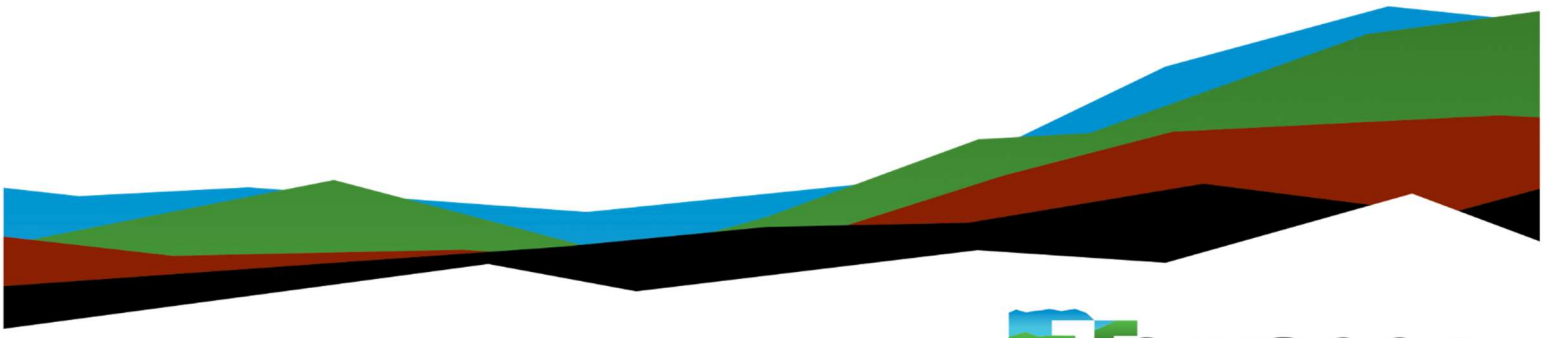
Tin Cup Trail Bridge

Geotechnical Engineering Report

May 10, 2023 | Terracon Project No. B3235005

Prepared for:

Allgeier Martin & Associates, Inc
7231 E 24th Street
Joplin, Missouri 64804



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May 10, 2023

Allgeier Martin & Associates, Inc
7231 E 24th Street
Joplin, Missouri 64804

Attn: Michael Atkinson
P: (417) 680 7352
E: Michael.Atkinson@amce.com

Re: Geotechnical Engineering Report
Tin Cup Trail Bridge
3404 W. McIntosh Circle Drive
Joplin, Missouri
Terracon Project No. B3235005

Dear Mr. Atkinson:

We have completed the scope of Geotechnical Engineering services for the above referenced project in general accordance with Terracon Proposal No. PB3235005 dated March 22nd, 2023. This report presents the findings of the subsurface exploration and provides geotechnical recommendations concerning earthwork and the design and construction of foundations for the proposed project.

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

Sincerely,

Terracon

STATE OF MISSOURI
KOLE C. BERG
NUMBER PE-2002016417
PROFESSIONAL ENGINEER
5/10/2023

Ripken B. Dodson, E.I.
Staff Geotechnical Engineer

Kole C. Berg, P.E.
Principal/Senior Geotechnical Consultant

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Note: This report was originally delivered in a web-based format. **Blue Bold** text in the report indicates a referenced section heading. The PDF version also includes hyperlinks which direct the reader to that section and clicking on the Terracon logo will bring you back to this page. For more interactive features, please view your project online at **client.terracon.com**.

Refer to each individual Attachment for a listing of contents.

Introduction

This report presents the results of our subsurface exploration and Geotechnical Engineering services performed for the proposed pedestrian bridge to be located at 3404 W. McIntosh Circle Drive in Joplin, Missouri. The purpose of these services was to provide information and geotechnical engineering recommendations relative to:

- Subsurface soil (and rock) conditions
- Groundwater conditions
- Seismic site class per IBC
- Site preparation and earthwork
- Foundation design and construction

The geotechnical engineering Scope of Services for this project included the advancement of test borings, laboratory testing, engineering analysis, and preparation of this report.

Drawings showing the site and boring locations are shown on the **Site Location** and **Exploration Plan**, respectively. The results of the laboratory testing performed on soil samples obtained from the site during our field exploration are included on the boring logs and/or as separate graphs in the **Exploration Results** section.

Project Description

Our initial understanding of the project was provided in our proposal and was discussed during project planning. A period of collaboration has transpired since the project was initiated, and our final understanding of the project conditions is as follows:

- Additional information regarding design of the suspension cable anchoring system was provided. The cables will be anchored using a "log anchor" that is embedded in the bedrock. The bedrock will be excavated to the desired depth, log anchor placed, and backfilled with concrete.

Item	Description
Information Provided	An email request for proposal was provided by Mr. Michael Atkinson on March 8th, 2023. The request included a .kmz file showing requested boring locations and information regarding anticipated loading conditions.
Project Description	A new pedestrian suspension bridge is planned. Foundation and cable anchorage is anticipated at the boring locations.

Item	Description
Maximum Loads	The following anticipated structural loads were provided by Mr. Michael Atkinson: ▪ Vertical (Uplift): 35 kips ▪ Horizontal: 70 kips
Grading	.No site grading or grade changes are planned.
Free-Standing Retaining Walls	No free-standing retaining walls are planned.

Terracon should be notified if any of the above information is inconsistent with the planned construction, as modifications to our recommendations may be necessary.

Site Conditions

The following description of site conditions is derived from our site visit in association with the field exploration and our review of publicly available geologic and topographic maps.

Item	Description
Parcel Information	The project is located south of 3404 W. McIntosh Circle Drive in Joplin, Missouri. Latitude/Longitude (approximate) 37.0506, -94.5303 See **Site Location**
Existing Improvements	None
Current Ground Cover	Grass and lightly vegetated
Existing Topography	The bridge abutment locations are relatively flat. The site drains toward the creek.

Geotechnical Characterization

We have developed a general characterization of the subsurface conditions based upon our review of the subsurface exploration, laboratory data, geologic setting and our understanding of the project. This characterization, termed GeoModel, forms the basis of our geotechnical calculations and evaluation of the site. Conditions observed at each exploration point are indicated on the individual logs. The individual logs can be found in the **Exploration Results** and the GeoModel can be found in the **Figures** attachment of this report.

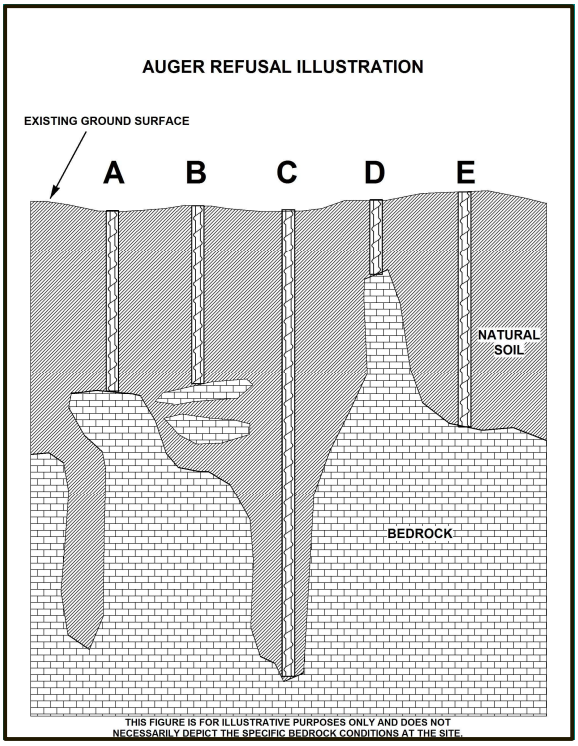
As part of our analyses, we identified the following model layers within the subsurface profile. For a more detailed view of the model layer depths at each boring location, refer to the GeoModel.

