Resource International, Inc.

AUG-33-16.69
PID NO. 99467
AUGLAIZE COUNTY, OHIO

GEOTECHNICAL EXPLORATION REPORT

Prepared For:
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Rii Project No. W-15-074

April 2016

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April 13, 2016

Mr. William H. Marty, P.E.
Principal
Carpenter Marty Transportation
7007 Discovery Boulevard
Dublin, Ohio 43017

Re: Geotechnical Exploration Report
AUG-33-16.69
PID No. 99467
Rii Project No. W-15-074

Mr. Marty:

Resource International, Inc. (Rii) is pleased to submit this geotechnical exploration report for the above-referenced project. Engineering logs have been prepared and are attached to this report along with the results of the laboratory testing. This report includes recommendations for the proposed realignment of roughly 1,000 feet of the existing Ametek Plastics railroad track near the intersection of Cemetery Road (CR 161) and US Route 33 in Auglaize County, Ohio.

We sincerely appreciate having been given the opportunity to be of service to you on this project. If you have any questions regarding the geotechnical exploration or this report, do not hesitate to contact us.

Sincerely,

RESOURCE INTERNATIONAL, INC.

James R. Howdyshell, P.E.
Project Engineer

Jonathan P. Sterenberg, P.E.
Director – Geotechnical Services

Enclosure: Geotechnical Exploration Report

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EXECUTIVE SUMMARY

Resource International, Inc. (Rii) has completed a geotechnical exploration report for the proposed realignment of approximately 1,000 feet of the existing Ametek Plastics railroad track passing through the intersection of Cemetery Road (CR 161) and US Route 33 in the city of Wapakoneta, within Auglaize County, Ohio. The existing track extends from the Ametek Plastics fabrication plant located in the northwestern quadrant of the intersection, and extends across the intersection to the southeast. Plan information available at the time of this report indicates that the subject track will be realigned with a new turn located in the northeast quadrant of the intersection, and that the new track will roughly parallel the north side of US Route 33 as it extends eastward. It is anticipated that up to 9.2 feet of new fill material will be required along the proposed alignment to bring the existing site to proposed grade, with the required fill depth increasing towards the east.

Exploration and Findings

On July 8, 2015 a total of four (4) test borings, designated as B-001-0-15 through B-004-0-15, were drilled for the proposed railroad realignment and extended to completion depths ranging from 20.0 to 25.0 feet beneath the existing ground surface.

The borings performed as part of this investigation were each located outside the limits of the existing pavement and consistently encountered 2.0 inches of topsoil at the ground surface, as identified by the significant presence of vegetation and organic material.

Underlying the surficial topsoil, borings B-001 through B-003 encountered primarily cohesive soils with granular seams and layers of varying thicknesses. Boring B-004, located on the eastern end of the proposed alignment, encountered entirely granular soils. The cohesive soils were generally described as brown, dark brown and gray sandy silt, silt and clay, and silty clay (ODOT A-4a, A-6a, and A-6b). The granular soils were generally described as brown, light brown, dark brown, gray and dark gray gravel, gravel with sand, and coarse and fine sand (ODOT A-1-a, A-1-b, and A-3a).

Analysis and Recommendations

The embankment foundation soils along the proposed alignment are anticipated to consist of predominantly cohesive materials comprised of brown, dark brown and gray sandy silt, silt and clay, and silty clay (ODOT A-4a, A-6a, and A-6b). It should be noted that granular materials were encountered at the location of boring B-004 on the east end of the proposed alignment. As a result, granular soils consisting of light brown coarse and fine sand (ODOT A-3a) are anticipated at the embankment foundation level in the vicinity of the eastern terminus.

The subgrade soils in boring B-001 were described as medium stiff to stiff and will likely require stabilization. Based on the results of the GB1 analysis, in order to create a good working platform on which to place the fill, Rii recommends either over excavation to a depth of 18 inches in this area and replacement with ODOT Item 703.16C granular material Type B or C, with 712.09 Geotextile Fabric Type D, or cement stabilization to a depth of 14 inches.

Based on the information available at the time of this report, it is anticipated that the proposed embankment will have an approximate length of 1,000 feet and a width of up to 40 feet, with slopes graded at 2(H):1(V) on both sides. Based on our discussions with Carpenter Marty, Rii understands that the proposed embankment material will be composed of ODOT Item 203 granular embankment fill, with 4.0 inches each of compacted sub-ballast and compacted ballast pad directly beneath the tracks. Furthermore, based on information available from the American Railway Engineering and Maintenance-of-Way Association (AREMA) a live-load surcharge on the order of 1,880 psf was approximated along the proposed embankment to model the loading effects of train traffic.

Analyses of the proposed embankment slopes under both short and long term conditions resulted in factor-of-safety values greater than 1.3. This is an indication that the proposed embankment, constructed with 2(H):1(V) side slopes, will be stable.

Total settlements of up to 1.37 inches at the center of the embankment and 0.89 inches at the toe of the embankment are anticipated. Based on the results of the analysis, 90 percent of the total settlement across the footprint of the proposed embankment is anticipated to occur over a period of approximately 10 days.

Please note that this executive summary does not contain all the information presented in the report. The unabridged subsurface exploration report should be read in its entirety to obtain a more complete understanding of the information presented.

1.0 INTRODUCTION

This report is a presentation of the geotechnical exploration performed for the proposed realignment of approximately 1,000 feet of the existing Ametek Plastics railroad track passing through the intersection of Cemetery Road (CR 161) and US Route 33 in the city of Wapakoneta, within Auglaize County, Ohio. The existing track extends from the Ametek Plastics fabrication plant located in the northwestern quadrant of the intersection, and extends across the intersection to the southeast. Plan information available at the time of this report indicates that the subject track will be realigned with a new turn located in the northeast quadrant of the intersection, and that the new track will roughly parallel the north side of US Route 33 as it extends eastward. It is anticipated that up to 9.2 feet of new fill material will be required along the proposed alignment to bring the existing site to proposed grade, with the required fill depth increasing towards the east. The project area is shown on the vicinity map presented in Appendix II of this report.

2.0 GEOLOGY AND OBSERVATIONS OF THE PROJECT

2.1 Site Geology

Both the Illinoian and Wisconsinan glaciers advanced over two-thirds of the State of Ohio, leaving behind glacial features such as moraines, kame deposits, lacustrine deposits and outwash terraces. The glacial and non-glacial regions comprise five physiographic sections grouped by age, depositional process and geomorphic occurrence. Physiographically, the site lies within the Central Ohio Clayey Till Plain Region within the Till Plains Section. This region is characterized by well-defined moraines with interspersed flat-lying ground and end moraines and intermorainal lake basins. Ground moraines are deposited during the retreat of a glacier, resulting in an undifferentiated mixture of clay, silt, sand and gravel. Ground moraines in the vicinity of the site are predominantly comprised of clayey till. End moraines are normally associated with ice melting that is neither advancing nor retreating for a period of time. The lake basins consist of silt, clay and till-filled deposits. A lake basin is present to the southeast of Wapakoneta, in the vicinity of the site, containing lacustrine sand that was deposited by a glacial lake or shallow water delta.

Based on bedrock geology and topography maps obtained from the Ohio Department of Natural Resources (ODNR), the bedrock underlying the glacial deposits at the site consists of two formations, the Lockport Dolomite Formation and the Cincinnati Group. The younger of the two, the Upper and Lower Silurian-aged Lockport Dolomite consists of variegated white to gray dolomite which is finely to coarsely crystalline, medium to massively bedded, fossiliferous, vuggy, and locally cherty. The older unit, which lies mostly in a buried valley running beneath the site, is the Upper Ordovician-aged Cincinnati Group. This unit consists of interbedded shale, limestone and dolomite. The shale ranges in color from gray, olive, red and green and is calcareous, silty and dolomitic. The limestone ranges from gray to olive in color, containing thin to medium,

irregular, nodular to wavy bedding, is argillaceous, and is finely to coarsely crystalline. The dolomite ranges from olive to yellowish gray, contains thin to medium beds, is argillaceous, and is also finely to coarsely crystalline. This unit contains sparse to abundant fossils.

According to bedrock topography mapping, the bedrock surface forms a narrow valley beneath Cemetery Road which trends in a north-south direction beneath the project site. To the north and south of the I-75 interchanges with US Route 33 and Wapakoneta Fisher Road, the valley underlying the site curves westward slightly and splits into "Y-shaped" valleys extending north and south in both directions. The bedrock valley bottom lies at an approximate elevation of 550 feet mean sea level (msl). The site overlies both the bottom of this valley and the eastern slope of this valley, which extends upward to an elevation of approximately 720 feet msl near the intersection of US Route 33 and Wapakoneta Fisher Road. Therefore, it is anticipated that the bedrock surface ranges in depth from roughly 220 to 370 feet below existing grade within the project limits. Illustrations of the general geology of Ohio are included in Appendix I.

2.2 Existing Site Conditions

The subject site is located along the southeastern limits of the City of Wapakoneta, in the center of Auglaize County, Ohio. At the existing intersection with US Route 33, Cemetery Road maintains one (1) lane of traffic in each direction along its primarily north-south alignment. Stop signs halt traffic along Cemetery Road in both directions at the intersection, while traffic along US Route 33 is allowed to freely pass through the intersection. US Route 33 crosses Cemetery Road in an east-west orientation, maintaining two (2) lanes of traffic in the westbound direction and one (1) through-lane in the eastbound direction. On the west side of the intersection, US Route 33 also maintains a dedicated left-hand turn lane, with a grass median separating the east and westbound lanes of traffic. A concrete median separates traffic along US Route 33 on the east side of the intersection with Cemetery Road.

The existing terrain across the subject site is relatively flat, with the roadways and existing railroad track slightly elevated from the surrounding properties. Drainage ditches parallel the paved surfaces of both roadways at the intersection collecting surface drainage. Within the immediate vicinity of the project site, land use consists primarily of commercially and residentially developed properties, while Saint Joseph Cemetery occupies the northeast quadrant of the intersection.

3.0 EXPLORATION

On July 8, 2015 a total of four (4) test borings, designated as B-001-0-15 through B-004-0-15, were drilled for the proposed railroad realignment and extended to completion depths ranging from 20.0 to 25.0 feet beneath the existing ground surface. The borings were performed at the locations illustrated on the boring plan presented in Appendix II of this report and summarized in Table 1.

Table 1. Test Boring Summary

Boring Number	Location [1]				Ground Elevation (feet) [2]	Boring Depth (feet)
	Station	Offset	Latitude	Longitude		
B-001-0-15	2444+41.83	19.7' Lt	40.555146872	-84.164280657	918.8	25.0
B-002-0-15	2441+28.61	5.0 Lt	40.555238517	-84.163145700	919.1	20.0
B-003-0-15	2438+28.61	5.0' Lt	40.555378010	-84.162081679	917.2	20.0
B-004-0-15	2435+28.22	5.7' Lt	40.555516954	-84.161016136	914.2	20.0

1. *Boring locations referenced to Ametek Plastics railroad centerline.*
2. *Ground surface elevations at the boring locations determined from available topographic mapping provided by Carpenter Marty.*

Boring locations were determined and field located by Rii personnel prior to drilling operations. During the field locating and reconnaissance, Rii utilized a handheld GPS unit to obtain state plane northing and easting coordinates at the boring locations. Ground surface elevations were interpolated from topographic information provided by Carpenter Marty.

The borings were drilled with an all-terrain vehicle (ATV) mounted rotary drilling machine, utilizing a 4.5-inch outside diameter, solid flight auger to advance the holes between sampling attempts. In general, standard penetration test (SPT) and split spoon sampling were performed at 2.5-foot intervals to a depth of 20.0 feet below the ground surface and at 5.0-foot intervals thereafter to the boring termination depths.

The SPT, per the American Society for Testing and Materials (ASTM) designation D1586, is conducted by using a 140-pound hammer free falling 30.0 inches to drive a 2.0-inch outside diameter split spoon sampler 18.0 inches. Rii utilized a calibrated automatic drop hammer to generate consistent energy transfer to the sampler. Driving resistance is recorded on the boring logs in terms of blows per 6.0-inch interval of the driving distance. The second and third intervals are added to obtain the number of blows per foot (N). SPT blow counts aid in estimating soil characteristics used to calculate bearing capacities and settlement potential. Measured blow count (N_m) values are corrected to an equivalent (60%) energy ratio, N_{60}, by the following equation. Both values are represented on boring logs presented in Appendix IV.

$$N_{60} = N_m*(ER/60)$$

Where:
N_m = measured N value
ER = drill rod energy ratio, expressed as a percent, for the system used

The hammer for the CME-750 drill rig operated by Rii on this project was calibrated on October 20, 2014 and has a drill rod energy ratio of 92.9 percent.

Upon completion of drilling, the borings were backfilled in accordance with the ODOT policy for sealing boreholes, utilizing a mixture of bentonite chips and soil cuttings generated during the drilling process.

During drilling, Rii personnel prepared field logs showing the encountered subsurface conditions. Soil samples obtained from the drilling operation were preserved in sealed glass jars and delivered to the soil laboratory. In the laboratory, the soil samples recovered from the roadway borings were visually classified and select samples were tested as noted in Table 2.

Table 2. Laboratory Test Schedule – Roadway Borings

Laboratory Test	Test Designation	Number of Tests Performed
Natural Moisture Content	ASTM D 2216	34
Plastic and Liquid Limits	AASHTO T89, T90	14
Gradation – Sieve/Hydrometer	AASHTO T88	14

These tests are necessary to classify the soil according to the Ohio Department of Transportation (ODOT) Classification System. The results are also used to estimate engineering properties of importance in determining subgrade design and soil related construction considerations. Results of the laboratory testing are presented on the boring logs in Appendix IV. A description of the soil terms used throughout this report is presented in Appendix III.

Hand penetrometer readings, which provide a rough estimate of the unconfined compressive strength of the soil, were reported on the boring logs in units of tons per square foot (tsf) and were utilized to classify the consistency of the cohesive soil in each layer. An indirect estimate of the unconfined compressive strength of the cohesive split spoon samples can also be made from a correlation with the blow counts (N_{60}). Please note that split spoon samples are considered to be disturbed and the laboratory determination of their shear strengths may vary from undisturbed conditions.

4.0 FINDINGS

Interpreted engineering logs have been prepared from the field logs, visual examination of samples and laboratory testing. Classification follows the current ODOT Specifications for Geotechnical Explorations (SGE). The following is a generalization of what was found in the test borings and what is represented on the boring logs.

4.1 Surface Materials

The borings performed as part of this investigation were each located outside the limits of the existing pavement and consistently encountered 2.0 inches of topsoil at the ground surface, as identified by the significant presence of vegetation and organic material.

4.2 Subsurface Soils

Underlying the surficial topsoil, borings B-001 through B-003 encountered primarily cohesive soils with granular seams and layers of varying thicknesses. Boring B-004, located on the eastern end of the proposed alignment, encountered entirely granular soils. The cohesive soils were generally described as brown, dark brown and gray sandy silt, silt and clay, and silty clay (ODOT A-4a, A-6a, and A-6b). The granular soils were generally described as brown, light brown, dark brown, gray and dark gray gravel, gravel with sand, and coarse and fine sand (ODOT A-1-a, A-1-b, and A-3a).

The shear strength and consistency of the cohesive soils are primarily derived from the hand penetrometer values (HP). The natural cohesive soils encountered generally ranged from medium stiff ($0.5 < HP \leq 1.0$ tsf) to hard ($HP > 4.0$ tsf). The unconfined compressive strength of the natural cohesive soil samples tested, obtained from the hand penetrometer, ranged from 0.75 to 4.5 tsf (limit of instrument), generally increasing with depth. The relative density of the granular soils is primarily derived from SPT blow counts (N_{60}). Based on the SPT blow counts obtained, the natural granular soils encountered were generally described as medium dense ($11 \leq N_{60} \leq 30$ blows per foot [bpf]) to dense ($31 \leq N_{60} \leq 50$ bpf). Overall blow counts recorded from the SPT sampling ranged from 8 to 43 bpf, generally increasing with depth.

Natural moisture contents of the soil samples tested ranged from 8 to 25 percent. The natural moisture contents of the cohesive soil samples tested for plasticity index ranged from 2 percent below to 9 percent above their corresponding plastic limits. In general, the soils exhibited natural moisture contents that ranged from slightly below to significantly above optimum moisture levels.

4.3 Bedrock

Bedrock was not encountered in any of the borings performed for this exploration.

4.4 Groundwater

During drilling, groundwater seepage was initially encountered in boring B-004 at a depth of 7.0 feet beneath the ground surface, corresponding to an elevation of 907.2 feet msl. More significant groundwater flow was encountered initially in each of the

borings at depths ranging from 8.0 to 16.0 feet beneath the ground surface, correlating to elevations ranging from 903.1 to 910.8 feet msl.

At the completion of drilling, groundwater had accumulated within each of the boreholes to depths ranging from 5.0 to 16.5 feet beneath the ground surface. Based on the ground surface elevations of the boring locations, groundwater levels at the completion of drilling varied in elevation from 902.6 to 909.2 feet msl. A summary of the depths and elevations at which groundwater was encountered in the borings is presented in Table 3.

Table 3. Groundwater Level Readings in Borings

Boring Number	Ground Elevation (feet) [1]	Groundwater Seepage		Initial Groundwater		Groundwater Upon Completion	
		Depth (feet)	Elevation (feet)	Depth (feet)	Elevation (feet)	Elevation (feet)	Elevation (feet)
B-001-0-15	918.8	-	-	8.0	910.8	10.0	908.8
B-002-0-15	919.1	-	-	16.0	903.1	16.5	902.6
B-003-0-15	917.2	-	-	12.0	905.2	10.0	907.2
B-004-0-15	914.2	7.0	907.2	8.0	906.2	5.0	909.2

1. *Ground surface elevations at the boring locations determined from available topographic mapping provided by Carpenter Marty.*

Please note that short-term water level readings, especially in cohesive soils, are not necessarily an accurate indication of the actual groundwater conditions. In addition, groundwater levels or the presence of groundwater are considered to be dependent on seasonal fluctuations in precipitation. A more comprehensive description of the subsurface conditions encountered during the drilling program can be found on the boring logs in Appendix IV.

5.0 ANALYSES AND RECOMMENDATIONS

Data obtained from the drilling and testing program have been used to determine embankment foundation and support capabilities along with shear strength parameters for evaluating the stability and settlement potential for the soils encountered at the site. These parameters have been used to provide guidelines for the design of the proposed embankment, as well as the construction specifications related to the placement of the fill material and general earthwork recommendations, which are discussed in the following paragraphs.

5.1 Embankment Subgrade Recommendations

The embankment foundation soils along the proposed alignment are anticipated to consist of predominantly cohesive materials comprised of brown, dark brown and gray sandy silt, silt and clay, and silty clay (ODOT A-4a, A-6a, and A-6b). It should be noted that granular materials were encountered at the location of boring B-004 on the east end of the proposed alignment. As a result, granular soils consisting of light brown coarse and fine sand (ODOT A-3a) are anticipated at the embankment foundation level in the vicinity of the eastern terminus.

Based on the soil conditions encountered during the drilling phase, it is estimated that the subgrade soils within the upper portions of the embankment foundation (existing ground surface) may require some level of stabilization under ODOT Geotechnical Bulletin GB1: Plan Subgrades. Profile information available at the time of this report indicates that embankment heights ranging from 0.0 to 9.2 feet or more will be required to bring the site to the proposed subgrade elevation. These heights were used in the GB1 spreadsheet analysis. It is recommended that the subgrade soils be thoroughly proofrolled prior to the placement of any new fill or any railroad construction materials (sub-ballast, ballast, ties, rails, etc.). The subgrade soils in boring B-001 were described as medium stiff to stiff and will likely require stabilization. Based on the GB1 analysis, in order to create a good working platform on which to place the fill, Rii recommends either over excavation to a depth of 18 inches in this area and replacement with ODOT Item 703.16C granular material Type B or C, with 712.09 Geotextile Fabric Type D, or cement stabilization to a depth of 14 inches. Other stabilization methods are presented in Section 5.4 of this report. The complete GB1 analysis of each soil boring is presented in Appendix V.

