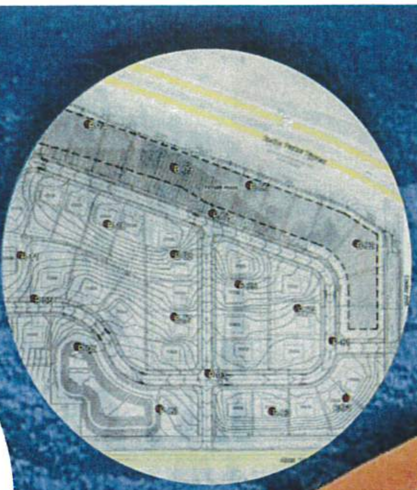
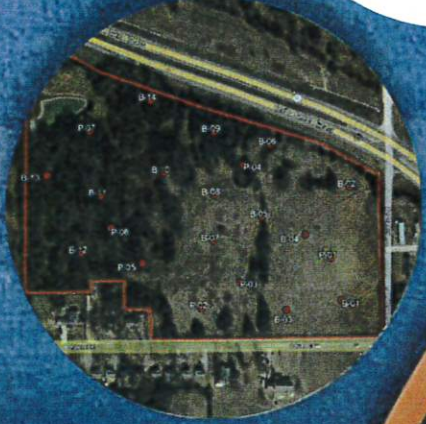




REPORT OF SUBSURFACE EXPLORATION AND GEOTECHNICAL EVALUATION
CHEROKEE NATION HOUSING
TAHLEQUAH, OKLAHOMA
WALLACE PROJECT NUMBER: 2240219
BUILDING & EARTH PROJECT NO.: TU220145

PREPARED FOR:
Wallace Design Collective

AUGUST 10, 2022

BUILDING & EARTH
Geotechnical, Environmental, and Materials Engineers

Table of Contents

References:

- Google Earth Aerial with Project Extents, provided by Wallace Design Collective, undated
- Boring Map, provided by Wallace Design Collective, dated June 16, 2022
- Preliminary grading plan, prepared by Wallace Design Collective, dated July 22, 2022

Table 1 Notes:

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

At the time of our subsurface exploration and site reconnaissance, most of the project site was covered with grass and topsoil. A few trees were located sporadically throughout the planned construction area. Heavy tree cover was noted along the north and west property boundaries.

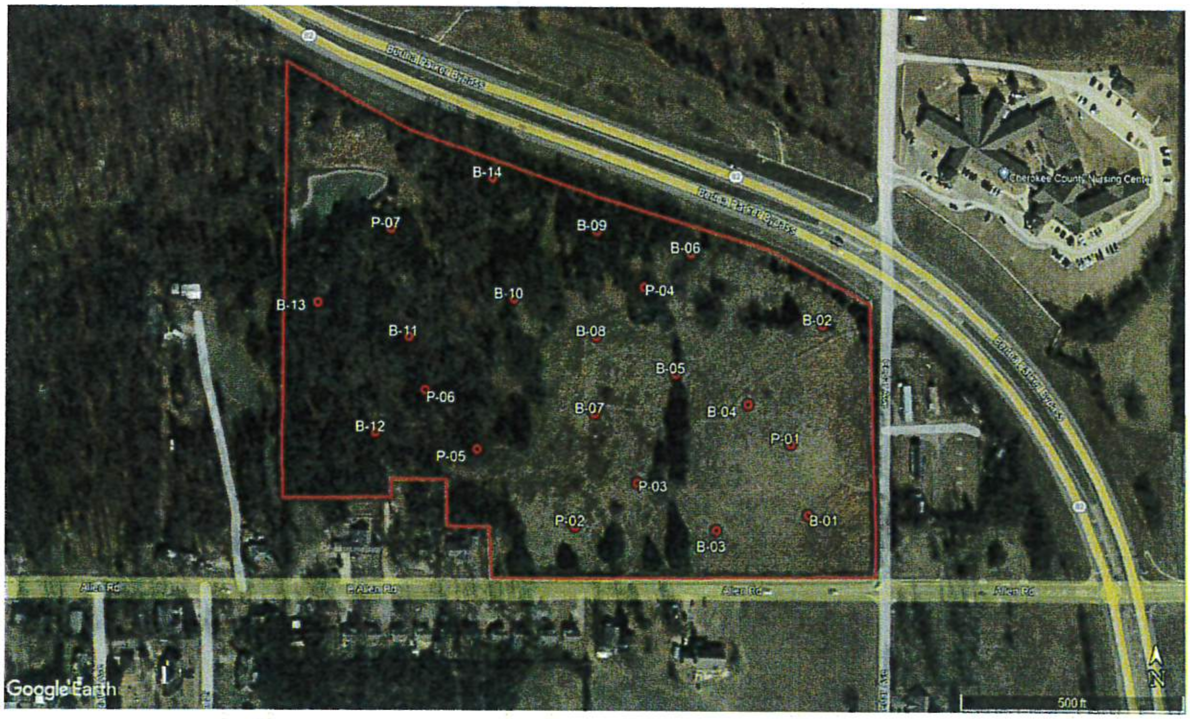


Figure 1: Google Earth aerial image, dated January 2017

Figure 4: Heavy tree cover along west side of the property. Tree clearance was performed in this area to access boring locations.

2.0 SCOPE OF SERVICES

The authorized subsurface exploration was performed on July 18, 19, and 20, 2022, in conformance with our proposal TU24203, dated June 27, 2022.

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 twenty-one (21) test borings. The site was drilled using a track-mounted Diedrich D-50 drill rig equipped with solid flight augers and an automatic hammer.

Prior to start of our subsurface exploration, Smitty's Backhoe Services, LLC, provided limited clearing of the site by cutting down some of the trees and brushes, to provide access to the planned boring locations.

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.

- Recommendations to be used for shallow footing design, including appropriate bearing material types, bearing pressures, and depths. For shear load resistance, recommended coefficient of friction and passive earth pressure values are provided.
- Recommendations to be used for post-tensioned slab foundation design
- 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 2015 based on SPT test boring information.
- Compaction requirements and recommended criteria to establish suitable material for structural backfill.
- Recommended minimum flexible and rigid pavement sections for minor residential streets.

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 at 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 Oklahoma State Geologic Map published by the United States Geological Survey (USGS), the subject property is underlain by the Keokuk Formation. This formation is described to comprise of chert and limestone. The subsurface conditions encountered at the project site generally correlate with the published geologic references.

3.2 EXISTING SURFACE CONDITIONS

At the time of our subsurface exploration, most of the project site was covered with grass and topsoil that had a thickness of about 2.5 to 4 inches. The topsoil conditions reported apply only to the specific boring locations.

Table 3 Notes:

(1) Not encountered in boring B-08 only.

(2) With exception of borings B-01, B-02, B-05, and P-05, all borings were terminated within this stratum at depths ranging between 2.5 and 15 feet below current grades. Auger refusal was encountered in borings B-03, B-04, B-06, B-07, B-10 through B-14, P-02, P-03, and P-06 at depths of about 2.5 to 13.3 feet. It should be noted that in some of the borings auger refusal material could not be ascertained due to poor recovery of the sample. Auger refusal may likely have occurred on chert boulders in the gravelly residuum or on intact rock unit associated with Keokuk Formation.

(3) Encountered in borings B-01, B-02, B-05, and P-05 only.

(4) For Atterberg limits, LL = Liquid Limit, and PI = Plasticity Index

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

3.3.1 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 boulders, buried debris or bedrock. Coring is required to sample the material below auger refusal, which was beyond the scope of work presented in this report.

Auger refusal was encountered at the following depths and elevations in the borings listed below.

Boring No.	Depth (ft)	Elevation (ft)	Boring No.	Depth (ft)	Elevation (ft)
B-03	2.5	899.0	B-12	10.0	905.5
B-04	10.5	897.0	B-13	5.0	914.5
B-06	8.0	924.0	B-14	9.3	923.2
B-07	6.1	900.9	P-02	9.0	893.0
B-10	13.1	901.9	P-03	8.0	896.0
B-11	13.3	896.2	P-06	7.6	900.9

Table 4: Auger Refusal Depths and Elevations

Boring No.	Existing Grade Elevation (ft.)	Planned Finished Grade Elevation (ft.)	Anticipated Cut (-) or Fill (+) (ft.)	Anticipated Subgrade Material
B-01	899.5	904.19	+4.7	Structural Fill
B-02	909.5	Unknown (future phase)	---	Unknown
B-03	901.5	905.67	+4.2	Structural Fill
B-04	907.5	905.68	-1.8	Lean Clay
B-05	911.5	909.0	-2.5	Clayey Chert Gravel
B-06	932.0	Unknown (future phase)	---	Unknown
B-07	907.0	906.81	-0.2	Sandy Silty Clay
B-08	917.0	915.0	-2.0	Clayey Chert Gravel
B-09	939.5	Unknown (future phase)	---	Unknown
B-10	915.0	919.41	+4.4	Structural Fill
B-11	909.5	913.5	+4.0	Structural Fill
B-12	915.5	912.96	-2.5	Clayey Chert Gravel
B-13	919.5	913.5	-6.0	Auger Refusal Material
B-14	932.5	Unknown (future phase)	---	Unknown
P-01	904.5	904.5	0	Lean Clay
P-02	899.0	900.0	+1.0	Structural Fill
P-03	904.0	904.0	0	Silty Clay
P-04	927.5	921.0	-6.5	Clayey Chert Gravel
P-05	902.0	900.0	-2.0	Clayey Chert Gravel
P-06	908.5	909.5	+1.0	Structural Fill
P-07	914.0	914.5	+0.5	Structural Fill

Table 5: Anticipated cut or fill depths at each boring location

If the provided grading plan is revised, Building & Earth should be allowed to review the plan and its effects on our recommendation.