Model Layer	Layer Name	General Description
1	Clayey Gravel	Light brown and gray clayey gravel with sand
2	Gravel	Gray gravel with sand and clay
3	Chert Bedrock	Highly fractured chert bedrock

The borings were observed during drilling and shortly after completion of drilling for the presence and level of water. Groundwater was observed at a depth of 8 feet in Boring B-1. Groundwater was not encountered in the other boring at these times. A longer period of time may be required for groundwater to develop and stabilize in a borehole. Longer term observations in piezometers or observation wells, sealed from the influence of surface water, are often required to define groundwater levels.

Groundwater levels may fluctuate due to seasonal variations in the amount of rainfall, runoff, fluctuations in the creek level, and other factors not evident at the time the borings were performed. "Perched" water could occur above lower permeability soil layers and/or near the soil/bedrock interface, and "trapped" water could be present within existing fill materials. Therefore, groundwater conditions at other times may be different than the conditions encountered in our exploratory borings. The potential for water level fluctuations and perched water should be considered when developing design and construction plans and specifications for the project.

Auger refusal is defined as the depth below the ground surface at which a boring can no longer be advanced with the soil drilling technique being used. Auger refusal is subjective and is based upon the type of drilling equipment used, the types of augers used, and the effort exerted by the driller. Auger refusal can occur on the upper surface of discontinuous bedrock (A), slabs of unweathered rock suspended in the residual soil matrix or "floaters" (B), in widened joints that may extend well below the surrounding bedrock surface (C), on rock "pinnacles" (D) rising above the surrounding bedrock surface, or on the upper surface of continuous bedrock (E). These possible auger refusal conditions are illustrated in the figure below. Linear interpolation of apparent bedrock elevations based upon the boring data is often used but can misrepresent actual rock removal quantities where anomalies exist, such as pinnacled rock, where rock could be shallower than that encountered in the borings. Additional borings, auger probes, test pits, or geophysical testing could be performed to obtain more specific bedrock information.



Seismic Site Class

The seismic design requirements for buildings and other structures are based on Seismic Design Category. The Site Class is required to determine the Seismic Design Category for a structure. The Site Class is based on the upper 100 feet of the site profile defined by a weighted average value of either shear wave velocity, standard penetration resistance, or undrained shear strength in accordance with Section 20.4 of ASCE 7 and the International Building Code (IBC). Based on the soil and bedrock encountered in our subsurface exploration, **Seismic Site Class C** can be considered for design of the project. The subsurface exploration at this site extended to a maximum depth of 20 feet. The site properties below the maximum boring depth were estimated based on our experience and knowledge of geologic conditions of the general area. Upon request, we could perform deeper borings or geophysical testing to confirm the conditions below the current maximum boring depth.

Geotechnical Overview

Based on conditions encountered at the boring locations, it appears feasible to support the new pedestrian bridge on spread footings. Parameters for footings bearing on medium stiff to stiff native clay or engineered fill materials and alternate parameters for spread footings bearing on chert bedrock are provided in this report. The planned

anchoring system of rock anchors cut into bedrock and backfilled with concrete appears feasible for the suspension cables.

We recommend riprap or other erosion control measures be implemented along the creek channel to reduce the potential for scour of the soil and weathered rock located near the bridge foundations. Even if riprap or other erosion control measures are placed, movement of creek banks can affect foundation performance.

The recommendations contained in this report are based upon the results of field and laboratory testing (presented in the **Exploration Results**), engineering analyses, and our current understanding of the proposed project. The **General Comments** section provides an understanding of the report limitations.

Earthwork

Terracon understands that earthwork for this project will be minimal, generally limited to excavation and backfilling for foundations. We understand that no grade changes or other earthwork operations are planned for the project. Site preparation, excavation, and placement of engineered fill should follow the recommendations presented in this section. The recommendations presented for design and construction of earth-supported elements including foundations are contingent upon the recommendations outlined in this section being followed. We recommend earthwork on this project be observed and evaluated by Terracon. The evaluation of earthwork should include observation and testing of foundation bearing soils, testing of backfill placed above and adjacent to foundations, and other geotechnical conditions exposed during the construction of the project.

Site Preparation

Vegetation, topsoil, and any loose, soft or otherwise unsuitable soils present within the proposed construction areas should be stripped. Based on information obtained at the boring locations, stripping depths on the order of 6 inches should be anticipated to remove the root zone materials. Organic soils removed during site preparation should not be used as fill below or directly adjacent to the bridge foundations or other new construction areas.

Excavation

The bottom of excavations should be thoroughly cleaned of loose soils and disturbed materials prior to backfill placement and/or construction.

Due to presence of chert bedrock, excavation will encounter very hard materials. A drilling rig equipped with hard formation drilling bits or teeth (rock drill type bit) having

high torque capacity may be required for installation of shallow foundations and anchoring systems to achieve appropriate pier depths.

Required excavation techniques will vary based on weathering of the materials to be excavated, and the fracturing, jointing and overall stratigraphy of the feature. Actual field conditions usually display a gradual weathering progression with poorly defined and uneven boundaries between layers of different materials.

Fill Material Types

Fill required to achieve design grade should be classified as structural fill and general fill. Structural fill (also referred to as engineered fill) is material used below or within 10 feet of structures or constructed slopes. General fill is material used to achieve grade outside of these areas.

Reuse of On-Site Soil: Excavated on-site soil may be selectively reused as fill below landscaping areas. Excavated on-site soil is not suitable for reuse as Structural Fill and should not be placed beneath settlement sensitive structures and within foundation bearing zones.

Material property requirements for on-site soil for use as general fill and engineered fill are noted in the table below:

Fill Type	USCS Classification	Acceptable Location for Placement
Native Gravels	GC, GW	All locations and elevations, except where free-draining material is required Organics, rock fragments larger than 3 inches, debris, or other unsuitable materials should be removed prior to re-use of on-site materials in engineered fill sections.

Imported Fill Materials: Imported fill materials should meet the following material property requirements. Regardless of its source, compacted fill should consist of approved materials that are free of organic matter and debris. Frozen material should not be used, and fill should not be placed on a frozen subgrade.

Fill Type	USCS Classification	Acceptable Location for Placement
Low Volume Change (LVC) material	GM [2] or CL (LL<45 and PI<23)	All locations and elevations, except where free-draining material is required
Free Draining Granular	GW, GP, SW, SP	Less than 5% passing No. 200 sieve

1. Engineered fill should consist of approved materials that are free of organic matter and debris. Frozen material should not be used, and fill should not be placed on a frozen subgrade.
2. MoDOT Type 5 or an approved alternate gradation of crushed limestone aggregate.
3. Granular materials with less than 5 percent fines (material passing the #200 sieve), such as ASTM C33 Size No. 57 aggregate or an approved alternate gradation.

Fill Placement and Compaction Requirements

Structural and general fill should meet the following compaction requirements.

