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Geotechnical Engineering Report

Cody Central Gathering Facility
SWC of Weld County Roads 6 and 15
Weld County, Colorado

Prepared for:
XTR Midstream, LLC
370 17th Street, Suite 5300
Denver, CO 80202

Prepared by:
Cole Garner Geotechnical
CGG Project No.: 17.22.199

December 11, 2017

Geotechnical and Materials Testing

Cole Garner Geotechnical
1070 W. 124th Ave, Ste. 300
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December 11, 2017

XTR Midstream, LLC
370 17th Street, Suite 5300
Denver, Colorado 80202

Attn: Mr. Matthew Eyser

Re: Geotechnical Engineering Report
Cody Central Gathering Facility
SWC of Weld County Roads 6 and 15
Weld County, Colorado
CGG Project No. 17.22.199

Cole Garner Geotechnical (CGG) has completed a design-level geotechnical engineering investigation for the proposed natural gas gathering facility in Weld County, Colorado. This study was performed in general accordance with our proposal number P17.22.177, dated October 23, 2017.

The following summary should be used in conjunction with the entire report for design and/or construction purposes. It should be recognized that specific details were not included or fully developed in this section, and the report must be read in its entirety for a comprehensive understanding of the items contained herein. The section titled General Comments should be read for an understanding of the report limitations.

- **Subsurface Conditions:** The overburden soils across the site primarily consist of lean clays with varying amounts of sand. Clayey sands were also encountered underlying the clays in borings in the general vicinity of the existing drainage area. Sedimentary claystone and sandstone bedrock was encountered underlying the clays/sands at depths ranging from about 7 to 14 feet in the southwest and northeast portions of the site, and at depths ranging from about 12 to 24 feet in the central areas of the site nearer the existing natural drainage feature. The bedrock extended to the depths explored. Other specific information regarding the lithology encountered is noted on the attached Boring Logs.

- **Shallow Groundwater Conditions:** Groundwater was encountered in our borings immediately after drilling at depths ranging from about 6 to 27 feet below existing site grades. When checked a minimum of one week later, groundwater was measured in our borings at depths ranging from about 5 to 15-½ feet below existing site grades for most of the site. In our preliminary study of the site (June 2017), groundwater ranged from about 2 to 7-½ feet below existing site grades for most of the site. ***The shallow groundwater and lower strength soils associated with these areas will***

significantly impact site grading and infrastructure construction, depending on proposed site grade changes.

Grading plans were being developed at the time of this report. ***We recommend that site grading plans be prepared to minimize earthen cut depths as much as possible and to raise site grades where groundwater is shallowest in order to help alleviate this condition.***

- **Expansive Bedrock:** Swell-consolidation testing of select samples from our borings indicates that the clay soils are generally low to moderately expansive. However, the claystone bedrock encountered at the site is considered to have at least moderate expansive potential. ***Expansive soils and bedrock, when subjected to typical post-construction wetting, will result in minor foundation movement and potential movement of building floor slabs, pavements, etc.***

  This report discusses potential foundation alternatives and other processes to help mitigate the effects of expansive soils and bedrock, however, even using these procedures, the risk of movement and distress will increase if excessive additional wetting or drying of the expansive materials is allowed to occur. Eliminating the risk of movement and distress is generally not considered feasible, but it may be possible to reduce this risk to normally acceptable levels by proper site preparation and construction techniques as discussed herein.

- **Structural Considerations:** Based on the subsurface conditions encountered in our borings, we have evaluated the use of both deep and shallow foundation systems commonly used in the region. These include deep foundations such as straight shaft piers (caissons) or helical piles drilled into bedrock, and shallow foundations such as conventional spread footings and/or mat foundations.

  Based on the subsurface conditions encountered in our borings, we believe the use of deep foundations (drilled piers or helical piles) should be utilized for all heavily-loaded structures or structures where movement must be held to a minimum. For lightly-loaded structures where more movement can be tolerated, the use of shallow foundations (spread footings or mat foundations) should be suitable provided they bear on suitable native soils or a zone of engineered fill. We anticipate that some remediation of soft soils will likely be required below shallow foundations at the site, particularly in proximity to the drainage feature that transects the site. Remediation of soft soils can typically be performed economically by compacting crushed aggregate or recycled concrete into the soft soils until a stable base is achieved.

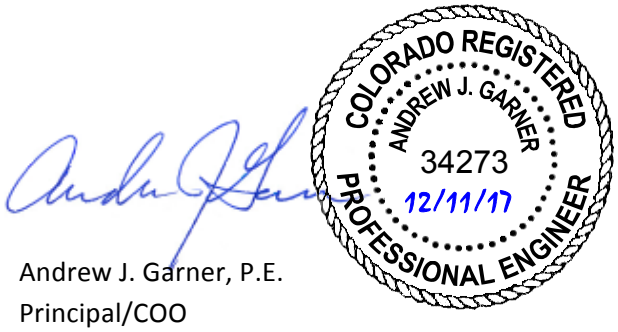
  In some areas of the site (i.e. southwest & northeast corners), remediation of shallow claystone bedrock may be required to reduce the expansive potential of these materials and allow for the use of shallow foundations. With no mitigation, foundation movement on the order of 4 to 6 inches or more could occur. Mitigation of expansive soil/bedrock typically involves sub-excavation, moisture-conditioning, and recompaction of these materials. We anticipate that subexcavation to a minimum

depth of about 10 feet below foundations would be effective to reduce the expansive potential of these materials and limit foundation movement to about one inch.

We appreciate being of service to you in the geotechnical engineering phase of this project, and are prepared to assist you during the construction phases as well. Please do not hesitate to contact us if you have any questions concerning this report or any of our testing, inspection, design and consulting services.

Sincerely,

Cole Garner Geotechnical



Glenn D. Ohlsen, P.E.
Project Engineer

Andrew J. Garner, P.E.
Principal/COO

Copies to: Addressee (1 PDF copy)

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GEOTECHNICAL ENGINEERING REPORT

CODY CENTRAL GATHERING FACILITY
SWC OF WELD COUNTY ROADS 6 AND 15
WELD COUNTY, COLORADO

CGG Project No. 17.22.199
December 11, 2017

INTRODUCTION

This report contains the results of our design-level geotechnical engineering exploration for the proposed natural gas gathering facility to be located at the southwest corner of the referenced intersection in Weld County, Colorado.

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

- Subsurface soil and bedrock conditions
- Groundwater conditions
- Foundation design and construction
- Lateral earth pressures
- Floor slab design and construction
- Below-grade construction
- Site preparation and Earthwork
- Drainage

The recommendations contained in this report are based upon the results of field and laboratory testing, engineering analyses, our experience with similar subsurface conditions and structures, and our understanding of the proposed project.

We previously performed a preliminary investigation of the property documented in our *Preliminary Geotechnical Engineering Report – Broomfield Central Gathering Facility – Weld County, Colorado*, (CGG Project No. 17.22.066) dated July 5, 2017. Our boring logs and summary of laboratory tests results from that report are attached in Appendix D.

PROJECT INFORMATION

The subject site includes approximately 156 acres of primarily vacant agricultural land located at the southwest corner of Weld County Roads 6 and 15 in unincorporated Weld County, Colorado. Five existing oil-gas well sites and other equipment are present within the larger parcel being evaluated. We understand that the client will be developing the property as a new natural gas gathering and processing facility. At the current time, planning for the site is in the early design stages, however, we understand that the plant will include the installation of equipment such as compressors, pumps, storage vessels, gas flare, and pipe rack assemblies. We assume that a MCC Building and additional small outbuildings will also be constructed. We assume that structural compressive loads will range from about 10 to 50 kips for pipe rack supports and smaller equipment, and up to about 100 to 200 kips for heavier equipment and taller flare structures.

Grading plans were being developed at the time this report was prepared, however, we estimate that site grading may include earthen cuts and fills of up to about 5 to 10 feet to bring the site to construction grade (exclusive of any mitigation required). Construction will also include paved and/or gravel-surfaced access drives, as well as some limited site landscaping.

If our understanding of the project, or assumptions above, is not accurate, or if you have additional useful information, please inform us as soon as possible.

SITE EXPLORATION PROCEDURES

The scope of the services performed for this project included site reconnaissance by a field engineer, a subsurface exploration program, laboratory testing and engineering analysis.

Field Exploration: During our earlier preliminary investigation at the site, we performed a total of ten (10) test borings. For this design-level study, we investigated the subsurface conditions with a total of eight (8) supplemental test borings. Borings were advanced with a truck-mounted drilling rig utilizing 4-inch diameter, solid stem auger. Borings were advanced to depths of about 35 to 50 feet below existing site grades.

A lithologic log of each boring was recorded by our field personnel during the drilling operations. At selected intervals, samples of the subsurface materials were obtained by driving modified California barrel (or standard split-spoon) samplers. Penetration resistance measurements were obtained by driving the sample barrel into the subsurface materials with a 140-pound automatic or manual hammer falling 30 inches (hammer type is noted on the Boring Logs included in Appendix A and D). The penetration resistance value is a useful index to the consistency, relative density or hardness of the materials encountered.

Groundwater measurements were made in each boring at the time of site exploration and a minimum of one week later. Borings were loosely backfilled with the auger cuttings upon completion of groundwater measurements.

Laboratory Testing: Samples retrieved during the field exploration were returned to the laboratory for observation by the project geotechnical engineer, and were classified in general accordance with the Unified Soil Classification System described in Appendix C. Samples of bedrock were classified in general accordance with the general notes for Rock Classification. At that time, an applicable laboratory-testing program was formulated to determine engineering properties of the subsurface materials. Following the completion of the laboratory testing, the field descriptions were confirmed or modified as necessary, and Boring Logs were prepared. These logs are presented in Appendix A.

Laboratory test results are presented in Appendix B. These results were used for the geotechnical engineering analyses and the development of foundation and earthwork recommendations. Laboratory tests were performed in general accordance with the applicable local or other accepted standards.

Selected soil and bedrock samples were tested for the following engineering properties:

- Water content
- Dry density
- Swell/Consolidation
- pH
- Grain size
- Plasticity Index
- Water-soluble sulfates
- Resistivity

SITE CONDITIONS

The site is bordered by Weld County Road 6 to the north, Weld County Road 15 to the east, and agricultural land to the south and west. At the time of our field exploration, the ground surface was mostly covered with a low growth of grass and weeds along with some areas of plowed field. An existing natural drainage area is present at the site and flows from the west-central portion of the property toward the southeast corner of the site. Multiple oil and gas wells (along with buried pipeline) are present across the site. An unpaved well access road is present off of Weld County Road 15. An overhead electric utility is also present across the site. Based on provided plans, the site slopes downwards to the southeast (as well as towards the existing drainage), with an estimated elevation differential of about 60 feet across the site.

SUBSURFACE CONDITIONS

Geology: Surficial geologic conditions at the site, as mapped by the U.S. Geological Survey (USGS) ([1]Colton, 1978), consist of Eolian Sand of Holocene and Pleistocene Age. These materials are described as windblown clay, silt, and sand.

Bedrock underlying the surface units consists of the Laramie Formation of Upper Cretaceous Age. This formation, as mapped in the area, is described to include interbedded claystone, shale, sandstone, and lignite. Thickness of the upper part of the unit in the area is reported to be about 700 feet.

Based upon review of the maps showing the extent of mining in the Boulder-Weld coal field for the area ([2]Amuedo and Ivey, 1975) and coal geology and resources ([3]Spencer, 1986), the project is not located within mapped areas of known coal resources or subsidence potential due to past mine workings. **However, areas of low to severe subsidence potential are mapped northwest of the site.** We understand that the referenced mapping studies are generally now considered out of date and that additional studies have likely been conducted that included the subject parcel. However, a more detailed evaluation of subsidence potential is beyond the scope of this study. The Colorado Geological Survey should be contacted for additional information.

Mapping completed by the Colorado Geological Survey ([4]Hart, 1972) indicates the site is located in an area of "High Swell Potential". This category generally includes bedrock, however, moderately expansive near surface soils may also be locally present.

Soil and Bedrock Conditions: The overburden soils across the site primarily consist of lean clays with varying amounts of sand. Clayey sands were also encountered underlying the clays in borings in the general vicinity of the existing drainage area. Sedimentary claystone and sandstone bedrock was encountered underlying the clays/sands at depths ranging from about 7 to 14 feet in the southwest and northeast portions of the site, and at depths ranging from about 12 to 24 feet in the central areas of the site nearer the existing natural drainage feature. The bedrock extended to the depths explored. Other specific information regarding the lithology encountered is noted on the attached Boring Logs.

Field and Laboratory Test Results: Field test results (from this and our earlier study) indicate that the clay soils vary from soft to hard in consistency. The clayey sand soils vary from loose to medium dense in relative density. Laboratory test results indicate that the clayey soils exhibit moderate plasticity.

[1] Colton, Roger B., 1978, ***Geologic Map of the Boulder - Fort Collins - Greeley Area, Colorado, Colorado***, United States Geological Survey, Map I-855-G.

[2] Amuedo, and Ivey, 1975, ***Coal Mine Subsidence and Land Use in the Boulder-Weld Coalfield, Boulder and Weld Counties, Colorado,*** Colorado Geological Survey.

[3] Spencer, F.D., 1986, ***Coal Geology and Coal, Oil, and Gas Resources of the Erie and Frederick Quadrangles, Boulder and Weld Counties, Colorado***, United States Geological Survey, Map B-1619.

[4] Hart, Stephen S., 1972, ***Potentially Swelling Soil and Rock in the Front Range Urban Corridor, Colorado***, Colorado Geological Survey, Sheet 1 of 4.

Select samples of the clay soils exhibited low expansive potential at existing moisture contents under light loads. When loaded further these clay samples generally exhibited moderate consolidation potential. Select samples of the claystone generally exhibited moderate to high expansive potential. Testing of select soil and bedrock samples for water-soluble sulfates indicated concentrations ranging from 400 to 1,900 parts per million (ppm). Laboratory test results indicate that the lean clay soils sampled at shallow depths have resistivity values ranging from 800 to 4,100 ohm-centimeters, and pH values ranging from 8.0 to 9.1.

Field Resistivity Testing: We performed resistivity testing (Wenner 4-Pin method) at two locations (north central and southwest portions of the site) as shown on the Boring Location Diagram. Two (2) tests were performed at each location in both the north-south and east-west orientations. A Nilsson Model 400 resistivity meter was used to perform testing. Electrode pin locations were spaced at intervals of 5, 10, 20, 50 and 100 feet. Electrode pin depth varied from about 3 to 12 inches depending upon pin spacing. Testing was performed in general accordance with ASTM G057-06 and Nilsson Model 400 manufacturer's recommendations. Test results are presented in Appendix B. Laboratory resistivity testing was also performed to determine the corrosivity potential of the soils. Results of corrosion testing are presented in the Corrosion Protection section of this report.

Groundwater Conditions: Groundwater was encountered in our borings immediately after drilling at depths ranging from about 6 to 27 feet below existing site grades. When checked a minimum of one week later, groundwater was measured in our borings at depths ranging from about 5 to 15-½ feet below existing site grades for most of the site. In our preliminary study of the site (June 2017), groundwater ranged from about 2 to 7-½ feet below existing site grades for most of the site.

Based upon review of U.S. Geological Survey Maps ([5]Hillier, et al, 1979), regional groundwater beneath the project occurs in colluvial or windblown deposits, or in consolidated sedimentary bedrock at depths generally ranging from 5 to 20 feet below existing grade, with depth to seasonal groundwater generally less than 10 feet below present ground surface.

Current groundwater observations may not be indicative of seasonal "high water" conditions. Fluctuations in groundwater levels can be several feet. We can implement a groundwater-monitoring plan upon request, should it be desired to further evaluate its effect on the project. The possibility of groundwater fluctuations should be considered in development of the project.

[5] Hillier, Donald E.; and Schneider, Paul A., Jr.; 1979, ***Depth to Water Table (1976-1977) in the Boulder – Fort Collins – Greeley Area, Front Range Urban Corridor, Colorado***, United States Geological Survey, Map I-855-I.

ENGINEERING RECOMMENDATIONS

Geotechnical Considerations: Based on the information obtained from our subsurface exploration(s), laboratory testing of selected samples, and a cursory review of geologic conditions, it is our opinion that the site appears suitable for development of the proposed project, however, the following main geotechnical conditions were identified as having a significant impact on development of the site:

- **Shallow Groundwater Conditions:** Groundwater was encountered in our borings immediately after drilling at depths ranging from about 6 to 27 feet below existing site grades. When checked a minimum of one week later, groundwater was measured in our borings at depths ranging from about 5 to 15-½ feet below existing site grades for most of the site. In our preliminary study of the site (June 2017), groundwater ranged from about 2 to 7-½ feet below existing site grades for most of the site. ***The shallow groundwater and lower strength soils associated with these areas will significantly impact site grading and infrastructure construction, depending on proposed site grade changes.***

  Grading plans were being developed at the time of this report. ***We recommend that site grading plans be prepared to minimize earthen cut depths as much as possible and to raise site grades where groundwater is shallowest in order to help alleviate this condition (where construction is planned for the shallow groundwater areas).***

  We do not anticipate any below-grade structures (basements, vaults, crawl spaces, etc.) for the project; however, if planned, we recommend basement floor elevations be set at least 3 feet above groundwater elevation. Installation of perimeter foundation drain systems will be needed where basement construction (or other below-grade structure) is utilized.

  Stabilization of soft soils should be anticipated for portions of the site during site grading, underground utility installation, and roadway construction. ***Final grading plans, construction sequencing, and other aspects of the design and construction of the development should be prepared with due consideration given to the potential constraints and/or construction difficulties associated with these conditions (stabilization, construction dewatering, etc.).***

- **Expansive Bedrock:** Swell-consolidation testing of select samples from our borings indicated that the clay soils are generally low expansive. However, the claystone bedrock encountered at the site exhibited moderate to high expansive potential. ***Expansive soils and bedrock, when subjected to typical post-construction wetting, can result in movement of lightly loaded foundations, building floor slabs, and other site features.***

  This report discusses potential foundation alternatives and other processes to help mitigate the effects of expansive soils and bedrock, however, even using these procedures, the risk of movement and distress will increase if excessive additional wetting or drying of the expansive materials is

allowed to occur. Eliminating the risk of movement and distress is generally not considered feasible, but it may be possible to reduce this risk to normally acceptable levels by proper site preparation and construction techniques as discussed herein.

The amount of movement associated with foundations, floor slabs, flatwork, etc. will be related to the wetting of underlying supporting soils. Therefore, it is imperative the recommendations outlined in the "Grading and Drainage" section of this report be followed to reduce potential movement.

- **Structural Considerations:** Based on the subsurface conditions encountered in our borings, we have evaluated the use of both deep and shallow foundation systems commonly used in the region. These include deep foundations such as straight shaft piers (caissons) or helical piles drilled into bedrock, and shallow foundations such as conventional spread-type footings or mat foundations.

  Based on the subsurface conditions encountered in our borings, we believe the use of deep foundations (drilled piers or helical piles) should be utilized for all heavily-loaded structures or structures where movement must be held to a minimum. For lightly-loaded structures that can tolerate more movement, the use of shallow foundations (spread footings or mat foundations) should be suitable provided they bear on suitable native soils or a zone of engineered fill. We anticipate that some remediation of soft soils will likely be required below shallow foundations at the site, particularly in proximity to the drainage feature that transects the site. Remediation of soft soils can typically be performed economically by compacting crushed aggregate or recycled concrete into the soft soils until a stable base is achieved.

  In some areas of the site (i.e. southwest & northeast corners), remediation of shallow claystone bedrock may be required to reduce the expansive potential of these materials and allow for the use of shallow foundations. Mitigation of expansive bedrock will involve sub-excavation, moisture-conditioning, and recompaction of these materials. Subexcavation to a minimum depth of about 10 feet below foundations would be effective to reduce the expansive potential of these materials and limit foundation movement to about one inch. New fill used to raise the site can be considered as part of this zone. Subexcavation will not be required at locations where a minimum 10 feet buffer between bottom of foundations and claystone bedrock is present.

  The type of foundation required for each structure will depend on future site grade changes, groundwater conditions, equipment loads, etc. We are happy to provide further consultation regarding these alternatives once grading plans are developed.

Design and construction recommendations for the foundation systems and other earth-connected phases of the project are outlined below.

Earthwork: The following presents recommendations for site preparation, excavation, subgrade preparation and placement of engineered fills on the project. The recommendations presented for design and construction of earth-supported elements including foundations, slabs and pavements are contingent upon following the recommendations outlined in this section.

Earthwork on the project should be observed and evaluated by CGG. The evaluation of earthwork should include observation and testing of engineered fill, subgrade preparation, foundation bearing soils, and other geotechnical conditions exposed during the construction of the project.

- **Site Preparation:** Strip and remove existing vegetation and other deleterious materials from proposed building/structure and pavement/flatwork areas. Stripped materials consisting of vegetation and organic materials should be wasted from the site or used to revegetate landscaped areas or exposed slopes after completion of grading operations.

  Unstable soils, high moisture content clays and shallow groundwater will likely be encountered on portions of the site. The stability of subgrade soils may also be affected by precipitation, proximity to the existing drainage, repetitive construction traffic or other factors. ***Stabilization of any existing soft soils will be required prior to placing new fill.*** For smaller areas, stabilization can generally be economically performed by placing and compacting or "crowding" larger-sized crushed aggregate or recycled concrete into the high moisture content, weak clay soils in order to provide for a stable base.

  Depending on how unstable the soil conditions are (or become), we estimate that 18 to 24 inches, or more, of crushed aggregate may be required. The thickness of this gravel layer may be reduced by a using layer(s) of bi-axial (or tri-axial) geogrid or woven geotextile reinforcement below the gravel. Use of lime, fly ash, kiln dust, cement or geotextiles could also be used for stabilization techniques. Laboratory evaluation is recommended to determine the effect of chemical stabilization on subgrade soils prior to construction. Lightweight excavation equipment may be required to reduce subgrade pumping.

  Expansive Bedrock Mitigation: As discussed, shallow foundations for lightly-loaded structures should be possible for most of the site; however, in areas of the site where claystone is present at shallow depths (and perched groundwater on top of the bedrock is not present), mitigation of expansive bedrock will be required. ***Mitigation would require deep subexcavation and recompaction of the expansive bedrock in order to reduce the potential for movement to normally tolerable levels.***

  The locations requiring mitigation will depend on final cut/fill depths planned as part of mass site grading, therefore, we should be contracted to review proposed grading plans in order to refine these recommendations. In general terms, this process will likely be required in the southwest portion of the site in order to utilize shallow foundations, and may also be required in other areas of the site depending upon final site grading. ***Subexcavation should extend a minimum of 10 feet***

below the lowest foundation element and a minimum of 5 feet laterally outside of each foundation. Fill placed for mass site grading can be considered part of this zone; therefore, in areas where significant depths of fill are to be placed, the depth of mitigation may be reduced (or eliminated). We should be contacted to review proposed grading changes.

Based on our experience, the success of this process is highly dependent on the earthwork contractor's procedures. Significant processing of the materials, the addition of significant amounts of water, and proper compaction are required. We recommend observation and testing of fill placement be performed by the Geotechnical Engineer on a full-time (or nearly full-time) basis. The amount of processing or moisture added by the contractor should be adjusted based on these results, if needed.

As discussed, this subexcavation alternative will not eliminate the expansive potential of the soils and bedrock at the site, and generally does not result in limiting foundation movement as effectively as the use of deep foundations. The amount of movement associated with this alternative can vary significantly depending upon the subsurface conditions at each building/structure location, the quality of the fill mixing and placement, and on the circumstances causing post-development wetting. We estimate that total foundation movement up to about 1 inch could still occur, even when the fill materials are properly processed and compacted under strict geotechnical observation and testing during construction.

- **Site Grading, Groundwater, and Subsurface Drainage:** The site should be initially graded to create a relatively level surface to receive fill and to provide for a relatively uniform thickness of fill beneath proposed structures.

  As discussed, groundwater was measured in our borings at depths ranging from about 5 to 15-½ feet below existing site grades for most of the site (for this current study) and at depths generally ranging from about 2 to 7-½ feet below existing site grades during our preliminary investigation of the site (June 2017). Grading plans were not available at the time of this report. ***We recommend that site grading plans be prepared to minimize cut earthen depths and raise site grades as much as possible to help alleviate this condition.***

  If basements, vaults, or other below-grade structures are planned, we recommend interior floor elevations be set at least 3 feet above groundwater elevation. Below-grade structures should be designed to be watertight or foundation drain systems should be utilized for below-grade structures.

- **Excavations:** It is anticipated that excavations for the proposed construction can be accomplished with conventional earthmoving equipment. Caving soils and groundwater are likely to be encountered in some portions of the site. The individual contractor(s) is responsible for designing

and constructing stable, temporary excavations as required maintaining stability of both the excavation sides and bottoming.

All excavations should be sloped or shored in the interest of safety following local and federal regulations, including current OSHA excavation and trench safety standards. While the clays may stand on relatively steep, temporary slopes, caving sands may also be encountered on the site. An excavation side slope configuration of 1-½ to 1 (horizontal to vertical) should be used unless the contractor's OSHA competent personnel allow for steeper side slopes.

