ARKANSAS DEPARTMENT OF TRANSPORTATION

SUBSURFACE INVESTIGATION

STATE JOB NO. BR4401

FEDERAL AID PROJECT STPB-0044(32)

WAR EAGLE CREEK STR. & APPRS. (S)

COUNTY ROAD NO. CR 7

IN MADISON **COUNTY**

The information contained herein was obtained by the Department for design and estimating purposes only. It is being furnished with the express understanding that said information does not constitute a part of the Proposal or Contract and represents only the best knowledge of the Department as to the location, character and depth of the materials encountered. The information is only included and made available so that bidders may have access to subsurface information obtained by the Department and is not intended to be a substitute for personal investigation, interpretation and judgment of the bidder. The bidder should be cognizant of the possibility that conditions affecting the cost and/or quantities of work to be performed may differ from those indicated herein.

ARKANSAS DEPARTMENT OF TRANSPORTATION
ArDOT.gov | IDriveArkansas.com | Lorie H. Tudor, P.E., Director
MATERIALS DIVISION
11301 West Baseline Road | P.O. Box 2261 | Little Rock, AR 72203-2261 | Phone: 501.569.2185 | Fax: 501.569.2368

April 18, 2024

TO: Mr. Rick Ellis, Bridge Engineer

SUBJECT: Job No. BR4401
War Eagle Creek Str. & Apprs. (S)
Madison County
County Road 7 (5551)

INTRODUCTION

Submitted herein are results of the subsurface investigation and geotechnical recommendations developed for the proposed replacement bridge on County Road 7 over War Eagle Creek in Madison County.

The proposed structure will be 355 feet in total length and consist of a 353-foot Continuous Composite Plate Girder Unit. The proposed structure will have an out-to-out width of 30.5 feet. The proposed alignment will be located north of the existing bridge.

Based on the geotechnical investigation request from Bridge Division, foundation loads are expected to be supported on spread footings or drilled shafts at the intermediate bents and H-Piles at the end bents. 2-Horizontal to 1-Vertical (2H:1V) end slopes and 3H:1V side slopes are planned at the proposed abutments. Abutment slopes will be constructed utilizing fill with a maximum embankment height of 10 feet for the west abutment (Bent 1) to 22 feet for the east abutment (Bent 4).

FIELD INVESTIGATION

A subsurface investigation was requested on November 28, 2023 by Bridge Division to develop recommendations for bridge foundations and to verify the suitability of bridge abutment embankment configuration. Four (4) borings were requested, and four (4) borings were drilled.

The approximate locations of the borings are presented in the Plan of Borings included in Attachment A. The borings were advanced with a track-mounted Acker Renegade rotary drill rig using a combination of hollow-stem auger and rock coring drilling methods. The boring logs showing the subsurface conditions and the results of field and laboratory tests are also included in Attachment A, immediately following the Plan of Borings. A legend is attached following the boring logs to describe the symbols, terms, and conventions used on logs. Standard Penetration Tests (SPT) were conducted in accordance with ASTM D1586 for field-testing and soil sampling. The correction factor for the hammer is indicated on the boring logs. Liners were not used inside the standard split-barrel samplers.

The number of blows required to drive the standard split-barrel sampler for each 6-inch increment of the total 18-inch drive were measured and recorded on the boring logs. SPT N-values are defined as the total number of blows required to advance the split barrel sampler the final 12 inches of the total 18-inch drive depth. The SPT N-values indicated on the logs are raw (uncorrected) blow counts measured in the field. Groundwater was also observed during the drilling process. Groundwater observations are noted on the logs.

Core samples of bedrock were retrieved using NQ3-size triple-tube core barrels (rock core diameter of 1-3/4 in. and hole diameter of 3 in.). For each core run, Total Core Recovery (TCR) and Rock Quality Designation (RQD) was determined in the field and further evaluated by licensed Professional Geologists (PG). TCR, expressed as a percent, is defined as the sum of all intact core pieces divided by the total length of the core run. RQD, also expressed as a percent, is defined as the sum of all intact core pieces that are longer than 4 inches divided by the total length of the core run. TCR and RQD values of each core run are indicated on each corresponding boring log. Core pictures are also included in Attachment A, following the boring logs and legend.

LAB INVESTIGATION

All samples were brought to the Materials Division laboratory for further evaluation and testing. These samples were tested to evaluate index properties and to verify soil type and classification. Lab tests were performed on representative soil samples to determine moisture content, Atterberg limits, and gradation. Tested soils were classified by a licensed PG in accordance with both USCS and AASHTO soil classification systems.

These test results are plotted or indicated on the logs using appropriate denotation (symbols in accordance with scale, number, text, etc.). Table 1 lists the laboratory tests; their corresponding ASTM and AASHTO test methods, and respective denotation on logs.

Rock cores were first examined by a licensed PG to verify TCR and RQD measured in the field and to obtain parameters for determination of Geological Strength Index (GSI) and Rock Mass Rating (RMR). Compressive strength of rock cores was then determined by laboratory uniaxial compressive tests on intact rock cores in accordance with ASTM D7012, Method C. Results of uniaxial compressive tests, GSI and RMR are included in Attachment B.

Table 1: Summary of Laboratory Tests and Methods

Laboratory Test	ASTM	AASHTO	Denotation on Logs
Moisture Content	D2216	T 265	Solid Circle Symbol (●)
Grain Size Distribution	D6913	T 88	Whole Number in the “Percent Passing No. 200 Sieve” Column (e.g., 12)
Atterberg Limits	D4318	T 89	Plus Symbol (+) on the Right for Liquid Limit
		T 90	Plus Symbol (+) on the Left for Plastic Limit
Resistivity	-	T 288	Not Denoted on Logs
pH	ARDOT 357		Not Denoted on Logs
Uniaxial Compression of Rock Cores	D7012, Method C	-	Not Denoted on Logs

The particle size through which 50% of particles by weight passing, D_{50}, is summarized in Table 2. Detailed particle size distribution curves used for D_{50} determination are included in Attachment C.

Table 2: Summary of D_{50} for Scour Analysis

Bridge	Station	Sample Type	Location	D_{50}, mm
War Eagle Creek	104+84, CL	Bulk	Creek Bank	0.32

To determine the corrosive potential of the foundation soils to steel piles, laboratory pH resistivity tests were performed with bulk soil samples obtained from Boring 4 (Sta. 107+31, CL) at 0 to 9.2 feet bgl. The results of pH and resistivity tests are summarized in Table 3.

Table 3: Results of Laboratory pH and Resistivity Test

Laboratory Test	Boring	Station	Sample Type	Results
pH	4	Bulk	Creek Bank	7.6
Resistivity				4,440 (Ohms)

SITE CONDITIONS

The existing bridge (No. 21595) is 135.7 feet long, 14.5 feet wide and consists of two railroad cars (2 spans total) supported by concrete piers. The existing bridge is located approximately 49 feet downstream from the proposed bridge. Site pictures for County Road 7 over War Eagle Creek are included in Attachment D.

SITE GEOLOGY AND GENERAL SUBSURFACE CONDITIONS

War Eagle Creek runs south to north through a broad valley surrounded by bluffs of limestone, sandstone, and shales of the Bloyd and Atoka Formations. Some of the shales within these formations have a history of being water sensitive and unstable. These shales have led to the development of multiple confirmed landslides adjacent to the project location. One of these landslides is located approximately 400 feet to the east of the existing bridge between County Road 7 and Highway 23. Outcrops of the Brentwood Limestone Member of the Bloyd Formation, are exposed on the west side of War Eagle Creek to the north (downstream) of the existing bridge. The remnants of an old bridge end are also exposed adjacent to this limestone outcrop. There is a large gravel bar on the east side of War Eagle Creek to the north (downstream) of the existing bridge. The confluence of Jackson Creek with War Eagle Creek is located approximately 100 feet southwest (upstream) of the existing bridge.

The project area is located in the Pennsylvanian aged Brentwood Member of the Bloyd Formation. According to the Arkansas Office of the State Geologist stratigraphic summary, the Brentwood formation can be described as a sequence of limestones separated by thick intervals of dark shale. The normal sequence usually has 2 to 4 limestone intervals; however, east of the type region, the unit becomes more sandy. The Woolsey Member is composed of terrestrial sediments comprised of dark-gray, fissile shale, often interbedded with thin siltstones. A thin coal bed, called the Baldwin Coal, occurs at or near the top of the Woolsey Member. This unit frequently contains quartz granules and is a common bluff-former. The Middle Bloyd Sandstone is normally mapped as part of the Dye Shale. The marine deposited Dye Shale Member is predominantly a dark-gray shale with scattered calcareous concretions. Where underlain by the Woolsey Member, the Dye Shale typically has beds of calcareous sandstone with scattered clay

pebbles and quartz granules, called the caprock, at its base. The Kessler Limestone Member is either a single unit of limestone or a sequence of limestone and interbedded shale. The limestones are bioclastic, oolitic, and contain abundant oncoliths, traces of clay-pebble conglomerate, and minor amounts of calcareous sandstone. The Kessler Member appears to be absent east of central Madison County. The Trace Creek Shale Member is composed of dark-gray shales with thin beds of sandstone. The sandstone beds become thicker and more common toward the top of the unit. The base of the formation is considered conformable, but unconformities are recognized at the base of the Dye Shale and at the base of the Trace Creek Member. Typical thicknesses for the Bloyd Formation range from 175 to 200 feet.

A generalized Subsurface Profile is included in Attachment E to aid in visualizing subsurface conditions and stratigraphy. Estimated elevations of competent rock are listed below in Table 4.

Table 4: Estimated Elevation of Competent Rock

Boring No.	Boring Location	Ground Surf. Elev.@ Boring Location, ft.	Estimated Elev. of Competent Rock, ft.
1	Sta. 104+19, 6' LT	1337.8	1331.5
2	Sta. 104+82, 9' LT	1330.6	1322.0
3	Sta. 106+29, CL	1334.4	1312.0
4	Sta. 107+31, CL	1335.0	1325.5

SEISMIC CONDITIONS

Seismic Site Class and Seismic Performance Zone – In light of the average subsurface conditions as revealed by the borings, a **Seismic Site Class C (Very Dense Soil and Soft Rock Profile)** was calculated for the proposed bridge over War Eagle Creek. Utilizing Seismic Site Class C and the approximate GPS coordinates of the project site, the following design peak ground acceleration coefficient (A_S), design short-period spectral acceleration coefficient (S_{DS}), as well as design long-period spectral acceleration coefficient (S_{D1}), were determined. These seismic coefficients are summarized in Table 5. For the design long-period spectral acceleration coefficient (S_{D1}) of 0.101g, a **Seismic Performance Zone 1** is considered applicable.

Design Response Spectrum is presented in Attachment F.

Table 5: Design Ground Motion Acceleration Response Coefficients

Acceleration Coefficient	Value (g)
A_S (Site PGA)	0.074
S_{DS} (0.2 sec)	0.177
S_{D1} (1 sec)	0.101

APPROACH EMBANKMENTS

Embankment Configuration – As noted, 2H:1V end slopes and 3H:1V side slopes are planned for the proposed embankments. Abutment slopes will be constructed utilizing fill with a maximum height of 10 feet at the west abutment and 22 feet at the east abutment.

Settlement Potential – The underlying soils mainly comprise of Sand with varying amounts of Silt, Clay, Gravel and Cobbles. It is anticipated that most of the settlement that occurs will be elastic settlement and will take place shortly after loading is applied. Due to the granular overburden soils and shallow depth to bedrock, long-term consolidation settlement is expected to be minimal.

