AGENCY OF TRANSPORTATION **OFFICE MEMORANDUM**

To: Gary Laroche, P.E., Structures Project Manager

SPM CEE

From: Stephen Madden, P.E, Geotechnical Engineer via Callie Ewald, P.E., Senior Geotechnical Engineer

Date: August 29th, 2025

Subject: Sunderland NH CULV(122) – Geotechnical Design Parameters Report

1.0 INTRODUCTION

As requested, we have completed geotechnical analyses of the proposed spread footing foundations as part of the Sunderland NH CULV(122) project. The project consists of the replacement of Bridge No. 19-7 (culvert) carrying US Route 7 over an unnamed stream in the town of Sunderland, VT. The project is located approximately 0.5 miles south of the intersection of US Route 7 and Vermont Route 313 (VT-313). The project will include replacement of the existing corrugated galvanized steel plate pipe culvert with a precast concrete box culvert with new headwalls and wingwalls. Contained herein are geotechnical recommendations for use in the design of the proposed replacement structure, as determined using the 2024 AASHTO LRFD Bridge Design Specifications.

2.0 FIELD INVESTIGATION

A field investigation was conducted by VTrans Geotechnical Engineering Section in August, 2022 to evaluate the subsurface profiles for design and construction of the proposed replacement structure. The findings of this investigation are detailed in the Preliminary Geotechnical Information report dated October 28th, 2022 as submitted by Eric Denardo (attached as **Appendix A**). Refer to this report for a detailed description of the field sampling and testing, laboratory analysis of soil samples, generalized subsurface profile, and boring logs.

3.0 SHALLOW FOUNDATION ANALYSIS

AASHTO's LRFD Bridge Design Specifications Manual (2024) was used as the reference for settlement and bearing resistance equations. Section 10.6.3.1.2 contains the equation used for bearing resistance. Neither depth factors nor load inclination factors were used in the analysis as they were not considered pertinent due to the designed embedment of the structure, per Section C.10.6.3.1.2a. Hough's Method, used to calculate settlement in normally consolidated cohesionless soils, can be found in Section 10.6.2.4.2.

It is recommended that the bottom of the wingwall footings be at least 4 ft below the ground surface based on frost susceptibility and bearing stratum at the site. An embedment value of 4 ft was used for the strength limit state analysis and an embedment value of 0 ft was used for the service limit state analysis, which tends to control the design, to account for potential scour conditions at the design flood elevation per Section 2.6.4.4.2. A conservative groundwater elevation at the bottom of footing elevation was used in design.

As per section 10.5.5.1 of the 2024 AASHTO LRFD Bridge Design Specifications, a resistance factor of 1.0 should be applied to the unfactored bearing resistance for use in service limit state design. Service limit state design includes, but is not limited to, settlement and scour. Section 10.5.5.2.2 specifies that a resistance factor of 0.45 should be applied to the unfactored bearing resistance for use in strength limit state design for spread footings on rock and soil. Strength limit state design includes, but is not limited to, checks for bearing resistance, sliding, and constructability. Potential for overturning is limited by controlling the location of the resultant of the reaction forces (eccentricity). Eccentricity, e, shall be limited as follows:

Foundations on soil: $|e| < b/3$
Foundations on rock: $|e| < 0.45b$

Eccentricity should be considered for settlement and bearing resistance design of spread footings by using effective footing widths based on AASHTO Section 10.6.1.3. All footing widths presented in this report are *effective* footing widths. The soil profiles used in these analyses were adapted from the subsurface investigation and can be found below in Table 3-1 and Table 3-2.

Table 3-1 Soil Profile Located at Inlet (B-102)

Approximate Elevation (ft)	Soil Profile
902.6 – 894.6 ft	Dense Sandy GRAVEL
894.6 – 877.6 ft	Medium Dense Silty Gravelly SAND
877.6 – 865.6 ft	Medium Dense Sandy SILT

Table 3-2 Soil Profile Located at Outlet (B-101)

Approximate Elevation (ft)	Soil Profile
902.1 – 894.1 ft	Dense Gravelly Silty SAND
894.1 – 875.1 ft	Medium Dense Sandy GRAVEL
875.1 – 866.3 ft	Dense Sandy SILT

3.1 Bearing Resistance (Inlet Bearing Stratum)

The maximum length of wingwalls used in the analysis was 14 ft, based on the Culvert Layout Plan sheet from the Final Plans dated July 23rd, 2025. The Substructure Details I sheet specifies a bottom of footing elevation of 880.83 ft at the inlet of the proposed culvert. Based on the geometry and elevations shown in the plans it appears as though the footings will bear on medium dense silty gravelly sand at the inlet. Based on boring information and subsequent calculations, the soil in this layer was assigned a friction angle, $\phi = 38^{o}$ and density, $\gamma = 130$ lb/ft^3. The embedment was assumed to be 4 ft below the ground surface.

For effective footing widths of 3 ft through 10 ft, the maximum factored bearing resistances for the strength and service limit states are given in Table 3-3. Soil settlement values were calculated for various footing widths based on the nominal bearing pressure at the service limit state using Hough's Method, as stated above in Section 3.0. Bearing pressure values that resulted in 1.0 inch of settlement were calculated for various footing widths and are also detailed below in Table 3-3. Based on calculations, the service limit state was found to govern design. Considering the granular nature of the foundation soils, any settlement is expected to occur during or immediately after construction. Attached to this report are graphs that detail the corresponding bearing resistances for various effective footing widths (**Appendix B**) and settlement graphs based on various bearing pressures (**Appendix C**).

Table 3-3 Factored Bearing Resistances at Various Effective Footing Widths (Inlet)

Maximum Wingwall Length (ft)	Effective Footing Width (ft)	Factored Bearing Resistance, Strength Limit State (ksf)	Factored Bearing Resistance, Service Limit State (ksf)	Bearing Pressure resulting in 1.0-inch of settlement
14	3	9.8	6.7	22.0
	4	11.0	8.5	11.8
	5	12.2	10.1	8.1
	6	13.3	11.6	6.2
	7	14.3	12.8	5.2
	8	15.3	13.8	4.4
	9	16.2	14.6	3.9
	10	17.0	15.2	3.6

3.2 Bearing Resistance (Outlet Bearing Stratum)

The maximum length of wingwalls used in the analysis was 15 ft, based on the Culvert Layout Plan sheet from the Final Plans dated July 23rd, 2025. The Substructure Details I sheet specifies a bottom of footing elevation of 875.19 ft at the outlet of the proposed culvert. Based on the geometry and elevations shown in the plans it appears as though the footings will bear primarily on dense sandy silt at the outlet. Based on the boring information and subsequent calculations, the soil in this layer was assigned a friction angle, $\phi = 38^o$ and density, $\gamma = 120$ lb/ft^3. The embedment was assumed to be 4 ft below the ground surface.

