GEOTECHNICAL ENGINEERING REPORT

FOR

MR. MARTY KIMBLE
PROJECT MANAGER, PLANNING & DEVELOMENT
CHEROKEE NATION
P.O. BOX 948, TAHLEQUAH, OK 74464

CHEROKEE SAFE HAVEN VILLAGE PROJECT
EAST OF 1429 JACK BROWN LANE

6/13/2024

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June 13, 2024
Mr. Marty Kimble
Project Manager
Planning and Development, Cherokee Nation
P.O. Box 948
Tahlequah, OK, 74464

Subject: Cherokee Safe Haven Village Project
East of 1429 Jack Brown Lane
Tahlequah, Oklahoma
Project No.: 240297

Dear Mr. Kimble,

CEC has completed the authorized subsurface exploration and geotechnical engineering evaluation for the above-referenced project in general accordance with our proposal/contract (Proposal No. OK24016) dated Apr. 11, 2024. The purpose of the geotechnical study was to explore and evaluate the subsurface conditions at three locations across the site and to provide foundation recommendations at the site. The attached CEC report contains a description of the findings of our field exploration and laboratory testing program, our engineering interpretation of the results with respect to the project characteristics, and our design recommendations as well as construction guidelines for the planned project.

Recommendations provided herein are contingent on the provisions outlined in the ADDITIONAL SERVICES and LIMITATIONS sections of this report. The project Owner should become familiar with these provisions in order to assess further involvement by CEC and other potential impacts to the proposed project. Please call us if you have any questions concerning this report.

Sincerely,

CEC Corporation
Certificate of Authorization #32, Expires 6/30/2024

REGISTERED PROFESSIONAL ENGINEER
BRETT
A. COWAN
21935
06/13/24
OKLAHOMA

Brett Cowan, P.E.
Geotechnical Lead Engineer

EXECUTIVE SUMMARY

Geotechnical Engineering Report
Safe Haven Village Project
East of 1429 Jack Brown Lane
Tahlequah, Oklahoma
Project No.: 240297

- Based on the subsurface conditions encountered in the borings, the project site appears to be suitable for the proposed shallow foundation construction. The primary geotechnical concerns for the project site are the presence of ***perched groundwater*** and the ***hardness and depth of bedrock*** at the site.

- Based upon the subsurface conditions encountered in the borings and with the recommended site preparation procedures, the site should be suitable for support of the proposed modular buildings on conventional spread footings founded within the undisturbed native soils. Footings founded in these materials may be proportioned for a maximum allowable bearing pressure of 1,250 psf.

- Long-term structural settlement for spread footings designed and constructed as outlined in this section should be minor; i.e., 1 inch or less. Differential settlement should be minor, i.e. 1/2 inch or less.

- Pavement subgrades should be prepared in accordance with the recommendations presented in the SITE DEVELOPMENT and STRUCTURAL FILL sections of this report.

- Recommended typical pavement sections are presented in Table 3 of the provided report.

This summary is intended for introductory and reference use only. A thorough reading of the entire report is essential for understanding the overall geotechnical-related design and construction concepts and limitations.

1 PROJECT

1.1 SITE CONDITIONS

1.1.1 GENERAL

CEC has completed the authorized subsurface exploration and geotechnical engineering evaluation for the proposed Cherokee Safe Haven Village Project located east of 1429 Jack Brown Lane in Tahlequah, Oklahoma. The services provided were in general accordance with our proposal/contract (Proposal No. OK24016) dated Apr. 11, 2024.

This report includes our recommendations related to the geotechnical aspects of the project design and construction. Conclusions and recommendations presented in the report are based on the subsurface information encountered at the location of our exploration and the provisions and requirements outlined in the ADDITIONAL SERVICES and LIMITATIONS sections of this report.

1.1.2 PROJECT DESCRIPTION

We understand that the proposed construction will include a community of 15 to 20 modular homes. It is our understanding that the proposed modular homes will be supported on shallow foundations.

The project consists of modular homes with an approximate footprint of 1500 sq. ft. per home. A boring layout was presented by email dated April. 9th, 2024. This layout and information was used to develop this proposed work.

The scope of the exploration and engineering evaluation for this study, as well as the conclusions and recommendations in this report are based on our understanding of the project as described above. If pertinent details of the project have changed or otherwise differ from our descriptions, we must be notified and engaged to review the changes and modify our recommendations, if needed.

1.2 SITE AND SUBSURFACE DESCRIPTION

The site is currently an existing grassy field, gently sloping from the north to the south. An access road goes from east to west along the north side of the property. The west side of the property is defined by a fence line for an adjacent property; while the east side is not defined and transitions to another owner with continuing grass with scattered trees. Overhead electric lines pass through the north-east portion of the property and an exposed rock ditch with trees bisects the property from the north to the south. The south side of the property has a buried utility easement running east to west before encountering a tree line as the property ends.

An approximate 2 to 8-inch thick layer of topsoil was encountered across the site except where exposed limestone rock was encountered. Generally brown, soft to very stiff, lean clay with sand extends approximately to a depth of 3.0 to 9.7 feet. The lean clay with sand generally extended to the top of the bedrock at an approximate depth of 3.0 to 9.7 feet within the borings; however, exposed limestone rock is located on the project site. In addition, a gray shale was encountered in the southern portion of the project site within Borings B-04, B-07, and B-08 at an approximate depth of 7 to 9.7 feet.

Weathered bedrock was encountered in most of the borings at approximate depths of 3.0 to 9.7 feet below the existing grade. The degree of weathering decreased with depth. The shale and limestone bedrock was soft to moderately hard and moderately hard, respectively. The bedrock was generally brown and/or gray in color.

Atterberg limits test performed on selected samples indicated a liquid limit (LL) value of 29 to 50 and a plasticity index (PI) value of 12 to 29. No. 200 Sieve Analysis tests indicated that the fines content of the soil ranged from approximately 82 to 89 percent for the samples tested. The moisture content of the samples generally ranged from approximately 12 to 32 percent. Bearing ratio (CBR) values of one bulk sample obtained from the site ranged from 0.9 to 5.5 at varying rates of compaction. The recommended design CBR value at 95 percent compaction is 3.1.

2 GEOTECHNICAL FINDINGS

2.1 FIELD ACTIVITIES

CEC explored the subsurface conditions at the site by drilling and sampling eight (8) borings in a grid pattern shown in Appendix A, Plate 1. Approximate locations of the borings are shown in Plate 2, Boring Location Diagram. The field exploration and laboratory testing programs are presented in APPENDIX A and APPENDIX B, respectively.

Bedrock was encountered within the borings during drilling operations. Groundwater observations were made both during drilling and after completion of drilling operations. This information is shown in Table 1 below. The materials encountered in the test borings would need to be observed over an extended period of time through use of piezometers or cased borings to better define groundwater conditions.

Table 1: Groundwater and Bedrock Depth

Boring No.	Groundwater depth during/after drilling (feet)	Bedrock Depth (feet)
B-01	Dry	5.5
B-02	Dry	3.5
B-03	8.5/2.6	8.5
B-04	14.0/8.6	9.5
B-05	Dry	5.0
B-06	6.0/3.1	3.0
B-07	7.0/7.0	9.5
B-08	7.0/8.1	7.0

Fluctuations of groundwater levels can occur due to seasonal variations in the amount of rainfall, runoff, and other factors not evident at the time the borings were performed. The possibility of groundwater level fluctuations should be considered when developing the design and construction plans for the project.

The site subsurface conditions are favorable for the development of perched groundwater conditions. In a “perched” groundwater condition, precipitation will infiltrate the upper lower plasticity more permeable soils and become perched on the underlying higher plasticity soils. Development of a perched groundwater condition could hamper completion of the site development portion of this project.

2.2 LAB TESTING RESULTS

Table 2: Lab Testing Results for Soil Profile							
Boring No.	Sample/Depth (ft)	% Moisture	LL	PL	PI	% 200 Passing	Soil Classification
B-01	SS-1/1.0	19.8	29	17	12	84.0	Lean Clay w/ Sand (A-6 (8))
B-02	SS-1/1.0	22.1	35	18	17	81.8	Lean Clay w/ Sand (A-6 (13))
B-03	SS-3/6.0	23.5	39	18	21	88.1	Lean Clay (A-6 (18))
B-04	SS-2/3.5	21.2	43	18	25	87.9	Lean Clay (A-7-6 (22))
B-05	SS-2/3.5	30.4	41	21	20	84.2	Lean Clay w/ Sand (A-7-6 (17))
B-06	SS-1/1.0	24.4	40	20	20	82.1	Lean Clay w/ Sand (A-6 (16))
B-07	SS-3/6.0	28.2	29	18	11	88.9	Lean Clay (A-6 (9))
B-08	SS-1/1.0	24.8	50	21	29	86.1	Fat Clay (A-7-6 (26))
B-08	SS-2/3.5	23.3	46	21	25	88.3	Lean Clay (A-7-6 (23))

3 RECOMMENDATIONS

3.1 GEOTECH DISCUSSION

Based on the results of our evaluation, it is our professional opinion that the proposed modular buildings and pavements can be developed using conventional construction techniques; however, in areas where shallow limestone bedrock is encountered, structural fill may be considered to establish a final grade. The recommendations presented in the following sections are based upon our understanding that minimal grading will be required to achieve final grades. We have assumed that the maximum cut and fill will be in the order of 1 to 2 feet. The primary geotechnical concerns for this project are perched groundwater and the hardness and depth of bedrock. Recommendations addressing the primary geotechnical concerns as well as general recommendations regarding geotechnical aspects of the project design and construction are presented below.

The recommendations submitted herein are based, in part, upon data obtained from our subsurface exploration. The nature and extent of subsurface variations that may exist at the proposed project site will not become evident until construction. If variations appear evident, then the recommendations presented in this report should be evaluated. In the event that any changes in the nature, design, or location of the proposed project are planned, the conclusions and recommendations contained in this report will not be considered valid unless the changes are reviewed, and our recommendations modified in writing.

3.2 PRIMARY GEOTECHNICAL CONCERNS

Perched Groundwater

The potential for perched groundwater exists within this project site due to shallow bedrock and fat clays with less permeable soils existing above them. It is anticipated that once these materials are exposed after seasonal rain events, these soils will become unstable and will pump, rut, and be easily disturbed. Prior to placement of structural fill, undercutting of unstable soils will likely be required.

Hardness and Depth of Bedrock

Auger refusal was encountered in Borings B-02 and B-05, within the upper 5 feet. However, exposed Limestone rock is located on the project site. The limestone bedrock encountered while drilling is anticipated to be difficult to excavate. Depths at which bedrock was encountered at the boring locations are presented in Table 1 above.

The depths of the bedrock should be taken into consideration while establishing finish grades and utility depths during the design phase of the project. Consideration could be given to raising the grades at the site to minimize rock excavation during site grading and during utility installation. Excavation of the bedrock will likely be required. Excavation of the less weathered bedrock is anticipated to be difficult, most particularly within confined excavations, i.e., foundation and utility excavations.

3.3 SITE DEVELOPMENT

3.3.1 STRIPPING

Initial site preparation should include removal of all vegetation and topsoil from the construction area. Stripping depths required will likely vary and should be adjusted to remove all vegetation and root systems. A CEC representative should monitor the stripping operations to observe that all unsuitable materials have been removed. Soils removed during site stripping operations could be used for final site grading outside the proposed building and pavement areas. Care should be exercised to separate these materials to avoid incorporation of the organic matter in structural fill sections.

3.3.2 EXISTING UTILITIES

Relocation of any existing utility lines within the zone of influence of proposed construction areas should also be completed as part of the site preparation. The lines should be relocated to areas outside of the proposed construction. Excavations created by removal of the existing lines should be cut wide enough to allow for use of heavy construction equipment to compact the backfill. In addition, the base of the excavations should be thoroughly evaluated by a geotechnical engineer or engineering technician prior to placement of backfill. All backfill should be placed in accordance with the recommendations presented in the STRUCTURAL FILL section.

3.3.3 LOW VOLUME CHANGE MATERIAL FOR MODULAR BUILDING AREA

Immediately following any required stripping or utility relocation, the proposed modular building areas should, as a minimum, be scarified, moisture conditioned, and recompacted to a depth of 8 inches. If soft or unstable soils are encountered during construction, these soils should be undercut and replaced below existing grade or the finish subgrade level, whichever is at a lower elevation. The undercut area should extend a minimum of 5 feet outside the perimeter building wall lines, where possible. Suitable soils removed during the undercutting operations can be stockpiled for use as structural fill.

All structural fill placed within the building footprint should consist of low plasticity structural fill as described in STRUCTURAL FILL section of this report.

3.3.4 SCARIFICATION, MOISTURE CONDITIONING AND COMPACTION

Prior to placement of structural fill, the moisture content of the exposed materials should be evaluated. Depending on the in-situ moisture content of the exposed materials, moisture conditioning of the exposed grade may be required prior to proofrolling and/or fill placement. The moisture content of the exposed materials in these fill areas should be adjusted to within the range recommended for structural fill, to allow the exposed material to be compacted to a minimum of 95 percent of the standard Proctor density. Extremely wet or unstable areas that hamper compaction of the subgrade may require undercutting and replacement with structural fill or other stabilization techniques. Suitable structural fill should be placed to design grade as soon as practical after reworking the subgrade to avoid moisture changes in the underlying soils.

