Geotechnical Engineering Report

Cimarron Water Treatment Facility
State Highway 33 and State Highway 74
Cimarron City, Logan County, Oklahoma
January 26, 2017
Terracon Project No. 03165393

Prepared for:
Environmental Properties Management LLC
A Subsidiary of Burns & McDonnell Engineering Company
Kansas City, Missouri

Prepared by:
Terracon Consultants, Inc.
Oklahoma City, Oklahoma

terracon.com

Terracon

Environmental ■ Facilities ■ Geotechnical ■ Materials

Terracon

January 26, 2017

Environmental Properties Management LLC
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9400 Ward Parkway
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Attn: Mr. Jeff Lux, P.E.
Project Manager
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Re: Geotechnical Engineering Report
Cimarron Water Treatment Facility
State Highway 33 and State Highway 74
Cimarron City, Logan County, Oklahoma
Terracon Project No. 03165393

Dear Mr. Lux:

Terracon Consultants, Inc. (Terracon) has completed the geotechnical engineering services for the above referenced project. These services were performed in general accordance with our Proposal No. P03165393 dated October 28, 2016. This geotechnical engineering report presents the results of the subsurface exploration and provides geotechnical recommendations concerning earthwork, the design and construction of the building, nitrate treatment areas, tank foundations and pavements, and subgrade preparation for the structures.

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

Sincerely,
Terracon Consultants, Inc.
Cert. Of Auth. #CA-4531 exp. 6/30/17

Sheila Speller
for Diana Vargas-Suaza, E.I.
Consultant

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Copies to: Addressee (1 via email)

TABLE OF CONTENTS

TABLE OF CONTENTS - (Cont'd.)

EXECUTIVE SUMMARY

A geotechnical exploration has been performed for the proposed Cimarron Water Treatment Facility to be constructed southeast of Cimarron City, Logan County, Oklahoma. Terracon's geotechnical scope of work included the advancement of twelve (12) test borings to approximate depths of 14 to 34 feet below existing site grades. Borings were terminated at shallower depths due to the shallow weathered rock encountered in the borings. Boring B-6 was eliminated per the Client's request.

Based on the information obtained from our subsurface exploration, the following geotechnical considerations were identified:

- The borings in the treatment area generally encountered stiff to hard lean clays with varying amounts of sand and silt, hard, fat clay and dense to very dense, clayey and silty sands, to depths of about 5 to 6 feet. The overburden soils were underlain by highly weathered to weathered shale and sandstone extending to the boring termination depths. Groundwater was encountered in borings B-5 and B-7 at depths of about 13 to 23.5 feet at the time of field exploration. Groundwater was not encountered in the remaining treatment area borings at the time of exploration.

- The borings in the alluvial area generally encountered very loose to medium dense sands with varying amounts of silt, clay and gravel, and layers of clayey gravel and lean to fat clays extending to depths of about 17 to 31.5 feet. The overburden soils were underlain by highly weathered to weathered sandstone or highly weathered shale extending to the boring termination depths. Groundwater was encountered in the borings at depths varying from about 6 to 10 feet while drilling.

- Based on the subsurface conditions encountered, the proposed building can be supported on shallow footing foundations in conjunction with a slab-on-grade. The nitrate treatment areas and tanks can be supported on mat foundations and circular mat foundations respectively.

- Based on the existing topography and the information provided by the client, we understand that 2 feet of cut and or fill will required for this project.

- The on-site soils within the anticipated depth of seasonal moisture change generally have low to moderate shrink/swell potential and appear suitable for supporting the building floor slab provided the recommended proofrolling and moisture/density control are incorporated into subgrade preparation and fill placement.

- Excavations for the treatment area may extend into weathered bedrock. Rock formations that have standard penetration test results of 4 or more inches per 50 blows can usually be excavated with heavy excavation equipment equipped with ripping teeth. Rock formations that have standard penetration test results of 3 inches or less per 50 blows usually require either pneumatic equipment to remove. However, variations in hardness of rock can occur with depth and distance from the borings.

- To improve long-term support for the proposed pavements and gravel base areas, we recommend chemically stabilizing the pavement and gravel base subgrade.
- The international Building Code seismic site classification for the treatment area can be generalized as site class C and the alluvial area as site class D.
- Earthwork on the project should be observed and evaluated by Terracon. The evaluation of earthwork should include observation and testing of engineered fill, subgrade preparation, foundation bearing soils, and other geotechnical conditions exposed during construction.

This geotechnical executive 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.

GEOTECHNICAL ENGINEERING REPORT
CIMARRON WATER TREATMENT FACILITY
STATE HIGHWAY 33 AND STATE HIGHWAY 74
CIMARRON CITY, LOGAN COUNTY, OKLAHOMA

Terracon Project No. 03165393
January 26, 2017

1.0 INTRODUCTION

This report presents the results of our geotechnical engineering services performed for the proposed Cimarron Water Treatment Facility planned southeast of Cimarron City in Logan County, Oklahoma. Twelve (12) test borings extending to approximate depths of 14 to 34 feet below existing site grades were drilled for this project. Most borings were terminated at shallower depths due to the shallow weathered rock encountered in the borings. Boring B-6 was eliminated per the Client's request. The borings were drilled at the general locations specified by Burns & McDonnell Engineering Company.

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

- subsurface soil and rock conditions
- earthwork
- seismic site classification and hazards
- groundwater conditions
- foundation design and construction
- floor slab subgrade support
- pavement and gravel base design and construction

Logs of the borings along with a site location and exploration plan are included in Appendix A of this report.

2.0 PROJECT INFORMATION

2.1 Project Description

Item	Description
Site layout	See Exhibits A-1 to A-3 in Appendix A.

Item	Description
Structures	The proposed development consists of a water treatment facility comprising a pre-engineered metal building approximately 100 feet by 115 feet in plan, three nitrate treatment areas of approximately 45 feet by 90 feet each, and several tanks. The building will house equipment skids and tanks, electrical equipment, and an administrative area. The nitrate treatment areas will consist of skids and tanks. Stand-alone tanks are anticipated to have diameters as large as 15 feet and contain between 12,000 and 30,000 gallons of water.
Anticipated Loads and foundations	We understand the building columns are anticipated to be founded on shallow spread footing foundations with anticipated bearing pressures of 2000 psf. The building is anticipated to have a slab on grade floor system with loading conditions which include a dead load of 200 psf and forklift traffic. The nitrate treatment areas are anticipated to be founded on continuous mats, while the tanks are anticipated to be constructed on circular mats.
Traffic	Permanent asphalt pavement is anticipated around the perimeter of the building and the treatment areas. Some portions of the site are anticipated to have gravel base areas. Traffic loads include tractor-trailers during construction and operation, and passenger automobiles. We understand, post-construction traffic will consist of a maximum of 2 to 4 semi tractor-trailers per a day.
Grading	Based on the information provided by the client, we understand that up to 2 feet of cut and/or fill are planned per structure.
Slopes	Based on the existing topography and the boring elevations, slopes are not anticipated for this project.

2.2 Site Location and Description

Item	Description
Location	The site is located southeast of Cimarron City, approximately 3/4 mile northeast of the State Highway 33 and State Highway 74 intersection in Logan County, Oklahoma
Current ground cover	Grass, bare ground and trees.
Existing topography	The site generally slopes down from south to north and from west to east with a difference in elevation of approximately elevation difference of about 11 feet between the treatment area borings and about 3 feet between the alluvial area borings.

3.0 SUBSURFACE CONDITIONS

3.1 Geology

The geology at the alluvial area consist of Alluvium deposits of Quaternary age underlain by the Garber unit of Permian age. Alluvium deposits consist of deposits of sand, silt, clay, gravel, and/or combinations of materials. Alluvium is found along the flood plains of streams and is normally present at places along all streams. The Garber unit consists of a series of red clay shales, red sandy shales, and massive commonly cross-bedded lenticular sandstones. The total thickness of the Garber unit is about 400 feet in Oklahoma County, it thickens to about 600 feet.

The geology at the water treatment facility area consists of the Garber Unit of Permian age and the Hennessey unit of Permian age. The Hennessey unit consists of red platy to blocky clay shales and mudstone. The total thickness of the unit is about 400 feet.

3.1 Typical Subsurface Profile

Specific conditions encountered at each boring location are indicated on the individual boring logs included in Appendix A of this report. Stratification boundaries on the boring logs represent the approximate location of changes in soil and rock types; in-situ, the transition between materials may be gradual. Based on the results of the borings, subsurface conditions on the project site can be generalized as follows.

Description	Approximate Depth to Bottom of Stratum	Material Encountered	Consistency/Density
		Treatment Area	
Stratum 1A	3 to 6 feet	Lean clay with varying amounts of silt, clay and fat clay	Stiff to hard
Stratum 1B[1]	3 to 5 feet	Clayey or silty sand	Dense to very dense
Stratum 2	Below the boring termination depths of 14 to 29 feet	Highly weathered to weathered shale	Soft to hard
		Highly weathered to weathered sandstone	Poorly cemented to well cemented
		Alluvial Area	
Stratum 1A	27.5 to 31 feet	Sand with varying amounts of silt, clay and gravel	Very loose to medium dense
Stratum 1B[2]	3 feet	Lean clay with varying amounts of silt and sand	Stiff to very stiff
Stratum 1C[3]	3 to 4 feet	Fat clay	Stiff to very stiff
Stratum 2[4]	31.5 feet	Clayey gravel	Very dense

Description	Approximate Depth to Bottom of Stratum	Material Encountered	Consistency/Density
Stratum 3	Below the boring termination depths of 19 to 34 feet	Highly weathered to weathered sandstone	Poorly cemented to well cemented
		Highly weathered shale	Soft

[1] Clayey and silty sand layers were encountered in borings B-4 and B-5
[2] Encountered in borings B-10 and B-11
[3] Encountered in borings B-12 and B-13
[4] Encountered in boring B-11

Laboratory tests were conducted on selected soil and rock samples and the test results are presented on the boring logs in Appendix A.

3.2 Groundwater

The borings were monitored for the presence and level of groundwater while drilling, immediately after drilling and after 24 hours of drilling. Because drilling fluid was introduced into borings B-8 to B-13, groundwater observations were made prior to the introduction of drilling fluid and after 24 hours of drilling completion. As reported in the lower left corner of the boring logs, groundwater was encountered at the following depths.

Boring No.	While drilling Depth (ft.)	After boring Depth (ft)	24 Hours After boring Depth (ft)
B-1	Not Encountered	Not Encountered	Not Encountered
B-2	Not Encountered	Not Encountered	Not Encountered
B-3	Not Encountered	Not Encountered	Not Encountered
B-4	Not Encountered	Not Encountered	Not Encountered
B-5	15.0	15.0	13.0
B-7	23.5	23.0	21.0
B-8	10.0	N/A	5.0
B-9	8.5	N/A	8.0
B-10	8.5	N/A	4.0
B-11	8.5	N/A	3.0
B-12	6.0	N/A	6.0
B-13	6.0	N/A	5.0

To obtain more accurate groundwater level information, longer observations in a monitoring well or piezometer that is sealed from the influence of surface water would be needed. Fluctuations in groundwater levels can occur due to seasonal variations in the amount of rainfall, runoff, altered natural drainage paths and other factors not evident at the time the borings were advanced. Consequently, the designer and contractor should be aware of this possibility while designing and constructing this project.

4.0 RECOMMENDATIONS FOR DESIGN AND CONSTRUCTION

4.1 Geotechnical Considerations

It is our understanding that less than 2 feet of cut and/or fill will be required to develop the design grades for this site. The borings in the treatment area generally encountered moderate to high strength, native soils underlain by predominantly sandstone and shale bedrock below depths ranging from approximately 5 to 6 feet. Based on the subsurface conditions encountered in the borings and the anticipated foundation loads, the following foundation recommendations can be made:

Based on the subsurface conditions encountered, the proposed building can be supported on shallow footing foundations in conjunction with a slab-on-grade. The nitrate treatment areas and tanks can be supported on mat foundations and circular mat foundations, respectively.

The on-site soils within the anticipated depth of seasonal moisture change generally have low to moderate shrink/swell potential and appear suitable for supporting the building floor slab provided the recommended proofrolling and moisture/density control are incorporated into subgrade preparation and fill placement.

Excavations for the treatment area may extend into weathered bedrock. Rock formations that have standard penetration test results of 4 or more inches per 50 blows can usually be excavated with heavy excavation equipment equipped with ripping teeth. Rock formations that have standard penetration test results of 3 inches or less per 50 blows usually require either pneumatic equipment to remove. However, variations in hardness of rock can occur with depth and distance from the borings.

To improve long-term support for the proposed pavements and gravel base areas, we recommend chemically stabilizing the pavement and gravel base subgrade.

Geotechnical engineering recommendations for earthwork and the foundations are outlined below. The recommendations made in this report are based upon our engineering analyses of the field and laboratory testing performed and our current understanding of the proposed project.

4.2 Earthwork

The following presents recommendations for site preparation, subgrade preparation, and placement and compaction of engineered fill on the project. The recommendations presented for design and construction of earth supported elements including foundations, floor slab, tank bottoms and pavement and aggregate surfaced access roads are contingent upon following the recommendations outlined in this section.

Earthwork on the project should be observed and evaluated by Terracon. 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. Grading for each structure should incorporate the limits of each proposed structure plus a minimum pad blow-up of five feet beyond proposed perimeter walls and any exterior columns.

4.2.1 Site Preparation

Site preparation should include removing vegetation, topsoil, and any other unsuitable materials encountered on-site in construction areas. The necessary stripping depths should be determined at the time of construction by a representative of the geotechnical engineer.

4.2.2 Excavations

Excavations should meet all OSHA and other applicable safety regulations. Grading plans should develop effective drainage away from open excavations.

On-site clayey soils encountered in the treatment area can be removed using standard backhoe and loader type equipment. Excavations that extend near the sandstone or shale bedrock materials may require heavy equipment and special rock removal techniques to remove the sandstone and shale. Rock formations that have standard penetration test (SPT) results of 4 inches or more per 50 blows can usually be excavated by heavy equipment outfitted with ripping teeth. Rock formations that have SPT results of 3 inches or less per 50 blows may require pneumatic breaker equipment to remove. Variations in the hardness of rock are likely to occur with depth and distance between boring locations.

Groundwater was encountered at depths ranging from approximately 13 to 23.5 feet at the treatment area boring locations and at depths ranging from about 3 to 10.5 in the Alluvial area. Based on the groundwater level measurements obtained in our borings, we do not expect to encounter groundwater in excavations extending to a depth no greater than approximately 13 feet in the Treatment area. However, based on the groundwater conditions encountered in the alluvial area, excavations in the alluvial will encounter groundwater. Therefore, dewatering will likely be required for any excavations and if earthwork is performed in the alluvial area.

The overburden soils encountered in the treatment area were generally classified as Soil Type A and Soil Type B per OSHA guidelines while the soils encountered in the alluvial area were generally classified as Soil Type B and Soil Type C per OSHA guidelines. The contractor is solely responsible for designing and constructing stable construction excavations and all excavations should comply with applicable local, state and OSHA excavation standards. Individual borings should be consulted for additional information on the material that could be anticipated in the excavation. Additional soil borings could be performed in areas where more defined soil classification is required.

The soils to be penetrated by the proposed excavations may vary significantly across the site. The contractor should verify that similar conditions exist throughout the proposed area of excavation. If different subsurface conditions are encountered at the time of construction, the actual conditions should be evaluated to determine any excavation modifications necessary to maintain safe conditions.

4.2.3 Subgrade Preparation

After site stripping and completing any required cuts, but before placing any engineered fill, we recommend the site be proofrolled under the observation of Terracon personnel with a loaded, tandem-axle dump truck weighing at least 25 tons to locate any zones that are soft or unstable. The proofrolling should involve overlapping passes in mutually perpendicular directions. Where rutting or pumping is observed during proofrolling, the unstable soils should be overexcavated and replaced with engineered fill materials as described in Section 4.2.5 if it cannot be adequately compacted in-place. In areas where weathered sandstone or shale is encountered, proofrolling will not be required.

After proofrolling and correcting any unstable subgrade, we recommend the exposed subgrade soils to receive new fill be scarified to a depth of 8 inches. The moisture content of the scarified soil should be adjusted to its optimum value or above, prior to being compacted to at least 95 percent of its maximum dry density as determined by the standard Proctor test method (ASTM D 698. In areas where weathered sandstone or shale is exposed, it will not be necessary to scarify and compact the weathered sandstone or shale.

We recommend the subgrade beneath the tanks and nitrate treatment areas be developed with approved engineered soil fill to within 6 inches below final design elevation. Oklahoma department of transportation (ODOT) Type A Aggregated Base or similar granular material should be placed to develop the final design grade to provide improved, all-weather support for constructing each tank and nitrate treatment area. This will reduce the possible deterioration of the soil subgrade and provide a stable working surface.

4.2.4 Fill Materials Requirements

All fill required to develop the design subgrade elevation should be an approved material that is free of organic matter and debris as outlined in the following table.

Fill Type[1]	Acceptable Location for Placement
On-site or Imported Cohesive Low Volume Change Soils with $LL \leq 40$ and $5 \leq PI \leq 15$[2]	All locations and elevations
On-site or Imported Cohesive Soils with $40 < LL \leq 45$ and $15 < PI \leq 25$[3]	All locations and elevations, except in the building floor slab area
Weathered Shale, Weathered Sandstone[4]	Excavated rock should be tested and approved prior to its use as low volume change fill material.
Aggregate Base[5]	ODOT Type "A" Aggregate Base Materials
On-Site Soils (with $5 < PI < 25$)	Pavement areas[6]

[1] Prior to any filling operations, samples of the proposed borrow and on-site materials should be obtained for laboratory Atterberg limits and moisture-density testing. These tests will provide a basis for material acceptance and evaluation of fill compaction by in-place density testing. A qualified soil technician should perform sufficient in-place density tests during the filling operations to evaluate that proper levels of compaction, including dry unit weight and moisture content, are being attained.

[2] Some of the on-site clays appear to meet the requirements of a cohesive low volume change soil.

[3] Some of the on-site clays appear to meet the requirements of a cohesive soil with $40 < LL \leq 45$ and $15 < PI \leq 25$.

[4] Excavated rock (shale, sandstone) used for fill should have a maximum particle size of 3 inches. We anticipate that the excavated shale and poorly cemented sandstone will break down by compaction and tracked construction equipment. Harder sandstone should not be used as fill unless it is mechanically crushed to less than 3 inches in maximum dimension and mixed with clayey soils.

[5] Gradation requirements for the Type "A" material can be found in section 703 of the ODOT Standard Specifications for Highway Construction.

[6] Provided the top 8 inches are stabilized with Class "C" fly ash or cement kiln dust as discussed in the Pavements and aggregate base section of this report.

4.2.5 Fill Placement Compaction Requirements

The recommended compaction and moisture content criteria for engineered fill materials are as follows:

Item	Description
Fill Lift Thickness	■ 9-inches or less in loose thickness where heavy, self-propelled compaction equipment is used; or ■ 4 to 6 inches in loose thickness when hand-guided equipment (i.e. jumping jack or plate compactor) is used.

Item	Description
Compaction Requirements[1]	■ Tank, nitrate and building areas: At least 98 percent of the material's maximum dry density as determined by the standard Proctor test method (ASTM D 698). ■ Other areas: At least 95% (ASTM D 698).
Moisture Content-Cohesive Soil	Moisture content that is at or above its optimum value as determined by the Standard Proctor test method at the time of placement and compaction.
Moisture Content-ODOT Type "A" Aggregate Base or Approved Alternate	Workable moisture content that does not result in pumping when proofrolled.

1. Should the results of the in-place density tests indicate the specified moisture or compaction limits have not been met, the area represented by the test should be reworked and retested as required until the specified moisture and compaction requirements are achieved.

4.2.6 Grading and Drainage

Effective drainage should be provided during construction and maintained throughout the life of the development. Infiltration of water into utility trenches or foundation excavations should be prevented during construction. Planters and other surface features which could retain water in areas adjacent to the building or pavements should be sealed or eliminated. In areas where sidewalks or paving do not immediately adjoin the structures, we recommend that protective slopes be provided with a minimum grade of approximately five percent for at least 10 feet from perimeter walls. 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.

Downspouts, roof drains or scuppers should discharge in a manner that carries the water several feet away from the building when the ground surface adjacent to the structure is not protected by exterior slabs or paving. Sprinkler systems should not be installed within five feet of foundation walls. Landscaped irrigation adjacent to the foundation systems should be minimized or eliminated.

4.2.7 Corrosion Potential

Corrosion tests were performed on four selected samples to provide an indication of the corrosion potential of the on-site materials. This limited testing program should not be interpreted as a comprehensive assessment of the site, but only provides an indication of conditions at the sampled locations.

The measured sulfate contents of the samples ranged from 28 to 91. Results of soluble sulfate testing indicate that ASTM Type I Portland cement is suitable for all concrete on and below grade. Foundation concrete can be designed for low sulfate exposure in accordance with the provisions of the ACI Design Manual, Section 318, Chapter 4.

The measured chloride contents of the samples ranged from 25 to 50 mg/kg. Based on these test results, the risk of chloride exposure to reinforcing steel is rated as negligible according to ACI guidelines.

Laboratory test results indicate that on-site soils have resistivities ranging from 3414 to 7760 ohm-centimeters, and pH values ranging from 7.7 to 8.84. These values indicate the soils are mildly corrosive to moderately corrosive. Iron and steel pipes can be protected from corrosion through the use of cathodic protection or a polyethylene wrap/coating. Corrosion protection should be provided per the manufacturer's specifications.

Refer to Summary of Laboratory Results contained in Appendix B for the complete results of the various corrosivity testing conducted on the site soils in conjunction with this geotechnical exploration.

4.3 Foundations

Based on the subsurface conditions encountered in borings B-1 and B-2 and the anticipated foundation loads, the single-story building can be supported on shallow footing foundations in conjunction with a slab-on-grade.

We understand the tanks will be supported on circular mat foundations and the nitrate areas will be founded on continuous mats.

The following recommendations for designing the foundations assume that procedures recommend in the report for developing a stable subgrade beneath the structures have been effectively implemented.

4.3.1 Shallow Footing Foundations

Description	Value
Foundation Type	Shallow footings
Bearing Material	Undisturbed native soils and/or approved engineered fill
Net Allowable Bearing Pressure[1]	■ 2,000 psf on engineered fill and/or undisturbed native soils within 2.5 feet of existing ground ■ 3,000 psf on native soils located 2.5 feet below existing grade
Allowable Friction Coefficient[2]	0.2

Description	Value
Time Rate of Settlement	Most of the foundation settlement will occur within a few weeks after application of foundation loads
Allowable Passive Pressure[3]	150 pcf
Minimum Embedment Depth	To reduce moisture changes in the soils beneath the footings and for frost protection, we recommend that perimeter footings bear at least 24 inches below finished grade. Interior footings may be placed at shallower depths.
Frost Depth	18 inches
Minimum Dimensions	Isolated: 30 inches Continuous: 16 inches wide
Estimated Total Settlement	Less than 1/2 inch
Estimated Differential Settlement	Less than 1/2 of the total settlement

[1] These are the pressures at the base of the foundation in excess of the adjacent overburden pressure. The allowable bearing pressures have a safety factor of approximately 3 and can be increased by 33 percent for transient loads.

[2] The allowable friction coefficient has a safety factor of approximately 2.

[3] This value is appropriate for the undisturbed native soils or engineered backfill placed along the sides of the foundation. The allowable passive pressure has a safety factor of approximately 2. Ignore passive pressure in frost zone.

Care should be taken to prevent wetting or drying of the bearing materials during construction. Any extremely wet or dry material, or any loose or disturbed material in the bottom of the foundation excavations, should be removed prior to placing concrete. The potential for wetting or drying of the bearing materials can be reduced by placing concrete as soon as possible after completing the foundation excavations and evaluating the bearing strata.

Foundation excavations should be observed by the geotechnical engineer. If the bearing conditions encountered differ significantly from those presented in this report, supplemental recommendations will be required.

4.3.2 Mat Foundations

Description	Value
Foundation Type	Mat foundations
Bearing Material	Engineered fill and/or undisturbed native soils
Net Allowable Bearing Pressure[1]	2,500 psf
Allowable Friction Coefficient[2]	0.2
Time Rate of Settlement	Most of the foundation settlement will occur within a few weeks after application of foundation loads
Allowable Passive Pressure[3]	150 pcf

Description	Value
Coefficient of Subgrade Reaction[4]	125 pci
Minimum Embedment Depth	24 inches below finished grade
Frost Depth	18 inches
Estimated Total Settlement	Less than 1 1/2 inches (tank center) Less than 3/4 inch (tank perimeter) Less than 1 inch (continuous mats)

[1] This is the pressure at the base of the foundation in excess of the adjacent overburden pressure. The allowable bearing pressure has a safety factor of approximately 3 and can be increased by 33 percent for transient loads.

[2] The allowable friction coefficient has a safety factor of approximately 2.

[3] This value is appropriate for the undisturbed native soils or engineered backfill placed along the sides of the foundation. The allowable passive pressure has a safety factor of approximately 2. Ignore passive pressure in frost zone.

[4] This value is based on a 30-inch diameter plate. This value is estimated based on soil type and soil stiffness. This value assumes the tank floor will be supported on 6 inches of granular base (such as ASTM D 448 No. 57) over undisturbed native soils.

Care should be taken to prevent wetting or drying of the bearing materials during construction. Any extremely wet or dry material, or any loose or disturbed material in the bottom of the foundation excavations, should be removed prior to placing concrete. The potential for wetting or drying of the bearing materials can be reduced by placing concrete as soon as possible after completing the foundation excavations and evaluating the bearing strata.

Foundation excavations should be observed by the geotechnical engineer. If the bearing conditions encountered differ significantly from those presented in this report, supplemental recommendations will be required.

Staged preloading by partially filling the tanks and monitoring tank movements is recommended. The preloading should be done prior to final connection of the inlet and outlet lines. The staged preloading with movement monitoring will confirm the structural integrity of the tanks, verify adequate bearing capacity and reduce the amount of settlement that the tanks will experience after they are placed in operation.

The differential settlement of the tank shell depends on the local variability of the soil conditions and the amount of fill materials placed below the tank. Settlement response of the tank foundation is impacted greatly by the quality of construction. Improper foundation design and construction or ground improvement methods could result in differential settlements that are significantly greater than we have estimated.

4.4 Building Floor Slab

The on-site soils encountered within the anticipated zone of seasonal moisture change in the treatment area were generally low to medium plasticity clays. These soils are not expected to experience significant volume changes with variations in subgrade moisture content. Therefore, these near surface soils are considered adequate for providing direct support for the building floor slab provided the recommended proofrolling and moisture/density control are incorporated into subgrade preparation and fill placement.

We recommend the floor slab be supported on aggregate base materials. A coefficient of subgrade reaction of 150 pci can be used to design a floor slab constructed on a 6-inch thickness of aggregate. The 6-inch thickness of aggregate should consist of 2 inches of fine aggregate meeting the requirements of ASTM D 448 No. 10 (screenings) underlain by 4 inches of Type “A” aggregate meeting the requirements of Section 703.01 of the ODOT 2009 Standard Specifications for Highway Construction. The aggregate should be adjusted to a workable moisture content, prior to being compacted to at least 95 percent of its maximum dry density as determined by the standard Proctor test method (ASTM D 698).

Control joints should be saw cut into the slab as soon as practical after concrete placement in accordance with ACI Design Manual, Section 302.1R-37 8.3.12 (tooled control joints are not recommended). Additionally, dowels should be placed at the location of proposed construction joints. To control the width of cracking (where it occurs) continuous slab reinforcement should be considered.

Effective separations and/or isolation joints should be provided between slabs and all foundations, columns or utility lines to allow independent movement. Interior trench backfill placed beneath slabs should be compacted in accordance with recommendations outlined in the Earthwork section of this report. Other design and construction considerations, as outlined in the ACI Design Manual, Section 302.1R are recommended.

