Geotechnical Engineering Report

Rock Cut Section Evaluation

Highway 270 – Highway 227 to Ouachita River (Widening)(S)

AHTD Job No. CA0607, Task Order No. C069

Hot Springs, Garland County, Arkansas

June 23, 2017, Revised February 26, 2018

Terracon Project No. 35145118

Prepared for:

Buchart Horn, Inc.
Memphis, Tennessee

Prepared by:

Terracon Consultants, Inc.
Little Rock, Arkansas

June 23, 2017, Revised February 26, 2018

Buchart Horn, Inc.
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Attn: Mr. Andy Pinkley, P.E., CPESC
Senior Engineer
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Re: Geotechnical Engineering Report
Rock Cut Section Evaluation
Hwy 270 – Hwy 227 to Ouachita River (Widening) (S)
Hot Springs, Garland County, Arkansas
Terracon Project No. 35145118

Dear Mr. Pinkley:

Terracon Consultants, Inc. (Terracon) has completed the geotechnical engineering services for the above-referenced project. The scope of our services was outlined in the Geotechnical Scope of Work, Terracon Proposal No. P35140348, dated December 2, 2014. The project was authorized per the Master Services Agreement signed December 11, 2014. This report presents results for AHTD Job No. CA0607, Hwy 270 Widening project from Hwy 227 to Ouachita River in Hot Springs, Garland County, Arkansas. This report provides recommendations for designing and constructing the rock cut slopes planned for the project.

We appreciate the opportunity to be of service to you on this project. If you have any questions concerning this report, or if we may be of further service, please contact us.

Sincerely,
Terracon Consultants, Inc.
Certificate of Authorization #223, Expires 12/31/2019

Shaun P. Baker, P.E.
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STATE OF ARKANSAS 2/26/2018 LICENSED PROFESSIONAL ENGINEER No.11817 SHAUN P. BAKER

Enclosures

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HOT SPRINGS, GARLAND COUNTY, ARKANSAS

Terracon Project No. 35145118

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1.0 INTRODUCTION

This report presents the results of the geotechnical engineering services completed for the AHTD Job No. CA0607, U.S. Highway 270 widening project from Arkansas Highway 227 to Ouachita River in Hot Springs, Garland County, Arkansas. Two borings (plus two supplemental borings) were performed to depths of about 53 to 60 feet below the existing ground surface. A site location map and boring location diagrams along with logs of the borings are included in Appendix A of this report.

The purpose of these services is to provide information and geotechnical engineering recommendations relative to:

- Subsurface soil and rock conditions
- Groundwater conditions
- Earthwork
- Rock rippability
- Rock cut slope stability and kinematic analysis
- Suitability of rock as fill and aggregate material

2.0 PROJECT INFORMATION

2.1 Project Description

Item	Description
Site layout	See Appendix A, Exhibits A-1 and A-2, Site Location Plan and Boring Location Plan
Grading	We understand the project involves widening of about 3 miles of Highway 270. The planned rock cut slopes are located approximately between Stations 20+00 and 60+00, Right of Center Line The preliminary design slopes are planned at 2H:1V (horizontal:vertical) with a maximum slope height of about 60 feet Based on the 60% plans and cross-sections provided to us by Buchart Horn, Inc., we estimate rock cuts up to 50 feet below existing grade could be necessary to reach final grade

2.2 Site Location and Description

Item	Description
Location	See Appendix A, Exhibit A-1, Site Location Plan U.S. Highway 270 between Arkansas Highway 227 and the Ouachita River in Hot Springs, Garland County, Arkansas Latitude N34.508779°, Longitude W93.177259° (western extent) Latitude N34.503322°, Longitude W93.125961° (eastern extent) More specifically, the planned rock cut slope is located approximately between Stations 20+00 and 60+00, Right of Center Line.
Existing improvements	Highway 270, two-lane highway with three lanes on both the eastern and western ends of the project alignment Highway 227, four-lane highway Asphaltic concrete pavement The area of the planned rock cut is undeveloped and covered by trees

3.0 SUBSURFACE CONDITIONS

3.1 Site Geology

Formation [1]	Description [2]
Stanley Shale (M_s) Mississippian Period	The Stanley Shale is composed of dark-gray shale interbedded with fine-grained sandstone. A thick sandstone member, the Hot Springs Sandstone, is found near the base of the sequence and an equivalent thin conglomerate/breccia occurs at the base of the unit in many other places. Stratigraphically minor amounts of tuff, chert, bedded and vein barite, and conglomerate have also been noted in various parts of the sequence.

1. Interactive Geologic Map of Arkansas and Geological Google Earth files published by the Arkansas Geological Survey, 2015, www.geology.ar.gov
2. "Stratigraphic Summary of Arkansas", published by the Arkansas Geological Commission, 1998, revised 2004.

3.2 Typical Subsurface Conditions

Based on the results of the borings, subsurface conditions can be generalized as follows:

Description	Approximate Depth to Bottom of Stratum (feet)	Material Observed	Weathering / Rock Hardness
Stratum 1	20 at CB-4 50 at CB-4A 13.5 at CB-5	Shale	Highly weathered to weathered / Soft
Stratum 2	47 at CB-4 Below termination depth of 60 feet at CB-4A 25 at CB-5	Shale	Slightly weathered to unweathered / Hard
Stratum 3	42 at CB-5 Below termination depth of 58.8 feet at CB-5	Sandstone	Slightly weathered to unweathered / Well cemented
Stratum 3a	1-foot layer from 37 to 38 feet at CB-5A	Well-graded sand with gravel / highly fractured sandstone, siltstone, and shale	Very dense
Stratum 4	Below termination depth of 55 feet at CB-5	Shale	Highly weathered / Soft
Stratum 4	Below termination depth of 60 feet at Boring CB-4A	Shale	Unweathered / Hard

3.3 Groundwater

The boreholes were observed while drilling and after boring completion for the presence and level of groundwater. Groundwater measurements are shown in the lower left corner of the boring logs and summarized in the following table where observed.

Boring Number	Depth to groundwater while drilling, (feet) [1]	Depth to groundwater after at least 1 day, (feet) [1, 2]
CB-4	Not observed prior to injecting water for coring	34 after one day [3]
CB-4A	Not observed prior to injecting water for coring	Not observed – an accurate measurement was not possible due to casing stuck in hole
CB-5	Not observed prior to injecting water for coring	17 after one day [3]
CB-5A	Not observed prior to injecting water for coring	17 after one day [3] 25 after 1 week [3]

1. Depths measured below existing ground surface
2. Groundwater depths are rounded to the nearest one-half foot
3. Water level measurements may have been influenced by water used for rock coring.

Water was not observed while drilling by dry auger to auger refusal. The water was bailed from the boreholes after coring was completed, and then water level measurements were taken at least one day after boring completion in the borings. Water was observed in the three boreholes shown in the table above. The borings were advanced into rock using rock coring techniques to the termination depths. Because water was injected in the borings, an accurate groundwater level could not be obtained immediately after boring completion. No water seeps or springs were observed in the exposed rock outcrops.

Groundwater level fluctuations occur due to seasonal variations in the amount of rainfall, runoff and other factors not evident at the time the borings were performed. Therefore, groundwater levels during construction or at other times in the life of the highway may be higher or lower than indicated on the boring logs. Additionally, perched water may be encountered or develop at or near the soil-rock interface, and in rock joints and bedding planes. Longer-term observations in piezometers or observation wells sealed from the influence of surface water are often required to define groundwater levels in these soil and rock types. The possibility of groundwater level fluctuations should be considered when developing the design and construction plans for the project.

4.0 RECOMMENDATIONS FOR DESIGN AND CONSTRUCTION

4.1 Geotechnical Considerations

Stability of slopes in rock is typically controlled by the presence and orientation of bedding, joints, fractures or other discontinuities in the rock mass. Generally, shale bedrock is much less durable and is susceptible to decomposition by freeze-thaw and moisture. Therefore, the shale can and sometimes does erode and undermine more competent rock above/below it, creating slope failures. Using the Franklin Rating System ("*A Shale Rating System and Tentative Applications to Shale Performance"*, J.A. Franklin, Transportation Research Record 790), we estimated a value R=5.8 for the shale observed along the project cut area. This value indicates the shale should be cut at a 1H:1V slope or shallower based on Figure 8 in the reference. These factors have been considered in the slope stability analyses and other recommendations for design.

The stability of the slopes is also affected by methods of excavation and the care taken to not disturb the rock mass behind the final slope face. Localized seepage or perched water levels could be encountered during excavation and affect certain areas of some of the cuts. The groundwater conditions observed were modeled in the stability analyses.

Recommendations regarding design and construction of cut slopes, and bedrock rippability assessment are provided in the following sections.

4.2 Rock Cut Slope Evaluation

Various geotechnical exploration and evaluation procedures were employed for the project to obtain necessary subsurface information to provide recommendations for cut slopes. These included:

- Exploratory borings
- Examining rock cores for rock decomposition, weathering, jointing, and fracture characteristics
- Determining the Rock Quality Designation (RQD) of the core samples
- Performing laboratory tests to obtain strength information for the soils and rock
- Conducting global slope stability analysis using the software program SLIDE
- Conducting Markland's Tests using RockPack III software to evaluate the kinematic potential for rock cut failure

4.2.1 Shear Strength of Rock Discontinuities

Rock slopes are typically controlled by the strength of joints, fractures and other discontinuities, and the orientation of these features relative to the cut slope. These predetermined potential failure planes typically exhibit residual frictional strength and zero cohesion. If the rock is massive and the joints and fractures are relatively continuous, then laboratory direct shear tests are conducted to estimate the residual frictional strength of the joints and/or other discontinuities. In the case where the joints and fractures are closely spaced they may still affect the cut slopes. However, in that situation, the cut slope is controlled more by the general structural trend of the rock mass and less by the friction angle of a single discontinuity.

Based on the results of our borings, laboratory testing results, and our field observations, we used accepted, published references for estimating the residual shear strength (cohesion and internal friction angle of the shale materials. The shear strengths were estimated based on Mohr-Coulomb and generalized Hoek-Brown rock properties. The rock properties used in our analyses are summarized in the following table. These parameters and the slope geometry used in our models are also shown on the graphical SLIDE output, which is presented in Appendix D.

Soil or Rock Type	Friction Angle (deg.)	Cohesion (psf)	Unit Weight (pcf)
Highly weathered shale	26	2,000	145
Weathered shale	28	5,000	160
Strong shale	30	60,000	165

The following paragraphs describe the analyses used in developing our recommendations, and provide our recommended rock cut slopes.

4.2.2 Stability Analysis

Stability of the rock cut slopes was analyzed using limit equilibrium procedures in accordance with the GLE/Morgenstern-Price method. Our analysis was performed using SLIDE, Version 7.0, a computer program developed by Rocscience, Inc. Stability was analyzed for drained (long-term) conditions.

Our analysis was based on the cross-section at Station 41+00, near borings CB-4 and CB-4A, which appeared to be the tallest cut section. The geologic model used a five-layer shale horizontal bed to represent the subsurface conditions observed at these borings for the purpose of our analysis. Three shale materials were used based on the subsurface conditions observed at the boring locations. A weaker shale layer was observed within the strong shale zone near the toe of the planned rock slope. The analyses were completed with groundwater at a depth of about 17 feet, or approximately elevation 482 feet, and without groundwater. Stability analysis models of 1H:1V and 1.5H:1V were used to evaluate the rock cut slope stability.

Based on the rock characteristics as determined by our field observation and structural geologic mapping and the subsurface conditions observed at the boring locations, the analysis model of the slopes used the non-circular search path method. Using this method, SLIDE randomly generates non-circular piece-wise linear slip surfaces through the formation and evaluates the factor of safety of those surfaces. Potential failure paths in these rock types would be a combination of these non-circular paths typically referred to as “Step Path” failures. A stair-step best characterizes this type of failure in bedrock. Based on our analyses, we determined that both the 1H:1V and 1.5H:1V rock cut slopes were stable. We also analyzed both cut slopes with and without a water level at 482 feet. Because of the strength of the bedrock, no difference was observed between the analyses with a water level and without a water level. The results of the analyses can be found in Exhibits D-1 through D-3.

4.2.3 Seismicity

Based on the subsurface conditions observed at the boring locations and the review of the seismic design parameters, the project site classifies as **Seismic Zone 1** per Section 3.10.6 of the AASHTO *LRFD Bridge Design Specifications, 6th Edition, 2012 edition*. A pseudo-static analysis was done for each final rock cut stability analysis. The seismic coefficient (k) value was estimated using LRFD guidelines published in FHWA-NHI-11-032 and USGS U.S. Seismic Design website. The USGS website provided a Peak Ground Acceleration (PGA) of 0.082g for the site. A k value for the pseudo-static analysis of the rock cuts was estimated to be 0.041g using the LRFD guidelines (½ of PGA).

4.2.4 Kinematic Analysis

Stereonets were developed using joint dip and dip direction information obtained from the field mapping using RockPack III software. Stereonets permit the three-dimensional analysis of discontinuities within a rock mass. This enables the identification of discontinuities having unfavorable orientation in an existing rock slope or allows for the determination of optimum slope geometries during the design phase. Stereonet analyses are often referred to as kinematic analyses. Kinematics is the branch of dynamics that examines motion or potential motion without considering mass and force. Potential plane, wedge, and toppling rock failures may be identified kinematically on stereonets.

A stereonet is the projection of planes and a 3-dimensional reference sphere through which they might pass, to a 2-dimensional representation. This allows the orientation of planes in space to be represented. There are several types of projections. The stereonet representing the rock cut section at this project site, shown in Exhibit D-4, is an equal area or Schmidt projection developed using RockPack III software.

In stereonet analyses, discontinuities are assumed to be planar. There are three possible representations of a plane in space on stereonets. They are poles, dip vectors, and great circles. The stereonets that follow use dip vectors and great circles.

The dip vector is a simple point, like a pole, except that it is plotted in the direction of the dip. It is the midpoint of the great circle that represents the plane of the discontinuity. As such, it depicts the dip direction and dip value of the plane in space. The closer the point is to the center the steeper the dip.

The great circle is formed by the intersection of the plane in space with the lower half of the reference sphere. The stereonet projection of this intersection is an arc. The great circle arc is used to define the proposed 1H:1V rock cut slope in 2-dimensional space. It is identified on the stereonet. The second feature plotted on the stereonet is the assumed or tested friction angle of the rock. This is also identified on the stereonet.

These two conditions can be represented on a stereonet and form a crescent-shaped critical zone and is referred to as Markland's Test. The Markland's Test is a kinematic analysis to determine which joints and discontinues have the potential for plane and wedge failure and block toppling. These features were taken into consideration when designing the rock cut slopes.

Discontinuity dip vectors that lie within this critical zone have the potential to lead to planer failure. Dip vectors outside the critical zone do not. Further, dip vectors in the critical zone that are greater than 20 degrees left or right of slope dip direction are unlikely to contribute to failure.

Plotting great circles of dip vectors outside the critical area is used to estimate possible wedge failures. When two great circle plots intersect in the critical area those dip vectors are used for analysis of potential wedge failure.

Based on the results of the field measurements, laboratory testing, and analysis, we determined that a number of features could potentially result in slope failure if the slopes were steeper the 1H:1V. The results of this analysis can be found in Exhibit D-4.

