CITY OF JOPLIN
ADDENDUM NUMBER 002

ISSUE DATE: 7/21/2026

Project: Tin Cup Parallel Force Main – Joplin, Missouri

This addendum forms a part of the contract described above. The original Contract Documents and any prior addenda remain in full force and effect as modified by the following that shall take precedence over any contrary provisions in the prior documents.

Information to Bidders The following is provided to Bidders for information only:

Questions

Q1	Depth/elevation of the rock beneath the creek bed
A1	The Geotechnical Report containing subsurface information for the Shoal Creek crossing is included with this Addendum. Borings **B-1** and **B-2** were performed at the proposed Shoal Creek crossing location and provide the available information regarding the depth and elevation of rock beneath the creek bed.

Daniel Johnson

7-21-26

Daniel Johnson, PE
Director of Public Works

Date

Each bidder shall acknowledge receipt of this addendum by affixing their signature below by noting this addendum on the bid form, and by attaching this addendum to the bid.

ACKNOWLEDGEMENT
The undersigned acknowledges receipt of this addendum and the Bid submitted in accordance with the information, instructions, and stipulations set forth herein.

Bidder: _____

Signed By: _____

Date: _____

BURNS McDONNELL

Subsurface Information for the Tin Cup Force Main Joplin, Missouri

THERE IS NO EXPRESS OR IMPLIED GUARANTEE AS TO THE ACCURACY OR COMPLETENESS OF THE INFORMATION AND DATA CONTAINED HEREIN, NOR OF THE INTERPRETATION THEREOF BY BURNS & McDONNELL OR ANY OF THEIR REPRESENTATIVES.

THE SUBSURFACE INFORMATION AND DATA CONTAINED HEREIN DO NOT FORM A PART OF ANY CONTRACT DOCUMENT ISSUED BY BURNS & McDONNELL.

City of Joplin
Joplin, Missouri
Project No. 119978
September 2020

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APPENDIX A – REPORT BY TERRACON

1.0 GENERAL

This subsurface information document consists of the data and results from a subsurface investigation described in a report titled *Geotechnical Engineering Report, Tin Cup Force Main; Joplin, Missouri; Terracon Project No. B3205008*, dated September 2, 2020. The investigation was performed by Terracon Consultants, Inc. (Terracon) of Springfield, Missouri. The report, as prepared by Terracon, is included in Appendix A of this document.

Drilling and laboratory testing for this investigation was performed by Terracon. The drilling phase was performed July 20 through July 23, 2020. It included the completion of eighteen (18) borings drilled to depths ranging from 6.5 feet to 50 feet below grade. Laboratory tests were conducted on select available samples following the completion of drilling operations. Boring logs and laboratory test results, as prepared by Terracon, are included in the report in Appendix A of this document.

Samples recovered during the subsurface investigation were transported to the laboratory by Terracon. Terracon was not compensated to store the samples after testing and reporting beyond their customary retention period prior to disposal.

2.0 WATER LEVEL INFORMATION

Groundwater observations, as provided by Terracon, are presented in Appendix A of this document. It should be noted by the reader that fluctuations in water levels may occur over more prolonged periods of readings and can be influenced by various outside factors. It may take groundwater several days, or longer, to reach its hydrostatic levels in holes in cohesive soils. Seasonal variations in rainfall, changes to on-site conditions, and changes to off-site conditions can affect groundwater levels. Fluctuations in groundwater levels from those noted should be anticipated during construction. Water levels observed and recorded reflect only those conditions that existed at the time of investigation and may vary from true phreatic groundwater levels.

3.0 LIMITATIONS

3.1 Document Use

The information presented in this document has been prepared for the use of Burns & McDonnell. No other warranty, express or implied, is made as to the information included in this document. In the event that conclusions and recommendations based on data contained in this document are made by others, such conclusions and recommendations are the responsibility of others.

The information gathered and presented in this document was not obtained for an environmental audit nor to evaluate the potential for hazardous materials at the Site. The equipment, techniques, and personnel used to perform geoenvironmental exploration differ substantially from those applied in soil and foundation engineering.

This document is not intended to be utilized as a Geotechnical Baseline Report.

3.2 Variations

The subsurface information submitted in this document is based upon data obtained from test borings completed at the approximate locations indicated in Appendix A of this document. This document does not reflect variations which may occur between test borings. The nature and extent of variations between the test borings may not become evident until construction is performed. Water levels, as described in this document, reflect only those conditions that existed at the time that this particular subsurface investigation was performed by Terracon. Fluctuations or changes in water levels and groundwater conditions can be influenced by sources outside the site investigated, by seasonal rainfall, and by changes in drainage conditions in and around the Site. Fluctuations can occur and should be anticipated between the time of investigation and the time of construction.

APPENDIX A – REPORT BY TERRACON

Tin Cup Force Main
Joplin, Missouri
Report Prepared for Burns & McDonnell
Report Prepared by Terracon
Report Dated 09/02/2020

Geotechnical Engineering Report

Tin Cup Force Main
Joplin, Missouri
September 2, 2020
Terracon Project No. B3205008

Prepared for:
Burns & McDonnell CAS LLC
Kansas City, Missouri

Prepared by:
Terracon Consultants, Inc.
Springfield, Missouri

September 2, 2020

Burns & McDonnell CAS LLC
9400 Ward Parkway
Kansas City, Missouri 64114

Attn: Mr. Bill Nash
E: bmnash@burnsmcd.com

Re: Geotechnical Engineering Report
Tin Cup Force Main
Joplin, Missouri
Terracon Project No. B3205008

Dear Mr. Nash:

We have completed a subsurface exploration and geotechnical engineering exploration for the referenced project. This study was performed in general accordance with Burns & McDonnell CAS LLC (B&M) Geotechnical Work Authorization, TRCN375G, dated July 16, 2020. This report presents the findings of the subsurface exploration and provides geotechnical recommendations concerning earthwork and the design 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 Consultants, Inc.

Joshua D. Elson, R.G.
Project Geologist

Ty G. Alexander, P.E.
Office Manager/Principal
Missouri: PE-2009002087

Nicholas A. Arens, P.E.
Project Engineer

REPORT TOPICS

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Note: This report was originally delivered in a web-based format. For more interactive features, please view your project online at client.terracon.com.

ATTACHMENTS

EXPLORATION AND TESTING PROCEDURES
PHOTOGRAPHY LOG
SITE LOCATION AND EXPLORATION PLANS
GEOLOGIC MAP
MINE MAP 1
MINE MAP 2
EXPLORATION RESULTS
SUPPORTING INFORMATION

Note: Refer to each individual Attachment for a listing of contents.

REPORT SUMMARY

A geotechnical exploration has been performed for the proposed Tin Cup Force Main located at in Joplin, Missouri. Eighteen (18) borings, designated B-1 through B-18, were performed to depths of approximately 6½ to 50 feet below the existing ground surface. The following geotechnical considerations were identified:

- On-site soils may become unstable when disturbed. During periods of dry weather, these soils may be stable upon initial exposure; however, these soils, if exposed, may become relatively soft and unstable under construction traffic. We recommend that the owner budget for the possibility that overexcavation and/or subgrade stabilization may be required and contractors be prepared to handle potentially unstable and/or soft conditions.

- Auger refusal was encountered at varying depths across the site indicating the subject site is located over a pinnacled bedrock unit. Pinnacles may extend into foundation and utility excavations. Accordingly, we recommend the owner obtain unit rates for rock excavation which may be required for shallow foundation construction and utility installation.

The professional opinions and recommendations presented in this report are based on evaluation of data developed by testing discrete samples obtained from widely-spaced borings. Site subsurface conditions have been inferred from available data, but actual subsurface conditions will only be revealed by excavation. So that variations in subsurface conditions which may affect the design can be addressed as they are encountered, we recommend that Terracon be retained to observe excavations and perform tests during the site preparation, earthwork and foundation construction phases of the project.

This executive summary should not be separated from or used apart from this report. This report presents fully developed recommendations and opinions based on our understanding of the project at the time the report was prepared. The report limitations are described in the **General Comments** section of this report.

Geotechnical Engineering Report

Tin Cup Force Main
Project Address
Joplin, Missouri

Terracon Project No. B3205008
September 2, 2020

INTRODUCTION

This report presents the results of our subsurface exploration and geotechnical engineering services performed for the proposed Tin Cup Force Main to be located at Project Address in Joplin, Missouri. The purpose of these services is to provide information and geotechnical engineering recommendations relative to:

- Subsurface soil and rock conditions
- Groundwater conditions
- Site preparation and earthwork
- Excavation considerations
- Dewatering considerations
- Lateral earth pressures

The geotechnical engineering services for this project included the advancement of eighteen (18) test borings to depths ranging from approximately 6½ to 50 feet below existing site grades.

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

The **General Comments** section provides an understanding of the report limitations.

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 in Joplin, Missouri. (See **Site Location**)
Existing Improvements	The proposed force main will be in primarily unimproved land adjacent to existing pavements or in undeveloped fields.
Current Ground Cover	Grass covered throughout, with occasional gravel, asphalt, or concrete pavement.
Existing Topography	Varies along length of the proposed force main.

PROJECT DESCRIPTION

The table below presents a brief summary of our project understanding. This summary has been used as the basis of our analyses and recommendations. Any changes to this summary should be made known to Terracon immediately so revisions can be provided if necessary.

Item	Description
Information Provided	Information was provided by Mr. Bill Nash, with B&M
Project Description	Design and construction of approximately 9,000 linear feet of 24-inch diameter pipe (force main). A trenchless crossing under Shoal Creek will require construction of temporary jacking and receiving pits on either side of the creek. The force main will be constructed within 8 feet of existing surface grade.

GEOLOGICAL ASSESSMENT

Geological Setting

The project site is located in the Springfield Plateau subsection of the Ozark Highlands Physiographic Province of Missouri. This province is characterized by gently rolling to nearly level upland areas dissected by stream and river valleys, underlain primarily by carbonate rocks (limestone and dolomite). Site drainage is generally south and west towards Capps Creek.

The general area is primarily mapped as being underlain by the limestones of the Osagean and Meramecian Series carbonate rocks, dated to the Mississippian Geologic Period and undifferentiated channel sandstones and shales, dated to the Pennsylvanian Geologic Period.

The Osagean Series in southwestern Missouri consists of the Keokuk Limestone, Burlington Limestone, Elsey Formation, Reeds Spring Formation, and Pierson Limestone, and is up to 400-feet in thickness.

Also specific to the general area of project site is the Grand Falls Chert. The Grand Falls Chert is a “silicified sequence of strata formerly part of the Reeds Spring and Elsy Formations and lower Keokuk Limestone. The formation consists of nearly 100% chert and varies from 24 to 40 feet thick in the area of the project site.

The Meramecian Series in southwestern Missouri consists of the Warsaw Formation, generally a maximum of 100 feet thick.

Undifferentiated Pennsylvanian channel sandstones and shales have an uncertain stratigraphic position and can range between 1 foot to 50 feet thick.

