

LITHOS

ENGINEERING

GEOTECHNICAL INVESTIGATION REPORT

Mesa Verde National Park

Morefield and Wetherill Pipeline Replacement Project

Mancos, Colorado

September 21, 2023



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September 21 2023
Project No. 21152

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Attention: Mr. Christopher Bailey, PE
Project Manager

Regarding: Geotechnical Investigation Report
Mesa Verde National Park
Morefield and Wetherill Waterline Replacement Project
Mancos, Colorado

Mr. Bailey,

This report presents the results of our geotechnical investigation and recommendations for the Morefield and Wetherill Waterline Replacement Project. This study was conducted in general accordance with the contract between Lithos Engineering and HDR Engineering, Inc. dated September 3, 2021 and updated per the contract addendum between Lithos Engineering and HDR Engineering, Inc. dated January 30, 2023. Contained herein are discussions of the general subsurface conditions, geotechnical engineering design, and construction considerations in support of the subject project.

If you have any questions regarding the contents of this report, please contact the undersigned.

Sincerely,
Lithos Engineering



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EXECUTIVE SUMMARY

The Mesa Verde National Park Morefield and Wetherill Waterline Replacement project consists of replacing approximately 16 miles of existing 6-inch diameter pressurized waterline. The following summarizes our general conclusions and recommendations in support of the project:

- The subsurface conditions encountered do not preclude the proposed waterline construction as we currently understand it.
- Subsurface materials encountered during the subsurface investigation of the Morefield Alignment include the following:
 - Fine Alluvium – encountered at surface and extends to depths of 1 foot to 33 feet, or to the end of exploration. Was encountered in 12 of the 15 geotechnical borings.
 - Coarse Alluvium – encountered at surface and extends to a depth of 9 feet. Was encountered in 1 of 15 geotechnical borings.
 - Rockfall Deposit – encountered at surface and extends to the end of exploration at approximately 80 feet below ground surface. Was encountered in 5 out of 15 geotechnical borings.
 - Landslide Deposit – encountered at depths ranging from surface to 9 feet and extends to end of exploration at approximately 40 feet below ground surface. Was encountered in 2 of 15 geotechnical borings.
 - Mancos Shale – encountered at depths ranging from 10 feet to 33 feet and extends to the end of exploration at approximately 80 feet below ground surface. Was encountered in 5 out of 15 geotechnical borings.
- Subsurface materials encountered during the subsurface investigation of the Wetherill Alignment include the following:
 - Fine Colluvium – encountered at surface or just below the Pavement Section and extends to depths ranging from 9 feet to 15 feet or to the end of exploration. Was encountered in 5 of the 32 geotechnical borings.
 - Loess – encountered at surface or just below the pavement section and extended to depths ranging from 0.5 feet to 15 feet or to the end of exploration. Was encountered in 3 of the 32 geotechnical borings.
 - Bedrock of the Cliffhouse Sandstone – encountered at depths ranging from just below the Pavement Section to 14.8 feet below ground surface and extend to depths ranging from 15 feet to 30 feet or to the end of exploration. Was encountered in 30 out of 32 geotechnical borings.
- Groundwater was encountered in 2 out of 47 geotechnical borings and ranged in depths from 15.0 to 41.0 feet below the existing ground surface. In general, we do not anticipate groundwater will not have a significant impact on design or construction.
- Laboratory and field steel corrosion potential testing along the Wetherill Alignment indicated soil and bedrock are not corrosive to metallic piping. Laboratory and field steel corrosion potential testing along the Morefield Alignment indicated non-corrosive soil and bedrock

conditions along the northern and southern ends of the alignment and corrosive conditions along the central portions of the alignment.

- Open-cut excavations along the Morefield Alignment will encounter Fine Alluvium. The three Morefield HDD alignments will encounter alluvium, rockfall, Mancos Shale, Point Lookout Sandstone, and Landslide deposits as presented on the Geologic Sections in the Construction Drawings.
- Open-cut excavations along the Wetherill Alignment will be excavated almost exclusively in sandstone bedrock unless the existing waterline is removed and replaced. Replacing the existing waterline in-place will minimize bedrock excavation. Excavations extending into sandstone bedrock may require the use of specialty excavation equipment due to relatively high strength.
- Asphalt replacement along the Morefield Alignment will occur in 1 section totaling roughly 1,400 linear feet. The Wetherill Alignment is nearly entirely underneath pavement, and approximately 55,000 linear feet of asphalt replacement is anticipated. Current Wetherill Mesa Road asphalt thickness ranges from 1- to 9-inches.

1 INTRODUCTION

In late 2021, Mesa Verde National Park retained HDR Engineering, Inc. (HDR) to serve as the lead design Engineer for the Morefield and Wetherill Waterline Replacement Project (Project). HDR retained Lithos Engineering (Lithos) to serve as the Project's Geotechnical Engineer. The purpose of this report is to present subsurface data collected and provide geotechnical design recommendations and construction considerations for the Project.

2 PROJECT BACKGROUND

The following sections describe the Project site and the proposed construction. Figures 1 through 7 present the approximate location of the proposed waterline replacement alignment and geotechnical borings.

2.1 Site Description

The Project site is generally located in the Northeastern and Southwestern areas of Mesa Verde National Park, west of Mancos, CO. More specifically, the Morefield Alignment (Northeastern, see Figures 1-2) extends from South of the Visitor and Research Center (VRC) to the Morefield Water Tank adjacent to the Morefield Campground (approximately 3.3-miles). The alignment follows Road H.5 E from the VRC East to Road 35510H.5 where it turns South. The remainder of the alignment runs in or parallel to Road 35510H.5 to the Morefield Water Tank. Where the road begins noticeable elevation change and contains switch backs, the alignment crosses the road in a more direct, linear route up the hillside. The Wetherill Alignment (Southwestern, see Figures 3-7) extends from the Navajo Tank along the Wetherill Mesa Rd to the Badger House Community Wetherill Mesa Parking Area (approximately 13.0-miles). Most of the Wetherill Alignment is directly in Wetherill Mesa Rd with only two sections outside of the paved roadway. Portions of the alignment not in the pavement roadway occur from the Navajo Tank down to the Wetherill Mesa Road, and the second occurs between the 300,000-gallon water tank and the Wetherill Mesa Road near the Wetherill Mesa Parking Area. Corrugated steel culverts occur frequently along the Northern section of the Wetherill Alignment. The existing waterline location is somewhat uncertain as the National Park Service was unable to accurately locate the entire length of both alignments.

2.2 Local Geology

The project site is located on the Mesa Verde Cuesta within the Colorado Plateaus province adjacent to the La Plata Mountains and lies completely within the Four Corners platform subdivision of the San Juan Basin. The Mesa Verde Cuesta slopes to the south at roughly 7 degrees. The cuesta was once 1,500 feet higher than it is presently and over millions of years of erosion has become the present day cuesta incised by rivers with mesas as the high points along the surface. The stratified layers of the Mesa Verde Group are (from youngest to oldest): the Cliffhouse Sandstone Formation; the Menefee Formation; and the Point Lookout Formation. The Mancos Shale underlies the Mesa Verde Group. The Laramide Orogeny along with several later orogenic sequences brought up the Mesa Verde Group and the Mancos Shale to its present prominence.

The surficial deposits range in depth of a few inches to tens of feet thick. The surficial deposits identified at the project site include alluvium, colluvium, and loess (windblown) deposits of Holocene and Pleistocene age. Rockfall deposits of the Holocene age and translational and rotational landslide deposits of Holocene and Pleistocene age were also identified in the project area and are prominent geologic

hazards. The landslide hazard observed at the site appears to be mostly relic and does not appear to be actively failing. A complete geologic hazard investigation was not included as part of this project.

2.3 Proposed Construction

The Project consists of replacing approximately 16.0-miles; 84,500 linear feet (LF) of an existing 6.0-inch diameter pressurized waterline. The replacement pipe will be 6.0-inch diameter stainless steel or FlexSteel with an invert of approximately 4.0-feet below existing grades except at locations where pipe is installed via horizontal directional drilling. We understand that the existing waterline's age, variable materials, and frequent leaks are amongst the primary concerns for the National Park Service and are the motivation for this Project. For example, replacement of these waterlines will "significantly reduce the risk of a catastrophic failure of service that would prevent use of the Morefield and Wetherill areas of the park" (SOS Task Order NO. 140P2021F0221, PG. 3).

2.3.1 Morefield Alignment

The Morefield Alignment consists of 3.3-miles of existing waterline with three different types of pipe material and three different ages. The older two segments will be replaced as part of this project. The third segment was recently replaced with stainless steel pipe in 2010 and will not be replaced as part of this project. Open-cut construction will be utilized to replace the majority of the pipeline alignment. Three unique sections will utilize horizontal directional drilling (HDD) for waterline replacement as generally identified below:

- A replacement length of approximately 1,400 feet under an isolated location where the Townsend Daisy (protected plant) grows naturally (See Figures 1-2).
- A replacement length of approximately 4,400 feet where the waterline alignment extends from the valley floor up to Top Ruins Road due to steep topography.
- A replacement length of approximately 1,300 feet from Top Ruins Road to the Morefield Water Tank due to steep topography and shallow, hard bedrock conditions.

The Morefield Alignment (18,000 LF) is mostly a double-track dirt road with two exceptions. The first occurs from the intersection of Rd H.5 and 35510H.5 South to the driveway for 35510 Road H.5, Mancos CO 81328, just North of LE-OC-02 (Figure 1, approximately 1,400 LF), which is a two-lane paved road. The second is where the alignment crosses Mesa Top Ruins Rd (Mesa Verde 1) Southwest of LE-HDD-11. This section of alignment includes approximately 200 LF of asphalt that will not be replaced due to the pipe installation of HDD. Outside of approximately 1,400 LF of asphalt replacement associated with this alignment, the remainder is situated in the double-track dirt road or open space.

2.3.2 Wetherill Alignment

The Wetherill Alignment consists of 13.0-miles of existing 6.0-inch diameter waterline that was routed underneath Wetherill Mesa Road in 1968. The Wetherill Alignment (59,000 LF) is mostly contained within the paved Wetherill Mesa Road section with two exceptions. The first occurs from the Navajo Tank to the Wetherill Mesa Road (1,800 LF), which is a double-track dirt road. The second occurs between the 300,000-gallon water tank and the Wetherill Mesa Road (370 LF) near the Wetherill Mesa Parking Area. We understand the section of waterline replacement extending from the Wetherill Mesa Parking Area to the Badger House Community Area will be rehabilitated in-place and is therefore not further addressed

in this report. The Wetherill Alignment from the Navajo Tank to the Wetherill Mesa Parking Area includes 56,500 LF of asphalt replacement, the remaining 2,500 LF is in dirt roadways or open space.

A larger reinforced concrete box culvert is located near the southern end of the Wetherill Alignment. A crossing of the culvert will be required to complete the waterline replacement.

3 GEOTECHNICAL INVESTIGATION

The geotechnical investigation included a subsurface investigation, geotechnical laboratory testing, and corrosion potential testing. The subsurface conditions encountered during the investigation are discussed in Section 4. Based on the investigation and subsequent laboratory testing, Section 5 and 6 present recommendations for geotechnical design and considerations for construction.

3.1 Subsurface Investigation

Lithos conducted geotechnical drilling on October 11th, 2021, through June 22nd, 2023. A total of 47 geotechnical borings were completed to investigate the general subsurface conditions at the Project site (Figures 1-7). Borings were generally numbered sequentially from North to South. Boring depths ranged from 15 to 89.7 feet below the existing ground surface. Groundwater was encountered in 2 of the borings.

There are three different types of geotechnical borings called out on Figures 1 – 7 and Appendix A. Geotechnical Boring denotations are structured as “LE-YY-XX”. Where:

- “YY” = either OC, BC, or HDD
 - “OC” = Open-Cut Boring, typical exploration depth of 15 feet below ground surface (bgs) with sampling every 5 feet.
 - “BC” = Shallow HDD, box culvert, or utility crossing Boring, typical exploration depth of between 20 – 30 feet bgs with sampling every 5 feet.
 - “HDD” = Deep Geotechnical Boring associated with HDD design. Typical exploration depth of 80 feet bgs with sampling every 5 feet utilizing Hollow-Stem Auger drilling method into competent bedrock, and then switching to Rock Coring method for the remainder of exploration.
- “XX” = numerical value, typically increasing in value the further South except for LE-OC-45 which is the furthest North; unique value for each boring location.

Geotechnical drilling was conducted by Drilling Engineers utilizing either a Central Mining Equipment (CME) 55 or 75 truck-mounted drilling rig (Appendix A). Drilling and sampling procedures were conducted in general accordance with ASTM’s identified in the following table:

Subsurface Investigation ASTM Standards	
Procedure	ASTM Standard
<i>Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils</i>	D 1586
<i>Standard Practice for Thick Wall, Ring-Line, Split Barrel, Drive Sampling of Soils</i>	D 3550
<i>Standard Practice for Rock Core Drilling and Sampling of Rock for Site Exploration</i>	D 2113

Continuous-flight hollow- or solid-stem augers were used to advance the borings below the existing ground surface. During drilling, Split Spoon (1.5-inch inner diameter) and Modified California (2.0-inch inner diameter) barrel samples were obtained in approximately 5-foot intervals. Collection of rock core samples with an HQ (2.5-inch inner diameter) rock core barrel was completed in select borings. The Split Spoon sampler was utilized to obtain disturbed samples of non-cohesive soils and the Modified California sampler was used to obtain relatively undisturbed samples of cohesive soils. Rock coring techniques were used to collect continuous runs of rock core suitable for logging and laboratory testing. The number of blows from a 140-pound hammer falling 30-inches required for 6-inch increments of sampler penetration, or drilling rate for rock core runs, are presented on the boring logs (Appendix A). Blow counts with less than 6-inches of penetration are presented showing the number of blows for the resulting depth of penetration (50/2" means 50 blows to drive the sampler 2-inches).

3.1.1 Morefield Alignment

A total of 15 geotechnical borings were completed for the replacement of the Morefield Alignment (Figures 1 – 2). Seven of the geotechnical borings were drilled to a depth of 15 feet to investigate subsurface conditions along the open-cut sections of the pipeline alignment. Drilling for these geotechnical borings utilized a solid-stem auger drilling method. Modified California samples were collected in even intervals for classification and geotechnical laboratory testing. Eight of the geotechnical borings were drilled to a depth of between 40 and 90 feet to investigate subsurface conditions along the potential HDD sections of the pipeline alignment. Drilling for these geotechnical borings utilized hollow-stem auger drilling in soils and HQ Rock Coring in bedrock. Modified California samples were collected in even intervals in soil and HQ Core for samples were collected in competent bedrock for classification and geotechnical laboratory testing.

3.1.2 Wetherill Alignment

A total of 32, relatively evenly spaced, geotechnical borings were completed for the replacement of the Wetherill Alignment (Figures 3 – 7). Borings were advanced to 15 feet along the open-cut sections of the alignment and between 20.0 and 30.0 feet for potential crossings of a reinforced concrete box culvert and a hillside. Drilling for these geotechnical borings utilized a solid-stem auger drilling method. Modified California samples were collected in even intervals for classification and geotechnical laboratory testing.

3.2 Geotechnical Laboratory Testing

A geotechnical laboratory testing program was selected by Lithos, and testing performed by Terracon, Advanced Terra Testing, Weld Laboratories, and University of Tennessee on representative samples collected during the subsurface investigation. A laboratory summary table and graphical testing results are provided in Appendix B. Laboratory tests conducted in general accordance with associated standards are presented in the table below.

Laboratory Testing					
<i>Geotechnical Testing</i>	<i>ASTM</i>	<i>Corrosion Testing</i>	<i>ASTM/ AWWA*</i>	<i>Rock Testing</i>	<i>ASTM</i>
#200 Sieve Wash	D1140	Water Soluble Sulfates	D4327	Point Load Strength Index	D5731
Unconfined Compressive Strength	D2166	Chlorides	D512	CERCHAR Abrasiveness	D7625
In Place Moisture and Density	D2937	Resistivity	G57	Moh's Scale of Hardness	C1895-20
Rock Moisture and Density	D2216 D7263	Redox	2580*	Splitting Tensile Strength	D3967
Atterberg Limits	D4318	pH of Soils	4500H*	Slake Durability	D4644
One-Dimensional Swell or Collapse of Soils	D4546	Sulfides	4500SD*		
Standard Proctor	D698	<i>Soil Nutrient Testing</i>	<i>WERA</i>		
California Bearing Ratio	D1883	Horticulture Soil Analysis	103		
		Horticulture Soluble Salts	103		

The boring logs presented in Appendix A include field-logged soil descriptions, amended as necessary to reflect laboratory classification testing results. Laboratory testing results were utilized in developing geotechnical design criteria and construction recommendations presented in subsequent sections.

3.3 Field Resistivity Testing

In addition to the subsurface investigation and laboratory testing program, in-situ soil resistance measurements were gathered along the alignment to investigate soil resistivity, a key indicator of corrosion potential to metallic pipe. Soil resistivity measurements were conducted using the Wenner Method in general accordance with ASTM G57-06 *Standard Test Method for Field Measurement of Soil Resistivity Using the Wenner Four-Electrode Method*. Measurements were taken parallel to the alignment at depths of 3- & 6-feet at locations shown in Figures 1 – 7.

The results of the field resistivity measurements were utilized to approximate the corrosion potential of the soils using the 10-Point System based on AWWA C105. The 10-Point System is based on the soil's resistivity, pH, oxidation-reduction (redox), sulfide content, and moisture. The 10-Point System defines scores for each category of corrosion potential as described above based on ranges of the categories values; if the summation of the scores of each category is greater than or equal to 10 then the soil is corrosive.

Corrosion potential data and corrosion protection recommendations are provided in Sections 4 and 5, respectively.

3.4 Geophysical Testing

A subsurface geophysical investigation was completed by Collier Geophysics (Collier) using seismic refraction tomography and seismic reflection in June, 2023. Multichannel-Analysis of Surface Waves (MASW) seismic soundings were conducted at 4 locations. This testing produced survey of 1D shear-waves (V_s) velocity models up to 200 feet in depth. Results were interpreted to locate the subsurface contact between the rockfall deposit and Mancos shale in areas tested. Results are presented in Attachment E and were used in HDD profile development and design.

4 SUBSURFACE CONDITIONS

Subsurface conditions were characterized based on the findings of the geotechnical investigation described in the previous section. Soil and bedrock descriptions noted on the boring logs and below are in general accordance with ASTM D 2487 – *Standard Practice for Classification of Soils for Engineering Purposes (USCS - Unified Soil Classification System)* and D 2488 – *Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)*. Boring logs and a supplementary boring log key, explaining boring log details, are provided in Appendix A.

4.1 Morefield Subsurface Materials

Primary materials encountered during the Morefield Alignment subsurface investigation include fine alluvium, coarse alluvium, rockfall deposit, landslide deposit, and bedrock of the Mancos Shale. Groundwater was encountered in 2 of the geotechnical borings, as further discussed in Section 4.4.

4.1.1 Fine Alluvium

Fine alluvium was encountered in 10 of the 15 geotechnical borings. Fine alluvium was encountered at ground surface to 0.5 feet below ground surface and extended to depths ranging from 1-foot to 33-feet below ground surface, or to the maximum depth of exploration (Appendix A). Fine alluvium was classified as the following in accordance with USCS:

- Lean Clay (CL)
- Fat Clay (CH)
- Lean Clay with sand (CL)

Where encountered and recovered, fine alluvium was described as medium stiff to hard; olive-brown, pale-olive, olive-gray, olive-yellow, dark-brown, and olive; and dry to moist. Fine alluvium recovered from drilling and sampling contained particles sizes ranging from clay to coarse gravel.

One representative sample of fine alluvium was tested for unconfined compressive strength. Unconfined compressive strength test results indicated a strength of 33 psi.

Four representative samples of fine alluvium were tested for swelling characteristics upon inundation. Samples exhibited ranges of 0 to 4.3 percent swell.

4.1.2 Coarse Alluvium

Coarse alluvium was encountered in 1 of the 15 geotechnical borings near the Morefield Water Tank. Coarse alluvium was encountered at ground surface and extended to a depth of 9-feet below ground surface (Appendix A). Fine alluvium was classified as the following in accordance with USCS:

- Silty Sand (SM)

Where encountered and recovered, coarse alluvium was described as loose, reddish brown, and moist. Coarse alluvium recovered from drilling and sampling contained particles sizes ranging from fines to fine gravel.

4.1.3 Rockfall Deposit

Rockfall Deposit was encountered in 4 of the 15 geotechnical borings on the steep slope from the valley floor to Top Ruins Road. Rockfall Deposit was encountered at ground surface and extended to depths between 37 feet and maximum depth of exploration. Rockfall deposit was noted as consisting of fine-grained matrix with intermittent boulders. Rockfall Deposit was classified as the following in accordance with USCS:

- sandy Lean Clay (CL)
- sandy Lean Clay with gravel (CL)
- sandy Lean Clay with gravel & cobbles (CL)
- Lean Clay with sand, gravel, & cobbles (CL)
- Lean Clay with sand (CL)
- Lean Clay with sand & gravel (CL)
- clayey SAND (SC)
- Boulders:
 - Sandstone
 - Clayey Sandstone
 - Silty Sandstone
 - Siltstone
 - Claystone
 - Sandy Claystone
 - Interbedded Shale and Siltstone
 - Interbedded Claystone and Siltstone
 - Interbedded Claystone and Sandstone

Where encountered and recovered, Rockfall Deposit was described as soft to hard; olive, pale olive, olive-brown, olive-gray, olive yellow, dark-brown, yellowish brown, dark yellowish brown, reddish brown, dark bluish gray, and gray; and dry to moist. Boulders within the Rockfall Deposit were additionally described as slightly to highly weathered with noted frequent calcite deposits and iron oxide staining. Rockfall Deposit recovered from drilling and sampling as well as inferred based on drilling action contained particles sizes ranging from clay to boulders.

The Rockfall Deposit is best described as clay with varying amounts of fine and medium sand as the primary matrix. The clasts of the matrix range in size from coarse sand to larger boulders and are primarily composed of the Siltstone and Sandstone from the Point Lookout Sandstone Formation. Sizes and existence of cobbles and boulders or any clast larger than 2 inches was inferred based on drilling action.

Three representative samples of rockfall deposit were tested for unconfined compressive strength. Unconfined compressive strength test results indicated a strength from 46 to 146 psi.

One representative sample was tested for CERCHAR abrasiveness. Corrected CAI test results indicate a CAI of 2.48.

4.1.4 Landslide Deposit

Landslide Deposit was encountered in 2 of the 15 geotechnical borings. Landslide Deposit was encountered at ground surface and 9-feet below ground surface and extended to depths of end of exploration (Appendix A). Landslide Deposit was classified as the following in accordance with USCS:

- clayey Sand (SC)
- Lean Clay with sand (CL)
- Boulders:
 - Sandstone

Where encountered and recovered, landslide deposit was described as dense; pale olive, olive brown, yellowish brown; moist. Landslide deposit consists of a non-cohesive soil matrix containing boulders mostly of the Menefee Formation and some of the Point Lookout Formation.

Three representative samples of landslide deposit were tested for unconfined compressive strength. Unconfined compressive strength test results indicated strength from 46 to 3,533 psi. An additional unconfined compressive strength was tested on a boulder of the Point Lookout formation resulting in a strength of 8 psi.

One representative sample was tested for splitting tensile strength. Splitting tensile strength test results indicate strength of 202 psi.

Two representative samples of sandstone boulders within the Rockfall Deposit were tested for CERCHAR abrasiveness. Corrected Cherchar-Abrasivity-Index (CAI) test results indicate values ranging from 2.09 to 3.83 generally indicating a moderately abrasive material.

One representative sandstone boulder sample within the Rockfall Deposit was tested on Moh's scale of hardness. Test results indicated a hardness of 2.5 indicating a relatively soft material.

One representative sample was tested for slake durability. Two cycles were tested, and a durability type was assigned to the sample. Cycle durability for the 1st cycle test results show an 87.5% durability. Cycle durability for the 2nd cycle test results show a 80.3% durability. The sample was classified as type II. This indicates that the material tested "retained specimen consist of large and small fragments."

4.1.5 Mancos Shale

Bedrock of the Mancos Shale was encountered in 5 of 15 geotechnical borings. Bedrock was encountered at depths ranging from 10 to 79 feet below the ground surface and extended to the maximum depth of exploration. Bedrock was classified as the following:

- Shale
- Sandy Shale
- Sandstone
- Siltstone
- Interbedded Shale and Siltstone

Where encountered and recovered, bedrock was described as fresh to highly weathered; very soft to hard; very fine grained to fine grained; reddish orange, dark-blueish-gray, bluish gray, and gray; iron oxidation; calcareous; and fossiliferous. Fossils were found throughout core samples at varying depths. This bedrock is relatively massive with rock-quality designations ranging from 0 to 100 percent. Blow counts in the Mancos shale ranged from 50/3" to 50/4". Discontinuities are generally the same throughout the Rock Core, they are described as:

- Discontinuity Type: Bedding
- Orientation: Horizontal
- Aperture: Tight
- Roughness: Smooth
- Shape: Flat

Six representative samples of shale were tested for unconfined compressive strength. Unconfined compressive strength test results indicated strength from 9 to 31 psi.

Twelve representative samples of shale were tested for point load strength. Corrected point load strength index test results indicate strengths ranging from 86.8 psi to 382.7 psi. Of these twelve samples, three samples were additionally subjected to diametrical shape point load strength index testing. Corrected point load strength index test results indicated a strength from 19.4 psi to 35.4 psi. Diametrical point load indicates testing was completed parallel to the bedding plane of the shale. As such, tested samples of shale showed a vertical strength (perpendicular to bedding planes) approximately 5 to 10 times greater than the horizontal strength (parallel to bedding planes).

Two representative samples of shale were tested for splitting tensile strength. Splitting tensile strength test results indicate a tensile strength of 532 psi and 708 psi.

Four representative samples of shale were tested for CERCHAR abrasiveness. Corrected CAI test results indicate a CAI from 2.00 to 3.01 generally indicating a non to low abrasive material.

Two representative samples of shale were tested on Moh's scale of hardness. Test results indicated a hardness of 1.6 and 1.7 indicating a soft material.

Two representative samples of shale were tested for slake durability. Two cycles were tested and a durability type was assigned to each sample. Cycle durability for the 1st cycle test results show a 94.4% and 97.6% durability. Cycle durability for the 2nd cycle test results show a 89.3% and 95.8% durability. Samples were classified as type I and II. This indicates that the shale tested "retained specimen remain virtually unchanged" and "retained specimen consist of large and small fragments."

4.2 Wetherill Subsurface Materials

Primary materials encountered during the subsurface investigation include fine colluvium, quaternary loess, and bedrock of the Cliffhouse Sandstone. Groundwater was not encountered in any of the 32 geotechnical borings, as further discussed in Section 4.4.

4.2.1 Fine Colluvium

Fine colluvium was encountered in 5 of 33 geotechnical borings. Fine colluvium was encountered at depths ranging from ground surface to 1.3 feet below ground surface and extended to depths ranging from 9-feet to 15-feet bgs, or to the maximum depth of exploration. Fine colluvium was classified as the following in accordance with the Unified Soil Classification System (USCS):

- sandy Lean Clay with gravel (ML)
- sandy Lean Clay (CL)
- Lean Clay (CL)
- Lean Clay with sand (CL)

Where encountered and recovered, fine colluvium was described as stiff to hard, olive-brown, olive-yellow, yellowish-brown, and moist. Additional descriptions of the fine colluvium are frequent iron oxide staining and roots near the surface where encountered. Fine colluvium recovered from drilling and sampling contained particles sizes ranging from clay to coarse gravel.

One representative sample of fine colluvium was tested for swelling characteristics upon inundation. Test results showed a 3.4 percent swell.

4.2.2 Quaternary Loess

Quaternary loess was encountered in 3 of 33 geotechnical borings at depths ranging from ground surface to 1.0 foot below ground surface and extended to depths ranging from 0.5 feet to 15 feet bgs or to the maximum depth of exploration. Quaternary loess was classified as the following in accordance with USCS:

- sandy Lean Clay (CL)
- Lean Clay with sand (CL)
- Lean Clay (CL)

Where encountered and recovered, quaternary loess was described as stiff to very stiff, dark-reddish-yellow to dark-brown, and moist. Coarse alluvium recovered from drilling and sampling contained particle sizes ranging from clay to fine gravel, with a maximum particle size of 0.5-inches.

4.2.3 Cliffhouse Sandstone

Bedrock of the Cliffhouse Sandstone was encountered in 30 of 32 geotechnical borings. Bedrock was encountered at depths ranging from 0.5 to 14.8 feet bgs and extended to the maximum depth of exploration. Bedrock was classified as the following:

- Siltstone
- Interbedded Claystone and Siltstone
- Sandstone
- Interbedded Claystone and Sandstone
- Claystone

Where encountered and recovered, bedrock was described as fresh to completely weathered; very soft to hard; clay size grains to fine sand size grains; olive-brown, yellowish-brown, reddish-brown, olive, olive-yellow, olive-gray, gray, and pale olive; and dry to moist. Additional descriptions of some of the Sandstone and Siltstone samples collected were calcite matrix and roots (top ten feet). Most bedrock samples collected contain iron oxide staining.

A boulder of the Cliffhouse sandstone was tested for unconfined compressive strength. Unconfined compressive strength test results indicated a strength of 38 psi.

4.3 Corrosion Potential Data

Field soil resistivity measurements were taken at pin spacings correlating to depths of 3- and 6-feet below ground surface at 8 separate locations along the 2 alignments. The table below presents the total number of soil resistivity measurements corresponding to each score of the AWWA 10-Point System.

Soil Corrosivity Based on Soil Resistivity – Field Measurements		
Soil Resistivity (Ω-cm)	10-Point System Resistivity Score	Number of Tests Correlating to Score
<1,500	10	0
1,500-1,800	8	0
1,800-2,100	5	0
2,100-2,500	2	0
2,500-3,000	1	0
>3,000	0	16

The table below presents the total 10-Point System score of tested samples submitted to the laboratory.

Soil Corrosivity Based on Soil Resistivity – Lab Measurements			
Sample ID	Sample Depth (ft.)	Total 10-Point System Score	Alignment
LE-OC-03	9	10	Morefield
LE-HDD-07	9	10	Morefield
LE-HDD-10	4	10	Morefield
LE-OC-12	0	0	Morefield
LE-OC-14	0	2	Wetherill
LE-BC-18	9	0	Wetherill
LE-OC-28	4	1	Wetherill

Any 10-Point System total scores greater than or equal to 10 correlates to a corrosive soil potential. Laboratory corrosivity results and field resistivity measurements are presented in Appendices B and C.

4.4 Groundwater

Groundwater was encountered in 2 of 47 geotechnical borings immediately after drilling at depths ranging from 15.0 to 41.0 feet below the ground surface, as summarized in the table below.

Groundwater Depth [ft]		
Boring ID	Depth ¹	Date
LE-HDD-09	41.0	10/21/21
LE-OC-12	15.0	10/18/21

¹Groundwater depth as measured below the existing ground surface

Groundwater levels are expected to fluctuate based on precipitation, seasonal variations, site development, and nearby water sources.

5 GEOTECHNICAL DESIGN RECOMMENDATIONS

The following sections are intended primarily for engineering design of the Project. Design recommendations include: lateral earth pressures, thrust restraint, modulus of soil reaction (E'), soil corrosivity, and pavement replacement. If additional geotechnical design recommendations are necessary, Lithos can be contacted to provide required information.

5.1 Lateral Earth Pressures

Lateral earth pressures presented are recommended for use during structural design. Lateral earth pressure values are a function of the properties and the geometry of the backfill materials, such as density and internal friction angle, and anticipated magnitude of lateral retention deflection. Lateral earth pressures for recommended backfill materials above groundwater are provided in the table below.

Lateral Earth Pressures – Above Ground Water Table							
Backfill Material Type	Internal Friction Angle (deg)	Earth Pressure Coefficients			Equivalent Fluid Pressure (pcf)		
		Active	At-Rest	Passive	Active	At-Rest	Passive
CDOT Class 2	26	0.39	0.56	2.56	47	67	307
CDOT Class 5 or 6	32	0.31	0.47	3.25	38	59	407
Clean Coarse-Grained Import Backfill (like squeegee)	34	0.28	0.44	3.54	36	56	449

For the lateral earth pressures presented above to remain applicable, backfill material placement adjacent to below grade structural elements shall be in accordance with procedures outlined in this report. In addition, if onsite material is processed and used as backfill, material requirements outlined in this report should be followed. For the tabulated lateral earth pressures to apply, backfilled material must be placed within a 1 horizontal to 1 vertical (1H:1V) backfill geometry, up and away from the base of structures.

Consideration has not been given to vertical loads applied to the backfill surfaces during or after construction as a result of traffic and/or other surcharge loads, sloping backfill, or soil-wall interfacial friction. Standard design values for typical, non-construction related vehicular traffic result in an additional 250 pounds per square foot (psf) vertical pressure.

5.2 Thrust Restraint

Buried pressurized pipes experience thrust forces at various locations such as bends, reducers, offsets, tees, wyes, dead ends, and valves requiring restraint. To counteract thrust forces within pressurized pipes, thrust blocks or restrained joints are recommended. Thrust blocks bearing against native soils can be designed using a passive earth pressure. Passive earth pressure can be assumed to be fully mobilized when movement equals 0.01 times the height of the thrust block. Assuming a negligible amount of movement, a passive earth pressure of 300 pcf per foot of depth with an average pressure over the face of the thrust block not to exceed 1,500 psf may be used. A minimum of 2-feet of cover over thrust blocks is recommended and thrust blocks should be oriented such that the passive pressure influence zones do not overlap for adjacent blocks and do not impact other subsurface utilities.

If thrust blocks cannot be utilized for restraint, restrained joints may be considered. To assist with restrained joint design, coefficients of friction between anticipated compacted pipe bedding materials and potential pipe materials are presented in the table below. If a different type of pipe than the those listed below is utilized in the final design, Lithos should be contacted to update the below recommendations. The following coefficient of friction values are based on the approved backfill materials listed in Section 6.2.2.

Coefficient of Friction for Buried Pipe ^{1,2}	
Pipe Type	Coefficient of Friction
FlexSteel	0.2
Steel	0.5

¹Soil-Pipe Interface Friction Coefficients for Buried PE4710 Pipe (2018),

²Jacking Force Prediction: An Interface Friction Approach Based on Pipe Surface Roughness (2006)

5.3 Modulus of Soil Reaction (E')

The modulus of soil reaction (E') is an empirically derived coefficient commonly used in flexible pipeline design. E' is related to the nature and degree of compaction of the pipe bedding material and the stiffness of the compacted pipe bedding. E' is not impacted as much by the pipe material as it is by the pipe bedding material (backfill) composition and compaction. For steel or FlexSteel pipe, Lithos recommends an E' value of 1,600 psi be used for design. The E' value presented above is applicable when there is 2-5 feet of cover; the backfill material is a SW, SP, GW, or GP type soil with 12% or less of fines; and is compacted to a minimum 95% standard proctor as tested by ASTM D698.

5.4 Soil Corrosivity

Based on the field and laboratory corrosion testing results, we recommend that corrosion protection measures be included as part of the design. Previous pipe performance and leaks can be another key indicator as to where soils may be more corrosive in nature. A more thorough corrosion potential investigation may be needed during final design if a blanket approach of corrosion along large stretches or the entire alignment(s) are not considered, and specific lengths of alignment are identified for additional corrosion protection measures. The table below identifies locations along the alignment where soil corrosion was measured:

Corrosion Protection Intervals			
Denotation	Corrosion Potential	Type of data acquisition	Alignment
FR-1	Non-corrosive (0)	Field	Morefield
LE-OC-03	Corrosive (10)	Lab	Morefield
LE-HDD-07	Corrosive (10)	Lab	Morefield
LE-HDD-10	Corrosive (10)	Lab	Morefield
FR-3	Non-corrosive (0)	Field	Morefield
LE-OC-12	Non-corrosive (0)	Lab	Morefield
FR-4	Non-corrosive (0)	Field	Wetherill
LE-OC-14	Non-corrosive (2)	Lab	Wetherill
LE-BC-18	Non-corrosive (0)	Lab	Wetherill
FR-5	Non-corrosive (0)	Field	Wetherill
LE-OC-28	Non-corrosive (1)	Lab	Wetherill
FR-6	Non-corrosive (0)	Field	Wetherill
FR-7	Non-corrosive (0)	Field	Wetherill
FR-8	Non-corrosive (0)	Field	Wetherill
FR-9	Non-corrosive (0)	Field	Wetherill

The above corrosion potentials are based on the field and laboratory results produced from testing locations and samples relatively evenly spaced along both alignments.

5.5 Pavement Recommendations

Pavement reconstruction will be needed for the roadway crossings along the Morefield Alignment at the crossing of Mesa Verde 1 and potentially at the northern end of the alignment just South of the intersection of Rd 35510H.5 and Rd H.5. Pavement reconstruction will be needed for most of the Wetherill Alignment, approximately 56,500 linear feet, with a replacement width of the excavated trench or other

acceptable NPS minimum such as a single traffic lane. For pavement replacement following open-cut pipeline construction, we generally recommend matching the existing pavement sections, assuming satisfactory existing performance. Existing thickness of the pavement section ranges in thickness of 1- to 9-inches for the asphalt section and 0- to 10-inches for the base coarse section. Our experience with similar roadways utilized a pavement section consisting of 6 inches of base course and 5 inches of asphalt.

6 CONSTRUCTION CONSIDERATIONS

The following sections are intended for the Engineer producing specifications and the Contractor constructing the Project. Construction considerations include: temporary excavations, site grading and earthwork, bedrock and oversized material excavation, and construction dewatering.

6.1 Temporary Excavations

General site safety including temporary excavations are the sole responsibility of the Contractor performing construction. Lithos is providing temporary excavation information solely as an informational benefit to the Project team, specifically the general Contractor. An Occupational Safety and Health Administration (OSHA) defined competent person should be identified by the Contractor to be in charge of temporary excavations. In general, the Contractor's competent person shall have experience or training in classifying soil types per OSHA standards, benching and shoring, and have the ability to detect potential temporary slope stability and protective system issues. OSHA regulation 1926 Subpart P should be followed in the construction and support of all excavations.

According to OSHA regulation 1926 Subpart P, OSHA defines an excavation as a man-made cut, trench, or depression formed by the removal of earth. A trench is a specific type of narrow excavation with a geometry of a greater depth than width and a width of 15-feet or less. Trenches 4-feet deep or greater shall be sloped, retained with shoring, or shielded appropriately. Shielding most commonly includes trench boxes. In general, shoring can include inclined, horizontal, or vertical systems depending on the excavation geometry and availability of retention alternatives. Sloping and benching shall be in accordance with OSHA recommendations. Benching shall include a maximum 4-foot vertical face for each bench and the overall excavation geometry less than or equal to the OSHA defined slope. All shielding or shoring in support of trench excavations greater than or equal to 20 feet, shall be designed by a Professional Engineer or be based on tabulated data prepared or approved by a registered professional engineer in accordance with OSHA 1926.652(b) and (c).

Temporary excavations and trenches are anticipated during the proposed construction. Lithos has evaluated and classified the soil and bedrock recovered from site explorations and anticipated to be exposed in excavations for the proposed construction. Based on the OSHA soil type classifications, the following table presents steepest recommended temporary excavation slopes to be utilized during construction.

OSHA Temporary Excavation Slopes		
Material Type ³	OSHA Classification	Maximum Recommended Slope (H:V) ^{1,2}
Onsite Silt or Sand Fine to Coarse Alluvium – disturbed Type A	Type B	1:1 (45°)
Onsite Clay Fine Alluvium - undisturbed	Type A	¾:1 (53°)
Solid Rock	Stable Rock	Vertical (90°)

¹ H:V is an abbreviation for Horizontal:Vertical

² Valid for trench excavations less than 20 feet in depth

³Reference OSHA Technical Manual – Section V: Chapter 2 for more detailed material descriptions

During construction, heavy equipment or excavated material stockpiles should be kept away from excavation edges to the furthest extent possible. Shoring design should consider the proximity of construction loads and stockpiled material to excavations. Underground utilities shall be fully understood and documented prior to initiating excavations. Finally, the Contractor's competent person shall inspect trenches and excavations routinely for signs of instability including sliding, toppling, subsidence and bulging, heaving or squeezing, boiling, and/or other visual concerns. Site Grading and Earthwork

Site grading and earthwork considerations are presented in the following subsections.

6.1.1 Excavation and Subgrade Preparation

In general, excavation and subgrade preparation consist of removal of excavated material as required for the proposed construction and scarifying and conditioning subgrade materials. If existing materials are desirable as backfill, excavated materials shall be stockpiled conveniently and processed prior to use. Material processing is discussed in the following section.

Subgrade materials encountered immediately below the proposed construction shall be observed and any unsuitable material shall be removed as determined by the Engineer. In addition, subgrades shall be scarified, moisture conditioned, and recompacted to a minimum depth of six inches below the base of the pipe bedding zone. Subgrade moisture and compaction specifications are provided in the following sections.

Material encountered near proposed pipe inverts ranged from very soft and very loose to medium stiff based on a blow count range of weight-of-hammer (0 blows per foot) to 6 blows per foot. In general, the only soft section identified during the geotechnical subsurface investigation that may require subgrade improvement is the southern section of the Wetherill Alignment between the 300,000-gallon water tank and the Wetherill Mesa Parking area. In areas where very soft subgrade material is encountered at the proposed pipe invert elevations, we recommend an over-excavation beneath the bottom of the pipe bedding zone. The over-excavation may be replaced with onsite soil that has been conditioned to near optimum moisture content and recompacted. If soils are unstable below 12 inches, aggregate crowding or stabilization fabric may be placed. Crowding aggregate material up to 3- to 4-inches in diameter, such as recycled concrete or native gravel/cobble, into the soil will help to stabilize the soft subgrade beneath the pipe bedding zone. Alternatively, a stabilization geofabric such as Mirafi HP270 may be placed at the bottom of the over-excavation.

If the bottom of the pipe zone is in bedrock then reconditioning of excavated material is not necessary.

6.1.2 Trench Backfill Material

Backfill is anticipated for the proposed construction within excavated trenches. Material recommendations are provided below:

- Processed onsite material (CDOT Class 2) is recommended for backfill within trenches above and below the pipe bedding zone.
- Imported CDOT Class 5 or 6 base course, CLSM fill, or a clean coarse-grained material such as: squeegee, ASTM C-33 (concrete sand), or ¾ inch crushed rock is recommended as backfill for the pipe bedding zone.
- Pipe bedding zone extends a minimum of springline to 4 inches below the invert of the proposed pipe.

Imported squeegee material should have 100 percent passing the 3/8-inch sieve and 0 to 5 percent passing the No. 200 sieve.

Processing of onsite material shall include removing frozen soil, wood, trash, organic material, cobbles and boulders larger than three inches in diameter, individual bedrock pieces larger than three inches in diameter, and other deleterious materials. If bedrock is utilized as backfill material, it should be broken down to a soil like consistency prior to use. In general, CLSM shall flow freely and be uniform in density and relatively low in permeability. If selected, the Contractor shall submit a CLSM mix design to the Engineer for approval prior to use. If other fill materials are preferred for any of the presented applications, Lithos should be contacted to review submitted material testing results.

6.1.3 Fill Placement and Compaction

Fill placement is anticipated during pipe bedding and trench backfilling. Backfill placement shall occur in maximum 12-inch loose lifts. Minimum recommended compaction specifications are outlined in the table below.

Soil Compaction Recommendations		
Material Type ³	Moisture and Compaction Specifications	
	Moisture Content ¹	Dry Density ²
Recommended Backfill Materials (6.2.2)	-2% to +2%	≥ 95%

¹ Moisture content relative to the optimum moisture content as determined by Standard proctor compaction testing (ASTM D698)

² Dry density relative to the maximum dry density as determined by Standard proctor compaction testing (ASTM D698)

³ The Geotechnical Engineer shall determine whether backfill material exhibits a suitable Standard Proctor compaction curve and can be tested in accordance with ASTM D698. If the material does not exhibit a Standard Proctor compaction curve, we recommend material is compacted to a minimum relative density of 65% (ASTM D4253 and ASTM D4254). Pipe and drain bedding should also be compacted to 65% relative density (ASTM D4253 and ASTM 4254).

Field density tests should be performed to verify adequate compaction throughout the depth of compacted material. The Geotechnical Engineer observing construction shall determine the testing frequency of placed fill to assure adequate compaction. In general, Lithos recommends testing each lift of

placed material during backfilling to determine if compaction specifications are achieved. Adequate moisture control will substantially aid in achieving the desired compaction and shall be carefully controlled throughout fill placement. If fill materials visibly exceed moisture specifications, Lithos recommends working and handling the materials until a moisture content near optimum is obtained. Non-cohesive, granular soils typically achieve a denser configuration if they are placed at a relatively high moisture content. If base course is utilized as fill, material behavior will be dependent on the fines content and plasticity. Lithos may be contacted to evaluate whether imported base course can be adequately tested as a cohesive or non-cohesive material. Lithos can also be consulted to aid in the further defining testing specifications for placed fill materials.

With the exception of CLSM, mechanical compaction is required for all materials placed as fill during construction. Compaction of cohesive materials is best accomplished with equipment such as a jumping jack or padfoot roller. Non-cohesive soils are best compacted with a vibratory plate or vibratory smooth-drum roller. Compaction utilizing any flooding type technique is not recommended. Care should specifically be taken when compacting backfill in the pipe bedding zone and on the first lift above the crown of the pipe. Generally, we recommend operating only light-weight compaction equipment such as jumping jacks and vibratory plates within the pipe bedding zone and close to the crown of installed pipelines.

6.2 Bedrock and Oversized Material Excavation

Bedrock excavation should be anticipated during the proposed construction. Excavation of large cobbles and boulders is anticipated. Cobbles should be expected to occur most frequently in the rockfall deposit along the Morefield Alignment and between the bedrock contact and ground surface along the Wetherill Alignment. Boulders should be anticipated within the rockfall deposit along the Morefield Alignment. Cobble and boulder size and frequency are based on inferred data from drilling action during the subsurface investigation. Encountered bedrock within the proposed construction envelope of the Wetherill Alignment was described as fresh to completely weathered with blow counts ranging from 18 blows per foot to 50 blows for 1-inch. Encountered bedrock within the proposed construction envelope of the Morefield Alignment was described as fresh to highly weathered with blow counts ranging from 50 blows for 6-inches to 50 blows for 2-inches. Selecting the correct excavation equipment will generally decrease operating costs and result in less unnecessary wear and fatigue on equipment. Based on anticipated geologic conditions, excavations in bedrock should be minimized by utilizing the trench of the existing waterline, if possible. Based on anticipated geologic conditions, excavations into soil or softer bedrock can be accomplished using common trenching equipment, such as appropriately powered excavators. However, should excavations occur within individual blocks/boulders in the rockfall deposit or within more competent bedrock units, a hydraulic breaker and/or a heavier duty bucket utilizing ripper or shank teeth may be required. Utilizing a minimal width bucket maximizing tooth pressure could also be considered. Unconfined compressive strength laboratory testing on sandstone bedrock ranged from 8 to 46 psi.

6.3 Construction Dewatering

As stated in Section 4.3, groundwater was encountered during the subsurface investigation at depths ranging from 14.0 to 41.0 feet below the existing ground surface. Temporary construction dewatering beyond removal of nuisance water or runoff from precipitation is not anticipated for the proposed construction. If required, construction dewatering must adhere to the Colorado Department of Public

Health and Environment (CDPHE) regulations and discharge permit requirements. Analytical testing of groundwater has not been completed for the Project and will be required per CDPHE regulations.

6.4 HDD Construction Recommendations

Three unique HDD segments will be constructed as part of the Morefield alignment as generally described below:

- 1) A 1,400-foot-long alignment under the Townsend Daisy protected area extending primarily through Mancos Shale bedrock.
- 2) A 4,300-foot-long alignment extending from the valley floor up to Top Ruins Road to avoid excavation up a relatively steep hillside. This alignment will extend primarily through Mancos Shale but will encounter Fine Alluvium near the northern-most entry location and Rockfall Deposit near the southern-most exit location. This alignment includes an entry-to-exit elevation differential of approximately 950 feet.
- 3) A 1,100-foot-long alignment extending under Top Ruins Road to the Morefield Water Tank to avoid difficult excavation through sandstone and relatively steep topography. This alignment will extend primarily through Mancos Shale and Point Lookout Sandstone but will also encounter Rockfall Deposits near the northern-most entry location and Landslide Deposits near the southern-most exit location. This alignment includes an entry-to-exit elevation differential of approximately 90 feet.

See Figures SH-1 through SH-3 for HDD geologic profiles based on subsurface data collected during the subsurface investigation. Each crossing will encounter different challenges based on alignment length, geometry, and subsurface materials. All crossings will need to be conducted in a footprint designated by the National Park Service to maximize preservation of ecological and anthropological resources in the National Park. Several unique challenges to HDD construction for this project are highlighted below in reference to geotechnical conditions discovered during the Geotechnical Investigation.

- The large elevation differential between entry and exit for HDD Alignments 2 and 3 will require additional construction considerations to stabilize the borehole in areas where drilling mud can not remain in the borehole (higher elevations) and the surrounding borehole consists of less inherently stable materials (Rockfall and Landslide deposits). In these instances, steel casing can be installed to the bedrock interface as a beneficial tool to stabilize the borehole and prevent issues with stability during construction.
- Sandstone boulders within the Rockfall and Landslide Deposits and the Point Lookout Sandstone are relatively abrasive materials and should be considered when selecting tooling and planning for tooling wear.
- Based on the length of Alignment 2, a larger HDD rig (sometimes referred to as a “maxi rig”) will be required to complete the installation and provide the necessary pull force and rotary torque capabilities.
- The primary material to be encountered along all three HDD Alignments will be Mancos Shale. The Mancos Shale is relatively soft for a bedrock unit and is expected to break down into relatively small particles during borehole creation and enlargement. Due to the relatively fine and clayey nature of the shale, deflocculating agents and reclamation including a centrifuge should be considered.

- General site layout, specifically at the upper end of HDD Alignment 2, will require planning and coordination. Flex steel is a unique pipe both for transport and site preparation and during fusing or coupling. Consideration for suitable working room versus layout constraints and NPS designated temporary easement is recommended.

Boring Logs included in Appendix A and Geotechnical Testing included in Appendix B contain a comprehensive summary of bedrock composition, strength, and abrasion and Rockfall and Landslide Deposit composition and boulder strength and abrasion. The selected HDD contractor is encouraged to carefully review these testing results when evaluating drilling procedure means and methods and selecting equipment and tooling for completing the project. In addition, Lithos provided a previous HDD Feasibility Report during preliminary design for the project that provides additional thoughts regarding HDD construction and can be reviewed when assessing construction.

6.5 Construction Observation and Quality Assurance

Site observations during the construction specifically to address the geotechnical components of the project by Lithos are recommended including: trench and bedrock excavations and pipe bedding and backfill placement and compaction. Quality assurance of compaction and backfill materials are necessary to improve long-term performance of the proposed construction and to avoid differential settlements. Lithos recommends that a qualified testing agency is retained during construction to monitor backfill materials and compaction. Lithos should be notified if unanticipated subsurface conditions are encountered during construction in order to re-evaluate and potentially change the design and/or construction recommendations presented in this report.

Lithos commonly performs a significant construction observation role during HDD construction when involved in plan and profile development and HDD specific design. Most commonly these roles are full time after initial set up during the pilot bore, reaming, pipe pull in, and any grouting work. We strongly recommend NPS consider knowledgeable observation support staff during the completion of the three HDD alignments based on the technicality and geometric and subsurface nuances of each alignment. In general, these bores contain a high degree of risk based on their complexity that can be managed with suitable personnel available.

7 LIMITATIONS

This study was conducted in accordance with generally accepted geotechnical engineering and engineering geologic practices and principals; no warranty, express or implied is made. The subsurface conditions described in this report were based on data obtained from widely spaced exploratory borings, geotechnical laboratory testing, information provided by the client, engineering judgement, and our experience with similar subsurface conditions and projects. The boring logs presented in this report only depict the subsurface conditions at the actual boring locations. Subsurface conditions are typically variable, both laterally and vertically, and the nature and extent of the subsurface variations across the site may not become evident until construction. The boundaries between different material types presented in this report are approximate and, in some cases, may be more abrupt or gradational than described herein. Groundwater levels may vary with time, adjacent water source levels, precipitation, and changes to the hydrogeological conditions at or surrounding the project site.

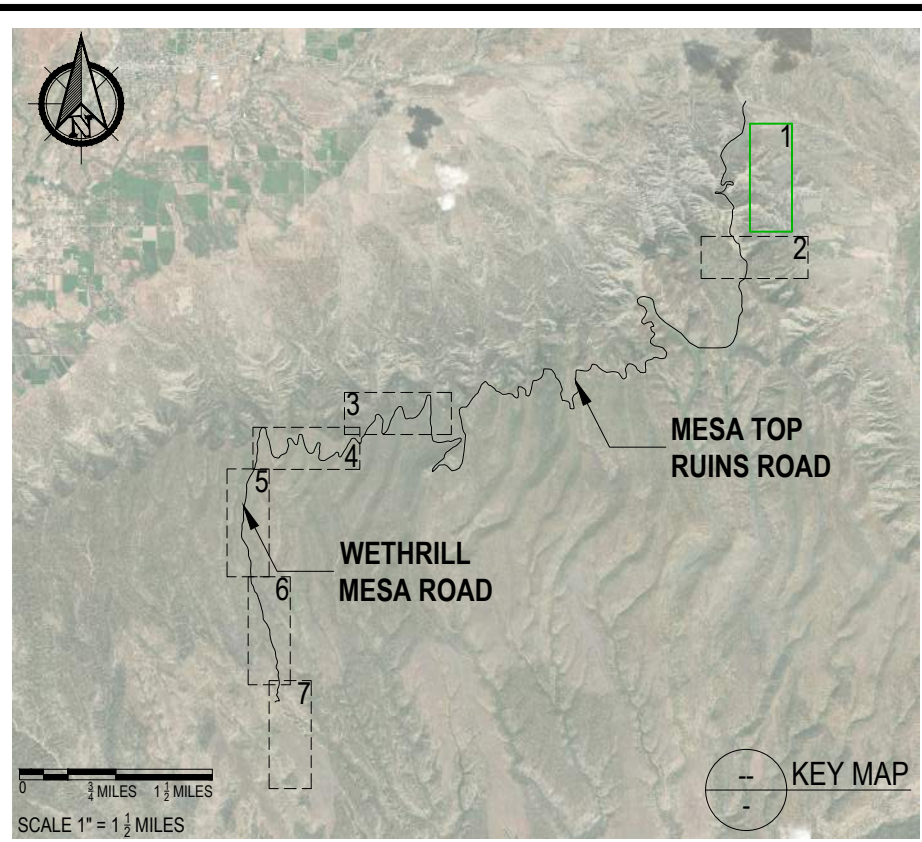
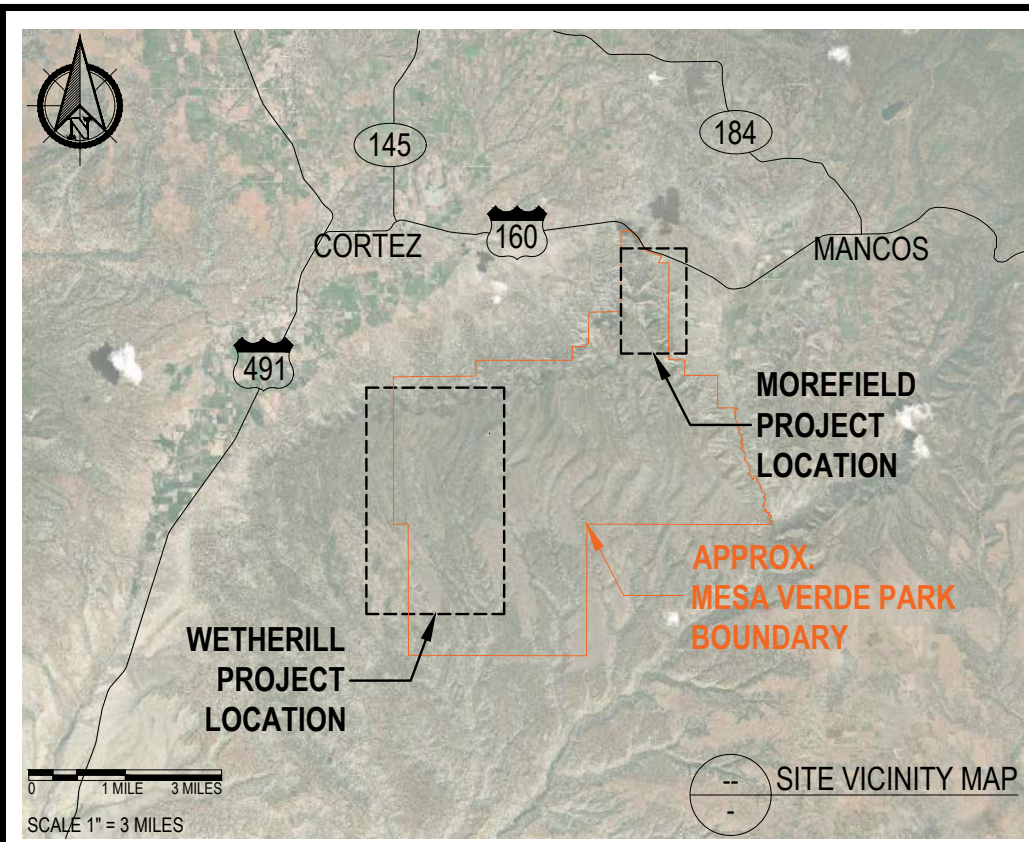
This report has been prepared exclusively for our client for design purposes for the subject project. Lithos Engineering is not responsible for technical interpretations by others of the data presented in this report or use of this report by others for the subject project or other projects. If differing site conditions are encountered during further evaluation of the subsurface conditions by others or during construction, Lithos Engineering should be notified immediately to determine if any changes to our recommendations presented in this report are warranted.

The recommendations presented in this report are only intended for the proposed design and construction as understood by Lithos Engineering at the time of issuing this report. If the proposed design and construction changes, Lithos Engineering should be notified immediately and given the opportunity to review the proposed changes and if necessary, modify our recommendations presented herein.

An environmental assessment was not included in Lithos Engineering scope of work for this project. Any statements regarding the absence or presence of hazardous and/or toxic substances presented herein are only intended for informational purposes. If the client is concerned about the environmental conditions at the site, Lithos Engineering recommends the client and/or Owner retain a qualified environmental firm to conduct an environmental site assessment.

REFERENCES

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- Montezuma County Road and Bridge Standard Specifications, Board of County Commissioners (2014).
- Occupational Safety and Health Administration (OSHA), Excavations: Hazard Recognition in Trenching and Shoring, Section V: Chapter 2.
- Research Association, Corrosion Control Polyethylene Encasement (2017).
- Soil-Pipe Interface Friction Coefficients for Buried PE4710 Pipe (2018).
- SOS Task Order NO. 140P2021F0221 (2021).



- LEGEND:
- APPROXIMATE PROPOSED WATERLINE
 - APPROX. PROPOSED BADGER HOUSE WATERLINE
 - LE-XX-XX ● APPROXIMATE LITHOS BORING LOCATION
 - OC = OPEN CUT BORING
 - BC = BORING FOR SHORT HDD OR UTILITY CROSSING
 - HDD = BORING FOR POTENTIAL HORIZONTAL DIRECTIONAL DRILLING ALIGNMENT
 - S-X ● BULK SAMPLE LOCATION
 - FR-X ◆ FIELD RESISTIVITY TESTING LOCATION

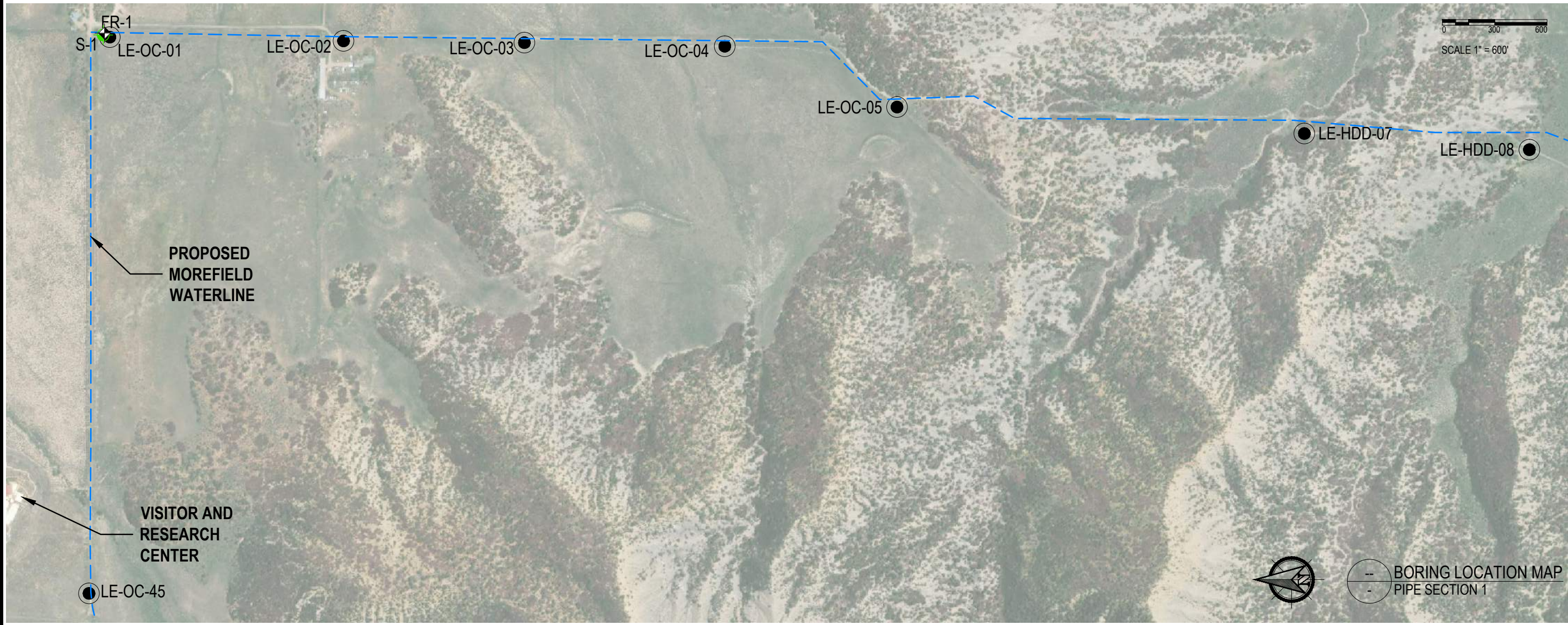


FIGURE NUMBER

1

CLIENT

F2R

OWNER

PROJECT NO.

21162

DRAWN BY:

JP

DESIGNED BY:

LH

CHECKED BY:

NS

LOCATION

CORTEZ, CO

DATE:

08/2023

PROJECT TITLE

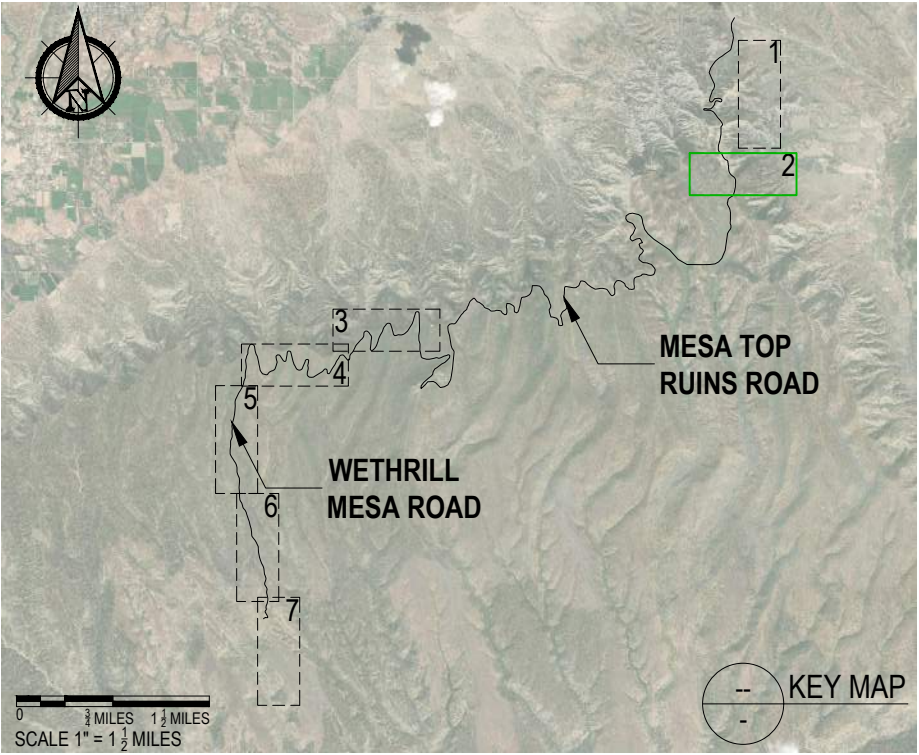
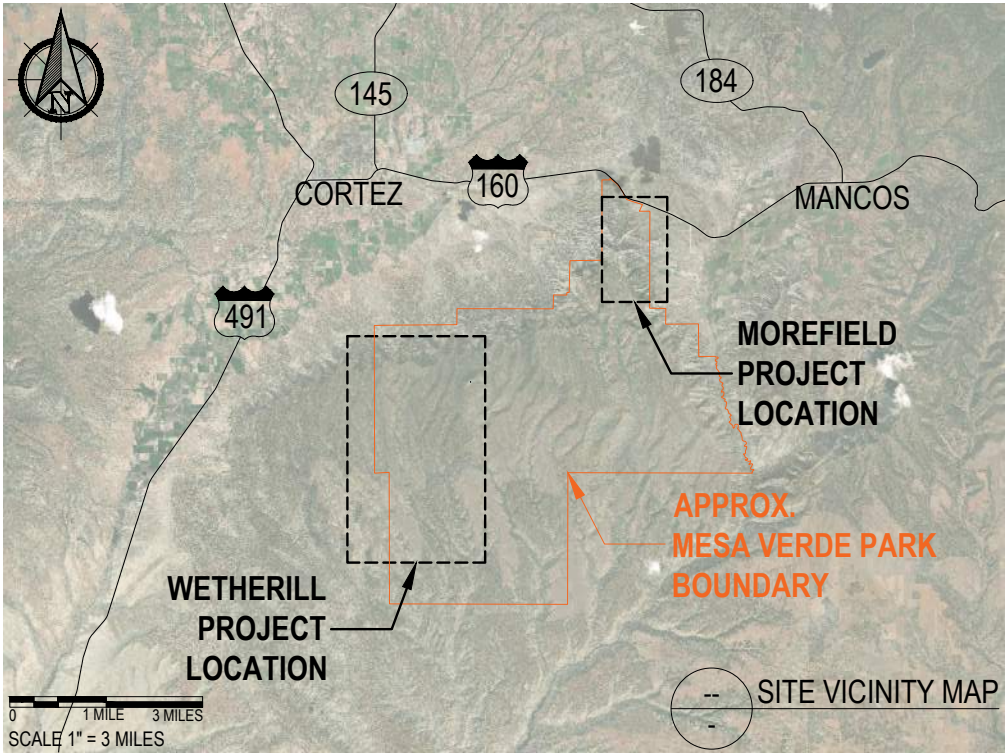
MOREFIELD ALIGNMENT WATERLINE REPLACEMENT

DRAWING TITLE

SITE VICINITY AND BORING LOCATION MAP 1

LITHOS ENGINEERING

2750 WADSWORTH BLVD, SUITE D-200
DENVER, COLORADO 80227
303.625.9502



- LEGEND:
- APPROXIMATE PROPOSED WATERLINE
 - APPROX. PROPOSED BADGER HOUSE WATERLINE
 - LE-XX-XX ● APPROXIMATE LITHOS BORING LOCATION
 - OC = OPEN CUT BORING
 - BC = BORING FOR SHORT HDD OR UTILITY CROSSING
 - HDD = BORING FOR POTENTIAL HORIZONTAL DIRECTIONAL DRILLING ALIGNMENT
 - S-X ● BULK SAMPLE LOCATION
 - FR-X ● FIELD RESISTIVITY TESTING LOCATION

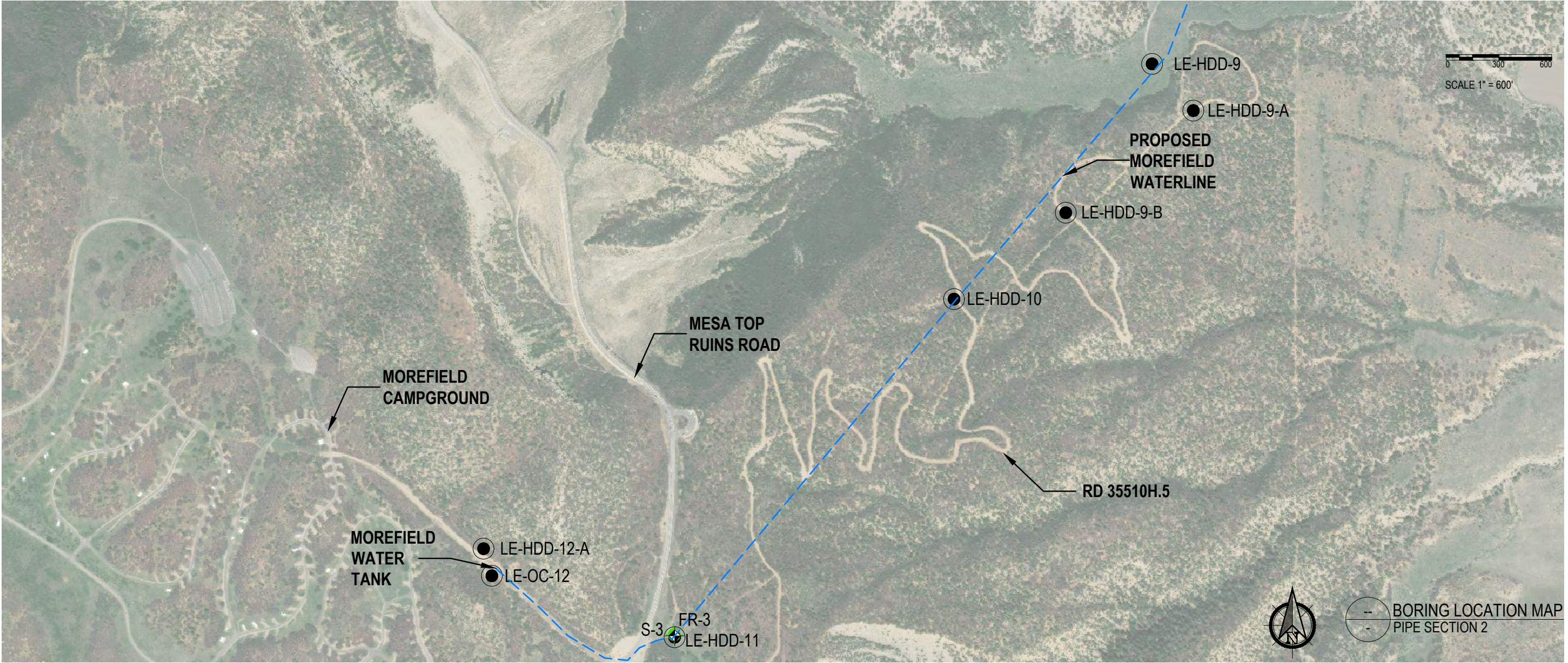


FIGURE NUMBER

2

CLIENT

F2R

OWNER

PROJECT NO.

21162

LOCATION

CORTEZ, CO

DATE

08/2023

DRAWN BY:

JP

DESIGNED BY:

LH

CHECKED BY:

NS

PROJECT TITLE

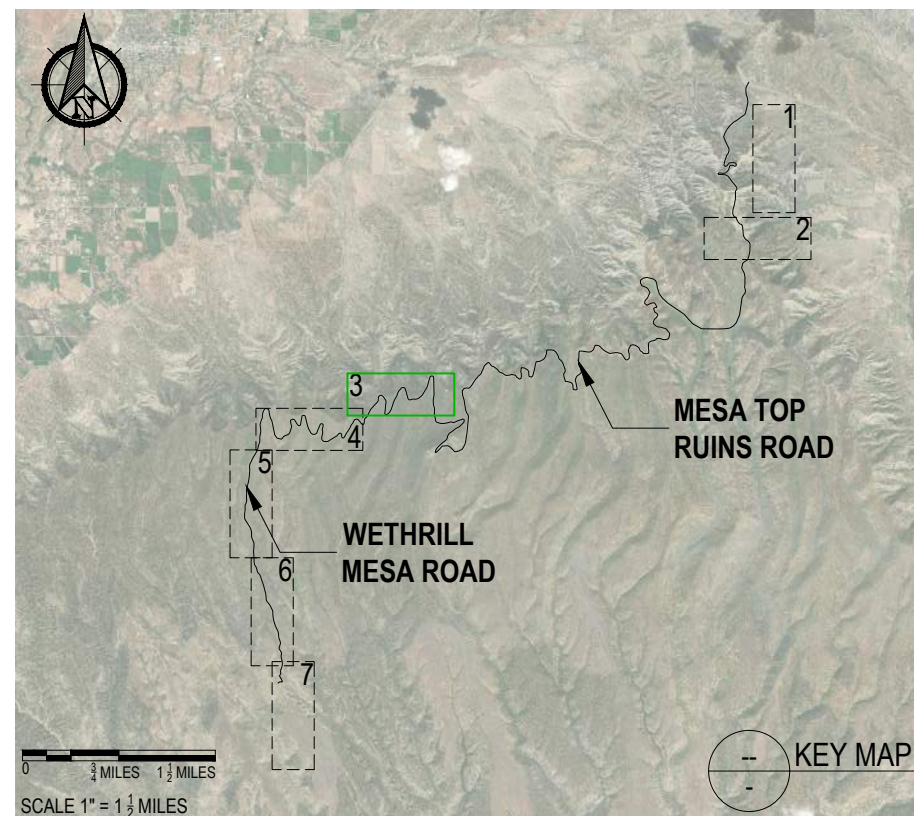
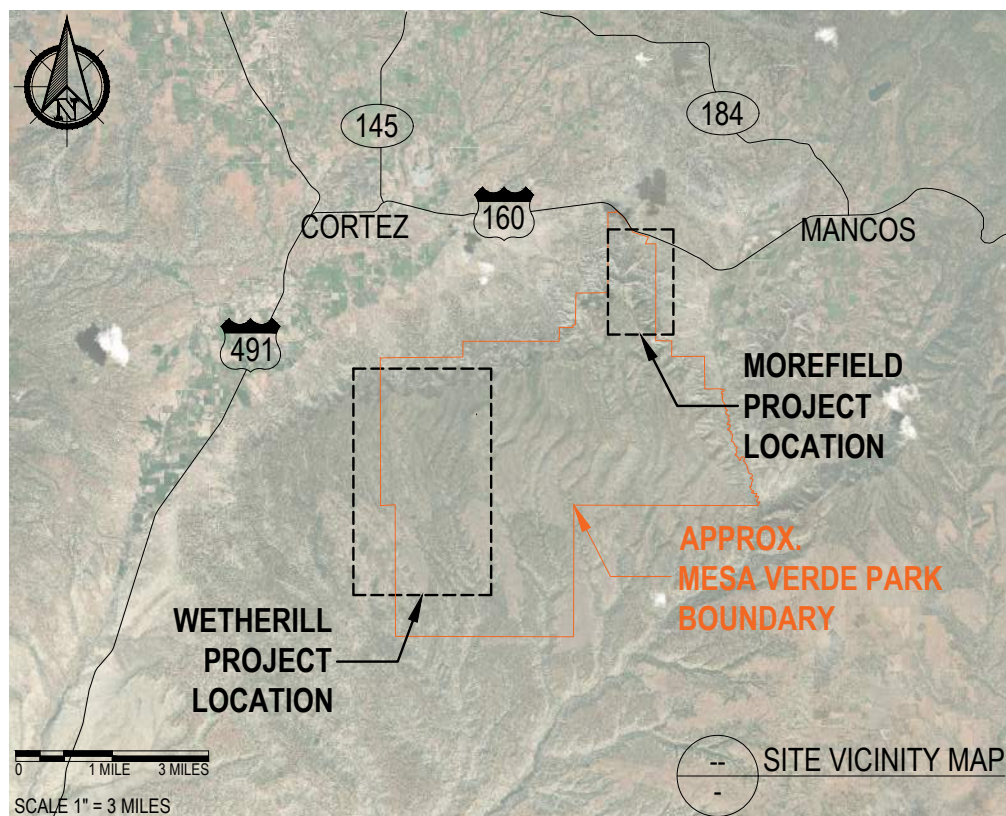
MOREFIELD ALIGNMENT WATERLINE REPLACEMENT

DRAWING TITLE

SITE VICINITY AND BORING LOCATION MAP 2

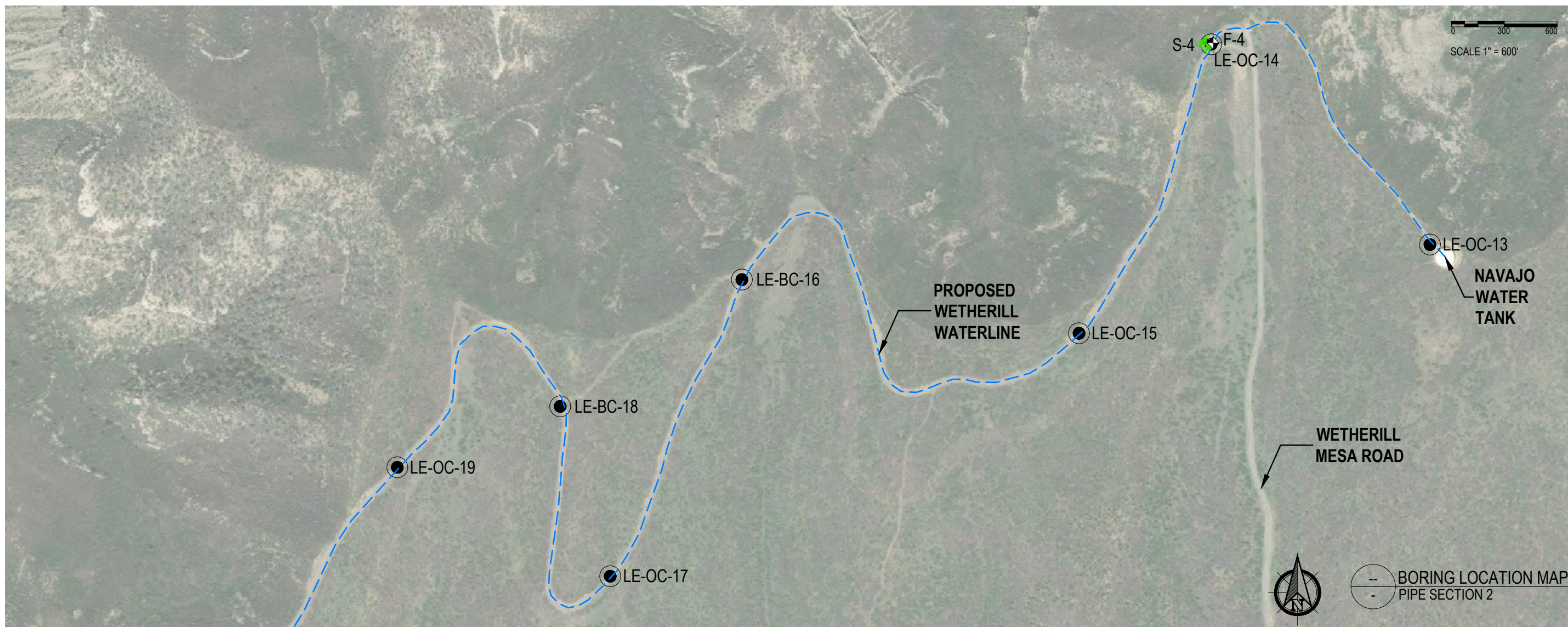
LITHOS ENGINEERING

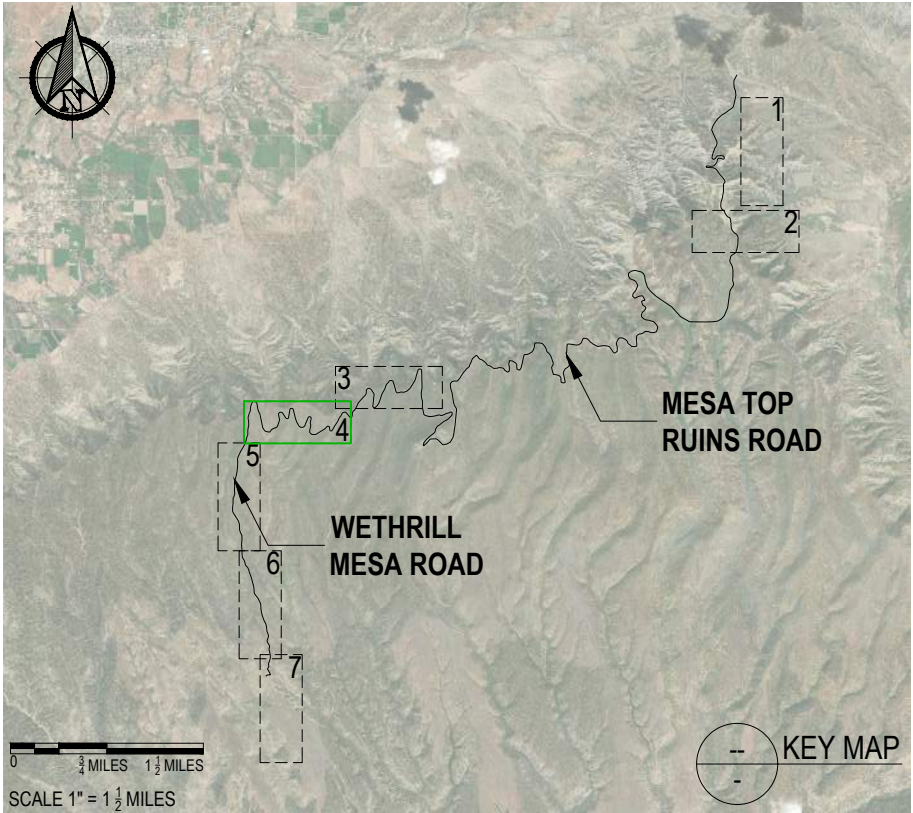
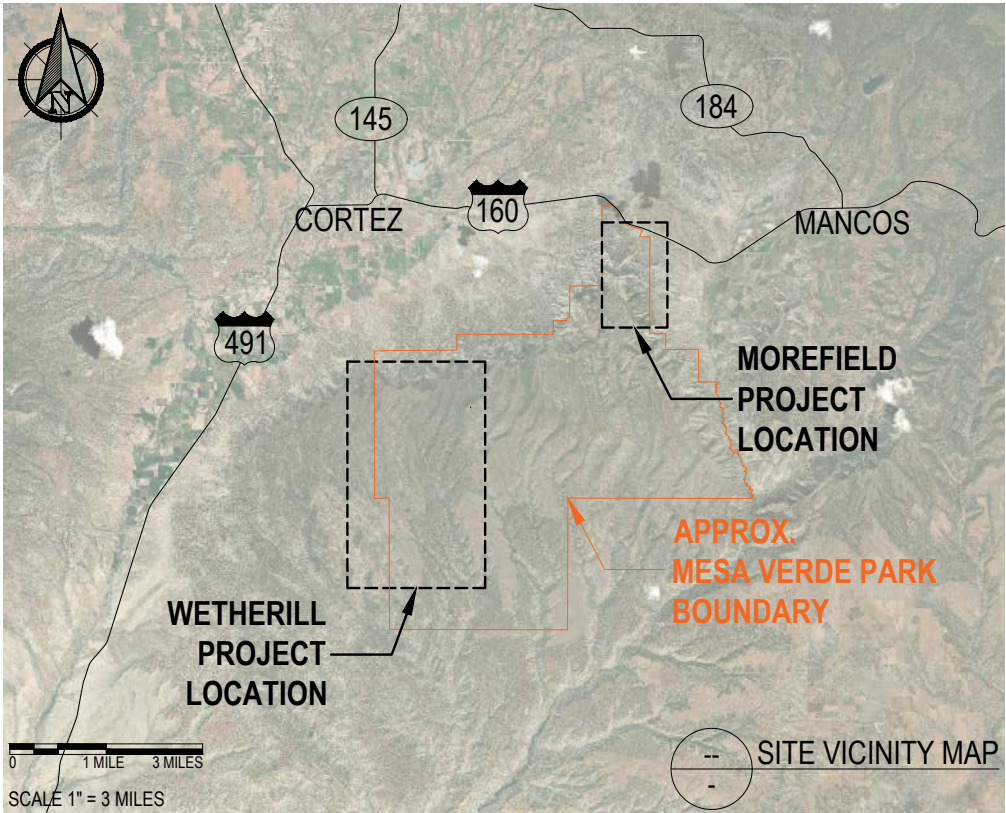
2750 WADSWORTH BLVD, SUITE D-200
DENVER, COLORADO 80227
303.625.9502



LEGEND:

- — — APPROXIMATE PROPOSED WATERLINE
- — — APPROX. PROPOSED BADGER HOUSE WATERLINE
- LE-XX-XX ● APPROXIMATE LITHOS BORING LOCATION
- OC = OPEN CUT BORING
- BC = BORING FOR SHORT HDD OR
UTILITY CROSSING
- HDD = BORING FOR POTENTIAL HORIZONTAL
DIRECTIONAL DRILLING ALIGNMENT
- S-X ⊕ BULK SAMPLE LOCATION
- FR-X ✦ FIELD RESISTIVITY TESTING LOCATION





- LEGEND:
- APPROXIMATE PROPOSED WATERLINE
 - APPROX. PROPOSED BADGER HOUSE WATERLINE
 - LE-XX-XX ● APPROXIMATE LITHOS BORING LOCATION
 - OC = OPEN CUT BORING
 - BC = BORING FOR SHORT HDD OR UTILITY CROSSING
 - HDD = BORING FOR POTENTIAL HORIZONTAL DIRECTIONAL DRILLING ALIGNMENT
 - S-X ● BULK SAMPLE LOCATION
 - FR-X ◆ FIELD RESISTIVITY TESTING LOCATION

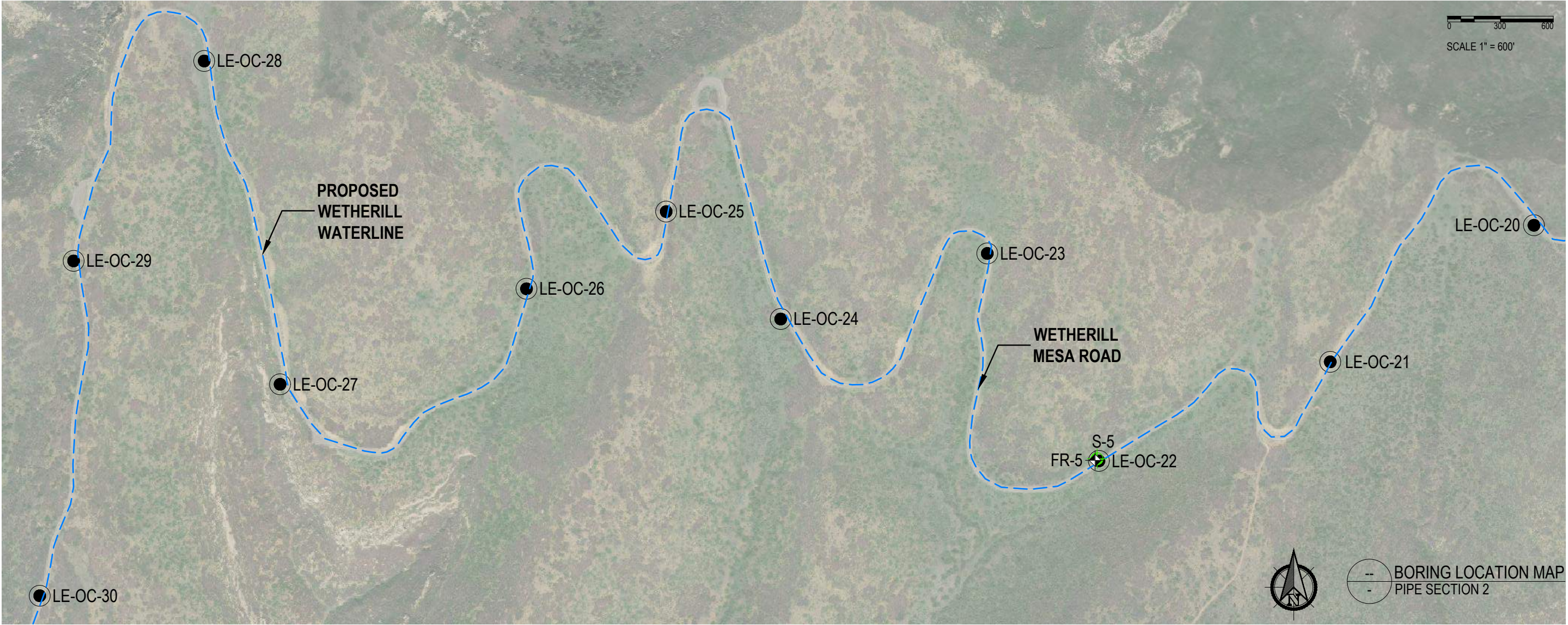


FIGURE NUMBER

4

CLIENT

F2R

OWNER



PROJECT NO.

