REPORT OF SUBSURFACE EXPLORATION
AND GEOTECHNICAL EVALUATION
CHEROKEE NATION CHILD DEVELOPMENT CENTER
CATOOSA, OKLAHOMA
BUILDING & EARTH PROJECT NO.: TU230102

PREPARED FOR:
Blue River Architects

MARCH 5, 2024

BUILDING & EARTH
Geotechnical, Environmental, and Materials Engineers

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March 5, 2024

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Attention: Mr. Kevin Oyler, AIA

Subject: Report of Subsurface Exploration and Geotechnical Evaluation
Cherokee Nation Child Development Center
Catoosa, Oklahoma
Building & Earth Project No: TU230102

Dear Mr. Oyler:

Building & Earth Sciences, Inc. has completed the authorized subsurface exploration and geotechnical engineering evaluation for the referenced project in Catoosa, Oklahoma.

The purpose of this exploration and evaluation was to determine general subsurface conditions at the site and to address applicable geotechnical aspects of the proposed construction and site development. The recommendations in this report are based on a physical reconnaissance of the site and observation and classification of samples obtained from a total of twenty-two (22) test borings conducted at the site. Confirmation of the anticipated subsurface conditions during construction is an essential part of geotechnical services.

We appreciate the opportunity to provide consultation services for the proposed project. If you have any questions regarding the information in this report or need any additional information, please call us.

Respectfully Submitted,
BUILDING & EARTH SCIENCES, INC.
Certificate of Authorization #3975, Expires 6/30/2024

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1.0 PROJECT & SITE DESCRIPTION

The project site is located on the west side of Country Club Drive, approximately 0.11 miles north of the intersection with North 193rd East Avenue in Catoosa, Oklahoma. General information relative to the proposed site and the proposed development is listed in Table 1 below. Photographs depicting the current site conditions are presented on the following pages.

Development Item	Detail	Description
General Site	Size (Ac.)	Approximately 7 acres
	Existing Development	Currently a vacant lot with residential houses to the north of the property, empty lot to the west, commercial development to the east, and Hard Rock casino to the south
	Ground Surface	The project area was covered with grass and topsoil
	Slopes	Site sloped down to the southeast and south with a grade difference of approximately 25 feet across the planned construction area
	Drainage	Natural run-off to the southeast. An existing shallow drainage ditch was noted along the south property boundary. Also, a 36-inch Corrugated Plastic Pipe (CPP) was noted within the southwest portion of the project area
	Anticipated Cuts & Fills	See note 2
Proposed Buildings	No. of Buildings	One (1)
	Square Ft.	~ 44,000
	Stories	Single story
	Construction	Pre-engineered metal building (assumed)
	Column Loads	On the order of 50 to 75 kips (provided)
	Wall Loads	2 to 3 kips per linear foot (provided)
	Preferred Foundation	Conventional shallow foundation (assumed)
	Preferred Slab	Conventional slab on grade (assumed)
Pavements	Traffic	Not Provided
	Standard Duty	Flexible and rigid, 115,000 ESAL (assumed)
	Heavy Duty	Flexible and rigid, 300,000 ESAL (assumed)

Table 1: Project and Site Description

References:

- Schematic Boring Plan, prepared by Blue River Architects, dated April 13, 2023
- Schematic Design Package, prepared by Blue River Architects, dated November 20, 2023
- Civil Drawings, prepared by Wallace Design Collective, dated February 9, 2024

Table 1 Notes:

1. If final loading conditions exceed preliminary given loads, Building & Earth should be allowed to review the structural design and its effects on our recommendations for foundation design.
2. If changes are made to the provided preliminary grading plan, Building & Earth should be allowed to review the updated plan and its effects on our recommendations.

At the time of our subsurface exploration and site reconnaissance, most of the project site was covered with grass and topsoil with some scattered trees. Historical aerial photographs of the site from November 2004 and August 2012, indicate the project area was disturbed during the construction of an overflow parking lot for the casino. It also appears the site was used as a staging area for the construction of the parking lot and for the construction of the CNB Employee Health Center up until September 2021. Google Earth historic aerials and photographs depicting the current site conditions are shown in Figures 1 through 6 below.

Figure 1: Google Earth aerial image, dated August 2022

Figure 2: Google Earth Image of Site (11/2004)

Figure 3: Google Earth Image of Site (8/2012)

Figure 4: Area of boring B-09 looking southwest

Figure 5: View looking south from boring SB-01

Figure 6: Underground drainage feature noted near boring P-02

Underground utilities comprising of water, sanitary sewer, and gas were noted along the east boundary of planned construction area. A shallow drainage ditch was noted along the south property boundary. In addition, an underground 36-inch CPP was noted near boring P-02 (refer to Figure 6).

2.0 SCOPE OF SERVICES

The initial authorized subsurface exploration was performed on June 26 and 27, 2023, in conformance with our proposal TU25156, dated May 22, 2023. Notice to proceed was provided by signing our proposal on June 6, 2023.

Occasionally some modification of the scope outlined in our proposal is required to provide for proper evaluation of the encountered subsurface conditions. Following completion of drilling, Building & Earth was instructed to put the project on hold, as changes were being made to the building layout and associated parking and access drives. Preliminary design plans prepared by Wallace Design Collective, dated November 20, 2023, indicated the layout of the building had changed from what was originally planned. Due to changes in the site plan and building layout, three (3) supplemental borings were drilled on January 18, 2024, to obtain information in unexplored areas of the planned construction area.

The purpose of the geotechnical exploration was to determine general subsurface conditions at specific boring locations and to gather data on which to base a geotechnical evaluation with respect to the proposed construction. The subsurface exploration for this project consisted of a total of twenty-two (22) test borings.

The site was drilled using CME 550X ATV and Diedrich D-50 track mounted drill rigs equipped with hollow stem and solid flight augers and an automatic hammer for performing Standard Penetration Tests (SPT) to help evaluate the relative soil strength. Refer to the Appendix for a description of the drilling and sampling procedures.

The boring locations were determined in the field by a representative of our staff using a handheld GPS device. As such, the boring locations shown on the Boring Location Plan attached to this report should be considered approximate.

The soil and rock samples recovered during our site investigation were visually classified and specific samples were selected by the project engineer for laboratory analysis. The laboratory analysis consisted of:

Test	ASTM	No. of Tests
Natural Moisture Content	D2216	103
Atterberg Limits	D4318	14
Material Finer Than No. 200 Sieve by Washing	D1140	4

Table 2: Scope of Laboratory Tests

The results of the laboratory analysis are presented on the enclosed Boring Logs and in tabular form in the Appendix of this report. Descriptions of the laboratory tests that were performed are also included in the Appendix.

The information gathered from the exploration was evaluated to determine a suitable foundation type for the proposed structure. The information was also evaluated to help determine if any special subgrade preparation procedures will be required during the earthwork phase of the project.

The results of the work are presented within this report that addresses:

- General site geology.
- Summary of existing surface conditions.
- A description of the subsurface conditions encountered at boring locations.
- A description of the groundwater conditions observed in the boreholes during drilling. Long-term monitoring was not included in our scope of work.

- Presentation of laboratory test results.
- Site preparation considerations including material types to be expected at the site, treatment of any encountered unsuitable soils, excavation considerations, and surface drainage.
- Recommendations to be used for shallow foundation design, including appropriate bearing materials, bearing pressures, and depths.
- Presentation of expected total and differential settlements.
- Recommendations to be used for design of slabs-on-grade, including modulus of subgrade reaction.
- Recommendations to be used for design and construction of site retaining walls, including lateral earth pressures and subsurface drainage provisions.
- Seismic Site Classification per IBC 2018 based on SPT test boring information.
- Compaction requirements and recommended criteria to establish suitable material for structural backfill.
- Recommendations for typical minimum flexible and rigid pavement sections.

3.0 GEOTECHNICAL SITE CHARACTERIZATION

The following discussion is intended to create a general understanding of the site from a geotechnical engineering perspective. It is not intended to be a discussion of every potential geotechnical issue that may arise, nor to provide every possible interpretation of the conditions identified. The following conditions and subsequent recommendations assume that significant changes in subsurface conditions do not occur between boreholes. However, anomalous conditions can occur due to variations in existing fill and the geologic conditions at the site, and it will be necessary to evaluate the assumed conditions during site grading and foundation installation.

3.1 GENERAL SITE GEOLOGY

Based upon review of the Oklahoma Geological Survey (OGS) *Geologic Map of the Mingo 7.5′ Quadrangle, Rogers, Tulsa, and Wagoner Counties, Oklahoma,* prepared by Thomas M. Stanley and Galen W. Miller (2006), the subject property is underlain by the Labette Formation. This formation is noted to consist of light olive gray to dusky yellow, medium light gray, laminated, very silty to sandy, micaceous, concretionary clayey shale.

The subsurface conditions encountered at the project site generally correlate with the referenced geologic map.

3.2 EXISTING SURFACE CONDITIONS

At the time of our subsurface exploration, most of the project site was covered with grass and sparse trees. The topsoil below the grass had a thickness of about 1 to 6 inches. The topsoil conditions reported apply only to the specific boring locations.

In areas of borings P-05 through P-07, the ground surface was covered with crushed aggregate with thickness ranging from about 2 to 3 inches.

The reported topsoil and aggregate thicknesses apply only to the specific boring locations and may vary in unexplored portions of the site. For this report, topsoil is defined as the soil horizon which contains the root mat of the noted vegetation. It should be noted that no testing has been performed to verify that soils meet the requirements of "topsoil". For this report, topsoil is defined as the soil horizon which contains the root mat of the noted vegetation.

3.3 SUBSURFACE CONDITIONS

A generalized stratification summary has been prepared using data from the test borings and is presented in the table below. The stratification depicts the general soil and rock conditions and stratum types encountered during our field investigation.

Stratum No.	Typical Thickness	Description	Consistency/ Rock Hardness	Lab Testing Data (5)
1 (1)	1.7 to 4.9'	**Fill Materials:** Lean Clays and Lean to Fat Clays (CL-CH), with roots, sand, sandstone fragments, wood, broken concrete fragments, , ferrous staining, and ferrous nodules, Various combinations and shades of brown, gray, yellow, and red	Stiff to very stiff	*Atterberg Limits:* *LL = 34 to 36* *PI = 13 to 18* *Percent Fines: 84%* *Moisture Contents: 11 to 20%*
2 (2)	7.2 to 17.6'	**Residuum:** Lean Clays (CL), Lean to Fat Clays (CL-CH), and some Fat Clays (CH). Sandy Lean Clays (CL), and Shaley Lean Clays (CL) with roots, sand, ferrous staining and nodules, and sandstone fragments Various combinations and shades of brown, gray, yellow, and red	Generally stiff to very stiff (3)	*Atterberg Limits:* *LL = 35 to 54* *PI = 16 to 32* *Percent Fines: 83 to 93%* *Moisture Contents: 10 to 25%*

Stratum No.	Typical Thickness	Description	Consistency/ Rock Hardness	Lab Testing Data (5)
3 (4)	Termination Layer	**Weathered Rock:** Clayey shale, Weathered shale, and Weathered Sandy Shale with ferrous staining Various combinations and shades of brown, yellow, olive, and gray	Soft rock unit	*Atterberg Limits:* *LL = 30 and 33* *PI = 6 and 13* *Moisture Contents:* *10 to 16%*

Table 3: Stratification Summary

Table 3 Notes:

1. Encountered only in borings B-09, P-02, P-03, P-04, P-08, P-09, and SB-03.
2. Borings B-04, B-08, B-09, B-10, P-01 through P-09 and SB-03 were terminated within this stratum.
3. Medium stiff clay soils were encountered in borings B-01, B-03, B-07, B-08, B-10, P-05, and SB-01. These lower consistency clay soils extended to depths of about 2 to 5 feet below current grades. In boring B-10, medium stiff clays extended to a depth of about 7 feet.
4. Encountered in borings B-01, B-02, B-03, B-05, B-06, B-07, SB-01, and SB-02. The referenced borings were terminated within this stratum at depths of about 13.9 to 19.9 ft below current grades.
5. For Atterberg Limits: LL = Liquid Limit, and PI = Plasticity Index

Subsurface profiles have been prepared based on the data obtained at specific boring locations. The subsurface profiles are presented in the Appendix. For specific details on the information obtained from individual borings, refer to the Boring Logs included in the Appendix. The ground surface elevations at the boring locations shown on the attached Boring Logs were estimated from the contour lines shown on the grading plan provided to our office and as such should be considered approximate.

3.3.1 GROUNDWATER

The table below presents a summary of groundwater conditions encountered in the some of the borings at the time of the subsurface exploration and prior to backfilling the boreholes.

Boring	Groundwater Depth During/After Drilling (ft)	Boring	Groundwater Depth During/After Drilling (ft)
B-01	Not encountered / 9.0	B-07	17.5 / 11.5
B-02	Not encountered / 11.0	B-08	16.5 / 14.5
B-06	17.0 / 8.5	---	---

Table 4: Groundwater Summary

Groundwater was not encountered in the other borings during drilling, and they were dry at completion of drilling operations and prior to backfilling.

The water levels reported are accurate only for the time and date that the borings were drilled. Long term monitoring of the boreholes was not included as part of our subsurface exploration. The borings were backfilled the same day that they were drilled.

3.4 SEISMIC SITE CLASSIFICATION

Basis of Evaluation	Recommended Site Classification
2018 International Building Code (IBC) and ASCE 7, Chapter 20	C
This recommended seismic site classification is based on the 2018 Edition of the International Building Code, the subsurface conditions encountered in the borings, and our knowledge of the geologic conditions of the site. Our subsurface exploration extended to a maximum depth of about 19.9 feet; hence the seismic site classification should be re-evaluated in the event subsurface information is made available to a depth of 100 feet.	

Table 5: Seismic Site Classification

4.0 SITE DEVELOPMENT CONSIDERATIONS

Review of the provided grading plan indicated that the existing grades within the proposed building area range between roughly 683 and 698 feet. We understand that consideration is being given to a finished floor elevation (FFE) of 693.25 feet for the planned building. Fill heights of up to 9 feet and cut depths of about 5 feet will be required to achieve design grades within the planned building area.

Within the planned pavement areas, fill heights of up to 7 feet and cut depths of approximately 10 feet will be required to achieve design grades.

If changes are made to the provided grading plan, Building & Earth should be allowed to review its effects on our recommendations.

Based on our evaluation of the subsurface conditions, and the given foundation loads, it appears that construction with a shallow foundation system is feasible. The site development recommendations outlined below are intended for development of the site to support construction with a shallow foundation system. ***If a different type of foundation system is preferred, Building & Earth should be allowed to review the site development recommendations to verify that they are appropriate for the preferred foundation system.***

The primary geotechnical considerations for this project are:

- In borings B-09, P-02, P-03, P-04, P-08, P-09, and SB-03, fill materials were encountered below the topsoil to depths of about 2.5 to 5 feet below current grades.
- Onsite fill materials and residual lean clay soils are moisture sensitive, prone to losing strength and stability with slight increase in soil moisture contents.
- Medium stiff clay soils were encountered in borings B-01, B-03, B-07, B-08, B-10, P-05, and SB-01. These lower consistency clay soils extended to depths of about 2 to 5 feet below current grades. In boring B-10, medium stiff clays extended to a depth of about 7 feet.
- Portions of the onsite residuum comprised of lean to fat clays (CL-CH) and fat clays (CH) that exhibited medium to high plasticity characteristics with a moderate to high shrink-swell potential.
- The potential for development of perched water at the interface of residual clays with underlying rock units.
- A weathered rock unit comprised of clayey shale, weathered shale, and weathered sandy shale was encountered in borings B-01, B-02, B-03, B-05, B-06, B-07, SB-01, and SB-02 at depths of approximately 7.5 to 18 feet below present grades.
- Groundwater seepage was encountered in borings B-06 through B-08 during drilling at depths of about 16.5 to 17.5 feet below existing grades. Free water was measured in borings B-01, B-02, and B-06 through B-08 at depths of about 8.5 to 14.5 feet, prior to backfilling the boreholes.

Recommendations addressing the site conditions are presented in the following sections.

4.1 INITIAL SITE PREPARATION

All trees, vegetation, roots, topsoil, aggregate base, and any other deleterious materials, should be removed from the proposed construction areas. Approximately 1 to 6 inches of topsoil and 2 to 3 inches of aggregate base was observed in the borings; however, topsoil and aggregate thicknesses could extend to greater depths in unexplored areas of the site.

Grubbing of trees should include removal of the tree stumps and the root systems. Desiccated clay soils may be present in the zone surrounding the trees. Desiccated clay soils should be undercut and replaced with structural fill.

Because of past use of the site, buried structures could be encountered such as remnants of foundations, utility lines, septic systems, subterranean drainage structures, etc. Where encountered, they should be removed and backfilled in accordance with requirements outlined in the *Structural Fill* section of this report.

The geotechnical engineer or their designated representative should observe grubbing, and stripping operations to evaluate that all unsuitable materials are removed from locations for proposed construction.

Materials disturbed during grubbing, and stripping operations should be stabilized in place or, if necessary, undercut to undisturbed materials and backfilled with properly compacted, approved structural fill.

During site preparation activities, the contractor should identify borrow source materials that will be used as structural fill and provide samples to the testing laboratory so that conformance to the structural fill requirements outlined below and appropriate moisture-density relationship curves can be determined.

4.2 DRAINAGE FEATURES AND LOW LYING AREAS

As previously mentioned, a shallow drainage ditch was noted along the south property boundary. Moist to wet, soft/loose soils are commonly present within and adjacent to drainage features and low lying areas.

The lateral extent and depth of soft/unstable and wet soils associated with the noted drainage features, and the low-lying areas of the site was not determined as part of the scope of work presented in this report. Site development concerns relating this material include the potential for groundwater seepage, wet soils, soft/loose soils, and unstable conditions.

4.3 GENERAL CONSIDERATIONS FOR GROUNDWATER INTERCEPTION

Per the grading plan, we understand that cut depths on the order of up to 10 feet will be required to achieve design grades within the north and northwest area of the planned construction. Based on conditions encountered in the borings, groundwater or perched water is likely to be encountered in areas of deep cuts.

In addition, the grading plan indicates that proposed grades on the north and west sides generally slope down towards the planned building and pavements. It should be noted that with grades sloping towards the proposed structures, there is a risk of surface water migration into the building and pavement areas, which could result in saturation and softening of subgrade soils.

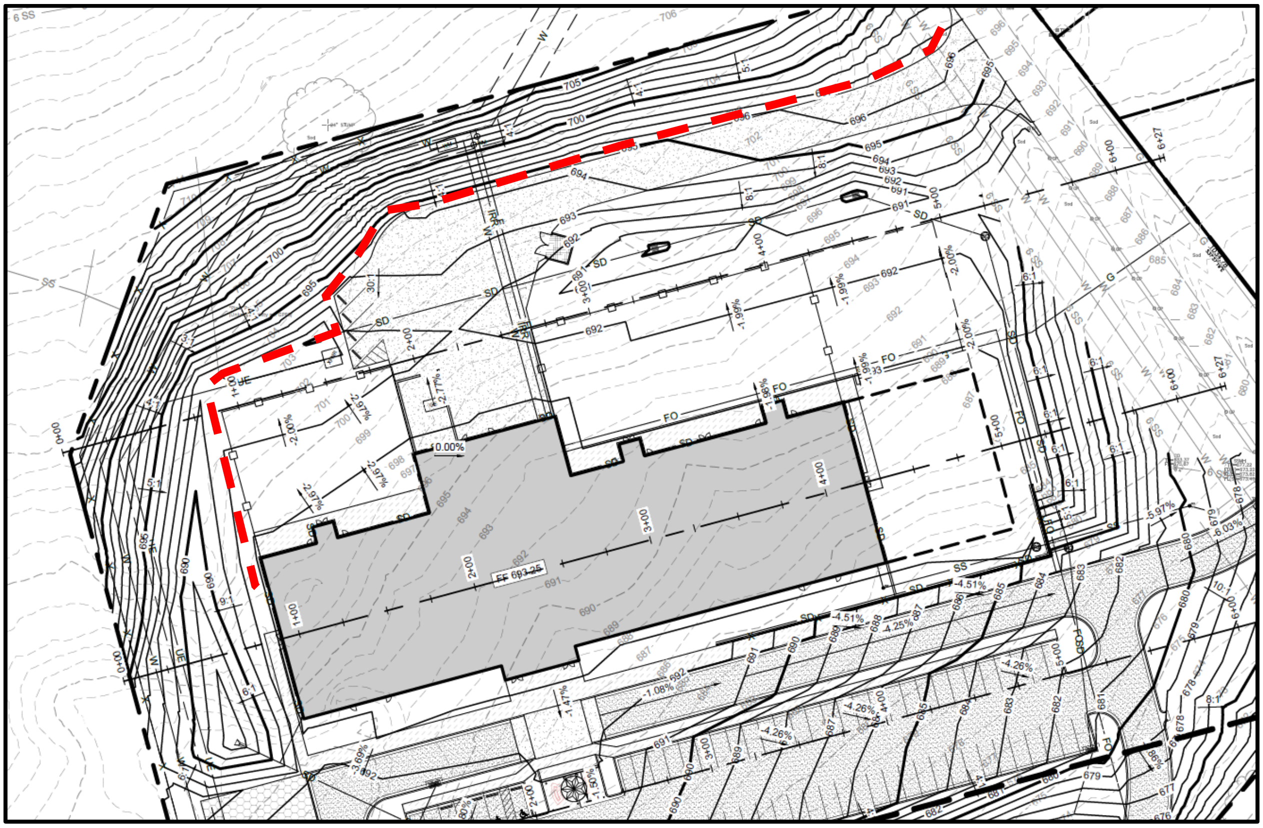


Figure 7: Approximate alignment of recommended open draining ditch/French drain

Prior to start of the construction, we recommend consideration be given to installation of an open drainage ditch or construct a French drain along the north side, between the toe of the planned slope and north access drive (see figure 7 for approximate alignment in red). The construction of an open drainage ditch or French drain is recommended to intercept water from uphill prior to infiltration into the building and pavement areas. The bottom of the open drainage ditch or French drain should extend into the top of weathered rock unit and it should be sloped such to allow for gravity flow to a suitable point of discharge. The civil engineer of record will need to be consulted to determine the alignment and profile.

4.4 MOISTURE SENSITIVE SOILS

Near-surface, moisture sensitive, lean clays were encountered across most of the site. These types of soil degrade when allowed to become wet. When saturated, these soils may not provide a stable platform for fill placement, and they may not be suitable for support of slabs-on-grade, foundations, and pavements. Therefore, not allowing water to pond by maintaining positive drainage and temporary dewatering methods (if required) is important to help avoid degradation and softening of the soils.

The contractor should anticipate some difficulty during the earthwork phase of this project if moisture levels are moderate to high during construction. Increased moisture levels will soften the subgrade and the soils may become unstable under the influence of construction traffic. Accordingly, construction during wet weather conditions should be avoided, as this could result in soft and unstable soil conditions that would require ground modification, such as in place stabilization or undercutting.

4.5 EVALUATION OF MEDIUM STIFF CLAY SOILS

The near-surface clay soils encountered in portions of the planned construction area exhibited medium stiff consistencies that extended to depths of about 2.5 to 5 feet. In boring B-10, located within a naturally low-lying area of the site, medium stiff clays extended to a depth of about 7 feet. Depending on the soil moisture contents at the time of construction, these low consistency soils may not be suitable for start of fill placement or provide adequate support for floor slabs, foundations, and pavements.

Following grading and prior to fill placement, all areas that will require fill or that will support structures should be carefully proofrolled with a fully loaded, tandem-axle dump truck (20- to 25-ton). A designated representative of the geotechnical engineer should observe the proofrolling process.

Areas passing the proofroll should be prepared in accordance with the *Subgrade Preparation and Evaluation* section of this report.

Areas with unstable or soft/loose soils should be marked in the field and further undercut to expose stiff and stable material. Where soft/unstable soils extend to depths greater than 2 feet below finished subgrade, consideration may be given to in-place stabilization by means of tracking surge stone (crushed stone with particle size ranging from 3 to 6 inches in dimension). Further detailed recommendations can be developed by the geotechnical engineer at the time of construction, dependent on the conditions encountered at that time.

4.6 EVALUATION OF FILL MATERIALS

In borings B-09, P-02, P-03, P-04, P-08, P-09, and SB-03, fill materials were encountered below the topsoil that extended to depths of about 2.5 to 5 feet below current grades. Some of the fill exhibited medium stiff consistencies and they included secondary constituents such as rock fragments, tree limbs, and broken concrete and brick.

Although encountered in only seven (7) of the twenty-two (22) borings, fill materials could be present in other unexplored areas of the proposed development.

There is a risk the existing fill contains soft zones, over-sized rock, large amounts of debris, organics, or otherwise unsuitable soils that could not be reasonably deduced from the widely spaced borings across the site.

As a minimum, we recommend that the geotechnical engineer or designated representative evaluate the fill by means of proofrolling with a heavy (20- to 25-ton), loaded tandem axle dump truck. Areas with unstable or soft/loose soils should be marked in the field. Additionally, test pits should be excavated within the delineated areas of concern to evaluate the condition of the existing fill below the exposed subgrade level.

Any soft/loose soils, organic materials, debris, over-sized rock, or any other unsuitable materials encountered in the fill should be removed full depth from construction areas and replaced with low plasticity *Structural Fill*.

4.7 BUILDING PAD PREPARATION

As previously mentioned in this report, we understand that fill heights of up to 9 feet and cut depths of about 5 feet will be required to achieve design grades within the planned building area. Based on the subsurface conditions encountered, following initial site preparation and grading, a combination of existing fill materials and residual soils are anticipated to be exposed within the planned building area.

The onsite clays generally exhibited medium to high plasticity characteristics. The potential vertical rise of the onsite soils encountered in the borings was evaluated using the Texas Department of Transportation’s test method TEX-124-E, Potential Vertical Rise (PVR). This method estimates the PVR of the soils based on the plasticity characteristics, thickness of the soil strata, and surcharge loads. For this project site, an active zone of 8 feet was used in the calculations. The TxDOT method estimates a PVR of 1¼ inches for the soil moisture contents encountered at the time of drilling. If the onsite soils are allowed to dry out, the PVR estimate could increase to 1½ inches.

A generally accepted practice is an allowance for a maximum vertical movement of 1-inch or less for grade supported slabs. **To reduce the PVR to ¾- to 1-inch, we recommend that floor slabs be supported on at least 24 inches of approved low plasticity structural fill.** In areas where more than 24 inches of structural fill is needed to achieve design grades, undercutting of onsite soils will not be required provided the exposed subgrade is in a firm and stable condition.

As a minimum, following grading and above recommended undercutting, the exposed fill materials and medium stiff clays should be evaluated in accordance with the *Evaluation of Medium Stiff Clays* and *Evaluation of Fill Materials* sections of this report.

All undercutting should extend at least 5 feet outside the perimeter building lines and the appurtenances. The base stone recommended to be placed below the floor slab (reference the *Floor Slab* section of this report) should not be considered part of the recommended low plasticity structural fill section.

4.8 PAVEMENT SUBGRADE PREPARATION

The grading plan provided to our office indicated that fill heights of up to 7 feet and cut depths of approximately 10 feet will be required to achieve design grades within the planned pavement areas.

Following initial site preparation and grading, a combination of existing fill materials, residual clays, and weathered shale unit are anticipated to be exposed within the planned pavement areas.

The onsite soils have a moderate to high shrink-swell potential, that could cause uneven surfaces of pavements and development of tension cracks in pavements when soil moisture contents change post construction. Also, a weathered shale unit is anticipated to be exposed in the deep cut areas within the north portion of the project area.

To provide for uniform subgrade conditions, we recommend undercutting to a level that will allow placement of at least 10 inches of imported low plasticity structural fill in all paving areas and preparing the subgrade prior to structural fill placement in accordance with the following *Subgrade Preparation and Evaluation* section.

In areas where more than 10 inches of structural fill is needed to achieve design grades, undercutting of onsite soils will not be required provided the exposed subgrade is in a firm and stable condition. Prior to the start of fill placement, the exposed fill materials and medium stiff clays should be evaluated in accordance with *Evaluation of Medium Stiff Clays* and *Evaluation of Fill Materials* sections of this report.

4.9 SUBGRADE PREPARATION AND EVALUATION

Prior to fill placement, the exposed subgrade should be scarified, moisture conditioned, and recompacted to a minimum depth of 12 inches. The subgrade soils should be moisture conditioned within a range of 1 percent below to 3 percent above the material's optimum moisture content, and the subgrade soils recompacted to at least 98 percent of the material's standard Proctor maximum dry density (ASTM D698).

Weather conditions at the time of construction will affect subgrade stability and undercutting depths and quantities. We recommend that the project geotechnical engineer or a qualified representative evaluate the subgrade after the site is prepared. Some unstable areas may be present in unexplored areas of the site. All areas that will require fill or that will support structures should be carefully proofrolled with a fully loaded, tandem-axle dump truck (20- to 25-ton), at the following times.