For effective footing widths of 3 ft through 10 ft, the maximum factored bearing resistances for the strength and service limit states are given in Table 3-4. Soil settlement values were calculated for various footing widths based on the nominal bearing pressure at the service limit state using Hough's Method, as stated above in Section 3.0. Bearing pressure values that resulted in 1.0 inch of settlement were calculated for various footing widths and are also detailed below in Table 3-4. Based on calculations, the service limit state was found to govern design. Considering the granular nature of the foundation soils, any settlement is expected to occur during or immediately after construction. Attached to this report are graphs that detail the corresponding bearing resistances for various effective footing widths (**Appendix B**) and settlement graphs based on various bearing pressures (**Appendix C**).

Table 3-4 Factored Bearing Resistances at Various Effective Footing Widths (Outlet)

Maximum Wingwall Length (ft)	Effective Footing Width (ft)	Factored Bearing Resistance, Strength Limit State (ksf)	Factored Bearing Resistance, Service Limit State (ksf)	Bearing Pressure resulting in 1.0-inch of settlement
14	3	9.0	6.3	28.2
	4	10.1	8.1	16.3
	5	11.2	9.7	11.3
	6	12.2	11.2	8.9
	7	13.2	12.6	7.3
	8	14.2	13.7	6.3
	9	15.0	14.7	5.6
	10	15.7	15.7	5.1

4.0 CULVERT WINGWALL STABILITY ANALYSIS

The overall stability of the proposed wingwalls was analyzed using the SLIDE 2018 limit equilibrium slope stability analysis program developed by Rocscience. The wingwalls at the inlet and outlet of the culvert were analyzed at a critical cross-section representing the full height of the wingwalls. The wingwall geometries and cross sections used were based on the Final Plans dated July 23rd, 2025. Per Section 11.6.3.7 of the *AASHTO LRFD Bridge Design Specifications*, a maximum resistance factor of 0.65 is allowable where the geotechnical parameters and subsurface stratigraphy are highly variable or based on limited information and a resistance factor of 0.75 is allowable where the geotechnical parameters and subsurface stratigraphy are well defined. The resistance factor of the slope is the inverse of the factor of safety as determined from the stability analysis.

Computer models were generated using SLIDE for Stations 1087+25 (Inlet) and 1088+00 (Outlet) and were analyzed using the Spencer Method. According to the VTrans Geotechnical Engineering Instruction on Soil Slope Stability Investigation & Evaluation Manual (GEC 14-01), the Spencer Method is recommended to be used for the analysis of failure surfaces of any shape. Soil parameters used in the analysis were equivalent to those developed for the shallow foundation analyses, as described in Section 3.0, and a conservative water table elevation was modeled. The maximum heights of the wingwalls were used based on the geometries shown in the Final Plans, corresponding to a height of 14 feet at both the inlet and the outlet.

Based on the analysis it appears that no deep-seated global stability issues will exist given the proposed conditions, and the overall stability of the wingwalls is acceptable. The resistance factors for slip surfaces beneath the wingwalls are less than AASHTO's maximum recommended value of 0.75. Refer to **Appendix D** for outputs of the completed analysis at Stations 1056+50 and 1057+00, respectively.

5.0 RECOMMENDATIONS

Shallow foundations appear to be feasible for the proposed wingwalls as detailed in the Preliminary Plans. Factored bearing resistances for various footing widths were calculated for the wingwalls and can be found in Tables 3-3 and 3-4. These calculations are based on the geometric and geotechnical assumptions outlined in Section 3.0 of this report. The bearing resistances presented in this report at the service limit state were calculated assuming a conservative scour condition (0 ft embedment). Sections 10.5.2 and 10.5.3 of AASHTO outline all design states relevant to spread footing design and their respective resistance factors. Eccentricity should be considered for settlement and bearing resistance design of spread footings by using effective footing widths based on AASHTO Section 10.6.1.3. Table 5-1 shows the appropriate resistance factors for various design states.

Table 5-1: Summary of Resistance Factors

Design State	Resistance Factor, φ
Settlement	1.0
Scour	1.0
Bearing Resistance	0.45
Sliding	0.80

5.1 Plan Notes & Details

Based on the variability of the soils encountered during the subsurface investigation, and locations of the borings with relation to the inlet and outlet, we recommend including the following information on the plans:

- For strength limit state, using a resistance factor of 0.45, the factored bearing resistance is 9.0 ksf
- For service limit state, using a resistance factor of 1.0, the factored bearing resistance is 4.0 ksf

5.2 Design Parameters

Table 5-2 highlights engineering properties assigned to the in-situ soils. Engineering properties of common construction materials are shown in Table 5-3. These values should be used when designing any substructure units. It is recommended that values of K_o be used for calculating earth pressures where the structure is not allowed to deflect longitudinally, away from or into the retained soil mass. Values for K_a should be utilized for an active earth pressure condition where the structure is moving away from the soil mass and K_p where the structure is moving toward the soil mass. The design earth pressure coefficients are based on horizontal surfaces (non-sloping backfill) and a vertical wall face.