The moisture content of cohesive soil has a significant effect on the physical properties of the material. It must be noted that the moisture contents illustrated on the boring logs, and utilized in this analysis, represent the conditions during the drilling phase of the project. The referenced borings for subgrade analysis were drilled on July 8, 2015. These soil conditions, especially in the surficial soils, may not coincide with the soil conditions that will be encountered during construction. Consequently, the extent/need for subgrade improvement is entirely dependent on the subgrade conditions (i.e., moisture contents) encountered at the time of construction.

5.2 Slope Stability Evaluation

The stability of a slope is evaluated by determining the ratio of the resisting forces to the driving forces, which is the factor-of-safety. The driving forces are produced by the weight of the soil in the upper portion of the slope, and the resisting forces are primarily derived from the shear strength of the soil as well as from the weight of the soil near the toe of the slope. A factor-of-safety of greater than 1.0 indicates a stable slope condition, and a factor-of-safety of less than 1.0 indicates a failing slope condition. For slopes not

supporting a structural foundation, the minimum required factor of safety against slope failure is 1.3.

Based on the information available at the time of this report, it is anticipated that the proposed embankment will have an approximate length of 1,000 feet and a width of up to 40 feet, with slopes graded at 2(H):1(V) on both sides. Based on our discussions with Carpenter Marty, Rii understands that the proposed embankment material will be composed of ODOT Item 203 granular embankment fill, with 4.0 inches each of compacted sub-ballast and compacted ballast pad directly beneath the tracks. Furthermore, based on information available from the American Railway Engineering and Maintenance-of-Way Association (AREMA) a live-load surcharge on the order of 1,880 psf was approximated along the proposed embankment to model the loading effects of train traffic.

The parameters utilized in the slope stability analysis of the proposed embankment are summarized in Table 4.

Table 4. Shear Strength Parameters Utilized in Stability Analyses

Material Type	Unit Weight, γ (pcf)	Effective Friction Angle, φ' (°)	Effective Cohesion, c' (psf)	Undrained Shear Strength, s_u (psf)
New Fill: ODOT Item 203	120	30	200	2,000
New Fill: Railroad Ballast	130	36	0	N/A
Medium Dense Granular Soils (ODOT A-1-a, A-1-b, A-3a)	120	30	0	N/A
Dense Granular Soils (ODOT A-1-a, A-1-b, A-3a)	125	32	0	N/A
Medium Stiff to Stiff Cohesive Soils (ODOT A-4a, A-6a, A-6b)	115	28	0	750
Stiff Cohesive Soils (ODOT A-4a, A-6a, A-6b)	120	30	0	1,500
Very Stiff to Hard Cohesive Soils (ODOT A-4a, A-6a, A-6b)	125	32	0	3,000

The long term shear strength parameters (drained/effective stress) for the existing soils encountered at the project site were determined using laboratory test results and engineering judgment. The undrained shear strength for the cohesive soils is based on hand penetrometer values of the soils within the respective zone. Shear strength parameters for new embankment fill were taken from the ODOT Geotechnical Bulletin 6 (GB-6) as a guide.

In order to verify the strength parameters presented in Table 4, it is recommended that the proposed embankment fill materials be periodically tested for index properties during construction. The index testing will verify that the proposed fill is consistent with the soils encountered in the borings, and that it is acceptable for use in the proposed embankment.

Based on the geotechnical exploration, and using the shear strength parameters provided in Table 4, a slope stability analysis of the proposed embankment was performed. Analyses of the proposed embankment slopes under both short and long term conditions resulted in factor-of-safety values greater than 1.3. This is an indication that the proposed embankment, constructed with 2(H):1(V) side slopes, will be stable. Results of the stability analyses have been included in Appendix VI and are summarized in Table 5.

Table 5. Summary of Slope Stability Results

Location [1]	Representative Boring	Condition Analyzed	Calculated Factor of Safety	
			Total Stress Condition	Effective Stress Condition
Sta. 2435+50	B-004-0-15	Existing Condition	1.66	1.66
		Proposed Embankment	1.63	1.46
Sta. 2438+50	B-003-0-15	Existing Condition	> 10	2.00
		Proposed Embankment	1.45	1.45
Sta. 2441+00	B-002-0-15	Existing Condition	> 10	2.46
		Proposed Embankment	1.68	1.36
Sta. 2444+50	B-001-0-15	Existing Condition	> 10	1.96
		Proposed Embankment	1.72	1.38

1. Locations of stability analyses referenced to centerline of track construction.

5.3 Settlement Evaluation

The compressibility parameters utilized in the settlement analyses of the proposed embankment are provided in Table 6.

Table 6. Compressibility Parameters Utilized in Settlement Analysis

Material Type	γ (pcf)	LL (%)	C_c (1)	C_r (2)	e_o (3)	C_v (4) (ft^2/yr)	N_{60}	C' (5)
Medium Dense Granular Soils (ODOT A-1-a, A-1-b, A-3a)	120	-	-	-	-	-	16	56 to 89
Dense Granular Soils (ODOT A-1-a, A-1-b, A-3a)	125	-	-	-	-	-	37	99 to 116
Medium Stiff to Stiff Cohesive Soils (ODOT A-6b)	115	35	0.225	0.023	0.546	400	-	-
Stiff Cohesive Soils (ODOT A-6a)	120	25	0.135	0.014	0.467	800	-	-
Very Stiff to Hard Cohesive Soils (ODOT A-4a)	125	23	0.117	0.012	0.452	1,000	-	-
Very Stiff to Hard Cohesive Soils (ODOT A-6a)	125	27	0.153	0.015	0.483	800	-	-

1. *Per Table 26, Section 5.4.2.5 of FHWA GEC 5.*
2. *Estimated at 10% of C_c per Section 5.4.2.5 of FHWA GEC 5.*
3. *Per Table 8-2 of Holtz and Kovacs (1981).*
4. *Per Figure 62, Section 5.4.5 of FHWA GEC 5.*
5. *Per Figure 10.6.2.4.2-1 of 2012 AASHTO LRFD BDS.*

Total settlements of up to 1.37 inches at the center of the embankment and 0.89 inches at the toe of the embankment are anticipated. Based on the results of the analysis, 90 percent of the total settlement across the footprint of the proposed embankment is anticipated to occur over a period of approximately 10 days. Please note that the consolidation settlement and time rate of consolidation are based on estimates using correlated compressibility parameters provided in Table 6 for the underlying soils. Actual settlement and time rate of consolidation should be determined by monitoring the settlement of the embankment using settlement platforms. Please note that the anticipated values represent the total settlement of both the proposed embankment and the underlying foundation soils.

If the total or differential settlement values predicted for the proposed embankment present an issue with respect to the deformation tolerances that the railroad tracks can withstand, then measures should be taken to minimize the amount of settlement that will occur. This can be achieved by preloading the site and consolidating the underlying soils prior to constructing the embankment.

5.4 Construction Considerations

All site work shall conform to the latest AREMA specifications or ODOT CMS including that all excavation, embankment preparation and construction follow ODOT Item 200 (Earthwork).

Prior to beginning excavation, grading and/or embankment operations across the site, all necessary clearing and grubbing shall be completed, including the complete removal of all topsoil and unsuitable fill materials (as determined by a geotechnical engineer or an experienced soil technician), vegetation, debris, saturated and/or soft/loose soils and/or existing pavement sections (where applicable) within the footprint of proposed pavement.

Cohesive soil, primarily those containing silt, tend to become unstable (i.e., soft and flexing) under repeated loading from heavy rubber-tired vehicles. Therefore, heavy vehicle traffic on subgrades should be limited as much as possible during construction. The subgrade should be closely observed to determine if unstable conditions do develop which will require stabilization as determined by the geotechnical engineer.

The proposed subgrade surfaces should be proofrolled with sufficient proofrolling apparatus (preferably a fully-loaded tandem-axle dump truck), prior to placing engineered fill. A geotechnical engineer or an experienced soil technician should be present during proofrolling to determine if soft soil with inadequate stability exists. Subgrade instability encountered during a proofroll is indicated by deflection, cracking or rutting of the surface. Soft soil is generally a result of the presence of very moist to wet cohesive soil. Deflecting subgrades may also be due to the presence of subsurface lenses of silt or fine sand, which typically contain water because the soil exhibits a higher porosity than the overlying and/or underlying cohesive soil. Based on the borings drilled, the moisture contents of the cohesive samples tested are considered to be slightly below to significantly above the corresponding optimum moisture contents. Soil in excess of the optimum moisture content creates the possibility of soft or unstable subgrades. It is likely that cohesive subgrade soil exhibiting natural moisture content in excess of its corresponding plastic limit will require some level of stabilization.

The extent/need for subgrade stabilization is entirely dependent on the subgrade conditions (i.e., moisture contents) encountered at the time of construction. If required, the method of stabilization employed is a function of the type of instability encountered, the location (i.e., depth) of the instability and the resources available.

Fine-grained soils, such as silt and fine-grained sand, have the potential to create a frost-susceptible subgrade. During construction, it is recommended that this type of material, where encountered, be over excavated and completely removed from within 3.0 feet of the proposed finished subgrade elevation. The overexcavation should be backfilled with engineered fill in accordance to the following paragraphs. Based on the soil conditions encountered in the borings performed for this project, fine-grained,

frost-susceptible soils are not anticipated to be encountered during construction of the proposed improvements.

Other stabilization options include 1) scarifying, drying and recompacting, 2) mixing wet soil with dry soil, 3) undercutting unsuitable surficial soil and replacing it with controlled density fill, and 4) a geogrid subgrade reinforcement system. Additional methods of subgrade stabilization are available and certainly may be effective (both physically and economically) in stabilizing the soil. The adequacy of any stabilization method should be verified through the construction of a test section. All proposed subgrade surfaces should be shaped to promote positive drainage, with a minimum slope of 2.0 percent or 0.25 inches per foot. Adequate drainage is necessary for maintaining the stability of the subgrade. Care should be taken during final grading so that no areas of potential ponding or standing water remain at the subgrade surface.

Generally, materials utilized for engineered fill should be free of waste construction debris and other deleterious materials and meet the following requirements:

- Maximum Dry Density per ASTM D 698 > 110 pcf
- Liquid Limit < 40
- Plasticity Index < 15
- Organic Matter < 3 percent
- Maximum Particle Size < 3 inches
- Silt Content (between 0.075 and 0.005 mm) < 45 percent

Compacted granular fill shall meet the above specification and additionally shall have a maximum 35 percent passing the No. 200 sieve.

It is anticipated that portions of the existing aggregate base material will be able to be reused as new aggregate base. In addition, most of the natural soils encountered on the site are considered suitable for reuse as structural fill for pavement support when compacted at their optimum moisture contents. Fill soil placed for pavement support should be placed in loose lifts not to exceed 8.0 inches. **All embankment fill should be placed and compacted in general accordance to Item 203 of the ODOT CMS**. Fill soil containing excess moisture shall be required to dry prior to or during compaction to a moisture content not greater than 3.0 percent above or below optimum. However, for material that displays pronounced elasticity or deformation under the action of loaded rubber tire construction equipment, the moisture content shall be reduced to optimum if necessary to secure stability.

Drying wet soil can be expedited by the use of plows, discs, or by other approved methods. The final determination of whether a material is suitable for reuse as fill should be made by the project geotechnical engineer or a field representative thereof. Fill soil should not be placed in a frozen condition or on a frozen subgrade.

All trenching and excavation procedures should follow applicable Occupational Safety and Health Administration (OSHA) standards, including adequate safety precautions conforming to OSHA standards for the personnel installing underground lines. Sloping or benching for excavations greater than 20 feet shall be designed by a registered professional engineer and should be provided by the contractor to the engineer for review and comment.

5.5 Groundwater Considerations

Based on the observations made during and after drilling in the borings performed for this exploration, it is anticipated that little to no groundwater seepage will be encountered during construction of the proposed embankment. Where (if) groundwater is encountered during construction of the proposed embankment, proper groundwater control should be employed and maintained to prevent disturbance of cohesive subgrade soil, and to prevent the possible development of a quick or "boiling" condition where soft silts and/or fine sands are encountered. It is preferable that the groundwater level, if encountered, be maintained at least 36 inches below the deepest excavation. It is anticipated that any seepage or groundwater encountered at this site should be able to be controlled by pumping from temporary sumps. As stated previously, groundwater levels or the presence of groundwater are considered to be dependent on seasonal fluctuations in precipitation. Note that determining and maintaining actual groundwater levels during construction is the responsibility of the contractor.

6.0 LIMITATIONS OF STUDY

The above recommendations are predicated upon construction inspection by a qualified soil technician under the direct supervision of a professional geotechnical engineer. Adequate testing and inspection during construction are considered necessary to assure an adequate foundation system and are part of our recommendations.

The recommendations for this project were developed utilizing soil information obtained from the test borings that were made at the proposed site. At this time we would like to point out that soil borings only depict the soil conditions at the specific locations and time at which they were made. The conditions at other locations on the site may differ from those occurring at the boring locations.

The conclusions and recommendations herein have been based upon the available soil information and the preliminary design details furnished by a representative of the owner of the proposed project. Any revision in the plans for the proposed construction from those anticipated in this report should be brought to the attention of the geotechnical engineer to determine whether any changes in earthwork recommendations are necessary. If deviations from the noted subsurface conditions are encountered during construction, they should also be brought to the attention of the geotechnical engineer.

The scope of our services does not include any environmental assessment or exploration for the presence or absence of hazardous or toxic materials in the soil, groundwater, or surface water within or beyond the site studied. Any statements in this report or on the test boring logs regarding odors, staining of soils, or other unusual conditions observed are strictly for the information of our client.

Our professional services have been performed, our findings obtained, and our recommendations prepared in accordance with generally accepted Geotechnical engineering principles and practices. Resource International is not responsible for the conclusions, opinions, or recommendations made by others based upon the data included.

APPENDIX I

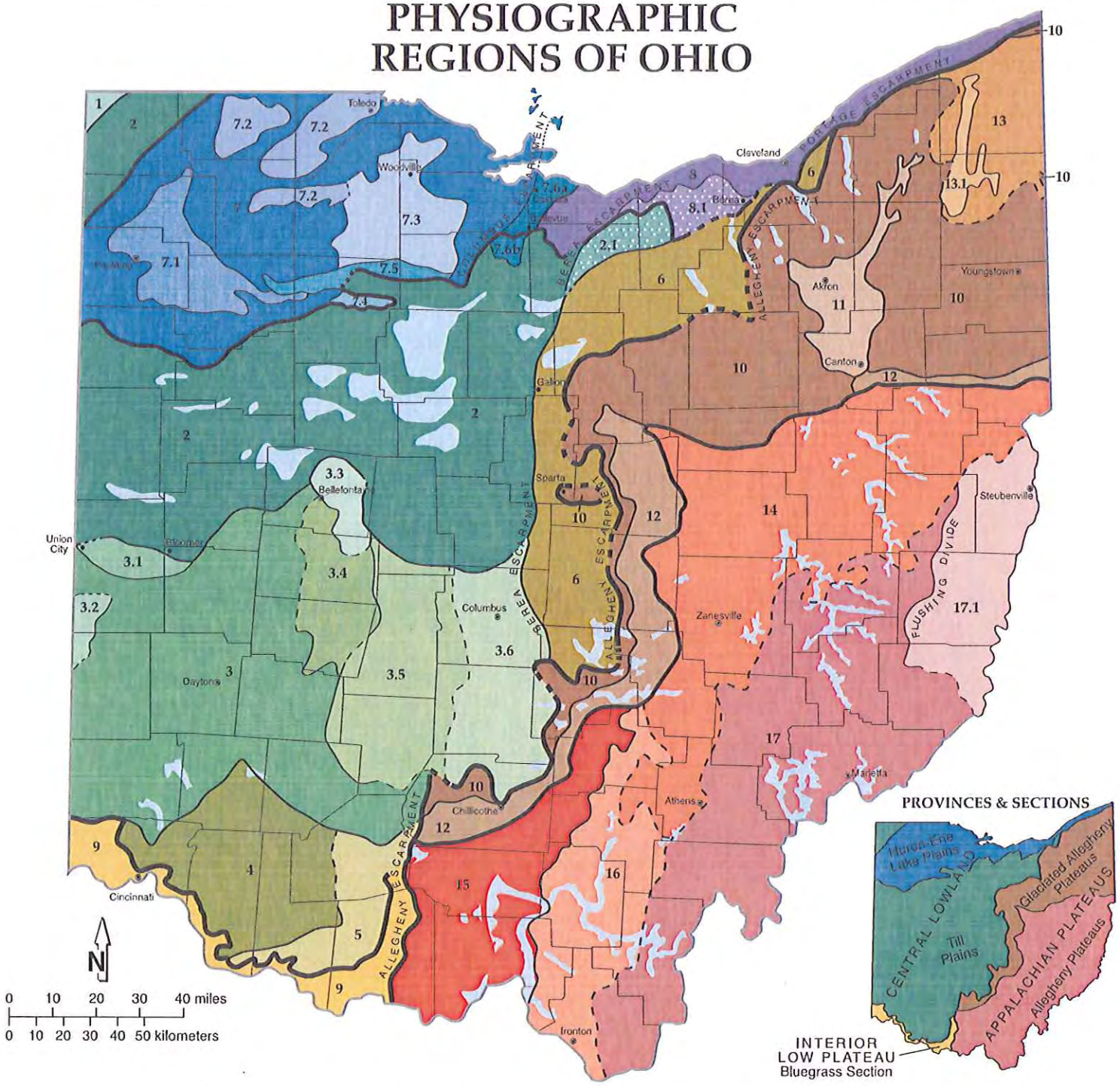
STATE GEOLOGY

STATE OF OHIO
Ted Strickland, Governor

DEPARTMENT OF NATURAL RESOURCES
Sean D. Logan, Director

DIVISION OF GEOLOGICAL SURVEY
Lawrence H. Wickstrom, Chief

PHYSIOGRAPHIC REGIONS OF OHIO



Till Plains

- 1. Steuben Till Plain
- 2. Central Ohio Clayey Till Plain
  - 2.1. Berea Headlands of the Till Plain
- 3. Southern Ohio Loamy Till Plain
  - 3.1. Union City-Bloomer Transitional Terrain
  - 3.2. Whitewater Interlobate Plain
  - 3.3. Bellefontaine Upland
  - 3.4. Mad River Interlobate Plain
  - 3.5. Darby Plain
  - 3.6. Columbus Lowland
- 4. Illinoian Till Plain
- 5. Dissected Illinoian Till Plain
- 6. Galion Glaciated Low Plateau

Transitional boundary

Lake basin/deposits outside Huron-Erie Lake Plains

Huron-Erie Lake Plains

- 7. Maumee Lake Plains
  - 7.1. Paulding Clay Basin
  - 7.2. Maumee Sand Plains
  - 7.3. Woodville Lake-Plain Reefs
  - 7.4. Findlay Embayment
  - 7.5. Fostoria Lake-Plain Shoals
  - 7.6a and 7.6b. Bellevue-Castalia Karst Plain
- 8. Erie Lake Plain
  - 8.1. Berea Headlands of the Erie Lake Plain