The use of a vapor retarder or barrier 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 and ACI 360 for procedures and cautions regarding the use and placement of a vapor retarder/barrier.

4.5 Seismic Hazards

The project site is located in a region of relatively low seismicity, except when considering the ground shaking hazard from induced earthquakes. The following table lists the relative likelihood of seismic hazards at the site and the methods Terracon used to evaluate the hazards.

Hazard	Relative Likelihood	Evaluation Method
Surface fault rupture	Low	Quaternary fault and fold database
Strong ground shaking	Low[1]	National seismic hazard maps
Soil liquefaction	Low	Field exploration and laboratory data
Landsliding	Low	Field reconnaissance and topographic maps
Settlement	Low	Empirical equations based on case histories

[1] See Section 4.5.6 for a discussion on induced earthquakes.

In Sections 4.5.1 through 4.5.5, we address seismic hazards from natural earthquakes only. In Section 4.5.6, we discuss the seismic hazard from both induced and natural earthquakes. That is, Sections 4.5.1 through 4.5.5 describe seismic hazards for the site based on the 2008 U.S. Geological Survey (USGS) United States National Seismic Hazard Model that are applicable to the seismic provisions of the 2015 IBC and ASCE 7-10.

4.5.1 Surface Fault Rupture

According to the Quaternary Fault and Fold Database of the United States (http://earthquake.usgs.gov/hazards/qfaults/) accessed on December 19, 2016, the only mapped fault in the State of Oklahoma is the Meers fault. The Meers fault has the following characteristics:

- The fault is located 145 km to the southwest in Comanche and Kiowa Counties.
- The total fault length is 54 km.
- The fault is one of at least four west- to northwest-trending faults that form the Frontal Wichita fault system, which is the boundary between the Anadarko basin to the northeast and the Wichita Mountains to the southwest.
- Two earthquakes occurred on the fault in the late Holocene (i.e., approximately the last 10,000 years) and a preceding event occurred in middle Pleistocene time or earlier.
- The slip-rate is less than 0.2 mm/year.

Given the distance from the Meers fault to the site, there is minimal risk of ground surface rupture due to faulting.

4.5.2 Strong Ground Shaking

We utilized the U.S. Seismic Design Maps web tool developed by the USGS and located at http://earthquake.usgs.gov/designmaps/us/application.php to determine design ground motion values for the site. Based on results of the exploration program, we assigned Site Class C to the Treatment Area and Site Class D to the Alluvial Area. Site Class is determined by the geologic profile to a depth of 100 feet, and our borings extended to a maximum depth of 14 to 34 feet. Therefore, we assumed that materials encountered at the bottom of the explorations extended to a depth of 100 feet in our determination of Site Class. Appendix B contains the Design Maps Detailed Report for both areas and the values are summarized in the table below.

Ground Motion Parameter	Site Class C Value[1]	Site Class D value[1]
PGA	0.125g	0.125g
S_s	0.223g	0.223g
S_1	0.071g	0.071g
F_{PGA}	1.200	1.549
F_a	1.200	1.600
F_v	1.700	2.400
PGA_M	0.151g	0.194g
S_{MS}	0.267g	0.357g
S_{M1}	0.121g	0.171g
S_{DS}	0.178g	0.238g
S_{D1}	0.081g	0.114g

[1] Latitude 35.882 and Longitude -97.583 degrees.

Deaggragation of the PGA value (https://geohazards.usgs.gov/deaggint/2008/) determined that nearly 92 percent of the hazard was from background seismicity with a magnitude (**M**) value of 5.6 and source-to-site distance (R) of 37 km. The remaining 8 percent of the hazard was attributable to the Meers fault with **M**7 and R = 145 km.

4.5.3 Soil Liquefaction

Liquefaction typically occurs in loose sands located below the water table. Of the two areas, only our explorations in the Alluvial Area encountered materials susceptible to liquefaction during strong ground shaking. However, we understand that no structures are to be located in the Alluvial Area and an evaluation of soil liquefaction for the area is not desired. Conversely, our explorations in the Treatment Area generally encountered clays over bedrock. Soft, saturated clay soils have experienced strength reduction during past earthquakes. However, groundwater in the Treatment Area, if observed, was located in the weathered bedrock below the potentially susceptible clay soils. Therefore, soils within the Treatment Area are not susceptible to soil liquefaction.

4.5.4 Landsliding

We anticipate that any permanent slopes at the site will be inclined at 3H:1V or flatter; and a maximum of 10 feet in height. Seismic loading of these relatively flat slopes is not anticipated to result in displacement except in the Alluvial Area where liquefaction of loose, saturated sands may result in a type of movement termed lateral spreading.

4.5.5 Earthquake Induced Settlement

Earthquake-induced settlement of materials in the Treatment Area is unlikely given the generally thin layer of stiff to hard clay overlying bedrock. Conversely, the loose sands in the Alluvial Area may experience both post-liquefaction reconsolidation settlement and dynamic compression as a result of earthquake loading. If fill is placed to raise grades at the site, the compaction recommendations of the Earthwork section of this report would essentially eliminate settlement of the structural fill.

4.5.6 USGS One-Year Hazard Forecast

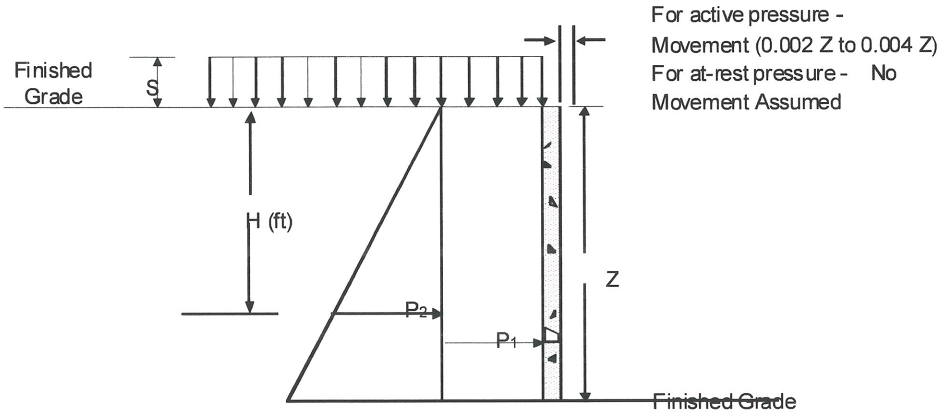
Earlier in 2016, the USGS published a one-year seismic hazard forecast from induced and natural earthquakes (Open-File Report 2016-1035). The forecast included the induced earthquakes listed in the table below. The list was obtained through a search of the USGS earthquake catalog (http://earthquake.usgs.gov/earthquakes/search/) for events with **M**4.5 or greater in the State of Oklahoma since December 12, 2011. We accessed the catalog on December 18, 2016.

Date	Location	Magnitude
11/7/16	3 km W of Cushing	5.0
9/3/16	14 km NW of Pawnee	5.8
2/13/16	31 km NW of Fairview	5.1
1/7/16	33 km NW of Fairview	4.7
11/30/15	26 km E of Cherokee	4.7
11/19/15	13 km SW of Cherokee	4.7
7/27/15	4 km NNE of Crescent	4.5
12/7/13	9 km ESE of Edmond	4.5

The report noted that the ground shaking seismic hazard for one-percent probability of exceedance in one year reaches 0.6g in northern Oklahoma. In addition, conversion of ground shaking to seismic intensity indicated that some places in Oklahoma have a chance of damage similar to that caused by natural earthquakes at sites in parts of California. If Environmental Properties Management LLC, A Subsidiary of Burns & McDonnell Engineering Company would like for Terracon to expand their evaluation of seismic hazards to include induced earthquakes, please contact us.

4.6 Lateral Earth Pressures

Walls with unbalanced backfill levels on opposite sides should be designed for earth pressures at least equal to those indicated in the following table. Earth pressures will be influenced by structural design of the walls, conditions of wall restraint, methods of construction and/or compaction and the strength of the materials being restrained. Two wall restraint conditions are shown. Active earth pressure is commonly used for design of free-standing cantilever retaining walls and assumes wall movement. The "at-rest" condition assumes no wall rotation. The recommended design lateral earth pressures do not include a factor of safety and do not provide for possible hydrostatic pressure on the walls.



EARTH PRESSURE COEFFICIENTS

EARTH PRESSURE CONDITIONS	COEFFICIENT FOR BACKFILL TYPE	EQUIVALENT FLUID PRESSURE (pcf)	SURCHARGE PRESSURE, P_1 (psf)	EARTH PRESSURE, P_2 (psf)
Active (Ka)	Granular - 0.33	40	(0.33)S	(40)H
	Lean Clay - 0.42	50	(0.42)S	(50)H
At-Rest (Ko)	Granular - 0.46	55	(0.46)S	(55)H
	Lean Clay - 0.58	70	(0.58)S	(70)H
Passive (Kp)	Granular - 3.0	360	---	---
	Lean Clay - 2.4	288	---	---

Conditions applicable to the above table include:

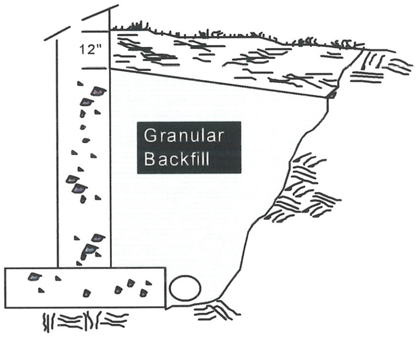
- For active earth pressure, wall must rotate about base, with top lateral movements 0.002 Z to 0.004 Z, where Z is wall height.
- For passive earth pressure, wall must move horizontally to mobilize resistance.
- Uniform surcharge, where S is surcharge pressure.
- In-situ soil backfill weight a maximum of 120 pcf.

- Horizontal backfill, compacted to at least 95 percent of standard Proctor (ASTM D-698) maximum dry density.
- Loading from heavy compaction equipment not included.
- No groundwater acting on wall.
- No safety factor included.
- Ignore passive pressure in frost zone.

Backfill placed against structures should consist of granular soils or low plasticity cohesive soils (PI ≤ 15). For the granular values to be valid, the granular backfill must extend out and up from the base of the wall at an angle of at least 45 and 60 degrees from vertical for the at-rest and passive cases, respectively. Additionally, the granular backfill must extend out from the base of the wall at an angle of at least 30 degrees from vertical for the active case. To calculate the resistance to sliding, values of 0.2 and 0.4 should be used as the allowable coefficients of friction between the footing and the underlying soil or weathered bedrock, respectively.

We recommend installing an exterior perimeter drain system along the below-grade walls. The exterior perimeter drains should be installed at the foundation level as shown on the adjacent figure and described in the following notes.

- Granular backfill should be clean, free-draining sand or crushed stone.
- Perforated pipe should be rigid PVC, sized to transport the expected water.
- Perforated pipe should be surrounded by at least 4 inches of ASTM C-33 No. 57 stone or equivalent with the stone and pipe encased in an approved filter fabric to restrict the migration of fines into the drain system.
- Exterior ground surface should consist of a 12-inch compacted clay cap or pavement section sloped to drain from building.



If adequate drainage is not possible, then combined hydrostatic and lateral earth pressures should be calculated for lean clay backfill using an equivalent fluid weighing 90 and 100 pcf for active and at-rest conditions, respectively. For granular backfill, an equivalent fluid weighing 85 and 90 pcf should be used for active and at-rest, respectively. These pressures do not include the influence of surcharge, equipment or floor loading, which should be added. Heavy equipment should not operate within a distance closer than the exposed height of retaining walls to prevent imposing lateral pressures larger than those provided.

4.7 Gravel Base Areas

Recommendations regarding site preparation, subgrade preparation and placement and compaction of engineered fill are provided in the Earthwork section of this report.

We recommend that the top 8 inches of the subgrade be stabilized with Class “C” fly ash or cement kiln dust. Based on past experience with soils similar to those present at the site, we estimate 10 to 14 percent Class “C” fly ash or cement kiln dust will be needed to adequately stabilize on-site soils. The actual percentage of additive should be determined at the time of construction by the geotechnical engineer. Before compaction, the stabilized soil zone should be adjusted to within 2 percent of the material’s optimum moisture as determined by the standard Proctor test method (ASTM D 698). After conditioning the soil to the required moisture content, the treated subgrade should be compacted to at least 98 percent of the material’s maximum dry density as determined by the standard Proctor test method (ASTM D 698). Compaction should be completed within about two hours after initially mixing the soil and stabilizing agent to optimize the stabilization benefit.

We understand traffic patterns and anticipated loading conditions will consist primarily of automobile traffic and occasional delivery and trash removal trucks. We also understand that approximately two to four semi-tractor a day will be entering the site after construction. Two aggregate base section categories have been provided. The light duty parking and drive category is for areas expected to receive only car traffic. The heavy duty parking and drive category assumes two to four semi-tractor trailers per day five days a week and three delivery and/or trash removal trucks per day in addition to car traffic. If the truck traffic loading expected is different than our assumptions, we should be provided the traffic information and allowed to review these aggregate base sections. The owner/user should consider placing signs at entryways to deter heavy trucks from light duty aggregate base areas.

Description	Value
Heavy Duty[1, 2]	12.0 inches of Type “A” Aggregate Base[3] 8.0” Stabilized Subgrade
Light Duty[1, 2]	6.0 inches of Type “A” Aggregate Base[3] 8.0” Stabilized Subgrade or Compacted Subgrade

1. It should be emphasized that aggregate base areas, regardless of the thickness or practical subgrade preparation measures, will require on-going maintenance and repairs to keep them in a serviceable condition. It is not practical to design an aggregate surfaced section of sufficient thickness that on-going maintenance will not be required. This is due to the porous nature of the aggregate that will allow precipitation and surface water to infiltrate and soften the subgrade soils, and the limited near surface strength of unconfined aggregate that makes it susceptible to rutting. When potholes, ruts, depressions or yielding subgrades develop they must be repaired prior to applying additional traffic loads. Typical repairs could consist of placing additional aggregate in ruts or depressed areas and, in some cases complete removal of aggregate surfacing, repair of

Description	Value

unstable subgrade, and replacement of the aggregate surfacing. Potholes and depressions should not be filled by blading adjacent ridges or high areas into the depressed areas. New material should be added to the depressed areas as they develop. Failure to make timely repairs will result in more rapid deterioration of the roadway/yard, making more extensive repairs necessary.

2. We recommend that ditches with inverts extending one foot below the soil subgrade be provided along both sides of the road. The road should be sloped to provide rapid drainage of surface water.
3. ODOT Type "A" aggregate meeting the requirements of Section 703.01. The aggregate should be compacted to at least 95 percent of its maximum dry density as determined by the standard Proctor test method (ASTM D 698).

4.8 Pavements

To improve long-term support for the proposed pavements, we recommend chemically stabilizing the pavement subgrade. Recommendations regarding site preparation, subgrade preparation, and placement and compaction of engineered fill are provided in the earthwork section of this report.

We recommend that the top 8 inches of the subgrade be stabilized with Class "C" fly ash or cement kiln dust. Based on past experience with soils similar to those present at the site, we estimate 10 to 14 percent Class "C" fly ash or cement kiln dust will be needed to adequately stabilize on-site soils. The actual percentage of additive should be determined at the time of construction by the geotechnical engineer. Before compaction, the stabilized soil zone should be adjusted to within 2 percent of the material's optimum moisture as determined by the standard Proctor test method (ASTM D 698). After conditioning the soil to the required moisture content, the treated subgrade should be compacted to at least 98 percent of the material's maximum dry density as determined by the standard Proctor test method (ASTM D 698). Compaction should be completed within about two hours after initially mixing the soil and stabilizing agent to optimize the stabilization benefit.

We understand traffic patterns and anticipated loading conditions will consist primarily of automobile traffic and occasional delivery and trash removal trucks. We also understand that approximately two to four semi-tractor trailers a day will be entering the site after construction. Two pavement section categories have been provided. The light duty parking and drive category is for areas expected to receive only car traffic. The heavy duty parking and drive category assumes two semi-tractor trailers per day five days a week and three delivery and/or trash removal trucks per day in addition to car traffic. If the truck traffic loading expected is different than our assumptions, we should be provided the traffic information and allowed to review these pavement sections. The owner/user should consider placing signs at entryways to deter heavy trucks from light duty pavement areas.

	Light Duty Parking and Drive	Heavy Duty Parking and Drive
Asphaltic Concrete[1]	2.0” Type “B” Asphaltic Concrete 3.0” Type “A” Asphaltic Concrete 8.0” Stabilized Subgrade	2.0” Type “B” Asphaltic Concrete 5.0” Type “A” Asphaltic Concrete 8.0” Stabilized Subgrade

[1] All materials should meet the ODOT Standard Specifications for Highway Construction.

Note: Reinforced concrete pads should be provided in front of and beneath trash receptacles. The dumpster trucks should be parked on the rigid concrete pavement when the trash receptacles are lifted. The concrete pads should be a minimum of 7 inches thick and properly reinforced.

These pavement sections are considered minimal sections based upon the expected traffic and the existing subgrade conditions. However, they are expected to function with periodic maintenance and overlays if good drainage is provided and maintained.

Pavement materials should not be placed when the surface is wet. Surface drainage should be provided away from the edge of paved areas to minimize lateral moisture transmission into the subgrade.

Openings in pavement, such as landscape islands, are sources for water infiltration into surroundings pavements. Water collects in the islands and migrates into the surrounding subgrade soils thereby degrading support of the pavement. This is especially applicable for islands with raised concrete curbs, irrigated foliage, and low permeability near-surface soils. The civil design for the pavements with these conditions should include features to restrict or to collect and discharge excess water from the islands. Examples of features are edge drains connected to the storm water collection system or other suitable outlet and impermeable barriers preventing lateral migration of water such as a cutoff wall installed to a depth below the pavement structure

Preventative maintenance should generally consist of both localized maintenance (e.g. crack sealing and patching) and global maintenance (e.g. surface sealing). It should be planned and provided for through an on-going pavement management program to enhance future pavement performance and preserve the pavement investment.

5.0 GENERAL COMMENTS

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

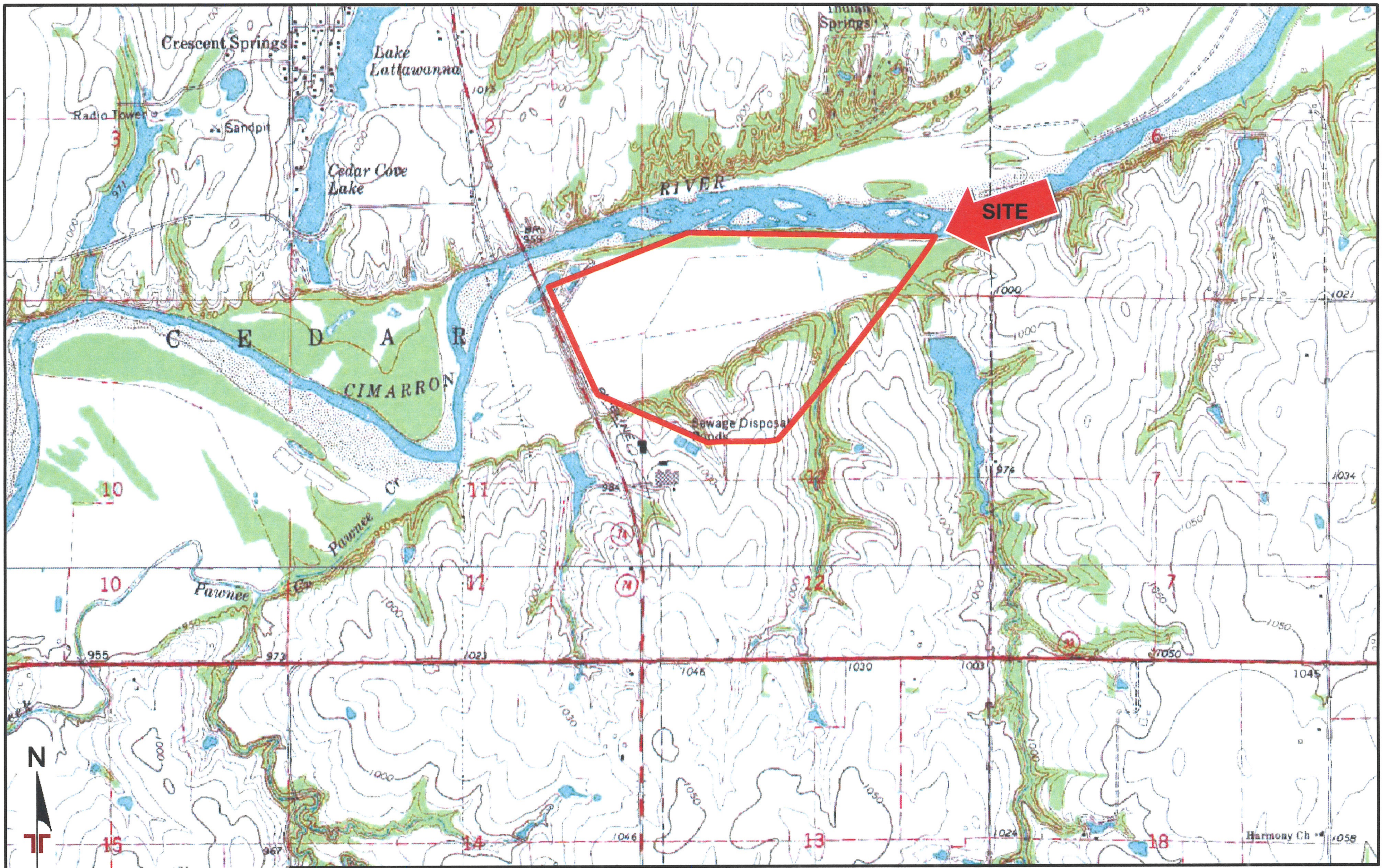
The analysis and recommendations presented in this report are based upon the data obtained from the borings performed at the indicated locations and from other information discussed in this report. This report does not reflect variations that may occur between borings, across the site, or due to the modifying effects of construction or 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 in the nature, design, or location of the project as outlined in this report are planned, the conclusions and recommendations contained in this report shall not be considered valid unless Terracon reviews the changes and either verifies or modifies the conclusions of this report in writing.

APPENDIX A

FIELD EXPLORATION



TOPOGRAPHIC MAP IMAGE COURTESY OF THE U.S. GEOLOGICAL SURVEY QUADRANGLES INCLUDE: CRESCENT, OK (1/1/1981) and NAVINA, OK (1/1/1970).

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

Project Manager:	DCVS	**Project No.**	03165393
Drawn by:	CAN	**Scale:**	1"=2,000'
Checked by:	DCVS	**File Name:**	A1-A3
Approved by:	JWB	**Date:**	DEC 2016

Terracon
4701 N Stiles Ave
Oklahoma City, OK 73105-3330

SITE LOCATION

Cimarron Water Treatment Facility
State Highway 33 & State Highway 74
Cimarron City, OK

Exhibit

A-1

AERIAL PHOTOGRAPHY PROVIDED BY MICROSOFT BING MAPS

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

Project Manager: DCVS	Project No. 03165393
Drawn by: CAN	Scale: AS SHOWN
Checked by: DCVS	File Name: A1-A3
Approved by: JWB	Date: DEC 2016

Terracon

4701 N Stiles Ave
Oklahoma City, OK 73105-3330

EXPLORATION PLAN

Cimarron Water Treatment Facility

State Highway 33 & State Highway 74
Cimarron City, OK

Exhibit

A-2

AERIAL PHOTOGRAPHY PROVIDED BY MICROSOFT BING MAPS

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

Project Manager: DCVS	Project No. 03165393
Drawn by: CAN	Scale: AS SHOWN
Checked by: DCVS	File Name: A1-A3
Approved by: JWB	Date: DEC 2016

Terracon
4701 N Stiles Ave
Oklahoma City, OK 73105-3330

EXPLORATION PLAN

Cimarron Water Treatment Facility
State Highway 33 & State Highway 74
Cimarron City, OK

Exhibit
A-3

Field Exploration Description

A total of twelve (12) test borings were drilled at the site on November 17 and 18, 2016. The borings were drilled to depths of approximately 14 to 34 feet below the ground surface at the approximate locations shown on the attached Boring Location Plan, Exhibit A-2. Some borings were terminated at shallower depths due to shallow bedrock. Boring B-6 was eliminated per the Client's request.

The borings were located in the field by Terracon personnel using a handheld GPS unit. The coordinates of each boring are shown on the boring logs. Surface elevations at the boring locations were provided by the Client. The surface elevations at the boring locations ranged from approximately 936 to 996 feet. The locations and elevations of the borings should be considered accurate only to the degree implied by the methods used to define them.

The borings were advanced using a tuck mounted, rotary drill rig equipped with continuous flight augers and a rotary bit. Representative samples were obtained by the split-barrel sampling procedure.

The split-barrel sampling procedure uses a standard 2-inch O.D. split-barrel sampling spoon that is driven into the bottom of the boring with a 140-pound drive hammer falling 30 inches. The number of blows required to advance the sampling spoon the last 12 inches, or less, of a typical 18-inch sampling interval or portion thereof, is recorded as the standard penetration resistance value, N. The N value is used to estimate the in-situ relative density of cohesionless soils and, to a lesser degree of accuracy, the consistency of cohesive soils and the hardness of sedimentary bedrock. The sampling depths, penetration distances, and the N values are reported on the boring logs. The samples were tagged for identification, sealed to reduce moisture loss and returned to the laboratory for further examination, testing and classification.

An automatic Standard Penetration Test (SPT) drive hammer was used to advance the split-barrel sampler. A greater mechanical efficiency is achieved with the automatic drive hammer when compared to a conventional safety drive hammer operated with a cathead and rope. This higher efficiency has been considered in our interpretation and analysis of the subsurface information provided with this report. The energy efficiency of our automatic drive hammer is approximately 82 percent.

A geologist prepared field boring logs as part of the drilling operations. These boring logs included visual classifications of the materials encountered during drilling and the geologist's interpretation of the subsurface conditions between samples. The final boring logs included with this report represent the geologist's interpretation of the field logs and include modifications based on observations and tests of the samples in the laboratory.

Exhibit A-4

As required by the Oklahoma Water Resources Board, any borings deeper than 20 feet, or borings that encounter groundwater or contaminated materials must be grouted or plugged in accordance with Oklahoma State statutes. One boring log must also be submitted to the Oklahoma Water Resources Board for each 10 acres of project site area. Terracon grouted the borings and submitted a log in order to comply with the Oklahoma Water Resources Board requirements.

BORING LOG NO. B-1

PROJECT: Cimarron Water Treatment Facility

CLIENT: Environmental Properties Management LLC
Kansas City, Missouri

SITE: State Highway 33 & State Highway 74
Cimarron City, Oklahoma

LOCATION See Exhibit A-2

Latitude: 35.88125° Longitude: -97.58076°
Northing: 321042.56 Easting: 2092178.53

Approximate Surface Elev: 985.0 (Ft.) +/-

DEPTH / ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (psf)	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
SANDY LEAN CLAY (CL), trace roots, brown to reddish-brown, stiff			☒	4	3-4-4 N=8			8			
-hard below 3.5'			☒	11	5-8-22 N=30	+9000 (HP)		9		30-13-17	68
6.0 979+/-	5										
+WEATHERED SANDSTONE, red, poorly cemented			⋈	6	50/6"			6			
			⋈	6	50/5"			6			
	10										
14.5 -well cemented at 13.5' 970.5+/-			⋈	7	38-50/1"			8			

Boring Terminated at 14.5 Feet

Driller: Paul Hacker
Helper: Matt Craig
Engineer/Geologist: Dillon Nolan
Boring Started: 5:15 PM
Boring Completed: 5:45 PM
Drill Rig: CME 970E
Drill Rig ID: 750X
Hammer Efficiency: 82%

Stratification lines are approximate. In-situ, the transition may be gradual.
+Classification estimated from disturbed samples. Core samples and petrographic analysis may reveal other rock types.