- **Construction Dewatering and Utility Trench Stabilization:** Based on current groundwater conditions, dewatering of excavations will likely be required for installation of underground utilities in at least portions of the site. The amount of water encountered will depend on the depth of the excavations, current/seasonal groundwater conditions, and location on the site. Water that collects in excavations may be pumped from low points and utilized on-site or directed to another suitable outfall. ***Testing and evaluation of effluent waters for environmental concerns may be required in order to prepare and submit construction dewatering permits.***

- **Fill Materials :** Clean on-site soils or approved imported materials may be used as fill material. Imported soils (if required) should conform to the following:

Gradation	**Percent finer by weight (ASTM C136)**
6"	100
3"	70-100
No. 4 Sieve	50-100
No. 200 Sieve	30 - 65

- Liquid Limit ..... 35 (max)
- Plasticity Index ..... 15 (max)
- Maximum expansive potential (%)* 0.5

*Measured on a sample compacted to approximately 95 percent of the ASTM D698 maximum dry density near optimum water content. The sample is confined under a 500 psf surcharge and submerged.

- **Fill Placement and Compaction:** Clean on-site soils, processed bedrock materials, or approved imported materials may be used as fill material. If imported soils are required, we should be contacted to evaluate samples of proposed fill materials prior to importation. General site fill and fill placed below foundations and floor slabs should be placed and compacted in horizontal lifts, using

equipment and procedures that will produce recommended moisture contents and densities throughout the lift as recommended below:

Item	Description
Fill Materials	On-site soils or processed bedrock materials (3 to 4 inch fragments max) Imported fill, if required, should meet the specifications above
Fill Lift Thickness	8 to 12 inches or less in loose thickness
Compaction Requirements	Clayey soils: 95% of standard Proctor dry density (ASTM D698) Imported granular soils: 95% of modified Proctor dry density (ASTM D1557)
Moisture Content	Clayey soils: Optimum to +4% above optimum moisture content Imported granular soils: -2% below to +2% above of optimum Pavement Subgrade: Optimum to +2% above optimum in pavement areas

At a minimum, fill soils placed for any sub-excavation fill, site grading, utility trench backfill and foundation backfill should be tested to confirm that earthwork is being performed according to our recommendations and project specifications. Subsequent lifts of fill should not be placed on previous lifts if the moisture content or dry density is determined to be less than specified.

Final Grading, Landscaping, and Surface Drainage: All grades must be adjusted to provide positive drainage away from structures during construction and maintained throughout the life of the proposed project. Infiltration of water into utility or foundation excavations must be prevented during construction. Landscaped irrigation, if any, should be minimized or eliminated in close proximity to structures.

Water permitted to pond near or adjacent to the perimeter of structures (either during or post-construction) can result in significantly higher soil movements than those discussed in this report. As a result, any estimations of potential movement described in this report cannot be relied upon if positive drainage is not obtained and maintained, and water is allowed to infiltrate the fill and/or subgrade.

Exposed ground (unpaved, landscaped areas) should be sloped at a minimum of 5 to 10 percent grade for at least 5 feet beyond the perimeter of buildings/structures, where possible. Swales sidewalk chases, area drains may be required to facilitate drainage. Backfill against footings, exterior walls and in utility and sprinkler line trenches should be well-compacted and free of all construction debris to reduce the possibility of moisture infiltration. After building construction and prior to project completion, we recommend that verification of final grading be performed to document that positive drainage, as described above, has been achieved.

Flatwork will be subject to post construction movement due to soil heave/settlement and frost action. Maximum grades practical should be used for paving and flatwork to prevent areas where water can pond. In addition, allowances in final grades should take into consideration post-construction movement of flatwork, particularly if such movement would be critical. Where paving or flatwork abut structures,

care should be taken that joints are properly sealed and maintained to prevent the infiltration of surface water.

Roof drains should be used on all buildings to discharge water a minimum of 5 feet away from foundations through the use of splash blocks or downspout extensions. A preferred alternative is to have the roof drains discharge to storm sewers by solid pipe or daylighted to a detention pond or other appropriate outfall.

Foundation Alternatives: Based on the subsurface conditions across the site and the nature of the proposed structures, the site is suitable for foundation systems commonly used in the region. We evaluated the use of both deep and shallow foundations on the site. Once grading plans are available we can help determine foundation type for each structure.

We believe deep foundations (drilled piers, helical piles) should be utilized for heavily-loaded structures on the site or for structures where movement must be limited. Deep foundations should also be utilized where expansive bedrock is present at shallow depths (southwest and northeast portions of site). Deep foundation elements are used to support structural loads and resist uplift due to soil/bedrock expansion by socketing the bottom of the foundation into the deeper bedrock materials. Deep foundations are typically designed to limit foundation movements to less than ½-inch.

Based on the presence of caving soils and groundwater, we believe that temporary casing could be required to construct drilled piers on some portions of the site. Considering the complications associated with constructing drilled piers where groundwater and caving soils are present, helical piles may be a more cost-effective deep foundation alternative for the site. Helical pile, design-build contractors (such as Alpine Site Services, Inc., Mr. Ron Alberts, (303) 420-0048) with experience installing in similar conditions should be consulted. We are available to further discuss the use of helical piles upon request.

Alternatively, shallow foundations (spread footings, mat foundations) should be suitable for lightly-loaded structures or where more movement can be tolerated. Shallow foundations should bear on suitable low-expansive native soils or on a zone of engineered fill or stabilized subgrade where soft or expansive soils/bedrock are encountered. Where shallower bedrock (and deeper groundwater) conditions are present following grading, spread footings should only be considered if the expansive bedrock conditions are mitigated as described above. ***While this process does not eliminate movement, we estimate post-construction movement would be reduced to typically acceptable ranges of about one inch.***

Details for each foundation alternative are provided below.

- **Drilled Pier or Helical Pile Foundations:** As discussed, we believe deep foundations (drilled piers, helical piles) should be utilized for heavily-loaded structures on the site, or at locations where expansive claystone bedrock is present at shallow depths (less than 10 feet below bottom of foundations). A qualified structural engineer should design deep foundations using the following criteria:

Criteria	Design Value
Maximum allowable end-bearing pressure[1]	30,000 pounds per square foot (psf)
Maximum skin friction[1]	2,500 psf
Estimated maximum soil/bedrock uplift force[2]	60 times Pier Diameter, kips
Minimum bedrock embedment[2, 3]	10 feet **and** below a depth of 20 feet
Minimum drilled pier length[3]	30 feet
Minimum pier diameter	12 inches
Minimum helical pile length	20 feet
Void thickness between piers	6 inches
Estimated total movement	Less than ½ inch
Roughen sides of pier	Lower 10 feet of pier

[1] Maximum end-bearing pressure and skin friction values are for medium hard to very hard bedrock. Skin friction resistance applies to both compressive and uplift forces.

[2] The minimum bedrock embedment depth recommended is considered sufficient to resist soil uplift forces with no consideration for dead-load. Full-length reinforcing should be designed based on the estimated soil uplift force minus structural dead loads.

[3] The minimum length and penetration values are considered adequate to achieve the required embedment below a depth of anticipated moisture variation. The minimum bedrock embedment recommended is the minimum that should be required below any casing depth, if applicable. Depending on site grading longer pier lengths could be required for portions of the site.

If helical piles are utilized, we recommend at least one load test (per pile type) be performed to confirm piles can provide adequate resistance to the required compressive, tension, and lateral load and to verify installation requirements.

A minimum practical horizontal spacing between piers of at least 3 diameters should be maintained, and adjacent piers/piles should bear at near the same elevation. The capacity of individual piers must be reduced when considering the effects of group action. Capacity reduction is a function of pier spacing and the number of piers within a group. For lateral and vertical loading conditions, the following reduction percentages due to group action should be used in the design:

Pier/Pile Spacing (x Pier Diameter (D))	Reduction (%)
3D	0
2D	25
1D	50

To satisfy forces in the horizontal direction, piers/piles may be designed for the following preliminary lateral load criteria based on L-pile/Com624 parameters:

Design Parameters	Design Values				
	Clay Soils above Groundwater	Clay Soils below Groundwater	Sand Soils above Groundwater	Sand Soils below Groundwater	Bedrock
Unit Weight, pcf (moist)	120	120	120	120	120
Average Undrained Shear Strength, psf	500	250	--	--	4,000
Angle of Internal Friction, ϕ (degrees)	0	0	28	26	0
Coefficient of Subgrade Reaction, k (pci)	30	30	25	20	1,000
Strain, ε_{50}	0.020	0.020	--	--	0.004

Drilling to design depths should be possible with conventional single flight power augers and heavy-duty caisson drill rigs. ***The presence of groundwater and potentially caving soils will likely require temporary steel casing during construction for portions of the site in order to achieve the recommended depth and penetration. For this condition, the use of a concrete pump truck with a tremie extension will be required to discharge concrete at the bottom of the pier hole in order to displace excessive water. Casing should be withdrawn in a slow continuous manner maintaining a sufficient head of concrete to prevent infiltration of water or the creation of voids in pier concrete.***

Due to potential sloughing and raveling, foundation concrete quantities may exceed calculated geometric volumes. Pier concrete with slump in the range of 5 to 7 inches is recommended. Pier-bearing surfaces must be cleaned prior to concrete placement. Pier concrete should be designed to achieve its 28-day design strength at these higher slumps.

Free-fall concrete placement in piers is acceptable provided provisions are taken to avoid striking the concrete on the sides of the hole or reinforcing steel. The use of a bottom-dump hopper, or an elephant's trunk discharging near the bottom of the hole is recommended to reduce to potential for concrete segregation. Pier-bearing surfaces must be cleaned prior to concrete placement. A representative of the geotechnical engineer should observe pier installation.

- **Shallow Foundations:** Shallow foundations (spread footings, mat foundations) should be suitable for lightly-loaded structures or structures where more movement can be tolerated. Shallow foundations should bear on either suitable low-expansive native soils or on a zone of engineered fill or stabilized subgrade where soft or expansive soils/bedrock are encountered. After site grading plans are developed, we should be consulted to help identify areas where mitigation will be required. The recommendations provided below are based on limiting total foundation movements to one inch.

In areas of the site (southwest, northeast) where shallow expansive claystone is likely to be present following grading, the soils/bedrock should be removed (subexcavated) to a minimum depth of 10 feet below the lowest perimeter foundation element. ***We recommend the subexcavation include the entire building footprint and that the base of the subexcavation extend 5 feet laterally beyond foundation edges.***

These subexcavated materials should be processed, properly moisture conditioned and recompacted according to the recommendations contained in the "Earthwork" section of this report to create a low expansive zone below foundations. Fill placement and compaction should be observed and tested by our firm.

The following foundation design criteria may be used for the structural design of foundations:

Criteria	Design Value
Bearing Conditions	Approved native soils or moisture-conditioned and compacted engineered fill ***To be determined following design of site grading***
Maximum net allowable bearing pressure[1]	3,000 psf
Minimum dead-load[1]	1,000 psf, or as high as practical
Modulus of Subgrade Reaction, k	50 pci
Void thickness, if required to help focus dead load[2]	4 inches
Min. depth below grade, exterior wall footings[3]	36 inches
Min. depth below grade, interior footings[3]	12 inches
Estimated total foundation movement	1 inch
Estimated differential movement	¾ to 1 inch

1. In order to maintain the minimum dead load, the design bearing pressure above may be applied to dead loads plus design live load conditions. The design bearing pressure may be increased by 1/3 when considering total loads that include wind or seismic conditions.
2. In order to maintain the minimum dead load pressure, it may be necessary to design and construct a system of grade beams and isolated footing pads using void space beneath the grade beams between footing pads (if utilized).
3. Finished grade is the lowest adjacent grade for perimeter footings and floor level for interior footings.

Additional foundation movements could occur if excessive amounts of water from any source infiltrates the foundation soils; therefore, proper drainage should be provided in the final design and during construction. Recommendations are provided in this report to help limit subsurface wetting. Failure to maintain proper surface drainage could result in excessive soil-related foundation movement.

The geotechnical engineer should be contacted to observe earthwork operations and foundation excavations. Frequent compaction testing of each lift of fill soil and occasional evaluation of the expansive potential of the fill should be performed during each day's earthwork operations.

Below-Grade Construction: As discussed, groundwater was encountered in our borings immediately after drilling at depths ranging from about 6 to 27 feet below existing site grades. When checked a minimum of one week later, groundwater was measured in our borings at depths ranging from about 5 to 15-½ feet below existing site grades for most of the site. In our preliminary study of the site (June 2017), groundwater ranged from about 2 to 7-½ feet below existing site grades for most of the site. Below-grade construction (interior space below exterior grades) is not anticipated as a part of the development. However, if the project will include below-grade construction, we normally recommend providing for a minimum 3 feet separation between foundations and groundwater to maintain dry interior conditions and allow for possible groundwater fluctuations. ***Preparation of site grading plans should take into account possible groundwater fluctuations, where basement/below-grade construction is planned.***

We recommend any below-grade vaults or tanks be designed as watertight structures. Where this is not possible, foundation drain systems will need to be installed at the base of all below-grade structures in order to collect and discharge perched groundwater that may develop. Foundation drainage systems typically include a perforated pipe, embedded in gravel, placed in a trench that is sloped to a low point. If below-grade construction is planned, we should be contacted to provide for perimeter drain construction recommendations.

Seismic Considerations: Based on the soil conditions encountered in the test holes drilled on the site, we estimate that a Site Class D is appropriate for the site according to the 2015 International Building Code (Section 1613.3.2 referencing Table 20.3-1 of ASCE 7, Chapter 20). This parameter was estimated based on extrapolation of data beyond the deepest depth explored, using methods allowed by the code. Actual shear wave velocity testing/analysis and/or exploration to 100 feet was not performed. ***Areas of the site where the bedrock is shallow (within 15 feet of the ground surface) may classify as Site Class C, however, geophysical testing would needed to confirm the proper Site Class.***

Interior, Non-structural Floor Slabs: We believe that floor slabs bearing on the on-site clay soils will likely provide acceptable performance in most portions of the site. ***However, floor slabs bearing in close proximity or within the claystone bedrock could experience excessive movement when subjected to post-construction wetting.*** If deep foundations are used, structural floor systems (supported above the soils on deep foundations) should also be considered to mitigate movement. Where deep subexcavation, as discussed above, is utilized for spread footings (in shallow claystone areas), we anticipate that there would be low risk of movement for slab-on-grade floors.

Based on our experience, normal movement of unreinforced or lightly reinforced slab-on-grade floors in the geologic region is considered to be about 1 to 2 inches. ***If movements in this range cannot be***

tolerated, deep foundations and structurally suspended floor should be used for all portions of the buildings.

To reduce potential slab movements, the subgrade soils should be prepared as outlined in the "Earthwork" section of this report and adequate surface drainage needs to be maintained. For structural design of concrete slabs-on-grade, a modulus of subgrade reaction of 100 pounds per cubic inch (pci) may be used for floors supported on the on-site soils.

Additional floor slab design and construction recommendations are as follows:

- Positive separations and/or isolation joints should be provided between slabs and all foundations, columns or utility lines to allow independent movement.

- Control joints should be provided in slabs to control the location and extent of cracking.

- A minimum 2-inch void space (or more depending on the option chosen by the owner) should be constructed below non-bearing partition walls placed on the floor slab. Special framing details should be provided at doorjambs and frames within partition walls to avoid potential distortion. Partition walls should be isolated from suspended ceilings. The thickness of the partition void should be checked periodically and adjusted as needed to maintain a void space.

- Interior trench backfill placed beneath slabs should be compacted in accordance with recommended specifications outlined below.

- The use of a vapor retarder should be considered beneath concrete slabs on grade that will be covered with wood, tile, carpet or other moisture sensitive or impervious coverings, or when the slab will support equipment sensitive to moisture. When conditions warrant the use of a vapor retarder, the slab designer and slab contractor should refer to ACI 302 for procedures and cautions regarding the use and placement of a vapor retarder.

- Floor slabs should not be constructed on frozen subgrade.

- Other design and construction considerations, as outlined in Section 302.1R of the *ACI Design Manual*, are recommended.

Pavement Thickness Design and Construction: The design of pavements for the project is based on the procedures outlined in the 1993 *Guideline for Design of Pavement Structures* by the American Association of State Highway and Transportation Officials (AASHTO), and the Colorado Department of Transportation (CDOT) *Pavement Design Manual*. ***For any public roadway improvements, Weld County will require submittal of a pavement thickness design report based on completion of additional geotechnical exploration and analyses after completion of site grading.***

The referenced design methods are based on the subgrade soil support properties and anticipated traffic values.

- **Subgrade Soils:** The clay subgrade soils encountered at the site are low expansive, therefore, we do not anticipate any expansive soil mitigation. These soils are considered to provide poor support for pavements. Based on the properties of the subgrade soils, we have estimated an R-value of 5, corresponding to a resilient modulus of 3,025 psi using the CDOT correlation. A k-value of 100 pci was used for design of rigid concrete pavements.

- **Assumed Traffic:** We assume that pavements/roadways associated with the project will include private driveways, fire lanes, and surface parking. We understand that roadways will likely be gravel-surfaced, however, asphalt concrete or Portland cement concrete pavements may also be included. Any improvements to adjacent public roadways will need to be designed and constructed according to the governing standards.

  Based on information provided by the client and our assumptions, the following traffic criteria were used for determining pavement thicknesses using a design life of 20 years:

  - Light-duty parking stalls - maximum daily traffic of 1,000 cars/light pick-up trucks per day (equivalent single-axle loads, ESAL's of 22,000) for a Design EDLA value of 3
  - Main access drives and other heavy-duty driving lanes – maximum of fifteen 20,000 to 25,000 pound single-axle trucks and two semi-tractor trailer trucks per week, two trash trucks per week, plus light traffic outlined above (73,000 ESAL's) for a Design EDLA value of 10

- **Pavement Sections:** For flexible pavement design a drainage coefficient of 1.0, a terminal serviceability index of 2.0, and an inherent reliability of 85 percent were used. Using, the appropriate ESAL values, environmental criteria and other factors, the design structural numbers (SN) of the pavement sections were determined on the basis of the 1993 AASHTO design equation.

  In addition to the flexible pavement design analyses, a rigid pavement design analysis was completed based upon AASHTO design procedures. Along with soil and traffic conditions, rigid pavement design is based on the Modulus of Rupture of the concrete, and other factors previously outlined. A modulus of rupture of 600 psi (working stress 450 psi) was used for pavement concrete. The rigid pavement thickness for each traffic category was determined on the basis of the AASHTO design equation.

Recommended alternatives for flexible and rigid pavements are summarized for each traffic area as follows:

Traffic Area	Alternative	Pavement Thickness (Inches)		
		Asphalt Concrete Surface	Aggregate Base Course	Portland Cement Concrete
Light-Duty Automobile and Light Truck Parking Only	A	4	6	--
	B	5-½	--	--
	C	--	--	5
Heavy-Duty Heavy Trucks, Delivery Trucks, Trash Trucks, Fire Trucks	A	4	9	--
	B	6-½	--	--
	C	--	--	6
Gravel-Surfaced Roads	A	--	12	--

* ***For areas subject to concentrated and repetitive loading conditions such as dumpster pads, and ingress/egress aprons, or other heavy truck traffic areas, we recommend using a Portland cement concrete pavement with a thickness of at least 6 inches. For dumpster pads, the concrete pavement area should be large enough to support the container and tipping axle of the refuse truck.***

- **Subgrade Preparation and Pavement Materials:** In order to provide a more uniform subgrade for site pavements, we recommend that pavements be constructed on a minimum of 12 inches of properly moisture conditioned and recompacted on-site soils. We recommend the pavement areas be rough graded and then thoroughly proof rolled with a loaded tandem axle dump truck, water truck, or other heavy equipment approved by the observing engineer prior to final grading and paving. Particular attention should be paid to high traffic areas that were rutted and disturbed earlier and to areas where backfilled trenches are located. Areas where unsuitable conditions are located should be repaired by removing and replacing the materials with properly compacted engineered fills. Confirmation of the moisture content and compaction level of the subgrade soils should be confirmed just prior to paving.

  Aggregate base course (if used) should consist of a blend of sand and gravel that meets strict specifications for quality and gradation. Use of materials meeting Colorado Department of Transportation (CDOT) Class 5 or 6 specifications is recommended. In addition, the base course material should be moisture stable. Aggregate base course material should be tested to determine compliance with these specifications prior to importation to the site. Aggregate base course should be placed in lifts not exceeding 6 inches and compacted to a minimum of 95 percent of modified Proctor density (ASTM D1557), within a moisture content range of 2 percent below to 2 percent above optimum. Where base course thickness exceeds 6 inches, the material should be placed and compacted in 2 or more lifts of equal thickness.

Asphalt concrete should be obtained from an approved mix design stating the Hveem properties, optimum asphalt content, job mix formula (JMF), and recommended mixing and placing temperatures. Aggregate used in asphalt concrete should meet a particular gradation. Use of materials meeting CDOT Grading S and SX specifications is recommended. The mix design should be performed using the Superpave procedures as outlined in the Standards for Traffic Level I. The mix design should be submitted prior to construction to verify its adequacy. The asphalt concrete should be placed in maximum 3-inch lifts and compacted to between 92 and 96 percent of Rice value (AASHTO T-209).

Where rigid pavements are used, the concrete should be obtained from an approved mix design conforming to CDOT Class P specifications. Concrete should be deposited by truck mixers or agitators and placed a maximum of 90 minutes from the time the water is added to the mix. Longitudinal and transverse joints should be provided as needed in concrete pavements for expansion/contraction and isolation. The location and extent of joints should be based upon the final pavement geometry. Sawed joints should be cut within 24 hours of concrete placement and should be a minimum depth of 25 percent of slab thickness plus 1/4 inch. All joints should be sealed to prevent entry of foreign material and doweled where necessary for load transfer. Where dowels cannot be used at joints accessible to wheel loads, pavement thickness should be increased by 25 percent at the joints and tapered to regular thickness in 5 feet.

- **Compliance:** Recommendations for pavement design and construction presented depend upon compliance with recommended material specifications. To assess compliance, observation and testing should be performed under the observation of the geotechnical engineer.

- **Pavement Performance:** Future performance of pavements constructed on the subgrade at this site will be dependent upon several factors, including:

    - Maintaining stable moisture content of the subgrade soils.
    - Providing for a planned program of preventative maintenance.

  The performance of all pavements can be enhanced by minimizing excess moisture, which can reach the subgrade soils. The following recommendations should be considered at minimum:

    - Site grading at a minimum 2 percent grade onto or away from pavements.
    - Water should not be allowed to pond behind curbs.
    - Compaction of any utility trenches for landscaped areas to the same criteria as the pavement subgrade.
    - Sealing all landscaped areas in or adjacent to pavements to minimize or prevent moisture migration to subgrade soils.
    - Placing compacted backfill against the exterior side of curb and gutter.

- Placing curb, gutter and/or sidewalk directly on subgrade soils without the use of base course materials.

Preventative maintenance should be planned and provided for an ongoing pavement management program in order to enhance future pavement performance. Preventative maintenance activities are intended to slow the rate of pavement deterioration and to preserve the pavement investment.

Preventative maintenance consists of both localized maintenance (e.g. crack sealing and patching) and global maintenance (e.g. surface sealing). Preventative maintenance is usually the first priority when implementing a planned pavement maintenance program and provides the highest return on investment for pavements.

Additional Design and Construction Considerations:

- **Exterior Slab Design and Construction:** Flatwork and pavements will be subject to post construction movement due to backfill settlement, soil/bedrock expansion, or frost heave. Maximum grades practical should be used for paving and flatwork to prevent areas where water can pond. In addition, allowances in final grades should take into consideration post-construction movement of flatwork, particularly if such movement would be critical. Where paving or flatwork abuts structures, care should be taken that joints are properly sealed and slopes maintained to prevent the infiltration of surface water. Portions of the flatwork adjacent to the structures may also bear on foundation backfill that is prone to settlement. In areas where settlement of flatwork cannot be tolerated, slabs should be integrated into foundation or supported structurally by haunches.

  To reduce the potential for damage, we recommend:

  - exterior slabs in critical areas be supported on a zone of recompacted soils.
  - Supporting of flatwork at building entrances and other critical areas on haunches attached by the building foundations.
  - placement of effective control joints on relatively close centers and isolation joints between slabs and other structural elements.
  - provision for adequate drainage in areas adjoining the slabs.
  - use of designs which allow vertical movement between the exterior slabs and adjoining structural elements.

- **Underground Utility Systems:** All underground piping within or near the proposed structures should be designed with flexible couplings, so minor deviations in alignment do not result in breakage or distress. Utility knockouts in foundation walls should be oversized to accommodate differential movements.

It is strongly recommended that a representative of the geotechnical engineer provide full-time observation and compaction testing of trench backfill within building and pavement areas.

- **Corrosion Protection:** Water-soluble sulfate testing of select samples of the soils and bedrock (from this and our earlier study) that will likely be in contact with project concrete indicated concentrations ranging from 400 to 1,900 parts per million (ppm). ACI rates the measured concentrations as being a moderate to severe risk of concrete sulfate attack. For severe risk of concrete sulfate attack, ACI recommends the use of ASTM Type V Portland cement (or equivalent) for all concrete on and below grade. Project concrete should be designed for severe sulfate risk in accordance with the provisions of Section 318, Chapter 4, of the *ACI Design Manual*.

  Laboratory test results indicate that the lean clay soils (or claystone bedrock) sampled at shallow depths have resistivity values ranging from 800 to 3,700 ohm-centimeters, and pH values ranging from 8.0 to 9.1. These values should be used to determine potential corrosive characteristics of the on-site soils with respect to contact with the various underground materials that will be used for project construction. A summary of the tests results is provided below.