Table 5-2: Engineering Properties of Bearing Stratum Soils

	Medium Dense Silty Gravelly SAND (Inlet)	**Dense Sandy SILT (Outlet)**
Unit Weight, γ (lbs/ft^3):	130	120
Internal Friction Angle, φ (degrees):	38	38
Coefficient of Friction, f		
- mass concrete cast against soil:	0.45	0.34
- soil against precast/formed concrete:	0.31	0.25
Active Earth Pressure Coef., K_a:	0.24	0.24
Passive Earth Pressure Coef., K_p:	4.20	4.20
At-Rest Earth Pressure Coefficient, K_o:	0.38	0.38

Table 5-3: Engineering Properties of Construction Materials

	703.04 – Granular Borrow	**704.08 – Granular Backfill for Structures**
Unit Weight, γ (lbs/ft^3):	130	140
Internal Friction Angle, φ (degrees):	32	34
Coefficient of Friction, f		
- mass concrete cast against soil:	0.45	0.55
- soil against precast/formed concrete:	0.40	0.48
Active Earth Pressure Coef., K_a:	0.31	0.28
Passive Earth Pressure Coef., K_p:	3.26	3.57
At-Rest Earth Pressure Coefficient, K_o:	0.47	0.44

5.3 Construction Considerations

5.3.1 Cofferdams/Temporary Earthwork Support

The Contractor should be reminded that Section 208.06 of VTrans' *2018 Standard Specifications for Construction* indicates that "The Contractor shall prepare detailed plans and a schedule of operations for each cofferdam specified in the Contract. Construction drawings shall be submitted in accordance with Section 105 (Control of the Work)."

5.3.2 Construction Dewatering

The bottom of footing elevations for the culverts are estimated to be beneath the water table based on where water was encountered during the subsurface investigation therefore temporary construction dewatering will likely be required to construct the foundations. Temporary dewatering will also be necessary to limit disturbance to and maintain the integrity of the bearing surface.

Temporary dewatering can likely be accomplished by open pumping from shallow sumps, temporary ditches, and trenches within and around the excavation limits. Sumps should be provided with filters suitable to prevent pumping of fine-grained soil particles. The water trapped by the temporary dewatering controls should be discharged to settling basins or an approved filter "sock" so that the fine particles suspended in the discharge have adequate time to "settle out" prior to discharge. All effluent water, or discharge, should comply with all applicable permits and regulations.

Sumps and trenches should lie outside a 1V:1H line extending downward and outward from the edge of footing. Installation and operation of the Contractor's dewatering system should be integrated with other earthwork operations and sequence of cutting, filling, foundation construction, and backfilling.

5.3.3 Placement and Compaction of Soils

Fills should be placed systematically in horizontal layers not more than 12 inches in thickness, prior to compaction. Cobbles larger than 8 inches should be removed from the fill prior to placement. Compaction equipment should preferably consist of large, self-propelled vibratory rollers. Where hand-guided equipment is used, such as a small vibratory plate compactor, the loose lift thickness shall not exceed 6 inches. Cobbles larger than 4 inches should be removed from the fill prior to placement.

Embankment fills should be compacted to a dry density of no less than 95% of the maximum dry density determined in accordance with AASHTO T-99, Method C. Granular Backfill for Structures, or other select materials placed within the roadway base section shall be compacted to a dry density equal to 95% of the maximum dry density as determined in accordance with AASHTO T-99.

6.0 CONCLUSION

If you have any questions or would like to discuss this report, please contact the Geotechnical Engineering Section via email.

Reviewed by: Callie Ewald, P.E., Senior Geotechnical Engineer

Enclosures: Appendix A: Preliminary Geotechnical Information (5 Pages)
Appendix B: Effective Footing Width vs. Bearing Resistance Graph (1 Page)
Appendix C: Anticipated Settlement based on Effective Footing Width and Applied Bearing Pressure (1 Page)
Appendix D: Global Stability Evaluation Outputs (2 Pages)

cc: Electronic Read File/MG
Project File/CEE
SPM

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Appendix A

VTrans Preliminary Geotechnical Information

AGENCY OF TRANSPORTATION **OFFICE MEMORANDUM**

To: Laura Stone, P.E., Scoping Engineer

END

From: Eric Denardo, P.E., Geotechnical Engineer

Date: October 28, 2022

Subject: Statewide-Southwest STP CULV(91) – Sunderland Bridge 19-7 Preliminary Geotechnical Information

1.0 INTRODUCTION

As requested, we have completed our preliminary geotechnical investigation of Bridge 19-7 located on US Route 7 over an unnamed brook in the town of Sunderland, VT. Bridge 19-7 is a corrugated galvanized metal steel plate pipe culvert located approximately 0.5 miles south of the intersection of VT Route 313 and US Route 7. This review included a subsurface investigation, the examination of well log data, hazardous site information on file at the Vermont Agency of Natural Resources (ANR), as well as published geologic maps relating to surficial and bedrock data. This project is currently in the scoping phase.

2.0 SUBSURFACE INFORMATION

2.1 Published Geologic Data

Mapping conducted in 1970 for the Surficial Geologic Map of Vermont shows the project site consists of glacial till (Doll, 1970).

According to the Bedrock Map of Vermont from 2011, published by the USGS and State of Vermont, the project site is underlain with bedrock consisting of Dolostone and Conglomerate from the Vermont Valley Sequence and Middlebury Synclinorium belt of the Dunham Dolostone. (Ratliffe, et. al, 2011).

2.2 Water Well Logs

The Vermont ANR maintains a record of private and public wells drilled in their Atlas database. Published online, these logs may provide general characteristics of the soil strata and depth to bedrock in the area. There were no water well logs found within a 1000 foot (ft) radius of the project site. The closest well was approximately 2200 ft north of the culvert. For this reason, information from this well is not considered pertinent to the project.

2.3 Hazardous Materials and Underground Storage Tanks

The ANR Atlas also maintains a database of all known hazardous waste sites and underground storage tanks. According to their published data there are no hazardous sites, hazardous waste generators, or underground storage tanks within 0.5 miles of the project site. The project site itself is not on the hazardous site list and should not be impacted by any sites outside of this radius.

2.4 Record Plans

No historic record plans were located for this project.

3.0 FIELD INVESTIGATION

A field investigation was conducted between August 17, 2022, and August 31, 2022. Two standard penetration borings were advanced in either shoulder at opposite corners of the existing structure, near the outlet (B-101) and inlet (B-102), to evaluate the subsurface profile and aid in design and construction of a replacement structure. A summary of the final location of each boring with corresponding ground surface elevation can be found in Table 3.1 below. The values for Northings and Eastings as well as ground surface elevations are based on the Vermont State Plane Grid Coordinate System NAD 83 and were located by the Geotechnical Engineering Section's Trimble Geoexplorer 600 handheld GPS with a decimeter accuracy. The elevations are based on the North American Vertical Datum, NAVD 88 and were determined by plotting the boring locations on the VTrans survey file x22b045-vt30-br19-7sv.dgn, dated July 2022. The locations and elevations of the borings should be considered accurate only to the degree implied by the method used to determine them.