The Osagean and Meramecian Series carbonate rocks are known to form a widespread karst terrain, a landform characterized by closed depressions, sinkholes, cave entrances, sinking streams, and a highly irregular "pinnacled" bedrock/soil interface. The karst landform is the consequence of the presence of soluble bedrock.

The Warsaw Formation (Meramecian Series) in the Joplin area is host to Mississippi Valley Pb-Zn deposits, part of the Tri-State Mining District. The Tri-State Mining District was historically heavily mined for lead and zinc.

Specifically, the alignment of the proposed Tin Cup Force Main is mapped as being underlain by the Osagean Series, see **Geologic Map**.

Review of Available Records

The following records were reviewed:

- Google Earth, Historical Aerial Photographs;
- USGS Earth Explorer, Historical Aerial Photographs, https://earthexplorer.usgs.gov/;
- USGS Topoview, Historical Topographic Maps, https://ngmdb.usgs.gov/topoview/;
- Jasper County, MO, GIS Data Viewer, http://www.jaspercountyassessor.org/;
- Missouri University, Missouri Spatial Data Information Service, http://www.msdis.missouri.edu/;
- Missouri Digital Heritage (MDH), Tri-State Mining Maps Collection, https://www.sos.mo.gov; and
- Missouri Department of Natural Resources (MDNR), GeoStrat, http://dnr.no.gov/geostrat/; and
- Missouri Southern State University (MSSU), University Archives and Special Collections.

Our review of records included reviewing aerial photographs from 1961, 1980, 1996, 2002, 2003, 2004, 2005, 2006, 2008, 2009, 2010, 2011, 2012, 2014, 2016, and 2017. Additionally, our records review included reviewing USGS 7.5-minute quadrangle historical topographic maps from 1962, 1979, 2015, and 2017. No features in conflict with the planed alignment were observed in historical aerial photographs or USGS topographic maps.

Terracon also requested documents from the Missouri Geological Survey (MGS) regarding multiple features identified in the review of the Inventory of Mines, Occurrences and Prospects data in GeoStrat. MGS provided a Geologic Map of Mining and Mineralized Area, surveyed 1916 to 1921. No features were observed on the map to be in conflict with the planned alignment, see **Mine Map 1**.

Two historical mining maps were found in the MDH Tri-State Mining Maps Collection and the MSSU Archives and Special Collections that includes the alignment and adjacent properties. These documents identify several prospects adjacent to but not within the planned alignment, see **Mine Map 2**.

Historical aerial photographs and historical topographic maps dating as far back to 1961 indicate that the planned alignment and general area has remained mostly undeveloped with sparse residential structures scattered around the area.

Site Reconnaissance

On July 17, 2020, Joshua Elson, R.G., of Terracon visited the project site to observe surface conditions. At the time of the site visit, the ground surface was primarily easily accessible areas of manicured lawn areas and pavements, however some sections of the alignment were moderately vegetated limiting observation of the ground surface. No characteristics associated with karst or mine features were observed, such as areas of subsidence or tailings piles. See the attached **Photographic Log** taken during the site visit.

Identified Geological Hazards

No evidence of karst or mining features, such as areas of subsidence or mine tailings piles, was identified during document review and site reconnaissance. While no evidence of historical mining activity was identified on the project during this study, it is important to note that historical mining activity was not always well documented, and the possibility exists that undocumented mining features could exists or that documented mining features may exist on the property that are incorrectly located on existing maps. Accordingly, while no evidence of historical mining on the subject property was discovered as a part of our research or site reconnaissance, development in the Joplin area inherently involves a degree of risk that undocumented mine features or mine features that have been incorrectly located on existing maps may be present on the site.

While it is not anticipated, should a mine feature be encountered during construction of the project, Terracon should be notified immediately to assess the situation and provide remediation recommendations.

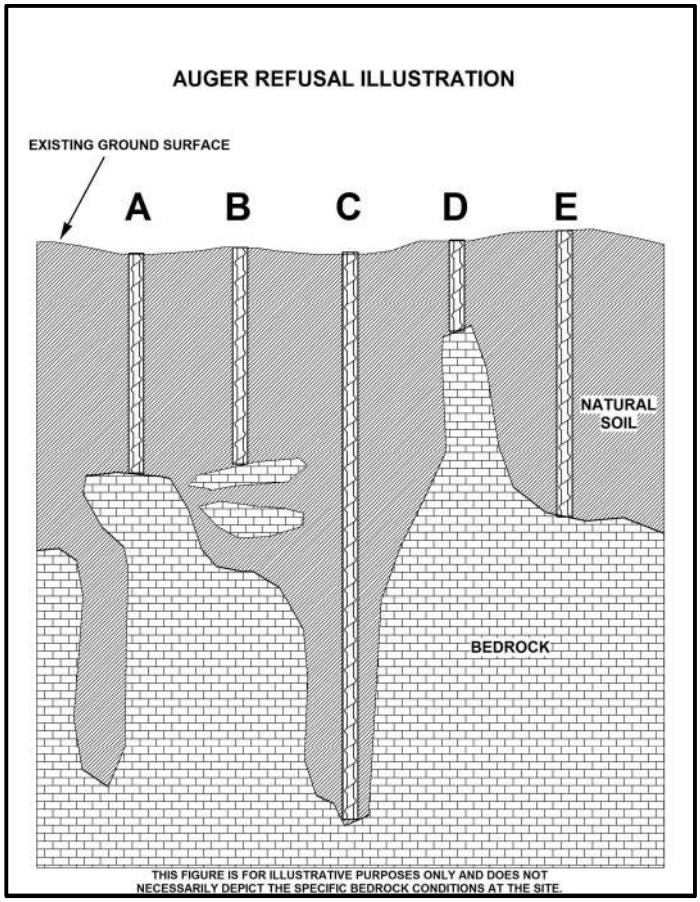
GEOTECHNICAL CHARACTERIZATION

We have developed a general characterization of the subsurface conditions based upon 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 site preparation and foundation options. Conditions encountered at each exploration point are indicated on the individual logs. The individual logs can be found in the **Exploration Results** section and the GeoModel can be found in the **Figures** section 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	**Fill**	Fill – lean clay with varying amounts of gravel and/or sand
2	**Coarse Soil**	Gravel with varying amounts of clay and sand
3	**Fine Soil**	Lean or fat clay with varying amounts of gravel and sand
4	**Bedrock**	Chert with occasional layers of limestone

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.



Groundwater Conditions

The boreholes were observed while drilling and after completion for the presence and level of groundwater. The water levels observed in the boreholes are shown on the boring logs in **Exploration Results**, and are summarized below.

Boring Number	Approximate Depth to Groundwater while Drilling (feet) [1]	Approximate Depth to Groundwater after Drilling (feet) [1,2]
B-1	8	N/A

1. Below ground surface
2. Obtaining accurate ground water depths after completion of drilling was not possible due to the introduction of water utilized in drilling methods.

Groundwater was not observed in the remaining borings while drilling, or for the short duration the borings were left open prior to backfilling. However, this does not necessarily mean the borings terminated above groundwater, or the water levels summarized above are stable groundwater levels. Due to the low permeability of the soils encountered in the borings, a relatively long period of time may be necessary for a groundwater level to develop and stabilize in a borehole. Long-term

observations in piezometers or observation wells, sealed from the influence of surface water, are often required to define groundwater levels in materials of this type.

Groundwater level fluctuations occur due to seasonal variations in the amount of rainfall, runoff and other factors not evident at the time the borings were performed, particularly in Borings B-1 and B-2 which are adjacent to Shoal Creek. Therefore, groundwater levels during construction or at other times in the life of the structure may be different than the levels indicated on the boring logs. The possibility of groundwater level fluctuations should be considered when developing the design and construction plans for the project.

GEOTECHNICAL OVERVIEW

General

We recommend that the exposed subgrade be thoroughly evaluated after stripping of any topsoil and at the base of all cut areas, and prior to the start of any fill operations. We recommend that the geotechnical engineer be retained to evaluate the bearing material for the foundations and subgrade soils. Subsurface conditions, as identified by the field and laboratory testing programs, have been reviewed and evaluated with respect to the proposed project plans known to us at this time.

Karst development is a common occurrence in this area due to the dissolution of the native limestone bedrock material. Though no evidence of sinkholes was noted in the review of topography and in the borings performed at the subject site, the development of karst features on the site is a possibility over time. The current state of the practice in geotechnical engineering does not allow for the accurate prediction of when or where sinkholes or karst-related subsidence could occur. The owner is advised that construction on this property or essentially any other site within this area, carries with it some risk that future sinkholes may develop.

The subject site is located in the tristate mining district which was historically heavily mined for lead and zinc deposits. Due to mine record keeping practices in the past some mine and prospect locations have been lost or are not recorded by the Missouri Department of Natural Resources. Because of the lack of record keeping occasional mine shafts are discovered during excavations. The owner is advised that construction on this property or essentially any other site within this area, carries with it some risk of subsidence from mine collapse or the encountering of mine shafts during excavations.

Bedrock Considerations

Auger refusal on apparent intact bedrock was encountered in borings B-1, B-2, B-3 and B-17 at depths between about 3 to 14 feet below present grades. Accordingly, site grading and excavations may encounter bedrock.

When the proposed grading plan is available and prior construction, additional borings or auger probes could be performed to obtain more specific bedrock information. Linear interpolation of apparent bedrock elevations based upon the boring data is often used but can misrepresent actual rock removal quantities where such anomalies exist.

We recommend the owner obtain unit rates for rock excavation for utility trenches and construction of temporary jacking and receiving pits.

Soft Subgrade Potential

The subgrade soils may become unstable when disturbed. During periods of dry weather, these soils may be stable upon initial exposure, however, these soils could become relatively soft and unstable under construction traffic. Further, depending upon site conditions during construction, overexcavation or stabilization of the subgrade and/or base of overexcavations may be needed to achieve a suitable working surface. Accordingly, we recommend that the owner budget for the possibility that overexcavation and/or subgrade stabilization may be required and contractors be prepared to handle potentially unstable and/or soft conditions.

Shallow Ground Water

Free water was noted at a depth of 8 feet in Boring B-1 (on the south bank of Shoal Creek) indicating that the site may contain shallow groundwater or localized areas of perched water. Accordingly, dewatering may be necessary in excavated areas. Terracon recommends that the contractor be ready to handle these conditions.

EARTHWORK

Earthwork is anticipated to include clearing and grubbing, excavations, and fill placement.

Site Preparation

Prior to placing fill, existing vegetation and root mat and existing pavements should be removed. In areas where the utility requires replacement of pavements, the subgrade beneath the pavements should be proofrolled with an adequately loaded vehicle such as a fully-loaded, tandem-axle dump truck. The proofrolling should be observed by the Geotechnical Engineer. Areas excessively deflecting under the proofroll should be delineated and subsequently addressed by the Geotechnical Engineer. Such areas should either be removed or modified by following the recommendations in the **Subgrade Stabilization** section. Excessively wet or dry material should either be removed, or moisture conditioned and recompacted.