- After an area has been stripped and undercut if required, prior to the placement of any fill.
- After grading an area to the finished subgrade elevation in a building or pavement area.
- After areas have been exposed to any precipitation, and/or have been exposed for more than 48 hours.

Some instability may exist during construction, depending on climatic and other factors immediately preceding and during construction. If any soft or otherwise unsuitable soils are identified during the proofrolling process, they should be undercut or stabilized prior to fill placement, pavement construction, or floor slab construction. All unsuitable material identified during construction should be removed and replaced in accordance with the *Structural Fill* section of this report.

4.10 STRUCTURAL FILL

Requirements for structural fill on this project are as follows:

Soil Type	USCS Classification	Property Requirements	Placement Location
Imported Lean Clay, Clayey Sand or Shale	CL, SC	LL<40, 7<PI≤18, γ_d>100 pcf, P200>30%, Maximum 3" particle size in any dimension, CBR ≥4.0 for pavements	**Low Plasticity Structural Fill** to be used for construction of building pad and pavements
Onsite Fill Materials and Residuum Lean Clays, Lean to Fat Clays, and Fat Clays	CL, CL-CH, CH	Not Applicable	**Not Suitable** for use as structural fill due to higher plasticity characteristics (see Note 4)
Onsite Weathered (Sandy) Shale and Clayey Shale	Not Applicable	Same as recommended for imported structural fill	**Likely Suitable** for use as low plasticity structural fill in building and pavement areas

Table 6: Structural Fill Requirements

Notes:

1. All structural fill should be free of vegetation, topsoil, and any other deleterious materials. The organic content of materials to be used for fill should be less than 3 percent.
2. LL indicates the soil Liquid Limit; PI indicates the soil Plasticity Index; γ_d indicates the maximum dry density as defined by the density standard outlined in the table below.
3. Laboratory testing of the materials proposed for fill should be performed to verify their conformance with the above recommendations. Any fill to be placed at the site should be reviewed and approved by the geotechnical engineer.
4. Although some of the lean clay soils appear to have plasticity characteristics that meet the recommendations for use a low plasticity structural fill, most of the clay soils had LL and PI values that exceeded the recommended upper limits for use as structural fill. Since it will be difficult to differentiate suitable from unsuitable material, the use of onsite clay soils as low plasticity structural fill is not recommended. Consideration may be given to using the onsite clays as structural fill, provided they are placed at levels of at least 4 feet and 1 foot below finished subgrade level in building and pavement areas, respectively.

Placement requirements for structural fill are as follows:

Specification	Requirement
Lift Thickness	Maximum loose lift thickness of 8 to 12 inches, depending on type of compaction equipment used.
Density	At least 98% of the standard Proctor (ASTM D698) maximum density.
Moisture	**Structural Fill:** 2% below to 2% above the optimum moisture content as determined by ASTM D698 **Onsite Clay Soils:** 1% below to 3% above the optimum moisture content as determined by ASTM D698
Density Testing Frequency	**Building and foundation areas**: One test per 2,500 square feet (SF) per lift with a minimum of three tests performed per lift **Pavement areas**: One test per 5,000 SF per lift with a minimum of three test per lift **Utility trenches**: One test per 150 linear feet per lift with a minimum of two tests performed per lift The testing frequency can be increased or decreased by the Geotechnical Engineer of Record in the field based on uniformity of material being placed and compactive effort used.

Table 7: Structural Fill Placement Requirement

4.10.1 CHEMICAL STABILIZATION

In lieu of importing lower plasticity structural fill for preparation of the proposed building pad and pavement subgrades, consideration can be given to chemically stabilizing the onsite materials to reduce the plasticity index to less than 15. Following the Soil Stabilization Mix Design Procedure OHDL-50 developed by the Oklahoma Department of Transportation (ODOT), dated April 15, 2022, the onsite soils can be chemically stabilized using quick lime or hydrated lime. The following table presents estimated quantities of the recommended chemical additives based on soil dry weight.

Lime Stabilizing Agent	ODOT Specification [1]	Estimated Quantity of Stabilizing Agent, % of Soil Dry Weight
Quick Lime	307 & 706.02	5
Hydrated Lime	307 & 706.01	6

Table 8: Chemical Stabilization Alternates

Notes:

1. ODOT – Oklahoma Department of Transportation, 2019 edition

Cement kiln dust (CKD) with high free lime content from pre-calciner plants, lime kiln dust (LKD), and carbide lime have also been successfully used with higher plasticity clay soils to reduce their plasticity and shrink-swell potential to within acceptable level. However, these types of chemical additive are by products and their composition varies depending on the source from which they are provided.

Further laboratory testing is recommended to estimate needed concentrations for these types of chemical additive when considered for this project. Building & Earth can assist with this service prior to the start of construction.

Chemical stabilization of the onsite materials should be performed in accordance with the applicable specifications of the Oklahoma Standard Specifications for Highway Construction, 2019 edition.

4.11 BENCHING OF EXISTING SLOPES

Existing slopes within the project site steeper than 5 horizontal to 1 vertical, 5(H): 1(V), and located in fill areas should be benched prior to fill placement. Benching of the slopes provides interlocking between the new fill and on-site materials and facilitates compaction of the fill. Benches should be cut as the fill placement progresses and should have a maximum bench height of 2 to 3 feet.

4.12 FILL SLOPES

For this report, we anticipate fill up to about 10 feet may be needed to achieve design grades at the east and south ends of the proposed building and pavement areas. Fill slopes will range from about 4(H):1(V) to 6(H):1(V).

Systematic fill placement and compaction is essential for satisfactory performance of fill slopes. In addition, for proper placement and compaction, the contractor should accurately locate the toe and crest of the slopes prior to fill placement and maintain an accurate field survey during construction to verify that the slopes are being constructed to the planned configurations.

Even if properly constructed, fill embankments tend to “creep” over time. Creep is the gradual, downward movement of soils near the slope face. The movement can lead to distress in structures supported on the fill. Therefore, pavements and buildings should be set back a minimum distance of 5 and 15 feet from the crest of fill embankments, respectively, or greater if a greater offset distance is required by the International Building Code (IBC).

The long-term stability of fill embankments is dependent on a stable subgrade. Embankments constructed over low-consistency material are susceptible to settlement and slope failure. Therefore, low-strength soils should be removed from beneath the embankment and a minimum of 10 feet beyond the toe of the embankment. Excavations should be backfilled with compacted and tested engineered fill. Building & Earth should verify that the underlying, subgrade soils within the area of influence of the slope exhibit a high consistency prior to embankment construction. All material used to construct the fill embankment should conform to the project requirements for engineered fill. Unsuitable materials (organics, debris, wet or soft soil) should not be placed in embankments. On-site soils must be carefully monitored during construction to ensure only high strength engineered fill is used to construct embankments.

Fill should be placed in thin, horizontal lifts and compacted and tested in accordance with the project requirements. Due to the difficulty in compacting soils on the face of the slope, fill embankments should be overbuilt and cut back to the desired configuration upon completion. In no case should the slope be constructed or reconfigured by pushing soil over the top edge of the slope. Careful control by the contractor during construction is important to ensure that no part of the slope exceeds the design inclination. The fill should be benched into the natural soils to prevent the formation of weak zones.

4.13 EXCAVATION CONSIDERATIONS

Excavations extending to depths greater than 4 feet should be cut to a stable slope or be temporarily braced. Temporary slopes should be constructed in strict compliance with current OSHA excavation regulations.

4.13.1 DIFFICULT EXCAVATION

A weathered rock unit comprised of clayey shale, weathered shale, and weathered sandy shale was encountered in borings B-01, B-02, B-03, B-05, B-06, B-07, SB-01, and SB-02 at depths of approximately 7.5 to 18 feet below present grades.

A large track hoe, in good working condition and equipped with rock teeth likely will be required for excavations extending into the weathered rock unit. Excavation difficulty will increase with increasing depth into the shale unit, possibly requiring the use of a hydraulic hoe ram attachment.

The depth that rock can be excavated is a function of the material, the equipment used, the skill of the operator, the desired rate of removal and other factors. The contractor should review the boring logs and should use his own method to evaluate excavation difficulty.

4.13.2 GROUNDWATER OR PERCHED WATER

Groundwater seepage was encountered in borings B-06 through B-08 during drilling at depths of about 16.5 to 17.5 feet below existing grades. Free water was measured in borings B-01, B-02, and B-06 through B-08 at depths of about 8.5 to 14.5 feet, prior to backfilling the boreholes.

The site is also prone to developing perched water within the residual clays near the contact with underlying rock units.

The recommendations presented in *the General Considerations for Groundwater Interception* section of this report should be considered to intercept water from uphill prior to infiltration into the building and pavement areas.

4.14 UTILITY TRENCH BACKFILL

All utility trenches should be backfilled and compacted in the manner specified above for structural fill. It may be necessary to reduce the lift thickness to 4 to 6 inches to achieve compaction using hand-operated equipment.

At the perimeter wall crossings, we recommend that clay soils or a flowable fill be used to backfill the utility trench. The clay or flowable fill will act as a relatively impermeable plug reducing the risk of water migration from the outside into the interior of the building. The plug should be at least 36 inches wide and should extend below the perimeter walls to provide for a proper seal.

4.15 LANDSCAPING AND DRAINAGE CONSIDERATION

The potential for soil moisture fluctuations within structure areas and pavement subgrades should be reduced to lessen the potential of subgrade movement. Site grading should include positive drainage away from buildings and pavements. Excessive irrigation of landscaping poses a risk of saturating and softening soils below shallow footings and pavements, which could result in settlement of footings and premature failure of pavements. In addition, ponding of water or irrigation of landscaped areas can result in swelling of higher plasticity clay soils and subsequent heave of grade supported slabs and lightly loaded footings.

4.16 WET WEATHER CONSTRUCTION

Excessive movement of construction equipment across the site during wet weather may result in ruts, which will collect rainwater, prolonging the time required to dry the subgrade soils. During rainy periods, additional effort will be required to properly prepare the site and establish/maintain an acceptable subgrade. The difficulty will increase in areas where clay or silty soils are exposed at the subgrade elevation.

Likewise, rainwater may become perched on clay soils, which could require additional dewatering efforts not needed during dry conditions.

A perched-water condition occurs when water seeping downward is slowed by a low permeability soil layer, such as the underlying clays. The perched-water level can be any number of feet above the true groundwater level. Due to the prevalence of clay soils encountered across the project site, the successful contractor should expect to encounter perched water during wet weather construction.

Grading contractors typically postpone grading operations during wet weather to wait for conditions that are more favorable. Contractors can typically disk or aerate the upper soils to promote drying during intermittent periods of favorable weather. When deadlines restrict postponement of grading operations, additional measures such as undercutting and replacing saturated soils or stabilization can be utilized to facilitate placement of additional fill material.

5.0 FOUNDATION RECOMMENDATIONS

Based on information provided to our office, we understand that the individual column loads will be on the order of 50 to 75 kips, and wall loads will be 2 to 3 kips per linear foot. ***If changes are made to the provided preliminary loads, our office should be contacted, such that our recommendations can be reviewed and revised if needed.***

5.1 PROPOSED BUILDING AND OUTDOOR CLASSROOM

Based on the conditions encountered during our field investigation, and after our site preparation recommendations are implemented, the proposed structures can be supported on conventional shallow foundations.

Following grading and based on the subsurface conditions encountered, we anticipate that a combination of properly compacted and approved low plasticity structural fill, residual clay soils, and weathered shale will be exposed at footing bearing elevations within the proposed building and outdoor classroom areas.

Footings founded in a combination of residual clays, new structural fill, and weathered shale can be designed using a maximum net allowable bearing capacity of 2,500 psf.

With anticipated fill heights on the order of up to 9 feet within the proposed building areas, proper placement and compaction of fill is crucial to reduce the risk of foundation settlement. We recommend that the fill placed within the proposed building and pavement areas be monitored on a continuous basis by a representative of Building & Earth. The thickness, material type, compaction, and moisture content of each lift should be determined.

Total settlement of footings bearing in weathered rock or stiff residuum that is underlain by weathered rock at shallow depth is estimated to be ½-inch or less. Total long-term settlement of footings in the deep fill areas could potentially approach 1-inch. In general, differential settlement of footings is estimated at ½-inch over a distance of 40 feet; however, in areas transitioning from weathered rock to deep fill, differential settlement could be on the order of ½-inch over a shorter distance than 40 feet.

Column footings should be at least 24 inches wide and strip footings should be at least 18 inches wide. These dimensions facilitate hand cleaning of footing subgrades disturbed by the excavation process and the placement of reinforcing steel. They also reduce the potential for localized punching shear failure.

5.1.1 UPLIFT AND SHEAR RESISTANCE

Uplift resistance of spread footings can be developed from the weight of the foundation, the effective weight of the overlying soils, and from the effective weight of the structure itself. Soil uplift resistance may be calculated as the weight of the soil prism defined by a diagonal line extending around the perimeter of the foundation, from the top of the foundation to the ground surface at an angle of 25 degrees from the vertical (Figure 8).

The maximum uplift capacity should be taken as the sum of the weight of the soil, plus the weight of the foundation, divided by an appropriate factor of safety. A total unit weight of 110 pounds per cubic foot (pcf) can be used for well-compacted structural fill that has been placed over the foundation.

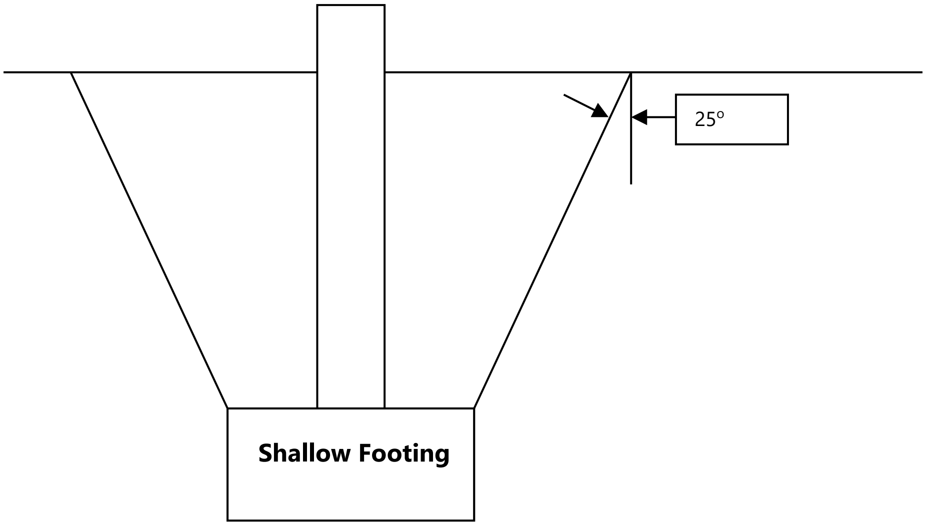


Figure 8: Soil uplift resistance sketch

Passive earth pressures of materials adjacent to the footings as well as bearing material friction at the base may be used to resist shear. The following table presents recommended friction coefficient and passive earth pressure values for the anticipated bearing materials. The structural engineer should use a factor of safety of at least 1.5 when sizing the foundations to resist shear loads using the below ultimate soil parameter values.

Material	Friction Coefficient	Equivalent Fluid Unit Weight for Passive Condition Lateral Earth Pressures (pcf)
Residuum, Structural Fill, and Weathered Shale	0.35	275

Table 9: Soil Parameter Values Resisting Shear

5.2 PROPOSED RETAINING WALLS

As mentioned previously, we understand that a new retaining wall with height up to 13 feet will be part of the new construction (southeast of the existing building). We assume the new retaining walls will be supported on shallow footings.

Per the provided grading information, we anticipate new fill on the order of 6 to 13 feet along the planned retaining wall alignment. Based on subsurface conditions encountered in borings B-10 and P-03, we anticipate stiff existing fill materials, and medium stiff to stiff residual clays to be present below the new structural fill zone.

Per the provided Grading Sections, Sheet No. C503, prepared by Wallace Design Collective, dated February 9, 2024, all retaining wall footings will be supported on at least 24 inches of new structural fill.

Provided that footings are bearing on at least 24 inches of new structural fill, a maximum net allowable bearing pressure of 2,000 psf can used in design of the retaining wall footings.

All footings should bear at least 24 inches below the adjacent exterior grade and the edge of footing facing the slope must be at least one footing width behind the face of the slope at bearing level, as shown in the figure below.

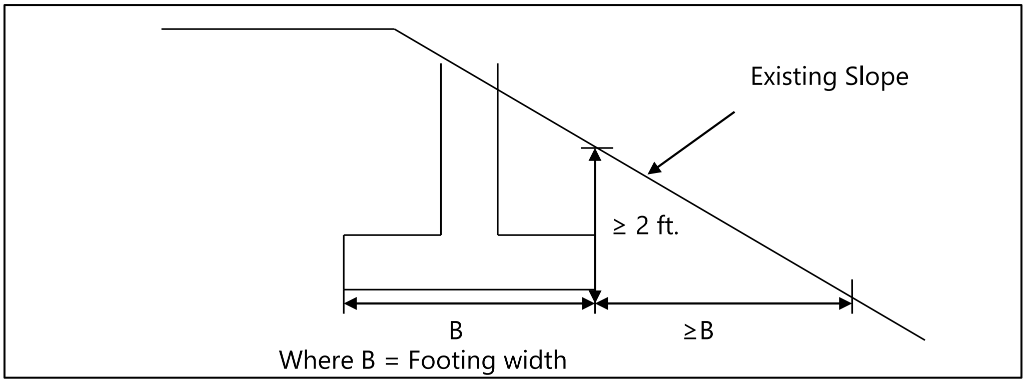


Figure 9: Recommendations for footing on slope

5.3 GENERAL CONSIDERATIONS

Due to the presence of existing fill and medium stiff clays in portions of the structure areas, a thorough evaluation of bearing materials exposed in the bottom of footing excavations is recommended. Evaluation of the bearing materials should include hand auger borings and dynamic cone penetration (DCP) testing to a level at least one (1) footing width below design bearing elevation. DCP testing will aid with verification of the in-place allowable bearing capacity of the bearing materials at the time of construction.

Materials that do not meet the recommended bearing capacity should be delineated and undercut to suitable material and replaced with approved structural fill. Lateral over-excavation of unsuitable soils should extend 8 inches beyond the edges of the footing for each foot of undercut depth below design bearing elevation. The footings should then be brought back up to design bearing elevation with properly compacted and approved *Structural Fill* (placed in loose lifts of no more than 6 inches thick and compacted to at least 95 percent of the standard Proctor maximum dry density) or controlled low-strength material (CLSM, Section 701.19 of Oklahoma Department of Transportation Standard Specifications, 2019).

The following items should be considered during the preparation of construction documents and foundation installation:

- The geotechnical engineer of record should observe the exposed foundation bearing surfaces prior to concrete placement to verify that the conditions anticipated during the subsurface exploration are encountered.
- All bearing surfaces must be free of soft or loose soil and debris prior to placing concrete.
- The bottom surface of all footings should be level.
- Concrete should be placed the same day the excavations are completed and bearing materials verified by the engineer. If the excavations are left open for an extended period, or if the bearing surfaces are disturbed after the initial observation, then the bearing surfaces should be re-evaluated prior to concrete placement.
- Water should not be allowed to pond in foundation excavations prior to concrete placement or above the concrete after the foundation is completed.
- Wherever possible, the foundation concrete should be placed "neat," using the sides of the excavations as forms. Where this is not possible, the excavations created by forming the foundations must be backfilled with suitable structural fill and properly compacted.
- Grades around the building pad should be sloped to drain away from the building foundations.
- Roof drains should be routed away from the foundation soils.

6.0 PERIMETER FOUNDATION AND UNDER-SLAB DRAINS

Perched water was encountered in the residuum near the contact with the weathered rock units. Grading plans indicate that finished grades within the building area may expose the weathered rock units or it will be slightly above the weathered rock units. Perched water seepage could potentially occur near finished subgrade level within the building area.

Consideration should be given to the installation of building perimeter foundation drains. Subdrains should consist of 4-inch diameter, high density polyethylene (HDPE) perforated pipe and should be surrounded by at least 6 inches of No. 57 stone and wrapped with a suitable geotextile filter fabric, such as Mirafi 140N or equivalent. The bottom of the pipe should be placed at least 6 inches below the bottom of the footings. The drain system should allow for gravity flow of water to a suitable point of discharge or to a sump pump.

We also recommend that consideration be given to the installation of an under-slab drainage system. Lateral drains should be located beneath the floor slabs. All subdrains should consist of 4-inch diameter, high density polyethylene (HDPE) perforated pipe and should be embedded in ASTM C33 No. 57 stone with thicknesses of 3 inches below the bottom and above the top of the pipe and wrapped with a suitable geotextile filter fabric consisting of Mirafi 140N or equivalent. The total thickness of the open graded, free draining layer of No. 57 stone should be at least 10 inches.

The lateral drains should be spaced no more than 25 feet on center. A slope of at least ½ percent should be maintained to promote gravity flow to sump pits where any collected water can be pumped to a suitable point of discharge, such as a storm sewer, or other suitable outfall for removal of groundwater.

The structural and civil engineer of records should be consulted, and construction documents should include plans, profiles, and details related to the recommended foundation perimeter and under-slab drains.

7.0 FLOOR SLABS

Site development recommendations presented in this report should be followed to provide for subgrade conditions suitable for support of grade supported slabs. Floor slabs will be supported on at least 24 inches of new lower plasticity structural fill.

Floor slabs should be supported on a layer of ½-inch up to 1½-inch, free-draining, gap-graded gravel, such as No. 57 stone, with no more than 5 percent passing the ASTM No. 200 sieve. When incorporating an under-slab drain system into the floor slab design, the layer of free draining stone should have a thickness of at least 4 inches outside the trench drain alignments and at least 10 inches within the trenches of the perforated drain lines.

The open graded stone should be consolidated in-place with vibratory equipment. The surface of these bases should be choked off with finer material. A clean fine-graded material with at least 10 to 30 percent of particles passing a No. 100 sieve but not contaminated with clay, silt or organic material is recommended.

We recommend a minimum 10-mil thick vapor retarder meeting ASTM E 1745, Class C requirements be placed directly below the slab-on-grade floors. A higher quality vapor retarder (Class A or B) may be used if desired to further inhibit the migration of moisture through the slab-on-grade and should be evaluated based on the floor covering and use. The vapor retarder should extend to the edge of the slab-on-grade floors and should be sealed at all seams and penetrations.

An effective modulus of subgrade of 150 pci can be used for slabs supported on the recommended base stone. The slab should be appropriately reinforced (if required) to support anticipated floor loads.

8.0 RETAINING WALLS

We anticipate retaining walls will retain new structural fill. We understand that retaining walls will have retained heights of 6 to 13 feet to accommodate planned grade changes. We recommended that all walls be backfilled with properly compacted and approved lower plasticity structural fill in accordance with the *Structural Fill* section of this report.

The following drained equivalent fluid pressures should be used to design the proposed walls. We recommend that a drainage blanket of ASTM No. 57 stone (chimney drain), with a minimum width of 18 inches be placed behind all walls. The clean stone should be wrapped in filter fabric to minimize intrusion of fines. A perforated drain line should be installed at the base of the wall and should extend to a sump where water can be collected and removed, or drains should discharge by gravity flow to a suitable outfall.

Retained Material	Soil Parameter Values		Equivalent Fluid Unit Weights for Active & At-Rest Lateral Earth Pressures (pcf)	
	Wet Unit Weight (pcf)	Effective Angle of Internal Friction	At-Rest Condition	Active Condition
Structural Fill	125	28°	66	45

Table 10: Soil Parameters and Lateral Earth Pressure Values (Drained Conditions)

Lateral pressures arising from surcharge loading should be added to the above earth pressures to determine the total lateral pressures. In addition, transient loads imposed on the retaining walls by construction equipment during backfilling should be taken into consideration. Excessively heavy grading equipment (that could impose temporary excessive lateral pressures) should not be allowed within 5 feet (horizontally) of the walls.

The above soil parameter and lateral earth pressure values assume the following:

- The wall backfill will be horizontal.
- Any backfill will be compacted to 98 percent of standard Proctor maximum dry density.
- No safety factor is included. The design of the stem walls should include a factor of safety of at least 1.5 against sliding and overturning using the above recommended values.

- Any surcharge is uniform.
- Wall friction is negligible.

9.0 PAVEMENT CONSIDERATIONS

Specific traffic information was not provided. For pavement design purposes, we have assumed two levels of traffic shown on the table below, for commonly used pavement sections. If the pavement were a typical roadway, according to the "AASHTO Guide for Design of Pavement Structures, 1993", these pavement sections would be adequate for the following assumed ESAL capacities:

Type	Assumed Equivalent Single Axle Loads (ESAL)
Standard Duty Parking Stalls for Passenger Vehicles	115,000
Heavy Duty Drives for Passenger Vehicles and Occasional Light Box Trucks and Trash Collection Trucks	300,000

Table 11: Assumed ESAL Capacities

In addition, we have assumed the following design parameters:

Design Criteria	Value
Design life (Years)	20
Terminal Serviceability	2.0
Reliability	85%
Initial Serviceability	4.2 (Flexible) 4.5 (Rigid)
Standard Deviation	0.45 (Flexible) 0.35 (Rigid)

Table 12: Assumed Design Parameters

All subgrade, base and pavement construction operations should meet minimum requirements of the Oklahoma Department of Transportation (ODOT), Standard Specifications for Highway Construction, dated 2019. The applicable sections of the specifications are identified as follows:

Material	Specification Section
Portland Cement Concrete Pavement	414 & 701
Bituminous Asphalt Wearing Layer	411 & 708
Bituminous Asphalt Binder Layer	411 & 708
Mineral Aggregate Base Materials	303 & 703

Table 13: ODOT Specification Sections

9.1 FLEXIBLE PAVEMENT

The asphalt pavement sections described herein were designed using the "AASHTO Guide for Design of Pavement Structures, 1993". Alternative pavement sections were designed by establishing the structural numbers used for the AASHTO design system and substituting materials based upon structural equivalency as follows:

Material	Structural No.
Asphalt Concrete	0.44
Crushed Stone Base	0.14
Approved Structural Fill	0.02

Table 14: Structural Equivalent Coefficient

Based on the materials encountered at the boring locations and after our recommendations for site preparation are implemented, flexible pavements at the subject site may be designed based on an estimated California Bearing Ratio (CBR) of 3. The following flexible pavement sections are based on the design parameters presented above:

Minimum Recommended Thickness (in)		Material
Standard Duty	Heavy Duty	
1.5	2.0	HMAC Surface Course (Superpave "S4")
2.5	3.0	HMAC Binder Course (Superpave "S3")
6.0	6.0	Crushed Aggregate Base (ODOT Type "A")
10.0	10.0	Approved Structural Fill (CBR ≥4.0)

Table 15: Asphalt Pavement Recommendations

In accordance with the ODOT specifications, asphaltic concrete should be compacted within 92 to 97 percent of the theoretical maximum specific gravity of the asphaltic concrete mix. The underlying aggregate base course should be compacted to at least 98 percent of the material's standard Proctor maximum dry density with a moisture content range of ± 2 percent of the optimum moisture content at the time of placement.

9.2 RIGID PAVEMENT

The following rigid pavement sections are based on the design parameters presented above. We assume a modulus of subgrade reaction (k) of 100 pci. We have assumed concrete elastic modulus (E_c) of 3.1 X 10^6 psi, and a concrete modulus of rupture (S'_c) of 600 psi.

Minimum Recommended Thickness (in)		Material
Standard Duty	Heavy Duty	
5.0	6.0	Portland Cement Concrete, f'_c=3,500 psi
4.0	4.0	Crushed Aggregate Base (ODOT Type "A")
10.0	10.0	Approved Structural Fill (CBR ≥4.0)

Table 16: Rigid Pavement Recommendations

For access drive approaches, trash compactor pads, loading areas, and other pavement areas that are frequently subject to high traffic loads with frequent braking and turning of wheels, consideration should be given to using a reinforced rigid pavement section comprised of seven (7) inches of Portland cement concrete and 6 inches ODOT Type "A" crushed aggregate base course.

The recommended aggregate base course will serve as a leveling course, improve the subgrade support properties, and reduce the risk of pumping of fine-grained subgrade soils through the joints.

The concrete should be protected against moisture loss, rapid temperature fluctuations, and construction traffic for several days after placement. All pavements should be sloped for positive drainage. We suggest that a curing compound be applied after the concrete has been finished.

For rigid pavements, we recommend a jointing plan be developed to control cracking and help preclude surficial migration of water into the base course and subgrade. If a jointing plan includes a widely spaced pattern (spacing typically greater than 30 times the slab thickness), consideration should be given to include steel reinforcement in rigid pavements, per Section 3.4 of the American Association of State Highway and Transportation Officials (AASHTO) Guide for Design of Pavement Structures 1993, and Section 3.8 of the American Concrete Institute (ACI) Guide for the Design and Construction of Concrete Parking Lots. Additionally, we recommend the joints be sealed to further preclude surficial moisture migration into the underlying supporting soils.