21162

LOCATION

CORTEZ, CO

DATE

08/2023

DRAWN BY:

JP

DESIGNED BY:

LH

CHECKED BY:

NS

PROJECT TITLE

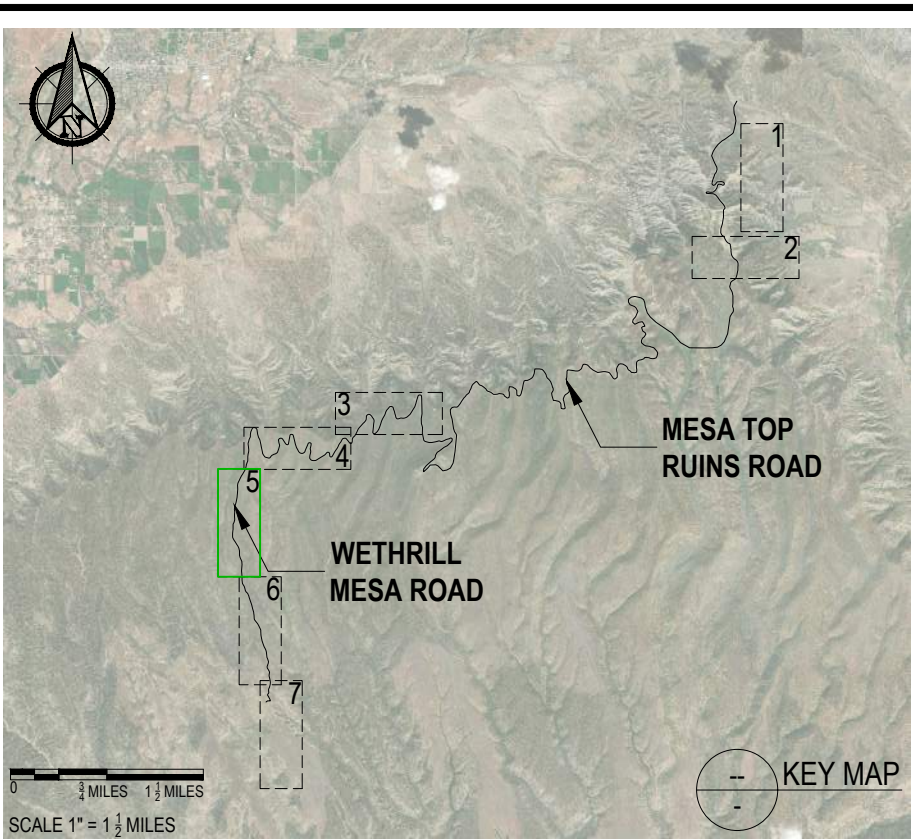
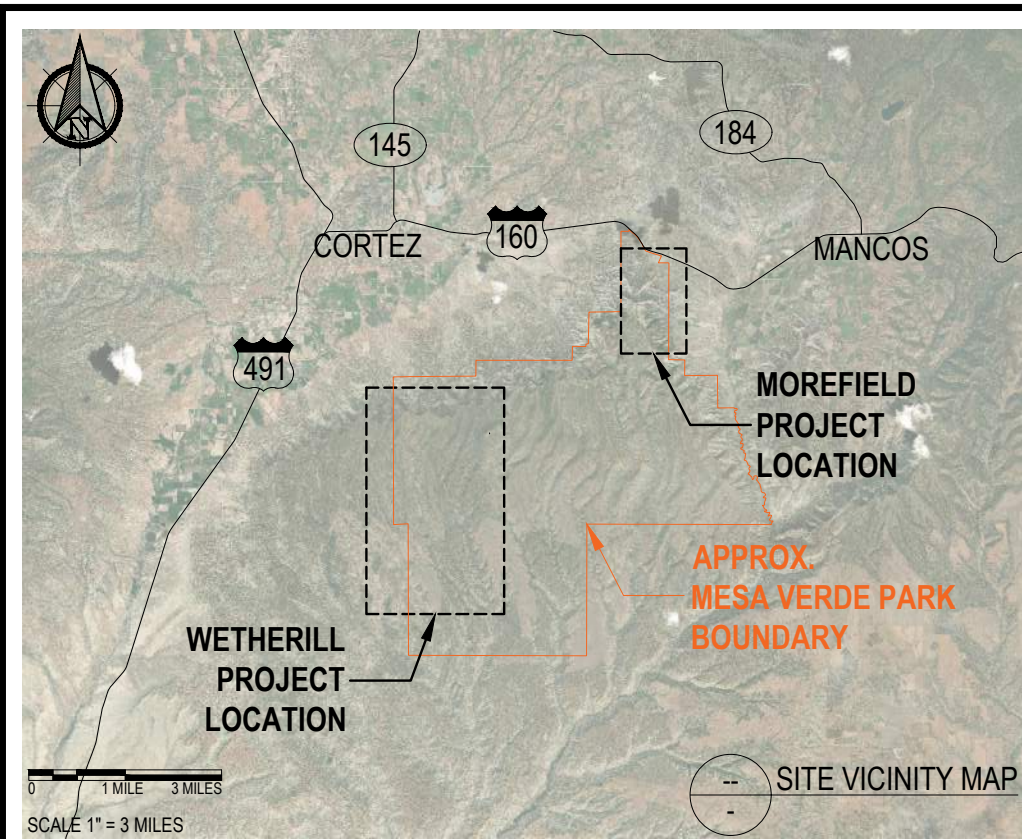
WETHERILL ALIGNMENT
WATERLINE REPLACEMENT

DRAWING TITLE

SITE VICINITY AND BORING
LOCATION MAP 2

LITHOS
ENGINEERING

2750 WADSWORTH BLVD, SUITE D-200
DENVER, COLORADO 80227
303.625.9502



- LEGEND:
- APPROXIMATE PROPOSED WATERLINE
 - APPROX. PROPOSED BADGER HOUSE WATERLINE
 - LE-XX-XX ● APPROXIMATE LITHOS BORING LOCATION
 - OC = OPEN CUT BORING
 - BC = BORING FOR SHORT HDD OR UTILITY CROSSING
 - HDD = BORING FOR POTENTIAL HORIZONTAL DIRECTIONAL DRILLING ALIGNMENT
 - S-X ● BULK SAMPLE LOCATION
 - FR-X ◆ FIELD RESISTIVITY TESTING LOCATION



FIGURE NUMBER

5

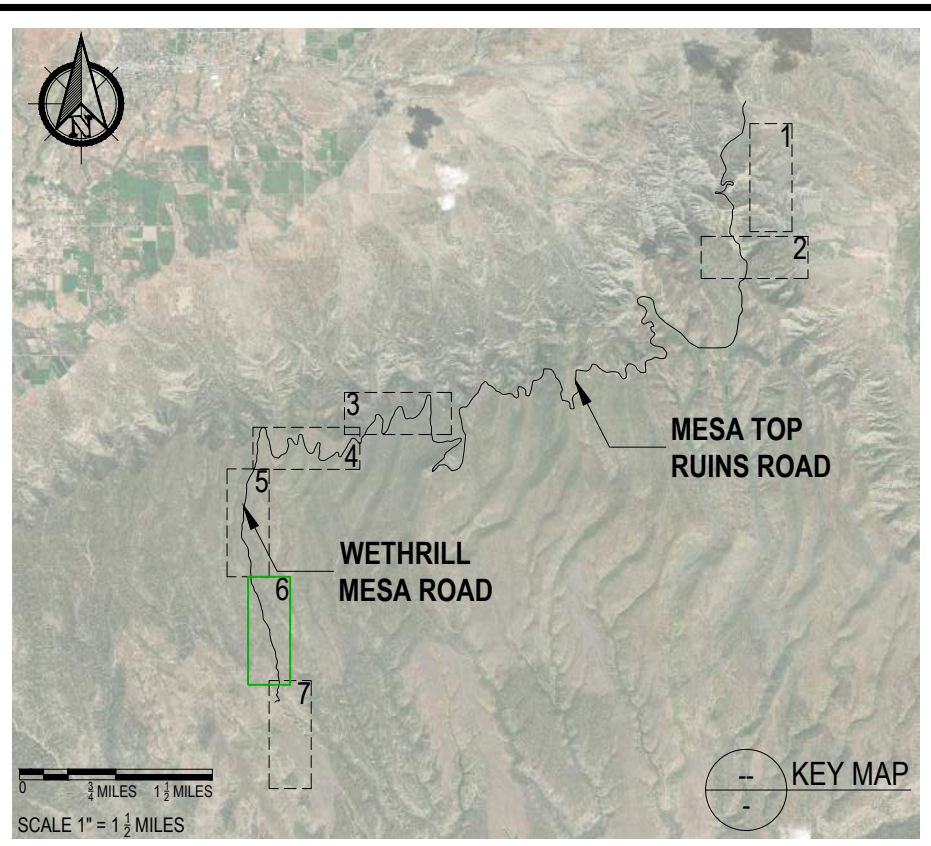
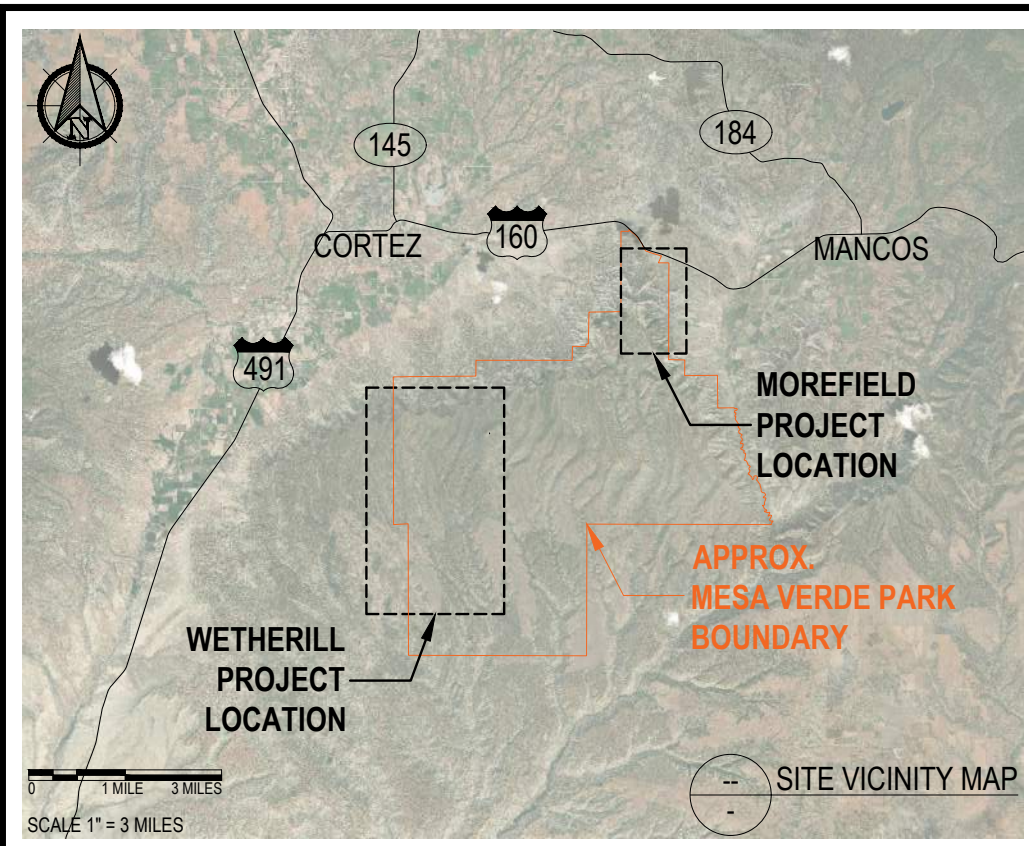
CLIENT	F2R		
	DRAWN BY: JP	DESIGNED BY: LH	CHECKED BY: NS
OWNER	CORTAZA COUNTY		
	PROJECT NO.: 21162	LOCATION: CORTAZA CO	DATE: 08/2023

WETHERILL ALIGNMENT
WATERLINE REPLACEMENT

SITE VICINITY AND BORING
LOCATION MAP 5

LITHOS
ENGINEERING

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DENVER, COLORADO 80227
303.625.9502



- LEGEND:
- APPROXIMATE PROPOSED WATERLINE
 - APPROX. PROPOSED BADGER HOUSE WATERLINE
 - LE-XX-XX ● APPROXIMATE LITHOS BORING LOCATION
 - OC = OPEN CUT BORING
 - BC = BORING FOR SHORT HDD OR UTILITY CROSSING
 - HDD = BORING FOR POTENTIAL HORIZONTAL DIRECTIONAL DRILLING ALIGNMENT
 - S-X ● BULK SAMPLE LOCATION
 - FR-X ◆ FIELD RESISTIVITY TESTING LOCATION

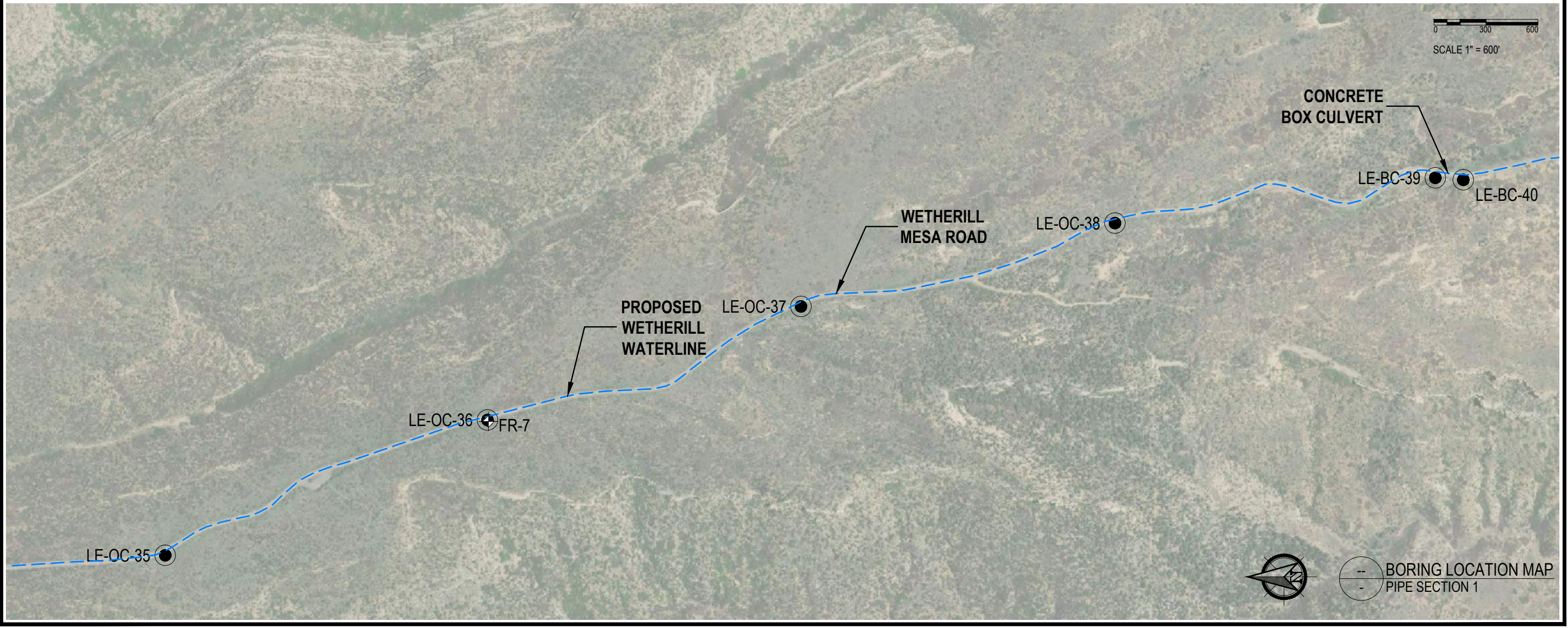


FIGURE NUMBER

6

CLIENT

F2R

OWNER

PROJECT NO.

21162

LOCATION

CORTEZ, CO

DATE

08/2023

DRAWN BY:

JP

DESIGNED BY:

LH

CHECKED BY:

NS

PROJECT TITLE

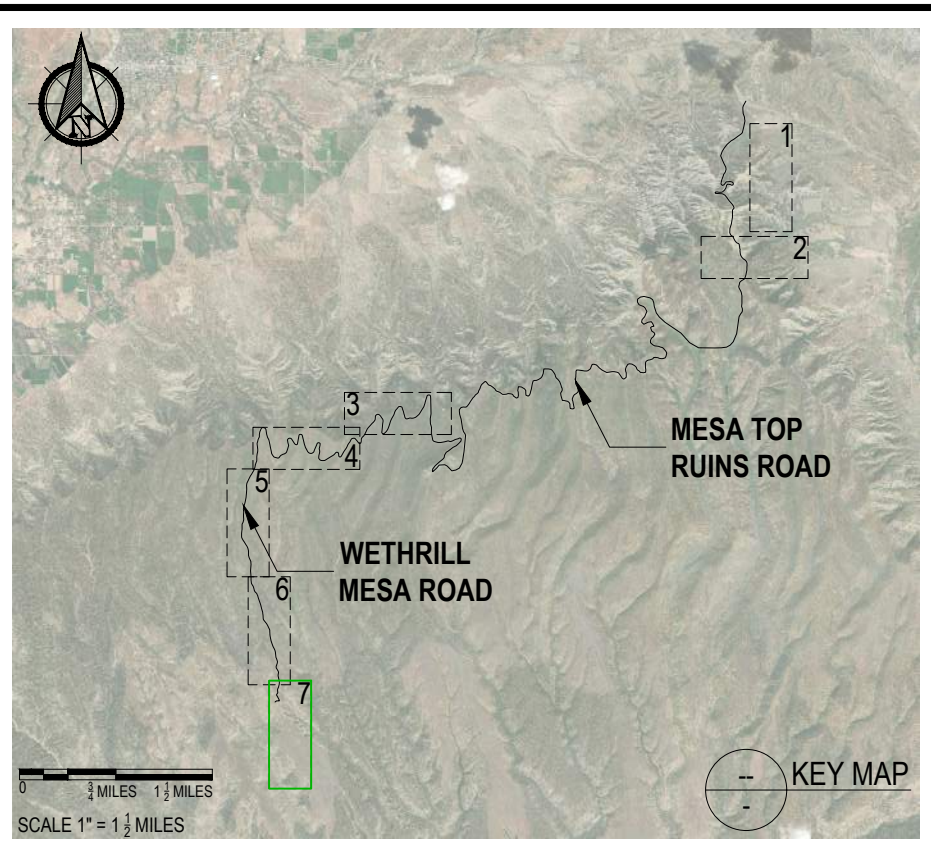
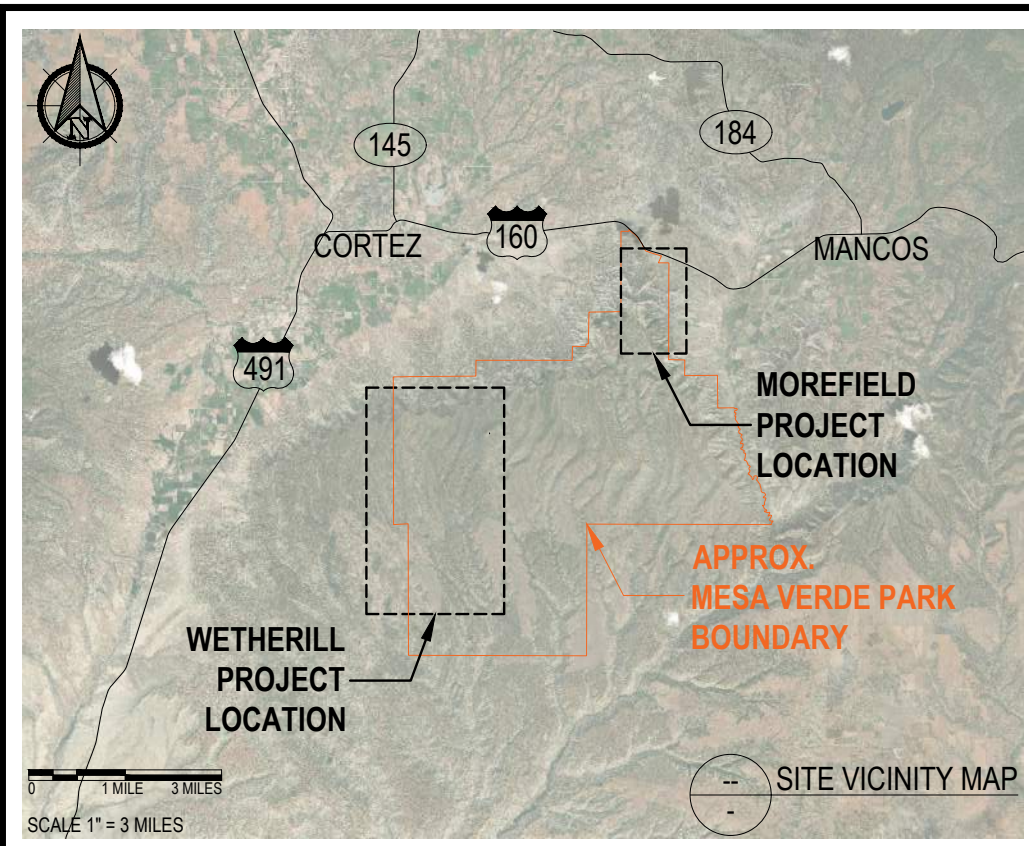
WETHERILL ALIGNMENT
WATERLINE REPLACEMENT

DRAWING TITLE

SITE VICINITY AND BORING
LOCATION MAP 6

LITHOS
ENGINEERING

2750 WADSWORTH BLVD, SUITE D-200
DENVER, COLORADO 80227
303.625.9502



- LEGEND:
- APPROXIMATE PROPOSED WATERLINE
 - APPROX. PROPOSED BADGER HOUSE WATERLINE
 - LE-XX-XX ● APPROXIMATE LITHOS BORING LOCATION
 - OC = OPEN CUT BORING
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 - HDD = BORING FOR POTENTIAL HORIZONTAL DIRECTIONAL DRILLING ALIGNMENT
 - S-X ● BULK SAMPLE LOCATION
 - FR-X ◆ FIELD RESISTIVITY TESTING LOCATION

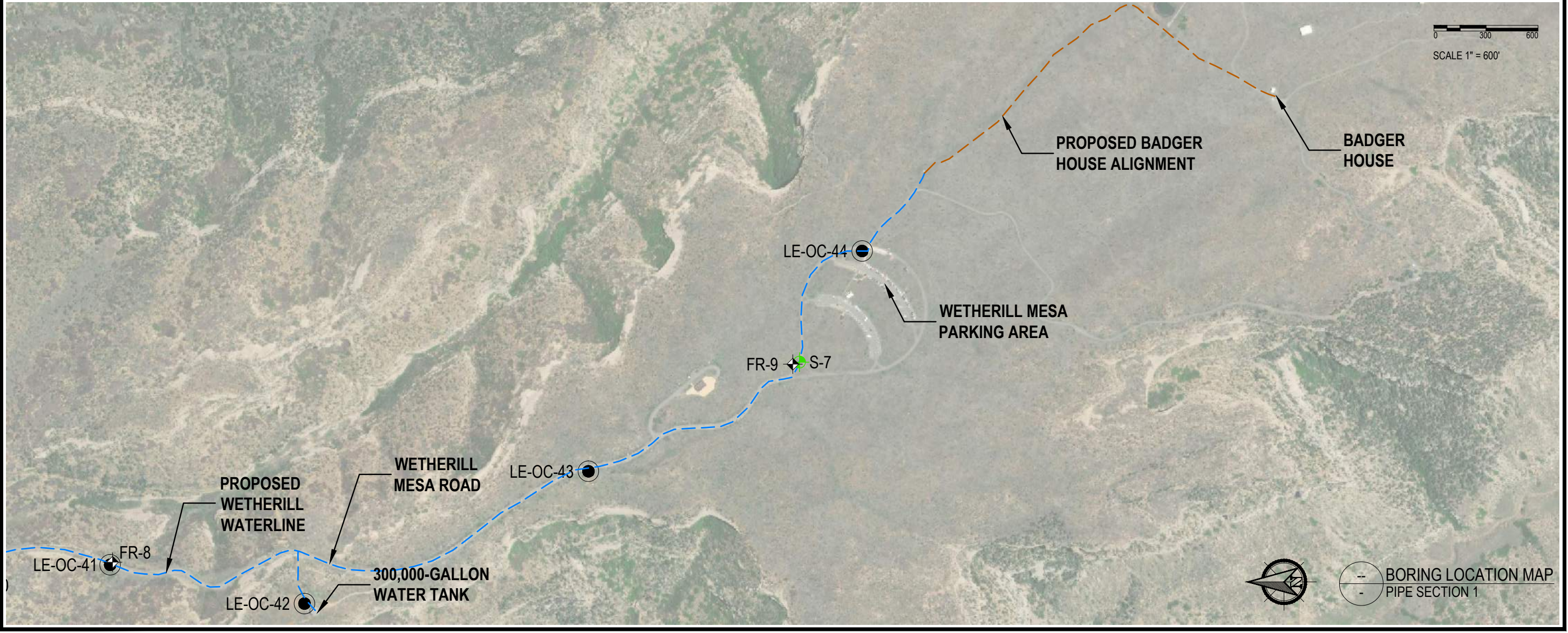


FIGURE NUMBER

7

CLIENT

F2R

OWNER

PROJECT NO.

21162

LOCATION

CORTEZ, CO

DATE

08/2023

DRAWN BY:

JP

DESIGNED BY:

LH

CHECKED BY:

NS

WETHERILL ALIGNMENT WATERLINE REPLACEMENT

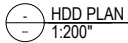
SITE VICINITY AND BORING LOCATION MAP 7

PROJECT TITLE

DRAWING TITLE

LITHOS ENGINEERING

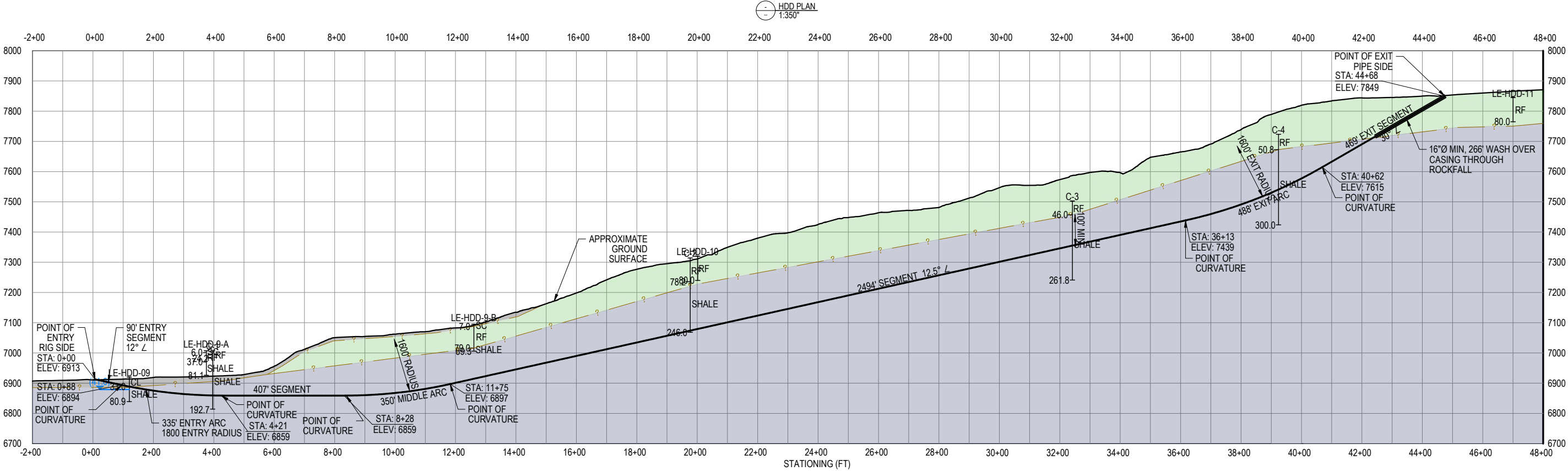
2750 WADSWORTH BLVD, SUITE D-200
DENVER, COLORADO 80227
303.625.9502



SHEET

SH-1

SHEET 1 OF 3



HORIZONTAL DIRECTIONAL DRILLING (HDD) GENERAL NOTES:

- HORIZONTAL DIRECTIONAL DRILLING MATERIALS
 - THE PRODUCT PIPE IS ASSUMED TO BE 6-INCH DIAMETER FLEXSTEEL PIPE.
 - DRILLING MUD SHOULD BE DESIGNED TO MAINTAIN BOREHOLE STABILITY AND FACILITATE MATERIAL EXCAVATION AND CIRCULATION THROUGHOUT PILOT BORE INSTALLATION, REAMING, AND FINAL PRODUCT PIPE PULL IN.
 - SPECIFIC HDD EQUIPMENT AND TOOLING SHOULD BE SELECTED IN ORDER TO SUCCESSFULLY COMPLETE THE PROPOSED INSTALLATION.
- HDD GEOMETRIC CONSTRAINTS
 - GROUND SURFACE TOPOGRAPHIC ASSUMPTIONS ARE BASED ON HDR PLAN AND PROFILE DRAWINGS.
 - TEMPORARY EASEMENT BOUNDARIES ARE NOT SHOWN FOR CLARITY.
 - "ENTRY" AND "EXIT" CURVE DESIGNATIONS ARE UNIQUE TO THE PILOT BORE AND DO NOT NECESSARILY APPLY TO REAM PASS(ES) OR PIPE PULL IN.
 - THE PRESENTED PLAN AND PROFILE IS INTENDED TO IDENTIFY GEOLOGY ALONG THE DESIGN HDD ALIGNMENT. IN THE EVEN OF DISCREPANCIES BETWEEN THE PRESENTED PLAN AND PROFILE AND THE CONTRACT DRAWINGS, THE CONTRACT DRAWINGS SHALL GOVERN.
- HORIZONTAL DIRECTIONAL DRILLING DESIGN
 - A GEOTECHNICAL SUBSURFACE INVESTIGATION WAS COMPLETED BY LITHOS INCLUDING BORINGS GENERALLY LOCATED AS SHOWN. ADDITIONAL INFORMATION ABOUT THIS LOCATION IS INCLUDED IN GEOTECHNICAL INVESTIGATION REPORT BY LITHOS ENGINEERING (GIR, 08-2023).

HDD MOREFIELD 2 ALIGNMENT GEOMETRY AND LENGTH TABLE			
ENTRY SEGMENT (FT)	90	TOTAL PIPE LENGTH ² (FT)	4633
ENTRY ARC LENGTH (FT)	335	MINIMUM RADIUS (FT)	1600
MIDDLE SEGMENT (FT)	407	ENTRY ANGLE	12°
MIDDLE ARC LENGTH (FT)	350	MIDDLE SEGMENT ANGLE	0°
MIDDLE SEGMENT II (FT)	2494	MIDDLE SEGMENT II ANGLE	14°
EXIT ARC LENGTH (FT)	488	EXIT ANGLE	30°
EXIT SEGMENT (FT)	469		
TOTAL PLAN DISTANCE ¹ (FT)	4468		

¹ DISTANCE AS MEASURED HORIZONTALLY, ON CENTER, BETWEEN ENTRY AND EXIT PITS AT A CONSTANT ELEVATION

² PIPE LENGTH FROM TIE-IN TO TIE-IN LOCATION

HDD PROFILE
1:1 VERTICAL EXAGGERATION

BORING LOCATIONS AND DRILLED DEPTH				
BORING	LATITUDE	LONGITUDE	ELEVATION	DRILLED DEPTH (FT)
LE-HDD-09	37.309972	-108.401492	6920	80.9
LE-HDD-9-A	37.309100	-108.401086	7007	81.1
LE-HDD-9-B	37.307619	-108.403261	7095	89.3
LE-HDD-10	37.306286	-108.405381	7320	80.0
LE-HDD-11	37.300986	-108.410864	7845	80.0

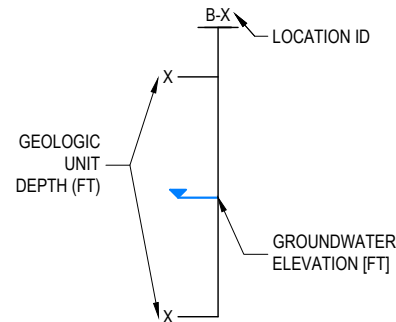
LINE TYPES AND SYMBOLS LEGEND:

- B-X APPROXIMATE BORING LOCATION
- APPROXIMATE HDD ALIGNMENT
- ? — BEDROCK INTERFACE
- — APPROXIMATE GEOPHYSICAL TESTING LOCATION

GEOLOGIC LEGEND:

- ALLUVIUM
- MANCOS SHALE
- ROCKFALL DEPOSIT

BORING & GEOPHYSICAL DATA DETAILS:



DATE
REVISION

OWNER

CLIENT

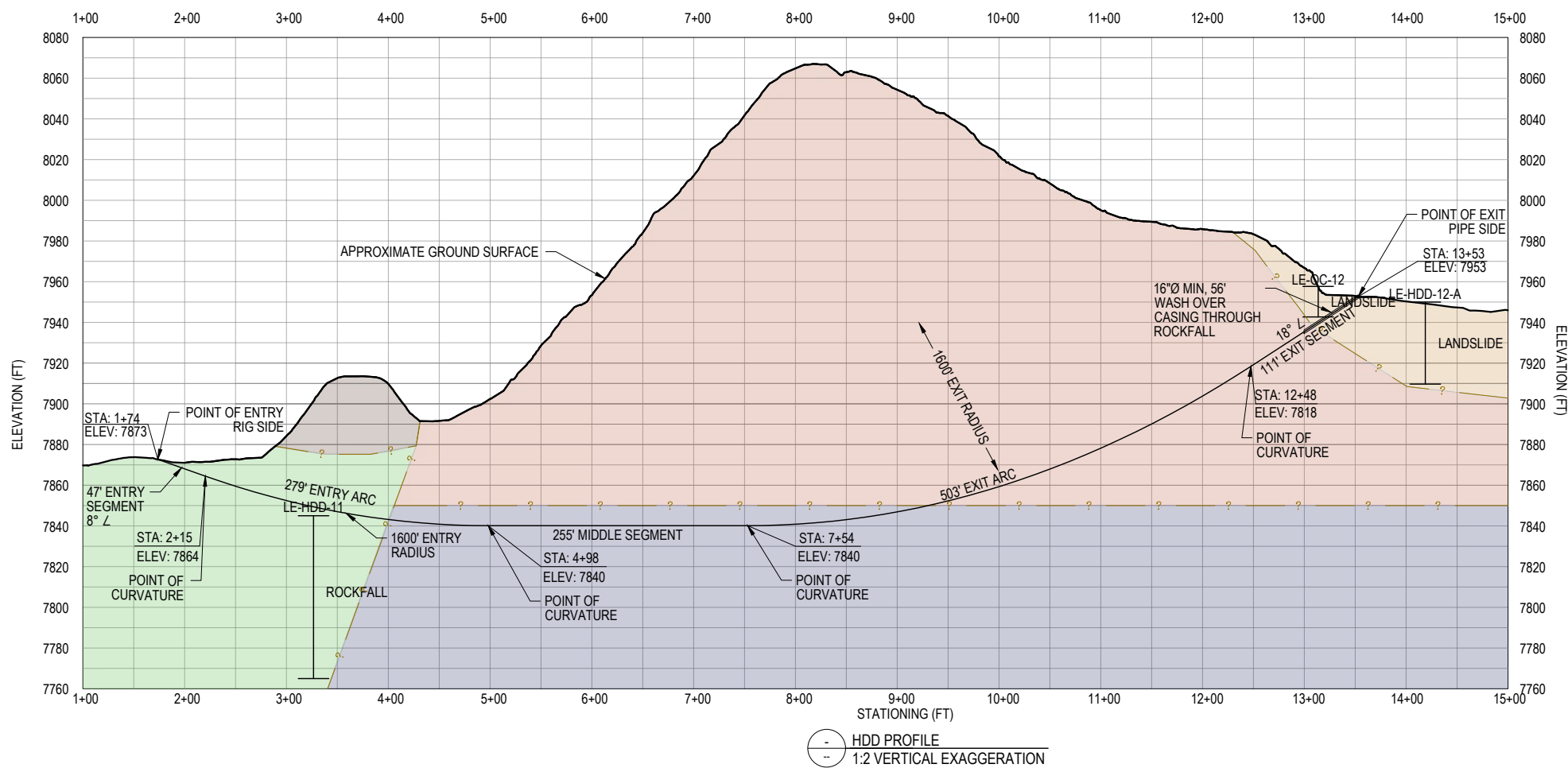
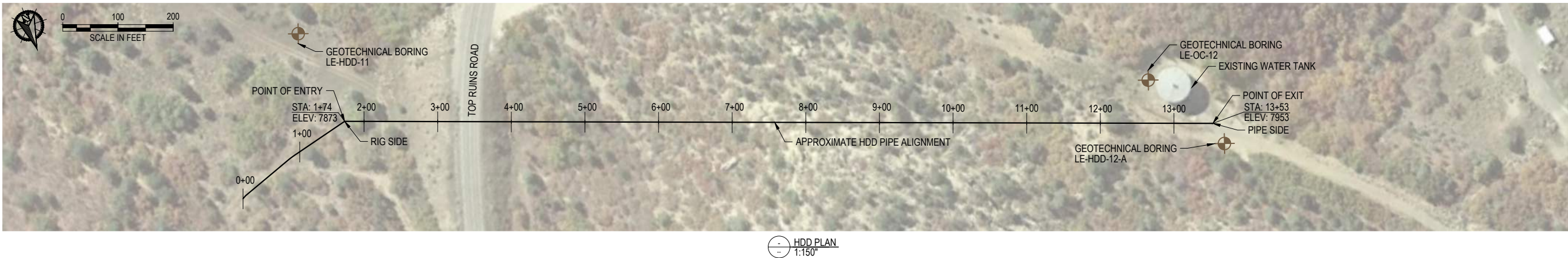
FCR

PROJECT	
MESA VERDE WATERLINES	
PROJECT NO.:	21152
LOCATION:	MONTEZUMA COUNTY, CO

SHEET TITLE

HORIZONTAL DIRECTIONAL
DRILLING (HDD)
PLAN AND PROFILE
MOREFIELD 2

KS	LH	NS	11/2023
DRAWN BY	DESIGNED BY	CHECKED BY	DATE



HORIZONTAL DIRECTIONAL DRILLING (HDD) GENERAL NOTES:

- HORIZONTAL DIRECTIONAL DRILLING MATERIALS
 - THE PRODUCT PIPE IS ASSUMED TO BE 6-INCH DIAMETER FLEXSTEEL PIPE.
 - DRILLING MUD SHOULD BE DESIGNED TO MAINTAIN BOREHOLE STABILITY AND FACILITATE MATERIAL EXCAVATION AND CIRCULATION THROUGHOUT PILOT BORE INSTALLATION, REAMING, AND FINAL PRODUCT PIPE PULL IN.
 - SPECIFIC HDD EQUIPMENT AND TOOLING SHOULD BE SELECTED IN ORDER TO SUCCESSFULLY COMPLETE THE PROPOSED INSTALLATION.
- HDD GEOMETRIC CONSTRAINTS
 - GROUND SURFACE TOPOGRAPHIC ASSUMPTIONS ARE BASED ON HDR PLAN AND PROFILE DRAWINGS.
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 - "ENTRY" AND "EXIT" CURVE DESIGNATIONS ARE UNIQUE TO THE PILOT BORE AND DO NOT NECESSARILY APPLY TO REAM PASS(ES) OR PIPE PULL IN.
 - THE PRESENTED PLAN AND PROFILE IS INTENDED TO IDENTIFY GEOLOGY ALONG THE DESIGN HDD ALIGNMENT. IN THE EVEN OF DISCREPENCIES BETWEEN THE PRESENTED PLAN AND PROFILE AND THE CONTRACT DRAWINGS, THE CONTRACT DRAWINGS SHALL GOVERN.
- HORIZONTAL DIRECTIONAL DRILLING DESIGN
 - A GEOTECHNICAL SUBSURFACE INVESTIGATION WAS COMPLETED BY LITHOS INCLUDING BORINGS GENERALLY LOCATED AS SHOWN. ADDITIONAL INFORMATION ABOUT THIS LOCATION IS INCLUDED IN GEOTECHNICAL INVESTIGATION REPORT BY LITHOS ENGINEERING (GIR, 08-2023).

HDD MOREFIELD 3 ALIGNMENT GEOMETRY AND LENGTH TABLE				
ENTRY SEGMENT (FT)	47	TOTAL PIPE LENGTH ²	1195	
ENTRY ARC LENGTH (FT)	279	MINIMUM RADIUS (FT)	1600	
MIDDLE SEGMENT (FT)	255	ENTRY ANGLE	10°	
EXIT ARC LENGTH (FT)	503	MIDDLE SEGMENT ANGLE	0°	
EXIT SEGMENT (FT)	111	EXIT ANGLE	18°	
TOTAL PLAN DISTANCE (FT) ¹	11+79			

¹ DISTANCE AS MEASURED HORIZONTALLY, ON CENTER, BETWEEN ENTRY AND EXIT PITS AT A CONSTANT ELEVATION

² PIPE LENGTH FROM TIE-IN TO TIE-IN LOCATION

BORING LOCATIONS AND DRILLED DEPTH				
BORING	LATITUDE	LONGITUDE	ELEVATION	DRILLED DEPTH (FT)
LE-HDD-11	37.300986	-108.410864	7845	80.0
LE-OC-12	37.301950	-108.414453	7931	15.0
LE-HDD-12-A	37.302206	-108.414678	7930	40.3

LINE TYPES AND SYMBOLS LEGEND:



APPROXIMATE BORING LOCATION

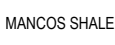
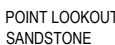


APPROXIMATE HDD ALIGNMENT



APPROXIMATE BEDROCK INTERFACE

GEOLOGIC LEGEND:



BORING DETAILS:

B-X BORE HOLE ID

GEOLOGIC UNIT
DEPTH (FT)

DATE

REVISION



OWNER		CLIENT	
MESA VERDE WATERLINES		21152	
PROJECT		LOCATION: MONTEZUMA COUNTY, CO	
PROJECT NO.:		21152	

HORIZONTAL DIRECTIONAL
DRILLING (HDD)
PLAN AND PROFILE
MOREFIELD 3

DRAWN BY	KS	DESIGNED BY	LH	CHECKED BY	NS	DATE	11/2023
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APPENDIX – A

Boring Log Key, Boring Logs and Discontinuity Log

BORING LOG KEY

ROCK CORING

Rock Descriptions:

Rock descriptions noted on logs of subsurface explorations are based on visual-manual examination of exposed rock and core samples, and will be presented in the following order: Field Hardness, Weathering, Color, Texture, Roughness, Discontinuity Spacing and Discontinuity Type, Orientation, Aperture, Shape, Infilling as shown in the following example:

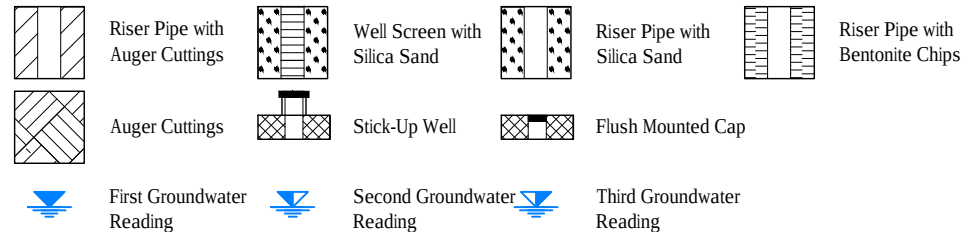
Gneiss, hard, slightly to moderately weathered, grayish red, medium-grained, slightly rough, closely spaced foliation, low angle, partly open aperture, irregular shape, quartz infill

Field Hardness		Weathering		Texture	
Description	Criteria	Description	Criteria	Description	Criteria
Very Hard	Cannot be scratched with a knife or sharp pick.	Fresh	No visible sign of rock material weathering; perhaps slight discoloration on major discontinuity surfaces.	Very Fine Grained	Grains not individually visible to the unaided eye
Hard	Can be scratched with a knife or pick only with difficulty	Slightly Weathered	Discoloration of rock material on discontinuity surfaces.	Fine Grained	Grains barely visible to the unaided eye, up to $\frac{1}{16}$ " diameter
Medium	Can be gouged $\frac{1}{16}$ " deep by firm pressure on knife or pick point	Moderately Weathered	Less than half of the rock material is decomposed and/or disintegrated to soil. Fresh or discolored rock is present either as a continuous framework or as corestones.	Medium Grained	Grain diameter between $\frac{1}{16}$ " and $\frac{3}{16}$ "
Soft	Can be grooved or gouged readily with knife or pick point	Highly Weathered	More than half of the rock material is decomposed and/or disintegrated to a soil. Fresh or discolored rock is present either as a discontinuous framework or as corestones	Coarse Grained	Grains diameter between $\frac{3}{16}$ " and $\frac{1}{4}$ "
Very Soft	Can be carved with knife and scratched readily by fingernail	Completely Weathered	All rock material is decomposed and/or disintegrated to soil. The original mass structure is still largely intact.	Very Coarse Grained	Grains larger than $\frac{1}{4}$ " in diameter

Roughness		Discontinuity Spacing		Discontinuity Type	
Description	Criteria	Description	Criteria	Description	Criteria
Slickensided	Visual evidence of grooves, striations and/or polishing on surface: recrystallization may have occurred on surface (mineral coating).	Extremely Close	$<\frac{3}{4}$ "	Joint	Break of geologic origin in the continuity of a body of rock along which there has been no visible displacement. Joints frequently form parallel to bedding planes, foliations, and cleavages and may be termed bedding plane joints, foliation joints, or cleavage joints accordingly
Smooth	Surface appears smooth and feels smooth with no asperities. <i>Like paper.</i>	Very Close	$<\frac{3}{4}$ "-2.5"	Shear	A discontinuity along which differential movement has taken place parallel to the discontinuity surface, sufficient to produce slickensides, (i.e. striations and polishing). Shear discontinuities may be accompanied by a zone of fractured rock up to a few inches wide.
Slightly Rough	Asperities on surface are visually discernible and can be felt. <i>Like sand paper.</i>	Close Moderate	>2.5"-8"	Foliation	A general term used for a planar arrangement of textural or structural features, most commonly applied to metamorphic rock such as cleavage in slate or schistosity in other rocks.
Rough	Asperities on surface are clearly visible and surface feels abrasive. <i>Like asphalt.</i>	Moderate	>8"-24"	Bedding	Bedding is the arrangement of sedimentary rock beds or layers. The bedding surface represents an original surface of deposition. The following terminology is used to describe the thickness of bedding as measured between bedding surfaces
Very Rough	Near vertical steps and/or ridges. <i>Like weathered asphalt with exposed aggregate.</i>	Wide	>24"-80"		
		Very Wide	>80"		

Orientation		Aperture		Shape	
Description	Criteria	Description	Criteria	Description	Criteria
Horizontal	0-5	Tight	<0.04	Planar	Flat.
Low Angle	5-35	Partly Open	>0.04 to 0.4	Irregular	Large to moderate asperities.
Moderately Dipping	35-55	Open	>0.4 to 2.0	Undulating	Wavy.
High Angle	55-85	Wide	>2.0	Stepped	Surface with steps (near vertical asperities).
Vertical	85-90				

Groundwater Monitoring Well Graphics:



Sample Graphics and Descriptions:

-  California Barrel Sampler: Barrel sampler loaded with sample liners and driven to collect a relatively representative and intact specimen of soil or weak rock
-  Split-Spoon Sampler: Split-barrel sampler driven in accordance with ASTM D1586 used to provide visual material descriptions and collect a disturbed specimen
-  Wire-Line Rock Coring: A continuous rock sample collected while drilling.

BORING LOG KEY

STANDARD GEOTECHNICAL DRILLING

Soil Classifications:

Clear Square Sieve Openings				U.S. Standard Series Sieve Sizes			
12"	3"	3/4"	4	10	40	200	
Boulders	Cobbles	Gravel		Sand			Silts and Clays
		Coarse	Fine	Coarse	Medium	Fine	
300mm	75mm	19mm	4.75mm	2.0mm	0.42mm	0.075mm	

Gradation Estimates by Field Observation			
Description	Quantity (%)		
Trace	<5		
Few	5 to 10		
Little	15 to 25		
Some	30 to 45		
Mostly	> 50		

Relative Density or Consistency of Non-cohesive and Cohesive Soils			
Non-cohesive Soils		Cohesive Soils	
Classification	Blows per 12 in	Classification	Blows per 12 in
Very Loose	0 to 4	Very Soft	0 to 2
Loose	5 to 10	Soft	3 to 4
Medium Dense	11-30	Medium Stiff	5 to 8
		Stiff	9 to 15
Dense	31 to 50	Very Stiff	16 to 30
Very Dense	>50	Hard	>30

Color: Sample colors are in general accordance with basic brown, red, yellow, and gray combinations

Description of Moisture	
Description	Criteria
Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, usually soil below the groundwater table

Plasticity	
Description	Criteria
Nonplastic	A $\frac{1}{8}$ " diameter thread cannot be rolled
Low	A $\frac{1}{8}$ " in diameter thread can be rolled with difficulty; a lump cannot be formed at a moisture lower than the plastic limit
Medium	A $\frac{1}{8}$ " in diameter thread can be rolled easily; a crumbly lump can be formed at a moisture lower than the plastic limit
High	A $\frac{1}{8}$ " in diameter thread can be rolled very easily; a lump can be formed at a moisture lower than the plastic limit

Description of Odor	
Description	Criteria
No Organic Odor	Organic odor is not present
Trace Organic Odor	Mild organic odor; mixture of soil and organics
Strong Organic Odor	Prominent organic odor; sample is primarily organic

Cementation	
Description	Criteria
Weak	Crumbles with light finger pressure
Moderate	Crumbles with considerable finger pressure
Strong	Will not crumble with finger pressure

Rock Descriptions:

Weathering	
Description	Criteria
Fresh	No visible sign of rock material weathering; perhaps slight discoloration on major discontinuity surfaces.
Slightly Weathered	Discoloration of rock material on discontinuity surfaces.
Moderately Weathered	Less than half of the rock material is decomposed and/or disintegrated to soil. Fresh or discolored rock is present either as a continuous framework or as corestones.
Highly Weathered	More than half of the rock material is decomposed and/or disintegrated to a soil. Fresh or discolored rock is present either as a discontinuous framework or as corestones
Completely Weathered	All rock material is decomposed and/or disintegrated to soil. The original mass structure is still largely intact.

Texture	
Description	Criteria
Very Fine Grained	Grains not individually visible to the unaided eye
Fine Grained	Grains barely visible to the unaided eye, up to $\frac{1}{16}$ " diameter
Medium Grained	Grain diameter between $\frac{1}{16}$ " and $\frac{3}{16}$ "
Coarse Grained	Grains diameter between $\frac{3}{16}$ " and $\frac{1}{4}$ "
Very Coarse Grained	Grains larger than $\frac{1}{4}$ " in diameter

Field Hardness	
Description	Criteria
Very Hard	Cannot be scratched with a knife or sharp pick.
Hard	Can be scratched with a knife or pick only with difficulty
Medium	Can be gouged $\frac{1}{16}$ " deep by firm pressure on knife or pick point
Soft	Can be grooved or gouged readily with knife or pick point
Very Soft	Can be carved with knife and scratched readily by fingernail

Geologic Interpretation:

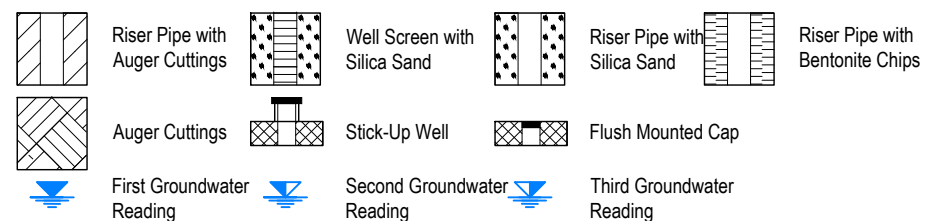
A **Geologic Interpretation** of encountered soil and bedrock units is provided for each specific **Visual Material Description**. Examples of geologic interpretations for soil that may be presented include: FILL, ALLUVIUM, AEOLIAN, AND GLACIAL TILL, AND RESIDUUM. Rock geologic interpretations are referenced based on a combination of field classifications and applicable geologic maps.

Sample Graphics and Descriptions:

-  California Barrel Sampler: Barrel sampler loaded with sample liners and driven to collect a relatively representative and intact specimen of soil or weak rock.
-  Split-Spoon Sampler: Split-barrel sampler driven in accordance with ASTM D1586 used to provide visual material descriptions and collect a disturbed specimen.
-  Shelby Tube Sampler: Thin wall tube hydraulically pushed into the subsurface to collect a representative and intact specimen of soil.
-  Bulk Sample: Bulk or bagged sample taken from auger cuttings.

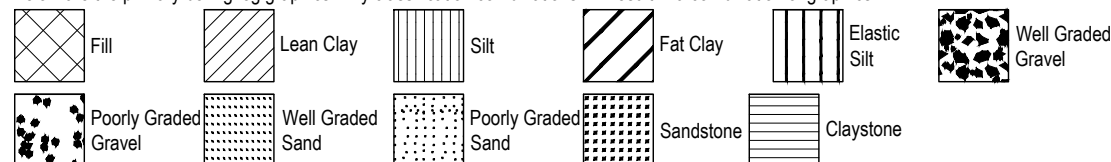
 Continuous Sampler: A 5-foot long sampler barrel that is driven to collect a continuous 5-foot run of cohesive and non-cohesive soil.

Groundwater Monitoring Well Graphics:



Boring Graphics:

Below are the primary boring log graphics. Any classification combinations will result in a combination of graphics.



BORING: LE-OC-01 Project Name: Mesa Verde Waterlines Project Number: 21152 Client's Name: HDR Owner's Name: Mesa Verde National Park Drilling Subcontractor: Terracon Lithos Representative: J. Halverson Date(s) of Drilling: 10/18/21					Drilling and Sampling Methods Drill Make and Model: CME-55 Drilling Method: Solid Stem Auger (SSA) Bit Type: Cutting Head Casing Description: N/A Hammer Weight (lbs)/Fall (in): 140/30 Sampler Type(s): Modified California Sampler Diameter(s): 2.0-inches					LITHOSENGINEERING Boring Location: 37.334181, -108.398647 Boring Elevation: 6,886.0-feet* Notes: Morefield Alignment *Elevation Approximate																																																																																																																																																																																		
Sampling Data <table><tr><td>Depth (ft)</td><td>Elevation (ft)</td><td>Sample Identification</td><td>Blow Count/6 in</td><td>Recovery (in) / RQD (%)</td><td>Drilling Rate (min./ft.)</td><td>Geologic Graphic</td></tr><tr><td>0</td><td>6885</td><td>5 11</td><td>5</td><td></td><td></td><td rowspan="4"></td></tr><tr><td>5</td><td>6880</td><td>5 8</td><td>10</td><td></td><td></td></tr><tr><td>10</td><td>6875</td><td>12 22</td><td>12</td><td></td><td></td></tr><tr><td>15</td><td>6870</td><td>15 29</td><td>10</td><td></td><td></td></tr><tr><td>20</td><td>6865</td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>25</td><td>6860</td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>30</td><td>6855</td><td></td><td></td><td></td><td></td><td></td></tr></table>					Depth (ft)	Elevation (ft)	Sample Identification	Blow Count/6 in	Recovery (in) / RQD (%)	Drilling Rate (min./ft.)	Geologic Graphic	0	6885	5 11	5				5	6880	5 8	10			10	6875	12 22	12			15	6870	15 29	10			20	6865						25	6860						30	6855						Visual Material Description Soil: -GEOLOGIC INTERPRETATION- USCS Classification (group symbol), particle sizes, density or consistency, color, moisture, odor, other descriptions Rock: -GEOLOGIC INTERPRETATION- Bedrock Classification, hardness, weather, color, texture, joint size, other descriptions FINE ALLUVIUM LEAN CLAY (CL), few fine sand, very stiff, olive gray, dry, few roots. As above except trace fine sand, trace coarse gravel, stiff, pale olive, moist, calcite veins. As above except hard, no roots. As above except hard, no roots. END OF EXPLORATION 15.0 ft.					Groundwater Depth / Monitoring Well Configuration <table><tr><td>Moisture Content (%)</td><td>Dry Unit Weight (pcf)</td><td>Water Soluble Sulfates (%)</td><td>Gravel Content (%)</td><td>Sand Content (%)</td><td>Fines Content (%)</td><td>Liquid Limit (%)</td><td>Plasticity Index (%)</td><td>UCS (psf)</td><td>Swell Pressure (psf)</td><td>Swell Percent (%)</td></tr><tr><td>7</td><td>100</td><td></td><td></td><td>91</td><td>30</td><td>14</td><td>4,744</td><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr></table>					Moisture Content (%)	Dry Unit Weight (pcf)	Water Soluble Sulfates (%)	Gravel Content (%)	Sand Content (%)	Fines Content (%)	Liquid Limit (%)	Plasticity Index (%)	UCS (psf)	Swell Pressure (psf)	Swell Percent (%)	7	100			91	30	14	4,744																																																																																																						
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BORING: LE-OC-02 Project Name: Mesa Verde Waterlines Project Number: 21152 Client's Name: HDR Owner's Name: Mesa Verde National Park Drilling Subcontractor: Terracon Lithos Representative: J. Halverson Date(s) of Drilling: 10/18/21					Drilling and Sampling Methods Drill Make and Model: CME-55 Drilling Method: Solid Stem Auger (SSA) Bit Type: Cutting Head Casing Description: N/A Hammer Weight (lbs)/Fall (in): 140/30 Sampler Type(s): Modified California Sampler Diameter(s): 2.0-inches					LITHOSENGINEERING Boring Location: 37.330486, -108.398725 Boring Elevation: 6,904.0-feet* Notes: Morefield Alignment *Elevation Approximate																																			
Sampling Data <table><tr><td rowspan="2">Depth (ft)</td><td rowspan="2">Elevation (ft)</td><td rowspan="2">Sample Identification</td><td rowspan="2">Blow Count/6 in</td><td rowspan="2">Recovery (in) / RQD (%)</td><td rowspan="2">Drilling Rate (min./ft.)</td><td rowspan="2">Geologic Graphic</td></tr><tr></tr></table>					Depth (ft)	Elevation (ft)	Sample Identification	Blow Count/6 in	Recovery (in) / RQD (%)	Drilling Rate (min./ft.)	Geologic Graphic	Visual Material Description Soil: -GEOLOGIC INTERPRETATION- USCS Classification (group symbol), particle sizes, density or consistency, color, moisture, odor, other descriptions Rock: -GEOLOGIC INTERPRETATION- Bedrock Classification, hardness, weather, color, texture, joint size, other descriptions					Groundwater Depth / Monitoring Well Configuration	Laboratory Testing Results <table><tr><td colspan="2">In-Situ States</td><td colspan="5">INDEX DATA</td><td colspan="2">Strength & Compressibility</td></tr><tr><td>Moisture Content (%)</td><td>Dry Unit Weight (pcf)</td><td>Water Soluble Sulfates (%)</td><td>Gravel Content (%)</td><td>Sand Content (%)</td><td>Fines Content (%)</td><td>Liquid Limit (%)</td><td>Plasticity Index (%)</td><td>UCS (psf)</td><td>Swell Pressure (psf)</td><td>Swell Percent (%)</td></tr></table>								In-Situ States		INDEX DATA					Strength & Compressibility		Moisture Content (%)	Dry Unit Weight (pcf)	Water Soluble Sulfates (%)	Gravel Content (%)	Sand Content (%)	Fines Content (%)	Liquid Limit (%)	Plasticity Index (%)	UCS (psf)	Swell Pressure (psf)	Swell Percent (%)
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0		2	7	10			FINE ALLUVIUM LEAN CLAY with sand (CL), little fine sand, stiff, pale olive to olive brown, moist, few roots, calcite veins.																																						
5	6900	10	16	12			As above except very stiff, pale olive, no roots.																																						
10	6895	4	8	10			As above except olive yellow, no calcite, no roots.	17	112			82	29	15		500	0																												
15	6890	6	16	8			As above except very stiff, olive yellow, calcite, no roots, weathered bedrock chunks.																																						
							END OF EXPLORATION																																						
20	6885																																												
25	6880																																												
30	6875																																												

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BORING: LE-OC-03 Project Name: Mesa Verde Waterlines Project Number: 21152 Client's Name: HDR Owner's Name: Mesa Verde National Park Drilling Subcontractor: Terracon Lithos Representative: J. Halverson Date(s) of Drilling: 10/18/21					Drilling and Sampling Methods Drill Make and Model: CME-55 Drilling Method: Solid Stem Auger (SSA) Bit Type: Cutting Head Casing Description: N/A Hammer Weight (lbs)/Fall (in): 140/30 Sampler Type(s): Modified California Sampler Diameter(s): 2.0-inches					LITHOSENGINEERING Boring Location: 37.327625, -108.398761 Boring Elevation: 6,914.0-feet* Notes: Morefield Alignment *Elevation Approximate																																																																																																					
Sampling Data <table><tr><td>Depth (ft)</td><td>Elevation (ft)</td><td>Sample Identification</td><td>Blow Count/6 in</td><td>Recovery (in) / RQD (%)</td><td>Drilling Rate (min./ft.)</td><td>Geologic Graphic</td></tr><tr><td>0</td><td></td><td>3</td><td>7</td><td>6</td><td></td><td></td></tr><tr><td>6910</td><td></td><td>13</td><td>25</td><td>8</td><td></td><td></td></tr><tr><td>6905</td><td></td><td>8</td><td>11</td><td>6</td><td></td><td></td></tr><tr><td>6900</td><td></td><td>9</td><td>15</td><td>8</td><td></td><td></td></tr><tr><td>6895</td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>6890</td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>6885</td><td></td><td></td><td></td><td></td><td></td><td></td></tr></table>					Depth (ft)	Elevation (ft)	Sample Identification	Blow Count/6 in	Recovery (in) / RQD (%)	Drilling Rate (min./ft.)	Geologic Graphic	0		3	7	6			6910		13	25	8			6905		8	11	6			6900		9	15	8			6895							6890							6885							Visual Material Description Soil: -GEOLOGIC INTERPRETATION- USCS Classification (group symbol), particle sizes, density or consistency, color, moisture, odor, other descriptions Rock: -GEOLOGIC INTERPRETATION- Bedrock Classification, hardness, weather, color, texture, joint size, other descriptions FINE ALLUVIUM LEAN CLAY with sand (CL), little fine sand, stiff, pale olive to olive brown, moist, few roots. LEAN CLAY (CL), few silt, few fine sand, hard, pale olive, moist, calcite. As above except very stiff, olive brown. As above except very stiff, olive brown. END OF EXPLORATION 15.0 ft.					Groundwater Depth / Monitoring Well Configuration <table><tr><td colspan="2">In-Situ States</td><td colspan="4">INDEX DATA</td><td colspan="2">Strength & Compressibility</td></tr><tr><td>Moisture Content (%)</td><td>Dry Unit Weight (pcf)</td><td>Water Soluble Sulfates (%)</td><td>Gravel Content (%)</td><td>Sand Content (%)</td><td>Fines Content (%)</td><td>Liquid Limit (%)</td><td>Plasticity Index (%)</td><td>UCS (psf)</td><td>Swell Pressure (psf)</td><td>Swell Percent (%)</td></tr><tr><td>13</td><td>113</td><td></td><td></td><td>94.8</td><td>44</td><td>26</td><td></td><td></td><td></td><td></td></tr><tr><td>14</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr></table>					In-Situ States		INDEX DATA				Strength & Compressibility		Moisture Content (%)	Dry Unit Weight (pcf)	Water Soluble Sulfates (%)	Gravel Content (%)	Sand Content (%)	Fines Content (%)	Liquid Limit (%)	Plasticity Index (%)	UCS (psf)	Swell Pressure (psf)	Swell Percent (%)	13	113			94.8	44	26					14										
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LITHOS
ENGINEERING

Boring Location:	37.324458, -108.398833
Boring Elevation:	6,941.0-feet*
Notes:	Morefield Alignment
*Elevation approximate	

[illegible]

Groundwater Data:	
Date:	Elapsed Time: Depth to Groundwater:
10/18/21	0-days DNE

BORING: LE-OC-05 Project Name: Mesa Verde Waterlines Project Number: 21152 Client's Name: HDR Owner's Name: Mesa Verde National Park Drilling Subcontractor: Terracon Lithos Representative: J. Halverson Date(s) of Drilling: 10/18/21					Drilling and Sampling Methods Drill Make and Model: CME-55 Drilling Method: Solid Stem Auger (SSA) Bit Type: Cutting Head Casing Description: N/A Hammer Weight (lbs)/Fall (in): 140/30 Sampler Type(s): Modified California Sampler Diameter(s): 2.0-inches					LITHOSENGINEERING Boring Location: 37.321733, -108.400039 Boring Elevation: 6,981.0-feet* Notes: Morefield Alignment *Elevation approximate								
Sampling Data					Visual Material Description					Laboratory Testing Results								
Depth (ft)	Elevation (ft)	Sample Identification	Blow Count/6 in	Recovery (in) / RQD (%)	Drilling Rate (min./ft.)	Geologic Graphic	Soil:		Groundwater Depth / Monitoring Well Configuration	In-Situ States		INDEX DATA			Strength & Compressibility			
							-GEOLOGIC INTERPRETATION-			Moisture Content (%)	Dry Unit Weight (pcf)	Water Soluble Sulfates (%)	Gravel Content (%)	Sand Content (%)	Fines Content (%)	Liquid Limit (%)	Plasticity Index (%)	UCS (psf)
0	6980	5	12	6			FINE ALLUVIUM LEAN CLAY with sand (CL), little fine sand, very stiff, pale olive, moist, calcite veins.											
5	6975	9	20	6			As above.			9	95				39	20		
10	6970	11	25	7			As above except hard.											
15	6965	10	13	8			As above.											
							END OF EXPLORATION		15.0 ft.									
20	6960																	
25	6955																	
30	6950																	

General Notes:

1) Soil classificaitons are in general accordance with ASTM D2487

2) The maximum particle size identified in the material description is dependent on sampler dimensions.

3) Additional information is provided on the Boring Log Key.

4) Groundwater measurements for monitoring wells present water levels at the time of drilling, highest level, and lowest level. Refer to the respective report for a complete history of groundwater values.

Groundwater Data:

Date: 10/18/21

Elapsed Time: 0-days

Depth to Groundwater: DNE

BORING: LE-HDD-07 Project Name: Mesa Verde Waterlines Project Number: 21152 Client's Name: HDR Owner's Name: Mesa Verde National Park Drilling Subcontractor: Terracon Lithos Representative: J. Halverson Date(s) of Drilling: 10/25/21					Drilling and Sampling Methods Drill Make and Model: CME-55 Drilling Method: HSA** & HQ Coring Bit Type: Cutting Head - Core Bit Casing Description: HSA & HQ Core Hammer Weight (lbs)/Fall (in): 140/30 Sampler Type(s): Modified California, HQ Core Sampler Diameter(s): 2.0-inches, 2.5-inches					LITHOSENGINEERING Boring Location: 37.315292, -108.400564 Boring Elevation: 6,918.0-feet* Notes: Morefield Alignment *Elevation approximate **Hollow Stem Auger																																																																																																																																																														
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General Notes:

1) Soil classification are in general accordance with ASTM D2487

2) The maximum particle size identified in the material description is dependent on sampler dimensions.

3) Additional information is provided on the Boring Log Key.

4) Groundwater measurements for monitoring wells present water levels at the time of drilling, highest level, and lowest level. Refer to the respective report for a complete history of groundwater values.

Groundwater Data:

Date: 10/25/21

Elapsed Time: 0-days

Depth to Groundwater: DNE

	Groundwater Data:
Date:	Elapsed Time: Depth to Groundwater:
10/25/21	0-days DNE

BORING: LE-HDD-07 Project Name: Mesa Verde Waterlines Project Number: 21152 Client's Name: HDR Owner's Name: Mesa Verde National Park Drilling Subcontractor: Terracon Lithos Representative: J. Halverson Date(s) of Drilling: 10/25/21					Drilling and Sampling Methods Drill Make and Model: CME-55 Drilling Method: HSA** & HQ Coring Bit Type: Cutting Head - Core Bit Casing Description: HSA & HQ Core Hammer Weight (lbs)/Fall (in): 140/30 Sampler Type(s): Modified California, HQ Core Sampler Diameter(s): 2.0-inches, 2.5-inches					LITHOSENGINEERING Boring Location: 37.315292, -108.400564 Boring Elevation: 6,918.0-feet* Notes: Morefield Alignment *Elevation approximate **Hollow Stem Auger						
Sampling Data					Visual Material Description					Laboratory Testing Results						
Depth (ft)	Elevation (ft)	Sample Identification	Blow Count/6 in	Recovery (in) / RQD (%)	Drilling Rate (min./ft.)	Geologic Graphic	Soil:		Groundwater Depth / Monitoring Well Configuration	In-Situ States		INDEX DATA			Strength & Compressibility	
							-GEOLOGIC INTERPRETATION-			Moisture Content (%)	Dry Unit Weight (pcf)	Water Soluble Sulfates (%)	Gravel Content (%)	Sand Content (%)	Fines Content (%)	Liquid Limit (%)
65							As above.									
6850				59 93	0.78		66'1" - Mechanical Break.									
70							67'7" - Mechanical Break.									
							As above.									
6845				62 92	0.89											
75							As above.									
6840				58.5 98	1.07		78'8.5" - Fossil.									
80							79'3.5" - Fossil.									
							END OF EXPLORATION		81.3 ft.							
6835																
85																
6830																
90																
6825																
95																
General Notes: 1) Soil classificaitons are in general accordance with ASTM D2487 2) The maximum particle size identified in the material description is dependent on sampler dimensions. 3) Additional information is provided on the Boring Log Key. 4) Groundwater measurements for monitoring wells present water levels at the time of drilling, highest level, and lowest level. Refer to the respective report for a complete history of groundwater values.										Groundwater Data: Date: 10/25/21 Elapsed Time: 0-days Depth to Groundwater: DNE						



Boring Location: 37.311736, -108.400886
Boring Elevation: 6,924.0-feet*
Notes: Morefield Alignment
*Elevation approximate ** Hollow Stem Auger

[illegible]

- 1) Soil classifications are in general accordance with ASTM D2487
- 2) The maximum particle size identified in the material description is dependent on sampler dimensions.
- 3) Additional information is provided on the Boring Log Key.
- 4) Groundwater measurements for monitoring wells present water levels at the time of drilling, highest level, and lowest level. Refer to the respective report for a complete history of groundwater values.

	Groundwater Data:	
Date:	Elapsed Time:	Depth to Groundwater:
10/22/21	0-days	DNE

BORING: LE-HDD-08 Project Name: Mesa Verde Waterlines Project Number: 21152 Client's Name: HDR Owner's Name: Mesa Verde National Park Drilling Subcontractor: Terracon Lithos Representative: J. Halverson Date(s) of Drilling: 10/22/21						Drilling and Sampling Methods Drill Make and Model: CME-55 Drilling Method: HSA** & HQ Coring Bit Type: Cutting Head - Core Bit Casing Description: HSA & HQ Core Hammer Weight (lbs)/Fall (in): 140/30 Sampler Type(s): Modified California, HQ Core Sampler Diameter(s): 2.0-inches, 2.5-inches						LITHOSENGINEERING Boring Location: 37.311736, -108.400886 Boring Elevation: 6,924.0-feet* Notes: Morefield Alignment *Elevation approximate ** Hollow Stem Auger															
Sampling Data						Visual Material Description						Laboratory Testing Results															
Depth (ft) Elevation (ft) Sample Identification Blow Count/6 in Recovery (in) / RQD (%) Drilling Rate (min./ft.) Geologic Graphic						Soil: -GEOLOGIC INTERPRETATION- USCS Classification (group symbol), particle sizes, density or consistency, color, moisture, odor, other descriptions Rock: -GEOLOGIC INTERPRETATION- Bedrock Classification, hardness, weather, color, texture, joint size, other descriptions						In-Situ States						INDEX DATA						Strength & Compressibility			
												Moisture Content (%)		Dry Unit Weight (pcf)		Water Soluble Sulfates (%)		Gravel Content (%)		Sand Content (%)		Fines Content (%)		Liquid Limit (%)		Plasticity Index (%)	
35 6890 61 92 0.94						As above.																					
40 6885 61 94 0.88						As above.																					
45 6880 58 94 .88						As above.																					
50 6875 63 95 0.81						As above.																					
55 6870 59 91 0.91						As above.																					
60 6865 62 100 1.07						As above.																					
6860 59 0.90																											
General Notes: 1) Soil classificaitons are in general accordance with ASTM D2487 2) The maximum particle size identified in the material description is dependent on sampler dimensions. 3) Additional information is provided on the Boring Log Key. 4) Groundwater measurements for monitoring wells present water levels at the time of drilling, highest level, and lowest level. Refer to the respective report for a complete history of groundwater values.														Groundwater Data: Date: 10/22/21 Elapsed Time: 0-days Depth to Groundwater: DNE													



Boring Location: 37.311736, -108.400886
Boring Elevation: 6,924.0-feet*
Notes: Morefield Alignment
*Elevation approximate ** Hollow Stem Auger

[illegible]

	Groundwater Data:	
Date:	Elapsed Time:	Depth to Groundwater:
10/22/21	0-days	DNE

	Groundwater Data:	
Date:	Elapsed Time:	Depth to Groundwater:
10/21/21	0-days	41.0-feet

BORING: LE-HDD-09 Project Name: Mesa Verde Waterlines Project Number: 21152 Client's Name: HDR Owner's Name: Mesa Verde National Park Drilling Subcontractor: Terracon Lithos Representative: J. Halverson Date(s) of Drilling: 10/21/21					Drilling and Sampling Methods Drill Make and Model: CME-55 Drilling Method: HSA** & HQ Coring Bit Type: Cutting Head - Core Bit Casing Description: HSA & HQ Core Hammer Weight (lbs)/Fall (in): 140/30 Sampler Type(s): Modified California, HQ Core Sampler Diameter(s): 2.0-inches, 2.5-inches					LITHOSENGINEERING Boring Location: 37.309972, -108.401492 Boring Elevation: 6,949.0-feet* Notes: Morefield Alignment *Elevation approximate ** Hollow Stem Auger																																																																																																																																																																																		
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Date:		Groundwater Data:	
10/21/21		Depth to Groundwater:	
0-days		41.0-feet	



Boring Location: 37.309972, -108.401492
Boring Elevation: 6,949.0-feet*
Notes: Morefield Alignment
*Elevation approximate ** Hollow Stem Auger

[illegible]

- 1) Soil classifications are in general accordance with ASTM D2487
- 2) The maximum particle size identified in the material description is dependent on sampler dimensions.
- 3) Additional information is provided on the Boring Log Key.
- 4) Groundwater measurements for monitoring wells present water levels at the time of drilling, highest level, and lowest level. Refer to the respective report for a complete history of groundwater values.

