

Geotechnical Data Report
Colorado Springs Southwestern Region
Engineering Geology Study

Yeh Project No.: 217-130

April 18, 2019

Prepared for:

City of Colorado Springs
Attn: Tyra Sandy, P.E.
30 S. Nevada Avenue, Suite 401
Colorado Springs, CO 80901

Prepared by:

Yeh and Associates, Inc.
627 Elkton Dr.
Colorado Springs, CO 80907

Phone: 719-434-1643
Fax: 303-781-9583

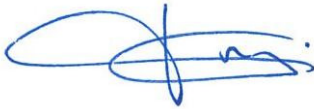
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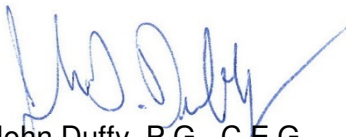


Hai Ming Lim, P.E.
Project Manager



Richard D. Andrew, P.G.
Vice president

Reviewed by:



John Duffy, P.G., C.E.G.
Senior Project Specialist

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1. PURPOSE AND SCOPE OF STUDY

The purpose of the Colorado Springs Southwestern Region Engineering Geology study is to compile available data pertaining to existing geotechnical reports, geologic mapping, terrain data, LiDAR data, satellite data, aerial photography, and existing infrastructure into a searchable and scalable digital database. Based on an evaluation of the existing data, a field and subsurface investigation plan was developed which included the installation of groundwater and slope movement monitoring instrumentation. The information contained in the digital data base and monitoring program is intended to be referenced by engineering professionals for the evaluation of future development and the existing facilities. The study was conducted with oversight by the City of Colorado Springs (COS) and Colorado Springs Utilities (CSU) and the guidance and support of the Colorado Geological Survey (CGS). No comparative or interpretive analysis of the information developed for the study presented herein and, in the database, has been made by the delivery team.

This report presents a summary of the data collected, reviewed, and organized in the database developed by Yeh and Associates (Yeh) for the Engineering Geology Study in two areas in the southwestern portion of Colorado Springs along the base of Cheyenne Mountain. Due to the complex geology, poor quality bedrock, topography, existing slope failures, ground water conditions, and site grading, this region has experienced numerous landslides events. Existing landslides range from large, prehistoric to historical, complex nested landslides to recent shallow landslides of various types.

The study areas recently experienced episodes of heavy precipitation (e.g. 1999, 2004, 2013, 2015), leading to the reactivation of existing slides and the development of new landslides. Extended periods of heavy precipitation coupled with late winter/early spring snowmelt (natural seasonal fluctuation) are known to elevate the groundwater system and increase the potential for slope instability.

Multiple geotechnical studies have been performed over the years to evaluate the possible causes of the ground movement. These studies led to the installation of various engineering measures designed to mitigate the ground movement. Several publications and mapping studies, such as the web-based Colorado Landslide Inventory Map maintained by the Colorado Geological Survey and the 2003 Colorado Springs Landslide Susceptibility Map (Published by White and Wait), were completed for the subject areas. These publications generally describe the locations and extents of landslides in the area based on field observations and the interpretation of aerial photographs. In addition, numerous geotechnical investigation reports



were prepared for the development of residential and commercial buildings and their related infrastructure. These reports provide a source for some of the pertinent engineering characteristics of the subsurface materials. All of these sources of information that have been generated over the years contain useful data which can be used to evaluate the subsurface conditions in planned developments and individual building sites. The City's goal is to make the existing data more readily available. This engineering geology study presents this information in a comprehensive geographical information system (GIS) geodatabase. ArcGIS was the platform selected to compile and present the database because of the intuitive mapping and analytical tools, and its compatibility with the GIS system currently used by COS and CSU. The GIS database (geodatabase) can be queried for existing test hole information, geotechnical reports, the classification and locations of the existing landslides, landslide features and geologic conditions within the study area.

The engineering geology study was divided into 3 tasks as summarized below:

Task 1- Existing data compilation and initial catalog of landslide hazards;

Task 2- Field reconnaissance;

Task 3- Geotechnical investigation, data report and installation of monitoring equipment.

A discussion of the services performed in each task and summary of the results and findings are presented in the following sections of this report.

2. AREAS OF STUDY

Two separate areas, located in the southwest portion of Colorado Springs, were included in this study and identified as Area 1 and Area 2. These two subject areas are presented together on Figure A-1, Site Location Plan, and individually on Figures A-3 and A-4 in Appendix A. Area 1 is located in southern portion of the study region, and Area 2 is in the northern portion of the study region. In general, Area 1 is bounded to the south by Cheyenne Mountain State Park, to the west by Cheyenne Mountain and Cheyenne Mountain Air Force Station, to the north by the Broadmoor Golf course, and to the east by Highway 115. In general, Area 2 is bounded to the south by Stratton Open Space, to the west by Cheyenne Mountain and Gold Camp Road, to the north by Bear Creek Park, and to the east by South 8th Street.

3. GEOLOGICAL SETTING AND SITE CONDITIONS

Several geologic maps, site-specific mapping performed by various engineering firms, and landslide susceptibility maps were utilized as the base geology information in the GIS



geodatabase. The definitions and descriptions of the geologic setting were based primarily on two sources: “Geologic map of the Colorado Springs Quadrangle, El Paso County, Colorado” by Christopher J. Carroll and Timothy A. Crawford in Year 2000, and the “Geologic map of the Cheyenne Mountain Quadrangle, El Paso County, Colorado” by Peter D. Rowley, John W. Himmelreich, Jr., Donald H. Kupfer, and Christine S. Siddoway in Year 2003. The geologic units within the study areas are presented in Figure A-2, Geologic Unit Map in Appendix A.

Based on these maps, the major geologic units in Area 1 are as follows:

- Bedrock Units: Pikes Peak granite (Ypp) and Granodiorite (Xgd) near the base of Cheyenne Mountain, and Pierre Shale (Kp) within the eastern portion of Area 1, below the colluvial and alluvial deposits units.
- Colluvial deposits: Colluvium (Qc), Landslide deposits (Qls and Qlsr) along the eastern portion, and portion of the northern section of Area 1.
- Alluvial deposits: Sheetwash (Qsw) are primarily located along the northern section and the eastern portion of Area 1. Pediment gravel 2 (Qg2) is located near the mid-section of Area 1.
- Alluvial fan deposits: Older fan deposits (Qfo, Qfo1, Qfo2, Qfy), older fan and rockfall deposits (Qfro) are located mostly on the western portion, and southern portion of Area 1. All of These units are located between Cheyenne Mountain and the colluvial and alluvial deposits.

Based on these maps, the major geologic units in Area 2 include the following:

- Bedrock Units: Pierre Shale (Kp) on the eastern portion of Area 2, and below the colluvial and alluvial deposit units.
- Colluvial deposits: Colluvium (Qc) located in the northwest portion of the Area 2.
- Alluvial deposits: Pediment gravel (Qg1, Qg2, Qg3) located near the mid-section and eastern portion of the Area 2, and Sheetwash deposits (Qsw) located on the eastern portion of Area 2.
- Alluvial fan deposits: Older fan deposits (Qfo) located at the western part of Area 2.

The Ute Pass Fault trends in a south to north direction and is located near the base of Cheyenne Mountain, west of the two study areas. In general, both Areas 1 and 2 are sloping to the east. Area 1 represents the majority of the lower elevations located in the northern and

southern sections. The mid-section of Area 1 is generally higher in elevation. Area 2, in general, slopes towards the southeast.

4. PROJECT TASKS

As mentioned above, the services provided for this project have been divided into three tasks. The details of each task are discussed below.

4.1 Task 1

Task 1 included collecting the existing available data, reviewing it for usefulness and accuracy, categorizing the data, and an initial cataloging of the data within a GIS geodatabase. The sources of the data included COS, CSU, CGS, United States Geological Survey (USGS), Pikes Peak Regional Building Department (PPRBD), public publications, and other various geological maps. The data collected, reviewed, cataloged and included in the GIS geodatabase is summarized in Table 1.

Table 1. Summary of Database Sources

Source	Data	Notes
City of Colorado Springs	Study area boundaries	
	City limits	
	Open drainage	
	Land use	Open space, residential areas, commercial areas, etc.
	Parcels	
	Storm inlets	
	Storm basins	
	Storm sewer lines	
	Storm manholes	
	Storm outlets	
	Aerial photos	Year 1998,1999, 2005, 2007, 2010, 2011, 2012, 2014 and 2016
	LiDAR Contours Maps	NAVD29, NAVD88
	LiDAR Hillshade Images	Shaded relief images created from contour maps
	Various geotechnical reports	Available reports and design for residential development and slope stabilization repair.
Colorado Geological Survey	Various geotechnical reports	Available reports reviewed by CGS for residential development

Source	Data	Notes
	DinSAR for Area 1	Ground movement monitoring using satellite images. Performed for Area 1 only.
	USGS Cheyenne Mountain 24k geology map	
	USGS Colorado Springs 24k geology map	
	USGS Manitou Springs 24k geology map	
	Steeply dipping bedrock	
	Recorded landslides	Includes landslide susceptibility map, slides recorded by consultants, slides interpreted from available data.

After collecting, reviewing and cataloging the data, the information was organized into discreet sortable fields, including the data from the various geotechnical reports. The data obtained from the geotechnical reports is summarized and presented in the following fields:

- Test borings and test pits performed by geotechnical engineering consultants with the data that was further organized by depth of boring and depth to bedrock;
- Groundwater monitoring wells (however, only a limited amount of information was available in many of the reports);
- Observed seeps and springs as described in the reports;
- Cross sections used for slope stability analysis performed by various consultants;
- Landslide fissures and other slope features as described in the reports;
- Mapped geologic setting as described in the reports.

The final GIS geodatabase includes a compilation of existing geotechnical reports, where the borehole locations were digitized and geo-referenced along with the surficial geology/soil maps included in this study. The borehole points can be queried in ArcGIS, a GIS program, or related map viewers for subsurface characteristics, provided that they are available in each of the specific geotechnical reports. Other boring point data in the Geotech Borings dataset does not presently have attributed subsurface data but both datasets are relationally linked to a pdf copy of the original geotechnical report embedded into the geodatabase.

4.2 Task 2

After the preliminary GIS geodatabase was constructed, the data was used to identify areas of interest that were prioritized for the field review in Task 2. The field review included mapping of the observed general geological features, landslide features, and the location of seeps. These features were located in the areas that were readily accessible to the field personnel. Satellite based ground movement monitoring was also performed from Year 2015 to 2018 using the “Synthetic Aperture Radar Interferometry Method” (InSAR- SqueeSAR™).

The field reconnaissance focused on the following areas of interest:

- Recent or ancient landslide features, e.g. headscarps or bulging toes of landslides.
- Previously recorded landslide areas.
- Land movement observed from LiDAR, InSAR or documented in the previous geotechnical studies.
- Potential landslide areas, e.g. steep slopes, soft clay formations, springs and seeps.
- Features that may indicate ground movement, e.g. large and long cracks in pavement, settlement on roadway.
- Field verification of existing mapped geology and soil units.
- “To be verified” areas identified during the data review process.

The field reconnaissance and site mapping were recorded with a portable handheld Global Positioning System (GPS) unit with an accuracy of approximately 10 feet. This unit interacted directly with the GIS base maps and database on a portable tablet providing real time field verification. The data was used to confirm the areas of interest and used to develop the scope for Task 3. Since the data was used for verification of the existing data only, they are not included in the GIS database.

Additionally, Yeh partnered with TRE Altamira (TRE) to perform the InSAR- SqueeSAR analysis to monitor the ground movement in both Areas 1 and 2, for the period beginning in November 2014 and ending in March 2018. The SqueeSAR analysis was performed using Sentinel satellite images. The analysis utilized a Rapid Motion Tracking (RMT) algorithm to process the satellite image and develop the relative vertical and east-west movements of the ground. For the purpose of this study, the relative vertical and east-west movements of the ground are calibrated to the NAD 1983 datum. The results of the SqueeSAR are presented electronically and incorporated into the GIS geodatabase.

4.3 Task 3

Task 3 included the geotechnical investigation, installation of monitoring equipment, preparation of the data report, and updates to the GIS geodatabase. After the completion of Tasks 1 and 2, the database was used to evaluate the locations of the geotechnical borings and monitoring instrumentation. The borings were identified based on the past and present recorded landslides, potential of reactivation or future landslides, benchmark for establishing the geological comparisons, and features that require further study including steep slopes, springs or seeps, and areas of potential future development where geotechnical investigation data is lacking. A total of 21 borings were identified, however, two borings were eliminated due to limited access.

4.3.1 Field Exploration Program and Instrumentations

The field exploration included sixteen (16) borings performed with a truck mounted drill rig. The drilling was completed initially with both CME-55 and CME-75 drilling rigs. The borings were advanced with 6 to 10 inches outside diameter hollow-stem auger through the pavement, native soil, and bedrock. The total depth of each of the borings is presented in Table 2.

Soil and bedrock samples were typically obtained at 5 feet intervals in the test borings. Samples were recovered using both Standard Penetration Test (SPT), Modified California barrels (MCal), and Shelby tube samplers. Additionally, a continuous dry core sampler was used to collect the material in between the sampling depth where applicable.

The SPT is a 1.375-inch inside diameter (ID) standard split barrel sampler. Recorded penetration resistance measurements (N-values) were obtained by driving a Standard Penetration Sampler into the subsurface materials with a 140-pound automatic hammer falling 30 inches. The Penetration Resistance (N-value) of a SPT is a useful index to the consistency and relative density or hardness of the materials encountered.

The Modified California Sampler is a 2.5-inch outside diameter (OD), 2.0 inch ID (1.95 inch ID with liners), split barrel sampler with internal liners, as per ASTM D3550. The Modified California Sampler drive length is 12 inches and "Penetration Resistance" refers to the sum of all blows.

The Shelby tube sampling procedure utilizes a thin-walled, steel tube with a sharp cutting edge that is pushed hydraulically into the bottom of the boring to obtain relatively undisturbed samples of cohesive or moderately cohesive soils.

The continuous dry core sampler is a 4-inch ID, split barrel, hollow sampler. The sampler is attached to the drilling head inside the hollow stem and extended slightly beyond the bottom of the hollow stem auger. When the hollow stem auger is cutting through the formation, the sampler will be pushed into the material and collect the material that will be drilled through by the auger. The samples collected are considered as disturbed but are suitable for visual evaluation of the subsurface material and provide a sample for laboratory index testing (moisture content, Atterberg limits). This type of sampler is suitable for soil and soft bedrock (e.g. claystone and soft shale bedrock).

Groundwater level observations were recorded at the completion of drilling, and on a monthly basis for test holes that were utilized for groundwater monitoring. Three types of groundwater monitoring methods were installed for this project. For shallow borings where groundwater was not anticipated, a “poorman” piezometer was installed. This instrumentation utilizes 2-inch outside diameter PVC pipes that were slotted in-house using regular PVC couplers to connect the pipes. For deeper borings where inclinometers were not planned, a 2-inch outside diameter standpipe piezometer manufactured specifically for groundwater monitoring were installed. These pipes were specially manufactured pipes that have a specific number of slots, and allow the pipes to connect firmly through the threads on each end of the pipes. The standpipe piezometers are stronger and maintain the integrity of the well throughout the boring depth. Silica sand and grout were used to fill the annular space and the plug around the pipes, respectively in accordance with Colorado Groundwater Association specifications. For deeper borings where inclinometers were planned, a vibrating wire (VW) piezometer was used to measure groundwater levels. The VW piezometer is used to measure depth to groundwater and corresponding pore pressure by measuring the pressure changes in the sensor. The VW piezometers were tied to the exterior of the piezometer, and a special grout mix was prepared to backfill the annular space around the inclinometers. The grout provides the stiffness required for inclinometer installations, and at the same time, allows the permeation of groundwater to enable the VW piezometer to measure groundwater depth. The observed groundwater depths/elevations are summarized in Table 2.

In selected borings, 2-inch outside diameter inclinometer casings were installed to monitor the rate and depth of potential ground movement. Grooves along the interior of the casing guide the inclinometer probe and gyroscopes inside the probe measure relative tilt in the probe/casing as it translates down and up the casing. Following the installation of the inclinometer casing, initial profiles of the casing were measured. The initial casing profile is used as a benchmark to compare future readings and changes the casing profile relative ground movement. The



available initial readings and the subsequent readings for the inclinometers installed are presented in Appendix D.

The locations of the borings were measured and recorded using a handheld GPS with an accuracy of approximately 10 feet. The borings were then plotted on the contour map to estimate the elevation of the borings.

Table 2. Summary of Field Exploration and Instrumentation¹

Borings	Depths (ft)	Inclinometer Depth (ft)	G.W. Monitoring Type and Depth (ft)	G.W. Readings	Notes
B1-4	100	100'	VW Piezometer @ 100'	86' @ C.O.D. 47' @ 9-27-18 11' @ 11-9-18 42' @ 12-13-18	
B1-5	49	--	Poorman @ 50'	Dry @ C.O.D. 13.2' @ 7-30-18 13' @ 9-27-18 13.5' @ 11-9-18 13' @ 12-13-18	
B1-6	40	40'	Standpipe @ 40'	Dry @ C.O.D. 4' @ 7-30-18 N/A @ 9-27-18 3.5' @ 11-9-18 2' @ 12-13-18	
B1-7	32	--	N/A	N/A	No instrumentation due to drilling refusal.
B1-8	100	100'	VW Piezometer @ 100'	Dry @ C.O.D. Dry @ 7-30-18 83.5' @ 9-27-18 85.5' @ 11-9-18 84' @ 12-13-18	
B1-11.1	105	105'		43' @ 9-27-18 80' @ 11-8-18 45' @ 12-12-18	
B1-11.2	105	105	VW Piezometer @ 105'	Dry @ C.O.D. 43' @ 9-27-18	
B1-12	50	--	Poorman @ 50'	Dry @ C.O.D. 37.6' @ 7-30-18 36' @ 9-27-18 36.5' @ 11-9-18 35' @ 12-13-18	
B1-14	25	--	Poorman @ 25'	Dry @ C.O.D.	No instrumentation due to drilling refusal.
B1-16	84	--	Standpipe @ 60'	23' @ C.O.D. 22.6' @ 7-30-18 23' @ 9-27-18 24' @ 11-9-18	

Borings	Depths (ft)	Inclinometer Depth (ft)	G.W. Monitoring Type and Depth (ft)	G.W. Readings	Notes
				26' @ 12-13-18	
B1-19	75	75'	VW Piezometer @ 75'	Dry @ C.O.D. Dry @ 7-30-18 7.5' @ 9-27-18 7' @ 11-9-18 8' @ 12-13-18	
B2-1	91	--	Poorman @ 90'	Dry @ C.O.D. 63' @ 9-27-18 64' @ 11-9-18 64' @ 12-13-18	
B2-5	101	100'	VW Piezometer @ 100'	Dry @ C.O.D. 44' @ 9-27-18 46' @ 11-9-18 47.5' @ 12-13-18	
B2-7	100	100'	VW Piezometer @ 100'	Dry @ C.O.D. 68' @ 9-27-18 67.5' @ 11-9-18 67.5' @ 12-13-18	
B2-8	50	50'	VW Piezometer @ 50'	Dry @ C.O.D. 22' @ 9-27-18 22' @ 11-8-18 23' @ 12-13-18	
B2-11	34	--	Poorman @ 30'	Dr @ C.O.D. Dry @ 7-30-18 31' @ 9-27-18 30' @ 11-9-18 27' @ 12-13-18	

¹ Depths rounded to the nearest whole number. Borings B1- represent borings in Area 1, Borings B2- represent borings in Area 2. The readings are updated monthly. Refer to the GIS database for the latest readings.

C.O.D.= Completion of Drilling

4.3.2 Laboratory Testing

The soil and bedrock samples collected during the subsurface exploration were transported to the Yeh laboratory in Colorado Springs. Samples were examined, and a laboratory testing program was developed to evaluate the engineering properties of the subsurface materials. These engineering properties represent the soils in undrained and drained (peak and residual strengths) conditions. Selected soil and bedrock samples were tested to evaluate their engineering properties, using the following tests:

- natural moisture content
- in-situ dry density



- grain size analysis
- Hydrometer test
- Atterberg limits
- Unconfined compression test
- Direct shear test
- Consolidated-undrained triaxial test with pore pressure measurements

The test results are shown on the boring logs and are included in Appendix C. USCS and AASHTO soil classifications for the claystone and shale bedrock presented in the Summary of Laboratory Test Results in Appendix C represent the soil classification of the processed samples for lab testing.

4.4 Continuous Monitoring

A continuous monitoring plan was established to collect the data from the groundwater monitoring devices and the inclinometers installed within Areas 1 and 2 on a monthly basis for a period of 1 year after the installation was completed. The data will be reviewed, interpreted and incorporated into the GIS database until the continuous monitoring is completed. These instrumentations may be left in place or removed as directed by the City of Colorado Springs when the continuous monitoring is completed.

In addition to the continuous monitoring of the instruments, SqueeSAR analysis, based on the satellite imagery, will occur at a 6-month interval for a total length of 12 months. The results of the SqueeSAR will also be incorporated into the GIS database as the information is obtained.

4.5 GIS Database User Guideline

The User Guideline provides a background of the project, general information on the searchable data fields within the geodatabase and the procedures for accessing the data. The GIS geodatabase and User Guideline can be accessed from City of Colorado Springs GIS website at:

<https://coloradosprings.maps.arcgis.com/home/signin.html>

5. LIMITATIONS

This report was prepared for the exclusive use by the City of Colorado Springs and its designated agencies. Within the limitations of the scope, schedule, and budget, the work presented in this report was performed in accordance with generally accepted principles and



practices in this area at the time this report was prepared. Yeh and Associates makes no other warranty, either express or implied.

The findings presented in this report are based upon data obtained from test borings and instrumentation at indicated locations, field observations, laboratory testing, our understanding of project area, and other sources of information referenced in this report. It is possible that subsurface conditions may vary between or beyond the locations of the test borings. The nature and extent of subsurface variations may not become evident until excavation is performed. Variations in the data may also occur with the passage of time

The scope of work of this study did not include hazardous materials sampling or environmental sampling, investigation, or analysis. In addition, we did not evaluate the site for potential impacts to natural resources, including wetlands, endangered species, or environmentally critical areas.