Based on our evaluation of the subsurface conditions, and the anticipated foundation loads, it appears that construction with either a conventional shallow foundation after the implementation of building pad preparation recommendations, or on a post-tensioned slab foundation. The site development recommendations outlined below are intended for development of the site to support construction with either of these foundation options.

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 BUILDING PAD AND PAVEMENT SUBGRADE PREPARATION

Review of the provided grading plan indicated that cut depths on the order of up to 10 feet will be required within the areas located on the west end of the project area (refer to red highlighted area in Figure 5 for cut locations).

A combination of cut and fill on the order of up to 4 feet is anticipated in areas located to the north, east, and central portions of the project area (refer to blue highlighted area in Figure 5).

In areas located to the southeast portion of the project area, fill heights on the order of up to 5 feet will be required to achieve design grades (refer to green highlighted area in Figure 5).

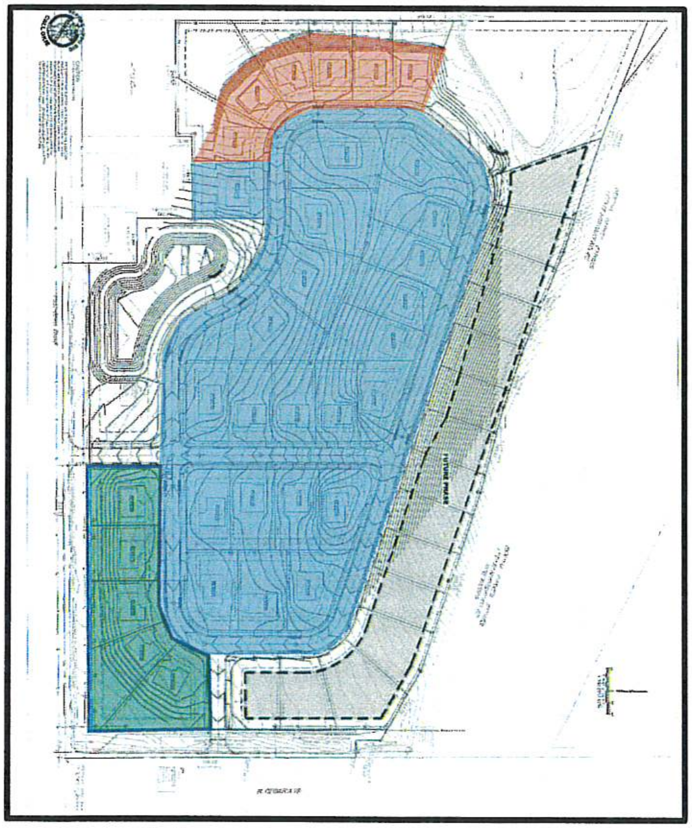


Figure 5: Approximate locations of cut/fill areas

In pavement areas where chert cobbles and boulders, and intact rock units (auger refusal material) are exposed at finished subgrade, it is recommended to undercut those areas to a level that will allow placement of at least 8 inches of approved structural fill.

As a minimum, prior to start of fill placement, the exposed subgrade should be scarified to a depth of 12 inches, moisture conditioned within range of 2 percent below to 2 percent above the optimum moisture content, and recompacted to at least 95 percent of the standard Proctor maximum dry density. Where the subgrade comprises of gravelly residuum with chert cobbles and boulders, or an intact rock unit, scarification and moisture conditioning of the subgrade will not be needed.

It should be emphasized that depending on weather conditions at the time of construction, the near-surface silty/clayey soils may be unstable. If scarification, moisture conditioning, and recompaction is not effective to establish a stable platform for start of structural fill placement, soft/unstable materials should be undercut to expose underlying stable material. The area should then be replaced with structural fill in accordance with the recommendation noted within the *Structural Fill* section of this report.

We recommend that the project geotechnical engineer or a 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 should be carefully proofrolled with a heavy (20- to 25-ton), loaded tandem axle dump truck at the following times.

- After an area has been stripped, 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 must be undercut or stabilized prior to fill placement, floor slab, or pavement construction. All unsuitable material identified during the construction shall be removed and replaced in accordance with the *Structural Fill* section of this report.

6. The near-surface soils have a high silt content, and they are prone to losing stability with slight increases in soil moisture levels. The contractor should use care during fill placement to prevent over wetting of the soils and to limit repeat construction traffic, as this will increase the risk of these soils losing stability. Strict moisture control during and after placement is needed to maintain a stable subgrade condition. Bulk samples of the onsite soils should be collected during initial site preparation for further laboratory testing to evaluate their suitability for use as structural fill.

Placement requirements for structural fill are as follows:

Specification	Requirement
Lift Thickness	Maximum loose lift thickness of 8 to 12 inches, depending on type of compaction equipment used.
Density	At least 95% of the standard Proctor (ASTM D698) maximum dry density
Moisture	±2% of the optimum moisture content as determined by ASTM D698
Density Testing Frequency	**Building and foundation areas**: One test per 2,500 square feet (SF) per lift with a minimum of three tests performed per lift **Pavement areas and utility trenches**: One test per 150 linear feet per lift with a minimum of 2 tests per lift

Table 7: Structural Fill Placement Requirements

4.4 BENCHING OF EXISTING SLOPES

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

4.5 CUT SLOPES

Based on the provided grading information, cut slopes up to 5 to 10 feet in height are expected to be constructed at the site. The maximum plan inclination of cut slopes is generally 3(H):1(V) with some areas at 2(H):1(V).

Due to the types of soils encountered at the site, we recommend that stability analysis be performed for cut slopes greater than 10 feet in height and constructed at an incline of 2(H):1(V). It is very important to note that the stability of cut slopes may depend on minor discontinuities that may not be detected in the borings. Therefore, careful inspection of the excavation process and the cut slope by Building & Earth during construction is critical.

4.6.2 GROUNDWATER OR PERCHED WATER

At the time of drilling, groundwater was encountered in borings B-01 and B-02 at depths of about 9 and 13.5 feet, respectively. 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 sump pumps or trench drains). The contractor should evaluate the most economical and practical dewatering method based on the conditions encountered at the time of construction.

4.7 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.

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

4.8 LANDSCAPING AND DRAINAGE CONSIDERATION

The potential for moisture fluctuations within building areas should be lessened to reduce the potential of subgrade movement. Site grading should include positive drainage away from buildings. Ponding of water adjacent to buildings and pavements could result in moisture increases and instability of onsite soils. Landscaping and irrigation immediately adjacent to buildings and pavements should be limited. Excessive irrigation of landscaping poses a risk of saturating and softening soils below footings and pavements, which could result in settlement of footings and premature failure of pavements.

4.9 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.

The geotechnical recommendations outlined in the *Site Development Considerations* section of this report should be incorporated into the structural design and they should be followed during construction. We recommend that the fill placed within the proposed building areas be monitored on a continuous basis by Building & Earth.

Total long-term settlement of spread footings designed and constructed as recommended above is estimated to be less than 1 inch. Differential settlement between any two points spaced 40 feet across the slab, or along continuous footings is estimated to be ½-inch or less.

5.2 SHEAR RESISTANCE

Passive earth pressures of materials adjacent to the footings as well as bearing material friction at the base may be used to resist shear.

The following table presents recommended friction coefficient and passive earth pressure values for new structural fill or onsite terrace deposits. The structural engineer should use a factor of safety of at least 1.5 when sizing the foundations to resist shear loads using the below ultimate soil parameter values.

Material	Friction Coefficient	Equivalent Fluid Unit Weight for Passive Condition Lateral Earth Pressures (pcf)
New Structural Fill or Residuum	0.35	250

Table 8: Soil Parameter Values Resisting Shear

5.3 POST-TENSIONED SLAB FOUNDATION

As an alternative to supporting the structures on conventional shallow footings, the planned construction may be supported on a post tensioned slab foundation with turndown edges or perimeter footings extending at least 2 feet below the finished exterior grade.

The previous recommendations presented for conventional shallow footings should be followed to provide for suitable bearing material conditions and perimeter footings or turndowns can be designed using a maximum net allowable bearing capacity of 2,500 psf.

Post-tensioned foundation systems may be designed using the procedures detailed in "Design of Post-Tensioned Slabs-on-Ground", Post Tensioning Institute publication PTI DC10.1-08 (3rd edition with 2008 Supplement), using the design parameter values presented in the following table.

- Concrete should be placed the same day the excavations are completed and bearing materials verified by the engineer. If the excavations are left open for an extended period, or if the bearing surfaces are disturbed after the initial observation, then the bearing surfaces should be re-evaluated prior to concrete placement.
- Wherever possible, the foundation concrete should be placed "neat", using the sides of the excavations as forms. Where this is not possible, the excavations created by forming the foundations must be backfilled with suitable structural fill and properly compacted.
- Grades around the building pad should be sloped to drain away from the building foundations.
- Roof drains should be routed away from the foundation soils.

6.0 FLOOR SLABS

Site development recommendations presented in this report should be followed to provide for subgrade conditions suitable for support of grade supported slabs. Floor slabs will be supported on at least 12 inches of approved lower plasticity structural fill.