Boring / Area	Material	Water-Soluble Sulfates (ppm)	Lab Resistivity (ohm-cm)	pH
3	Lean Clay	1,600	2,600	8.39
5	Lean Clay	900	3,000	8.97
7	Lean Clay	1,900	3,700	9.09
8	Lean Clay	1,800	--	--
9	Lean Clay	--	2,500	8.98
11	Lean Clay	400	1,500	8.42
18	Claystone	1,400	800	8.63
R1	Lean Clay	600	1,800	7.98
R2	Lean Clay	600	1,700	8.08

GENERAL COMMENTS

CGG should be retained to review the final design plans and specifications so comments can be made regarding interpretation and implementation of our geotechnical recommendations in the design and specifications. CGG should also be retained to provide testing and observation during the excavation, grading, foundation and construction phases of the project.

The analysis and recommendations presented in this report are based upon the data obtained from the borings performed at the indicated locations and from other information discussed in this report. This report does not reflect variations that may occur between borings, across the site, or due to the modifying effects of weather. The nature and extent of such variations may not become evident until

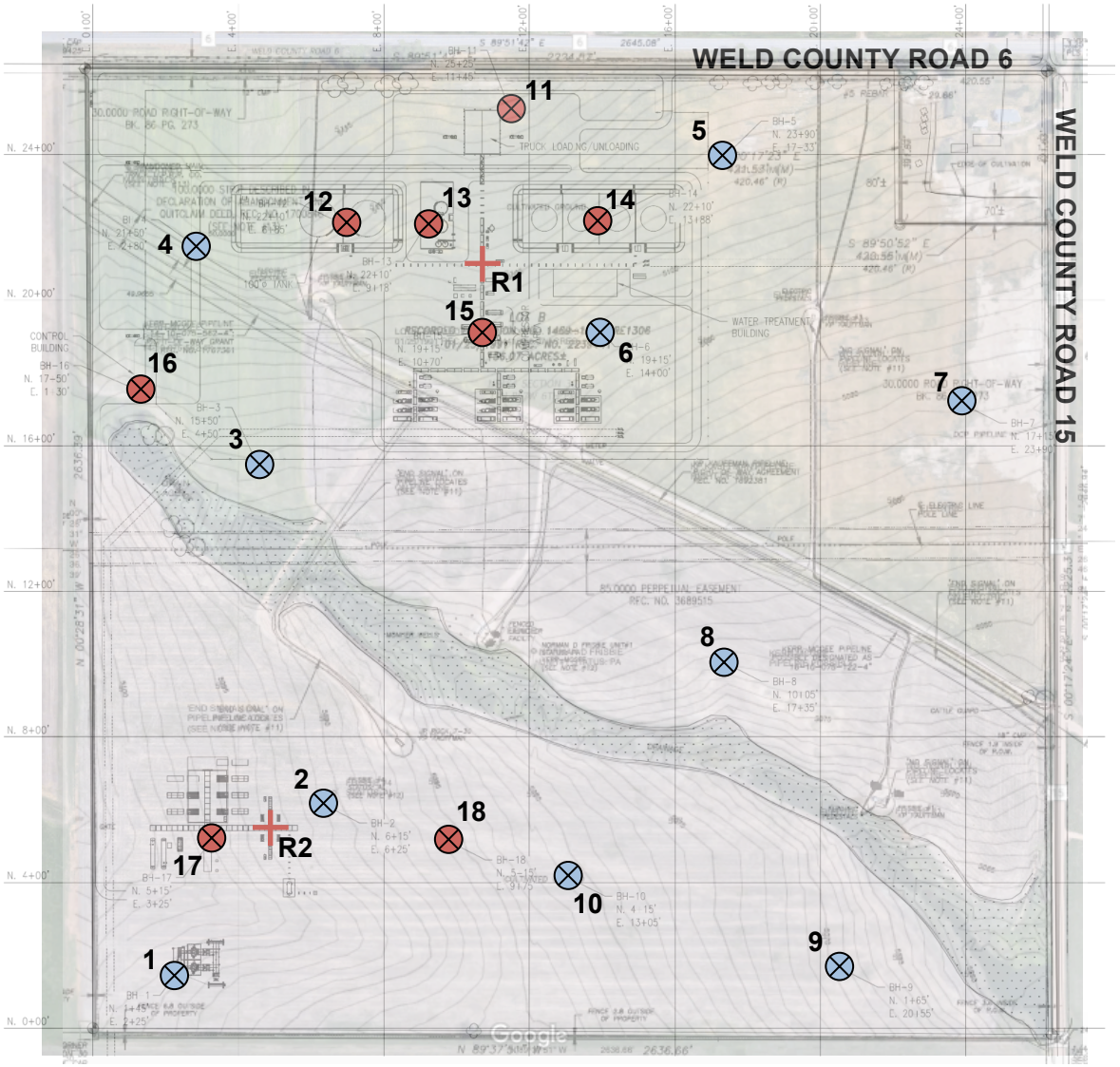
during or after construction. If variations appear, we should be immediately notified so that further evaluation and supplemental recommendations can be provided.

The scope of services for this project does not include, either specifically or by implication, any environmental or biological (e.g., mold, fungi, bacteria) assessment of the site or identification or prevention of pollutants, hazardous materials or conditions. If the owner is concerned about the potential for such contamination or pollution, other studies should be undertaken.

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

APPENDIX A

BORING LOCATION DIAGRAM
BORING LOGS



R1 FIELD RESISTIVITY TESTING LOCATIONS

1 BORING LOCATIONS FROM EARLIER STUDY (PRELIM GEOTECH REPORT 17.22.066)

11 SUPPLEMENTAL BORINGS FOR DESIGN-LEVEL GEOTECHNICAL ENGINEERING REPORT

BORING LOCATION DIAGRAM
CODY CENTRAL GATHERING FACILITY
SWC OF WELD COUNTY ROADS 6 & 15
WELD COUNTY, COLORADO
CGG PROJECT NO. 17.22.199

Cole Garner Geotechnical
1070 W. 124th Ave., Suite 300
Westminster, CO 80234
(303) 996-2999

Cole Garner Geotechnical
1070 W. 124th Avenue, Suite 300
Westminster, CO. 80234
Telephone: 303.996.2999

BORING NUMBER 11

CLIENT XTR Midstream, LLC
PROJECT NAME Cody Central Gathering Facility
PROJECT NUMBER 17.22.199
PROJECT LOCATION WCR 6 and WCR 15 - Weld County, CO
DATE STARTED 10/31/17 **COMPLETED** 10/31/17
GROUND SURFACE ELEV. 5115 ft **PROPOSED ELEV.** Not Provided
DRILLING CONTRACTOR Elite Drilling
SURFACE CONDITIONS Low growth of grass and weeds
DRILLING METHOD CME-55 / Solid Stem Auger
GROUND WATER LEVELS:
HAMMER TYPE Automatic
▽ **DURING DRILLING** 15.00 ft / Elev 5100.00 ft
LOGGED BY BE **CHECKED BY** AG
▼ **AFTER DRILLING** 12.00 ft / Elev 5103.00 ft - 11/14/17

GRAPHIC LOG	MATERIAL DESCRIPTION	DEPTH (ft)	USCS SYMBOL	SAMPLE TYPE	RECOVERY %	PENETRATION blows/in	MOISTURE CONTENT (%)	DRY UNIT WT. (pcf)	SWELL-CONSOL /SURCHARGE LOAD, %psf
	SANDY LEAN CLAY, brown, white, grey, tan, calcareous, iron-stained, dry to moist, stiff to hard	0							
			CL	CB	100	41 / 12	13.3	93	+0.2/200
			CL	CB	100	11 / 12	10.6		
	9 5106.0								
	CLAYSTONE BEDROCK, varies to Clayey Sandstone, grey, brown, tan, light brown, calcareous, iron-stained, moist, firm to very hard	10	-	CB	100	33 / 12	20.3	105	+4.1/500
	▼								
	▽		-	CB	100	50 / 6	15.4	113	
		20	-	CB	100	50 / 9	20.1		
			-	SS	100	50 / 10	19.8		
		30							
	35 5080.0		-	SS	100	50 / 4	22.1		

Approximate bottom of borehole at 35.0 feet.

GEOTECH BH COLUMNS - GINT STD US LAB.GDT - 12/8/17 12:19 - C:\USERS\PUBLIC\DOCUMENTS\BENTLEY\GINT\PROJECTS GEO 2017\17.22.199 CODY CENTRAL GATHERING FACILITY.GPJ

Cole Garner Geotechnical
1070 W. 124th Avenue, Suite 300
Westminster, CO. 80234
Telephone: 303.996.2999

BORING NUMBER 12

CLIENT XTR Midstream, LLC
PROJECT NAME Cody Central Gathering Facility
PROJECT NUMBER 17.22.199
PROJECT LOCATION WCR 6 and WCR 15 - Weld County, CO
DATE STARTED 11/1/17 **COMPLETED** 11/1/17
GROUND SURFACE ELEV. 5110 ft **PROPOSED ELEV.** Not Provided
DRILLING CONTRACTOR Unlimited Access Drilling
SURFACE CONDITIONS Low growth of grass and weeds
DRILLING METHOD CME-45 / Solid Stem Auger
GROUND WATER LEVELS:
HAMMER TYPE Automatic
▽ **DURING DRILLING** None
LOGGED BY KF **CHECKED BY** AG
▼ **AFTER DRILLING** 15.50 ft / Elev 5094.50 ft - 11/14/17

GRAPHIC LOG	MATERIAL DESCRIPTION	DEPTH (ft)	USCS SYMBOL	SAMPLE TYPE	RECOVERY %	PENETRATION blows/in	MOISTURE CONTENT (%)	DRY UNIT WT. (pcf)	SWELL-CONSOL /SURCHARGE LOAD, %psf
	LEAN CLAY with SAND, with some gravel, red-brown, light brown, calcareous, iron-stained, moist, medium stiff	0							
			CL	CB	100	10 / 12	14.4	109	
		10	CL	CB	100	6 / 12	19.0	105	-0.4/500
	14 5096.0								
	CLAYSTONE BEDROCK, grey, dark brown, red-brown, iron-stained, moist, firm to very hard ▼		-	CB	100	34 / 12	15.0	115	+2.9/1000
		20	-	CB	100	40 / 12	17.1		
			-	CB	100	50 / 8	17.9	116	
		30	-	CB	100	50 / 5	16.1		
			-	CB	100	50 / 6	16.6	116	
		40							
	45 5065.0		-	CB	100	50 / 3	12.2		

Approximate bottom of borehole at 45.0 feet.

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Cole Garner Geotechnical
1070 W. 124th Avenue, Suite 300
Westminster, CO. 80234
Telephone: 303.996.2999

BORING NUMBER 13

CLIENT XTR Midstream, LLC
PROJECT NAME Cody Central Gathering Facility
PROJECT NUMBER 17.22.199
PROJECT LOCATION WCR 6 and WCR 15 - Weld County, CO
DATE STARTED 10/31/17 **COMPLETED** 10/31/17
GROUND SURFACE ELEV. 5108 ft **PROPOSED ELEV.** Not Provided
DRILLING CONTRACTOR Elite Drilling
SURFACE CONDITIONS Low growth of grass and weeds
DRILLING METHOD CME-55 / Solid Stem Auger
GROUND WATER LEVELS:
HAMMER TYPE Automatic
▽ **DURING DRILLING** 14.00 ft / Elev 5094.00 ft
LOGGED BY BE **CHECKED BY** AG
▼ **AFTER DRILLING** 13.00 ft / Elev 5095.00 ft - 11/14/17

GRAPHIC LOG	MATERIAL DESCRIPTION	DEPTH (ft)	USCS SYMBOL	SAMPLE TYPE	RECOVERY %	PENETRATION blows/in	MOISTURE CONTENT (%)	DRY UNIT WT. (pcf)	SWELL-CONSOL /SURCHARGE LOAD, %psf
		0							
	SANDY LEAN CLAY, brown, light brown, tan, iron-stained, moist, medium stiff		CL	CB	100	7 / 12	11.2	109	-0.2/500
	7 5101.0								
	SANDSTONE BEDROCK, fine- to medium-grained, grey, brown, moist, very hard	10	-	CB	100	50 / 6	12.1		
	▽▼		-	CB	0	50 / 5			
	17 5091.0								
	CLAYSTONE BEDROCK, varies sandy, grey, brown, iron-stained, moist, firm to hard	20	-	CB	100	29 / 12	17.1	101	+0.6/2000
			-	CB	100	50 / 9	17.3	114	
		30	-	CB	100	44 / 12	14.7	119	
	35 5073.0		-	CB	100	50 / 10	19.6	110	

Approximate bottom of borehole at 35.0 feet.

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Cole Garner Geotechnical
1070 W. 124th Avenue, Suite 300
Westminster, CO. 80234
Telephone: 303.996.2999

BORING NUMBER 14

CLIENT XTR Midstream, LLC
PROJECT NAME Cody Central Gathering Facility
PROJECT NUMBER 17.22.199
PROJECT LOCATION WCR 6 and WCR 15 - Weld County, CO
DATE STARTED 11/3/17 **COMPLETED** 11/3/17
GROUND SURFACE ELEV. 5105 ft **PROPOSED ELEV.** Not Provided
DRILLING CONTRACTOR Unlimited Access Drilling
SURFACE CONDITIONS Low growth of grass and weeds
DRILLING METHOD CME-45 / Solid Stem Auger
GROUND WATER LEVELS:
HAMMER TYPE Automatic
▽ **DURING DRILLING** 17.00 ft / Elev 5088.00 ft
LOGGED BY KF **CHECKED BY** AG
▼ **AFTER DRILLING** 12.00 ft / Elev 5093.00 ft - 11/14/17

GRAPHIC LOG	MATERIAL DESCRIPTION	DEPTH (ft)	USCS SYMBOL	SAMPLE TYPE	RECOVERY %	PENETRATION blows/in	MOISTURE CONTENT (%)	DRY UNIT WT. (pcf)	SWELL-CONSOL /SURCHARGE LOAD, %psf
	LEAN CLAY with SAND, light brown, brown, moist, soft to medium stiff	0							
			CL	CB	100	10 / 12	26.6	91	-1.5/500
		10	CL	CB	100	5 / 12	23.4	97	
	12 ▼5093.0								
	SANDSTONE BEDROCK, fine-grained, varies clayey, olive-brown, red-brown, grey, light brown, moist, hard		-	CB	100	50 / 9	13.1		
	17 ▽5088.0								
	CLAYSTONE BEDROCK, varies sandy, grey, brown, iron-stained, moist, hard to very hard	20	-	CB	100	50 / 8	14.4	117	
			-	CB	100	50 / 4	21.5		
		30	-	CB	100	50 / 8	14.5		
		40	-	CB	100	50 / 7	15.7	115	
	50 5055.0	50	-	CB	100	50 / 9	15.1	119	

Approximate bottom of borehole at 50.0 feet.

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Telephone: 303.996.2999

BORING NUMBER 15

CLIENT XTR Midstream, LLC
PROJECT NAME Cody Central Gathering Facility
PROJECT NUMBER 17.22.199
PROJECT LOCATION WCR 6 and WCR 15 - Weld County, CO
DATE STARTED 10/31/17 **COMPLETED** 10/31/17
GROUND SURFACE ELEV. 5102 ft **PROPOSED ELEV.** Not Provided
DRILLING CONTRACTOR Elite Drilling
SURFACE CONDITIONS Low growth of grass and weeds
DRILLING METHOD CME-55 / Solid Stem Auger
GROUND WATER LEVELS:
HAMMER TYPE Automatic
▽ **DURING DRILLING** 13.00 ft / Elev 5089.00 ft
LOGGED BY BE **CHECKED BY** AG
▼ **AFTER DRILLING** 11.00 ft / Elev 5091.00 ft - 11/14/17

GRAPHIC LOG	MATERIAL DESCRIPTION	DEPTH (ft)	USCS SYMBOL	SAMPLE TYPE	RECOVERY %	PENETRATION blows/in	MOISTURE CONTENT (%)	DRY UNIT WT. (pcf)	SWELL-CONSOL /SURCHARGE LOAD, %psf
	LEAN CLAY with SAND, grey, light brown, moist, medium stiff	0							
			CL	CB	100	7 / 12	22.7		
	9 5093.0								
	CLAYSTONE BEDROCK, varies sandy, grey, brown, light brown, olive-brown, orange, iron-stained, moist, medium hard to hard ▼ ▽	10	-	CB	100	50 / 8	14.2	118	
			-	CB	100	43 / 12	14.4	110	+3.1/1000
		20	-	CB	100	50 / 12	20.8	109	
			-	CB	100	50 / 7	14.5		
		30	-	CB	100	50 / 8	12.5	121	
			-	CB	100	50 / 7	15.3		
		40							
			-	CB	100	50 / 7	16.6	116	
	50 5052.0	50	-	CB	100	50 / 6	17.7		

Approximate bottom of borehole at 50.0 feet.

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BORING NUMBER 16

CLIENT XTR Midstream, LLC
PROJECT NAME Cody Central Gathering Facility
PROJECT NUMBER 17.22.199
PROJECT LOCATION WCR 6 and WCR 15 - Weld County, CO
DATE STARTED 10/31/17 **COMPLETED** 10/31/17
GROUND SURFACE ELEV. 5097 ft **PROPOSED ELEV.** Not Provided
DRILLING CONTRACTOR Elite Drilling
SURFACE CONDITIONS Low growth of grass and weeds
DRILLING METHOD CME-55 / Solid Stem Auger
GROUND WATER LEVELS:
HAMMER TYPE Automatic
▽ **DURING DRILLING** 6.00 ft / Elev 5091.00 ft
LOGGED BY BE **CHECKED BY** AG
▼ **AFTER DRILLING** 5.00 ft / Elev 5092.00 ft - 11/14/17

GRAPHIC LOG	MATERIAL DESCRIPTION	DEPTH (ft)	USCS SYMBOL	SAMPLE TYPE	RECOVERY %	PENETRATION blows/in	MOISTURE CONTENT (%)	DRY UNIT WT. (pcf)	SWELL-CONSOL /SURCHARGE LOAD, %psf
	SANDY LEAN CLAY, brown, dark brown, calcareous, moist to wet, medium stiff to stiff	0							
			CL	CB	100	11 / 12	20.2		
			CL	CB	100	11 / 12	16.9	111	-0.8/500
		10	CL	CB	100	10 / 12	16.6	116	
	13 5084.0								
	CLAYSTONE BEDROCK, grey, orange-brown, brown, iron-stained, moist, medium hard to hard		-	CB	100	47 / 12	15.2	112	+3.3/500
		20	-	CB	100	50 / 11	17.9		
			-	CB	100	50 / 7	14.6	119	
		30	-	CB	100	50 / 8			
	35 5062.0		-	CB	100	50 / 11	20.6	108	

Approximate bottom of borehole at 35.0 feet.

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BORING NUMBER 17

CLIENT XTR Midstream, LLC
PROJECT NAME Cody Central Gathering Facility
PROJECT NUMBER 17.22.199
PROJECT LOCATION WCR 6 and WCR 15 - Weld County, CO
DATE STARTED 11/1/17 **COMPLETED** 11/1/17
GROUND SURFACE ELEV. 5097 ft **PROPOSED ELEV.** Not Provided
DRILLING CONTRACTOR Unlimited Access Drilling
SURFACE CONDITIONS Low growth of grass and weeds
DRILLING METHOD CME-45 / Solid Stem Auger
GROUND WATER LEVELS:
HAMMER TYPE Automatic
▽ **DURING DRILLING** 15.00 ft / Elev 5082.00 ft
LOGGED BY KF **CHECKED BY** AG
▼ **AFTER DRILLING** 13.00 ft / Elev 5084.00 ft - 11/14/17

GRAPHIC LOG	MATERIAL DESCRIPTION	DEPTH (ft)	USCS SYMBOL	SAMPLE TYPE	RECOVERY %	PENETRATION blows/in	MOISTURE CONTENT (%)	DRY UNIT WT. (pcf)	SWELL-CONSOL /SURCHARGE LOAD, %psf
	SANDY LEAN CLAY, brown, light brown, dry to moist, medium stiff	0							
			CL	CB	100	6 / 12	9.5	108	+2.0/500
	7 5090.0								
	CLAYSTONE BEDROCK, grey, light grey, yellow-brown, moist, hard	10	-	CB	100	50 / 8	11.4	125	+2.4/500
	14 5083.0 ▼								
	SANDSTONE BEDROCK, fine- to medium-grained, red-brown, light brown, moist, firm to very hard ▽		-	CB	100	50 / 2			
		20	-	CB	100	31 / 12	14.0		
	22 5075.0								
	SANDY CLAYSTONE BEDROCK, dark grey, grey, light brown, red-brown, white, iron-stained, hard to very hard		-	CB	100	50 / 9	14.1	120	
		30	-	CB	100	50 / 6	13.9	120	
			-	CB	100	50 / 6	14.9		
		40							
			-	CB	100	50 / 6	17.8	111	
	50 5047.0	50	-	CB	100	50 / 6	18.0	111	

Approximate bottom of borehole at 50.0 feet.

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Telephone: 303.996.2999

BORING NUMBER 18

CLIENT XTR Midstream, LLC
PROJECT NAME Cody Central Gathering Facility
PROJECT NUMBER 17.22.199
PROJECT LOCATION WCR 6 and WCR 15 - Weld County, CO
DATE STARTED 11/1/17 **COMPLETED** 11/1/17
GROUND SURFACE ELEV. 5086 ft **PROPOSED ELEV.** Not Provided
DRILLING CONTRACTOR Unlimited Access Drilling
SURFACE CONDITIONS Low growth of grass and weeds
DRILLING METHOD CME-45 / Solid Stem Auger
GROUND WATER LEVELS:
HAMMER TYPE Automatic
▽ **DURING DRILLING** 27.00 ft / Elev 5059.00 ft
LOGGED BY KF **CHECKED BY** AG
▼ **AFTER DRILLING** 10.00 ft / Elev 5076.00 ft - 11/14/17

GRAPHIC LOG	MATERIAL DESCRIPTION	DEPTH (ft)	USCS SYMBOL	SAMPLE TYPE	RECOVERY %	PENETRATION blows/in	MOISTURE CONTENT (%)	DRY UNIT WT. (pcf)	SWELL-CONSOL /SURCHARGE LOAD, %psf
	LEAN CLAY with SAND, olive-brown, red-brown, grey, iron-stained, moist, stiff	0							
			CL	CB	100	18 / 12	15.1	115	+0.7/500
		5							
	9	5077.0							
	CLAYSTONE BEDROCK, varies sandy, light grey, dark grey, light brown, iron-stained, moist, firm to very hard ▼	10	-	CB	100	33 / 12	13.3		
			-	CB	100	43 / 12	13.9	117	+4.1/1000
		20	-	CB	100	27 / 12			
			-	CB	100	50 / 11	15.3		
	▽	30	-	CB	100	50 / 8	15.5	118	
	35	5051.0	-	CB	100	50 / 6	14.8		

Approximate bottom of borehole at 35.0 feet.

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APPENDIX B

LABORATORY TEST RESULTS
FIELD RESISTIVITY TEST RESULTS

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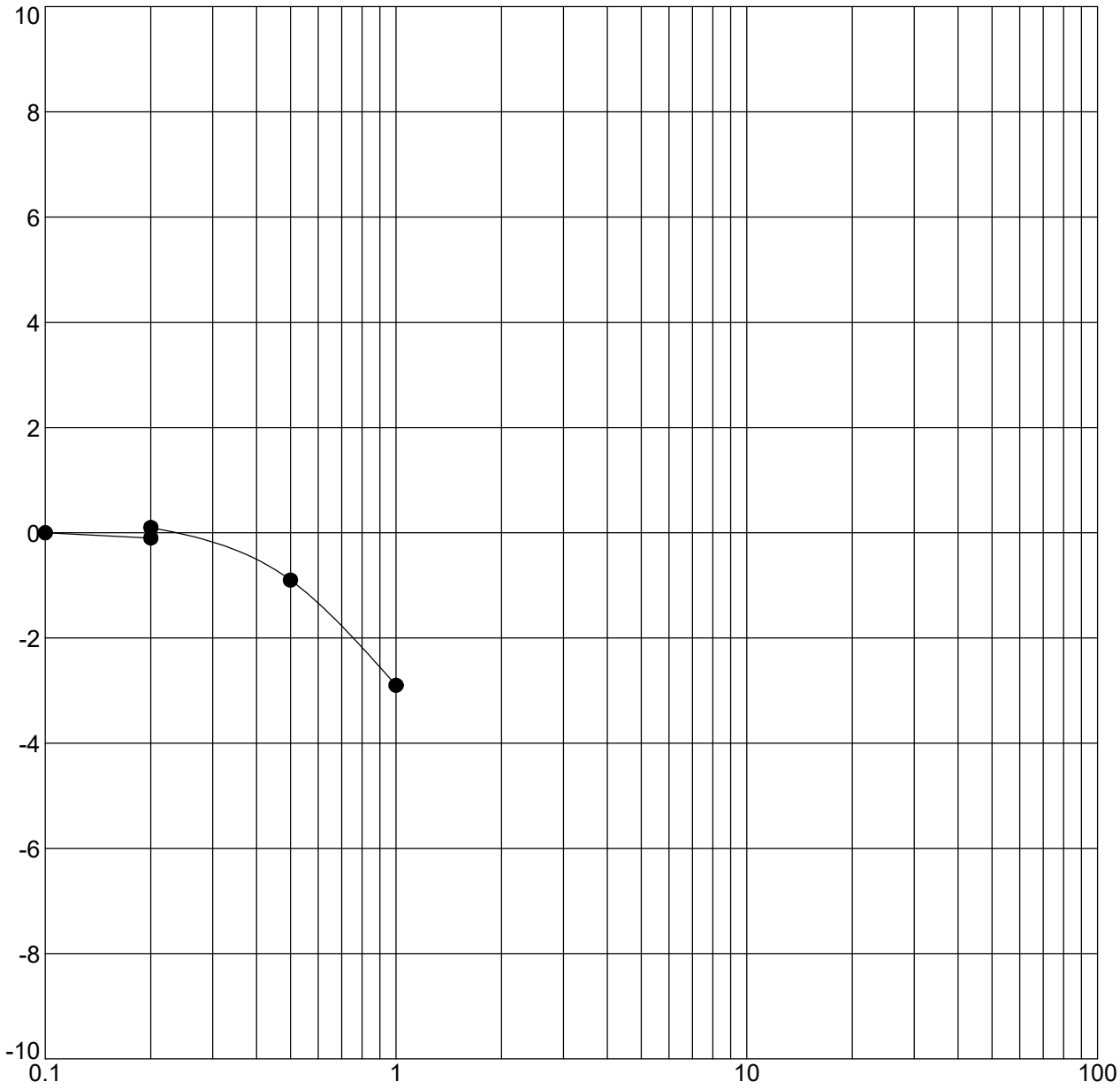
SWELL/CONSOLIDATION TEST

CLIENT XTR Midstream, LLC **PROJECT NAME** Cody Central Gathering Facility

PROJECT NUMBER 17.22.199 **PROJECT LOCATION** WCR 6 and WCR 15 - Weld County, CO



BOREHOLE	DEPTH	Classification	γ_d	MC%
● 11	2.0	SANDY LEAN CLAY	93	13

Note: Water Added to Sample at 200 psf.