3.3.5 PROOFROLLING

Following any required undercutting and moisture conditioning, and prior to placement of structural fill, it is recommended that the exposed soil grade be proofrolled. Proofrolling of the subgrade aids in identifying soft or disturbed areas. Unsuitable areas identified by the proofrolling operation should be undercut and replaced with structural fill. Proofrolling can be accomplished through use of a fully-loaded, tandem-axle dump truck or similar equipment providing an equivalent subgrade loading.

3.4 CLIMATIC CONDITIONS

Weather conditions will influence the site preparation required. In spring and late fall, following periods of rainfall, the moisture content of the near-surface soils may be significantly above the optimum moisture content. This condition could seriously impede grading by causing an unstable subgrade condition. Typical remedial measures include aerating the wet subgrade, removal of the wet materials and replacing them with dry materials, or treating the material with lime, cement or Class “C” fly ash.

If site grading commences during summer months, moisture contents may be low. Typically discing and moisture conditioning of the exposed subgrade materials to the moisture content criteria outlined in the

STRUCTURAL FILL section will reduce this swell potential of the dry materials. As an alternative, the dry materials could be undercut and replaced with structural fill.

3.5 TEMPORARY EXCAVATIONS

3.5.1 EXCAVATIONS

It is anticipated that excavations for the proposed structure and utilities will be in existing undisturbed native soils, and potentially the limestone bedrock. Excavation of the native soils should be possible with conventional equipment such as backhoes, loaders, etc. The presence of shallow limestone may impact the excavation techniques and equipment required to complete excavations at the site. In general, bedrock displaying Standard Penetration Test "N" values of 50 blows for 4 inches of penetration or more (displayed on the boring logs as 50/4, 50/5 or 50/6) can be excavated using standard construction equipment outfitted with rock ripping teeth. Bedrock displaying "N" values of 50 blows per 3 inches of penetration or less (displayed as 50/3, 50/2 or 50/1) may require pneumatic hammers or blasting for removal.

Typical temporary dewatering techniques are anticipated to be sufficient to remove any water seepage that may be encountered in shallow excavations. Excavations extending deeper into bedrock may require more sophisticated dewatering methods/equipment.

3.5.2 FOUNDATION AND UTILITY EXCAVATIONS

Excavations should be cut to a stable slope or be temporarily braced, depending on the excavation depths and the subsurface conditions encountered. ***Temporary construction slopes should be designed in strict compliance with the most recent governing regulations.*** The contractor should also be aware that slope height, slope inclination or excavation depths (including utility trench excavations) should in no case exceed those specified in local, state and/or federal safety regulations, such as OSHA Health and Safety Standard for Excavations, 29 CFR Part 1926, or successor regulations.

Construction slopes should be closely observed for signs of mass movement: tension cracks at the crest, bulging at the toe, etc. If potential stability problems are observed, a geotechnical engineer should be contacted immediately. ***The responsibility for excavation safety and stability of temporary construction slopes lie solely with the contractor.*** Shoring, bracing or underpinning, may be required to provide structural stability and to protect personnel working within the excavation.

3.5.3 CONSTRUCTION CONSIDERATIONS

Stockpiles should be placed well away from the edge of the excavation and their height should be controlled so they do not surcharge the sides of the excavation. Surface drainage should be carefully controlled to prevent flow of water into the excavations.

3.6 STRUCTURAL FILL

3.6.1 MATERIALS

All structural fill and backfill required to achieve design grades should consist of approved materials, free of organic matter and debris. All structural fill placed within footprint of the building should consist of nonplastic to lower plasticity soil with a maximum Plasticity Index (PI) of 22 percent, as determined by the Atterberg limits test ASTM D 4318, wet preparation procedure.

3.6.2 EXISTING SOILS

Based on subsurface conditions encountered at this site, it appears that a portion of the soils encountered at the site would be suitable for use as the lower plasticity structural fill within the building footprint. Additional testing at the time of construction is recommended to further evaluate the use of these soils as low plasticity structural fill.

3.6.3 COMPACTION CRITERIA

Fill should be placed in lifts having a maximum loose lift thickness of 9 inches. All fill should be compacted to a minimum of 95 percent of the material's maximum dry density as determined by ASTM D 698 (standard Proctor compaction). If the plasticity index of the soils is less than or equal to 12, the moisture content of the fill at time of compaction should be within a range of 2 percent below to 2 percent above optimum moisture content as defined by the standard Proctor compaction procedure.

3.6.4 ORGANIC SOILS

The more highly organic soils removed during site preparation could be utilized during final grading in landscaped areas of the site. Depth of organic fill and degree of compaction should be established to provide a stable surface that will be conducive to growth of grass cover.

3.7 FOUNDATIONS

3.7.1 GENERAL

All foundation excavations should be inspected by a CEC engineer or senior field professional to ensure the footings are supported on suitable bearing materials. Soft zones, voids or unsuitable materials identified during excavation should be removed and replaced with properly compacted structural fill materials.

3.7.2 ALLOWABLE BEARING CAPACITY

Based upon the subsurface conditions encountered in the borings and with the recommended site preparation procedures, the site should be suitable for support of the proposed modular buildings on conventional spread footings founded within the undisturbed native soils. Footings founded in these materials may be proportioned for a maximum allowable bearing pressure of 1,250 psf.

Continuous wall footings should have a minimum width of 16 inches and isolated spread footings should have a minimum width of 24 inches. All exterior footings and footings founded in unheated portions of the structure should be supported a minimum of 24 inches below final exterior grade to provide protection against frost penetration.

3.7.3 ESTIMATED SETTLEMENT

Long-term structural settlement for spread footings designed and constructed as outlined in this section should be minor; i.e., 1 inch or less. Differential settlement should be minor, i.e. 1/2 inch or less.

3.7.4 CONSTUCTION CONSIDERATIONS

The base of all footing excavations should be free of all water and soft materials prior to placing concrete. Concrete should be placed as soon as possible after excavating so that excessive drying or disturbance of the bearing materials does not occur. Should the materials at bearing level become excessively dry, saturated or disturbed, we recommend that the effected materials be removed prior to placing concrete.

It is recommended that all footing excavations be evaluated and tested by the geotechnical engineer immediately prior to placement of foundation concrete. Unsuitable areas identified at this time should be corrected. Corrective procedures would be dependent upon conditions encountered and may include deepening of foundation elements, or undercutting of unsuitable materials and replacement with controlled structural fill.

3.8 PAVEMENTS

3.8.1 GENERAL

It is assumed that traffic across the proposed pavement areas will consist primarily of light passenger cars and lightly loaded truck traffic in drive areas. If actual traffic is greater than that anticipated, a shortened pavement life would be anticipated.

3.8.2 PAVEMENT SUBGRADE PREPARATION

Pavement subgrades should be prepared in accordance with the recommendations presented in the SITE DEVELOPMENT and STRUCTURAL FILL sections of this report. Construction scheduling, involving paving and grading by separate contractors, typically results in a time lapse between the end of grading operations and the commencement of paving. Disturbance, desiccation, and/or wetting of the subgrade between grading and paving can result in deterioration of the previously completed subgrade. A non-uniform subgrade can result in poor pavement performance and local failures relatively soon after pavements are constructed.

We recommend that the pavement subgrades be proofrolled and the moisture content and density of the top 12 inches of subgrade be checked within two days prior to commencement of actual paving operations. Proofrolling should be accomplished with multiple passes of a fully-loaded, tandem-axle dump truck or similar equipment providing an equivalent subgrade loading. If any significant event, such as precipitation, occurs after proofrolling, the subgrade should be reviewed by qualified geotechnical engineering personnel immediately prior to placing the pavement. The subgrade should be in its finished form at the time of the final review.

If soft or unstable soils are encountered during construction, these soils should be undercut and replaced or stabilized. If soft or unstable soil conditions extend to depths greater than 18 inches below the finish pavement subgrade elevation, CEC should be notified to provide additional recommendations concerning appropriate stabilization methods. Additional stabilization methods may include the use of a geogrid and/or surge stone.

A bulk sample was utilized to confirm pavement minimum recommendations below; a CBR of approximately 3 should be utilized for full pavement design if traffic information can be provided. In addition, the sample was tested for soluble sulfates. The sample was considered relatively low at 80 parts per million (ppm) indicating stabilization of the subgrade using calcium-based admixtures can be considered.

3.8.3 TYPICAL PAVEMENT SECTIONS

Table 3: Typical Pavement Sections		
Pavement Area	**Minimum Asphaltic Concrete (AC) Design Thickness, inches**	**Minimum Portland Cement Concrete (PCC) Design Thickness, inches**
Standard Duty (Parking Areas)	<u>AC with Granular Base</u> 1.5" S5 Surface Course[1] 3.5" S3 Base Course[1] 6.0 Aggregate Base[3] Geotextile Separator Fabric[2] (Optional) 8.0 Recompacted Subgrade <u>AC with Stabilized Subgrade</u> 1.5" S5 Surface Course[1] 3.5" S3 Base Course[1] 8.0 Stabilized Subgrade[4]	5.0 PCC 6.0 Aggregate Base[3] Geotextile Separator Fabric[2] (Optional) 8.0 Recompacted Subgrade
Heavy Duty (Driving Lanes)	<u>AC with Granular Base</u> 1.5" S5 Surface Course[1] 4.5" S3 Base Course[1] 6.0 Aggregate Base[3] Geotextile Separator Fabric[2] (Optional) 8.0 Recompacted Subgrade[4] <u>AC with Stabilized Base</u> 1.5" S5 Surface Course[1] 4.5" S3 Base Course[1] 8.0 Stabilized Subgrade[4]	6.0 PCC 6.0 Aggregate Base[3] Geotextile Separator Fabric[2] (Optional) 8.0 Recompacted Subgrade
Heavy Truck Usage[5] (All heavy trucking areas)	N/A	7.0 PCC 6.0 Aggregate Base[3] Geotextile Separator Fabric[2] (Optional) 8.0 Recompacted Subgrade

1. ODOT "Standard Specifications for Highway Construction" Section 708
2. AASHTO M288 Class 2 and Appendices A1 and A3
3. ODOT "Standard Specifications for Highway Construction" Section 703.01, Type A
4. In accordance with the appropriate ODOT Specification listed In Section 3.3.8 of this report.
5. Trash receptacle pads, Delivery truck loading, unloading, areas and approaches.

General Notes:

A. RAS is not allowed in any mix.

B. In all surface mixes, RAP is limited to 12% Maximum.

Consideration should be given to placing a separator fabric between the granular base and the recompacted soil subgrade to limit the intrusion of fines into the granular base. Additional maintenance consisting of periodic seal coats and one intermediate mill and overlay, in addition to regular crack maintenance, may be required to achieve the service life.

All pavements should be sloped approximately 1/4 inch per foot to provide rapid surface drainage. This includes the underlying subgrade soils since the granular base material readily transmits water. The granular section should be graded to adjacent storm sewer inlets or drainage ditches to provide drainage from the granular section. Water allowed to pond on or adjacent to the pavement could saturate the subgrade and cause premature pavement deterioration. The edges of the pavement sections should be protected by the use of curbs and gutters or thickened edge pavement sections.

3.8.4 PAVEMENT MATERIALS

Aggregate Base Materials. Aggregate base course material should consist of a crushed limestone meeting the requirements for Aggregate Type A, as set forth in Section 703.01 of the ODOT "Standard Specifications for Highway Construction" (2019). Aggregate base course materials should be compacted to a minimum of 98% of the material's maximum dry density determined in accordance with the procedures outlined in ASTM D 698 (standard Proctor compaction).

Geotextile Separator Fabric. A geotextile separator fabric could be placed between the aggregate base and the recompacted soil subgrade to limit the intrusion of fines into the granular base. The geotextile fabric should meet the requirements of AASHTO M288 for a Class 2 separation geotextile and be placed in accordance with AASHTO M288 appendices A1 and A3.

Asphaltic Concrete Mixtures. Asphaltic concrete surface course and base course mixtures should be in accordance with the requirements for Type S3 and S5 mixtures, respectively, referenced in Sections 411 and 708 of the of the ODOT "Standard Specifications for Highway Construction" (2019).

Portland Cement Concrete Mixtures. The Portland cement concrete pavement mixture should be in accordance the requirements referenced in Sections 414 and 701 of the ODOT "Standard Specifications for Highway Construction" (2019).

3.8.5 PAVEMENT CONSTRUCTION CONSIDERATIONS

Proper drainage below the pavement section helps prevent softening of the subgrade and has a significant impact on pavement performance and pavement life of all pavement types. Therefore, we recommend that a granular blanket drain be constructed at all storm sewer inlets within the pavement areas. The blanket drain should consist of clean, crushed stone aggregate extending a minimum of 6 inches below pavement subgrade level. The blanket drains should extend a minimum of 8 feet away from the curb at all storm sewer inlets, and should be a minimum of 8 feet wide. The grade within the blanket drain should be sloped toward the storm sewer inlet, and weep holes should be drilled through the inlet to provide drainage of the granular section into the inlet. Placement of geotextile filter fabric across the weep holes could be considered to prevent loss of soil through the weep holes.