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

See Exhibit A-3 for description of field procedures.

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

See Appendix C for explanation of symbols and abbreviations.

Notes:

Surface Cover: Grass Field

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
4701 N Stiles Ave
Oklahoma City, OK

Boring Started: 11/17/2016	Boring Completed: 11/17/2016
Drill Rig: 387	Driller: P. Hacker
Project No.: 03165393	Exhibit: A-5

BORING LOG NO. B-2

Page 1 of 1

PROJECT: Cimarron Water Treatment Facility

CLIENT: Environmental Properties Management LLC
Kansas City, Missouri

SITE: State Highway 33 & State Highway 74
Cimarron City, Oklahoma

LOCATION See Exhibit A-2

Latitude: 35.88104° Longitude: -97.58042°
Northing: 320964.71 Easting: 2092267.83

Approximate Surface Elev: 989.0 (Ft.) +/-

GRAPHIC LOG	DEPTH		ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (psf)	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
		SANDY SILTY CLAY (CL-ML), dark red to reddish-gray, very stiff				☒	12	6-8-9 N=17	+9000 (HP)		6		24-18-6	52
		-hard below 3.5'				☒	6	17-19-21 N=40			7			
	6.0		983+/-	5										
		+HIGHLY WEATHERED SHALE, red, soft				☒	14	21-38-50/4"			9		26-17-9	84
							4	50/4"			9			
	10.0		979+/-	10										
		+WEATHERED SANDSTONE, red, well cemented												
	14.0		975+/-				2	50/2"			7			

Boring Terminated at 14 Feet

Driller: Paul Hacker
Helper: Matt Craig
Engineer/Geologist: Dillon Nolan
Boring Started: 4:30 PM
Boring Completed: 5:10 PM
Drill Rig: CME 970E
Drill Rig ID: 750X
Hammer Efficiency: 82%

Stratification lines are approximate. In-situ, the transition may be gradual.
+Classification estimated from disturbed samples. Core samples and petrographic analysis may reveal other rock types.

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

See Exhibit A-3 for description of field procedures.

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

See Appendix C for explanation of symbols and abbreviations.

Notes:

Surface Cover: Grass Field

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
4701 N Stiles Ave
Oklahoma City, OK

Boring Started: 11/17/2016	Boring Completed: 11/17/2016
Drill Rig: 387	Driller: P. Hacker
Project No.: 03165393	Exhibit: A-6

BORING LOG NO. B-3

Page 1 of 1

PROJECT: Cimarron Water Treatment Facility

CLIENT: Environmental Properties Management LLC
Kansas City, Missouri

SITE: State Highway 33 & State Highway 74
Cimarron City, Oklahoma

LOCATION See Exhibit A-2

Latitude: 35.88086° Longitude: -97.58056°
Northing: 320899.51 Easting: 2092224.76

Approximate Surface Elev: 991.5 (Ft.) +/-

GRAPHIC LOG	DEPTH / DESCRIPTION / ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (psf)	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
▨	**SANDY LEAN CLAY (CL)**, red, stiff			☒	6	6-6-8 N=14			7			
	3.0 988.5+/-											
▨	**FAT CLAY (CH)**, trace fine sand, dark red, hard			☒	10	10-15-18 N=33	+9000 (HP)		18		52-21-31	89
	6.0 985.5+/-	5										
▤	**+HIGHLY WEATHERED SHALE**, reddish-gray, soft			☒	14	40-50/5"			14			
▤				☒	12	21-28-50/5"			13		29-14-15	99
▤		10										
▤	14.5 977+/-			☒	12	32-50/2"			10			

Boring Terminated at 14.5 Feet

Driller: Paul Hacker
Helper: Matt Craig
Engineer/Geologist: Dillon Nolan
Boring Started: 3:30 PM
Boring Completed: 4:25 PM
Drill Rig: CME 970E
Drill Rig ID: 750X
Hammer Efficiency: 82%

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

+Classification estimated from disturbed samples. Core samples and petrographic analysis may reveal other rock types.

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

See Exhibit A-3 for description of field procedures.

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

See Appendix C for explanation of symbols and abbreviations.

Notes:

Surface Cover: Grass Field

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
4701 N Stiles Ave
Oklahoma City, OK

Boring Started: 11/17/2016	Boring Completed: 11/17/2016
Drill Rig: 387	Driller: P. Hacker
Project No.: 03165393	Exhibit: A-7

BORING LOG NO. B-4

Page 1 of 1

PROJECT: Cimarron Water Treatment Facility

CLIENT: Environmental Properties Management LLC
Kansas City, Missouri

SITE: State Highway 33 & State Highway 74
Cimarron City, Oklahoma

LOCATION See Exhibit A-2

Latitude: 35.8807° Longitude: -97.58057°
Northing: 320880.12 Easting: 2092352.53

Approximate Surface Elev: 992.5 (Ft.) +/-

GRAPHIC LOG	DEPTH		ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (psf)	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
▨	3.0	**SANDY LEAN CLAY (CL)**, red to reddish-gray, very stiff	989.5+/-			☒	14	8-7-12 N=19	+9000 (HP)		10			
▨	5.0	**SILTY SAND (SM)**, red, dense	987.5+/-	5		☒	12	30-18-21 N=39			7			
▤		**+HIGHLY WEATHERED SHALE**, red to reddish-gray, soft				☒	14	18-21-50/3"			13			96
▤						☒	14	33-50/5"			11			
▤	14.0		978.5+/-	10		☒	3	50/3"			7			

Boring Terminated at 14 Feet

Driller: Paul Hacker
Helper: Matt Craig
Engineer/Geologist: Dillon Nolan
Boring Started: 2:50 PM
Boring Completed: 3:15 PM
Drill Rig: CME 970E
Drill Rig ID: 750X
Hammer Efficiency: 82%

Stratification lines are approximate. In-situ, the transition may be gradual.
+Classification estimated from disturbed samples. Core samples and petrographic analysis may reveal other rock types.

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

See Exhibit A-3 for description of field procedures.

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

See Appendix C for explanation of symbols and abbreviations.

Notes:

Surface Cover: Grass Field

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
4701 N Stiles Ave
Oklahoma City, OK

Boring Started: 11/17/2016	Boring Completed: 11/17/2016
Drill Rig: 387	Driller: P. Hacker
Project No.: 03165393	Exhibit: A-8

BORING LOG NO. B-5

Page 1 of 1

PROJECT: Cimarron Water Treatment Facility

CLIENT: Environmental Properties Management LLC
Kansas City, Missouri

SITE: State Highway 33 & State Highway 74
Cimarron City, Oklahoma

LOCATION See Exhibit A-2

Latitude: 35.88037° Longitude: -97.58059°
Northing: 320742.17 Easting: 2092224.01

Approximate Surface Elev: 996.0 (Ft.) +/-

GRAPHIC LOG	DEPTH		ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (psf)	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
▨		**CLAYEY SAND (SC)**, red, very dense				☒	14	12-15-50/6"			7			
	3.0		993+/-											
▨		**LEAN CLAY (CL)**, red, hard				☒	16	15-18-25 N=43	+9000 (HP)		13			91
				5										
	6.0		990+/-											
⁘		**+HIGHLY WEATHERED SANDSTONE**, red, poorly cemented to cemented				☒	11	33-50/4"			14			
						⋈	6	50/3"			9			
				10										
					▼									
	14.0		982+/-			⋈	5	50/5"			17			
					▽									

Boring Terminated at 14 Feet

Driller: Paul Hacker
Helper: Matt Craig
Engineer/Geologist: Dillon Nolan
Boring Started: 2:10 PM
Boring Completed: 3:00 PM
Drill Rig: CME 970E
Drill Rig ID: 750X
Hammer Efficiency: 82%

Stratification lines are approximate. In-situ, the transition may be gradual.
+Classification estimated from disturbed samples. Core samples and petrographic analysis may reveal other rock types.

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Backfilled with cuttings above 4'; grouted 4' to 14'; backfilled with cuttings from 14' to termination depth.

See Exhibit A-3 for description of field procedures.

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

See Appendix C for explanation of symbols and abbreviations.

Notes:

Surface Cover: Grass Field

WATER LEVEL OBSERVATIONS

▽ *15 ft While drilling*
▽ *15 ft After Boring*
▼ *13 ft After 24 Hours*

Terracon
4701 N Stiles Ave
Oklahoma City, OK

Boring Started: 11/17/2016	Boring Completed: 11/17/2016
Drill Rig: 387	Driller: P. Hacker
Project No.: 03165393	Exhibit: A-9

BORING LOG NO. B-7

Page 1 of 1

PROJECT: Cimarron Water Treatment Facility

CLIENT: Environmental Properties Management LLC
Kansas City, Missouri

SITE: State Highway 33 & State Highway 74
Cimarron City, Oklahoma

LOCATION See Exhibit A-2

Latitude: 35.8811° Longitude: -97.58099°
Northing: 320986.85 Easting: 2092121.01

Approximate Surface Elev: 991.5 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (psf)	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
LEAN CLAY WITH SAND (CL), red, very stiff			☒	7	5-6-11 N=17	+9000 (HP)		9		31-18-13	75
6.0	985.5+/-										
+HIGHLY WEATHERED SHALE, red to dark red, soft to moderately hard			☒	4	16-50/3"			8			73
			☒	8	25-50/3"			9			
13.5	978+/-										
+WEATHERED SANDSTONE, red, cemented			☒	3	50/3"			7			
-poorly cemented below 18.5'			☒	5	50/5"			10			
		▼									
		▽ ▽									
			☒	5	50/5"			13			
29.0 -well cemented below 28.5'	962.5+/-		☒	2	50/2"			18			

Boring Terminated at 29 Feet

Driller: Paul Hacker
Helper: Matt Craig
Engineer/Geologist: Dillon Nolan
Boring Started: 1:00 PM
Boring Completed: 2:00 PM
Drill Rig: CME 970E
Drill Rig ID: 750X
Hammer Efficiency: 82%

Stratification lines are approximate. In-situ, the transition may be gradual.
+Classification estimated from disturbed samples. Core samples and petrographic analysis may reveal other rock types.

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Backfilled with cuttings above 4'; grouted 4' to 14'; backfilled with cuttings from 14' to termination depth.

See Exhibit A-3 for description of field procedures.

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

See Appendix C for explanation of symbols and abbreviations.

Notes:

Surface Cover: Grass Field

WATER LEVEL OBSERVATIONS

- ▽ *23.5 ft While Drilling*
- ▽ *23 ft After Boring*
- ▼ *21 ft After 24 Hours*

Terracon
4701 N Stiles Ave
Oklahoma City, OK

Boring Started: 11/17/2016	Boring Completed: 11/17/2016
Drill Rig: 387	Driller: P. Hacker
Project No.: 03165393	Exhibit: A-10

BORING LOG NO. B-8

PROJECT: Cimarron Water Treatment Facility

CLIENT: Environmental Properties Management LLC
Kansas City, Missouri

SITE: State Highway 33 & State Highway 74
Cimarron City, Oklahoma

LOCATION See Exhibit A-2

Latitude: 35.88775° Longitude: -97.5826°
Northing: 323425.84 Easting: 2092149.84

Approximate Surface Elev: 939.0 (Ft.) +/-

GRAPHIC LOG	DEPTH / ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (psf)	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
	SILTY SAND (SM), reddish-brown, loose			☒	14	3-3-3 N=6			6			
		5	▨	☒	16	5-3-3 N=6			4			
				☒	16	3-4-4 N=8			5		NP	20
	8.5 930.5+/-											
	POORLY GRADED SAND (SP), fine grained, light reddish-brown, loose	10	▽	☒	18	4-4-2 N=6			12			
	-fine to medium grained below 13'	15		☒	12	2-2-4 N=6			19		NP	4
		20		☒	10	3-3-3 N=6			15			
	-medium dense below 24'	25		☒	9	4-6-8 N=14			21		NP	2
		30		☒	12	4-8-20 N=28			13		NP	3
	31.0 908+/-											
	+WEATHERED SANDSTONE, red, well cemented											
	34.0 905+/-				0	50/1"						

Boring Terminated at 34 Feet

Driller: Paul Hacker
Helper: Matt Craig
Engineer/Geologist: Dillon Nolan
Boring Started: 3:15 PM
Boring Completed: 4:30 PM
Drill Rig: CME 970E
Drill Rig ID: 750X
Hammer Efficiency: 82%

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

+Classification estimated from disturbed samples. Core samples and petrographic analysis may reveal other rock types.

Hammer Type: Automatic

Advancement Method:
0' - 13.5' Power Auger
13.5' - 34' Wash Boring

Abandonment Method:
Backfilled with cuttings above 4'; grouted 4' to 14'; backfilled with cuttings from 14' to termination depth.

See Exhibit A-3 for description of field procedures.

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

See Appendix C for explanation of symbols and abbreviations.

Notes:

Surface Cover: Grass Field

WATER LEVEL OBSERVATIONS

▽ *10 ft While Drilling*

▨ *5 ft Wet Cave In After 24 Hours*

Terracon
4701 N Stiles Ave
Oklahoma City, OK

Boring Started: 11/18/2016	Boring Completed: 11/18/2016
Drill Rig: 387	Driller: P. Hacker
Project No.: 03165393	Exhibit: A-11

BORING LOG NO. B-9

Page 1 of 1

PROJECT: Cimarron Water Treatment Facility

CLIENT: Environmental Properties Management LLC
Kansas City, Missouri

SITE: State Highway 33 & State Highway 74
Cimarron City, Oklahoma

GRAPHIC LOG	LOCATION See Exhibit A-2 Latitude: 35.8866° Longitude: -97.57927° Northing: 323005.27 Easting: 2093125.68 Approximate Surface Elev: 936.0 (Ft.) +/- DEPTH / ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (psf)	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
	POORLY GRADED SAND WITH SILT (SP-SM), fine grained, light reddish-brown, medium dense			☒	12	9-7-8 N=15			8			
		5		☒	18	6-8-9 N=17			10			
	-fine to medium grained below 6' 7.5 928.5+/-		▨ ▽	☒	18	7-8-6 N=14			18		NP	8
	POORLY GRADED SAND (SP), fine to medium grained, light reddish-brown, very loose	10		☒	18	2-2-1 N=3			15			
	-loose below 13.5' 18.5 917.5+/-	15		☒	10	2-2-4 N=6			18		NP	3
	WELL GRADED SAND WITH SILT (SW-SM), light reddish-brown, loose 23.5 912.5+/-	20		☒	12	4-4-4 N=8			10		NP	7
	POORLY GRADED SAND WITH SILT (SP-SM), fine grained, light reddish-brown, medium dense 27.5 908.5+/-	25		☒		5-5-7 N=12			10		NP	8
	+WEATHERED SANDSTONE, red, well cemented 29.0 907+/-				1	50/2"						

Boring Terminated at 29 Feet

Driller: Paul Hacker
Helper: Matt Craig
Engineer/Geologist: Dillon Nolan
Boring Started: 2:15 PM
Boring Completed: 3:00 PM
Drill Rig: CME 970E
Drill Rig ID: 750X
Hammer Efficiency: 82%

Stratification lines are approximate. In-situ, the transition may be gradual.
+Classification estimated from disturbed samples. Core samples and petrographic analysis may reveal other rock types.

Hammer Type: Automatic

Advancement Method:
0' - 13.5' Power Auger
13.5' - 29' Wash Boring

Abandonment Method:
Backfilled with cuttings above 4'; grouted 4' to 14'; backfilled with cuttings from 14' to termination depth.

See Exhibit A-3 for description of field procedures.

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

See Appendix C for explanation of symbols and abbreviations.

Notes:

Surface Cover: Grass Field

WATER LEVEL OBSERVATIONS

▽ *8.5 ft While Drilling*

▨ *8 ft Wet Cave In After 24 Hours*

Terracon
4701 N Stiles Ave
Oklahoma City, OK

Boring Started: 11/18/2016	Boring Completed: 11/18/2016
Drill Rig: 387	Driller: P. Hacker
Project No.: 03165393	Exhibit: A-12

BORING LOG NO. B-10

Page 1 of 1

PROJECT: Cimarron Water Treatment Facility

CLIENT: Environmental Properties Management LLC
Kansas City, Missouri

SITE: State Highway 33 & State Highway 74
Cimarron City, Oklahoma

LOCATION See Exhibit A-2

Latitude: 35.88693° Longitude: -97.57183°
Northing: 323144.58 Easting: 2095331.7

Approximate Surface Elev: 937.0 (Ft.) +/-

GRAPHIC LOG	DEPTH / ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (psf)	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
	SILTY CLAY WITH SAND (CL-ML), dark reddish-brown, stiff 3.0 934+/-			☒	10	5-5-7 N=12			15		24-18-6	
	SILTY SAND (SM), fine grained, light reddish-brown, medium dense	5	▨	☒	12	6-6-4 N=10			9		NP	39
	-loose below 6' 7.5 929.5+/-			☒	16	5-4-4 N=8			10			
	POORLY GRADED SAND (SP), fine grained, light reddish-brown, loose -brown to grayish brown below 8.5'	10	▽	☒	16	1-2-3 N=5			18		NP	5
	18.5 918.5+/-	15		☒	14	3-3-2 N=5			18			
	POORLY GRADED SAND WITH SILT (SP-SM), fine grained, brown to grayish-brown, loose	20		☒	9	1-3-4 N=7			18		NP	10
	24.5 912.5+/-			☒	15	4-5-50/5"			14		NP	5
	25.0 **+HIGHLY WEATHERED SANDSTONE**, red, poorly cemented 912+/-	25										

Boring Terminated at 25 Feet

Driller: Paul Hacker
Helper: Matt Craig
Engineer/Geologist: Dillon Nolan
Boring Started: 1:15 PM
Boring Completed: 2:00 PM
Drill Rig: CME 970E
Drill Rig ID: 750X
Hammer Efficiency: 82%

Stratification lines are approximate. In-situ, the transition may be gradual.
+Classification estimated from disturbed samples. Core samples and petrographic analysis may reveal other rock types.

Hammer Type: Automatic

Advancement Method:
0' - 10' Power Auger
10' - 25' Wash Boring

Abandonment Method:
Backfilled with cuttings above 4'; grouted 4' to 14'; backfilled with cuttings from 14' to termination depth.

See Exhibit A-3 for description of field procedures.

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

See Appendix C for explanation of symbols and abbreviations.

Notes:

Surface Cover: Grass Field

WATER LEVEL OBSERVATIONS

▽ *8.5 ft While Drilling*

▨ *4 ft Wet Cave In After 24 Hours*

Terracon
4701 N Stiles Ave
Oklahoma City, OK

Boring Started: 11/18/2016	Boring Completed: 11/18/2016
Drill Rig: 387	Driller: P. Hacker
Project No.: 03165393	Exhibit: A-13

BORING LOG NO. B-11

Page 1 of 1

PROJECT: Cimarron Water Treatment Facility

SITE: State Highway 33 & State Highway 74
Cimarron City, Oklahoma

CLIENT: Environmental Properties Management LLC
Kansas City, Missouri

LOCATION See Exhibit A-2

Latitude: 35.88321° Longitude: -97.58491°
Northing: 321775.94 Easting: 2091462.7

Approximate Surface Elev: 937.0 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (psf)	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
LEAN CLAY WITH SAND (CL), brown, very stiff				☒	2	11-12-15 N=27	+9000 (HP)		8			74
3.0	934+/-		▨									
SILTY SAND (SM), fine grained, light reddish-brown, loose		5		☒	14	4-3-4 N=7			3		NP	20
				☒	14	3-2-5 N=7			20			
8.5	928.5+/-		▽									
POORLY GRADED SAND WITH SILT (SP-SM), fine grained, light brown to reddish-brown, loose to medium dense		10		☒	12	3-3-5 N=8			16		NP	7
									15			
-medium dense below 13.5'		15		☒	12	6-7-10 N=17						
18.5	918.5+/-											
POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM), fine grained, light brown to reddish-brown, medium dense		20		☒	4	1-1-12 N=13			12		NP	11
-fine to medium grained below 23.5'		25		☒	12	5-7-8 N=15			14		NP	11
28.5	908.5+/-											
CLAYEY GRAVEL (GC), red, very dense		30		☒	3	50/3"			15			
31.5	905.5+/-											
+WEATHERED SANDSTONE, red, cemented												
34.0	903+/-			☒	0	50/4"						

Boring Terminated at 34 Feet

Driller: Paul Hacker
Helper: Matt Craig
Engineer/Geologist: Dillon Nolan
Boring Started: 9:00 AM
Boring Completed: 10:15 AM
Drill Rig: CME 970E
Drill Rig ID: 750X
Hammer Efficiency: 82%

Stratification lines are approximate. In-situ, the transition may be gradual.
+Classification estimated from disturbed samples. Core samples and petrographic analysis may reveal other rock types.

Hammer Type: Automatic

Advancement Method:
0' - 13.5' Power Auger
13.5' - 34' Wash Boring

Abandonment Method:
Backfilled with cuttings above 4'; grouted 4' to 14'; backfilled with cuttings from 14' to termination depth.

See Exhibit A-3 for description of field procedures.

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

See Appendix C for explanation of symbols and abbreviations.

Notes:

Surface Cover: Grass Field

WATER LEVEL OBSERVATIONS

▽ *8.5 ft While Drilling*

▨ *3 ft Wet Cave In After 24 Hours*

Terracon
4701 N Stiles Ave
Oklahoma City, OK

Boring Started: 11/18/2016	Boring Completed: 11/18/2016
Drill Rig: 387	Driller: P. Hacker
Project No.: 03165393	Exhibit: A-14

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 03165393 CIMARRON WATER TREATMENT FACILITY.GPJ

BORING LOG NO. B-12

PROJECT: Cimarron Water Treatment Facility

CLIENT: Environmental Properties Management LLC
Kansas City, Missouri

SITE: State Highway 33 & State Highway 74
Cimarron City, Oklahoma

LOCATION See Exhibit A-2

Latitude: 35.88354° Longitude: -97.5815°
Northing: 321887.69 Easting: 2092462.14

Approximate Surface Elev: 936.0 (Ft.) +/-

GRAPHIC LOG	DEPTH / ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (psf)	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
▨	**FAT CLAY (CH)**, dark red, very stiff			☒	10	6-8-10 N=18	+9000 (HP)		18		61-20-41	95
	4.0 — 932+/-											
🟨	**POORLY GRADED SAND (SP)**, fine grained, light reddish-brown, loose to medium dense	5		☒	14	6-7-8 N=15			5			
			▽	☒	12	6-3-3 N=6			19		NP	3
		10		☒	11	12-3-2 N=5			21			
		15		☒	2	2-2-3 N=5			27		NP	3
	-fine to medium grained below 18.5'	20		☒	11	7-8-12 N=20			16		NP	5
	23.5 — 912.5+/-											
☰	24.5 **+HIGHLY WEATHERED SHALE**, red, soft — 911.5+/-			☒	8	29-50/3"			14			

Boring Terminated at 24.5 Feet

Driller: Paul Hacker
Helper: Matt Craig
Engineer/Geologist: Dillon Nolan
Boring Started: 10:30 AM
Boring Completed: 11:15 AM
Drill Rig: CME 970E
Drill Rig ID: 750X
Hammer Efficiency: 82%

Stratification lines are approximate. In-situ, the transition may be gradual.
+Classification estimated from disturbed samples. Core samples and petrographic analysis may reveal other rock types.

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Backfilled with cuttings above 4'; grouted 4' to 14'; backfilled with cuttings from 14' to termination depth.

See Exhibit A-3 for description of field procedures.

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

See Appendix C for explanation of symbols and abbreviations.

Notes:

Surface Cover: Grass Field

WATER LEVEL OBSERVATIONS

▽ *6 ft While Drilling*

▨ *6 ft Wet Cave In After 24 Hours*

Terracon
4701 N Stiles Ave
Oklahoma City, OK

Boring Started: 11/17/2016	Boring Completed: 11/17/2016
Drill Rig: 387	Driller: P. Hacker
Project No.: 03165393	Exhibit: A-15

BORING LOG NO. B-13

Page 1 of 1

PROJECT: Cimarron Water Treatment Facility

SITE: **State Highway 33 & State Highway 74**
Cimarron City, Oklahoma

CLIENT: Environmental Properties Management LLC
Kansas City, Missouri

LOCATION See Exhibit A-2

Latitude: 35.88429° Longitude: -97.5792°
Northing: 322179.69 Easting: 2093160.69

Approximate Surface Elev: 936.0 (Ft.) +/-

GRAPHIC LOG	DEPTH		ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (psf)	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
▨		**FAT CLAY (CH)**, dark reddish-brown, stiff				☒	14	3-4-5 N=9	6000 (HP)		25		72-24-48	97
	3.0		933+/-											
▨		**SANDY LEAN CLAY (CL)**, with clay, red, loose		5	▨ ▽	☒	15	3-3-3 N=6			24		31-14-17	63
	6.0		930+/-											
▨		**POORLY GRADED SAND WITH SILT (SP-SM)**, fine grained, brown to light reddish-brown, loose				☒	12	4-2-2 N=4			26			
		-very loose below 8.5'		10		☒	14	1-1-2 N=3			17		NP	6
	13.5		922.5+/-											
▨		**POORLY GRADED SAND (SP)**, fine grained, brown to light reddish-brown, loose		15		☒	11	2-2-3 N=5			18		NP	2
	17.0		919+/-											
▨		**+WEATHERED SANDSTONE**, red, cemented				☒	0	50/4"						
	19.0		917+/-											

Boring Terminated at 19 Feet

Driller: Paul Hacker
Helper: Matt Craig
Engineer/Geologist: Dillon Nolan
Boring Started: 12:15 PM
Boring Completed: 1:00 PM
Drill Rig: CME 970E
Drill Rig ID: 750X
Hammer Efficiency: 82%

Stratification lines are approximate. In-situ, the transition may be gradual.
+Classification estimated from disturbed samples. Core samples and petrographic analysis may reveal other rock types.

Hammer Type: Automatic

Advancement Method:
0' - 6' Power Auger
6' - 19' Wash Boring

Abandonment Method:
Backfilled with cuttings above 4'; grouted 4' to 14'; backfilled with cuttings from 14' to termination depth.

See Exhibit A-3 for description of field procedures.

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

See Appendix C for explanation of symbols and abbreviations.