Although not referenced in the ODOT specifications, based on our experience with project sites in this region and anticipated traffic loads, we recommend Portland cement concrete should have a minimum 28-day compressive strength of 3,500 psi, maximum slump of 4 inches, and air content of 5 to 7 percent.

9.3 GENERAL PAVEMENT DESIGN CONSIDERATIONS

With the use of aggregate base course, the aggregate should have uniform thickness and the subgrade graded such as to provide positive drainage from the granular base. The aggregate base section should grade toward a storm sewer or drainage ditch to provide drainage from the aggregate base.

Pavements should be sloped, approximately ¼ inch per foot, to provide rapid surface drainage. Water allowed to pond on or adjacent to the pavement could saturate the subgrade and cause premature deterioration of the pavements due to loss of strength and stability.

Periodic maintenance of the pavement should be anticipated. This should include sealing of cracks and joints and maintaining proper surface drainage to avoid ponding water on or near the pavement areas.

10.0 SUBGRADE REHABILITATION

The subgrade soils often become disturbed during the period between initial site grading and construction of surface improvements. The amount and depth of disturbance will vary with soil type, weather conditions, construction traffic, and drainage.

The engineer should evaluate the subgrade soil during final grading to verify that the subgrade is suitable to receive pavement and/or concrete slab base materials. The final evaluation may include proofrolling or density tests.

Subgrade rehabilitation can become a point of controversy when different contractors are responsible for site grading and building construction. The construction documents should specifically state which contractor will be responsible for maintaining and rehabilitating the subgrade. Rehabilitation may include moisture conditioning and re-compacting soils. When deadlines or weather restrict grading operations, additional measures such as undercutting and replacing saturated soils or chemical stabilization can often be utilized.

11.0 CONSTRUCTION MONITORING

Field verification of site conditions is an essential part of the services provided by the geotechnical consultant. To confirm our recommendations, it will be necessary for Building & Earth personnel to make periodic visits to the site during site grading. Typical construction monitoring services are listed below.

- Periodic observations and consultations by a member of our engineering staff during site grading
- Field density tests during structural fill placement on a continuous basis
- Observation and verification of the bearing surfaces exposed after foundation excavation
- Reinforcing steel inspections
- Molding and testing of concrete cylinders
- Structural steel inspections, including field welded and bolted connections
- Continuous monitoring and testing during pavement installation

12.0 CLOSING AND LIMITATIONS

This report was prepared for Blue River Architects for specific application to the subject project located in Catoosa, Oklahoma. The information in this report is not transferable. This report should not be used for a different development on the same property without first being evaluated by the engineer.

The recommendations in this report were based on the information obtained from our field exploration and laboratory analysis. The data collected is representative of the locations tested. Variations are likely to occur at other locations throughout the site. Engineering judgment was applied regarding conditions between borings. It will be necessary to confirm the anticipated subsurface conditions during construction.

This report has been prepared in accordance with generally accepted standards of geotechnical engineering practice. No other warranty is expressed or implied. If changes are made, or anticipated to be made, to the nature, design, or location of the project as outlined in this report, Building & Earth must be informed of the changes and given the opportunity to either verify or modify the conclusions of this report in writing, or the recommendations of this report will no longer be valid.

The scope of services for this project did not include any environmental assessment of the site or identification of pollutants or hazardous materials or conditions. If the owner is concerned about environmental issues Building & Earth would be happy to provide an additional scope of services to address those concerns.

This report is intended for use during design and preparation of specifications and may not address all conditions at the site during construction. Contractors reviewing this information should acknowledge that this document is for design information only.

An article published by the Geoprofessional Business Association (GBA), titled *Important Information About Your Geotechnical Report*, has been included in the Appendix. We encourage all individuals to become familiar with the article to help manage risk.

Appendix Table of Contents

GEOTECHNICAL INVESTIGATION METHODOLOGIES

The subsurface exploration, which is the basis of the recommendations of this report, has been performed in accordance with industry standards. Detailed methodologies employed in the investigation are presented in the following sections.

DRILLING PROCEDURES – STANDARD PENETRATION TEST (ASTM D1586)

At each boring location, soil samples were obtained at standard sampling intervals with a split-spoon sampler. The borehole was first advanced to the sample depth by augering and the sampling tools were placed in the open hole. The sampler was then driven 18 inches into the ground with a 140-pound automatic hammer free-falling 30 inches. The number of blows required to drive the sampler each 6-inch increment was recorded. The initial increment is considered the "seating" blows, where the sampler penetrates loose or disturbed soil in the bottom of the borehole.

The blows required to penetrate the final two (2) increments are added together and are referred to as the Standard Penetration Test (SPT) N-value. The N-value, when properly evaluated, gives an indication of the soil's strength and ability to support structural loads. Many factors can affect the SPT N-value, so this result cannot be used exclusively to evaluate soil conditions.

The SPT testing was performed using a drill rig equipped with an automatic hammer. Automatic hammers mechanically control the height of the hammer drop, and doing so, deliver higher energy efficiency (90 to 99 % efficiency) than manual hammers (60 % efficiency) which are dropped using a manually operated rope and cathead system. Because historic data correlations were developed based on use of a manual hammer, it is necessary to adjust the N-values obtained using an automatic hammer to make these correlations valid. Therefore, an energy correction factor of 1.3 was applied to the recorded field N-values from the automatic hammer for the purpose of our evaluation. The N-values discussed or mentioned in this report and shown on the boring logs are recorded field values.

Samples retrieved from the boring locations were labeled and stored in plastic bags at the jobsite before being transported to our laboratory for analysis. The project engineer prepared Boring Logs summarizing the subsurface conditions at the boring locations.

BORING LOG DESCRIPTION

Building & Earth Sciences, Inc. used the gINT software program to prepare the attached boring logs. The gINT program provides the flexibility to custom design the boring logs to include the pertinent information from the subsurface exploration and results of our laboratory analysis. The soil and laboratory information included on our logs is summarized below:

DEPTH AND ELEVATION

The depth below the ground surface and the corresponding elevation are shown in the first two columns.

SAMPLE TYPE

The method used to collect the sample is shown. The typical sampling methods include Split Spoon Sampling, Shelby Tube Sampling, Grab Samples, and Rock Core. A key is provided at the bottom of the log showing the graphic symbol for each sample type.

SAMPLE NUMBER

Each sample collected is numbered sequentially.

BLOWS PER INCREMENT, REC%, RQD%

When Standard Split Spoon sampling is used, the blows required to drive the sampler each 6-inch increment are recorded and shown in column 5. When rock core is obtained the recovery ration (REC%) and Rock Quality Designation (RQD%) is recorded.

SOIL DATA

Column 6 is a graphic representation of four different soil parameters. Each of the parameters use the same graph, however, the values of the graph subdivisions vary with each parameter. Each parameter presented on column 6 is summarized below:

- N-value- The Standard Penetration Test N-value, obtained by adding the number of blows required to drive the sampler the final 12 inches, is recorded . The graph labels range from 0 to 50.
- Qu – Unconfined Compressive Strength estimate from the Pocket Penetrometer test in tons per square foot (tsf). The graph labels range from 0 to 5 tsf.
- Atterberg Limits – The Atterberg Limits are plotted with the plastic limit to the left, and liquid limit to the right, connected by a horizontal line. The difference in the plastic and liquid limits is referred to as the Plasticity Index. The Atterberg Limits test results are also included in the Remarks column on the far right of the boring log. The Atterberg Limits graph labels range from 0 to 100%.
- Moisture – The Natural Moisture Content of the soil sample as determined in our laboratory.

SOIL DESCRIPTION

The soil description prepared in accordance with ASTM D2488, Visual Description of Soil Samples. The Munsel Color chart is used to determine the soil color. Strata changes are indicated by a solid line, with the depth of the change indicated on the left side of the line and the elevation of the change indicated on the right side of the line. If subtle changes within a soil type occur, a broken line is used. The Boring Termination or Auger Refusal depth is shown as a solid line at the bottom of the boring.

GRAPHIC

The graphic representation of the soil type is shown. The graphic used for each soil type is related to the Unified Soil Classification chart.   A chart showing the graphic associated with each soil classification is included.

REMARKS

Remarks regarding borehole observations, and additional information regarding the laboratory results and groundwater observations.

Major Divisions			***Symbols***		***Group Name & Typical Description***
			Lithology	***Group***	
Coarse Grained Soils *More than 50% of material is larger than No. 200 sieve size*	***Gravel and Gravelly Soils*** *More than 50% of coarse fraction is larger than No. 4 sieve*	***Clean Gravels*** *(Less than 5% fines)*	▨	***GW***	*Well-graded gravels, gravel – sand mixtures, little or no fines*
			▨	***GP***	*Poorly-graded gravels, gravel – sand mixtures, little or no fines*
		Gravels with Fines *(More than 12% fines)*	▨	***GM***	*Silty gravels, gravel – sand – silt mixtures*
			▨	***GC***	*Clayey gravels, gravel – sand – clay mixtures*
	Sand and Sandy Soils *More than 50% of coarse fraction is smaller than No. 4 sieve*	***Clean Sands*** *(Less than 5% fines)*	▨	***SW***	*Well-graded sands, gravelly sands, little or no fines*
			▨	***SP***	*Poorly-graded sands, gravelly sands, little or no fines*
		Sands with Fines *(More than 12% fines)*	▨	***SM***	*Silty sands, sand – silt mixtures*
			▨	***SC***	*Clayey sands, sand – clay mixtures*
Fine Grained Soils *More than 50% of material is smaller than No. 200 sieve size*	***Silts and Clays*** *Liquid Limit less than 50*	***Inorganic***	▨	***ML***	*Inorganic silts and very find sands, rock flour, silty or clayey fine sands or clayey silt with slight plasticity*
			▨	***CL***	*Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays*
		Organic	▨	***OL***	*Organic silts and organic silty clays of low plasticity*
	Silts and Clays *Liquid Limit greater than 50*	***Inorganic***	▨	***MH***	*Inorganic silts, micaceous or diatomaceous fine sand, or silty soils*
			▨	***CH***	*Inorganic clays of high plasticity*
		Organic	▨	***OH***	*Organic clays of medium to high plasticity, organic silts*
Highly Organic Soils			▨	***PT***	*Peat, humus, swamp soils with high organic contents*

Table 1: Soil Classification Chart (based on ASTM D2487)

SOIL CLASSIFICATION METHODOLOGY

Building & Earth Sciences classifies soil in general accordance with the Unified Soil Classification System (USCS) presented in ASTM D2487. Table 1 and Figure 1 exemplify the general guidance of the USCS. Soil consistencies and relative densities are presented in general accordance with Terzaghi, Peck, & Mesri's (1996) method, as shown on Table 2, when quantitative field and/or laboratory data is available. Table 2 includes Consistency and Relative Density correlations with N-values obtained using either a manual hammer (60 percent efficiency) or automatic hammer (90 percent efficiency). The *Blows Per Increment* and *SPT N-values* displayed on the boring logs are the unaltered values measured in the field. When field and/or laboratory data is not available, we may classify soil in general accordance with the Visual Manual Procedure presented in ASTM D2488.

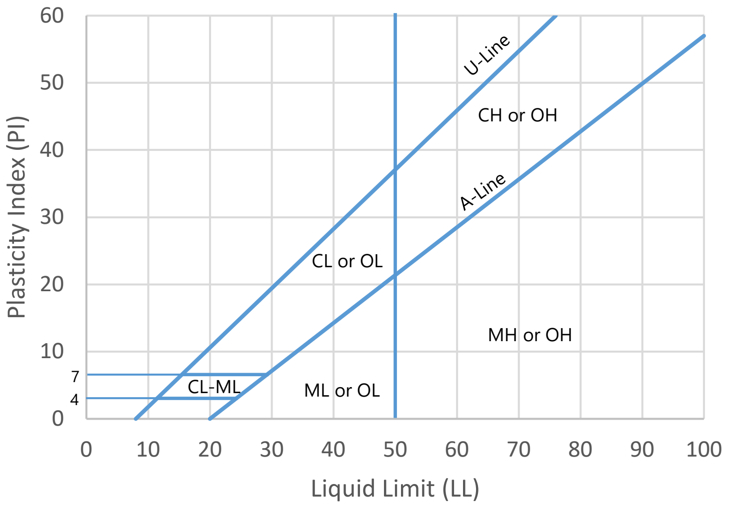


Figure 1: Plasticity Chart (based on ASTM D2487)

Non-cohesive: Coarse-Grained Soil			Cohesive: Fine-Grained Soil			
SPT Penetration (blows/foot)		Relative Density	SPT Penetration (blows/foot)		Consistency	Estimated Range of Unconfined Compressive Strength (tsf)
			Automatic Hammer*	Manual Hammer		
Automatic Hammer*	Manual Hammer		< 2	< 2	Very Soft	< 0.25
0 - 3	0 - 4	Very Loose	2 - 3	2 - 4	Soft	0.25 – 0.50
3 - 8	4 - 10	Loose	3 - 6	4 - 8	Medium Stiff	0.50 – 1.00
8 - 23	10 - 30	Medium Dense	6 - 12	8 - 15	Stiff	1.00 – 2.00
23 - 38	30 - 50	Dense	12 - 23	15 - 30	Very Stiff	2.00 – 4.00
> 38	> 50	Very Dense	> 23	> 30	Hard	> 4.00

Table 2: Soil Consistency and Relative Density (based on Terzaghi, Peck & Mesri, 1996)

* - Modified based on 80% hammer efficiency

KEY TO LOGS

☒	Standard Penetration Test ASTM D1586 or AASHTO T-206	▼	Dynamic Cone Penetrometer (Sower DCP) ASTM STP-399
■	Shelby Tube Sampler ASTM D1587	○	No Sample Recovery
▥	Rock Core Sample ASTM D2113	▽	Groundwater at Time of Drilling
■	Auger Cuttings	▼	Groundwater as Indicated

Table 1: Symbol Legend

Soil	Particle Size	U.S. Standard
Boulders	Larger than 300 mm	N.A.
Cobbles	300 mm to 75 mm	N.A.
Gravel	75 mm to 4.75 mm	3-inch to #4 sieve
Coarse	75 mm to 19 mm	3-inch to ¾-inch sieve
Fine	19 mm to 4.75 mm	¾-inch to #4 sieve
Sand	4.75 mm to 0.075 mm	#4 to #200 Sieve
Coarse	4.75 mm to 2 mm	#4 to #10 Sieve
Medium	2 mm to 0.425 mm	#10 to #40 Sieve
Fine	0.425 mm to 0.075 mm	#40 to #200 Sieve
Fines	Less than 0.075 mm	Passing #200 Sieve
Silt	Less than 5 μm	N.A.
Clay	Less than 2 μm	N.A.

Table 2: Standard Sieve Sizes

N-Value ☐	Standard Penetration Test Resistance calculated using ASTM D1586 or AASHTO T-206. Calculated as sum of original, field recorded values.	Atterberg Limits ├─┤ PL LL	A measure of a soil's plasticity characteristics in general accordance with ASTM D4318. The soil Plasticity Index (PI) is representative of this characteristic and is bracketed by the Liquid Limit (LL) and the Plastic Limit (PL).
Qu ▲	Unconfined compressive strength, typically estimated from a pocket penetrometer. Results are presented in tons per square foot (tsf).	% Moisture ●	Percent natural moisture content in general accordance with ASTM D2216.

Table 3: Soil Data

Hollow Stem Auger	Flights on the outside of the shaft advance soil cuttings to the surface. The hollow stem allows sampling through the middle of the auger flights.
Mud Rotary / Wash Bore	A cutting head advances the boring and discharges a drilling fluid to support the borehole and circulate cuttings to the surface.
Solid Flight Auger	Flights on the outside bring soil cuttings to the surface. Solid stem requires removal from borehole during sampling.
Hand Auger	Cylindrical bucket (typically 3-inch diameter and 8 inches long) attached to a metal rod and turned by human force.

Table 4: Soil Drilling Methods

Descriptor	Meaning
Trace	Likely less than 5%
Few	5 to 10%
Little	15 to 25%
Some	30 to 45%
Mostly	50 to 100%

Table 5: Descriptors

Manual Hammer	The operator tightens and loosens the rope around a rotating drum assembly to lift and drop a sliding, 140-pound hammer falling 30 inches.
Automatic Trip Hammer	An automatic mechanism is used to lift and drop a sliding, 140-pound hammer falling 30 inches.
Dynamic Cone Penetrometer (Sower DCP) ASTM STP-399	Uses a 15-pound steel mass falling 20 inches to strike an anvil and cause penetration of a 1.5-inch diameter cone seated in the bottom of a hand augered borehole. The blows required to drive the embedded cone a depth of 1-3/4 inches have been correlated by others to N-values derived from the Standard Penetration Test (SPT).

Table 6: Sampling Methods

Non-plastic	A 1/8-inch thread cannot be rolled at any water content.
Low	The thread can barely be rolled and the lump cannot be formed when drier than the plastic limit.
Medium	The thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be re-rolled after reaching the plastic limit. The lump crumbles when drier than the plastic limit.
High	It takes considerable time rolling and kneading to reach the plastic limit. The thread can be re-rolled several times after reaching the plastic limit. The lump can be formed without crumbling when drier than the plastic limit.

Table 7: Plasticity

Dry	Absence of moisture, dusty, dry to the touch.
Moist	Damp but no visible water.
Wet	Visible free water, usually soil is below water table.

Table 8: Moisture Condition

Stratified	Alternating layers of varying material or color with layers at least ½ inch thick.
Laminated	Alternating layers of varying material or color with layers less than ¼ inch thick.
Fissured	Breaks along definite planes of fracture with little resistance to fracturing.
Slickensides	Fracture planes appear polished or glossy, sometimes striated.
Blocky	Cohesive soil that can be broken down into small angular lumps which resist further breakdown.
Lensed	Inclusion of small pockets of different soils, such as small lenses of sand scattered through a mass of clay.
Homogeneous	Same color and appearance throughout.

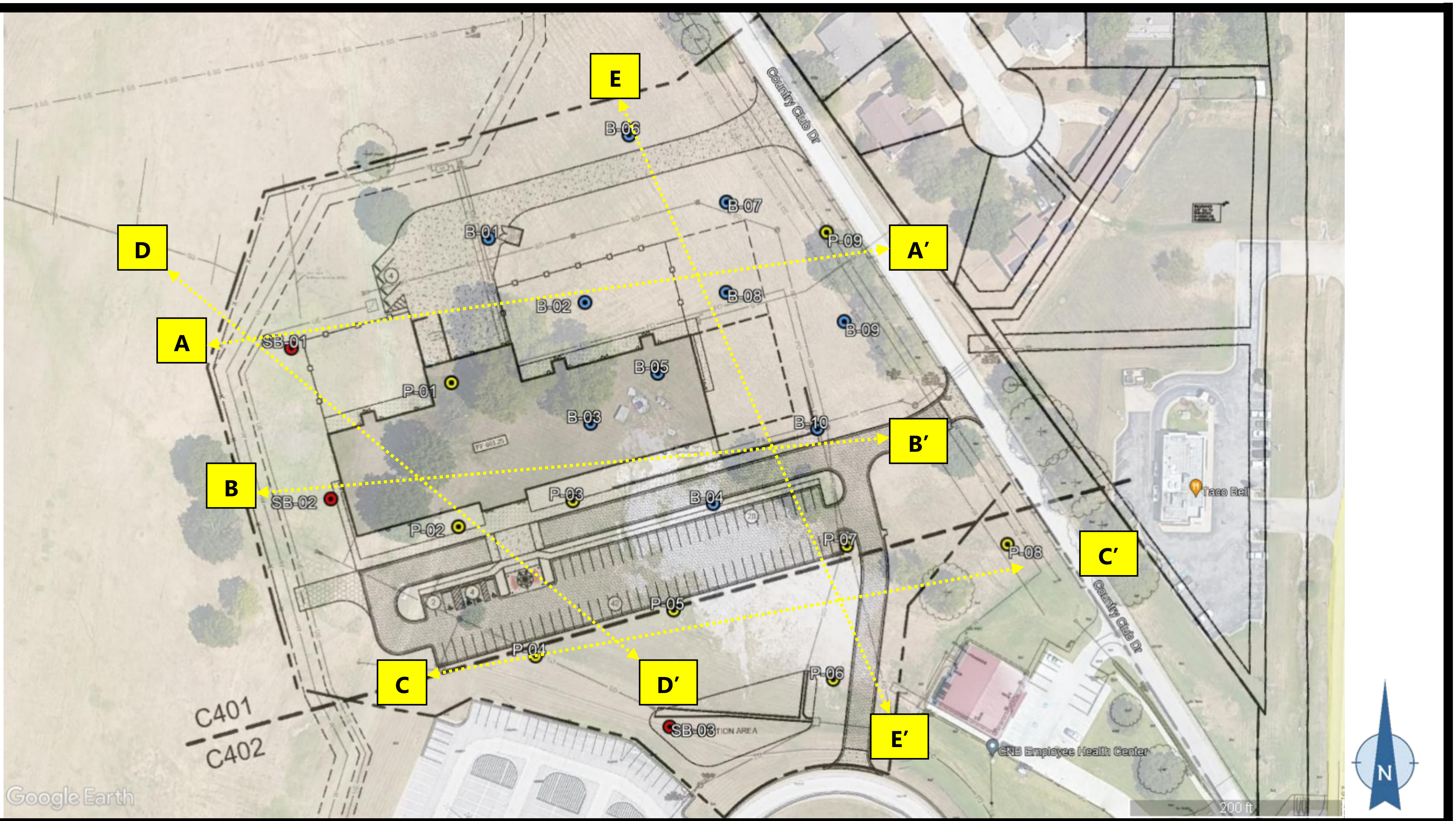
Table 9: Structure

KEY TO HATCHES

Hatch	*Description*	*Hatch*	*Description*	*Hatch*	*Description*
▨	***GW*** *- Well-graded gravels, gravel – sand mixtures, little or no fines*	▨	*Asphalt*	▨	*Clay with Gravel*
▨	***GP*** *- Poorly-graded gravels, gravel – sand mixtures, little or no fines*	▨	*Aggregate Base*	▨	*Sand with Gravel*
▨	***GM*** *- Silty gravels, gravel – sand – silt mixtures*	▨	*Topsoil*	▨	*Silt with Gravel*
▨	***GC*** *- Clayey gravels, gravel – sand – clay mixtures*	▨	*Concrete*	▨	*Gravel with Sand*
▨	***SW*** *- Well-graded sands, gravelly sands, little or no fines*	▨	*Coal*	▨	*Gravel with Clay*
▨	***SP*** *- Poorly-graded sands, gravelly sands, little or no fines*	▨	***CL-ML*** *- Silty Clay*	▨	*Gravel with Silt*
▨	***SM*** *- Silty sands, sand – silt mixtures*	▨	*Sandy Clay*	▨	*Limestone*
▨	***SC*** *- Clayey sands, sand – clay mixtures*	▨	*Clayey Chert*	▨	*Chalk*
▨	***ML*** *- Inorganic silts and very find sands, rock flour, silty or clayey fine sands or clayey silt with slight plasticity*	▨	*Low and High Plasticity Clay*	▨	*Siltstone*
▨	***CL*** *- Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays*	▨	*Low Plasticity Silt and Clay*	▨	*Till*
▨	***OL*** *- Organic silts and organic silty clays of low plasticity*	▨	*High Plasticity Silt and Clay*	▨	*Sandy Clay with Cobbles and Boulders*
▨	***MH*** *- Inorganic silts, micaceous or diatomaceous fine sand, or silty soils*	▨	*Fill*	▨	*Sandstone with Shale*
▨	***CH*** *- Inorganic clays of high plasticity*	▨	*Weathered Rock*	▨	*Coral*
▨	***OH*** *- Organic clays of medium to high plasticity, organic silts*	▨	*Sandstone*	▨	*Boulders and Cobbles*
▨	***PT*** *- Peat, humus, swamp soils with high organic contents*	▨	*Shale*	▨	*Soil and Weathered Rock*

Table 1: Key to Hatches Used for Boring Logs and Soil Profiles

BORING LOCATION PLAN



REFERENCE USED TO PRODUCE THIS DRAWING:

Google Earth Satellite Imagery dated 8/11/2022 with overlay of Site Plan - Overall, prepared by Wallace Design Collective, dated 02/09/2024

BORING LOCATION PLAN

DATE: 01/18/2024

PROJECT NO.

TU230102

PROJECT NAME / LOCATION:

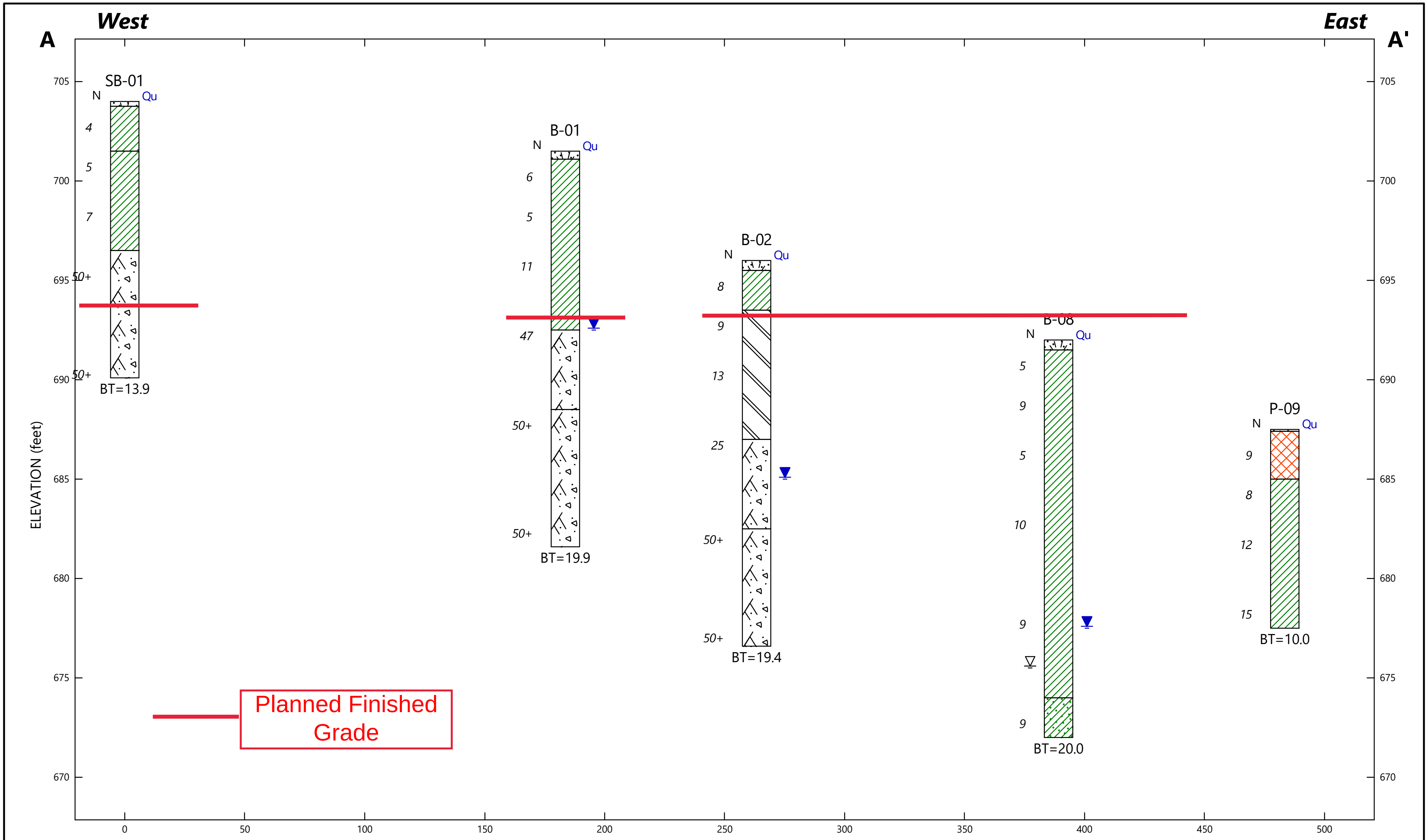
Cherokee Nation Child
Development Center
Catoosa, Oklahoma

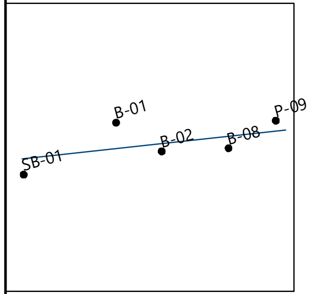
SCALE:

As Shown

BUILDING & EARTH
Geotechnical, Environmental, and Materials Engineers

SUBSURFACE PROFILES





Site Map Scale 1 inch equals 360 feet

Key to Hatches

- Topsoil
- USCS Low to High Plasticity Clay
- USCS Low Plasticity Clay
- USCS Low Plasticity Sandy Clay
- Weathered Rock
- Fill

Legend

BT=Boring Termination, TPT=Test Pit Terminated
AR=Auger Refusal, ER=Excavation Refusal
N=Standard Penetration Test N-Value
Qu=Unconfined compressive strength estimate
from pocket penetrometer test (tsf)

▽ Water Level Reading at time of drilling.
▼ Water Level Reading after drilling.