Date: 11/17/17

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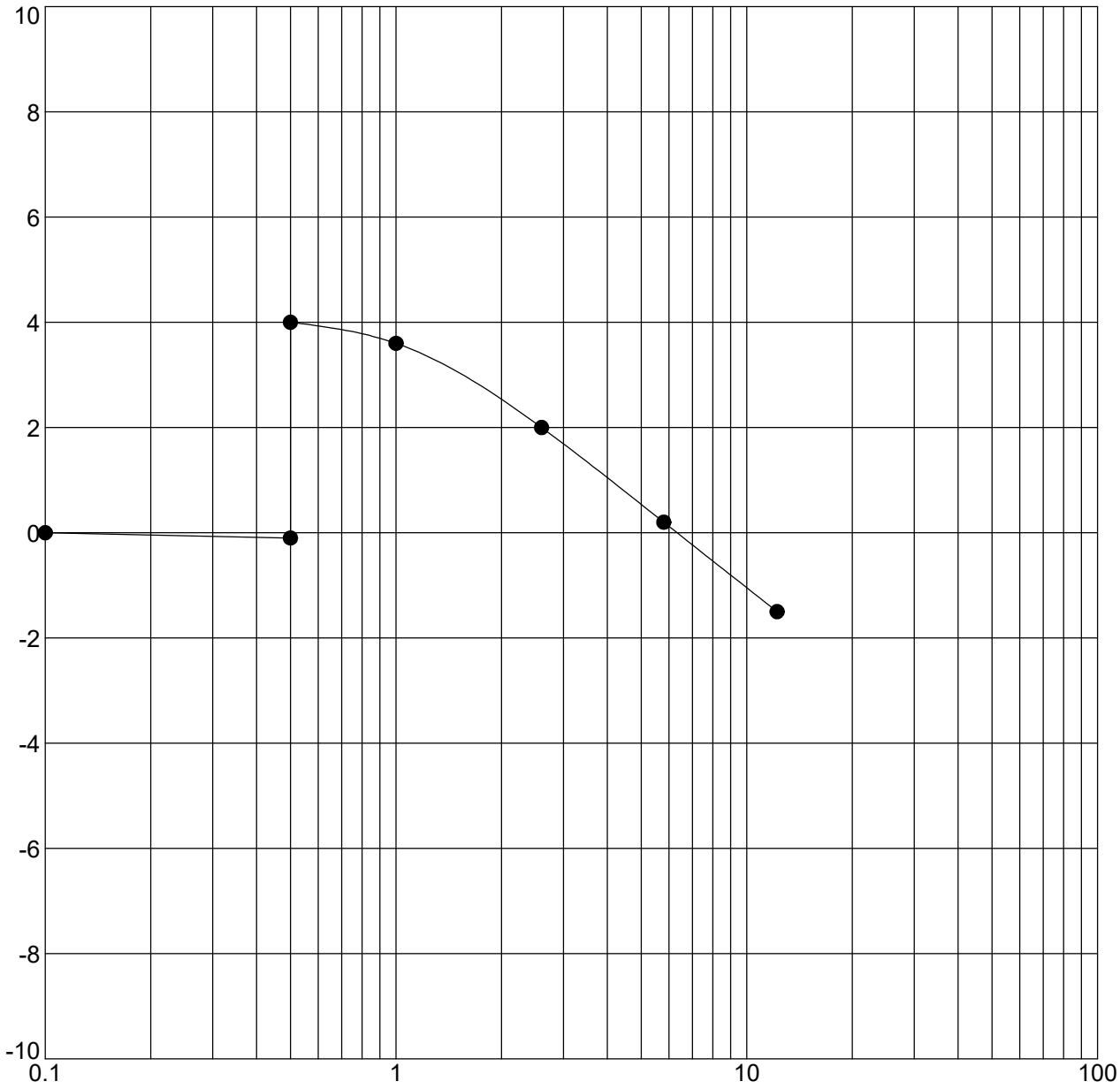
SWELL/CONSOLIDATION TEST

CLIENT XTR Midstream, LLC **PROJECT NAME** Cody Central Gathering Facility

PROJECT NUMBER 17.22.199 **PROJECT LOCATION** WCR 6 and WCR 15 - Weld County, CO



BOREHOLE	DEPTH	Classification	γ_d	MC%
● 11	9.0	**CLAYSTONE BEDROCK**	105	20

Note: Water Added to Sample at 500 psf.

Date: 11/17/17

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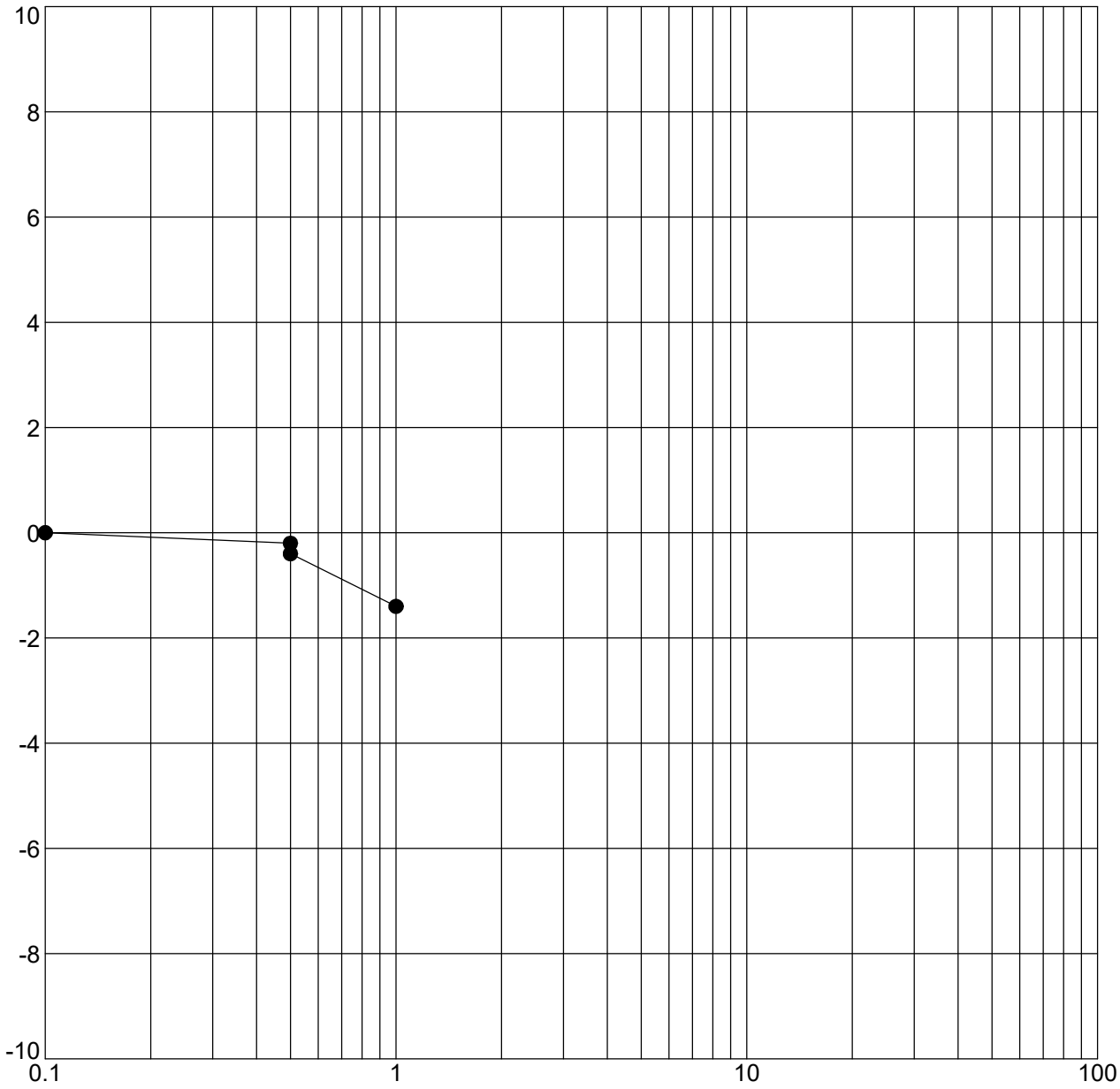
SWELL/CONSOLIDATION TEST

CLIENT XTR Midstream, LLC **PROJECT NAME** Cody Central Gathering Facility

PROJECT NUMBER 17.22.199 **PROJECT LOCATION** WCR 6 and WCR 15 - Weld County, CO



BOREHOLE	DEPTH	Classification	γ_d	MC%
● 12	9.0	**LEAN CLAY with SAND**	105	19

Note: Water Added to Sample at 500 psf.

Date: 11/17/17

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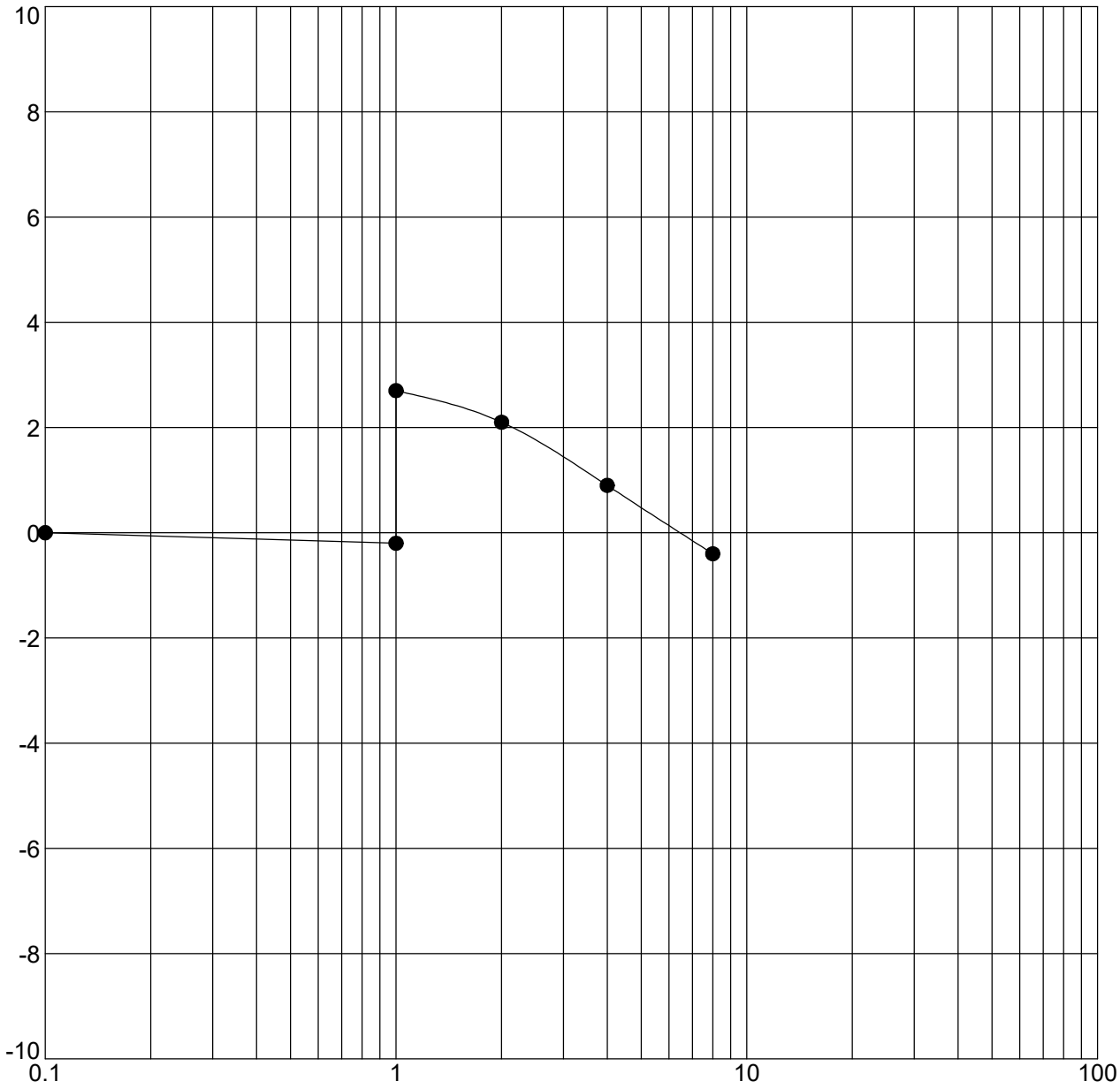
SWELL/CONSOLIDATION TEST

CLIENT XTR Midstream, LLC **PROJECT NAME** Cody Central Gathering Facility

PROJECT NUMBER 17.22.199 **PROJECT LOCATION** WCR 6 and WCR 15 - Weld County, CO



BOREHOLE	DEPTH	Classification	γ_d	MC%
● 12	14.0	CLAYSTONE BEDROCK	115	15

Note: Water Added to Sample at 1000 psf.

Date: 11/17/17

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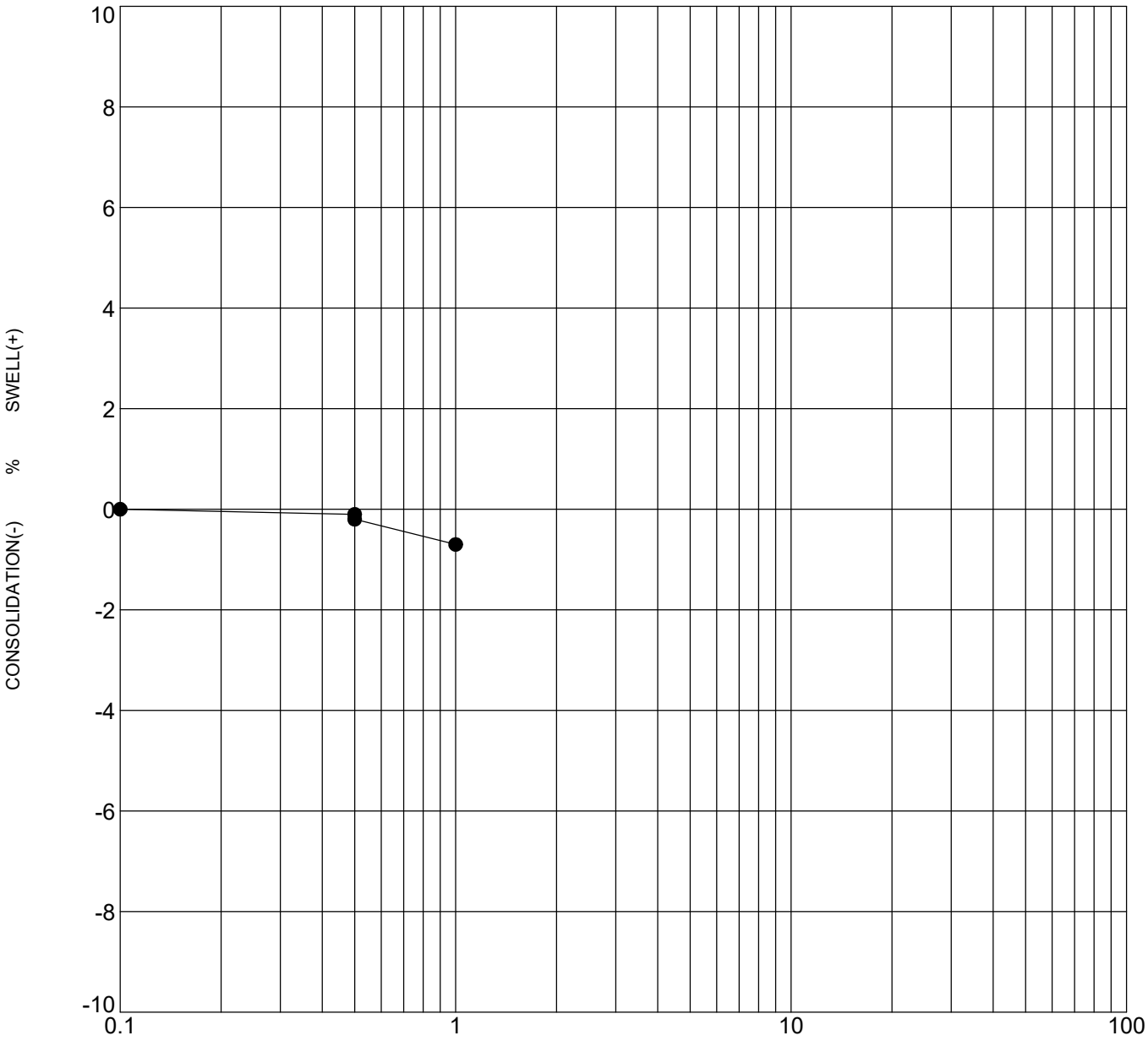
SWELL/CONSOLIDATION TEST

CLIENT XTR Midstream, LLC **PROJECT NAME** Cody Central Gathering Facility

PROJECT NUMBER 17.22.199 **PROJECT LOCATION** WCR 6 and WCR 15 - Weld County, CO



BOREHOLE	DEPTH	Classification	γ_d	MC%
● 13	4.0	SANDY LEAN CLAY	109	11

Note: Water Added to Sample at 500 psf.

Date: 11/17/17

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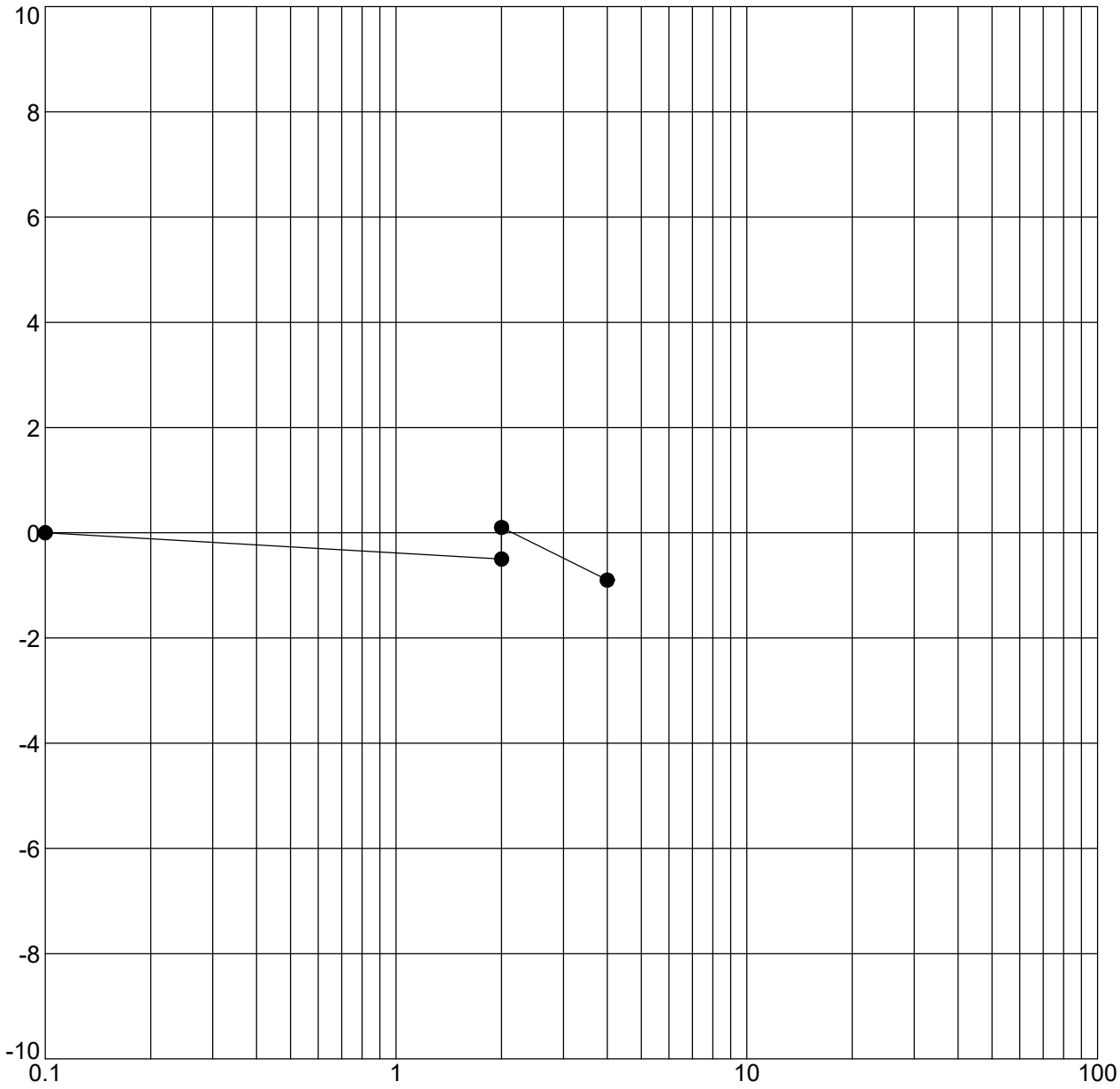
SWELL/CONSOLIDATION TEST

CLIENT XTR Midstream, LLC **PROJECT NAME** Cody Central Gathering Facility

PROJECT NUMBER 17.22.199 **PROJECT LOCATION** WCR 6 and WCR 15 - Weld County, CO



BOREHOLE	DEPTH	Classification	γ_d	MC%
● 13	19.0	CLAYSTONE BEDROCK	101	17

Note: Water Added to Sample at 2000 psf.

Date: 11/17/17

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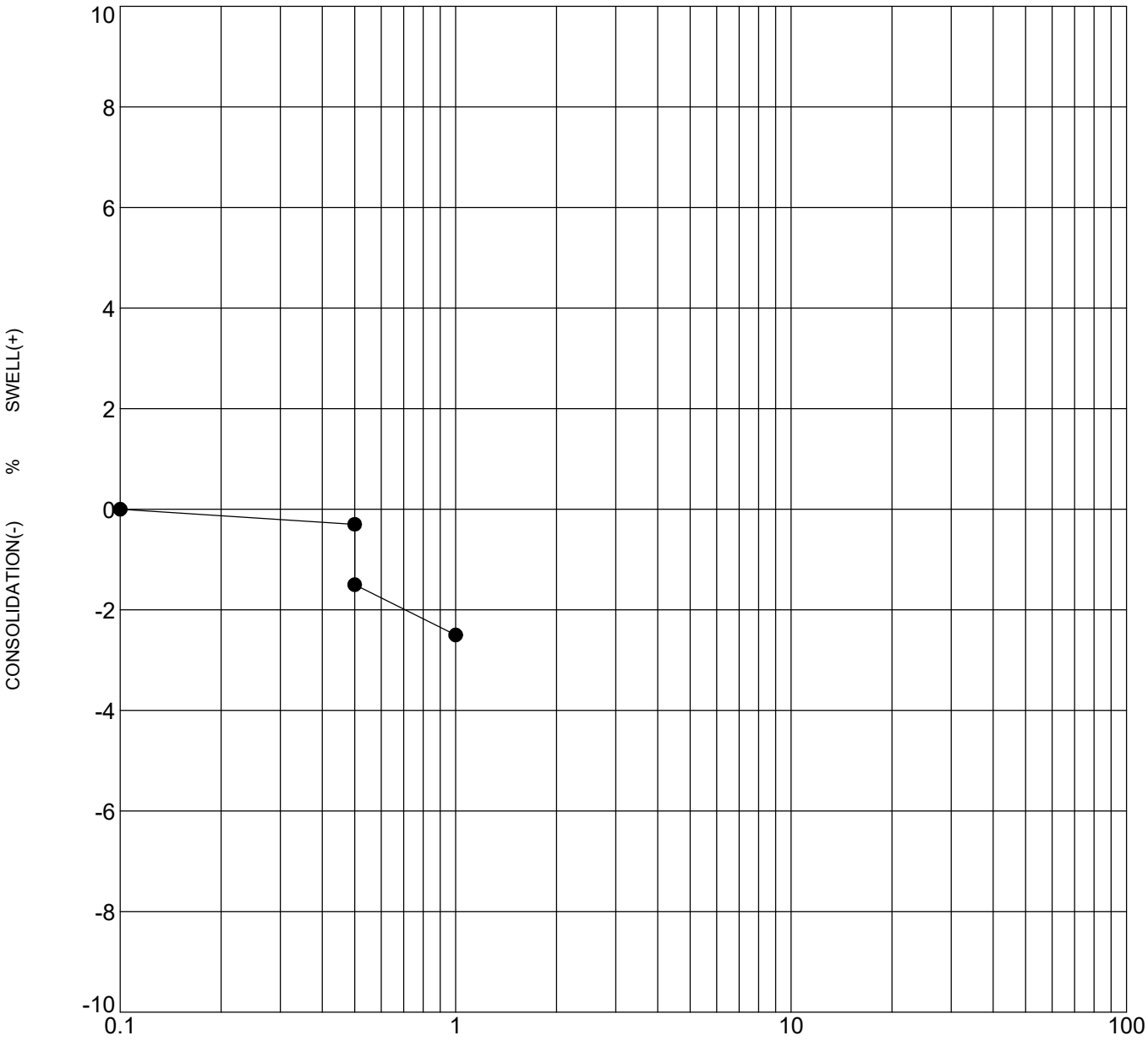
SWELL/CONSOLIDATION TEST

CLIENT XTR Midstream, LLC **PROJECT NAME** Cody Central Gathering Facility

PROJECT NUMBER 17.22.199 **PROJECT LOCATION** WCR 6 and WCR 15 - Weld County, CO



BOREHOLE	DEPTH	Classification	γ_d	MC%
● 14	4.0	LEAN CLAY	91	27

Note: Water Added to Sample at 500 psf.