Item	Structural Fill	General Fill
Maximum Lift Thickness	8 inches or less in loose thickness when heavy, self-propelled compaction equipment is used 4 to 6 inches in loose thickness when hand-guided equipment (i.e., a jumping jack or plate compactor) is used	Same as structural fill
Minimum Compaction Requirements [1,2,3]	95% of max. below, above, and adjacent to foundations	92% of max.
Water Content Range [1]	Low plasticity cohesive: -3% to +3% of optimum High plasticity cohesive: 0 to +4% of optimum Granular: -3% to +3% of optimum	As required to achieve min. compaction requirements

1. Maximum density and optimum water content as determined by the standard Proctor test (ASTM D 698).
2. High plasticity cohesive fill should not be compacted to more than 100% of standard Proctor maximum dry density.
3. If the granular material is a coarse sand or gravel, or of a uniform size, or has a low fines content, compaction comparison to relative density may be more appropriate. In this case, granular materials should be compacted to at least 70% relative density (ASTM D 4253 and D 4254). Materials not amenable to density testing should be placed and compacted to a stable condition observed by the Geotechnical Engineer or representative.

Earthwork Construction Considerations

Shallow excavations for the proposed structure are anticipated to be accomplished with conventional construction equipment. Upon completion of filling and grading, care should be taken to maintain the subgrade water content prior to construction of foundations. Construction traffic over the completed subgrades should be avoided. The site should also be graded to prevent ponding of surface water on the prepared subgrades or in excavations. Water collecting over or adjacent to construction areas should be removed. If the subgrade freezes, desiccates, saturates, or is disturbed, the affected material should be removed, or the materials should be scarified, moisture conditioned, and recompacted prior to floor slab construction.

The groundwater table and the creek water level at the time of construction could affect overexcavation efforts, especially for overexcavation and replacement of lower strength soils. During construction, the contractor should be prepared to remove runoff water entering the construction site. The project site is relatively low in elevation in comparison with the surrounding terrain. Therefore, runoff water from rain events will accumulate at the project site. If the construction site becomes inundated with water during construction, the contractor should be prepared to use pumps or other applicable methods to remove water entering the construction site.

As a minimum, excavations should be performed in accordance with OSHA 29 CFR, Part 1926, Subpart P, "Excavations" and its appendices, and in accordance with any applicable local and/or state regulations.

Construction site safety is the sole responsibility of the contractor who controls the means, methods, and sequencing of construction operations. Under no circumstances shall the information provided herein be interpreted to mean Terracon is assuming responsibility for construction site safety or the contractor's activities; such responsibility shall neither be implied nor inferred.

Construction Observation and Testing

The earthwork efforts should be observed by the Geotechnical Engineer (or others under their direction). Observation should include documentation of adequate removal of surficial materials (vegetation and topsoil), evaluation of fill materials, and testing of density and moisture content for fill/backfill materials.

In areas of foundation excavations, the bearing subgrade should be evaluated by a representative of the Geotechnical Engineer. If unanticipated conditions are observed, the Geotechnical Engineer should prescribe mitigation options.

In addition to the documentation of the essential parameters necessary for construction, the continuation of the Geotechnical Engineer into the construction phase of the project provides the continuity to maintain the Geotechnical Engineer's evaluation of subsurface conditions, including assessing variations and associated design changes.

Shallow Foundations

Based on the conditions encountered at the borings, the bridge can be supported on shallow footing foundations that bear on native clayey gravel soils and/or engineered fill. Alternately, if a higher allowable bearing pressure is needed, all foundation excavations could be extended deeper to bear on the weathered bedrock. Parameters for soil-bearing and rock-bearing footings are provided in the following section.

Shallow Foundation Design Parameters

Item	Description
Maximum Net Allowable Bearing Pressure [1, 2]	3,000 psf (foundation bearing on engineered fill) 7,000 psf (foundation bearing on bedrock)
Minimum Embedment below Finished Grade [6]	3 feet
Estimated Total Settlement from Structural Loads [2]	On the order of 1 inch
Estimated Differential Settlement [2, 5]	About 1/2 to 2/3 of total settlement

1. The maximum net allowable bearing pressure is the pressure in excess of the minimum surrounding overburden pressure at the footing base elevation.
2. Values provided are for maximum loads noted in **Project Description**. Additional geotechnical consultation will be necessary if higher loads are anticipated.
3. Unsuitable or soft soils should be overexcavated and replaced per the recommendations presented in **Earthwork**.

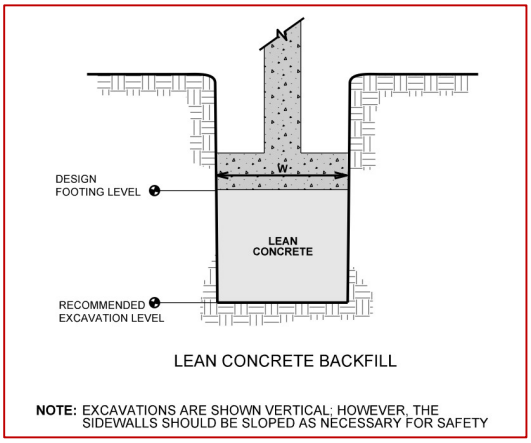
Item	Description

4. Embedment necessary to minimize the effects of frost and/or seasonal water content variations.
5. Differential settlements are noted for equivalent-loaded foundations and bearing elevation as measured over a span of 50 feet.

Foundation Construction Considerations

The base of all foundation excavations should be free of water and loose soil prior to placing concrete. Concrete should be placed soon after excavating to reduce bearing soil disturbance. Care should be taken to prevent wetting or drying of the bearing materials during construction. If the soils at the bearing level become excessively dry, disturbed, saturated, or frozen, the affected soil should be removed prior to placing concrete. If the excavations must remain open overnight or for an extended period of time, placement of a lean concrete mud-mat over the bearing soils should be considered.

The bearing materials at the base of each footing excavation should be evaluated by a representative of the Geotechnical Engineer. If unsuitable bearing materials are observed, the excavation should be extended deeper to suitable soils. The footings could bear directly on suitable soils at the lower level or on lean concrete backfill as shown on the following figure.



Cable Anchors

The suspension cables are planned to be anchored into rock using a log anchor system. A portion of the bedrock will be excavated, the log anchor will be placed, and then the excavation will be backfilled with lean concrete. The cables will tie into the anchor at an angle of approximately 26 degrees from horizontal. The tension in the cable will be approximately 80 kips.

Potential failure mechanisms typically considered when designing rock anchors to resist uplift loads include

- failure of the steel bar in tension
- shear failure along the bar/grout interface
- shear failure along the grout/rock interface below grade walls
- stability of the overall rock mass

Please Refer to Section 5.9.2, Federal Highway Administration (FHWA) Publication IF-99-015, Geotechnical Engineering Circular No. 4, Ground Anchors and Anchored Systems, 1999, for further information on evaluating the controlling failure mechanism for a particular rock anchor configuration.

Based on the high percent recovery and low rock quality designation (RQD) values of the rock core samples recovered from our exploratory borings, rock mass stability will be the controlling failure mechanism for design of rock anchors for this project.

Based on the information above and the condition of the chert bedrock, we recommend the following be used in design and construction of the anchoring system:

Item	Description
Total Unit Weight of Chert	130 pcf
Equivalent Fluid Unit Weight for Allowable Passive Pressure in Chert	500 psf per foot of depth (pcf)
Allowable Bond Stress [1]	30 psi
Coefficient of Sliding Friction [2]	0.5

1. Can be used for rock anchors within highly weathered chert
2. Rock to concrete interface value

General Comments

Our analysis and opinions are based upon our understanding of the project, the geotechnical conditions in the area, and the data obtained from our site exploration. Variations will occur between exploration point locations or due to the modifying effects of construction or weather. The nature and extent of such variations may not become evident until during or after construction. Terracon should be retained as the Geotechnical Engineer, where noted in this report, to provide observation and testing services during pertinent construction phases. If variations appear, we can provide further evaluation and supplemental recommendations. If variations are noted in the absence of our observation and testing services on-site, we should be immediately notified so that we can provide evaluation and supplemental recommendations.