During drilling operations, split spoon samples and standard penetration tests (SPT) were taken continuously to a depth of 10 ft below ground surface (bgs) then at 5 ft intervals to a depth of 37 ft bgs. Bedrock was not encountered in either boring.

Soil samples were visually identified in the field and SPT blow counts were recorded on the boring logs. Soil and rock samples were preserved and returned to the Construction and Materials Bureau Central Laboratory for testing and further evaluation. Upon completion of the laboratory testing, the boring logs were revised to reflect the results of the laboratory classification results.

Table 3.1 *Boring Locations and Elevations.*

Boring No.	Northing (ft)	Easting (ft)	Station	Offset (ft)	Approximate Ground Surface Elevation (ft)
B-101	197620.8	1471089.3	56+28	-22.4	902.1
B-102	197562.7	1471104.7	55+83	16.5	902.6

4.0 SOIL PROFILE

The field investigation indicates that the soil strata of the project site generally consist of loose to dense silt, sand, and gravel to a depth of 25 ft bgs, and medium dense sand and silt from 25 to 37 ft bgs. Cobbles were noted by the drillers in B-101 between depths of 19.6 and 22.0 ft bgs.

5.0 RECOMMENDATIONS

Based on this information, possible foundation options for bridge replacement at a similar elevation as the existing structure include the following:

- Reinforced concrete box with new wingwalls and headwalls with spread footings founded on soil
- Precast or steel arch bridge with spread footings founded on soil or piles
- Replacement metal pipe culvert with new headwalls and wingwalls with spread footings founded on soil

- Concrete rigid frame supported on H-piles, micropiles, or spread footings

Based on the materials encountered during drilling, we believe sheet piles can be driven to a depth of at least 35 ft in order to retain the roadway if phased construction is selected. Cobbly material was noted from 19.6 to 22 ft bgs in B-101. This was the only instance of cobbles and should not prevent sheet piling from being used.

When a design alternative, as well as a preliminary alignment has been chosen, the Geotechnical Engineering Section can review the preferred alternative and assist with any further geotechnical analyses and review of foundation elements required.

If you have any questions or would like to discuss this report, please contact us via email. Typed boring logs are attached and are available in the CADD design files:
M:\Projects\22b045\MaterialsResearch

6.0 REFERENCES

Doll, C. G., 1970, Surficial Geologic Map of Vermont, Vermont Geological Survey, Montpelier, VT.

Ratcliffe, N. M., Stanley, R. S., Gale, M. H., Thompson, P. J., Walsh, G. J., 2011, Bedrock Geologic Map of Vermont, Vermont Geological Survey, Montpelier, VT.

Vermont Agency of Natural Resources Department of Environmental Conservation, Natural Resources Atlas, www.anr.vermont.gov/maps/nr-atlas%20, accessed 10/12/2022.

Enclosures: Boring Logs (2 Pages)

Reviewed by: Stephen Madden, Geotechnical Engineer SPM

cc: Electronic Read File/MG
Project File
END

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STATE OF VERMONT
AGENCY OF TRANSPORTATION
CONSTRUCTION AND
MATERIALS BUREAU
CENTRAL LABORATORY

BORING LOG

Statewide-Southwest
STP CULV(91)
Sunderland, US 7 BR 19-7

Boring No.: **B-101 (Br. 19-7)**
Page No.: 1 of 1
Pin No.: 22b045
Checked By: END

Boring Crew: McGinley, Aubut, Arles
Date Started: 8/17/22 Date Finished: 8/17/22
VTSPG NAD83: N 197620.80 ft E 1471089.30 ft
Station: 56+28.00 Offset: -22.40
Ground Elevation: 902.1 ft

	Casing	Sampler
Type:	WB	SS
I.D.:	3 in	1.5 in
Hammer Wt:	N.A.	140 lb.
Hammer Fall:	N.A.	30 in.
Hammer/Rod Type:	Auto/AWJ	
Rig:	CME 55 TRACK	C_E = 1.52

Groundwater Observations

Date	Depth (ft)	Notes
08/17/22	10.6	WT After Drilling

Depth (ft)	Strata (1)	CLASSIFICATION OF MATERIALS (Description)	Blows/6" (N Value)	Moisture Content %	Gravel %	Sand %	Fines %
0.0		Field Note:, Asphalt 0.0'-1.0'					
		Visual Description:, Poorly graded Gravel, white, Dry, Rec. = 1.5 ft, Split sample	10-7-7-12 (14)				
		Visual Description:, Sand with Silt and Gravel, Lt brn, Dry, Split sample					
		A-2-4, SiSa, Lt brn, MTD, Rec. = 1.7 ft	16-15-19-21 (34)	8.7	10.8	58.7	30.5
5		Visual Description:, Poorly graded Sand with Silt, Lt brn, Dry, Rec. = 1.3 ft	13-22-22-22 (44)				
		Visual Description:, Poorly graded Sand with Silt and trace Gravel, Lt brn, Dry, Rec. = 1.2 ft, Gravel in end of sampler	15-14-20-26 (34)				
10		A-1-b, SaGr, brn, Dry, Rec. = 0.7 ft	13-19-16-14 (35)	5.2	46.3	41.5	12.2
15		Visual Description:, Poorly graded Sand trace Gravel, brn, Wet, Rec. = 0.4 ft	9-6-4-8 (10)				
20		Field Note:, Attempted NX core. Appears to be nested cobbles 19.6'-22.0', NX cleanout 18.5'-19.6'					
25		Field Note:, No recovery	15-14-21-26 (35)				
30		A-4, SaSi, Rec. = 1.0 ft, Gravel in end of sampler	9-15-19-27 (34)	21.0	18.8	20.1	61.1
35		Visual Description:, Poorly graded Gravel with Silt, Lt brn, Wet, Rec. = 0.2 ft, Refusal at 35.8' 50 blows per 6"	16-R@3" (R)				

Hole stopped @ 35.8 ft

Remarks:
Hole collapsed @ 11.0'.

Notes:
1. Stratification lines represent approximate boundary between material types. Transition may be gradual.
2. N Values have not been corrected for hammer energy. C_E is the hammer energy correction factor.
3. Water level readings have been made at times and under conditions stated. Fluctuations may occur due to other factors than those present at the time measurements were made.

