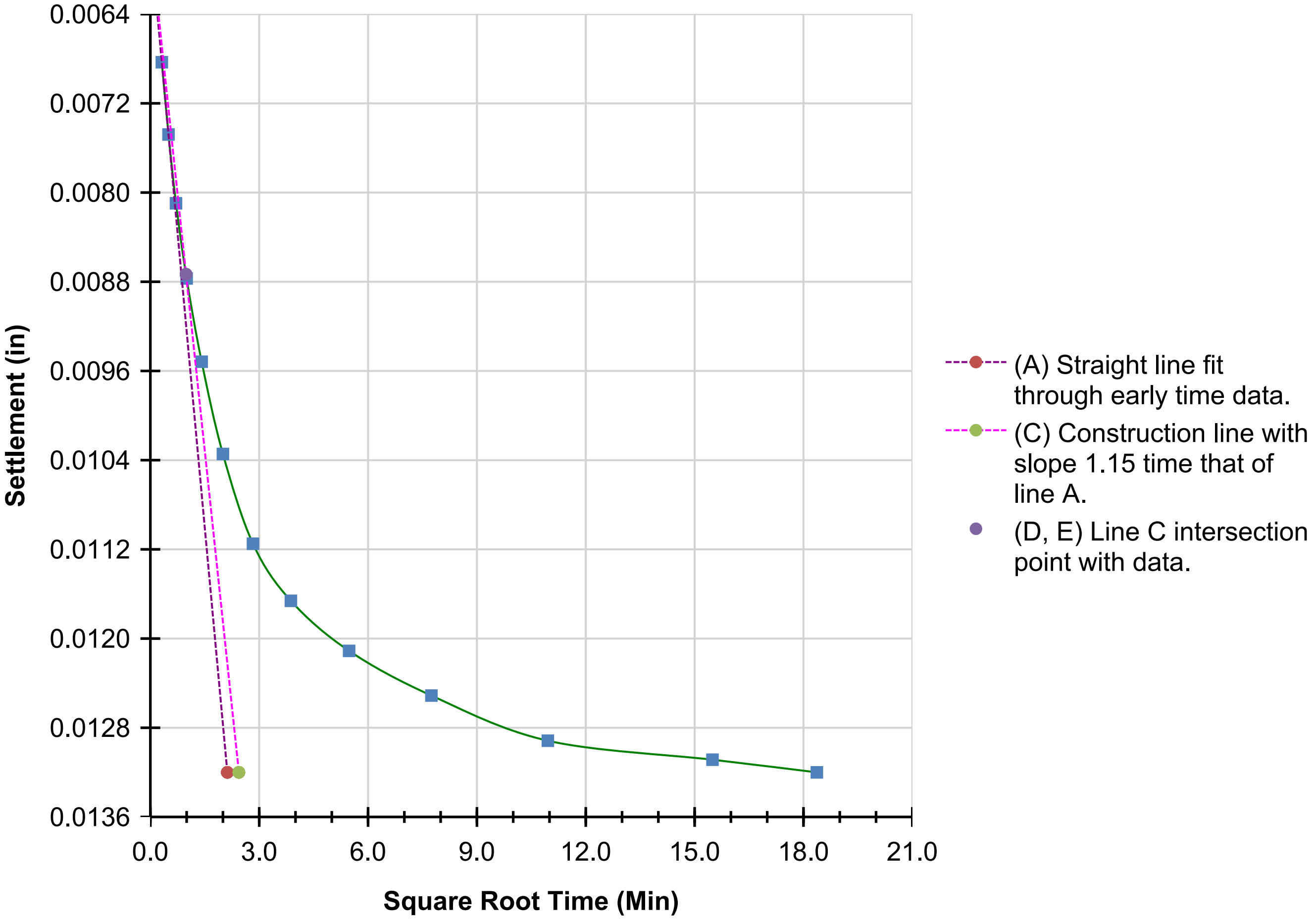
Moisture Content: Inundated
Test Condition: initial seating 0.05TSF
Test Procedure: ASTM D2435
Seating Pressure Used: YES
Seating Pressure (tsf): 0.050

Preconsolidation Stress:

Percent Strain [LOG] Graph (tsf): NA
Final Voids Graph (tsf): 0.893

Square Root Time [1] 0.250 tsf

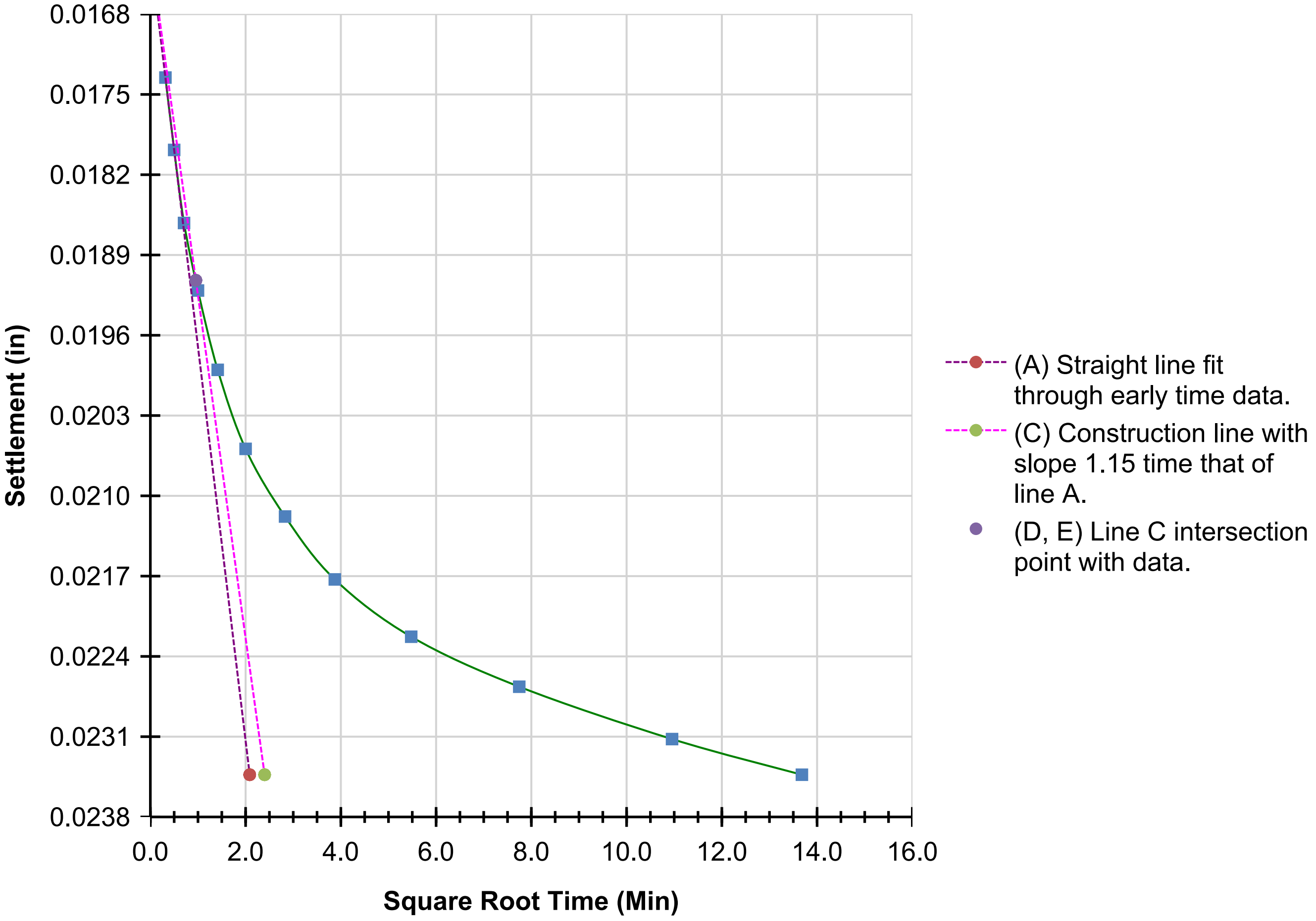
ASTM D2435



Tangent Construction Results	
T90 (Min)	0.967
T50 (Min)	0.227
Cv (in²/Min)	0.8944

Square Root Time [2] 0.500 tsf

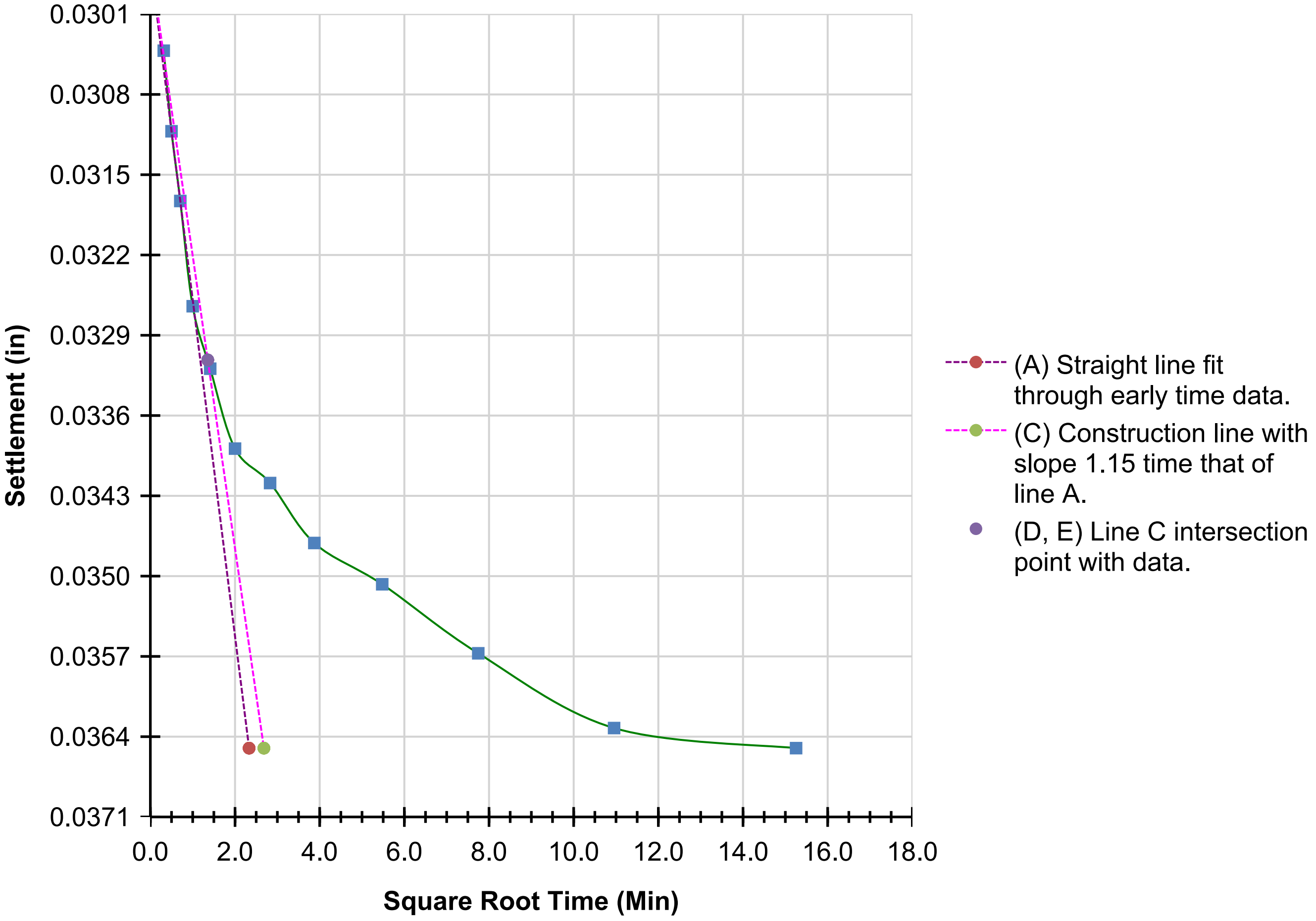
ASTM D2435



Tangent Construction Results	
T90 (Min)	0.913
T50 (Min)	0.213
Cv (in²/Min)	0.9132

Square Root Time [3] 1.000 tsf

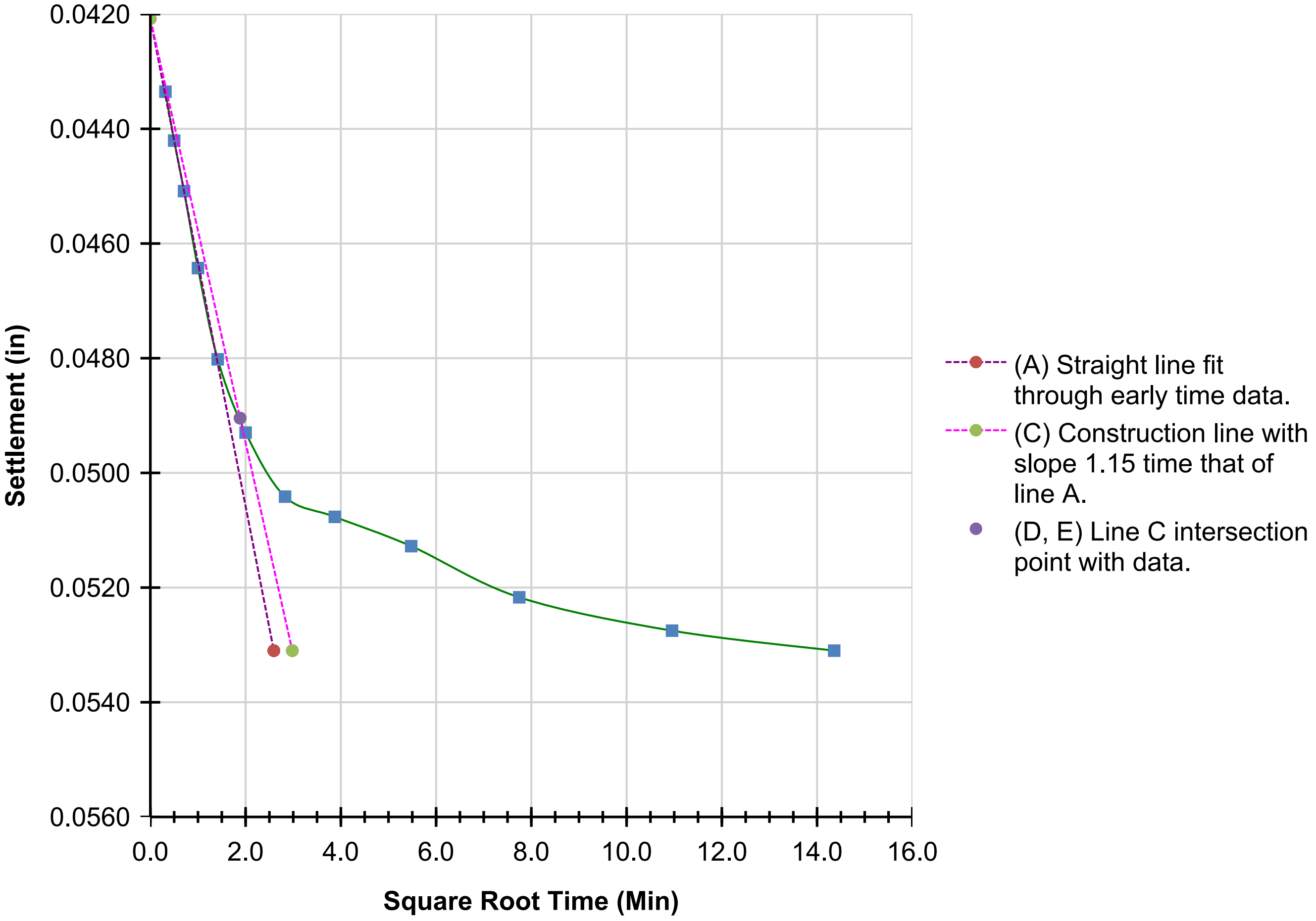
ASTM D2435



Tangent Construction Results	
T90 (Min)	1.839
T50 (Min)	0.426
Cv (in²/Min)	0.4322

Square Root Time [4] 2.000 tsf

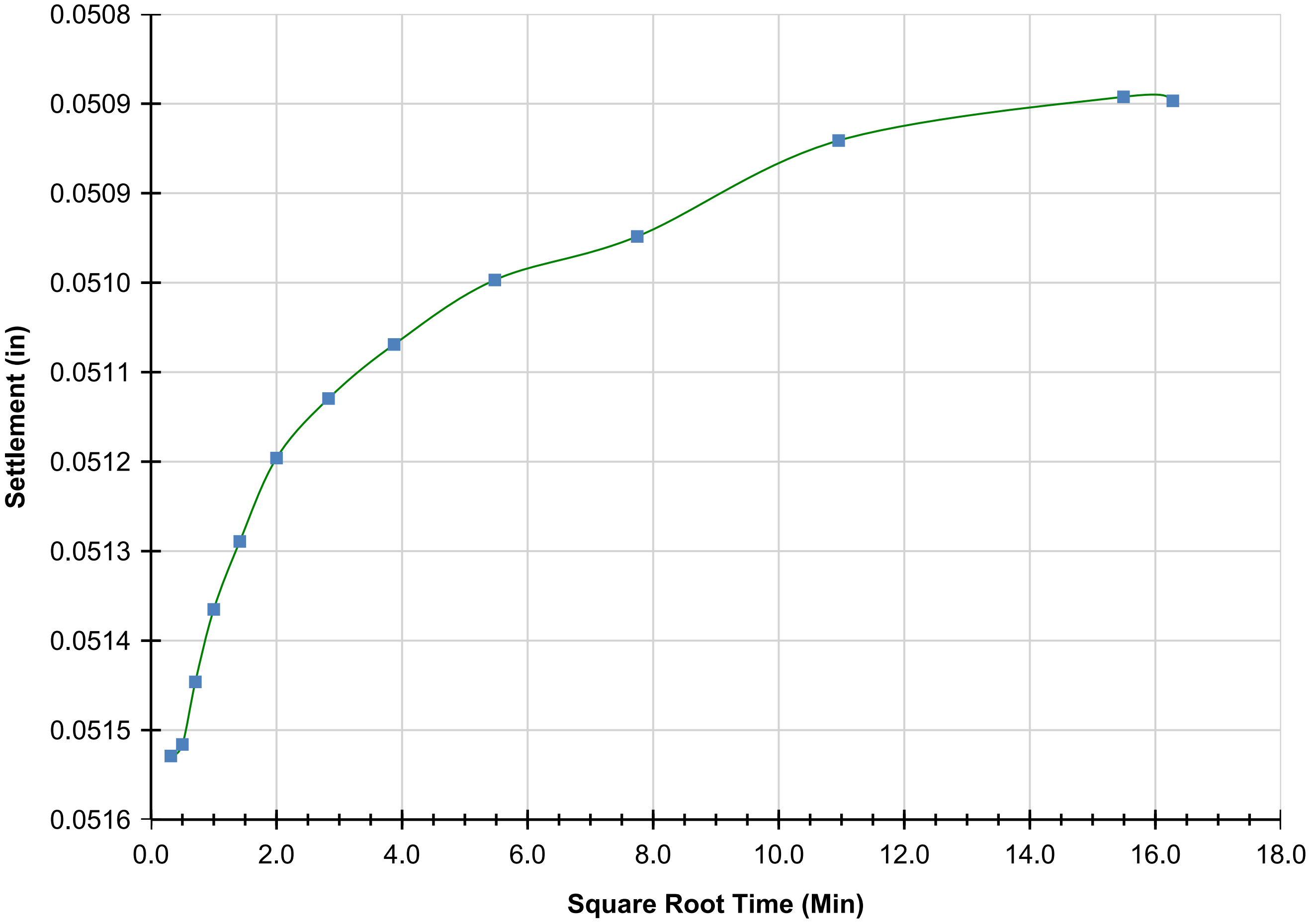
ASTM D2435



Tangent Construction Results	
T90 (Min)	3.550
T50 (Min)	0.799
Cv (in²/Min)	0.2153

Square Root Time [5] 1.000 tsf

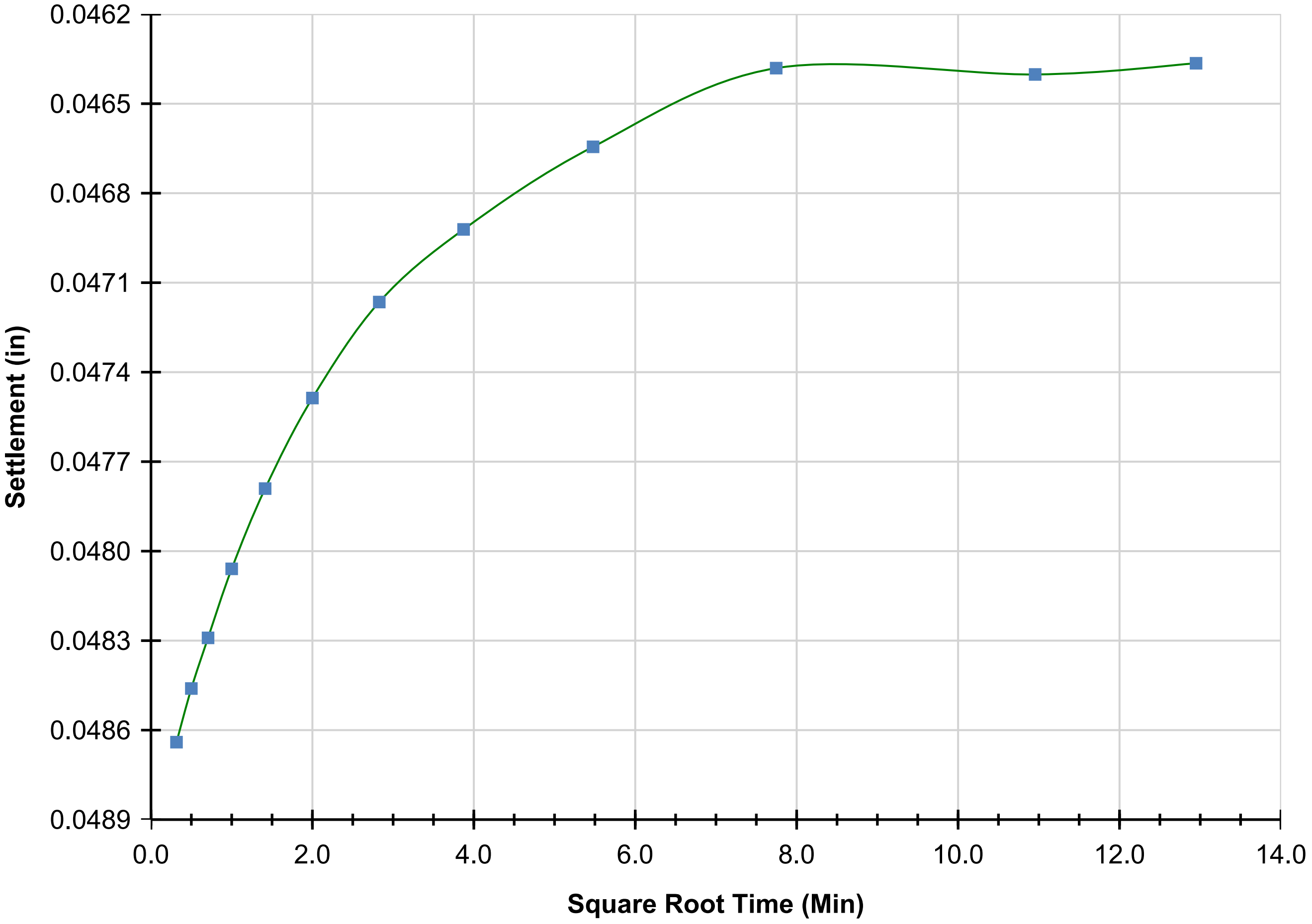
ASTM D2435



Tangent Construction Results	
T90 (Min)	NA
T50 (Min)	NA
Cv (in²/Min)	NA

Square Root Time [6] 0.250 tsf

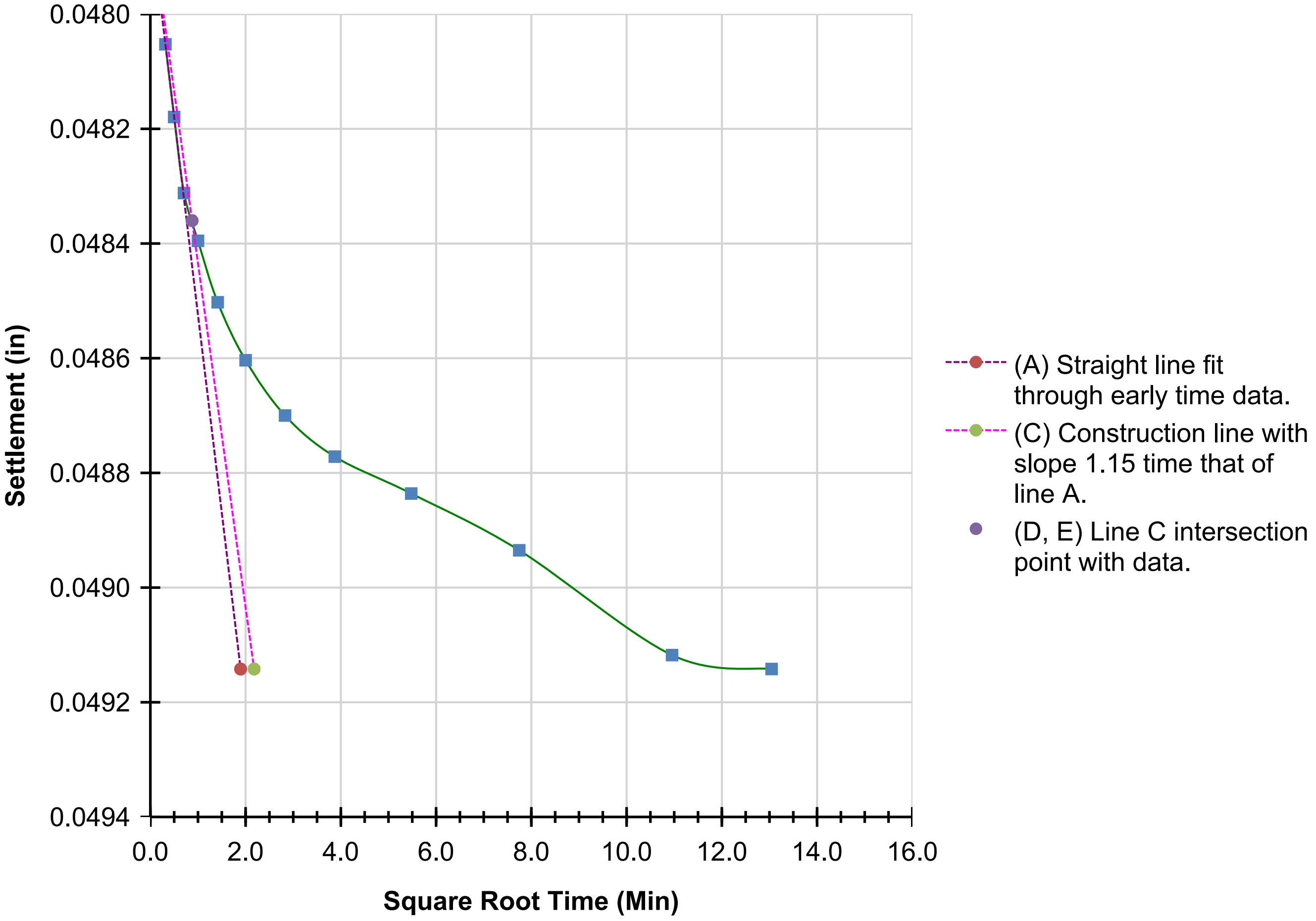
ASTM D2435



Tangent Construction Results	
T90 (Min)	NA
T50 (Min)	NA
Cv (in²/Min)	NA

Square Root Time [7] 0.500 tsf

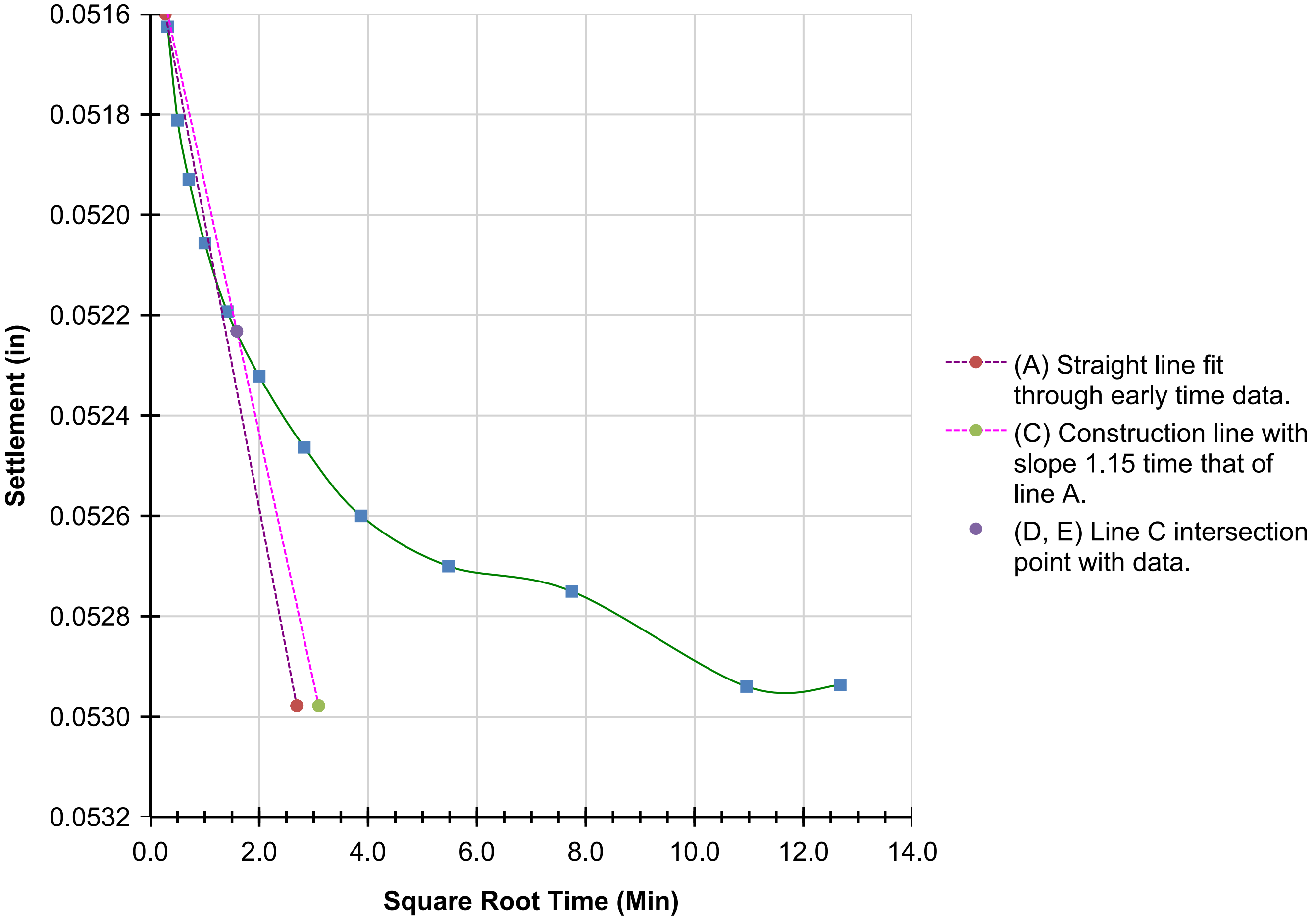
ASTM D2435



Tangent Construction Results	
T90 (Min)	0.767
T50 (Min)	0.179
Cv (in²/Min)	0.9647

Square Root Time [8] 1.000 tsf

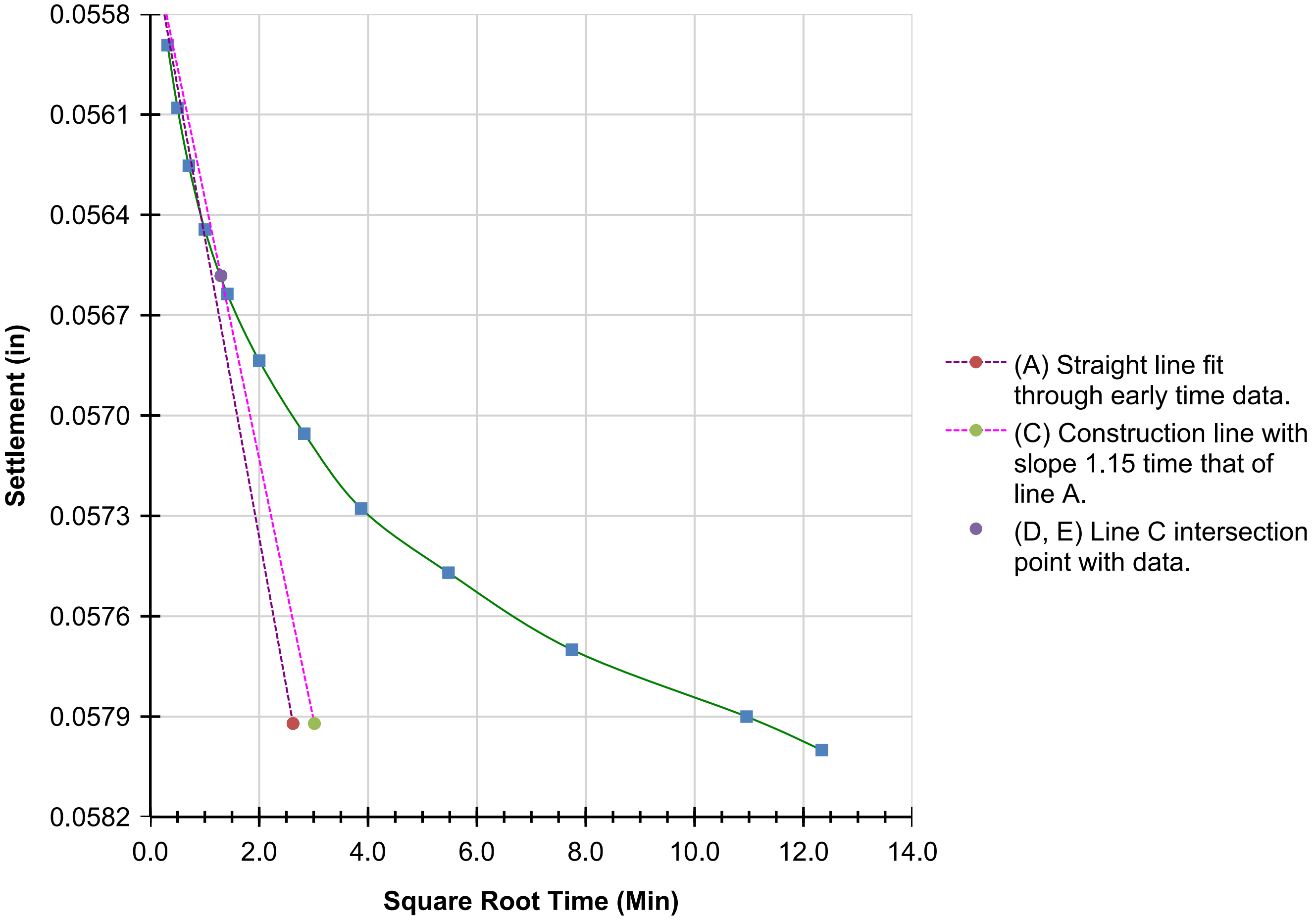
ASTM D2435



Tangent Construction Results	
T90 (Min)	2.525
T50 (Min)	0.384
Cv (in²/Min)	0.4421

Square Root Time [9] 2.000 tsf

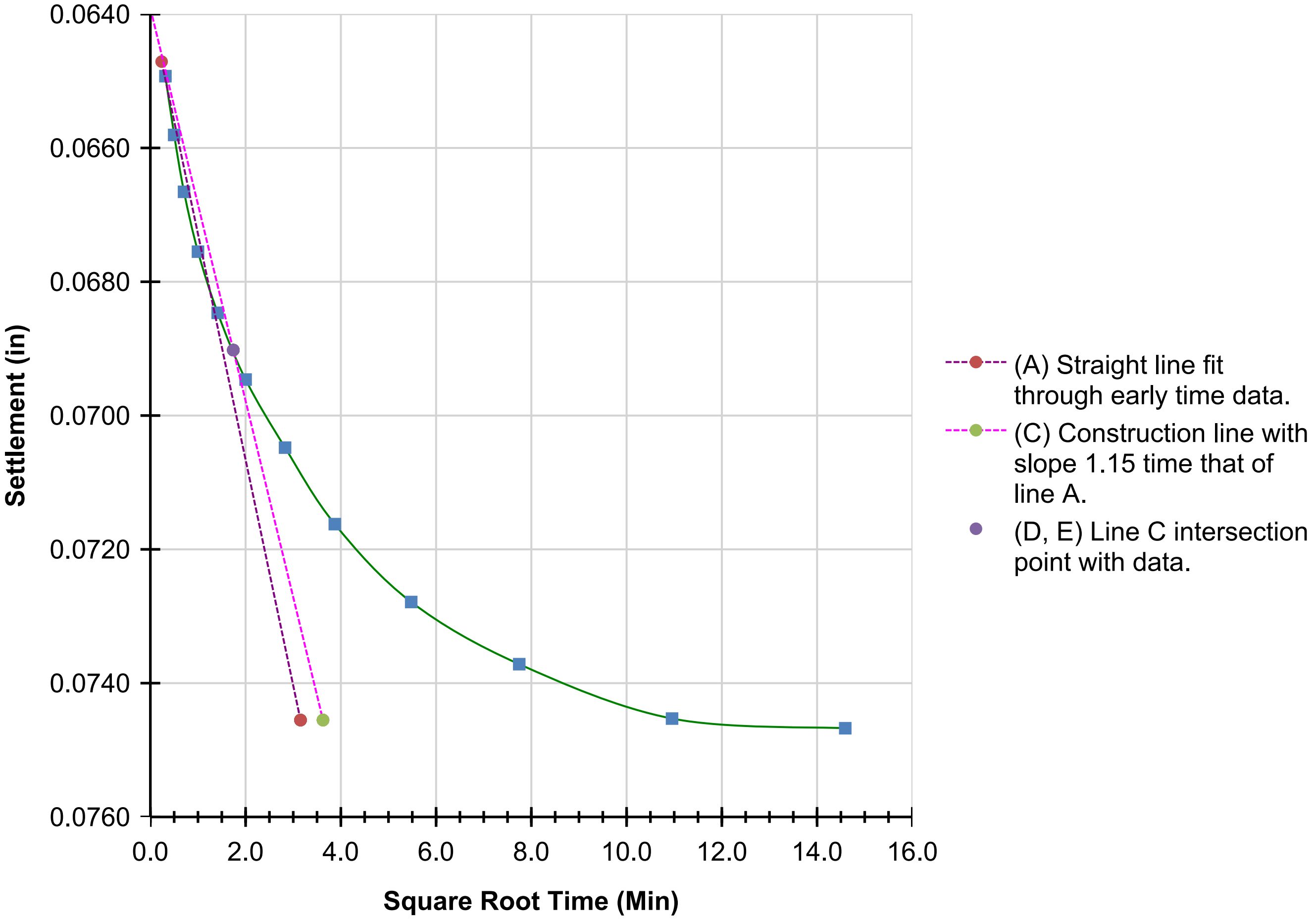
ASTM D2435



Tangent Construction Results	
T90 (Min)	1.684
T50 (Min)	0.317
Cv (in²/Min)	0.5244

Square Root Time [10] 4.000 tsf

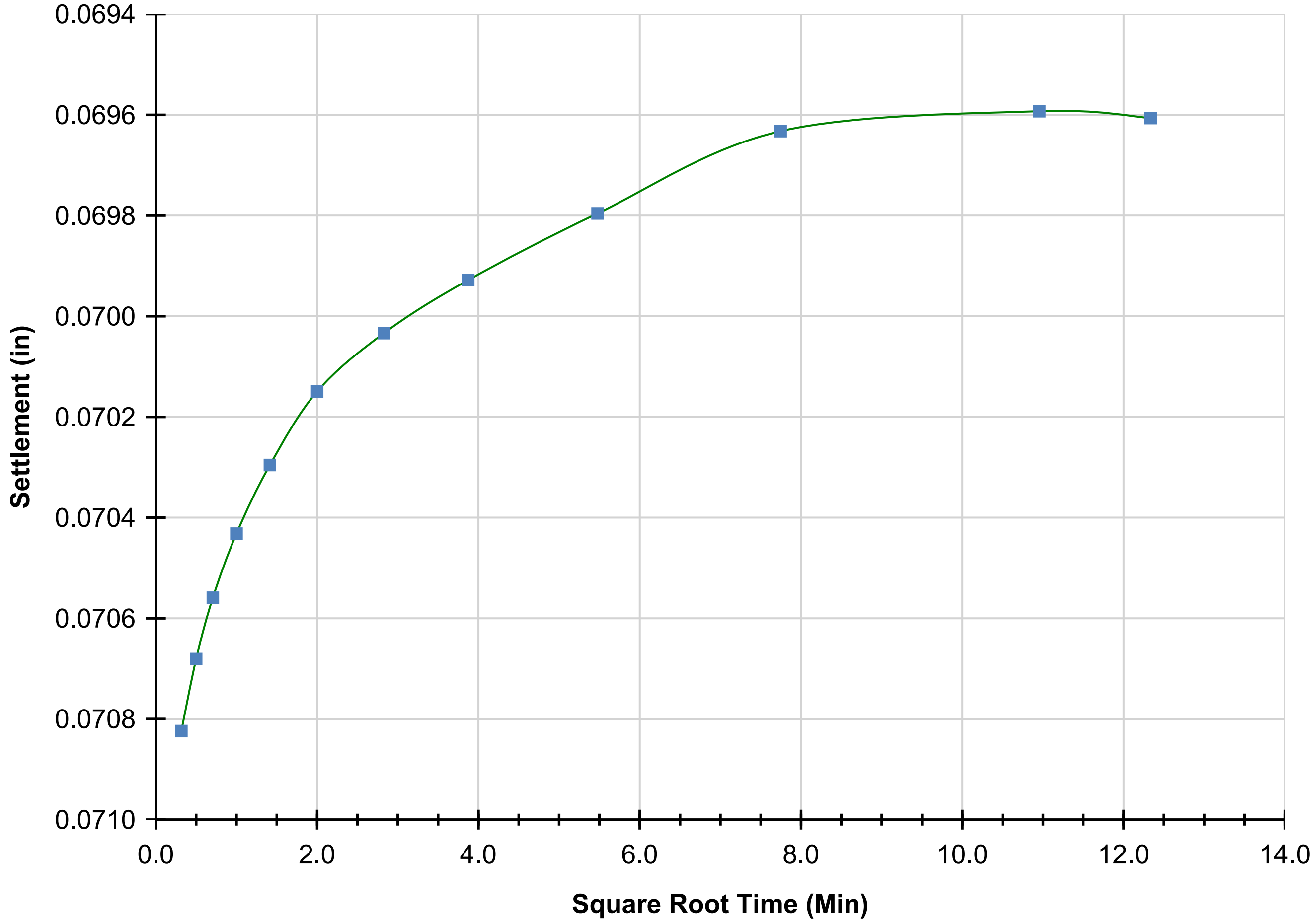
ASTM D2435



Tangent Construction Results	
T90 (Min)	3.032
T50 (Min)	0.546
Cv (in²/Min)	0.2861

Square Root Time [11] 1.000 tsf

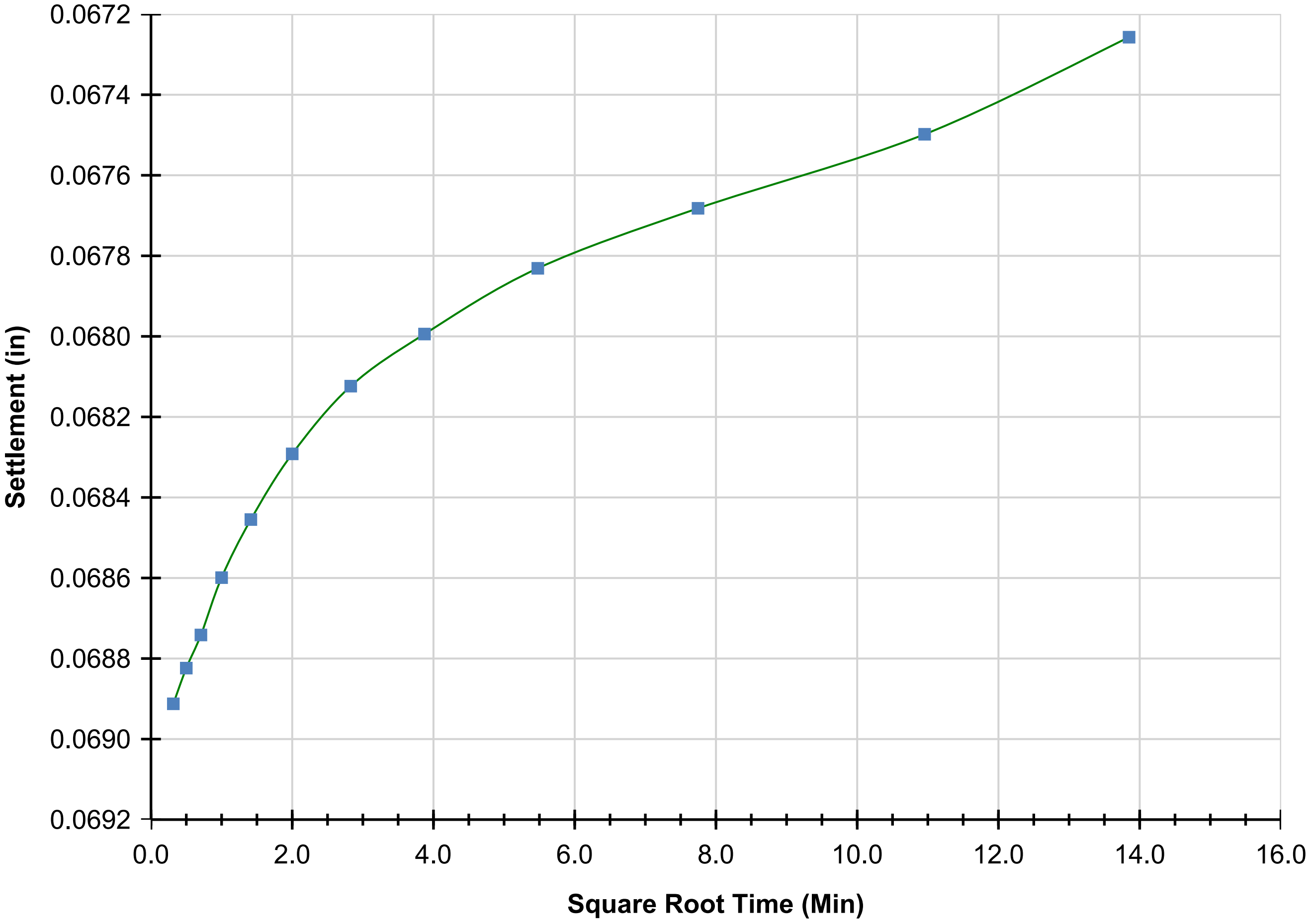
ASTM D2435



Tangent Construction Results	
T90 (Min)	NA
T50 (Min)	NA
Cv (in²/Min)	NA

Square Root Time [12] 0.500 tsf

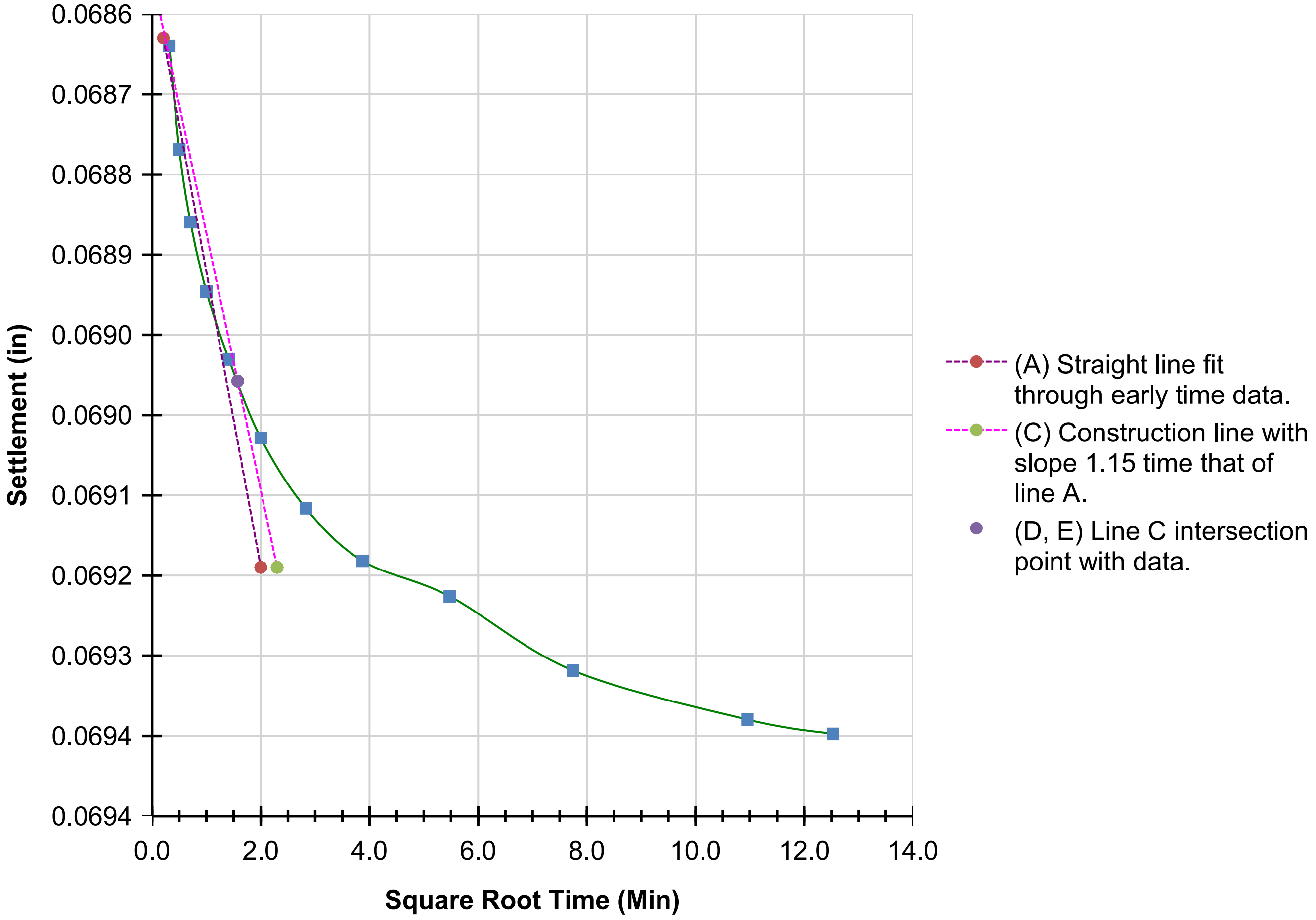
ASTM D2435



Tangent Construction Results	
T90 (Min)	NA
T50 (Min)	NA
Cv (in²/Min)	NA

Square Root Time [13] 1.000 tsf

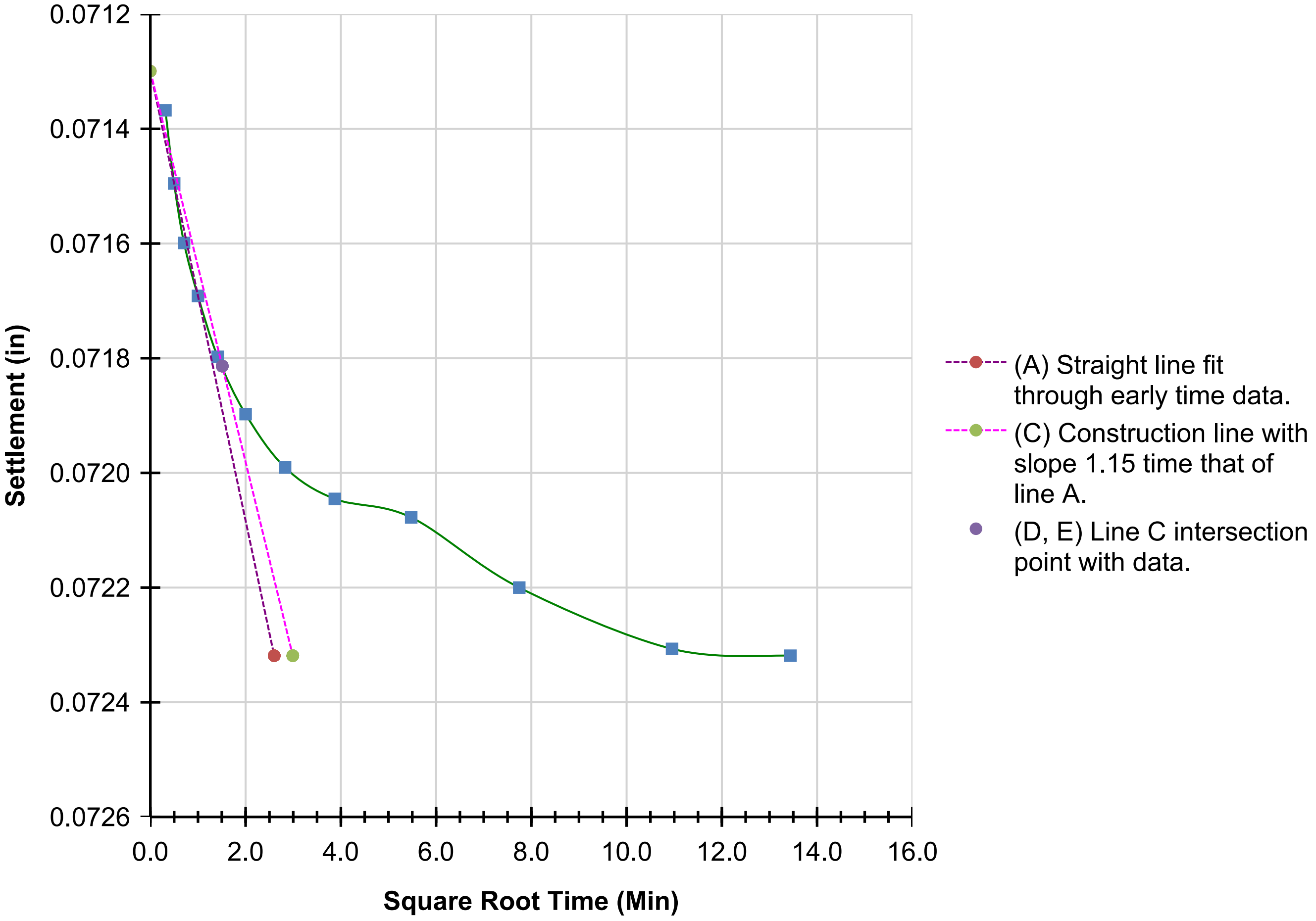
ASTM D2435



Tangent Construction Results	
T90 (Min)	2.479
T50 (Min)	0.422
Cv (in²/Min)	0.3730

Square Root Time [14] 2.000 tsf

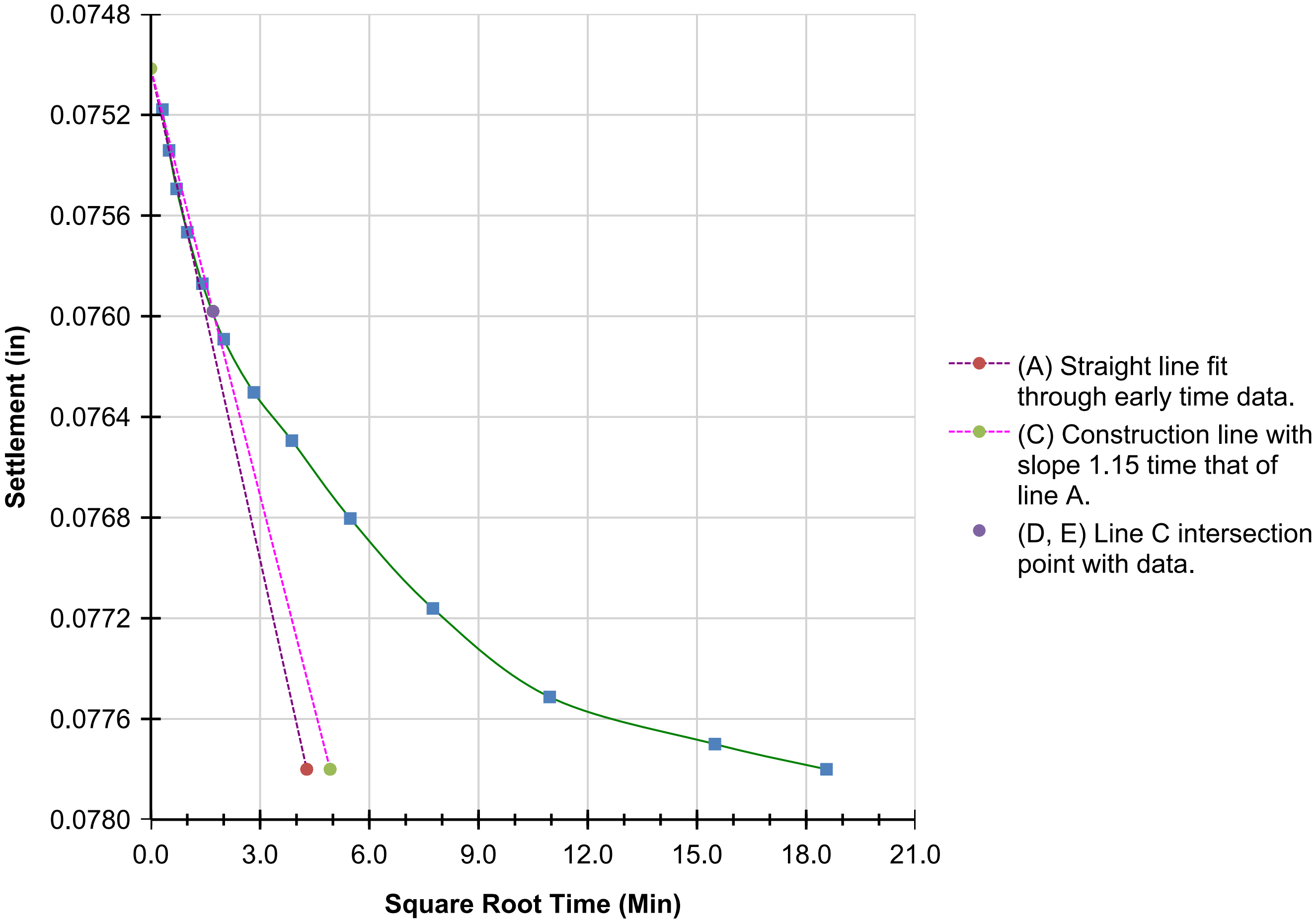
ASTM D2435



Tangent Construction Results	
T90 (Min)	2.277
T50 (Min)	0.466
Cv (in²/Min)	0.3336

Square Root Time [15] 4.000 tsf

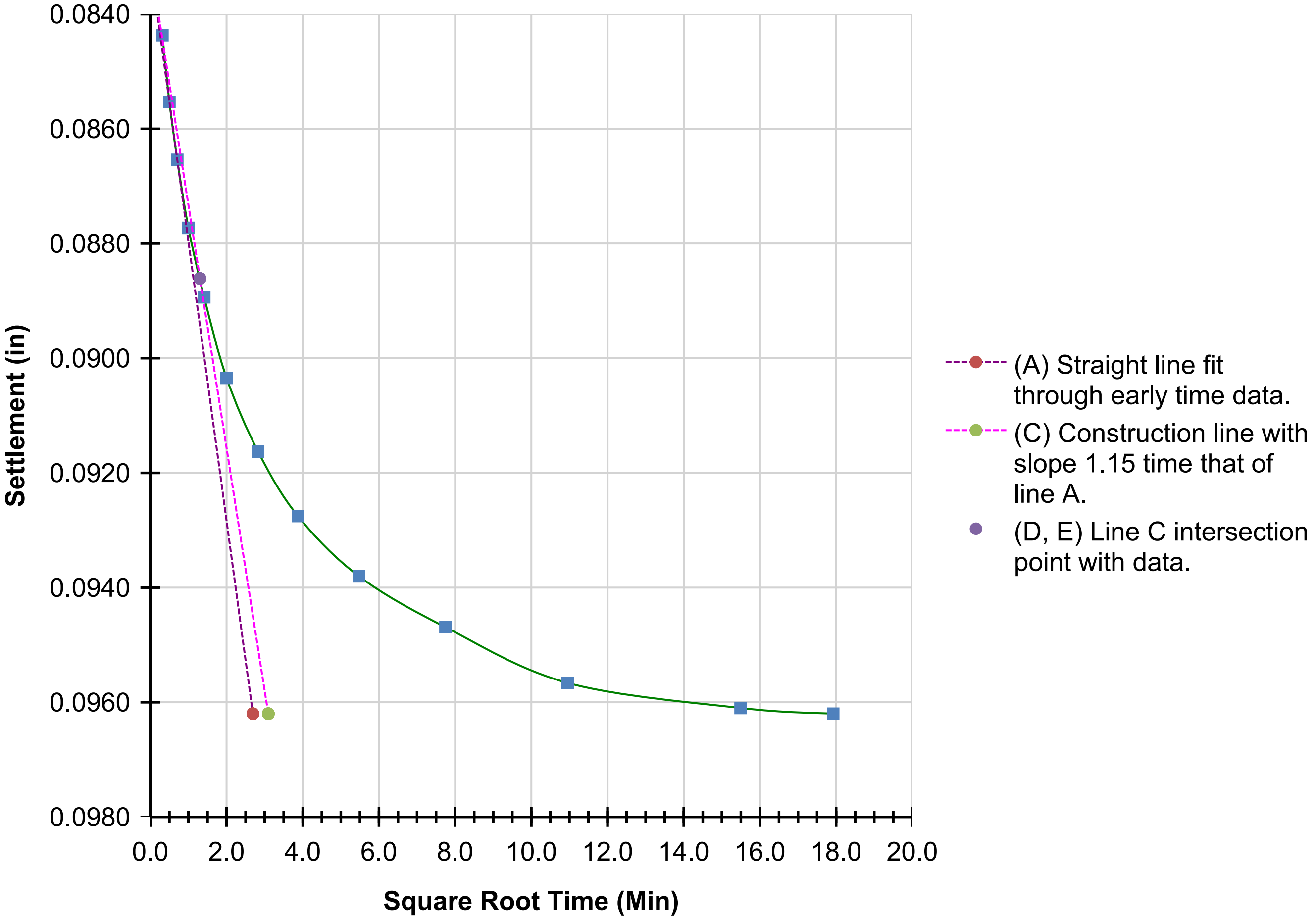
ASTM D2435



Tangent Construction Results	
T90 (Min)	2.909
T50 (Min)	0.647
Cv (in²/Min)	0.2347

Square Root Time [16] 8.000 tsf

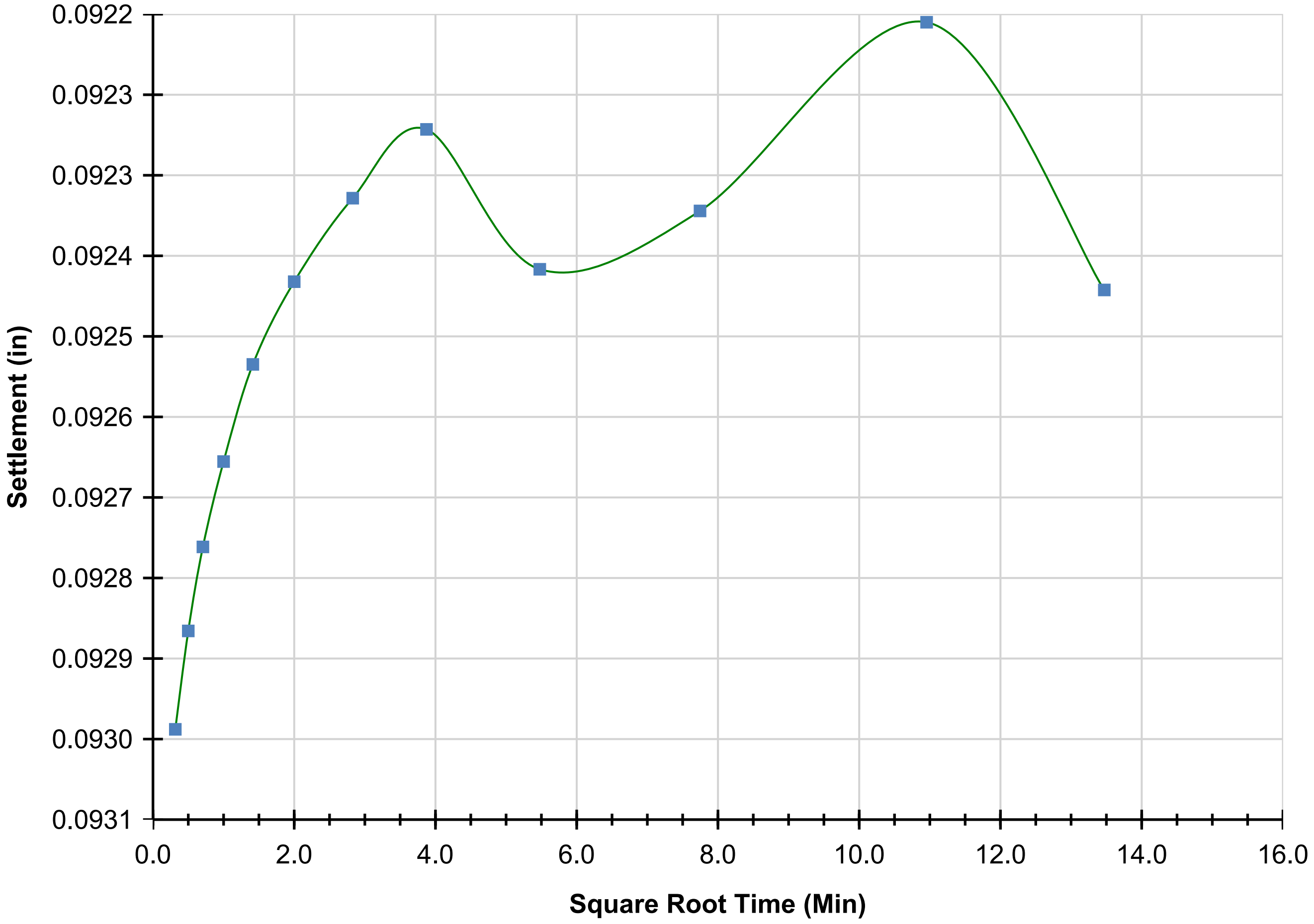
ASTM D2435



Tangent Construction Results	
T90 (Min)	1.695
T50 (Min)	0.395
Cv (in²/Min)	0.3584

Square Root Time [17] 2.000 tsf

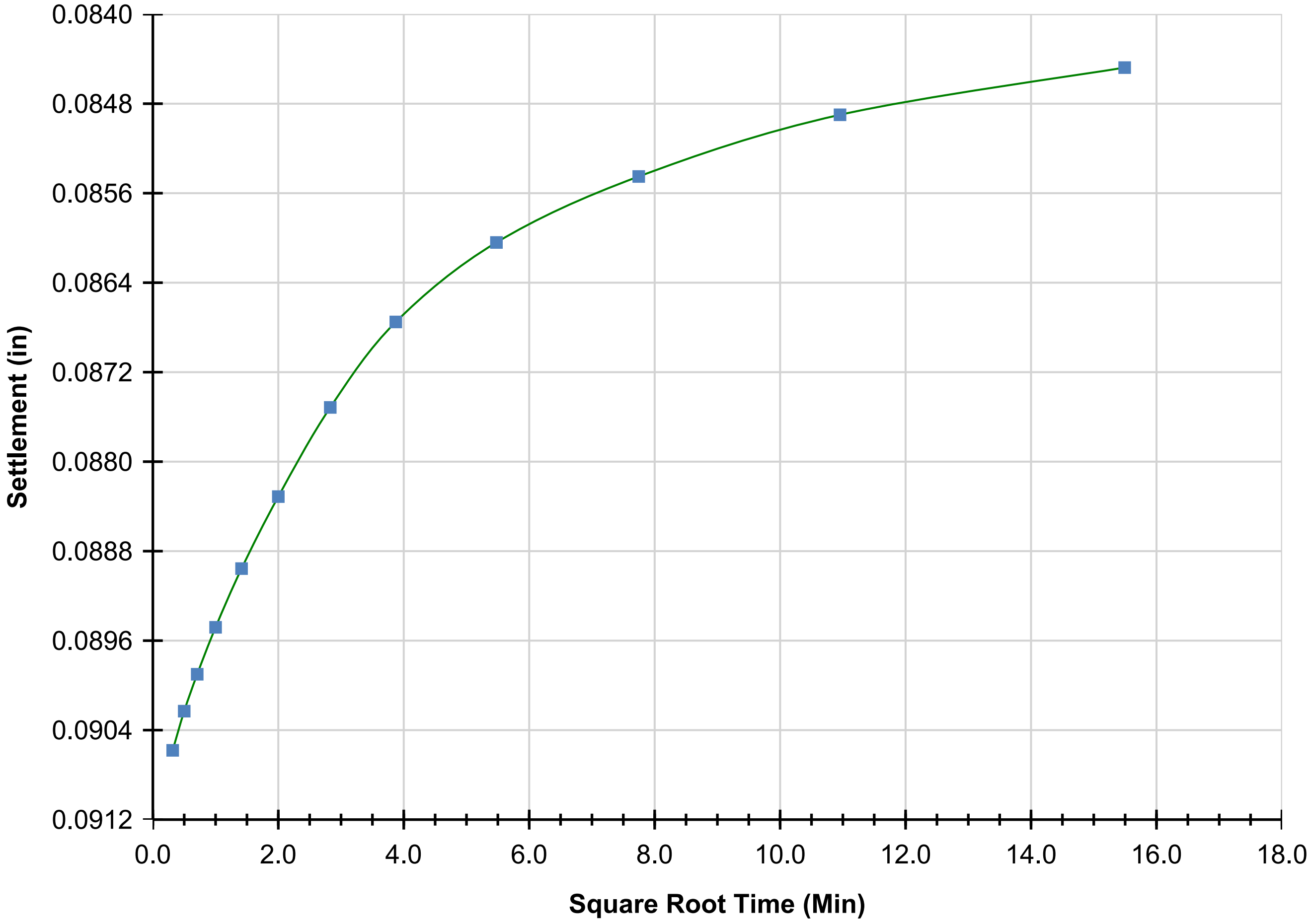
ASTM D2435



Tangent Construction Results	
T90 (Min)	NA
T50 (Min)	NA
Cv (in²/Min)	NA

Square Root Time [18] 0.250 tsf

ASTM D2435



Tangent Construction Results	
T90 (Min)	NA
T50 (Min)	NA
Cv (in²/Min)	NA

APPENDIX E

Calculations

APPENDIX E.1

Seismic Site Classification & Overburden Corrections

WRA	Seismic Site Classification	Method B (Ñ Method)	AASHTO Table 3.10.3.1-1

Struct.:	*Opitz blvd, Woodbridge, VA*	Boring No:	*9*	Sample	Calck	chk	Interpr.
Station:	*Abut. B (Use historic borings)*	Boring Ground EL	*200.0*	Length	skk	SCB 12/21/21	α
Footing Subgr.EL:	*200.0*	No of Samples:	*10*	*10.00 ft*	12/10/21		0.5

Ñ by Boring

Sample No	Depth (ft)	N_i	Layer Top EL (ft)	Layer Bottom. EL (ft)	Layer Depth (ft)	z_i (ft)	d_i (ft)	d_i/N
S-1	*0.0*	*10*	200.0	190.0	10.0	10.0	10.0	1.000
S-2	*10.0*	*15*	190.0	180.0	20.0	20.0	10.0	0.667
S-3	*20.0*	*20*	180.0	170.0	30.0	30.0	10.0	0.500
S-4	*30.0*	*50*	170.0	160.0	40.0	40.0	10.0	0.200
S-5	*40.0*	*50*	160.0	150.0	50.0	50.0	10.0	0.200
S-6	*50.0*	*100*	150.0	140.0	60.0	60.0	10.0	0.100
S-7	*60.0*	*100*	140.0	130.0	70.0	70.0	10.0	0.100
S-8	*70.0*	*100*	130.0	120.0	80.0	80.0	10.0	0.100
S-9	*80.0*	*100*	120.0	110.0	90.0	90.0	10.0	0.100
S-10	*90.0*	*100*	110.0	100.0	100.0	100.0	10.0	0.100

Results

Footing Depth

0.0

No of Layers:

10

Sample Length

10.00 ft

$$\sum_{i=1}^{n} d_i = 100.0$$

$$\sum_{i=1}^{n} \frac{d_i}{N_i} =3.067$$

$$\bar{N} = \frac{\sum_{i=1}^{n} d_i}{\sum_{i=1}^{n} \frac{d_i}{N_i}}$$

Average SPT N

Ñ = 33

Site Class:

D

Ñ by Layer

Layers	Layer Depth	Soil Type	Sample for SPT From	To	Ave. SPT N_i	z_i	d_i	d_i/N

Results

LAYERS 0

Footing Depth (z_0)

0.0

$$\sum_{i=1}^{n} d_i \quad 0$$

$$\sum_{i=1}^{n} \frac{d_i}{N_i} \quad 0.000$$

Ave. SPT

Ñ =

Site Class:

Overburden Correction for
SPT N Values

skk 12/22/21 Ver.7.0

Test Boring : B-A1-6

Sheet 1 of 4

Project:	*I-95 Expressway /Opitz Blvd*		Boring No.	*B-A1-6*	
	Woodbridge, VA		Ground Water Depth:	*58.0*	ft
WRA #	*32175-000*		Hammer Efficiency:	*0.850*	*(assumed)*
Assumed Soil Unit Wt.	Dry	*120.0* pcf	Calc by: *skk*	Date:	*12/22/2021*
	Saturated	*125.0* pcf	Chk by: *scb*	Date:	*12/22/2021*

Efficiency

$N_{60} = N\ (\eta/0.6)$

ASCE - Lio & Whitman (1986)

$$(N_1)_{60} = N_{60} \sqrt{\frac{2000\ psf}{\sigma_z'}}$$

AASHTO

$$N1 = C_N N$$

$$C_N = [0.77 \log_{10}(40/\sigma'_v)],\ \text{and}\ C_N < 2.0$$

Selected Method

AASHTO

Water (pcf) 62.4

Sample No.	Sample Depth		SPT N Value			Soil Type	Unit Wt. (pcf)		Depth	Overburden(psf)		N	N_{60}	$(N_1)_{60}$
	From	To	1st	2nd	3rd		Dry	Sat.	z^i	$D\sigma_z^i$ (psf)	σ_z^i			
S- 1	0.5	-2.0	6	7	5	Sand	120.0	125.0	2.0	240.0	240.0	12	17	29
S- 2	2.5	-4.0	2	3	2	Sand	120.0	125.0	4.0	240.0	480.0	5	7	10
S- 3	6.0	-7.5	0	2	17	Sand	120.0	125.0	7.5	420.0	900.0	19	27	34
S- 4	8.5	-10.0	2	3	4	Sand	120.0	125.0	10.0	300.0	1200.0	7	10	12
S- 5	11.0	-12.5	2	3	4	Sand	120.0	125.0	12.5	300.0	1500.0	7	10	11
S- 6	13.5	-15.0	3	3	3	Sand	120.0	125.0	15.0	300.0	1800.0	6	9	9
S- 7	16.0	-17.5	3	4	4	Sand	120.0	125.0	17.5	300.0	2100.0	8	11	11
S- 8	18.5	-20.0	3	6	4	Sand	120.0	125.0	20.0	300.0	2400.0	10	14	13
S- 9	23.5	-25.0	3	4	3	Sand	120.0	125.0	25.0	600.0	3000.0	7	10	9
S- 10	28.5	-30.0	3	6	8	Sand	120.0	125.0	30.0	600.0	3600.0	14	20	16
S- 11	33.5	-35.0	5	9	8	Sand	120.0	125.0	35.0	600.0	4200.0	17	24	18
S- 12	38.5	-40.0	3	3	4	Sand	120.0	125.0	40.0	600.0	4800.0	7	10	7
S- 13	43.5	-45.0	2	4	8	Sand	120.0	125.0	45.0	600.0	5400.0	12	17	11
S- 14	48.5	-50.0	8	20	19	Sand	120.0	125.0	50.0	600.0	6000.0	39	55	35
S- 15	53.8	-55.3		50	50	Sand	120.0	125.0	55.3	636.0	6636.0	100	142	85
S- 16	58.5	-60.0		50	50	Sand	120.0	125.0	60.0	449.2	7085.2	100	142	82

Internal Friction Angle
for Test Boring Samples skk 12/22/21 Ver.7.0

Test Boring : B-A1-6
Sheet 2 of 4

Project: I-95 Expressway /Opitz Blvd
Woodbridge, VA
WRA # 32175-000
Calc by: skk Date: 12/22/21

Boring No. B-A1-6
Ground Water Depth: 58.0 ft
Hammer Efficiency: 0.850
Chk by: scb Date: 12/22/21

Internal Friction Angle Estimations
Based on Corrected SPT N values

Notes:
Methodology references are provided in sheet 3 of 3

Round-off Digits
0

Sample No.	z^i	$(N_1)_{60}$	Peck, Hanson &Thornburn		Hatanaka & Uchida		Japan SHB	NC-DOT	AASHTO LRFD 2016 Table 10.4.6.5.4-1	
			Kulhawy (1990)	Wolff (1989)	Original (1996)	Mayne (2001)		0.3(N+90)	Min	Max
S-1	2.0	29	36	35	44	41	36	31	30	35
S-2	4.0	10	30	30	34	32	27	29	27	32
S-3	7.5	34	37	37	44	43	38	33	35	40
S-4	10.0	12	31	31	35	34	28	29	30	35
S-5	12.5	11	30	30	35	33	28	29	30	35
S-6	15.0	9	30	30	33	32	27	29	27	32
S-7	17.5	11	30	30	35	33	28	29	30	35
S-8	20.0	13	31	31	36	34	29	30	30	35
S-9	25.0	9	30	30	33	32	27	29	27	32
S-10	30.0	16	32	32	38	36	30	31	30	35
S-11	35.0	18	33	32	39	37	31	32	30	35
S-12	40.0	7	29	29	32	30	25	29	27	32
S-13	45.0	11	30	30	35	33	28	31	30	35
S-14	50.0	35	37	37	44	43	38	39	35	40
S-15	55.3	85	46	49	44	56	45	57	38	43
S-16	60.0	82	45	48	44	56	45	57	38	43

Internal Friction Angle

Results Summary skk 12/22/21 Ver.7.0

Test Boring : B-A1-6

Sheet 3 of 4

Project: I-95 Expressway /Opitz Blvd
Woodbridge, VA
WRA # 32175-000
Calc by: scb Date:

Boring No. 3-A1-6
Ground Water Depth: 58.0 ft
Hammer Efficiency: 0.850
Chk by: Date: 12/22/21

Layer Input

Layer No.	Top Depth (ft)	Soil/Layer Type	SPT Sample No.		Ave $(N_1)_{60}$	Peck, Hanson &Thornburn		Hatanaka & Uchida		Japan SHB	NC-DOT	Range	
			From	To		Kulhawy (1990)	Wolf (1989)	Original (1996)	Mayne (2001)			Min	Max
1	*0*	*Fill*	*1*	*8*	16	32°	32°	38°	36°	30°	32°	30°	38°
2	*20*	*Potomac*	*9*	*11*	14	31°	31°	37°	35°	29°	31°	29°	37°
3	*38*	*Residual*	*12*	*13*	9	30°	30°	33°	32°	27°	30°	27°	33°
4	*48*	*Dr*	*14*	*16*	67	43°	45°	44°	52°	45°	47°	43°	52°

Selected Samples (worksheet)

Layer	1	2	3	4	5	6	7	8	9	10	11	12	Notes
Layer-1	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*					
Layer-2	*9*	*10*	*11*										
Layer-3	*12*	*13*											
Layer-4	*14*	*15*	*16*										

SPT N Values (worksheet)

													N_{Ave}
Layer-1	29	10	34	12	11	9	11	13					16
Layer-2	9	16	18										14
Layer-3	7	11											9
Layer-4	35	85	82										67

Internal Friction Angle

Reference

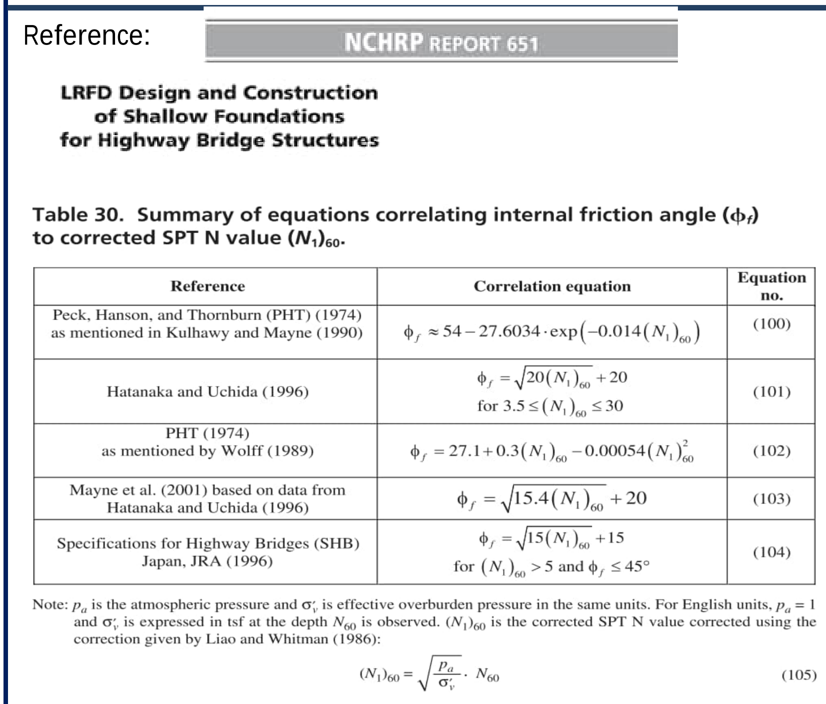
Test Boring : B-A1-6

Sheet 4 of 4

Project: I-95 Expressway /Opitz Blvd
Woodbridge, VA
WRA # 32175-000
Calc by: skk Date: 12/22/2021

Boring No. B-A1-6
Ground Water Depth: 58.0 ft
Hammer Efficiency: 0.850
Chk by: scb Date: 12/22/21

Reference:



NCHRP REPORT 651

LRFD Design and Construction of Shallow Foundations for Highway Bridge Structures

Table 30. Summary of equations correlating internal friction angle (ϕ_f) to corrected SPT N value ($(N_1)_{60}$).