Bluegrass Section

- 9. Outer Bluegrass Region

Glaciated Allegheny Plateaus

- 10. Killbuck-Glaciated Pittsburgh Plateau
- 11. Akron-Canton Interlobate Plateau
- 12. Illinoian Glaciated Allegheny Plateau
- 13. Grand River Low Plateau
  - 13.1 Grand River Finger-Lake Plain

Allegheny Plateaus

- 14. Muskingum-Pittsburgh Plateau
- 15. Shawnee-Mississippian Plateau
- 16. Ironton Plateau
- 17. Marietta Plateau
  - 17.1. Little Switzerland Plateau

4/98

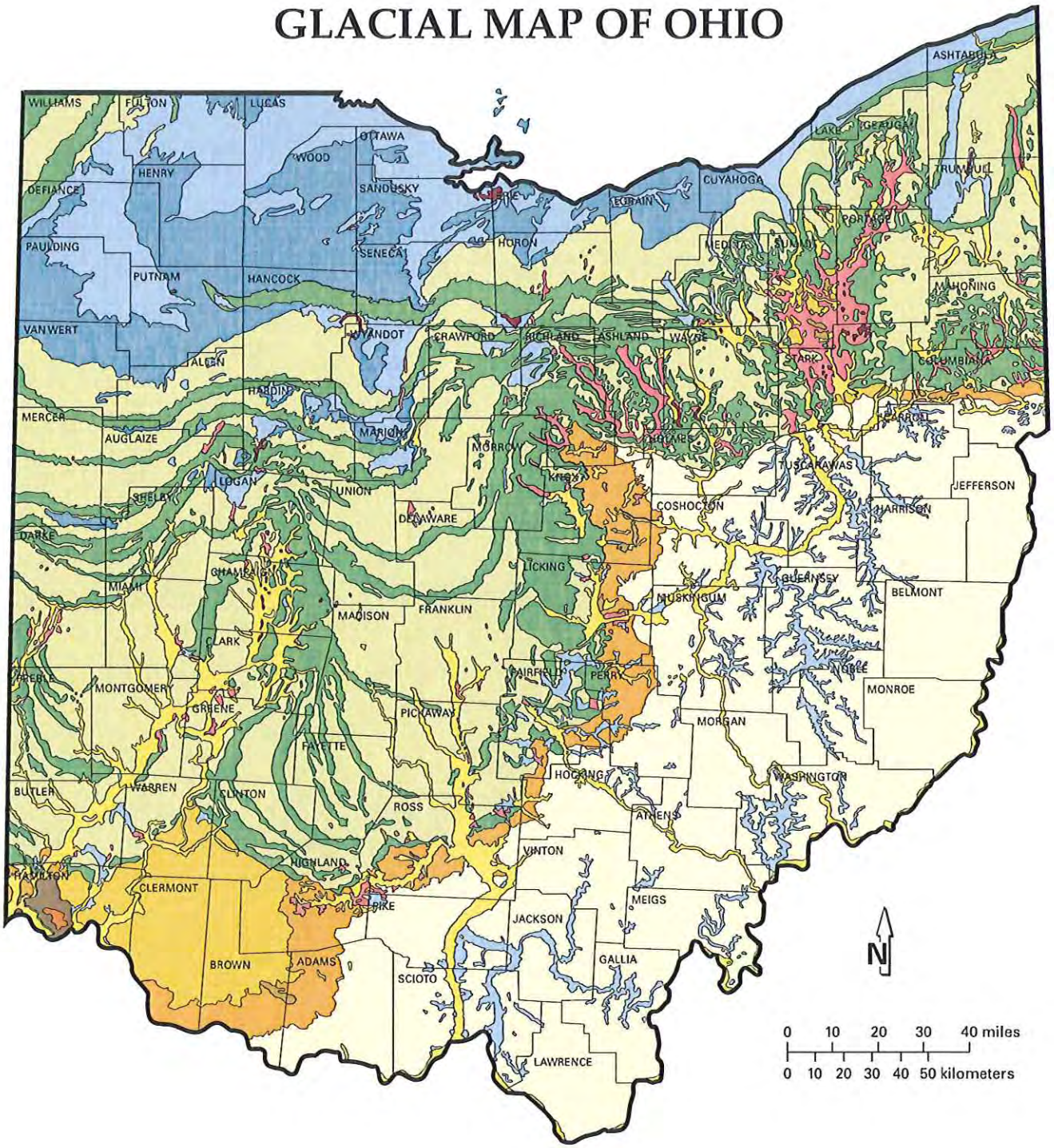
Recommended citation: Ohio Division of Geological Survey, 1998, Physiographic regions of Ohio: Ohio Department of Natural Resources, Division of Geological Survey, page-size map with text, 2 p., scale 1:2,100,00.

STATE OF OHIO
Bob Taft, Governor

DEPARTMENT OF NATURAL RESOURCES
Samuel W. Speck, Director

DIVISION OF GEOLOGICAL SURVEY
Thomas M. Berg, Chief

GLACIAL MAP OF OHIO



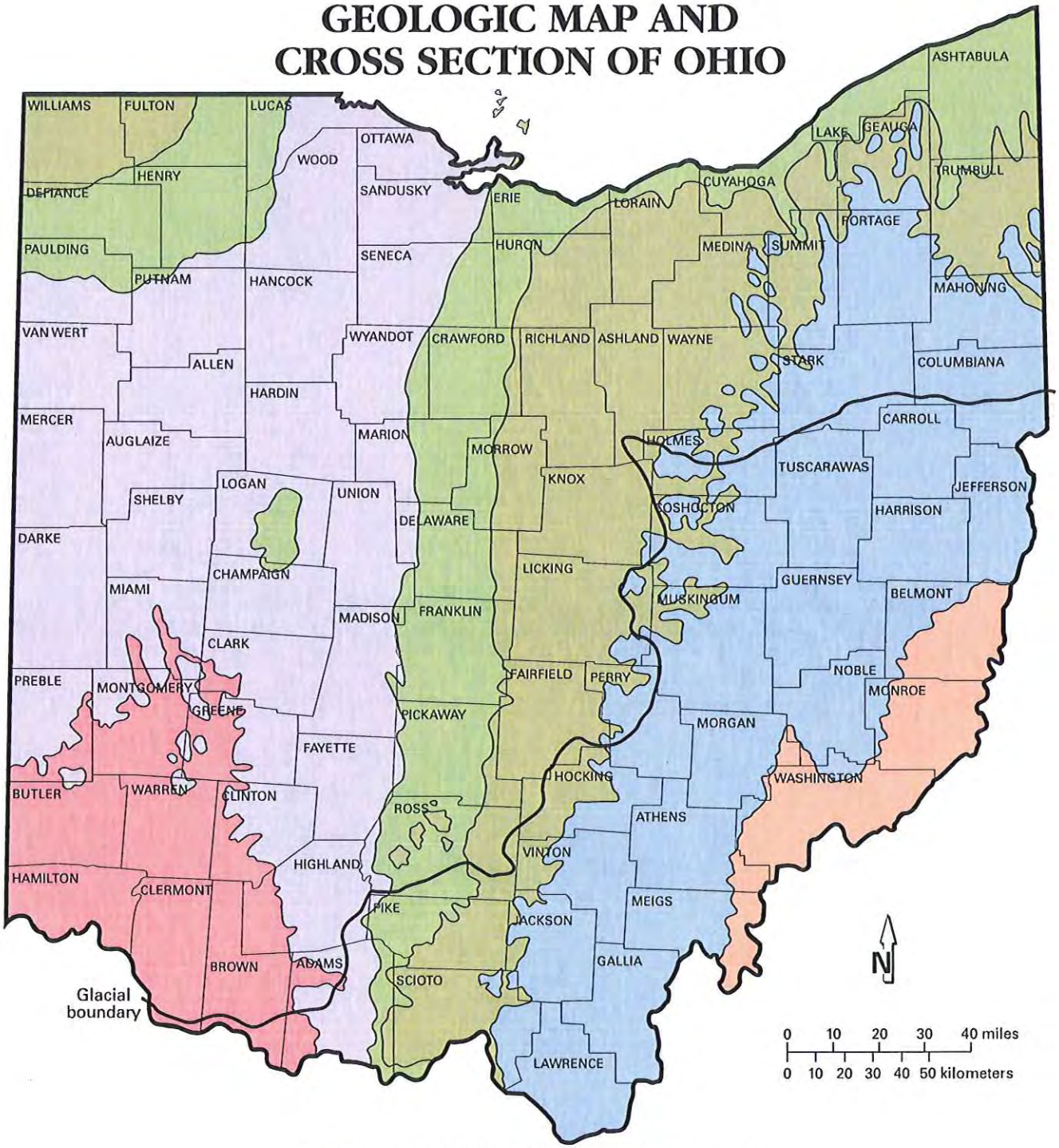
WISCONSINAN (14,000 to 24,000 years old)	ILLINOIAN (130,000 to 300,000 years old)	PRE-ILLINOIAN (older than 300,000 years)	
Ground moraine	Ground moraine	Ground moraine	Kames and eskers
Wave-planed ground moraine	Dissected ground moraine	Dissected ground moraine	Outwash
End moraine	Hummocky moraine		Lake deposits
			Peat
			Colluvium

STATE OF OHIO
Bob Taft, Governor

DEPARTMENT OF NATURAL RESOURCES
Samuel W. Speck, Director

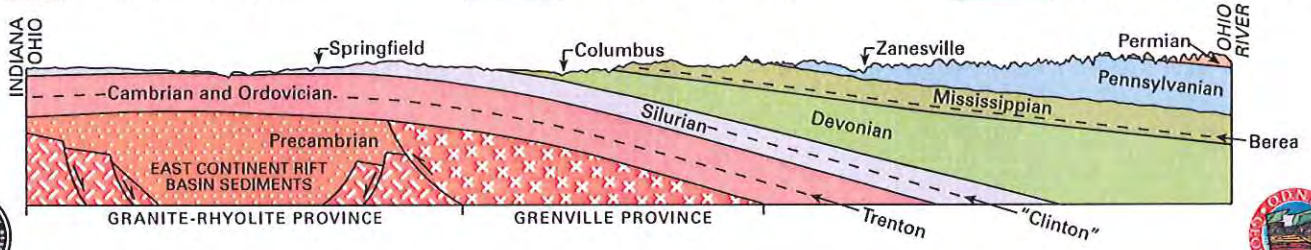
DIVISION OF GEOLOGICAL SURVEY
Thomas M. Berg, Chief

GEOLOGIC MAP AND CROSS SECTION OF OHIO



GEOLOGIC SYSTEM (million years before present)

- Permian (286-245)
- Pennsylvanian (320-286)
- Mississippian (360-320)
- Devonian (408-360)
- Silurian (438-408)
- Ordovician (505-438)



APPENDIX II

VICINITY MAP AND BORING PLAN

BORING PLAN

AUG-33-16.69
AUGLAIZE COUNTY, OHIO

PROJECT NO. Rii W-15-074	DRAWN RRM	RESOURCE INTERNATIONAL, INC.
SCALE: 1"=80' (0 40 80) N	REVIEWED JRH	
	DATE 7-17-15	

APPENDIX III

DESCRIPTION OF SOIL TERMS

DESCRIPTION OF SOIL TERMS

The following terminology was used to describe soils throughout this report and is generally adapted from ASTM 2487/2488 and ODOT Specifications for Geotechnical Explorations.

Granular Soils - The relative compactness of granular soils is described as:
ODOT A-1, A-2, A-3, A-4 (non-plastic) or USCS GW, GP, GM, GC, SW, SP, SM, SC, ML (non-plastic)

Description	Blows per foot – SPT (N_{60})		
Very Loose	Below		5
Loose	5	-	10
Medium Dense	11	-	30
Dense	31	-	50
Very Dense	Over		50

Cohesive Soils - The relative consistency of cohesive soils is described as:
ODOT A-4, A-5, A-6, A-7, A-8 or USCS ML, CL, OL, MH, CH, OH, PT

Description	Unconfined Compression (tsf)		
Very Soft	Less than		0.25
Soft	0.25	-	0.5
Medium Stiff	0.5	-	1.0
Stiff	1.0	-	2.0
Very Stiff	2.0	-	4.0
Hard	Over		4.0

Gradation - The following size-related denominations are used to describe soils:

Soil Fraction		USCS Size	ODOT Size
Boulders		Larger than 12”	Larger than 12”
Cobbles		12” to 3”	12” to 3”
Gravel	coarse	3” to ¾”	3” to ¾“
	fine	¾” to 4.75 mm (¾” to #4 Sieve)	¾” to 2.0 mm (¾” to #10 Sieve)
Sand	coarse	4.75 mm to 2.0 mm (#4 to #10 Sieve)	2.0 mm to 0.42 mm (#10 to #40 Sieve)
	medium	2.0 mm to 0.42 mm (#10 to #40 Sieve)	-
	fine	0.42 mm to 0.074 mm (#40 to #200 Sieve)	0.42 mm to 0.074 mm (#40 to #200 Sieve)
Silt		0.074 mm to 0.005 mm (#200 to 0.005 mm)	0.074 mm to 0.005 mm (#200 to 0.005 mm)
Clay		Smaller than 0.005 mm	Smaller than 0.005 mm

Modifiers of Components - Modifiers of components are as follows:

Term	Range		
Trace	0%	-	10%
Little	10%	-	20%
Some	20%	-	35%
And	35%	-	50%

Moisture Table - The following moisture-related denominations are used to describe cohesive soils:

Term	Range - USCS	Range - ODOT
Dry	0% to 10%	Well below Plastic Limit
Damp	>2% below Plastic Limit	Below Plastic Limit
Moist	2% below to 2% above Plastic Limit	Above PL to 3% below LL
Very Moist	>2% above Plastic Limit	
Wet	≥ Liquid Limit	3% below LL to above LL

Organic Content – The following terms are used to describe organic soils:

Term	Organic Content (%)
Slightly organic	2-4
Moderately organic	4-10
Highly organic	>10

Bedrock – The following terms are used to describe the relative strength of bedrock:

Description	Field Parameter
Very Weak	Can be carved with knife and scratched by fingernail. Pieces 1 in. thick can be broken by finger pressure.
Weak	Can be grooved or gouged with knife readily. Small, thin pieces can be broken by finger pressure.
Slightly Strong	Can be grooved or gouged 0.05 in deep with knife. 1 in. size pieces from hard blows of geologist hammer.
Moderately Strong	Can be scratched with knife or pick. 1/4 in. size grooves or gouges from blows of geologist hammer.
Strong	Can be scratched with knife or pick with difficulty. Hard hammer blows to detach hand specimen.
Very Strong	Cannot be scratched by knife or pick. Hard repeated blows of geologist hammer to detach hand specimen.
Extremely Strong	Cannot be scratched by knife or pick. Hard repeated blows of geologist hammer to chip hand specimen.

CLASSIFICATION OF SOILS

Ohio Department of Transportation

(The classification of a soil is found by proceeding from top to bottom of the chart. The first classification that the test data fits is the correct classification.)

SYMBOL	DESCRIPTION	Classifcation AASHTO	Classifcation OHIO	$LL_O/LL \times 100$*	% Pass #40	% Pass #200	Liquid Limit (LL)	Plastic Index (PI)	Group Index Max.	REMARKS
	Gravel and/or Stone Fragments	A-1-a			30 Max.	15 Max.		6 Max.	0	Min. of 50% combined gravel, cobble and boulder sizes
	Gravel and/or Stone Fragments with Sand	A-1-b			50 Max.	25 Max.		6 Max.	0	
F.S.	Fine Sand	A-3			51 Min.	10 Max.	NON-PLASTIC		0	
	Coarse and Fine Sand	--	A-3a			35 Max.		6 Max.	0	Min. of 50% combined coarse and fine sand sizes
	Gravel and/or Stone Fragments with Sand and Silt	A-2-4				35 Max.	40 Max.	10 Max.	0	
		A-2-5					41 Min.			
	Gravel and/or Stone Fragments with Sand, Silt and Clay	A-2-6				35 Max.	40 Max.	11 Min.	4	
		A-2-7					41 Min.			
	Sandy Silt	A-4	A-4a	76 Min.		36 Min.	40 Max.	10 Max.	8	Less than 50% silt sizes
	Silt	A-4	A-4b	76 Min.		50 Min.	40 Max.	10 Max.	8	50% or more silt sizes
	Elastic Silt and Clay	A-5		76 Min.		36 Min.	41 Min.	10 Max.	12	
	Silt and Clay	A-6	A-6a	76 Min.		36 Min.	40 Max.	11 - 15	10	
	Silty Clay	A-6	A-6b	76 Min.		36 Min.	40 Max.	16 Min.	16	
	Elastic Clay	A-7-5		76 Min.		36 Min.	41 Min.	≦LL-30	20	
	Clay	A-7-6		76 Min.		36 Min.	41 Min.	>LL-30	20	
	Organic Silt	A-8	A-8a	75 Max.		36 Min.				W/o organics would classify as A-4a or A-4b
	Organic Clay	A-8	A-8b	75 Max.		36 Min.				W/o organics would classify as A-5, A-6a, A-6b, A-7-5 or A-7-6

MATERIAL CLASSIFIED BY VISUAL INSPECTION

- Sod and Topsoil
- Pavement or Base
- Uncontrolled Fill (Describe)
- Bouldery Zone
- Peat, S-Sedimentary W-Woody F-Fibrous L-Loamy & etc

* Only perform the oven-dried liquid limit test and this calculation if organic material is present in the sample.

APPENDIX IV

BORING LOGS:

B-001-0-15 through B-004-0-15

BORING LOGS

Definitions of Abbreviations

AS	=	Auger sample
GI	=	Group index as determined from the Ohio Department of Transportation classification system
HP	=	Unconfined compressive strength as determined by a hand penetrometer (tons per square foot)
LOI	=	Percent organic content (by weight) as determined by ASTM D2974 (loss on ignition test)
PID	=	Photo-ionization detector reading (parts per million)
QR	=	Unconfined compressive strength of intact rock core sample as determined by ASTM D2938 (pounds per square inch)
QU	=	Unconfined compressive strength of soil sample as determined by ASTM D2166 (pounds per square foot)
RC	=	Rock core sample
REC	=	Ratio of total length of recovered soil or rock to the total sample length, expressed as a percentage
RQD	=	Rock quality designation – estimate of the degree of jointing or fracture in a rock mass, expressed as a percentage:

$$\frac{\sum \text{segments equal to or longer than 4.0 inches}}{\text{core run length}} \times 100$$

S	=	Sulfate content (parts per million)
SPT	=	Standard penetration test blow counts, per ASTM D1586. Driving resistance recorded in terms of blows per 6-inch interval while letting a 140-pound hammer free fall 30 inches to drive a 2-inch outer diameter (O.D.) split spoon sampler a total of 18 inches. The second and third intervals are added to obtain the number of blows per foot (N_m).
N_{60}	=	Measured blow counts corrected to an equivalent (60 percent) energy ratio (ER) by the following equation: $N_{60} = N_m*(ER/60)$
SS	=	Split spoon sample
2S	=	For instances of no recovery from standard SS interval, a 2.5 inch O.D. split spoon is driven the full length of the standard SS interval plus an additional 6.0 inches to obtain a representative sample. Only the final 6.0 inches of sample is retained. Blow counts from 2S sampling are not correlated with N_{60} values.
3S	=	Same as 2S, but using a 3.0 inch O.D. split spoon sampler.
TR	=	Top of rock
W	=	Initial water level measured during drilling
▼	=	Water level measured at completion of drilling

Classification Test Data

Gradation (as defined on Description of Soil Terms):

GR	=	% Gravel
SA	=	% Sand
SI	=	% Silt
CL	=	% Clay

Atterberg Limits:

LL	=	Liquid limit
PL	=	Plastic limit
PI	=	Plasticity Index
WC	=	Water content (%)

RESOURCE INTERNATIONAL, INC.