STATE OF VERMONT
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BORING LOG

Statewide-Southwest
STP CULV(91)
Sunderland, US 7 BR 19-7

Boring No.: **B-102 (Br. 19-7)**
Page No.: 1 of 1
Pin No.: 22b045
Checked By: END

Boring Crew: McGinley, Aubut, Arles
Date Started: 8/18/22 Date Finished: 8/31/22
VTSPG NAD83: N 197562.70 ft E 1471104.70 ft
Station: 55+83.00 Offset: 16.50
Ground Elevation: 902.6 ft

	Casing	Sampler
Type:	WB	SS
I.D.:	3 in	1.5 in
Hammer Wt:	N.A.	140 lb.
Hammer Fall:	N.A.	30 in.
Hammer/Rod Type:	Auto/AWJ	
Rig:	CME 55 TRACK	C_E = 1.52

Groundwater Observations

Date	Depth (ft)	Notes
08/09/22		No water to depth

Depth (ft)	Strata (1)	CLASSIFICATION OF MATERIALS (Description)	Blows/6" (N Value)	Moisture Content %	Gravel %	Sand %	Fines %
		Field Note:, Asphalt 0.0'-0.8'					
		Visual Description:, Poorly graded Gravel with trace Sand, white, Dry, Rec. = 1.0 ft	12-13-15-16 (28)				
		A-4, SaSi, Lt brn, Dry, Rec. = 1.6 ft	16-18-23-26 (41)	7.7	19.3	43.4	37.3
5		Field Note:, No recovery, Gravel in end of sampler. Rollercone cleanout 5.9'-6.0'	33-R@3" (R)				
		Field Note:, Attempted core at 6' appears to be cobbles/boulders					
		Visual Description:, Silt and Sand with little Gravel, Lt brn, Dry, Rec. = 0.6 ft	8-7-5-9 (12)				
10		Visual Description:, Coarse to medium Sand and Gravel with trace Silt, Lt brn, Wet, Rec. = 0.7 ft	8-7-11-12 (18)				
		A-2-4, SiGrSa, Lt brn, Wet, Rec. = 0.6 ft	12-13-13-13 (26)	12.0	31.5	41.7	26.8
15		Visual Description:, Coarse to medium Gravel with little coarse Sand, Lt brn, Wet, Rec. = 0.3 ft	5-28-17-7 (45)				
20		Field Note:, No recovery, Refusal @ 5", 50 blows per 6". Rollercone cleanout 20.5'-25.0'	R@5" (R)				
25		A-4, SaSi, Lt brn, MTW, Rec. = 0.6 ft	17-16-20-24 (36)	18.2	17.0	30.9	52.1
30		A-4, SaSi, Lt brn/white, MTD, Rec. = 1.5 ft	10-12-9-16 (21)	26.2	1.9	26.5	71.6
35		Visual Description:, Clay with Gravel, Lt brn, MTW, Rec. = 2.0 ft	6-8-11-14 (19)				
		Hole stopped @ 37.0 ft					
40		Remarks: Hole collapsed @ 12.7'.					

Notes:
1. Stratification lines represent approximate boundary between material types. Transition may be gradual.
2. N Values have not been corrected for hammer energy. C_E is the hammer energy correction factor.
3. Water level readings have been made at times and under conditions stated. Fluctuations may occur due to other factors than those present at the time measurements were made.

Appendix B

Effective Footing Width vs. Bearing Resistance

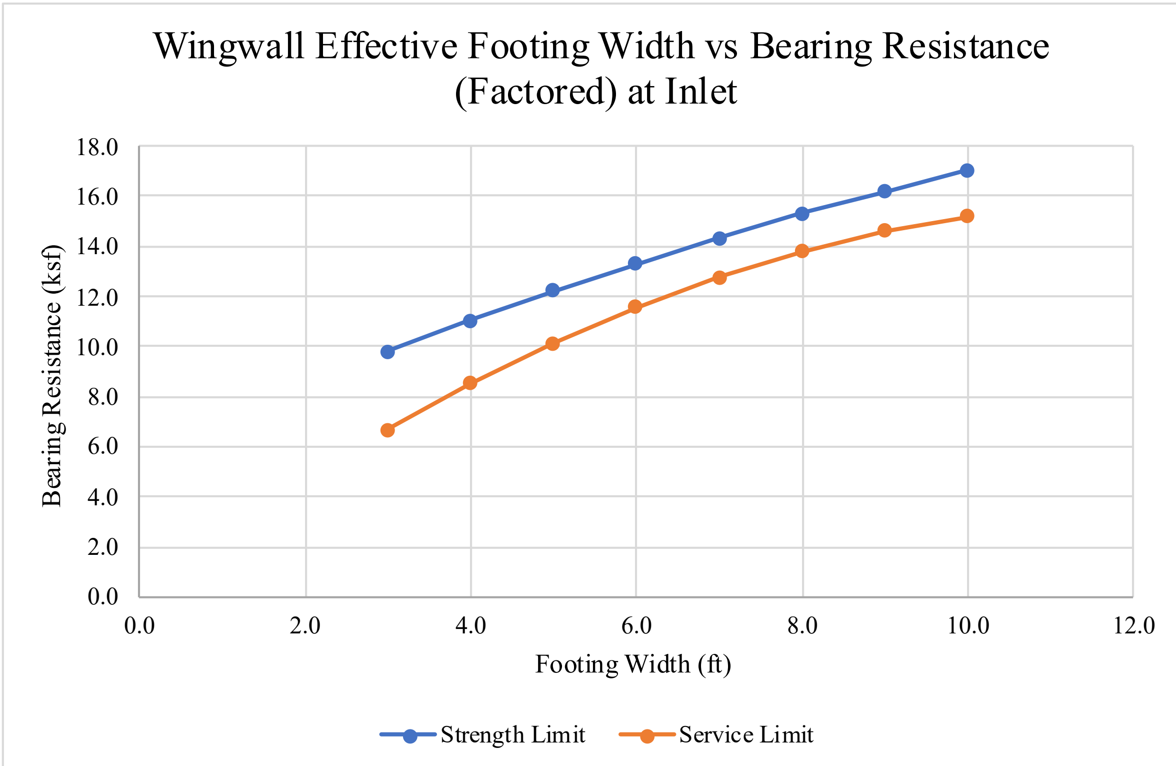


Figure B.1 Factored bearing resistance of soil at inlet with respect to effective footing width