Approach Stability – Slope stability analyses were performed utilizing a commercial computer program Slide2 (Version 2021) developed by RocScience. Spencer analysis method was utilized to analyze both bridge abutments. Three general loading conditions were analyzed with respect to slope stability: Short Term/End of Construction Condition, Long Term Condition, and Seismic/Pseudo-Static Condition. A horizontal acceleration coefficient (K_h) of 0.037 (0.5 A_S/g) was utilized for analysis of the Seismic/Psuedo-Static Condition. A surcharge of 250 psf was used to model the live load in the Long-Term Condition.

Slope stability analyses were performed on the 2H:1V end slopes at the west abutment (Bent 1) and the east abutment (Bent 4), to evaluate suitability of the plan configuration. Table 6 includes the results of the slope stability analyses utilizing the plan embankment layout. Graphic results of the slope stability analyses are included in Attachment G.

Table 6: Results of Slope Stability Analyses Utilizing Plan Configuration

Design Condition	Calculated Factor of Safety		Recommended Factor of Safety
	West Embankment	East Embankment	
End of Construction (Short Term)	3.38	2.74	1.3
Long Term	1.84	1.44	1.4
Pseudo-Static (Seismic)	3.09	2.51	1.05

Based on results from the slope stability analyses, plan configuration of the embankments are suitable.

FOUNDATION RECOMMENDATIONS

Based on plans provided by Bridge Division, spread footings or drilled shafts are considered to support the foundation loads at the intermediate bents (Bents 2 & 3), and H-Piles are planned at the end bents (Bents 1 & 4). Due to depth of bedrock and zones of soft weathered shale, spread footings are not considered as an economical foundation type. Therefore, it is recommended that Drilled Shafts be utilized at the intermediate bents. Alternative foundation types can be evaluated upon request.

Drilled Shafts (Bents 2 & 3) – Drilled shafts should be socketed a minimum of two shaft diameters into the competent slightly weathered to unweathered limestone. A final shaft diameter has not been determined but it is expected that 6, 7, or 8 foot diameter shafts are to be utilized at the intermediate bents socketed 12, 14, and 16 feet into competent rock, respectively.

It is recommended the drilled shafts be designed utilizing the estimated elevation of competent rock summarized in Table 4. Actual competent rockline elevation at the drilled shaft locations can vary and must be field verified. Depending on specific rock quality, deepening or shortening of shaft length may be warranted. Settlement of properly constructed drilled shafts socketed into the competent rock should be negligible.

For drilled shafts socketed into competent, slightly weathered to unweathered limestone, a **nominal bearing resistance of 200 ksf** is recommended. A resistance factor (φ_{stat}) of 0.50 is considered suitable for drilled shaft tip resistance in competent rock. Applying the resistance factor to the nominal bearing resistance gives a **factored bearing resistance of 100 ksf.** Due to the roughness of the shaft side wall after drilling and the rate of deterioration of the shale mass once exposed to the atmosphere, it is recommended that shaft side resistance be neglected

H-Piles (Bents 1 & 4) – It is anticipated that steel H-Piles will be utilized to support the foundation loads at the end bents (Bents 1 & 4). Final pile size has not been determined. Steel H-Piles should be driven to practical refusal and bear in the competent slightly weathered to unweathered limestone. It is expected that preboring will be required at all bents in order to achieve minimum pile penetration requirements and to penetrate the overburden soils and gravel and cobble layers.

Practical refusal is defined as a maximum penetration of 1.0 inch from 20 blows by a pile hammer. For estimating pile length, a pile penetration of 6 inches into slightly weathered to unweather rock is estimated. This estimated penetration is based on the results of the borings and our experience with similar foundation rock. The results of the borings indicate moderate to severe driving conditions are to be expected. Consequently, rock points are recommended for all H-piles driven to refusal.

A minimum pile penetration of 10 feet, measured below natural ground surface, is recommended. Greater pile length/penetration may be warranted due to the lateral resistance demand. Preboring is expected to be required to achieve the minimum 10 feet of penetration at Bents 1 and 4. Based on the results of the borings and the assumption of approximately 6 inches of penetration into competent rock, the estimated shallowest pile tip elevations are summarized in Table 7.

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Table 7: Recommended Shallowest Prebore Elevation and Pile Tip Elevation

Boring No.	Boring Location	Estimated Elev. of Competent Rock, ft	Recommended Shallowest Prebore Elev., ft
1	104+19, 6' LT	1331.5	1327.5
4	107+31, CL	1325.5	1325.0

Geotechnical Input Parameters for LPile/Group – Lateral load analysis will be performed by the Structural Engineer using commercial computer programs LPile and/or Group. The geotechnical input parameters are located in Attachment H.

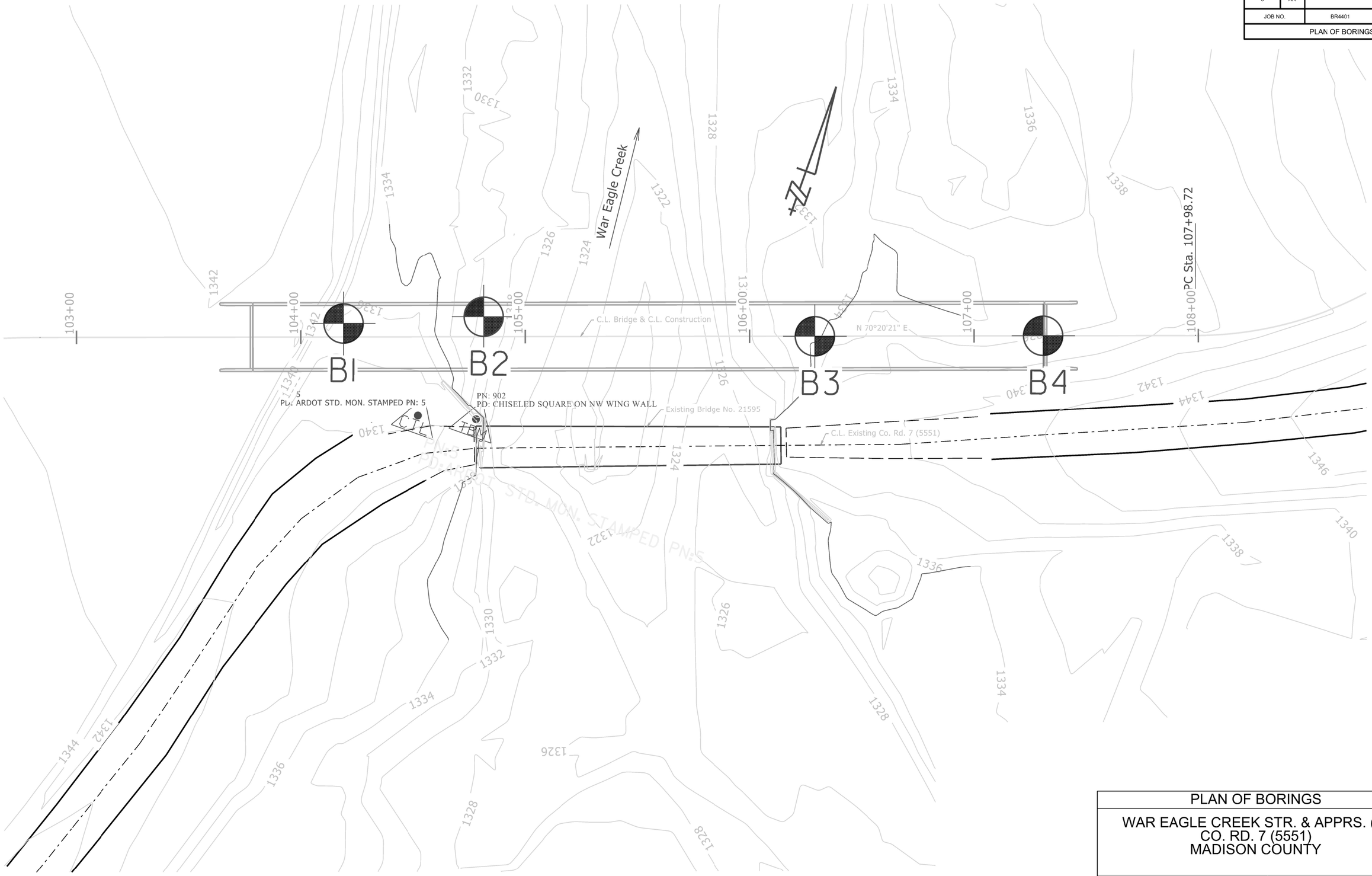
If there are any questions concerning these recommendations, please contact the Materials Division.

Paul Tinsley
Materials Engineer

PT:yz:pjt:cjs
cc: State Construction Engineer
District 9 Engineer
G. C. File

Attachment A

FED. ROAD DIST. NO.	STATE	FED. AID PROJ. NO.	SHEET NO.	TOTAL SHEETS
6	AR			
JOB NO.		BR4401		
PLAN OF BORINGS				



PLAN OF BORINGS	
WAR EAGLE CREEK STR. & APPRS. (S) CO. RD. 7 (5551) MADISON COUNTY	
JOB NO. BR4401	SHEET 1/1
NTS	

ARKANSAS DEPARTMENT OF TRANSPORTATION
MATERIALS DIVISION - GEOTECHNICAL SEC.

BORING NO. 1
PAGE 1 OF 1

JOB NO. BR4401 Madison County
JOB NAME: War Eagle Creek Str. & Apprs. (S)
Co. Rd. 7 (5551)
STATION: 104+19
LOCATION: 6' Left of Construction Centerline
LOGGED BY: Jessie Burdine

DATE: February 20, 2024
TYPE OF DRILLING:
Hollow Stem Auger - Diamond Core
EQUIPMENT: Acker 1

HAMMER CORRECTION FACTOR: 1.42

COMPLETION DEPTH: 28.8

DEPTH FT.	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL SURFACE ELEVATION: 1337.8	SOIL GROUP	MOISTURE CONTENT (%) PL — LL (10 20 30 40 50 60 70)	PERCENT PASSING NO. 200 SIEVE	NO. OF BLOWS PER 6-IN.	% TCR	% RQD
5			Moist, Very Dense, Brown Sand with Silt, Gravel, and Cobbles				6 30 (4")		
			LIMESTONE WITH OCCASIONAL SHALE PARTINGS - Unweathered, Moderately Hard, Gray					89	77
10								100	95
15			LIMESTONE - Unweathered, Moderately Hard, Gray*					94	80
20								100	38
			SHALE - Weathered, Soft, Dark Gray						
25			SHALE - Slightly Weathered, Medium Hard, Dark Gray					100	100
30			Boring Terminated						
35									

REMARKS: *A water stratum was encountered at 10 feet below ground level.

ARKANSAS DEPARTMENT OF TRANSPORTATION
MATERIALS DIVISION - GEOTECHNICAL SEC.