Appendix A

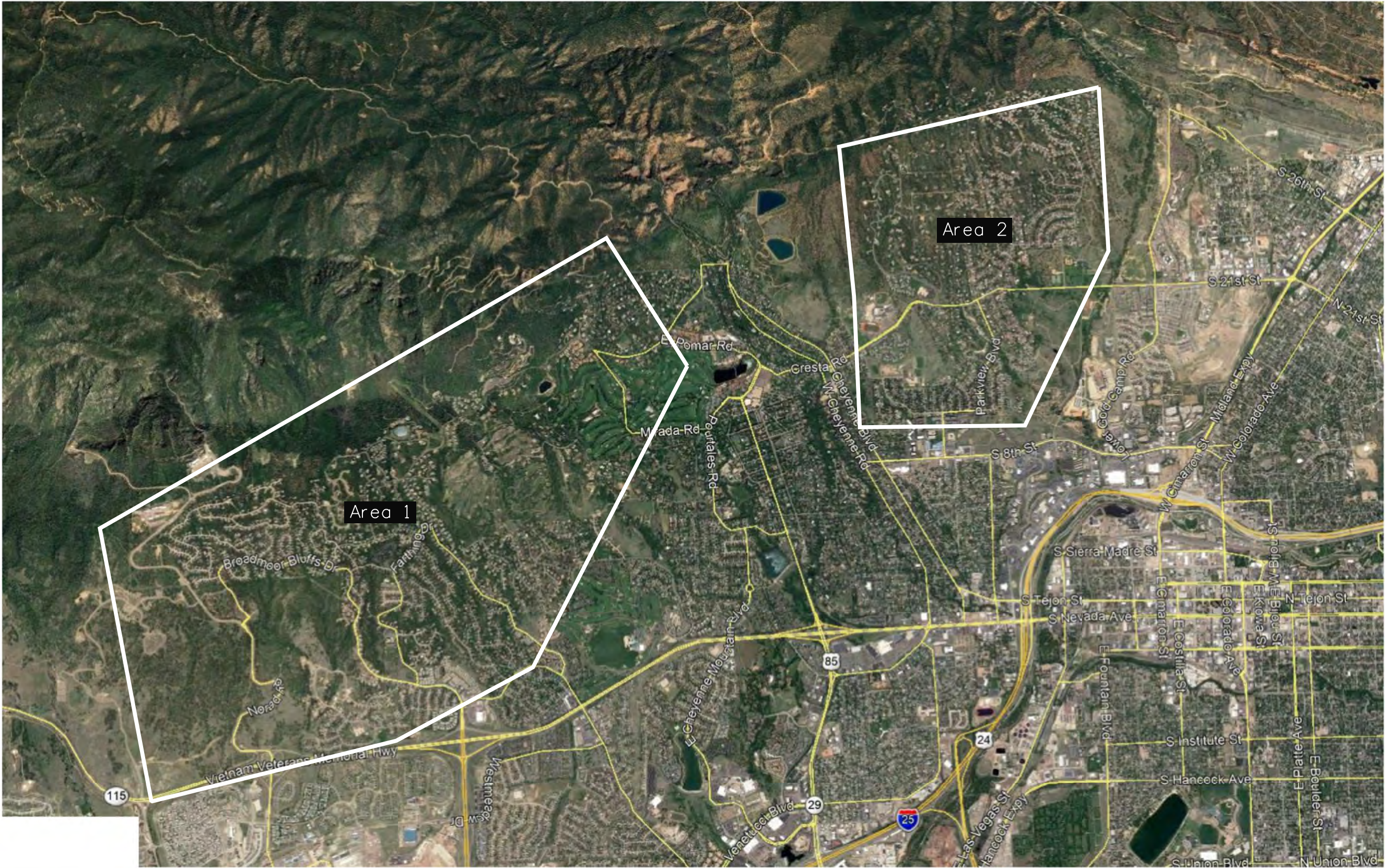
A-1: SITE LOCATION PLAN

A-2: AREA 1 AND 2 GEOLOGIC MAP

A-3: AREA 1 BORING LOCATION PLAN

A-4: AREA 2 BORING LOCATION PLAN





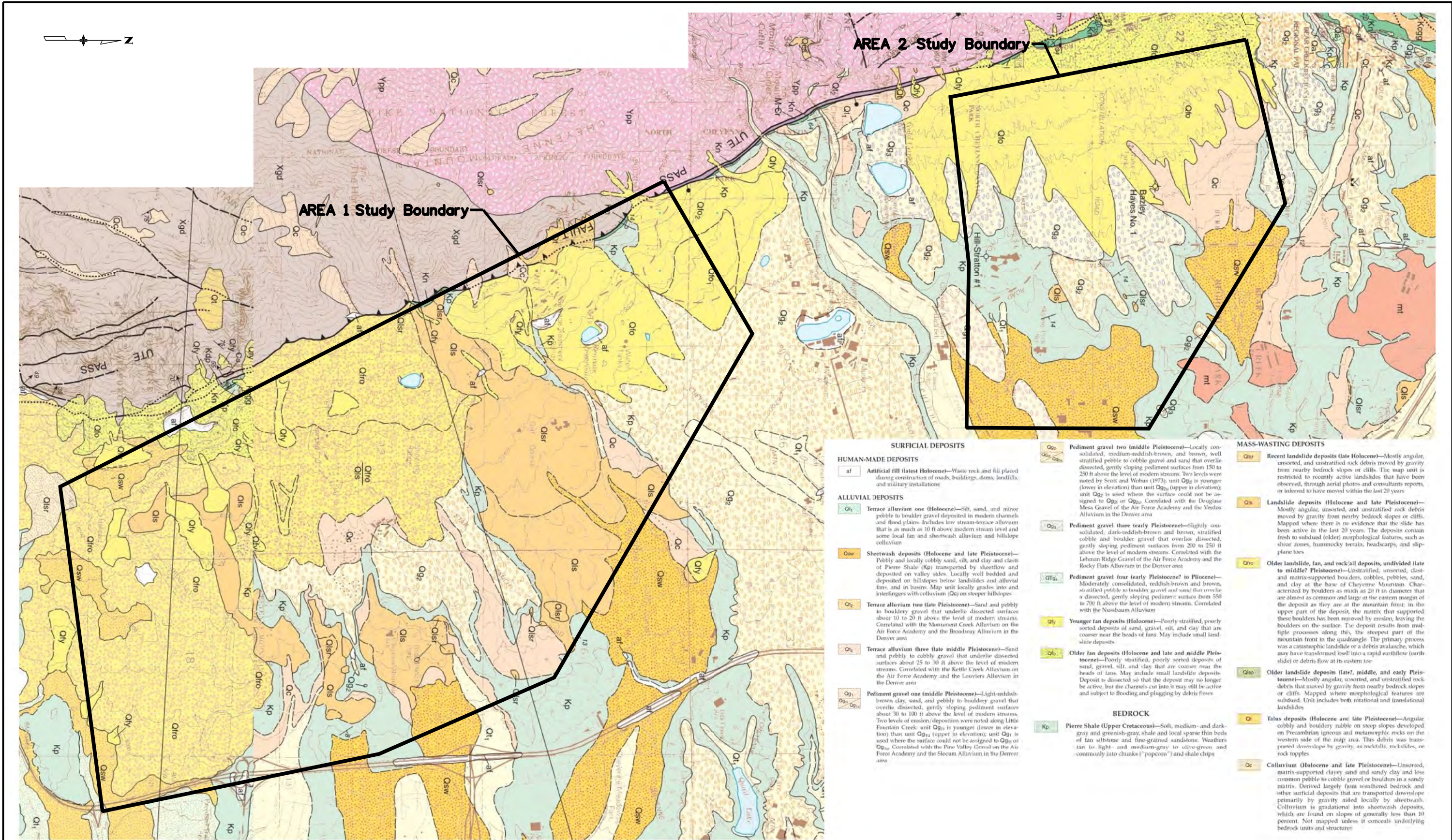
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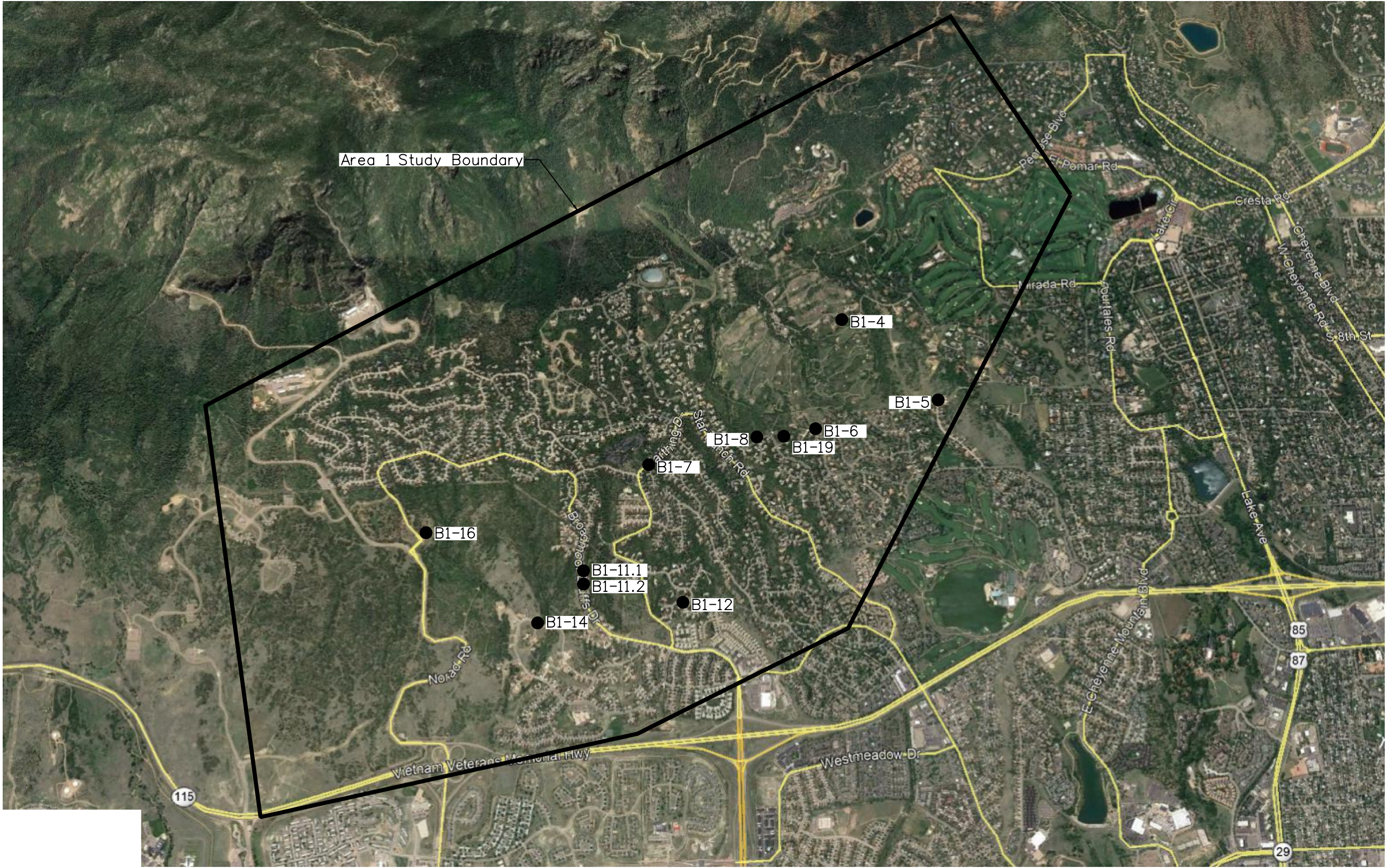
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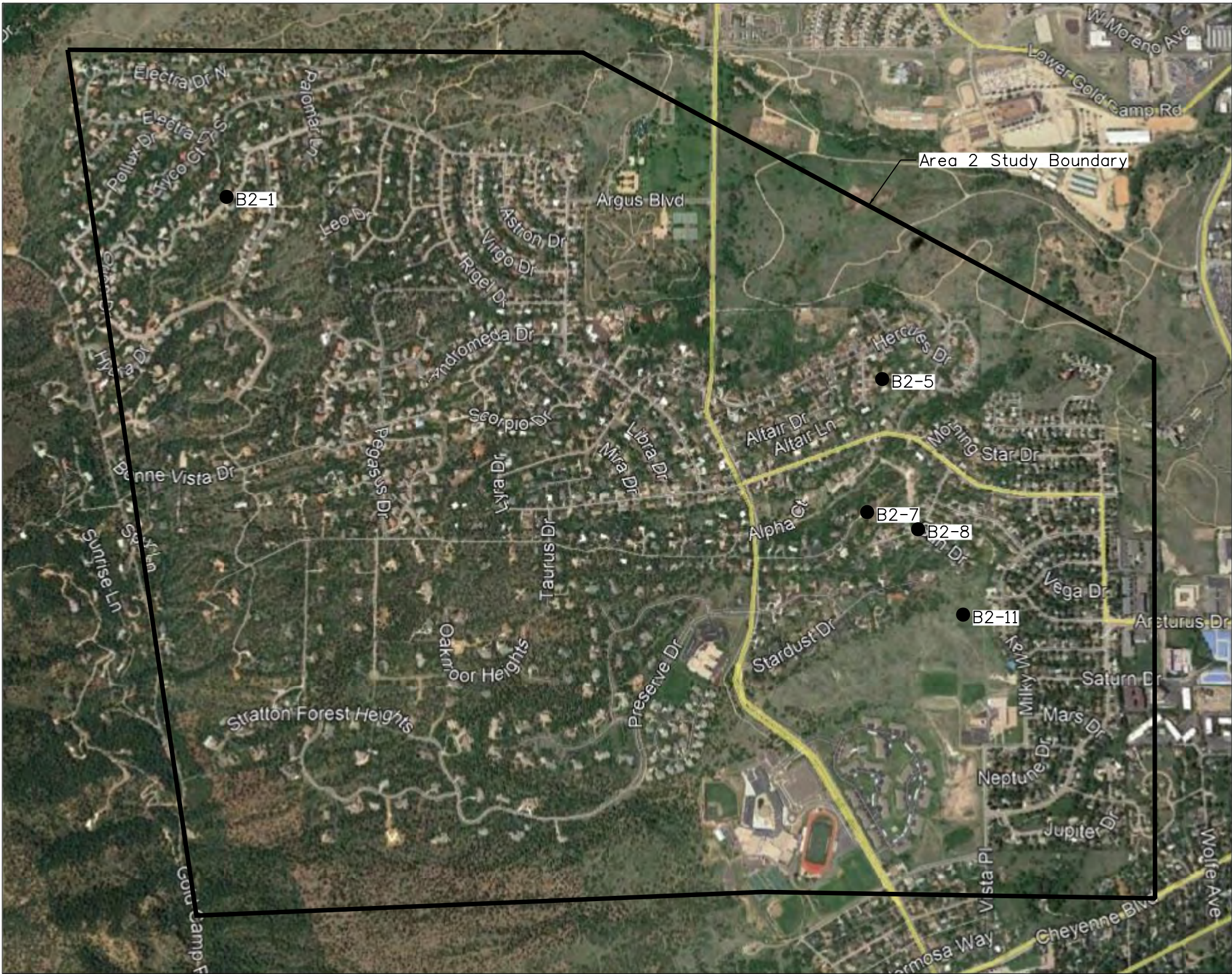
ENGINEERING GEOLOGY STUDY
COLORADO SPRINGS, COLORADO

SITE LOCATION PLAN





● Approximate Boring Location



● Approximate Boring Location

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Appendix B

GEOTECHNICAL BORING LOGS





Legend for Symbols Used on Borehole Logs

Sample Types



Auger Cuttings



Rock Core



Modified California
Sampler
(2.5 inch OD, 2.0
inch ID)



Shelby Tube



Standard
Penetration Test
(ASTM D1586)

Lithology Symbols (see Boring Logs for complete descriptions)



Asphalt



Cobbles and gravel



USCS High Plasticity
Clay



USCS Low Plasticity
Clay



USCS Low Plasticity
Sandy Clay



USCS Poorly-graded
Gravel



USCS Poorly-graded
Gravel with Clay



USCS Poorly-graded
Sandy Gravel



USCS Well-graded
Sandy Gravel



USCS Clayey Sand



USCS Silty Sand



USCS Poorly-graded
Sand



USCS Well-graded
Gravelly Sand



Topsoil



Claystone



Shale



Weathered Bedrock

Lab Test Standards

Moisture Content	ASTM D2216
Dry Density	ASTM D7263
Sand/Fines Content	ASTM D421, ASTM C136, ASTM D1140
Atterberg Limits	ASTM D4318
AASHTO Class.	AASHTO M145, ASTM D3282
USCS Class.	ASTM D2487
(Fines = % Passing #200 Sieve	
Sand = % Passing #4 Sieve, but not passing	
#200 Sieve)	

Other Lab Test Abbreviations

pH	Soil pH (AASHTO T289-91)
S	Water-Soluble Sulfate Content (AASHTO T290-91, ASTM D4327)
Chl	Water-Soluble Chloride Content (AASHTO T291-91, ASTM D4327)
S/C	Swell/Consolidation (ASTM D4546)
UCCS	Unconfined Compressive Strength (ASTM D2166)
R-Value	Resistance R-Value (ASTM D2844)
DS (C)	Direct Shear cohesion (ASTM D3080)
DS (phi)	Direct Shear friction angle (ASTM D3080)
Re	Electrical Resistivity (AASHTO T288-91)
PtL	Point Load Strength Index (ASTM D5731)

Notes

- "Penetration Resistance" on the Boring Logs refers to the uncorrected N value for SPT samples only, as per ASTM D1586. For samples obtained with a Modified California (MC) sampler, drive depth is 12 inches, and "Penetration Resistance" refers to the sum of all blows. Where blow counts were > 50 for the 3rd increment (SPT) or 2nd increment (MC), "Penetration Resistance" combines the last and 2nd-to-last blows and lengths; for other increments with > 50 blows, the blows for the last increment are reported.
- The Modified California sampler used to obtain samples is a 2.5-inch OD, 2.0-inch ID (1.95-inch ID with liners), split-barrel sampler with internal liners, as per ASTM D3550. Sampler is driven with a 140-pound hammer, dropped 30 inches per blow.
- "ER" for the hammer is the Reported Calibrated Energy Transfer Ratio for that specific hammer, as provided by the drilling company.



Boring Began: 6/21/201

Total Depth: 100.3 ft

Weather Notes: Sunny, Hot

Boring Completed: 7/3/2018

Ground Elevation: 6329.0 ft

Inclination from Horiz.: Vertical

Drilling Method(s): Hollow-Stem Auger /
Continuous Sampler

Coordinates: Lat: Long:

Location: N38.77279, W104.84290

Night Work: ☐

Driller: Authentic Drilling

Drill Rig: CME 75

Logged By: L. Southerland

Hammer Type: Automatic (hydraulic), ER: 95%

Final By: M. Lim

Groundwater Levels:

Symbol	▽		
Depth	86.0 ft	-	-
Date	7/3/18	-	-

BORING LOG 2015 217-130 COS GEOLOGIC STUDY BORING LOGS FOR REPORT.GPJ 2015 YEH ASSOCIATES TEMPLATE (BACKUP 2018-09-19) - COPY.GDT COS LIBRARY 2-20-19.GLB 4/19/19

Elevation (feet)	Depth (feet)	Sample Type/ Advancement Method	Rock		Soil Samples		Lithology	Material Description	Moisture Content (%)	Dry Density (pcf)	Fines Content (%)	Atterberg Limits		AASHTO & USCS Classifi- cations	Field Notes and Other Lab Tests
			Recovery (%)	RQD (%)	Blows per 6 in	Penetration Resistance						Liquid Limit	Plasticity Index		
6320	10		31					0.0 - 13.5 ft. fat CLAY, brown, moist, stiff.							
					5-7	12									
			90												
			90						21.0	93.1	95.1	51	30	A-7-6 (31) CH	
6310	20				6-10	16		- brown with gray below 10.5'.	20.8						
			100												
					14-16	30		13.5 - 19.5 ft. WEATHERED CLAYSTONE, gray and brown, soft, moist, high plasticity.							
			88						15.0						
6300	30		100		43-50/5"	50/5"		19.5 - 26.0 ft. CLAYSTONE, gray and brown, medium hard, moist, high plasticity.							
			0												
					47-50/3"	50/3"			13.9	120.0	98.0	51	32	A-7-6 (34) CH	
			0												
6290	40				50/5"	50/5"		26.0 - 100.3 ft. SHALE, gray, moderately weathered, medium hard, damp.							
			0												
					50/5"	50/5"									
			59												
6280	50				50/4"	50/4"									
			73												
					50/4"	50/4"									
					50/3"	50/3"									
															45.0 ft - Possible shell fragments in bottom of liner, bagged

[illegible]



Boring Began: 5/31/2018

Total Depth: 49.3 ft

Weather Notes: Sunny, Clear

Boring Completed: 5/31/2018

Ground Elevation: 6106.0 ft

Inclination from Horiz.: Vertical

Drilling Method(s): Hollow-Stem Auger /
Continuous Sampler

Coordinates: Lat: Long:

Location: N38.77815, W104.83655

Night Work: ☐

Driller: Authentic Drilling

Groundwater Levels: Not Observed

Drill Rig: CME 75

Logged By: L. Southerland

Hammer Type: Automatic (hydraulic), ER: 95%

Final By: M. Lim

Symbol	-	-	-
Depth	-	-	-
Date	-	-	-

BORING LOG 2015 217-130 COS GEOLOGIC STUDY BORING LOGS FOR REPORT.GPJ 2015 YEH ASSOCIATES TEMPLATE (BACKUP 2018-09-19) - COPY.GDT COS LIBRARY 2-20-19.GLB 4/19/19

Elevation (feet)	Depth (feet)	Sample Type/ Advancement Method	Rock		Soil Samples		Lithology	Material Description	Moisture Content (%)	Dry Density (pcf)	Fines Content (%)	Atterberg Limits		AASHTO & USCS Classifi- cations	Field Notes and Other Lab Tests
			Recovery (%)	RQD (%)	Blows per 6 in	Penetration Resistance						Liquid Limit	Plasticity Index		
6100			8					0.0 - 0.5 ft. 6" ASPHALT.							
					1-4	5		0.5 - 14.0 ft. fat CLAY, trace of gravel, light brown, wet to moist, medium stiff to very stiff.	25.6	96.9	90.1	63	44	A-7-6 (43) CH	
	10		43												
			100						20.4	104.3	94.7	50	31	A-7-6 (32) CH	
6090					9-19	28		- olive brown below 11'.							
			100												
6080					15-22	37		14.0 - 19.5 ft. CLAYSTONE, gray, medium hard.							
			100												
6070	20				30-50/5"	50/5"		19.5 - 49.3 ft. SHALE, gray, predominantly decomposed to moderately weathered, soft to medium hard.							
					50/6"	50/6"									
	30				50/6"	50/6"									
					50/5"	50/5"									
6060	40				50/5"	50/5"									
					50/5"	50/5"									
					50/4"	50/4"		Bottom of Hole at 49.3 ft.							



Boring Began: 6/1/2018

Total Depth: 40.3 ft

Weather Notes: Sunny, Clear

Boring Completed: 6/4/2018

Ground Elevation: 6192.0 ft

Inclination from Horiz.: Vertical

Drilling Method(s): Hollow-Stem Auger /

Coordinates: Lat: Long:

Continuous Sampler

Location: N38.77082, W104.83466

Night Work: ☐

Driller: Authentic Drilling

Groundwater Levels: Not Observed

Drill Rig: CME 75

Logged By: L. Southerland

Hammer Type: Automatic (hydraulic), ER: 95%

Final By: M. Lim

Symbol	Depth	Date
-	-	-
-	-	-

Elevation (feet)	Depth (feet)	Sample Type/ Advancement Method	Rock		Soil Samples		Lithology	Material Description	Moisture Content (%)	Dry Density (pcf)	Fines Content (%)	Atterberg Limits		AASHTO & USCS Classifi- cations	Field Notes and Other Lab Tests
			Recovery (%)	RQD (%)	Blows per 6 in	Penetration Resistance						Liquid Limit	Plasticity Index		
6190			6					0.0 - 0.6 ft. ASPHALT.							
					4-6	10		0.6 - 19.0 ft. fat CLAY, dark brown, moist, stiff, granitic gravels, some iron concretions.							
								- Sand seams @ 5'.							
			100												
10			88												
					9-50/2"	50/2"		- brown below 11', presence of cobbles and large boulders.							
6180															
20			26					19.0 - 35.0 ft. CLAYSTONE, dark gray, medium hard, moist.							
6170					19-29	48									
			100												
					50/5"	50/5"									
30															
6160					50/6"	50/6"		35.0 - 40.3 ft. SHALE, dark gray, moderately weathered, medium hard, fissile, moist.							
40					50/4"	50/4"									
								Bottom of Hole at 40.3 ft.							
6150															

12.5 ft - Auger refusal @ 12.5' in initial boring due to large boulders, relocated to north side of cul-de-sac

Project Number: 217-130

Boring No.: **B1-7**

Boring Began: 6/5/2018

Total Depth: 32.0 ft

Weather Notes: Sunny, Clear

Boring Completed: 6/5/2018

Ground Elevation: 6439.0 ft

Inclination from Horiz.: Vertical

Drilling Method(s): Hollow-Stem Auger /
Continuous Sampler

Coordinates: Lat: Long:
Location: N38.76111, W104.83202

Night Work: ☐

Driller: Authentic Drilling

Logged By: L. Southerland

Drill Rig: CME 75

Hammer Type: Automatic (hydraulic), ER: 95%

Final By: M. Lim

Groundwater Levels: Not Observed

Symbol			
Depth	-	-	-
Date	-	-	-

Elevation (feet)	Depth (feet)	Sample Type/ Advancement Method	Rock		Soil Samples		Lithology	Material Description	Moisture Content (%)	Dry Density (pcf)	Fines Content (%)	Atterberg Limits		AASHTO & USCS Classifi- cations	Field Notes and Other Lab Tests
			Recovery (%)	RQD (%)	Blows per 6 in	Penetration Resistance						Liquid Limit	Plasticity Index		
6430	10		49					0.0 - 0.3 ft. 4" ASPHALT. 0.3 - 11.0 ft. clayey SAND with gravel, brown and dark brown, medium plasticity, damp, loose to medium dense. - cobbles @ 8'.	7.1	107.9	24.4	29	16	A-2-6 (1) SC	
					4-7	11									
			68												
			100		8-17	25									
			46												
6420	20				16-9-18	27		11.0 - 21.0 ft. clayey SAND trace of large gravel layers, brown, moist, medium dense to dense.	8.3		45.3	39	20	A-6 (5) SC	
			34												
					10-13-34	47									
			100												
															
6410	30							21.0 - 32.0 ft. GRAVEL and cobbles with boulders, brown, very dense.							
					50/6"	50/6"									
					22-50/4"	50/4"									
6400			Bottom of Hole at 32.0 ft.												32.0 ft - Auger refusal possibly in boulders, terminated @ 32'.



Boring Began: 6/7/2018

Total Depth: 100.3 ft

Weather Notes: Clear, Hot

Boring Completed: 6/8/2018

Ground Elevation: 6297.0 ft

Inclination from Horiz.: Vertical

Drilling Method(s): Hollow-Stem Auger /
Continuous Sampler

Coordinates: Lat: Long:

Location: N38.76729, W104.83394

Night Work: ☐

Driller: Authentic Drilling

Groundwater Levels: Not Observed

Drill Rig: CME 75

Logged By: L. Southerland

Hammer Type: Automatic (hydraulic), ER: 95%

Final By: M. Lim

Symbol	Depth	Date
-	-	-
-	-	-

Elevation (feet)	Depth (feet)	Sample Type/ Advancement Method	Rock		Soil Samples		Lithology	Material Description	Moisture Content (%)	Dry Density (pcf)	Fines Content (%)	Atterberg Limits		AASHTO & USCS Classifi- cations	Field Notes and Other Lab Tests
			Recovery (%)	RQD (%)	Blows per 6 in	Penetration Resistance						Liquid Limit	Plasticity Index		
			0					0.0 - 0.5 ft. 6" ASPHALT.							
					21-19	40		0.5 - 14.0 ft. fat CLAY , brown and gray, moist, hard to stiff, iron concretions, possible calcareous infilling.							
6290			100												
	10		85		4-6	10			24.5		95.0	54	35	A-7-6 (36) CH	UCCS=8219psf
			100		13-28	41									
6280			100					14.0 - 20.0 ft. CLAYSTONE , gray - brown to gray, medium hard, moist, possible calcareous infilling.							
	20		100		19-35	54			17.0	112.8		48	30	A-7-6 (33) CL	
			50					20.0 - 44.0 ft. SHALE , dark gray, moderately weathered, medium hard, high plasticity.							
					50/6"	50/6"									
6270			44												
	30				50/6"	50/6"									
			100												
					50/6"	50/6"									
6260															
	40				50/5"	50/5"									
6250			100		34-20	54		44.0 - 48.0 ft. CLAYSTONE , black, predominantly decomposed, hard, moist, high plasticity, possible landslide deposits.	12.4	99.7	100.0	79	56	A-7-6 (65) CH	
					50/5"	50/5"									
	50		100					48.0 - 100.3 ft. SHALE , dark gray, moderately weathered, medium hard, fissile damp, high plasticity. - possible perched water zone from							



Elevation (feet)	Depth (feet)	Sample Type/ Advancement Method	Rock		Soil Samples		Lithology	Material Description	Moisture Content (%)	Dry Density (pcf)	Fines Content (%)	Atterberg Limits		AASHTO & USCS Classifi- cations	Field Notes and Other Lab Tests
			Recovery (%)	RQD (%)	Blows per 6 in	Penetration Resistance						Liquid Limit	Plasticity Index		
					50/5"	50/5"		50-53'. 48.0 - 100.3 ft. SHALE , dark gray, moderately weathered, medium hard, fissile damp, high plasticity. <i>(continued)</i>							
6240					50/4"	50/4"									
	60				50/4"	50/4"									
					50/4"	50/4"									
6230					50/3"	50/3"									
	70				50/4"	50/4"									
					50/3"	50/3"									
6220					50/4"	50/4"									
	80				50/3"	50/3"									
					50/4"	50/4"									
6210					50/3"	50/3"									
	90				50/3"	50/3"									
					50/3"	50/3"									
6200					50/3"	50/3"									
	100				50/3"	50/3"		Bottom of Hole at 100.3 ft.							
6190															



Boring Began: 7/2/2018

Total Depth: 100.3 ft

Weather Notes: Sunny, 80 °F

Boring Completed: 7/2/2018

Ground Elevation:

Inclination from Horiz.: Vertical

Drilling Method(s): Hollow-Stem Auger /
Continuous Sampler

Coordinates: Lat: Long:

Location:

Night Work: ☐

Driller: Authentic Drilling

Drill Rig: CME 75

Logged By: L. Southerland

Hammer Type: Automatic (hydraulic), ER: 95%

Final By: M. Lim

Groundwater Levels:

Symbol	▽		
Depth	63.0 ft	-	-
Date	7/5/18	-	-

Elevation (feet)	Depth (feet)	Sample Type/ Advancement Method	Rock		Soil Samples		Lithology	Material Description	Moisture Content (%)	Dry Density (pcf)	Fines Content (%)	Atterberg Limits		AASHTO & USCS Classifi- cations	Field Notes and Other Lab Tests
			Recovery (%)	RQD (%)	Blows per 6 in	Penetration Resistance						Liquid Limit	Plasticity Index		
			0					0.0 - 9.0 ft. clayey SAND with decomposed granite gravel layers, brown to red, damp, medium dense.							
					7-11	18									
			60												
					6-6	12									
	10		83					9.0 - 13.5 ft. sandy lean CLAY , brown, damp, stiff.							
					8-8	16									
			35					13.5 - 21.0 ft. sandy GRAVEL decomposed granite with clay layers, brown to gray, damp, dense.							
					33-17	50									
	20		53												
					11-8	19									
			68												
					No record	No record									
	30		80												
					8-13	21									
			77					34.0 - 59.0 ft. GRAVEL and cobbles , decomposed granite with clay seams, brown and red, moist, medium dense to very dense.							
	40				50/1.5"	50/1.5"									
					50/1.5"	50/1.5"									
	50				13-35	48									



Elevation (feet)	Depth (feet)	Sample Type/ Advancement Method	Rock		Soil Samples		Lithology	Material Description	Moisture Content (%)	Dry Density (pcf)	Fines Content (%)	Atterberg Limits		AASHTO & USCS Classifi- cations	Field Notes and Other Lab Tests
			Recovery (%)	RQD (%)	Blows per 6 in	Penetration Resistance						Liquid Limit	Plasticity Index		
			100					34.0 - 59.0 ft. GRAVEL and cobbles, decomposed granite with clay seams, brown and red, moist, medium dense to very dense. (continued)							
					50/5"	50/5"									
	60				40-50/4"	50/4"		59.0 - 66.0 ft. CLAYSTONE, dark gray with brown, hard, moist.							
			100												
					50/6"	50/6"									
			100												
	70				50/6"	50/6"		66.0 - 100.3 ft. SHALE, dark gray, moderately weathered, medium hard, fissile moist to damp.							
			100												
					50/6"	50/6"									
			100												
					50/6"	50/6"									
	80				50/4"	50/4"		- hard below 78'.	10.8			47	24	A-7-6 (27) CL	
			77												
					50/4"	50/4"									
					50/4"	50/4"									
	90				50/4"	50/4"									
					50/5.5"	50/5.5"									
	100				50/4"	50/4"		Bottom of Hole at 100.3 ft.							



Boring Began: 8/16/2018

Total Depth: 105.3 ft

Weather Notes: Sunny, Clear, 80

Boring Completed: 8/17/2018

Ground Elevation: 6258.0 ft

°F

Drilling Method(s): Hollow-Stem Auger

Coordinates: Lat: Long:

Inclination from Horiz.: Vertical

Driller: Authentic Drilling

Location: N38.75727, W104.82343

Night Work: ☐

Drill Rig: CME 75

Hammer Type: Automatic (hydraulic), ER: 95%

Logged By: L. Southerland

Final By: M. Lim

Groundwater Levels: Not Observed

Symbol	-	-	-
Depth	-	-	-
Date	-	-	-

Elevation (feet)	Depth (feet)	Sample Type/ Advancement Method	Soil Samples		Lithology	Material Description	Moisture Content (%)	Dry Density (pcf)	Fines Content (%)	Atterberg Limits		AASHTO & USCS Classifi- cations	Field Notes and Other Lab Tests
			Blows per 6 in	Penetration Resistance						Liquid Limit	Plasticity Index		
6258	0					0.0 - 0.3 ft. TOPSOIL with grass rootlets.							
6255	5		3-4	7		0.3 - 10.0 ft. poorly graded SAND with gravel and clay seams, decomposed granite gravels, reddish brown, damp, loose.							
6250	10		6-10	16		10.0 - 20.0 ft. poorly graded SAND , with clay layers and decomposed granite gravel seams, reddish brown, damp, medium dense.							
6245	15		5-5-5	10									
6240	20		4-7-8	15		20.0 - 25.0 ft. sandy lean CLAY , dark brown, moist, very stiff.	7.7		30.4	32	15	A-2-6 (1) SC	
6235	25		6-7	13		25.0 - 39.0 ft. poorly graded SAND , with decomposed granite gravels, reddish brown, moist, medium dense.	1.9		11.7	24	1	A-2-4 (0)	
6230	30		6-6-9	15		- dark brown below 30'.	2.5		10.4	23	5	A-1-b (0) SW-SC	
6225													



Elevation (feet)	Depth (feet)	Sample Type/ Advancement Method	Soil Samples		Lithology	Material Description	Moisture Content (%)	Dry Density (pcf)	Fines Content (%)	Atterberg Limits		AASHTO & USCS Classifi- cations	Field Notes and Other Lab Tests
			Blows per 6 in	Penetration Resistance						Liquid Limit	Plasticity Index		
6220			6-8-9	17		25.0 - 39.0 ft. poorly graded SAND, with decomposed granite gravels, reddish brown, moist, medium dense. (continued)							
40			9-7-9	16		39.0 - 48.0 ft. clayey SAND with clay seams, dark brown, medium plasticity, moist, medium dense.	16.6		41.6	30	14	A-6 (2) SC	
45			7-7	14			16.3		51.3	39	23	A-6 (8) CL	
50			34-50/4"	50/4"		48.0 - 58.0 ft. CLAYSTONE, olive gray, hard.							
55			50/5.5"	50/5.5"		-iron staining at 55 ft..							
60			50/4.5"	50/4.5"		58.0 - 105.3 ft. SHALE, dark gray, moderately weathered, medium hard to hard, fissile.							
65			50/4"	50/4"									
70			50/4"	50/4"									
75			50/4"	50/4"									



Elevation (feet)	Depth (feet)	Sample Type/ Advancement Method	Soil Samples		Lithology	Material Description	Moisture Content (%)	Dry Density (pcf)	Fines Content (%)	Atterberg Limits		AASHTO & USCS Classifi- cations	Field Notes and Other Lab Tests
			Blows per 6 in	Penetration Resistance						Liquid Limit	Plasticity Index		
6180						58.0 - 105.3 ft. SHALE, dark gray, moderately weathered, medium hard to hard, fissile. (continued)							
	80		50/3.5"	50/3.5"									
6175													
	85		50/5"	50/5"									
6170													
	90		50/3"	50/3"									
6165													
	95		50/3"	50/3"									
6160													
	100		50/3"	50/3"									
6155													
	105		50/3"	50/3"		Bottom of Hole at 105.3 ft.							
6150													
6145													
6140													

Boring Began: 6/6/2018

Total Depth: 49.5 ft

Weather Notes: Sunny, Hot, Clear

Boring Completed: 6/6/2018

Ground Elevation: 6128.0 ft

Inclination from Horiz.: Vertical

Drilling Method(s): Hollow-Stem Auger /
Continuous Sampler

Coordinates: Lat: Long:

Location: N38.76286, W104.82186

Night Work: ☐

Driller: Authentic Drilling

Logged By: L. Southerland

Drill Rig: CME 75

Hammer Type: Automatic (hydraulic), ER: 95%

Final By: M. Lim

Groundwater Levels: Not Observed

Symbol	Depth	Date
--------	-------	------

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[illegible]

Bottom of Hole at 49.5 ft.