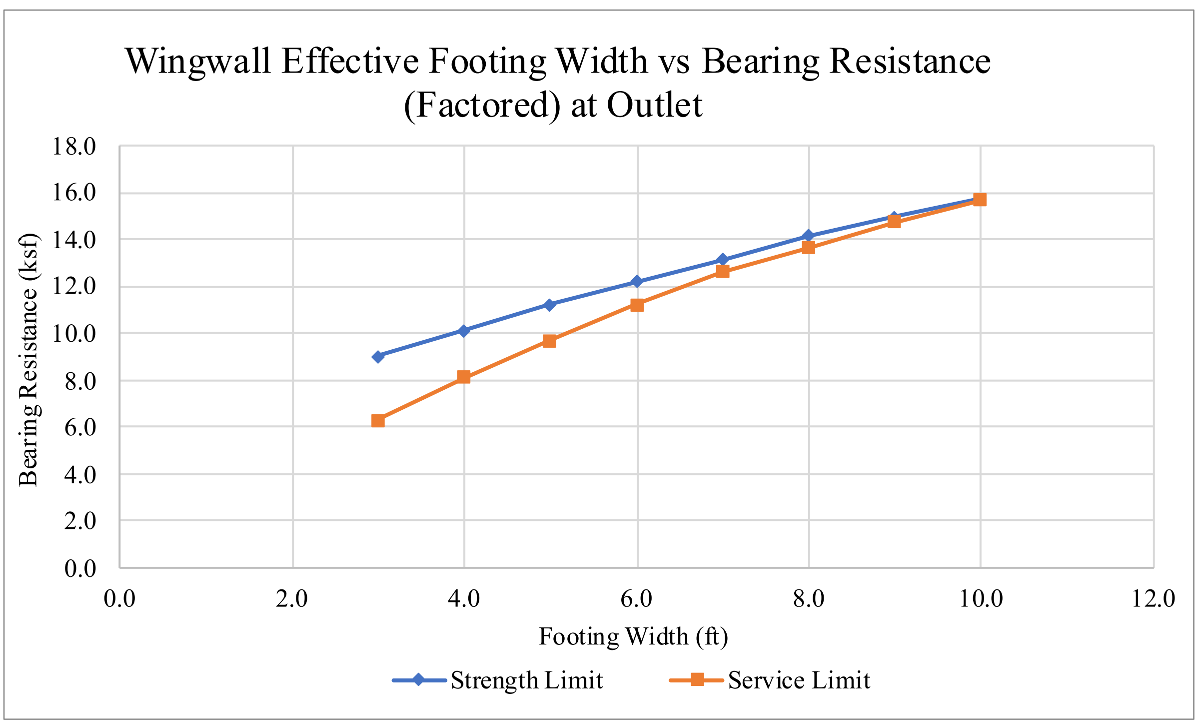


Figure B.2 Factored bearing resistance of soil at outlet with respect to effective footing width

Appendix C

Anticipated Settlement based on Effective Footing Width and Applied Bearing Pressure

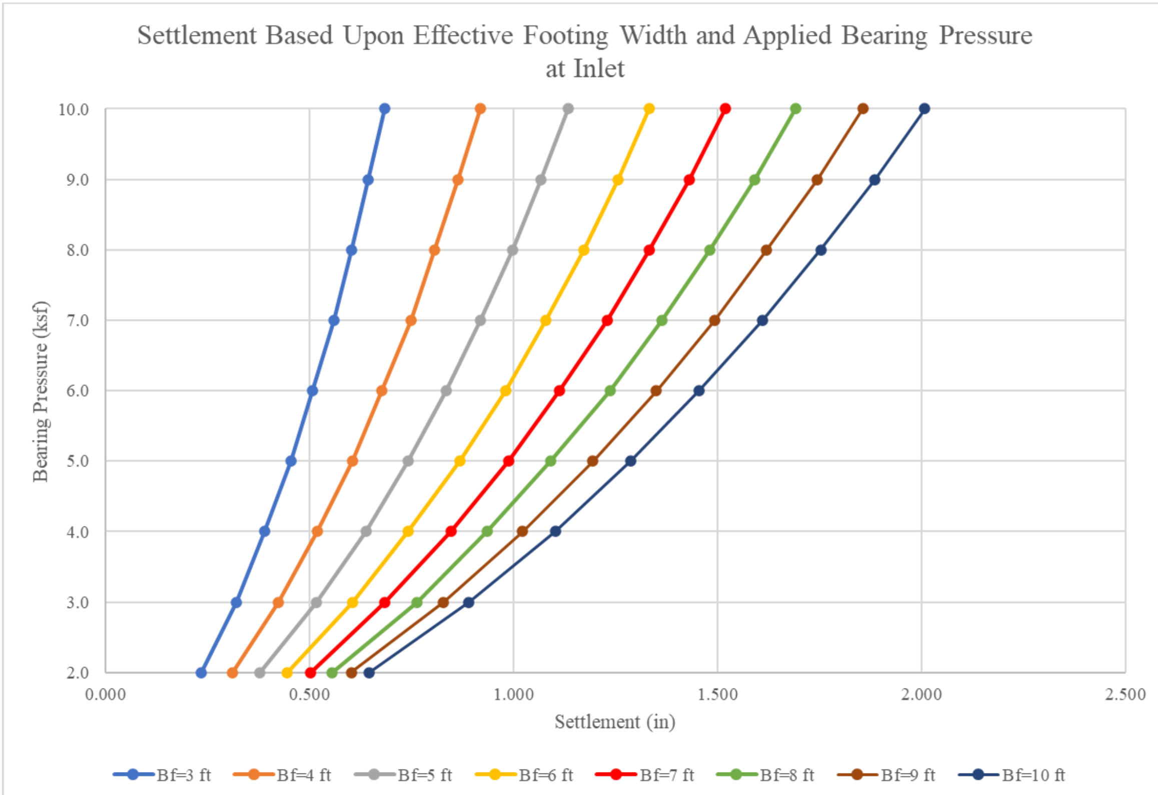


Figure C.1 Settlement based on effective footing width and applied bearing pressure (inlet)