Reference	Correlation equation	Equation no.
Peck, Hanson, and Thornburn (PHT) (1974) as mentioned in Kulhawy and Mayne (1990)	$\phi_f \approx 54 - 27.6034 \cdot \exp\left(-0.014\left(N_1\right)_{60}\right)$	(100)
Hatanaka and Uchida (1996)	$\phi_f = \sqrt{20\left(N_1\right)_{60}} + 20$ for $3.5 \le \left(N_1\right)_{60} \le 30$	(101)
PHT (1974) as mentioned by Wolff (1989)	$\phi_f = 27.1 + 0.3\left(N_1\right)_{60} - 0.00054\left(N_1\right)_{60}^2$	(102)
Mayne et al. (2001) based on data from Hatanaka and Uchida (1996)	$\phi_f = \sqrt{15.4\left(N_1\right)_{60}} + 20$	(103)
Specifications for Highway Bridges (SHB) Japan, JRA (1996)	$\phi_f = \sqrt{15\left(N_1\right)_{60}} + 15$ for $\left(N_1\right)_{60} > 5$ and $\phi_f \le 45°$	(104)

Note: p_a is the atmospheric pressure and σ'_v is effective overburden pressure in the same units. For English units, $p_a = 1$ and σ'_v is expressed in tsf at the depth N_{60} is observed. $(N_1)_{60}$ is the corrected SPT N value corrected using the correction given by Liao and Whitman (1986):

$$(N_1)_{60} = \sqrt{\frac{p_a}{\sigma'_v}} \cdot N_{60} \qquad (105)$$

AASHTO LRFD 2016 Table 10.4.6.5.4-1

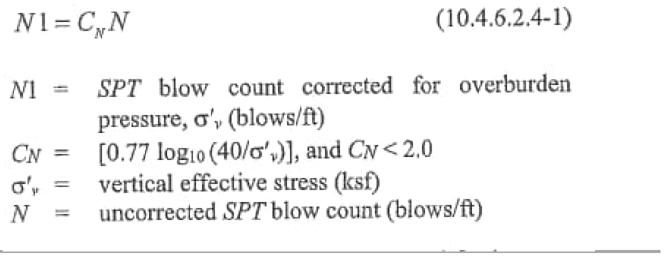
(Description boundaries modified)

$(N_1)_{60}$	Friction Angle		Descrip.
	Min	Max	
1	25	30	Very Loose
4	25	30	
5	27	32	Loose
10	27	32	
11	30	35	Medium
30	30	35	
31	35	40	Dense
50	35	40	
51	38	43	Very Dense
100	38	43	

Overburden Correction References

ASCE Liao and R.V.Whitman, 1986, "Overburden Correction Factors for SPT in Sand" Journal of Geotechnical Engineering, ASCE, v.112:3, p.373-377

AASHTO Equation 10.4.6.2.4-1



$$N1 = C_N N \qquad (10.4.6.2.4\text{-}1)$$

$N1$ = SPT blow count corrected for overburden pressure, σ'_v (blows/ft)
C_N = $[0.77 \log_{10}(40/\sigma'_v)]$, and $C_N < 2.0$
σ'_v = vertical effective stress (ksf)
N = uncorrected SPT blow count (blows/ft)

APPENDIX E.2

MSE Wall Calculations – Wall 1, Wall2, and Wall 3

APPENDIX E.2

MSE Wall Calculations – Wall 1, Wall2, and Wall 3

MSE Wall - External Stability Check

Static Sliding, Eccentricity & Bearing

Ref:FHWA-NHI-10-024 &025

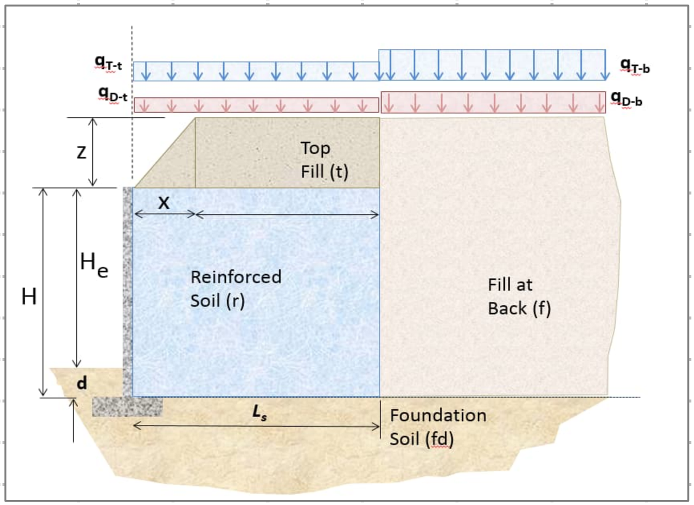
Version: 2016-06
Coding: skk 10/27/2016
Validation: scb by MSE-W 10/31

Project:	Opitz Blve	WRA#:	032023.000	Design:	skk 12/14/2021
Str. No.	Wall-2 @ Abutment C	Wall No.:	Wall 2	Check:	SCB 12/21/21

Assumptions/Notes:

Front of the abutment is modeled as a triangular portion.

Lateral loads behind the wall are assumed to be horizontal (per MSE-W assumption for slope < 45 deg.)



Wall Configuration

Backfill Slope

Broken Back Slope:

Height z (ft.)= 10.00

Length x (ft.)= 6.00

Infinite Backfill: Yes

Infinite Slope β_{inf} = 0.00

Fall face assumed vertical

α= 0.00 deg.

Case	β_{eq}	Δh	h
5	0.00	0.00	30.00

Wall Dimensions

Exposed wall height H_e = 28.00 ft. *Table C.11..10.2.2.-1 Minimum Embedment*

Embedded Height d = 2.00 ft. Minimum Embedment = $H/20$ 1.50 *ok*

Total Wall Length 36.00 ft. <== (for bearing capacity calculations)

Reinforced Backfill	Friction Angle	ϕ_r =	34.0	degree	Unit Wt.	γ_r=	105.0 pcf
Retained Fill (f)	(above and behind reinf. zone)	ϕ_f =	32.0	degree		γ_f=	120.0 pcf
Foundation Soil:		ϕ_{fd} =	32.0	degree		γ_{fd}=	120.0 pcf
Cohesion:	c_{fd} = 0.0 psf	Mayerhof Bearing, q_{ult}=	20.96	ksf			
Top of wall Backfill	Friction Angle	ϕ_t =	34.0	degree	Unit Wt.	γ_t=	105.0 pcf

Surcharge Loading

Traffic @ wall Top	↓	$q_{T\text{-}t}$=	250 psf	Dead -top	↓	$q_{D\text{-}t}$=	0 psf
Traffic @ behind wall	↓	$q_{T\text{-}b}$=	250 psf	Dead -Behind	↓	$q_{D\text{-}b}$=	0 psf
Added horizontal Load	←	$P_{BR\text{-}H}$=	1000 lb/LF				

Design Height and Estimated Reinforcement Length

Estimated Reinforcement Length : L = 23.00 ft. *Check for minimum L*

Design Height of the wall: $H = H_e + d$ H = 30.00 ft. L_{min} = 7.0 ft. *ok*

Ratio for Estimated Reinforcement Length (> 0.7): 0.77 (L/H) *ok* $L \leq 2H$ *ok to use this spreadsheet*

Results Summmary

LRFD:				ASD:		Bearing Resistnace:	
Direct Sliding	CDR=	1.477		$FS_{Sliding}$	2.277	Required Factored Bearing=	6.427 ksf
Bearing Resist.	CDR=	2.120		$FS_{bearing}$	5.061	Required Service Bearing=	4.141 ksf
1.244	e/L =	0.201	Critical	e/L =	0.129	e/L = 0.135	e = 3.11 ft

MSE Wall - External Stability Check

Static Sliding, Eccentricity & Bearing

Ref:FHWA-NHI-10-024 &025

Version: 2016-06
Coding: skk 10/27/2016
Validation: scb by MSE-W 10/31

Project: Opitz Blve
WRA#: 032023.000
Design: skk 12/14/2021
Str. No. Wall-2 @ Abutment C
Check: SCB 12/21/21

Load Factors	EV	EH	ES	LS
Strength I (maximum)	1.35	1.50	1.50	1.75
Strength I (minimum)	1.00	0.90	0.75	0.00
Service I	1.00	1.00	1.00	1.00

Resistance Factors	
Sliding of MSE wall on foundation soil	1.00
Bearing resistance	0.65
Tensile resistance (for steel strips)	0.75

Calculation of β_{eq} and h

L = 23.0 ft. H = 30.0 ft. x = ft. z = ft.

Case	Description		β_{eq}		Δh		L_T	$L_R=L-L_T$
1	For x<z;	$\beta_{eq}=0$		Δh = z		L_T=0		
2	x< L	$\beta_{eq}=\tan^{-1}(z/2H)$		Δh = z		L_T=x		
3	L<x< 2H	$\beta_{eq}=\tan^{-1}(z/2H)$		Δh = Lz/x		L_T=L		
4	x > 2H	$\beta_{eq}=\tan^{-1}(z/x)$		Δh = Lz/x		L_T=L		
5	Infinite	$\beta_{eq}=\beta_{infinite}$	0.00		0.00	L_T=L	0.00	23.00
5	<=Current Case	β_{eq}=	0.00 degree	Δh =	0.00 ft.		0.00	23.00

β_{eq}=

$h = H + \Delta h$ h = 30.00 ft.

Coulomb Active Earth Pressure Coefficient for Retained fill

Reference: Eq. 3.11.5.3-1 AASHTO

$$K_A = \frac{\sin^2(\theta+\phi')}{\sin^2\theta\,\sin(\theta-\delta)\left[1+\sqrt{\dfrac{\sin(\phi+\delta)\,\sin(\phi'-\beta)}{\sin(\theta-\delta)\,\sin(\theta+\beta)}}\right]^2}$$

Note: $\phi' > \beta$ $\phi f'$ = 32.0 degree

β = 0.00 degree

$\theta = 90 + \alpha$ θ = 90.0 degree

$\delta = \beta$ δ = 0.0 degree

T_1= 0.2808 T_2= 1 $\Gamma = [1 + \text{sqrt}(T_1/T_2)]^2$ Γ = 2.3407

T_t= 0.7192 T_b= 1 $K_A = T_t / (T_b * \Gamma)$ K_{af} = 0.307

Rankine Earth Pressure Coefficients

$$K_A = \cos\beta\left[\frac{\cos\beta - \sqrt{\cos^2\beta - \cos^2\phi'}}{\cos\beta + \sqrt{\cos^2\beta - \cos^2\phi'}}\right]$$

Equation 5.12 from FHWA-IF-03-017

(for comparison purposes)

T_{sq}= 0.5299 T_{cos}= 1

$K_A = T_{cos}(T_{cons}-T_{sq})/(T_{cos}+T_{sq})$

K_A = 0.307

Note :

MSE Wall - External Stability Check

Static Sliding, Eccentricity & Bearing

Ref:FHWA-NHI-10-024 &025

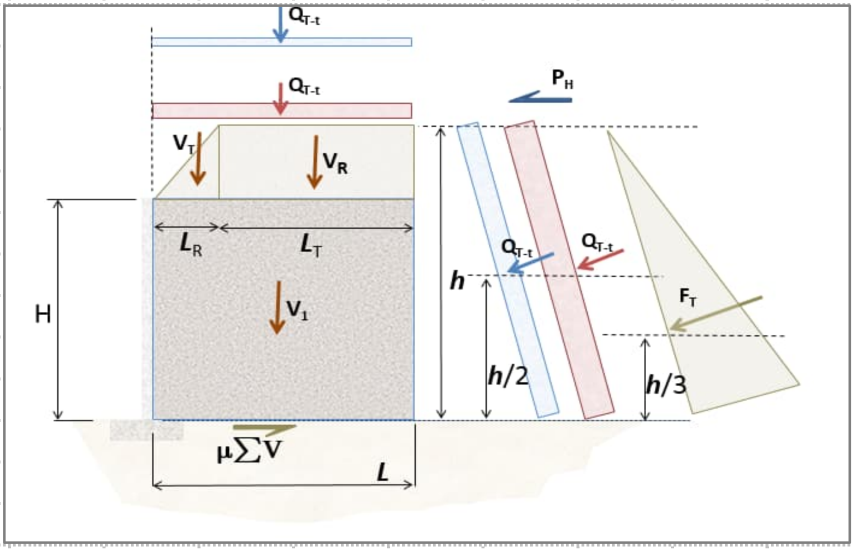
Version: 2016-06
Coding: skk 10/27/2016
Validation: scb by MSE-W 10/31

Project: Opitz Blve
WRA#: 032023.000
Design: skk 12/14/2021
Str. No. Wall-2 @ Abutment C
Check: SCB 12/21/21

Loads and Moments:

Data for Calculations:

L = 23.00 ft.
H = 30.00 ft.
h = 30.00 ft.
L_T = 0.00 ft.
L_R = 23.00 ft.
K_{af} = 0.307
γ_r = 105.0 pcf
γ_f = 120.0 pcf
γ_t = 105.0 pcf
$\boldsymbol{\beta}$ = 0.00 deg.
$q_{D\ top}$ = 0 psf
$q_{D\text{-}b}$ = 0 psf
$q_{T\text{-}top}$ = 250 psf
$q_{T\text{-}beh}$ = 250 psf



p_H = 1000 lb/LF rounding force 2 length 2 2

Un-factored Loads: Horizontal, Vertical & Moment about Point A

								Arm	M
						(kips/LF)	12	(ft.)	(ft. kips)
1	$V_1 = \gamma_r H L$	*Reinforced Mass*	EV	↓	V_1	72.45	$L/2$=	11.50	833.18
2	$V_T = (1/2)\gamma_t (h-H) L_T$	*Top Tringle Mass*	EV	↓	V_T	0.00	$2L_T/3$=	0.00	0.00
3	$V_R = \gamma_t (h-H) L_R$	*Top Rectangle Mass*	EV	↓	V_R	0.00	$L_T+L_R/2$=	11.50	0.00
4	$F_{TV}=(1/2)\gamma_f h^2 K_{af} \sin \boldsymbol{\beta}$ F_T= 16.58	*Earth Pressure*	EH	↓	F_{TV}	0.00	L=	23.00	0.00
5	$F_{TH}=(1/2)\gamma_f h^2 K_{af} \cos \boldsymbol{\beta}$	*Earth Pressure*	EH	←	F_{TH}	16.58	$h/3$=	10.00	165.80
6	$Q_{D\ top\text{-}V}= (q_{D\ top}) L$	*Surch.Dead:Top*	ES-t	↓	$Q_{Dtop\text{-}V}$	0.00	$L/2$=	11.50	0.00
7	$Q_{DV}= (q_D) h K_{af} \sin \boldsymbol{\beta}$	*Surch.Dead:Behind*	ES-b	↓	Q_{DbV}	0.00	L=	23.00	0.00
8	$Q_{DH}= (q_D) h K_{af} \cos \boldsymbol{\beta}$	*Surch.Dead:Behind*	ES-b	←	Q_{DbH}	0.00	$h/2$=	15.00	0.00
9	$Q_{T\ top\text{-}V}= (q_T) L$	*Surch.Traffic:Top*	LS-t	↓	$Q_{T\ top\text{-}V}$	5.75	$L/2$=	11.50	66.13
10	$Q_{TV}= (q_{T\text{-}b}) h K_{af} \sin \boldsymbol{\beta}$	*Surch.Traffic:Behind*	LS-b	↓	Q_{TbV}	0.00	L=	23.00	0.00
11	$Q_{TH}= (q_{T\text{-}b}) h K_{af} \cos \boldsymbol{\beta}+P_{BR}$	*Surch.traffic:Behind*	LS-b	←	Q_{TbH}	3.30	$h/2$=	15.00	49.50

1 2 3 4 5 6 7 8 9 10 11 12 13 14

MSE Wall - External Stability Check

Static Sliding, Eccentricity & Bearing

Ref:FHWA-NHI-10-024 &025

Version: 2016-06
Coding: skk 10/27/2016
Validation: scb by MSE-W 10/31

Project: Opitz Blve
WRA#: 032023.000
Design: skk 12/14/2021
Str. No. Wall-2 @ Abutment C
Check: SCB 12/21/21

	Static Sliding				5		2		3		4	
	5	9	11	8			Strength I(max)		Strength I(Min)		Critical	
	Horizontal Driving Forces				ASD		Max.Load Factor		Min.Load Factor		Crit.Load Factor	
	Horizontal Forces				Factor	Load	Factor	Load	Factor	Load	Factor	Load
5	Earth Pressure	←	16.58	EH	1.0	16.58	1.50	24.87	0.90	14.92	1.50	24.87
8	Surch.Dead:Behind	←	0.00	ES-b	1.0	0.00	1.50	0.00	0.75	0.00	1.50	0.00
11	Surch.traffic:Behind	←	3.30	LS-b	1.0	3.30	1.75	5.78	0.00	0.00	1.75	5.78
	Total Horizontal			$\Sigma H_{driving}$		19.88	---	30.65	---	14.92	---	30.65
	Vertical Loads											
1	Reinforced Mass	↓	72.45	EV	1.0	72.45	1.35	97.81	1.00	72.45	1.00	72.45
2	Top Tringle Mass	↓	0.00	EV	1.0	0.00	1.35	0.00	1.00	0.00	1.00	0.00
3	Top Rectangle Mass	↓	0.00	EV	1.0	0.00	1.35	0.00	1.00	0.00	1.00	0.00
4	Earth Pressure	↓	0.00	EH	1.0	0.00	1.50	0.00	0.90	0.00	1.50	0.00
6	Surch.Dead:Top	↓	0.00	ES-t	1.0	0.00	1.35	0.00	1.00	0.00	1.00	0.00
7	Surch.Dead:Behind	↓	0.00	ES-b	1.0	0.00	1.50	0.00	0.75	0.00	1.50	0.00
9	Surch.Traffic:Top	↓	5.75	LS-t	0.0	0.00	1.75	10.06	0.00	0.00	0.00	0.00
10	Surch.Traffic:Behind	↓	0.00	LS-b	1.0	0.00	1.75	0.00	0.00	0.00	1.75	0.00
	Total Vertical			ΣV		72.45	---	107.87	---	72.45	---	72.45
	Resisting Horizontal Loads for		ϕ_{crit}=	32.00		ASD		Max		Min		Crit.
1	Reinforced Mass	↓				45.27		61.12		45.27		45.27
2	Top Tringle Mass	↓				0.00		0.00		0.00		0.00
3	Top Rectangle Mass	↓				0.00		0.00		0.00		0.00
4	Earth Pressure	↓				0.00		0.00		0.00		0.00
6	Surch.Dead:Top	↓				0.00		0.00		0.00		0.00
7	Surch.Dead:Behind	↓				0.00		0.00		0.00		0.00
9	Surch.Traffic:Top	↓				0.00		6.29		0.00		0.00
10	Surch.Traffic:Behind	↓				0.00		0.00		0.00		0.00
	Cohesion	$C_H = c_{fd} L$				0.00		0.00		0.00		0.00
				ΣV_{resist}		45.27		67.40		45.27		45.27

Results

ASD FS_{SL}= 2.277

LRFD CDR= 1.477

Note: For geogrid reinforced MSE, the sliding friction angle may be taken as minimum of ϕ_{fd} and two thirds of reinforced soil friction angle, (2/3) ϕ_r

ϕ_{fd}= 32.00
Sliding ϕ_r= 34
2/3 ϕ_r= 22.67
ϕ_{crit}= 22.67

Load F	Max	Min	Crit	ASD
EV	1.35	1.00	1.00	1.0
EH	1.50	0.90	1.50	1.0
ES-t	1.35	1.00	1.00	1.0
ES-b	1.50	0.75	1.50	1.0
LS-t	1.75	0.00	0.00	0.0
LS-b	1.75	0.00	1.75	1.0

Sheet 5

MSE Wall - External Stability Check

Static Sliding, Eccentricity & Bearing

Ref:FHWA-NHI-10-024 &025

Version: 2016-06
Coding: skk 10/27/2016
Validation: scb by MSE-W 10/31

Project: Opitz Blve
WRA#: 032023.000
Design: skk 12/14/2021
Str. No. Wall-2 @ Abutment C
Check: SCB 12/21/21

	Eccentricity:				5		2		3		4	
	5	9		8								
					ASD	LRFD	Max.Load Factor	Factored Load	Min.Load Factor	Factored Load	Crit.Load Factor	Factored Load
	Moments: Counter-Clockwis		14		Un-factored							
5	Earth Pressure	←	165.80	EH	1.0	165.80	1.50	248.70	0.90	149.22	1.50	248.70
8	Surch.Dead:Behind	←	0.00	ES-b	1.0	0.00	1.50	0.00	0.75	0.00	1.50	0.00
11	Surch.traffic:Behind	←	49.50	LS-b	1.0	49.50	1.75	86.63	0.00	0.00	1.75	86.63
	Total: Counter-Clockwise Moments			ΣM_-		215.30	---	335.33	---	149.22	---	335.33
	Moments: Clockwise		14									
1	Reinforced Mass	↓	833.18	EV	1.0	833.18	1.35	1124.79	1.00	833.18	1.00	833.18
2	Top Tringle Mass	↓	0.00	EV	1.0	0.00	1.35	0.00	1.00	0.00	1.00	0.00
3	Top Rectangle Mass	↓	0.00	EV	1.0	0.00	1.35	0.00	1.00	0.00	1.00	0.00
4	Earth Pressure	↓	0.00	EH	1.0	0.00	1.50	0.00	0.90	0.00	1.50	0.00
6	Surch.Dead:Top	↓	0.00	ES-t	1.0	0.00	1.35	0.00	1.00	0.00	1.00	0.00
7	Surch.Dead:Behind	↓	0.00	ES-b	1.0	0.00	1.50	0.00	0.75	0.00	1.50	0.00
9	Surch.Traffic:Top	↓	66.13	LS-t	0.0	0.00	1.75	115.73	0.00	0.00	0.00	0.00
10	Surch.Traffic:Behind	↓	0.00	LS-b	1.0	0.00	1.75	0.00	0.00	0.00	1.75	0.00
	Total: Clockwise Moments			ΣM_+		833.18	---	1240.52	---	833.18	---	833.18
	5	9				8						
	Vertical Load		11									
1	Reinforced Mass	↓	72.45	EV	1.0	72.45	1.35	97.81	1.00	72.45	1.00	72.45
2	Top Tringle Mass	↓	0.00	EV	1.0	0.00	1.35	0.00	1.00	0.00	1.00	0.00
3	Top Rectangle Mass	↓	0.00	EV	1.0	0.00	1.35	0.00	1.00	0.00	1.00	0.00
4	Earth Pressure	↓	0.00	EH	1.0	0.00	1.50	0.00	0.90	0.00	1.50	0.00
6	Surch.Dead:Top	↓	0.00	ES-t	1.0	0.00	1.35	0.00	1.00	0.00	1.00	0.00
7	Surch.Dead:Behind	↓	0.00	ES-b	1.0	0.00	1.50	0.00	0.75	0.00	1.50	0.00
9	Surch.Traffic:Top	↓	5.75	LS-t	0.0	0.00	1.75	10.06	0.00	0.00	0.00	0.00
10	Surch.Traffic:Behind	↓	0.00	LS-b	1.0	0.00	1.75	0.00	0.00	0.00	1.75	0.00
	Total Vertical Loads			ΣV		72.45	---	107.87	---	72.45	---	72.45
	Resultant from point A, y			(ft.)		8.53		8.39		9.44		6.87
	Eccentricity: $e = L/2\text{-}y$			(ft.)								

Results:

		$e{=}L/2\text{-}y$	e/L	
ASD		2.97 ft.	0.129	Ok
LRFD	Max	3.11 ft.	0.135	Ok
LRFD	Min	2.06 ft.	0.090	Ok
LRFD	Crit.	4.63 ft.	0.201	Ok

Load F	Max	Min	Crit	ASD
EV	1.35	1.00	1.00	1.0
EH	1.50	0.90	1.50	1.0
ES-t	1.35	1.00	1.00	1.0
ES-b	1.50	0.75	1.50	1.0
LS-t	1.75	0.00	0.00	0.0
LS-b	1.75	0.00	1.75	1.0

MSE Wall - External Stability Check

Static Sliding, Eccentricity & Bearing

Ref:FHWA-NHI-10-024 &025

Version: 2016-06
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Validation: scb by MSE-W 10/31

Project: Opitz Blve
WRA#: 032023.000
Design: skk 12/14/2021
Str. No. Wall-2 @ Abutment C
Check: SCB 12/21/21

Critical Bearing:

					5		2		3		4	
	5		9	14 8	Eccentri	Eccentricity:	e = $L/2$-y		Meyerhof str.		$\sigma_V = \Sigma V/(L-2e)$	
					ASD	LRFD	Max.Load Factor	Factored Load	Min.Load Factor	Factored Load	Crit.Load Factor	Factored Load
	Moments: Counter-Clockwise				Un-factored							
5	Earth Pressure	←	165.80	EH	1.0	165.80	1.50	248.70	0.90	149.22	1.50	248.70
8	Surch.Dead:Behind	←	0.00	ES-b	1.0	0.00	1.50	0.00	0.75	0.00	1.50	0.00
11	Surch.traffic:Behind	←	49.50	LS-b	1.0	49.50	1.75	86.63	0.00	0.00	1.75	86.63
	Total: Counter-Clockwise Moments			ΣM_-		215.30	---	335.33	---	149.22	---	335.33
	5		9	14 8								
	Moments: Clockwise											
1	Reinforced Mass	↓	833.18	EV	1.0	833.18	1.35	1124.79	1.00	833.18	1.35	1124.79
2	Top Tringle Mass	↓	0.00	EV	1.0	0.00	1.35	0.00	1.00	0.00	1.35	0.00
3	Top Rectangle Mass	↓	0.00	EV	1.0	0.00	1.35	0.00	1.00	0.00	1.35	0.00
4	Earth Pressure	↓	0.00	EH	1.0	0.00	1.50	0.00	0.90	0.00	1.50	0.00
6	Surch.Dead:Top	↓	0.00	ES-t	1.0	0.00	1.35	0.00	1.00	0.00	1.50	0.00
7	Surch.Dead:Behind	↓	0.00	ES-b	1.0	0.00	1.50	0.00	0.75	0.00	1.50	0.00
9	Surch.Traffic:Top	↓	66.13	LS-t	1.0	66.13	1.75	115.73	0.00	0.00	1.75	115.73
10	Surch.Traffic:Behind	↓	0.00	LS-b	1.0	0.00	1.75	0.00	0.00	0.00	1.75	0.00
	Total: Clockwise Moments			ΣM_+		899.31	---	1240.52	---	833.18	---	1240.52
	5		9	11 8								
	Vertical Load											
1	Reinforced Mass	↓	72.45	EV	1.0	72.45	1.35	97.81	1.00	72.45	1.35	97.81
2	Top Tringle Mass	↓	0.00	EV	1.0	0.00	1.35	0.00	1.00	0.00	1.35	0.00
3	Top Rectangle Mass	↓	0.00	EV	1.0	0.00	1.35	0.00	1.00	0.00	1.35	0.00
4	Earth Pressure	↓	0.00	EH	1.0	0.00	1.50	0.00	0.90	0.00	1.50	0.00
6	Surch.Dead:Top	↓	0.00	ES-t	1.0	0.00	1.35	0.00	1.00	0.00	1.50	0.00
7	Surch.Dead:Behind	↓	0.00	ES-b	1.0	0.00	1.50	0.00	0.75	0.00	1.50	0.00
9	Surch.Traffic:Top	↓	5.75	LS-t	1.0	5.75	1.75	10.06	0.00	0.00	1.75	10.06
10	Surch.Traffic:Behind	↓	0.00	LS-b	1.00	0.00	1.75	0.00	0.00	0.00	1.75	0.00
	Total Vertical Loads			ΣV		78.20	---	107.87	---	72.45	---	107.87
	Resultant from point A, y (ft.)					8.75		8.39		9.44		8.39
										1.5	1.75	

Results:	ASD	LRFD	LRFD	LRFD
	Ser.	Max	Min	Crit.
ΣV (kips)	78.20	107.87	72.45	107.87
(ft)	8.75	8.39	9.44	8.39
$e = L/2-y$ (ft)	2.75	3.11	2.06	3.11
e/L	0.120	0.135	0.090	0.135
$\sigma_V = \Sigma V/(L-2e)$ (ksf)	4.470	6.427	3.837	6.427

Load F	Max	Min	Crit	ASD
EV	1.35	1.00	1.35	1.0
EH	1.50	0.90	1.50	1.0
ES-t	1.35	1.00	1.50	1.0
ES-b	1.50	0.75	1.50	1.0
LS-t	1.75	0.00	1.75	1.0
LS-b	1.75	0.00	1.75	1.0

1.50	Chosen to match MSE-W approach

MSE Wall - External Stability Check

Static Sliding, Eccentricity & Bearing

Ref:FHWA-NHI-10-024 &025

Version: 2016-06
Coding: skk 10/27/2016
Validation: scb by MSE-W 10/31

Project: Opitz Blve
WRA#: 032023.000
Design: skk 12/14/2021
Str. No. Wall-2 @ Abutment C
Check: SCB 12/21/21

Critical Bearing (ctd):

Foundation Length L_w = 23.0 ft.

Mayerhof Bearing Capacity/Nominal Resistance, q_{ult}= 20.96 ksf

ASD *Values corresponds to un-factored loads & capacities*

Eccentricity	e	2.75	ft.
Vertical Loads, un-factored	ΣV	72.45	kips/LF
Required Allowable Bearing Capacity	σ_V =	4.14	ksf
Ultimate Bearing Capacity	q_{ult}=	20.96	ksf
Factor of Safety against Bearing	$FS_{bearing}$=	5.061	

LRFD *Values corresponds to maximum load factors*

		Serv.	Max	Min	Crit.
Eccentricity	e	2.75	3.11	2.06	3.11
Vertical Loads, un-factored	ΣV	78.20	107.87	72.45	107.87
Required Factored Bearing Stress	σ_V =	4.47	6.43	3.84	6.43
Nominal Bearing Capacity	q_{ult}=	20.96	20.96	20.96	20.96
Resistance factor for Bearing:	Φ_b=	0.5	0.65	0.65	0.65
Factored Bearing Resistance		10.48	13.62	13.62	13.62
	CDR=	2.34	2.12	3.55	2.12

Bearing Resistance: CDR $_{min}$= 2.12

Summary:

LRFD CDR	Target	Calc.	
Sliding	1.00	1.48	ok
Bearing	1.00	2.12	

ASD FS	Target	Calc.
Sliding	2.00	2.28
Bearing	3.00	5.06

Eccentricity	Max	ASD	LRFD
e/L	0.250	0.129	0.201
		ok	*ok*

Bearing Resistance / Capacity

Required Factored Bearing Resistance: 6.43 ksf

Required Allowable Bearing Capacity: 4.14 ksf

Notes: For excentricity and sliding

MSE Wall - External Stability Check

Static Sliding, Eccentricity & Bearing

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Str. No.: Wall-2 @ Abutment C
Check: SCB 12/21/21

EVALUATION OF NOMINAL BEARING RESISTANCE

DATA FROM PREVIOUS SHEETS:

20.96

Soil Parameters

Cohesion c =	0.0	psf	Foundatn Subgr. Soil Unit Wt. γ_{fs}	125.0	pcf
Friction Ang. ϕ_f =	32.0	degree	Surcharge Soil Unit Wt. γ_{sur}	120.0	pcf

Soils above footing bearing are as competent as subgrade soils? Yes

Foundation Dimensions

Footing Width B=	23.00	ft.	Footing Depth D_f =	2.00	ft
Footing Length L=	36.00	ft.	G.Water Depth D_w =	50.00	ft

Foundation Loads:

Unfactored Vert. Load V=	72.5	kips		Load Angle θ	0.0	deg
Unfactored Horz.Load H=	19.9	kips		Moment:	----	
Eccentricity: e_b=	3.0	ft.	*(<5.8) ok*	e_L (ft)=		*(<9.0) ok*

CALCULATION OF BEARING NOMINAL RESISTANCE:

Bearing Capacity Factors :

$N_c=(N_q-1)\cot\phi$ $N_\gamma = 2\,(N_q+1)\tan\phi$ $N_q=e^{(\pi\tan\phi)}\tan^2(45^o+\phi/2)$

N_c = 35.49 N_γ= 30.21 N_q= 23.18

Effective Footing Dimensions: (Area reduction for assumed eccentricity)

$B' = B-2e_b$ = 17.1 ft $L'=L-2e_L$ = 36.0 ft

Footing Shape Correction Factors:

For $\phi = 0$	$S_c = 1+(B'/5L')$	S_γ= 1.0	S_q= 1
For $\phi > 0$	$S_c = 1+(B'/L')\,(N_q/N_c)$	$S_\gamma = 1 - 0.4\,(B'/L')$	$S_q = 1+(B'/L')\tan\phi$
	S_c= 0.963	S_γ= 0.81	S_q= 1.296

Groundwater Correction Factors

C_{wq}= 1.000 $C_{w\gamma}$= 1.000

Depth Correction Factor:

Competent surcharge soils: Yes D_f/B= 0.12 d_q= 1.00

Load Inclination Factors:

i_c = 1.000 i_q = 0.640 i_γ = 0.465

Nominal Bearing Resistance:

$q_n = c\,(N_c\,S_c\,i_c) + \gamma_{sur}\,D_f\,(N_q\,S_q\,d_q\,i_q)\,C_{wq} + 0.5\,\gamma_{fs}\,B\,(N_\gamma\,S_\gamma\,i_\gamma)\,C_{w\gamma}$ ASD FOS 2.0

C term 0.00 q term 4.62 B term 16.34 LRFD Φq 0.65

q_n = *20.96* ksf Allowable q *10.48* ksf Factored q *13.62* ksf

NOTES:

Calc based on assumed foundation length and water table depth.

WRA

MSE Wall - External Stability Check

Static Sliding, Eccentricity & Bearing

Ref:FHWA-NHI-10-024 &025

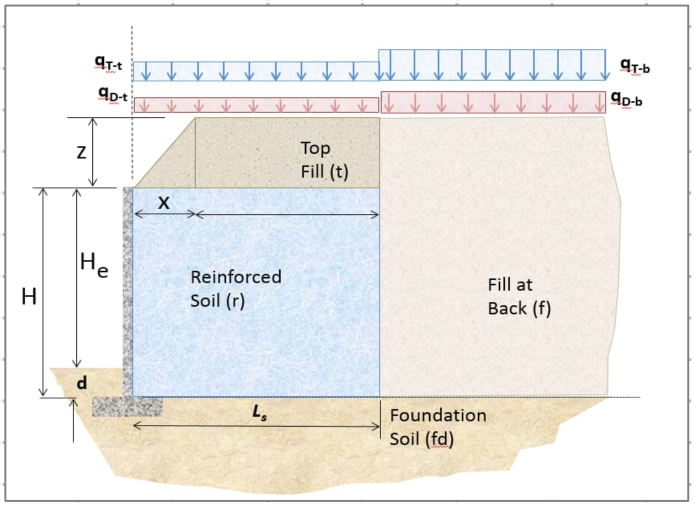
Version: 2016-06
Coding: skk 10/27/2016
Validation: scb by MSE-W 10/31

Project:	Opitz Blve	WRA#:	032023.000	Design:	skk 01/03/2021
Str. No.	Walls 1 & 3 at Abut.C	Wall No.:	Max H=30'	Check:	scb 01/03/2022

Assumptions/Notes:

Front of the abutment is modeled as a triangular portion.

Lateral loads behind the wall are assumed to be horizontal (per MSE-W assumption for slope < 45 deg.)



Wall Configuration

Backfill Slope

Broken Back Slope:

Height z (ft.)= 10.00

Length x (ft.)= 6.00

Infinite Backfill: Yes

Infinite Slope β_{inf} = 0.00

Fall face assumed vertical

α= 0.00 deg.

Case	β_{eq}	Δh	h
5	0.00	0.00	30.00

Wall Dimensions

Exposed wall height H_e = 28.00 ft.

Embedded Height d = 2.00 ft.

Total Wall Length 36.00 ft. <== (for bearing capacity calculations)

Table C.11..10.2.2.-1 Minimum Embedment

Minimum Embedment = $H/20$ 1.50 *ok*

Reinforced Backfill	Friction Angle	ϕ_r =	34.0	degree	Unit Wt.	γ_r=	105.0 pcf
Retained Fill (f)	(above and behind reinf. zone)	ϕ_f =	34.0	degree		γ_f=	105.0 pcf
Foundation Soil:		ϕ_{fd} =	30.0	degree		γ_{fd}=	120.0 pcf
Cohesion:	c_{fd} = 0.0 psf			Mayerhof Bearing, q_{ult}=	16.64 ksf		
Top of wall Backfill	Friction Angle	ϕ_t =	34.0	degree	Unit Wt.	γ_t=	105.0 pcf

Surcharge Loading

Traffic @ wall Top	↓	q_{T-t}=	250 psf	Dead -top	↓	q_{D-t}=	0 psf
Traffic @ behind wall	↓	q_{T-b}=	250 psf	Dead -Behind	↓	q_{D-b}=	0 psf
Added horizontal Load	←	P_{BR-H}=	100 lb/LF				

Design Height and Estimated Reinforcement Length

Estimated Reinforcement Length : L = 21.00 ft. *Check for minimum L*

Design Height of the wall: $H = H_e + d$ H = 30.00 ft. L_{min} = 7.0 ft. *ok*

Ratio for Estimated Reinforcement Length (> 0.7): 0.70 (L/H) *chk* $L \le 2H$ *ok to use this spreadsheet*

Results Summmary

LRFD:			ASD:		Bearing Resistnace:	
Direct Sliding	CDR=	1.595	$FS_{Sliding}$	2.450	Required Factored Bearing=	6.256 ksf
Bearing Resist.	CDR=	1.729	$FS_{bearing}$	4.106	Required Service Bearing=	4.053 ksf
e/L = 0.186	CDR=	1.344 Critical	e/L =	0.120	e =	2.63 ft

MSE Wall - External Stability Check

Static Sliding, Eccentricity & Bearing

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Load Factors	EV	EH	ES	LS
Strength I (maximum)	1.35	1.50	1.50	1.75
Strength I (minimum)	1.00	0.90	0.75	0.00
Service I	1.00	1.00	1.00	1.00

Resistance Factors	
Sliding of MSE wall on foundation soil	1.00
Bearing resistance	0.65
Tensile resistance (for steel strips)	0.75

Calculation of β_{eq} and h

L = 21.0 ft. H = 30.0 ft. x = ft. z = ft.

Case Description			β_{eq}		Δh		L_T	$L_R=L-L_T$
1	For x<z;	$\beta_{eq}=0$		$\Delta h=z$		$L_T=0$		
2	x< L	$\beta_{eq}=\tan^{-1}(z/2H)$		$\Delta h=z$		$L_T=x$		
3	L<x< 2H	$\beta_{eq}=\tan^{-1}(z/2H)$		$\Delta h=Lz/x$		$L_T=L$		
4	x > 2H	$\beta_{eq}=\tan^{-1}(z/x)$		$\Delta h=Lz/x$		$L_T=L$		
5	Infinite	$\beta_{eq}=\beta_{infinite}$	0.00		0.00	$L_T=L$	0.00	21.00
5	<=Current Case	$\beta_{eq}=$	0.00 degree	$\Delta h=$	0.00 ft.		0.00	21.00

$\beta_{eq}=$ $h=H+\Delta h$ h = 30.00 ft.

Coulomb Active Earth Pressure Coefficient for Retained fill

Reference: Eq. 3.11.5.3-1 AASHTO

$$K_A=\frac{\sin^2(\theta+\phi')}{\sin^2\theta\,\sin(\theta-\delta)\left[1+\sqrt{\frac{\sin(\phi+\delta)\,\sin(\phi'-\beta)}{\sin(\theta-\delta)\,\sin(\theta+\beta)}}\right]^2}$$

Note: $\phi'>\beta$ $\phi f'$ = 34.0 degree
β = 0.00 degree
$\theta=90+\alpha$ θ = 90.0 degree
$\delta=\beta$ δ = 0.0 degree

T_1= 0.3127 T_2= 1 $\Gamma=[1+\text{sqrt}(T_1/T_2)]^2$ Γ= 2.4311
T_t= 0.6873 T_b= 1 $K_A=T_t/(T_b*\Gamma)$ K_{af} = 0.283

Rankine Earth Pressure Coefficients

$$K_A=\cos\beta\left[\frac{\cos\beta-\sqrt{\cos^2\beta-\cos^2\phi'}}{\cos\beta+\sqrt{\cos^2\beta-\cos^2\phi'}}\right]$$

Equation 5.12 from FHWA-IF-03-017

(for comparison purposes)

T_{sq} = 0.5592 T_{cos} = 1
$K_A=T_{cos}(T_{cons}-T_{sq})/(T_{cos}+T_{sq})$
K_A = 0.283

Note :

MSE Wall - External Stability Check

Static Sliding, Eccentricity & Bearing

Ref:FHWA-NHI-10-024 &025

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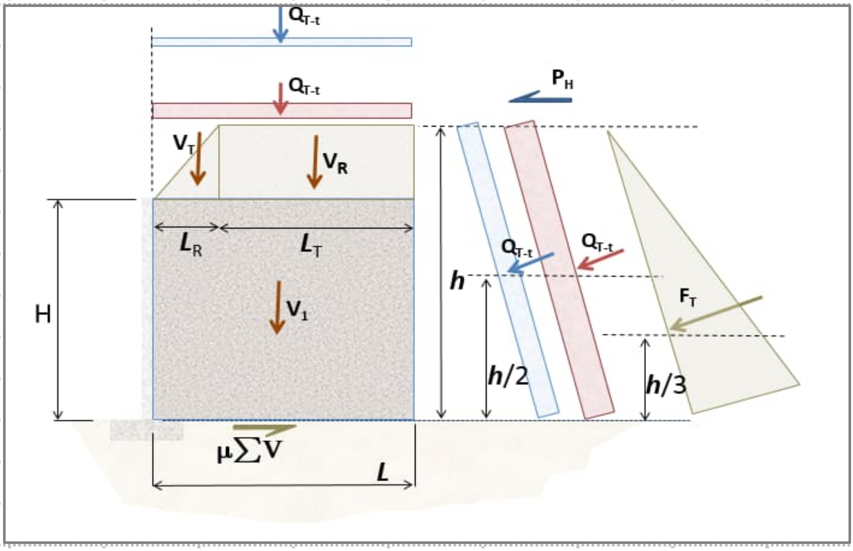
Str. No. Walls 1 & 3 at Abut.C
Check: scb 01/03/2022

Loads and Moments:

Data for Calculations:

L =	21.00	ft.
H =	30.00	ft.
h =	30.00	ft.
L_T=	0.00	ft.
L_R=	21.00	ft.
K_{af} =	0.283	
γ_r=	105.0	pcf
γ_f=	105.0	pcf
γ_t=	105.0	pcf
$\boldsymbol{\beta}$=	0.00	deg.
$q_{D\ top}$=	0	psf
$q_{D\text{-}b}$=	0	psf
$q_{T\text{-}top}$=	250	psf
$q_{T\text{-}beh}$=	250	psf



p_H= 100 lb/LF   rounding   force 2   length 2   2

Un-factored Loads: Horizontal, Vertical & Moment about Point A

										Arm	M
						(kips/LF)		12	(ft.)	(ft. kips)	
1	V_1= $\gamma_r\,H\,L$	Reinforced Mass	EV	↓	V_1	66.15	$L/2$=		10.50	694.58	
2	V_T= (1/2) $\gamma_t\,(h - H)\,L_T$	Top Tringle Mass	EV	↓	V_T	0.00	$2L_T/3$=		0.00	0.00	
3	V_R= $\gamma_t\,(h - H)\,L_R$	Top Rectangle Mass	EV	↓	V_R	0.00	$L_T + L_R/2$=		10.50	0.00	
4	F_{TV}=(1/2) $\gamma_f\,h^2 K_{af}$ sin $\boldsymbol{\beta}$	Earth Pressure	EH	↓	F_{TV}	0.00	L =		21.00	0.00	
	F_T= 13.37										
5	F_{TH}=(1/2) $\gamma_f\,h^2 K_{af}$ cos $\boldsymbol{\beta}$	Earth Pressure	EH	←	F_{TH}	13.37	$h/3$=		10.00	133.70	
6	$Q_{D\ top\text{-}V}$= ($q_{D\ top}$) L	Surch.Dead:Top	ES-t	↓	$Q_{Dtop\text{-}V}$	0.00	$L/2$=		10.50	0.00	
7	Q_{DV}= (q_D) $h\,K_{af}$ sin $\boldsymbol{\beta}$	Surch.Dead:Behind	ES-b	↓	Q_{DbV}	0.00	L =		21.00	0.00	
8	Q_{DH}= (q_D) $h\,K_{af}$ cos $\boldsymbol{\beta}$	Surch.Dead:Behind	ES-b	←	Q_{DbH}	0.00	$h/2$=		15.00	0.00	
9	$Q_{T\ top\text{-}V}$= (q_T) L	Surch.Traffic:Top	LS-t	↓	$Q_{T\ top\text{-}V}$	5.25	$L/2$=		10.50	55.13	
10	Q_{TV}= ($q_{T\text{-}b}$) $h\,K_{af}$ sin $\boldsymbol{\beta}$	Surch.Traffic:Behind	LS-b	↓	Q_{TbV}	0.00	L =		21.00	0.00	
11	Q_{TH}= ($q_{T\text{-}b}$) $h\,K_{af}$ cos $\boldsymbol{\beta}$+P_{BR}	Surch.traffic:Behind	LS-b	←	Q_{TbH}	2.22	$h/2$=		15.00	33.30	

1 2 3 4 5 6 7 8 9 10 11 12 13 14

MSE Wall - External Stability Check

Static Sliding, Eccentricity & Bearing

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	Static Sliding				5		2		3		4	
	5	9	11	8			Strength I(max)		Strength I(Min)		Critical	
	Horizontal Driving Forces				ASD		Max.Load Factor		Min.Load Factor		Crit.Load Factor	
	Horizontal Forces				Factor	Load	Factor	Load	Factor	Load	Factor	Load
5	Earth Pressure	←	13.37	EH	1.0	13.37	1.50	20.06	0.90	12.03	1.50	20.06
8	Surch.Dead:Behind	←	0.00	ES-b	1.0	0.00	1.50	0.00	0.75	0.00	1.50	0.00
11	Surch.traffic:Behind	←	2.22	LS-b	1.0	2.22	1.75	3.89	0.00	0.00	1.75	3.89
	Total Horizontal			$\Sigma H_{driving}$		15.59	---	23.94	---	12.03	---	23.94
	Vertical Loads											
1	Reinforced Mass	↓	66.15	EV	1.0	66.15	1.35	89.30	1.00	66.15	1.00	66.15
2	Top Tringle Mass	↓	0.00	EV	1.0	0.00	1.35	0.00	1.00	0.00	1.00	0.00
3	Top Rectangle Mass	↓	0.00	EV	1.0	0.00	1.35	0.00	1.00	0.00	1.00	0.00
4	Earth Pressure	↓	0.00	EH	1.0	0.00	1.50	0.00	0.90	0.00	1.50	0.00
6	Surch.Dead:Top	↓	0.00	ES-t	1.0	0.00	1.35	0.00	1.00	0.00	1.00	0.00
7	Surch.Dead:Behind	↓	0.00	ES-b	1.0	0.00	1.50	0.00	0.75	0.00	1.50	0.00
9	Surch.Traffic:Top	↓	5.25	LS-t	0.0	0.00	1.75	9.19	0.00	0.00	0.00	0.00
10	Surch.Traffic:Behind	↓	0.00	LS-b	1.0	0.00	1.75	0.00	0.00	0.00	1.75	0.00
	Total Vertical			ΣV		66.15	---	98.49	---	66.15	---	66.15
	Resisting Horizontal Loads for		Φ_{crit}=	30.00		ASD		Max		Min		Crit.
1	Reinforced Mass	↓				38.19		51.56		38.19		38.19
2	Top Tringle Mass	↓				0.00		0.00		0.00		0.00
3	Top Rectangle Mass	↓				0.00		0.00		0.00		0.00
4	Earth Pressure	↓				0.00		0.00		0.00		0.00
6	Surch.Dead:Top	↓				0.00		0.00		0.00		0.00
7	Surch.Dead:Behind	↓				0.00		0.00		0.00		0.00
9	Surch.Traffic:Top	↓				0.00		5.30		0.00		0.00
10	Surch.Traffic:Behind	↓				0.00		0.00		0.00		0.00
	Cohesion	$C_H = c_{fd} L$				0.00		0.00		0.00		0.00
				ΣV_{resist}		38.19		56.86		38.19		38.19

Results

ASD FS_{SL}= 2.450

LRFD CDR= 1.595

Note: For geogrid reinforced MSE, the sliding friction angle may be taken as minimum of ϕ_{fd} and two thirds of reinforced soil friction angle, (2/3) ϕ_r

Φ_{fd}= 30.00

Sliding Φ_r= 34

2/3 Φ_r= 22.67

Φ_{crit}= 22.67

Load F	Max	Min	Crit	ASD
EV	1.35	1.00	1.00	1.0
EH	1.50	0.90	1.50	1.0
ES-t	1.35	1.00	1.00	1.0
ES-b	1.50	0.75	1.50	1.0
LS-t	1.75	0.00	0.00	0.0
LS-b	1.75	0.00	1.75	1.0

MSE Wall - External Stability Check

Static Sliding, Eccentricity & Bearing

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Project: Opitz Blve
WRA#: 032023.000
Design: skk 01/03/2021
Str. No. Walls 1 & 3 at Abut.C
Check: scb 01/03/2022

	Eccentricity:				5		2		3		4	
	5	9		8								
					ASD	LRFD	Max.Load Factor	Factored Load	Min.Load Factor	Factored Load	Crit.Load Factor	Factored Load
	Moments: Counter-Clockwis		14		Un-factored							
5	Earth Pressure	←	133.70	EH	1.0	133.70	1.50	200.55	0.90	120.33	1.50	200.55
8	Surch.Dead:Behind	←	0.00	ES-b	1.0	0.00	1.50	0.00	0.75	0.00	1.50	0.00
11	Surch.traffic:Behind	←	33.30	LS-b	1.0	33.30	1.75	58.28	0.00	0.00	1.75	58.28
	Total: Counter-Clockwise Moments			ΣM_-		167.00	---	258.83	---	120.33	---	258.83
	Moments: Clockwise		14									
1	Reinforced Mass	↓	694.58	EV	1.0	694.58	1.35	937.68	1.00	694.58	1.00	694.58
2	Top Tringle Mass	↓	0.00	EV	1.0	0.00	1.35	0.00	1.00	0.00	1.00	0.00
3	Top Rectangle Mass	↓	0.00	EV	1.0	0.00	1.35	0.00	1.00	0.00	1.00	0.00
4	Earth Pressure	↓	0.00	EH	1.0	0.00	1.50	0.00	0.90	0.00	1.50	0.00
6	Surch.Dead:Top	↓	0.00	ES-t	1.0	0.00	1.35	0.00	1.00	0.00	1.00	0.00
7	Surch.Dead:Behind	↓	0.00	ES-b	1.0	0.00	1.50	0.00	0.75	0.00	1.50	0.00
9	Surch.Traffic:Top	↓	55.13	LS-t	0.0	0.00	1.75	96.48	0.00	0.00	0.00	0.00
10	Surch.Traffic:Behind	↓	0.00	LS-b	1.0	0.00	1.75	0.00	0.00	0.00	1.75	0.00
	Total: Clockwise Moments			ΣM_+		694.58	---	1034.16	---	694.58	---	694.58
	5	9				8						
	Vertical Load		11									
1	Reinforced Mass	↓	66.15	EV	1.0	66.15	1.35	89.30	1.00	66.15	1.00	66.15
2	Top Tringle Mass	↓	0.00	EV	1.0	0.00	1.35	0.00	1.00	0.00	1.00	0.00
3	Top Rectangle Mass	↓	0.00	EV	1.0	0.00	1.35	0.00	1.00	0.00	1.00	0.00
4	Earth Pressure	↓	0.00	EH	1.0	0.00	1.50	0.00	0.90	0.00	1.50	0.00
6	Surch.Dead:Top	↓	0.00	ES-t	1.0	0.00	1.35	0.00	1.00	0.00	1.00	0.00
7	Surch.Dead:Behind	↓	0.00	ES-b	1.0	0.00	1.50	0.00	0.75	0.00	1.50	0.00
9	Surch.Traffic:Top	↓	5.25	LS-t	0.0	0.00	1.75	9.19	0.00	0.00	0.00	0.00
10	Surch.Traffic:Behind	↓	0.00	LS-b	1.0	0.00	1.75	0.00	0.00	0.00	1.75	0.00
	Total Vertical Loads			ΣV		66.15	---	98.49	---	66.15	---	66.15
	Resultant from point A, y			(ft.)		7.98		7.87		8.68		6.59
	Eccentricity:	$e = L/2-y$		(ft.)								

Results:

		$e=L/2-y$	e/L	
ASD		2.52 ft.	0.120	Ok
LRFD	Max	2.63 ft.	0.125	Ok
LRFD	Min	1.82 ft.	0.087	Ok
LRFD	Crit.	3.91 ft.	0.186	Ok

Load F	Max	Min	Crit	ASD
EV	1.35	1.00	1.00	1.0
EH	1.50	0.90	1.50	1.0
ES-t	1.35	1.00	1.00	1.0
ES-b	1.50	0.75	1.50	1.0
LS-t	1.75	0.00	0.00	0.0
LS-b	1.75	0.00	1.75	1.0

MSE Wall - External Stability Check

Static Sliding, Eccentricity & Bearing

Ref:FHWA-NHI-10-024 &025

Version: 2016-06
Coding: skk 10/27/2016
Validation: scb by MSE-W 10/31

Project: Opitz Blve
WRA#: 032023.000
Design: skk 01/03/2021
Str. No. Walls 1 & 3 at Abut.C
Check: scb 01/03/2022

	Critical Bearing:				5		2		3		4	
	5	9	14	8	Eccentri	Eccentricity:	$e = L/2\text{-}y$		Meyerhof str.		$\sigma_V = \Sigma V/(L-2e)$	
					ASD	LRFD	Max.Load Factor	Factored Load	Min.Load Factor	Factored Load	Crit.Load Factor	Factored Load
	Moments: Counter-Clockwise				Un-factored							
5	Earth Pressure	←	133.70	EH	1.0	133.70	1.50	200.55	0.90	120.33	1.50	200.55
8	Surch.Dead:Behind	←	0.00	ES-b	1.0	0.00	1.50	0.00	0.75	0.00	1.50	0.00
11	Surch.traffic:Behind	←	33.30	LS-b	1.0	33.30	1.75	58.28	0.00	0.00	1.75	58.28
	Total: Counter-Clockwise Moments			ΣM_-		167.00	---	258.83	---	120.33	---	258.83
	5	9	14	8								
	Moments: Clockwise											
1	Reinforced Mass	↓	694.58	EV	1.0	694.58	1.35	937.68	1.00	694.58	1.35	937.68
2	Top Tringle Mass	↓	0.00	EV	1.0	0.00	1.35	0.00	1.00	0.00	1.35	0.00
3	Top Rectangle Mass	↓	0.00	EV	1.0	0.00	1.35	0.00	1.00	0.00	1.35	0.00
4	Earth Pressure	↓	0.00	EH	1.0	0.00	1.50	0.00	0.90	0.00	1.50	0.00
6	Surch.Dead:Top	↓	0.00	ES-t	1.0	0.00	1.35	0.00	1.00	0.00	1.50	0.00
7	Surch.Dead:Behind	↓	0.00	ES-b	1.0	0.00	1.50	0.00	0.75	0.00	1.50	0.00
9	Surch.Traffic:Top	↓	55.13	LS-t	1.0	55.13	1.75	96.48	0.00	0.00	1.75	96.48
10	Surch.Traffic:Behind	↓	0.00	LS-b	1.0	0.00	1.75	0.00	0.00	0.00	1.75	0.00
	Total: Clockwise Moments			ΣM_+		749.71	---	1034.16	---	694.58	---	1034.16
	5	9	11	8								
	Vertical Load											
1	Reinforced Mass	↓	66.15	EV	1.0	66.15	1.35	89.30	1.00	66.15	1.35	89.30
2	Top Tringle Mass	↓	0.00	EV	1.0	0.00	1.35	0.00	1.00	0.00	1.35	0.00
3	Top Rectangle Mass	↓	0.00	EV	1.0	0.00	1.35	0.00	1.00	0.00	1.35	0.00
4	Earth Pressure	↓	0.00	EH	1.0	0.00	1.50	0.00	0.90	0.00	1.50	0.00
6	Surch.Dead:Top	↓	0.00	ES-t	1.0	0.00	1.35	0.00	1.00	0.00	1.50	0.00
7	Surch.Dead:Behind	↓	0.00	ES-b	1.0	0.00	1.50	0.00	0.75	0.00	1.50	0.00
9	Surch.Traffic:Top	↓	5.25	LS-t	1.0	5.25	1.75	9.19	0.00	0.00	1.75	9.19
10	Surch.Traffic:Behind	↓	0.00	LS-b	1.00	0.00	1.75	0.00	0.00	0.00	1.75	0.00
	Total Vertical Loads			ΣV		71.40	---	98.49	---	66.15	---	98.49
	Resultant from point A, y (ft.)					8.16		7.87		8.68		7.87
										1.5	1.75	

Results:	ASD	LRFD	LRFD	LRFD
	Ser.	Max	Min	Crit.
ΣV (kips)	71.40	98.49	66.15	98.49
(ft)	8.16	7.87	8.68	7.87
$e = L/2\text{-}y$ (ft)	2.34	2.63	1.82	2.63
e/L	0.111	0.125	0.087	0.125
$\sigma_V = \Sigma V/(L-2e)$ (ksf)	4.374	6.256	3.810	6.256

Load F	Max	Min	Crit	ASD
EV	1.35	1.00	1.35	1.0
EH	1.50	0.90	1.50	1.0
ES-t	1.35	1.00	1.50	1.0
ES-b	1.50	0.75	1.50	1.0
LS-t	1.75	0.00	1.75	1.0
LS-b	1.75	0.00	1.75	1.0

1.50 Chosen to match MSE-W approach

MSE Wall - External Stability Check

Static Sliding, Eccentricity & Bearing
Ref:FHWA-NHI-10-024 &025

Version: 2016-06
Coding: skk 10/27/2016
Validation: scb by MSE-W 10/31

Project: Opitz Blve
WRA#: 032023.000
Design: skk 01/03/2021
Str. No. Walls 1 & 3 at Abut.C
Check: scb 01/03/2022

Critical Bearing (ctd):

Foundation Length L_w = 21.0 ft.

Mayerhof Bearing Capacity/Nominal Resistance, q_{ult}= 16.64 ksf

ASD	*Values corresponds to un-factored loads & capacities*			
	Eccentricity	e	2.34	ft.
	Vertical Loads, un-factored	ΣV	66.15	kips/LF
	Required Allowable Bearing Capacity	σ_V =	4.05	ksf
	Ultimate Bearing Capacity	q_{ult}=	16.64	ksf
	Factor of Safety against Bearing	$FS_{bearing}$=	4.106	

LRFD	*Values corresponds to maximum load factors*			Serv.	Max	Min	Crit.
	Eccentricity	e		2.34	2.63	1.82	2.63
	Vertical Loads, un-factored	ΣV		71.40	98.49	66.15	98.49
	Required Factored Bearing Stress	σ_V =		4.37	6.26	3.81	6.26
	Nominal Bearing Capacity	q_{ult}=		16.64	16.64	16.64	16.64
	Resistance factor for Bearing:	Φ_b=		0.5	0.65	0.65	0.65
	Factored Bearing Resistance			8.32	10.82	10.82	10.82
		CDR=		1.90	1.73	2.84	1.73
		Bearing Resistance: CDR $_{min}$=	1.73				

Summary:

LRFD CDR	Target	Calc.	
Sliding	1.00	1.60	ok
Bearing	1.00	1.73	

ASD FS	Target	Calc.
Sliding	2.00	2.45
Bearing	3.00	4.11

Eccentricity	Max	ASD	LRFD
e/L	0.250	0.120	0.186
		ok	*ok*

Bearing Resistance / Capacity

Required Factored Bearing Resistance: 6.26 ksf
Required Allowable Bearing Capacity: 4.05 ksf

Notes: For excentricity and sliding

MSE Wall - External Stability Check

Static Sliding, Eccentricity & Bearing

Ref:FHWA-NHI-10-024 &025

Version:	2016-06
Coding:	skk 10/27/2016
Validation:	scb by MSE-W 10/31

Project:	Opitz Blve	WRA#:	032023.000	Design:	skk 01/03/2021
Str. No.:	Walls 1 & 3 at Abut.C			Check:	scb 01/03/2022

EVALUATION OF NOMINAL BEARING RESISTANCE

DATA FROM PREVIOUS SHEETS:

Soil Parameters				*16.64*	
Cohesion c =	0.0	psf	Foundatn Subgr. Soil Unit Wt. γ_{fs}	125.0	pcf
Friction Ang. ϕ_f =	30.0	degree	Surcharge Soil Unit Wt. γ_{sur}	120.0	pcf
Soils above footing bearing are as competent as subgrade soils?				Yes	

Foundation Dimensions					
Footing Width B=	21.00	ft.	Footing Depth D_f =	2.00	ft
Footing Length L=	36.00	ft.	G.Water Depth D_w =	50.00	ft

Foundation Loads:						
Unfactored Vert. Load V=	66.2	kips		Load Angle θ	0.0	deg
Unfactored Horz.Load H=	15.6	kips		Moment:	----	
Eccentricity: e_b=	2.5	ft.	*(<5.3) ok*	e_L (ft)=		*(<9.0) ok*

CALCULATION OF BEARING NOMINAL RESISTANCE:

Bearing Capacity Factors :

$N_c=(N_q-1)\cot\phi$	$N_\gamma = 2\,(N_q+1)\tan\phi$	$N_q=e^{(\pi\tan\phi)}\tan^2(45^o+\phi/2)$
N_c = 30.14	N_γ= 22.40	N_q= 18.40

Effective Footing Dimensions: (Area reduction for assumed eccentricity)

$B' = B-2e_b$ = 16.0 ft L'=L-2e_L = 36.0 ft

Footing Shape Correction Factors:

For ϕ = 0	S_c = 1+ (B'/5L')	S_γ= 1.0	S_q= 1
For ϕ > 0	$S_c = 1+ (B'/L')\,(N_q/N_c)$	S_γ= 1 - 0.4 (B'/L')	S_q= 1+ (B'/L') tan ϕ
	S_c= 0.881	S_γ= 0.823	S_q= 1.256

Groundwater Correction Factors

C_{wq}= 1.000 $C_{w\gamma}$= 1.000

Depth Correction Factor:

Competent surcharge soils: Yes D_f/B= 0.13 d_q= 1.00

Load Inclination Factors: 1000

i_c = 1.000 i_q = 0.692 i_γ = 0.529

Nominal Bearing Resistance:

$q_n = c\,(N_c\,S_c\,i_c) + \gamma_{sur}\,D_f\,(N_q\,S_q\,d_q\,i_q)\,C_{wq} + 0.5\,\gamma_{fs}\,B\,(N_\gamma\,S_\gamma\,i_\gamma)\,C_{w\gamma}$ ASD FOS 2.0

C term	0.00	q term	3.84	B term	12.80	LRFD Φq	0.65
q_n =	*16.64* ksf	Allowable q	*8.32* ksf	Factored q	*10.82* ksf		

NOTES:

Calc based on assumed foundation length and water table depth.