COS Engineering Geology Study

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Boring No.: **B1-14**

Total Depth: 25.0 ft
Ground Elevation: 6109.0 ft
Coordinates: Lat: Long:
Location: N38.75436, W104.82055

Night Work: ☐

Logged By: L. Southerland

Final By: M. Lim

Groundwater Levels: Not Observed

Symbol			
Depth	-	-	-
Date	-	-	-

[illegible]

Boring Began: 6/18/2018

Boring Completed: 6/19/2018

Drilling Method(s): Hollow-Stem Auger /
Continuous Sampler

Driller: Authentic Drilling

Drill Rig: CME 75

Hammer Type: Automatic (hydraulic), ER: 95%

Total Depth: 83.5 ft

Ground Elevation: 6334.0 ft

Coordinates: Lat: Long:

Location: N38.74812, W104.82738

Logged By: L. Southerland

Final By: M. Lim

Weather Notes: Sunny, 70F

Inclination from Horiz.: Vertical

Night Work: ☐

Groundwater Levels:

Symbol	▽		
Depth	24.0 ft	-	-
Date	6/18/18	-	-

Elevation (feet)	Depth (feet)	Sample Type/ Advancement Method	Rock		Soil Samples		Lithology	Material Description	Moisture Content (%)	Dry Density (pcf)	Fines Content (%)	Atterberg Limits		AASHTO & USCS Classifications	Field Notes and Other Lab Tests
			Recovery (%)	RQD (%)	Blows per 6 in	Penetration Resistance						Liquid Limit	Plasticity Index		
6330			0		8-8	16	0.0 - 0.5 ft. 6" ASPHALT. 0.5 - 9.0 ft. poorly graded GRAVEL with clay, reddish brown, damp, medium dense to dense. - approxiamtely 1' of clay layer @ 5'.								
	10		32												
6320					9-10	19	9.0 - 19.0 ft. clayey SAND, reddish brown, medium plasticity, damp, medium dense.	9.9	123.1	37.6	32	18	A-6 (2) SC		
	20				7-11	18									
6310					12-21	33	19.0 - 28.0 ft. poorly graded GRAVEL, reddish brown, damp, medium dense.								
	30				10-14	24									
6300					11-15	26	28.0 - 59.0 ft. clayey SAND trace of gravels, reddish brown, low plasticity, damp, medium dense to dense.	9.6 9.7	119.8	18.7	29	14	A-2-6 (0) SC		
	40				9-13	22									
6290					17-22	39									
					17-19	36		9.7							UCCS=796psf



Elevation (feet)	Depth (feet)	Sample Type/ Advancement Method	Rock		Soil Samples		Lithology	Material Description	Moisture Content (%)	Dry Density (pcf)	Fines Content (%)	Atterberg Limits		AASHTO & USCS Classifi- cations	Field Notes and Other Lab Tests
			Recovery (%)	RQD (%)	Blows per 6 in	Penetration Resistance						Liquid Limit	Plasticity Index		
6280					9-39	48		28.0 - 59.0 ft. clayey SAND trace of gravels, reddish brown, low plasticity, damp, medium dense to dense. (continued)							
					17-20	37									
60					8-17	25		59.0 - 75.0 ft. CLAYSTONE , gray with brown, firm to hard, high plasticity, moist.	19.7	111.1	83.2	50	34	A-7-6 (28) CH	68.5 ft - Possible reworked piece of vegetation
			100												
6270					18-44	62									
			95												
70					15-31	46						81	63		
			100												
6260					30-45	75		75.0 - 83.5 ft. SHALE , gray, moderately weathered, medium hard, fissile.							
			83												
80					50/5"	50/5"									
			91												
6250								Bottom of Hole at 83.5 ft.							85.0 ft - Due to cave in of boring, terminated @ 83.5'
6240															
6230															



Boring Began: 6/4/2018

Total Depth: 75.0 ft

Weather Notes: Sunny, Clear

Boring Completed: 6/4/2018

Ground Elevation: 6245.0 ft

Inclination from Horiz.: Vertical

Drilling Method(s): Hollow-Stem Auger /

Coordinates: Lat: Long:

Continuous Sampler

Location: N38.76896, W104.83405

Night Work: ☐

Driller: Authentic Drilling

Groundwater Levels: Not Observed

Drill Rig: CME 75

Logged By: L. Southerland

Hammer Type: Automatic (hydraulic), ER: 95%

Final By: M. Lim

Symbol	Depth	Date
-	-	-
-	-	-

Elevation (feet)	Depth (feet)	Sample Type/ Advancement Method	Rock		Soil Samples		Lithology	Material Description	Moisture Content (%)	Dry Density (pcf)	Fines Content (%)	Atterberg Limits		AASHTO & USCS Classifi- cations	Field Notes and Other Lab Tests
			Recovery (%)	RQD (%)	Blows per 6 in	Penetration Resistance						Liquid Limit	Plasticity Index		
6240			63					0.0 - 0.3 ft. 4" ASPHALT.							
					13-20	33		0.3 - 7.0 ft. fat CLAY, brown, moist, very stiff.							
			45												
6230	10		100		13-20	33		7.0 - 17.0 ft. fat CLAY trace of gravels, brown and olive gray, moist, very stiff, with some iron concretions.	15.7	109.4	94.2	53	29	A-7-6 (31) CH	
			100												
					7-14	21									
			100												
6220	20		100		13-22	35		17.0 - 35.0 ft. CLAYSTONE, brown and dark brown, predominantly decomposed, firm to medium hard, moist to wet, medium to high high plasticity.				49	27		
					8-16	24									
			100						27.9	94.5		56	34	A-7-6 (35) CH	
6210	30		95		12-23	35									
					18-28	46			16.7		98.8	49	28	A-7-6 (31) CL	
			88					35.0 - 54.0 ft. CLAYSTONE, dark gray, medium hard to very hard, moist, medium to high plasticity.							
					33-50/3"	50/3"									



Elevation (feet)	Depth (feet)	Sample Type/ Advancement Method	Rock		Soil Samples		Lithology	Material Description	Moisture Content (%)	Dry Density (pcf)	Fines Content (%)	Atterberg Limits		AASHTO & USCS Classifi- cations	Field Notes and Other Lab Tests
			Recovery (%)	RQD (%)	Blows per 6 in	Penetration Resistance						Liquid Limit	Plasticity Index		
6200			52					35.0 - 54.0 ft. CLAYSTONE, dark gray, medium hard to very hard, moist, medium to high plasticity. (continued)							
					20-30	50			14.9	114.7	98.3	49	29	A-7-6 (31) CL	
			93												
					23-50/5"	50/5"						82	64		
6190			68					54.0 - 67.5 ft. CLAYSTONE, dark gray, predominantly decomposed, firm, moist, high plasticity, possible remolded claystone.							
					15-30	45									
			100												
					12-21	33			18.5	106.9		54	34	A-7-6 (37) CH	
6180					19-27	46		- gravels seam @ 63.5'. 67.5 - 75.0 ft. SHALE, dark gray, medium hard.							
			80												
					50/5"	50/5"									
			93												
6170					50/5"	50/5"									
			82												
Bottom of Hole at 75.0 ft.															
6160															



Boring Began: 5/16/2018

Total Depth: 90.5 ft

Weather Notes: Sunny, warm

Boring Completed: 5/16/2018

Ground Elevation: 6537.0 ft

Inclination from Horiz.: Vertical

Drilling Method(s): Hollow-Stem Auger /

Coordinates: Lat: Long:

Continuous Sampler

Location: N38.82031, W104.87654

Night Work: ☐

Driller: Vine Laboratories

Groundwater Levels: Not Observed

Drill Rig: CME 55

Logged By: S. White

Hammer Type: Automatic (hydraulic), ER: 90%

Final By: M. Lim

Symbol			
Depth	-	-	-
Date	-	-	-

Elevation (feet)	Depth (feet)	Sample Type/ Advancement Method	Rock		Soil Samples		Lithology	Material Description	Moisture Content (%)	Dry Density (pcf)	Fines Content (%)	Atterberg Limits		AASHTO & USCS Classifi- cations	Field Notes and Other Lab Tests
			Recovery (%)	RQD (%)	Blows per 6 in	Penetration Resistance						Liquid Limit	Plasticity Index		
								0.0 - 0.7 ft. 4" ASPHALT over 4" base.							
			86					0.7 - 13.0 ft. silty SAND with gravels, reddish orange, dry to damp, medium dense, decomposed granite, occasional 2" granite clasts.							
					15-15	30									
6530			100												
	10				10-11-13	24									
			100												
					10-11-13	24		13.0 - 25.0 ft. clayey SAND , brown with orange, medium plasticity, damp, medium dense.	2.6		44.3	31	17	A-6 (3) SC	
6520			57												
	20				6-7-6	13									
			100												
			70												
					6-5-7	12		25.0 - 34.0 ft. silty SAND with gravels, brown with orange, damp, medium dense.							
6510															
	30				8-10-13	23			0.4		12.0	NV	NP	A-2-4 (0)	
			100												
					10-8-8	16		34.0 - 50.0 ft. sandy lean CLAY with variable amounts of gravel and sand, brown, damp, very stiff to hard.							
6500			91												
	40				11-13-13	26									
			100												
					8-9-8	17									
6490															



Elevation (feet)	Depth (feet)	Sample Type/ Advancement Method	Rock		Soil Samples		Lithology	Material Description	Moisture Content (%)	Dry Density (pcf)	Fines Content (%)	Atterberg Limits		AASHTO & USCS Classifi- cations	Field Notes and Other Lab Tests
			Recovery (%)	RQD (%)	Blows per 6 in	Penetration Resistance						Liquid Limit	Plasticity Index		
6480	50		100					50.0 - 55.0 ft. clayey SAND with some gravels, brown, low plasticity, dry to damp, medium dense, calcite deposits up to 1" thick.	1.8		12.6	25	12	A-2-6 (0) SC	
				16-13-7	20										
			100					55.0 - 90.5 ft. CLAYSTONE, gray to brown, hard to very hard, damp.							
				23-30	53										
			100												
	60														
					40-50/5"	50/5"									
					50/6"	50/6"									
	70														
					23-38-50/5"	50/5"									
					15-31-53	84									
	80														
	90														
					50/6"	50/6"									
Bottom of Hole at 90.5 ft.															
90.0 ft - Boring terminated @ 90.5' due to time constraint on drilling															



Boring Began: 5/29/2018

Total Depth: 100.5 ft

Weather Notes: Partly Cloudy

Boring Completed: 5/31/2018

Ground Elevation: 6227.0 ft

Inclination from Horiz.: Vertical

Drilling Method(s): Hollow-Stem Auger /

Coordinates: Lat: Long:

Continuous Sampler

Location: N38.81538, W104.85350

Night Work: ☐

Driller: Authentic Drilling

Groundwater Levels: Not Observed

Drill Rig: CME 75

Logged By: L. Southerland

Hammer Type: Automatic (hydraulic), ER: 95%

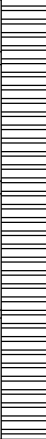
Final By: M. Lim

Symbol	-	-	-
Depth	-	-	-
Date	-	-	-

BORING LOG 2015 217-130 COS GEOLOGIC STUDY BORING LOGS FOR REPORT.GPJ 2015 YEH ASSOCIATES TEMPLATE (BACKUP 2018-09-19) - COPY.GDT COS LIBRARY 2-20-19.GLB 4/19/19

Elevation (feet)	Depth (feet)	Sample Type/ Advancement Method	Rock		Soil Samples		Lithology	Material Description	Moisture Content (%)	Dry Density (pcf)	Fines Content (%)	Atterberg Limits		AASHTO & USCS Classifi- cations	Field Notes and Other Lab Tests
			Recovery (%)	RQD (%)	Blows per 6 in	Penetration Resistance						Liquid Limit	Plasticity Index		
6220	10	X	14					0.0 - 0.3 ft. 4" ASPHALT.							
					4-6	10		0.3 - 12.0 ft. lean CLAY trace of gravel, gray - brown, moist, stiff to very stiff, iron concretions.							
			90												
					8-13	21									
6210	20	X	100					12.0 - 17.0 ft. fat CLAY, olive gray, moist, very stiff.	20.4	107.3	97.4	51	34	A-7-6 (35) CH	
					9-19	28									
			100					17.0 - 33.0 ft. CLAYSTONE, olive brown and gray, medium hard to very hard, moist.	13.1			49	30	A-7-6 (32) CL	
					20-43	63									
6200	30	X													
					30-50/5"	50/5"									
			100												
					37-50/6"	50/6"									
6190	40	X													
					50/4"	50/4"		33.0 - 100.5 ft. SHALE, gray to dark gray, hard to very hard, fissile , damp.							
			36												
					50/4"	50/4"									
6180	50	X													
					50/4"	50/4"									
			94												
					50/4"	50/4"									
		X													
		X													
		X													
		X													
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Elevation (feet)	Depth (feet)	Sample Type/ Advancement Method	Rock		Soil Samples		Lithology	Material Description	Moisture Content (%)	Dry Density (pcf)	Fines Content (%)	Atterberg Limits		AASHTO & USCS Classifi- cations	Field Notes and Other Lab Tests																																																																																
			Recovery (%)	RQD (%)	Blows per 6 in	Penetration Resistance						Liquid Limit	Plasticity Index																																																																																		
6170	60		30		50/5"	50/5"		33.0 - 100.5 ft. SHALE, gray to dark gray, hard to very hard, fissile , damp. (continued)																																																																																							
					50/2"	50/2"																																																																																									
6160	70		100		50/3"	50/3"																																																																																									
					50/4"	50/4"																																																																																									
6150	80		100		50/4"	50/4"																																																																																									
					50/3"	50/3"																																																																																									
6140	90		91		50/6"	50/6"																																																																																									
					50/6"	50/6"																																																																																									
6130	100				50/4"	50/4"																																																																																									
					50/4"	50/4"																																																																																									
6120					50/4"	50/4"																																																																																									



Boring Began: 6/19/2018

Total Depth: 100.2 ft

Weather Notes: Sunny, 90 F

Boring Completed: 6/20/2018

Ground Elevation: 6266.0 ft

Inclination from Horiz.: Vertical

Drilling Method(s): Hollow-Stem Auger /
Continuous Sampler

Coordinates: Lat: Long:

Location: N38.81183, W104.85411

Night Work: ☐

Driller: Authentic Drilling

Drill Rig: CME 75

Logged By: L. Southerland

Hammer Type: Automatic (hydraulic), ER: 95%

Final By: M. Lim

Groundwater Levels: Not Observed

Symbol	-	-	-
Depth	-	-	-
Date	-	-	-

BORING LOG 2015 217-130 COS GEOLOGIC STUDY BORING LOGS FOR REPORT.GPJ 2015 YEH ASSOCIATES TEMPLATE (BACKUP 2018-09-19) - COPY.GDT COS LIBRARY 2-20-19.GLB 4/19/19

Elevation (feet)	Depth (feet)	Sample Type/ Advancement Method	Rock		Soil Samples		Lithology	Material Description	Moisture Content (%)	Dry Density (pcf)	Fines Content (%)	Atterberg Limits		AASHTO & USCS Classifi- cations	Field Notes and Other Lab Tests
			Recovery (%)	RQD (%)	Blows per 6 in	Penetration Resistance						Liquid Limit	Plasticity Index		
6260			40					0.0 - 14.0 ft. sandy GRAVEL, reddish brown, dry, medium dense to loose.							
					10-10	20									
			24												
6250	10				3-5-2	7		14.0 - 19.0 ft. lean CLAY, gray - brown, moist, medium stiff.							
					3-5-2	7			11.8		97.2	46	29	A-7-6 (30) CL	15.0 ft - - presence of boulders @ 15', auger refusal in 2 previous borings
6240	20		100					19.0 - 39.0 ft. CLAYSTONE, gray, medium hard, medium plasticity, moist, waxy. Calcareous infilling @ 22'. - possible bentonite seam @ 29'. Possible perched water zone from 38.5-44'. 39.0 - 100.2 ft. SHALE, dark gray, moderately weathered, hard to very hard, fissile, medium to high plasticity.							
					23-31	54									
6230					20-33	53						44	24		
			100												
					25-32	57									
6220	30		95												
					20-24	44									
			98												
6210	40				50/5"	50/5"			5.8						38.5 ft - possible perched water zone from 38.5-44'
			83												
					50/4"	50/4"									
6200															
			89												
					50/5"	50/5"									
6190	50		93												



Elevation (feet)	Depth (feet)	Sample Type/ Advancement Method	Rock		Soil Samples		Lithology	Material Description	Moisture Content (%)	Dry Density (pcf)	Fines Content (%)	Atterberg Limits		AASHTO & USCS Classifi- cations	Field Notes and Other Lab Tests
			Recovery (%)	RQD (%)	Blows per 6 in	Penetration Resistance						Liquid Limit	Plasticity Index		
6210			82		50/6"	50/6"		39.0 - 100.2 ft. SHALE, dark gray, moderately weathered, hard to very hard, fissile, medium to high plasticity. (continued)							
	60				50/4"	50/4"						46	29	A-7-6 (30) CL	
			89												
					50/6"	50/6"									
6200			87												
	70				50/5"	50/5"									
			87												
					50/4"	50/4"									
6190			94												
	80				50/5"	50/5"									
			85												
					50/4"	50/4"		Bottom of Hole at 100.2 ft.							
6180			96												
	90				50/3"	50/3"									
			85												
					50/4"	50/4"									
6170															
	100				50/2"	50/2"									
6160															



Boring Began: 5/17/2018

Total Depth: 50.3 ft

Weather Notes: Sunny

Boring Completed: 5/29/2018

Ground Elevation: 6178.0 ft

Inclination from Horiz.: Vertical

Drilling Method(s): Hollow-Stem Auger /
Continuous Sampler

Coordinates: Lat: Long:

Location: N38.81143, W104.85246

Night Work: ☐

Driller: Vine Laboratories

Drill Rig: CME 55

Logged By: M. Boyd

Hammer Type: Automatic (hydraulic), ER: 90%

Final By: M. Lim

Groundwater Levels: Not Observed

Symbol	Depth	Date
-	-	-
-	-	-

Elevation (feet)	Depth (feet)	Sample Type/ Advancement Method	Soil Samples		Lithology	Material Description	Moisture Content (%)	Dry Density (pcf)	Fines Content (%)	Atterberg Limits		AASHTO & USCS Classifi- cations	Field Notes and Other Lab Tests
			Blows per 6 in	Penetration Resistance						Liquid Limit	Plasticity Index		
			4-6	10		0.0 - 0.8 ft. 6" ASPHALT over 4" base.							
			3-3-5	8		0.8 - 6.5 ft. lean CLAY with gravel, brown, damp, stiff.							
			3-4-6	10									
			7-7-6	13			5.0						
			5-8	13		6.5 - 26.0 ft. lean CLAY , olive, moist, stiff to very stiff.							
6170			3-4-6	10			17.0		87.1	42	26	A-7-6 (22) CL	
	10		7-9-8	17			12.3		76.0	40	24	A-6 (17) CL	
			5-5	10			20.2	100.1					
			5-7-8	15			17.9		74.1	45	27	A-7-6 (19) CL	
6160													
	20		6-7	13		- brown and gray to dark brown below 21'.							
			5-5-7	12									
			5-6-6	12									
			5-9	14									
			5-8-13	21			15.2		96.8	43	27	A-7-6 (27) CL	
6150						26.0 - 31.5 ft. CLAYSTONE , dark brown, medium hard, moist, medium plasticity.							
	30		19-27-29	56									
			11-19	30									
			11-28-30	58									
			50/5"	50/5"		31.5 - 50.3 ft. SHALE , dark gray to black, very hard, very friable/platy.							
			50/5"	50/5"									
			50/4"	50/4"									
6140			50/4"	50/4"									
	40		50/5"	50/5"									
			50/5"	50/5"									
			50/4"	50/4"									
6130													
	50		50/4"	50/4"		Bottom of Hole at 50.3 ft.							

BORING LOG 2015 217-130 COS GEOLOGIC STUDY BORING LOGS FOR REPORT.GPJ 2015 YEH ASSOCIATES TEMPLATE (BACKUP 2018-09-19) - COPY.GDT COS LIBRARY 2-20-19.GLB 4/19/19



Boring Began: 5/15/2018

Total Depth: 34.3 ft

Weather Notes: Clear to P.

Boring Completed: 5/15/2018

Ground Elevation: 6155.0 ft

Cloudy

Drilling Method(s): Hollow-Stem Auger

Coordinates: Lat: Long:

Inclination from Horiz.: Vertical

Driller: Vine Laboratories

Location: N38.80914, W104.85081

Night Work: ☐

Drill Rig: CME 55

Hammer Type: Automatic (hydraulic), ER: 90%

Logged By: R. Desterhouse

Final By: M. Lim

Groundwater Levels: Not Observed

Symbol	Depth	Date
-	-	-
-	-	-

BORING LOG 2015 217-130 COS GEOLOGIC STUDY BORING LOGS FOR REPORT.GPJ 2015 YEH ASSOCIATES TEMPLATE (BACKUP 2018-09-19) - COPY GDT COS LIBRARY 2-20-19.GLB 4/19/19

Elevation (feet)	Depth (feet)	Sample Type/ Advancement Method	Soil Samples		Lithology	Material Description	Moisture Content (%)	Dry Density (pcf)	Fines Content (%)	Atterberg Limits		AASHTO & USCS Classifi- cations	Field Notes and Other Lab Tests
			Blows per 6 in	Penetration Resistance						Liquid Limit	Plasticity Index		
						0.0 - 12.0 ft. lean CLAY , brown, moist, stiff to very stiff, presence of organic materials.							
6150	5		5-11	16									
6145	10		5-16	21									
			6-17	23			18.8	111.8	95.5	49	33	A-7-6 (34) CL	
			8-15	23									
			12-11-15	26		12.0 - 15.0 ft. WEATHERED CLAYSTONE , olive gray, decomposed, firm to medium hard, moist, calcareous streaks, rust staining.							
6140	15		15-32	47									
			12-19-30	49		15.0 - 28.0 ft. CLAYSTONE , olive gray to dark brown, medium hard to hard, moist, some sandstone interbeds, calcareous streaks, rust staining.							
			26-50/3"	50/3"									
			25-40-50/4"	50/4"									
6135	20					- crystallized wood chip in sample @ 19'.							
6130	25		50/6"	50/6"									
6125	30		50/5"	50/5"		28.0 - 34.3 ft. SHALE , dark gray, medium hard.							
			50/4"	50/4"									
						Bottom of Hole at 34.3 ft.							

Appendix C

LABORATORY TEST RESULTS





Summary of Laboratory Test Results

Project No: 217-130 Project Name: COS Engineering Geology Study, Colorado Springs, Colorado

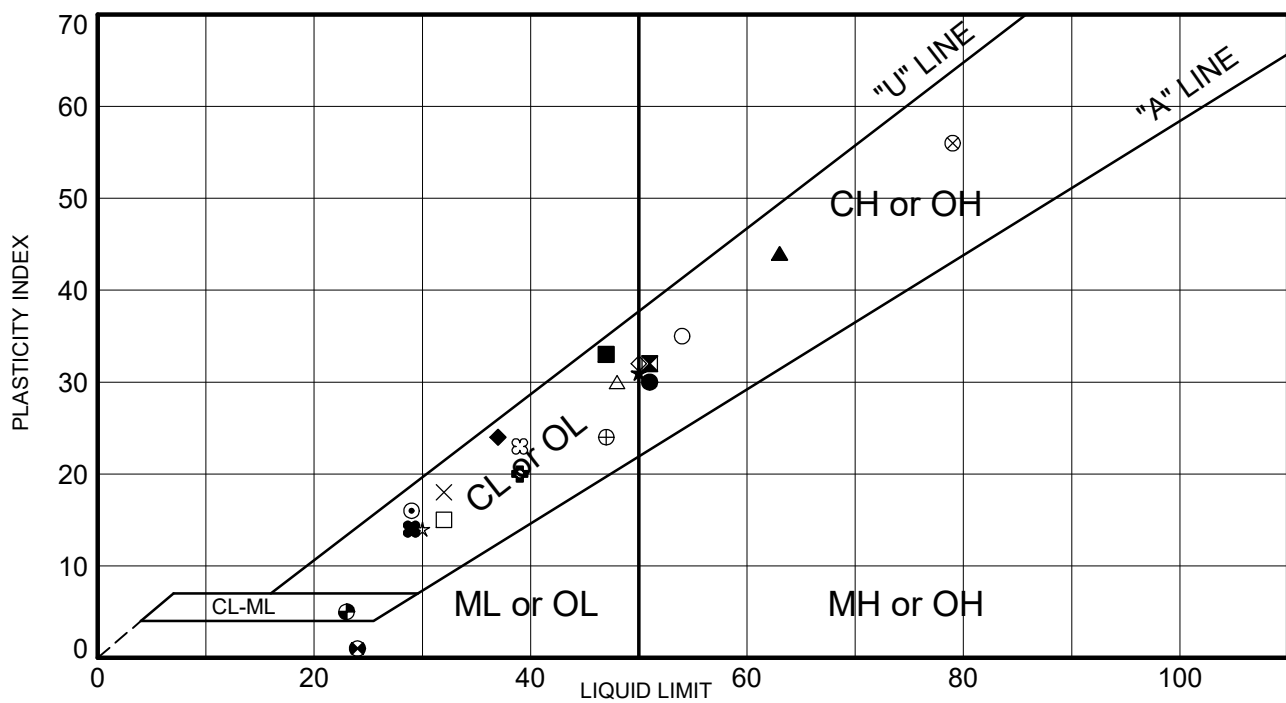
Sample Location			Natural Moisture Content (%)	Natural Dry Density (pcf)	Gradation			Atterberg			pH	Water Soluble Sulfate (%)	% Swell (+) / Consolidation (-)	Unconf. Comp. Strength (psf)	R-Value	Classification	
Boring No.	Depth (ft)	Sample Type			Gravel > #4 (%)	Sand (%)	Fines < #200 (%)	LL	PL	PI						AASHTO	USCS
B1-4	8.5	SH	21.0	93.1			95.1	51	21	30						A-7-6(31)	CH
B1-4	10.5	MC	20.8													--	--
B1-4	19.0	CORE	15.0													--	--
B1-4	23.5	MC	13.9	120.0			98.0	51	19	32						A-7-6(34)	CH
B1-5	4.0	MC	25.6	96.9			90.1	63	19	44						A-7-6(43)	CH
B1-5	9.0	SH	20.4	104.3			94.7	50	19	31						A-7-6(32)	CH
B1-7	8.5	SH	7.1	107.9			24.4	29	13	16						A-2-6(1)	SC
B1-7	13.5	SPT	8.3				45.3	39	19	20						A-6(5)	SC
B1-8	8.5	SH	24.5				95.0	54	19	35				8219		A-7-6(36)	CH
B1-8	19.3	MC	17.0	112.8	0.0	0.0		48	18	30						A-7-6(33)	CL
B1-8	45.0	MC	12.4	99.7	0.0	0.0	100.0	79	23	56						A-7-6(65)	CH
B1-11.1	77.0	CORE	10.8					47	23	24						A-7-6(27)	CL
B1-11.2	20.0	SPT	7.7				30.4	32	17	15						A-2-6(1)	SC
B1-11.2	25.0	MC	1.9				11.7	24	23	1						A-2-4(0)	
B1-11.2	30.0	SPT	2.5		17.0	72.6	10.4	23	18	5						A-1-b(0)	SW-SC
B1-11.2	40.0	SPT	16.6				41.6	30	16	14						A-6(2)	SC
B1-11.2	45.0	MC	16.3				51.3	39	16	23						A-6(8)	CL
B1-12	13.0	SH	17.8	110.3			90.0	47	14	33				14017		A-7-6(30)	CL
B1-12	23.0	SH	15.0	111.2			62.7	37	13	24						A-6(12)	CL
B1-14	10.5	MC	15.3	108.8			71.2	50	18	32						A-7-6(21)	CH
B1-16	9.5	MC	9.9	123.1			37.6	32	14	18						A-6(2)	SC
B1-16	29.5	MC	9.6	119.8			18.7	29	15	14						A-2-6(0)	SC
B1-16	30.0	CORE	9.7													--	--
B1-16	44.5	MC	9.7											796		--	--
B1-16	59.5	MC	19.7	111.1			83.2	50	16	34						A-7-6(28)	CH



