LANDSLIDE EXPLORATION
MED-18-13.54
MEDINA COUNTY, OHIO
PID#: 92953

Prepared For:

GPD GROUP, INC.
520 South Main Street, Suite 2531
Akron, Ohio 44311

Prepared by:

NATIONAL ENGINEERING & ARCHITECTURAL SERVICES, INC.
2800 Corporate Exchange Drive, Suite 240
Columbus, Ohio 43231

NEAS PROJECT 15-0091

March 8, 2017

EXECUTIVE SUMMARY

The Ohio Department of Transportation (ODOT) has proposed a project for improvements to State Route 18 (MED-18-13.54, PID 92953) in the City of Medina, Medina County, Ohio. The SR-18 roadway alignment is located in the Killbuck-Glaciated Pittsburgh Plateau physiographic region, which is part of the Glaciated Allegheny Plateaus. This area is characterized by ridges and flat uplands dissected by steep valleys. This topography is reflected in the steep valley of the West Branch Rocky River which crosses MED-18 midway at an elevation of about 910 feet (ft) as compared to the western and eastern ends of the alignment which rise to ~1,000 ft and 1,060, respectively. The alignment is underlain by till from 80 to 320 ft deep.

For Part 2 of MED-18-13.54 project, four main parts of SR-18 need to be improved: 1) Culverts #1, #3 and #6 with full height headwalls; (2) Historical Landslides on SR-18 Station 127+00 (BMP: 13.76) and 166+00 (BMP: 14.5); 3）Retaining Wall #4 (RW4) at Goodwill Building side hill cut section; and 4) Retaining Wall No. 2 (RW2) at SR-18 Station 135+17. National Engineering & Architectural Services, Inc. (NEAS), formerly Barr Engineering, Inc., has been contracted to perform geotechnical engineering services for the project. The purpose of the geotechnical engineering services was to perform geotechnical explorations within the project limits to obtain information concerning the subsurface soil and groundwater conditions relevant to the design and construction of the project. The scope of work performed by NEAS as part of the referenced project included: a review of published geotechnical information; performing 10 total test borings (4 utilized within this report); laboratory testing of soil samples in accordance with the SGE; performing geotechnical engineering analysis to assess the historical landslide sites on SR-18 Station 127+00 and 166+00; and development of this summary report.

NEAS presents this Landslide Exploration Report for the historical landslide sites on SR-18 Station 127+00 (BMP: 13.76) and 166+00 (BMP: 14.5) for the Part 2 MED-18-13.54 Improvements to State Route 18 (SR-18) within the City of Medina, Ohio. This report presents a summary of the encountered superficial and subsurface conditions and our recommendations for the landslide stability in accordance with Load and Resistance Factor Design (LRFD) method as set forth in AASHTO's Publication LRFD Bridge Design Specifications, (AASHTO, 2014) and ODOT's 2016 Specifications for Geotechnical Explorations (SGE) (ODOT, 2016) (ODOT, 2016).

The general subsurface profile is relatively uniform and consistent with the geological model for the project. At the SR-18 Station 127+00 landslide site, the soil profile consists of surficial materials comprised of 10 ft of clay-rich embankment fill overlying a further 10 ft of very compact glacial till that might also be embankment. The underlying soils are natural, fine grained, cohesive glacial till that exhibit relatively strong strength properties. Free groundwater was encountered at an elevation of ~937 ft which is generally consistent with the estimated flow-line elevation of 939 ft. Bedrock was not encountered within depth of the boring performed.

At the Station 127+00 landslide site, the soil profile consists of surficial materials comprised of 7 ft of cohesive embankment fill soil (A-6a) following by natural, fine grained, cohesive glacial till. An intermittent layer of natural, fine to coarse grained, non-cohesive till was encountered at elevations between 936.1 ft and 928.6 ft in B-027-1-16 and at elevations between 921.0 ft and 913.0 ft in B-027-2-16. Free groundwater was encountered at the elevations of ~ 937 ft. Bedrock was not encountered within depth of the boring performed.

Global stability analyses were performed for the landslide sites at existing condition and post construction condition. Based on the results of the analyses, it is our opinion that the subsurface conditions encountered at both locations are generally satisfactory and the sites can be considered to be stable at existing condition and post construction condition.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF APPENDICES

1. INTRODUCTION

1.1. General

NEAS, formerly Barr Engineering, Inc. (BEI), presents our Landslide Exploration Report for the landslides at Station 127+00 [begin mile point (BMP): 13.76] and 166+00 (BMP: 14.5) along State Route 18 (SR-18), as part of the SR-18 widening and improvement project (MED-18-13.54, PID 92953) in the City of Medina, Medina County, Ohio. This report presents a summary of the encountered superficial and subsurface conditions and our recommendations based on landslides analysis in accordance with Load and Resistance Factor Design (LRFD) method as set forth in AASHTO's Publication LRFD Bridge Design Specifications, 7th Edition with 2015 interim revisions (BDS) (AASHTO, 2014) and ODOT's 2016 Specifications for Geotechnical Explorations (SGE) (ODOT, 2016) (ODOT, 2016).

The Part 2 MED-18-13.54 project consists of:

- Culverts #1, #3 and #6 with full height headwalls;
- Historical Landslides on SR-18 Station 127+00 and 166+00;
- Retaining Wall #4 Goodwill Building side hill cut section;
- Retaining Wall #2 at SR-18 Station 135+17.

The exploration was conducted in general accordance with National Engineering & Architectural Services, Inc.'s (NEAS's) proposal to GPD Group (GPD), dated March 25, 2016 and with the provisions of ODOT's *Specifications for Geotechnical Explorations* (SGE) (ODOT, 2016).

The scope of work performed by NEAS as part of the referenced project included: a review of published geotechnical information; performing 10 total test borings (4 utilized within this report); laboratory testing of soil samples in accordance with the SGE; performing geotechnical engineering analysis to assess the stability of slope; and development of this summary report.

1.2. Landslide Overview

Two historical landslides, located on SR-18 Station 127+00 (BMP: 13.76) and Station 166+00 (BMP: 14.5), were identified through ODOT's GEOMS database in 2015 Part 1 exploration MED-18-13.54 project. Both of the locations had a preliminary score of 1 point which was considered to be non-rated. The preliminary score of 1 indicates that the landslide has a low probability of additional movement and a low probability of significant impact to the roadway.

According to district geotechnical engineer, "Both of these locations are rated a "1" because of the shallow surface failure (shoulder) that is present. The depth of the sliding surface is 3 feet at both locations. Longer guardrail posts along with a w-section of guardrail were placed along the bottom of the guardrail in order to help retain the shoulder in these two locations. The slope at the 13.76 location is estimated to be 13 feet high and the length of affected roadway is 230 feet. The slope at the 14.50 location is estimated to be 17 feet high and the length of affected roadway is 265 feet."

2. GEOLOGY AND OBSERVATIONS OF THE PROJECT

2.1. Geology and Physiography

The project site is located in the Killbuck-Glaciated Pittsburgh Plateau physiographic region, which is part of the Glaciated Allegheny Plateaus (Brockman, 1998). This area is characterized by ridges and flat uplands dissected by steep valleys. This topography is reflected in the steep valley of the West Branch Rocky River which crosses MED-18 midway at an elevation of about 910 ft as compared to the western and eastern ends of the alignment which rise to ~1,000 ft and 1,060, respectively.

The landslides site at Station 127+00 and Sta 166+00 is underlain by Wisconsinan-age till (unsorted mix of clay, silt, sand, gravel and boulders) over sandstone and shale deposited in Mississippian-age (ODNR, 2000). Bedrock topography maps indicated depth of bedrock ranging from elevation 650 ft to 1,000 ft, placing it between 50 ft and 260 ft deep (Schumacher, et al, 1996). It is mapped as Mississippian-age Cuyahoga Formation (Slucher, et al, 1996).

2.2. Hydrology/Hydrogeology

SR-18 crosses over West Branch Rocky River at approximately STA 141+00 where the flow line elevation is 910 ft and likely represents the local groundwater table. Broadway Creek, a tributary to West Branch flows under SR-18 at approximately STA 102+50 (U.S. Department of the Interior, 2013) and a tributary to Broadway flows under the alignment at ~STA 111+50.

The West Branch Rocky River and the area immediately adjacent to it are located in a special flood hazard zone subject to inundation by the 1% annual chance flood (US Department of Homeland Security, 2013). The base flood elevation where SR-18 crosses West Branch is 917 ft.

2.3. Mining and Oil/Gas Production

No abandoned mines are noted on ODNR's Abandoned Underground Mine Locator in the vicinity of the landslides site (ODNR [1], 2016).

The following (Table 1) gas wells were noted in the vicinity of the alignment (ODNR, 2015[(2)]). All but three are abandoned and/or plugged. The remaining three have not produced gas since 1993.

Table 1: Gas wells in Proximity to the Alignment

Well Name	Owner	Well No.	Formation	Status	Direction from Alignment
Medina Community Hospital	Ohio Fuel Gas Co.	Well No. 8	Gas-Clinton Sand	Plugged & Abandoned	~520 ft south
	Hydrocarbon Resources LTD	MCZ#1		Not Drilled	
	Buckeye Well Surveys	1	Gas-Clinton Sand	Abandoned 1996	
J H Witzel	O.F.S	2	Gas	Plugged & Abandoned	~765 ft south
ES Johnson	Martin H Lax	1	Gas	Abandoned 1991	~380 ft north
-	-	5	Gas	Plugged & Abandoned	~601 ft south
Tru-Fit	Tru-Filt Products Corp	5, 6A	Gas	Installed 1983 -Ohio Shale – Berea Sandstone – no production since 1993	~120 ft south

2.4. Historical Records and Previous Phases of Project Exploration

The following report/plans were available for review and evaluation for this report (ODOT, 2016):

- Draft subgrade exploration report dated August 19, 2015 for Project MED-18-13.54 Part 1 prepared by Barr Engineering, INC. (BEI, 2015).

Three soil borings (B-015-0-14, B-016-0-14 and B-027-0-14) drilled as Part 1 of the MED-18-13.54 subgrade exploration project were reviewed for this report (Table 2). A summary of the Part I borings information (location, elevation, etc.) is provided in Table 2 below, the location is depicted on the Soil Boring Location Plan provided in Appendix A, and the Part 1 boring log is provided in Appendix B.

Table 2: Part 1 Boring Summary

Boring Number	Location (Sta/offset)	Latitude	Longitude	Elevation (NAVD 88) (ft)	Depth (ft)	Structure
B-015-0-14	127+12, 23' LT	41.137745	-81.827227	959.6	31.5	Retaining Wall
B-016-0-14	127+42, 19' RT	41.137619	-81.827141	959.9	30.0	Retaining Wall
B-027-0-14	165+02, 38' LT	41.136436	-81.813598	957.6	9.0	Pavement Subgrade

2.5. Site Reconnaissance

The site reconnaissance of the roadways was conducted on July 16, 2015 and August 7, 2015. The existing embankment slope at Sta. 127+00 is next to a lake with a steep slope of approximately 1. 5H:1V (Photograph 1). The embankment slope is thickly vegetated with a grassed yard at the foot. A culvert runs from the southernmost point of the lake under SR-18 to connect with a pond on the opposite side of the road. The guardrail at the top of the embankment is vertical, but appears to be relatively new (Photograph 2). Several of the older trees in the area are also slanted downslope slightly, while the newer trees are

slanted slightly more upslope (Photograph 3). Several sources of water flow into and out of this area, including 2 culverts, a lake, the roadway, and potential overflow of the pond, making high water levels during heavy rainfall extremely likely.

Photograph 1: Embankment at historical landslide near Sta 127+00

Photograph 2: Guardrail at historical landslide near Sta 127+00

Photograph 3: Tree alignments at historical landslide near Sta 127+00

This location at Station 166+00 is adjacent to a swamp (Photograph 4) and on a steep, grass and weed covered embankment of greater than1.5:1 slope in several places (Photograph 5). A thick wooded area is located between the bottom of the embankment and the swamp. The guardrail shows no signs of slope movement (it also appears to be relatively new), however a telephone pole is leaning significantly downslope (Photograph 6). Water is conveyed to and from the swamp by 2 culverts, runoff from the roadway, and runoff from a large empty lot to the north. The lot appears to send very large quantities of water into the swamp area, causing a massive eroded channel connecting the two locations (Photograph 7). The swamp appeared to have lower water levels than usual, as a large dry area to the north was covered in deposits from the swamp with very little growth occurring (Photograph 8).

Photograph 4: Swamp at historical landslide near Sta 166+00

Photograph 5: Embankment at historical landslide near Sta 166+00

Photograph 6: Guardrail at historical landslide near Sta 166+00

Photograph 7: Eroded channel at historical landslide near Sta 166+00

Photograph 8: Large dry area at historical landslide near Sta 166+00

3. GEOTECHNICAL EXPLORATION

3.1. Field Exploration Program

The exploration for the landslide sites was conducted by NEAS between September 19, 2016 and September 21, 2016 and included 4 borings drilled to depths of 61.5 ft bgs (B-014-1-16 and B-015-1-16) and 51.5 ft bgs (B-027-1-16 and B-027-2-16). The boring locations were selected by NEAS in general accordance with the guidelines contained in the SGE with the intent to evaluate subsurface soil and groundwater conditions. The borings were typically located along/near the landslide site in locations that were not restricted by maintenance of traffic, underground utilities or dictated by terrain (i.e. steep embankment slopes).

Stationing, offset, elevations and latitude and longitude locations of the boring are provided in Table 3 below.

Table 3: Project Boring Summary

Boring Number	Location (Sta/Offset)[2]	Latitude[1]	Longitude[1]	Elevation (NAVD 88) (ft)	Depth (ft)
B-014-1-16	126+68, 27' LT	41.137761	-81.827385	959.2	61.5
B-015-1-16	127+62, 22' LT	41.137721	-81.827046	960.0	61.5
B-027-1-16	165+87, 32' LT	41.136432	-81.813293	960.6	51.5
B-027-2-16	166+76, 35' LT	41.136429	-81.812974	963.5	51.5

Notes:
1. *As-drilled boring location and corresponding ground surface elevation were surveyed in the field by GPD Group.*
2. *Stationing in reference to centerline of Construction SR-18.*

The borings were drilled using a CME 55 truck mounted drilling rig utilizing 3.25-inch diameter hollow stem augers. Soil samples were recovered at intervals of 2.5-ft to end of boring (EOB) in three borings B-014-1-16, B-027-1-16 and B-027-2-16, except in boring B-015-1-16 soil samples were recovered at intervals of 2.5-ft starting from depth of 32.5 ft bgs to EOB (AASHTO T-206 “Standard Method for Penetration Test and Split Barrel Sampling of Soils.”). The soil samples obtained from the exploration program were visually observed in the field by the NEAS field representative and preserved for review by a Geologist and possible laboratory testing. Standard penetration tests (SPT) were conducted using a CME auto hammer that has been calibrated to be 81.8% efficient as indicated on the boring logs.

Field boring log was prepared by drilling personnel, and included lithological description, SPT results recorded as blows per 6-inch increment of penetration, and estimated unconfined shear strength values on specimens exhibiting cohesion (using a hand-penetrometer). Groundwater measurements were attempted during the boring drilling procedures and immediately following the completion of the borehole. After completing the boring, the borehole was sealed with auger cuttings, bentonite grout and asphalt patch following SGE section 407.

3.2. Laboratory Testing Program

The laboratory testing program consisted of classification testing and moisture content determinations. Data from the laboratory-testing program were incorporated onto the borings logs (Appendix B). Soil samples are retained at the laboratory for 60 days following report submittal, after which time they will be discarded.

3.2.1. Classification Testing

Representative soil samples were selected for index properties (Atterberg Limits) and gradation testing for classification purposes on approximately 31% of the samples. At the boring location, samples were selected for testing with the intent of identification and classification of all significant soil units. Soils not selected for testing were compared to laboratory tested samples/strata and classified visually. Moisture content testing was conducted on all samples. The laboratory testing was performed in general accordance with applicable AASHTO specifications.

A final classification of the soil strata was made in accordance with AASHTO M-145 "Classification of Soils and Soil-Aggregate Mixtures for Highway Construction Purposes," as modified by ODOT "Classification of Soils" once laboratory test results became available. The results of the soil classification are presented on the boring logs in Appendix B.

3.2.2. Standard Penetration Test Results

Standard Penetration Tests (SPT) and split-barrel (commonly known as split-spoon) sampling of soils were performed at 2.5-ft interval in the project borings performed. To account for the high efficiency (automatic) hammers used during SPT sampling, field SPT N-values were converted based on the calibrated efficiency (energy ratio) of the specific drill rig's hammer. Field N-values were converted to an equivalent rod energy of 60% (N_{60}) for use in analysis or for correlation purposes. The resulting N_{60} values are presented on the boring logs provided in Appendix B.

4. GEOTECHNICAL FINDINGS

The subsurface conditions encountered during NEAS's explorations are described in the following subsections and on the boring log presented in Appendix B. The boring log represents NEAS's interpretation of the subsurface conditions encountered at the boring location based on our site observations, field log, visual review of the soil samples by NEAS's geologist, and laboratory test results. The lines designating the interfaces between various soil strata on the boring log represent the approximate interface location; the actual transition between strata may be gradual and indistinct. The subsurface soil and groundwater characterizations included herein, including summary test data, are based on the subsurface findings from the geotechnical explorations performed by NEAS as part of the referenced project, results of historical explorations, and consideration of the geological history of the site.

4.1. Subsurface Conditions at Sta. 127+00

4.1.1. Overburden Soil at Sta. 127+00

The subsurface profile at the site near Sta. 127+00 is generally consistent with the geological model for the project in regards to the materials encountered. The subsurface profile within the proposed project area consists of surficial materials comprised of either granular base, asphalt pavement or brick section underlain by natural, fine grained, cohesive glacial till primarily comprised of stiff to hard silty clay (A-6b), medium stiff to very stiff silt and clay (A-6a), very stiff clay (A-7-6), very stiff to hard sandy silt (A-4a) and medium stiff to hard silt (A-4b). With respect to the soil strength, the cohesive soils can be described as having a relative consistency ranging from medium stiff to hard correlating to converted SPT-N values (N_{60}) between 8 and 59 blows per foot (bpf). Natural moisture contents of the cohesive soil

ranged from 11% to 33% in moisture. Bedrock was not encountered within depths of the borings performed.

4.1.2. Groundwater at Sta. 127+00

Groundwater measurements were attempted during the boring drilling procedures and immediately following the completion of the borehole. Groundwater was observed during drilling in both borings performed at Sta. 127+00 site. Based on these borings, free groundwater was encountered between depths of 14.0 and 22.0 ft bgs (between elevations 938.0 and 945.2 ft amsl). It should be noted that groundwater is affected by many hydrologic characteristics in the area and may vary from those measured at the time of the exploration. Ordinary High Water Mark (OHWM) at the site is at an elevation of 935.3 ft amsl, which should be used in the analysis.

4.2. Subsurface Conditions at Sta. 166+00

4.2.1. Overburden Soil at Sta. 166+00

The subsurface profile at the site near Sta. 166+00 is generally consistent with the geological model for the project in regards to the materials encountered. The subsurface profile within the proposed project area consists of surficial materials comprised of existing pavement underlain by cohesive embankment fill soil (A-6a) over natural, fine grained, cohesive glacial till. The cohesive glacial till primarily consists of very stiff to hard silty clay (A-6b), very stiff to hard clay (A-7-6), and very stiff to hard sandy silt (A-4a), and stiff silt and clay (A-6a). The intermittent layers of granular soils were encountered in both borings, medium dense sandy silt (A-4a) at elevations between 936.1 ft and 928.6 ft in B-027-1-16 and very dense gravel with sand and silt (A-2-4) at elevations between 921.0 ft and 913.0 ft in B-027-2-16. Bedrock was not encountered within depths of the borings performed.

4.2.1. Groundwater at Sta. 166+00

Groundwater was observed during drilling in both borings performed at Sta. 166+00 site. Based on these borings, free groundwater was encountered between depths of 19.0 and 29.0 ft bgs (between elevations 941.6 and 934.5 ft amsl). It should be noted that groundwater is affected by many hydrologic characteristics in the area and may vary from those measured at the time of the exploration. The wetland elevation at the swamp near the site has a boundary elevation of 951.0 ft amsl, which should be used in the analysis.

5. ANALYSIS AND RECOMMENDATIONS

ODOT's GeoMS database identified two historical landslides to the north of SR-18 near Station 127+00 (BMP: 13.76) and near Station 166+00 (BMP: 14.5). The slope stability analysis for the historical landslide sites on SR-18 Station 127+00 and 166+00 is as part of the Part 2 MED-18-13.54 widening and improvement project in Medina County, Ohio.

Based on the above information in addition to: 1) the soil characteristics gathered during the subsurface exploration (i.e., SPT results, laboratory test results, etc.); 2) the developed generalized soil profile at the landslide locations and other assumptions presented in subsequent sections of this report; and, 3) the landslide site plans provided by GPD Group, geotechnical analyses consisting of global stability, and seismic analysis were performed for the landslide locations.