BORING NO. 2
PAGE 1 OF 1

JOB NO. BR4401 Madison County
JOB NAME: War Eagle Creek Str. & Apprs. (S)
Co. Rd. 7 (5551)
STATION: 104+82
LOCATION: 9' Left of Construction Centerline
LOGGED BY: Jessie Burdine

DATE: February 21, 2024
TYPE OF DRILLING:
Hollow Stem Auger - Diamond Core
EQUIPMENT: Acker 1

HAMMER CORRECTION FACTOR: 1.42

COMPLETION DEPTH: 29.5

DEPTH FT.	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL SURFACE ELEVATION: 1330.6	SOIL GROUP	MOISTURE CONTENT (%) PL 10 20 30 40 50 60 70 LL	PERCENT PASSING NO. 200 SIEVE	NO. OF BLOWS PER 6-IN.	% TCR	% RQD
			Moist, Medium Dense, Brown Poorly Graded Sand with Silt, Gravel, and Cobbles	SP-SM	•	5	1 8-12		
5			LIMESTONE BOULDER						
			NO SAMPLE RECOVERY					34	22
10			LIMESTONE - Slightly Weathered, Moderately Hard, Gray					94	46
			SHALE - Weathered, Soft, Dark Gray						
15			SHALE - Slightly Weathered, Medium Hard, Dark Gray	-				90	85
20			LIMESTONE - Slightly Weathered, Moderately Hard, Gray						
			SHALE - Highly Weathered, Soft, Dark Gray						
			SHALE - Slightly Weathered with Weathered Layers, Medium Hard, Dark Gray					100	68
25			LIMESTONE WITH FREQUENT SHALE PARTINGS - Slightly Weathered, Moderately Hard, Gray						
			LIMESTONE - Unweathered, Moderately Hard, Gray					100	86
30			Boring Terminated						
35									

REMARKS:

ARKANSAS DEPARTMENT OF TRANSPORTATION
MATERIALS DIVISION - GEOTECHNICAL SEC.

BORING NO. 3
PAGE 1 OF 2

JOB NO. BR4401 Madison County
JOB NAME: War Eagle Creek Str. & Apprs. (S)
Co. Rd. 7 (5551)
STATION: 106+29
LOCATION: Construction Centerline
LOGGED BY: Jessie Burdine

DATE: February 14, 2024
TYPE OF DRILLING:
Hollow Stem Auger - Diamond Core
EQUIPMENT: Acker 1

HAMMER CORRECTION FACTOR: 1.42

COMPLETION DEPTH: 44.2

DEPTH FT.	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	SOIL GROUP	MOISTURE CONTENT (%) PL 10 20 30 40 50 60 70 LL	PERCENT PASSING NO. 200 SIEVE	NO. OF BLOWS PER 6-IN.	% TCR	% RQD
			SURFACE ELEVATION: 1334.4						
			Moist, Loose, Dark Brown Poorly Graded Sand with Silt, Gravel, and Cobbles	SP-SM	•	11	5 5-5		
5				-					
			Moist, Medium Dense, Dark Brown Poorly Graded Gravel with Silt and Sand	GP-GM	•	10	9 16-13		
				-					
			Wet, Medium Dense, Dark Brown Silty Sand with Gravel	SM	•	14	6 11-13		
10									
			Wet, Loose, Dark Brown Gravel with Silty Sand	-			8 5-4		
15									
			Wet, Medium Dense, Dark Brown Poorly Graded Gravel with Silt and Sand	GP-GM		6	7 8-8		
			Shale						
20									
			SHALE - Weathered, Medium Hard, Gray				15 (1")		
			LIMESTONE - Slightly Weathered, Moderately Hard with Hard Layers, Gray					100	85
25									
								100	100
30									
			LIMESTONE - Unweathered, Moderately Hard, Gray	-				100	100
35									

REMARKS:

ARKANSAS DEPARTMENT OF TRANSPORTATION
MATERIALS DIVISION - GEOTECHNICAL SEC.

BORING NO. 3
PAGE 2 OF 2

JOB NO. BR4401 Madison County
JOB NAME: War Eagle Creek Str. & Apprs. (S)
Co. Rd. 7 (5551)
STATION: 106+29
LOCATION: Construction Centerline
LOGGED BY: Jessie Burdine

DATE: February 14, 2024
TYPE OF DRILLING:
Hollow Stem Auger - Diamond Core
EQUIPMENT: Acker 1

HAMMER CORRECTION FACTOR: 1.42

COMPLETION DEPTH: 44.2

DEPTH FT.	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL SURFACE ELEVATION: 1334.4	SOIL GROUP	MOISTURE CONTENT (%) PL 10 20 30 40 50 60 70 LL	PERCENT PASSING NO. 200 SIEVE	NO. OF BLOWS PER 6-IN.	% TCR	% RQD
			Clay Layer with Rock Fragments					100	90
40			LIMESTONE WITH OCCASIONAL SHALE PARTINGS - Unweatherd, Moderately Hard, Gray					100	100
45			Boring Terminated						
50									
55									
60									
65									
70									

REMARKS:

ARKANSAS DEPARTMENT OF TRANSPORTATION
MATERIALS DIVISION - GEOTECHNICAL SEC.

BORING NO. 4
PAGE 1 OF 1

JOB NO. BR4401 Madison County
JOB NAME: War Eagle Creek Str. & Apprs. (S)
Co. Rd. 7 (5551)
STATION: 107+31
LOCATION: Construction Centerline
LOGGED BY: Jessie Burdine and Donald Thornton

DATE: February 13, 2024
TYPE OF DRILLING:
Hollow Stem Auger - Diamond Core
EQUIPMENT: Acker 1

HAMMER CORRECTION FACTOR: 1.42

COMPLETION DEPTH: 33.4

DEPTH FT.	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL SURFACE ELEVATION: 1335.0	SOIL GROUP	MOISTURE CONTENT (%) PL 10 20 30 40 50 60 70 LL	PERCENT PASSING NO. 200 SIEVE	NO. OF BLOWS PER 6-IN.	% TCR	% RQD
5			Moist, Loose, Dark Brown Clayey Sand with Gravel		•	28	7 6-4		
			Moist, Loose, Dark Brown Clayey Sand		•	33	1 6-4		
			Wet, Loose, Dark Brown Clayey Sand with Gravel		•	23	2 4-5		
10			LIMESTONE - Unweathered, Moderately Hard, Occasional Fractures, Gray					100	97
15									
			SHALE - Weathered, Medium Hard with Soft Layers, Occasional Fractures, Gray					90	36
20									
								100	56
25			LIMESTONE - Unweathered, Moderately Hard, Occasional Fractures, Gray					100	98
30									
			SANDSTONE WITH FREQUENT SHALE PARTINGS AND SEAMS - Unweathered, Cemented, Calcareous, Gray					100	96
35			Boring Terminated						

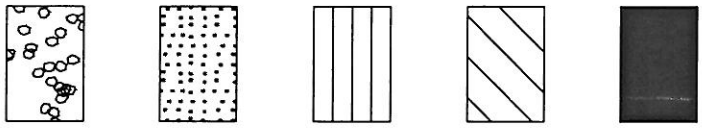
REMARKS:

LEGEND

SOIL TYPES

(SHOWN IN SYMBOL COLUMN)

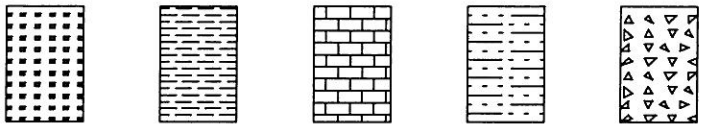
(PREDOMINANT TYPE SHOWN HEAVY)



GRAVEL | SAND | SILT | CLAY | ORGANIC MATTER

ROCK TYPES

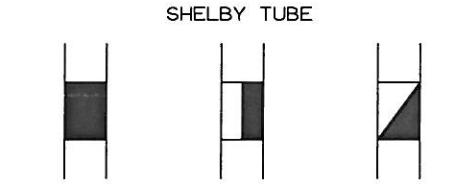
(SHOWN IN SYMBOL COLUMN)



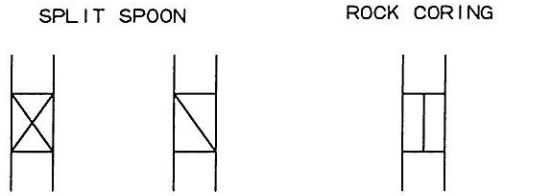
SANDSTONE | SHALE or SILTSTONE | LIMESTONE or DOLOMITE | ALTERNATING LAYERS of SHALE and SANDSTONE | OTHER

SAMPLER TYPES

(SHOWN IN SAMPLE COLUMN)



UNDISTURBED SAMPLE RECOVERY | DISTURBED SAMPLE RECOVERY | NO RECOVERY



SAMPLE RECOVERY | NO RECOVERY | % RECOVERY INDICATED ON LOGS

TERMS DESCRIBING CONSISTENCY OR CONDITION

GRANULAR SOIL		CLAY		CLAY-SHALE		SHALE	
'N' Value	Density	'N' Value	Consistency	'N' Value	Consistency	'N' Value	Consistency
0-4	Very Loose	0-1	Very Soft	0-1	Very Soft		
5-10	Loose	2-4	Soft	2-4	Soft	31-60	Soft
11-30	Medium Dense	5-8	Medium Stiff	5-8	Medium Stiff	Over 60	
31-50	Dense	9-15	Stiff	9-15	Stiff	More than 2'	
Over 50	Very Dense	16-30	Very Stiff	16-30	Very Stiff	Penetration	
		31-60	Hard	31-60	Hard	in 60 Blows:	Medium Hard
		Over 60	Very Hard	Over 60	Very Hard	Less than 2'	
						Penetration	
						in 60 Blows:	Hard

1. Ground water elevations indicated on boring logs represent ground water elevations at date or time shown on boring log. Absence of water surface implies that no ground water data is available but does not necessarily mean that ground water will not be encountered at locations or within the vertical reaches of these borings.
2. Borings represent subsurface conditions at their respective locations for their respective depths. Variations in conditions between or adjacent to boring locations may be encountered.
3. Terms used for describing soils according to their texture or grain size distribution are in accordance with the Unified Soil Classification System.

Standard Penetration Test – Driving a 2.0" O.D., 1-3/8" I.D. sampler a distance of 1.0 foot into undisturbed soil with a 140 pound hammer free falling a distance of 30 inches. It is customary to drive the spoon 6.0 inches to seat into undisturbed soil, then perform the test. The number of hammer blows for seating the spoon and performing the test are recorded for each 6 inches of penetration on the drill log. The field "N" Value (N_f) can be obtained by adding the bottom two numbers for example: $\frac{6}{8-9} \Rightarrow 8+9=17 blows/ft$. The "N" Value corrected to 60% efficiency (N_{60}) can be obtained by multiplying N_f by the hammer correction factor published on the boring log.