Summary of Laboratory Test Results

Project No: 217-130 Project Name: COS Engineering Geology Study, Colorado Springs, Colorado

Sample Location			Natural Moisture Content (%)	Natural Dry Density (pcf)	Gradation			Atterberg			pH	Water Soluble Sulfate (%)	% Swell (+) / Consolidation (-)	Unconf. Comp. Strength (psf)	R-Value	Classification	
Boring No.	Depth (ft)	Sample Type			Gravel > #4 (%)	Sand (%)	Fines < #200 (%)	LL	PL	PI						AASHTO	USCS
B1-16	68.5	MC						81	18	63						--	--
B1-19	9.5	MC	15.7	109.4			94.2	53	24	29						A-7-6(31)	CH
B1-19	18.5	SH						49	22	27						--	--
B1-19	24.5	CORE	27.9	94.5				56	22	34						A-7-6(35)	CH
B1-19	33.5	MC	16.7				98.8	49	21	28						A-7-6(31)	CL
B1-19	43.5	MC	14.9	114.7			98.3	49	20	29						A-7-6(31)	CL
B1-19	44.5	CORE														--	--
B1-19	48.5	MC						82	18	64						--	--
B1-19	60.0	MC	18.5	106.9				54	20	34						A-7-6(37)	CH
B2-1	15.0	SPT	2.6				44.3	31	14	17						A-6(3)	SC
B2-1	30.0	SPT	0.4				12.0	NP	NP	NP						A-2-4(0)	
B2-1	50.0	SPT	1.8				12.6	25	13	12						A-2-6(0)	SC
B2-5	13.5	MC	20.4	107.3			97.4	51	17	34						A-7-6(35)	CH
B2-5	28.5	MC	13.1					49	19	30						A-7-6(32)	CL
B2-7	15.0	SPT	11.8				97.2	46	17	29						A-7-6(30)	CL
B2-7	23.5	SH						44	20	24						--	--
B2-7	38.5	MC	5.8													--	--
B2-7	58.0	CORE						46	17	29						A-7-6(30)	CL
B2-8	5.0	SPT	5.0													--	--
B2-8	7.5	SPT	17.0				87.1	42	16	26						A-7-6(22)	CL
B2-8	9.0	SPT	12.3				76.0	40	16	24						A-6(17)	CL
B2-8	14.0	MC	20.2	100.1												--	--
B2-8	15.0	SPT	17.9				74.1	45	18	27						A-7-6(19)	CL
B2-8	25.0	SPT	15.2				96.8	43	16	27						A-7-6(27)	CL
B2-11	10.0	MC	18.8	111.8			95.5	49	16	33						A-7-6(34)	CL



BOREHOLE	DEPTH	LL	PL	PI	Passing #200	USCS Sample Description	AASHTO Class.
● B1-4	8.5	51	21	30	95	FAT CLAY(CH)	A-7-6(31)
⊠ B1-4	23.5	51	19	32	98	FAT CLAY(CH)	A-7-6(34)
▲ B1-5	4.0	63	19	44	90	FAT CLAY(CH)	A-7-6(43)
★ B1-5	9.0	50	19	31	95	FAT CLAY(CH)	A-7-6(32)
⊙ B1-7	8.5	29	13	16	24	CLAYEY SAND(SC)	A-2-6(1)
⊕ B1-7	13.5	39	19	20	45	CLAYEY SAND(SC)	A-6(5)
○ B1-8	8.5	54	19	35	95	FAT CLAY(CH)	A-7-6(36)
△ B1-8	19.3	48	18	30	100	LEAN CLAY(CL)	A-7-6(33)
⊗ B1-8	45.0	79	23	56	100	FAT CLAY(CH)	A-7-6(65)
⊕ B1-11.1	77.0	47	23	24	99	LEAN CLAY(CL)	A-7-6(27)
□ B1-11.2	20.0	32	17	15	30	CLAYEY SAND(SC)	A-2-6(1)
⊙ B1-11.2	25.0	24	23	1	12		A-2-4(0)
⬤ B1-11.2	30.0	23	18	5	10	WELL-GRADED SAND with SILTY CLAY and GRAVEL(SW-SG)	A-1-b(0)
☆ B1-11.2	40.0	30	16	14	42	CLAYEY SAND(SC)	A-6(2)
⊗ B1-11.2	45.0	39	16	23	51	SANDY LEAN CLAY(CL)	A-6(8)
■ B1-12	13.0	47	14	33	90	LEAN CLAY(CL)	A-7-6(30)
◆ B1-12	23.0	37	13	24	63	SANDY LEAN CLAY(CL)	A-6(12)
◇ B1-14	10.5	50	18	32	71	FAT CLAY with SAND(CH)	A-7-6(21)



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ATTERBERG LIMITS

FIGURE

Project No. 217-130

Drawn By: Dan

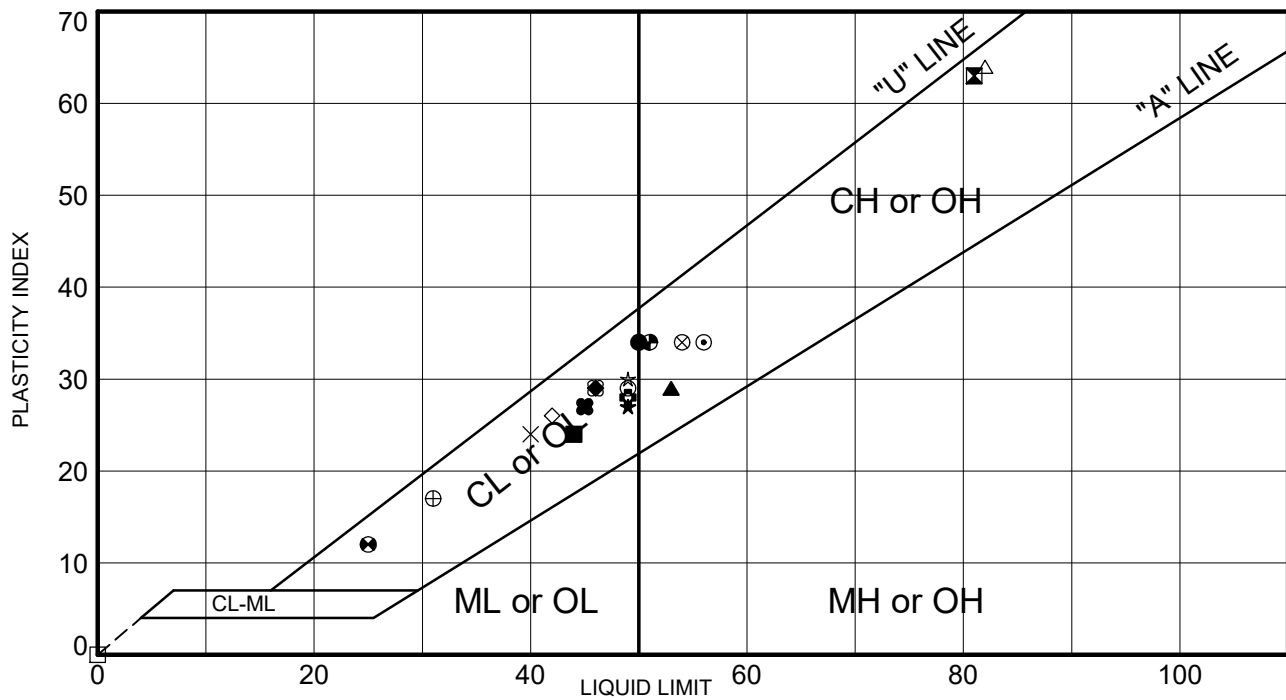
Checked By: Ming

Date: 4/19/2019

Yeh Lab: COS

COS Engineering Geology Study
Colorado Springs, Colorado

C - 1



BOREHOLE	DEPTH	LL	PL	PI	Passing #200	USCS Sample Description	AASHTO Class.
● B1-16	59.5	50	16	34	83	FAT CLAY with SAND(CH)	A-7-6(28)
⊠ B1-16	68.5	81	18	63			
▲ B1-19	9.5	53	24	29	94	FAT CLAY(CH)	A-7-6(31)
★ B1-19	18.5	49	22	27			
⊙ B1-19	24.5	56	22	34	93	FAT CLAY(CH)	A-7-6(35)
⊕ B1-19	33.5	49	21	28	99	LEAN CLAY(CL)	A-7-6(31)
○ B1-19	43.5	49	20	29	98	LEAN CLAY(CL)	A-7-6(31)
△ B1-19	48.5	82	18	64			
⊗ B1-19	60.0	54	20	34	99	FAT CLAY(CH)	A-7-6(37)
⊕ B2-1	15.0	31	14	17	44	CLAYEY SAND(SC)	A-6(3)
□ B2-1	30.0	NP	NP	NP	12		A-2-4(0)
⊕ B2-1	50.0	25	13	12	13	CLAYEY SAND(SC)	A-2-6(0)
⬤ B2-5	13.5	51	17	34	97	FAT CLAY(CH)	A-7-6(35)
☆ B2-5	28.5	49	19	30	99	LEAN CLAY(CL)	A-7-6(32)
⊗ B2-7	15.0	46	17	29	97	LEAN CLAY(CL)	A-7-6(30)
■ B2-7	23.5	44	20	24			
◆ B2-7	58.0	46	17	29	98	LEAN CLAY(CL)	A-7-6(30)
◇ B2-8	7.5	42	16	26	87	LEAN CLAY(CL)	A-7-6(22)



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ATTERBERG LIMITS

FIGURE

Project No. 217-130

Drawn By: Dan

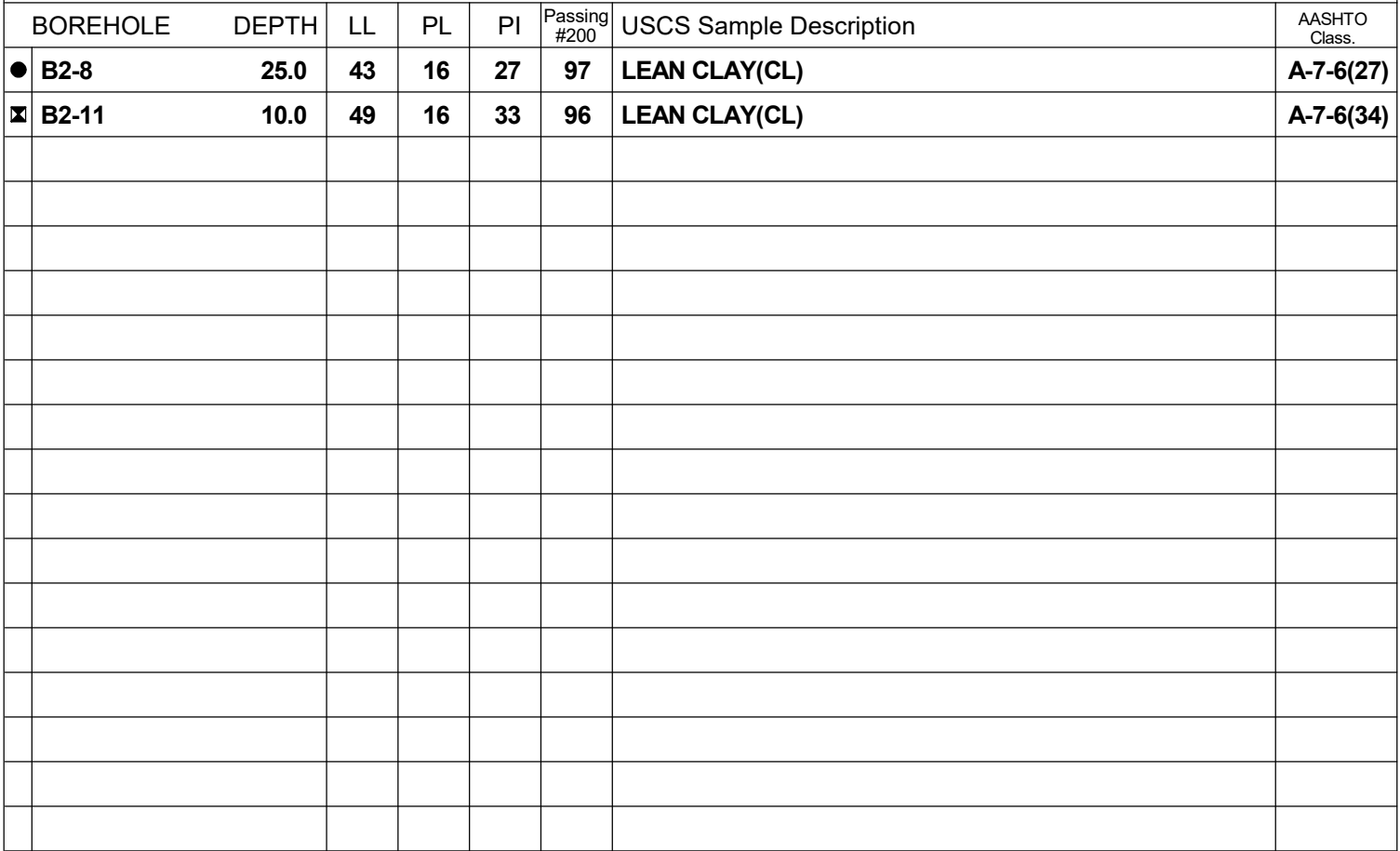
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Date: 4/19/2019

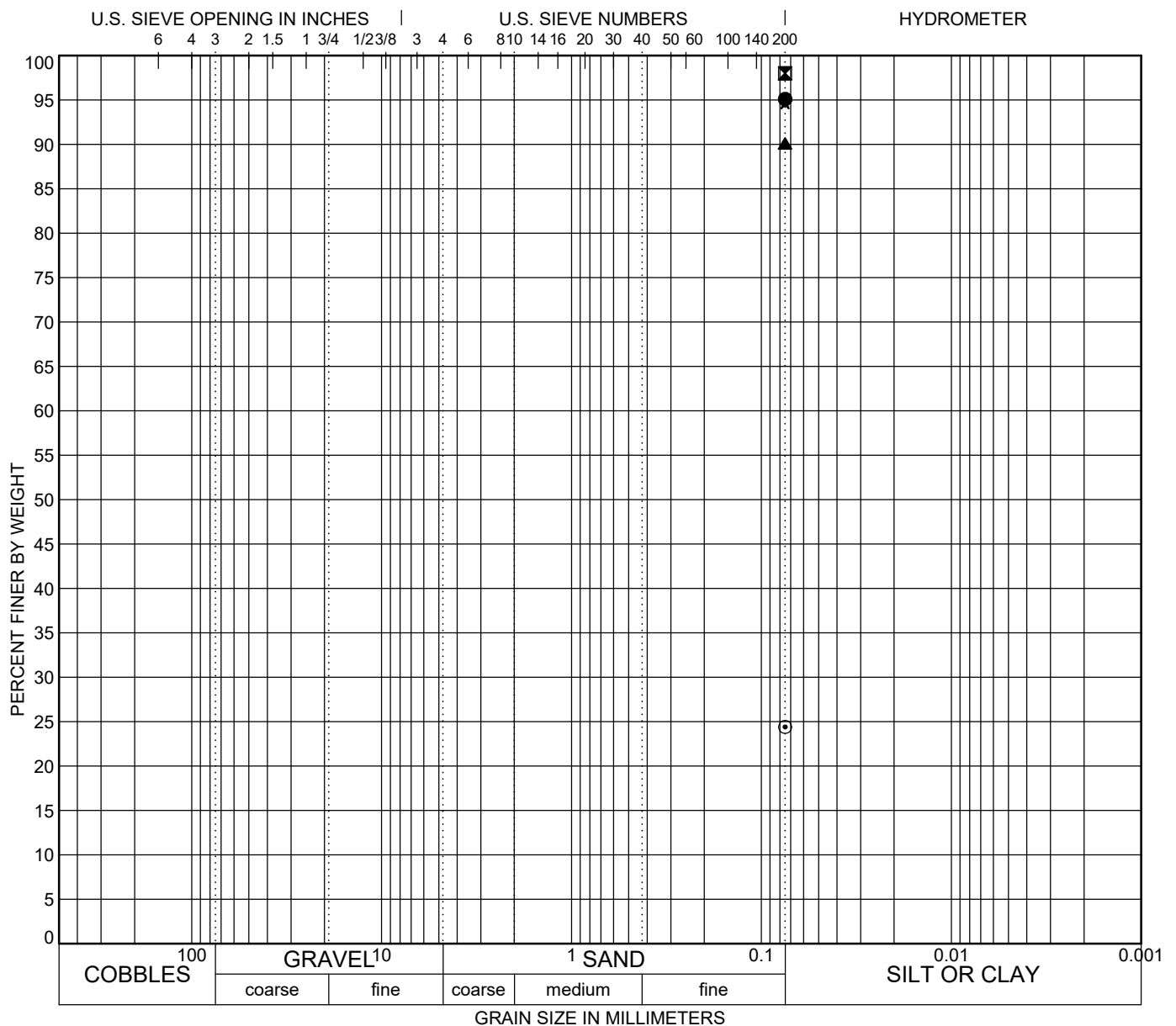
Yeh Lab: COS

COS Engineering Geology Study
Colorado Springs, Colorado

C - 2



 Yeh and Associates, Inc. Consulting Engineers & Scientists			ATTERBERG LIMITS	FIGURE C - 3
Project No. 217-130 Drawn By: Dan Checked By: Ming	Date: 4/19/2019 Yeh Lab: COS	COS Engineering Geology Study Colorado Springs, Colorado		



BOREHOLE	DEPTH	AASHTO Classification	USCS Classification	LL	PL	PI	%Gravel	%Sand	%Fines	
									%Silt	%Clay
● B1-4	8.5	A-7-6(31)	CH	51	21	30			95.1	
⊠ B1-4	23.5	A-7-6(34)	CH	51	19	32			98.0	
▲ B1-5	4.0	A-7-6(43)	CH	63	19	44			90.1	
★ B1-5	9.0	A-7-6(32)	CH	50	19	31			94.7	
⊙ B1-7	8.5	A-2-6(1)	SC	29	13	16			24.4	



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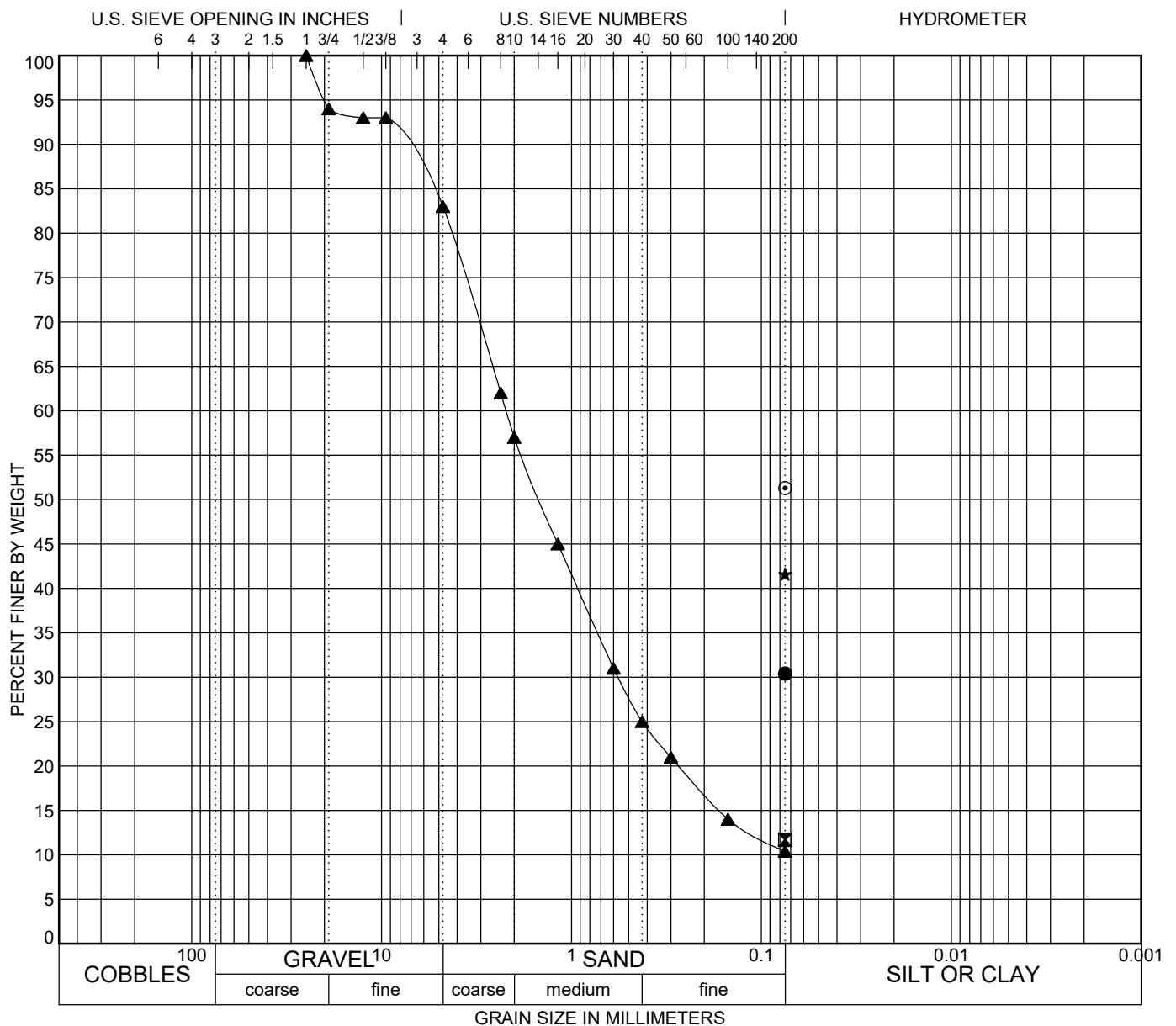
SIEVE ANALYSIS

FIGURE

Project No. 217-130 Date: 4/19/2019
 Drawn By: Dan Yeh Lab: COS
 Checked By: Ming

COS Engineering Geology Study
 Colorado Springs, Colorado

C- 4



BOREHOLE	DEPTH	AASHTO Classification	USCS Classification	LL	PL	PI	%Gravel	%Sand	%Fines	
									%Silt	%Clay
● B1-11.2	20.0	A-2-6(1)	SC	32	17	15			30.4	
▣ B1-11.2	25.0	A-2-4(0)		24	23	1			11.7	
▲ B1-11.2	30.0	A-1-b(0)	SW-SC	23	18	5	17.0	72.6	10.4	
★ B1-11.2	40.0	A-6(2)	SC	30	16	14			41.6	
⊙ B1-11.2	45.0	A-6(8)	CL	39	16	23			51.3	



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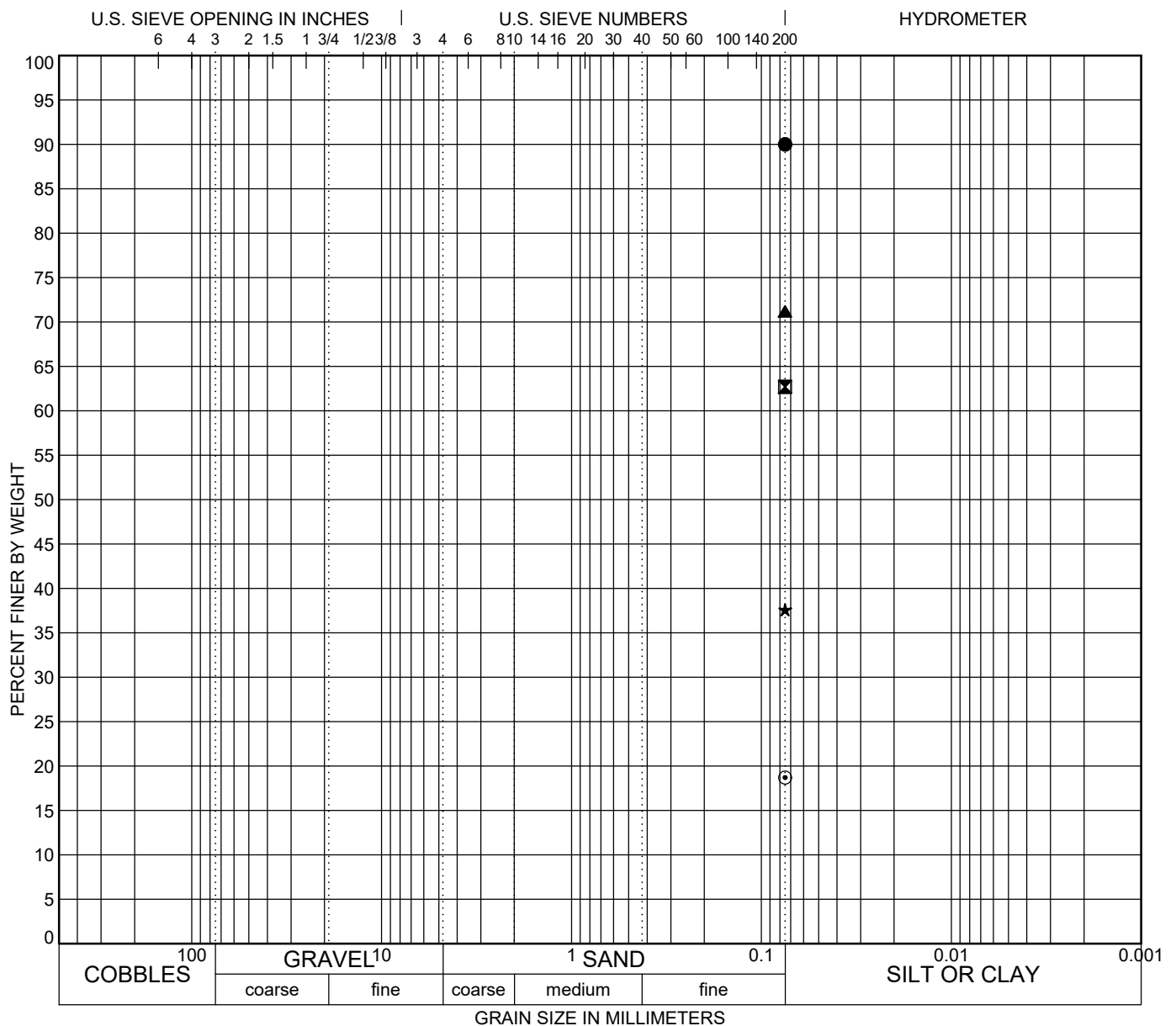
SIEVE ANALYSIS

FIGURE

Project No. 217-130 Date: 4/19/2019
Drawn By: Dan Yeh Lab: COS
Checked By: Ming

COS Engineering Geology Study
Colorado Springs, Colorado

C- 6



BOREHOLE	DEPTH	AASHTO Classification	USCS Classification	LL	PL	PI	%Gravel	%Sand	%Fines	
									%Silt	%Clay
● B1-12	13.0	A-7-6(30)	CL	47	14	33			90.0	
⊠ B1-12	23.0	A-6(12)	CL	37	13	24			62.7	
▲ B1-14	10.5	A-7-6(21)	CH	50	18	32			71.2	
★ B1-16	9.5	A-6(2)	SC	32	14	18			37.6	
⊙ B1-16	29.5	A-2-6(0)	SC	29	15	14			18.7	



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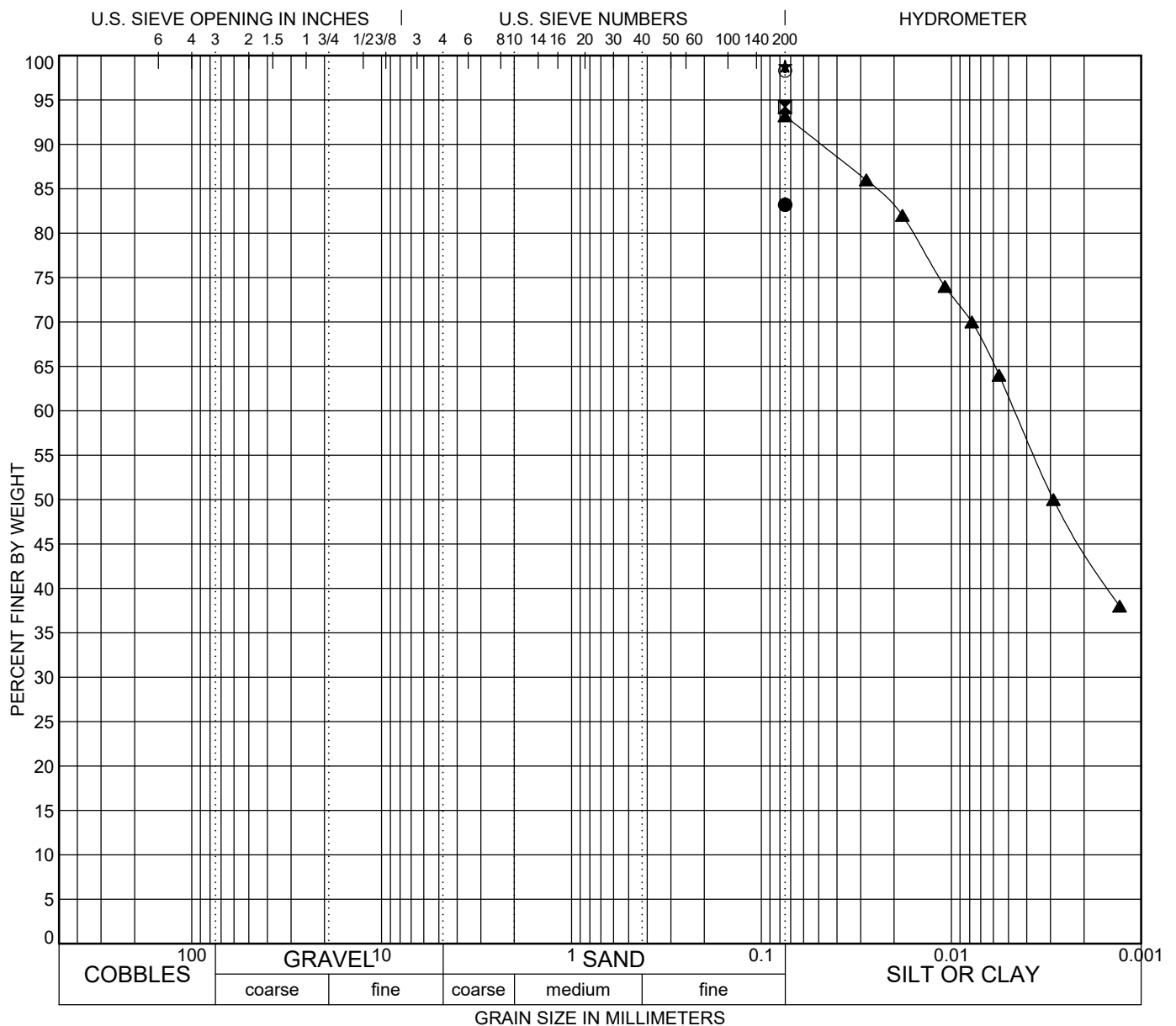
SIEVE ANALYSIS