The geotechnical engineering analyses were performed in accordance with ODOT's SGE (ODOT, 2016) and AASHTO's LRFD BDS (AASHTO, 2014). Based on the results of the analysis, it is our opinion that the subsurface conditions encountered at both locations are generally satisfactory and the sites can be considered to be stable before and after construction.

5.1. Landslide Assumptions

The geometry of the landslide sites on SR-18 Station 127+00 and 166+00 is assumed to be consistent with that shown in the site plans provided by GPD Group. ODOT's SGE and AASHTO's LRFD BDS dictate analysis parameters to be used in the analysis process. Based on planned roadway grades and alignment, AASHTO's LRFD BDS dictates that the slopes shall be evaluated for a live load surcharge of 250 pound per square foot (psf).

5.1.1. Generalized Soil Profile for Analysis

For analysis purposes, each boring log was reviewed and a generalized material profile was developed for analysis. Utilizing the generalized soil profile, engineering properties for each soil strata was estimated based on their field (i.e., SPT N_{60} Values, hand penetrometer values, etc.) and laboratory (i.e., Atterberg Limits, grain size, etc.) test results using correlations provided in published engineering manuals, research reports and guidance documents. Engineering soil properties were estimated for each individual classified layer per boring location. Soil layers from both borings with similar behavior (i.e., cohesive or non-cohesive/granular) and characteristics (i.e., relative compactness/consistency, moisture content, etc.) were grouped into generalized soil units (i.e., Soil Types) and weighted average values of the estimated engineering soil properties were assigned to each Soil Type to develop a generalized soil profile for analysis. The summary of the generalized soil profile including designated Soil Types, elevations, average engineering soil properties per boring location are presented in the following Tables 4-10.

Table 4: Soil Profile and Estimated Engineering Properties at Sta 127+00 (B-014-1-16)

Landslide Analysis near Sta 127+00, B-014-1-16						
Soil Description	Unit Weight[1] (pcf)	Moist Unit Weight[1] (pcf)	Saturated Unit Weight[1] (pcf)	Undrained Shear Strength[2] (psf)	Effective Cohesion[3] (psf)	Effective Friction Angle[3] (degrees)
Silty Clay Depth (959.2 ft - 947.2 ft)	110	110	120	1550	150	23
Silt and Clay Depth (947.2 ft - 942.2 ft)	125	115	125	3400	250	27
Silty Clay Depth (942.2 ft - 937.2 ft)	120	110	120	1600	150	23
Clay Depth (937.2 ft - 935.2 ft)	120	110	120	1500	150	22
Silt and Clay Depth (935.2 ft - 929.7 ft)	122	112	122	1900	200	24
Sandy Silt Depth (929.7 ft - 924.7 ft)	128	118	128	4350	300	30
Silt and Clay Depth (924.7 ft - 919.7 ft)	135	125	135	5550	400	32
Sandy Silt Depth (919.7 ft - 912.2 ft)	135	125	135	5500	400	33
Silt Elevation (912.2 ft - 899.7 ft)	125	115	125	2800	250	27
Silt and Clay Elevation (899.7 ft - 897.7 ft)	135	125	135	5600	400	32

Notes:

1. *Values interpreted from Geotechnical Bulletin 7 Table 1.*
2. *Values calculated from Terzaghi and Peck (1967) if $N1_{60}$<52, else Stroud and Butler (1975) was used.*
3. *Values interpreted from Geotechnical Bulletin 7 Table 2.*

Table 5: Soil Profile and Estimated Engineering Properties at Sta 127+00 (B-015-0-14)

Landslide Analysis near Sta 127+00: , B-015-0-14						
Soil Description	**Unit Weight[1] (pcf)**	**Moist Unit Weight[1] (pcf)**	**Saturated Unit Weight[1] (pcf)**	**Undrained Shear Strength[2] (psf)**	**Effective Cohesion[3] (psf)**	**Effective Friction Angle[3] (degrees)**
Silty Clay Depth (959.6 ft - 950.1 ft)	115	115	125	3150	250	27
Silty Clay Depth (950.1 ft - 947.6 ft)	118	118	128	3500	300	28
Silt and Clay Depth (947.6 ft - 940.3 ft)	125	125	135	6150	400	33
Silty Clay Depth (940.3 ft - 938.6 ft)	110	110	120	1600	150	23
Sandy Silt Depth (938.6 ft - 928.1 ft)	120	110	120	1550	150	24

Notes:

1. *Values interpreted from Geotechnical Bulletin 7 Table 1.*
2. *Values calculated from Terzaghi and Peck (1967) if $N1_{60}$<52, else Stroud and Butler (1975) was used.*
3. *Values interpreted from Geotechnical Bulletin 7 Table 2.*

Table 6: Soil Profile and Estimated Engineering Properties at Sta 127+00 (B-015-1-16)

Landslide Analysis near Sta 127+00, B-015-1-16						
Soil Description	**Unit Weight[1] (pcf)**	**Moist Unit Weight[1] (pcf)**	**Saturated Unit Weight[1] (pcf)**	**Undrained Shear Strength[2] (psf)**	**Effective Cohesion[3] (psf)**	**Effective Friction Angle[3] (degrees)**
No Soil Samples Depth (960 ft - 927.5 ft)	-	-	-	-	-	-
Sandy Silt Depth (927.5 ft - 915.5 ft)	130	120	130	5250	350	32
Silt and Clay Depth (915.5 ft - 908 ft)	128	118	128	3850	300	28
Sandy Silt Depth (908 ft - 898.5 ft)	125	115	125	3450	250	28

Notes:

1. *Values interpreted from Geotechnical Bulletin 7 Table 1.*
2. *Values calculated from Terzaghi and Peck (1967) if $N1_{60}$<52, else Stroud and Butler (1975) was used.*
3. *Values interpreted from Geotechnical Bulletin 7 Table 2.*

Table 7: Soil Profile and Estimated Engineering Properties at Sta 127+00 (B-016-0-14)

Landslide Analysis near Sta 127+00: , B-016-0-14						
Soil Description	**Unit Weight[1] (pcf)**	**Moist Unit Weight[1] (pcf)**	**Saturated Unit Weight[1] (pcf)**	**Undrained Shear Strength[2] (psf)**	**Effective Cohesion[3] (psf)**	**Effective Friction Angle[3] (degrees)**
Silt and Clay Depth (959.2 ft - 956.9 ft)	108	108	118	1100	100	22
Clay Depth (956.9 ft - 952.6 ft)	110	110	120	1550	150	22
Silty Clay Depth (952.6 ft - 948.6 ft)	110	110	120	1500	150	23
Clay Depth (948.6 ft - 944.6 ft)	110	110	120	1250	150	22
Gravel with Sand and Silt Depth (944.6 ft - 940.6 ft)	132	122	132	-	-	40
Silty Clay Depth (940.6 ft - 936.6 ft)	135	125	135	6100	400	33
Silt and Clay Depth (936.6 ft - 932.6 ft)	118	108	118	1100	100	22
Sandy Silt Depth (932.6 ft - 929.9 ft)	125	115	125	3100	250	28

Notes:

1. *Values interpreted from Geotechnical Bulletin 7 Table 1.*
2. *Values calculated from Terzaghi and Peck (1967) if $N1_{60}$<52, else Stroud and Butler (1975) was used.*
3. *Values interpreted from Geotechnical Bulletin 7 Table 2.*

Table 8: Soil Profile and Estimated Engineering Properties at Sta 127+00 (B-016-1-16)

Landslide Analysis near Sta 127+00: , B-016-1-16						
Soil Description	**Unit Weight[1] (pcf)**	**Moist Unit Weight[1] (pcf)**	**Saturated Unit Weight[1] (pcf)**	**Undrained Shear Strength[2] (psf)**	**Effective Cohesion[3] (psf)**	**Effective Friction Angle[3] (degrees)**
No Sampling Depth (959.9 ft - 928.4 ft)	-	-	-	-	-	-
Sandy Silt Depth (928.4 ft - 925.5 ft)	125	115	125	2750	250	27
Silt and Clay Depth (925.5 ft - 909.4 ft)	130	120	130	5050	350	31

Notes:

1. *Values interpreted from Geotechnical Bulletin 7 Table 1.*
2. *Values calculated from Terzaghi and Peck (1967) if $N1_{60}$<52, else Stroud and Butler (1975) was used.*
3. *Values interpreted from Geotechnical Bulletin 7 Table 2.*

Table 9: Soil Profile and Estimated Engineering Properties near Sta 166+00 (B-027-1-16)

Landslide Analysis near Sta. 166+00, B-027-1-16						
Soil Description	Unit Weight[1] (pcf)	Moist Unit Weight[1] (pcf)	Saturated Unit Weight[1] (pcf)	Undrained Shear Strength[2] (psf)	Effective Cohesion[3] (psf)	Effective Friction Angle[3] (degrees)
Silt and Clay Depth (960.6 ft - 956.1 ft)	112	112	122	2250	200	25
Silty Clay Depth (956.1 ft - 946.1 ft)	112	112	122	1950	200	24
Clay Depth (946.1 ft - 943.1 ft)	110	110	120	1250	150	22
Sandy Silt Depth (943.1 ft - 936.1 ft)	120	110	120	1650	150	24
Sandy Silt Depth (936.1 ft - 928.6 ft)	125	115	125	-	-	31
Sandy Silt Depth (928.6 ft - 909.1 ft)	135	125	135	6250	400	34

Notes:
1. *Values interpreted from Geotechnical Bulletin 7 Table 1.*
2. *Values calculated from Terzaghi and Peck (1967) if $N1_{60}$<52, else Stroud and Butler (1975) was used.*
3. *Values interpreted from Geotechnical Bulletin 7 Table 2.*

Table 10: Soil Profile and Estimated Engineering Properties near Sta 166+00 (B-027-2-16)

Landslide Analysis near Sta. 166+00, B-027-2-16						
Soil Description	Unit Weight[1] (pcf)	Moist Unit Weight[1] (pcf)	Saturated Unit Weight[1] (pcf)	Undrained Shear Strength[2] (psf)	Effective Cohesion[3] (psf)	Effective Friction Angle[3] (degrees)
Silt and Clay Depth (963.5 ft - 956.5 ft)	112	112	122	1750	200	24
Silty Clay Depth (956.5 ft - 947 ft)	112	112	122	1800	200	24
Clay Depth (947 ft - 941.5 ft)	110	110	120	1350	150	22
Sandy Silt Depth (941.5 ft - 936.5 ft)	118	118	128	4100	300	30
Sandy Silt Depth (936.5 ft - 928.5 ft)	125	115	125	-	-	32
Silty Clay Depth (928.5 ft - 926.5 ft)	122	112	122	2250	200	25
Sandy Silt Depth (926.5 ft - 921 ft)	135	125	135	6250	400	34
Gravel with Sand and Silt Depth (921 ft - 913 ft)	140	130	140	-	-	41
Silt and Clay Elevation (913 ft - 912 ft)	128	118	128	4250	300	29

Notes:
1. *Values interpreted from Geotechnical Bulletin 7 Table 1.*
2. *Values calculated from Terzaghi and Peck (1967) if $N1_{60}$<52, else Stroud and Butler (1975) was used.*
3. *Values interpreted from Geotechnical Bulletin 7 Table 2.*

5.2. Global Stability

For purposes of evaluating the stability of the landslides site on SR-18 Station 127+00 and 166+00, NEAS reviewed cross-sections within the project limits that were interpreted to represent conditions that posed the greatest potential for slope instability. In general, cross-sections along the SR-18 alignment were reviewed to determine if the section would represent a combination of existing subsurface conditions and planned site grading that would be most critical to slope stability (i.e., maximum embankment height measured from toe of slope to the top, proposed cut into existing embankment slopes, weak or thick soil layer, etc.). Based on our review of the available information at the referenced locations and the associated soil properties, two cross-sections, Station 127+00 and Station 166+00 in reference to SR-18 were estimated to be most "critical" at the corresponding location and were analyzed for global stability.

NEAS developed several representative cross-sectional models to use as the basis for global stability analyses for these historical landslide locations. The models were developed from NEAS's interpretation of the available information which included: 1) The site plans provided by GPD Group; 2) a live load surcharge of 250 psf, accounting for traffic induced loads; and, 3) test borings and laboratory data developed as part of this report. With respect to the soils' engineering properties, the provided Soil Profile and Estimated Engineering Properties presented in Section 5.1.1. of this report were used in our analyses.

The above referenced slope stability models were analyzed for short-term (Total Stress), long-term (Effective Stress) and flood (Effective Stress) slope stability utilizing the software entitled *Slide 7.0* by Rock Science, Inc. The FOS is the ratio of the resisting forces and the driving forces, with the desired safety factor being more than about 1.33 which equates to an AASHTO resistance factor less than 0.75 (per AASHTO's LRFD BDS the specified resistance factors are essentially the inverse of the FOS that should be targeted in slope stability programs). For this analysis, a resistance factor of 0.75 or lower is targeted as the slope does not contain or support a structural element.

5.2.1. Global Stability Analysis at Sta 127+00

Based on our slope stability analysis for the Station 127+00 section, the minimum slope stability safety factor is about 1.33 (0.75 resistance factor), which equals the desired value of 1.33. The results of the analyses are summarized in Table 11. Based on the results of the analyses, it is our opinion that the subsurface conditions encountered at this location are generally satisfactory and the site can be considered to be stable at existing condition and post construction condition. The graphical output of the slope stability program (cross-sectional model, calculated safety factor, and critical failure plane) is presented in Appendix C.

Table 11: Global Stability Analysis Summary at Sta 127+00

Global Stability Analsysis at Sta 127+00					
Condition	**Boring No.**	**Description**	**Minimum Factor of Safety**	**Equivalent Resistance Factor**	**Status (OK/NG)**
Existing	B-014-1-16	Short Term	3.94	0.25	OK
		Long Term	1.33	0.75	OK
Post Construction	B-014-1-16	Short Term	4.03	0.25	OK
		Long Term	1.56	0.64	OK
Existing	B-015-0-16 & B-015-1-16	Short Term	4.78	0.21	OK
		Long Term	1.58	0.63	OK
Post Construction	B-015-0-14 & B-015-1-16	Short Term	4.95	0.20	OK
		Long Term	1.65	0.61	OK

5.2.1. Global Stability Analysis at Sta 166+00

Based on our slope stability analysis for the Station 166+00 section, the minimum slope stability safety factor is about 1.69 (0.59 resistance factor), which exceeds the desired value of 1.33. Embankment configuration at this location will stay the same after proposed construction. However, traffic will be shifted away from the slope. Therefore, slope stability safety factor of the slope after construction can be expected to be slightly higher than the results of the existing slopes. The results of the analyses are summarized in Table 12. Based on the results of the analyses, it is our opinion that the subsurface conditions encountered at this location are generally satisfactory and the site can be considered to be stable at existing condition and post construction condition. The graphical output of the slope stability

program (cross-sectional model, calculated safety factor, and critical failure plane) is presented in Appendix D.

Table 12: Global Stability Analysis Summary at Sta 166+00

Global Stability Analsysis at Sta 166+00					
Condition	**Boring No.**	**Description**	**Minimum Factor of Safety**	**Equivalent Resistance Factor**	**Status (OK/NG)**
Existing / Post Construction	B-027-1-16	Short Term	4.83	0.21	OK
		Long Term	1.74	0.58	OK
Existing / Post Construction	B-027-2-16	Short Term	5.65	0.18	OK
		Long Term	1.71	0.59	OK

5.3. Seismic Design Parameters

ODOT has indicated that the whole state lies within Seismic Zone 1. Based on the results of the subsurface exploration, the laboratory test data, and our review of the AASHTO Site Class Definition from Table 3.10.3.1-1 of the AASHTO LRFD Bridge Design Specifications, NEAS recommends a project site classification of D – stiff soil. Typically, SPT N-values within the upper 90 ft of the profile are between 15 bpf and 60 bpf. Seismic design parameters for the site were developed using USGS Seismic Design Maps per AASHTO Guide Specifications for LRFD Seismic Bridge Design. Seismic design parameters for Station 127+00 and Station 166+00 are the same and are presented in Table 13 below. The detailed reports are presented in Appendix C. These values were interpreted for use in our slope stability analysis where seismic forces are considered.

Table 13: AASHTO Spectrum for 7% PE in 75 Years

Variable	Symbol (AASHTO 3.10)	Value
Latitude		41.137912
Longitude		-81.826561
Site Class		D
Peak Ground Acceleration	PGA	0.042g
Short Period Acceleration	S_s	0.090g
Long Period Acceleration	S_1	0.032g
Site Factor (zero period)	F_{PGA}	1.6
Site Factor (short period)	F_a	1.6
Site Factor (long period)	F_v	2.4
Zero period response seismic coefficient	$A_s = F_{PGA} * PGA$	0.067g
Short period response seismic coefficient (0.2 seconds)	$S_{DS} = F_a * S_s$	0.144g
Long period response seismic coefficient (1.0 second)	$S_{D1} = F_v * S_1$	0.077g

5.4. Recommendations

These recommendations are based on a review of existing data, field and laboratory testing results, and engineering analysis and judgment. The landslide plans including its location and geometry were part of a conceptual design for the overall road improvement by GPD Group. If any element of the project evolves

to be significantly different than is described therein, these recommendations should be reviewed by a geotechnical engineer to assess their continuing validity before they are incorporated into the utilization.

Geotechnical elements of the project should be evaluated in general accordance with the provisions of ODOT SGE and, as appropriate, AASHTO Bridge Design Specifications, Seventh Edition with current Interims, (LRFD BDS) using the Load and Resistance Factor (LRFD) method of design. Materials should be as specified in ODOT Construction and Materials Specifications (CMS) - 2016.

- Slope stability should be evaluated using the soil description and properties provided in Tables 4-10.
- The change of groundwater level should be considered which could greatly decrease the stability of the slope.
- Soils in the base of all excavations should be observed for suitability by a geotechnical engineer or soil technician working under the direct supervision of a geotechnical engineer.

6. QUALIFICATIONS

This investigation was performed in accordance with accepted geotechnical engineering practice for the purpose of characterizing the subsurface conditions at the site of Station 127+00 and Station 166+00 for the MED-18-13.54 project. This report has been prepared for GPD Group, ODOT and their design consultants to be used solely in evaluating the soils underlying the referred site and presenting geotechnical engineering recommendations specific to this project. The assessment of general site environmental conditions or the presence of pollutants in the soil, rock and groundwater of the site was beyond the scope of this geotechnical exploration. Our recommendations are based on the results of our field explorations, laboratory tests results from representative soil samples, and geotechnical engineering analyses. The results of the field explorations and laboratory tests, which form the basis of our recommendations, are presented in the appendices as noted. This report does not reflect any variations that may occur between the borings or elsewhere on the site, or variations whose nature and extent may not become evident until a later stage of construction. In the event that any changes in the nature, geometry of the referred site is made, the conclusions and recommendations contained in this report should not be considered valid until they are reviewed, and have been modified or verified in writing by a geotechnical engineer.

It has been a pleasure to be of service to GPD Group in performing this geotechnical exploration for the MED-18-13.54 project. Please call if there are any questions, or if we can be of further service.

Respectfully Submitted,

Jawdat Siddiqi, P.E.
President

Chunmei He, Ph.D., P.E.
Geotechnical Engineer

REFERENCES

AASHTO. (2014). *Standard Specifications for Highway Bridges, 17th Edition.* Washington, D.C.: American Association of State Highway and Transporation Officials.

FEMA. (2016). *National Flood Hazard Layer kmz v3.0.* Federal Emergency Management Agency.

ODGS. (1998). Physiographic regions of Ohio: Ohio Department of Natural Resources, Division of Geological Survey. page-size map with text, 2p., scale 1:2,100,00.

ODGS. (2003). Bedrock-topography data for Ohio: Ohio Department of Natural Resources, Division of Geological Survey Map BG-3, 1 CD-ROM, GIS file formats. Revised January 9, 2004.

ODNR [1]. (2016). Ohio Abandoned Mine Locator Interactive Map. *Mines of Ohio*. Ohio Department of Natural Resources, Division of Geological Survey & Division of Mineral Resources. Retrieved from https://gis.ohiodnr.gov/MapViewer/?config= OhioMines

ODNR [2]. (2016). Ohio Oil & Gas Locator Interactive Map. *Ohio Oil & Gas Wells*. Ohio Department of Natural Resources, Division of Oil and Gas. Retrieved from https://gis.ohiodnr.gov/MapViewer/?config= oilgaswells

ODOT. (2007). *2007 Bridge Design Manual*. Columbus, OH: Ohio Department of Transportation: Office of Structural Engineering. Retrieved from http://www.dot.state.oh.us/Divisions/Engineering/Structures/standard/Bridges/Pages/BDM2004.aspx

ODOT. (2015). *Specifications for Geotechnical Explorations.* Ohio Department of Transportation: Office of Geotechnical Engineering.

ODOT. (2016). *FALCON Geotechnical Document Management System (GDMS).* Ohio Department of Transportation: Office of Geotechnical Engineering. Retrieved from http://falcon.odotgeoms.org/FalconWebV3/default.aspx

Pavey, R. R., Goldthwait, R. P., Brockman, C. S., Hull, D. N., Swinford, E. M., & Van Horn, R. G. (1999). Quarternary geology of Ohio: Ohio Department of Natural Resources, Division of Geological Survey Map M-2. 1:500,000-scale map and 1:250,000-scale GIS files.