Construction traffic on the pavements has not been considered in the design. If construction scheduling dictates the pavements will be subject to traffic by construction equipment/vehicles, the designs should be reconsidered to include the effects of the additional traffic loading.

3.9 LANDSCAPING AND SITE GRADING CONSIDERATIONS

Foundation performance depends greatly on how well surface water drains from the site. This drainage should be maintained both during construction and over the entire life of the project. The ground surface around structures should be graded such that water drains rapidly away from structures without ponding. The surface gradient needed to do this depends on the landscaping type.

Planters should be built such that water exiting from them will not seep into the foundation areas. Should excessive irrigation, waterline breaks or unusually high rainfall occur, saturated zones and “perched” groundwater may develop. Consequently, the site should be graded so that water drains away readily without saturating the foundation or landscaped areas. Potential sources of water such as water pipes, drains, garden ponds and the like should be frequently examined for signs of leakage or damage. Any such leakage or damage should be promptly repaired.

Consideration should also be given to limit landscaping and irrigation adjacent to the building and pavement areas. Trees and large bushes can develop an intricate root system that can draw moisture from the subgrade soils, causing them to shrink during dry periods of the year. Desiccation of soils below foundations can result in settlement of foundations.

Beneath the perimeter of the building, all utility trenches should be backfilled with either compacted non-pervious fill material or lean concrete to reduce water infiltration into the interior of the building. Special care should be taken during installation of sub-floor water and sewer lines to prevent the possibility of leaks.

4 ADDITIONAL SERVICES

We recommend that CEC conduct a comprehensive review of the final plans and specifications to ensure accurate interpretation and implementation of our construction recommendations during the design phase. If CEC is not retained for this review, we assume no responsibility for misinterpretation of our recommendations.

For effective monitoring during construction, we advise that a representative from CEC oversees all drilled pier activities. This includes observing site preparation and drill shaft construction. These services enable CEC to assess soil conditions encountered, evaluate the applicability of our recommendations, and suggest design or construction changes if needed.

The following outlines geotechnical engineering and construction testing services essential for implementing our recommendations. To maintain continuity from design through construction, we recommend retaining CEC for these services:

1. An experienced engineering technician should observe the subgrade throughout the proposed construction area immediately following demolition, stripping, and undercutting to identify areas requiring additional undercutting and to evaluate the suitability of the exposed surface for fill placement.
2. An experienced engineering technician should monitor and test all fill placed within the construction areas to determine whether the type of material, moisture content and degree of compaction are within recommended limits.
3. An experienced engineering technician should observe the moisture conditioning and proofrolling of the subgrade prior to placement of structural fill to evaluate the suitability of the exposed surface for fill placement.
4. An experienced technician or engineer should observe and test all foundation excavations. Where unsuitable bearing conditions are observed, remedial procedures can be established in the field to avoid construction delays.
5. If stabilization of the site soils is necessary, mixing operations should be closely monitored to determine whether mixing procedures are providing uniform distribution and thorough blending of the stabilizing agent.

5 LIMITATIONS

Prepared in accordance with generally accepted geotechnical engineering practice in the site area at the time of our study, this report carries no expressed or implied warranty. The recommendations assume CEC will conduct adequate tests and observations during construction. Our services did not encompass environmental assessments for hazardous materials.

The recommendations in this report are derived from our on-site observations, subsurface explorations, and limited laboratory tests, guided by our current understanding of the proposed construction. Subsurface conditions may differ beyond the explored points. Should variations arise during construction, prompt notification is essential for a review and supplemental recommendations.

The report's use is limited to the client's specified purposes within a reasonable time, not exceeding three years from the report date. Changes in land use, site conditions, regulations, or other factors may necessitate additional work. Any party other than the client seeking to use this report must notify CEC. Depending on the intended use, additional work and an updated report may be required. Non-compliance releases CEC from liability, and the client agrees to defend, indemnify, and hold CEC harmless from any claims associated with unauthorized use or non-compliance.

APPENDIX A
FIELD EXPLORATION PROGRAM

DRILLING & SAMPLING PROCEDURES

CEC conducted the field work for this study on May 15th and 21st, 2024. The exploration consisted of eight borings drilled to an approximate depth of 4.5 to 14.5 feet below the existing ground surface level. The boring locations were provided on April 9th, 2024. The boring was performed with a truck-mounted (CME 45), rotary drill rig using solid augers to advance the boreholes. Samples were obtained by performing standard penetration tests (SPT) using a 2-inch O.D. split-barrel sampler. The split-barrel sampling was conducted in general accordance with ASTM D 1586 (ASTM D 1586, Standard Test Method for Penetration and Split-Barrel Sampling of Soils). The split-barrel sampler is driven into the bottom of the boring over an 18-inch sampling interval by a 140-pound autohammer that is dropped a distance of 30 inches. The SPT N-value, recorded on the boring log, is the number of blows required to drive the split-barrel sampler the final 12 inches of the 18-inch sampling interval. The samples were sealed and returned to our laboratory for further examination and classification.

Representatives of Hinderliter and CEC established the boring locations in the field near the locations indicated on the provided site plan. These locations were identified in the field by measuring distances from existing site features to the respective boring locations. Right angles were estimated. Elevations at the boring locations were determined through use of an engineer's level and were referenced to the top of the finish floor of the maintenance building located to the north of the site across the entrance road to the property (see Plate 2). The elevation of the benchmark was assumed to be 100.0 feet. Locations and elevations of the borings should be considered accurate only to the degree implied by the methods used to obtain them.

The boring log included in this APPENDIX, presents such data as material descriptions, consistency and rock hardness evaluations, depths, sampling intervals and observed groundwater conditions. Conditions encountered in the boring were monitored and recorded by the drill crew. The field log included visual classification of the materials encountered during drilling, as well as drilling characteristics. Our final boring log represents the engineer's interpretation of the field log combined with laboratory observation and testing of the samples. Stratification boundaries indicated on the boring log were based on observations during our field work, an extrapolation of information obtained by examining samples from the boring and comparisons of soils with similar engineering characteristics. Locations of these boundaries are approximate, and the transitions between material types may be gradual rather than clearly defined.

Site Location

Project Details	
Number:	240297
Name:	Cherokee Safe Haven Village Project
Project Location	East of 1429 Jack Brown Lane, Tahlequah, Oklahoma
Client:	Mr. Marty Kimble
Contractor:	Hinderliter

Drawing Details				
No	Revision	By	Date	DATE:
				5/24/2024
				SCALE:
				NONE
				PLATE:
				1

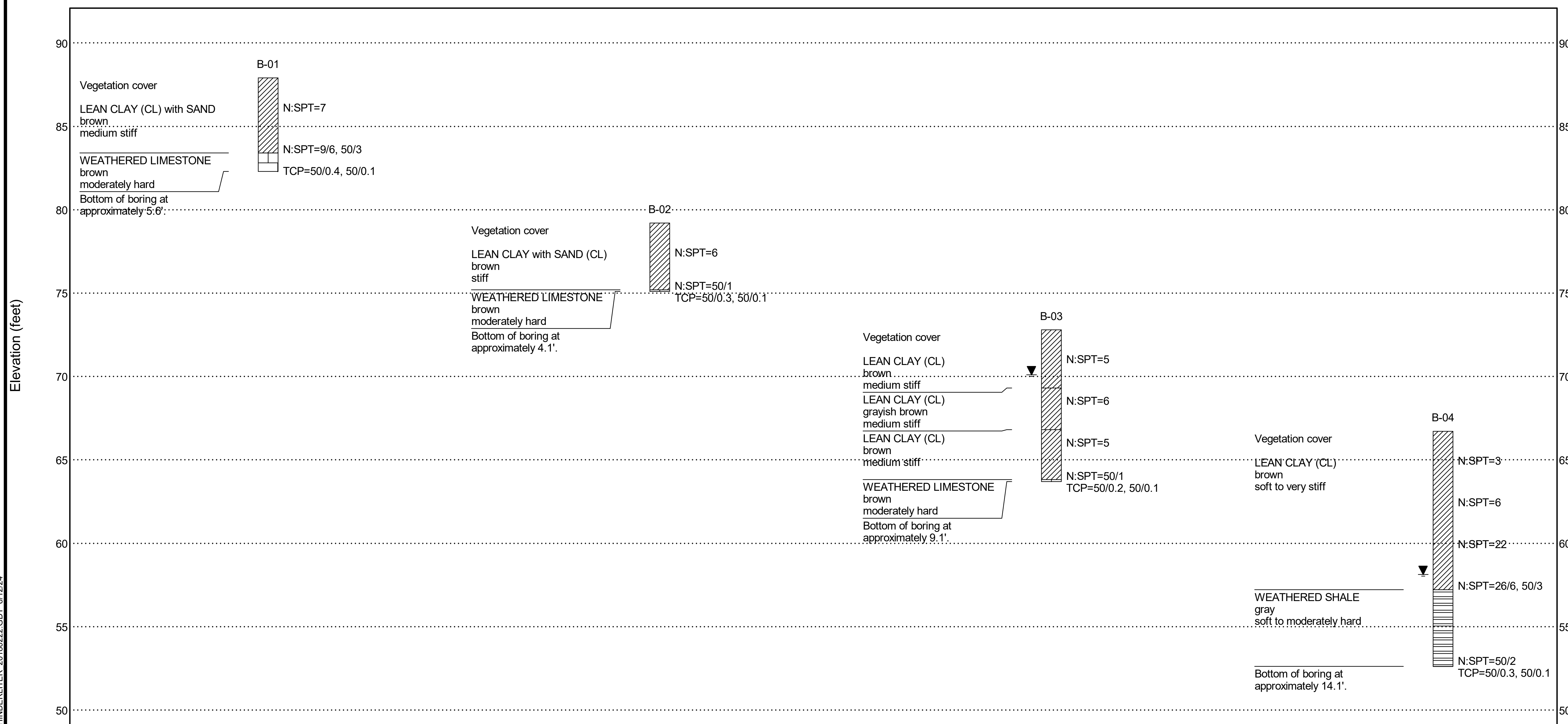
Project No.:	File Name:	Drawn By:	Checked By:
240297		OD	BAC

Boring Location Diagrams

Project Details		Drawing Details				
Number:	240297	No	Revision	By	Date	DATE:
Name:	Cherokee Safe Haven Village Project					5/24/2024
Project Location	East of 1429 Jack Brown Lane, Tahlequah, Oklahoma					SCALE: NONE
						PLATE:
Client:	Mr. Marty Kimble					2
Contractor:	Hinderliter					

Property of CEC and is intended for use by the client only, all others will require written consent.

Project No.:	File Name:	Drawn By:	Checked By:
240297		OD	BAC



Hinderliter Geotechnical Engineering
4071 SW 3rd Street
Oklahoma City OK 73107
Telephone: 405-942-4090
Website:

LEGEND:
N:SPT=Standard Penetration Test
TCP=Texas Cone Penetrometer
R=Recovery
RQD=Rock Quality Designation
UC=Unconfined Compressive Strength