ROCK CORE PHOTO

Job No.: BR4401
Job Name: Hwy. 10 - Hwy. 96 (Greenwood Bypass) (S)



ROCK CORE PHOTO

Job No.: BR4401
Job Name: Hwy. 10 - Hwy. 96 (Greenwood Bypass) (S)



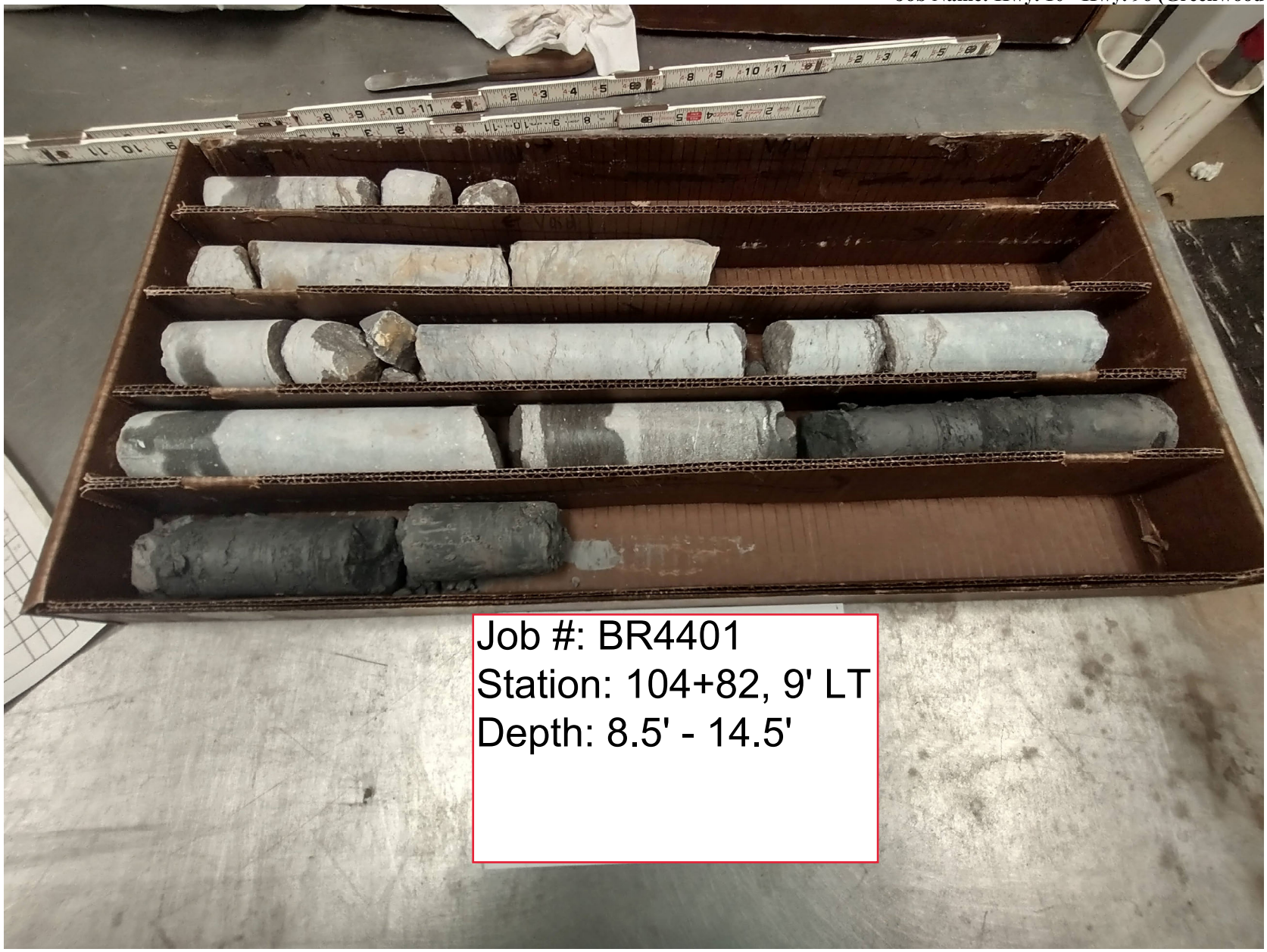
ROCK CORE PHOTO

Job No.: BR4401
Job Name: Hwy. 10 - Hwy. 96 (Greenwood Bypass) (S)



ROCK CORE PHOTO

Job No.: BR4401
Job Name: Hwy. 10 - Hwy. 96 (Greenwood Bypass) (S)



ROCK CORE PHOTO

Job No.: BR4401
Job Name: Hwy. 10 - Hwy. 96 (Greenwood Bypass) (S)



ROCK CORE PHOTO

Job No.: BR4401
Job Name: Hwy. 10 - Hwy. 96 (Greenwood Bypass) (S)



ROCK CORE PHOTO

Job No.: BR4401
Job Name: Hwy. 10 - Hwy. 96 (Greenwood Bypass) (S)



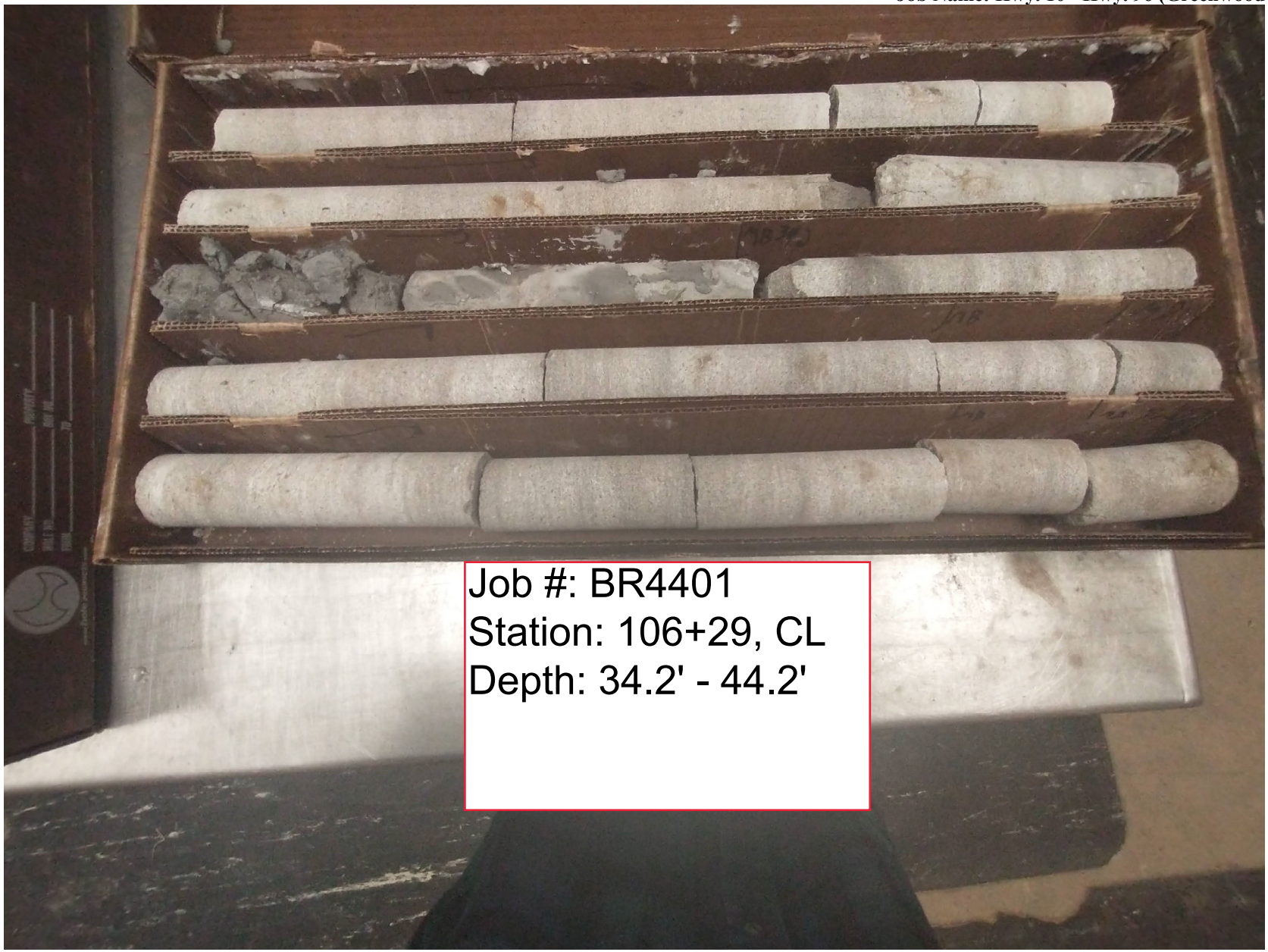
ROCK CORE PHOTO

Job No.: BR4401
Job Name: Hwy. 10 - Hwy. 96 (Greenwood Bypass) (S)



ROCK CORE PHOTO

Job No.: BR4401
Job Name: Hwy. 10 - Hwy. 96 (Greenwood Bypass) (S)



ROCK CORE PHOTO

Job No.: BR4401
Job Name: Hwy. 10 - Hwy. 96 (Greenwood Bypass) (S)



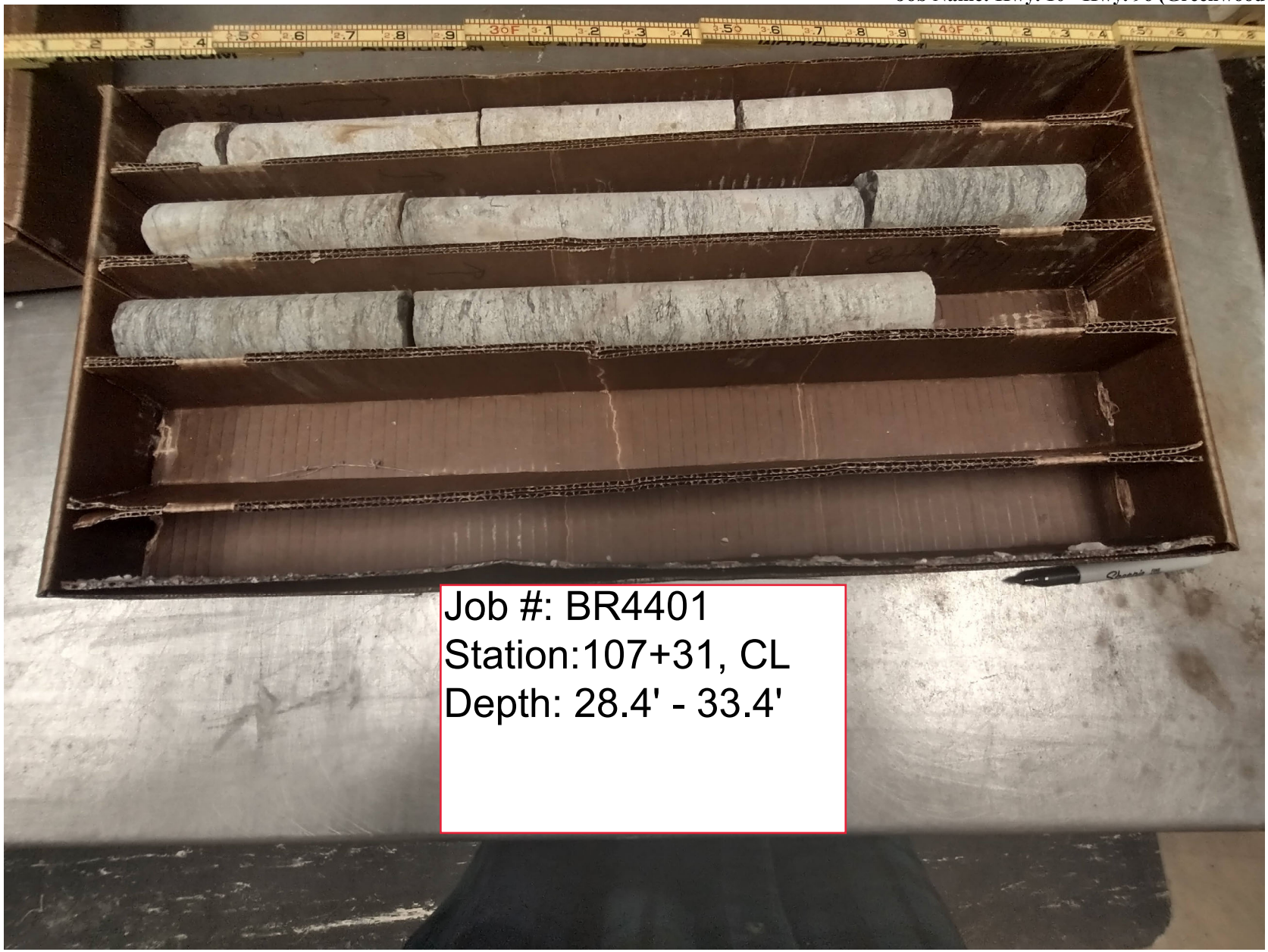
ROCK CORE PHOTO

Job No.: BR4401
Job Name: Hwy. 10 - Hwy. 96 (Greenwood Bypass) (S)