Date: 11/17/17

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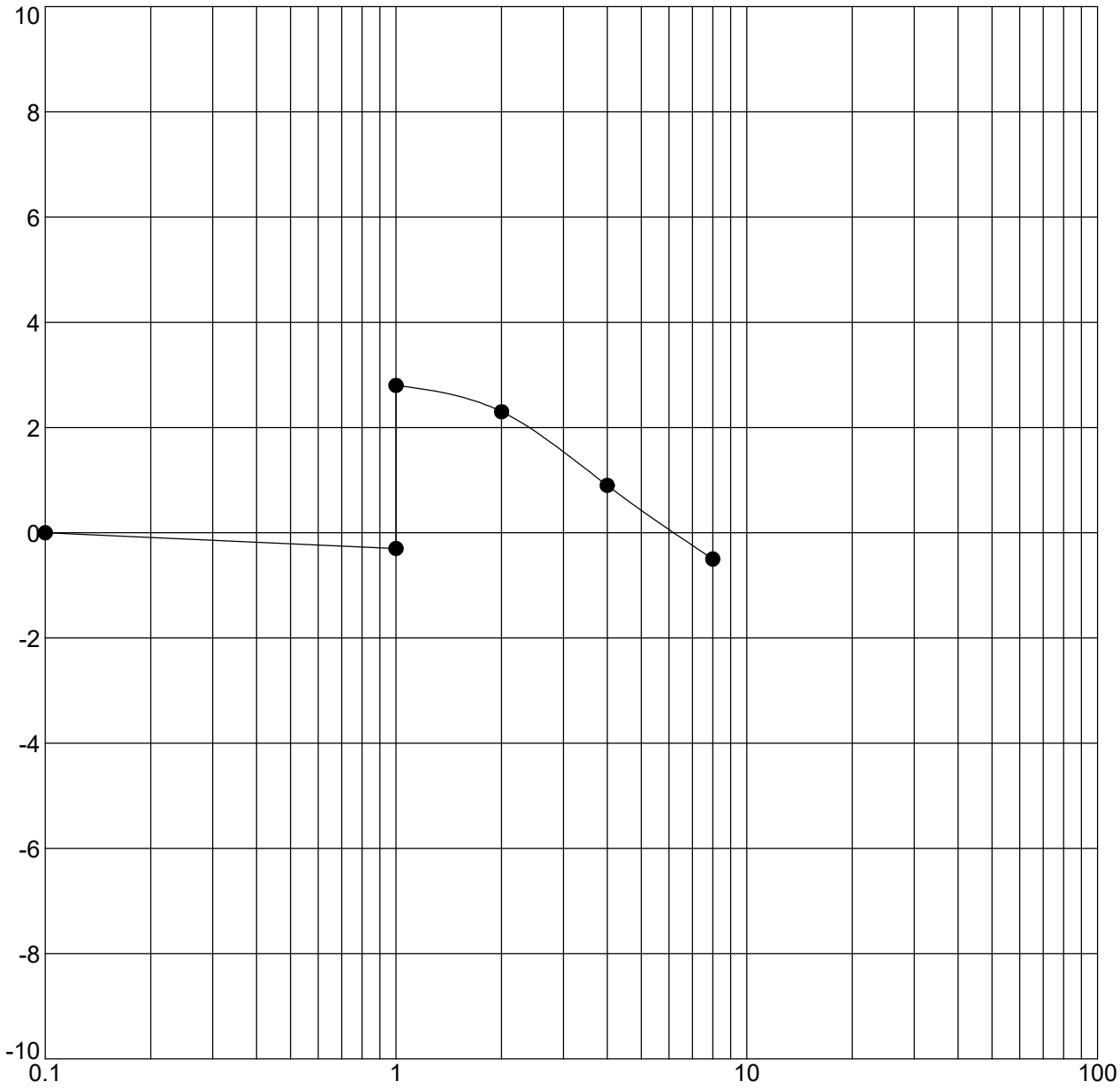
SWELL/CONSOLIDATION TEST

CLIENT XTR Midstream, LLC **PROJECT NAME** Cody Central Gathering Facility

PROJECT NUMBER 17.22.199 **PROJECT LOCATION** WCR 6 and WCR 15 - Weld County, CO



BOREHOLE	DEPTH	Classification	γ_d	MC%
● 15	14.0	CLAYSTONE BEDROCK	110	14

Note: Water Added to Sample at 1000 psf.

Date: 11/18/17

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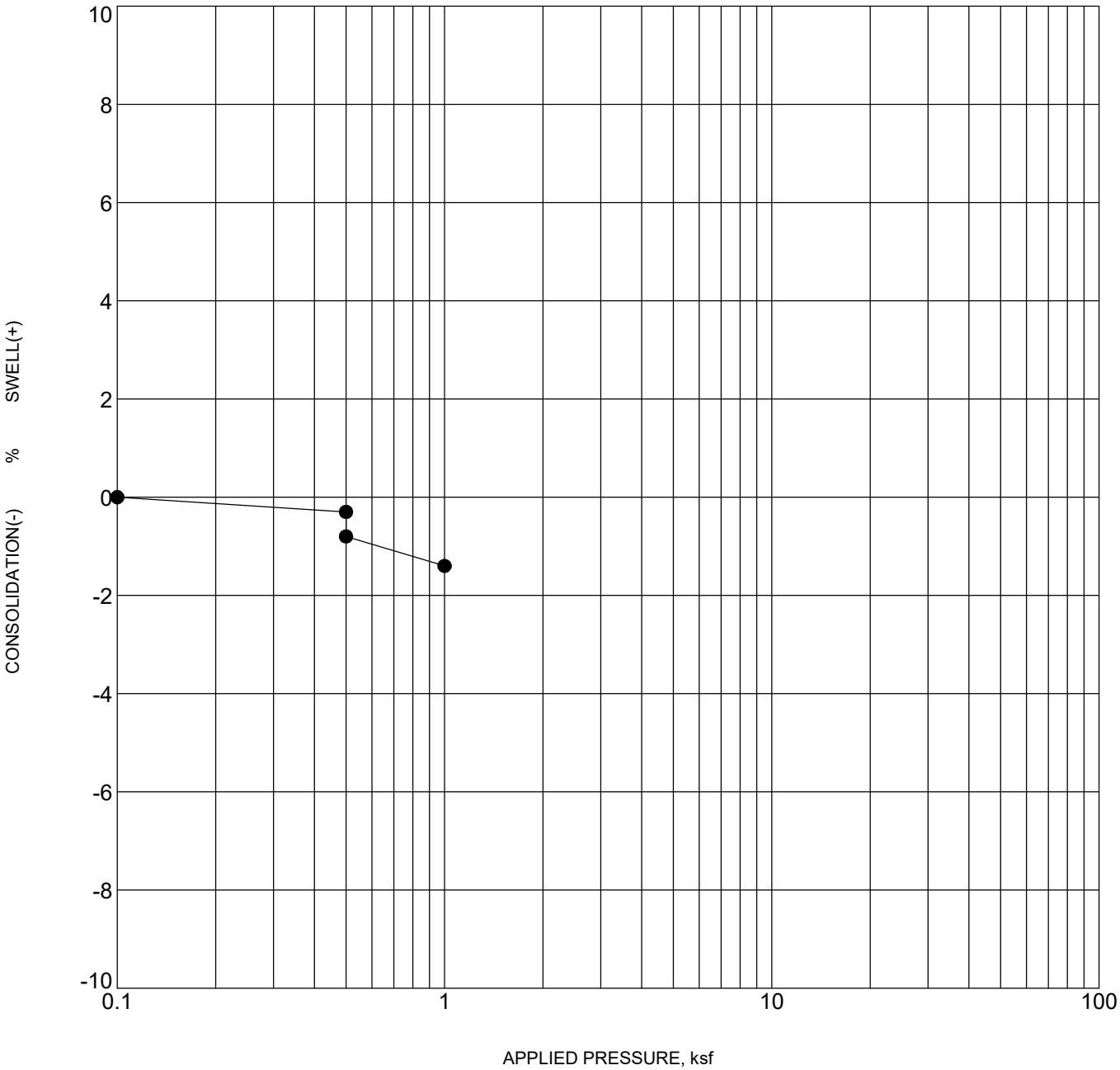
SWELL/CONSOLIDATION TEST

CLIENT XTR Midstream, LLC **PROJECT NAME** Cody Central Gathering Facility

PROJECT NUMBER 17.22.199 **PROJECT LOCATION** WCR 6 and WCR 15 - Weld County, CO



BOREHOLE	DEPTH	Classification	γ_d	MC%
● **16**	**4.0**	**SANDY LEAN CLAY**	**111**	**17**

Note: Water Added to Sample at 500 psf.

Date: 11/18/17

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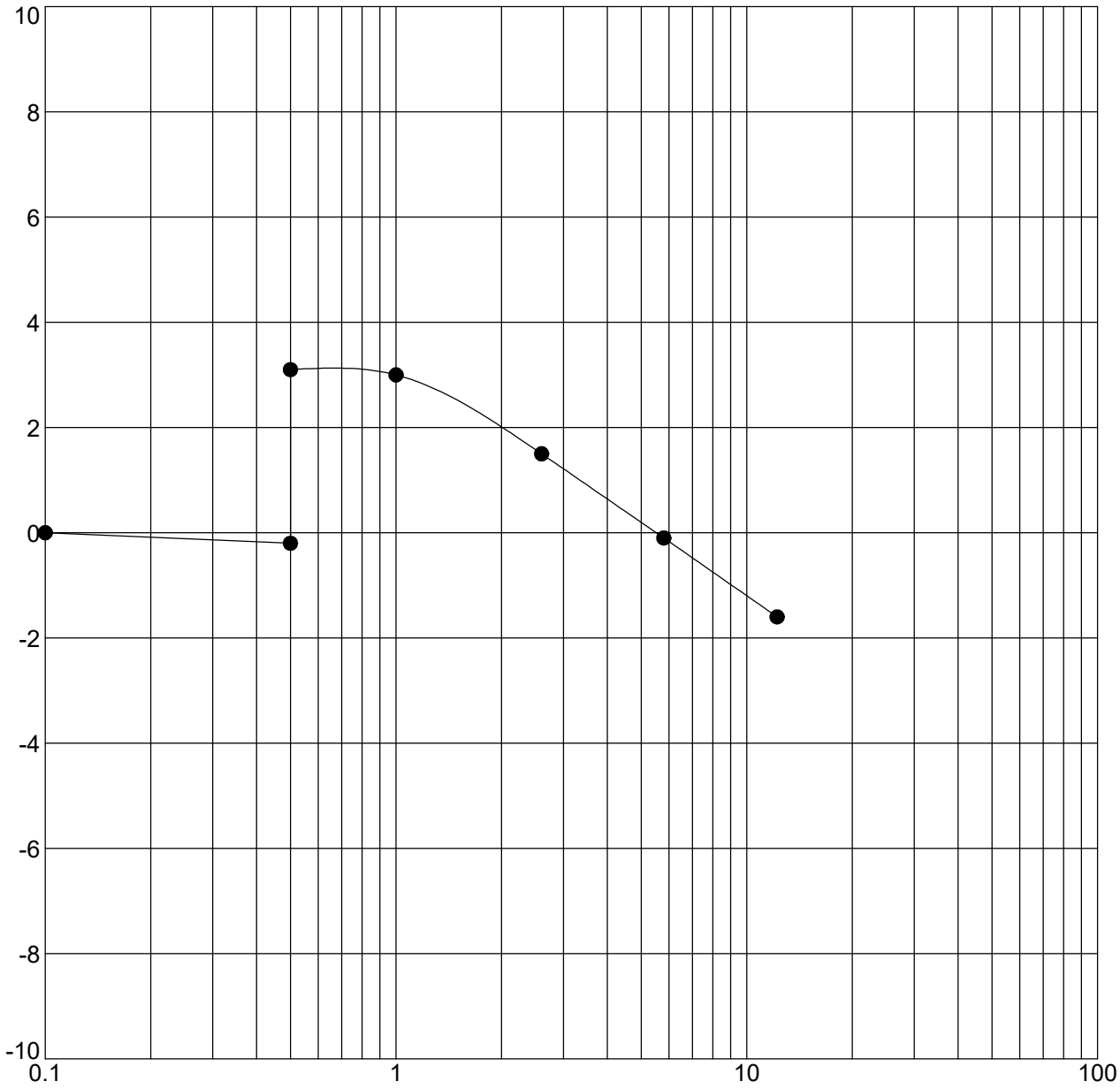
SWELL/CONSOLIDATION TEST

CLIENT XTR Midstream, LLC **PROJECT NAME** Cody Central Gathering Facility

PROJECT NUMBER 17.22.199 **PROJECT LOCATION** WCR 6 and WCR 15 - Weld County, CO



BOREHOLE	DEPTH	Classification	γ_d	MC%
● 16	14.0	CLAYSTONE BEDROCK	112	15

Note: Water Added to Sample at 500 psf.

Date: 11/18/17

CONSOL STRAIN - GINT STD US LAB.GDT - 12/8/17 11:07 - C:\USERS\PUBLIC\DOCUMENTS\BENTLEY\GINT\PROJECTS GEO 2017\17.22.199 CODY CENTRAL GATHERING FACILITY.GPJ

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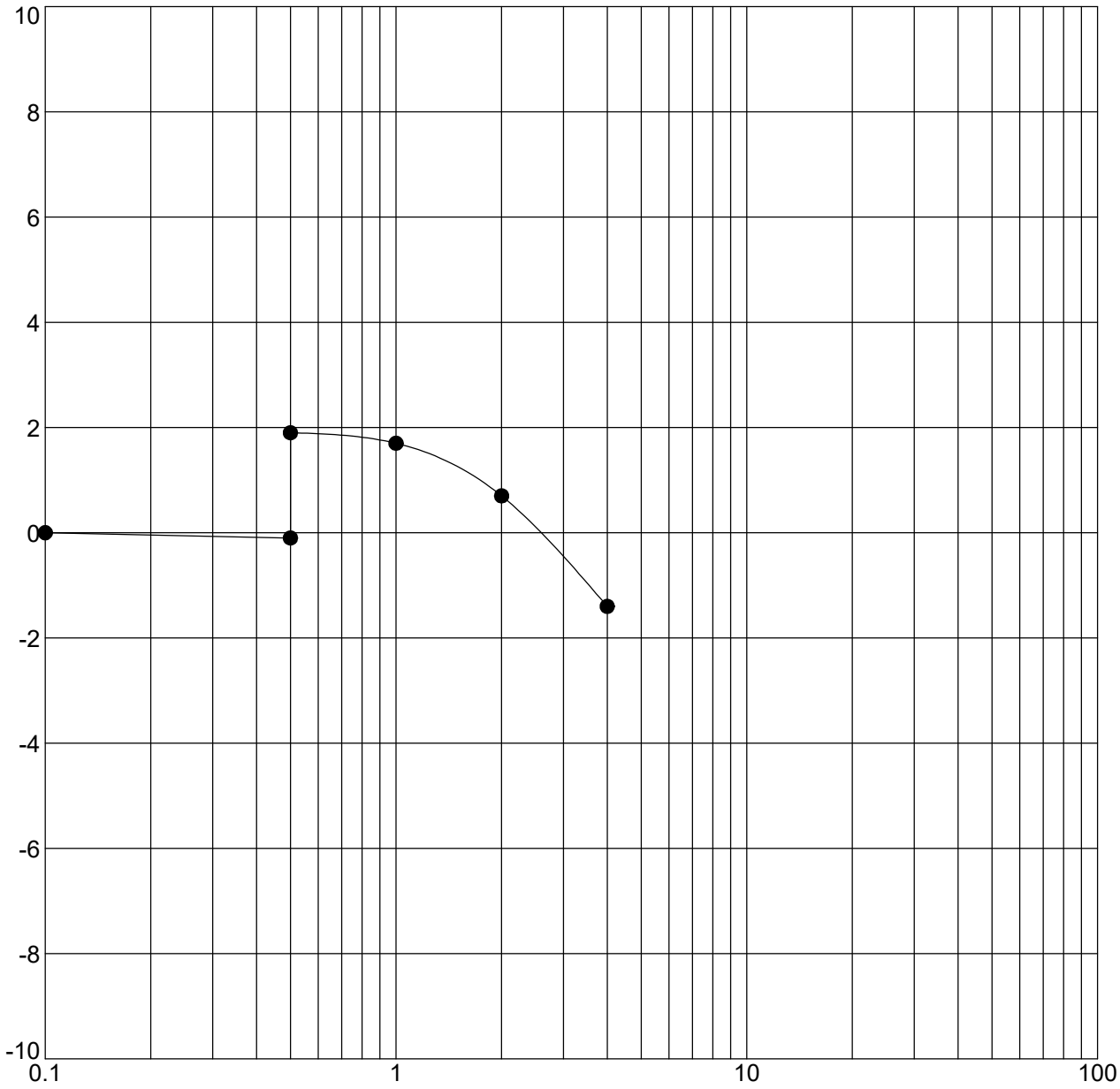
SWELL/CONSOLIDATION TEST

CLIENT XTR Midstream, LLC **PROJECT NAME** Cody Central Gathering Facility

PROJECT NUMBER 17.22.199 **PROJECT LOCATION** WCR 6 and WCR 15 - Weld County, CO



BOREHOLE	DEPTH	Classification	γ_d	MC%
● 17	4.0	SANDY LEAN CLAY	108	10

Note: Water Added to Sample at 500 psf.

Date: 11/18/17

CONSOL STRAIN - GINT STD US LAB.GDT - 12/8/17 11:07 - C:\USERS\PUBLIC\DOCUMENTS\BENTLEY\GINT\PROJECTS GEO 2017\17.22.199 CODY CENTRAL GATHERING FACILITY.GPJ

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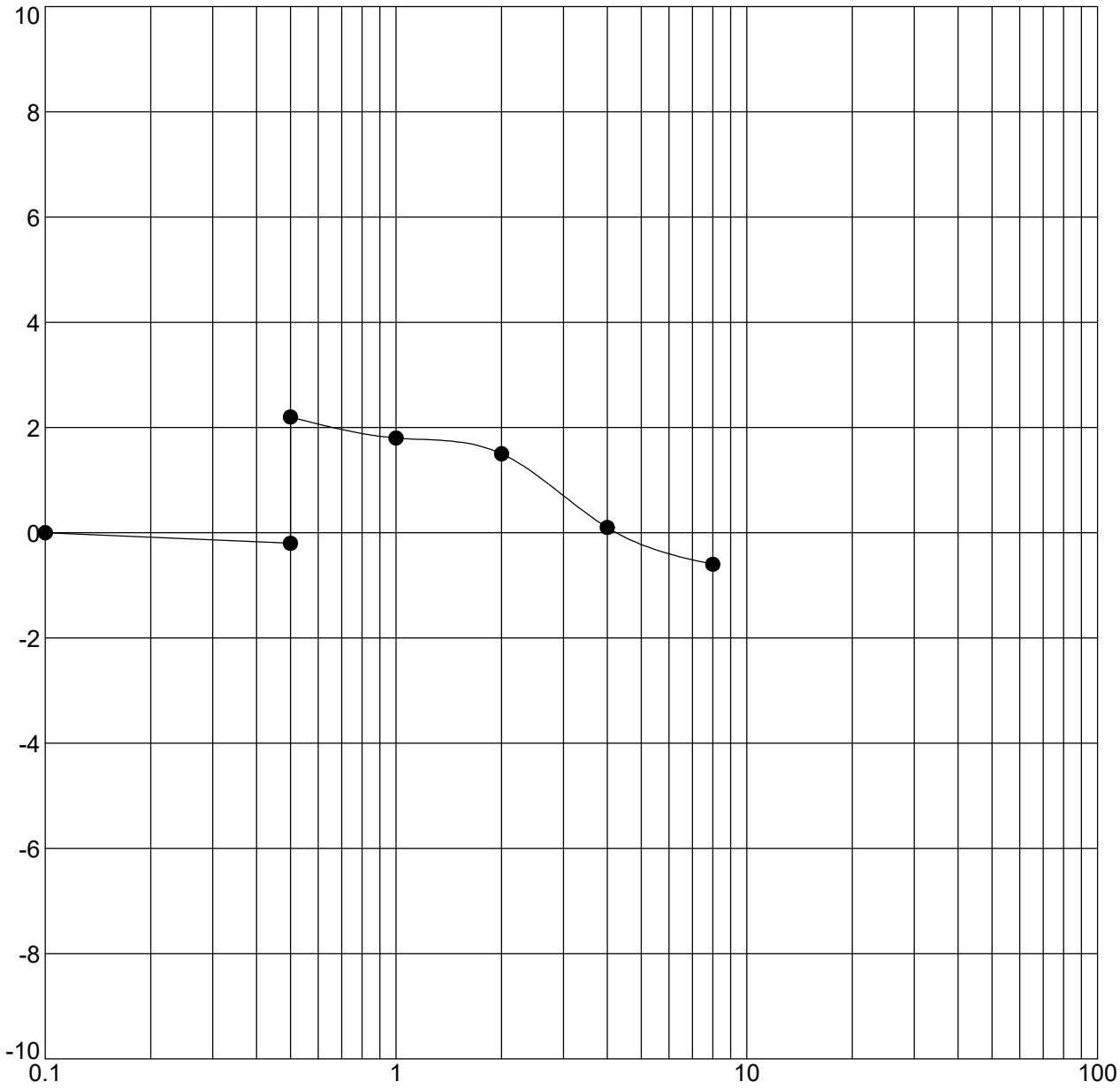
SWELL/CONSOLIDATION TEST

CLIENT XTR Midstream, LLC **PROJECT NAME** Cody Central Gathering Facility

PROJECT NUMBER 17.22.199 **PROJECT LOCATION** WCR 6 and WCR 15 - Weld County, CO



BOREHOLE	DEPTH	Classification	γ_d	MC%
● 17	9.0	**CLAYSTONE BEDROCK**	125	11

Note: Water Added to Sample at 500 psf.