	Groundwater Data:
Date:	Elapsed Time: Depth to Groundwater:
 10/21/21	0-days 41.0-feet
	

	Groundwater Data:	
Date:	Elapsed Time:	Depth to Groundwater:
6/21/23	0-days	DNE

BORING: LE-HDD-9-A Project Name: Mesa Verde Waterlines Project Number: 21152 Client's Name: HDR Owner's Name: Mesa Verde National Park Drilling Subcontractor: Terracon Lithos Representative: K. Stevenson Date(s) of Drilling: 6/20-21/23					Drilling and Sampling Methods Drill Make and Model: CME-75 Drilling Method: Hollow Stem Auger (HSA) Bit Type: Cutting Head Casing Description: HSA Hammer Weight (lbs)/Fall (in): 140/30 Sampler Type(s): Mod. Cal. / HQ Core Sampler Diameter(s): 2.0 in. / 2.4 in.					LITHOS ENGINEERING Boring Location: 37.309100, -108.401086 Boring Elevation: 7007.0-feet* Notes: Moorefield Alignment *Elevation approximate.																																																																																																						
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<table><tr><td>35</td><td></td><td>50/5"</td><td>5</td><td></td><td></td><td></td></tr><tr><td>6970</td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>40</td><td></td><td>50/4"</td><td>4</td><td>11 0</td><td>1.22</td><td></td></tr><tr><td>6965</td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>45</td><td></td><td></td><td></td><td>52 7.8</td><td>1.32</td><td></td></tr><tr><td>6960</td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>50</td><td></td><td></td><td></td><td>51 32.4</td><td>0.94</td><td></td></tr><tr><td>6955</td><td></td><td></td><td></td><td>39 10.3</td><td>1.31</td><td></td></tr><tr><td>55</td><td></td><td></td><td></td><td>30 66.7</td><td>0.77</td><td></td></tr><tr><td>6950</td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>60</td><td></td><td></td><td></td><td>60 81.7</td><td>0.72</td><td></td></tr><tr><td>6945</td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td><td></td><td>60 90.0</td><td>0.50</td><td></td></tr></table>							35		50/5"	5				6970							40		50/4"	4	11 0	1.22		6965							45				52 7.8	1.32		6960							50				51 32.4	0.94		6955				39 10.3	1.31		55				30 66.7	0.77		6950							60				60 81.7	0.72		6945											60 90.0	0.50		37.0 ft. MANCOS SHALE Sandy Shale, very soft, slightly weathered, gray, very fine grained, moist, calcareous. Shale, very soft, slightly weathered gray, very fine grained, extremely thin bedding, moist, calcareous, iron oxidation, highly fractured generally parallel to bedding planes. As above except moderately weathered, clay seams and calcite vein less than 0.25 inches seen in sample. As above except slightly weathered. As above except slightly to moderately weathered. As above. As above. Sandstone, very soft, highly weathered, reddish orange, very fine to fine grained, moist, iron oxidation. Shale, very soft, slightly weathered, gray, very fine grained, extremely thin bedding, moist, iron oxidation, calcareous, few fractures parallel to bedding plane. As above except fresh to slightly weathered.														
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BORING: LE-HDD-9-A Project Name: Mesa Verde Waterlines Project Number: 21152 Client's Name: HDR Owner's Name: Mesa Verde National Park Drilling Subcontractor: Terracon Lithos Representative: K. Stevenson Date(s) of Drilling: 6/20-21/23					Drilling and Sampling Methods Drill Make and Model: CME-75 Drilling Method: Hollow Stem Auger (HSA) Bit Type: Cutting Head Casing Description: HSA Hammer Weight (lbs)/Fall (in): 140/30 Sampler Type(s): Mod. Cal. / HQ Core Sampler Diameter(s): 2.0 in. / 2.4 in.					LITHOS ENGINEERING Boring Location: 37.309100, -108.401086 Boring Elevation: 7007.0-feet* Notes: Moorefield Alignment *Elevation approximate.											
Sampling Data						Visual Material Description						Laboratory Testing Results									
												In-Situ States		INDEX DATA				Strength & Compressibility			
												Moisture Content (%)		Dry Unit Weight (pcf)		Water Soluble Sulfates (%)		Gravel Content (%)		Sand Content (%)	
65						As above.															
6940																					
60																					
96.7						1.07															
70																					
6935																					
60																					
98.3						0.97															
75																					
6930																					
47																					
95.7						0.85															
80						Siltstone, very soft, moderately weathered, gray, very fine grained, moist. Little recovery in this section															
						Shale, very soft, fresh to slightly weathered, gray, very fine grained, extremely thin bedding, moist, iron oxidation, calcarous.															
6925						81.1 ft.															
						END OF EXPLORATION															
85																					
6920																					
90																					
6915																					
95																					
General Notes:																Groundwater Data:					
1) Soil classificaitons are in general accordance with ASTM D2487																Date: 6/21/23					
2) The maximum particle size identified in the material description is dependent on sampler dimensions.																Elapsed Time: 0-days					
3) Additional information is provided on the Boring Log Key.																Depth to Groundwater: DNE					
4) Groundwater measurements for monitoring wells present water levels at the time of drilling, highest level, and lowest level. Refer to the respective report for a complete history of groundwater values.																					

	Groundwater Data:
Date:	Elapsed Time: Depth to Groundwater:
6/22/23	0-days DNE

BORING: LE-HDD-9-B

Project Name: Mesa Verde Waterlines
 Project Number: 21152
 Client's Name: HDR
 Owner's Name: Mesa Verde National Park
 Drilling Subcontractor: Terracon
 Lithos Representative: K. Stevenson
 Date(s) of Drilling: 6/22/23

Drilling and Sampling Methods

Drill Make and Model: CME-75
 Drilling Method: Hollow Stem Auger (HSA)
 Bit Type: Cutting Head
 Casing Description: HSA
 Hammer Weight (lbs)/Fall (in): 140/30
 Sampler Type(s): Modified California
 Sampler Diameter(s): 2.0 in.



Boring Location: 37.307619, -108.403261

Boring Elevation: 7095.0-feet*

Notes: Moorefield Alignment

*Elevation approximate.

Sampling Data						Visual Material Description		Groundwater Depth / Monitoring Well Configuration	Laboratory Testing Results												
Depth (ft)	Elevation (ft)	Sample Identification	Blow Count/6 in	Recovery (in) / RQD (%)	Drilling Rate (min./ft.)				Geologic Graphic	In-Situ States			INDEX DATA				Strength & Compressibility				
										Moisture Content (%)	Dry Unit Weight (pcf)	Water Soluble Sulfates (%)	Gravel Content (%)	Sand Content (%)	Fines Content (%)	Liquid Limit (%)	Plasticity Index (%)	UCS (psf)	Swell Pressure (psf)	Swell Percent (%)	
35	7060																				
40	7055		19 45	5			As above except very fine to coarse grained.														
45	7050																				
50	7045		15 28	6			As above except highly to completely weathered.		12	122	7	33	60	34	18						
55	7040		50/5"	5			Sandstone Boulder, very soft, moderately weathered, olive yellow, very fine to fine grained, moist, iron oxidation, calcareous.														
60	7035																				
			36				Clayey Sandstone Boulder, very soft, highly weathered, olive														

General Notes:

- Soil classifications are in general accordance with ASTM D2487
- The maximum particle size identified in the material description is dependent on sampler dimensions.
- Additional information is provided on the Boring Log Key.
- Groundwater measurements for monitoring wells present water levels at the time of drilling, highest level, and lowest level. Refer to the respective report for a complete history of groundwater values.

Groundwater Data:		Data:	
Date:	Elapsed Time:	Depth to Groundwater:	
6/22/23	0-days	DNE	

BORING: LE-HDD-9-B Project Name: Mesa Verde Waterlines Project Number: 21152 Client's Name: HDR Owner's Name: Mesa Verde National Park Drilling Subcontractor: Terracon Lithos Representative: K. Stevenson Date(s) of Drilling: 6/22/23					Drilling and Sampling Methods Drill Make and Model: CME-75 Drilling Method: Hollow Stem Auger (HSA) Bit Type: Cutting Head Casing Description: HSA Hammer Weight (lbs)/Fall (in): 140/30 Sampler Type(s): Modified California Sampler Diameter(s): 2.0 in.					LITHOS ENGINEERING Boring Location: 37.307619, -108.403261 Boring Elevation: 7095.0-feet* Notes: Moorefield Alignment *Elevation approximate.																																																																																																																							
Sampling Data <table><tr><td>Depth (ft)</td><td>Elevation (ft)</td><td>Sample Identification</td><td>Blow Count/6 in</td><td>Recovery (in) / RQD (%)</td><td>Drilling Rate (min./ft.)</td><td>Geologic Graphic</td></tr><tr><td>65</td><td>7030</td><td>✖</td><td>43</td><td>5</td><td></td><td rowspan="5"></td></tr><tr><td>70</td><td>7025</td><td></td><td></td><td></td><td></td></tr><tr><td>75</td><td>7020</td><td>✖</td><td>50/6"</td><td>6</td><td></td></tr><tr><td>80</td><td>7015</td><td></td><td></td><td></td><td></td></tr><tr><td>85</td><td>7010</td><td>✖</td><td>50/3"</td><td>3</td><td></td></tr><tr><td>90</td><td>7005</td><td>✖</td><td>50/3"</td><td>3</td><td></td><td></td></tr><tr><td>95</td><td>7000</td><td></td><td></td><td></td><td></td><td></td></tr></table>					Depth (ft)	Elevation (ft)	Sample Identification	Blow Count/6 in	Recovery (in) / RQD (%)	Drilling Rate (min./ft.)	Geologic Graphic	65	7030	✖	43	5			70	7025					75	7020	✖	50/6"	6		80	7015					85	7010	✖	50/3"	3		90	7005	✖	50/3"	3			95	7000						Visual Material Description Soil: -GEOLOGIC INTERPRETATION- USCS Classification (group symbol), particle sizes, density or consistency, color, moisture, odor, other descriptions Rock: -GEOLOGIC INTERPRETATION- Bedrock Classification, hardness, weather, color, texture, joint size, other descriptions to reddish brown, very fine to medium grained, moist, iron oxidation, calcareous. 69' - 72' auger grinding. Claystone Boulder, very soft, moderately weathered, olive yellow, very fine to fine grained, moist, iron oxidation. 79.0 ft.- MANCOS SHALE Sandy Shale, very soft, slightly weathered, gray, very fine grained, extremely thin bedding, moist, calcareous. 89.3 ft.- As above. END OF EXPLORATION					Groundwater Depth / Monitoring Well Configuration <table><tr><td colspan="2">In-Situ States</td><td colspan="4">INDEX DATA</td><td colspan="2">Strength & Compressibility</td></tr><tr><td>Moisture Content (%)</td><td>Dry Unit Weight (pcf)</td><td>Water Soluble Sulfates (%)</td><td>Gravel Content (%)</td><td>Sand Content (%)</td><td>Fines Content (%)</td><td>Liquid Limit (%)</td><td>Plasticity Index (%)</td><td>UCS (psf)</td><td>Swell Pressure (psf)</td><td>Swell Percent (%)</td></tr><tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>13</td><td>125</td><td></td><td>0</td><td>5</td><td>95</td><td>40</td><td>24</td><td></td><td></td><td></td></tr><tr><td>5</td><td>106</td><td></td><td></td><td></td><td></td><td></td><td></td><td>1,247</td><td></td><td></td></tr><tr><td>5</td><td>108</td><td></td><td>3</td><td>24</td><td>73</td><td>31</td><td>14</td><td>3,117</td><td></td><td></td></tr></table>					In-Situ States		INDEX DATA				Strength & Compressibility		Moisture Content (%)	Dry Unit Weight (pcf)	Water Soluble Sulfates (%)	Gravel Content (%)	Sand Content (%)	Fines Content (%)	Liquid Limit (%)	Plasticity Index (%)	UCS (psf)	Swell Pressure (psf)	Swell Percent (%)												13	125		0	5	95	40	24				5	106							1,247			5	108		3	24	73	31	14	3,117		
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BORING: LE-HDD-10 Project Name: Mesa Verde Waterlines Project Number: 21152 Client's Name: HDR Owner's Name: Mesa Verde National Park Drilling Subcontractor: Terracon Lithos Representative: J. Halverson Date(s) of Drilling: 10/20/21					Drilling and Sampling Methods Drill Make and Model: CME-55 Drilling Method: Hollow Stem Auger (HSA) Bit Type: Cutting Head Casing Description: HSA Hammer Weight (lbs)/Fall (in): 140/30 Sampler Type(s): Modified California Sampler Diameter(s): 2.0-inches					LITHOS ENGINEERING Boring Location: 37.306286, -108.405381 Boring Elevation: 7,314.0-feet* Notes: Morefield Alignment *Elevation approximate																																																																																		
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4																																																																																												
ROCKFALL DEPOSIT - Clay matrix with chunks of siltstone ranging in size from coarse sand to larger boulders. Size of boulders indicated by hatching were inferred based on drill rig action. Sandy LEAN CLAY with gravel (CL), some fine to coarse sand, little fine to coarse gravel, stiff, dark brown, moist, maximum particle size 2" or greater. Sandstone Boulder, medium, highly weathered, olive yellow, mostly fine sand, calcite, approx. 6.0 feet. Sandy LEAN CLAY with gravel and cobbles (CL), some fine to coarse sand, little gravel, little cobbles, hard, gray (matrix) to pale olive (siltstone chunks), dry to moist, calcite, cobbles inferred from drill rig action and fractured material within collected sample. No recovery. Sandy LEAN CLAY with gravel and cobbles (CL), some fine to coarse sand, little gravel, little cobbles, hard, gray (matrix) to pale olive (siltstone chunks), dry to moist, iron oxidation, calcite, cobbles inferred from drill rig action and fractured material within collected sample. As above except no iron oxidation. As above.																																																																																												
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BORING: LE-HDD-10 Project Name: Mesa Verde Waterlines Project Number: 21152 Client's Name: HDR Owner's Name: Mesa Verde National Park Drilling Subcontractor: Terracon Lithos Representative: J. Halverson Date(s) of Drilling: 10/20/21					Drilling and Sampling Methods Drill Make and Model: CME-55 Drilling Method: Hollow Stem Auger (HSA) Bit Type: Cutting Head Casing Description: HSA Hammer Weight (lbs)/Fall (in): 140/30 Sampler Type(s): Modified California Sampler Diameter(s): 2.0-inches					LITHOS ENGINEERING Boring Location: 37.306286, -108.405381 Boring Elevation: 7,314.0-feet* Notes: Morefield Alignment *Elevation approximate							
Sampling Data					Visual Material Description					Laboratory Testing Results							
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							-GEOLOGIC INTERPRETATION-			Moisture Content (%)	Dry Unit Weight (pcf)	Water Soluble Sulfates (%)	Gravel Content (%)	Sand Content (%)	Fines Content (%)	Liquid Limit (%)	Plasticity Index (%)
35	7280	 25	50/5"	6			LEAN CLAY with sand, gravel and cobbles (ML), little fine to coarse sand, little gravel, little cobbles, few clay, hard, dark brown (matrix) to pale olive (siltstone chunks), dry to moist, iron oxidation, calcite, cobbles inferred from drill rig action and fractured material within collected sample.										
40	7275	 19	36	10			As above.										
45	7270	 20	50	9			As above except olive brown (matrix).										
50	7265	 50/2"		2			As above except olive brown (matrix).										
55	7260	 50/3"		4			As above except olive brown (matrix).										
60	7255	 50/0"		0			Sandstone Boulder, very hard, pale olive, no recovery.										
7250		 13					LEAN CLAY with sand (CL), little fine to coarse sand, few										
General Notes: 1) Soil classifications are in general accordance with ASTM D2487 2) The maximum particle size identified in the material description is dependent on sampler dimensions. 3) Additional information is provided on the Boring Log Key. 4) Groundwater measurements for monitoring wells present water levels at the time of drilling, highest level, and lowest level. Refer to the respective report for a complete history of groundwater values.										Groundwater Data: Date: 10/20/21 Elapsed Time: 0-days Depth to Groundwater: DNE							

BORING: LE-HDD-10 Project Name: Mesa Verde Waterlines Project Number: 21152 Client's Name: HDR Owner's Name: Mesa Verde National Park Drilling Subcontractor: Terracon Lithos Representative: J. Halverson Date(s) of Drilling: 10/20/21					Drilling and Sampling Methods Drill Make and Model: CME-55 Drilling Method: Hollow Stem Auger (HSA) Bit Type: Cutting Head Casing Description: HSA Hammer Weight (lbs)/Fall (in): 140/30 Sampler Type(s): Modified California Sampler Diameter(s): 2.0-inches					LITHOSENGINEERING Boring Location: 37.306286, -108.405381 Boring Elevation: 7,314.0-feet* Notes: Morefield Alignment *Elevation approximate																																						
Sampling Data <table><tr><td rowspan="2">Depth (ft)</td><td rowspan="2">Elevation (ft)</td><td rowspan="2">Sample Identification</td><td rowspan="2">Blow Count/6 in</td><td rowspan="2">Recovery (in) / RQD (%)</td><td rowspan="2">Drilling Rate (min./ft.)</td><td rowspan="2">Geologic Graphic</td></tr><tr></tr></table>					Depth (ft)	Elevation (ft)	Sample Identification	Blow Count/6 in	Recovery (in) / RQD (%)	Drilling Rate (min./ft.)	Geologic Graphic	Visual Material Description Soil: -GEOLOGIC INTERPRETATION- USCS Classification (group symbol), particle sizes, density or consistency, color, moisture, odor, other descriptions Rock: -GEOLOGIC INTERPRETATION- Bedrock Classification, hardness, weather, color, texture, joint size, other descriptions					Groundwater Depth / Monitoring Well Configuration	Laboratory Testing Results <table><tr><td colspan="2">In-Situ States</td><td colspan="6">INDEX DATA</td><td colspan="2">Strength & Compressibility</td></tr><tr><td>Moisture Content (%)</td><td>Dry Unit Weight (pcf)</td><td>Water Soluble Sulfates (%)</td><td>Gravel Content (%)</td><td>Sand Content (%)</td><td>Fines Content (%)</td><td>Liquid Limit (%)</td><td>Plasticity Index (%)</td><td>UCS (psf)</td><td>Swell Pressure (psf)</td><td>Swell Percent (%)</td></tr></table>										In-Situ States		INDEX DATA						Strength & Compressibility		Moisture Content (%)	Dry Unit Weight (pcf)	Water Soluble Sulfates (%)	Gravel Content (%)	Sand Content (%)	Fines Content (%)	Liquid Limit (%)	Plasticity Index (%)	UCS (psf)	Swell Pressure (psf)	Swell Percent (%)
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65		50/5"	11				gravel, few cobbles, little silt, hard, olive brown (matrix) to pale olive (siltstone/sandstone chunks), dry to moist, iron oxidation, calcite, cobbles inferred from drill rig action and fractured material within collected sample.																																									
7245		50/5"	5				LEAN CLAY with sand, gravel and cobbles (CL), little fine to coarse sand, little gravel, little cobbles, few clay, hard, olive brown (matrix) to pale olive (siltstone chunks), dry to moist, iron oxidation, calcite, cobbles inferred from drill rig action and fractured material within collected sample.																																									
7240		19 40	10				LEAN CLAY with sand (CL), little fine to coarse sand, few gravel, few cobbles, little silt, hard, olive brown (matrix) to pale olive (siltstone/sandstone chunks), dry to moist, iron oxidation, calcite.																																									
7235		33 50/4"	9				LEAN CLAY with sand, gravel and cobbles (CL), little fine to coarse sand, little gravel, little cobbles, few clay, hard, olive brown (matrix) to pale olive (siltstone chunks), dry to moist, iron oxidation, calcite, cobbles inferred from drill rig action and fractured material within collected sample.																																									
							END OF EXPLORATION	80.0 ft.																																								
7230																																																
85																																																
7225																																																
90																																																
7220																																																
95																																																

 General Notes: 1) Soil classificaitons are in general accordance with ASTM D2487 2) The maximum particle size identified in the material description is dependent on sampler dimensions. 3) Additional information is provided on the Boring Log Key. 4) Groundwater measurements for monitoring wells present water levels at the time of drilling, highest level, and lowest level. Refer to the respective report for a complete history of groundwater values. | | | | | Groundwater Data: Date: 10/20/21 Elapsed Time: 0-days Depth to Groundwater: DNE | | | | |

BORING: LE-HDD-11 Project Name: Mesa Verde Waterlines Project Number: 21152 Client's Name: HDR Owner's Name: Mesa Verde National Park Drilling Subcontractor: Terracon Lithos Representative: J. Halverson Date(s) of Drilling: 10/19/21						Drilling and Sampling Methods Drill Make and Model: CME-55 Drilling Method: HSA & HQ Coring Bit Type: Cutting Head - Core Bit Casing Description: HSA & HQ Core Hammer Weight (lbs)/Fall (in): 140/30 Sampler Type(s): Modified California, HQ Core Sampler Diameter(s): 2.0-inches, 2.5-inches						LITHOSENGINEERING Boring Location: 37.300986, -108.410864 Boring Elevation: 7,855.0-feet* Notes: Morefield Alignment *Elevation approximate **Hollow Stem Auger																	
Sampling Data						Visual Material Description						Laboratory Testing Results																	
												In-Situ States						INDEX DATA						Strength & Compressibility					
												Moisture Content (%)		Dry Unit Weight (pcf)		Water Soluble Sulfates (%)		Gravel Content (%)		Sand Content (%)		Fines Content (%)		Liquid Limit (%)		Plasticity Index (%)		UCS (psf)	
Depth (ft) Elevation (ft) Sample Identification Blow Count/6 in Recovery (in) / RQD (%) Drilling Rate (min./ft.) Geologic Graphic						Soil: -GEOLOGIC INTERPRETATION- USCS Classification (group symbol), particle sizes, density or consistency, color, moisture, odor, other descriptions Rock: -GEOLOGIC INTERPRETATION- Bedrock Classification, hardness, weather, color, texture, joint size, other descriptions						Groundwater Depth / Monitoring Well Configuration																	
0 7855						ROCKFALL DEPOSIT - Clay matrix with chunks of siltstone ranging in size from coarse sand to larger boulders. Size of boulders indicated by hatching were inferred based on drill rig action. LEAN CLAY with sand (CL), little fine sand, very stiff, olive brown, dry to moist, few roots. As above except few silt, hard, dark brown.																							
5 7850												10 109												13, 301					
10 7845						LEAN CLAY with sand and gravel (CL), little fine to medium sand, little fine to coarse gravel, hard, olive gray, dry, maximum particle size 1.0-inches, gravel is siltstone chunks, calcite veins.						8 122						75 32 17						32, 988					
15 7840						As above except maximum particle size 2.0-inches.																							
20 7835						Drill rig action indicates multiple boulders from 19 to 80 feet. Collected samples include inferred boulder material. Matrix inferred based on samples collected from LE-HDD-10. Interbedded Claystone (CS) and Sandstone (SS) Boulder, soft (CS) to medium (SS), slightly to moderately weathered, gray (CS) to pale olive (SS), mostly fine sand, some clay, iron oxidation, calcite. Sandstone Boulder, hard, slightly to moderately weathered, pale olive, mostly fine sand size grains, iron oxidation, calcite.																							
25 7830						Boulder as above except no calcite.																							
30 7825																													
General Notes: 1) Soil classification are in general accordance with ASTM D2487 2) The maximum particle size identified in the material description is dependent on sampler dimensions. 3) Additional information is provided on the Boring Log Key. 4) Groundwater measurements for monitoring wells present water levels at the time of drilling, highest level, and lowest level. Refer to the respective report for a complete history of groundwater values.												Groundwater Data: Date: 10/19/21 Elapsed Time: 0-days Depth to Groundwater: DNE																	

BORING: LE-HDD-11 Project Name: Mesa Verde Waterlines Project Number: 21152 Client's Name: HDR Owner's Name: Mesa Verde National Park Drilling Subcontractor: Terracon Lithos Representative: J. Halverson Date(s) of Drilling: 10/19/21					Drilling and Sampling Methods Drill Make and Model: CME-55 Drilling Method: HSA & HQ Coring Bit Type: Cutting Head - Core Bit Casing Description: HSA & HQ Core Hammer Weight (lbs)/Fall (in): 140/30 Sampler Type(s): Modified California, HQ Core Sampler Diameter(s): 2.0-inches, 2.5-inches					LITHOSENGINEERING Boring Location: 37.300986, -108.410864 Boring Elevation: 7,855.0-feet* Notes: Morefield Alignment *Elevation approximate **Hollow Stem Auger								
Sampling Data						Visual Material Description						Laboratory Testing Results						
						Soil: -GEOLOGIC INTERPRETATION- USCS Classification (group symbol), particle sizes, density or consistency, color, moisture, odor, other descriptions						Groundwater Depth / Monitoring Well Configuration						
						Rock: -GEOLOGIC INTERPRETATION- Bedrock Classification, hardness, weather, color, texture, joint size, other descriptions												
Depth (ft)	Elevation (ft)	Sample Identification	Blow Count/6 in	Recovery (in) / RQD (%)	Drilling Rate (min./ft.)	Geologic Graphic												
35	7820	50/6"	6				Boulder as above except medium, olive yellow.											
40	7815	41 50/3"	5				Boulder as above except olive yellow.											
45	7810	50/5"	5				Boulder as above except olive yellow.											
50	7805	11 25	10				Interbedded Claystone (CS) and Siltstone (SS) Boulder, soft (CS) to medium (SS), slightly to moderately weathered, pale olive (SS) to olive gray (CS), mostly silt, some clay, mica grains (SS), gypsum crystal growth.											
55	7800	26 25	8				Boulder as above except slightly weathered, iron oxidation.											
60	7795	50/5"	4				Boulder as above.											
							No recovery for both SPT and Modified California sampling											
General Notes: 1) Soil classificaitons are in general accordance with ASTM D2487 2) The maximum particle size identified in the material description is dependent on sampler dimensions. 3) Additional information is provided on the Boring Log Key. 4) Groundwater measurements for monitoring wells present water levels at the time of drilling, highest level, and lowest level. Refer to the respective report for a complete history of groundwater values.												Groundwater Data: Date: 10/19/21 Elapsed Time: 0-days Depth to Groundwater: DNE						

BORING: LE-HDD-11

Project Name: Mesa Verde Waterlines
 Project Number: 21152
 Client's Name: HDR
 Owner's Name: Mesa Verde National Park
 Drilling Subcontractor: Terracon
 Lithos Representative: J. Halverson
 Date(s) of Drilling: 10/19/21

Drilling and Sampling Methods

Drill Make and Model: CME-55
 Drilling Method: HSA & HQ Coring
 Bit Type: Cutting Head - Core Bit
 Casing Description: HSA & HQ Core
 Hammer Weight (lbs)/Fall (in): 140/30
 Sampler Type(s): Modified California, HQ Core
 Sampler Diameter(s): 2.0-inches, 2.5-inches



Boring Location: 37.300986, -108.410864
 Boring Elevation: 7,855.0-feet*
 Notes: Morefield Alignment
 *Elevation approximate **Hollow Stem Auger

Sampling Data						Visual Material Description	Groundwater Depth / Monitoring Well Configuration	Laboratory Testing Results												
Depth (ft)	Elevation (ft)	Sample Identification	Blow Count/6 in	Recovery (in) / RQD (%)	Drilling Rate (min./ft.)			Geologic Graphic	In-Situ States			INDEX DATA				Strength & Compressibility				
									Moisture Content (%)	Dry Unit Weight (pcf)	Water Soluble Sulfates (%)	Gravel Content (%)	Sand Content (%)	Fines Content (%)	Liquid Limit (%)	Plasticity Index (%)	UCS (psf)	Swell Pressure (psf)	Swell Percent (%)	
65	7790	50/0"	0																	
70	7785	50/4"	3																	
75	7780	50/1"	1																	
80	7775			29.5 12	1.2															
85	7770																			
90	7765																			
95	7760																			

General Notes:

- 1) Soil classifications are in general accordance with ASTM D2487
- 2) The maximum particle size identified in the material description is dependent on sampler dimensions.
- 3) Additional information is provided on the Boring Log Key.
- 4) Groundwater measurements for monitoring wells present water levels at the time of drilling, highest level, and lowest level. Refer to the respective report for a complete history of groundwater values.

Groundwater Data:		Data:	
Date:	10/19/21	Elapsed Time:	0-days
Depth to Groundwater:	DNE		

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Boring Location:	37.301950, -108.414453
Boring Elevation:	7,931.0-feet*
Notes:	Morefield Alignment
*Elevation approximate.	

[illegible]

- 1) Soil classifications are in general accordance with ASTM D2487
- 2) The maximum particle size identified in the material description is dependent on sampler dimensions.
- 3) Additional information is provided on the Boring Log Key.
- 4) Groundwater measurements for monitoring wells present water levels at the time of drilling, highest level, and lowest level. Refer to the respective report for a complete history of groundwater values.

	Groundwater Data:	
Date:	Elapsed Time:	Depth to Groundwater:
 10/18/21	0-days	15.0-feet
		

BORING: LE-HDD-12-A Project Name: Mesa Verde Waterlines Project Number: 21152 Client's Name: HDR Owner's Name: Mesa Verde National Park Drilling Subcontractor: Terracon Lithos Representative: K. Stevenson Date(s) of Drilling: 6/20/23					Drilling and Sampling Methods Drill Make and Model: CME-75 Drilling Method: Hollow Stem Auger (HSA) Bit Type: Cutting Head Casing Description: HSA Hammer Weight (lbs)/Fall (in): 140/30 Sampler Type(s): Mod. Cal. / HQ Core Sampler Diameter(s): 2.0 in. / 2.4 in.					LITHOSENGINEERING Boring Location: 37.302206, -108.414678 Boring Elevation: 7930.0-feet* Notes: Moorefield Alignment *Elevation approximate.																																																																																																																																																				
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20	7910	50/0"		0																																																																																																																																																										
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BORING: LE-HDD-12-A Project Name: Mesa Verde Waterlines Project Number: 21152 Client's Name: HDR Owner's Name: Mesa Verde National Park Drilling Subcontractor: Terracon Lithos Representative: K. Stevenson Date(s) of Drilling: 6/20/23					Drilling and Sampling Methods Drill Make and Model: CME-75 Drilling Method: Hollow Stem Auger (HSA) Bit Type: Cutting Head Casing Description: HSA Hammer Weight (lbs)/Fall (in): 140/30 Sampler Type(s): Mod. Cal. / HQ Core Sampler Diameter(s): 2.0 in. / 2.4 in.					LITHOS ENGINEERING Boring Location: 37.302206, -108.414678 Boring Elevation: 7930.0-feet* Notes: Moorefield Alignment *Elevation approximate.																																																										
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<table><tr><td>35</td><td>7895</td><td></td><td></td><td></td><td>21 0.0</td><td>0.74</td><td rowspan="2"></td></tr><tr><td>40</td><td>7890</td><td>13 18</td><td>7</td><td></td><td></td><td></td></tr><tr><td>45</td><td>7885</td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>50</td><td>7880</td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>55</td><td>7875</td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>60</td><td>7870</td><td></td><td></td><td></td><td></td><td></td><td></td></tr></table>							35	7895				21 0.0	0.74		40	7890	13 18	7				45	7885							50	7880							55	7875							60	7870							Clayey SAND (SC), mostly fine to coarse sand, some clay, trace fine gravel, maximum particle size 0.25 in., yellowish brown, moist, iron oxidation. As above.														
35	7895				21 0.0	0.74																																																														
40	7890	13 18	7																																																																	
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							As above except dense.																																																													
							END OF EXPLORATION					40.3 ft.																																																								

General Notes:

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Groundwater Data:	
Date:	Elapsed Time:
6/20/23	0-days
	DNE

BORING: LE-OC-13 Project Name: Mesa Verde Waterlines Project Number: 21152 Client's Name: HDR Owner's Name: Mesa Verde National Park Drilling Subcontractor: Terracon Lithos Representative: J. Halverson Date(s) of Drilling: 10/26/21						Drilling and Sampling Methods Drill Make and Model: CME-55 Drilling Method: Solid Stem Auger (SSA) Bit Type: Cutting Head Casing Description: N/A Hammer Weight (lbs)/Fall (in): 140/30 Sampler Type(s): Modified California Sampler Diameter(s): 2.0-inches						LITHOSENGINEERING Boring Location: 37.271278, -108.497169 Boring Elevation: 8,317.0-feet* Notes: Wetherill Alignment *Elevation approximate											
Sampling Data						Visual Material Description						Laboratory Testing Results											
												In-Situ States		INDEX DATA			Strength & Compressibility						
												Moisture Content (%)	Dry Unit Weight (pcf)	Water Soluble Sulfates (%)	Gravel Content (%)	Sand Content (%)	Fines Content (%)	Liquid Limit (%)	Plasticity Index (%)	UCS (psf)	Swell Pressure (psf)	Swell Percent (%)	
Depth (ft)	Elevation (ft)	Sample Identification	Blow Count/6 in	Recovery (in) / RQD (%)	Drilling Rate (min./ft.)	Geologic Graphic							Groundwater Depth / Monitoring Well Configuration										
0		5	11	6			FINE COLLUVIUM LEAN CLAY with sand (CL), little fine to coarse sand, few fine gravel, very stiff, olive yellow, moist, iron oxidation.																
8315																							
5		11	21	8			As above except few fine to coarse gravel, maximum particle size 2" or greater -- sandstone chunks.						9	111				71	32	17			
8310																							
10		11	16	10			As above except no gravel, coarser grains are sandstone chunks.																
8305																							
15		18	19	8			As above.																
8300							CLIFFHOUSE SANDSTONE Siltstone, soft, moderately weathered, yellowish brown to pale olive to gray, few fine sand, few clay, calcite, iron oxidation.																
							END OF EXPLORATION																
20																							
8295																							
25																							
8290																							
30																							
8285																							
General Notes: 1) Soil classificaitons are in general accordance with ASTM D2487 2) The maximum particle size identified in the material description is dependent on sampler dimensions. 3) Additional information is provided on the Boring Log Key. 4) Groundwater measurements for monitoring wells present water levels at the time of drilling, highest level, and lowest level. Refer to the respective report for a complete history of groundwater values.												Groundwater Data: Date: 10/26/21 Elapsed Time: 0-days Depth to Groundwater: DNE											

LITHOS
ENGINEERING

Boring Location: 37.274411, -108.501456

Boring Elevation: 8,123.0-feet*

Notes: Wetherill Alignment

*Elevation approximate

[illegible]

Groundwater Data:		
Date:	Elapsed Time:	Depth to Groundwater:
10/26/21	0-days	DNE

BORING: LE-OC-15 Project Name: Mesa Verde Waterlines Project Number: 21152 Client's Name: HDR Owner's Name: Mesa Verde National Park Drilling Subcontractor: Terracon Lithos Representative: K. Stevenson Date(s) of Drilling: 11/03/21					Drilling and Sampling Methods Drill Make and Model: CME-55 Drilling Method: Solid Stem Auger (SSA) Bit Type: Cutting Head Casing Description: N/A Hammer Weight (lbs)/Fall (in): 140/30 Sampler Type(s): Modified California Sampler Diameter(s): 2.0-inches					LITHOSENGINEERING Boring Location: 37.269883, -108.504039 Boring Elevation: 8,254.0-feet* Notes: Wetherill Alignment *Elevation approximate																																																																																										
Sampling Data <table><tr><td>Depth (ft)</td><td>Elevation (ft)</td><td>Sample Identification</td><td>Blow Count/6 in</td><td>Recovery (in) / RQD (%)</td><td>Drilling Rate (min./ft.)</td><td>Geologic Graphic</td></tr><tr><td>0</td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>5</td><td>8250</td><td>21 25</td><td>12</td><td></td><td></td><td></td></tr><tr><td>10</td><td>8245</td><td>32 50</td><td>12</td><td></td><td></td><td></td></tr><tr><td>15</td><td>8240</td><td>50/6"</td><td>6</td><td></td><td></td><td></td></tr><tr><td>20</td><td>8235</td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>25</td><td>8230</td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>30</td><td>8225</td><td></td><td></td><td></td><td></td><td></td></tr></table>					Depth (ft)	Elevation (ft)	Sample Identification	Blow Count/6 in	Recovery (in) / RQD (%)	Drilling Rate (min./ft.)	Geologic Graphic	0							5	8250	21 25	12				10	8245	32 50	12				15	8240	50/6"	6				20	8235						25	8230						30	8225						Visual Material Description Soil: -GEOLOGIC INTERPRETATION- USCS Classification (group symbol), particle sizes, density or consistency, color, moisture, odor, other descriptions Rock: -GEOLOGIC INTERPRETATION- Bedrock Classification, hardness, weather, color, texture, joint size, other descriptions PAVEMENT SECTION Asphalt: 7.0-inches Base: 8.0-inches CLIFFHOUSE SANDSTONE Siltstone, soft, moderately weathered, olive yellow to olive brown, few fine sand, iron oxidation, calcite. As above except no calcite. As above except medium, pale olive, iron oxidation, calcite. END OF EXPLORATION					Groundwater Depth / Monitoring Well Configuration <table><tr><td colspan="2">In-Situ States</td><td colspan="4">INDEX DATA</td><td colspan="2">Strength & Compressibility</td></tr><tr><td>Moisture Content (%)</td><td>Dry Unit Weight (pcf)</td><td>Water Soluble Sulfates (%)</td><td>Gravel Content (%)</td><td>Sand Content (%)</td><td>Fines Content (%)</td><td>Liquid Limit (%)</td><td>Plasticity Index (%)</td><td>UCS (psf)</td><td>Swell Pressure (psf)</td><td>Swell Percent (%)</td></tr><tr><td>17</td><td></td><td></td><td></td><td></td><td>92</td><td></td><td></td><td></td><td></td><td></td></tr></table>					In-Situ States		INDEX DATA				Strength & Compressibility		Moisture Content (%)	Dry Unit Weight (pcf)	Water Soluble Sulfates (%)	Gravel Content (%)	Sand Content (%)	Fines Content (%)	Liquid Limit (%)	Plasticity Index (%)	UCS (psf)	Swell Pressure (psf)	Swell Percent (%)	17					92					
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BORING: LE-BC-16 Project Name: Mesa Verde Waterlines Project Number: 21152 Client's Name: HDR Owner's Name: Mesa Verde National Park Drilling Subcontractor: Terracon Lithos Representative: K. Stevenson Date(s) of Drilling: 11/03/21					Drilling and Sampling Methods Drill Make and Model: CME-55 Drilling Method: Solid Stem Auger (SSA) Bit Type: Cutting Head Casing Description: N/A Hammer Weight (lbs)/Fall (in): 140/30 Sampler Type(s): Modified California Sampler Diameter(s): 2.0-inches					LITHOS ENGINEERING Boring Location: 37.270719, -108.510644 Boring Elevation: 8,127.0-feet* Notes: Wetherill Alignment *Elevation approximate																																																																																																																																																		
Sampling Data <table><tr><td>Depth (ft)</td><td>Elevation (ft)</td><td>Sample Identification</td><td>Blow Count/6 in</td><td>Recovery (in) / RQD (%)</td><td>Drilling Rate (min./ft.)</td><td>Geologic Graphic</td></tr><tr><td>0</td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>8125</td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>5</td><td></td><td>13 15</td><td>6</td><td></td><td></td><td></td></tr><tr><td>8120</td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>10</td><td></td><td>50/6"</td><td>6</td><td></td><td></td><td></td></tr><tr><td>8115</td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>15</td><td></td><td>50/2"</td><td>2</td><td></td><td></td><td></td></tr><tr><td>8110</td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>20</td><td></td><td>50/2"</td><td>2</td><td></td><td></td><td></td></tr><tr><td>8105</td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>25</td><td></td><td>50/2"</td><td>0</td><td></td><td></td><td></td></tr><tr><td>8100</td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>30</td><td></td><td>50/2"</td><td>0</td><td></td><td></td><td></td></tr><tr><td>8095</td><td></td><td></td><td></td><td></td><td></td><td></td></tr></table>					Depth (ft)	Elevation (ft)	Sample Identification	Blow Count/6 in	Recovery (in) / RQD (%)	Drilling Rate (min./ft.)	Geologic Graphic	0							8125							5		13 15	6				8120							10		50/6"	6				8115							15		50/2"	2				8110							20		50/2"	2				8105							25		50/2"	0				8100							30		50/2"	0				8095							Visual Material Description Soil: -GEOLOGIC INTERPRETATION- USCS Classification (group symbol), particle sizes, density or consistency, color, moisture, odor, other descriptions Rock: -GEOLOGIC INTERPRETATION- Bedrock Classification, hardness, weather, color, texture, joint size, other descriptions					Laboratory Testing Results <table><tr><td colspan="3">In-Situ States</td><td colspan="5">INDEX DATA</td><td colspan="2">Strength & Compressibility</td></tr><tr><td>Moisture Content (%)</td><td>Dry Unit Weight (pcf)</td><td>Water Soluble Sulfates (%)</td><td>Gravel Content (%)</td><td>Sand Content (%)</td><td>Fines Content (%)</td><td>Liquid Limit (%)</td><td>Plasticity Index (%)</td><td>UCS (psf)</td><td>Swell Pressure (psf)</td><td>Swell Percent (%)</td></tr><tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr></table>										In-Situ States			INDEX DATA					Strength & Compressibility		Moisture Content (%)	Dry Unit Weight (pcf)	Water Soluble Sulfates (%)	Gravel Content (%)	Sand Content (%)	Fines Content (%)	Liquid Limit (%)	Plasticity Index (%)	UCS (psf)	Swell Pressure (psf)	Swell Percent (%)											
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PAVEMENT SECTION Asphalt: 5.0-inches Base: 4.0-inches CLIFFHOUSE SANDSTONE Interbedded Claystone (CS) and Siltstone (SS), very soft (CS) to soft (SS), moderately weathered, olive brown, mostly silt, some clay, iron oxidation, calcite. Siltstone, very soft, slightly weathered, gray, trace fine sand, iron oxidation, calcite. As above except soft, moderately weathered, olive yellow, no calcite. As above except soft, moderately weathered, olive yellow, calcite. No recovery. No recovery. END OF EXPLORATION					Groundwater Depth / Monitoring Well Configuration																																																																																																																																																							
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BORING: LE-OC-17 Project Name: Mesa Verde Waterlines Project Number: 21152 Client's Name: HDR Owner's Name: Mesa Verde National Park Drilling Subcontractor: Terracon Lithos Representative: K. Stevenson Date(s) of Drilling: 11/03/21						Drilling and Sampling Methods Drill Make and Model: CME-55 Drilling Method: Solid Stem Auger (SSA) Bit Type: Cutting Head Casing Description: N/A Hammer Weight (lbs)/Fall (in): 140/30 Sampler Type(s): Modified California Sampler Diameter(s): 2.0-inches						LITHOSENGINEERING Boring Location: 37.266072, -108.513217 Boring Elevation: 8,205.0-feet* Notes: Wetherill Alignment *Elevation approximate												
Sampling Data						Visual Material Description						Laboratory Testing Results												
												In-Situ States		INDEX DATA			Strength & Compressibility							
Depth (ft)	Elevation (ft)	Sample Identification	Blow Count/6 in	Recovery (in) / RQD (%)	Drilling Rate (min./ft.)	Geologic Graphic	Soil: -GEOLOGIC INTERPRETATION- USCS Classification (group symbol), particle sizes, density or consistency, color, moisture, odor, other descriptions Rock: -GEOLOGIC INTERPRETATION- Bedrock Classification, hardness, weather, color, texture, joint size, other descriptions						Groundwater Depth / Monitoring Well Configuration	Moisture Content (%)	Dry Unit Weight (pcf)	Water Soluble Sulfates (%)	Gravel Content (%)	Sand Content (%)	Fines Content (%)	Liquid Limit (%)	Plasticity Index (%)	UCS (psf)	Swell Pressure (psf)	Swell Percent (%)
0	8205						PAVEMENT SECTION Asphalt: 6.0-inches Base: 6.0-inches																	
5	8200	19 20	0				CLIFFHOUSE SANDSTONE Siltstone, soft, moderately weathered, olive yellow, few fine sand, iron oxidation, calcite, dry. No recovery.																	
10	8195	12 12	12				As above except very soft, completely weathered, olive, iron oxidation, calcite, trace roots.																	
15	8190	17 34	12				As above except few clay.																	
20	8185						END OF EXPLORATION																	
25	8180																							
30	8175																							
General Notes: 1) Soil classificaitons are in general accordance with ASTM D2487 2) The maximum particle size identified in the material description is dependent on sampler dimensions. 3) Additional information is provided on the Boring Log Key. 4) Groundwater measurements for monitoring wells present water levels at the time of drilling, highest level, and lowest level. Refer to the respective report for a complete history of groundwater values.												Groundwater Data: Date: 11/03/21 Elapsed Time: 0-days Depth to Groundwater: DNE												

BORING: LE-BC-18 Project Name: Mesa Verde Waterlines Project Number: 21152 Client's Name: HDR Owner's Name: Mesa Verde National Park Drilling Subcontractor: Terracon Lithos Representative: K. Stevenson Date(s) of Drilling: 11/03/21					Drilling and Sampling Methods Drill Make and Model: CME-55 Drilling Method: Solid Stem Auger (SSA) Bit Type: Cutting Head Casing Description: N/A Hammer Weight (lbs)/Fall (in): 140/30 Sampler Type(s): Modified California Sampler Diameter(s): 2.0-inches					LITHOS ENGINEERING Boring Location: 37.268731, -108.5142 Boring Elevation: 8,293.0-feet* Notes: Wetherill Alignment *Elevation approximate																																																																																																					
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BORING: LE-OC-19 Project Name: Mesa Verde Waterlines Project Number: 21152 Client's Name: HDR Owner's Name: Mesa Verde National Park Drilling Subcontractor: Terracon Lithos Representative: K. Stevenson Date(s) of Drilling: 11/03/21					Drilling and Sampling Methods Drill Make and Model: CME-55 Drilling Method: Solid Stem Auger (SSA) Bit Type: Cutting Head Casing Description: N/A Hammer Weight (lbs)/Fall (in): 140/30 Sampler Type(s): Modified California Sampler Diameter(s): 2.0-inches					LITHOSENGINEERING Boring Location: 37.267775, -108.517389 Boring Elevation: 8,186.0-feet* Notes: Wetherill Alignment *Elevation approximate						
Sampling Data					Visual Material Description					Laboratory Testing Results						
Depth (ft)	Elevation (ft)	Sample Identification	Blow Count/6 in	Recovery (in) / RQD (%)	Drilling Rate (min./ft.)	Geologic Graphic	Soil:		Groundwater Depth / Monitoring Well Configuration	In-Situ States		INDEX DATA			Strength & Compressibility	
							-GEOLOGIC INTERPRETATION-			Moisture Content (%)	Dry Unit Weight (pcf)	Water Soluble Sulfates (%)	Gravel Content (%)	Sand Content (%)	Fines Content (%)	Liquid Limit (%)
0	8185						PAVEMENT SECTION									
							Asphalt: 4.0-inches									
							Base: 7.0-inches									
							CLIFFHOUSE SANDSTONE									
							Silty Sandstone, soft, moderately weathered, pale olive, mostly fine sand, some silt, iron oxidation, calcite.									
5	8180	12 14	12				As above except highly weathered, more calcite.									
							As above.									
10	8175	50/5"	3				END OF EXPLORATION									
15	8170	25 33	12													
20	8165															
25	8160															
30	8155															

General Notes:

1) Soil classificaitons are in general accordance with ASTM D2487

2) The maximum particle size identified in the material description is dependent on sampler dimensions.

3) Additional information is provided on the Boring Log Key.

4) Groundwater measurements for monitoring wells present water levels at the time of drilling, highest level, and lowest level. Refer to the respective report for a complete history of groundwater values.

Groundwater Data:

Date: 11/03/21

Elapsed Time: 0-days

Depth to Groundwater: DNE

BORING: LE-OC-20 Project Name: Mesa Verde Waterlines Project Number: 21152 Client's Name: HDR Owner's Name: Mesa Verde National Park Drilling Subcontractor: Terracon Lithos Representative: K. Stevenson Date(s) of Drilling: 11/03/21					Drilling and Sampling Methods Drill Make and Model: CME-55 Drilling Method: Solid Stem Auger (SSA) Bit Type: Cutting Head Casing Description: N/A Hammer Weight (lbs)/Fall (in): 140/30 Sampler Type(s): Modified California Sampler Diameter(s): 2.0-inches					LITHOSENGINEERING Boring Location: 37.263633, -108.521247 Boring Elevation: 8,168.0-feet* Notes: Wetherill Alignment *Elevation approximate																																																																																										
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BORING: LE-OC-22 Project Name: Mesa Verde Waterlines Project Number: 21152 Client's Name: HDR Owner's Name: Mesa Verde National Park Drilling Subcontractor: Terracon Lithos Representative: K. Stevenson Date(s) of Drilling: 11/02/21					Drilling and Sampling Methods Drill Make and Model: CME-55 Drilling Method: Solid Stem Auger (SSA) Bit Type: Cutting Head Casing Description: N/A Hammer Weight (lbs)/Fall (in): 140/30 Sampler Type(s): Modified California Sampler Diameter(s): 2.0-inches					LITHOSENGINEERING Boring Location: 37.259936, -108.529767 Boring Elevation: 7,992.0-feet* Notes: Wetherill Alignment *Elevation approximate																																																																																																																																			
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BORING: LE-OC-24 Project Name: Mesa Verde Waterlines Project Number: 21152 Client's Name: HDR Owner's Name: Mesa Verde National Park Drilling Subcontractor: Terracon Lithos Representative: K. Stevenson Date(s) of Drilling: 11/02/21					Drilling and Sampling Methods Drill Make and Model: CME-55 Drilling Method: Solid Stem Auger (SSA) Bit Type: Cutting Head Casing Description: N/A Hammer Weight (lbs)/Fall (in): 140/30 Sampler Type(s): Modified California Sampler Diameter(s): 2.0-inches					LITHOSENGINEERING Boring Location: 37.262153, -108.536003 Boring Elevation: 8,071.0-feet* Notes: Wetherill Alignment *Elevation approximate																																																																																										
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BORING: LE-OC-25 Project Name: Mesa Verde Waterlines Project Number: 21152 Client's Name: HDR Owner's Name: Mesa Verde National Park Drilling Subcontractor: Terracon Lithos Representative: K. Stevenson Date(s) of Drilling: 11/02/21					Drilling and Sampling Methods Drill Make and Model: CME-55 Drilling Method: Solid Stem Auger (SSA) Bit Type: Cutting Head Casing Description: N/A Hammer Weight (lbs)/Fall (in): 140/30 Sampler Type(s): Modified California Sampler Diameter(s): 2.0-inches					LITHOSENGINEERING Boring Location: 37.263833, -108.53825 Boring Elevation: 8,176.0-feet* Notes: Wetherill Alignment *Elevation approximate																																																																																																																																																																															
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General Notes:

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3) Additional information is provided on the Boring Log Key.

4) Groundwater measurements for monitoring wells present water levels at the time of drilling, highest level, and lowest level. Refer to the respective report for a complete history of groundwater values.

Groundwater Data:	
Date:	Elapsed Time:
11/02/21	0-days
	DNE

BORING: LE-OC-26 Project Name: Mesa Verde Waterlines Project Number: 21152 Client's Name: HDR Owner's Name: Mesa Verde National Park Drilling Subcontractor: Terracon Lithos Representative: K. Stevenson Date(s) of Drilling: 11/02/21					Drilling and Sampling Methods Drill Make and Model: CME-55 Drilling Method: Solid Stem Auger (SSA) Bit Type: Cutting Head Casing Description: N/A Hammer Weight (lbs)/Fall (in): 140/30 Sampler Type(s): Modified California Sampler Diameter(s): 2.0-inches					LITHOSENGINEERING Boring Location: 37.262622, -108.540983 Boring Elevation: 8,069.0-feet* Notes: Wetherill Alignment *Elevation approximate																																																																																										
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BORING: LE-OC-27 Project Name: Mesa Verde Waterlines Project Number: 21152 Client's Name: HDR Owner's Name: Mesa Verde National Park Drilling Subcontractor: Terracon Lithos Representative: K. Stevenson Date(s) of Drilling: 11/02/21					Drilling and Sampling Methods Drill Make and Model: CME-55 Drilling Method: Solid Stem Auger (SSA) Bit Type: Cutting Head Casing Description: N/A Hammer Weight (lbs)/Fall (in): 140/30 Sampler Type(s): Modified California Sampler Diameter(s): 2.0-inches					LITHOSENGINEERING Boring Location: 37.261119, -108.545808 Boring Elevation: 8,041.0-feet* Notes: Wetherill Alignment *Elevation approximate																																																																																															
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BORING: LE-OC-28 Project Name: Mesa Verde Waterlines Project Number: 21152 Client's Name: HDR Owner's Name: Mesa Verde National Park Drilling Subcontractor: Terracon Lithos Representative: K. Stevenson Date(s) of Drilling: 11/02/21					Drilling and Sampling Methods Drill Make and Model: CME-55 Drilling Method: Solid Stem Auger (SSA) Bit Type: Cutting Head Casing Description: N/A Hammer Weight (lbs)/Fall (in): 140/30 Sampler Type(s): Modified California Sampler Diameter(s): 2.0-inches					LITHOSENGINEERING Boring Location: 37.266183, -108.547303 Boring Elevation: 8,096.0-feet* Notes: Wetherill Alignment *Elevation approximate																																																																																															
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BORING: LE-OC-29 Project Name: Mesa Verde Waterlines Project Number: 21152 Client's Name: HDR Owner's Name: Mesa Verde National Park Drilling Subcontractor: Terracon Lithos Representative: K. Stevenson Date(s) of Drilling: 11/02/21					Drilling and Sampling Methods Drill Make and Model: CME-55 Drilling Method: Solid Stem Auger (SSA) Bit Type: Cutting Head Casing Description: N/A Hammer Weight (lbs)/Fall (in): 140/30 Sampler Type(s): Modified California Sampler Diameter(s): 2.0-inches					LITHOSENGINEERING Boring Location: 37.263047, -108.549858 Boring Elevation: 8,237.0-feet* Notes: Wetherill Alignment *Elevation approximate																																																																																																																																																		
Sampling Data <table><tr><td>Depth (ft)</td><td>Elevation (ft)</td><td>Sample Identification</td><td>Blow Count/6 in</td><td>Recovery (in) / RQD (%)</td><td>Drilling Rate (min./ft.)</td><td>Geologic Graphic</td></tr><tr><td>0</td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>8235</td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>5</td><td></td><td>11 13</td><td>12</td><td></td><td></td><td></td></tr><tr><td>8230</td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>10</td><td></td><td>17 34</td><td>12</td><td></td><td></td><td></td></tr><tr><td>8225</td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>15</td><td></td><td>15 14</td><td>12</td><td></td><td></td><td></td></tr><tr><td>8220</td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>20</td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>8215</td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>25</td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>8210</td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>30</td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>8205</td><td></td><td></td><td></td><td></td><td></td><td></td></tr></table>					Depth (ft)	Elevation (ft)	Sample Identification	Blow Count/6 in	Recovery (in) / RQD (%)	Drilling Rate (min./ft.)	Geologic Graphic	0							8235							5		11 13	12				8230							10		17 34	12				8225							15		15 14	12				8220							20							8215							25							8210							30							8205							Visual Material Description Soil: -GEOLOGIC INTERPRETATION- USCS Classification (group symbol), particle sizes, density or consistency, color, moisture, odor, other descriptions Rock: -GEOLOGIC INTERPRETATION- Bedrock Classification, hardness, weather, color, texture, joint size, other descriptions					Groundwater Depth / Monitoring Well Configuration					Laboratory Testing Results <table><tr><td colspan="3">In-Situ States</td><td colspan="4">INDEX DATA</td><td colspan="3">Strength & Compressibility</td></tr><tr><td>Moisture Content (%)</td><td>Dry Unit Weight (pcf)</td><td>Water Soluble Sulfates (%)</td><td>Gravel Content (%)</td><td>Sand Content (%)</td><td>Fines Content (%)</td><td>Liquid Limit (%)</td><td>Plasticity Index (%)</td><td>UCS (psf)</td><td>Swell Pressure (psf)</td><td>Swell Percent (%)</td></tr><tr><td>6</td><td>83</td><td>0.002</td><td></td><td>44</td><td>29</td><td>16</td><td></td><td></td><td></td><td></td></tr></table>					In-Situ States			INDEX DATA				Strength & Compressibility			Moisture Content (%)	Dry Unit Weight (pcf)	Water Soluble Sulfates (%)	Gravel Content (%)	Sand Content (%)	Fines Content (%)	Liquid Limit (%)	Plasticity Index (%)	UCS (psf)	Swell Pressure (psf)	Swell Percent (%)	6	83	0.002		44	29	16				
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BORING: LE-OC-30 Project Name: Mesa Verde Waterlines Project Number: 21152 Client's Name: HDR Owner's Name: Mesa Verde National Park Drilling Subcontractor: Terracon Lithos Representative: K. Stevenson Date(s) of Drilling: 11/02/21					Drilling and Sampling Methods Drill Make and Model: CME-55 Drilling Method: Solid Stem Auger (SSA) Bit Type: Cutting Head Casing Description: N/A Hammer Weight (lbs)/Fall (in): 140/30 Sampler Type(s): Modified California Sampler Diameter(s): 2.0-inches					LITHOSENGINEERING Boring Location: 37.257803, -108.550514 Boring Elevation: 8,156.0-feet* Notes: Wetherill Alignment *Elevation approximate																																																																																																											
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BORING: LE-OC-31 Project Name: Mesa Verde Waterlines Project Number: 21152 Client's Name: HDR Owner's Name: Mesa Verde National Park Drilling Subcontractor: Terracon Lithos Representative: K. Stevenson Date(s) of Drilling: 11/02/21					Drilling and Sampling Methods Drill Make and Model: CME-55 Drilling Method: Solid Stem Auger (SSA) Bit Type: Cutting Head Casing Description: N/A Hammer Weight (lbs)/Fall (in): 140/30 Sampler Type(s): Modified California Sampler Diameter(s): 2.0-inches					LITHOSENGINEERING Boring Location: 37.252697, -108.552781 Boring Elevation: 8,014.0-feet* Notes: Wetherill Alignment *Elevation approximate																																																																																										
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BORING: LE-OC-32 Project Name: Mesa Verde Waterlines Project Number: 21152 Client's Name: HDR Owner's Name: Mesa Verde National Park Drilling Subcontractor: Terracon Lithos Representative: K. Stevenson Date(s) of Drilling: 11/02/21						Drilling and Sampling Methods Drill Make and Model: CME-55 Drilling Method: Solid Stem Auger (SSA) Bit Type: Cutting Head Casing Description: N/A Hammer Weight (lbs)/Fall (in): 140/30 Sampler Type(s): Modified California Sampler Diameter(s): 2.0-inches						LITHOS ENGINEERING Boring Location: 37.247303, -108.553636 Boring Elevation: 7,935.0-feet* Notes: Wetherill Alignment *Elevation approximate										
Sampling Data						Visual Material Description						Laboratory Testing Results										
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							Moisture Content (%)	Dry Unit Weight (pcf)	Water Soluble Sulfates (%)	Gravel Content (%)	Sand Content (%)	Fines Content (%)		Liquid Limit (%)	Plasticity Index (%)	UCS (psf)	Swell Pressure (psf)	Swell Percent (%)				
0	7935						PAVEMENT SECTION Asphalt: 3.0-inches Base: 7.0-inches															
							CLIFFHOUSE SANDSTONE															
5	7930	13 50	10				Silty Sandstone, very soft, completely weathered, olive yellow to gray, mostly fine sand, little silt, iron oxidation, calcite, moist.															
10	7925	50/3"	0				No recovery.															
15	7920	50/3"	0				No recovery.															
							END OF EXPLORATION															
20	7915																					
25	7910																					
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BORING: LE-OC-33 Project Name: Mesa Verde Waterlines Project Number: 21152 Client's Name: HDR Owner's Name: Mesa Verde National Park Drilling Subcontractor: Terracon Lithos Representative: K. Stevenson Date(s) of Drilling: 11/02/21					Drilling and Sampling Methods Drill Make and Model: CME-55 Drilling Method: Solid Stem Auger (SSA) Bit Type: Cutting Head Casing Description: N/A Hammer Weight (lbs)/Fall (in): 140/30 Sampler Type(s): Modified California Sampler Diameter(s): 2.0-inches					LITHOS ENGINEERING Boring Location: 37.241953, -108.554125 Boring Elevation: 7,884.0-feet* Notes: Wetherill Alignment *Elevation approximate																																																																																															
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PAVEMENT SECTION Asphalt: 4.0-inches Base: 3.0-inches CLIFFHOUSE SANDSTONE Sandstone, very soft, completely weathered, olive yellow, mostly fine sand, little silt, iron oxidation, calcite. No recovery. No recovery. END OF EXPLORATION					0.6 ft. 15.0 ft.																																																																																																				
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BORING: LE-OC-34 Project Name: Mesa Verde Waterlines Project Number: 21152 Client's Name: HDR Owner's Name: Mesa Verde National Park Drilling Subcontractor: Terracon Lithos Representative: K. Stevenson Date(s) of Drilling: 11/01/21					Drilling and Sampling Methods Drill Make and Model: CME-55 Drilling Method: Solid Stem Auger (SSA) Bit Type: Cutting Head Casing Description: N/A Hammer Weight (lbs)/Fall (in): 140/30 Sampler Type(s): Modified California Sampler Diameter(s): 2.0-inches					LITHOSENGINEERING Boring Location: 37.237056, -108.551817 Boring Elevation: 7,713.0-feet* Notes: Wetherill Alignment *Elevation approximate											
Sampling Data					Visual Material Description					Laboratory Testing Results											
Depth (ft)	Elevation (ft)	Sample Identification	Blow Count/6 in	Recovery (in) / RQD (%)	Drilling Rate (min./ft.)	Geologic Graphic	Soil: -GEOLOGIC INTERPRETATION- USCS Classification (group symbol), particle sizes, density or consistency, color, moisture, odor, other descriptions					Groundwater Depth / Monitoring Well Configuration	In-Situ States		INDEX DATA			Strength & Compressibility			
							Rock: -GEOLOGIC INTERPRETATION- Bedrock Classification, hardness, weather, color, texture, joint size, other descriptions						Moisture Content (%)	Dry Unit Weight (pcf)	Water Soluble Sulfates (%)	Gravel Content (%)	Sand Content (%)	Fines Content (%)	Liquid Limit (%)	Plasticity Index (%)	UCS (psf)
0							PAVEMENT SECTION Asphalt: 6.0-inches Base: 4.0-inches														
							CLIFFHOUSE SANDSTONE														
5	7710	27 33		12			Sandstone, very soft, completely weathered, olive yellow to pale olive, mostly fine sand, few silt, iron oxidation, calcite, roots, bedding plane organic deposits.														
							As above except olive gray, no organic bedding, no roots.														
10	7705	50/6"		6																	
							No recovery.														
15	7700	50/1"		0			END OF EXPLORATION														
20	7695																				
25	7690																				
30	7685																				

General Notes:

1) Soil classificaitons are in general accordance with ASTM D2487

2) The maximum particle size identified in the material description is dependent on sampler dimensions.

3) Additional information is provided on the Boring Log Key.

4) Groundwater measurements for monitoring wells present water levels at the time of drilling, highest level, and lowest level. Refer to the respective report for a complete history of groundwater values.

Date:		Groundwater Data:	
11/01/21		Elapsed Time: 0-days	
		Depth to Groundwater: DNE	

BORING: LE-OC-35 Project Name: Mesa Verde Waterlines Project Number: 21152 Client's Name: HDR Owner's Name: Mesa Verde National Park Drilling Subcontractor: Terracon Lithos Representative: K. Stevenson Date(s) of Drilling: 11/01/21						Drilling and Sampling Methods Drill Make and Model: CME-55 Drilling Method: Solid Stem Auger (SSA) Bit Type: Cutting Head Casing Description: N/A Hammer Weight (lbs)/Fall (in): 140/30 Sampler Type(s): Modified California Sampler Diameter(s): 2.0-inches						LITHOS ENGINEERING Boring Location: 37.231494, -108.551317 Boring Elevation: 7,640.0-feet* Notes: Wetherill Alignment *Elevation approximate													
Sampling Data						Visual Material Description						Laboratory Testing Results													
Depth (ft)	Elevation (ft)	Sample Identification	Blow Count/6 in	Recovery (in) / RQD (%)	Drilling Rate (min./ft.)	Geologic Graphic	Soil: -GEOLOGIC INTERPRETATION- USCS Classification (group symbol), particle sizes, density or consistency, color, moisture, odor, other descriptions						Groundwater Depth / Monitoring Well Configuration	In-Situ States		INDEX DATA				Strength & Compressibility					
							Rock: -GEOLOGIC INTERPRETATION- Bedrock Classification, hardness, weather, color, texture, joint size, other descriptions							Moisture Content (%)	Dry Unit Weight (pcf)	Water Soluble Sulfates (%)	Gravel Content (%)	Sand Content (%)	Fines Content (%)	Liquid Limit (%)	Plasticity Index (%)	UCS (psf)	Swell Pressure (psf)	Swell Percent (%)	
0	7640						PAVEMENT SECTION Asphalt: 6.0-inches Base: 7.0-inches																		
							CLIFFHOUSE SANDSTONE																		
5	7635	50/6"	6				Sandstone, very soft, highly weathered, yellowish brown, mostly fine sand, few silt, iron oxidation, mica grains.						4	79											
10	7630	50/1"	0				No recovery.																		
15	7625	50/2"	0				No recovery.																		
							END OF EXPLORATION																		
20	7620																								
25	7615																								
30	7610																								
General Notes: 1) Soil classificaitons are in general accordance with ASTM D2487 2) The maximum particle size identified in the material description is dependent on sampler dimensions. 3) Additional information is provided on the Boring Log Key. 4) Groundwater measurements for monitoring wells present water levels at the time of drilling, highest level, and lowest level. Refer to the respective report for a complete history of groundwater values.												Groundwater Data: Date: 11/01/21 Elapsed Time: 0-days Depth to Groundwater: DNE													

BORING: LE-OC-36 Project Name: Mesa Verde Waterlines Project Number: 21152 Client's Name: HDR Owner's Name: Mesa Verde National Park Drilling Subcontractor: Terracon Lithos Representative: K. Stevenson Date(s) of Drilling: 11/01/21					Drilling and Sampling Methods Drill Make and Model: CME-55 Drilling Method: Solid Stem Auger (SSA) Bit Type: Cutting Head Casing Description: N/A Hammer Weight (lbs)/Fall (in): 140/30 Sampler Type(s): Modified California Sampler Diameter(s): 2.0-inches					LITHOSENGINEERING Boring Location: 37.226369, -108.548619 Boring Elevation: 7,558.0-feet* Notes: Wetherill Alignment *Elevation approximate																																																																																											
Sampling Data <table><tr><td>Depth (ft)</td><td>Elevation (ft)</td><td>Sample Identification</td><td>Blow Count/6 in</td><td>Recovery (in) / RQD (%)</td><td>Drilling Rate (min./ft.)</td><td>Geologic Graphic</td></tr><tr><td>0</td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>5</td><td></td><td>21 30</td><td>12</td><td></td><td></td><td></td></tr><tr><td>10</td><td></td><td>50/3"</td><td>0</td><td></td><td></td><td></td></tr><tr><td>15</td><td></td><td>50/2"</td><td>0</td><td></td><td></td><td></td></tr><tr><td>20</td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>25</td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>30</td><td></td><td></td><td></td><td></td><td></td><td></td></tr></table>					Depth (ft)	Elevation (ft)	Sample Identification	Blow Count/6 in	Recovery (in) / RQD (%)	Drilling Rate (min./ft.)	Geologic Graphic	0							5		21 30	12				10		50/3"	0				15		50/2"	0				20							25							30							Visual Material Description Soil: -GEOLOGIC INTERPRETATION- USCS Classification (group symbol), particle sizes, density or consistency, color, moisture, odor, other descriptions Rock: -GEOLOGIC INTERPRETATION- Bedrock Classification, hardness, weather, color, texture, joint size, other descriptions					Laboratory Testing Results <table><tr><td colspan="3">In-Situ States</td><td colspan="4">INDEX DATA</td><td colspan="2">Strength & Compressibility</td></tr><tr><td>Moisture Content (%)</td><td>Dry Unit Weight (pcf)</td><td>Water Soluble Sulfates (%)</td><td>Gravel Content (%)</td><td>Sand Content (%)</td><td>Fines Content (%)</td><td>Liquid Limit (%)</td><td>Plasticity Index (%)</td><td>UCS (psf)</td><td>Swell Pressure (psf)</td><td>Swell Percent (%)</td></tr><tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr></table>					In-Situ States			INDEX DATA				Strength & Compressibility		Moisture Content (%)	Dry Unit Weight (pcf)	Water Soluble Sulfates (%)	Gravel Content (%)	Sand Content (%)	Fines Content (%)	Liquid Limit (%)	Plasticity Index (%)	UCS (psf)	Swell Pressure (psf)	Swell Percent (%)											
Depth (ft)	Elevation (ft)	Sample Identification	Blow Count/6 in	Recovery (in) / RQD (%)	Drilling Rate (min./ft.)	Geologic Graphic																																																																																															
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PAVEMENT SECTION Asphalt: 4.0-inches Base: 4.0-inches CLIFFHOUSE SANDSTONE Sandstone, soft, highly weathered, olive yellow, mostly fine sand, few silt, iron oxidation. No recovery. No recovery. END OF EXPLORATION					Groundwater Depth / Monitoring Well Configuration																																																																																																

General Notes:

1) Soil classificaitons are in general accordance with ASTM D2487

2) The maximum particle size identified in the material description is dependent on sampler dimensions.

3) Additional information is provided on the Boring Log Key.

4) Groundwater measurements for monitoring wells present water levels at the time of drilling, highest level, and lowest level. Refer to the respective report for a complete history of groundwater values.

Date:	Groundwater Data:
11/01/21	Elapsed Time: 0-days
	Depth to Groundwater: DNE

BORING: LE-OC-37 Project Name: Mesa Verde Waterlines Project Number: 21152 Client's Name: HDR Owner's Name: Mesa Verde National Park Drilling Subcontractor: Terracon Lithos Representative: K. Stevenson Date(s) of Drilling: 11/01/21					Drilling and Sampling Methods Drill Make and Model: CME-55 Drilling Method: Solid Stem Auger (SSA) Bit Type: Cutting Head Casing Description: N/A Hammer Weight (lbs)/Fall (in): 140/30 Sampler Type(s): Modified California Sampler Diameter(s): 2.0-inches					LITHOSENGINEERING Boring Location: 37.221386, -108.546353 Boring Elevation: 7,505.0-feet* Notes: Wetherill Alignment *Elevation approximate																																																																															
Sampling Data <table><tr><td>Depth (ft)</td><td>Elevation (ft)</td><td>Sample Identification</td><td>Blow Count/6 in</td><td>Recovery (in) / RQD (%)</td><td>Drilling Rate (min./ft.)</td><td>Geologic Graphic</td></tr><tr><td>0</td><td>7505</td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>5</td><td>7500</td><td>18 16</td><td>11</td><td></td><td></td><td></td></tr><tr><td>10</td><td>7495</td><td>50/3"</td><td>3</td><td></td><td></td><td></td></tr><tr><td>15</td><td>7490</td><td>50/1"</td><td>1</td><td></td><td></td><td></td></tr><tr><td>20</td><td>7485</td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>25</td><td>7480</td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>30</td><td>7475</td><td></td><td></td><td></td><td></td><td></td></tr></table>					Depth (ft)	Elevation (ft)	Sample Identification	Blow Count/6 in	Recovery (in) / RQD (%)	Drilling Rate (min./ft.)	Geologic Graphic	0	7505						5	7500	18 16	11				10	7495	50/3"	3				15	7490	50/1"	1				20	7485						25	7480						30	7475						Visual Material Description Soil: -GEOLOGIC INTERPRETATION- USCS Classification (group symbol), particle sizes, density or consistency, color, moisture, odor, other descriptions Rock: -GEOLOGIC INTERPRETATION- Bedrock Classification, hardness, weather, color, texture, joint size, other descriptions PAVEMENT SECTION Asphalt: 4.0-inches Base: 7.0-inches CLIFFHOUSE SANDSTONE Sandstone, soft, completely weathered, olive yellow to reddish brown, mostly fine sand, few silt, iron oxidation, calcite, moist. 8.5' - Harder drilling. As above. As above. END OF EXPLORATION					Groundwater Depth / Monitoring Well Configuration <table><tr><td colspan="2">In-Situ States</td><td colspan="4">INDEX DATA</td><td colspan="2">Strength & Compressibility</td></tr><tr><td>Moisture Content (%)</td><td>Dry Unit Weight (pcf)</td><td>Water Soluble Sulfates (%)</td><td>Gravel Content (%)</td><td>Sand Content (%)</td><td>Fines Content (%)</td><td>Liquid Limit (%)</td><td>Plasticity Index (%)</td><td>UCS (psf)</td><td>Swell Pressure (psf)</td><td>Swell Percent (%)</td></tr></table>					In-Situ States		INDEX DATA				Strength & Compressibility		Moisture Content (%)	Dry Unit Weight (pcf)	Water Soluble Sulfates (%)	Gravel Content (%)	Sand Content (%)	Fines Content (%)	Liquid Limit (%)	Plasticity Index (%)	UCS (psf)	Swell Pressure (psf)	Swell Percent (%)
Depth (ft)	Elevation (ft)	Sample Identification	Blow Count/6 in	Recovery (in) / RQD (%)	Drilling Rate (min./ft.)	Geologic Graphic																																																																																			
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General Notes: 1) Soil classificaitons are in general accordance with ASTM D2487 2) The maximum particle size identified in the material description is dependent on sampler dimensions. 3) Additional information is provided on the Boring Log Key. 4) Groundwater measurements for monitoring wells present water levels at the time of drilling, highest level, and lowest level. Refer to the respective report for a complete history of groundwater values.					Groundwater Data: Date: 11/01/21 Elapsed Time: 0-days Depth to Groundwater: DNE																																																																																				

BORING: LE-OC-38 Project Name: Mesa Verde Waterlines Project Number: 21152 Client's Name: HDR Owner's Name: Mesa Verde National Park Drilling Subcontractor: Terracon Lithos Representative: K. Stevenson Date(s) of Drilling: 11/01/21					Drilling and Sampling Methods Drill Make and Model: CME-55 Drilling Method: Solid Stem Auger (SSA) Bit Type: Cutting Head Casing Description: N/A Hammer Weight (lbs)/Fall (in): 140/30 Sampler Type(s): Modified California Sampler Diameter(s): 2.0-inches					LITHOSENGINEERING Boring Location: 37.216394, -108.544689 Boring Elevation: 7,421.0-feet* Notes: Wetherill Alignment *Elevation approximate						
Sampling Data					Visual Material Description					Laboratory Testing Results						
Depth (ft)	Elevation (ft)	Sample Identification	Blow Count/6 in	Recovery (in) / RQD (%)	Drilling Rate (min./ft.)	Geologic Graphic	Soil:		Groundwater Depth / Monitoring Well Configuration	In-Situ States		INDEX DATA			Strength & Compressibility	
							-GEOLOGIC INTERPRETATION-			Moisture Content (%)	Dry Unit Weight (pcf)	Water Soluble Sulfates (%)	Gravel Content (%)	Sand Content (%)	Fines Content (%)	Liquid Limit (%)
0	7420						PAVEMENT SECTION									
							Asphalt: 6.0-inches									
							Base: 6.0-inches									
							CLIFFHOUSE SANDSTONE									
							Sandstone, medium, highly weathered, reddish brown, mostly fine sand, few silt, iron oxidation, calcite.									
5	7415	5 25	12				No recovery.									
10	7410	50/6"	0													
15	7405	50/1"	1				As above except olive yellow.									
							END OF EXPLORATION									
20	7400															
25	7395															
30	7390															

General Notes:

1) Soil classificaitons are in general accordance with ASTM D2487

2) The maximum particle size identified in the material description is dependent on sampler dimensions.

3) Additional information is provided on the Boring Log Key.

4) Groundwater measurements for monitoring wells present water levels at the time of drilling, highest level, and lowest level. Refer to the respective report for a complete history of groundwater values.

Groundwater Data:

Date: 11/01/21

Elapsed Time: 0-days

Depth to Groundwater: DNE

BORING: LE-BC-39 Project Name: Mesa Verde Waterlines Project Number: 21152 Client's Name: HDR Owner's Name: Mesa Verde National Park Drilling Subcontractor: Terracon Lithos Representative: K. Stevenson Date(s) of Drilling: 11/01/21					Drilling and Sampling Methods Drill Make and Model: CME-55 Drilling Method: Solid Stem Auger (SSA) Bit Type: Cutting Head Casing Description: N/A Hammer Weight (lbs)/Fall (in): 140/30 Sampler Type(s): Modified California Sampler Diameter(s): 2.0-inches					LITHOS ENGINEERING Boring Location: 37.2113, -108.543781 Boring Elevation: 7,234.0-feet* Notes: Wetherill Alignment *Elevation approximate																																																																																															
Sampling Data <table><tr><td>Depth (ft)</td><td>Elevation (ft)</td><td>Sample Identification</td><td>Blow Count/6 in</td><td>Recovery (in) / RQD (%)</td><td>Drilling Rate (min./ft.)</td><td>Geologic Graphic</td></tr><tr><td>0</td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>5</td><td>7230</td><td>9 10</td><td>12</td><td></td><td></td><td></td></tr><tr><td>10</td><td>7225</td><td>9 9</td><td>12</td><td></td><td></td><td></td></tr><tr><td>15</td><td>7220</td><td>50/5"</td><td>0</td><td></td><td></td><td></td></tr><tr><td>20</td><td>7215</td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>25</td><td>7210</td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>30</td><td>7205</td><td></td><td></td><td></td><td></td><td></td></tr></table>					Depth (ft)	Elevation (ft)	Sample Identification	Blow Count/6 in	Recovery (in) / RQD (%)	Drilling Rate (min./ft.)	Geologic Graphic	0							5	7230	9 10	12				10	7225	9 9	12				15	7220	50/5"	0				20	7215						25	7210						30	7205						Visual Material Description Soil: -GEOLOGIC INTERPRETATION- USCS Classification (group symbol), particle sizes, density or consistency, color, moisture, odor, other descriptions Rock: -GEOLOGIC INTERPRETATION- Bedrock Classification, hardness, weather, color, texture, joint size, other descriptions					Groundwater Depth / Monitoring Well Configuration					Laboratory Testing Results <table><tr><td colspan="2">In-Situ States</td><td colspan="4">INDEX DATA</td><td colspan="2">Strength & Compressibility</td></tr><tr><td>Moisture Content (%)</td><td>Dry Unit Weight (pcf)</td><td>Water Soluble Sulfates (%)</td><td>Gravel Content (%)</td><td>Sand Content (%)</td><td>Fines Content (%)</td><td>Liquid Limit (%)</td><td>Plasticity Index (%)</td><td>UCS (psf)</td><td>Swell Pressure (psf)</td><td>Swell Percent (%)</td></tr><tr><td>12</td><td>88</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr></table>					In-Situ States		INDEX DATA				Strength & Compressibility		Moisture Content (%)	Dry Unit Weight (pcf)	Water Soluble Sulfates (%)	Gravel Content (%)	Sand Content (%)	Fines Content (%)	Liquid Limit (%)	Plasticity Index (%)	UCS (psf)	Swell Pressure (psf)	Swell Percent (%)	12	88									
Depth (ft)	Elevation (ft)	Sample Identification	Blow Count/6 in	Recovery (in) / RQD (%)	Drilling Rate (min./ft.)	Geologic Graphic																																																																																																			
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General Notes: 1) Soil classificaitons are in general accordance with ASTM D2487 2) The maximum particle size identified in the material description is dependent on sampler dimensions. 3) Additional information is provided on the Boring Log Key. 4) Groundwater measurements for monitoring wells present water levels at the time of drilling, highest level, and lowest level. Refer to the respective report for a complete history of groundwater values.										Groundwater Data: Date: 11/01/21 Elapsed Time: 0-days Depth to Groundwater: DNE																																																																																															

BORING: LE-BC-40 Project Name: Mesa Verde Waterlines Project Number: 21152 Client's Name: HDR Owner's Name: Mesa Verde National Park Drilling Subcontractor: Terracon Lithos Representative: K. Stevenson Date(s) of Drilling: 11/01/21					Drilling and Sampling Methods Drill Make and Model: CME-55 Drilling Method: Solid Stem Auger (SSA) Bit Type: Cutting Head Casing Description: N/A Hammer Weight (lbs)/Fall (in): 140/30 Sampler Type(s): Modified California Sampler Diameter(s): 2.0-inches					LITHOSENGINEERING Boring Location: 37.210853, -108.543822 Boring Elevation: 7,221.0-feet* Notes: Wetherill Alignment *Elevation approximate																																																																																																																																																																																					
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LITHOS
ENGINEERING

Boring Location: 37.208056, -108.543725

Boring Elevation: 7,201.0-feet*

Notes: Wetherill Alignment

*Elevation approximate

[illegible]

- 1) Soil classifications are in general accordance with ASTM D2487
- 2) The maximum particle size identified in the material description is dependent on sampler dimensions.
- 3) Additional information is provided on the Boring Log Key.
- 4) Groundwater measurements for monitoring wells present water levels at the time of drilling, highest level, and lowest level. Refer to the respective report for a complete history of groundwater values.

