Report of Subsurface Exploration and Geotechnical Evaluation
Will Rogers Birthplace Ranch
Oologah, Oklahoma
BUILDING & EARTH SCIENCES, INC.
PROJECT NO.: TU240148

PREPARED FOR:
CNB Construction

October 1, 2024

BUILDING & EARTH
Geotechnical, Environmental, and Materials Engineers

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October 1, 2024

CNB Construction
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Catoosa, Oklahoma 74015

Attention: Mr. Jesse Gates
Project Manager

Subject: Subsurface Exploration and Geotechnical Evaluation
Will Rogers Birthplace Ranch
Oologah, Oklahoma
Building & Earth Sciences, Inc. Project No: TU240148

Dear Mr. Jesse Gates:

Building & Earth Sciences, Inc. has completed the authorized subsurface exploration and geotechnical engineering evaluation for the Will Rogers Birthplace Ranch located at 9501 East 380 Road in Oologah, 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 12 soil 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 6/30/2026

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Staff Professional

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Appendices

1.0 PROJECT AND SITE DESCRIPTION

The subject site is located at 9501 East 380 Road, Oologah, Oklahoma. Information relative to the proposed site and the proposed development is listed in Table 1 below. Photographs depicting the current site condition are presented on the following page.

Table 1: Project and Site Description

Detail	Description
General Site	
Size (Ac.)	±14
Existing Development	Will Rogers Birthplace Ranch and associated pavement. Northern portion of the project area is an empty field
Vegetation	The project site was covered with grass and topsoil. Some sparse tree coverage throughout the site with heavy tree cover to the east.
Slopes	The site gently slopes down to the south and east towards Oologah Lake
Retaining Walls	None noted
Drainage	Natural surface drainage to the south and east
Cuts & Fills	Minimal cut and fill heights of up to 2 feet (assumed)
Proposed Buildings	
No. of Bldgs	Seven (7)
Square Ft.	Ranging from 1,200 to 5,500 sq ft
Stories	Single
Construction	Pre-engineered metal building (assumed)
Column Loads	Less than 50 kips (assumed)
Wall Loads	1 to 3 kips per linear foot (assumed)
Preferred Foundation	Conventional Shallow Foundation
Preferred Slab	Slab-on-Grade
Pavements	
Traffic	Not provided, assume passenger vehicles for parking stalls, and occasional light box truck and trash collection truck for drive aisles
Standard Duty	Rigid and Flexible, assumed ESAL 100,000
Heavy Duty	Rigid and Flexible, assumed ESAL 300,000

Reference: Overall Site Plan, prepared by EDG, dated May 9, 2024

Notes:

1. If actual loading conditions exceed our assumed loads, Building & Earth Sciences, Inc. should be allowed to review the proposed structural design and its effects on our recommendations for foundation design.

2. When a grading plan is finalized, Building & Earth Sciences, Inc. should be allowed to review the plan and its effects on our recommendations.

Site Photos

Photograph 1: Near boring B-01 looking southeast

Photograph 2: West of boring P-05, looking east

Photograph 3: Center of the project site, looking southeast

2.0 SCOPE OF SERVICES

The authorized subsurface exploration was performed on September 11 and 12, 2024 in conformance with our proposal TU26151, dated May 16, 2024. Notice to proceed was provided by signing the Project Service Agreement No. KX0014046.02 on September 13, 2024.

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 twelve (12) test borings. Refer to the Geotechnical Investigation Methodologies Appendix for a description of the drilling and sampling procedures. The site was drilled using a Diedrich D-50 equipped with an automatic hammer for performing Standard Penetration Tests (SPT) to help evaluate the relative soil strength.

The soil 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 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 Laboratory Test Procedures Appendix.

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:

Table 2: Scope of Laboratory Tests

Test	ASTM	No. of Tests
Natural Moisture Content	D2216	32
Atterberg Limits	D4318	8
Material Finer Than No. 200 Sieve by Washing	D1140	3

The information gathered from the exploration was evaluated to determine a suitable foundation type for the proposed structures. 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 groundwater conditions observed in the boreholes during drilling. Long-term monitoring was excluded from 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.
- Seismic Site Classification per IBC 2018 based on SPT test boring information.
- Compaction requirements and recommended criteria to establish suitable material for structural backfill.
- Recommended typical minimum flexible an rigid pavement sections based on assumed traffic loading conditions.

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 that may be present within unexplored areas of the site or 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

According to the Geologic Map of the Tulsa 30X60 Minute Quadrangle, Cherokee, Delaware, Mayes, Rogers, Tulsa, Wagoner, and Washington Counties published by Thomas M. Stanley and Carla M. Eichler (2022), the subject site is underlain by the Desmoinesian age, Labette Formation and Oologah Formation. The Labette Formation is noted to consist of a grayish brown to dark gray, laminated, very silty to sandy, concretionary clayshale. Various non-descript very sandy shale or shaly sandstone horizons occur. The Oologah Formation is noted to consist of light to medium gray, wavy bedded, skeletal to whole fossil mudstone to wackestone with local packstone textures in the upper half of the unit.

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

3.2 EXISTING SURFACE CONDITIONS

At the time of our exploration, most of the project site was covered with grass and topsoil that was approximately 2 to 6 inches in thickness. At boring location P-04, the ground surface was covered with asphaltic concrete pavement that had a thickness of approximately 5.5 inches. The topsoil and pavement thicknesses reported apply only to the specific boring locations. It should be noted that pavement and topsoil thicknesses likely vary at unexplored locations of the project site.

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/rock conditions and strata types encountered during our field investigation.

Table 3: Stratification Summary

Stratum No.	Description	Consistency/ Relative Density
1	**Near-surface Low Plasticity Clays and Clayey Gravel:** Lean Clays (CL) and Sandy Lean Clays (CL) with roots, limestone fragments, and limestone gravel, and Clayey Limestone Gravel	Very stiff clays Dense to very dense clayey gravel
2	**Residuum:** Sandy Lean Clay (CL), Lean to Fat Clay (CL-CH), Sandy Fat Clay (CH), Gravelly Lean Clay (CL) and Clayey Limestone Gravel (GC) with roots, limestone fragments and gravel, and calcareous deposits	Dense to very dense gravelly residuum Stiff to very stiff clays
3	**Labette Formation:** Weathered Shales and Sandstone	*Weathered Shale:* Soft *Sandstones:* Cemented(auger refusal material)
4	**Oologah Formation:** Limestone and Fractured Limestone with clay seams and layers	Hard(auger refusal material)

Subsurface profiles which show the thickness of the strata referenced above have also been prepared based on the data obtained at the specific boring locations. The subsurface profiles are presented in the Subsurface Soil Profiles Appendix. For specific details on the information obtained from individual borings, refer to the Boring Logs included in the Boring Logs Appendix. The elevations of the borings indicated in this report were estimated based on Google Earth data and as such should be considered approximate.

3.3.1 NEAR-SURFACE LOW PLASTICITY CLAYS AND CLAYEY GRAVEL

Near-surface, low plasticity Lean Clays and Sandy Lean Clays (CL) and Clayey Limestone Gravel (GC) were encountered in most borings to a depth of roughly 2 feet.

The near surface clay soils typically exhibited a very stiff consistency and were generally shades of brown and gray. Roots, limestone fragments and gravel were noted in the clay soil samples. Atterberg Limits tests performed on selected clay samples exhibited low plasticity with Liquid Limit values of 32 and Plasticity Indices of 12 and 13. Except for boring P-04, the moisture contents ranged from about 4 to 8 percent and generally indicated the soils were in a dry condition. At boring location P-04, the near-surface clays immediately below the pavement had a moisture content of roughly 22 percent.

The near surface clayey gravel was dense to very dense and generally various shades and combinations of brown, yellow, red, and gray in color. The moisture contents ranged from about 6 to 12 percent and generally indicated the clayey gravel was in a dry condition.

3.3.2 RESIDUUM

The residual soils encountered below the topsoil and the near-surface low plasticity soils extended to either the top of weathered shale, limestone, or sandstone, auger refusal, or the planned termination depths ranging from about 1.7 to 12 feet below the ground surface.

The residual soils consisted primarily of Sandy Fat Clay (CH), Lean Clay (CL), Sandy Lean Clay (CL), Lean to Fat Clay (CL-CH), and Clayey Limestone Gravel (GC). The residual clay soils typically exhibited a stiff to very consistency. With increasing depth and moisture contents, the clays exhibited a medium stiff consistency at select boring locations P-02 and P-03. The gravelly residuum generally exhibited dense to very dense relative densities. The residual soils were generally shades of yellow, red, brown, and gray. Roots, limestone fragments and gravel, and calcareous deposits were also noted at several sample locations.

Most of the residual clays exhibited medium to high plasticity characteristics with Liquid Limit values ranging from 21 to 75 and Plasticity Indices ranging from 12 to 46. Wash No. 200 Sieve Tests indicated that the samples contained 22 to 79 percent soil fines (clay & silt). Moisture contents ranged widely from about 11 to 40 percent. Except for some of the clay soils encountered within depth of 5 feet, most of the fat clay soils had elevated moisture contents generally ranging from 22 to 40 percent with an average of 30 percent.

3.3.3 LABETTE FORMATION

Weathered Shale and Sandstone associated with the Labette Formation were encountered in borings B-03 and B-06. Weathered rock is formed by natural in-place physical and chemical weathering of the parent rock. Weathered shale was encountered beneath the residual soils in boring B-03 at a depth of approximately 9 feet. The weathered shale was various shades of black, olive, and brown in color. The weathered shale extended to the top of the limestone unit associated with the Oologah Formation at a depth of approximately 12 feet.

In boring B-06 sandstone was encountered at a depth of approximately 5 feet below current grades. The sandstone was cemented and various shades of brown and yellow in color. Auger refusal occurred on the sandstone at depth of about 5.5 feet.

3.3.4 OOLOGAH FORMATION

Limestone and Fractured Limestone associated with the Oologah Formation was encountered in borings B-01, B-02, B-03, B-04, B-07, and P-01. The limestone was hard and contained some clay seams and layers. The limestone was various shades of gray, yellow, and brown in color. Auger refusal occurred on the hard limestone at depths of ranging from about 2 to 12 feet below the ground surface.

3.3.5 AUGER REFUSAL

Auger refusal is the drilling depth at which the borehole can no longer be advanced using soil drilling procedures. Auger refusal can occur on a variety of materials and varies with the drilling equipment used. Coring is required to identify the material below auger refusal, which was excluded from our scope of work. Auger refusal was encountered in most borings at the depths listed in the table below.

It appears that that auger refusal occurred in the sandstone and limestone units as well as possibly on cobbles or boulders within the gravelly residuum. The type of auger refusal material was not ascertained as part of our scope of work. Supplemental rock coring would be needed to assess the general condition of the auger refusal materials. In addition, close observation will be needed to determine whether intact rock or boulder/cobbles are encountered in excavations during construction.

Table 4: Auger Refusal Depths

Boring No.	Depth (ft)	Boring No.	Depth (ft)
B-01	3.6	B-06	5.5
B-02	2	B-07	7
B-03	12	P-01	4.5
B-04	12	P-05	4.5
B-05	2		

3.3.6 GROUNDWATER

At the time of drilling, groundwater was not encountered in any of the borings during drilling and they were dry at the completion of drilling activities and prior to backfilling.

It should be noted that although all borings were dry during and following completion of drilling, portions of the fat clay soils encountered above the rock units and auger refusal materials had relatively high moisture contents. Elevated moisture contents suggest a high probability for development of perched water within the residuum near the contact with the underlying rock units.

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 they were drilled.

Table 5: 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 12.1 feet; hence the seismic site classification should be re-evaluated in the event subsurface information is made available to a depth of 100 feet.	

4.0 SITE DEVELOPMENT CONSIDERATIONS

A grading plan was not available at the time of this report. We anticipate cut and fill heights of less than 2 feet will be required to reach finished grades. ***Once a grading plan is available, Building & Earth Sciences, Inc. should be allowed to review the plan and its effects on our recommendations.***

Based on our evaluation of the subsurface conditions encountered in the borings, and the assumed foundation loads, it appears that construction with a Conventional Shallow Foundation system is feasible. The site development recommendations outlined below are intended for development of the site to support construction with a Conventional Shallow Foundation system. ***If a different type of foundation system is preferred, Building & Earth Sciences, Inc. 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:

- Onsite near-surface residual lean clays are moisture sensitive and are prone to losing strength and stability with slight increase in soil moisture contents.
- Most of the residual clays encountered below the topsoil and near-surface soils exhibited high plasticity characteristics with a high shrink-swell potential.
- Although groundwater was not encountered at the time of the subsurface exploration, elevated soil moisture contents suggest a high probability for development of perched water in the residuum near the contact with rock units, and possibly distinct gravelly layers within the residuum during and following wet weather conditions.
- Auger refusal on hard sandstone and limestone units, and possibly on cobbles/boulders within the gravelly residuum at depths ranging from about 2 to 12 feet below current grades. In borings B-05 and and P-05 the auger refusal was likely due to limestone cobbles and boulders within the gravelly residuum.