4.3 Rock Cut Slope and Rockfall Catchment Ditch Recommendations

Complete design of a rock cut must consider, and is contingent upon, the appropriate configuration of the rockfall catchment ditch at the toe of the cut. If an adequate rockfall catchment ditch can be designed, the rockfall hazard can usually be reduced.

Using a 1H:1V rock slope, a maximum cut slope height of 60 feet, and the catchment ditch slope of 6H:1V, we evaluated the minimum depth and width required for a rock catch ditch to be constructed at the toe of the slope. A catchment ditch slope of 4H:1V could be considered as an alternative if it is desired to reduce the width or amount of rock excavation. Based on the planned 1H:1V rock cut slope, the results of the analyses, and the rock characteristics of the shale and sandstone beds, we expect rockfall to roll/slide. We referenced "*Rockfall Catchment Area Design Guide*" (FHWA-OR-RD-02-04) for designing the catchment ditch. Recommended cut slopes and rockfall catchment ditch widths are provided in the following table.

Recommended Minimum Rock Cut Slopes	
Native soils	3H:1V
Shale and sandstone bedrock	1H:1V
Catchment ditch	6H:1V Minimum width = 28 feet between the rock cut slope toe and edge of pavement 95 percent rockfall retained[1]
	4H:1V Minimum width = 21 feet between the rock cut slope toe and edge of pavement 95 percent rockfall retained[1]

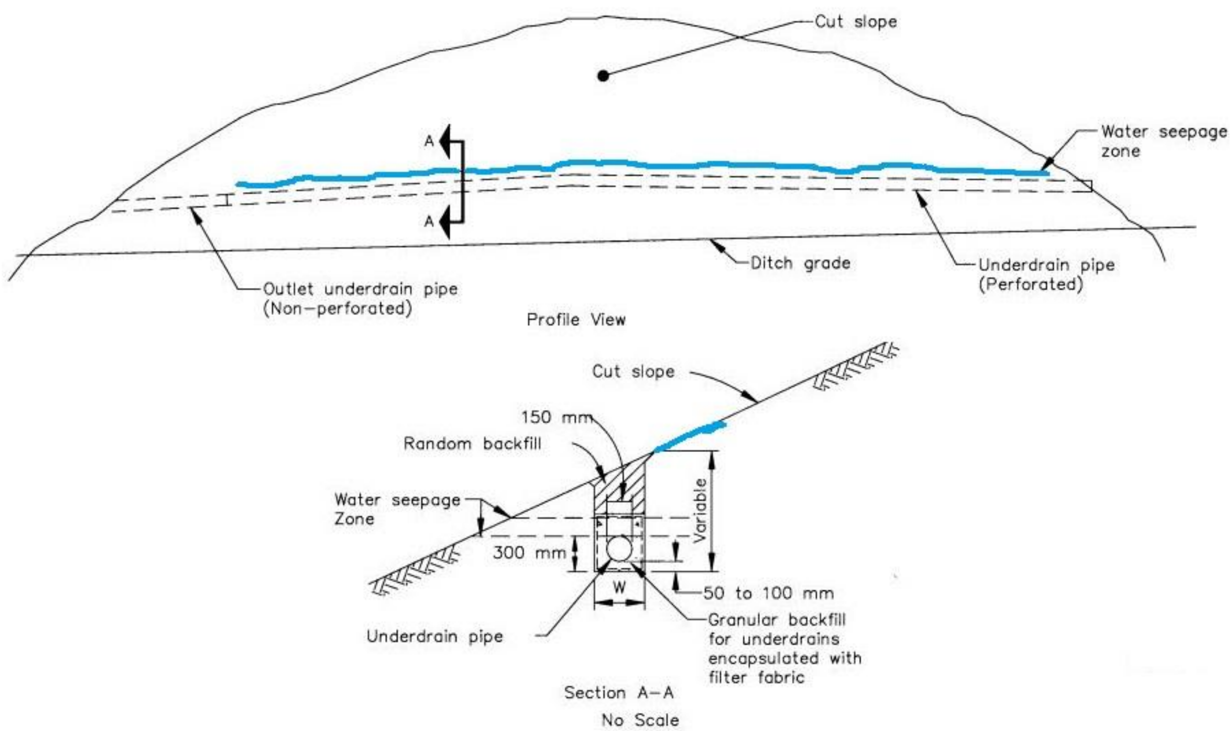
[1] A minimum width of 36 feet should be used for the 6H:1V ditch slope and 28 feet for the 4H:1V ditch slope if it is desired to retain 99 percent of the rockfall

4.4 Earthwork Considerations

4.4.1 Erosion and Drainage Considerations

We recommend that cut slopes be protected by vegetation to reduce the potential for erosion or shallow, localized sloughing. To reduce the potential of surface water from running over the crest of the cut slopes and down onto the slopes, we recommend surface drainage ditches be constructed along the top of the cut slopes a few feet behind the crest where necessary to intercept surface runoff from upslope. These ditches should discharge at locations beyond the ends of the cut.

Groundwater was observed at varying depths in the borings, but no seeps or springs were observed in the exposed rock outcrops. Perched water and interstitial water in the joints and bedding could be encountered during construction. Usually, water that is encountered in rock during construction is alleviated by natural seepage and evaporation. If large amounts of water are produced in fractures or apparent springs during construction that do not appear to be diminishing, the Geotechnical Engineer of Record should be notified to evaluate the conditions and provide recommendations for alleviating the water. The following figure provides an example of an underdrain system for controlling water seepage in the cut slope. The drain should be installed just below the observed seepage zone and positively sloped to discharge away from the slope.



4.4.2 Excavation

Native soils can be excavated using conventional backhoes, front-end loaders, and motorized scrapers. However, due to the limited overburden thickness and variable rock depth, our experience indicates that it can be difficult to strip soils off the rock. At many locations, the contractor will likely choose not to strip the soils, but to excavate soil and rock at the same time, unless directed otherwise. This should be taken into consideration when evaluating material quality and quantities.

Highly weathered shale was observed at the ground surface at the boring locations. Auger refusal on shale was observed at depths of about 20 feet and 15 feet below the existing ground surface at Borings CB-4 and CB-5, respectively. Sandstone and siltstone beds and quartz veins of varying thickness were observed throughout the rock cores. Traces of clay infill were observed in some of the rock cores.

Excavation of the shale and sandstone is expected to be difficult. Typically rock that can be penetrated with our flight augers can sometimes be excavated with large, heavy-duty, track-mounted, excavation equipment such as track-hoes equipped with rock teeth or bulldozers equipped with ripping attachments. We anticipate that the weathering and bedding of the shale will aid in excavation. Pneumatic or hydraulic hammering, tractor-mounted rock breakers, and blasting should be expected to excavate rock near and below the depths of 15 to 20 feet that we encountered auger refusal.

Excavation of shale with heavy-duty equipment or blasting may result in rock disturbance below the desired depth. Loosened shale pieces should be removed entirely to sound rock.

All excavations should comply with applicable local, state, and federal safety regulations. Construction site safety generally is the sole responsibility of the contractor, who shall also be solely responsible for the means, methods, and sequencing of construction operations. We are providing this information solely as a service to our client. Under no circumstances should the information provided above be interpreted to mean that Terracon is assuming responsibility for construction site safety or the contractor's activities; such responsibility is not being implied and should not be inferred.

4.4.3 Bedrock Rippability

Field seismic wave (compressive P-wave) velocity is one indicator in assessing rock rippability. Typical seismic wave velocity values for various materials related to this project are listed in the following table. These typical values are cited from U.S. Army Corps of Engineers, Engineer Manual 1110-1-1802, "*Geophysical Exploration for Engineering and Environmental Investigations*."

Material	Seismic Velocity (ft/second)
Sand	1,500 – 2,950
Clay	2,950 – 5,900
Shale	2,650 – 12,150
Sandstone	7,200 – 13,100

Ripper performance charts published in the Caterpillar Performance Handbook correlate seismic velocity values for various rock types with tractor size. These charts are only a guide, and the actual rippability is dependent upon rock mass discontinuity (joints/fractures/bedding) spacing and orientation.

Several caveats are in order before one makes a final judgment about the suitability and use of equipment for an excavation project. Favorable conditions for rippability include: frequent planes of weakness such as joints, fractures or laminations, weathering, moisture content, stratification, brittleness, and 'lower' shear strength. Unfavorable conditions for rippability include: massive rock with fewer planes of weakness, crystalline rocks, non-brittle energy-absorbing rock matrix, and 'higher' shear strength. Other variables relative to rippability include: the size of the equipment used, the skill of the operator, inclusions or 'hard spots" in the rock, the condition of the equipment used, and the orientation of any planes of weakness such as fractures or layer bedding.

4.4.4 Use of Bedrock as Aggregate Base and Fill Material

Five shale composite core samples were tested for Slake Durability tests. The test results are summarized in the following table and are also included in Appendix C.

Sample	Material Source [1]	Slake Durability Index
OC-1	Outcrop OC-1	99.1
OC-2	Outcrop OC-1	97.4
OC-3	Outcrop OC-2	98.0
OC-4	Outcrop OC-3	99.3
OC-5	Outcrop OC-4	99.5

1. Samples collected from rock outcrops at the approximate locations shown on Exhibit A-2 Boring Location Plan

Based on the Gambles' Slake Durability Classification, the shale materials tested exhibit medium high to very high durability. These preliminary test results indicate that shale can be considered as Selected Material provided the materials are crushed and processed to meet the requirements in Section 302, Selected Material, AHTD *Standard Specifications for Highway Construction*, Edition 2013. The excavated shale and sandstone should not be considered for use as Aggregate Base Course or Mineral Aggregate.

5.0 GENERAL COMMENTS

Terracon Consultants, Inc. should be retained to review the final design plans and specifications so comments can be made regarding interpretation and implementation of our geotechnical recommendations in the design and specifications. Terracon Consultants, Inc. also should be retained to provide observation and testing services during grading, excavation, construction, and other earth-related construction phases of the project.

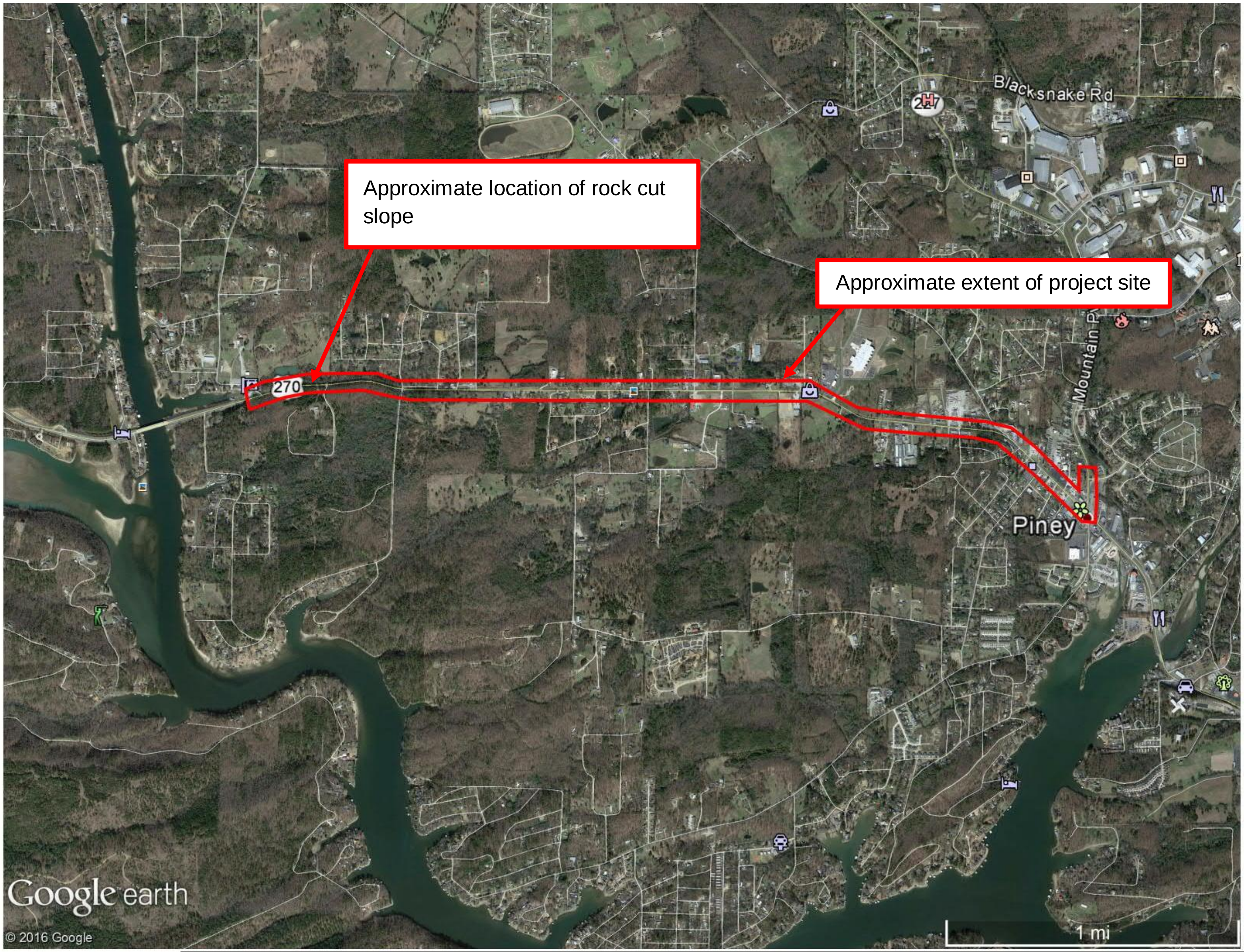
The analysis and recommendations presented in this report are based upon the data obtained from the borings performed at the indicated locations and from other information discussed in this report. This report does not reflect variations that may occur between borings, across the site, or due to the modifying effects of weather. The nature and extent of such variations may not become evident until during or after construction. If variations appear, we should be immediately notified so that further evaluation and supplemental recommendations can be provided.

The scope of services of this project does not include either specifically or by implication any environmental assessment of the site or identification of contaminated or hazardous materials or conditions. If the owner is concerned about the potential of such contamination, other studies should be undertaken.

This report has been prepared for the exclusive use of our client for specific application to the project discussed and has been prepared in accordance with generally accepted geotechnical engineering practices. No warranties, either express or implied, are intended or made. Site safety, excavation support, and dewatering requirements are the responsibility of others. In the event that any changes in the nature, design, or location of the project as outlined in this report are planned, the conclusions and recommendations contained in this report shall not be considered valid unless Terracon Consultants, Inc. reviews the changes, and either verifies or modifies the conclusions of this report in writing.