Our Scope of Services does not include either specifically or by implication any environmental or biological (e.g., mold, fungi, bacteria) assessment of the site or identification or prevention of pollutants, hazardous materials or conditions. If the owner is concerned about the potential for such contamination or pollution, other studies should be undertaken.

Our services and any correspondence are intended for the sole benefit and exclusive use of our client for specific application to the project discussed and are accomplished in accordance with generally accepted geotechnical engineering practices with no third-party beneficiaries intended. Any third-party access to services or correspondence is solely for information purposes to support the services provided by Terracon to our client. Reliance upon the services and any work product is limited to our client and is not intended for third parties. Any use or reliance of the provided information by third parties is done solely at their own risk. No warranties, either express or implied, are intended or made.

Site characteristics as provided are for design purposes and not to estimate excavation cost. Any use of our report in that regard is done at the sole risk of the excavating cost estimator as there may be variations on the site that are not apparent in the data that could significantly affect excavation cost. Any parties charged with estimating excavation costs should seek their own site characterization for specific purposes to obtain the specific level of detail necessary for costing. Site safety and cost estimating including excavation support and dewatering requirements/design are the responsibility of others. Construction and site development have the potential to affect adjacent properties. Such impacts can include damages due to vibration, modification of groundwater/surface water flow during construction, foundation movement due to undermining or subsidence from excavation, as well as noise or air quality concerns. Evaluation of these items on nearby properties are commonly associated with contractor means and methods and are not addressed in this report. The owner and contractor should consider a preconstruction/precondition survey of surrounding development. If changes in the nature, design, or location of the project are planned, our conclusions and recommendations shall not be considered valid unless we review the changes and either verify or modify our conclusions in writing.

Figures

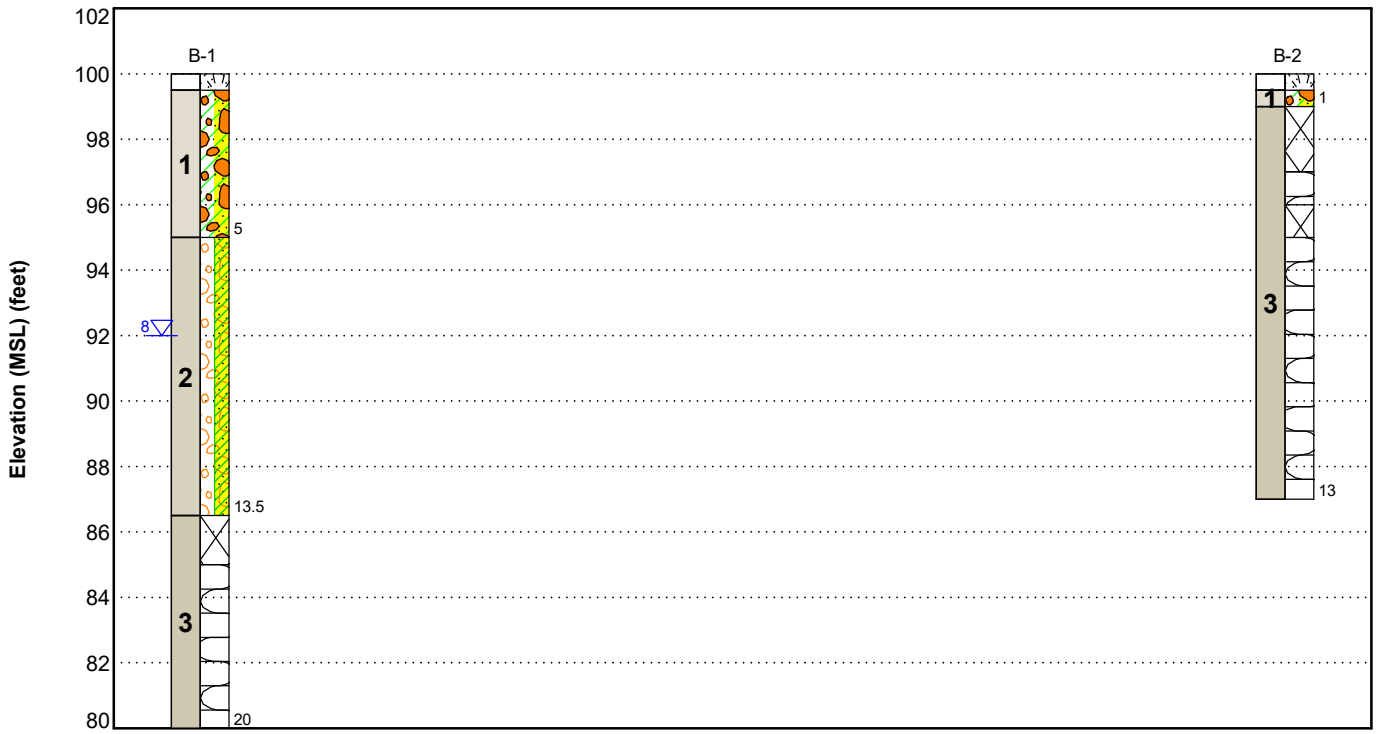
Contents:

GeoModel

Tin Cup Trail Bridge
3404 W McIntosh Cir Dr | Joplin, MO
Terracon Project No. B3235005

Terracon
1401 Illinois Ave
Joplin, MO

GeoModel



This is not a cross section. This is intended to display the Geotechnical Model only. See individual logs for more detailed conditions.

Model Layer	Layer Name	General Description
1	**Clayey Gravel**	Light brown and gray clayey gravel with sand
2	**Gravel**	Gray gravel with sand and clay
3	**Chert**	Highly fractured chert bedrock

LEGEND

- Topsoil
- Clayey Gravel with Sand
- Well-graded Gravel with clay and sand
- Weathered Rock
- Bedded Chert 1

▽ First Water Observation

The groundwater levels shown are representative of the date and time of our exploration. Significant changes are possible over time.
Water levels shown are as measured during and/or after drilling. In some cases, boring advancement methods mask the presence/absence of groundwater. See individual logs for details.

NOTES:
Layering shown on this figure has been developed by the geotechnical engineer for purposes of modeling the subsurface conditions as required for the subsequent geotechnical engineering for this project. Numbers adjacent to soil column indicate depth below ground surface.

Attachments

Exploration and Testing Procedures

Field Exploration

Number of Borings	Approximate Boring Depth (feet) [1]	Location
1	10 feet below the level of auger refusal	Anchorage location B-2
1	5 feet below the level of auger refusal	Anchorage location B-1

1. Due to difficult rock coring in the chert bedrock and use of multiple drill bits, an amendment to the original scope was approved for Boring B-1 for 5 feet of rock core to be collected.

Boring Layout and Elevations: Terracon personnel provided the boring layout using handheld GPS equipment (estimated horizontal accuracy of about ±10 feet) and referencing existing site features. Approximate ground surface elevations were not obtained. If elevations and a more precise boring layout are desired, we recommend borings be surveyed.