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

4.1 INITIAL SITE PREPARATION

All trees, vegetation, roots, topsoil and deleterious materials should be removed from the proposed construction areas. Approximately 2 to 6 inches of topsoil were observed in the borings. The topsoil thickness is accurate only at the specific boring locations but can be extrapolated between boreholes for initial cost estimating purposes.

A pavement section comprised of approximately 5.5 inches of asphalt was observed in boring P-04.

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.

Demolition of buildings should include removal of slabs, foundations, any below-grade walls, and utilities.

Existing underground utility lines are likely present within the proposed building area. All abandoned utility lines should be removed and any existing utility lines that will remain in use should be rerouted outside the proposed building areas. The trench excavations, following removal and rerouting, should be backfilled in accordance with requirements outlined in the *Structural Fill* section of this report.

Within the proposed pavement areas, any abandoned utilities should be excavated and removed, or if they are to remain in-place should be sealed. Existing utility lines and their trenches can become a source of water infiltration. This may result in saturation and softening of surrounding soil or subsurface erosion and cause vertical movement in the overlying soils.

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

Materials disturbed during clearing 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 MOISTURE SENSITIVE SOILS

Moisture sensitive near-surface lean clays were encountered across most of the site during the subsurface exploration. These soils will degrade if allowed to become saturated. 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.

4.3 BUILDING PAD PREPARATION

Based on the subsurface conditions encountered in the borings and the laboratory test results, the topsoil and near surface lean clay soils are generally underlain by highly plastic lean to fat clay (CL-CH) and fat clay (CH).

The potential vertical rise of the onsite higher plasticity soils 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 clay soils based on the plasticity characteristics, fraction of material passing through the No. 40 sieve, thickness of the soil strata, moisture contents, and surcharge loads.

For this project site, an active zone of 8 feet was used in the calculations. The TxDOT method indicates a PVR of about 1¾ inches for the soil moisture contents encountered at the time of drilling.

In general, a maximum PVR criterium of 1-inch is commonly considered to be acceptable for slab-on-grade design purposes. However, portions of the proposed building may require stricter tolerances such as ¾-inch or ½-inch PVR in consideration of planned equipment or racking systems. The owner and design team should provide our office with alternate specific differential vertical movement criteria for further evaluation if stricter criteria are to be considered for this project.

To reduce the maximum PVR to 1-inch, it is recommended to undercut the building areas to a level that will allow for placement of at least 4 feet of approved low plasticity structural fill. Auger refusal materials may be encountered prior to reaching the recommended undercut levels within parts of the proposed building areas. Where rock units or dense clayey gravel are encountered prior to achieving the recommended undercut level, further undercutting will not be required. The undercutting should extend at least 5 feet horizontally outside the buildings and their appurtenances.

It appears that the near-surface lean clays and clayey gravel meet the low plasticity structural fill criteria presented in the Structural Fill section of this report. Near-surface materials that meet the structural fill criteria can be stockpiled for use as fill in the proposed building areas.

Following undercutting, the subgrade should be thoroughly evaluated by means of proofrolling with a loaded tandem-axle dump truck. Soft, unstable soils should be undercut to underlying stiff and stable materials prior to structural fill placement.

The contractor should use caution during building pad preparation as to not allowing the fat clays (CH) exposed in at the bottom of the undercut areas to dry while exposed to the elements. Drying of the fat clay soils would increase their swell potential and the subsequent risk of heave of slabs and lightly loaded footings. Desiccated fat clay soils should be undercut prior to placement of approved low plasticity structural fill.

4.4 PAVEMENT SUBGRADE PREPARATION

Borings P-01 through P-05 drilled in the proposed pavement areas encountered near-surface, low plasticity lean clays, gravelly clays, and clayey gravel. Assuming that finished subgrade levels will be close to existing grades, the pavement subgrade can be prepared and evaluated following the recommendations presented in the following *Subgrade Preparation and Evaluation* section.

Where fat clays (CH) are exposed at finished subgrade level, it is recommended to undercut those areas to a level that will allow for placement of at least 18 inches of approved, low plasticity structural fill.

The geotechnical engineer or designated representative should evaluate the condition of the pavement subgrade to identify and delineate any fat clays soils that should be undercut as outlined above.

4.5 SUBGRADE PREPARATION AND EVALUATION

Following undercutting and prior to fill placement in proposed building and pavement areas, the exposed soil subgrade should be scarified to a minimum depth of 12 inches, moisture conditioned within a range of 0 to 3 percent above the material's optimum moisture content and recompacted to at least 95 percent of the material's standard Proctor maximum dry density (ASTM D698). Where rock units or dense clayey gravel is exposed, scarification and moisture conditioning of the subgrade is not needed.

We recommend that the project geotechnical engineer or their qualified representative evaluate the subgrade after the site is prepared. Some unsuitable or unstable areas may be present in unexplored areas of the site. All areas that will require fill or that will support structures and pavements should be carefully proofrolled with a heavy (20- to 25-ton), tandem-axle dump truck at the following times.

- After an area has been stripped, and undercut as recommended, prior to the placement of any fill.
- After grading an area to the finished subgrade elevation in building and pavement areas.
- 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, or slab and pavement construction. All unsuitable material identified during construction should be removed and replaced in accordance with the *Structural Fill* section of this report.

4.6 STRUCTURAL FILL

Requirements for structural fill on this project are as follows:

Table 6: Structural Fill Requirements

Soil Type	USCS Classification	Property Requirements	Placement Location
Imported Sandy Lean Clay, Clayey Sand, or Clayey Gravel	CL, SC, GC	LL<40, PI<18, γ_d>100 pcf, P200>30%, Maximum 3" particle size in any dimension	Low Plasticity Structural Fill to be used for construction of building pad and in pavement areas (see Note 5)
Near-surface Low Plasticity Clays and Clayey Gravel	CL, GC	Same as recommended above for imported structural fill	Possibly suitable for placement as low plasticity structural fill (see Note 3)
Onsite Higher Plasticity Gravelly Residuum, Lean to Fat Clays and Fat Clays	GC, CL-CH, CH	Not Applicable	Not suitable for placement as low plasticity structural fill in building and pavement areas due to variability in type of soils and high plasticity characteristics. (see Note 5)

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 unless approved by the geotechnical engineer.
2. LL indicates the soil Liquid Limit; PI indicates the soil Plasticity Index; γd indicates the maximum dry density as defined by the density standard outlined in the table below.
3. Laboratory testing of the soils proposed for fill should be performed in order to verify their conformance with the above recommendations.
4. Any fill to be placed at the site should be reviewed by the geotechnical engineer.
5. Material native to the region that may not meet the above structural fill criteria may be used if it contains more than 70% sand and gravel retained on a No. 200 sieve (with maximum particle size of 3 inches) and is approved by the geotechnical engineer. Bulk samples of such material should be provided for, but not necessarily limited to, particle size analysis, Atterberg limits, and moisture-density relationship testing.

Placement requirements for structural fill are as follows:

Table 7: Structural Fill Replacement Requirements

Specification	Requirement
Lift Thickness	Maximum loose lift thickness of 8 to 12 inches, depending on type of compaction equipment used.
Density	Minimum of 95 percent of maximum dry density as defined by ASTM D698 at all locations and depths.
Moisture	**Low Plasticity Structural Fill and Onsite Lean Clays and Gravelly Clay:** ±2% of the optimum moisture content as determined by ASTM D698
Density Testing Frequency	**Building 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 tests performed 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.

4.7 EXCAVATION CONSIDERATIONS

All excavations performed at the site should follow OSHA guidelines for temporary excavations. Excavated soils should be stockpiled according to OSHA regulations to limit the potential cave-in of soils.

4.7.1 DIFFICULT EXCAVATION

Auger refusal was encountered in borings B-01 through B-07, P-01, and P-05 at depths ranging from 2 to 12 feet below current grades. The auger refusal occurred on limestone, sandstone, and limestone cobbles and boulders within the gravelly residuum. Auger refusal could be encountered above the planned subgrade elevation or during utility installation.

The depth that weathered rock and 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. Large earthmoving equipment can typically rip weathered rock that can be excavated with a track hoe, however, the contractor should review the site conditions and determine the excavation techniques needed. If more detailed information is desired as to the rippability of the weathered rock, Building & Earth Sciences, Inc. can provide a proposal to perform a Seismic Refraction Study to determine Seismic Wave Velocities in the rock.

4.7.2 GROUNDWATER AND PERCHED WATER

Although groundwater was not encountered at the time of the subsurface exploration, elevated soil moisture contents suggest a high probability for development of perched water in the residuum near the contact with rock units, and possibly distinct gravelly layers within the residuum during and following wet weather conditions.

It should be noted that fluctuations in the water level could occur due to seasonal variations in rainfall. The contractor must be prepared to remove groundwater seepage from excavations if encountered during construction. Excavations extending below groundwater levels will require dewatering systems (such as well points, sump pumps or trench drains). The contractor should evaluate the most economical and practical dewatering method.

4.8 UTILITY TRENCH BACKFILL

All utility trenches must 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.

4.9 LANDSCAPING AND DRAINAGE CONSIDERATION

The potential for soil moisture fluctuations within building 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 could result in swelling of the high plasticity residual clay soils.

4.10 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. 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

Specific structural loading conditions were not known at the time of this report; however, based on our experience with similar projects, we anticipate that the individual column loads will be less than 50 kips and wall loads will be less than 1 to 3 kips per linear foot. ***If these assumptions concerning structural loading are incorrect, our office should be contacted, such that our recommendations can be reviewed.***

5.1 SHALLOW FOUNDATIONS

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

Based on the subsurface conditions encountered in the borings and the recommended building pad preparation, we anticipate the following bearing materials for the various proposed structures:

- Hay barn (boring B-01), Fire Protection Infrastructure (boring B-04), Interpretive Center (boring B-06), and Event Center (boring B-07): structural fill.
- Maintenance building (borings B-02 and B-03): combination of structural fill and limestone unit.
- Caretaker's Home (boring B-05): very dense clayey gravel with possible cobbles and boulder.

Shallow footings bearing in the anticipated and recommended bearing materials can be designed using an allowable soil bearing capacity of 2,500 psf.

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. ***All exterior footings should bear at least 24 inches below the adjacent exterior grade.***

Total settlement of footings designed and constructed as recommended above is estimated at 3/4- inch or less. Differential settlement is estimated at 1/2-inch between any points spaced 40 feet along continuous footings and between isolated spread footings.

For buildings where the footings bear in a combination of structural fill, dense to very dense clayey gravel, and rock units, the differential settlement could occur over shorter distances than stated above within the transition zone from structural fill to the rock units or clayey gravel stratum. If this is not acceptable, consideration should be given to undercutting the rock units and clayey gravel exposed in footing excavations to a level at least 12 inches below bottom of footing elevation to allow for replacement with approved structural fill.

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 prior to placing concrete.
- 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 reevaluated 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.
- The site should be sloped to drain away from the building foundations.
- Roof drains should be routed away from the foundation soils.

6.0 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 approved low plasticity structural fill.

We recommend floor slabs for the proposed structures be supported on a minimum four-inch 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. The purpose of this layer is to help distribute concentrated loads and act as a capillary break for moisture migration through the subgrade soil.

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 vapor 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 underlain by low plasticity structural fill. The slab should be appropriately reinforced (if required) to support anticipated floor loads

Where applicable, we recommend that the floor slab be isolated from the foundation footings so differential settlement of the structure will not induce shear stresses on the floor slab. Temperature and shrinkage reinforcements in slabs on grade maybe considered and incorporated accordingly in the slab design. ACI 360-10 provides guidance on the proper quantity of such reinforcement. The slab should also be appropriately reinforced to support the proposed loads as required. If welded-wire mesh reinforcement is utilized, the mesh reinforcement should be placed 2 inches below the slab surface or upper one-third of the slab thickness, whichever is closer to the surface. Adequate construction joints, contraction joints and isolation joints should also be provided in the slab to reduce the impacts of cracking and shrinkage, in general accordance with ACI standards and guidelines (ACI360R-10).