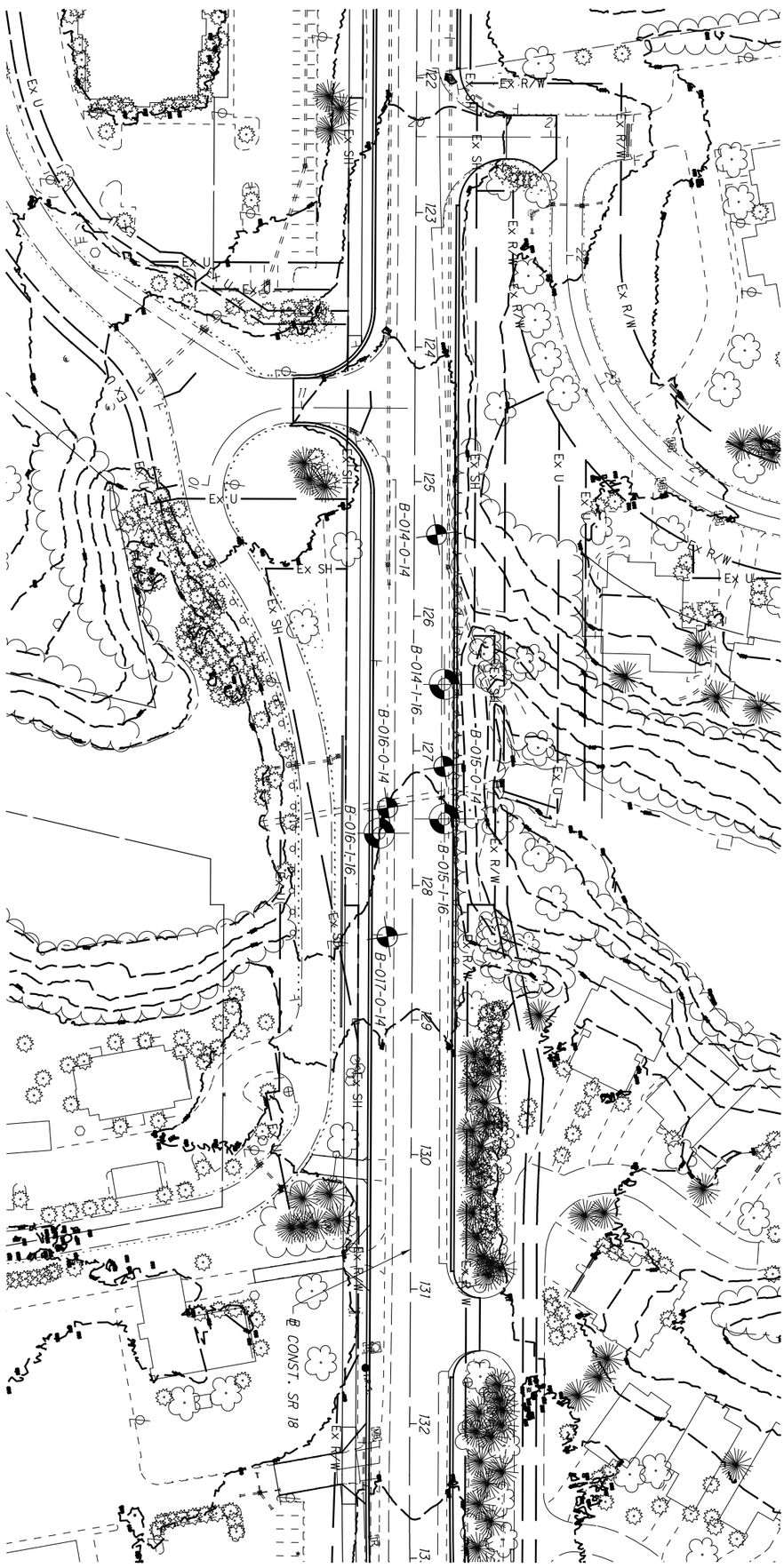
USDA. (2015, September). Web Soil Survey. Retrieved from http://websoilsurvey.nrcs.usda.gov

USGS & ODGS. (2005, June). Geologic Units of Ohio. *ohgeol.kmz*. United States Geologic Survey.

APPENDIX A

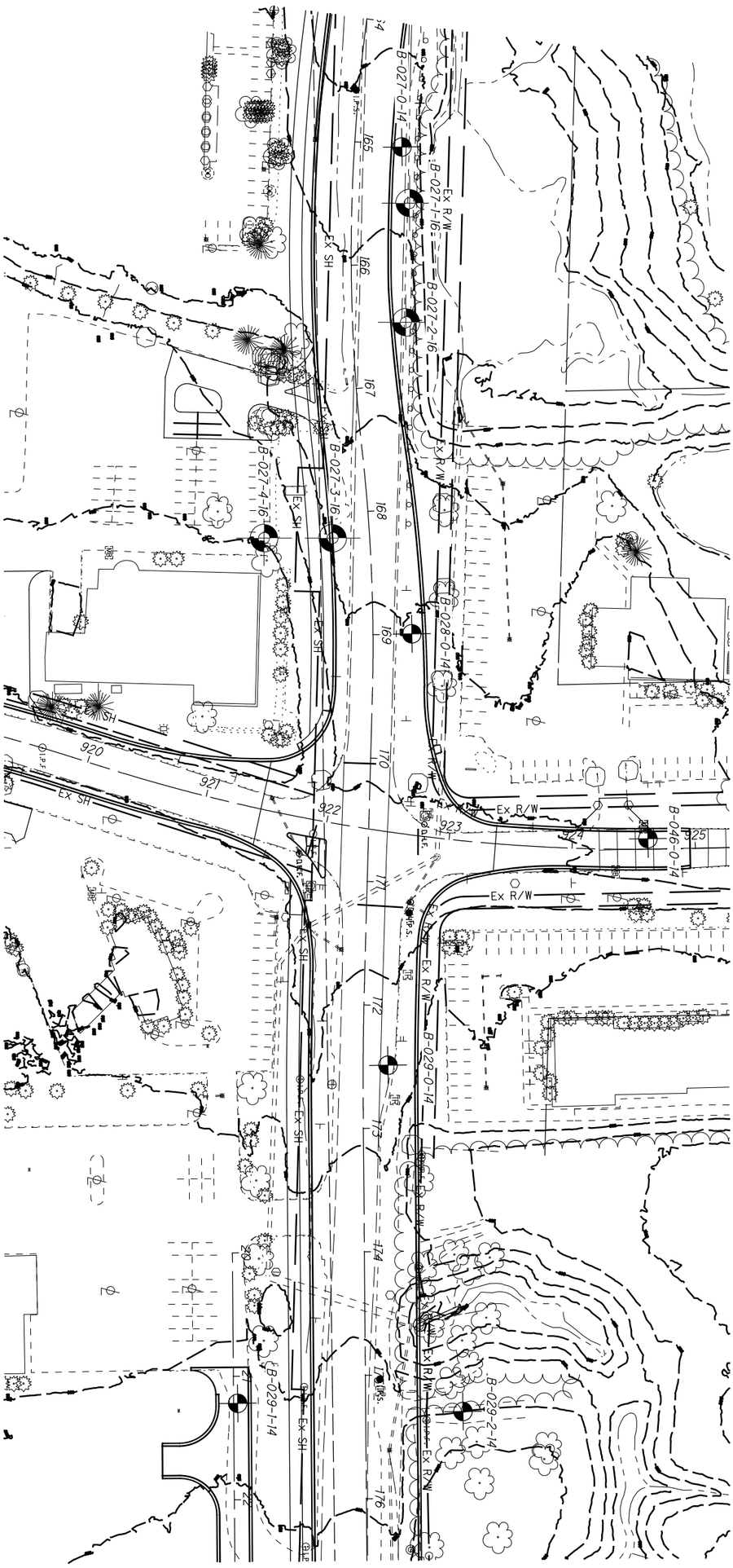
SOIL BORING LOCATION PLAN

2016 PROJECT BORING



	2/5	MED-18-12.99	LANDSLIDE & CULVERT #3 STA. 121+50 TO STA. 133+00 SR 18	DRAWN AJT CHECKED CH	0 25 10 50 HORIZONTAL SCALE IN FEET

2016 PROJECT BORING



	4/5	MED-18-12.99	LANDSLIDE & GOOD WILL STABILITY STA. 164+00 TO STA. 176+50 SR 18	DRAWN AJT CHECKED CH	0 25 10 50 HORIZONTAL SCALE IN FEET

APPENDIX B

SOIL BORING LOGS

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 3/8/17 14:57 - \\COLUMBUSLAB\LAB\ACTIVE PROJECTS\ACTIVE SOIL PROJECTS\1ARCHIVE BY YEAR\2016 ARCHIVE\MED-18-13.5

PROJECT: MED-18-13.54	DRILLING FIRM / OPERATOR: BEI / ASHBAUGH	DRILL RIG: CME 55	STATION / OFFSET: 126+68, 27' LT.	EXPLORATION ID B-014-1-16
TYPE: LANDSLIDE	SAMPLING FIRM / LOGGER: BEI / K.BAME	HAMMER: CME AUTOMATIC	ALIGNMENT: PR S.R. 18	
PID: 92953 SFN:	DRILLING METHOD: 3.25" HSA	CALIBRATION DATE: 12/3/15	ELEVATION: 959.2 (MSL) EOB: 61.5 ft.	PAGE 1 OF 2
START: 9/20/16 END: 9/21/16	SAMPLING METHOD: SPT	ENERGY RATIO (%): 81.8	LAT / LONG: 41.137761, -81.827385	

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
6.0", **ASPHALT**	959.2																	
8.0", **BRICK**	958.7																	
10.0", **GRANULAR BASE**	958.0																	
VERY STIFF TO HARD, BROWN MOTTLED WITH GRAY BECOMING GRAYISH BROWN, **SILTY CLAY**, LITTLE SAND, TRACE GRAVEL, DAMP TO MOIST	957.2		3 3 4	10	72	SS-1	2.5 - 3.75	8	9	10	28	45	39	18	21	19	A-6b (12)	
			4 4 5	12	50	SS-2	3.0 - 3.5	-	-	-	-	-	-	-	-	19	A-6b (V)	
			4 3 7	14	83	SS-3	4.5+	-	-	-	-	-	-	-	-	15	A-6b (V)	
@10.0'; SS-4 CONTAINS FEW ROOTS AND DECAYED ORGANICS			3 5 6	15	61	SS-4	4.0- 4.5+	-	-	-	-	-	-	-	-	17	A-6b (V)	
	947.2																	
MEDIUM STIFF TO VERY STIFF, BROWN MOTTLED WITH GRAY, **SILT AND CLAY**, LITTLE SAND, TRACE GRAVEL, DAMP TO MOIST		W	3 4 7	15	78	SS-5	3.9 - 4.0	4	6	11	37	42	33	19	14	17	A-6a (10)	
@15.0'; SS-6 BECOMES GRAYISH BROWN			5 20 9	40	33	SS-6	0.5 - 2.75	-	-	-	-	-	-	-	-	23	A-6a (V)	
	942.2																	
STIFF TO VERY STIFF, GRAYISH BROWN MOTTLED WITH GRAY, **SILTY CLAY**, LITTLE SAND, TRACE GRAVEL, MOIST			4 4 7	15	56	SS-7	1.5 - 2.3	5	7	9	31	48	40	20	20	23	A-6b (12)	
			4 4 4	11	17	SS-8	1.50	-	-	-	-	-	-	-	-	28	A-6b (V)	
	937.2																	
VERY STIFF, GRAYISH BROWN MOTTLED WITH BROWN, **CLAY**, "AND" SILT, TRACE SAND, TRACE GRAVEL, CONTAINS FEW ROOT HAIRS AND HAS SLIGHT ORGANIC ODOR, MOIST	935.2		3 4 5	12	83	SS-9	2.25	1	1	4	48	46	47	27	20	33	A-7-6 (13)	
STIFF TO VERY STIFF, GRAYISH BROWN MOTTLED WITH BROWN AND ORANGISH BROWN, **SILT AND CLAY**, TRACE SAND, TRACE GRAVEL, DAMP TO MOIST @25.0'; SS-10 CONTAINS IRON STAINS			3 5 7	16	100	SS-10	1.75 - 2.5	-	-	-	-	-	-	-	-	25	A-6a (V)	
@27.0'; SS-11 BECOMES BROWN MOTTLED WITH GRAY			2 4 7	15	94	SS-11	1.75 - 2.0	3	3	4	43	47	34	21	13	25	A-6a (9)	
	929.7																	

PID: 92953	SFN:	PROJECT: MED-18-13.54	STATION / OFFSET: 126+68, 27' LT.	START: 9/20/16	END: 9/21/16	PG 2 OF 2	B-014-1-16

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
VERY STIFF TO HARD, BROWNISH GRAY, **SANDY SILT**, SOME CLAY, LITTLE GRAVEL, DAMP *(continued)*	929.2	31			92	ST-12	2.5 - 4.5+	11	9	14	38	28	23	15	8	13	A-4a (6)	
	924.7	32																
HARD, BROWNISH GRAY, **SILT AND CLAY**, LITTLE SAND, TRACE GRAVEL, DAMP		33	7 12 14	35	100	SS-13	4.5+	-	-	-	-	-	-	-	-	12	A-6a (V)	
		34																
		35	7 13 19	44	100	SS-14	4.5+	5	7	13	41	34	26	15	11	12	A-6a (8)	
		36																
		37																
		38	8 15 18	45	94	SS-15	4.5+	-	-	-	-	-	-	-	-	13	A-6a (V)	
	919.7	39																
HARD, GRAYISH BROWN, **SANDY SILT**, "AND" CLAY, TRACE GRAVEL, DAMP		40																
		41	10 19 24	59	100	SS-16	4.5+	3	5	14	40	38	28	18	10	15	A-4a (8)	
		42																
		43	7 15 18	45	100	SS-17	4.5+	-	-	-	-	-	-	-	-	16	A-4a (V)	
		44																
		45																
		46	7 9 12	29	100	SS-18	4.5+	-	-	-	-	-	-	-	-	16	A-4a (V)	
	912.2	47																
MEDIUM STIFF TO HARD, GRAYISH BROWN, **SILT**, SOME TO "AND" CLAY, TRACE SAND, TRACE GRAVEL, MOIST TO WET		48	4 8 10	25	100	SS-19	3.3 - 4.2	1	1	1	50	47	31	21	10	24	A-4b (8)	
		49																
		50																
		51	8 6 8	19	100	SS-20	2.0 - 2.2	-	-	-	-	-	-	-	-	23	A-4b (V)	
		52																
		53	3 3 3	8	100	SS-21	1.6 - 2.25	0	1	3	61	35	27	20	7	26	A-4b (8)	
		54																
		55																
@55.0'; ST-22 NO RECOVERY		56			0	ST-22	-	-	-	-	-	-	-	-	-	-		
		57																
		58	5 10 18	38	100	SS-23	0.5 - 1.5	-	-	-	-	-	-	-	-	27	A-4b (V)	
	899.7	59																
HARD, GRAYISH BROWN, **SILT AND CLAY**, SOME SAND, TRACE GRAVEL, DAMP		60																
	897.7	61	9 14 19	45	100	SS-24	4.5+	-	-	-	-	-	-	-	-	14	A-6a (V)	
		EOB																

NOTES: GROUNDWATER ENCOUNTERED AT 14.0' DURING DRILLING. HOLE DID NOT CAVE.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PLACED 0.5 BAG ASPHALT PATCH; PUMPED 90 GAL. BENTONITE GROUT

PROJECT: MED-18-12.99	DRILLING FIRM / OPERATOR: BARR / ASHBAUGH	DRILL RIG: CME 45B	STATION / OFFSET: 127+12, 23 LT	EXPLORATION ID B-015-0-14
TYPE: RETAINING WALL	SAMPLING FIRM / LOGGER: BARR / ASHBAUGH	HAMMER: CME AUTOMATIC	ALIGNMENT: SR-18	
PID: 92953 BR ID:	DRILLING METHOD: 3.25" HSA	CALIBRATION DATE: 1/26/14	ELEVATION: 959.6 (MSL), EOB: 31.5 ft.	PAGE 1 OF 2
START: 7/8/15 END: 7/8/15	SAMPLING METHOD: SPT	ENERGY RATIO (%): 77.4	COORD: 41.137745, -81.827227	

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GR	CS	FS	SI	CL	LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
6", **ASPHALT**	959.1																	
6", **BRICK**	958.6																	
SOFT TO VERY STIFF, BROWN CHANGING TO BROWN AND GRAY, **SILTY CLAY**, LITTLE SAND, TRACE GRAVEL, MOIST **(FILL)**		1	4 7 9	21	44	SS-1	1.7 - 2.1	-	-	-	-	-	-	-	-	21	A-6b (V)	
		2																
		3	3 4 4	10	6	SS-2	0.4 - 0.5	-	-	-	-	-	-	-	-	24	A-6b (V)	
		4																
		5	4 6 7	17	39	SS-3	1.2 - 1.5	-	-	-	-	-	-	-	-	24	A-6b (V)	
		6																
		7																
@7.5'; CHANGES TO VERY STIFF TO HARD		8	8 16 25	53	56	SS-4	2.0 - 4.5+	7	8	11	32	42	38	19	19	18	A-6b (11)	
	950.1	9																
VERY STIFF TO HARD, BROWN, **SILTY CLAY**, LITTLE SAND, TRACE GRAVEL, DAMP		10	7 10 12	28	67	SS-5	2.0 - 4.5+	-	-	-	-	-	-	-	-	18	A-6b (V)	
	947.6	11																
STIFF TO HARD, SILT AND CLAY, **LITTLE SAND, TRACE GRAVEL**, DAMP		12																
		13	4 8 29	48	72	SS-6	2.0 - 4.5+	5	6	12	34	43	33	18	15	18	A-6a (10)	
		14																
		15																
		16	5 18 50/5"	-	88	SS-7	1.7 - 4.5+	-	-	-	-	-	-	-	-	16	A-6a (V)	
@16.4'; ENCOUNTERED COBBLE		17																
		18	36 50	-	83	SS-8	4.5+	-	-	-	-	-	-	-	-	17	A-6a (V)	
	940.3	19																
STIFF, BROWN MOTTLED WITH GRAY, **SILTY CLAY**, SOME SAND, LITTLE GRAVEL, MOIST		20																
	938.6	21	3 5 5	13	100	SS-9	1.2 - 1.6	16	10	12	29	33	36	19	17	20	A-6b (8)	
		22																
@22.5'; SS-10 NO RECOVERY		23 W	5 3 4	9	0	SS-10	-	-	-	-	-	-	-	-	-	-		
		24																
		25																
VERY SOFT TO MEDIUM STIFF, BROWN MOTTLED WITH GRAY, **SANDY SILT**, SOME CLAY, TRACE GRAVEL, MOIST		26	4 3 3	8	22	SS-11	0.5 - 0.8	-	-	-	-	-	-	-	-	29	A-4a (V)	
		27																
		28	WOH 3 3	8	100	SS-12	0.2 - 0.6	6	8	12	46	28	26	16	10	18	A-4a (8)	
		29																

NOTES: GROUNDWATER ENCOUNTERED AT 23.5' DURING DRILLING. CAVE DEPTH 26.0'.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PLACED .5 BAG ASPHALT PATCH; SOIL MIXED WITH BENTONITE PELLETS

PID: 92953	BR ID:	PROJECT: MED-18-12.99	STATION / OFFSET: 127+11.51, 23.0 LT	START: 7/8/15	END: 7/8/15	PG 2 OF 2	B-015-0-14

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GR	CS	FS	SI	CL	LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
@30.0'; SS-13 NO RECOVERY	929.6																	
	928.1	31 EOB	7 9 10	25	0	SS-13	-	-	-	-	-	-	-	-	-	-		

NOTES: GROUNDWATER ENCOUNTERED AT 23.5' DURING DRILLING. CAVE DEPTH 26.0'.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PLACED .5 BAG ASPHALT PATCH; SOIL MIXED WITH BENTONITE PELLETS

PROJECT: MED-18-13.54	DRILLING FIRM / OPERATOR: BEI / ASHBAUGH	DRILL RIG: CME 55	STATION / OFFSET: 127+62, 22' LT.	EXPLORATION ID B-015-1-16
TYPE: LANDSLIDE	SAMPLING FIRM / LOGGER: BEI / K.BAME	HAMMER: CME AUTOMATIC	ALIGNMENT: PR S.R. 18	
PID: 92953 SFN:	DRILLING METHOD: 3.25" HSA	CALIBRATION DATE: 12/3/15	ELEVATION: 960.0 (MSL) EOB: 61.5 ft.	PAGE 1 OF 2
START: 9/20/16 END: 9/20/16	SAMPLING METHOD: SPT	ENERGY RATIO (%): 81.8	LAT / LONG: 41.137721, -81.827046	

MATERIAL DESCRIPTION AND NOTES	ELEV. 960.0	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
AUGERED DOWN (NO SAMPLING)		1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 W 22 23 24 25 26 27 28 29																

PID: 92953	SFN:	PROJECT: MED-18-13.54	STATION / OFFSET: 127+62, 22' LT.	START: 9/20/16	END: 9/20/16	PG 2 OF 2	B-015-1-16

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
AUGERED DOWN *(continued)*	930.0	31																
	927.5	32																
VERY STIFF TO HARD, GRAYISH BROWN, **SANDY SILT**, SOME CLAY, TRACE GRAVEL, DAMP		33	4 6 9	20	89	SS-1	2.25 - 3.25	6	9	13	41	31	24	16	8	14	A-4a (7)	
		34																
		35																
		36	6 12 17	40	100	SS-2	4.5+	-	-	-	-	-	-	-	-	13	A-4a (V)	
		37																
		38	6 13 20	45	100	SS-3	4.5+	-	-	-	-	-	-	-	-	12	A-4a (V)	
		39																
		40																
		41	7 19 22	56	89	SS-4	4.0 - 4.5+	-	-	-	-	-	-	-	-	21	A-4a (V)	
		42																
		43	8 15 21	49	94	SS-5	4.5+	-	-	-	-	-	-	-	-	14	A-4a (V)	
	915.5	44																
STIFF TO HARD, GRAYISH BROWN, **SILT AND CLAY**, LITTLE SAND, TRACE GRAVEL, DAMP		45																
		46	8 11 16	37	100	SS-6	2.5 - 4.25	4	6	12	36	42	27	16	11	15	A-6a (8)	
		47																
		48	7 8 12	27	100	SS-7	2.0 - 4.0	-	-	-	-	-	-	-	-	19	A-6a (V)	
		49																
@50.0'; SS-8 BECOMES BROWN, TRACE SAND (INTERBEDDED SILT AND CLAY), MOIST		50																
		51	8 10 11	29	100	SS-8	1.75 - 2.25	-	-	-	-	-	-	-	-	27	A-6a (V)	
	908.0	52																
MEDIUM STIFF TO HARD, GRAYISH BROWN, **SANDY SILT**, "AND" TO LITTLE CLAY, MOIST		53	4 4 6	14	100	SS-9	0.5 - 1.0	0	0	1	44	55	31	21	10	27	A-4a (8)	
		54																
		55																
@55.0'; SS-10 TO SS-12 BECOME TRACE GRAVEL, DAMP		56	7 9 10	26	100	SS-10	1.25 - 2.0	-	-	-	-	-	-	-	-	20	A-4a (V)	
		57																
		58	2 3 7	14	89	SS-11	4.0 - 4.25	-	-	-	-	-	-	-	-	14	A-4a (V)	
		59																
@60.0'; SS-12 CONTAINS IRON STAINS		60																
	898.5	61 EOB	13 17 25	57	100	SS-12	4.5+	10	14	18	38	20	20	15	5	11	A-4a (5)	

NOTES: GROUNDWATER ENCOUNTERED AT 22.0' DURING DRILLING. HOLE DID NOT CAVE.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PUMPED 90 GAL. BENTONITE GROUT

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 11/17/15 11:02 - \\COLUMBUSLABLABACTIVE PROJECTS\ACTIVE SOIL PROJECTS\MED-18-13.54 (ODOT)\GINT FILES\MED-18-13.