ROCK CORE PHOTO

Job No.: BR4401
Job Name: Hwy. 10 - Hwy. 96 (Greenwood Bypass) (S)



Attachment B

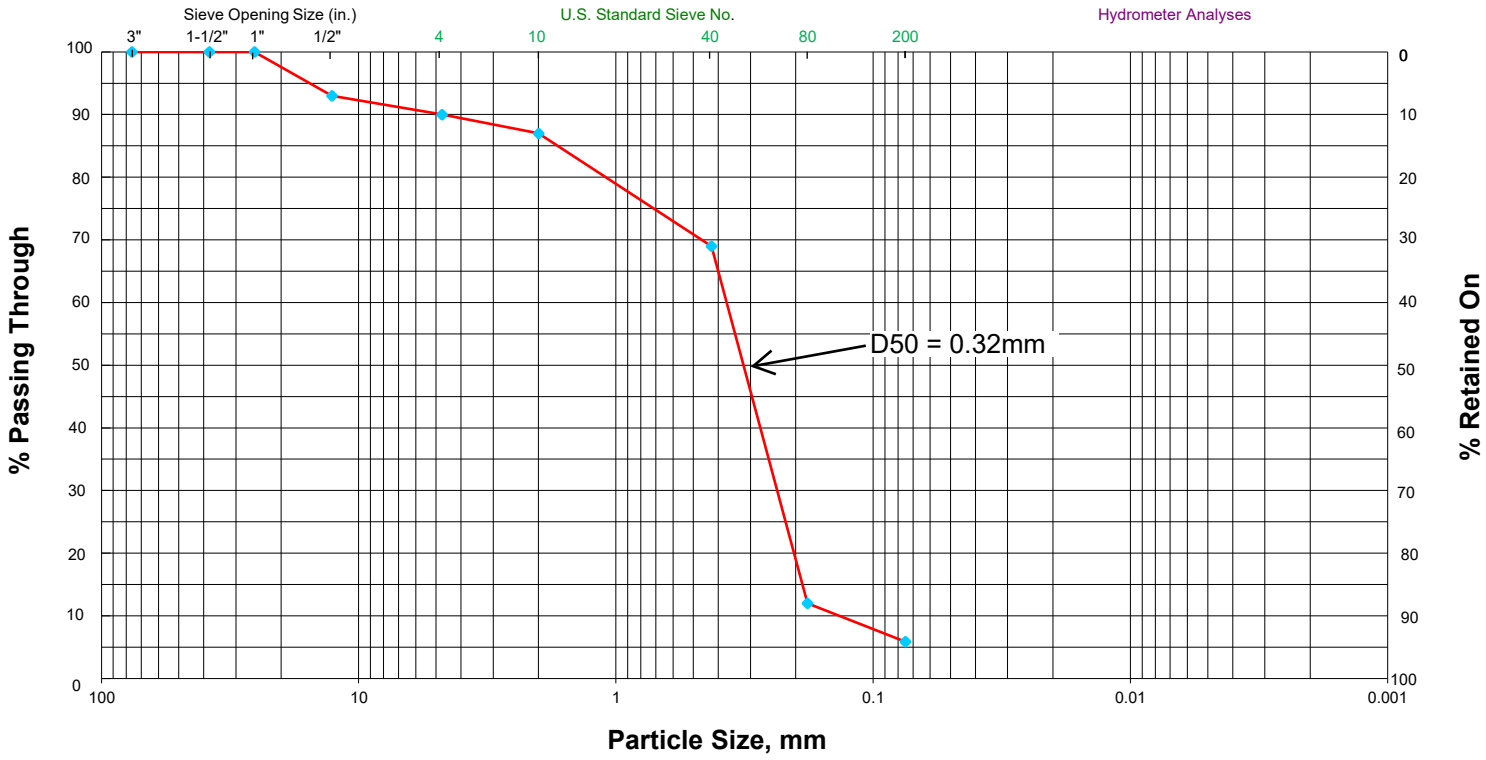
Summary of Rock Core Uniaxial Compression Test Results, Geological Strength Index (GSI) and Rock Mass Rating (RMR)

Project Number: BR4401
Project Name: War Eagle Creek STR. & APPRS. (S)
Date Tested: 02/29/2023

GSI: 75

Sample Location			Uniaxial Compressive Strength									RMR							Notes
Station	Location	Depth (ft.)	Diameter (in.)	Height (in.)	Weight (g)	Unit Weight (pcf)	Total Load (lbs.)	Correction Factor	Stress (psi)	Rock Type	Uniaxial Compressive Strength Rating	RQD Rating	Spacing of Joints	Condition of Joints	Groundwater Condition	Sum	Class Number	Description	
104+19	6' LT	6.2	1.76	4.56	484.53	166	22,300	1.00	9,166	Limestone	7	17	25	25	7	74	II	GOOD ROCK	
104+19	6' LT	10.1	1.75	3.90	414.15	168	28,820	1.00	11,982	Limestone	7	20	25	25	7	77	II	GOOD ROCK	
104+19	6' LT	22.8								Shale		8	25	25	7	65	II	GOOD ROCK	Broke during prep
104+82	9' LT	9.2	1.75	3.79	403.72	169	28,000	1.00	11,641	Limestone	7	8	20	20	7	55	III	FAIR ROCK	
104+82	9' LT	11.1	1.76	4.45	480.84	169	34,600	1.00	14,222	Limestone	7	13	20	20	7	60	III	FAIR ROCK	
106+29	CL	21.2								Shale		17	25	25	7	74	II	GOOD ROCK	Broke during prep
106+29	CL	23.8	1.76	3.49	367.98	165	35,440	1.00	14,567	Limestone	7	20	25	25	7	77	II	GOOD ROCK	
106+29	CL	28.4	1.75	3.64	384.54	167	26,850	1.00	11,163	Limestone	7	20	25	25	7	77	II	GOOD ROCK	
106+29	CL	43.4	1.75	4.67	472.66	160	16,830	1.00	6,997	Limestone	4	20	20	25	7	72	II	GOOD ROCK	
107+31	CL	10.5	1.76	4.21	452.68	168	19,680	1.00	8,089	Limestone	7	20	25	25	7	77	II	GOOD ROCK	
107+31	CL	32.2	1.76	4.41	432.23	153	20,810	1.00	8,554	Sandstone W/ Shale	7	20	25	25	7	77	II	GOOD ROCK	

Attachment C



BR4401 Particle Size Distribution Curve

Station 104+84/CL

Attachment D

SITE PICTURES

Job No.: BR4401
Job Name: War Eagle Creek Str. & Apprs. (S)



Existing Bridge Deck Looking West (January 2024)

SITE PICTURES

Job No.: BR4401
Job Name: War Eagle Creek Str. & Apprs. (S)



Existing Bridge Deck Looking East (January 2024)

SITE PICTURES

Job No.: BR4401
Job Name: War Eagle Creek Str. & Apprs. (S)



Looking South (Upstream) at War Eagle Creek (January 2024)

SITE PICTURES

Job No.: BR4401
Job Name: War Eagle Creek Str. & Apprs. (S)



Looking North (Downstream) at War Eagle Creek (January 2024)

SITE PICTURES

Job No.: BR4401
Job Name: War Eagle Creek Str. & Apprs. (S)



Looking East at Pre-Existing Bridge End (January 2024)

SITE PICTURES

Job No.: BR4401
Job Name: War Eagle Creek Str. & Apprs. (S)



Looking South at Limestone Outcrop Downstream from Existing Bridge (January 2024)

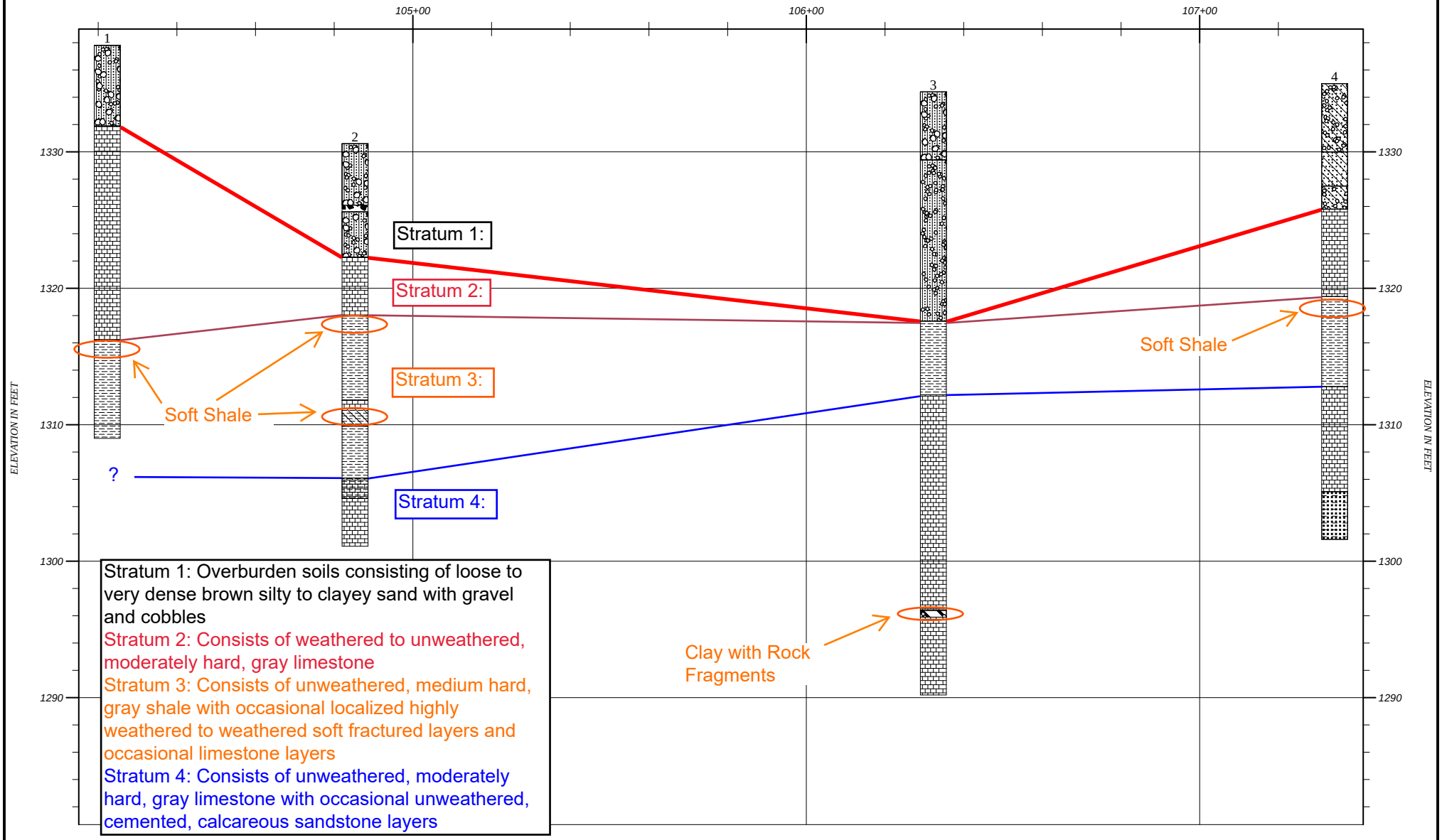
SITE PICTURES

Job No.: BR4401
Job Name: War Eagle Creek Str. & Apprs. (S)