7.0 PAVEMENT CONSIDERATIONS

Specific traffic information was not provided. We assumed that proposed pavements will be subjected to passenger cars and occasional light box trucks and trash collection trucks.

We have assumed Equivalent Single Axle Loads (ESAL) values of 100,000 for standard duty parking stalls and 300,000 for heavy duty drive aisles. 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 assumed daily traffic volume.

Based on the materials encountered at the boring locations and after our recommendations for site preparation are implemented, pavements at the subject site may be designed based on a California Bearing Ratio (CBR) of three and a half (3.5). Note that no CBR or plate load testing was completed to develop these recommendations

It has been our experience that parking lots experience a certain level of wear and stress greater than roadways designed for similar traffic volumes. Therefore, parking lots are typically designed using the AASHTO method and adjusted based on experience. If the owner would like Building & Earth Sciences, Inc. to assess other likely traffic volumes, we will gladly review other options.

In addition, we have assumed the following design parameters:

Table 8: Assumed Design Parameters

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

Note: All 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:

Table 9: DOT Specification Sections

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

7.1 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:

Table 10: Structural Equivalent Coefficient

Material	Structural No.
Asphalt Concrete	0.44
Crushed Stone Base	0.14

The following flexible pavement sections are based on the design parameters presented above:

Table 11: Asphalt Pavement Recommendations

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")

7.2 RIGID PAVEMENT

The following rigid pavement sections are based on the design parameters presented above. We assume an effective 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.

Table 12: Rigid Pavement Recommendations

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")

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 recommended the pavements be reinforced to hold any cracks that might develop tightly together and restrain their growth.

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 six (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.

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.

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

All pavement components must be placed and compacted in accordance with the applicable sections of the Oklahoma Department of Transportation (ODOT), Standard Specifications for Highway Construction, dated 2019. All base and pavement construction operations should meet minimum requirements of the Oklahoma Department of Transportation (ODOT), Standard Specifications for Highway Construction, dated 2019.

8.0 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 at least 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.

9.0 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.

10.0 CONSTRUCTION MONITORING

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

- Periodic observation and consultation by a member of our engineering staff during site development.
- Continuous monitoring during structural fill placement.
- Field density testing during structural fill placement.
- Observation and verification of the bearing surfaces exposed after foundation excavation.
- Molding and testing of concrete cylinders.
- Structural steel inspections.
- Sampling of asphalt for verification and coring for determination of in-place density and thickness.

11.0 CLOSING AND LIMITATIONS

This report was prepared for CNB Construction, for specific application to the Will Rogers Birthplace Ranch located in Oologah, 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 in regards to 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. In the event that changes are made, or anticipated to be made, to the nature, design, or location of the project as outlined in this report, Building & Earth Sciences, Inc. 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 Sciences, Inc. 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 Supporting Documentation Appendix. We encourage all individuals to become familiar with the article to help manage risk.

A-1
BORING LOCATION PLAN

REFERENCE USED TO PRODUCE THIS DRAWING:

Google Earth Satellite Imagery dated 11/11/2022, with Site plan overlay provided by EDG, dated May 9, 2024

BORING LOCATION PLAN

DATE: 9/12/2024

PROJECT NO.

TU240148

PROJECT NAME / LOCATION:

Will Rogers Birthplace Ranch
Oologah, Oklahoma

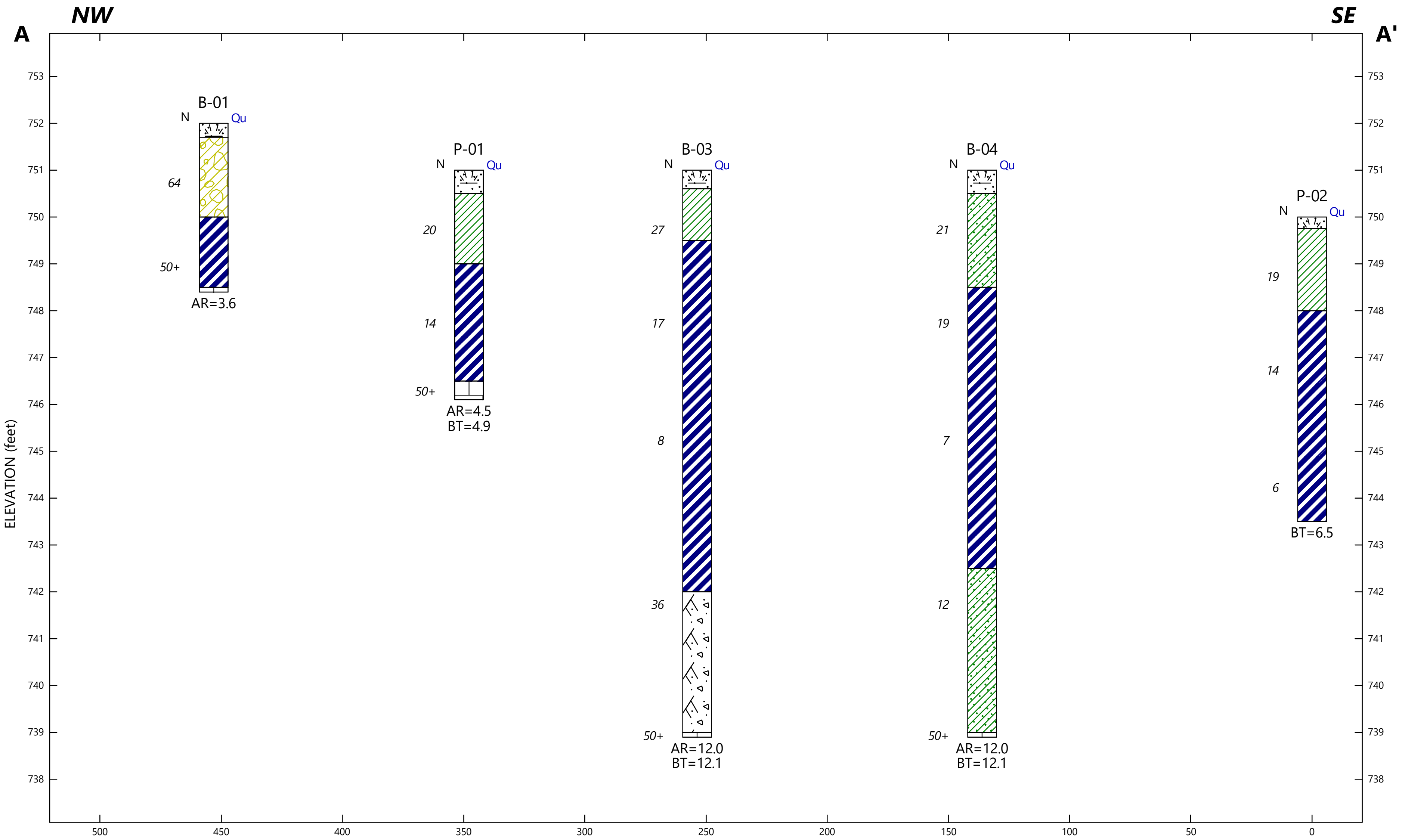
SCALE:

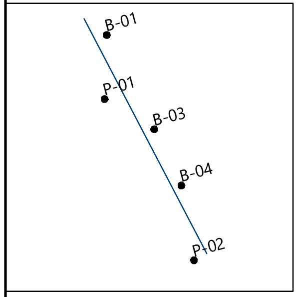
As Shown

BUILDING & EARTH
Geotechnical, Environmental, and Materials Engineers

A-2

SUBSURFACE SOIL PROFILES





Site Map Scale 1 inch equals 360 feet

Key to Hatches

- ▨ Topsoil
- ▨ USCS Clayey Gravel
- ▨ USCS High Plasticity Clay
- ▨ Limestone
- ▨ USCS Low Plasticity Clay
- ▨ Weathered Rock
- ▨ USCS Low Plasticity Sandy 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 59

Horizontal Scale (feet)
Vertical Exaggeration: 19.5x

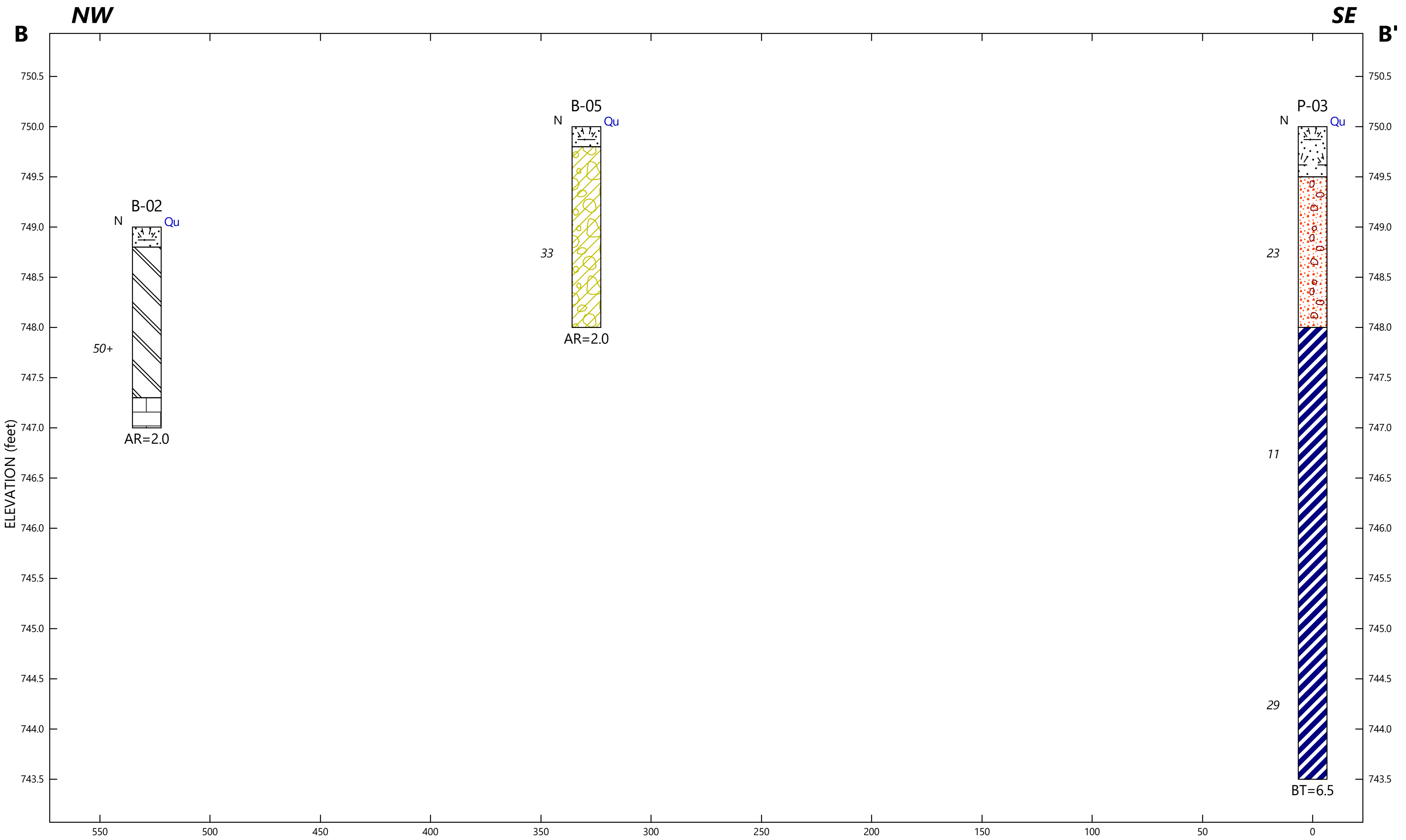
Building & Earth Sciences, Inc.
1403 South 70th East Avenue, Tulsa, OK 74112

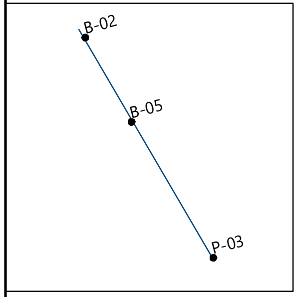
Will Rogers Birthplace Ranch
Oologah, OK

A-A': Subsurface Profile

PROJECT NO: TU240148	PLATE NO: A-1	DATE: 10/1/24

BUILDING & EARTH
Geotechnical, Environmental, and Materials Engineers





Site Map Scale 1 inch equals 400 feet

Key to Hatches

- ▨ Topsoil
- ▨ USCS Clayey Gravel
- ▨ USCS Low to High Plasticity Clay
- ▨ Sandy Clay with Cobbles and Boulders
- ▦ Limestone
- ▨ 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: 45.5x