Fill Material Types

Materials used for fill should meet the following material property requirements:

Fill Type [1]	USCS Classification	Acceptable Location for Placement
High Plasticity Material	CH (LL≥70 or PI≥40)	1 foot below base of pavements
Moderate to High Plasticity Material	CH or CL, with 70>LL≥45 or 40>PI≥25	
Granular Material [2]	GM, GC, SM, or SC	All locations and elevations
Low Plasticity Material [3]	CL (LL<45 & PI<25) or Granular Material [3]	

1. Compacted structural 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. A sample of each material type should be submitted to Terracon for evaluation. On-site soils generally appear suitable for use as fill, subject to the "acceptable location for placement" limitations described in this table or
2. Crushed limestone aggregate, limestone screenings or granular material such as sand, gravel or crushed stone containing at least 15 percent low plasticity fines.
3. Low plasticity cohesive soil or granular soil having low plasticity fines. Material should be approved by the geotechnical engineer.

Fill Compaction Requirements

Fill should meet the following compaction requirements.

Item	Description
Fill Lift Thickness[1]	9 inches or less in loose thickness
Compaction Requirements[2]	At least 95 percent of the material's maximum standard Proctor dry density[3]
Water Content Range	Low plasticity cohesive: -2 percent to +2 percent of optimum[3] High plasticity cohesive: 0 to +4 percent of optimum[3] Granular: Workable moisture levels[4]

1. Reduced lift thicknesses of 4 to 6 inches are recommended in confined areas (e.g., utility trenches, foundation excavations, and foundation backfill) and when hand-operated compaction equipment is used.
2. We recommend that engineered fill be tested for moisture content and compaction during placement. If the results of the in-place density tests indicate the specified moisture or compaction limits have not been met, the area represented by the test should be reworked and retested as required until the specified moisture and compaction requirements are achieved. As stated within ASTM D 698, this procedure is intended for soils with 30 percent or less material larger than ¾ inch. Accordingly, we recommend full time proofroll observation be performed instead of moisture density testing for materials containing more than 30 percent aggregate retained on the ¾-inch sieve.
3. As determined by the standard Proctor test (ASTM D 698).
4. Specifically, moisture levels should be maintained low enough to allow for satisfactory compaction to be achieved without the cohesionless fill material pumping when proofrolled.

Earthwork Construction Considerations

Shallow excavations for the proposed trench excavations for the installation of the new sewer line are anticipated to be accomplished with conventional construction equipment, including equipment to excavate bedrock. However, layers of competent bedrock, such as was encountered in borings B-1, B-2, and possibly in B-3 and B-17, may require breaking with pneumatic rock breakers or blasting. Upon completion of filling and grading, care should be taken to maintain the subgrade water content. 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 becomes excessively wet or dry, frozen, or is disturbed, the affected material should be removed, or the materials should be scarified, moisture conditioned, and recompacted prior to further construction.

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 and tested by a representative of the Geotechnical Engineer. Observation and testing should include documentation of removal of vegetation and topsoil, proofrolling, and mitigation of areas delineated by the proofroll to require mitigation.

In areas of foundation excavations, the bearing subgrade should be evaluated by the Geotechnical Engineer. If unacceptable conditions are encountered, the Geotechnical Engineer should be contacted to recommend mitigation options.

TRENCHLESS EXCAVATIONS

Subsurface Profile

Subsurface profiles at the site can be generalized by fine-grained clay soils with varying amounts of sand and gravel (undocumented fill) and gravels with varying amounts of sand and clay overlaying chert with occasional limestone. The water levels observed in the boreholes are shown on the boring logs in **Exploration Results**, and are summarized in **Groundwater Conditions**. A summary of the geotechnical properties is provided in the table below.

Geotechnical Soil Properties

Soil Profile	Approximate Elevations (feet)	Location	Material Type	Drained c (psf)[1]	Undrained c (psf)[1]	Qu (psi)[1]	f ' (deg)[1]	g (pcf)[1]
Layer 1	872 – 869	B-2	Fill - CL	0	1,200	--	28	120
Layer 2	854-840.5	B-1	GP-GC	--	--	--	28	120
Layer 4	Below 840.5	B-1	Chert	--	--	9,800	--	150
Layer 4	Below 869	B-2	Chert	--	--	5,900	--	150

Notes:
1. c = cohesion, Qu = average unconfined compressive strength, f = effective internal angle of friction, γ = moist unit weight

Construction Risk

Based on the information available at this time, and the subsurface conditions encountered in our borings, it is our opinion that the proposed crossing is feasible. However, there are potential risks associated with this crossing that if left unmitigated will likely cause difficulties during installation of the force main.

In general, subsurface conditions along the proposed trenchless crossing alignment consist of a gravelly soil unit overlying relatively shallow bedrock. The bedrock encountered was predominantly chert with limestone and in-filled clay seams ranging from highly weathered to slightly weathered, and extremely fractured to slightly fractured. Open or water filled voids may also be present in this formation. The chert had unconfined compressive strengths ranging from 2,970 to 13,250 psi and a Mohs hardness ranging from 7 to 8. We have identified the following risks the owner and contractor should consider:

Loss of Drilling Fluid Returns

The borings encountered extremely fractured bedrock and clay filled seams that will likely cause formational fluid loss during installation of the force main. The loss of drilling fluid can contribute

to the buildup of cuttings in the annulus causing an increase in rotary torque and increase the risk of stuck tooling and/or damage to the force main. We anticipate the complete loss of drilling fluid returns will increase the total volume of drilling fluid makeup water and bentonite required during construction.

Drill Hole Stability

The crossing is expected to encounter extremely fractured zones of bedrock and very loose poorly graded gravel with clay that will impact the stability of the hole. These zones of fractured and loose material will increase the risk of overmining, stuck tooling, and damage to the force main during pullback. These zones are also expected to have reduced and/or total drilling fluid loss that will further increase the risk of drill hole stability during construction. The use of a larger diameter casing within the entry/exit tangents can help mitigate the risk of drill hole stability and drilling fluid loss. However, extremely fractured or very loose gravelly materials encountered outside of the entry and exit tangents where casing cannot be advanced will have an increased risk hole instability and formational fluid loss.

Pilot Hole Steering

Pilot hole steering is expected to be difficult along the majority of the alignment due to the strength, fracturing, and hardness of the chert, and the very loose gravelly soils. The contractor should expect difficult steering where clay seams are encountered in the bedrock and the potential for voids to be encountered where borings were not performed. These abrupt transitions from soil to rock will increase the risk of hard points and relatively large offsets that result in lost/stuck tooling and damage to the force main during pullback.

Construction Observation

We recommend the crossing be documented and observed by qualified personnel experienced in trenchless construction and be able to provide recommendations during drilling in real time to mitigate risk and increase the potential for a successful crossing.

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. Natural variations may 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 or collaboration through this system 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 costs. 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 impact excavation costs. 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, cost estimating, excavation support, and dewatering requirements/design are the responsibility of others. 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

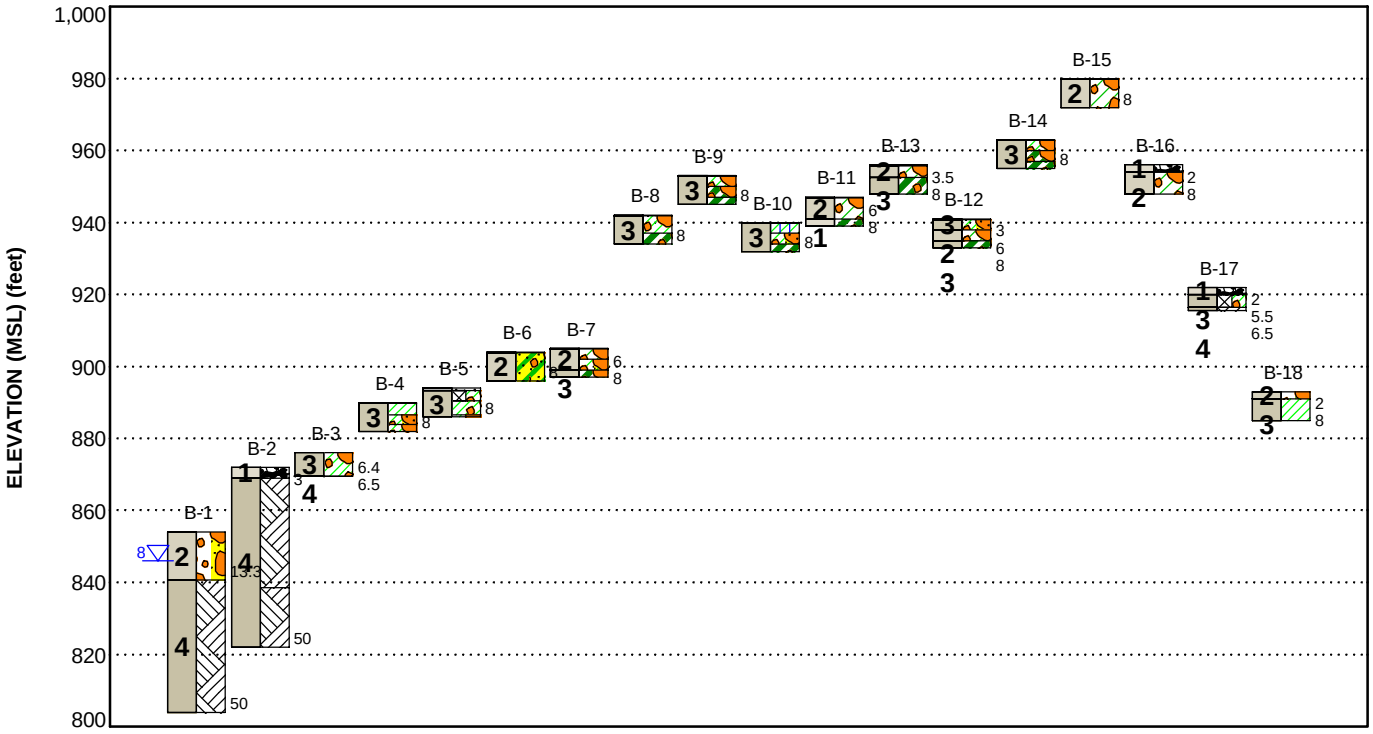
Contents:

GeoModel

GEOMODEL

Tin Cup Force Main ■ Joplin, Missouri
Terracon Project No. B3205008

Terracon GeoReport



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	**Fill**	Fill - lean clay with varying amounts of gravel and/or sand
2	**Coarse Soil**	Gravel with varying amounts of clay and sand
3	**Fine Soil**	Lean or fat clay with varying amounts of gravel and sand
4	**Bedrock**	Chert with occosional layers of limestone

LEGEND

- Poorly-graded Gravel with Sand
- Gravelly Lean Clay
- Gravelly Lean Caly with Sand
- Clayey Gravel
- Fat Clay with Gravel
- Bedrock
- Topsoil
- Lean Clay with Gravel
- Clayey Gravel with Sand
- Fat Clay
- Fill
- Lean Clay
- Clayey Sand with Gravel
- Gravelly Fat Clay
- Silty Clay

▽ First Water Observation

Groundwater levels are temporal. The 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	Boring Depth (feet) [1]	Planned Location
2	50	jacking
16	6½ to 8 or auger refusal	pavement / utilities

1. Below ground surface
2. Borings B-3 and B-17 encountered auger refusal on a possible cobble, boulder, or bedrock prior to their planned termination depth. All other borings extended to their planned depths.