PROJECT: MED-18-12.99	DRILLING FIRM / OPERATOR: BARR / J.HODGES	DRILL RIG: CME 45B	STATION / OFFSET: 127+42, 19 RT	EXPLORATION ID B-016-0-14
TYPE: RETAINING WALL	SAMPLING FIRM / LOGGER: BARR / C.PATRICK	HAMMER: CME AUTOMATIC	ALIGNMENT: SR-18	
PID: 92953 BR ID:	DRILLING METHOD: 3.25" HSA	CALIBRATION DATE: 1/26/14	ELEVATION: 959.9 (MSL), EOB: 30.0 ft.	PAGE 1 OF 1
START: 7/2/15 END: 7/2/15	SAMPLING METHOD: SPT	ENERGY RATIO (%): 77.4	COORD: 41.137619, -81.827141	

MATERIAL DESCRIPTION AND NOTES	ELEV. 959.9	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GR	CS	FS	SI	CL	LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
3", **ASPHALT**	959.7																	
2", **GRANULAR BASE**	959.5																	
HARD, BROWN WITH GRAY, **SILT AND CLAY**, LITTLE SAND, TRACE GRAVEL, DAMP **(FILL)**	956.9		3 3 4	9	56	SS-1	4.5+	-	-	-	-	-	-	-	-	18	A-6a (V)	
VERY STIFF TO HARD, BROWN WITH GRAY, **CLAY**, SOME SILT, LITTLE SAND, TRACE GRAVEL, CONTAINS FEW ROOT HAIRS, MOIST **(FILL)** @4.5'; SS-3 CONTAINS FIELD TILL FRAGMENTS	952.6		3 4 5	12	100	SS-2	2.75 - 3.0	1	3	9	28	59	47	20	27	21	A-7-6 (16)	
			3 4 6	13	100	SS-3	2.5 - 4.5+	-	-	-	-	-	-	-	-	21	A-7-6 (V)	
VERY STIFF, BROWN WITH GRAY, **SILTY CLAY**, LITTLE SAND, TRACE GRAVEL, DAMP **(POSSIBLE FILL)**	948.6		4 4 5	12	100	SS-4	2.6 - 4.0	-	-	-	-	-	-	-	-	17	A-6b (V)	
STIFF TO VERY STIFF, GRAYISH BROWN MOTTLED W/ GRAY BROWN AND DARK GRAY, **CLAY**, "AND" SILT, LITTLE SAND, CONTAINS FEW FINE ROOTS, MOIST	944.6	W	3 3 5	10	100	SS-5	1.4 - 3.2	0	4	9	36	51	49	21	28	24	A-7-6 (17)	
DENSE, GRAYISH BROWN, **GRAVEL WITH SAND AND SILT**, LITTLE CLAY, MOIST	940.6		7 23 13	46	78	SS-6	-	-	-	-	-	-	-	-	-	24	A-2-4 (V)	
STIFF, BROWN MOTTLED WITH GRAYISH BROWN, **SILTY CLAY**, LITTLE SAND,TRACE GRAVEL, MOIST	936.6		6 11 27	49	78	SS-7	1.4 - 1.7	-	-	-	-	-	-	-	-	23	A-6b (V)	
STIFF TO VERY STIFF, OLIVE GRAY MOTTLED WITH GRAY, **SILT AND CLAY**, LITTLE SAND, TRACE GRAVEL, MOIST	932.6		3 3 4	9	100	SS-8	1.25 - 4.0	-	-	-	-	-	-	-	-	22	A-6a (V)	
VERY STIFF, GRAY, **SANDY SILT**, LITTLE CLAY, TRACE GRAVEL, DAMP	929.9	EOB	4 8 11	25	100	SS-9	2.75 - 3.25	8	15	16	42	19	22	16	6	13	A-4a (5)	

NOTES: GROUNDWATER ENCOUNTERED AT 15.0' DURING DRILLING. CAVE DEPTH 20.0'.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PLACED .5 BAG ASPHALT PATCH; SHOVELED SOIL CUTTINGS

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 3/8/17 14:57 - \\COLUMBUSLAB\LAB\ACTIVE PROJECTS\ACTIVE SOIL PROJECTS\1ARCHIVE BY YEAR\2016 ARCHIVE\MED-18-13.5

PROJECT: MED-18-13.54	DRILLING FIRM / OPERATOR: BEI / ASHBAUGH	DRILL RIG: CME 55	STATION / OFFSET: 127+78, 18' RT.	EXPLORATION ID B-016-1-16
TYPE: CULVERT	SAMPLING FIRM / LOGGER: BEI / K.BAME	HAMMER: CME AUTOMATIC	ALIGNMENT: PR S.R. 18	
PID: 92953 SFN:	DRILLING METHOD: 3.25" HSA	CALIBRATION DATE: 12/3/15	ELEVATION: 960.9 (MSL) EOB: 51.5 ft.	PAGE 1 OF 2
START: 9/22/16 END: 9/22/16	SAMPLING METHOD: SPT	ENERGY RATIO (%): 81.8	LAT / LONG: 41.137607, -81.827014	

MATERIAL DESCRIPTION AND NOTES	ELEV. 960.9	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
AUGERED DOWN (No sampling)		1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29																

PID: 92953	SFN:	PROJECT: MED-18-13.54	STATION / OFFSET: 127+78, 18' RT.	START: 9/22/16	END: 9/22/16	PG 2 OF 2	B-016-1-16

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
AUGERED DOWN *(continued)*	930.9	31 32																
	928.4																	
VERY STIFF, GRAY TO BROWN, **SANDY SILT**, SOME CLAY, TRACE GRAVEL, DAMP		33 34	5 6 10	22	83	SS-1	3.75 - 4.0	5	7	12	45	31	26	17	9	15	A-4a (8)	
	925.5	35 36	5 10 17	37	100	SS-2	4.5+	-	-	-	-	-	-	-	-	13	A-6a (V)	
VERY STIFF TO HARD, GRAY, **SILT AND CLAY**, SOME SAND, TRACE GRAVEL, CONTAINS SILT LENSES, DAMP		37 38 39	8 15 24	53	100	SS-3	4.5+	10	10	11	37	32	26	15	11	11	A-6a (7)	
		40 41 42	8 13 20	45	100	SS-4	4.5+	-	-	-	-	-	-	-	-	12	A-6a (V)	
		43 44	7 16 21	50	100	SS-5	4.5+	-	-	-	-	-	-	-	-	13	A-6a (V)	
		45 46 47	7 12 19	42	100	SS-6	4.5+	-	-	-	-	-	-	-	-	15	A-6a (V)	
@47.5'; SS-7 AND SS-8 BECOME LITTLE SAND		48 49	6 8 12	27	89	SS-7	3.0 - 4.5+	3	4	9	37	47	31	18	13	18	A-6a (9)	
@50.0'; SS-8 BECOMES BROWN, (INTERBEDDED SILT AND CLAY), MOIST	909.4	50 51 EOB	6 9 13	30	100	SS-8	2.75 - 3.75	-	-	-	-	-	-	-	-	25	A-6a (V)	

NOTES: GROUNDWATER NOT ENCOUNTERED DURING DRILLING. HOLE DID NOT CAVE.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PLACED 0.5 BAG ASPHALT PATCH; PUMPED 76 GAL. BENTONITE GROUT

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 11/17/15 10:53 - \\COLUMBUSLAB\LABACTIVE PROJECTS\ACTIVE SOIL PROJECTS\MED-18-13.54 (ODOT)\GINT FILES\MED-18-13.

PROJECT: MED-18-12.99	DRILLING FIRM / OPERATOR: BARR / ASHBAUGH	DRILL RIG: CME 45B	STATION / OFFSET: 165+02, 38 LT
TYPE: EXISTING PAVEMENT SUBGRADE	SAMPLING FIRM / LOGGER: BARR / ASHBAUGH	HAMMER: CME AUTOMATIC	ALIGNMENT: SR-18
PID: 92953 BR ID:	DRILLING METHOD: 3.25" HSA	CALIBRATION DATE: 1/26/14	ELEVATION: 957.6 (MSL), EOB: 9.0 ft.
START: 7/8/15 END: 7/8/15	SAMPLING METHOD: SPT	ENERGY RATIO (%): 77.4	COORD: 41.136436, -81.813598

EXPLORATION ID B-027-0-14

PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GR	CS	FS	SI	CL	LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
	957.6																	
5", **ASPHALT**	957.2																	
4", **BRICK**	956.9																	
10", **GRANULAR BASE**	956.1																	
HARD, BROWN AND GRAY, **SILTY CLAY**, LITTLE SAND, TRACE GRAVEL, DAMP **(FILL)**	954.6	1	10 14 22	46	67	SS-1	4.5+	4	8	11	30	47	34	18	16	17	A-6b (10)	
		2																
	953.6	3	50/4"	-	25	SS-2	-	-	-	-	-	-	-	-	-	2	A-2-4 (V)	
VERY DENSE, BROWN AND REDDISH BROWN, **GRAVEL WITH SAND AND SILT**, TRACE CLAY, CONTAINS BRICK FRAGMENTS, DRY **(FILL)**	952.8	4																
		5	11 37 67	134	67	SS-3	4.5+	3	5	9	33	50	36	19	17	17	A-6b (11)	
		6	50	-	100	SS-4	4.5+	-	-	-	-	-	-	-	-	16	A-6b (V)	
BROWN, **SILTY CLAY**, LITTLE SAND, SOME GRAVEL, CONTAINS BRICK FRAGMENTS, DAMP **(FILL)**		7																
		8	14 29 50	102	78	SS-5	4.5+	-	-	-	-	-	-	-	-	11	A-6b (V)	
HARD, BROWN MOTTLED WITH GRAY, **SILTY CLAY**, LITTLE SAND, TRACE GRAVEL, DAMP @6.0'; SS-4 AND SS-5 BECOME GRAY MOTTLED WITH BROWN	948.6	EOB 9																

NOTES: GROUNDWATER NOT ENCOUNTERED DURING DRILLING. CAVE DEPTH 5.0'.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PLACED .5 BAG ASPHALT PATCH; SHOVELED SOIL CUTTINGS

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 3/8/17 14:57 - \\COLUMBUSLAB\LAB\ACTIVE PROJECTS\ACTIVE SOIL PROJECTS\1ARCHIVE BY YEAR\2016 ARCHIVE\MED-18-13.5

PROJECT: MED-18-13.54	DRILLING FIRM / OPERATOR: BEI / ASHBAUGH	DRILL RIG: CME 55	STATION / OFFSET: 165+87, 32' LT.	EXPLORATION ID B-027-1-16
TYPE: LANDSLIDE	SAMPLING FIRM / LOGGER: BEI / K.BAME	HAMMER: CME AUTOMATIC	ALIGNMENT: PR S.R. 18	
PID: 92953 SFN:	DRILLING METHOD: 3.25" HSA	CALIBRATION DATE: 12/3/15	ELEVATION: 960.6 (MSL) EOB: 51.5 ft.	PAGE 1 OF 2
START: 9/19/16 END: 9/19/16	SAMPLING METHOD: SPT	ENERGY RATIO (%): 81.8	LAT / LONG: 41.136432, -81.813293	

MATERIAL DESCRIPTION AND NOTES	ELEV. 960.6	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
6.0", **ASPHALT**	960.1																	
18.0", **GRANULAR BASE**	958.6																	
VERY STIFF TO HARD, BROWN AND GRAYISH BROWN, **SILT AND CLAY**, "AND" SAND, LITTLE GRAVEL, CONTAINS SLAG, ROOT HAIRS, AND FEW ORGANICS, DAMP **(FILL)**	956.1		7 6 7	18	61	SS-1	3.25 - 4.5+	11	16	21	24	28	30	18	12	16	A-6a (4)	
VERY STIFF TO HARD, BROWN AND GRAY, **SILTY CLAY**, LITTLE SAND, TRACE GRAVEL, DAMP TO MOIST			5 6 10	22	67	SS-2	4.5+	6	5	9	33	47	35	18	17	17	A-6b (11)	
			4 3 4	10	61	SS-3	3.25 - 3.75	-	-	-	-	-	-	-	-	19	A-6b (V)	
@10.0'; SS-4 TO SS-5 BECOME BROWN MOTTLED WITH GRAY, SS-4 CONTAINS FEW IRON STAINS			2 4 7	15	67	SS-4	4.5+	-	-	-	-	-	-	-	-	20	A-6b (V)	
			4 5 7	16	72	SS-5	2.4 - 3.1	-	-	-	-	-	-	-	-	20	A-6b (V)	
	946.1																	
VERY STIFF TO HARD, BROWN TO GRAYISH BROWN, **CLAY**, "AND" SILT, LITTLE SAND, MOIST	943.1				100	ST-6	3.25 - 4.5+	0	2	9	47	42	53	29	24	31	A-7-6 (16)	
VERY STIFF TO HARD, GRAY AND BROWN, **SANDY SILT**, LITTLE GRAVEL, LITTLE CLAY, DAMP		W	4 4 3	10	89	SS-7	2.0 - 4.5+	20	20	19	25	16	28	18	10	17	A-4a (1)	
@20.0'; SS-8 AND SS-9 BECOME GRAY			3 4 6	14	100	SS-8	2.75 - 3.25	-	-	-	-	-	-	-	-	14	A-4a (V)	
			3 5 7	16	83	SS-9	2.5 - 2.75	-	-	-	-	-	-	-	-	14	A-4a (V)	
	936.1																	
MEDIUM DENSE, GRAY, **SANDY SILT**, TRACE CLAY, TRACE GRAVEL, WET			6 7 7	19	100	SS-10	-	1	0	48	45	6	NP	NP	NP	21	A-4a (3)	
			7 8 9	23	78	SS-11	-	-	-	-	-	-	-	-	-	23	A-4a (V)	

PID: 92953 | SFN: | PROJECT: MED-18-13.54 | STATION / OFFSET: 165+87, 32' LT. | START: 9/19/16 | END: 9/19/16 | PG 2 OF 2 | B-027-1-16

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
MEDIUM DENSE, GRAY, **SANDY SILT**, TRACE CLAY, TRACE GRAVEL, WET *(continued)*	930.6	31	2 4 4	11	83	SS-12	-	-	-	-	-	-	-	-	-	26	A-4a (V)	
	928.6	32																
VERY STIFF TO HARD, GRAY, **SANDY SILT**, SOME CLAY, TRACE GRAVEL, DAMP		33	4 5 7	16	89	SS-13	2.75 - 3.5	-	-	-	-	-	-	-	-	13	A-4a (V)	
		34																
		35	5 10 21	42	17	SS-14	-	-	-	-	-	-	-	-	-	15	A-4a (V)	
		36																
		37																
@37.5'; SS-15 TO SS-19 BECOME GRAYISH BROWN		38	4 14 25	53	100	SS-15	4.5+	5	7	16	40	32	26	17	9	13	A-4a (7)	
		39																
		40	11 15 20	48	100	SS-16	4.25 - 4.5+	-	-	-	-	-	-	-	-	11	A-4a (V)	
		41																
		42																
		43	19 34 35	94	100	SS-17	-	-	-	-	-	-	-	-	-	18	A-4a (V)	
		44																
		45																
		46	3 8 7	20	89	SS-18	4.5+	6	4	14	41	35	26	16	10	15	A-4a (8)	
		47																
		48	10 15 22	50	100	SS-19	2.75 - 4.5+	-	-	-	-	-	-	-	-	14	A-4a (V)	
		49																
		50																
@50.0'; SS-20 BECOMES GRAY		51	19 26 32	79	72	SS-20	2.00	-	-	-	-	-	-	-	-	17	A-4a (V)	
	909.1	EOB																

NOTES: GROUNDWATER ENCOUNTERED AT 19.0' DURING DRILLING. HOLE DID NOT CAVE.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PLACED 0.5 BAG ASPHALT PATCH; PUMPED 76 GAL. BENTONITE GROUT

PROJECT: MED-18-13.54	DRILLING FIRM / OPERATOR: BEI / ASHBAUGH	DRILL RIG: CME 55	STATION / OFFSET: 166+76, 35' LT.	EXPLORATION ID B-027-2-16
TYPE: LANDSLIDE	SAMPLING FIRM / LOGGER: BEI / K.BAME	HAMMER: CME AUTOMATIC	ALIGNMENT: PR S.R. 18	
PID: 92953 SFN:	DRILLING METHOD: 3.25" HSA	CALIBRATION DATE: 12/3/15	ELEVATION: 963.5 (MSL) EOB: 51.5 ft.	PAGE 1 OF 2
START: 9/19/16 END: 9/19/16	SAMPLING METHOD: SPT	ENERGY RATIO (%): 81.8	LAT / LONG: 41.136429, -81.812974	

MATERIAL DESCRIPTION AND NOTES	ELEV. 963.5	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
6.0", **ASPHALT**	963.0																	
18.0", **GRANULAR BASE**	961.5																	
VERY STIFF TO HARD, BROWN AND GRAYISH BROWN, **SILT AND CLAY**, LITTLE SAND, TRACE GRAVEL, SS-1 CONTAINS ASPHALT AND BLACK WOOD FRAGMENTS, DAMP TO MOIST **(FILL)**			3 2 5	10	61	SS-1	2.0 - 3.5	-	-	-	-	-	-	-	-	26	A-6a (V)	
@5.0'; SS-2 CONTAINS ROOTS AND IRON STAINING	956.5		3 6 7	18	72	SS-2	4.5+	6	8	12	36	38	32	19	13	15	A-6a (9)	
VERY STIFF TO HARD, BROWN AND GRAYISH BROWN BECOMING BROWN, **SILTY CLAY**, LITTLE SAND, TRACE GRAVEL, DAMP TO MOIST			3 5 7	16	72	SS-3	3.5 - 4.25	-	-	-	-	-	-	-	-	16	A-6b (V)	
			2 4 7	15	78	SS-4	4.5+	4	7	10	37	42	35	19	16	17	A-6b (10)	
			4 5 7	16	67	SS-5	4.0 - 4.5+	-	-	-	-	-	-	-	-	19	A-6b (V)	
	947.0		2 3 5	11	61	SS-6	3.5 - 4.5+	-	-	-	-	-	-	-	-	20	A-6b (V)	
STIFF TO VERY STIFF, DARK BROWN AND BLACK BECOMING DARK GRAYISH BROWN AND BROWN, **CLAY**, "AND" SILT, LITTLE TO SOME SAND, TRACE TO SOME GRAVEL, SS-7 CONTAINS A SLIGHT ORGANIC ODOR, DAMP TO MOIST			2 4 5	12	83	SS-7	1.75 - 2.25	3	4	11	42	40	46	25	21	27	A-7-6 (14)	
			4 3 4	10	44	SS-8	1.0 - 1.5	-	-	-	-	-	-	-	-	22	A-7-6 (V)	
	941.5				92	ST-9	3.0 - 4.5+	6	8	12	45	29	24	16	8	15	A-4a (8)	
VERY STIFF TO HARD, BROWN TO BROWNISH GRAY, **SANDY SILT**, SOME CLAY, TRACE GRAVEL, DAMP TO MOIST			6 11 13	33	83	SS-10	4.5+	6	9	13	46	26	23	15	8	12	A-4a (7)	
	936.5																	
MEDIUM DENSE TO DENSE, GRAYISH BROWN, **SANDY SILT**, TRACE CLAY, MOIST TO WET		W	8 11 14	34	100	SS-11	-	-	-	-	-	-	-	-	-	25	A-4a (V)	