APPENDIX E.2

MSE Wall Calculations – Wall 1, Wall2, and Wall 3

Elastic Settlement for Embankment
Hough Method Ref:FHWA-NHI-06-088

SOIL PROFILE
Data Input

Sheet 1 of 2
Version: V.12.03

Project Data

Project:	Opitz Blvd Express Lane	**Location:**	Abutment C
WRA WO#:	45893-001	**Date:**	11/4/2021
Subject:	T-Ramp Loading at the edge.		

Calcualtion / Check

Calc :	jy
Date:	4-Nov-21
Chk:	sk
Date:	14-Dec-21

Subsurface Test Borings	B-A2-1
Number of Layers (up to 14)	5
Depth to Groundwater (ft):	20
SPT Corrected for overburden (Yes/No)	Yes
SPT Correction for Efficiency (Yes/No)	Yes
Select the Rig for Hammer Eff.	3. Salut

SPT Hammer Efficiency

Rig No.	E_m
1. CME 55 (E2CR)	84%
2. CME 45 (F&R)	78%
3. Salut	88%
4. CME 45 Cathead	66%

Soil Types for C' Curve Selection

E_m = 88%

γ_{water} = 62.4

1	1 - Clean Uniform medium SAND	
2	2 - Well Graded Silty SAND and GRAVEL	
3	3 - Clean well graded fine to coarse Silty SAND	
4	4 - Well graded fine to medium Silty SAND	
5	5 - Inorganic SILT	Yes
		No

Layer Data

Layer No.	Bottom Depth (ft)	SPT N Value	Soil Unit Wt. (pcf)		Curve for Bearing Capacity Index-C'			Soil Layer		Overburden		SPT N Value (correctd)	$C'_{(top)}$	$C'_{(bott)}$	C'
				Soil USCS	**Top Curve**	**% Top Curve**	**Description**	Top (z_1) (ft)	Bott.(z_2) (ft)	center p_c (psf)	bottom p_2 (psf)				
1	3.0	19	115.0	SM	1	100.0	100% Ty.1+0% Ty.2	0.0	3.0	172.5	345.0	56	294	195	294
2	6.5	7	120.0	SM	1	100.0	100% Ty.1+0% Ty.2	3.0	6.5	555.0	765.0	19	85	75	85
3	25.0	15	125.0	SP/GP	1	100.0	100% Ty.1+0% Ty.2	6.5	25.0	1921.3	2765.5	22	94	82	94
4	50.0	70	125.0	SP/GP	1	100.0	100% Ty.1+0% Ty.2	25.0	50.0	3548.0	4330.5	77	557	315	557
5	100.0	100	125.0	SP/GP	1	100.0	100% Ty.1+0% Ty.2	50.0	100.0	5895.5	7460.5	85	697	375	697

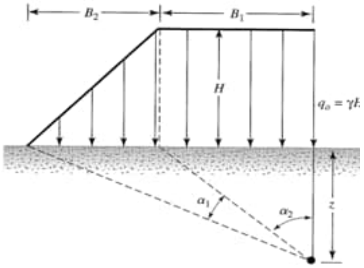
Elastic Settlement for Embankment Calc jy Sheet 2 of 2

Hough Method Settlement Estimations Chk: sk Version: V.2.00

Project: Opitz Blvd Express Lane Location: Abutment C Subject: Subject: T-Ramp Loading at the edge.

Stress Destribution for Two Areas		Area 1	Area 2	Area 3
Multiplier		1	1	0
Height of Embankment		26	26	0
Soil Unit Weight		105	105	0
Rectangular Loading Width	B_1	18	18	0
Triangular Loading Width	B_2	0	0	0
FHWA Recommended factor for final settlement:			k_{FHWA}	0.5
Default Min. Value for B_2=	1E-10			

Formulas:



$$\Delta\sigma_z = \frac{q_o}{\pi}\left[\left(\frac{B_1 + B_2}{B_2}\right)(\alpha_1 + \alpha_2) - \frac{B_1}{B_2}(\alpha_2)\right]$$

$$\Delta H = H\left(\frac{1}{C'}\right)\log_{10}\frac{p_o + \Delta p}{p_o}$$

Settlement Calculations:

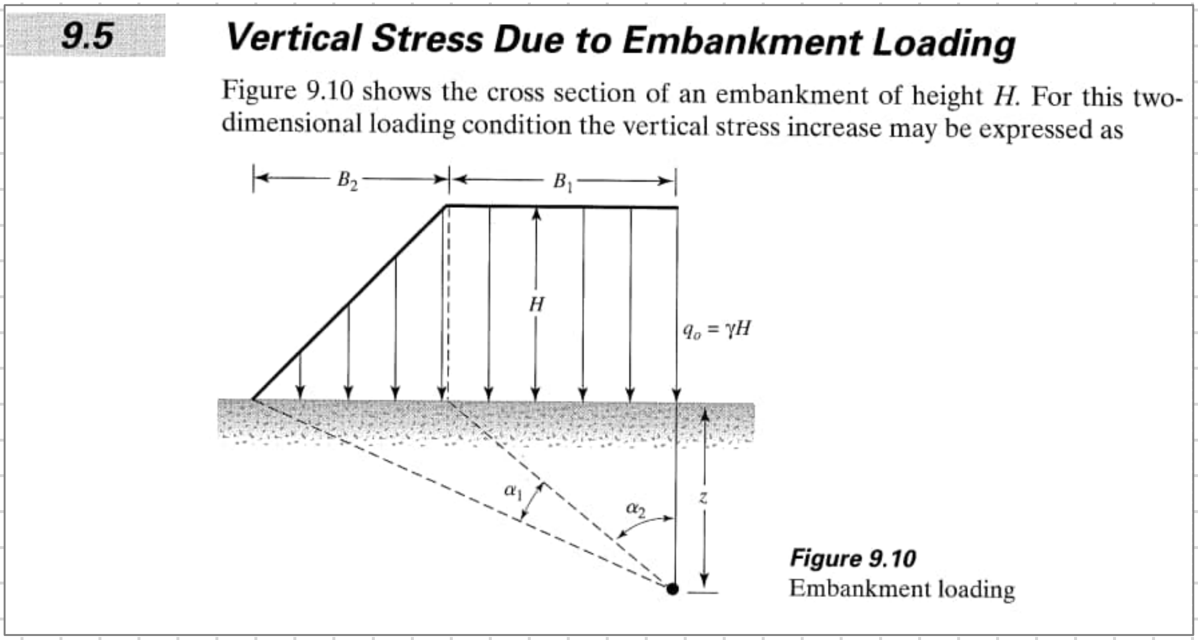
Layer Data					Angles (radians)						Influence Factors			$q_0^{(a)}$	$q_0^{(b)}$	$q_0^{(c)}$		Settlements	
Layer No.	Middle Depth z_{mid} (ft)	Layer Thick. h_i (ft)	Overbr. Press. p_0 (psf)	Bear. Factor C'	Area (a)		Area (b)		Area (c)		Area(a)	Area (b)	Area (c)	2730	2730	0	Total Δp (psf)	Per Layer (inch)	Cumu. (inch)
					B_1	B_2	B_1	B_2	B_1	B_2				$q_0 * I_z^{(c)}$	$q_0 * I_z^{(c)}$	$q_0 * I_z^{(c)}$			
					18.0	0.0	18.0	0.0	0.0	0.0				$\Delta p^{(a)}$	$\Delta p^{(b)}$	$\Delta p^{(c)}$			
					$\alpha_1^{(a)}$	$\alpha_2^{(a)}$	$\alpha_1^{(b)}$	$\alpha_2^{(b)}$	$\alpha_1^{(c)}$	$\alpha_2^{(c)}$	$I_z^{(a)}$	$I_z^{(b)}$	$I_z^{(c)}$	(psf)	(psf)	(psf)			
1	1.5	3.0	172.5	294	0.000	1.488	0.000	1.488	0.000	0.000	0.474	0.474	0.000	1292.7	1292.7	0.0	2585.3	0.15	0.15
2	4.8	3.5	555.0	85	0.000	1.313	0.000	1.313	0.000	0.000	0.418	0.418	0.000	1140.9	1140.9	0.0	2281.7	0.35	0.50
3	15.8	18.5	1921.3	94	0.000	0.852	0.000	0.852	0.000	0.000	0.271	0.271	0.000	740.4	740.4	0.0	1480.8	0.59	1.08
4	37.5	25.0	3548.0	557	0.000	0.448	0.000	0.448	0.000	0.000	0.142	0.142	0.000	388.8	388.8	0.0	777.5	0.05	1.13
5	75.0	50.0	5895.5	697	0.000	0.236	0.000	0.236	0.000	0.000	0.075	0.075	0.000	204.8	204.8	0.0	409.5	0.03	1.16
																	ΔH=	1.16 inches	

Final settlement ***(k_{FHWA} * ΔH) 1.16 x 0.50 = 0.58 inches*** (center and middle of infinite strip)

Edge of at aboutment, loading is half 0.29 inches. (at the pile locations, 60 %)

Elastic Stress Distribution

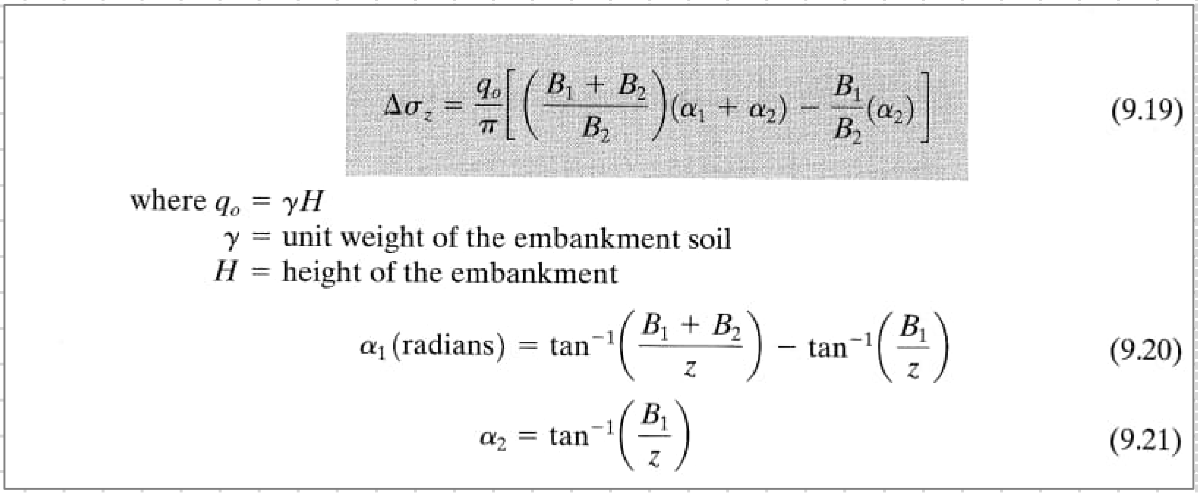
Ref: Das, Braja M, (2001), *Principles of Geotechnical Engineering* ,
5th Edition, Brooks/Cole - Thomson Learning, Inc. Pacific Grove, California



9.5 Vertical Stress Due to Embankment Loading

Figure 9.10 shows the cross section of an embankment of height H. For this two-dimensional loading condition the vertical stress increase may be expressed as

Figure 9.10
Embankment loading



$$\Delta\sigma_z = \frac{q_o}{\pi}\left[\left(\frac{B_1 + B_2}{B_2}\right)(\alpha_1 + \alpha_2) - \frac{B_1}{B_2}(\alpha_2)\right] \tag{9.19}$$

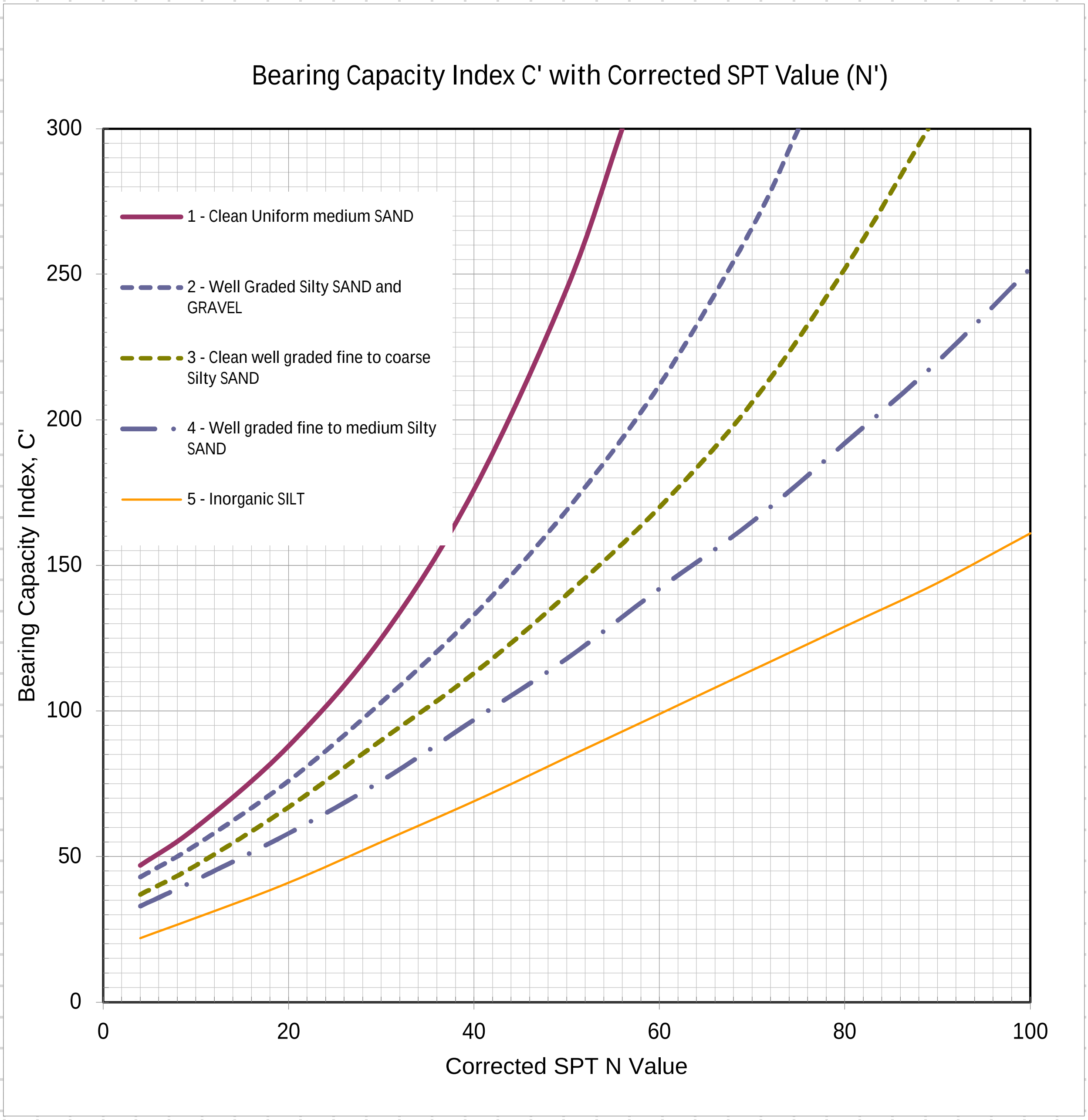
where $q_o = \gamma H$
γ = unit weight of the embankment soil
H = height of the embankment

$$\alpha_1\,(\text{radians}) = \tan^{-1}\left(\frac{B_1 + B_2}{z}\right) - \tan^{-1}\left(\frac{B_1}{z}\right) \tag{9.20}$$

$$\alpha_2 = \tan^{-1}\left(\frac{B_1}{z}\right) \tag{9.21}$$

Reference: **FHWA (2006) Soils and Foundation, FHWA-NHI-06-088 (2006) Vol 1**

Figure 7.7



Settlement

$$\Delta H = H\left(\frac{1}{C'}\right)\log_{10}\frac{p_o + \Delta p}{p_o}$$

APPENDIX E.2

MSE Wall Calculations – Wall 1, Wall2, and Wall 3

BACK-TO-BACK
MSE (BBMSC)
WALLS
Version 01.00 sk 12/14/2021

Project: *Opitz Blvd*
Sheet 1 of 2
Virginia
WRA No. *445893-000*
Structure: *T-Ramp Back-to-Back Walls, Wall 1 & Wall 3.*
Calc by: *skk 12/14/2021*
Chk by:

Wall Data

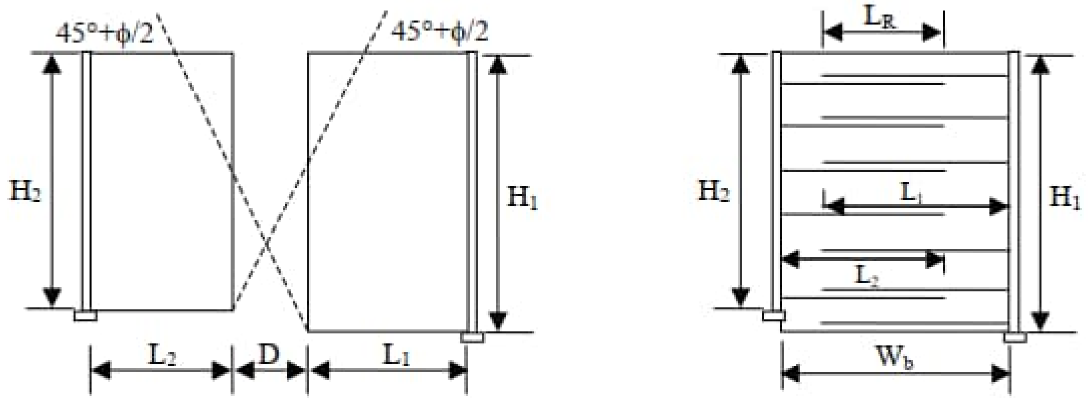
Friction Angle (Reinforced fill)	φ	*34*	deg	Reinforcement Lengths	*0.7*	*H*
Total Width of the Ramp	W_b	*36.3*	ft.	Minimum strap Length	*8.0*	ft.
Depth below subgrade		*2.0*	ft.			
Wall height above Parapet		*3.0*	ft.	Minimum distance for Back to Back Walls		
Wall height included in Clear Height		*1.0*	ft.	Min for BBMSE , D_{min}	*2.0*	ft
Amount to be added to clear heigh	h_a	4.0	ft.	$D^* = H_1 \tan(45° - \varphi/2)$		

Wall	Drawing Readings		Exposed Height hc		Effective Heights		Sorted	
	From Drawings (h_o)		$h_e = h_c + h_a$		$h_{eff} = h_o + h_a$		Taller Wall	Shorter Wall
Station	West Wall	East Wall	West Wall	East Wall	West Wall	East Wall	H_1	H_2
(ft.)	(ft.)	(ft.)	(ft.)	(ft.)	(ft.)	(ft.)	(ft.)	(ft.)
27+00	*22.0*	*26.0*	24.0	28.0	26.0	30.0	30.0	26.0
26+50	*20.0*	*24.0*	22.0	26.0	24.0	28.0	28.0	24.0
26+00	*20.0*	*23.0*	22.0	25.0	24.0	27.0	27.0	24.0
25+50	*18.0*	*22.0*	20.0	24.0	22.0	26.0	26.0	22.0
25+00	*17.0*	*19.0*	19.0	21.0	21.0	23.0	23.0	21.0
24+50	*15.0*	*15.0*	17.0	17.0	19.0	19.0	19.0	19.0
24+00	*13.0*	*13.0*	15.0	15.0	17.0	17.0	17.0	17.0
23+50	*11.0*	*11.0*	13.0	13.0	15.0	15.0	15.0	15.0
23+00	*9.0*	*9.0*	11.0	11.0	13.0	13.0	13.0	13.0
22+50	*6.0*	*6.0*	8.0	8.0	10.0	10.0	10.0	10.0

Wall	L_1	L_2	D		L_R	Conditions for Back to Back		Design Strap Length	
Station	0.7H	0.7H	$(W_b - L_1 - L_2)$	D^*	$0.3 H_2$	$W_b / H_1 > 1.1$	$D < D^*$	L_{1D}	L_{2D}
(ft.)	(ft.)	(ft.)	(ft.)	(ft.)	(ft.)			(ft.)	(ft.)
27+00	21.0	18.2	-2.9	16.0	7.8	1.2	BBMSE	23.5	20.7
26+50	19.6	16.8	-0.1	14.9	7.2	1.3	BBMSE	23.2	20.4
26+00	18.9	16.8	0.6	14.4	7.2	1.3	BBMSE	22.8	20.7
25+50	18.2	15.4	2.7	13.8	6.6	1.4	MSE	18.2	15.4
25+00	16.1	14.7	5.5	12.2	6.3	1.6	MSE	16.1	14.7
24+50	13.3	13.3	9.7	10.1	5.7	1.9	MSE	13.3	13.3
24+00	11.9	11.9	12.5	9.0	5.1	2.1	MSE	11.9	11.9
23+50	10.5	10.5	15.3	8.0	4.5	2.4	MSE	10.5	10.5
23+00	9.1	9.1	18.1	6.9	3.9	2.8	MSE	9.1	9.1
22+50	8.0	8.0	20.3	5.3	3.0	3.6	MSE	8.0	8.0

Notes from the Reference:

FHWA NHI-10-024
MSE Walls and RSS – Vol I



Case I

Case II

Figure 6-9. Back–to–back MSE walls.

Case I

(i) $D > 0$ (must). (ii) D may be greater than D_{min} and/or D*

Case II

For Case II geometries with overlaps (L_R) greater than $0.3H_2$, the following guidelines should be used:

- $L_1/H_1 \geq 0.6$ where L_1 and H_1 is the length of the reinforcement and height, respectively, of the taller wall.
- $L_2/H_2 \geq 0.6$ where L_2 and H_2 is the length of the reinforcement and height, respectively of the shorter wall.
- $W_b/H_1 \geq 1.1$ where W_b is the base width as shown in Figure 6-9 and H_1 is the height of the taller wall.

APPENDIX E.2

MSE Wall Calculations – Wall 1, Wall2, and Wall 3

MSE Wall - External Stability Check

Static Sliding, Eccentricity & Bearing

Ref:FHWA-NHI-10-024 &025

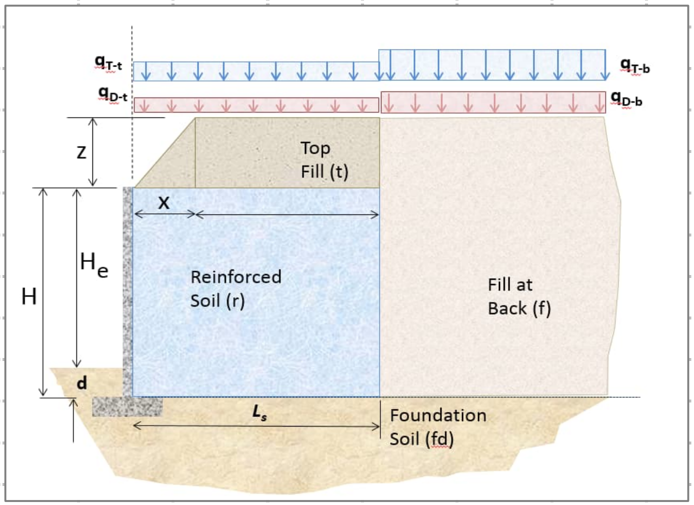
Version: 2016-06
Coding: skk 10/27/2016
Validation: scb by MSE-W 10/31

Project: Opitz Blve
WRA#: 032023.000
Design: skk 12/20/2021
Wall ID Walls 1 & 3, Sta.24+50 (h=19')
Wall No.: Wall 1&3
Check: scb 12/20/2021

Assumptions/Notes:

Front of the abutment is modeled as a triangular portion.

Lateral loads behind the wall are assumed to be horizontal (per MSE-W assumption for slope < 45 deg.)



Wall Configuration

Backfill Slope

Broken Back Slope:

Height z (ft.)= 10.00

Length x (ft.)= 6.00

Infinite Backfill: Yes

Infinite Slope β_{inf} = 0.00

Fall face assumed vertical

α= 0.00 deg.

Case	β_{eq}	Δh	h
5	0.00	0.00	19.00

Wall Dimensions

Exposed wall height H_e = 17.00 ft.

Embedded Height d = 2.00 ft.

Total Wall Length 50.00 ft. <== (for bearing capacity calculations)

Table C.11..10.2.2.-1 Minimum Embedment

Minimum Embedment = H /20 0.95 *ok*

Reinforced Backfill Friction Angle ϕ_r = 34.0 degree Unit Wt. γ_r= 105.0 pcf

Retained Fill (f) (above and behind reinf. zone) ϕ_f = 34.0 degree γ_f= 105.0 pcf

Foundation Soil: ϕ_{fd} = 30.0 degree γ_{fd}= 110.0 pcf

Cohesion: c_{fd} = 0.0 psf Mayerhof Bearing, q_{ult}= 12.31 ksf

Top of wall Backfill Friction Angle ϕ_t = 34.0 degree Unit Wt. γ_t= 105.0 pcf

Surcharge Loading

Traffic @ wall Top ↓ q_{T-t}= 250 psf Dead -top ↓ q_{D-t}= 0 psf

Traffic @ behind wall ↓ q_{T-b}= 250 psf Dead -Behind ↓ q_{D-b}= 0 psf

Added horizontal Load ← P_{BR-H}= 0 lb/LF

Design Height and Estimated Reinforcement Length

Estimated Reinforcement Length : L = 13.40 ft. *Check for minimum L*

Design Height of the wall: $H = H_e + d$ H = 19.00 ft. L_{min} = 7.0 ft. *ok*

Ratio for Estimated Reinforcement Length (> 0.7): 0.71 *(L /H)* *ok* $L \leq 2H$ *ok to use this spreadsheet*

Results Summmary

LRFD:			ASD:		Bearing Resistnace:		
Direct Sliding	CDR=	1.486	$FS_{Sliding}$	2.303	Required Factored Bearing=	4.232	ksf
Bearing Resist.	CDR=	1.891	$FS_{bearing}$	4.743	Required Service Bearing=	2.596	ksf
1.225	e/L =	0.204 Critical	e/L =	0.130	e/L = 0.130 e =	1.74	ft

MSE Wall - External Stability Check

Static Sliding, Eccentricity & Bearing

Ref:FHWA-NHI-10-024 &025

Version: 2016-06
Coding: skk 10/27/2016
Validation: scb by MSE-W 10/31

Project: Opitz Blve
WRA#: 032023.000
Design: skk 12/20/2021
Str. No. Walls 1 & 3, Sta.24+50 (h=19')
Check: scb 12/20/2021

Load Factors	EV	EH	ES	LS
Strength I (maximum)	1.35	1.50	1.50	1.75
Strength I (minimum)	1.00	0.90	0.75	0.00
Service I	1.00	1.00	1.00	1.00

Resistance Factors	
Sliding of MSE wall on foundation soil	1.00
Bearing resistance	0.65
Tensile resistance (for steel strips)	0.75

Calculation of $\boldsymbol{\beta}_{eq}$ and h

L = 13.4 ft. H = 19.0 ft. x = ft. z = ft.

Case Description			$\boldsymbol{\beta}_{eq}$		Δh		L_T	$L_R = L - L_T$
1	For x<z;	$\beta_{eq} = 0$		$\Delta h = z$		L_T=0		
2	x< L	$\beta_{eq}=\tan^{-1}(z/2H)$		$\Delta h = z$		L_T=x		
3	L<x< 2H	$\beta_{eq}=\tan^{-1}(z/2H)$		$\Delta h = L\,z/x$		L_T=L		
4	x > 2H	$\beta_{eq}=\tan^{-1}(z/x)$		$\Delta h = L\,z/x$		L_T=L		
5	Infinite	$\beta_{eq}=\beta_{\text{infinite}}$	0.00		0.00	L_T=L	0.00	13.40
5	<=*Current Case*	β_{eq}=	0.00 degree	Δh =	0.00 ft.		0.00	13.40
	β_{eq}=		$h = H + \Delta h$	h =	19.00 ft.			

Coulomb Active Earth Pressure Coefficient for Retained fill

Reference: Eq. 3.11.5.3-1 AASHTO

$$K_A = \frac{\sin^2(\theta+\phi')}{\sin^2\theta\,\sin(\theta-\delta)\left[1+\sqrt{\frac{\sin(\phi+\delta)\,\sin(\phi'-\beta)}{\sin(\theta-\delta)\,\sin(\theta+\beta)}}\right]^2}$$

Note: $\phi' > \beta$ — $\phi f'$ = 34.0 degree

β = 0.00 degree

$\theta = 90 + \alpha$ — θ = 90.0 degree

$\delta = \beta$ — δ = 0.0 degree

T_1= 0.3127 T_2= 1 $\Gamma = [1 + \text{sqrt}(T_1/T_2)]^2$ Γ = 2.4311

T_t= 0.6873 T_b= 1 $K_A = T_t / (T_b * \Gamma)$ K_{af} = 0.283

Rankine Earth Pressure Coefficients

$$K_A = \cos\beta\left[\frac{\cos\beta - \sqrt{\cos^2\beta - \cos^2\phi'}}{\cos\beta + \sqrt{\cos^2\beta - \cos^2\phi'}}\right]$$

Equation 5.12 from FHWA-IF-03-017

(for comparison purposes)

T_{sq}= 0.5592 T_{cos}= 1

$K_A = T_{cos}(T_{cons}-T_{sq})/(T_{cos}+T_{sq})$

K_A = 0.283

Note :

MSE Wall - External Stability Check

Static Sliding, Eccentricity & Bearing

Ref:FHWA-NHI-10-024 &025

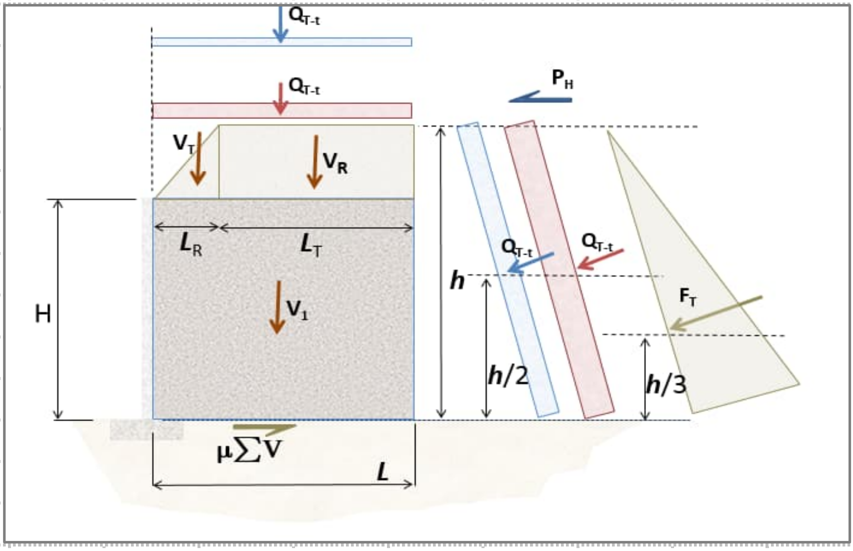
Version: 2016-06
Coding: skk 10/27/2016
Validation: scb by MSE-W 10/31

Project: Opitz Blve
WRA#: 032023.000
Design: skk 12/20/2021
Str. No. Walls 1 & 3, Sta.24+50 (h=19')
Check: scb 12/20/2021

Loads and Moments:

Data for Calculations:

L = 13.40 ft.
H = 19.00 ft.
h = 19.00 ft.
L_T = 0.00 ft.
L_R = 13.40 ft.
K_{af} = 0.283
γ_r = 105.0 pcf
γ_f = 105.0 pcf
γ_t = 105.0 pcf
β = 0.00 deg.
$q_{D\ top}$ = 0 psf
$q_{D\text{-}b}$ = 0 psf
$q_{T\text{-}top}$ = 250 psf
$q_{T\text{-}beh}$ = 250 psf



p_H = 0 lb/LF rounding force 2 length 2 2

Un-factored Loads: Horizontal, Vertical & Moment about Point A

								Arm	M
						(kips/LF)	12	(ft.)	(ft. kips)
1	$V_1 = \gamma_r H L$	*Reinforced Mass*	EV	↓	V_1	26.73	$L/2$=	6.70	179.09
2	$V_T = (1/2)\gamma_t (h-H) L_T$	*Top Tringle Mass*	EV	↓	V_T	0.00	$2L_T/3$=	0.00	0.00
3	$V_R = \gamma_t (h-H) L_R$	*Top Rectangle Mass*	EV	↓	V_R	0.00	$L_T+L_R/2$=	6.70	0.00
4	$F_{TV}=(1/2)\gamma_f h^2 K_{af} \sin\beta$ F_T= 5.36	*Earth Pressure*	EH	↓	F_{TV}	0.00	L=	13.40	0.00
5	$F_{TH}=(1/2)\gamma_f h^2 K_{af} \cos\beta$	*Earth Pressure*	EH	←	F_{TH}	5.36	$h/3$=	6.33	33.93
6	$Q_{D\ top\text{-}V} = (q_{D\ top}) L$	*Surch.Dead:Top*	ES-t	↓	$Q_{Dtop\text{-}V}$	0.00	$L/2$=	6.70	0.00
7	$Q_{DV} = (q_D) h K_{af} \sin\beta$	*Surch.Dead:Behind*	ES-b	↓	Q_{DbV}	0.00	L=	13.40	0.00
8	$Q_{DH} = (q_D) h K_{af} \cos\beta$	*Surch.Dead:Behind*	ES-b	←	Q_{DbH}	0.00	$h/2$=	9.50	0.00
9	$Q_{T\ top\text{-}V} = (q_T) L$	*Surch.Traffic:Top*	LS-t	↓	$Q_{T\ top\text{-}V}$	3.35	$L/2$=	6.70	22.45
10	$Q_{TV} = (q_{T\text{-}b}) h K_{af} \sin\beta$	*Surch.Traffic:Behind*	LS-b	↓	Q_{TbV}	0.00	L=	13.40	0.00
11	$Q_{TH} = (q_{T\text{-}b}) h K_{af} \cos\beta + P_{BR}$	*Surch.traffic:Behind*	LS-b	←	Q_{TbH}	1.34	$h/2$=	9.50	12.73

1 2 3 4 5 6 7 8 9 10 11 12 13 14

MSE Wall - External Stability Check

Static Sliding, Eccentricity & Bearing

Ref:FHWA-NHI-10-024 &025

Version: 2016-06

Coding: skk 10/27/2016

Validation: scb by MSE-W 10/31

Project: Opitz Blve

WRA#: 032023.000

Design: skk 12/20/2021

Str. No. Walls 1 & 3, Sta.24+50 (h=19')

Check: scb 12/20/2021

	Static Sliding				5		2		3		4	
	5	9	11	8			Strength I(max)		Strength I(Min)		Critical	
	Horizontal Driving Forces				ASD		Max.Load Factor		Min.Load Factor		Crit.Load Factor	
	Horizontal Forces				Factor	Load	Factor	Load	Factor	Load	Factor	Load
5	Earth Pressure	←	5.36	EH	1.0	5.36	1.50	8.04	0.90	4.82	1.50	8.04
8	Surch.Dead:Behind	←	0.00	ES-b	1.0	0.00	1.50	0.00	0.75	0.00	1.50	0.00
11	Surch.traffic:Behind	←	1.34	LS-b	1.0	1.34	1.75	2.35	0.00	0.00	1.75	2.35
	Total Horizontal			$\Sigma H_{driving}$		6.70	---	10.39	---	4.82	---	10.39
	Vertical Loads											
1	Reinforced Mass	↓	26.73	EV	1.0	26.73	1.35	36.09	1.00	26.73	1.00	26.73
2	Top Tringle Mass	↓	0.00	EV	1.0	0.00	1.35	0.00	1.00	0.00	1.00	0.00
3	Top Rectangle Mass	↓	0.00	EV	1.0	0.00	1.35	0.00	1.00	0.00	1.00	0.00
4	Earth Pressure	↓	0.00	EH	1.0	0.00	1.50	0.00	0.90	0.00	1.50	0.00
6	Surch.Dead:Top	↓	0.00	ES-t	1.0	0.00	1.35	0.00	1.00	0.00	1.00	0.00
7	Surch.Dead:Behind	↓	0.00	ES-b	1.0	0.00	1.50	0.00	0.75	0.00	1.50	0.00
9	Surch.Traffic:Top	↓	3.35	LS-t	0.0	0.00	1.75	5.86	0.00	0.00	0.00	0.00
10	Surch.Traffic:Behind	↓	0.00	LS-b	1.0	0.00	1.75	0.00	0.00	0.00	1.75	0.00
	Total Vertical			ΣV		26.73	---	41.95	---	26.73	---	26.73
	Resisting Horizontal Loads for		Φ_{crit}=	30.00		ASD		Max		Min		Crit.
1	Reinforced Mass	↓				15.43		20.83		15.43		15.43
2	Top Tringle Mass	↓				0.00		0.00		0.00		0.00
3	Top Rectangle Mass	↓				0.00		0.00		0.00		0.00
4	Earth Pressure	↓				0.00		0.00		0.00		0.00
6	Surch.Dead:Top	↓				0.00		0.00		0.00		0.00
7	Surch.Dead:Behind	↓				0.00		0.00		0.00		0.00
9	Surch.Traffic:Top	↓				0.00		3.38		0.00		0.00
10	Surch.Traffic:Behind	↓				0.00		0.00		0.00		0.00
	Cohesion	$C_H = c_{fd} L$				0.00		0.00		0.00		0.00
				ΣV_{resist}		15.43		24.22		15.43		15.43

Results

ASD	FS_{SL}=	2.303
LRFD	CDR=	1.486

Load F	Max	Min	Crit	ASD
EV	1.35	1.00	1.00	1.0
EH	1.50	0.90	1.50	1.0
ES-t	1.35	1.00	1.00	1.0
ES-b	1.50	0.75	1.50	1.0
LS-t	1.75	0.00	0.00	0.0
LS-b	1.75	0.00	1.75	1.0

Note: For geogrid reinforced MSE, the sliding friction angle may be taken as minimum of ϕ_{fd} and two thirds of reinforced soil friction angle, (2/3) ϕ_r

Φ_{fd}= 30.00   Sliding Φ_r= 34

2/3 Φ_r= 22.67 Φ_{crit}= 22.67

MSE Wall - External Stability Check

Static Sliding, Eccentricity & Bearing

Ref:FHWA-NHI-10-024 &025

Version: 2016-06
Coding: skk 10/27/2016
Validation: scb by MSE-W 10/31

Project: Opitz Blve
WRA#: 032023.000
Design: skk 12/20/2021
Str. No. Walls 1 & 3, Sta.24+50 (h=19')
Check: scb 12/20/2021

	Eccentricity:				5		2		3		4	
	5	9		8								
					ASD	LRFD	Max.Load Factor	Factored Load	Min.Load Factor	Factored Load	Crit.Load Factor	Factored Load
	Moments: Counter-Clockwis		14		Un-factored							
5	Earth Pressure	←	33.93	EH	1.0	33.93	1.50	50.90	0.90	30.54	1.50	50.90
8	Surch.Dead:Behind	←	0.00	ES-b	1.0	0.00	1.50	0.00	0.75	0.00	1.50	0.00
11	Surch.traffic:Behind	←	12.73	LS-b	1.0	12.73	1.75	22.28	0.00	0.00	1.75	22.28
	Total: Counter-Clockwise Moments			ΣM_-		46.66	---	73.17	---	30.54	---	73.17
	Moments: Clockwise		14									
1	Reinforced Mass	↓	179.09	EV	1.0	179.09	1.35	241.77	1.00	179.09	1.00	179.09
2	Top Tringle Mass	↓	0.00	EV	1.0	0.00	1.35	0.00	1.00	0.00	1.00	0.00
3	Top Rectangle Mass	↓	0.00	EV	1.0	0.00	1.35	0.00	1.00	0.00	1.00	0.00
4	Earth Pressure	↓	0.00	EH	1.0	0.00	1.50	0.00	0.90	0.00	1.50	0.00
6	Surch.Dead:Top	↓	0.00	ES-t	1.0	0.00	1.35	0.00	1.00	0.00	1.00	0.00
7	Surch.Dead:Behind	↓	0.00	ES-b	1.0	0.00	1.50	0.00	0.75	0.00	1.50	0.00
9	Surch.Traffic:Top	↓	22.45	LS-t	0.0	0.00	1.75	39.29	0.00	0.00	0.00	0.00
10	Surch.Traffic:Behind	↓	0.00	LS-b	1.0	0.00	1.75	0.00	0.00	0.00	1.75	0.00
	Total: Clockwise Moments			ΣM_+		179.09	---	281.06	---	179.09	---	179.09
	5	9				8						
	Vertical Load		11									
1	Reinforced Mass	↓	26.73	EV	1.0	26.73	1.35	36.09	1.00	26.73	1.00	26.73
2	Top Tringle Mass	↓	0.00	EV	1.0	0.00	1.35	0.00	1.00	0.00	1.00	0.00
3	Top Rectangle Mass	↓	0.00	EV	1.0	0.00	1.35	0.00	1.00	0.00	1.00	0.00
4	Earth Pressure	↓	0.00	EH	1.0	0.00	1.50	0.00	0.90	0.00	1.50	0.00
6	Surch.Dead:Top	↓	0.00	ES-t	1.0	0.00	1.35	0.00	1.00	0.00	1.00	0.00
7	Surch.Dead:Behind	↓	0.00	ES-b	1.0	0.00	1.50	0.00	0.75	0.00	1.50	0.00
9	Surch.Traffic:Top	↓	3.35	LS-t	0.0	0.00	1.75	5.86	0.00	0.00	0.00	0.00
10	Surch.Traffic:Behind	↓	0.00	LS-b	1.0	0.00	1.75	0.00	0.00	0.00	1.75	0.00
	Total Vertical Loads			ΣV		26.73	---	41.95	---	26.73	---	26.73
	Resultant from point A, y			(ft.)		4.95		4.96		5.56		3.96
	Eccentricity: $e = L/2-y$			(ft.)								

Results:

		$e=L/2-y$	e/L	
ASD		1.75 ft.	0.130	Ok
LRFD	Max	1.74 ft.	0.130	Ok
LRFD	Min	1.14 ft.	0.085	Ok
LRFD	Crit.	2.74 ft.	0.204	Ok

Load F	Max	Min	Crit	ASD
EV	1.35	1.00	1.00	1.0
EH	1.50	0.90	1.50	1.0
ES-t	1.35	1.00	1.00	1.0
ES-b	1.50	0.75	1.50	1.0
LS-t	1.75	0.00	0.00	0.0
LS-b	1.75	0.00	1.75	1.0

MSE Wall - External Stability Check

Static Sliding, Eccentricity & Bearing

Ref:FHWA-NHI-10-024 &025

Version: 2016-06
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Str. No. Walls 1 & 3, Sta.24+50 (h=19')
Check: scb 12/20/2021

	Critical Bearing:				5		2		3		4	
	5	9	14	8	Eccentri	Eccentricity:		e = *L* /2-*y*		Meyerhof str.	$\sigma_V = \Sigma V/(L-2e)$	
					ASD	LRFD	Max.Load Factor	Factored Load	Min.Load Factor	Factored Load	Crit.Load Factor	Factored Load
	Moments: Counter-Clockwise				Un-factored							
5	Earth Pressure	←	33.93	EH	1.0	33.93	1.50	50.90	*0.90*	30.54	1.50	50.90
8	Surch.Dead:Behind	←	0.00	ES-b	1.0	0.00	1.50	0.00	*0.75*	0.00	1.50	0.00
11	Surch.traffic:Behind	←	12.73	LS-b	1.0	12.73	1.75	22.28	*0.00*	0.00	1.75	22.28
	Total: Counter-Clockwise Moments			ΣM_-		46.66	---	73.17	---	30.54	---	73.17
	5	9	14	8								
	Moments: Clockwise											
1	Reinforced Mass	↓	179.09	EV	1.0	179.09	*1.35*	241.77	*1.00*	179.09	1.35	241.77
2	Top Tringle Mass	↓	0.00	EV	1.0	0.00	*1.35*	0.00	*1.00*	0.00	1.35	0.00
3	Top Rectangle Mass	↓	0.00	EV	1.0	0.00	*1.35*	0.00	*1.00*	0.00	1.35	0.00
4	Earth Pressure	↓	0.00	EH	1.0	0.00	*1.50*	0.00	*0.90*	0.00	1.50	0.00
6	Surch.Dead:Top	↓	0.00	ES-t	1.0	0.00	*1.35*	0.00	*1.00*	0.00	1.50	0.00
7	Surch.Dead:Behind	↓	0.00	ES-b	1.0	0.00	*1.50*	0.00	*0.75*	0.00	1.50	0.00
9	Surch.Traffic:Top	↓	22.45	LS-t	1.0	22.45	*1.75*	39.29	*0.00*	0.00	1.75	39.29
10	Surch.Traffic:Behind	↓	0.00	LS-b	1.0	0.00	*1.75*	0.00	*0.00*	0.00	1.75	0.00
	Total: Clockwise Moments			ΣM_+		201.54	---	281.06	---	179.09	---	281.06
	5	9	11	8								
	Vertical Load											
1	Reinforced Mass	↓	26.73	EV	1.0	26.73	*1.35*	36.09	*1.00*	26.73	1.35	36.09
2	Top Tringle Mass	↓	0.00	EV	1.0	0.00	*1.35*	0.00	*1.00*	0.00	1.35	0.00
3	Top Rectangle Mass	↓	0.00	EV	1.0	0.00	*1.35*	0.00	*1.00*	0.00	1.35	0.00
4	Earth Pressure	↓	0.00	EH	1.0	0.00	*1.50*	0.00	*0.90*	0.00	1.50	0.00
6	Surch.Dead:Top	↓	0.00	ES-t	1.0	0.00	*1.35*	0.00	*1.00*	0.00	1.50	0.00
7	Surch.Dead:Behind	↓	0.00	ES-b	1.0	0.00	*1.50*	0.00	*0.75*	0.00	1.50	0.00
9	Surch.Traffic:Top	↓	3.35	LS-t	1.0	3.35	*1.75*	5.86	*0.00*	0.00	1.75	5.86
10	Surch.Traffic:Behind	↓	0.00	LS-b	*1.00*	0.00	*1.75*	0.00	*0.00*	0.00	1.75	0.00
	Total Vertical Loads			Σ V		30.08	---	41.95	---	26.73	---	41.95
	Resultant from point A, *y*		(ft.)			5.15		4.96		5.56		4.96
										1.5	1.75	

Results:	ASD	LRFD	LRFD	LRFD
	Ser.	Max	Min	Crit.
Σ V (kips)	30.08	41.95	26.73	41.95
(ft)	5.15	4.96	5.56	4.96
e = *L* /2-*y* (ft)	1.55	1.74	1.14	1.74
e/*L*	0.116	0.130	0.085	0.130
$\sigma_V = \Sigma V/(L-2e)$ (ksf)	2.921	4.232	2.405	4.232

Load F	Max	Min	Crit	ASD
EV	1.35	1.00	1.35	*1.0*
EH	1.50	0.90	1.50	*1.0*
ES-t	*1.35*	1.00	*1.50*	*1.0*
ES-b	1.50	0.75	1.50	*1.0*
LS-t	1.75	0.00	1.75	*1.0*
LS-b	1.75	0.00	1.75	*1.0*

1.50 Chosen to match MSE-W approach

MSE Wall - External Stability Check

Static Sliding, Eccentricity & Bearing

Ref:FHWA-NHI-10-024 &025

Version: 2016-06
Coding: skk 10/27/2016
Validation: scb by MSE-W 10/31

Project: Opitz Blve
WRA#: 032023.000
Design: skk 12/20/2021
Str. No. Walls 1 & 3, Sta.24+50 (h=19')
Check: scb 12/20/2021

Critical Bearing (ctd):

Foundation Length L_w = 13.4 ft.

Mayerhof Bearing Capacity/Nominal Resistance, q_{ult}= 12.31 ksf

ASD *Values corresponds to un-factored loads & capacities*

Eccentricity	e	1.55	ft.
Vertical Loads, un-factored	ΣV	26.73	kips/LF
Required Allowable Bearing Capacity	σ_V =	2.60	ksf
Ultimate Bearing Capacity	q_{ult}=	12.31	ksf
Factor of Safety against Bearing	$FS_{bearing}$=	4.743	

LRFD *Values corresponds to maximum load factors*

		Serv.	Max	Min	Crit.
Eccentricity	e	1.55	1.74	1.14	1.74
Vertical Loads, un-factored	ΣV	30.08	41.95	26.73	41.95
Required Factored Bearing Stress	σ_V =	2.92	4.23	2.40	4.23
Nominal Bearing Capacity	q_{ult}=	12.31	12.31	12.31	12.31
Resistance factor for Bearing:	Φ_b=	0.5	0.65	0.65	0.65
Factored Bearing Resistance		6.16	8.00	8.00	8.00
	CDR=	2.11	1.89	3.33	1.89

Bearing Resistance: CDR $_{min}$= 1.89

Summary:

LRFD CDR	Target	Calc.	
Sliding	1.00	1.49	ok
Bearing	1.00	1.89	

ASD FS	Target	Calc.
Sliding	2.00	2.30
Bearing	3.00	4.74

Eccentricity	Max	ASD	LRFD
e/L	0.250	0.130	0.204
		ok	*ok*

Bearing Resistance / Capacity

Required Factored Bearing Resistance: 4.23 ksf

Required Allowable Bearing Capacity: 2.60 ksf

Notes: For excentricity and sliding

MSE Wall - External Stability Check
Static Sliding, Eccentricity & Bearing
Ref:FHWA-NHI-10-024 &025

Version: 2016-06
Coding: skk 10/27/2016
Validation: scb by MSE-W 10/31

Project: Opitz Blve
WRA#: 032023.000
Design: skk 12/20/2021
Str. No.: Walls 1 & 3, Sta.24+50 (h=19')
Check: scb 12/20/2021

EVALUATION OF NOMINAL BEARING RESISTANCE

DATA FROM PREVIOUS SHEETS:

Soil Parameters *12.31*

Cohesion $c =$ 0.0 psf
Foundatn Subgr. Soil Unit Wt. γ_{fs} 125.0 pcf
Friction Ang. $\phi_f =$ 30.0 degree
Surcharge Soil Unit Wt. γ_{sur} 110.0 pcf
Soils above footing bearing are as competent as subgrade soils? Yes

Foundation Dimensions

Footing Width $B=$ 13.40 ft.
Footing Depth $D_f =$ 2.00 ft
Footing Length $L=$ 50.00 ft.
G.Water Depth $D_w =$ 50.00 ft

Foundation Loads:

Unfactored Vert. Load V= 26.7 kips
Load Angle θ 0.0 deg
Unfactored Horz.Load H= 6.7 kips
Moment: ----
Eccentricity: $e_b=$ 1.7 ft. *(<3.4) ok*
e_L (ft)= *(<12.5) ok*

CALCULATION OF BEARING NOMINAL RESISTANCE:

Bearing Capacity Factors :

$N_c=(N_q-1)\cot\phi$
$N_\gamma = 2\,(N_q+1)\tan\phi$
$N_q=e^{(\pi \tan\phi)} \tan^2(45^o+\phi/2)$

$N_c =$ 30.14
$N_\gamma =$ 22.40
$N_q =$ 18.40

Effective Footing Dimensions: (Area reduction for assumed eccentricity)

$B' = B-2e_b =$ 9.9 ft
$L'=L-2e_L =$ 50.0 ft

Footing Shape Correction Factors:

For $\phi = 0$ $S_c = 1+(B'/5L')$ $S_\gamma = 1.0$ $S_q = 1$
For $\phi > 0$ $S_c = 1+(B'/L')\,(N_q/N_c)$ $S_\gamma = 1 - 0.4\,(B'/L')$ $S_q = 1+(B'/L')\tan\phi$
$S_c =$ 0.731 $S_\gamma =$ 0.921 $S_q =$ 1.114

Groundwater Correction Factors

$C_{wq} =$ 1.000 $C_{w\gamma} =$ 1.000

Depth Correction Factor:

Competent surcharge soils: Yes $D_f/B =$ 0.20 $d_q =$ 1.00

Load Inclination Factors:

$i_c =$ 1.000 $i_q =$ 0.705 $i_\gamma =$ 0.528

Nominal Bearing Resistance:

$q_n = c\,(N_c\,S_c\,i_c) + \gamma_{sur}\,D_f\,(N_q\,S_q\,d_q\,i_q)\,C_{wq} + 0.5\,\gamma_{fs}\,B\,(N_\gamma\,S_\gamma\,i_\gamma)\,C_{w\gamma}$

ASD FOS 2.0
LRFD Φq 0.65

C term 0.00 q term 3.18 B term 9.13

$q_n =$ *12.31* ksf Allowable q *6.16* ksf Factored q *8.00* ksf

NOTES:

Calc based on assumed foundation length and water table depth.

APPENDIX E.2

MSE Wall Calculations – Wall 1, Wall2, and Wall 3

Whitman, Requardt & Associates, LLP
Engineers · Architects · Environmental Planners Est. 1915

Elastic Settlement for Embankment
Hough Method Ref:FHWA-NHI-06-088

SOIL PROFILE
Data Input

Sheet 1 of 2
Version: V.12.03

Project Data

Project:	Opitz Blvd Express Lane	**Location:**	T-Ramp
			Sta. 24+50 (H=19')
WRA WO#:	45893-001	**Date:**	12/20/2021
Subject:	T-Ramp Loading mostly granular fill		

Calcualtion / Check

Calc :	skk
Date:	20-Dec-21
Chk:	SCB 12/21/21
Date:	

Subsurface Test Borings	B-A3-2 (lower DR)
Number of Layers (up to 14)	7
Depth to Groundwater (ft):	20
SPT Corrected for overburden (Yes/No)	Yes
SPT Correction for Efficiency (Yes/No)	Yes
Select the Rig for Hammer Eff.	3. Salut

SPT Hammer Efficiency

Rig No.	E_m
1. CME 55 (E2CR)	84%
2. CME 45 (F&R)	78%
3. Salut	88%
4. CME 45 Cathead	66%

Soil Types for C' Curve Selection

E_m = 88%

γ_{water} = 62.4

1	1 - Clean Uniform medium SAND
2	2 - Well Graded Silty SAND and GRAVEL
3	3 - Clean well graded fine to coarse Silty SAND
4	4 - Well graded fine to medium Silty SAND
5	5 - Inorganic SILT

Yes
No

Layer Data

Layer No.	Bottom Depth (ft)	SPT N Value	Soil Unit Wt. (pcf)		Curve for Bearing Capacity Index-C'			Soil Layer		Overburden		SPT N Value (correctd)	$C'_{(top)}$	$C'_{(bott)}$	C'
				Soil USCS	**Top Curve**	**% Top Curve**	**Description**	Top (z_1) (ft)	Bott.(z_2) (ft)	center p_c (psf)	bottom p_2 (psf)				
1	3.0	55	115.0	SM	1	100.0	100% Ty.1+0% Ty.2	0.0	3.0	172.5	345.0	161	3656	1546	3656
2	8.5	11	120.0	SM	1	100.0	100% Ty.1+0% Ty.2	3.0	8.5	675.0	1005.0	28	116	97	116
3	18.5	16	125.0	SP/GP	1	100.0	100% Ty.1+0% Ty.2	8.5	18.5	1630.0	2255.0	26	108	92	108
4	23.5	37	125.0	SP/GP	1	100.0	100% Ty.1+0% Ty.2	18.5	23.5	2505.1	2661.6	48	227	161	227
5	28.5	100	125.0	ML	5	100.0	100% Ty.5+0% Ty.6	23.5	28.5	2818.1	2974.6	124	193	193	193
6	36.0	33	125.0	SP/GP	1	100.0	100% Ty.1+0% Ty.2	28.5	36.0	3209.4	3444.1	38	162	126	162
7	50.0	100	125.0	SP/GP	1	100.0	100% Ty.1+0% Ty.2	36.0	50.0	3882.3	4320.5	105	1165	569	1165

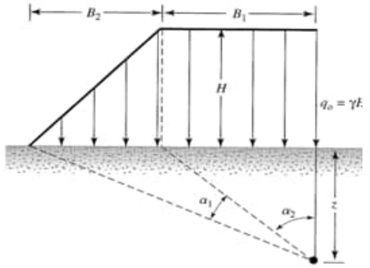
Elastic Settlement for Embankment	Calc skk		Sheet 2 of 2
Hough Method Settlement Estimations	Chk:		Version: V.2.00
Project: Opitz Blvd Express Lane	Location: T-Ramp	Subject:	Subject: T-Ramp Loading mostly granular fill

Stress Destribution for Two Areas

		Area 1	Area 2	Area 3
Multiplier		1	1	0
Height of Embankment		19	19	0
Soil Unit Weight		108	108	0
Rectangular Loading Width	B_1	18	18	0
Triangular Loading Width	B_2	0	0	0
FHWA Recommended factor for final settlement:	k_{FHWA}			0.5

Default Min. Value for B_2= 1E-10

Formulas:



$$\Delta\sigma_z = \frac{q_o}{\pi}\left[\left(\frac{B_1 + B_2}{B_2}\right)(\alpha_1 + \alpha_2) - \frac{B_1}{B_2}(\alpha_2)\right]$$

$$\Delta H = H\left(\frac{1}{C'}\right)\log_{10}\frac{p_o + \Delta p}{p_o}$$

Settlement Calculations:

Layer Data					Angles (radians)						Influence Factors			$q_0^{(a)}$	$q_0^{(b)}$	$q_0^{(c)}$		Settlements	
Layer No.	Middle Depth	Layer Thick.	Overbr. Press.	Bear. Factor	Area (a)		Area (b)		Area (c)		Area(a)	Area (b)	Area (c)	2052	2052	0	Total Δp	Per Layer	Cumu.
					B_1	B_2	B_1	B_2	B_1	B_2				$q_0 * I_z^{(c)}$	$q_0 * I_z^{(c)}$	$q_0 * I_z^{(c)}$			
	z_{mid}	h_i	p_0	C'	18.0	0.0	18.0	0.0	0.0	0.0				$\Delta p^{(a)}$	$\Delta p^{(b)}$	$\Delta p^{(c)}$			
	(ft)	(ft)	(psf)		$\alpha_1^{(a)}$	$\alpha_2^{(a)}$	$\alpha_1^{(b)}$	$\alpha_2^{(b)}$	$\alpha_1^{(c)}$	$\alpha_2^{(c)}$	$I_z^{(a)}$	$I_z^{(b)}$	$I_z^{(c)}$	(psf)	(psf)	(psf)	(psf)	(inch)	(inch)
1	1.5	3.0	172.5	3656	0.000	1.488	0.000	1.488	0.000	0.000	0.474	0.474	0.000	971.6	971.6	0.0	1943.2	0.01	0.01
2	5.8	5.5	675.0	116	0.000	1.262	0.000	1.262	0.000	0.000	0.402	0.402	0.000	824.1	824.1	0.0	1648.2	0.31	0.32
3	13.5	10.0	1630.0	108	0.000	0.927	0.000	0.927	0.000	0.000	0.295	0.295	0.000	605.8	605.8	0.0	1211.5	0.27	0.58
4	21.0	5.0	2505.1	227	0.000	0.709	0.000	0.709	0.000	0.000	0.226	0.226	0.000	462.7	462.7	0.0	925.5	0.04	0.62
5	26.0	5.0	2818.1	193	0.000	0.606	0.000	0.606	0.000	0.000	0.193	0.193	0.000	395.4	395.4	0.0	790.8	0.03	0.65
6	32.3	7.5	3209.4	162	0.000	0.509	0.000	0.509	0.000	0.000	0.162	0.162	0.000	332.4	332.4	0.0	664.8	0.05	0.70
7	43.0	14.0	3882.3	1165	0.000	0.396	0.000	0.396	0.000	0.000	0.126	0.126	0.000	259.0	259.0	0.0	517.9	0.01	0.71
																	ΔH=	0.71 inches	

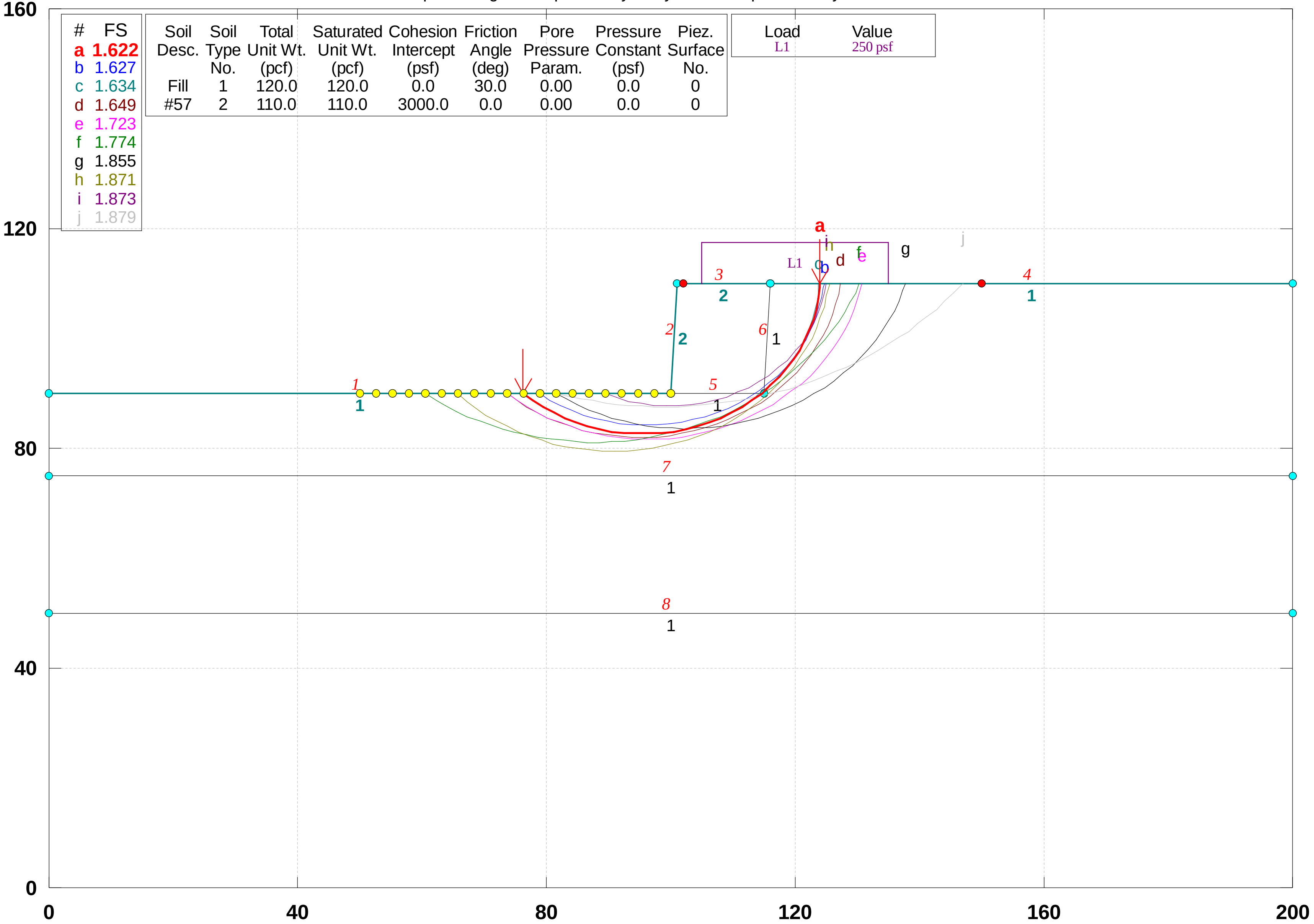
Final settlement ***(k_{FHWA} * ΔH) 0.71 x 0.50 = 0.35 inches***

APPENDIX E.2

MSE Wall Calculations – Wall 1, Wall2, and Wall 3

I-95 Exressway/Opitz Blvd (Trial-02) Global Stability Sta 24+50

c:\users\skesavan\desktop\retaining wall\slope stability anlaysis\trial-02.pl2   Run By: Username   12/28/2021   03:02PM



#	FS
a	1.622
b	1.627
c	1.634
d	1.649
e	1.723
f	1.774
g	1.855
h	1.871
i	1.873
j	1.879

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
Fill	1	120.0	120.0	0.0	30.0	0.00	0.0	0
#57	2	110.0	110.0	3000.0	0.0	0.00	0.0	0

Load	Value
L1	250 psf

GSTABL7 v.2 FSmin=1.622

Safety Factors Are Calculated By The Modified Bishop Method

APPENDIX E.2

MSE Wall Calculations – Wall 1, Wall2, and Wall 3

MSE Wall - External Stability Check

Static Sliding, Eccentricity & Bearing

Ref:FHWA-NHI-10-024 &025

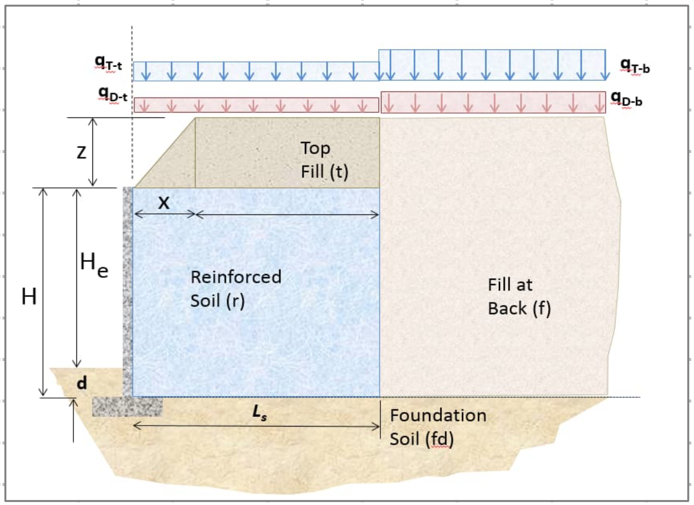
Version: 2016-06
Coding: skk 10/27/2016
Validation: scb by MSE-W 10/31

Project:	Opitz Blve	WRA#:	032023.000	Design:	skk 12/20/2021
Wall ID	Walls 1 & 3, Sta.22+50 (H=10')	Wall No.:		Check:	scb 12/20/2021

Assumptions/Notes:

Front of the abutment is modeled as a triangular portion.

Lateral loads behind the wall are assumed to be horizontal (per MSE-W assumption for slope < 45 deg.)



Wall Configuration

Backfill Slope

Broken Back Slope: No
Height *z* (ft.)=
Length *x* (ft.)=

Infinite Backfill: Yes
Infinite Slope β_{inf} = 0.00
Fall face assumed vertical
α= 0.00 deg.

Case	β_{eq}	Δh	h
5	0.00	0.00	10.00

Wall Dimensions

Exposed wall height	H_e =	8.00	ft.	*Table C.11..10.2.2.-1 Minimum Embedment*
Embedded Height	*d* =	2.00	ft.	Minimum Embedment = *H* /20 0.50 *ok*
Total Wall Length		30.00	ft. <==	(for bearing capacity calculations)

Reinforced Backfill	Friction Angle	ϕ_r =	34.0	degree	Unit Wt. γ_r=	105.0	pcf
Retained Fill (f)	(above and behind reinf. zone)	ϕ_f =	34.0	degree	γ_f=	105.0	pcf
Foundation Soil:		ϕ_{fd} =	30.0	degree	γ_{fd}=	120.0	pcf
Cohesion:	c_{fd} = 0.0 psf			Mayerhof Bearing, q_{ult}=	8.68	ksf	
Top of wall Backfill	Friction Angle	ϕ_t =	34.0	degree	Unit Wt. γ_t=	105.0	pcf

Surcharge Loading

Traffic @ wall Top	↓	q_{T-t}=	250	psf	Dead -top	↓	q_{D-t}=	0	psf
Traffic @ behind wall	↓	q_{T-b}=	250	psf	Dead -Behind	↓	q_{D-b}=	0	psf
Added horizontal Load	←	P_{BR-H}=	0	lb/LF					

Design Height and Estimated Reinforcement Length

Estimated Reinforcement Length : *L* = 8.00 ft. *Check for minimum L*

Design Height of the wall: *H* = H_e + *d* *H* = 10.00 ft. L_{min} = 8.0 ft. *ok*

Ratio for Estimated Reinforcement Length (> 0.7): 0.80 (*L* /*H*) *ok* *L* ≤ 2*H* *ok to use this spreadsheet*

Results Summmary

LRFD:			ASD:		Bearing Resistnace:		
Direct Sliding	CDR=	1.395	$FS_{Sliding}$	2.204	Required Factored Bearing=	2.409	ksf
Bearing Resist.	CDR=	2.342	$FS_{bearing}$	6.576	Required Service Bearing=	1.320	ksf
e /*L* = 0.203	CDR=	1.232 Critical	*e* /*L* =	0.127	e/L = 0.115 e =	0.92	ft

MSE Wall - External Stability Check

Static Sliding, Eccentricity & Bearing

Ref:FHWA-NHI-10-024 &025

Version: 2016-06
Coding: skk 10/27/2016
Validation: scb by MSE-W 10/31

Project: Opitz Blve
WRA#: 032023.000
Design: skk 12/20/2021
Str. No. Walls 1 & 3, Sta.22+50 (H=10')
Check: scb 12/20/2021

Load Factors	EV	EH	ES	LS
Strength I (maximum)	1.35	1.50	1.50	1.75
Strength I (minimum)	1.00	0.90	0.75	0.00
Service I	1.00	1.00	1.00	1.00

Resistance Factors	
Sliding of MSE wall on foundation soil	1.00
Bearing resistance	0.65
Tensile resistance (for steel strips)	0.75

Calculation of $\boldsymbol{\beta}_{eq}$ and h

L = 8.0 ft. H = 10.0 ft. x = ft. z = ft.

Case Description			$\boldsymbol{\beta}_{eq}$		Δh		L_T	$L_R = L - L_T$
1	For x<z;	$\boldsymbol{\beta}_{eq} = 0$		$\Delta h = z$		$L_T=0$		
2	x< L	$\boldsymbol{\beta}_{eq}=\tan^{-1}(z/2H)$		$\Delta h = z$		$L_T=x$		
3	L<x< 2H	$\boldsymbol{\beta}_{eq}=\tan^{-1}(z/2H)$		$\Delta h = L\,z/x$		$L_T=L$		
4	x > 2H	$\boldsymbol{\beta}_{eq}=\tan^{-1}(z/x)$		$\Delta h = L\,z/x$		$L_T=L$		
5	Infinite	$\boldsymbol{\beta}_{eq}=\boldsymbol{\beta}_{infinite}$	0.00		0.00	$L_T=L$	0.00	8.00
5	<=*Current Case*	$\boldsymbol{\beta}_{eq}$=	0.00 degree	Δh =	0.00 ft.		0.00	8.00
	$\boldsymbol{\beta}_{eq}$=		$h = H + \Delta h$	h =	10.00 ft.			