Notes:

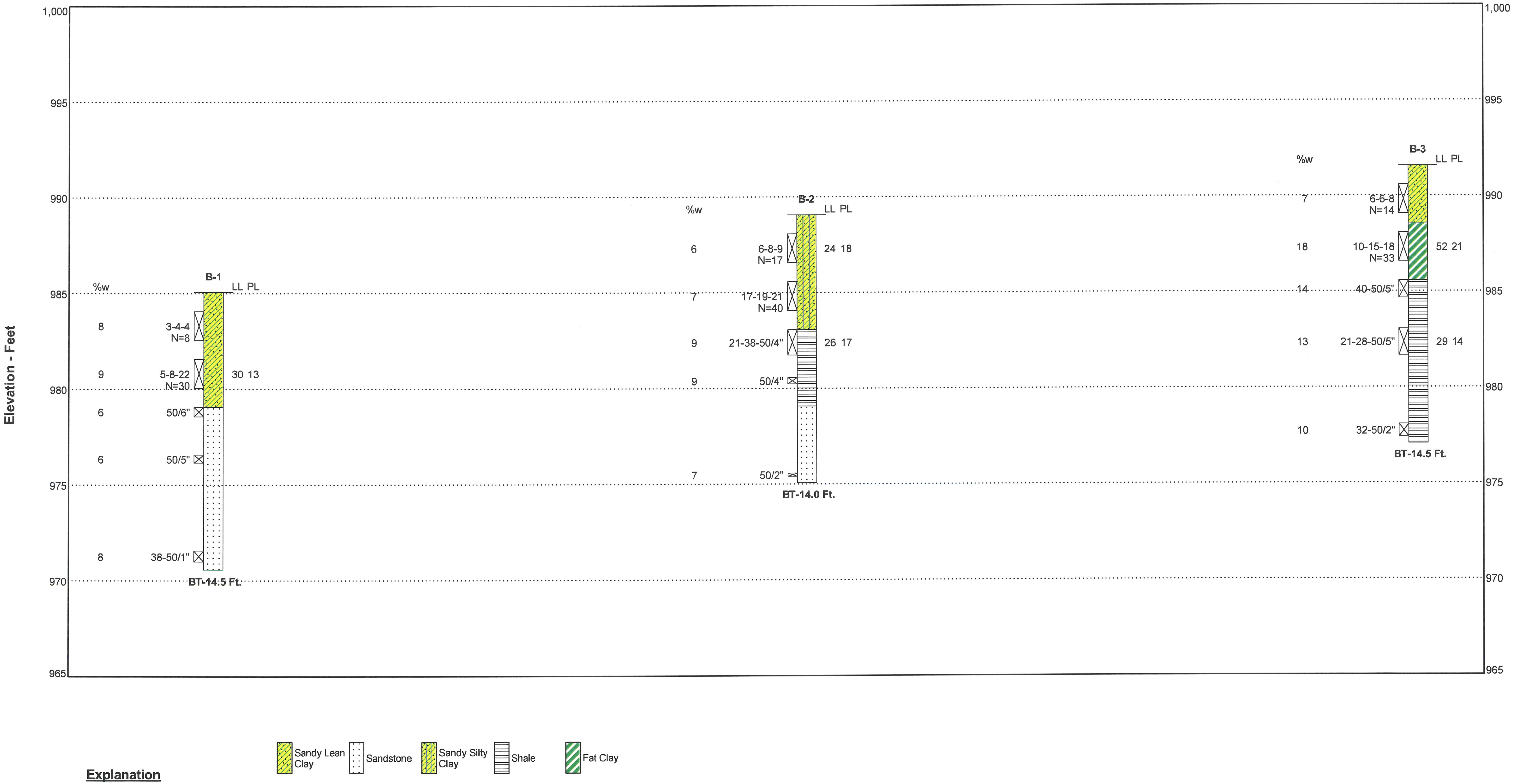
Surface Cover: Grass Field

WATER LEVEL OBSERVATIONS

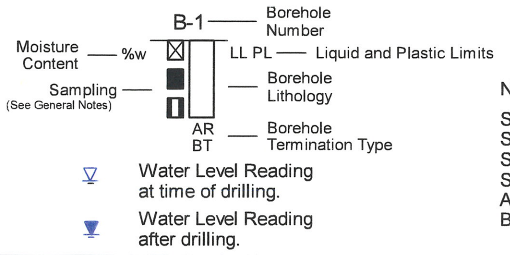
▽ *6 ft While Drilling*
▽ *6 ft After Boring*
▨ *5 ft Wet Cave In After 24 Hours*

Terracon
4701 N Stiles Ave
Oklahoma City, OK

Boring Started: 11/18/2016	Boring Completed: 11/18/2016
Drill Rig: 387	Driller: P. Hacker
Project No.: 03165393	Exhibit: A-16



Explanation



NOTES:

See Exhibit A-2 for orientation of soil profile.
See General Notes in Appendix C for symbols and soil classifications.
Soils profile provided for illustration purposes only.
Soils between borings may differ
AR - Auger Refusal
BT - Boring Termination

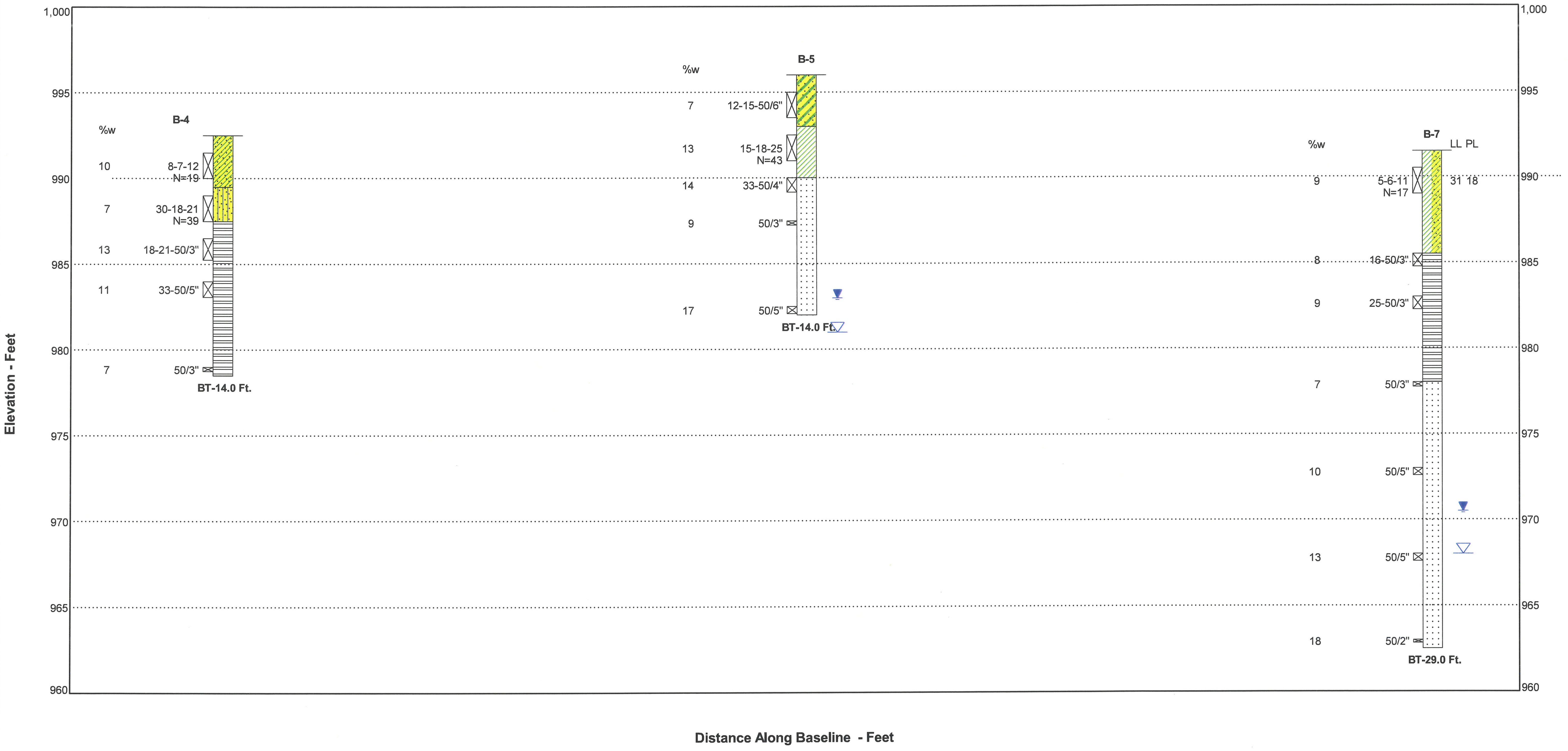
Project Manager: DCVS	Project No.: 03165393
Drawn by: SRS	Scale: N.T.S.
Approved by: DCVS	File Name: 03165393.A-17
Date: 12/22/2016	

Terracon
4701 N Stiles Ave
Oklahoma City, OK
PH. 405-525-0453 FAX. 405-557-0549

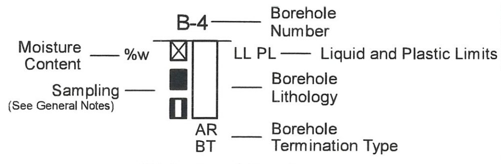
SUBSURFACE PROFILE

CIMARRON WATER TREATMENT FACILITY
STATE HIGHWAY 33 & STATE HIGHWAY 74
CIMARRON CITY, OKLAHOMA

EXHIBIT
A-17



Explanation



▽ Water Level Reading at time of drilling.

▼ Water Level Reading after drilling.

▨ Sandy Lean Clay
▨ Silty Sand
▤ Shale
▨ Clayey Sand
▨ Lean Clay
▨ Sandstone
▨ Lean Clay with Sand

NOTES:
See Exhibit A-2 for orientation of soil profile.
See General Notes in Appendix C for symbols and soil classifications.
Soils profile provided for illustration purposes only.
Soils between borings may differ
AR - Auger Refusal
BT - Boring Termination

Project Manager: DCVS
Drawn by: SRS
Approved by: DCVS
Date: 12/22/2016

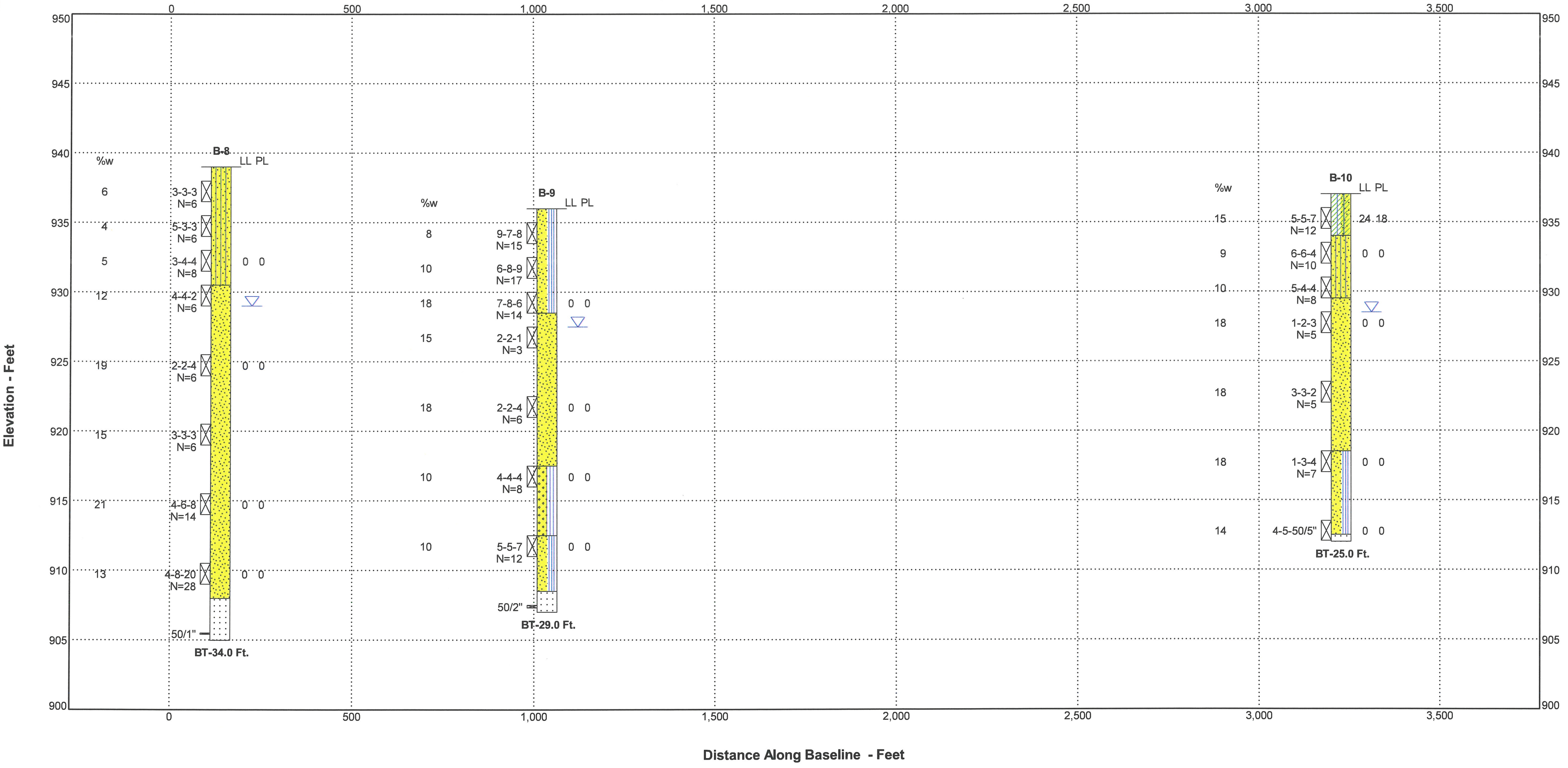
Project No.: 03165393
Scale: N.T.S.
File Name: 03165393.A-18

Terracon
4701 N Stiles Ave
Oklahoma City, OK
PH. 405-525-0453
FAX. 405-557-0549

SUBSURFACE PROFILE

CIMARRON WATER TREATMENT FACILITY
STATE HIGHWAY 33 & STATE HIGHWAY 74
CIMARRON CITY, OKLAHOMA

EXHIBIT
A-18



▨ Silty Sand ▨ Poorly-graded Sand ▨ Sandstone ▨ Poorly-graded Sand with Silt ▨ Well-graded Sand with Silt

▨ Silty Clay with Sand

Explanation

B-8 — Borehole Number

Moisture Content — %w

☒ LL PL — Liquid and Plastic Limits

Sampling (See General Notes)

Borehole Lithology

AR BT — Borehole Termination Type

▽ Water Level Reading at time of drilling.

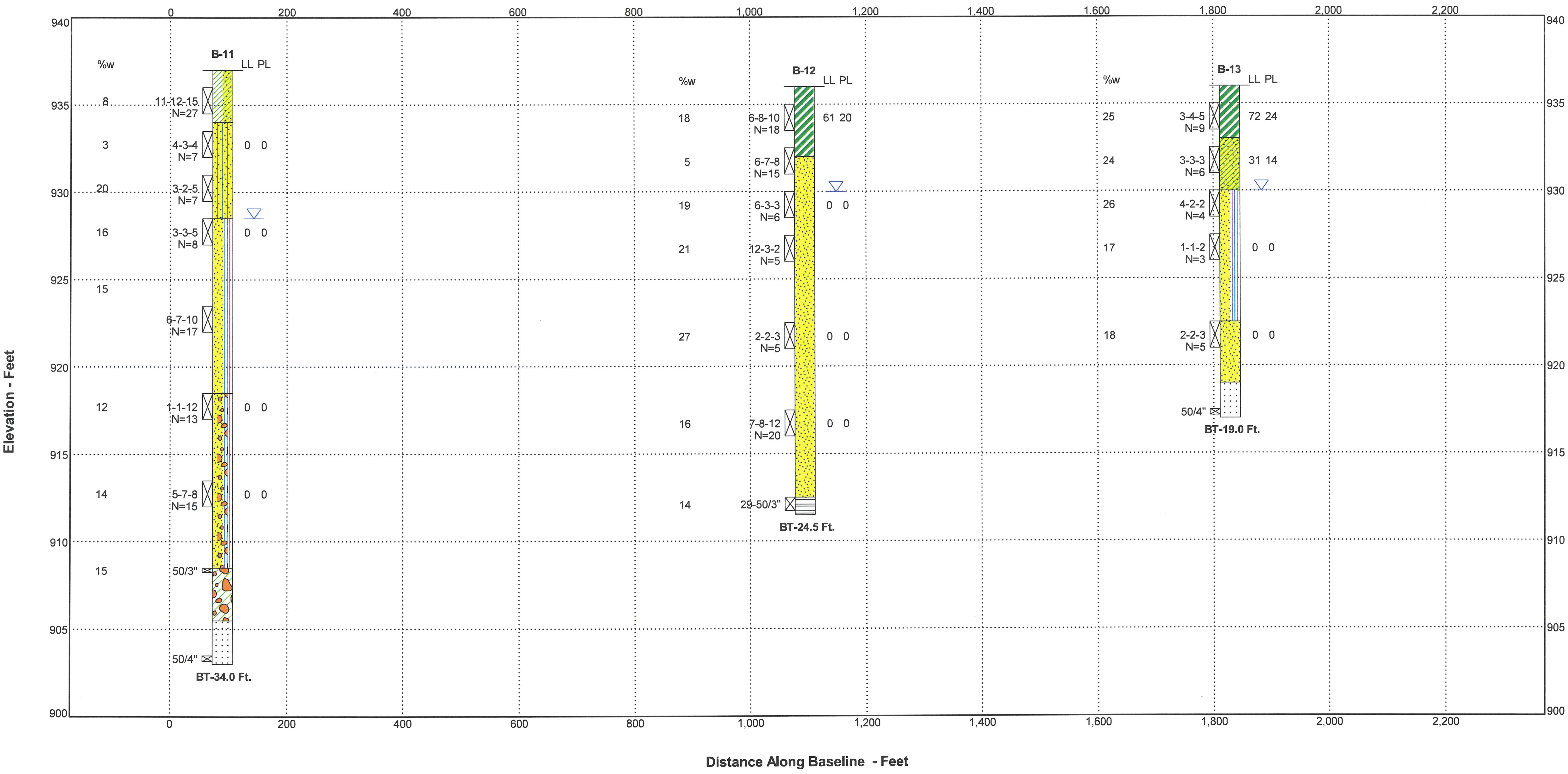
▼ Water Level Reading after drilling.

NOTES:

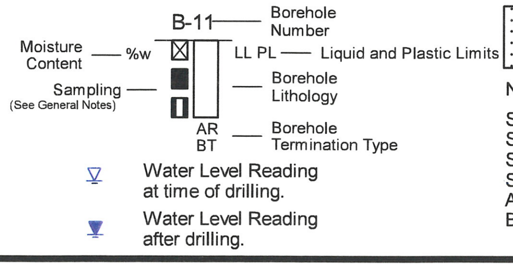
See Exhibit A-2 for orientation of soil profile.
See General Notes in Appendix C for symbols and soil classifications.
Soils profile provided for illustration purposes only.
Soils between borings may differ
AR - Auger Refusal
BT - Boring Termination

Project Manager: DCVS	Project No.: 03165393	Terracon 4701 N Stiles Ave Oklahoma City, OK PH. 405-525-0453 FAX. 405-557-0549	SUBSURFACE PROFILE	EXHIBIT
Drawn by: SRS	Scale: N.T.S.		CIMARRON WATER TREATMENT FACILITY STATE HIGHWAY 33 & STATE HIGHWAY 74 CIMARRON CITY, OKLAHOMA	A-19
Approved by: DCVS	File Name: 03165393.A-19			
Date: 12/22/2016				

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. SMART FENCE 03165393 CIMARRON WATER TREATMENT FACILITY.GPJ



Explanation



- ▨ Lean Clay with Sand
- ▨ Silty Sand
- ▨ Poorly-graded Sand with Silt
- ▨ Poorly-graded Sand with Silt and Gravel
- ▨ Clayey Gravel
- ▨ Sandstone
- ▨ Fat Clay
- ▨ Poorly-graded Sand
- ▨ Highly Weathered Shale
- ▨ Sandy Lean Clay

NOTES:
See Exhibit A-2 for orientation of soil profile.
See General Notes in Appendix C for symbols and soil classifications.
Soils profile provided for illustration purposes only.
Soils between borings may differ
AR - Auger Refusal
BT - Boring Termination

Project Manager: DCVS	Project No.: 03165393	Terracon 4701 N Stiles Ave Oklahoma City, OK PH. 405-525-0453 FAX. 405-557-0549	SUBSURFACE PROFILE CIMARRON WATER TREATMENT FACILITY STATE HIGHWAY 33 & STATE HIGHWAY 74 CIMARRON CITY, OKLAHOMA	EXHIBIT A-20
Drawn by: SRS	Scale: N.T.S.			
Approved by: DCVS	File Name: 03165393.A-20			
Date: 12/21/2016				

DEQ OKLAHOMA DEPARTMENT OF ENVIRONMENTAL QUALITY

Contact Jeff Lux

ENVIRONMENTAL COMPLAINTS AND LOCAL SERVICES DIVISION
REPORT FOR ON-SITE SEWAGE TREATMENT
SOIL PROFILE DESCRIPTION TEST
(PLEASE PRINT or TYPE)

Work Order No. ☐
System No. ☐
Date Rec'd ☐

GENERAL INFORMATION:

Name and Mailing Address of Property Owner: Water Treatment Plant 100 N Hwy 74 Guthrie 73044
First Name / Last Name / Mailing Address / City / Zip Code

Owner Phone Number: 642-5152 Owner's E-Mail Address *(Optional)*:

Property Address: Above Logan, Oklahoma
Street Address / City / Zip Code / County

Legal Description: Sec 12, 16-N, 4-W Lot Size in ft² or 640+ acres:

Finding Location: Hwy 33+74 go N to Metal Gate - ESOR *(Blocks or miles from a given point)*

Water Supply: ☐ Individual Private Well or ☑ Public Water Supply – Name: Logan Co. Water

WATERBODY PROTECTION AREA:

Dispersal field located in Water Body Protection Area: check one Zone 1 ☐ Zone 2 ☐ or None ☑

Flow Certification: 27A O.S. 2001, Section 2-6-403 states-"It shall be the duty of the person contracting with an installer who is modifying or installing an on-site sewage treatment system for a residence or business to certify the number of bedrooms in the residence or the water usage of the business that will be served by the sewage treatment system so that the system can be properly sized."

The following information was certified on DEQ Form 641-581cert. (Certification Documentation Form)

☐ This individual sewage treatment system will serve an individual residence or duplex with the following # of bedrooms

☑ The estimated flow or actual flow for this small public sewage system is 25 gal/day and is a Water Treatment Plant *(Type of Facility)*
5ppl/nokitchen

SOIL TEST RESULTS: ☐ Design Only Print First and Last Name of Designer: Design Date:

Depth of Test Hole	HOLE #1 *Group*	HOLE #1 *Limiting Layer w/in Interval**	HOLE #2 *Group*	HOLE #2 *Limiting Layer w/in Interval**	HOLE #3 *Group*	HOLE #3 *Limiting Layer w/in Interval**
0-6"	2a		2a		2a	
6-12"	2a		2a		2a	
12-18"	2a		2a		2a	
18-24"	2a		2a		2a	
24-30"	2a		2a		2a	
30-36"	2a		2a		2a	
36-42"	2a		2a		2a	
42-48"	2a		2a		2a	
48"-54"	2a		2a		2a	

**Limiting layers: GW = Ground Water RX = Redox RC = Rock G5 = Group 5 Soil*

SEPARATION RANGE

Depth of "shallowest limiting layer": 54 inches
Test hole with the lowest clay content in separation range: Hole # 1
Most prevalent soil group found in the separation range: Group 2a

DISPERSAL ALLOWED / APPLICABLE SIZING RANGE

System Type	*Sizing Range*	*Option*
[✓ CSA] – Conventional Subsurface Absorption	12-30"	☑Y ☐N
LPD – Low Pressure Dosing	12-30"	☑Y ☐N
SE – Shallow Extended	6-24"	☑Y ☐N
ET/A – Evapotranspiration/Absorption	12-30"	☐Y ☑N
L – Lagoon	N/A	☐Y ☑N
ADI – Aerobic w/ Drip Irrigation	0-18"	☐Y ☑N
ASI – Aerobic w/Spray Irrigation	0-18"	☐Y ☑N

RECOMMENDED SYSTEM AND SIZING CRITERIA:

TREATMENT REQUIRED check one	(a) HOLE WITH HIGHEST CLAY CONTENT IN SIZING RANGE	(b) MOST PREVALENT SOIL GROUP IN SIZING RANGE IN THE HOLE IDENTIFIED IN (a)
☑ Septic tank ☐ Aerobic treatment ☐ Aerobic treatment with nitrogen reduction	☐ #1 ☑ #2 ☐ #3	☐ 1 ☐ 2 ☑ 2a ☐ 3 ☐ 3a ☐ 4 ☐ 5

CERTIFIED SOIL TESTER USE ONLY:

I certify that I conducted the above-described soil profile description test in compliance with OAC 252:641 on 11-18-16 *(Date Test Performed)*

Ray Graham — Ray Graham — Cell 405-990-2045 — SP069
Soil Tester's Signature / Please Print First Name / Last Name / Certification Number

4327 Cardinal — Edmond OK 73034 — Fax 405-562-4306 — 11-18-16
Address / City / State / Zip / Phone # / Date Signed

DEQ USE ONLY:

☐ Soil Test Performed by DEQ on (date):
☐ DEQ Soil Profile Test ☐ Verification of Design ☐ Joint Soil Profile

OR

☒ DEQ Reviewed and Accepted
☐ DEQ Reviewed and Rejected (date and initial)
Notes:

Jamie D'Amico — 64666 — 11-29-16
Environmental Specialist's Signature / Employee ID / Date Signed and Paperwork Issued

Work Order No. ☐

Revised 8/1/2014 DEQ Form 641-581SP

Exhibit A-21

APPENDIX B

LABORATORY TESTING AND ANALYSIS

Laboratory Test Description

Samples retrieved during the field exploration were taken to the laboratory for further observation by the project geotechnical engineer and were classified in accordance with the Unified Soil Classification System (USCS) described in Appendix C. Samples of bedrock were classified in accordance with the general notes for Sedimentary Rock Classification. At that time, the field descriptions were confirmed or modified as necessary and an applicable laboratory testing program was formulated to determine engineering properties of the subsurface materials.

Laboratory tests were conducted on selected soil and rock samples and the test results are presented on the logs in Appendix A. The laboratory test 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 ASTM, local or other accepted standards.

Selected soil samples obtained from the site were tested for the following engineering properties:

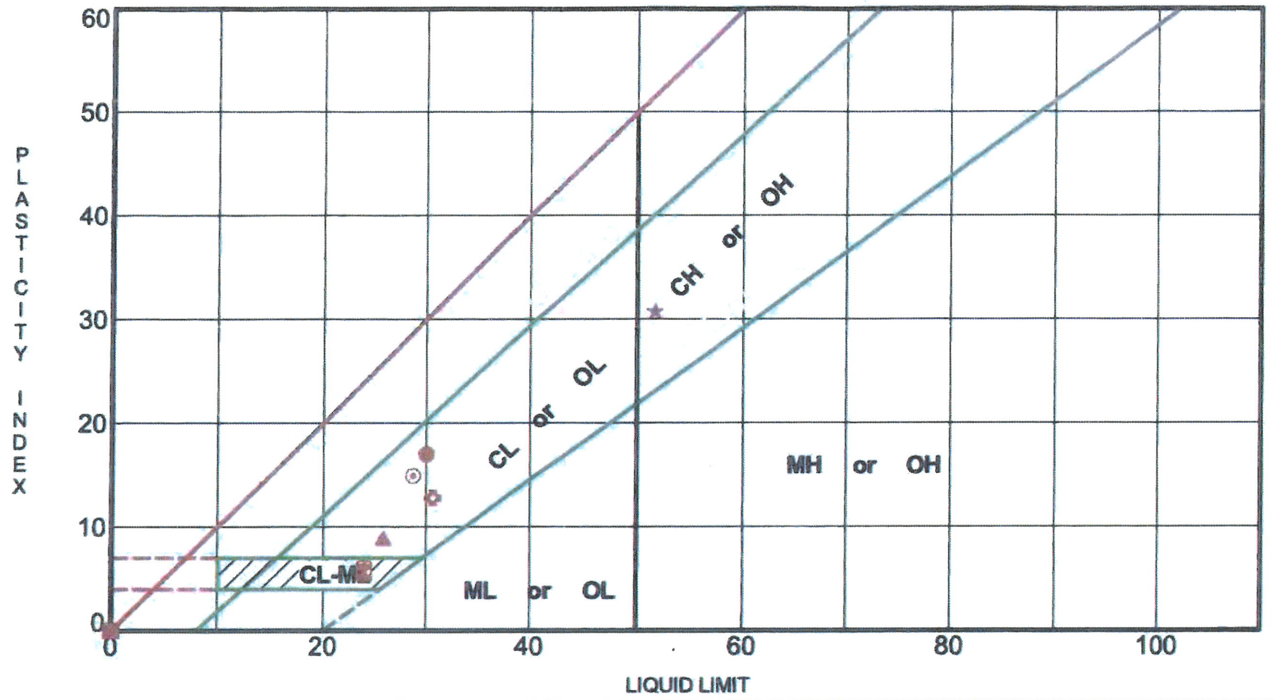
- Visual Classification (ASTM D2488)
- In-situ Water Content (ASTM D2216)
- Atterberg Limits (ASTM D4318)
- Moisture Density Relationship (ASTM D-698)
- CBR Test (ASTM D1883)
- Direct Shear Test (ASTM D3080)
- Chloride content (ASTM D512)
- Sulfate content (ASTM D516)
- Sulfides (AWWA 4500-S D)
- Red-Ox (AWWA 2580)
- pH (AWWA 450 H))
- Miller Box Electrical Resistivity (ASTM G57)
- Total Salts (AWWA 2540)

Procedural standards noted above are for reference to methodology in general. In some cases variations to methods are applied as a result of local practice or professional judgment.