PID: 92953	SFN:	PROJECT: MED-18-13.54	STATION / OFFSET: 166+76, 35' LT.	START: 9/19/16	END: 9/19/16	PG 2 OF 2	B-027-2-16

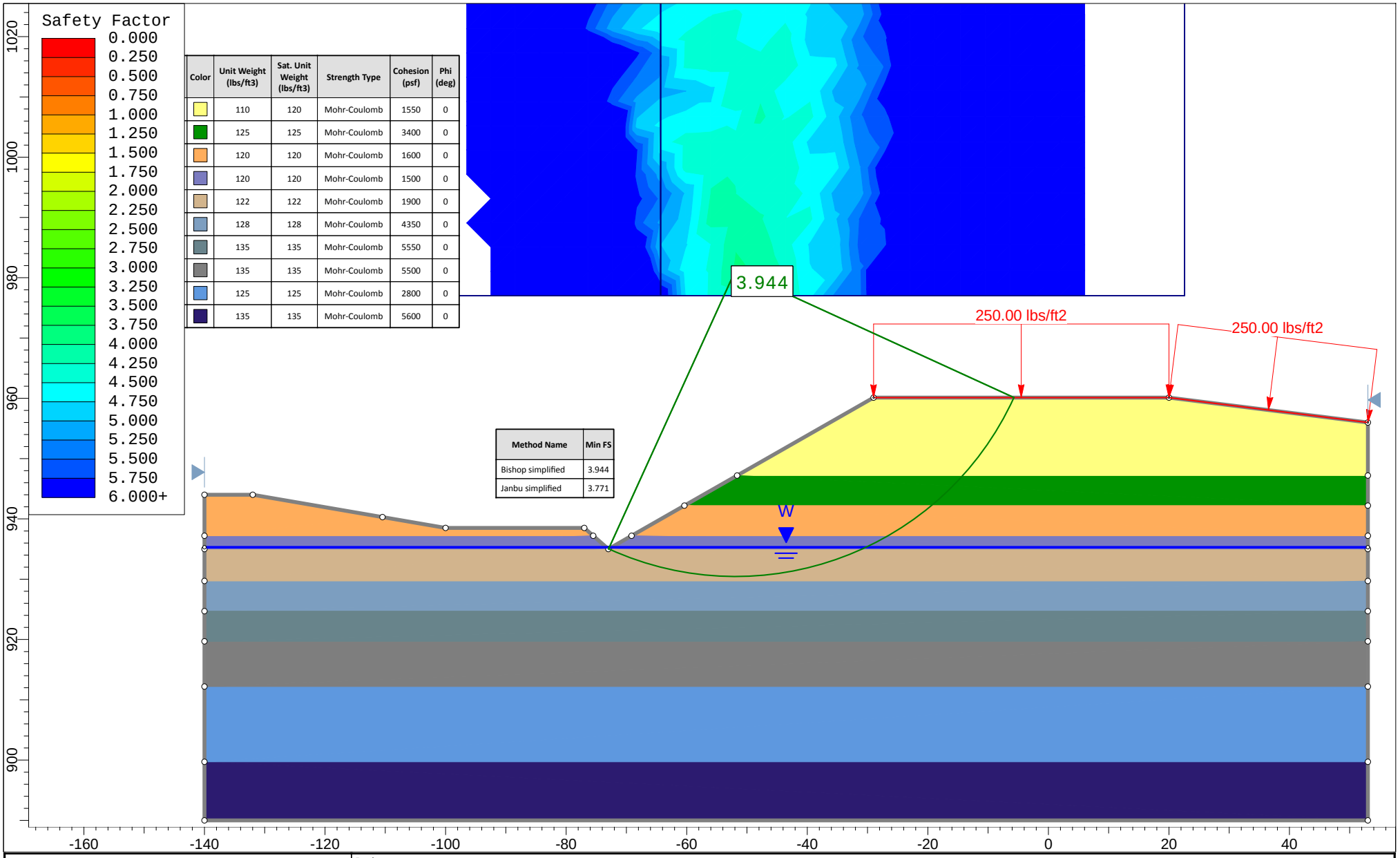
MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
MEDIUM DENSE TO DENSE, GRAYISH BROWN, **SANDY SILT**, TRACE CLAY, MOIST TO WET *(continued)*	933.5	31	5 6 8	19	94	SS-12	-	0	0	47	47	6	NP	NP	NP	23	A-4a (4)	
		32																
		33	3 5 7	16	100	SS-13	-	-	-	-	-	-	-	-	-	18	A-4a (V)	
	928.5	34																
VERY STIFF, BROWNISH GRAY, **SILTY CLAY**, LITTLE SAND, LITTLE GRAVEL, DAMP		35																
		36	3 5 8	18	100	SS-14	2.0 - 4.0	-	-	-	-	-	-	-	-	12	A-6b (V)	
	926.5	37																
HARD, GRAYISH BROWN, **SANDY SILT**, LITTLE TO SOME CLAY, TRACE TO LITTLE GRAVEL, DAMP		38			63	ST-15	4.5+	14	13	28	28	17	18	13	5	9	A-4a (2)	
		39																
		40	40 42 50/5"	-	82	SS-16	4.5+	4	6	25	42	23	20	14	6	8	A-4a (6)	
	921.0	41																
VERY DENSE, BROWN AND GRAYISH BROWN BECOMING BROWN, **GRAVEL WITH SAND AND SILT**, TRACE CLAY, SS-17 CONTAINS IRON STAINING, DAMP TO MOIST		42																
		43	16 39 50/5"	-	94	SS-17	-	-	-	-	-	-	-	-	-	11	A-2-4 (V)	
		44																
		45																
		46	22 32 45	105	100	SS-18	-	24	21	27	20	8	NP	NP	NP	11	A-2-4 (0)	
		47																
		48	8 16 22	52	83	SS-19	-	-	-	-	-	-	-	-	-	17	A-2-4 (V)	
		49																
	913.0	50	8			SS-20A	-	-	-	-	-	-	-	-	-	12	A-2-4 (V)	
STIFF, BROWN, **SILT AND CLAY**, LITTLE SAND, TRACE GRAVEL, MOIST	912.0	51	10 15	34	100	SS-20B	1.25 - 1.75	3	4	13	43	37	27	15	12	16	A-6a (9)	
		EOB																

NOTES: GROUNDWATER ENCOUNTERED AT 29.0' DURING DRILLING, 36.0' UPON COMPLETION. HOLE DID NOT CAVE.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PLACED 0.5 BAG ASPHALT PATCH; SHOVELED SOIL CUTTINGS

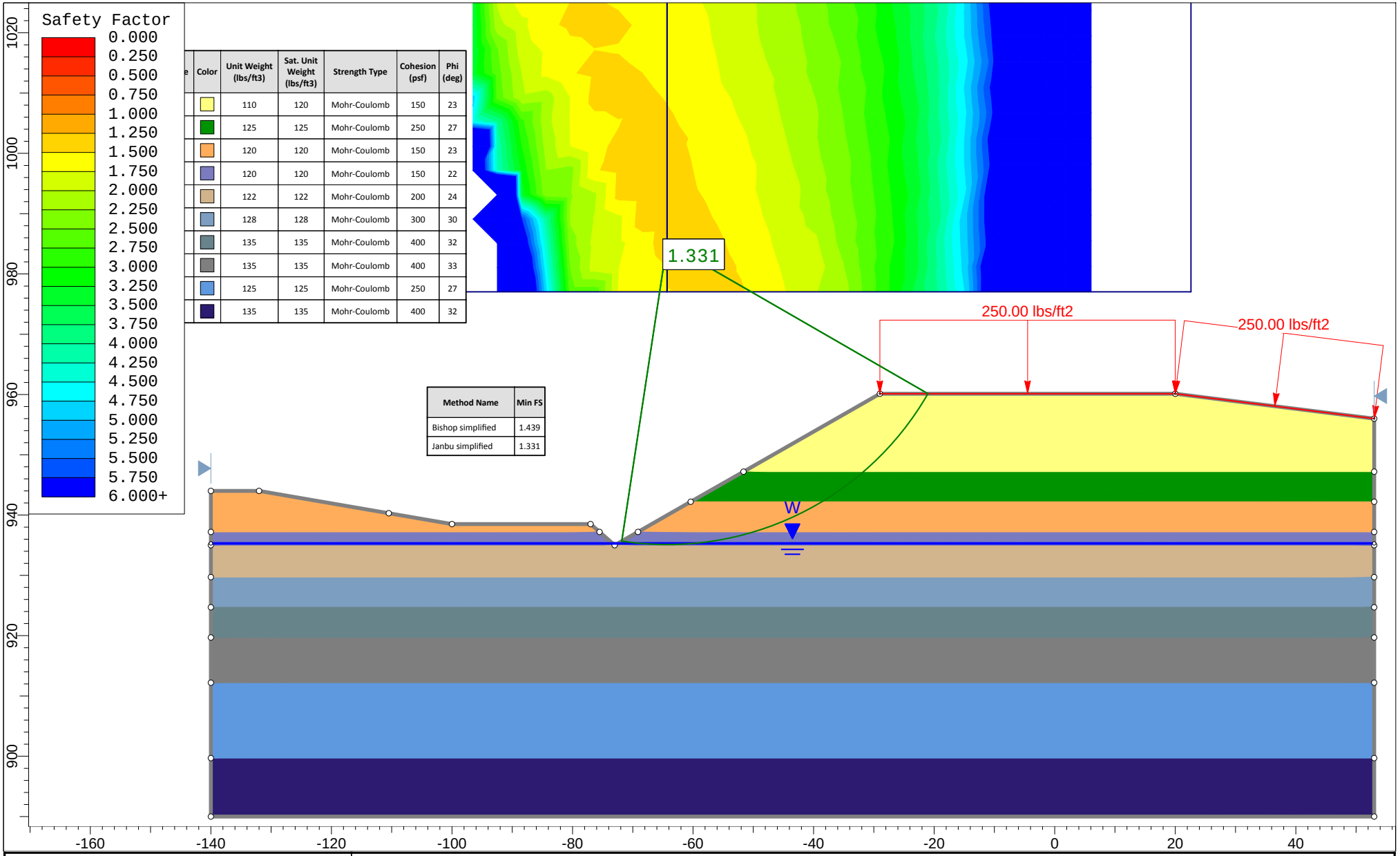
APPENDIX C

GLOBAL STABILITY ANALYSIS



rocscience	*Project*	Landslide at MED-18 Sta 127	
	Analysis Description	Circular_Total Stress Analysis	
	Drawn By ZM	*Scale* 1:264	*Company* National Engineering & Architectural Services, Inc
	Date 1/26/2017, 4:13:49 PM		*File Name* Sta127_Circular_Total_B_014-1.slim

SLIDEINTERPRET 7.022

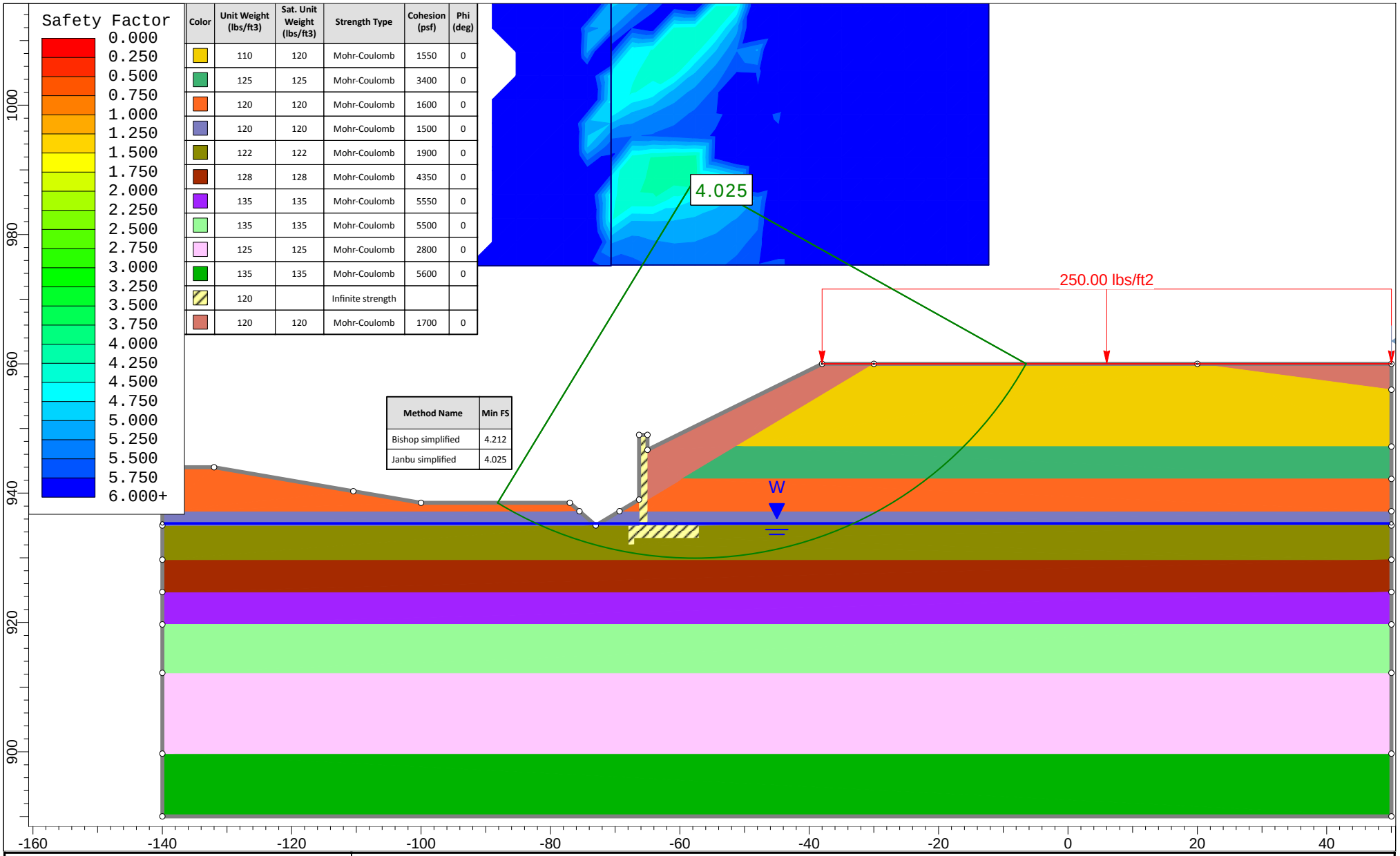


Color	Unit Weight (lbs/ft3)	Sat. Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
	110	120	Mohr-Coulomb	150	23
	125	125	Mohr-Coulomb	250	27
	120	120	Mohr-Coulomb	150	23
	120	120	Mohr-Coulomb	150	22
	122	122	Mohr-Coulomb	200	24
	128	128	Mohr-Coulomb	300	30
	135	135	Mohr-Coulomb	400	32
	135	135	Mohr-Coulomb	400	33
	125	125	Mohr-Coulomb	250	27
	135	135	Mohr-Coulomb	400	32

Method Name	Min FS
Bishop simplified	1.439
Janbu simplified	1.331

Project	Landslide at MED-18 Sta 127		
Analysis Description	Circular_Effective Stress Analysis		
Drawn By	ZM	Scale 1:264	Company National Engineering & Architectural Services, Inc
Date	1/26/2017, 4:13:49 PM		File Name Sta127_Circular_Effective_B_014-1.slim

SLIDEINTERPRET 7.022

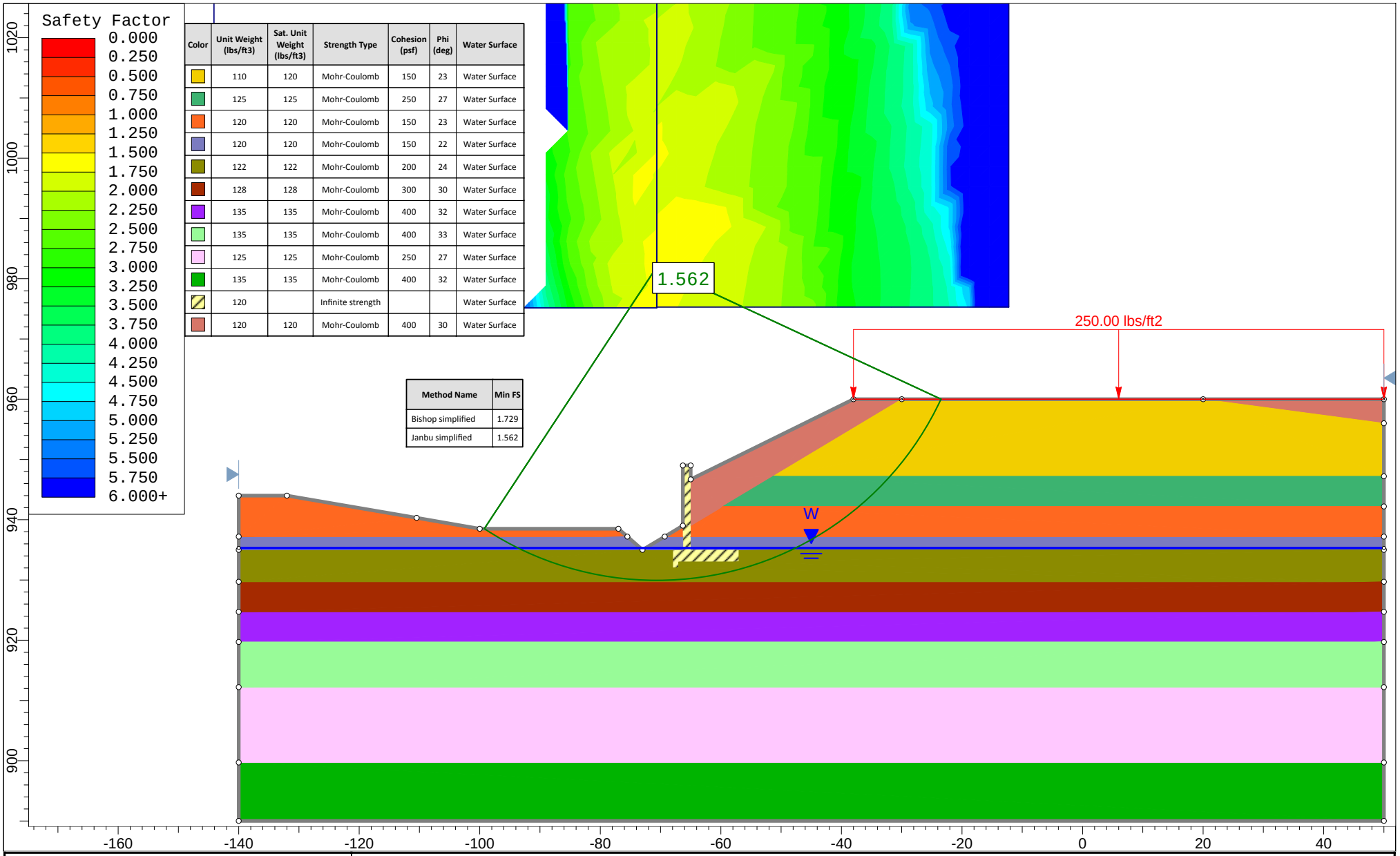


Color	Unit Weight (lbs/ft3)	Sat. Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
	110	120	Mohr-Coulomb	1550	0
	125	125	Mohr-Coulomb	3400	0
	120	120	Mohr-Coulomb	1600	0
	120	120	Mohr-Coulomb	1500	0
	122	122	Mohr-Coulomb	1900	0
	128	128	Mohr-Coulomb	4350	0
	135	135	Mohr-Coulomb	5550	0
	135	135	Mohr-Coulomb	5500	0
	125	125	Mohr-Coulomb	2800	0
	135	135	Mohr-Coulomb	5600	0
	120		Infinite strength		
	120	120	Mohr-Coulomb	1700	0