	Groundwater Data:
Date:	Elapsed Time: Depth to Groundwater:
 11/01/21	0-days DNE
	
	



Boring Location: 37.204958, -108.544469

Boring Elevation: 7,315.0-feet*

Notes: Wetherill Alignment

*Elevation approximate

[illegible]

	Groundwater Data:	
Date:	Elapsed Time:	Depth to Groundwater:
 10/12/21	0-days	DNE
		

BORING: LE-OC-43 Project Name: Mesa Verde Waterlines Project Number: 21152 Client's Name: HDR Owner's Name: Mesa Verde National Park Drilling Subcontractor: Terracon Lithos Representative: K. Stevenson Date(s) of Drilling: 11/01/21					Drilling and Sampling Methods Drill Make and Model: CME-55 Drilling Method: Solid Stem Auger (SSA) Bit Type: Cutting Head Casing Description: N/A Hammer Weight (lbs)/Fall (in): 140/30 Sampler Type(s): Modified California Sampler Diameter(s): 2.0-inches					LITHOSENGINEERING Boring Location: 37.200444, -108.541831 Boring Elevation: 7,277.0-feet* Notes: Wetherill Alignment *Elevation approximate																																																																																																																																			
Sampling Data <table><tr><td>Depth (ft)</td><td>Elevation</td><td>Sample Identification</td><td>Blow Count/6 in</td><td>Recovery (in) / RQD (%)</td><td>Drilling Rate (min./ft.)</td><td>Geologic Graphic</td></tr><tr><td>0</td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>7275</td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>5</td><td></td><td>50/5"</td><td>5</td><td></td><td></td><td></td></tr><tr><td>7270</td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>10</td><td></td><td>50/4"</td><td>4</td><td></td><td></td><td></td></tr><tr><td>7265</td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>15</td><td></td><td>50/6"</td><td>6</td><td></td><td></td><td></td></tr><tr><td>7260</td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>20</td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>7255</td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>25</td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>7250</td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>30</td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>7245</td><td></td><td></td><td></td><td></td><td></td><td></td></tr></table>					Depth (ft)	Elevation	Sample Identification	Blow Count/6 in	Recovery (in) / RQD (%)	Drilling Rate (min./ft.)	Geologic Graphic	0							7275							5		50/5"	5				7270							10		50/4"	4				7265							15		50/6"	6				7260							20							7255							25							7250							30							7245							Visual Material Description Soil: -GEOLOGIC INTERPRETATION- USCS Classification (group symbol), particle sizes, density or consistency, color, moisture, odor, other descriptions Rock: -GEOLOGIC INTERPRETATION- Bedrock Classification, hardness, weather, color, texture, joint size, other descriptions PAVEMENT Asphalt: 4.0-inches Base: 8.0-inches 1.0 ft.- QUATERNARY LOESS - WIND BLOWN DEPOSIT Sandy LEAN CLAY (CL), some fine sand, pale olive, moist. 3.0 ft.- CLIFFHOUSE SANDSTONE Sandy Claystone, very soft, highly weathered, pale olive, some fine sand. As above except yellowish brown, trace clay, iron oxidation. Clayey Sandstone, very soft, highly weathered, yellowish brown, mostly fine sand, little clay, iron oxidation, moist. 15.0 ft.- END OF EXPLORATION					Groundwater Depth / Monitoring Well Configuration <table><tr><td>Moisture Content (%)</td><td>Dry Unit Weight (pcf)</td><td>Water Soluble Sulfates (%)</td><td>Gravel Content (%)</td><td>Sand Content (%)</td><td>Fines Content (%)</td><td>Liquid Limit (%)</td><td>Plasticity Index (%)</td><td>UCS (psf)</td><td>Swell Pressure (psf)</td><td>Swell Percent (%)</td></tr><tr><td>8</td><td></td><td>0.0005</td><td></td><td>66</td><td>34</td><td>19</td><td></td><td></td><td></td><td></td></tr></table>					Moisture Content (%)	Dry Unit Weight (pcf)	Water Soluble Sulfates (%)	Gravel Content (%)	Sand Content (%)	Fines Content (%)	Liquid Limit (%)	Plasticity Index (%)	UCS (psf)	Swell Pressure (psf)	Swell Percent (%)	8		0.0005		66	34	19				
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BORING: LE-OC-44 Project Name: Mesa Verde Waterlines Project Number: 21152 Client's Name: HDR Owner's Name: Mesa Verde National Park Drilling Subcontractor: Terracon Lithos Representative: J. Halverson Date(s) of Drilling: 10/12/21					Drilling and Sampling Methods Drill Make and Model: CME-75 Drilling Method: Solid Stem Auger (SSA) Bit Type: Cutting Head Casing Description: N/A Hammer Weight (lbs)/Fall (in): 140/30 Sampler Type(s): Modified California Sampler Diameter(s): 2.0-inches					LITHOSENGINEERING Boring Location: 37.196097, -108.537442 Boring Elevation: 7,238.0-feet* Notes: Wetherill Alignment *Elevation approximate																																																		
Sampling Data <table><tr><td rowspan="5">Depth (ft)</td><td rowspan="5">Elevation (ft)</td><td rowspan="5">Sample Identification</td><td>Blow Count/6 in</td><td>Recovery (in) / RQD (%)</td><td>Drilling Rate (min./ft.)</td><td rowspan="5">Geologic Graphic</td></tr><tr><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td></tr></table>					Depth (ft)	Elevation (ft)	Sample Identification	Blow Count/6 in	Recovery (in) / RQD (%)	Drilling Rate (min./ft.)	Geologic Graphic													Visual Material Description Soil: -GEOLOGIC INTERPRETATION- USCS Classification (group symbol), particle sizes, density or consistency, color, moisture, odor, other descriptions Rock: -GEOLOGIC INTERPRETATION- Bedrock Classification, hardness, weather, color, texture, joint size, other descriptions					Groundwater Depth / Monitoring Well Configuration	Laboratory Testing Results <table><tr><td colspan="2">In-Situ States</td><td colspan="6">INDEX DATA</td><td colspan="2">Strength & Compressibility</td></tr><tr><td>Moisture Content (%)</td><td>Dry Unit Weight (pcf)</td><td>Water Soluble Sulfates (%)</td><td>Gravel Content (%)</td><td>Sand Content (%)</td><td>Fines Content (%)</td><td>Liquid Limit (%)</td><td>Plasticity Index (%)</td><td>UCS (psf)</td><td>Swell Pressure (psf)</td><td>Swell Percent (%)</td></tr></table>										In-Situ States		INDEX DATA						Strength & Compressibility		Moisture Content (%)	Dry Unit Weight (pcf)	Water Soluble Sulfates (%)	Gravel Content (%)	Sand Content (%)	Fines Content (%)	Liquid Limit (%)	Plasticity Index (%)	UCS (psf)	Swell Pressure (psf)	Swell Percent (%)
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PAVEMENT SECTION Asphalt: 2.0-inches Base: 0.0-inches 0.2 ft.																																																												
QUATERNARY LOESS - WIND BLOWN DEPOSIT LEAN CLAY with sand (CL), little fine to coarse sand, few fine gravel, stiff, dark brown, moist, maximum particle size 0.5-inches. As above.					141197727135000.2																																																							
LEAN CLAY (CL), few silt, trace fine sand, very stiff, dark reddish yellow, moist, medium plasticity, few organics, trace calcite.					211049642255001.1																																																							
As above. 15.0 ft.																																																												
END OF EXPLORATION																																																												

General Notes:

1) Soil classificaitons are in general accordance with ASTM D2487

2) The maximum particle size identified in the material description is dependent on sampler dimensions.

3) Additional information is provided on the Boring Log Key.

4) Groundwater measurements for monitoring wells present water levels at the time of drilling, highest level, and lowest level. Refer to the respective report for a complete history of groundwater values.

Date: 10/12/21		Groundwater Data: Elapsed Time: 0-days	Depth to Groundwater: DNE
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Project Name: Mesa Verde Waterlines
Project Number: 21152
Client's Name: HDR
Owner's Name: Mesa Verde National Park
Drilling Subcontractor: Terracon
Lithos Representative: J. Halverson
Date(s) of Drilling: 10/18/21

Drill Make and Model: CME-55

Drilling Method: Solid Stem Auger (SSA)

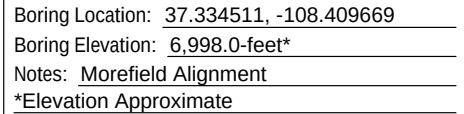
Bit Type: Cutting Head

Casing Description: N/A

Hammer Weight (lbs)/Fall (in): 140/30

Sampler Type(s): Modified California

Sampler Diameter(s): 2.0-inches

[illegible]

- 1) Soil classifications are in general accordance with ASTM D2487
- 2) The maximum particle size identified in the material description is dependent on sampler dimensions.
- 3) Additional information is provided on the Boring Log Key.
- 4) Groundwater measurements for monitoring wells present water levels at the time of drilling, highest level, and lowest level. Refer to the respective report for a complete history of groundwater values.

	Groundwater Data:	
Date:	Elapsed Time:	Depth to Groundwater:
 10/18/21	0-days	DNE
		
		

LE-HDD-07

Run 1 – 14'6"-16'

14' 11.5" – Bedding Discontinuity, horizontal, wide, smooth, irregular, completely weathered, no infilling, weathered bedrock and competent bedrock contact.

15' 1" – Bedding Discontinuity, horizontal, open, smooth, planar, unweathered, no infilling.

15' 3.75" – Bedding Discontinuity, horizontal, open, smooth, slightly rough, slightly weathered, infilled with weathered bedrock material

Run 2 – 16'-21'

17' 2.875" – Bedding Discontinuity, horizontal, partially open, smooth, irregular, unweathered, no infilling.

17' 3.25" – Bedding Discontinuity, horizontal, partially open, smooth, planar, unweathered, no infilling.

17' 8.75" – Bedding Discontinuity, horizontal, partially open, smooth, planar, unweathered, no infilling.

20' 4.75" – Bedding Discontinuity, horizontal, open, smooth, planar, unweathered, no infilling.

Run 3 – 21'-26'

21' 8.5" – Bedding Discontinuity, horizontal, open, slightly rough, slightly rough, unweathered, no infilling.

23' 1.5" – Bedding Discontinuity, horizontal, open, slightly rough, slightly rough, unweathered, no infilling.

23' 6" – Bedding Discontinuity, horizontal, partially open, slightly rough, slightly rough, unweathered, no infilling.

23' 7.25" – Bedding Discontinuity, horizontal, partially open, slightly rough, slightly rough, unweathered, no infilling.

24' 10.25" – Bedding Discontinuity, horizontal, partially open, slightly rough, slightly rough, unweathered, no infilling.

Run 4 – 26'-31'

26' 7" – Bedding Discontinuity, horizontal, partially open, slightly rough, slightly rough, unweathered, no infilling.

27' 11" – Bedding Discontinuity, horizontal, partially open, slightly rough, slightly rough, unweathered, no infilling.

29' 1.5" – Bedding Discontinuity, horizontal, tight, slightly rough, slightly rough, unweathered, no infilling.

30' 7" – Bedding Discontinuity, horizontal, wide, slightly rough, slightly rough, unweathered, calcite based fossils infilling approximately 0.25-inches thick.

Run 5 – 31'-36'1"

32' 10.5" – Bedding Discontinuity, horizontal, partially open, smooth, planar, unweathered, no infilling.

33' 7.5" – Fossil Discontinuity, horizontal, partially open, undulating, slightly rough, unweathered, no infilling.

Run 6 – 36'1"-41'1"

36' 11.5" – Bedding Discontinuity, partially open, smooth, planar, unweathered, no infilling.

40' 5" – Bedding Discontinuity, horizontal, partially open, smooth, planar, unweathered, no infilling.

Run 7 – 41'1"-43'7"

41'5.25" – Fossil Discontinuity, horizontal, partially open, undulating, slightly rough, unweathered, no infilling.

Run 8 – 43'7"-46'1"

No discontinuities.

Run 9 – 46'1"-51'1"

46' 9" – Fossil Discontinuity, horizontal, partially open, undulating, slightly rough, unweathered, no infilling.

50'6.5" – Bedding Discontinuity, horizontal, partially open, smooth, slightly rough, unweathered, no infilling.

Run 10 – 51'1"-56'1"

51'2.5" – Bedding Discontinuity, horizontal, wide, smooth, slightly rough, unweathered, no infilling.

51'3" – Bedding Discontinuity, horizontal, wide, smooth, slightly rough, unweathered, no infilling.

52' 0.75" – Bedding Discontinuity, horizontal, partially open, smooth, irregular, unweathered, no infilling.

52'11" – Bedding Discontinuity, horizontal, partially open, smooth, slightly rough, unweathered, no infilling.

54' 8.5" – Bedding Discontinuity, horizontal, partially open, smooth, planar, unweathered, no infilling.

Run 11 – 56'1"-61'1"

58' 3.75" – Bedding Discontinuity, low angle, partially open, smooth, irregular, unweathered, no infilling.

59' 6.375" – Bedding Discontinuity, horizontal, partially open, smooth, planar, unweathered, no infilling.

60' 0.625" – Bedding Discontinuity, horizontal, partially open, smooth, planar, unweathered, no infilling.

Run 12 – 61'1"-66'1"

63' 8" – Bedding Discontinuity, horizontal, partially open, smooth, planar, unweathered, no infilling.

65' 8" – Bedding Discontinuity, horizontal, partially open, smooth, planar, unweathered, no infilling.

65' 10.25" – Bedding Discontinuity, horizontal, partially open, smooth, planar, unweathered, no infilling.

Run 13 – 66'1"-71'1"

68' 5" – Bedding Discontinuity, horizontal, partially open, smooth, planar, unweathered, no infilling.

69' 4.125" – Bedding Discontinuity, horizontal, partially open, smooth, irregular, unweathered, no infilling.

70' 2.25" – Bedding Discontinuity, horizontal, partially open, smooth, irregular, unweathered, no infilling.

70' 9.75" – Bedding Discontinuity, horizontal, partially open, smooth, planar, unweathered, no infilling.

Run 14 – 71'1"-76'3"

72' 10" – Bedding Discontinuity, low angle, partially open, smooth, planar, unweathered, no infilling.

73' 6.5" – Bedding Discontinuity, horizontal, partially open, smooth, planar, unweathered, no infilling.

73' 8.5" – Bedding Discontinuity, horizontal, partially open, slightly rough, irregular, unweathered, no infilling.

Run 15 – 76'3"-81'3"

76' 10.25" – Bedding Discontinuity, horizontal, partially open, smooth, irregular, unweathered, no infilling, 25% SA with small fossils.

78' 2.375" – Bedding Discontinuity, horizontal, partially open, smooth, planar, unweathered, no infilling.

78' 8.5" – Fossil Discontinuity, horizontal, partially open, undulating, slightly rough, unweathered, no infilling.

79' 5" – Fossil Discontinuity, horizontal, partially open, undulating, slightly rough, unweathered, no infilling.

LE-HDD-08

Run 1 – 19'6"-21'

20' 2" – Bedding Discontinuity, horizontal, wide, smooth, irregular, completely weathered, no infilling, weathered bedrock and competent bedrock contact.

Run 2 – 21'-26'

21' 3.75" – Bedding Discontinuity, horizontal, partially open, slightly rough, slightly rough, unweathered, no infilling.

21' 5.875" – Bedding Discontinuity, horizontal, partially open, smooth, irregular, unweathered, no infilling.

21' 11.5" – Bedding Discontinuity, horizontal, partially open, slightly rough, slightly rough, unweathered, no infilling.

23' 1.75" – Fossil Discontinuity, horizontal, partially open, smooth, planar, unweathered, no infilling.

23' 6" – Bedding Discontinuity, horizontal, partially open, slightly rough, slightly rough, unweathered, no infilling.

24' 1.5" – Bedding Discontinuity, horizontal, partially open, slightly rough, planar, unweathered, no infilling.

24' 2.125" – Bedding Discontinuity, horizontal, partially open, smooth, irregular, unweathered, no infilling.

24' 2.625" – Bedding Discontinuity, horizontal, partially open, smooth, planar, unweathered, no infilling.

24' 3.25" – Bedding Discontinuity, horizontal, partially open, slightly rough, slightly rough, slightly weathered, no infilling.

24' 7.625" – Bedding Discontinuity, horizontal, wide, slightly rough, irregular, unweathered, no infilling.

24' 11.875" – Fossil Discontinuity, horizontal, partially open, undulating, slightly rough, unweathered, no infilling.

25' 10" – Bedding Discontinuity, low angle, partially open, smooth, planar, unweathered, no infilling.

25' 11" – Bedding Discontinuity, horizontal, partially open, slightly rough, irregular, slightly weathered, no infilling.

Run 3 – 26'-31'

29'11.125" 34'0.625" – Bedding Discontinuity, low angle, open, slightly rough, slightly rough, unweathered, no infilling.

30' 8.5625" – Bedding Discontinuity, horizontal, partially open, smooth, planar, unweathered, no infilling.

30'10.9375" – Bedding Discontinuity, horizontal, open, slightly rough, slightly rough, unweathered, no infilling.

Run 4 – 31'-36'1"

34'0.625" – Bedding Discontinuity, horizontal, partially open, smooth, planar, unweathered, no infilling.

34'2.375" – Bedding Discontinuity, horizontal, partially open, slightly rough, irregular, unweathered, no infilling.

Run 5 – 36'1"-41'2"

36' 4.5" – Bedding Discontinuity, horizontal, partially open, slightly rough, planar, unweathered, no infilling.

38' 2.75" – Bedding Discontinuity, horizontal, partially open, smooth, planar, unweathered, no infilling.

Run 6 – 41'2"-46'2"

41' 10.75" – Bedding Discontinuity, horizontal, partially open, smooth, planar, unweathered, no infilling.

42' 10.125" – Fossil Discontinuity, horizontal, partially open, smooth, planar, unweathered, no infilling.

44' 7.3125" – Bedding Discontinuity, horizontal, partially open, smooth, planar, unweathered, no infilling.

45' 8.5" – Bedding Discontinuity, horizontal, partially open, smooth, planar, unweathered, no infilling.

Run 7 – 46'2"-51'5"

47'3.375" – Bedding Discontinuity, horizontal, partially open, smooth, irregular, unweathered, no infilling.

47' 6" – Bedding Discontinuity, horizontal, partially open, slightly rough, planar, unweathered, no infilling.

47' 10.0625" – Bedding Discontinuity, horizontal, partially open, slightly rough, planar, unweathered, no infilling.

49' 1.625" – Bedding Discontinuity, horizontal, partially open, smooth, planar, unweathered, no infilling.

50' 0.5" – Bedding Discontinuity, horizontal, partially open, smooth, planar, unweathered, no infilling.

50' 8.75" – Bedding Discontinuity, horizontal, partially open, smooth, planar, unweathered, no infilling.

Run 8 – 51'5"-56'5"

51' 7.875" – Bedding Discontinuity, horizontal, partially open, smooth, planar, unweathered, no infilling.

51' 9.25" – Bedding Discontinuity, horizontal, partially open, slightly rough, planar, unweathered, no infilling.

52' 9.8125" – Bedding Discontinuity, horizontal, partially open, smooth, planar, unweathered, no infilling.

53' 7.0625" – Bedding Discontinuity, horizontal, partially open, smooth, planar, unweathered, no infilling.

54' 2.0625" – Bedding Discontinuity, horizontal, partially open, smooth, planar, unweathered, no infilling.

Run 9 – 56'5"-61'7"

57' 3.375" – Bedding Discontinuity, horizontal, partially open, smooth, planar, unweathered, no infilling.

58' 11.875" – Bedding Discontinuity, horizontal, partially open, slightly rough, irregular, unweathered, no infilling.

60' 4.25" – Bedding Discontinuity, horizontal, partially open, smooth, planar, unweathered, no infilling.

61' 2.375" – Bedding Discontinuity, horizontal, partially open, smooth, planar, unweathered, no infilling.

Run 10 – 61'7"-66'7"

62' 4.375" – Bedding Discontinuity, low angle, partially open, slightly rough, planar, unweathered, no infilling.

62' 9.25" – Bedding Discontinuity, horizontal, partially open, smooth, irregular, unweathered, no infilling.

63' 8.875" – Bedding Discontinuity, horizontal, tight, slightly rough, planar, unweathered, no infilling.

65' 4.75" – Bedding Discontinuity, horizontal, partially open, slightly rough, irregular, unweathered, no infilling.

66' – Bedding Discontinuity, horizontal, partially open, slightly rough, irregular, unweathered, no infilling.

Run 11 – 66'7"-71'8"

68' 5.375" – Bedding Discontinuity, horizontal, partially open, slightly rough, planar, unweathered, no infilling.

69' 4.125" – Bedding Discontinuity, horizontal, partially open, slightly rough, planar, unweathered, no infilling.

70' 6" – Bedding Discontinuity, horizontal, partially open, smooth, planar, unweathered, no infilling.

Run 12 – 71'8"-76'8"

72' 3.25" – Bedding Discontinuity, horizontal, partially open, slightly rough, irregular, unweathered, no infilling.

73' 1.5" – Bedding Discontinuity, low angle, partially open, smooth, planar, unweathered, no infilling.

73' 6.75" – Bedding Discontinuity, low angle, partially open, smooth, planar, unweathered, no infilling.

73' 11.5" – Bedding Discontinuity, low angle, partially open, smooth, planar, unweathered, no infilling.

74' 4.25" – Bedding Discontinuity, low angle, partially open, smooth, planar, unweathered, no infilling.

76' – Bedding Discontinuity, horizontal, partially open, smooth, planar, unweathered, no infilling.

Run 13 – 76'8"-81'8"

76' 11.625" – Bedding Discontinuity, horizontal, open, slightly rough, planar, unweathered, no infilling.

77' 4.75" – Bedding Discontinuity, horizontal, open, slightly rough, irregular, unweathered, no infilling.

78' 5.25" – Bedding Discontinuity, low angle, partially open, smooth, planar, unweathered, no infilling.

78' 9.375" – Bedding Discontinuity, low angle, partially open, slightly rough, planar, unweathered, no infilling.

80' 8.25" – Bedding Discontinuity, horizontal, open, smooth, undulating, unweathered, no infilling.

LE-HDD-09

Run 1 – 44'2"-45'8"

45' 2.25" – Bedding Discontinuity, horizontal, open, slightly rough, irregular, unweathered, no infilling.

Run 2 – 45'8"-50'8"

46' 0.25" – Bedding Discontinuity, horizontal, open, slightly rough, planar, unweathered, no infilling.

46' 1.6875" – Bedding Discontinuity, horizontal, open, smooth, planar, unweathered, no infilling.

46' 11.5625" – Bedding Discontinuity, horizontal, partially open, slightly rough, planar, unweathered, no infilling.

48' 3.5" – Bedding Discontinuity, horizontal, tight, slightly rough, irregular, unweathered, no infilling.

49' 8.375" – Bedding Discontinuity, horizontal, partially open, smooth, planar, unweathered, no infilling.

50' 4.875" – Bedding Discontinuity, horizontal, partially open, smooth, planar, unweathered, no infilling.

Run 3 – 50'8"-55'8"

51' 0.75" – Bedding Discontinuity, horizontal, partially open, slightly rough, irregular, unweathered, no infilling.

51' 4.625" – Bedding Discontinuity, horizontal, tight, slightly rough, planar, unweathered, no infilling.

52' 5.375" – Bedding Discontinuity, horizontal, partially open, smooth, planar, unweathered, no infilling.

52' 10.625" – Bedding Discontinuity, horizontal, open, smooth, planar, unweathered, no infilling.

53' 4.875" – Bedding Discontinuity, horizontal, open, slightly rough, irregular, unweathered, no infilling.

54' 0.875" – Bedding Discontinuity, horizontal, wide, smooth, planar, unweathered, no infilling.

54' 2" – Bedding Discontinuity, horizontal, wide, slightly rough, planar, unweathered, no infilling.

54' 8.5" – Bedding Discontinuity, horizontal, wide, smooth, planar, unweathered, no infilling.

55' 2.5" – Bedding Discontinuity, horizontal, open, smooth, irregular, unweathered, no infilling.

55' 3.5" – Bedding Discontinuity, horizontal, open, slightly rough, irregular, unweathered, no infilling.

Run 4 – 55'8"-60'8"

56' 6.25" – Bedding Discontinuity, horizontal, partially open, smooth, planar, unweathered, no infilling.

56' 7.25" – Bedding Discontinuity, horizontal, wide, slightly rough, irregular, unweathered, no infilling.

57' 10.5" – Bedding Discontinuity, horizontal, partially open, smooth, planar, unweathered, no infilling.

58' 11.125" – Bedding Discontinuity, horizontal, partially open, smooth, planar, unweathered, no infilling.

60' 3.5" – Bedding Discontinuity, horizontal, partially open, slightly rough, planar, unweathered, no infilling.

60' 6.625" – Bedding Discontinuity, horizontal, partially open, slightly rough, planar, unweathered, no infilling.

Run 5 – 60'8"-65'8"

61' 4.625" – Bedding Discontinuity, horizontal, open, smooth, planar, unweathered, no infilling.

62' 5.9375" – Bedding Discontinuity, horizontal, partially open, slightly rough, planar, unweathered, no infilling.

63' 7.25" – Bedding Discontinuity, horizontal, partially open, slightly rough, planar, unweathered, no infilling.

64' 1.125" – Bedding Discontinuity, horizontal, partially open, slightly rough, planar, unweathered, no infilling.

64' 9.125" – Bedding Discontinuity, horizontal, partially open, slightly rough, planar, unweathered, no infilling.

65' 2" – Bedding Discontinuity, horizontal, partially open, slightly rough, irregular, unweathered, no infilling.

Run 6 – 65'8" - 70'8"

65' 10.375" – Bedding Discontinuity, horizontal, open, smooth, planar, unweathered, no infilling.

67' 5.6875" – Bedding Discontinuity, horizontal, partially open, slightly rough, planar, unweathered, no infilling.

68' 8.75" – Bedding Discontinuity, horizontal, partially open, smooth, planar, unweathered, no infilling.

69' 1" – Bedding Discontinuity, horizontal, partially open, smooth, planar, unweathered, no infilling.

Run 7 – 70'8" - 75'8"

71' 7.75" – Bedding Discontinuity, horizontal, partially open, slightly rough, planar, unweathered, no infilling.

72' 8" – Bedding Discontinuity, horizontal, partially open, slightly rough, planar, unweathered, no infilling.

73' 4.25" – Bedding Discontinuity, horizontal, partially open, slightly rough, planar, unweathered, no infilling.

73' 7.6875" – Bedding Discontinuity, horizontal, partially open, slightly rough, planar, unweathered, no infilling.

73' 8.375" – Bedding Discontinuity, horizontal, partially open, slightly rough, planar, unweathered, no infilling.

74' 4" – Bedding Discontinuity, horizontal, partially open, slightly rough, planar, unweathered, no infilling.

Run 8 – 75'8" - 80'11"

75' 9.25" – Bedding Discontinuity, horizontal, partially open, smooth, planar, unweathered, no infilling.

76' 5.75" – Bedding Discontinuity, horizontal, partially open, slightly rough, planar, unweathered, no infilling.

77' 1" – Bedding Discontinuity, horizontal, partially open, smooth, planar, unweathered, no infilling.

78' 1.125" – Bedding Discontinuity, horizontal, partially open, slightly rough, planar, unweathered, no infilling.

78' 11.625" – Bedding Discontinuity, horizontal, partially open, slightly rough, planar, unweathered, no infilling.

Note: Discontinuity Logs were not completed for LE-HDD-9-A, LE-HDD-9-B, or LE-HDD-12-A. See Appendix D for photographs of core.



APPENDIX – B

Geotechnical Laboratory Testing Results

Geotechnical Laboratory Testing Results																	
Sample Identification		In-Place States		Material Classification and Index Testing						Water Soluble Sulfates (%)	One-Dimensional Compression Testing		Proctor		CBR (%)	USCS ²	USCS Classification
Boring	Sample Depth (ft)	Moisture Content (%)	Dry Density (pcf)	Particle Size			Atterberg Limits				Swell-Consolidation (%/psf)	Unconfined Compressive Strength ¹ (psi)	Maximum Dry Density (pcf)	Optimum Water Content (%)	0.20-inch Penetration		
				Gravel (%)	Sand (%)	Fines (%)	Liquid Limit	Plastic Limit	Plasticity Index								
LE-OC-45	4	9	117			96	35	15	20		+4.3/500					CL	Lean Clay
LE-OC-01	4	7	100			91	30	16	14			33				CL	Lean Clay
LE-OC-02	9	17	112			82	29	14	15		+0/500					CL	Lean Clay with Sand
LE-OC-03	4	13	113			95	44	18	26							CL	Lean Clay
	9	14														CL	Lean Clay
LE-OC-04	4	13	116			96	43	17	26							CL	Lean Clay
LE-OC-05	4	9	95				39	19	20							CL	Lean Clay with Sand
LE-HDD-07	4	15	102				50	29	21							CH	Fat Clay
	9	14														CH	Fat Clay
LE-HDD-08	4	6	94			87	28	18	10	0.029						CL	Lean Clay
LE-HDD-9-A	15			0	65	35	21	1	20			146				BR	Silty Sandstone
	24	10	123	0	26	74	35	20	15							CL	Lean Clay with Sand
	39	7		0	32	68										BR	Sandy Shale
	46	5														BR	Shale
	64	3														BR	Shale
LE-HDD-9-B	9	17	112	1	23	76	36	20	16							CL	Lean Clay with Sand
	19	13	114													BR	Sandstone
	49	12	122	7	33	60	34	18	16							BR	Sandy Claystone
	74	13	125	0	5	95	40	24	16							BR	Claystone
	84	5	106													BR	Sandy Shale
	89	5	108	3	24	73	31	14	17							BR	Sandy Shale
LE-HDD-10	4	4														CL	Sandy Lean Clay with Gravel
LE-HDD-11	4	10	109									92				CL	Lean Clay with Sand
	9	8	122			75	32	15	17			229				CL	Lean Clay with Sand
LE-OC-12	0	8														CL	Lean Clay
	9	13	116													BR	Sandstone
LE-HDD-12-A	31	6														BR	Sandstone
LE-OC-13	4	9	111			71	32	15	17							CL	Lean Clay with Sand
LE-OC-14	0	9														CL	Sandy Lean Clay with Gravel
	4	6	120			55	34	14	20		+3.4/500					CL	Sandy Lean Clay
LE-OC-15	4	17				92										BR	Siltstone
LE-BC-18	4	10				64	30	15	15							CL	Sandy Lean Clay
	9	7														BR	Sandy Claystone
LE-OC-20	4	9				65										BR	Siltstone
LE-OC-22	4	13	96			57	25	14	11							CL	Sandy Lean Clay
LE-OC-24	4	5				34										BR	Clayey Sandstone
LE-OC-26	4	9	87			57	26	14	12							CL	Sandy Lean Clay
LE-OC-27	4	2														BR	Sandstone
LE-OC-28	4	6														CL	Lean Clay with Sand
LE-OC-29	4	6	83			44	29	13	16	0.002						SC	Clayey Sand
LE-OC-31	4	9	80													BR	Silty Sandstone
LE-OC-35	4	4	79													BR	Sandstone
LE-BC-39	4	12	88													BR	Silty Sandstone
LE-OC-43	4	8				66	34	15	19	0.0005						CL	Sandy Lean Clay
LE-OC-44	4	14	119			77	27	14	13		+0.2/500					CL	Lean Clay with Sand
	9	21	104			88	42	17	25		+1.1/500					CL	Lean Clay
S-1	0				20	80							109	17	6	CL	Lean Clay with Sand
S-3	0				40	60							106	16	3	CL	Sandy Lean Clay
S-4	0				34	66							111	16	2	CL	Sandy Lean Clay
S-5	0				52	48										SC	Clayey Sand
S-6	0												107	15	2	SM	Silty Sand
S-7	0				30	70							111	14		CL	Sandy Lean Clay

¹Select UCS results on bedrock samples near the three Morefield HDD alignments are shown on Page 3.

²Where Atterberg Limits and Fines Content testing was not performed, USCS Classifications visually determined in the field during the subsurface investigation.

Laboratory Corrosion Testing Results																	
Sample Identification		Results of Corrosion Analysis														USCS ²	USCS Classification
Boring	Sample Depth (ft)	pH	10-point Corrosion System	Minimum Lab Resistivity (ohm-cm)	10-point Corrosion System	Redox (mV vs. Ag/AgCl)	10-point Corrosion System	Free Sulfides (mg/kg DMB)	10-point Corrosion System	Chloride (mg/kg) DMB	10-point Corrosion System	Sulfate (mg/kg) DMB	10-point Corrosion System	Sulfate-S (mg/kg DMB)	10-point System total score ¹		
LE-OC-03	9	9	3	213	10	250	0	<1	0	379	2	8760	6	2920	21	CL	Lean Clay
LE-HDD-07	9	8	0	547	10	254	0	<1	0	35	0	3858	4	1286	14	CH	Fat Clay
LE-HDD-10	4	8	0	1279	10	246	0	<1	0	72	0	1124	2	375	12	CL	Sandy Lean Clay with Gravel
LE-OC-12	0	8	0	3882	0	235	0	<1	0	13	0	104	0	35	0	CL	Lean Clay
LE-OC-14	0	8	0	2167	2	238	0	<1	0	30	0	88	0	29	2	CL	Sandy Lean Clay with Gravel
LE-BC-18	9	8	0	4309	0	227	0	<1	0	30	0	46	0	15	0	BR	Sandy Claystone
LE-OC-28	4	8	0	2855	1	234	0	<1	0	64	0	70	0	23	1	CL	Lean Clay with Sand

¹A total score greater than 10 correlates to corrosive soil.

²Where Atterberg Limits and Fines Content testing was not performed, USCS Classifications visually determined in the field during the subsurface investigation.

Horticulture Testing Results																
Sample Identification		pH (lb/acre)	Phosphorus (lb/acre)	Potassium (lb/acre)	Calcium (lb/acre)	Magnesium (lb/acre)	Zinc (lb/acre)	Iron (lb/acre)	Manganese (lb/acre)	Boron (lb/acre)	Sodium (lb/acre)	Sulfur (lb/acre)	Organic Matter (%)	Soluble Salts (dS/m)	USCS ¹	USCS Classification
Boring	Sample Depth (ft)		P	K	Ca	Mg	Zn	Fe	Mn	B	Na					
S-1	0	8	21 M	604 V	12490	322 S	1 S	0 S	2 S	1.3	16	4	6	0.12	CL	Lean Clay with Sand
S-3	0	7.7	215 V	276 H	5276 S	742 S	2 S	5 S	23 S	1.6	19	4	3	0.04	CL	Sandy Lean Clay
S-4	0	8.7	1 L	51 L	11600	981 S	1 S	0 S	1 S	0.7	22	4	3	0.09	CL	Sandy Lean Clay
S-5	0	7.3	198 V	532 V	4924 S	449 S	5 S	5 S	51 S	2.2	12	13	4	0.13	SC	Clayey Sand
S-7	0	7.7	47 H	138 M	4306 S	567 S	2 S	11 S	39 S	1.4	17	8	2	0.06	CL	Sandy Lean Clay

¹Where Atterberg Limits and Fines Content testing was not performed, USCS Classifications visually determined in the field during the subsurface investigation.

Rock Testing Results Near HDD Alignments												
Sample Identification		Unconfined Compressive Strength ¹ (psi)	Point Load Strength Index ²		Splitting Tensile Strength (psi)	CERCHAR Abrasiveness	Moh's Scale of Hardness	Slake Durability			USCS Classification	
Boring	Sample Depth (ft)		Approximate Compressive Strength Horizontal to Bedding Plane (psi)	Approximate Compressive Strength Vertical to Bedding Plane (psi)		Corrected CAI		1st Cycle Durability (%)	2nd Cycle Durability (%)	Type ³		
LE-HDD-07	16	26									Shale	
	51	24									Interbedded Shale and Siltstone	
LE-HDD-08	21	31									Shale	
LE-HDD-09	50	18									Shale	
LE-HDD-9-A	20					2.48					Sandstone	
	46						1.6	94.4	89.3	II	Shale	
	50					Shale						
	53				3.01	Shale						
	54	3781	663			Shale						
	57	5472	805							Shale		
	61				2.00					Shale		
	63		3698								Shale	
			1986									
			2447									
	64							97.6	95.8	I	Shale	
	69					2.56						Shale
	71				532						Shale	
	73		7319								Shale	
			8315									
			7473									
	74				708						Shale	
	75		5675	440							Shale	
	76							1.7				Shale
	80		5680									Shale
		8703										
		6226										
LE-HDD-09-B	19	113									Sandstone	
	84	9									Sandy Shale	
	89	22									Sandy Shale	
LE-HDD-11	79	46									Siltstone	
LE-OC-12	9	40									Sandstone	
LE-HDD-12-A	23	3014					2.5				Sandstone	
	24										Sandstone	
	27					2.83					Sandstone	
	28	4033									Sandy Claystone	
	29					2.09					Sandstone	
	30				202						Clayey Sandstone	
	31							87.5	80.3	II	Clayey Sandstone	
Point Lookout Sandstone Boulder	0	8									Sandstone	
Cliffhouse Sandstone Boulder	0	38									Sandstone	

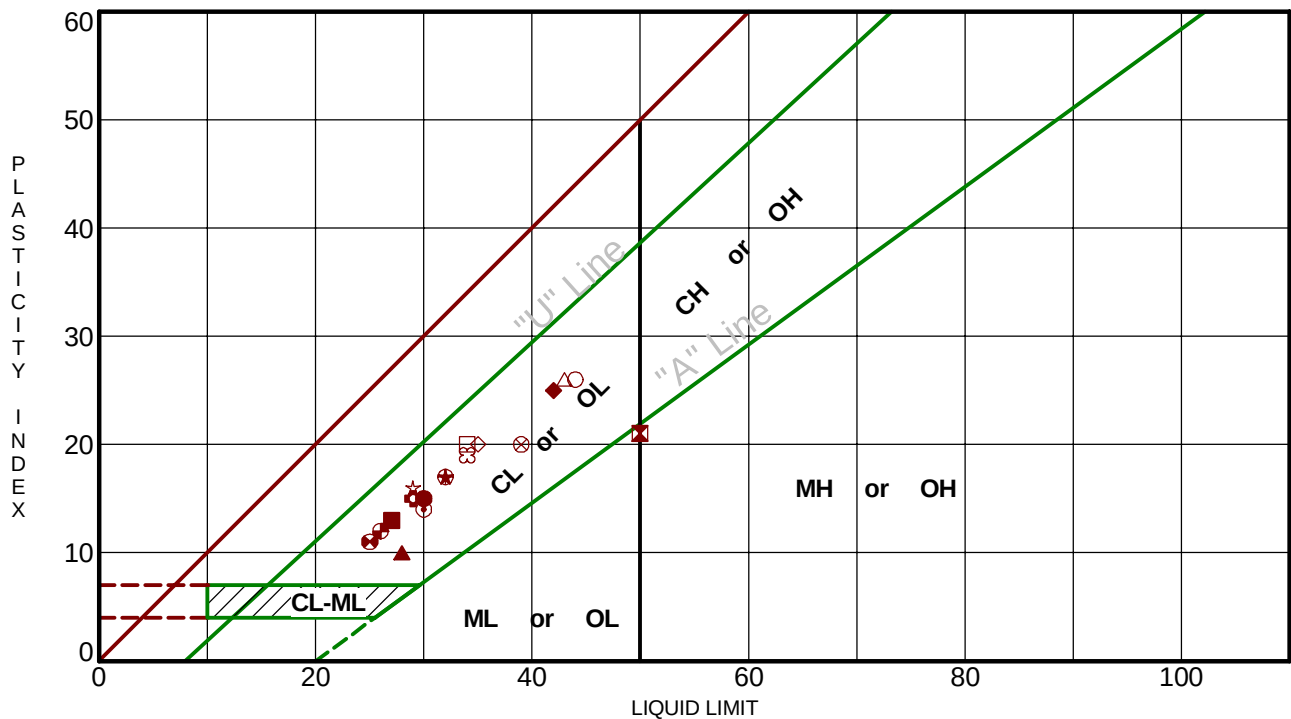
¹Select UCS results on bedrock samples near the three Morefield HDD alignments are shown on Page 3.

²See ASTM D5731 for complete differences between two tests.

³Type I indicates "retained specimen remain virtually unchanged"; Type II indicates "retained specimen consist of large and small fragments."

ATTERBERG LIMITS RESULTS

ASTM D4318



Boring ID	Depth	LL	PL	PI	Fines	USCS	Description
● LE-BC-18	4 - 5	30	15	15	63.6	CL	SANDY LEAN CLAY
⊠ LE-HDD-07	4 - 5	50	29	21			
▲ LE-HDD-08	4 - 5	28	18	10	87.1	CL	LEAN CLAY
★ LE-HDD-11	9 - 10	32	15	17	75.1	CL	LEAN CLAY with SAND
⊙ LE-OC-01	4 - 5	30	16	14	90.5	CL	LEAN CLAY
⊕ LE-OC-02	9 - 10	29	14	15	82.1	CL	LEAN CLAY with SAND
○ LE-OC-03	4 - 5	44	18	26	94.8	CL	LEAN CLAY
△ LE-OC-04	4 - 5	43	17	26	95.6	CL	LEAN CLAY
⊗ LE-OC-05	4 - 5	39	19	20			
⊕ LE-OC-13	4 - 5	32	15	17	70.7	CL	LEAN CLAY with SAND
□ LE-OC-14	4 - 5	34	14	20	54.5	CL	SANDY LEAN CLAY
⊕ LE-OC-22	4 - 5	25	14	11	57.3	CL	SANDY LEAN CLAY
⊕ LE-OC-26	4 - 5	26	14	12	56.8	CL	SANDY LEAN CLAY
★ LE-OC-29	4 - 5	29	13	16	43.8	SC	CLAYEY SAND
⊗ LE-OC-43	4 - 5	34	15	19	66.2	CL	SANDY LEAN CLAY
■ LE-OC-44	4 - 5	27	14	13	76.7	CL	LEAN CLAY with SAND
◆ LE-OC-44	9 - 10	42	17	25	88.1	CL	LEAN CLAY
◇ LE-OC-45	4 - 5	35	15	20	96.4	CL	LEAN CLAY

PROJECT: Mesa Verde Pipeline

SITE: 1901 Sharp Point Drive
Fort Collins, CO

Terracon
1901 Sharp Point Dr Ste C
Fort Collins, CO

PROJECT NUMBER: Lithos Project No. 21152

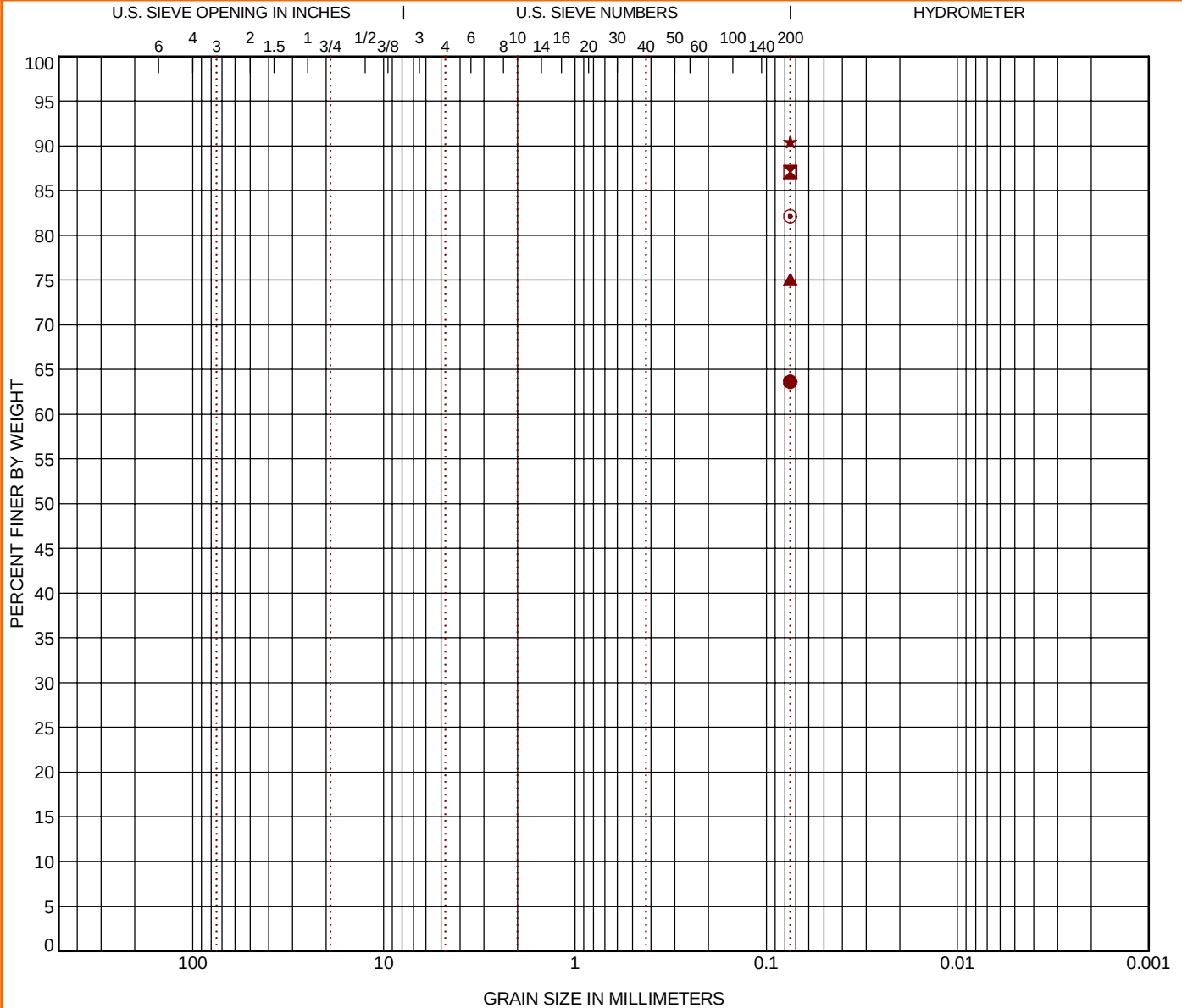
CLIENT: Lithos Engineering
Fort Collins, CO

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. ATTERBERG LIMITS 20215009 MISC LAB TESTING.GPJ TERRACON_DATATEMPLATE.GDT 1/14/22

GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GRAIN SIZE: USCS-2 20215009 MISC LAB TESTING .GPJ TERRACON_DATATEMPLATE.GDT 1/14/22



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Boring ID	Depth	USCS Classification				WC (%)	LL	PL	PI	Cc	Cu
LE-BC-18	4 - 5	SANDY LEAN CLAY (CL)				10.0	30	15	15		
LE-HDD-08	4 - 5	LEAN CLAY (CL)				6.1	28	18	10		
LE-HDD-11	9 - 10	LEAN CLAY with SAND (CL)				8.4	32	15	17		
LE-OC-01	4 - 5	LEAN CLAY (CL)				7.4	30	16	14		
LE-OC-02	9 - 10	LEAN CLAY with SAND (CL)				16.5	29	14	15		
Boring ID	Depth	D ₁₀₀	D ₆₀	D ₃₀	D ₁₀	%Cobbles	%Gravel	%Sand	%Silt	%Fines	%Clay
LE-BC-18	4 - 5	0.075								63.6	
LE-HDD-08	4 - 5	0.075								87.1	
LE-HDD-11	9 - 10	0.075								75.1	
LE-OC-01	4 - 5	0.075								90.5	
LE-OC-02	9 - 10	0.075								82.1	

PROJECT: Mesa Verde Pipeline

SITE: 1901 Sharp Point Drive
Fort Collins, CO



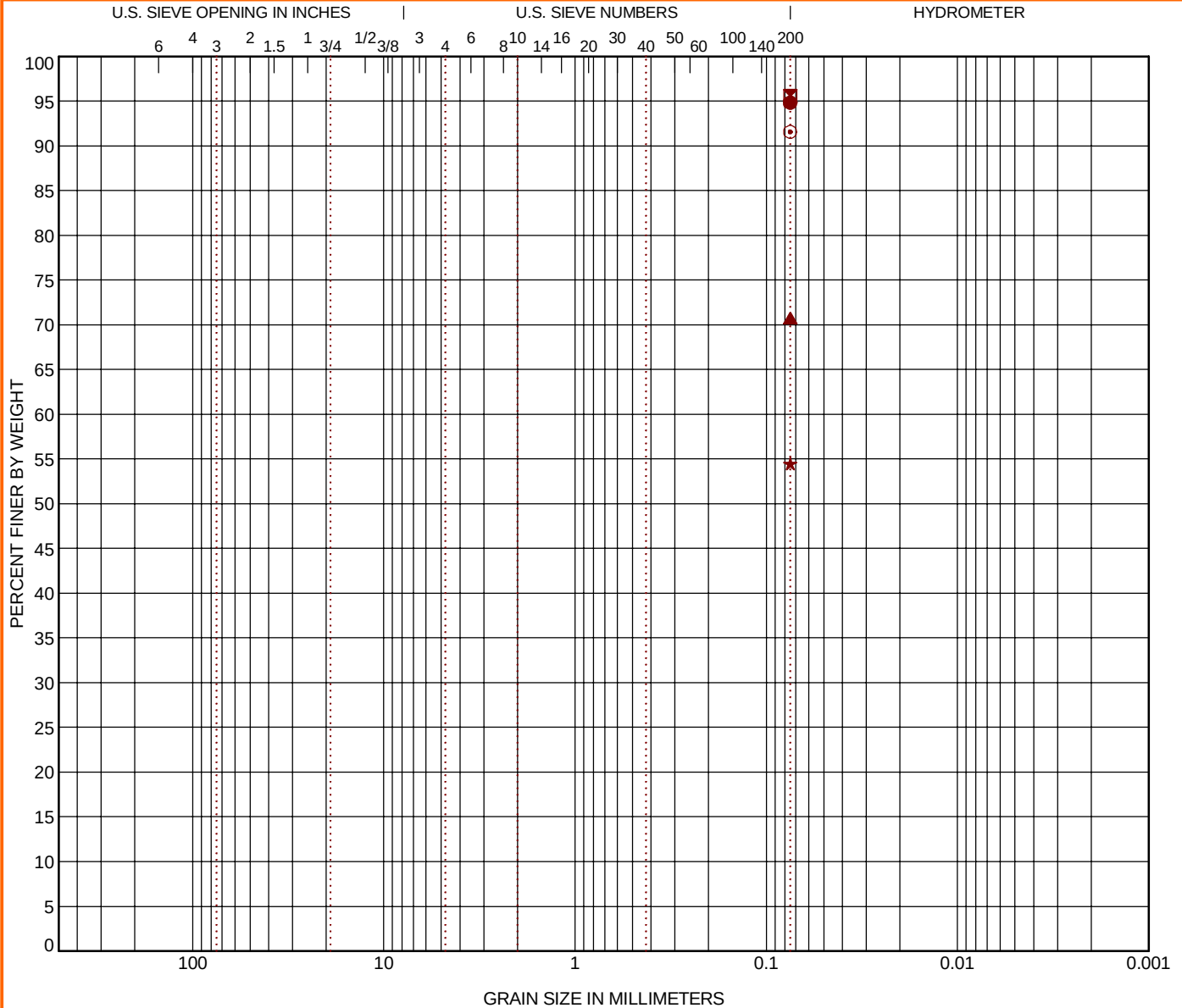
PROJECT NUMBER: Lithos Project No. 21152

CLIENT: Lithos Engineering
Fort Collins, CO

GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GRAIN SIZE: USCS-2 20215009 MISC LAB TESTING .GPJ TERRACON_DATATEMPLATE.GDT 1/14/22



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Boring ID	Depth	USCS Classification				WC (%)	LL	PL	PI	Cc	Cu
LE-OC-03	4 - 5	LEAN CLAY (CL)				13.2	44	18	26		
LE-OC-04	4 - 5	LEAN CLAY (CL)				12.8	43	17	26		
LE-OC-13	4 - 5	LEAN CLAY with SAND (CL)				9.5	32	15	17		
LE-OC-14	4 - 5	SANDY LEAN CLAY (CL)				6.3	34	14	20		
LE-OC-15	4 - 5					17.0					
Boring ID	Depth	D ₁₀₀	D ₆₀	D ₃₀	D ₁₀	%Cobbles	%Gravel	%Sand	%Silt	%Fines	%Clay
LE-OC-03	4 - 5	0.075								94.8	
LE-OC-04	4 - 5	0.075								95.6	
LE-OC-13	4 - 5	0.075								70.7	
LE-OC-14	4 - 5	0.075								54.5	
LE-OC-15	4 - 5	0.075								91.6	

PROJECT: Mesa Verde Pipeline

SITE: 1901 Sharp Point Drive
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Terracon
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Fort Collins, CO

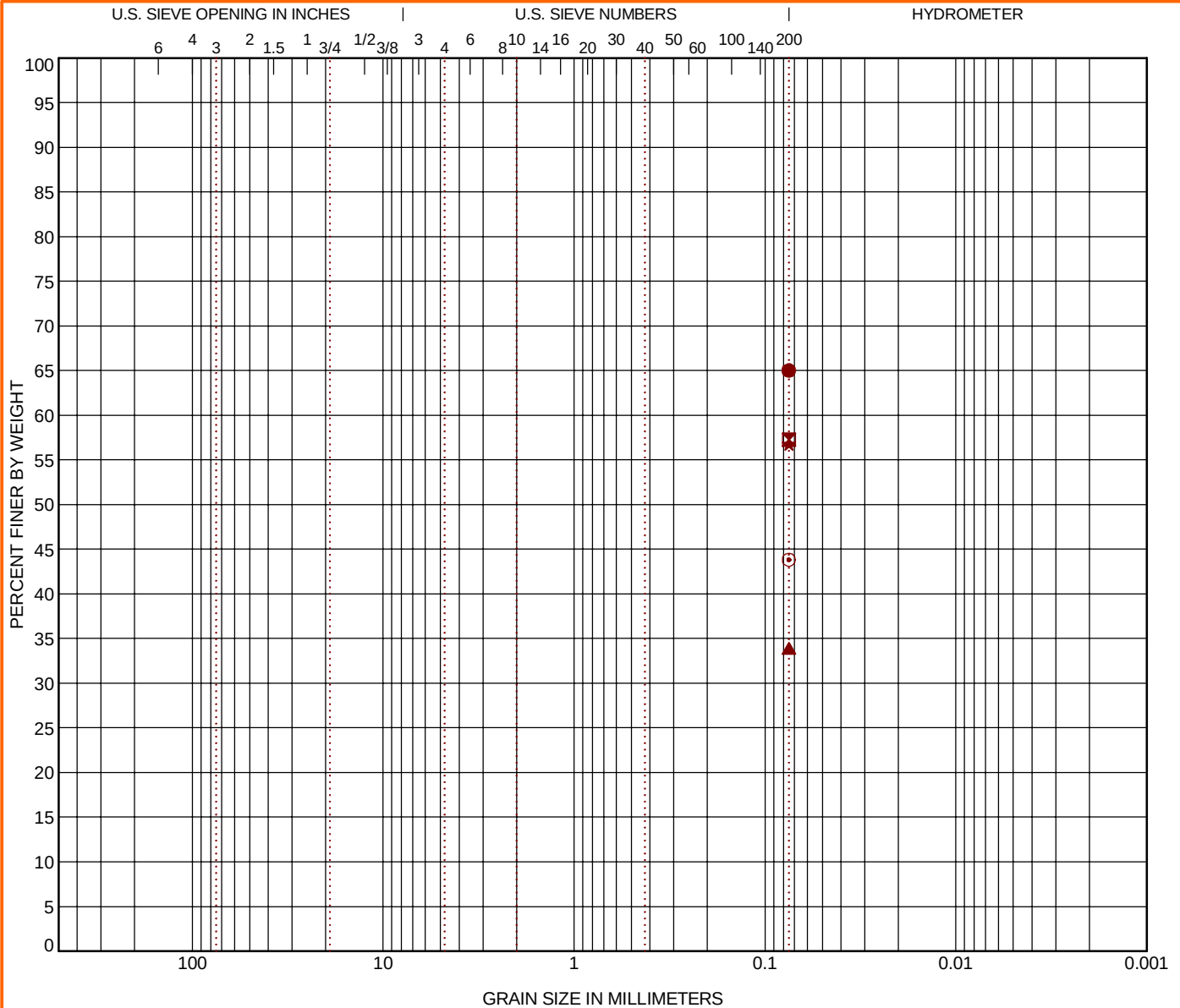
PROJECT NUMBER: Lithos Project No. 21152

CLIENT: Lithos Engineering
Fort Collins, CO

GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GRAIN SIZE: USCS-2 20215009 MISC LAB TESTING .GPJ TERRACON_DATATEMPLATE.GDT 1/14/22



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Boring ID	Depth	USCS Classification				WC (%)	LL	PL	PI	Cc	Cu
● LE-OC-20	4 - 5					9.4					
⊠ LE-OC-22	4 - 5	SANDY LEAN CLAY (CL)				12.6	25	14	11		
▲ LE-OC-24	4 - 5					5.4					
★ LE-OC-26	4 - 5	SANDY LEAN CLAY (CL)				8.6	26	14	12		
⊙ LE-OC-29	4 - 5	CLAYEY SAND (SC)				6.4	29	13	16		
Boring ID	Depth	D ₁₀₀	D ₆₀	D ₃₀	D ₁₀	%Cobbles	%Gravel	%Sand	%Silt	%Fines	%Clay
● LE-OC-20	4 - 5	0.075								65.0	
⊠ LE-OC-22	4 - 5	0.075								57.3	
▲ LE-OC-24	4 - 5	0.075								33.9	
★ LE-OC-26	4 - 5	0.075								56.8	
⊙ LE-OC-29	4 - 5	0.075								43.8	

PROJECT: Mesa Verde Pipeline

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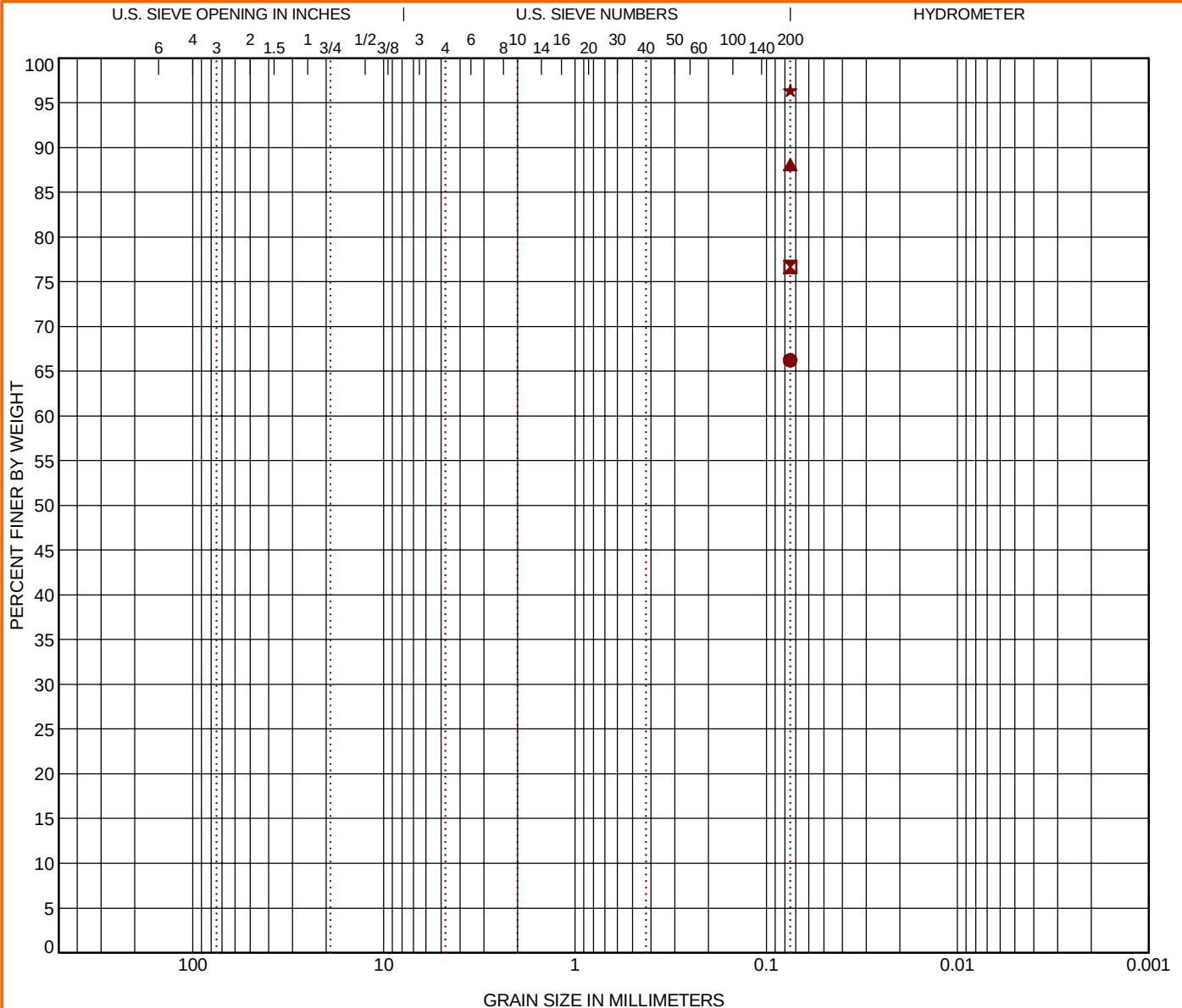
PROJECT NUMBER: Lithos Project No. 21152

CLIENT: Lithos Engineering
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GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GRAIN SIZE: USCS-2 20215009 MISC LAB TESTING .GPJ TERRACON_DATATEMPLATE.GDT 1/14/22



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Boring ID	Depth	USCS Classification	WC (%)	LL	PL	PI	Cc	Cu
● LE-OC-43	4 - 5	SANDY LEAN CLAY (CL)	8.0	34	15	19		
◻ LE-OC-44	4 - 5	LEAN CLAY with SAND (CL)	13.7	27	14	13		
▲ LE-OC-44	9 - 10	LEAN CLAY (CL)	21.0	42	17	25		
★ LE-OC-45	4 - 5	LEAN CLAY (CL)	8.6	35	15	20		

Boring ID	Depth	D ₁₀₀	D ₆₀	D ₃₀	D ₁₀	%Cobbles	%Gravel	%Sand	%Silt	%Fines	%Clay
● LE-OC-43	4 - 5	0.075								66.2	
◻ LE-OC-44	4 - 5	0.075								76.7	
▲ LE-OC-44	9 - 10	0.075								88.1	
★ LE-OC-45	4 - 5	0.075								96.4	

PROJECT: Mesa Verde Pipeline

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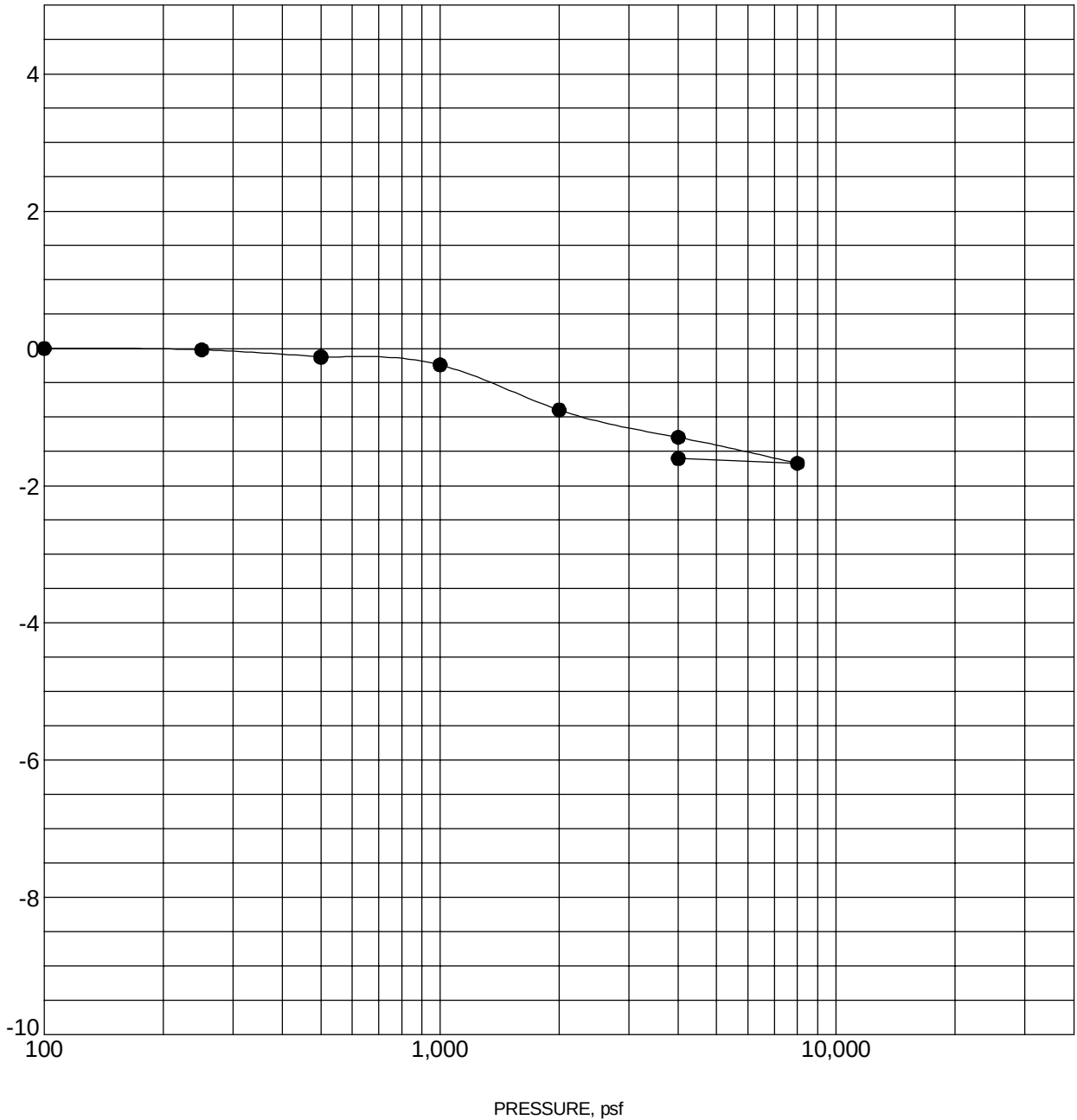
PROJECT NUMBER: Lithos Project No. 21152

CLIENT: Lithos Engineering
Fort Collins, CO

SWELL CONSOLIDATION TEST
ASTM D4546

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. TC_CONSOL_STRAIN-USCS 20215009 MISC LAB TESTING.GPJ TERRACON_DATATEMPLATE.GDT 1/14/22

AXIAL STRAIN, %



Specimen Identification	Classification	γ_d , pcf	WC, %
● LE-OC-02 9 - 10 ft	LEAN CLAY with SAND(CL)	112	16.5

NOTES: Sample exhibited no movement upon wetting under an applied pressure of 500 psf.

PROJECT: Mesa Verde Pipeline

SITE: 1901 Sharp Point Drive
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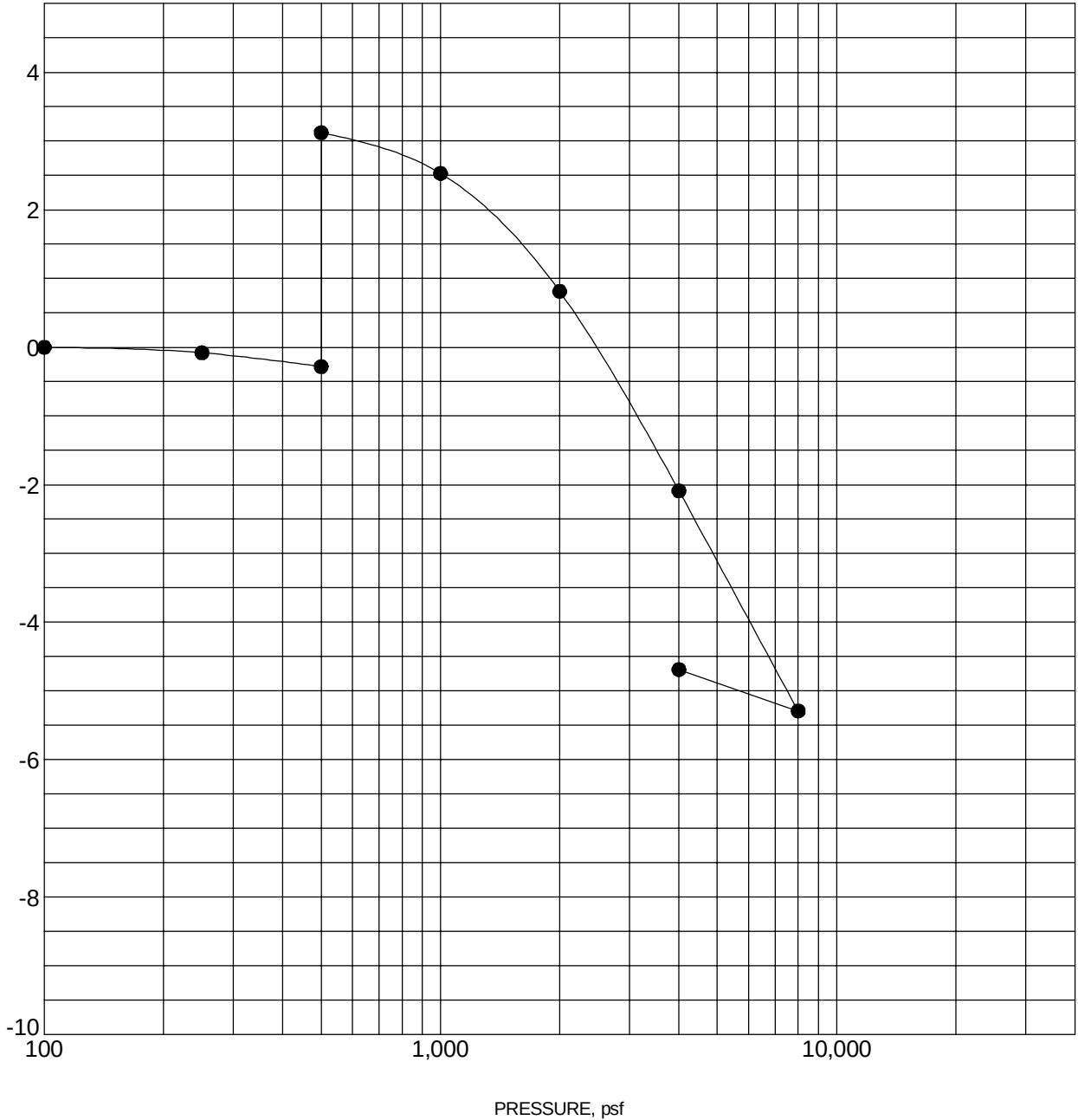
PROJECT NUMBER: Lithos Project No. 21152

CLIENT: Lithos Engineering
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SWELL CONSOLIDATION TEST
ASTM D4546

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. TC_CONSOL_STRAIN-USCS 20215009 MISC LAB TESTING .GPJ TERRACON_DATATEMPLATE.GDT 1/14/22

AXIAL STRAIN, %



Specimen Identification		Classification	γ_d , pcf	WC, %
●	LE-OC-14 4 - 5 ft	SANDY LEAN CLAY(CL)	120	6.3

NOTES: Sample exhibited 3.4 percent swell upon wetting under an applied pressure of 150 psf.

PROJECT: Mesa Verde Pipeline

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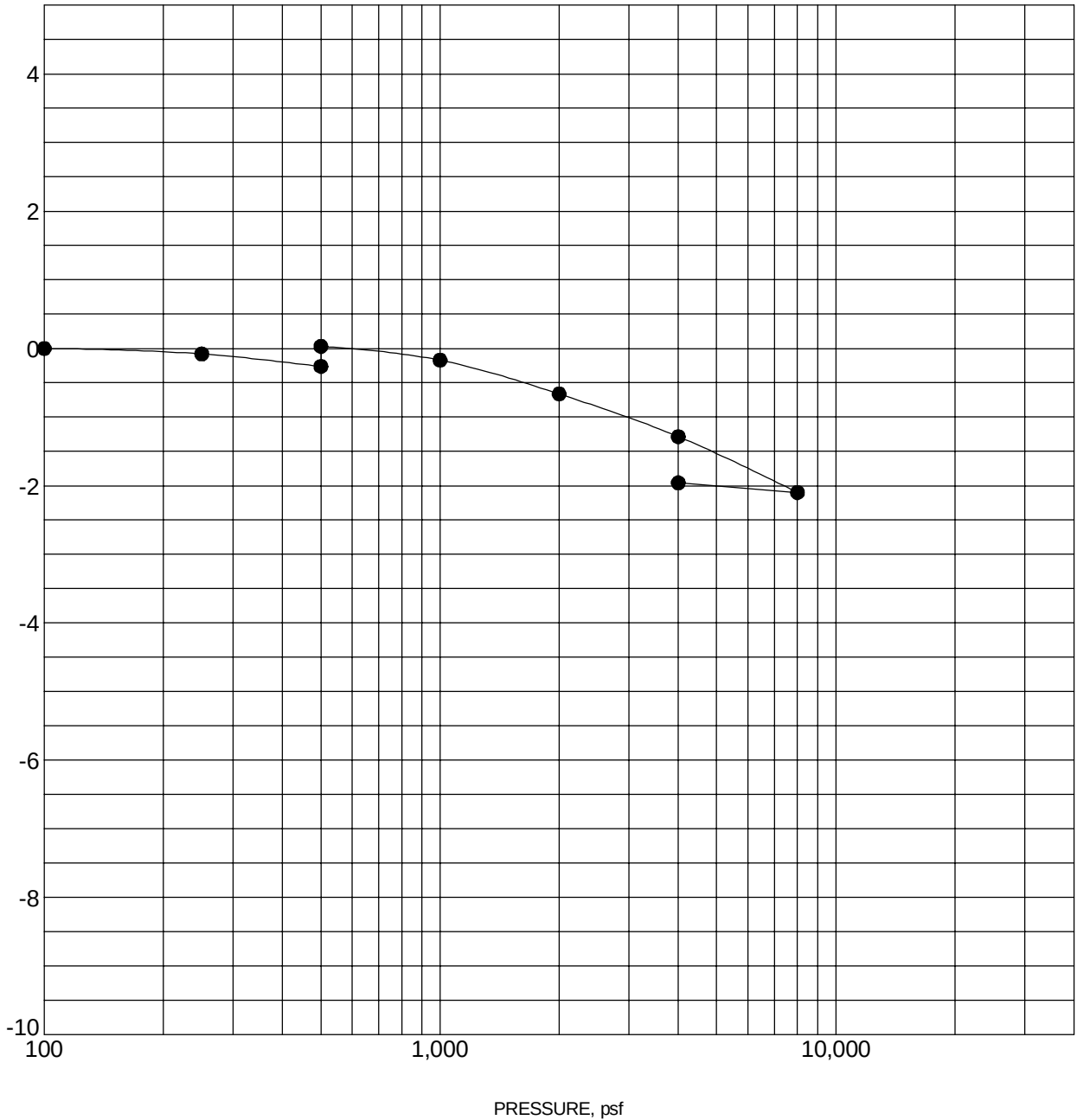
PROJECT NUMBER: Lithos Project No. 21152

CLIENT: Lithos Engineering
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SWELL CONSOLIDATION TEST
ASTM D4546

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. TC_CONSOL_STRAIN-USCS 20215009 MISC LAB TESTING.GPJ TERRACON_DATATEMPLATE.GDT 1/14/22

AXIAL STRAIN, %



Specimen Identification		Classification	γ_d , pcf	WC, %
●	LE-OC-44 4 - 5 ft	LEAN CLAY with SAND(CL)	119	13.7

NOTES: Sample exhibited 0.2 percent swell upon wetting under an applied pressure of 500 psf.

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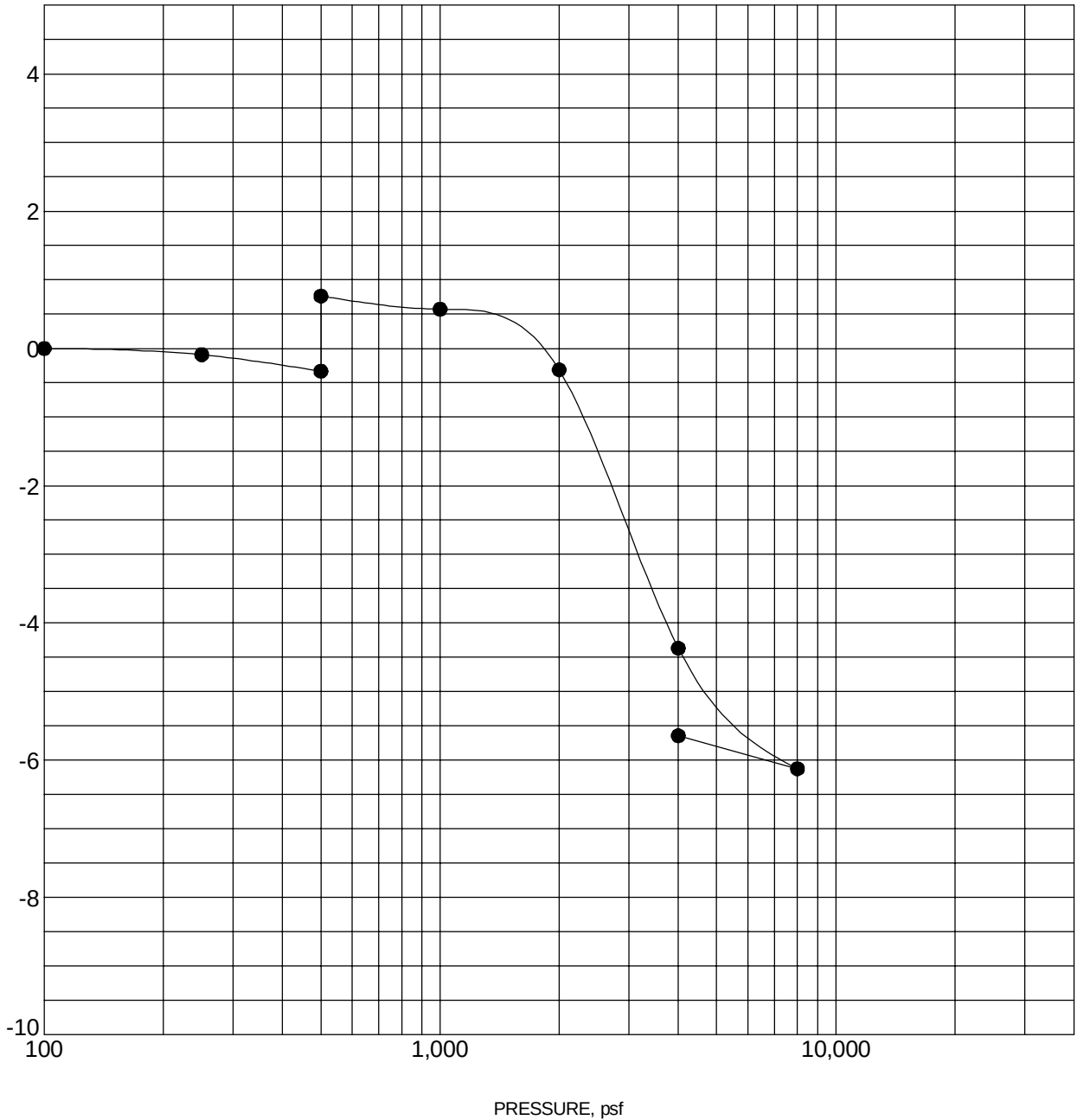
PROJECT NUMBER: Lithos Project No. 21152

CLIENT: Lithos Engineering
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SWELL CONSOLIDATION TEST
ASTM D4546

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AXIAL STRAIN, %



Specimen Identification		Classification	γ_d , pcf	WC, %
●	LE-OC-44 9 - 10 ft	LEAN CLAY(CL)	104	21.0

NOTES: Sample exhibited 1.1 percent swell upon wetting under an applied pressure of 500 psf.

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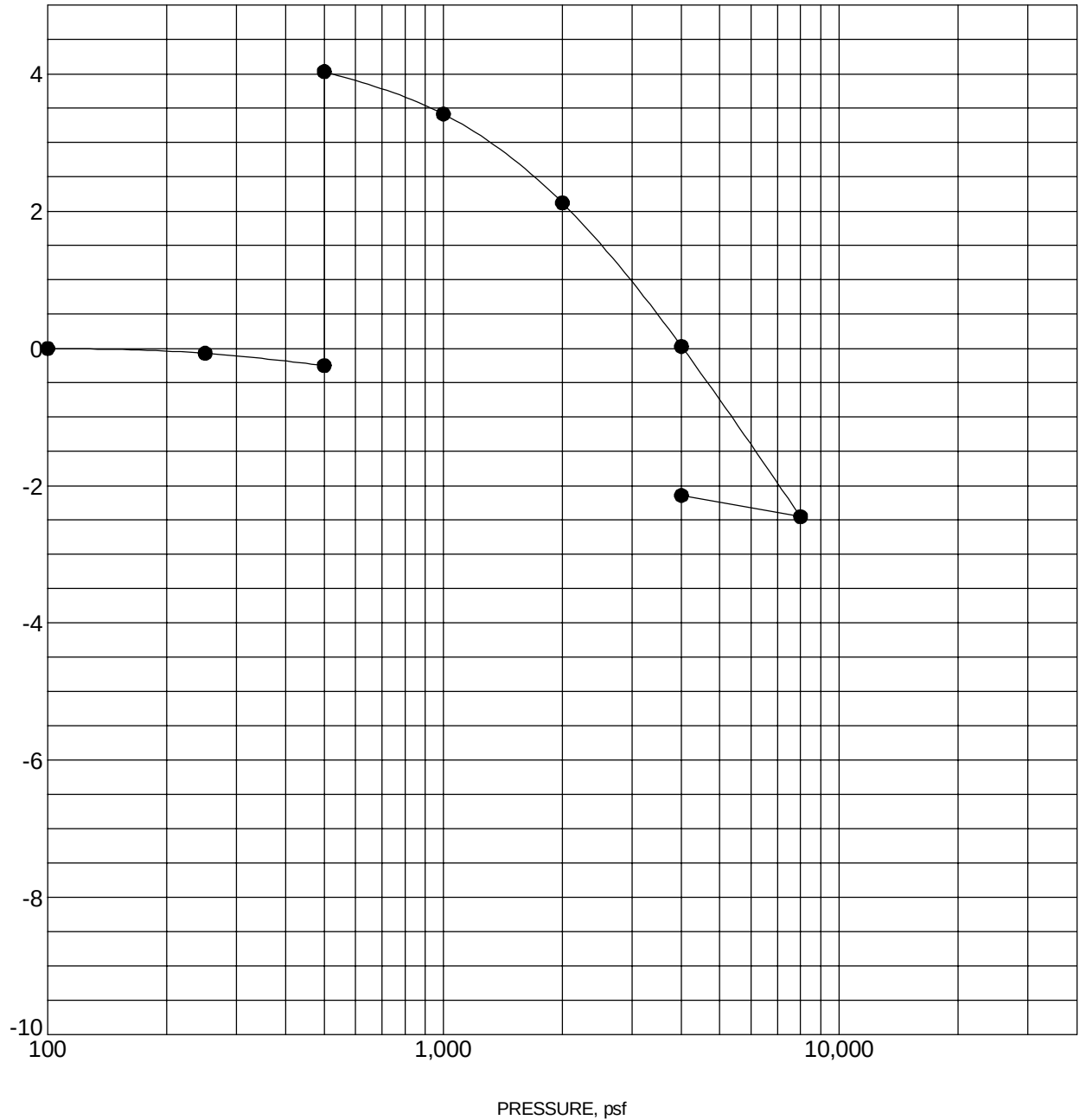
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SWELL CONSOLIDATION TEST
ASTM D4546

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. TC_CONSOL_STRAIN-USCS 20215009 MISC LAB TESTING.GPJ TERRACON_DATATEMPLATE.GDT 1/14/22

AXIAL STRAIN, %



Specimen Identification	Classification	γ_d , pcf	WC, %
● LE-OC-45 4 - 5 ft	LEAN CLAY(CL)	117	8.6

NOTES: Sample exhibited 4.3 percent swell upon wetting under an applied pressure of 500 psf.