APPENDIX A

FIELD EXPLORATION



AERIAL PHOTOGRAPHY PROVIDED BY GOOGLE EARTH

DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

Project Manager: SPB	Project No. 35145118
Drawn by: RSR	Scale: AS SHOWN
Checked by: SL	File Name: SLP-BLP
Approved by: SPB	Date: 10/5/2016

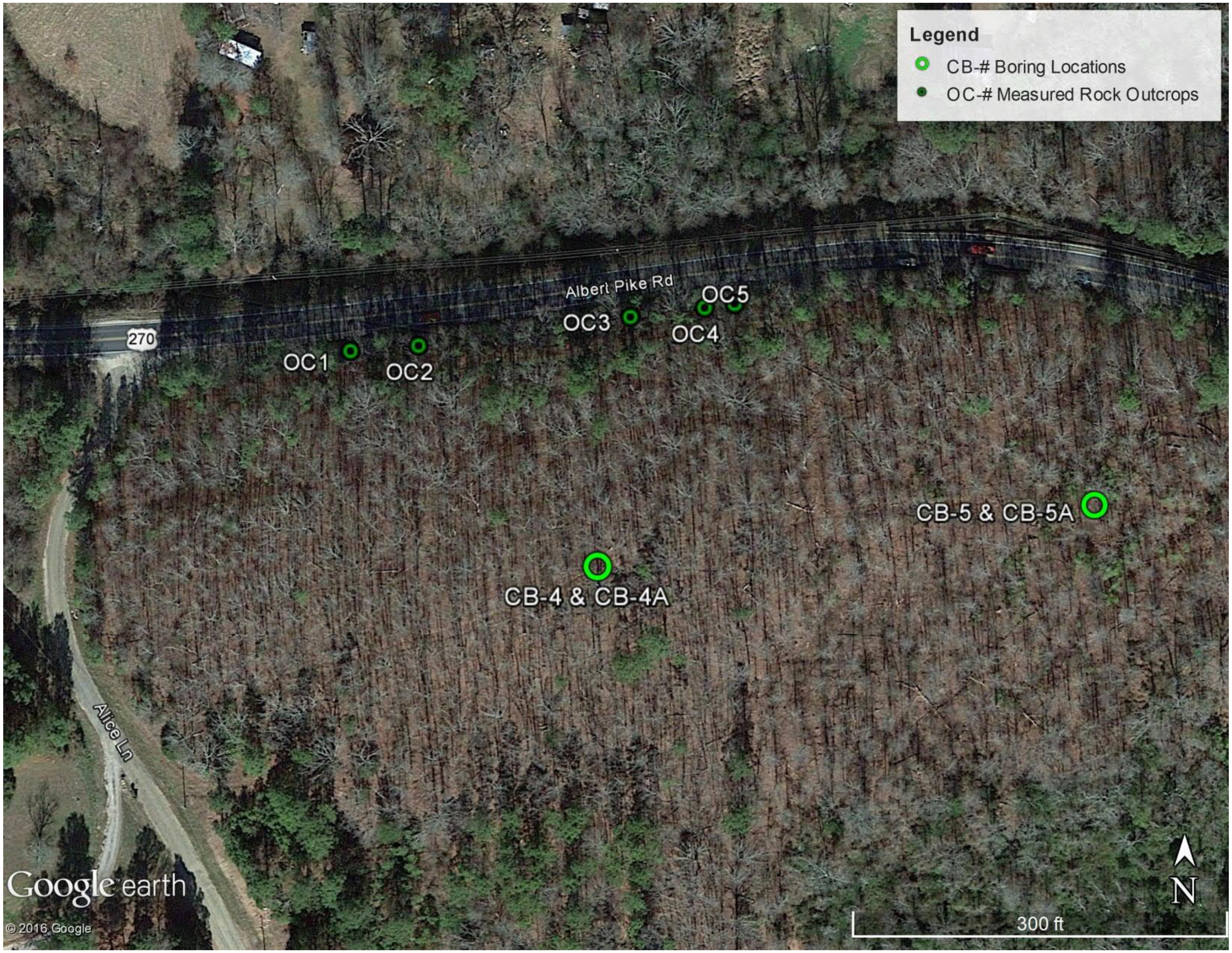
Terracon

25809 I-30 South
Bryant, AR 72022

SITE LOCATION PLAN

Rock Cut Evaluation
Hwy 270 – Hwy 227 to Ouachita River (Widening)(S)
AHTD Job No. CA0607, Task Order No. C069
Hot Springs, Garland County, Arkansas

Exhibit
A-1



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AERIAL PHOTOGRAPHY PROVIDED BY GOOGLE EARTH

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Terracon
25809 I-30 South
Bryant, AR 72022

BORING LOCATION PLAN

Rock Cut Evaluation
Hwy 270 – Hwy 227 to Ouachita River (Widening)(S)
AHTD Job No. CA0607, Task Order No. C069
Hot Springs, Garland County, Arkansas

Exhibit
A-2

Field Exploration Description

Two borings, designated CB-4 and CB-5, were drilled at the site on August 16 and 17, 2016. Two additional borings, designated CB-4A and CB-5A, were drilled between September 13 and 16, 2016, near the original boring locations to collect supplemental data. The borings were drilled to termination depths of about 53 to 60 feet below the ground surface at the approximate locations shown on Exhibit A-2 Boring Location Plan. Planned Borings CB-1, CB-2 and CB-3 could not be drilled because the landowners refused access on their property or did not respond back to our attempts to contact and notify them.

Terracon personnel established the borings in the field by using a hand-held GPS unit to establish the approximate locations shown on the Boring Location Plan. The approximate latitude and longitude coordinates were estimated using Google Earth Pro, and then used with the GPS to locate the borings in the field. After completing the field exploration, the boring locations and ground surface elevations were recorded by Harmon Surveying, Inc. The locations and elevations of the borings should be considered accurate only to the degree implied by the methods used to define them.

Boring location information and elevations are provided in the following table:

Summary of Boring Locations and Elevations					
Boring	**Station (estimated from provided plans)**	**Offset (East facing)**	**Northing**	**Easting**	**Elevation (feet)**
CB-4	40+80	160 ft R	1984831.1	959744.6	500.7
CB-5	45+00	60 ft R	1984885.9	960100.5	498.2

Survey data provided by Harmon Surveying

The boreholes were advanced with truck- and track-mounted drill rigs using 3-1/4" hollow-stem augers to advance the borings until auger refusal at depths of about 15 to 20 feet below existing grades. Rotary wash drilling with roller rock bits and rock coring techniques were used to extend the borings below the auger refusal depths. Samples were obtained using the split-barrel sampling procedure. Rock samples were obtained from below auger refusal depths using the rock coring sampling procedure. Water circulation loss was also monitored during the coring process. The boreholes were checked for the presence of groundwater while drilling, before injecting water, at the completion of the drilling, and at least a day after drilling completion. The borings were backfilled with auger cuttings and bentonite chips.

In the split-barrel sampling procedure, the number of blows required to advance a standard 2-inch O.D. split-barrel sampler the last 12 inches of the total 18-inch penetration by means of a 140-pound standard hammer with a free fall of 30 inches, is the standard penetration resistance value (SPT-N). This value is used to estimate the in-situ consistency of cohesive soils, relative density of granular soils, and relative hardness of weathered bedrock.

An automatic SPT hammer was used to advance the split-barrel sampler in the borings performed on this site. A significantly greater efficiency is achieved with the automatic hammer compared to the conventional safety hammer operated with a cathead and rope. This higher efficiency has an appreciable effect on the SPT-N value.

Rock core was obtained in approximate 5-foot long runs using NQ2-size and HQ-size, diamond-bit core barrels. The lithology, percent recovery (REC%) and rock quality designation (RQD) of the rock core were evaluated by a geotechnical engineer. This information is provided on the boring logs.

The samples were tagged for identification, sealed to reduce moisture loss, and taken to our laboratory for further examination, testing, and classification. Photographs of the disturbed rock and intact rock core samples were taken after they were returned to our laboratory. The photographs are included as Exhibits D-1 through D-13.

Field logs were prepared by the drill crew. The logs included visual classifications of the materials encountered during drilling as well as the driller's interpretation of the subsurface conditions between samples. The final boring logs included with this report represent the engineer's interpretation of the subsurface conditions at the boring locations based on field and laboratory data and observation of the samples.

Our exploration services include storing the collected soil and rock samples and making them available for inspection until after construction is completed. The samples will then be discarded unless requested otherwise.

A Terracon geological engineer also visited the toe of the existing rock cut slopes to evaluate the condition of the shale bedrock exposed in outcrops and to obtain data for kinematic analysis. The approximate locations of the rock outcrops are shown on Exhibit A-2 Boring Location Plan as OC-1 through OC-5. Terracon mapped the bedrock and prominent joints and bedding planes. We observed the joint spacing, joint opening, presence and type of infill, joint linearity, and joint smoothness for evaluating the Rock Mass Ratio (RMR). We collected five samples of shale and sandstone from the exposed outcrops. The samples were taken to the laboratory for further evaluation and laboratory testing.

In addition, measurements were taken on prominent planar surfaces of beds and joints in the exposed shale and sandstone bedrock. The dip direction and dip inclination of beds and joints were measured using a Brunton international pocket transit. These data were used as part of a rock cut slope stability analysis to evaluate potential of rock plane, wedge, and toppling failure.

BORING LOG NO. CB-4

PROJECT: CA0607 - Hwy 227-Ouachita River (Widening)(S)

CLIENT: Buchart Horn, Inc. Memphis, Tennessee

SITE: Hwy 270 Hot Springs, Garland County, Arkansas

LOCATION See Exhibit A-2

Latitude: 34.509206° Longitude: -93.170389°
Northing: 1984831.1 Easting: 959744.6
Station: 40+80 Offset: 160 ft R

Surface Elev.: 500.7 (Ft.)

DEPTH	Description	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	POINT LOAD INDEX (psi) - parallel	POINT LOAD INDEX (psi) - perpendicular	UNCONFINED COMPRESSIVE STRENGTH (psi)	WATER CONTENT (%)
	HIGHLY WEATHERED SHALE, grayish-brown, soft										
					SPT	12	24-37-47 N=84				
			5		SPT	10	13-20-24 N=44				
			10		SPT	13	12-27-40 N=67				
13.5		487									
	WEATHERED SHALE, dark gray and olive-brown, soft				SPT	9	37-50/4"				
			15								
	Auger refusal at about 20 feet				SPT	5	42-50/2"				
20.0		480.5	20								
	SHALE, dark gray, hard, slightly weathered to unweathered, closely jointed, weathered joints, trace clay infill, joints dip shallow to steep (10 to 85 deg.)				Core	17	Run 1 REC = 71% RQD = 42%				
			25		Core	55	Run 2 REC = 92% RQD = 30%	290			
					Core	60					

Stratification lines are approximate. In-situ, the transition may be gradual.

**Classification estimated from disturbed or core samples. Petrographic analysis may reveal other rock types.

Hammer Type: Automatic

Advancement Method:
0 to 20 ft: 3-1/4" Hollow-stem auger
20 to 53 ft: NQ2 diamond-bit core barrel

Abandonment Method:
Boring backfilled with soil cuttings and bentonite upon completion.

See Exhibit A-3 for description of field procedures.

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Locations and elevations obtained from survey

Notes:

WATER LEVEL OBSERVATIONS

Complete (100%) circulation loss below 47 feet

34 ft After One Day

Terracon
25809 I 30
Bryant, AR

Boring Started: 8/17/2016	Boring Completed: 8/17/2016
Drill Rig: ATV, #776	Driller: TM
Project No.: 35145118	Exhibit: A-4

BORING LOG NO. CB-4

PROJECT: CA0607 - Hwy 227-Ouachita River (Widening)(S)

CLIENT: Buchart Horn, Inc. Memphis, Tennessee

SITE: Hwy 270 Hot Springs, Garland County, Arkansas

LOCATION See Exhibit A-2

Latitude: 34.509206° Longitude: -93.170389°
Northing: 1984831.1 Easting: 959744.6
Station: 40+80 Offset: 160 ft R

Surface Elev.: 500.7 (Ft.)

DEPTH	Description	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	POINT LOAD INDEX (psi) - parallel	POINT LOAD INDEX (psi) - perpendicular	UNCONFINED COMPRESSIVE STRENGTH (psi)	WATER CONTENT (%)
	SHALE, dark gray, hard, slightly weathered to unweathered, closely jointed, weathered joints, trace clay infill, joints dip shallow to steep (10 to 85 deg.) *(continued)*		30		Core	60	Run 3 REC = 100% RQD = 52%				
			35	▽	Core	57	Run 4 REC = 95% RQD = 55%				
			40		Core	60	Run 5 REC = 100% RQD = 68%	352			
			45		Core	60	Run 6 REC = 100% RQD = 66%	175			
47.0		453.5									
	HIGHLY WEATHERED SHALE, dark gray to olive-brown, soft, highly fractured based on coring, classified based on cuttings		50		Core	0	Run 7 REC = 0% RQD = 0%				
					Core	0	Run 8 REC = 0% RQD = 0%				
53.0	***Boring Terminated at 53 Feet***	447.5									

Stratification lines are approximate. In-situ, the transition may be gradual.

**Classification estimated from disturbed or core samples. Petrographic analysis may reveal other rock types.

Hammer Type: Automatic

Advancement Method:
0 to 20 ft: 3-1/4" Hollow-stem auger
20 to 53 ft: NQ2 diamond-bit core barrel

Abandonment Method:
Boring backfilled with soil cuttings and bentonite upon completion.

See Exhibit A-3 for description of field procedures.

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Locations and elevations obtained from survey

Notes:

WATER LEVEL OBSERVATIONS

Complete (100%) circulation loss below 47 feet

▽ *34 ft After One Day*

Terracon
25809 I 30
Bryant, AR

Boring Started: 8/17/2016	Boring Completed: 8/17/2016
Drill Rig: ATV, #776	Driller: TM
Project No.: 35145118	Exhibit: A-4

BORING LOG NO. CB-4A

PROJECT: CA0607 - Hwy 227-Ouachita River (Widening)(S)

CLIENT: Buchart Horn, Inc. Memphis, Tennessee

SITE: Hwy 270 Hot Springs, Garland County, Arkansas

GRAPHIC LOG	LOCATION See Exhibit A-2 Latitude: 34.509206° Longitude: -93.170389° Northing: 1984831.1 Easting: 959744.6 Station: 40+80 Offset: 160 ft R Surface Elev.: 500.7 (Ft.) DEPTH / ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	POINT LOAD INDEX (psi) - parallel	POINT LOAD INDEX (psi) - perpendicular	UNCONFINED COMPRESSIVE STRENGTH (psi)	WATER CONTENT (%)
	See Boring Log CB-4 for soil and rock conditions from 0 to 45 feet	5 10 15 20 25								

Stratification lines are approximate. In-situ, the transition may be gradual.

**Classification estimated from disturbed or core samples. Petrographic analysis may reveal other rock types.

Hammer Type: Automatic

Advancement Method:
0 to 45 feet 4" casing advancer with rock bit

Abandonment Method:
Boring backfilled with soil cuttings and bentonite upon completion.

See Exhibit A-3 for description of field procedures.

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Locations and elevations obtained from survey

Notes:

WATER LEVEL OBSERVATIONS

Water level not determined

Terracon
25809 I 30
Bryant, AR

Boring Started: 9/16/2016	Boring Completed: 9/17/2016
Drill Rig: ATV, #776	Driller: TF
Project No.: 35145118	Exhibit: A-5

BORING LOG NO. CB-4A

PROJECT: CA0607 - Hwy 227-Ouachita River (Widening)(S)

CLIENT: Buchart Horn, Inc. Memphis, Tennessee

SITE: Hwy 270 Hot Springs, Garland County, Arkansas

LOCATION See Exhibit A-2

Latitude: 34.509206° Longitude: -93.170389°
Northing: 1984831.1 Easting: 959744.6
Station: 40+80 Offset: 160 ft R

Surface Elev.: 500.7 (Ft.)