FIGURE

Project No. 217-130 Date: 4/19/2019
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COS Engineering Geology Study
 Colorado Springs, Colorado

C- 7



BOREHOLE	DEPTH	AASHTO Classification	USCS Classification	LL	PL	PI	%Gravel	%Sand	%Fines	
									%Silt	%Clay
● B1-16	59.5	A-7-6(28)	CH	50	16	34			83.2	
☒ B1-19	9.5	A-7-6(31)	CH	53	24	29			94.2	
▲ B1-19	24.5	A-7-6(35)	CH	56	22	34			31.6	61.6
★ B1-19	33.5	A-7-6(31)	CL	49	21	28			98.8	
◎ B1-19	43.5	A-7-6(31)	CL	49	20	29			98.3	



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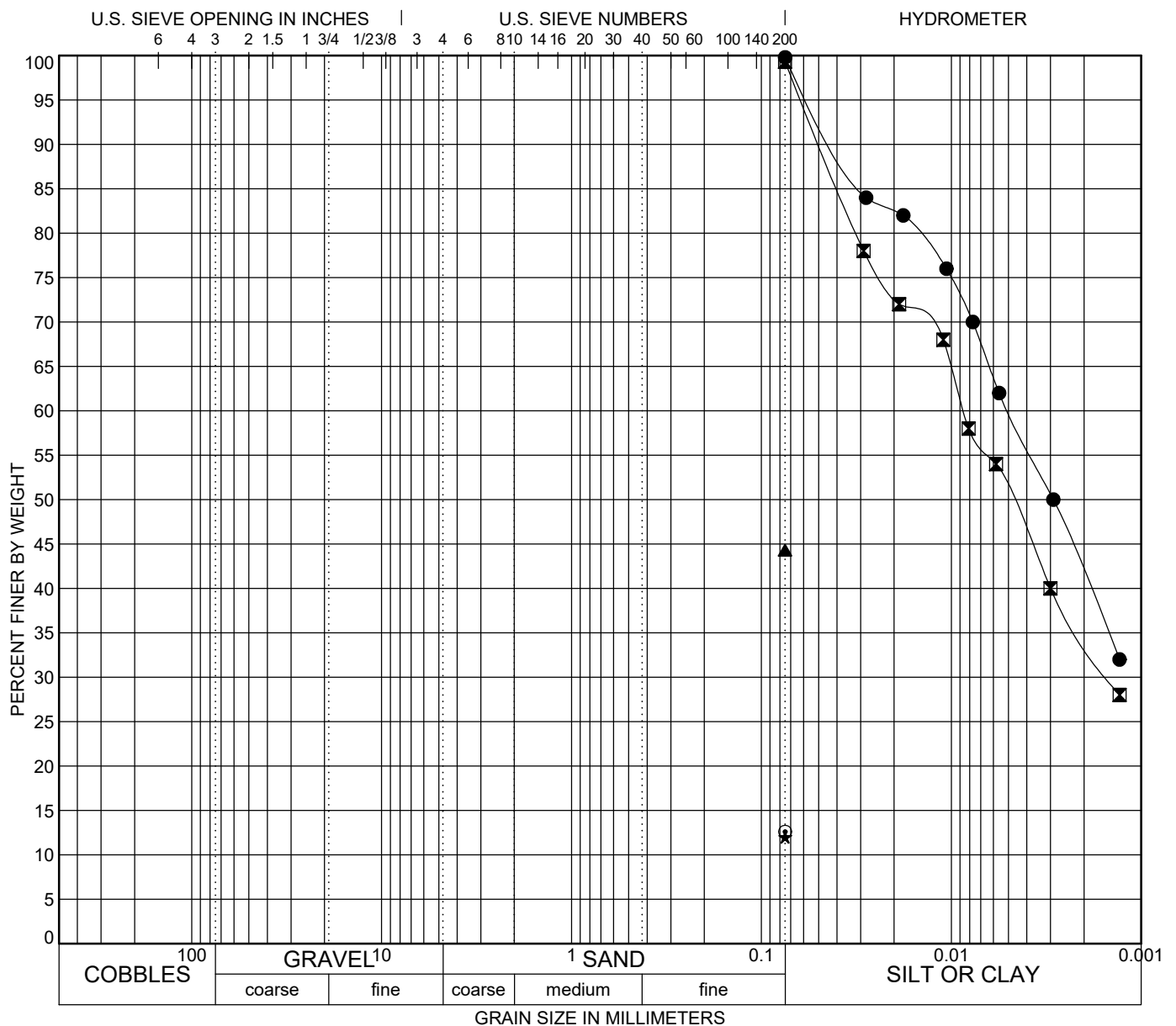
SIEVE ANALYSIS

FIGURE

Project No. 217-130 Date: 4/19/2019
Drawn By: Dan Yeh Lab: COS
Checked By: Ming

COS Engineering Geology Study
Colorado Springs, Colorado

C- 8



BOREHOLE	DEPTH	AASHTO Classification	USCS Classification	LL	PL	PI	%Gravel	%Sand	%Fines	
									%Silt	%Clay
● B1-19	44.5	--							39.9	59.9
☒ B1-19	60.0	A-7-6(37)	CH	54	20	34			48.5	50.8
▲ B2-1	15.0	A-6(3)	SC	31	14	17			44.3	
★ B2-1	30.0	A-2-4(0)		NP	NP	NP			12.0	
◎ B2-1	50.0	A-2-6(0)	SC	25	13	12			12.6	



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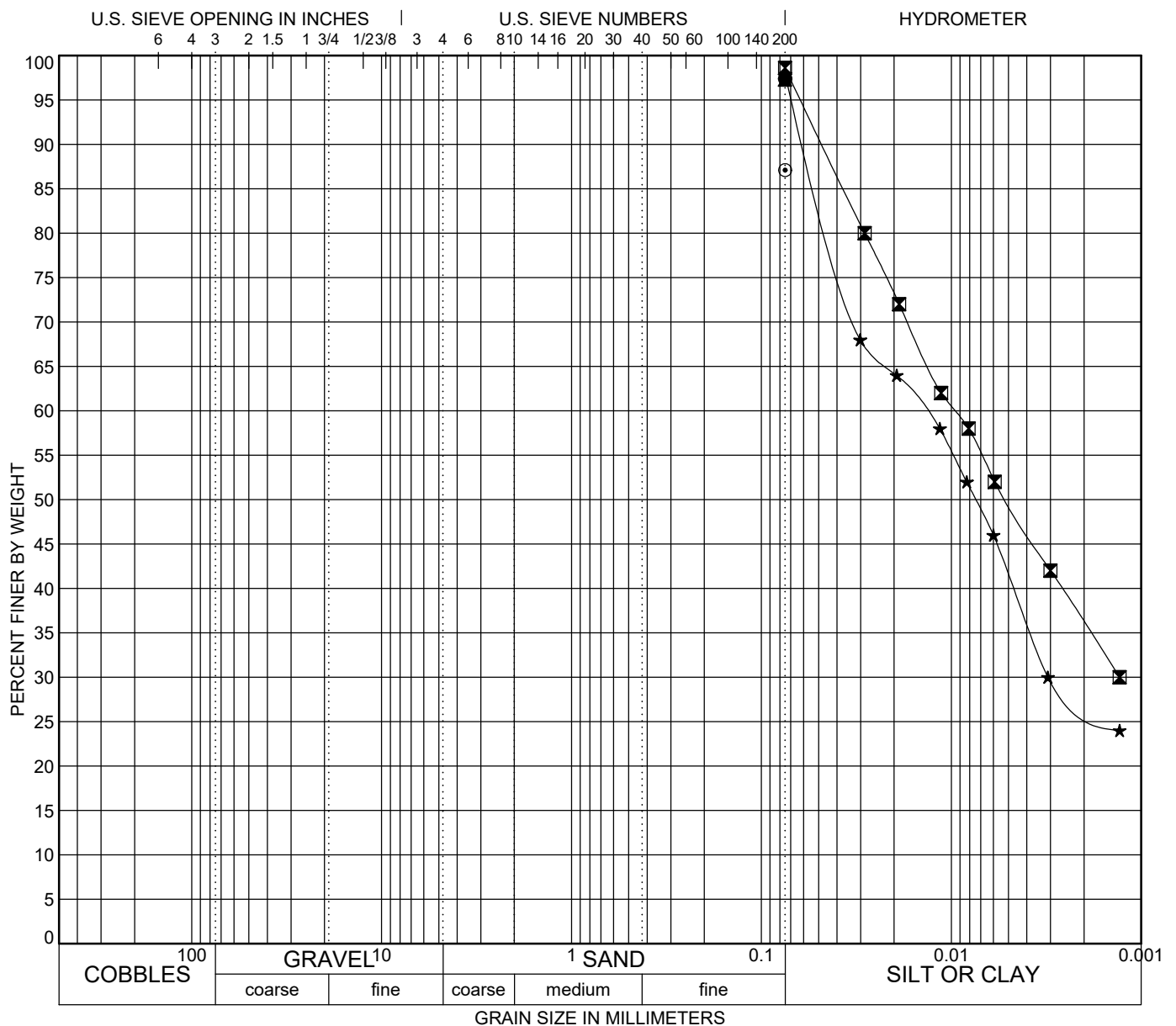
SIEVE ANALYSIS

FIGURE

Project No. 217-130 Date: 4/19/2019
 Drawn By: Dan Yeh Lab: COS
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COS Engineering Geology Study
 Colorado Springs, Colorado

C- 9



BOREHOLE	DEPTH	AASHTO Classification	USCS Classification	LL	PL	PI	%Gravel	%Sand	%Fines	
									%Silt	%Clay
● B2-5	13.5	A-7-6(35)	CH	51	17	34			97.4	
☒ B2-5	28.5	A-7-6(32)	CL	49	19	30			49.0	49.6
▲ B2-7	15.0	A-7-6(30)	CL	46	17	29			97.2	
★ B2-7	58.0	A-7-6(30)	CL	46	17	29			56.3	41.6
⊙ B2-8	7.5	A-7-6(22)	CL	42	16	26			87.1	



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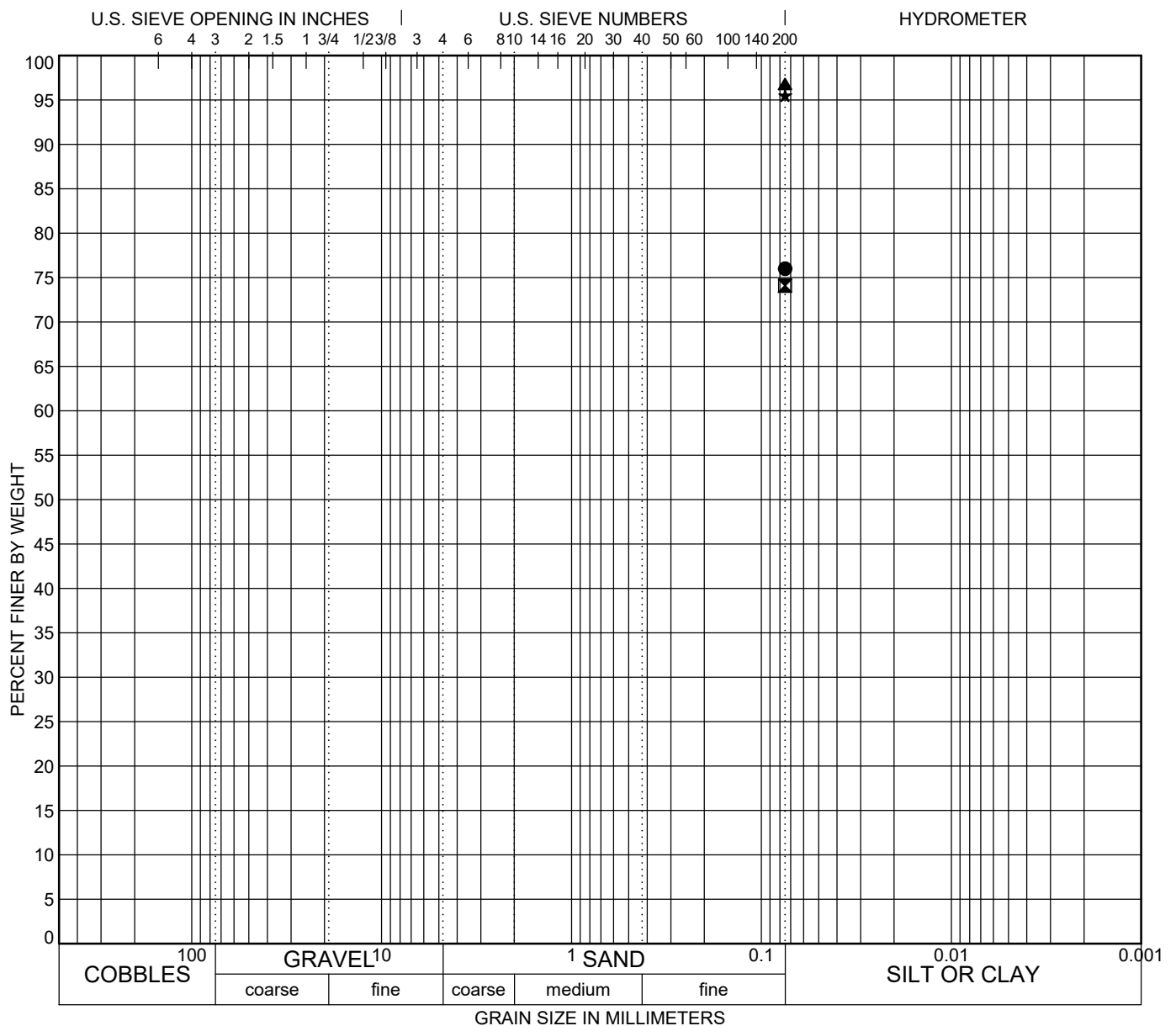
SIEVE ANALYSIS

FIGURE

Project No. 217-130 Date: 4/19/2019
 Drawn By: Dan Yeh Lab: COS
 Checked By: Ming

COS Engineering Geology Study
 Colorado Springs, Colorado

C- 10



BOREHOLE	DEPTH	AASHTO Classification	USCS Classification	LL	PL	PI	%Gravel	%Sand	%Fines	
									%Silt	%Clay
● B2-8	9.0	A-6(17)	CL	40	16	24			76.0	
☒ B2-8	15.0	A-7-6(19)	CL	45	18	27			74.1	
▲ B2-8	25.0	A-7-6(27)	CL	43	16	27			96.8	
★ B2-11	10.0	A-7-6(34)	CL	49	16	33			95.5	



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SIEVE ANALYSIS

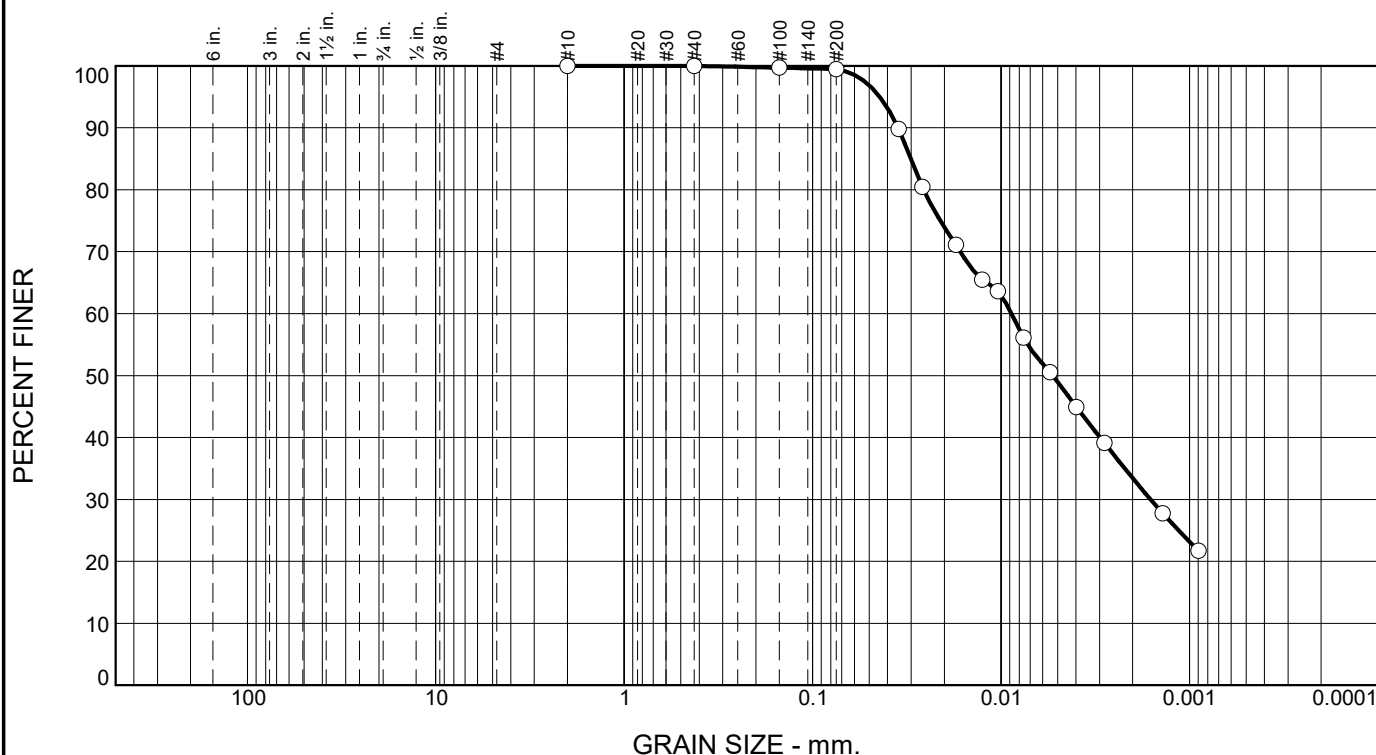
FIGURE

Project No. 217-130 Date: 4/19/2019
 Drawn By: Dan Yeh Lab: COS
 Checked By: Ming

COS Engineering Geology Study
 Colorado Springs, Colorado

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Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	0.0	0.5	50.5	49.0

TEST RESULTS			
Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
#10	100.0		
#40	100.0		
#100	99.7		
#200	99.5		
0.0350 mm.	89.8		
0.0261 mm.	80.4		
0.0174 mm.	71.1		
0.0126 mm.	65.5		
0.0104 mm.	63.6		
0.0076 mm.	56.1		
0.0055 mm.	50.5		
0.0040 mm.	44.9		
0.0028 mm.	39.1		
0.0014 mm.	27.7		
0.0009 mm.	21.7		

* (no specification provided)

Material Description
 Fat Clay, dark brown with shale partings

Atterberg Limits (ASTM D 4318)
 PL= 26 LL= 52 PI= 26

Classification
 USCS (D 2487)= CH AASHTO (M 145)=

Coefficients
 D₉₀= 0.0352 D₈₅= 0.0301 D₆₀= 0.0088
 D₅₀= 0.0053 D₃₀= 0.0016 D₁₅=
 D₁₀= C_u= C_c=

Remarks
 F.M.=0.00

Date Received: _____ Date Tested: 10/15/2018
 Tested By: T.Reid
 Checked By: Y.Lee
 Title: _____

Vertical Loads were applied for Project Request

Source of Sample: B1-18 Depth: 20.0'

Date Sampled:

Kleinfelder, Inc.

Irving, TX

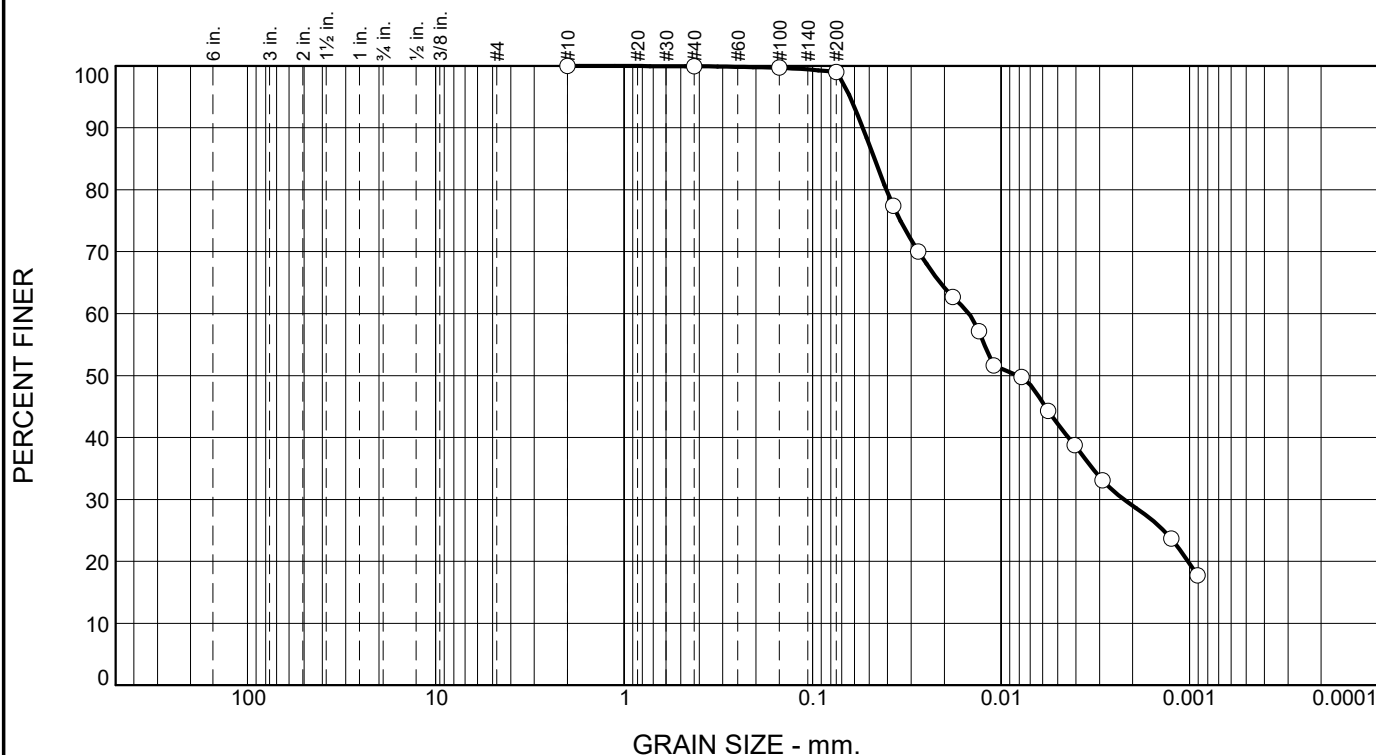
Client: YEH Associates

Project: YEH & Associates Misc Lab Testing
COS Geology Study_PN: 217-130

Project No: 20192271.001A

Figure

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	0.1	0.9	56.8	42.2

TEST RESULTS			
Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
#10	100.0		
#40	99.9		
#100	99.7		
#200	99.0		
0.0374 mm.	77.4		
0.0275 mm.	70.0		
0.0180 mm.	62.7		
0.0131 mm.	57.1		
0.0109 mm.	51.6		
0.0078 mm.	49.8		
0.0056 mm.	44.3		
0.0041 mm.	38.8		
0.0029 mm.	33.1		
0.0012 mm.	23.7		
0.0009 mm.	17.7		

* (no specification provided)

Material Description		
Lean Clay, dark brown		
Atterberg Limits (ASTM D 4318)		
PL= 26	LL= 48	PI= 22
Classification		
USCS (D 2487)= CL AASHTO (M 145)=		
Coefficients		
D ₉₀ = 0.0542	D ₈₅ = 0.0470	D ₆₀ = 0.0148
D ₅₀ = 0.0081	D ₃₀ = 0.0022	D ₁₅ =
D ₁₀ =	C _u =	C _c =
F.M.=0.00		
Remarks		
Date Received: _____ Date Tested: 10/15/2018		
Tested By: T.Reid		
Checked By: Y.Lee		
Title: _____		

Source of Sample: B2-7 Depth: 23.5'

Date Sampled:

Kleinfelder, Inc.