Boring Layout and Elevations: The boring layout was performed by Terracon. Coordinates were obtained with a handheld GPS unit (estimated horizontal accuracy of about ±20 feet). Approximate elevations were obtained by interpolation from a topographic map generated from Jasper County LiDAR data and are rounded to the nearest foot. If more precise boring locations and elevations are desired, we recommend the borings be surveyed.

Subsurface Exploration Procedures: The borings were advanced with an ATV-mounted rotary drill rig using continuous flight, solid-stem augers. Samples were obtained in the borings as noted in **Exploration Results**. The split-barrel sampling procedure was performed using a standard 2-inch outer diameter, split-barrel sampling spoon that 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 was 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 their respective test depths. Water levels were observed and recorded during drilling and sampling. For safety purposes, all borings were backfilled with auger cuttings after their completion.

Auger refusal materials were explored with rock coring procedures. An NQ2 rock core barrel was utilized to perform the rock cores at Borings B-1 and B-2. Water was used as a drilling fluid for cooling the rock bit and the spent water was discharged on site. Due to the use of water for rock coring, groundwater observations were not performed after the start of rock coring and through the completion of the boring.

The sampling depths, penetration distances, and other sampling information were recorded on the field boring logs. The samples were placed in appropriate containers and taken to our soil laboratory for testing and classification by a Geotechnical Engineer. Our exploration team prepared field boring logs as part of the drilling operations. These field logs included visual classifications of the materials encountered during drilling and our interpretation of the subsurface conditions between samples. Final boring logs were prepared from the field logs. The final boring logs represent the

Geotechnical Engineer's interpretation of the field logs and include modifications based on observations and tests of the samples in our laboratory.

Laboratory Testing

Classification of the soil samples was performed in general accordance with the Unified Soil Classification System (USCS) based on the material's texture and plasticity. The project engineer reviewed the field data and assigned laboratory tests to better understand the engineering properties of the various soil and rock strata.

- Water (Moisture) Content of Soil and Rock by Mass
- Liquid Limit, Plastic Limit, and Plasticity Index of Soils
- Particle-Size Analysis of Soils
- Unconfined Compressive Strength of Cohesive Soil
- Unconfined Compressive Strength of Rock
- Maximum Dry Density and Optimum Water Content by Standard Proctor Method
- Chemical Analyses – pH, Soluble Sulfates, Chloride Ion, Electrical Resistivity, Redox Potential, Sulfides

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

PHOTOGRAPHY LOG



Looking north from near B-1. Outcrop of Grand Fall Chert is observed below bridge deck.



Looking south at B-1 from north side bridge abutment.



View looking north taken from edge of roadway east of B-3.



View looking east from near the intersection of Cougar Drive and McClelland Boulevard.



View looking east from center of McClelland Boulevard south of B-4.



View looking south east taken from near B-6.



View looking east from near B-7.



View looking southwest from near B-12.



View looking east taken from west of the intersection of Glendale Road and McClelland Park Road.



View looking north at B-15 (near center left).



View looking west. B-17 and power line easement are located right corner.



View looking east taken south of B-17.



View looking northeast at gravel drive to the east end of the proposed alignment.

SITE LOCATION AND EXPLORATION PLANS

Contents:

Site Location Plan
Boring Location Plan
Mine Map 1
Mine Map 2
Geologic Map

SITE LOCATION

Tin Cup Force Main ■ Joplin, Missouri
September 2, 2020 ■ Terracon Project No. B3205008

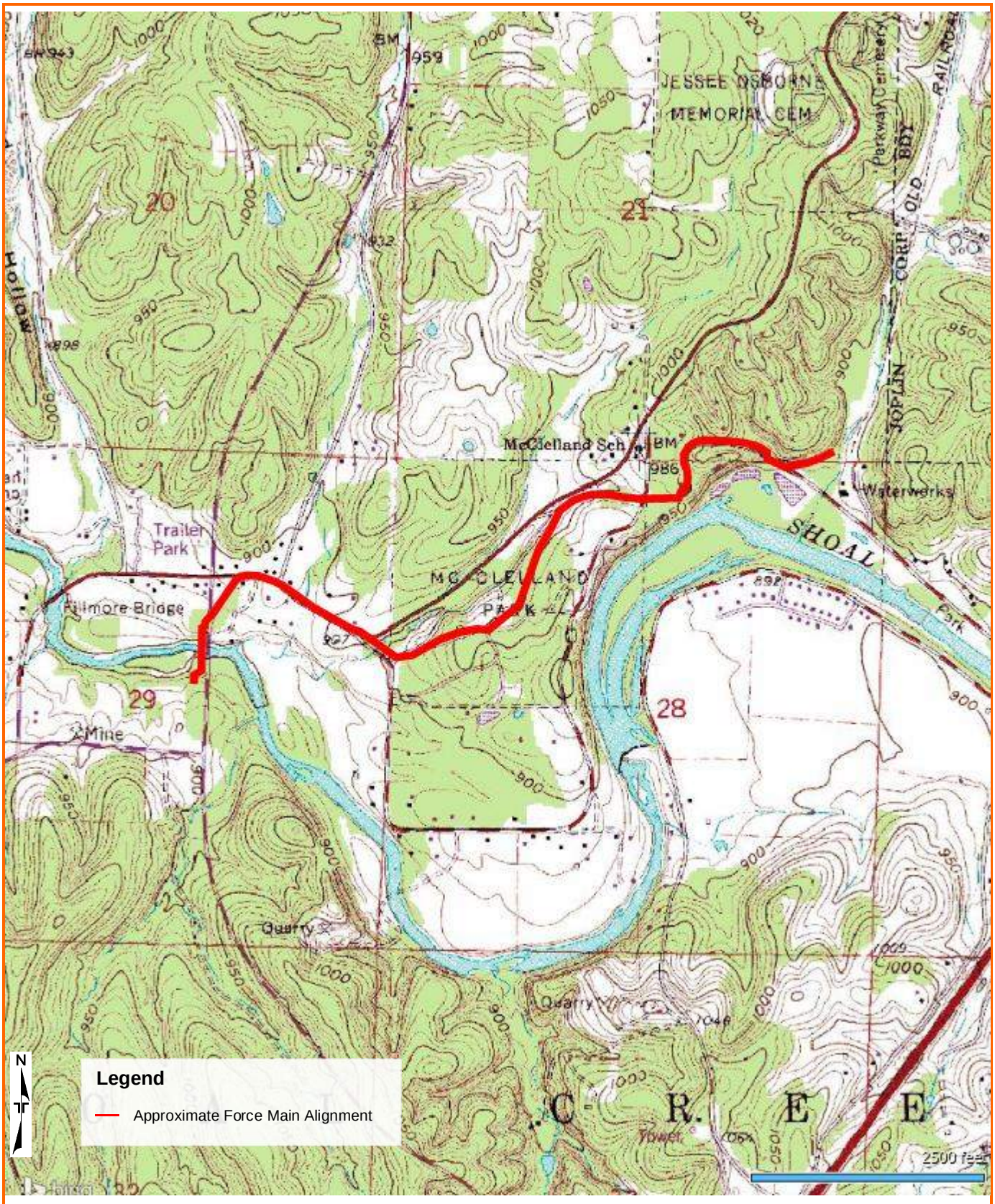


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

MAP PROVIDED BY MICROSOFT BING MAPS

BORING LOCATION PLAN

Tin Cup Force Main ■ Joplin, Missouri
September 2, 2020 ■ Terracon Project No. B3205008