DEPTH	Description	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	POINT LOAD INDEX (psi) - parallel	POINT LOAD INDEX (psi) - perpendicular	UNCONFINED COMPRESSIVE STRENGTH (psi)	WATER CONTENT (%)
	See Boring Log CB-4 for soil and rock conditions from 0 to 45 feet *(continued)*		30, 35, 40								
45.0	**SHALE**, dark gray, slightly weathered, soft	455.5	45				17-30-27 N=57				
50.0	**SHALE**, dark gray, slightly fractured, unweathered to slightly weathered, hard, vertical fractures with some iron staining	450.5	50				Run 1 REC = 100% RQD = 35%				
			55				Run 2 REC = 100% RQD = 65%				

Stratification lines are approximate. In-situ, the transition may be gradual.
**Classification estimated from disturbed or core samples. Petrographic analysis may reveal other rock types.

Hammer Type: Automatic

Advancement Method:
0 to 45 feet 4" casing advancer with rock bit

Abandonment Method:
Boring backfilled with soil cuttings and bentonite upon completion.

See Exhibit A-3 for description of field procedures.

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Locations and elevations obtained from survey

Notes:

WATER LEVEL OBSERVATIONS

Water level not determined

Terracon
25809 I 30
Bryant, AR

Boring Started: 9/16/2016	Boring Completed: 9/17/2016
Drill Rig: ATV, #776	Driller: TF
Project No.: 35145118	Exhibit: A-5

BORING LOG NO. CB-4A

PROJECT: CA0607 - Hwy 227-Ouachita River (Widening)(S)

CLIENT: Buchart Horn, Inc. Memphis, Tennessee

SITE: Hwy 270 Hot Springs, Garland County, Arkansas

LOCATION See Exhibit A-2

Latitude: 34.509206° Longitude: -93.170389°
Northing: 1984831.1 Easting: 959744.6
Station: 40+80 Offset: 160 ft R

Surface Elev.: 500.7 (Ft.)

GRAPHIC LOG	DEPTH / DESCRIPTION / ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	POINT LOAD INDEX (psi) - parallel	POINT LOAD INDEX (psi) - perpendicular	UNCONFINED COMPRESSIVE STRENGTH (psi)	WATER CONTENT (%)
	SHALE, dark gray, slightly fractured, unweathered to slightly weathered, hard, vertical fractures with some iron staining *(continued)*					Run 3 REC = 98% RQD = 79%				
	60.0 ... 440.5	60								
	Boring Terminated at 60 Feet									

Stratification lines are approximate. In-situ, the transition may be gradual.
**Classification estimated from disturbed or core samples. Petrographic analysis may reveal other rock types.

Hammer Type: Automatic

Advancement Method:
0 to 45 feet 4" casing advancer with rock bit

Abandonment Method:
Boring backfilled with soil cuttings and bentonite upon completion.

See Exhibit A-3 for description of field procedures.

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Locations and elevations obtained from survey

Notes:

WATER LEVEL OBSERVATIONS

Water level not determined

Terracon
25809 I 30
Bryant, AR

Boring Started: 9/16/2016	Boring Completed: 9/17/2016
Drill Rig: ATV, #776	Driller: TF
Project No.: 35145118	Exhibit: A-5

BORING LOG NO. CB-5

PROJECT: CA0607 - Hwy 227-Ouachita River (Widening)(S)

CLIENT: Buchart Horn, Inc. Memphis, Tennessee

SITE: Hwy 270 Hot Springs, Garland County, Arkansas

LOCATION See Exhibit A-2

Latitude: 34.509367° Longitude: -93.169211°
Northing: 1984885.9 Easting: 960100.5
Station: 45+00 Offset: 60 ft R

Surface Elev.: 498.2 (Ft.)

DEPTH		ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	POINT LOAD INDEX (psi) - parallel	POINT LOAD INDEX (psi) - perpendicular	UNCONFINED COMPRESSIVE STRENGTH (psi)	WATER CONTENT (%)
	HIGHLY WEATHERED SHALE, grayish-brown and dark brown, soft				Split spoon	8	18-50/5"				
					Split spoon	4	14-50/5"				
8.5		489.5	5								
	HIGHLY WEATHERED SHALE, brownish-gray, soft				Split spoon	7	27-50/4"				
13.5		484.5	10								
	SHALE, dark gray, moderately hard to hard, slightly weathered to unweathered, closely jointed, weathered joints, trace clay infill, joints dip moderately (28 to 40 deg.) Auger refusal at about 15 feet				Split spoon	4	50/4"				
			15	▼ (about 17 ft)	Core	16	Run 1 REC = 67% RQD = 0%				
	very thin (2") sandstone beds at about 20, 23, and 24 feet		20		Core	60	Run 2 REC = 100% RQD = 35%	145			
25.0		473			Core	59	Run 3 REC = 98% RQD = 25%				
	SANDSTONE, gray to dark gray, well cemented, slightly weathered to unweathered, highly fractured, recemented fractures, weathered joints, trace clay infill, joints dip shallow to steep (5 to 87 deg., mostly 45 deg.), signs of structural folding in laminations		25		Core	60					

Stratification lines are approximate. In-situ, the transition may be gradual.

**Classification estimated from disturbed or core samples. Petrographic analysis may reveal other rock types.

Hammer Type: Automatic

Advancement Method:
0 to 20 ft: 3-1/4" Hollow-stem auger
20 to 53 ft: NQ2 diamond-bit core barrel

Abandonment Method:
Boring backfilled with soil cuttings and bentonite upon completion.

See Exhibit A-3 for description of field procedures.

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Locations and elevations obtained from survey

Notes:

Approx. 40% circulation loss while coring from 15 to 55 feet

WATER LEVEL OBSERVATIONS

40% circulation loss from 15 to 55 feet

Complete (100%) Water loss after 42ft

▼ *17 ft After One Day*

Terracon
25809 I 30
Bryant, AR

Boring Started: 8/16/2016	Boring Completed: 8/16/2016
Drill Rig: ATV, #776	Driller: TM
Project No.: 35145118	Exhibit: A-6

BORING LOG NO. CB-5

PROJECT: CA0607 - Hwy 227-Ouachita River (Widening)(S)

CLIENT: Buchart Horn, Inc. Memphis, Tennessee

SITE: Hwy 270 Hot Springs, Garland County, Arkansas

LOCATION See Exhibit A-2

Latitude: 34.509367° Longitude: -93.169211°
Northing: 1984885.9 Easting: 960100.5
Station: 45+00 Offset: 60 ft R

Surface Elev.: 498.2 (Ft.)

GRAPHIC LOG	DEPTH / MATERIAL DESCRIPTION / ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	POINT LOAD INDEX (psi) - parallel	POINT LOAD INDEX (psi) - perpendicular	UNCONFINED COMPRESSIVE STRENGTH (psi)	WATER CONTENT (%)
Sandstone	**SANDSTONE**, gray to dark gray, well cemented, slightly weathered to unweathered, highly fractured, recemented fractures, weathered joints, trace clay infill, joints dip shallow to steep (5 to 87 deg., mostly 45 deg.), signs of structural folding in laminations *(continued)* thin (6") highly weathered, clayey shale beds at about 26 and 31 feet, olive-brown	30		Core	60	Run 4 REC = 100% RQD = 54%	232			
		35		Core	60	Run 5 REC = 100% RQD = 74%				
	42.0 — 456	40		Core	60	Run 6 REC = 100% RQD = 85%	1408	3041		
Shale	**HIGHLY WEATHERED SHALE**, with very thin to thin sandstone beds, gray and olive-gray, soft, highly fractured based on coring, classified based on cuttings	45		Core	7	Run 7 REC = 12% RQD = 0%				
		50		Core	23	Run 8 REC = 38% RQD = 0%	1053			
	55.0 — 443	55		Core	0	Run 9 REC = 0% RQD = 0%				
	Boring Terminated at 55 Feet									

Stratification lines are approximate. In-situ, the transition may be gradual.
**Classification estimated from disturbed or core samples. Petrographic analysis may reveal other rock types.

Hammer Type: Automatic

Advancement Method:
0 to 20 ft: 3-1/4" Hollow-stem auger
20 to 53 ft: NQ2 diamond-bit core barrel

Abandonment Method:
Boring backfilled with soil cuttings and bentonite upon completion.

See Exhibit A-3 for description of field procedures.

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.
Locations and elevations obtained from survey

Notes:

Complete (100%) circulation loss while coring below 42 feet

WATER LEVEL OBSERVATIONS

40% circulation loss from 15 to 55 feet

Complete (100%) Water loss after 42ft

▼ *17 ft After One Day*

Terracon
25809 I 30
Bryant, AR

Boring Started: 8/16/2016	Boring Completed: 8/16/2016
Drill Rig: ATV, #776	Driller: TM
Project No.: 35145118	Exhibit: A-6

BORING LOG NO. CB-5A

PROJECT: CA0607 - Hwy 227-Ouachita River (Widening)(S)

CLIENT: Buchart Horn, Inc. Memphis, Tennessee

SITE: Hwy 270 Hot Springs, Garland County, Arkansas

LOCATION See Exhibit A-2

Latitude: 34.509367° Longitude: -93.169211°
Northing: 1984885.9 Easting: 960100.5
Station: 45+00 Offset: 60 ft R

Surface Elev.: 498.2 (Ft.)

GRAPHIC LOG	DEPTH / DESCRIPTION / ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	POINT LOAD INDEX (psi) - parallel	POINT LOAD INDEX (psi) - perpendicular	UNCONFINED COMPRESSIVE STRENGTH (psi)	WATER CONTENT (%)
	See Boring Log CB-5 for soil and rock conditions from 0 to 22 feet 22.0 — 476	5 10 15 20	▽ (17 ft)							
Sandstone	**SANDSTONE**, fine grained, light brown to gray, well cemented, extremely fractured, very close fracture spacing, slightly weathered, multiple high-angle intersecting fractures 27.0 — 471	25	▼ (25 ft)	Rock Core		Run 1 REC = 23% RQD = 10%				

Stratification lines are approximate. In-situ, the transition may be gradual.
**Classification estimated from disturbed or core samples. Petrographic analysis may reveal other rock types.

Hammer Type: Automatic

Advancement Method:
0 to 15 ft: 4 1/4" Hollow Stem Auger, 15 to 22 ft: 3 7/8" Tri-cone bit Wash Rotary
22 to 37 ft: HQ Rock Core, 0 to 40.8 ft: 4" Casing Advancer
40.8 to 58.8: HQ Rock Core

Abandonment Method:
Boring backfilled with soil cuttings and bentonite upon completion.

See Exhibit A-3 for description of field procedures.

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.
Locations and elevations obtained from survey

Notes:

WATER LEVEL OBSERVATIONS

Water loss (50%) at 37 feet
▽ *17 ft After One Day*
▼ *25 ft After One Week*

Terracon
25809 I 30
Bryant, AR

Boring Started: 9/13/2016	Boring Completed: 9/16/2016
Drill Rig: ATV, #679	Driller: TF
Project No.: 35145118	Exhibit: A-7

BORING LOG NO. CB-5A

PROJECT: CA0607 - Hwy 227-Ouachita River (Widening)(S)

CLIENT: Buchart Horn, Inc. Memphis, Tennessee

SITE: Hwy 270 Hot Springs, Garland County, Arkansas

LOCATION See Exhibit A-2

Latitude: 34.509367° Longitude: -93.169211°
Northing: 1984885.9 Easting: 960100.5
Station: 45+00 Offset: 60 ft R

Surface Elev.: 498.2 (Ft.)

DEPTH	Description	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	POINT LOAD INDEX (psi) - parallel	POINT LOAD INDEX (psi) - perpendicular	UNCONFINED COMPRESSIVE STRENGTH (psi)	WATER CONTENT (%)
29.5	**SANDSTONE**, very fine grained, dark gray, well cemented, moderately fractured, very close fracture spacing, slightly weathered, cross-cutting weathered joints and fractures *(continued)*	468.5	30		Core		Run 2 REC = 55% RQD = 24%				
32.0	**SANDSTONE**, very fine grained, slightly shaley, dark gray, well cemented, moderately fractured, very close fracture spacing, slightly weathered, weathered joints and fractures with shaley fragments in top 12 inches; many low to high angle fractures	466									
37.0	**SANDSTONE**, very fine grained, dark brown, well cemented, moderately fractured, very close fracture spacing, slightly weathered, many low to high angle fractures; very thin siltstone beds with dark gray shale laminations at about 33.9 feet	461	35		Core		Run 3 REC = 100% RQD = 45%				
38.0	**WELL GRADED SAND WITH GRAVEL (SW)**, mix of sandstone, siltstone and shale fragments with abundant quartz crystals, gray to light brown, very dense	460			SPT		3-9-50/0"				
43.8	**SANDSTONE**, very fine grained, gray, well cemented, slightly fractured, unweathered, few dark gray shale laminations	454.5	40		Core		Run 5 REC = 83% RQD = 33%				
	SANDSTONE, very fine grained, gray, well cemented, moderately fractured, very close fracture spacing, slightly weathered to unweathered, many low to high angle cross-cutting fractures		45		Core		Run 6 REC = 100% RQD = 83%				
			50		Core		Run 7 REC = 100% RQD = 75%				
			55		Core		Run 8 REC = 100%				

Stratification lines are approximate. In-situ, the transition may be gradual.
**Classification estimated from disturbed or core samples. Petrographic analysis may reveal other rock types.

Hammer Type: Automatic

Advancement Method:
0 to 15 ft: 4 1/4" Hollow Stem Auger, 15 to 22 ft: 3 7/8" Tri-cone bit Wash Rotary
22 to 37 ft: HQ Rock Core, 0 to 40.8 ft: 4" Casing Advancer
40.8 to 58.8: HQ Rock Core

Abandonment Method:
Boring backfilled with soil cuttings and bentonite upon completion.

See Exhibit A-3 for description of field procedures.

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.
Locations and elevations obtained from survey

Notes:

WATER LEVEL OBSERVATIONS
Water loss (50%) at 37 feet
17 ft After One Day
25 ft After One Week

Terracon
25809 I 30
Bryant, AR

Boring Started: 9/13/2016	Boring Completed: 9/16/2016
Drill Rig: ATV, #679	Driller: TF
Project No.: 35145118	Exhibit: A-7

BORING LOG NO. CB-5A

PROJECT: CA0607 - Hwy 227-Ouachita River (Widening)(S)

CLIENT: Buchart Horn, Inc. Memphis, Tennessee

SITE: Hwy 270 Hot Springs, Garland County, Arkansas

LOCATION See Exhibit A-2

Latitude: 34.509367° Longitude: -93.169211°
Northing: 1984885.9 Easting: 960100.5
Station: 45+00 Offset: 60 ft R

Surface Elev.: 498.2 (Ft.)

GRAPHIC LOG	DEPTH / DESCRIPTION / ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	POINT LOAD INDEX (psi) - parallel	POINT LOAD INDEX (psi) - perpendicular	UNCONFINED COMPRESSIVE STRENGTH (psi)	WATER CONTENT (%)
	SANDSTONE, very fine grained, gray, well cemented, moderately fractured, very close fracture spacing, slightly weathered to unweathered, many low to high angle cross-cutting fractures *(continued)* — 58.8 — 439.5					RQD = 100%				
	Boring Terminated at 58.8 Feet									

Stratification lines are approximate. In-situ, the transition may be gradual.
**Classification estimated from disturbed or core samples. Petrographic analysis may reveal other rock types.