Method Name	Min FS
Bishop simplified	4.212
Janbu simplified	4.025

SLIDEINTERPRET 7.022

Project	Landslide at MED-18 Sta 127		
Analysis Description	Circular_Total Stress Analysis		
Drawn By	ZM	*Scale* 1:246	*Company* National Engineering & Architectural Services, Inc
Date	1/26/2017, 4:13:49 PM		*File Name* Sta127_Circular_Total_1ft_withHeadwall_B_014-1.slim

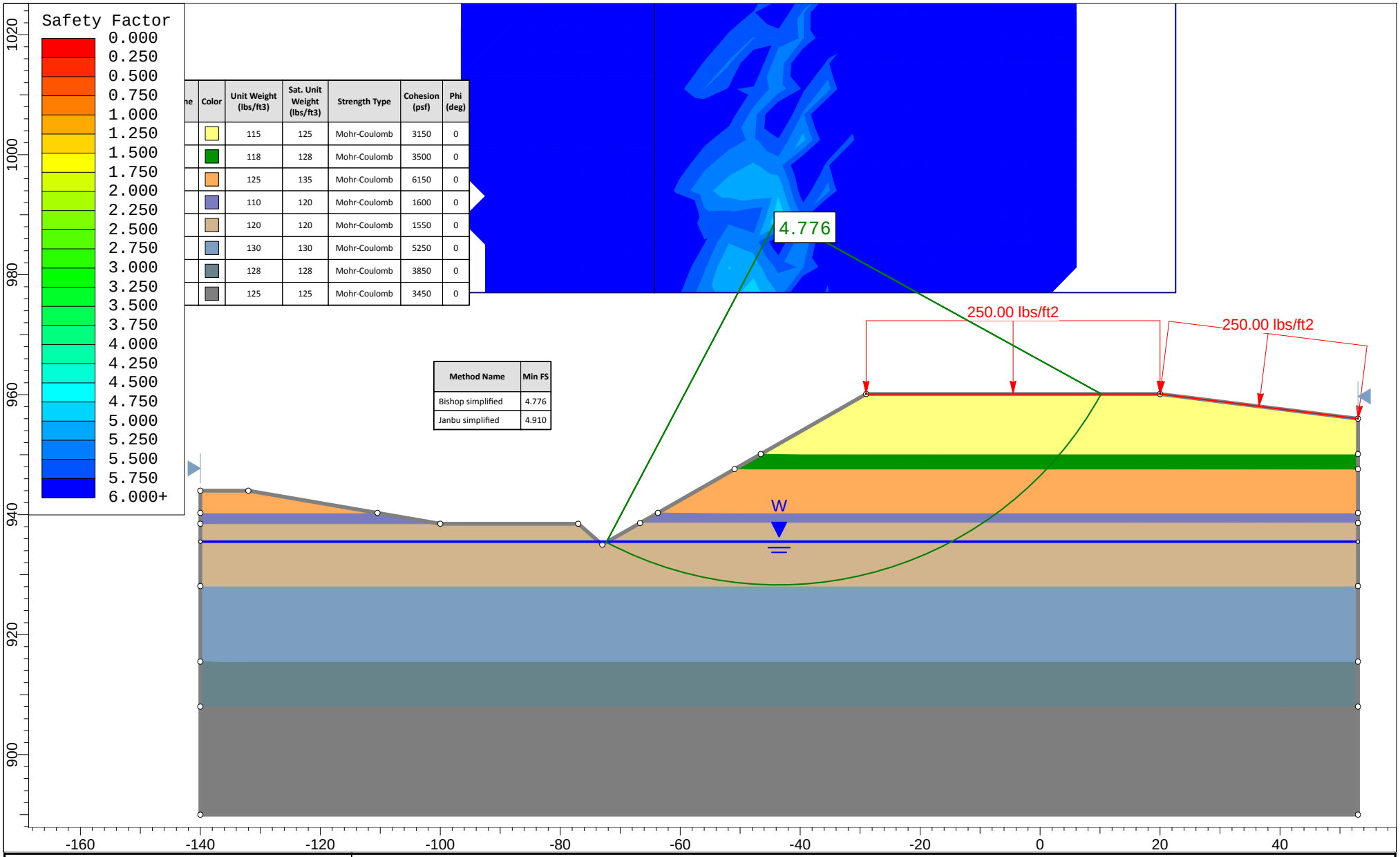


Color	Unit Weight (lbs/ft3)	Sat. Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface
	110	120	Mohr-Coulomb	150	23	Water Surface
	125	125	Mohr-Coulomb	250	27	Water Surface
	120	120	Mohr-Coulomb	150	23	Water Surface
	120	120	Mohr-Coulomb	150	22	Water Surface
	122	122	Mohr-Coulomb	200	24	Water Surface
	128	128	Mohr-Coulomb	300	30	Water Surface
	135	135	Mohr-Coulomb	400	32	Water Surface
	135	135	Mohr-Coulomb	400	33	Water Surface
	125	125	Mohr-Coulomb	250	27	Water Surface
	135	135	Mohr-Coulomb	400	32	Water Surface
	120		Infinite strength			Water Surface
	120	120	Mohr-Coulomb	400	30	Water Surface

Method Name	Min FS
Bishop simplified	1.729
Janbu simplified	1.562

Project	Landslide at MED-18 Sta 127		
Analysis Description	Circular_Effective Stress Analysis		
Drawn By	ZM	Scale 1:264	Company National Engineering & Architectural Services, Inc
Date	1/26/2017, 4:13:49 PM		File Name Sta127_Circular_Effective_1ft_withHeadwall_B_014-1.slim

SLIDEINTERPRET 7.022

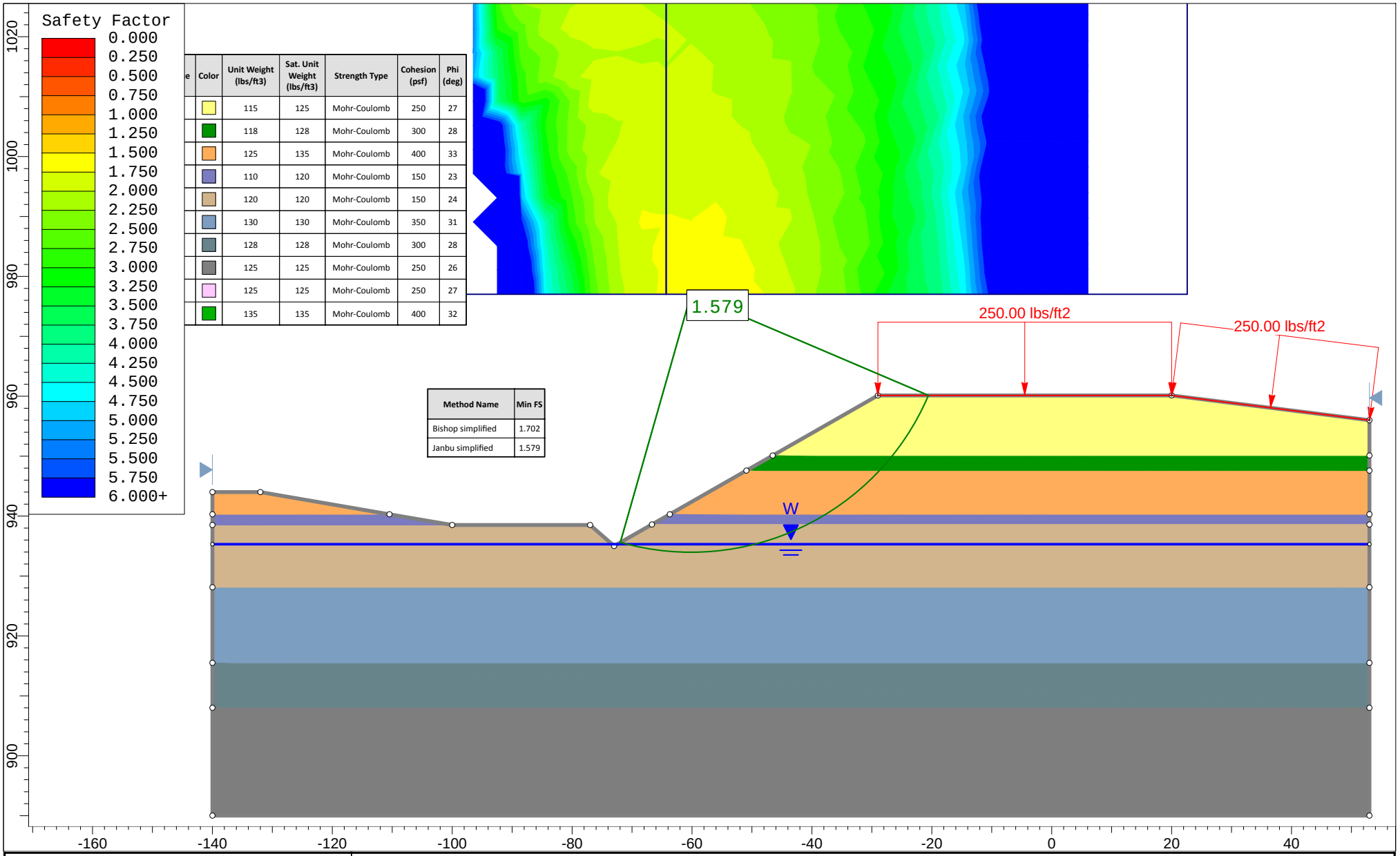


Color	Unit Weight (lbs/ft3)	Sat. Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
	115	125	Mohr-Coulomb	3150	0
	118	128	Mohr-Coulomb	3500	0
	125	135	Mohr-Coulomb	6150	0
	110	120	Mohr-Coulomb	1600	0
	120	120	Mohr-Coulomb	1550	0
	130	130	Mohr-Coulomb	5250	0
	128	128	Mohr-Coulomb	3850	0
	125	125	Mohr-Coulomb	3450	0

Method Name	Min FS
Bishop simplified	4.776
Janbu simplified	4.910

SLIDEINTERPRET 7.022

Project	Landslide at MED-18 Sta 127		
Analysis Description	Circular_Total Stress Analysis		
Drawn By	ZM	Scale 1:265	Company National Engineering & Architectural Services, Inc
Date	1/26/2017, 4:13:49 PM		File Name Sta127_Circular_Total_B_015.slim



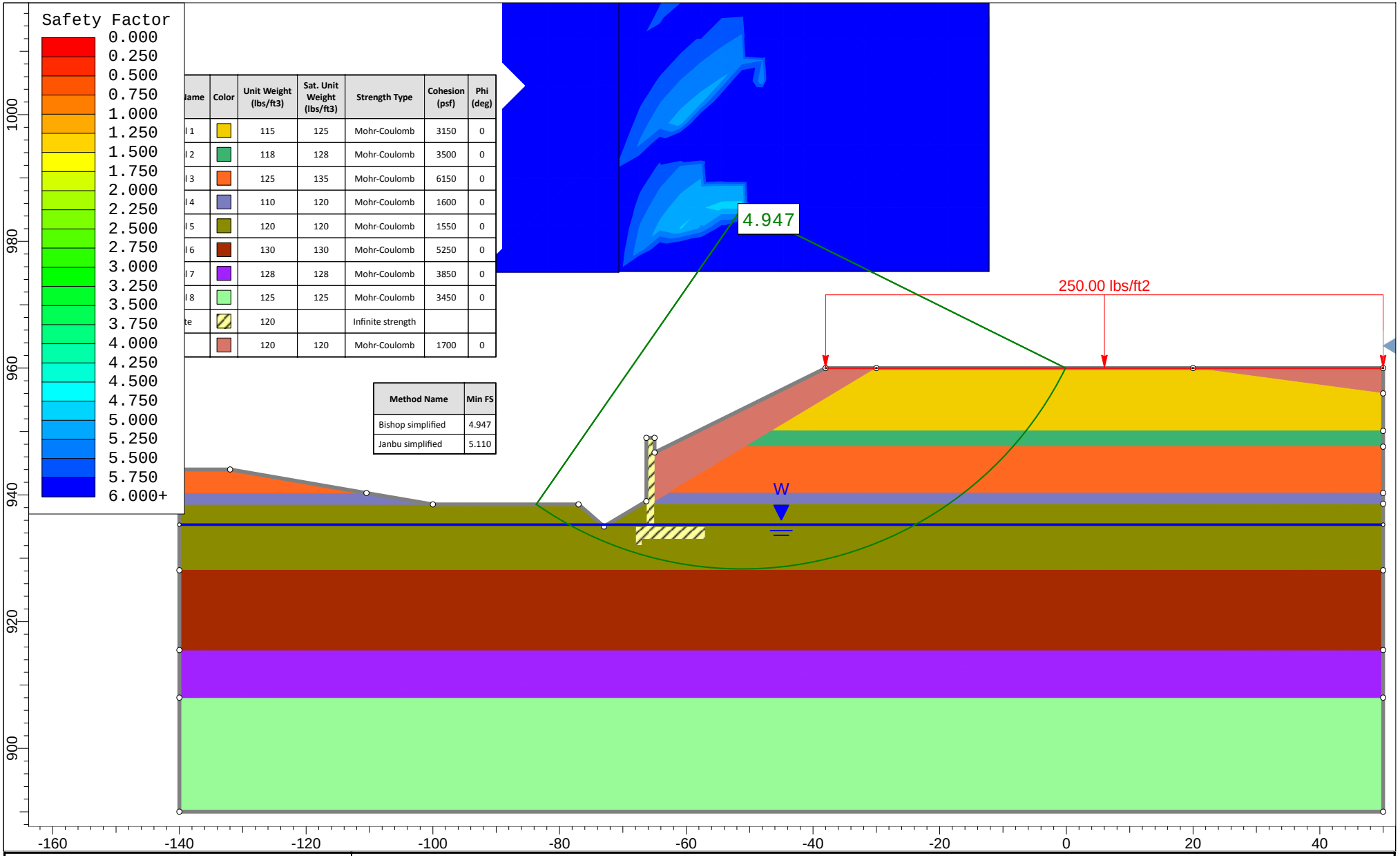
e	Color	Unit Weight (lbs/ft3)	Sat. Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
		115	125	Mohr-Coulomb	250	27
		118	128	Mohr-Coulomb	300	28
		125	135	Mohr-Coulomb	400	33
		110	120	Mohr-Coulomb	150	23
		120	120	Mohr-Coulomb	150	24
		130	130	Mohr-Coulomb	350	31
		128	128	Mohr-Coulomb	300	28
		125	125	Mohr-Coulomb	250	26
		125	125	Mohr-Coulomb	250	27
		135	135	Mohr-Coulomb	400	32

Method Name	Min FS
Bishop simplified	1.702
Janbu simplified	1.579

rocscience

SLIDEINTERPRET 7.022

Project	Landslide at MED-18 Sta 127		
Analysis Description	Circular_Effective Stress Analysis		
Drawn By	ZM	*Scale* 1:265	*Company* National Engineering & Architectural Services, Inc
Date	1/26/2017, 4:13:49 PM		*File Name* Sta127_Circular_Effective_B_015.slim



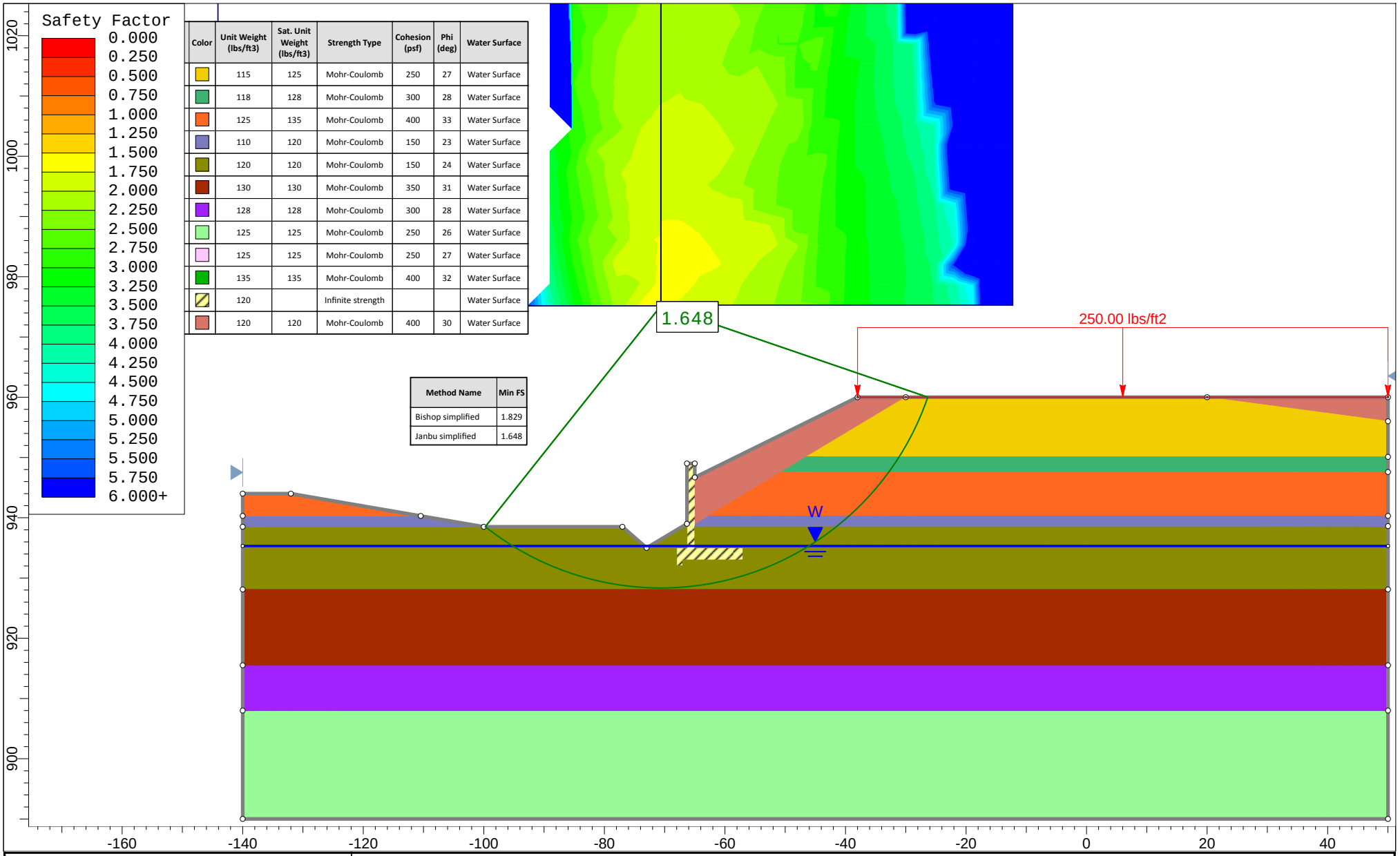
Name	Color	Unit Weight (lbs/ft3)	Sat. Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
l 1		115	125	Mohr-Coulomb	3150	0
l 2		118	128	Mohr-Coulomb	3500	0
l 3		125	135	Mohr-Coulomb	6150	0
l 4		110	120	Mohr-Coulomb	1600	0
l 5		120	120	Mohr-Coulomb	1550	0
l 6		130	130	Mohr-Coulomb	5250	0
l 7		128	128	Mohr-Coulomb	3850	0
l 8		125	125	Mohr-Coulomb	3450	0
te		120		Infinite strength		
		120	120	Mohr-Coulomb	1700	0

Method Name	Min FS
Bishop simplified	4.947
Janbu simplified	5.110

rocscience

SLIDEINTERPRET 7.022

Project	Landslide at MED-18 Sta 127		
Analysis Description	Circular_Total Stress Analysis		
Drawn By	ZM	*Scale* 1:251	*Company* National Engineering & Architectural Services, Inc
Date	1/26/2017, 4:13:49 PM		*File Name* Sta127_Circular_Total_1ft_withHeadwall_B_015.slim