Building & Earth Sciences, Inc.
1403 South 70th East Avenue, Tulsa, OK 74112

Will Rogers Birthplace Ranch
Oologah, OK

B-B': Subsurface Profile

PROJECT NO: TU240148	PLATE NO: B-1	DATE: 10/1/24

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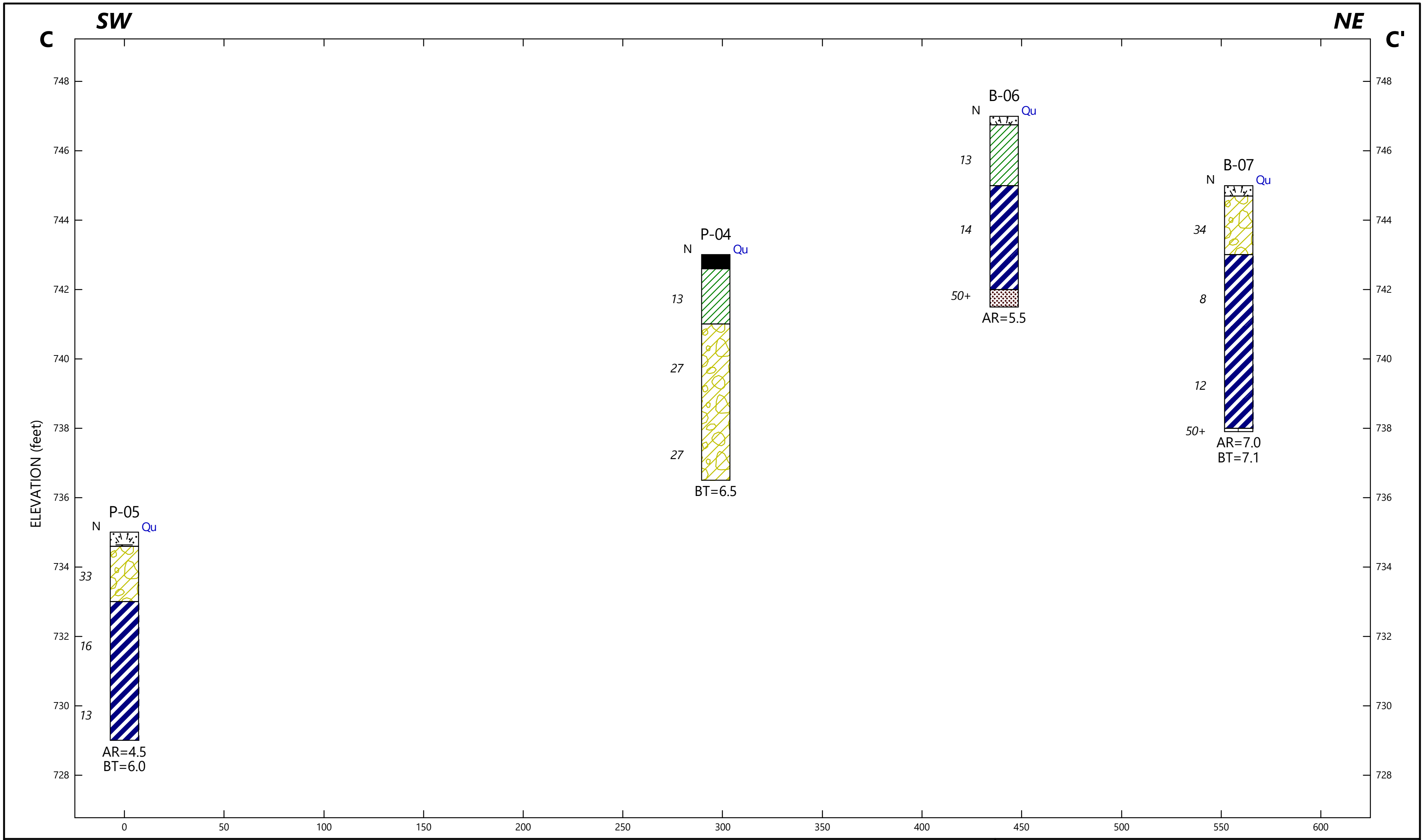
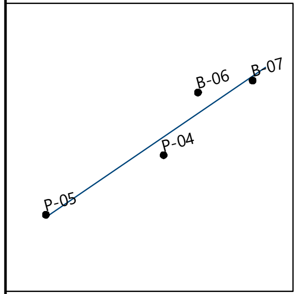
Geotechnical, Environmental, and Materials Engineers





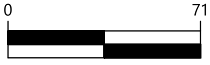
Site Map Scale 1 inch equals 435 feet

Key to Hatches

▨	Topsoil
▨	Sandstone
■	Asphalt
▨	USCS Low Plasticity Clay
▨	USCS Clayey Gravel
▨	USCS High Plasticity Clay
▦	Limestone

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: 17.5x

Building & Earth Sciences, Inc.
1403 South 70th East Avenue, Tulsa, OK 74112

Will Rogers Birthplace Ranch
Oologah, OK

C-C': Subsurface Profile

PROJECT NO: TU240148	PLATE NO: C-1	DATE: 9/30/24

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Geotechnical, Environmental, and Materials Engineers

A-3

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 in the Soil Classification Methodology section of this Appendix.

REMARKS

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

A-4
BORING LOGS

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Geotechnical, Environmental, and Materials Engineers

LOG OF BORING

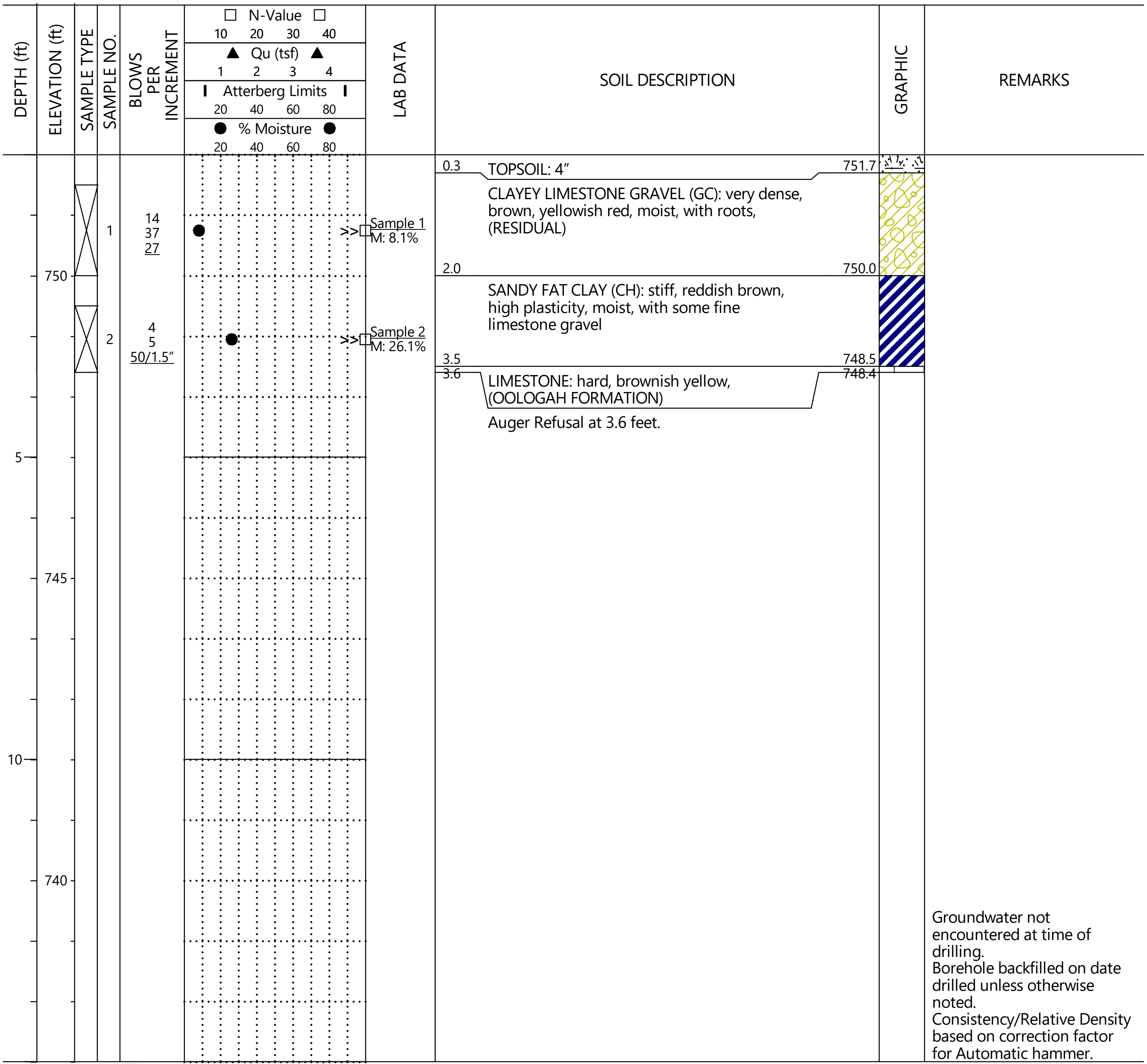
Designation: B-01

Sheet 1 of 1

1403 South 70th East Avenue
Tulsa, OK 74112
Office: (918) 439-9005

PROJECT NAME: Will Rogers Birthplace Ranch
PROJECT NUMBER: TU240148
DRILLING METHOD: Solid Flight Auger
EQUIPMENT USED: Diedrich D-50
HAMMER TYPE: Automatic
BORING LOCATION: Hay barn

LOCATION: Oologah, OK
DATE DRILLED: 9/12/24
WEATHER: Sunny, clear
ELEVATION: 752
DRILL CREW: Building & Earth
LOGGED BY: Q. Mann



SAMPLE NO.	BLOWS PER INCREMENT	LAB DATA
1	14 37 27	Sample 1 M: 8.1%
2	4 5 50/1.5"	Sample 2 M: 26.1%

Depth	Soil Description	Elevation
0.3	TOPSOIL: 4"	751.7
2.0	CLAYEY LIMESTONE GRAVEL (GC): very dense, brown, yellowish red, moist, with roots, (RESIDUAL)	750.0
3.5	SANDY FAT CLAY (CH): stiff, reddish brown, high plasticity, moist, with some fine limestone gravel	748.5
3.6	LIMESTONE: hard, brownish yellow, (OOLOGAH FORMATION)	748.4