Exhibit B-1

ATTERBERG LIMITS RESULTS

ASTM D4318



Boring ID	Depth	LL	PL	PI	Fines	USCS	Description
● B-1	3.5 - 5	30	13	17	68	CL	SANDY LEAN CLAY
⊠ B-2	1 - 2.5	24	18	6	52	CL-ML	SANDY SILTY CLAY
▲ B-2	6 - 7.3	26	17	9	84		HIGHLY WEATHERED SHALE
★ B-3	3.5 - 5	52	21	31	89	CH	FAT CLAY
⊙ B-3	8.5 - 9.9	29	14	15	99		HIGHLY WEATHERED SHALE
✿ B-7	1 - 2.5	31	18	13	75	CL	LEAN CLAY with SAND
○ B-8	6 - 7.5	NP	NP	NP	20	SM	SILTY SAND
△ B-8	13.5 - 15	NP	NP	NP	4	SP	POORLY GRADED SAND
⊗ B-8	23.5 - 25	NP	NP	NP	2	SP	POORLY GRADED SAND
⊕ B-8	28.5 - 30	NP	NP	NP	3	SP	POORLY GRADED SAND
□ B-9	6 - 7.5	NP	NP	NP	8	SP-SM	POORLY GRADED SAND with SILT
● B-9	13.5 - 15	NP	NP	NP	3	SP	POORLY GRADED SAND
● B-9	18.5 - 20	NP	NP	NP	7	SW-SM	WELL-GRADED SAND with SILT
☆ B-9	23.5 - 25	NP	NP	NP	8	SP-SM	POORLY GRADED SAND with SILT
⊠ B-10	1 - 2.5	24	18	6		CL-ML	SILTY CLAY with SAND
■ B-10	3.5 - 5	NP	NP	NP	39	SM	SILTY SAND
◆ B-10	8.5 - 10	NP	NP	NP	5	SP	POORLY GRADED SAND
◇ B-10	18.5 - 20	NP	NP	NP	10	SP-SM	POORLY GRADED SAND with SILT
× B-10	23.5 - 24.9	NP	NP	NP	5		HIGHLY WEATHERED SANDSTONE
■ B-11	3.5 - 5	NP	NP	NP	20	SM	SILTY SAND

PROJECT: Cimarron Water Treatment Facility

SITE: State Highway 33 & State Highway 74
Cimarron City, Oklahoma

Terracon
4701 N Stiles Ave
Oklahoma City, OK

PROJECT NUMBER: 03165393

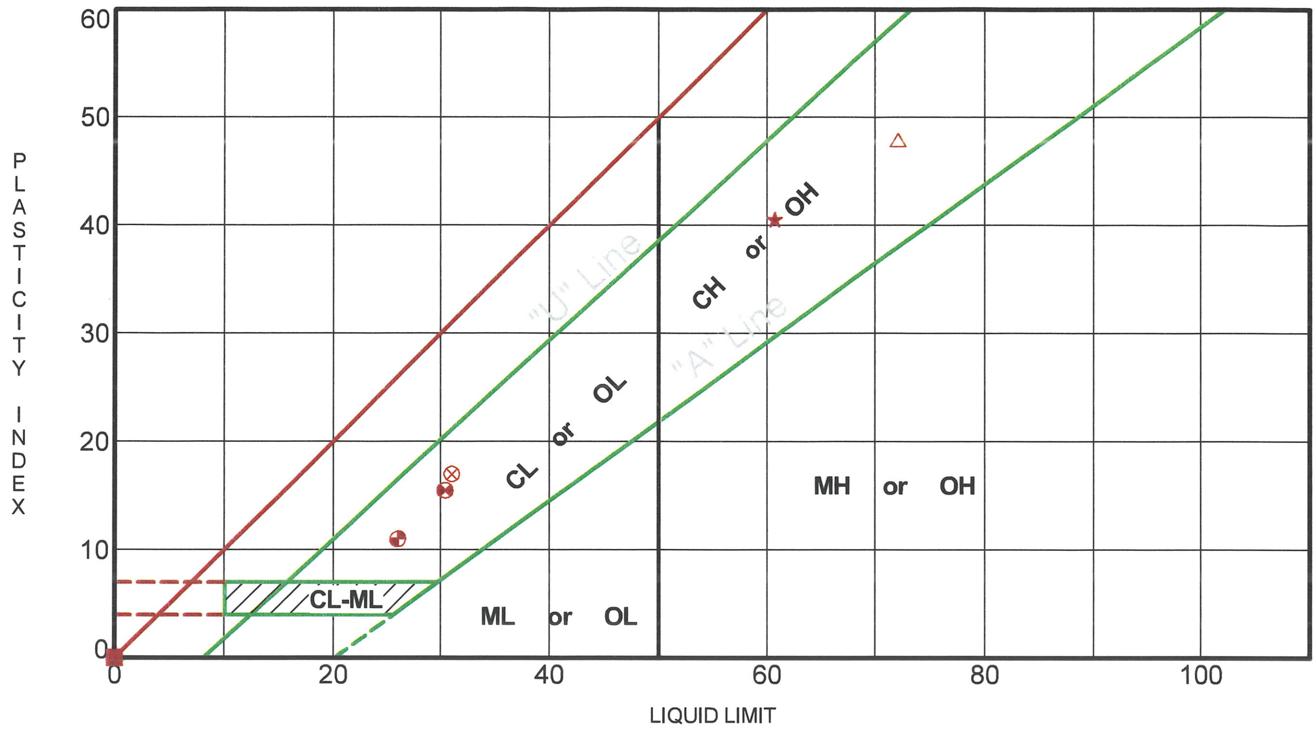
CLIENT: Environmental Properties Management LLC
Kansas City, Missouri

EXHIBIT: B-2

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. ATTERBERG LIMITS 03165393 CIMARRON WATER TREATMENT FACILITY.GPJ TERRACON2015.GDT 12/21/16

ATTERBERG LIMITS RESULTS

ASTM D4318



	Boring ID	Depth	LL	PL	PI	Fines	USCS	Description
●	**B-11**	**8.5 - 10**	**NP**	**NP**	**NP**	**7**	**SP-SM**	**POORLY GRADED SAND with SILT**
⊠	**B-11**	**18.5 - 20**	**NP**	**NP**	**NP**	**11**	**SP-SM**	**POORLY GRADED SAND with SILT and GRAVEL**
▲	**B-11**	**23.5 - 25**	**NP**	**NP**	**NP**	**11**	**SP-SM**	**POORLY GRADED SAND with SILT**
★	**B-12**	**1 - 2.5**	**61**	**20**	**41**	**95**	**CH**	**FAT CLAY**
⊙	**B-12**	**6 - 7.5**	**NP**	**NP**	**NP**	**3**	**SP**	**POORLY GRADED SAND**
✿	**B-12**	**13.5 - 15**	**NP**	**NP**	**NP**	**3**	**SP**	**POORLY GRADED SAND**
○	**B-12**	**18.5 - 20**	**NP**	**NP**	**NP**	**5**	**SP**	**POORLY GRADED SAND**
△	**B-13**	**1 - 2.5**	**72**	**24**	**48**	**97**	**CH**	**FAT CLAY**
⊗	**B-13**	**3.5 - 5**	**31**	**14**	**17**	**63**	**CL**	**SANDY LEAN CLAY**
⊕	**B-13**	**8.5 - 10**	**NP**	**NP**	**NP**	**6**	**SP-SM**	**POORLY GRADED SAND with SILT**
□	**B-13**	**13.5 - 15**	**NP**	**NP**	**NP**	**2**	**SP**	**POORLY GRADED SAND**
⊛	**B-1 & B-7 (Bulk)**	**0 - 5**	**30**	**15**	**15**	**63**	**CL**	**SANDY LEAN CLAY**
◕	**B-2 & B-4(Bulk)**	**0 - 5**	**26**	**15**	**11**	**62**	**CL**	**SANDY LEAN CLAY**

PROJECT: Cimarron Water Treatment Facility

SITE: State Highway 33 & State Highway 74
Cimarron City, Oklahoma

Terracon
4701 N Stiles Ave
Oklahoma City, OK

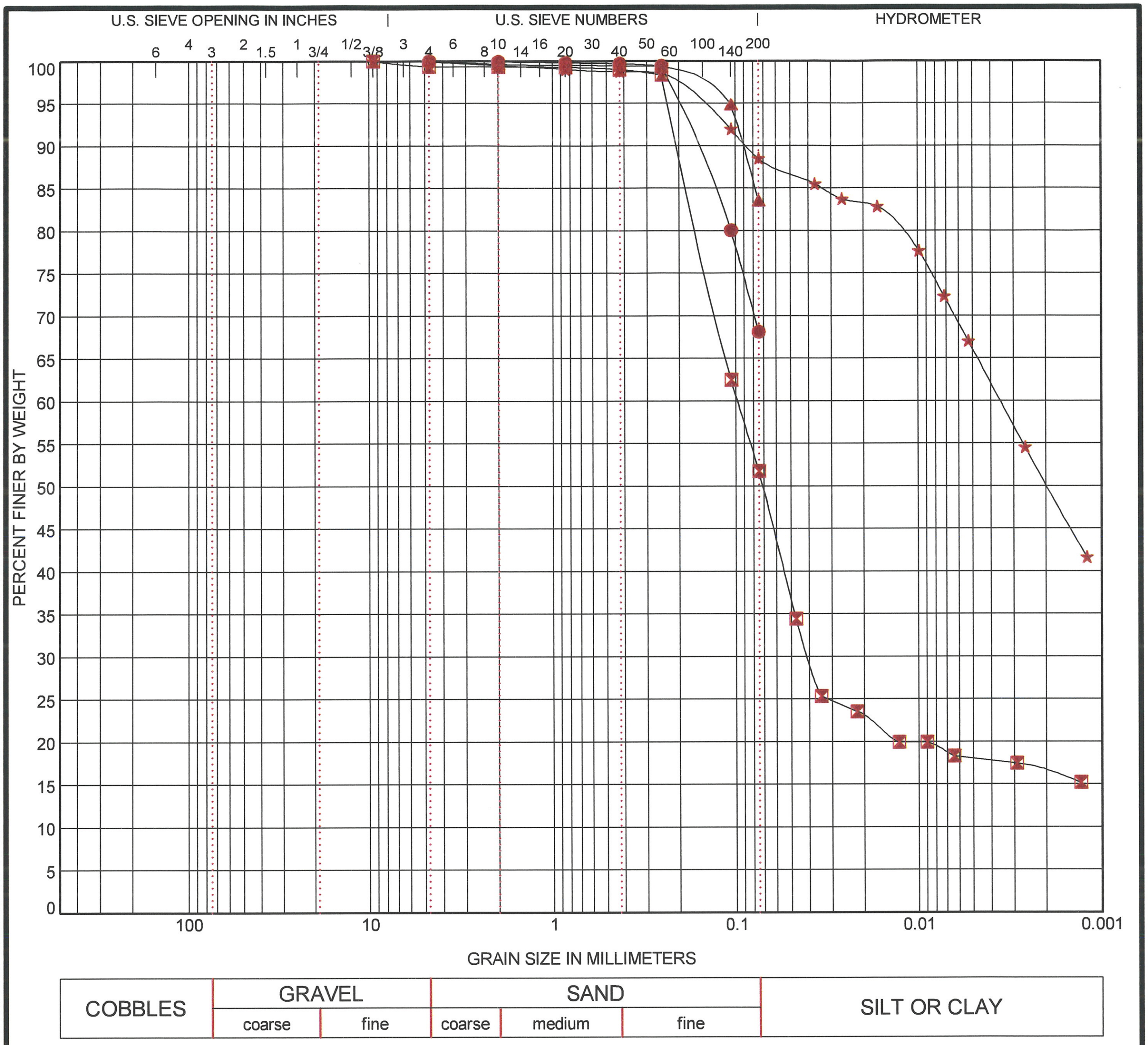
PROJECT NUMBER: 03165393

CLIENT: Environmental Properties Management LLC
Kansas City, Missouri

EXHIBIT: B-3

GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136



	Boring ID	Depth	USCS Classification	AASHTO Classification	WC (%)	LL	PL	PI	Cc	Cu
●	B-1	3.5 - 5	SANDY LEAN CLAY (CL)	A-6 (9)	9	30	13	17		
⧗	B-2	1 - 2.5	SANDY SILTY CLAY (CL-ML)	A-4 (1)	6	24	18	6		
▲	B-2	6 - 7.3	HIGHLY WEATHERED SHALE		9	26	17	9		
★	B-3	3.5 - 5	FAT CLAY (CH)	A-7-6 (30)	18	52	21	31		

	Boring ID	Depth	D_{100}	D_{60}	D_{30}	D_{10}	%Gravel	%Sand	%Silt	%Fines	%Clay
●	B-1	3.5 - 5	4.75				0.0	31.9		68.1	
⧗	B-2	1 - 2.5	9.5	0.098	0.04		0.7	47.6	33.7		18.0
▲	B-2	6 - 7.3	4.75				0.0	16.4		83.6	
★	B-3	3.5 - 5	9.5	0.004			0.1	11.4	22.5		66.0

PROJECT: Cimarron Water Treatment Facility

SITE: State Highway 33 & State Highway 74
Cimarron City, Oklahoma

Terracon
4701 N Stiles Ave
Oklahoma City, OK

PROJECT NUMBER: 03165393

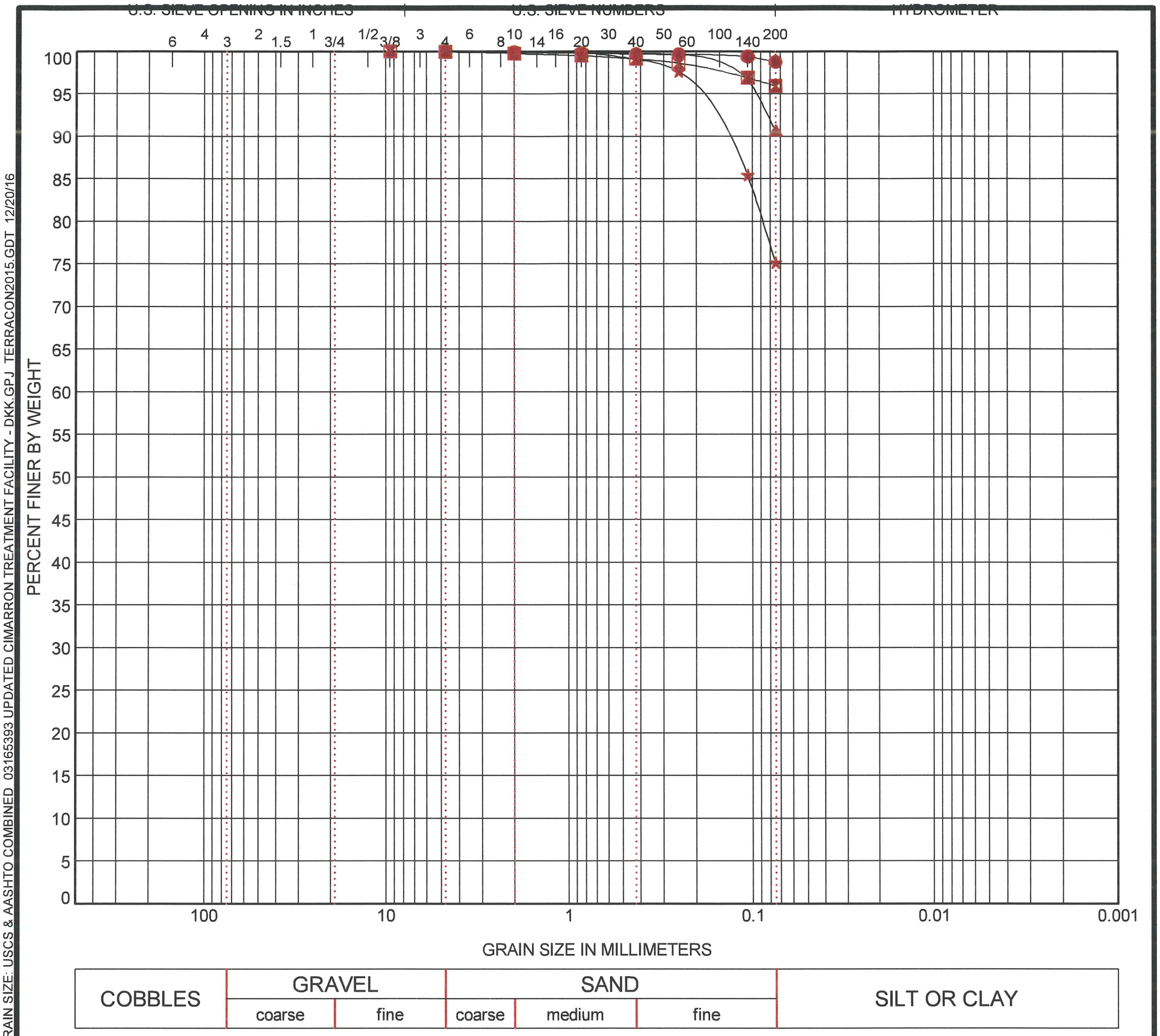
CLIENT: Environmental Properties Management LLC
Kansas City, Missouri

EXHIBIT: B-4

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GRAIN SIZE: USCS & AASHTO COMBINED 03165393 UPDATED CIMARRON TREATMENT FACILITY - DKK.GPJ TERRACON2015.GDT 12/20/16

GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136



	Boring ID	Depth	USCS Classification	AASHTO Classification	WC (%)	LL	PL	PI	Cc	Cu
●	B-3	8.5 - 9.9	HIGHLY WEATHERED SHALE		13	29	14	15		
☒	B-4	6 - 7.3	HIGHLY WEATHERED SHALE		13					
▲	B-5	3.5 - 5	LEAN CLAY (CL)		13					
★	B-7	1 - 2.5	LEAN CLAY with SAND (CL)	A-6 (8)	9	31	18	13		

	Boring ID	Depth	D_{100}	D_{60}	D_{30}	D_{10}	%Gravel	%Sand	%Silt	%Fines	%Clay
●	B-3	8.5 - 9.9	4.75				0.0	1.2		98.8	
☒	B-4	6 - 7.3	9.5				0.1	4.0		96.0	
▲	B-5	3.5 - 5	9.5				0.0	9.3		90.7	
★	B-7	1 - 2.5	2				0.0	24.8		75.2	

PROJECT: Cimarron Water Treatment Facility

SITE: State Highway 33 & State Highway 74
Cimarron City, Oklahoma

Terracon
4701 N Stiles Ave
Oklahoma City, OK

PROJECT NUMBER: 03165393

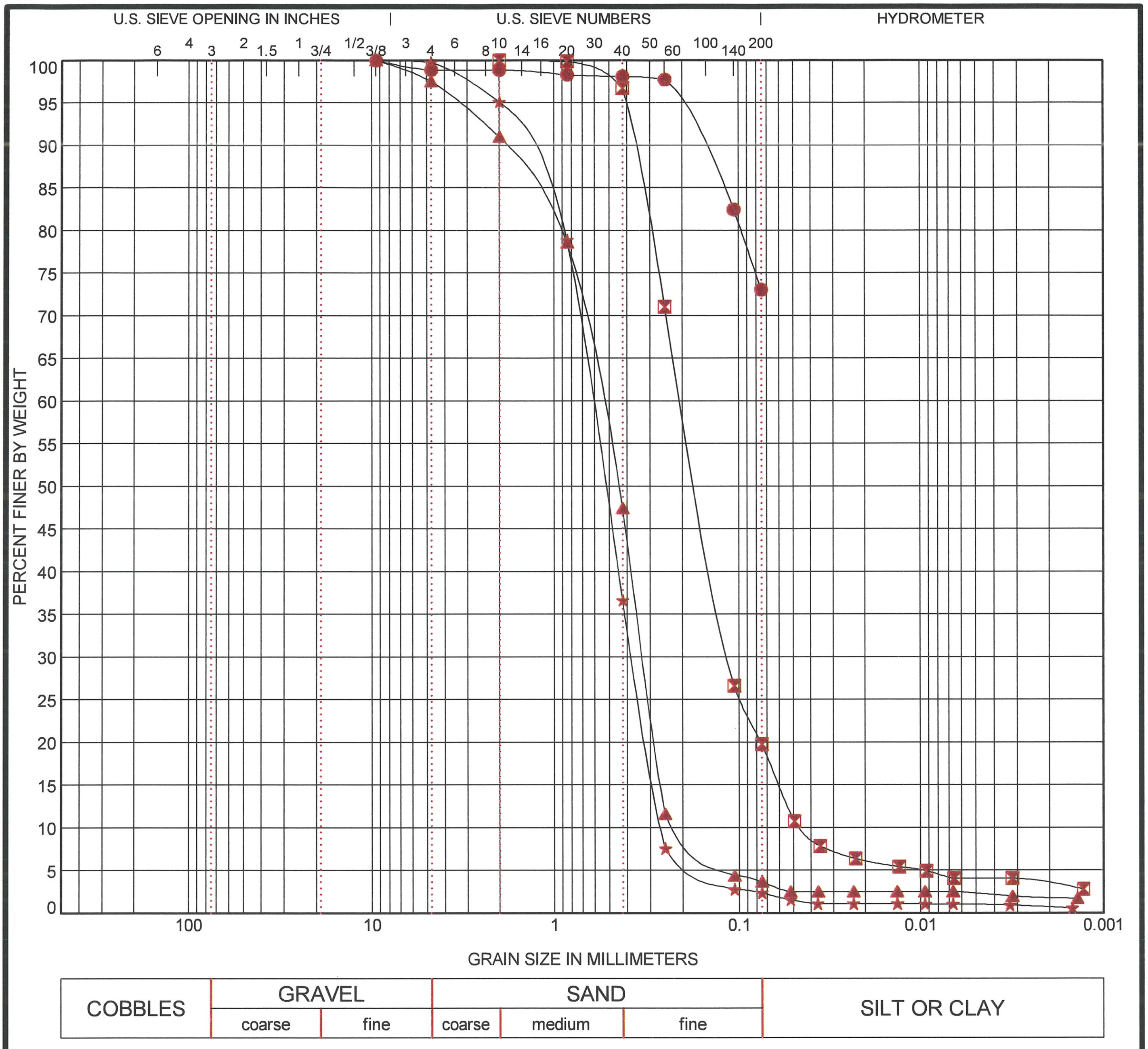
CLIENT: Environmental Properties Management LLC
Kansas City, Missouri

EXHIBIT: B-5

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GRAIN SIZE: USCS & AASHTO COMBINED 03165393 UPDATED CIMARRON TREATMENT FACILITY - DKK.GPJ TERRACON2015.GDT 12/20/16

GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136



	Boring ID	Depth	USCS Classification	AASHTO Classification	WC (%)	LL	PL	PI	Cc	Cu
●	B-7	6 - 6.8	HIGHLY WEATHERED SHALE		8					
☒	B-8	6 - 7.5	SILTY SAND (SM)	A-2-4 (0)	5	NP	NP	NP	1.40	4.45
▲	B-8	13.5 - 15	POORLY GRADED SAND (SP)	A-1-b (0)	19	NP	NP	NP	0.93	2.72
★	B-8	23.5 - 25	POORLY GRADED SAND (SP)	A-1-b (0)	21	NP	NP	NP	0.87	2.39

	Boring ID	Depth	D_{100}	D_{60}	D_{30}	D_{10}	%Gravel	%Sand	%Silt	%Fines	%Clay
●	B-7	6 - 6.8	9.5				1.1	25.8		73.0	
☒	B-8	6 - 7.5	2	0.202	0.113	0.045	0.0	80.2	15.7		4.0
▲	B-8	13.5 - 15	9.5	0.562	0.328	0.206	2.5	93.9	1.4		2.3
★	B-8	23.5 - 25	9.5	0.624	0.377	0.261	0.2	97.4	1.4		1.0

PROJECT: Cimarron Water Treatment Facility

SITE: State Highway 33 & State Highway 74
Cimarron City, Oklahoma

Terracon
4701 N Stiles Ave
Oklahoma City, OK

PROJECT NUMBER: 03165393

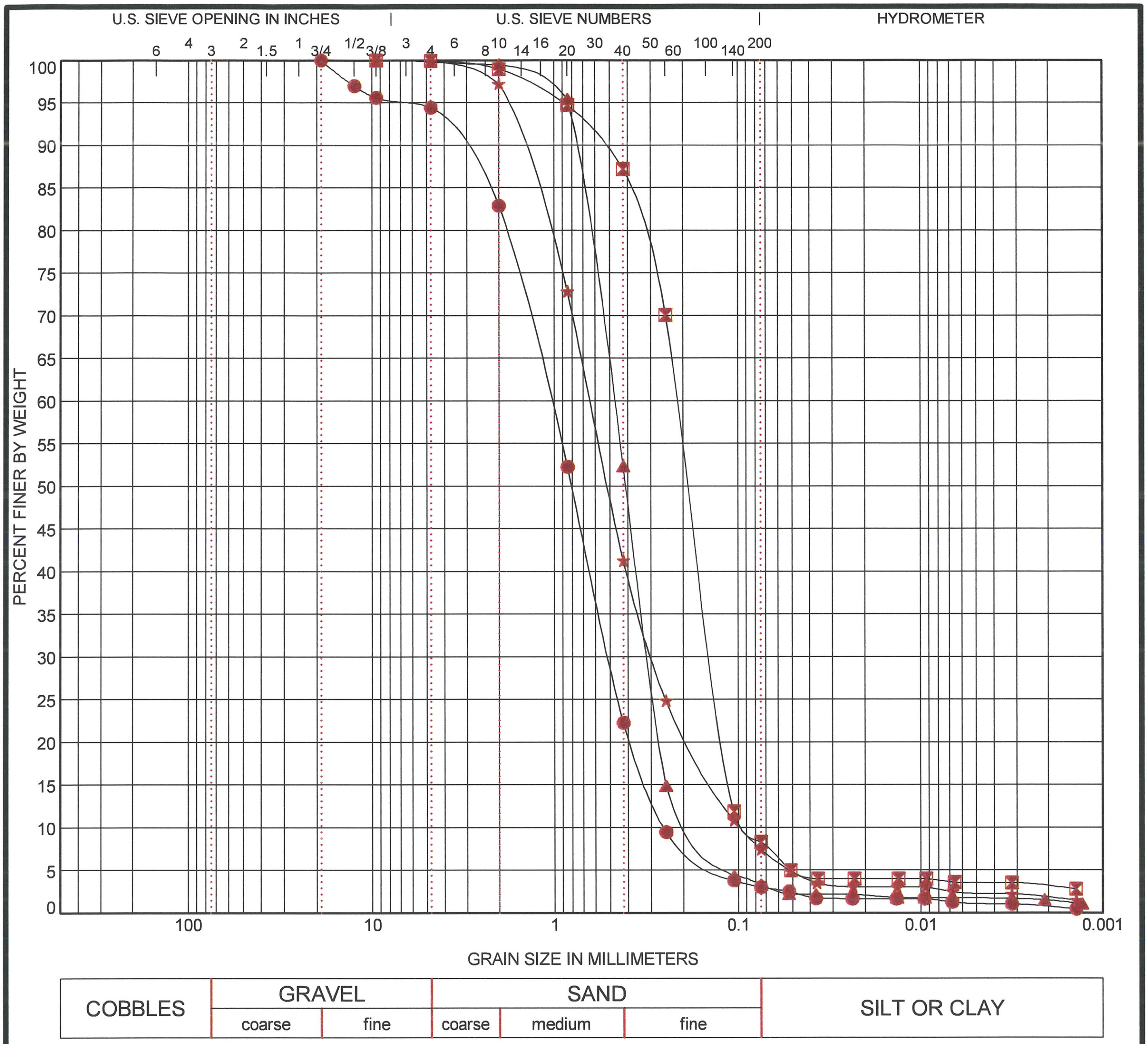
CLIENT: Environmental Properties Management LLC
Kansas City, Missouri