PROJECT: Mesa Verde Pipeline

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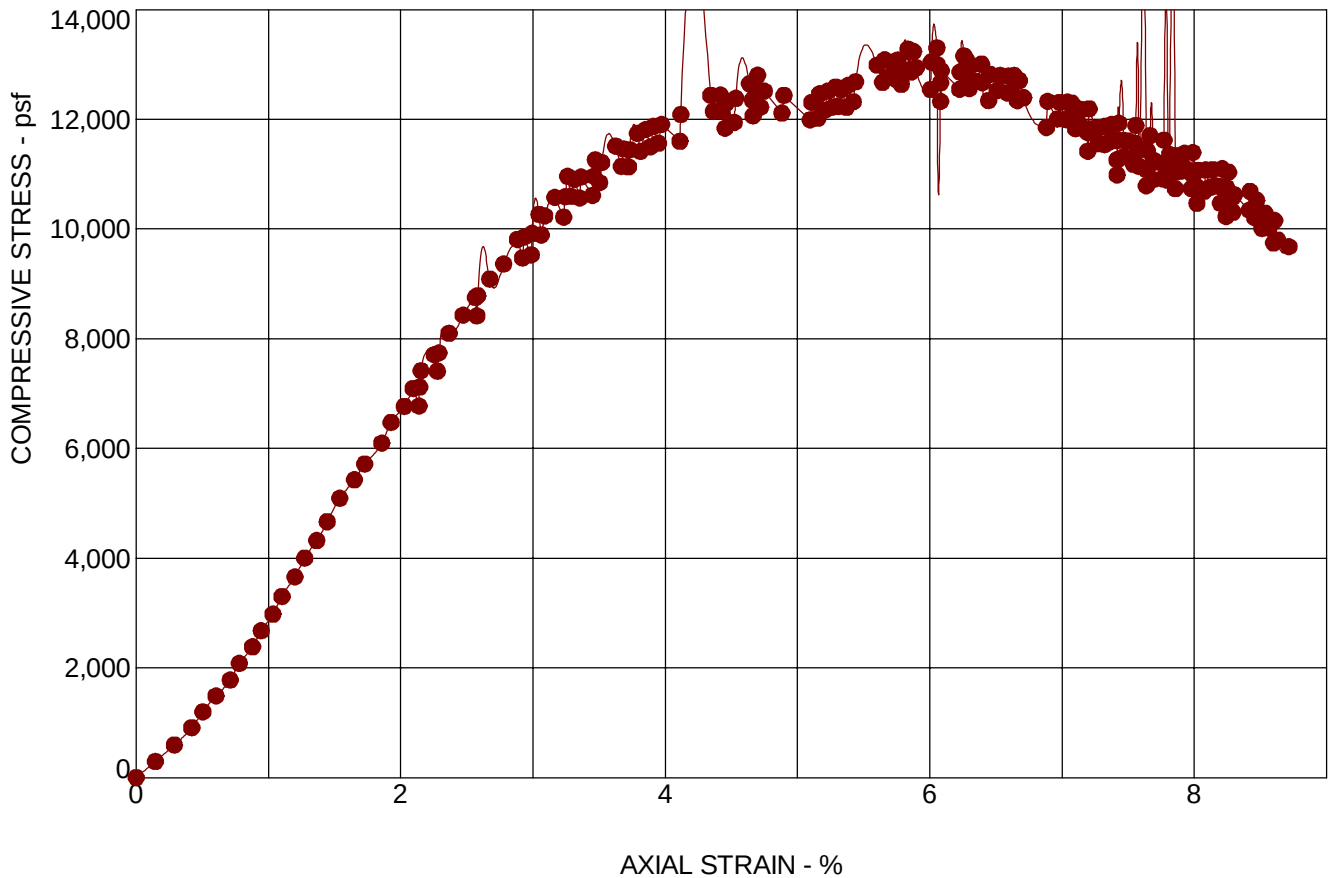


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UNCONFINED COMPRESSION TEST

ASTM D2166



SPECIMEN FAILURE PHOTOGRAPH



SPECIMEN TEST DATA

Moisture Content:	%	9.7
Dry Density:	pcf	109
Diameter:	in.	1.94
Height:	in.	3.85
Height / Diameter Ratio:		1.98
Calculated Saturation:	%	49.06
Calculated Void Ratio:		0.52
Assumed Specific Gravity:		2.65
Failure Strain:	%	6.05
Unconfined Compressive Strength	(psf)	13301
Undrained Shear Strength:	(psf)	6650
Strain Rate:	in/min	0.0800
Remarks:		

SAMPLE TYPE: CARS

SAMPLE LOCATION: LE-HDD-11 @ 4 - 5 feet

DESCRIPTION:

LL

PL

PI

Percent < #200 Sieve

PROJECT: Mesa Verde Pipeline

PROJECT NUMBER: Lithos Project No. 21152

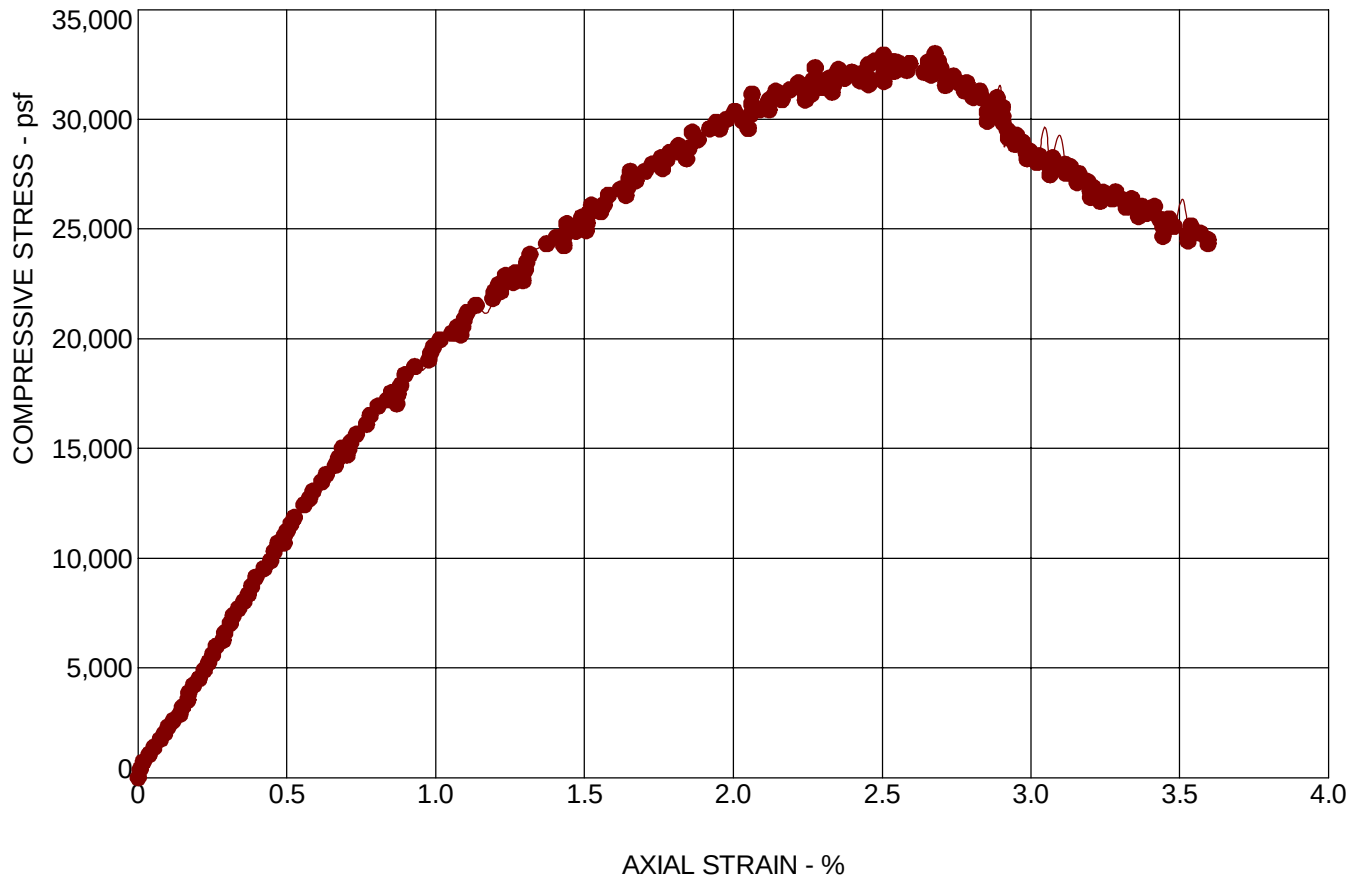
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UNCONFINED COMPRESSION TEST

ASTM D2166



SPECIMEN FAILURE PHOTOGRAPH



SPECIMEN TEST DATA

Moisture Content:	%	8.4
Dry Density:	pcf	122
Diameter:	in.	1.94
Height:	in.	4.00
Height / Diameter Ratio:		2.06
Calculated Saturation:	%	63.09
Calculated Void Ratio:		0.35
Assumed Specific Gravity:		2.65
Failure Strain:	%	2.68
Unconfined Compressive Strength	(psf)	32988
Undrained Shear Strength:	(psf)	16494
Strain Rate:	in/min	0.0800
Remarks:		

SAMPLE TYPE: CARS

SAMPLE LOCATION: LE-HDD-11 @ 9 - 10 feet

DESCRIPTION: LEAN CLAY with SAND(CL)

LL
32

PL
15

PI
17

Percent < #200 Sieve
75.1

PROJECT: Mesa Verde Pipeline

PROJECT NUMBER: Lithos Project No. 21152

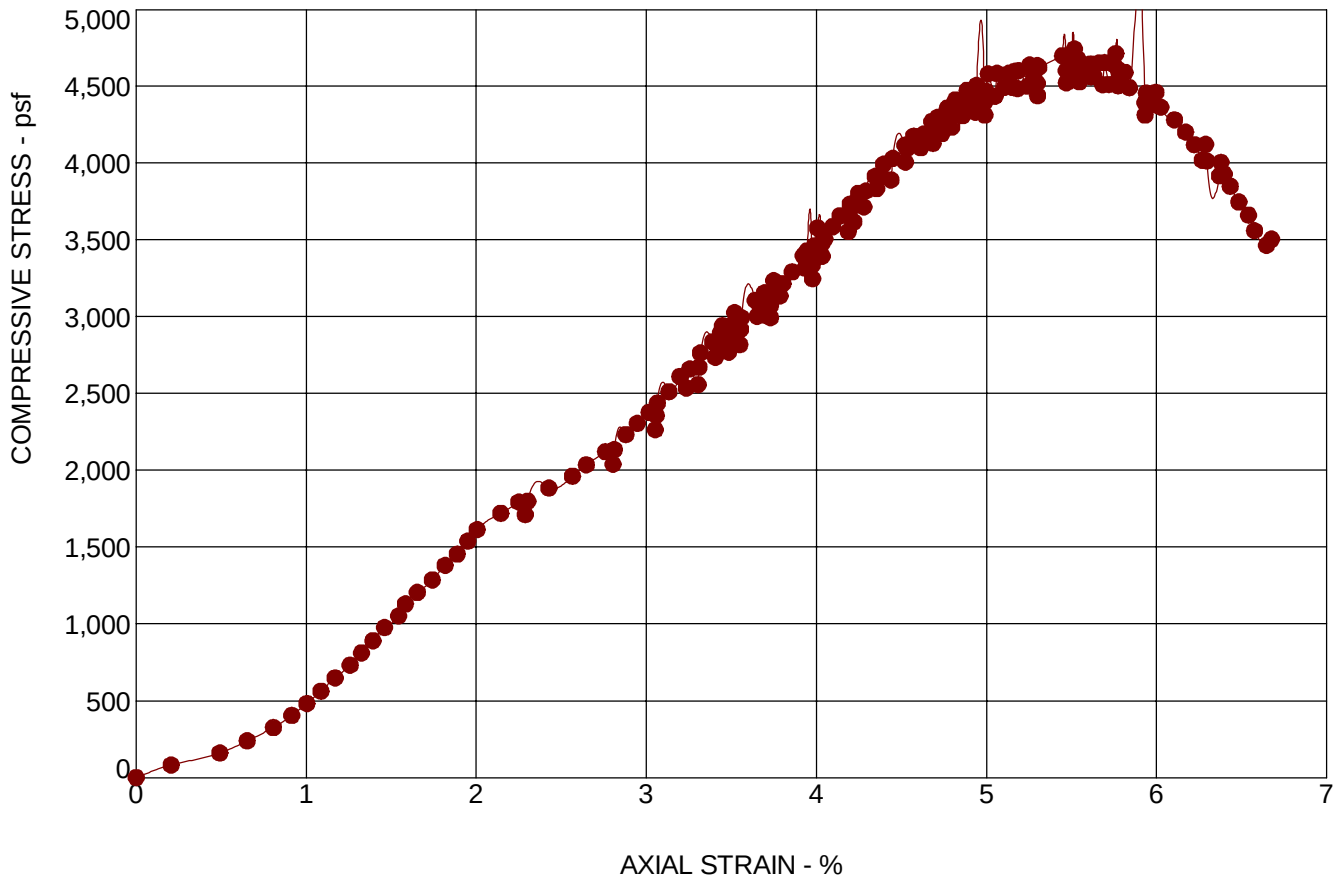
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UNCONFINED COMPRESSION TEST

ASTM D2166



SPECIMEN FAILURE PHOTOGRAPH



SPECIMEN TEST DATA

Moisture Content:	%	7.4
Dry Density:	pcf	100
Diameter:	in.	1.93
Height:	in.	3.39
Height / Diameter Ratio:		1.75
Calculated Saturation:	%	30.02
Calculated Void Ratio:		0.65
Assumed Specific Gravity:		2.65
Failure Strain:	%	5.52
Unconfined Compressive Strength	(psf)	4744
Undrained Shear Strength:	(psf)	2372
Strain Rate:	in/min	0.0800
Remarks:		

SAMPLE TYPE: CARS

SAMPLE LOCATION: LE-OC-01 @ 4 - 5 feet

DESCRIPTION: LEAN CLAY(CL)

LL

PL

PI

Percent < #200 Sieve

30

16

14

90.5

PROJECT: Mesa Verde Pipeline

PROJECT NUMBER: Lithos Project No. 21152

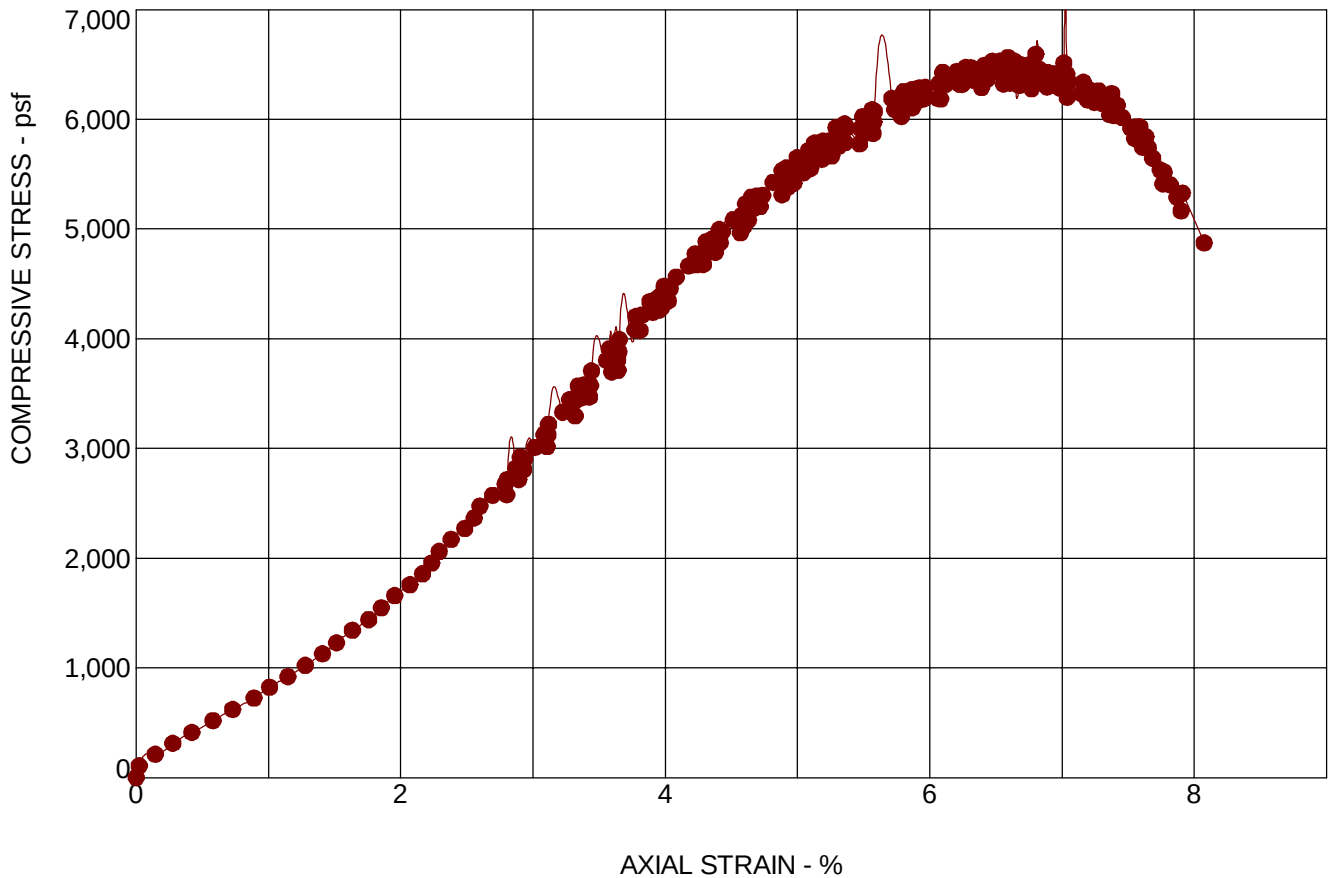
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Fort Collins, CO

UNCONFINED COMPRESSION TEST

ASTM D2166



SPECIMEN FAILURE PHOTOGRAPH



SPECIMEN TEST DATA

Moisture Content:	%	12.6
Dry Density:	pcf	116
Diameter:	in.	1.93
Height:	in.	3.96
Height / Diameter Ratio:		2.05
Calculated Saturation:	%	
Calculated Void Ratio:		
Assumed Specific Gravity:		
Failure Strain:	%	6.80
Unconfined Compressive Strength	(psf)	6593
Undrained Shear Strength:	(psf)	3296
Strain Rate:	in/min	0.0800
Remarks:		

SAMPLE TYPE: CARS

SAMPLE LOCATION: LE-OC-12 @ 9 - 10 feet

DESCRIPTION:

LL

PL

PI

Percent < #200 Sieve

PROJECT: Mesa Verde Pipeline

PROJECT NUMBER: Lithos Project No. 21152

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Fort Collins, CO

MOISTURE-DENSITY RELATIONSHIP

ASTM D698/D1557

Source of Material S-1 @ 0 - 5 feet

Description of Material _____

Remarks: _____

Test Method ASTM D698 Method B

TEST RESULTS

Maximum Dry Density 109.3 PCF

Optimum Water Content 17.2 %

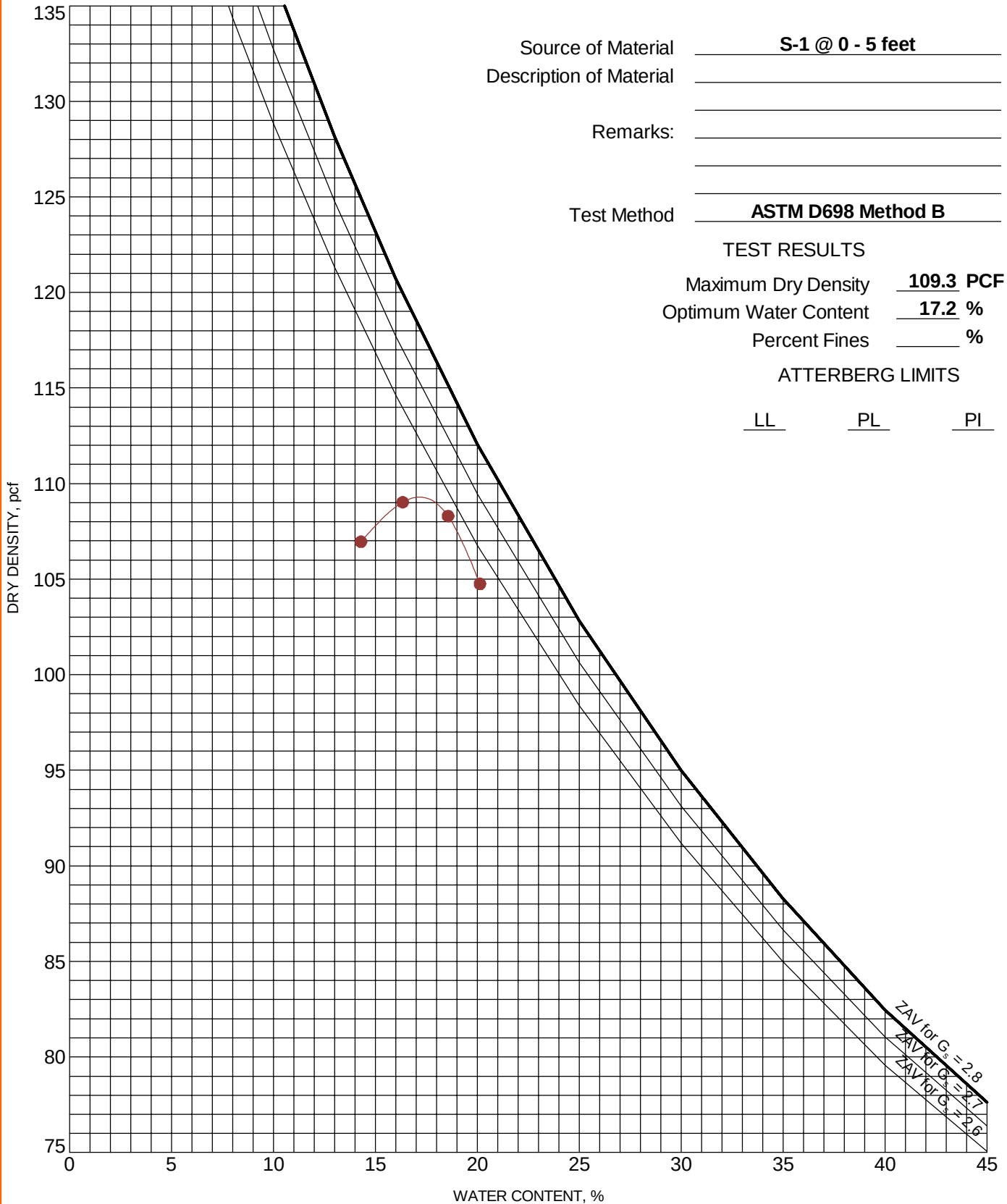
Percent Fines _____ %

ATTERBERG LIMITS

LL

PL

PI



PROJECT: Mesa Verde Pipeline

SITE: 1901 Sharp Point Drive
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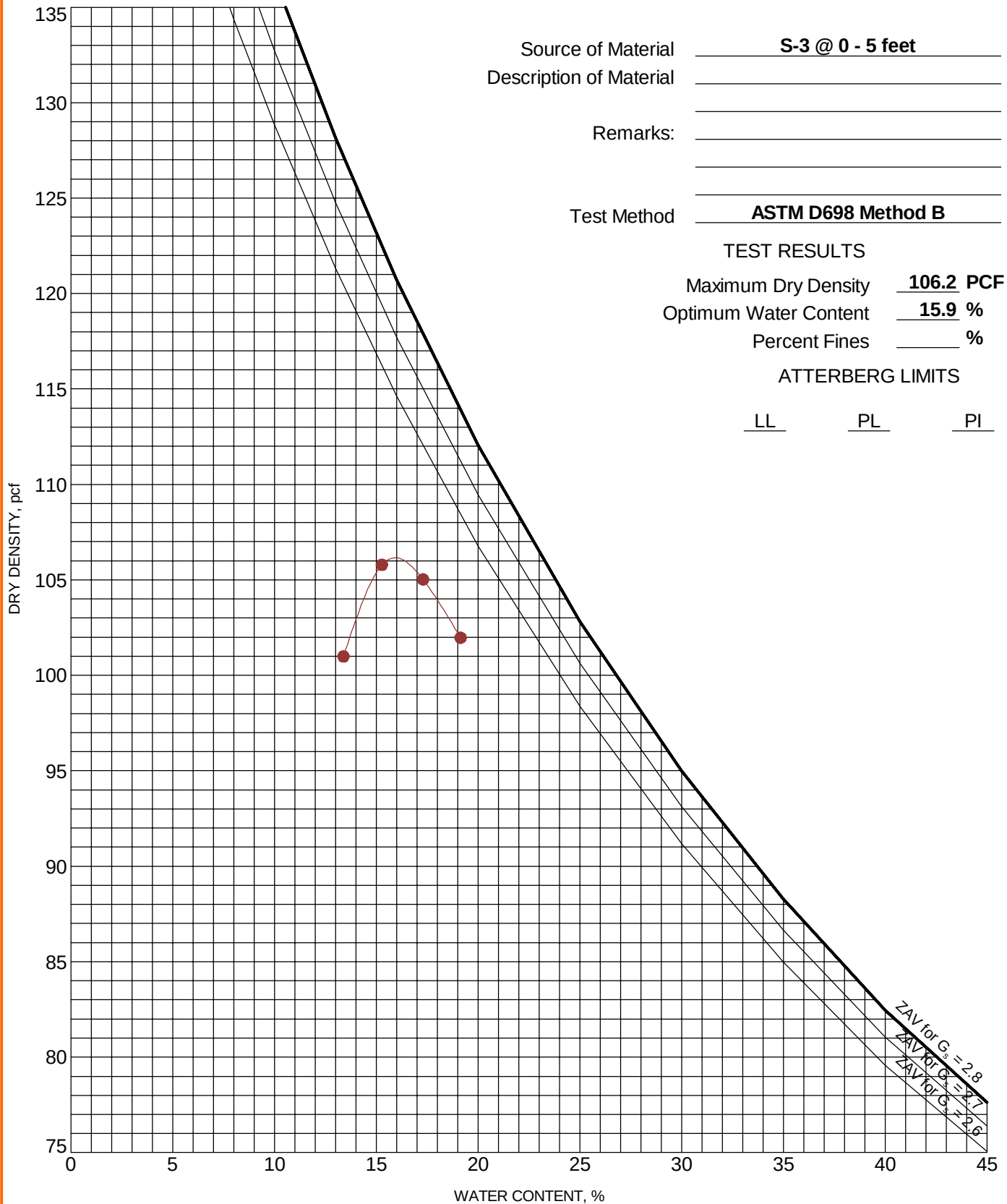
PROJECT NUMBER: Lithos Project No. 21152

CLIENT: Lithos Engineering
Fort Collins, CO

MOISTURE-DENSITY RELATIONSHIP

ASTM D698/D1557

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. COMPACTION - V2 20215009 MISC LAB TESTING_CHATTANOOGA.GPJ TERRACON_DATATEMPLATE.GDT 1/18/22



Source of Material S-3 @ 0 - 5 feet
Description of Material _____
Remarks: _____
Test Method ASTM D698 Method B

TEST RESULTS

Maximum Dry Density 106.2 PCF
Optimum Water Content 15.9 %
Percent Fines _____ %

ATTERBERG LIMITS

LL PL PI

PROJECT: Mesa Verde Pipeline

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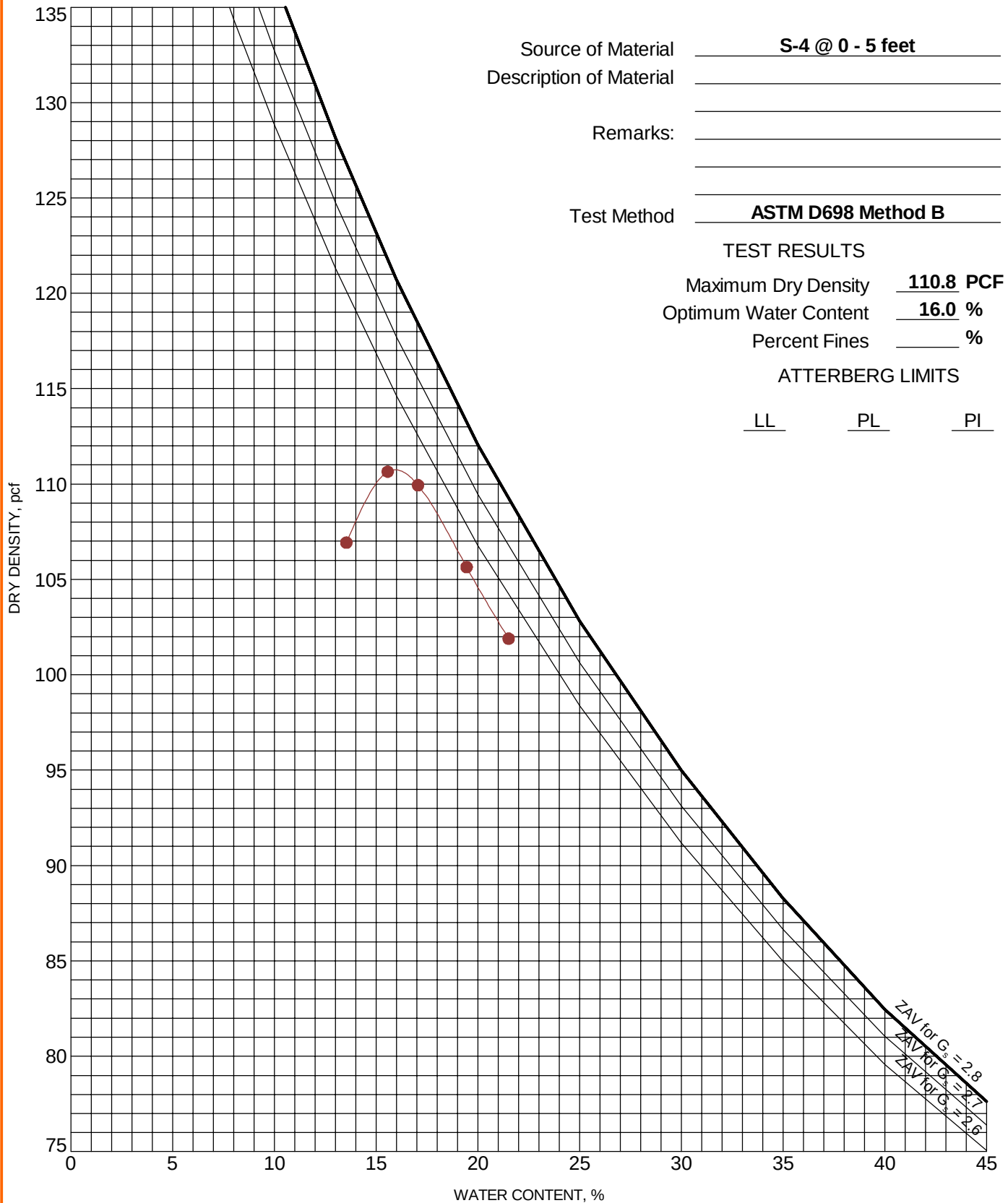
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CLIENT: Lithos Engineering
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MOISTURE-DENSITY RELATIONSHIP

ASTM D698/D1557

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Source of Material S-4 @ 0 - 5 feet
Description of Material _____
Remarks: _____
Test Method ASTM D698 Method B

TEST RESULTS

Maximum Dry Density 110.8 PCF
Optimum Water Content 16.0 %
Percent Fines _____ %

ATTERBERG LIMITS

LL PL PI

PROJECT: Mesa Verde Pipeline

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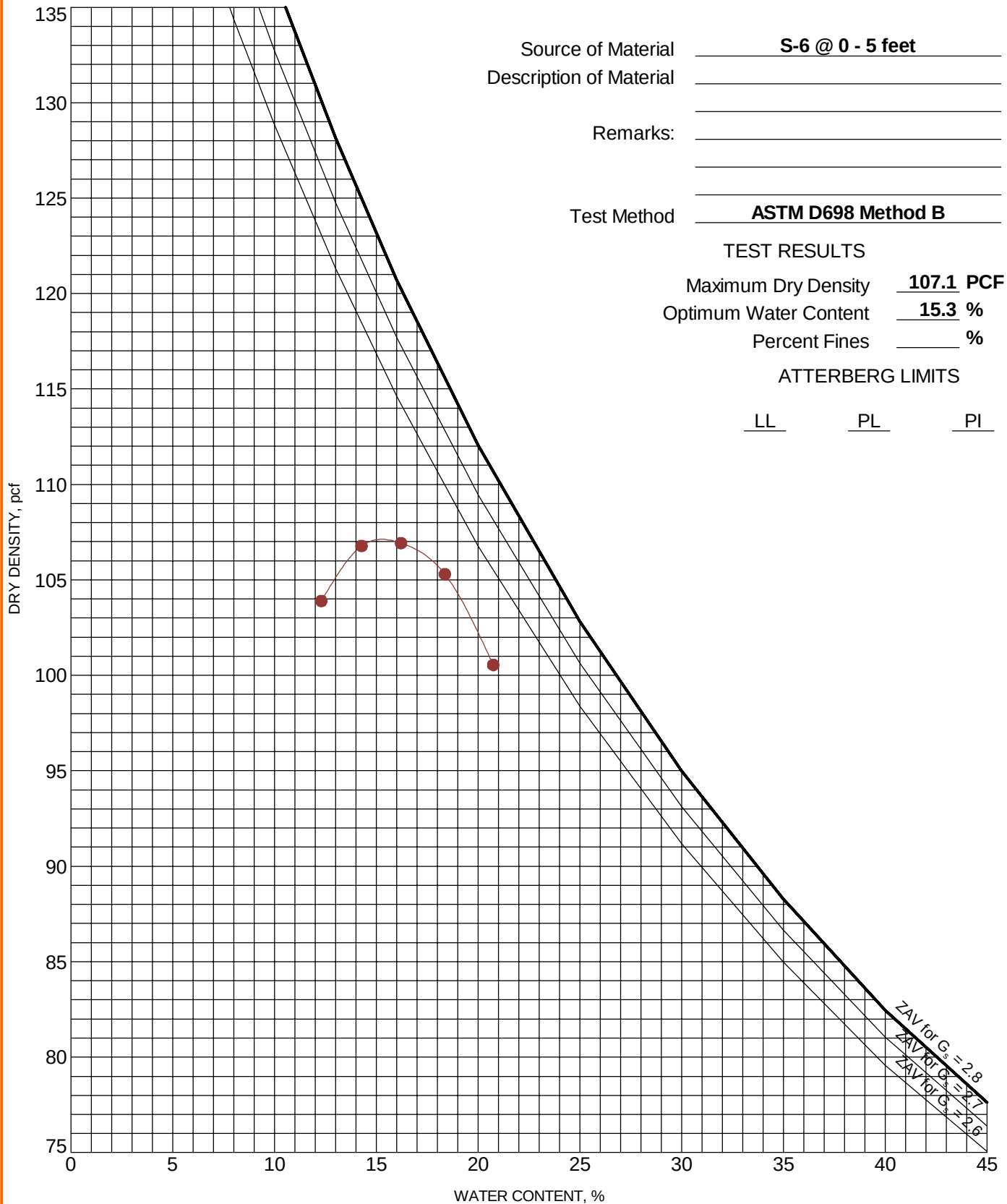
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MOISTURE-DENSITY RELATIONSHIP

ASTM D698/D1557

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Source of Material S-6 @ 0 - 5 feet
Description of Material _____
Remarks: _____
Test Method ASTM D698 Method B

TEST RESULTS

Maximum Dry Density 107.1 PCF
Optimum Water Content 15.3 %
Percent Fines _____ %

ATTERBERG LIMITS

LL PL PI

PROJECT: Mesa Verde Pipeline

SITE: 1901 Sharp Point Drive
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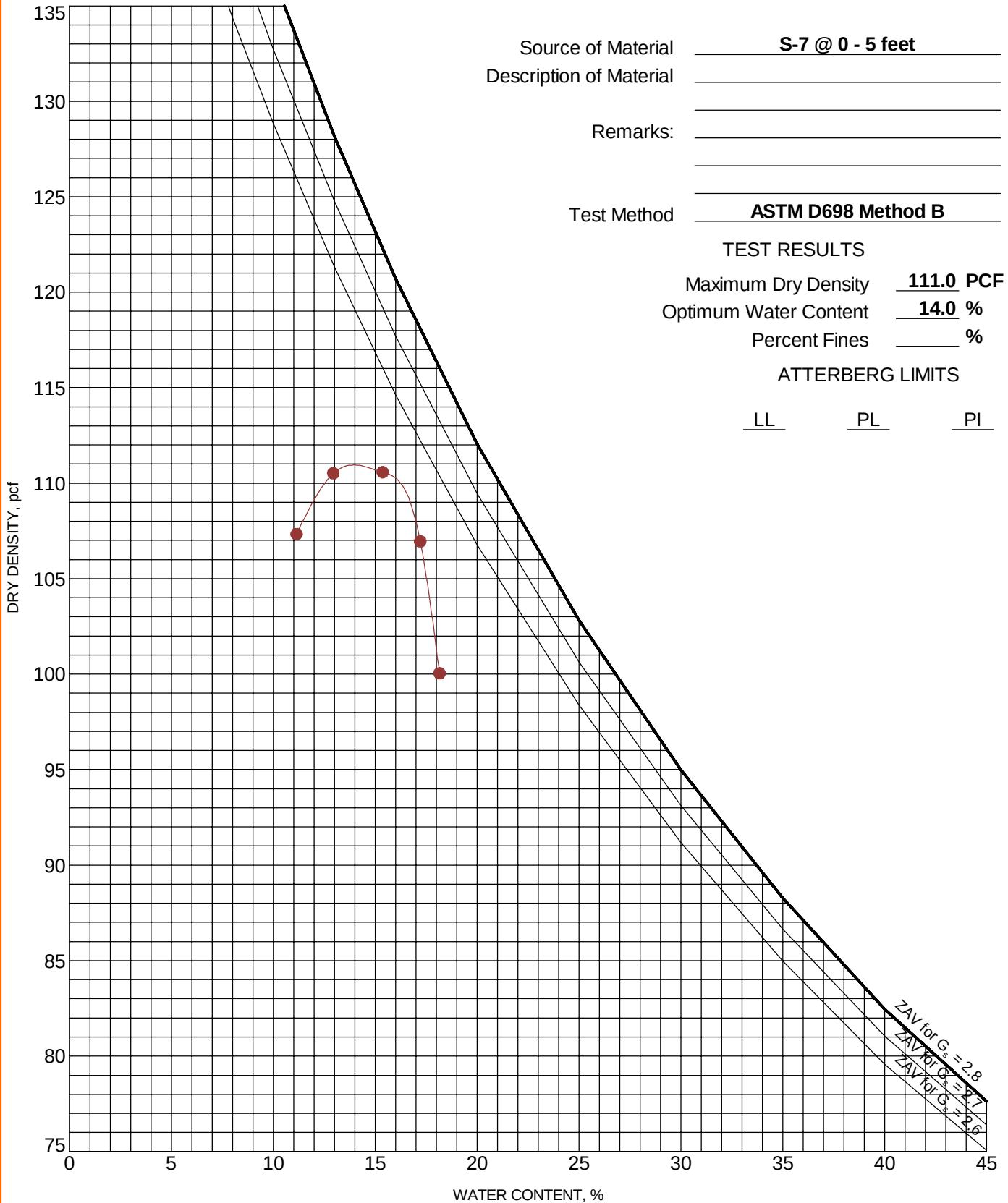
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MOISTURE-DENSITY RELATIONSHIP

ASTM D698/D1557

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PROJECT: Mesa Verde Pipeline

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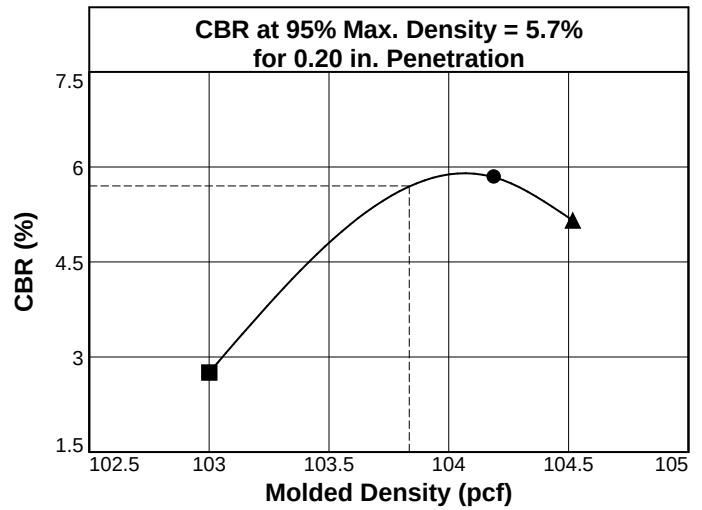
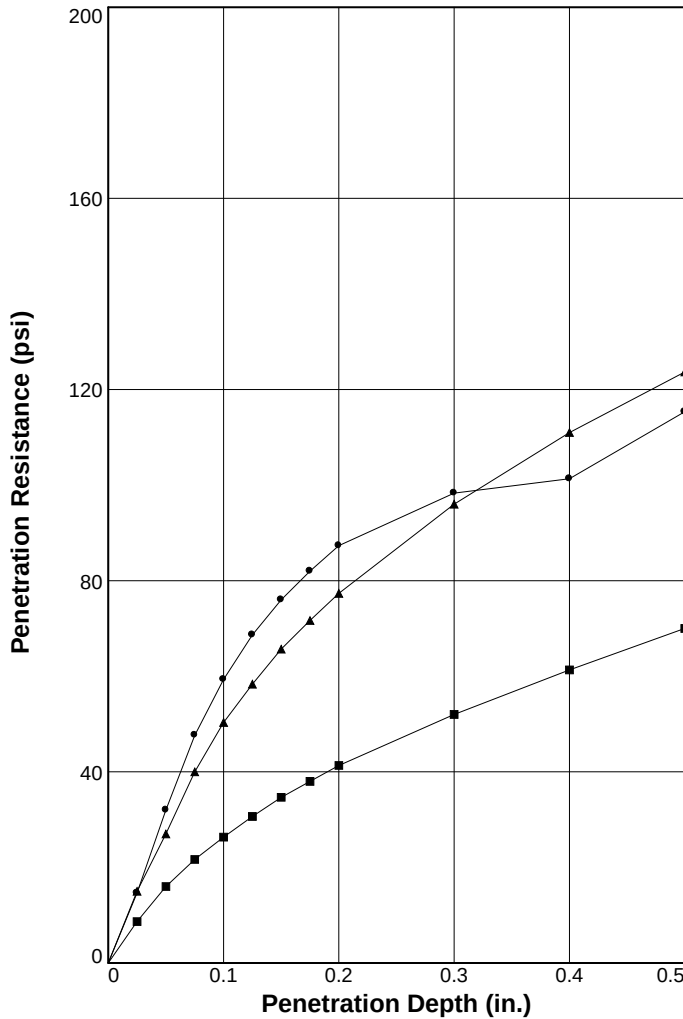
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PROJECT NUMBER: Lithos Project No. 21152

CLIENT: Lithos Engineering
Fort Collins, CO

BEARING RATIO TEST REPORT

ASTM D1883-16



	Molded			Soaked			CBR (%)		Linearity Correction (in.)	Surcharge (lbs.)	Max. Swell (%)
	Density (pcf)	Percent of Max. Dens.	Moisture (%)	Density (pcf)	Percent of Max. Dens.	Moisture (%)	0.10 in.	0.20 in.			
1 ○	104.2	95.3	15.0	103.1	94.3	18.6	6.0	5.8	0.002	10	1.1
2 △	104.5	95.6	16.5	104.0	95.1	19.4	5.0	5.2	0.000	10	0.5
3 □	103.0	94.2	19.1	102.4	93.7	20.4	2.6	2.8	0.000	10	0.6

Material Description		USCS	Max. Dens. (pcf)	Optimum Moisture (%)	LL	PI
Dark Brown Clay						

Project No: 20215009

Project: Mesa Verde Pipeline

Source of Sample: Bulk Samples **Depth:** 0.0-5.0 ft

Sample Number: S-1

Date: N/A

Test Description/Remarks:

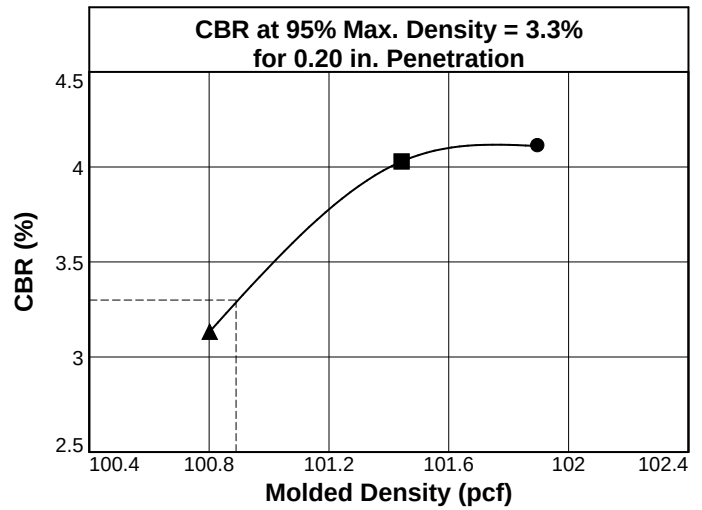
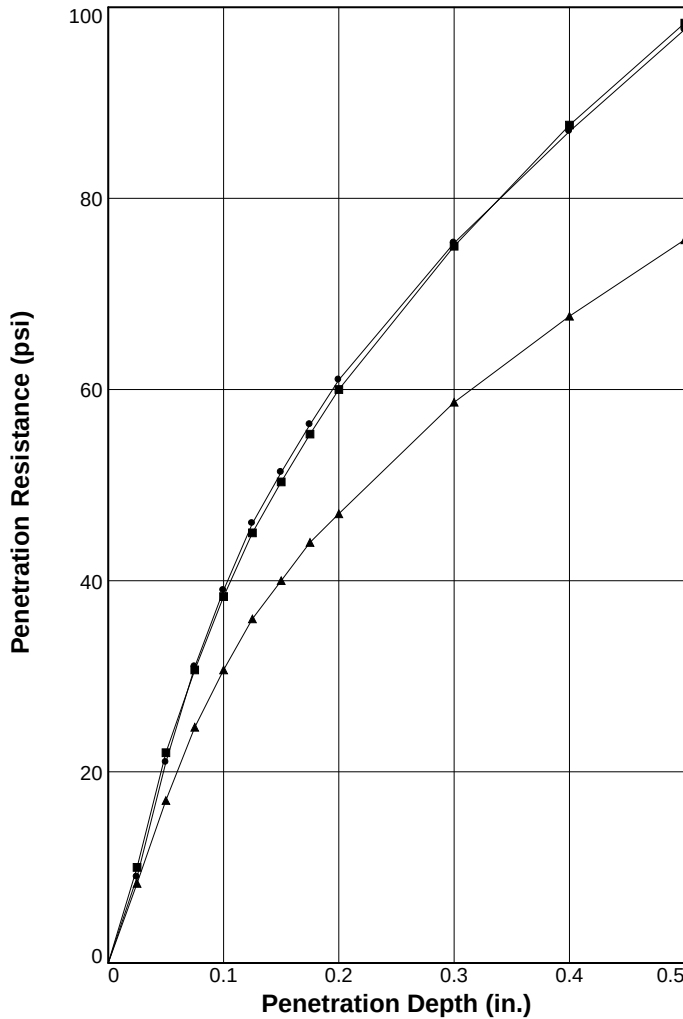
Compaction based on ASTM D698 efforts.

BEARING RATIO TEST REPORT

Terracon Consultants, Inc.

BEARING RATIO TEST REPORT

ASTM D1883-16



	Molded			Soaked			CBR (%)		Linearity Correction (in.)	Surcharge (lbs.)	Max. Swell (%)
	Density (pcf)	Percent of Max. Dens.	Moisture (%)	Density (pcf)	Percent of Max. Dens.	Moisture (%)	0.10 in.	0.20 in.			
1 ○	101.9	96	14.4	100.7	94.8	20.2	4.0	4.1	0.005	10	1.2
2 △	100.8	94.9	15.7	100.0	94.2	20.5	3.1	3.1	0.000	10	0.8
3 □	101.4	95.5	18.2	101.4	95.5	20.2	3.9	4.0	0.003	10	0.1
Material Description							USCS	Max. Dens. (pcf)	Optimum Moisture (%)	LL	PI
Dark Brown Clay							TNP	106.2	15.9	TNP	TNP

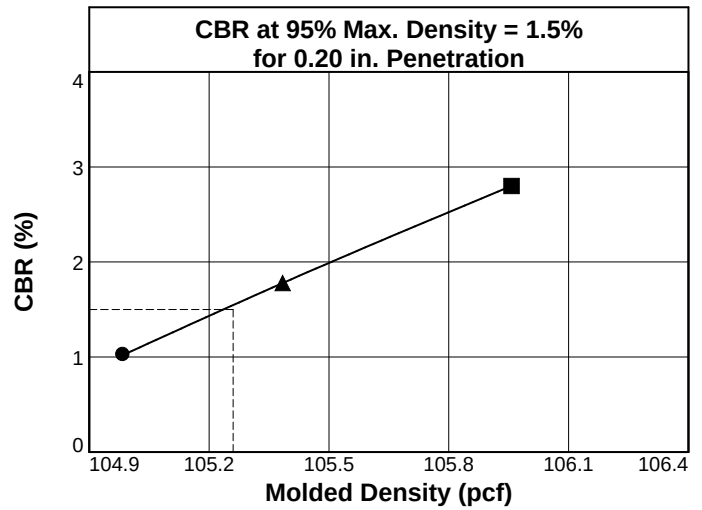
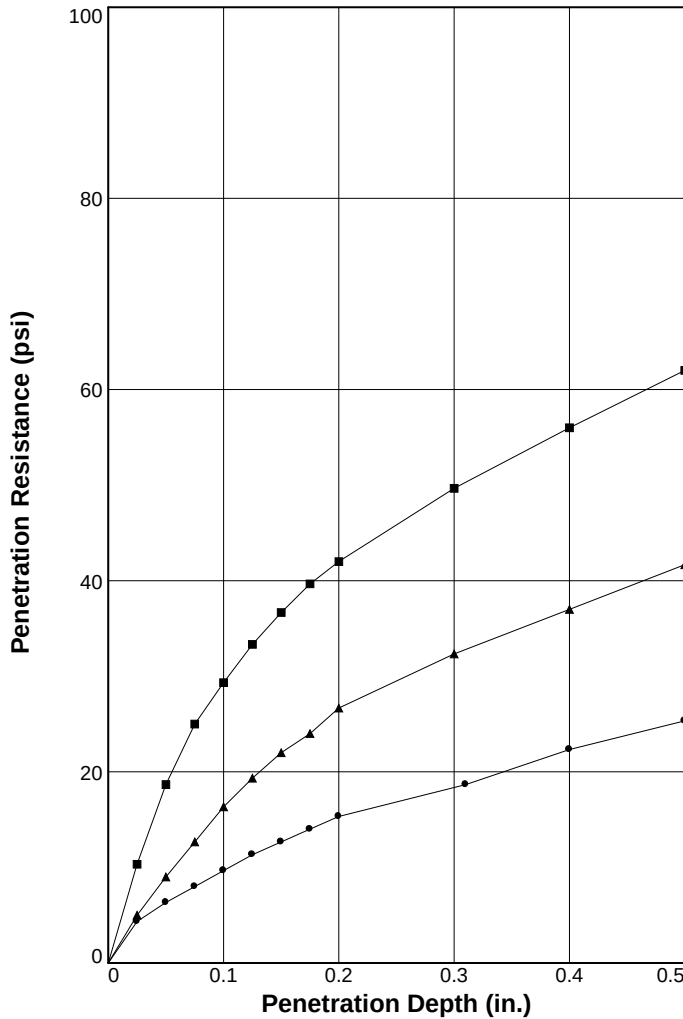
Project No: 20215009
Project: Mesa Verde Pipeline
Source of Sample: Bulk Samples **Depth:** 0.0-5.0 ft
Sample Number: S-3
Date: N/A

Test Description/Remarks:
 Compaction based on ASTM D698 efforts.

BEARING RATIO TEST REPORT
Terracon Consultants, Inc.

BEARING RATIO TEST REPORT

ASTM D1883-16



	Molded			Soaked			CBR (%)		Linearity Correction (in.)	Surcharge (lbs.)	Max. Swell (%)
	Density (pcf)	Percent of Max. Dens.	Moisture (%)	Density (pcf)	Percent of Max. Dens.	Moisture (%)	0.10 in.	0.20 in.			
1 ○	105.0	94.8	13.8	101.8	91.8	21.1	1.0	1.0	0.000	10	3.2
2 △	105.4	95.1	15.5	104.1	94	19.8	1.6	1.8	0.000	10	1.2
3 □	106.0	95.7	17.2	105.4	95.1	19.8	2.9	2.8	0.000	10	0.5

Material Description	USCS	Max. Dens. (pcf)	Optimum Moisture (%)	LL	PI
Light Brown Clay with Gravel					

Project No: 20215009

Project: Mesa Verde Pipeline

Source of Sample: Bulk Samples **Depth:** 0.0-5.0 ft

Sample Number: S-4

Date: N/A

Test Description/Remarks:

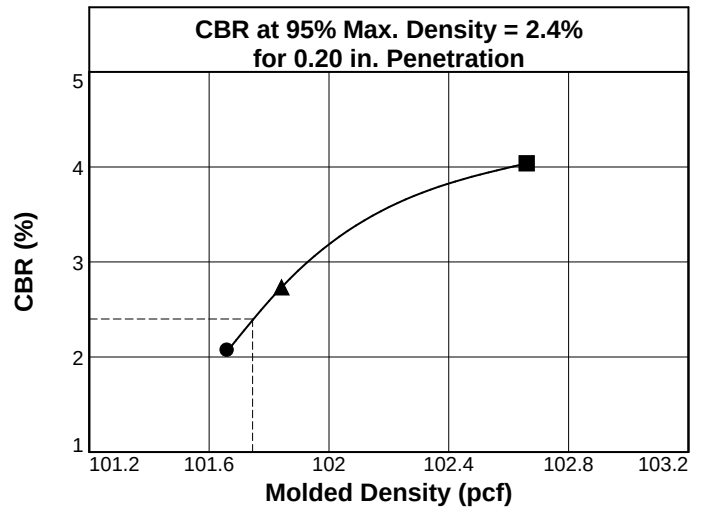
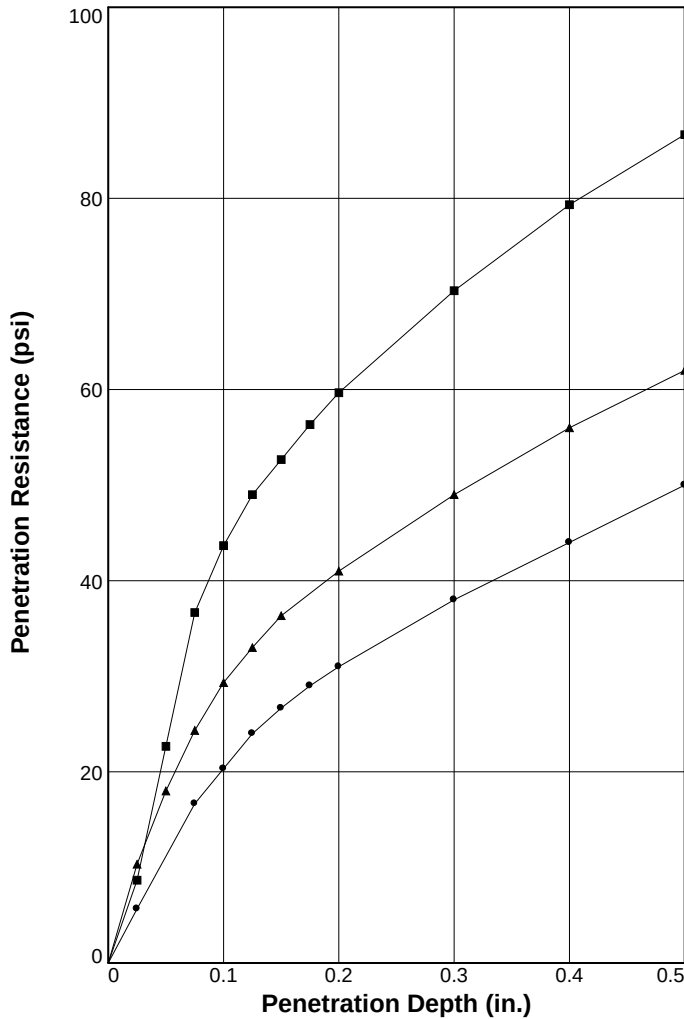
Compaction based on ASTM D698 efforts.

BEARING RATIO TEST REPORT

Terracon Consultants, Inc.

BEARING RATIO TEST REPORT

ASTM D1883-16



	Molded			Soaked			CBR (%)		Linearity Correction (in.)	Surcharge (lbs.)	Max. Swell (%)
	Density (pcf)	Percent of Max. Dens.	Moisture (%)	Density (pcf)	Percent of Max. Dens.	Moisture (%)	0.10 in.	0.20 in.			
1 ○	101.7	95	13.4	99.9	93.3	20.5	2.0	2.1	0.000	10	1.8
2 △	101.8	95.1	15.5	100.4	93.7	20.6	2.9	2.7	0.000	10	1.4
3 □	102.7	95.9	17.6	102.0	95.3	20.2	4.5	4.0	0.008	10	0.6
Material Description							USCS	Max. Dens. (pcf)	Optimum Moisture (%)	LL	PI
Brown Clay							TNP	107.1	15.3	TNP	TNP

Project No: 20215009

Project: Mesa Verde Pipeline

Source of Sample: Bulk Samples **Depth:** 0.0-5.0 ft

Sample Number: S-6

Date: N/A

Test Description/Remarks:

Compaction based on ASTM D698 efforts.

BEARING RATIO TEST REPORT

Terracon Consultants, Inc.

Point Load Strength Index

ASTM D5731 (Axial Shape)

CLIENT	Lithos Engineering			JOB NO.	2962-050
PROJECT	Mesa Verde			LOCATION	--
PROJECT NO.	21152				
BORING NO.	LE-HDD-9-A	LE-HDD-9-A	LE-HDD-9-A	LE-HDD-9-A	
DEPTH	54'3"-54'8"	57'3"-57'8"	63'2"-63'8"	63'2"-63'8"	
SAMPLE NO.					
DATE SAMPLED					
DATE TESTED	07/28/23	07/28/23	07/28/23	07/28/23	
TECHNICIAN	DL	DL	DL	DL	
ROCK TYPE					
Distance Between Platens (in) - D:	1.500	1.232	2.089	1.257	
Minimum Specimen Width (in) - W:	2.392	2.388	2.390	2.391	
Equivalent Core Diameter (in ²) - De ² :	4.568	3.746	6.357	3.827	
Minimum Failure Plane Area (in ²) - A:	3.588	2.942	4.993	3.005	
Maximum Load (lbs):	731	903	925	333	
Uncorrected Point Load Strength Index (psi):	159.9	240.9	145.6	87.1	
Size Correction Factor - F:	1.038	0.992	1.118	0.997	
Direction of Load with Respect to Fracture:	Normal	Normal	Normal	Normal	
Failure Mode:	Combination	Combination	Combination	Combination	
Corrected Point Load Strength Index (psi):	166.0	239.1	162.7	86.8	
Corrected Point Load Strength Index (kPa):	1144.4	1648.6	1121.8	598.8	
Approximate Compressive Strength (psi):	3781	5472	3698	1986	
BORING NO.	LE-HDD-9-A	LE-HDD-9-A	LE-HDD-9-A	LE-HDD-9-A	
DEPTH	63'2"-63'8"	73'3"-73'10"	73'3"-73'10"	73'3"-73'10"	
SAMPLE NO.					
DATE SAMPLED					
DATE TESTED	07/28/23	07/28/23	07/28/23	07/28/23	
TECHNICIAN	DL	DL	DL	DL	
DESCRIPTION					
Distance Between Platens (in) - D:	1.167	1.531	1.698	2.145	
Minimum Specimen Width (in) - W:	2.394	2.390	2.392	2.393	
Equivalent Core Diameter (in ²) - De ² :	3.557	4.659	5.171	6.536	
Minimum Failure Plane Area (in ²) - A:	2.794	3.659	4.062	5.133	
Maximum Load (lbs):	387	1437	1772	1911	
Uncorrected Point Load Strength Index (psi):	108.8	308.4	342.6	292.3	
Size Correction Factor - F:	0.981	1.042	1.067	1.125	
Direction of Load with Respect to Fracture:	Normal	Normal	Normal	Normal	
Failure Mode:	Combination	Combination	Combination	Combination	
Corrected Point Load Strength Index (psi):	106.7	321.4	365.6	328.8	
Corrected Point Load Strength Index (kPa):	736.0	2216.0	2520.9	2267.2	
Approximate Compressive Strength (psi):	2447	7319	8315	7473	
NOTES					
Data entry by:	DL			Date:	07/28/23
Checked by:	SS			Date:	07/28/23
File name:	2962050_Point Load ASTM D5731_1.xlsm				

Point Load Strength Index

ASTM D5731 (Axial Shape)

CLIENT	Lithos Engineering			JOB NO.	2962-050
PROJECT	Mesa Verde			LOCATION	--
PROJECT NO.	21152				
BORING NO.	LE-HDD-9-A	LE-HDD-9-A	LE-HDD-9-A	LE-HDD-9-A	
DEPTH	75'0"-75'6"	79'7"-80'0"	79'7"-80'0"	79'7"-80'0"	
SAMPLE NO.					
DATE SAMPLED					
DATE TESTED	07/28/23	07/28/23	07/28/23	07/28/23	
TECHNICIAN	DL	DL	DL	DL	
ROCK TYPE					
Distance Between Platens (in) - D:	2.168	1.912	1.706	1.840	
Minimum Specimen Width (in) - W:	2.399	2.394	2.398	2.394	
Equivalent Core Diameter (in ²) - De ² :	6.622	5.828	5.209	5.609	
Minimum Failure Plane Area (in ²) - A:	5.201	4.577	4.091	4.405	
Maximum Load (lbs):	1466	1329	1865	1414	
Uncorrected Point Load Strength Index (psi):	221.3	228.0	358.1	252.1	
Size Correction Factor - F:	1.128	1.096	1.069	1.087	
Direction of Load with Respect to Fracture:	Normal	Normal	Normal	Normal	
Failure Mode:	Combination	Combination	Combination	Combination	
Corrected Point Load Strength Index (psi):	249.7	250.0	382.7	273.9	
Corrected Point Load Strength Index (kPa):	1721.4	1723.4	2638.6	1888.8	
Approximate Compressive Strength (psi):	5675	5680	8703	6226	
BORING NO.					
DEPTH					
SAMPLE NO.					
DATE SAMPLED					
DATE TESTED					
TECHNICIAN					
DESCRIPTION					
Distance Between Platens (in) - D:					
Minimum Specimen Width (in) - W:					
Equivalent Core Diameter (in ²) - De ² :					
Minimum Failure Plane Area (in ²) - A:					
Maximum Load (lbs):					
Uncorrected Point Load Strength Index (psi):					
Size Correction Factor - F:					
Direction of Load with Respect to Fracture:					
Failure Mode:					
Corrected Point Load Strength Index (psi):					
Corrected Point Load Strength Index (kPa):					
Approximate Compressive Strength (psi):					
NOTES					
Data entry by:	DL	Date:			07/28/23
Checked by:	SS	Date:			07/28/23
File name:	2962050_Point Load ASTM D5731_2.xlsm				

**CERCHAR Abrasiveness
ASTM D7625**

CLIENT	Lithos Engineering			JOB NO.	2962-050
PROJECT	Mesa Verde			LOCATION	--
PROJECT NO.	21152				

BORING NO.	LE-HDD-9-A	LE-HDD-9-A	LE-HDD-9-A	LE-HDD-9-A
DEPTH	20'	52'8"-53'1"	61'1"-61'5"	69'3"-69'8"
SAMPLE NO.				
DATE SAMPLED				
DATE TESTED	08/03/23	08/03/23	08/03/23	08/03/23
TECHNICIAN	HN	HN	HN	HN
ROCK TYPE				

Surface Type:	Saw Cut	Saw Cut	Saw Cut	Saw Cut
Moisture Condition	As Received	As Received	As Received	As Received
Reading A.1 (in):	0.00530	0.01180	0.00480	0.00760
Reading A.2 (in):	0.01050	0.01160	0.00770	0.00770
Reading A.3 (in):	0.00470	0.01130	0.00380	0.00850
Reading A.4 (in):	0.01290	0.00600	0.01050	0.01040
Reading A.5 (in):	0.01260	0.01070	0.00880	0.01050
Reading B.1 (in):	0.00390	0.01140	0.00640	0.00900
Reading B.2 (in):	0.01020	0.01380	0.00310	0.00900
Reading B.3 (in):	0.00450	0.01000	0.00480	0.00800
Reading B.4 (in):	0.01200	0.00670	0.00930	0.01030
Reading B.5 (in):	0.00920	0.01050	0.00970	0.00740
Average Reading (in):	0.00858	0.01038	0.00689	0.00884
Average Reading (mm):	0.2179	0.2637	0.1750	0.2245
Uncorrected CAI or CAI _s :	2.18	2.64	1.75	2.25
Corrected CAI:	2.48	3.01	2.00	2.56

NOTES	CAI_s is the CAI calculated on saw cut specimens. Corrected CAI for saw cut specimens based on ISRM suggested formula CAI = 1.14 *CAI_s Applied pins had a Rockwell Hardness of 54-56.
-------	---

Data entry by:	HN	Date: 08/03/23
Checked by:	DL	Date: 08/04/23
File name:	2962050_CERCHAR ASTM D7625_0.xlsm	

**CHERCHAR Abrasiveness
ASTM D7625**

CLIENT Lithos Engineering
JOB NO. 2962-050
PROJECT Mesa Verde
PROJECT NO. 21152
LOCATION --

BORING NO. LE-HDD-9-A
DEPTH 20'
SAMPLE NO. --
DATE SAMPLED --
DATE TESTED 08/03/23
TECHNICIAN HN
ROCK TYPE --

Before Picture



NOTES

Picture File: 1.JPG
File name: 2962050__CHERCHAR ASTM D7625_0.xlsm

CHERCHAR Abrasiveness ASTM D7625

CLIENT Lithos Engineering
JOB NO. 2962-050
PROJECT Mesa Verde
PROJECT NO. 21152
LOCATION --

BORING NO. LE-HDD-9-A
DEPTH 20'
SAMPLE NO. --
DATE SAMPLED --
DATE TESTED 08/03/23
TECHNICIAN HN
ROCK TYPE --

After Picture



NOTES

Picture File: 1a.JPG
File name: 2962050__CHERCHAR ASTM D7625_0.xlsm

CHERCHAR Abrasiveness ASTM D7625

CLIENT Lithos Engineering
JOB NO. 2962-050
PROJECT Mesa Verde
PROJECT NO. 21152
LOCATION --

BORING NO. LE-HDD-9-A
DEPTH 52'8"-53'1"
SAMPLE NO. --
DATE SAMPLED --
DATE TESTED 08/03/23
TECHNICIAN HN
ROCK TYPE --

Before Picture



NOTES

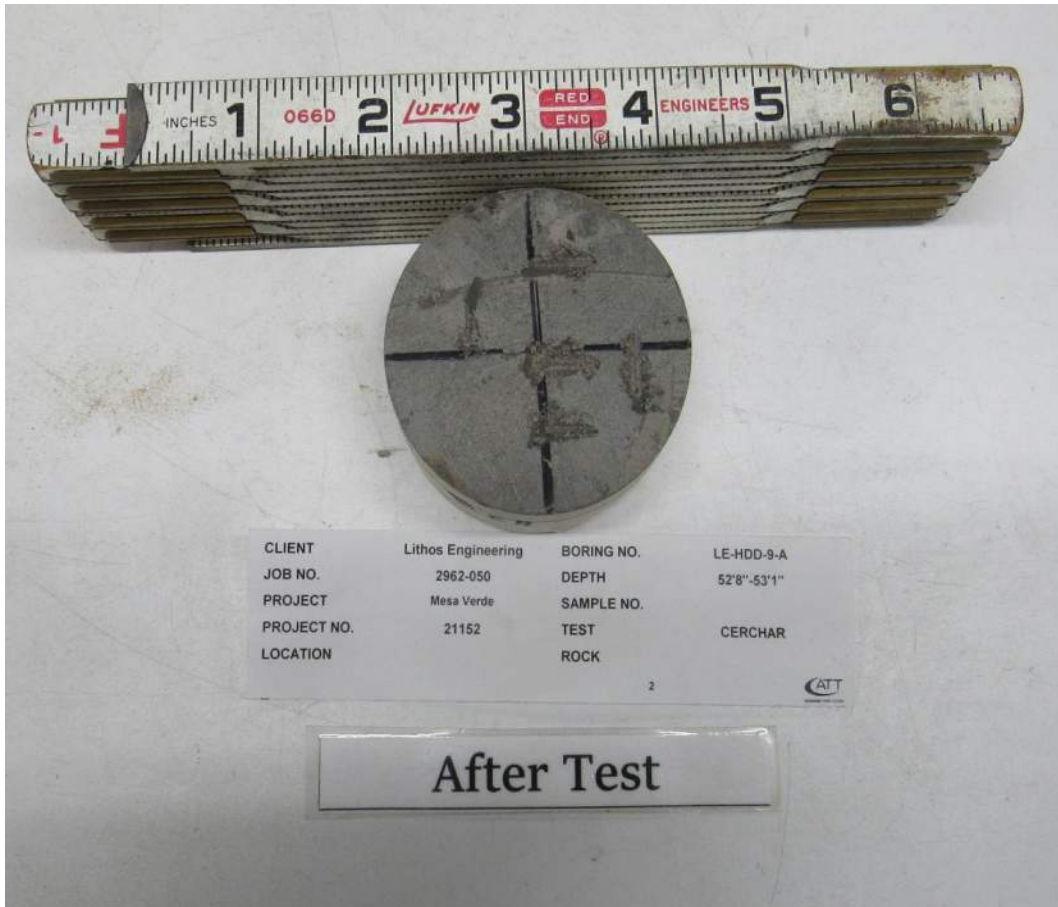
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CHERCHAR Abrasiveness ASTM D7625

CLIENT Lithos Engineering
JOB NO. 2962-050
PROJECT Mesa Verde
PROJECT NO. 21152
LOCATION --

BORING NO. LE-HDD-9-A
DEPTH 52'8"-53'1"
SAMPLE NO. --
DATE SAMPLED --
DATE TESTED 08/03/23
TECHNICIAN HN
ROCK TYPE --

After Picture



NOTES

Picture File: 2a.JPG
File name: 2962050__CHERCHAR ASTM D7625_0.xlsm



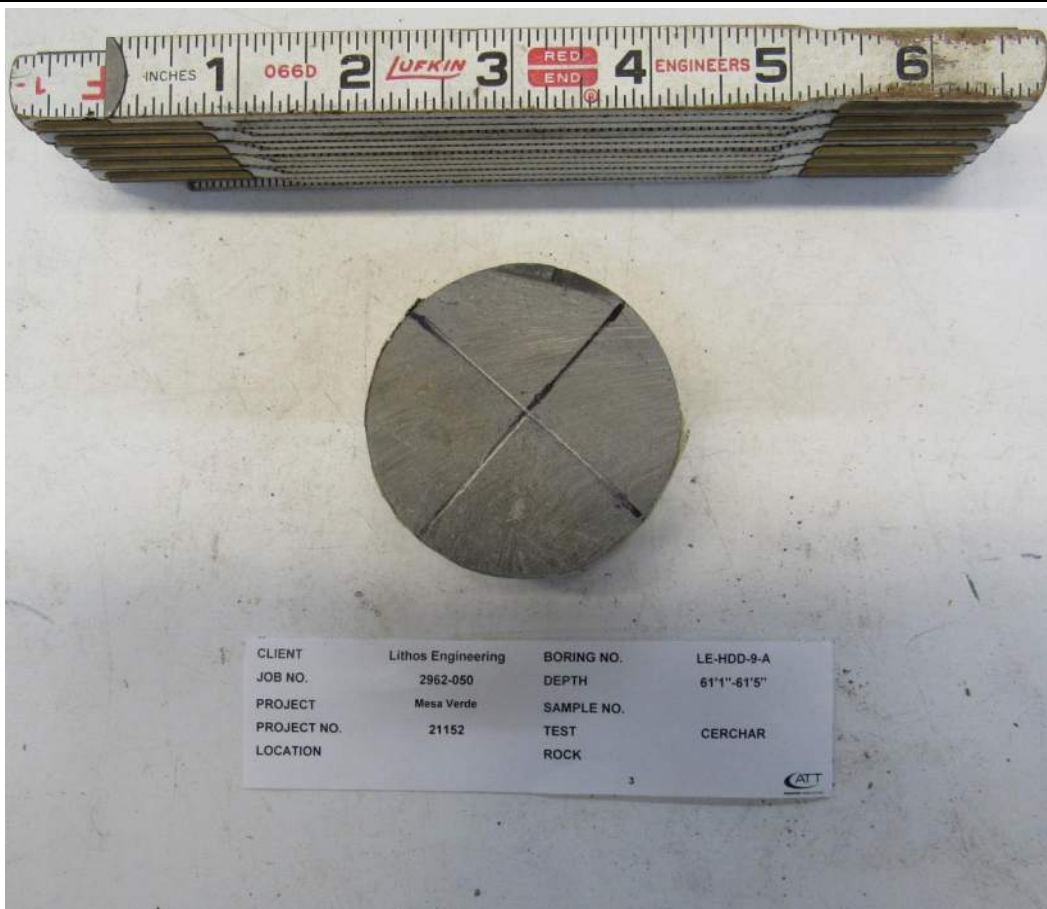
ADVANCED TERRA TESTING

CHERCHAR Abrasiveness ASTM D7625

CLIENT Lithos Engineering
JOB NO. 2962-050
PROJECT Mesa Verde
PROJECT NO. 21152
LOCATION --

BORING NO. LE-HDD-9-A
DEPTH 61'1"-61'5"
SAMPLE NO. --
DATE SAMPLED --
DATE TESTED 08/03/23
TECHNICIAN HN
ROCK TYPE --

Before Picture



NOTES

Picture File: 3.JPG
File name: 2962050__CHERCHAR ASTM D7625_0.xlsm



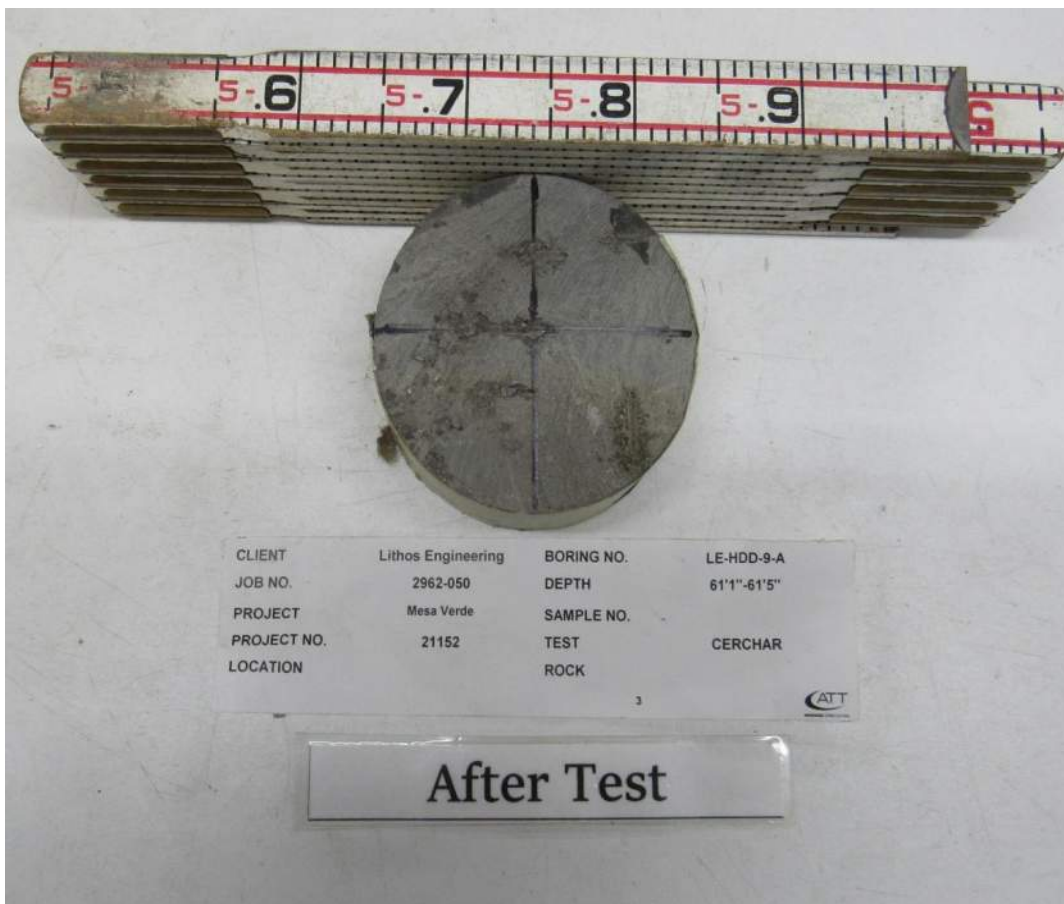
ADVANCED TERRA TESTING

CHERCHAR Abrasiveness
ASTM D7625

CLIENT Lithos Engineering
JOB NO. 2962-050
PROJECT Mesa Verde
PROJECT NO. 21152
LOCATION --

BORING NO. LE-HDD-9-A
DEPTH 61'1"-61'5"
SAMPLE NO. --
DATE SAMPLED --
DATE TESTED 08/03/23
TECHNICIAN HN
ROCK TYPE --

After Picture



NOTES

Picture File: 3a.JPG
File name: 2962050__CHERCHAR ASTM D7625_0.xlsm

CHERCHAR Abrasiveness ASTM D7625

CLIENT Lithos Engineering
JOB NO. 2962-050
PROJECT Mesa Verde
PROJECT NO. 21152
LOCATION --

BORING NO. LE-HDD-9-A
DEPTH 69'3"-69'8"
SAMPLE NO. --
DATE SAMPLED --
DATE TESTED 08/03/23
TECHNICIAN HN
ROCK TYPE --

Before Picture



NOTES

Picture File: 4.JPG
File name: 2962050__CHERCHAR ASTM D7625_0.xlsm



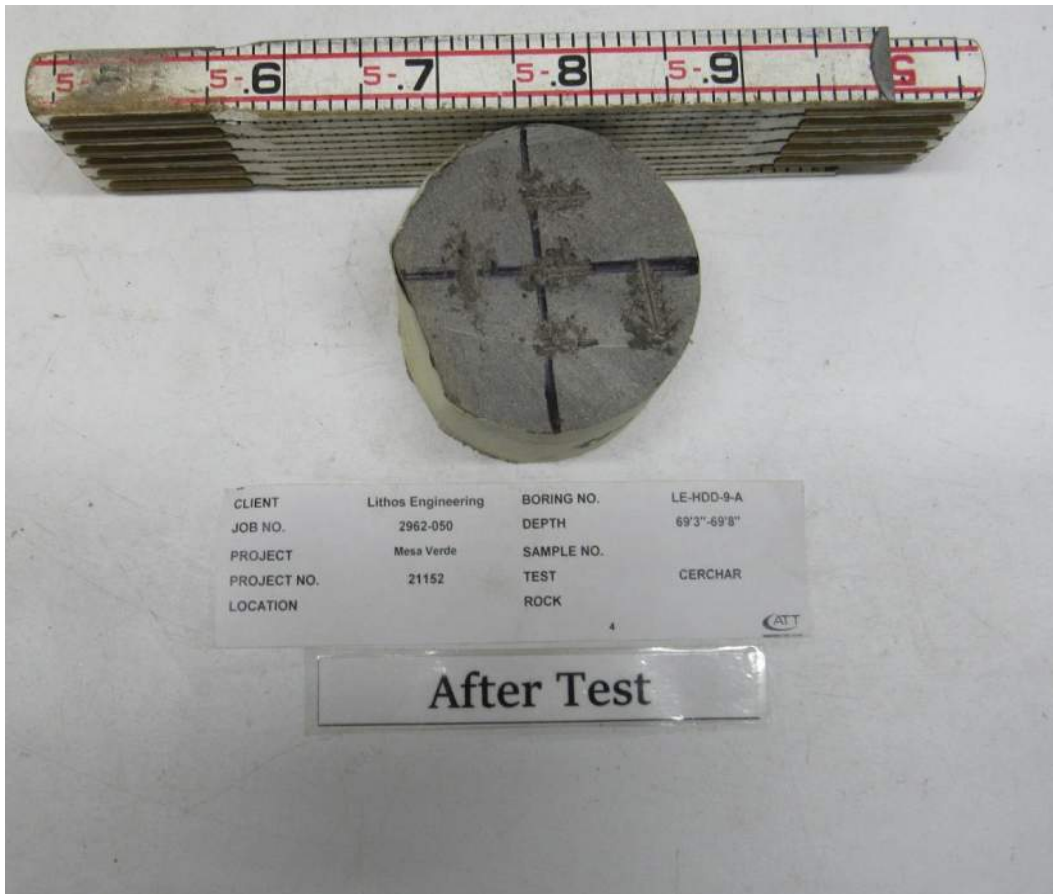
ADVANCED TERRA TESTING

CHERCHAR Abrasiveness ASTM D7625

CLIENT Lithos Engineering
JOB NO. 2962-050
PROJECT Mesa Verde
PROJECT NO. 21152
LOCATION --

BORING NO. LE-HDD-9-A
DEPTH 69'3"-69'8"
SAMPLE NO. --
DATE SAMPLED --
DATE TESTED 08/03/23
TECHNICIAN HN
ROCK TYPE --

After Picture



NOTES

Picture File: 4a.JPG
File name: 2962050__CHERCHAR ASTM D7625_0.xlsm



ADVANCED TERRA TESTING

**CERCHAR Abrasiveness
ASTM D7625**

CLIENT	Lithos Engineering	JOB NO.	2962-050
PROJECT	Mesa Verde	LOCATION	--
PROJECT NO.	21152		

BORING NO.	LE-HDD-12-A	LE-HDD-12-A
DEPTH	27'2"-27'8"	29'0"-29'3"
SAMPLE NO.		
DATE SAMPLED		
DATE TESTED	08/03/23	08/03/23
TECHNICIAN	HN	HN
ROCK TYPE		

Surface Type:	Saw Cut	Saw Cut
Moisture Condition	As Received	As Received
Reading A.1 (in):	0.01070	0.00970
Reading A.2 (in):	0.01090	0.00520
Reading A.3 (in):	0.00700	0.00770
Reading A.4 (in):	0.00870	0.00580
Reading A.5 (in):	0.01080	0.01090
Reading B.1 (in):	0.00940	0.00680
Reading B.2 (in):	0.01320	0.00510
Reading B.3 (in):	0.00760	0.00700
Reading B.4 (in):	0.00970	0.00490
Reading B.5 (in):	0.00970	0.00900
Average Reading (in):	0.00977	0.00721
Average Reading (mm):	0.2482	0.1831
Uncorrected CAI or CAI _s :	2.48	1.83
Corrected CAI:	2.83	2.09

NOTES	CAI _s is the CAI calculated on saw cut specimens. Corrected CAI for saw cut specimens based on ISRM suggested formula CAI = 1.14 *CAI _s Applied pins had a Rockwell Hardness of 54-56.
-------	--