Auger Refusal at 3.6 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		

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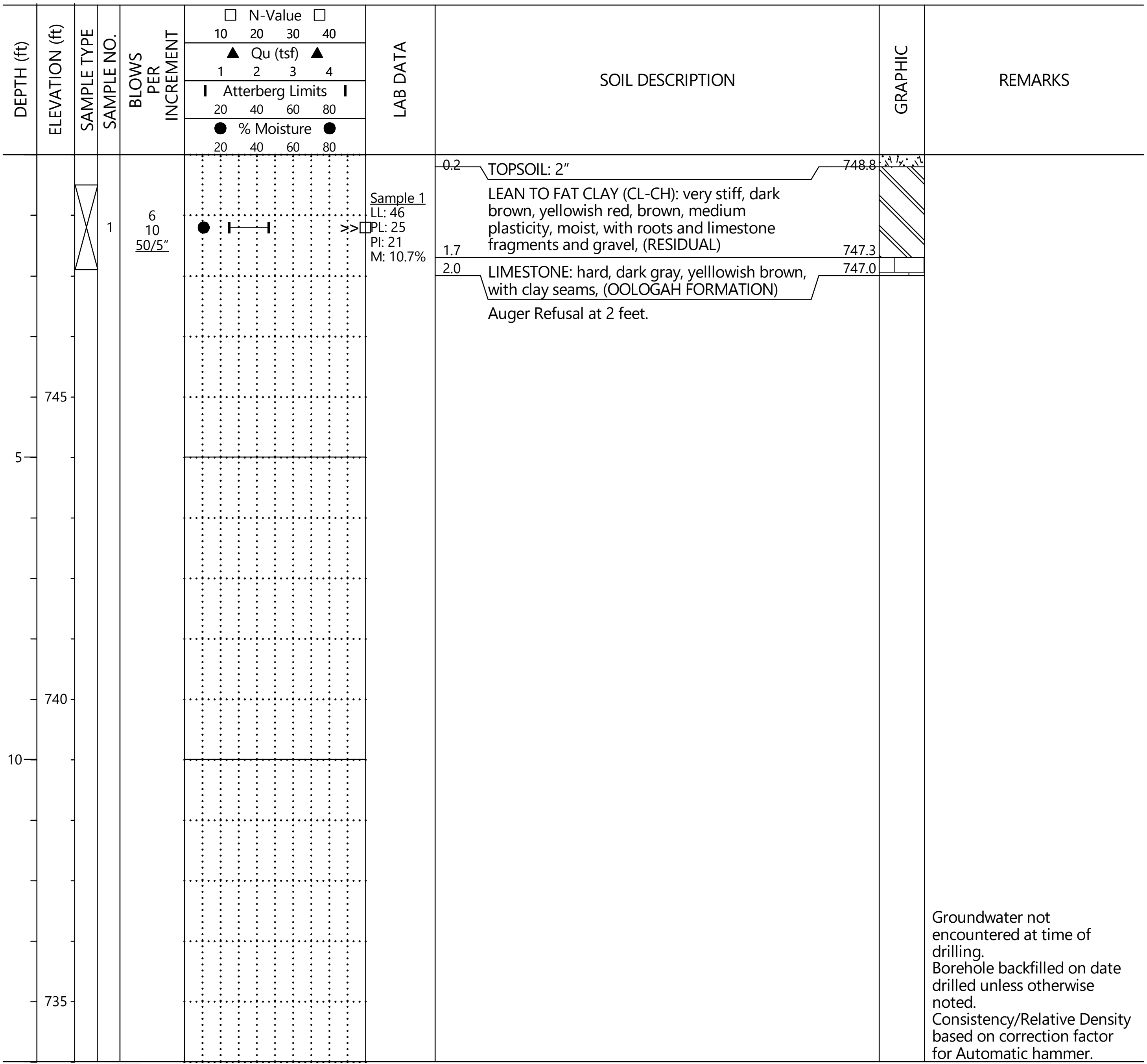
1403 South 70th East Avenue
Tulsa, OK 74112
Office: (918) 439-9005

LOG OF BORING

Designation: B-02

Sheet 1 of 1

PROJECT NAME: Will Rogers Birthplace Ranch
PROJECT NUMBER: TU240148
DRILLING METHOD: Solid Flight Auger
EQUIPMENT USED: Diedrich D-50
HAMMER TYPE: Automatic
BORING LOCATION: North corner of maintenance building
LOCATION: Oologah, OK
DATE DRILLED: 9/12/24
WEATHER: Sunny, clear
ELEVATION: 749
DRILL CREW: Building & Earth
LOGGED BY: Q. Mann



DEPTH (ft)	ELEVATION (ft)	SAMPLE NO.	BLOWS PER INCREMENT	LAB DATA	SOIL DESCRIPTION	REMARKS
0.2	748.8				TOPSOIL: 2"	
1.7	747.3	1	6 10 50/5"	Sample 1 LL: 46 PL: 25 PI: 21 M: 10.7%	LEAN TO FAT CLAY (CL-CH): very stiff, dark brown, yellowish red, brown, medium plasticity, moist, with roots and limestone fragments and gravel, (RESIDUAL)	
2.0	747.0				LIMESTONE: hard, dark gray, yelllowish brown, with clay seams, (OOLOGAH FORMATION)	
					Auger Refusal at 2 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
% 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		

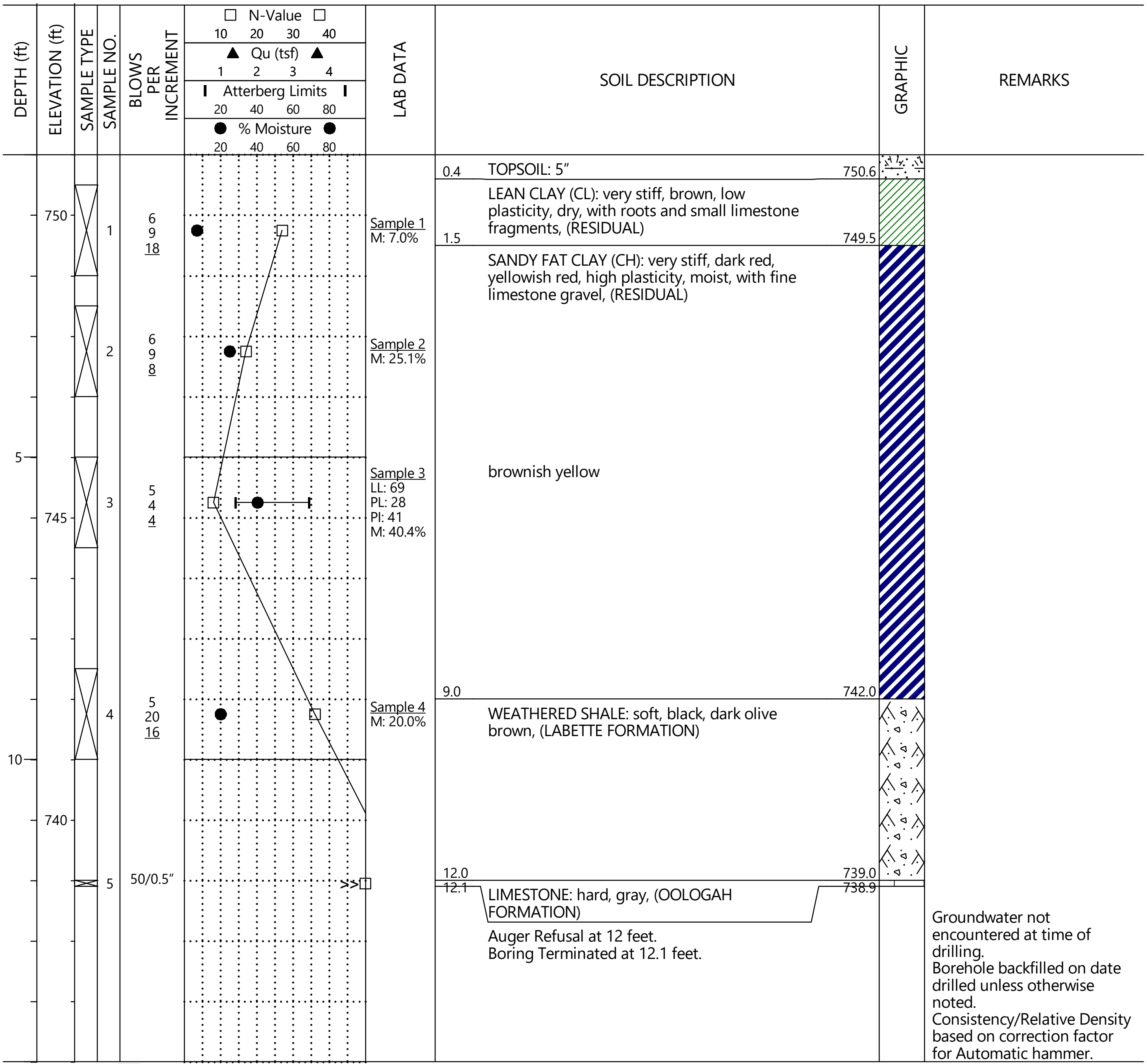
M: NATURAL MOISTURE CONTENT
F: PERCENT PASSING NO. 200 SIEVE

BUILDING & EARTH
Geotechnical, Environmental, and Materials Engineers

1403 South 70th East Avenue
Tulsa, OK 74112
Office: (918) 439-9005

LOG OF BORING
Designation: B-03
Sheet 1 of 1

PROJECT NAME: Will Rogers Birthplace Ranch
PROJECT NUMBER: TU240148
DRILLING METHOD: Solid Flight Auger
EQUIPMENT USED: Diedrich D-50
HAMMER TYPE: Automatic
BORING LOCATION: South corner of maintenance building
LOCATION: Oologah, OK
DATE DRILLED: 9/12/24
WEATHER: Sunny, clear
ELEVATION: 751
DRILL CREW: Building & Earth
LOGGED BY: Q. Mann



SAMPLE NO.	BLOWS PER INCREMENT	LAB DATA
1	6 9 18	Sample 1 M: 7.0%
2	6 9 8	Sample 2 M: 25.1%
3	5 4 4	Sample 3 LL: 69 PL: 28 PI: 41 M: 40.4%
4	5 20 16	Sample 4 M: 20.0%
5	50/0.5"	

DEPTH (ft)	SOIL DESCRIPTION	ELEVATION (ft)
0.4	TOPSOIL: 5"	750.6
1.5	LEAN CLAY (CL): very stiff, brown, low plasticity, dry, with roots and small limestone fragments, (RESIDUAL)	749.5
9.0	SANDY FAT CLAY (CH): very stiff, dark red, yellowish red, high plasticity, moist, with fine limestone gravel, (RESIDUAL) brownish yellow	742.0
12.0	WEATHERED SHALE: soft, black, dark olive brown, (LABETTE FORMATION)	739.0
12.1	LIMESTONE: hard, gray, (OOLOGAH FORMATION)	738.9

Auger Refusal at 12 feet.
Boring Terminated at 12.1 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
% 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

BUILDING & EARTH
Geotechnical, Environmental, and Materials Engineers

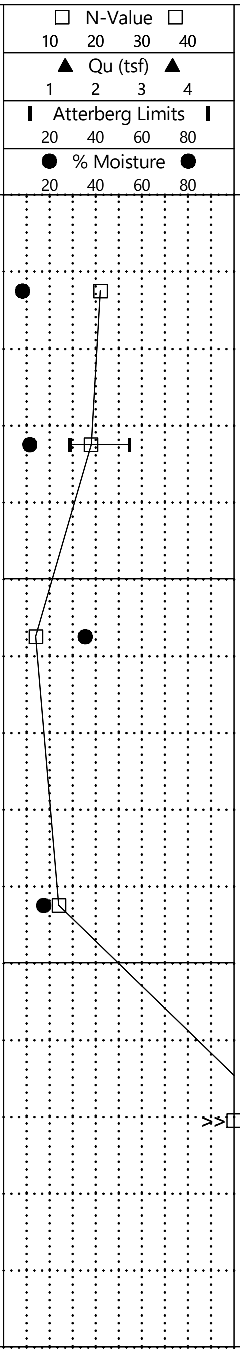
LOG OF BORING

Designation: B-04

Sheet 1 of 1

1403 South 70th East Avenue
Tulsa, OK 74112
Office: (918) 439-9005

PROJECT NAME:	Will Rogers Birthplace Ranch	LOCATION:	Oologah, OK
PROJECT NUMBER:	TU240148	DATE DRILLED:	9/12/24
DRILLING METHOD:	Solid Flight Auger	WEATHER:	Sunny, clear
EQUIPMENT USED:	Diedrich D-50	ELEVATION:	751
HAMMER TYPE:	Automatic	DRILL CREW:	Building & Earth
BORING LOCATION:	Fire Protection Infrastructure	LOGGED BY:	Q. Mann



DEPTH (ft)	ELEVATION (ft)	SAMPLE TYPE	SAMPLE NO.	BLOWS PER INCREMENT	LAB DATA	SOIL DESCRIPTION	GRAPHIC	REMARKS
0.5	750.5					TOPSOIL: 6"		
	750	☒	1	7 10 11	Sample 1 M: 8.2%	SANDY LEAN CLAY (CL): very stiff, reddish brown, medium plasticity, dry, with roots and some fine gravel, (RESIDUAL)		
2.5	748.5	☒	2	6 11 8	Sample 2 LL: 54 PL: 29 PI: 25 M: 11.4% F: 24.7%	SANDY FAT CLAY (CH): very stiff, red, yellowish red, moist, with limestone gravel, (RESIDUAL)		
5	745	☒	3	4 3 4	Sample 3 M: 35.4%	stiff, yellowish brown, dark red, with increased moisture contents		
8.5	742.5	☒	4	3 5 7	Sample 4 M: 17.4%	SANDY LEAN CLAY (CL): stiff to very stiff, white, dark yellowish brown, gray, medium plasticity, moist, with calcareous deposits, (RESIDUAL)		
10	740							
12.0 12.1	739.0 738.9	☒	5	50/0.5"		LIMESTONE: hard, gray, (OOLOGAH FORMATION) Auger Refusal at 12 feet. Boring Terminated at 12.1 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		