Subsurface Exploration Procedures: We advanced the borings with a track-mounted rotary drill rig using continuous flight augers (solid stem and/or hollow stem, as necessary, depending on soil conditions). Four samples were obtained in the upper 10 feet of each boring and at intervals of 5 feet thereafter. In the split-barrel sampling procedure, a standard 2-inch outer diameter split-barrel sampling spoon was driven into the ground by a 140-pound automatic hammer falling a distance of 30 inches. The number of blows required to advance the sampling spoon the last 12 inches of a normal 18-inch penetration is recorded as the Standard Penetration Test (SPT) resistance value. The SPT resistance values, also referred to as N-values, are indicated on the boring logs at the test depths. Rock coring was performed with a NQ rock core barrel and diamond edged rock core bit. For safety purposes, all borings were backfilled with auger cuttings after their completion.

We also observed the boreholes while drilling and at the completion of drilling for the presence of groundwater. The groundwater levels are shown on the attached boring logs.

Our exploration team prepared field boring logs to record the sampling depths, penetration distances, other sampling information, visual classifications of the materials observed during drilling, and our interpretation of the subsurface conditions between samples. The samples were placed in appropriate containers and taken to our laboratory for testing and classification. The final boring logs provided with this report include

modifications based on the results of the laboratory tests and observations of the recovered samples.

Laboratory Testing

The project engineer reviewed the field data and assigned laboratory tests. The laboratory testing program included the following types of tests:

- Moisture Content
- Grain Size Analysis
- Rock Core Compressive Strength

The laboratory testing program often included examination of soil samples by an engineer. Based on the results of our field and laboratory programs, we described and classified the soil samples in accordance with the Unified Soil Classification System.

Rock classification was conducted using locally accepted practices for engineering purposes; petrographic analysis may reveal other rock types. Rock core samples typically provide an improved specimen for this classification. Boring log rock classification was determined using the Description of Rock Properties.

Rock Core Compressive Strength Testing

Rock core compressive strength was selected at the location indicated in the table below. Due to the low Rock Quality Designation of the rock core samples, selection of 4+ inch samples for rock breaks were limited.

Boring #	Rock Break Depth (feet)	Q_u (ksf)
B-1	13.7-14.1	4,758

Site Location and Exploration Plans

Contents:

Site Location Plan
Exploration Plan

Note: All attachments are one page unless noted above.

Site Location

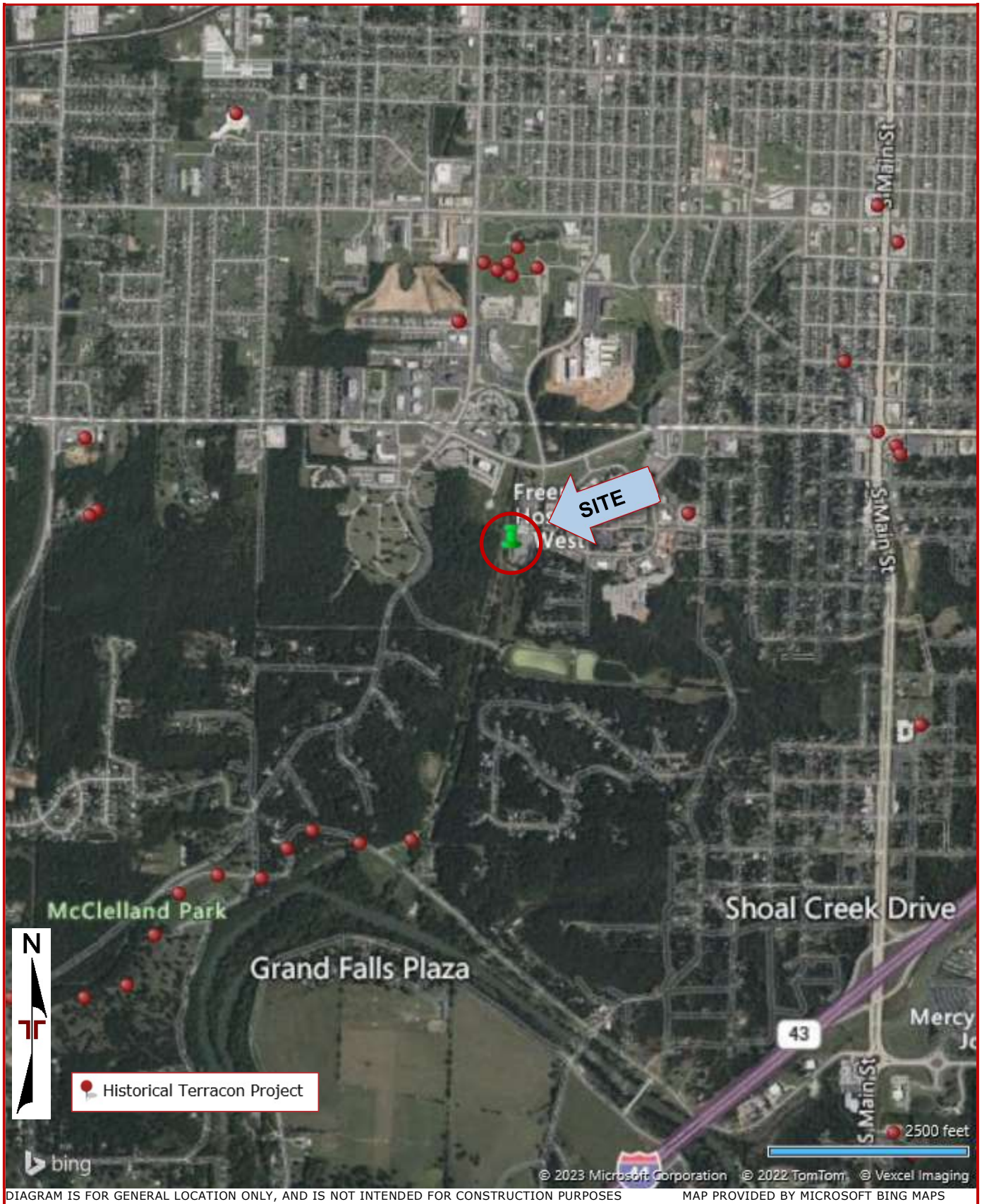


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES MAP PROVIDED BY MICROSOFT BING MAPS