PROJECT: AUG-33-16.69	DRILLING FIRM / OPERATOR: RII / S.B.	DRILL RIG: CME 750 (SN 98048)	STATION / OFFSET: 181+83.02 / 60.3' LT
TYPE: ROADWAY	SAMPLING FIRM / LOGGER: RII / C.D.	HAMMER: CME AUTOMATIC	ALIGNMENT: US ROUTE 33 CENTERLINE
PID: 99467 BR ID:	DRILLING METHOD: 4.5" - CFA	CALIBRATION DATE: 10/20/14	ELEVATION: 918.8 (MSL) EOB: 25.0 ft.
START: 7/8/15 END: 7/8/15	SAMPLING METHOD: SPT	ENERGY RATIO (%): 92.9	LAT / LONG: 40.555146872, -84.164280657

EXPLORATION ID B-001-0-15

PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 918.8	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
0.2' - TOPSOIL (2.0")	918.6																	
MEDIUM STIFF TO STIFF, DARK BROWN TO BROWN **SILTY CLAY**, SOME COARSE TO FINE SAND, LITTLE TO SOME FINE GRAVEL, MOIST. -Root fibers present in SS-1		1–2	2 3 2	8	78	SS-1	1.00	22	11	16	28	23	38	18	20	22	A-6b (7)	
		3–5	2 3 3	9	100	SS-2	1.50	-	-	-	-	-	-	-	-	25	A-6b (V)	
		6–7	2 3 2	8	100	SS-3	0.75	13	5	17	37	28	31	15	16	24	A-6b (8)	
	910.8	8																
MEDIUM DENSE, DARK BROWN **COARSE AND FINE SAND**, SOME SILT, TRACE FINE GRAVEL, TRACE CLAY, WET.	908.3	9–10	2 5 7	19	100	SS-4	1.25	-	-	-	-	-	-	-	-	21	A-3a (V)	
VERY STIFF TO HARD, GRAY **SILT AND CLAY**, LITTLE COARSE TO FINE SAND, LITTLE FINE GRAVEL, MOIST.		11–12	10 12 13	39	100	SS-5	4.5+	-	-	-	-	-	-	-	-	12	A-6a (V)	
		14–15	4 8 11	29	67	SS-6	4.5+	19	6	11	30	34	27	14	13	15	A-6a (7)	
	900.8	16–17	10 13 13	40	100	SS-7	4.00	-	-	-	-	-	-	-	-	13	A-6a (V)	
DENSE, DARK GRAY **COARSE AND FINE SAND**, TRACE FINE GRAVEL, TRACE SILT, WET.	896.8	19–20	8 11 14	39	89	SS-8	-	-	-	-	-	-	-	-	-	13	A-3a (V)	
HARD, GRAY **SILT AND CLAY**, TRACE COARSE TO FINE SAND, TRACE FINE GRAVEL, DAMP.	893.8	24–25	9 12 16	43	33	SS-9	4.5+	-	-	-	-	-	-	-	-	10	A-6a (V)	
		EOB																

NOTES: GROUNDWATER INITIALLY ENCOUNTERED @ 8.0' AND AT COMPLETION @ 10.0'; CAVE-IN DEPTH @ 21.4'

ABANDONMENT METHODS, MATERIALS, QUANTITIES: COMPACTED WITH THE AUGER 50 LBS BENTONITE CHIPS AND SOIL CUTTINGS

2015-ODOT BORING LOG-BRIDGE ID - OH DOT.GDT - 7/24/15 16:21 - U:\GI8\PROJECTS\2015\W-15-074.GPJ

RESOURCE INTERNATIONAL, INC.

PROJECT: AUG-33-16.69	DRILLING FIRM / OPERATOR: RII / S.B.	DRILL RIG: CME 750 (SN 98048)	STATION / OFFSET: 185+00.00 / 40' LT	**EXPLORATION ID**
TYPE: ROADWAY	SAMPLING FIRM / LOGGER: RII / C.D.	HAMMER: CME AUTOMATIC	ALIGNMENT: US ROUTE 33 CENTERLINE	**B-002-0-15**
PID: 99467 BR ID:	DRILLING METHOD: 4.5" - CFA	CALIBRATION DATE: 10/20/14	ELEVATION: 919.1 (MSL) EOB: 20.0 ft.	PAGE
START: 7/8/15 END: 7/8/15	SAMPLING METHOD: SPT	ENERGY RATIO (%): 92.9	LAT / LONG: 40.555238517, -84.163145700	1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 919.1	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
0.2' - TOPSOIL (2.0")	918.9																	
VERY STIFF TO HARD, BROWN TO GRAY **SANDY SILT**, SOME CLAY, LITTLE FINE GRAVEL, DAMP TO MOIST.		1 2	2 4 5	14	100	SS-1	4.5+	14	11	16	32	27	24	14	10	12	A-4a (5)	
		3 4 5	2 4 4	12	100	SS-2	2.50	-	-	-	-	-	-	-	-	13	A-4a (V)	
		6 7	4 8 12	31	100	SS-3	4.5+	13	12	17	34	24	21	13	8	12	A-4a (5)	
		8 9 10	4 8 8	25	100	SS-4	4.5+	-	-	-	-	-	-	-	-	11	A-4a (V)	
-Rock fragments present in SS-5		11 12	10 12 16	43	100	SS-5	4.5+	-	-	-	-	-	-	-	-	10	A-4a (V)	
HARD, GRAY **SILT AND CLAY**, LITTLE COARSE TO FINE SAND, LITTLE FINE GRAVEL, MOIST.	906.1	13 14 15	4 8 9	26	100	SS-6	4.5+	13	7	12	30	38	26	13	13	14	A-6a (8)	
MEDIUM DENSE TO DENSE, GRAY **GRAVEL**, TRACE COARSE SAND, WET.	903.6	16 17	4 5 10	23	100	SS-7	-	94	6	0	0	0	NP	NP	NP	15	A-1-a (0)	
	899.1	18 19 20 EOB	7 14 12	40	100	SS-8	-	-	-	-	-	-	-	-	-	8	A-1-a (V)	

NOTES: GROUNDWATER INITIALLY ENCOUNTERED @ 16.0' AND AT COMPLETION @ 16.5'

ABANDONMENT METHODS, MATERIALS, QUANTITIES: COMPACTED WITH THE AUGER 50 LBS BENTONITE CHIPS AND SOIL CUTTINGS

2015-ODOT BORING LOG-BRIDGE ID - OH DOT.GDT - 7/24/15 16:21 - U:\GI8\PROJECTS\2015\W-15-074.GPJ

RESOURCE INTERNATIONAL, INC.

PROJECT: AUG-33-16.69	DRILLING FIRM / OPERATOR: RII / S.B.	DRILL RIG: CME 750 (SN 98048)	STATION / OFFSET: 188+00.00 / 40' LT
TYPE: ROADWAY	SAMPLING FIRM / LOGGER: RII / C.D.	HAMMER: CME AUTOMATIC	ALIGNMENT: US ROUTE 33 CENTERLINE
PID: 99467 BR ID:	DRILLING METHOD: 4.5" - CFA	CALIBRATION DATE: 10/20/14	ELEVATION: 917.2 (MSL) EOB: 20.0 ft.
START: 7/8/15 END: 7/8/15	SAMPLING METHOD: SPT	ENERGY RATIO (%): 92.9	LAT / LONG: 40.555378010, -84.162081679

EXPLORATION ID
B-003-0-15

PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 917.2	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
0.2' - TOPSOIL (2.0")	917.0																	
VERY STIFF TO HARD, BROWN TO GRAY **SILT AND CLAY**, LITTLE TO SOME COARSE TO FINE SAND, LITTLE FINE GRAVEL, DAMP TO MOIST. -Root fibers present in SS-1		1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20	2 4 4	12	83	SS-1	3.25	18	8	13	29	32	28	15	13	13	A-6a (6)	
			3 3 4	11	100	SS-2	4.5+	-	-	-	-	-	-	-	-	12	A-6a (V)	
			7 11 12	36	100	SS-3	4.5+	-	-	-	-	-	-	-	-	10	A-6a (V)	
			3 7 10	26	100	SS-4	4.5+	-	-	-	-	-	-	-	-	10	A-6a (V)	
			4 7 11	28	100	SS-5	4.50	17	7	12	26	38	27	13	14	13	A-6a (7)	
	904.2																	
MEDIUM DENSE, GRAY **GRAVEL**, SOME COARSE TO FINE SAND, TRACE SILT, WET.	902.7		3 4 4	12	100	SS-6	-	-	-	-	-	-	-	-	-	12	A-1-a (V)	
STIFF, GRAY **SILT AND CLAY**, SOME COARSE TO FINE SAND, LITTLE FINE GRAVEL, MOIST.							2.00	22	7	11	26	34	25	13	12	14	A-6a (6)	
			5 9 12	33	100	SS-7	1.50	13	9	12	29	37	25	13	12	14	A-6a (7)	
	897.2	EOB	3 7 9	25	100	SS-8	1.50	-	-	-	-	-	-	-	-	12	A-6a (V)	

NOTES: GROUNDWATER INITIALLY ENCOUNTERED @ 12.0' AND AT COMPLETION @ 10.0'; CAVE-IN DEPTH @ 18.4'

ABANDONMENT METHODS, MATERIALS, QUANTITIES: COMPACTED WITH THE AUGER 50 LBS BENTONITE CHIPS AND SOIL CUTTINGS

2015-ODOT BORING LOG-BRIDGE ID - OH DOT.GDT - 7/24/15 16:21 - U:\GI8\PROJECTS\2015\W-15-074.GPJ

RESOURCE INTERNATIONAL, INC.

PROJECT: AUG-33-16.69	DRILLING FIRM / OPERATOR: RII / S.B.	DRILL RIG: CME 750 (SN 98048)	STATION / OFFSET: 191+00.00 / 40' LT
TYPE: ROADWAY	SAMPLING FIRM / LOGGER: RII / C.D.	HAMMER: CME AUTOMATIC	ALIGNMENT: US ROUTE 33 CENTERLINE
PID: 99467 BR ID:	DRILLING METHOD: 4.5" - CFA	CALIBRATION DATE: 10/20/14	ELEVATION: 914.2 (MSL) EOB: 20.0 ft.
START: 7/8/15 END: 7/8/15	SAMPLING METHOD: SPT	ENERGY RATIO (%): 92.9	LAT / LONG: 40.555516954, -84.161016136

EXPLORATION ID B-004-0-15

PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 914.2	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
0.2' - TOPSOIL (2.0")	914.0																	
MEDIUM DENSE, LIGHT BROWN **COARSE AND FINE SAND**, LITTLE SILT, TRACE CLAY, TRACE FINE GRAVEL, MOIST.	911.2	1 2	3 4 4	12	100	SS-1	-	1	2	78	12	7	NP	NP	NP	9	A-3a (0)	
MEDIUM DENSE, BROWN **GRAVEL AND SAND**, TRACE CLAY, TRACE SILT, WET. -Rock fragments present in SS-2		3 4	3 5 4	14	100	SS-2	-	-	-	-	-	-	-	-	-	9	A-1-b (V)	
		5 6 7	3 4 5	14	100	SS-3	-	26	25	38	4	7	NP	NP	NP	18	A-1-b (0)	
		8 9	2 5 6	17	100	SS-4	-	-	-	-	-	-	-	-	-	12	A-1-b (V)	
MEDIUM DENSE TO DENSE, GRAY **GRAVEL**, SOME COARSE SAND, TRACE CLAY, WET.	903.7	10 11 12	5 5 8	20	100	SS-5	-	-	-	-	-	-	-	-	-	15	A-1-a (V)	
		13 14 15	5 6 6	19	100	SS-6	-	66	32	0	0	2	NP	NP	NP	9	A-1-a (0)	
-Rock fragments present in SS-7		16 17	7 9 14	36	56	SS-7	-	-	-	-	-	-	-	-	-	13	A-1-a (V)	
	894.2	18 19 20 EOB	7 9 12	33	100	SS-8	-	-	-	-	-	-	-	-	-	8	A-1-a (V)	

NOTES: SEEPAGE ENCOUNTERED @ 7.0'; GROUNDWATER INITIALLY ENCOUNTERED @ 8.0' AND AT COMPLETION @ 5.0'; CAVE-IN DEPTH @ 5.0'

ABANDONMENT METHODS, MATERIALS, QUANTITIES: COMPACTED WITH THE AUGER 50 LBS BENTONITE CHIPS AND SOIL CUTTINGS

2015-ODOT BORING LOG-BRIDGE ID - OH DOT.GDT - 7/24/15 16:21 - U:\GI8\PROJECTS\2015\W-15-074.GPJ

APPENDIX V

GB1 SUBGRADE STABILIZATION SUMMARY

Subgrade Analysis

V. 12.00 12/30/11

Design CBR 7

Global Options		
320	R&R	No
206	CS	Option
	LS	No
	LKD	Option
206	Depth	14

Classification Counts by Sample																	
R	1a	1b	3	3a	2-4	2-5	2-6	2-7	4a	4b	5	6a	6b	7-5	7-6	8a	8b
0	0	3	0	2	0	0	0	0	4	0	0	4	3	0	0	0	0
		19%		13%					25%			25%	19%				
0%	31%								69%								

Surface Class	
2-5	0
4b	0
5	0
7-5	0
7-6	0
8a	0
8b	0
R	0

% Borings	
N_{60L}<= 5	0%
<=10	25%
>=20	0%
M+	50%
R	0%

% Surface	
25%	
0%	25%

Rig	ER
A	93
B	
C	
D	
E	
F	
G	
H	

Total Borings	4
PID	99467
Location	AUG-33-16.69

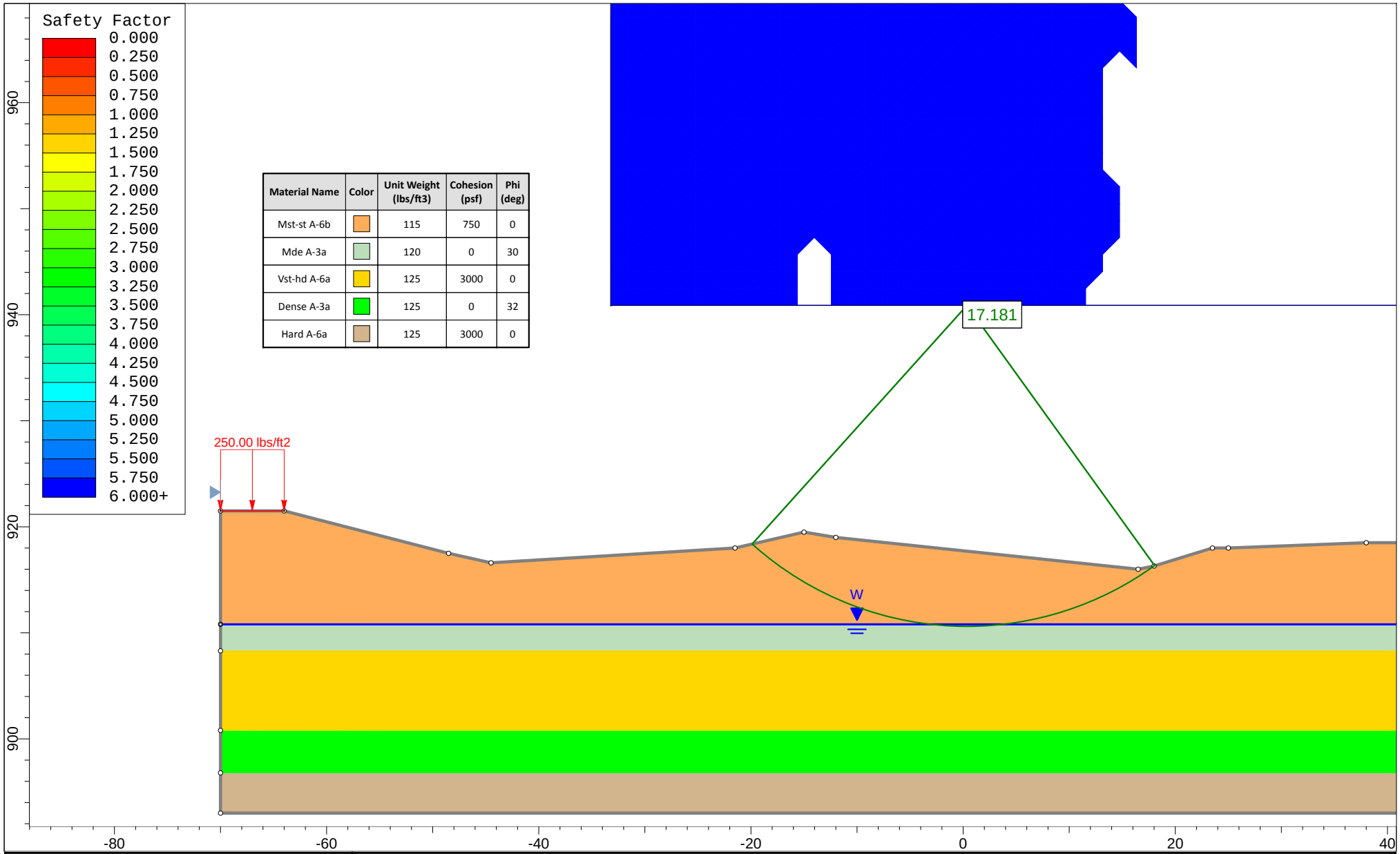
	N_{60}	N_{60L}	PI	Clay	M	M_{OPT}	GI
Average	16.8	10.8	13.4	21.1	14.6	11.1	6.00
Maximum	36	12	38 18 20 37 32 65		25	16	7
Minimum	8	8	21 13 8 4 7 11		9	6	5

UC @ Surface
18.0
18
18

#	B #	Boring Location	Boring Depth	Boring To	Cut Fill	Subgrade Depth	Subgrade To	n_2	n_3	N	Rig	N_{60}	N_{60L}	LL	PL	PI	% Silt	% Clay	P 200	M	M_{OPT}	Ohio DOT	GI	Comments	Problem w/ Class	Problem w/ MN	UC Class	UC MN	Analysis
1	B-001	Ametek Plastics RR	1.0	2.5	3.5	4.5	6.0	3	2	5	A	8		38	18	20	28	23	51	22	16	6b	7			N		18	
		STA 2444+41.83	3.5	5.0		7.0	8.5	3	3	6		9								25	16	6b				N		16	UC 18" or
		19.7' Lt	6.0	7.5		9.5	11.0	3	2	5		8		31	15	16	37	28	65	24	16	6b				N		18	CS 14"
			8.5	10.0		12.0	13.5	5	7	12		19	8							21	8	3a				M			
2	B-002	Ametek Plastics RR	1.0	2.5	2.7	3.7	5.2	4	5	9	A	14		24	14	10	32	27	59	12	10	4a	5						
		STA 2441+28.61	3.5	5.0		6.2	7.7	4	4	8		12								13	10	4a							
		5.0' Lt	6.0	7.5		8.7	10.2	8	12	20		31		21	13	8	34	24	58	12	10	4a							
			8.5	10.0		11.2	12.7	8	8	16		25	12							11	10	4a							
3	B-003	Ametek Plastics RR	1.0	2.5	5.0	6.0	7.5	4	4	8	A	12		28	15	13	29	32	61	13	14	6a							
		STA 2438+28.61	3.5	5.0		8.5	10.0	3	4	7		11								12	14	6a				N		14	
		5.0' Lt	6.0	7.5		11.0	12.5	11	12	23		36								10	14	6a							
			8.5	10.0		13.5	15.0	7	10	17		26	11							10	14	6a							
4	B-004	Ametek Plastics RR	1.0	2.5	9.2	10.2	11.7	4	4	8	A	12		NP	NP	NP	12	7	19	9	8	3a							
		STA 2435+28.22	3.5	5.0		12.7	14.2	5	4	9		14								9	6	1b							
		5.7' Lt	6.0	7.5		15.2	16.7	4	5	9		14		NP	NP	NP	4	7	11	18	6	1b				MN		---	
			8.5	10.0		17.7	19.2	5	6	11		17	12							12	6	1b				M			