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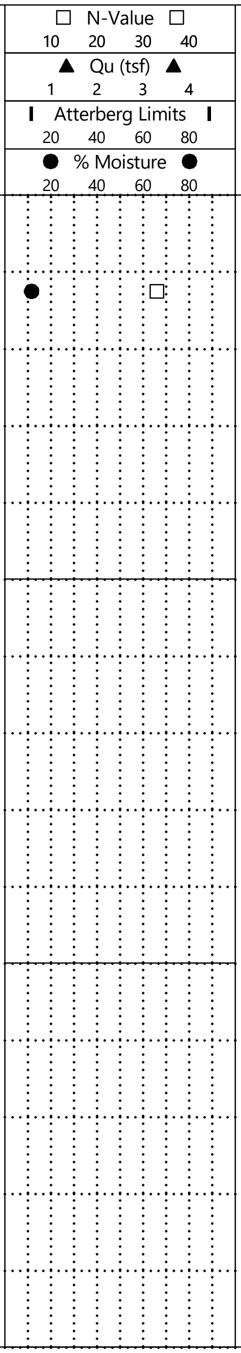
LOG OF BORING
Designation: B-05
Sheet 1 of 1

1403 South 70th East Avenue
Tulsa, OK 74112
Office: (918) 439-9005

PROJECT NAME: Will Rogers Birthplace Ranch
PROJECT NUMBER: TU240148
DRILLING METHOD: Solid Flight Auger
EQUIPMENT USED: Diedrich D-50
HAMMER TYPE: Automatic
BORING LOCATION: Caretaker's Home

LOCATION: Oologah, OK
DATE DRILLED: 9/12/24
WEATHER: Sunny, clear
ELEVATION: 750
DRILL CREW: Building & Earth
LOGGED BY: Q. Mann



DEPTH (ft)	ELEVATION (ft)	SAMPLE TYPE	SAMPLE NO.	BLOWS PER INCREMENT	LAB DATA	SOIL DESCRIPTION	GRAPHIC	REMARKS
0.2	750 749.8					TOPSOIL: 2"		
		☒	1	12 15 18	Sample 1 M: 11.6%	CLAYEY LIMESTONE GRAVEL (GC): dense, dark brown, yellowish red, yellow, moist, with roots, (RESIDUAL)		
2.0	748.0					Auger Refusal at 2 feet.		
5	745							
10	740							
	735							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		

LOG OF BORING

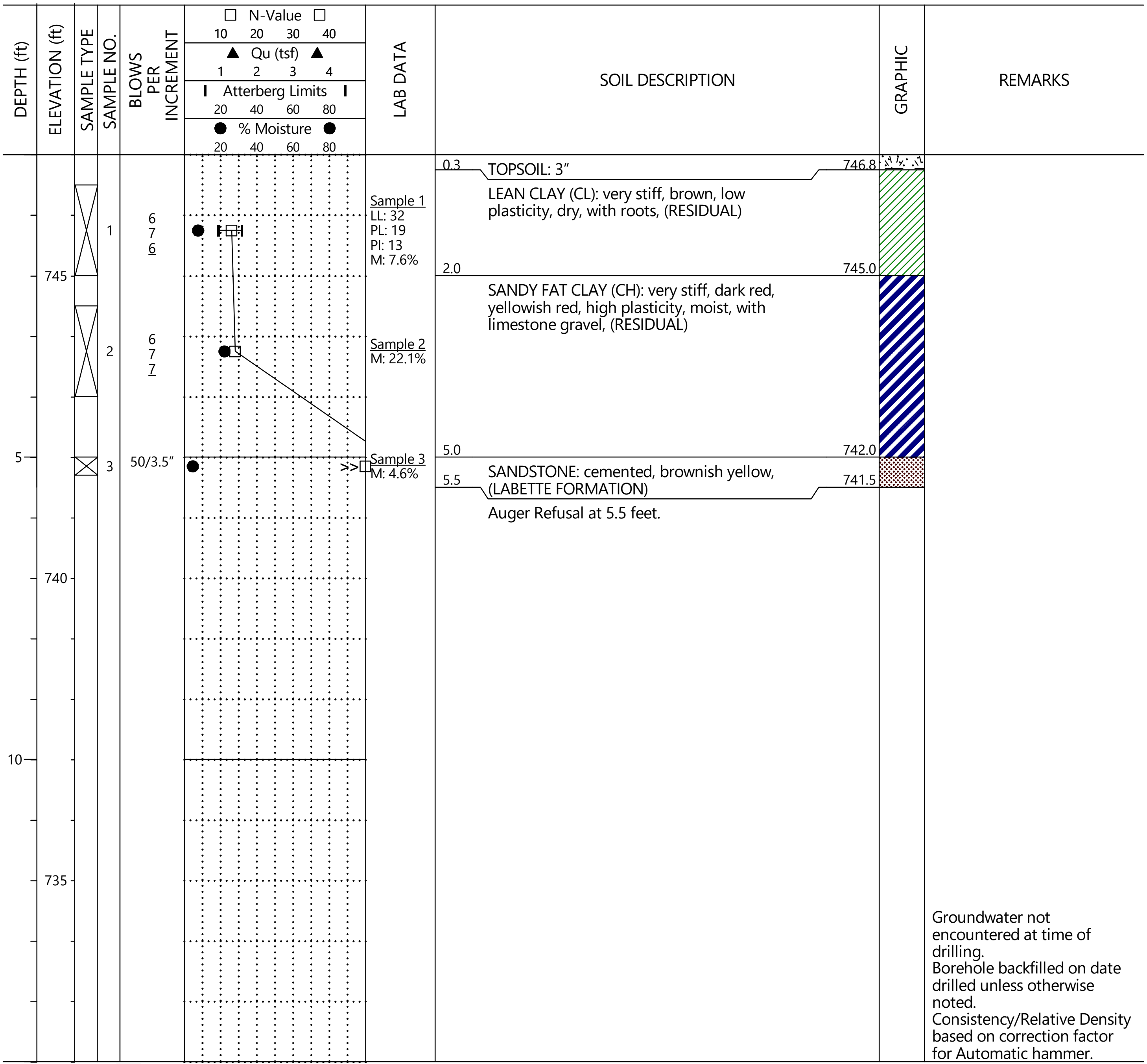
Designation: B-06

Sheet 1 of 1

1403 South 70th East Avenue
Tulsa, OK 74112
Office: (918) 439-9005

PROJECT NAME: Will Rogers Birthplace Ranch
PROJECT NUMBER: TU240148
DRILLING METHOD: Solid Flight Auger
EQUIPMENT USED: Diedrich D-50
HAMMER TYPE: Automatic
BORING LOCATION: Interpretive Center

LOCATION: Oologah, OK
DATE DRILLED: 9/11/24
WEATHER: Sunny, clear
ELEVATION: 747
DRILL CREW: Building & Earth
LOGGED BY: Q. Mann



Depth (ft)	Elevation (ft)	Sample No.	Blows per Increment	Lab Data	Soil Description
0.3	746.8				TOPSOIL: 3”
2.0	745.0	1	6 7 6	Sample 1 LL: 32 PL: 19 PI: 13 M: 7.6%	LEAN CLAY (CL): very stiff, brown, low plasticity, dry, with roots, (RESIDUAL)
5.0	742.0	2	6 7 7	Sample 2 M: 22.1%	SANDY FAT CLAY (CH): very stiff, dark red, yellowish red, high plasticity, moist, with limestone gravel, (RESIDUAL)
5.5	741.5	3	50/3.5”	Sample 3 M: 4.6%	SANDSTONE: cemented, brownish yellow, (LABETTE FORMATION)

Auger Refusal at 5.5 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

BUILDING & EARTH
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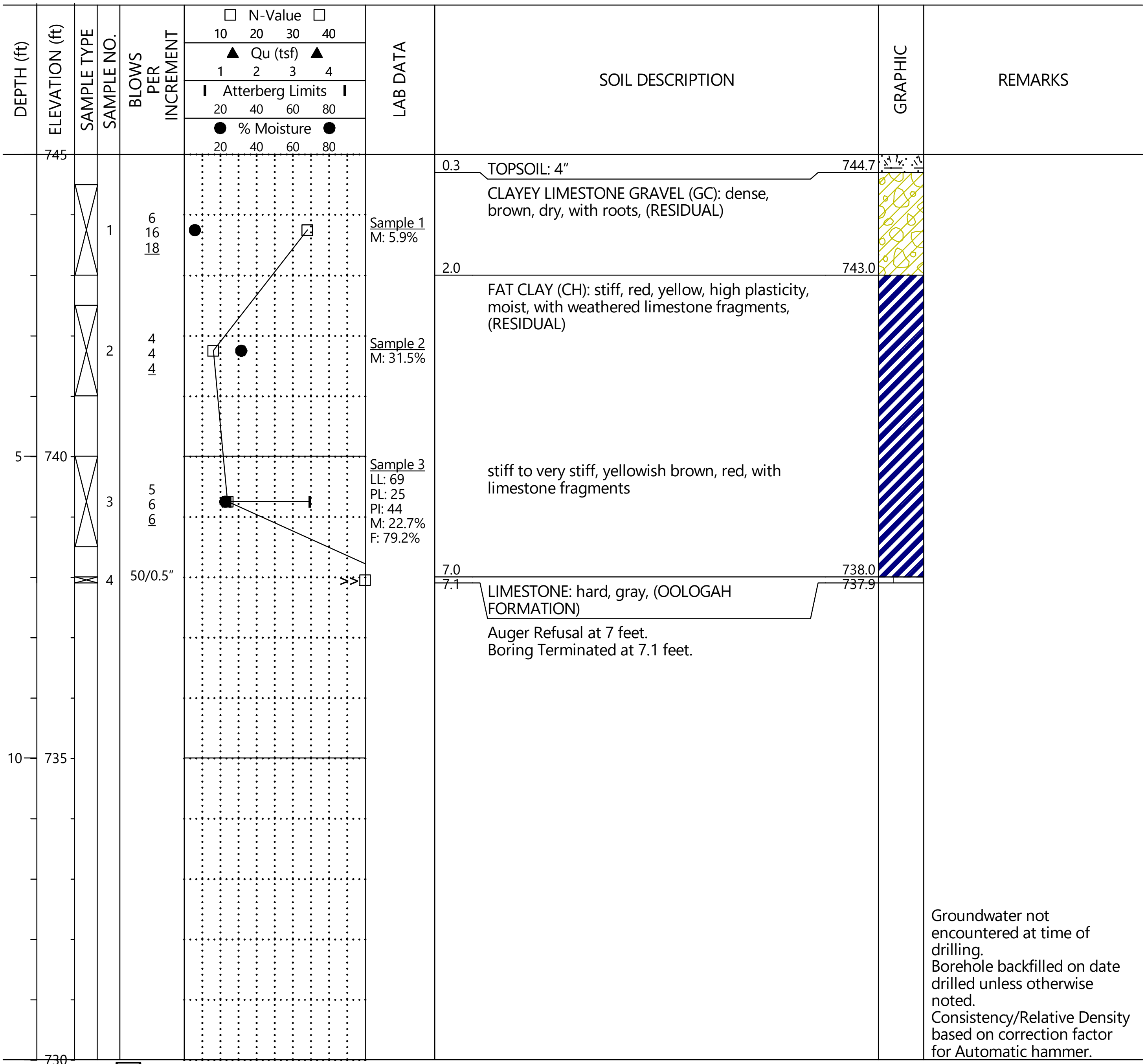
LOG OF BORING

Designation: B-07

Sheet 1 of 1

1403 South 70th East Avenue
Tulsa, OK 74112
Office: (918) 439-9005

PROJECT NAME:	Will Rogers Birthplace Ranch	LOCATION:	Oologah, OK
PROJECT NUMBER:	TU240148	DATE DRILLED:	9/11/24
DRILLING METHOD:	Solid Flight Auger	WEATHER:	Sunny, clear
EQUIPMENT USED:	Diedrich D-50	ELEVATION:	745
HAMMER TYPE:	Automatic	DRILL CREW:	Building & Earth
BORING LOCATION:	Event Center	LOGGED BY:	Q. Mann



SAMPLE NO.	BLOWS PER INCREMENT	LAB DATA
1	6 16 18	Sample 1 M: 5.9%
2	4 4 4	Sample 2 M: 31.5%
3	5 6 6	Sample 3 LL: 69 PL: 25 PI: 44 M: 22.7% F: 79.2%
4	50/0.5"	

0.3 TOPSOIL: 4" 744.7

CLAYEY LIMESTONE GRAVEL (GC): dense, brown, dry, with roots, (RESIDUAL)