EXHIBIT: B-6

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GRAIN SIZE: USCS & AASHTO COMBINED 03165393 UPDATED CIMARRON TREATMENT FACILITY - DKK.GPJ TERRACON2015.GDT 12/20/16

GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136



	Boring ID	Depth	USCS Classification	AASHTO Classification	WC (%)	LL	PL	PI	Cc	Cu
●	B-8	28.5 - 30	POORLY GRADED SAND (SP)	A-1-b (0)	13	NP	NP	NP	0.96	4.13
☒	B-9	6 - 7.5	POORLY GRADED SAND with SILT (SP-SM)	A-3 (0)	18	NP	NP	NP	1.01	2.44
▲	B-9	13.5 - 15	POORLY GRADED SAND (SP)	A-3 (0)	18	NP	NP	NP	1.19	2.86
★	B-9	18.5 - 20	WELL-GRADED SAND with SILT (SW-SM)	A-1-b (0)	10	NP	NP	NP	1.40	6.59

	Boring ID	Depth	D_{100}	D_{60}	D_{30}	D_{10}	%Gravel	%Sand	%Silt	%Fines	%Clay
●	B-8	28.5 - 30	19	1.055	0.508	0.256	5.6	91.4	1.9		1.2
☒	B-9	6 - 7.5	9.5	0.215	0.138	0.088	0.1	91.6	4.7		3.6
▲	B-9	13.5 - 15	9.5	0.481	0.31	0.168	0.2	96.5	1.6		1.7
★	B-9	18.5 - 20	9.5	0.641	0.295	0.097	0.1	92.5	5.1		2.4

PROJECT: Cimarron Water Treatment Facility

SITE: State Highway 33 & State Highway 74
Cimarron City, Oklahoma

Terracon
4701 N Stiles Ave
Oklahoma City, OK

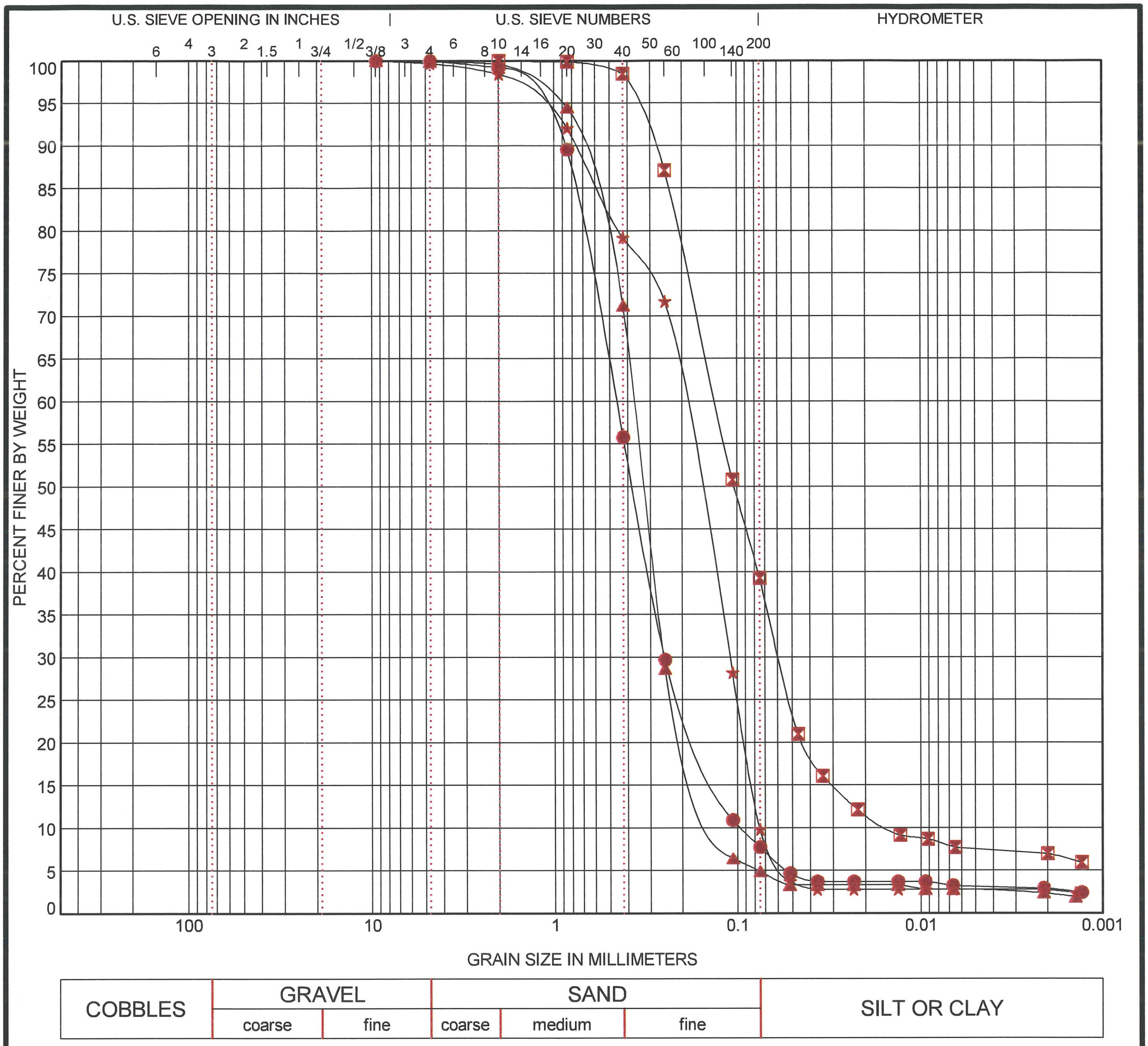
PROJECT NUMBER: 03165393

CLIENT: Environmental Properties Management LLC
Kansas City, Missouri

EXHIBIT: B-7

GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136



	Boring ID	Depth	USCS Classification	AASHTO Classification	WC (%)	LL	PL	PI	Cc	Cu
●	B-9	23.5 - 25	POORLY GRADED SAND with SILT (SP-SM)	A-3 (0)	10	NP	NP	NP	1.42	4.83
⊠	B-10	3.5 - 5	SILTY SAND (SM)	A-4 (0)	9	NP	NP	NP	1.74	8.69
▲	B-10	8.5 - 10	POORLY GRADED SAND (SP)	A-3 (0)	18	NP	NP	NP	1.44	3.04
★	B-10	18.5 - 20	POORLY GRADED SAND with SILT (SP-SM)	A-3 (0)	18	NP	NP	NP	0.81	2.64

	Boring ID	Depth	D_{100}	D_{60}	D_{30}	D_{10}	%Gravel	%Sand	%Silt	%Fines	%Clay
●	B-9	23.5 - 25	9.5	0.463	0.252	0.096	0.0	92.2	4.6		3.2
⊠	B-10	3.5 - 5	2	0.132	0.059	0.015	0.0	60.8	31.7		7.5
▲	B-10	8.5 - 10	9.5	0.37	0.254	0.122	0.1	95.0	2.2		2.7
★	B-10	18.5 - 20	9.5	0.198	0.11	0.075	0.3	89.8	7.1		2.8

PROJECT: Cimarron Water Treatment Facility

SITE: State Highway 33 & State Highway 74
Cimarron City, Oklahoma

Terracon
4701 N Stiles Ave
Oklahoma City, OK

PROJECT NUMBER: 03165393

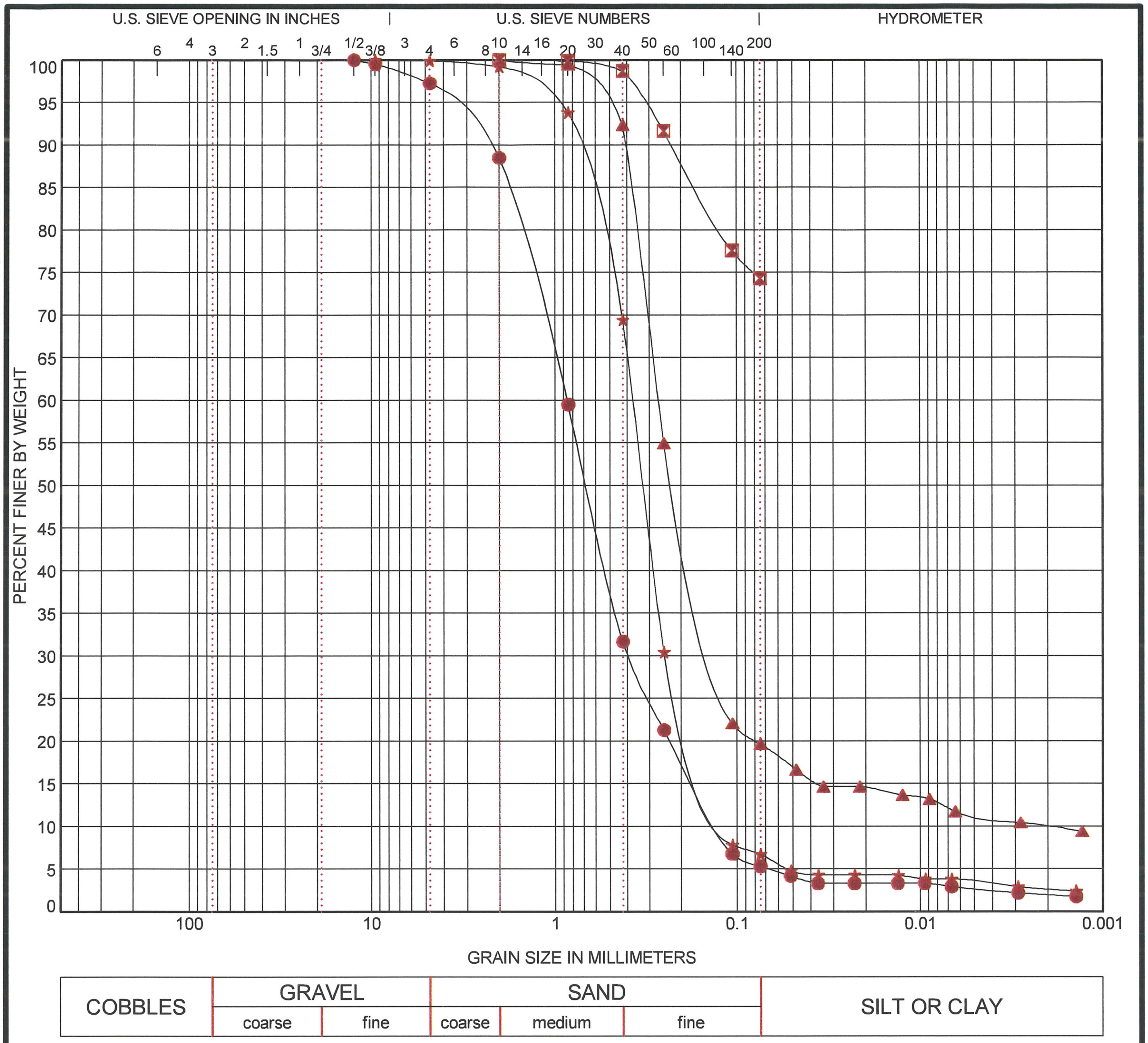
CLIENT: Environmental Properties Management LLC
Kansas City, Missouri

EXHIBIT: B-8

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GRAIN SIZE: USCS & AASHTO COMBINED 03165393 UPDATED CIMARRON TREATMENT FACILITY - DKK.GPJ TERRACON2015.GDT 12/20/16

GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136



	Boring ID	Depth	USCS Classification	AASHTO Classification	WC (%)	LL	PL	PI	Cc	Cu
●	B-10	23.5 - 24.9	WELL-GRADED SAND with SILT (SW-SM)	A-1-b (0)	14	NP	NP	NP	1.38	6.72
☒	B-11	1 - 2.5	LEAN CLAY with SAND (CL)		8					
▲	B-11	3.5 - 5	SILTY SAND (SM)	A-2-4 (0)	3	NP	NP	NP	30.98	131.46
★	B-11	8.5 - 10	POORLY GRADED SAND with SILT (SP-SM)	A-3 (0)	16	NP	NP	NP	1.41	3.25

	Boring ID	Depth	D_{100}	D_{60}	D_{30}	D_{10}	%Gravel	%Sand	%Silt	%Fines	%Clay
●	B-10	23.5 - 24.9	12.5	0.863	0.39	0.128	2.7	92.0	2.6		2.7
☒	B-11	1 - 2.5	2				0.0	25.7		74.3	
▲	B-11	3.5 - 5	2	0.269	0.13	0.002	0.0	80.3	8.3		11.3
★	B-11	8.5 - 10	9.5	0.374	0.246	0.115	0.1	93.2	3.2		3.5

PROJECT: Cimarron Water Treatment Facility

SITE: State Highway 33 & State Highway 74
Cimarron City, Oklahoma

Terracon
4701 N Stiles Ave
Oklahoma City, OK

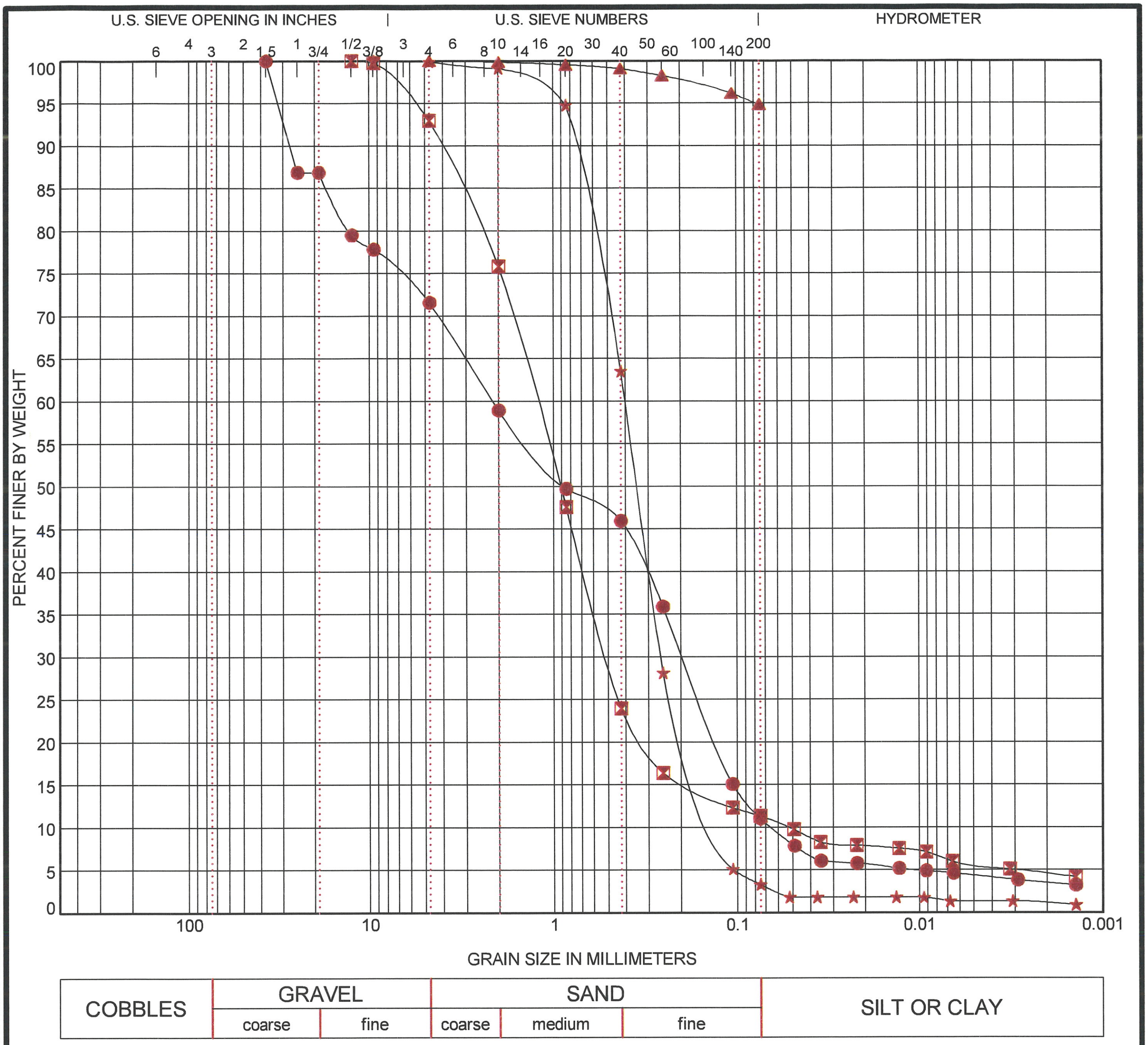
PROJECT NUMBER: 03165393

CLIENT: Environmental Properties Management LLC
Kansas City, Missouri

EXHIBIT: B-9

GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136



	Boring ID	Depth	USCS Classification	AASHTO Classification	WC (%)	LL	PL	PI	Cc	Cu
●	B-11	18.5 - 20	POORLY GRADED SAND with SILT and GRAVEL (SP-SM)	A-1-b (0)	12	NP	NP	NP	0.27	32.96
☒	B-11	23.5 - 25	POORLY GRADED SAND with SILT (SP-SM)	A-1-b (0)	14	NP	NP	NP	3.96	23.56
▲	B-12	1 - 2.5	FAT CLAY (CH)	A-7-6 (43)	18	61	20	41		
★	B-12	6 - 7.5	POORLY GRADED SAND (SP)	A-3 (0)	19	NP	NP	NP	1.29	3.17

	Boring ID	Depth	D_{100}	D_{60}	D_{30}	D_{10}	%Gravel	%Sand	%Silt	%Fines	%Clay
●	B-11	18.5 - 20	37.5	2.153	0.196	0.065	28.4	60.5	6.7		4.4
☒	B-11	23.5 - 25	12.5	1.239	0.508	0.053	7.0	81.6	5.7		5.7
▲	B-12	1 - 2.5	4.75				0.0	5.1		94.9	
★	B-12	6 - 7.5	9.5	0.403	0.257	0.127	0.1	96.6	2.0		1.4

PROJECT: Cimarron Water Treatment Facility

SITE: State Highway 33 & State Highway 74
Cimarron City, Oklahoma

Terracon
4701 N Stiles Ave
Oklahoma City, OK

PROJECT NUMBER: 03165393

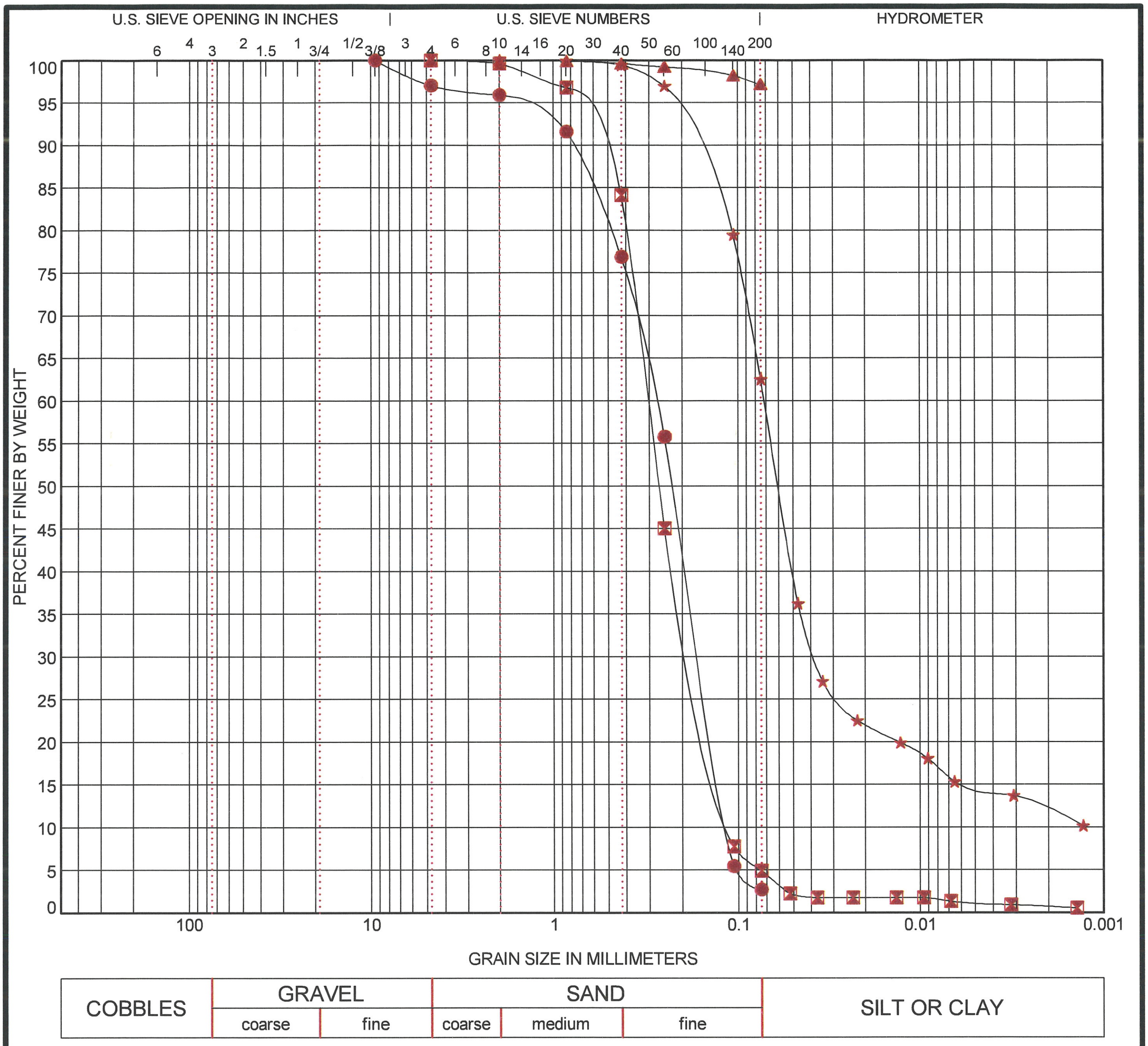
CLIENT: Environmental Properties Management LLC
Kansas City, Missouri

EXHIBIT: B-10

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GRAIN SIZE: USCS & AASHTO COMBINED 03165393 UPDATED CIMARRON TREATMENT FACILITY - DKK.GPJ TERRACON2015.GDT 12/20/16

GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136



	Boring ID	Depth	USCS Classification	AASHTO Classification	WC (%)	LL	PL	PI	Cc	Cu
●	B-12	13.5 - 15	POORLY GRADED SAND (SP)	A-3 (0)	27	NP	NP	NP	0.81	2.43
☒	B-12	18.5 - 20	POORLY GRADED SAND (SP)	A-3 (0)	16	NP	NP	NP	0.91	2.74
▲	B-13	1 - 2.5	FAT CLAY (CH)	A-7-6 (53)	25	72	24	48		
★	B-13	3.5 - 5	SANDY LEAN CLAY (CL)	A-6 (8)	24	31	14	17		

	Boring ID	Depth	D_{100}	D_{60}	D_{30}	D_{10}	%Gravel	%Sand	%Silt	%Fines	%Clay
●	B-12	13.5 - 15	9.5	0.278	0.161	0.115	2.9	94.3		2.7	
☒	B-12	18.5 - 20	4.75	0.306	0.177	0.112	0.0	95.1	3.8		1.2
▲	B-13	1 - 2.5	4.75				0.0	2.8		97.2	
★	B-13	3.5 - 5	2	0.072	0.038		0.0	37.5	47.8		14.8

PROJECT: Cimarron Water Treatment Facility

SITE: State Highway 33 & State Highway 74
Cimarron City, Oklahoma

Terracon
4701 N Stiles Ave
Oklahoma City, OK

PROJECT NUMBER: 03165393

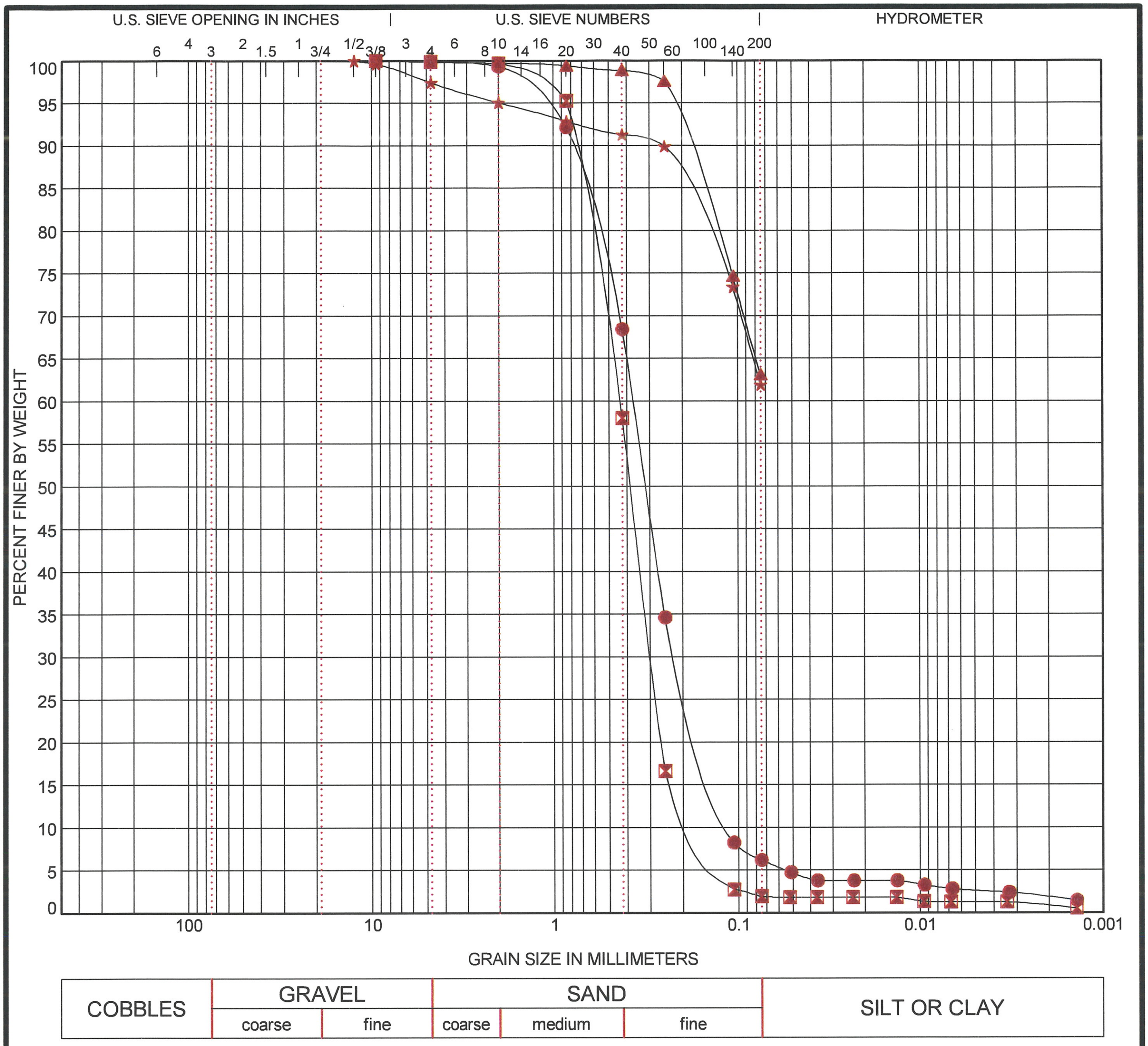
CLIENT: Environmental Properties Management LLC
Kansas City, Missouri