0 59

Horizontal Scale (feet)
Vertical Exaggeration: 8.5x

Building & Earth Sciences, Inc.
1403 South 70th East Avenue, Tulsa, Oklahoma 74133

Cherokee Nation Child Development Center
Catoosa, OK

A-A': Subsurface Profile

PROJECT NO: TU230102	PLATE NO: A-1	DATE: 3/4/24

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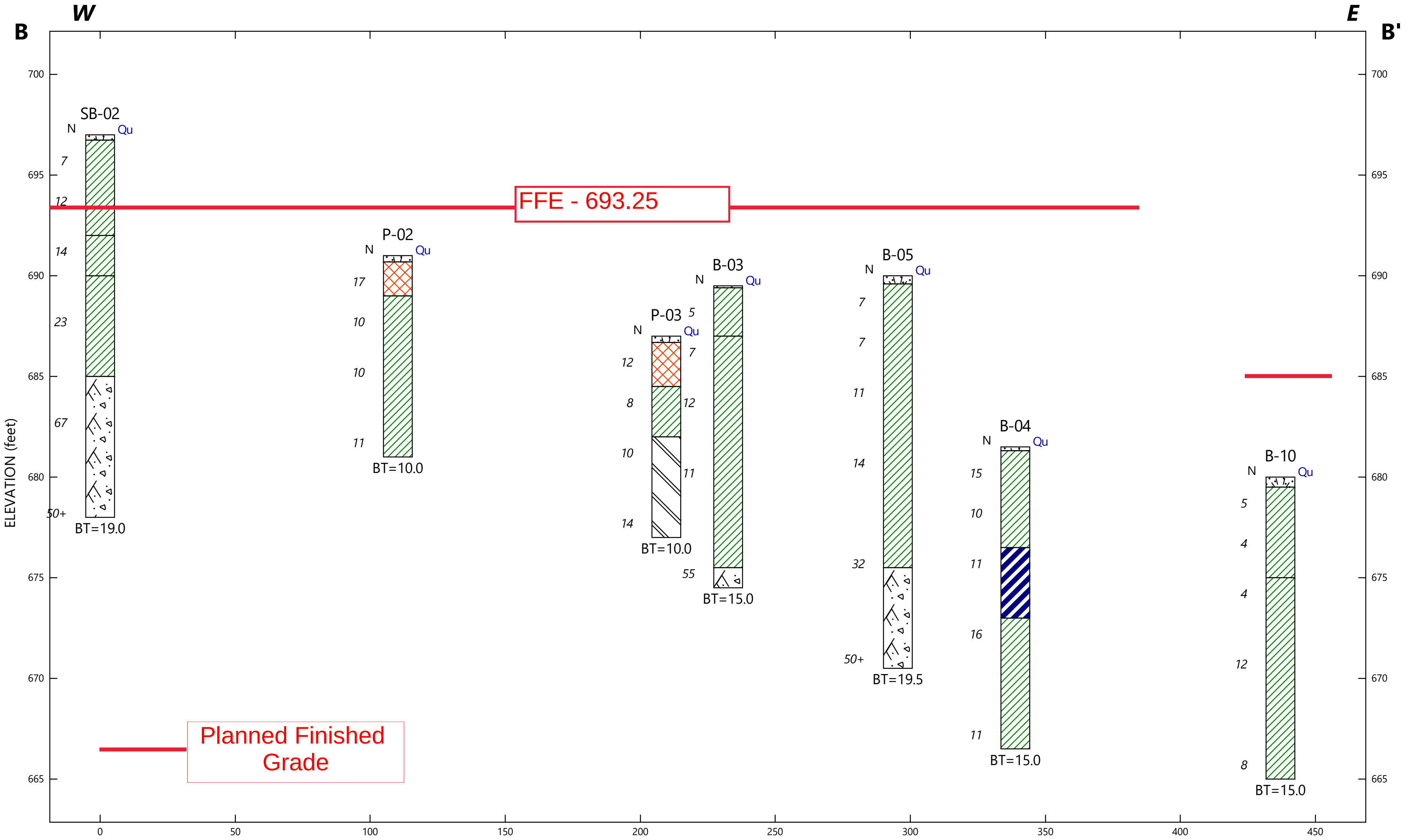
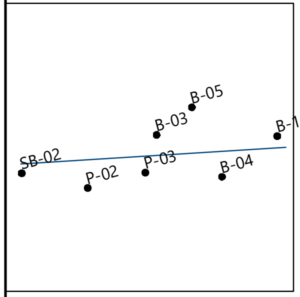




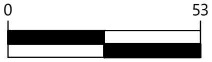
Site Map Scale 1 inch equals 325 feet

Key to Hatches

▨	Topsoil
▨	USCS High Plasticity Clay
🟩	USCS Low Plasticity Clay
🟥	Fill
▨	Weathered Rock
▨	USCS Low to High Plasticity Clay

Legend

BT=Boring Termination, TPT=Test Pit Terminated
AR=Auger Refusal, ER=Excavation Refusal
N=Standard Penetration Test N-Value
Qu=Unconfined compressive strength estimate from pocket penetrometer test (tsf)
▽ Water Level Reading at time of drilling.
▼ Water Level Reading after drilling.



Horizontal Scale (feet)
Vertical Exaggeration: 7.5x

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Cherokee Nation Child Development Center
Catoosa, OK

B-B': Subsurface Profile

PROJECT NO: TU230102	PLATE NO: B-1	DATE: 3/4/24

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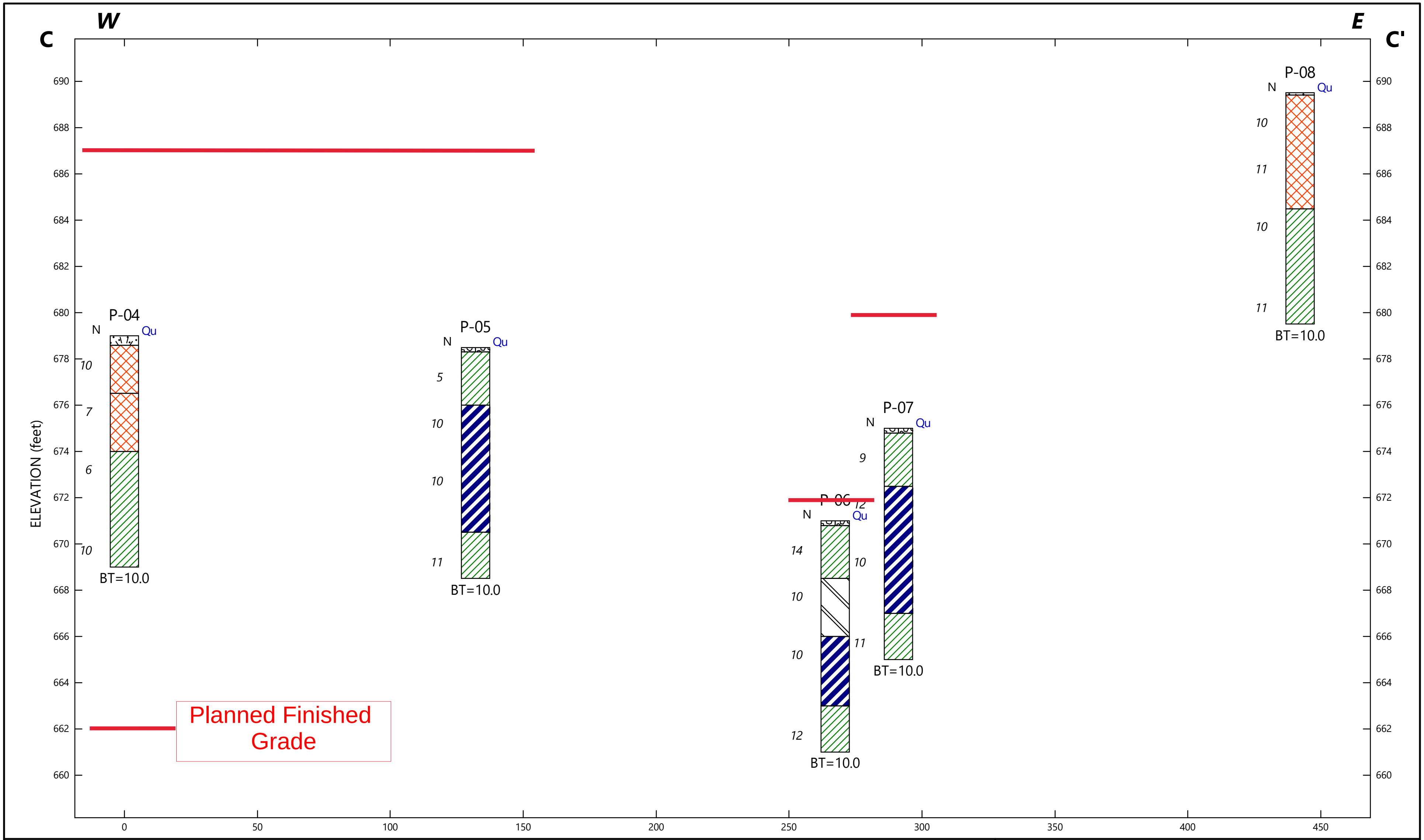
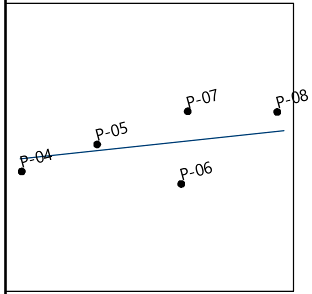




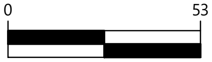
Site Map Scale 1 inch equals 325 feet

Key to Hatches

▨ Topsoil	▨ Aggregate Base Material
▨ Fill	▨ USCS High Plasticity Clay
▨ USCS Low Plasticity Clay	▨ USCS Low to High Plasticity Clay

Legend

BT=Boring Termination, TPT=Test Pit Terminated
AR=Auger Refusal, ER=Excavation Refusal
N=Standard Penetration Test N-Value
Qu=Unconfined compressive strength estimate from pocket penetrometer test (tsf)
▽ Water Level Reading at time of drilling.
▼ Water Level Reading after drilling.



Horizontal Scale (feet)
Vertical Exaggeration: 8.5x

Building & Earth Sciences, Inc.
1403 South 70th East Avenue, Tulsa, Oklahoma 74133

Cherokee Nation Child Development Center
Catoosa, OK

C-C': Subsurface Profile

PROJECT NO: TU230102	PLATE NO: C-1	DATE: 3/4/24

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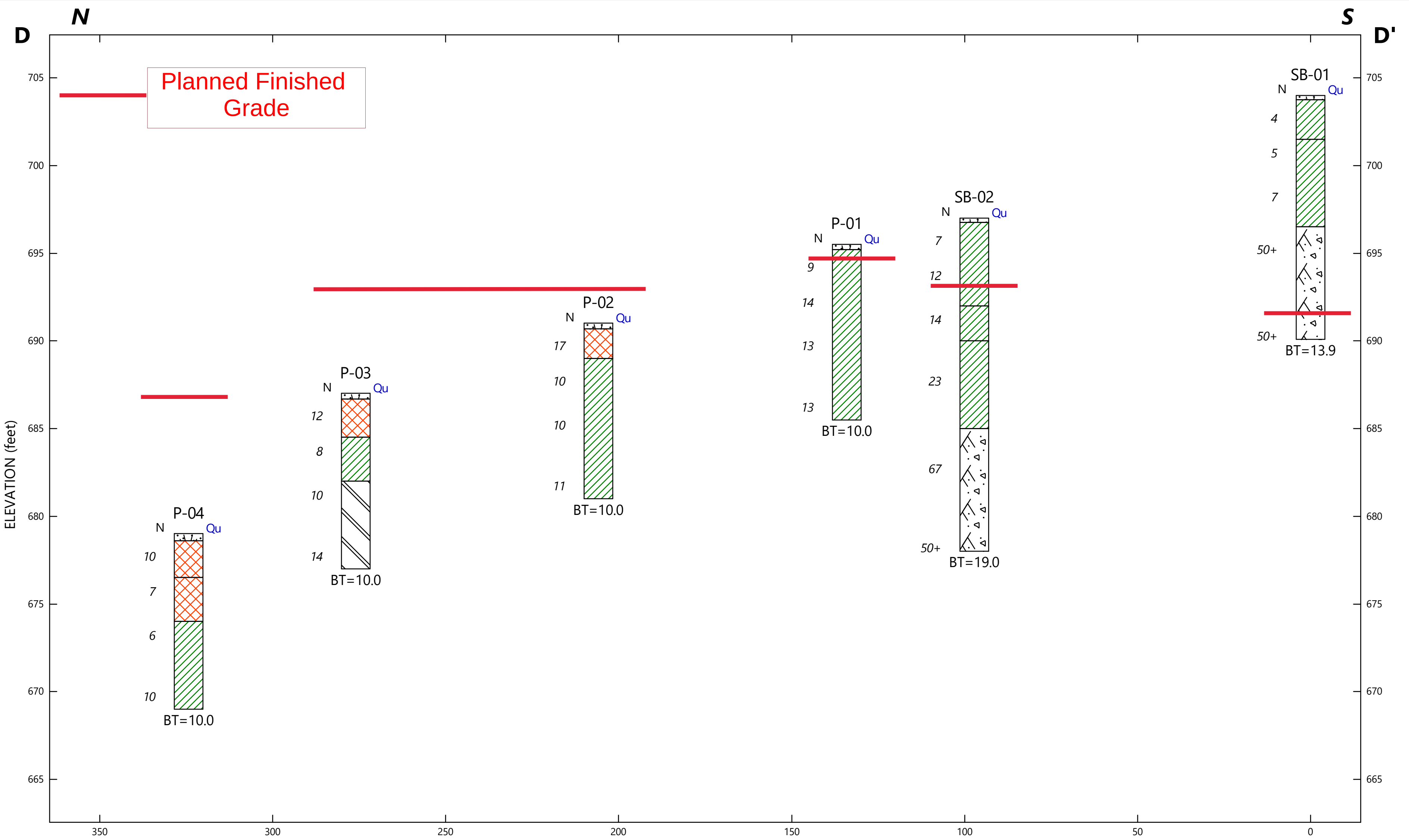

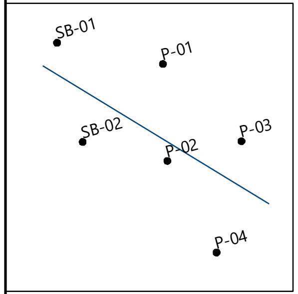

Site Map Scale 1 inch equals 255 feet

Key to Hatches

- ▨ Topsoil
- 🟩 USCS Low Plasticity Clay
- 🟥 Fill
- ▨ USCS Low to High Plasticity Clay
- ▨ Weathered Rock

Legend

BT=Boring Termination, TPT=Test Pit Terminated
AR=Auger Refusal, ER=Excavation Refusal
N=Standard Penetration Test N-Value
Qu=Unconfined compressive strength estimate
from pocket penetrometer test (tsf)
∇ Water Level Reading at time of drilling.
▼ Water Level Reading after drilling.

0 41

Horizontal Scale (feet)
Vertical Exaggeration: 5x

Building & Earth Sciences, Inc.
1403 South 70th East Avenue, Tulsa, Oklahoma 74133

Cherokee Nation Child Development Center
Catoosa, OK

D-D': Subsurface Profile

PROJECT NO: TU230102	PLATE NO: D-1	DATE: 3/4/24

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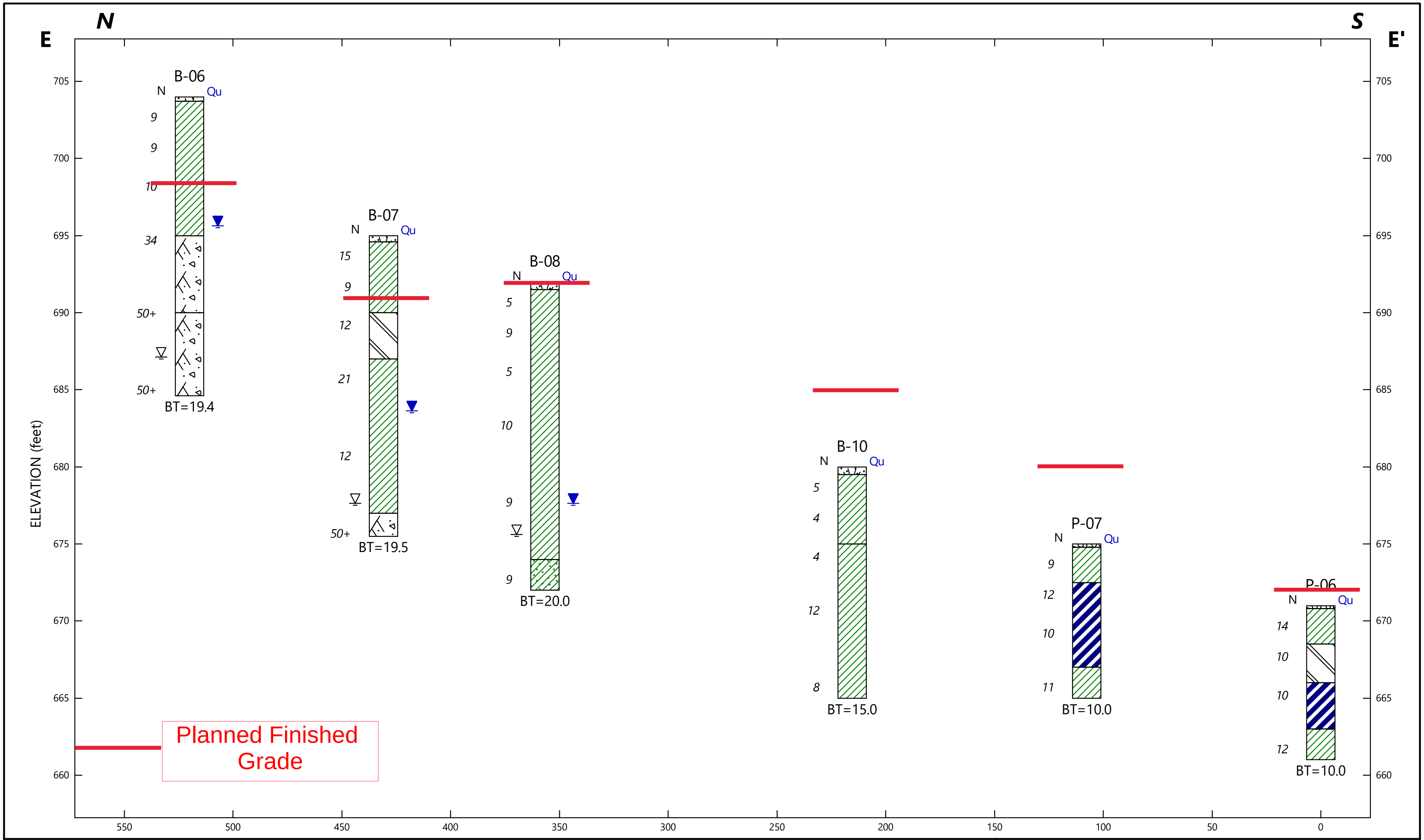

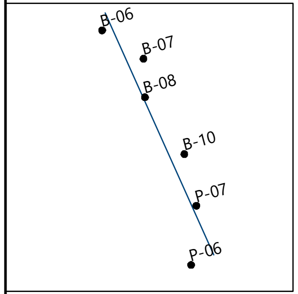

Site Map Scale 1 inch equals 400 feet

Key to Hatches

- ▨ Topsoil
- ▨ USCS Low Plasticity Clay
- ▨ Weathered Rock
- ▨ USCS Low to High Plasticity Clay
- ▨ USCS Low Plasticity Sandy Clay
- ▨ Aggregate Base Material
- ▨ USCS High Plasticity Clay

Legend

BT=Boring Termination, TPT=Test Pit Terminated
AR=Auger Refusal, ER=Excavation Refusal
N=Standard Penetration Test N-Value
Qu=Unconfined compressive strength estimate from pocket penetrometer test (tsf)
▽ Water Level Reading at time of drilling.
▼ Water Level Reading after drilling.

0 65

Horizontal Scale (feet)
Vertical Exaggeration: 7x

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1403 South 70th East Avenue, Tulsa, Oklahoma 74133

Cherokee Nation Child Development Center
Catoosa, OK

E-E': Subsurface Profile

PROJECT NO: TU230102	PLATE NO: E-1	DATE: 3/4/24

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Geotechnical, Environmental, and Materials Engineers

BORING LOGS

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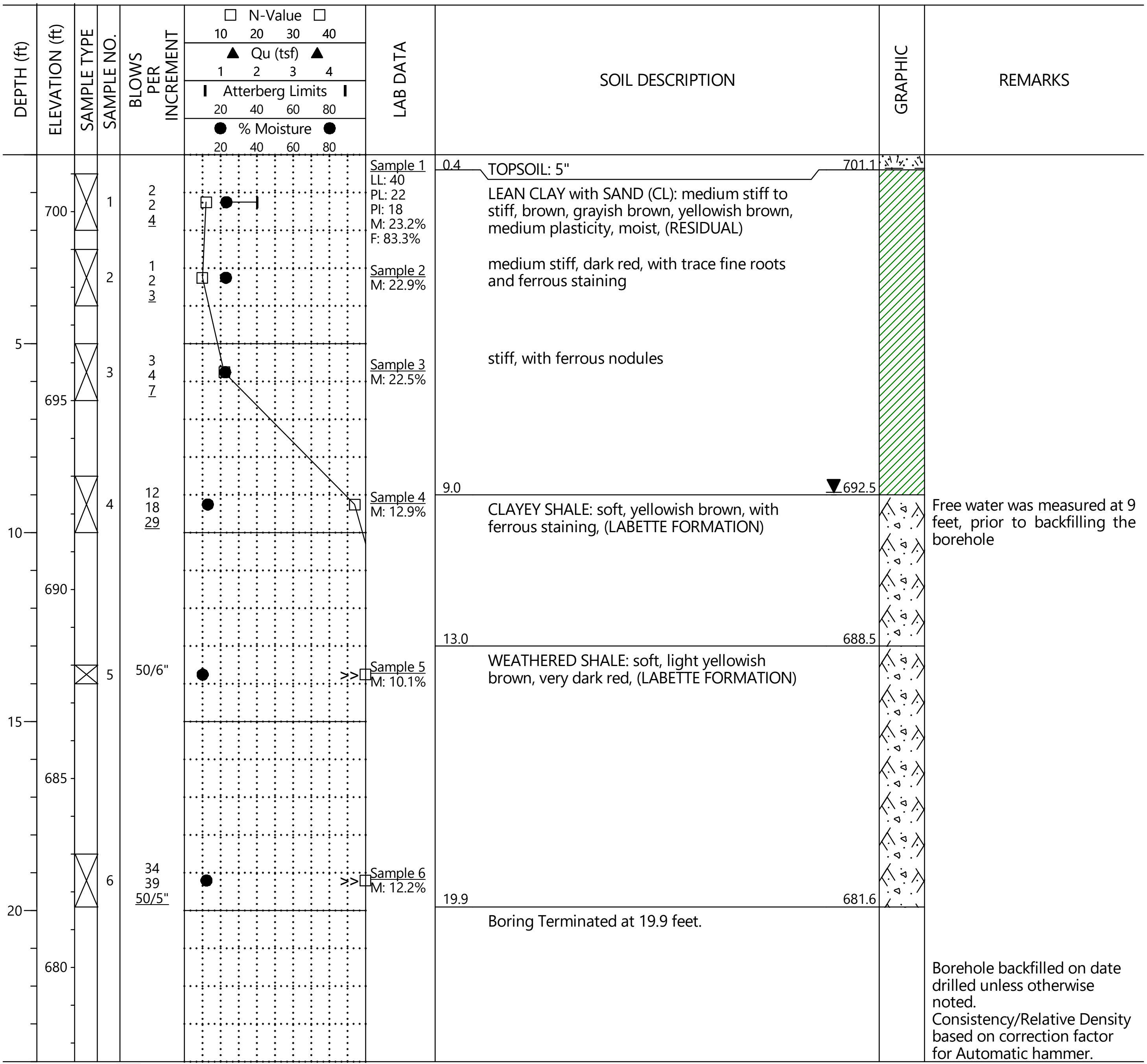
LOG OF BORING
Designation: B-01
Sheet 1 of 1

1403 S 70th E Ave
Tulsa, OK 74112
Office: (918) 439-9005

PROJECT NAME:	Cherokee Nation Child Development Center	LOCATION:	Catoosa, OK
PROJECT NUMBER:	TU230102	DATE DRILLED:	6/26/23
DRILLING METHOD:	Solid Flight Auger	WEATHER:	Sunny
EQUIPMENT USED:	CME 550X ATV	ELEVATION:	701.5
HAMMER TYPE:	Automatic	DRILL CREW:	DSO
BORING LOCATION:	36.170481, -95.764222	LOGGED BY:	S.Harris



SAMPLE NO.	BLOWS PER INCREMENT	LAB DATA
1	2 2 4	Sample 1 LL: 40 PL: 22 PI: 18 M: 23.2% F: 83.3%
2	1 2 3	Sample 2 M: 22.9%
3	3 4 7	Sample 3 M: 22.5%
4	12 18 29	Sample 4 M: 12.9%
5	50/6"	Sample 5 M: 10.1%
6	34 39 50/5"	Sample 6 M: 12.2%

0.4 TOPSOIL: 5" 701.1

LEAN CLAY with SAND (CL): medium stiff to stiff, brown, grayish brown, yellowish brown, medium plasticity, moist, (RESIDUAL)

medium stiff, dark red, with trace fine roots and ferrous staining

stiff, with ferrous nodules

9.0 ▼692.5

CLAYEY SHALE: soft, yellowish brown, with ferrous staining, (LABETTE FORMATION)

13.0 688.5

WEATHERED SHALE: soft, light yellowish brown, very dark red, (LABETTE FORMATION)

19.9 681.6

Boring Terminated at 19.9 feet.

Free water was measured at 9 feet, prior to backfilling the borehole

Borehole backfilled on date drilled unless otherwise noted.
Consistency/Relative Density based on correction factor for Automatic hammer.

SAMPLE TYPE ☒ Split Spoon

N-VALUE	STANDARD PENETRATION RESISTANCE (AASHTO T-206)	**REC**	RECOVERY	**LL:**	LIQUID LIMIT **M:** NATURAL MOISTURE CONTENT
% MOISTURE	PERCENT NATURAL MOISTURE CONTENT	**RQD**	ROCK QUALITY DESIGNATION	**PL:**	PLASTIC LIMIT **F:** PERCENT PASSING NO. 200 SIEVE
▽	GROUNDWATER LEVEL IN THE BOREHOLE AT TIME OF DRILLING	**UD**	UNDISTURBED	**PI:**	PLASTICITY INDEX
▼	STABILIZED GROUNDWATER LEVEL	**Qu**	POCKET PENETROMETER UNCONFINED COMPRESSIVE STRENGTH		

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Geotechnical, Environmental, and Materials Engineers

LOG OF BORING

Designation: B-02

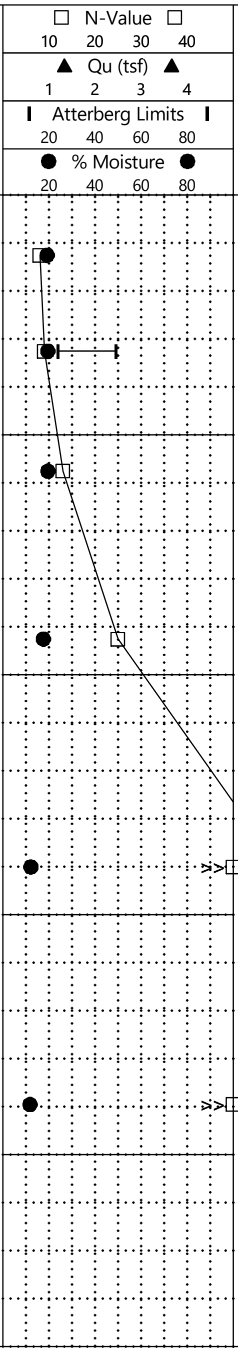
Sheet 1 of 1

1403 S 70th E Ave
Tulsa, OK 74112
Office: (918) 439-9005

PROJECT NAME: Cherokee Nation Child Development Center
PROJECT NUMBER: TU230102
DRILLING METHOD: Solid Flight Auger
EQUIPMENT USED: CME 550X ATV
HAMMER TYPE: Automatic
BORING LOCATION: 36.170328, -95.763936

LOCATION: Catoosa, OK
DATE DRILLED: 6/26/23
WEATHER: Sunny
ELEVATION: 696
DRILL CREW: DSO
LOGGED BY: S.Harris

SAMPLE TYPE	SAMPLE NO.	BLOWS PER INCREMENT	LAB DATA
☒	1	3 3 5	Sample 1 M: 19.2%
☒	2	2 4 5	Sample 2 LL: 49 PL: 24 PI: 25 M: 19.5%
☒	3	3 6 7	Sample 3 M: 19.5%
☒	4	5 7 18	Sample 4 M: 17.6%
☒	5	25 50/6"	Sample 5 M: 12.1%
☒	6	30 50/5"	Sample 6 M: 11.8%



DEPTH (ft)	SOIL DESCRIPTION	ELEVATION (ft)
0.5	TOPSOIL: 6"	695.5
2.5	LEAN CLAY (CL): stiff, brown, low plasticity, moist, with fine roots, (RESIDUAL)	693.5
9.0	LEAN TO FAT CLAY (CL-CH): stiff, grayish brown, yellowish brown, medium to high plasticity, moist, with ferrous nodules, (RESIDUAL) very stiff	687.0
13.5	CLAYEY SHALE: soft, yellowish brown, with ferrous staining, (LABETTE FORMATION)	682.5
19.4	WEATHERED SHALE: soft, pale brown, yellowish brown, with ferrous staining, (LABETTE FORMATION)	676.6

Boring Terminated at 19.4 feet.