Exploration Plan

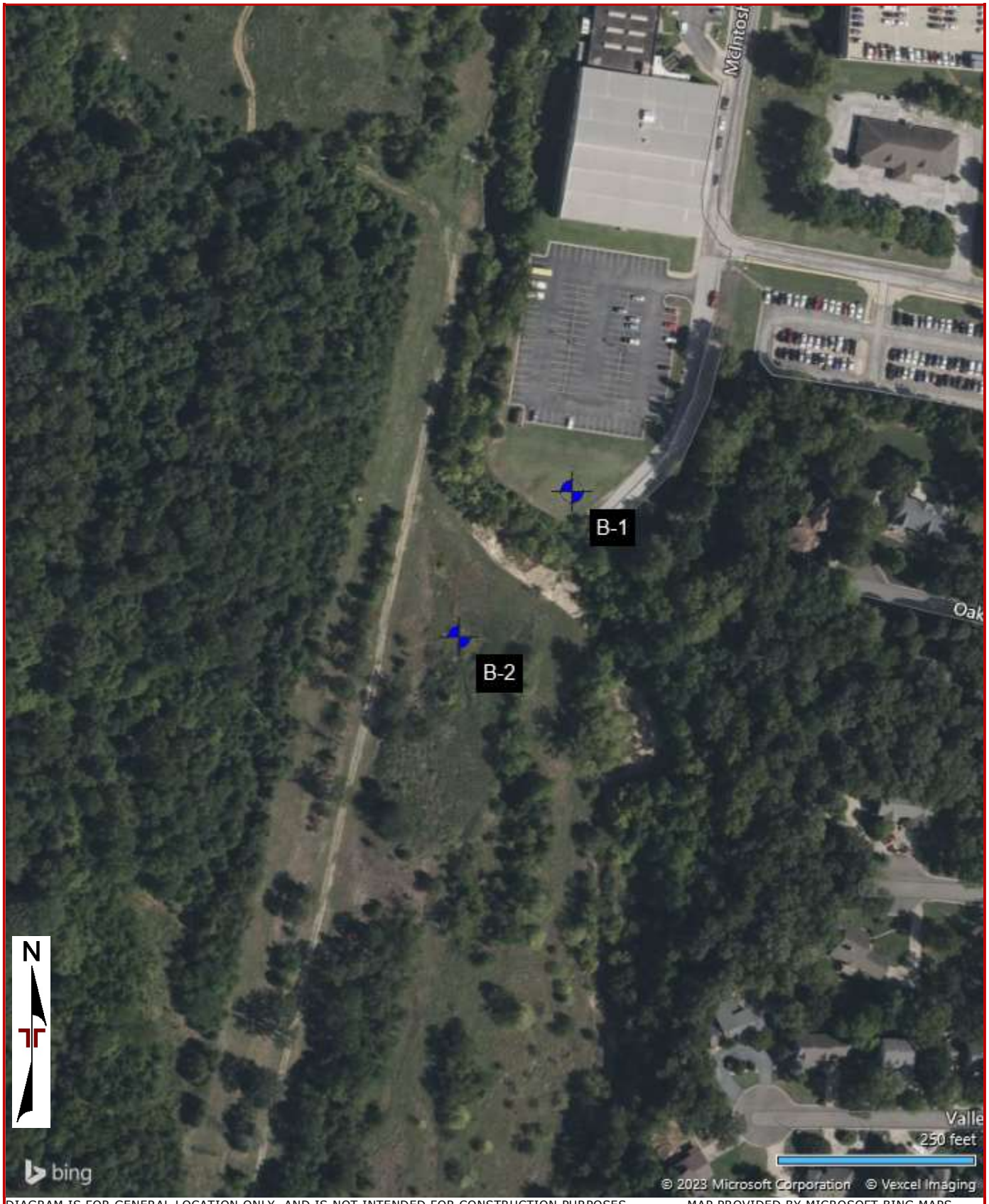


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

MAP PROVIDED BY MICROSOFT BING MAPS

Exploration and Laboratory Results

Contents:

Boring Logs (B-1 and B-2)
Grain Size Distribution

Note: All attachments are one page unless noted above.

Tin Cup Trail Bridge
3404 W McIntosh Cir Dr | Joplin, MO
Terracon Project No. B3235005

Terracon
1401 Illinois Ave
Joplin, MO

Boring Log No. B-1

Location: See Exploration Plan

Latitude: 37.0506° Longitude: -94.5303°

Model Layer	Graphic Log	Depth (Ft.)	Description	Depth (Ft.)	Water Level Observations	Sample Type	Recovery (")	Field Test Results	HP (tsf)	Water Content (%)	Atterberg Limits LL-PL-PI
		0.5	**TOPSOIL (6")**								
1			**CLAYEY GRAVEL WITH SAND (GC)**, reddish brown and gray, loose				2	3-4-4 N=8		13.7	
							2	3-4-4 N=8		19.9	
		5.0		5							
2			**WELL GRADED GRAVEL WITH CLAY AND SAND (GW-GC)**, gray and brown, loose to medium dense				6	9-9-5 N=14		11.3	
							2	4-3-2 N=5		16.4	
		13.5		10							
3			**WEATHERED CHERT**				0	50/1"			
		15.0		15							
			CHERT, gray, extremely fractured, moderately weathered, very strong					Recovery: 100% RQD: 28%			
		20.0		20							
			Boring Terminated at 20 Feet								

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Water Level Observations
▽ 8' While drilling

Notes
Elevation Reference: Elevations were not determined.

Advancement Method
4" Center Flight Auger, then NQ Rock Coring

Abandonment Method
Boring backfilled with auger cuttings upon completion.

Drill Rig
#546

Hammer Type
Automatic

Driller
Terracon

Logged by
Terracon

Boring Started
04-20-2023

Boring Completed
04-20-2023

Tin Cup Trail Bridge
3404 W McIntosh Cir Dr | Joplin, MO
Terracon Project No. B3235005

Terracon
1401 Illinois Ave
Joplin, MO

Boring Log No. B-2

Location: See Exploration Plan

Latitude: 37.0501° Longitude: -94.5308°

Model Layer	Graphic Log	Depth (Ft.)	Description	Depth (Ft.)	Water Level Observations	Sample Type	Recovery ()	Field Test Results	HP (tsf)	Water Content (%)	Atterberg Limits LL-PL-PI
		0.5	**TOPSOIL (6")**								
1		1.0	**CLAYEY GRAVEL WITH SAND (GC)**, reddish brown and gray, loose								
3			**WEATHERED CHERT**				2	50/4"		11.7	
		3.0									
			CHERT, gray, extremely fractured, moderately weathered, very strong								
		4.0									
			WEATHERED CHERT								
		5.0		5							
			CHERT, gray, extremely fractured, moderately weathered, very strong					Recovery: 85% RQD: 23%			
				10				Recovery: 100% RQD: 62%			
		13.0									
			Boring Terminated at 13 Feet								

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Water Level Observations
Groundwater not encountered while drilling

Drill Rig
#546

Hammer Type
Automatic

Driller
Terracon

Logged by
Terracon

Boring Started
04-19-2023

Boring Completed
04-19-2023

Notes
Elevation Reference: Elevations were not determined.