Date: 11/18/17

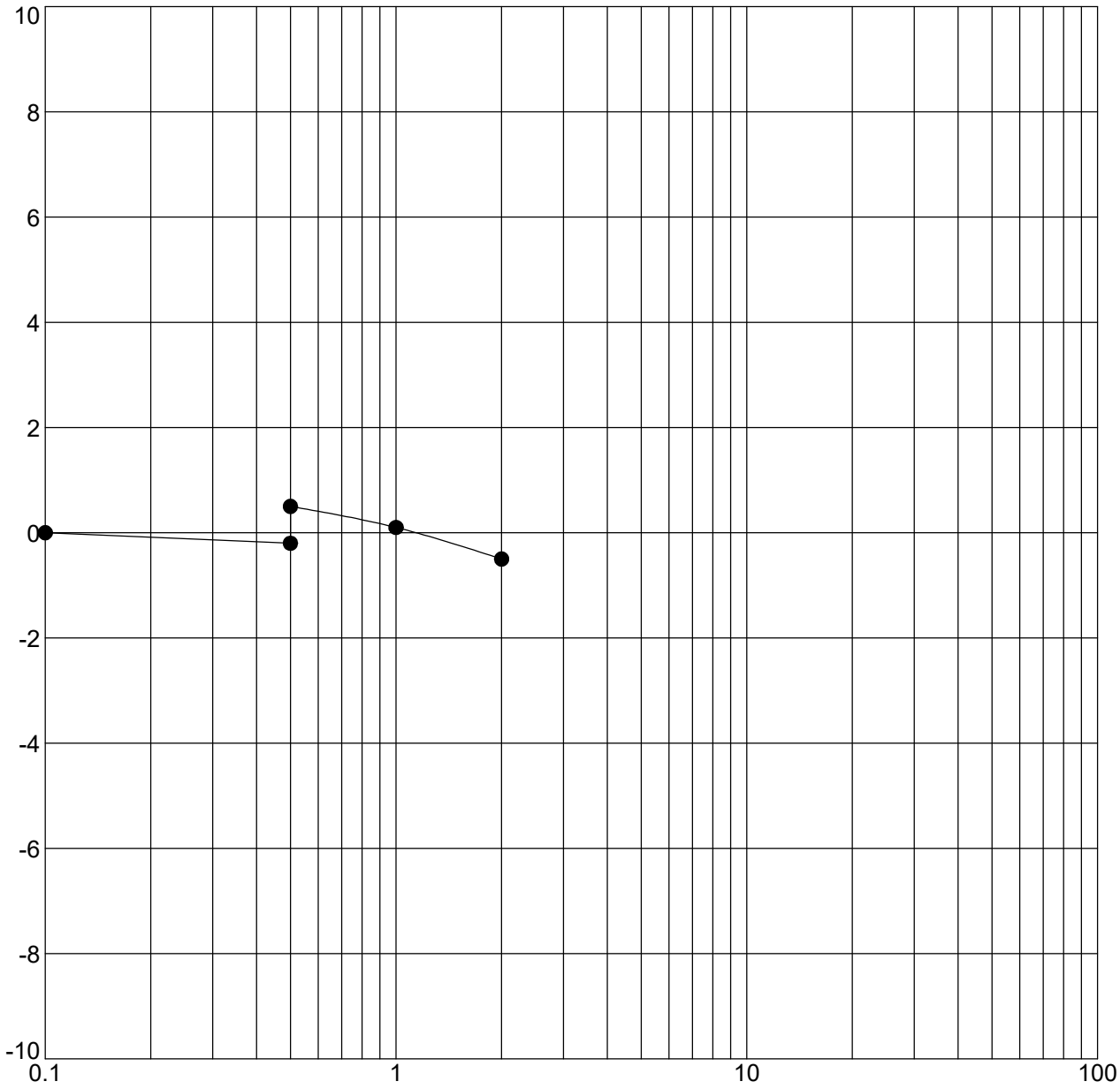
CONSOL STRAIN - GINT STD US LAB.GDT - 12/8/17 11:07 - C:\USERS\PUBLIC\DOCUMENTS\BENTLEY\GINT\PROJECTS GEO 2017\17.22.199 CODY CENTRAL GATHERING FACILITY.GPJ

Cole Garner Geotechnical
1070 W. 124th Avenue, Suite 300
Westminster, CO. 80234
Telephone: 303.996.2999

SWELL/CONSOLIDATION TEST

CLIENT XTR Midstream, LLC **PROJECT NAME** Cody Central Gathering Facility

PROJECT NUMBER 17.22.199 **PROJECT LOCATION** WCR 6 and WCR 15 - Weld County, CO



BOREHOLE	DEPTH	Classification	γ_d	MC%
● 18	4.0	**LEAN CLAY with SAND**	115	15

Note: Water Added to Sample at 500 psf.

Date: 11/18/17

CONSOL STRAIN - GINT STD US LAB.GDT - 12/8/17 11:07 - C:\USERS\PUBLIC\DOCUMENTS\BENTLEY\GINT\PROJECTS GEO 2017\17.22.199 CODY CENTRAL GATHERING FACILITY.GPJ

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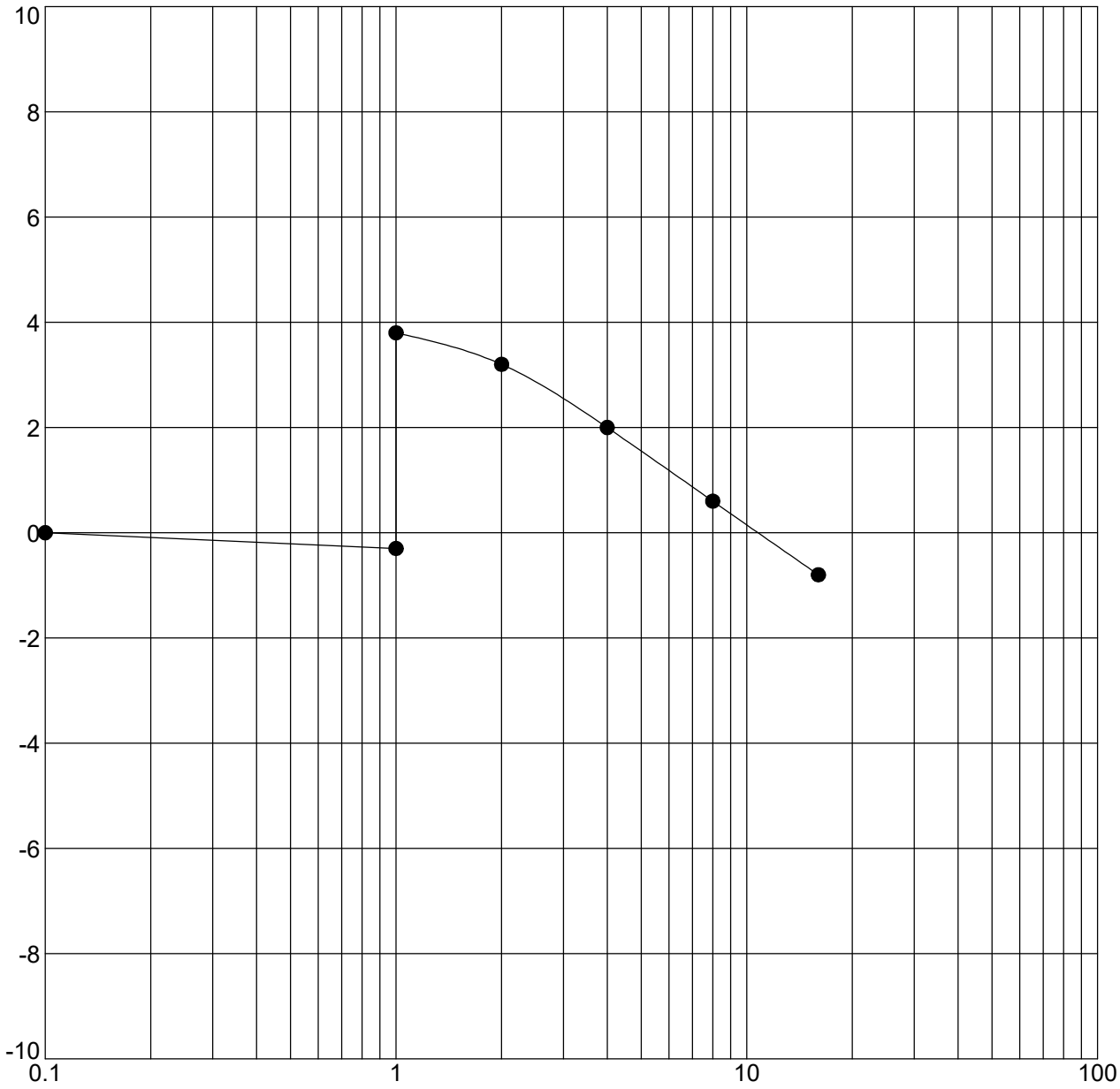
SWELL/CONSOLIDATION TEST

CLIENT XTR Midstream, LLC **PROJECT NAME** Cody Central Gathering Facility

PROJECT NUMBER 17.22.199 **PROJECT LOCATION** WCR 6 and WCR 15 - Weld County, CO



BOREHOLE	DEPTH	Classification	γ_d	MC%
● 18	14.0	CLAYSTONE BEDROCK	117	14

Note: Water Added to Sample at 1000 psf.

Date: 11/18/17

CONSOL STRAIN - GINT STD US LAB.GDT - 12/8/17 11:07 - C:\USERS\PUBLIC\DOCUMENTS\BENTLEY\GINT\PROJECTS GEO 2017\17.22.199 CODY CENTRAL GATHERING FACILITY.GPJ

intertek psi
Total Quality. Assured.

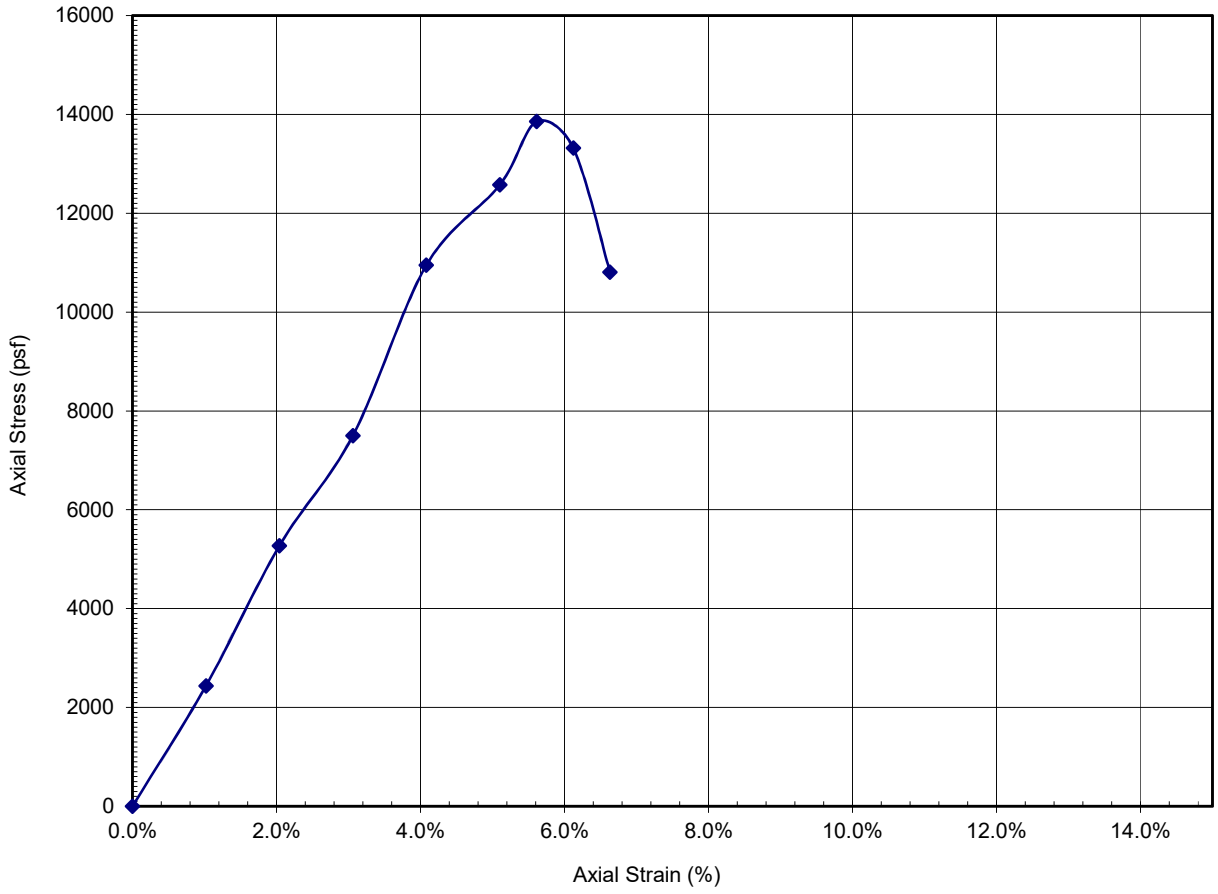
UNCONFINED COMPRESSION REPORT

Tested For: Cole Garner Geotechnical
1070 W 124th Avenue
Suite 300
Westminster, CO 80234

Project Name: CG Lab Testing

Cody CGF
17.22.199
Project No. 05321313-21
Sample No. 12
Depth 34

UNCONFINED COMPRESSION TEST: ASTM D2166



Wet Density (pcf)	135.1	**Initial Height (in)**	3.92
Dry Density (pcf)	115.8	**Initial Diameter (in)**	1.94
Moisture Content (%)	16.6	**Relative Compaction (%)**	
Compressive Strength (psf)	13,900	**Deviation From OMC (%)**	

Remarks:

Respectfully Submitted,
Professional Service Industries, Inc.

REPORTS MAY NOT BE REPRODUCED, EXCEPT IN FULL, WITHOUT WRITTEN PERMISSION BY PROFESSIONAL SERVICE INDUSTRIES, INC.

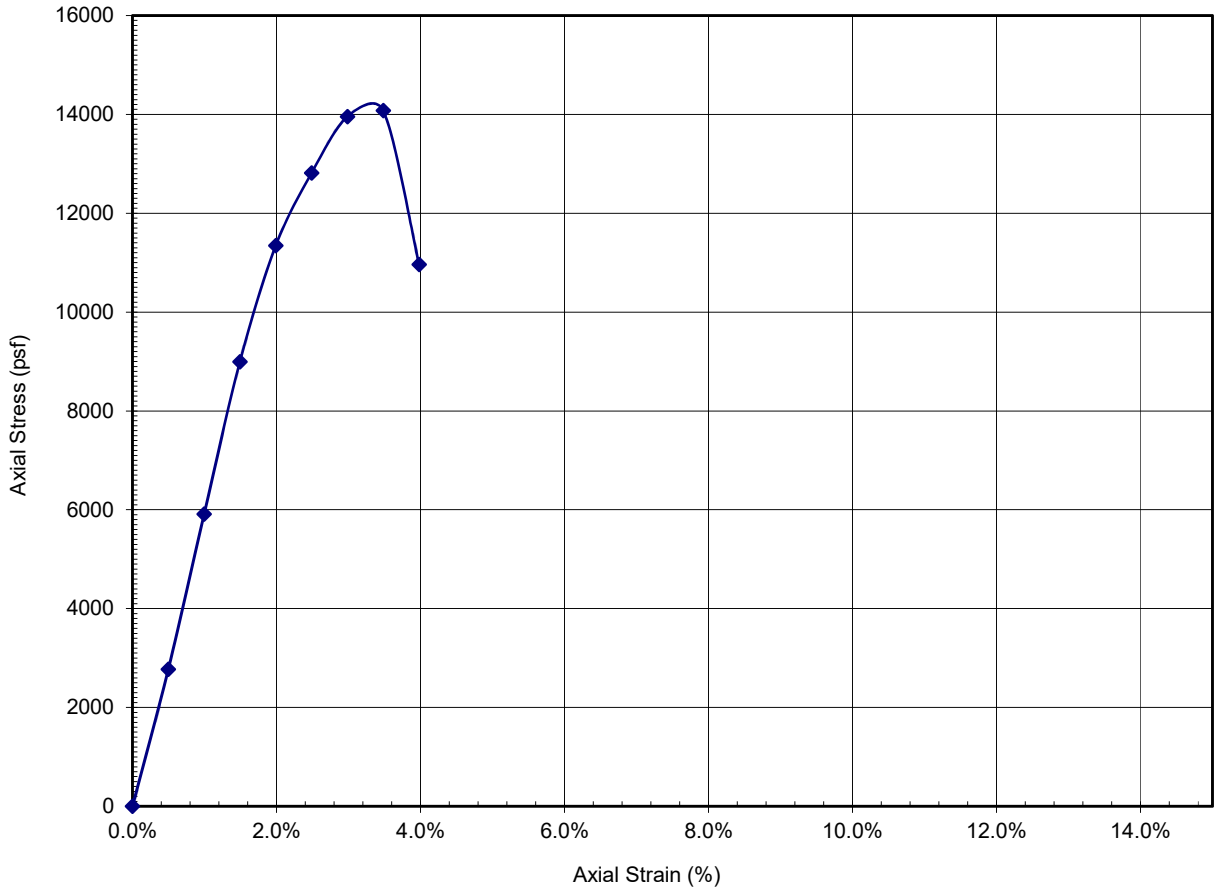
UNCONFINED COMPRESSION REPORT

Tested For: Cole Garner Geotechnical
1070 W 124th Avenue
Suite 300
Westminster, CO 80234

Project Name: CG Lab Testing

Cody CGF
17.22.199
Project No. 05321313-21
Sample No. 15
Depth 44

UNCONFINED COMPRESSION TEST: ASTM D2166



Wet Density (pcf)	140.8	**Initial Height (in)**	4.02
Dry Density (pcf)	125.1	**Initial Diameter (in)**	1.94
Moisture Content (%)	12.6	**Relative Compaction (%)**	
Compressive Strength (psf)	14,100	**Deviation From OMC (%)**	

Remarks:

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Professional Service Industries, Inc.

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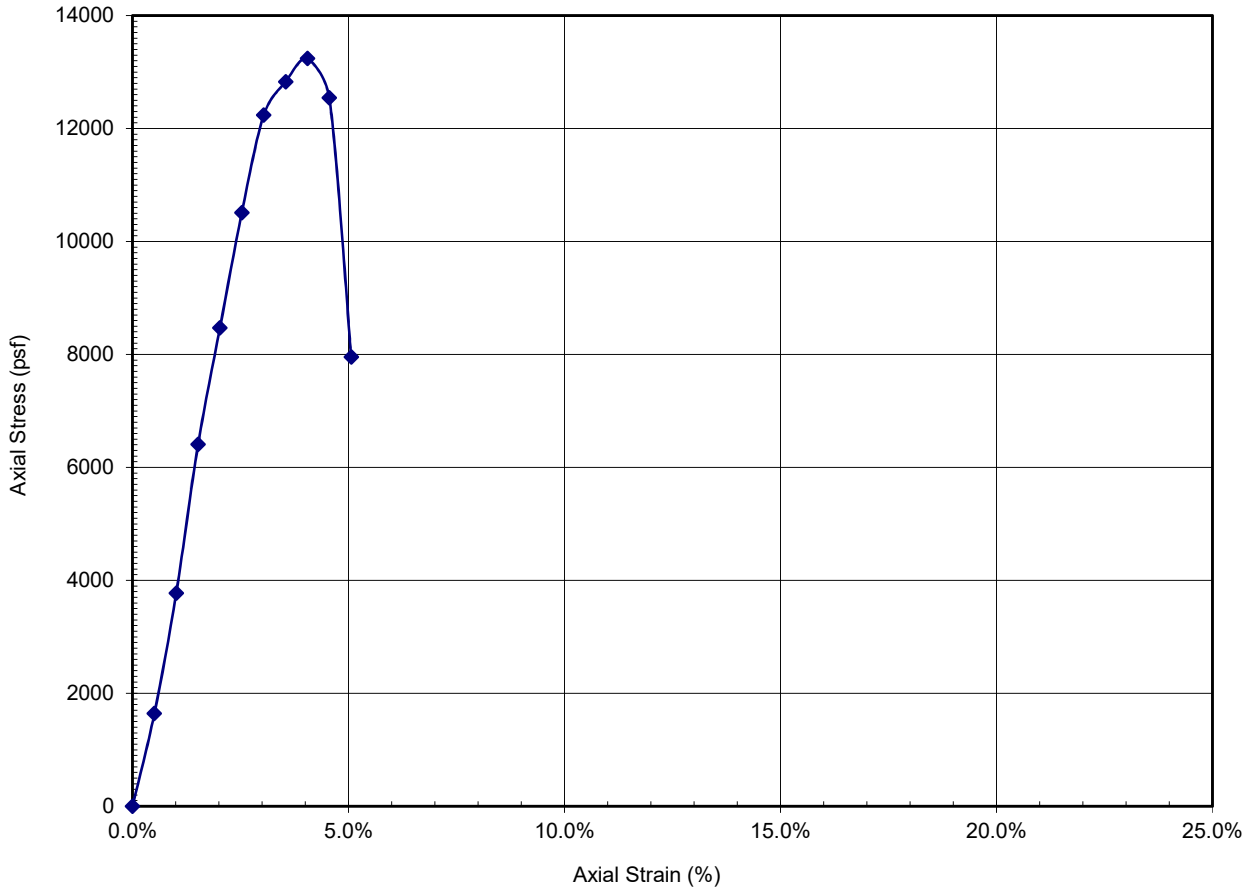
UNCONFINED COMPRESSION REPORT

Tested For: Cole Garner Geotechnical
1070 W 124th Avenue
Suite 300
Westminster, CO 80234

Project Name: CG Lab Testing

Cody CGF
17.22.199
Project No. 05321313-21
Sample No. 17
Depth 24

UNCONFINED COMPRESSION TEST: ASTM D2166



Wet Density (pcf)	136.5	**Initial Height (in)**	3.95
Dry Density (pcf)	119.7	**Initial Diameter (in)**	1.94
Moisture Content (%)	14.1	**Relative Compaction (%)**	
Compressive Strength (psf)	13,200	**Deviation From OMC (%)**	

Remarks:

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Professional Service Industries, Inc.

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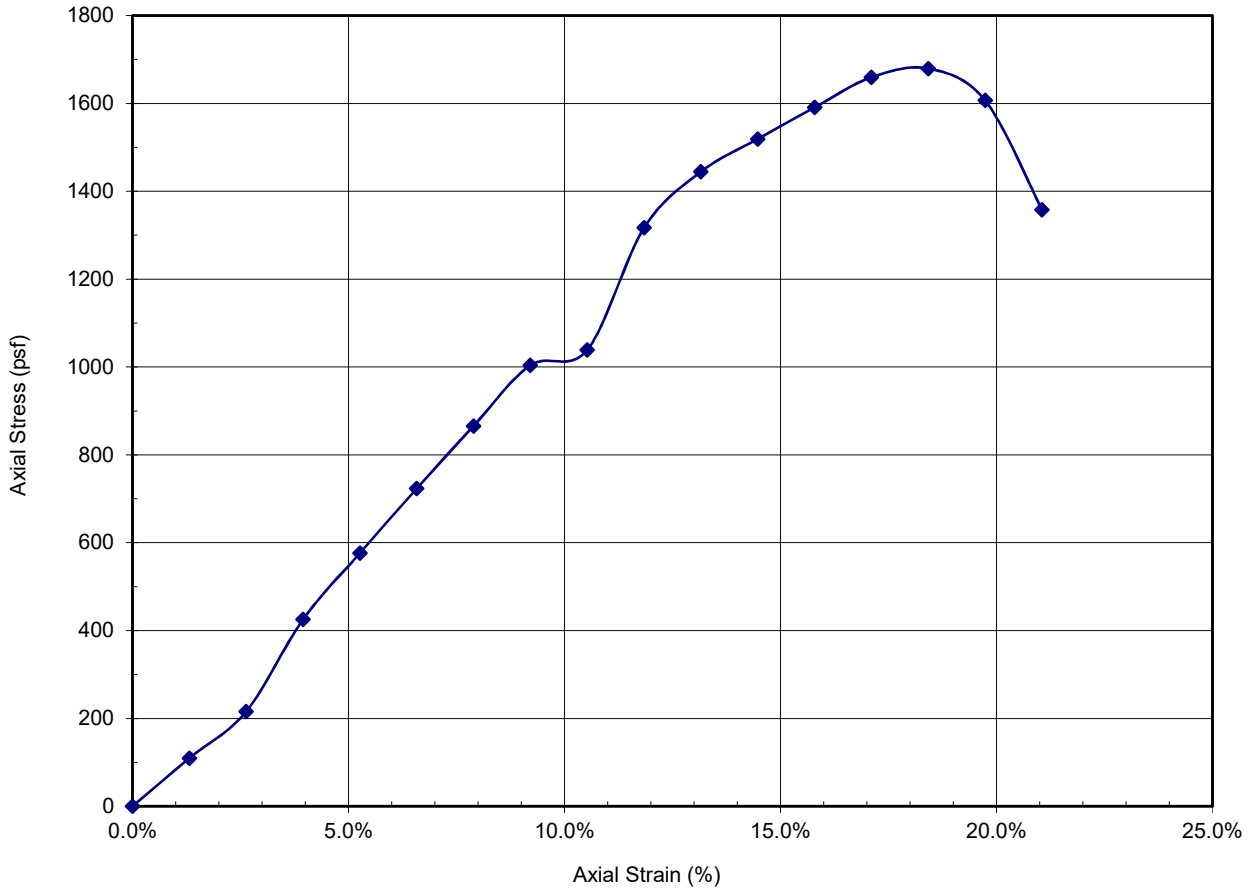
UNCONFINED COMPRESSION REPORT

Tested For: Cole Garner Geotechnical
1070 W 124th Avenue
Suite 300
Westminster, CO 80234

Project Name: CG Lab Testing

Cody CGF
17.22.199
Project No. 05321313-21
Sample No. 16
Depth 9

UNCONFINED COMPRESSION TEST: ASTM D2166



Wet Density (pcf)	135.0	**Initial Height (in)**	3.80
Dry Density (pcf)	113.0	**Initial Diameter (in)**	1.9
Moisture Content (%)	19.6	**Relative Compaction (%)**	
Compressive Strength (psf)	1,700	**Deviation From OMC (%)**	

Remarks:

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Professional Service Industries, Inc.