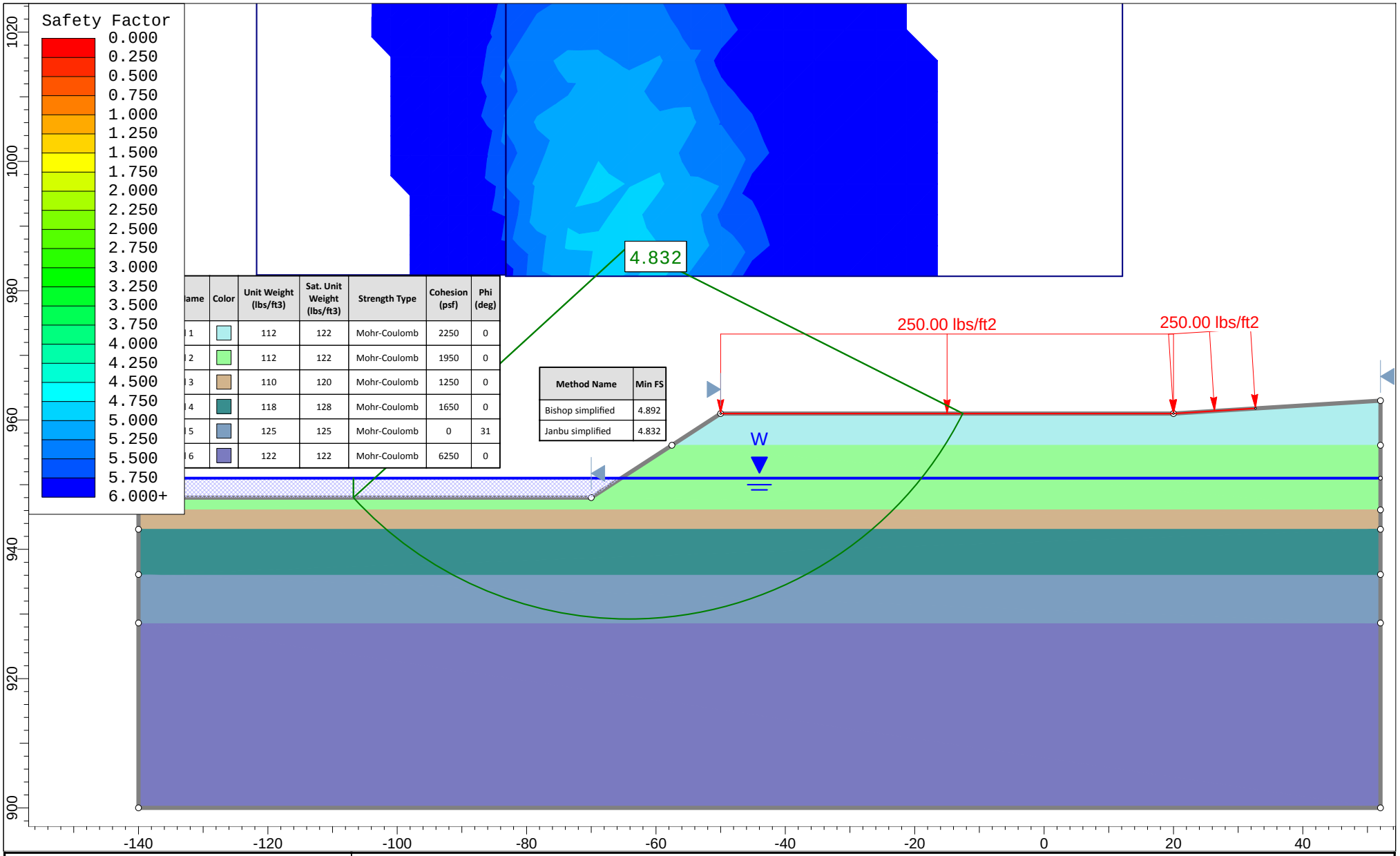


Color	Unit Weight (lbs/ft3)	Sat. Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface
	115	125	Mohr-Coulomb	250	27	Water Surface
	118	128	Mohr-Coulomb	300	28	Water Surface
	125	135	Mohr-Coulomb	400	33	Water Surface
	110	120	Mohr-Coulomb	150	23	Water Surface
	120	120	Mohr-Coulomb	150	24	Water Surface
	130	130	Mohr-Coulomb	350	31	Water Surface
	128	128	Mohr-Coulomb	300	28	Water Surface
	125	125	Mohr-Coulomb	250	26	Water Surface
	125	125	Mohr-Coulomb	250	27	Water Surface
	135	135	Mohr-Coulomb	400	32	Water Surface
	120		Infinite strength			Water Surface
	120	120	Mohr-Coulomb	400	30	Water Surface

Method Name	Min FS
Bishop simplified	1.829
Janbu simplified	1.648

SLIDEINTERPRET 7.022

Project	Landslide at MED-18 Sta 127		
Analysis Description	Circular_Effective Stress Analysis		
Drawn By	ZM	*Scale* 1:264	*Company* National Engineering & Architectural Services, Inc
Date	1/26/2017, 4:13:49 PM		*File Name* Sta127_Circular_Effective_1ft_withHeadwall_B_015.slim



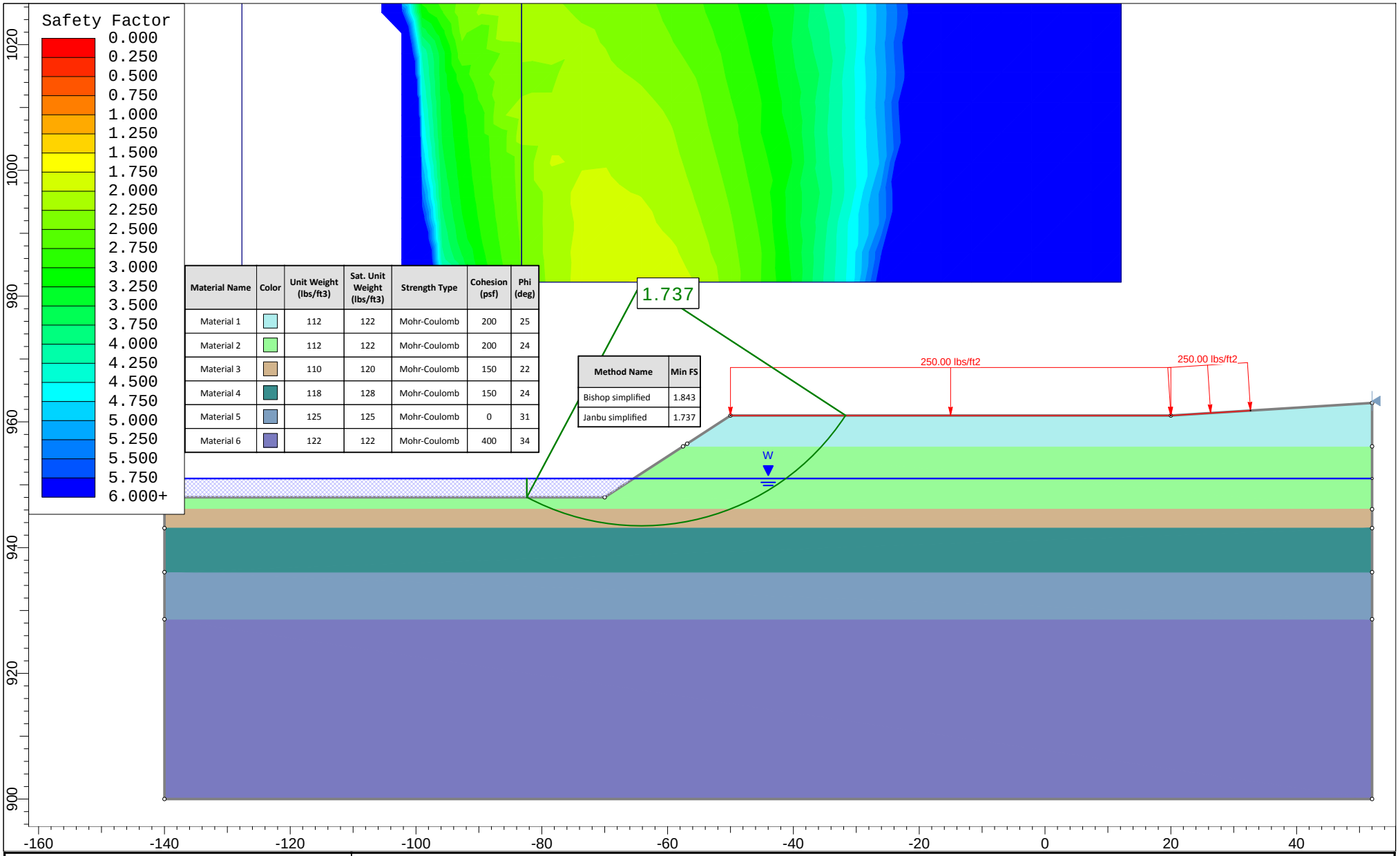
ame	Color	Unit Weight (lbs/ft3)	Sat. Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
1		112	122	Mohr-Coulomb	2250	0
2		112	122	Mohr-Coulomb	1950	0
3		110	120	Mohr-Coulomb	1250	0
4		118	128	Mohr-Coulomb	1650	0
5		125	125	Mohr-Coulomb	0	31
6		122	122	Mohr-Coulomb	6250	0

Method Name	Min FS
Bishop simplified	4.892
Janbu simplified	4.832

rocscience

SLIDEINTERPRET 7.022

Project	MED-18 Landslide at Sta 166		
Analysis Description	Circular-Total Stress Analysis		
Drawn By	ZM	Scale 1:246	Company National Engineering & Architectural Services, Inc.
Date	1/26/2017, 11:23:54 AM		File Name Sta166_Circular_Total_B_027_1.slim

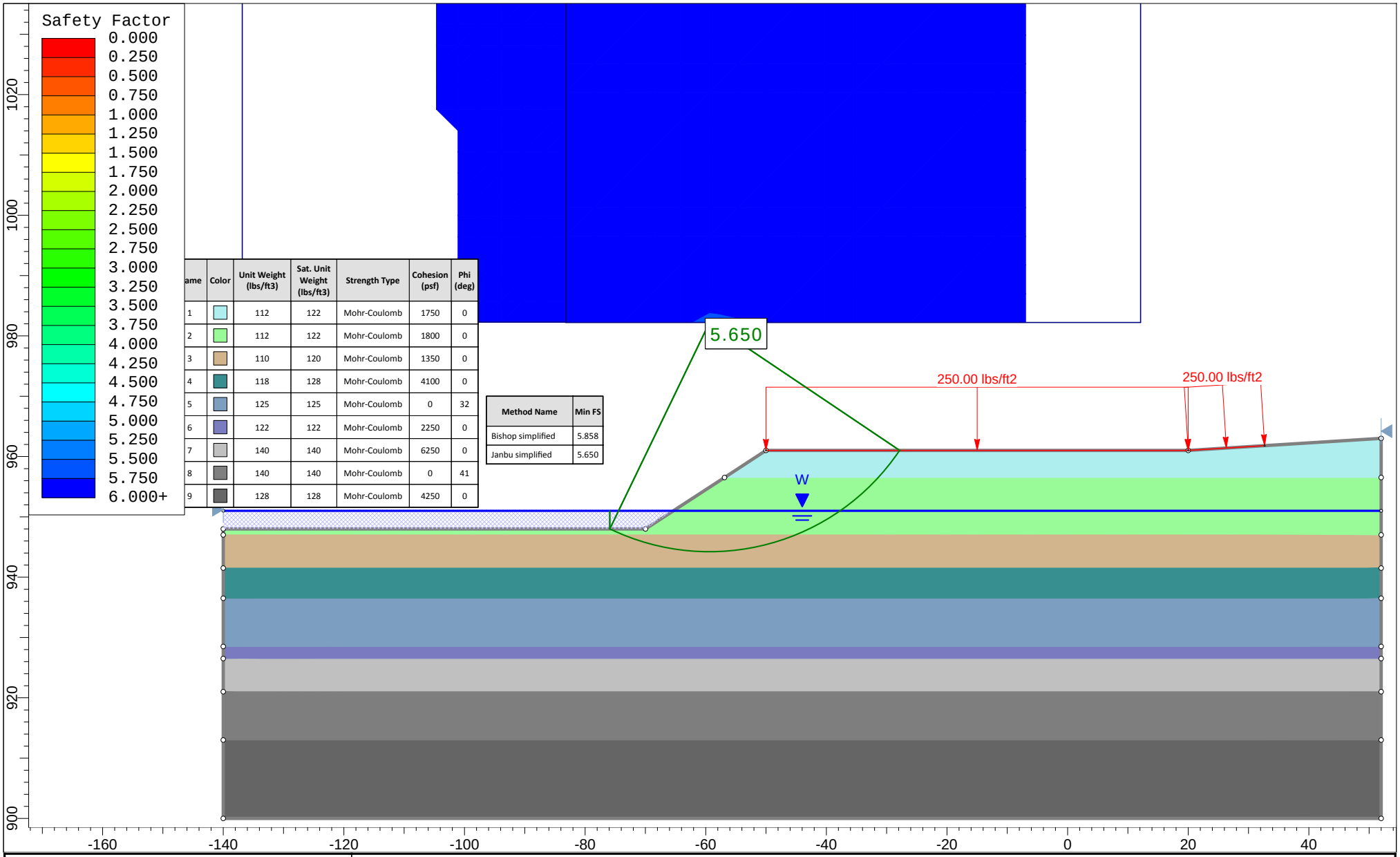


Material Name	Color	Unit Weight (lbs/ft3)	Sat. Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Material 1		112	122	Mohr-Coulomb	200	25
Material 2		112	122	Mohr-Coulomb	200	24
Material 3		110	120	Mohr-Coulomb	150	22
Material 4		118	128	Mohr-Coulomb	150	24
Material 5		125	125	Mohr-Coulomb	0	31
Material 6		122	122	Mohr-Coulomb	400	34

Method Name	Min FS
Bishop simplified	1.843
Janbu simplified	1.737

Project	MED-18 Landslide at Sta 166		
Analysis Description	Circular-Effective Stress Analysis		
Drawn By	ZM	Scale 1:253	Company National Engineering & Architectural Services, Inc.
Date	1/26/2017, 11:23:54 AM		File Name Sta166_Circular_Effective_B_027_1.slim

SLIDEINTERPRET 7.022

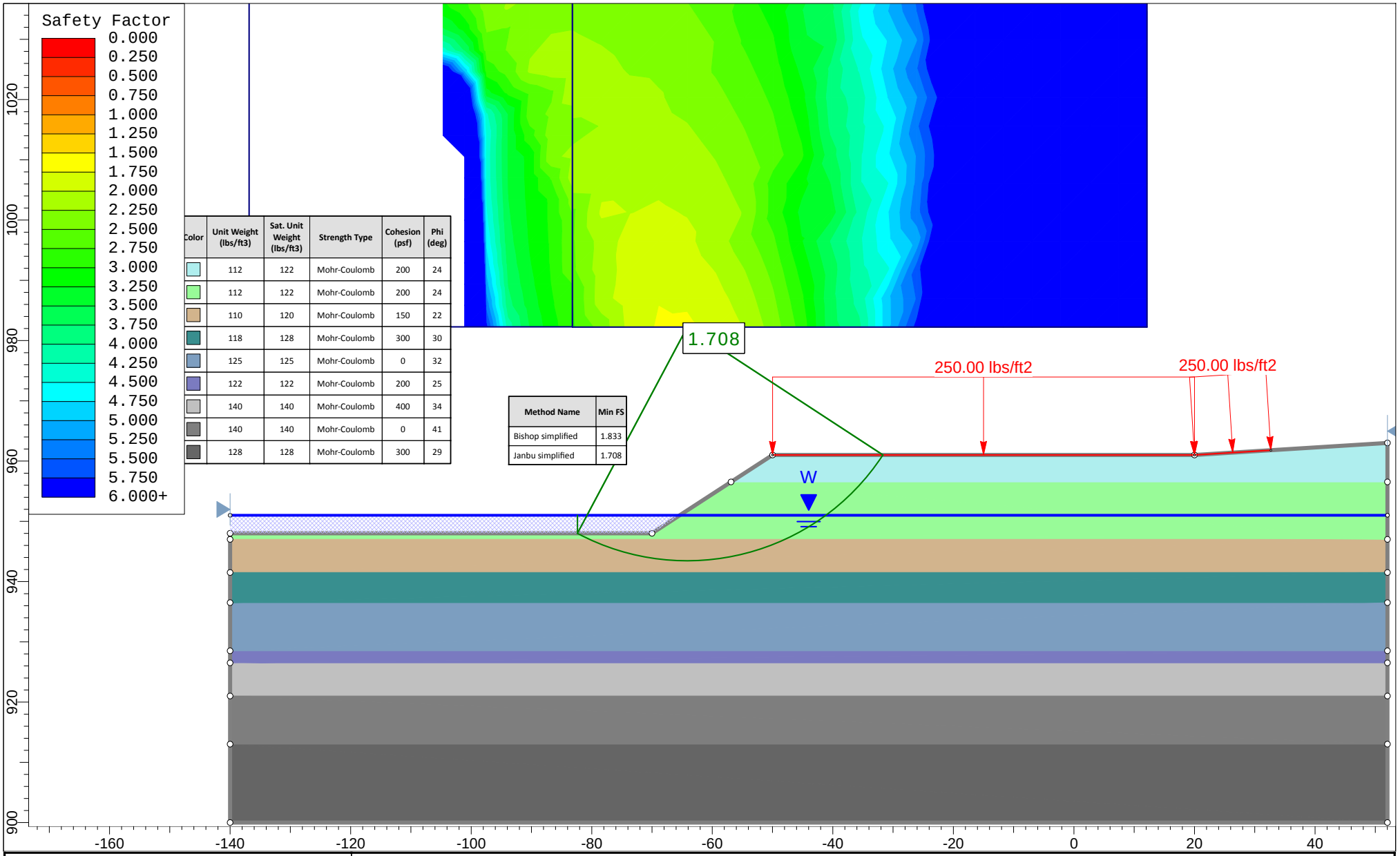


ame	Color	Unit Weight (lbs/ft3)	Sat. Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
1		112	122	Mohr-Coulomb	1750	0
2		112	122	Mohr-Coulomb	1800	0
3		110	120	Mohr-Coulomb	1350	0
4		118	128	Mohr-Coulomb	4100	0
5		125	125	Mohr-Coulomb	0	32
6		122	122	Mohr-Coulomb	2250	0
7		140	140	Mohr-Coulomb	6250	0
8		140	140	Mohr-Coulomb	0	41
9		128	128	Mohr-Coulomb	4250	0

Method Name	Min FS
Bishop simplified	5.858
Janbu simplified	5.650

Project	MED-18 Landslide at Sta 166		
Analysis Description	Circular-Total Stress Analysis		
Drawn By	ZM	Scale 1:264	Company National Engineering & Architectural Services, Inc.
Date	1/26/2017, 11:23:54 AM		File Name Sta166_Circular_Total_B_027_2.slim

SLIDEINTERPRET 7.022



Color	Unit Weight (lbs/ft3)	Sat. Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
	112	122	Mohr-Coulomb	200	24
	112	122	Mohr-Coulomb	200	24
	110	120	Mohr-Coulomb	150	22
	118	128	Mohr-Coulomb	300	30
	125	125	Mohr-Coulomb	0	32
	122	122	Mohr-Coulomb	200	25
	140	140	Mohr-Coulomb	400	34
	140	140	Mohr-Coulomb	0	41
	128	128	Mohr-Coulomb	300	29

Method Name	Min FS
Bishop simplified	1.833
Janbu simplified	1.708

SLIDEINTERPRET 7.022

Project	MED-18 Landslide at Sta 166			
Analysis Description	Circular-Effective Stress Analysis			
Drawn By	ZM	Scale	1:264	Company: National Engineering & Architectural Services, Inc.
Date	1/26/2017, 11:23:54 AM			File Name: Sta166_Circular_Effective_B_027_2.slim

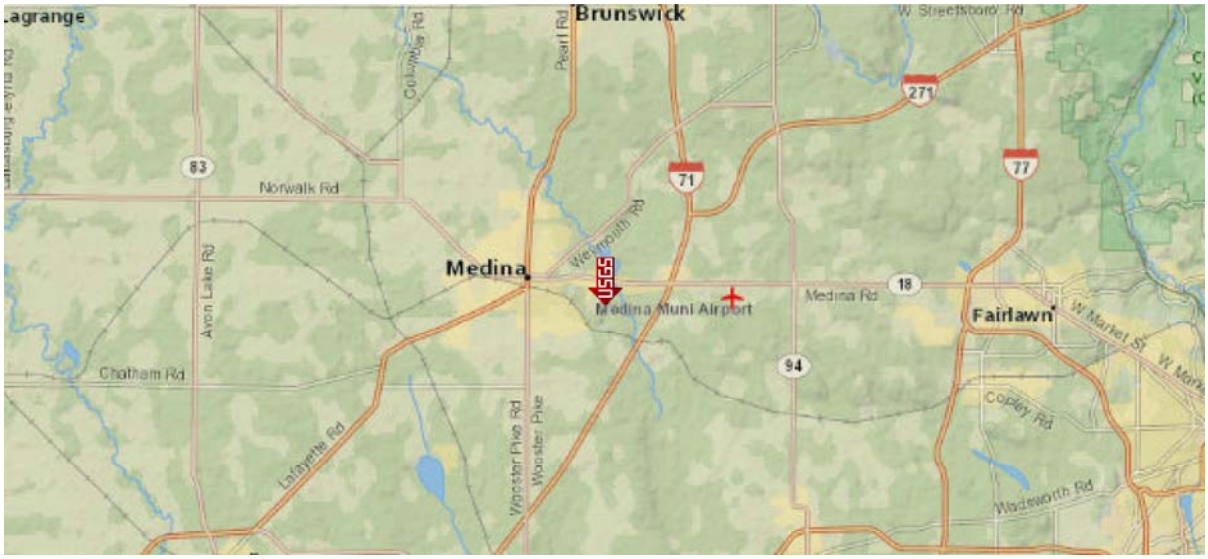
APPENDIX D

SEISMIC ANALYSIS

USGS Design Maps Summary Report

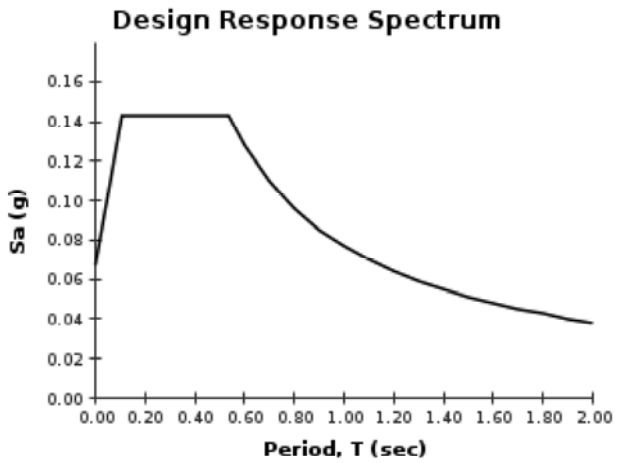
User–Specified Input

Report Title	Historical Landslide Location Sta 127+00 Wed February 1, 2017 18:45:21 UTC
Building Code Reference Document	2009 AASHTO Guide Specifications for LRFD Seismic Bridge Design (which utilizes USGS hazard data available in 2002)
Site Coordinates	41.13791°N, 81.82656°W
Site Soil Classification	Site Class D – "Stiff Soil"



USGS–Provided Output

PGA =	0.042 g	**A_s =**	0.067 g
S_s =	0.090 g	**S_{DS} =**	0.143 g
S_1 =	0.032 g	**S_{D1} =**	0.077 g



Design Maps Detailed Report

2009 AASHTO Guide Specifications for LRFD Seismic Bridge Design (41.13791°N, 81.82656°W)

Site Class D – "Stiff Soil"

Article 3.4.1 — Design Spectra Based on General Procedure

Note: Maps in the 2009 AASHTO Specifications are provided by AASHTO for Site Class B. Adjustments for other Site Classes are made, as needed, in Article 3.4.2.3.