Advancement Method
4" Center Flight Auger, then NQ Rock Coring

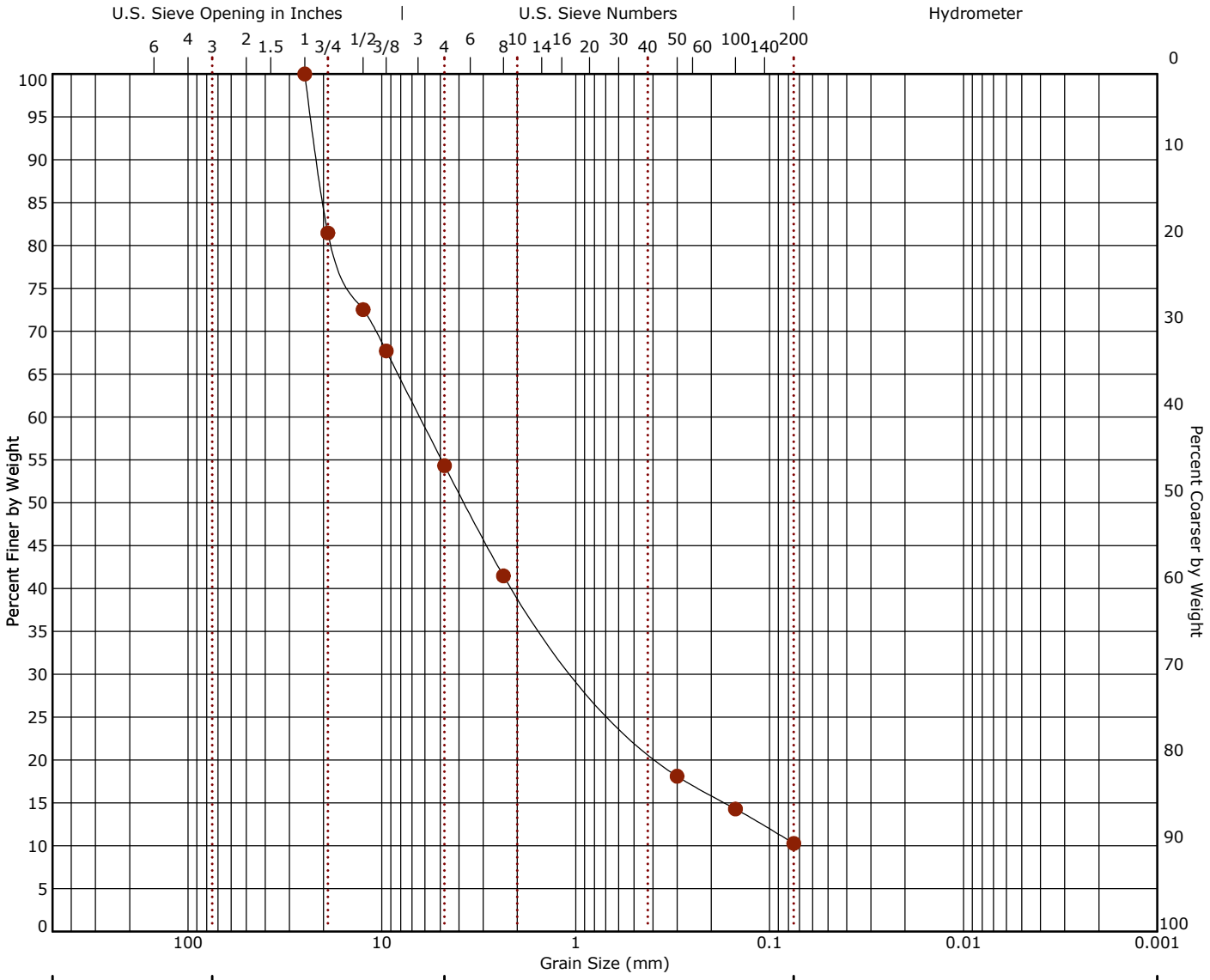
Abandonment Method
Boring backfilled with auger cuttings upon completion.

Tin Cup Trail Bridge
3404 W McIntosh Cir Dr | Joplin, MO
Terracon Project No. B3235005

Terracon
1401 Illinois Ave
Joplin, MO

Grain Size Distribution

ASTM D422 / ASTM C136



Cobbles	Gravel		Sand			Silt or Clay
	coarse	fine	coarse	medium	fine	

Boring ID	Depth	% Cobbles	% Gravel	% Sand	% Fines	% Silt	% Clay	USCS
● B-1	6 - 7.5	0.0	45.7	44.1	10.3			GW-GC

Description
● Well graded gravel with clay and sand

Remarks
●

● Sieve	● % Finer	Sieve	% Finer	Sieve	% Finer
1"	100.0				
3/4"	81.46				
1/2"	72.53				
3/8"	67.7				
#4	54.32				
#100	41.47				
#200	18.11				
	14.29				
	10.27				

Grain Size			
	●		
D_{60}	6.374		
D_{30}	0.857		
D_{10}			

Coefficients			
	●		
C_C	1.61		
C_U	89.08		

Supporting Information

Contents:

General Notes
Unified Soil Classification System
Description of Rock Properties

Note: All attachments are one page unless noted above.

Terracon
4765 W Junction St
Springfield, MO

General Notes

Sampling	Water Level	Field Tests
 Standard Penetration Test	 Water Initially Encountered  Water Level After a Specified Period of Time  Water Level After a Specified Period of Time  Cave In Encountered Water levels indicated on the soil boring logs are the levels measured in the borehole at the times indicated. Groundwater level variations will occur over time. In low permeability soils, accurate determination of groundwater levels is not possible with short term water level observations.	N Standard Penetration Test Resistance (Blows/Ft.) (HP) Hand Penetrometer (T) Torvane (DCP) Dynamic Cone Penetrometer UC Unconfined Compressive Strength (PID) Photo-Ionization Detector (OVA) Organic Vapor Analyzer

Descriptive Soil Classification

Soil classification as noted on the soil boring logs is based Unified Soil Classification System. Where sufficient laboratory data exist to classify the soils consistent with ASTM D2487 "Classification of Soils for Engineering Purposes" this procedure is used. ASTM D2488 "Description and Identification of Soils (Visual-Manual Procedure)" is also used to classify the soils, particularly where insufficient laboratory data exist to classify the soils in accordance with ASTM D2487. In addition to USCS classification, coarse grained soils are classified on the basis of their in-place relative density, and fine-grained soils are classified on the basis of their consistency. See "Strength Terms" table below for details. The ASTM standards noted above are for reference to methodology in general. In some cases, variations to methods are applied as a result of local practice or professional judgment.

Location And Elevation Notes

Exploration point locations as shown on the Exploration Plan and as noted on the soil boring logs in the form of Latitude and Longitude are approximate. See Exploration and Testing Procedures in the report for the methods used to locate the exploration points for this project. Surface elevation data annotated with +/- indicates that no actual topographical survey was conducted to confirm the surface elevation. Instead, the surface elevation was approximately determined from topographic maps of the area.

Strength Terms

Relative Density of Coarse-Grained Soils (More than 50% retained on No. 200 sieve.) Density determined by Standard Penetration Resistance		Consistency of Fine-Grained Soils (50% or more passing the No. 200 sieve.) Consistency determined by laboratory shear strength testing, field visual-manual procedures or standard penetration resistance		
Relative Density	**Standard Penetration or N-Value (Blows/Ft.)**	**Consistency**	**Unconfined Compressive Strength Qu (tsf)**	**Standard Penetration or N-Value (Blows/Ft.)**
Very Loose	0 - 3	Very Soft	less than 0.25	0 - 1
Loose	4 - 9	Soft	0.25 to 0.50	2 - 4
Medium Dense	10 - 29	Medium Stiff	0.50 to 1.00	4 - 8
Dense	30 - 50	Stiff	1.00 to 2.00	8 - 15
Very Dense	> 50	Very Stiff	2.00 to 4.00	15 - 30
		Hard	> 4.00	> 30

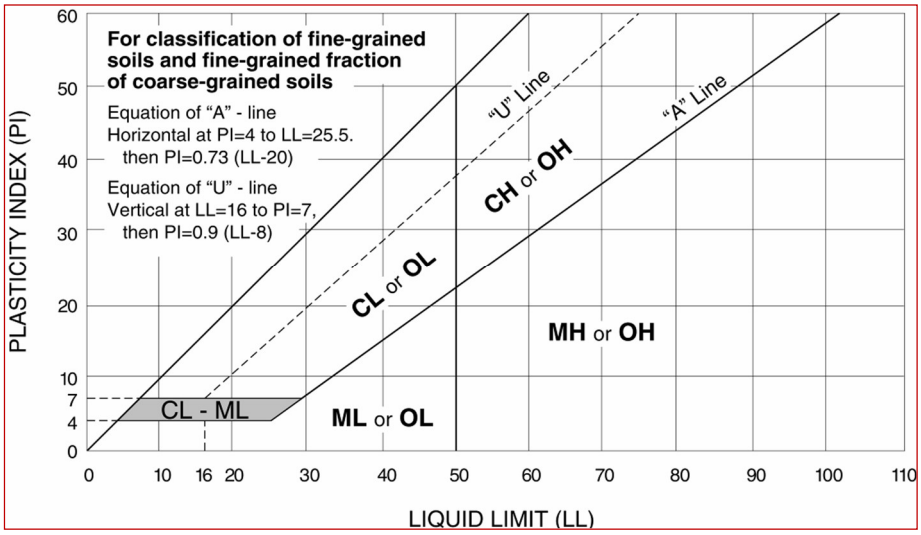
Relevance of Exploration and Laboratory Test Results

Exploration/field results and/or laboratory test data contained within this document are intended for application to the project as described in this document. Use of such exploration/field results and/or laboratory test data should not be used independently of this document.