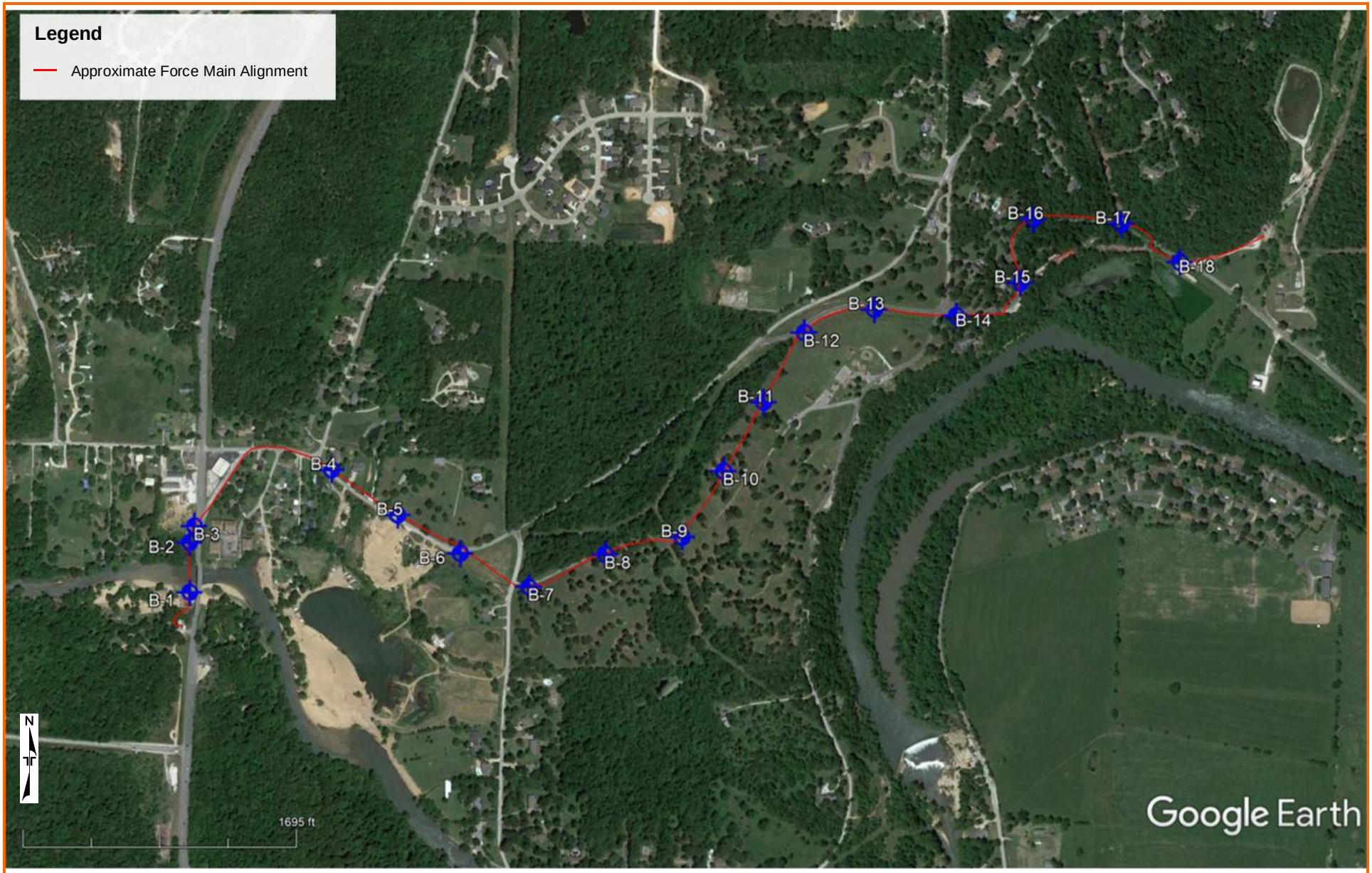


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

MAP PROVIDED BY GOOGLE EARTH PRO

MINE MAP 1

Tin Cup Force Main ■ Joplin, Missouri

September 2, 2020 ■ Terracon Project No. B3205008

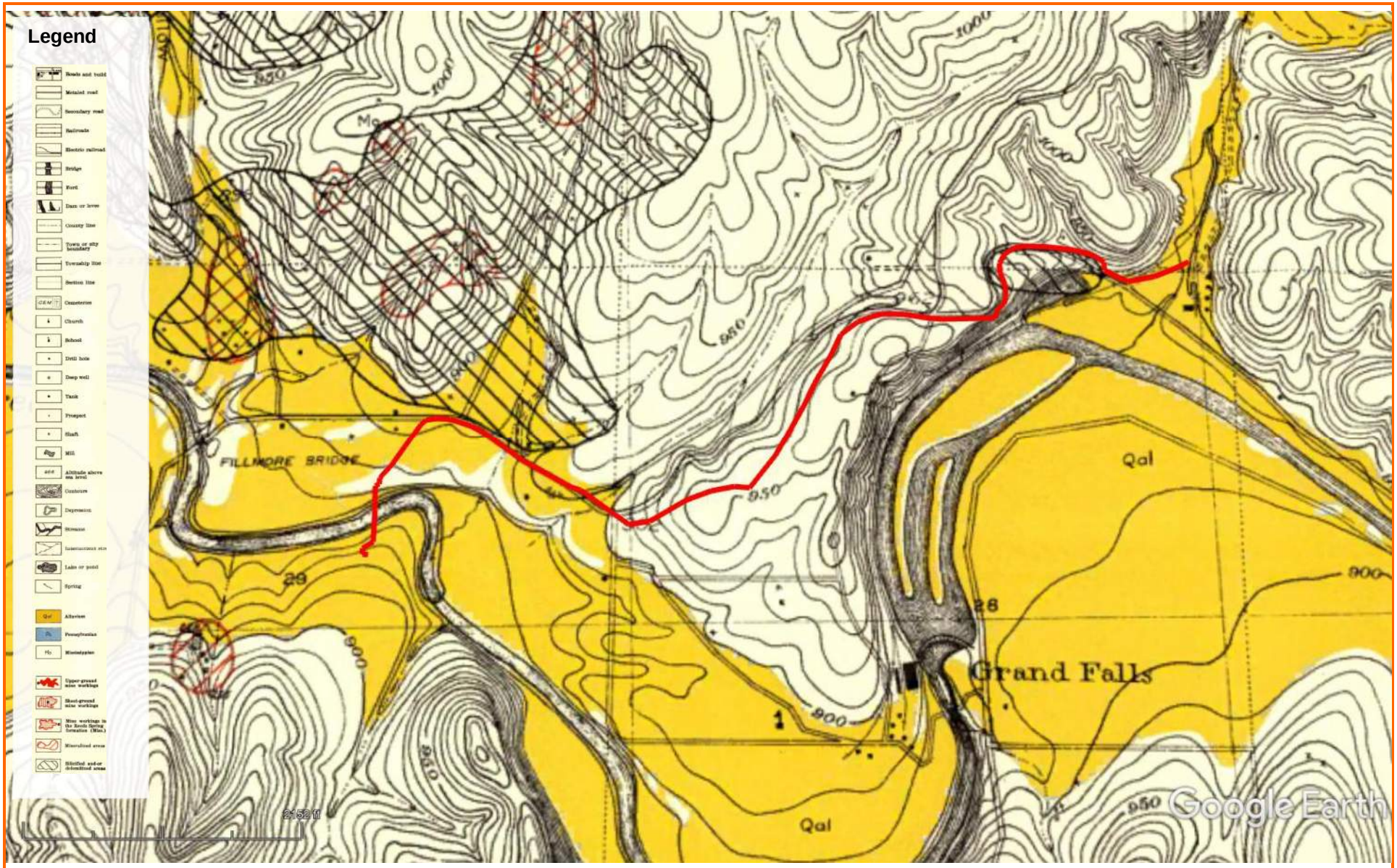


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

MAP PROVIDED BY MISSOURI GEOLOGICAL SURVEY

MINE MAP 2

Tin Cup Force Main ■ Joplin, Missouri

September 2, 2020 ■ Terracon Project No. B3205008

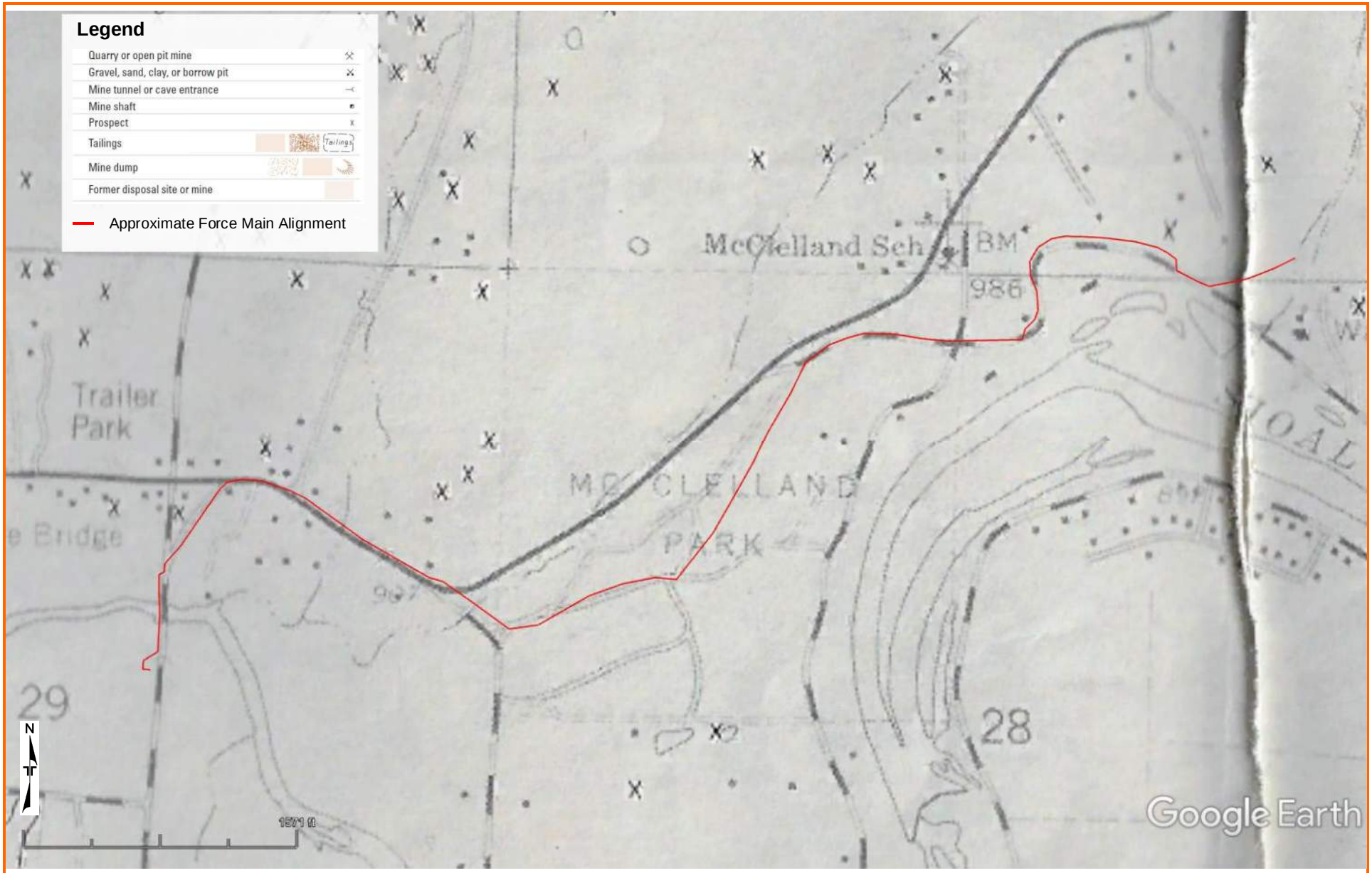


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

MAP PROVIDED BY MISOSURI STATE SOUTHERN UNIVERSITY

GEOLOGIC MAP

Tin Cup Force Main ■ Joplin, Missouri
September 2, 2020 ■ Terracon Project No. B3205008