2.0 743.0

FAT CLAY (CH): stiff, red, yellow, high plasticity, moist, with weathered limestone fragments, (RESIDUAL)

stiff to very stiff, yellowish brown, red, with limestone fragments

7.0 738.0

7.1 737.9

LIMESTONE: hard, gray, (OOLOGAH FORMATION)

Auger Refusal at 7 feet.
Boring Terminated at 7.1 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
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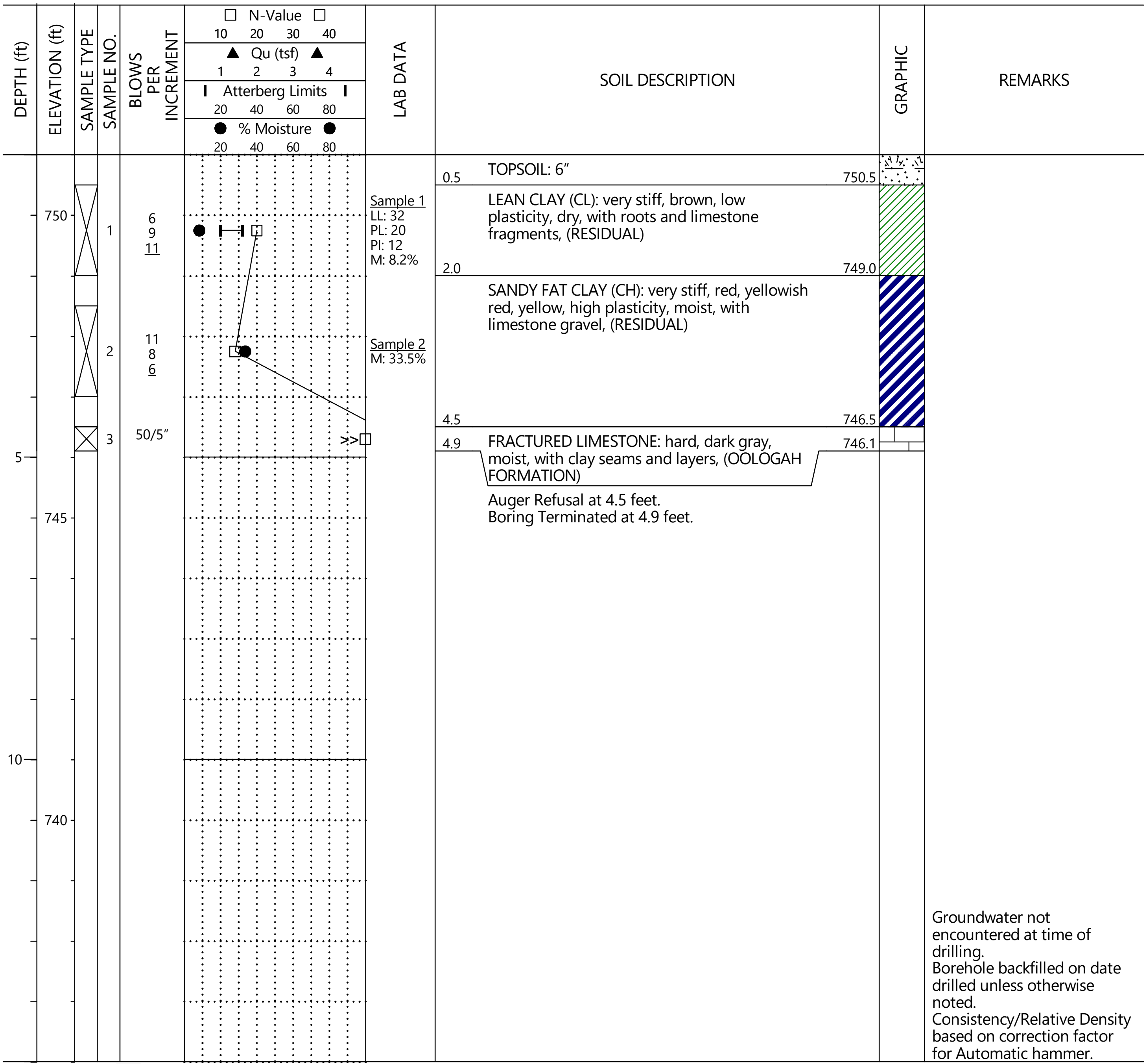
LOG OF BORING
Designation: P-01
Sheet 1 of 1

1403 South 70th East Avenue
Tulsa, OK 74112
Office: (918) 439-9005

PROJECT NAME: Will Rogers Birthplace Ranch
PROJECT NUMBER: TU240148
DRILLING METHOD: Hollow Stem Auger
EQUIPMENT USED: Diedrich D-50
HAMMER TYPE: Automatic
BORING LOCATION: North end of access drive

LOCATION: Oologah, OK
DATE DRILLED: 9/12/24
WEATHER: Sunny, clear
ELEVATION: 751
DRILL CREW: Building & Earth
LOGGED BY: Q. Mann



DEPTH (ft)	ELEVATION (ft)	SAMPLE TYPE	SAMPLE NO.	BLOWS PER INCREMENT	LAB DATA	SOIL DESCRIPTION
0.5	750.5					TOPSOIL: 6”
2.0	749.0	☒	1	6 9 11	Sample 1 LL: 32 PL: 20 PI: 12 M: 8.2%	LEAN CLAY (CL): very stiff, brown, low plasticity, dry, with roots and limestone fragments, (RESIDUAL)
4.5	746.5	☒	2	11 8 6	Sample 2 M: 33.5%	SANDY FAT CLAY (CH): very stiff, red, yellowish red, yellow, high plasticity, moist, with limestone gravel, (RESIDUAL)
4.9	746.1	☒	3	50/5”		FRACTURED LIMESTONE: hard, dark gray, moist, with clay seams and layers, (OOLOGAH FORMATION)

Auger Refusal at 4.5 feet.
Boring Terminated at 4.9 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

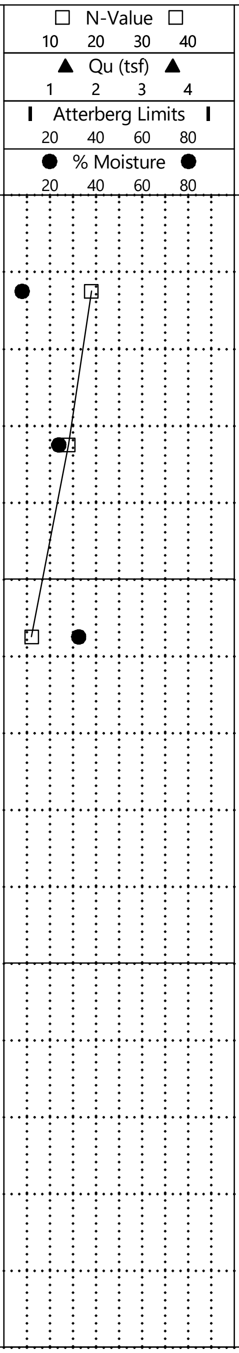
Designation: P-02

Sheet 1 of 1

1403 South 70th East Avenue
Tulsa, OK 74112
Office: (918) 439-9005

PROJECT NAME: Will Rogers Birthplace Ranch
PROJECT NUMBER: TU240148
DRILLING METHOD: Solid Flight Auger
EQUIPMENT USED: Diedrich D-50
HAMMER TYPE: Automatic
BORING LOCATION: Access Drive/ West end of parking lot

LOCATION: Oologah, OK
DATE DRILLED: 9/12/24
WEATHER: Sunny, clear
ELEVATION: 750
DRILL CREW: Building & Earth
LOGGED BY: Q. Mann



DEPTH (ft)	ELEVATION (ft)	SAMPLE TYPE	SAMPLE NO.	BLOWS PER INCREMENT	LAB DATA	SOIL DESCRIPTION	GRAPHIC	REMARKS
0	750							
0.3	749.8					TOPSOIL: 3”		
		☒	1	6 9 10	Sample 1 M: 7.9%	LEAN CLAY (CL): very stiff, low plasticity, dry, with roots and limestone fragments, (RESIDUAL)	▨	
2.0	748.0							
		☒	2	11 8 6	Sample 2 M: 23.8%	SANDY FAT CLAY (CH): very stiff, dark red, yellowish red, high plasticity, moist, with limestone gravel, (RESIDUAL)	▨	
5	745	☒	3	5 4 2	Sample 3 M: 32.5%	medium stiff, with increased moisture content	▨	
6.5	743.5					Boring Terminated at 6.5 feet.		
10	740							
	735							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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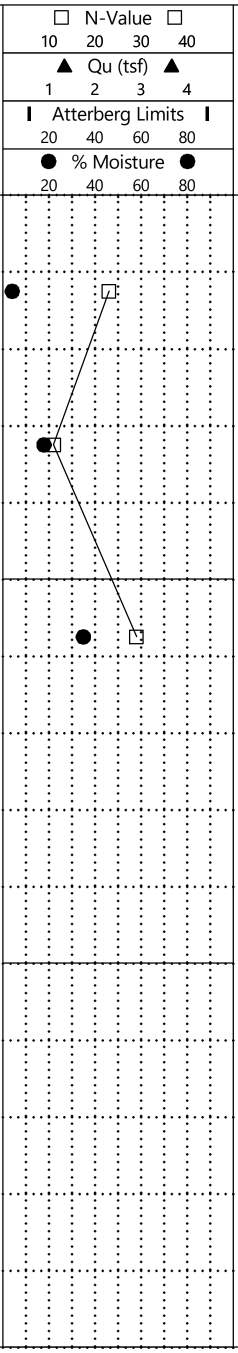
Geotechnical, Environmental, and Materials Engineers

LOG OF BORING
Designation: P-03
Sheet 1 of 1

1403 South 70th East Avenue
Tulsa, OK 74112
Office: (918) 439-9005

PROJECT NAME:	Will Rogers Birthplace Ranch	LOCATION:	Oologah, OK
PROJECT NUMBER:	TU240148	DATE DRILLED:	9/11/24
DRILLING METHOD:	Solid Flight Auger	WEATHER:	Sunny, clear
EQUIPMENT USED:	Diedrich D-50	ELEVATION:	750
HAMMER TYPE:	Automatic	DRILL CREW:	Building & Earth
BORING LOCATION:	SE corner of parking lot	LOGGED BY:	Q. Mann



DEPTH (ft)	ELEVATION (ft)	SAMPLE TYPE	SAMPLE NO.	BLOWS PER INCREMENT	LAB DATA	SOIL DESCRIPTION	GRAPHIC	REMARKS
0.5	749.5					TOPSOIL: 6"		
2.0	748.0	☒	1	6 10 13	Sample 1 M: 4.1%	GRAVELLY LEAN CLAY (CL): very stiff, brown, low plasticity, moist, with roots and limestone fragments and gravel, (RESIDUAL)		
		☒	2	4 6 5	Sample 2 M: 17.8%	SANDY FAT CLAY (CH): stiff, dark red, yellowish red, moist, with weathered limestone fragments, (RESIDUAL)		
6.5	743.5	☒	3	12 14 15	Sample 3 M: 34.9%	medium stiff, with limestone gravel and increased moisture content		N value not representative of clay consistency due to increased gravel content
						Boring Terminated at 6.5 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 — 745; 10 — 740; 735

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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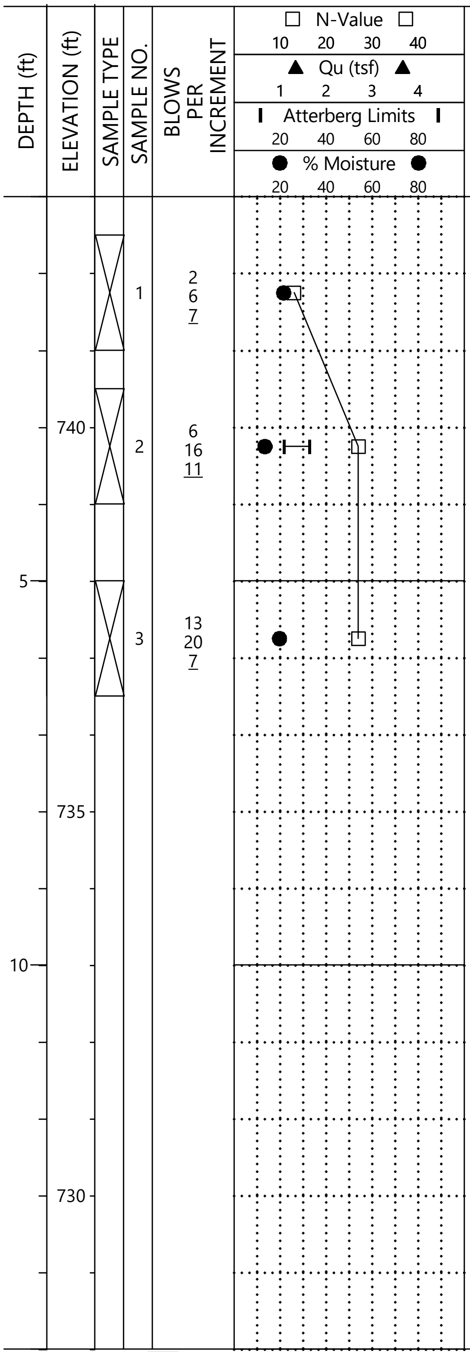
LOG OF BORING
Designation: P-04
Sheet 1 of 1