REMARKS

Free water was measured at 11 feet, prior to backfilling the borehole

Borehole backfilled on date drilled unless otherwise noted.
Consistency/Relative Density based on correction factor for Automatic hammer.

SAMPLE TYPE ☒ Split Spoon

N-VALUE STANDARD PENETRATION RESISTANCE (AASHTO T-206)
% MOISTURE PERCENT NATURAL MOISTURE CONTENT
▽ GROUNDWATER LEVEL IN THE BOREHOLE AT TIME OF DRILLING
▼ STABILIZED GROUNDWATER LEVEL
REC RECOVERY
RQD ROCK QUALITY DESIGNATION
UD UNDISTURBED
Qu POCKET PENETROMETER UNCONFINED COMPRESSIVE STRENGTH
LL: LIQUID LIMIT
PL: PLASTIC LIMIT
PI: PLASTICITY INDEX
M: NATURAL MOISTURE CONTENT
F: PERCENT PASSING NO. 200 SIEVE

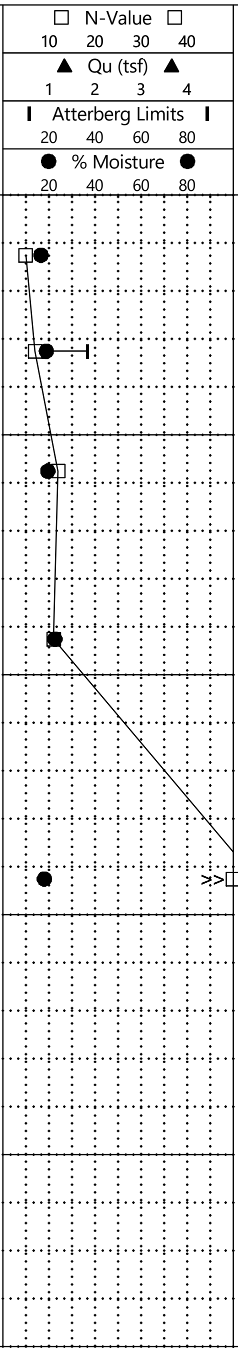
LOG OF BORING

Designation: B-03

Sheet 1 of 1

PROJECT NAME: Cherokee Nation Child Development Center
PROJECT NUMBER: TU230102
DRILLING METHOD: Solid Flight Auger
EQUIPMENT USED: CME 550X ATV
HAMMER TYPE: Automatic
BORING LOCATION: 36.170035, -95.763920

LOCATION: Catoosa, OK
DATE DRILLED: 6/27/23
WEATHER: Overcast
ELEVATION: 689.5
DRILL CREW: DSO
LOGGED BY: S.Harris



DEPTH (ft)	ELEVATION (ft)	SAMPLE TYPE	SAMPLE NO.	BLOWS PER INCREMENT	LAB DATA	SOIL DESCRIPTION	REMARKS
0.1	689.4					TOPSOIL: 2"	
		☒	1	2 2 3	Sample 1 M: 16.5%	LEAN CLAY (CL): medium stiff, brown, low plasticity, moist, with roots, (RESIDUAL)	
2.5	687.0	☒	2	3 3 4	Sample 2 LL: 37 PL: 17 PI: 20 M: 18.9%	LEAN CLAY (CL): stiff, yellowish brown, red, light brown, medium plasticity, moist, with ferrous nodules, (RESIDUAL)	
5	685	☒	3	3 5 7	Sample 3 M: 19.5%	stiff to very stiff	
10	680	☒	4	3 4 7	Sample 4 M: 22.6%	stiff, with sand and roots	
14.0	675.5	☒	5	10 23 32	Sample 5 M: 18.0%	WEATHERED SHALE: soft, pale brown, with ferrous staining, (LABETTE FORMATION)	
15.0	674.5					Boring Terminated at 15 feet.	
20	670						Groundwater not encountered at time of drilling. Borehole backfilled on date drilled unless otherwise noted. Consistency/Relative Density based on correction factor for Automatic hammer.

SAMPLE TYPE ☒ Split Spoon

N-VALUE STANDARD PENETRATION RESISTANCE (AASHTO T-206)
% MOISTURE PERCENT NATURAL MOISTURE CONTENT
∇ GROUNDWATER LEVEL IN THE BOREHOLE AT TIME OF DRILLING
▼ STABILIZED GROUNDWATER LEVEL
REC RECOVERY
RQD ROCK QUALITY DESIGNATION
UD UNDISTURBED
Qu POCKET PENETROMETER UNCONFINED COMPRESSIVE STRENGTH
LL: LIQUID LIMIT
PL: PLASTIC LIMIT
PI: PLASTICITY INDEX
M: NATURAL MOISTURE CONTENT
F: PERCENT PASSING NO. 200 SIEVE

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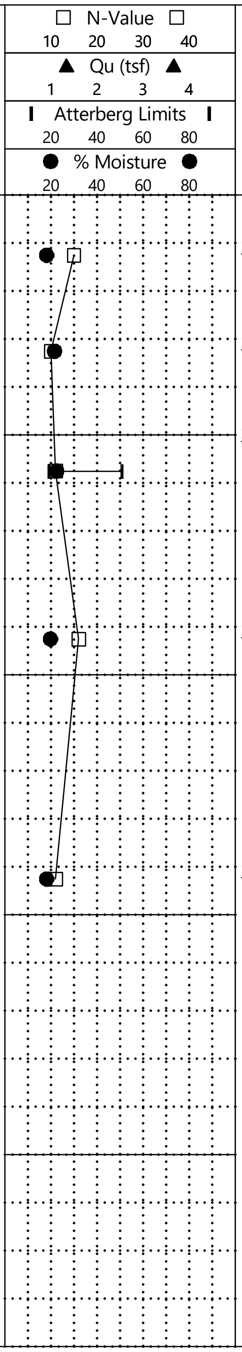
LOG OF BORING

Designation: B-04

Sheet 1 of 1

PROJECT NAME: Cherokee Nation Child Development Center
PROJECT NUMBER: TU230102
DRILLING METHOD: Solid Flight Auger
EQUIPMENT USED: CME 550X ATV
HAMMER TYPE: Automatic
BORING LOCATION: 36.169837, -95.763548

LOCATION: Catoosa, OK
DATE DRILLED: 6/27/23
WEATHER: Overcast
ELEVATION: 681.5
DRILL CREW: DSO
LOGGED BY: S.Harris



DEPTH (ft)	ELEVATION (ft)	SAMPLE TYPE	SAMPLE NO.	BLOWS PER INCREMENT	LAB DATA	SOIL DESCRIPTION	REMARKS
0.2	681.3					TOPSOIL: 3"	
	680	☒	1	5 7 8	Sample 1 M: 18.1%	LEAN CLAY (CL): very stiff, dark grayish brown, dark red, yellow, medium plasticity, moist, with trace fine roots, (RESIDUAL)	
		☒	2	4 5 5	Sample 2 M: 21.5%	stiff, with ferrous nodules	
5.0	676.5	☒	3	4 5 6	Sample 3 LL: 51 PL: 19 PI: 32 M: 22.4%	FAT CLAY (CH): stiff, dark gray, reddish yellow, high plasticity, moist, with ferrous nodules, (RESIDUAL)	
8.5	673.0	☒	4	6 7 9	Sample 4 M: 19.8%	LEAN CLAY (CL): very stiff, dark red, gray, yellow, medium plasticity, moist, with sand pockets, (RESIDUAL)	
		☒	5	3 4 7	Sample 5 M: 18.1%	stiff, light brown, with trace sandstone fragments	
15.0	666.5					Boring Terminated at 15 feet.	
20	660						Groundwater not encountered at time of drilling. Borehole backfilled on date drilled unless otherwise noted. Consistency/Relative Density based on correction factor for Automatic hammer.

SAMPLE TYPE ☒ Split Spoon

N-VALUE STANDARD PENETRATION RESISTANCE (AASHTO T-206)
% MOISTURE PERCENT NATURAL MOISTURE CONTENT
▽ GROUNDWATER LEVEL IN THE BOREHOLE AT TIME OF DRILLING
▼ STABILIZED GROUNDWATER LEVEL
REC RECOVERY
RQD ROCK QUALITY DESIGNATION
UD UNDISTURBED
Qu POCKET PENETROMETER UNCONFINED COMPRESSIVE STRENGTH
LL: LIQUID LIMIT
PL: PLASTIC LIMIT
PI: PLASTICITY INDEX
M: NATURAL MOISTURE CONTENT
F: PERCENT PASSING NO. 200 SIEVE

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LOG OF BORING

Designation: B-05

Sheet 1 of 1

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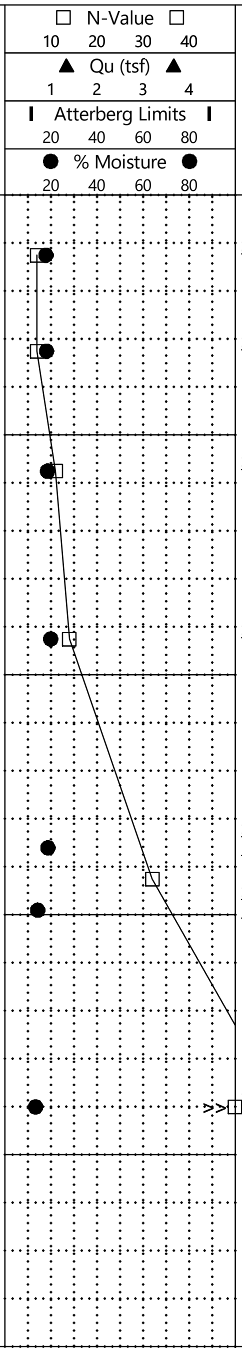
Office: (918) 439-9005

PROJECT NAME: Cherokee Nation Child Development Center
PROJECT NUMBER: TU230102
DRILLING METHOD: Solid Flight Auger
EQUIPMENT USED: CME 550X ATV
HAMMER TYPE: Automatic
BORING LOCATION: 36.170157, -95.763717

LOCATION: Catoosa, OK
DATE DRILLED: 6/26/23
WEATHER: Sunny
ELEVATION: 690
DRILL CREW: DSO
LOGGED BY: S.Harris



DEPTH (ft)	ELEVATION (ft)	SAMPLE TYPE	SAMPLE NO.	BLOWS PER INCREMENT	LAB DATA	SOIL DESCRIPTION	REMARKS
0	690						
0.4	689.6					TOPSOIL: 5"	
		☒	1	3 3 4	Sample 1 M: 17.8%	LEAN CLAY (CL): stiff, brown, low plasticity, moist, with roots, (RESIDUAL)	
		☒	2	3 3 4	Sample 2 M: 18.1%	with trace sand and ferrous nodules	
5	685	☒	3	2 5 6	Sample 3 M: 18.5%	medium plasticity	
		☒	4	3 5 9	Sample 4 M: 19.9%	very stiff, reddish brown, yellowish brown, with sandstone fragments	
10	680						
		☒	5T 5B	5 10 22	Sample 5T M: 18.7% Sample 5B M: 14.3%		
14.5	675.5					WEATHERED SHALE: soft, pale brown, with ferrous staining, (LABETTE FORMATION)	
15	675						
		☒	6	25 50/5.5"	Sample 6 M: 13.3%		
19.5	670.5					Boring Terminated at 19.5 feet.	
20	670						Groundwater not encountered at time of drilling. Borehole backfilled on date drilled unless otherwise noted. Consistency/Relative Density based on correction factor for Automatic hammer.

SAMPLE TYPE ☒ Split Spoon

N-VALUE STANDARD PENETRATION RESISTANCE (AASHTO T-206)
% MOISTURE PERCENT NATURAL MOISTURE CONTENT
∇ GROUNDWATER LEVEL IN THE BOREHOLE AT TIME OF DRILLING
▼ STABILIZED GROUNDWATER LEVEL

REC RECOVERY
RQD ROCK QUALITY DESIGNATION
UD UNDISTURBED
Qu POCKET PENETROMETER UNCONFINED COMPRESSIVE STRENGTH

LL: LIQUID LIMIT
PL: PLASTIC LIMIT
PI: PLASTICITY INDEX

M: NATURAL MOISTURE CONTENT
F: PERCENT PASSING NO. 200 SIEVE

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LOG OF BORING

Designation: B-06

Sheet 1 of 1

1403 S 70th E Ave
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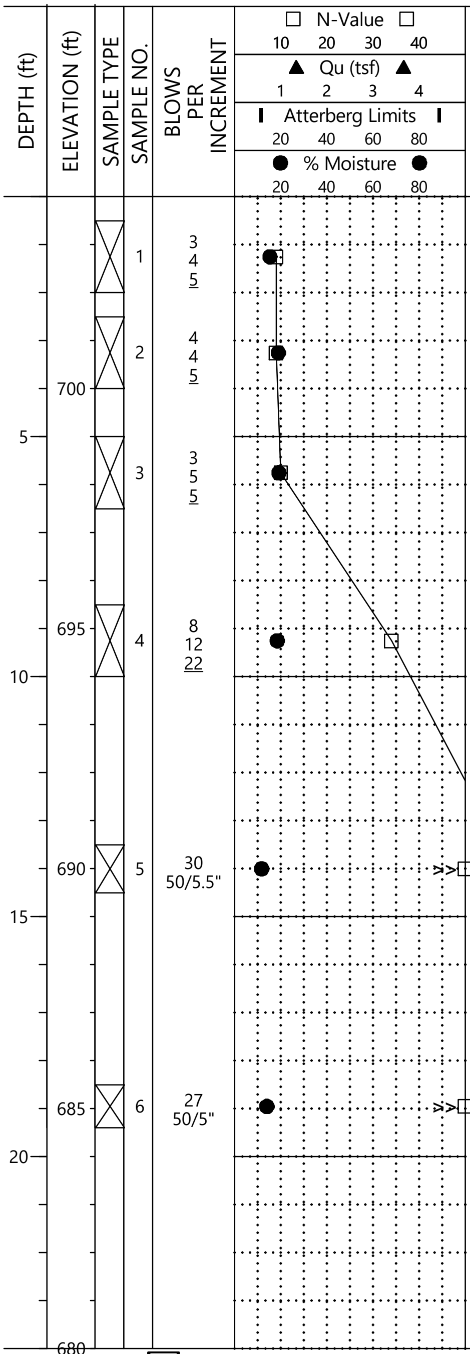
Office: (918) 439-9005

PROJECT NAME: Cherokee Nation Child Development Center
PROJECT NUMBER: TU230102
DRILLING METHOD: Solid Flight Auger
EQUIPMENT USED: CME 550X ATV
HAMMER TYPE: Automatic
BORING LOCATION: 36.170728, -95.763802

LOCATION: Catoosa, OK
DATE DRILLED: 6/26/23
WEATHER: Sunny
ELEVATION: 704
DRILL CREW: DSO
LOGGED BY: S.Harris



SAMPLE TYPE	SAMPLE NO.	BLOWS PER INCREMENT	LAB DATA
☒	1	3 4 5	Sample 1 M: 15.3%
☒	2	4 4 5	Sample 2 M: 19.0%
☒	3	3 5 5	Sample 3 M: 19.2%
☒	4	8 12 22	Sample 4 M: 18.5%
☒	5	30 50/5.5"	Sample 5 M: 11.7%
☒	6	27 50/5"	Sample 6 M: 14.0%

	SOIL DESCRIPTION	
0.3	TOPSOIL: 4"	703.7
	LEAN CLAY (CL): stiff, dark brown, yellowish brown, low to medium plasticity, moist, with roots, (RESIDUAL)	
	medium plasticity, with ferrous nodules	
	red, with ferrous staining and nodules	
9.0	CLAYEY SHALE: soft, yellowish brown, grayish brown, with ferrous staining, (LABETTE FORMATION)	695.0
14.0	WEATHERED SHALE: soft, yellowish brown, with ferrous staining, (LABETTE FORMATION)	690.0
	grayish brown	
19.4	Boring Terminated at 19.4 feet.	684.6

GRAPHIC: ▨

REMARKS

Groundwater encountered at 17 feet (EL 687) at time of drilling and stabilized at 8.5 feet (EL 695.5).

Borehole backfilled on date drilled unless otherwise noted.
Consistency/Relative Density based on correction factor for Automatic hammer.

SAMPLE TYPE ☒ Split Spoon

N-VALUE STANDARD PENETRATION RESISTANCE (AASHTO T-206)
% MOISTURE PERCENT NATURAL MOISTURE CONTENT
▽ GROUNDWATER LEVEL IN THE BOREHOLE AT TIME OF DRILLING
▼ STABILIZED GROUNDWATER LEVEL

REC RECOVERY
RQD ROCK QUALITY DESIGNATION
UD UNDISTURBED
Qu POCKET PENETROMETER UNCONFINED COMPRESSIVE STRENGTH

LL: LIQUID LIMIT
PL: PLASTIC LIMIT
PI: PLASTICITY INDEX
M: NATURAL MOISTURE CONTENT
F: PERCENT PASSING NO. 200 SIEVE

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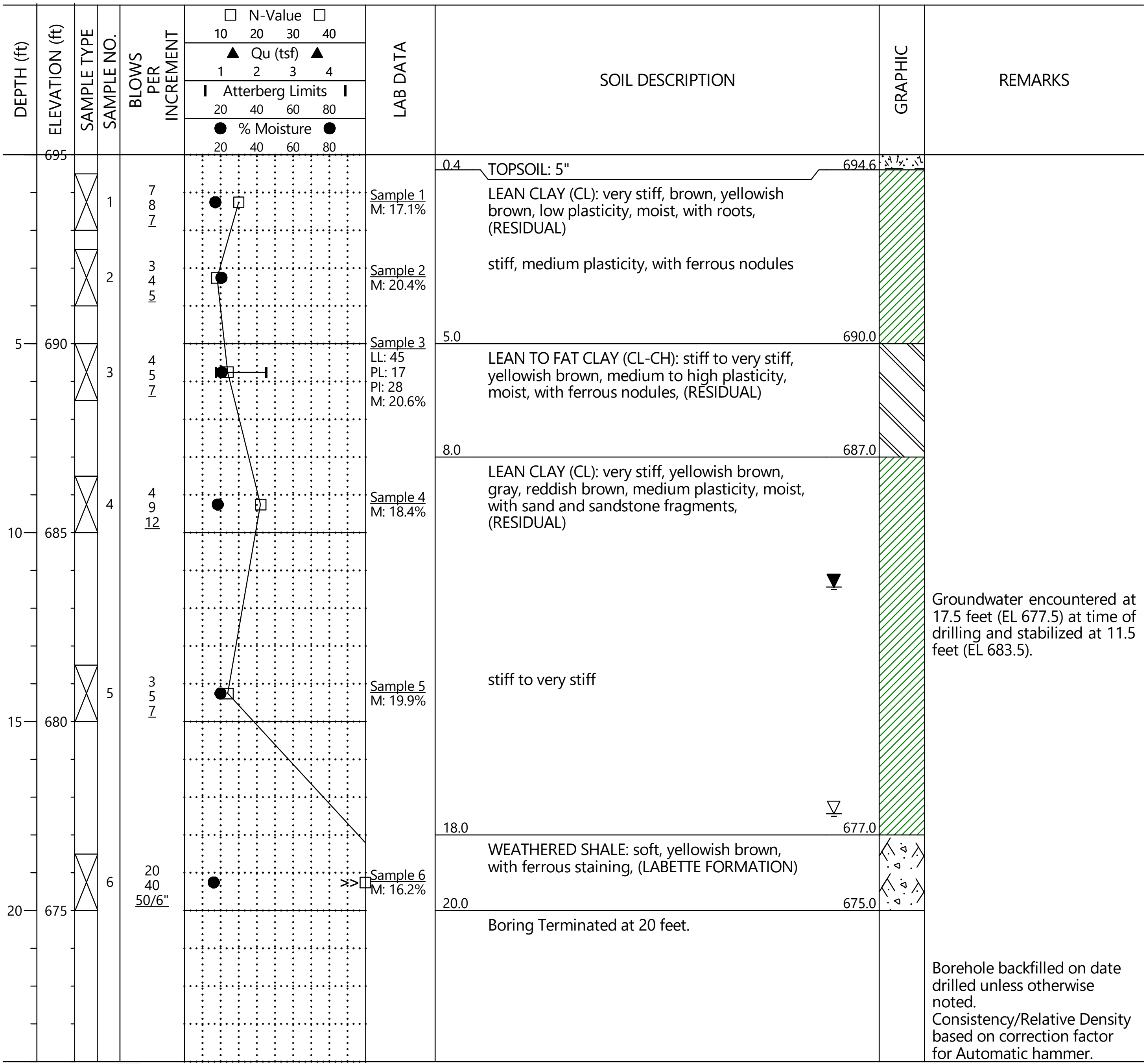
LOG OF BORING
Designation: B-07
Sheet 1 of 1

PROJECT NAME: Cherokee Nation Child Development Center
PROJECT NUMBER: TU230102
DRILLING METHOD: Solid Flight Auger
EQUIPMENT USED: CME 550X ATV
HAMMER TYPE: Automatic
BORING LOCATION: 36.170572, -95.763509
LOCATION: Catoosa, OK
DATE DRILLED: 6/26/23
WEATHER: Sunny
ELEVATION: 695
DRILL CREW: DSO
LOGGED BY: S.Harris



SAMPLE NO.	BLOWS PER INCREMENT	LAB DATA
1	7 8 7	Sample 1 M: 17.1%
2	3 4 5	Sample 2 M: 20.4%
3	4 5 7	Sample 3 LL: 45 PL: 17 PI: 28 M: 20.6%
4	4 9 12	Sample 4 M: 18.4%
5	3 5 7	Sample 5 M: 19.9%
6	20 40 50/6"	Sample 6 M: 16.2%

	SOIL DESCRIPTION	
0.4	TOPSOIL: 5"	694.6
	LEAN CLAY (CL): very stiff, brown, yellowish brown, low plasticity, moist, with roots, (RESIDUAL) stiff, medium plasticity, with ferrous nodules	
5.0		690.0
	LEAN TO FAT CLAY (CL-CH): stiff to very stiff, yellowish brown, medium to high plasticity, moist, with ferrous nodules, (RESIDUAL)	
8.0		687.0
	LEAN CLAY (CL): very stiff, yellowish brown, gray, reddish brown, medium plasticity, moist, with sand and sandstone fragments, (RESIDUAL) stiff to very stiff	
18.0		677.0
	WEATHERED SHALE: soft, yellowish brown, with ferrous staining, (LABETTE FORMATION)	
20.0		675.0
	Boring Terminated at 20 feet.	

REMARKS:

Groundwater encountered at 17.5 feet (EL 677.5) at time of drilling and stabilized at 11.5 feet (EL 683.5).

Borehole backfilled on date drilled unless otherwise noted.
Consistency/Relative Density based on correction factor for Automatic hammer.

SAMPLE TYPE ☒ Split Spoon

N-VALUE STANDARD PENETRATION RESISTANCE (AASHTO T-206)
% MOISTURE PERCENT NATURAL MOISTURE CONTENT
▽ GROUNDWATER LEVEL IN THE BOREHOLE AT TIME OF DRILLING
▼ STABILIZED GROUNDWATER LEVEL
REC RECOVERY
RQD ROCK QUALITY DESIGNATION
UD UNDISTURBED
Qu POCKET PENETROMETER UNCONFINED COMPRESSIVE STRENGTH
LL: LIQUID LIMIT
PL: PLASTIC LIMIT
PI: PLASTICITY INDEX
M: NATURAL MOISTURE CONTENT
F: PERCENT PASSING NO. 200 SIEVE

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LOG OF BORING
Designation: B-08
Sheet 1 of 1

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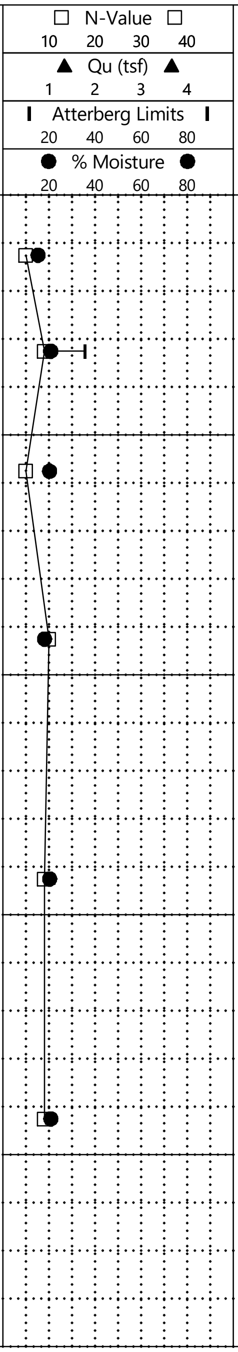
Office: (918) 439-9005

PROJECT NAME:	Cherokee Nation Child Development Center	LOCATION:	Catoosa, OK
PROJECT NUMBER:	TU230102	DATE DRILLED:	6/26/23
DRILLING METHOD:	Solid Flight Auger	WEATHER:	Sunny
EQUIPMENT USED:	CME 550X ATV	ELEVATION:	692
HAMMER TYPE:	Automatic	DRILL CREW:	DSO
BORING LOCATION:	36.170354, -95.763510	LOGGED BY:	S.Harris



DEPTH (ft)	ELEVATION (ft)	SAMPLE TYPE	SAMPLE NO.	BLOWS PER INCREMENT	LAB DATA	SOIL DESCRIPTION	REMARKS
0.5	691.5					TOPSOIL: 6"	
		☒	1	2 2 3	Sample 1 M: 15.3%	LEAN CLAY with SAND (CL): medium stiff, brown, very dark brown, medium plasticity, moist, with trace fine roots and limestone fragments, (RESIDUAL)	
	690	☒	2	2 4 5	Sample 2 LL: 35 PL: 19 PI: 16 M: 20.8% F: 83.8%	stiff, reddish brown	
5		☒	3	2 2 3	Sample 3 M: 20.3%	medium stiff, grayish brown, with ferrous nodules	
	685	☒	4	3 5 5	Sample 4 M: 18.1%	stiff, reddish brown, grayish brown, with sand	
10	680						
		☒	5	3 4 5	Sample 5 M: 20.3%		
15	675						Groundwater encountered at 16.5 feet (EL 675.5) at time of drilling and stabilized at 14.5 feet (EL 677.5).
18.0	674.0					SANDY LEAN CLAY (CL): stiff, yellowish brown, low plasticity, wet, with sandstone fragments, (RESIDUAL)	
		☒	6	3 3 6	Sample 6 M: 20.8%		
20.0	672.0					Boring Terminated at 20 feet.	
	670						Borehole backfilled on date drilled unless otherwise noted. Consistency/Relative Density based on correction factor for Automatic hammer.