We recommend floor slabs (both conventionally reinforced and post-tensioned 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. This base stone layer should not be considered part of the recommended structural fill section.

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 130 pci can be used for slabs supported on the recommended base stone underlain by imported low plasticity structural fill. The slab should be appropriately reinforced (if required) to support anticipated floor loads.

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:

Material	Structural No.
Asphalt Concrete	0.44
Crushed Stone Base	0.14

Table 13: Structural Equivalent Coefficient

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

Minimum Recommended Thickness (in)	Material
2.0	HMAC Surface Course (Superpave "S4")
3.5	HMAC Binder Course (Superpave "S3")
6.0	Crushed Aggregate Base (ODOT Type "A")

Table 14: Asphalt Pavement Recommendations

7.2 RIGID PAVEMENT

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

Minimum Recommended Thickness (in)	Material
6.0	Portland Cement Concrete, f'_c=3,500 psi
4.0	Crushed Aggregate Base (ODOT Type "A")

Table 15: Rigid Pavement Recommendations

For approaches, consideration should be given to using a rigid pavement section comprised of seven (7) inches of Portland cement concrete over six (6) inches of crushed aggregate base course.

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.

9.0 CONSTRUCTION MONITORING

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

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

10.0 CLOSING AND LIMITATIONS

This report was prepared for Wallace Design Collective for specific application to the subject project located in Tahlequah, 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 regard to conditions between borings. It will be necessary to confirm the anticipated subsurface conditions during construction.

Appendix Table of Contents

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 CLASSIFICATION METHODOLOGY

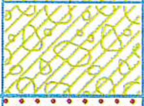
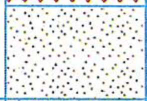
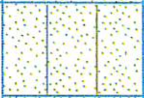
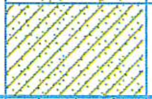
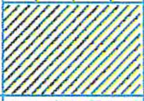
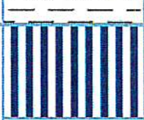
Major Divisions			Symbols		Group Name & Typical Description
			Lithology	Group	
Coarse Grained Soils More than 50% of material is larger than No. 200 sieve size	**Gravel and Gravelly Soils** More than 50% of coarse fraction is larger than No. 4 sieve	**Clean Gravels** (Less than 5% fines)		**GW**	Well-graded 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

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

KEY TO LOGS

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

Table 1: Symbol Legend

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

Table 2: Standard Sieve Sizes

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

Table 3: Soil Data

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

Table 4: Soil Drilling Methods

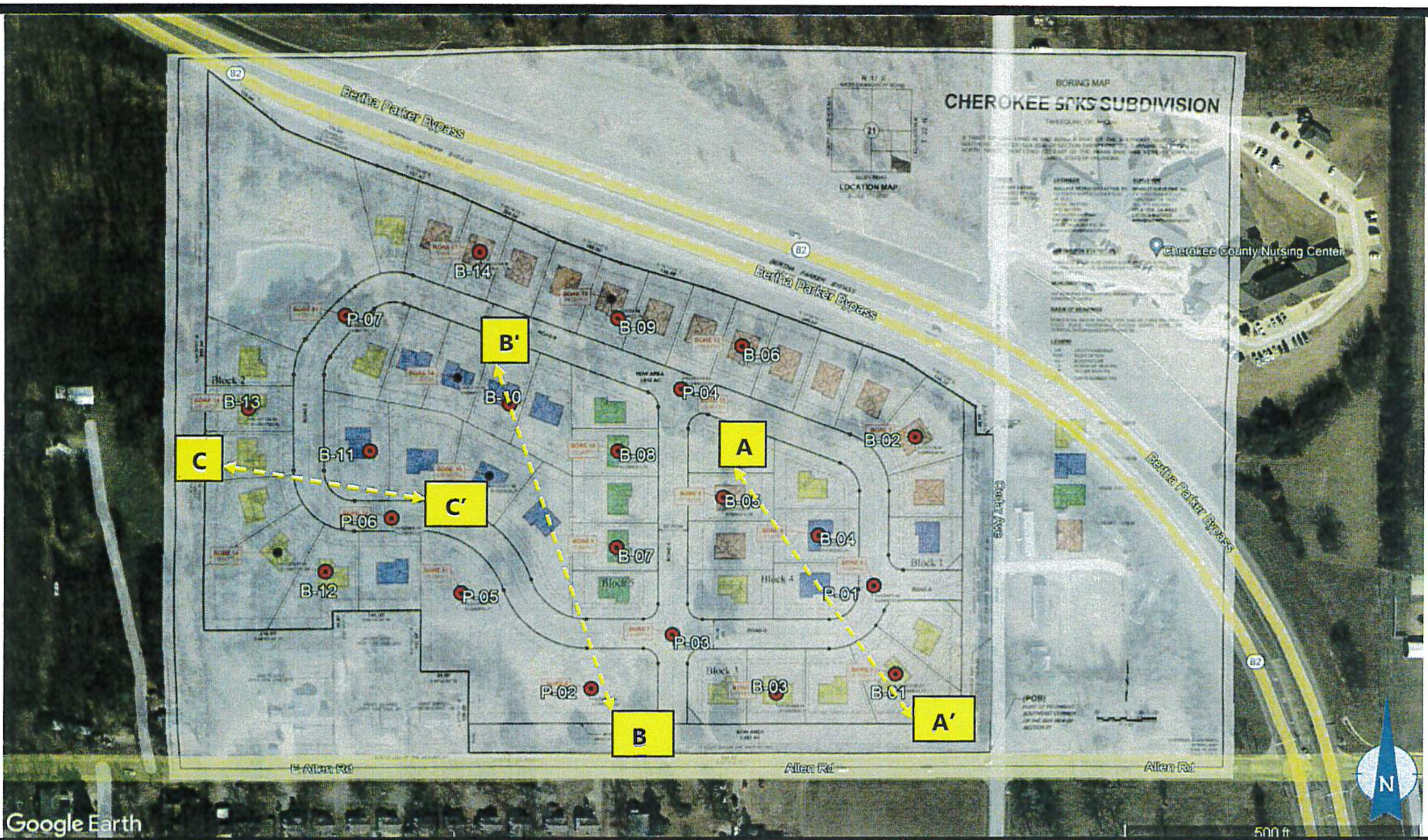
Descriptor	Meaning
Trace	Likely less than 5%
Few	5 to 10%
Little	15 to 25%
Some	30 to 45%
Mostly	50 to 100%

Table 5: Descriptors

KEY TO HATCHES

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

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



REFERENCE USED TO PRODUCE THIS DRAWING:	**BORING LOCATION PLAN**		**DATE: 07/18/2022**
Google Earth Satellite Imagery dated January 2018 with overlay of site plan, provided by Wallace Design Collective, dated June 16, 2022	**PROJECT NO.**	**PROJECT NAME / LOCATION:**	**SCALE:**
	TU220145	Cherokee Nation Housing Tahlequah, Oklahoma	As Shown

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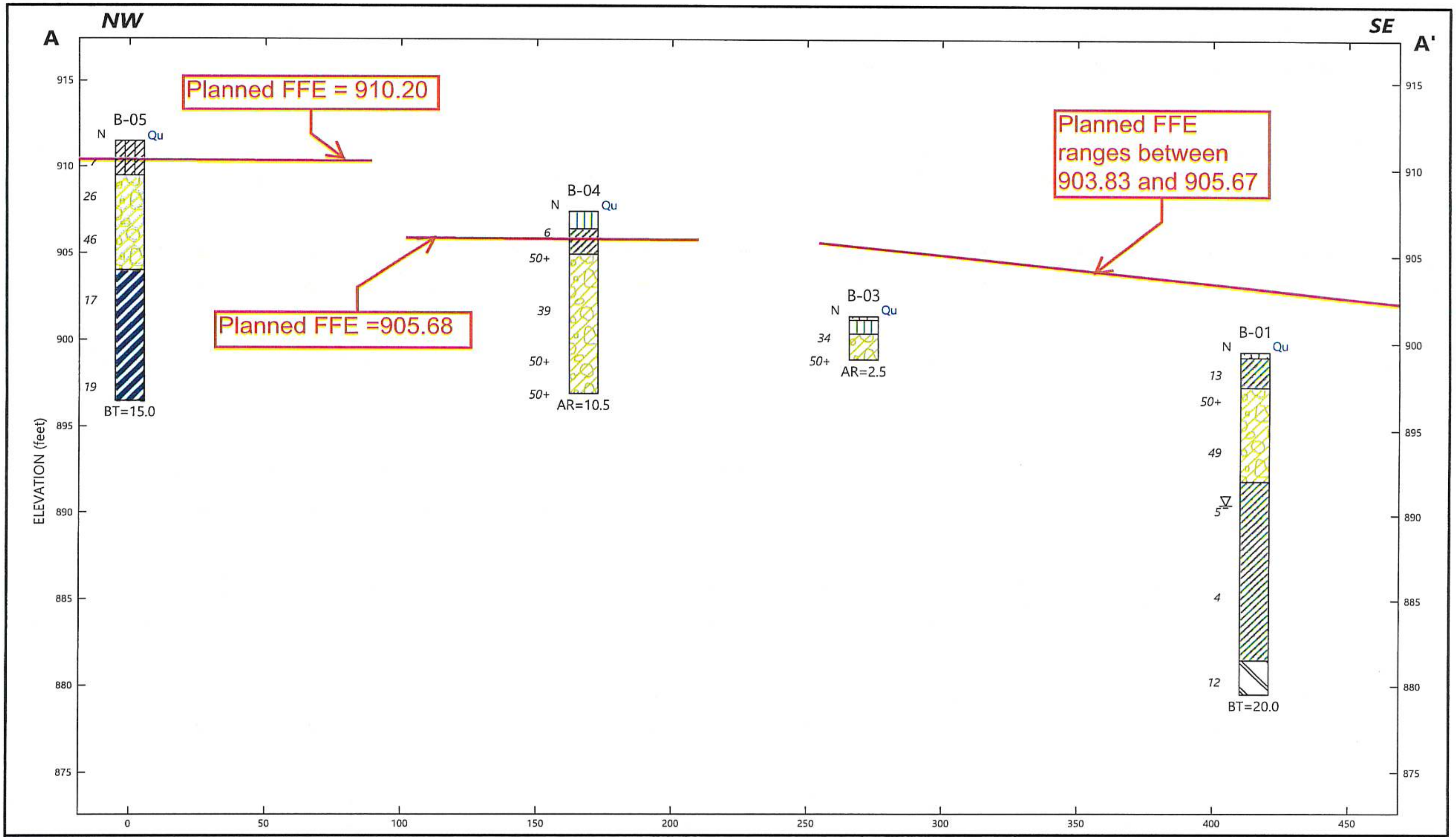