Coulomb Active Earth Pressure Coefficient for Retained fill

Reference: Eq. 3.11.5.3-1 AASHTO

$$K_A = \frac{\sin^2(\theta+\phi')}{\sin^2\theta\,\sin(\theta-\delta)\left[1+\sqrt{\dfrac{\sin(\phi+\delta)\,\sin(\phi'-\beta)}{\sin(\theta-\delta)\,\sin(\theta+\beta)}}\right]^2}$$

Note: $\phi' > \boldsymbol{\beta}$ $\phi f'$ = 34.0 degree

$\boldsymbol{\beta}$ = 0.00 degree

$\boldsymbol{\theta} = 90 + \boldsymbol{\alpha}$ $\boldsymbol{\theta}$ = 90.0 degree

$\boldsymbol{\delta} = \boldsymbol{\beta}$ $\boldsymbol{\delta}$ = 0.0 degree

T_1 = 0.3127 T_2 = 1 $\Gamma = [1 + \text{sqrt}(T_1/T_2)]^2$ Γ = 2.4311

T_t = 0.6873 T_b = 1 $K_A = T_t / (T_b * \Gamma)$ K_{af} = 0.283

Rankine Earth Pressure Coefficients

$$K_A = \cos\beta\left[\frac{\cos\beta - \sqrt{\cos^2\beta - \cos^2\phi'}}{\cos\beta + \sqrt{\cos^2\beta - \cos^2\phi'}}\right]$$

Equation 5.12 from FHWA-IF-03-017

(for comparison purposes)

T_{sq} = 0.5592 T_{cos} = 1

$K_A = T_{cos}(T_{cons} - T_{sq})/(T_{cos} + T_{sq})$

K_A = 0.283

Note :

MSE Wall - External Stability Check

Static Sliding, Eccentricity & Bearing

Ref:FHWA-NHI-10-024 &025

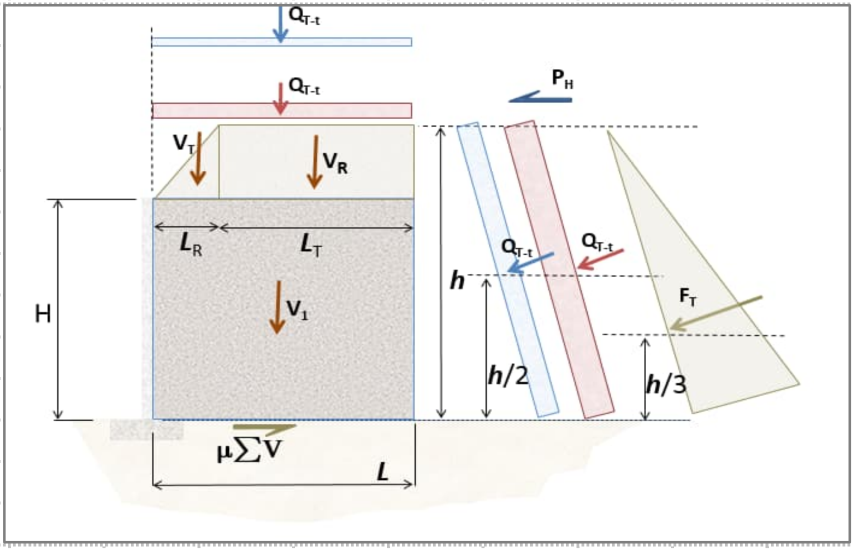
Version: 2016-06
Coding: skk 10/27/2016
Validation: scb by MSE-W 10/31

Project: Opitz Blve
WRA#: 032023.000
Design: skk 12/20/2021
Str. No. Walls 1 & 3, Sta.22+50 (H=10')
Check: scb 12/20/2021

Loads and Moments:

Data for Calculations:

L = 8.00 ft.
H = 10.00 ft.
h = 10.00 ft.
L_T = 0.00 ft.
L_R = 8.00 ft.
K_{af} = 0.283
γ_r = 105.0 pcf
γ_f = 105.0 pcf
γ_t = 105.0 pcf
β = 0.00 deg.
$q_{D\ top}$ = 0 psf
$q_{D\text{-}b}$ = 0 psf
$q_{T\text{-}top}$ = 250 psf
$q_{T\text{-}beh}$ = 250 psf
p_H = 0 lb/LF



Un-factored Loads: Horizontal, Vertical & Moment about Point A

				rounding	force	2	length	2	2
								Arm	M
						(kips/LF)	12	(ft.)	(ft. kips)
1	$V_1 = \gamma_r H L$	*Reinforced Mass*	EV	↓	V_1	8.40	$L/2$=	4.00	33.60
2	$V_T = (1/2)\ \gamma_t\ (h - H)\ L_T$	*Top Tringle Mass*	EV	↓	V_T	0.00	$2L_T/3$=	0.00	0.00
3	$V_R = \gamma_t\ (h - H)\ L_R$	*Top Rectangle Mass*	EV	↓	V_R	0.00	$L_T + L_R/2$=	4.00	0.00
4	$F_{TV} = (1/2)\ \gamma_f\ h^2 K_{af} \sin\beta$ F_T= 1.49	*Earth Pressure*	EH	↓	F_{TV}	0.00	L =	8.00	0.00
5	$F_{TH} = (1/2)\ \gamma_f\ h^2 K_{af} \cos\beta$	*Earth Pressure*	EH	←	F_{TH}	1.49	$h/3$=	3.33	4.96
6	$Q_{D\ top\text{-}V} = (q_{D\ top})\ L$	*Surch.Dead:Top*	ES-t	↓	$Q_{Dtop\text{-}V}$	0.00	$L/2$=	4.00	0.00
7	$Q_{DV} = (q_D)\ h\ K_{af} \sin\beta$	*Surch.Dead:Behind*	ES-b	↓	Q_{DbV}	0.00	L =	8.00	0.00
8	$Q_{DH} = (q_D)\ h\ K_{af} \cos\beta$	*Surch.Dead:Behind*	ES-b	←	Q_{DbH}	0.00	$h/2$=	5.00	0.00
9	$Q_{T\ top\text{-}V} = (q_T)\ L$	*Surch.Traffic:Top*	LS-t	↓	$Q_{T\ top\text{-}V}$	2.00	$L/2$=	4.00	8.00
10	$Q_{TV} = (q_{T\text{-}b})\ h\ K_{af} \sin\beta$	*Surch.Traffic:Behind*	LS-b	↓	Q_{TbV}	0.00	L =	8.00	0.00
11	$Q_{TH} = (q_{T\text{-}b})\ h\ K_{af} \cos\beta + P_{BR}$	*Surch.traffic:Behind*	LS-b	←	Q_{TbH}	0.71	$h/2$=	5.00	3.55

MSE Wall - External Stability Check

Static Sliding, Eccentricity & Bearing

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Project: Opitz Blve

WRA#: 032023.000

Design: skk 12/20/2021

Str. No. Walls 1 & 3, Sta.22+50 (H=10')

Check: scb 12/20/2021

	Static Sliding				5		2		3		4	
	5	9	11	8			Strength I(max)		Strength I(Min)		Critical	
	Horizontal Driving Forces				ASD		Max.Load Factor		Min.Load Factor		Crit.Load Factor	
	Horizontal Forces				Factor	Load	Factor	Load	Factor	Load	Factor	Load
5	Earth Pressure	←	1.49	EH	1.0	1.49	1.50	2.24	0.90	1.34	1.50	2.24
8	Surch.Dead:Behind	←	0.00	ES-b	1.0	0.00	1.50	0.00	0.75	0.00	1.50	0.00
11	Surch.traffic:Behind	←	0.71	LS-b	1.0	0.71	1.75	1.24	0.00	0.00	1.75	1.24
	Total Horizontal			$\Sigma H_{driving}$		2.20	---	3.48	---	1.34	---	3.48
	Vertical Loads											
1	Reinforced Mass	↓	8.40	EV	1.0	8.40	1.35	11.34	1.00	8.40	1.00	8.40
2	Top Tringle Mass	↓	0.00	EV	1.0	0.00	1.35	0.00	1.00	0.00	1.00	0.00
3	Top Rectangle Mass	↓	0.00	EV	1.0	0.00	1.35	0.00	1.00	0.00	1.00	0.00
4	Earth Pressure	↓	0.00	EH	1.0	0.00	1.50	0.00	0.90	0.00	1.50	0.00
6	Surch.Dead:Top	↓	0.00	ES-t	1.0	0.00	1.35	0.00	1.00	0.00	1.00	0.00
7	Surch.Dead:Behind	↓	0.00	ES-b	1.0	0.00	1.50	0.00	0.75	0.00	1.50	0.00
9	Surch.Traffic:Top	↓	2.00	LS-t	0.0	0.00	1.75	3.50	0.00	0.00	0.00	0.00
10	Surch.Traffic:Behind	↓	0.00	LS-b	1.0	0.00	1.75	0.00	0.00	0.00	1.75	0.00
	Total Vertical			ΣV		8.40	---	14.84	---	8.40	---	8.40

	Resisting Horizontal Loads for		Φ_{crit}=	30.00	ASD	Max	Min	Crit.
1	Reinforced Mass	↓			4.85	6.55	4.85	4.85
2	Top Tringle Mass	↓			0.00	0.00	0.00	0.00
3	Top Rectangle Mass	↓			0.00	0.00	0.00	0.00
4	Earth Pressure	↓			0.00	0.00	0.00	0.00
6	Surch.Dead:Top	↓			0.00	0.00	0.00	0.00
7	Surch.Dead:Behind	↓			0.00	0.00	0.00	0.00
9	Surch.Traffic:Top	↓			0.00	2.02	0.00	0.00
10	Surch.Traffic:Behind	↓			0.00	0.00	0.00	0.00
	Cohesion	$C_H = c_{fd} L$			0.00	0.00	0.00	0.00
				ΣV_{resist}	4.85	8.57	4.85	4.85

Results

ASD FS_{SL}= 2.204

LRFD CDR= 1.395

Note: For geogrid reinforced MSE, the sliding friction angle may be taken as minimum of ϕ_{fd} and two thirds of reinforced soil friction angle, (2/3) ϕ_r

Φ_{fd}= 30.00

Sliding Φ_r= 34

2/3 Φ_r= 22.67

Φ_{crit}= 22.67

Load F	Max	Min	Crit	ASD
EV	1.35	1.00	1.00	1.0
EH	1.50	0.90	1.50	1.0
ES-t	1.35	1.00	1.00	1.0
ES-b	1.50	0.75	1.50	1.0
LS-t	1.75	0.00	0.00	0.0
LS-b	1.75	0.00	1.75	1.0

MSE Wall - External Stability Check

Static Sliding, Eccentricity & Bearing

Ref:FHWA-NHI-10-024 &025

Version: 2016-06
Coding: skk 10/27/2016
Validation: scb by MSE-W 10/31

Project: Opitz Blve
WRA#: 032023.000
Design: skk 12/20/2021
Str. No. Walls 1 & 3, Sta.22+50 (H=10')
Check: scb 12/20/2021

	Eccentricity:				5		2		3		4	
	5	9		8								
					ASD	LRFD	Max.Load Factor	Factored Load	Min.Load Factor	Factored Load	Crit.Load Factor	Factored Load
	Moments: Counter-Clockwis		14		Un-factored							
5	Earth Pressure	←	4.96	EH	1.0	4.96	1.50	7.44	0.90	4.46	1.50	7.44
8	Surch.Dead:Behind	←	0.00	ES-b	1.0	0.00	1.50	0.00	0.75	0.00	1.50	0.00
11	Surch.traffic:Behind	←	3.55	LS-b	1.0	3.55	1.75	6.21	0.00	0.00	1.75	6.21
	Total: Counter-Clockwise Moments			ΣM_-		8.51	---	13.65	---	4.46	---	13.65
	Moments: Clockwise		14									
1	Reinforced Mass	↓	33.60	EV	1.0	33.60	1.35	45.36	1.00	33.60	1.00	33.60
2	Top Tringle Mass	↓	0.00	EV	1.0	0.00	1.35	0.00	1.00	0.00	1.00	0.00
3	Top Rectangle Mass	↓	0.00	EV	1.0	0.00	1.35	0.00	1.00	0.00	1.00	0.00
4	Earth Pressure	↓	0.00	EH	1.0	0.00	1.50	0.00	0.90	0.00	1.50	0.00
6	Surch.Dead:Top	↓	0.00	ES-t	1.0	0.00	1.35	0.00	1.00	0.00	1.00	0.00
7	Surch.Dead:Behind	↓	0.00	ES-b	1.0	0.00	1.50	0.00	0.75	0.00	1.50	0.00
9	Surch.Traffic:Top	↓	8.00	LS-t	0.0	0.00	1.75	14.00	0.00	0.00	0.00	0.00
10	Surch.Traffic:Behind	↓	0.00	LS-b	1.0	0.00	1.75	0.00	0.00	0.00	1.75	0.00
	Total: Clockwise Moments			ΣM_+		33.60	---	59.36	---	33.60	---	33.60
	5	9				8						
	Vertical Load		11									
1	Reinforced Mass	↓	8.40	EV	1.0	8.40	1.35	11.34	1.00	8.40	1.00	8.40
2	Top Tringle Mass	↓	0.00	EV	1.0	0.00	1.35	0.00	1.00	0.00	1.00	0.00
3	Top Rectangle Mass	↓	0.00	EV	1.0	0.00	1.35	0.00	1.00	0.00	1.00	0.00
4	Earth Pressure	↓	0.00	EH	1.0	0.00	1.50	0.00	0.90	0.00	1.50	0.00
6	Surch.Dead:Top	↓	0.00	ES-t	1.0	0.00	1.35	0.00	1.00	0.00	1.00	0.00
7	Surch.Dead:Behind	↓	0.00	ES-b	1.0	0.00	1.50	0.00	0.75	0.00	1.50	0.00
9	Surch.Traffic:Top	↓	2.00	LS-t	0.0	0.00	1.75	3.50	0.00	0.00	0.00	0.00
10	Surch.Traffic:Behind	↓	0.00	LS-b	1.0	0.00	1.75	0.00	0.00	0.00	1.75	0.00
	Total Vertical Loads			ΣV		8.40	---	14.84	---	8.40	---	8.40
	Resultant from point A, y			(ft.)		2.99		3.08		3.47		2.37
	Eccentricity: $e = L/2 - y$			(ft.)								

Results:

		$e = L/2 - y$	e/L	
ASD		1.01 ft.	0.127	Ok
LRFD	Max	0.92 ft.	0.115	Ok
LRFD	Min	0.53 ft.	0.066	Ok
LRFD	Crit.	1.63 ft.	0.203	Ok

Load F	Max	Min	Crit	ASD
EV	1.35	1.00	1.00	1.0
EH	1.50	0.90	1.50	1.0
ES-t	1.35	1.00	1.00	1.0
ES-b	1.50	0.75	1.50	1.0
LS-t	1.75	0.00	0.00	0.0
LS-b	1.75	0.00	1.75	1.0

MSE Wall - External Stability Check

Static Sliding, Eccentricity & Bearing

Ref:FHWA-NHI-10-024 &025

Version: 2016-06

Coding: skk 10/27/2016

Validation: scb by MSE-W 10/31

Project: Opitz Blve

WRA#: 032023.000

Design: skk 12/20/2021

Str. No. Walls 1 & 3, Sta.22+50 (H=10')

Check: scb 12/20/2021

	Critical Bearing:				5		2		3		4	
	5	9	14	8	Eccentri	Eccentricity:	e = *L* /2-*y*		Meyerhof str.		$\sigma_V = \Sigma V /(L -2e)$	
					ASD	LRFD	Max.Load	Factored	Min.Load	Factored	Crit.Load	Factored
	Moments: Counter-Clockwise				Un-factored		Factor	Load	Factor	Load	Factor	Load
5	Earth Pressure	←	4.96	EH	1.0	4.96	1.50	7.44	0.90	4.46	1.50	7.44
8	Surch.Dead:Behind	←	0.00	ES-b	1.0	0.00	1.50	0.00	0.75	0.00	1.50	0.00
11	Surch.traffic:Behind	←	3.55	LS-b	1.0	3.55	1.75	6.21	0.00	0.00	1.75	6.21
	Total: Counter-Clockwise Moments			ΣM_-		8.51	---	13.65	---	4.46	---	13.65
	5	9	14	8								
	Moments: Clockwise											
1	Reinforced Mass	↓	33.60	EV	1.0	33.60	1.35	45.36	1.00	33.60	1.35	45.36
2	Top Tringle Mass	↓	0.00	EV	1.0	0.00	1.35	0.00	1.00	0.00	1.35	0.00
3	Top Rectangle Mass	↓	0.00	EV	1.0	0.00	1.35	0.00	1.00	0.00	1.35	0.00
4	Earth Pressure	↓	0.00	EH	1.0	0.00	1.50	0.00	0.90	0.00	1.50	0.00
6	Surch.Dead:Top	↓	0.00	ES-t	1.0	0.00	1.35	0.00	1.00	0.00	1.50	0.00
7	Surch.Dead:Behind	↓	0.00	ES-b	1.0	0.00	1.50	0.00	0.75	0.00	1.50	0.00
9	Surch.Traffic:Top	↓	8.00	LS-t	1.0	8.00	1.75	14.00	0.00	0.00	1.75	14.00
10	Surch.Traffic:Behind	↓	0.00	LS-b	1.0	0.00	1.75	0.00	0.00	0.00	1.75	0.00
	Total: Clockwise Moments			ΣM_+		41.60	---	59.36	---	33.60	---	59.36
	5	9	11	8								
	Vertical Load											
1	Reinforced Mass	↓	8.40	EV	1.0	8.40	1.35	11.34	1.00	8.40	1.35	11.34
2	Top Tringle Mass	↓	0.00	EV	1.0	0.00	1.35	0.00	1.00	0.00	1.35	0.00
3	Top Rectangle Mass	↓	0.00	EV	1.0	0.00	1.35	0.00	1.00	0.00	1.35	0.00
4	Earth Pressure	↓	0.00	EH	1.0	0.00	1.50	0.00	0.90	0.00	1.50	0.00
6	Surch.Dead:Top	↓	0.00	ES-t	1.0	0.00	1.35	0.00	1.00	0.00	1.50	0.00
7	Surch.Dead:Behind	↓	0.00	ES-b	1.0	0.00	1.50	0.00	0.75	0.00	1.50	0.00
9	Surch.Traffic:Top	↓	2.00	LS-t	1.0	2.00	1.75	3.50	0.00	0.00	1.75	3.50
10	Surch.Traffic:Behind	↓	0.00	LS-b	1.00	0.00	1.75	0.00	0.00	0.00	1.75	0.00
	Total Vertical Loads			Σ V		10.40	---	14.84	---	8.40	---	14.84
		Resultant from point A, *y*		(ft.)		3.18		3.08		3.47		3.08
										1.5	1.75	

Results:		ASD	LRFD	LRFD	LRFD
		Ser.	Max	Min	Crit.
Σ V	(kips)	10.40	14.84	8.40	14.84
	(ft)	3.18	3.08	3.47	3.08
e = *L* /2-*y*	(ft)	0.82	0.92	0.53	0.92
e/*L*		0.102	0.115	0.066	0.115
σ_V=ΣV /(L -2e)	(ksf)	1.634	2.409	1.211	2.409

Load F	Max	Min	Crit	ASD
EV	1.35	1.00	1.35	1.0
EH	1.50	0.90	1.50	1.0
ES-t	1.35	1.00	1.50	1.0
ES-b	1.50	0.75	1.50	1.0
LS-t	1.75	0.00	1.75	1.0
LS-b	1.75	0.00	1.75	1.0

1.50 Chosen to match MSE-W approach

MSE Wall - External Stability Check

Static Sliding, Eccentricity & Bearing

Ref:FHWA-NHI-10-024 &025

Version: 2016-06
Coding: skk 10/27/2016
Validation: scb by MSE-W 10/31

Project: Opitz Blve
WRA#: 032023.000
Design: skk 12/20/2021
Str. No. Walls 1 & 3, Sta.22+50 (H=10')
Check: scb 12/20/2021

Critical Bearing (ctd):

Foundation Length L_w = 8.0 ft.

Mayerhof Bearing Capacity/Nominal Resistance, q_{ult}= 8.68 ksf

ASD *Values corresponds to un-factored loads & capacities*

Eccentricity	e	0.82	ft.
Vertical Loads, un-factored	ΣV	8.40	kips/LF
Required Allowable Bearing Capacity	σ_V =	1.32	ksf
Ultimate Bearing Capacity	q_{ult}=	8.68	ksf
Factor of Safety against Bearing	$FS_{bearing}$=	6.576	

LRFD *Values corresponds to maximum load factors*

		Serv.	Max	Min	Crit.
Eccentricity	e	0.82	0.92	0.53	0.92
Vertical Loads, un-factored	ΣV	10.40	14.84	8.40	14.84
Required Factored Bearing Stress	σ_V =	1.63	2.41	1.21	2.41
Nominal Bearing Capacity	q_{ult}=	8.68	8.68	8.68	8.68
Resistance factor for Bearing:	Φ_b=	0.5	0.65	0.65	0.65
Factored Bearing Resistance		4.34	5.64	5.64	5.64
	CDR=	2.66	2.34	4.66	2.34

Bearing Resistance: CDR_{min}= 2.34

Summary:

LRFD CDR	Target	Calc.	
Sliding	1.00	1.40	ok
Bearing	1.00	2.34	

ASD FS	Target	Calc.
Sliding	2.00	2.20
Bearing	3.00	6.58

Eccentricity	Max	ASD	LRFD
e/L	0.250	0.127	0.203
		ok	*ok*

Bearing Resistance / Capacity

Required Factored Bearing Resistance: 2.41 ksf

Required Allowable Bearing Capacity: 1.32 ksf

Notes: For excentricity and sliding

MSE Wall - External Stability Check
Static Sliding, Eccentricity & Bearing
Ref:FHWA-NHI-10-024 &025

Version: 2016-06
Coding: skk 10/27/2016
Validation: scb by MSE-W 10/31

Project:	Opitz Blve	WRA#:	032023.000	Design:	skk 12/20/2021
Str. No.:	Walls 1 & 3, Sta.22+50 (H=10')			Check:	scb 12/20/2021

EVALUATION OF NOMINAL BEARING RESISTANCE

DATA FROM PREVIOUS SHEETS:

Soil Parameters *8.68*

Cohesion $c =$	0.0	psf	Foundatn Subgr. Soil Unit Wt. γ_{fs}	125.0	pcf
Friction Ang. $\phi_f =$	30.0	degree	Surcharge Soil Unit Wt. γ_{sur}	120.0	pcf

Soils above footing bearing are as competent as subgrade soils? Yes

Foundation Dimensions

Footing Width $B=$	8.00	ft.	Footing Depth $D_f =$	2.00	ft
Footing Length $L=$	30.00	ft.	G.Water Depth $D_w =$	50.00	ft

Foundation Loads:

Unfactored Vert. Load V=	8.4	kips	Load Angle θ	0.0	deg
Unfactored Horz.Load H=	2.2	kips	Moment:	----	
Eccentricity: $e_b=$	1.0	ft. *(<2.0) ok*	e_L (ft)=		*(<7.5) ok*

CALCULATION OF BEARING NOMINAL RESISTANCE:

Bearing Capacity Factors :

$N_c=(N_q-1)\cot\phi$ $N_\gamma = 2(N_q+1)\tan\phi$ $N_q=e^{(\pi\tan\phi)}\tan^2(45^\circ+\phi/2)$

$N_c = 30.14$ $N_\gamma = 22.40$ $N_q = 18.40$

Effective Footing Dimensions: (Area reduction for assumed eccentricity)

$B' = B-2e_b = 6.0$ ft $L'=L-2e_L =$ 30.0 ft

Footing Shape Correction Factors:

For $\phi = 0$	$S_c = 1+(B'/5L')$	$S_\gamma = 1.0$	$S_q = 1$
For $\phi > 0$	$S_c = 1+(B'/L')(N_q/N_c)$	$S_\gamma = 1-0.4(B'/L')$	$S_q = 1+(B'/L')\tan\phi$
	$S_c =$ 0.732	$S_\gamma =$ 0.92	$S_q =$ 1.115

Groundwater Correction Factors

$C_{wq} =$ 1.000 $C_{w\gamma} =$ 1.000

Depth Correction Factor:

Competent surcharge soils: Yes $D_f/B =$ 0.33 $d_q =$ 1.00

Load Inclination Factors:

$i_c =$ 1.000 $i_q =$ 0.692 $i_\gamma =$ 0.511

Nominal Bearing Resistance:

$q_n = c(N_c S_c i_c) + \gamma_{sur} D_f (N_q S_q d_q i_q) C_{wq} + 0.5\gamma_{fs} B(N_\gamma S_\gamma i_\gamma) C_{w\gamma}$ ASD FOS 2.0

C term 0.00 q term 3.41 B term 5.27 LRFD Φq 0.65

$q_n =$ *8.68* ksf Allowable q *4.34* ksf Factored q *5.64* ksf

NOTES:

Calc based on assumed foundation length and water table depth.

APPENDIX E.2

MSE Wall Calculations – Wall 1, Wall2, and Wall 3

Whitman, Requardt & Associates, LLP
Engineers · Architects · Environmental Planners Est. 1915

Elastic Settlement for Embankment
Hough Method Ref:FHWA-NHI-06-088

SOIL PROFILE
Data Input

Sheet 1 of 2
Version: V.12.03

Project Data

Project:	Opitz Blvd Express Lane	**Location:**	T-Ramp
			Sta. 22+50 (H=10')
WRA WO#:	45893-001	**Date:**	12/20/2021
Subject:	T-Ramp Loading mostly soil		

Calcualtion / Check

Calc :	skk
Date:	20-Dec-21
Chk:	SCB 12/21/21
Date:	

Subsurface Test Borings	B-A3-5 (Weak hole)
Number of Layers (up to 14)	7
Depth to Groundwater (ft):	20
SPT Corrected for overburden (Yes/No)	Yes
SPT Correction for Efficiency (Yes/No)	Yes
Select the Rig for Hammer Eff.	3. Salut

SPT Hammer Efficiency

Rig No.	E_m
1. CME 55 (E2CR)	84%
2. CME 45 (F&R)	78%
3. Salut	88%
4. CME 45 Cathead	66%

Soil Types for C' Curve Selection

E_m = 88%

γ_{water} = 62.4

1	1 - Clean Uniform medium SAND
2	2 - Well Graded Silty SAND and GRAVEL
3	3 - Clean well graded fine to coarse Silty SAND
4	4 - Well graded fine to medium Silty SAND
5	5 - Inorganic SILT

Yes
No

Layer Data

Layer No.	Bottom Depth (ft)	SPT N Value	Soil Unit Wt. (pcf)	Curve for Bearing Capacity Index-C'				Soil Layer		Overburden		SPT N Value (correctd)	$C'_{(top)}$	$C'_{(bott)}$	C'
				Soil USCS	Top Curve	% Top Curve	Description	Top (z_1) (ft)	Bott.(z_2) (ft)	center p_c (psf)	bottom p_2 (psf)				
1	**4.0**	**12**	**115.0**	**SM**	**1**	**100.0**	100% Ty.1+0% Ty.2	0.0	4.0	230.0	460.0	35	147	117	147
2	**7.0**	**6**	**120.0**	**SM**	**1**	**100.0**	100% Ty.1+0% Ty.2	4.0	7.0	640.0	820.0	16	76	68	76
3	**16.0**	**7**	**125.0**	**SP/GP**	**1**	**100.0**	100% Ty.1+0% Ty.2	7.0	16.0	1382.5	1945.0	12	66	59	66
4	**18.0**	**4**	**125.0**	**SP/GP**	**1**	**100.0**	100% Ty.1+0% Ty.2	16.0	18.0	2070.0	2195.0	6	51	46	51
5	**20.0**	**4**	**125.0**	**ML**	**5**	**100.0**	100% Ty.5+0% Ty.6	18.0	20.0	2320.0	2445.0	5	23	23	23
6	**36.0**	**15**	**125.0**	**SP/GP**	**1**	**100.0**	100% Ty.1+0% Ty.2	20.0	36.0	2945.8	3446.6	18	82	73	82
7	**50.0**	**25**	**125.0**	**SP/GP**	**1**	**100.0**	100% Ty.1+0% Ty.2	36.0	50.0	3884.8	4323.0	26	108	92	108

Elastic Settlement for Embankment
Hough Method Settlement Estimations

Calc skk
Chk:

Sheet 2 of 2
Version: V.2.00

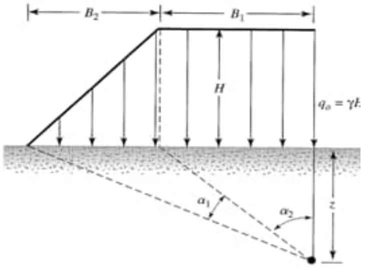
Project: Opitz Blvd Express Lane Location: T-Ramp Subject: Subject: T-Ramp Loading mostly soil

Stress Destribution for Two Areas

	Area 1	Area 2	Area 3
Multiplier	1	1	0
Height of Embankment	10	10	0
Soil Unit Weight	115	115	0
Rectangular Loading Width B_1	18	18	0
Triangular Loading Width B_2	0	0	0
FHWA Recommended factor for final settlement: k_{FHWA}			0.5

Default Min. Value for B_2= 1E-10

Formulas:



$$\Delta\sigma_z = \frac{q_o}{\pi}\left[\left(\frac{B_1 + B_2}{B_2}\right)(\alpha_1 + \alpha_2) - \frac{B_1}{B_2}(\alpha_2)\right]$$

$$\Delta H = H\left(\frac{1}{C'}\right)\log_{10}\frac{p_o + \Delta p}{p_o}$$

Settlement Calculations:

Layer Data					Angles (radians)						Influence Factors			$q_0^{(a)}$	$q_0^{(b)}$	$q_0^{(c)}$		Settlements	
Layer No.	Middle Depth	Layer Thick.	Overbr. Press.	Bear. Factor	Area (a)		Area (b)		Area (c)		Area(a)	Area (b)	Area (c)	1150	1150	0	Total		
					B_1	B_2	B_1	B_2	B_1	B_2				$q_0 * I_z^{(c)}$	$q_0 * I_z^{(c)}$	$q_0 * I_z^{(c)}$	Δp	Per	Cumu.
	z_{mid}	h_i	p_0	C'	18.0	0.0	18.0	0.0	0.0	0.0				$\Delta p^{(a)}$	$\Delta p^{(b)}$	$\Delta p^{(c)}$		Layer	
	(ft)	(ft)	(psf)		$\alpha_1^{(a)}$	$\alpha_2^{(a)}$	$\alpha_1^{(b)}$	$\alpha_2^{(b)}$	$\alpha_1^{(c)}$	$\alpha_2^{(c)}$	$I_z^{(a)}$	$I_z^{(b)}$	$I_z^{(c)}$	(psf)	(psf)	(psf)	(psf)	(inch)	(inch)
1	2.0	4.0	230.0	147	0.000	1.460	0.000	1.460	0.000	0.000	0.465	0.465	0.000	534.4	534.4	0.0	1068.8	0.25	0.25
2	5.5	3.0	640.0	76	0.000	1.274	0.000	1.274	0.000	0.000	0.406	0.406	0.000	466.4	466.4	0.0	932.9	0.18	0.43
3	11.5	9.0	1382.5	66	0.000	1.002	0.000	1.002	0.000	0.000	0.319	0.319	0.000	366.9	366.9	0.0	733.7	0.30	0.73
4	17.0	2.0	2070.0	51	0.000	0.814	0.000	0.814	0.000	0.000	0.259	0.259	0.000	298.0	298.0	0.0	595.9	0.05	0.78
5	19.0	2.0	2320.0	23	0.000	0.758	0.000	0.758	0.000	0.000	0.241	0.241	0.000	277.6	277.6	0.0	555.2	0.10	0.88
6	28.0	16.0	2945.8	82	0.000	0.571	0.000	0.571	0.000	0.000	0.182	0.182	0.000	209.1	209.1	0.0	418.1	0.13	1.02
7	43.0	14.0	3884.8	108	0.000	0.396	0.000	0.396	0.000	0.000	0.126	0.126	0.000	145.1	145.1	0.0	290.3	0.05	1.07
																	ΔH=	1.07 inches	

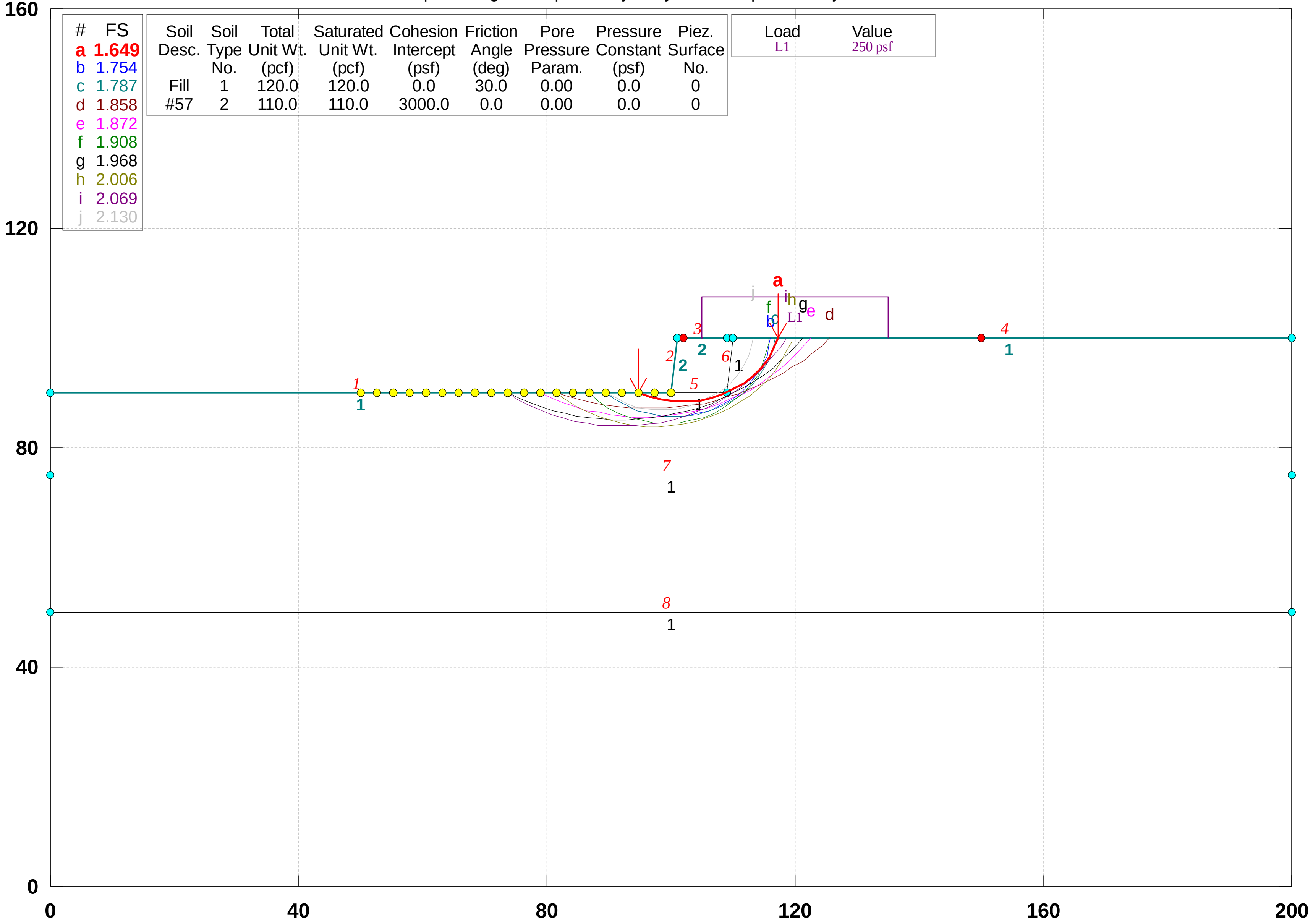
Final settlement ***(k_{FHWA} * ΔH)*** ***1.07 x 0.50 = 0.53 inches***

APPENDIX E.2

MSE Wall Calculations – Wall 1, Wall2, and Wall 3

I-95 Exressway/Opitz Blvd (Trial-03) Global Stability Sta 22+50

c:\users\skesavan\desktop\retaining wall\slope stability anlaysis\trial-03.pl2   Run By: Username   12/28/2021   03:07PM



#	FS
a	1.649
b	1.754
c	1.787
d	1.858
e	1.872
f	1.908
g	1.968
h	2.006
i	2.069
j	2.130

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
Fill	1	120.0	120.0	0.0	30.0	0.00	0.0	0
#57	2	110.0	110.0	3000.0	0.0	0.00	0.0	0

Load	Value
L1	250 psf

GSTABL7 v.2 FSmin=1.649

Safety Factors Are Calculated By The Modified Bishop Method

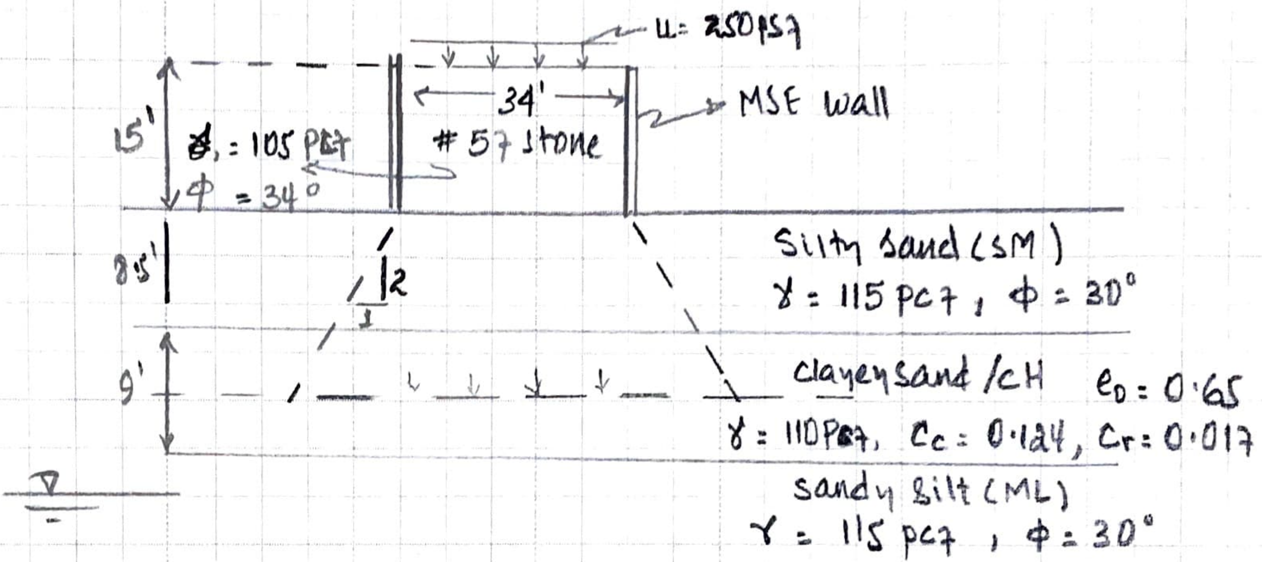
APPENDIX E.2

MSE Wall Calculations – Wall 1, Wall2, and Wall 3

Project I-95 Express Lanes - Opitz Blvd Conn W.O. # 45893.001 Date 1/4/2022
Designed by JY Checked by SS Sheet 1 of 1

consolidation Settlement computation (MSE Wall Sta. 23+50)

Boring considered in the analysis (B-A3-4)



P_0 @ center of clayey layer = (115 * 8.5) + (110 * 4.5)

= 1.472 ksf

$$\Delta p = \left((105\ \text{pcf} * 15\ \text{ft}) + 250\ \text{psf}\right)\frac{34\ \text{ft}}{47\ \text{ft}} = 1.32\ \text{ksf}$$

P_c (Pre consolidation pressure) = 1.786 ksf

$P_0 + \Delta p$ = 1.472 ksf + 1.32 ksf = 2.792 ksf > P_c

$$S_c = \frac{C_r H}{1+e_0}\log \frac{P_c}{P_0} + \frac{C_c H}{1+e_0}\log\left(\frac{P_0+\Delta P}{P_c}\right)$$

$$= \frac{0.017}{1.65}\log\left(\frac{1.786}{1.472}\right) + \frac{0.124(9)}{1.65}\log\left(\frac{2.792}{1.786}\right)$$

= 0.0078 ft + 0.1312 = 0.14 ft = 1.67 inches

Whitman, Requardt & Associates, LLP
Engineers · Architects · Environmental Planners Est. 1915

Elastic Settlement for Embankment
Hough Method Ref:FHWA-NHI-06-088

SOIL PROFILE
Data Input

Sheet 1 of 2
Version: V.12.03

Project Data

Project:	Opitz Blvd Express Lane	**Location:**	T-Ramp
			Sta. 23+50 (H=10')
WRA WO#:	45893-001	**Date:**	1/4/2022
Subject:	T-Ramp Loading mostly soil		

Calcualtion / Check

Calc :	skk
Date:	4-Jan-22
Chk:	scb
Date:	4-Jan-22

Subsurface Test Borings	B-A3-4 (Weak hole)
Number of Layers (up to 14)	5
Depth to Groundwater (ft):	20
SPT Corrected for overburden (Yes/No)	Yes
SPT Correction for Efficiency (Yes/No)	Yes
Select the Rig for Hammer Eff.	3. Salut

SPT Hammer Efficiency

Rig No.	E_m
1. CME 55 (E2CR)	84%
2. CME 45 (F&R)	78%
3. Salut	88%
4. CME 45 Cathead	66%

E_m = 88%

γ_{water} = 62.4

Soil Types for C' Curve Selection

1	1 - Clean Uniform medium SAND
2	2 - Well Graded Silty SAND and GRAVEL
3	3 - Clean well graded fine to coarse Silty SAND
4	4 - Well graded fine to medium Silty SAND
5	5 - Inorganic SILT

Yes
No

Layer Data

Layer No.	Bottom Depth (ft)	SPT N Value	Soil Unit Wt. (pcf)	Soil USCS	Curve for Bearing Capacity Index-C' Top Curve	% Top Curve	Description	Soil Layer Top (z_1) (ft)	Bott.(z_2) (ft)	Overburden center p_c (psf)	bottom p_2 (psf)	SPT N Value (correctd)	C'$_{(top)}$	C'$_{(bott)}$	C'
1	3.0	70	115.0	SM	1	100.0	100% Ty.1+0% Ty.2	0.0	3.0	172.5	345.0	205	7256	2922	7256
2	12.0	10	120.0	SM	1	100.0	100% Ty.1+0% Ty.2	3.0	12.0	885.0	1425.0	22	94	82	94
3	21.0	200	125.0	SP/GP	1	100.0	100% Ty.1+0% Ty.2	12.0	21.0	1987.5	2487.6	294	20752	8012	20752
4	25.0	100	125.0	SP/GP	1	100.0	100% Ty.1+0% Ty.2	21.0	25.0	2612.8	2738.0	128	1951	883	1951
5	70.0	100	125.0	SP/GP	1	100.0	100% Ty.1+0% Ty.2	25.0	70.0	4146.5	5555.0	102	1083	536	1083

Whitman, Requardt & Associates, LLP
Engineers · Architects · Environmental Planners Est. 1915

Elastic Settlement for Embankment		Calc	skk	Sheet 2 of 2	
Hough Method	Settlement Estimations	Chk:	scb	Version:	V.2.00

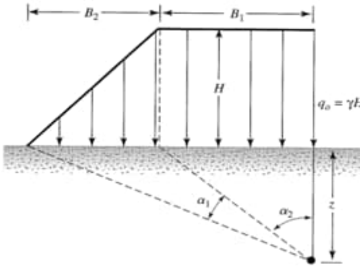
Project: Opitz Blvd Express Lane Location: T-Ramp Subject: Subject: T-Ramp Loading mostly soil

Stress Destribution for Two Areas

		Area 1	Area 2	Area 3
Multiplier		1	1	0
Height of Embankment		10	10	0
Soil Unit Weight		115	115	0
Rectangular Loading Width	B_1	18	18	0
Triangular Loading Width	B_2	0	0	0
FHWA Recommended factor for final settlement:	k_{FHWA}			0.5

Default Min. Value for B_2= 1E-10

Formulas:



$$\Delta\sigma_z = \frac{q_o}{\pi}\left[\left(\frac{B_1 + B_2}{B_2}\right)(\alpha_1 + \alpha_2) - \frac{B_1}{B_2}(\alpha_2)\right]$$

$$\Delta H = H\left(\frac{1}{C'}\right)\log_{10}\frac{p_0 + \Delta p}{p_0}$$

Settlement Calculations:

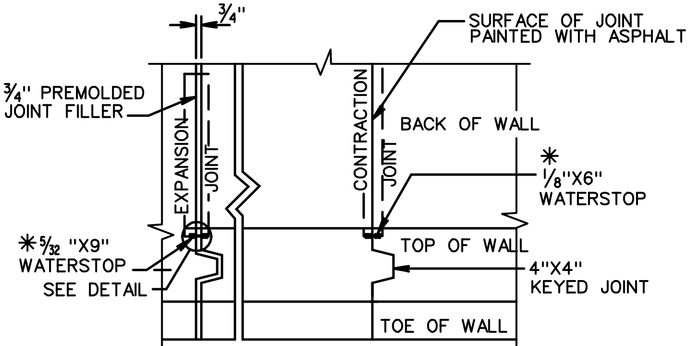
Layer Data					Angles (radians)						Influence Factors			$q_0^{(a)}$	$q_0^{(b)}$	$q_0^{(c)}$		Settlements	
Layer No.	Middle Depth	Layer Thick.	Overbr. Press.	Bear. Factor	Area (a)		Area (b)		Area (c)		Area(a)	Area (b)	Area (c)	1150	1150	0	Total	Per	Cumu.
					B_1	B_2	B_1	B_2	B_1	B_2				$q_0{*}\ I_z^{(c)}$	$q_0{*}\ I_z^{(c)}$	$q_0{*}\ I_z^{(c)}$	Δp	Layer	
	z_{mid}	h_i	p_0	C'	18.0	0.0	18.0	0.0	0.0	0.0				$\Delta p^{(a)}$	$\Delta p^{(b)}$	$\Delta p^{(c)}$			
	(ft)	(ft)	(psf)		$\alpha_1^{(a)}$	$\alpha_2^{(a)}$	$\alpha_1^{(b)}$	$\alpha_2^{(b)}$	$\alpha_1^{(c)}$	$\alpha_2^{(c)}$	$I_z^{(a)}$	$I_z^{(b)}$	$I_z^{(c)}$	(psf)	(psf)	(psf)	(psf)	(inch)	(inch)
1	1.5	3.0	172.5	7256	0.000	1.488	0.000	1.488	0.000	0.000	0.474	0.474	0.000	544.5	544.5	0.0	1089.1	0.00	0.00
2	7.5	9.0	885.0	94	0.000	1.176	0.000	1.176	0.000	0.000	0.374	0.374	0.000	430.4	430.4	0.0	860.9	0.34	0.34
3	16.5	9.0	1987.5	20752	0.000	0.829	0.000	0.829	0.000	0.000	0.264	0.264	0.000	303.4	303.4	0.0	606.7	0.00	0.34
4	23.0	4.0	2612.8	1951	0.000	0.664	0.000	0.664	0.000	0.000	0.211	0.211	0.000	243.1	243.1	0.0	486.2	0.00	0.35
5	47.5	45.0	4146.5	1083	0.000	0.362	0.000	0.362	0.000	0.000	0.115	0.115	0.000	132.6	132.6	0.0	265.2	0.01	0.36
																	ΔH=	0.36 inches	

Final settlement ***(k_{FHWA} * ΔH)*** ***0.36 x 0.50 = 0.18 inches***

Consolidation Settlement 1.67 inch Total 1.85 inch

APPENDIX E.3

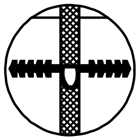
RW-3 Gravity Retaining Wall



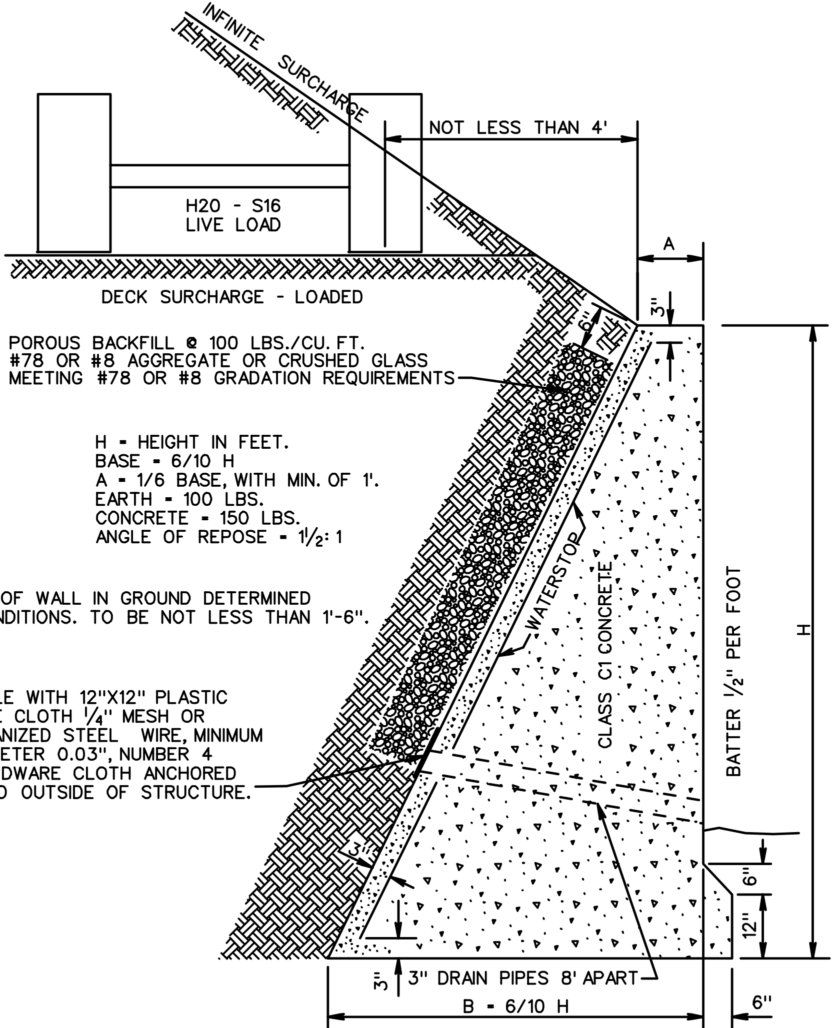
CONTRACTION JOINTS AT INTERVALS NOT EXCEEDING 30'.

EXPANSION JOINTS AT INTERVALS NOT EXCEEDING 90'.

* WATER STOPS TO BE ELASTOMERIC OR OTHER APPROVED MATERIAL. DIMENSIONS SHOWN ARE ABSOLUTE MINIMUM.



WATERSTOP DETAIL



H = HEIGHT IN FEET.
BASE = 6/10 H
A = 1/6 BASE, WITH MIN. OF 1'.
EARTH = 100 LBS.
CONCRETE = 150 LBS.
ANGLE OF REPOSE = 1½: 1

NOTE:
DEPTH OF WALL IN GROUND DETERMINED BY CONDITIONS. TO BE NOT LESS THAN 1'-6".

HEIGHT OF WALL "H" IN FEET	THICKNESS AT TOP "A" IN FEET	THICKNESS AT BASE B=.6H	COMPRESSION AT TOE LBS. PER SQ. FT.	AREA OF SECTION SQ. FT.
3	1'-0"	1'-9⅝"	856	4.83
4	1'-0"	2'-4¾"	1141	7.43
5	1'-0"	3'-0"	1427	10.63
6	1'-0"	3'-7¼"	1712	14.43
7	1'-0"	4'-2⅜"	1997	18.83
8	1'-0"	4'-9⅝"	2283	23.83
9	1'-0"	5'-4¾"	2568	29.43
10	1'-0"	6'-0"	2853	35.63
11	1'-1 1/4 "	6'-7¼"	3139	42.98
12	1'-2 3/8 "	7'-2⅜"	3424	51.03
13	1'-3 5/8 "	7'-9⅝"	3709	59.78
14	1'-4 3/4 "	8'-4¾"	3995	69.23
15	1'-6"	9'-0"	4280	79.38

SAFE BEARING CAPACITY OF SOIL	
ROCK MINIMUM	10,000 - 20,000 LBS. PER SQ. FT.
GRAVEL AND COARSE SAND, WELL CEMENTED	16,000 - 20,000 LBS. PER SQ. FT.
CLAY IN THICK BEDS, ALWAYS DRY	12,000 - 16,000 LBS. PER SQ. FT.
CLAY IN THICK BEDS, MODERATELY DRY	8,000 - 12,000 LBS. PER SQ. FT.
CLAY, SOFT	2,000 - 4,000 LBS. PER SQ. FT.
SAND, DRY, COMPACT, AND WELL CEMENTED	8,000 - 12,000 LBS. PER SQ. FT.
SAND, CLEAN, DRY	4,000 - 8,000 LBS. PER SQ. FT.
ALLUVIAL SOILS, ETC	1,000 - 2,000 LBS. PER SQ. FT.

NOTE: IF COMPRESSION AT TOE EXCEEDS SAFE BEARING CAPACITY OF SOIL, A SPECIAL FOOTING IS TO BE USED.

CONCRETE GRAVITY RETAINING WALLS
INFINITE SURCHARGE AND DECK SURCHARGE - LOADED

VIRGINIA DEPARTMENT OF TRANSPORTATION

SPECIFICATION REFERENCE

506

REV 8/07

APPENDIX E.3

RW-3 Gravity Retaining Wall

WRA

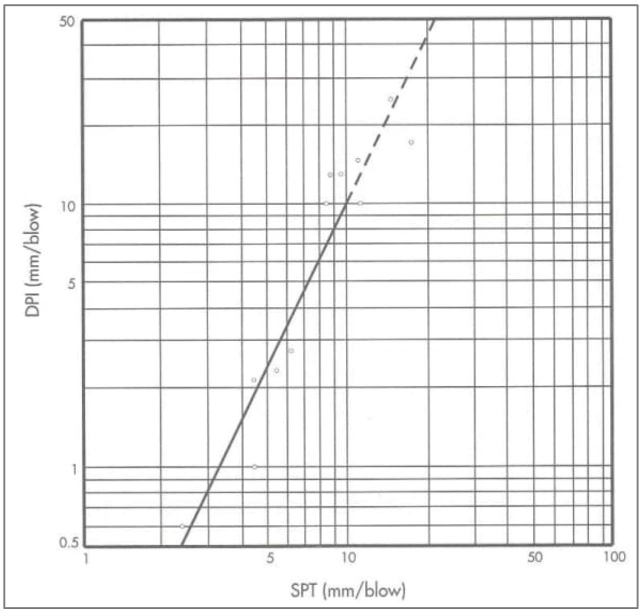
Friction Angle from DCP and STP Corelations

Project: *I-95 Expressway /Opitz Blvd*
Woodbridge, VA
WRA # *32175-000*
DCP No. DCP-SE
Calc by: *skk 12/27/2021*
Chk by: *scb*
Test Hole: *DCP-SE*
Test Date:
DCP Weight Used: *8 kg (17.6 lb)*

DCP Penetration Index (DPI) and SPT Results

Ref: MnROAD (1993), User guide to the DCP

Mn/DOT Office of Material Research and Engineering



SPT N and Friction Angle

AASHTO LRFD 2016 Table 10.4.6.5.4-1

(Description boundaries modified)

$(N_1)_{60}$	Friction Angle		Descrip.
	Min	Max	
1	25°	30°	Very Loose
4	25°	30°	
5	27°	32°	Loose
10	27°	32°	
11	30°	35°	Medium
30	30°	35°	
31	35°	40°	Dense
50	35°	40°	
51	38°	43°	Very Dense
100	38°	43°	

Log - Log Straight Line

	Point-1	Point -2	
I_{SPT} (y)	3.0	10.0	$m =$ 0.4767
I_{DCP} (x)	0.8	10.0	$c=$ 0.5233

Equation $\log_{10}(I_{SPT}) = m \log_{10}(I_{DCP})+c$

Overburden Corretion

Assumed soil Unit Wt. *120.0* pcf

$N_1 = C_N N$

$C_N = [0.77 \log_{10}(40/\sigma'_v)]$, and $C_N < 2.0$

Wt. Factor 2

	Sample Mid Depth (ft.)	DCP blows/6"	Estimation of Equivalent SPT N					Surcharge Pressure (ksf)	Overburden Corrected N_1 blows/12"	Friction Angle ϕ AASHTOTable 10.4.6.5.4-1	
			I_{DCP} mm/blow	$\log_{10}(I_{DCP})$	$\log_{10}(I_{SPT})$	I_{DCP} mm/blow	SPT N blows/12"			Min	Max
1	*0.50*	*2*	152.4	2.183	1.564	36.6	8	0.060	16	30°	35°
2	*1.50*	*3*	101.6	2.007	1.480	30.2	10	0.180	18	30°	35°
3	*2.50*	*3*	101.6	2.007	1.480	30.2	10	0.300	16	30°	35°
4	*3.50*	*3*	101.6	2.007	1.480	30.2	10	0.420	15	30°	35°
5	*4.50*	*3*	101.6	2.007	1.480	30.2	10	0.540	14	30°	35°
6	*5.50*	*4*	76.2	1.882	1.420	26.3	11	0.660	15	30°	35°
7	*6.50*	*7*	43.5	1.639	1.305	20.2	15	0.780	19	30°	35°
8	*6.75*	*6*	50.8	1.706	1.336	21.7	14	0.810	18	30°	35°
9											
10											

Notes: For lighter hammer weight, a factor 2 is used per ASTM D6951.

APPENDIX E.3

RW-3 Gravity Retaining Wall

Nominal Bearing Resistance

Reference: AASHTO LRFD

sk	Ver:	V.03.00
WR&A	Date:	12/29/21

Project & Structure Data:

Project: *I-95 Express Way /Opitz Blvd* Structure: *RW-3 Walls at SE Quadrant*

WRA #: *045893-001* Foundation: *Foundations for 5 ft wall*

Calculated by: *skk, 12/29/2021* **Checked by:** *skk, 12/29/2021*

Soil Parameters

Cohesion c = *0.0* psf Foundatn Subgr. Soil Unit Wt. γ_{fs} *125.0* pcf

Friction Ang. ϕ_f = *30.0* degree Surcharge Soil Unit Wt. γ_{sur} *125.0* pcf

Soils above footing bearing are as competent as subgrade soils? *Yes*

Foundation Dimensions

Footing Width B= *5.00* ft Footing Depth D_f = *5.0* ft

Footing Length L= *40.0* ft G.Water Depth D_w = *15.0* ft

Foundation Loads:

Unfactored Vert. Load V= *0.0* kips Load Angle θ *0.0* deg

Unfactored Horz.Load H= *0.0* kips Moment: *----*

Assumed Eccentricity: e_b (ft)= *0.0* *(<0.8) ok* e_L (ft)= *0.0* *(<6.7) ok*

Bearing Capacity Factors :

$N_c=(N_q-1)\cot\phi$ $N_\gamma = 2\,(N_q+1)\tan\phi$ $N_q=e^{(\pi\tan\phi)}\tan^2(45^o+\phi/2)$

N_c = 30.14 N_γ = 22.40 N_q = 18.40

Effective Footing Dimensions:

(Area reduction for assumed eccentricity)

$B' = B-2e_b$ = 5.0 ft $L'=L-2e_L$ = 40.0 ft

Footing Shape Correction Factors:

For $\phi = 0$ $S_c = 1+ (B'/5L')$ S_γ= 1.0 S_q= 1

For $\phi > 0$ $S_c = 1+ (B'/L')\,(N_q/N_c)$ $S_\gamma = 1 - 0.4\,(B'/L')$ $S_q = 1+ (B'/L')\tan\phi$

S_c= 0.687 S_γ= 0.95 S_q= 1.072

Groundwater Correction Factors

C_{wq}= 1.000 $C_{w\gamma}$= 1.000

Depth Correction Factor:

Competent surcharge soils: *Yes* D_f/B= 1.00 d_q= 1.00

Load Inclination Factors:

i_c = 1.000 i_q = 1.000 i_γ = 1.000

Nominal Bearing Resistance:

$q_n = c\,(N_c\,S_c\,i_c) + \gamma_{sur}\,D_f\,(N_q\,S_q\,d_q\,i_q)\,C_{wq} + 0.5\,\gamma_{fs}\,B'\,(N_\gamma\,S_\gamma\,i_\gamma)\,C_{w\gamma}$ ASD FOS *3.0*

C term 0.00 q term 12.33 B term 6.65 LRFD Φq *0.45*

q_n = *18.98* ksf q_{all} *6.33* ksf $q_{factored}$ *8.54* ksf

Notes: *Correction value for slope =* *0.69* ***qall*** ***4.37 ksf***

APPENDIX E.3

RW-3 Gravity Retaining Wall

Reduction Coefficients (RC_{BC}) - Footing on Slope	Coding: skk 01/01/22 Ver.01	Project: *I-95 Expressway at Opitz Blvd*	Sheet 1 of 3
Ref: Table 10.6.3.1.2c-2, AASHTO LRFD Bridge Design Spec.	Validation: gk 01/03/22	WRA W/O # *45893-001*	
Subject: *RW-3 Wall Foundation, Max Height Case, Southeast Quadrent*		Calc: *skk 01/03/22*	Chk: *gk 01/03/22*

Input

Slope Angle: (Range 20 to 30 deg)

x = *47.00 ft.*

y = *22.00 ft.*

β= 25.1°

Internal Friciton Angle: (Range 20 to 40 deg)

ϕ= *30.0°*

Foundation Dimensions

b = *8.00 ft.*

B = *4.30 ft.*

H = *32.00 ft.*

Interpolation Range

ϕ =	30.0°	B/H =	0.13
ϕ_1=	30°	$[B/H]_1$ =	0.20
ϕ_2=	30°	$[B/H]_2$ =	0.20
β =	25.1°	b/B =	1.86
β_1 =	20°	$[b/B]_1$ =	1.25
β_2 =	30°	$[b/B]_2$ =	2.50

Schematic

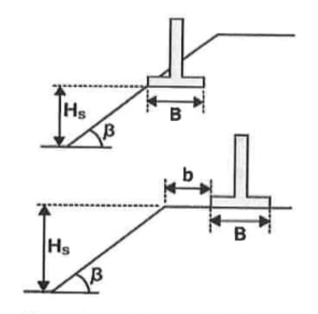
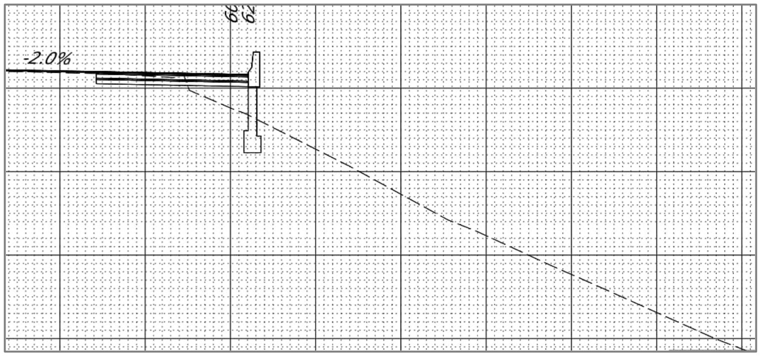


Figure 10.6.3.1.2c-1—Definition of Footing and Slope Geometric Parameters for Determination of RC_{BC}

Typical Section

Section at Sta.70+25



Results: Final RC_{BC} 0.69

Interpolation

Final RC_{BC}	*VLOOKUP Code Multiplier* *1.00E+04* ϕ=30	 *1.00E+03* ß=25	 *1.00E+03* B/H=0.13	 *1.00E+00* b/B=1.86	**VLOOKUP Code**	RC_{BC}
	ϕ=30	ß=20	B/H=0.2	b/B=1.25	*320201.25*	0.72
0.69	*0.69*	*0.83*	*0.83*	b/B=2.50	*320202.50*	0.94
			B/H=0.2	b/B=1.25	*320201.25*	0.72
			0.83	b/B=2.50	*320202.50*	0.94
		ß=30	B/H=0.2	b/B=1.25	*330201.25*	0.38
		0.56	*0.56*	b/B=2.50	*330202.50*	0.74
			B/H=0.2	b/B=1.25	*330201.25*	0.38
			0.56	b/B=2.50	*330202.50*	0.74
	ϕ=30	ß=20	B/H=0.2	b/B=1.25	*320201.25*	0.72
	0.69	*0.83*	*0.83*	b/B=2.50	*320202.50*	0.94
			B/H=0.2	b/B=1.25	*320201.25*	0.72
			0.83	b/B=2.50	*320202.50*	0.94
		ß=30	B/H=0.2	b/B=1.25	*330201.25*	0.38
		0.56	*0.56*	b/B=2.50	*330202.50*	0.74
			B/H=0.2	b/B=1.25	*330201.25*	0.38
			0.56	b/B=2.50	*330202.50*	0.74
Interpolation direction	<--	<--	<---			<--

Notes:

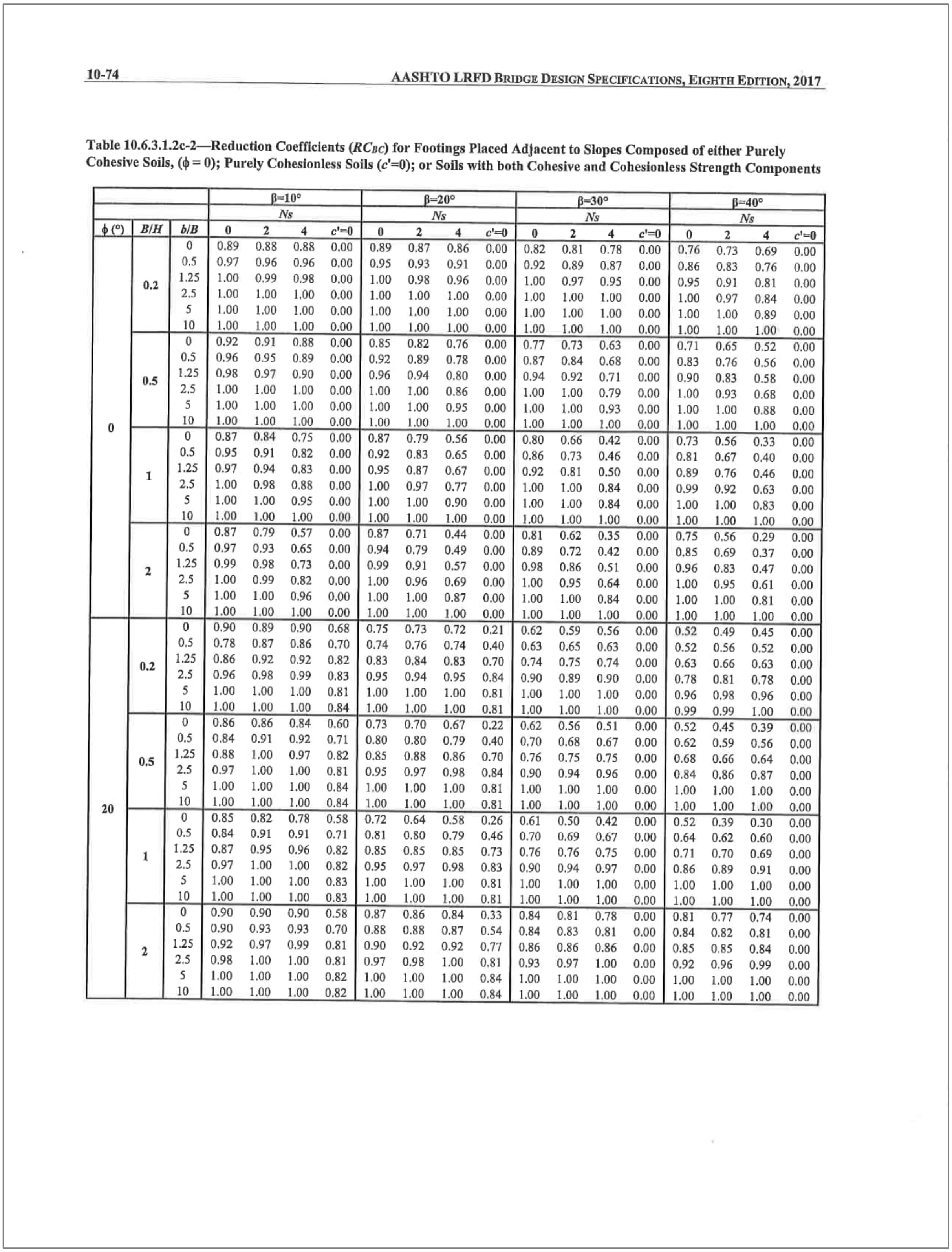
Coefficients for (B/H)=0.2 are assumed for cases (B/H)<0.2.

Purely Cohesionless soils (c'=0)

Friction angle (ϕ) should be greater than slope angle.

Reduction Coefficients (RC $_{BC}$) - Footing on Slope

Ref: Table 10.6.3.1.2c-2, AASHTO LRFD Bridge Design Specifications, 8th Ed.



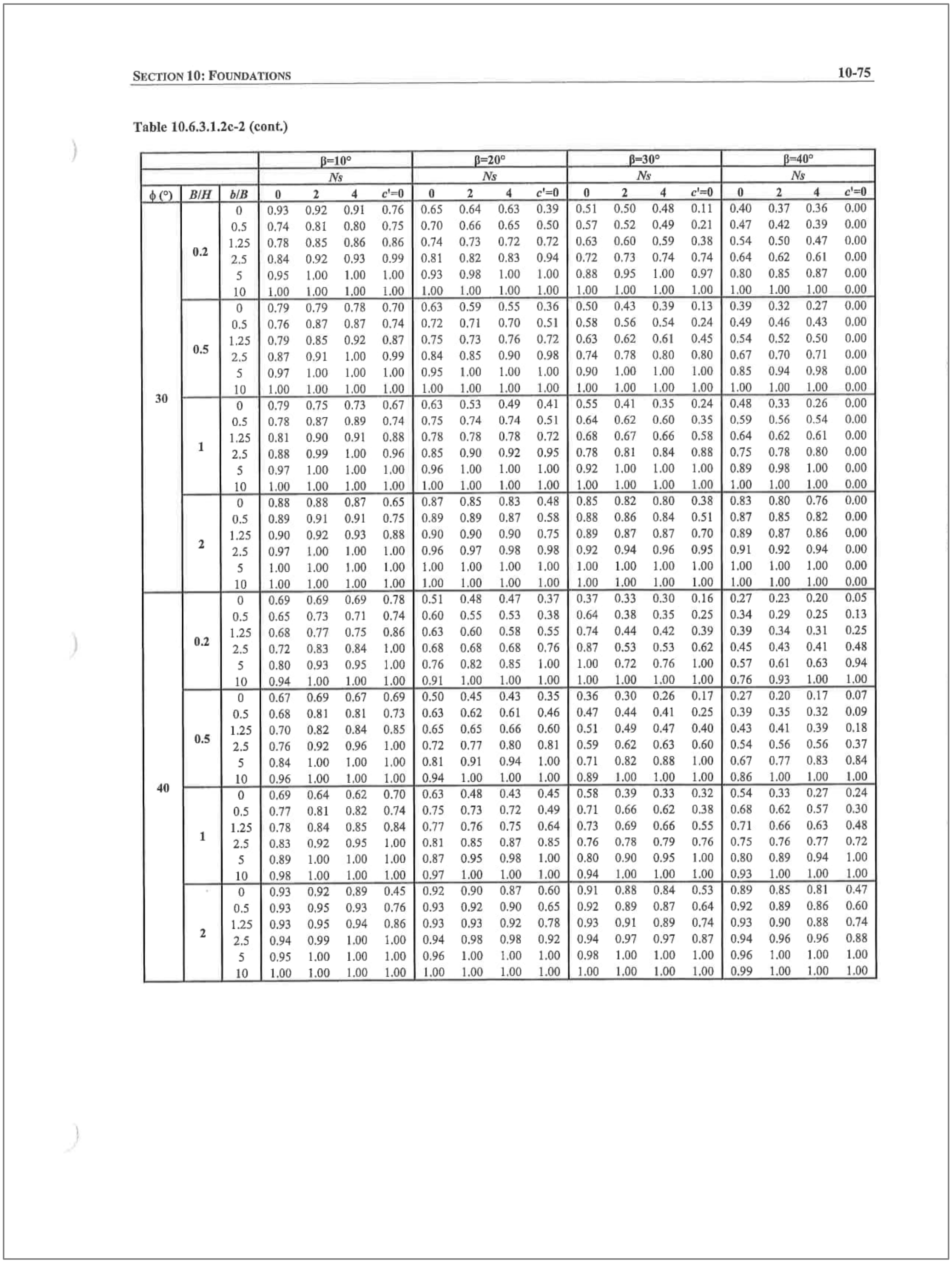
10-74 AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS, EIGHTH EDITION, 2017

Table 10.6.3.1.2c-2—Reduction Coefficients (RC_{BC}) for Footings Placed Adjacent to Slopes Composed of either Purely Cohesive Soils, ($\phi = 0$); Purely Cohesionless Soils (c'=0); or Soils with both Cohesive and Cohesionless Strength Components

			β=10°				β=20°				β=30°				β=40°			
			Ns				*Ns*				*Ns*				*Ns*			
ϕ (°)	***B/H***	***b/B***	**0**	**2**	**4**	***c*'=0**	**0**	**2**	**4**	***c*'=0**	**0**	**2**	**4**	***c*'=0**	**0**	**2**	**4**	***c*'=0**
0	**0.2**	0	0.89	0.88	0.88	0.00	0.89	0.87	0.86	0.00	0.82	0.81	0.78	0.00	0.76	0.73	0.69	0.00
		0.5	0.97	0.96	0.96	0.00	0.95	0.93	0.91	0.00	0.92	0.89	0.87	0.00	0.86	0.83	0.76	0.00
		1.25	1.00	0.99	0.98	0.00	1.00	0.98	0.96	0.00	1.00	0.97	0.95	0.00	0.95	0.91	0.81	0.00
		2.5	1.00	1.00	1.00	0.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	0.00	1.00	0.97	0.84	0.00
		5	1.00	1.00	1.00	0.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	0.00	1.00	1.00	0.89	0.00
		10	1.00	1.00	1.00	0.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	0.00
	0.5	0	0.92	0.91	0.88	0.00	0.85	0.82	0.76	0.00	0.77	0.73	0.63	0.00	0.71	0.65	0.52	0.00
		0.5	0.96	0.95	0.89	0.00	0.92	0.89	0.78	0.00	0.87	0.84	0.68	0.00	0.83	0.76	0.56	0.00
		1.25	0.98	0.97	0.90	0.00	0.96	0.94	0.80	0.00	0.94	0.92	0.71	0.00	0.90	0.83	0.58	0.00
		2.5	1.00	1.00	1.00	0.00	1.00	1.00	0.86	0.00	1.00	1.00	0.79	0.00	1.00	0.93	0.68	0.00
		5	1.00	1.00	1.00	0.00	1.00	1.00	0.95	0.00	1.00	1.00	0.93	0.00	1.00	1.00	0.88	0.00
		10	1.00	1.00	1.00	0.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	0.00
	1	0	0.87	0.84	0.75	0.00	0.87	0.79	0.56	0.00	0.80	0.66	0.42	0.00	0.73	0.56	0.33	0.00
		0.5	0.95	0.91	0.82	0.00	0.92	0.83	0.65	0.00	0.86	0.73	0.46	0.00	0.81	0.67	0.40	0.00
		1.25	0.97	0.94	0.83	0.00	0.95	0.87	0.67	0.00	0.92	0.81	0.50	0.00	0.89	0.76	0.46	0.00
		2.5	1.00	0.98	0.88	0.00	1.00	0.97	0.77	0.00	1.00	1.00	0.84	0.00	0.99	0.92	0.63	0.00
		5	1.00	1.00	0.95	0.00	1.00	1.00	0.90	0.00	1.00	1.00	0.84	0.00	1.00	1.00	0.83	0.00
		10	1.00	1.00	1.00	0.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	0.00
	2	0	0.87	0.79	0.57	0.00	0.87	0.71	0.44	0.00	0.81	0.62	0.35	0.00	0.75	0.56	0.29	0.00
		0.5	0.97	0.93	0.65	0.00	0.94	0.79	0.49	0.00	0.89	0.72	0.42	0.00	0.85	0.69	0.37	0.00
		1.25	0.99	0.98	0.73	0.00	0.99	0.91	0.57	0.00	0.98	0.86	0.51	0.00	0.96	0.83	0.47	0.00
		2.5	1.00	0.99	0.82	0.00	1.00	0.96	0.69	0.00	1.00	0.95	0.64	0.00	1.00	0.95	0.61	0.00
		5	1.00	1.00	0.96	0.00	1.00	1.00	0.87	0.00	1.00	1.00	0.84	0.00	1.00	1.00	0.81	0.00
		10	1.00	1.00	1.00	0.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	0.00
20	**0.2**	0	0.90	0.89	0.90	0.68	0.75	0.73	0.72	0.21	0.62	0.59	0.56	0.00	0.52	0.49	0.45	0.00
		0.5	0.78	0.87	0.86	0.70	0.74	0.76	0.74	0.40	0.63	0.65	0.63	0.00	0.52	0.56	0.52	0.00
		1.25	0.86	0.92	0.92	0.82	0.83	0.84	0.83	0.70	0.74	0.75	0.74	0.00	0.63	0.66	0.63	0.00
		2.5	0.96	0.98	0.99	0.83	0.95	0.94	0.95	0.84	0.90	0.89	0.90	0.00	0.78	0.81	0.78	0.00
		5	1.00	1.00	1.00	0.81	1.00	1.00	1.00	0.81	1.00	1.00	1.00	0.00	0.96	0.98	0.96	0.00
		10	1.00	1.00	1.00	0.84	1.00	1.00	1.00	0.81	1.00	1.00	1.00	0.00	0.99	0.99	1.00	0.00
	0.5	0	0.86	0.86	0.84	0.60	0.73	0.70	0.67	0.22	0.62	0.56	0.51	0.00	0.52	0.45	0.39	0.00
		0.5	0.84	0.91	0.92	0.71	0.80	0.80	0.79	0.40	0.70	0.68	0.67	0.00	0.62	0.59	0.56	0.00
		1.25	0.88	1.00	0.97	0.82	0.85	0.88	0.86	0.70	0.76	0.75	0.75	0.00	0.68	0.66	0.64	0.00
		2.5	0.97	1.00	1.00	0.81	0.95	0.97	0.98	0.84	0.90	0.94	0.96	0.00	0.84	0.86	0.87	0.00
		5	1.00	1.00	1.00	0.84	1.00	1.00	1.00	0.81	1.00	1.00	1.00	0.00	1.00	1.00	1.00	0.00
		10	1.00	1.00	1.00	0.84	1.00	1.00	1.00	0.81	1.00	1.00	1.00	0.00	1.00	1.00	1.00	0.00
	1	0	0.85	0.82	0.78	0.58	0.72	0.64	0.58	0.26	0.61	0.50	0.42	0.00	0.52	0.39	0.30	0.00
		0.5	0.84	0.91	0.91	0.71	0.81	0.80	0.79	0.46	0.70	0.69	0.67	0.00	0.64	0.62	0.60	0.00
		1.25	0.87	0.95	0.96	0.82	0.85	0.85	0.85	0.73	0.76	0.76	0.75	0.00	0.71	0.70	0.69	0.00
		2.5	0.97	1.00	1.00	0.82	0.95	0.97	0.98	0.83	0.90	0.94	0.97	0.00	0.86	0.89	0.91	0.00
		5	1.00	1.00	1.00	0.83	1.00	1.00	1.00	0.81	1.00	1.00	1.00	0.00	1.00	1.00	1.00	0.00
		10	1.00	1.00	1.00	0.83	1.00	1.00	1.00	0.81	1.00	1.00	1.00	0.00	1.00	1.00	1.00	0.00
	2	0	0.90	0.90	0.90	0.58	0.87	0.86	0.84	0.33	0.84	0.81	0.78	0.00	0.81	0.77	0.74	0.00
		0.5	0.90	0.93	0.93	0.70	0.88	0.88	0.87	0.54	0.84	0.83	0.81	0.00	0.84	0.82	0.81	0.00
		1.25	0.92	0.97	0.99	0.81	0.90	0.92	0.92	0.77	0.86	0.86	0.86	0.00	0.85	0.85	0.84	0.00
		2.5	0.98	1.00	1.00	0.81	0.97	0.98	1.00	0.81	0.93	0.97	1.00	0.00	0.92	0.96	0.99	0.00
		5	1.00	1.00	1.00	0.82	1.00	1.00	1.00	0.84	1.00	1.00	1.00	0.00	1.00	1.00	1.00	0.00
		10	1.00	1.00	1.00	0.82	1.00	1.00	1.00	0.84	1.00	1.00	1.00	0.00	1.00	1.00	1.00	0.00

Reduction Coefficients (RC $_{BC}$) - Footing on Slope

Ref: Table 10.6.3.1.2c-2, AASHTO LRFD Bridge Design Specifications, 8th Ed.