Unified Soil Classification System

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests [A]				Soil Classification	
				Group Symbol	Group Name [B]
Coarse-Grained Soils: More than 50% retained on No. 4 sieve	**Gravels:** More than 50% of coarse fraction retained on No. 4 sieve	**Clean Gravels:** Less than 5% fines [C]	Cu≥4 and 1≤Cc≤3 [E]	GW	Well-graded gravel [F]
			Cu<4 and/or [Cc<1 or Cc>3.0] [E]	GP	Poorly graded gravel [F]
		Gravels with Fines: More than 12% fines [C]	Fines classify as ML or MH	GM	Silty gravel [F, G, H]
			Fines classify as CL or CH	GC	Clayey gravel [F, G, H]
	Sands: 50% or more of coarse fraction passes No. 4 sieve	**Clean Sands:** Less than 5% fines [D]	Cu≥6 and 1≤Cc≤3 [E]	SW	Well-graded sand [I]
			Cu<6 and/or [Cc<1 or Cc>3.0] [E]	SP	Poorly graded sand [I]
		Sands with Fines: More than 12% fines [D]	Fines classify as ML or MH	SM	Silty sand [G, H, I]
			Fines classify as CL or CH	SC	Clayey sand [G, H, I]
Fine-Grained Soils: 50% or more passes the No. 200 sieve	**Silts and Clays:** Liquid limit less than 50	**Inorganic:**	PI > 7 and plots above "A" line [J]	CL	Lean clay [K, L, M]
			PI < 4 or plots below "A" line [J]	ML	Silt [K, L, M]
		Organic:	$\frac{LL\ oven\ dried}{LL\ not\ dried} < 0.75$	OL	Organic clay [K, L, M, N]
					Organic silt [K, L, M, O]
	Silts and Clays: Liquid limit 50 or more	**Inorganic:**	PI plots on or above "A" line	CH	Fat clay [K, L, M]
			PI plots below "A" line	MH	Elastic silt [K, L, M]
		Organic:	$\frac{LL\ oven\ dried}{LL\ not\ dried} < 0.75$	OH	Organic clay [K, L, M, P]
					Organic silt [K, L, M, Q]
Highly organic soils:	Primarily organic matter, dark in color, and organic odor			PT	Peat

[A] Based on the material passing the 3-inch (75-mm) sieve.
[B] If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.
[C] Gravels with 5 to 12% fines require dual symbols: GW-GM well-graded gravel with silt, GW-GC well-graded gravel with clay, GP-GM poorly graded gravel with silt, GP-GC poorly graded gravel with clay.
[D] Sands with 5 to 12% fines require dual symbols: SW-SM well-graded sand with silt, SW-SC well-graded sand with clay, SP-SM poorly graded sand with silt, SP-SC poorly graded sand with clay.
[E] $Cu = D_{60}/D_{10}$ $Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}}$
[F] If soil contains ≥ 15% sand, add "with sand" to group name.
[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.
[H] If fines are organic, add "with organic fines" to group name.
[I] If soil contains ≥ 15% gravel, add "with gravel" to group name.
[J] If Atterberg limits plot in shaded area, soil is a CL-ML, silty clay.
[K] If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel," whichever is predominant.
[L] If soil contains ≥ 30% plus No. 200 predominantly sand, add "sandy" to group name.
[M] If soil contains ≥ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.
[N] PI ≥ 4 and plots on or above "A" line.
[O] PI < 4 or plots below "A" line.
[P] PI plots on or above "A" line.
[Q] PI plots below "A" line.



Rock Classification Notes

WEATHERING	
Term	**Description**
Fresh	Mineral crystals appear bright; show no discoloration. Features show little or now staining on surfaces. Discoloration does not extend into intact rock.
Slightly weathered	Rock generally fresh except along fractures. Some fractures stained and discoloration may extend <0.5 inches into rock.
Moderately weathered	Significant portions of rock are dull and discolored. Rock may be significantly weaker than in fresh state near fractures. Soil zones of limited extent may occur along some fractures.
Highly weathered	Rock dull and discolored throughout. Majority of rock mass is significantly weaker and has decomposed and/or disintegrated; isolated zones of stronger rock and/or soil may occur throughout.
Completely weathered	All rock material is decomposed and/or disintegrated to soil. The rock mass or fabric is still evident and largely intact. Isolated zones of stronger rock may occur locally.

STRENGTH OR HARDNESS		
Description	**Field Identification**	**Uniaxial Compressive Strength, psi**
Extremely strong	Can only be chipped with geological hammer. Rock rings on hammer blows. Cannot be scratched with a sharp pick. Hand specimens require several hard hammer blows to break.	>36,000
Very strong	Several blows of a geological hammer to fracture. Cannot be scratched with a 20d common steel nail. Can be scratched with a geologist's pick only with difficulty.	15,000-36,000
Strong	More than one blow of a geological hammer needed to fracture. Can be scratched with a 20d nail or geologist's pick. Gouges or grooves to ¼ inch deep can be excavated by a hard blow of a geologist's pick. Hand specimens can be detached by a moderate blow.	7,500-15,000
Medium strong	One blow of geological hammer needed to fracture. Can be distinctly scratched with 20d nail. Can be grooved or gouged 1/16 in. deep by firm pressure with a geologist's pick point. Can be fractured with single firm blow of geological hammer. Can be excavated in small chips (about 1-in. maximum size) by hard blows of the point of a geologist's pick;	3,500-7,500
Weak	Shallow indent by firm blow with geological hammer point. Can be gouged or grooved readily with geologist's pick point. Can be excavated in pieces several inches in size by moderate blows of a pick point. Small thin pieces can be broken by finger pressure.	700-3,500
Very weak	Crumbles under firm blow with geological hammer point. Can be excavated readily with the point of a geologist's pick. Pieces 1-in. or more in thickness can be broken with finger pressure. Can be scratched readily by fingernail.	150-700

DISCONTINUITY DESCRIPTION			
Fracture Spacing (Joints, Faults, Other Fractures)		**Bedding Spacing (May Include Foliation or Banding)**	
Description	**Spacing**	**Description**	**Spacing**
Intensely fractured	< 2.5 inches	**Laminated**	< ½-inch
Highly fractured	2.5 – 8 inches	**Very thin**	½ – 2 inches
Moderately fractured	8 inches to 2 feet	**Thin**	2 inches – 1 foot
Slightly fractured	2 to 6.5 feet	**Medium**	1 – 3 feet
Very slightly fractured	> 6.5 feet	**Thick**	3 – 10 feet
		Massive	> 10 feet

ROCK QUALITY DESIGNATION (RQD) [1]	
Description	**RQD Value (%)**
Very Poor	0 - 25
Poor	25 – 50
Fair	50 – 75
Good	75 – 90
Excellent	90 - 100

1. The combined length of all sound and intact core segments equal to or greater than 4 inches in length, expressed as a percentage of the total core run length.