EXHIBIT: B-11

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GRAIN SIZE: USCS & AASHTO COMBINED 03165393 UPDATED CIMARRON TREATMENT FACILITY - DKK.GPJ TERRACON2015.GDT 12/20/16

GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136



	Boring ID	Depth	USCS Classification	AASHTO Classification	WC (%)	LL	PL	PI	Cc	Cu
●	B-13	8.5 - 10	POORLY GRADED SAND with SILT (SP-SM)	A-3 (0)	17	NP	NP	NP	1.11	3.32
⊠	B-13	13.5 - 15	POORLY GRADED SAND (SP)	A-3 (0)	18	NP	NP	NP	1.20	2.65
▲	B-1 & B-7 (Bulk)	0 - 5	SANDY LEAN CLAY (CL)	A-6 (7)		30	15	15		
★	B-2 & B-4(Bulk)	0 - 5	SANDY LEAN CLAY (CL)	A-6 (4)		26	15	11		

	Boring ID	Depth	D_{100}	D_{60}	D_{30}	D_{10}	%Gravel	%Sand	%Silt	%Fines	%Clay
●	B-13	8.5 - 10	9.5	0.372	0.215	0.112	0.0	93.8	3.6		2.6
⊠	B-13	13.5 - 15	9.5	0.441	0.297	0.166	0.1	98.0	0.7		1.3
▲	B-1 & B-7 (Bulk)	0 - 5	9.5				0.2	36.7		63.1	
★	B-2 & B-4(Bulk)	0 - 5	12.5				2.6	35.5		61.9	

PROJECT: Cimarron Water Treatment Facility

SITE: State Highway 33 & State Highway 74
Cimarron City, Oklahoma

Terracon
4701 N Stiles Ave
Oklahoma City, OK

PROJECT NUMBER: 03165393

CLIENT: Environmental Properties Management LLC
Kansas City, Missouri

EXHIBIT: B-12

Terracon

Laboratory Compaction Characteristics of Soil

13910 West 96th Terrace
Lenexa, Kansas 66215
913-492-7777

Client Name: Environmental Properties Management LLC

Project No.: 03165393 Date: 12/8/2016

Project Name: Cimarron Water Treatmen Facility

Location: State Highway 33 and State Highway 74
Cimarron City, Logan County, Oklahoma

Source Material: B-1 & B-7, Bulk, 1 to 5.0 feet

Sample Description: Sandy Lean Clay, reddish brown

TEST RESULTS

Maximum Dry Unit Wt.:	113.5	pcf
Optimum Water Content:	13.6	%

Material Designation: CL Sample date: 11/17/2016

Test Method: ASTM D698 (Standard)

Test Procedure: Method B

Sample Preparation: Dry Preparation

Rammer: X Mechanical ____ Manual

Liquid Limit: 30 Plastic Limit: 15

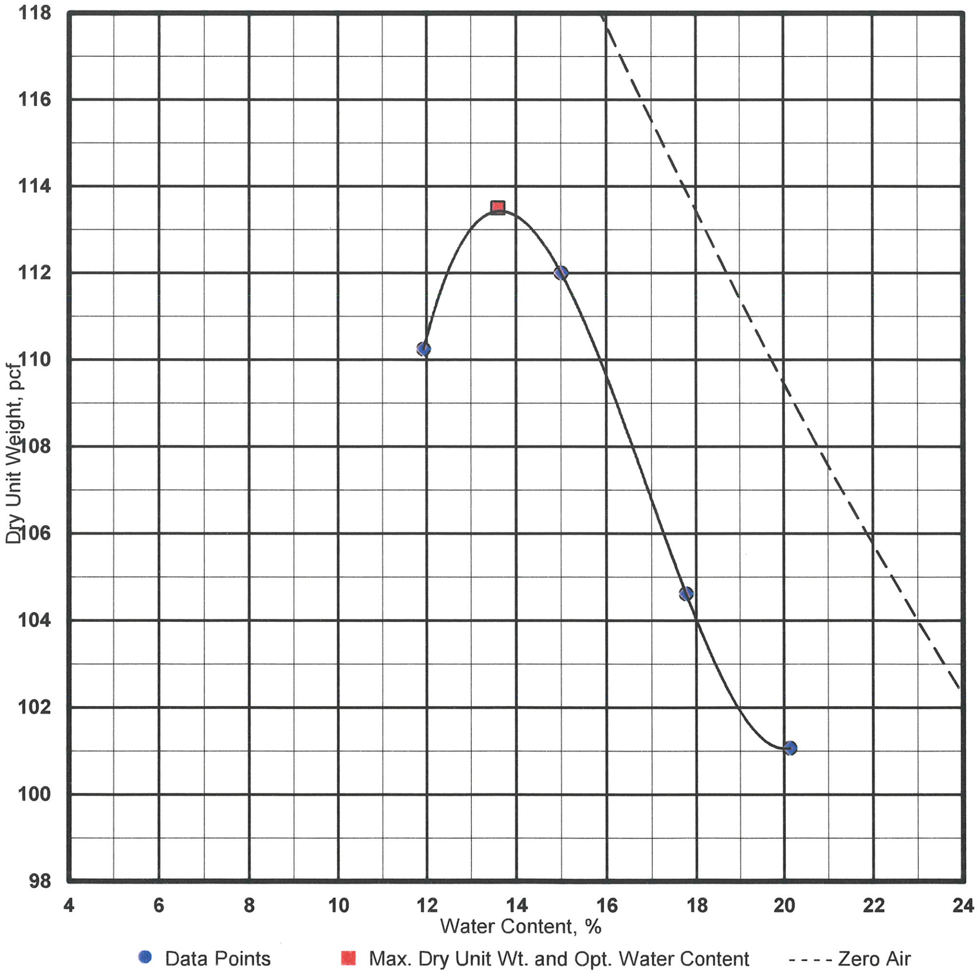
Plasticity Index: 15

Natural Moisture, %: ____

% passing # 200 sieve: 63.1

Reviewed by: DCVS

Zero air voids for specific gravity of 2.70



N:\Projects\2016\03165393\PROJECT DOCUMENTS (Reports-Letters-Drafts to Clients)\Proctors (Exhibits B-13 & B-14)\[Exhibit B-13 ProctorReport B1&B7-Bulk-0.0.xlsx]REF **Exhibit B-13**

Laboratory Compaction Characteristics of Soil

Terracon
13910 West 96th Terrace
Lenexa, Kansas 66215
913-492-7777

Client Name: Environmental Properties Management LLC
Project No.: 03165393 Date: 12/8/2016
Project Name: Cimarron Water Treatmen Facility
Location: State Highway 33 and State Highway 74
Cimarron City, Logan County, Oklahoma
Source Material: B-2 & B-4, Bulk, 1 to 5.0 feet
Sample Description: Sandy Lean Clay, reddish brown

TEST RESULTS

Maximum Dry Unit Wt.: 116.7 pcf
Optimum Water Content: 12.1 %

Material Designation: CL Sample date: 11/17/2016
Liquid Limit: 26 Plastic Limit: 15
Test Method: ASTM D698 (Standard)
Plasticity Index: 11
Test Procedure: Method B
Natural Moisture, %: ____
Sample Preparation: Dry Preparation
% passing # 200 sieve: 61.9
Rammer: X Mechanical ____ Manual
Reviewed by: DCVS

Zero air voids for specific gravity of 2.70

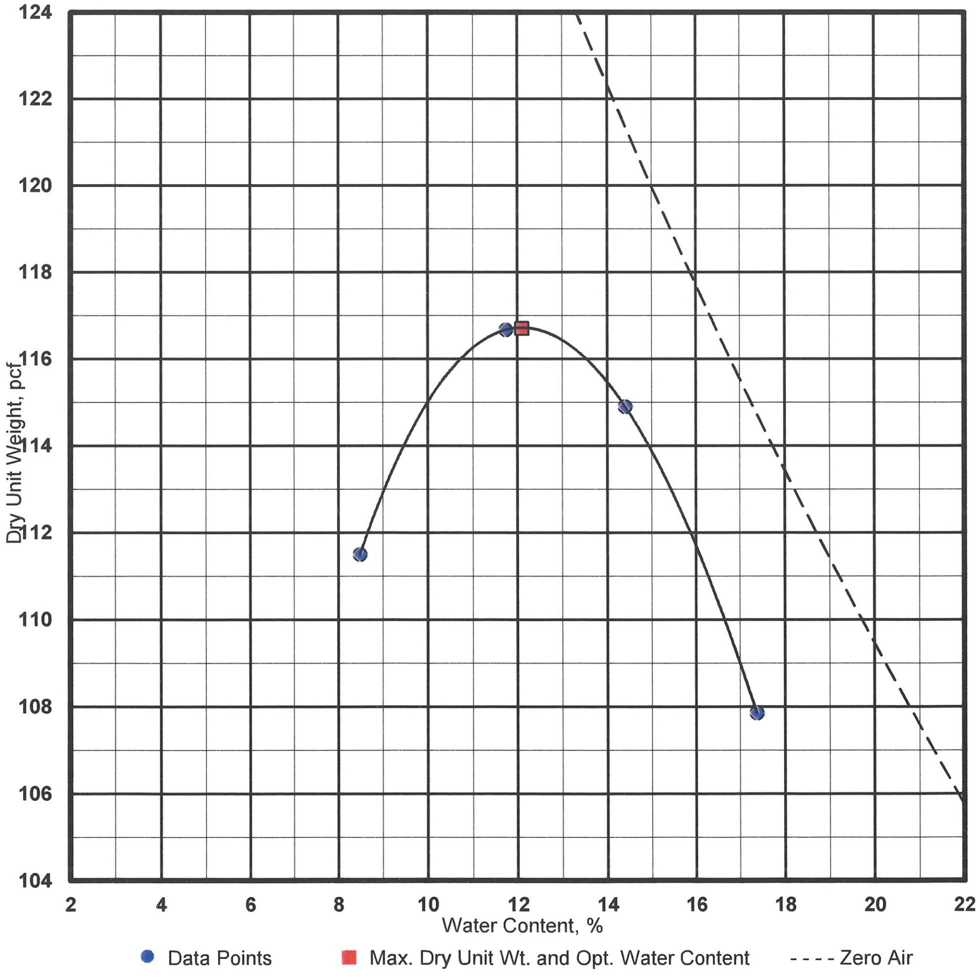


Exhibit B-14

California Bearing Ratio of Laboratory-Compacted Soils

Report Number: 03165393.0000
Service Date:
Report Date: 12/12/16
Task:

Terracon
13910 West 963th Terrace
Lenexa, Kansas 66215
Ph. 913.492.7777; Fx 913.492.7443

Client

Environmental Properties Management LLC
A Subsidiary of Burns & McDonnell Eng. Company
Kansas City, Missouri 64111

Project

Cimarron Water Treatment Facility
State Highway 33 and State Highway 74
Cimarron City, Logan County, Oklahoma

Project No. 03165393

SAMPLE INFORMATION

Sample Number: Composite
Boring Number: B-1 & B-7
Sample Location: Bulk
Depth: 1 to 5.0 feet
Material Description: Sandy Lean Clay, reddish brown

Proctor Method: ASTM D698 - Method C
Maximum Dry Density (pcf): 113.5
Optimum Moisture: 13.6
Liquid Limit: 30
Plasticity Index: 15

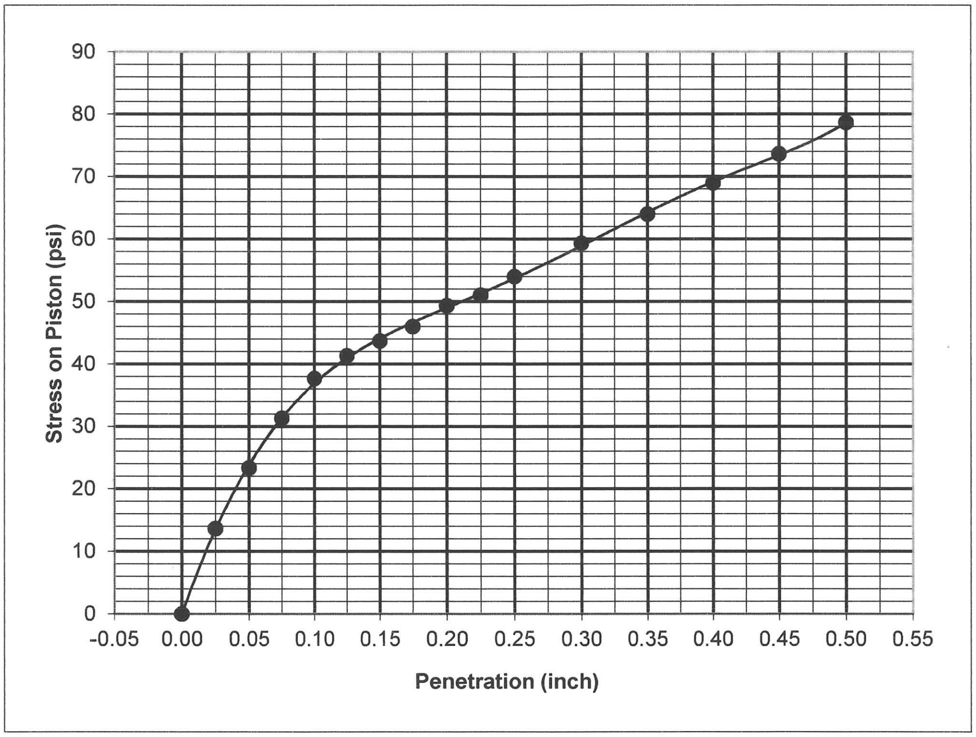
CBR TEST DATA

CBR Value at 0.100 inch **3.8**
CBR Value at 0.200 inch **3.3**

Surcharge Weight (lbs) 10
Soaking Condition Soaked
Length of Soaking (hours) 96
Swell (%) 0.9

DENSITY DATA
Dry Density Before Soaking (pcf) 105.6
Compaction of Proctor (%) 93.1

MOISTURE DATA
Before Compaction (%) 17.2
After Compaction (%) 14.7
Top 1" After Soaking (%) 20.1
Average After Soaking (%) 18.2



Comments:
Test Methods: ASTM D1883

Services:
Terracon Rep:
Reported To:
Contractor:

Started:
Finished:

Report Distribution

Reviewed by DCVS

Exhibit B-15

California Bearing Ratio of Laboratory-Compacted Soils

Report Number: 03165393.0000
Service Date:
Report Date: 12/12/16
Task:

Terracon
13910 West 963th Terrace
Lenexa, Kansas 66215
Ph. 913.492.7777; Fx 913.492.7443

Client

Environmental Properties Management LLC
A Subsidiary of Burns & McDonnell Eng. Company
Kansas City, Missouri 64111

Project

Cimarron Water Treatment Facility
State Highway 33 and State Highway 74
Cimarron City, Logan County, Oklahoma

Project No. 03165393

SAMPLE INFORMATION

Sample Number: Composite
Boring Number: B-2 & B-4
Sample Location: Bulk
Depth: 0.0 to 5.0 feet
Material Description: Sandy Lean Clay, reddish brown

Proctor Method: ASTM D698 - Method C
Maximum Dry Density (pcf): 116.7
Optimum Moisture: 12.1
Liquid Limit: 26
Plasticity Index: 11

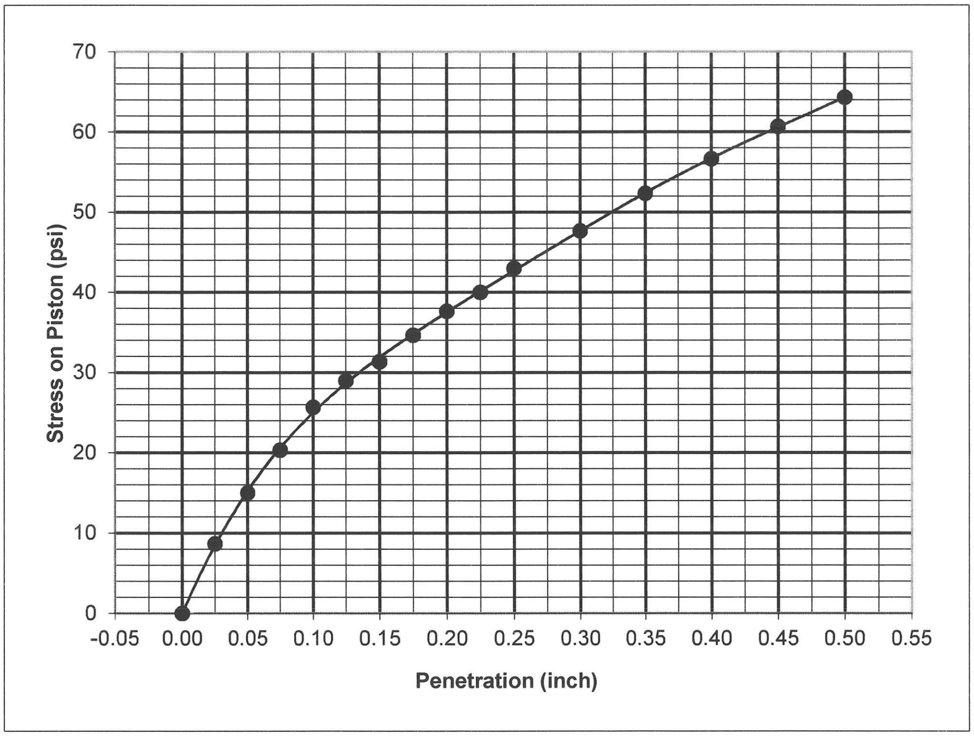
CBR TEST DATA

CBR Value at 0.100 inch **2.6**
CBR Value at 0.200 inch **2.5**

Surcharge Weight (lbs) 10
Soaking Condition Soaked
Length of Soaking (hours) 96
Swell (%) 1.4

DENSITY DATA
Dry Density Before Soaking (pcf) 110.4
Compaction of Proctor (%) 94.6

MOISTURE DATA
Before Compaction (%) 14.1
After Compaction (%) 13.9
Top 1" After Soaking (%) 19.2
Average After Soaking (%) 16.5



Comments:
Test Methods: ASTM D1883

Services:
Terracon Rep:
Reported To:
Contractor:

Started:
Finished:

Report Distribution

Reviewed by DCVS

Exhibit B-16

CHEMICAL LABORATORY TEST REPORT

Project Number: 03165393
Service Date: 12/12/16
Report Date: 12/13/16
Task:

Terracon
750 Pilot Road, Suite F
Las Vegas, Nevada 89119
(702) 597-9393

Client

Project

Cimarron Treatment Facility

Sample Submitted By: Terracon (03) **Date Received:** 12/7/2016 **Lab No.: 16-1084**

Results of Corrosion Analysis

Sample No.	1	3, 3, 3	2, 1, 1	3, 4
Sample Location	B-1	B-1, B-5, B-7	B-2, B-3, B-4	B-3, B-4
Sample Depth (ft.)	1.0-2.5	6.0-7.5	3.5-5, 1-2.5, 1-2.5	6.-7.5 & 8.5-10
pH Analysis, AWWA 4500 H	8.84	8.58	7.70	7.79
Water Soluble Sulfate (SO4), ASTM D 516 (mg/kg)	30	28	91	69
Sulfides, AWWA 4500-S D (mg/kg)	Nil	Nil	Nil	Nil
Chlorides, ASTM D 512, (mg/kg)	30	43	50	25
Red-Ox, AWWA 2580, (mV)	+633	+641	+667	+662
Resistivity, ASTM G-57, (ohm-cm)	7760	7566	3880	3414
Total Salts, AWWA 2540, (mg/kg)	308	302	1042	549

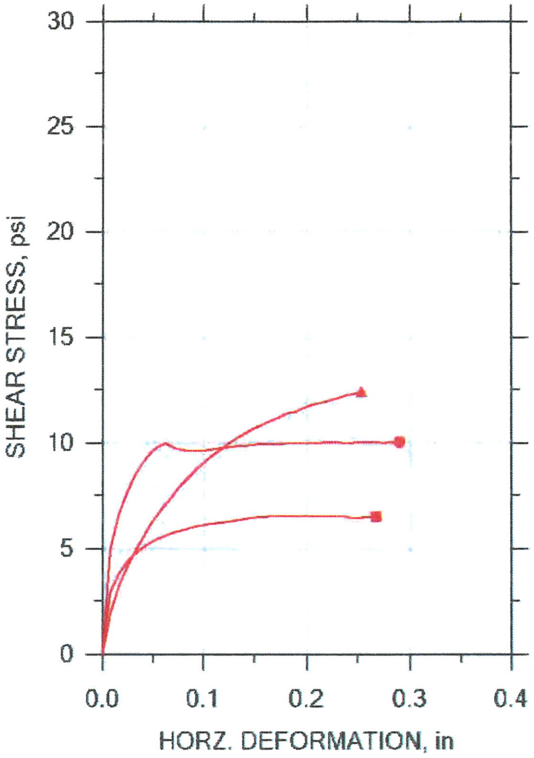
Nil = <1.0 mg/kg

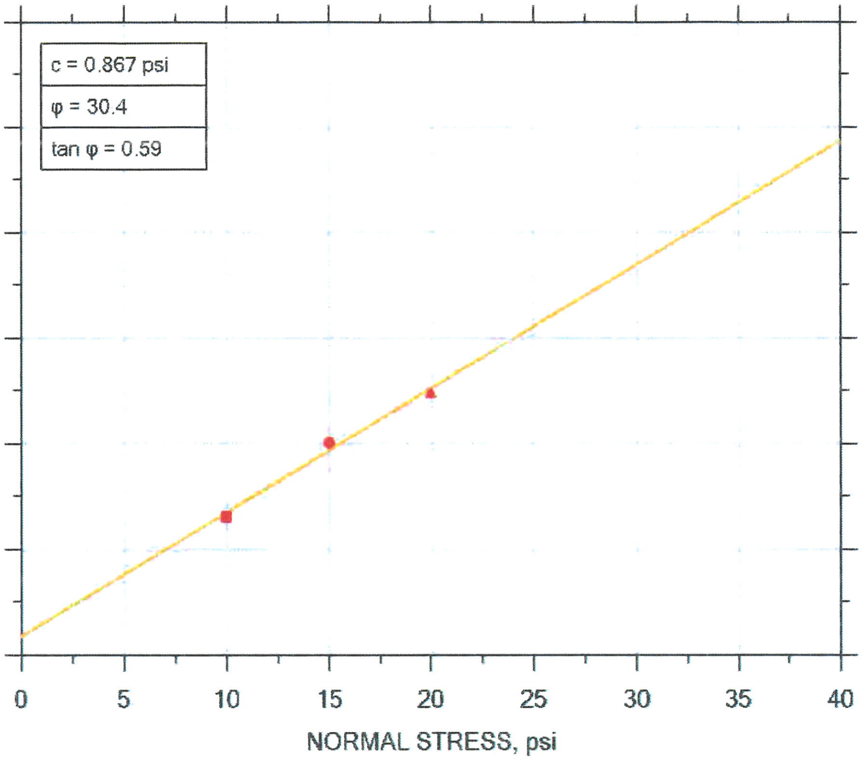
Analyzed By: Kurt D. Ergun

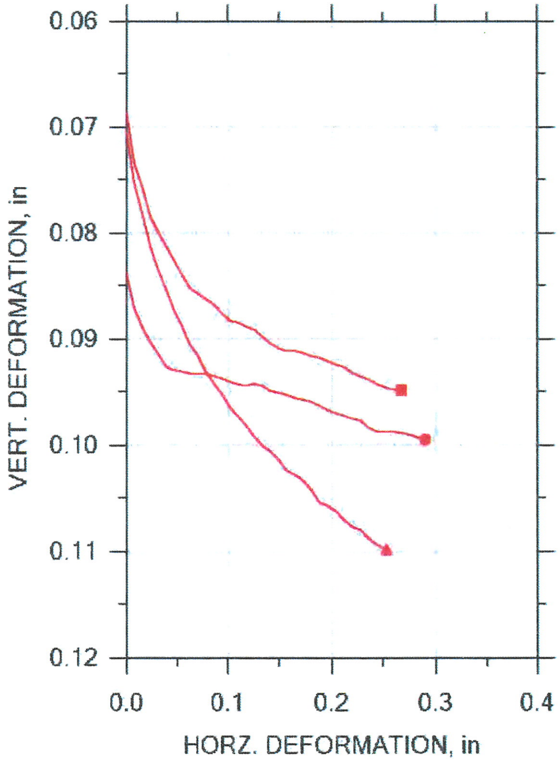
Kurt D. Ergun
Chemist

DIRECT SHEAR TEST by ASTM D3080

Terracon
Consulting Engineers & Scientists







	Symbol	■	●	▲	
	Test No.	10 PSI	15.0 PSI	20 PSI	
	Sample No.	BULK	BULK	BULK	
	Shape	Circular	Circular	Circular	
Initial	Dimension, in	2.5	2.4992	2.5	
	Area, in²	4.9087	4.9056	4.9087	
	Height, in	0.98425	0.98465	0.98465	
	Water Content, %	13.74	13.74	13.60	
	Dry Density, pcf	107.7	107.7	107.8	
	Saturation, %	64.83	64.90	64.35	
	Void Ratio	0.5765	0.57595	0.57473	
	Consol. Height, in	0.91564	0.9008	0.91407	
	Consol. Void Ratio	0.4666	0.44175	0.46186	
Final	Water Content, %	19.44	18.84	18.90	
	Dry Density, pcf	119.2	119.9	121.4	
	Saturation, %	124.56	122.99	128.79	
	Void Ratio	0.42457	0.41673	0.39908	
	Normal Stress, psi	9.9944	14.998	19.995	
	Max. Shear Stress, psi	6.5464	10.045	12.416	
	Ult. Shear Stress, psi	6.5209	10.045	12.416	
	Time to Failure, min	990.34	1716.7	1334.3	
	Disp. Rate, in/min	0.00019528	0.00019528	0.00019528	
	Estimated Specific Gravity	2.72	2.72	2.72	
	Liquid Limit	---	---	---	
	Plastic Limit	---	---	---	
	Plasticity Index	---	---	---	

Project: CIMARRON TREATMENT FACILITY
Location: Cimarron City, Logan County, Oklahoma
Project No.: 03165393
Boring No.: B-1 & B-7
Sample Type: REMOLDED
Description: REDDISH BROWN SANDY LEAN CLAY CL
Remarks: TEST PERFORMED AS PER ASTM D3080.

Exhibit B-18

USGS Design Maps Detailed Report

ASCE 7-10 Standard (35.882°N, 97.583°W)

Site Class D – "Stiff Soil", Risk Category I/II/III

Section 11.4.1 — Mapped Acceleration Parameters

Note: Ground motion values provided below are for the direction of maximum horizontal spectral response acceleration. They have been converted from corresponding geometric mean ground motions computed by the USGS by applying factors of 1.1 (to obtain S_S) and 1.3 (to obtain S_1). Maps in the 2010 ASCE-7 Standard are provided for Site Class B. Adjustments for other Site Classes are made, as needed, in Section 11.4.3.

From Figure 22-1 [1]	$S_S = 0.223$ g
From Figure 22-2 [2]	$S_1 = 0.071$ g

Section 11.4.2 — Site Class

The authority having jurisdiction (not the USGS), site-specific geotechnical data, and/or the default has classified the site as Site Class D, based on the site soil properties in accordance with Chapter 20.