SAMPLE TYPE ☒ Split Spoon

N-VALUE	STANDARD PENETRATION RESISTANCE (AASHTO T-206)	**REC**	RECOVERY	**LL:**	LIQUID LIMIT
% MOISTURE	PERCENT NATURAL MOISTURE CONTENT	**RQD**	ROCK QUALITY DESIGNATION	**PL:**	PLASTIC LIMIT
∇	GROUNDWATER LEVEL IN THE BOREHOLE AT TIME OF DRILLING	**UD**	UNDISTURBED	**PI:**	PLASTICITY INDEX
▼	STABILIZED GROUNDWATER LEVEL	**Qu**	POCKET PENETROMETER UNCONFINED COMPRESSIVE STRENGTH		

M: NATURAL MOISTURE CONTENT
F: PERCENT PASSING NO. 200 SIEVE

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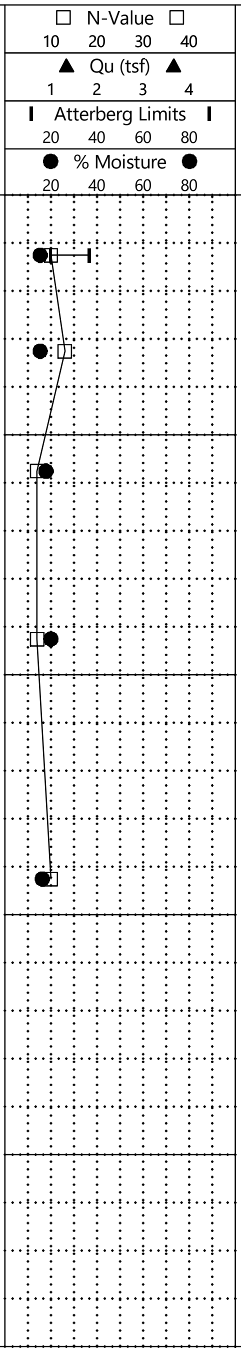
LOG OF BORING
Designation: B-09
Sheet 1 of 1

PROJECT NAME: Cherokee Nation Child Development Center
PROJECT NUMBER: TU230102
DRILLING METHOD: Solid Flight Auger
EQUIPMENT USED: CME 550X ATV
HAMMER TYPE: Automatic
BORING LOCATION: 36.170284, -95.763151
LOCATION: Catoosa, OK
DATE DRILLED: 6/27/23
WEATHER: Overcast
ELEVATION: 684
DRILL CREW: DSO
LOGGED BY: S.Harris



DEPTH (ft)	ELEVATION (ft)	SAMPLE TYPE	SAMPLE NO.	BLOWS PER INCREMENT	LAB DATA	SOIL DESCRIPTION	REMARKS
0.1	683.9					TOPSOIL: 1"	
		☒	1	2 4 6	Sample 1 LL: 36 PL: 19 PI: 17 M: 15.3%	LEAN CLAY (CL): stiff, brown, yellow, medium plasticity, moist, with sandstone fragments, wood debris, and roots, (FILL)	
2.5	681.5	☒	2	6 6 7	Sample 2 M: 15.3%	LEAN CLAY (CL): very stiff, yellowish brown, reddish brown, medium plasticity, moist, with sandstone fragments and ferrous nodules, (RESIDUAL)	
	680						
5		☒	3	3 3 4	Sample 3 M: 17.8%	stiff, with trace fine roots	
	675	☒	4	4 3 4	Sample 4 M: 20.0%	gray, with sand pockets	
10							
	670	☒	5	5 4 6	Sample 5 M: 16.2%		
15.0	669.0					Boring Terminated at 15 feet.	
	665						
20							Groundwater not encountered at time of drilling. Borehole backfilled on date drilled unless otherwise noted. Consistency/Relative Density based on correction factor for Automatic hammer.
	660						

SAMPLE TYPE ☒ Split Spoon

N-VALUE STANDARD PENETRATION RESISTANCE (AASHTO T-206)
% MOISTURE PERCENT NATURAL MOISTURE CONTENT
▽ GROUNDWATER LEVEL IN THE BOREHOLE AT TIME OF DRILLING
▼ STABILIZED GROUNDWATER LEVEL
REC RECOVERY
RQD ROCK QUALITY DESIGNATION
UD UNDISTURBED
Qu POCKET PENETROMETER UNCONFINED COMPRESSIVE STRENGTH
LL: LIQUID LIMIT
PL: PLASTIC LIMIT
PI: PLASTICITY INDEX
M: NATURAL MOISTURE CONTENT
F: PERCENT PASSING NO. 200 SIEVE

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LOG OF BORING
Designation: B-10
Sheet 1 of 1

1403 S 70th E Ave
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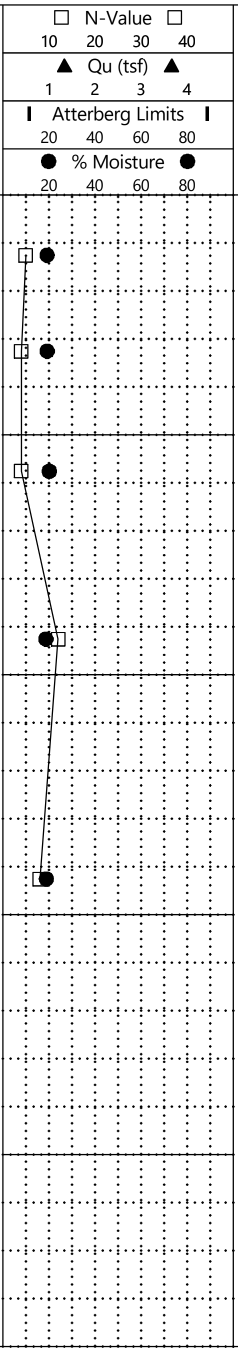
Office: (918) 439-9005

PROJECT NAME: Cherokee Nation Child Development Center
PROJECT NUMBER: TU230102
DRILLING METHOD: Solid Flight Auger
EQUIPMENT USED: CME 550X ATV
HAMMER TYPE: Automatic
BORING LOCATION: 36.170021, -95.763230

LOCATION: Catoosa, OK
DATE DRILLED: 6/27/23
WEATHER: Overcast
ELEVATION: 680
DRILL CREW: DSO
LOGGED BY: S.Harris

DEPTH (ft)	ELEVATION (ft)	SAMPLE TYPE	SAMPLE NO.	BLOWS PER INCREMENT	LAB DATA	SOIL DESCRIPTION	GRAPHIC	REMARKS
0	680							
0.5	679.5					TOPSOIL: 6"		
		☒	1	2 2 3	Sample 1 M: 19.2%	LEAN CLAY (CL): medium stiff, reddish brown, low plasticity, moist, with trace fine roots, (RESIDUAL)	▨	
		☒	2	2 2 2	Sample 2 M: 19.2%	brown, medium plasticity	▨	
5	675						▨	
		☒	3	1 2 2	Sample 3 M: 20.1%		▨	
7.0	673.0					LEAN CLAY (CL): stiff to very stiff, reddish brown, brown, yellowish brown, medium plasticity, moist, with sand and ferrous staining, (RESIDUAL)	▨	
		☒	4	4 5 7	Sample 4 M: 18.7%		▨	
10	670						▨	
		☒	5	4 3 5	Sample 5 M: 18.9%	stiff, light brown	▨	
15.0	665.0					Boring Terminated at 15 feet.		
20	660							Groundwater not encountered at time of drilling. Borehole backfilled on date drilled unless otherwise noted. Consistency/Relative Density based on correction factor for Automatic hammer.



SAMPLE TYPE ☒ Split Spoon

N-VALUE STANDARD PENETRATION RESISTANCE (AASHTO T-206)
% MOISTURE PERCENT NATURAL MOISTURE CONTENT
∇ GROUNDWATER LEVEL IN THE BOREHOLE AT TIME OF DRILLING
▼ STABILIZED GROUNDWATER LEVEL
REC RECOVERY
RQD ROCK QUALITY DESIGNATION
UD UNDISTURBED
Qu POCKET PENETROMETER UNCONFINED COMPRESSIVE STRENGTH
LL: LIQUID LIMIT
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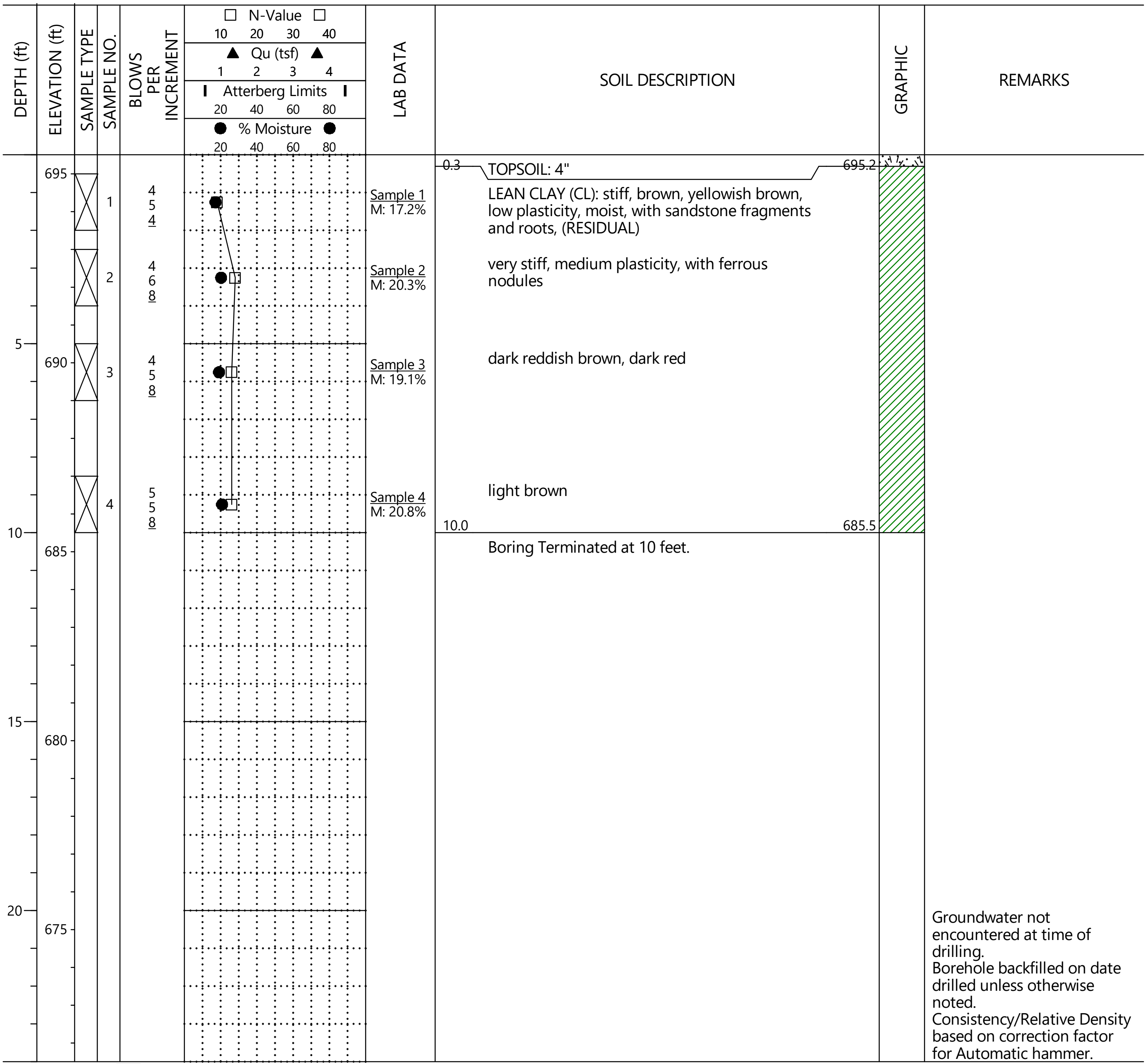
LOG OF BORING

Designation: P-01

Sheet 1 of 1

PROJECT NAME: Cherokee Nation Child Development Center
PROJECT NUMBER: TU230102
DRILLING METHOD: Solid Flight Auger
EQUIPMENT USED: CME 550X ATV
HAMMER TYPE: Automatic
BORING LOCATION: 36.170133, -95.764337

LOCATION: Catoosa, OK
DATE DRILLED: 6/27/23
WEATHER: Overcast
ELEVATION: 695.5
DRILL CREW: DSO
LOGGED BY: S.Harris



DEPTH (ft)	ELEVATION (ft)	SAMPLE TYPE	SAMPLE NO.	BLOWS PER INCREMENT	LAB DATA	SOIL DESCRIPTION
0.3	695.2					TOPSOIL: 4"
		☒	1	4 5 4	Sample 1 M: 17.2%	LEAN CLAY (CL): stiff, brown, yellowish brown, low plasticity, moist, with sandstone fragments and roots, (RESIDUAL)
		☒	2	4 6 8	Sample 2 M: 20.3%	very stiff, medium plasticity, with ferrous nodules
		☒	3	4 5 8	Sample 3 M: 19.1%	dark reddish brown, dark red
		☒	4	5 5 8	Sample 4 M: 20.8%	light brown
10.0	685.5					Boring Terminated at 10 feet.

REMARKS:
Groundwater not encountered at time of drilling.
Borehole backfilled on date drilled unless otherwise noted.
Consistency/Relative Density based on factor for Automatic hammer.

SAMPLE TYPE ☒ Split Spoon

N-VALUE STANDARD PENETRATION RESISTANCE (AASHTO T-206)
% MOISTURE PERCENT NATURAL MOISTURE CONTENT
∇ GROUNDWATER LEVEL IN THE BOREHOLE AT TIME OF DRILLING
▼ STABILIZED GROUNDWATER LEVEL
REC RECOVERY
RQD ROCK QUALITY DESIGNATION
UD UNDISTURBED
Qu POCKET PENETROMETER UNCONFINED COMPRESSIVE STRENGTH
LL: LIQUID LIMIT
PL: PLASTIC LIMIT
PI: PLASTICITY INDEX
M: NATURAL MOISTURE CONTENT
F: PERCENT PASSING NO. 200 SIEVE

LOG OF BORING

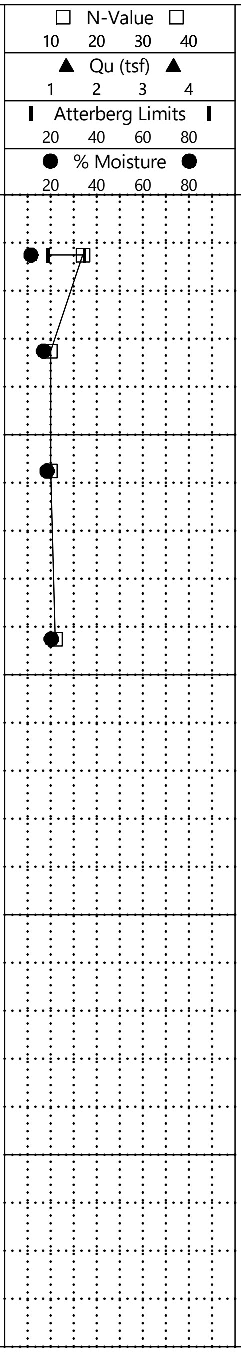
Designation: P-02

Sheet 1 of 1

1403 S 70th E Ave
Tulsa, OK 74112
Office: (918) 439-9005

PROJECT NAME: Cherokee Nation Child Development Center
PROJECT NUMBER: TU230102
DRILLING METHOD: Solid Flight Auger
EQUIPMENT USED: CME 550X ATV
HAMMER TYPE: Automatic
BORING LOCATION: 36.169783, -95.764319

LOCATION: Catoosa, OK
DATE DRILLED: 6/27/23
WEATHER: Overcast
ELEVATION: 691
DRILL CREW: DSO
LOGGED BY: S.Harris



DEPTH (ft)	ELEVATION (ft)	SAMPLE TYPE	SAMPLE NO.	BLOWS PER INCREMENT	LAB DATA	SOIL DESCRIPTION	REMARKS
0.3	690.7					TOPSOIL: 4"	
	690	☒	1	9 8 9	Sample 1 LL: 34 PL: 19 PI: 15 M: 11.4% F: 83.9%	LEAN CLAY with SAND (CL): very stiff, brown, yellowish brown, low to medium plasticity, moist, with broken concrete, tree limbs, and fine roots, (FILL)	
2.0	689.0						
		☒	2	4 4 6	Sample 2 M: 16.9%	LEAN CLAY (CL): stiff, very dark brown, very dark red, medium plasticity, moist, (RESIDUAL)	
5	685	☒	3	6 5 5	Sample 3 M: 18.4%	gray, grayish brown	
		☒	4	3 5 6	Sample 4 M: 20.2%	light gray, wet, with ferrous staining	
10.0	681.0					Boring Terminated at 10 feet.	
10	680						
15	675						
20	670						Groundwater not encountered at time of drilling. Borehole backfilled on date drilled unless otherwise noted. Consistency/Relative Density based on factor for Automatic hammer.

SAMPLE TYPE ☒ Split Spoon

N-VALUE STANDARD PENETRATION RESISTANCE (AASHTO T-206)
% MOISTURE PERCENT NATURAL MOISTURE CONTENT
∇ GROUNDWATER LEVEL IN THE BOREHOLE AT TIME OF DRILLING
▼ STABILIZED GROUNDWATER LEVEL

REC RECOVERY
RQD ROCK QUALITY DESIGNATION
UD UNDISTURBED
Qu POCKET PENETROMETER UNCONFINED COMPRESSIVE STRENGTH

LL: LIQUID LIMIT
PL: PLASTIC LIMIT
PI: PLASTICITY INDEX
M: NATURAL MOISTURE CONTENT
F: PERCENT PASSING NO. 200 SIEVE

BUILDING & EARTH
Geotechnical, Environmental, and Materials Engineers

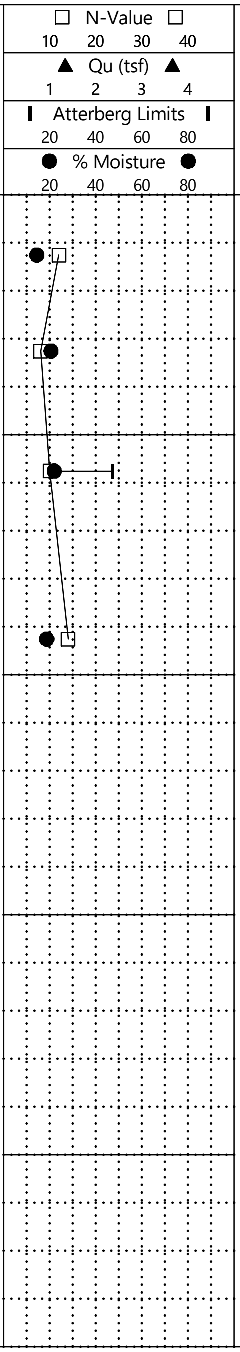
LOG OF BORING

Designation: P-03

Sheet 1 of 1

1403 S 70th E Ave
Tulsa, OK 74112
Office: (918) 439-9005

PROJECT NAME:	Cherokee Nation Child Development Center	LOCATION:	Catoosa, OK
PROJECT NUMBER:	TU230102	DATE DRILLED:	6/27/23
DRILLING METHOD:	Solid Flight Auger	WEATHER:	Overcast
EQUIPMENT USED:	CME 550X ATV	ELEVATION:	687
HAMMER TYPE:	Automatic	DRILL CREW:	DSO
BORING LOCATION:	36.169845, -95.763975	LOGGED BY:	S.Harris



DEPTH (ft)	ELEVATION (ft)	SAMPLE TYPE	SAMPLE NO.	BLOWS PER INCREMENT	LAB DATA	SOIL DESCRIPTION	GRAPHIC	REMARKS
0.3	686.7					TOPSOIL: 4"		
2.5	684.5	☒	1	7 7 5	Sample 1 M: 14.4%	LEAN CLAY with Silt (CL): stiff to very stiff, brown, low plasticity, moist, with roots, (FILL)		
5.0	682.0	☒	2	3 4 4	Sample 2 M: 20.5%	LEAN CLAY (CL): stiff, brown, red, yellow, medium plasticity, moist, with sandstone fragments and ferrous nodules, (RESIDUAL)		
		☒	3	3 5 5	Sample 3 LL: 47 PL: 20 PI: 27 M: 22.0%	LEAN TO FAT CLAY (CL-CH): stiff, brown, medium to high plasticity, moist, with ferrous staining and nodules, (RESIDUAL)		
10.0	677.0	☒	4	5 5 9	Sample 4 M: 18.7%	very stiff, reddish brown		
						Boring Terminated at 10 feet.		Groundwater not encountered at time of drilling. Borehole backfilled on date drilled unless otherwise noted. Consistency/Relative Density based on correction factor for Automatic hammer.

Depth scale: 5, 10, 15, 20. Elevation scale: 685, 680, 675, 670, 665.

SAMPLE TYPE ☒ Split Spoon

N-VALUE STANDARD PENETRATION RESISTANCE (AASHTO T-206)
% MOISTURE PERCENT NATURAL MOISTURE CONTENT
▽ GROUNDWATER LEVEL IN THE BOREHOLE AT TIME OF DRILLING
▼ STABILIZED GROUNDWATER LEVEL
REC RECOVERY
RQD ROCK QUALITY DESIGNATION
UD UNDISTURBED
Qu POCKET PENETROMETER UNCONFINED COMPRESSIVE STRENGTH
LL: LIQUID LIMIT
PL: PLASTIC LIMIT
PI: PLASTICITY INDEX
M: NATURAL MOISTURE CONTENT
F: PERCENT PASSING NO. 200 SIEVE

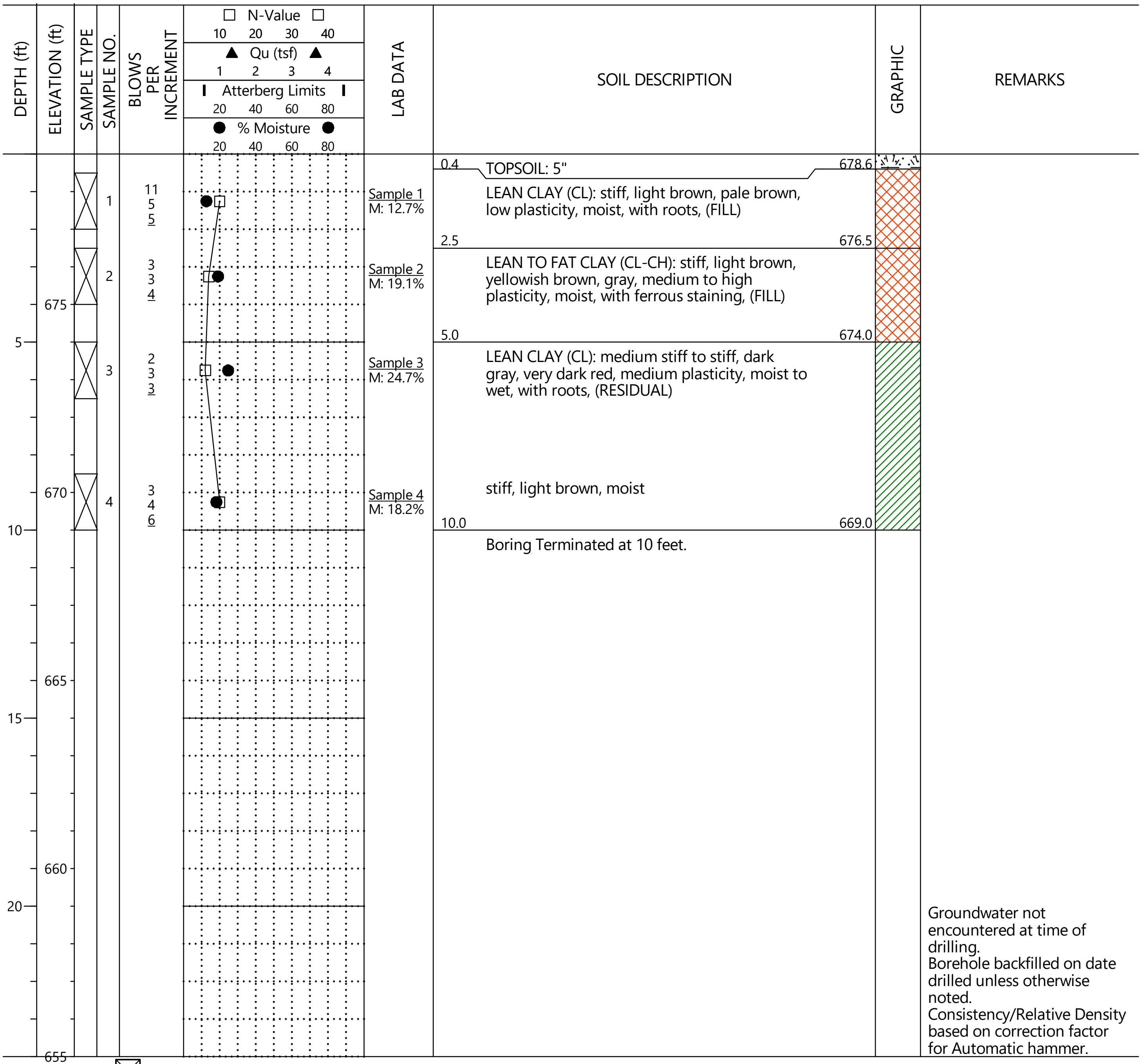
LOG OF BORING

Designation: P-04

Sheet 1 of 1

1403 S 70th E Ave
Tulsa, OK 74112
Office: (918) 439-9005

PROJECT NAME:	Cherokee Nation Child Development Center	LOCATION:	Catoosa, OK
PROJECT NUMBER:	TU230102	DATE DRILLED:	6/27/23
DRILLING METHOD:	Solid Flight Auger	WEATHER:	Overcast
EQUIPMENT USED:	CME 550X ATV	ELEVATION:	679
HAMMER TYPE:	Automatic	DRILL CREW:	DSO
BORING LOCATION:	36.169463, -95.764090	LOGGED BY:	S.Harris



DEPTH (ft)	ELEVATION (ft)	SAMPLE TYPE	SAMPLE NO.	BLOWS PER INCREMENT	LAB DATA	SOIL DESCRIPTION	REMARKS
0.4	678.6					TOPSOIL: 5"	
2.5	676.5	☒	1	11 5 5	Sample 1 M: 12.7%	LEAN CLAY (CL): stiff, light brown, pale brown, low plasticity, moist, with roots, (FILL)	
5.0	674.0	☒	2	3 3 4	Sample 2 M: 19.1%	LEAN TO FAT CLAY (CL-CH): stiff, light brown, yellowish brown, gray, medium to high plasticity, moist, with ferrous staining, (FILL)	
		☒	3	2 3 3	Sample 3 M: 24.7%	LEAN CLAY (CL): medium stiff to stiff, dark gray, very dark red, medium plasticity, moist to wet, with roots, (RESIDUAL)	
10.0	669.0	☒	4	3 4 6	Sample 4 M: 18.2%	stiff, light brown, moist	
						Boring Terminated at 10 feet.	

Groundwater not encountered at time of drilling.
Borehole backfilled on date drilled unless otherwise noted.
Consistency/Relative Density based on correction factor for Automatic hammer.