Hammer Type: Automatic

Advancement Method:
0 to 15 ft: 4 1/4" Hollow Stem Auger, 15 to 22 ft: 3 7/8" Tri-cone bit Wash Rotary
22 to 37 ft: HQ Rock Core, 0 to 40.8 ft: 4" Casing Advancer
40.8 to 58.8: HQ Rock Core

Abandonment Method:
Boring backfilled with soil cuttings and bentonite upon completion.

See Exhibit A-3 for description of field procedures.

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.
Locations and elevations obtained from survey

Notes:

WATER LEVEL OBSERVATIONS

Water loss (50%) at 37 feet
17 ft After One Day
25 ft After One Week

Terracon
25809 I 30
Bryant, AR

Boring Started: 9/13/2016	Boring Completed: 9/16/2016
Drill Rig: ATV, #679	Driller: TF
Project No.: 35145118	Exhibit: A-7

APPENDIX B

LABORATORY TESTING

Laboratory Testing Description

Samples retrieved during the field exploration were taken to the laboratory for further observation by the project geotechnical engineer. Descriptive classifications of any soils indicated on the boring logs are in accordance with the Explanation of Boring Log Information and the Unified Soil Classification System included in Appendix E. Also shown are estimated Unified Soil Classification Symbols. Rock was described in accordance with Exhibit E-3 General Notes – Sedimentary Rock Classification. All classification was by visual/manual procedures, (ASTM D 2487).

The field descriptions were confirmed or modified as necessary and an applicable laboratory testing program was formulated to determine engineering properties of the subsurface materials. Selected rock samples obtained from the site were tested for the following engineering properties:

- ASTM D5731-08 Standard Test Method for Determination of the Point Load Strength Index of Rock and Application to Rock Strength Classifications
- ASTM D4644-08 Standard Test Method for Slake Durability of Shales and Similar Weak Rocks
- ASTM D4318-10e1 Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils

The laboratory test results are reported on the boring logs and have been used for the geotechnical engineering analyses, and the rock cut slope design recommendations. Laboratory tests were performed in general accordance with the applicable ASTM, local or other accepted standards. Procedural standards noted above are for reference to methodology in general. In some cases, variations to methods may have been applied as a result of local practice or professional judgment.

Point Load Strength Index tests were performed on selected rock core samples in the parallel and perpendicular orientations. Results of those eight point load strength index tests are presented on Exhibits B-2 through B-9.

Slake Durability tests were performed on selected rock core samples. Results of those five slake durability tests are presented on Exhibits B-10 and B-11.

Terracon

611 Lunken Park Drive, Cincinnati, Ohio 45226, Phone: 513-321-5816

ASTM D 5731 - Point Load Test Index Calculation Sheet

Project No.: 35145118

Client Name: Buchart-Horn Inc

Material : Shale

Hole #: CB-4, 1

Depth : 26-27'

Lab. No. : 5948

Enter PSI Value from Gauge Here : 250 psi

Value in pounds load : 1125 lbs

Load in Newtons (P): 5062.5 N

Load Test Index, $I_s = P/D^2_e$ = 2.00 N/mm^2

I_s = 2.00 Mpa

Enter Initial Diameter of Sample = 1.982 inches

Diameter in Millimeters, D = 50.3428 mm

Enter Reform Dial Final Diameter = 1.975 inches

Final dia. in millimeters, D' = 50.165 mm

D^2_e = D x D' = 2525.447 mm^2

Terracon

611 Lunken Park Drive, Cincinnati, Ohio 45226, Phone: 513-321-5816

ASTM D 5731 - Point Load Test Index Calculation Sheet

Project No.: 35145118

Client Name: Buchart-Horn Inc

Material : Shale

Hole #: CB-4, 2

Depth : 38-39'

Lab. No. : 5949

Enter PSI Value from Gauge Here : 300 psi

Value in pounds load : 1350 lbs

Load in Newtons (P): 6075 N

Enter Initial Diameter of Sample = 1.972 inches

Diameter in Millimeters, D = 50.0888 mm

Enter Reform Dial Final Diameter = 1.968 inches

Final dia. in millimeters, D' = 49.9872 mm

Load Test Index, $I_s = P/D^2_e$ = 2.43 N/mm^2

$D^2_e = D \times D'$ = 2503.799 mm^2

I_s = 2.43 Mpa

Exhibit B-3

Terracon

611 Lunken Park Drive, Cincinnati, Ohio 45226, Phone: 513-321-5816

ASTM D 5731 - Point Load Test Index Calculation Sheet

Project No.: 35145118

Client Name: Buchart-Horn Inc

Material : Shale

Hole #: CB-4, 3

Depth : 46-47'

Lab. No. : 5950

Enter PSI Value from Gauge Here : 150 psi

Value in pounds load : 675 lbs

Load in Newtons (P): 3037.5 N

Load Test Index, $I_s = P/D^2_e$ = 1.21 N/mm^2

I_s = 1.21 Mpa

Enter Initial Diameter of Sample = 1.978 inches

Diameter in Millimeters, D = 50.2412 mm

Enter Reform Dial Final Diameter = 1.971 inches

Final dia. in millimeters, D' = 50.0634 mm

D^2_e = D x D' = 2515.245 mm^2

Terracon

611 Lunken Park Drive, Cincinnati, Ohio 45226, Phone: 513-321-5816

ASTM D 5731 - Point Load Test Index Calculation Sheet

Project No.: 35145118

Client Name: Buchart-Horn Inc

Material : Sandy Shale

Hole #: CB-5, 1

Depth : 21-22'

Lab. No. : 5951

Enter PSI Value from Gauge Here : 125 psi

Value in pounds load : 562.5 lbs

Load in Newtons (P): 2531.25 N

Enter Initial Diameter of Sample = 1.982 inches

Diameter in Millimeters, D = 50.3428 mm

Enter Reform Dial Final Diameter = 1.976 inches

Final dia. in millimeters, D' = 50.1904 mm

Load Test Index, $I_s = P/D^2_e =$ 1.00 N/mm^2

$D^2_e = D \times D' =$ 2526.725 mm^2

$I_s =$ 1.00 Mpa

Exhibit B-5

Terracon

611 Lunken Park Drive, Cincinnati, Ohio 45226,   Phone: 513-321-5816

ASTM D 5731 - Point Load Test Index Calculation Sheet

Project No.: 35145118

Client Name: Buchart-Horn Inc

Material : Shaley sandstone

Hole #: CB-5, 2

Depth : 31-32'

Lab. No. : 5952

Enter PSI Value from Gauge Here : 200 psi

Value in pounds load : 900 lbs

Load in Newtons (P): 4050 N

Enter Initial Diameter of Sample = 1.983 inches

Diameter in Millimeters, D = 50.3682 mm

Enter Reform Dial Final Diameter = 1.975 inches

Final dia. in millimeters, D' = 50.165 mm

Load Test Index, $I_s = P/D^2_e$ = 1.60 N/mm^2

D^2_e = D x D' = 2526.721 mm^2

I_s =	1.60 Mpa

Exhibit B-6

611 Lunken Park Drive, Cincinnati, Ohio 45226, Phone: 513-321-5816

ASTM D 5731 - Point Load Test Index Calculation Sheet

Project No.: 35145118

Client Name: Buchart-Horn Inc

Material : Shaley Sandstone

Hole #: CB-5, 3

Depth : 40-41'

Lab. No. : 5953

Enter PSI Value from Gauge Here : 1200 psi

Value in pounds load : 5400 lbs

Load in Newtons (P): 24300 N

Load Test Index, $I_s = P/D^2_e$ = 9.71 N/mm^2

I_s = 9.71 Mpa

Enter Initial Diameter of Sample = 1.984 inches

Diameter in Millimeters, D = 50.3936 mm

Enter Reform Dial Final Diameter = 1.955 inches

Final dia. in millimeters, D' = 49.657 mm

D^2_e = D x D' = 2502.395 mm^2

Exhibit B-7

Terracon

611 Lunken Park Drive, Cincinnati, Ohio 45226, Phone: 513-321-5816

ASTM D 5731 - Point Load Test Index Calculation Sheet

Project No.: 35145118

Client Name: Buchart-Horn Inc

Material : Shaley Sandstone

Hole #: CB-5, 3

Depth : 40-41'

Lab. No. : 5953A

Enter PSI Value from Gauge Here : 1300 psi

Value in pounds load : 5850 lbs

Load in Newtons (P): 26325 N

Load Test Index, $I_s = P/D^2_e$ = 20.97 N/mm^2

I_s = 20.97 Mpa

Perpendicular

Enter Initial Diameter of Sample = 1.438 inches

Diameter in Millimeters, D = 36.5252 mm

Enter Reform Dial Final Diameter = 1.353 inches

Final dia. in millimeters, D' = 34.3662 mm

D^2_e = D x D' = 1255.232 mm^2

Terracon

611 Lunken Park Drive, Cincinnati, Ohio 45226, Phone: 513-321-5816

ASTM D 5731 - Point Load Test Index Calculation Sheet

Project No.: 35145118

Client Name: Buchart-Horn Inc

Material : Sandstone

Hole #: CB-5, 4

Depth : 47-52'

Lab. No. : 5954

Enter PSI Value from Gauge Here : 900 psi

Value in pounds load : 4050 lbs

Load in Newtons (P): 18225 N

Enter Initial Diameter of Sample = 1.986 inches

Diameter in Millimeters, D = 50.4444 mm

Enter Reform Dial Final Diameter = 1.96 inches

Final dia. in millimeters, D' = 49.784 mm

Load Test Index, $I_s = P/D^2_e =$ 7.26 N/mm^2

$D^2_e = D \times D' =$ 2511.324 mm^2

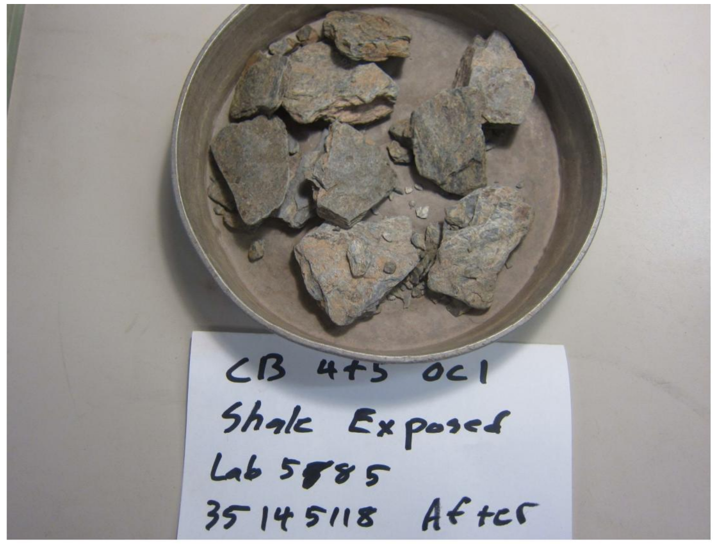
$I_s =$ 7.26 Mpa

SLAKE DURABILITY TEST SUMMARY

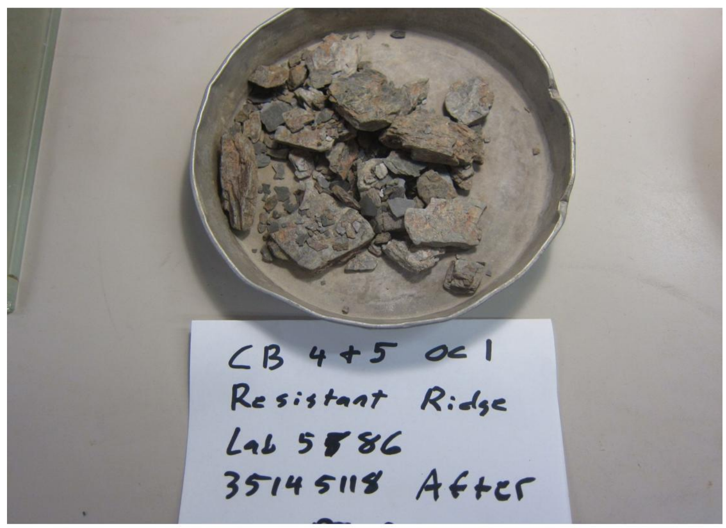
TERRACON

Client:	Buchart-Horn Inc.	Date:	9/7/2016
Project:	CA0607 Hwy 270 Widening	W.O.#	35145118.000
Location:			

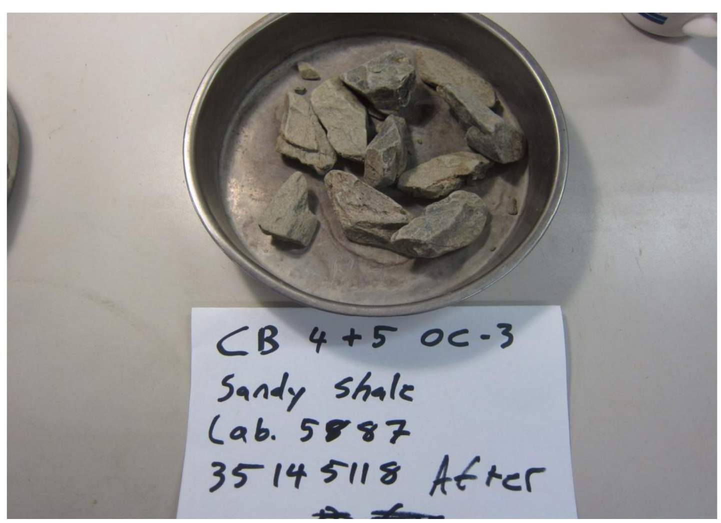
Boring No.			CB-4&5,OC-1(5885)
Depth (ft)			Shale-Exposed
Tare Weight:			151.1
Moist weight (Sample+Tare):			758.6
Dry weight (Sample+Tare):			736.3
Natural Moisture Content (%):			3.8
After Cycle No. 1			
Temperature (°F)			Dry Weight
Start	End	Average	(Sample+Tare)
		0	725.6
After Cycle No. 2			
Temperature (°F)			Dry Weight
Start	End	Average	(Sample+Tare)
		0	719.0
SLAKE DURABILITY INDEX:			**99.1**
Fragments Retained - Type:			2



Boring No.			CB-4&5,OC-1(5886)
Depth (ft)			Shale-resistant ridge
Tare Weight:			77.6
Moist weight (Sample+Tare):			521.9
Dry weight (Sample+Tare):			505.5
Natural Moisture Content (%):			3.8
After Cycle No. 1			
Temperature (°F)			Dry Weight
Start	End	Average	(Sample+Tare)
		0	484.5
After Cycle No. 2			
Temperature (°F)			Dry Weight
Start	End	Average	(Sample+Tare)
			472.0
SLAKE DURABILITY INDEX:			**97.4**
Fragments Retained - Type:			2



Boring No.			CB-4&5,OC-3 (5887)
Depth (ft)			Shaley sandstone
Tare Weight:			165.1
Moist weight (Sample+Tare):			654.7
Dry weight (Sample+Tare):			644.8
Natural Moisture Content (%):			2.1
After Cycle No. 1			
Temperature (°F)			Dry Weight
Start	End	Average	(Sample+Tare)
		0	636.5
After Cycle No. 2			
Temperature (°F)			Dry Weight
Start	End	Average	(Sample+Tare)
			631.9
SLAKE DURABILITY INDEX:			**99.3**
Fragments Retained - Type:			1