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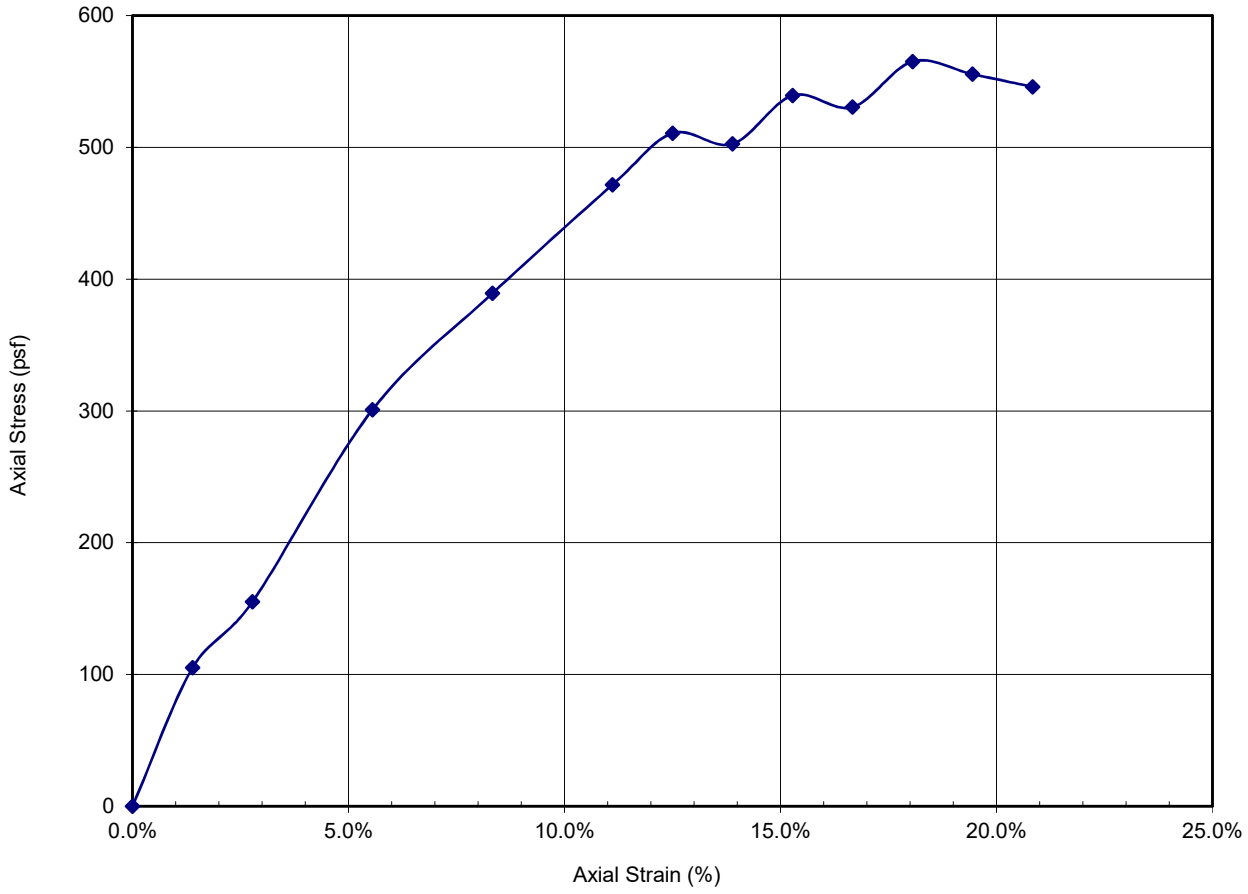
UNCONFINED COMPRESSION REPORT

Tested For: Cole Garner Geotechnical
1070 W 124th Avenue
Suite 300
Westminster, CO 80234

Project Name: CG Lab Testing

Cody CGF
17.22.199
Project No. 05321313-21
Sample No. 14
Depth 9

UNCONFINED COMPRESSION TEST: ASTM D2166



Wet Density (pcf)	120.0	**Initial Height (in)**	3.60
Dry Density (pcf)	97.3	**Initial Diameter (in)**	1.94
Moisture Content (%)	23.4	**Relative Compaction (%)**	
Compressive Strength (psf)	600	**Deviation From OMC (%)**	

Remarks: sample compressed and increased in diameter without producing a fracture plane.

Respectfully Submitted,
Professional Service Industries, Inc.

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SUMMARY OF LABORATORY RESULTS

CLIENT XTR Midstream, LLC

PROJECT NAME Cody Central Gathering Facility

PROJECT NUMBER 17.22.199

PROJECT LOCATION WCR 6 and WCR 15 - Weld County, CO

Borehole	Depth	Soil Description	Water Content (%)	Dry Density (pcf)	Swell (+) or Consolidation (-)/ Surcharge (%/psf)	Water Soluble Sulfates (ppm)	Passing #200 Sieve (%)	Atterberg Limits		
								Liquid Limit	Plastic Limit	Plasticity Index
11	2	SANDY LEAN CLAY	13.3	92.6	+0.2/200	400				
11	4	SANDY LEAN CLAY	10.6							
11	9	CLAYSTONE BEDROCK	20.3	104.7	+4.1/500		98	48	20	28
11	14	CLAYSTONE BEDROCK	15.4	112.5						
11	19	CLAYSTONE BEDROCK	20.1							
11	24	CLAYSTONE BEDROCK	19.8							
11	34	CLAYSTONE BEDROCK	22.1							
12	4	LEAN CLAY with SAND	14.4	109.2						
12	9	LEAN CLAY with SAND	19.0	104.6	-0.4/500		75	44	21	23
12	14	CLAYSTONE BEDROCK	15.0	114.9	+2.9/1000					
12	19	CLAYSTONE BEDROCK	17.1							
12	24	CLAYSTONE BEDROCK	17.9	116.2						
12	29	CLAYSTONE BEDROCK	16.1							
12	34	CLAYSTONE BEDROCK	16.6	116.0						
12	44	CLAYSTONE BEDROCK	12.2							
13	4	SANDY LEAN CLAY	11.2	109.4	-0.2/500					
13	9	SANDSTONE BEDROCK	12.1				29	NP	NP	NP
13	19	CLAYSTONE BEDROCK	17.1	100.9	+0.6/2000					
13	24	CLAYSTONE BEDROCK	17.3	113.9						
13	29	CLAYSTONE BEDROCK	14.7	118.5						
13	34	CLAYSTONE BEDROCK	19.6	109.7						
14	4	LEAN CLAY	26.6	91.2	-1.5/500					
14	9	LEAN CLAY with SAND	23.4	97.0						
14	14	CLAYEY SANDSTONE BEDROCK	13.1							
14	19	CLAYSTONE BEDROCK	14.4	117.5						
14	24	CLAYSTONE BEDROCK	21.5							
14	29	CLAYSTONE BEDROCK	14.5							
14	39	CLAYSTONE BEDROCK	15.7	115.2						
14	49	CLAYSTONE BEDROCK	15.1	119.4						
15	4	LEAN CLAY	22.7							

LAB SUMMARY - GINT STD US LAB.GDT - 12/8/17 11:09 - C:\USERS\PUBLIC\DOCUMENTS\BENTLEY\GINT\PROJECTS GEO 2017\17.22.199 CODY CENTRAL GATHERING FACILITY.GPJ

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SUMMARY OF LABORATORY RESULTS

CLIENT XTR Midstream, LLC

PROJECT NAME Cody Central Gathering Facility

PROJECT NUMBER 17.22.199

PROJECT LOCATION WCR 6 and WCR 15 - Weld County, CO

Borehole	Depth	Soil Description	Water Content (%)	Dry Density (pcf)	Swell (+) or Consolidation (-)/ Surcharge (%/psf)	Water Soluble Sulfates (ppm)	Passing #200 Sieve (%)	Atterberg Limits		
								Liquid Limit	Plastic Limit	Plasticity Index
15	9	CLAYSTONE BEDROCK	14.2	117.9						
15	14	CLAYSTONE BEDROCK	14.4	109.6	+3.1/1000		98	49	21	28
15	19	CLAYSTONE BEDROCK	20.8	108.7						
15	24	CLAYSTONE BEDROCK	14.5							
15	29	CLAYSTONE BEDROCK	12.5	120.7						
15	34	CLAYSTONE BEDROCK	15.3							
15	44	CLAYSTONE BEDROCK	16.6	115.8						
15	49	CLAYSTONE BEDROCK	17.7							
16	2	SANDY LEAN CLAY	20.2							
16	4	SANDY LEAN CLAY	16.9	110.9	-0.8/500		67	37	21	16
16	9	SANDY LEAN CLAY	16.6	115.8						
16	14	CLAYSTONE BEDROCK	15.2	112.1	+3.3/500					
16	19	CLAYSTONE BEDROCK	17.9							
16	24	CLAYSTONE BEDROCK	14.6	119.2						
16	34	CLAYSTONE BEDROCK	20.6	108.3						
17	4	SANDY LEAN CLAY	9.5	108.0	+2.0/500					
17	9	CLAYSTONE BEDROCK	11.4	124.7	+2.4/500		80	33	21	12
17	19	SANDSTONE BEDROCK	14.0							
17	24	SANDY CLAYSTONE BEDROCK	14.1	120.0						
17	29	SANDY CLAYSTONE BEDROCK	13.9	120.3						
17	34	SANDY CLAYSTONE BEDROCK	14.9							
17	44	SANDY CLAYSTONE BEDROCK	17.8	110.9						
17	49	SANDY CLAYSTONE BEDROCK	18.0	111.5						
18	4	LEAN CLAY with SAND	15.1	114.6	+0.7/500		84	46	21	25
18	9	CLAYSTONE BEDROCK	13.3			1400				
18	14	CLAYSTONE BEDROCK	13.9	117.5	+4.1/1000					
18	24	CLAYSTONE BEDROCK	15.3							
18	29	SANDY CLAYSTONE BEDROCK	15.5	117.8						
18	34	SANDY CLAYSTONE BEDROCK	14.8							

LAB SUMMARY - GINT STD US LAB.GDT - 12/8/17 11:09 - C:\USERS\PUBLIC\DOCUMENTS\BENTLEY\GINT\PROJECTS GEO 2017\17.22.199 CODY CENTRAL GATHERING FACILITY.GPJ

Field Resistivity Testing
Wenner 4-Pin Method

Project Name:	**Cody Central Gathering Facility**	**Date:**	**11/22/17**
Ciient:	**XTR Midstream, LLC**	**Tested By:**	**G. Ohlsen**
Project Location:	**SWC of Weld County Roads 6 & 15 - Weld County, Colorado**		
Test Line ID:	**R1**		
Test Line Location:	**North Central Pad Area (Refer to Boring Location Diagram)**		

Electrode Pin Spacing (S) ft	X	**Resistance Reading (R)** Ohm	X	**191.5 = Resistivity** Ohm-cm
Line Orientation: N-S				
5		3.20		3,064
10		0.89		1,704
20		0.29		1,111
50		0.10		958
100		0.10		1,915
Line Orientation: E-W				
5		1.80		1,724
10		0.90		1,724
20		0.32		1,226
50		0.060		575
100		0.029		555

CG Geotech

Field Resistivity Testing
Wenner 4-Pin Method

Project Name:	**Cody Central Gathering Facility**	**Date:**	**11/22/17**
Ciient:	**XTR Midstream, LLC**	**Tested By:**	**G. Ohlsen**
Project Location:	**SWC of Weld County Roads 6 & 15 - Weld County, Colorado**		
Test Line ID:	**R2**		
Test Line Location:	**SW Pad Area (Refer to Boring Location Diagram)**		

Electrode Pin Spacing (S) ft	**X**	**Resistance Reading (R)** Ohm	**X**	**191.5 = Resistivity** Ohm-cm
Line Orientation: N-S				
5		1.45		1,388
10		0.55		1,053
20		0.28		1,072
50		0.10		958
100		0.035		670
Line Orientation: E-W				
5		1.80		1,724
10		0.63		1,206
20		0.22		843
50		0.10		958
100		0.050		958

CG Geotech

APPENDIX C

GENERAL NOTES

GENERAL NOTES

DRILLING & SAMPLING SYMBOLS:

SS:	Split Spoon - 1⅜" I.D., 2" O.D., unless otherwise noted	HS:	Hollow Stem Auger
ST:	Thin-Walled Tube – 2.5" O.D., unless otherwise noted	PA:	Power Auger
RS:	Ring Sampler - 2.42" I.D., 3" O.D., unless otherwise noted	HA:	Hand Auger
CB:	California Barrel - 1.92" I.D., 2.5" O.D., unless otherwise noted	RB:	Rock Bit
BS:	Bulk Sample or Auger Sample	WB:	Wash Boring or Mud Rotary

The number of blows required to advance a standard 2-inch O.D. split-spoon sampler (SS) the last 12 inches of the total 18-inch penetration with a 140-pound hammer falling 30 inches is considered the "Standard Penetration" or "N-value". For 2.5" O.D. California Barrel samplers (CB) the penetration value is reported as the number of blows required to advance the sampler 12 inches using a 140-pound hammer falling 30 inches, reported as "blows per inch," and is not considered equivalent to the "Standard Penetration" or "N-value".

WATER LEVEL MEASUREMENT SYMBOLS:

WL:	Water Level	WS:	While Sampling
WCI:	Wet Cave in	WD:	While Drilling
DCI:	Dry Cave in	BCR:	Before Casing Removal
AB:	After Boring	ACR:	After Casing Removal

Water levels indicated on the boring logs are the levels measured in the borings at the times indicated. Groundwater levels at other times and other locations across the site could vary. In pervious soils, the indicated levels may reflect the location of groundwater. In low permeability soils, the accurate determination of groundwater levels may not be possible with only short-term observations.

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

FINE-GRAINED SOILS			COARSE-GRAINED SOILS			BEDROCK		
(CB) Blows/Ft.	(SS) Blows/Ft.	Consistency	(CB) Blows/Ft.	(SS) Blows/Ft.	Relative Density	(CB) Blows/Ft.	(SS) Blows/Ft.	Consistency
< 3	0-2	Very Soft	0-5	< 3	Very Loose	< 24	< 20	Weathered
3-5	3-4	Soft	6-14	4-9	Loose	24-35	20-29	Firm
6-10	5-8	Medium Stiff	15-46	10-29	Medium Dense	36-60	30-49	Medium Hard
11-18	9-15	Stiff	47-79	30-50	Dense	61-96	50-79	Hard
19-36	16-30	Very Stiff	> 79	> 50	Very Dense	> 96	> 79	Very Hard
> 36	> 30	Hard						

RELATIVE PROPORTIONS OF SAND AND GRAVEL

Descriptive Terms of Other Constituents	Percent of Dry Weight
Trace	< 15
With	15 – 29
Modifier	> 30

GRAIN SIZE TERMINOLOGY

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

RELATIVE PROPORTIONS OF FINES

Descriptive Terms of Other Constituents	Percent of Dry Weight
Trace	< 5
With	5 – 12
Modifiers	> 12

PLASTICITY DESCRIPTION

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

UNIFIED SOIL CLASSIFICATION SYSTEM

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

[A] Based on the material passing the 3-in. (75-mm) sieve

[B] If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.

[C] Gravels with 5 to 12% fines require dual symbols: GW-GM well graded gravel with silt, GW-GC well graded gravel with clay, GP-GM poorly graded gravel with silt, GP-GC poorly graded gravel with clay.

[D] Sands with 5 to 12% fines require dual symbols: SW-SM well graded sand with silt, SW-SC well graded sand with clay, SP-SM poorly graded sand with silt, SP-SC poorly graded sand with clay

[E] $Cu = D_{60}/D_{10}$ $\quad Cc = \dfrac{(D_{30})^2}{D_{10} \times D_{60}}$

[F] If soil contains ≥ 15% sand, add "with sand" to group name.

[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

[H] If fines are organic, add "with organic fines" to group name.

[I] If soil contains ≥ 15% gravel, add "with gravel" to group name.

[J] If Atterberg limits plot in shaded area, soil is a CL-ML, silty clay.

[K] If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel," whichever is predominant.

[L] If soil contains ≥ 30% plus No. 200 predominantly sand, add "sandy" to group name.

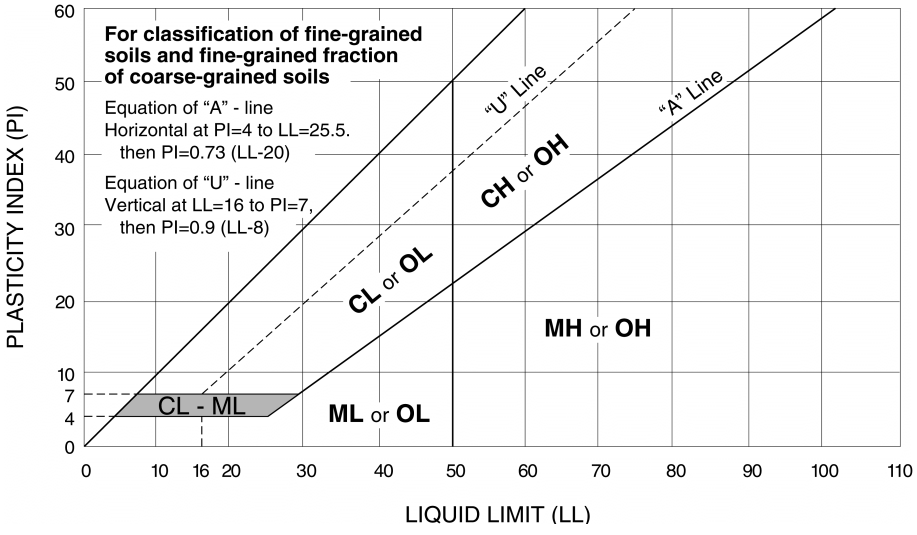
[M] If soil contains ≥ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.

[N] PI ≥ 4 and plots on or above "A" line.

[O] PI < 4 or plots below "A" line.

[P] PI plots on or above "A" line.

[Q] PI plots below "A" line.



ROCK CLASSIFICATION
(Based on ASTM C-294)

Sedimentary Rocks

Sedimentary rocks are stratified materials laid down by water or wind. The sediments may be composed of particles or pre-existing rocks derived by mechanical weathering, evaporation or by chemical or organic origin. The sediments are usually indurated by cementation or compaction.

Chert Very fine-grained siliceous rock composed of micro-crystalline or cyrptocrystalline quartz, chalcedony or opal. Chert is various colored, porous to dense, hard and has a conchoidal to splintery fracture.

Claystone Fine-grained rock composed of or derived by erosion of silts and clays or any rock containing clay. Soft massive and may contain carbonate minerals.

Conglomerate Rock consisting of a considerable amount of rounded gravel, sand and cobbles with or without interstitial or cementing material. The cementing or interstitial material may be quartz, opal, calcite, dolomite, clay, iron oxides or other materials.

Dolomite A fine-grained carbonate rock consisting of the mineral dolomite [$CaMg(CO_3)_2$]. May contain noncarbonate impurities such as quartz, chert, clay minerals, organic matter, gypsum and sulfides. Reacts with hydrochloric acid (HCL).

Limestone A fine-grained carbonate rock consisting of the mineral calcite ($CaCO_3$). May contain noncarbonate impurities such as quartz, chert, clay minerals, organic matter, gypsum and sulfides. Reacts with hydrochloric acid (HCL).

Sandstone Rock consisting of particles of sand with or without interstitial and cementing materials. The cementing or interstitial material may be quartz, opal, calcite, dolomite, clay, iron oxides or other material.

Shale Fine-grained rock composed of or derived by erosion of silts and clays or any rock containing clay. Shale is hard, platy, of fissile may be gray, black, reddish or green and may contain some carbonate minerals (calcareous shale).

Siltstone Fine grained rock composed of or derived by erosion of silts or rock containing silt. Siltstones consist predominantly of silt sized particles (0.0625 to 0.002 mm in diameter) and are intermediate rocks between claystones and sandstones and may contain carbonate minerals.

LABORATORY TEST
SIGNIFICANCE AND PURPOSE

TEST	SIGNIFICANCE	PURPOSE
California Bearing Ratio	Used to evaluate the potential strength of subgrade soil, subbase, and base course material, including recycled materials for use in road and airfield pavements.	***Pavement Thickness Design***
Consolidation	Used to develop an estimate of both the rate and amount of both differential and total settlement of a structure.	***Foundation Design***
Direct Shear	Used to determine the consolidated drained shear strength of soil or rock.	***Bearing Capacity, Foundation Design, and Slope Stability***
Dry Density	Used to determine the in-place density of natural, inorganic, fine-grained soils.	***Index Property Soil Behavior***
Expansion	Used to measure the expansive potential of fine-grained soil and to provide a basis for swell potential classification.	***Foundation and Slab Design***
Gradation	Used for the quantitative determination of the distribution of particle sizes in soil.	***Soil Classification***
Liquid & Plastic Limit, Plasticity Index	Used as an integral part of engineering classification systems to characterize the fine-grained fraction of soils, and to specify the fine-grained fraction of construction materials.	***Soil Classification***
Permeability	Used to determine the capacity of soil or rock to conduct a liquid or gas.	***Groundwater Flow Analysis***
pH	Used to determine the degree of acidity or alkalinity of a soil.	***Corrosion Potential***
Resistivity	Used to indicate the relative ability of a soil medium to carry electrical currents.	***Corrosion Potential***
R-Value	Used to evaluate the potential strength of subgrade soil, subbase, and base course material, including recycled materials for use in road and airfield pavements.	***Pavement Thickness Design***
Soluble Sulfate	Used to determine the quantitative amount of soluble sulfates within a soil mass.	***Corrosion Potential***
Unconfined Compression	To obtain the approximate compressive strength of soils that possess sufficient cohesion to permit testing in the unconfined state.	***Bearing Capacity Analysis for Foundations***
Water Content	Used to determine the quantitative amount of water in a soil mass.	***Index Property Soil Behavior***

REPORT TERMINOLOGY
(Based on ASTM D653)

Allowable Soil Bearing Capacity	The recommended maximum contact stress developed at the interface of the foundation element and the supporting material.
Alluvium	Soil, the constituents of which have been transported in suspension by flowing water and subsequently deposited by sedimentation.
Aggregate Base Course	A layer of specified material placed on a subgrade or subbase usually beneath slabs or pavements.
Backfill	A specified material placed and compacted in a confined area.
Bedrock	A natural aggregate of mineral grains connected by strong and permanent cohesive forces. Usually requires drilling, wedging, blasting or other methods of extraordinary force for excavation.
Bench	A horizontal surface in a sloped deposit.
Caisson (Drilled Pier or Shaft)	A concrete foundation element cast in a circular excavation which may have an enlarged base. Sometimes referred to as a cast-in-place pier or drilled shaft.
Coefficient of Friction	A constant proportionality factor relating normal stress and the corresponding shear stress at which sliding starts between the two surfaces.
Colluvium	Soil, the constituents of which have been deposited chiefly by gravity such as at the foot of a slope or cliff.
Compaction	The densification of a soil by means of mechanical manipulation
Concrete Slab-on-Grade	A concrete surface layer cast directly upon a base, subbase or subgrade, and typically used as a floor system.
Differential Movement	Unequal settlement or heave between, or within foundation elements of structure.
Earth Pressure	The pressure exerted by soil on any boundary such as a foundation wall.
ESAL	Equivalent Single Axle Load, a criteria used to convert traffic to a uniform standard, (18,000 pound axle loads).
Engineered Fill	Specified material placed and compacted to specified density and/or moisture conditions under observations of a representative of a geotechnical engineer.
Equivalent Fluid	A hypothetical fluid having a unit weight such that it will produce a pressure against a lateral support presumed to be equivalent to that produced by the actual soil. This simplified approach is valid only when deformation conditions are such that the pressure increases linearly with depth and the wall friction is neglected.
Existing Fill (or Man-Made Fill)	Materials deposited throughout the action of man prior to exploration of the site.
Existing Grade	The ground surface at the time of field exploration.

REPORT TERMINOLOGY
(Based on ASTM D653)

Expansive Potential	The potential of a soil to expand (increase in volume) due to absorption of moisture.
Finished Grade	The final grade created as a part of the project.
Footing	A portion of the foundation of a structure that transmits loads directly to the soil.
Foundation	The lower part of a structure that transmits the loads to the soil or bedrock.
Frost Depth	The depth at which the ground becomes frozen during the winter season.
Grade Beam	A foundation element or wall, typically constructed of reinforced concrete, used to span between other foundation elements such as drilled piers.
Groundwater	Subsurface water found in the zone of saturation of soils or within fractures in bedrock.
Heave	Upward movement.
Lithologic	The characteristics which describe the composition and texture of soil and rock by observation.
Native Grade	The naturally occurring ground surface.
Native Soil	Naturally occurring on-site soil, sometimes referred to as natural soil.
Optimum Moisture Content	The water content at which a soil can be compacted to a maximum dry unit weight by a given compactive effort.
Perched Water	Groundwater, usually of limited area maintained above a normal water elevation by the presence of an intervening relatively impervious continuous stratum.
Scarify	To mechanically loosen soil or break down existing soil structure.
Settlement	Downward movement.
Skin Friction (Side Shear)	The frictional resistance developed between soil and an element of the structure such as a drilled pier.
Soil (Earth)	Sediments or other unconsolidated accumulations of solid particles produced by the physical and chemical disintegration of rocks, and which may or may not contain organic matter.
Strain	The change in length per unit of length in a given direction.
Stress	The force per unit area acting within a soil mass.
Strip	To remove from present location.
Subbase	A layer of specified material in a pavement system between the subgrade and base course.
Subgrade	The soil prepared and compacted to support a structure, slab or pavement system.