Irving, TX

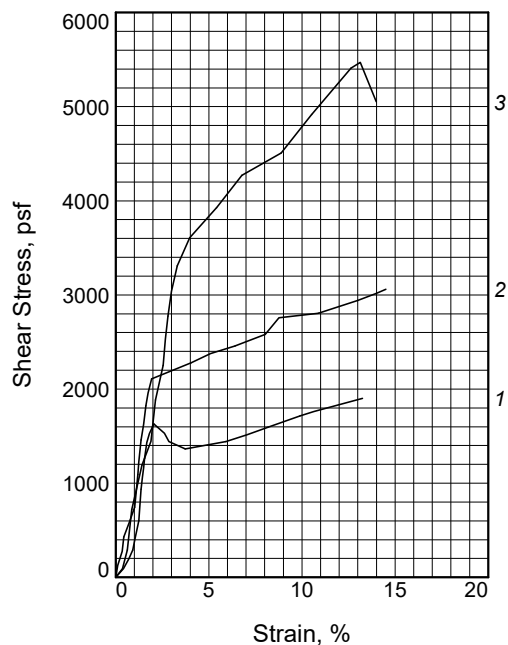
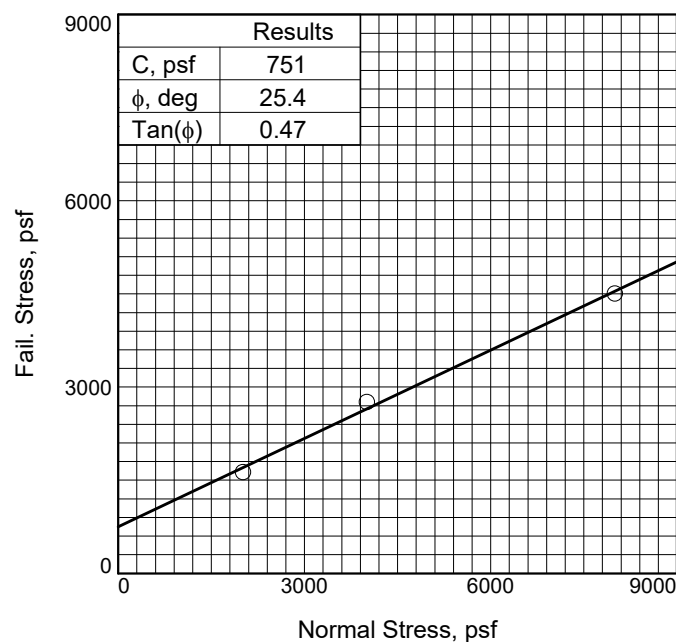
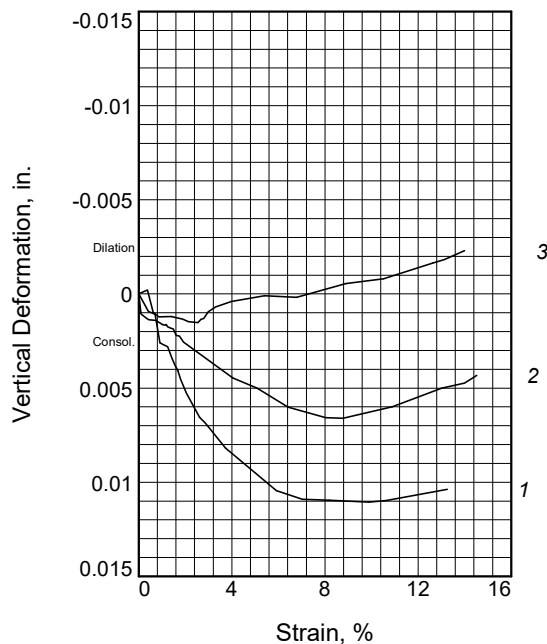
Client: YEH Associates

Project: YEH & Associates Misc Lab Testing
COS Geology Study_PN: 217-130

Project No: 20192271.001A

Figure

Vertical Loads were applied for Project Request



Sample No.		1	2	3
Initial	Water Content, %	21.0	21.1	20.4
	Dry Density, pcf	104.3	104.9	106.0
	Saturation, %	92.2	94.1	93.5
	Void Ratio	0.6165	0.6063	0.5903
	Diameter, in.	2.412	2.412	2.412
	Height, in.	1.000	1.000	1.000
At Test	Water Content, %	23.2	22.3	21.7
	Dry Density, pcf	104.3	104.6	106.0
	Saturation, %	101.6	98.6	99.4
	Void Ratio	0.6165	0.6113	0.5903
	Diameter, in.	2.412	2.412	2.412
	Height, in.	1.000	1.003	1.000
Normal Stress, psf		2010	4003	7999
Fail. Stress, psf		1630	2759	4508
Strain, %		2.1	8.8	8.9
Ult. Stress, psf				
Strain, %				
Strain rate, %/min.		0.0022	0.0017	0.0069

Sample Type: Undisturbed

Description: Lean Clay, brown and olive brown

Assumed Specific Gravity= 2.7

Remarks:

Figure 1

Client: YEH Associates

Project: YEH & Associates Misc Lab Testing

COS Geology Study_PN: 217-130

Source of Sample: B1-16

Depth: 68.5'

Proj. No.: 20192271.001A

Date Sampled:

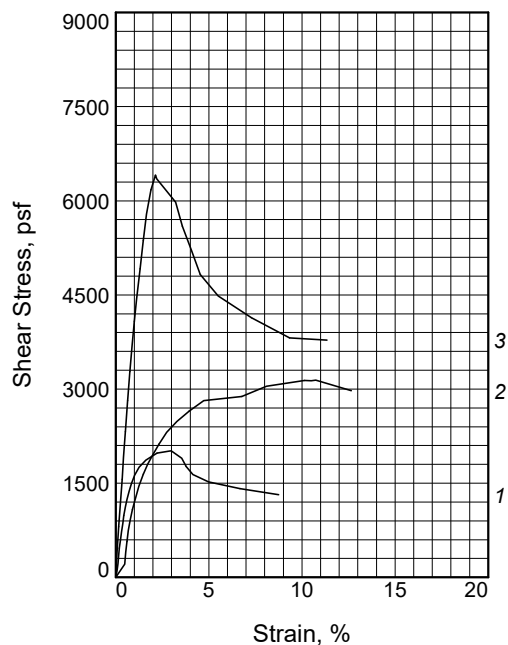
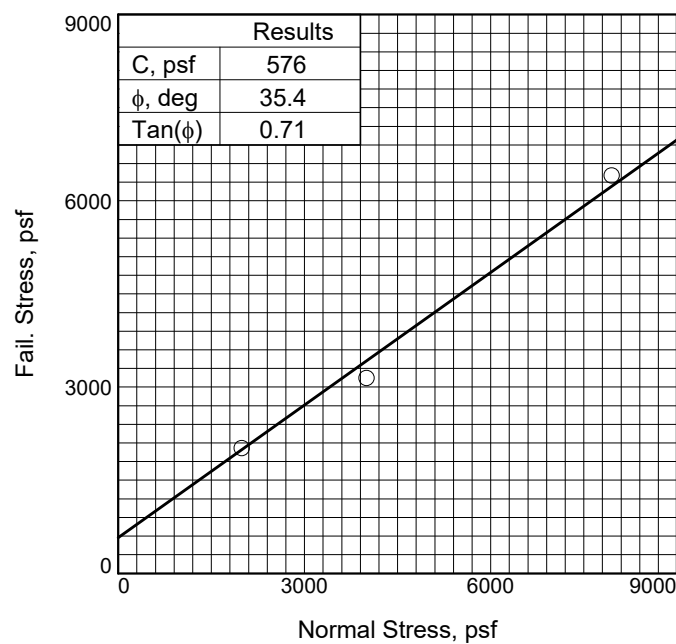
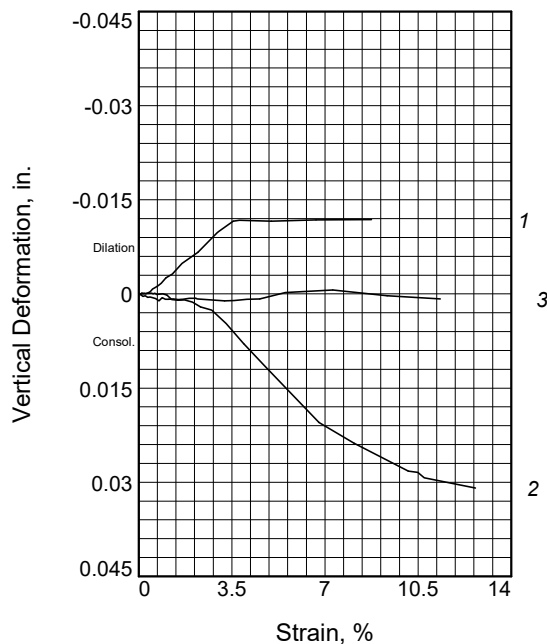
DIRECT SHEAR TEST REPORT

Kleinfelder, Inc.

Irving, TX

Tested By: E.Arapi/T.Reid

Checked By: Y.Lee



Sample No.		1	2	3
Initial	Water Content, %	19.2	17.6	16.1
	Dry Density, pcf	107.0	107.1	110.7
	Saturation, %	90.2	83.0	83.0
	Void Ratio	0.5752	0.5736	0.5232
	Diameter, in.	2.500	2.500	2.500
	Height, in.	1.000	1.000	1.000
At Test	Water Content, %	24.1	23.9	21.7
	Dry Density, pcf	106.8	107.5	111.2
	Saturation, %	112.5	113.7	113.3
	Void Ratio	0.5788	0.5675	0.5159
	Diameter, in.	2.500	2.500	2.500
	Height, in.	1.002	0.996	0.995
Normal Stress, psf		1991	4000	7947
Fail. Stress, psf		2016	3145	6408
Strain, %		2.9	10.7	2.1
Ult. Stress, psf				
Strain, %				
Strain rate, %/min.		0.0064	0.0064	0.0064

Sample Type: Undisturbed

Description: Brown and Dark Brown lean clay w/
shale seams.

LL= N/A

PI= N/A

Assumed Specific Gravity= 2.7

Remarks: Peak Strength

Client: YEH Associates

Project: YEH & Associates Misc Lab Testing

COS Geology Study_PN: 217-130

Source of Sample: B1-19

Depth: 18.5'-19.5'

Proj. No.: 20192271.001A

Date Sampled:

DIRECT SHEAR TEST REPORT

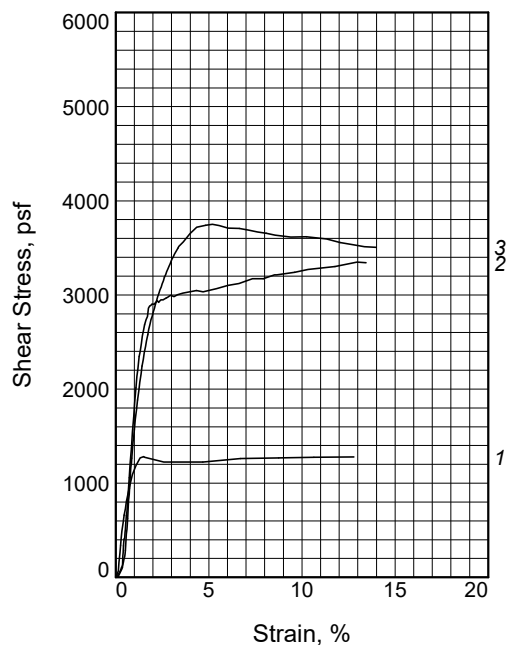
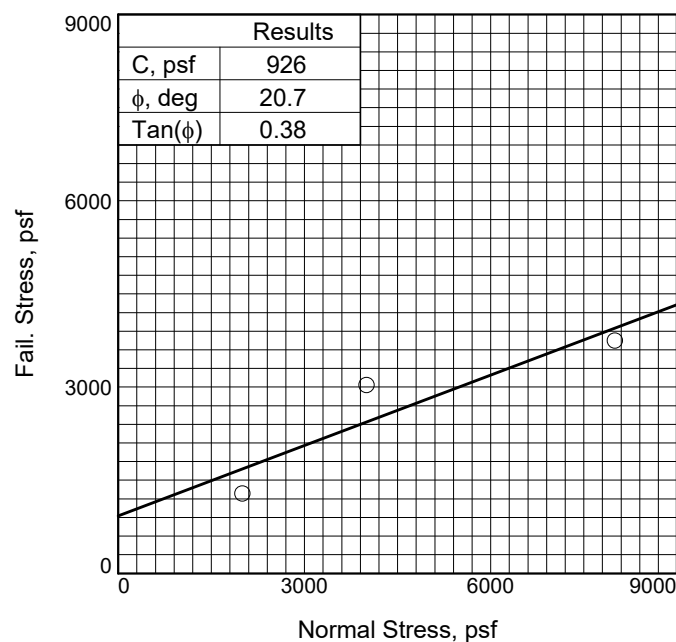
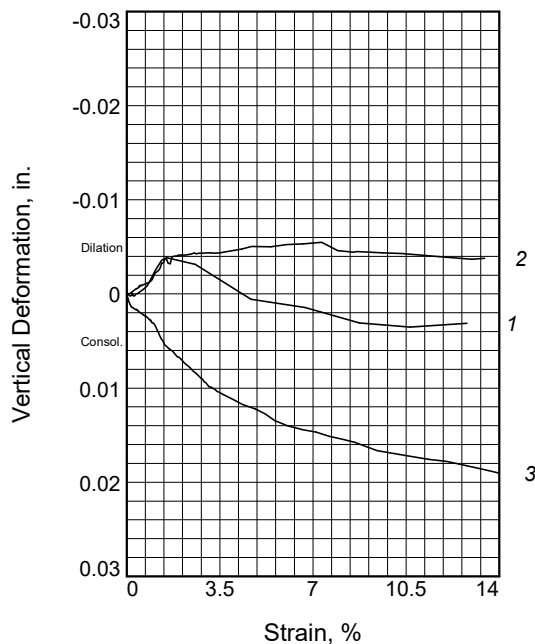
Kleinfelder, Inc.

Irving, TX

Figure 1

Tested By: T.Reid

Checked By: Y.Lee



Sample No.	1	2	3
Initial	Water Content, %	21.8	21.3
	Dry Density, pcf	99.7	100.7
	Saturation, %	85.3	85.5
	Void Ratio	0.6901	0.6733
	Diameter, in.	2.500	2.500
	Height, in.	1.000	1.000
At Test	Water Content, %	29.3	22.8
	Dry Density, pcf	99.0	100.8
	Saturation, %	112.7	91.6
	Void Ratio	0.7028	0.6725
	Diameter, in.	2.500	2.500
	Height, in.	1.008	0.995
Normal Stress, psf		1999	4000
Fail. Stress, psf		1284	3034
Strain, %		1.5	4.7
Ult. Stress, psf			
Strain, %			
Strain rate, %/min.		0.0024	0.0019

Sample Type: Undisturbed

Description: Fat Clay, dark brown, with calcareous nodules

Assumed Specific Gravity= 2.7

Remarks:

Figure 1

Client: YEH Associates

Project: YEH & Associates Misc Lab Testing
COS Geology Study_PN: 217-130

Source of Sample: B1-19

Sample Number: RUN 11

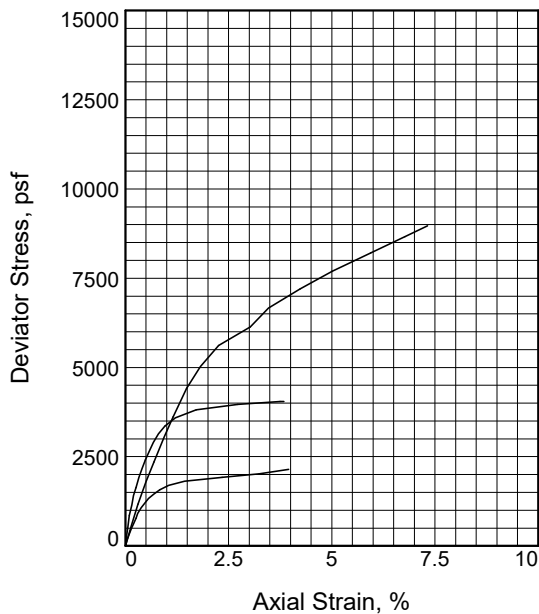
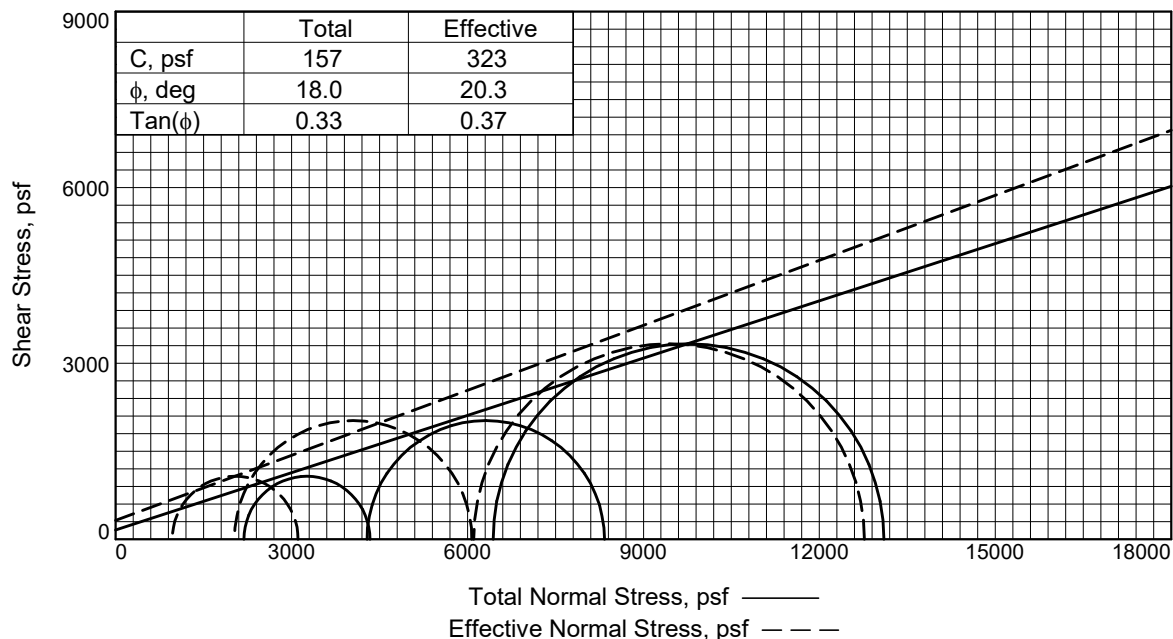
Proj. No.: 20192271.001A

Date Sampled:

DIRECT SHEAR TEST REPORT
Kleinfelder, Inc.
Irving, TX

Tested By: E.arapi/T.REid

Checked By: Y.Lee



Sample No.		1	2	3
Initial	Water Content, %	17.3	17.3	17.3
	Dry Density, pcf	101.0	101.0	101.0
	Saturation, %	70.0	70.0	70.0
	Void Ratio	0.6685	0.6685	0.6685
	Diameter, in.	2.868	2.868	2.868
	Height, in.	5.550	5.550	5.550
At Test	Water Content, %	21.9	21.0	20.1
	Dry Density, pcf	104.1	105.6	107.2
	Saturation, %	95.4	95.2	95.0
	Void Ratio	0.6189	0.5964	0.5725
	Diameter, in.	2.835	2.879	2.920
	Height, in.	5.512	5.269	5.044
Strain rate, %/min.		0.0033	0.0050	0.0026
Eff. Cell Pressure, psi		15.19	29.76	44.69
Fail. Stress, psf		2148	4049	6664
Excess Pore Pr., psf		1225	2261	332
Strain, %		4.0	3.7	3.5
Ult. Stress, psf				
Excess Pore Pr., psf				
Strain, %				
$\bar{\sigma}_1$ Failure, psf		3111	6074	12768
$\bar{\sigma}_3$ Failure, psf		963	2025	6104

Type of Test:

CU with Pore Pressures

Sample Type: Undisturbed

Description: Fat Clay, olive brown, with dark gray shale partings and iron oxide stains

Assumed Specific Gravity= 2.7

Remarks: Test was ran as a Single Specimen Staged Test

Client: YEH Associates

Project: YEH & Associates Misc Lab Testing
COS Geology Study_PN: 217-130

Source of Sample: B1-7 **Depth:** 3.5'

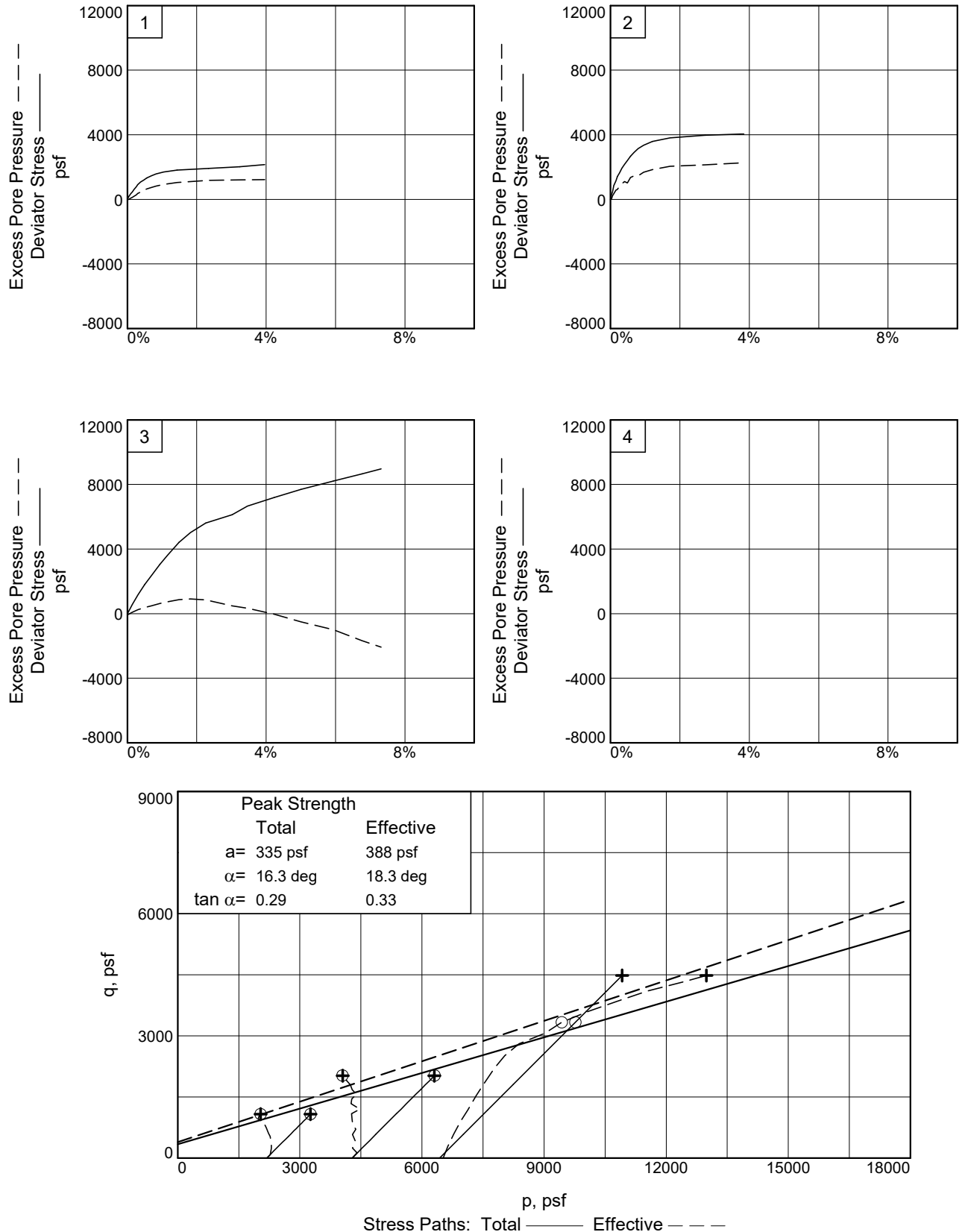
Proj. No.: 20192271.001A

Date Sampled:

TRIAXIAL SHEAR TEST REPORT
Kleinfelder, Inc.
Irving, TX

Figure 1

Consolidation Pressures and/or Normal Loads were applied per Project and/or Client Request
Soil Classification is based on Visual Classification Method



Client: YEH Associates
Project: YEH & Associates Misc Lab Testing
Source of Sample: B1-7 **Depth:** 3.5'
Project No.: 20192271.001A

Figure 2

Kleinfelder, Inc.

Tested By: E.Arapi/T.Reid

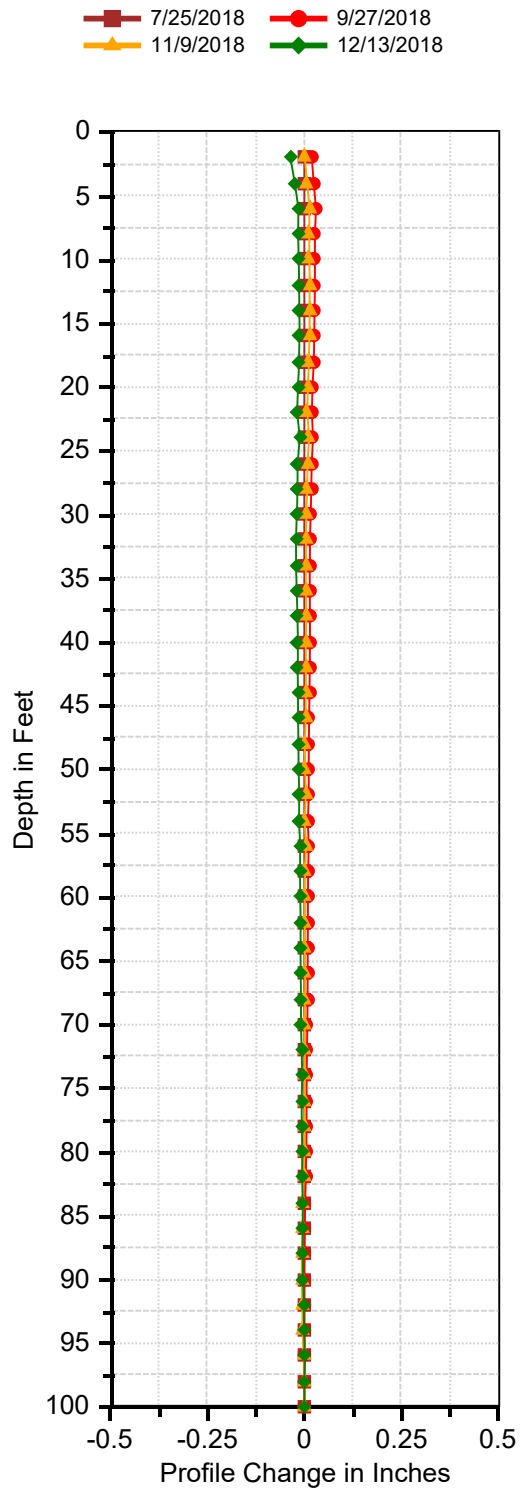
Checked By: Y.Lee

INCLINOMETER RESULTS

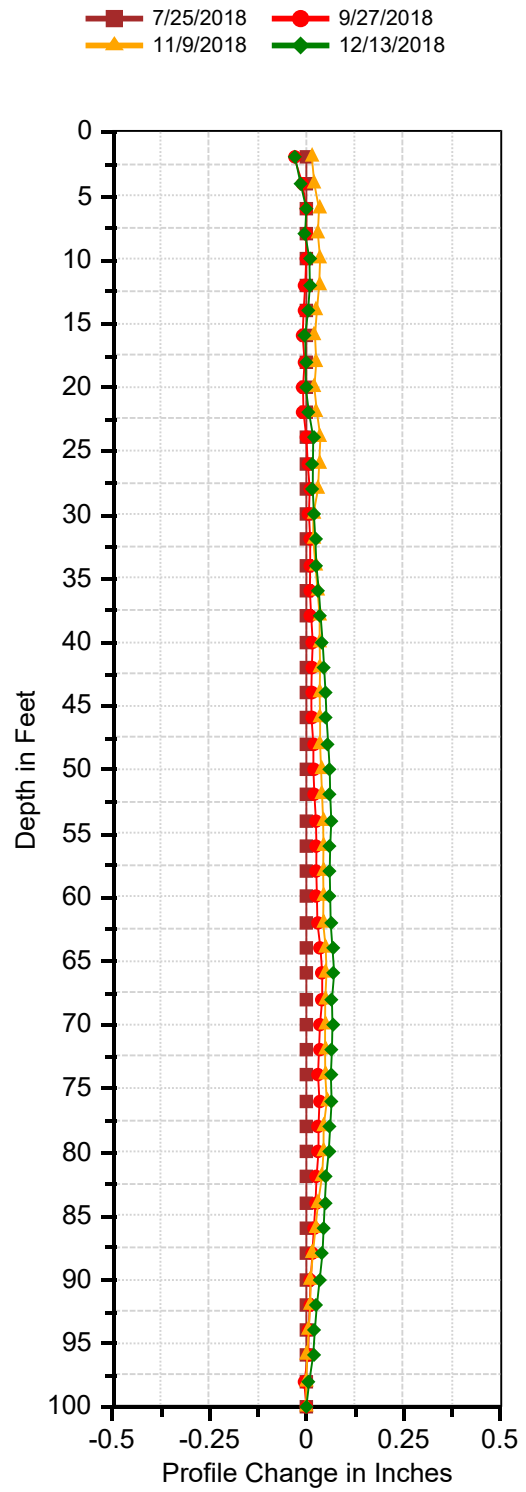


Boring B1-4
A-axis Orientation: 25° (A+) to 205° (A-)

CS B1_4 A



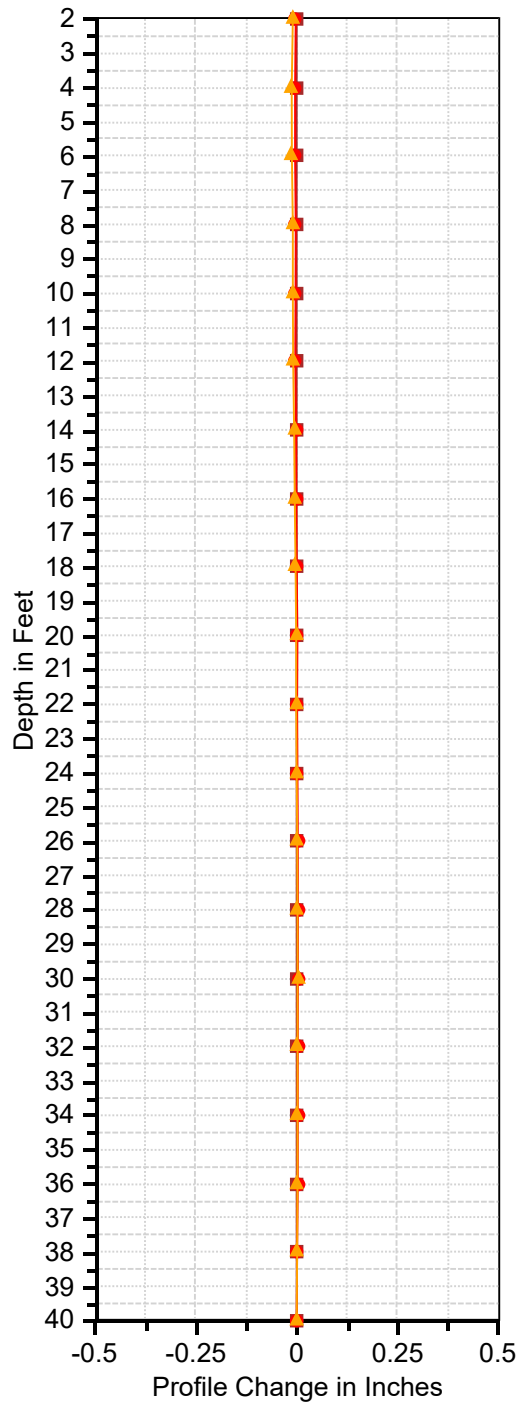
CS B1_4 B



Boring B1-6
A-axis Orientation: 105° (A+) to 285° (A-)