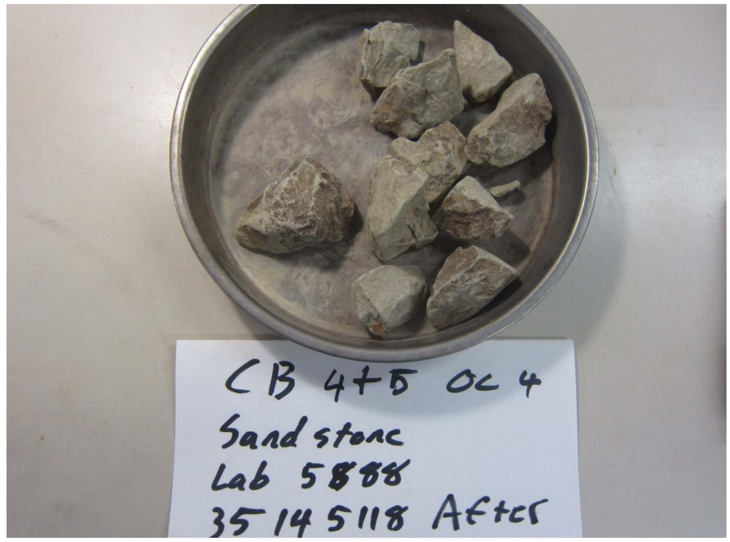


SLAKE DURABILITY TEST SUMMARY

TERRACON

Client:	Buchart-Horn Inc.	Date:	9/7/2016
Project:	CA0607 Hwy 270 Widening	W.O.#	35145118.000
Location:			

Boring No.			CB-4&5,OC-4(5888)
Depth (ft)			Sandstone
Tare Weight:			162.3
Moist weight (Sample+Tare):			712.2
Dry weight (Sample+Tare):			709.3
Natural Moisture Content (%):			0.5
After Cycle No. 1			
Temperature (°F)			Dry Weight
Start	End	Average	(Sample+Tare)
		0	703.0
After Cycle No. 2			
Temperature (°F)			Dry Weight
Start	End	Average	(Sample+Tare)
		0	699.8
SLAKE DURABILITY INDEX:			**99.5**
Fragments Retained - Type:			1



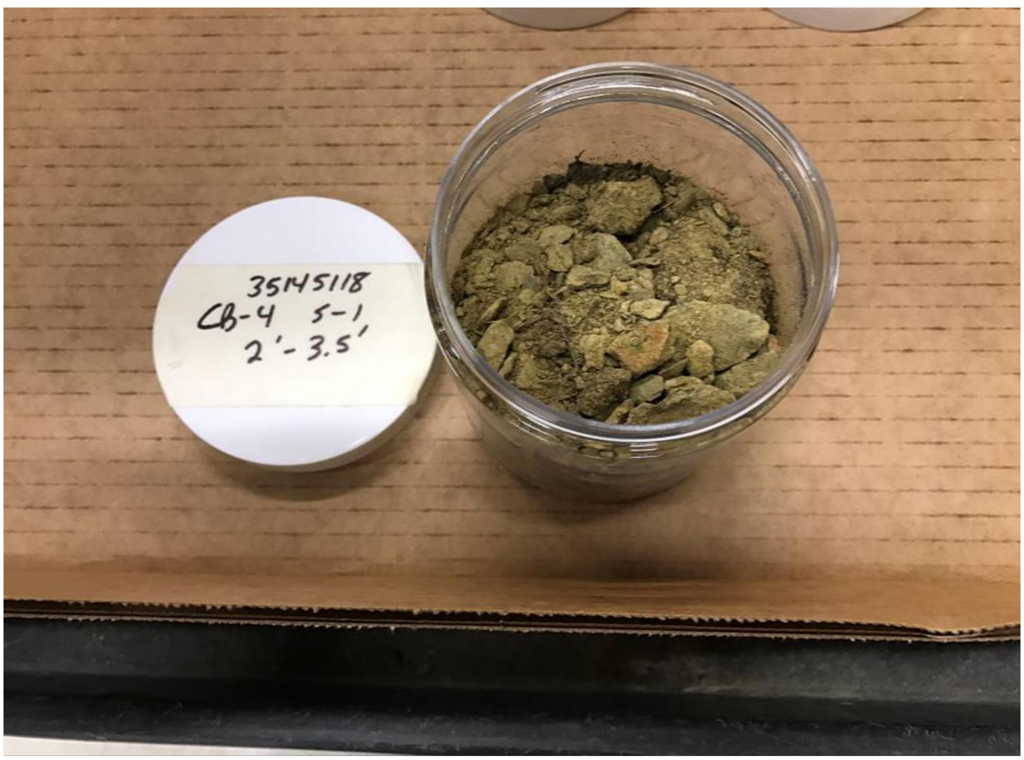
Boring No.			CB-4&5,OC-2(5889)
Depth (ft)			Shale-Fresh Exposed
Tare Weight:			148.7
Moist weight (Sample+Tare):			806.6
Dry weight (Sample+Tare):			764.6
Natural Moisture Content (%):			6.8
After Cycle No. 1			
Temperature (°F)			Dry Weight
Start	End	Average	(Sample+Tare)
		0	738.2
After Cycle No. 2			
Temperature (°F)			Dry Weight
Start	End	Average	(Sample+Tare)
			723.1
SLAKE DURABILITY INDEX:			**98.0**
Fragments Retained - Type:			2

Boring No.			
Depth (ft)			
Tare Weight:			
Moist weight (Sample+Tare):			
Dry weight (Sample+Tare):			
Natural Moisture Content (%):			
After Cycle No. 1			
Temperature (°F)			Dry Weight
Start	End	Average	(Sample+Tare)
		0	
After Cycle No. 2			
Temperature (°F)			Dry Weight
Start	End	Average	(Sample+Tare)
SLAKE DURABILITY INDEX:			
Fragments Retained - Type:			1

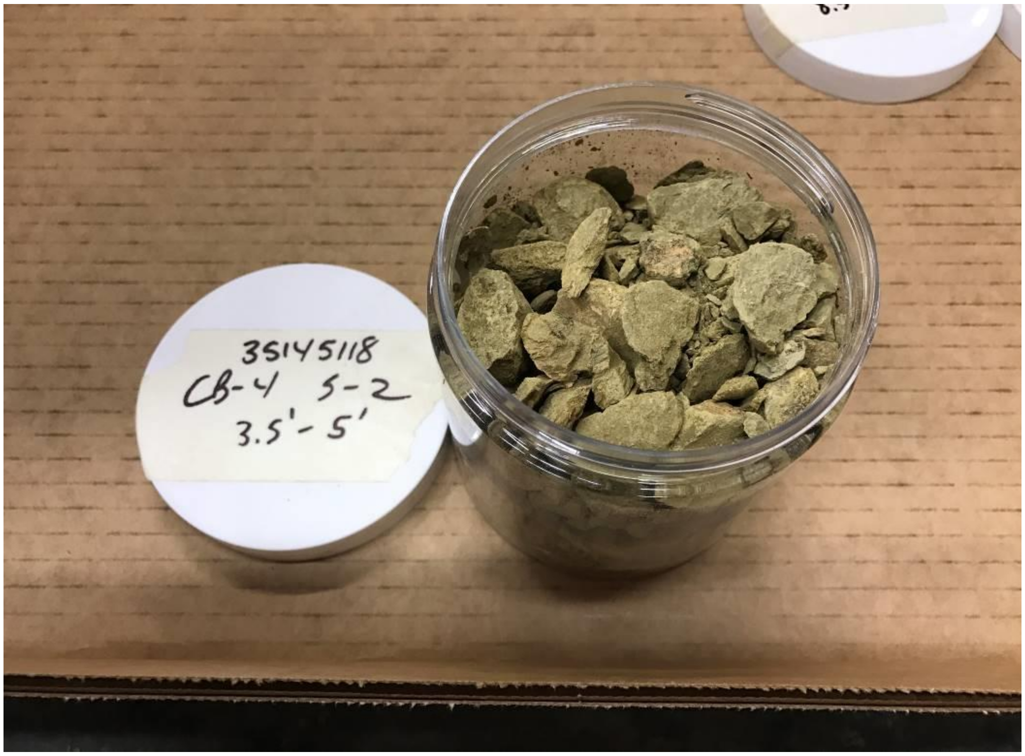
APPENDIX C

PHOTOGRAPHIC LOG

Boring CB-4, Samples 1 through 5



Boring CB-4, Sample 1, 2' to 3.5'



Boring CB-4, Sample 2, 3.5' to 5'

Boring CB-4, Sample 3, 8.5' to 10'

Boring CB-4, Sample 4, 13.5' to 15'

Boring CB-4, Sample 5, 18.5' to 20'

Boring CB-4, Run 1, 2, & 3, 20' to 31'

Boring CB-4, Run 3 cont., 4, & 5, 31' to 40'

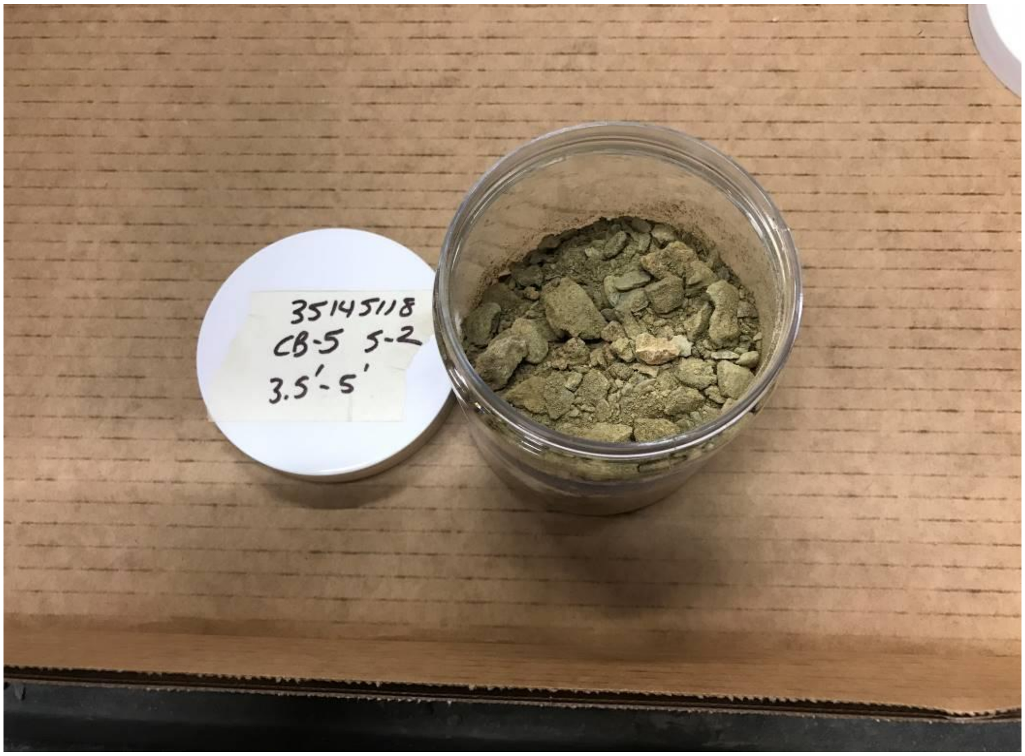
Boring CB-4, Run 5 cont. & 6, 40' to 47'

Boring CB-4A, Sample 1, 45' to 46.5'

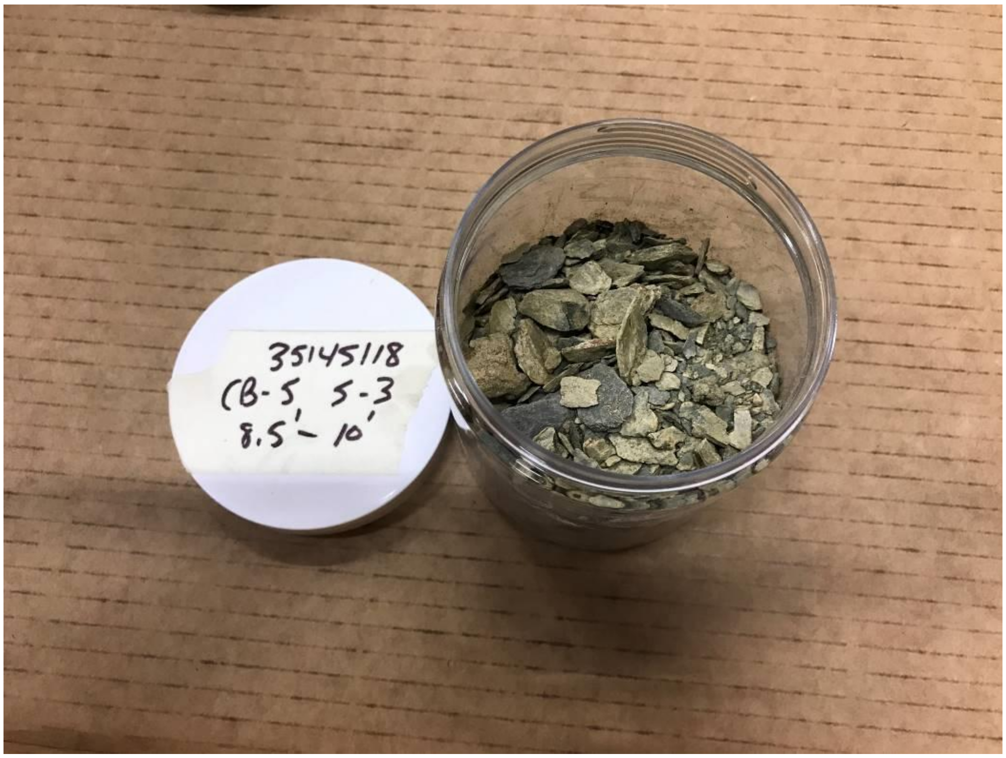
Boring CB-4A, Run 1, 2, & 3, 50' to 60'

Boring CB-5, Samples 1 through 4

CB-5, Sample 1, 2' to 3.5'



CB-5, Sample 2, 3.5' to 5'



CB-5, Sample 3, 8.5' to 10'

CB-5, Sample 4, 13.5' to 15'

CB-5, Run 1, 2, & 3, 15' to 25'

CB-5, Run 3 cont., 4, & 5, 27' to 34'

CB-5, Run 5 cont. & 6, 34' to 42'

CB-5, Run 7 & 8, 42' to 52'

CB-5A, Run 1 & 2, 22' to 32'

CB-5A, Run 3, Sample 4, & Run 5, 32' to 43.8'

CB-5A, Run 6 & 7, 43.8' to 53.8'