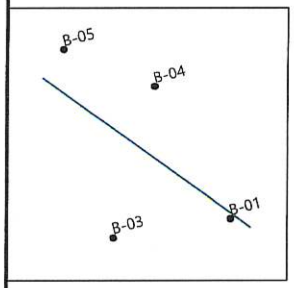

Site Map Scale 1 inch equals 325 feet

Key to Hatches

▨	Topsoil
▨	USCS Low to High Plasticity Clay
▨	USCS High Plasticity Clay
▨	USCS Low Plasticity Clay
▥	USCS Silt
▨	USCS Clayey Gravel
▨	USCS Silty 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 53
Horizontal Scale (feet)
Vertical Exaggeration: 6.5x

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1403 South 70th East Avenue, Tulsa, OK 74133

CN Housing
Tahlequah, OK

A-A': Subsurface Profile

PROJECT NO: TU220145	PLATE NO: A-1	DATE: 8/10/22

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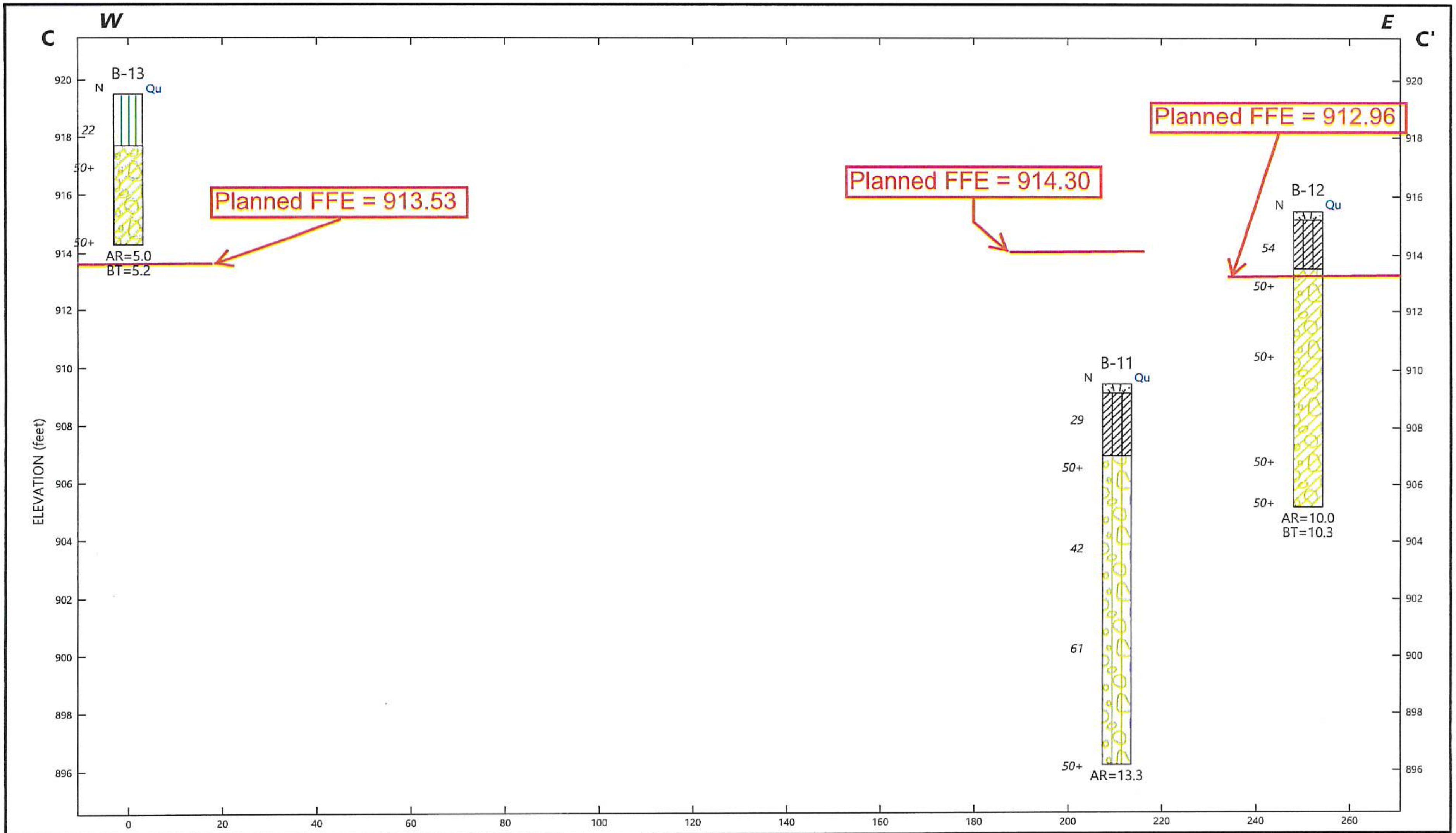

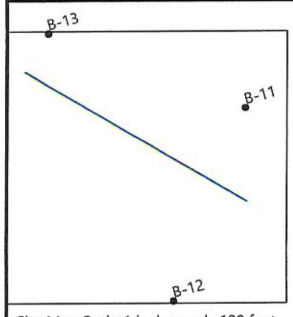

Site Map Scale 1 inch equals 190 feet

Key to Hatches

- ▨ Topsoil
- ▨ USCS Clayey Gravel
- ▨ USCS Silty Clay
- ▨ USCS Silt
- ▨ USCS Silty Gravel

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: 6.5x

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CN Housing
Tahlequah, OK

C-C': Subsurface Profile

PROJECT NO: TU220145	PLATE NO: C-1	DATE: 8/10/22

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Tulsa, OK 74133
Office: (918) 439-9005

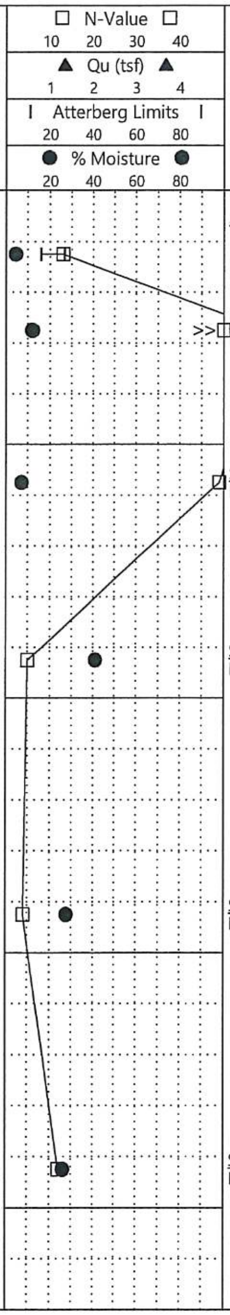
LOG OF BORING

Designation: B-01

Sheet 1 of 1

PROJECT NAME: CN Housing
PROJECT NUMBER: TU220145
DRILLING METHOD: Solid Flight Auger
EQUIPMENT USED: Diedrich D-50 ATV
HAMMER TYPE: Automatic
BORING LOCATION: See Boring Location Plan

LOCATION: Tahlequah, OK
DATE DRILLED: 7/20/22
WEATHER: Sunny
ELEVATION: 899.5
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
0.3	899.2					TOPSOIL: 3"		
2.0	897.5	☒	1	5 6 7	Sample 1 LL: 27 PL: 16 PI: 11 M: 4.4%	LEAN CLAY (CL): very stiff, grayish brown, low plasticity, dry, with roots, (RESIDUAL)		
		☒	2	50/6"	Sample 2 M: 12.0%	CLAYEY CHERT GRAVEL (GC): very dense, dark red, pale yellow, with chert cobbles, (RESIDUAL)		
5	895							
7.5	892.0	☒	3	15 21 28	Sample 3 M: 7.2%			
	890	☒	4	2 2 3	Sample 4 M: 41.1%	LEAN CLAY (CL): medium stiff, brownish yellow, dark red, low plasticity, moist, with sandstone fragments, (RESIDUAL) ∇ wet, with ferrous staining		Groundwater encountered at 9 feet (EL 890.5) at time of drilling.
10								
15	885	☒	5	1 2 2	Sample 5 M: 27.6%			
18.0	881.5							
20.0	879.5	☒	6	4 6 6	Sample 6 M: 26.1%	LEAN TO FAT CLAY (CL-CH): stiff to very stiff, gray, reddish brown, medium to high plasticity, moist, (RESIDUAL)		
20	880					Boring Terminated at 20 feet.		Borehole backfilled on date drilled unless otherwise noted. Consistency/Relative Density based on correction factor for Automatic hammer.