APPENDIX D

INFORMATION FROM PREVIOUS GEOTECHNICAL STUDY:
BORING LOGS
SUMMARY OF LABORATORY TEST RESULTS

Cole Garner Geotechnical
1070 W. 124th Avenue, Suite 300
Westminster, CO. 80234
Telephone: 303.996.2999

BORING NUMBER 1

CLIENT XTR Midstream, LLC
PROJECT NAME Broomfield Central Gathering Facility
PROJECT NUMBER 17.22.066
PROJECT LOCATION Weld County Roads 6 and 15 - Weld County, CO
DATE STARTED 5/30/17 **COMPLETED** 5/30/17
GROUND SURFACE ELEV. 5095 ft **PROPOSED ELEV.** Not Provided
DRILLING CONTRACTOR Dakota Drilling
SURFACE CONDITIONS Low growth of grass/weeds
DRILLING METHOD CME-55/Solid Stem Auger
GROUND WATER LEVELS:
HAMMER TYPE Manual
▽ **DURING DRILLING** 15.00 ft / Elev 5080.00 ft
LOGGED BY BE **CHECKED BY** AG
▼ **AFTER DRILLING** 13.00 ft / Elev 5082.00 ft - 6/6/17

GRAPHIC LOG	MATERIAL DESCRIPTION	DEPTH (ft)	USCS SYMBOL	SAMPLE TYPE	RECOVERY %	PENETRATION blows/in	MOISTURE CONTENT (%)	DRY UNIT WT. (pcf)	SWELL-CONSOL /SURCHARGE LOAD, %psf
	LEAN CLAY with SAND, brown, light brown, moist, very stiff	0							
			CL	CB	100	26 / 12	16.9	111	
			CL	CB	100	20 / 12	19.7	107	
	7 5088.0								
	CLAYSTONE BEDROCK, varies sandy, light brown, brown, olive-brown, grey, iron-stained, moist, medium hard to very hard	10	-	CB	100	45 / 12	16.1	111	+3.6/500
	▼								
	▽		-	CB	100	50 / 5	12.7	131	
		20	-	CB	100	50 / 7	13.7	120	
	25 5070.0		-	CB	100	50 / 6			

Approximate bottom of borehole at 25.0 feet.

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BORING NUMBER 2

CLIENT XTR Midstream, LLC
PROJECT NAME Broomfield Central Gathering Facility
PROJECT NUMBER 17.22.066
PROJECT LOCATION Weld County Roads 6 and 15 - Weld County, CO
DATE STARTED 5/30/17 **COMPLETED** 5/30/17
GROUND SURFACE ELEV. 5091 ft **PROPOSED ELEV.** Not Provided
DRILLING CONTRACTOR Dakota Drilling
SURFACE CONDITIONS Low growth of grass/weeds
DRILLING METHOD CME-55/Solid Stem Auger
GROUND WATER LEVELS:
HAMMER TYPE Manual
▽ **DURING DRILLING** 15.00 ft / Elev 5076.00 ft
LOGGED BY BE **CHECKED BY** AG
▼ **AFTER DRILLING** 5.50 ft / Elev 5085.50 ft - 6/6/17

GRAPHIC LOG	MATERIAL DESCRIPTION	DEPTH (ft)	USCS SYMBOL	SAMPLE TYPE	RECOVERY %	PENETRATION blows/in	MOISTURE CONTENT (%)	DRY UNIT WT. (pcf)	SWELL-CONSOL /SURCHARGE LOAD, %psf
	SANDY LEAN CLAY to CLAYEY SAND, brown, dark brown, iron-stained, calcareous, moist, very stiff/medium dense	0							
			SC	CB	100	24 / 12	20.1	102	
	▼ 5084.0								
	7								
	CLAYSTONE BEDROCK, sandy, light brown, brown, grey, iron-stained, moist, medium hard to very hard								
		10	-	CB	100	50 / 9	17.4	109	+4.8/500
	▽		-	CB	100	50 / 10	16.6	114	
		20	-	CB	100	50 / 9	18.2	112	
			-	CB	100	50 / 6	14.4	121	
		30	-	CB	100	50 / 8	14.1	119	
	35 5056.0		-	CB	100	50 / 5	12.3	114	

Approximate bottom of borehole at 35.0 feet.

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BORING NUMBER 3

CLIENT XTR Midstream, LLC
PROJECT NAME Broomfield Central Gathering Facility
PROJECT NUMBER 17.22.066
PROJECT LOCATION Weld County Roads 6 and 15 - Weld County, CO
DATE STARTED 5/24/17 **COMPLETED** 5/24/17
GROUND SURFACE ELEV. 5094.5 ft **PROPOSED ELEV.** Not Provided
DRILLING CONTRACTOR Elite Drilling
SURFACE CONDITIONS Plowed field
DRILLING METHOD CME-55/Solid Stem Auger
GROUND WATER LEVELS:
HAMMER TYPE Automatic
▽ **DURING DRILLING** 6.00 ft / Elev 5088.50 ft
LOGGED BY BE **CHECKED BY** AG
▼ **AFTER DRILLING** 5.00 ft / Elev 5089.50 ft - 6/6/17

GRAPHIC LOG	MATERIAL DESCRIPTION	DEPTH (ft)	USCS SYMBOL	SAMPLE TYPE	RECOVERY %	PENETRATION blows/in	MOISTURE CONTENT (%)	DRY UNIT WT. (pcf)	SWELL-CONSOL /SURCHARGE LOAD, %psf
		0							
	LEAN CLAY with SAND, light brown, brown, dark brown, moist to wet, soft		CL	CB	100	5 / 12	24.5	98	-1.5/500
		10	CL	CB	100	4 / 12	19.9	106	
12		5082.5							
	CLAYEY SAND, fine to coarse grained, with some gravel, brown, iron-stained, moist to wet, loose		SC	CB	100	9 / 12	14.5	124	
18		5076.5							
	SANDY LEAN CLAY, brown, iron-stained, moist to wet, medium stiff	20	CL	CB	100	9 / 12	17.3	111	
24		5070.5							
25	**CLAYSTONE BEDROCK**, sandy, light brown, brown, iron-stained, moist to wet, very hard	5069.5	-	CB	100	50 / 3	17.8	108	

Approximate bottom of borehole at 25.0 feet.

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BORING NUMBER 4

CLIENT XTR Midstream, LLC
PROJECT NAME Broomfield Central Gathering Facility
PROJECT NUMBER 17.22.066
PROJECT LOCATION Weld County Roads 6 and 15 - Weld County, CO
DATE STARTED 5/16/17 **COMPLETED** 5/16/17
GROUND SURFACE ELEV. 5110 ft **PROPOSED ELEV.** Not Provided
DRILLING CONTRACTOR Elite Drilling
SURFACE CONDITIONS Low growth of grass/weeds
DRILLING METHOD CME-55/Solid Stem Auger
GROUND WATER LEVELS:
HAMMER TYPE Automatic
▽ **DURING DRILLING** 12.00 ft / Elev 5098.00 ft
LOGGED BY BE **CHECKED BY** AG
▼ **AFTER DRILLING** 6.50 ft / Elev 5103.50 ft - 6/6/17

GRAPHIC LOG	MATERIAL DESCRIPTION	DEPTH (ft)	USCS SYMBOL	SAMPLE TYPE	RECOVERY %	PENETRATION blows/in	MOISTURE CONTENT (%)	DRY UNIT WT. (pcf)	SWELL-CONSOL /SURCHARGE LOAD, %psf
	LEAN CLAY with SAND, light brown, brown, dark brown, moist to wet, soft to stiff	0							
			CL	CB	100	5 / 12	20.0	88	
		10	CL	CB	100	17 / 12	13.7	116	
	12 ▽5098.0								
	CLAYSTONE BEDROCK, sandy, light brown, brown, dark brown, grey, iron-stained, moist, medium hard to very hard		-	CB	100	44 / 12	14.5	118	
		20	-	CB	100	41 / 12	15.0	119	
			-	CB	100	50 / 11	17.3	114	
		30	-	CB	100	50 / 8	13.0	121	
	35 5075.0		-	CB	100	50 / 6	16.7	118	

Approximate bottom of borehole at 35.0 feet.

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BORING NUMBER 5

CLIENT XTR Midstream, LLC
PROJECT NAME Broomfield Central Gathering Facility
PROJECT NUMBER 17.22.066
PROJECT LOCATION Weld County Roads 6 and 15 - Weld County, CO
DATE STARTED 5/16/17 **COMPLETED** 5/16/17
GROUND SURFACE ELEV. 5104.5 ft **PROPOSED ELEV.** Not Provided
DRILLING CONTRACTOR Elite Drilling
SURFACE CONDITIONS Low growth of grass/weeds
DRILLING METHOD CME-55/Solid Stem Auger
GROUND WATER LEVELS:
HAMMER TYPE Automatic
▽ **DURING DRILLING** 19.00 ft / Elev 5085.50 ft
LOGGED BY BE **CHECKED BY** AG
▼ **AFTER DRILLING** 3.00 ft / Elev 5101.50 ft - 6/6/17

GRAPHIC LOG	MATERIAL DESCRIPTION	DEPTH (ft)	USCS SYMBOL	SAMPLE TYPE	RECOVERY %	PENETRATION blows/in	MOISTURE CONTENT (%)	DRY UNIT WT. (pcf)	SWELL-CONSOL /SURCHARGE LOAD, %psf
	0								
	LEAN CLAY with SAND, light brown, brown, tan, olive-brown, calcareous, iron-stained, moist to wet, medium stiff ▼		CL	CB	100	9 / 12	23.0	101	
	8 5096.5								
	CLAYSTONE BEDROCK, varies sandy, light brown, brown, grey, iron-stained, moist, firm to very hard	10	-	CB	100	39 / 12	19.0	110	+2.0/500
			-	CB	100	33 / 12	19.3	109	
	▽	20	-	SS	100	50 / 5			
	25 5079.5		-	CB	100	50 / 8	15.9	118	

Approximate bottom of borehole at 25.0 feet.

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BORING NUMBER 6

CLIENT XTR Midstream, LLC
PROJECT NAME Broomfield Central Gathering Facility
PROJECT NUMBER 17.22.066
PROJECT LOCATION Weld County Roads 6 and 15 - Weld County, CO
DATE STARTED 5/16/17 **COMPLETED** 5/16/17
GROUND SURFACE ELEV. 5098.5 ft **PROPOSED ELEV.** Not Provided
DRILLING CONTRACTOR Elite Drilling
SURFACE CONDITIONS Low growth of grass/weeds
DRILLING METHOD CME-55/Solid Stem Auger
GROUND WATER LEVELS:
HAMMER TYPE Automatic
▽ **DURING DRILLING** 8.50 ft / Elev 5090.00 ft
LOGGED BY BE **CHECKED BY** AG
▼ **AFTER DRILLING** 7.00 ft / Elev 5091.50 ft - 6/6/17

GRAPHIC LOG	MATERIAL DESCRIPTION	DEPTH (ft)	USCS SYMBOL	SAMPLE TYPE	RECOVERY %	PENETRATION blows/in	MOISTURE CONTENT (%)	DRY UNIT WT. (pcf)	SWELL-CONSOL /SURCHARGE LOAD, %psf
		0							
	LEAN CLAY with SAND, brown, dark brown, moist, soft to medium stiff		CL	CB	100	10 / 12	19.2	106	+0.1/500
			CL	CB	100	3 / 12	23.4	100	
	7 ▼5091.5								
	CLAYEY SAND, fine to coarse grained, brown, grey, iron-stained, moist to wet, loose to medium dense ▽	10	SC	CB	100	16 / 12	19.6	107	
			SC	CB	100	12 / 12	16.8	113	
	18 5080.5								
	CLAYSTONE BEDROCK, varies sandy, light brown, brown, dark grey, iron-stained, moist, medium hard	20	-	CB	100	43 / 12	16.8	113	
	25 5073.5		-	CB	100	36 / 12	15.0	116	

Approximate bottom of borehole at 25.0 feet.

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BORING NUMBER 7

CLIENT XTR Midstream, LLC
PROJECT NAME Broomfield Central Gathering Facility
PROJECT NUMBER 17.22.066
PROJECT LOCATION Weld County Roads 6 and 15 - Weld County, CO
DATE STARTED 5/16/17 **COMPLETED** 5/16/17
GROUND SURFACE ELEV. 5088.5 ft **PROPOSED ELEV.** Not Provided
DRILLING CONTRACTOR Elite Drilling
SURFACE CONDITIONS Low growth of grass/weeds
DRILLING METHOD CME-55/Solid Stem Auger
GROUND WATER LEVELS:
HAMMER TYPE Automatic
▽ **DURING DRILLING** 17.00 ft / Elev 5071.50 ft
LOGGED BY BE **CHECKED BY** AG
▼ **AFTER DRILLING** 2.00 ft / Elev 5086.50 ft - 6/6/17

GRAPHIC LOG	MATERIAL DESCRIPTION	DEPTH (ft)	USCS SYMBOL	SAMPLE TYPE	RECOVERY %	PENETRATION blows/in	MOISTURE CONTENT (%)	DRY UNIT WT. (pcf)	SWELL-CONSOL /SURCHARGE LOAD, %psf
	LEAN CLAY with SAND, light brown, brown, grey, calcareous, moist to wet, stiff ▼	0							
			CL	CB	100	18 / 12	18.8	110	
	9 5079.5								
	CLAYSTONE BEDROCK, varies sandy, light brown, dark brown, grey, calcareous, iron-stained, moist, firm to very hard	10	-	CB	100	30 / 12	16.8	115	+4.2/500
			-	CB	100	50 / 11	14.6	120	
	▽	20	-	CB	100	50 / 7	17.6	112	
			-	CB	100	50 / 8	19.3		
		30	-	CB	100	50 / 11	18.8	111	
			-	CB	100	50 / 7	14.4	121	
		40	-	CB	100	50 / 11	17.2	112	
			-	CB	100	50 / 5	16.5	113	
	50 5038.5	50	-	CB	100	50 / 6	15.1	117	

Approximate bottom of borehole at 50.0 feet.

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BORING NUMBER 8

CLIENT XTR Midstream, LLC
PROJECT NAME Broomfield Central Gathering Facility
PROJECT NUMBER 17.22.066
PROJECT LOCATION Weld County Roads 6 and 15 - Weld County, CO
DATE STARTED 5/30/17 **COMPLETED** 5/30/17
GROUND SURFACE ELEV. 5078.5 ft **PROPOSED ELEV.** Not Provided
DRILLING CONTRACTOR Dakota Drilling
SURFACE CONDITIONS Low growth of grass/weeds
DRILLING METHOD CME-55/Solid Stem Auger
GROUND WATER LEVELS:
HAMMER TYPE Manual
▽ **DURING DRILLING** 10.00 ft / Elev 5068.50 ft
LOGGED BY BE **CHECKED BY** AG
▼ **AFTER DRILLING** 5.00 ft / Elev 5073.50 ft - 6/6/17

GRAPHIC LOG	MATERIAL DESCRIPTION	DEPTH (ft)	USCS SYMBOL	SAMPLE TYPE	RECOVERY %	PENETRATION blows/in	MOISTURE CONTENT (%)	DRY UNIT WT. (pcf)	SWELL-CONSOL /SURCHARGE LOAD, %psf
		0							
	LEAN CLAY with SAND, light brown, brown, moist to wet, soft to medium stiff		CL	CB	100	8 / 12	18.1	106	-0.4/500
			CL	CB	100	4 / 12	25.5	96	
	9 5069.5								
	SANDY LEAN CLAY to CLAYEY SAND, varies with gravel, light brown, brown, tan, moist to wet, medium stiff to very stiff/loose to medium dense ▽	10	CL/SC	CB	100	6 / 12	21.5	104	
			CL/SC	CB	100	22 / 12	13.1	122	
	19 5059.5								
	CLAYSTONE BEDROCK, sandy, brown, olive-brown, grey, iron-stained, moist to wet, medium hard	20	-	CB	100	50 / 12	19.2	110	
	25 5053.5		-	CB	100	50 / 12	19.9	109	

Approximate bottom of borehole at 25.0 feet.

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BORING NUMBER 9

CLIENT XTR Midstream, LLC
PROJECT NAME Broomfield Central Gathering Facility
PROJECT NUMBER 17.22.066
PROJECT LOCATION Weld County Roads 6 and 15 - Weld County, CO
DATE STARTED 5/30/17 **COMPLETED** 5/30/17
GROUND SURFACE ELEV. 5070 ft **PROPOSED ELEV.** Not Provided
DRILLING CONTRACTOR Dakota Drilling
SURFACE CONDITIONS Low growth of grass/weeds
DRILLING METHOD CME-55/Solid Stem Auger
GROUND WATER LEVELS:
HAMMER TYPE Manual
▽ **DURING DRILLING** 17.00 ft / Elev 5053.00 ft
LOGGED BY BE **CHECKED BY** AG
▼ **AFTER DRILLING** 7.50 ft / Elev 5062.50 ft - 6/6/17

GRAPHIC LOG	MATERIAL DESCRIPTION	DEPTH (ft)	USCS SYMBOL	SAMPLE TYPE	RECOVERY %	PENETRATION blows/in	MOISTURE CONTENT (%)	DRY UNIT WT. (pcf)	SWELL-CONSOL /SURCHARGE LOAD, %psf
		0							
	LEAN CLAY with SAND, light brown, brown, moist to wet, very stiff		CL	CB	100	24 / 12	13.5	116	-0.4/500
	▼ 5061.0								
	9								
	CLAYEY SAND with GRAVEL, light brown, brown, moist to wet, medium dense	10	SC	CB	100	30 / 12	12.5	127	
	14 5056.0								
	CLAYSTONE BEDROCK with CLAYEY SANDSTONE lenses, light brown, brown, dark brown, olive-brown, grey, calcareous, iron-stained, moist, medium hard to very hard		-	CB	100	46 / 12	14.6	115	
	▽	20	-	CB	100	50 / 12	15.8	116	
			-	CB	100	50 / 6	14.3	116	
		30	-	CB	100	50 / 6	14.1	114	
	35 5035.0		-	CB	100	50 / 5	12.3	119	

Approximate bottom of borehole at 35.0 feet.

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BORING NUMBER 10

CLIENT XTR Midstream, LLC
PROJECT NAME Broomfield Central Gathering Facility
PROJECT NUMBER 17.22.066
PROJECT LOCATION Weld County Roads 6 and 15 - Weld County, CO
DATE STARTED 5/30/17 **COMPLETED** 5/30/17
GROUND SURFACE ELEV. 5081 ft **PROPOSED ELEV.** Not Provided
DRILLING CONTRACTOR Dakota Drilling
SURFACE CONDITIONS Low growth of grass/weeds
DRILLING METHOD CME-55/Solid Stem Auger
GROUND WATER LEVELS:
HAMMER TYPE Manual
▽ **DURING DRILLING** 15.00 ft / Elev 5066.00 ft
LOGGED BY BE **CHECKED BY** AG
▼ **AFTER DRILLING** 6.00 ft / Elev 5075.00 ft - 6/6/17

GRAPHIC LOG	MATERIAL DESCRIPTION	DEPTH (ft)	USCS SYMBOL	SAMPLE TYPE	RECOVERY %	PENETRATION blows/in	MOISTURE CONTENT (%)	DRY UNIT WT. (pcf)	SWELL-CONSOL /SURCHARGE LOAD, %psf
		0							
	LEAN CLAY with SAND, light brown, brown, dark brown, iron-stained, moist to wet, medium stiff		CL	CB	100	10 / 12	19.2	102	
	▼								
	8 5073.0								
	CLAYEY SAND, some gravel, light brown, dark brown, moist to wet, medium dense	10	SC	CB	100	41 / 12	19.1	105	+2.7/500
	14 5067.0								
	CLAYSTONE BEDROCK, varies sandy, light brown, brown, olive-brown, grey, iron-stained, calcareous, moist, hard to very hard ▽		-	CB	100	50 / 9	12.8	117	+3.2/1000
		20	-	CB	100	50 / 9	17.5	112	
	25 5056.0		-	CB	100	50 / 6	15.5	117	

Approximate bottom of borehole at 25.0 feet.

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Cole Garner Geotechnical
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SUMMARY OF LABORATORY RESULTS

CLIENT XTR Midstream, LLC

PROJECT NAME Broomfield Central Gathering Facility

PROJECT NUMBER 17.22.066

PROJECT LOCATION Weld County Roads 6 and 15 - Weld County, CO

Borehole	Depth	Soil Description	Water Content (%)	Dry Density (pcf)	Swell (+) or Consolidation (-)/ Surcharge (%/psf)	Water Soluble Sulfates (ppm)	Passing #200 Sieve (%)	Atterberg Limits		
								Liquid Limit	Plastic Limit	Plasticity Index
1	2	LEAN CLAY with SAND	16.9	111.1						
1	4	LEAN CLAY with SAND(CL)	19.7	107.0			81	47	21	26
1	9	CLAYSTONE BEDROCK	16.1	111.1	+3.6/500					
1	14	CLAYSTONE BEDROCK	12.7	131.1						
1	19	CLAYSTONE BEDROCK	13.7	120.1						
2	4	CLAYEY SAND(SC)	20.1	101.6			46	35	23	12
2	9	CLAYSTONE BEDROCK	17.4	109.3	+4.8/500					
2	14	CLAYSTONE BEDROCK	16.6	113.9						
2	19	CLAYSTONE BEDROCK	18.2	112.2						
2	24	CLAYSTONE BEDROCK	14.4	120.9						
2	29	CLAYSTONE BEDROCK	14.1	118.7						
2	34	CLAYSTONE BEDROCK	12.3	114.4						
3	4	LEAN CLAY with SAND(CL)	24.5	97.7	-1.5/500	1600	85	46	21	25
3	9	LEAN CLAY with SAND	19.9	105.8						
3	14	CLAYEY SAND	14.5	123.8						
3	19	SANDY LEAN CLAY	17.3	111.2						
3	24	CLAYSTONE BEDROCK	17.8	108.1						
4	4	LEAN CLAY with SAND	20.0	88.0						
4	9	LEAN CLAY with SAND	13.7	116.4			74	44	21	23
4	14	CLAYSTONE BEDROCK	14.5	118.1						
4	19	CLAYSTONE BEDROCK	15.0	118.7						
4	24	CLAYSTONE BEDROCK	17.3	114.2						
4	29	CLAYSTONE BEDROCK	13.0	120.9						
4	34	CLAYSTONE BEDROCK	16.7	117.6						
5	4	LEAN CLAY with SAND	23.0	101.5			79	47	20	27
5	9	CLAYSTONE BEDROCK	19.0	110.4	+2.0/500	900				
5	14	CLAYSTONE BEDROCK	19.3	109.3						
5	24	CLAYSTONE BEDROCK	15.9	117.6						
6	2	LEAN CLAY with SAND	19.2	105.6	+0.1/500					
6	4	LEAN CLAY with SAND	23.4	99.9						

LAB SUMMARY - GINT STD US LAB.GDT - 6/28/17 15:03 - C:\USERS\PUBLIC\DOCUMENTS\BENTLEY\GINT\PROJECTS GED 2017\17.22.066 BROOMFIELD CENTRAL GATHERING FACILITY.GPJ

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SUMMARY OF LABORATORY RESULTS

CLIENT XTR Midstream, LLC

PROJECT NAME Broomfield Central Gathering Facility

PROJECT NUMBER 17.22.066

PROJECT LOCATION Weld County Roads 6 and 15 - Weld County, CO

Borehole	Depth	Soil Description	Water Content (%)	Dry Density (pcf)	Swell (+) or Consolidation (-)/ Surcharge (%/psf)	Water Soluble Sulfates (ppm)	Passing #200 Sieve (%)	Atterberg Limits		
								Liquid Limit	Plastic Limit	Plasticity Index
6	9	CLAYEY SAND	19.6	106.7						
6	14	CLAYEY SAND	16.8	112.7			42	36	22	14
6	19	CLAYSTONE BEDROCK	16.8	112.6						
6	24	CLAYSTONE BEDROCK	15.0	116.1						
7	4	LEAN CLAY with SAND	18.8	110.1			70	44	21	23
7	9	CLAYSTONE BEDROCK	16.8	114.7	+4.2/500	1900				
7	14	CLAYSTONE BEDROCK	14.6	119.6						
7	19	CLAYSTONE BEDROCK	17.6	112.5						
7	24	CLAYSTONE BEDROCK	19.3							
7	29	CLAYSTONE BEDROCK	18.8	110.6						
7	34	CLAYSTONE BEDROCK	14.4	121.0						
7	39	CLAYSTONE BEDROCK	17.2	112.2						
7	44	CLAYSTONE BEDROCK	16.5	113.1						
7	49	CLAYSTONE BEDROCK	15.1	117.0						
8	2	LEAN CLAY with SAND	18.1	106.3	-0.4/500					
8	4	LEAN CLAY with SAND	25.5	95.8		1800				
8	9	SANDY LEAN CLAY to CLAYEY SAND	21.5	103.6						
8	14	SANDY LEAN CLAY to CLAYEY SAND	13.1	122.1						
8	19	CLAYSTONE BEDROCK	19.2	110.3						
8	24	CLAYSTONE BEDROCK	19.9	108.7						
9	4	LEAN CLAY with SAND(CL)	13.5	116.3	-0.4/500		74	43	21	22
9	9	CLAYEY SAND with GRAVEL	12.5	127.3						
9	14	CLAYSTONE BEDROCK	14.6	115.0						
9	19	SANDY CLAYSTONE TO CLAYEY SANDSTONE BEDROCK	15.8	116.5						
9	24	SANDY CLAYSTONE TO CLAYEY SANDSTONE BEDROCK	14.3	115.7						
9	29	CLAYSTONE BEDROCK	14.1	114.1						
9	34	CLAYSTONE BEDROCK	12.3	119.1						
10	4	LEAN CLAY with SAND	19.2	102.0						
10	9	CLAYEY SAND	19.1	104.6	+2.7/500					
10	14	CLAYSTONE BEDROCK	12.8	116.7	+3.2/1000					

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								Liquid Limit	Plastic Limit	Plasticity Index
10	19	CLAYSTONE BEDROCK	17.5	111.8						
10	24	CLAYSTONE BEDROCK	15.5	117.4						

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