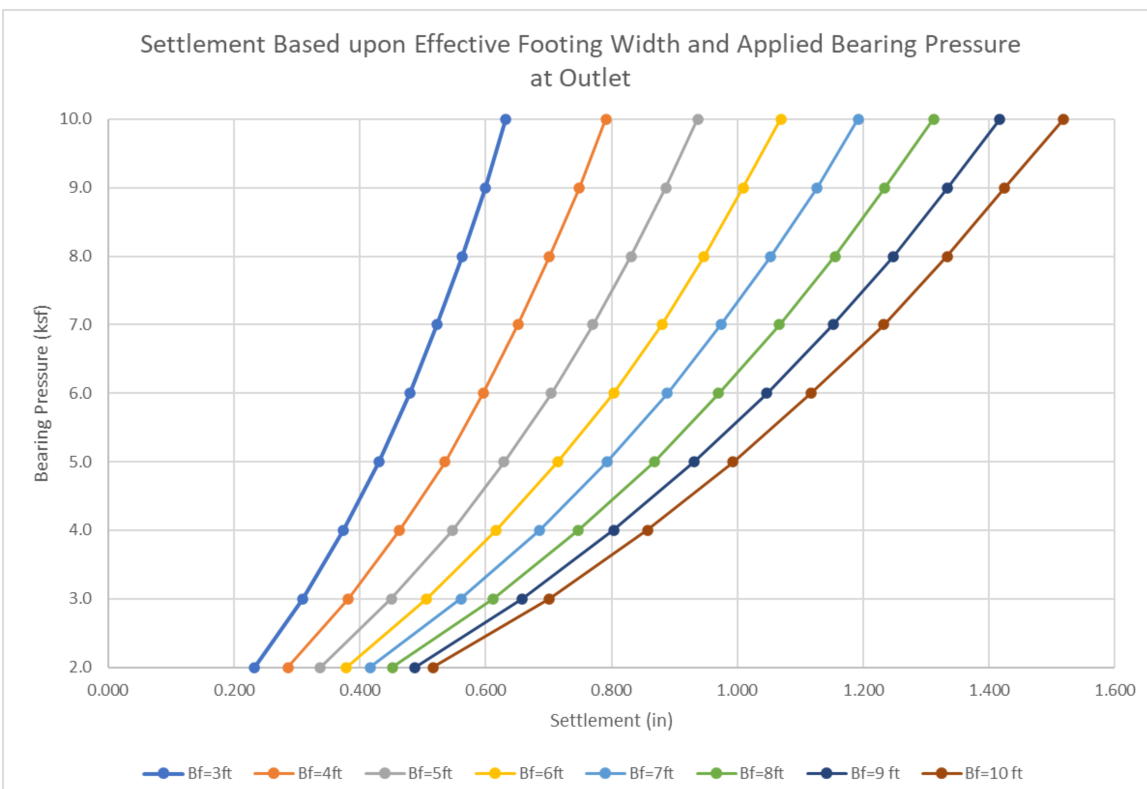
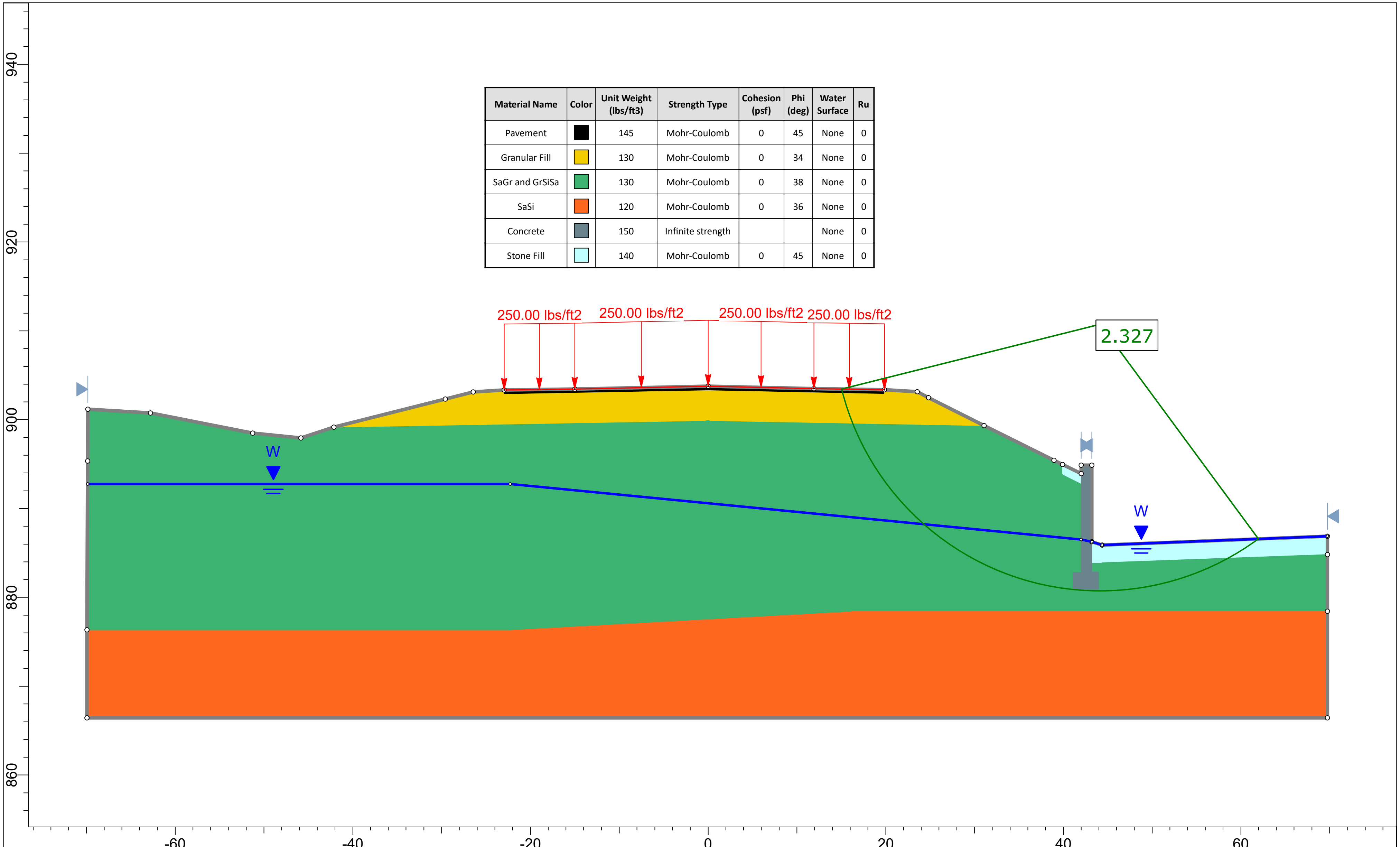