SECTION 10: FOUNDATIONS 10-75

Table 10.6.3.1.2c-2 (cont.)

			β=10°				β=20°				β=30°				β=40°			
			Ns				*Ns*				*Ns*				*Ns*			
ϕ (°)	*B/H*	*b/B*	0	2	4	*c'*=0	0	2	4	*c'*=0	0	2	4	*c'*=0	0	2	4	*c'*=0
30	**0.2**	0	0.93	0.92	0.91	0.76	0.65	0.64	0.63	0.39	0.51	0.50	0.48	0.11	0.40	0.37	0.36	0.00
		0.5	0.74	0.81	0.80	0.75	0.70	0.66	0.65	0.50	0.57	0.52	0.49	0.21	0.47	0.42	0.39	0.00
		1.25	0.78	0.85	0.86	0.86	0.74	0.73	0.72	0.72	0.63	0.60	0.59	0.38	0.54	0.50	0.47	0.00
		2.5	0.84	0.92	0.93	0.99	0.81	0.82	0.83	0.94	0.72	0.73	0.74	0.74	0.64	0.62	0.61	0.00
		5	0.95	1.00	1.00	1.00	0.93	0.98	1.00	1.00	0.88	0.95	1.00	0.97	0.80	0.85	0.87	0.00
		10	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00
	0.5	0	0.79	0.79	0.78	0.70	0.63	0.59	0.55	0.36	0.50	0.43	0.39	0.13	0.39	0.32	0.27	0.00
		0.5	0.76	0.87	0.87	0.74	0.72	0.71	0.70	0.51	0.58	0.56	0.54	0.24	0.49	0.46	0.43	0.00
		1.25	0.79	0.85	0.92	0.87	0.75	0.73	0.76	0.72	0.63	0.62	0.61	0.45	0.54	0.52	0.50	0.00
		2.5	0.87	0.91	1.00	0.99	0.84	0.85	0.90	0.98	0.74	0.78	0.80	0.80	0.67	0.70	0.71	0.00
		5	0.97	1.00	1.00	1.00	0.95	1.00	1.00	1.00	0.90	1.00	1.00	1.00	0.85	0.94	0.98	0.00
		10	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00
	1	0	0.79	0.75	0.73	0.67	0.63	0.53	0.49	0.41	0.55	0.41	0.35	0.24	0.48	0.33	0.26	0.00
		0.5	0.78	0.87	0.89	0.74	0.75	0.74	0.74	0.51	0.64	0.62	0.60	0.35	0.59	0.56	0.54	0.00
		1.25	0.81	0.90	0.91	0.88	0.78	0.78	0.78	0.72	0.68	0.67	0.66	0.58	0.64	0.62	0.61	0.00
		2.5	0.88	0.99	1.00	0.96	0.85	0.90	0.92	0.95	0.78	0.81	0.84	0.88	0.75	0.78	0.80	0.00
		5	0.97	1.00	1.00	1.00	0.96	1.00	1.00	1.00	0.92	1.00	1.00	1.00	0.89	0.98	1.00	0.00
		10	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00
	2	0	0.88	0.88	0.87	0.65	0.87	0.85	0.83	0.48	0.85	0.82	0.80	0.38	0.83	0.80	0.76	0.00
		0.5	0.89	0.91	0.91	0.75	0.89	0.89	0.87	0.58	0.88	0.86	0.84	0.51	0.87	0.85	0.82	0.00
		1.25	0.90	0.92	0.93	0.88	0.90	0.90	0.90	0.75	0.89	0.87	0.87	0.70	0.89	0.87	0.86	0.00
		2.5	0.97	1.00	1.00	1.00	0.96	0.97	0.98	0.98	0.92	0.94	0.96	0.95	0.91	0.92	0.94	0.00
		5	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00
		10	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00
40	**0.2**	0	0.69	0.69	0.69	0.78	0.51	0.48	0.47	0.37	0.37	0.33	0.30	0.16	0.27	0.23	0.20	0.05
		0.5	0.65	0.73	0.71	0.74	0.60	0.55	0.53	0.38	0.64	0.38	0.35	0.25	0.34	0.29	0.25	0.13
		1.25	0.68	0.77	0.75	0.86	0.63	0.60	0.58	0.55	0.74	0.44	0.42	0.39	0.39	0.34	0.31	0.25
		2.5	0.72	0.83	0.84	1.00	0.68	0.68	0.68	0.76	0.87	0.53	0.53	0.62	0.45	0.43	0.41	0.48
		5	0.80	0.93	0.95	1.00	0.76	0.82	0.85	1.00	1.00	0.72	0.76	1.00	0.57	0.61	0.63	0.94
		10	0.94	1.00	1.00	1.00	0.91	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.76	0.93	1.00	1.00
	0.5	0	0.67	0.69	0.67	0.69	0.50	0.45	0.43	0.35	0.36	0.30	0.26	0.17	0.27	0.20	0.17	0.07
		0.5	0.68	0.81	0.81	0.73	0.63	0.62	0.61	0.46	0.47	0.44	0.41	0.25	0.39	0.35	0.32	0.09
		1.25	0.70	0.82	0.84	0.85	0.65	0.65	0.66	0.60	0.51	0.49	0.47	0.40	0.43	0.41	0.39	0.18
		2.5	0.76	0.92	0.96	1.00	0.72	0.77	0.80	0.81	0.59	0.62	0.63	0.60	0.54	0.56	0.56	0.37
		5	0.84	1.00	1.00	1.00	0.81	0.91	0.94	1.00	0.71	0.82	0.88	1.00	0.67	0.77	0.83	0.84
		10	0.96	1.00	1.00	1.00	0.94	1.00	1.00	1.00	0.89	1.00	1.00	1.00	0.86	1.00	1.00	1.00
	1	0	0.69	0.64	0.62	0.70	0.63	0.48	0.43	0.45	0.58	0.39	0.33	0.32	0.54	0.33	0.27	0.24
		0.5	0.77	0.81	0.82	0.74	0.75	0.73	0.72	0.49	0.71	0.66	0.62	0.38	0.68	0.62	0.57	0.30
		1.25	0.78	0.84	0.85	0.84	0.77	0.76	0.75	0.64	0.73	0.69	0.66	0.55	0.71	0.66	0.63	0.48
		2.5	0.83	0.92	0.95	1.00	0.81	0.85	0.87	0.85	0.76	0.78	0.79	0.76	0.75	0.76	0.77	0.72
		5	0.89	1.00	1.00	1.00	0.87	0.95	0.98	1.00	0.80	0.90	0.95	1.00	0.80	0.89	0.94	1.00
		10	0.98	1.00	1.00	1.00	0.97	1.00	1.00	1.00	0.94	1.00	1.00	1.00	0.93	1.00	1.00	1.00
	2	0	0.93	0.92	0.89	0.45	0.92	0.90	0.87	0.60	0.91	0.88	0.84	0.53	0.89	0.85	0.81	0.47
		0.5	0.93	0.95	0.93	0.76	0.93	0.92	0.90	0.65	0.92	0.89	0.87	0.64	0.92	0.89	0.86	0.60
		1.25	0.93	0.95	0.94	0.86	0.93	0.93	0.92	0.78	0.93	0.91	0.89	0.74	0.93	0.90	0.88	0.74
		2.5	0.94	0.99	1.00	1.00	0.94	0.98	0.98	0.92	0.94	0.97	0.97	0.87	0.94	0.96	0.96	0.88
		5	0.95	1.00	1.00	1.00	0.96	1.00	1.00	1.00	0.98	1.00	1.00	1.00	0.96	1.00	1.00	1.00
		10	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.99	1.00	1.00	1.00

APPENDIX E.4

Soldier Pile and Lagging (SPL) Wall

WHITMAN, REQUARDT & ASSOCIATES, LLP
801 South Caroline St., Baltimore, MD 21231

Soldier Pile Wall Design

Simplified Method - Cantilever / Single Anchor

Version 05.00 Coded S Kesavan 05/28/15, Reformatted Feb.2022

Project:	Opitz Blvd Wall, Sta. 64+50, Boring B-A3-1		
Location:	West Approach	WRA No.	45893-001
Calc by:	skk 2021/12/14	Chk by:	

Design Type:	*Soldier Pile Design*
Wall Type:	*Cantilever*
Design Methodology	*LRFD*

Load & Resistance Factors		ASD	LRFD	Selected
Active Earth Pr. K_a	(Υ_{EH})	*1.00*	*1.50*	1.50
Passive Earth Pr. K_p	(Φ)	*1.00*	*0.75*	0.75
Live Load Surcharge	(Υ_{LS})	*1.00*	*1.75*	1.75
Earth Load Surcharge	(Υ_{LS})	*1.00*	*1.50*	1.50
Embedment FOS -Teng Method		*1.40*	*1.20*	1.20

Cantilever

Single Ancho

Wall H= 12.0 ft *Rqd Zx 126 in^3*

Results ☐ Solve

OK

Final Embedment=1.20 Do	23.92	ft
Pile Tip Elevation:	179.08	ft
Factored Anchor Force:	N/A	
Factored Bending Moment:	525	ft-k/pile

Do = 19.930 0 EL 183.07

Unit Wt. of Water (pcf) 62.4

Geometry: Top of Wall / Anchor/ Top of Soil Elevations and Angles

E.1 Top of wall (>soil-1) EL *215.00* ft (Should be greater than or equal to top of Layer-1 elevation)

Dredge Side (Left / Low Side):				Retained Side (Right / High Side):			
E.3 Top of Dredge Line EL (Top of Layer-5 elevation)	EL	*203.00*	ft	E.2 Top of Retained (Soil-1)	EL	*215.00*	ft
				E.4 Anchor /Raker	EL		ft
E.5 Water on Dredge Side	EL	*181.00*	ft	E.6 Water-Retained Side	EL	*181.00*	ft

Geometry: Pile Spacing and Wall & Retained Soil Angles

Pile Spacing s *6.00* ft Pile/Hole Dia. (b) *14.0* inch Wall Face Angle θ= *90.0˚*

(For Sheet Pile Wall Design, s and b assumed at 1.0 ft) Ret. Slope Angle: **β** = *0.0˚*

Is Special Loading Widths Required below dredge? *No* (may required for secant piles)

Below Dredge Loading Widths: Active side s_w= *1.00* ft Passive Side s_p= *3.50* ft

Soil Parameters			Above Dredge				Below Dredge			
			Soil Layers above dredge:			*1*	Soil Layers below dredge:			*3*
Soil Layer ID			1	2	3	4	5	6	7	8
Layer top EL		(ft)	215.00				203.00	*190.00*	*185.00*	
Layer Soil Type:		sand/~~clay~~	*Sand*				*Sand*	*Sand*	*Sand*	
Total unit Weight	γ_i	(pcf)	*120.0*				*120.0*	*125.0*	*125.0*	
Friction Angle	ϕ_i	degree	*30.0˚*				*30.0˚*	*34.0˚*	*38.0˚*	
Wall Friction Angle	δ_i	degree	*0.0˚*				*0.0˚*	*0.0˚*	*0.0˚*	
Cohesion	c_i	(psf)	*0.0*				*0.0*	*0.0*	*0.0*	
Selected Pressure Coeff: (Yes/No)			*No*				*No*	*No*	*No*	
Activ/At-rest Earth Pressure Coeff. Ka										
Passive Earth Pressure Coeff. Kp										
Check: Layer bottom EL		(ft)	203.00				190.00	185.00	Last	

WRA	Soldier Pile Wall Design	Soldier Pile Design	West Approach
	Opitz Blvd Wall, Sta. 64+50, Boring B-A3-1	45893-001	skk 2021/12/14

Surcharge Loads: *(Lat. Pressure from equivalent soil column - dependent on Ka/Ko)*

Dead Loads (Vertical):	q_{sur-D}	*0.000*	ksf	Live Loads (Vertical):	q_{sur-L}	*0.250*	ksf
~~Dredge side Mud surcharge~~	q_{sur-D}	~~*0.500*~~	ksf	(not included yet)			

Lateral Load from Special Surcharge: *(Lat. Pressure from Elastic solutions -not dependent on Ka/Ko)*

Single Horizontal force:	Q spe	*0.000*	kips/LF	Elevation	*-9.000*	ft

Distributed Horizontal Pressure: *Define special surcharge up to 5 boxes:* Number of Boxes *0*

No. of Boxes						
Elev (ft)	From	*14.00*				
	To	*4.00*	*-6.00*			
Pressure	(psf)	*0.0*	*0.0*			

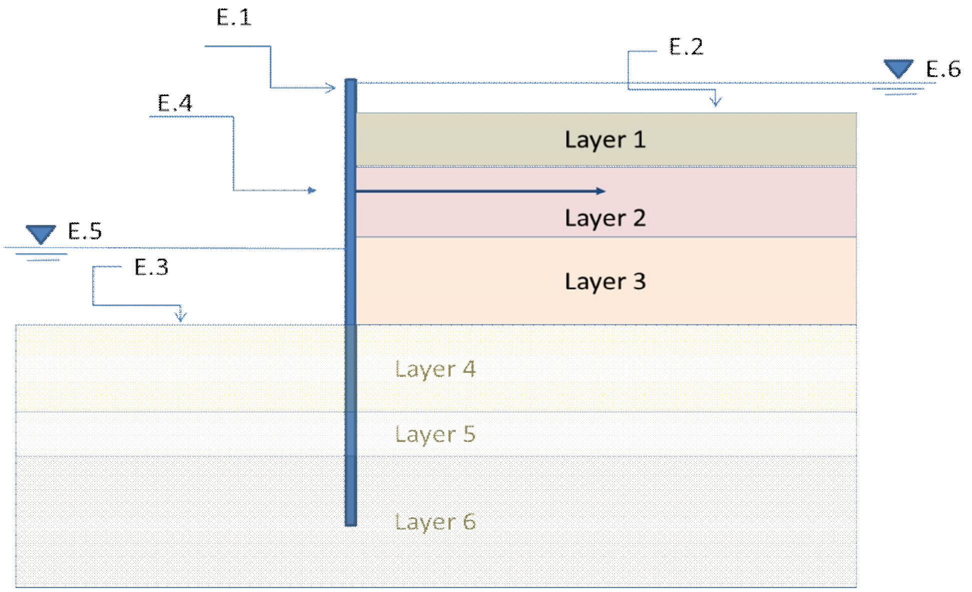
Note: Dredge @

EL 203.00

Input Parameter Sketch

Raker	0	kips	*@*	*EL*	*-9.5*

Input Parameter Sketch



Dimension Diagram:

Soldier Pile Wall Design Soldier Pile Design West Approach
Opitz Blvd Wall, Sta. 64+50, Boring B-A3-1 45893-001 skk 2021/12/14

Calculations

Sheet Pile WT=1/Soldier Pile WT=2 *WT=* *2*

Trial D_o *19.93* ft (pile penetration depth below dredge level) Trial Pile Tip EL 183.07 ft

s (ft)= 6.00 b (ft)= 1.17 s_w (ft) = 1.17 s_p (ft) = 3.50 Sp= 3.50 ft

Total Retained above Dredge H_R= 12.00 ft Anchor Height above Dredge L_A = -203.00 ft

L_{wR}= -22.00 ft L_{wL}= -22.00 ft L_x= -183.07 ft

185.00

Soil ID			1	2	3	4	5	6	7	8
Layer top EL		(ft)	215.00				203.00	190.00	185.00	
Layer Bottom EL		(ft)	203.00				190.00	185.00	183.07	
Right side Water EL (H)		(ft)	181.00				181.00	181.00	181.00	
Right Water Condition (dry/wet/mixed)			Dry				Dry	Dry	Dry	
Left side Water EL (L)		(ft)					181.00	181.00	181.00	
Left Water Condition (dry/wet/mixed)							Dry	Dry	Dry	
Right Side Layer Thicknesses										
Thickness -Total	H_i	(ft)	12.00	0.00	0.00	0.00	13.00	5.00	1.93	0.00
Thickness -Dry	H_{iD}	(ft)	12.00	0.00	0.00	0.00	13.00	5.00	1.93	0.00
Thickness -Wet	H_{iW}	(ft)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Left Side Layer Thicknesses										
Thickness -Total							13.00	5.00	1.93	0.00
Thickness -Dry							13.00	5.00	1.93	0.00
Thickness -Wet							0.00	0.00	0.00	0.00

Layer Parameters			1	2	3	4	5	6	7	8
Total unit Weight	γ_i	(ksf)	0.1200	0.0000	0.0000	0.0000	0.1200	0.1250	0.1250	0.0000
Total unit Weight	γ_{ib}	(ksf)	0.0576	0.0000	0.0000	0.0000	0.0576	0.0626	0.0626	0.0000
Active EP Coef		k_a	0.333	0.000	0.000	0.000	0.333	0.283	0.238	0.000
Passive EP Coef		k_p					3.039	3.522	4.183	0.000
Cos δ			1.000	0.000	0.000	0.000	1.000	1.000	1.000	0.000
Load Factor for Ka			1.50	0.00	0.00	0.00	1.50	1.50	1.50	0.00
Resistance Factor for Kp			0.75	0.00	0.00	0.00	0.75	0.75	0.75	0.00
Factored Active EP Coef.		Ka	0.500	0.000	0.000	0.000	0.500	0.425	0.357	0.000
Factored Passive EP Coef.		Kp	0.00	0.00	0.00	0.00	2.279	2.642	3.137	0.000
y to layer top		(ft)	31.93	0.00	0.00	0.00	19.93	6.93	1.93	0.00
Loading Width - Active Side		(ft)	6.00	0.00	0.00	0.00	1.17	1.17	1.17	0.00
Loading Width - Passive Side		(ft)					3.50	3.50	3.50	0.00

Moment about Pile Tip (F*y) - Driving Moments

F F*y

Retained Side: Soil-1 (i = 1) Active Above Dredge EL

k_{ai}= 0.333 Υ_{EH} = 1.50 Cos δ= 1.000 K_{Ai}= 0.499

Loading w= s 6.00 ft y to layer top: 31.93 ft

Geostatic Pressurre g_i : Layer I = 1

	Layer-1	Layer-2	Layer-3	Layer-4	Layer-5	Layer-6	Layer-7	Layer-8
Dry - H_{iD}	12.00	0.00	0.00	0.00	13.00	5.00	1.93	0.00
Dry γ	0.120	0.000	0.000	0.000	0.120	0.125	0.125	0.000
Wet - H_{iW}	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wet γ_b	0.058	0.000	0.000	0.000	0.058	0.063	0.063	0.000
Sum								

$g_{i\text{-top}}$ = 0.000 H_{iD} = 12.00 ft H_{iW} = 0.00 ft

$g_{i\text{-water}}$ = 1.440 γ_i = 0.1200 kcf γ_{ib} = 0.0576 kcf

$g_{i\text{-bottom}}$ = 1.440 $p_{iD\text{-}R}$ = 0.000 ksf/LF $p_{iD\text{-}T}$ = 0.719 ksf/LF

$p_{iW\text{-}R}$ = 0.719 ksf/LF $p_{iW\text{-}T}$ = 0.000 ksf/LF

					F	F*y
Dry- Rectangular:	$P_{iD\text{-}R}$ =	0.0000	kips/w	y=25.93	0.00	0.00
Dry- Trangular:	$P_{iD\text{-}T}$ =	25.8936	kips/w	y=23.93	25.89	619.65
Wet- Rectangular:	$P_{iW\text{-}R}$ =	0.000	kips/w	y=19.93	0.00	0.00
Wet- Trangular:	$P_{iW\text{-}T}$ =	0.00	kips/w	y=19.93	0.00	0.00

Retained Side: Soil-2 (i = 2) Active Above Dredge EL

k_{ai}= 0.000 Υ_{EH} = 1.50 Cos δ= 0.000 K_{Ai}= 0.000

Loading w= b 0.00 ft y to layer top: 0.00 ft

Geostatic Pressurre g_i : Layer I = 2

	Layer-1	Layer-2	Layer-3	Layer-4	Layer-5	Layer-6	Layer-7	Layer-8
Dry - H_{iD}	12.00	0.00	0.00	0.00	13.00	5.00	1.93	0.00
Dry γ	0.1200	0.0000	0.0000	0.0000	0.1200	0.1250	0.1250	0.0000
Wet - H_{iW}	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wet γ_b	0.0576	0.0000	0.0000	0.0000	0.0576	0.0626	0.0626	0.0000
Sum	1.440							

$g_{i\text{-top}}$ = 1.440 H_{iD} = 0.00 ft H_{iW} = 0.00 ft

$g_{i\text{-water}}$ = 1.440 γ_i = 0.0000 kcf γ_{ib} = 0.0000 kcf

$g_{i\text{-bottom}}$ = 1.440 $p_{iD\text{-}R}$ = 0.000 ksf/LF $p_{iD\text{-}T}$ = 0.000 ksf/LF

$p_{iW\text{-}R}$ = 0.000 ksf/LF $p_{iW\text{-}T}$ = 0.000 ksf/LF

					F	F*y
Dry- Rectangular:	$P_{iD\text{-}R}$ =	0.00	kips/w	y=0.00	0.00	0.00
Dry- Trangular:	$P_{iD\text{-}T}$ =	0.00	kips/w	y=0.00	0.00	0.00

Wet- Rectangular: P_{iW-R} = 0.00 kips/w y=0.00 0.00 0.00

Wet- Trangular: P_{iW-T} = 0.00 kips/w y=0.00 0.00 0.00

Retained Side: Soil-3 (i = 3) Active Above Dredge EL

k_{ai}= 0.000 Υ_{EH} = 1.50 Cos δ= 0.000 K_{Ai}= 0.000

Loading w= b 0.00 ft y to layer top: 0.00 ft

Geostatic Pressurre g_i : Layer I = 3

	Layer-1	Layer-2	Layer-3	Layer-4	Layer-5	Layer-6	Layer-7	Layer-8
Dry - H_{iD}	12.00	0.00	0.00	0.00	13.00	5.00	1.93	0.00
Dry γ	0.1200	0.0000	0.0000	0.0000	0.1200	0.1250	0.1250	0.0000
Wet - H_{iW}	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wet γ_b	0.0576	0.0000	0.0000	0.0000	0.0576	0.0626	0.0626	0.0000
Sum	1.440	0.000						

g_{i-top} = 1.440 H_{iD} = 0.00 ft H_{iW} = 0.00 ft

$g_{i-water}$ = 1.440 γ_i = 0.0000 kcf γ_{ib} = 0.0000 kcf

$g_{i-bottom}$ = 1.440 p_{iD-R} = 0.000 ksf/LF p_{iD-T} = 0.000 ksf/LF

p_{iW-R} = 0.000 ksf/LF p_{iW-T} = 0.000 ksf/LF

Dry- Rectangular: P_{iD-R} = 0.0000 kips/w y=0.00 0.00 0.00

Dry- Trangular: P_{iD-T} = 0.0000 kips/w y=0.00 0.00 0.00

Wet- Rectangular: P_{iW-R} = 0.000 kips/w y=0.00 0.00 0.00

Wet- Trangular: P_{iW-T} = 0.00 kips/w y=0.00 0.00 0.00

Retained Side: Soil-4 (i = 4) Active Above Dredge EL

k_{ai}= 0.000 Υ_{EH} = 1.50 Cos δ= 0.000 K_{Ai}= 0.000

Loading w= b 0.00 ft y to layer top: 0.00 ft

Geostatic Pressurre g_i : Layer I = 4

	Layer-1	Layer-2	Layer-3	Layer-4	Layer-5	Layer-6	Layer-7	Layer-8
Dry - H_{iD}	12.00	0.00	0.00	0.00	13.00	5.00	1.93	0.00
Dry γ	0.1200	0.0000	0.0000	0.0000	0.1200	0.1250	0.1250	0.0000
Wet - H_{iW}	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wet γ_b	0.0576	0.0000	0.0000	0.0000	0.0576	0.0626	0.0626	0.0000
Sum	1.440	0.000	0.000					

g_{i-top} = 1.440 H_{iD} = 0.00 ft H_{iW} = 0.00 ft

$g_{i-water}$ = 1.440 γ_i = 0.0000 kcf γ_{ib} = 0.0000 kcf

$g_{i-bottom}$ = 1.440 p_{iD-R} = 0.000 ksf/LF p_{iD-T} = 0.000 ksf/LF

p_{iW-R} = 0.000 ksf/LF p_{iW-T} = 0.000 ksf/LF

Dry- Rectangular: P_{iD-R} = 0.0000 kips/w y=0.00 0.00 0.00

Dry- Trangular: P_{iD-T} = 0.0000 kips/w y=0.00 0.00 0.00

Wet- Rectangular:	P_{iW-R} =	0.000	kips/w	y=0.00	0.00	0.00
Wet- Trangular:	P_{iW-T} =	0.00	kips/w	y=0.00	0.00	0.00

Retained Side: Soil-5 (i = 5) Active Below Dredge EL

k_{ai}= 0.333 Υ_{EH} = 1.50 Cos δ= 1.000 K_{Ai}= 0.500

Loading w= b 1.17 ft y to layer top: 19.93 ft

Geostatic Pressurre $g_{i\text{-}top}$: Layer I = 5

	Layer-1	Layer-2	Layer-3	Layer-4	Layer-5	Layer-6	Layer-7	Layer-8
Dry - H_{iD}	12.00	0.00	0.00	0.00	13.00	5.00	1.93	0.00
Dry γ	0.1200	0.0000	0.0000	0.0000	0.1200	0.1250	0.1250	0.0000
Wet - H_{iW}	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wet γ_b	0.0576	0.0000	0.0000	0.0000	0.0576	0.0626	0.0626	0.0000
Sum	1.440	0.000	0.000	0.000				

$g_{i\text{-}top}$ = 1.440 H_{iD} = 13.00 ft H_{iW} = 0.00 ft

$g_{i\text{-}water}$ = 3.000 γ_i = 0.1200 kcf γ_{ib} = 0.0576 kcf

$g_{i\text{-}bottom}$ = 3.000 p_{iD-R} = 0.719 ksf/LF p_{iD-T} = 0.779 ksf/LF

p_{iW-R} = 1.499 ksf/LF p_{iW-T} = 0.000 ksf/LF

Dry- Rectangular:	P_{iD-R} =	10.9091	kips/w	y=13.43	10.91	146.51
Dry- Trangular:	P_{iD-T} =	5.9091	kips/w	y=11.26	5.91	66.56
Wet- Rectangular:	P_{iW-R} =	0.000	kips/w	y=6.93	0.00	0.00
Wet- Trangular:	P_{iW-T} =	0.0000	kips/w	y=6.93	0.00	0.00

Retained Side: Soil-6 (i = 6) Active Below Dredge EL

k_{ai}= 0.283 Υ_{EH} = 1.50 Cos δ= 1.000 K_{Ai}= 0.425

Loading w= b 1.17 ft y to layer top: 6.93 ft

Geostatic Pressurre $g_{i\text{-}top}$: Layer I = 6

	Layer-1	Layer-2	Layer-3	Layer-4	Layer-5	Layer-6	Layer-7	Layer-8
Dry - H_{iD}	12.00	0.00	0.00	0.00	13.00	5.00	1.93	0.00
Dry γ	0.1200	0.0000	0.0000	0.0000	0.1200	0.1250	0.1250	0.0000
Wet - H_{iW}	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wet γ_b	0.0576	0.0000	0.0000	0.0000	0.0576	0.0626	0.0626	0.0000
Sum	1.440	0.000	0.000	0.000	1.560			

$g_{i\text{-}top}$ = 3.000 H_{iD} = 5.00 ft H_{iW} = 0.00 ft

$g_{i\text{-}water}$ = 3.625 γ_i = 0.1250 kcf γ_{ib} = 0.0626 kcf

$g_{i\text{-}bottom}$ = 3.625 p_{iD-R} = 1.274 ksf/LF p_{iD-T} = 0.265 ksf/LF

1.53881 p_{iW-R} = 1.539 ksf/LF p_{iW-T} = 0.000 ksf/LF

Dry- Rectangular:	P_{iD-R} =	7.4288	kips/w	y=4.43	7.43	32.91
Dry- Trangular:	P_{iD-T} =	0.7738	kips/w	y=3.60	0.77	2.78
Wet- Rectangular:	P_{iW-R} =	0.000	kips/w	y=1.93	0.00	0.00

Wet- Trangular: P_{iW-T} = 0.0000 kips/w y=1.93 0.00 0.00

Retained Side: Soil-7 (i = 7) Active Below Dredge EL

k_{ai}= 0.238 Υ_{EH} = 1.50 Cos δ= 1.000 K_{Ai}= 0.357

Loading w= b 1.17 ft y to layer top: 1.93 ft

Geostatic Pressurre $g_{i\text{-}top}$: Layer I = 7

	Layer-1	Layer-2	Layer-3	Layer-4	Layer-5	Layer-6	Layer-7	Layer-8
Dry - H_{iD}	12.00	0.00	0.00	0.00	13.00	5.00	1.93	0.00
Dry γ	0.1200	0.0000	0.0000	0.0000	0.1200	0.1250	0.1250	0.0000
Wet - H_{iW}	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wet γ_b	0.0576	0.0000	0.0000	0.0000	0.0576	0.0626	0.0626	0.0000
Sum	1.440	0.000	0.000	0.000	1.560	0.625		

$g_{i\text{-}top}$ = 3.625 H_{iD} = 1.93 ft H_{iW} = 0.00 ft

$g_{i\text{-}water}$ = 3.866 γ_i = 0.1250 kcf γ_{ib} = 0.0626 kcf

$g_{i\text{-}bottom}$ = 3.866 $p_{iD\text{-}R}$ = 1.294 ksf/LF $p_{iD\text{-}T}$ = 0.086 ksf/LF

1.38027 $p_{iW\text{-}R}$ = 1.380 ksf/LF $p_{iW\text{-}T}$ = 0.000 ksf/LF

Dry- Rectangular: P_{iD-R} = 2.9145 kips/w y=0.97 2.91 2.81

Dry- Trangular: P_{iD-T} = 0.0970 kips/w y=0.64 0.10 0.06

Wet- Rectangular: P_{iW-R} = 0.000 kips/w y=0.00 0.00 0.00

Wet- Trangular: P_{iW-T} = 0.0000 kips/w y=0.00 0.00 0.00

Retained Side: Soil-8 (i = 8) Active Below Dredge EL

k_{ai}= 0.000 Υ_{EH} = 1.50 Cos δ= 0.000 K_{Ai}= 0.000

Loading w= b 0.00 ft y to layer top: 0.00 ft

Geostatic Pressurre $g_{i\text{-}top}$: Layer I = 8

	Layer-1	Layer-2	Layer-3	Layer-4	Layer-5	Layer-6	Layer-7	Layer-8
Dry - H_{iD}	12.00	0.00	0.00	0.00	13.00	5.00	1.93	0.00
Dry γ	0.1200	0.0000	0.0000	0.0000	0.1200	0.1250	0.1250	0.0000
Wet - H_{iW}	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wet γ_b	0.0576	0.0000	0.0000	0.0000	0.0576	0.0626	0.0626	0.0000
Sum	1.440	0.000	0.000	0.000	1.560	0.625	0.241	

$g_{i\text{-}top}$ = 3.866 H_{iD} = 0.00 ft H_{iW} = 0.00 ft

$g_{i\text{-}water}$ = 3.866 γ_i = 0.0000 kcf γ_{ib} = 0.0000 kcf

$g_{i\text{-}bottom}$ = 3.866 $p_{iD\text{-}R}$ = 0.000 ksf/LF $p_{iD\text{-}T}$ = 0.000 ksf/LF

0 $p_{iW\text{-}R}$ = 0.000 ksf/LF $p_{iW\text{-}T}$ = 0.000 ksf/LF

Dry- Rectangular: P_{iD-R} = 0.0000 kips/w y=0.00 0.00 0.00

Dry- Trangular: P_{iD-T} = 0.0000 kips/w y=0.00 0.00 0.00

Wet- Rectangular: P_{iW-R} = 0.000 kips/w y=0.00 0.00 0.00

Wet- Trangular: P_{iW-T} = 0.0000 kips/w y=0.00 0.00 0.00

Retained Side : Water Pressure F F*y

Component 1 of 2 :Water pressure/force above dredge line:

L_{wR} = -22.00 ft γ_w (kcf)= 0.0624 $p_{w1} = \gamma_w L_{wR}$ 0.0000 ksf/LF

Loading width above dredge, s = 6.00 ft

$P_{W1-At} = 0.5\, p_{w1} L_{wR}\, s$ = 0.000 kips/LF y=12.60 0.00 0.00

Component 2 of 2 :Water pressure/force below dredge line:

Rectangular: p_{w1} = 0.0000 ksf

Loading width below dredge, s_w = 1.17 ft D_o= 19.93 ft

$P_{W1-Br} = p_{w1} D_o s_w$= 0.000 kips/pile y=9.97 0.00 0.00

Triangular: L_{adj} = -22.00 ft γ_w = 0.0624 kcf

D_o+L_{adj} = -2.07 ft $p_{w1-bt} = \gamma_w (D_o+L_{adj})$= -0.1291 ksf

Loading width below dredge, s_w = 1.17 ft

$P_{W1-Bt} = 0.5\, p_{w1-bt} (D_o+L_{adj})$ w= 0.16 kips/LF -y=0.69 0.16 -0.11

Aerial Surcharge Above Dredge F F*y

Factored Surcharge :

q_{sur-D} 0.0000 ksf q_{sur-L} 0.4375 ksf q_{total}= 0.4375 ksf

Soil	Ka	ΩKa	Total H	w (ft)	Cos δ	Q_i kips/w	$y_{layer\ top}$ (ft)	y_i (ft)	F	F*y
1	0.333	0.500	12.00	6.00	1.000	15.73	31.93	25.93	15.73	407.99
2	0.000	0.000	0.00	0.00	0.000	0.00	0.00	0.00	0.00	0.00
3	0.000	0.000	0.00	0.00	0.000	0.00	0.00	0.00	0.00	0.00
4	0.000	0.000	0.00	0.00	0.000	0.00	0.00	0.00	0.00	0.00
5	0.333	0.500	13.00	1.17	1.000	3.31	19.93	13.43	3.31	44.51
6	0.283	0.425	5.00	1.17	1.000	1.08	6.93	4.43	1.08	4.80
7	0.238	0.357	1.93	1.17	1.000	0.35	1.93	0.97	0.35	0.34
8	0.000	0.000	0.00	0.00	0.000	0.00	0.00	0.00	0.00	0.00

Special Surcharge Concentrated Load F F*y

L_S -212.00 ft D_O= 19.93 Qs= 0.00 kips/LF

Loading Width, w= s 6.00 ft

$P_{s2} = Q_S\, w$ 0.00 kips/pile -y=192.07 0.00 0.00

Special Surcharge Elastic Solutions to Distributed Loads

D_O= 19.93 Pile Bottom (z=0) elev. 183.07

Loading Width: Above dredge, w= s_p 6.00 ft Below dr. 1.17

Dredge EL 203.00 No of Boxes 0

No. of Boxes		*0*	*0*	*0*	*0*	*0*	
Elev (ft)	From	*14.00*	*0.00*	*0.00*	*0.00*	*0.00*	
	To	*4.00*	*-6.00*	*0.00*	*0.00*	*0.00*	
Pressure	(ksf)	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	
Loading Width		0.00	0.00	0.00	0.00	0.00	
Length		10.00	6.00	0.00	0.00	0.00	Total
Load F	(kips)	0.00	0.00	0	0	0	0.00
y	(ft)	-174.07	-186.07	-183.07	-183.07	-183.07	
F*y	ft-kips	0	0	0	0	0	0.00

0.00 0.00

Total	74.57	1328.82

Moment about Pile Tip (F*y) - Resisting Moments

Dredge Side: Layer 5 (i = 5) Passive

k_{pi}= 3.039 Ω = 0.75 Cos δ= 1.000 K_{Pi}= 2.279

Loading w= min(s, 3b) 3.50 ft y to layer top: 19.93 ft

Geostatic Pressurre g_i Layer I = 5

	Layer-1	Layer-2	Layer-3	Layer-4	Layer-5	Layer-6	Layer-7	Layer-8
Dry - L_{iD}	0.00	0.00	0.00	0.00	13.00	5.00	1.93	0.00
Dry γ	0.0000	0.0000	0.0000	0.0000	0.1200	0.1250	0.1250	0.0000
Wet - L_{iW}	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wet γ_b	0.0000	0.0000	0.0000	0.0000	0.0576	0.0626	0.0626	0.0000
Sum	0.000	0.000	0.000	0.000				

$g_{i\text{-top}}$ = 0.000 H_{iD} = 13.00 ft H_{iW} = 0.00 ft

$g_{i\text{-water}}$ = 1.560 γ_i = 0.1200 kcf γ_{ib} = 0.0576 kcf

$g_{i\text{-bottom}}$ = 1.560 $p_{iD\text{-}R}$ = 0.000 ksf/LF $p_{iD\text{-}T}$ = 3.556 ksf/LF

3.55563 $p_{iW\text{-}R}$ = 3.556 ksf/LF $p_{iW\text{-}T}$ = 0.000 ksf/LF

Dry- Rectangular:	$P_{iD\text{-}R}$ =	0.000	kips/w	y=13.43	0.00	0.00
Dry- Trangular:	$P_{iD\text{-}T}$ =	80.891	kips/w	y=11.26	80.89	911.13
Wet- Rectangular:	$P_{iD\text{-}R}$ =	0.000	kips/w	y=6.93	0.00	0.00
Dry- Trangular:	$P_{iD\text{-}T}$ =	0.000	kips/w	y=6.93	0.00	0.00

Dredge Side: Layer 6 (i = 6) Passive

k_{pi}= 3.522 Ω = 0.75 Cos δ= 1.000 K_{Pi}= 2.642

Loading w= min(s, 3b) 3.50 ft y to layer top: 6.93 ft

Geostatic Pressurre g_i Layer I = 6

	Layer-1	Layer-2	Layer-3	Layer-4	Layer-5	Layer-6	Layer-7	Layer-8
Dry - L_{iD}	0.00	0.00	0.00	0.00	13.00	5.00	1.93	0.00
Dry γ	0.0000	0.0000	0.0000	0.0000	0.1200	0.1250	0.1250	0.0000
Wet - L_{iW}	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wet γ_b	0.0000	0.0000	0.0000	0.0000	0.0576	0.0626	0.0626	0.0000
Sum	0.000	0.000	0.000	0.000	1.560			

$g_{i\text{-top}}$ = 1.560 H_{iD} = 5.00 ft H_{iW} = 0.00 ft

$g_{i\text{-water}}$ = 2.185 γ_i = 0.1250 kcf γ_{ib} = 0.0626 kcf

$g_{i\text{-bottom}}$ = 2.185 $p_{iD\text{-}R}$ = 4.121 ksf/LF $p_{iD\text{-}T}$ = 1.651 ksf/LF

5.77168 $p_{iW\text{-}R}$ = 5.772 ksf/LF $p_{iW\text{-}T}$ = 0.000 ksf/LF

Dry- Rectangular:	$P_{iD\text{-}R}$ =	72.113	kips/w	y=4.43	72.11	319.49
Dry- Trangular:	$P_{iD\text{-}T}$ =	14.446	kips/w	y=3.60	14.45	51.96
Wet- Rectangular:	$P_{iD\text{-}R}$ =	0.000	kips/w	y=1.93	0.00	0.00
Dry- Trangular:	$P_{iD\text{-}T}$ =	0.000	kips/w	y=1.93	0.00	0.00

Dredge Side: Layer 7 (i = 7) Passive

k_{pi}= 4.183 Ω = 0.75 Cos δ= 1.000 K_{Pi}= 3.137

Loading w= min(s, 3b) 3.50 ft y to layer top: 1.93 ft

Geostatic Pressurre g_i Layer I = 7

	Layer-1	Layer-2	Layer-3	Layer-4	Layer-5	Layer-6	Layer-7	Layer-8
Dry - L_{iD}	0.00	0.00	0.00	0.00	13.00	5.00	1.93	0.00
Dry γ	0.0000	0.0000	0.0000	0.0000	0.1200	0.1250	0.1250	0.0000
Wet - L_{iW}	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wet γ_b	0.0000	0.0000	0.0000	0.0000	0.0576	0.0626	0.0626	0.0000
Sum	0.000	0.000	0.000	0.000	1.560	0.625		

$g_{i\text{-top}}$ = 2.185 H_{iD} = 1.93 ft H_{iW} = 0.00 ft

$g_{i\text{-water}}$ = 2.426 γ_i = 0.1250 kcf γ_{ib} = 0.0626 kcf

$g_{i\text{-bottom}}$ = 2.426 $p_{iD\text{-}R}$ = 6.855 ksf/LF $p_{iD\text{-}T}$ = 0.757 ksf/LF

7.61191 $p_{iW\text{-}R}$ = 7.612 ksf/LF $p_{iW\text{-}T}$ = 0.000 ksf/LF

Dry- Rectangular:	$P_{iD\text{-}R}$ =	46.314	kips/w	y=0.97	46.31	44.70
Dry- Trangular:	$P_{iD\text{-}T}$ =	2.557	kips/w	y=0.64	2.56	1.65
Wet- Rectangular:	$P_{iD\text{-}R}$ =	0.000	kips/w	y=0.00	0.00	0.00
Dry- Trangular:	$P_{iD\text{-}T}$ =	0.000	kips/w	y=0.00	0.00	0.00

Dredge Side: Layer 8 (i = 8) Passive

k_{pi}= 0.000 Ω = 0.75 Cos δ= 0.000 K_{Pi}= 0.000

Loading w= min(s, 3b) 0.00 ft y to layer top: 0.00 ft

Geostatic Pressurre g_i Layer I = 8

	Layer-1	Layer-2	Layer-3	Layer-4	Layer-5	Layer-6	Layer-7	Layer-8
Dry - L_{iD}	0.00	0.00	0.00	0.00	13.00	5.00	1.93	0.00
Dry γ	0.0000	0.0000	0.0000	0.0000	0.1200	0.1250	0.1250	0.0000
Wet - L_{iW}	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wet γ_b	0.0000	0.0000	0.0000	0.0000	0.0576	0.0626	0.0626	0.0000
Sum	0.000	0.000	0.000	0.000	1.560	0.625	0.241	

$g_{i\text{-top}}$ = 2.426 H_{iD} = 0.00 ft H_{iW} = 0.00 ft

$g_{i\text{-water}}$ = 2.426 γ_i = 0.0000 kcf γ_{ib} = 0.0000 kcf

$g_{i\text{-bottom}}$ = 2.426 $p_{iD\text{-}R}$ = 0.000 ksf/LF $p_{iD\text{-}T}$ = 0.000 ksf/LF

0 $p_{iW\text{-}R}$ = 0.000 ksf/LF $p_{iW\text{-}T}$ = 0.000 ksf/LF

Dry- Rectangular:	$P_{iD\text{-}R}$ =	0.000	kips/w	y=0.00	0.00	0.00
Dry- Trangular:	$P_{iD\text{-}T}$ =	0.000	kips/w	y=0.00	0.00	0.00
Wet- Rectangular:	$P_{iD\text{-}R}$ =	0.000	kips/w	y=0.00	0.00	0.00
Dry- Trangular:	$P_{iD\text{-}T}$ =	0.000	kips/w	y=0.00	0.00	0.00

Dredge Side: Added Raker

R1	0.00	kips/LF	@ EL	-9.50	-y=192.57	0.00	0.00
			Tip @ EL	183.07			

Dredge Side: Water Pressure F F*y

Component 1 of 2 :Water pressure/force above dredge line:

L_{wL} = -22.00 ft γ_w (kcf)= 0.0624 $p_{w1} = \gamma_w L_{wR}$ 0.0000 ksf/LF

Loading width above dredge, s = 6.00 ft D_o= 19.93 ft

$P_{W2\text{-}At} = 0.5\ p_{w1}\ L_{wR}\ s$ 0.000 kips/LF y=12.60 0.00 0.00

Component 2 of 2 :Water pressure/force below dredge line:

Rectangular: $p_{w1} =$ 0.0000 ksf

Loading width below dredge, s_w = 1.17 ft

$P_{w2\text{-}Br} = p_{w1} D_o s_w =$ 0.00 kips/pile y=9.97 0.00 0.00

Triangular:

L_{adj} = -22.00 ft $p_{w3} = \gamma_w (D_o + L_{adj})$ -0.129 ksf/LF

$P_{w2\text{-}Bt} = 0.5 p_{w3} (D_o + D_{adj}) s_w$ 0.156 kips/pile -y=0.69 0.16 -0.11

Dredge Side: Anchor Force *Last*

T= 0.00 kips/LF -y=183.07 0.00 0.00

Total	216.48	1328.82
Difference:	*141.91*	*0.00*

Active Earth Pre.Coeff.(Coulomb) *(For β>φ ; Sin(φ-β) is assumed 0)*

Layer	φ	δ	β	θ	Sin (φ+δ)	Sin (φ–β)	Sin (θ–δ)	Sin (θ+β)	Sin (θ+φ)	Γ	k_a
1	30.0˚	0.0˚	0.0˚	90.0˚	0.500	0.500	1.000	1.000	0.866	2.250	0.333
5	30.0˚	0.0˚	0.0˚	90.0˚	0.500	0.500	1.000	1.000	0.866	2.250	0.333
6	34.0˚	0.0˚	0.0˚	90.0˚	0.559	0.559	1.000	1.000	0.829	2.431	0.283
7	38.0˚	0.0˚	0.0˚	90.0˚	0.616	0.616	1.000	1.000	0.788	2.610	0.238

Note: *Ka is calculatated based on AASHTO equations 3.11.5.3-1 and 3.11.5.3-2*

Passive Earth Pres.Coef.-Vertical Wall (AASHTO Figure 3.11.5.4-2) β= 0.0˚

Layer	φ	δ	δ/φ	Interpolation of R			β/φ	k_p at	k_p at	Chart k_p	R*Kp
				R_{down}	R_{up}	R		β/φ=0	β/φ=1		
5	30.0˚	0.0˚	0.00	0.467	0.467	0.467	0.000	6.508	15.638	6.508	3.039
6	34.0˚	0.0˚	0.00	0.383	0.383	0.383	0.000	9.197	30.518	9.197	3.522
7	38.0˚	0.0˚	0.00	0.302	0.302	0.302	0.000	13.852	61.339	13.852	4.183
				#VALUE!							

(For Comparison)

Passive Earth Pressure Coeff. (Coulomb) *Bowles(1982), Eq.11-6* β= 0.0˚ θ= 90.0˚

Layer	φ	δ	Sin (φ+δ)	Sin (φ+β)	Sin (θ+δ)	Sin (θ+β)	Γ	Sin (θ-φ)	Sin (θ)	Coulomb K_p	Rankine K_p
5	*30.0˚*	*0.0˚*	*0.500*	*0.500*	*1.000*	*1.000*	*0.250*	*0.866*	*1.000*	*3.000*	*3.000*
6	*34.0˚*	*0.0˚*	*0.559*	*0.559*	*1.000*	*1.000*	*0.194*	*0.829*	*1.000*	*3.537*	*3.537*
7	*38.0˚*	*0.0˚*	*0.616*	*0.616*	*1.000*	*1.000*	*0.148*	*0.788*	*1.000*	*4.204*	*4.204*

Fifth Order interpolation Function for Kp

Coeff.	ϕ^5	ϕ^4	ϕ^3	ϕ^2	φ	Const.
β/φ=0	2.26E-06	-2.34E-04	9.45E-03	-1.73E-01	1.48E+00	-2.91E+00
β/φ=1	6.51E-06	-4.69E-04	1.33E-02	-1.70E-01	1.13E+00	-1.63E+00

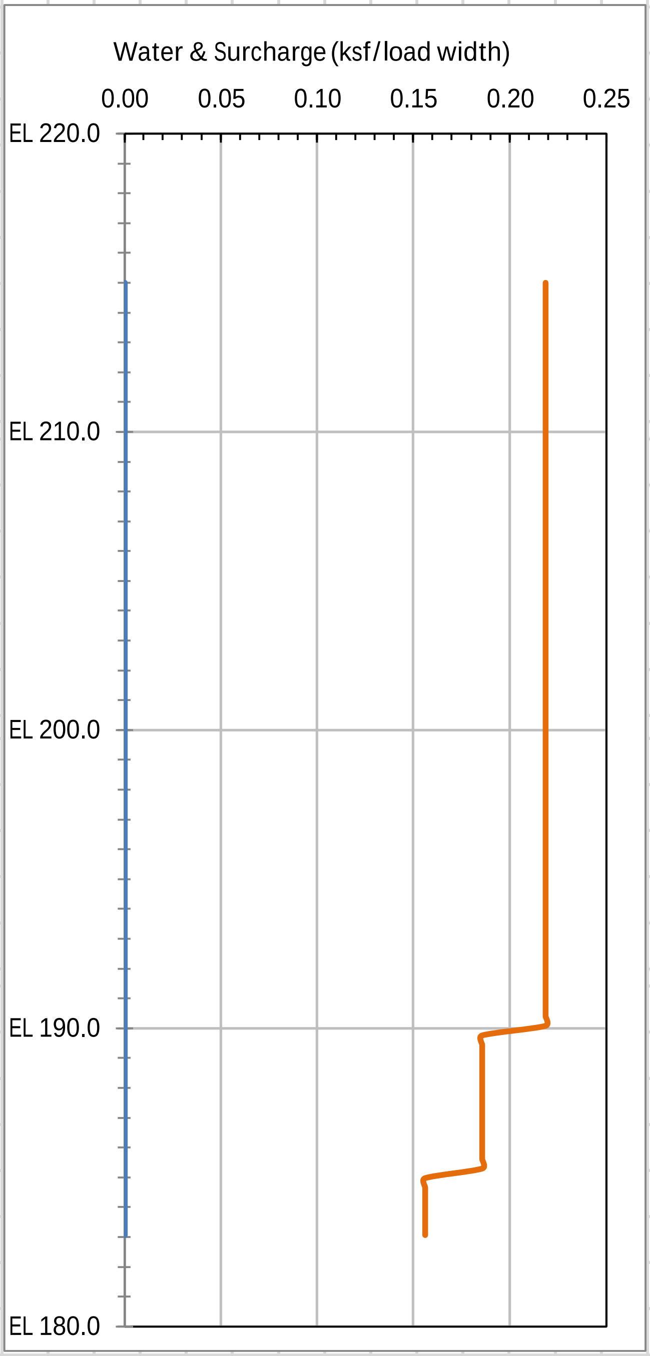
ASD	Yes	
LRFD	No	Sand
		Rock

Layer	Ka	Kp
1	0.333	☒
2		☒
3		☒
4		☒
5	0.333	3.039
6	0.283	3.522
7	0.238	4.183
8		

Interpolated R Values based AASHTO Table 3-11.5.4-2

	δ / ϕ_f									
ϕ	-1.0	-0.9	-0.8	-0.7	-0.6	-0.5	-0.4	-0.3	-0.2	-0.1	0.0
10	1.000	0.993	0.985	0.978	0.962	0.946	0.929	0.912	0.898	0.881	0.864
11	1.000	0.992	0.983	0.975	0.956	0.938	0.919	0.900	0.884	0.865	0.846
12	1.000	0.991	0.981	0.971	0.951	0.930	0.910	0.889	0.871	0.850	0.828
13	1.000	0.989	0.978	0.968	0.945	0.923	0.900	0.877	0.857	0.834	0.811
14	1.000	0.988	0.976	0.964	0.940	0.915	0.891	0.866	0.844	0.819	0.793
15	1.000	0.987	0.974	0.961	0.934	0.907	0.881	0.854	0.830	0.803	0.775
16	1.000	0.985	0.971	0.956	0.927	0.898	0.870	0.841	0.814	0.786	0.756
17	1.000	0.984	0.968	0.951	0.921	0.889	0.858	0.827	0.799	0.768	0.736
18	1.000	0.982	0.964	0.946	0.914	0.880	0.847	0.814	0.783	0.751	0.717
19	1.000	0.981	0.961	0.941	0.908	0.871	0.835	0.800	0.768	0.733	0.697
20	1.000	0.979	0.958	0.936	0.901	0.862	0.824	0.787	0.752	0.716	0.678
21	1.000	0.977	0.955	0.931	0.893	0.851	0.818	0.772	0.735	0.697	0.657
22	1.000	0.976	0.952	0.926	0.885	0.840	0.812	0.757	0.718	0.678	0.636
23	1.000	0.974	0.948	0.922	0.876	0.830	0.807	0.741	0.700	0.658	0.616
24	1.000	0.973	0.945	0.917	0.868	0.819	0.801	0.726	0.683	0.639	0.595
25	1.000	0.971	0.942	0.912	0.860	0.808	0.795	0.711	0.666	0.620	0.574
26	1.000	0.969	0.937	0.905	0.850	0.796	0.773	0.694	0.648	0.600	0.553
27	1.000	0.967	0.933	0.898	0.840	0.783	0.751	0.677	0.629	0.580	0.531
28	1.000	0.964	0.928	0.892	0.831	0.771	0.730	0.661	0.611	0.560	0.510
29	1.000	0.962	0.924	0.885	0.821	0.758	0.708	0.644	0.592	0.540	0.488
30	1.000	0.960	0.919	0.878	0.811	0.746	0.686	0.627	0.574	0.520	0.467
31	1.000	0.957	0.914	0.870	0.799	0.732	0.669	0.609	0.554	0.499	0.446
32	1.000	0.954	0.908	0.861	0.787	0.717	0.653	0.591	0.534	0.479	0.425
33	1.000	0.952	0.903	0.853	0.776	0.703	0.636	0.572	0.515	0.458	0.404
34	1.000	0.949	0.897	0.844	0.764	0.688	0.620	0.554	0.495	0.438	0.383
35	1.000	0.946	0.892	0.836	0.752	0.674	0.603	0.536	0.475	0.417	0.362
36	1.000	0.942	0.885	0.825	0.738	0.658	0.585	0.517	0.455	0.397	0.342
37	1.000	0.939	0.878	0.815	0.724	0.641	0.567	0.497	0.435	0.377	0.322
38	1.000	0.935	0.871	0.804	0.710	0.625	0.548	0.478	0.415	0.356	0.302
39	1.000	0.932	0.864	0.794	0.696	0.608	0.530	0.458	0.395	0.336	0.282
40	1.000	0.928	0.857	0.783	0.682	0.592	0.512	0.439	0.375	0.316	0.262
41	1.000	0.924	0.848	0.770	0.666	0.574	0.492	0.419	0.368	0.297	0.244
42	1.000	0.920	0.839	0.757	0.649	0.555	0.473	0.399	0.361	0.278	0.227
43	1.000	0.915	0.829	0.744	0.633	0.537	0.453	0.379	0.353	0.259	0.209
44	1.000	0.911	0.820	0.731	0.616	0.518	0.434	0.359	0.346	0.240	0.192
45	1.000	0.907	0.811	0.718	0.600	0.500	0.414	0.339	0.339	0.221	0.174

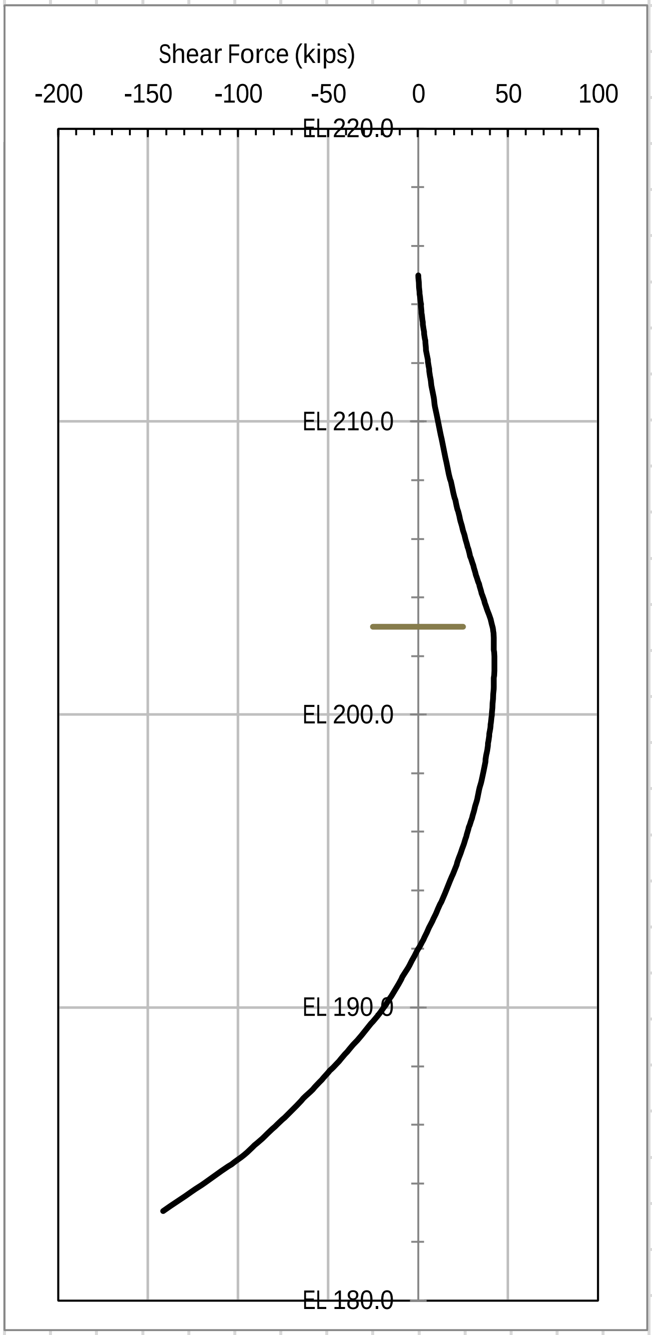
Results: Moment and Shear Diagrams

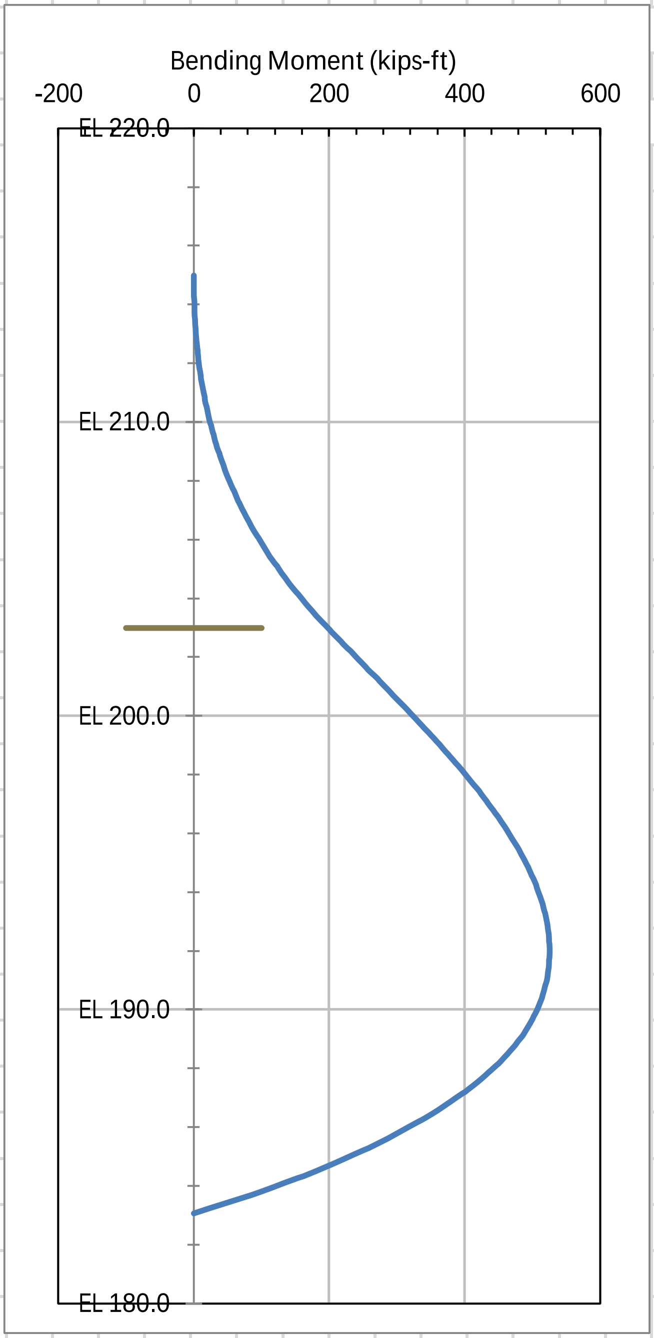


Notes:

Soldier Pile Wall Design	Soldier Pile Design	West Approach
Opitz Blvd Wall, Sta. 64+50, Boring B-A3-1	45893-001	skk 2021/12/14

Results: Moment and Shear Diagrams





Max Moment:	525.2	ft-kips	Yield Strenght, f_y :	50	ksi
Required Zx :	126.1	inch^3	Resistance Factor	1	(for f_y)

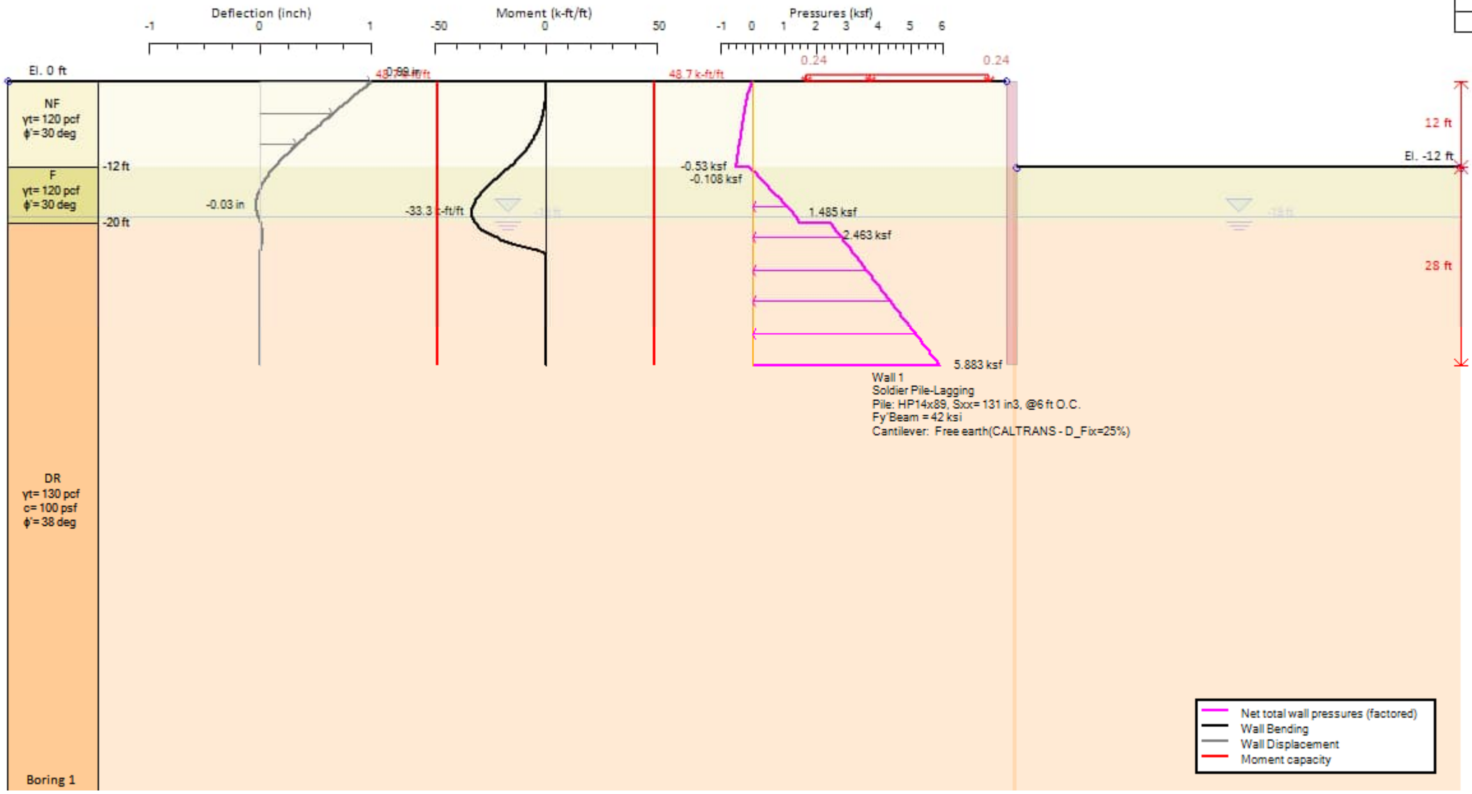
Notes:

APPENDIX E.4

Soldier Pile and Lagging (SPL) Wall

Base model

Concrete Code:	EC2-German Annex/1.5
Steel Code:	AISC 360-16 ALL.
1st Wall Limit Equilibrium	California Shoring Manual-11
Drain State Clays	Default
Water γ= 62.4 pcf	Simple flow
Drive	Ka
Resist	Kp



Project: Opitz Blvd SPL Wall at West Approach
Results for Design Section 0: Base model

ANALYSIS AND CHECKING SUMMARY

The following tables summarize critical resuls for all design sections. These results may include wall moments, shears, displacements, stress checks, wall embedment safety factors, basal & slope stability safety factors, etc.

Summary vs Design Section

Base model	Wall Moment	Wall Shear	Wall Displace	Max Support	Critical Support	Embedment	Comments
	(k-ft/ft)	(k/ft)	(in)	Reaction (k/ft)	Check	Wall FS	
Base model	33.3	14.04	0	No supports	No supports	2.295	Calculation successful

Extended Summary

Table: Extended summary for all design sections.

Design Section	Calculation Result	Wall Displacement	Settlement
Name		(in)	(in)
Base model	Calculation successful	0.99	1.07

Table: Extended summary for wall moments and shears for all design sections.

Design Section	Wall Moment	Wall Moment	Wall Shear	Wall Shear
Name	(k-ft/ft)	(k-ft)	(k/ft)	(k)
Base model	33.3	199.83	14.04	84.25

Table: Extended summary for wall stress checks for all design sections.

Design Section	STR Combined	STR Moment	STR Shear	Wall Concrete Service
Name	Wall Ratio	Wall Ratio	Wall Ratio	Stress Ratio FIC
Base model	0.684	0.684	0.722	N/A

Table notes:

STR Combined: Combined stress check, along eccentricity line considering axial load and moment (demand/capacity).
STR Moment : Moment stress check, assuming constant axial load on wall (demand/capacity).
STR Shear : Shear stress check (shear force demand/wall shear capacity).

Table: Extended summary for support results for all design sections

Design Section	Max Support	Max Support	Critical	STR Support	Support Geotech
Name	Reaction (k/ft)	Reaction (k)	Support Check	Ratio	Capacity Ratio (pull
Base model	No supports	No supports	No supports	No supports	No supports

Table notes:

STR Support ratio: Critical structural stress check for support (force demand/structural capacity).
Support geotech capacity ratio: Critical geotechnical capacity stress check (demand/geotechnical capacity).
Critical support check: Critical demand/design capacity ratio (structural or geotechnical).

Table: Summary for basal stability and wall embedment safety factors from conventional analyses.

Design Section	FS	Toe FS	Toe FS	Toe FS
Name	Basal	Passive	Rotation	Length
Base model	3.359	12.528	5.299	2.295

Table notes:

FSbasal : Critical basal stability safety factor (relevant only when soft clays are present beneath the excavation).
TOE FS Passive : Safety factor for wall embedment based on FS= Available horizontal thrust resistance/Driving hor. thrust.
TOE FS Rotation: Safety factor for wall embedment based on FS= Available resisting moment/Driving moment.
TOE FS Length : Safety factor for wall embedment based on FS= Available wall embedment/Required embedment for FS=1.0

Table: Summary for wall embedment safety factors from elastoplastic analyses.