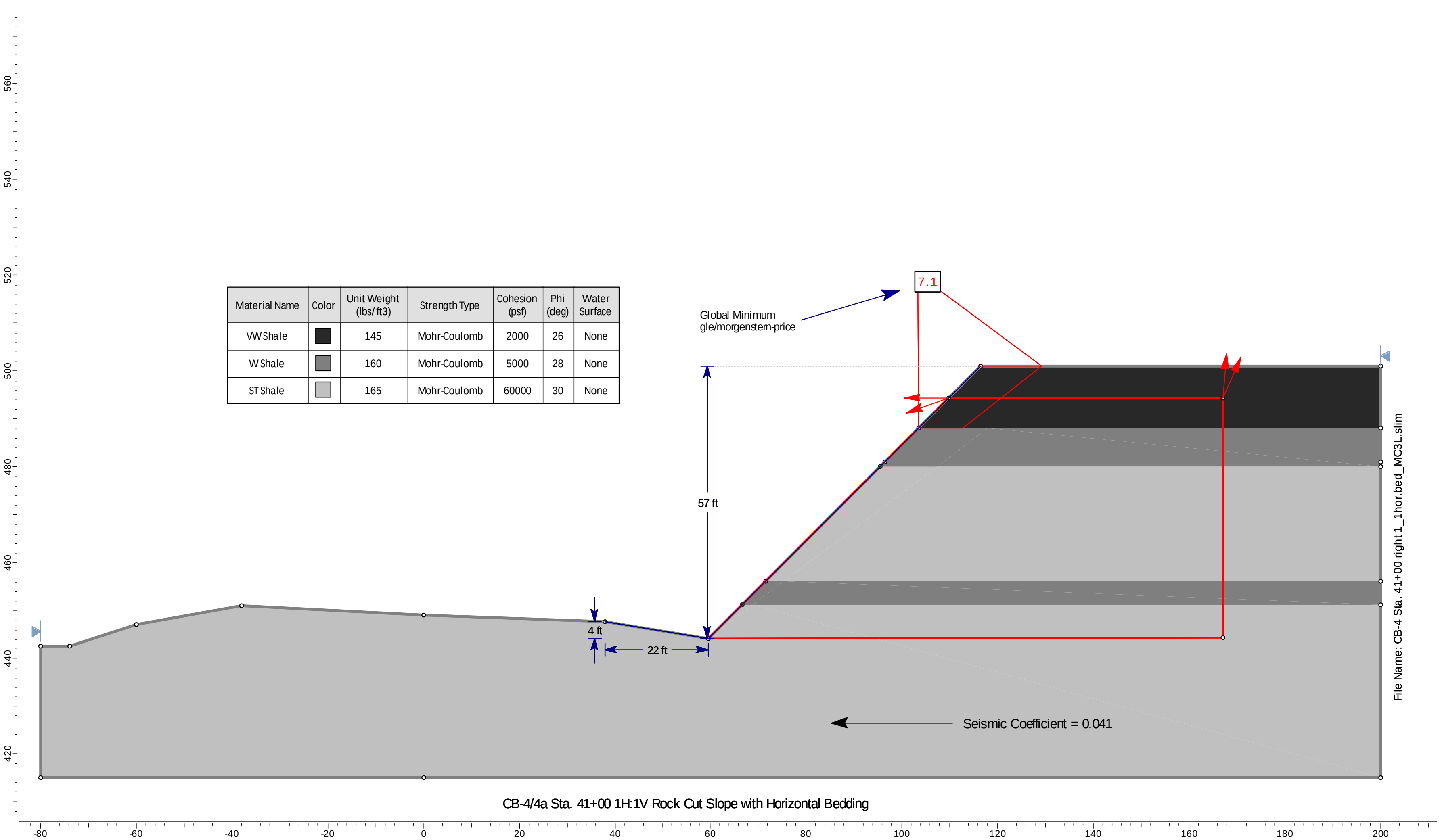
CB-5A, Run 8, 53.8' to 58.8'

APPENDIX D

ROCK CUT SLOPE STABILITY ANALYSIS

Proposed Rock Cut Station 41+00

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface
VW Shale		145	Mohr-Coulomb	2000	26	None
W Shale		160	Mohr-Coulomb	5000	28	None
ST Shale		165	Mohr-Coulomb	60000	30	None

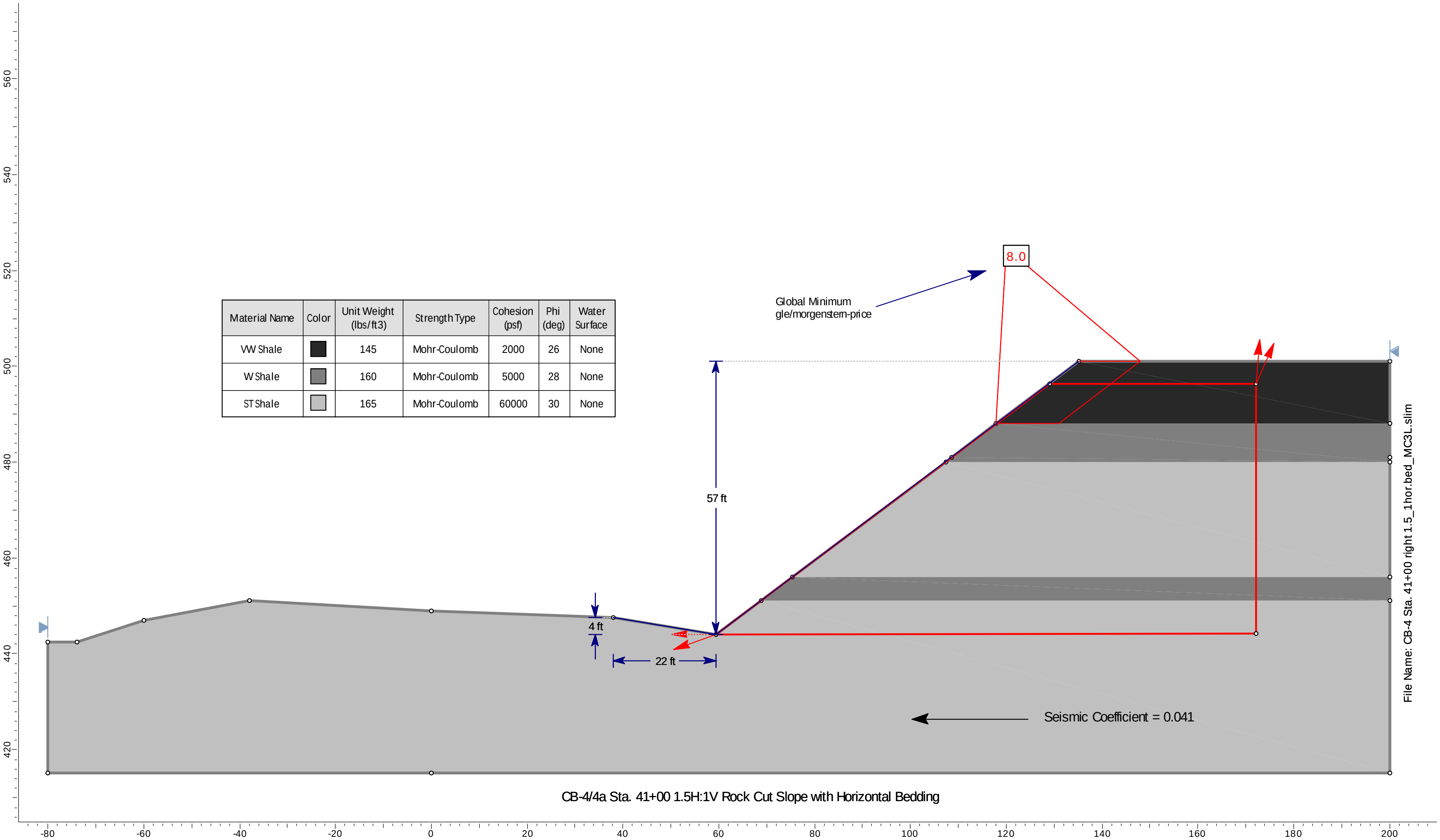


CB-4/4a Sta. 41+00 1H:1V Rock Cut Slope with Horizontal Bedding

STATION 41+00 STABILITY ANALYSIS
CA0607 Hwy 270 Widening
Garland County, Arkansas

Drawn by: DAF	Terracon	Terracon Project No. 35145118
Designed by: DAF	25809 I-30 South Bryant, Arkansas 72022	FN:CB-4 Sta. 41+00 right1_1hor.bed_MC3L.slim
Scale: Shown		Date:10/07/2016

Exhibit D-2



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface
VW Shale		145	Mohr-Coulomb	2000	26	None
W Shale		160	Mohr-Coulomb	5000	28	None
ST Shale		165	Mohr-Coulomb	60000	30	None

CB-4/4a Sta. 41+00 1.5H:1V Rock Cut Slope with Horizontal Bedding

STATION 41+00 STABILITY ANALYSIS
CA0607 Hwy 270 Widening
Garland County, Arkansas

Drawn by: DAF

Designed by: DAF

Scale: Shown

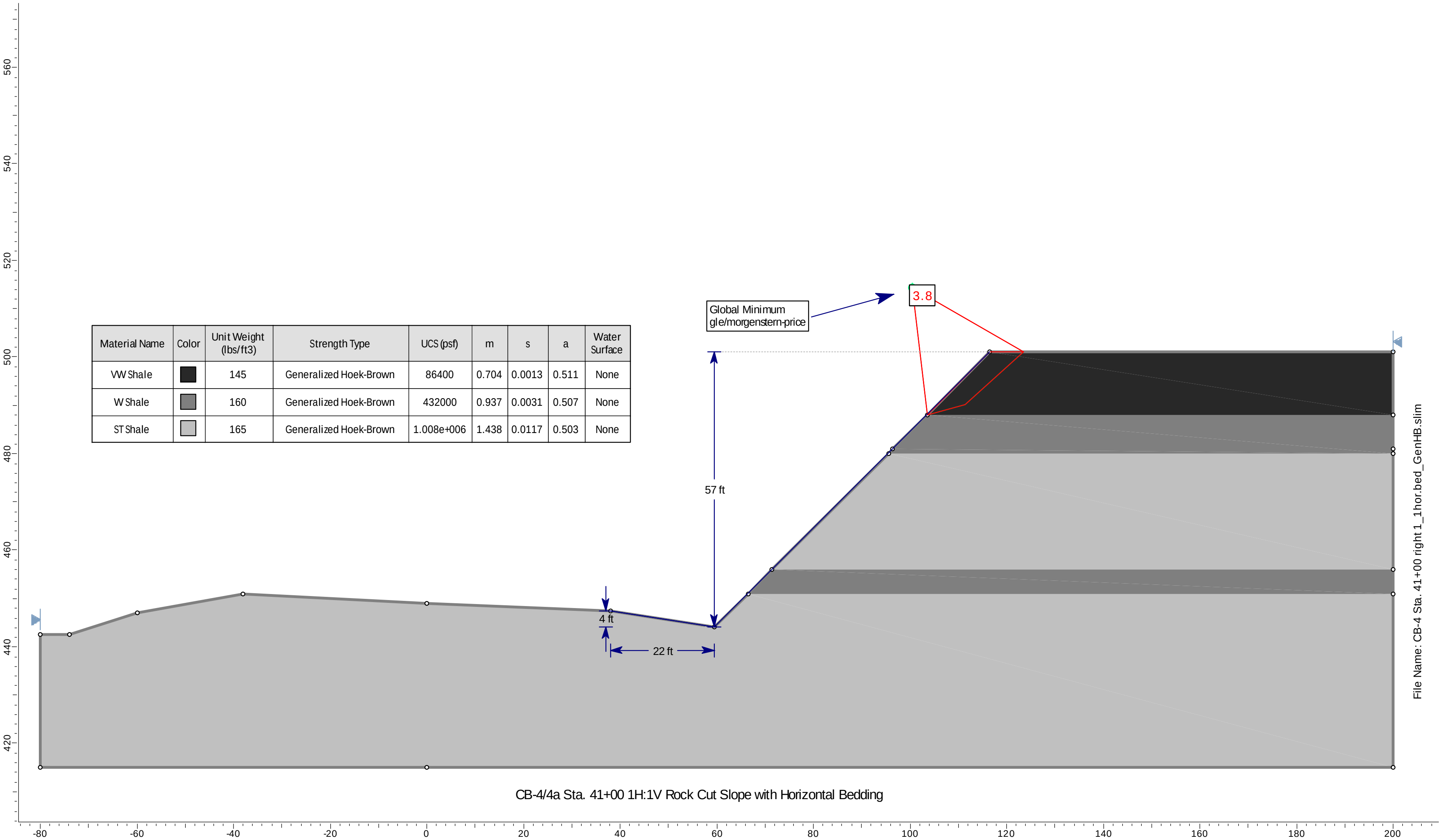
Terracon
25809 I-30 South
Bryant, Arkansas 72022

Terracon Project No. 35145118

FN:CB-4 Sta. 41+00 right1.5_1hor.bed_MC3L.slim

Date:10/07/2016

Exhibit D-3



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	UCS (psf)	m	s	a	Water Surface
VW Shale		145	Generalized Hoek-Brown	86400	0.704	0.0013	0.511	None
W Shale		160	Generalized Hoek-Brown	432000	0.937	0.0031	0.507	None
ST Shale		165	Generalized Hoek-Brown	1.008e+006	1.438	0.0117	0.503	None

CB-4/4a Sta. 41+00 1H:1V Rock Cut Slope with Horizontal Bedding

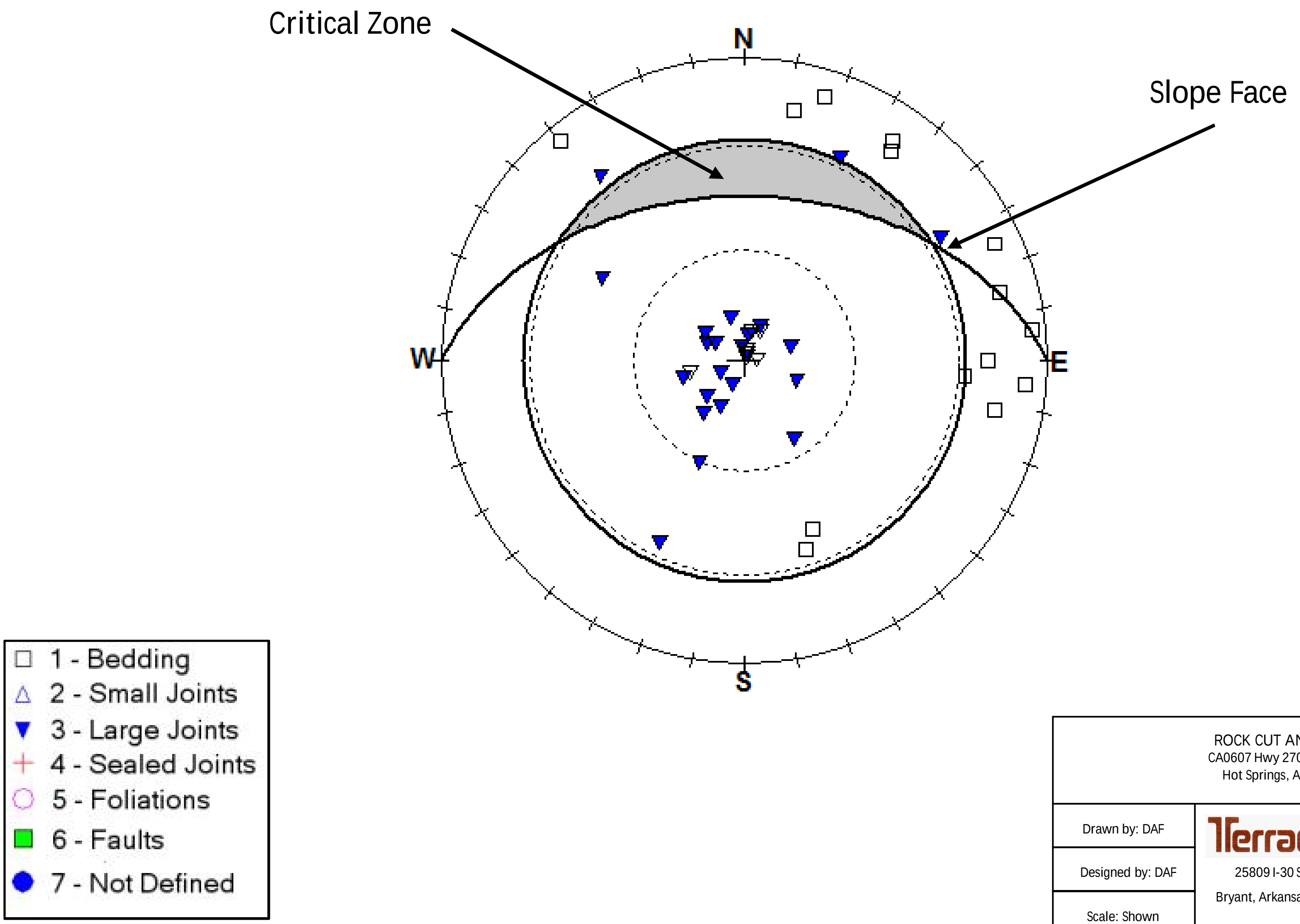
STATION 41+00 STABILITY ANALYSIS
CA0607 Hwy 270 Widening
Garland County, Arkansas