SAMPLE TYPE ☒ Split Spoon

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

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

1403 South 70th East Avenue
Tulsa, OK 74133
Office: (918) 439-9005

PROJECT NAME:	CN Housing	LOCATION:	Tahlequah, OK
PROJECT NUMBER:	TU220145	DATE DRILLED:	7/20/22
DRILLING METHOD:	Solid Flight Auger	WEATHER:	Sunny
EQUIPMENT USED:	Diedrich D-50 ATV	ELEVATION:	901.5
HAMMER TYPE:	Automatic	DRILL CREW:	Building & Earth
BORING LOCATION:	See Boring Location Plan	LOGGED BY:	Q. Mann

DEPTH (ft)	ELEVATION (ft)	SAMPLE TYPE	SAMPLE NO.	BLOWS PER INCREMENT	☐ N-Value ☐ 10 20 30 40 / ▲ Qu (tsf) ▲ 1 2 3 4 / I Atterberg Limits I 20 40 60 80 / ● % Moisture ● 20 40 60 80	LAB DATA	SOIL DESCRIPTION	GRAPHIC	REMARKS
0.2	901.3						TOPSOIL: 2.5"		
1.0	900.5						SILT (ML): grayish brown, dry, with chert gravel, (RESIDUAL)		
		☒	1	6 12 22	● ☐	Sample 1 M: 2.8%	CLAYEY CHERT GRAVEL (GC): very dense, white, light reddish brown, with chert cobbles and boulders, (RESIDUAL)		
2.5	899.0	☒	2	50/0"	● >>☐	Sample 2 M: 2.4%			
							Auger Refusal at 2.5 feet.		Boring offset 5' west with refusal at same depth. No recovery
5									
	895								
10									
	890								
15									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.
	885								

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		

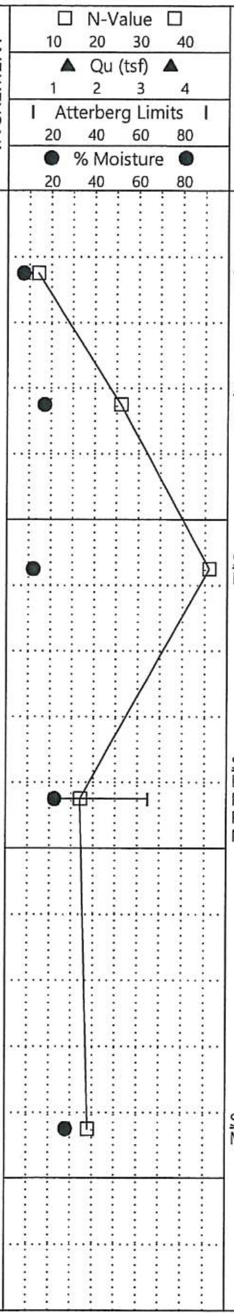
LOG OF BORING

Designation: B-05

Sheet 1 of 1

PROJECT NAME: CN Housing
PROJECT NUMBER: TU220145
DRILLING METHOD: Solid Flight Auger
EQUIPMENT USED: Diedrich D-50 ATV
HAMMER TYPE: Automatic
BORING LOCATION: See Boring Location Plan

LOCATION: Tahlequah, OK
DATE DRILLED: 7/19/22
WEATHER: Sunny
ELEVATION: 911.5
DRILL CREW: Building & Earth
LOGGED BY: Q. Mann



DEPTH (ft)	ELEVATION (ft)	SAMPLE TYPE	SAMPLE NO.	BLOWS PER INCREMENT	LAB DATA	SOIL DESCRIPTION	REMARKS
	910	☒	1	5 4 3	Sample 1 M: 7.3%	SILTY CLAY (CL-ML): stiff, grayish brown, low plasticity, dry to moist, with lean clay, (RESIDUAL)	
2.0	909.5					CHERT GRAVEL (GC): dense, dark gray, dark red, white, moist, with sandy clay layers, (RESIDUAL)	
		☒	2	11 11 15	Sample 2 M: 17.0% F: 59.8%		
5	905	☒	3	16 21 25	Sample 3 M: 12.1%	very dense	
7.5	904.0					FAT CLAY (CH): very stiff, brownish yellow, red, gray, high plasticity, moist, (RESIDUAL)	
10	900	☒	4	4 7 10	Sample 4 LL: 64 PL: 23 PI: 41 M: 22.3%		
		☒	5	5 9 10	Sample 5 M: 27.9%	dark yellowish brown, dark red, with ferrous staining and chert fragments	
15.0	896.5					Boring Terminated at 15 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.
15	895						

SAMPLE TYPE ☒ Split Spoon

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

LOG OF BORING

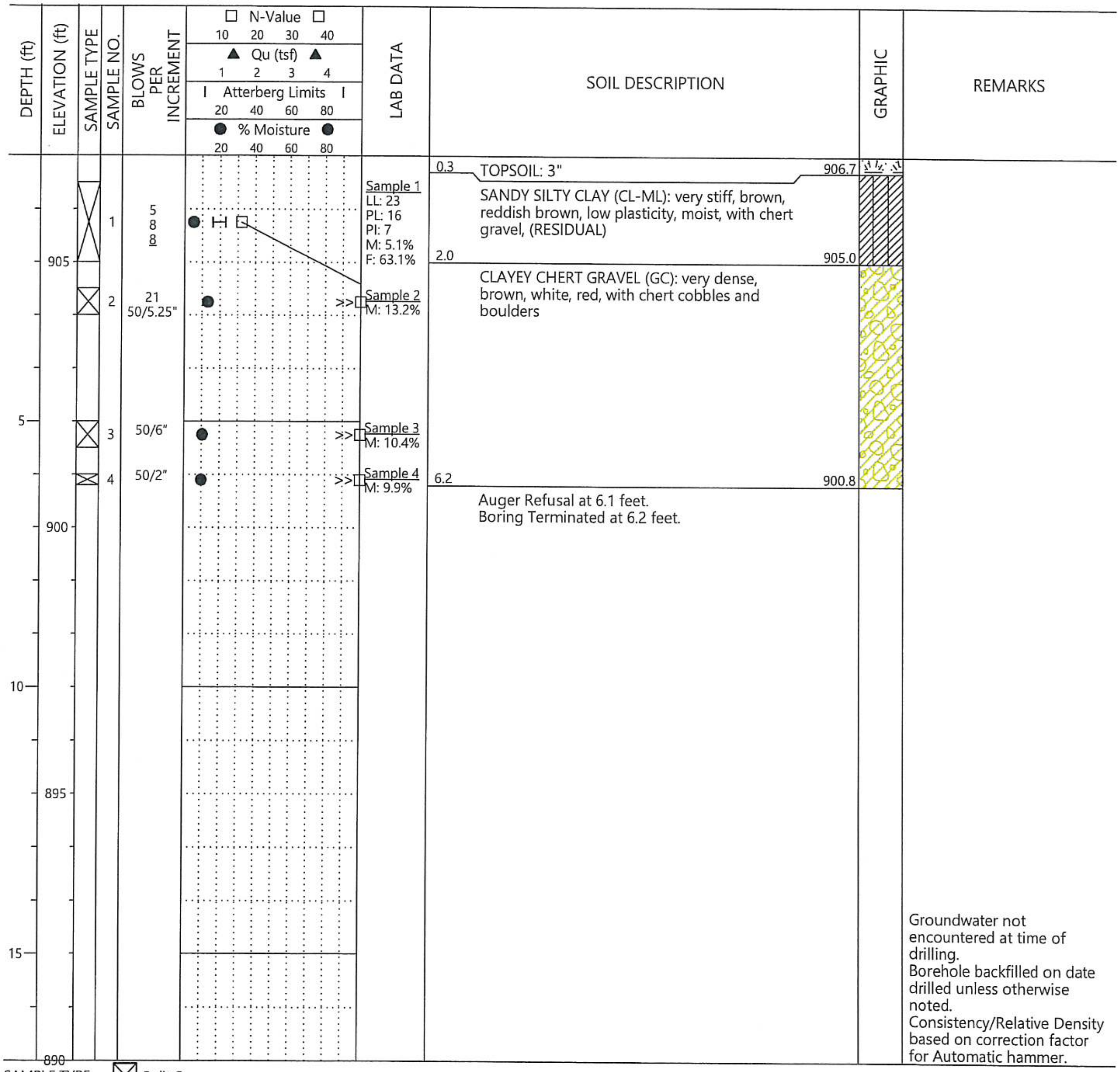
Designation: B-07

Sheet 1 of 1

1403 South 70th East Avenue
Tulsa, OK 74133
Office: (918) 439-9005

PROJECT NAME: CN Housing
PROJECT NUMBER: TU220145
DRILLING METHOD: Solid Flight Auger
EQUIPMENT USED: Diedrich D-50 ATV
HAMMER TYPE: Automatic
BORING LOCATION: See Boring Location Plan

LOCATION: Tahlequah, OK
DATE DRILLED: 7/18/22
WEATHER: Sunny
ELEVATION: 907
DRILL CREW: Building & Earth
LOGGED BY: Q. Mann