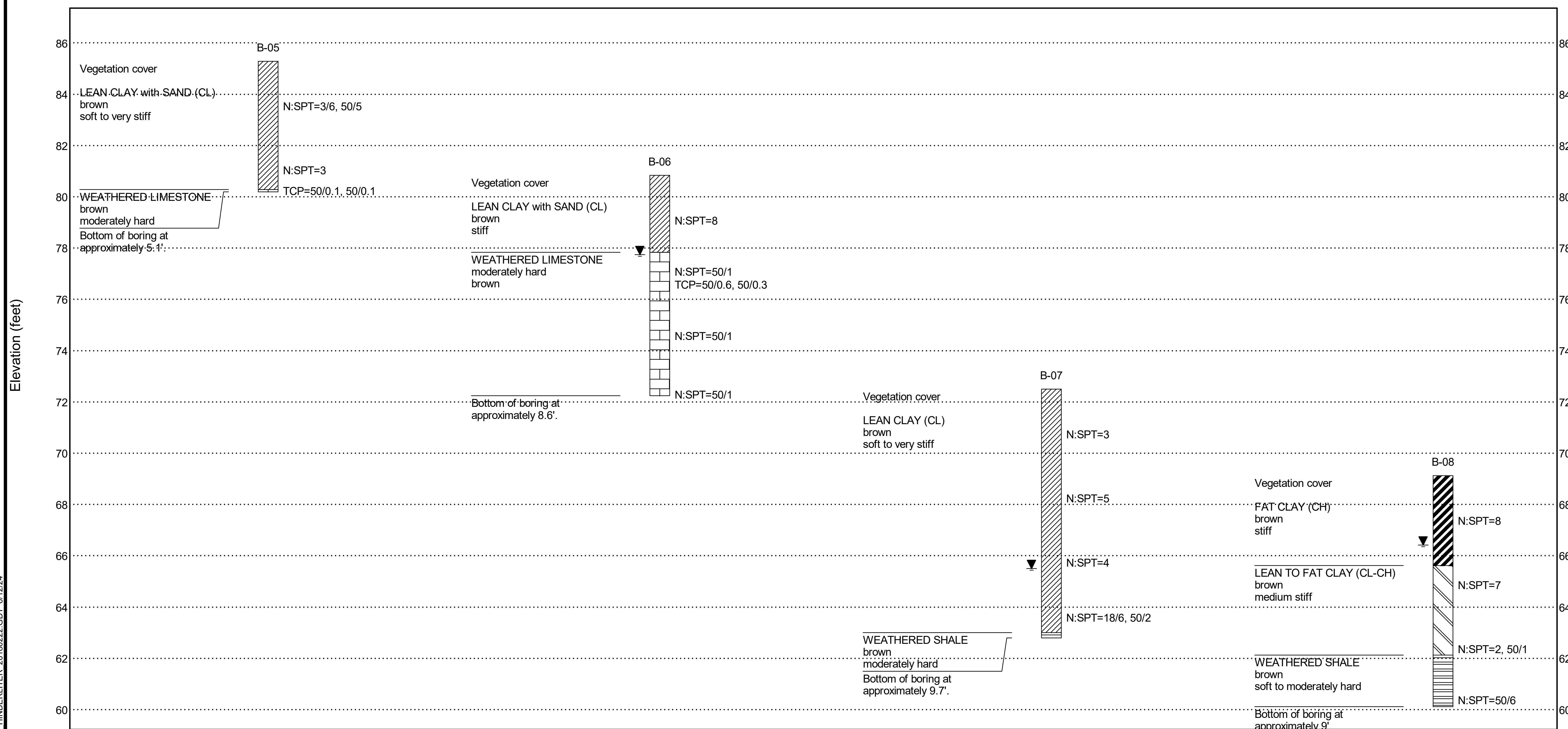
SUBSURFACE FENCE DIAGRAM

Project: Cherokee Safe Haven Village Project

Location: East of 1429 Jack Brown Lane, Tahlequah, OK

Number: CEC-24-09

US FENCE 11X17 CEC-24-09.GPJ DT HINDERLITER 20180222.GDT 6/12/24



LEGEND:
N:SPT=Standard Penetration Test
TCP=Texas Cone Penetrometer
R=Recovery
RQD=Rock Quality Designation
UC=Unconfined Compressive Strength

HGE
Hinderliter Geotechnical Engineering
4071 SW 3rd Street
Oklahoma City OK 73107
Telephone: 405-942-4090
Website:

SUBSURFACE FENCE DIAGRAM

Project: Cherokee Safe Haven Village Project

Location: East of 1429 Jack Brown Lane, Tahlequah, OK

Number: CEC-24-09

LOG OF BORING B-01

Hinderliter Geotechnical Engineering
4071 SW 3rd Street
Oklahoma City OK 73107
Telephone: 405-942-4090

CLIENT: CEC Corporation
PROJECT: Cherokee Safe Haven Village Project
LOCATION: East of 1429 Jack Brown Lane, Tahlequah, OK
NUMBER: CEC-24-09

DATE(S) DRILLED: 5/15/24

DRILLING METHOD(S):
Truck mounted CME-45 drill. 6" flight augers. SPT penetration testing and sampling.

GROUNDWATER INFORMATION:
No groundwater encountered while drilling or sampling.

SURFACE ELEVATION: 87.9

FIELD DATA				LABORATORY DATA									
SOIL SYMBOL	DEPTH (FT)	SAMPLES	N: BLOWS/FT P: TONS/SQ FT T: BLOWS R: % RQD: %	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT LL	PLASTIC LIMIT PL	PLASTICITY INDEX PI	DRY DENSITY POUNDS/CU.FT	MINUS NO. 4 SIEVE (%)	MINUS NO. 10 SIEVE (%)	MINUS NO. 40 SIEVE (%)	MINUS NO. 200 SIEVE (%)	DESCRIPTION OF STRATUM
													Vegetation cover
	1–2	X	N = 7	19.8	29	17	12		99.7	99.6	94	84.0	LEAN CLAY (CL) with SAND brown medium stiff
	4	X	N = 9/6, 50/3	17.6									
	5		T = 50/0.4, 50/0.1										WEATHERED LIMESTONE brown moderately hard
													Bottom of boring at approximately 5.6'.

N - STANDARD PENETRATION TEST RESISTANCE
P - POCKET PENETROMETER RESISTANCE
T - TXDOT CONE PENETRATION RESISTANCE
R - ROCK CORE RECOVERY
RQD - ROCK QUALITY DESIGNATION

REMARKS:

LOG OF BORING B-02

HGE
Hinderliter Geotechnical Engineering
4071 SW 3rd Street
Oklahoma City OK 73107
Telephone: 405-942-4090

CLIENT: CEC Corporation
PROJECT: Cherokee Safe Haven Village Project
LOCATION: East of 1429 Jack Brown Lane, Tahlequah, OK
NUMBER: CEC-24-09

DATE(S) DRILLED: 5/21/24

DRILLING METHOD(S):
Truck mounted CME-45 drill. 6" flight augers. SPT penetration testing and sampling.

GROUNDWATER INFORMATION:
No groundwater encountered while drilling or sampling.

SURFACE ELEVATION: 79.2

SOIL SYMBOL	DEPTH (FT)	SAMPLES	N: BLOWS/FT P: TONS/SQ FT T: BLOWS R: % RQD: %	MOISTURE CONTENT (%)	LIQUID LIMIT LL	PLASTIC LIMIT PL	PLASTICITY INDEX PI	DRY DENSITY POUNDS/CU.FT	MINUS NO. 4 SIEVE (%)	MINUS NO. 10 SIEVE (%)	MINUS NO. 40 SIEVE (%)	MINUS NO. 200 SIEVE (%)	DESCRIPTION OF STRATUM
													Vegetation cover
	1												LEAN CLAY with SAND (CL)
	2		N = 6	22.1	35	18	17		96.4	96.3	91.6	81.8	brown stiff
	3												
	4		N = 50/1	27.2									
			T = 50/0.3 50/0.1										WEATHERED LIMESTONE brown moderately hard
													Bottom of boring at approximately 4.1'.

N - STANDARD PENETRATION TEST RESISTANCE
P - POCKET PENETROMETER RESISTANCE
T - TXDOT CONE PENETRATION RESISTANCE
R - ROCK CORE RECOVERY
RQD - ROCK QUALITY DESIGNATION

REMARKS:

LOG OF BORING B-03

HGE
Hinderliter Geotechnical Engineering
4071 SW 3rd Street
Oklahoma City OK 73107
Telephone: 405-942-4090

CLIENT: CEC Corporation
PROJECT: Cherokee Safe Haven Village Project
LOCATION: East of 1429 Jack Brown Lane, Tahlequah, OK
NUMBER: CEC-24-09

DATE(S) DRILLED: 5/21/24

DRILLING METHOD(S):
Truck mounted CME-45 drill. 6" flight augers. SPT penetration testing and sampling.

GROUNDWATER INFORMATION:
Groundwater encountered at approximately 8 1/2' while deriiling and measured at 2' 8" after boring.

SURFACE ELEVATION: 72.81

FIELD DATA / LABORATORY DATA

SOIL SYMBOL	DEPTH (FT)	SAMPLES	N: BLOWS/FT P: TONS/SQ FT T: BLOWS R: % RQD: %	MOISTURE CONTENT (%)	ATTERBERG LIMITS LIQUID LIMIT LL	PLASTIC LIMIT PL	PLASTICITY INDEX PI	DRY DENSITY POUNDS/CU.FT	MINUS NO. 4 SIEVE (%)	MINUS NO. 10 SIEVE (%)	MINUS NO. 40 SIEVE (%)	MINUS NO. 200 SIEVE (%)	DESCRIPTION OF STRATUM
	0–3												Vegetation cover
	1–2.5	SPT	N = 5	24.5									LEAN CLAY (CL) brown medium stiff
	3.5–5	SPT	N = 6	19.9									LEAN CLAY (CL) grayish brown medium stiff
	6–7.5	SPT	N = 5	23.5	39	18	21		99.8	99.6	97.6	88.1	LEAN CLAY (CL) brown medium stiff
	8.5–9	SPT	N = 50/1										
	9–9.1		T = 50/0.2 50/0.1										WEATHERED LIMESTONE brown moderately hard

Bottom of boring at approximately 9.1'.

N - STANDARD PENETRATION TEST RESISTANCE
P - POCKET PENETROMETER RESISTANCE
T - TXDOT CONE PENETRATION RESISTANCE
R - ROCK CORE RECOVERY
RQD - ROCK QUALITY DESIGNATION

REMARKS:

LOG OF BORING B-04

Hinderliter Geotechnical Engineering
4071 SW 3rd Street
Oklahoma City OK 73107
Telephone: 405-942-4090

CLIENT: CEC Corporation
PROJECT: Cherokee Safe Haven Village Project
LOCATION: East of 1429 Jack Brown Lane, Tahlequah, OK
NUMBER: CEC-24-09

DATE(S) DRILLED: 5/21/24

DRILLING METHOD(S):
Truck mounted CME-45 drill. 6" flight augers. SPT penetration testing and sampling.

GROUNDWATER INFORMATION:
Groundwater encountered at approximately 14' while drilling and measured at 8' 7" after boring.

SURFACE ELEVATION: 66.72

FIELD DATA / LABORATORY DATA

DEPTH (FT)	N: BLOWS/FT, P: TONS/SQ FT, T: BLOWS, R: %, RQD: %	MOISTURE CONTENT (%)	LIQUID LIMIT LL	PLASTIC LIMIT PL	PLASTICITY INDEX PI	DRY DENSITY POUNDS/CU.FT	MINUS NO. 4 SIEVE (%)	MINUS NO. 10 SIEVE (%)	MINUS NO. 40 SIEVE (%)	MINUS NO. 200 SIEVE (%)	DESCRIPTION OF STRATUM
0											Vegetation cover
0–9.5											LEAN CLAY (CL) brown soft to very stiff
1–2.5	N = 3	24.2									
3.5–5	N = 6	21.2	43	18	25		100	99.2	94	87.9	
6–7.5	N = 22	14.0									
8.5–10	N = 26/6, 50/3	12.0									
9.5–14.1											WEATHERED SHALE gray soft to moderately hard
13.5–14.1	N = 50/2 T = 50/0.3, 50/0.1	12.7									
14.1											Bottom of boring at approximately 14.1'.

N - STANDARD PENETRATION TEST RESISTANCE
P - POCKET PENETROMETER RESISTANCE
T - TXDOT CONE PENETRATION RESISTANCE
R - ROCK CORE RECOVERY
RQD - ROCK QUALITY DESIGNATION

REMARKS:

LOG OF BORING B-05

Hinderliter Geotechnical Engineering
4071 SW 3rd Street
Oklahoma City OK 73107
Telephone: 405-942-4090

CLIENT: CEC Corporation
PROJECT: Cherokee Safe Haven Village Project
LOCATION: East of 1429 Jack Brown Lane, Tahlequah, OK
NUMBER: CEC-24-09

DATE(S) DRILLED: 5/15/24

DRILLING METHOD(S):
Truck mounted CME-45 drill. 6" flight augers. SPT penetration testing and sampling.

GROUNDWATER INFORMATION:
No groundwater encountered while drilling or sampling.

SURFACE ELEVATION: 85.29

SOIL SYMBOL	DEPTH (FT)	SAMPLES	N: BLOWS/FT P: TONS/SQ FT T: BLOWS R: % RQD: %	MOISTURE CONTENT (%)	LIQUID LIMIT LL	PLASTIC LIMIT PL	PLASTICITY INDEX PI	DRY DENSITY POUNDS/CU.FT	MINUS NO. 4 SIEVE (%)	MINUS NO. 10 SIEVE (%)	MINUS NO. 40 SIEVE (%)	MINUS NO. 200 SIEVE (%)	DESCRIPTION OF STRATUM
													Vegetation cover
	1–2		N = 3/6, 50/5	18.3									LEAN CLAY with SAND (CL) brown soft to very stiff
	3												
	4		N = 3	30.4	41	21	20		100	99.8	98.6	84.2	
	5		T = 50/0.1 50/0.1										WEATHERED LIMESTONE brown moderately hard
													Bottom of boring at approximately 5.1'.

N - STANDARD PENETRATION TEST RESISTANCE
P - POCKET PENETROMETER RESISTANCE
T - TXDOT CONE PENETRATION RESISTANCE
R - ROCK CORE RECOVERY
RQD - ROCK QUALITY DESIGNATION

REMARKS:

LOG OF BORING B-06

Hinderliter Geotechnical Engineering
4071 SW 3rd Street
Oklahoma City OK 73107
Telephone: 405-942-4090

CLIENT: CEC Corporation
PROJECT: Cherokee Safe Haven Village Project
LOCATION: East of 1429 Jack Brown Lane, Tahlequah, OK
NUMBER: CEC-24-09

DATE(S) DRILLED: 5/21/24

DRILLING METHOD(S):
Truck mounted CME-45 drill. 6" flight augers. SPT penetration testing and sampling.

GROUNDWATER INFORMATION:
Groundwater encountered at approximately 6' while drilling and measured at 3' 2" after boring.