Design Section	FS Mobilized	FS
Name	Passive	True/Active
Base model	N/A	N/A

Table notes:

FS Mobilized Passive : Safety factor= Available horizontal passive resistance/Mobilized passive thrust.
FS True/Active : Soil thrust on retained wall side/Minimum theoretically horizontal active force thrust.

Table: Summary for hydraulic safety factors, water flow, and slope stability

Design Section Name	Hydraulic Heave FS	Qflow (ft3/hr)	FSslope
Base model	2.717	N/A	N/A

Max. Moment vs Stage

	Base Model
M stg0 (k-ft/ft)	DS: 0
M stg1 (k-ft/ft)	-33.3

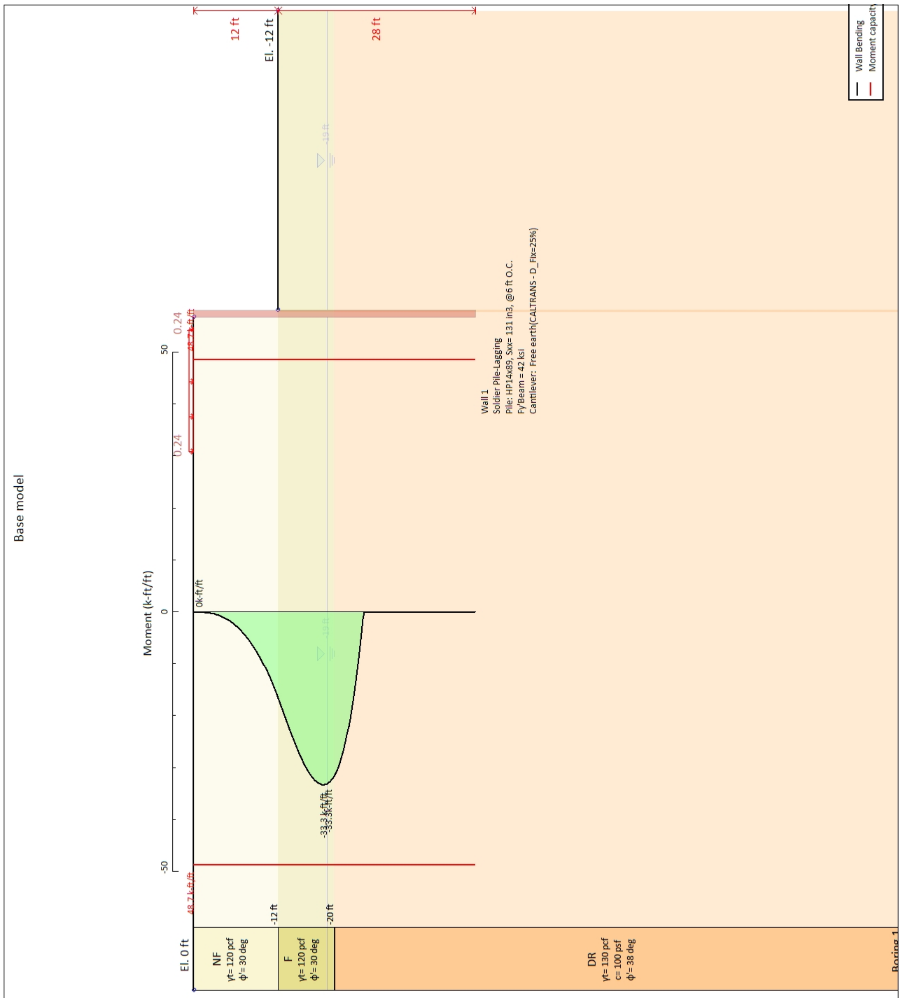
Max. Shear vs Stage

	Base Model
V stg0 (k/ft)	DS: 0
V stg1 (k/ft)	-14.04

Max. Support F vs Stage

	Base Model
Rmax Stage 0 (k/ft)	DS: 0
Rmax Stage 1 (k/ft)	

ANALYSIS AND CHECKING SUMMARY



Company: My Company Engineer: Engineer	Quick summary	Deep Excavation LCC DeepEX 2020
\\ad...pEx - Opitz Blvd\Tiral-1 12 ft fill-6-ft spacing - Copy.DEEP		2/17/2022

Summary of Wall Moments and Toe Requirements

Top Wall	Wall	L-Wall	H-Exc.	Max+M/Cap	Max-M/Cap	FS Toe	FS Toe	FS Toe	FS 1 Toe EL.	Slope
(ft)	Section	(ft)	(ft)	(k-ft/ft)	(k-ft/ft)	Passive	Rotation	Embedment	(ft)	Stab. FS
0	Wall 1	40	12	0/48.71	33.3/48.71	12.528	5.299	2.295	-24.2	N/A

Summary of Basal Stability and Predicted Wall Movements According to Clough 1989 Method Wall: W

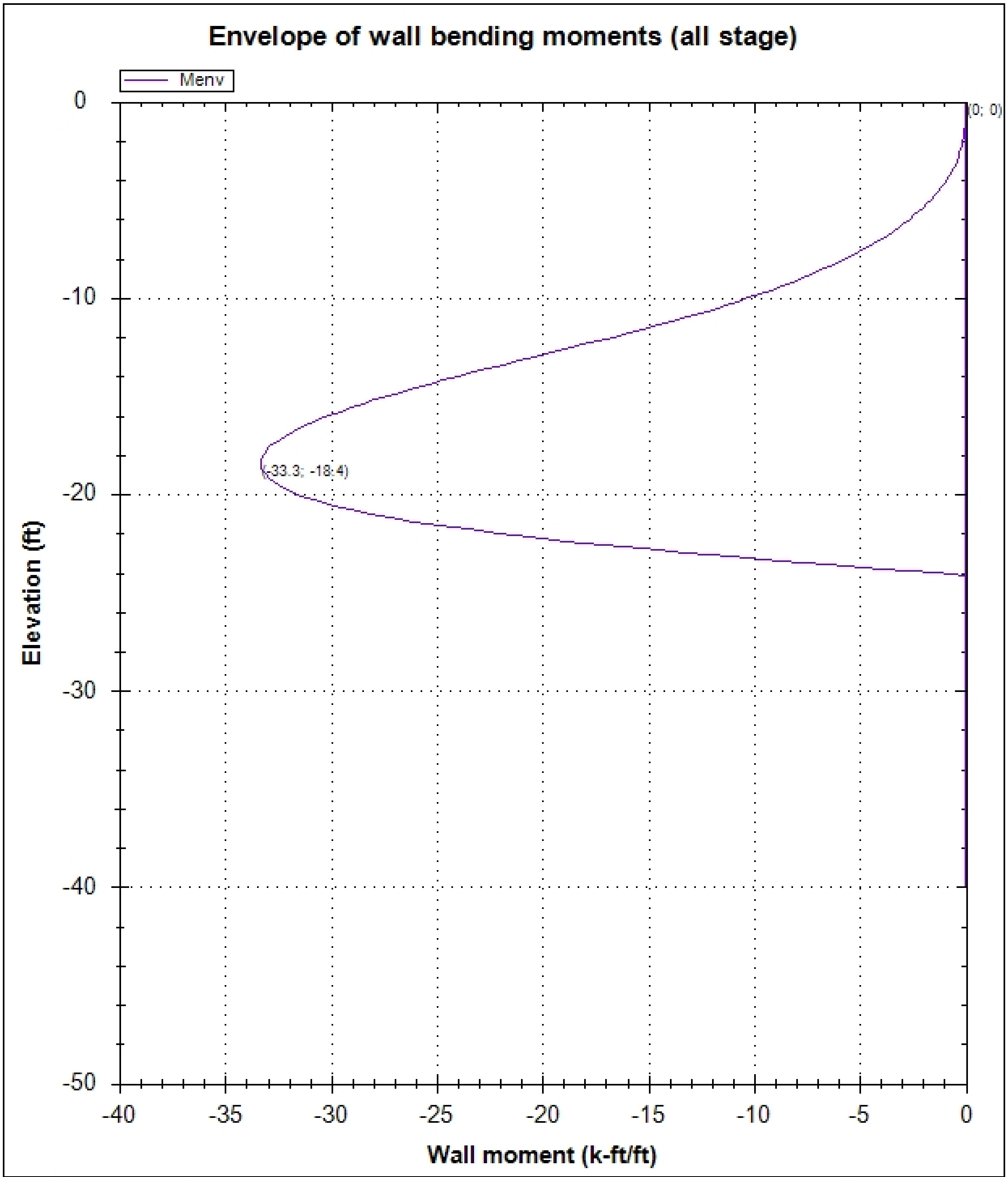
1. FSmin	2. DxMax (in)	2. Stiffness	2. FSbasal	3. Dx/H (%)	3. Stiffness	3. FSbasal
@ stage 1	@ stage 1	@ DxMax	@ DxMax	@ stage 1	@ Dx/H max	@ Dx/H max
3.359	0.396	23.5	3.359	0.275	23.45	3.359

General assumptions for last stage: Stage 1

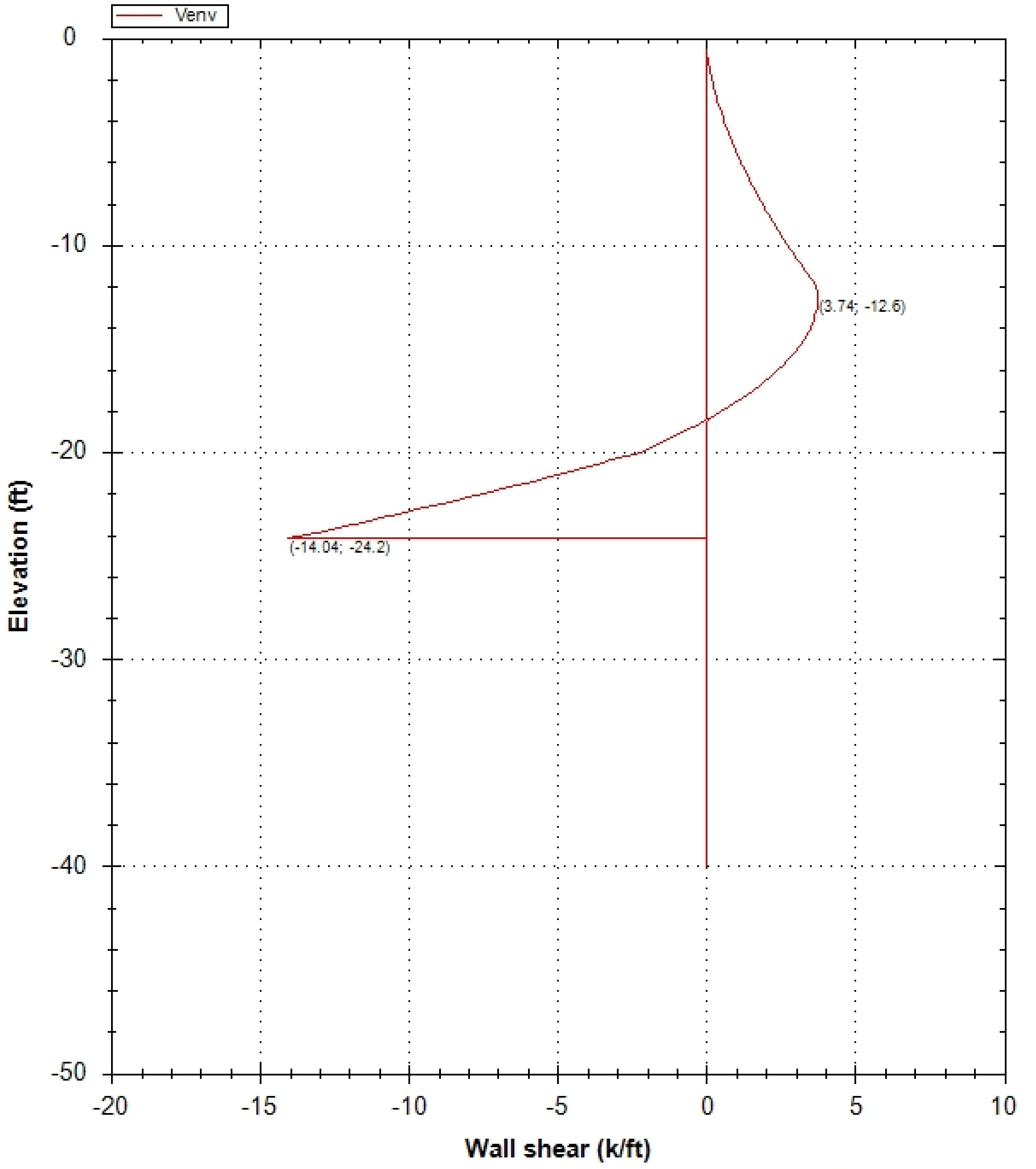
Concrete Code:	EC2-German Annex/1.5
Steel Code:	AISC 360-16 ALL.
1st Wall Limit Equilibrium	California Shoring Manual-11
Drain State Clays	Default
Water γ= 62.4 pcf	Simple flow
Drive	Ka
Resist	Kp

Envelope of results

A sequence of result diagrams for each excavation stage is reported

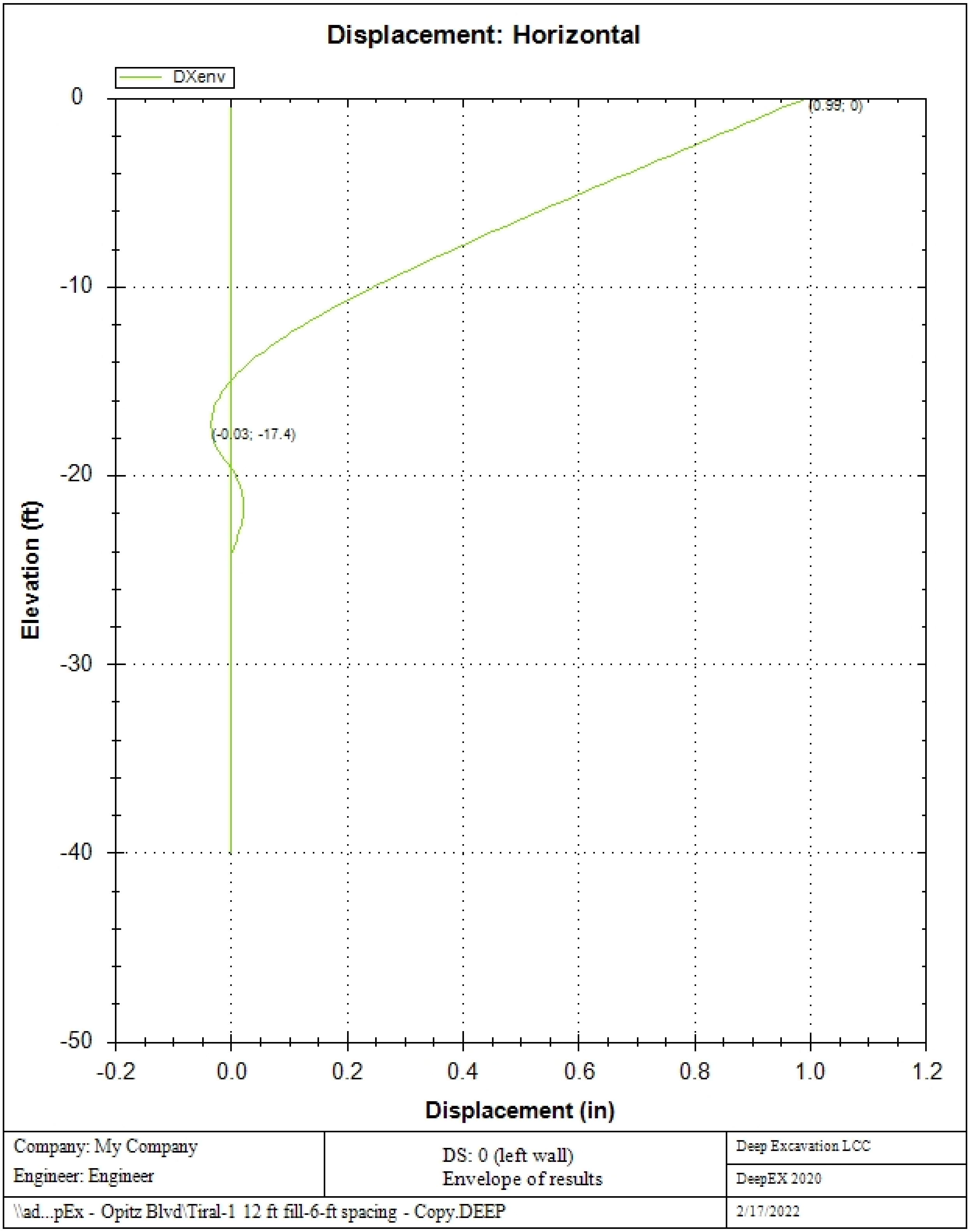


Company: My Company Engineer: Engineer	DS: 0 (left wall) Envelope of results	Deep Excavation LCC DeepEX 2020
\\ad...pEx - Opitz Blvd\Tiral-1 12 ft fill-6-ft spacing - Copy.DEEP		2/17/2022



Envelope of wall shear (all stage)

Company: My Company Engineer: Engineer	DS: 0 (left wall) Envelope of results	Deep Excavation LCC DeepEX 2020
\\ad...pEx - Opitz Blvd\Tiral-1 12 ft fill-6-ft spacing - Copy.DEEP		2/17/2022



Company: My Company Engineer: Engineer	DS: 0 (left wall) Envelope of results	Deep Excavation LCC DeepEX 2020
\\ad...pEx - Opitz Blvd\Tiral-1 12 ft fill-6-ft spacing - Copy.DEEP		2/17/2022

Extended vs Stage

	Calculation Result	Wall Displaceme	Settlement	Wall Moment	Wall Moment
		(in)	(in)	(k-ft/ft)	(k-ft)
Stage 0	Calculated	0	N/A	0	0
Stage 1	Calculated	0.99	1.07	33.3	199.83

	Wall Shear	Wall Shear	STR Combined	STR Moment	STR Shear
	(k/ft)	(k)	Wall Ratio	Wall Ratio	Wall Ratio
Stage 0	0	0	0	0	0
Stage 1	14.04	84.25	0.684	0.684	0.722

Table notes:

STR Combined: Combined stress check, along eccentricity line considering axial load and moment (demand/capacity).
STR Moment : Moment stress check, assuming constant axial load on wall (demand/capacity).
STR Shear : Shear stress check (shear force demand/wall shear capacity).

	Max Support	Max Support	Critical	STR Support	Support Geotech
	Reaction (k/ft)	Reaction (k)	Support Check	Ratio	Capacity Ratio (pull out
Stage 0	0	0	N/A	No supports	No supports
Stage 1	0	0	N/A	No supports	No supports

Table notes:

STR Support ratio: Critical structural stress check for support (force demand/structural capacity).
Support geotech capacity ratio: Critical geotechnical capacity stress check (demand/geotechnical capacity).
Critical support check: Critical demand/design capacity ratio (structural or geotechnical).

	FS	Toe FS	Toe FS	Toe FS	Zcut	FS Mobilized	FS
	Basal	Passive	Rotation	Length	(nonlinear)	Passive	True/Active
Stage 0	1000	49.035	39.735	200	N/A	N/A	N/A
Stage 1	3.359	12.528	5.299	2.295	N/A	N/A	N/A

	Hydraulic	Qflow	FSslope
	Heave FS	(ft3/hr)	
Stage 0	3.396	N/A	N/C
Stage 1	2.717	N/A	N/C

Support Force/S vs Stage

	No Supports
0:Stage 0	No support
1:Stage 1	

Support Force vs Stage
Support Force vs Stage

	No Supports
0:Stage 0	No support
1:Stage 1	

Embedment FS vs Stage

	Min Toe FS	FS1 Passive	FS2 Rotation	FS3 Length (from FS1, FS2)	FS4 Mobilized Passive	FS5 Actual Drive Thrust / Theory
Stage 0	39.735	49.035	39.735	200	N/A	N/A
0:Stage 0	2.295	12.528	5.299	2.295	N/A	N/A

Table notes:

FSbasal : Critical basal stability safety factor (relevant only when soft clays are present beneath the excavation).
Wall embedment safety factors from conventional analysis (limit-equilibrium):
FS1 Passive : Safety factor for wall embedment based on FS= Available horizontal thrust resistance/Driving hor. thrust.
FS2 Rotation: Safety factor for wall embedment based on FS= Available resisting moment/Driving moment.
FS3 Length : Safety factor for wall embedment based on FS= Available wall embedment/Required embedment for FS=1.0
Wall embedment safety factors from non-linear analysis:
FS4 Mobilized Passive : Safety factor= Available horizontal passive resistance/Mobilized passive thrust.

FS5 True/Active : Soil thrust on retained wall side/Minimum theoretically horizontal active force thrust.

Tables for stress checks follow: Support force/Design capacity

Support Check vs Stage

	No Supports
0:Stage 0	No support
1:Stage 1	

Forces (Res. F, M/Drive F, M)

	FS1 Passive	FS2 Rotation	FS3 Length	FS4 Mobilized Passive	FS5 Actual Drive	Fh EQ Soil	Fh EQ Water
	(FxResist/FxDrive)	(Mresist/Mdrive)	(Embedment/ToeFS=1)	(FxPassive/FxPas_Mobili	/ Theory Active		
Stage 0	1165.768/23.774	15377.64/387	40/0.2	N/A	N/A	N/A	N/A
Stage 1	554.709/44.279	5419.83/299.43	28/12.2	N/A	N/A	N/A	N/A

Reinforcement Requirements

	Parameter Description
Note:	Wall does not use steel reinforcement. Section does not apply.

SOIL DATA

Name	g tot	g dry	Frict	C'	Su	FRp	FRcv	Eload	rEur	kAp	kPp	kAcv	kPcv	Vary	Spring	Color
	(pcf)	(pcf)	(deg)	(psf)	(psf)	(deg)	(deg)	(ksf)	(-)	NL	NL	NL	NL		Model	
NF	120	120	30	0	N/A	N/A	N/A	300	3	0.33	3	N/A	N/A	True	EXP	🟨
F	120	120	30	0	N/A	N/A	N/A	300	3	0.33	3	N/A	N/A	True	EXP	🟨
DR	130	130	38	100	N/A	N/A	N/A	600	3	0.24	4.2	N/A	N/A	True	EXP	🟧

Name	Poisson	Min Ka	Min sh	ko.NC	nOCR	aH.EXP	aV.EXP	qSkin	qNails	kS.nails	PL
	v	(clays)	(clays)	-	-	(0 to 1)	(0 to 1)	(psi)	(psi)	(k/ft3)	(ksi)
NF	0.35	-	-	0.5	0.5	1	0	12	4.8	20	-
F	0.35	-	-	0.441	0.44	1	0	12	4.8	20	-
DR	0.35	-	-	0.384	0.5	1	0	30	14.5	30	-

gtot = total soil specific weight
gdry = dry weigth of the soil
Frict = friction angle
C' = effective cohesion
Su = Undrained shear strength (only for CLAY soils in undrained conditions, used as a cutoff strength in NL analysis)
Evc = Virgin compression elastic modulus
Eur = unloading/reloading elastic modulus
Kap = Peak active thrust coefficient (initial value, may be modified on each stage according to analysis settings).
Kpp = Peak passive thrust coefficient (initial value, may be modified on each stage according to analysis settings).
Kacv = Constant volume active thrust coeff (only for clays, initial value)
Kpcv = Constant volume passive thrust coeff (only for clays, initial value).
Spring models= spring model (LIN= constant E over the soil layer height , EXP=exponential , SIMC=simplified winkler)
LIN= Linear-Elastic-Perfectly Plastic,
EXP: Exponential, SUB: Modulus of Subgrade Reaction
SIMC= Simplified Clay mode

DESIGN APPROACHES AND COMBINATION FACTORS

The Design Approaches (from Codes or Customized by the user) and related safety factors are the following:
Ftan fr=mult factor for friction angle
F C'= safety factor on effective cohesion (Eurocode 7 methods)

F Su'= safety factof for undrained shear strength (Eurocode 7 methods)
F EQ= Load factor for seismic loads
F perm load= Load factor for permanent loads (dead load, etc)
F temp load= Load factor on live loads and other temporary loads
F perm supp= Reduction factor for resistance for pull out checking of permanent tiebacks
F temp supp= Reduction factor for resistance for pull out checking of temporary tiebacks
F earth Dstab= Load factor for driving earth pressures, unfavorable (on retained side)
F earth stab= Safety factor for passive pressures, favorable (on excavation side)
F GWT Dstab (ground water)= Load factor for driving water pressures, unfavorable
F GWT stab (ground water)= Load factor for resisting water pressure, favorable
F HYD Dstab= Load factor for hydraulic heave, unfavorable (hydraulic checking)
F HYD stab= Resistance factor for hydraulic heave, favorable (hydraulic checking)
F UPL Dstab= Load factor for uplift check, unfavorable
F UPL stab= Resistance factor for uplift check, favorable

Stage	Design Code Name	Design Case	F(tan fr)	F (c')	F (Su)	F (EQ)	F(perm load)	F(temp load)	F(perm sup)	F(temp sup)	F Earth (Dstab)	F Earth (stab)	F GWT (Dstab)	F GWT (stab)	F HYD (Dstab)	F HYD (stab)	F UPL (Dstab)	F UPL (stab)
0	Default	Service Factors	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	Default	Service Factors	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

APPENDIX E.5

Abutment and Pier Piles

Pile Design Summary By skk 1/4/2022

Driven Output Check sb 1/4/2022

HP 10x 57 Piles, with Nominal Capicity of 385 kips

Bridge Element	Pile Cap Subgrade EL (ft.)	(Depth Ref) Ground EL (ft.)	Pile top Depth (ft.)	DRIVEN INPUT						RESULTS Pile Depth (ft.)	Estimated Pile Tip EL (ft.)	Estimated Pile Top EL (ft.)	Estimated Pile Length (ft.)
				Boring ID (ft.)	Opitz Sta. (ft.)	Groundwater		Top of DR					
						EL (ft.)	Depth (ft.)	EL (ft.)	Depth (ft.)				
Abut.A	205	205	*0*	1 & 2	65+44	182	23	180	25	55	150	206	56
Pier 1	189	194	*5*	4	66+52	182	12	178	16	50	144	190	46
Pier 2	186	191	*5*	5 & 6	68+10	169	22	167	24	45	146	187	41
Pier 3	185	190	*5*	7 & 8	69+78	167	23	166	24	45	145	186	41
Abut B	201	201	*0*	9 & 10	70+15	167	34	165	36	50	151	202	51
Abut C	191	191	*0*	B-A2-1	67+50	165	26	162	29	50	141	192	51

Notes
Pile cap subgrade is assumed at existing grade for Abutment C.
PDA testing should be perfomed on a 70 feet long pile at each locations.
All ground elevations are approximate.

DRIVEN 1.2

GENERAL PROJECT INFORMATION

Filename: C:\HOLD\ABUT-A.DVN
Project Name: Opitz Abut A   Project Date: 02/20/2020
Project Client: Transurban
Computed By: SKK
Project Manager: MJ

PILE INFORMATION

Pile Type: H Pile - HP10X57
Top of Pile: 0.00 ft
Perimeter Analysis: Box
Tip Analysis: Box Area

ULTIMATE CONSIDERATIONS

Water Table Depth At Time Of:	- Drilling:	15.00 ft
	- Driving/Restrike	15.00 ft
	- Ultimate:	15.00 ft
Ultimate Considerations:	- Local Scour:	0.00 ft
	- Long Term Scour:	0.00 ft
	- Soft Soil:	0.00 ft

ULTIMATE PROFILE

Layer	Type	Thickness	Driving Loss	Unit Weight	Strength	Ultimate Curve
1	Cohesionless	25.00 ft	0.00%	120.00 pcf	30.0/30.0	Nordlund
2	Cohesionless	25.00 ft	0.00%	120.00 pcf	36.0/38.0	Nordlund
3	Cohesionless	10.00 ft	0.00%	120.00 pcf	36.0/38.0	Nordlund
4	Cohesionless	10.00 ft	0.00%	120.00 pcf	36.0/38.0	Nordlund

RESTRIKE - SKIN FRICTION

Depth	Soil Type	Effective Stress At Midpoint	Sliding Friction Angle	Adhesion	Skin Friction
0.01 ft	Cohesionless	0.60 psf	22.81	N/A	0.00 Kips
9.01 ft	Cohesionless	540.60 psf	22.81	N/A	5.07 Kips
14.99 ft	Cohesionless	899.40 psf	22.81	N/A	14.04 Kips
15.01 ft	Cohesionless	1800.29 psf	22.81	N/A	14.08 Kips
24.01 ft	Cohesionless	2059.49 psf	22.81	N/A	33.38 Kips
24.99 ft	Cohesionless	2087.71 psf	22.81	N/A	35.77 Kips
25.01 ft	Cohesionless	2376.29 psf	27.37	N/A	35.84 Kips
34.01 ft	Cohesionless	2635.49 psf	27.37	N/A	78.05 Kips
43.01 ft	Cohesionless	2894.69 psf	27.37	N/A	128.57 Kips
49.99 ft	Cohesionless	3095.71 psf	27.37	N/A	173.47 Kips
50.01 ft	Cohesionless	3816.29 psf	27.37	N/A	173.60 Kips
59.01 ft	Cohesionless	4075.49 psf	27.37	N/A	238.88 Kips
59.99 ft	Cohesionless	4103.71 psf	27.37	N/A	246.49 Kips
60.01 ft	Cohesionless	4392.29 psf	27.37	N/A	246.65 Kips
69.01 ft	Cohesionless	4651.49 psf	27.37	N/A	321.15 Kips
69.99 ft	Cohesionless	4679.71 psf	27.37	N/A	329.76 Kips

RESTRIKE - END BEARING

Depth	Soil Type	Effective Stress At Tip	Bearing Cap. Factor	Limiting End Bearing	End Bearing
0.01 ft	Cohesionless	1.20 psf	30.00	9.45 Kips	0.01 Kips
9.01 ft	Cohesionless	1081.20 psf	30.00	9.45 Kips	9.45 Kips
14.99 ft	Cohesionless	1798.80 psf	30.00	9.45 Kips	9.45 Kips
15.01 ft	Cohesionless	1800.58 psf	30.00	9.45 Kips	9.45 Kips
24.01 ft	Cohesionless	2318.98 psf	30.00	9.45 Kips	9.45 Kips
24.99 ft	Cohesionless	2375.42 psf	30.00	9.45 Kips	9.45 Kips
25.01 ft	Cohesionless	2376.58 psf	110.40	190.54 Kips	134.38 Kips
34.01 ft	Cohesionless	2894.98 psf	110.40	190.54 Kips	163.69 Kips
43.01 ft	Cohesionless	3413.38 psf	110.40	190.54 Kips	190.54 Kips
49.99 ft	Cohesionless	3815.42 psf	110.40	190.54 Kips	190.54 Kips
50.01 ft	Cohesionless	3816.58 psf	110.40	190.54 Kips	190.54 Kips
59.01 ft	Cohesionless	4334.98 psf	110.40	190.54 Kips	190.54 Kips
59.99 ft	Cohesionless	4391.42 psf	110.40	190.54 Kips	190.54 Kips
60.01 ft	Cohesionless	4392.58 psf	110.40	190.54 Kips	190.54 Kips
69.01 ft	Cohesionless	4910.98 psf	110.40	190.54 Kips	190.54 Kips
69.99 ft	Cohesionless	4967.42 psf	110.40	190.54 Kips	190.54 Kips

RESTRIKE - SUMMARY OF CAPACITIES

Depth	Skin Friction	End Bearing	Total Capacity
0.01 ft	0.00 Kips	0.01 Kips	0.01 Kips
9.01 ft	5.07 Kips	9.45 Kips	14.52 Kips
14.99 ft	14.04 Kips	9.45 Kips	23.49 Kips
15.01 ft	14.08 Kips	9.45 Kips	23.52 Kips
24.01 ft	33.38 Kips	9.45 Kips	42.83 Kips
24.99 ft	35.77 Kips	9.45 Kips	45.22 Kips
25.01 ft	35.84 Kips	134.38 Kips	170.22 Kips
34.01 ft	78.05 Kips	163.69 Kips	241.75 Kips
43.01 ft	128.57 Kips	190.54 Kips	319.11 Kips
49.99 ft	173.47 Kips	190.54 Kips	364.01 Kips
50.01 ft	173.60 Kips	190.54 Kips	364.14 Kips
59.01 ft	238.88 Kips	190.54 Kips	429.42 Kips
59.99 ft	246.49 Kips	190.54 Kips	437.03 Kips
60.01 ft	246.65 Kips	190.54 Kips	437.19 Kips
69.01 ft	321.15 Kips	190.54 Kips	511.69 Kips
69.99 ft	329.76 Kips	190.54 Kips	520.30 Kips

DRIVING - SKIN FRICTION

Depth	Soil Type	Effective Stress At Midpoint	Sliding Friction Angle	Adhesion	Skin Friction
0.01 ft	Cohesionless	0.60 psf	22.81	N/A	0.00 Kips
9.01 ft	Cohesionless	540.60 psf	22.81	N/A	5.07 Kips
14.99 ft	Cohesionless	899.40 psf	22.81	N/A	14.04 Kips
15.01 ft	Cohesionless	1800.29 psf	22.81	N/A	14.08 Kips
24.01 ft	Cohesionless	2059.49 psf	22.81	N/A	33.38 Kips
24.99 ft	Cohesionless	2087.71 psf	22.81	N/A	35.77 Kips
25.01 ft	Cohesionless	2376.29 psf	27.37	N/A	35.84 Kips
34.01 ft	Cohesionless	2635.49 psf	27.37	N/A	78.05 Kips
43.01 ft	Cohesionless	2894.69 psf	27.37	N/A	128.57 Kips
49.99 ft	Cohesionless	3095.71 psf	27.37	N/A	173.47 Kips
50.01 ft	Cohesionless	3816.29 psf	27.37	N/A	173.60 Kips
59.01 ft	Cohesionless	4075.49 psf	27.37	N/A	238.88 Kips
59.99 ft	Cohesionless	4103.71 psf	27.37	N/A	246.49 Kips
60.01 ft	Cohesionless	4392.29 psf	27.37	N/A	246.65 Kips
69.01 ft	Cohesionless	4651.49 psf	27.37	N/A	321.15 Kips
69.99 ft	Cohesionless	4679.71 psf	27.37	N/A	329.76 Kips

DRIVING - END BEARING

Depth	Soil Type	Effective Stress At Tip	Bearing Cap. Factor	Limiting End Bearing	End Bearing
0.01 ft	Cohesionless	1.20 psf	30.00	9.45 Kips	0.01 Kips
9.01 ft	Cohesionless	1081.20 psf	30.00	9.45 Kips	9.45 Kips
14.99 ft	Cohesionless	1798.80 psf	30.00	9.45 Kips	9.45 Kips
15.01 ft	Cohesionless	1800.58 psf	30.00	9.45 Kips	9.45 Kips
24.01 ft	Cohesionless	2318.98 psf	30.00	9.45 Kips	9.45 Kips
24.99 ft	Cohesionless	2375.42 psf	30.00	9.45 Kips	9.45 Kips
25.01 ft	Cohesionless	2376.58 psf	110.40	190.54 Kips	134.38 Kips
34.01 ft	Cohesionless	2894.98 psf	110.40	190.54 Kips	163.69 Kips
43.01 ft	Cohesionless	3413.38 psf	110.40	190.54 Kips	190.54 Kips
49.99 ft	Cohesionless	3815.42 psf	110.40	190.54 Kips	190.54 Kips
50.01 ft	Cohesionless	3816.58 psf	110.40	190.54 Kips	190.54 Kips
59.01 ft	Cohesionless	4334.98 psf	110.40	190.54 Kips	190.54 Kips
59.99 ft	Cohesionless	4391.42 psf	110.40	190.54 Kips	190.54 Kips
60.01 ft	Cohesionless	4392.58 psf	110.40	190.54 Kips	190.54 Kips
69.01 ft	Cohesionless	4910.98 psf	110.40	190.54 Kips	190.54 Kips
69.99 ft	Cohesionless	4967.42 psf	110.40	190.54 Kips	190.54 Kips

DRIVING - SUMMARY OF CAPACITIES

Depth	Skin Friction	End Bearing	Total Capacity
0.01 ft	0.00 Kips	0.01 Kips	0.01 Kips
9.01 ft	5.07 Kips	9.45 Kips	14.52 Kips
14.99 ft	14.04 Kips	9.45 Kips	23.49 Kips
15.01 ft	14.08 Kips	9.45 Kips	23.52 Kips
24.01 ft	33.38 Kips	9.45 Kips	42.83 Kips
24.99 ft	35.77 Kips	9.45 Kips	45.22 Kips
25.01 ft	35.84 Kips	134.38 Kips	170.22 Kips
34.01 ft	78.05 Kips	163.69 Kips	241.75 Kips
43.01 ft	128.57 Kips	190.54 Kips	319.11 Kips
49.99 ft	173.47 Kips	190.54 Kips	364.01 Kips
50.01 ft	173.60 Kips	190.54 Kips	364.14 Kips
59.01 ft	238.88 Kips	190.54 Kips	429.42 Kips
59.99 ft	246.49 Kips	190.54 Kips	437.03 Kips
60.01 ft	246.65 Kips	190.54 Kips	437.19 Kips
69.01 ft	321.15 Kips	190.54 Kips	511.69 Kips
69.99 ft	329.76 Kips	190.54 Kips	520.30 Kips

ULTIMATE - SKIN FRICTION

Depth	Soil Type	Effective Stress At Midpoint	Sliding Friction Angle	Adhesion	Skin Friction
0.01 ft	Cohesionless	0.60 psf	22.81	N/A	0.00 Kips
9.01 ft	Cohesionless	540.60 psf	22.81	N/A	5.07 Kips
14.99 ft	Cohesionless	899.40 psf	22.81	N/A	14.04 Kips
15.01 ft	Cohesionless	1800.29 psf	22.81	N/A	14.08 Kips
24.01 ft	Cohesionless	2059.49 psf	22.81	N/A	33.38 Kips
24.99 ft	Cohesionless	2087.71 psf	22.81	N/A	35.77 Kips
25.01 ft	Cohesionless	2376.29 psf	27.37	N/A	35.84 Kips
34.01 ft	Cohesionless	2635.49 psf	27.37	N/A	78.05 Kips
43.01 ft	Cohesionless	2894.69 psf	27.37	N/A	128.57 Kips
49.99 ft	Cohesionless	3095.71 psf	27.37	N/A	173.47 Kips
50.01 ft	Cohesionless	3816.29 psf	27.37	N/A	173.60 Kips
59.01 ft	Cohesionless	4075.49 psf	27.37	N/A	238.88 Kips
59.99 ft	Cohesionless	4103.71 psf	27.37	N/A	246.49 Kips
60.01 ft	Cohesionless	4392.29 psf	27.37	N/A	246.65 Kips
69.01 ft	Cohesionless	4651.49 psf	27.37	N/A	321.15 Kips
69.99 ft	Cohesionless	4679.71 psf	27.37	N/A	329.76 Kips

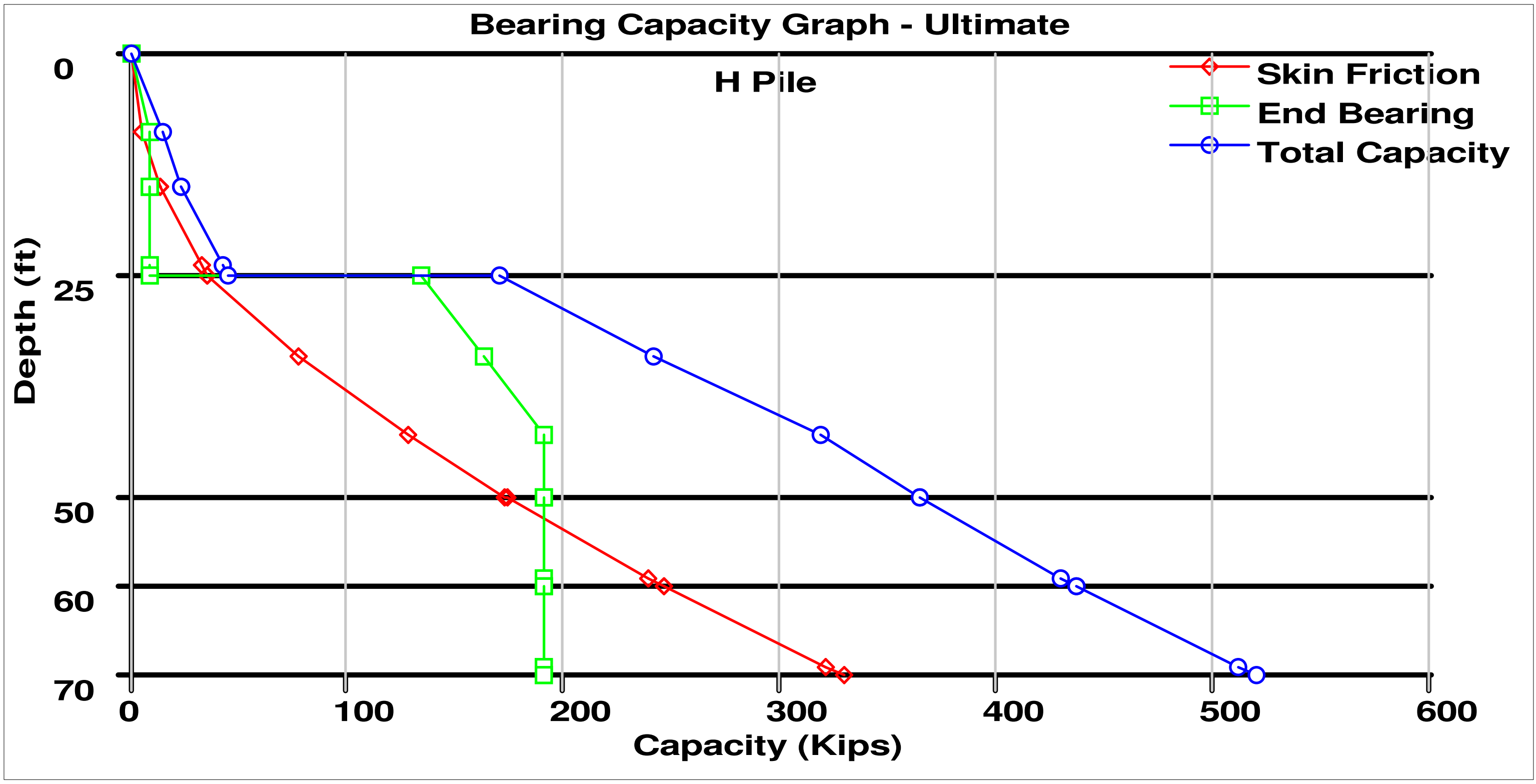
ULTIMATE - END BEARING

Depth	Soil Type	Effective Stress At Tip	Bearing Cap. Factor	Limiting End Bearing	End Bearing
0.01 ft	Cohesionless	1.20 psf	30.00	9.45 Kips	0.01 Kips
9.01 ft	Cohesionless	1081.20 psf	30.00	9.45 Kips	9.45 Kips
14.99 ft	Cohesionless	1798.80 psf	30.00	9.45 Kips	9.45 Kips
15.01 ft	Cohesionless	1800.58 psf	30.00	9.45 Kips	9.45 Kips
24.01 ft	Cohesionless	2318.98 psf	30.00	9.45 Kips	9.45 Kips
24.99 ft	Cohesionless	2375.42 psf	30.00	9.45 Kips	9.45 Kips
25.01 ft	Cohesionless	2376.58 psf	110.40	190.54 Kips	134.38 Kips
34.01 ft	Cohesionless	2894.98 psf	110.40	190.54 Kips	163.69 Kips
43.01 ft	Cohesionless	3413.38 psf	110.40	190.54 Kips	190.54 Kips
49.99 ft	Cohesionless	3815.42 psf	110.40	190.54 Kips	190.54 Kips
50.01 ft	Cohesionless	3816.58 psf	110.40	190.54 Kips	190.54 Kips
59.01 ft	Cohesionless	4334.98 psf	110.40	190.54 Kips	190.54 Kips
59.99 ft	Cohesionless	4391.42 psf	110.40	190.54 Kips	190.54 Kips
60.01 ft	Cohesionless	4392.58 psf	110.40	190.54 Kips	190.54 Kips
69.01 ft	Cohesionless	4910.98 psf	110.40	190.54 Kips	190.54 Kips
69.99 ft	Cohesionless	4967.42 psf	110.40	190.54 Kips	190.54 Kips

ULTIMATE - SUMMARY OF CAPACITIES

Depth	Skin Friction	End Bearing	Total Capacity
0.01 ft	0.00 Kips	0.01 Kips	0.01 Kips
9.01 ft	5.07 Kips	9.45 Kips	14.52 Kips
14.99 ft	14.04 Kips	9.45 Kips	23.49 Kips
15.01 ft	14.08 Kips	9.45 Kips	23.52 Kips
24.01 ft	33.38 Kips	9.45 Kips	42.83 Kips
24.99 ft	35.77 Kips	9.45 Kips	45.22 Kips
25.01 ft	35.84 Kips	134.38 Kips	170.22 Kips
34.01 ft	78.05 Kips	163.69 Kips	241.75 Kips
43.01 ft	128.57 Kips	190.54 Kips	319.11 Kips
49.99 ft	173.47 Kips	190.54 Kips	364.01 Kips
50.01 ft	173.60 Kips	190.54 Kips	364.14 Kips
59.01 ft	238.88 Kips	190.54 Kips	429.42 Kips
59.99 ft	246.49 Kips	190.54 Kips	437.03 Kips
60.01 ft	246.65 Kips	190.54 Kips	437.19 Kips
69.01 ft	321.15 Kips	190.54 Kips	511.69 Kips
69.99 ft	329.76 Kips	190.54 Kips	520.30 Kips

Filename: C:\HOLD\ABUT-A.DVN



DRIVEN 1.2

GENERAL PROJECT INFORMATION

Filename: C:\HOLD\ABUT-B.DVN
Project Name: Opitz Abut B   Project Date: 02/20/2020
Project Client: Transurban
Computed By: SKK
Project Manager: MJ

PILE INFORMATION

Pile Type: H Pile - HP10X57
Top of Pile: 0.00 ft
Perimeter Analysis: Box
Tip Analysis: Box Area

ULTIMATE CONSIDERATIONS

Water Table Depth At Time Of:	- Drilling:	34.00 ft
	- Driving/Restrike	34.00 ft
	- Ultimate:	34.00 ft
Ultimate Considerations:	- Local Scour:	0.00 ft
	- Long Term Scour:	0.00 ft
	- Soft Soil:	0.00 ft

ULTIMATE PROFILE

Layer	Type	Thickness	Driving Loss	Unit Weight	Strength	Ultimate Curve
1	Cohesionless	36.00 ft	0.00%	120.00 pcf	30.0/30.0	Nordlund
2	Cohesionless	14.00 ft	0.00%	125.00 pcf	36.0/38.0	Nordlund
3	Cohesionless	10.00 ft	0.00%	125.00 pcf	36.0/38.0	Nordlund
4	Cohesionless	10.00 ft	0.00%	120.00 pcf	36.0/38.0	Nordlund

RESTRIKE - SKIN FRICTION

Depth	Soil Type	Effective Stress At Midpoint	Sliding Friction Angle	Adhesion	Skin Friction
0.01 ft	Cohesionless	0.60 psf	22.81	N/A	0.00 Kips
9.01 ft	Cohesionless	540.60 psf	22.81	N/A	5.07 Kips
18.01 ft	Cohesionless	1080.60 psf	22.81	N/A	20.26 Kips
27.01 ft	Cohesionless	1620.60 psf	22.81	N/A	45.58 Kips
33.99 ft	Cohesionless	2039.40 psf	22.81	N/A	72.18 Kips
34.01 ft	Cohesionless	4080.29 psf	22.81	N/A	72.26 Kips
35.99 ft	Cohesionless	4137.31 psf	22.81	N/A	80.79 Kips
36.01 ft	Cohesionless	4195.51 psf	27.37	N/A	80.91 Kips
45.01 ft	Cohesionless	4477.21 psf	27.37	N/A	152.62 Kips
49.99 ft	Cohesionless	4633.09 psf	27.37	N/A	196.18 Kips
50.01 ft	Cohesionless	5071.91 psf	27.37	N/A	196.36 Kips
59.01 ft	Cohesionless	5353.61 psf	27.37	N/A	282.11 Kips
59.99 ft	Cohesionless	5384.29 psf	27.37	N/A	291.99 Kips
60.01 ft	Cohesionless	5697.89 psf	27.37	N/A	292.20 Kips
69.01 ft	Cohesionless	5957.09 psf	27.37	N/A	387.61 Kips
69.99 ft	Cohesionless	5985.31 psf	27.37	N/A	398.50 Kips

RESTRIKE - END BEARING

Depth	Soil Type	Effective Stress At Tip	Bearing Cap. Factor	Limiting End Bearing	End Bearing
0.01 ft	Cohesionless	1.20 psf	30.00	9.45 Kips	0.01 Kips
9.01 ft	Cohesionless	1081.20 psf	30.00	9.45 Kips	9.45 Kips
18.01 ft	Cohesionless	2161.20 psf	30.00	9.45 Kips	9.45 Kips
27.01 ft	Cohesionless	3241.20 psf	30.00	9.45 Kips	9.45 Kips
33.99 ft	Cohesionless	4078.80 psf	30.00	9.45 Kips	9.45 Kips
34.01 ft	Cohesionless	4080.58 psf	30.00	9.45 Kips	9.45 Kips
35.99 ft	Cohesionless	4194.62 psf	30.00	9.45 Kips	9.45 Kips
36.01 ft	Cohesionless	4195.83 psf	110.40	190.54 Kips	190.54 Kips
45.01 ft	Cohesionless	4759.23 psf	110.40	190.54 Kips	190.54 Kips
49.99 ft	Cohesionless	5070.97 psf	110.40	190.54 Kips	190.54 Kips
50.01 ft	Cohesionless	5072.23 psf	110.40	190.54 Kips	190.54 Kips
59.01 ft	Cohesionless	5635.63 psf	110.40	190.54 Kips	190.54 Kips
59.99 ft	Cohesionless	5696.97 psf	110.40	190.54 Kips	190.54 Kips
60.01 ft	Cohesionless	5698.18 psf	110.40	190.54 Kips	190.54 Kips
69.01 ft	Cohesionless	6216.58 psf	110.40	190.54 Kips	190.54 Kips
69.99 ft	Cohesionless	6273.02 psf	110.40	190.54 Kips	190.54 Kips

RESTRIKE - SUMMARY OF CAPACITIES

Depth	Skin Friction	End Bearing	Total Capacity
0.01 ft	0.00 Kips	0.01 Kips	0.01 Kips
9.01 ft	5.07 Kips	9.45 Kips	14.52 Kips
18.01 ft	20.26 Kips	9.45 Kips	29.71 Kips
27.01 ft	45.58 Kips	9.45 Kips	55.03 Kips
33.99 ft	72.18 Kips	9.45 Kips	81.63 Kips
34.01 ft	72.26 Kips	9.45 Kips	81.71 Kips
35.99 ft	80.79 Kips	9.45 Kips	90.24 Kips
36.01 ft	80.91 Kips	190.54 Kips	271.45 Kips
45.01 ft	152.62 Kips	190.54 Kips	343.16 Kips
49.99 ft	196.18 Kips	190.54 Kips	386.72 Kips
50.01 ft	196.36 Kips	190.54 Kips	386.90 Kips
59.01 ft	282.11 Kips	190.54 Kips	472.65 Kips
59.99 ft	291.99 Kips	190.54 Kips	482.53 Kips
60.01 ft	292.20 Kips	190.54 Kips	482.73 Kips
69.01 ft	387.61 Kips	190.54 Kips	578.15 Kips
69.99 ft	398.50 Kips	190.54 Kips	589.04 Kips

DRIVING - SKIN FRICTION

Depth	Soil Type	Effective Stress At Midpoint	Sliding Friction Angle	Adhesion	Skin Friction
0.01 ft	Cohesionless	0.60 psf	22.81	N/A	0.00 Kips
9.01 ft	Cohesionless	540.60 psf	22.81	N/A	5.07 Kips
18.01 ft	Cohesionless	1080.60 psf	22.81	N/A	20.26 Kips
27.01 ft	Cohesionless	1620.60 psf	22.81	N/A	45.58 Kips
33.99 ft	Cohesionless	2039.40 psf	22.81	N/A	72.18 Kips
34.01 ft	Cohesionless	4080.29 psf	22.81	N/A	72.26 Kips
35.99 ft	Cohesionless	4137.31 psf	22.81	N/A	80.79 Kips
36.01 ft	Cohesionless	4195.51 psf	27.37	N/A	80.91 Kips
45.01 ft	Cohesionless	4477.21 psf	27.37	N/A	152.62 Kips
49.99 ft	Cohesionless	4633.09 psf	27.37	N/A	196.18 Kips
50.01 ft	Cohesionless	5071.91 psf	27.37	N/A	196.36 Kips
59.01 ft	Cohesionless	5353.61 psf	27.37	N/A	282.11 Kips
59.99 ft	Cohesionless	5384.29 psf	27.37	N/A	291.99 Kips
60.01 ft	Cohesionless	5697.89 psf	27.37	N/A	292.20 Kips
69.01 ft	Cohesionless	5957.09 psf	27.37	N/A	387.61 Kips
69.99 ft	Cohesionless	5985.31 psf	27.37	N/A	398.50 Kips

DRIVING - END BEARING

Depth	Soil Type	Effective Stress At Tip	Bearing Cap. Factor	Limiting End Bearing	End Bearing
0.01 ft	Cohesionless	1.20 psf	30.00	9.45 Kips	0.01 Kips
9.01 ft	Cohesionless	1081.20 psf	30.00	9.45 Kips	9.45 Kips
18.01 ft	Cohesionless	2161.20 psf	30.00	9.45 Kips	9.45 Kips
27.01 ft	Cohesionless	3241.20 psf	30.00	9.45 Kips	9.45 Kips
33.99 ft	Cohesionless	4078.80 psf	30.00	9.45 Kips	9.45 Kips
34.01 ft	Cohesionless	4080.58 psf	30.00	9.45 Kips	9.45 Kips
35.99 ft	Cohesionless	4194.62 psf	30.00	9.45 Kips	9.45 Kips
36.01 ft	Cohesionless	4195.83 psf	110.40	190.54 Kips	190.54 Kips
45.01 ft	Cohesionless	4759.23 psf	110.40	190.54 Kips	190.54 Kips
49.99 ft	Cohesionless	5070.97 psf	110.40	190.54 Kips	190.54 Kips
50.01 ft	Cohesionless	5072.23 psf	110.40	190.54 Kips	190.54 Kips
59.01 ft	Cohesionless	5635.63 psf	110.40	190.54 Kips	190.54 Kips
59.99 ft	Cohesionless	5696.97 psf	110.40	190.54 Kips	190.54 Kips
60.01 ft	Cohesionless	5698.18 psf	110.40	190.54 Kips	190.54 Kips
69.01 ft	Cohesionless	6216.58 psf	110.40	190.54 Kips	190.54 Kips
69.99 ft	Cohesionless	6273.02 psf	110.40	190.54 Kips	190.54 Kips

DRIVING - SUMMARY OF CAPACITIES

Depth	Skin Friction	End Bearing	Total Capacity
0.01 ft	0.00 Kips	0.01 Kips	0.01 Kips
9.01 ft	5.07 Kips	9.45 Kips	14.52 Kips
18.01 ft	20.26 Kips	9.45 Kips	29.71 Kips
27.01 ft	45.58 Kips	9.45 Kips	55.03 Kips
33.99 ft	72.18 Kips	9.45 Kips	81.63 Kips
34.01 ft	72.26 Kips	9.45 Kips	81.71 Kips
35.99 ft	80.79 Kips	9.45 Kips	90.24 Kips
36.01 ft	80.91 Kips	190.54 Kips	271.45 Kips
45.01 ft	152.62 Kips	190.54 Kips	343.16 Kips
49.99 ft	196.18 Kips	190.54 Kips	386.72 Kips
50.01 ft	196.36 Kips	190.54 Kips	386.90 Kips
59.01 ft	282.11 Kips	190.54 Kips	472.65 Kips
59.99 ft	291.99 Kips	190.54 Kips	482.53 Kips
60.01 ft	292.20 Kips	190.54 Kips	482.73 Kips
69.01 ft	387.61 Kips	190.54 Kips	578.15 Kips
69.99 ft	398.50 Kips	190.54 Kips	589.04 Kips

ULTIMATE - SKIN FRICTION

Depth	Soil Type	Effective Stress At Midpoint	Sliding Friction Angle	Adhesion	Skin Friction
0.01 ft	Cohesionless	0.60 psf	22.81	N/A	0.00 Kips
9.01 ft	Cohesionless	540.60 psf	22.81	N/A	5.07 Kips
18.01 ft	Cohesionless	1080.60 psf	22.81	N/A	20.26 Kips
27.01 ft	Cohesionless	1620.60 psf	22.81	N/A	45.58 Kips
33.99 ft	Cohesionless	2039.40 psf	22.81	N/A	72.18 Kips
34.01 ft	Cohesionless	4080.29 psf	22.81	N/A	72.26 Kips
35.99 ft	Cohesionless	4137.31 psf	22.81	N/A	80.79 Kips
36.01 ft	Cohesionless	4195.51 psf	27.37	N/A	80.91 Kips
45.01 ft	Cohesionless	4477.21 psf	27.37	N/A	152.62 Kips
49.99 ft	Cohesionless	4633.09 psf	27.37	N/A	196.18 Kips
50.01 ft	Cohesionless	5071.91 psf	27.37	N/A	196.36 Kips
59.01 ft	Cohesionless	5353.61 psf	27.37	N/A	282.11 Kips
59.99 ft	Cohesionless	5384.29 psf	27.37	N/A	291.99 Kips
60.01 ft	Cohesionless	5697.89 psf	27.37	N/A	292.20 Kips
69.01 ft	Cohesionless	5957.09 psf	27.37	N/A	387.61 Kips
69.99 ft	Cohesionless	5985.31 psf	27.37	N/A	398.50 Kips

ULTIMATE - END BEARING

Depth	Soil Type	Effective Stress At Tip	Bearing Cap. Factor	Limiting End Bearing	End Bearing
0.01 ft	Cohesionless	1.20 psf	30.00	9.45 Kips	0.01 Kips
9.01 ft	Cohesionless	1081.20 psf	30.00	9.45 Kips	9.45 Kips
18.01 ft	Cohesionless	2161.20 psf	30.00	9.45 Kips	9.45 Kips
27.01 ft	Cohesionless	3241.20 psf	30.00	9.45 Kips	9.45 Kips
33.99 ft	Cohesionless	4078.80 psf	30.00	9.45 Kips	9.45 Kips
34.01 ft	Cohesionless	4080.58 psf	30.00	9.45 Kips	9.45 Kips
35.99 ft	Cohesionless	4194.62 psf	30.00	9.45 Kips	9.45 Kips
36.01 ft	Cohesionless	4195.83 psf	110.40	190.54 Kips	190.54 Kips
45.01 ft	Cohesionless	4759.23 psf	110.40	190.54 Kips	190.54 Kips
49.99 ft	Cohesionless	5070.97 psf	110.40	190.54 Kips	190.54 Kips
50.01 ft	Cohesionless	5072.23 psf	110.40	190.54 Kips	190.54 Kips
59.01 ft	Cohesionless	5635.63 psf	110.40	190.54 Kips	190.54 Kips
59.99 ft	Cohesionless	5696.97 psf	110.40	190.54 Kips	190.54 Kips
60.01 ft	Cohesionless	5698.18 psf	110.40	190.54 Kips	190.54 Kips
69.01 ft	Cohesionless	6216.58 psf	110.40	190.54 Kips	190.54 Kips
69.99 ft	Cohesionless	6273.02 psf	110.40	190.54 Kips	190.54 Kips

ULTIMATE - SUMMARY OF CAPACITIES

Depth	Skin Friction	End Bearing	Total Capacity
0.01 ft	0.00 Kips	0.01 Kips	0.01 Kips
9.01 ft	5.07 Kips	9.45 Kips	14.52 Kips
18.01 ft	20.26 Kips	9.45 Kips	29.71 Kips
27.01 ft	45.58 Kips	9.45 Kips	55.03 Kips
33.99 ft	72.18 Kips	9.45 Kips	81.63 Kips
34.01 ft	72.26 Kips	9.45 Kips	81.71 Kips
35.99 ft	80.79 Kips	9.45 Kips	90.24 Kips
36.01 ft	80.91 Kips	190.54 Kips	271.45 Kips
45.01 ft	152.62 Kips	190.54 Kips	343.16 Kips
49.99 ft	196.18 Kips	190.54 Kips	386.72 Kips
50.01 ft	196.36 Kips	190.54 Kips	386.90 Kips
59.01 ft	282.11 Kips	190.54 Kips	472.65 Kips
59.99 ft	291.99 Kips	190.54 Kips	482.53 Kips
60.01 ft	292.20 Kips	190.54 Kips	482.73 Kips
69.01 ft	387.61 Kips	190.54 Kips	578.15 Kips
69.99 ft	398.50 Kips	190.54 Kips	589.04 Kips

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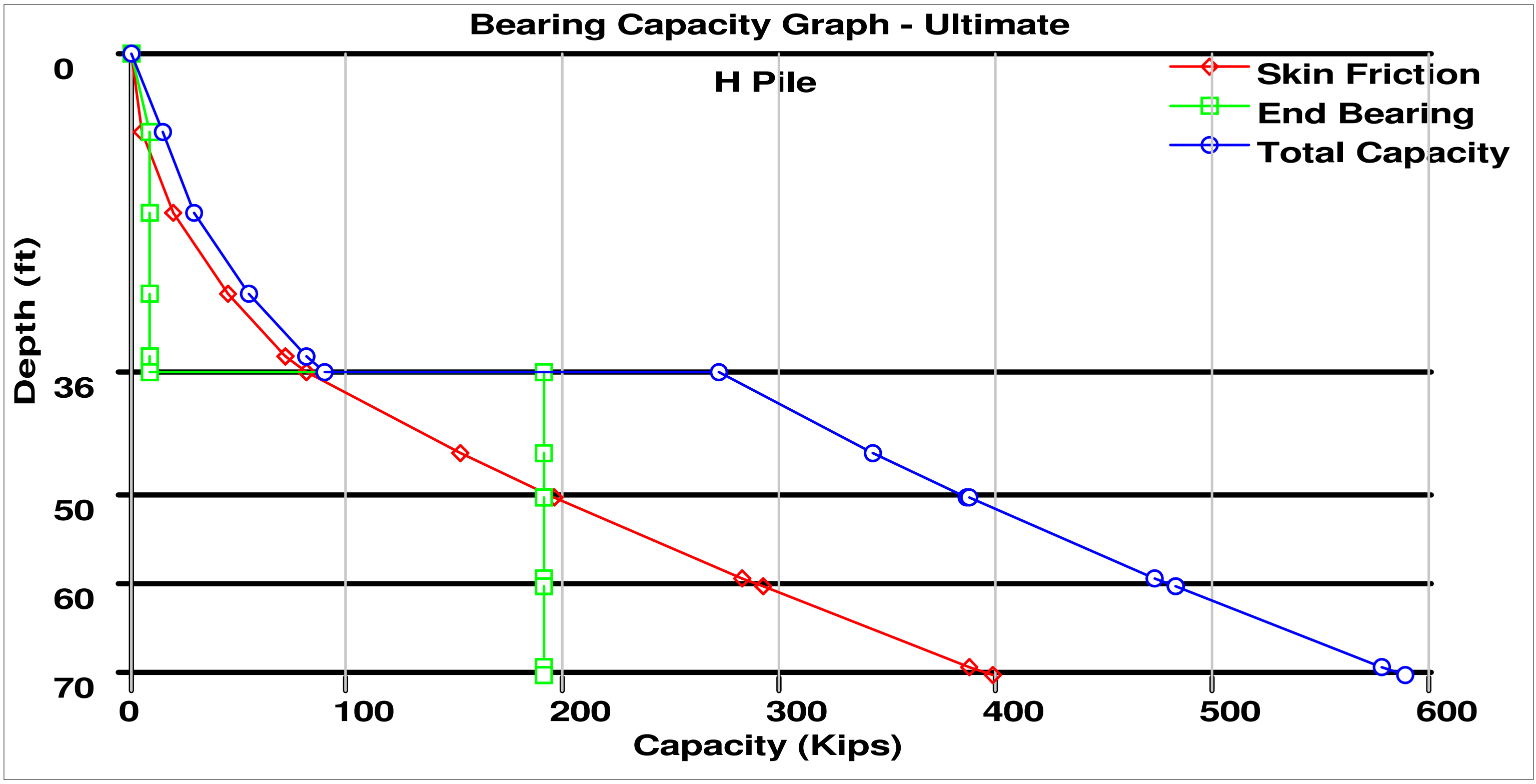

DRIVEN 1.2

GENERAL PROJECT INFORMATION

Filename: C:\HOLD\ABUT-C.DVN
Project Name: Opitz Abut C   Project Date: 02/20/2020
Project Client: Transurban
Computed By: SKK
Project Manager: MJ

PILE INFORMATION

Pile Type: H Pile - HP10X57
Top of Pile: 0.00 ft
Perimeter Analysis: Box
Tip Analysis: Box Area

ULTIMATE CONSIDERATIONS

Water Table Depth At Time Of:	- Drilling:	26.00 ft
	- Driving/Restrike	26.00 ft
	- Ultimate:	26.00 ft
Ultimate Considerations:	- Local Scour:	0.00 ft
	- Long Term Scour:	0.00 ft
	- Soft Soil:	0.00 ft

ULTIMATE PROFILE

Layer	Type	Thickness	Driving Loss	Unit Weight	Strength	Ultimate Curve
1	Cohesionless	29.00 ft	0.00%	120.00 pcf	30.0/30.0	Nordlund
2	Cohesionless	21.00 ft	0.00%	130.00 pcf	36.0/38.0	Nordlund
3	Cohesionless	10.00 ft	0.00%	130.00 pcf	36.0/38.0	Nordlund
4	Cohesionless	10.00 ft	0.00%	130.00 pcf	36.0/38.0	Nordlund

RESTRIKE - SKIN FRICTION

Depth	Soil Type	Effective Stress At Midpoint	Sliding Friction Angle	Adhesion	Skin Friction
0.01 ft	Cohesionless	0.60 psf	22.81	N/A	0.00 Kips
9.01 ft	Cohesionless	540.60 psf	22.81	N/A	5.07 Kips
18.01 ft	Cohesionless	1080.60 psf	22.81	N/A	20.26 Kips
25.99 ft	Cohesionless	1559.40 psf	22.81	N/A	42.20 Kips
26.01 ft	Cohesionless	3120.29 psf	22.81	N/A	42.26 Kips
28.99 ft	Cohesionless	3206.11 psf	22.81	N/A	52.21 Kips
29.01 ft	Cohesionless	3293.14 psf	27.37	N/A	52.31 Kips
38.01 ft	Cohesionless	3597.34 psf	27.37	N/A	109.93 Kips
47.01 ft	Cohesionless	3901.54 psf	27.37	N/A	177.29 Kips
49.99 ft	Cohesionless	4002.26 psf	27.37	N/A	201.74 Kips
50.01 ft	Cohesionless	4712.74 psf	27.37	N/A	201.91 Kips
59.01 ft	Cohesionless	5016.94 psf	27.37	N/A	282.27 Kips
59.99 ft	Cohesionless	5050.06 psf	27.37	N/A	291.61 Kips
60.01 ft	Cohesionless	5388.74 psf	27.37	N/A	291.80 Kips
69.01 ft	Cohesionless	5692.94 psf	27.37	N/A	382.98 Kips
69.99 ft	Cohesionless	5726.06 psf	27.37	N/A	393.50 Kips

RESTRIKE - END BEARING

Depth	Soil Type	Effective Stress At Tip	Bearing Cap. Factor	Limiting End Bearing	End Bearing
0.01 ft	Cohesionless	1.20 psf	30.00	9.45 Kips	0.01 Kips
9.01 ft	Cohesionless	1081.20 psf	30.00	9.45 Kips	9.45 Kips
18.01 ft	Cohesionless	2161.20 psf	30.00	9.45 Kips	9.45 Kips
25.99 ft	Cohesionless	3118.80 psf	30.00	9.45 Kips	9.45 Kips
26.01 ft	Cohesionless	3120.58 psf	30.00	9.45 Kips	9.45 Kips
28.99 ft	Cohesionless	3292.22 psf	30.00	9.45 Kips	9.45 Kips
29.01 ft	Cohesionless	3293.48 psf	110.40	190.54 Kips	186.22 Kips
38.01 ft	Cohesionless	3901.88 psf	110.40	190.54 Kips	190.54 Kips
47.01 ft	Cohesionless	4510.28 psf	110.40	190.54 Kips	190.54 Kips
49.99 ft	Cohesionless	4711.72 psf	110.40	190.54 Kips	190.54 Kips
50.01 ft	Cohesionless	4713.08 psf	110.40	190.54 Kips	190.54 Kips
59.01 ft	Cohesionless	5321.48 psf	110.40	190.54 Kips	190.54 Kips
59.99 ft	Cohesionless	5387.72 psf	110.40	190.54 Kips	190.54 Kips
60.01 ft	Cohesionless	5389.08 psf	110.40	190.54 Kips	190.54 Kips
69.01 ft	Cohesionless	5997.48 psf	110.40	190.54 Kips	190.54 Kips
69.99 ft	Cohesionless	6063.72 psf	110.40	190.54 Kips	190.54 Kips

RESTRIKE - SUMMARY OF CAPACITIES

Depth	Skin Friction	End Bearing	Total Capacity
0.01 ft	0.00 Kips	0.01 Kips	0.01 Kips
9.01 ft	5.07 Kips	9.45 Kips	14.52 Kips
18.01 ft	20.26 Kips	9.45 Kips	29.71 Kips
25.99 ft	42.20 Kips	9.45 Kips	51.65 Kips
26.01 ft	42.26 Kips	9.45 Kips	51.71 Kips
28.99 ft	52.21 Kips	9.45 Kips	61.66 Kips
29.01 ft	52.31 Kips	186.22 Kips	238.53 Kips
38.01 ft	109.93 Kips	190.54 Kips	300.47 Kips
47.01 ft	177.29 Kips	190.54 Kips	367.83 Kips
49.99 ft	201.74 Kips	190.54 Kips	392.28 Kips
50.01 ft	201.91 Kips	190.54 Kips	392.45 Kips
59.01 ft	282.27 Kips	190.54 Kips	472.81 Kips
59.99 ft	291.61 Kips	190.54 Kips	482.15 Kips
60.01 ft	291.80 Kips	190.54 Kips	482.34 Kips
69.01 ft	382.98 Kips	190.54 Kips	573.52 Kips
69.99 ft	393.50 Kips	190.54 Kips	584.04 Kips

DRIVING - SKIN FRICTION

Depth	Soil Type	Effective Stress At Midpoint	Sliding Friction Angle	Adhesion	Skin Friction
0.01 ft	Cohesionless	0.60 psf	22.81	N/A	0.00 Kips
9.01 ft	Cohesionless	540.60 psf	22.81	N/A	5.07 Kips
18.01 ft	Cohesionless	1080.60 psf	22.81	N/A	20.26 Kips
25.99 ft	Cohesionless	1559.40 psf	22.81	N/A	42.20 Kips
26.01 ft	Cohesionless	3120.29 psf	22.81	N/A	42.26 Kips
28.99 ft	Cohesionless	3206.11 psf	22.81	N/A	52.21 Kips
29.01 ft	Cohesionless	3293.14 psf	27.37	N/A	52.31 Kips
38.01 ft	Cohesionless	3597.34 psf	27.37	N/A	109.93 Kips
47.01 ft	Cohesionless	3901.54 psf	27.37	N/A	177.29 Kips
49.99 ft	Cohesionless	4002.26 psf	27.37	N/A	201.74 Kips
50.01 ft	Cohesionless	4712.74 psf	27.37	N/A	201.91 Kips
59.01 ft	Cohesionless	5016.94 psf	27.37	N/A	282.27 Kips
59.99 ft	Cohesionless	5050.06 psf	27.37	N/A	291.61 Kips
60.01 ft	Cohesionless	5388.74 psf	27.37	N/A	291.80 Kips
69.01 ft	Cohesionless	5692.94 psf	27.37	N/A	382.98 Kips
69.99 ft	Cohesionless	5726.06 psf	27.37	N/A	393.50 Kips