Drawn by: DAF	Terracon	Terracon Project No. 35145118
Designed by: DAF	25809 I-30 South Bryant, Arkansas 72022	FN:CB-4 Sta. 41+00 right1_1hor.bed_GenHB.slim
Scale: Shown		Date:10/07/2016

Exhibit D-3

Marklands Test Stereonet

CB_4,5: Cut dip direction 0 degrees, Cut dip 45 degrees (1:1)



ROCK CUT ANALYSIS
CA0607 Hwy 270 Widening
Hot Springs, Arkansas

Drawn by: DAF	Terracon	Terracon Project No. 35145118
Designed by: DAF	25809 I-30 South Bryant, Arkansas 72022	FN: CB_4,5_DDR_0_1to1.pptx
Scale: Shown		Date:09/20/2016

Exhibit D-4

APPENDIX E

SUPPORTING DOCUMENTS

EXPLANATION OF BORING LOG INFORMATION

DESCRIPTION OF SYMBOLS AND ABBREVIATIONS

SAMPLING

Auger	Split Spoon
Shelby Tube	Macro Core
Ring Sampler	Rock Core
Grab Sample	No Recovery

WATER LEVEL

- **Water Initially Encountered**
- **Water Level After a Specified Period of Time**
- **Water Level After a Specified Period of Time**

Water levels indicated on the soil boring logs are the levels measured in the borehole at the times indicated. Groundwater level variations will occur over time. In low permeability soils, accurate determination of groundwater levels is not possible with short term water level observations.

FIELD TESTS

(HP)	**Hand Penetrometer**
(T)	**Torvane**
(b/f)	**Standard Penetration Test (blows per foot)**
(PID)	**Photo-Ionization Detector**
(OVA)	**Organic Vapor Analyzer**

DESCRIPTIVE SOIL CLASSIFICATION

Soil classification is based on the Unified Soil Classification System. Coarse Grained Soils have more than 50% of their dry weight retained on a #200 sieve; their principal descriptors are: boulders, cobbles, gravel or sand. Fine Grained Soils have less than 50% of their dry weight retained on a #200 sieve; they are principally described as clays if they are plastic, and silts if they are slightly plastic or non-plastic. Major constituents may be added as modifiers and minor constituents may be added according to the relative proportions based on grain size. In addition to gradation, coarse-grained soils are defined on the basis of their in-place relative density and fine-grained soils on the basis of their consistency.

LOCATION AND ELEVATION NOTES

Unless otherwise noted, Latitude and Longitude are approximately determined using a hand-held GPS device. The accuracy of such devices is variable. Surface elevation data annotated with +/- indicates that no actual topographical survey was conducted to confirm the surface elevation. Instead, the surface elevation was approximately determined from topographic maps of the area.

STRENGTH TERMS

RELATIVE DENSITY OF COARSE-GRAINED SOILS (More than 50% retained on No. 200 sieve.) Density determined by Standard Penetration Resistance Includes gravels, sands and silts.			**CONSISTENCY OF FINE-GRAINED SOILS** (50% or more passing the No. 200 sieve.) Consistency determined by laboratory shear strength testing, field visual-manual procedures or standard penetration resistance			
Descriptive Term (Density)	**Standard Penetration or N-Value Blows/Ft.**	**Ring Sampler Blows/Ft.**	**Descriptive Term (Consistency)**	**Unconfined Compressive Strength, Qu, psf**	**Standard Penetration or N-Value Blows/Ft.**	**Ring Sampler Blows/Ft.**
Very Loose	0 - 3	0 - 6	Very Soft	less than 500	0 - 1	< 3
Loose	4 - 9	7 - 18	Soft	500 to 1,000	2 - 4	3 - 4
Medium Dense	10 - 29	19 - 58	Medium-Stiff	1,000 to 2,000	4 - 8	5 - 9
Dense	30 - 50	59 - 98	Stiff	2,000 to 4,000	8 - 15	10 - 18
Very Dense	> 50	≥ 99	Very Stiff	4,000 to 8,000	15 - 30	19 - 42
			Hard	> 8,000	> 30	> 42

RELATIVE PROPORTIONS OF SAND AND GRAVEL

Descriptive Term(s) of other constituents	Percent of Dry Weight
Trace	< 15
With	15 - 29
Modifier	> 30

GRAIN SIZE TERMINOLOGY

Major Component of Sample	Particle Size
Boulders	Over 12 in. (300 mm)
Cobbles	12 in. to 3 in. (300mm to 75mm)
Gravel	3 in. to #4 sieve (75mm to 4.75 mm)
Sand	#4 to #200 sieve (4.75mm to 0.075mm
Silt or Clay	Passing #200 sieve (0.075mm)

RELATIVE PROPORTIONS OF FINES

Descriptive Term(s) of other constituents	Percent of Dry Weight
Trace	< 5
With	5 - 12
Modifier	> 12

PLASTICITY DESCRIPTION

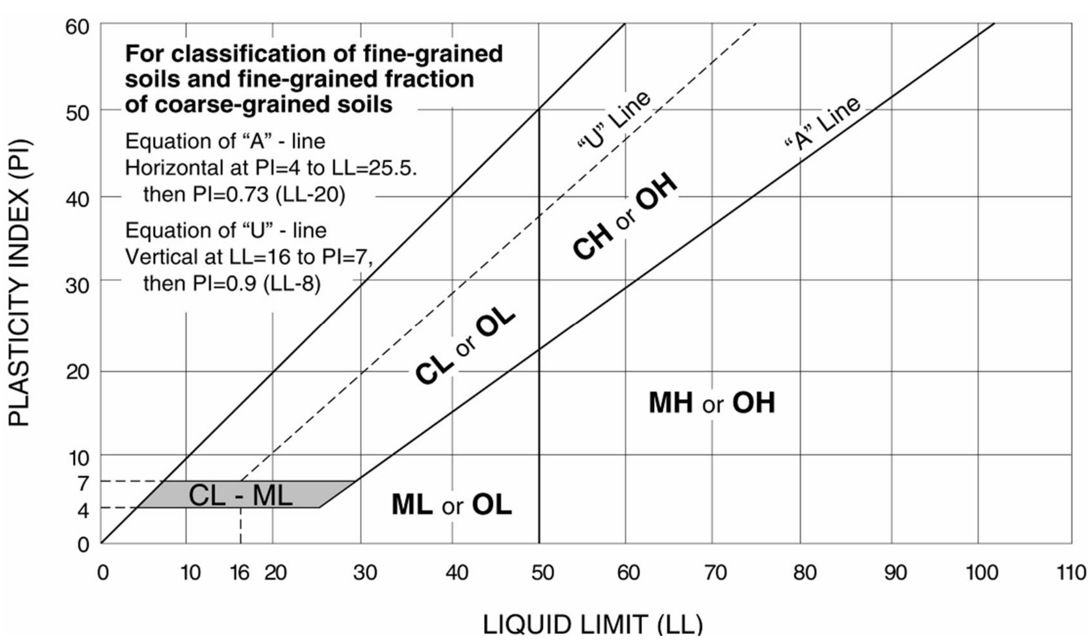
Term	Plasticity Index
Non-plastic	0
Low	1 - 10
Medium	11 - 30
High	> 30

Terracon

UNIFIED SOIL CLASSIFICATION SYSTEM

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests [A]				Soil Classification: Group Symbol	Soil Classification: Group Name [B]
Coarse Grained Soils: More than 50% retained on No. 200 sieve	**Gravels:** More than 50% of coarse fraction retained on No. 4 sieve	**Clean Gravels:** Less than 5% fines [C]	$Cu \geq 4$ and $1 \leq Cc \leq 3$ [E]	GW	Well-graded gravel [F]
			$Cu < 4$ and/or $1 > Cc > 3$ [E]	GP	Poorly graded gravel [F]
		Gravels with Fines: More than 12% fines [C]	Fines classify as ML or MH	GM	Silty gravel [F,G,H]
			Fines classify as CL or CH	GC	Clayey gravel [F,G,H]
	Sands: 50% or more of coarse fraction passes No. 4 sieve	**Clean Sands:** Less than 5% fines [D]	$Cu \geq 6$ and $1 \leq Cc \leq 3$ [E]	SW	Well-graded sand [I]
			$Cu < 6$ and/or $1 > Cc > 3$ [E]	SP	Poorly graded sand [I]
		Sands with Fines: More than 12% fines [D]	Fines classify as ML or MH	SM	Silty sand [G,H,I]
			Fines classify as CL or CH	SC	Clayey sand [G,H,I]
Fine-Grained Soils: 50% or more passes the No. 200 sieve	**Silts and Clays:** Liquid limit less than 50	**Inorganic:**	PI > 7 and plots on or above "A" line [J]	CL	Lean clay [K,L,M]
			PI < 4 or plots below "A" line [J]	ML	Silt [K,L,M]
		Organic:	$\frac{\text{Liquid limit - oven dried}}{\text{Liquid limit - not dried}} < 0.75$	OL	Organic clay [K,L,M,N]
					Organic silt [K,L,M,O]
	Silts and Clays: Liquid limit 50 or more	**Inorganic:**	PI plots on or above "A" line	CH	Fat clay [K,L,M]
			PI plots below "A" line	MH	Elastic Silt [K,L,M]
		Organic:	$\frac{\text{Liquid limit - oven dried}}{\text{Liquid limit - not dried}} < 0.75$	OH	Organic clay [K,L,M,P]
					Organic silt [K,L,M,Q]
Highly organic soils:	Primarily organic matter, dark in color, and organic odor			PT	Peat

[A] Based on the material passing the 3-inch (75-mm) sieve
[B] If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.
[C] Gravels with 5 to 12% fines require dual symbols: GW-GM well-graded gravel with silt, GW-GC well-graded gravel with clay, GP-GM poorly graded gravel with silt, GP-GC poorly graded gravel with clay.
[D] Sands with 5 to 12% fines require dual symbols: SW-SM well-graded sand with silt, SW-SC well-graded sand with clay, SP-SM poorly graded sand with silt, SP-SC poorly graded sand with clay
[E] $Cu = D_{60}/D_{10}$ $\quad Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}}$
[F] If soil contains ≥ 15% sand, add "with sand" to group name.
[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.
[H] If fines are organic, add "with organic fines" to group name.
[I] If soil contains ≥ 15% gravel, add "with gravel" to group name.
[J] If Atterberg limits plot in shaded area, soil is a CL-ML, silty clay.
[K] If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel," whichever is predominant.
[L] If soil contains ≥ 30% plus No. 200 predominantly sand, add "sandy" to group name.
[M] If soil contains ≥ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.
[N] PI ≥ 4 and plots on or above "A" line.
[O] PI < 4 or plots below "A" line.
[P] PI plots on or above "A" line.
[Q] PI plots below "A" line.



GENERAL NOTES

Sedimentary Rock Classification

DESCRIPTIVE ROCK CLASSIFICATION:

Sedimentary rocks are composed of cemented clay, silt and sand sized particles. The most common minerals are clay, quartz and calcite. Rock composed primarily of calcite is called limestone; rock of sand size grains is called sandstone, and rock of clay and silt size grains is called mudstone or claystone, siltstone, or shale. Modifiers such as shaly, sandy, dolomitic, calcareous, carbonaceous, etc. are used to describe various constituents. Examples: sandy shale; calcareous sandstone.

LIMESTONE	Light to dark colored, crystalline to fine-grained texture, composed of $CaCo_3$, reacts readily with HCl.
DOLOMITE	Light to dark colored, crystalline to fine-grained texture, composed of $CaMg(CO_3)_2$, harder than limestone, reacts with HCl when powdered.
CHERT	Light to dark colored, very fine-grained texture, composed of micro-crystalline quartz ($Si0_2$), brittle, breaks into angular fragments, will scratch glass.
SHALE	Very fine-grained texture, composed of consolidated silt or clay, bedded in thin layers. The unlaminated equivalent is frequently referred to as siltstone, claystone or mudstone.
SANDSTONE	Usually light colored, coarse to fine texture, composed of cemented sand size grains of quartz, feldspar, etc. Cement usually is silica but may be such minerals as calcite, iron-oxide, or some other carbonate.
CONGLOMERATE	Rounded rock fragments of variable mineralogy varying in size from near sand to boulder size but usually pebble to cobble size (½ inch to 6 inches). Cemented together with various cementing agents. Breccia is similar but composed of angular, fractured rock particles cemented together.

PHYSICAL PROPERTIES:

DEGREE OF WEATHERING

Slight	Slight decomposition of parent material on joints. May be color change.
Moderate	Some decomposition and color change throughout.
High	Rock highly decomposed, may be extremely broken.

HARDNESS AND DEGREE OF CEMENTATION

Limestone and Dolomite:

Hard	Difficult to scratch with knife.
Moderately Hard	Can be scratched easily with knife, cannot be scratched with fingernail.
Soft	Can be scratched with fingernail.

Shale, Siltstone and Claystone

Hard	Can be scratched easily with knife, cannot be scratched with fingernail.
Moderately Hard	Can be scratched with fingernail.
Soft	Can be easily dented but not molded with fingers.

Sandstone and Conglomerate

Well Cemented	Capable of scratching a knife blade.
Cemented	Can be scratched with knife.
Poorly Cemented	Can be broken apart easily with fingers.

BEDDING AND JOINT CHARACTERISTICS

Bed Thickness	Joint Spacing	Dimensions
Very Thick	Very Wide	>10′
Thick	Wide	3′ - 10′
Medium	Moderately Close	1′ - 3′
Thin	Close	2″ - 1′
Very Thin	Very Close	.4″ - 2″
Laminated	—	.1″ - .4″

Bedding Plane	A plane dividing sedimentary rocks of the same or different lithology.
Joint	Fracture in rock, generally more or less vertical or transverse to bedding, along which no appreciable movement has occurred.
Seam	Generally applies to bedding plane with an unspecified degree of weathering.

SOLUTION AND VOID CONDITIONS

Solid	Contains no voids.
Vuggy (Pitted)	Rock having small solution pits or cavities up to ½ inch diameter, frequently with a mineral lining.
Porous	Containing numerous voids, pores, or other openings, which may or may not interconnect.
Cavernous	Containing cavities or caverns, sometimes quite large.

Exhibit E-3

Terracon