SURFACE ELEVATION: 80.84

Depth (FT)	Field Data (N: Blows/Ft, P: Tons/Sq Ft, T: Blows, R: %, RQD: %)	Moisture Content (%)	Liquid Limit (LL)	Plastic Limit (PL)	Plasticity Index (PI)	Dry Density Pounds/Cu.Ft	Minus No. 4 Sieve (%)	Minus No. 10 Sieve (%)	Minus No. 40 Sieve (%)	Minus No. 200 Sieve (%)	Description of Stratum
0–3											Vegetation cover
1–2	N = 8	24.4	40	20	20		99.8	99	95.3	82.1	LEAN CLAY with SAND (CL) brown stiff
3–8.6	N = 50/1	19.6									WEATHERED LIMESTONE moderately hard brown
4	T = 50/0.6, 50/0.3	21.0									
6	N = 50/1										
8.6	N = 50/1										Bottom of boring at approximately 8.6'.

N - STANDARD PENETRATION TEST RESISTANCE
P - POCKET PENETROMETER RESISTANCE
T - TXDOT CONE PENETRATION RESISTANCE
R - ROCK CORE RECOVERY
RQD - ROCK QUALITY DESIGNATION

REMARKS:

LOG OF BORING B-07

HGE
Hinderliter Geotechnical Engineering
4071 SW 3rd Street
Oklahoma City OK 73107
Telephone: 405-942-4090

CLIENT: CEC Corporation
PROJECT: Cherokee Safe Haven Village Project
LOCATION: East of 1429 Jack Brown Lane, Tahlequah, OK
NUMBER: CEC-24-09

DATE(S) DRILLED: 5/21/24

DRILLING METHOD(S):
Truck mounted CME-45 drill. 6" flight augers. SPT penetration testing and sampling.

GROUNDWATER INFORMATION:
Groundwater encountered at approximately 7' while deriiling and measured at 7' 0" after boring.

SURFACE ELEVATION: 72.5

FIELD DATA / LABORATORY DATA

SOIL SYMBOL	DEPTH (FT)	SAMPLES	N: BLOWS/FT P: TONS/SQ FT T: BLOWS R: % RQD: %	MOISTURE CONTENT (%)	ATTERBERG LIMITS LIQUID LIMIT LL	PLASTIC LIMIT PL	PLASTICITY INDEX PI	DRY DENSITY POUNDS/CU.FT	MINUS NO. 4 SIEVE (%)	MINUS NO. 10 SIEVE (%)	MINUS NO. 40 SIEVE (%)	MINUS NO. 200 SIEVE (%)	DESCRIPTION OF STRATUM
	0												Vegetation cover
	1–2	X	N = 3	27.4									LEAN CLAY (CL) brown soft to very stiff
	4	X	N = 5	21.6									
	6.5	X	N = 4	28.2	29	18	11		99.9	99.5	98.4	88.9	
	9	X	N = 18/6, 50/2	24.7									
	9.5–9.7												WEATHERED SHALE brown moderately hard

Bottom of boring at approximately 9.7'.

N - STANDARD PENETRATION TEST RESISTANCE
P - POCKET PENETROMETER RESISTANCE
T - TXDOT CONE PENETRATION RESISTANCE
R - ROCK CORE RECOVERY
RQD - ROCK QUALITY DESIGNATION

REMARKS:

LOG OF BORING B-08

Hinderliter Geotechnical Engineering
4071 SW 3rd Street
Oklahoma City OK 73107
Telephone: 405-942-4090

CLIENT: CEC Corporation
PROJECT: Cherokee Safe Haven Village Project
LOCATION: East of 1429 Jack Brown Lane, Tahlequah, OK
NUMBER: CEC-24-09
DATE(S) DRILLED: 5/21/24

DRILLING METHOD(S):
Truck mounted CME-45 drill. 6" flight augers. SPT penetration testing and sampling.

GROUNDWATER INFORMATION:
Groundwater encountered at approximately 8 1/2' while deriiling and measured at 2' 8" after boring.

SURFACE ELEVATION: 69.12

DEPTH (FT)	SAMPLES	FIELD DATA: N: BLOWS/FT, P: TONS/SQ FT, T: BLOWS, R: %, RQD: %	MOISTURE CONTENT (%)	LIQUID LIMIT LL	PLASTIC LIMIT PL	PLASTICITY INDEX PI	DRY DENSITY POUNDS/CU.FT	MINUS NO. 4 SIEVE (%)	MINUS NO. 10 SIEVE (%)	MINUS NO. 40 SIEVE (%)	MINUS NO. 200 SIEVE (%)	DESCRIPTION OF STRATUM
0–3.5												Vegetation cover
	X	N = 8	24.8	50	21	29		100	99.4	96.3	86.1	FAT CLAY (CH) brown stiff
3.5–7	X	N = 7	23.3	46	21	25		100	99.9	97.7	88.3	LEAN TO FAT CLAY (CL-CH) brown medium stiff
	X	N = 2, 50/1	32.0									
7–9	X	N = 50/6	27.4									WEATHERED SHALE brown soft to moderately hard
9												Bottom of boring at approximately 9'.

N - STANDARD PENETRATION TEST RESISTANCE
P - POCKET PENETROMETER RESISTANCE
T - TXDOT CONE PENETRATION RESISTANCE
R - ROCK CORE RECOVERY
RQD - ROCK QUALITY DESIGNATION

REMARKS:

APPENDIX B
LABORATORY TESTING PROGRAM

GENERAL

Laboratory tests were performed on select, representative samples to evaluate pertinent engineering properties of these materials. We directed our laboratory testing program primarily toward classifying the subsurface materials as well as measuring index values of the on-site materials. Laboratory tests were performed in general accordance with applicable standards. The results of the laboratory tests are presented on the respective coring logs. The laboratory testing program consisted of the following:

- **Moisture content tests**, ASTM D 2216, Standard Test Method for Laboratory Determination of Water
- **Atterberg limits**, ASTM D 4318, Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
- **No. 200 sieve**, ASTM D 1140, Standard Test Methods for Amount of Material in Soils Finer Than the No. 200 Sieve
- **Visual classification**, ASTM D 2488, Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)
- **Moisture Density Test,** AASHTO T-99, Standard Method of Test For Moisture-Density Relations of Soils Using a 2.5-kg (5.5. lb) Rammer and a 305-mm (12-in.) Drop
- **California Bearing Ratio (CBR) Strength**, ASTM D 1883, Standard Test Method for CBR
- **Soluble Sulfates**, OHD L-49, Method of Test for Determining Soluble Sulfate Content of Soil

CEC

13801 N. Meridian Ave.
Oklahoma City, OK 73134
Phone:(405) 753-6840

Geotechnical Lab Summary

Report Date: 05/22/2024
Project: 240297.1
Task Order #3 - Geotechnical Testing, Cherokee Safe Haven Village Project
Location: Native Soil;Borings
Client: Cherokee Nation

Date Sampled: 05/15/2024
Sampled By: Hinderliter

Lab No: 3433

TEST RESULTS

Report No: 240297.1-1694

Sample Location	Depth	Color	Soil Description	Class.	LL	PI	% Moisture	3/8" Sieve	#4 Sieve	#10 Sieve	#40 Sieve	#100 Sieve	#200 Sieve
B-1 S-1		Brown	Lean Clay w/Sand	A-6(8)	29	12	19.8	99.7	99.7	99.6	94.0	87.6	84.0
B-1 S-2		Brown					17.6						
B-2 S-1		Dark Brown	Lean Clay w/Sand	A-6(13)	35	17	22.1	96.5	96.4	96.3	91.6	86.6	81.8
B-2 S-2		Brown					27.2						
B-3 S-1		Dark Brown					24.5						
B-3 S-2		Grayish Brown					19.9						
B-3 S-3		Brown	Lean Clay	A-6(18)	39	21	23.5	100.0	99.8	99.6	97.6	94.2	88.1
B-4 S-1		Dark Brown					24.2						
B-4 S-2		Brown	Lean Clay	A-7-6(22)	43	25	21.2	100.0	100.0	99.2	94.0	90.5	87.9
B-4 S-3		Brown					14.0						
B-4 S-4		Brown					12.0						
B-4 S-5		Dark Brown					12.7						
B-5 S-1		Brown					18.3						
B-5 S-2		Brown	Lean Clay w/Sand	A-7-6(17)	41	20	30.4	100.0	100.0	99.8	98.6	91.7	84.2
B-6 S-1		Brown	Lean Clay w/Sand	A-6(16)	40	20	24.4	100.0	99.8	99.0	95.3	89.4	82.1
B-6 S-3		Brown					19.6						
B-6 S-4		Brown					21.0						
B-7 S-1		Dark Brown					27.4						
B-7 S-2		Brown					21.6						
B-7 S-3		Brown	Lean Clay	A-6(9)	29	11	28.2	100.0	99.9	99.5	98.4	96.1	88.9
B-7 S-4		Brown					24.7						
B-8 S-1		Dark Brown	Fat Clay	A-7-6(26)	50	29	24.8	100.0	100.0	99.4	96.2	90.8	86.1
B-8 S-2		Brown	Lean Clay	A-7-6(23)	46	25	23.3	100.0	100.0	99.9	97.7	92.9	88.3
B-8 S-3		Brown					32.0						
B-8 S-4		Grayish Brown					27.4						
BCS	Composite	Brown	Lean Clay w/Sand	A-6(13)	36	17	23.2	99.3	98.5	98.1	91.5	86.6	82.2

Test Methods: AASHTO T11, T88, T89, T90, T99, T255, OHDL-49; ASTM D1140, D422, D4318, D698, D2216, C1580

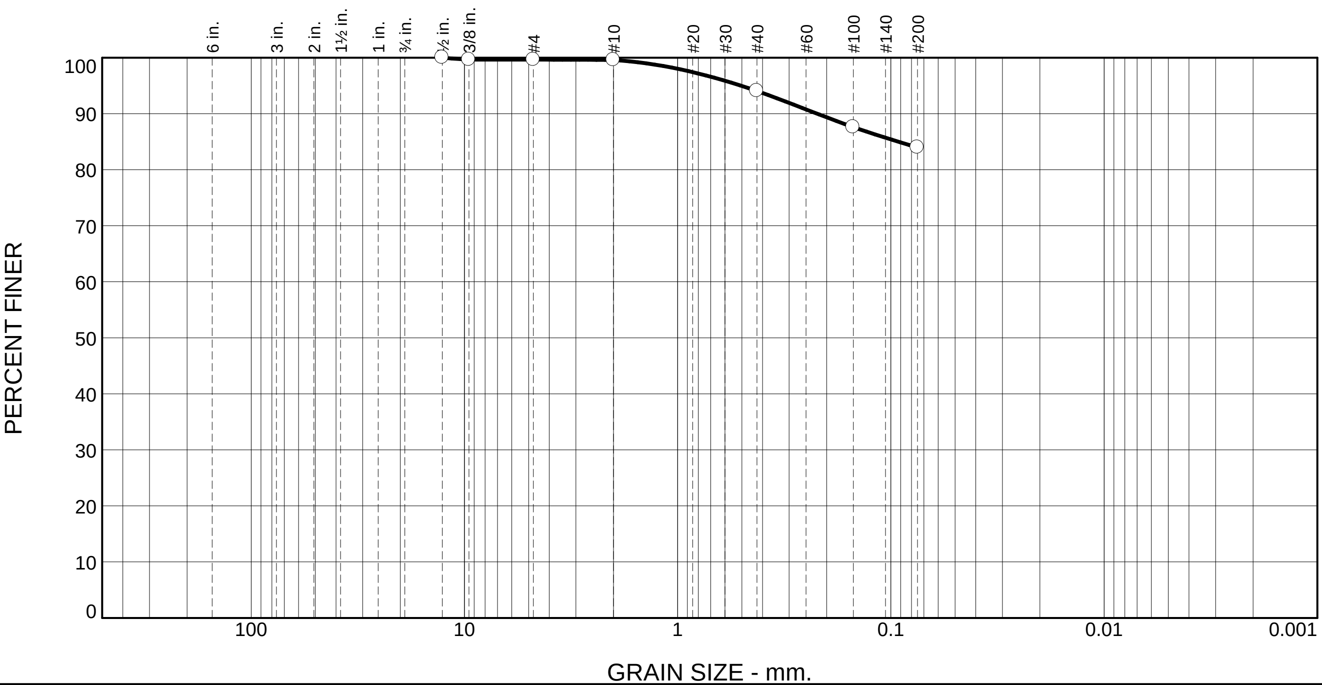
1-ec CEC Corporation Attn: Brett Cowan
1-ec Hinderliter Geotechnical Engineering
Attn: Mark Hinderliter

Respectfully Submitted,
CEC Corporation

LICENSED PROFESSIONAL ENGINEER
BRETT A. COWAN
21935
OKLAHOMA

Brett Cowan, Geotechnical Engineer
06/11/2024

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.3	0.1	5.6	10.0	84.0	

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1/2"	100.0		
3/8"	99.7		
#4	99.7		
#10	99.6		
#40	94.0		
#100	87.6		
#200	84.0		

* (no specification provided)

Material Description

Lean Clay w/ Sand

Atterberg Limits (ASTM D 4318)

PL= 17 **LL=** 29 **PI=** 12

Classification

USCS (D 2487)= CL **AASHTO (M 145)=** A-6(8)