DRIVING - END BEARING

Depth	Soil Type	Effective Stress At Tip	Bearing Cap. Factor	Limiting End Bearing	End Bearing
0.01 ft	Cohesionless	1.20 psf	30.00	9.45 Kips	0.01 Kips
9.01 ft	Cohesionless	1081.20 psf	30.00	9.45 Kips	9.45 Kips
18.01 ft	Cohesionless	2161.20 psf	30.00	9.45 Kips	9.45 Kips
25.99 ft	Cohesionless	3118.80 psf	30.00	9.45 Kips	9.45 Kips
26.01 ft	Cohesionless	3120.58 psf	30.00	9.45 Kips	9.45 Kips
28.99 ft	Cohesionless	3292.22 psf	30.00	9.45 Kips	9.45 Kips
29.01 ft	Cohesionless	3293.48 psf	110.40	190.54 Kips	186.22 Kips
38.01 ft	Cohesionless	3901.88 psf	110.40	190.54 Kips	190.54 Kips
47.01 ft	Cohesionless	4510.28 psf	110.40	190.54 Kips	190.54 Kips
49.99 ft	Cohesionless	4711.72 psf	110.40	190.54 Kips	190.54 Kips
50.01 ft	Cohesionless	4713.08 psf	110.40	190.54 Kips	190.54 Kips
59.01 ft	Cohesionless	5321.48 psf	110.40	190.54 Kips	190.54 Kips
59.99 ft	Cohesionless	5387.72 psf	110.40	190.54 Kips	190.54 Kips
60.01 ft	Cohesionless	5389.08 psf	110.40	190.54 Kips	190.54 Kips
69.01 ft	Cohesionless	5997.48 psf	110.40	190.54 Kips	190.54 Kips
69.99 ft	Cohesionless	6063.72 psf	110.40	190.54 Kips	190.54 Kips

DRIVING - SUMMARY OF CAPACITIES

Depth	Skin Friction	End Bearing	Total Capacity
0.01 ft	0.00 Kips	0.01 Kips	0.01 Kips
9.01 ft	5.07 Kips	9.45 Kips	14.52 Kips
18.01 ft	20.26 Kips	9.45 Kips	29.71 Kips
25.99 ft	42.20 Kips	9.45 Kips	51.65 Kips
26.01 ft	42.26 Kips	9.45 Kips	51.71 Kips
28.99 ft	52.21 Kips	9.45 Kips	61.66 Kips
29.01 ft	52.31 Kips	186.22 Kips	238.53 Kips
38.01 ft	109.93 Kips	190.54 Kips	300.47 Kips
47.01 ft	177.29 Kips	190.54 Kips	367.83 Kips
49.99 ft	201.74 Kips	190.54 Kips	392.28 Kips
50.01 ft	201.91 Kips	190.54 Kips	392.45 Kips
59.01 ft	282.27 Kips	190.54 Kips	472.81 Kips
59.99 ft	291.61 Kips	190.54 Kips	482.15 Kips
60.01 ft	291.80 Kips	190.54 Kips	482.34 Kips
69.01 ft	382.98 Kips	190.54 Kips	573.52 Kips
69.99 ft	393.50 Kips	190.54 Kips	584.04 Kips

ULTIMATE - SKIN FRICTION

Depth	Soil Type	Effective Stress At Midpoint	Sliding Friction Angle	Adhesion	Skin Friction
0.01 ft	Cohesionless	0.60 psf	22.81	N/A	0.00 Kips
9.01 ft	Cohesionless	540.60 psf	22.81	N/A	5.07 Kips
18.01 ft	Cohesionless	1080.60 psf	22.81	N/A	20.26 Kips
25.99 ft	Cohesionless	1559.40 psf	22.81	N/A	42.20 Kips
26.01 ft	Cohesionless	3120.29 psf	22.81	N/A	42.26 Kips
28.99 ft	Cohesionless	3206.11 psf	22.81	N/A	52.21 Kips
29.01 ft	Cohesionless	3293.14 psf	27.37	N/A	52.31 Kips
38.01 ft	Cohesionless	3597.34 psf	27.37	N/A	109.93 Kips
47.01 ft	Cohesionless	3901.54 psf	27.37	N/A	177.29 Kips
49.99 ft	Cohesionless	4002.26 psf	27.37	N/A	201.74 Kips
50.01 ft	Cohesionless	4712.74 psf	27.37	N/A	201.91 Kips
59.01 ft	Cohesionless	5016.94 psf	27.37	N/A	282.27 Kips
59.99 ft	Cohesionless	5050.06 psf	27.37	N/A	291.61 Kips
60.01 ft	Cohesionless	5388.74 psf	27.37	N/A	291.80 Kips
69.01 ft	Cohesionless	5692.94 psf	27.37	N/A	382.98 Kips
69.99 ft	Cohesionless	5726.06 psf	27.37	N/A	393.50 Kips

ULTIMATE - END BEARING

Depth	Soil Type	Effective Stress At Tip	Bearing Cap. Factor	Limiting End Bearing	End Bearing
0.01 ft	Cohesionless	1.20 psf	30.00	9.45 Kips	0.01 Kips
9.01 ft	Cohesionless	1081.20 psf	30.00	9.45 Kips	9.45 Kips
18.01 ft	Cohesionless	2161.20 psf	30.00	9.45 Kips	9.45 Kips
25.99 ft	Cohesionless	3118.80 psf	30.00	9.45 Kips	9.45 Kips
26.01 ft	Cohesionless	3120.58 psf	30.00	9.45 Kips	9.45 Kips
28.99 ft	Cohesionless	3292.22 psf	30.00	9.45 Kips	9.45 Kips
29.01 ft	Cohesionless	3293.48 psf	110.40	190.54 Kips	186.22 Kips
38.01 ft	Cohesionless	3901.88 psf	110.40	190.54 Kips	190.54 Kips
47.01 ft	Cohesionless	4510.28 psf	110.40	190.54 Kips	190.54 Kips
49.99 ft	Cohesionless	4711.72 psf	110.40	190.54 Kips	190.54 Kips
50.01 ft	Cohesionless	4713.08 psf	110.40	190.54 Kips	190.54 Kips
59.01 ft	Cohesionless	5321.48 psf	110.40	190.54 Kips	190.54 Kips
59.99 ft	Cohesionless	5387.72 psf	110.40	190.54 Kips	190.54 Kips
60.01 ft	Cohesionless	5389.08 psf	110.40	190.54 Kips	190.54 Kips
69.01 ft	Cohesionless	5997.48 psf	110.40	190.54 Kips	190.54 Kips
69.99 ft	Cohesionless	6063.72 psf	110.40	190.54 Kips	190.54 Kips

ULTIMATE - SUMMARY OF CAPACITIES

Depth	Skin Friction	End Bearing	Total Capacity
0.01 ft	0.00 Kips	0.01 Kips	0.01 Kips
9.01 ft	5.07 Kips	9.45 Kips	14.52 Kips
18.01 ft	20.26 Kips	9.45 Kips	29.71 Kips
25.99 ft	42.20 Kips	9.45 Kips	51.65 Kips
26.01 ft	42.26 Kips	9.45 Kips	51.71 Kips
28.99 ft	52.21 Kips	9.45 Kips	61.66 Kips
29.01 ft	52.31 Kips	186.22 Kips	238.53 Kips
38.01 ft	109.93 Kips	190.54 Kips	300.47 Kips
47.01 ft	177.29 Kips	190.54 Kips	367.83 Kips
49.99 ft	201.74 Kips	190.54 Kips	392.28 Kips
50.01 ft	201.91 Kips	190.54 Kips	392.45 Kips
59.01 ft	282.27 Kips	190.54 Kips	472.81 Kips
59.99 ft	291.61 Kips	190.54 Kips	482.15 Kips
60.01 ft	291.80 Kips	190.54 Kips	482.34 Kips
69.01 ft	382.98 Kips	190.54 Kips	573.52 Kips
69.99 ft	393.50 Kips	190.54 Kips	584.04 Kips

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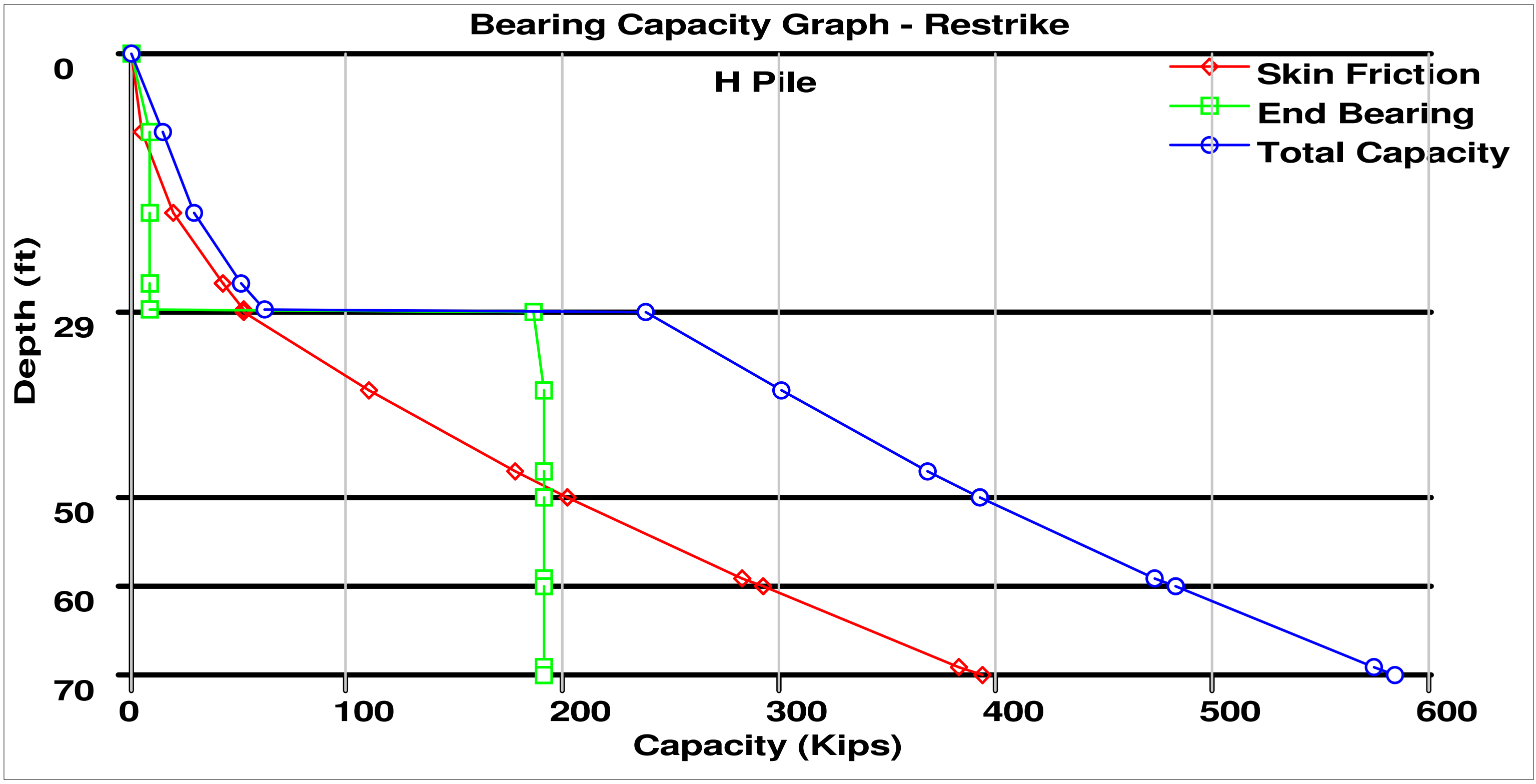

DRIVEN 1.2

GENERAL PROJECT INFORMATION

Filename: C:\HOLD\PIER-1.DVN
Project Name: Opitz Pier-1 Project Date: 02/20/2020
Project Client: Transurban
Computed By: SKK
Project Manager: MJ

PILE INFORMATION

Pile Type: H Pile - HP10X57
Top of Pile: 0.00 ft
Perimeter Analysis: Box
Tip Analysis: Box Area

ULTIMATE CONSIDERATIONS

Water Table Depth At Time Of:	- Drilling:	12.00 ft
	- Driving/Restrike	12.00 ft
	- Ultimate:	12.00 ft
Ultimate Considerations:	- Local Scour:	0.00 ft
	- Long Term Scour:	0.00 ft
	- Soft Soil:	0.00 ft

ULTIMATE PROFILE

Layer	Type	Thickness	Driving Loss	Unit Weight	Strength	Ultimate Curve
1	Cohesionless	16.00 ft	0.00%	120.00 pcf	30.0/30.0	Nordlund
2	Cohesionless	24.00 ft	0.00%	130.00 pcf	38.0/38.0	Nordlund
3	Cohesionless	10.00 ft	0.00%	130.00 pcf	38.0/38.0	Nordlund
4	Cohesionless	10.00 ft	0.00%	130.00 pcf	38.0/38.0	Nordlund

RESTRIKE - SKIN FRICTION

Depth	Soil Type	Effective Stress At Midpoint	Sliding Friction Angle	Adhesion	Skin Friction
0.01 ft	Cohesionless	0.60 psf	22.81	N/A	0.00 Kips
9.01 ft	Cohesionless	540.60 psf	22.81	N/A	5.07 Kips
11.99 ft	Cohesionless	719.40 psf	22.81	N/A	8.98 Kips
12.01 ft	Cohesionless	1440.29 psf	22.81	N/A	9.01 Kips
15.99 ft	Cohesionless	1554.91 psf	22.81	N/A	15.46 Kips
16.01 ft	Cohesionless	1670.74 psf	28.89	N/A	15.51 Kips
25.01 ft	Cohesionless	1974.94 psf	28.89	N/A	54.24 Kips
34.01 ft	Cohesionless	2279.14 psf	28.89	N/A	104.89 Kips
39.99 ft	Cohesionless	2481.26 psf	28.89	N/A	145.14 Kips
40.01 ft	Cohesionless	3293.14 psf	28.89	N/A	145.29 Kips
49.01 ft	Cohesionless	3597.34 psf	28.89	N/A	215.82 Kips
49.99 ft	Cohesionless	3630.46 psf	28.89	N/A	224.22 Kips
50.01 ft	Cohesionless	3969.14 psf	28.89	N/A	224.40 Kips
59.01 ft	Cohesionless	4273.34 psf	28.89	N/A	308.18 Kips
59.99 ft	Cohesionless	4306.46 psf	28.89	N/A	318.03 Kips

RESTRIKE - END BEARING

Depth	Soil Type	Effective Stress At Tip	Bearing Cap. Factor	Limiting End Bearing	End Bearing
0.01 ft	Cohesionless	1.20 psf	30.00	9.45 Kips	0.01 Kips
9.01 ft	Cohesionless	1081.20 psf	30.00	9.45 Kips	9.45 Kips
11.99 ft	Cohesionless	1438.80 psf	30.00	9.45 Kips	9.45 Kips
12.01 ft	Cohesionless	1440.58 psf	30.00	9.45 Kips	9.45 Kips
15.99 ft	Cohesionless	1669.82 psf	30.00	9.45 Kips	9.45 Kips
16.01 ft	Cohesionless	1671.08 psf	110.40	190.54 Kips	94.49 Kips
25.01 ft	Cohesionless	2279.48 psf	110.40	190.54 Kips	128.89 Kips
34.01 ft	Cohesionless	2887.88 psf	110.40	190.54 Kips	163.29 Kips
39.99 ft	Cohesionless	3292.12 psf	110.40	190.54 Kips	186.15 Kips
40.01 ft	Cohesionless	3293.48 psf	110.40	190.54 Kips	186.22 Kips
49.01 ft	Cohesionless	3901.88 psf	110.40	190.54 Kips	190.54 Kips
49.99 ft	Cohesionless	3968.12 psf	110.40	190.54 Kips	190.54 Kips
50.01 ft	Cohesionless	3969.48 psf	110.40	190.54 Kips	190.54 Kips
59.01 ft	Cohesionless	4577.88 psf	110.40	190.54 Kips	190.54 Kips
59.99 ft	Cohesionless	4644.12 psf	110.40	190.54 Kips	190.54 Kips

RESTRIKE - SUMMARY OF CAPACITIES

Depth	Skin Friction	End Bearing	Total Capacity
0.01 ft	0.00 Kips	0.01 Kips	0.01 Kips
9.01 ft	5.07 Kips	9.45 Kips	14.52 Kips
11.99 ft	8.98 Kips	9.45 Kips	18.43 Kips
12.01 ft	9.01 Kips	9.45 Kips	18.46 Kips
15.99 ft	15.46 Kips	9.45 Kips	24.90 Kips
16.01 ft	15.51 Kips	94.49 Kips	110.00 Kips
25.01 ft	54.24 Kips	128.89 Kips	183.13 Kips
34.01 ft	104.89 Kips	163.29 Kips	268.18 Kips
39.99 ft	145.14 Kips	186.15 Kips	331.29 Kips
40.01 ft	145.29 Kips	186.22 Kips	331.51 Kips
49.01 ft	215.82 Kips	190.54 Kips	406.36 Kips
49.99 ft	224.22 Kips	190.54 Kips	414.76 Kips
50.01 ft	224.40 Kips	190.54 Kips	414.93 Kips
59.01 ft	308.18 Kips	190.54 Kips	498.72 Kips
59.99 ft	318.03 Kips	190.54 Kips	508.57 Kips

DRIVING - SKIN FRICTION

Depth	Soil Type	Effective Stress At Midpoint	Sliding Friction Angle	Adhesion	Skin Friction
0.01 ft	Cohesionless	0.60 psf	22.81	N/A	0.00 Kips
9.01 ft	Cohesionless	540.60 psf	22.81	N/A	5.07 Kips
11.99 ft	Cohesionless	719.40 psf	22.81	N/A	8.98 Kips
12.01 ft	Cohesionless	1440.29 psf	22.81	N/A	9.01 Kips
15.99 ft	Cohesionless	1554.91 psf	22.81	N/A	15.46 Kips
16.01 ft	Cohesionless	1670.74 psf	28.89	N/A	15.51 Kips
25.01 ft	Cohesionless	1974.94 psf	28.89	N/A	54.24 Kips
34.01 ft	Cohesionless	2279.14 psf	28.89	N/A	104.89 Kips
39.99 ft	Cohesionless	2481.26 psf	28.89	N/A	145.14 Kips
40.01 ft	Cohesionless	3293.14 psf	28.89	N/A	145.29 Kips
49.01 ft	Cohesionless	3597.34 psf	28.89	N/A	215.82 Kips
49.99 ft	Cohesionless	3630.46 psf	28.89	N/A	224.22 Kips
50.01 ft	Cohesionless	3969.14 psf	28.89	N/A	224.40 Kips
59.01 ft	Cohesionless	4273.34 psf	28.89	N/A	308.18 Kips
59.99 ft	Cohesionless	4306.46 psf	28.89	N/A	318.03 Kips

DRIVING - END BEARING

Depth	Soil Type	Effective Stress At Tip	Bearing Cap. Factor	Limiting End Bearing	End Bearing
0.01 ft	Cohesionless	1.20 psf	30.00	9.45 Kips	0.01 Kips
9.01 ft	Cohesionless	1081.20 psf	30.00	9.45 Kips	9.45 Kips
11.99 ft	Cohesionless	1438.80 psf	30.00	9.45 Kips	9.45 Kips
12.01 ft	Cohesionless	1440.58 psf	30.00	9.45 Kips	9.45 Kips
15.99 ft	Cohesionless	1669.82 psf	30.00	9.45 Kips	9.45 Kips
16.01 ft	Cohesionless	1671.08 psf	110.40	190.54 Kips	94.49 Kips
25.01 ft	Cohesionless	2279.48 psf	110.40	190.54 Kips	128.89 Kips
34.01 ft	Cohesionless	2887.88 psf	110.40	190.54 Kips	163.29 Kips
39.99 ft	Cohesionless	3292.12 psf	110.40	190.54 Kips	186.15 Kips
40.01 ft	Cohesionless	3293.48 psf	110.40	190.54 Kips	186.22 Kips
49.01 ft	Cohesionless	3901.88 psf	110.40	190.54 Kips	190.54 Kips
49.99 ft	Cohesionless	3968.12 psf	110.40	190.54 Kips	190.54 Kips
50.01 ft	Cohesionless	3969.48 psf	110.40	190.54 Kips	190.54 Kips
59.01 ft	Cohesionless	4577.88 psf	110.40	190.54 Kips	190.54 Kips
59.99 ft	Cohesionless	4644.12 psf	110.40	190.54 Kips	190.54 Kips

DRIVING - SUMMARY OF CAPACITIES

Depth	Skin Friction	End Bearing	Total Capacity
0.01 ft	0.00 Kips	0.01 Kips	0.01 Kips
9.01 ft	5.07 Kips	9.45 Kips	14.52 Kips
11.99 ft	8.98 Kips	9.45 Kips	18.43 Kips
12.01 ft	9.01 Kips	9.45 Kips	18.46 Kips
15.99 ft	15.46 Kips	9.45 Kips	24.90 Kips
16.01 ft	15.51 Kips	94.49 Kips	110.00 Kips
25.01 ft	54.24 Kips	128.89 Kips	183.13 Kips
34.01 ft	104.89 Kips	163.29 Kips	268.18 Kips
39.99 ft	145.14 Kips	186.15 Kips	331.29 Kips
40.01 ft	145.29 Kips	186.22 Kips	331.51 Kips
49.01 ft	215.82 Kips	190.54 Kips	406.36 Kips
49.99 ft	224.22 Kips	190.54 Kips	414.76 Kips
50.01 ft	224.40 Kips	190.54 Kips	414.93 Kips
59.01 ft	308.18 Kips	190.54 Kips	498.72 Kips
59.99 ft	318.03 Kips	190.54 Kips	508.57 Kips

ULTIMATE - SKIN FRICTION

Depth	Soil Type	Effective Stress At Midpoint	Sliding Friction Angle	Adhesion	Skin Friction
0.01 ft	Cohesionless	0.60 psf	22.81	N/A	0.00 Kips
9.01 ft	Cohesionless	540.60 psf	22.81	N/A	5.07 Kips
11.99 ft	Cohesionless	719.40 psf	22.81	N/A	8.98 Kips
12.01 ft	Cohesionless	1440.29 psf	22.81	N/A	9.01 Kips
15.99 ft	Cohesionless	1554.91 psf	22.81	N/A	15.46 Kips
16.01 ft	Cohesionless	1670.74 psf	28.89	N/A	15.51 Kips
25.01 ft	Cohesionless	1974.94 psf	28.89	N/A	54.24 Kips
34.01 ft	Cohesionless	2279.14 psf	28.89	N/A	104.89 Kips
39.99 ft	Cohesionless	2481.26 psf	28.89	N/A	145.14 Kips
40.01 ft	Cohesionless	3293.14 psf	28.89	N/A	145.29 Kips
49.01 ft	Cohesionless	3597.34 psf	28.89	N/A	215.82 Kips
49.99 ft	Cohesionless	3630.46 psf	28.89	N/A	224.22 Kips
50.01 ft	Cohesionless	3969.14 psf	28.89	N/A	224.40 Kips
59.01 ft	Cohesionless	4273.34 psf	28.89	N/A	308.18 Kips
59.99 ft	Cohesionless	4306.46 psf	28.89	N/A	318.03 Kips

ULTIMATE - END BEARING

Depth	Soil Type	Effective Stress At Tip	Bearing Cap. Factor	Limiting End Bearing	End Bearing
0.01 ft	Cohesionless	1.20 psf	30.00	9.45 Kips	0.01 Kips
9.01 ft	Cohesionless	1081.20 psf	30.00	9.45 Kips	9.45 Kips
11.99 ft	Cohesionless	1438.80 psf	30.00	9.45 Kips	9.45 Kips
12.01 ft	Cohesionless	1440.58 psf	30.00	9.45 Kips	9.45 Kips
15.99 ft	Cohesionless	1669.82 psf	30.00	9.45 Kips	9.45 Kips
16.01 ft	Cohesionless	1671.08 psf	110.40	190.54 Kips	94.49 Kips
25.01 ft	Cohesionless	2279.48 psf	110.40	190.54 Kips	128.89 Kips
34.01 ft	Cohesionless	2887.88 psf	110.40	190.54 Kips	163.29 Kips
39.99 ft	Cohesionless	3292.12 psf	110.40	190.54 Kips	186.15 Kips
40.01 ft	Cohesionless	3293.48 psf	110.40	190.54 Kips	186.22 Kips
49.01 ft	Cohesionless	3901.88 psf	110.40	190.54 Kips	190.54 Kips
49.99 ft	Cohesionless	3968.12 psf	110.40	190.54 Kips	190.54 Kips
50.01 ft	Cohesionless	3969.48 psf	110.40	190.54 Kips	190.54 Kips
59.01 ft	Cohesionless	4577.88 psf	110.40	190.54 Kips	190.54 Kips
59.99 ft	Cohesionless	4644.12 psf	110.40	190.54 Kips	190.54 Kips

ULTIMATE - SUMMARY OF CAPACITIES

Depth	Skin Friction	End Bearing	Total Capacity
0.01 ft	0.00 Kips	0.01 Kips	0.01 Kips
9.01 ft	5.07 Kips	9.45 Kips	14.52 Kips
11.99 ft	8.98 Kips	9.45 Kips	18.43 Kips
12.01 ft	9.01 Kips	9.45 Kips	18.46 Kips
15.99 ft	15.46 Kips	9.45 Kips	24.90 Kips
16.01 ft	15.51 Kips	94.49 Kips	110.00 Kips
25.01 ft	54.24 Kips	128.89 Kips	183.13 Kips
34.01 ft	104.89 Kips	163.29 Kips	268.18 Kips
39.99 ft	145.14 Kips	186.15 Kips	331.29 Kips
40.01 ft	145.29 Kips	186.22 Kips	331.51 Kips
49.01 ft	215.82 Kips	190.54 Kips	406.36 Kips
49.99 ft	224.22 Kips	190.54 Kips	414.76 Kips
50.01 ft	224.40 Kips	190.54 Kips	414.93 Kips
59.01 ft	308.18 Kips	190.54 Kips	498.72 Kips
59.99 ft	318.03 Kips	190.54 Kips	508.57 Kips

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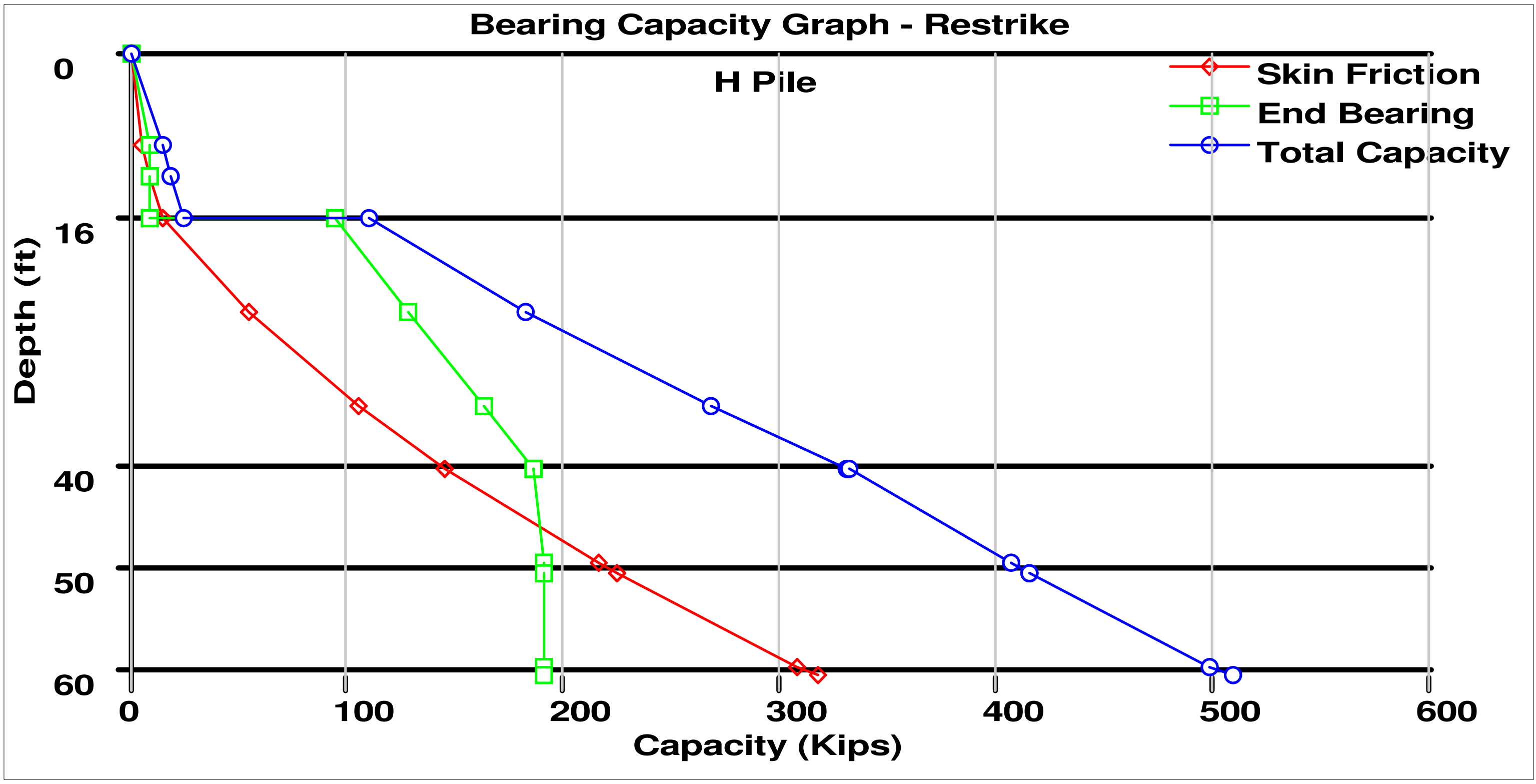

DRIVEN 1.2

GENERAL PROJECT INFORMATION

Filename: C:\HOLD\PIER-2.DVN
Project Name: Opitz Pier-2 Project Date: 02/20/2020
Project Client: Transurban
Computed By: SKK
Project Manager: MJ

PILE INFORMATION

Pile Type: H Pile - HP10X57
Top of Pile: 5.00 ft
Perimeter Analysis: Box
Tip Analysis: Pile Area

ULTIMATE CONSIDERATIONS

Water Table Depth At Time Of:	- Drilling:	22.00 ft
	- Driving/Restrike	22.00 ft
	- Ultimate:	22.00 ft
Ultimate Considerations:	- Local Scour:	0.00 ft
	- Long Term Scour:	0.00 ft
	- Soft Soil:	0.00 ft

ULTIMATE PROFILE

Layer	Type	Thickness	Driving Loss	Unit Weight	Strength	Ultimate Curve
1	Cohesionless	24.00 ft	0.00%	120.00 pcf	30.0/30.0	Nordlund
2	Cohesionless	26.00 ft	0.00%	130.00 pcf	38.0/38.0	Nordlund
3	Cohesionless	10.00 ft	0.00%	120.00 pcf	38.0/38.0	Nordlund
4	Cohesionless	10.00 ft	0.00%	120.00 pcf	38.0/38.0	Nordlund

RESTRIKE - SKIN FRICTION

Depth	Soil Type	Effective Stress At Midpoint	Sliding Friction Angle	Adhesion	Skin Friction
0.01 ft	Cohesionless	0.00 psf	0.00	N/A	0.00 Kips
4.99 ft	Cohesionless	0.00 psf	0.00	N/A	0.00 Kips
5.00 ft	Cohesionless	600.00 psf	22.81	N/A	0.00 Kips
9.01 ft	Cohesionless	840.60 psf	22.81	N/A	3.51 Kips
18.01 ft	Cohesionless	1380.60 psf	22.81	N/A	18.70 Kips
21.99 ft	Cohesionless	1619.40 psf	22.81	N/A	28.65 Kips
22.01 ft	Cohesionless	2640.29 psf	22.81	N/A	28.70 Kips
23.99 ft	Cohesionless	2697.31 psf	22.81	N/A	34.26 Kips
24.01 ft	Cohesionless	2755.54 psf	28.89	N/A	34.35 Kips
33.01 ft	Cohesionless	3059.74 psf	28.89	N/A	94.35 Kips
42.01 ft	Cohesionless	3363.94 psf	28.89	N/A	166.27 Kips
49.99 ft	Cohesionless	3633.66 psf	28.89	N/A	240.02 Kips
50.01 ft	Cohesionless	4513.09 psf	28.89	N/A	240.22 Kips
59.01 ft	Cohesionless	4772.29 psf	28.89	N/A	333.78 Kips
59.99 ft	Cohesionless	4800.51 psf	28.89	N/A	344.59 Kips
60.01 ft	Cohesionless	5089.09 psf	28.89	N/A	344.81 Kips
69.01 ft	Cohesionless	5348.29 psf	28.89	N/A	449.67 Kips
69.99 ft	Cohesionless	5376.51 psf	28.89	N/A	461.70 Kips

RESTRIKE - END BEARING

Depth	Soil Type	Effective Stress At Tip	Bearing Cap. Factor	Limiting End Bearing	End Bearing
0.01 ft	Cohesionless	0.00 psf	30.00	1.55 Kips	0.00 Kips
4.99 ft	Cohesionless	0.00 psf	30.00	1.55 Kips	0.00 Kips
5.00 ft	Cohesionless	600.00 psf	30.00	1.55 Kips	1.22 Kips
9.01 ft	Cohesionless	1081.20 psf	30.00	1.55 Kips	1.55 Kips
18.01 ft	Cohesionless	2161.20 psf	30.00	1.55 Kips	1.55 Kips
21.99 ft	Cohesionless	2638.80 psf	30.00	1.55 Kips	1.55 Kips
22.01 ft	Cohesionless	2640.58 psf	30.00	1.55 Kips	1.55 Kips
23.99 ft	Cohesionless	2754.62 psf	30.00	1.55 Kips	1.55 Kips
24.01 ft	Cohesionless	2755.88 psf	110.40	31.34 Kips	25.63 Kips
33.01 ft	Cohesionless	3364.28 psf	110.40	31.34 Kips	31.29 Kips
42.01 ft	Cohesionless	3972.68 psf	110.40	31.34 Kips	31.34 Kips
49.99 ft	Cohesionless	4512.12 psf	110.40	31.34 Kips	31.34 Kips
50.01 ft	Cohesionless	4513.38 psf	110.40	31.34 Kips	31.34 Kips
59.01 ft	Cohesionless	5031.78 psf	110.40	31.34 Kips	31.34 Kips
59.99 ft	Cohesionless	5088.22 psf	110.40	31.34 Kips	31.34 Kips
60.01 ft	Cohesionless	5089.38 psf	110.40	31.34 Kips	31.34 Kips
69.01 ft	Cohesionless	5607.78 psf	110.40	31.34 Kips	31.34 Kips
69.99 ft	Cohesionless	5664.22 psf	110.40	31.34 Kips	31.34 Kips

RESTRIKE - SUMMARY OF CAPACITIES

Depth	Skin Friction	End Bearing	Total Capacity
0.01 ft	0.00 Kips	0.00 Kips	0.00 Kips
4.99 ft	0.00 Kips	0.00 Kips	0.00 Kips
5.00 ft	0.00 Kips	1.22 Kips	1.22 Kips
9.01 ft	3.51 Kips	1.55 Kips	5.06 Kips
18.01 ft	18.70 Kips	1.55 Kips	20.26 Kips
21.99 ft	28.65 Kips	1.55 Kips	30.20 Kips
22.01 ft	28.70 Kips	1.55 Kips	30.26 Kips
23.99 ft	34.26 Kips	1.55 Kips	35.82 Kips
24.01 ft	34.35 Kips	25.63 Kips	59.98 Kips
33.01 ft	94.35 Kips	31.29 Kips	125.63 Kips
42.01 ft	166.27 Kips	31.34 Kips	197.61 Kips
49.99 ft	240.02 Kips	31.34 Kips	271.36 Kips
50.01 ft	240.22 Kips	31.34 Kips	271.55 Kips
59.01 ft	333.78 Kips	31.34 Kips	365.12 Kips
59.99 ft	344.59 Kips	31.34 Kips	375.92 Kips
60.01 ft	344.81 Kips	31.34 Kips	376.15 Kips
69.01 ft	449.67 Kips	31.34 Kips	481.01 Kips
69.99 ft	461.70 Kips	31.34 Kips	493.04 Kips

DRIVING - SKIN FRICTION

Depth	Soil Type	Effective Stress At Midpoint	Sliding Friction Angle	Adhesion	Skin Friction
0.01 ft	Cohesionless	0.00 psf	0.00	N/A	0.00 Kips
4.99 ft	Cohesionless	0.00 psf	0.00	N/A	0.00 Kips
5.00 ft	Cohesionless	600.00 psf	22.81	N/A	0.00 Kips
9.01 ft	Cohesionless	840.60 psf	22.81	N/A	3.51 Kips
18.01 ft	Cohesionless	1380.60 psf	22.81	N/A	18.70 Kips
21.99 ft	Cohesionless	1619.40 psf	22.81	N/A	28.65 Kips
22.01 ft	Cohesionless	2640.29 psf	22.81	N/A	28.70 Kips
23.99 ft	Cohesionless	2697.31 psf	22.81	N/A	34.26 Kips
24.01 ft	Cohesionless	2755.54 psf	28.89	N/A	34.35 Kips
33.01 ft	Cohesionless	3059.74 psf	28.89	N/A	94.35 Kips
42.01 ft	Cohesionless	3363.94 psf	28.89	N/A	166.27 Kips
49.99 ft	Cohesionless	3633.66 psf	28.89	N/A	240.02 Kips
50.01 ft	Cohesionless	4513.09 psf	28.89	N/A	240.22 Kips
59.01 ft	Cohesionless	4772.29 psf	28.89	N/A	333.78 Kips
59.99 ft	Cohesionless	4800.51 psf	28.89	N/A	344.59 Kips
60.01 ft	Cohesionless	5089.09 psf	28.89	N/A	344.81 Kips
69.01 ft	Cohesionless	5348.29 psf	28.89	N/A	449.67 Kips
69.99 ft	Cohesionless	5376.51 psf	28.89	N/A	461.70 Kips

DRIVING - END BEARING

Depth	Soil Type	Effective Stress At Tip	Bearing Cap. Factor	Limiting End Bearing	End Bearing
0.01 ft	Cohesionless	0.00 psf	30.00	1.55 Kips	0.00 Kips
4.99 ft	Cohesionless	0.00 psf	30.00	1.55 Kips	0.00 Kips
5.00 ft	Cohesionless	600.00 psf	30.00	1.55 Kips	1.22 Kips
9.01 ft	Cohesionless	1081.20 psf	30.00	1.55 Kips	1.55 Kips
18.01 ft	Cohesionless	2161.20 psf	30.00	1.55 Kips	1.55 Kips
21.99 ft	Cohesionless	2638.80 psf	30.00	1.55 Kips	1.55 Kips
22.01 ft	Cohesionless	2640.58 psf	30.00	1.55 Kips	1.55 Kips
23.99 ft	Cohesionless	2754.62 psf	30.00	1.55 Kips	1.55 Kips
24.01 ft	Cohesionless	2755.88 psf	110.40	31.34 Kips	25.63 Kips
33.01 ft	Cohesionless	3364.28 psf	110.40	31.34 Kips	31.29 Kips
42.01 ft	Cohesionless	3972.68 psf	110.40	31.34 Kips	31.34 Kips
49.99 ft	Cohesionless	4512.12 psf	110.40	31.34 Kips	31.34 Kips
50.01 ft	Cohesionless	4513.38 psf	110.40	31.34 Kips	31.34 Kips
59.01 ft	Cohesionless	5031.78 psf	110.40	31.34 Kips	31.34 Kips
59.99 ft	Cohesionless	5088.22 psf	110.40	31.34 Kips	31.34 Kips
60.01 ft	Cohesionless	5089.38 psf	110.40	31.34 Kips	31.34 Kips
69.01 ft	Cohesionless	5607.78 psf	110.40	31.34 Kips	31.34 Kips
69.99 ft	Cohesionless	5664.22 psf	110.40	31.34 Kips	31.34 Kips

DRIVING - SUMMARY OF CAPACITIES

Depth	Skin Friction	End Bearing	Total Capacity
0.01 ft	0.00 Kips	0.00 Kips	0.00 Kips
4.99 ft	0.00 Kips	0.00 Kips	0.00 Kips
5.00 ft	0.00 Kips	1.22 Kips	1.22 Kips
9.01 ft	3.51 Kips	1.55 Kips	5.06 Kips
18.01 ft	18.70 Kips	1.55 Kips	20.26 Kips
21.99 ft	28.65 Kips	1.55 Kips	30.20 Kips
22.01 ft	28.70 Kips	1.55 Kips	30.26 Kips
23.99 ft	34.26 Kips	1.55 Kips	35.82 Kips
24.01 ft	34.35 Kips	25.63 Kips	59.98 Kips
33.01 ft	94.35 Kips	31.29 Kips	125.63 Kips
42.01 ft	166.27 Kips	31.34 Kips	197.61 Kips
49.99 ft	240.02 Kips	31.34 Kips	271.36 Kips
50.01 ft	240.22 Kips	31.34 Kips	271.55 Kips
59.01 ft	333.78 Kips	31.34 Kips	365.12 Kips
59.99 ft	344.59 Kips	31.34 Kips	375.92 Kips
60.01 ft	344.81 Kips	31.34 Kips	376.15 Kips
69.01 ft	449.67 Kips	31.34 Kips	481.01 Kips
69.99 ft	461.70 Kips	31.34 Kips	493.04 Kips

ULTIMATE - SKIN FRICTION

Depth	Soil Type	Effective Stress At Midpoint	Sliding Friction Angle	Adhesion	Skin Friction
0.01 ft	Cohesionless	0.00 psf	0.00	N/A	0.00 Kips
4.99 ft	Cohesionless	0.00 psf	0.00	N/A	0.00 Kips
5.00 ft	Cohesionless	600.00 psf	22.81	N/A	0.00 Kips
9.01 ft	Cohesionless	840.60 psf	22.81	N/A	3.51 Kips
18.01 ft	Cohesionless	1380.60 psf	22.81	N/A	18.70 Kips
21.99 ft	Cohesionless	1619.40 psf	22.81	N/A	28.65 Kips
22.01 ft	Cohesionless	2640.29 psf	22.81	N/A	28.70 Kips
23.99 ft	Cohesionless	2697.31 psf	22.81	N/A	34.26 Kips
24.01 ft	Cohesionless	2755.54 psf	28.89	N/A	34.35 Kips
33.01 ft	Cohesionless	3059.74 psf	28.89	N/A	94.35 Kips
42.01 ft	Cohesionless	3363.94 psf	28.89	N/A	166.27 Kips
49.99 ft	Cohesionless	3633.66 psf	28.89	N/A	240.02 Kips
50.01 ft	Cohesionless	4513.09 psf	28.89	N/A	240.22 Kips
59.01 ft	Cohesionless	4772.29 psf	28.89	N/A	333.78 Kips
59.99 ft	Cohesionless	4800.51 psf	28.89	N/A	344.59 Kips
60.01 ft	Cohesionless	5089.09 psf	28.89	N/A	344.81 Kips
69.01 ft	Cohesionless	5348.29 psf	28.89	N/A	449.67 Kips
69.99 ft	Cohesionless	5376.51 psf	28.89	N/A	461.70 Kips

ULTIMATE - END BEARING

Depth	Soil Type	Effective Stress At Tip	Bearing Cap. Factor	Limiting End Bearing	End Bearing
0.01 ft	Cohesionless	0.00 psf	30.00	1.55 Kips	0.00 Kips
4.99 ft	Cohesionless	0.00 psf	30.00	1.55 Kips	0.00 Kips
5.00 ft	Cohesionless	600.00 psf	30.00	1.55 Kips	1.22 Kips
9.01 ft	Cohesionless	1081.20 psf	30.00	1.55 Kips	1.55 Kips
18.01 ft	Cohesionless	2161.20 psf	30.00	1.55 Kips	1.55 Kips
21.99 ft	Cohesionless	2638.80 psf	30.00	1.55 Kips	1.55 Kips
22.01 ft	Cohesionless	2640.58 psf	30.00	1.55 Kips	1.55 Kips
23.99 ft	Cohesionless	2754.62 psf	30.00	1.55 Kips	1.55 Kips
24.01 ft	Cohesionless	2755.88 psf	110.40	31.34 Kips	25.63 Kips
33.01 ft	Cohesionless	3364.28 psf	110.40	31.34 Kips	31.29 Kips
42.01 ft	Cohesionless	3972.68 psf	110.40	31.34 Kips	31.34 Kips
49.99 ft	Cohesionless	4512.12 psf	110.40	31.34 Kips	31.34 Kips
50.01 ft	Cohesionless	4513.38 psf	110.40	31.34 Kips	31.34 Kips
59.01 ft	Cohesionless	5031.78 psf	110.40	31.34 Kips	31.34 Kips
59.99 ft	Cohesionless	5088.22 psf	110.40	31.34 Kips	31.34 Kips
60.01 ft	Cohesionless	5089.38 psf	110.40	31.34 Kips	31.34 Kips
69.01 ft	Cohesionless	5607.78 psf	110.40	31.34 Kips	31.34 Kips
69.99 ft	Cohesionless	5664.22 psf	110.40	31.34 Kips	31.34 Kips

ULTIMATE - SUMMARY OF CAPACITIES

Depth	Skin Friction	End Bearing	Total Capacity
0.01 ft	0.00 Kips	0.00 Kips	0.00 Kips
4.99 ft	0.00 Kips	0.00 Kips	0.00 Kips
5.00 ft	0.00 Kips	1.22 Kips	1.22 Kips
9.01 ft	3.51 Kips	1.55 Kips	5.06 Kips
18.01 ft	18.70 Kips	1.55 Kips	20.26 Kips
21.99 ft	28.65 Kips	1.55 Kips	30.20 Kips
22.01 ft	28.70 Kips	1.55 Kips	30.26 Kips
23.99 ft	34.26 Kips	1.55 Kips	35.82 Kips
24.01 ft	34.35 Kips	25.63 Kips	59.98 Kips
33.01 ft	94.35 Kips	31.29 Kips	125.63 Kips
42.01 ft	166.27 Kips	31.34 Kips	197.61 Kips
49.99 ft	240.02 Kips	31.34 Kips	271.36 Kips
50.01 ft	240.22 Kips	31.34 Kips	271.55 Kips
59.01 ft	333.78 Kips	31.34 Kips	365.12 Kips
59.99 ft	344.59 Kips	31.34 Kips	375.92 Kips
60.01 ft	344.81 Kips	31.34 Kips	376.15 Kips
69.01 ft	449.67 Kips	31.34 Kips	481.01 Kips
69.99 ft	461.70 Kips	31.34 Kips	493.04 Kips

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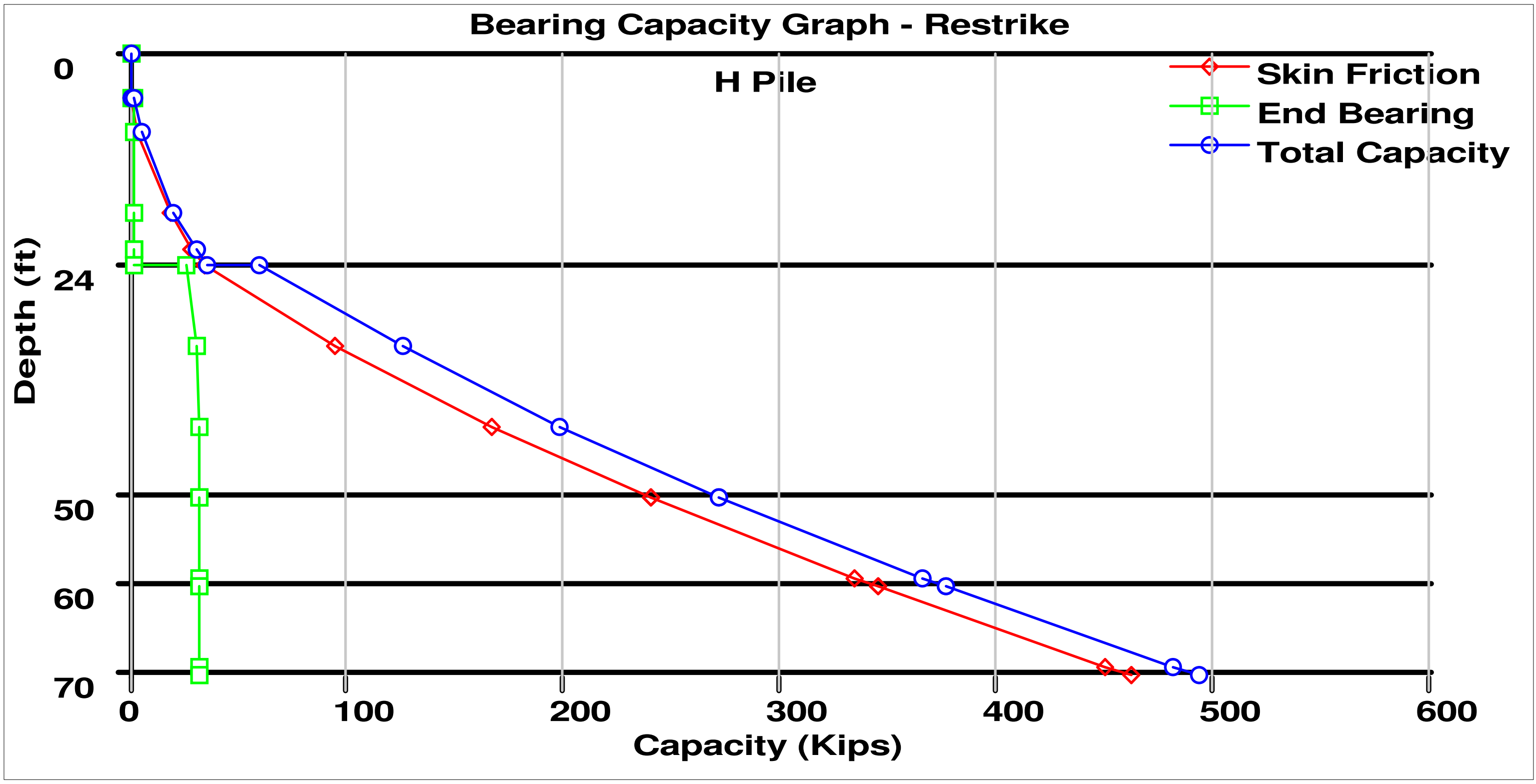


DRIVEN 1.2

GENERAL PROJECT INFORMATION

Filename: C:\HOLD\PIER-3.DVN
Project Name: Opitz Pier-2 Project Date: 02/20/2020
Project Client: Transurban
Computed By: SKK
Project Manager: MJ

PILE INFORMATION

Pile Type: H Pile - HP10X57
Top of Pile: 5.00 ft
Perimeter Analysis: Box
Tip Analysis: Box Area

ULTIMATE CONSIDERATIONS

Water Table Depth At Time Of:	- Drilling:	23.00 ft
	- Driving/Restrike	23.00 ft
	- Ultimate:	23.00 ft
Ultimate Considerations:	- Local Scour:	0.00 ft
	- Long Term Scour:	0.00 ft
	- Soft Soil:	0.00 ft

ULTIMATE PROFILE

Layer	Type	Thickness	Driving Loss	Unit Weight	Strength	Ultimate Curve
1	Cohesionless	24.00 ft	0.00%	120.00 pcf	30.0/30.0	Nordlund
2	Cohesionless	16.00 ft	0.00%	130.00 pcf	38.0/38.0	Nordlund
3	Cohesionless	10.00 ft	0.00%	120.00 pcf	38.0/38.0	Nordlund
4	Cohesionless	10.00 ft	0.00%	120.00 pcf	38.0/38.0	Nordlund

RESTRIKE - SKIN FRICTION

Depth	Soil Type	Effective Stress At Midpoint	Sliding Friction Angle	Adhesion	Skin Friction
0.01 ft	Cohesionless	0.00 psf	0.00	N/A	0.00 Kips
4.99 ft	Cohesionless	0.00 psf	0.00	N/A	0.00 Kips
5.00 ft	Cohesionless	600.00 psf	22.81	N/A	0.00 Kips
9.01 ft	Cohesionless	840.60 psf	22.81	N/A	3.51 Kips
18.01 ft	Cohesionless	1380.60 psf	22.81	N/A	18.70 Kips
22.99 ft	Cohesionless	1679.40 psf	22.81	N/A	31.46 Kips
23.01 ft	Cohesionless	2760.29 psf	22.81	N/A	31.52 Kips
23.99 ft	Cohesionless	2788.51 psf	22.81	N/A	34.36 Kips
24.01 ft	Cohesionless	2817.94 psf	28.89	N/A	34.45 Kips
33.01 ft	Cohesionless	3122.14 psf	28.89	N/A	95.67 Kips
39.99 ft	Cohesionless	3358.06 psf	28.89	N/A	151.36 Kips
40.01 ft	Cohesionless	3899.49 psf	28.89	N/A	151.53 Kips
49.01 ft	Cohesionless	4158.69 psf	28.89	N/A	233.07 Kips
49.99 ft	Cohesionless	4186.91 psf	28.89	N/A	242.56 Kips
50.01 ft	Cohesionless	4475.49 psf	28.89	N/A	242.76 Kips
59.01 ft	Cohesionless	4734.69 psf	28.89	N/A	335.59 Kips
59.99 ft	Cohesionless	4762.91 psf	28.89	N/A	346.31 Kips

RESTRIKE - END BEARING

Depth	Soil Type	Effective Stress At Tip	Bearing Cap. Factor	Limiting End Bearing	End Bearing
0.01 ft	Cohesionless	0.00 psf	30.00	9.45 Kips	0.00 Kips
4.99 ft	Cohesionless	0.00 psf	30.00	9.45 Kips	0.00 Kips
5.00 ft	Cohesionless	600.00 psf	30.00	9.45 Kips	7.41 Kips
9.01 ft	Cohesionless	1081.20 psf	30.00	9.45 Kips	9.45 Kips
18.01 ft	Cohesionless	2161.20 psf	30.00	9.45 Kips	9.45 Kips
22.99 ft	Cohesionless	2758.80 psf	30.00	9.45 Kips	9.45 Kips
23.01 ft	Cohesionless	2760.58 psf	30.00	9.45 Kips	9.45 Kips
23.99 ft	Cohesionless	2817.02 psf	30.00	9.45 Kips	9.45 Kips
24.01 ft	Cohesionless	2818.28 psf	110.40	190.54 Kips	159.35 Kips
33.01 ft	Cohesionless	3426.68 psf	110.40	190.54 Kips	190.54 Kips
39.99 ft	Cohesionless	3898.52 psf	110.40	190.54 Kips	190.54 Kips
40.01 ft	Cohesionless	3899.78 psf	110.40	190.54 Kips	190.54 Kips
49.01 ft	Cohesionless	4418.18 psf	110.40	190.54 Kips	190.54 Kips
49.99 ft	Cohesionless	4474.62 psf	110.40	190.54 Kips	190.54 Kips
50.01 ft	Cohesionless	4475.78 psf	110.40	190.54 Kips	190.54 Kips
59.01 ft	Cohesionless	4994.18 psf	110.40	190.54 Kips	190.54 Kips
59.99 ft	Cohesionless	5050.62 psf	110.40	190.54 Kips	190.54 Kips

RESTRIKE - SUMMARY OF CAPACITIES

Depth	Skin Friction	End Bearing	Total Capacity
0.01 ft	0.00 Kips	0.00 Kips	0.00 Kips
4.99 ft	0.00 Kips	0.00 Kips	0.00 Kips
5.00 ft	0.00 Kips	7.41 Kips	7.41 Kips
9.01 ft	3.51 Kips	9.45 Kips	12.96 Kips
18.01 ft	18.70 Kips	9.45 Kips	28.15 Kips
22.99 ft	31.46 Kips	9.45 Kips	40.91 Kips
23.01 ft	31.52 Kips	9.45 Kips	40.96 Kips
23.99 ft	34.36 Kips	9.45 Kips	43.81 Kips
24.01 ft	34.45 Kips	159.35 Kips	193.81 Kips
33.01 ft	95.67 Kips	190.54 Kips	286.21 Kips
39.99 ft	151.36 Kips	190.54 Kips	341.90 Kips
40.01 ft	151.53 Kips	190.54 Kips	342.07 Kips
49.01 ft	233.07 Kips	190.54 Kips	423.61 Kips
49.99 ft	242.56 Kips	190.54 Kips	433.10 Kips
50.01 ft	242.76 Kips	190.54 Kips	433.30 Kips
59.01 ft	335.59 Kips	190.54 Kips	526.13 Kips
59.99 ft	346.31 Kips	190.54 Kips	536.85 Kips

DRIVING - SKIN FRICTION

Depth	Soil Type	Effective Stress At Midpoint	Sliding Friction Angle	Adhesion	Skin Friction
0.01 ft	Cohesionless	0.00 psf	0.00	N/A	0.00 Kips
4.99 ft	Cohesionless	0.00 psf	0.00	N/A	0.00 Kips
5.00 ft	Cohesionless	600.00 psf	22.81	N/A	0.00 Kips
9.01 ft	Cohesionless	840.60 psf	22.81	N/A	3.51 Kips
18.01 ft	Cohesionless	1380.60 psf	22.81	N/A	18.70 Kips
22.99 ft	Cohesionless	1679.40 psf	22.81	N/A	31.46 Kips
23.01 ft	Cohesionless	2760.29 psf	22.81	N/A	31.52 Kips
23.99 ft	Cohesionless	2788.51 psf	22.81	N/A	34.36 Kips
24.01 ft	Cohesionless	2817.94 psf	28.89	N/A	34.45 Kips
33.01 ft	Cohesionless	3122.14 psf	28.89	N/A	95.67 Kips
39.99 ft	Cohesionless	3358.06 psf	28.89	N/A	151.36 Kips
40.01 ft	Cohesionless	3899.49 psf	28.89	N/A	151.53 Kips
49.01 ft	Cohesionless	4158.69 psf	28.89	N/A	233.07 Kips
49.99 ft	Cohesionless	4186.91 psf	28.89	N/A	242.56 Kips
50.01 ft	Cohesionless	4475.49 psf	28.89	N/A	242.76 Kips
59.01 ft	Cohesionless	4734.69 psf	28.89	N/A	335.59 Kips
59.99 ft	Cohesionless	4762.91 psf	28.89	N/A	346.31 Kips

DRIVING - END BEARING

Depth	Soil Type	Effective Stress At Tip	Bearing Cap. Factor	Limiting End Bearing	End Bearing
0.01 ft	Cohesionless	0.00 psf	30.00	9.45 Kips	0.00 Kips
4.99 ft	Cohesionless	0.00 psf	30.00	9.45 Kips	0.00 Kips
5.00 ft	Cohesionless	600.00 psf	30.00	9.45 Kips	7.41 Kips
9.01 ft	Cohesionless	1081.20 psf	30.00	9.45 Kips	9.45 Kips
18.01 ft	Cohesionless	2161.20 psf	30.00	9.45 Kips	9.45 Kips
22.99 ft	Cohesionless	2758.80 psf	30.00	9.45 Kips	9.45 Kips
23.01 ft	Cohesionless	2760.58 psf	30.00	9.45 Kips	9.45 Kips
23.99 ft	Cohesionless	2817.02 psf	30.00	9.45 Kips	9.45 Kips
24.01 ft	Cohesionless	2818.28 psf	110.40	190.54 Kips	159.35 Kips
33.01 ft	Cohesionless	3426.68 psf	110.40	190.54 Kips	190.54 Kips
39.99 ft	Cohesionless	3898.52 psf	110.40	190.54 Kips	190.54 Kips
40.01 ft	Cohesionless	3899.78 psf	110.40	190.54 Kips	190.54 Kips
49.01 ft	Cohesionless	4418.18 psf	110.40	190.54 Kips	190.54 Kips
49.99 ft	Cohesionless	4474.62 psf	110.40	190.54 Kips	190.54 Kips
50.01 ft	Cohesionless	4475.78 psf	110.40	190.54 Kips	190.54 Kips
59.01 ft	Cohesionless	4994.18 psf	110.40	190.54 Kips	190.54 Kips
59.99 ft	Cohesionless	5050.62 psf	110.40	190.54 Kips	190.54 Kips

DRIVING - SUMMARY OF CAPACITIES

Depth	Skin Friction	End Bearing	Total Capacity
0.01 ft	0.00 Kips	0.00 Kips	0.00 Kips
4.99 ft	0.00 Kips	0.00 Kips	0.00 Kips
5.00 ft	0.00 Kips	7.41 Kips	7.41 Kips
9.01 ft	3.51 Kips	9.45 Kips	12.96 Kips
18.01 ft	18.70 Kips	9.45 Kips	28.15 Kips
22.99 ft	31.46 Kips	9.45 Kips	40.91 Kips
23.01 ft	31.52 Kips	9.45 Kips	40.96 Kips
23.99 ft	34.36 Kips	9.45 Kips	43.81 Kips
24.01 ft	34.45 Kips	159.35 Kips	193.81 Kips
33.01 ft	95.67 Kips	190.54 Kips	286.21 Kips
39.99 ft	151.36 Kips	190.54 Kips	341.90 Kips
40.01 ft	151.53 Kips	190.54 Kips	342.07 Kips
49.01 ft	233.07 Kips	190.54 Kips	423.61 Kips
49.99 ft	242.56 Kips	190.54 Kips	433.10 Kips
50.01 ft	242.76 Kips	190.54 Kips	433.30 Kips
59.01 ft	335.59 Kips	190.54 Kips	526.13 Kips
59.99 ft	346.31 Kips	190.54 Kips	536.85 Kips

ULTIMATE - SKIN FRICTION

Depth	Soil Type	Effective Stress At Midpoint	Sliding Friction Angle	Adhesion	Skin Friction
0.01 ft	Cohesionless	0.00 psf	0.00	N/A	0.00 Kips
4.99 ft	Cohesionless	0.00 psf	0.00	N/A	0.00 Kips
5.00 ft	Cohesionless	600.00 psf	22.81	N/A	0.00 Kips
9.01 ft	Cohesionless	840.60 psf	22.81	N/A	3.51 Kips
18.01 ft	Cohesionless	1380.60 psf	22.81	N/A	18.70 Kips
22.99 ft	Cohesionless	1679.40 psf	22.81	N/A	31.46 Kips
23.01 ft	Cohesionless	2760.29 psf	22.81	N/A	31.52 Kips
23.99 ft	Cohesionless	2788.51 psf	22.81	N/A	34.36 Kips
24.01 ft	Cohesionless	2817.94 psf	28.89	N/A	34.45 Kips
33.01 ft	Cohesionless	3122.14 psf	28.89	N/A	95.67 Kips
39.99 ft	Cohesionless	3358.06 psf	28.89	N/A	151.36 Kips
40.01 ft	Cohesionless	3899.49 psf	28.89	N/A	151.53 Kips
49.01 ft	Cohesionless	4158.69 psf	28.89	N/A	233.07 Kips
49.99 ft	Cohesionless	4186.91 psf	28.89	N/A	242.56 Kips
50.01 ft	Cohesionless	4475.49 psf	28.89	N/A	242.76 Kips
59.01 ft	Cohesionless	4734.69 psf	28.89	N/A	335.59 Kips
59.99 ft	Cohesionless	4762.91 psf	28.89	N/A	346.31 Kips

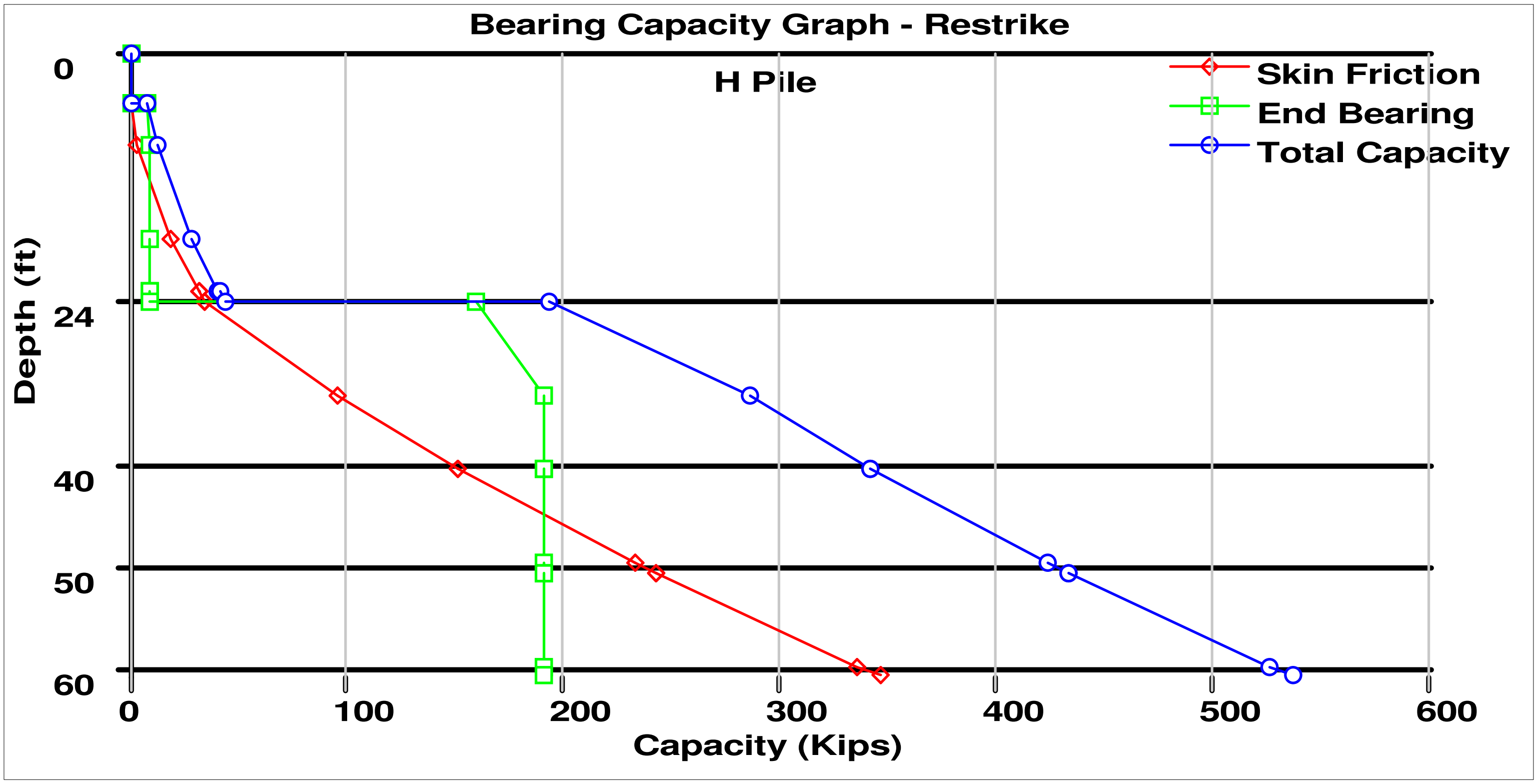
ULTIMATE - END BEARING

Depth	Soil Type	Effective Stress At Tip	Bearing Cap. Factor	Limiting End Bearing	End Bearing
0.01 ft	Cohesionless	0.00 psf	30.00	9.45 Kips	0.00 Kips
4.99 ft	Cohesionless	0.00 psf	30.00	9.45 Kips	0.00 Kips
5.00 ft	Cohesionless	600.00 psf	30.00	9.45 Kips	7.41 Kips
9.01 ft	Cohesionless	1081.20 psf	30.00	9.45 Kips	9.45 Kips
18.01 ft	Cohesionless	2161.20 psf	30.00	9.45 Kips	9.45 Kips
22.99 ft	Cohesionless	2758.80 psf	30.00	9.45 Kips	9.45 Kips
23.01 ft	Cohesionless	2760.58 psf	30.00	9.45 Kips	9.45 Kips
23.99 ft	Cohesionless	2817.02 psf	30.00	9.45 Kips	9.45 Kips
24.01 ft	Cohesionless	2818.28 psf	110.40	190.54 Kips	159.35 Kips
33.01 ft	Cohesionless	3426.68 psf	110.40	190.54 Kips	190.54 Kips
39.99 ft	Cohesionless	3898.52 psf	110.40	190.54 Kips	190.54 Kips
40.01 ft	Cohesionless	3899.78 psf	110.40	190.54 Kips	190.54 Kips
49.01 ft	Cohesionless	4418.18 psf	110.40	190.54 Kips	190.54 Kips
49.99 ft	Cohesionless	4474.62 psf	110.40	190.54 Kips	190.54 Kips
50.01 ft	Cohesionless	4475.78 psf	110.40	190.54 Kips	190.54 Kips
59.01 ft	Cohesionless	4994.18 psf	110.40	190.54 Kips	190.54 Kips
59.99 ft	Cohesionless	5050.62 psf	110.40	190.54 Kips	190.54 Kips

ULTIMATE - SUMMARY OF CAPACITIES

Depth	Skin Friction	End Bearing	Total Capacity
0.01 ft	0.00 Kips	0.00 Kips	0.00 Kips
4.99 ft	0.00 Kips	0.00 Kips	0.00 Kips
5.00 ft	0.00 Kips	7.41 Kips	7.41 Kips
9.01 ft	3.51 Kips	9.45 Kips	12.96 Kips
18.01 ft	18.70 Kips	9.45 Kips	28.15 Kips
22.99 ft	31.46 Kips	9.45 Kips	40.91 Kips
23.01 ft	31.52 Kips	9.45 Kips	40.96 Kips
23.99 ft	34.36 Kips	9.45 Kips	43.81 Kips
24.01 ft	34.45 Kips	159.35 Kips	193.81 Kips
33.01 ft	95.67 Kips	190.54 Kips	286.21 Kips
39.99 ft	151.36 Kips	190.54 Kips	341.90 Kips
40.01 ft	151.53 Kips	190.54 Kips	342.07 Kips
49.01 ft	233.07 Kips	190.54 Kips	423.61 Kips
49.99 ft	242.56 Kips	190.54 Kips	433.10 Kips
50.01 ft	242.76 Kips	190.54 Kips	433.30 Kips
59.01 ft	335.59 Kips	190.54 Kips	526.13 Kips
59.99 ft	346.31 Kips	190.54 Kips	536.85 Kips