War Eagle Creek Tributary Upstream and to the Southwest of the Existing Bridge (January 2024)

Attachment E



Plan View



Strata symbols

- silty sand, gravel and cobbles
- limestone/dolomite
- shale/siltstone
- boulders
- shale with clay seams
- limestone/dolomite with shale seams
- silty sand with gravel
- clay with gravel
- clayey sand and gravel
- clayey sand
- sandstone with shale seams

ARDOT GENERALIZED SUBSURFACE PROFILE

HORIZONTAL SCALE:	DRAWN BY/APPROVED BY	DATE DRAWN
VERTICAL SCALE:		3/6/2024

War Eagle Creek Str. & Apprs. (S)
Co. Rd. 7 (5551)

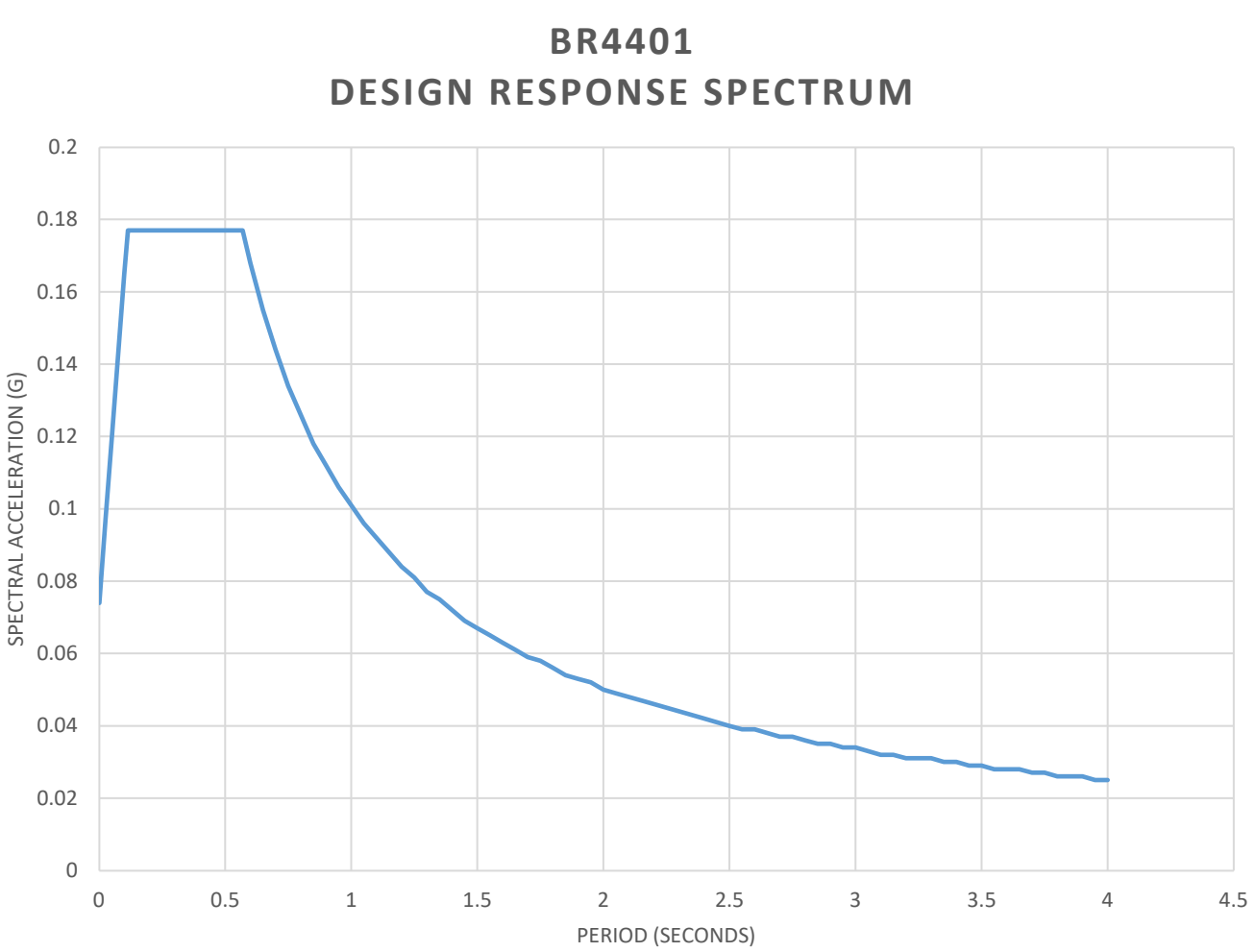
PROJECT NO. BR4401
Madison County

Attachment F

Title:	BR4401
Latitude:	36.006749
Longitude:	-93.711619
Site Class	C

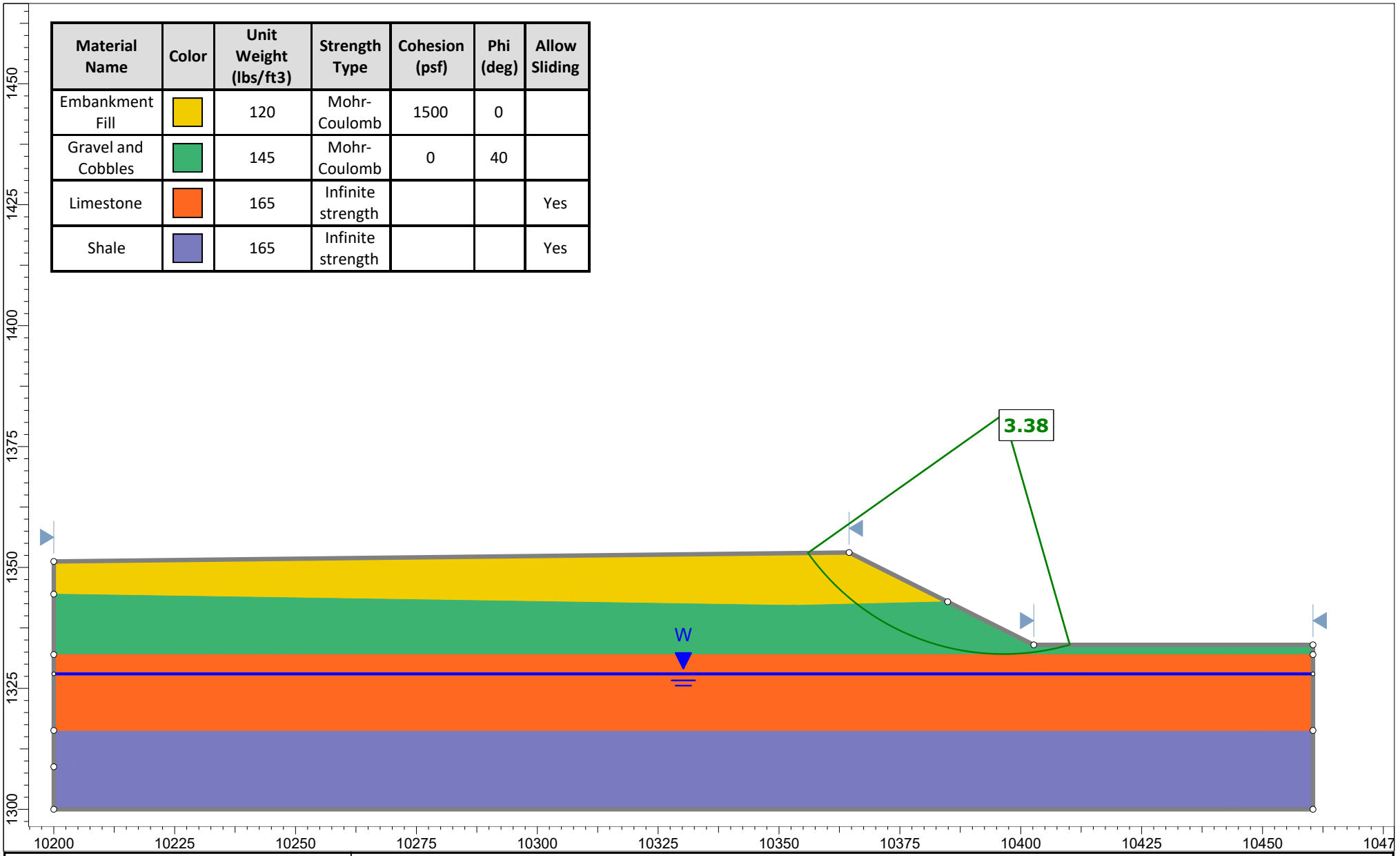
Get USGS Data

PGA:	0.062
F_{PGA}:	1.2
A_S:	0.074
S_S:	0.147
F_A:	1.2
S_{DS}:	0.177
S_1:	0.059
F_V:	1.7
S_{D1}:	0.101
S_{Dc}:	A
T_S:	0.569
T_0:	0.114



Attachment G

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Allow Sliding
Embankment Fill		120	Mohr-Coulomb	1500	0	
Gravel and Cobbles		145	Mohr-Coulomb	0	40	
Limestone		165	Infinite strength			Yes
Shale		165	Infinite strength			Yes