Data entry by:	HN	Date: 08/03/23
Checked by:	DL	Date: 08/04/23
File name:	2962050_CERCHAR ASTM D7625_1.xlsm	

CHERCHAR Abrasiveness ASTM D7625

CLIENT Lithos Engineering
JOB NO. 2962-050
PROJECT Mesa Verde
PROJECT NO. 21152
LOCATION --

BORING NO. LE-HDD-12-A
DEPTH 27'2"-27'8"
SAMPLE NO. --
DATE SAMPLED --
DATE TESTED 08/03/23
TECHNICIAN HN
ROCK TYPE --

Before Picture



CLIENT Lithos Engineering
JOB NO. 2962-050
PROJECT Mesa Verde
PROJECT NO. 21152
LOCATION --

BORING NO. LE-HDD-12-A
DEPTH 27'2"-27'8"
SAMPLE NO. --
TEST CERCHAR
ROCK

NOTES

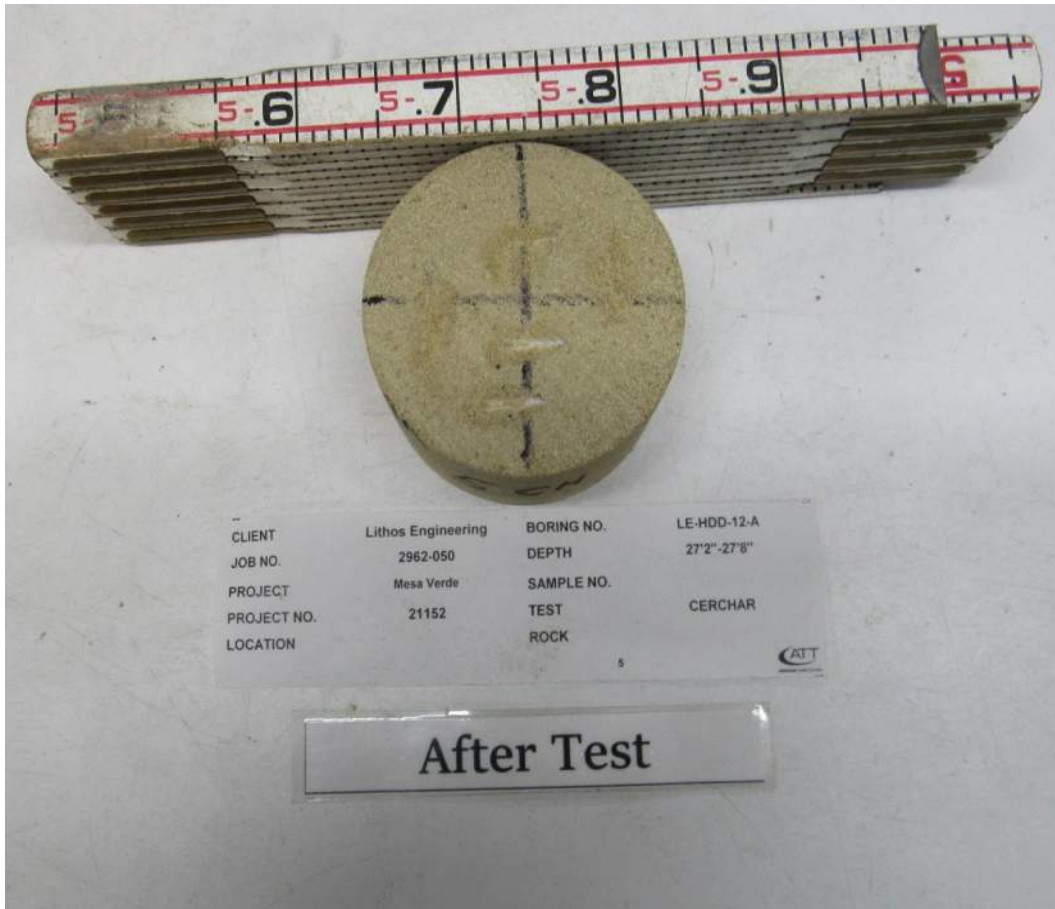
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CHERCHAR Abrasiveness ASTM D7625

CLIENT Lithos Engineering
JOB NO. 2962-050
PROJECT Mesa Verde
PROJECT NO. 21152
LOCATION --

BORING NO. LE-HDD-12-A
DEPTH 27'2"-27'8"
SAMPLE NO. --
DATE SAMPLED --
DATE TESTED 08/03/23
TECHNICIAN HN
ROCK TYPE --

After Picture



NOTES

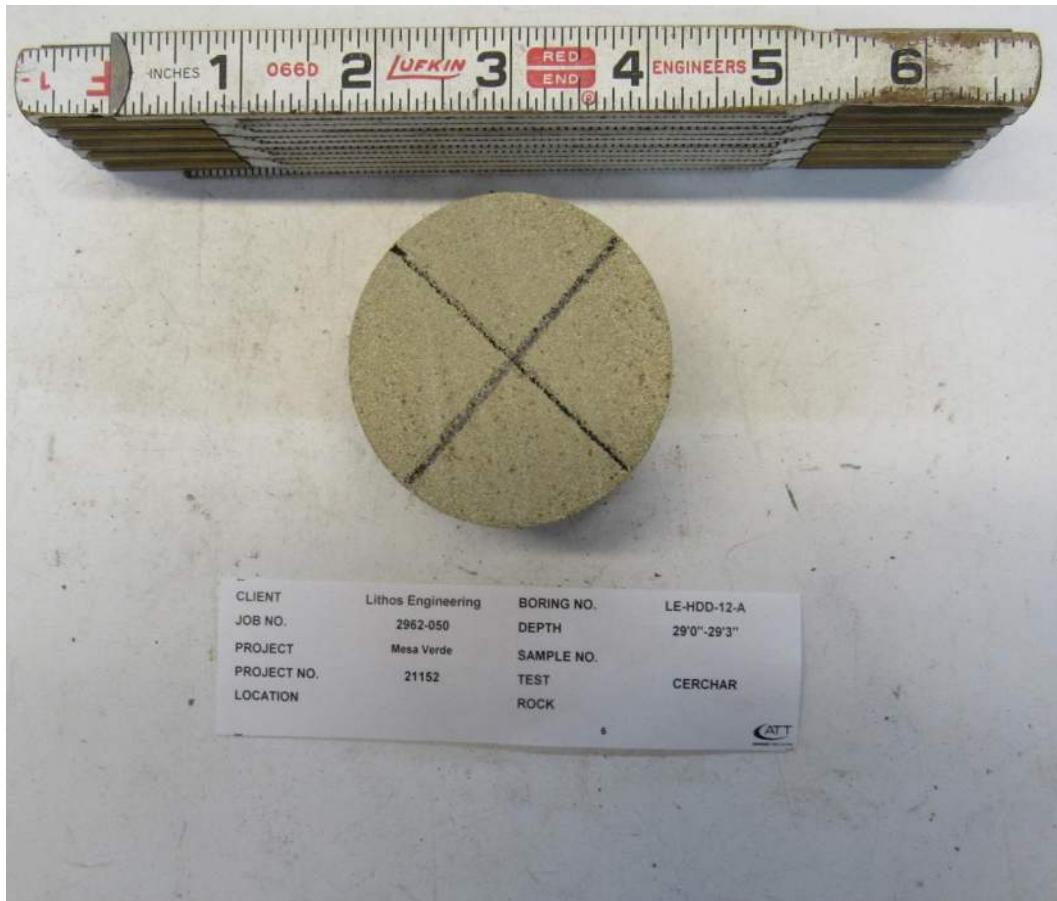
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CHERCHAR Abrasiveness ASTM D7625

CLIENT Lithos Engineering
JOB NO. 2962-050
PROJECT Mesa Verde
PROJECT NO. 21152
LOCATION --

BORING NO. LE-HDD-12-A
DEPTH 29'0"-29'3"
SAMPLE NO. --
DATE SAMPLED --
DATE TESTED 08/03/23
TECHNICIAN HN
ROCK TYPE --

Before Picture



NOTES

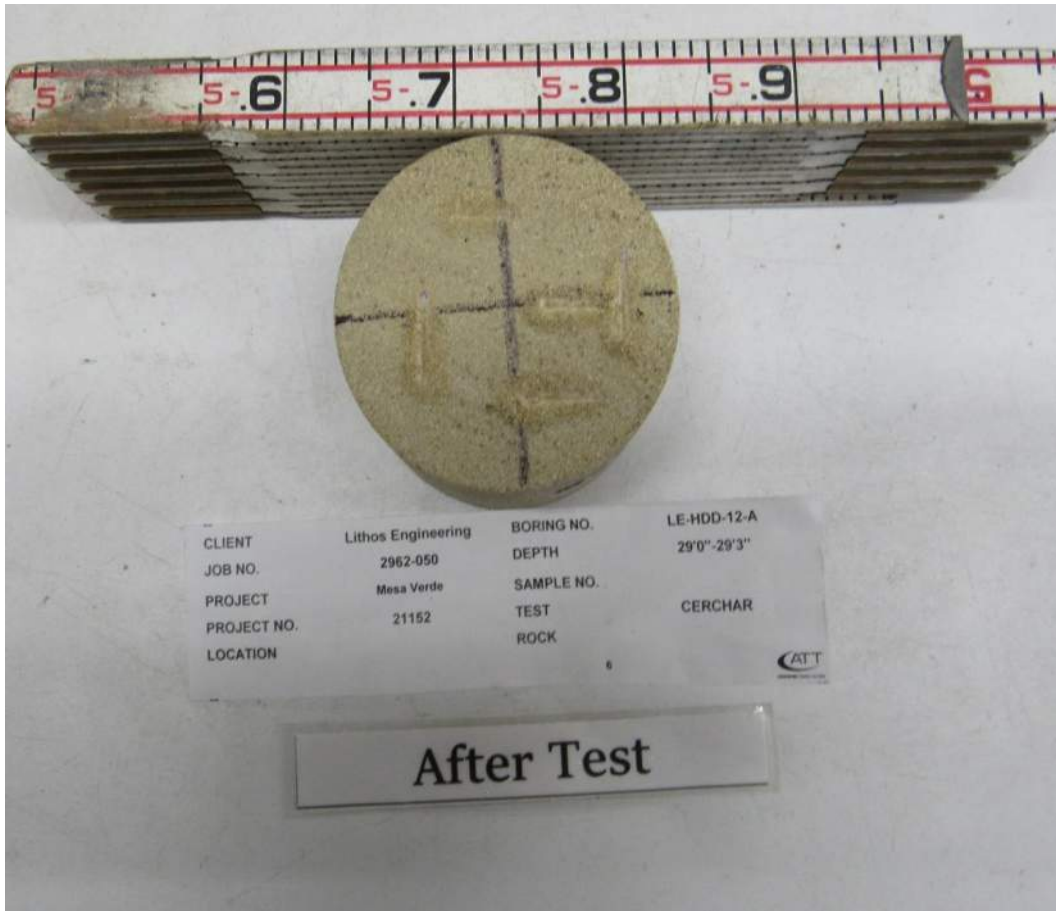
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CHERCHAR Abrasiveness ASTM D7625

CLIENT Lithos Engineering
JOB NO. 2962-050
PROJECT Mesa Verde
PROJECT NO. 21152
LOCATION --

BORING NO. LE-HDD-12-A
DEPTH 29'0"-29'3"
SAMPLE NO. --
DATE SAMPLED --
DATE TESTED 08/03/23
TECHNICIAN HN
ROCK TYPE --

After Picture



NOTES

Picture File: 6a.JPG
File name: 2962050__CHERCHAR ASTM D7625_1.xlsm

Point Load Strength Index

ASTM D5731 (Diametrical Shape)

CLIENT	Lithos Engineering		JOB NO.	2962-050
PROJECT	Mesa Verde		LOCATION	--
PROJECT NO.	21152			
BORING NO.	LE-HDD-9-A	LE-HDD-9-A	LE-HDD-9-A	
DEPTH	54'3"-54'8"	57'3"-57'8"	75'0"-75'6"	
SAMPLE NO.				
DATE SAMPLED				
DATE TESTED	07/28/23	07/28/23	07/23/23	
TECHNICIAN	DL	DL	DL	
ROCK TYPE				
Distance Between Platens (in) - D:	2.394	2.381	2.391	
Minimum Specimen Width (in) - W:	2.779	2.523	3.269	
Equivalent Core Diameter (in ²) - De ² :	5.731	5.669	5.717	
Minimum Failure Plane Area (in ²) - A:	--	--	--	
Maximum Load (lbs):	153	184	101	
Uncorrected Point Load Strength Index (psi):	26.7	32.5	17.7	
Size Correction Factor - F:	1.092	1.089	1.091	
Direction of Load with Respect to Fracture:	Parallel	Parallel	Parallel	
Failure Mode:	Fracture	Fracture	Fracture	
Corrected Point Load Strength Index (psi):	29.2	35.4	19.4	
Corrected Point Load Strength Index (kPa):	201.2	244.1	133.5	
Approximate Compressive Strength (psi):	663	805	440	
BORING NO.				
DEPTH				
SAMPLE NO.				
DATE SAMPLED				
DATE TESTED				
TECHNICIAN				
DESCRIPTION				
Distance Between Platens (in) - D:				
Minimum Specimen Width (in) - W:				
Equivalent Core Diameter (in ²) - De ² :				
Minimum Failure Plane Area (in ²) - A:				
Maximum Load (lbs):				
Uncorrected Point Load Strength Index (psi):				
Size Correction Factor - F:				
Direction of Load with Respect to Fracture:				
Failure Mode:				
Corrected Point Load Strength Index (psi):				
Corrected Point Load Strength Index (kPa):				
Approximate Compressive Strength (psi):				
NOTES				
Data entry by:	DL	Date:	07/28/23	
Checked by:	SS	Date:	07/28/23	
File name:	2962050_Point Load ASTM D5731_0.xlsm			

MOH'S SCALE OF HARDNESS

CLIENT	Lithos Engineering		JOB NO.	2962-050	
PROJECT	Mesa Verde		LOCATION	--	
PROJECT NO.	21152				
BORING NO.	LE-HDD-9-A	LE-HDD-9-A	LE-HDD-12-A		
DEPTH	50'0"-50'4"	75'9"-76'1"	23'7"-23'9"		
SAMPLE NO.					
DATE TESTED	08/01/23	08/01/23	08/01/23		
TECHNICIAN	HN	HN	HN		
ROCK TYPE					
Moisture Condition	As Received	As Received	As Received	As Received	
Reading 1:	2.0	1.5	2.5		
Reading 2:	1.5	2.0	3.0		
Reading 3:	1.5	1.5	2.5		
Reading 4:	1.5	2.0	2.5		
Reading 5:	1.5	1.5	2.0		
Average MOH'S Hardness:	1.6	1.7	2.5		
NOTES	MOH'S Hardness of a rock specimen isn't necessarily the same as hardness of its minerals contents, due to factors such as cementing, grain size, angularity, mineral distribution. Measurements are conducted based on the ability of a harder mineral to scratch a softer one (rated on a scale of 1-10).				
Data entry by:	HN	Date:		08/01/23	
Checked by:	DL	Date:		08/01/23	
File name:	2962050_MOH'S SCALE OF HARDNESS - R0_0.xlsm				

Splitting Tensile Strength ASTM D3967

CLIENT	Lithos Engineering	JOB NO.	2962-050
PROJECT	Mesa Verde	LOCATION	--
PROJECT NO.	21152		

BORING NO.	LE-HDD-9-A	LE-HDD-9-A	LE-HDD-12-A
DEPTH	71'0"-72'2"	74'0"-74'4"	30'0"-30'5"
SAMPLE NO.			
DATE SAMPLED			
DATE TESTED	07/31/23	07/31/23	07/31/23
TECHNICIAN	DL	DL	DL
ROCK TYPE			

Diameter (in):	2.395	2.393	2.365
Height (in):	1.486	1.461	1.437
Mass of Wet Rock (g):	266.50	265.40	223.70
Wet Density (lbs/ft³):	151.7	153.9	135.0
Wet Density (g/cm³):	2.43	2.46	2.16
Peak Load (lbs):	2976	3888	1077
Splitting Tensile Strength (psi):	532	708	202
Splitting Tensile Strength (kPa):	3670	4881	1391
Failure Type:	Multiple Plane	Multiple Plane	Single Plane

BORING NO.	
DEPTH	
SAMPLE NO.	
DATE SAMPLED	
DATE TESTED	
TECHNICIAN	
ROCK TYPE	

Diameter (in):	
Height (in):	
Mass of Wet Rock (g):	
Wet Density (lbs/ft³):	
Wet Density (g/cm³):	
Peak Load (lbs):	
Splitting Tensile Strength (psi):	
Splitting Tensile Strength (kPa):	
Failure Type:	

NOTES	
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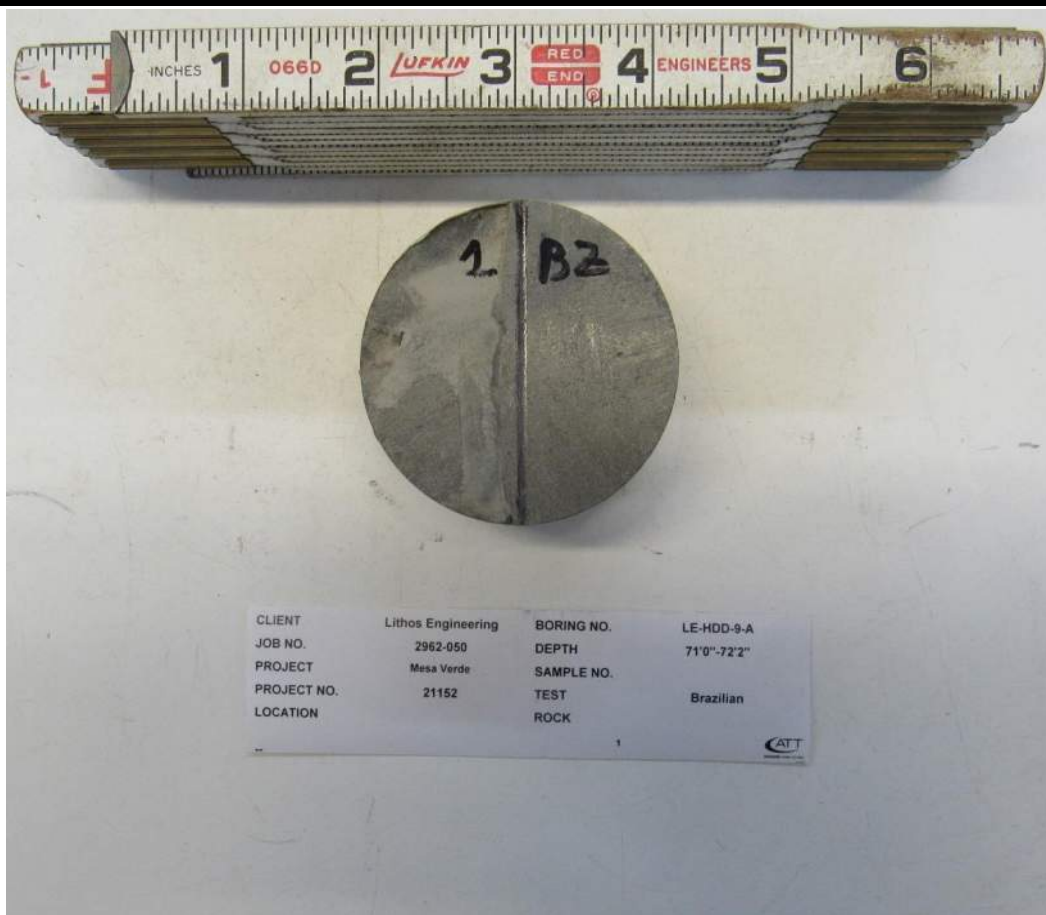
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Checked by:	SS	Date:	08/02/23
File name:	2962050_Brazilian ASTM D3967_0.xlsm		

Splitting Tensile ASTM D3967

CLIENT Lithos Engineering
 JOB NO. 2962-050
 PROJECT Mesa Verde
 PROJECT NO. 21152
 LOCATION --

BORING NO. LE-HDD-9-A
 DEPTH 71'0"-72'2"
 SAMPLE NO.
 DATE SAMPLED
 DATE TESTED 07/31/23
 TECHNICIAN DL
 ROCK TYPE

Before Picture



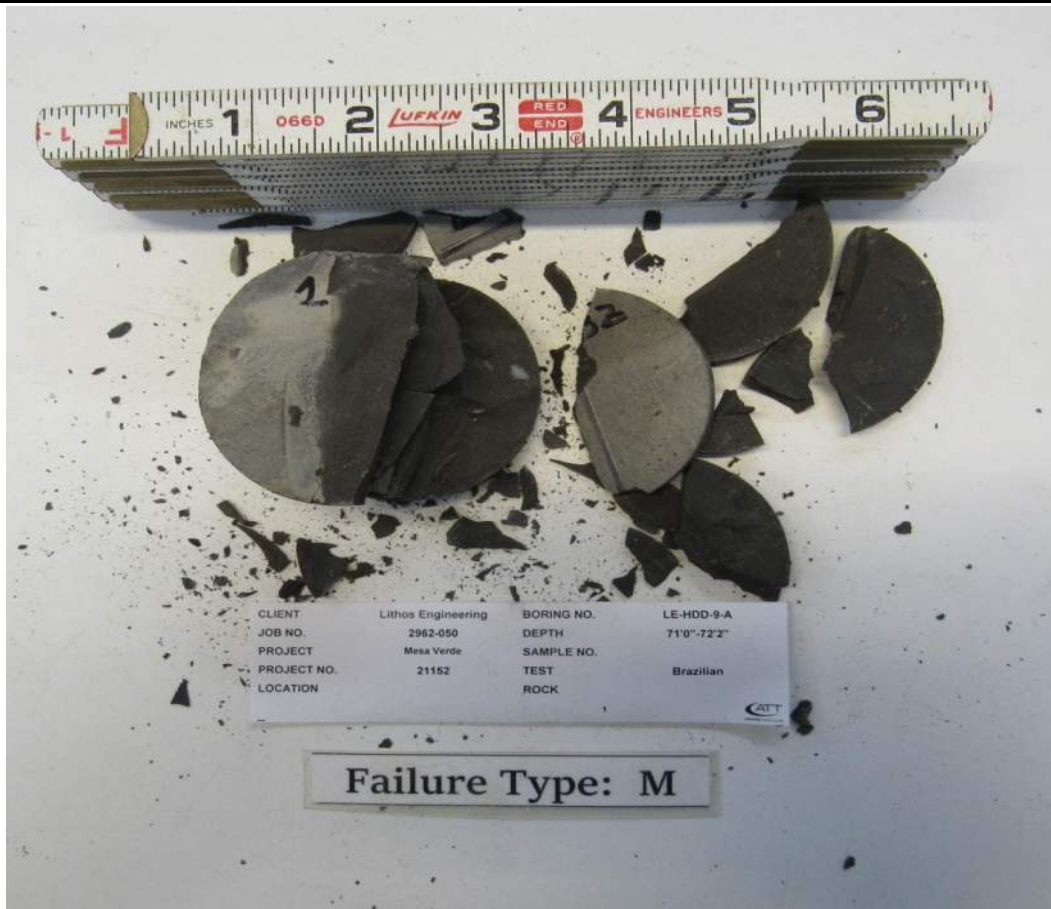
NOTES

Picture File: 1.JPG
 File name: 2962050__Brazilian ASTM D3967_0.xlsm

Splitting Tensile ASTM D3967

CLIENT	Lithos Engineering	BORING NO.	LE-HDD-9-A
JOB NO.	2962-050	DEPTH	71'0"-72'2"
PROJECT	Mesa Verde	SAMPLE NO.	
PROJECT NO.	21152	DATE SAMPLED	
LOCATION	--	DATE TESTED	07/31/23
		TECHNICIAN	DL
		ROCK TYPE	

After Picture



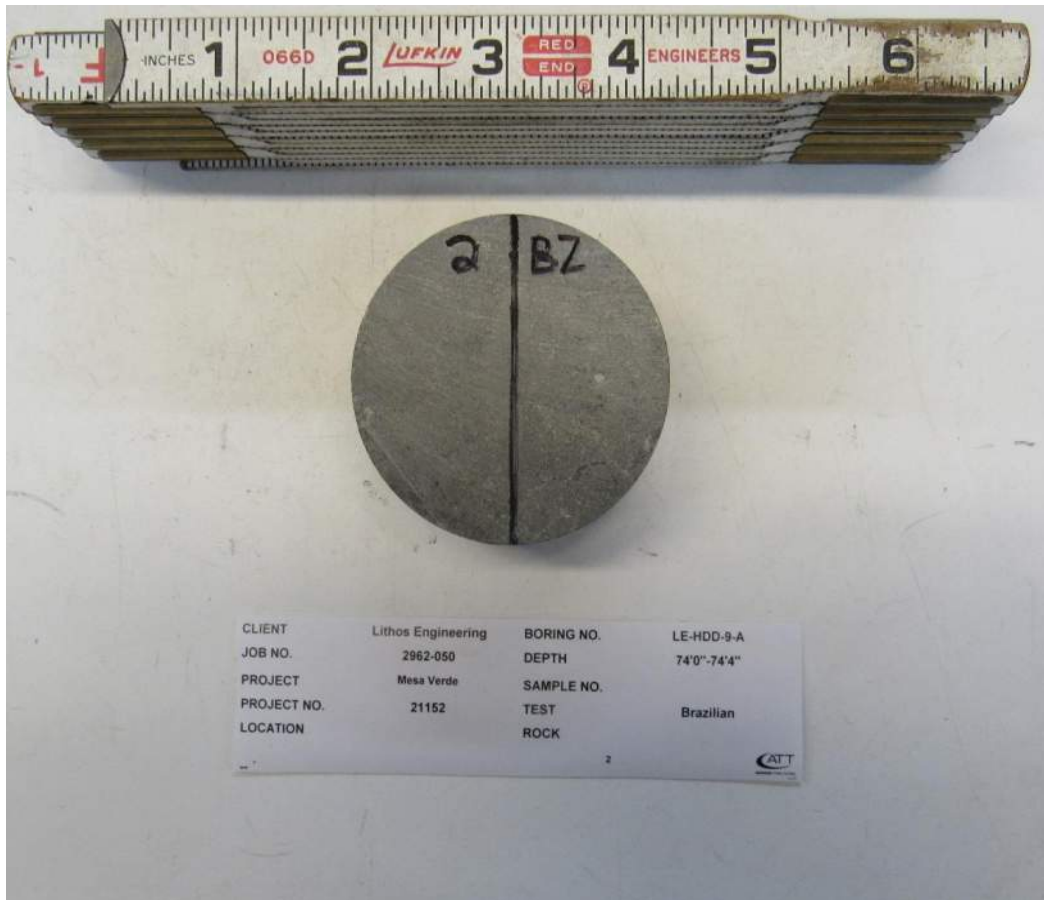
NOTES

Picture File: 1a.JPG
 File name: 2962050__Brazilian ASTM D3967_0.xlsm

Splitting Tensile ASTM D3967

CLIENT	Lithos Engineering	BORING NO.	LE-HDD-9-A
JOB NO.	2962-050	DEPTH	74'0"-74'4"
PROJECT	Mesa Verde	SAMPLE NO.	
PROJECT NO.	21152	DATE SAMPLED	
LOCATION	--	DATE TESTED	07/31/23
		TECHNICIAN	DL
		ROCK TYPE	

Before Picture



NOTES

Picture File: 2.JPG
 File name: 2962050__Brazilian ASTM D3967_0.xlsm

Splitting Tensile ASTM D3967

CLIENT	Lithos Engineering	BORING NO.	LE-HDD-9-A
JOB NO.	2962-050	DEPTH	74'0"-74'4"
PROJECT	Mesa Verde	SAMPLE NO.	
PROJECT NO.	21152	DATE SAMPLED	
LOCATION	--	DATE TESTED	07/31/23
		TECHNICIAN	DL
		ROCK TYPE	

After Picture



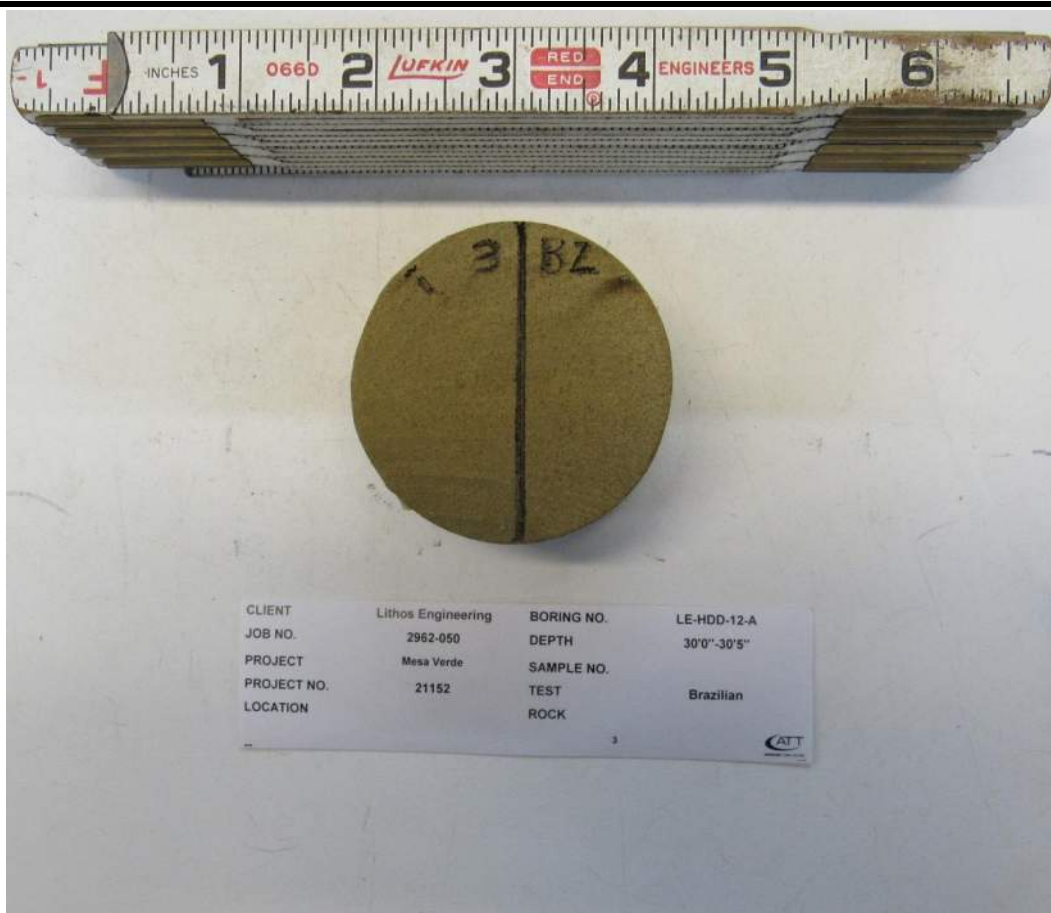
NOTES

Picture File: 2a.JPG
 File name: 2962050__Brazilian ASTM D3967_0.xlsm

Splitting Tensile ASTM D3967

CLIENT	Lithos Engineering	BORING NO.	LE-HDD-12-A
JOB NO.	2962-050	DEPTH	30'0"-30'5"
PROJECT	Mesa Verde	SAMPLE NO.	
PROJECT NO.	21152	DATE SAMPLED	
LOCATION	--	DATE TESTED	07/31/23
		TECHNICIAN	DL
		ROCK TYPE	

Before Picture



NOTES

Picture File: 3.JPG
 File name: 2962050__Brazilian ASTM D3967_0.xlsm

Splitting Tensile ASTM D3967

CLIENT	Lithos Engineering	BORING NO.	LE-HDD-12-A
JOB NO.	2962-050	DEPTH	30'0"-30'5"
PROJECT	Mesa Verde	SAMPLE NO.	
PROJECT NO.	21152	DATE SAMPLED	
LOCATION	--	DATE TESTED	07/31/23
		TECHNICIAN	DL
		ROCK TYPE	

After Picture



NOTES

Picture File: 3a.JPG
 File name: 2962050__Brazilian ASTM D3967_0.xlsm

Unconfined Compressive Strength ASTM D7012 Method C

CLIENT	Lithos Engineering	JOB NO.	2962-050		
PROJECT	Mesa Verde	LOCATION	--		
PROJECT NO.	21152				

BORING NO.	LE-HDD-9-A	LE-HDD-9-A	LE-HDD-9-A	LE-HDD-9-A	LE-HDD-9-A
DEPTH	54'3"-54'8"	57'3"-57'8"	63'2"-63'8"	73'3"-73'10"	75'0"-75'6"
SAMPLE NO.					
DATE SAMPLED					
DATE TESTED					
TECHNICIAN					
ROCK TYPE					

Diameter (in):					
Height (in):					
Mass of Wet Rock (g):					
Wet Density (lbs/ft³):					
Wet Density (g/cm³):					
	Sample Not Testable	Sample Not Testable	Sample Not Testable	Sample Not Testable	Sample Not Testable
Peak Load (lbs):					
Compressive Strength (psi)					
Compressive Strength (MPa)					
Failure Type:					

BORING NO.	LE-HDD-9-A	LE-HDD-12-A	LE-HDD-12-A		
DEPTH	79'7"-80'0"	22'8"-23'3"	28'5"-29'0"		
SAMPLE NO.					
DATE SAMPLED					
DATE TESTED		08/01/23	08/01/23		
TECHNICIAN		DL	DL		
ROCK TYPE					

Diameter (in):		2.365	2.373		
Height (in):		4.891	4.950		
Mass of Wet Rock (g):		747.20	764.90		
Wet Density (lbs/ft³):		132.5	133.1		
Wet Density (g/cm³):		2.122	2.132		
	Sample Not Testable				
Peak Load (lbs):		13240	14612		
Compressive Strength (psi)		3014	3304		
Compressive Strength (MPa)		21	23		
Failure Type:		Shear / Fracture	Shear / Fracture		

NOTES					
-------	--	--	--	--	--

Data entry by:	DL	Date:	08/03/23
Checked by:	HN	Date:	08/04/23
File name:	2962050__Rock UCS-TCS ASTM D7012 Method A and C_0.xlsm		

Unconfined Compressive Strength ASTM D7012 Method C

CLIENT Lithos Engineering
JOB NO. 2962-050
PROJECT Mesa Verde
PROJECT NO. 21152
LOCATION --

BORING NO. LE-HDD-9-A
DEPTH 54'3"-54'8"
SAMPLE NO.
DATE SAMPLED
DATE TESTED
TECHNICIAN
ROCK TYPE

Before Picture



NOTES

Picture File: 4_untestable.JPG
File name: 2962050__Rock UCS-TCS ASTM D7012 Method A and C_0.xlsm

Unconfined Compressive Strength ASTM D7012 Method C

CLIENT	Lithos Engineering	BORING NO.	LE-HDD-9-A
JOB NO.	2962-050	DEPTH	57'3"-57'8"
PROJECT	Mesa Verde	SAMPLE NO.	
PROJECT NO.	21152	DATE SAMPLED	
LOCATION	--	DATE TESTED	
		TECHNICIAN	
		ROCK TYPE	

Before Picture



CLIENT	Lithos Engineering	BORING NO.	LE-HDD-9-A
JOB NO.	2962-050	DEPTH	57'3"-57'8"
PROJECT	Mesa Verde	SAMPLE NO.	
PROJECT NO.	21152	TEST	UCS
LOCATION		ROCK	

NOTES

Picture File: 5_untestable.JPG
 File name: 2962050__Rock UCS-TCS ASTM D7012 Method A and C_0.xlsm

Unconfined Compressive Strength ASTM D7012 Method C

CLIENT	Lithos Engineering	BORING NO.	LE-HDD-9-A
JOB NO.	2962-050	DEPTH	63'2"-63'8"
PROJECT	Mesa Verde	SAMPLE NO.	
PROJECT NO.	21152	DATE SAMPLED	
LOCATION	--	DATE TESTED	
		TECHNICIAN	
		ROCK TYPE	

Before Picture



NOTES

Picture File: 6_not testable.JPG
 File name: 2962050__Rock UCS-TCS ASTM D7012 Method A and C_0.xlsm

Unconfined Compressive Strength ASTM D7012 Method C

CLIENT Lithos Engineering
JOB NO. 2962-050
PROJECT Mesa Verde
PROJECT NO. 21152
LOCATION --

BORING NO. LE-HDD-9-A
DEPTH 73'3"-73'10"
SAMPLE NO.
DATE SAMPLED
DATE TESTED
TECHNICIAN
ROCK TYPE

Before Picture



NOTES

Picture File: 7_untestable.JPG
File name: 2962050__Rock UCS-TCS ASTM D7012 Method A and C_0.xlsm

Unconfined Compressive Strength ASTM D7012 Method C

CLIENT	Lithos Engineering	BORING NO.	LE-HDD-9-A
JOB NO.	2962-050	DEPTH	75'0"-75'6"
PROJECT	Mesa Verde	SAMPLE NO.	
PROJECT NO.	21152	DATE SAMPLED	
LOCATION	--	DATE TESTED	
		TECHNICIAN	
		ROCK TYPE	

Before Picture



NOTES

Picture File: 8_untestable.JPG
 File name: 2962050__Rock UCS-TCS ASTM D7012 Method A and C_0.xlsm

Unconfined Compressive Strength ASTM D7012 Method C

CLIENT	Lithos Engineering	BORING NO.	LE-HDD-9-A
JOB NO.	2962-050	DEPTH	79'7"-80'0"
PROJECT	Mesa Verde	SAMPLE NO.	
PROJECT NO.	21152	DATE SAMPLED	
LOCATION	--	DATE TESTED	
		TECHNICIAN	
		ROCK TYPE	

Before Picture



NOTES

Picture File: 9_untestable.JPG
File name: 2962050__Rock UCS-TCS ASTM D7012 Method A and C_0.xlsm

Unconfined Compressive Strength ASTM D7012 Method C

CLIENT	Lithos Engineering	BORING NO.	LE-HDD-12-A
JOB NO.	2962-050	DEPTH	22'8"-23'3"
PROJECT	Mesa Verde	SAMPLE NO.	
PROJECT NO.	21152	DATE SAMPLED	
LOCATION	--	DATE TESTED	08/01/23
		TECHNICIAN	DL
		ROCK TYPE	

Before Picture



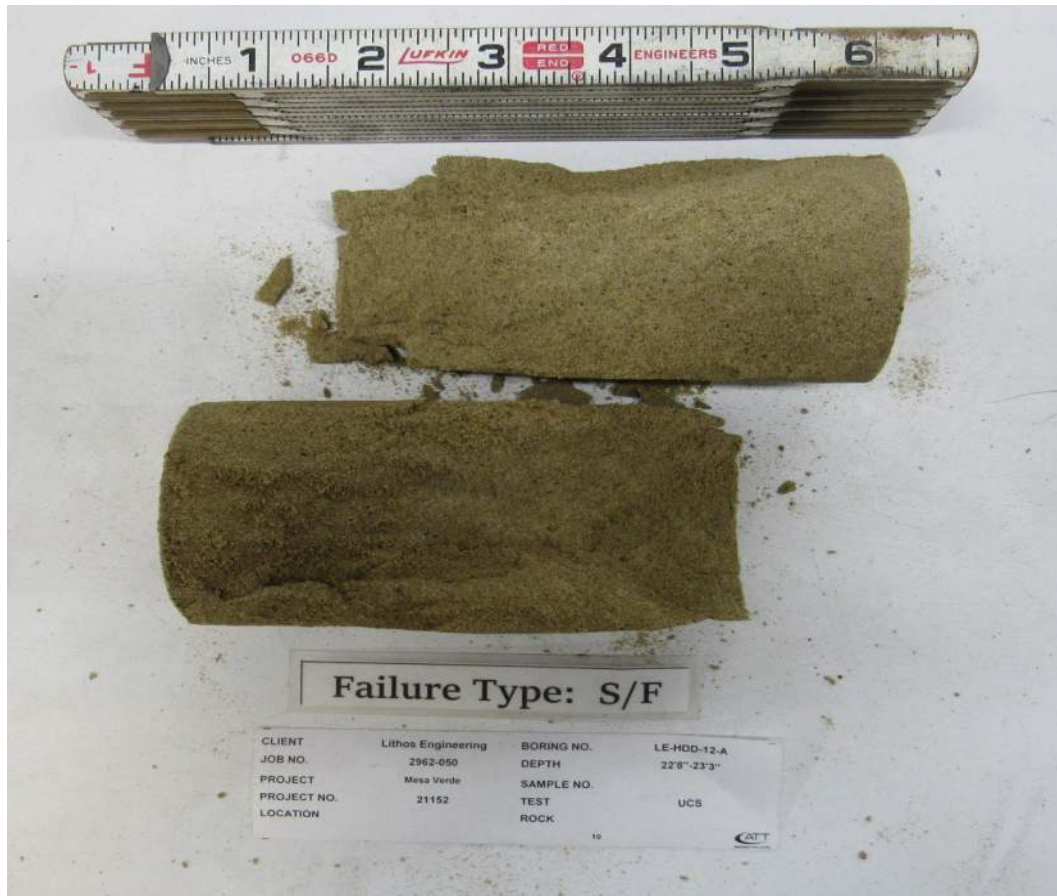
NOTES

Picture File: 10.JPG
 File name: 2962050__Rock UCS-TCS ASTM D7012 Method A and C_0.xlsm

Unconfined Compressive Strength ASTM D7012 Method C

CLIENT	Lithos Engineering	BORING NO.	LE-HDD-12-A
JOB NO.	2962-050	DEPTH	22'8"-23'3"
PROJECT	Mesa Verde	SAMPLE NO.	
PROJECT NO.	21152	DATE SAMPLED	
LOCATION	--	DATE TESTED	08/01/23
		TECHNICIAN	DL
		ROCK TYPE	

After Picture



NOTES

Picture File: 10a.JPG
File name: 2962050__Rock UCS-TCS ASTM D7012 Method A and C_0.xlsm

Unconfined Compressive Strength ASTM D7012 Method C

CLIENT	Lithos Engineering	BORING NO.	LE-HDD-12-A
JOB NO.	2962-050	DEPTH	28'5"-29'0"
PROJECT	Mesa Verde	SAMPLE NO.	
PROJECT NO.	21152	DATE SAMPLED	
LOCATION	--	DATE TESTED	08/01/23
		TECHNICIAN	DL
		ROCK TYPE	

Before Picture



NOTES

Picture File: 11.JPG
 File name: 2962050__Rock UCS-TCS ASTM D7012 Method A and C_0.xlsm

Unconfined Compressive Strength ASTM D7012 Method C

CLIENT	Lithos Engineering	BORING NO.	LE-HDD-12-A
JOB NO.	2962-050	DEPTH	28'5"-29'0"
PROJECT	Mesa Verde	SAMPLE NO.	
PROJECT NO.	21152	DATE SAMPLED	
LOCATION	--	DATE TESTED	08/01/23
		TECHNICIAN	DL
		ROCK TYPE	

After Picture



NOTES

Picture File: 11a.JPG
 File name: 2962050__Rock UCS-TCS ASTM D7012 Method A and C_0.xlsm



Slake Durability ASTM D4644

CLIENT	Lithos Engineering	JOB NO.	2962-050
PROJECT	Mesa Verde	LOCATION	--
PROJECT NO.	21152		
BORING NO.	LE-HDD-9-A	LE-HDD-9-A	* LE-HDD-12-A
DEPTH	46'4"-47'4"	63'9"-64'5"	30'9"-31'0"
SAMPLE NO.			
DATE SAMPLED			
DATE TESTED	07/25-31/2023	07/25-31/2023	07/25-31/2023
TECHNICIAN	SS/DL	SS/DL	DL/SS
ROCK TYPE			
Initial Mass of Wet Sample and Drum (g):	1769.8	1651.6	1451.6
Initial Mass of Dry Sample and Drum (g):	1746.1	1638.8	1436.3
Mass of Drum (g):	1245.8	1136.0	1179.5
Moisture (%):	4.7	2.5	6.0
1st Cycle Mass of Sample and Drum (g):	1717.9	1626.7	1404.1
Initial Temperature (°C):	24.2	24.2	24.2
Final Temperature (°C):	24.3	24.1	23.9
Average Temperature (°C):	24.3	24.2	24.1
2nd Cycle Mass of Sample and Drum (g):	1692.7	1617.8	1385.8
Initial Temperature (°C):	22.2	22.0	21.9
Final Temperature (°C):	22.3	22.1	22.1
Average Temperature (°C):	22.3	22.1	22.0
1st Cycle Durability (%):	94.4	97.6	87.5
2nd Cycle Durability (%):	89.3	95.8	80.3
Type:	II	I	II
NOTES	* Not enough sample weight/size based on ASTM recommendations		



**Slake Durability
ASTM D4644**

File name: 2962050__Slake Durability ASTM D4644_0.xlsm

Slake Durability ASTM D4644

CLIENT Lithos Engineering
JOB NO. 2962-050
PROJECT Mesa Verde
PROJECT NO. 21152
LOCATION --

BORING NO. LE-HDD-9-A
DEPTH 46'4"-47'4"
SAMPLE NO. --
DATE SAMPLED --
DATE TESTED 07/25-31/2023
TECHNICIAN SS/DL
ROCK TYPE --

Before Picture



NOTES

* Not enough sample weight/size based on ASTM recommendations

Picture File: 1.JPG
File name: 2962050__Slake Durability ASTM D4644_0.xlsm

Slake Durability ASTM D4644

CLIENT Lithos Engineering
 JOB NO. 2962-050
 PROJECT Mesa Verde
 PROJECT NO. 21152
 LOCATION --

BORING NO. LE-HDD-9-A
 DEPTH 46'4"-47'4"
 SAMPLE NO. --
 DATE SAMPLED --
 DATE TESTED 07/25-31/2023
 TECHNICIAN SS/DL
 ROCK TYPE --

After Picture



NOTES

* Not enough sample weight/size based on ASTM recommendations

Picture File: 1a.JPG
 File name: 2962050__Slake Durability ASTM D4644_0.xlsm

Slake Durability ASTM D4644

CLIENT Lithos Engineering
 JOB NO. 2962-050
 PROJECT Mesa Verde
 PROJECT NO. 21152
 LOCATION --

BORING NO. LE-HDD-9-A
 DEPTH 63'9"-64'5"
 SAMPLE NO. --
 DATE SAMPLED --
 DATE TESTED 07/25-31/2023
 TECHNICIAN SS/DL
 ROCK TYPE --

Before Picture



NOTES

* Not enough sample weight/size based on ASTM recommendations

Picture File: 2.JPG
 File name: 2962050__Slake Durability ASTM D4644_0.xlsm

Slake Durability ASTM D4644

CLIENT Lithos Engineering
 JOB NO. 2962-050
 PROJECT Mesa Verde
 PROJECT NO. 21152
 LOCATION --

BORING NO. LE-HDD-9-A
 DEPTH 63'9"-64'5"
 SAMPLE NO. --
 DATE SAMPLED --
 DATE TESTED 07/25-31/2023
 TECHNICIAN SS/DL
 ROCK TYPE --

After Picture



NOTES

* Not enough sample weight/size based on ASTM recommendations

Picture File: 2a.JPG
 File name: 2962050__Slake Durability ASTM D4644_0.xlsm

Slake Durability ASTM D4644

CLIENT	Lithos Engineering	BORING NO.	* LE-HDD-12-A
JOB NO.	2962-050	DEPTH	30'9"-31'0"
PROJECT	Mesa Verde	SAMPLE NO.	--
PROJECT NO.	21152	DATE SAMPLED	--
LOCATION	--	DATE TESTED	07/25-31/2023
		TECHNICIAN	DL/SS
		ROCK TYPE	--

Before Picture



NOTES

* Not enough sample weight/size based on ASTM recommendations

Picture File: 3.JPG
File name: 2962050__Slake Durability ASTM D4644_0.xlsm

Slake Durability ASTM D4644

CLIENT	Lithos Engineering	BORING NO.	* LE-HDD-12-A
JOB NO.	2962-050	DEPTH	30'9"-31'0"
PROJECT	Mesa Verde	SAMPLE NO.	--
PROJECT NO.	21152	DATE SAMPLED	--
LOCATION	--	DATE TESTED	07/25-31/2023
		TECHNICIAN	DL/SS
		ROCK TYPE	--

After Picture



NOTES

* Not enough sample weight/size based on ASTM recommendations

Picture File: 3a.JPG
File name: 2962050__Slake Durability ASTM D4644_0.xlsm



ADVANCED TERRA TESTING

Moisture and Density ASTM D 2216 and ASTM D 7263

CLIENT	Lithos Engineering	JOB NO.	2962-050
PROJECT	Mesa Verde	LOCATION	--
PROJECT NO.	21152		

BORING NO.			
DEPTH	10'	50'	75'
SAMPLE NO.	LE-HDD-9-B	LE-HDD-9-B	LE-HDD-9-B
DATE SAMPLED			
DATE TESTED	08/17/23	08/17/23	08/17/23
TECHNICIAN	BDF	BDF	BDF
DESCRIPTION			

Mass of Wet Soil and Pan (g):	352.22	301.91	319.68
Mass of Dry Soil and Pan (g):	317.82	282.67	297.88
Mass of Pan (g):	119.65	123.49	123.48
Moisture (%):	17.4	12.1	12.5
Diameter (in):	1.93	1.93	1.93
Height (in):	3.99	3.47	3.98
Mass of Wet Soil and Ring (g):	511.11	657.16	537.13
Mass of Ring (g):	107.57	291.36	106.50
Wet Density (lbs/ft³):	131.9	137.0	140.8
Dry Density (lbs/ft³):	112.4	122.2	125.1
Wet Density (kg/m³):	2113	2194	2255
Dry Density (kg/m³):	1801	1958	2005

BORING NO.			
DEPTH			
SAMPLE NO.			
DATE SAMPLED			
DATE TESTED			
TECHNICIAN			
DESCRIPTION			

Mass of Wet Soil and Pan (g):			
Mass of Dry Soil and Pan (g):			
Mass of Pan (g):			
Moisture (%):			
Diameter (in):			
Height (in):			
Mass of Wet Soil and Ring (g):			
Mass of Ring (g):			
Wet Density (lbs/ft³):			
Dry Density (lbs/ft³):			
Wet Density (kg/m³):			
Dry Density (kg/m³):			

NOTES			
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Data entry by:	CK	Date:	08/21/23
Checked by:	BDF	Date:	08/25/23
File name:	2962050_Moisture and Density ASTM D7236_0.xlsm		

**Moisture
ASTM D 2216**

CLIENT	Lithos Engineering	JOB NO.	2962-050
PROJECT	Mesa Verde	LOCATION	--
PROJECT NO.	21152		
BORING NO. DEPTH SAMPLE NO. DATE SAMPLED DATE TESTED TECHNICIAN DESCRIPTION	40' LE-HDD-9-A 08/24/23 BDF		
Mass of Wet Soil and Pan (g): Mass of Dry Soil and Pan (g): Mass of Pan (g): Moisture (%):	62.65 58.90 6.68 7.2		
BORING NO. DEPTH SAMPLE NO. DATE SAMPLED DATE TESTED TECHNICIAN DESCRIPTION			
Mass of Wet Soil and Pan (g): Mass of Dry Soil and Pan (g): Mass of Pan (g): Moisture (%):			
BORING NO. DEPTH SAMPLE NO. DATE SAMPLED DATE TESTED TECHNICIAN DESCRIPTION			
Mass of Wet Soil and Pan (g): Mass of Dry Soil and Pan (g): Mass of Pan (g): Moisture (%):			
NOTES			
Data entry by:	CK	Date:	08/25/23
Checked by:	BDF	Date:	08/25/23
File name:	2962050_Moisture ASTM D2216_0.xlsm		



Atterberg Limits ASTM D 4318

ADVANCED TERRA TESTING

CLIENT Lithos Engineering
JOB NO. 2962-050
PROJECT Mesa Verde
PROJECT NO. 21152
LOCATION --
DATE TESTED 08/20/23
TECHNICIAN BDF

BORING NO. --
DEPTH 75'
SAMPLE NO. LE-HDD-9-B
DATE SAMPLED --
SAMPLED BY --
DESCRIPTION --

Plastic Limits

Mass of Wet Pan and Soil (g):	26.67	25.03
Mass of Dry Pan and Soil (g):	25.54	24.03
Mass of Pan (g):	18.65	17.70
Moisture (%)	16.4	15.9

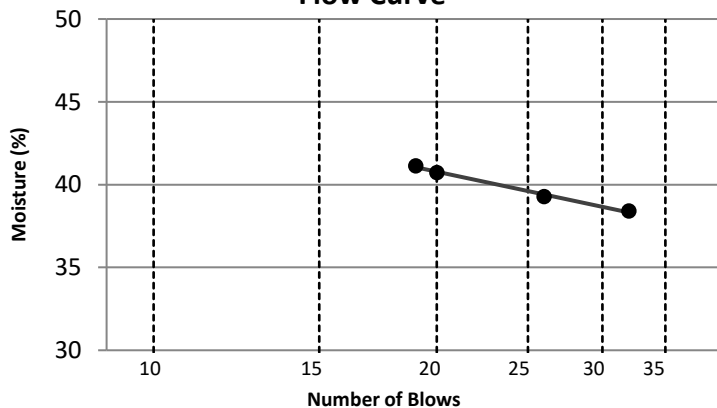
Liquid Limits

Number of Blows	19	20	26	32
Mass of Wet Pan and Soil (g):	28.42	29.85	29.36	27.72
Mass of Dry Pan and Soil (g):	25.56	26.51	26.33	25.22
Mass of Pan (g):	18.60	18.30	18.60	18.70
Moisture (%)	41.1	40.7	39.3	38.4

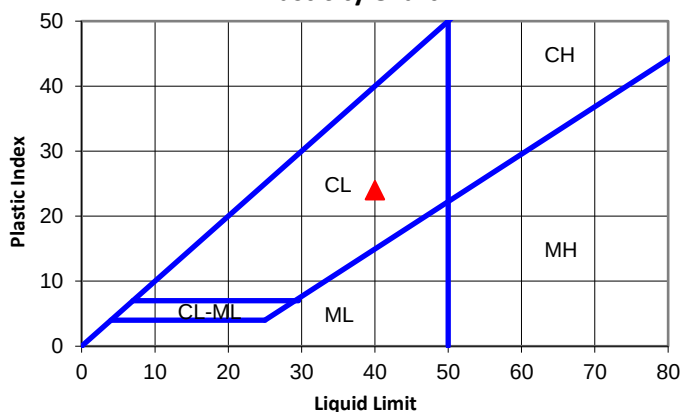
Plastic Index

Plastic Limit: **16** Atterberg Classification: CL
Liquid Limit: **40** Method: A
Plastic Index: **24**

Flow Curve



Plasticity Chart



NOTES

Data entry by: BDF
Checked by: CK
File name: 2962050_Atterberg ASTM D4318_0.xlsm

Date: 08/21/23
Date: 08/23/23



Atterberg Limits ASTM D 4318

ADVANCED TERRA TESTING

CLIENT Lithos Engineering
JOB NO. 2962-050
PROJECT Mesa Verde
PROJECT NO. 21152
LOCATION --
DATE TESTED 08/22/23
TECHNICIAN CK

BORING NO. --
DEPTH 10'
SAMPLE NO. LE-HDD-9-B
DATE SAMPLED --
SAMPLED BY --
DESCRIPTION --

Plastic Limits

Mass of Wet Pan and Soil (g):	28.86	27.88	28.68
Mass of Dry Pan and Soil (g):	27.49	26.51	27.33
Mass of Pan (g):	18.75	17.75	18.59
Moisture (%)	15.7	15.6	15.4

Liquid Limits

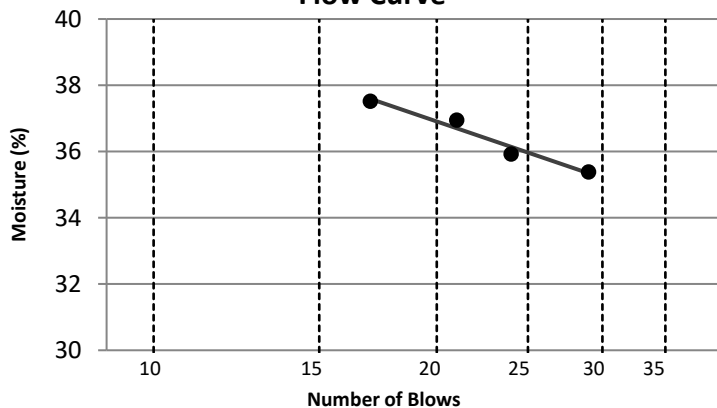
Number of Blows	17	21	24	29
Mass of Wet Pan and Soil (g):	31.40	32.50	31.01	29.56
Mass of Dry Pan and Soil (g):	27.89	28.77	27.72	26.72
Mass of Pan (g):	18.53	18.68	18.56	18.68
Moisture (%)	37.5	37.0	35.9	35.4

Plastic Index

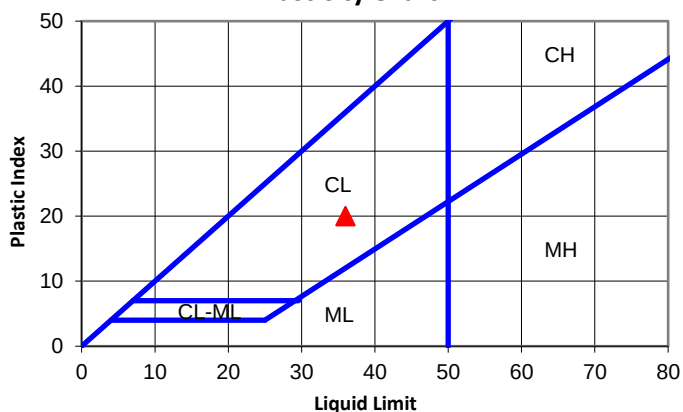
Plastic Limit: 16
Liquid Limit: 36
Plastic Index: 20

Atterberg Classification: CL
Method: A

Flow Curve



Plasticity Chart



NOTES

Data entry by: CK
Checked by: BDF
File name: 2962050_Atterberg ASTM D4318_1.xlsm

Date: 08/23/23
Date: 08/25/23



Atterberg Limits ASTM D 4318

ADVANCED TERRA TESTING

CLIENT Lithos Engineering
JOB NO. 2962-050
PROJECT Mesa Verde
PROJECT NO. 21152
LOCATION --
DATE TESTED 08/23/23
TECHNICIAN JT

BORING NO. --
DEPTH 50'
SAMPLE NO. LE-HDD-9-B
DATE SAMPLED --
SAMPLED BY --
DESCRIPTION --

Plastic Limits

Mass of Wet Pan and Soil (g):	25.31	25.13	25.31
Mass of Dry Pan and Soil (g):	24.34	24.24	24.39
Mass of Pan (g):	18.47	18.69	18.62
Moisture (%)	16.6	16.1	15.8

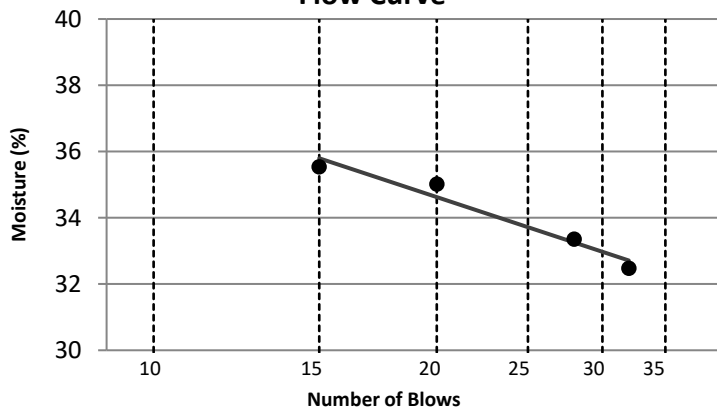
Liquid Limits

Number of Blows	15	20	28	32
Mass of Wet Pan and Soil (g):	27.24	29.12	27.19	28.46
Mass of Dry Pan and Soil (g):	24.98	26.39	25.01	26.09
Mass of Pan (g):	18.60	18.59	18.48	18.79
Moisture (%)	35.5	35.0	33.4	32.5

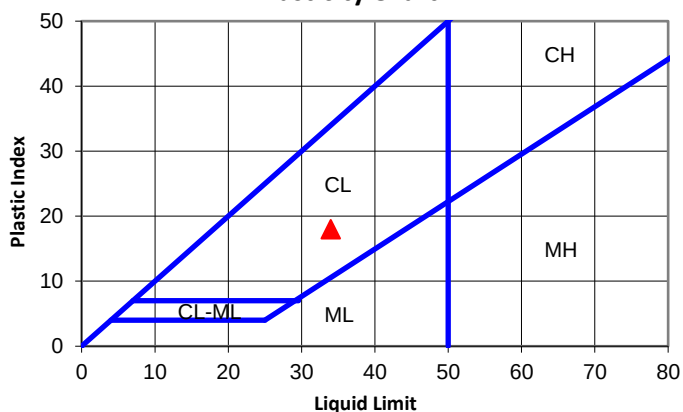
Plastic Index

Plastic Limit: **16** Atterberg Classification: CL
Liquid Limit: **34** Method: A
Plastic Index: **18**

Flow Curve



Plasticity Chart



NOTES

Data entry by: JT
Checked by: BDF
File name: 2962050_Atterberg ASTM D4318_2.xlsm

Date: 08/24/23
Date: 08/25/23



ADVANCED TERRA TESTING

**Percent Minus #200
ASTM D 1140**

CLIENT Lithos Engineering
JOB NO. 2962-050
PROJECT Mesa Verde
PROJECT NO. 21152
LOCATION --
DATE TESTED 08/18/23
TECHNICIAN WB

BORING NO. --
DEPTH 75'
SAMPLE NO. LE-HDD-9-B
DATE SAMPLED --
DESCRIPTION --

Hygroscopic Moisture

Mass Wet Pan and Soil (g): 319.68
Mass Dry Pan and Soil (g): 297.88
Mass of Pan (g): 123.48
Moisture (%): **12.5**

Sample Data

Total Wet Mass of Sample (g): 196.2
Total Dry Mass of Sample (g): 174.4

Sieve Number	Sieve Size (mm)	Mass of Pan and Soil (g)	Mass of Pan (g)	Mass of Individual Retained Soil (g)	Correction Factor	Percent Passing by Weight (%)
#4	4.75	0.4	0.0	0.4	1.00	99.8
#200	0.075	132.3	123.5	8.8	1.00	94.8

USCS Classification ASTM D 2487

Atterberg Classification: CL
Group Symbol: CL
USCS Classification: Lean Clay

NOTES

Data entry by: JT
Checked by: BDF
File name: 2962050__Percent Minus #200 ASTM D1140_0.xlsm

Date: 08/21/23
Date: 08/25/23



ADVANCED TERRA TESTING

**Percent Minus #200
ASTM D 1140**

CLIENT	Lithos Engineering	BORING NO.	--
JOB NO.	2962-050	DEPTH	10'
PROJECT	Mesa Verde	SAMPLE NO.	LE-HDD-9-B
PROJECT NO.	21152	DATE SAMPLED	--
LOCATION	--	DESCRIPTION	--
DATE TESTED	08/18/23		
TECHNICIAN	WB		

Hygroscopic Moisture

Mass Wet Pan and Soil (g): 352.22
Mass Dry Pan and Soil (g): 317.82
Mass of Pan (g): 119.65
Moisture (%): **17.4**

Sample Data

Total Wet Mass of Sample (g): 232.6
Total Dry Mass of Sample (g): 198.2

Sieve Number	Sieve Size (mm)	Mass of Pan and Soil (g)	Mass of Pan (g)	Mass of Individual Retained Soil (g)	Correction Factor	Percent Passing by Weight (%)
#4	4.75	1.5	0.0	1.5	1.00	99.3
#200	0.075	165.6	119.7	45.9	1.00	76.1

USCS Classification ASTM D 2487

Atterberg Classification: CL
Group Symbol: CL
USCS Classification: Lean Clay With Sand

NOTES

Data entry by: BDF
Checked by: CK
File name: 2962050__Percent Minus #200 ASTM D1140_1.xlsm

Date: 08/25/23
Date: 08/25/23



ADVANCED TERRA TESTING

**Percent Minus #200
ASTM D 1140**

CLIENT	Lithos Engineering	BORING NO.	--
JOB NO.	2962-050	DEPTH	50'
PROJECT	Mesa Verde	SAMPLE NO.	LE-HDD-9-B
PROJECT NO.	21152	DATE SAMPLED	--
LOCATION	--	DESCRIPTION	--
DATE TESTED	08/18/23		
TECHNICIAN	WB		

Hygroscopic Moisture

Mass Wet Pan and Soil (g): 301.91
Mass Dry Pan and Soil (g): 282.67
Mass of Pan (g): 123.49
Moisture (%): **12.1**

Sample Data

Total Wet Mass of Sample (g): 178.4
Total Dry Mass of Sample (g): 159.2

Sieve Number	Sieve Size (mm)	Mass of Pan and Soil (g)	Mass of Pan (g)	Mass of Individual Retained Soil (g)	Correction Factor	Percent Passing by Weight (%)
#4	4.75	10.6	0.0	10.6	1.00	93.3
#200	0.075	177.1	123.5	53.6	1.00	59.7

USCS Classification ASTM D 2487

Atterberg Classification: CL
Group Symbol: CL
USCS Classification: Sandy Lean Clay

NOTES

Data entry by: BDF
Checked by: CK
File name: 2962050__Percent Minus #200 ASTM D1140_2.xlsm

Date: 08/25/23
Date: 08/25/23

Unconfined Compressive Strength

ASTM D2166

CLIENT	Lithos Engineering	BORING NO.	--
JOB NO.	2962-050	DEPTH	85'
PROJECT	Mesa Verde	SAMPLE NO.	LE-HDD-9-B
PROJECT NO.	21152	DATE SAMPLED	--
LOCATION	--	DESCRIPTION	--
DATE TESTED	08/23/23		
TECHNICIAN	AC		

Test Parameters

Strain Rate (in/min): 0.030
Strain Rate (cm/min): 0.076

Raw Data Files: 2962-050_85_LE-HDD-9-B_UCS_08-23.

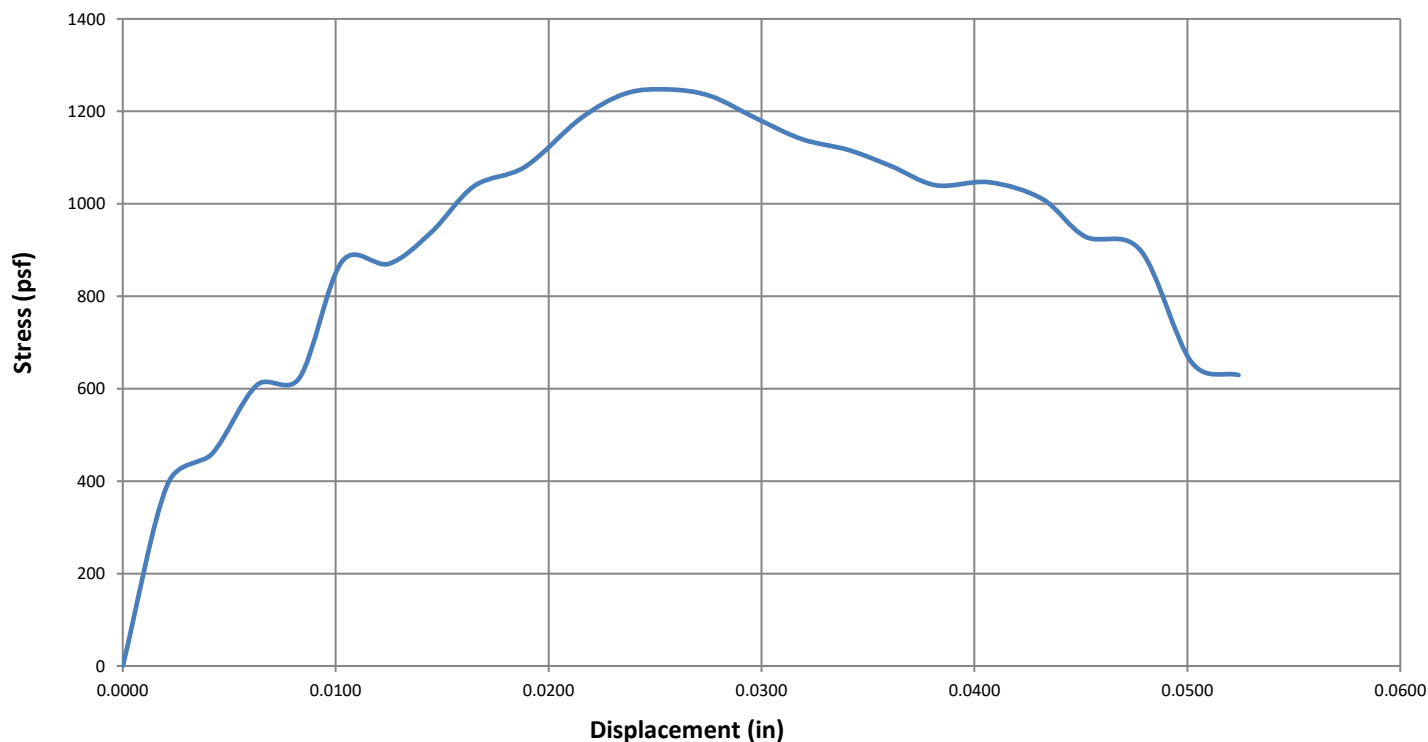
Moisture & Density Data

Mass of Wet Soil and Pan (g):	422.83	Initial Wet Density (pcf):	111.5
Mass of Dry Soil and Pan (g):	411.44	Initial Dry Density (pcf):	106.4
Mass of Pan (g):	172.30	Initial Wet Density (kg/m ³):	1785
Mass of Wet Soil (g):	250.53	Initial Dry Density (kg/m ³):	1704
Initial Diameter (in):	1.914	Initial Moisture (%):	4.8
Initial Height (in):	2.976		

Test Results

Peak Stress (psf):	1247	Axial Strain at Peak Stress (%):	0.9
Peak Stress (kPa):	60	Height to Diameter Ratio:	1.6:1

Displacement vs. Stress



NOTES:

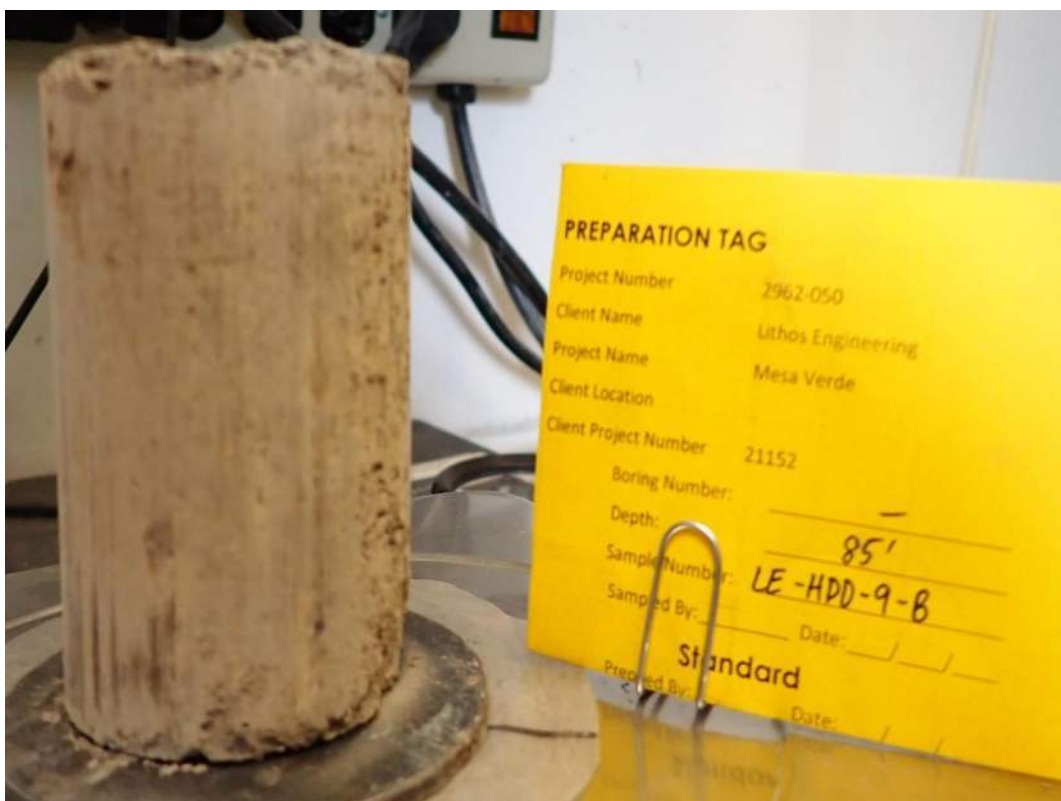
Data entry by:	AC	Date: 08/28/23
Checked by:	BDF	Date: 08/28/23
File name:	2962050__ UCS ASTM D2166_0.xlsm	



ADVANCED TERRA TESTING

Unconfined Compressive Strength
ASTM D2166
(Before Picture)

CLIENT	Lithos Engineering	BORING NO.	--
JOB NO.	2962-050	DEPTH	85'
PROJECT	Mesa Verde	SAMPLE NO.	LE-HDD-9-B
PROJECT NO.	21152	DATE SAMPLED	--
LOCATION	--	DESCRIPTION	--
DATE TESTED	08/23/23		
TECHNICIAN	AC		



NOTES

Picture File: P8234520.JPG
File name: 2962050__UCS ASTM D2166_0.xlsm



ADVANCED TERRA TESTING

**Unconfined Compressive Strength
ASTM D2166
(After Picture)**

CLIENT	Lithos Engineering	BORING NO.	--
JOB NO.	2962-050	DEPTH	85'
PROJECT	Mesa Verde	SAMPLE NO.	LE-HDD-9-B
PROJECT NO.	21152	DATE SAMPLED	--
LOCATION	--	DESCRIPTION	--
DATE TESTED	08/23/23		
TECHNICIAN	AC		



NOTES

Picture File: P8234521.JPG
File name: 2962050__UCS ASTM D2166_0.xlsm

**Unconfined Compressive Strength
ASTM D2166**

CLIENT	Lithos Engineering	BORING NO.	--
JOB NO.	2962-050	DEPTH	85'
PROJECT	Mesa Verde	SAMPLE NO.	LE-HDD-9-B
PROJECT NO.	21152	DATE SAMPLED	--
LOCATION	--	DESCRIPTION	--
DATE TESTED	08/23/23		
TECHNICIAN	AC		

Displacement (in)	Displacement (cm)	Strain (%)	Average Cross Sectional Area (in ²)	Load (lbs)	Load (N)	Stress (psf)	Stress (kPa)
0.0000	0.000	0.00	2.88	0	0	0	0
0.0021	0.005	0.07	2.88	8	35	393	19
0.0042	0.011	0.14	2.88	9	41	459	22
0.0063	0.016	0.21	2.88	12	54	608	29
0.0083	0.021	0.28	2.89	12	56	623	30
0.0103	0.026	0.35	2.89	18	78	875	42
0.0125	0.032	0.42	2.89	17	78	870	42
0.0145	0.037	0.49	2.89	19	84	939	45
0.0165	0.042	0.55	2.89	21	93	1038	50
0.0189	0.048	0.64	2.90	22	97	1080	52
0.0215	0.055	0.72	2.90	24	106	1185	57
0.0236	0.060	0.79	2.90	25	111	1238	59
0.0256	0.065	0.86	2.90	25	112	1247	60
0.0276	0.070	0.93	2.90	25	111	1233	59
0.0298	0.076	1.00	2.91	24	106	1184	57
0.0319	0.081	1.07	2.91	23	102	1140	55
0.0341	0.087	1.15	2.91	23	100	1116	53
0.0361	0.092	1.21	2.91	22	97	1081	52
0.0382	0.097	1.28	2.91	21	94	1040	50
0.0407	0.103	1.37	2.92	21	94	1047	50
0.0432	0.110	1.45	2.92	20	91	1010	48
0.0452	0.115	1.52	2.92	19	84	929	44
0.0478	0.121	1.61	2.92	18	81	899	43
0.0502	0.128	1.69	2.93	13	59	657	31
0.0524	0.133	1.76	2.93	13	57	629	30

Unconfined Compressive Strength

ASTM D2166

CLIENT	Lithos Engineering	BORING NO.	--
JOB NO.	2962-050	DEPTH	25'
PROJECT	Mesa Verde	SAMPLE NO.	LE-HDD-9-A
PROJECT NO.	21152	DATE SAMPLED	--
LOCATION	--	DESCRIPTION	--
DATE TESTED	08/23/23		
TECHNICIAN	AC		

Test Parameters

Strain Rate (in/min): 0.039
Strain Rate (cm/min): 0.100

Raw Data Files: 2962-050_25_LE-HDD-9-A_UCS_08-23.