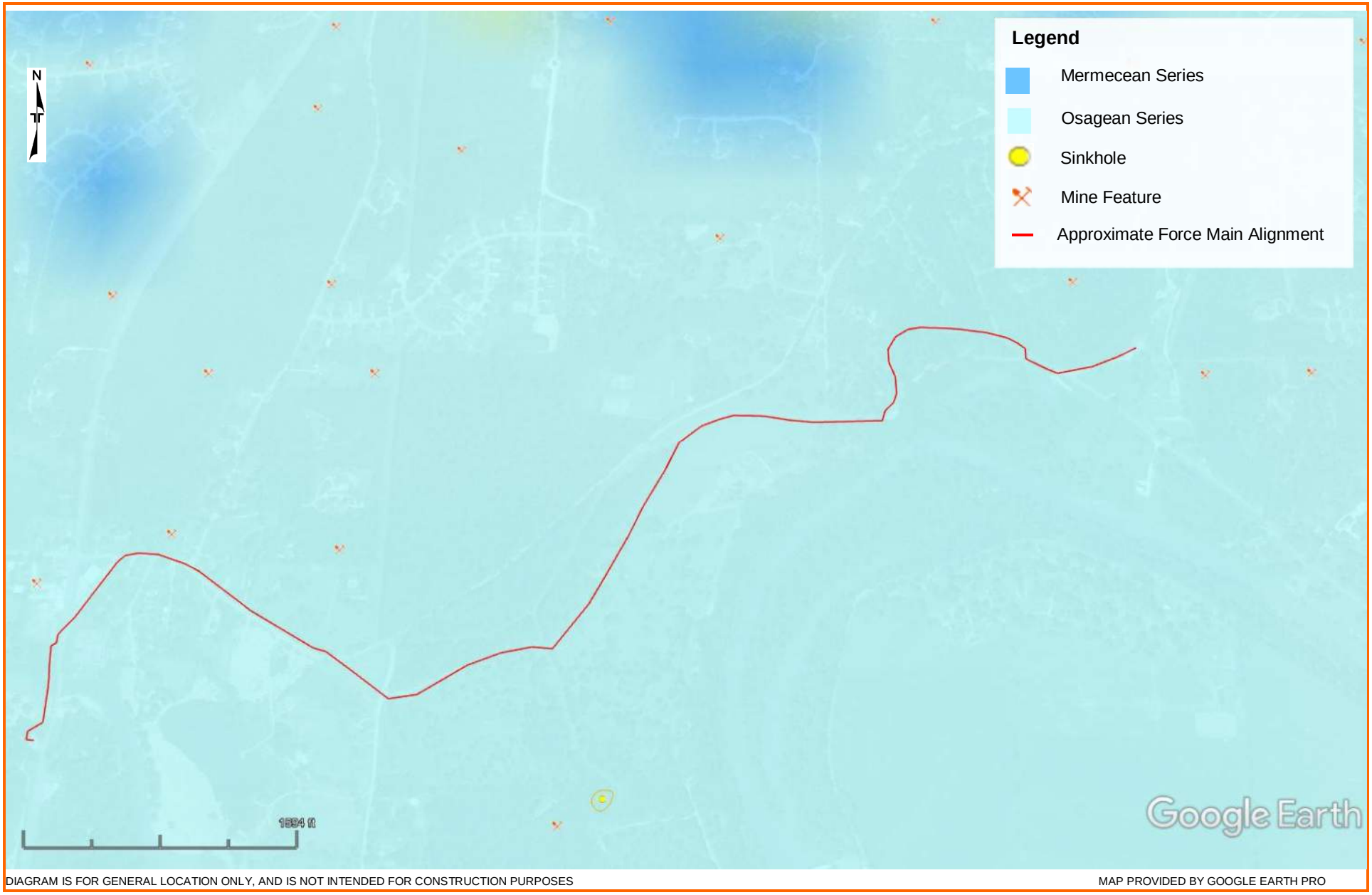


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

MAP PROVIDED BY GOOGLE EARTH PRO

EXPLORATION RESULTS

Contents:

Boring Logs
Unconfined Compressive Strength of Intact Rock Core Specimens
Rock Core Photographs
Grain Size Distribution
Laboratory Compaction Characteristics of Soil Reports (Proctor Values)
Results of Corrosion Analysis

BORING LOG NO. B-1

PROJECT: Tin Cup Force Main

CLIENT: Burns & McDonnell CAS LLC
Kansas City, Missouri

SITE: Glendale Rd. and McClelland Blvd.
Joplin, Missouri

LOCATION See Exploration Plan

Latitude: 37.035° Longitude: -94.5579°

Surface Elev.: 854 (Ft.)

MODEL LAYER	GRAPHIC LOG	DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (Inches)	FIELD TEST RESULTS	REC%	RQD%	LABORATORY HP (tsf)	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI	Strength (psi)
2		0.0	854.0											
							4	4-4-2 N=6			N/A	5.5		
							4	4-2-1 N=3			N/A	5.8		
				5			4	8-4-2 N=6			N/A	15.5		
					▽		8	4-8-6 N=14			N/A	17.3		
				10										
		13.3	840.5											
4				15					100	100				
									100	90				9,330
				20					100	88				
				25					100	83				11,020
				30					100	88				
				35					100	88				5,580
				40					100	100				
				45					100	95				13,250
		50.0	804	50					100	0				

POORLY GRADED GRAVEL WITH SAND (GP), brown and gray, very loose to loose

medium dense below 8.5 feet

CHERT, tannish white and black, slightly fractured, thick bedding, slightly weathered, with occasional layers of fine-grained, gray limestone (approximately 75% chert)

Boring Terminated at 50 Feet

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
4.5" center flight auger to auger refusal and followed with NQ2 core barrel

Abandonment Method:
Boring backfilled with bentonite chips upon completion.

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.

Elevations were interpolated from a topographic site plan.

Notes:
Coarse grained materials in soil column is primarily chert.

WATER LEVEL OBSERVATIONS

▽ *While drilling*

Terracon
508 E. 9th St.
Joplin, MO

Boring Started: 07-22-2020 | Boring Completed: 07-22-2020

Drill Rig: CME 750X | Driller: DH

Project No.: B3205008

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL B3205008 TIN CUP FORCE MAI.GPJ TERRACON_DATATEMPLATE.GDT 8/25/20

BORING LOG NO. B-2

PROJECT: Tin Cup Force Main

CLIENT: Burns & McDonnell CAS LLC
Kansas City, Missouri

SITE: Glendale Rd. and McClelland Blvd.
Joplin, Missouri

LOCATION See Exploration Plan

Latitude: 37.0357° Longitude: -94.5578°

Surface Elev.: 872 (Ft.)

MODEL LAYER	GRAPHIC LOG	DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (Inches)	FIELD TEST RESULTS	REC%	RQD%	LABORATORY HP (tsf)	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI	Strength (psi)
1			**FILL - GRAVELLY LEAN CLAY (CL)**, brown				2	3-4-7 N=11			N/A	17.7		
		3.0	869											
4			**CHERT**, tannish white, extremely fractured, massive bedding, highly weathered, (100% Chert) Wash away from 3.0 to 3.8 feet (No Rod Drop)	5					63	17				
									100	28				2,970
				10					87	7				
			Clay seam from 14.4 to 15.2 feet (No Rod Drop) Wash away from 16.3 to 17.0 feet (No Rod Drop) Clay seam from 17.0 to 18.0 feet (Rod Drop)	15					80	10				5,810
			Moderately to slightly fractured below 20 feet	20					100	83				
				25					100	97				6,240
				30					100	90				
		33.5	838.5	35					100	57				
			CHERT, tannish white and black, slightly fractured, thick bedding, slightly weathered, with occasional layers of fine-grained, gray limestone (approximately 57% chert)	40					100	65				5,460
				45					100	80				9,260
		50.0	822	50										
			Boring Terminated at 50 Feet											

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
4.5" center flight auger to auger refusal and followed with NQ2 core barrel

Abandonment Method:
Boring backfilled with bentonite chips upon completion.

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.

Elevations were interpolated from a topographic site plan.

Notes:
Coarse grained materials in soil column is primarily chert.

WATER LEVEL OBSERVATIONS

Water not obeserved while drilling

Terracon
508 E. 9th St.
Joplin, MO

Boring Started: 07-23-2020 | Boring Completed: 07-23-2020

Drill Rig: CME 750X | Driller: DH

Project No.: B3205008

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL B3205008 TIN CUP FORCE MAI.GPJ TERRACON_DATATEMPLATE.GDT 8/25/20

BORING LOG NO. B-3

PROJECT: Tin Cup Force Main

CLIENT: Burns & McDonnell CAS LLC
Kansas City, Missouri

SITE: Glendale Rd. and McClelland Blvd.
Joplin, Missouri

LOCATION See Exploration Plan

Latitude: 37.0362° Longitude: -94.5578°

Surface Elev.: 876 (Ft.)

MODEL LAYER	GRAPHIC LOG	DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (Inches)	FIELD TEST RESULTS	REC%	RQD%	LABORATORY HP (tsf)	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI	Strength (psi)
3														
							8	6-5-3 N=8			N/A	10.1		
				5			10	4-6-10 N=16			N/A	7.0		
4		6.4	869.5				2	50/5"			N/A	9.1		
		6.5	869.5											

GRAVELLY LEAN CLAY (CL), brown, stiff to very stiff

CHERT, tannish white

Auger Refusal at 6.5 Feet

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
4.5" center flight auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

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.

Elevations were interpolated from a topographic site plan.

Notes:

Coarse grained materials in soil column is primarily chert.
Auger refusal on appareant cobble, boulder or bedrock at 6.5 feet.

WATER LEVEL OBSERVATIONS

Water not obeserved while drilling

Terracon
508 E. 9th St.
Joplin, MO

Boring Started: 07-21-2020 | Boring Completed: 07-21-2020

Drill Rig: CME 750X | Driller: DH

Project No.: B3205008

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL B3205008 TIN CUP FORCE MAI.GPJ TERRACON_DATATEMPLATE.GDT 8/25/20

BORING LOG NO. B-4

PROJECT: Tin Cup Force Main

CLIENT: Burns & McDonnell CAS LLC
Kansas City, Missouri

SITE: Glendale Rd. and McClelland Blvd.
Joplin, Missouri

LOCATION See Exploration Plan

Latitude: 37.0371° Longitude: -94.5548°

Surface Elev.: 890 (Ft.)

MODEL LAYER	GRAPHIC LOG	DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (Inches)	FIELD TEST RESULTS	REC%	RQD%	LABORATORY HP (tsf)	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI	Strength (psi)
		0.2	890											
			TOPSOIL											
			LEAN CLAY (CL), trace gravel, brown, medium stiff				10	4-4-3 N=7			3.25 (HP)	17.4	34-17-17	
		3.5	886.5											
3			**GRAVELLY LEAN CLAY WITH SAND (CL)**, brown, stiff				10	5-7-7 N=14			N/A	9.8		
		6.0	884	5										
			GRAVELLY LEAN CLAY (CL), brown, hard				12	31-30-13-9 N=43			3.5 (HP)	12.3		
		8.0	882											
			Boring Terminated at 8 Feet											

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
4.5" center flight auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

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.

Elevations were interpolated from a topographic site plan.

Notes:
Coarse grained materials in soil column is primarily chert.

WATER LEVEL OBSERVATIONS

Water not obeserved while drilling

Terracon
508 E. 9th St.
Joplin, MO

Boring Started: 07-21-2020 | Boring Completed: 07-21-2020

Drill Rig: CME 750X | Driller: DH

Project No.: B3205008

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL B3205008 TIN CUP FORCE MAI.GPJ TERRACON_DATATEMPLATE.GDT 8/25/20

BORING LOG NO. B-5

PROJECT: Tin Cup Force Main

CLIENT: Burns & McDonnell CAS LLC
Kansas City, Missouri

SITE: Glendale Rd. and McClelland Blvd.
Joplin, Missouri

LOCATION See Exploration Plan

Latitude: 37.0364° Longitude: -94.5534°

Surface Elev.: 894 (Ft.)

MODEL LAYER	GRAPHIC LOG	DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (Inches)	FIELD TEST RESULTS	REC%	RQD%	LABORATORY HP (tsf)	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI	Strength (psi)
		0.7	893.5											
			TOPSOIL											
3			**LEAN CLAY WITH GRAVEL (CL)**, brown, soft, (Possible Fill)				10	2-1-2 N=3			3.0 (HP)	12.9		
		3.5	890.5											
			LEAN CLAY WITH GRAVEL (CL), brown, medium stiff	5			12	8-5-3 N=8			N/A	16.7		
							10	3-6-9-11 N=15			1.5 (HP)	22.3		
		7.5	886.5											
		8.0	**GRAVELLY LEAN CLAY (CL)**, brown, very stiff 886											
			Boring Terminated at 8 Feet											

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
4.5" center flight auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

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.

Elevations were interpolated from a topographic site plan.

Notes:
Coarse grained materials in soil column is primarily chert.