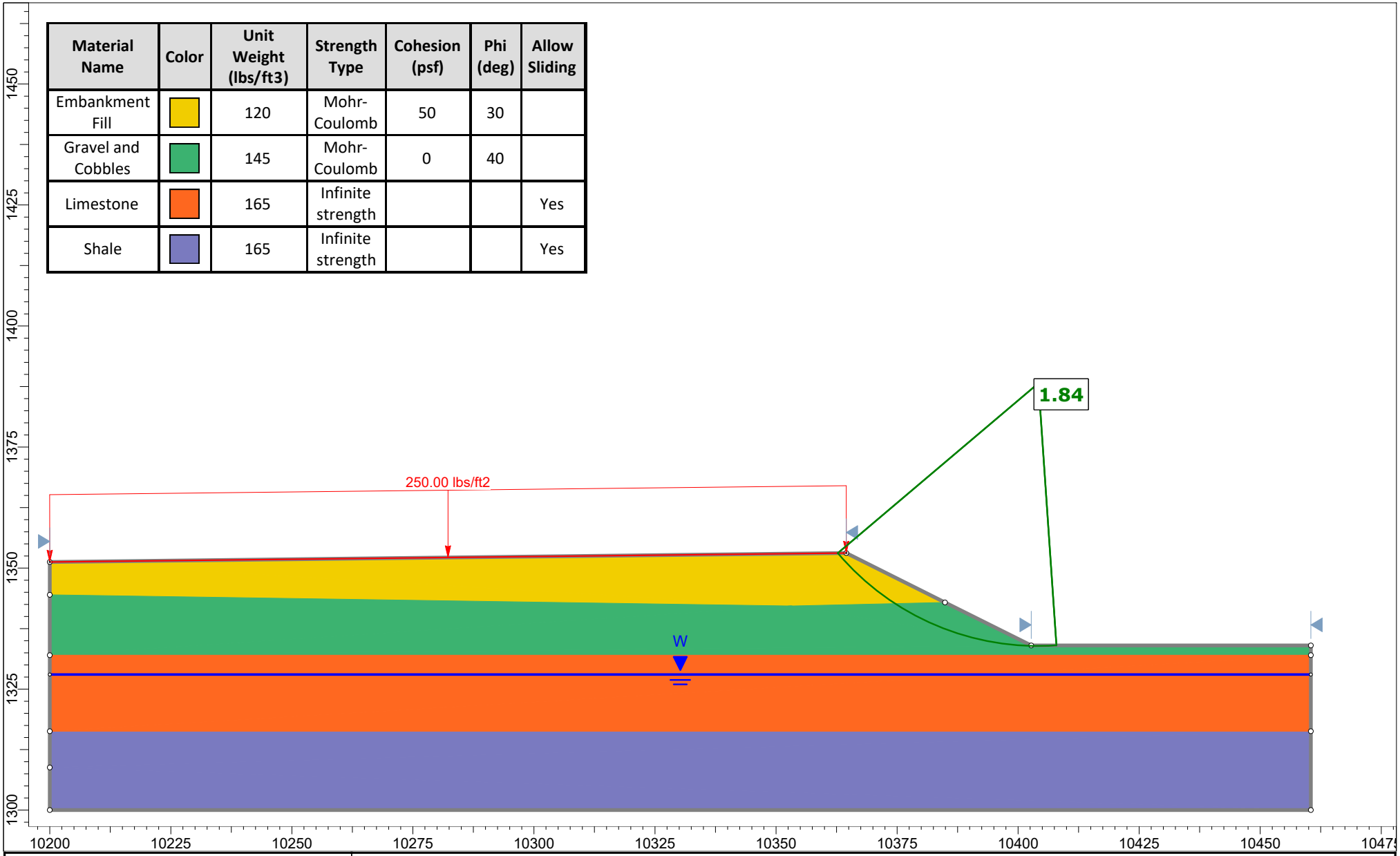


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SLIDEINTERPRET 9.020

Project	BR4401- War Eagle Creek Str. & Apprs. (S)		
Site	County Road 7 over War Eagle Creek	Analysis Type	Short Term/End of Construction
Analyzed By	PT	Configuration	West Embankment
Date	4/11/2024		

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Allow Sliding
Embankment Fill		120	Mohr-Coulomb	50	30	
Gravel and Cobbles		145	Mohr-Coulomb	0	40	
Limestone		165	Infinite strength			Yes
Shale		165	Infinite strength			Yes

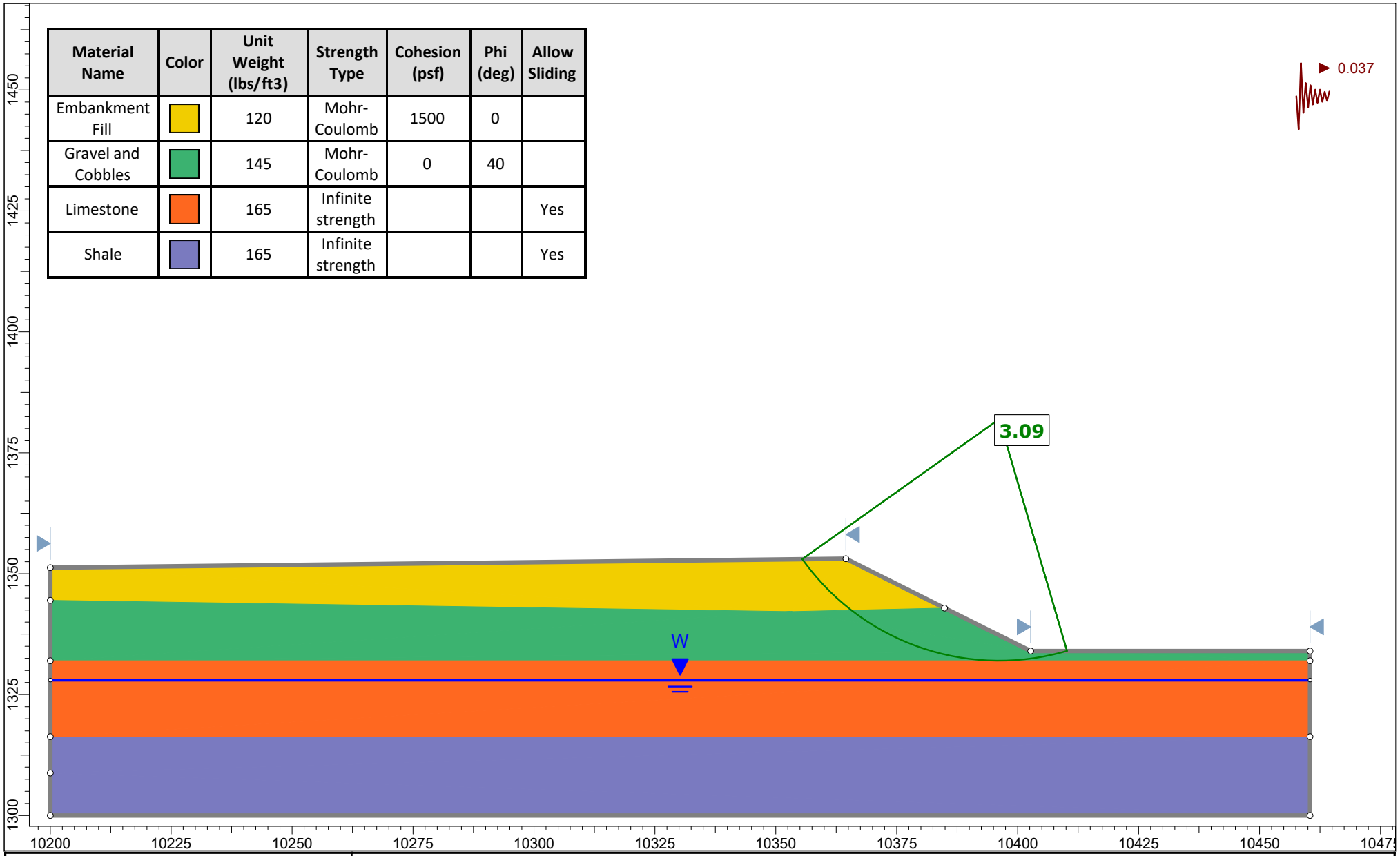


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SLIDEINTERPRET 9.020

Project	BR4401- War Eagle Creek Str. & Apprs. (S)		
Site	County Road 7 over War Eagle Creek	Analysis Type	Long Term
Analyzed By	PT	Configuration	West Embankment
Date	4/11/2024		

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Allow Sliding
Embankment Fill		120	Mohr-Coulomb	1500	0	
Gravel and Cobbles		145	Mohr-Coulomb	0	40	
Limestone		165	Infinite strength			Yes
Shale		165	Infinite strength			Yes

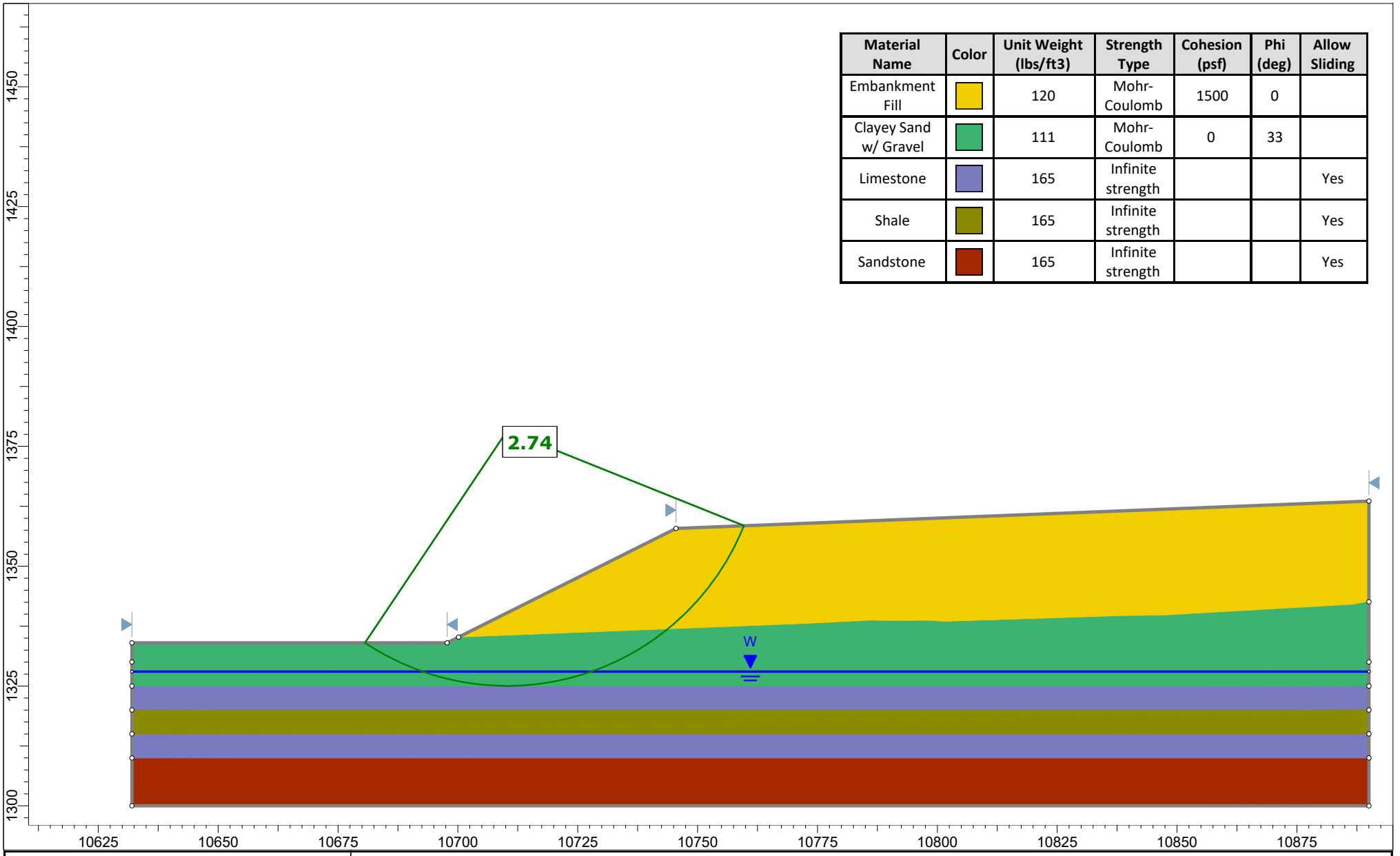


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SLIDEINTERPRET 9.020

Project	BR4401- War Eagle Creek Str. & Apprs. (S)		
Site	County Road 7 over War Eagle Creek	Analysis Type	Seismic
Analyzed By	PT	Configuration	West Embankment
Date	4/11/2024		

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Allow Sliding
Embankment Fill		120	Mohr-Coulomb	1500	0	
Clayey Sand w/ Gravel		111	Mohr-Coulomb	0	33	
Limestone		165	Infinite strength			Yes
Shale		165	Infinite strength			Yes
Sandstone		165	Infinite strength			Yes