APPENDIX VI

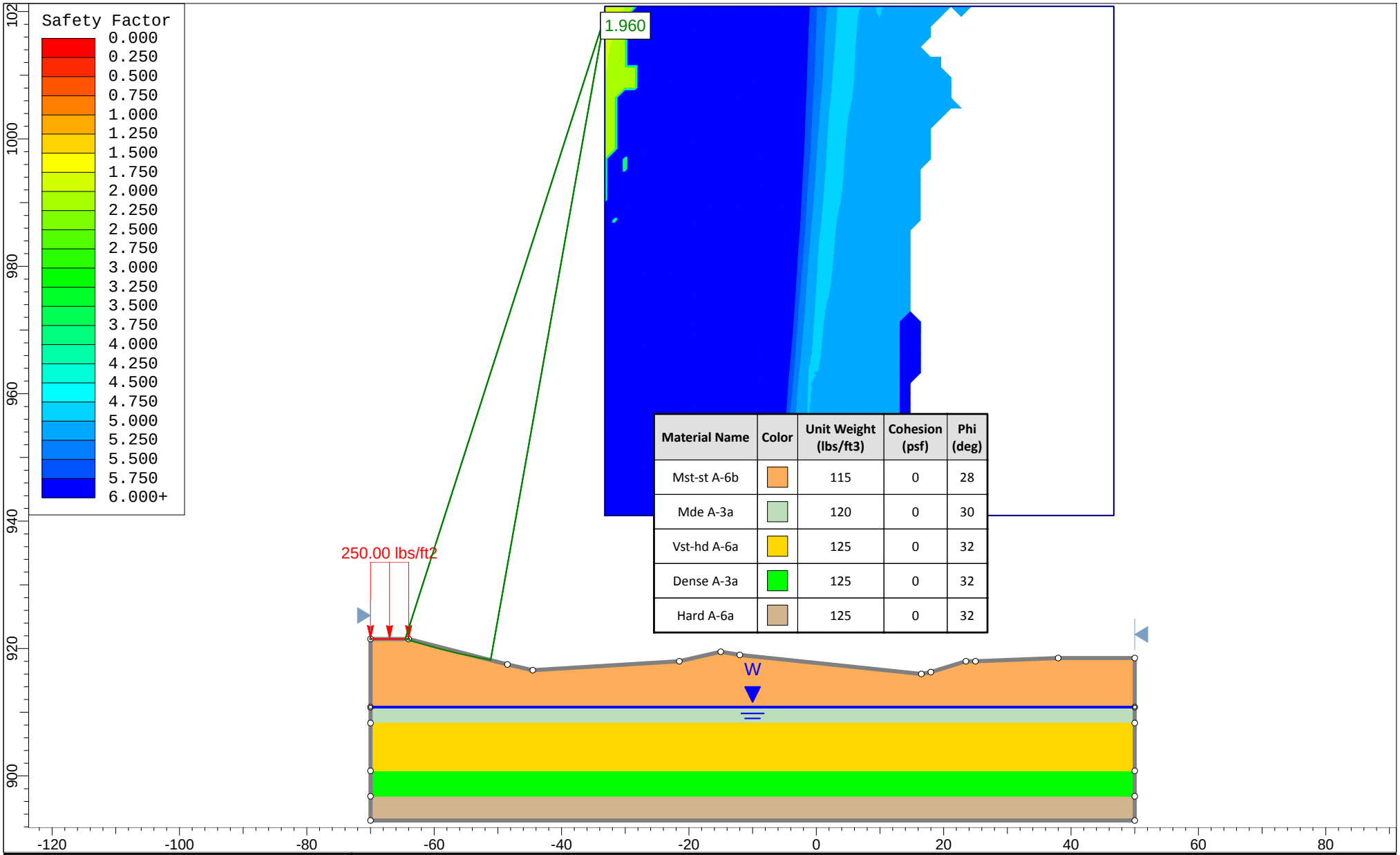
SLOPE STABILITY ANALYSIS OUTPUTS



Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
Mst-st A-6b		115	750	0
Mde A-3a		120	0	30
Vst-hd A-6a		125	3000	0
Dense A-3a		125	0	32
Hard A-6a		125	3000	0

SLIDEINTERPRET 6.032

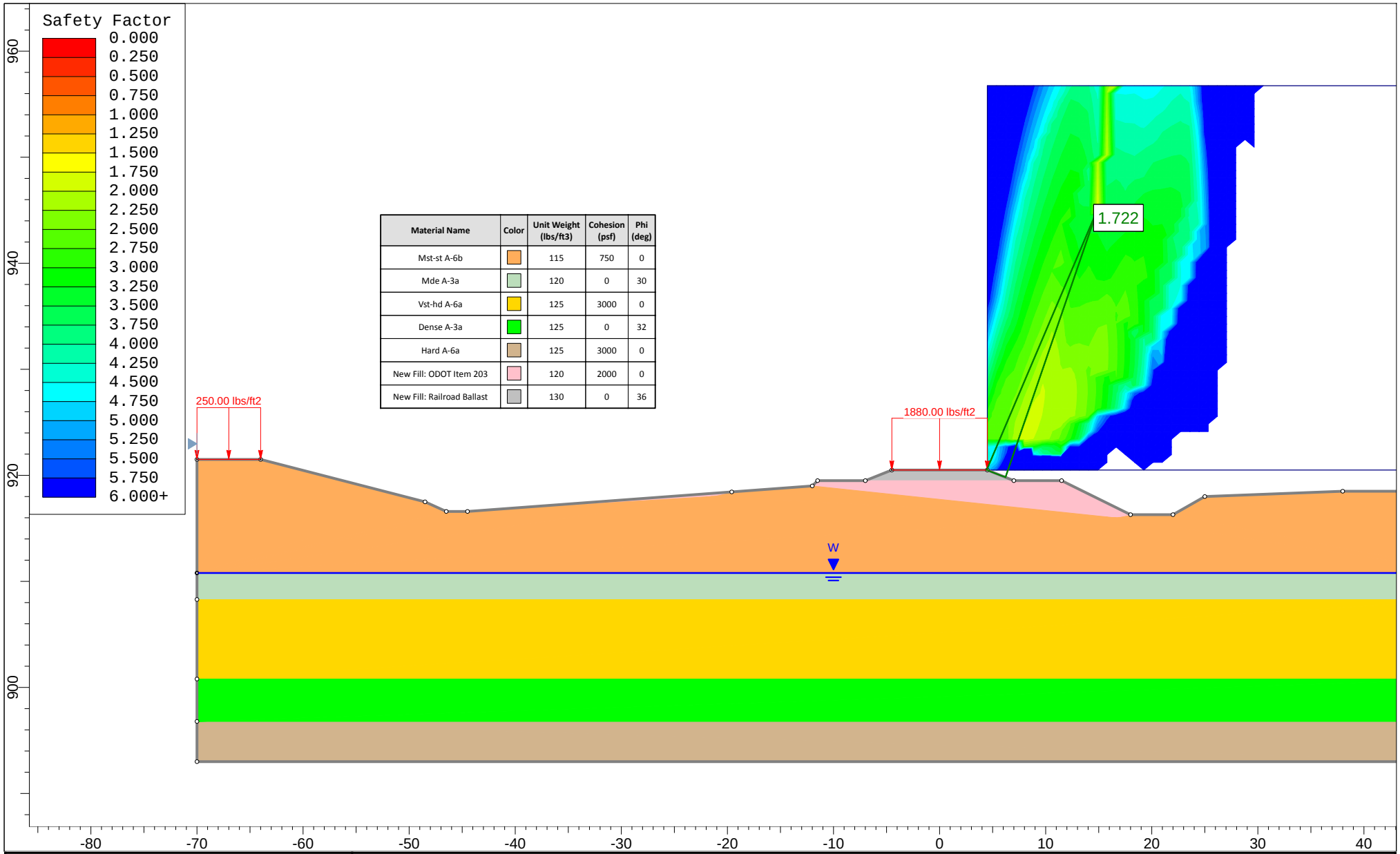
Project	AUG-33-16.69 Proposed Railroad Realignment - Sta. 2444+50		
Analysis Description	Existing Total Stress Conditions - Spencer Method		
Drawn By JRH	*Scale* 1:150	*Company*	Resource International, Inc.
Date 07.27.2015		*File Name*	B-001 Existing - Total.slim



Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
Mst-st A-6b		115	0	28
Mde A-3a		120	0	30
Vst-hd A-6a		125	0	32
Dense A-3a		125	0	32
Hard A-6a		125	0	32

SLIDEINTERPRET 6.032

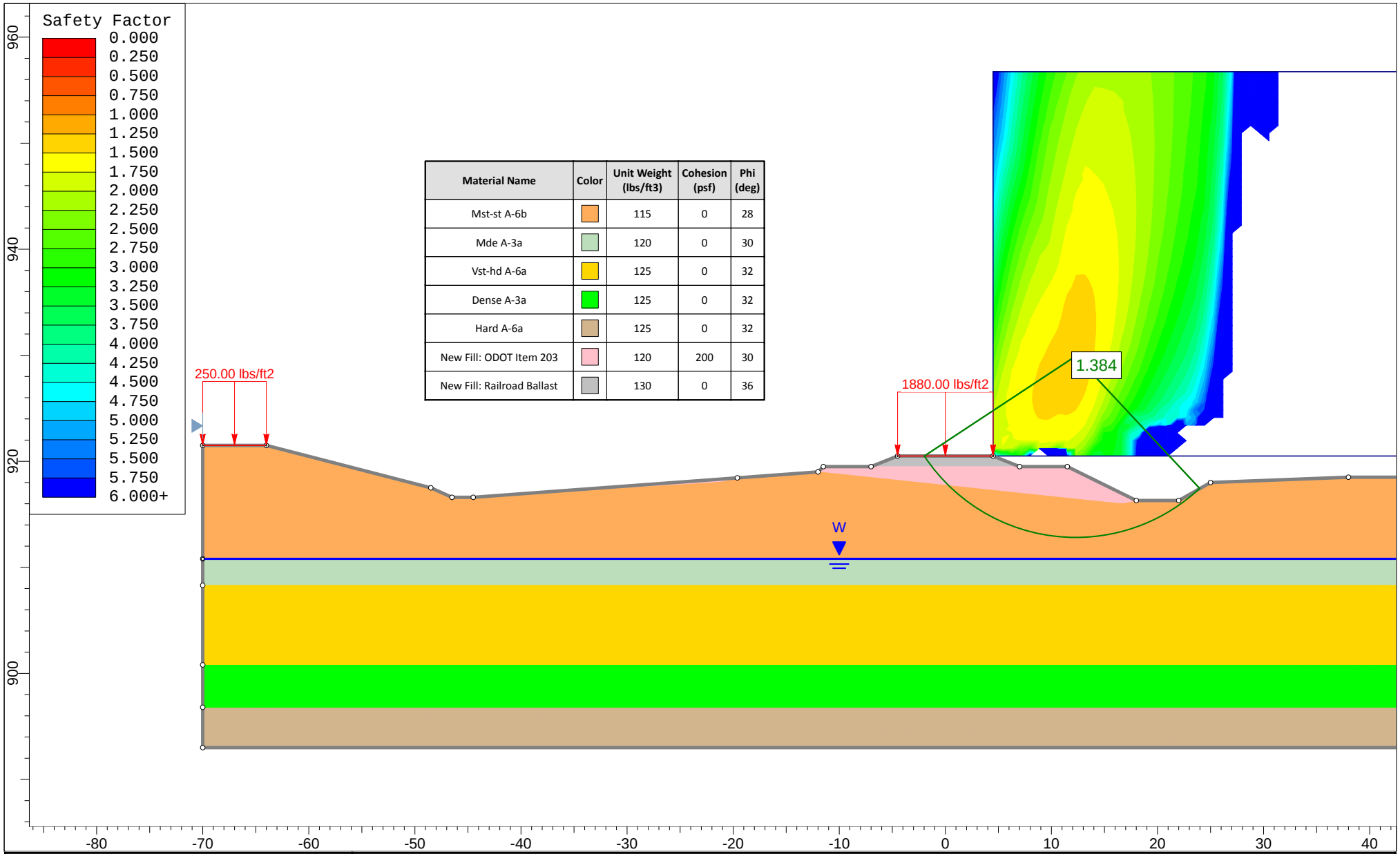
Project	AUG-33-16.69 Proposed Railroad Realignment - Sta. 2444+50		
Analysis Description	Existing Effective Stress Conditions - Spencer Method		
Drawn By JRH	*Scale* 1:250	*Company* Resource International, Inc.	
Date 07.27.2015		*File Name* B-001 Existing - Effective.slim	



Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
Mst-st A-6b		115	750	0
Mde A-3a		120	0	30
Vst-hd A-6a		125	3000	0
Dense A-3a		125	0	32
Hard A-6a		125	3000	0
New Fill: ODOT Item 203		120	2000	0
New Fill: Railroad Ballast		130	0	36

SLIDEINTERPRET 6.032

Project	AUG-33-16.69 Proposed Railroad Realignment - Sta. 2444+50		
Analysis Description	Proposed Total Stress Conditions - Spencer Method		
Drawn By	JRH	*Scale* 1:150	*Company* Resource International, Inc.
Date	07.27.2015		*File Name* B-001 Proposed - Total.slim

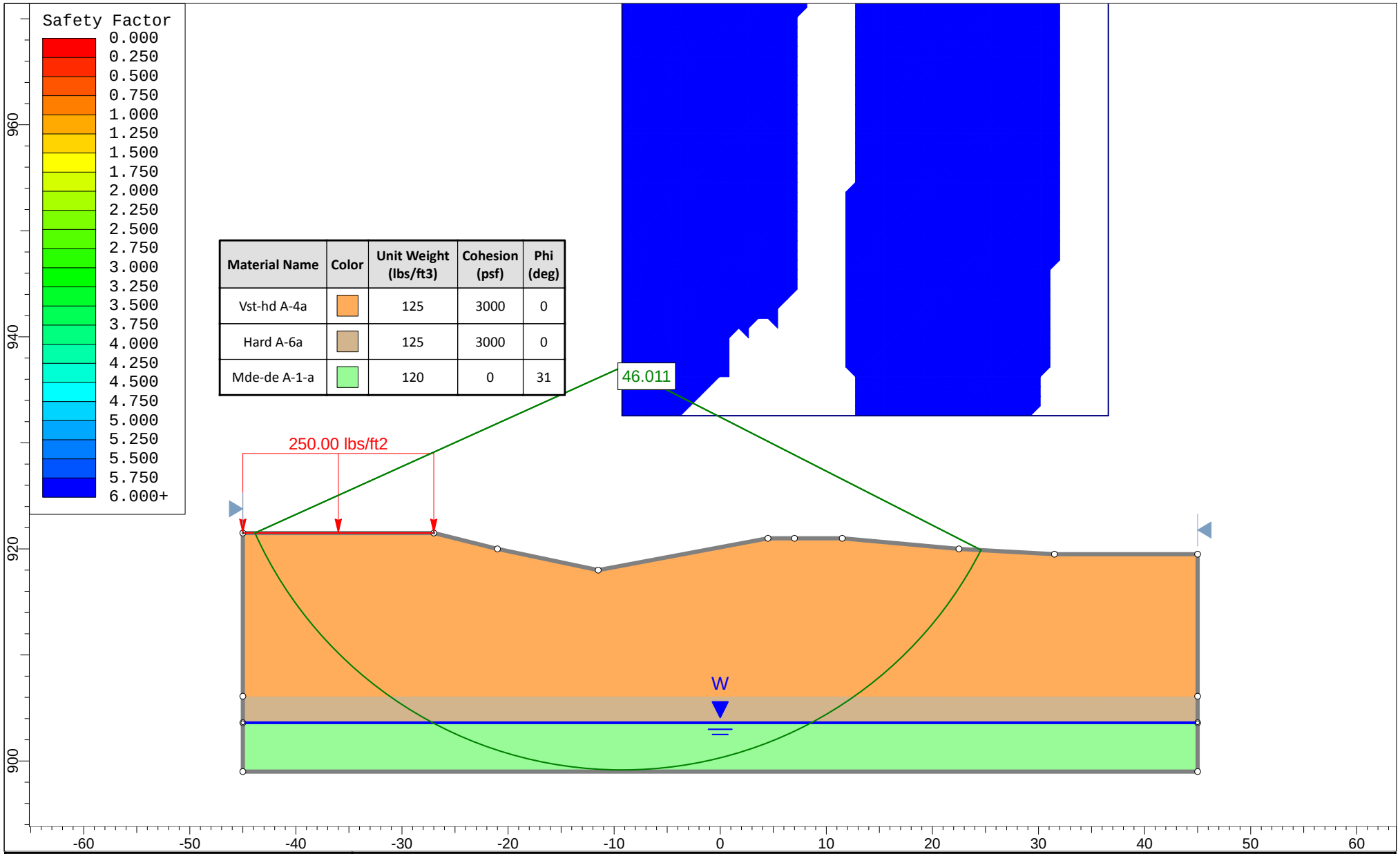


Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
Mst-st A-6b		115	0	28
Mde A-3a		120	0	30
Vst-hd A-6a		125	0	32
Dense A-3a		125	0	32
Hard A-6a		125	0	32
New Fill: ODOT Item 203		120	200	30
New Fill: Railroad Ballast		130	0	36

rocscience

SLIDEINTERPRET 6.032

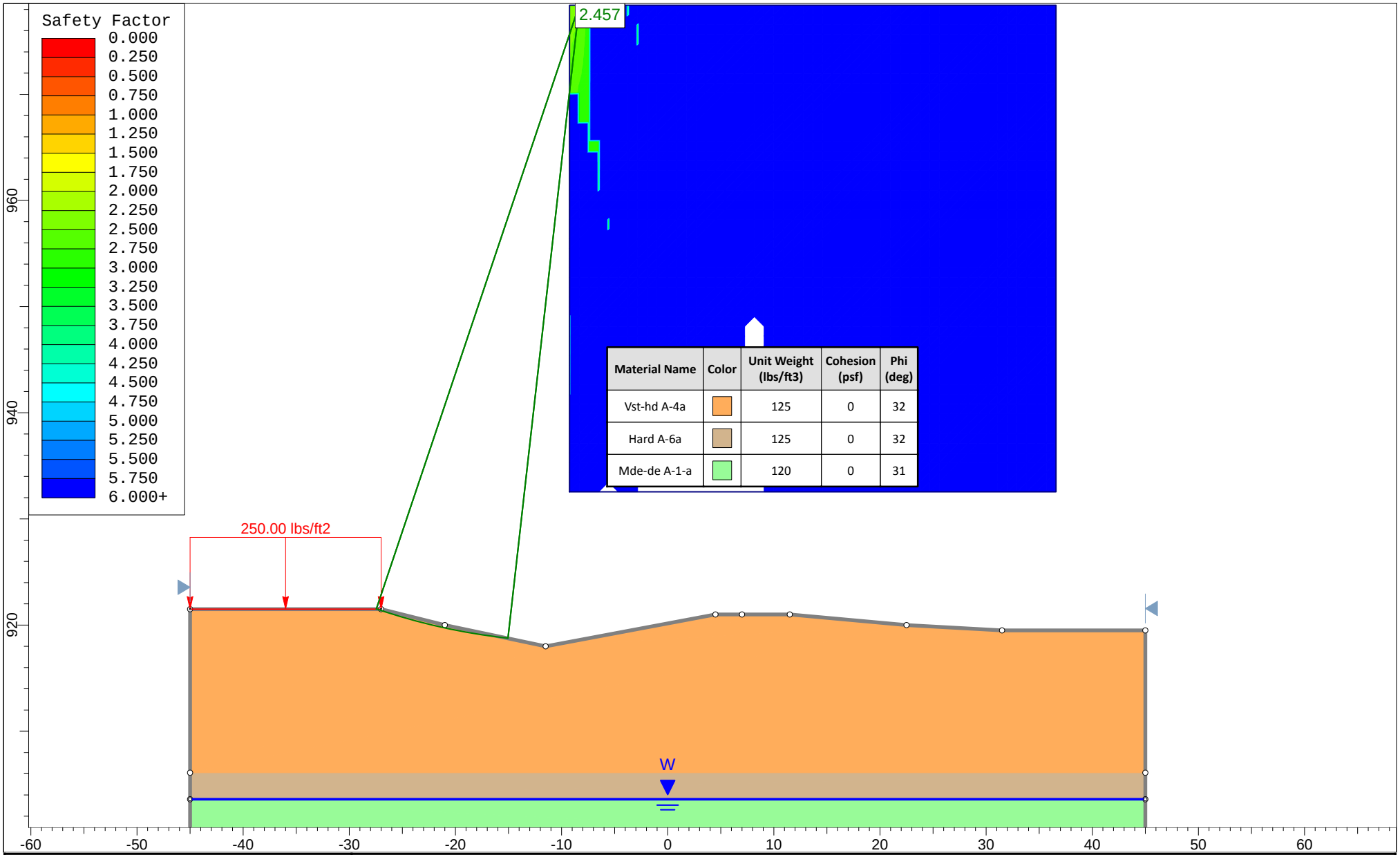
Project	AUG-33-16.69 Proposed Railroad Realignment - Sta. 2444+50		
Analysis Description	Proposed Effective Stress Conditions - Spencer Method		
Drawn By	JRH	*Scale* 1:150	*Company* Resource International, Inc.
Date	07.27.2015		*File Name* B-001 Proposed - Effective.slim



Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
Vst-hd A-4a		125	3000	0
Hard A-6a		125	3000	0
Mde-de A-1-a		120	0	31

SLIDEINTERPRET 6.032

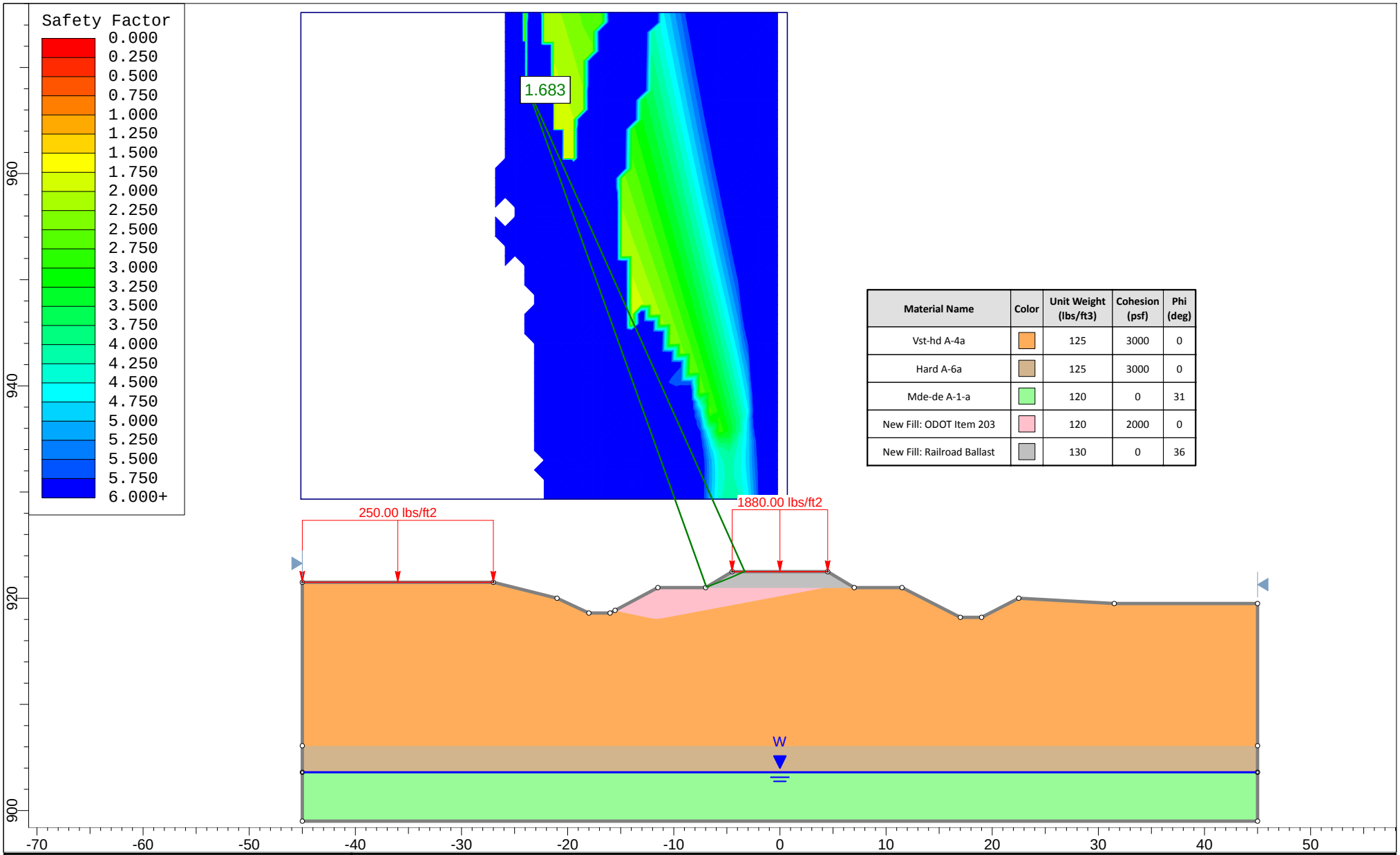
Project	AUG-33-16.69 Proposed Railroad Realignment - Sta. 2441+00		
Analysis Description	Existing Total Stress Conditions - Spencer Method		
Drawn By JRH	*Scale* 1:150	*Company* Resource International, Inc.	
Date 07.27.2015		*File Name* B-002 Existing - Total.slim	



Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
Vst-hd A-4a		125	0	32
Hard A-6a		125	0	32
Mde-de A-1-a		120	0	31

SLIDEINTERPRET 6.032

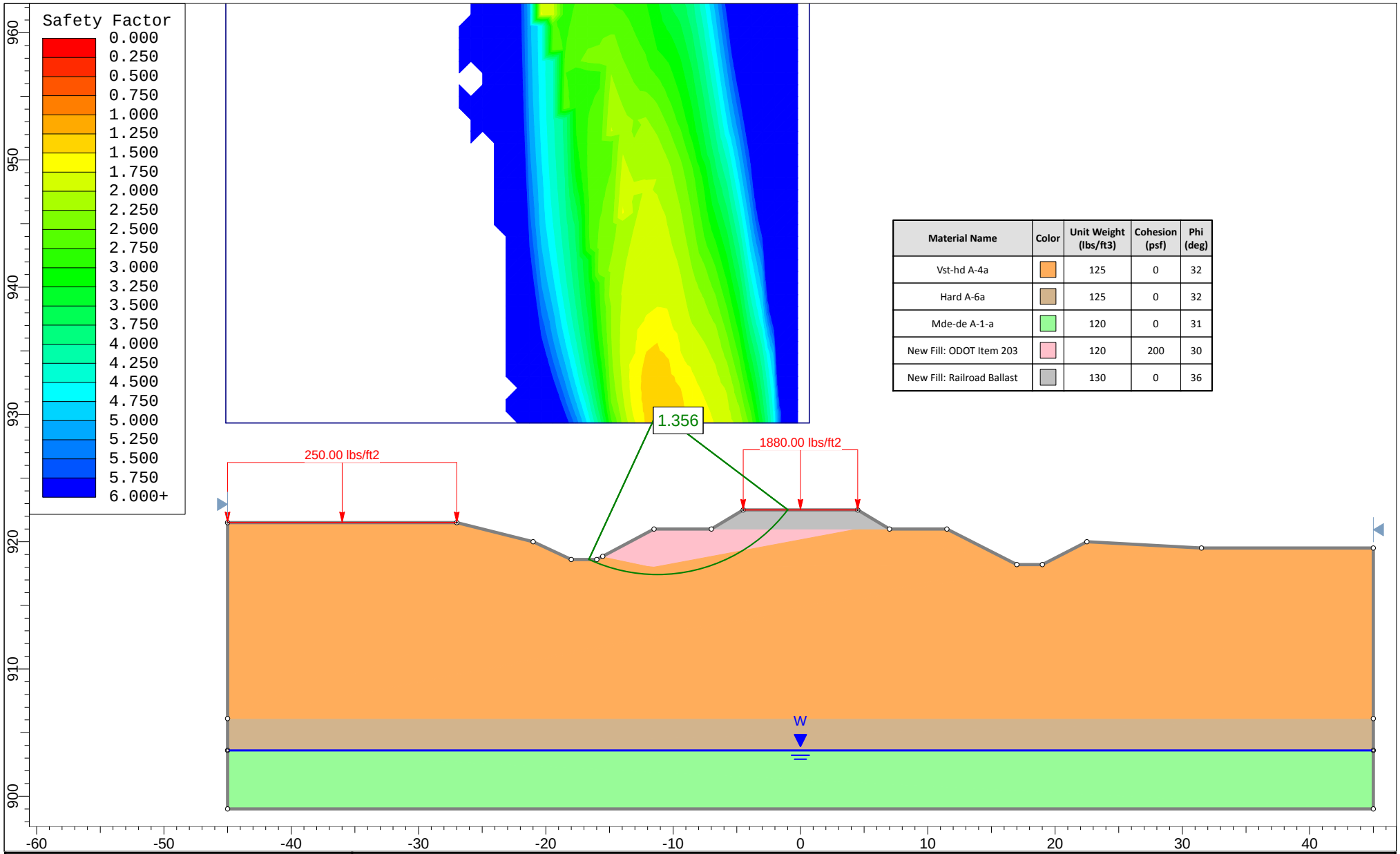
Project	AUG-33-16.69 Proposed Railroad Realignment - Sta. 2441+00		
Analysis Description	Existing Effective Stress Conditions - Spencer Method		
Drawn By JRH	*Scale* 1:150	*Company*	Resource International, Inc.
Date 07.27.2015		*File Name*	B-002 Existing - Effective.slim



Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
Vst-hd A-4a		125	3000	0
Hard A-6a		125	3000	0
Mde-de A-1-a		120	0	31
New Fill: ODOT Item 203		120	2000	0
New Fill: Railroad Ballast		130	0	36

SLIDEINTERPRET 6.032

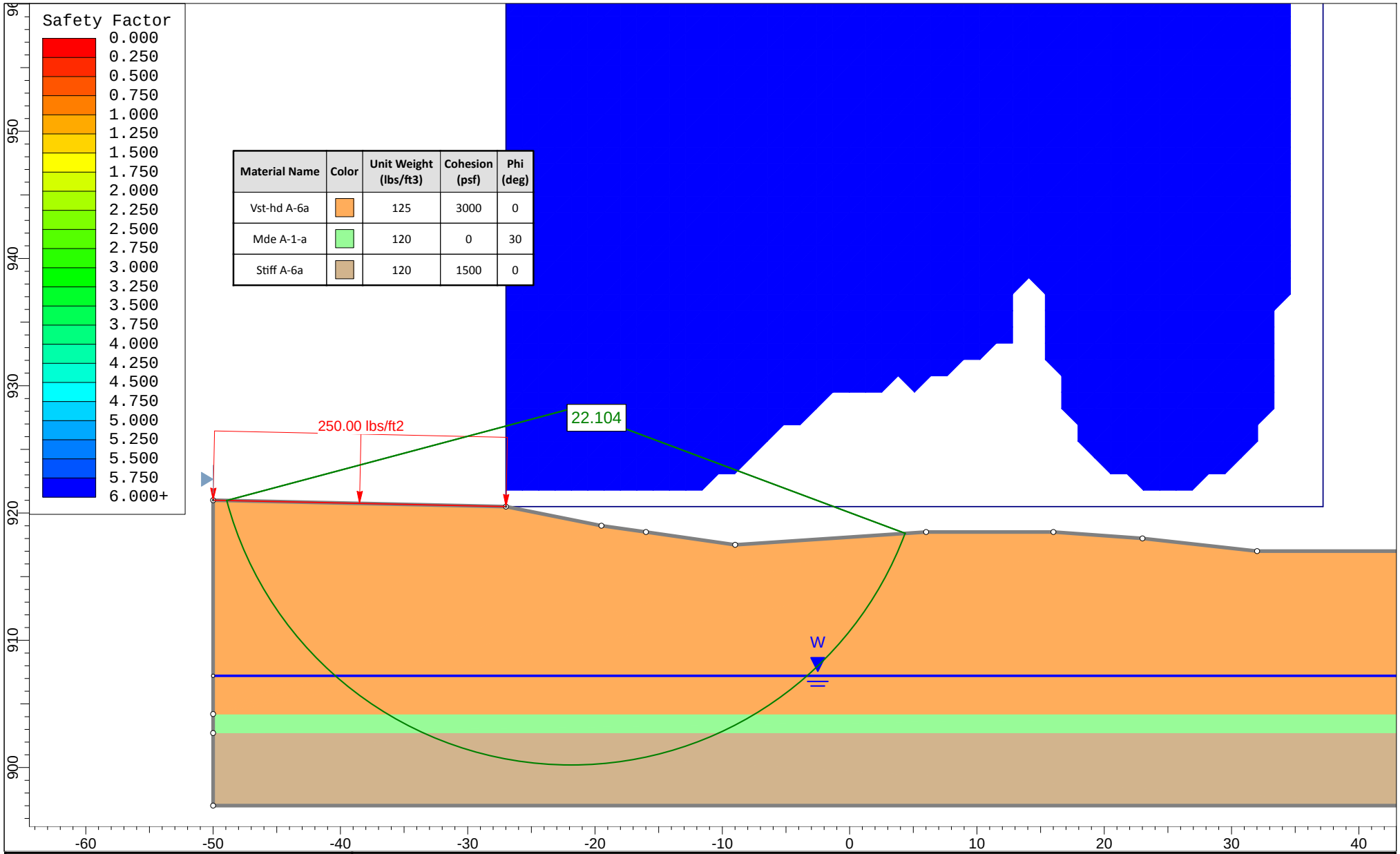
Project	AUG-33-16.69 Proposed Railroad Realignment - Sta. 2441+00		
Analysis Description	Proposed Total Stress Conditions - Spencer Method		
Drawn By JRH	*Scale* 1:150	*Company*	Resource International, Inc.
Date 07.27.2015		*File Name*	B-002 Proposed - Total.slim



Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
Vst-hd A-4a		125	0	32
Hard A-6a		125	0	32
Mde-de A-1-a		120	0	31
New Fill: ODOT Item 203		120	200	30
New Fill: Railroad Ballast		130	0	36

SLIDEINTERPRET 6.032

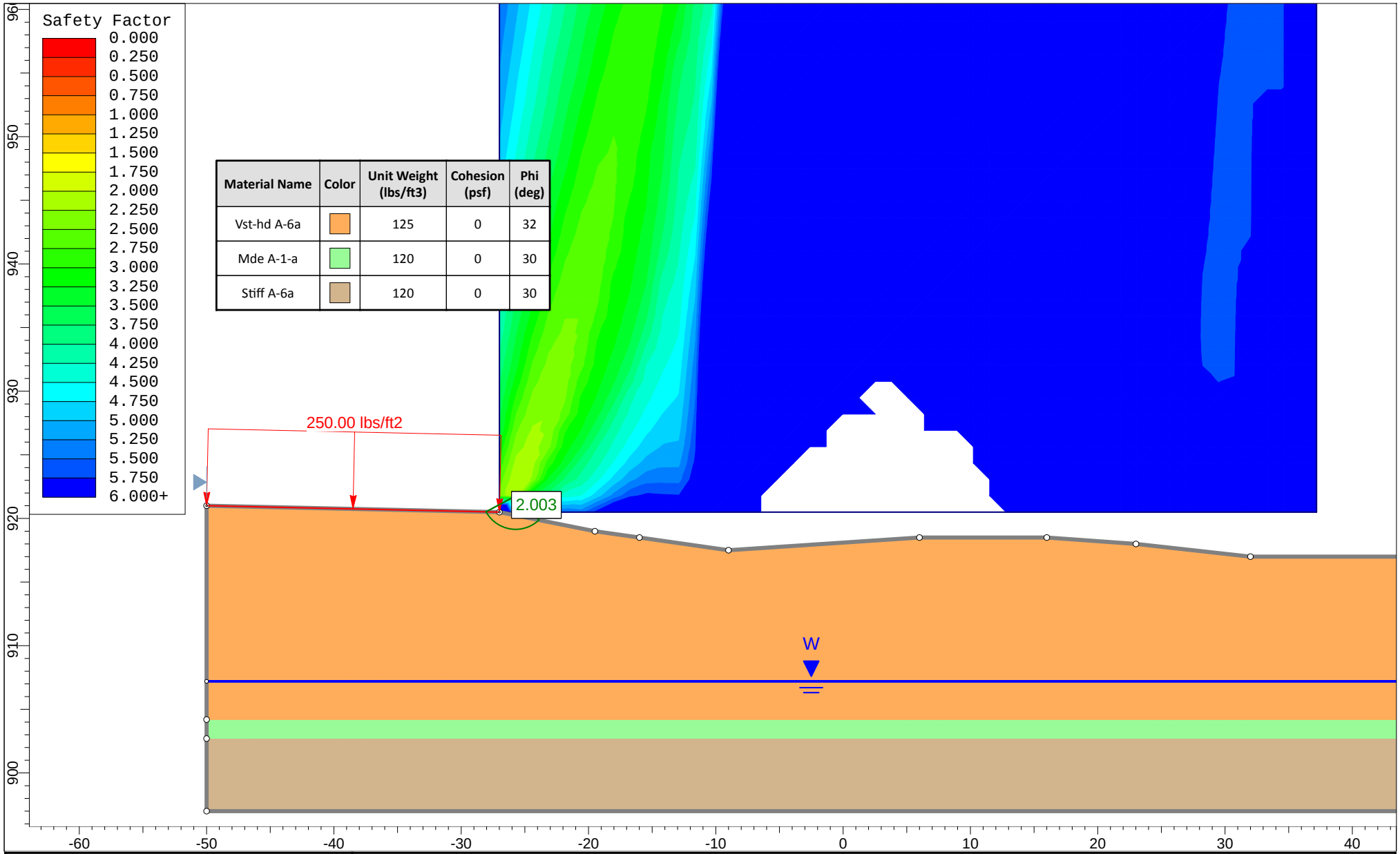
Project	AUG-33-16.69 Proposed Railroad Realignment - Sta. 2441+00		
Analysis Description	Proposed Effective Stress Conditions - Spencer Method		
Drawn By	JRH	*Scale* 1:125	*Company* Resource International, Inc.
Date	07.27.2015		*File Name* B-002 Proposed - Effective.slim



Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
Vst-hd A-6a		125	3000	0
Mde A-1-a		120	0	30
Stiff A-6a		120	1500	0

SLIDEINTERPRET 6.032

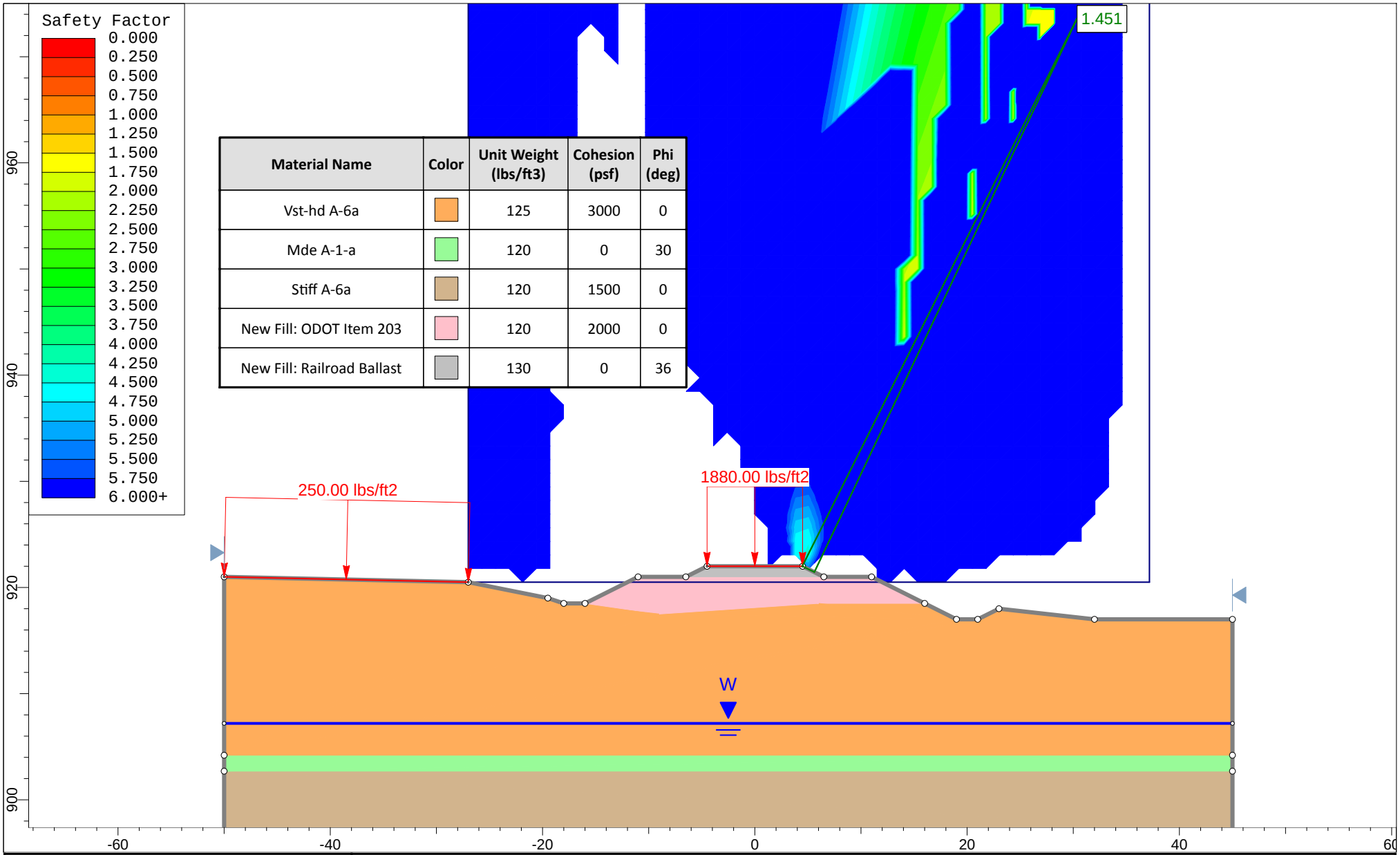
Project	AUG-33-16.69 Proposed Railroad Realignment - Sta. 2438+50		
Analysis Description	Existing Total Stress Conditions - Spencer Method		
Drawn By JRH	*Scale* 1:125	*Company*	Resource International, Inc.
Date 07.27.2015		*File Name*	B-003 Existing - Total.slim



Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
Vst-hd A-6a		125	0	32
Mde A-1-a		120	0	30
Stiff A-6a		120	0	30

SLIDEINTERPRET 6.032

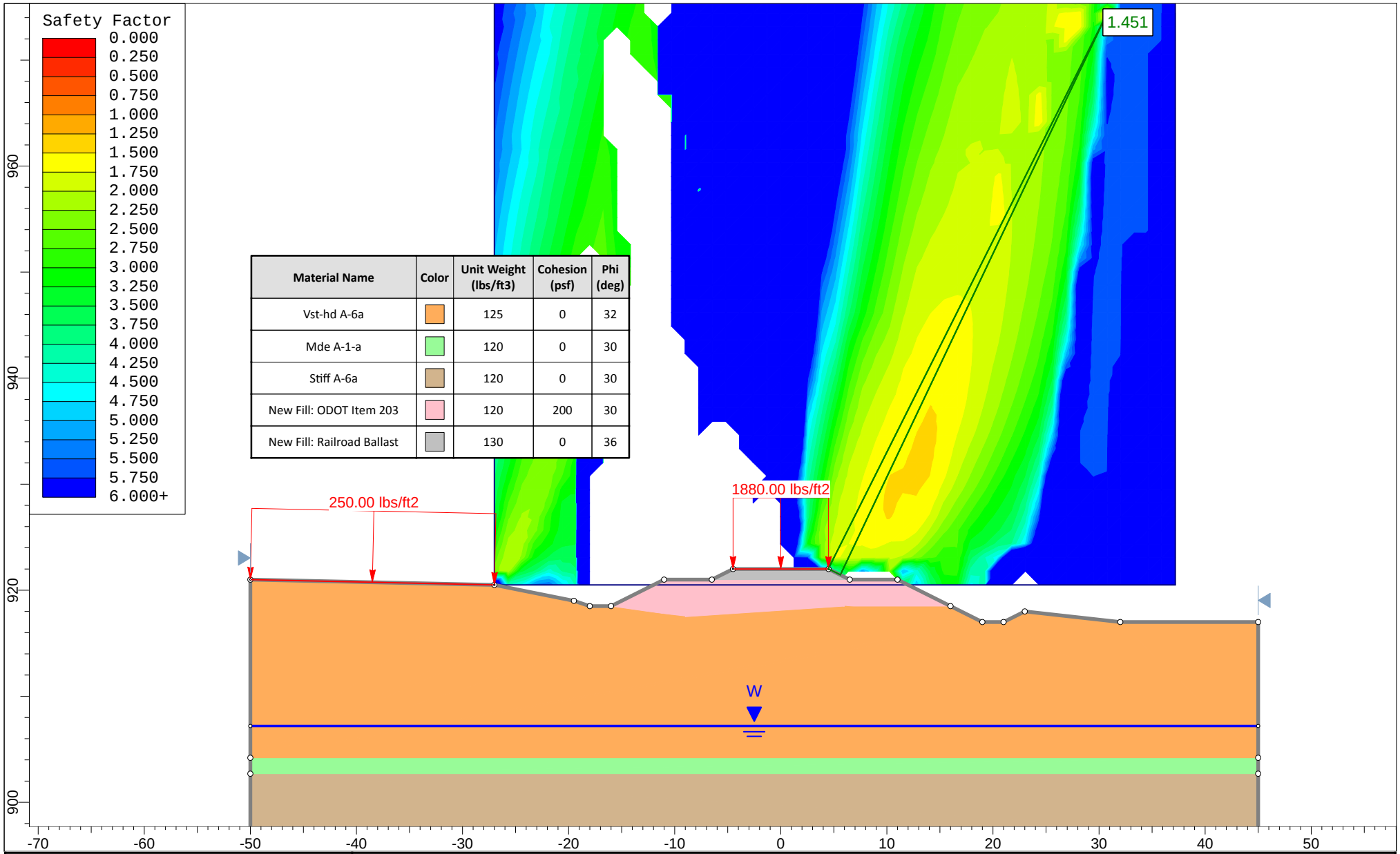
Project	AUG-33-16.69 Proposed Railroad Realignment - Sta. 2438+50		
Analysis Description	Existing Effective Stress Conditions - Spencer Method		
Drawn By JRH	*Scale* 1:125	*Company* Resource International, Inc.	
Date 07.27.2015		*File Name* B-003 Existing - Effective.slim	



Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
Vst-hd A-6a		125	3000	0
Mde A-1-a		120	0	30
Stiff A-6a		120	1500	0
New Fill: ODOT Item 203		120	2000	0
New Fill: Railroad Ballast		130	0	36

SLIDEINTERPRET 6.032

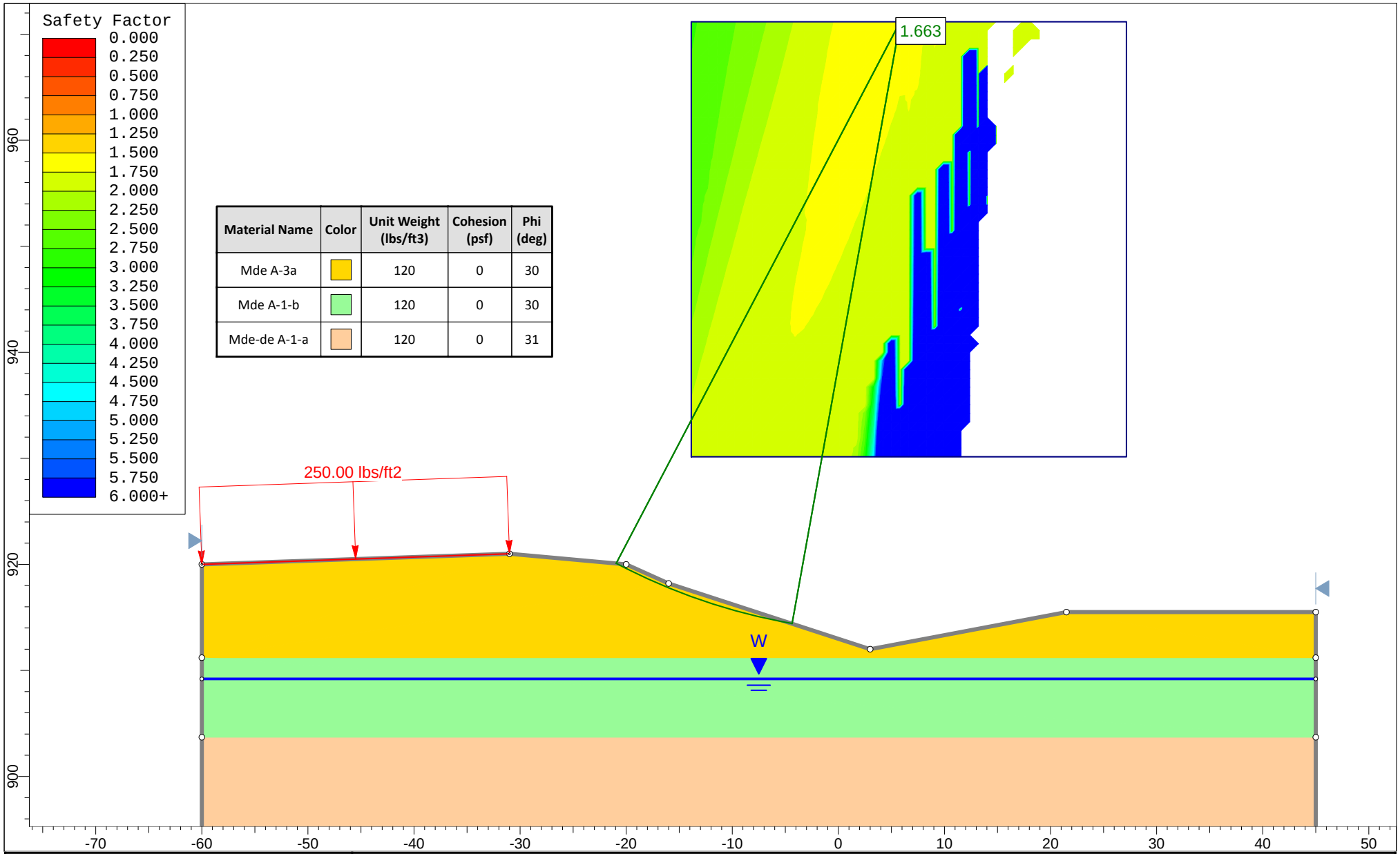
Project	AUG-33-16.69 Proposed Railroad Realignment - Sta. 2438+50		
Analysis Description	Proposed Total Stress Conditions - Spencer Method		
Drawn By JRH	*Scale* 1:150	*Company*	Resource International, Inc.
Date 07.27.2015		*File Name*	B-003 Proposed - Total.slim



Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
Vst-hd A-6a		125	0	32
Mde A-1-a		120	0	30
Stiff A-6a		120	0	30
New Fill: ODOT Item 203		120	200	30
New Fill: Railroad Ballast		130	0	36

Project	AUG-33-16.69 Proposed Railroad Realignment - Sta. 2438+50		
Analysis Description	Proposed Effective Stress Conditions - Spencer Method		
Drawn By: JRH	Scale: 1:150	Company: Resource International, Inc.	
Date: 07.27.2015		File Name: B-003 Proposed - Effective.slim	

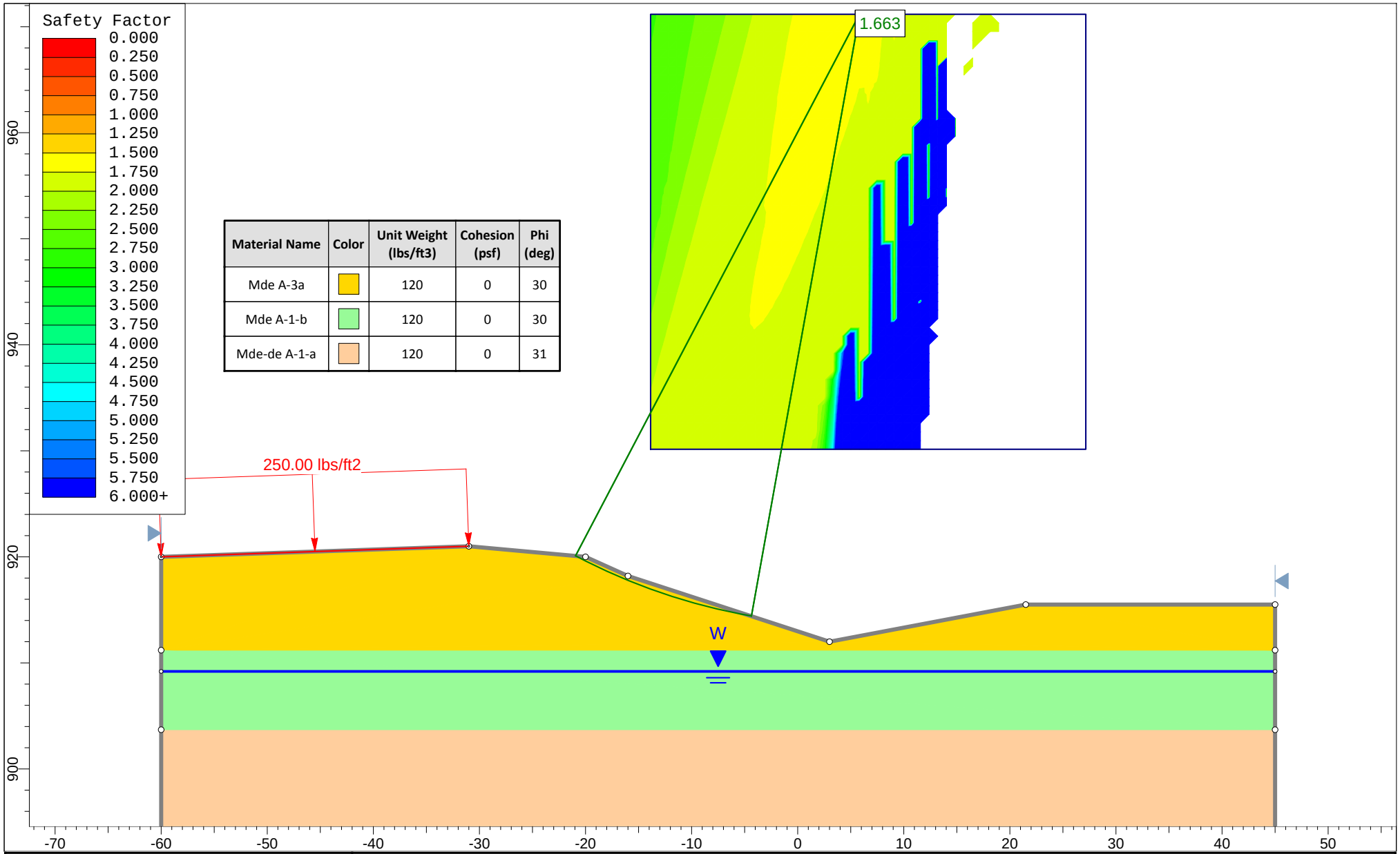
SLIDEINTERPRET 6.032



Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
Mde A-3a		120	0	30
Mde A-1-b		120	0	30
Mde-de A-1-a		120	0	31

SLIDEINTERPRET 6.032

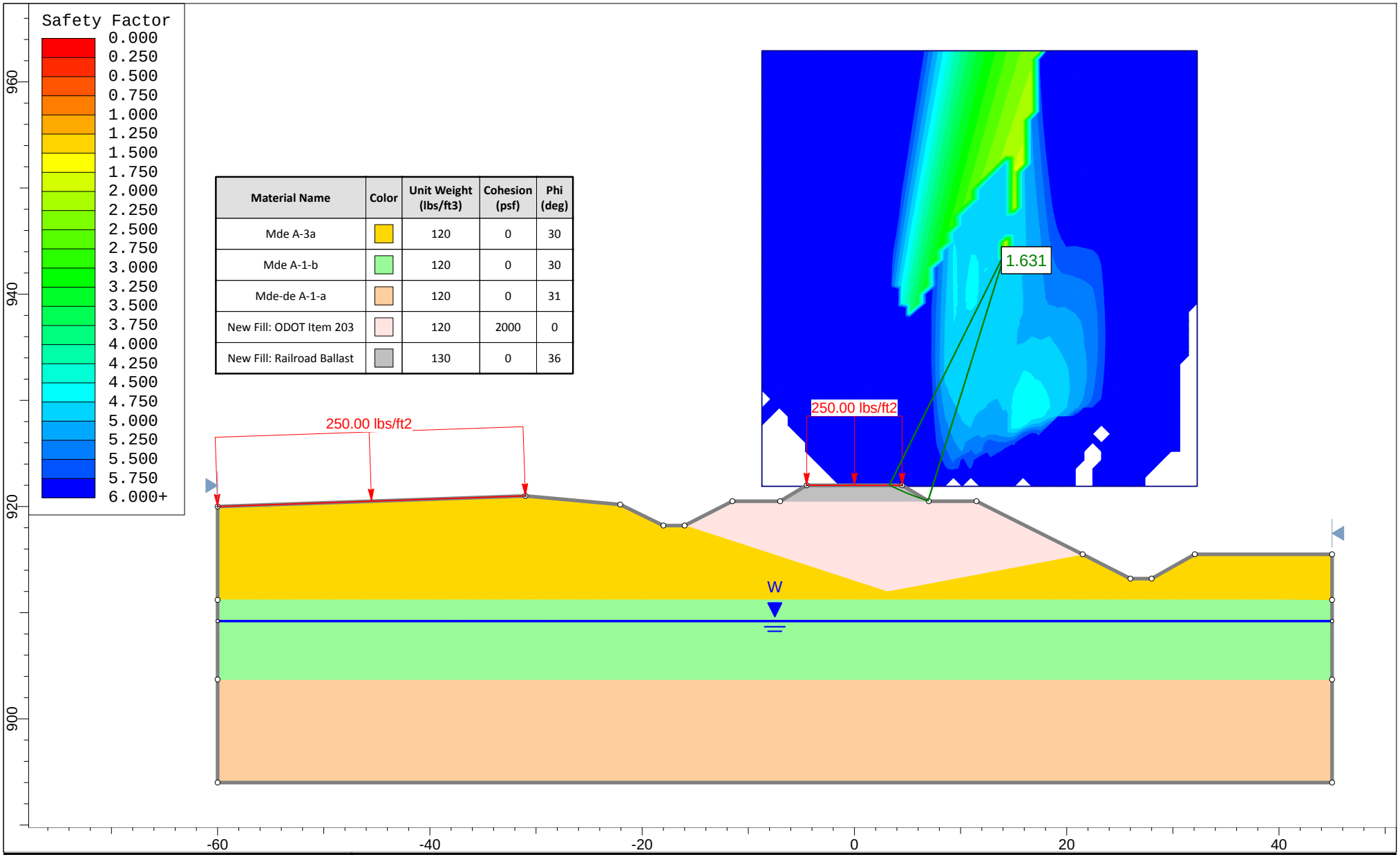
Project	AUG-33-16.69 Proposed Railroad Realignment - Sta. 2435+50		
Analysis Description	Existing Total Stress Conditions - Spencer Method		
Drawn By JRH	*Scale* 1:150	*Company*	Resource International, Inc.
Date 07.27.2015		*File Name*	B-004 Existing - Total.slim



Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
Mde A-3a		120	0	30
Mde A-1-b		120	0	30
Mde-de A-1-a		120	0	31

SLIDEINTERPRET 6.032

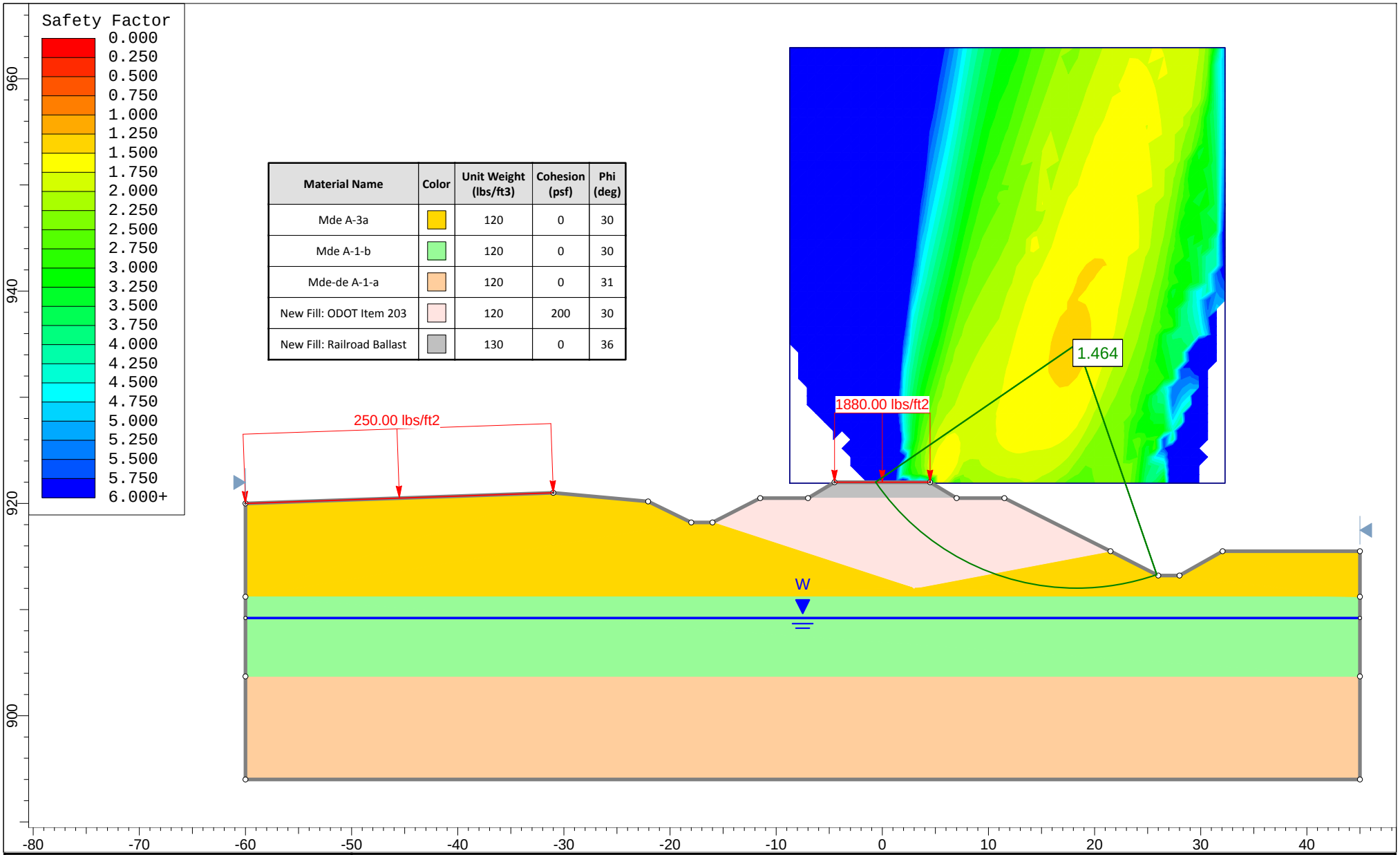
Project	AUG-33-16.69 Proposed Railroad Realignment - Sta. 2435+50		
Analysis Description	Existing Effective Stress Conditions - Spencer Method		
Drawn By JRH	*Scale* 1:150	*Company*	Resource International, Inc.
Date 07.27.2015		*File Name*	B-004 Existing - Effective.slim



Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
Mde A-3a		120	0	30
Mde A-1-b		120	0	30
Mde-de A-1-a		120	0	31
New Fill: ODOT Item 203		120	2000	0
New Fill: Railroad Ballast		130	0	36

SLIDEINTERPRET 6.032

Project	AUG-33-16.69 Proposed Railroad Realignment - Sta. 2435+50		
Analysis Description	Proposed Total Stress Conditions - Spencer Method		
Drawn By JRH	*Scale* 1:150	*Company*	Resource International, Inc.
Date 07.27.2015		*File Name*	B-004 Proposed - Total.slim



Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
Mde A-3a		120	0	30
Mde A-1-b		120	0	30
Mde-de A-1-a		120	0	31
New Fill: ODOT Item 203		120	200	30
New Fill: Railroad Ballast		130	0	36

SLIDEINTERPRET 6.032

Project	AUG-33-16.69 Proposed Railroad Realignment - Sta. 2435+50		
Analysis Description	Proposed Effective Stress Conditions - Spencer Method		
Drawn By JRH	*Scale* 1:150	*Company*	Resource International, Inc.
Date 07.27.2015		*File Name*	B-004 Proposed - Effective.slim

APPENDIX VII

SETTLEMENT CALCULATIONS

W-15-074 AUG-33-16.69

Railroad Embankment Settlement

Calculated By: JRH Date: 07.28.2015

Checked By: JPS Date: 08.03.2015

Boring B-004, Sta. 2435+50

H=	9.2	ft	Total embankment height	Proposed Grade	922.26
B'=	38.0	ft	Effective width	Existing Grade	913.1
D_w =	5.0	ft	Depth below bottom of dam		
q_e =	1,099	psf	Equivalent bearing pressure at bottom of dam		

Layer	Soil Class.	Soil Type	Layer Depth (ft)		Layer Thickness H (ft)	Depth to Midpoint (ft)	γ (pcf)	σ_{vo} Bottom (psf)	σ_{vo} Midpoint (psf)	σ_{vo}' Midpoint (psf)	σ_p' (1) (psf)	LL	C_c (2)	C_r (3)	e_o (4)	N_{60}	$(N1)_{60}$ (5)	C' (6)	Z_f/B	Total Settlement at Center of Embankment: I (7)	$\Delta\sigma_v$ (8) (psf)	σ_{vf}' Midpoint (psf)	S_c (9,10) (ft)	S_c (in)	Total Settlement at Toe: I (7)	$\Delta\sigma_v$ (8) (psf)	σ_{vf}' Midpoint (psf)	S_c (9,10) (ft)	S_c (in)
1	A-3a	G	0.0	1.0	1.0	0.5	120	120	60	60	4,060					16	32	89	0.01	1.000	1,099	1,159	0.014	0.174	0.500	550	610	0.011	0.136
		G	1.0	2.0	1.0	1.5	120	240	180	180	4,180					16	29	82	0.04	0.994	1,093	1,273	0.010	0.125	0.500	550	730	0.007	0.089
		G	2.0	3.0	1.0	2.5	120	360	300	300	4,300					16	26	76	0.07	0.988	1,086	1,386	0.009	0.105	0.500	550	850	0.006	0.072
2	A-1-b	G	3.0	4.0	1.0	3.5	120	480	420	420	4,420					16	24	72	0.09	0.982	1,080	1,500	0.008	0.092	0.500	550	970	0.005	0.061
		G	4.0	5.0	1.0	4.5	120	600	540	540	4,540					16	23	69	0.12	0.976	1,073	1,613	0.007	0.083	0.500	550	1,090	0.004	0.053
		G	5.0	6.0	1.0	5.5	120	720	660	629	4,629					16	22	68	0.14	0.971	1,067	1,696	0.006	0.077	0.500	550	1,178	0.004	0.048
		G	6.0	7.0	1.0	6.5	120	840	780	686	4,686					16	22	67	0.17	0.965	1,060	1,747	0.006	0.073	0.500	550	1,236	0.004	0.046
		G	7.0	8.0	1.0	7.5	120	960	900	744	4,744					16	21	66	0.20	0.959	1,054	1,798	0.006	0.070	0.500	550	1,294	0.004	0.044
		G	8.0	10.0	2.0	9.0	120	1,200	1,080	830	4,830					16	21	65	0.24	0.953	1,047	1,878	0.011	0.132	0.500	550	1,380	0.007	0.082
3	A-1-a	G	10.0	12.0	2.0	11.0	120	1,440	1,320	946	4,946					16	20	63	0.29	0.935	1,028	1,974	0.010	0.121	0.492	541	1,486	0.006	0.074
		G	12.0	14.0	2.0	13.0	120	1,680	1,560	1,061	5,061					16	19	62	0.34	0.924	1,015	2,076	0.009	0.112	0.484	532	1,593	0.006	0.068
		G	14.0	16.0	2.0	15.0	120	1,920	1,800	1,176	5,176					16	19	61	0.39	0.912	1,002	2,178	0.009	0.105	0.476	523	1,699	0.005	0.063
		G	16.0	18.0	2.0	17.0	125	2,170	2,045	1,296	5,296					37	42	116	0.45	0.900	989	2,285	0.004	0.051	0.468	514	1,811	0.002	0.030
		G	18.0	20.0	2.0	19.0	125	2,420	2,295	1,421	5,421					37	41	113	0.50	0.860	945	2,367	0.004	0.047	0.460	506	1,927	0.002	0.028
																				Total Settlement:				1.367 in	Total Settlement:				0.894 in

1. $\sigma_p' = \sigma_{vo}' + \sigma_m$; Estimate σ_m of 4,000 psf for moderately overconsolidated soil deposit; Ref. Table 11.2, Coduto 2003
2. $C_c = 0.009(LL-10)$; Ref. Table 26, FHWA GEC 5
3. $C_r = 0.05(C_c)$ for embankment fill and $0.10(C_c)$ for natural cohesive soils; Ref. Section 5.4.2.5 of FHWA GEC 5
4. $e_o = (C_c/1.15)+0.35$; Ref. Table 8-2, Holtz and Kovacs 1981
5. $(N1)_{60} = C_n N_{60}$, where $C_N = [0.77\log(40/\sigma_{vo}')] \leq 2.0$ ksf; Ref. Section 10.4.6.2.4, AASHTO LRFD BDS
6. Bearing capacity index; Ref. Figure 10.6.2.4.2-1, AASHTO LRFD BDS
7. Influence factor for strip loaded footing
8. $\Delta\sigma_v = q_e(I)$
9. $S_c = [C_c/(1+e_o)](H)\log(\sigma_{vf}'/\sigma_{vo}')$ for $\sigma_p' \leq \sigma_{vo}' < \sigma_{vf}'$; $[C_r/(1+e_o)](H)\log(\sigma_p'/\sigma_{vo}')$ for $\sigma_{vo}' < \sigma_{vf}' \leq \sigma_p'$; $[Cr/(1+e_o)](H)\log(\sigma_p'/\sigma_{vo}')+[C_c/(1+e_o)](H)\log(\sigma_{vf}'/\sigma_p')$ for $\sigma_{vo}' < \sigma_p' < \sigma_{vf}'$; Ref. Section 10.6.2.4.3, AASHTO LRFD BDS (Cohesiv soil layers)
10. $S_c = H(1/C')\log(\sigma_{vf}'/\sigma_{vo}')$; Ref. Section 10.6.2.4.2, AASHTO LRFD BDS (Granular soil layers)

W-15-074 AUG-33-16.69
Railroad Embankment Settlement

Calculated By: JRH Date: 07.28.2015
Checked By: JPS Date: 08.03.2015

Boring B-004, Sta. 2435+50

H=	9.2	ft	Total wall height
B'=	38.0	ft	Effective footing width due to eccentricity
D_w =	5.0	ft	Depth below bottom of footing
q_e =	1,099	psf	Equivalent bearing pressure at bottom of wall

	A-4a		
c_v =	0	ft^2/yr	Coefficient of consolitation
t =	10	days	Time following completion of construction
H_{dr} =	13.0	ft	Length of longest drainage path considered
T_v =	0.000		Time factor
U =	0	%	Degree of consolidation

$(S_c)_t$ = 1.218 in Settlement complete at 89% of primary consolidation

Layer	Soil Type	Soil Type	Layer Depth (ft)		Layer Thickness (ft)	Depth to Midpoint (ft)	γ (pcf)	σ_{vo} Bottom (psf)	σ_{vo} Midpoint (psf)	σ_{vo}' Midpoint (psf)	σ_p' (1) (psf)	LL	C_c (2)	C_r (3)	e_o (4)	N_{60}	$(N1)_{60}$ (5)	C' (6)	Z_f/B	I (7)	$\Delta\sigma_v$ (8) (psf)	σ_{vf}' Midpoint (psf)	Total Settlement at Facing of Wall: S_c (9,10) (ft)	S_c (in)	Layer Settlement (in)	Settlement Complete at 89% of Primary Consolidation: $(S_c)_t$ (11) (in)	Layer Settlement (in)
1	A-3a	G	0.0	1.0	1.0	0.5	120	120	60	60	4,060					16	32	89	0.01	1.000	1,099	1,159	0.014	0.174	0.801	0.174	0.801
		G	1.0	2.0	1.0	1.5	120	240	180	180	4,180					16	29	82	0.04	0.994	1,093	1,273	0.010	0.125		0.125	
		G	2.0	3.0	1.0	2.5	120	360	300	300	4,300					16	26	76	0.07	0.988	1,086	1,386	0.009	0.105		0.105	
		G	3.0	4.0	1.0	3.5	120	480	420	420	4,420					16	24	72	0.09	0.982	1,080	1,500	0.008	0.092		0.092	
2	A-1-b	G	4.0	5.0	1.0	4.5	120	600	540	540	4,540					16	23	69	0.12	0.976	1,073	1,613	0.007	0.083		0.083	
		G	5.0	6.0	1.0	5.5	120	720	660	629	4,629					16	22	68	0.14	0.971	1,067	1,696	0.006	0.077		0.077	
		G	6.0	7.0	1.0	6.5	120	840	780	686	4,686					16	22	67	0.17	0.965	1,060	1,747	0.006	0.073		0.073	
		G	7.0	8.0	1.0	7.5	120	960	900	744	4,744					16	21	66	0.20	1.000	1,099	1,843	0.006	0.072		0.072	
		G	8.0	10.0	2.0	9.0	120	1,200	1,080	830	4,830					16	21	65	0.24	0.953	1,047	1,878	0.011	0.132	0.254	0.132	0.254
		G	10.0	12.0	2.0	11.0	120	1,440	1,320	946	4,946					16	20	63	0.29	0.947	1,041	1,987	0.010	0.122		0.122	
3	A-1-a	G	12.0	14.0	2.0	13.0	120	1,680	1,560	1,061	5,061					16	19	62	0.34	0.924	1,015	2,076	0.009	0.112	0.112	0.112	0.112
		G	14.0	16.0	2.0	15.0	120	1,920	1,800	1,176	5,176					16	19	61	0.39	0.912	1,002	2,178	0.009	0.105	0.105	0.000	0.000
		G	16.0	18.0	2.0	17.0	125	2,170	2,045	1,296	5,296					37	42	116	0.45	0.900	989	2,285	0.004	0.051	0.051	0.051	0.051
		G	18.0	20.0	2.0	19.0	125	2,420	2,295	1,421	5,421					37	41	113	0.50	0.860	945	2,367	0.004	0.047	0.047	0.000	0.000

1. $\sigma_p' = \sigma_{vo}'+\sigma_m$; Estimate σ_m of 4,000 psf for moderately overconsolidated soil deposit; Ref. Table 11.2, Coduto 2003
2. $C_c = 0.009(LL-10)$; Ref. Table 26, FHWA GEC 5
3. $C_r = 0.05(C_c)$ for embankment fill and $0.10(C_c)$ for natural cohesive soils; Ref. Section 5.4.2.5 of FHWA GEC 5
4. $e_o = (C_c/1.15)+0.35$; Ref. Table 8-2, Holtz and Kovacs 1981
5. $(N1)_{60} = C_n N_{60}$, where $C_N = [0.77\log(40/\sigma_{vo}')] \leq 2.0$ ksf; Ref. Section 10.4.6.2.4, AASHTO LRFD BDS
6. Bearing capacity index; Ref. Figure 10.6.2.4.2-1, AASHTO LRFD BDS
7. Influence factor for strip loaded footing
8. $\Delta\sigma_v = q_e(I)$
9. $S_c = [C_c/(1+e_o)](H)\log(\sigma_{vf}'/\sigma_{vo}')$ for $\sigma_p' \leq \sigma_{vo}' < \sigma_{vf}'$; $[C_r/(1+e_o)](H)\log(\sigma_p'/\sigma_{vo}')$ for $\sigma_{vo}' < \sigma_{vf}' \leq \sigma_p'$; $[Cr/(1+e_o)](H)\log(\sigma_p'/\sigma_{vo}')+[C_c/(1+e_o)](H)\log(\sigma_{vf}'/\sigma_p')$ for $\sigma_{vo}' < \sigma_p' < \sigma_{vf}'$; Ref. Section 10.6.2.4.3, AASHTO LRFD BDS (Cohesiv soil layers)
10. $S_c = H(1/C')\log(\sigma_{vf}'/\sigma_{vo}')$; Ref. Section 10.6.2.4.2, AASHTO LRFD BDS (Granular soil layers)
11. $(S_c)_t = S_c(U/100)$; U = 100 for all granular soils at time t = 0

Settlement Remaining After Hold Period: 0.152 in