Coefficients

D_{90}= 0.2218 D_{85}= 0.0921 D_{60}=
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: **Date Tested:**
Tested By:
Checked By: S. Roach
Title: Lab Manager

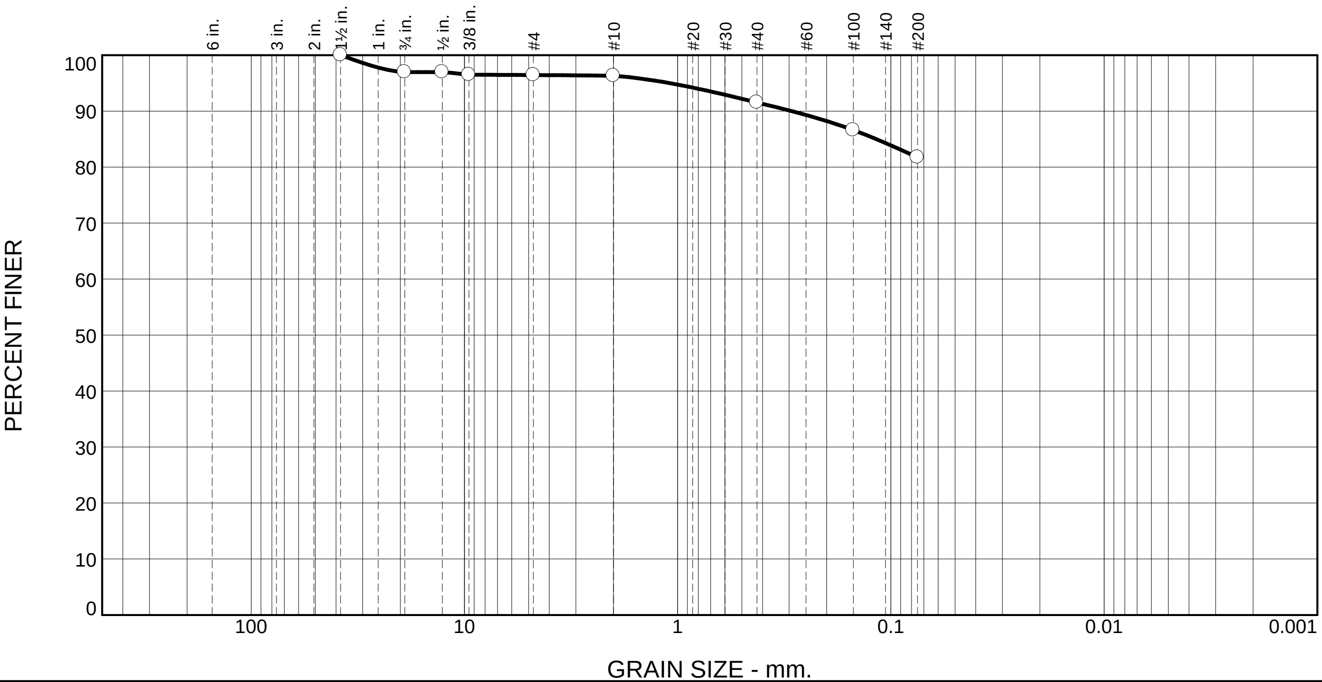
Location: B-1 S-1

Date Sampled: 5/15/24

CEC materials testing

Client: Cherokee Nation
Project: Safe Haven Village
Project No: 240297.1 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	3.0	0.6	0.1	4.7	9.8	81.8	

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1-1/2"	100.0		
3/4"	97.0		
1/2"	97.0		
3/8"	96.5		
#4	96.4		
#10	96.3		
#40	91.6		
#100	86.6		
#200	81.8		

* (no specification provided)

Material Description

Dark Brown Lean Clay w/ Sand

Atterberg Limits (ASTM D 4318)

PL= 18 **LL=** 34 **PI=** 16

Classification

USCS (D 2487)= CL **AASHTO (M 145)=** A-6(12)

Coefficients

D_{90}= 0.2922 D_{85}= 0.1173 D_{60}=
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: **Date Tested:**

Tested By:

Checked By: S. Roach

Title: Lab Manager

Location: B-2 S-1

Date Sampled: 5/15/24

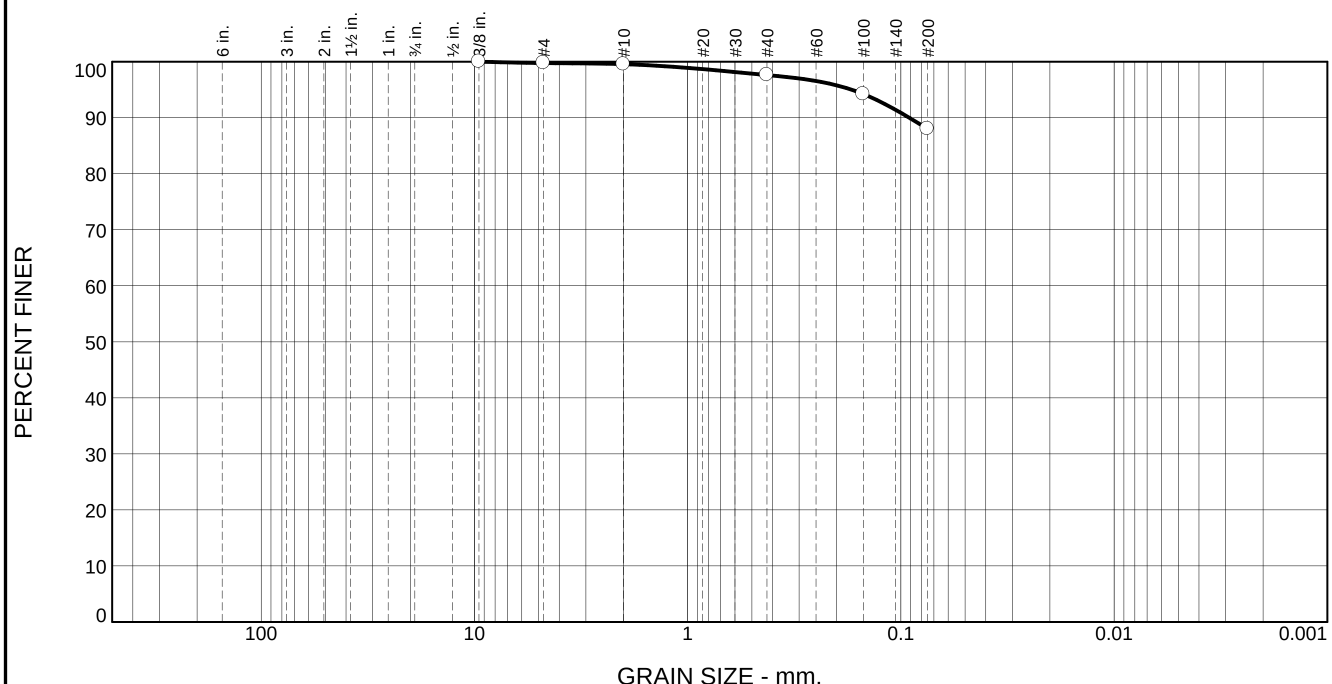
CEC materials testing

Client: Cherokee Nation

Project: Safe Haven Village

Project No: 240297.1 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.2	0.2	2.0	9.6	88.0	

TEST RESULTS			
Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
3/8"	100.0		
#4	99.8		
#10	99.6		
#40	97.6		
#100	94.2		
#200	88.0		

* (no specification provided)

Material Description

Brown Lean Clay

Atterberg Limits (ASTM D 4318)

PL= 18 **LL=** 39 **PI=** 21

Classification

USCS (D 2487)= CL **AASHTO (M 145)=** A-6(18)

Coefficients

D_{90}= 0.0914 D_{85}= D_{60}=
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: **Date Tested:**

Tested By:

Checked By: S. Roach

Title: Lab Manager

Location: B-3 S-3

Date Sampled: 5/15/24

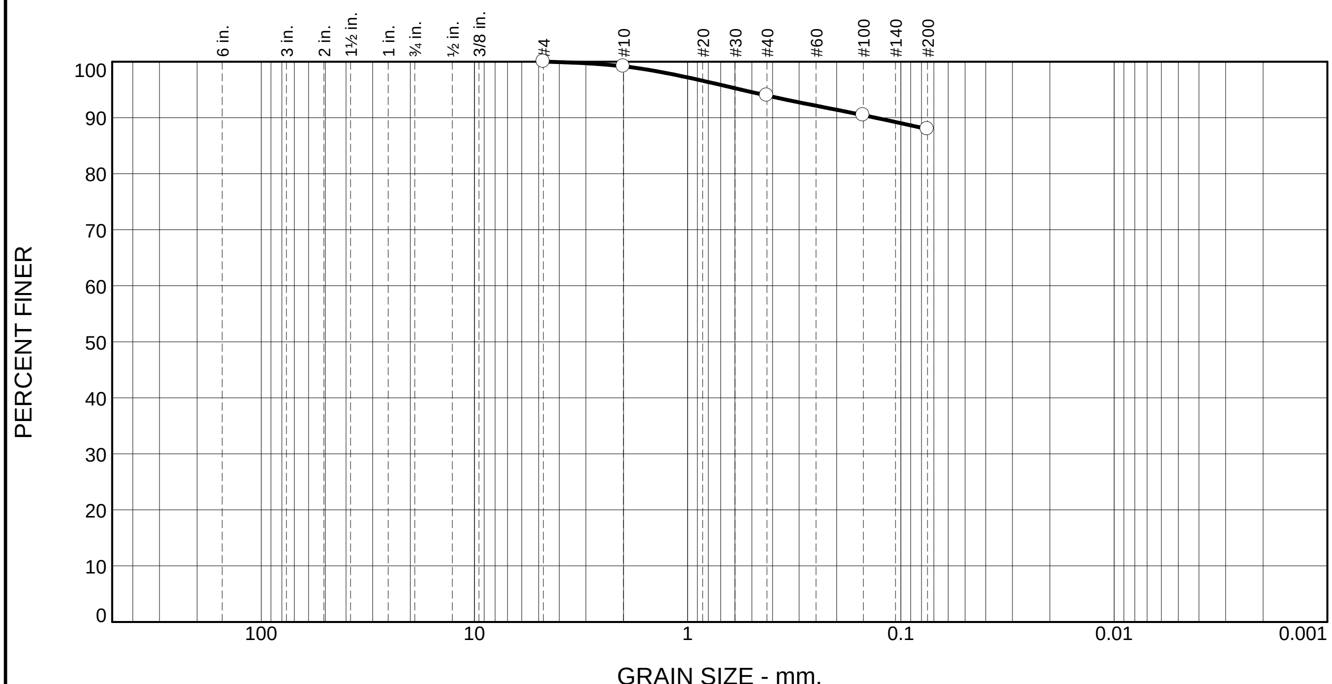
CEC materials testing

Client: Cherokee Nation

Project: Safe Haven Village

Project No: 240297.1 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.8	5.2	6.0	88.0	

Test Results (AASHTO T 27 & AASHTO T 11)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
#4	100.0		
#10	99.2		
#40	94.0		
#100	90.4		
#200	88.0		

* (no specification provided)

Material Description

Brown Lean Clay

Atterberg Limits (ASTM D 4318)

PL= 18 **LL=** 43 **PI=** 25

Classification

USCS (D 2487)= CL **AASHTO (M 145)=** A-7-6(22)

Coefficients

D_{90}= 0.1318 D_{85}= D_{60}=
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: ____ **Date Tested:** ____

Tested By: ____

Checked By: S. Roach

Title: Lab Manager

Location: B-4 S-2

Date Sampled: 5/15/24

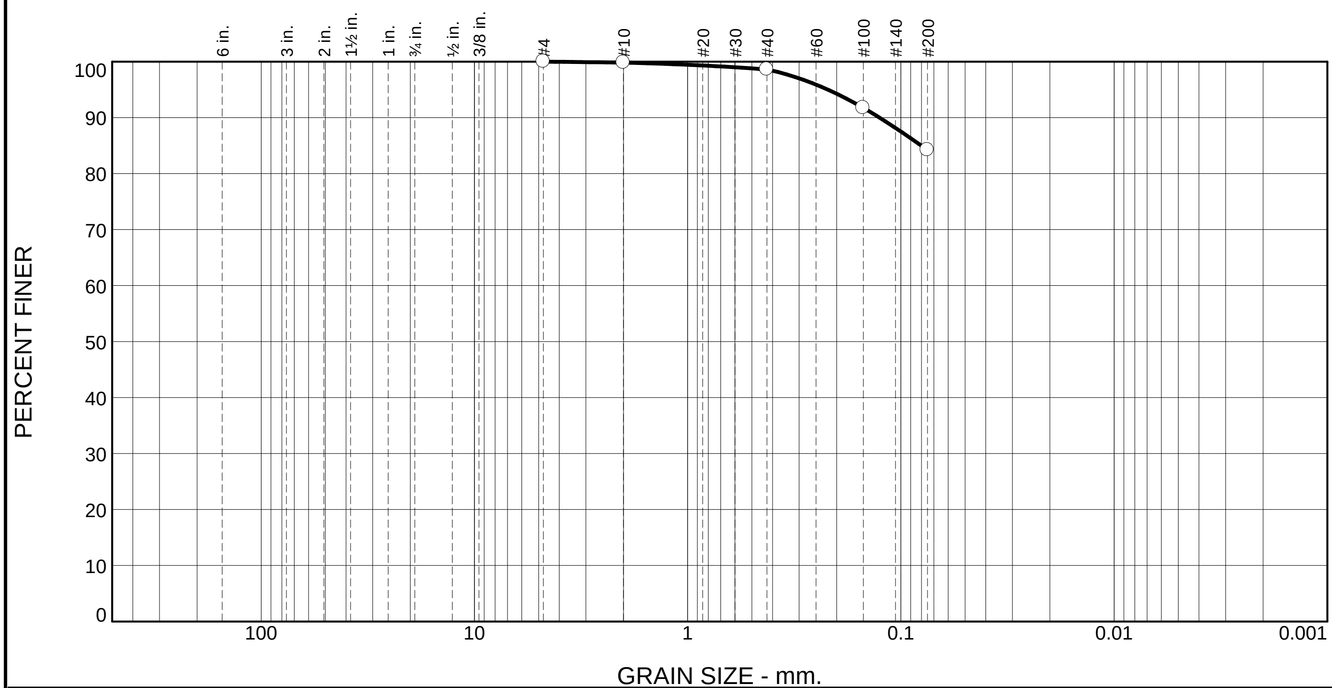
CEC materials testing

Client: Cherokee Nation

Project: Safe Haven Village

Project No: 240297.1 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.2	1.2	14.4	84.2	