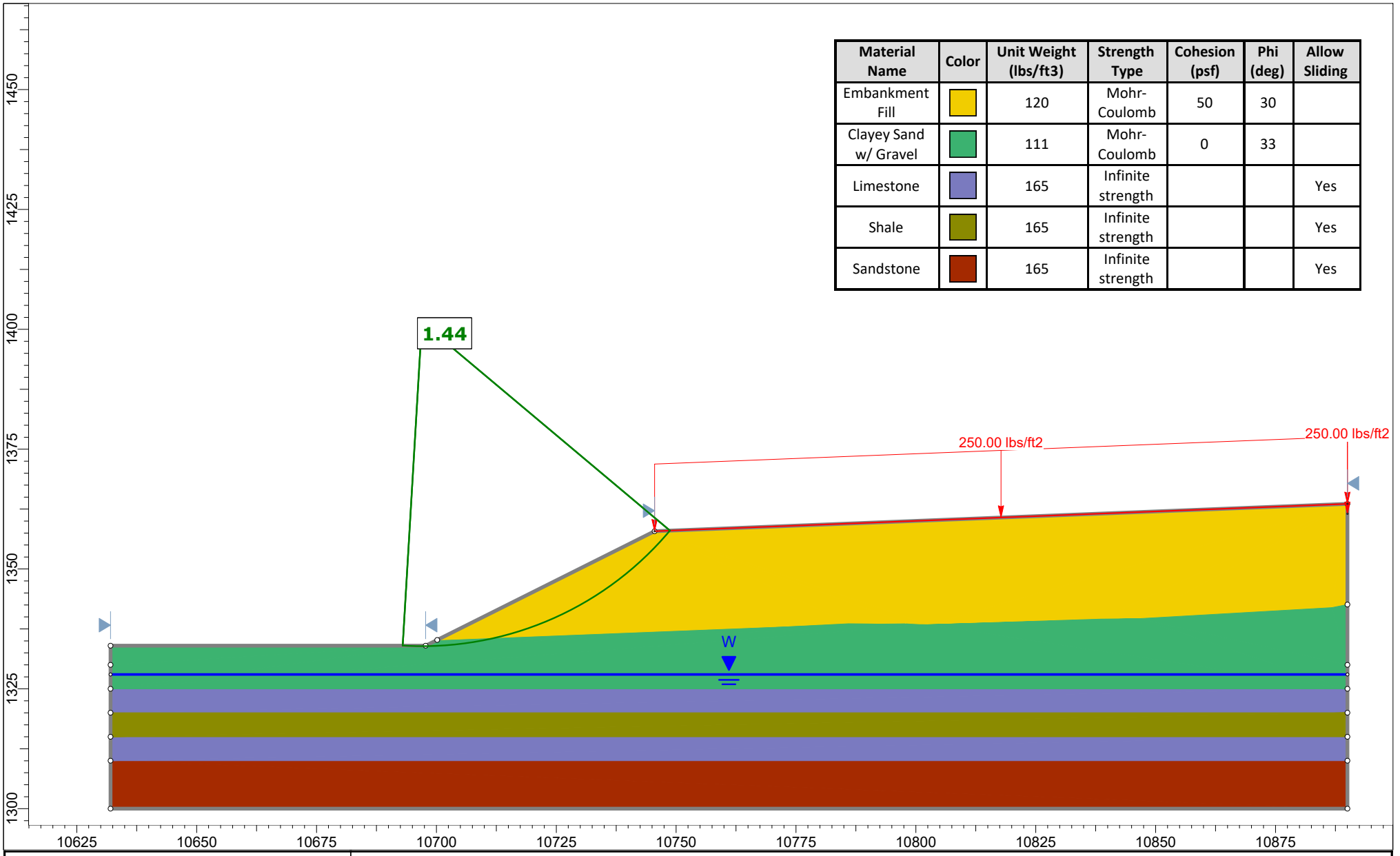


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SLIDEINTERPRET 9.020

Project	BR4401 - War Eagle Creek Str. & Apprs. (S)		
Site	County Road 7 over War Eagle Creek	Analysis Type	Short Term/End of Construction
Analyzed By	PT	Configuration	East Embankment
Date	4/11/2024		

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Allow Sliding
Embankment Fill		120	Mohr-Coulomb	50	30	
Clayey Sand w/ Gravel		111	Mohr-Coulomb	0	33	
Limestone		165	Infinite strength			Yes
Shale		165	Infinite strength			Yes
Sandstone		165	Infinite strength			Yes

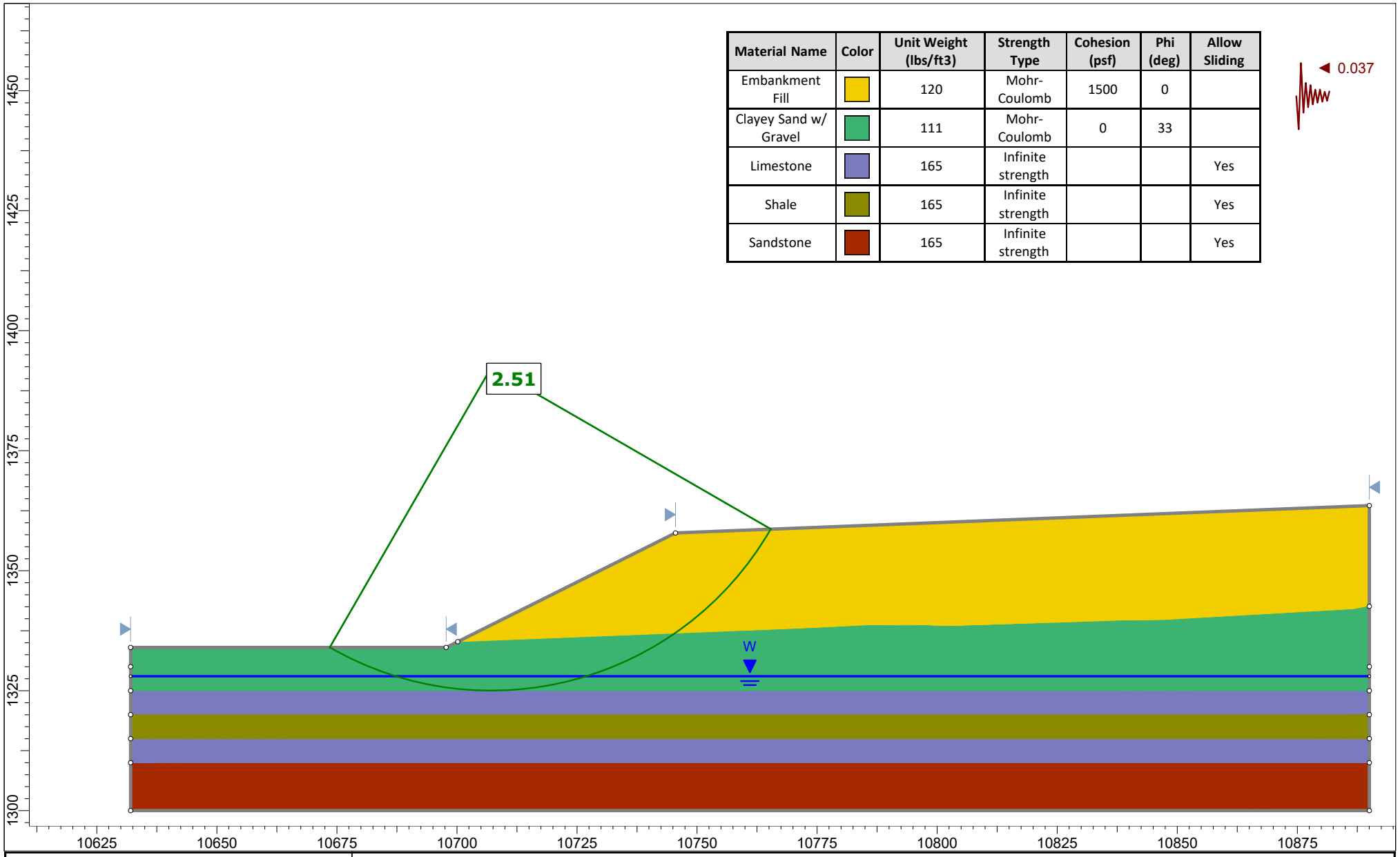


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SLIDEINTERPRET 9.020

Project	BR4401 - War Eagle Creek Str. & Apprs. (S)		
Site	County Road 7 over War Eagle Creek	Analysis Type	Long Term
Analyzed By	PT	Configuration	East Embankment
Date	4/11/2024		

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Allow Sliding
Embankment Fill		120	Mohr-Coulomb	1500	0	
Clayey Sand w/ Gravel		111	Mohr-Coulomb	0	33	
Limestone		165	Infinite strength			Yes
Shale		165	Infinite strength			Yes
Sandstone		165	Infinite strength			Yes



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SLIDEINTERPRET 9.020

Project	BR4401 - War Eagle Creek Str. & Apprs. (S)		
Site	County Road 7 over War Eagle Creek	Analysis Type	Seismic
Analyzed By	PT	Configuration	East Embankment
Date	4/11/2024		

Attachment H

Job No.:	BR44401
Site No.:	1

Input by:	PT	3/19/2024
Checked by:	YZ	4/16/2024
Back-checked by:		

Bent 1 - Boring 1

Elevation, ft		Material	Model	Effective Unit Weight, γ',pcf	Undrained Shear Strength of Soil (C_u) (psf)	Strain Factor (ε_{50} for Soil) / k_m for Rock)	Friction Angle, ϕ, °	Soil Modulus, k, pci	Uniaxial Compressive Strength, q_u, psi	Rock Mass Modulus, E_{rm}, 10^6 psi	RQD, %
Top	Bottom										
Above Ground Surface		Fill	Soft Clay (Matlock)	120	750	0.010	NA	NA	NA	NA	NA
Ground	1332	Sand with Silt, Gravel and Cobbles	Sand (Reese)	145	NA	NA	42	240	NA	NA	NA
1332	1328	Unweathered Limestone	Weak Rock	165	NA	0.0005	NA	NA	9166	6.9	77
1328	1316	Unweathered Limestone	Weak Rock	100	NA	0.0005	NA	NA	11982	7.3	87
1316	1314	Weathered Shale	Weak Rock	80	NA	0.0005	NA	NA	NA	5.6	38
Below 1314		Slightly Weathered Shale	Weak Rock	No Data							

Bent 4 - Boring 4

Elevation, ft		Material	Model	Effective Unit Weight, γ',pcf	Undrained Shear Strength of Soil (C_u) (psf)	Strain Factor (ε_{50} for Soil) / k_m for Rock)	Friction Angle, ϕ, °	Soil Modulus, k, pci	Uniaxial Compressive Strength, q_u, psi	Rock Mass Modulus, E_{rm}, 10^6 psi	RQD, %
Top	Bottom										
Above Ground Surface		Fill	Soft Clay (Matlock)	120	750	0.010	NA	NA	NA	NA	NA
Ground	1327	Clayey Sand with Gravel	Sand (Reese)	110	NA	NA	33	124	NA	NA	NA
1327	1326	Clayey Sand with Gravel	Sand (Reese)	60	NA	NA	33	78	NA	NA	NA
1326	1319	Unweathered Limestone	Weak Rock	100	NA	0.0005	NA	NA	8089	7.3	97
1319	1312	Weathered Shale	Weak Rock	85	NA	0.0005	NA	NA	No Data	7.3	46
1312	1305	Unweathered Limestone	Weak Rock	100	NA	0.0005	NA	NA	No Data	7.3	98
Below 1305		Unweathered Sandstone	Weak Rock	100	NA	0.0005	NA	NA	8554	7.3	96