Table 20.3–1 Site Classification

Site Class	$\bar{v}_s$	$\bar{N}$ or $\bar{N}_{ch}$	$\bar{s}_u$
A. Hard Rock	>5,000 ft/s	N/A	N/A
B. Rock	2,500 to 5,000 ft/s	N/A	N/A
C. Very dense soil and soft rock	1,200 to 2,500 ft/s	>50	>2,000 psf
D. Stiff Soil	600 to 1,200 ft/s	15 to 50	1,000 to 2,000 psf
E. Soft clay soil	<600 ft/s	<15	<1,000 psf
	Any profile with more than 10 ft of soil having the characteristics: • Plasticity index $PI > 20$, • Moisture content $w \geq 40\%$, and • Undrained shear strength $\bar{s}_u < 500$ psf		
F. Soils requiring site response analysis in accordance with Section 21.1		See Section 20.3.1	

For SI: 1ft/s = 0.3048 m/s 1lb/ft² = 0.0479 kN/m²

Exhibit B-1

Section 11.4.3 — Site Coefficients and Risk–Targeted Maximum Considered Earthquake (MCE_R) Spectral Response Acceleration Parameters

Table 11.4–1: Site Coefficient F_a

Site Class	Mapped MCE_R Spectral Response Acceleration Parameter at Short Period				
	$S_S \le 0.25$	$S_S = 0.50$	$S_S = 0.75$	$S_S = 1.00$	$S_S \ge 1.25$
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.2	1.2	1.1	1.0	1.0
D	$\boxed{1.6}$	1.4	1.2	1.1	1.0
E	2.5	1.7	1.2	0.9	0.9
F	See Section 11.4.7 of ASCE 7				

Note: Use straight–line interpolation for intermediate values of S_S

For Site Class = D and S_S = 0.223 g, F_a = 1.600

Table 11.4–2: Site Coefficient F_v

Site Class	Mapped MCE_R Spectral Response Acceleration Parameter at 1–s Period				
	$S_1 \le 0.10$	$S_1 = 0.20$	$S_1 = 0.30$	$S_1 = 0.40$	$S_1 \ge 0.50$
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.7	1.6	1.5	1.4	1.3
D	$\boxed{2.4}$	2.0	1.8	1.6	1.5
E	3.5	3.2	2.8	2.4	2.4
F	See Section 11.4.7 of ASCE 7				

Note: Use straight–line interpolation for intermediate values of S_1

For Site Class = D and S_1 = 0.071 g, F_v = 2.400

Exhibit B-1

Equation (11.4-1): $S_{MS} = F_aS_S = 1.600 \times 0.223 = 0.357$ g

---

Equation (11.4-2): $S_{M1} = F_vS_1 = 2.400 \times 0.071 = 0.171$ g

---

Section 11.4.4 — Design Spectral Acceleration Parameters

Equation (11.4-3): $S_{DS} = \tfrac{2}{3} S_{MS} = \tfrac{2}{3} \times 0.357 = 0.238$ g

---

Equation (11.4-4): $S_{D1} = \tfrac{2}{3} S_{M1} = \tfrac{2}{3} \times 0.171 = 0.114$ g

---

Section 11.4.5 — Design Response Spectrum

From Figure 22-12[5] $T_L = 12$ seconds

Figure 11.4-1: Design Response Spectrum

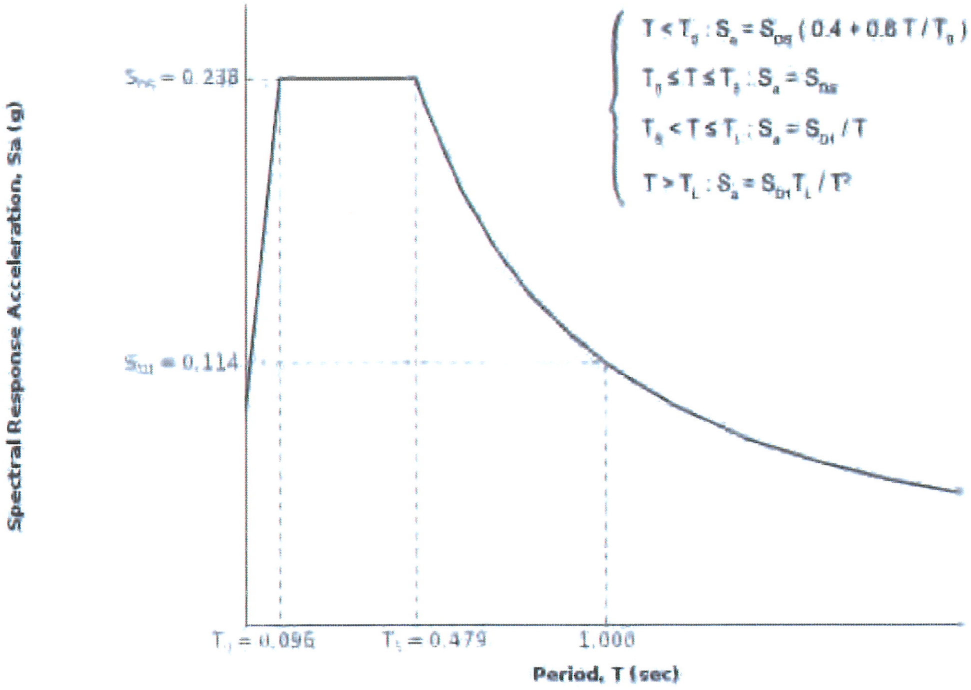


Exhibit B-1

Section 11.4.6 — Risk-Targeted Maximum Considered Earthquake (MCE_R) Response Spectrum

The MCE_R Response Spectrum is determined by multiplying the design response spectrum above by 1.5.

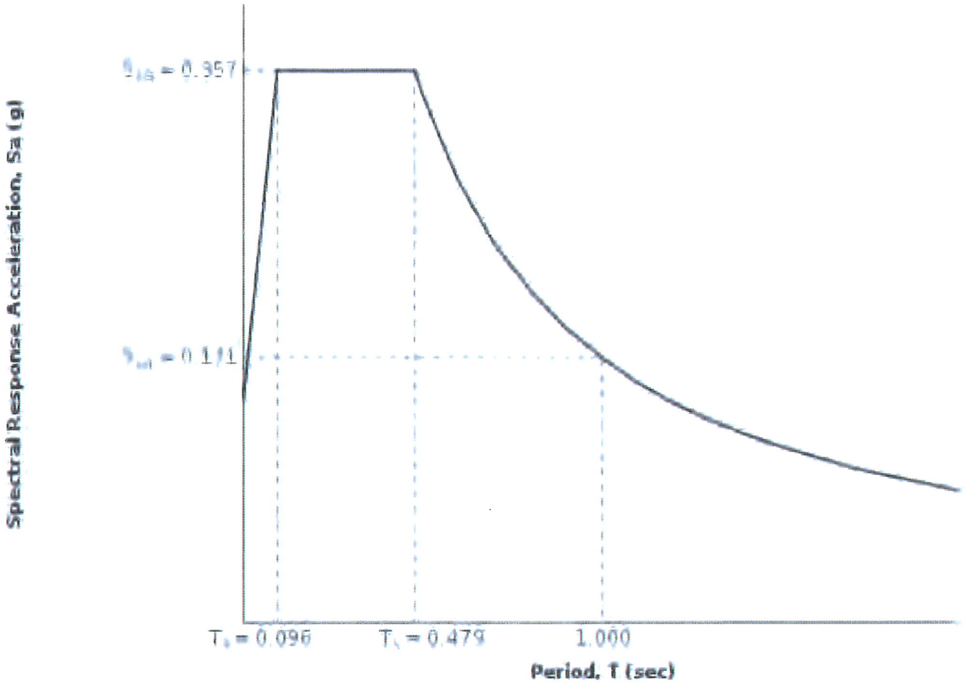


Exhibit B-

Section 11.8.3 — Additional Geotechnical Investigation Report Requirements for Seismic Design Categories D through F

From Figure 22-7 [4] PGA = 0.125

Equation (11.8–1): $PGA_M = F_{PGA}PGA = 1.549 \times 0.125 = 0.194$ g

Table 11.8–1: Site Coefficient F_{PGA}

Site Class	Mapped MCE Geometric Mean Peak Ground Acceleration, PGA				
	PGA ≤ 0.10	PGA = 0.20	PGA = 0.30	PGA = 0.40	PGA ≥ 0.50
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.2	1.2	1.1	1.0	1.0
D	1.6	1.4	1.2	1.1	1.0
E	2.5	1.7	1.2	0.9	0.9
F	See Section 11.4.7 of ASCE 7				

Note: Use straight–line interpolation for intermediate values of PGA

For Site Class = D and PGA = 0.125 g, F_{PGA} = 1.549

Section 21.2.1.1 — Method 1 (from Chapter 21 – Site-Specific Ground Motion Procedures for Seismic Design)

From Figure 22-17 [5] $C_{RS} = 0.872$

From Figure 22-18 [6] $C_{R1} = 0.883$

Exhibit B-

Section 11.6 — Seismic Design Category

Table 11.6-1 Seismic Design Category Based on Short Period Response Acceleration Parameter

VALUE OF S_{DS}	**RISK CATEGORY**		
	I or II	**III**	**IV**
$S_{DS} < 0.167g$	A	A	A
$0.167g \le S_{DS} < 0.33g$	B	B	C
$0.33g \le S_{DS} < 0.50g$	C	C	D
$0.50g \le S_{DS}$	D	D	D

For Risk Category = I and S_{DS} = 0.238 g, Seismic Design Category = B

Table 11.6-2 Seismic Design Category Based on 1-S Period Response Acceleration Parameter

VALUE OF S_{D1}	**RISK CATEGORY**		
	I or II	**III**	**IV**
$S_{D1} < 0.067g$	A	A	A
$0.067g \le S_{D1} < 0.133g$	B	B	C
$0.133g \le S_{D1} < 0.20g$	C	C	D
$0.20g \le S_{D1}$	D	D	D

For Risk Category = I and S_{D1} = 0.114 g, Seismic Design Category = B

Note: When S_1 is greater than or equal to 0.75g, the Seismic Design Category is **E** for buildings in Risk Categories I, II, and III, and **F** for those in Risk Category IV, irrespective of the above.

Seismic Design Category ≡ "the more severe design category in accordance with Table 11.6-1 or 11.6-2" = B

Note: See Section 11.6 for alternative approaches to calculating Seismic Design Category.

References

1. *Figure 22-1*: http://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/2010_ASCE-7_Figure_22-1.pdf
2. *Figure 22-2*: http://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/2010_ASCE-7_Figure_22-2.pdf
3. *Figure 22-12*: http://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/2010_ASCE-7_Figure_22-12.pdf
4. *Figure 22-7*: http://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/2010_ASCE-7_Figure_22-7.pdf
5. *Figure 22-17*: http://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/2010_ASCE-7_Figure_22-17.pdf
6. *Figure 22-18*: http://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/2010_ASCE-7_Figure_22-18.pdf

Exhibit B-1

USGS Design Maps Detailed Report

ASCE 7-10 Standard (35.882°N, 97.583°W)

Site Class C – "Very Dense Soil and Soft Rock", Risk Category I/II/III

Section 11.4.1 — Mapped Acceleration Parameters

Note: Ground motion values provided below are for the direction of maximum horizontal spectral response acceleration. They have been converted from corresponding geometric mean ground motions computed by the USGS by applying factors of 1.1 (to obtain S_S) and 1.3 (to obtain S_1). Maps in the 2010 ASCE-7 Standard are provided for Site Class B. Adjustments for other Site Classes are made, as needed, in Section 11.4.3.

From Figure 22-1 [1]	$S_S = 0.223$ g
From Figure 22-2 [2]	$S_1 = 0.071$ g

Section 11.4.2 — Site Class

The authority having jurisdiction (not the USGS), site-specific geotechnical data, and/or the default has classified the site as Site Class C, based on the site soil properties in accordance with Chapter 20.

Table 20.3–1 Site Classification

Site Class	$\bar{v}_s$	$\bar{N}$ or $\bar{N}_{ch}$	$\bar{s}_u$
A. Hard Rock	>5,000 ft/s	N/A	N/A
B. Rock	2,500 to 5,000 ft/s	N/A	N/A
C. Very dense soil and soft rock	1,200 to 2,500 ft/s	>50	>2,000 psf
D. Stiff Soil	600 to 1,200 ft/s	15 to 50	1,000 to 2,000 psf
E. Soft clay soil	<600 ft/s	<15	<1,000 psf
	Any profile with more than 10 ft of soil having the characteristics: • Plasticity index *PI* > 20, • Moisture content *w* ≥ 40%, and • Undrained shear strength $\bar{s}_u$ < 500 psf		
F. Soils requiring site response analysis in accordance with Section 21.1	See Section 20.3.1		

For SI: 1ft/s = 0.3048 m/s 1lb/ft² = 0.0479 kN/m²

Exhibit B-2

Section 11.4.3 — Site Coefficients and Risk-Targeted Maximum Considered Earthquake (MCE_R) Spectral Response Acceleration Parameters

Table 11.4-1: Site Coefficient F_a

Site Class	Mapped MCE $_R$ Spectral Response Acceleration Parameter at Short Period				
	$S_S \le 0.25$	$S_S = 0.50$	$S_S = 0.75$	$S_S = 1.00$	$S_S \ge 1.25$
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.2	1.2	1.1	1.0	1.0
D	1.6	1.4	1.2	1.1	1.0
E	2.5	1.7	1.2	0.9	0.9
F	See Section 11.4.7 of ASCE 7				

Note: Use straight–line interpolation for intermediate values of S_S

For Site Class = C and S_s = 0.223 g, F_a = 1.200

Table 11.4-2: Site Coefficient F_v

Site Class	Mapped MCE $_R$ Spectral Response Acceleration Parameter at 1–s Period				
	$S_1 \le 0.10$	$S_1 = 0.20$	$S_1 = 0.30$	$S_1 = 0.40$	$S_1 \ge 0.50$
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.7	1.6	1.5	1.4	1.3
D	2.4	2.0	1.8	1.6	1.5
E	3.5	3.2	2.8	2.4	2.4
F	See Section 11.4.7 of ASCE 7				

Note: Use straight–line interpolation for intermediate values of S_1

For Site Class = C and S_1 = 0.071 g, F_v = 1.700

Exhibit B-

Equation (11.4-1): $S_{MS} = F_aS_S = 1.200 \times 0.223 = 0.267$ g

Equation (11.4-2): $S_{M1} = F_vS_1 = 1.700 \times 0.071 = 0.121$ g

Section 11.4.4 — Design Spectral Acceleration Parameters

Equation (11.4-3): $S_{DS} = \frac{2}{3} S_{MS} = \frac{2}{3} \times 0.267 = 0.178$ g

Equation (11.4-4): $S_{D1} = \frac{2}{3} S_{M1} = \frac{2}{3} \times 0.121 = 0.081$ g

Section 11.4.5 — Design Response Spectrum

From Figure 22-12 [3] $T_L = 12$ seconds

Figure 11.4-1: Design Response Spectrum

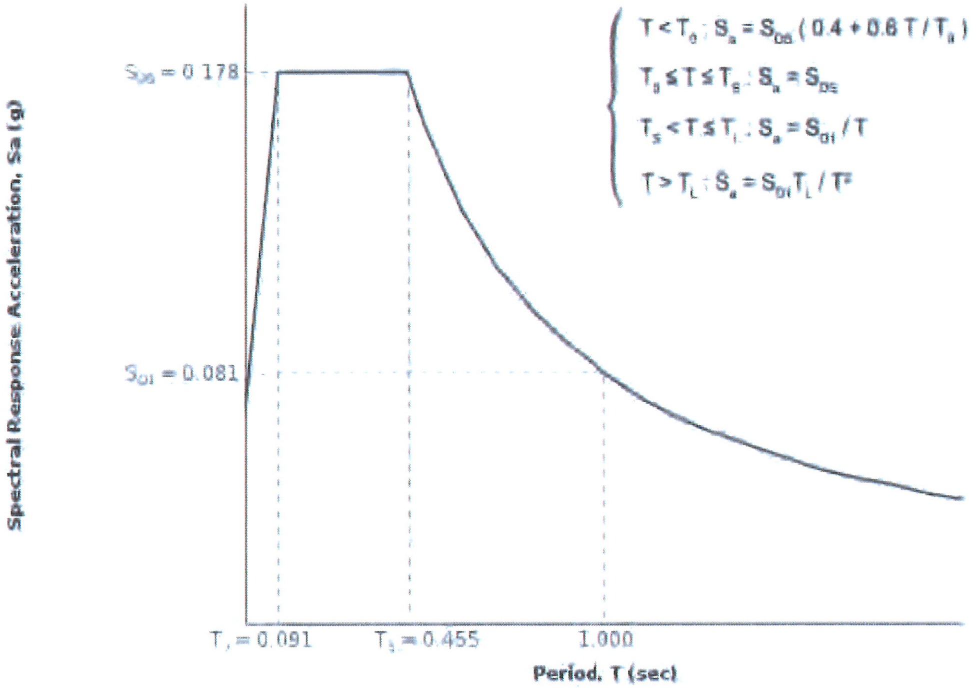


Exhibit B-

Section 11.4.6 — Risk-Targeted Maximum Considered Earthquake (MCE_R) Response Spectrum

The MCE_R Response Spectrum is determined by multiplying the design response spectrum above by 1.5.

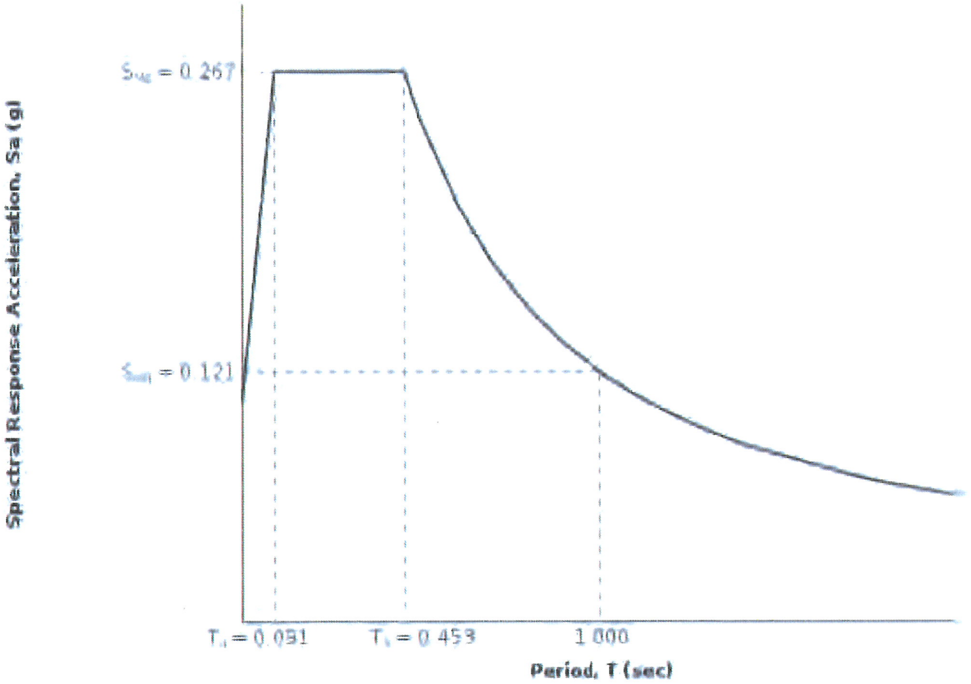


Exhibit B-2

Section 11.8.3 — Additional Geotechnical Investigation Report Requirements for Seismic Design Categories D through F

From Figure 22-7 [4] PGA = 0.125

Equation (11.8–1): $PGA_M = F_{PGA}PGA = 1.200 \times 0.125 = 0.151$ g

Table 11.8–1: Site Coefficient F_{PGA}

Site Class	Mapped MCE Geometric Mean Peak Ground Acceleration, PGA				
	PGA ≤ 0.10	PGA = 0.20	PGA = 0.30	PGA = 0.40	PGA ≥ 0.50
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.2	1.2	1.1	1.0	1.0
D	1.6	1.4	1.2	1.1	1.0
E	2.5	1.7	1.2	0.9	0.9
F	See Section 11.4.7 of ASCE 7				

Note: Use straight–line interpolation for intermediate values of PGA

For Site Class = C and PGA = 0.125 g, F_{PGA} = 1.200

Section 21.2.1.1 — Method 1 (from Chapter 21 – Site-Specific Ground Motion Procedures for Seismic Design)

From Figure 22-17 [5] C_{RS} = 0.872

From Figure 22-18 [6] C_{R1} = 0.883

Exhibit B-2

Section 11.6 — Seismic Design Category

Table 11.6-1 Seismic Design Category Based on Short Period Response Acceleration Parameter

VALUE OF S_{DS}	RISK CATEGORY		
	I or II	III	IV
$S_{DS} < 0.167g$	A	A	A
$0.167g \le S_{DS} < 0.33g$	B	B	C
$0.33g \le S_{DS} < 0.50g$	C	C	D
$0.50g \le S_{DS}$	D	D	D

For Risk Category = I and S_{DS} = 0.178 g, Seismic Design Category = B

Table 11.6-2 Seismic Design Category Based on 1-S Period Response Acceleration Parameter

VALUE OF S_{D1}	RISK CATEGORY		
	I or II	III	IV
$S_{D1} < 0.067g$	A	A	A
$0.067g \le S_{D1} < 0.133g$	B	B	C
$0.133g \le S_{D1} < 0.20g$	C	C	D
$0.20g \le S_{D1}$	D	D	D

For Risk Category = I and S_{D1} = 0.081 g, Seismic Design Category = B

Note: When S_1 is greater than or equal to 0.75g, the Seismic Design Category is **E** for buildings in Risk Categories I, II, and III, and **F** for those in Risk Category IV, irrespective of the above.

Seismic Design Category ≡ "the more severe design category in accordance with Table 11.6-1 or 11.6-2" = B

Note: See Section 11.6 for alternative approaches to calculating Seismic Design Category.

References

1. *Figure 22-1*: http://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/2010_ASCE-7_Figure_22-1.pdf
2. *Figure 22-2*: http://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/2010_ASCE-7_Figure_22-2.pdf
3. *Figure 22-12*: http://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/2010_ASCE-7_Figure_22-12.pdf
4. *Figure 22-7*: http://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/2010_ASCE-7_Figure_22-7.pdf
5. *Figure 22-17*: http://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/2010_ASCE-7_Figure_22-17.pdf
6. *Figure 22-18*: http://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/2010_ASCE-7_Figure_22-18.pdf

Exhibit B-2

APPENDIX C
SUPPORTING DOCUMENTS

GENERAL NOTES

DESCRIPTION OF SYMBOLS AND ABBREVIATIONS

SAMPLING

▯ Auger	☒ Split Spoon
■ Shelby Tube	▮ Pressure Meter
◩ Texas Cone	▮ Rock Core
✋ Grab Sample	▱ No Recovery

WATER LEVEL

▽	Water Initially Encountered
▽	Water Level After a Specified Period of Time
▼	Water Level After a Specified Period of Time

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

FIELD TESTS

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

DESCRIPTIVE SOIL CLASSIFICATION

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

LOCATION AND ELEVATION NOTES

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

STRENGTH TERMS

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

RELATIVE PROPORTIONS OF SAND AND GRAVEL

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

GRAIN SIZE TERMINOLOGY

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

RELATIVE PROPORTIONS OF FINES

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

PLASTICITY DESCRIPTION

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

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Exhibit C-1

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-inch (75-mm) sieve

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

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

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

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

[F] If soil contains $\geq$ 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 $\geq$ 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 $\geq$ 30% plus No. 200 predominantly sand, add "sandy" to group name.

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

[N] $PI \geq 4$ 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.

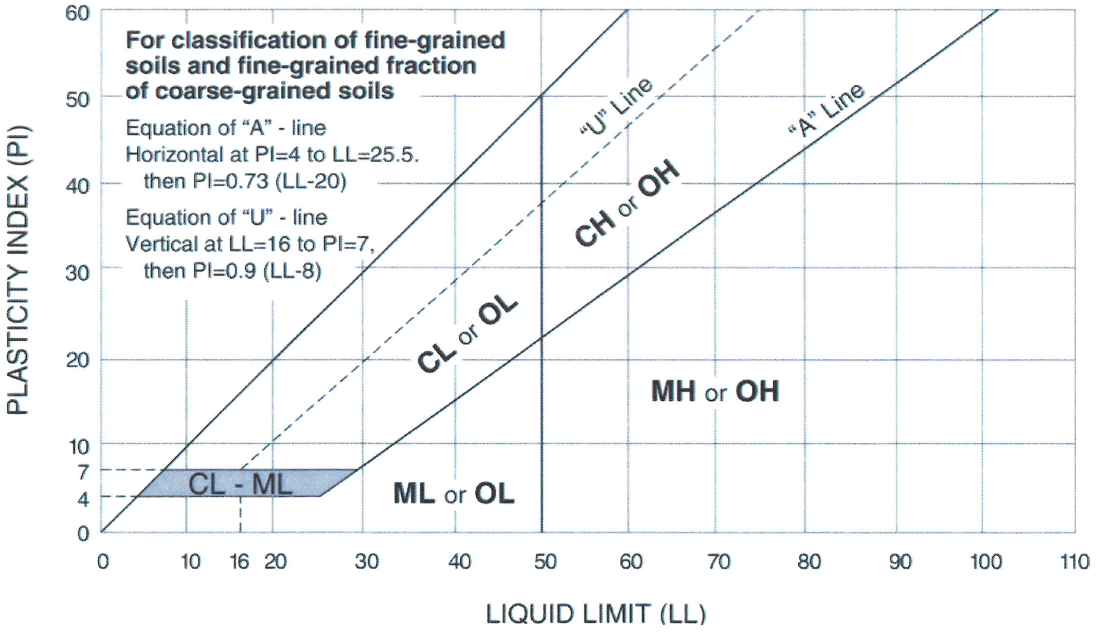

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Exhibit C-2

GENERAL NOTES

Sedimentary Rock Classification

DESCRIPTIVE ROCK CLASSIFICATION:

	Sedimentary rocks are composed of cemented clay, silt and sand sized particles. The most common minerals are clay, quartz and calcite. Rock composed primarily of calcite is called limestone; rock of sand size grains is called sandstone, and rock of clay and silt size grains is called mudstone or claystone, siltstone, or shale. Modifiers such as shaly, sandy, dolomitic, calcareous, carbonaceous, etc. are used to describe various constituents. Examples: sandy shale; calcareous sandstone.
LIMESTONE	Light to dark colored, crystalline to fine-grained texture, composed of $CaCo_3$, reacts readily with HCl.
DOLOMITE	Light to dark colored, crystalline to fine-grained texture, composed of $CaMg(CO_3)_2$, harder than limestone, reacts with HCl when powdered.
CHERT	Light to dark colored, very fine-grained texture, composed of micro-crystalline quartz (SiO_2), brittle, breaks into angular fragments, will scratch glass.
SHALE	Very fine-grained texture, composed of consolidated silt or clay, bedded in thin layers. The unlaminated equivalent is frequently referred to as siltstone, claystone or mudstone.
SANDSTONE	Usually light colored, coarse to fine texture, composed of cemented sand size grains of quartz, feldspar, etc. Cement usually is silica but may be such minerals as calcite, iron-oxide, or some other carbonate.
CONGLOMERATE	Rounded rock fragments of variable mineralogy varying in size from near sand to boulder size but usually pebble to cobble size (½ inch to 6 inches). Cemented together with various cementing agents. Breccia is similar but composed of angular, fractured rock particles cemented together.

PHYSICAL PROPERTIES:

DEGREE OF WEATHERING

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

HARDNESS AND DEGREE OF CEMENTATION

Limestone and Dolomite:

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

Shale, Siltstone and Claystone

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

Sandstone and Conglomerate

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

BEDDING AND JOINT CHARACTERISTICS

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

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

SOLUTION AND VOID CONDITIONS

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

Exhibit C-3