SAMPLE NO.	BLOWS PER INCREMENT	LAB DATA
1	5 8 8	Sample 1 LL: 23 PL: 16 PI: 7 M: 5.1% F: 63.1%
2	21 50/5.25"	Sample 2 M: 13.2%
3	50/6"	Sample 3 M: 10.4%
4	50/2"	Sample 4 M: 9.9%

DEPTH (ft)	SOIL DESCRIPTION	ELEVATION (ft)
0.3	TOPSOIL: 3"	906.7
2.0	SANDY SILTY CLAY (CL-ML): very stiff, brown, reddish brown, low plasticity, moist, with chert gravel, (RESIDUAL)	905.0
6.2	CLAYEY CHERT GRAVEL (GC): very dense, brown, white, red, with chert cobbles and boulders	900.8

Auger Refusal at 6.1 feet.
Boring Terminated at 6.2 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)
% MOISTURE PERCENT NATURAL MOISTURE CONTENT
∇ GROUNDWATER LEVEL IN THE BOREHOLE AT TIME OF DRILLING
▼ STABILIZED GROUNDWATER LEVEL

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

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

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LOG OF BORING

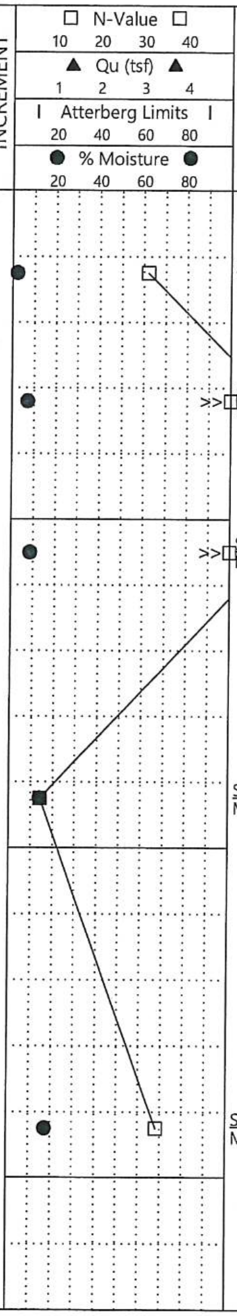
Designation: B-09

Sheet 1 of 1

1403 South 70th East Avenue
Tulsa, OK 74133
Office: (918) 439-9005

PROJECT NAME: CN Housing
PROJECT NUMBER: TU220145
DRILLING METHOD: Solid Flight Auger
EQUIPMENT USED: Diedrich D-50 ATV
HAMMER TYPE: Automatic
BORING LOCATION: See Boring Location Plan

LOCATION: Tahlequah, OK
DATE DRILLED: 7/19/22
WEATHER: Sunny
ELEVATION: 939.5
DRILL CREW: Building & Earth
LOGGED BY: Q. Mann



DEPTH (ft)	ELEVATION (ft)	SAMPLE TYPE	SAMPLE NO.	BLOWS PER INCREMENT	LAB DATA	SOIL DESCRIPTION	REMARKS
0.3	939.2					TOPSOIL: 3.5"	
		☒	1	9 11 20	Sample 1 M: 2.2%	SILT (ML): hard, grayish brown, dry, with chert cobbles, (RESIDUAL)	
2.0	937.5						
		☒	2	17 31 50/4"	Sample 2 M: 7.1%	CLAYEY CHERT GRAVEL (GC): very dense, light reddish brown, white, with chert cobbles, (RESIDUAL)	
	935						
5		☒	3	37 50/5"	Sample 3 M: 8.7%		
		☒	4	6 4 3	Sample 4 M: 13.8%	red, with stiff clay layers	
	930						
10							
		☒	5	6 19 15	Sample 5 M: 17.3%	dense	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.
	925						
15.0	924.5					Boring Terminated at 15 feet.	

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-11

Sheet 1 of 1

1403 South 70th East Avenue
Tulsa, OK 74133
Office: (918) 439-9005

PROJECT NAME: CN Housing
PROJECT NUMBER: TU220145
DRILLING METHOD: Solid Flight Auger
EQUIPMENT USED: Diedrich D-50 ATV
HAMMER TYPE: Automatic
BORING LOCATION: See Boring Location Plan

LOCATION: Tahlequah, OK
DATE DRILLED: 7/18/22
WEATHER: Sunny
ELEVATION: 909.5
DRILL CREW: Building & Earth
LOGGED BY: Q. Mann

DEPTH (ft)	ELEVATION (ft)	SAMPLE TYPE	SAMPLE NO.	BLOWS PER INCREMENT	☐ N-Value ☐ (10 20 30 40) ▲ Qu (tsf) ▲ (1 2 3 4) I Atterberg Limits I (20 40 60 80) ● % Moisture ● (20 40 60 80)	LAB DATA	SOIL DESCRIPTION	REMARKS
0.3	909.2						TOPSOIL: 3"	
		☒	1	10 12 17	● ☐	Sample 1 M: 4.1%	SILTY CLAY (CL-ML): hard, grayish brown, dry, with chert gravel, (RESIDUAL)	
2.5	907.0							
		☒	2	17 50/3"	● >>☐	Sample 2 M: 4.6%	SILTY CHERT GRAVEL (GM): very dense, pale brown, white, reddish brown, with chert cobbles and boulders, (RESIDUAL)	
5	905	☒	3	10 17 25	● H ☐	Sample 3 LL: 23 PL: 20 PI: 3 M: 6.6% F: 12.2%		
10	900	☒	4	18 19 42	● >>☐	Sample 4 M: 10.8%	reddish yellow, red	
13.3	896.2	☒	5	50/0"	>>☐		Auger Refusal at 13.3 feet.	no recovery
15	895							Groundwater not encountered at time of drilling. Borehole backfilled on date drilled unless otherwise noted. Consistency/Relative Density based on correction factor for Automatic hammer.

SAMPLE TYPE ☒ Split Spoon

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

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

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

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

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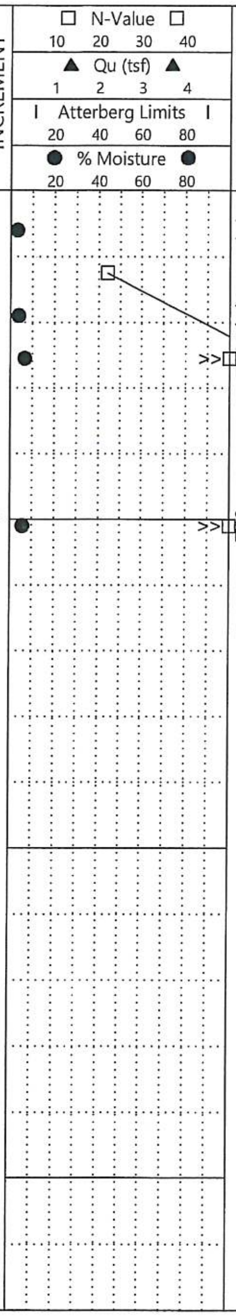
LOG OF BORING
Designation: B-13
Sheet 1 of 1

1403 South 70th East Avenue
Tulsa, OK 74133
Office: (918) 439-9005

PROJECT NAME: CN Housing
PROJECT NUMBER: TU220145
DRILLING METHOD: Solid Flight Auger
EQUIPMENT USED: Diedrich D-50 ATV
HAMMER TYPE: Automatic
BORING LOCATION: See Boring Location Plan

LOCATION: Tahlequah, OK
DATE DRILLED: 7/19/22
WEATHER: Sunny
ELEVATION: 919.5
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
		☒	1T	6 8 14	Sample 1T M: 3.1%	SILT (ML): very stiff, grayish brown, brown, dry, with fine roots and chert fragments, (RESIDUAL)		
			1B		Sample 1B M: 3.8%			
1.8	917.7							
		☒	2	35 50/1.5"	Sample 2 M: 6.6%	CLAYEY CHERT GRAVEL (GC): very dense, light reddish brown, white, with chert cobbles and boulders, (RESIDUAL)		
5	915	☒	3	50/1.75"	Sample 3 M: 5.7%			
5.2	914.3					Auger Refusal at 5 feet. Boring Terminated at 5.2 feet.		
10	910							
15	905							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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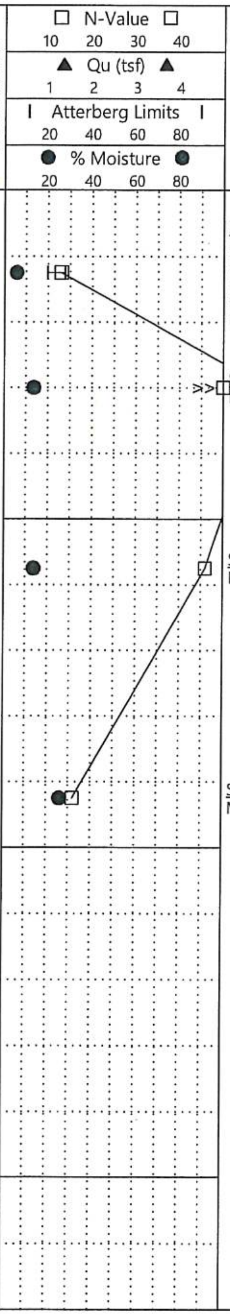
LOG OF BORING
Designation: P-01
Sheet 1 of 1