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
#4	100.0		
#10	99.8		
#40	98.6		
#100	91.7		
#200	84.2		

* (no specification provided)

Material Description

Lean Clay w/ Sand

Atterberg Limits (ASTM D 4318)

PL= 21 **LL=** 41 **PI=** 20

Classification

USCS (D 2487)= CL **AASHTO (M 145)=** A-7-6(17)

Coefficients

D_{90}= 0.1260 D_{85}= 0.0802 D_{60}=
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: ____ **Date Tested:** ____

Tested By: ____

Checked By: S. Roach

Title: Lab Manager

Location: B-5 S-2

Date Sampled: 5/15/24

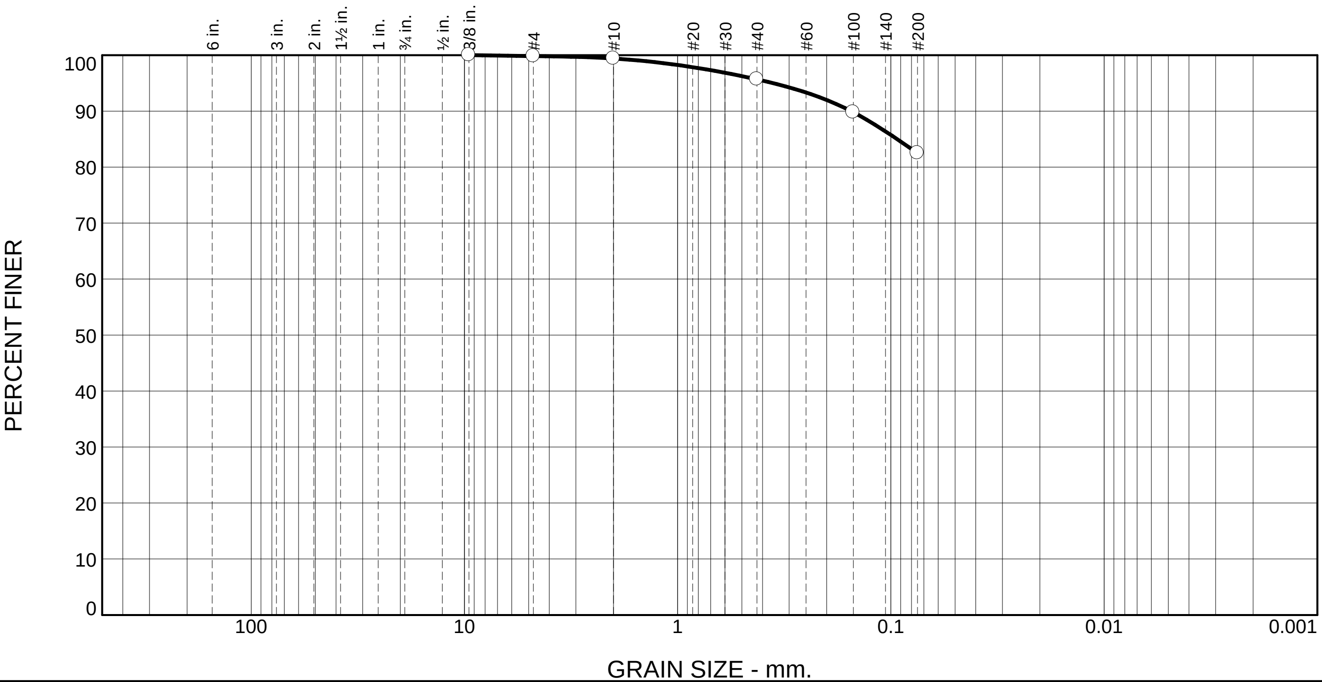
CEC materials testing

Client: Cherokee Nation

Project: Safe Haven Village

Project No: 240297.1 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.2	0.4	3.7	13.2	82.5	

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
3/8"	100.0		
#4	99.8		
#10	99.4		
#40	95.7		
#100	89.8		
#200	82.5		

* (no specification provided)

Material Description

Brown Lean Clay w/ Sand

Atterberg Limits (ASTM D 4318)

PL= 20 **LL=** 40 **PI=** 20

Classification

USCS (D 2487)= CL **AASHTO (M 145)=** A-6(16)

Coefficients

D_{90}= 0.1536 D_{85}= 0.0935 D_{60}=
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: **Date Tested:**
Tested By:
Checked By: S. Roach
Title: Lab Manager

Location: B-6 S-1

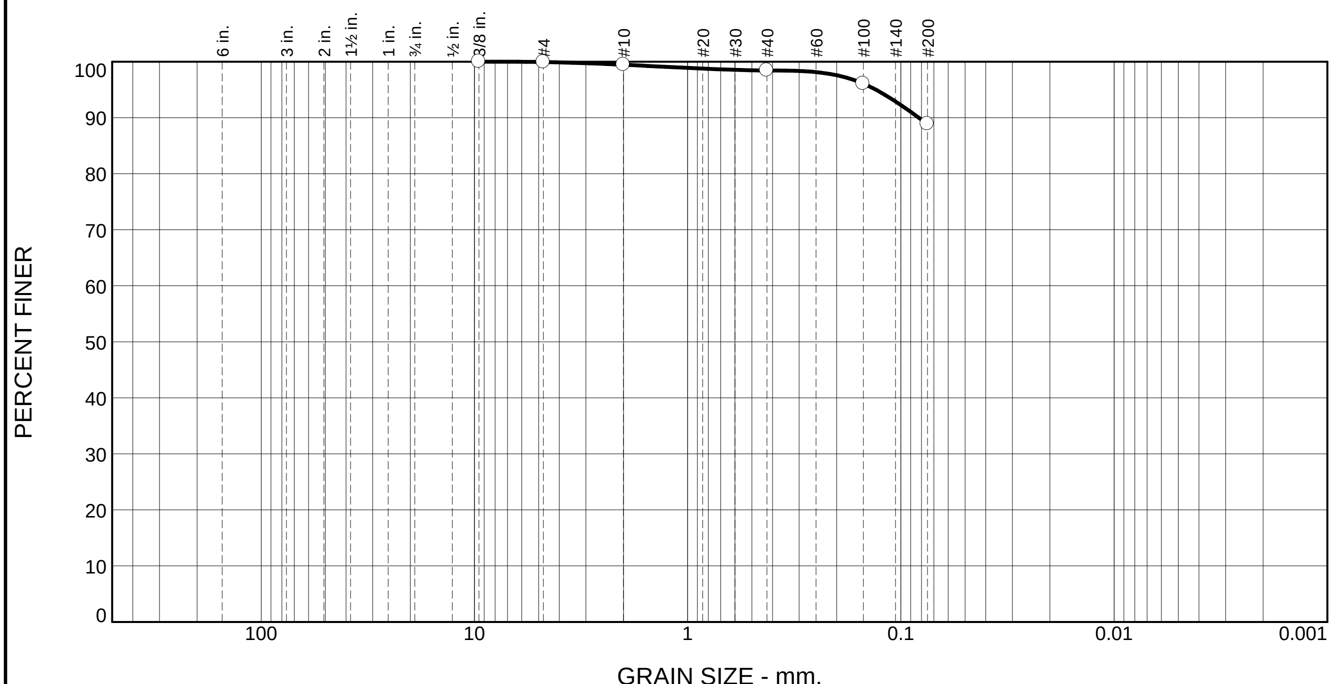
Date Sampled: 5/15/24

CEC materials testing

Client: Cherokee Nation
Project: Safe Haven Village

Project No: 240297.1 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.1	0.4	1.1	9.5	88.9	

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
3/8"	100.0		
#4	99.9		
#10	99.5		
#40	98.4		
#100	96.1		
#200	88.9		

* (no specification provided)

Material Description

Brown Lean Clay

Atterberg Limits (ASTM D 4318)

PL= 18 **LL=** 29 **PI=** 11

Classification

USCS (D 2487)= CL **AASHTO (M 145)=** A-6(9)

Coefficients

D_{90}= 0.0824 D_{85}= D_{60}=
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: **Date Tested:**
Tested By:
Checked By: S. Roach
Title: Lab Manager

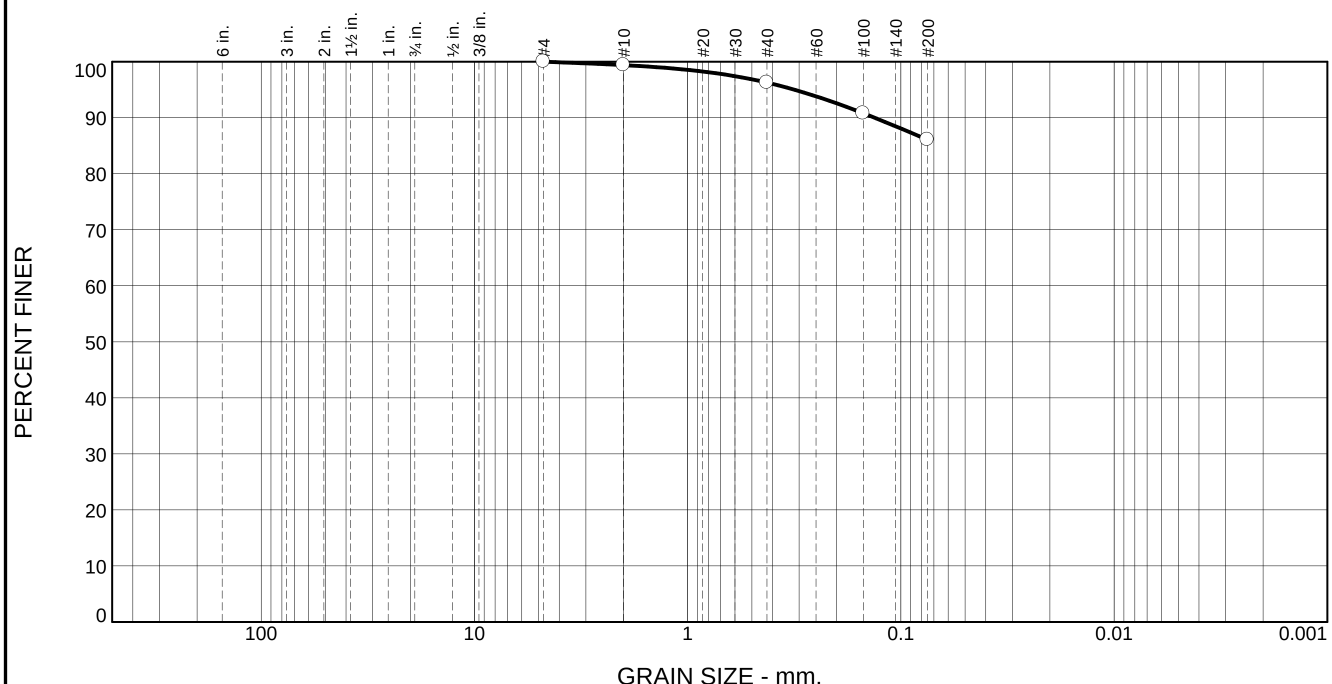
Location: B-7 S-3

Date Sampled: 5/15/24

CEC materials testing

Client: Cherokee Nation
Project: Safe Haven Village
Project No: 240297.1 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.6	3.1	10.2	86.1	

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
#4	100.0		
#10	99.4		
#40	96.3		
#100	90.8		
#200	86.1		

* (no specification provided)

Material Description

Brown Fat Clay

Atterberg Limits (ASTM D 4318)

PL= 21 **LL=** 50 **PI=** 29

Classification

USCS (D 2487)= CH **AASHTO (M 145)=** A-7-6(26)

Coefficients

D_{90}= 0.1329 D_{85}= D_{60}=
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: **Date Tested:**
Tested By:
Checked By: S. Roach
Title: Lab Manager