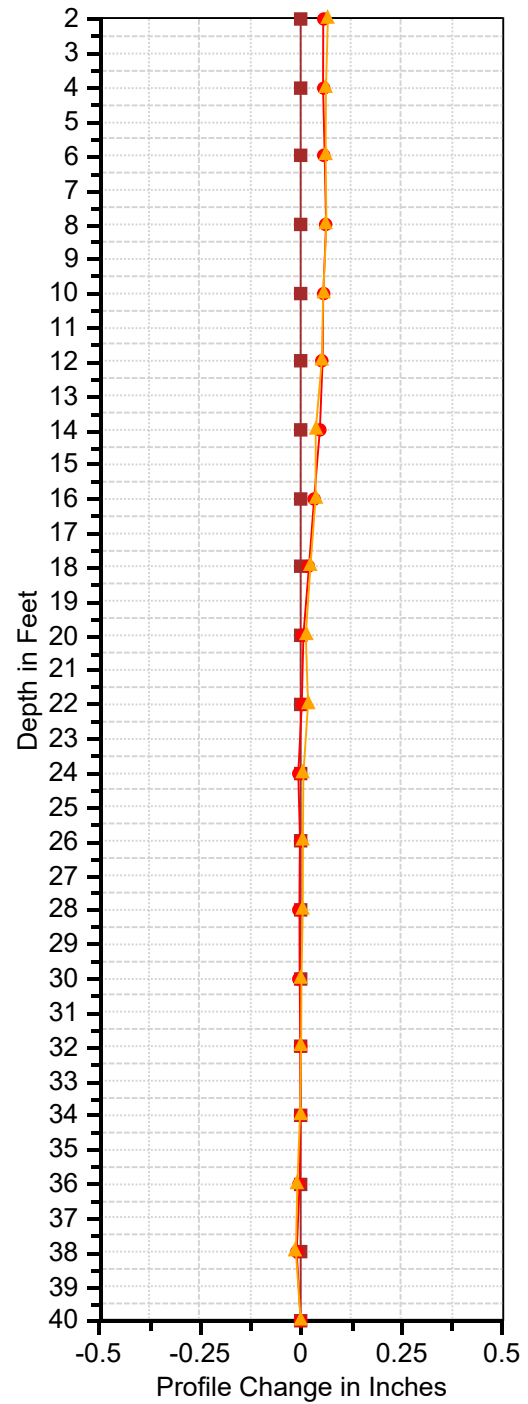
CS B1_6 A

7/30/2018 11/13/2018 12/12/2018



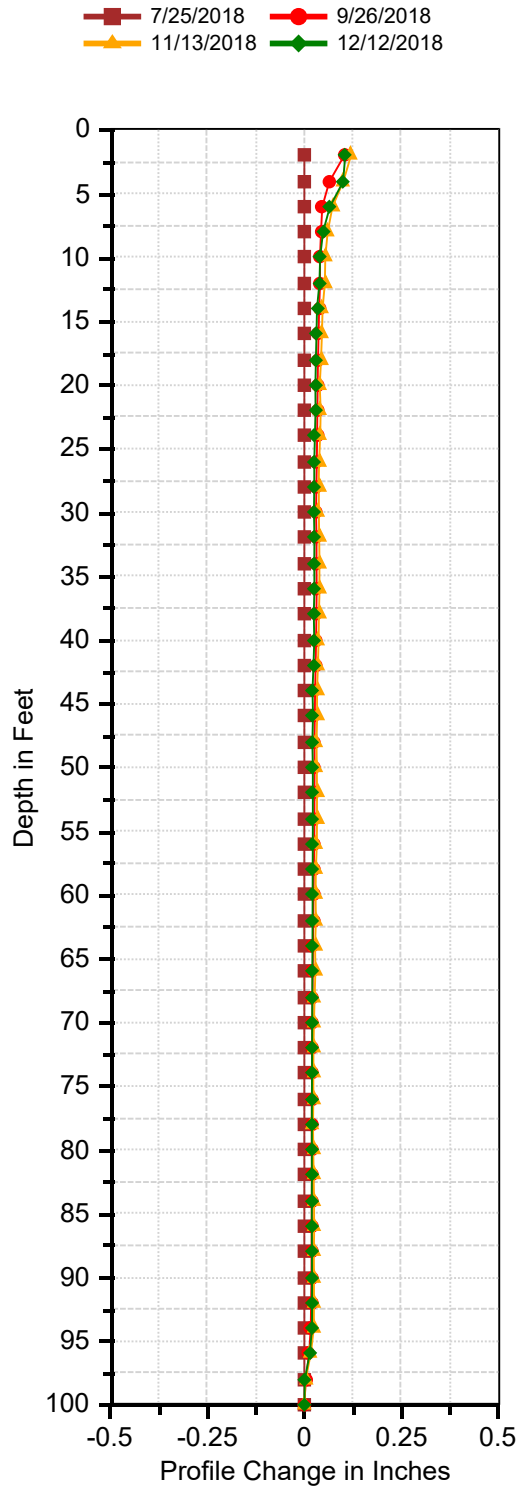
CS B1_6 B

7/30/2018 11/13/2018 12/12/2018

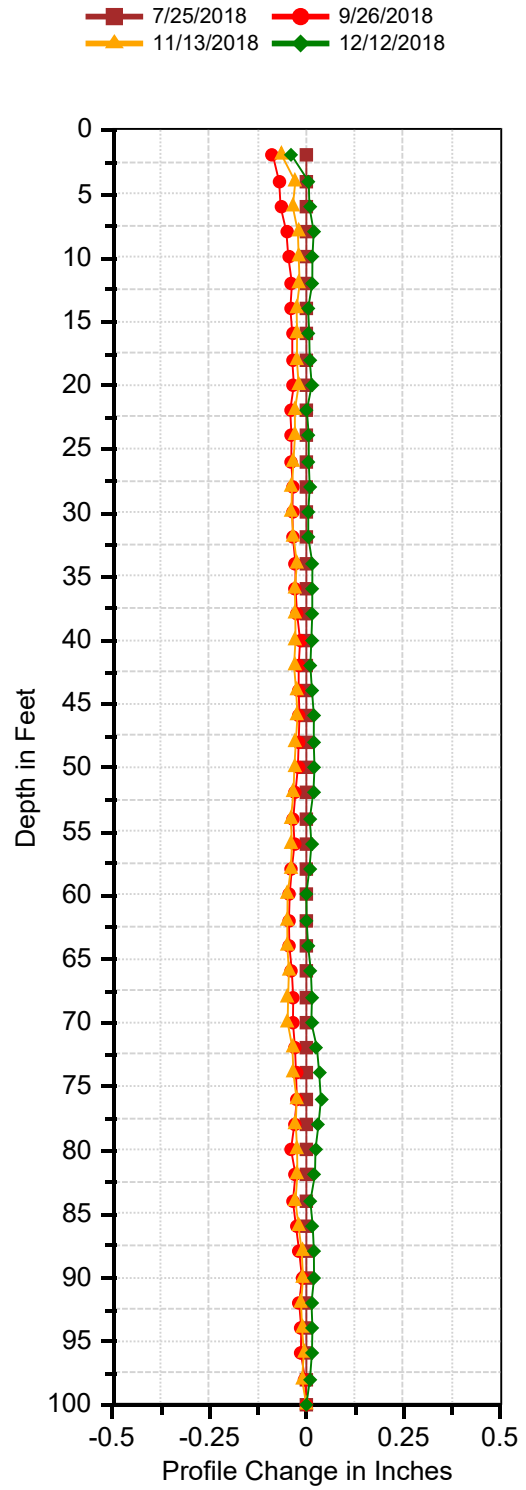


Boring B1-8
A-axis Orientation: 331° (A+) to 151° (A-)

CS B1_8 A



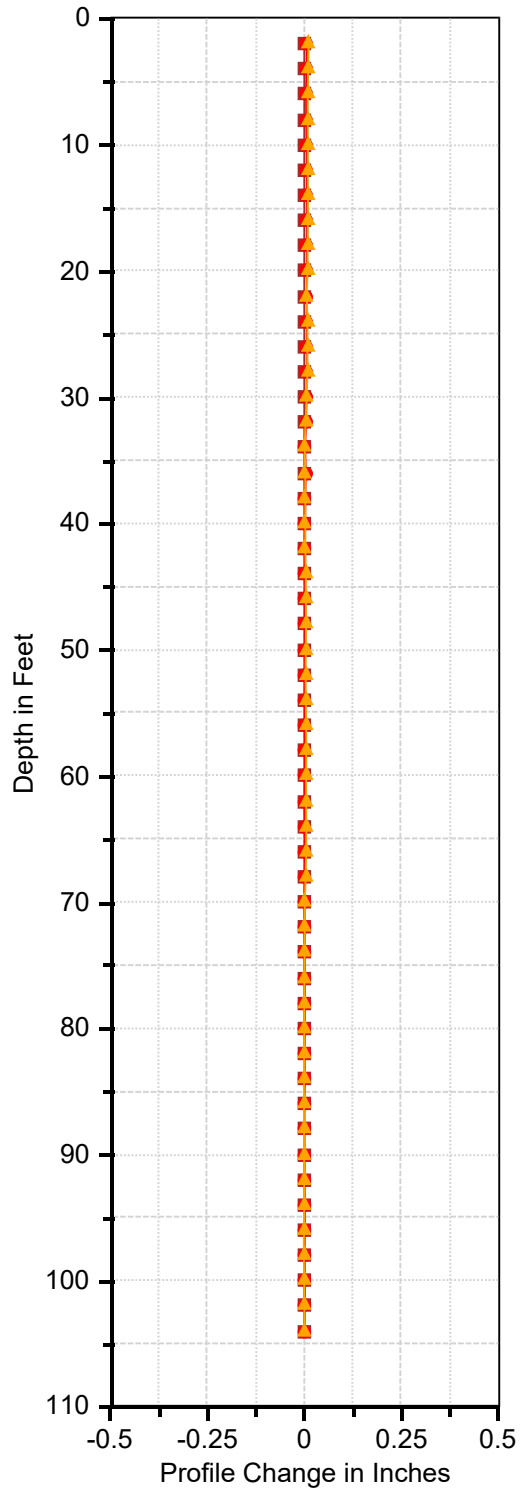
CS B1_8 B



Boring B1-11
A-axis Orientation: 175° (A+) to 355° (A-)

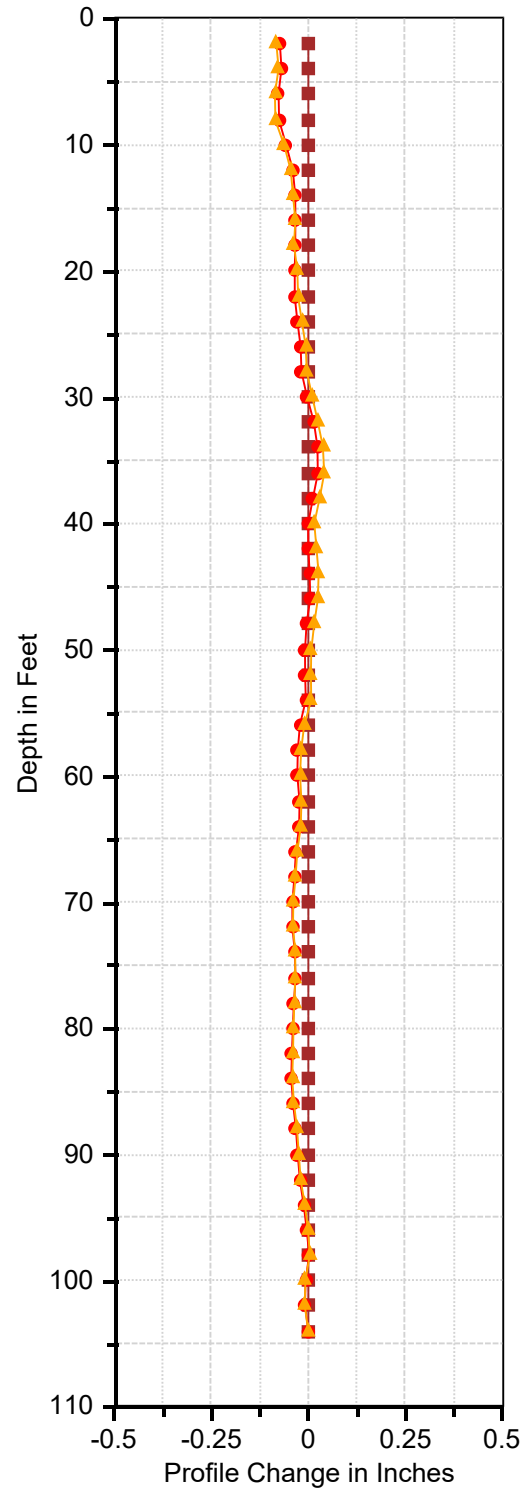
CS B1_11 A

9/26/2018 11/8/2018 12/12/2018



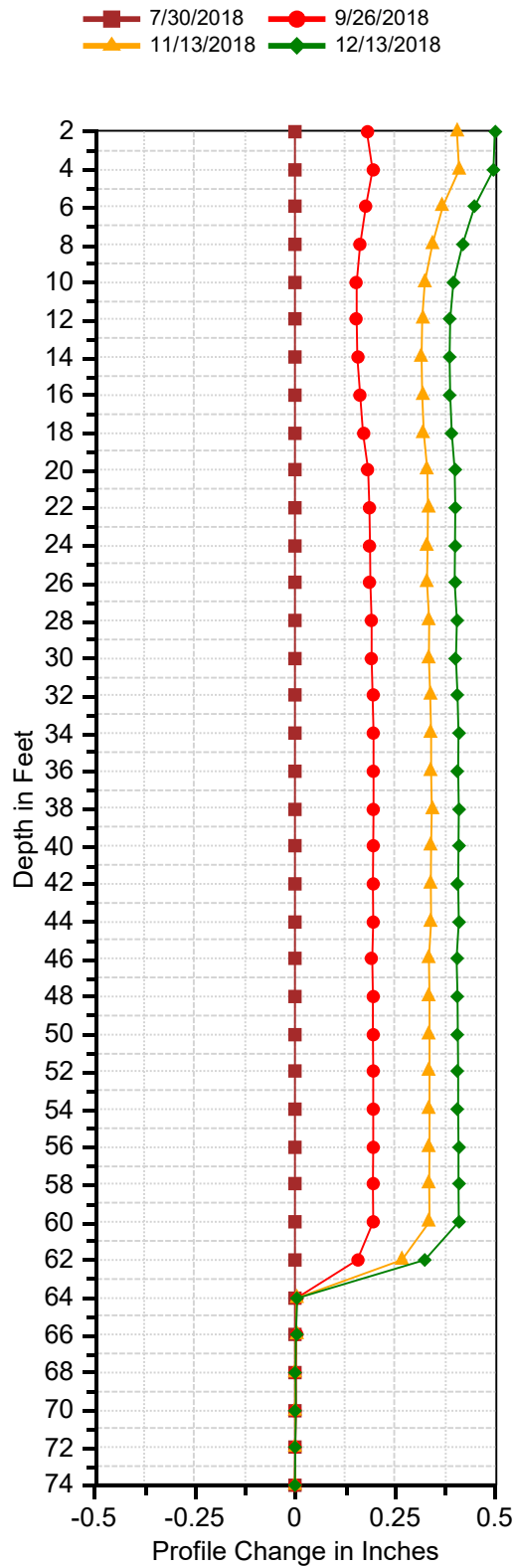
CS B1_11 B

9/26/2018 11/8/2018 12/12/2018

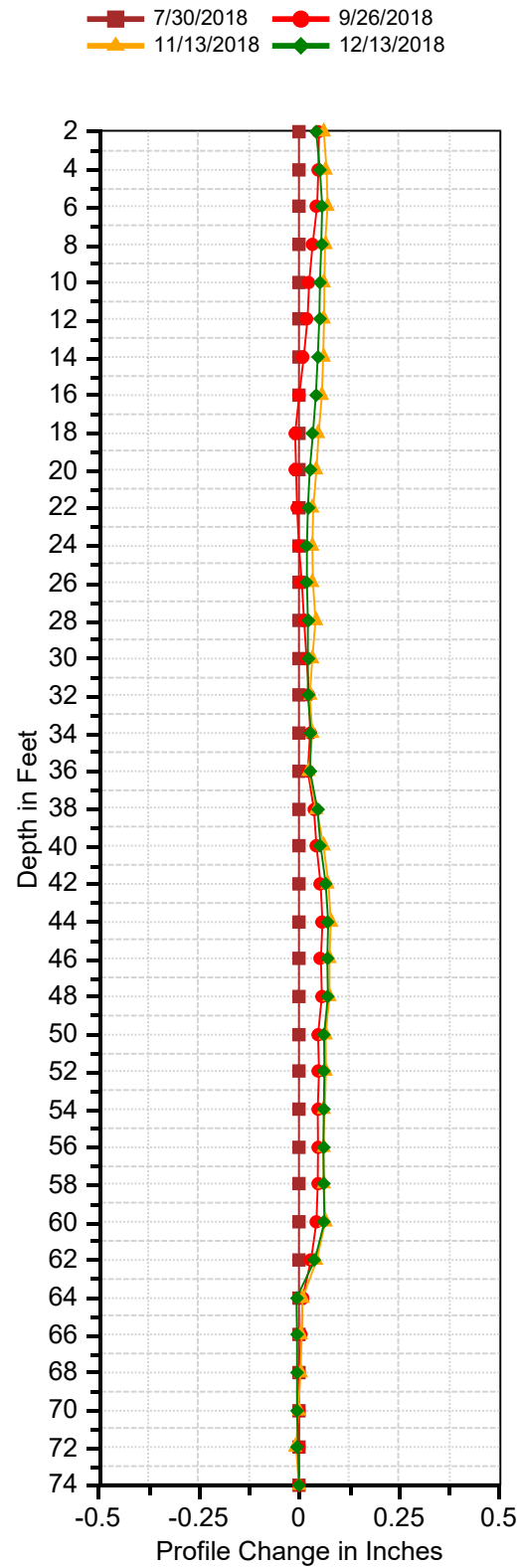


Boring B1-19
A-axis Orientation: 35° (A+) to 215° (A-)

CS B1_19 A

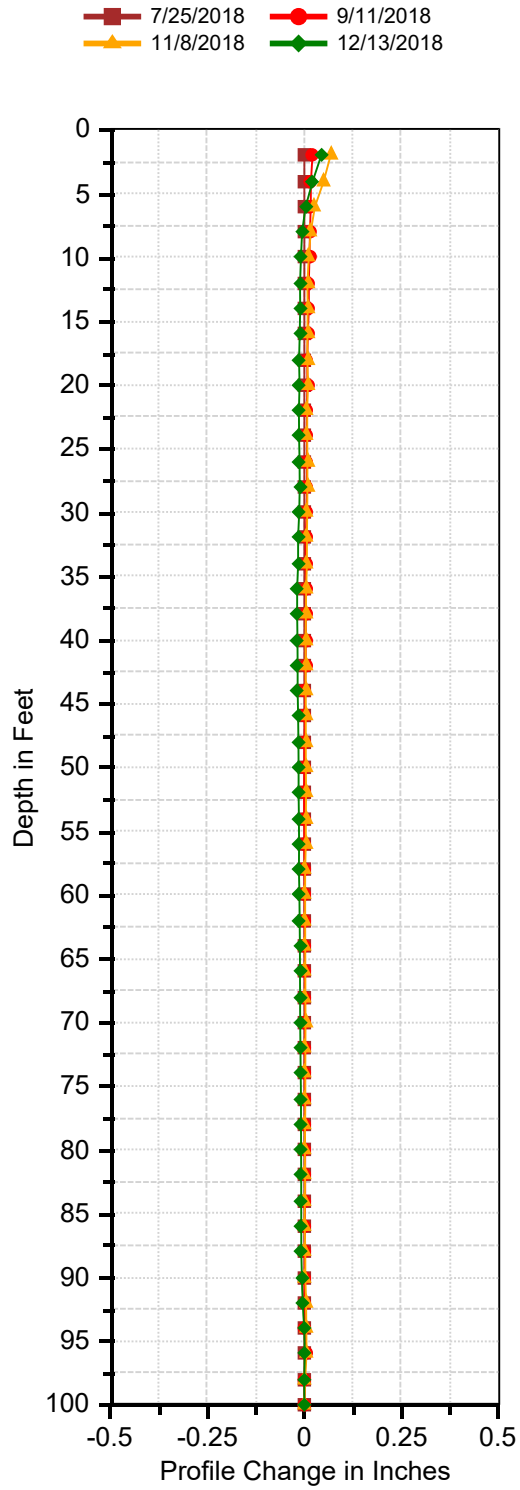


CS B1_19 B

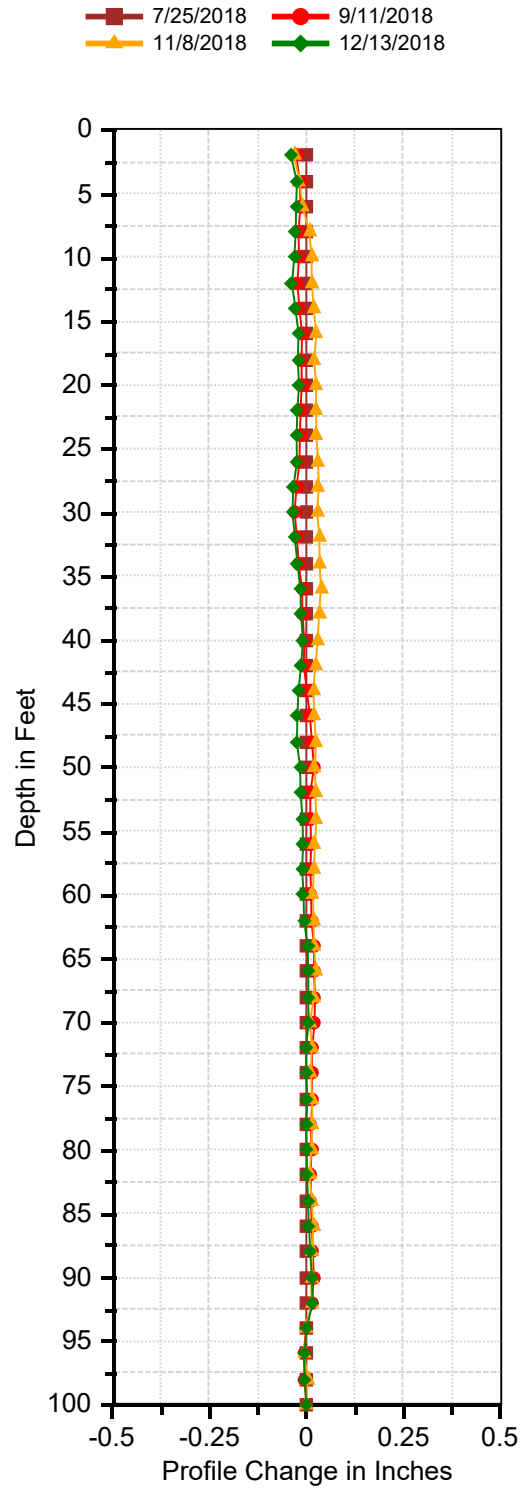


Boring B2-5
A-axis Orientation: 100° (A+) to 280° (A-)

CS B2_5 A

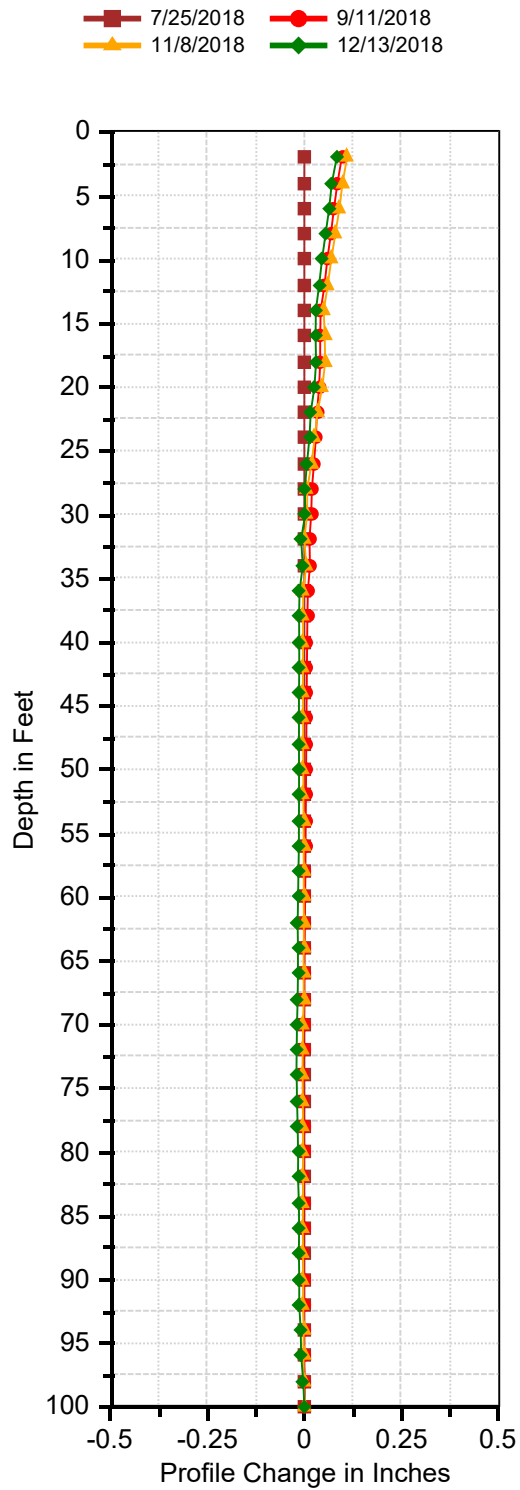


CS B2_5 B

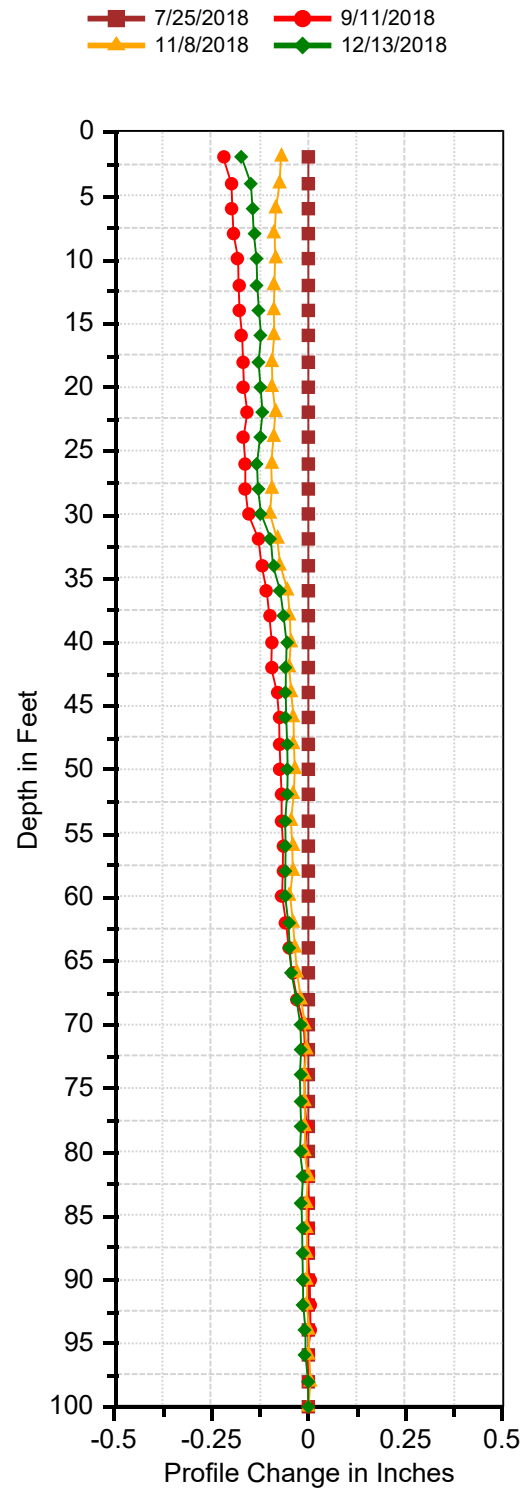


Boring B2-7
A-axis Orientation: 140° (A+) to 320° (A-)

CS B2_7 A

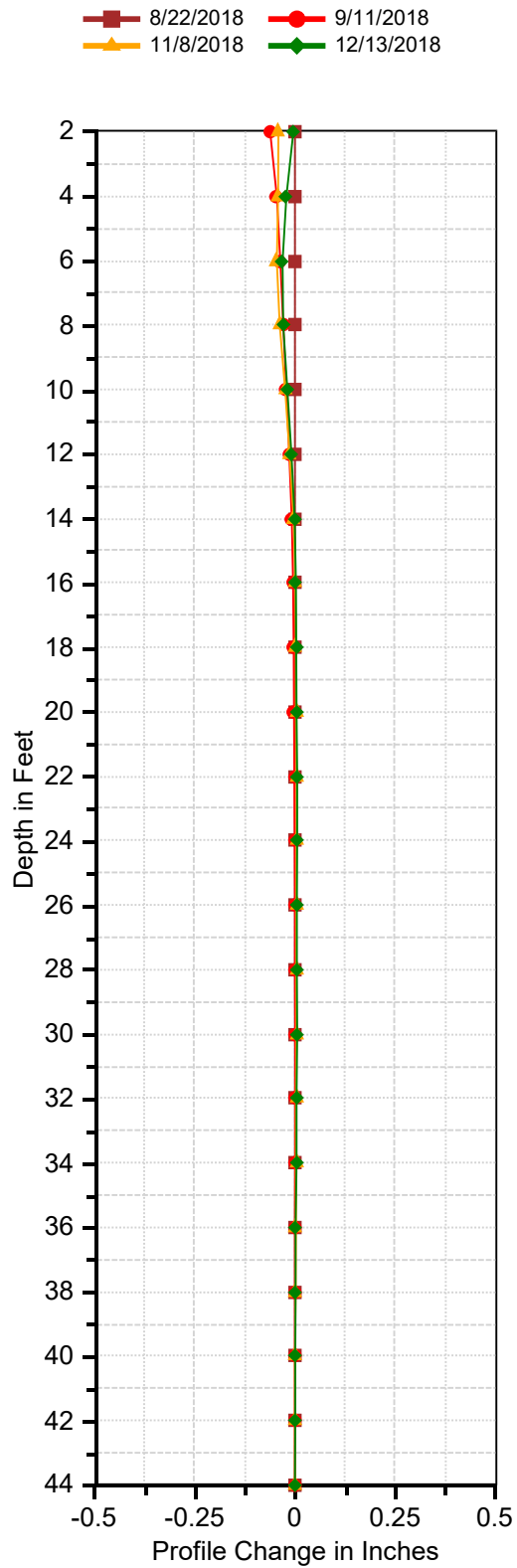


CS B2_7 B

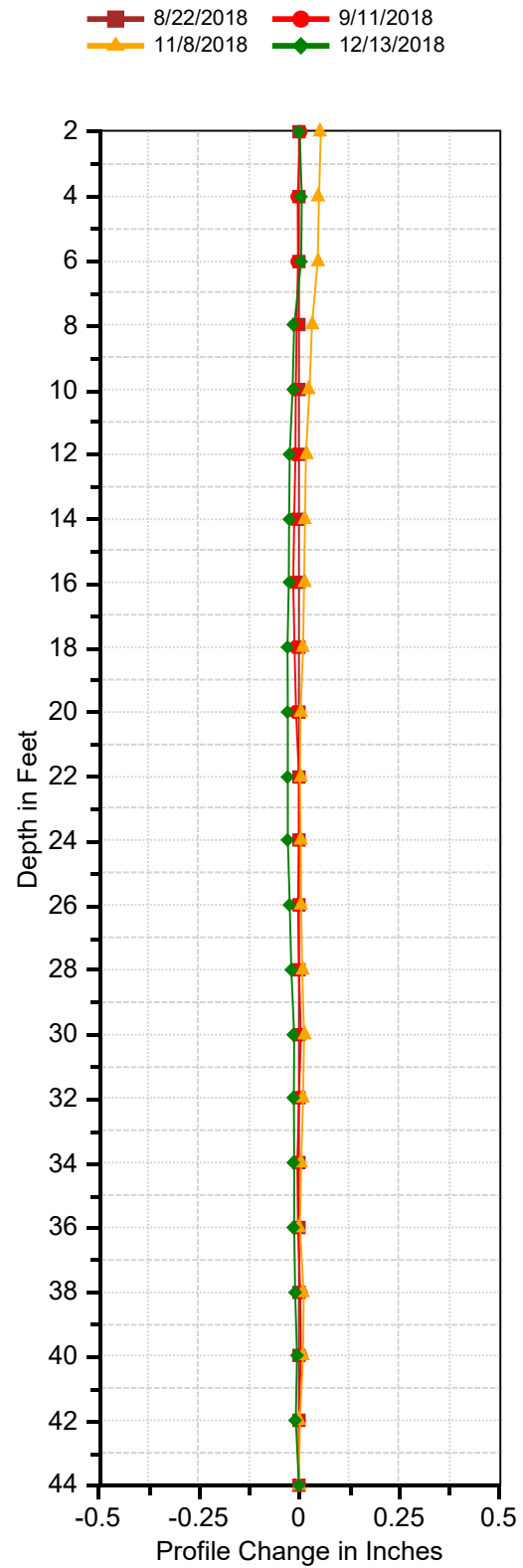


Boring B2-8
A-axis Orientation: 175° (A+) to 355° (A-)