Filename: C:\HOLD\PIER-3.DVN



APPENDIX E.5

Abutment and Pier Piles

```
================================================================================

                     LPile for Windows, Version 2019-11.009

                 Analysis of Individual Piles and Drilled Shafts
                Subjected to Lateral Loading Using the p-y Method
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================================================================================

This copy of LPile is being used by:

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--------------------------------------------------------------------------------
                             Files Used for Analysis
--------------------------------------------------------------------------------

Path to file locations:
\Users\skesavan\Desktop\00 Opitz Geotech Report skk_Desktop\Program Runs\LPILE - Opitz Blvd\

Name of input data file:
Abut Pile.lp11-B.lp11d

Name of output report file:
Abut Pile.lp11-B.lp11o

Name of plot output file:
Abut Pile.lp11-B.lp11p

Name of runtime message file:
Abut Pile.lp11-B.lp11r



--------------------------------------------------------------------------------
                            Date and Time of Analysis
--------------------------------------------------------------------------------

               Date:  December 28, 2021           Time:   7:17:45



--------------------------------------------------------------------------------
                                  Problem Title
--------------------------------------------------------------------------------

Project Name:Opitz Blvd
Job Number:45893-001
Client: Transurban
Engineer: skk
Description: HP 10x57 Pile



--------------------------------------------------------------------------------
                          Program Options and Settings
--------------------------------------------------------------------------------

Computational Options:
 - Conventional Analysis
Engineering Units Used for Data Input and Computations:
 - US Customary System Units (pounds, feet, inches)

Analysis Control Options:
 - Maximum number of iterations allowed                =          500
```

```
 - Deflection tolerance for convergence                =   1.0000E-05 in
 - Maximum allowable deflection                        =     100.0000 in
 - Number of pile increments                           =          100

Loading Type and Number of Cycles of Loading:
 - Static loading specified

 - Analysis uses p-y modification factors for p-y curves
 - Analysis uses layering correction (Method of Georgiadis)
 - No distributed lateral loads are entered
 - Loading by lateral soil movements acting on pile not selected
 - Input of shear resistance at the pile tip not selected
 - Input of moment resistance at the pile tip not selected
 - Input of side resistance moment along pile not selected
 - Computation of pile-head foundation stiffness matrix not selected
 - Push-over analysis of pile not selected
 - Buckling analysis of pile not selected

Output Options:
 - Output files use decimal points to denote decimal symbols.
 - Values of pile-head deflection, bending moment, shear force, and
   soil reaction are printed for full length of pile.
 - Printing Increment (nodal spacing of output points) = 1
 - No p-y curves to be computed and reported for user-specified depths
 - Print using wide report formats



--------------------------------------------------------------------------------
                     Pile Structural Properties and Geometry
--------------------------------------------------------------------------------

Number of pile sections defined                        =            1
Total length of pile                                   =       30.000 ft
Depth of ground surface below top of pile              =       0.0000 ft

Pile diameters used for p-y curve computations are defined using 2 points.

p-y curves are computed using pile diameter values interpolated with depth over
the length of the pile. A summary of values of pile diameter vs. depth follows.

            Depth Below           Pile
Point        Pile Head          Diameter
 No.           feet              inches
-----      -------------     -------------
  1            0.000            10.2000
  2           30.000            10.2000


Input Structural Properties for Pile Sections:
----------------------------------------------

Pile Section No. 1:

   Section 1 is a H weak axis steel pile
   Length of section                                   =    30.000000 ft
   Pile width                                          =    10.000000 in
   Shear capacity of section                           =       0.0000 lbs



--------------------------------------------------------------------------------
                       Ground Slope and Pile Batter Angles
--------------------------------------------------------------------------------

Ground Slope Angle                                     =        0.000 degrees
                                                       =        0.000 radians

Pile Batter Angle                                      =        0.000 degrees
                                                       =        0.000 radians


--------------------------------------------------------------------------------
                       Soil and Rock Layering Information
--------------------------------------------------------------------------------
```

```
The soil profile is modelled using 2 layers

Layer 1 is sand, p-y criteria by Reese et al., 1974

   Distance from top of pile to top of layer           =       0.0000 ft
   Distance from top of pile to bottom of layer        =    10.000000 ft
   Effective unit weight at top of layer               =   120.000000 pcf
   Effective unit weight at bottom of layer            =   120.000000 pcf
   Friction angle at top of layer                      =    32.000000 deg.
   Friction angle at bottom of layer                   =    32.000000 deg.
   Subgrade k at top of layer                          =   100.000000 pci
   Subgrade k at bottom of layer                       =   100.000000 pci


Layer 2 is stiff clay with water-induced erosion

   Distance from top of pile to top of layer           =    10.000000 ft
   Distance from top of pile to bottom of layer        =    40.000000 ft
   Effective unit weight at top of layer               =    65.000000 pcf
   Effective unit weight at bottom of layer            =    65.000000 pcf
   Undrained cohesion at top of layer                  =        3000. psf
   Undrained cohesion at bottom of layer               =        3000. psf
   Epsilon-50 at top of layer                          =       0.0000
   Epsilon-50 at bottom of layer                       =       0.0000
   Subgrade k at top of layer                          =       0.0000 pci
   Subgrade k at bottom of layer                       =       0.0000 pci

   NOTE: Default values for Epsilon-50 will be computed for this layer.

   NOTE: Default values for subgrade k will be computed for this layer.

 (Depth of the lowest soil layer extends 10.000 ft below the pile tip)



--------------------------------------------------------------------------------
                        Summary of Input Soil Properties
--------------------------------------------------------------------------------

Layer         Soil Type         Layer      Effective    Cohesion     Angle of        E50
 Num.           Name            Depth       Unit Wt.                 Friction         or            kpy
          (p-y Curve Type)       ft           pcf          psf         deg.          krm            pci
-----   -------------------   ----------   ----------   ----------   ----------   ----------   ----------
  1            Sand               0.00     120.0000        --          32.0000        --         100.0000
          (Reese, et al.)      10.0000     120.0000        --          32.0000        --         100.0000
  2          Stiff Clay        10.0000      65.0000       3000.          --         default      default
          with Free Water      40.0000      65.0000       3000.          --         default      default


--------------------------------------------------------------------------------
                    p-y Modification Factors for Group Action
--------------------------------------------------------------------------------

Distribution of p-y modifiers with depth defined using 2 points

Point      Depth X         p-mult         y-mult
 No.          ft
-----     ----------     ----------     ----------
  1          0.000         0.5000         1.0000
  2        100.000         0.5000         1.0000



--------------------------------------------------------------------------------
                               Static Loading Type
--------------------------------------------------------------------------------

Static loading criteria were used when computing p-y curves for all analyses.


--------------------------------------------------------------------------------
                Pile-head Loading and Pile-head Fixity Conditions
--------------------------------------------------------------------------------
```

```
Number of loads specified = 1

Load    Load         Condition               Condition            Axial Thrust      Compute Top y     Run
Analysis
 No.    Type             1                       2                 Force, lbs      vs. Pile Length
-----   ----   --------------------   -----------------------   ----------------   ---------------    -------
-----
   1     2     V =        5000. lbs   S =       0.0000 in/in             50000.          No               Yes

V = shear force applied normal to pile axis
M = bending moment applied to pile head
y = lateral deflection normal to pile axis
S = pile slope relative to original pile batter angle
R = rotational stiffness applied to pile head
Values of top y vs. pile lengths can be computed only for load types with
specified shear loading (Load Types 1, 2, and 3).
Thrust force is assumed to be acting axially for all pile batter angles.



--------------------------------------------------------------------------------
     Computations of Nominal Moment Capacity and Nonlinear Bending Stiffness
--------------------------------------------------------------------------------

Axial thrust force values were determined from pile-head loading conditions

Number of Pile Sections Analyzed = 1

Pile Section No. 1:
-------------------

Dimensions and Properties of Steel H Weak Axis:
---------------------------------------------

Length of Section                                      =    30.000000 ft
Flange Width                                           =    10.200000 in
Section Depth                                          =    10.000000 in
Flange Thickness                                       =     0.565000 in
Web Thickness                                          =     0.565000 in
Yield Stress of Pipe                                   =    50.000000 ksi
Elastic Modulus                                        =       29000. ksi
Cross-sectional Area                                   =    16.537550 sq. in.
Moment of Inertia                                      =   100.063738 in^4
Elastic Bending Stiffness                              =     2901848. kip-in^2
Plastic Modulus, Z                                     =    30.099181in^3
Plastic Moment Capacity = Fy Z                         =        1505.in-kip

Axial Structural Capacities:
----------------------------

Nom. Axial Structural Capacity = Fy As                 =      826.877 kips
Nominal Axial Tensile Capacity                         =     -826.877 kips



Number of Axial Thrust Force Values Determined from Pile-head Loadings = 1

   Number     Axial Thrust Force
                   kips
   ------     ------------------
      1              50.000

Definition of Run Messages:

   Y = part of pipe section has yielded.


Axial Thrust Force =     50.000 kips

    Bending       Bending       Bending      Depth to      Max Total  Run
   Curvature      Moment       Stiffness      N Axis        Stress    Msg
    rad/in.       in-kip       kip-in2          in            ksi
------------- ------------- ------------- ------------- ------------- ---
   0.00000707    20.5060402      2901683.    19.8526161     4.0581718
   0.00001413    41.0120803      2901683.    12.4763081     5.0929212
   0.00002120    61.5181205      2901683.    10.0175387     6.1276706
```

```
  0.00002827    82.0241606       2901683.      8.7881540     7.1624199
  0.00003533   102.5302008       2901683.      8.0505232     8.1971693
  0.00004240   123.0362409       2901683.      7.5587694     9.2319187
  0.00004947   143.5422811       2901683.      7.2075166    10.2666680
  0.00005654   164.0483212       2901683.      6.9440770    11.3014174
  0.00006360   184.5543614       2901683.      6.7391796    12.3361668
  0.00007067   205.0604015       2901683.      6.5752616    13.3709162
  0.00007774   225.5664417       2901683.      6.4411469    14.4056655
  0.00008480   246.0724818       2901683.      6.3293847    15.4404149
  0.00009187   266.5785220       2901683.      6.2348166    16.4751643
  0.00009894   287.0845621       2901683.      6.1537583    17.5099136
   0.0001060   307.5906023       2901683.      6.0835077    18.5446630
   0.0001131   328.0966424       2901683.      6.0220385    19.5794124
   0.0001201   348.6026826       2901683.      5.9678009    20.6141617
   0.0001272   369.1087227       2901683.      5.9195898    21.6489111
   0.0001343   389.6147629       2901683.      5.8764535    22.6836605
   0.0001413   410.1208030       2901683.      5.8376308    23.7184099
   0.0001484   430.6268432       2901683.      5.8025055    24.7531592
   0.0001555   451.1328833       2901683.      5.7705735    25.7879086
   0.0001625   471.6389235       2901683.      5.7414181    26.8226580
   0.0001696   492.1449636       2901683.      5.7146923    27.8574073
   0.0001767   512.6510038       2901683.      5.6901046    28.8921567
   0.0001837   533.1570439       2901683.      5.6674083    29.9269061
   0.0001908   553.6630841       2901683.      5.6463932    30.9616555
   0.0001979   574.1691242       2901683.      5.6268791    31.9964048
   0.0002049   594.6751644       2901683.      5.6087109    33.0311542
   0.0002120   615.1812045       2901683.      5.5917539    34.0659036
   0.0002191   635.6872447       2901683.      5.5758908    35.1006529
   0.0002261   656.1932848       2901683.      5.5610193    36.1354023
   0.0002332   676.6993250       2901683.      5.5470490    37.1701517
   0.0002403   697.2053651       2901683.      5.5339005    38.2049010
   0.0002473   717.7114053       2901683.      5.5215033    39.2396504
   0.0002544   738.2174454       2901683.      5.5097949    40.2743998
   0.0002615   758.7234856       2901683.      5.4987194    41.3091492
   0.0002685   779.2295257       2901683.      5.4882267    42.3438985
   0.0002756   799.7355659       2901683.      5.4782722    43.3786479
   0.0002897   840.7476462       2901683.      5.4598199    45.4481466
   0.0003039   881.7597265       2901683.      5.4430841    47.5176454
   0.0003180   922.7718068       2901683.      5.4278359    49.5871441
   0.0003321   962.4164303       2897566.      5.4155958    50.0000000  Y
   0.0003463   999.6513162       2886826.      5.4073270    50.0000000  Y
   0.0003604         1035.       2871023.      5.4023379    50.0000000  Y
   0.0003745         1067.       2848392.      5.3986091    50.0000000  Y
   0.0003887         1096.       2818785.      5.3949974    50.0000000  Y
   0.0004028         1121.       2783546.      5.3914802    50.0000000  Y
   0.0004169         1144.       2744866.      5.3880442    50.0000000  Y
   0.0004311         1165.       2703409.      5.3845803    50.0000000  Y
   0.0004452         1184.       2660196.      5.3813780    50.0000000  Y
   0.0004594         1202.       2616018.      5.3782446    50.0000000  Y
   0.0004735         1217.       2571164.      5.3750762    50.0000000  Y
   0.0004876         1232.       2526177.      5.3719837    50.0000000  Y
   0.0005018         1245.       2481377.      5.3689771    50.0000000  Y
   0.0005159         1257.       2437004.      5.3660446    50.0000000  Y
   0.0005300         1268.       2393257.      5.3631753    50.0000000  Y
   0.0005442         1279.       2350161.      5.3602583    50.0000000  Y
   0.0005583         1288.       2307689.      5.3575367    50.0000000  Y
   0.0005724         1297.       2266199.      5.3548510    50.0000000  Y
   0.0005866         1306.       2225787.      5.3521928    50.0000000  Y
   0.0006007         1313.       2186260.      5.3496625    50.0000000  Y
   0.0006148         1320.       2147557.      5.3470911    50.0000000  Y
   0.0006290         1327.       2110094.      5.3445261    50.0000000  Y
   0.0006431         1333.       2073399.      5.3422306    50.0000000  Y
   0.0006572         1339.       2037763.      5.3397170    50.0000000  Y
   0.0006714         1345.       2003144.      5.3375681    50.0000000  Y
   0.0006855         1350.       1969343.      5.3350864    50.0000000  Y
   0.0006996         1355.       1936577.      5.3330058    50.0000000  Y
   0.0007138         1359.       1904653.      5.3305992    50.0000000  Y
   0.0007279         1364.       1873651.      5.3286529    50.0000000  Y
   0.0007420         1368.       1843468.      5.3262951    50.0000000  Y
   0.0007562         1372.       1814154.      5.3244201    50.0000000  Y
   0.0007703         1375.       1785567.      5.3222471    50.0000000  Y
   0.0007844         1379.       1757888.      5.3202203    50.0000000  Y
   0.0007986         1382.       1730856.      5.3183398    50.0000000  Y
   0.0008127         1385.       1704607.      5.3162858    50.0000000  Y
   0.0008268         1388.       1679147.      5.3144922    50.0000000  Y
   0.0008410         1391.       1654192.      5.3125858    50.0000000  Y
   0.0008975         1401.       1561198.      5.3053851    50.0000000  Y
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    0.0009540         1410.      1477492.     5.2987224    50.0000000  Y
    0.0010106         1417.      1401820.     5.2924846    50.0000000  Y
    0.0010671         1423.      1333162.     5.2865798    50.0000000  Y
    0.0011236         1428.      1270678.     5.2809324    50.0000000  Y
    0.0011802         1432.      1213612.     5.2756225    50.0000000  Y
    0.0012367         1436.      1161292.     5.2708860    50.0000000  Y
    0.0012933         1440.      1113223.     5.2660613    50.0000000  Y
    0.0013498         1443.      1068800.     5.2617285    50.0000000  Y
    0.0014063         1445.      1027852.     5.2575091    50.0000000  Y
    0.0014629         1448.       989716.     5.2535615    50.0000000  Y
    0.0015194         1450.       954391.     5.2498172    50.0000000  Y
    0.0015759         1452.       921386.     5.2461350    50.0000000  Y
    0.0016325         1454.       890581.     5.2427997    50.0000000  Y


--------------------------------------------------------------------------------
   Summary of Results for Nominal Moment Capacity for Section 1
--------------------------------------------------------------------------------

                                            Nominal
Load               Axial                    Moment
 No.              Thrust                  Capacity
                   kips                     in-kips
----         ----------------          ----------------
  1             50.0000000000                    1454.

Note that the values in the above table are not factored by a strength
reduction factor for LRFD.

The value of the strength reduction factor depends on the provisions of the
LRFD code being followed.

The above values should be multiplied by the appropriate strength reduction
factor to compute ultimate moment capacity according to the LRFD structural
design standard being followed.




--------------------------------------------------------------------------------
           Layering Correction Equivalent Depths of Soil & Rock Layers
--------------------------------------------------------------------------------

         Top of    Equivalent
          Layer     Top Depth  Same Layer  Layer is        F0          F1
Layer     Below       Below     Type As    Rock or     Integral    Integral
 No.    Pile Head   Grnd Surf     Layer     is Below    for Layer   for Layer
           ft          ft         Above    Rock Layer      lbs         lbs
-----  ----------  ----------  ----------  ----------  ----------  ----------
  1          0.00        0.00      N.A.        No            0.00      95039.
  2       10.0000    145.7845      No          No          95039.      N.A.

Notes: The F0 integral of Layer n+1 equals the sum of the F0 and F1 integrals
       for Layer n. Layering correction equivalent depths are computed only
       for soil types with both shallow-depth and deep-depth expressions for
       peak lateral load transfer. These soil types are soft and stiff clays,
       non-liquefied sands, and cemented c-phi soil.




--------------------------------------------------------------------------------
                 Computed Values of Pile Loading and Deflection
                   for Lateral Loading for Load Case Number 1
--------------------------------------------------------------------------------

Pile-head conditions are Shear and Pile-head Rotation (Loading Type 2)

Shear force at pile head                               =       5000.0 lbs
Rotation of pile head                                  =    0.000E+00 radians
Axial load at pile head                                =      50000.0 lbs

(Zero slope for this load indicates fixed-head conditions)

   Depth    Deflect.    Bending     Shear      Slope      Total     Bending   Soil Res.  Soil Spr.  Distrib.
     X         y       Moment      Force        S       Stress    Stiffness      p        Es*H     Lat. Load
```

```
   feet      inches     in-lbs       lbs      radians      psi*      lb-in^2    lb/inch    lb/inch    lb/inch
---------- ---------- ---------- ---------- ---------- ---------- ---------- ---------- ---------- ----------
      0.00     0.1093   -196331.      5000.       0.00     13030.   2.90E+09       0.00       0.00       0.00
    0.3000     0.1089   -178309.      4985.  -2.32E-04     12111.   2.90E+09    -8.1303   268.8014       0.00
    0.6000     0.1077   -160353.      4939.  -4.42E-04     11196.   2.90E+09   -17.4257   582.7306       0.00
    0.9000     0.1057   -142587.      4860.  -6.30E-04     10291.   2.90E+09   -26.8631   914.9076       0.00
    1.2000     0.1031   -125137.      4747.  -7.96E-04      9401.   2.90E+09   -35.5697      1242.       0.00
    1.5000    0.09997   -108120.      4605.  -9.41E-04      8534.   2.90E+09   -43.3193      1560.       0.00
    1.8000    0.09634    -91640.      4438.   -0.00107      7694.   2.90E+09   -49.5718      1852.       0.00
    2.1000    0.09230    -75782.      4251.   -0.00117      6886.   2.90E+09   -54.1275      2111.       0.00
    2.4000    0.08792    -60609.      4051.   -0.00125      6113.   2.90E+09   -57.0830      2337.       0.00
    2.7000    0.08327    -46162.      3842.   -0.00132      5376.   2.90E+09   -58.9179      2547.       0.00
    3.0000    0.07842    -32468.      3628.   -0.00137      4678.   2.90E+09   -59.9597      2753.       0.00
    3.3000    0.07342    -19545.      3416.   -0.00140      4020.   2.90E+09   -58.3003      2859.       0.00
    3.6000    0.06833     -7372.      3203.   -0.00142      3399.   2.90E+09   -60.0322      3163.       0.00
    3.9000    0.06321      4024.      2980.   -0.00142      3229.   2.90E+09   -63.7461      3630.       0.00
    4.2000    0.05811     14593.      2745.   -0.00141      3767.   2.90E+09   -66.5331      4122.       0.00
    4.5000    0.05307     24297.      2498.   -0.00138      4262.   2.90E+09   -70.7978      4802.       0.00
    4.8000    0.04815     33078.      2236.   -0.00135      4709.   2.90E+09   -74.9876      5607.       0.00
    5.1000    0.04337     40879.      1959.   -0.00130      5107.   2.90E+09   -78.5696      6522.       0.00
    5.4000    0.03877     47653.      1671.   -0.00125      5452.   2.90E+09   -81.4732      7565.       0.00
    5.7000    0.03438     53361.      1374.   -0.00118      5743.   2.90E+09   -83.6383      8757.       0.00
    6.0000    0.03024     57973.      1070.   -0.00112      5978.   2.90E+09   -85.0168     10122.       0.00
    6.3000    0.02635     61470.   763.3427   -0.00104      6156.   2.90E+09   -85.5728     11691.       0.00
    6.6000    0.02274     63844.   455.8020  -9.64E-04      6277.   2.90E+09   -85.2831     13503.       0.00
    6.9000    0.01941     65098.   157.6534  -8.84E-04      6341.   2.90E+09   -80.3550     14904.       0.00
    7.2000    0.01637     65297.  -114.2972  -8.03E-04      6351.   2.90E+09   -70.7287     15552.       0.00
    7.5000    0.01363     64565.  -351.9873  -7.23E-04      6314.   2.90E+09   -61.3214     16200.       0.00
    7.8000    0.01117     63023.  -556.4615  -6.43E-04      6236.   2.90E+09   -52.2754     16848.       0.00
    8.1000    0.00899     60790.  -729.2401  -5.67E-04      6122.   2.90E+09   -43.7128     17496.       0.00
    8.4000    0.00709     57976.  -872.2469  -4.93E-04      5978.   2.90E+09   -35.7354     18144.       0.00
    8.7000    0.00545     54687.  -987.7343  -4.23E-04      5811.   2.90E+09   -28.4243     18792.       0.00
    9.0000    0.00404     51017.     -1078.  -3.57E-04      5624.   2.90E+09   -21.8399     19440.       0.00
    9.3000    0.00287     47052.     -1146.  -2.97E-04      5422.   2.90E+09   -16.0226     20088.       0.00
    9.6000    0.00191     42870.     -1195.  -2.41E-04      5208.   2.90E+09   -10.9936     20736.       0.00
    9.9000    0.00114     38535.     -1227.  -1.90E-04      4987.   2.90E+09    -6.7553     21384.       0.00
   10.2000   5.38E-04     34104.     -1298.  -1.45E-04      4762.   2.90E+09   -32.9266    220320.       0.00
   10.5000   9.11E-05     29239.     -1368.  -1.06E-04      4514.   2.90E+09    -5.7391    226800.       0.00
   10.8000  -2.25E-04     24293.     -1352.  -7.28E-05      4262.   2.90E+09    14.5948    233280.       0.00
   11.1000  -4.33E-04     19531.     -1274.  -4.56E-05      4019.   2.90E+09    28.8411    239760.       0.00
   11.4000  -5.54E-04     15138.     -1154.  -2.41E-05      3795.   2.90E+09    37.8690    246240.       0.00
   11.7000  -6.07E-04     11233.     -1009.  -7.75E-06      3596.   2.90E+09    42.5846    252720.       0.00
   12.0000  -6.09E-04      7876.  -853.3121   4.11E-06      3425.   2.90E+09    43.8788    259200.       0.00
   12.3000  -5.77E-04      5087.  -697.6741   1.21E-05      3283.   2.90E+09    42.5868    265680.       0.00
   12.6000  -5.22E-04      2849.  -549.9887   1.71E-05      3169.   2.90E+09    39.4606    272160.       0.00
   12.9000  -4.54E-04      1121.  -415.6872   1.95E-05      3081.   2.90E+09    35.1513    278640.       0.00
   13.2000  -3.81E-04  -151.1912  -298.0527   2.01E-05      3031.   2.90E+09    30.2012    285120.       0.00
   13.5000  -3.09E-04     -1032.  -198.6119   1.94E-05      3076.   2.90E+09    25.0437    291600.       0.00
   13.8000  -2.42E-04     -1588.  -117.5187   1.78E-05      3104.   2.90E+09    20.0081    298080.       0.00
   14.1000  -1.81E-04     -1885.   -53.9110   1.56E-05      3119.   2.90E+09    15.3295    304560.       0.00
   14.4000  -1.29E-04     -1982.    -6.2289   1.32E-05      3124.   2.90E+09    11.1606    311040.       0.00
   14.7000  -8.60E-05     -1934.    27.5133   1.08E-05      3122.   2.90E+09     7.5851    317520.       0.00
   15.0000  -5.15E-05     -1788.    49.5034   8.48E-06      3115.   2.90E+09     4.6317    324000.       0.00
   15.3000  -2.49E-05     -1581.    61.9570   6.39E-06      3104.   2.90E+09     2.2870    330480.       0.00
   15.6000  -5.42E-06     -1344.    66.9870   4.58E-06      3092.   2.90E+09     0.5075    336960.       0.00
   15.9000   8.07E-06     -1100.    66.5156   3.06E-06      3079.   2.90E+09    -0.7694    343440.       0.00
   16.2000   1.66E-05  -866.1557    62.2196   1.84E-06      3068.   2.90E+09    -1.6173    349920.       0.00
   16.5000   2.13E-05  -652.8803    55.5051   9.02E-07      3057.   2.90E+09    -2.1130    356400.       0.00
   16.8000   2.31E-05  -466.8437    47.5045   2.07E-07      3047.   2.90E+09    -2.3318    362880.       0.00
   17.1000   2.28E-05  -310.9225    39.0899  -2.75E-07      3039.   2.90E+09    -2.3430    369360.       0.00
   17.4000   2.12E-05  -185.2972    30.8977  -5.83E-07      3033.   2.90E+09    -2.2082    375840.       0.00
   17.7000   1.86E-05   -88.2490    23.3599  -7.53E-07      3028.   2.90E+09    -1.9795    382320.       0.00
   18.0000   1.57E-05   -16.8349    16.7385  -8.18E-07      3024.   2.90E+09    -1.6991    388800.       0.00
   18.3000   1.28E-05    32.5627    11.1601  -8.08E-07      3025.   2.90E+09    -1.4000    395280.       0.00
   18.6000   9.91E-06    63.8088     6.6485  -7.48E-07      3027.   2.90E+09    -1.1064    401760.       0.00
   18.9000   7.36E-06    80.7014     3.1541  -6.59E-07      3028.   2.90E+09    -0.8349    408240.       0.00
   19.2000   5.17E-06    86.7552     0.5787  -5.55E-07      3028.   2.90E+09    -0.5958    414720.       0.00
   19.5000   3.37E-06    85.0680    -1.2031  -4.48E-07      3028.   2.90E+09    -0.3941    421200.       0.00
   19.8000   1.94E-06    78.2543    -2.3284  -3.47E-07      3027.   2.90E+09    -0.2311    427680.       0.00
   20.1000   8.71E-07    68.4287    -2.9333  -2.56E-07      3027.   2.90E+09    -0.1050    434160.       0.00
   20.4000   1.03E-07    57.2265    -3.1450  -1.78E-07      3026.   2.90E+09   -0.01255    440640.       0.00
   20.7000  -4.10E-07    45.8490    -3.0758  -1.14E-07      3026.   2.90E+09    0.05095    447120.       0.00
   21.0000  -7.18E-07    35.1216    -2.8212  -6.38E-08      3025.   2.90E+09    0.09050    453600.       0.00
   21.3000  -8.69E-07    25.5592    -2.4583  -2.61E-08      3025.   2.90E+09     0.1111    460080.       0.00
   21.6000  -9.06E-07    17.4311    -2.0469   5.42E-10      3024.   2.90E+09     0.1175    466560.       0.00
   21.9000  -8.65E-07    10.8215    -1.6307   1.81E-08      3024.   2.90E+09     0.1137    473040.       0.00
   22.2000  -7.76E-07     5.6833    -1.2399   2.83E-08      3024.   2.90E+09     0.1034    479520.       0.00
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   22.5000  -6.62E-07     1.8839    -0.8930   3.30E-08      3024.   2.90E+09    0.08933    486000.       0.00
   22.8000  -5.39E-07    -0.7583    -0.5996   3.37E-08      3023.   2.90E+09    0.07369    492480.       0.00
   23.1000  -4.19E-07    -2.4452    -0.3624   3.17E-08      3024.   2.90E+09    0.05808    498960.       0.00
   23.4000  -3.10E-07    -3.3789    -0.1794   2.81E-08      3024.   2.90E+09    0.04357    505440.       0.00
   23.7000  -2.17E-07    -3.7471   -0.04550   2.37E-08      3024.   2.90E+09    0.03082    511920.       0.00
   24.0000  -1.40E-07    -3.7151    0.04623   1.90E-08      3024.   2.90E+09    0.02014    518400.       0.00
   24.3000  -7.96E-08    -3.4211     0.1034   1.46E-08      3024.   2.90E+09    0.01160    524880.       0.00
   24.6000  -3.46E-08    -2.9761     0.1334   1.07E-08      3024.   2.90E+09    0.00511    531360.       0.00
   24.9000  -2.88E-09    -2.4642     0.1434   7.28E-09      3024.   2.90E+09   4.30E-04    537840.       0.00
   25.2000   1.78E-08    -1.9461     0.1393   4.54E-09      3024.   2.90E+09   -0.00269    544320.       0.00
   25.5000   2.98E-08    -1.4626     0.1263   2.43E-09      3023.   2.90E+09   -0.00456    550800.       0.00
   25.8000   3.53E-08    -1.0379     0.1082   8.78E-10      3023.   2.90E+09   -0.00547    557280.       0.00
   26.1000   3.61E-08    -0.6838    0.08819  -1.90E-10      3023.   2.90E+09   -0.00566    563760.       0.00
   26.4000   3.39E-08    -0.4029    0.06832  -8.64E-10      3023.   2.90E+09   -0.00538    570240.       0.00
   26.7000   2.99E-08    -0.1915    0.05002  -1.23E-09      3023.   2.90E+09   -0.00479    576720.       0.00
   27.0000   2.51E-08   -0.04230    0.03408  -1.38E-09      3023.   2.90E+09   -0.00406    583200.       0.00
   27.3000   2.00E-08    0.05433    0.02087  -1.37E-09      3023.   2.90E+09   -0.00328    589680.       0.00
   27.6000   1.52E-08     0.1085    0.01045  -1.27E-09      3023.   2.90E+09   -0.00252    596160.       0.00
   27.9000   1.09E-08     0.1300    0.00265  -1.12E-09      3023.   2.90E+09   -0.00182    602640.       0.00
   28.2000   7.11E-09     0.1280   -0.00279  -9.62E-10      3023.   2.90E+09   -0.00120    609120.       0.00
   28.5000   3.94E-09     0.1103   -0.00617  -8.14E-10      3023.   2.90E+09  -6.73E-04    615600.       0.00
   28.8000   1.25E-09    0.08387   -0.00777  -6.94E-10      3023.   2.90E+09  -2.16E-04    622080.       0.00
   29.1000  -1.06E-09    0.05463   -0.00782  -6.08E-10      3023.   2.90E+09   1.85E-04    628560.       0.00
   29.4000  -3.12E-09    0.02776   -0.00650  -5.56E-10      3023.   2.90E+09   5.51E-04    635040.       0.00
   29.7000  -5.06E-09    0.00803   -0.00388  -5.34E-10      3023.   2.90E+09   9.03E-04    641520.       0.00
   30.0000  -6.97E-09       0.00       0.00  -5.29E-10      3023.   2.90E+09    0.00125    324000.       0.00

* This analysis computed pile response using nonlinear moment-curvature rela-
  tionships. Values of total stress due to combined axial and bending stresses
  are computed only for elastic sections only and do not equal the actual
  stresses in concrete and steel. Stresses in concrete and steel may be inter-
  polated from the output for nonlinear bending properties relative to the
  magnitude of bending moment developed in the pile.


Output Summary for Load Case No. 1:

Pile-head deflection             =     0.10932575 inches
Computed slope at pile head      =       0.000000 radians
Maximum bending moment           =       -196331. inch-lbs
Maximum shear force              =          5000. lbs
Depth of maximum bending moment  =       0.000000 feet below pile head
Depth of maximum shear force     =       0.000000 feet below pile head
Number of iterations             =             10
Number of zero deflection points =              5


--------------------------------------------------------------------------------
            Summary of Pile-head Responses for Conventional Analyses
--------------------------------------------------------------------------------

Definitions of Pile-head Loading Conditions:

Load Type 1: Load 1 = Shear, V, lbs, and Load 2 = Moment, M, in-lbs
Load Type 2: Load 1 = Shear, V, lbs, and Load 2 = Slope, S, radians
Load Type 3: Load 1 = Shear, V, lbs, and Load 2 = Rot. Stiffness, R, in-lbs/rad.
Load Type 4: Load 1 = Top Deflection, y, inches, and Load 2 = Moment, M, in-lbs
Load Type 5: Load 1 = Top Deflection, y, inches, and Load 2 = Slope, S, radians


Load Load                Load                    Axial    Pile-head  Pile-head  Max Shear Max Moment
Case Type   Pile-head    Type      Pile-head    Loading  Deflection   Rotation    in Pile    in Pile
 No.  1       Load 1       2         Load 2       lbs       inches     radians      lbs      in-lbs
---- ----- ---------- ---------- ---------- ---------- ---------- ---------- ---------- ----------
  1  V, lb      5000.   S, rad         0.00     50000.     0.1093       0.00      5000.   -196331.


Maximum pile-head deflection = 0.1093257457 inches
Maximum pile-head rotation   = -0.0000000000 radians = -0.000000 deg.

The analysis ended normally.
```
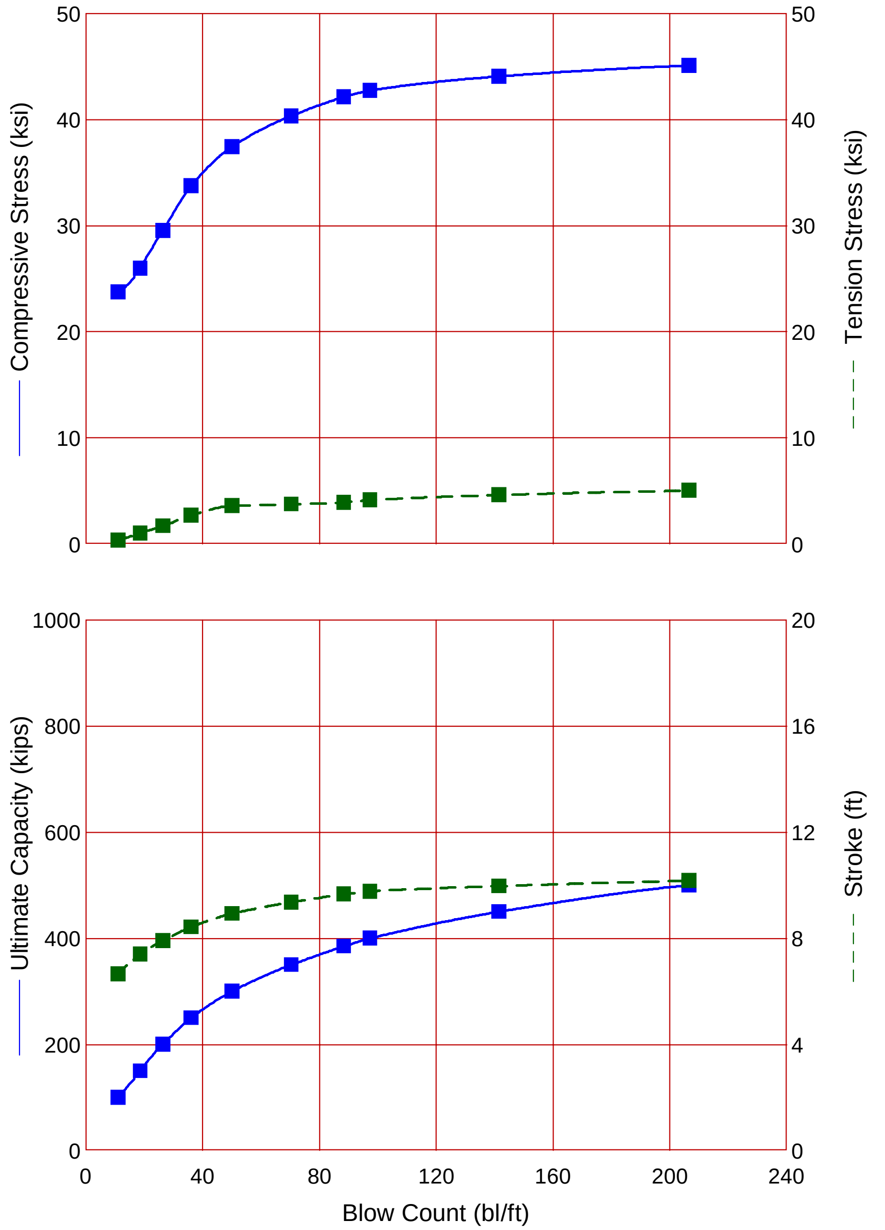

APPENDIX E.5

Abutment and Pier Piles

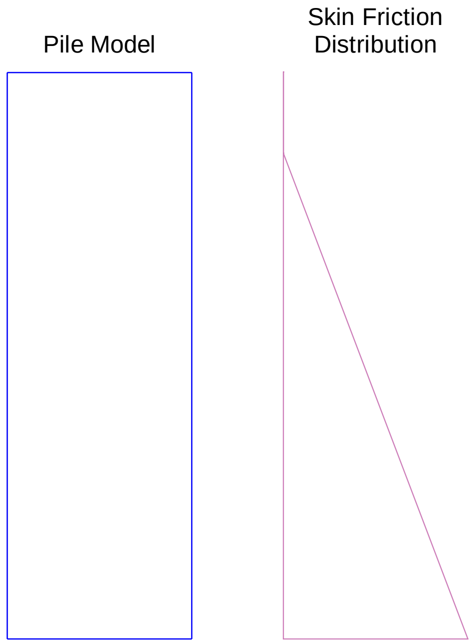
Whitman Requardt and Associates
Opitz Blvd Delmag D16-32 (40.2 ft.kips)

21-Dec-2021
GRLWEAP Version 2010



DELMAG D 16-32

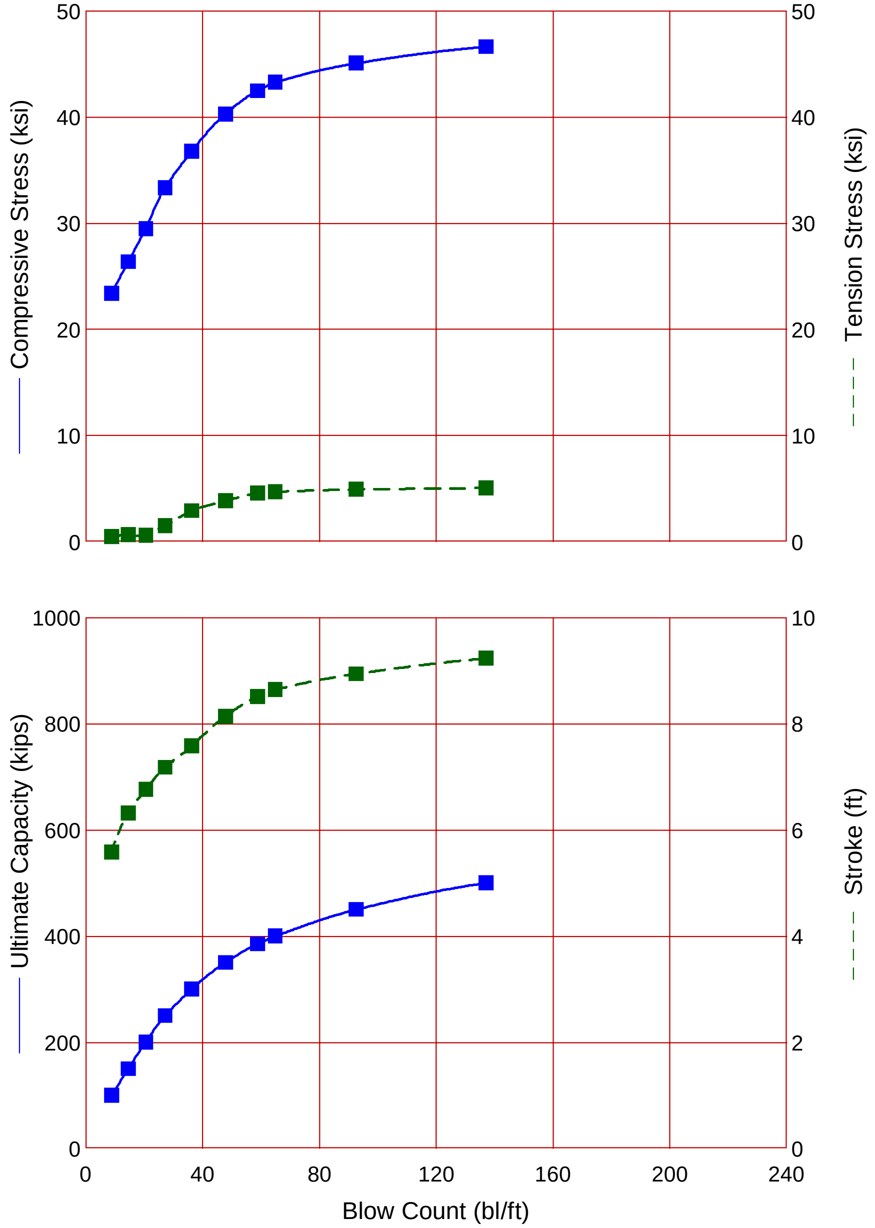
Ram Weight	3.52	kips
Efficiency	0.800	
Pressure	1500 (100%)	psi
Helmet Weight	1.90	kips
Hammer Cushion	60155	kips/in
COR of H.C.	0.800	
Skin Quake	0.100	in
Toe Quake	0.100	in
Skin Damping	0.050	s/ft
Toe Damping	0.150	s/ft
Pile Length	70.00	ft
Pile Penetration	60.00	ft
Pile Top Area	16.70	in2



Res. Shaft = 15 %
(Proportional)

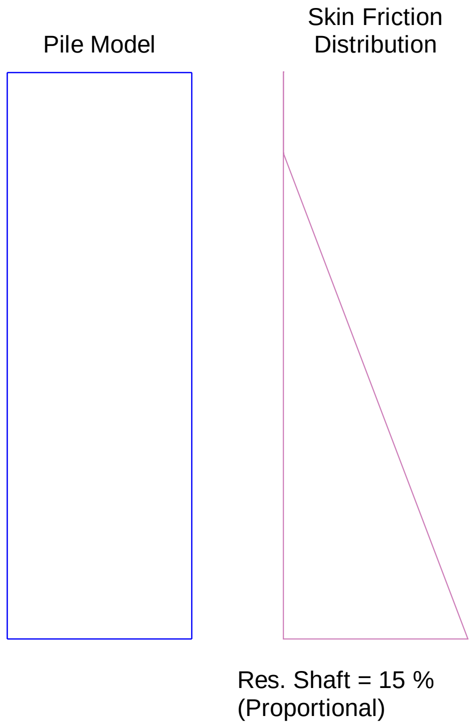
Whitman Requardt and Associates
Opitz Blvd Delmag D22-13 (48.5 ft.kips)

21-Dec-2021
GRLWEAP Version 2010



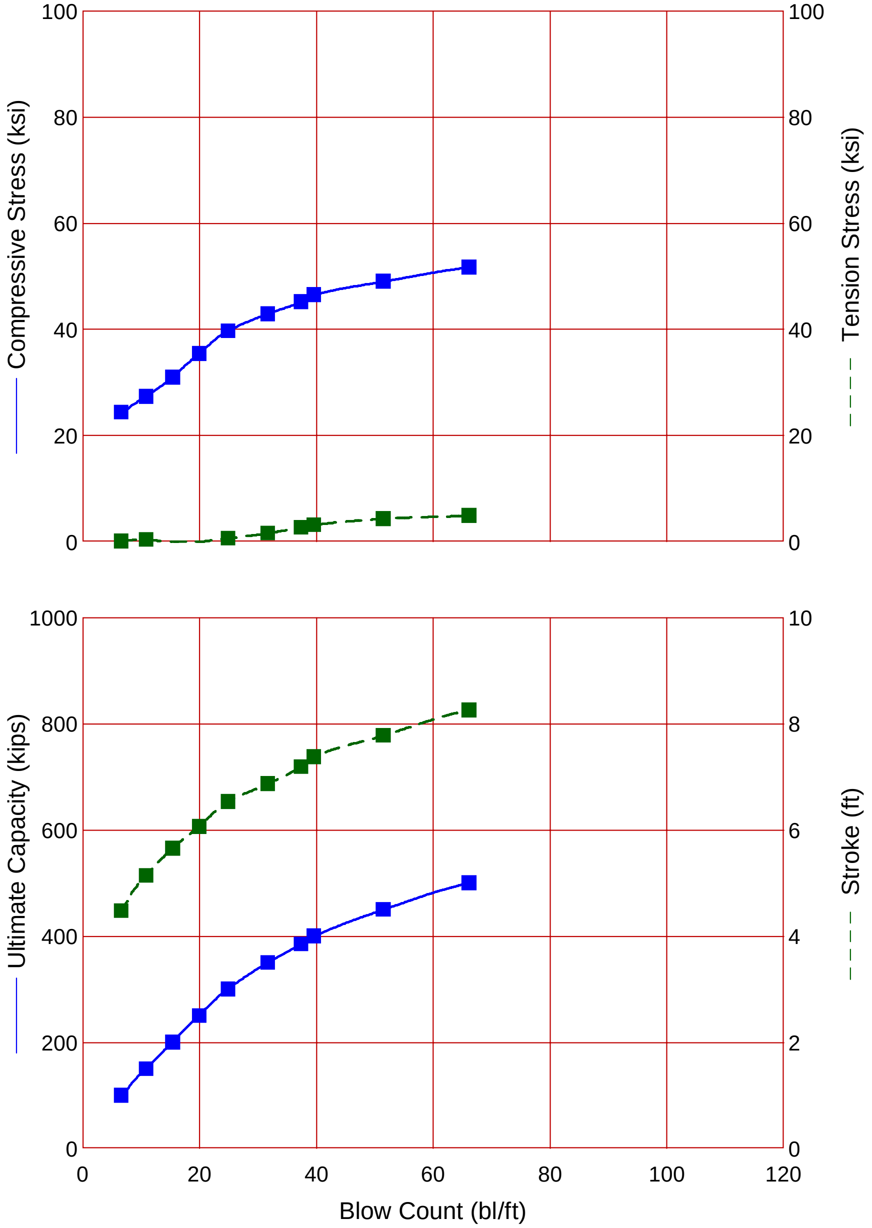
DELMAG   D 22-13

Ram Weight	4.85	kips
Efficiency	0.800	
Pressure	1050 (100%)	psi
Helmet Weight	1.90	kips
Hammer Cushion	60155	kips/in
COR of H.C.	0.800	
Skin Quake	0.100	in
Toe Quake	0.100	in
Skin Damping	0.050	s/ft
Toe Damping	0.150	s/ft
Pile Length	70.00	ft
Pile Penetration	60.00	ft
Pile Top Area	16.70	in2



Whitman Requardt and Associates
Opitz Blvd Delmag D30 (59.7 ft.kips)

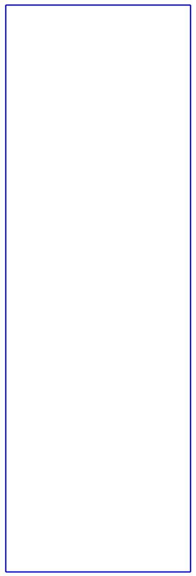
21-Dec-2021
GRLWEAP Version 2010



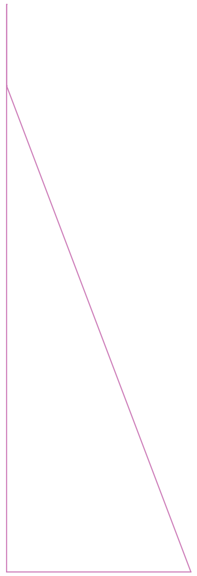
DELMAG   D 30

Ram Weight	6.60	kips
Efficiency	0.800	
Pressure	1480 (100%)	psi
Helmet Weight	1.90	kips
Hammer Cushion	60155	kips/in
COR of H.C.	0.800	
Skin Quake	0.100	in
Toe Quake	0.100	in
Skin Damping	0.050	s/ft
Toe Damping	0.150	s/ft
Pile Length	70.00	ft
Pile Penetration	60.00	ft
Pile Top Area	16.70	in2

Pile Model



Skin Friction
Distribution



Res. Shaft = 15 %
(Proportional)

APPENDIX E.6

MOT Pavement Section

FLEXIBLE
PAVEMENT DESIGN

Whitman, Requardt & Associates, LLP
Engineers · Architects · Environmental Planners Est. 1915

Design Per VDOT Specifications Ver.04.10 skk 9/14/2021

Ver.4.10 Sheet 1 of 2

1. Project Data

Project:	Optiz Blvd	**Section:**	MOT Pavement Section	**Design:**	skk
	Woodbridge, VA	**Station:**	I-95 GP SB Shoulders	**Check:**	jmb
WRA #	45893-001	**Date:**	1/28/2022		

2. Traffic Growth Rate

Traffic Grouth Rate Provided ?		*Given/Assumed*		Given Growth Rate (***g***):	*2.00%*
Data & Calculation of Traffic Growth Rate	**Year**			Time Duration	
	ADT			Calculated g	
				Growth Rate for Design:	*2.00%*

3. Design Year Average Daily Traffic (ADT)

Construction/Design Year		*2022*			
ADT for Design Year Given?		*Needs to be Estimated*		Given ADT Data	
Data & Calculation of Design Year ADT	Data Used Year	*2018*		g:	2.00%
	ADT	*67,192*		Calculated ADT:	72731
				Project ADT for Cons. Year:	72,731

4. Data for Pavement Design

Initial Structural Design Life (Performance Period)	*0.5*	years		
Reliability R (%) (for calculation of Z_R)	*95*	%	Calculated Z_R=	-1.645
Initial Serviceability ($\textbf{PSI}$)$_1$	*4.2*			
Terminal Serviceability ($\textbf{PSI}$)$_2$	*2.8*		Calcualted **Δ** (*PSI*) =	1.4
Percent Truck	*7.42%*			
Truck Factor *Needs to be Estimated*	*1.10*	*(See Sec 5 for truck factor Estimation)*		
Directional Split/Distribution (Note 1)	*100%*			
Design Lane Factor/Distribution (Note 2)	*70%*			
Subgrade CBR (for M_R calculations)	*3.33*		Method	*AASHTO 1993*
Overall Standard Deviation	*0.49*		Calculated M_R=	5,000

5. Rigorous ESAL Calculations

Data	ADT= 72,731	Lane dis. 100%		Dir.Dis. 70%	g= 2.00%		n= 0.5
Class	Vehcle Type	% ADT	ADT by Type	Growth factor	Design Traffic	ESAL Factor	Design ESAL
1	Car	*92.58*	67,334	0.498	8,559,379	0.0002	1,712
2	*Single Unit Trucks*	*1.60*	1,164	0.498	147,926	*0.46*	68,046
3	*Combined Trucks*	*5.82*	4,233	0.498	538,082	*1.05*	564,986
	Total:	100.00	72,731			ESAL	634,744
					Equivalent Truck Factor	0.9253	

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Design Per VDOT Specifications Ver.04.10 skk 9/14/2021

Sheet 2 of 2

Project: Optiz Blvd
Woodbridge, VA
WRA # 45893-001
Design: skk

Section: MOT Pavement Section
Station: I-95 GP SB Shoulders
Date: 1/28/2022
Check: jmb

6. Calculated Design Sructural Number

ADT 72,731 g: 2.00% Growth Factor 0.498 Truck Factor: 0.9253

Traffic 26,546,815 per year Wt 18 (18kips ESAL) = 634,744

Calculated Resilient Modulus M_r 5000 psi per AASHTO 1993

Reliability Standard Dev. Z_R -1.645 Δ (*PSI*) = 1.4 Overall STD 0.49

Calculated Design Structural Number: **4.310**

7. Specified Layer and Lift Design

(VDOT Specifications)

Lift ID	Layer Description	Struct. Coeff.	Drainage Coeff.	Selected Thickness (in)	Check Thickness Limits	Layer Lift Thickness Min. (in)	Layer Lift Thickness Max (in)	Calculatd SN
1	*05. SMA 12.5*	0.44	1.0	*2.00*	*-Ok-*	1.50	3.00	0.88
2	*09. BM-25.0*	0.44	1.0	*3.00*	*-Ok-*	2.50	4.00	1.32
3	*09. BM-25.0*	0.44	1.0	*4.00*	*-Ok-*	2.50	4.00	1.76
4	*11. Agg.Base*	0.12	1.0	*6.00*	*-Ok-*	3.00	8.00	0.72

Totals: Total Pavement Thickness= 15 inches Total SN= **4.680**

Required SN 4.310 ***Ok***

8. Summary of Pavement Section

Total Number of Layers: 3

Layer No	Layer Description	Layer Thickness	
1	**SMA 12.5**	**2.0 inch**	5
2	**BM-25.0**	**7.0 inch**	9
3	**Agg.Base**	**6.0 inch**	11

9. Notes

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PAVEMENT DESIGN

WRA Whitman, Requardt & Associates, LLP
Engineers · Architects · Environmental Planners Est. 1915

Design Per VDOT Specifications Ver.04.10 skk 9/14/2021

Ver.4.10 Sheet 1 of 2

1. Project Data

Project:	Optiz Blvd	**Section:**	Mainline Sections	**Design:**	skk
	Woodbridge, VA	**Station:**	Express Lanes	**Check:**	jmb
WRA #	45893-001	**Date:**	1/28/2022		

2. Traffic Growth Rate

Traffic Grouth Rate Provided ?	*Given/Assumed*			Given Growth Rate (***g***):	*2.00%*
Data & Calculation of Traffic Growth Rate	**Year**			Time Duration	
	ADT			Calculated g	
				Growth Rate for Design:	*2.00%*

3. Design Year Average Daily Traffic (ADT)

Construction/Design Year		*2022*			
ADT for Design Year Given?		*Needs to be Estimated*		Given ADT Data	
Data & Calculation of Design Year ADT	Data Used Year	*2018*		g:	2.00%
	ADT	*67,192*		Calculated ADT:	72731
				Project ADT for Cons. Year:	72,731

4. Data for Pavement Design

Initial Structural Design Life (Performance Period)		*30*	years	
Reliability *R* (%)	(for calculation of Z_R)	*95*	% Calculated Z_R=	-1.645
Initial Serviceability	$(PSI)_1$	*4.2*		
Terminal Serviceability	$(PSI)_2$	*2.8*	Calcualted **Δ** (*PSI*) =	1.4
Percent Truck		*1.00%*	*Assumed*	
Truck Factor	*Needs to be Estimated*	*1.10*	*(See Sec 5 for truck factor Estimation)*	
Directional Split/Distribution	(Note 1)	*100%*		
Design Lane Factor/Distribution	(Note 2)	*70%*		
Subgrade CBR	(for M_R calculations)	*3.3*	Method	*AASHTO 1993*
Overall Standard Deviation		*0.49*	Calculated M_R=	5,000

5. Rigorous ESAL Calculations

Data	ADT= 72,731	Lane dis. 100%		Dir.Dis. 70%	g= 2.00%		n= 30
Class	Vehcle Type	% ADT	ADT by Type	Growth factor	Design Traffic	ESAL Factor	Design ESAL
1	Car	*92.58*	67,334	40.568	697,930,351	0.0002	139,586
2	*Single Unit Trucks*	*1.60*	1,164	40.568	12,061,877	*0.46*	5,548,463
3	*Combined Trucks*	*5.82*	4,233	40.568	43,875,077	*1.05*	46,068,831
	Total:	100.00	72,731			ESAL	51,756,880
						Equivalent Truck Factor	6.8655

FLEXIBLE
PAVEMENT DESIGN

Whitman, Requardt & Associates, LLP
Engineers · Architects · Environmental Planners Est. 1915

Design Per VDOT Specifications Ver.04.10 skk 9/14/2021

Sheet 2 of 2

Project: Optiz Blvd
Woodbridge, VA
WRA # 45893-001
Design: skk

Section: Mainline Sections
Station: Express Lanes
Date: 1/28/2022
Check: jmb

6. Calculated Design Sructural Number

ADT 72,731	g: 2.00%	Growth Factor	40.568	Truck Factor:	6.8655
Traffic	26,546,815 per year	Wt 18 (18kips ESAL) =		51,756,880	
Calculated Resilient Modulus M_r	5000 psi	per	AASHTO 1993		
Reliability Standard Dev. Z_R	-1.645	Δ (*PSI*) =	1.4	Overall STD	0.49
		Calculated Design Structural Number:			**7.930**

7. Specified Layer and Lift Design

(VDOT Specifications)

Lift ID	Layer Description	Struct. Coeff.	Drainage Coeff.	Selected Thickness (in)	Check Thickness Limits	Layer Lift Thickness Min. (in)	Layer Lift Thickness Max (in)	Calculatd SN
1	*05. SMA 12.5*	0.44	1.0	*2.00*	*-Ok-*	1.50	3.00	0.88
2	*07. IM-19.0*	0.44	1.0	*2.00*	*-Ok-*	2.00	3.00	0.88
3	*09. BM-25.0*	0.44	1.0	*3.00*	*-Ok-*	2.50	4.00	1.32
4	*09. BM-25.0*	0.44	1.0	*4.00*	*-Ok-*	2.50	4.00	1.76
5	*09. BM-25.0*	0.44	1.0	*4.00*	*-Ok-*	2.50	4.00	1.76
6	*11. Agg.Base*	0.12	1.0	*6.00*	*-Ok-*	3.00	8.00	0.72
7	*11. Agg.Base*	0.12	1.0	*6.00*	*-Ok-*	3.00	8.00	0.72
Totals:		Total Pavement Thickness=		27 inches			Total SN=	**8.040**
					Required SN		7.930	***Ok***

8. Summary of Pavement Section

Total Number of Layers: 4

Layer No	Layer Description	Layer Thickness	
1	**SMA 12.5**	**2.0 inch**	5
2	**IM-19.0**	**2.0 inch**	7
3	**BM-25.0**	**11.0 inch**	9
4	**Agg.Base**	**12.0 inch**	11

9. Notes

APPENDIX E.6

MOT Pavement Section

FOR INDEX OF SHEETS SEE SHEET 1B

THIS PROJECT WAS DEVELOPED UTILIZING THE DEPARTMENT'S ENGINEERING DESIGN PACKAGE (GEOPAK).
GEOPAK Computer Identification No. 94105

ALL CONSTRUCTION IS TO BE PERFORMED WITHIN EXISTING RIGHT OF WAY.

COMMONWEALTH OF VIRGINIA

DEPARTMENT OF TRANSPORTATION

PLAN AND PROFILE OF PROPOSED
STATE HIGHWAY

FHWA 534 DATA 4A121
UPC 94105

STATE	FEDERAL AID PROJECT	STATE ROUTE	STATE PROJECT	SHEET NO.
VA.	HSIP-095-2(521) (SEE TABULATION BELOW FOR SECTION NUMBERS)	95	(FO) 0095-076-005 (SEE TABULATION BELOW FOR SECTION NUMBERS)	1

FUNCTIONAL CLASSIFICATION AND TRAFFIC DATA	
URBAN PRINCIPAL ARTERIAL FREEWAY - 70mph MIN. DESIGN SPEED	
	Fr: 1.18 MILES S. OF DUMFRIES ROAD To: 0.18 MILES N. OF PWC PKWY
ADT (2012)	95,000
ADT (2034)	104,000
DHV	9,500
D (%) (design hour)	60
T (%) (design hour)	7
V (MPH)	70 (DESIGN), 65 (POSTED)

PRINCE WILLIAM COUNTY
I-95 LEFT SHOULDER & AUXILIARY LANES IMPROVEMENTS
FROM: 1.18 MILES S. OF DUMFRIES ROAD
TO: 0.18 MILES N. OF PRINCE WILLIAM COUNTY PKWY

PROJECT MANAGER Jeffrey S. Daily, P.E. (703)259-2993
SURVEYED BY VDOT NOVA District Survey
DESIGN SUPERVISED BY Thomas H. Heil, P.E. (703)246-0028
DESIGNED BY Rummel, Klepper & Kahl, LLP (703)246-0028

CONVENTIONAL SIGNS

STATE LINE
COUNTY LINE
CITY, TOWN OR VILLAGE
RIGHT OF WAY LINE
FENCE LINE
UNFENCED PROPERTY LINE
FENCED PROPERTY LINE
WATER LINE
SANITARY SEWER LINE
GAS LINE
ELECTRIC UNDERGROUND CABLE
TRAVELED WAY
GUARD RAIL
RETAINING WALL
RAILROADS
BASE OR SURVEY LINE

LEVEE OR EMBANKMENT
BRIDGES
CULVERTS
DROP INLET
POWER POLES
TELEPHONE OR TELEGRAPH POLES
TELEPHONE OR TELEGRAPH LINES
HEDGE
TREES
HEAVY WOODS
GROUND ELEVATION
GRADE ELEVATION

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DESIGN FEATURES RELATING TO CONSTRUCTION OR TO REGULATION AND CONTROL OF TRAFFIC MAY BE SUBJECT TO CHANGE AS DEEMED NECESSARY BY THE DEPARTMENT.

THIS PROJECT IS TO BE CONSTRUCTED IN ACCORDANCE WITH THE DEPARTMENT'S 2007 ROAD AND BRIDGE SPECIFICATIONS, 2008 ROAD AND BRIDGE STANDARDS, 2009 MUTCD, 2011 VIRGINIA SUPPLEMENT TO THE MUTCD, 2011 VIRGINIA WORK AREA PROTECTION MANUAL AND AS AMENDED BY CONTRACT PROVISIONS AND THE COMPLETE ELECTRONIC PDF VERSION OF THE PLAN ASSEMBLY.

ALL CURVES ARE TO BE SUPERELEVATED, TRANSITIONED AND WIDENED IN ACCORDANCE WITH STANDARD TC - 5.01R, EXCEPT WHERE OTHERWISE NOTED.

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Prince William County Population 402,002 (2010 Census)

STATE PROJECT NO.	SECTION	FEDERAL AID PROJECT NO.	TYPE CODE	UPC NO.	EQUALITIES	LENGTH INCLUDING BRIDGE(S)		LENGTH EXCLUDING BRIDGE(S)		BRIDGE PROJECT NO.	TYPE PROJECT	DESCRIPTION
					FEET	FEET	MILES	FEET	MILES			
0095-076-005	P-101	HSIP-5A01(047)	SFTY	94105	N/A	37.900	7.18	37,200	7.05	N/A	Prelim. Engr.	FR: 1.18 MILES S. OF DUMFRIES RD.
	M-501	HSIP-095-2(521)	SFTY	94105	N/A	37.900	7.18	37,200	7.05	N/A	Construction	TO: 0.18 MILES N. OF PWC PKWY

Project Lengths are based on I-95 Southbound Baseline

REVISED

RECOMMENDED FOR APPROVAL FOR CONSTRUCTION	
6/19/12 DATE	Diane L. Mitchell PROGRAMMING DIVISION DIRECTOR
6/20/12 DATE	Mohammad Mirshahi STATE LOCATION AND DESIGN ENGINEER
6/22/12 DATE	Reta Busher CHIEF OF PLANNING AND PROGRAMMING

APPROVED FOR CONSTRUCTION	
6/22/12 DATE	Malcolm T. Kerley CHIEF ENGINEER

APPROVED	
DATE	DIVISION ADMINISTRATOR FEDERAL HIGHWAY ADMINISTRATION U.S. DEPARTMENT OF TRANSPORTATION

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$DGNLEV

LIMITED ACCESS HIGHWAY

By Resolution of Commonwealth Transportation
Board dated January 18, 2001

PROJECT MANAGER Jeffrey S. Daily, P.E. (703)259-2993
SURVEYED BY VDOT NOVA District Survey
DESIGN SUPERVISED BY Thomas M. Heil, P.E. (703)246-0028
DESIGNED BY Rummel, Klepper & Kahl, LLP (703)246-0028

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HYDRAULIC ENGINEER

THOMAS M. HEIL
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Rummel, Klepper & Kahl, LLP
Fairfax, Virginia
ROADWAY ENGINEER

REVISED	STATE	STATE ROUTE	STATE PROJECT	SHEET NO.
	VA.	95	0095-076-005.M501	22

DESIGN FEATURES RELATING TO CONSTRUCTION
OR TO REGULATION AND CONTROL OF TRAFFIC
MAY BE SUBJECT TO CHANGE AS DEEMED
NECESSARY BY THE DEPARTMENT

CURVE DATA

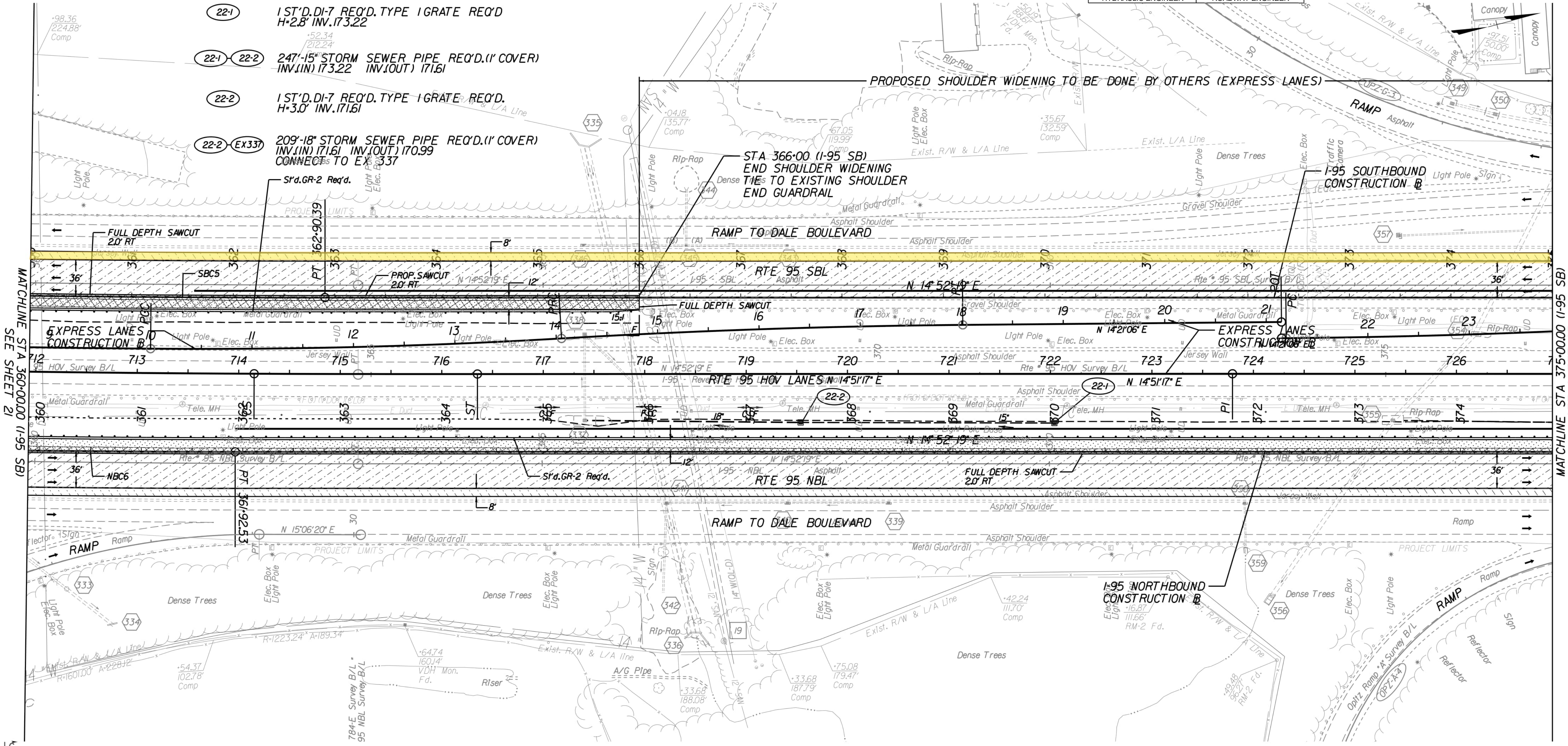
Curve SBC5
PI = 352+93.57
DELTA = 5° 09′ 37.02″ (LT)
D = 0° 15′ 31″
T = 998.17′
L = 1,994.99′
R = 22,150.82′
PC = 342+95.40
PT = 362+90.39
V = 70 mph
e = NC

(22-1) 1 ST'D. DI-7 REQ'D. TYPE I GRATE REQ'D
H=2.8′ INV. 173.22

(22-1)-(22-2) 247′-15″ STORM SEWER PIPE REQ'D. (1′ COVER)
INV. (IN) 173.22 INV. (OUT) 171.61

(22-2) 1 ST'D. DI-7 REQ'D. TYPE I GRATE REQ'D.
H=3.0′ INV. 171.61

(22-2)-(EX337) 209′-18″ STORM SEWER PIPE REQ'D. (1′ COVER)
INV. (IN) 171.61 INV. (OUT) 170.99
CONNECT TO EX 337



|C Denotes Construction Limits in Cuts
|F Denotes Construction Limits in Fills

☒	Denotes Demolition of Pavement
⁘	Denotes Proposed Pavement
▨	Denotes Mill & Overlay Pavement
🟨	Denotes 10″ Mill & Overlay Pavement

CURVE DATA

Curve NBC6
PI = 359+41.48
DELTA = 1° 47′ 39.74″ (LT)
D = 0° 21′ 26″
T = 251.08′
L = 502.13′
R = 16,033.34′
PCC = 356+90.40
PT = 361+92.53
V = 70 mph
e = NC

SCALE
0 50′ 100′

PROJECT	SHEET NO.
0095-076-005	22

5/16/2012
7:40:41 PM

LIMITED ACCESS HIGHWAY By Resolution of Commonwealth Transportation Board dated January 18, 2001

PROJECT MANAGER Jeffrey S. Daily, P.E. (703)259-2993
SURVEYED BY VDOT NOVA District Survey
DESIGN SUPERVISED BY Thomas M. Heil, P.E. (703)246-0028
DESIGNED BY Rummel, Klepper & Kahl, LLP (703)246-0028

CURVE DATA

Curve SBC5
PI = 396+40.06
DELTA = 7° 55' 19.08" (RT)
D = 0° 15' 16"
T = 1,558.99'
L = 3,113.01'
R = 22,514.93'
PC = 380+81.07
PT = 411+94.08
V = 70 mph
e = NC

WILLIAM S. SPRINGER Lic. No. 024778

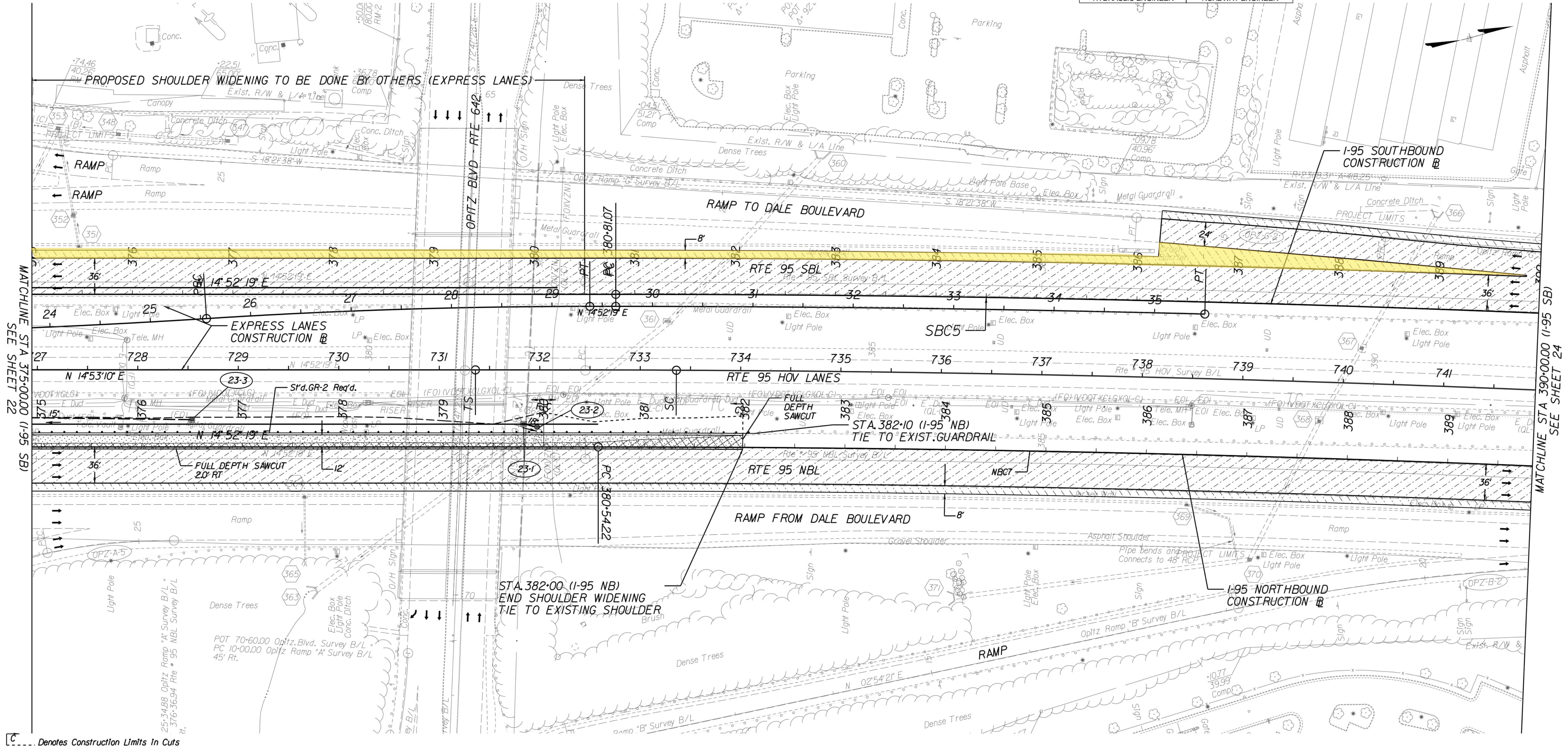
THOMAS M. HEIL Lic. No. 044111

Rummel, Klepper & Kahl, LLP
Fairfax, Virginia
HYDRAULIC ENGINEER

Rummel, Klepper & Kahl, LLP
Fairfax, Virginia
ROADWAY ENGINEER

REVISED	STATE	ROUTE	PROJECT	SHEET NO.
	VA.	95	0095-076-005,M501	23

DESIGN FEATURES RELATING TO CONSTRUCTION OR TO REGULATION AND CONTROL OF TRAFFIC MAY BE SUBJECT TO CHANGE AS DEEMED NECESSARY BY THE DEPARTMENT



C - - - Denotes Construction Limits in Cuts
F — — Denotes Construction Limits in Fills

☒	Denotes Demolition of Pavement
⬚	Denotes Proposed Pavement
▨	Denotes Mill & Overlay Pavement
🟨	Denotes 10" Mill & Overlay Pavement

CURVE DATA

Curve NBC7
PI = 396+35.62
DELTA = 7° 55' 18.96" (RT)
D = 0° 15' 03"
T = 1,581.41'
L = 3,157.77'
R = 22,838.74'
PC = 380+54.22
PT = 412+11.99
V = 70 mph
e = NC

(23-1)	1 ST'D DI-7B REQ'D TYPE 1 GRATE REQ'D H=3.0', INV. 180.2
(23-1)-(23-2)	10'-18" STORM SEWER PIPE REQ'D (1' COVER) INV.(IN) 180.2 INV.(OUT) 179.8 CONNECT TO EX 362
(23-2)	MODIFY EXISTING DROP INLET ADJUST TO GRADE. RAISE 1.0' 1 ST'D MH-1 FRAME & COVER REQ'D CONVERT DI TO MANHOLE
(23-3)	1 ST'D. DI-7 REQ'D TYPE 1 GRATE REQ'D H=2.3' INV. 179.0
(23-2)-(EX355)	304'-15" STORM SEWER PIPE REQ'D (1' COVER) INV.(IN) 179.0 INV.(OUT) 175.0 CONNECT TO EX 355

SCALE
0 50' 100'

PROJECT	SHEET NO.
0095-076-005	23