SAMPLE TYPE ☒ Split Spoon

N-VALUE STANDARD PENETRATION RESISTANCE (AASHTO T-206)
% MOISTURE PERCENT NATURAL MOISTURE CONTENT
∇ GROUNDWATER LEVEL IN THE BOREHOLE AT TIME OF DRILLING
▼ STABILIZED GROUNDWATER LEVEL
REC RECOVERY
RQD ROCK QUALITY DESIGNATION
UD UNDISTURBED
Qu POCKET PENETROMETER UNCONFINED COMPRESSIVE STRENGTH
LL: LIQUID LIMIT
PL: PLASTIC LIMIT
PI: PLASTICITY INDEX
M: NATURAL MOISTURE CONTENT
F: PERCENT PASSING NO. 200 SIEVE

BUILDING & EARTH
Geotechnical, Environmental, and Materials Engineers

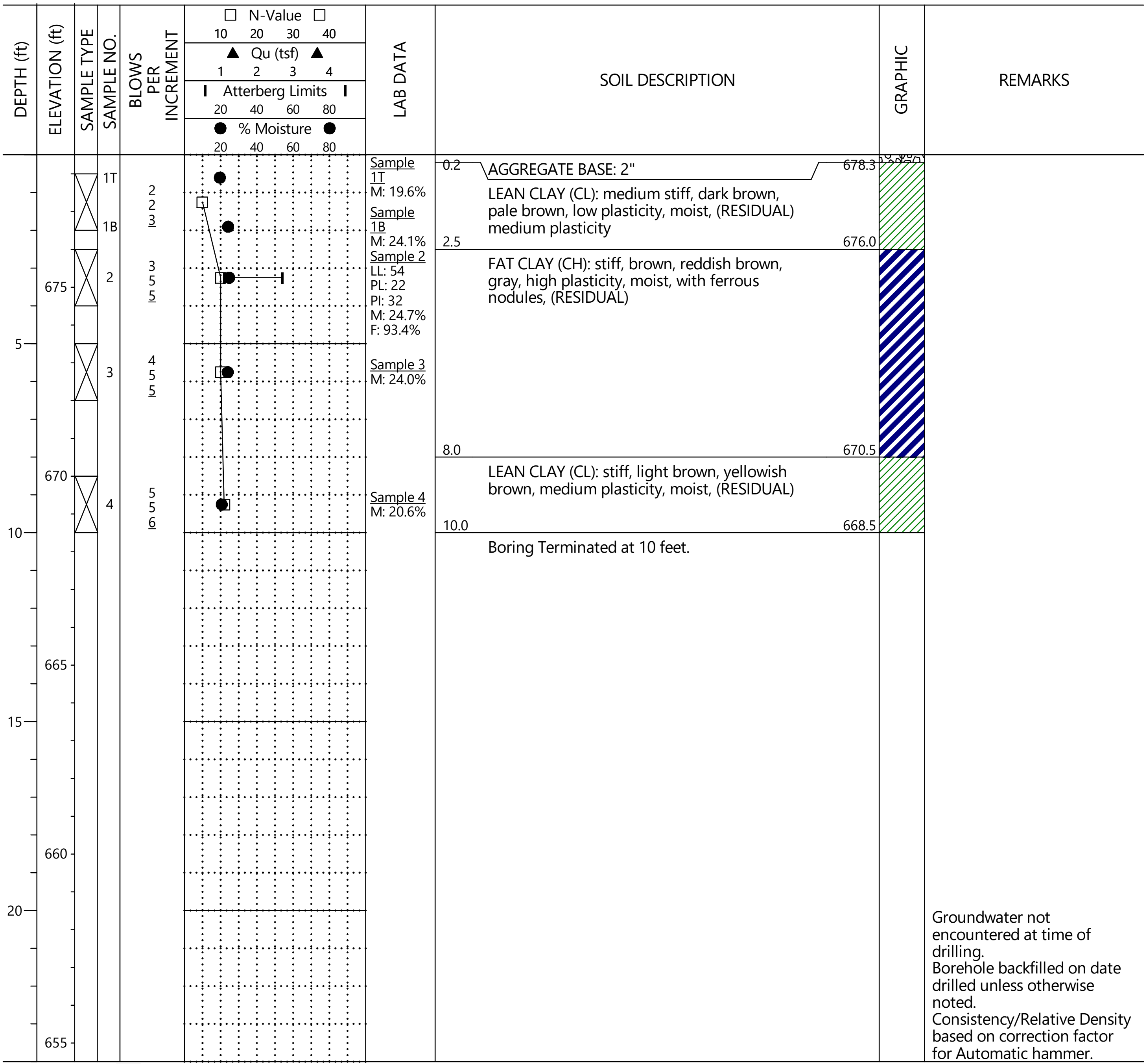
LOG OF BORING

Designation: P-05

Sheet 1 of 1

1403 S 70th E Ave
Tulsa, OK 74112
Office: (918) 439-9005

PROJECT NAME:	Cherokee Nation Child Development Center	LOCATION:	Catoosa, OK
PROJECT NUMBER:	TU230102	DATE DRILLED:	6/27/23
DRILLING METHOD:	Solid Flight Auger	WEATHER:	Overcast
EQUIPMENT USED:	CME 550X ATV	ELEVATION:	678.5
HAMMER TYPE:	Automatic	DRILL CREW:	DSO
BORING LOCATION:	36.169574, -95.763669	LOGGED BY:	S.Harris



SAMPLE NO.	BLOWS PER INCREMENT	LAB DATA
1T		Sample 1T M: 19.6%
1B	2 2 3	Sample 1B M: 24.1%
2	3 5 5	Sample 2 LL: 54 PL: 22 PI: 32 M: 24.7% F: 93.4%
3	4 5 5	Sample 3 M: 24.0%
4	5 5 6	Sample 4 M: 20.6%

Depth	SOIL DESCRIPTION	Elevation
0.2	AGGREGATE BASE: 2"	678.3
2.5	LEAN CLAY (CL): medium stiff, dark brown, pale brown, low plasticity, moist, (RESIDUAL) medium plasticity	676.0
8.0	FAT CLAY (CH): stiff, brown, reddish brown, gray, high plasticity, moist, with ferrous nodules, (RESIDUAL)	670.5
10.0	LEAN CLAY (CL): stiff, light brown, yellowish brown, medium plasticity, moist, (RESIDUAL)	668.5
	Boring Terminated at 10 feet.	

REMARKS: Groundwater not encountered at time of drilling.
Borehole backfilled on date drilled unless otherwise noted.
Consistency/Relative Density based on correction factor for Automatic hammer.

SAMPLE TYPE ☒ Split Spoon

N-VALUE	STANDARD PENETRATION RESISTANCE (AASHTO T-206)	**REC**	RECOVERY	**LL:** LIQUID LIMIT	**M:** NATURAL MOISTURE CONTENT
% MOISTURE	PERCENT NATURAL MOISTURE CONTENT	**RQD**	ROCK QUALITY DESIGNATION	**PL:** PLASTIC LIMIT	**F:** PERCENT PASSING NO. 200 SIEVE
▽	GROUNDWATER LEVEL IN THE BOREHOLE AT TIME OF DRILLING	**UD**	UNDISTURBED	**PI:** PLASTICITY INDEX	
▼	STABILIZED GROUNDWATER LEVEL	**Qu**	POCKET PENETROMETER UNCONFINED COMPRESSIVE STRENGTH		

BUILDING & EARTH
Geotechnical, Environmental, and Materials Engineers

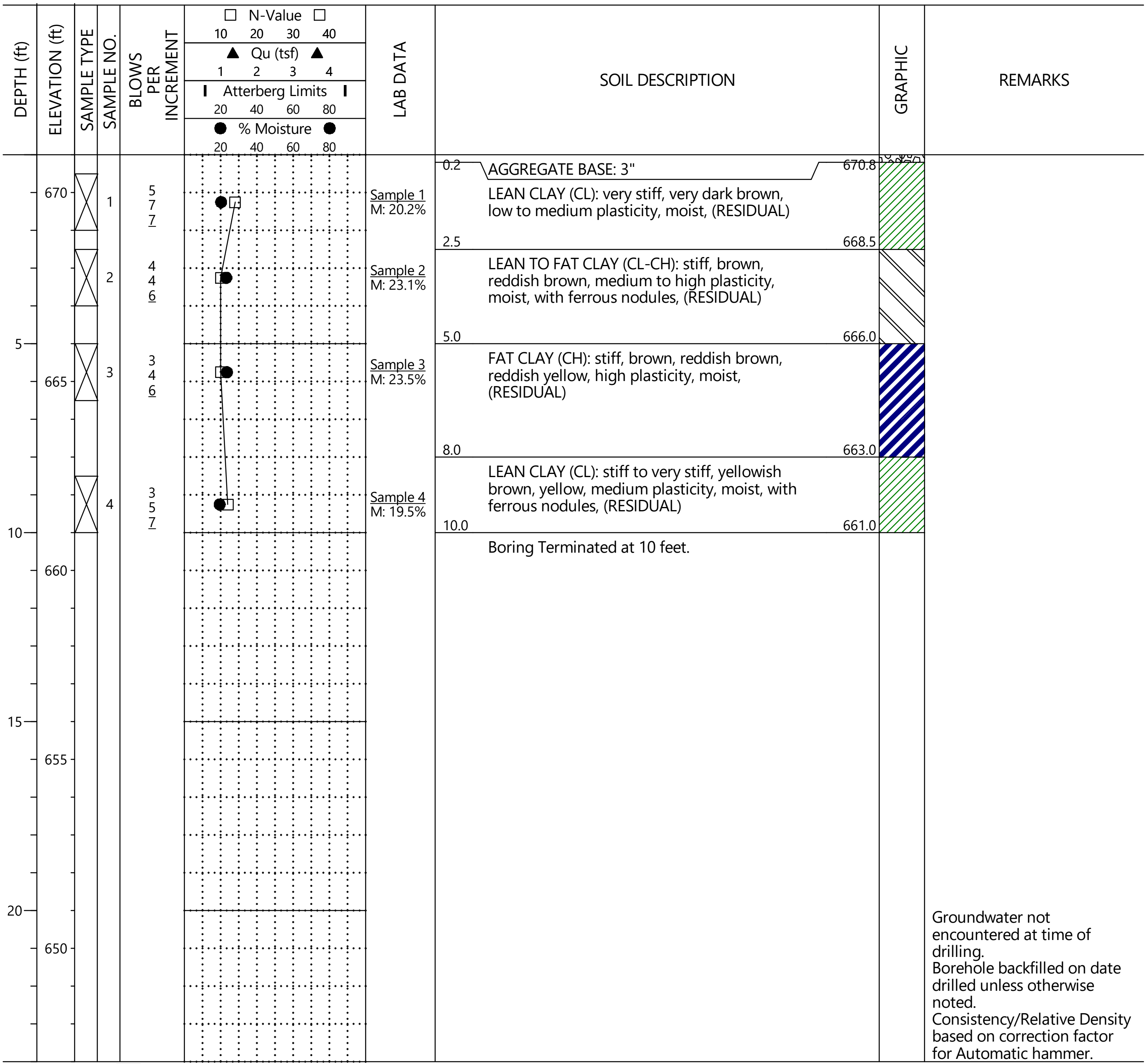
LOG OF BORING

Designation: P-06

Sheet 1 of 1

1403 S 70th E Ave
Tulsa, OK 74112
Office: (918) 439-9005

PROJECT NAME:	Cherokee Nation Child Development Center	LOCATION:	Catoosa, OK
PROJECT NUMBER:	TU230102	DATE DRILLED:	6/27/23
DRILLING METHOD:	Solid Flight Auger	WEATHER:	Overcast
EQUIPMENT USED:	CME 550X ATV	ELEVATION:	671
HAMMER TYPE:	Automatic	DRILL CREW:	DSO
BORING LOCATION:	36.169399, -95.763177	LOGGED BY:	S.Harris



SAMPLE NO.	BLOWS PER INCREMENT	LAB DATA
1	5 7 7	Sample 1 M: 20.2%
2	4 4 6	Sample 2 M: 23.1%
3	3 4 6	Sample 3 M: 23.5%
4	3 5 7	Sample 4 M: 19.5%

	SOIL DESCRIPTION	
0.2	AGGREGATE BASE: 3"	670.8
	LEAN CLAY (CL): very stiff, very dark brown, low to medium plasticity, moist, (RESIDUAL)	
2.5		668.5
	LEAN TO FAT CLAY (CL-CH): stiff, brown, reddish brown, medium to high plasticity, moist, with ferrous nodules, (RESIDUAL)	
5.0		666.0
	FAT CLAY (CH): stiff, brown, reddish brown, reddish yellow, high plasticity, moist, (RESIDUAL)	
8.0		663.0
	LEAN CLAY (CL): stiff to very stiff, yellowish brown, yellow, medium plasticity, moist, with ferrous nodules, (RESIDUAL)	
10.0		661.0
	Boring Terminated at 10 feet.	

REMARKS

Groundwater not encountered at time of drilling.
Borehole backfilled on date drilled unless otherwise noted.
Consistency/Relative Density based on correction factor for Automatic hammer.

SAMPLE TYPE ☒ Split Spoon

N-VALUE	STANDARD PENETRATION RESISTANCE (AASHTO T-206)	**REC**	RECOVERY	**LL:**	LIQUID LIMIT **M:** NATURAL MOISTURE CONTENT
% MOISTURE	PERCENT NATURAL MOISTURE CONTENT	**RQD**	ROCK QUALITY DESIGNATION	**PL:**	PLASTIC LIMIT **F:** PERCENT PASSING NO. 200 SIEVE
▽	GROUNDWATER LEVEL IN THE BOREHOLE AT TIME OF DRILLING	**UD**	UNDISTURBED	**PI:**	PLASTICITY INDEX
▼	STABILIZED GROUNDWATER LEVEL	**Qu**	POCKET PENETROMETER UNCONFINED COMPRESSIVE STRENGTH		

BUILDING & EARTH
Geotechnical, Environmental, and Materials Engineers

LOG OF BORING

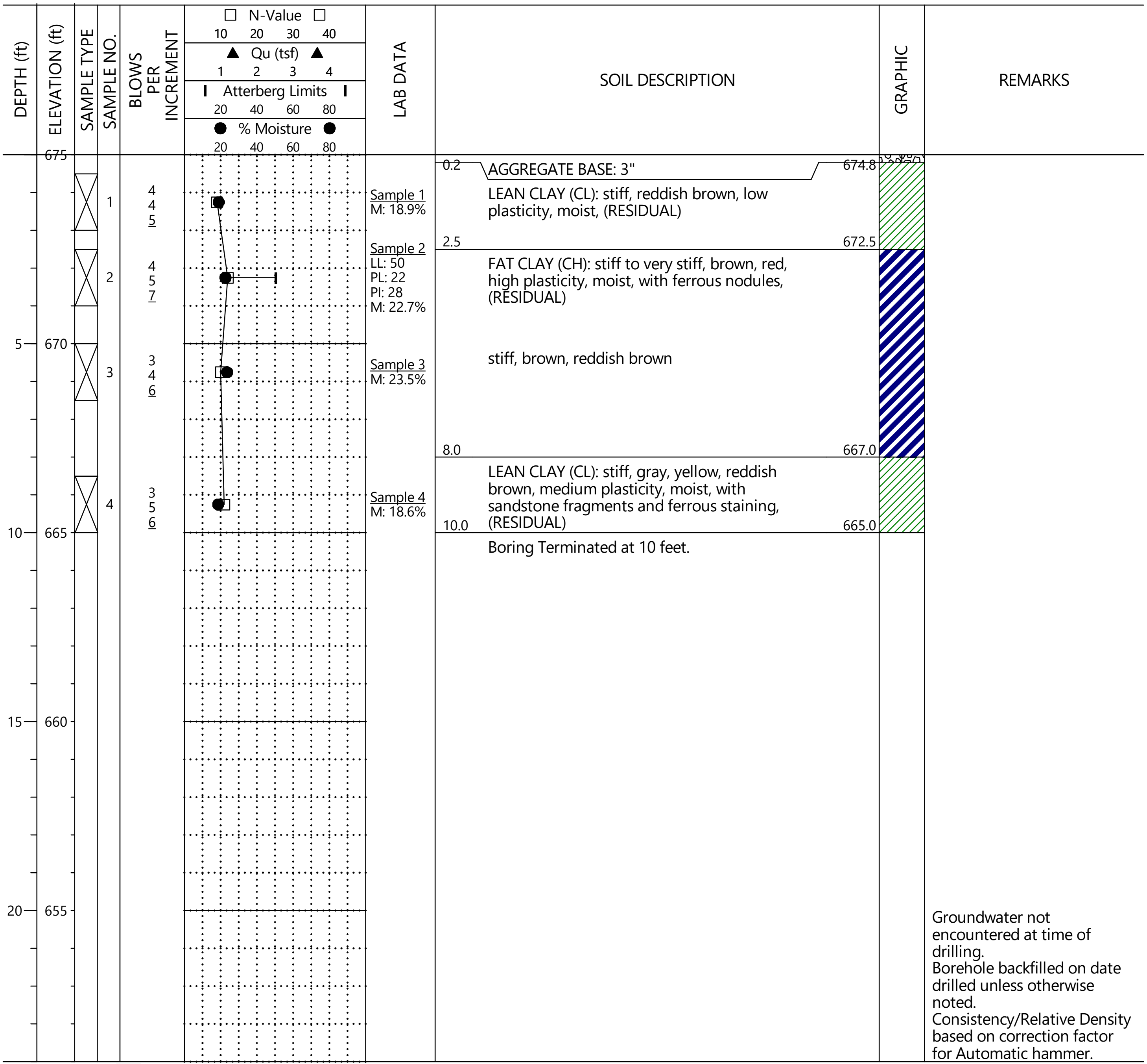
Designation: P-07

Sheet 1 of 1

1403 S 70th E Ave
Tulsa, OK 74112
Office: (918) 439-9005

PROJECT NAME: Cherokee Nation Child Development Center
PROJECT NUMBER: TU230102
DRILLING METHOD: Solid Flight Auger
EQUIPMENT USED: CME 550X ATV
HAMMER TYPE: Automatic
BORING LOCATION: 36.169732, -95.763137

LOCATION: Catoosa, OK
DATE DRILLED: 6/27/23
WEATHER: Overcast
ELEVATION: 675
DRILL CREW: DSO
LOGGED BY: S.Harris



DEPTH (ft)	ELEVATION (ft)	SAMPLE TYPE	SAMPLE NO.	BLOWS PER INCREMENT	LAB DATA	SOIL DESCRIPTION	REMARKS
0.2	674.8					AGGREGATE BASE: 3"	
		☒	1	4 4 5	Sample 1 M: 18.9%	LEAN CLAY (CL): stiff, reddish brown, low plasticity, moist, (RESIDUAL)	
2.5	672.5	☒	2	4 5 7	Sample 2 LL: 50 PL: 22 PI: 28 M: 22.7%	FAT CLAY (CH): stiff to very stiff, brown, red, high plasticity, moist, with ferrous nodules, (RESIDUAL)	
5	670	☒	3	3 4 6	Sample 3 M: 23.5%	stiff, brown, reddish brown	
8.0	667.0	☒	4	3 5 6	Sample 4 M: 18.6%	LEAN CLAY (CL): stiff, gray, yellow, reddish brown, medium plasticity, moist, with sandstone fragments and ferrous staining, (RESIDUAL)	
10.0	665.0					Boring Terminated at 10 feet.	
15	660						
20	655						Groundwater not encountered at time of drilling. Borehole backfilled on date drilled unless otherwise noted. Consistency/Relative Density based on correction factor for Automatic hammer.

SAMPLE TYPE ☒ Split Spoon

N-VALUE	STANDARD PENETRATION RESISTANCE (AASHTO T-206)	**REC**	RECOVERY	**LL:**	LIQUID LIMIT	**M:**	NATURAL MOISTURE CONTENT
% MOISTURE	PERCENT NATURAL MOISTURE CONTENT	**RQD**	ROCK QUALITY DESIGNATION	**PL:**	PLASTIC LIMIT	**F:**	PERCENT PASSING NO. 200 SIEVE
▽	GROUNDWATER LEVEL IN THE BOREHOLE AT TIME OF DRILLING	**UD**	UNDISTURBED	**PI:**	PLASTICITY INDEX		
▼	STABILIZED GROUNDWATER LEVEL	**Qu**	POCKET PENETROMETER UNCONFINED COMPRESSIVE STRENGTH				

BUILDING & EARTH
Geotechnical, Environmental, and Materials Engineers

LOG OF BORING

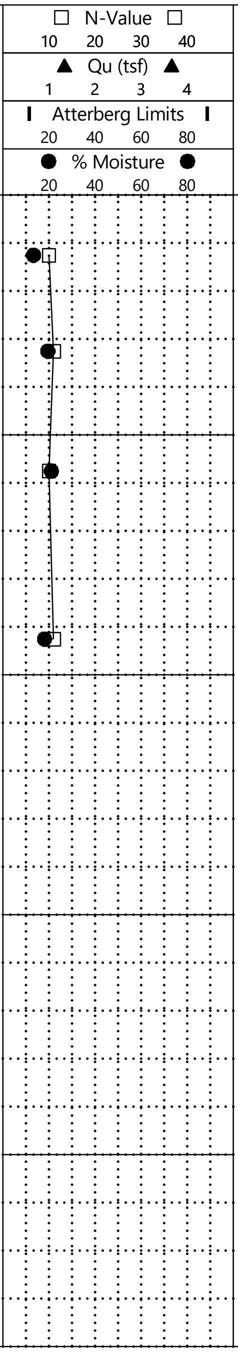
Designation: P-08

Sheet 1 of 1

1403 S 70th E Ave
Tulsa, OK 74112
Office: (918) 439-9005

PROJECT NAME: Cherokee Nation Child Development Center
PROJECT NUMBER: TU230102
DRILLING METHOD: Solid Flight Auger
EQUIPMENT USED: CME 550X ATV
HAMMER TYPE: Automatic
BORING LOCATION: 36.169734, -95.762638

LOCATION: Catoosa, OK
DATE DRILLED: 6/27/23
WEATHER: Partly Cloudy
ELEVATION: 689.5
DRILL CREW: DSO
LOGGED BY: S.Harris



DEPTH (ft)	ELEVATION (ft)	SAMPLE TYPE	SAMPLE NO.	BLOWS PER INCREMENT	LAB DATA	SOIL DESCRIPTION	GRAPHIC	REMARKS
0.1	689.4					TOPSOIL: 1"		
		☒	1	9 5 5	Sample 1 M: 13.2%	LEAN CLAY (CL): stiff, brown, low plasticity, moist, with brick fragments and trace fine roots, (FILL)	▨	
		☒	2	4 5 6	Sample 2 M: 19.5%	red, with tree limbs and ferrous nodules	▨	
5.0	684.5							
5	685	☒	3	4 4 6	Sample 3 M: 21.0%	LEAN CLAY (CL): stiff, brown, yellowish brown, gray, medium plasticity, moist, with trace sand, (RESIDUAL)	▨	
	680	☒	4	4 5 6	Sample 4 M: 18.1%		▨	
10.0	679.5							
10						Boring Terminated at 10 feet.		
15	675							
20	670							Groundwater not encountered at time of drilling. Borehole backfilled on date drilled unless otherwise noted. Consistency/Relative Density based on correction factor for Automatic hammer.

SAMPLE TYPE ☒ Split Spoon

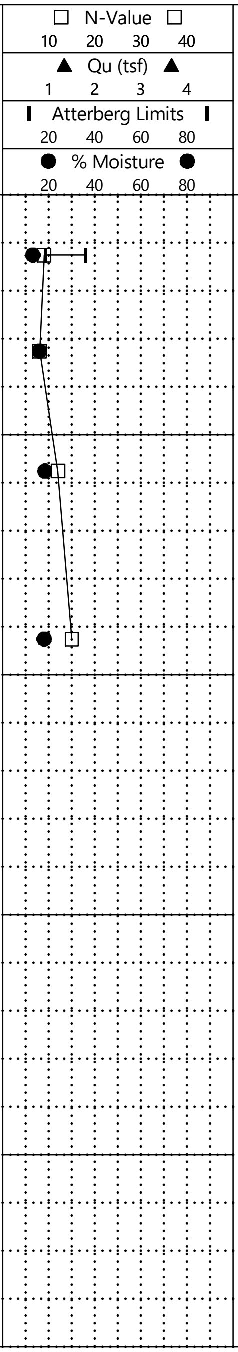
N-VALUE	STANDARD PENETRATION RESISTANCE (AASHTO T-206)	**REC**	RECOVERY	**LL:**	LIQUID LIMIT	**M:**	NATURAL MOISTURE CONTENT
% MOISTURE	PERCENT NATURAL MOISTURE CONTENT	**RQD**	ROCK QUALITY DESIGNATION	**PL:**	PLASTIC LIMIT	**F:**	PERCENT PASSING NO. 200 SIEVE
∇	GROUNDWATER LEVEL IN THE BOREHOLE AT TIME OF DRILLING	**UD**	UNDISTURBED	**PI:**	PLASTICITY INDEX		
▼	STABILIZED GROUNDWATER LEVEL	**Qu**	POCKET PENETROMETER UNCONFINED COMPRESSIVE STRENGTH				

BUILDING & EARTH
Geotechnical, Environmental, and Materials Engineers

LOG OF BORING
Designation: P-09
Sheet 1 of 1

1403 S 70th E Ave
Tulsa, OK 74112
Office: (918) 439-9005

PROJECT NAME:	Cherokee Nation Child Development Center	LOCATION:	Catoosa, OK
PROJECT NUMBER:	TU230102	DATE DRILLED:	6/27/23
DRILLING METHOD:	Solid Flight Auger	WEATHER:	Overcast
EQUIPMENT USED:	CME 550X ATV	ELEVATION:	687.5
HAMMER TYPE:	Automatic	DRILL CREW:	DSO
BORING LOCATION:	36.170501, -95.763206	LOGGED BY:	S.Harris



DEPTH (ft)	ELEVATION (ft)	SAMPLE TYPE	SAMPLE NO.	BLOWS PER INCREMENT	LAB DATA	SOIL DESCRIPTION	GRAPHIC	REMARKS
0.1	687.4					TOPSOIL: 2"		
		☒	1	4 4 5	Sample 1 LL: 36 PL: 18 PI: 18 M: 13.1%	LEAN CLAY (CL): stiff, brown, yellowish brown, medium plasticity, moist, with sandstone fragments and trace roots, (FILL)	▨	
2.5	685.0	☒	2	3 4 4	Sample 2 M: 16.0%	LEAN CLAY (CL): stiff, brown, reddish brown, medium plasticity, moist, with ferrous nodules and trace fine roots, (RESIDUAL)	▨	
5		☒	3	3 5 7	Sample 3 M: 18.3%	stiff to very stiff, yellowish brown, medium plasticity	▨	
	680	☒	4	5 7 8	Sample 4 M: 18.0%	very stiff, reddish brown, with ferrous staining	▨	
10.0	677.5					Boring Terminated at 10 feet.		
15	675							
20	670							Groundwater not encountered at time of drilling. Borehole backfilled on date drilled unless otherwise noted. Consistency/Relative Density based on correction factor for Automatic hammer.
	665							

SAMPLE TYPE ☒ Split Spoon

N-VALUE STANDARD PENETRATION RESISTANCE (AASHTO T-206)
% MOISTURE PERCENT NATURAL MOISTURE CONTENT
∇ GROUNDWATER LEVEL IN THE BOREHOLE AT TIME OF DRILLING
▼ STABILIZED GROUNDWATER LEVEL

REC RECOVERY
RQD ROCK QUALITY DESIGNATION
UD UNDISTURBED
Qu POCKET PENETROMETER UNCONFINED COMPRESSIVE STRENGTH

LL: LIQUID LIMIT
PL: PLASTIC LIMIT
PI: PLASTICITY INDEX

M: NATURAL MOISTURE CONTENT
F: PERCENT PASSING NO. 200 SIEVE

LOG OF BORING

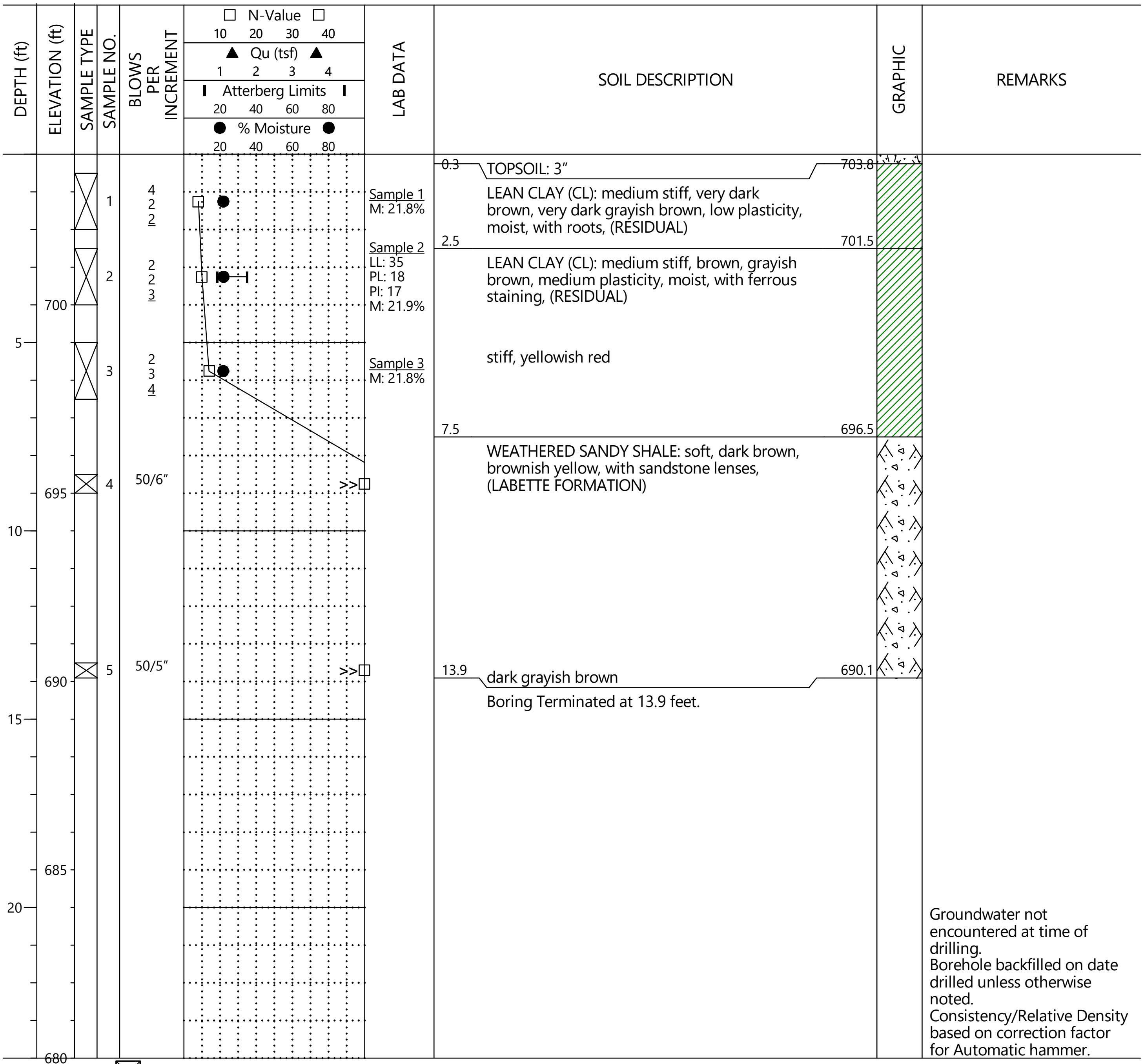
Designation: SB-01

Sheet 1 of 1

1403 S 70th E Ave
Tulsa, OK 74112
Office: (918) 439-9005

Geotechnical, Environmental, and Materials Engineers

PROJECT NAME:	Cherokee Nation Child Development Center	LOCATION:	Catoosa, OK
PROJECT NUMBER:	TU230102	DATE DRILLED:	1/18/24
DRILLING METHOD:	Hollow Stem Auger	WEATHER:	Sunny, cold
EQUIPMENT USED:	Diedrich D-50	ELEVATION:	704
HAMMER TYPE:	Automatic	DRILL CREW:	Building & Earth
BORING LOCATION:	36.170216, -95.764809	LOGGED BY:	J. Swyden



SAMPLE NO.	SAMPLE TYPE	BLOWS PER INCREMENT	LAB DATA
1	☒	4 2 2	Sample 1 M: 21.8%
2	☒	2 2 3	Sample 2 LL: 35 PL: 18 PI: 17 M: 21.9%
3	☒	2 3 4	Sample 3 M: 21.8%
4	☒	50/6"	
5	☒	50/5"	

	SOIL DESCRIPTION	
0.3	TOPSOIL: 3"	703.8
	LEAN CLAY (CL): medium stiff, very dark brown, very dark grayish brown, low plasticity, moist, with roots, (RESIDUAL)	
2.5		701.5
	LEAN CLAY (CL): medium stiff, brown, grayish brown, medium plasticity, moist, with ferrous staining, (RESIDUAL)	
	stiff, yellowish red	
7.5		696.5
	WEATHERED SANDY SHALE: soft, dark brown, brownish yellow, with sandstone lenses, (LABETTE FORMATION)	
13.9	dark grayish brown	690.1
	Boring Terminated at 13.9 feet.	