WATER LEVEL OBSERVATIONS

Water not obeserved while drilling

Terracon
508 E. 9th St.
Joplin, MO

Boring Started: 07-21-2020 | Boring Completed: 07-21-2020

Drill Rig: CME 750X | Driller: DH

Project No.: B3205008

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL B3205008 TIN CUP FORCE MAI.GPJ TERRACON_DATATEMPLATE.GDT 8/25/20

BORING LOG NO. B-6

PROJECT: Tin Cup Force Main

CLIENT: Burns & McDonnell CAS LLC
Kansas City, Missouri

SITE: Glendale Rd. and McClelland Blvd.
Joplin, Missouri

LOCATION See Exploration Plan

Latitude: 37.0358° Longitude: -94.552°

Surface Elev.: 904 (Ft.)

MODEL LAYER	GRAPHIC LOG	DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (Inches)	FIELD TEST RESULTS	REC%	RQD%	LABORATORY HP (tsf)	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI	Strength (psi)
		0.1	904											
			TOPSOIL											
2			**CLAYEY SAND WITH GRAVEL (CL)**, brown, hard				12	8-16-15 N=31			N/A	7.2		
							12	24-30-12 N=42			N/A	5.3		
			red below 5 feet	5										
							20	17-28-32-32 N=60			4.25 (HP)	12.4	39-15-24	
		8.0	896											
			Boring Terminated at 8 Feet											

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
4.5" center flight auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

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.

Elevations were interpolated from a topographic site plan.

Notes:
Coarse grained materials in soil column is primarily chert.

WATER LEVEL OBSERVATIONS

Water not obeserved while drilling

Terracon
508 E. 9th St.
Joplin, MO

Boring Started: 07-21-2020 | Boring Completed: 07-21-2020

Drill Rig: CME 750X | Driller: DH

Project No.: B3205008

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL B3205008 TIN CUP FORCE MAI.GPJ TERRACON_DATATEMPLATE.GDT 8/25/20

BORING LOG NO. B-7

PROJECT: Tin Cup Force Main

CLIENT: Burns & McDonnell CAS LLC
Kansas City, Missouri

SITE: Glendale Rd. and McClelland Blvd.
Joplin, Missouri

LOCATION See Exploration Plan

Latitude: 37.0351° Longitude: -94.5505°

Surface Elev.: 905 (Ft.)

MODEL LAYER	GRAPHIC LOG	DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (Inches)	FIELD TEST RESULTS	REC%	RQD%	LABORATORY HP (tsf)	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI	Strength (psi)
		0.1	905											
			TOPSOIL											
			CLAYEY GRAVEL (GC), brown, very dense				8	16-18-50 N=68			N/A	8.2		
2		3.0	902											
			CLAYEY GRAVEL WITH SAND (GC), reddish brown, very dense				16	21-25-25 N=50			N/A	12.1	25-19-6	
		6.0	899	5										
3			**GRAVELLY FAT CLAY (CH)**, red, hard				16	34-32-24-19 N=56			3.0 (HP)	12.4		
		8.0	897											
			Boring Terminated at 8 Feet											

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
4.5" center flight auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

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.

Elevations were interpolated from a topographic site plan.

Notes:
Coarse grained materials in soil column is primarily chert.

WATER LEVEL OBSERVATIONS

Water not obeserved while drilling

Terracon
508 E. 9th St.
Joplin, MO

Boring Started: 07-21-2020 | Boring Completed: 07-21-2020

Drill Rig: CME 750X | Driller: DH

Project No.: B3205008

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL B3205008 TIN CUP FORCE MAI.GPJ TERRACON_DATATEMPLATE.GDT 8/25/20

BORING LOG NO. B-8

PROJECT: Tin Cup Force Main

CLIENT: Burns & McDonnell CAS LLC
Kansas City, Missouri

SITE: Glendale Rd. and McClelland Blvd.
Joplin, Missouri

LOCATION See Exploration Plan

Latitude: 37.0357° Longitude: -94.5474°

Surface Elev.: 942 (Ft.)

MODEL LAYER	GRAPHIC LOG	DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (Inches)	FIELD TEST RESULTS	REC%	RQD%	LABORATORY HP (tsf)	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI	Strength (psi)
		0.2	942											
			TOPSOIL											
3			**GRAVELLY LEAN CLAY (CL)**, brown, hard				8	15-25-17 N=42			N/A	12.5		
							6	15-27-25 N=52			N/A	5.2		
		5.0	937	5										
			FAT CLAY WITH GRAVEL (CH), red, hard											
							12	11-32-36-31 N=68			N/A	29.0		
		8.0	934											
			Boring Terminated at 8 Feet											

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
4.5" center flight auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

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.

Elevations were interpolated from a topographic site plan.

Notes:
Coarse grained materials in soil column is primarily chert.

WATER LEVEL OBSERVATIONS

Water not obeserved while drilling

Terracon
508 E. 9th St.
Joplin, MO

Boring Started: 07-21-2020 | Boring Completed: 07-21-2020

Drill Rig: CME 750X | Driller: DH

Project No.: B3205008

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL B3205008 TIN CUP FORCE MAI.GPJ TERRACON_DATATEMPLATE.GDT 8/25/20

BORING LOG NO. B-9

PROJECT: Tin Cup Force Main

CLIENT: Burns & McDonnell CAS LLC
Kansas City, Missouri

SITE: Glendale Rd. and McClelland Blvd.
Joplin, Missouri

LOCATION See Exploration Plan

Latitude: 37.036° Longitude: -94.5463°

Surface Elev.: 953 (Ft.)

MODEL LAYER	GRAPHIC LOG	DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (Inches)	FIELD TEST RESULTS	REC%	RQD%	LABORATORY HP (tsf)	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI	Strength (psi)
		0.1	953											
			TOPSOIL											
			GRAVELLY LEAN CLAY (CL), reddish brown, hard				8	17-24-11 N=35			N/A	13.4		
		3.0	950											
3			**GRAVELLY FAT CLAY (CH)**, red, hard	5			10	11-9-31 N=40			2.25 (HP)	28.4		
		6.0	947											
			FAT CLAY (CH), trace gravel, red, hard				8	4-7-50/5"			3.0 (HP)	28.0		
		8.0	945											
			Boring Terminated at 8 Feet											

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
4.5" center flight auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

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.

Elevations were interpolated from a topographic site plan.

Notes:
Coarse grained materials in soil column is primarily chert.

WATER LEVEL OBSERVATIONS

Water not obeserved while drilling

Terracon
508 E. 9th St.
Joplin, MO

Boring Started: 07-21-2020 | Boring Completed: 07-21-2020

Drill Rig: CME 750X | Driller: DH

Project No.: B3205008

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL B3205008 TIN CUP FORCE MAI.GPJ TERRACON_DATATEMPLATE.GDT 8/25/20

BORING LOG NO. B-10

PROJECT: Tin Cup Force Main

CLIENT: Burns & McDonnell CAS LLC
Kansas City, Missouri

SITE: Glendale Rd. and McClelland Blvd.
Joplin, Missouri

LOCATION See Exploration Plan

Latitude: 37.0371° Longitude: -94.5453°

Surface Elev.: 940 (Ft.)

MODEL LAYER	GRAPHIC LOG	DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (Inches)	FIELD TEST RESULTS	REC%	RQD%	LABORATORY HP (tsf)	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI	Strength (psi)
		0.1	940											
			TOPSOIL											
			SILTY CLAY (CL-ML), trace gravel, reddish brown, hard				10	15-16-18 N=34			N/A	17.0	28-22-6	
		3.0	937											
3			**GRAVELLY LEAN CLAY WITH SAND (CL)**, reddish brown, hard	5			12	25-25-22 N=47			1.5 (HP)	23.5		
		6.0	934											
			FAT CLAY WITH GRAVEL (CH), red, hard				18	23-23-18-22 N=41			1.5 (HP)	32.4		
		8.0	932											
			Boring Terminated at 8 Feet											

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
4.5" center flight auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

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.

Elevations were interpolated from a topographic site plan.

Notes:
Coarse grained materials in soil column is primarily chert.

WATER LEVEL OBSERVATIONS

Water not obeserved while drilling

Terracon
508 E. 9th St.
Joplin, MO

Boring Started: 07-21-2020 | Boring Completed: 07-21-2020

Drill Rig: CME 750X | Driller: DH

Project No.: B3205008

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL B3205008 TIN CUP FORCE MAI.GPJ TERRACON_DATATEMPLATE.GDT 8/25/20

BORING LOG NO. B-11

PROJECT: Tin Cup Force Main

CLIENT: Burns & McDonnell CAS LLC
Kansas City, Missouri

SITE: Glendale Rd. and McClelland Blvd.
Joplin, Missouri

LOCATION See Exploration Plan

Latitude: 37.0383° Longitude: -94.5447°

Surface Elev.: 947 (Ft.)

MODEL LAYER	GRAPHIC LOG	DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (Inches)	FIELD TEST RESULTS	REC%	RQD%	LABORATORY HP (tsf)	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI	Strength (psi)
		0.1	947											
			TOPSOIL											
2			**CLAYEY GRAVEL (GC)**, brown to reddish brown, very dense				6	12-50/5"			N/A	5.2		
				5			6	13-48-45 N=93			N/A	15.5		
1		6.0	941											
			FAT CLAY WITH GRAVEL (CH), red, hard				10	18-19-50/4"			3.75 (HP)	15.2		
		8.0	939											
			Boring Terminated at 8 Feet											

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
4.5" center flight auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

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.

Elevations were interpolated from a topographic site plan.

Notes:
Coarse grained materials in soil column is primarily chert.

WATER LEVEL OBSERVATIONS

Water not obeserved while drilling

Terracon
508 E. 9th St.
Joplin, MO

Boring Started: 07-21-2020 | Boring Completed: 07-21-2020

Drill Rig: CME 750X | Driller: DH

Project No.: B3205008

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL B3205008 TIN CUP FORCE MAI.GPJ TERRACON_DATATEMPLATE.GDT 8/25/20

BORING LOG NO. B-12

PROJECT: Tin Cup Force Main

CLIENT: Burns & McDonnell CAS LLC
Kansas City, Missouri

SITE: Glendale Rd. and McClelland Blvd.
Joplin, Missouri

LOCATION See Exploration Plan

Latitude: 37.0395° Longitude: -94.5432°

Surface Elev.: 941 (Ft.)

MODEL LAYER	GRAPHIC LOG	DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (Inches)	FIELD TEST RESULTS	REC%	RQD%	LABORATORY HP (tsf)	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI	Strength (psi)
		0.2	941											
			TOPSOIL											
3			**GRAVELLY LEAN CLAY WITH SAND (CL)**, reddish brown, hard				8	9-25-34 N=59			N/A	14.5		
		3.0	938											
2			**CLAYEY GRAVEL (GC)**, reddish brown, very dense	5			5	50/5"			N/A	7.9		
		6.0	935											
3			**FAT CLAY WITH GRAVEL (CH)**, red, very stiff				17	9-11-18-8 N=29			3.25 (HP)	30.5		
		8.0	933											
			Boring Terminated at 8 Feet											

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
4.5" center flight auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

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.

Elevations were interpolated from a topographic site plan.

Notes:
Coarse grained materials in soil column is primarily chert.