CS B2_8 A

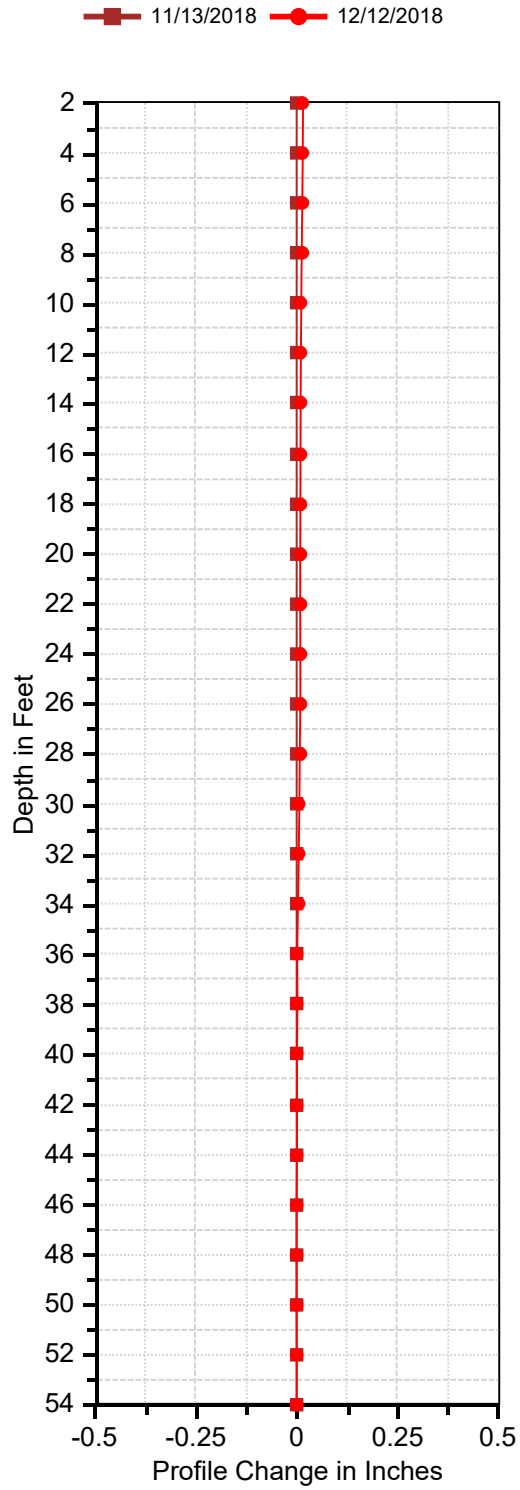


CS B2_8 B

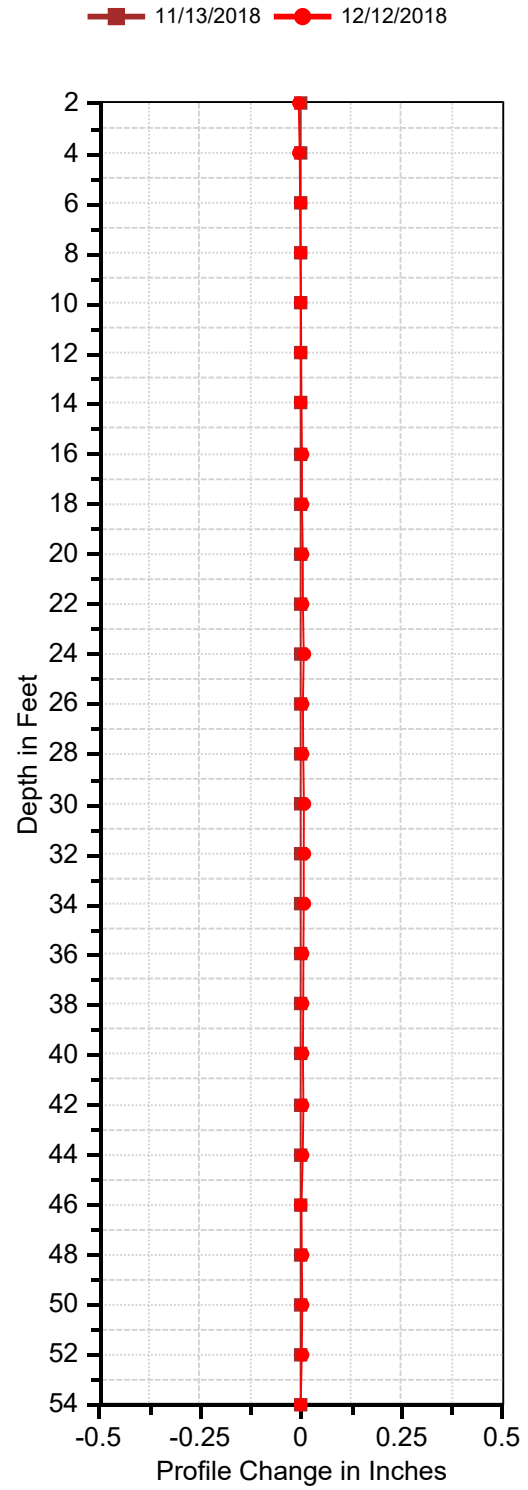


Boring KLF-B
A-axis Orientation: 160° (A+) to 340° (A-)

CS KLF_B A

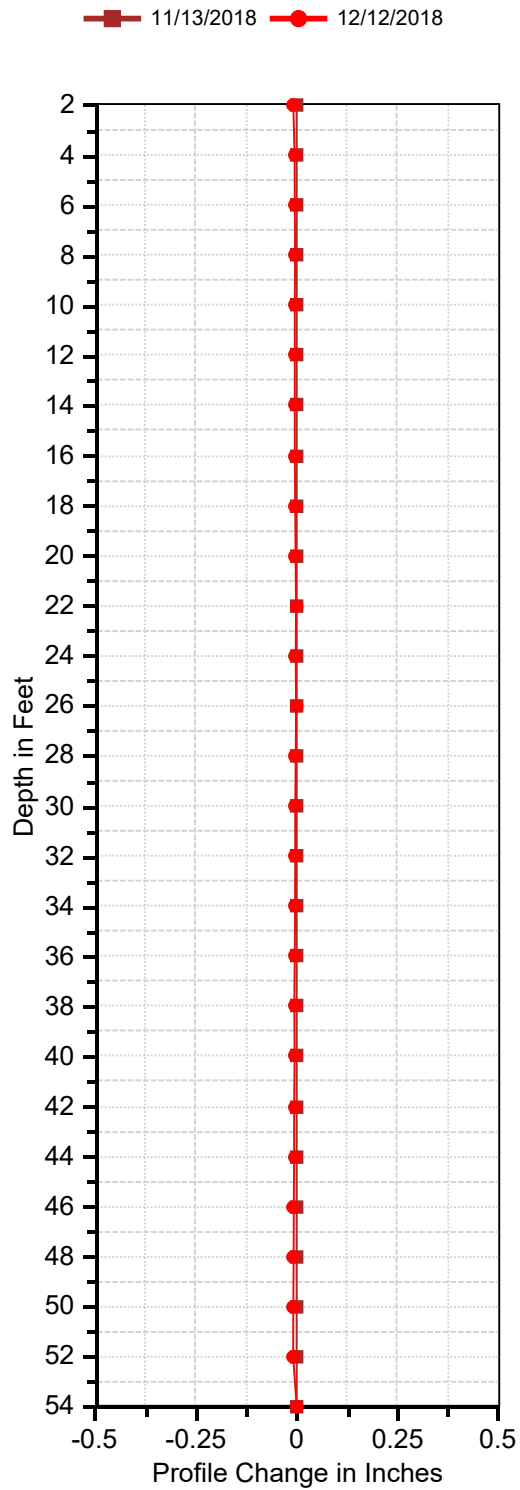


CS KLF_B B

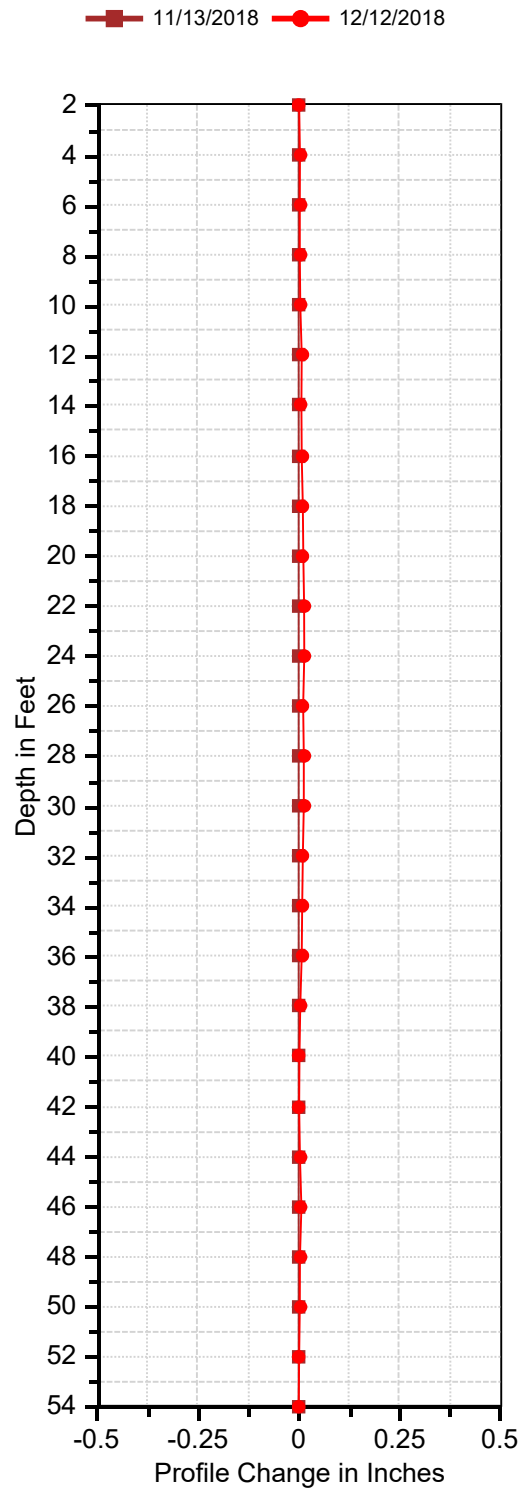


Boring KLF-R
A-axis Orientation: 160° (A+) to 340° (A-)

CS KLF_R A



CS KLF_R B



Appendix E

PHOTOS OF DRY CORE SAMPLES



Boring No. B1-4	Sample Depths*		
Row 1 Sample Descriptions:	0'-3.5'		
Row 2 Sample Descriptions:	3.5'-8.5'		
Row 3 Sample Descriptions:	8.5'-13.5'		
Row 4 Sample Descriptions:	13.5'-18.5'		



* Sample Depths are estimated based on depths of drilling.

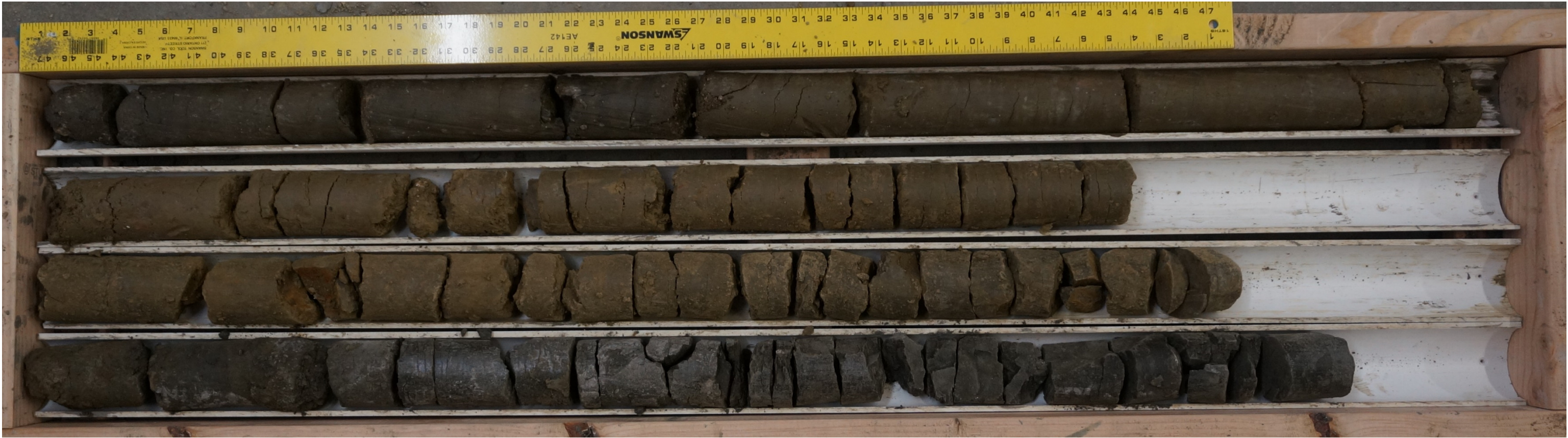
 Yeh and Associates, Inc. Consulting Engineers & Scientists	PROJECT NO. 217-130	Dry Core Soil Samples Depth: 0'-18.5'	BORING B1-4
	DRAWN: 9/18/2018		
	DRAWN BY: HML	Engineering Geology Study Colorado Springs, CO	
	CHECKED BY: RDA		
	FILE NAME:		

Boring No. B1-4	Sample Depths*		
Row 1 Sample Descriptions:	33.5'-38.5'		
Row 2 Sample Descriptions:	38.5'-43.5'		
Row 3 Sample Descriptions:			
Row 4 Sample Descriptions:			



* Sample Depths are estimated based on depths of drilling.

Boring No. B1-6	Sample Depths*		
Row 1 Sample Descriptions:	4'-9'		
Row 2 Sample Descriptions:	11'-14'		
Row 3 Sample Descriptions:	14'-19'		
Row 4 Sample Descriptions:	19'-24'		



* Sample Depths are estimated based on depths of drilling.

Boring No. B1-7	Sample Depths*		
Row 1 Sample Descriptions:	0'-3.5'		
Row 2 Sample Descriptions:	3.5'-8.5'		
Row 3 Sample Descriptions:	8.5'-13.5'		
Row 4 Sample Descriptions:	13.5'-18.5'	18.5'-23.5'	



* Sample Depths are estimated based on depths of drilling.

Boring No. B1-8	Sample Depths*	
Row 1 Sample Descriptions:	3.5'-8.5'	
Row 2 Sample Descriptions:	8.5'-13.5'	
Row 3 Sample Descriptions:	13.5'-18.5'	
Row 4 Sample Descriptions:	18.5'-23.5'	



* Sample Depths are estimated based on depths of drilling.

Boring No. B1-8	Sample Depths*	
Row 1 Sample Descriptions:	28.5'-33.5'	
Row 2 Sample Descriptions:	33.5'-38.5'	
Row 3 Sample Descriptions:	38.5'-43.5'	
Row 4 Sample Descriptions:	43.5'-48.5'	



* Sample Depths are estimated based on depths of drilling.

Boring No. B1-8	Sample Depths*		
Row 1 Sample Descriptions:	48.5'-53.5'		
Row 2 Sample Descriptions:			
Row 3 Sample Descriptions:			
Row 4 Sample Descriptions:			



* Sample Depths are estimated based on depths of drilling.

Boring No. B1-11A	Sample Depths*		
Row 1 Sample Descriptions:	3.5'-8.5'	8.5-13.5'	
Row 2 Sample Descriptions:	13.5'-18.5'	18.5'-23.5'	
Row 3 Sample Descriptions:	23.5'-28.5'		
Row 4 Sample Descriptions:	28.5'-33.5'		



* Sample Depths are estimated based on depths of drilling.



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Consulting Engineers & Scientists

PROJECT NO. 217-130
DRAWN: 9/18/2018
DRAWN BY: HML
CHECKED BY: RDA
FILE NAME:

Dry Core Soil Samples
Depth: 3.5'-33.5'

Engineering Geology Study
Colorado Springs, CO

BORING

B1-11A

Boring No. B1-11A	Sample Depths*		
Row 1 Sample Descriptions:	33.5'-38.5'	50'-52.5'	
Row 2 Sample Descriptions:	60'-63.5'		
Row 3 Sample Descriptions:	63.5'-68.5'		
Row 4 Sample Descriptions:	68.5'-73.5'		



* Sample Depths are estimated based on depths of drilling.

Boring No. B1-11A	Sample Depths*		
Row 1 Sample Descriptions:			
Row 2 Sample Descriptions:	73.5'-78.5'		
Row 3 Sample Descriptions:	78.5'-83.5'		
Row 4 Sample Descriptions:			



* Sample Depths are estimated based on depths of drilling.

Boring No. B1-12	Sample Depths*		
Row 1 Sample Descriptions:	0-3.5'		
Row 2 Sample Descriptions:	3.5'-8.5'		
Row 3 Sample Descriptions:	8.5'-13.5'		
Row 4 Sample Descriptions:	13.5'-18.5'		



* Sample Depths are estimated based on depths of drilling.



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Consulting Engineers & Scientists

PROJECT NO. 217-130
DRAWN: 9/18/2018
DRAWN BY: HML
CHECKED BY: RDA
FILE NAME:

Dry Core Soil Samples
Depth: 0'-18.5'

Engineering Geology Study
Colorado Springs, CO

BORING

B1-12

Boring No. B1-12	Sample Depths*		
Row 1 Sample Descriptions:	18.5'-23.5'		
Row 2 Sample Descriptions:	23.5'-28.5'		
Row 3 Sample Descriptions:	28.5'-33.5'		
Row 4 Sample Descriptions:	33.5'-38.5'		



* Sample Depths are estimated based on depths of drilling.

Boring No. B1-12	Sample Depths*		
Row 1 Sample Descriptions:	38.5'-43.5'		
Row 2 Sample Descriptions:	43.5'-44'		
Row 3 Sample Descriptions:			
Row 4 Sample Descriptions:			



* Sample Depths are estimated based on depths of drilling.

Boring No. B1-14	Sample Depths*		
Row 1 Sample Descriptions:	3.5'-8.5'		
Row 2 Sample Descriptions:	8.5'-13.5'		
Row 3 Sample Descriptions:	13.5'-18.5'		
Row 4 Sample Descriptions:	18.5'-23.5'		



* Sample Depths are estimated based on depths of drilling.



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FILE NAME:

Dry Core Soil Samples
Depth: 3.5'-23.5'

Engineering Geology Study
Colorado Springs, CO

BORING

B1-14

Boring No. B1-16	Sample Depths*		
Row 1 Sample Descriptions:	3.5'-7'		
Row 2 Sample Descriptions:	59.5'-64.5'		
Row 3 Sample Descriptions:	64.5'-68.5'		
Row 4 Sample Descriptions:	68.5'-73.5'		



* Sample Depths are estimated based on depths of drilling.



Yeh and Associates, Inc.
Consulting Engineers & Scientists

PROJECT NO. 217-130
DRAWN: 9/18/2018
DRAWN BY: HML
CHECKED BY: RDA
FILE NAME:

Dry Core Soil Samples
Depth: 3.5'-7', 59.5'-73.5'

Engineering Geology Study
Colorado Springs, CO

BORING

B1-16

Boring No. B1-16	Sample Depths*		
Row 1 Sample Descriptions:	73.5'-78.5'		
Row 2 Sample Descriptions:	78.5'-83.5'		
Row 3 Sample Descriptions:			
Row 4 Sample Descriptions:			



* Sample Depths are estimated based on depths of drilling.

 Yeh and Associates, Inc. Consulting Engineers & Scientists	PROJECT NO. 217-130	Dry Core Soil Samples Depth: 73.5'-83.5'	BORING B1-16
	DRAWN: 9/18/2018		
	DRAWN BY: HML	Engineering Geology Study Colorado Springs, CO	
	CHECKED BY: RDA		
	FILE NAME:		

Boring No. B1-19	Sample Depths*		
Row 1 Sample Descriptions:	0'-3.5'		
Row 2 Sample Descriptions:	3.5'-8.5'		
Row 3 Sample Descriptions:	9.5'-13.5'		
Row 4 Sample Descriptions:	13.5'-18.5'		



* Sample Depths are estimated based on depths of drilling.



Yeh and Associates, Inc.
Consulting Engineers & Scientists

PROJECT NO. 217-130
DRAWN: 9/18/2018
DRAWN BY: HML
CHECKED BY: RDA
FILE NAME:

Dry Core Soil Samples
Depth: 0'-18.5'

Engineering Geology Study
Colorado Springs, CO

BORING

B1-19

Boring No. B1-19	Sample Depths*		
Row 1 Sample Descriptions:	18.5'-23.5'		
Row 2 Sample Descriptions:	23.5'-28.5'		
Row 3 Sample Descriptions:	28.5'-33.5'		
Row 4 Sample Descriptions:	33.5'-38.5'		



* Sample Depths are estimated based on depths of drilling.

 Yeh and Associates, Inc. Consulting Engineers & Scientists	PROJECT NO. 217-130	Dry Core Soil Samples Depth: 18.5'-38.5'	BORING B1-19
	DRAWN: 9/18/2018		
	DRAWN BY: HML	Engineering Geology Study Colorado Springs, CO	
	CHECKED BY: RDA		
	FILE NAME:		

Boring No. B1-19	Sample Depths*		
Row 1 Sample Descriptions:	38.5'-43.5'		
Row 2 Sample Descriptions:	43.5'-48.5'		
Row 3 Sample Descriptions:	48.5'-55'		
Row 4 Sample Descriptions:	55'-60'		



* Sample Depths are estimated based on depths of drilling.

Boring No. B1-19	Sample Depths*		
Row 1 Sample Descriptions:	58.5'-63.5'		
Row 2 Sample Descriptions:	63.5'-68.5'		
Row 3 Sample Descriptions:			
Row 4 Sample Descriptions:			



* Sample Depths are estimated based on depths of drilling.

Boring No. B2-1	Sample Depths*		
Row 1 Sample Descriptions:	50'-55'		
Row 2 Sample Descriptions:	55'-60'		
Row 3 Sample Descriptions:			
Row 4 Sample Descriptions:			



* Sample Depths are estimated based on depths of drilling.



Yeh and Associates, Inc.
Consulting Engineers & Scientists

PROJECT NO. 217-130
DRAWN: 9/18/2018
DRAWN BY: HML
CHECKED BY: RDA
FILE NAME:

Dry Core Soil Samples
Depth: 50'-60'

Engineering Geology Study
Colorado Springs, CO

BORING

B2-1

Boring No. B2-5	Sample Depths*		
Row 1 Sample Descriptions:	3.5'-8.5'		
Row 2 Sample Descriptions:	8.5'-13.5'		
Row 3 Sample Descriptions:	13.5'-18.5'		
Row 4 Sample Descriptions:	18.5'-23.5'		



* Sample Depths are estimated based on depths of drilling.



Yeh and Associates, Inc.
Consulting Engineers & Scientists

PROJECT NO. 217-130
DRAWN: 9/18/2018
DRAWN BY: HML
CHECKED BY: RDA
FILE NAME:

Dry Core Soil Samples
Depth: 3.5'-23.5'

Engineering Geology Study
Colorado Springs, CO

BORING

B2-5

Boring No. B2-5	Sample Depths*		
Row 1 Sample Descriptions:	23.5'-28.5'		
Row 2 Sample Descriptions:	28.5'-33.5'		
Row 3 Sample Descriptions:	33.5'-38.5'		
Row 4 Sample Descriptions:	38.5'-43.5'		



* Sample Depths are estimated based on depths of drilling.

 Yeh and Associates, Inc. Consulting Engineers & Scientists	PROJECT NO. 217-130	Dry Core Soil Samples Depth: 23.5'-43.5'	BORING B2-5
	DRAWN: 9/18/2018		
	DRAWN BY: HML	Engineering Geology Study Colorado Springs, CO	
	CHECKED BY: RDA		
	FILE NAME:		

Boring No. B2-5	Sample Depths*		
Row 1 Sample Descriptions:	43.5'-48.5'		
Row 2 Sample Descriptions:	48.5'-53.5'		
Row 3 Sample Descriptions:	53.5'-58.5'		
Row 4 Sample Descriptions:	58.5'-63.5'		



* Sample Depths are estimated based on depths of drilling.

Boring No. B2-5	Sample Depths*		
Row 1 Sample Descriptions:	63.5'-68.5'		
Row 2 Sample Descriptions:	68.5'-73.5'		
Row 3 Sample Descriptions:	73.5'-78.5'		
Row 4 Sample Descriptions:	78.5'-83.5'		



* Sample Depths are estimated based on depths of drilling.

Boring No. B2-7	Sample Depths*		
Row 1 Sample Descriptions:	0'-3.5'		
Row 2 Sample Descriptions:	3.5'-8.5'		
Row 3 Sample Descriptions:	8.5'-13.5'		
Row 4 Sample Descriptions:	13.5'-18.5'		



* Sample Depths are estimated based on depths of drilling.



Yeh and Associates, Inc.
Consulting Engineers & Scientists

PROJECT NO. 217-130
DRAWN: 9/18/2018
DRAWN BY: HML
CHECKED BY: RDA
FILE NAME:

Dry Core Soil Samples
Depth: 0'-18.5'

Engineering Geology Study
Colorado Springs, CO

BORING

B2-7

Boring No. B2-7	Sample Depths*		
Row 1 Sample Descriptions:	18.5'-23.5'		
Row 2 Sample Descriptions:	23.5'-28.5'		
Row 3 Sample Descriptions:	28.5'-33.5'		
Row 4 Sample Descriptions:	33.5'-38.5'		



* Sample Depths are estimated based on depths of drilling.

 Yeh and Associates, Inc. Consulting Engineers & Scientists	PROJECT NO. 217-130	Dry Core Soil Samples Depth: 18.5'-38.5'	BORING B2-7
	DRAWN: 9/18/2018		
	DRAWN BY: HML	Engineering Geology Study Colorado Springs, CO	
	CHECKED BY: RDA		
	FILE NAME:		

Boring No. B2-7	Sample Depths*		
Row 1 Sample Descriptions:	38.5'-43.5'		
Row 2 Sample Descriptions:	43.5'-48.5'		
Row 3 Sample Descriptions:	48.5'-53.5'		
Row 4 Sample Descriptions:	53.5'-58.5'		



* Sample Depths are estimated based on depths of drilling.

Boring No. B2-7	Sample Depths*		
Row 1 Sample Descriptions:	58.5'-63.5'		
Row 2 Sample Descriptions:	63.5'-68.5'		
Row 3 Sample Descriptions:	68.5'-73.5'		
Row 4 Sample Descriptions:	73.5'-78.5'		



* Sample Depths are estimated based on depths of drilling.

Boring No. B2-7	Sample Depths*		
Row 1 Sample Descriptions:	78.5'-83.5'		
Row 2 Sample Descriptions:	83.5'-88.5'		
Row 3 Sample Descriptions:			
Row 4 Sample Descriptions:			



* Sample Depths are estimated based on depths of drilling.



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FILE NAME:

Dry Core Soil Samples
Depth: 78.5'-88.5'

Engineering Geology Study
Colorado Springs, CO

BORING

B2-7