1403 South 70th East Avenue
Tulsa, OK 74133
Office: (918) 439-9005

PROJECT NAME: CN Housing
PROJECT NUMBER: TU220145
DRILLING METHOD: Solid Flight Auger
EQUIPMENT USED: Diedrich D-50 ATV
HAMMER TYPE: Automatic
BORING LOCATION: See Boring Location Plan

LOCATION: Tahlequah, OK
DATE DRILLED: 7/19/22
WEATHER: Sunny
ELEVATION: 904.5
DRILL CREW: Building & Earth
LOGGED BY: Q. Mann



DEPTH (ft)	ELEVATION (ft)	SAMPLE TYPE	SAMPLE NO.	BLOWS PER INCREMENT	LAB DATA	SOIL DESCRIPTION	REMARKS
0.2	904.3					TOPSOIL: 3"	
						LEAN CLAY (CL): very stiff, grayish brown, brown, low plasticity, dry, with fine roots, (RESIDUAL)	
		☒	1	5 6 7	Sample 1 LL: 28 PL: 20 PI: 8 M: 5.6% F: 89%		
2.5	902.0					CLAYEY CHERT GRAVEL (GC): very dense, dark yellowish brown, dark red, white, with chert cobbles, (RESIDUAL)	
		☒	2	33 50/6"	Sample 2 M: 13.5%		
	900						
5							
		☒	3	35 32 14	Sample 3 M: 13.7%		
						with very stiff clay layers	
		☒	4	4 6 10	Sample 4 M: 26.2%		
	895						
10.0	894.5					Boring Terminated at 10 feet.	
10							
	890						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.
15							

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

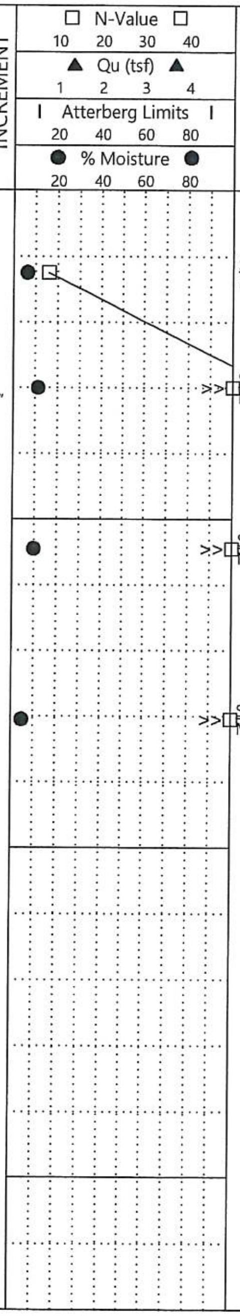
BUILDING & EARTH
Geotechnical, Environmental, and Materials Engineers

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

1403 South 70th East Avenue
Tulsa, OK 74133
Office: (918) 439-9005

PROJECT NAME: CN Housing
PROJECT NUMBER: TU220145
DRILLING METHOD: Solid Flight Auger
EQUIPMENT USED: Diedrich D-50 ATV
HAMMER TYPE: Automatic
BORING LOCATION: See Boring Location Plan

LOCATION: Tahlequah, OK
DATE DRILLED: 7/18/22
WEATHER: Sunny
ELEVATION: 904
DRILL CREW: Building & Earth
LOGGED BY: Q. Mann



DEPTH (ft)	ELEVATION (ft)	SAMPLE TYPE	SAMPLE NO.	BLOWS PER INCREMENT	LAB DATA	SOIL DESCRIPTION	ELEVATION (ft)	REMARKS
0.2						TOPSOIL: 2.5"	903.8	
		☒	1	4 4 4	Sample 1 M: 6.2%	SILTY CLAY (CL-ML): stiff, brown, grayish brown, low plasticity, dry, with fine roots, (RESIDUAL)		
2.5		☒	2	34 50/5.75"	Sample 2 M: 11.4%	CLAYEY CHERT GRAVEL (GC): very dense, reddish brown, pale yellow, dark gray, with chert cobbles and boulders, (RESIDUAL)	901.5	
5	900	☒	3	35 50/4"	Sample 3 M: 9.8%			
8.1		☒	4	50/0.5"	Sample 4 M: 4.8%	Auger Refusal at 8 feet. Boring Terminated at 8.1 feet.	895.9	
10	895							
15	890							Groundwater not encountered at time of drilling. Borehole backfilled on date drilled unless otherwise noted. Consistency/Relative Density based on correction factor for Automatic hammer.

SAMPLE TYPE ☒ Split Spoon

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

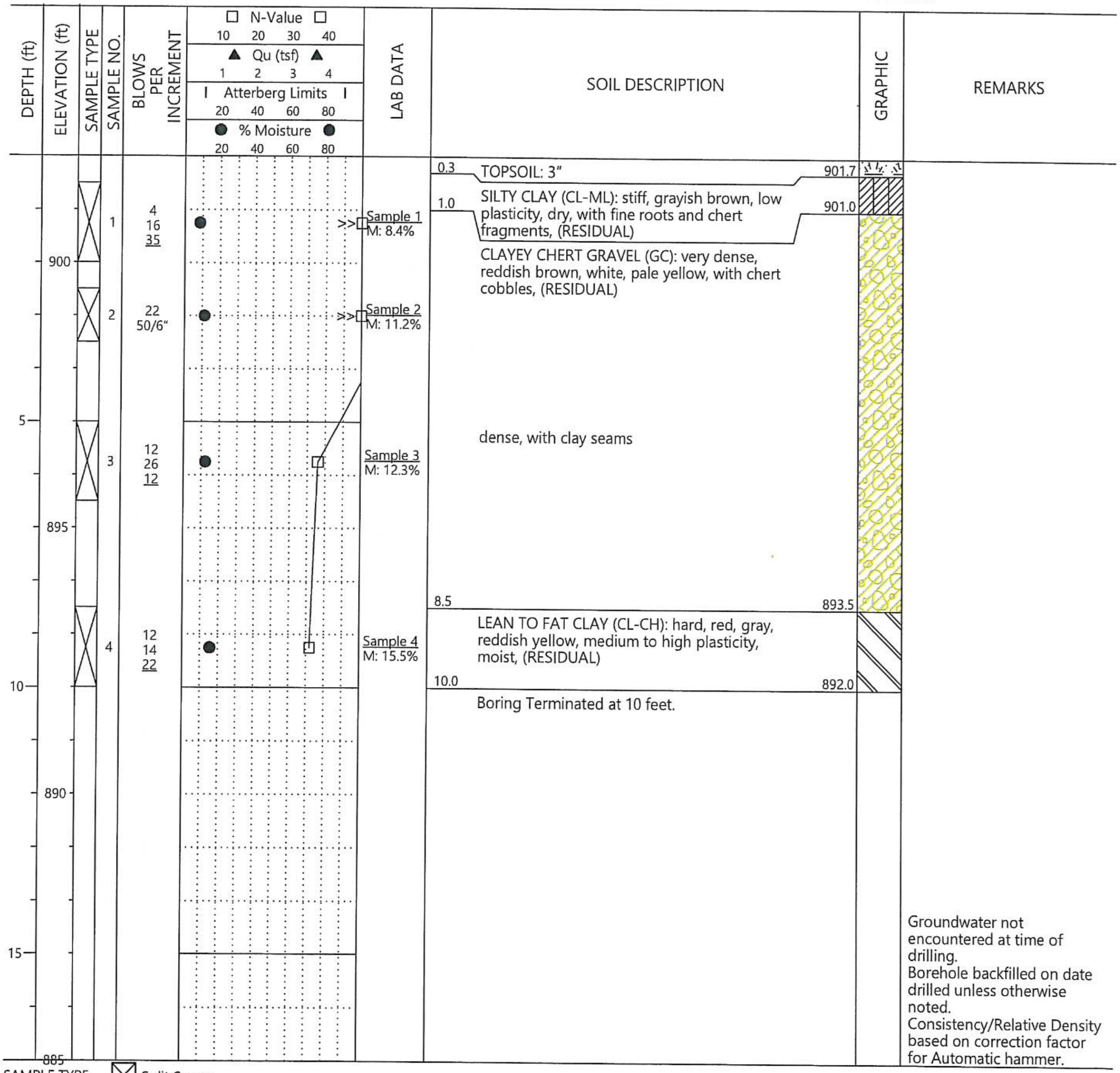
BUILDING & EARTH
Geotechnical, Environmental, and Materials Engineers

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

1403 South 70th East Avenue
Tulsa, OK 74133
Office: (918) 439-9005

PROJECT NAME: CN Housing
PROJECT NUMBER: TU220145
DRILLING METHOD: Solid Flight Auger
EQUIPMENT USED: Diedrich D-50 ATV
HAMMER TYPE: Automatic
BORING LOCATION: See Boring Location Plan

LOCATION: Tahlequah, OK
DATE DRILLED: 7/18/22
WEATHER: Sunny
ELEVATION: 902
DRILL CREW: Building & Earth
LOGGED BY: Q. Mann



Depth (ft)	Elevation (ft)	Sample No.	Blows per Increment	Lab Data	Soil Description
0.3	901.7				TOPSOIL: 3"
1.0	901.0				SILTY CLAY (CL-ML): stiff, grayish brown, low plasticity, dry, with fine roots and chert fragments, (RESIDUAL)
		1	4 16 35	Sample 1 M: 8.4%	CLAYEY CHERT GRAVEL (GC): very dense, reddish brown, white, pale yellow, with chert cobbles, (RESIDUAL)
		2	22 50/6"	Sample 2 M: 11.2%	
		3	12 26 12	Sample 3 M: 12.3%	dense, with clay seams
8.5	893.5				LEAN TO FAT CLAY (CL-CH): hard, red, gray, reddish yellow, medium to high plasticity, moist, (RESIDUAL)
		4	12 14 22	Sample 4 M: 15.5%	
10.0	892.0				Boring Terminated at 10 feet.