Location: B-8 S-1

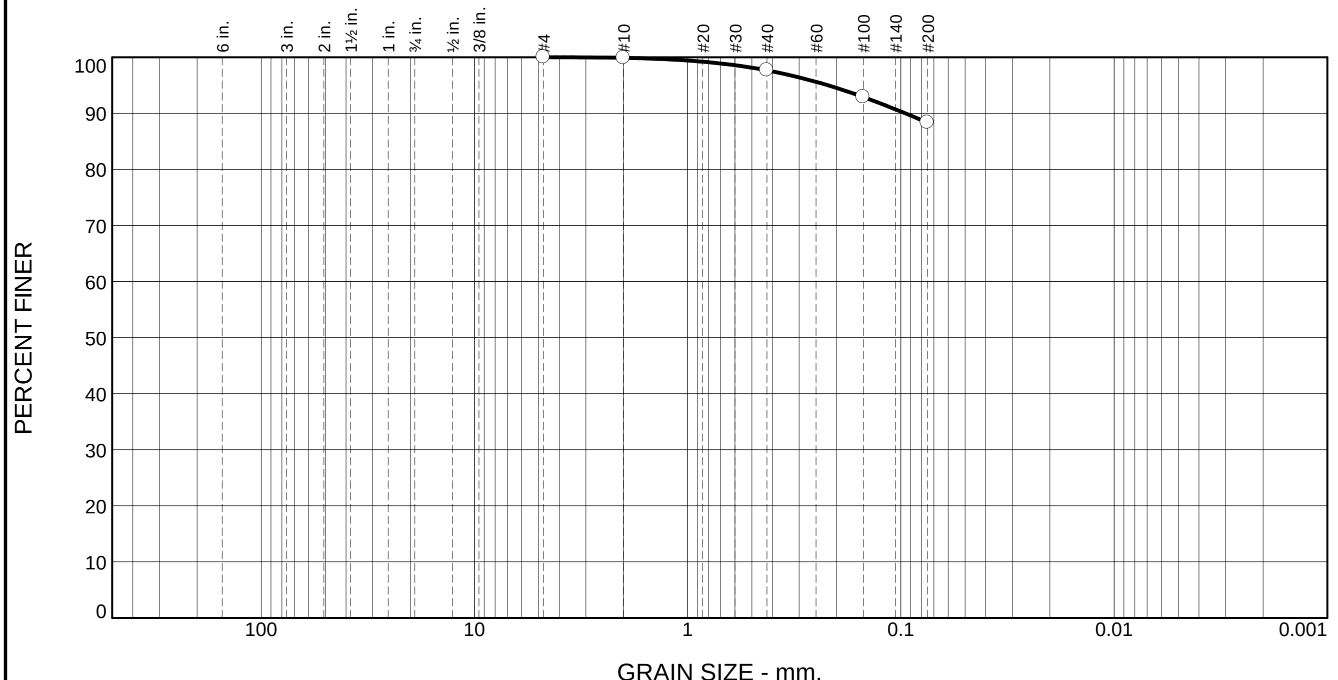
Date Sampled: 5/15/24

CEC materials testing

Client: Cherokee Nation
Project: Safe Haven Village

Project No: 240297.1 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.1	2.2	9.4	88.3	

TEST RESULTS			
Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
#4	100.0		
#10	99.9		
#40	97.7		
#100	92.9		
#200	88.3		

* (no specification provided)

Material Description

Lean Clay

Atterberg Limits (ASTM D 4318)

PL= 21 **LL=** 46 **PI=** 25

Classification

USCS (D 2487)= CL **AASHTO (M 145)=** A-7-6(23)

Coefficients

D_{90}= 0.0956 D_{85}= D_{60}=
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: ____ **Date Tested:** ____

Tested By: ____

Checked By: S. Roach

Title: Lab Manager

Location: B-8 S-2

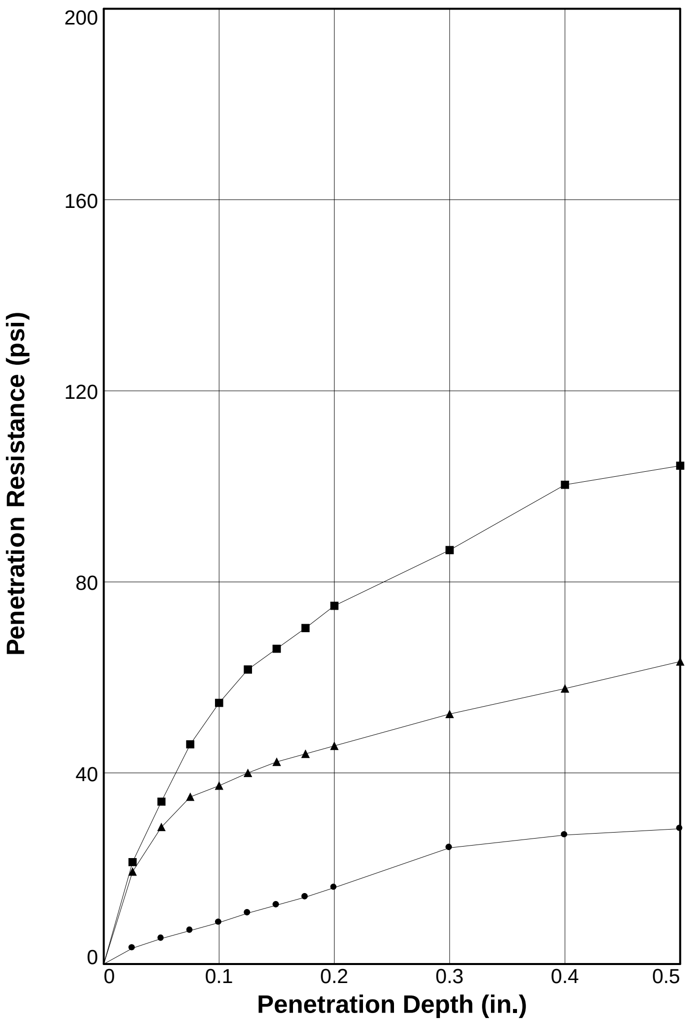
Date Sampled: 5/15/24

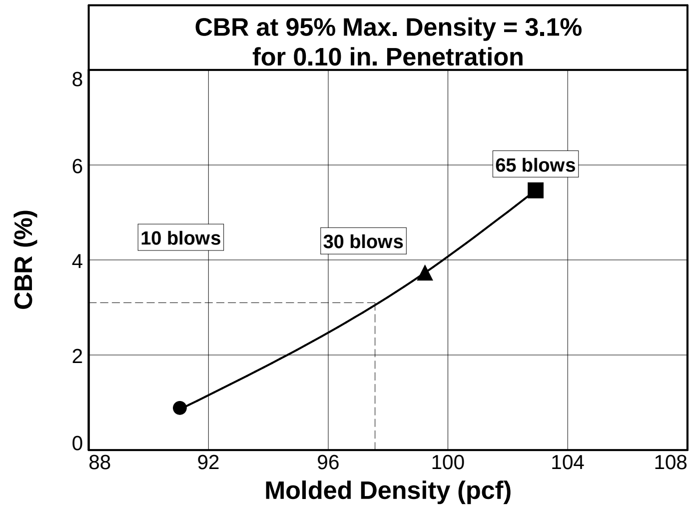
CEC materials testing

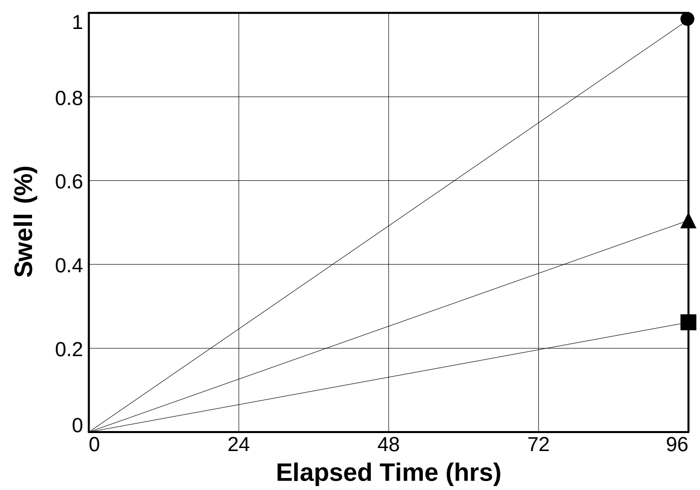
Client: Cherokee Nation
Project: Safe Haven Village

Project No: 240297.1 **Figure**

BEARING RATIO TEST REPORT
ASTM D 1883-07







	Molded			Soaked			CBR (%)		Linearity Correction (in.)	Surcharge (lbs.)	Max. Swell (%)
	Density (pcf)	Percent of Max. Dens.	Moisture (%)	Density (pcf)	Percent of Max. Dens.	Moisture (%)	0.10 in.	0.20 in.			
1 ○	91.1	88.7	20.2	90.2	87.8	27.0	0.9	1.1	0.000	10	1
2 △	99.2	96.6	20.9	98.7	96.1	23.7	3.7	3.0	0.000	10	0.5
3 □	102.9	100.2	20.4	102.7	100	21.6	5.5	5.0	0.000	10	0.3

Material Description	USCS	Max. Dens. (pcf)	Optimum Moisture (%)	LL	PI
Lean Clay w/ Sand	CL	102.7	18.1	36	17

Project No: 240297.1

Project: Safe Haven Village

Location: BCS Composite Sample

Date: 5/15/24

CEC materials testing

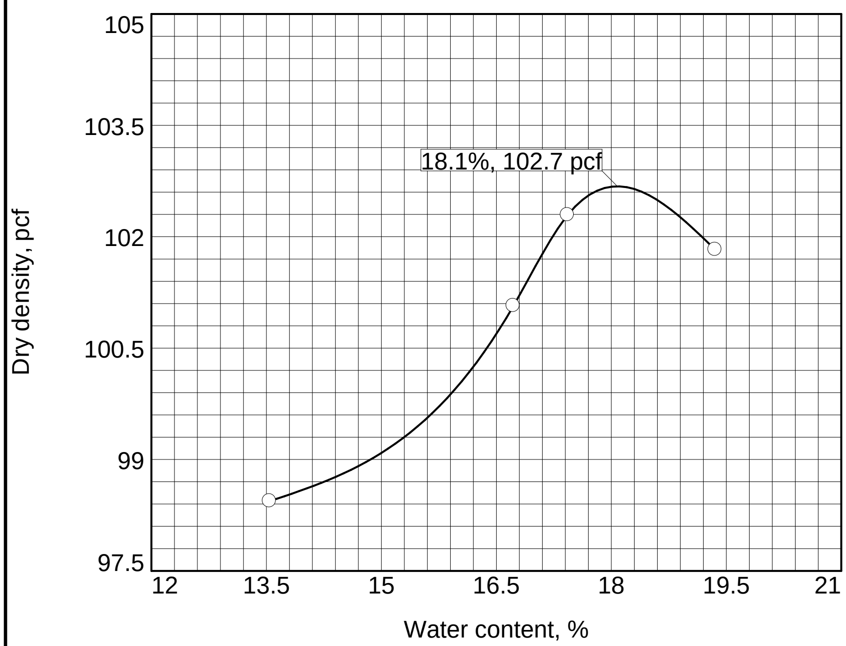
Test Description/Remarks:

Composite Sample

Sulfate PPM=80

Figure ________

COMPACTION TEST REPORT



Preparation Method	
Rammer: Wt.	5.5 lb.
Drop	12 in.
Type	
Layers: No.	Three
Blows per	25
Mold Size	0.0331 cu. ft.
Test Performed on Material Passing ___ Sieve	#4
%>#4	1.5
%<No.200	82.2
Atterberg (D 4318): LL	36
PI	17
NM (D 2216)	23.2
Sp.G. (D 854)	
USCS (D 2487)	CL
AASHTO (M 145)	A-6(13)
Date: Sampled	5/15/24
Received	
Tested	
Tested By	

COMPACTION TESTING DATA
AASHTO T 99-15 Method A Standard

	1	2	3	4	5	6
WM + WS	5881.4	5974.5	6006.8	6028.0		
WM	4203.3	4203.3	4203.3	4203.3		
WW + T #1	546.6	643.2	550.7	519.6		
WD + T #1	502.9	593.7	502.4	465.4		
TARE #1	180.2	297.7	225.3	185.4		
WW + T #2						
WD + T #2						
TARE #2						
MOIST.	13.5	16.7	17.4	19.4		
DRY DENS.	98.4	101.1	102.3	101.8		

SIEVE TEST RESULTS

Opening Size	% Passing	Specs.
1-1/2"	100.0	
3/4"	100.0	
1/2'	99.6	
3/8"	99.3	
#4	98.5	
#10	98.1	
#40	91.5	
#100	86.6	
#200	82.2	

TEST RESULTS

Maximum dry density = 102.7 pcf

Optimum moisture = 18.1 %

Material Description

Lean Clay w/ Sand

Remarks:

Project No. 240297.1 **Client:** Cherokee Nation

Project: Safe Haven Village

○ **Location:** BCS Composite Sample

CEC materials testing

Checked by: S. Roach

Title: Lab Manager

Figure