1403 South 70th East Avenue
Tulsa, OK 74112
Office: (918) 439-9005

PROJECT NAME: Will Rogers Birthplace Ranch
PROJECT NUMBER: TU240148
DRILLING METHOD: Solid Flight Auger
EQUIPMENT USED: Diedrich D-50
HAMMER TYPE: Automatic
BORING LOCATION: Parking lot for birthplace home
LOCATION: Oologah, OK
DATE DRILLED: 9/11/24
WEATHER: Sunny, clear
ELEVATION: 743
DRILL CREW: Building & Earth
LOGGED BY: Q. Mann

DEPTH (ft)	ELEVATION (ft)	SOIL DESCRIPTION	REMARKS
0.4	742.6	ASPHALT: 5.5”	Offset approximately 20’ NW due to overhead power lines.
2.0	741.0	LEAN CLAY (CL): very stiff, dark brown, dark grayish brown, medium plasticity, moist, with limestone fragments, (RESIDUAL)	
6.5	736.5	CLAYEY LIMESTONE GRAVEL (GC): dense, red, yellowish red, dark gray, low plasticity, moist, (RESIDUAL) yellowish brown	
		Boring Terminated at 6.5 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	SAMPLE NO.	BLOWS PER INCREMENT	LAB DATA
☒	1	2 6 7	Sample 1 M: 21.5%
☒	2	6 16 11	Sample 2 LL: 33 PL: 21 PI: 12 M: 13.4% F: 22.1%
☒	3	13 20 7	Sample 3 M: 19.7%



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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1403 South 70th East Avenue
Tulsa, OK 74112
Office: (918) 439-9005

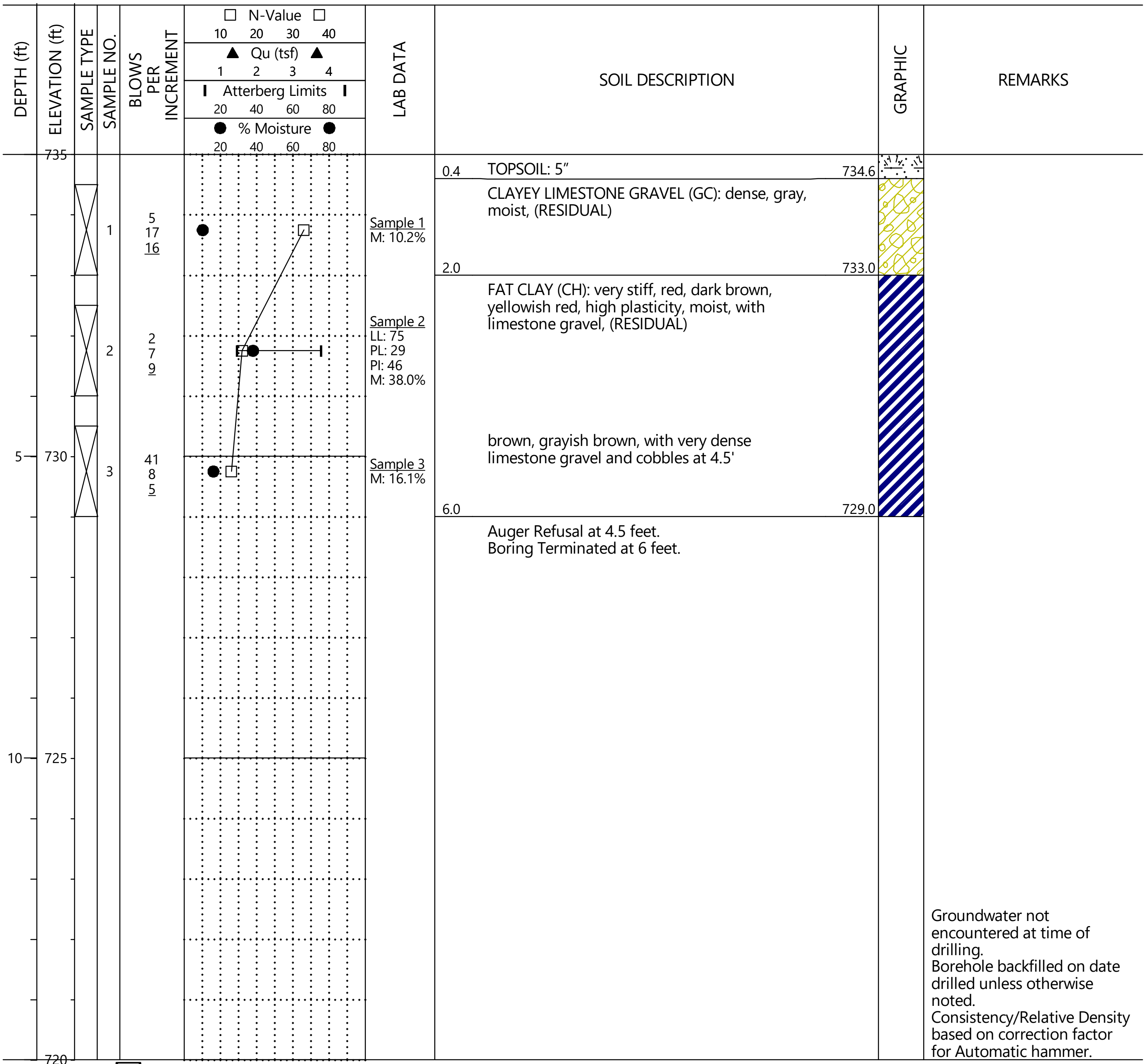
LOG OF BORING

Designation: P-05

Sheet 1 of 1

PROJECT NAME: Will Rogers Birthplace Ranch
PROJECT NUMBER: TU240148
DRILLING METHOD: Solid Flight Auger
EQUIPMENT USED: Diedrich D-50
HAMMER TYPE: Automatic
BORING LOCATION: South access drive

LOCATION: Oologah, OK
DATE DRILLED: 9/11/24
WEATHER: Sunny, clear
ELEVATION: 735
DRILL CREW: Building & Earth
LOGGED BY: Q. Mann



Sample 1
M: 10.2%

Sample 2
LL: 75
PL: 29
PI: 46
M: 38.0%

Sample 3
M: 16.1%

TOPSOIL: 5”

CLAYEY LIMESTONE GRAVEL (GC): dense, gray, moist, (RESIDUAL)

FAT CLAY (CH): very stiff, red, dark brown, yellowish red, high plasticity, moist, with limestone gravel, (RESIDUAL)

brown, grayish brown, with very dense limestone gravel and cobbles at 4.5'

Auger Refusal at 4.5 feet.
Boring Terminated at 6 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				

A-5

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	8.1					
B-01	2.5 - 3.6	26.1					
B-02	0.5 - 1.9	10.7	46	25	21		
B-03	0.5 - 2.0	7.0					
B-03	2.5 - 4.0	25.1					
B-03	5.0 - 6.5	40.4	69	28	41		
B-03	8.5 - 10.0	20.0					
B-04	0.5 - 2.0	8.2					
B-04	2.5 - 4.0	11.4	54	29	25	25	SC
B-04	5.0 - 6.5	35.4					
B-04	8.5 - 10.0	17.4					
B-05	0.5 - 2.0	11.6					
B-06	0.5 - 2.0	7.6	32	19	13		
B-06	2.5 - 4.0	22.1					
B-06	5.0 - 5.3	4.6					
B-07	0.5 - 2.0	5.9					
B-07	2.5 - 4.0	31.5					
B-07	5.0 - 6.5	22.7	69	25	44	79	CH
P-01	0.5 - 2.0	8.2	32	20	12		
P-01	2.5 - 4.0	33.5					
P-02	0.5 - 2.0	7.9					
P-02	2.5 - 4.0	23.8					
P-02	5.0 - 6.5	32.5					
P-03	0.5 - 2.0	4.1					
P-03	2.5 - 4.0	17.8					
P-03	5.0 - 6.5	34.9					
P-04	0.5 - 2.0	21.5					
P-04	2.5 - 4.0	13.4	33	21	12	22	SC
P-04	5.0 - 6.5	19.7					
P-05	0.5 - 2.0	10.2					
P-05	2.5 - 4.0	38.0	75	29	46		

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-05	4.5 - 6.0	16.1					

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.

A-6
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.

A-7

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.

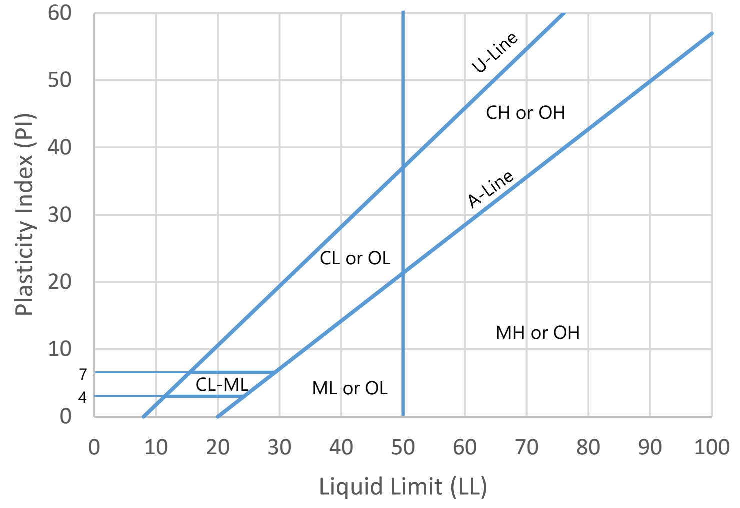
SOIL CLASSIFICATION METHODOLOGY

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*

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.



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

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

* - Modified based on 80% hammer efficiency

KEY TO LOGS

BUILDING & EARTH
Geotechnical, Environmental, and Materials Engineers

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

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	0.075 mm to 2 µm	N.A.
Clay	Less than 2 µm	N.A.

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.

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.

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%

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).

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.

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.

Moisture Condition

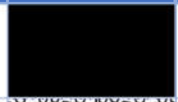
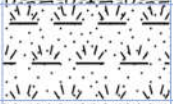
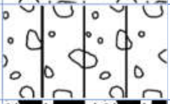
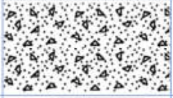
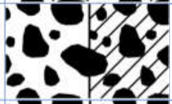
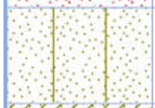
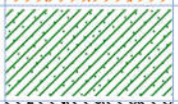
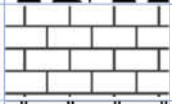
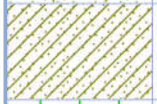
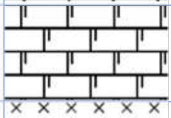
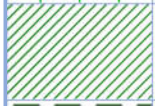
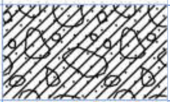
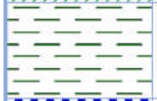
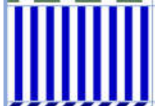
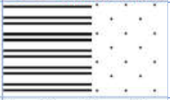
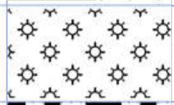
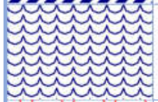
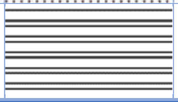
Stratified	Alternating layers of varying material or color with layers at least ½ inch thick.
Laminated	Alternating layers of varying material or color with layers less than ¼ inch thick.
Fissured	Breaks along definite planes of fracture with little resistance to fracturing.
Slickensides	Fracture planes 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.

Structure

KEY TO HATCHES

BUILDING & EARTH
Geotechnical, Environmental, and Materials Engineers

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

Key to Hatches Used for Boring Logs and Soil Profiles

IMPORTANT INFORMATION ABOUT THIS GEOTECHNICAL-ENGINEERING REPORT

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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