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

SAMPLE TYPE ☒ Split Spoon

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

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

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

BUILDING & EARTH
Geotechnical, Environmental, and Materials Engineers

1403 South 70th East Avenue
Tulsa, OK 74133
Office: (918) 439-9005

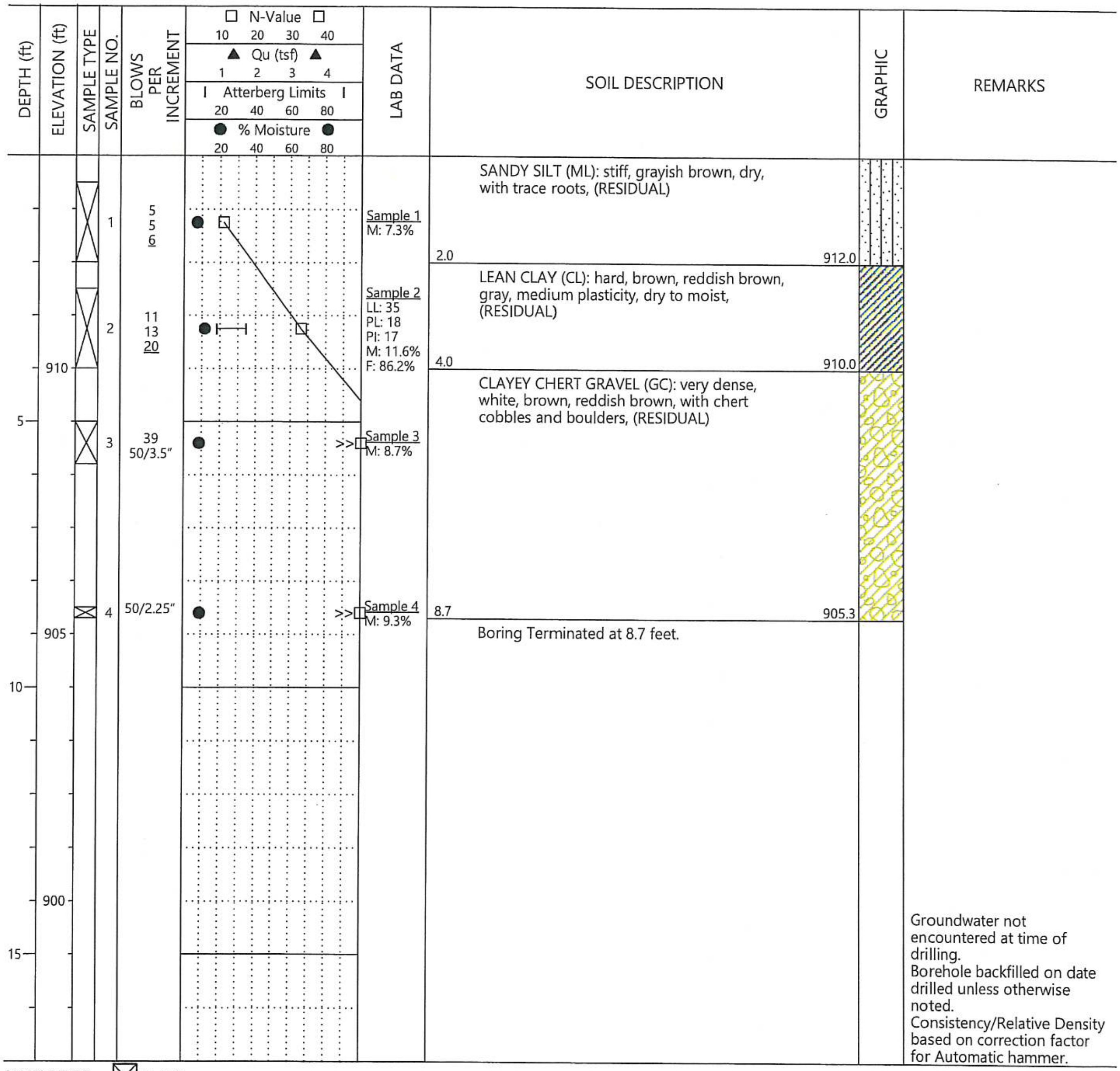
LOG OF BORING

Designation: P-07

Sheet 1 of 1

PROJECT NAME: CN Housing
PROJECT NUMBER: TU220145
DRILLING METHOD: Solid Flight Auger
EQUIPMENT USED: Diedrich D-50 ATV
HAMMER TYPE: Automatic
BORING LOCATION: See Boring Location Plan

LOCATION: Tahlequah, OK
DATE DRILLED: 7/19/22
WEATHER: Sunny
ELEVATION: 914
DRILL CREW: Building & Earth
LOGGED BY: Q. Mann



DEPTH (ft)	ELEVATION (ft)	SAMPLE TYPE	SAMPLE NO.	BLOWS PER INCREMENT	LAB DATA	SOIL DESCRIPTION	REMARKS
		☒	1	5 5 6	Sample 1 M: 7.3%	SANDY SILT (ML): stiff, grayish brown, dry, with trace roots, (RESIDUAL)	
2.0	912.0	☒	2	11 13 20	Sample 2 LL: 35 PL: 18 PI: 17 M: 11.6% F: 86.2%	LEAN CLAY (CL): hard, brown, reddish brown, gray, medium plasticity, dry to moist, (RESIDUAL)	
4.0	910.0	☒	3	39 50/3.5"	Sample 3 M: 8.7%	CLAYEY CHERT GRAVEL (GC): very dense, white, brown, reddish brown, with chert cobbles and boulders, (RESIDUAL)	
		☒	4	50/2.25"	Sample 4 M: 9.3%		
8.7	905.3					Boring Terminated at 8.7 feet.	Groundwater not encountered at time of drilling. Borehole backfilled on date drilled unless otherwise noted. Consistency/Relative Density based on correction factor for Automatic hammer.

SAMPLE TYPE ☒ Split Spoon

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

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	4.4	27	16	11		
B-01	2.5 - 3.0	12.0					
B-01	5.0 - 6.5	7.2					
B-01	8.5 - 10.0	41.1					
B-01	13.5 - 15.0	27.6					
B-01	18.5 - 20.0	26.1					
B-02	0.5 - 2.0	7.8					
B-02	2.5 - 2.9	7.4					
B-02	5.0 - 6.5	10.5	43	16	27		
B-02	8.5 - 10.0	23.8					
B-02	13.5 - 15.0	31.9					
B-03	0.5 - 2.0	2.8					
B-03	2.5 - 2.6	2.4					
B-04	0.6	4.3					
B-04	1.9	10.6					
B-04	2.5 - 3.0	5.4					
B-04	5.0 - 6.5	18.8					
B-05	0.5 - 2.0	7.3					
B-05	2.5 - 4.0	17.0				60	
B-05	5.0 - 6.5	12.1					
B-05	8.5 - 10.0	22.3	64	23	41		
B-05	13.5 - 15.0	27.9					
B-06	0.5 - 2.0	3.5	29	22	7		
B-06	2.5 - 2.9	4.8					
B-06	5.0 - 6.5	7.0					
B-07	0.5 - 2.0	5.1	23	16	7	63	
B-07	2.5 - 3.0	13.2					
B-07	5.0 - 5.5	10.4					
B-07	6.0 - 6.2	9.9					
B-08	0.5 - 2.0	7.3					
B-08	2.5 - 4.0	7.9					

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-01	2.5 - 3.5	13.5					
P-01	5.0 - 6.5	13.7					
P-01	8.5 - 10.0	26.2					
P-02	0.5 - 2.0	5.5					
P-02	2.5 - 4.0	17.4	37	18	19		
P-02	5.0 - 5.5	9.9					
P-03	0.5 - 2.0	6.2					
P-03	2.5 - 3.5	11.4					
P-03	5.0 - 5.9	9.8					
P-03	8.0 - 8.1	4.8					
P-04	0.5 - 2.0	2.6					
P-04	2.5 - 4.0	6.4					
P-04	5.0 - 6.5	6.2					
P-05	0.5 - 2.0	8.4					
P-05	2.5 - 3.5	11.2					
P-05	5.0 - 6.5	12.3					
P-05	8.5 - 10.0	15.5					
P-06	0.5 - 2.0	7.3	25	18	7	51	
P-06	2.5 - 3.5	12.0					
P-06	5.0 - 5.3	4.6					
P-06	7.5 - 7.6	3.7					
P-07	0.5 - 2.0	7.3					
P-07	2.5 - 4.0	11.6	35	18	17	86	CL
P-07	5.0 - 5.8	8.7					
P-07	8.5 - 8.7	9.3					

TABLE L-1: General Soil Classification Test Results

Soils with a Liquid Limit (LL) greater than 50 and Plasticity Index (PI) greater than 25 usually exhibit significant volume change with varying moisture content and are considered to be highly plastic
(1) Indicates visual classification. WR indicates weathered rock.

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.

GEOTECHNICAL
BUSINESS COUNCIL
of the Geoprofessional Business Association

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