Groundwater not encountered at time of drilling.
Borehole backfilled on date drilled unless otherwise noted.
Consistency/Relative Density based on correction factor for Automatic hammer.

SAMPLE TYPE ☒ Split Spoon

N-VALUE	STANDARD PENETRATION RESISTANCE (AASHTO T-206)	**REC**	RECOVERY	**LL:** LIQUID LIMIT	**M:** NATURAL MOISTURE CONTENT
% MOISTURE	PERCENT NATURAL MOISTURE CONTENT	**RQD**	ROCK QUALITY DESIGNATION	**PL:** PLASTIC LIMIT	**F:** PERCENT PASSING NO. 200 SIEVE
∇	GROUNDWATER LEVEL IN THE BOREHOLE AT TIME OF DRILLING	**UD**	UNDISTURBED	**PI:** PLASTICITY INDEX	
▼	STABILIZED GROUNDWATER LEVEL	**Qu**	POCKET PENETROMETER UNCONFINED COMPRESSIVE STRENGTH		

BUILDING & EARTH
Geotechnical, Environmental, and Materials Engineers

LOG OF BORING

Designation: SB-02

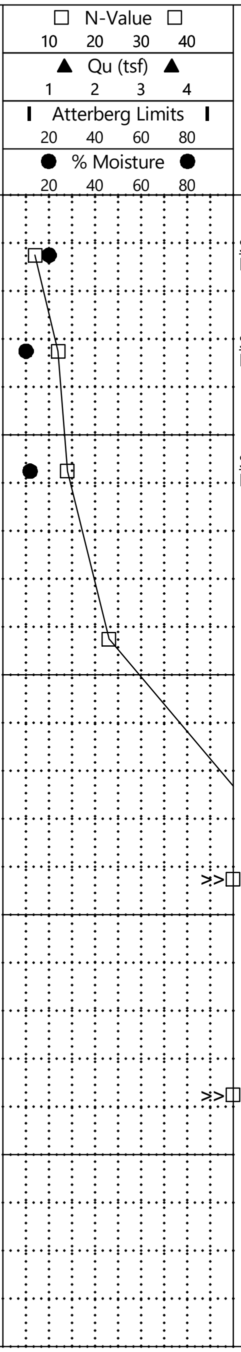
Sheet 1 of 1

1403 S 70th E Ave
Tulsa, OK 74112
Office: (918) 439-9005

PROJECT NAME: Cherokee Nation Child Development Center
PROJECT NUMBER: TU230102
DRILLING METHOD: Hollow Stem Auger
EQUIPMENT USED: Diedrich D-50
HAMMER TYPE: Automatic
BORING LOCATION: 36.169852, -95.764699

LOCATION: Catoosa, OK
DATE DRILLED: 1/18/24
WEATHER: Sunny, cold
ELEVATION: 697
DRILL CREW: Building & Earth
LOGGED BY: J. Swyden

DEPTH (ft)	ELEVATION (ft)	SAMPLE TYPE	SAMPLE NO.	BLOWS PER INCREMENT	LAB DATA	SOIL DESCRIPTION	REMARKS
0.3	696.8					TOPSOIL: 3"	
		☒	1	4 4 3	Sample 1 M: 20.1%	LEAN CLAY (CL): stiff, very dark brown, very dark grayish brown, dark reddish brown, low plasticity, moist, with roots, (RESIDUAL)	
		☒	2	4 6 6	Sample 2 M: 10.1%	stiff to very stiff, brown, yellowish red, dry to moist	
5.0	692.0	☒	3	7 7 7	Sample 3 M: 11.8%	LEAN CLAY (CL): very stiff, yellowish red, brown, dark yellowish brown, low plasticity, dry to moist, with ferrous nodules, (RESIDUAL)	
7.0	690.0					SHALEY LEAN CLAY (CL): very stiff, reddish brown, yellowish red, brown, medium plasticity, moist, (RESIDUAL)	
		☒	4	10 10 13			
12.0	685.0					WEATHERED SHALE: soft, olive brown, dark yellowish brown, dark grayish brown, (LABETTE FORMATION)	
		☒	5	18 32 35			
19.0	678.0	☒	6	50/6"		yellowish red Boring Terminated at 19 feet.	Groundwater not encountered at time of drilling. Borehole backfilled on date drilled unless otherwise noted. Consistency/Relative Density based on correction factor for Automatic hammer.



SAMPLE TYPE ☒ Split Spoon

N-VALUE STANDARD PENETRATION RESISTANCE (AASHTO T-206)
% MOISTURE PERCENT NATURAL MOISTURE CONTENT
∇ GROUNDWATER LEVEL IN THE BOREHOLE AT TIME OF DRILLING
▼ STABILIZED GROUNDWATER LEVEL

REC RECOVERY
RQD ROCK QUALITY DESIGNATION
UD UNDISTURBED
Qu POCKET PENETROMETER UNCONFINED COMPRESSIVE STRENGTH

LL: LIQUID LIMIT
PL: PLASTIC LIMIT
PI: PLASTICITY INDEX

M: NATURAL MOISTURE CONTENT
F: PERCENT PASSING NO. 200 SIEVE

BUILDING & EARTH
Geotechnical, Environmental, and Materials Engineers

LOG OF BORING

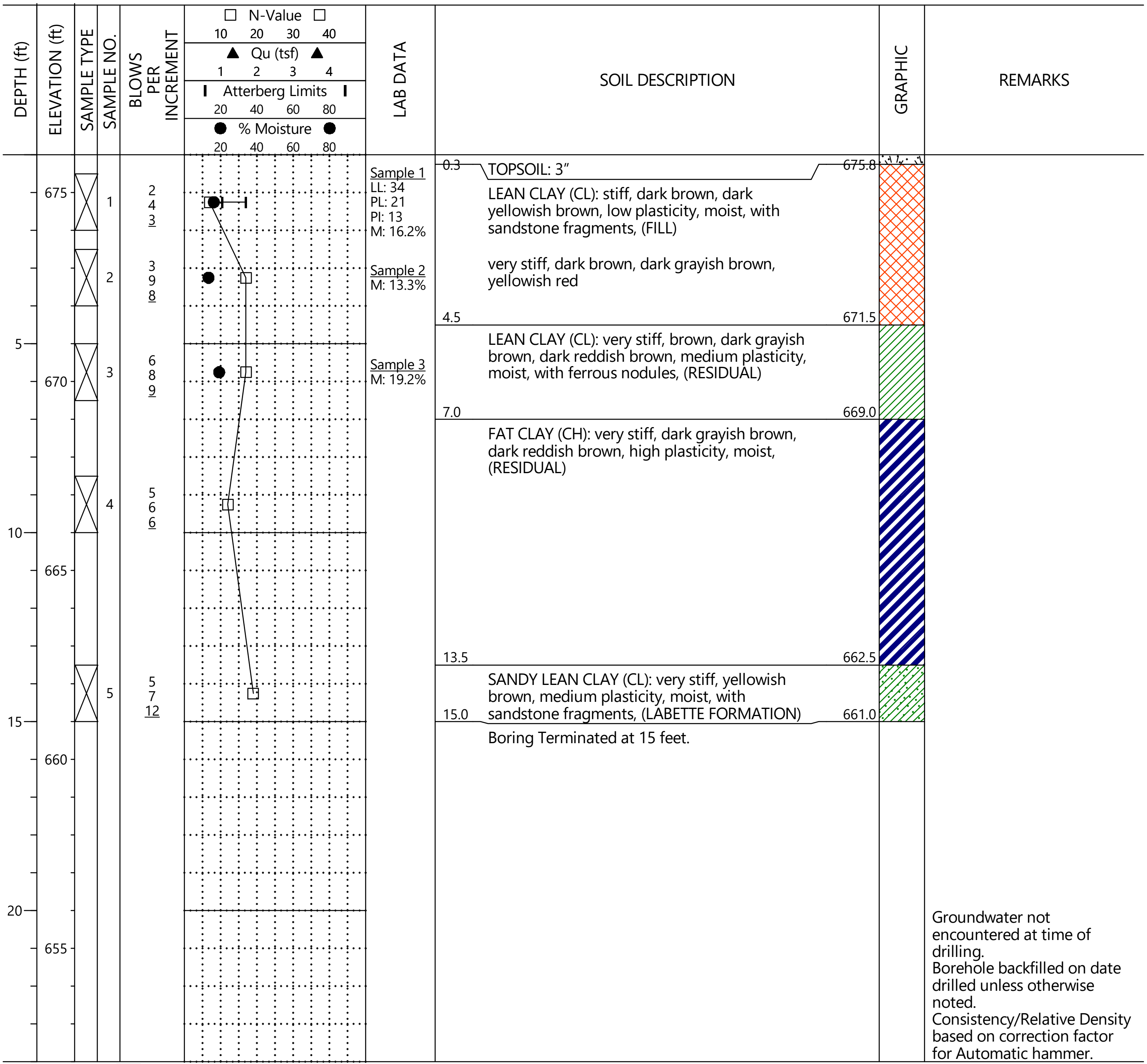
Designation: SB-03

Sheet 1 of 1

1403 S 70th E Ave
Tulsa, OK 74112
Office: (918) 439-9005

PROJECT NAME: Cherokee Nation Child Development Center
PROJECT NUMBER: TU230102
DRILLING METHOD: Hollow Stem Auger
EQUIPMENT USED: Diedrich D-50
HAMMER TYPE: Automatic
BORING LOCATION: 36.169284, -95.763681

LOCATION: Catoosa, OK
DATE DRILLED: 1/18/24
WEATHER: Sunny, cold
ELEVATION: 676
DRILL CREW: Building & Earth
LOGGED BY: J. Swyden



SAMPLE NO.	BLOWS PER INCREMENT	LAB DATA
1	2 4 3	Sample 1 LL: 34 PL: 21 PI: 13 M: 16.2%
2	3 9 8	Sample 2 M: 13.3%
3	6 8 9	Sample 3 M: 19.2%
4	5 6 6	
5	5 7 12	

DEPTH (ft)	SOIL DESCRIPTION	ELEVATION (ft)
0.3	TOPSOIL: 3”	675.8
4.5	LEAN CLAY (CL): stiff, dark brown, dark yellowish brown, low plasticity, moist, with sandstone fragments, (FILL) very stiff, dark brown, dark grayish brown, yellowish red	671.5
7.0	LEAN CLAY (CL): very stiff, brown, dark grayish brown, dark reddish brown, medium plasticity, moist, with ferrous nodules, (RESIDUAL)	669.0
13.5	FAT CLAY (CH): very stiff, dark grayish brown, dark reddish brown, high plasticity, moist, (RESIDUAL)	662.5
15.0	SANDY LEAN CLAY (CL): very stiff, yellowish brown, medium plasticity, moist, with sandstone fragments, (LABETTE FORMATION)	661.0
	Boring Terminated at 15 feet.	

REMARKS:
Groundwater not encountered at time of drilling.
Borehole backfilled on date drilled unless otherwise noted.
Consistency/Relative Density based on correction factor for Automatic hammer.

SAMPLE TYPE ☒ Split Spoon

N-VALUE STANDARD PENETRATION RESISTANCE (AASHTO T-206)
% MOISTURE PERCENT NATURAL MOISTURE CONTENT
∇ GROUNDWATER LEVEL IN THE BOREHOLE AT TIME OF DRILLING
▼ STABILIZED GROUNDWATER LEVEL
REC RECOVERY
RQD ROCK QUALITY DESIGNATION
UD UNDISTURBED
Qu POCKET PENETROMETER UNCONFINED COMPRESSIVE STRENGTH
LL: LIQUID LIMIT
PL: PLASTIC LIMIT
PI: PLASTICITY INDEX
M: NATURAL MOISTURE CONTENT
F: PERCENT PASSING NO. 200 SIEVE

LABORATORY TEST PROCEDURES

A brief description of the laboratory tests performed is provided in the following sections.

DESCRIPTION OF SOILS (VISUAL-MANUAL PROCEDURE) (ASTM D2488)

The soil samples were visually examined by our engineer and soil descriptions were provided. Representative samples were then selected and tested in accordance with the aforementioned laboratory-testing program to determine soil classifications and engineering properties. This data was used to correlate our visual descriptions with the Unified Soil Classification System (USCS).

NATURAL MOISTURE CONTENT (ASTM D2216)

Natural moisture contents (M%) were determined on selected samples. The natural moisture content is the ratio, expressed as a percentage, of the weight of water in a given amount of soil to the weight of solid particles.

ATTERBERG LIMITS (ASTM D4318)

The Atterberg Limits test was performed to evaluate the soil's plasticity characteristics. The soil Plasticity Index (PI) is representative of this characteristic and is bracketed by the Liquid Limit (LL) and the Plastic Limit (PL). The Liquid Limit is the moisture content at which the soil will flow as a heavy viscous fluid. The Plastic Limit is the moisture content at which the soil is between "plastic" and the semi-solid stage. The Plasticity Index (PI = LL - PL) is a frequently used indicator for a soil's potential for volume change. Typically, a soil's potential for volume change increases with higher plasticity indices.

MATERIAL FINER THAN NO. 200 SIEVE BY WASHING (ASTM D1140)

Grain-size tests were performed to determine the partial soil particle size distribution. The amount of material finer than the openings on the No. 200 sieve (0.075 mm) was determined by washing soil over the No. 200 sieve. The results of wash #200 tests are presented on the boring logs included in this report and in the table of laboratory test results.

LABORATORY TEST RESULTS

The results of the laboratory testing are presented in the following tables.

BORING NO.	DEPTH	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	% PASSING #200 SIEVE	CLASSIFICATION
B-01	0.5 - 2.0	23.2	40	22	18	83	CL
B-01	2.5 - 4.0	22.9					
B-01	5.0 - 6.5	22.5					
B-01	8.5 - 10.0	12.9					
B-01	13.5 - 14.0	10.1					
B-01	18.5 - 19.9	12.2					
B-02	0.5 - 2.0	19.2					
B-02	2.5 - 4.0	19.5	49	24	25		
B-02	5.0 - 6.5	19.5					
B-02	8.5 - 10.0	17.6					
B-02	13.5 - 14.5	12.1					
B-02	18.5 - 19.4	11.8					
B-03	0.5 - 2.0	16.5					
B-03	2.5 - 4.0	18.9	37	17	20		
B-03	5.0 - 6.5	19.5					
B-03	8.5 - 10.0	22.6					
B-03	13.5 - 15.0	18.0					
B-04	0.5 - 2.0	18.1					
B-04	2.5 - 4.0	21.5					
B-04	5.0 - 6.5	22.4	51	19	32		
B-04	8.5 - 10.0	19.8					
B-04	13.5 - 15.0	18.1					
B-05	0.5 - 2.0	17.8					
B-05	2.5 - 4.0	18.1					
B-05	5.0 - 6.5	18.5					
B-05	8.5 - 10.0	19.9					
B-05	13.6	18.7					
B-05	14.9	14.3					
B-05	18.5 - 19.5	13.3					
B-06	0.5 - 2.0	15.3					
B-06	2.5 - 4.0	19.0					

TABLE L-1: General Soil Classification Test Results

Soils with a Liquid Limit (LL) greater than 50 and Plasticity Index (PI) greater than 25 usually exhibit significant volume change with varying moisture content and are considered to be highly plastic

(1) Indicates visual classification. WR indicates weathered rock.

LABORATORY TEST RESULTS

The results of the laboratory testing are presented in the following tables.

BORING NO.	DEPTH	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	% PASSING #200 SIEVE	CLASSIFICATION
B-06	5.0 - 6.5	19.2					
B-06	8.5 - 10.0	18.5					
B-06	13.5 - 14.5	11.7					
B-06	18.5 - 19.4	14.0					
B-07	0.5 - 2.0	17.1					
B-07	2.5 - 4.0	20.4					
B-07	5.0 - 6.5	20.6	45	17	28		
B-07	8.5 - 10.0	18.4					
B-07	13.5 - 15.0	19.9					
B-07	18.5 - 20.0	16.2					
B-08	0.5 - 2.0	15.3					
B-08	2.5 - 4.0	20.8	35	19	16	84	CL
B-08	5.0 - 6.5	20.3					
B-08	8.5 - 10.0	18.1					
B-08	13.5 - 15.0	20.3					
B-08	18.5 - 20.0	20.8					
B-09	0.5 - 2.0	15.3	36	19	17		
B-09	2.5 - 4.0	15.3					
B-09	5.0 - 6.5	17.8					
B-09	8.5 - 10.0	20.0					
B-09	13.5 - 15.0	16.2					
B-10	0.5 - 2.0	19.2					
B-10	2.5 - 4.0	19.2					
B-10	5.0 - 6.5	20.1					
B-10	8.5 - 10.0	18.7					
B-10	13.5 - 15.0	18.9					
P-01	0.5 - 2.0	17.2					
P-01	2.5 - 4.0	20.3					
P-01	5.0 - 6.5	19.1					
P-01	8.5 - 10.0	20.8					
P-02	0.5 - 2.0	11.4	34	19	15	84	CL

TABLE L-1: General Soil Classification Test Results

Soils with a Liquid Limit (LL) greater than 50 and Plasticity Index (PI) greater than 25 usually exhibit significant volume change with varying moisture content and are considered to be highly plastic

(1) Indicates visual classification. WR indicates weathered rock.

LABORATORY TEST RESULTS

The results of the laboratory testing are presented in the following tables.

BORING NO.	DEPTH	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	% PASSING #200 SIEVE	CLASSIFICATION
P-02	2.5 - 4.0	16.9					
P-02	5.0 - 6.5	18.4					
P-02	8.5 - 10.0	20.2					
P-03	0.5 - 2.0	14.4					
P-03	2.5 - 4.0	20.5					
P-03	5.0 - 6.5	22.0	47	20	27		
P-03	8.5 - 10.0	18.7					
P-04	0.5 - 2.0	12.7					
P-04	2.5 - 4.0	19.1					
P-04	5.0 - 6.5	24.7					
P-04	8.5 - 10.0	18.2					
P-05	0.6	19.6					
P-05	1.9	24.1					
P-05	2.5 - 4.0	24.7	54	22	32	93	CH
P-05	5.0 - 6.5	24.0					
P-05	8.5 - 10.0	20.6					
P-06	0.5 - 2.0	20.2					
P-06	2.5 - 4.0	23.1					
P-06	5.0 - 6.5	23.5					
P-06	8.5 - 10.0	19.5					
P-07	0.5 - 2.0	18.9					
P-07	2.5 - 4.0	22.7	50	22	28		
P-07	5.0 - 6.5	23.5					
P-07	8.5 - 10.0	18.6					
P-08	0.5 - 2.0	13.2					
P-08	2.5 - 4.0	19.5					
P-08	5.0 - 6.5	21.0					
P-08	8.5 - 10.0	18.1					
P-09	0.5 - 2.0	13.1	36	18	18		
P-09	2.5 - 4.0	16.0					
P-09	5.0 - 6.5	18.3					

TABLE L-1: General Soil Classification Test Results

Soils with a Liquid Limit (LL) greater than 50 and Plasticity Index (PI) greater than 25 usually exhibit significant volume change with varying moisture content and are considered to be highly plastic

(1) Indicates visual classification. WR indicates weathered rock.

LABORATORY TEST RESULTS

The results of the laboratory testing are presented in the following tables.

BORING NO.	DEPTH	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	% PASSING #200 SIEVE	CLASSIFICATION
P-09	8.5 - 10.0	18.0					
SB-01	0.5 - 2.0	21.8					
SB-01	2.5 - 4.0	21.9	35	18	17		
SB-01	5.0 - 6.5	21.8					
SB-02	0.5 - 2.0	20.1					
SB-02	2.5 - 4.0	10.1					
SB-02	5.0 - 6.5	11.8					
SB-03	0.5 - 2.0	16.2	34	21	13		
SB-03	2.5 - 4.0	13.3					
SB-03	5.0 - 6.5	19.2					

TABLE L-1: General Soil Classification Test Results

Soils with a Liquid Limit (LL) greater than 50 and Plasticity Index (PI) greater than 25 usually exhibit significant volume change with varying moisture content and are considered to be highly plastic

(1) Indicates visual classification. WR indicates weathered rock.

Important Information about This

Geotechnical-Engineering Report

Subsurface problems are a principal cause of construction delays, cost overruns, claims, and disputes.

While you cannot eliminate all such risks, you can manage them. The following information is provided to help.

Geotechnical Services Are Performed for Specific Purposes, Persons, and Projects

Geotechnical engineers structure their services to meet the specific needs of their clients. A geotechnical-engineering study conducted for a civil engineer may not fulfill the needs of a constructor — a construction contractor — or even another civil engineer. Because each geotechnical- engineering study is unique, each geotechnical-engineering report is unique, prepared *solely* for the client. No one except you should rely on this geotechnical-engineering report without first conferring with the geotechnical engineer who prepared it. *And no one — not even you* — should apply this report for any purpose or project except the one originally contemplated.

Read the Full Report

Serious problems have occurred because those relying on a geotechnical-engineering report did not read it all. Do not rely on an executive summary. Do not read selected elements only.

Geotechnical Engineers Base Each Report on a Unique Set of Project-Specific Factors

Geotechnical engineers consider many unique, project-specific factors when establishing the scope of a study. Typical factors include: the client's goals, objectives, and risk-management preferences; the general nature of the structure involved, its size, and configuration; the location of the structure on the site; and other planned or existing site improvements, such as access roads, parking lots, and underground utilities. Unless the geotechnical engineer who conducted the study specifically indicates otherwise, do not rely on a geotechnical-engineering report that was:

- not prepared for you;
- not prepared for your project;
- not prepared for the specific site explored; or
- completed before important project changes were made.

Typical changes that can erode the reliability of an existing geotechnical-engineering report include those that affect:

- the function of the proposed structure, as when it's changed from a parking garage to an office building, or from a light-industrial plant to a refrigerated warehouse;
- the elevation, configuration, location, orientation, or weight of the proposed structure;
- the composition of the design team; or
- project ownership.

As a general rule, *always* inform your geotechnical engineer of project changes—even minor ones—and request an assessment of their impact. *Geotechnical engineers cannot accept responsibility or liability for problems that occur because their reports do not consider developments of which they were not informed.*

Subsurface Conditions Can Change

A geotechnical-engineering report is based on conditions that existed at the time the geotechnical engineer performed the study. *Do not rely on a geotechnical-engineering report whose adequacy may have been affected by*: the passage of time; man-made events, such as construction on or adjacent to the site; or natural events, such as floods, droughts, earthquakes, or groundwater fluctuations. *Contact the geotechnical engineer before applying this report to determine if it is still reliable.* A minor amount of additional testing or analysis could prevent major problems.

Most Geotechnical Findings Are Professional Opinions

Site exploration identifies subsurface conditions only at those points where subsurface tests are conducted or samples are taken. Geotechnical engineers review field and laboratory data and then apply their professional judgment to render an opinion about subsurface conditions throughout the site. Actual subsurface conditions may differ — sometimes significantly — from those indicated in your report. Retaining the geotechnical engineer who developed your report to provide geotechnical-construction observation is the most effective method of managing the risks associated with unanticipated conditions.

A Report's Recommendations Are Not Final

Do not overrely on the confirmation-dependent recommendations included in your report. *Confirmation-dependent recommendations are not final,* because geotechnical engineers develop them principally from judgment and opinion. Geotechnical engineers can finalize their recommendations *only* by observing actual subsurface conditions revealed during construction. *The geotechnical engineer who developed your report cannot assume responsibility or liability for the report's confirmation-dependent recommendations if that engineer does not perform the geotechnical-construction observation required to confirm the recommendations' applicability.*

A Geotechnical-Engineering Report Is Subject to Misinterpretation

Other design-team members' misinterpretation of geotechnical-engineering reports has resulted in costly problems. Confront that risk by having your geotechnical engineer confer with appropriate members of the design team after submitting the report. Also retain your geotechnical engineer to review pertinent elements of the design team's plans and specifications. Constructors can also misinterpret a geotechnical-engineering report. Confront that risk by having your geotechnical engineer participate in prebid and preconstruction conferences, and by providing geotechnical construction observation.

Do Not Redraw the Engineer's Logs

Geotechnical engineers prepare final boring and testing logs based upon their interpretation of field logs and laboratory data. To prevent errors or omissions, the logs included in a geotechnical-engineering report should *never* be redrawn for inclusion in architectural or other design drawings. Only photographic or electronic reproduction is acceptable, *but recognize that separating logs from the report can elevate risk.*

Give Constructors a Complete Report and Guidance

Some owners and design professionals mistakenly believe they can make constructors liable for unanticipated subsurface conditions by limiting what they provide for bid preparation. To help prevent costly problems, give constructors the complete geotechnical-engineering report, *but* preface it with a clearly written letter of transmittal. In that letter, advise constructors that the report was not prepared for purposes of bid development and that the report's accuracy is limited; encourage them to confer with the geotechnical engineer who prepared the report (a modest fee may be required) and/or to conduct additional study to obtain the specific types of information they need or prefer. A prebid conference can also be valuable. *Be sure constructors have sufficient time* to perform additional study. Only then might you be in a position to give constructors the best information available to you, while requiring them to at least share some of the financial responsibilities stemming from unanticipated conditions.

Read Responsibility Provisions Closely

Some clients, design professionals, and constructors fail to recognize that geotechnical engineering is far less exact than other engineering disciplines. This lack of understanding has created unrealistic expectations that have led to disappointments, claims, and disputes. To help reduce the risk of such outcomes, geotechnical engineers commonly include a variety of explanatory provisions in their reports. Sometimes labeled "limitations," many of these provisions indicate where geotechnical engineers' responsibilities begin and end, to help others recognize their own responsibilities and risks. *Read these provisions closely.* Ask questions. Your geotechnical engineer should respond fully and frankly.

Environmental Concerns Are Not Covered

The equipment, techniques, and personnel used to perform an *environmental* study differ significantly from those used to perform a *geotechnical* study. For that reason, a geotechnical-engineering report does not usually relate any environmental findings, conclusions, or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. *Unanticipated environmental problems have led to numerous project failures.* If you have not yet obtained your own environmental information, ask your geotechnical consultant for risk-management guidance. *Do not rely on an environmental report prepared for someone else.*

Obtain Professional Assistance To Deal with Mold

Diverse strategies can be applied during building design, construction, operation, and maintenance to prevent significant amounts of mold from growing on indoor surfaces. To be effective, all such strategies should be devised for the *express purpose* of mold prevention, integrated into a comprehensive plan, and executed with diligent oversight by a professional mold-prevention consultant. Because just a small amount of water or moisture can lead to the development of severe mold infestations, many mold- prevention strategies focus on keeping building surfaces dry. While groundwater, water infiltration, and similar issues may have been addressed as part of the geotechnical- engineering study whose findings are conveyed in this report, the geotechnical engineer in charge of this project is not a mold prevention consultant; *none of the services performed in connection with the geotechnical engineer's study were designed or conducted for the purpose of mold prevention. Proper implementation of the recommendations conveyed in this report will not of itself be sufficient to prevent mold from growing in or on the structure involved.*

Rely, on Your GBC-Member Geotechnical Engineer for Additional Assistance

Membership in the Geotechnical Business Council of the Geoprofessional Business Association exposes geotechnical engineers to a wide array of risk-confrontation techniques that can be of genuine benefit for everyone involved with a construction project. Confer with you GBC-Member geotechnical engineer for more information.

GBC GEOTECHNICAL BUSINESS COUNCIL
of the Geoprofessional Business Association

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