Figure C.2 Settlement based on effective footing width and applied bearing pressure (outlet)

Appendix D

Global Stability Evaluation Outputs



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Ru
Pavement	Black	145	Mohr-Coulomb	0	45	None	0
Granular Fill	Yellow	130	Mohr-Coulomb	0	34	None	0
SaGr and GrSiSa	Green	130	Mohr-Coulomb	0	38	None	0
SaSi	Orange	120	Mohr-Coulomb	0	36	None	0
Concrete	Grey	150	Infinite strength			None	0
Stone Fill	Light blue	140	Mohr-Coulomb	0	45	None	0

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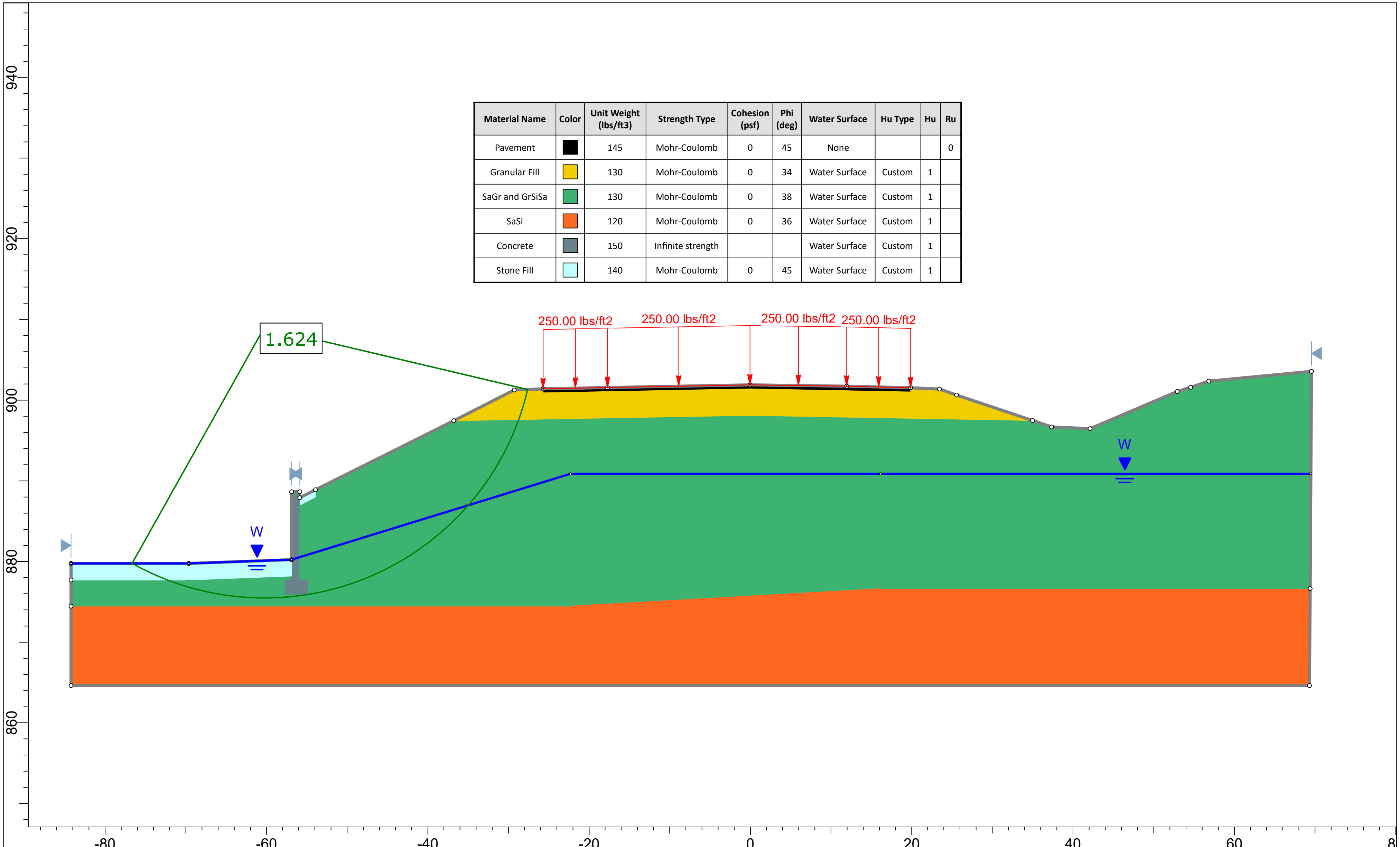
SLIDEINTERPRET 8.032

Project	Sunderland NH CULV(122)		
Analysis Description	1088+00 Inlet GS Analysis		
Drawn By SPM	*Scale* 1:179	*Company*	VTrans Geotechnical Engineering Section
Date	08/28/2025	*File Name*	1087+25.slmd



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Hu Type	Hu	Ru
Pavement		145	Mohr-Coulomb	0	45	None			0
Granular Fill		130	Mohr-Coulomb	0	34	Water Surface	Custom	1	
SaGr and GrSiSa		130	Mohr-Coulomb	0	38	Water Surface	Custom	1	
SaSi		120	Mohr-Coulomb	0	36	Water Surface	Custom	1	
Concrete		150	Infinite strength			Water Surface	Custom	1	
Stone Fill		140	Mohr-Coulomb	0	45	Water Surface	Custom	1	

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SLIDEINTERPRET 8.032

Project	Sunderland NH CULV(122)		
Analysis Description	1088+00 Outlet GS Analysis		
Drawn By SPM	*Scale* 1:197	*Company*	VTrans Geotechnical Engineering Section
Date	08/28/2025	*File Name*	1088+00.slmd