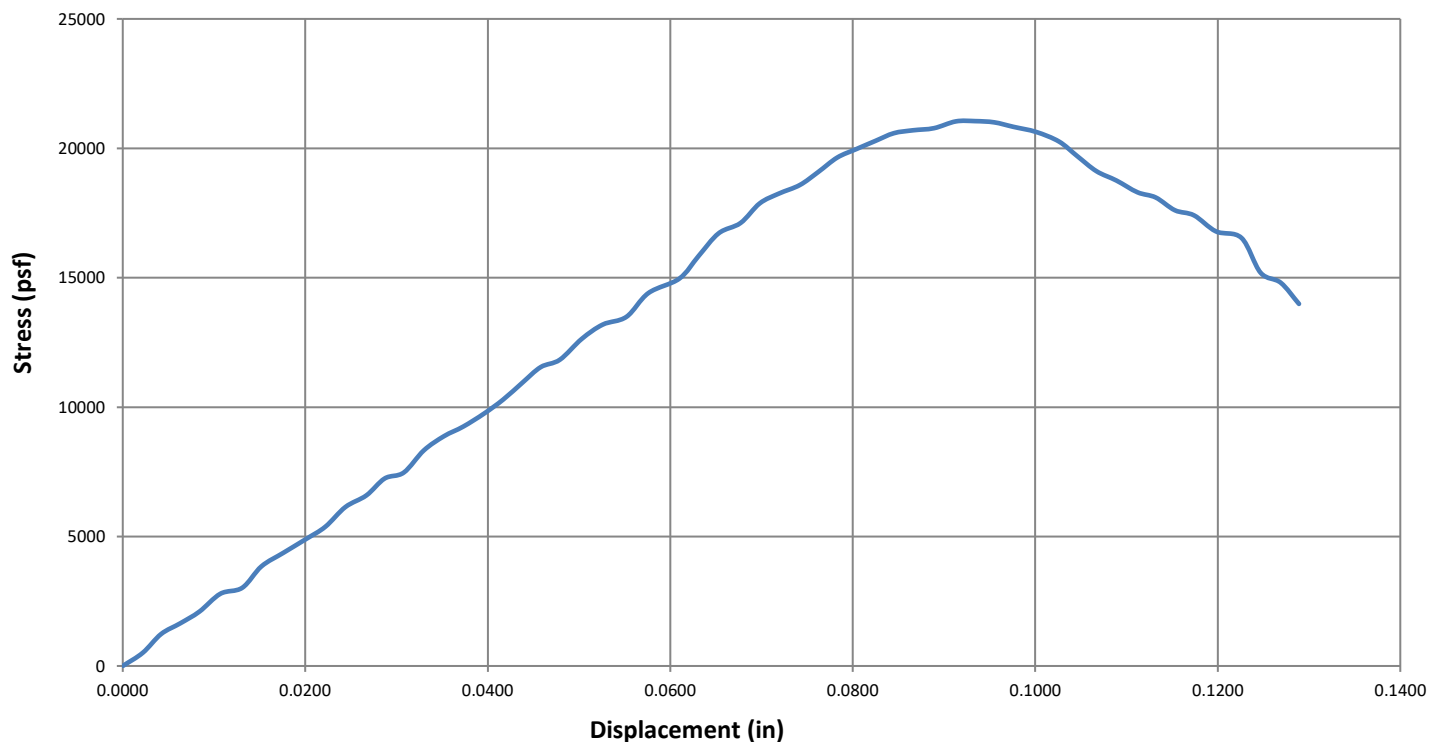
Moisture & Density Data

Mass of Wet Soil and Pan (g):	579.27	Initial Wet Density (pcf):	134.8
Mass of Dry Soil and Pan (g):	543.15	Initial Dry Density (pcf):	122.9
Mass of Pan (g):	171.30	Initial Wet Density (kg/m ³):	2159
Mass of Wet Soil (g):	407.97	Initial Dry Density (kg/m ³):	1968
Initial Diameter (in):	1.932	Initial Moisture (%):	9.7
Initial Height (in):	3.933		

Test Results

Peak Stress (psf):	21051	Axial Strain at Peak Stress (%):	2.4
Peak Stress (kPa):	1008	Height to Diameter Ratio:	2.0:1

Displacement vs. Stress



NOTES:

Data entry by:	AC	Date: 08/28/23
Checked by:	BDF	Date: 08/28/23
File name:	2962050__ UCS ASTM D2166_1.xlsm	



ADVANCED TERRA TESTING

**Unconfined Compressive Strength
ASTM D2166
(Before Picture)**

CLIENT	Lithos Engineering	BORING NO.	--
JOB NO.	2962-050	DEPTH	25'
PROJECT	Mesa Verde	SAMPLE NO.	LE-HDD-9-A
PROJECT NO.	21152	DATE SAMPLED	--
LOCATION	--	DESCRIPTION	--
DATE TESTED	08/23/23		
TECHNICIAN	AC		



NOTES

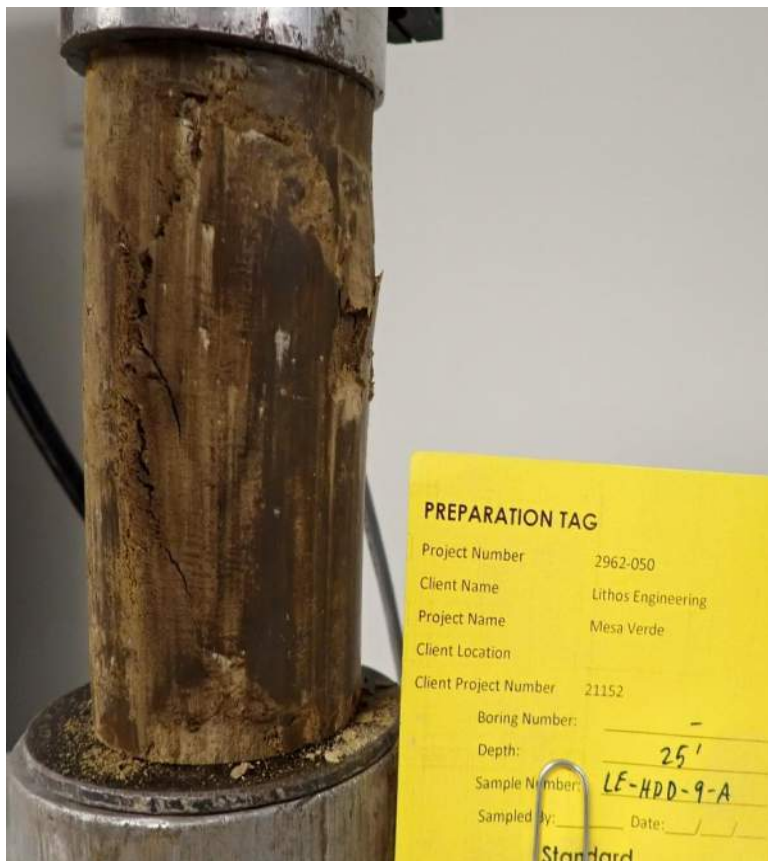
Picture File: P8234527.JPG
File name: 2962050__UCS ASTM D2166_1.xlsm



ADVANCED TERRA TESTING

**Unconfined Compressive Strength
ASTM D2166
(After Picture)**

CLIENT	Lithos Engineering	BORING NO.	--
JOB NO.	2962-050	DEPTH	25'
PROJECT	Mesa Verde	SAMPLE NO.	LE-HDD-9-A
PROJECT NO.	21152	DATE SAMPLED	--
LOCATION	--	DESCRIPTION	--
DATE TESTED	08/23/23		
TECHNICIAN	AC		



NOTES

Picture File: P8234528.JPG
File name: 2962050__UCS ASTM D2166_1.xlsm

**Unconfined Compressive Strength
ASTM D2166**

CLIENT	Lithos Engineering	BORING NO.	--
JOB NO.	2962-050	DEPTH	25'
PROJECT	Mesa Verde	SAMPLE NO.	LE-HDD-9-A
PROJECT NO.	21152	DATE SAMPLED	--
LOCATION	--	DESCRIPTION	--
DATE TESTED	08/23/23		
TECHNICIAN	AC		

Displacement (in)	Displacement (cm)	Strain (%)	Average Cross Sectional Area (in ²)	Load (lbs)	Load (N)	Stress (psf)	Stress (kPa)
0.0000	0.000	0.00	2.93	0	0	0	0
0.0022	0.006	0.06	2.93	10	46	512	25
0.0042	0.011	0.11	2.93	25	112	1234	59
0.0063	0.016	0.16	2.94	34	149	1648	79
0.0084	0.021	0.21	2.94	43	191	2100	101
0.0107	0.027	0.27	2.94	57	253	2790	134
0.0131	0.033	0.33	2.94	62	275	3022	145
0.0152	0.039	0.39	2.94	79	350	3849	184
0.0176	0.045	0.45	2.94	89	398	4371	209
0.0201	0.051	0.51	2.95	100	447	4908	235
0.0222	0.056	0.56	2.95	110	490	5379	258
0.0244	0.062	0.62	2.95	126	560	6141	294
0.0267	0.068	0.68	2.95	135	601	6591	316
0.0287	0.073	0.73	2.95	149	661	7243	347
0.0308	0.078	0.78	2.95	153	682	7474	358
0.0330	0.084	0.84	2.96	171	761	8331	399
0.0352	0.089	0.89	2.96	182	811	8877	425
0.0373	0.095	0.95	2.96	190	845	9246	443
0.0396	0.101	1.01	2.96	201	892	9753	467
0.0417	0.106	1.06	2.96	212	942	10295	493
0.0438	0.111	1.11	2.96	225	1003	10947	524
0.0458	0.116	1.16	2.97	238	1058	11546	553
0.0479	0.122	1.22	2.97	244	1085	11832	567
0.0503	0.128	1.28	2.97	261	1159	12638	605
0.0526	0.134	1.34	2.97	272	1211	13190	632
0.0552	0.140	1.40	2.97	279	1239	13490	646
0.0576	0.146	1.46	2.98	298	1324	14406	690
0.0610	0.155	1.55	2.98	310	1377	14967	717
0.0631	0.160	1.60	2.98	328	1458	15837	758
0.0653	0.166	1.66	2.98	346	1539	16716	800
0.0677	0.172	1.72	2.98	355	1577	17114	819
0.0698	0.177	1.77	2.98	370	1648	17872	856
0.0719	0.183	1.83	2.99	378	1683	18250	874
0.0742	0.188	1.89	2.99	386	1715	18582	890
0.0762	0.194	1.94	2.99	396	1762	19081	914
0.0783	0.199	1.99	2.99	408	1815	19643	941
0.0804	0.204	2.04	2.99	415	1846	19972	956
0.0825	0.210	2.10	2.99	422	1877	20289	971
0.0845	0.215	2.15	3.00	428	1905	20584	986
0.0866	0.220	2.20	3.00	431	1916	20696	991
0.0889	0.226	2.26	3.00	433	1925	20778	995
0.0913	0.232	2.32	3.00	439	1951	21041	1007
0.0934	0.237	2.37	3.00	439	1953	21051	1008

**Unconfined Compressive Strength
ASTM D2166**

CLIENT	Lithos Engineering	BORING NO.	--
JOB NO.	2962-050	DEPTH	25'
PROJECT	Mesa Verde	SAMPLE NO.	LE-HDD-9-A
PROJECT NO.	21152	DATE SAMPLED	--
LOCATION	--	DESCRIPTION	--
DATE TESTED	08/23/23		
TECHNICIAN	AC		

Displacement (in)	Displacement (cm)	Strain (%)	Average Cross Sectional Area (in ²)	Load (lbs)	Load (N)	Stress (psf)	Stress (kPa)
0.0955	0.243	2.43	3.00	438	1949	21003	1006
0.0976	0.248	2.48	3.01	435	1934	20830	997
0.1001	0.254	2.55	3.01	431	1917	20631	988
0.1026	0.261	2.61	3.01	424	1884	20262	970
0.1046	0.266	2.66	3.01	412	1833	19698	943
0.1067	0.271	2.71	3.01	400	1780	19117	915
0.1089	0.277	2.77	3.02	393	1747	18754	898
0.1112	0.282	2.83	3.02	383	1705	18301	876
0.1132	0.288	2.88	3.02	379	1688	18100	867
0.1153	0.293	2.93	3.02	369	1643	17606	843
0.1174	0.298	2.98	3.02	365	1625	17409	834
0.1198	0.304	3.05	3.02	353	1568	16791	804
0.1226	0.311	3.12	3.03	348	1546	16537	792
0.1247	0.317	3.17	3.03	319	1421	15191	727
0.1269	0.322	3.23	3.03	312	1386	14807	709
0.1289	0.327	3.28	3.03	294	1310	13989	670

Unconfined Compressive Strength

ASTM D2166

CLIENT	Lithos Engineering	BORING NO.	--
JOB NO.	2962-050	DEPTH	90'
PROJECT	Mesa Verde	SAMPLE NO.	LE-HDD-9-B
PROJECT NO.	21152	DATE SAMPLED	--
LOCATION	--	DESCRIPTION	--
DATE TESTED	08/25/23		
TECHNICIAN	AC		

Test Parameters

Strain Rate (in/min): 0.035
Strain Rate (cm/min): 0.090

Raw Data Files: 2962-050_90_LE-HDD-9-B_UCS_08-25.

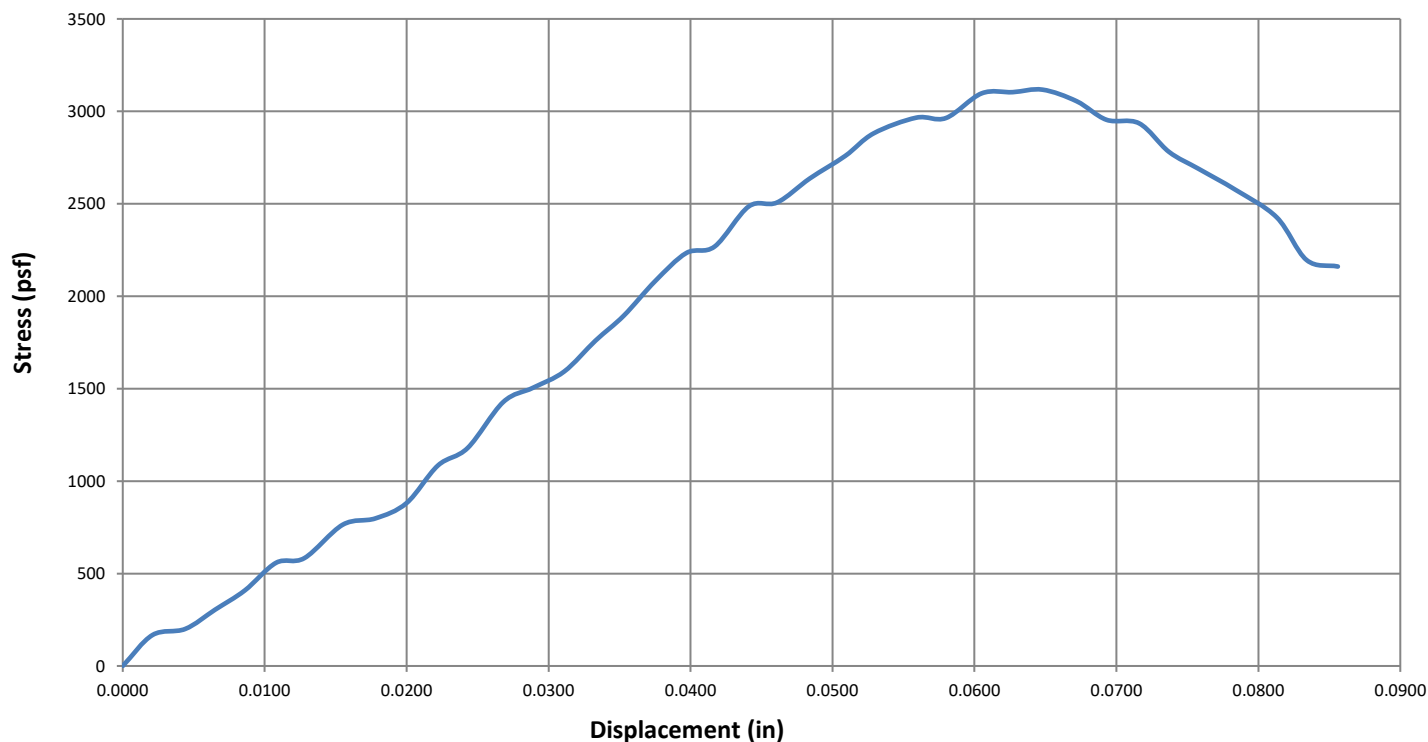
Moisture & Density Data

Mass of Wet Soil and Pan (g):	491.14	Initial Wet Density (pcf):	113.2
Mass of Dry Soil and Pan (g):	476.62	Initial Dry Density (pcf):	107.9
Mass of Pan (g):	179.89	Initial Wet Density (kg/m ³):	1813
Mass of Wet Soil (g):	311.25	Initial Dry Density (kg/m ³):	1729
Initial Diameter (in):	1.939	Initial Moisture (%):	4.9
Initial Height (in):	3.547		

Test Results

Peak Stress (psf):	3117	Axial Strain at Peak Stress (%):	1.8
Peak Stress (kPa):	149	Height to Diameter Ratio:	1.8:1

Displacement vs. Stress



NOTES:

Data entry by:	AC	Date: 08/28/23
Checked by:	BDF	Date: 08/28/23
File name:	2962050__ UCS ASTM D2166_2.xlsm	

Unconfined Compressive Strength ASTM D2166 (Before Picture)

CLIENT	Lithos Engineering	BORING NO.	--
JOB NO.	2962-050	DEPTH	90'
PROJECT	Mesa Verde	SAMPLE NO.	LE-HDD-9-B
PROJECT NO.	21152	DATE SAMPLED	--
LOCATION	--	DESCRIPTION	--
DATE TESTED	08/25/23		
TECHNICIAN	AC		



NOTES

Picture File: P8254569.JPG
File name: 2962050__UCS ASTM D2166_2.xlsm



ADVANCED TERRA TESTING

**Unconfined Compressive Strength
ASTM D2166
(After Picture)**

CLIENT	Lithos Engineering	BORING NO.	--
JOB NO.	2962-050	DEPTH	90'
PROJECT	Mesa Verde	SAMPLE NO.	LE-HDD-9-B
PROJECT NO.	21152	DATE SAMPLED	--
LOCATION	--	DESCRIPTION	--
DATE TESTED	08/25/23		
TECHNICIAN	AC		



NOTES

Picture File: P8254570.JPG
File name: 2962050__UCS ASTM D2166_2.xlsm

**Unconfined Compressive Strength
ASTM D2166**

CLIENT	Lithos Engineering	BORING NO.	--
JOB NO.	2962-050	DEPTH	90'
PROJECT	Mesa Verde	SAMPLE NO.	LE-HDD-9-B
PROJECT NO.	21152	DATE SAMPLED	--
LOCATION	--	DESCRIPTION	--
DATE TESTED	08/25/23		
TECHNICIAN	AC		

Displacement (in)	Displacement (cm)	Strain (%)	Average Cross Sectional Area (in ²)	Load (lbs)	Load (N)	Stress (psf)	Stress (kPa)
0.0000	0.000	0.00	2.95	0	0	0	0
0.0021	0.005	0.06	2.95	3	15	168	8
0.0044	0.011	0.12	2.96	4	18	200	10
0.0065	0.017	0.18	2.96	6	28	304	15
0.0086	0.022	0.24	2.96	8	37	409	20
0.0108	0.027	0.30	2.96	11	51	558	27
0.0128	0.033	0.36	2.96	12	53	584	28
0.0155	0.039	0.44	2.97	16	70	764	37
0.0178	0.045	0.50	2.97	16	73	798	38
0.0200	0.051	0.56	2.97	18	81	882	42
0.0222	0.056	0.63	2.97	22	100	1084	52
0.0243	0.062	0.69	2.97	24	108	1179	56
0.0268	0.068	0.76	2.98	29	131	1427	68
0.0289	0.073	0.81	2.98	31	138	1505	72
0.0311	0.079	0.88	2.98	33	147	1593	76
0.0333	0.085	0.94	2.98	36	162	1759	84
0.0353	0.090	1.00	2.98	39	175	1895	91
0.0375	0.095	1.06	2.98	43	192	2081	100
0.0397	0.101	1.12	2.99	46	206	2234	107
0.0417	0.106	1.18	2.99	47	209	2269	109
0.0441	0.112	1.24	2.99	52	230	2486	119
0.0461	0.117	1.30	2.99	52	232	2507	120
0.0484	0.123	1.36	2.99	55	244	2637	126
0.0509	0.129	1.44	3.00	57	255	2759	132
0.0529	0.134	1.49	3.00	60	267	2881	138
0.0559	0.142	1.58	3.00	62	275	2966	142
0.0580	0.147	1.64	3.00	62	275	2964	142
0.0605	0.154	1.71	3.00	65	287	3097	148
0.0627	0.159	1.77	3.01	65	288	3104	149
0.0648	0.165	1.83	3.01	65	290	3117	149
0.0672	0.171	1.89	3.01	64	284	3055	146
0.0693	0.176	1.95	3.01	62	275	2954	141
0.0716	0.182	2.02	3.01	61	273	2935	141
0.0737	0.187	2.08	3.02	58	259	2781	133
0.0758	0.193	2.14	3.02	56	251	2689	129
0.0784	0.199	2.21	3.02	54	240	2575	123
0.0813	0.207	2.29	3.02	51	227	2426	116
0.0834	0.212	2.35	3.02	46	205	2196	105
0.0856	0.217	2.41	3.03	45	202	2161	103

Unconfined Compressive Strength

ASTM D2166

CLIENT	Lithos Engineering	BORING NO.	--
JOB NO.	2962-050	DEPTH	20'
PROJECT	Mesa Verde	SAMPLE NO.	LE-HDD-9-B
PROJECT NO.	21152	DATE SAMPLED	--
LOCATION	--	DESCRIPTION	--
DATE TESTED	08/25/23		
TECHNICIAN	AC		

Test Parameters

Strain Rate (in/min): 0.037
Strain Rate (cm/min): 0.093

Raw Data Files: 2962-050_20_LE-HDD-9-B_UCS_08-25.

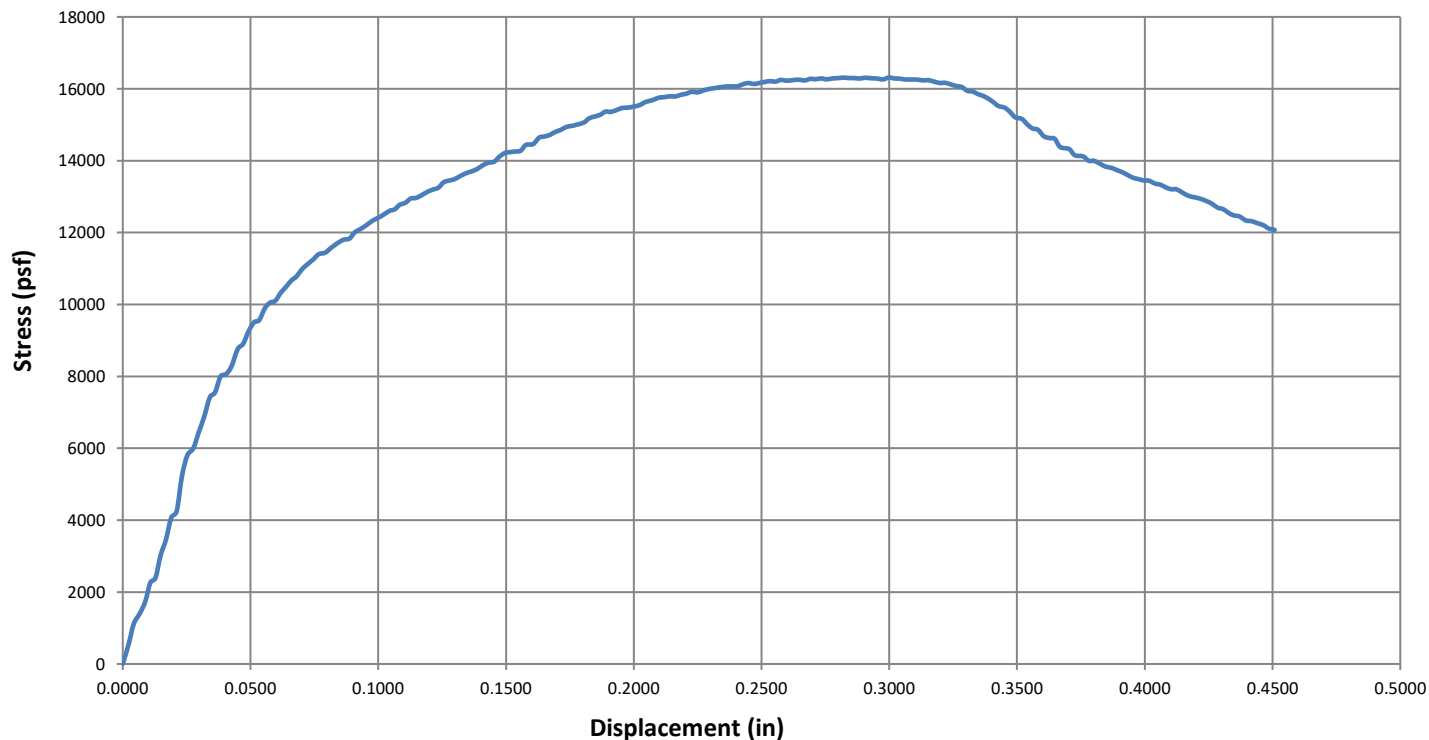
Moisture & Density Data

Mass of Wet Soil and Pan (g):	545.05	Initial Wet Density (pcf):	128.6
Mass of Dry Soil and Pan (g):	503.89	Initial Dry Density (pcf):	113.8
Mass of Pan (g):	186.33	Initial Wet Density (kg/m ³):	2060
Mass of Wet Soil (g):	358.72	Initial Dry Density (kg/m ³):	1824
Initial Diameter (in):	1.924	Initial Moisture (%):	13.0
Initial Height (in):	3.655		

Test Results

Peak Stress (psf):	16313	Axial Strain at Peak Stress (%):	8.2
Peak Stress (kPa):	781	Height to Diameter Ratio:	1.9:1

Displacement vs. Stress



NOTES:

Data entry by:	AC	Date: 08/28/23
Checked by:	BDF	Date: 08/28/23
File name:	2962050__ UCS ASTM D2166_3.xlsm	



ADVANCED TERRA TESTING

**Unconfined Compressive Strength
ASTM D2166
(Before Picture)**

CLIENT	Lithos Engineering	BORING NO.	--
JOB NO.	2962-050	DEPTH	20'
PROJECT	Mesa Verde	SAMPLE NO.	LE-HDD-9-B
PROJECT NO.	21152	DATE SAMPLED	--
LOCATION	--	DESCRIPTION	--
DATE TESTED	08/25/23		
TECHNICIAN	AC		



NOTES

Picture File: P8254565.JPG
File name: 2962050__UCS ASTM D2166_3.xlsm



ADVANCED TERRA TESTING

**Unconfined Compressive Strength
ASTM D2166
(After Picture)**

CLIENT	Lithos Engineering	BORING NO.	--
JOB NO.	2962-050	DEPTH	20'
PROJECT	Mesa Verde	SAMPLE NO.	LE-HDD-9-B
PROJECT NO.	21152	DATE SAMPLED	--
LOCATION	--	DESCRIPTION	--
DATE TESTED	08/25/23		
TECHNICIAN	AC		



NOTES

Picture File: P8254566.JPG
File name: 2962050__UCS ASTM D2166_3.xlsm

**Unconfined Compressive Strength
ASTM D2166**

CLIENT	Lithos Engineering	BORING NO.	--
JOB NO.	2962-050	DEPTH	20'
PROJECT	Mesa Verde	SAMPLE NO.	LE-HDD-9-B
PROJECT NO.	21152	DATE SAMPLED	--
LOCATION	--	DESCRIPTION	--
DATE TESTED	08/25/23		
TECHNICIAN	AC		

Displacement (in)	Displacement (cm)	Strain (%)	Average Cross Sectional Area (in ²)	Load (lbs)	Load (N)	Stress (psf)	Stress (kPa)
0.0000	0.000	0.00	2.91	0	0	0	0
0.0023	0.006	0.06	2.91	11	49	547	26
0.0043	0.011	0.12	2.91	23	100	1116	53
0.0067	0.017	0.18	2.91	29	127	1410	68
0.0088	0.022	0.24	2.91	35	156	1734	83
0.0108	0.027	0.30	2.92	46	204	2263	108
0.0128	0.033	0.35	2.92	48	216	2392	115
0.0148	0.038	0.40	2.92	61	272	3019	145
0.0169	0.043	0.46	2.92	70	312	3457	166
0.0190	0.048	0.52	2.92	83	368	4075	195
0.0211	0.054	0.58	2.92	86	383	4245	203
0.0232	0.059	0.63	2.93	106	473	5236	251
0.0253	0.064	0.69	2.93	118	525	5806	278
0.0276	0.070	0.76	2.93	122	543	5995	287
0.0297	0.075	0.81	2.93	131	583	6438	308
0.0318	0.081	0.87	2.93	140	622	6862	329
0.0341	0.087	0.93	2.93	151	673	7420	355
0.0361	0.092	0.99	2.94	154	685	7550	361
0.0383	0.097	1.05	2.94	163	726	8002	383
0.0404	0.103	1.11	2.94	165	732	8059	386
0.0425	0.108	1.16	2.94	169	752	8271	396
0.0450	0.114	1.23	2.94	179	797	8761	419
0.0471	0.120	1.29	2.95	182	810	8901	426
0.0492	0.125	1.35	2.95	189	842	9249	443
0.0514	0.131	1.41	2.95	195	866	9505	455
0.0534	0.136	1.46	2.95	196	872	9563	458
0.0556	0.141	1.52	2.95	203	902	9894	474
0.0576	0.146	1.58	2.95	206	917	10050	481
0.0597	0.152	1.63	2.96	207	922	10102	484
0.0618	0.157	1.69	2.96	212	943	10323	494
0.0639	0.162	1.75	2.96	216	959	10489	502
0.0659	0.167	1.80	2.96	219	975	10662	510
0.0680	0.173	1.86	2.96	222	986	10780	516
0.0700	0.178	1.92	2.96	226	1004	10969	525
0.0722	0.183	1.98	2.97	229	1018	11113	532
0.0746	0.189	2.04	2.97	232	1032	11256	539
0.0767	0.195	2.10	2.97	235	1046	11400	546
0.0792	0.201	2.17	2.97	236	1050	11441	548
0.0815	0.207	2.23	2.97	239	1063	11573	554
0.0841	0.214	2.30	2.98	242	1076	11709	561
0.0864	0.219	2.36	2.98	244	1086	11801	565
0.0887	0.225	2.43	2.98	245	1089	11832	566
0.0908	0.231	2.48	2.98	249	1106	12005	575

**Unconfined Compressive Strength
ASTM D2166**

CLIENT	Lithos Engineering	BORING NO.	--
JOB NO.	2962-050	DEPTH	20'
PROJECT	Mesa Verde	SAMPLE NO.	LE-HDD-9-B
PROJECT NO.	21152	DATE SAMPLED	--
LOCATION	--	DESCRIPTION	--
DATE TESTED	08/25/23		
TECHNICIAN	AC		

Displacement (in)	Displacement (cm)	Strain (%)	Average Cross Sectional Area (in ²)	Load (lbs)	Load (N)	Stress (psf)	Stress (kPa)
0.0932	0.237	2.55	2.98	251	1116	12106	580
0.0953	0.242	2.61	2.99	253	1125	12203	584
0.0975	0.248	2.67	2.99	256	1137	12319	590
0.0995	0.253	2.72	2.99	257	1144	12396	594
0.1015	0.258	2.78	2.99	259	1152	12471	597
0.1043	0.265	2.85	2.99	262	1165	12602	603
0.1064	0.270	2.91	2.99	263	1170	12646	605
0.1084	0.275	2.97	3.00	266	1182	12773	612
0.1106	0.281	3.03	3.00	267	1188	12829	614
0.1127	0.286	3.08	3.00	270	1200	12949	620
0.1148	0.292	3.14	3.00	270	1202	12964	621
0.1169	0.297	3.20	3.00	272	1210	13037	624
0.1191	0.303	3.26	3.01	274	1219	13128	629
0.1213	0.308	3.32	3.01	276	1226	13194	632
0.1235	0.314	3.38	3.01	277	1231	13247	634
0.1256	0.319	3.44	3.01	280	1246	13399	642
0.1277	0.324	3.49	3.01	281	1251	13447	644
0.1298	0.330	3.55	3.01	282	1256	13485	646
0.1322	0.336	3.62	3.02	284	1265	13577	650
0.1344	0.341	3.68	3.02	286	1273	13652	654
0.1364	0.346	3.73	3.02	287	1278	13701	656
0.1385	0.352	3.79	3.02	289	1285	13762	659
0.1409	0.358	3.85	3.02	291	1296	13871	664
0.1429	0.363	3.91	3.03	293	1303	13938	667
0.1454	0.369	3.98	3.03	294	1307	13974	669
0.1474	0.374	4.03	3.03	297	1321	14111	676
0.1495	0.380	4.09	3.03	299	1331	14211	680
0.1515	0.385	4.15	3.03	300	1334	14238	682
0.1536	0.390	4.20	3.03	300	1337	14256	683
0.1557	0.395	4.26	3.04	301	1339	14276	684
0.1578	0.401	4.32	3.04	305	1355	14439	691
0.1606	0.408	4.39	3.04	305	1358	14461	692
0.1630	0.414	4.46	3.04	309	1376	14643	701
0.1651	0.419	4.52	3.04	310	1380	14673	703
0.1672	0.425	4.57	3.05	311	1385	14721	705
0.1693	0.430	4.63	3.05	313	1394	14800	709
0.1715	0.436	4.69	3.05	315	1400	14860	712
0.1737	0.441	4.75	3.05	317	1409	14942	715
0.1758	0.447	4.81	3.05	317	1412	14967	717
0.1778	0.452	4.86	3.06	318	1417	15005	718
0.1805	0.458	4.94	3.06	320	1423	15062	721
0.1825	0.464	4.99	3.06	323	1435	15177	727
0.1847	0.469	5.05	3.06	324	1441	15229	729

**Unconfined Compressive Strength
ASTM D2166**

CLIENT	Lithos Engineering	BORING NO.	--
JOB NO.	2962-050	DEPTH	20'
PROJECT	Mesa Verde	SAMPLE NO.	LE-HDD-9-B
PROJECT NO.	21152	DATE SAMPLED	--
LOCATION	--	DESCRIPTION	--
DATE TESTED	08/25/23		
TECHNICIAN	AC		

Displacement (in)	Displacement (cm)	Strain (%)	Average Cross Sectional Area (in ²)	Load (lbs)	Load (N)	Stress (psf)	Stress (kPa)
0.1868	0.474	5.11	3.06	325	1446	15274	731
0.1889	0.480	5.17	3.07	327	1455	15366	736
0.1910	0.485	5.23	3.07	327	1455	15357	735
0.1934	0.491	5.29	3.07	329	1461	15411	738
0.1954	0.496	5.35	3.07	330	1467	15466	741
0.1975	0.502	5.40	3.07	330	1469	15475	741
0.1997	0.507	5.46	3.08	331	1473	15501	742
0.2022	0.514	5.53	3.08	332	1478	15544	744
0.2047	0.520	5.60	3.08	334	1488	15636	749
0.2075	0.527	5.68	3.08	336	1494	15688	751
0.2097	0.533	5.74	3.08	337	1501	15752	754
0.2118	0.538	5.79	3.09	338	1503	15765	755
0.2141	0.544	5.86	3.09	339	1506	15791	756
0.2163	0.549	5.92	3.09	339	1507	15787	756
0.2184	0.555	5.98	3.09	340	1512	15833	758
0.2205	0.560	6.03	3.09	341	1516	15862	759
0.2226	0.565	6.09	3.10	342	1522	15915	762
0.2251	0.572	6.16	3.10	342	1522	15901	761
0.2271	0.577	6.21	3.10	343	1527	15951	764
0.2293	0.582	6.27	3.10	344	1532	15992	766
0.2313	0.588	6.33	3.10	345	1535	16015	767
0.2334	0.593	6.39	3.11	346	1539	16038	768
0.2358	0.599	6.45	3.11	347	1542	16061	769
0.2379	0.604	6.51	3.11	347	1543	16068	769
0.2406	0.611	6.58	3.11	347	1545	16069	769
0.2426	0.616	6.64	3.11	349	1551	16123	772
0.2448	0.622	6.70	3.12	350	1555	16159	774
0.2470	0.627	6.76	3.12	349	1554	16134	773
0.2491	0.633	6.82	3.12	350	1558	16160	774
0.2512	0.638	6.87	3.12	351	1561	16190	775
0.2534	0.644	6.93	3.12	352	1565	16214	776
0.2555	0.649	6.99	3.13	352	1564	16199	776
0.2576	0.654	7.05	3.13	353	1570	16247	778
0.2599	0.660	7.11	3.13	353	1569	16225	777
0.2624	0.666	7.18	3.13	353	1572	16242	778
0.2645	0.672	7.24	3.13	354	1574	16253	778
0.2670	0.678	7.31	3.14	354	1573	16233	777
0.2691	0.684	7.36	3.14	355	1578	16277	779
0.2711	0.689	7.42	3.14	355	1578	16266	779
0.2734	0.694	7.48	3.14	355	1581	16288	780
0.2754	0.700	7.53	3.14	355	1580	16264	779
0.2779	0.706	7.60	3.15	356	1583	16289	780
0.2800	0.711	7.66	3.15	356	1585	16298	780

**Unconfined Compressive Strength
ASTM D2166**

CLIENT	Lithos Engineering	BORING NO.	--
JOB NO.	2962-050	DEPTH	20'
PROJECT	Mesa Verde	SAMPLE NO.	LE-HDD-9-B
PROJECT NO.	21152	DATE SAMPLED	--
LOCATION	--	DESCRIPTION	--
DATE TESTED	08/25/23		
TECHNICIAN	AC		

Displacement (in)	Displacement (cm)	Strain (%)	Average Cross Sectional Area (in ²)	Load (lbs)	Load (N)	Stress (psf)	Stress (kPa)
0.2821	0.717	7.72	3.15	357	1587	16310	781
0.2842	0.722	7.78	3.15	357	1587	16299	780
0.2862	0.727	7.83	3.15	357	1588	16300	780
0.2883	0.732	7.89	3.16	357	1588	16285	780
0.2904	0.738	7.95	3.16	358	1591	16307	781
0.2931	0.744	8.02	3.16	358	1591	16293	780
0.2952	0.750	8.08	3.16	358	1591	16285	780
0.2976	0.756	8.14	3.17	357	1590	16261	779
0.2998	0.761	8.20	3.17	359	1596	16313	781
0.3020	0.767	8.26	3.17	358	1595	16288	780
0.3040	0.772	8.32	3.17	359	1595	16283	780
0.3062	0.778	8.38	3.17	358	1594	16260	779
0.3089	0.785	8.45	3.18	359	1595	16258	778
0.3110	0.790	8.51	3.18	359	1596	16254	778
0.3132	0.796	8.57	3.18	358	1595	16234	777
0.3154	0.801	8.63	3.18	359	1596	16238	777
0.3178	0.807	8.69	3.18	358	1593	16194	775
0.3198	0.812	8.75	3.19	358	1591	16162	774
0.3219	0.818	8.81	3.19	358	1592	16166	774
0.3242	0.823	8.87	3.19	357	1589	16119	772
0.3263	0.829	8.93	3.19	356	1585	16075	770
0.3284	0.834	8.98	3.19	356	1583	16047	768
0.3306	0.840	9.05	3.20	354	1574	15942	763
0.3327	0.845	9.10	3.20	354	1573	15923	762
0.3348	0.850	9.16	3.20	352	1567	15849	759
0.3374	0.857	9.23	3.20	351	1562	15782	756
0.3406	0.865	9.32	3.21	348	1549	15636	749
0.3427	0.870	9.38	3.21	346	1538	15521	743
0.3451	0.877	9.44	3.21	345	1535	15476	741
0.3471	0.882	9.50	3.21	343	1525	15367	736
0.3493	0.887	9.56	3.21	339	1510	15207	728
0.3519	0.894	9.63	3.22	339	1507	15161	726
0.3539	0.899	9.68	3.22	336	1493	15019	719
0.3560	0.904	9.74	3.22	333	1482	14899	713
0.3582	0.910	9.80	3.22	333	1480	14860	711
0.3605	0.916	9.86	3.23	329	1463	14679	703
0.3628	0.922	9.93	3.23	328	1459	14629	700
0.3648	0.927	9.98	3.23	328	1457	14606	699
0.3669	0.932	10.04	3.23	323	1436	14380	689
0.3704	0.941	10.13	3.24	322	1431	14324	686
0.3726	0.946	10.19	3.24	318	1415	14151	678
0.3758	0.955	10.28	3.24	318	1414	14121	676
0.3781	0.960	10.34	3.24	315	1402	13995	670

**Unconfined Compressive Strength
ASTM D2166**

CLIENT	Lithos Engineering	BORING NO.	--
JOB NO.	2962-050	DEPTH	20'
PROJECT	Mesa Verde	SAMPLE NO.	LE-HDD-9-B
PROJECT NO.	21152	DATE SAMPLED	--
LOCATION	--	DESCRIPTION	--
DATE TESTED	08/25/23		
TECHNICIAN	AC		

Displacement (in)	Displacement (cm)	Strain (%)	Average Cross Sectional Area (in ²)	Load (lbs)	Load (N)	Stress (psf)	Stress (kPa)
0.3801	0.965	10.40	3.24	315	1403	13998	670
0.3824	0.971	10.46	3.25	314	1396	13918	666
0.3845	0.977	10.52	3.25	312	1389	13839	663
0.3870	0.983	10.59	3.25	312	1386	13800	661
0.3891	0.988	10.65	3.25	310	1381	13738	658
0.3912	0.994	10.70	3.26	309	1376	13680	655
0.3934	0.999	10.76	3.26	308	1369	13598	651
0.3955	1.005	10.82	3.26	306	1362	13523	648
0.3976	1.010	10.88	3.26	306	1359	13487	646
0.3996	1.015	10.93	3.26	305	1356	13449	644
0.4016	1.020	10.99	3.27	305	1356	13444	644
0.4040	1.026	11.05	3.27	303	1349	13364	640
0.4062	1.032	11.11	3.27	303	1347	13331	638
0.4084	1.037	11.17	3.27	301	1340	13250	634
0.4104	1.042	11.23	3.28	300	1336	13206	632
0.4125	1.048	11.29	3.28	300	1337	13202	632
0.4151	1.054	11.36	3.28	298	1327	13097	627
0.4174	1.060	11.42	3.28	297	1320	13015	623
0.4197	1.066	11.48	3.28	296	1317	12979	621
0.4218	1.071	11.54	3.29	295	1314	12941	620
0.4242	1.077	11.61	3.29	294	1308	12875	616
0.4263	1.083	11.66	3.29	293	1302	12802	613
0.4285	1.088	11.72	3.29	290	1291	12694	608
0.4306	1.094	11.78	3.30	290	1288	12654	606
0.4328	1.099	11.84	3.30	287	1278	12549	601
0.4348	1.104	11.90	3.30	286	1272	12479	597
0.4371	1.110	11.96	3.30	285	1270	12447	596
0.4396	1.117	12.03	3.30	283	1259	12335	591
0.4417	1.122	12.08	3.31	283	1259	12320	590
0.4443	1.129	12.16	3.31	282	1253	12256	587
0.4464	1.134	12.21	3.31	281	1249	12205	584
0.4486	1.139	12.27	3.31	279	1240	12109	580
0.4508	1.145	12.33	3.32	278	1237	12077	578

Atterberg Limits ASTM D 4318

CLIENT Lithos Engineering
JOB NO. 2962-050
PROJECT Mesa Verde
PROJECT NO. 21152
LOCATION --
DATE TESTED 08/25/23
TECHNICIAN BDF

BORING NO. --
DEPTH 15'
SAMPLE NO. LE-HHD-9-A
DATE SAMPLED --
SAMPLED BY --
DESCRIPTION --

Plastic Limits

Mass of Wet Pan and Soil (g):	30.33	29.57
Mass of Dry Pan and Soil (g):	28.34	27.78
Mass of Pan (g):	18.29	18.71
Moisture (%)	19.8	19.7

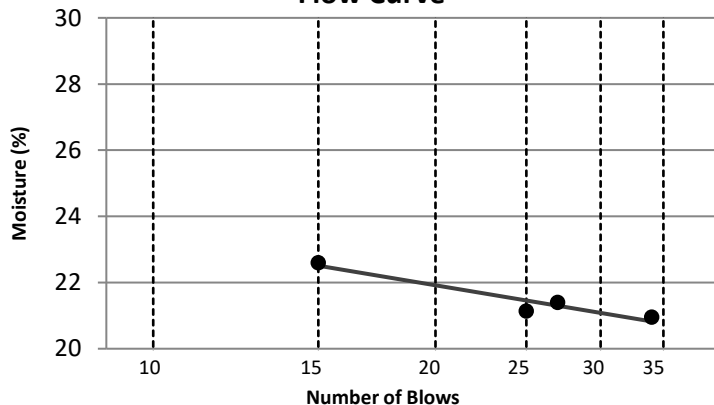
Liquid Limits

Number of Blows	15	27	25	34
Mass of Wet Pan and Soil (g):	31.27	30.90	28.71	31.48
Mass of Dry Pan and Soil (g):	28.88	28.76	26.89	29.19
Mass of Pan (g):	18.34	18.73	18.31	18.23
Moisture (%)	22.6	21.4	21.1	21.0

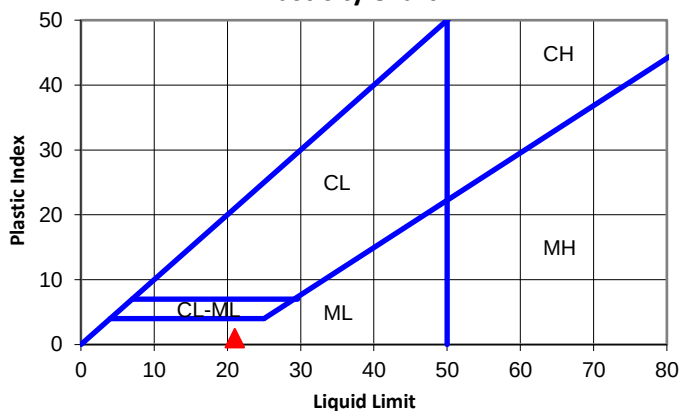
Plastic Index

Plastic Limit: **20** Atterberg Classification: **ML**
Liquid Limit: **21** Method: **A**
Plastic Index: **1**

Flow Curve



Plasticity Chart



NOTES

Data entry by: BDF
Checked by: WB
File name: 2962050 Atterberg ASTM D4318 3.xlsm

Date: 08/26/23
Date: 08/28/23

Percent Minus #200
ASTM D 1140

CLIENT	Lithos Engineering	BORING NO.	--
JOB NO.	2962-050	DEPTH	15'
PROJECT	Mesa Verde	SAMPLE NO.	LE-HHD-9-A
PROJECT NO.	21152	DATE SAMPLED	--
LOCATION	--	DESCRIPTION	--
DATE TESTED	08/26/23		
TECHNICIAN	BDF		

Hygroscopic Moisture of Fines

Mass Wet Pan and Soil (g): 292.27
 Mass Dry Pan and Soil (g): 290.30
 Mass of Pan (g): 118.63
 Moisture (%): **1.1**

Sample Data

Total Wet Mass of Sample (g): 346.7
 Total Dry Mass of Sample (g): 342.8
 Split Fraction: #4
 Mass of Sub-Sample Fraction (g): 173.64

Sieve Number	Sieve Size (mm)	Mass of Pan and Soil (g)	Mass of Pan (g)	Mass of Individual Retained Soil (g)	Correction Factor	Percent Passing by Weight (%)
#4	4.75	1.7	0.0	1.7	1.00	99.5
#200	0.075	230.6	118.6	111.9	1.00	34.6

USCS Classification ASTM D 2487

Atterberg Classification: ML
 Group Symbol: SM
 USCS Classification: Silty Sand

NOTES

Data entry by: BDF
 Checked by: WB
 File name: 2962050__Percent Minus #200 ASTM D1140_3.xlsm

Date: 08/28/23
 Date: 08/28/23



Grain Size Analysis with Hydrometer ASTM D 6913 And D 7928

ADVANCED TERRA TESTING

CLIENT Lithos Engineering
JOB NO. 2962-050
PROJECT Mesa Verde
PROJECT NO. 21152
LOCATION --
DATE TESTED 08/29/23
TECHNICIAN WB

BORING NO. --
DEPTH 40'
SAMPLE NO. LE-HDD-9-A
DATE SAMPLED --
DESCRIPTION --

Hygroscopic Moisture of Fines

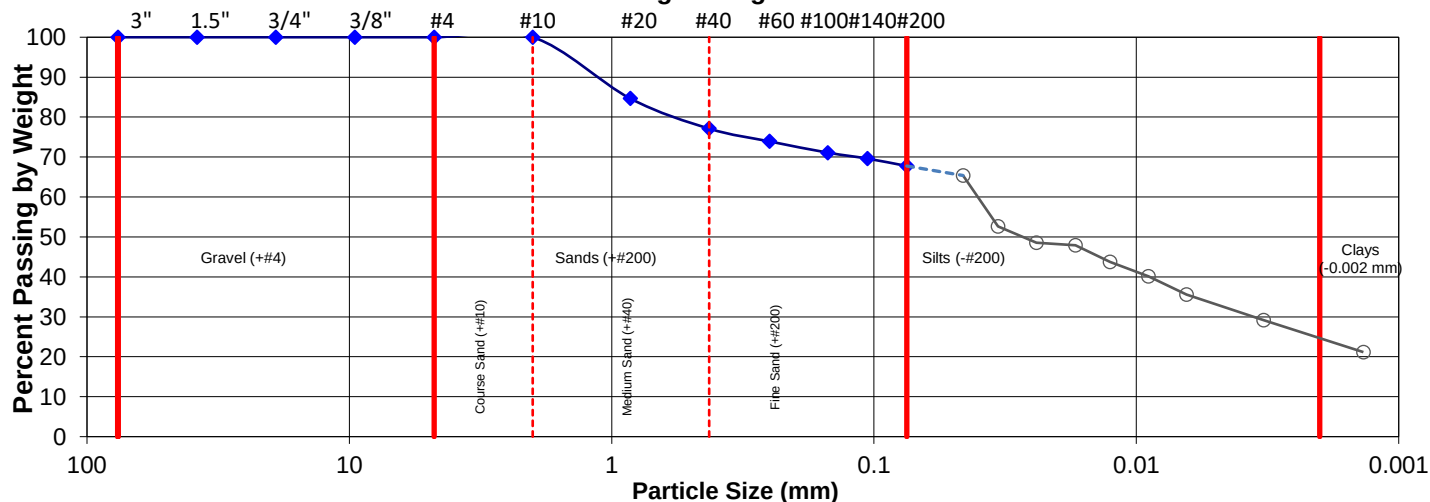
Mass Wet Pan and Soil (g): 107.63
Mass Dry Pan and Soil (g): 101.77
Mass of Pan (g): 6.72
Moisture (%): **6.2**

Sample Data

Total Wet Mass of Sample (g): 216.1
Total Dry Mass of Sample (g): 203.5
Split Fraction: #10
Mass of Sub-Sample Fraction (g): 45.70

Sieve Number	Sieve Size (mm)	Mass of Pan and Soil (g)	Mass of Pan (g)	Mass of Individual Retained Soil (g)	Correction Factor	Percent Passing by Weight (%)
3"	76.2	--	--	--	--	--
1.5"	38.1	--	--	--	--	--
3/4"	19.05	--	--	--	--	--
3/8"	9.53	--	--	--	--	--
#4	4.75	--	--	--	--	--
#10	2.00	0.0	0.0	0.00	1.000	100.0
#20	0.850	6.6	0.0	6.60	1.000	84.7
#40	0.425	3.3	0.0	3.25	1.000	77.1
#60	0.250	1.4	0.0	1.38	1.000	73.9
#100	0.150	1.2	0.0	1.21	1.000	71.1
#140	0.106	0.6	0.0	0.64	1.000	69.6
#200	0.075	0.8	0.0	0.80	1.000	67.8

Percent Passing vs Log of Particle Size



USCS Classification ASTM D 2487

Atterberg Classification: --
Group Symbol: --
USCS Classification: --

Coefficient of Curvature - C_c : --
Coefficient of Uniformity - C_u : --

Data entry by: WB

Date: 08/30/23

Checked by: BDF

Date: 08/30/23

File name: 2962050_Grain Size with Hydrometer ASTM D6913 D7928_0.xlsm Page 1 of 2



Grain Size Analysis with Hydrometer ASTM D 6913 And D 7928

ADVANCED TERRA TESTING

CLIENT Lithos Engineering
JOB NO. 2962-050
PROJECT Mesa Verde
PROJECT NO. 21152
LOCATION --
DATE TESTED 08/29/23
TECHNICIAN WB

BORING NO. --
DEPTH 40'
SAMPLE NO. LE-HDD-9-A
DATE SAMPLED --
DESCRIPTION --

Hydrometer and Flask Parameters

Hydrometer ID: 0805
Average Mass Offset (g/L): 9.87
Hydrometer Bulb Volume (cm³): 56.50
Meniscus Correction (g/L): 1.00
H_b (cm): 24.5
H_{cb} (cm): 6.8
H_s (cm): 8.2

Flask ID: 1191
Flask Volume (cm³): 1000.1
Flask Surface Area (cm²): 28.78
Assumed Specific Gravity 2.65
Hydrometer Type: 152H

Percent Finer by Mass at 2 µm: **23.8**

Hydrometer Data

Elapsed Time (minutes)	Hydrometer Reading (g/L)	Offset Reading (g/L)	Temperature (°C)	Effective Depth (cm)	Maximum Particle Diameter in Suspension (mm)	Percent Finer by Mass (%)
1	34.00	5.86	21.7	11.29	0.046	65.4
2	28.50	5.86	21.7	12.19	0.034	52.6
4	26.75	5.86	21.7	12.48	0.024	48.5
8	26.25	5.64	22.3	12.56	0.017	47.9
15	24.50	5.67	22.2	12.85	0.013	43.7
30	23.00	5.71	22.1	13.10	0.009	40.2
60	21.00	5.67	22.2	13.43	0.006	35.6
240	18.25	5.71	22.1	13.88	0.003	29.1
1440	15.00	5.89	21.6	14.41	0.001	21.2

NOTES:



Grain Size Analysis with Hydrometer ASTM D 6913 And D 7928

ADVANCED TERRA TESTING

CLIENT Lithos Engineering
JOB NO. 2962-050
PROJECT Mesa Verde
PROJECT NO. 21152
LOCATION --
DATE TESTED 08/29/23
TECHNICIAN BDF

BORING NO. --
DEPTH 90'
SAMPLE NO. LE-HDD-9-B
DATE SAMPLED --
DESCRIPTION --

Hygroscopic Moisture of Fines

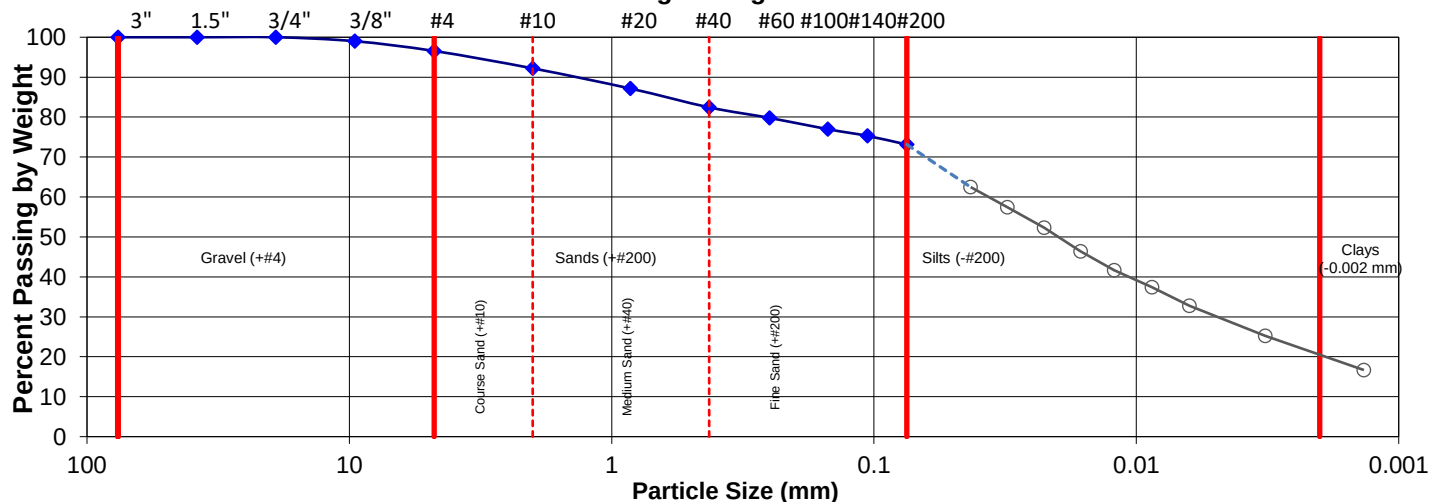
Mass Wet Pan and Soil (g): 94.03
Mass Dry Pan and Soil (g): 92.99
Mass of Pan (g): 6.73
Moisture (%): **1.2**

Sample Data

Total Wet Mass of Sample (g): 299.0
Total Dry Mass of Sample (g): 295.7
Split Fraction: #10
Mass of Sub-Sample Fraction (g): 54.93

Sieve Number	Sieve Size (mm)	Mass of Pan and Soil (g)	Mass of Pan (g)	Mass of Individual Retained Soil (g)	Correction Factor	Percent Passing by Weight (%)
3"	76.2	--	--	--	--	--
1.5"	38.1	--	--	--	--	--
3/4"	19.05	0.0	--	0.0	1.00	100.0
3/8"	9.53	3.0	--	3.0	1.00	99.0
#4	4.75	7.2	--	7.2	1.00	96.6
#10	2.00	12.9	--	12.88	1.000	92.2
#20	0.850	3.0	--	2.97	0.922	87.2
#40	0.425	2.8	--	2.78	0.922	82.4
#60	0.250	1.6	--	1.55	0.922	79.8
#100	0.150	1.7	--	1.67	0.922	77.0
#140	0.106	1.0	--	0.98	0.922	75.3
#200	0.075	1.3	--	1.28	0.922	73.1

Percent Passing vs Log of Particle Size



USCS Classification ASTM D 2487

Atterberg Classification: CL

Coefficient of Curvature - C_c : --

Group Symbol: CL

Coefficient of Uniformity - C_u : --

USCS Classification: Lean Clay With Sand

Data entry by: WB

Date: 08/30/23

Checked by: BDF

Date: 08/30/23

File name: 2962050_Grain Size with Hydrometer ASTM D6913 D7928_1.xlsm Page 1 of 2



Grain Size Analysis with Hydrometer ASTM D 6913 And D 7928

ADVANCED TERRA TESTING

CLIENT Lithos Engineering
JOB NO. 2962-050
PROJECT Mesa Verde
PROJECT NO. 21152
LOCATION --
DATE TESTED 08/29/23
TECHNICIAN BDF

BORING NO. --
DEPTH 90'
SAMPLE NO. LE-HDD-9-B
DATE SAMPLED --
DESCRIPTION --

Hydrometer and Flask Parameters

Hydrometer ID: 0805
Average Mass Offset (g/L): 9.87
Hydrometer Bulb Volume (cm³): 56.50
Meniscus Correction (g/L): 1.00
H_b (cm): 24.5
H_{cb} (cm): 6.8
H_s (cm): 8.2

Flask ID: 1185
Flask Volume (cm³): 995.9
Flask Surface Area (cm²): 28.45
Assumed Specific Gravity 2.65
Hydrometer Type: 152H

Percent Finer by Mass at 2 µm: **19.6**

Hydrometer Data

Elapsed Time (minutes)	Hydrometer Reading (g/L)	Offset Reading (g/L)	Temperature (°C)	Effective Depth (cm)	Maximum Particle Diameter in Suspension (mm)	Percent Finer by Mass (%)
1	42.50	5.56	22.5	9.88	0.043	62.5
2	39.50	5.56	22.5	10.37	0.031	57.4
4	36.50	5.56	22.5	10.86	0.022	52.3
8	33.00	5.56	22.5	11.44	0.016	46.4
15	30.25	5.60	22.4	11.89	0.012	41.7
30	27.75	5.64	22.3	12.30	0.009	37.4
60	25.00	5.64	22.3	12.76	0.006	32.8
240	20.75	5.82	21.8	13.46	0.003	25.3
1440	15.75	5.89	21.6	14.28	0.001	16.7

NOTES:



ADVANCED TERRA TESTING

**Percent Minus #200
ASTM D 1140**

CLIENT Lithos Engineering
JOB NO. 2962-050
PROJECT Mesa Verde
PROJECT NO. 21152
LOCATION --
DATE TESTED 08/29/23
TECHNICIAN WB

BORING NO. --
DEPTH 25'
SAMPLE NO. LE-HDD-9-A
DATE SAMPLED --
DESCRIPTION --

Hygroscopic Moisture of Fines

Mass Wet Pan and Soil (g): 421.80
Mass Dry Pan and Soil (g): 416.63
Mass of Pan (g): 171.30
Moisture (%): **2.1**

Sample Data

Total Wet Mass of Sample (g): 378.3
Total Dry Mass of Sample (g): 370.5
Split Fraction: #4
Mass of Sub-Sample Fraction (g): 250.50

Sieve Number	Sieve Size (mm)	Mass of Pan and Soil (g)	Mass of Pan (g)	Mass of Individual Retained Soil (g)	Correction Factor	Percent Passing by Weight (%)
#4	4.75	1.0	0.0	1.0	1.00	99.7
#200	0.075	235.5	171.3	64.2	1.00	73.6

USCS Classification ASTM D 2487

Atterberg Classification: CL
Group Symbol: CL
USCS Classification: Lean Clay With Sand

NOTES

Data entry by: WB
Checked by: BDF
File name: 2962050__Percent Minus #200 ASTM D1140_4.xlsm

Date: 08/30/23
Date: 08/30/23



Atterberg Limits ASTM D 4318

ADVANCED TERRA TESTING

CLIENT Lithos Engineering
JOB NO. 2962-050
PROJECT Mesa Verde
PROJECT NO. 21152
LOCATION --
DATE TESTED 08/28/23
TECHNICIAN BDF

BORING NO. --
DEPTH 25'
SAMPLE NO. LE-HDD-9-A
DATE SAMPLED --
SAMPLED BY --
DESCRIPTION --

Plastic Limits

Mass of Wet Pan and Soil (g):	26.17	26.16
Mass of Dry Pan and Soil (g):	25.14	25.20
Mass of Pan (g):	18.47	18.64
Moisture (%)	15.5	14.7

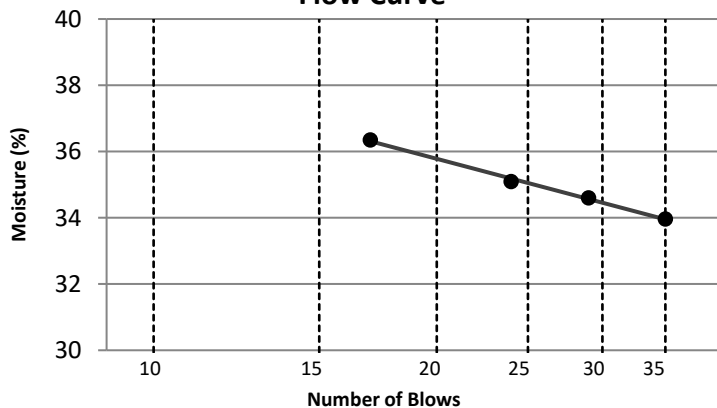
Liquid Limits

Number of Blows	17	24	29	35
Mass of Wet Pan and Soil (g):	30.22	30.17	28.18	26.63
Mass of Dry Pan and Soil (g):	27.07	27.18	25.68	24.39
Mass of Pan (g):	18.42	18.68	18.43	17.79
Moisture (%)	36.3	35.1	34.6	34.0

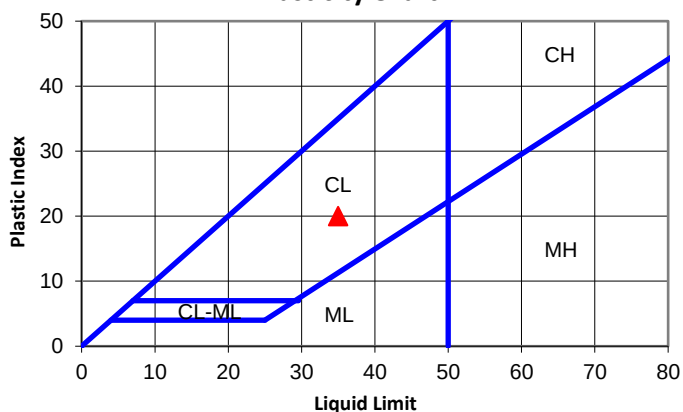
Plastic Index

Plastic Limit: **15** Atterberg Classification: CL
Liquid Limit: **35** Method: A
Plastic Index: **20**

Flow Curve



Plasticity Chart



NOTES

Data entry by: WB
Checked by: BDF
File name: 2962050_Atterberg ASTM D4318_4.xlsm

Date: 08/29/23
Date: 08/30/23



Atterberg Limits ASTM D 4318

ADVANCED TERRA TESTING

CLIENT Lithos Engineering
JOB NO. 2962-050
PROJECT Mesa Verde
PROJECT NO. 21152
LOCATION --
DATE TESTED 08/29/23
TECHNICIAN MK

BORING NO. --
DEPTH 90'
SAMPLE NO. LE-HDD-9-B
DATE SAMPLED --
SAMPLED BY --
DESCRIPTION --

Plastic Limits

Mass of Wet Pan and Soil (g):	28.56	28.81	27.59
Mass of Dry Pan and Soil (g):	27.10	27.35	26.17
Mass of Pan (g):	18.50	18.68	17.61
Moisture (%)	17.0	16.8	16.6

Liquid Limits

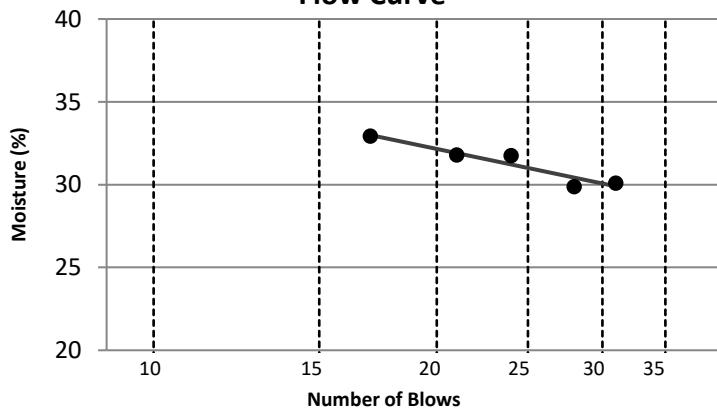
Number of Blows	17	21	24	31	28
Mass of Wet Pan and Soil (g):	31.88	31.15	29.17	30.11	28.87
Mass of Dry Pan and Soil (g):	28.63	28.18	26.57	27.41	26.54
Mass of Pan (g):	18.79	18.81	18.38	18.44	18.74
Moisture (%)	32.9	31.8	31.7	30.1	29.9

Plastic Index

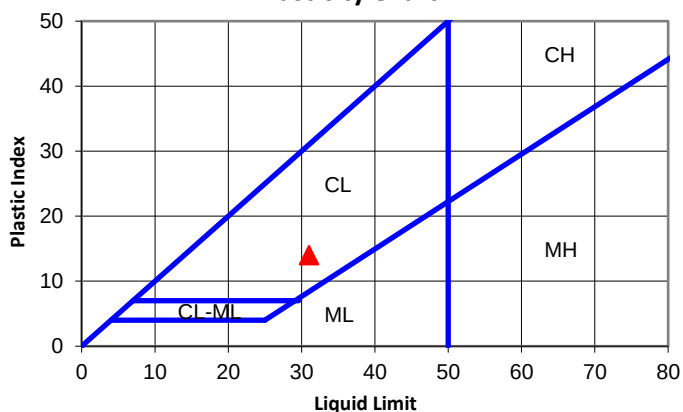
Plastic Limit: 17
Liquid Limit: 31
Plastic Index: 14

Atterberg Classification: CL
Method: A

Flow Curve



Plasticity Chart



NOTES

Data entry by: MK
Checked by: BDF
File name: 2962050_Atterberg ASTM D4318_5.xlsm

Date: 08/30/23
Date: 08/30/23



APPENDIX – C

Field Resistivity Measurements

SUMMARY OF FIELD RESISTIVITY TESTING									
Location Number	Test Number	Ground Cover Material	Roadway Offset (ft.)	Approximate Alignment Offset (ft.) ¹	Pin Spacing (ft.)	Measurement Depth (ft.)	Resistance (Ω)	Resistivity (Ω -cm)	10-Point System Resistivity Score
FR-1	1	ML	24	10	3	3	36.20	20,798	0
	2	ML	24	10	6	6	8.98	10,319	0
FR-3	1	ML	6	0	3	3	30.50	17,523	0
	2	ML	6	0	6	6	11.10	12,755	0
FR-4	1	ML	40	30	3	3	32.40	18,615	0
	2	ML	40	30	6	6	16.20	18,615	0
FR-5	1	ML	20	25	3	3	56.00	32,174	0
	2	ML	20	25	6	6	13.80	15,857	0
FR-6	1	ML	20	15	3	3	28.00	16,087	0
	2	ML	20	15	6	6	15.40	17,696	0
FR-7	1	ML	13	18	3	3	28.30	16,259	0
	2	ML	13	18	6	6	26.20	30,106	0
FR-8	1	ML	15	10	3	3	38.40	22,062	0
	2	ML	15	10	6	6	17.50	20,109	0
FR-9	1	ML	13	13	3	3	14.50	8,331	0
	2	ML	13	13	6	6	3.30	3,792	0



APPENDIX – D

Rock Core Photographs



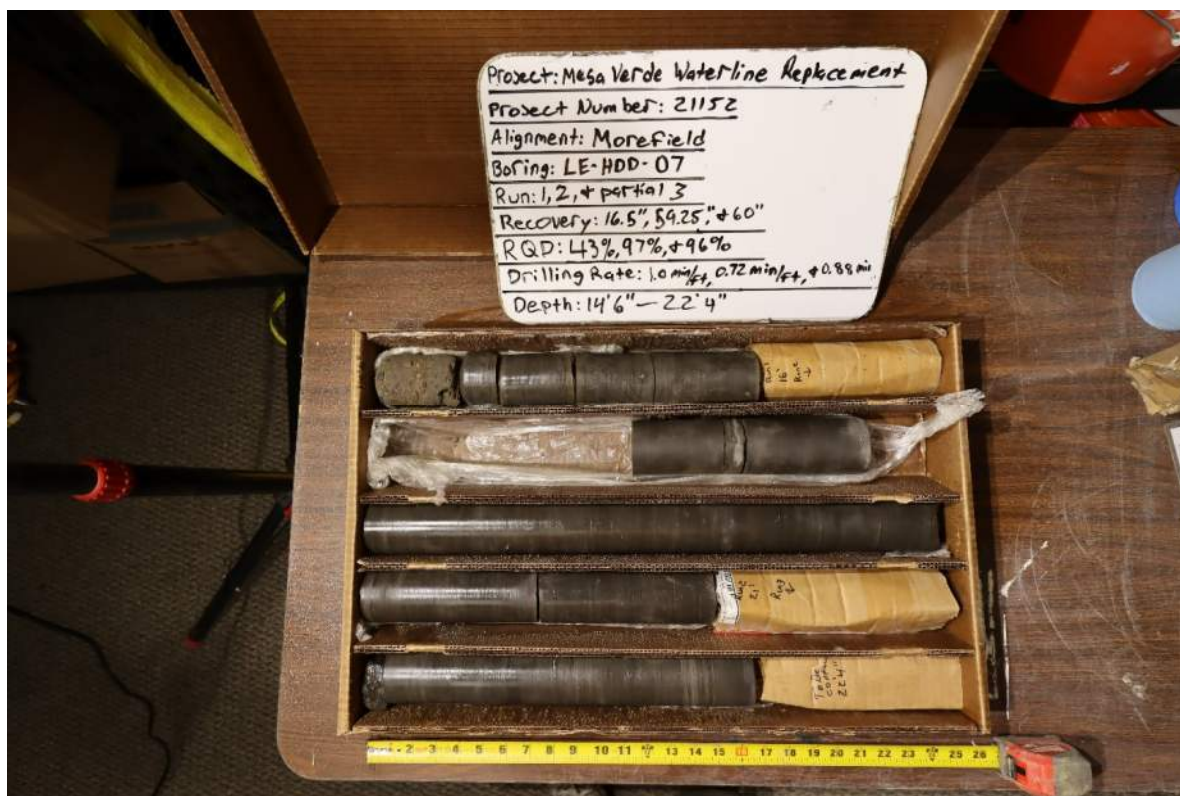
CORE PHOTO 1. LE-HDD-07, RUN: 1, DEPTH: 14'6" – 16', RECOVERY: 16.5", RQD: 43%



CORE PHOTO 2. LE-HDD-07, RUN: 2, DEPTH: 16' – 21', RECOVERY: 59.25", RQD: 97%



CORE PHOTO 3. LE-HDD-07, RUN: 3, DEPTH: 21' – 26', RECOVERY: 60%, RQD: 96%



CORE PHOTO 4. LE-HDD-07, RUNS: 1, 2, & partial 3, DEPTH: 14' 6" – 22' 4"



CORE PHOTO 5. LE-HDD-07, RUN: 4, DEPTH: 26' – 31', RECOVERY: 58.75", RQD: 98%



CORE PHOTO 6. LE-HDD-07, RUN: 5, DEPTH: 31' – 36' 1", RECOVERY: 61", RQD: 100%



CORE PHOTO 7. LE-HDD-07, RUN: 6, DEPTH: 36'1" – 41'1", RECOVERY: 52.75", RQD: 88%



CORE PHOTO 8. LE-HDD-07, RUNS: 5 & partial 6, DEPTH: 31' – 39'7"



CORE PHOTO 9. LE-HDD-07, RUN: 5, FOSSIL DISCONTINUITY, DEPTH: 33' 7.5"



CORE PHOTO 10. LE-HDD-07, RUNS: partial 6, 7, 8, & partial 9, DEPTH: 39' 7" - 48' 6"



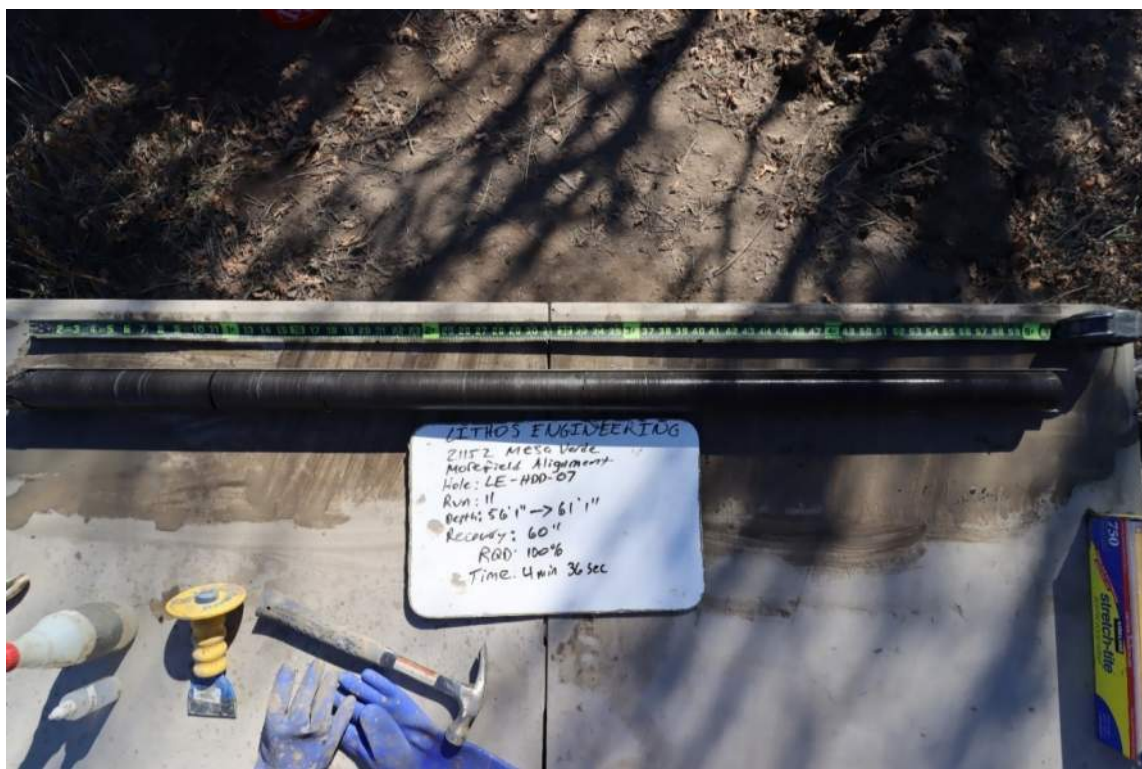
CORE PHOTO 11. LE-HDD-07, RUN: 7, FOSSIL DISCONTINUITY, DEPTH: 41' 5.25"



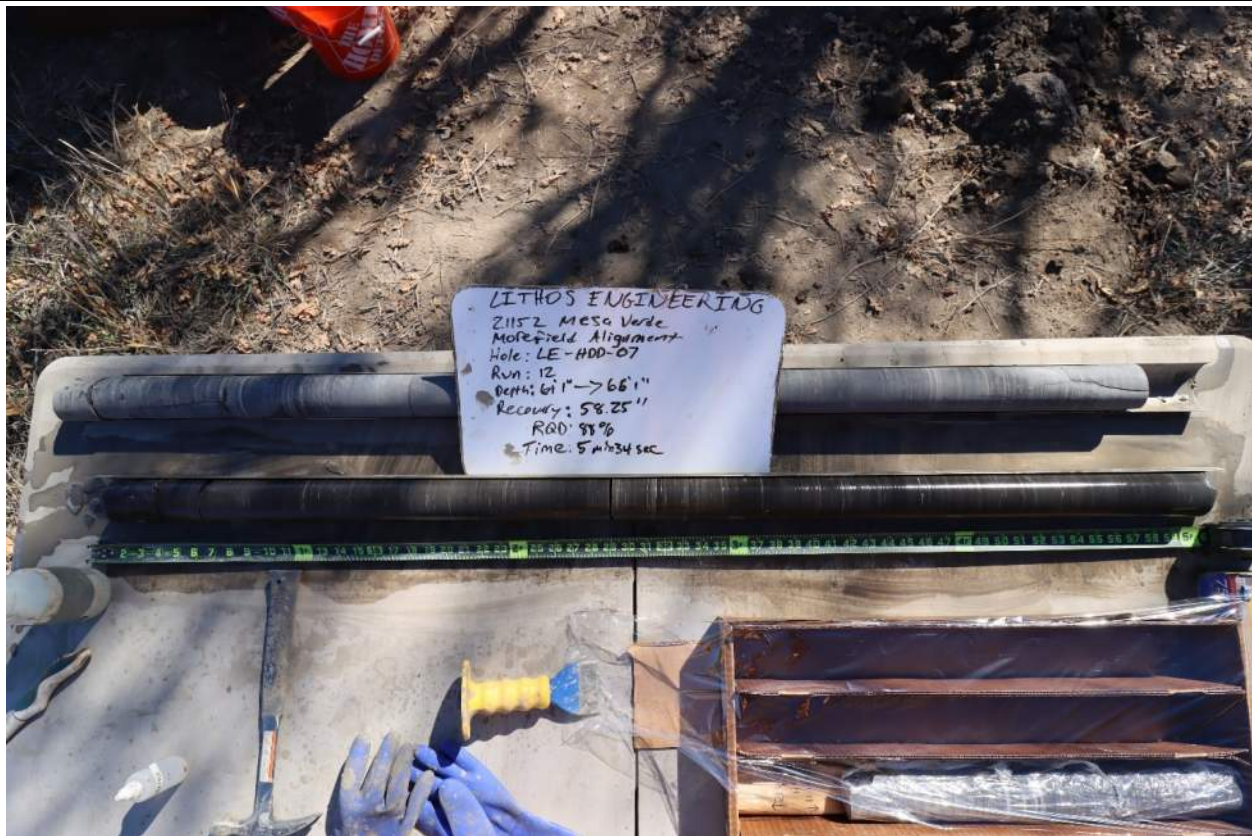
CORE PHOTO 12. LE-HDD-07, RUNS: partial 9 & 10, DEPTH: 48' 6" - 56' 1"



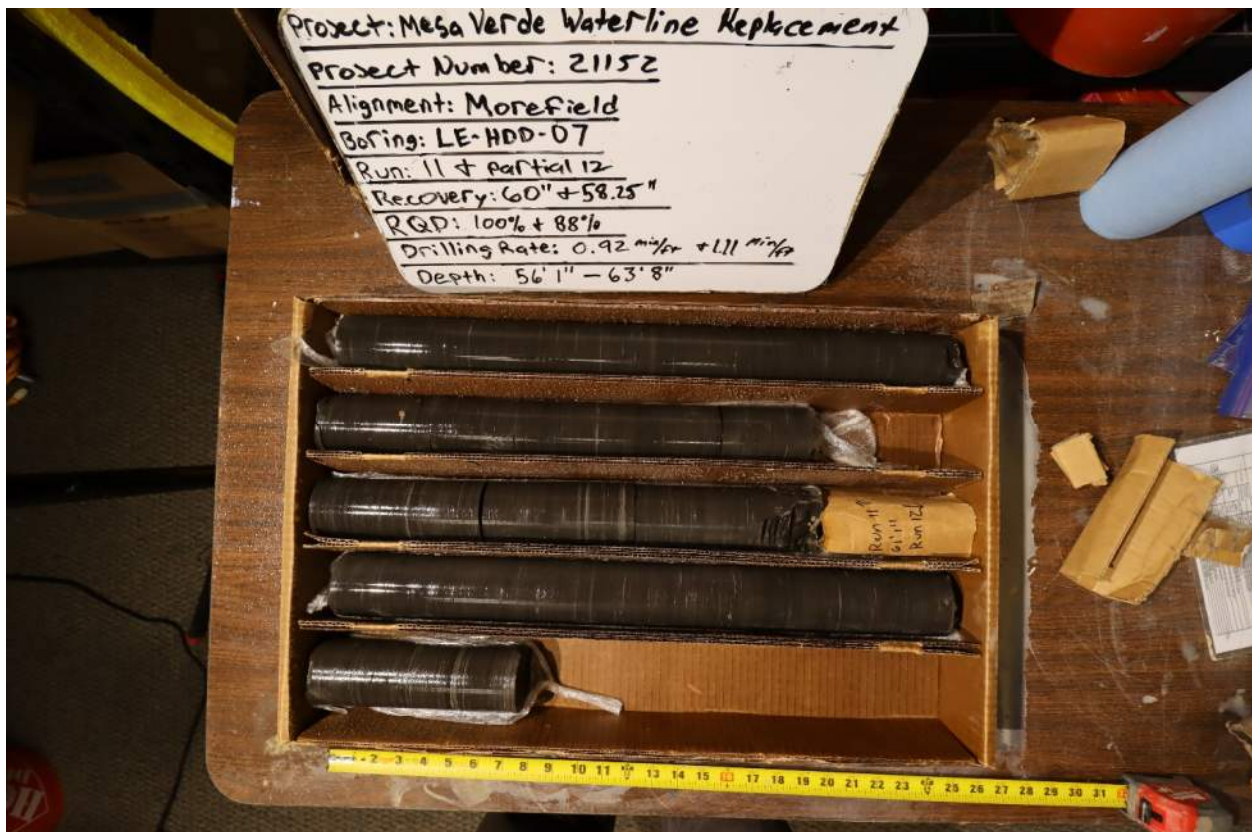
CORE PHOTO 13. LE-HDD-07, RUN: 10, DEPTH: 51'1" – 56'1", RECOVERY: 60", RQD: 97%



CORE PHOTO 14. LE-HDD-07, RUN: 11, DEPTH: 56'1" – 61'1", RECOVERY: 60", RQD: 100%



CORE PHOTO 15. LE-HDD-07, RUN: 12, DEPTH: 61'1" – 66'1", RECOVERY: 58.25", RQD: 88%



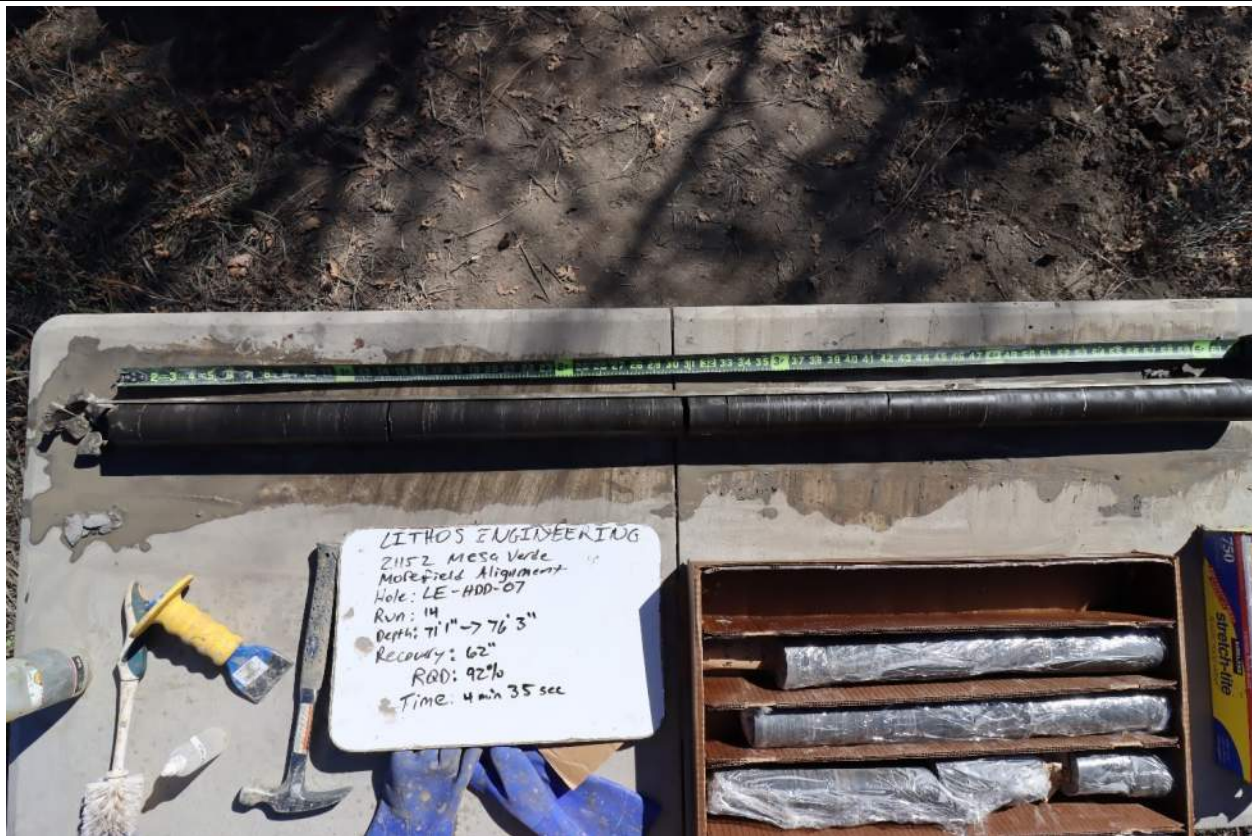
CORE PHOTO 16. LE-HDD-07, RUNS: 11 & partial 12, DEPTH: 56'1" – 63'8"



CORE PHOTO 17. LE-HDD-07, RUN: 13, DEPTH: 66'1" – 71'1", RECOVERY: 59", RQD: 93%



CORE PHOTO 18. LE-HDD-07, RUNS: partial 12, 13, & partial 14, DEPTH: 63'8" – 72'10"