From Figure 3.4.1-2 [1]	PGA = 0.042 g
From Figure 3.4.1-3 [2]	S_S = 0.090 g
From Figure 3.4.1-4 [3]	S_1 = 0.032 g

Article 3.4.2.1 — Site Class Definitions

The authority having jurisdiction (not the USGS), site-specific geotechnical data, and/or the default has classified the site as Site Class D, based on the site soil properties in accordance with Article 3.4.2.

Table 3.4.2.1–1 Site Class Definitions

SITE CLASS	SOIL PROFILE NAME	Soil shear wave velocity, $\overline{v}_s$, (ft/s)	Standard penetration resistance, $\overline{N}$	Soil undrained shear strength, $\overline{s}_u$, (psf)
A	Hard rock	$\overline{v}_s > 5{,}000$	N/A	N/A
B	Rock	$2{,}500 < \overline{v}_s \leq 5{,}000$	N/A	N/A
C	Very dense soil and soft rock	$1{,}200 < \overline{v}_s \leq 2{,}500$	$\overline{N} > 50$	>2,000 psf
D	Stiff soil profile	$600 \leq \overline{v}_s < 1{,}200$	$15 \leq \overline{N} \leq 50$	1,000 to 2,000 psf
E	Stiff soil profile	$\overline{v}_s < 600$	$\overline{N} < 15$	<1,000 psf
E	—	Any profile with more than 10 ft of soil having the characteristics: 1. Plasticity index $PI > 20$, 2. Moisture content $w \geq 40\%$, and 3. Undrained shear strength $\overline{s}_u < 500$ psf		
F	—	Any profile containing soils having one or more of the following characteristics: 1. Soils vulnerable to potential failure or collapse under seismic loading such as liquefiable soils, quick and highly sensitive clays, collapsible weakly cemented soils. 2. Peats and/or highly organic clays ($H > 10$ feet of peat and/or highly organic clay where H = thickness of soil) 3. Very high plasticity clays ($H > 25$ feet with plasticity index $PI > 75$) 4. Very thick soft/medium stiff clays ($H > 120$ feet)		

For SI: 1ft/s = 0.3048 m/s 1lb/ft² = 0.0479 kN/m²

Article 3.4.2.3 — Site Coefficients

Table 3.4.2.3-1 (for F_{pga})—Values of F_{pga} as a Function of Site Class and Mapped Peak Ground Acceleration Coefficient

Site Class	Mapped Peak Ground Acceleration				
	PGA ≤ 0.10	PGA = 0.20	PGA = 0.30	PGA = 0.40	PGA ≥ 0.50
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.2	1.2	1.1	1.0	1.0
D	1.6	1.4	1.2	1.1	1.0
E	2.5	1.7	1.2	0.9	0.9
F	See AASHTO Article 3.4.3				

Note: Use straight–line interpolation for intermediate values of PGA

For Site Class = D and PGA = 0.042 g, F_{PGA} = 1.600

Table 3.4.2.3-1 (for F_a)—Values of F_a as a Function of Site Class and Mapped Short-Period Spectral Acceleration Coefficient

Site Class	Spectral Response Acceleration Parameter at Short Periods				
	$S_S \leq 0.25$	$S_S = 0.50$	$S_S = 0.75$	$S_S = 1.00$	$S_S \geq 1.25$
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.2	1.2	1.1	1.0	1.0
D	1.6	1.4	1.2	1.1	1.0
E	2.5	1.7	1.2	0.9	0.9
F	See AASHTO Article 3.4.3				

Note: Use straight–line interpolation for intermediate values of S_S

For Site Class = D and S_S = 0.090 g, F_a = 1.600

Table 3.4.2.3-2—Values of F_v as a Function of Site Class and Mapped 1-sec Period Spectral Acceleration Coefficient

Site Class	Mapped Spectral Response Acceleration Coefficient at 1-sec Periods				
	$S_1 \le 0.10$	$S_1 = 0.20$	$S_1 = 0.30$	$S_1 = 0.40$	$S_1 \ge 0.50$
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.7	1.6	1.5	1.4	1.3
D	2.4	2.0	1.8	1.6	1.5
E	3.5	3.2	2.8	2.4	2.4
F	See AASHTO Article 3.4.3				

Note: Use straight–line interpolation for intermediate values of S_1

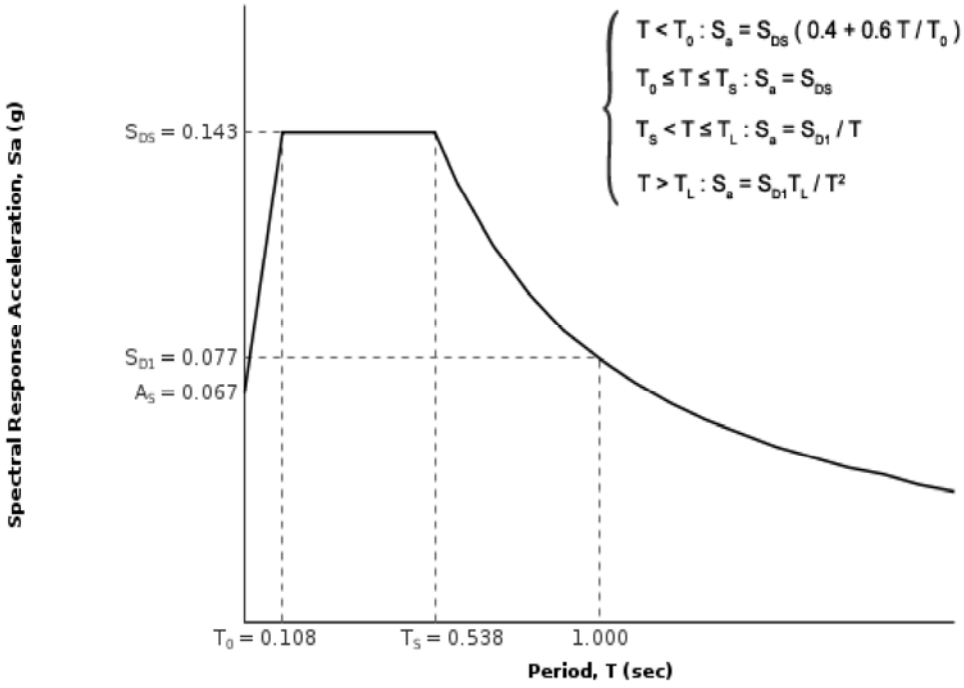
For Site Class = D and S_1 = 0.032 g, F_v = 2.400

Equation (3.4.1-1): $A_S = F_{PGA}\ PGA = 1.600 \times 0.042 = 0.067$ g

Equation (3.4.1-2): $S_{DS} = F_a\ S_S = 1.600 \times 0.090 = 0.143$ g

Equation (3.4.1-3): $S_{D1} = F_v\ S_1 = 2.400 \times 0.032 = 0.077$ g

Figure 3.4.1-1: Design Response Spectrum



Article 3.5 - Selection of Seismic Design Category (SDC)

Table 3.5-1—Partitions for Seismic Design Categories A, B, C, and D

VALUE OF S_{D1}	SDC
S_{D1} < 0.15g	A
0.15g ≤ S_{D1} < 0.30g	B
0.30g ≤ S_{D1} < 0.50g	C
0.50g ≤ S_{D1}	D

For S_{D1} = 0.077 g, Seismic Design Category = A

Seismic Design Category ≡ "the design category in accordance with Table 3.5-1" = A

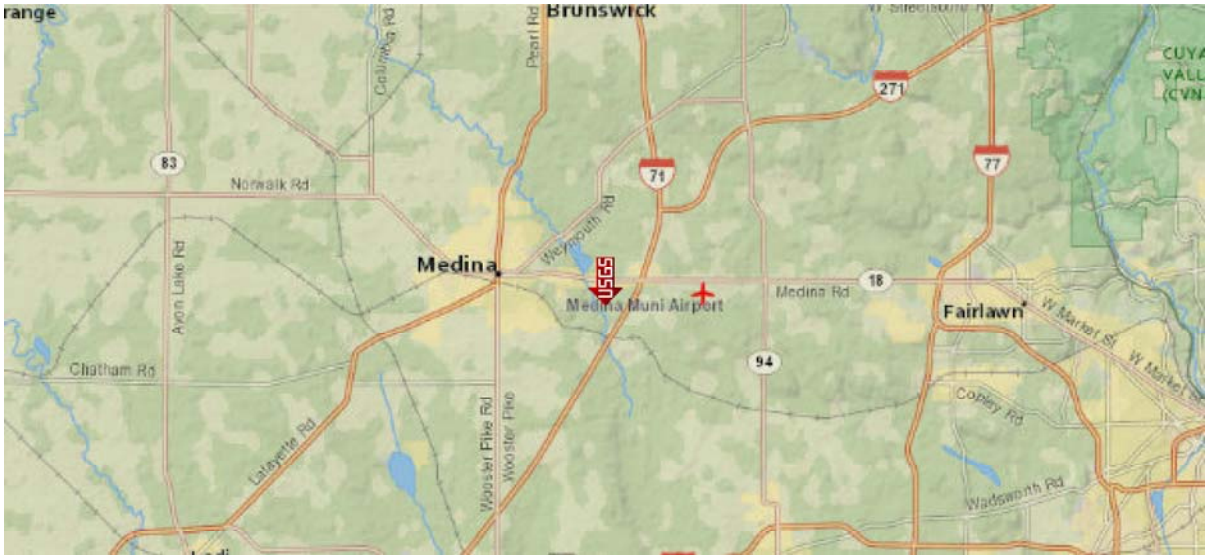
References

1. *Figure 3.4.1-2*: http://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/AASHTO-2009-Figure-3.4.1-2.pdf
2. *Figure 3.4.1-3*: http://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/AASHTO-2009-Figure-3.4.1-3.pdf
3. *Figure 3.4.1-4*: http://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/AASHTO-2009-Figure-3.4.1-4.pdf

USGS Design Maps Summary Report

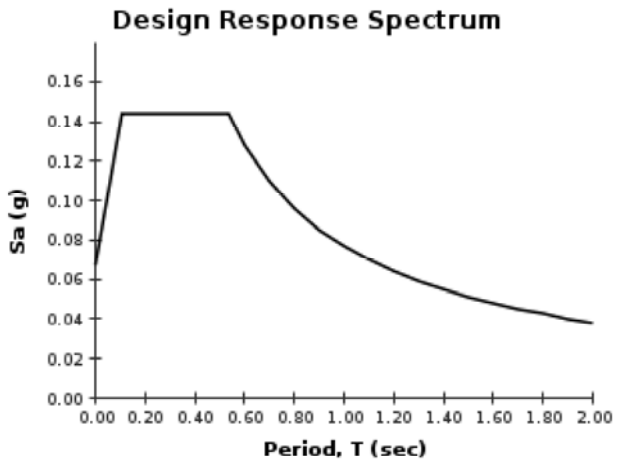
User–Specified Input

Report Title	Historical Landslide Location Sta 166+00 Wed February 1, 2017 18:42:55 UTC
Building Code Reference Document	2009 AASHTO Guide Specifications for LRFD Seismic Bridge Design (which utilizes USGS hazard data available in 2002)
Site Coordinates	41.13658°N, 81.81247°W
Site Soil Classification	Site Class D – "Stiff Soil"



USGS–Provided Output

PGA =	0.042 g	**A_s =**	0.067 g
S_s =	0.090 g	**S_{DS} =**	0.144 g
S_1 =	0.032 g	**S_{D1} =**	0.077 g



Design Maps Detailed Report

2009 AASHTO Guide Specifications for LRFD Seismic Bridge Design (41.13658°N, 81.81247°W)

Site Class D – "Stiff Soil"

Article 3.4.1 — Design Spectra Based on General Procedure

Note: Maps in the 2009 AASHTO Specifications are provided by AASHTO for Site Class B. Adjustments for other Site Classes are made, as needed, in Article 3.4.2.3.

From Figure 3.4.1-2 [1]	PGA = 0.042 g
From Figure 3.4.1-3 [2]	S_S = 0.090 g
From Figure 3.4.1-4 [3]	S_1 = 0.032 g

Article 3.4.2.1 — Site Class Definitions

The authority having jurisdiction (not the USGS), site-specific geotechnical data, and/or the default has classified the site as Site Class D, based on the site soil properties in accordance with Article 3.4.2.

Table 3.4.2.1–1 Site Class Definitions

SITE CLASS	SOIL PROFILE NAME	Soil shear wave velocity, $\overline{v}_s$, (ft/s)	Standard penetration resistance, $\overline{N}$	Soil undrained shear strength, $\overline{s}_u$, (psf)
A	Hard rock	$\overline{v}_s > 5{,}000$	N/A	N/A
B	Rock	$2{,}500 < \overline{v}_s \leq 5{,}000$	N/A	N/A
C	Very dense soil and soft rock	$1{,}200 < \overline{v}_s \leq 2{,}500$	$\overline{N} > 50$	>2,000 psf
D	Stiff soil profile	$600 \leq \overline{v}_s < 1{,}200$	$15 \leq \overline{N} \leq 50$	1,000 to 2,000 psf
E	Stiff soil profile	$\overline{v}_s < 600$	$\overline{N} < 15$	<1,000 psf
E	—	Any profile with more than 10 ft of soil having the characteristics: 1. Plasticity index $PI > 20$, 2. Moisture content $w \geq 40\%$, and 3. Undrained shear strength $\overline{s}_u < 500$ psf		
F	—	Any profile containing soils having one or more of the following characteristics: 1. Soils vulnerable to potential failure or collapse under seismic loading such as liquefiable soils, quick and highly sensitive clays, collapsible weakly cemented soils. 2. Peats and/or highly organic clays ($H > 10$ feet of peat and/or highly organic clay where H = thickness of soil) 3. Very high plasticity clays ($H > 25$ feet with plasticity index $PI > 75$) 4. Very thick soft/medium stiff clays ($H > 120$ feet)		

For SI: 1ft/s = 0.3048 m/s 1lb/ft² = 0.0479 kN/m²

Article 3.4.2.3 — Site Coefficients

Table 3.4.2.3-1 (for F_{pga})—Values of F_{pga} as a Function of Site Class and Mapped Peak Ground Acceleration Coefficient

Site Class	Mapped Peak Ground Acceleration				
	PGA ≤ 0.10	PGA = 0.20	PGA = 0.30	PGA = 0.40	PGA ≥ 0.50
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.2	1.2	1.1	1.0	1.0
D	1.6	1.4	1.2	1.1	1.0
E	2.5	1.7	1.2	0.9	0.9
F	See AASHTO Article 3.4.3				

Note: Use straight–line interpolation for intermediate values of PGA

For Site Class = D and PGA = 0.042 g, F_{PGA} = 1.600

Table 3.4.2.3-1 (for F_a)—Values of F_a as a Function of Site Class and Mapped Short-Period Spectral Acceleration Coefficient

Site Class	Spectral Response Acceleration Parameter at Short Periods				
	$S_S \leq 0.25$	$S_S = 0.50$	$S_S = 0.75$	$S_S = 1.00$	$S_S \geq 1.25$
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.2	1.2	1.1	1.0	1.0
D	1.6	1.4	1.2	1.1	1.0
E	2.5	1.7	1.2	0.9	0.9
F	See AASHTO Article 3.4.3				

Note: Use straight–line interpolation for intermediate values of S_S

For Site Class = D and S_S = 0.090 g, F_a = 1.600

Table 3.4.2.3-2—Values of F_v as a Function of Site Class and Mapped 1-sec Period Spectral Acceleration Coefficient

Site Class	Mapped Spectral Response Acceleration Coefficient at 1-sec Periods				
	$S_1 \le 0.10$	$S_1 = 0.20$	$S_1 = 0.30$	$S_1 = 0.40$	$S_1 \ge 0.50$
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.7	1.6	1.5	1.4	1.3
D	2.4	2.0	1.8	1.6	1.5
E	3.5	3.2	2.8	2.4	2.4
F	See AASHTO Article 3.4.3				

Note: Use straight–line interpolation for intermediate values of S_1

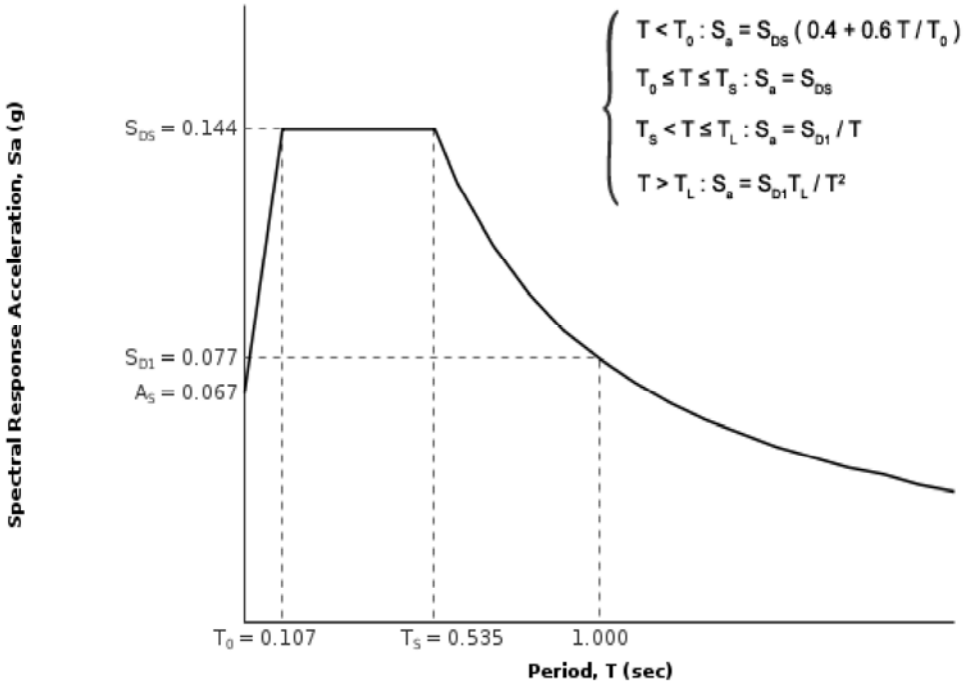
For Site Class = D and S_1 = 0.032 g, F_v = 2.400

Equation (3.4.1-1): $A_S = F_{PGA}\ PGA = 1.600 \times 0.042 = 0.067$ g

Equation (3.4.1-2): $S_{DS} = F_a\ S_S = 1.600 \times 0.090 = 0.144$ g

Equation (3.4.1-3): $S_{D1} = F_v\ S_1 = 2.400 \times 0.032 = 0.077$ g

Figure 3.4.1-1: Design Response Spectrum



Article 3.5 - Selection of Seismic Design Category (SDC)

Table 3.5-1—Partitions for Seismic Design Categories A, B, C, and D

VALUE OF S_{D1}	SDC
S_{D1} < 0.15g	A
0.15g ≤ S_{D1} < 0.30g	B
0.30g ≤ S_{D1} < 0.50g	C
0.50g ≤ S_{D1}	D

For S_{D1} = 0.077 g, Seismic Design Category = A

Seismic Design Category ≡ "the design category in accordance with Table 3.5-1" = A

References

1. *Figure 3.4.1-2*: http://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/AASHTO-2009-Figure-3.4.1-2.pdf
2. *Figure 3.4.1-3*: http://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/AASHTO-2009-Figure-3.4.1-3.pdf
3. *Figure 3.4.1-4*: http://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/AASHTO-2009-Figure-3.4.1-4.pdf