CORE PHOTO 19. LE-HDD-07, RUN: 14, DEPTH: 71'1" – 76'3", RECOVERY: 62", RQD: 92%



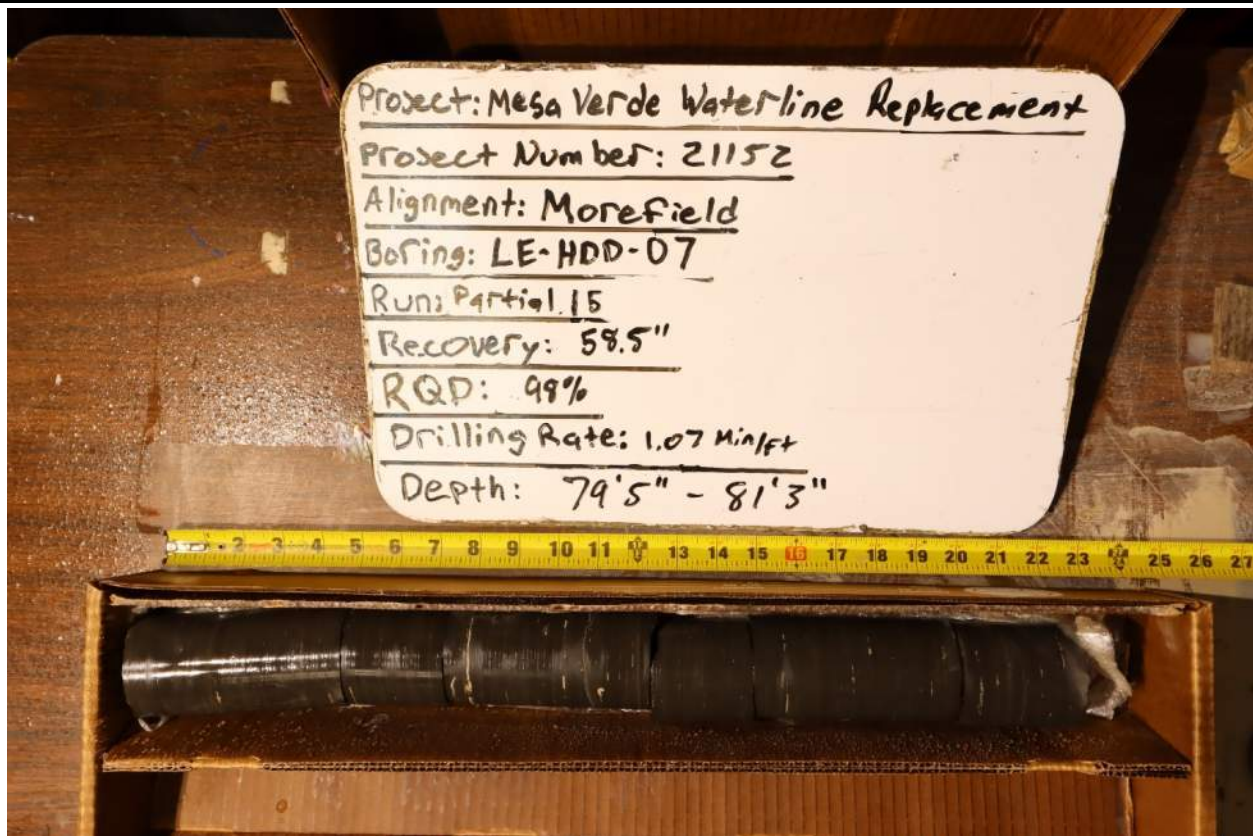
CORE PHOTO 20. LE-HDD-07, RUNS: partial 14 & partial 15, DEPTH: 72'10" – 79'5"



CORE PHOTO 21. LE-HDD-07, RUN: 15, FOSSIL DISCONTINUITY, DEPTH: 78' 8.5"



CORE PHOTO 22. LE-HDD-07, RUN: 15, DEPTH: 76'3" – 81'3", RECOVERY: 58.5", RQD: 98%



CORE PHOTO 23. LE-HDD-07, RUN: partial 15, DEPTH: 79'5" – 81'3"



CORE PHOTO 24. LE-HDD-07, RUN: 15, FOSSIL DISCONTINUITY, DEPTH: 79'5"



CORE PHOTO 25. LE-HDD-07, RUN: 15, FOSSIL DISCONTINUITY, DEPTH: 79'5"



CORE PHOTO 26. LE-HDD-08, RUN: 2, DEPTH: 21' – 26', RECOVERY: 57.5", RQD: 75%



CORE PHOTO 27. LE-HDD-08, RUN: 3, DEPTH: 26' - 31', RECOVERY: 60", RQD: 94%



CORE PHOTO 28. LE-HDD-08, RUNS: 1, 2, & partial 3, DEPTH: 19'6" - 27'11"



CORE PHOTO 29. LE-HDD-08, RUN: 2, FOSSIL DISCONTINUITY, DEPTH: 23'1.75"



CORE PHOTO 30. LE-HDD-08, RUN: 4, DEPTH: 31' – 36'1", RECOVERY: 61", RQD: 92%



CORE PHOTO 31. LE-HDD-08, RUN: 5, DEPTH: 36'1" – 41'2", RECOVERY: 61", RQD: 94%



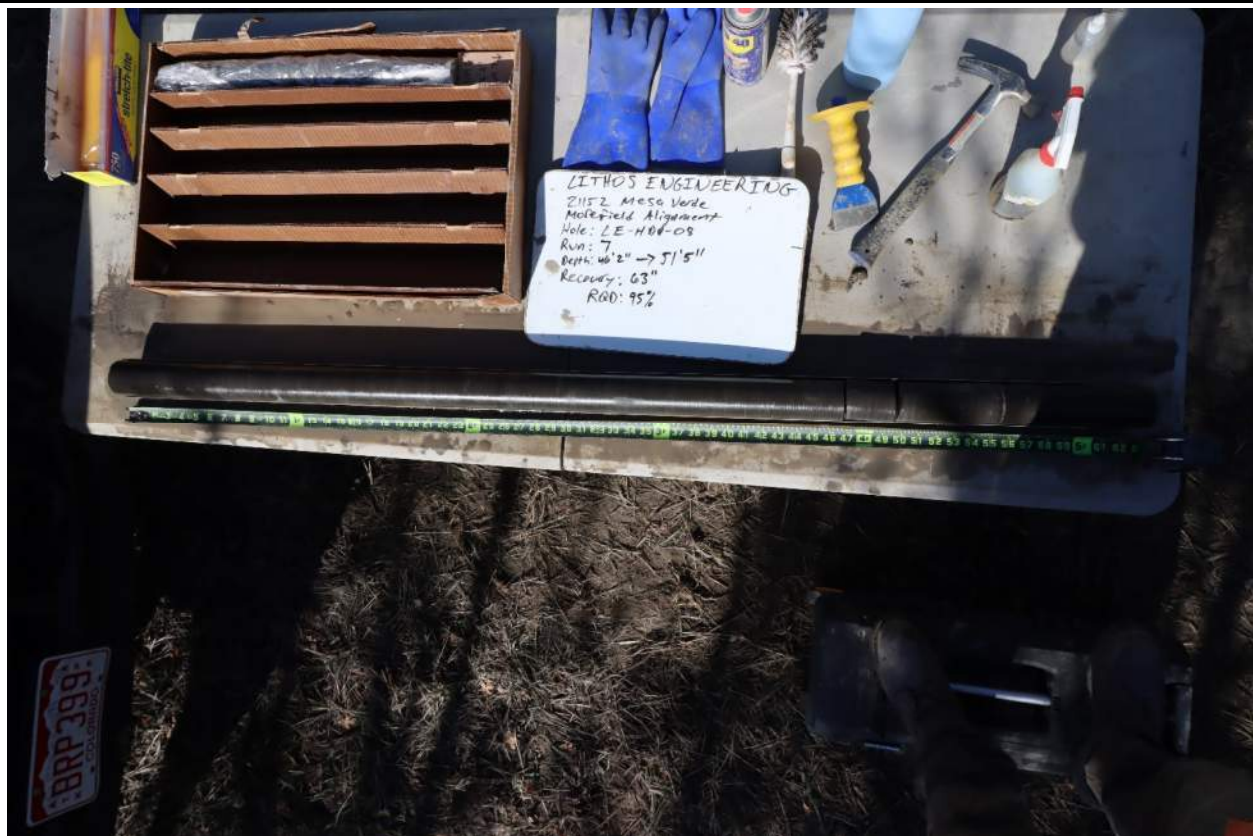
CORE PHOTO 32. LE-HDD-08, RUN: 6, DEPTH: 41'2" – 46'2", RECOVERY: 58", RQD: 94%



CORE PHOTO 33. LE-HDD-08, RUNS: partial 5 & partial 6, DEPTH: 36'4.5" – 44'7.3125"



CORE PHOTO 34. LE-HDD-08, RUN: 6, FOSSIL DISCONTINUITY, DEPTH: 42'10.125"



CORE PHOTO 35. LE-HDD-08, RUN: 7, DEPTH: 46'2" – 51'5", RECOVERY: 63%, RQD: 95%



CORE PHOTO 36. LE-HDD-08, RUNS: partial 6 & 7, DEPTH: 44'7.3125" – 51'5"



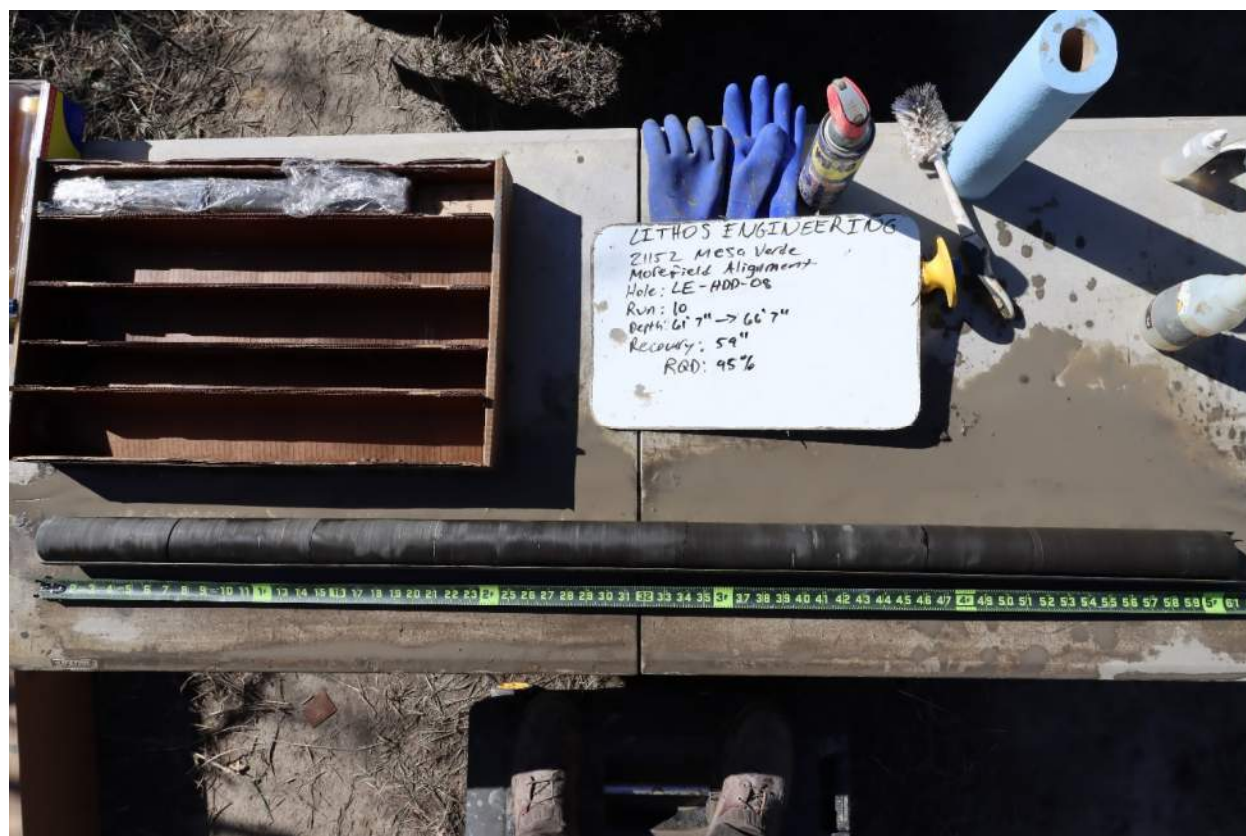
CORE PHOTO 37. LE-HDD-08, RUN: 8, DEPTH: 51'5" – 56'5", RECOVERY: 59", RQD: 91%



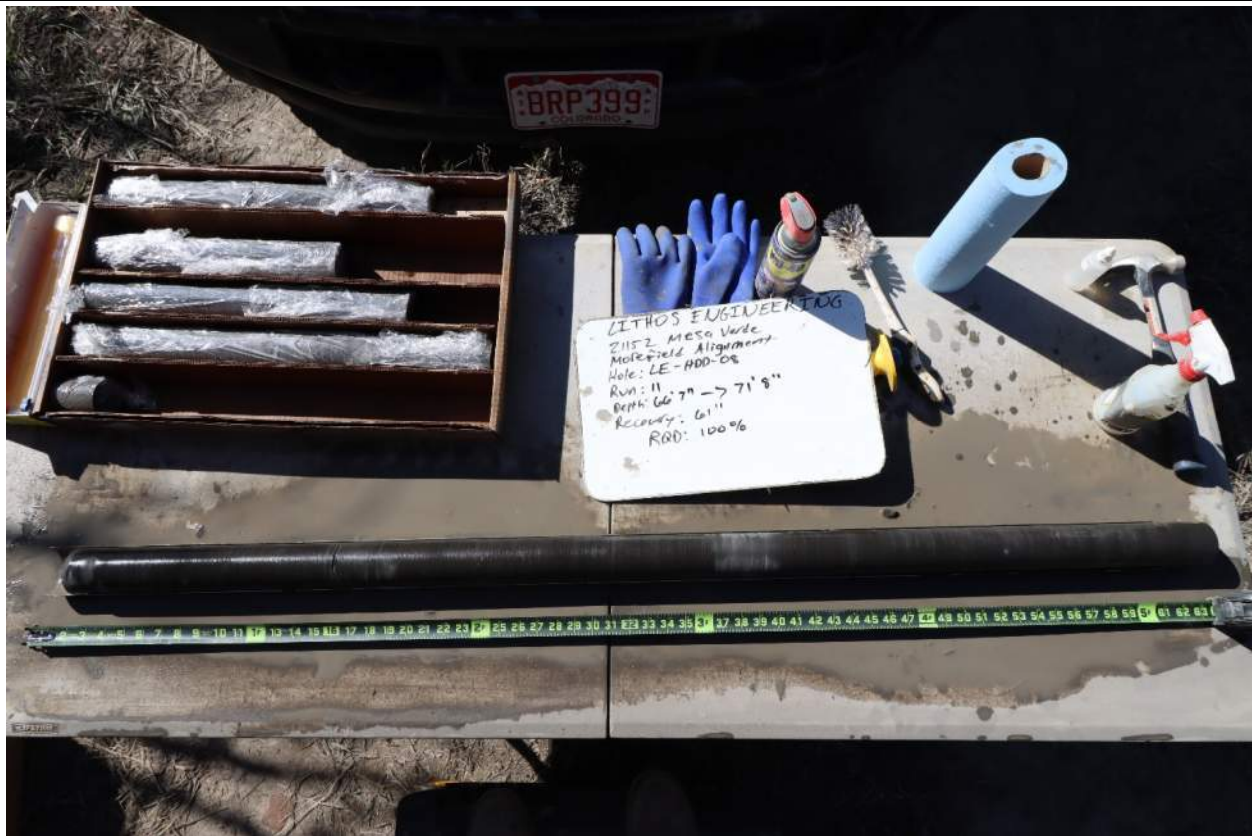
CORE PHOTO 38. LE-HDD-08, RUN: 9, DEPTH: 56'5" – 61'7", RECOVERY: 62", RQD: 100%



CORE PHOTO 39. LE-HDD-08, RUNS: 8 & partial 9, DEPTH: 51'5" – 59'8.25"



CORE PHOTO 40. LE-HDD-08, RUN: 10, DEPTH: 61'7" – 66'7", RECOVERY: 59", RQD: 95%



CORE PHOTO 41. LE-HDD-08, RUN: 11, DEPTH: 66'7" – 71'8", RECOVERY: 61", RQD: 100%



CORE PHOTO 42. LE-HDD-08, RUNS: partial 9, 10, & partial 11, DEPTH: 59'8.25" – 68'5.375"



CORE PHOTO 43. LE-HDD-08, RUN: 12, DEPTH: 71'8" – 76'8", RECOVERY: 60", RQD: 100%



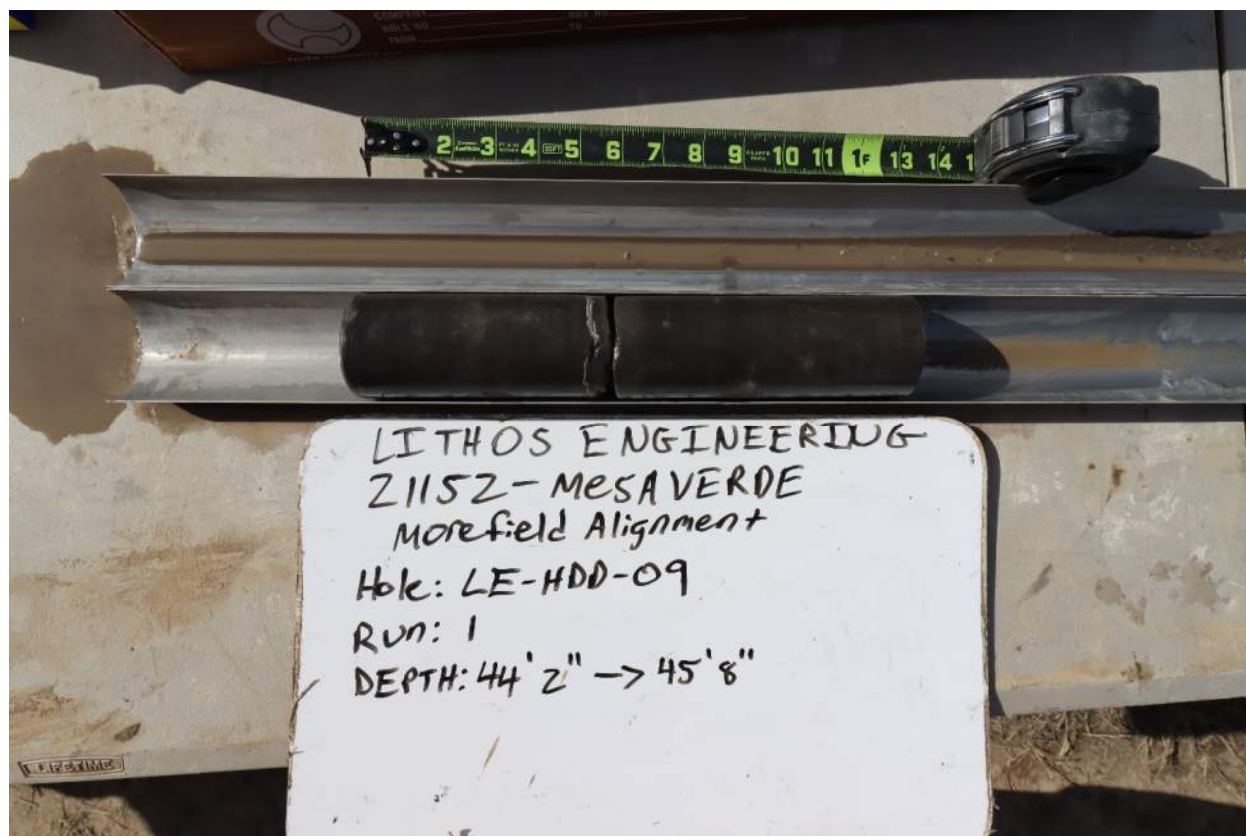
CORE PHOTO 44. LE-HDD-08, RUNS: partial 11 & 12, DEPTH: 68'5.375" – 76'8"



CORE PHOTO 45 & 46. LE-HDD-08, RUN: 13, DEPTH: 76'8" – 81'8", RECOVERY: 58.75", RQD: 92%



CORE PHOTO 47. LE-HDD-08, RUNS: 13, DEPTH: 76'8" - 81'8"



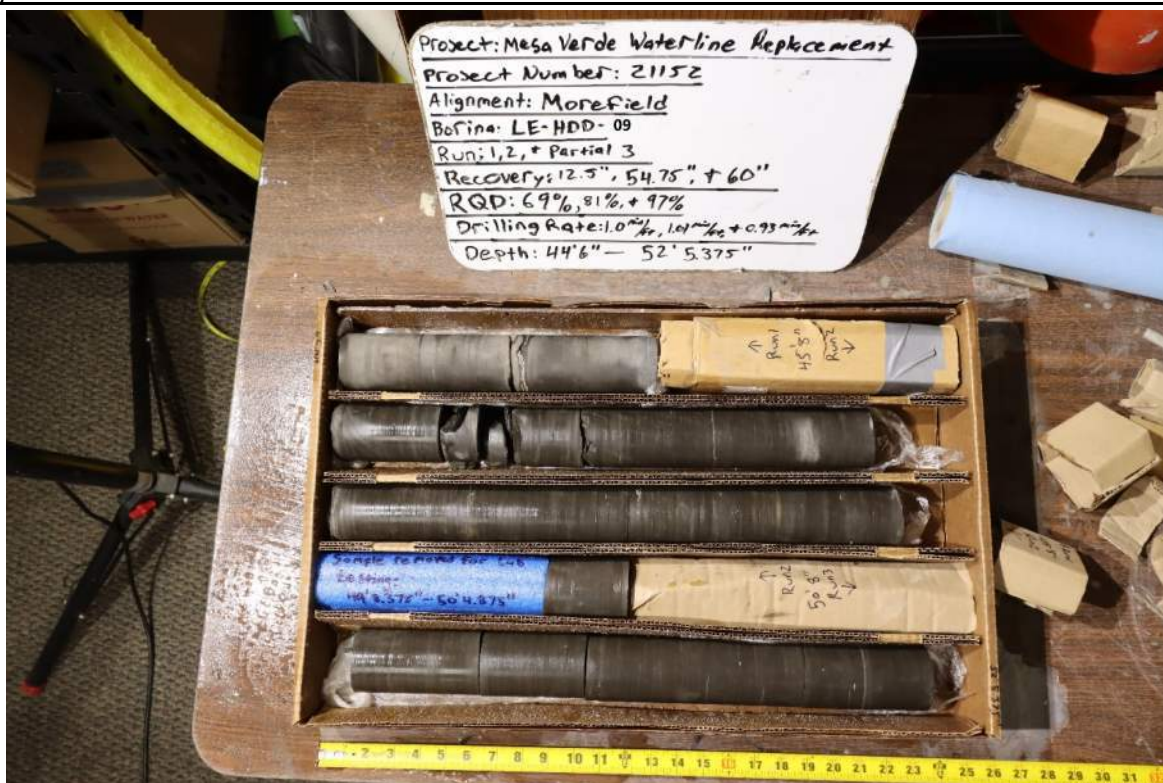
CORE PHOTO 48. LE-HDD-09, RUN: 1, DEPTH: 44'2" - 45'8", RECOVERY: 12.5", RQD: 69%



CORE PHOTO 49. LE-HDD-09, RUN: 2, DEPTH: 45'8" – 50'8", RECOVERY: 54.75", RQD: 81%



CORE PHOTO 50. LE-HDD-09, RUN: 3, DEPTH: 50'8" – 55'8", RECOVERY: 60", RQD: 97%



CORE PHOTO 51. LE-HDD-09, RUNS: 1, 2, & partial 3, DEPTH: 44'6" - 52'5.375"



CORE PHOTO 52. LE-HDD-09, RUN: 4, DEPTH: 55'8" - 60'8", RECOVERY: 58", RQD: 88%



CORE PHOTO 53. LE-HDD-09, RUNS: partial 3 & partial 4, DEPTH: 52'5.375" – 59'8.75"



CORE PHOTO 54. LE-HDD-09, RUN: 5, DEPTH: 60'8" – 65'8", RECOVERY: 58.5", RQD: 93%



CORE PHOTO 55. LE-HDD-09, RUN: 6, DEPTH: 65'8" – 70'8", RECOVERY: 60", RQD: 94%



CORE PHOTO 56. LE-HDD-09, RUNS: partial 4, 5, & partial 6, DEPTH: 59'8.75" – 67'5.6875"



CORE PHOTO 57. LE-HDD-09, RUN: 7, DEPTH: 70'8" – 75'8", RECOVERY: 59.5", RQD: 92%



CORE PHOTO 58. LE-HDD-09, RUNS: partial 6 & 7, DEPTH: 67'5.6875" – 75'8"



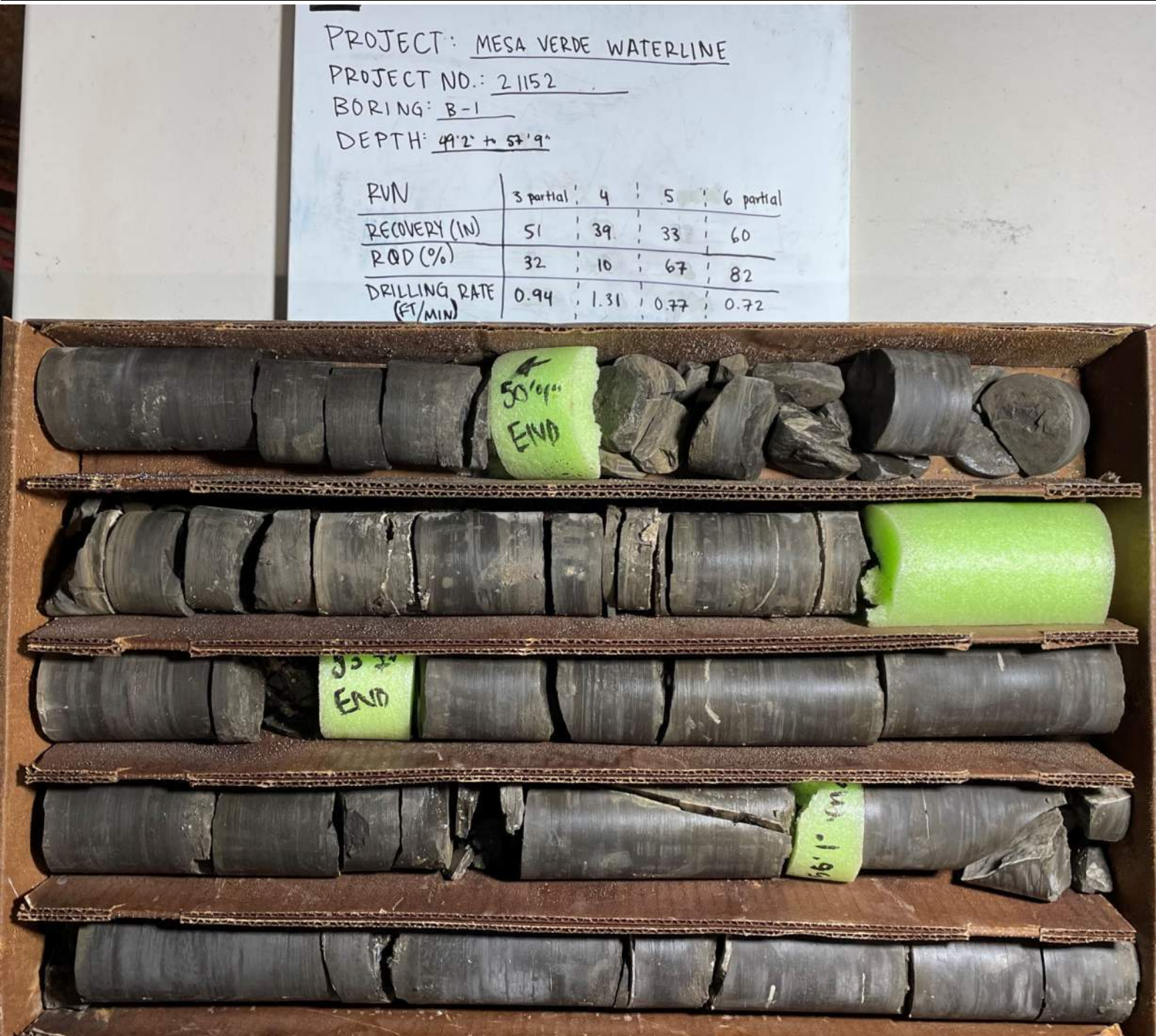
CORE PHOTO 59. LE-HDD-09, RUN: 8, DEPTH: 75'8" – 80'11", RECOVERY: 63", RQD: 94%



CORE PHOTO 60. LE-HDD-09, RUN: 8, DEPTH: 75'8" – 80'11"



CORE PHOTO 61. LE-HDD-09-A, CORE BOX 1, RUNS: 1, 2, & 3 PARTIAL, DEPTH: 39'1" – 49'2"



CORE PHOTO 62. LE-HDD-09-A, CORE BOX 2, RUNS: 3 PARTIAL, 4, 5, & 6 PARTIAL, DEPTH: 49'2" – 57'9"



CORE PHOTO 63. LE-HDD-09-A, CORE BOX 3, RUNS: 6 PARTIAL & 7, DEPTH: 57'9" – 66'1"



CORE PHOTOS 64, 65, 66. LE-HDD-09-A, RUN 6, NOTED INCLUSION NOT OF SHALE IN CORE SAMPLE



CORE PHOTO 67. LE-HDD-09-A, CORE BOX 3, RUNS: 8 & 9 PARTIAL, DEPTH: 66'1" – 74'0"



CORE PHOTO 68. LE-HDD-09-A, CORE BOX 5, RUNS: 9 PARTIAL & 10, DEPTH: 74'0" – 81'1"



CORE PHOTO 69. LE-HDD-11, RUN: 1, DEPTH: 75' – 80', RECOVERY: 29.5", RQD: 12%



CORE PHOTO 70. LE-HDD-11, RUN: 1, DEPTH: 75' – 80'

PROJECT: MESA VERDE WATERLINE

PROJECT NO.: 21152

BORING: B-

DEPTH: 19'3" to 30'9" BOX: 1 of 2

RUN	1	2	3 partial
RECOVERY (IN)	55	33	50
ROD (%)	54	70	19
DRILLING RATE (FT/MIN)	0.77	0.79	0.65



CORE PHOTO 71. LE-HDD-12-A, RUNS: 1, 2, & 3 PARTIAL, DEPTH: 19'3" – 30'9"



CORE PHOTO 72. LE-HDD-12-A, RUNS: 3 PARTIAL & 4, DEPTH: 30'9" – 39'3"



CORE PHOTO 73. LE-HDD-12-A, RUNS: 3, DEPTH: 29'3" – 34'3", NOTE TRANSTION FROM SANDSTONE BOULDER TO SOIL



APPENDIX – E

Geophysical Letter Report



7711 W. 6th Ave., Ste G/H | Lakewood, CO 80214 | (720) 487-9200

August 1, 2023

Lance Heyer, PE

Lithos Engineering
5205 South College Ave, Suite B
Fort Collins, Colorado 80525
Email: lance@lithoseng.com

RE: Geophysical Letter Report | Project # 230172
Geophysical Investigation, Mesa Verde Rockfall Thickness
Mesa Verde National Park, CO

On behalf of Lithos Engineering (Lithos) Collier Geophysics (Collier) performed geophysical investigations at Mesa Verde National Park, Colorado to aid in the assessment of rockfall/colluvium/undifferentiated overburden (hereafter referred to as simply rockfall) thickness for engineering design in the Morefield Waterline Replacement Project. To achieve this objective, Collier performed Multichannel-Analysis of Surface Waves (MASW) seismic soundings at four (4) transect positions along the rockfall section of the Morefield Waterline Alignment (**Figure 1**). The results from these surveys produced 1D shear-wave (Vs) velocity models for depths up to 200 ft below ground surface (bgs). Interpretation of these results indicate that along the eastern toe of the rockfall deposit stiffer bedrock materials occur around 30 ft below ground surface (bgs), with bedrock deepening to likely greater than 80 ft along the central portion of the alignment, and then shallowing somewhat to possibly the 40-50 ft range near the top of the rockfall slope.

The following report describes the data collection, processing, and interpretation procedures for this work. For any additional details of the MASW method or processing techniques described herein, Collier can submit method addenda upon request.

Site Description

The project site is located along the northeastern edge of Mesa Verde National Park, outside of Mancos, Colorado (**Figure 1**). The Morefield Waterline Alignment extends from the Park Visitor Center to the Morefield Water Tank just east of the Morefield Campground. A section of this alignment runs up a steep rockfall slope from the Mancos Valley floor to Mesa Top Ruins Road. Geotechnical drilling along this section of the alignment reveals thick packages of unconsolidated rockfall materials consisting of sands with variable amounts of clay surrounding large sandstone boulders. Below this alluvial/colluvial material interface exists bedrock comprised of the Mancos Shale Formation. MASW soundings were completed along several portions of this rockfall slope (using RD 35510H.5 as access).

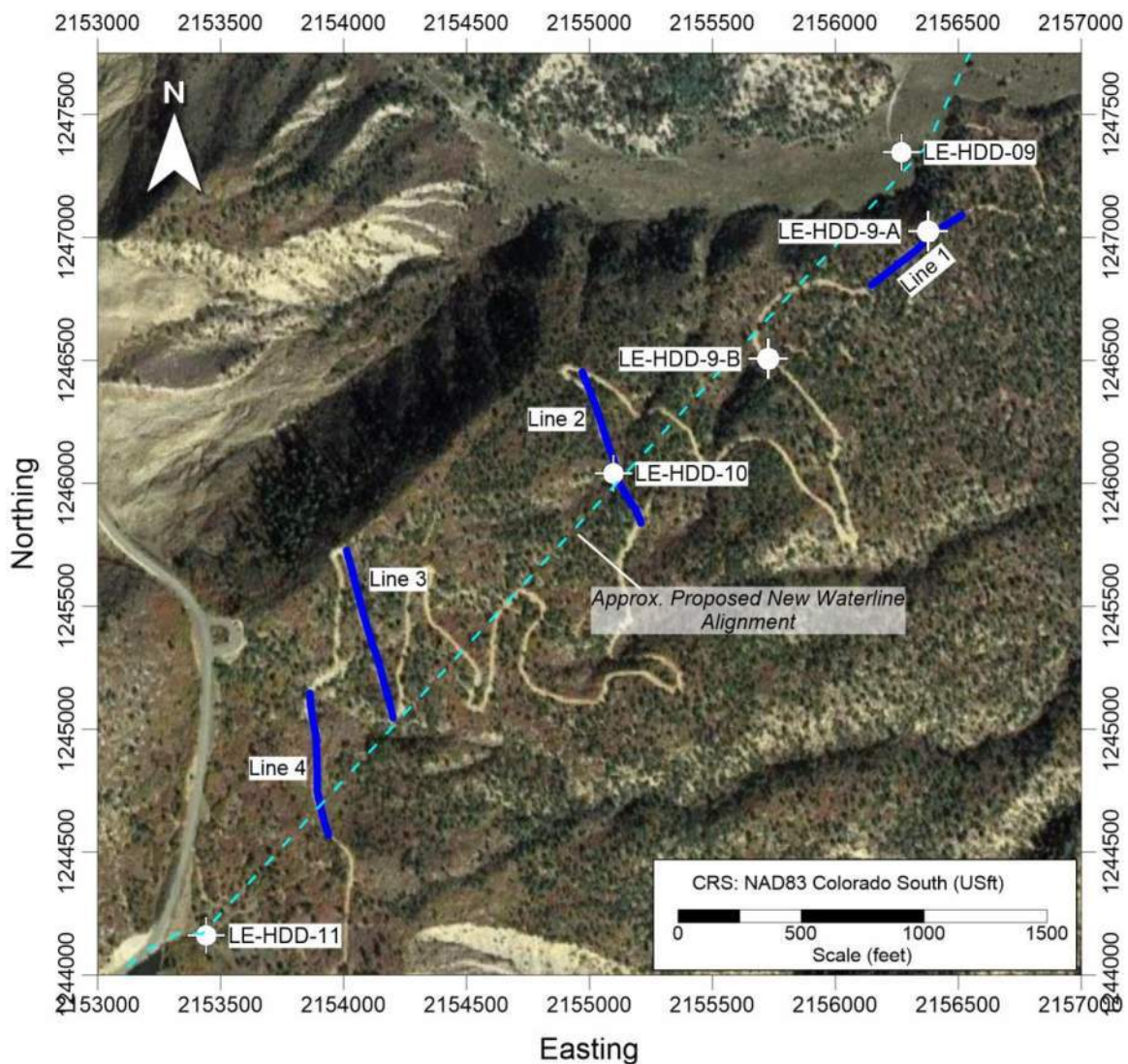


Figure 1: Site Location, showing approximate location of proposed new Morefield Water Line, five (5) geotechnical boring locations, and MASW sounding transects (blue).



Figure 2: Example photographs of site conditions along RD 35510H.5 during the time of the seismic investigation

Data Acquisition

The MASW method uses properties of recorded surface seismic waves (large amplitude seismic wave-modes which are a consequence of the air-earth free-surface boundary condition) to assess shear wave velocity variations within the subsurface. Rayleigh seismic surface waves (the seismic surface wave mode analyzed in this investigation) have particle motions that are retrograde elliptical, exactly like ocean waves. Meaning, as a surface wave radiates from a source, earth particles move in backwards rotating ellipses that become smaller with depth. The size of these ellipses for a given earth material is dependent on the frequency of the surface wave, with higher frequencies producing smaller particle ellipses and lower frequencies producing larger particle ellipses. As such, higher frequency surface waves are sensitive to the material properties of the shallow subsurface and lower frequencies are more sensitive to the deeper subsurface materials. By measuring and assessing the frequency and relative velocities of surface waves incident on a set of recorders (i.e. geophones), models of the subsurface can be generated that describe the shear-wave (V_s) velocity (a key component of surface wave propagation) as a function of depth. This approach works well to image the contact between unconsolidated overburden overlying a stiff bedrock formation(s).

For this project specifically, Collier deployed linear arrays of geophones and used an active-source hammer to produce surface waves. These linear arrays allowed for the development of deep 1D models of shear wave velocity to be made along the rockfall portion of the Morefield Water Line Alignment.

Collier deployed four (4) linear transects (**Figure 1**) of geophones with lengths varying from 600-720 feet using 10-foot geophone spacing. Surface waves were generated using a 40 lb accelerated impact source, hitch mounted to a UTV (right photo – **Figure 2**). Source-points were located at the ends of each array as well as at every 12th geophone for each array. These

variety of source points allowed for a broad range of surface wave frequencies to be assessed and used in modeling Vs values to depths greater than 200 ft bgs.

Individual shot records were recorded using 60 second record lengths, at a 4 millisecond sample interval. Data collection was controlled by a series of three (3) Geometrics Geode 24-bit Seismographs. Positional information for each array was collected via an Emlid Reach RS2 GPS base-rover pair operating in differential mode.

Data Processing

MASW analysis consists of generating a frequency-velocity transform from surface wave arrivals record in a seismic shot record, picking the energy peaks of the fundamental mode in the transformed data to derive a dispersion curve, and inverting this dispersion curve to a layered Vs model. **Figure 3** illustrates the dispersion curve picking approach used for the MASW records, with a sample from this investigation.

These steps were completed for each of the four linear transects completed for this investigation using the software ParkSeis 3.0 by Park Seismic.

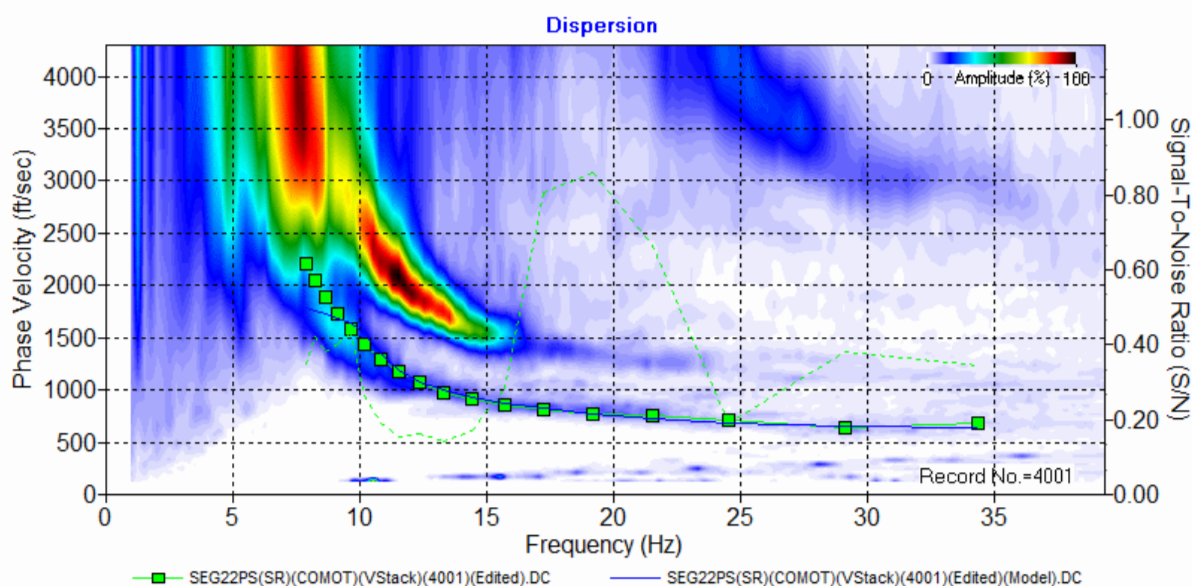


Figure 3: Example of dispersion image from Line 4 (green symbols indicate dispersion curve picks) from this project.

Results and Discussion

The Vs model results for reach of the seismic transects are presented in large format figures appended to this report (**Figures A-1 – A-4**). Each figure displays the 1D Vs model derived for each transect as well as the location of the model transect along the Morefield Alignment. Where geotechnical boring was proximally located to the MASW transects, simplified lithologic logs have been overlain on the 1D Vs models.

Figure A-1 displays the results for Line 1 on the eastern portion of the alignment. The model describes Vs values below 1,200 ft/s for the upper 25 ft bgs with a strong velocity contrast, where Vs values increase to near 2,000 ft/s, occurring around 30 ft bgs. The geotechnical boring LE-HDD-09A is located along the Line 1 MASW transect, and indicates rockfall deposits occurring in the upper 37 ft bgs before encountering more competent Mancos Shale bedrock. This simplified lithology log has been overlain on the Line 1 Vs sounding. Collier considers the ~30 ft bgs Vs velocity contrast in the Line 1 sounding compared to the bedrock encounter at 37 ft bgs in LE-HDD-09A a good correlation, given that the Vs sounding for Line 1 is derived from sampling the subsurface beneath a 720-foot long geophone array. This correlation allows Collier to infer that Vs velocity contrasts on the order of 1000 ft/s at this site are likely due to the contact between rockfall and bedrock materials.

Figure A-2 shows the results for the Line 2 transect midway up the alignment along RD 35510H.5. Here the model describes Vs values below 1,500 ft/s in the upper 55 ft bgs. Then from 55 to 85 ft bgs Vs values increase to over 2,500 ft/s. As such, the Vs model for Line 2 does not have as sharp of a velocity contrast as Line 1. The lithology log for LE-HDD-10 is overlain on the Vs model in **Figure A-2** showing that no bedrock materials were encountered in the 80 foot deep boring. From the drilling log however, blow counts become greater than 50/6" at around 50 ft bgs and are maintained throughout the rest of the boring. This increase in blow counts does correlate with the start of the velocity increase seen in the Line 2 Vs model. Given the observations in the Line 1 Vs model compared to LE-HDD-09A; in the absence of additional information, Collier would infer the top of stiffer bedrock materials to occur around 80 ft bgs at the Line 2 transect. Although bedrock was not encountered up to 80 ft bgs in LE-HDD-10, it is possible that the bedrock contact exists just beyond the termination of the boring. However, it is also possible that the relative stiffness of the rockfall deposits between the 60-80 ft depth is the primary source of the Vs increases seen in the Line 2 model and that the overburden/bedrock contact has a lower velocity contrast at this location, making it less detectable in the model.

The MASW models for transects 3 and 4 are shown in **Figures A-3 & A-4** respectively. The Line 3 model shows a very strong velocity contrast (over 2,000 ft/s increase) at ~45 ft bgs, which Collier would interpret as a high material stiffness interface, i.e. the rockfall/bedrock contact. The Vs model for Line 4, however, has a generally more gradual linear velocity increase from the ground surface to ~90 ft bgs, where velocities then remain high and relatively constant throughout the rest of the model. There is a velocity contrast of just under 1,000 ft/s around 50 ft bgs in the Line 4 model, which may represent a discrete material stiffness boundary such as the overburden/bedrock contact. Both the Line 3 and Line 4 models do not have proximal geotechnical data to provide correlation which, so the interpretation of these models are based on the correlations observed for Lines 1 and 2.

It is important to note that the boring log for LE-HDD-11 further west of the MASW Lines 3 or 4 did not encounter Mancos Shale bedrock within its 80 foot depth. There were some mentions of interbedded shales at the base of this boring but they were not identified as the top of the Mancos in the logs. These boring data are in contrast to the ~50 foot bgs Vs increases seen in the Lines 3 & 4 Vs models, which Collier would otherwise consider as the top of the stiffer bedrock. This discrepancy again may be due to stiff overburden/rockfall deposit materials such as those with very high blow counts being the primary cause of the Vs value increases seen in the Lines 3 and 4 models and that these do not directly reflect the bedrock surface. However, there is some elevation difference between the Line 4 MASW sounding location and the LE-HDD-11 boring. Comparison of the elevations to stiffer materials at these locations may reveal a stronger correlation between the boring data and the MASW Vs model result.

Overall, the Vs models across the rockfall deposit portion of the Morefield alignment describes shallow bedrock (~30 ft bgs) occurring at the eastern toe of the slope, and the deepest bedrock is interpreted along the center of the alignment near LE-HDD-10, with likely greater than 80 feet of overburden materials. At the top of the rockfall slope, the Vs models imply that bedrock materials may exist shallower than the center, possibly in the 40-50 ft bgs range; however, given the less distinct Vs contrasts in this area, they may have a higher degree of weathering than elsewhere along the alignment.

Closure

Collier Geophysics deployed 1D MASW sounding methods along a steep rockfall portion of the Morefield Water Line Alignment in Mesa Verde National Park to aid in the assessment of bedrock depth for the proposed HDD engineering design of the waterline replacement. The interpreted results from this seismic investigation are: shallow Mancos Shale bedrock, around 30 feet depth, occurs along the eastern toe of the slope; deeper ~80 ft overburden/bedrock contact is observed within the central area of the alignment; and, interpreted moderate (40 to 50 foot) depth bedrock along the top of the alignment nearer to Mesa Top Ruins Road. These interpretations were made based on the assessment of relative Vs contrasts observed in 1D modeled shear wave velocity data for each of four linear MASW transects using limited geotechnical boring information also along the alignment.

The geophysical methods and field procedures defined in this report were applicable to the project objectives and have been successfully applied by Collier geophysicists to investigations of similar size and nature. However, sometimes field or subsurface conditions are different from those anticipated and the resultant data may not achieve the investigation objectives. Collier warrants that our services were performed within the limits prescribed for this project, with the usual thoroughness and competence of the geophysical profession. Collier conducted this project using the current standards of the geophysical industry which include in-house quality control standards to produce a precise geophysical survey.

If you have any questions regarding the field procedures, seismic data analysis or interpretations presented herein, please do not hesitate to contact us. We appreciate the opportunity to work on this project and look forward to providing Lithos with geophysical services in the future.

Respectfully Submitted,

Collier Geophysics, LLC

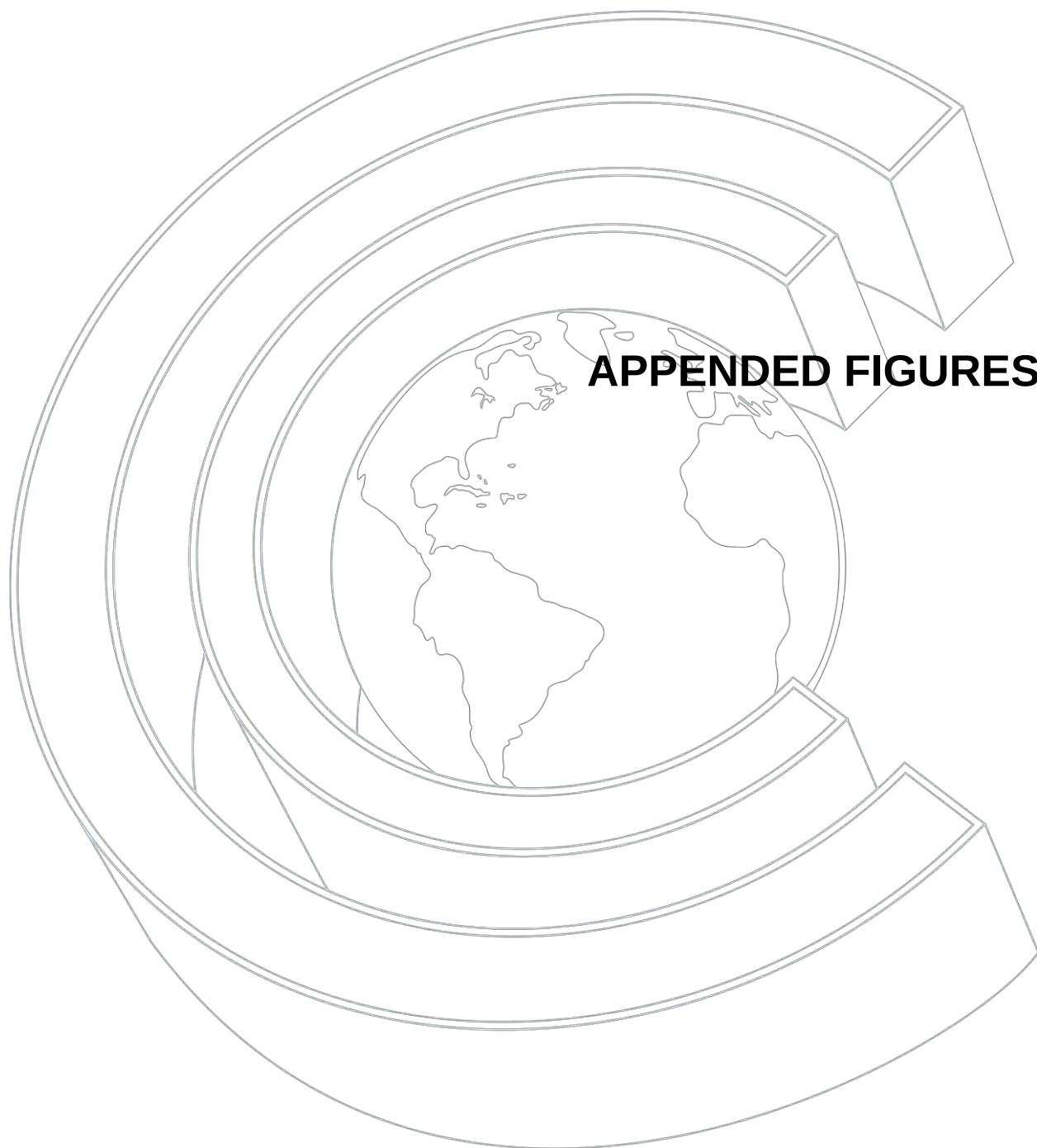


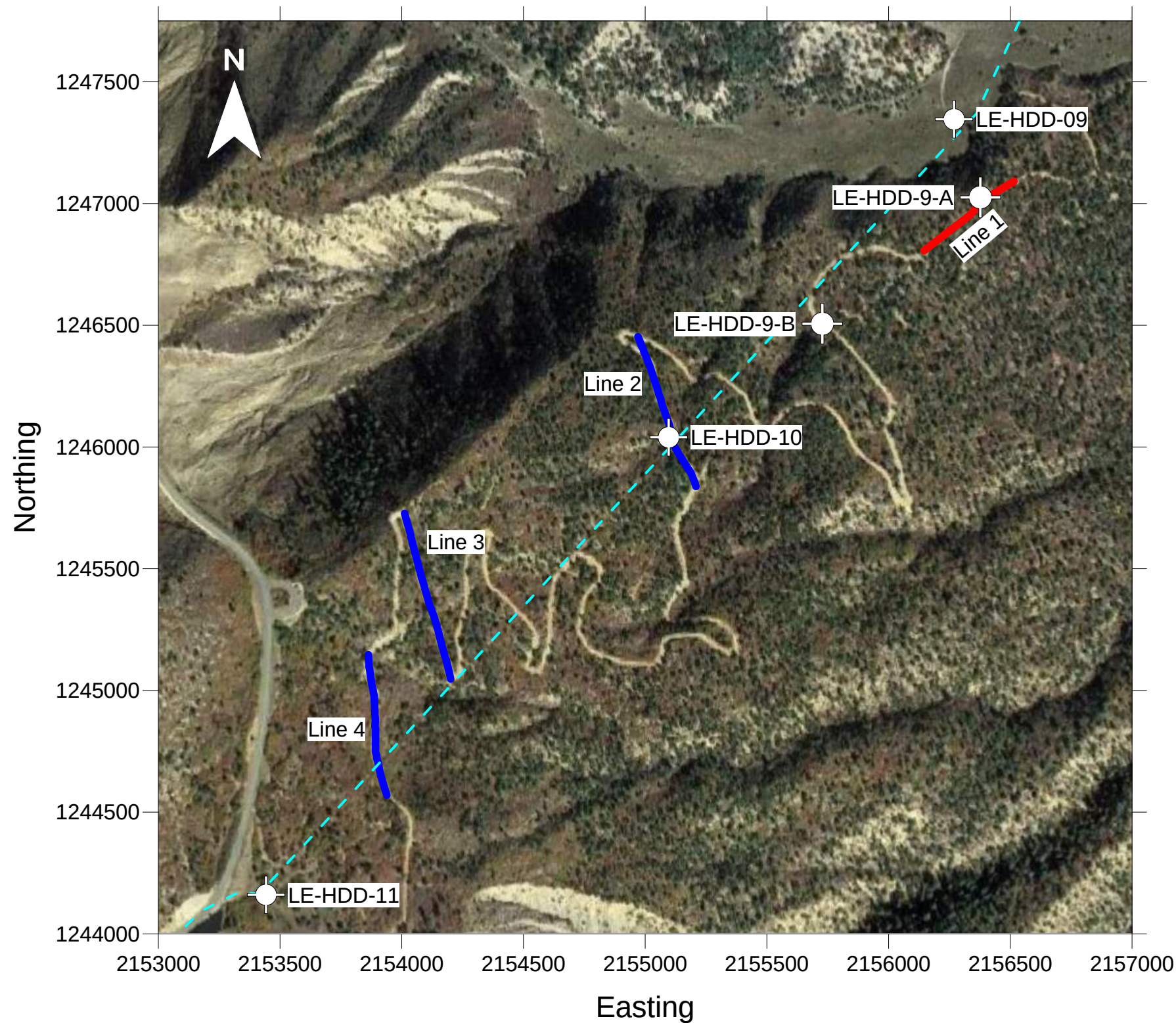
Roy Bowling
Geophysicist



Phil Sirles
Principal Geophysicist

(1 copy e-mailed PDF format)



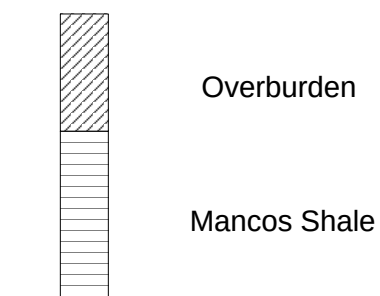


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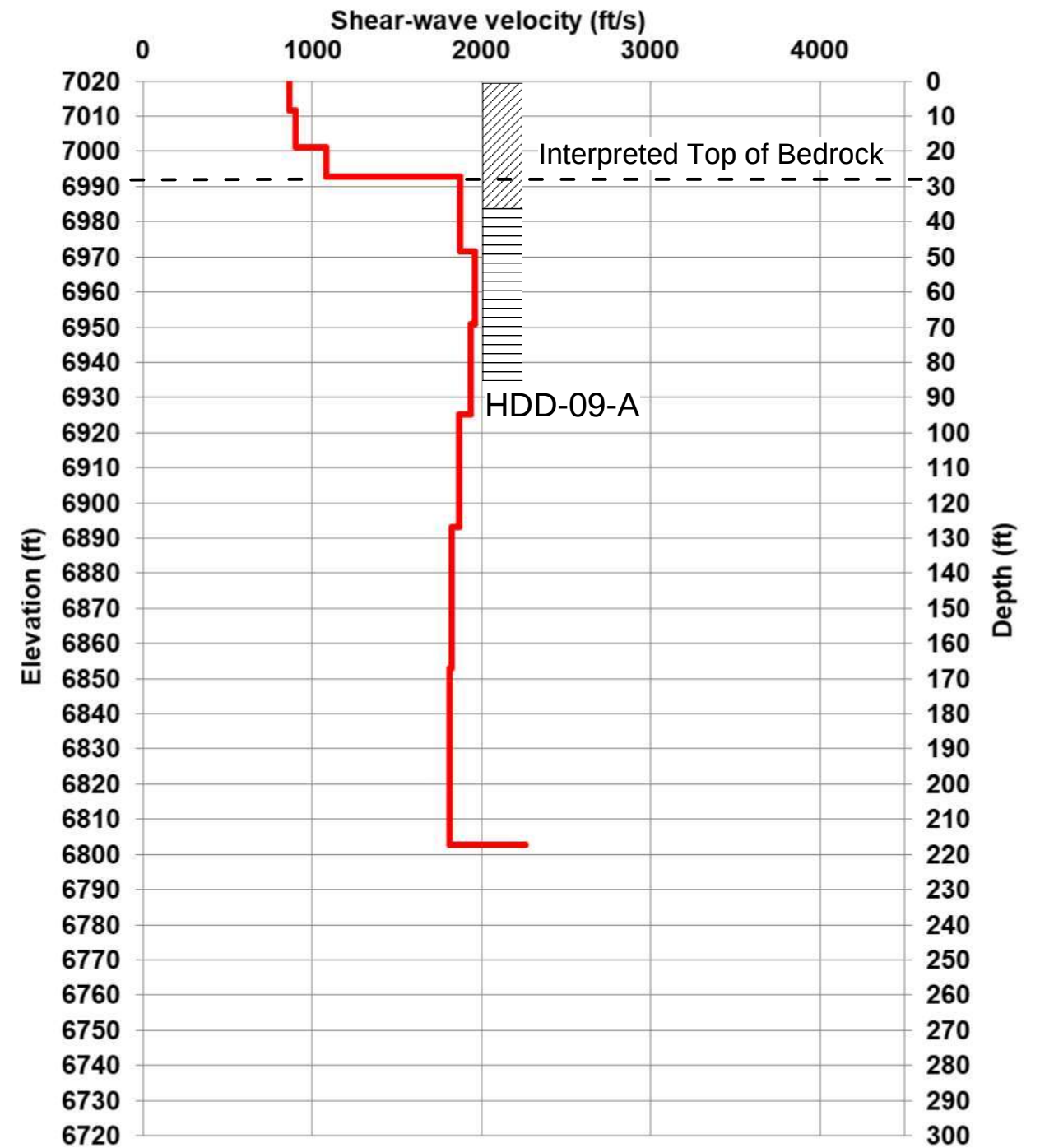
Approx. Proposed
New Waterline Alignment



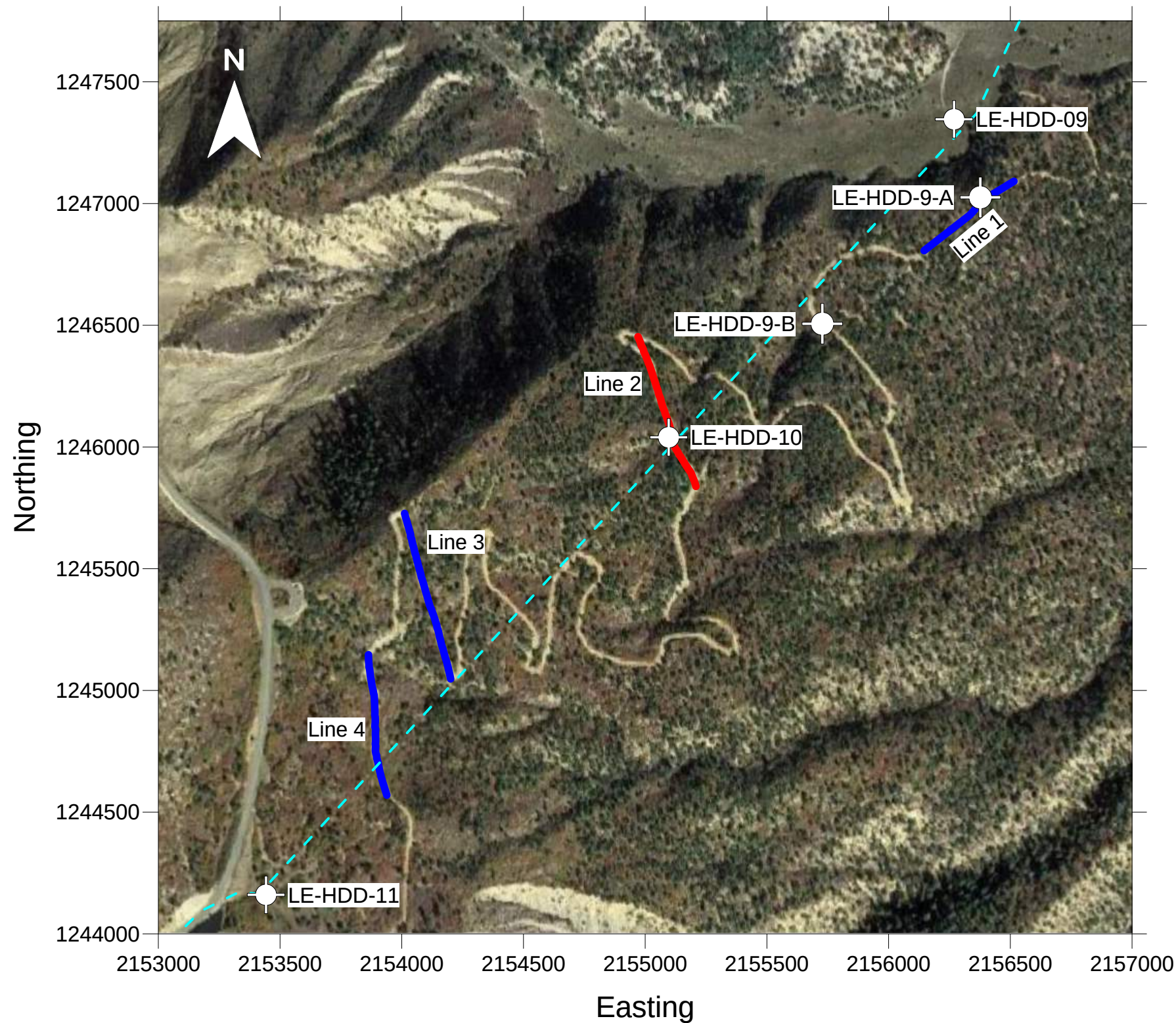
HDD Boring



Line 1



Mesa Verde, NP MASW Investigation: Line 1 Cortez, CO		
 COLLIER GEOPHYSICS	Lithos	
	Project #: 230172	Figure A-1
Drafted by: N.Rebman	Reviewed by: R. Bowling	Aug. 2023



CRS: NAD83 Colorado South (USft)
0 500 1000 1500
Scale (feet)

Approx. Proposed
New Waterline Alignment

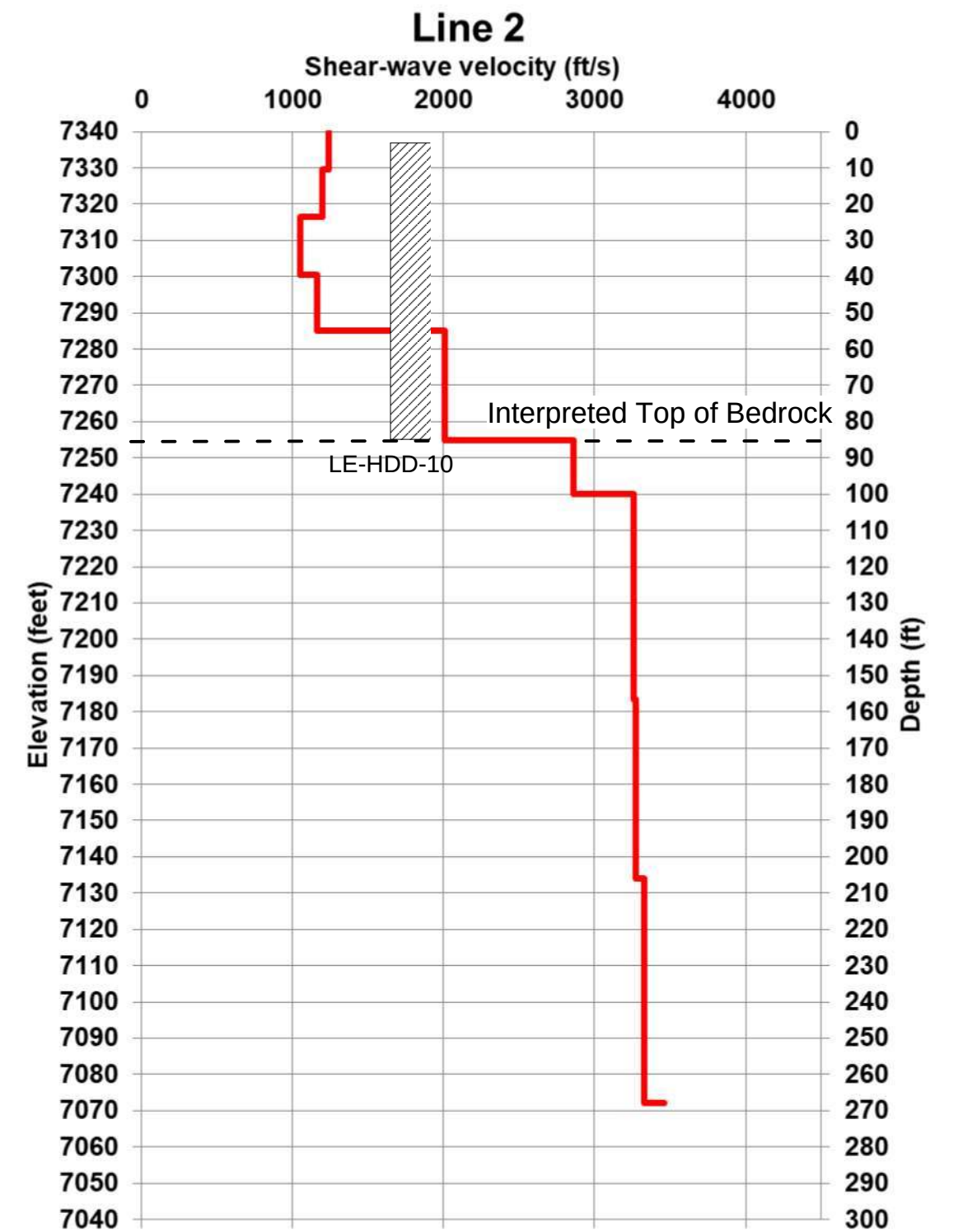


HDD Boring

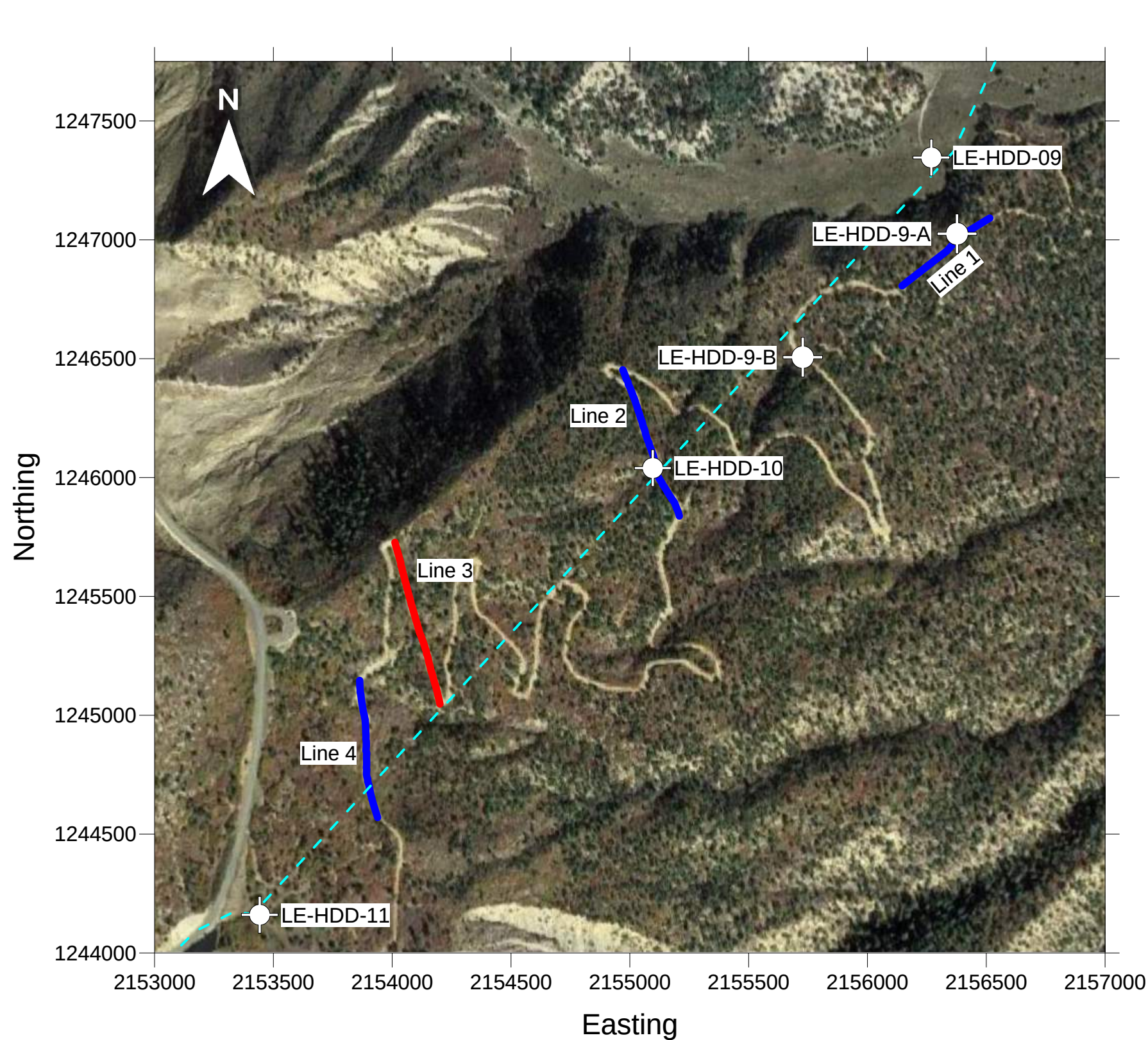


Overburden

Mancos Shale



Mesa Verde, NP MASW Investigation: Line 2 Cortez, CO		
 COLLIER GEOPHYSICS	Lithos	
	Project #: 230172	Figure A-2
Drafted by: N.Rebman	Reviewed by: R. Bowling	Aug. 2023



CRS: NAD83 Colorado South (USft)

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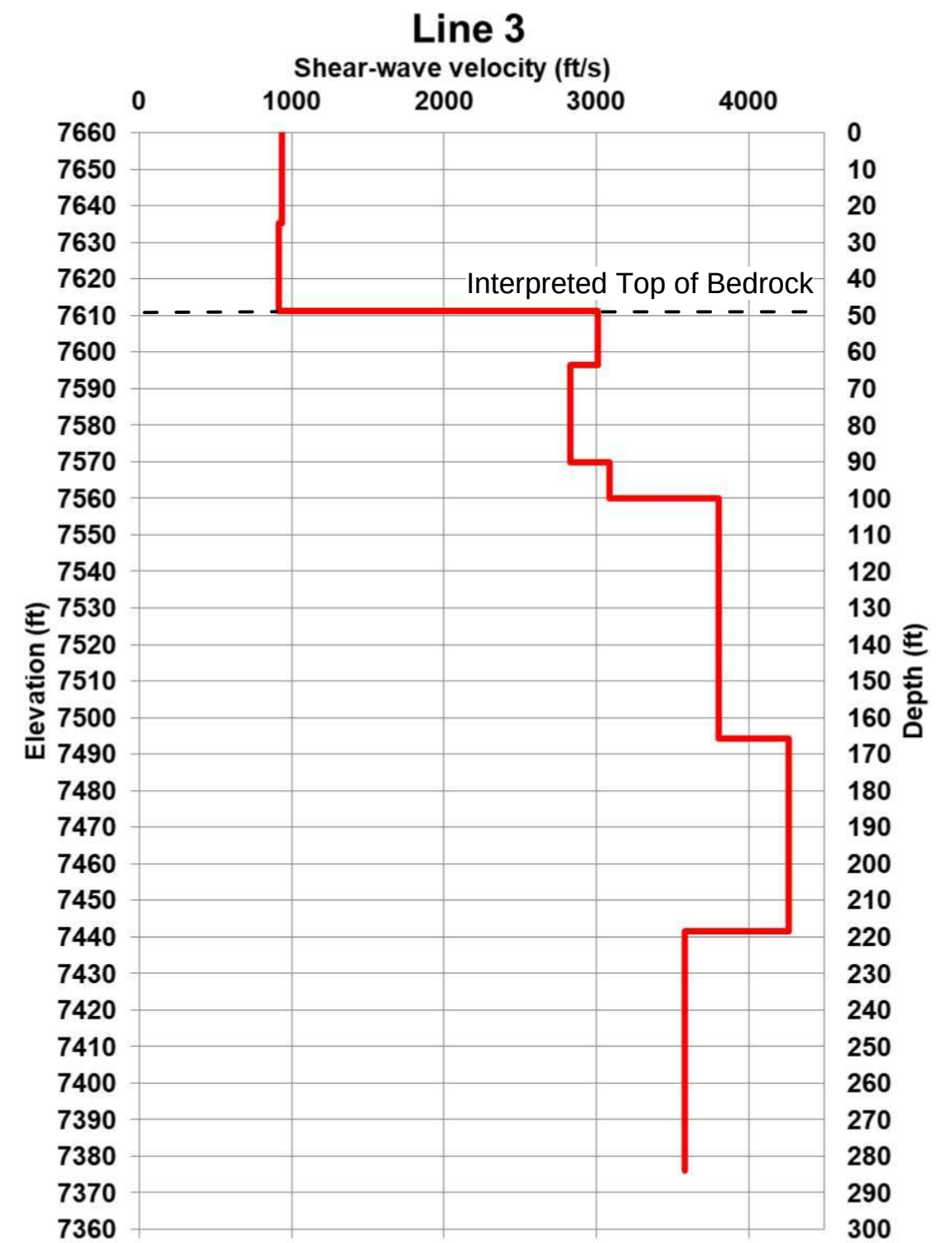
Scale (feet)

Approx. Proposed
New Waterline Alignment

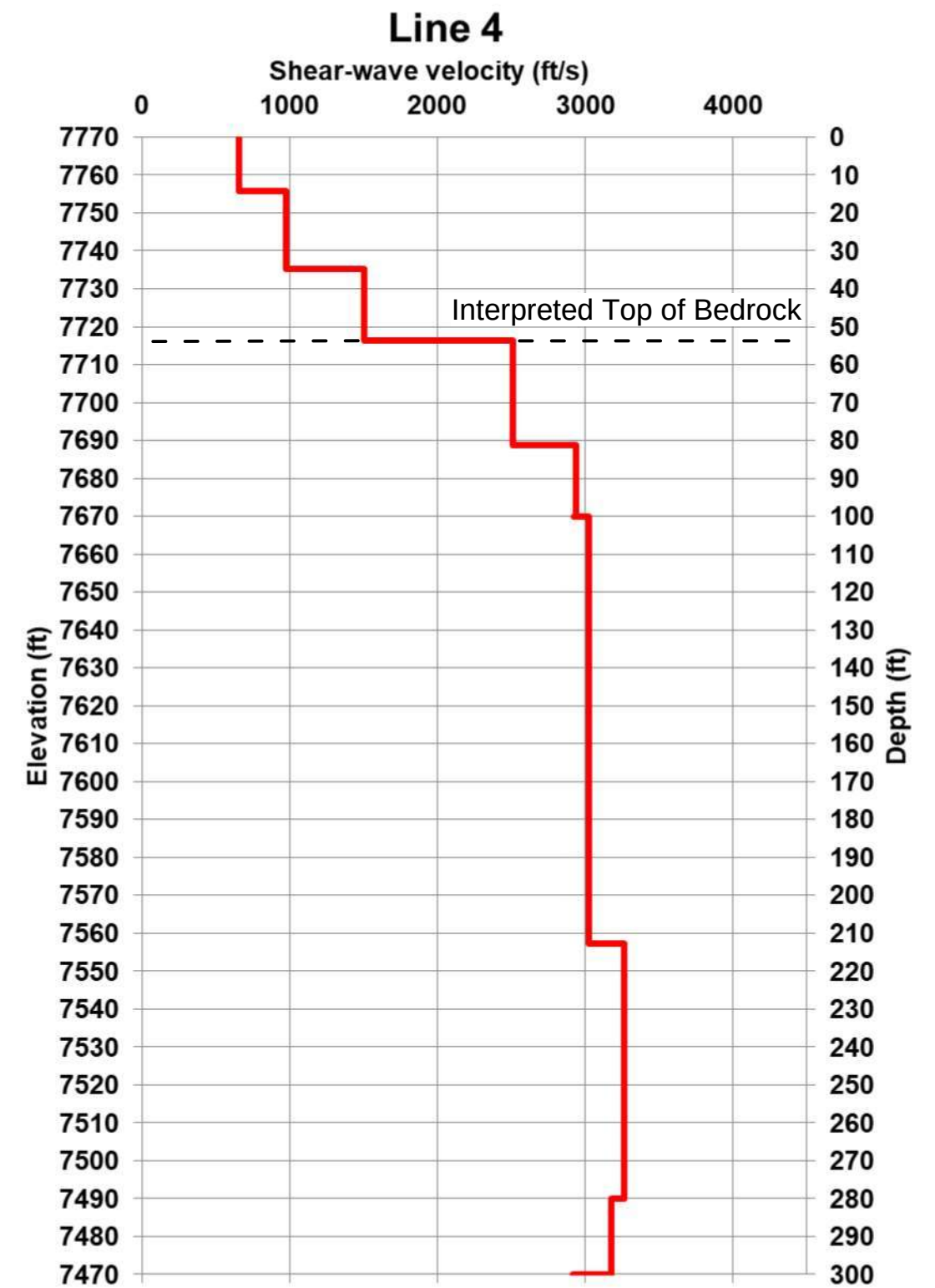
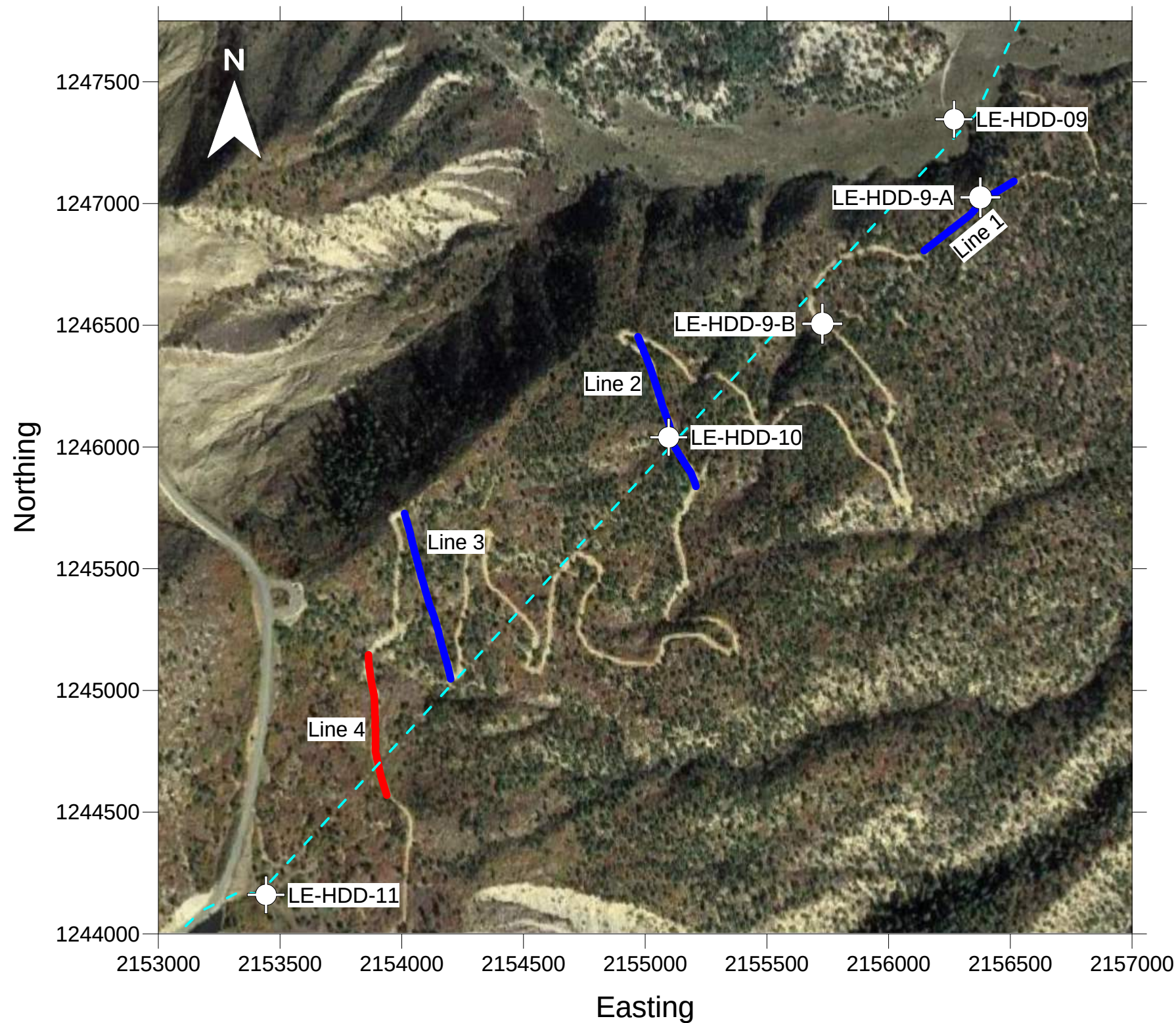


HDD Boring

MASW Profile Location



Mesa Verde, NP MASW Investigation: Line 3 Cortez, CO		
COLLIER GEOPHYSICS	Lithos	
	Project #: 230172	Figure A-3
Drafted by: N.Rebman	Reviewed by: R. Bowling	Aug. 2023



CRS: NAD83 Colorado South (USft)
0 500 1000 1500
Scale (feet)



MASW Profile Location



Approx. Proposed
New Waterline Alignment



HDD Boring

Mesa Verde, NP MASW Investigation: Line 4 Cortez, CO		
 COLLIER GEOPHYSICS	Lithos	
	Project #: 230172	Figure A-4
Drafted by: N.Rebman	Reviewed by: R. Bowling	Aug. 2023