WATER LEVEL OBSERVATIONS

Water not obeserved while drilling

Terracon
508 E. 9th St.
Joplin, MO

Boring Started: 07-21-2020 | Boring Completed: 07-21-2020

Drill Rig: CME 750X | Driller: DH

Project No.: B3205008

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL B3205008 TIN CUP FORCE MAI.GPJ TERRACON_DATATEMPLATE.GDT 8/25/20

BORING LOG NO. B-13

PROJECT: Tin Cup Force Main

CLIENT: Burns & McDonnell CAS LLC
Kansas City, Missouri

SITE: Glendale Rd. and McClelland Blvd.
Joplin, Missouri

LOCATION See Exploration Plan

Latitude: 37.0399° Longitude: -94.5447°

Surface Elev.: 956 (Ft.)

MODEL LAYER	GRAPHIC LOG	DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (Inches)	FIELD TEST RESULTS	REC%	RQD%	LABORATORY HP (tsf)	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI	Strength (psi)
		0.2	956											
			TOPSOIL											
2			**CLAYEY GRAVEL**, reddish brown, dense				6	13-22-25 N=47			N/A	5.6		
		3.5	952.5											
3			**FAT CLAY WITH GRAVEL**, red, very stiff to hard	5			10	6-13-25 N=38			1.5 (HP)	19.9		
							16	8-11-19-12 N=30			4.0 (HP)	21.7		
		8.0	948											
			Boring Terminated at 8 Feet											

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
4.5" center flight auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

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.

Elevations were interpolated from a topographic site plan.

Notes:
Coarse grained materials in soil column is primarily chert.

WATER LEVEL OBSERVATIONS

Water not obeserved while drilling

Terracon
508 E. 9th St.
Joplin, MO

Boring Started: 07-21-2020 | Boring Completed: 07-21-2020

Drill Rig: CME 750X | Driller: DH

Project No.: B3205008

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL B3205008 TIN CUP FORCE MAI.GPJ TERRACON_DATATEMPLATE.GDT 8/25/20

BORING LOG NO. B-14

PROJECT: Tin Cup Force Main

CLIENT: Burns & McDonnell CAS LLC
Kansas City, Missouri

SITE: Glendale Rd. and McClelland Blvd.
Joplin, Missouri

LOCATION See Exploration Plan

Latitude: 37.0398° Longitude: -94.5413°

Surface Elev.: 963 (Ft.)

MODEL LAYER	GRAPHIC LOG	DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (Inches)	FIELD TEST RESULTS	REC%	RQD%	LABORATORY HP (tsf)	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI	Strength (psi)
		0.2	963											
			TOPSOIL											
			GRAVELLY LEAN CLAY (CL), tan and gray, very stiff				10	7-10-13 N=23			2.25 (HP)	16.3	37-17-20	
		3.0	960											
3			**GRAVELLY FAT CLAY (CH)**, red and tan, hard	5			8	37-50/5"			N/A	14.1		
		6.0	957											
			FAT CLAY WITH GRAVEL (CH), red, hard				18	6-7-24-15 N=31			3.25 (HP)	18.8		
		8.0	955											
			Boring Terminated at 8 Feet											

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
4.5" center flight auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

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.

Elevations were interpolated from a topographic site plan.

Notes:
Coarse grained materials in soil column is primarily chert.

WATER LEVEL OBSERVATIONS

Water not obeserved while drilling

Terracon
508 E. 9th St.
Joplin, MO

Boring Started: 07-21-2020 | Boring Completed: 07-21-2020

Drill Rig: CME 750X | Driller: DH

Project No.: B3205008

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL B3205008 TIN CUP FORCE MAI.GPJ TERRACON_DATATEMPLATE.GDT 8/25/20

BORING LOG NO. B-15

PROJECT: Tin Cup Force Main

CLIENT: Burns & McDonnell CAS LLC
Kansas City, Missouri

SITE: Glendale Rd. and McClelland Blvd.
Joplin, Missouri

LOCATION See Exploration Plan

Latitude: 37.0404° Longitude: -94.5402°

Surface Elev.: 980 (Ft.)

MODEL LAYER	GRAPHIC LOG	DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (Inches)	FIELD TEST RESULTS	REC%	RQD%	LABORATORY HP (tsf)	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI	Strength (psi)
		0.1	980											
		TOPSOIL												
2		**CLAYEY GRAVEL (GC)**, brown, very dense					5	50/5"			N/A	7.2		
		red below 3 feet					6	50/6"			N/A	14.9		
				5			8	50/6"			N/A	7.8		
		8.0	972											
		Boring Terminated at 8 Feet												

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
4.5" center flight auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

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.

Elevations were interpolated from a topographic site plan.

Notes:
Coarse grained materials in soil column is primarily chert.

WATER LEVEL OBSERVATIONS

Water not obeserved while drilling

Terracon
508 E. 9th St.
Joplin, MO

Boring Started: 07-20-2020 | Boring Completed: 07-20-2020

Drill Rig: CME 750X | Driller: DH

Project No.: B3205008

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL B3205008 TIN CUP FORCE MAI.GPJ TERRACON_DATATEMPLATE.GDT 8/25/20

BORING LOG NO. B-16

PROJECT: Tin Cup Force Main

CLIENT: Burns & McDonnell CAS LLC
Kansas City, Missouri

SITE: Glendale Rd. and McClelland Blvd.
Joplin, Missouri

LOCATION See Exploration Plan

Latitude: 37.0413° Longitude: -94.54°

Surface Elev.: 956 (Ft.)

MODEL LAYER	GRAPHIC LOG	DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (Inches)	FIELD TEST RESULTS	REC%	RQD%	LABORATORY HP (tsf)	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI	Strength (psi)
1			**FILL - GRAVELLY LEAN CLAY (CL)**, brown											
		2.0	954			X	5	4-8-7 N=15			N/A	9.5		
2			**CLAYEY GRAVEL (GC)**, brown, very dense											
						X	8	21-50			N/A	6.4		
			reddish brown below 5 feet	5										
						X	6	23-50/5"			N/A	7.2		
		8.0	948											
			Boring Terminated at 8 Feet											

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
4.5" center flight auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

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.

Elevations were interpolated from a topographic site plan.

Notes:
Coarse grained materials in soil column is primarily chert.

WATER LEVEL OBSERVATIONS

Water not obeserved while drilling

Terracon
508 E. 9th St.
Joplin, MO

Boring Started: 07-20-2020 | Boring Completed: 07-20-2020

Drill Rig: CME 750X | Driller: DH

Project No.: B3205008

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL B3205008 TIN CUP FORCE MAI.GPJ TERRACON_DATATEMPLATE.GDT 8/25/20

BORING LOG NO. B-17

PROJECT: Tin Cup Force Main

CLIENT: Burns & McDonnell CAS LLC
Kansas City, Missouri

SITE: Glendale Rd. and McClelland Blvd.
Joplin, Missouri

LOCATION See Exploration Plan

Latitude: 37.0414° Longitude: -94.5379°

Surface Elev.: 922 (Ft.)

MODEL LAYER	GRAPHIC LOG	DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (Inches)	FIELD TEST RESULTS	REC%	RQD%	LABORATORY HP (tsf)	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI	Strength (psi)
1			**FILL - LEAN CLAY**, reddish brown											
		2.0	920			X	6	1-2-6 N=8			2.0 (HP)	14.3		
3			**LEAN CLAY WITH GRAVEL AND SAND**, reddish brown, very stiff, (Possible Fill)											
		5.5	916.5	5		X	6	3-7-10 N=17			2.25 (HP)	16.3		
4		6.5	915.5				0	50/0"						
			Auger Refusal at 6.5 Feet											

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
4.5" center flight auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

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.

Elevations were interpolated from a topographic site plan.

Notes:
Auger refusal on appareant cobble, boulder or bedrock at 6.5 feet.

WATER LEVEL OBSERVATIONS

Water not obeserved while drilling

Terracon
508 E. 9th St.
Joplin, MO

Boring Started: 07-20-2020 | Boring Completed: 07-20-2020

Drill Rig: CME 750X | Driller: DH

Project No.: B3205008

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL B3205008 TIN CUP FORCE MAI.GPJ TERRACON_DATATEMPLATE.GDT 8/25/20

BORING LOG NO. B-18

PROJECT: Tin Cup Force Main

CLIENT: Burns & McDonnell CAS LLC
Kansas City, Missouri

SITE: Glendale Rd. and McClelland Blvd.
Joplin, Missouri

LOCATION See Exploration Plan

Latitude: 37.0467° Longitude: -94.5365°

Surface Elev.: 893 (Ft.)

MODEL LAYER	GRAPHIC LOG	DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (Inches)	FIELD TEST RESULTS	REC%	RQD%	LABORATORY HP (tsf)	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI	Strength (psi)
2			**POORLY GRADED GRAVEL WITH CLAY (GP)**, brown, dense											
		2.0	891			X	6	16-16-17 N=33				9.8		
3			**LEAN CLAY (CL)**, trace gravel and sand, tan and brown, medium stiff to stiff	5		X	14	3-5-8 N=13			2.25 (HP)	19.6	36-17-19	
		8.0	885			X	20	4-3-4-5 N=7			1.0 (HP)	23.0		
			Boring Terminated at 8 Feet											

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
4.5" center flight auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

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.

Elevations were interpolated from a topographic site plan.

Notes:

WATER LEVEL OBSERVATIONS

Water not obeserved while drilling

Terracon
508 E. 9th St.
Joplin, MO

Boring Started: 07-20-2020 | Boring Completed: 07-20-2020

Drill Rig: CME 750X | Driller: DH

Project No.: B3205008

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL B3205008 TIN CUP FORCE MAI.GPJ TERRACON_DATATEMPLATE.GDT 8/25/20

Unconfined Compressive Strength of Intact Rock Core Specimens

Project Name: Tin Cup Force Main

Project No.: B3205008

Client: Burns & McDonnell

Date: 8/19/2020

Tested By: IJP

Reviewed By: JDE

Boring	Depth (feet)	Recovery (%)	RQD (%)	Strength (psi)	Type of Rock
B-1	16.7	100	90	**9,330**	Chert
B-1	26.9	100	83	**11,020**	Chert
B-1	38.7	100	88	**5,580**	Chert
B-1	48.5	100	95	**13,250**	Chert
B-2	7.2	100	28	**2,970**	Chert
B-2	19.5	80	10	**5,810**	Chert
B-2	27.8	100	97	**6,240**	Chert
B-2	41.0	100	65	**5,460**	Chert
B-2	48.2	100	80	**9,260**	Chert

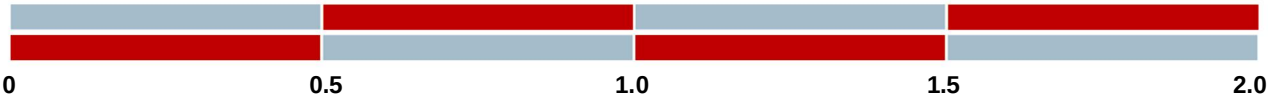
Boring B-1
Depth: 14.0’ to 24.0’





Boring B-1
Depth: 24.0’ to 34.0’





Boring B-1
Depth: 34.0’ to 44.0’



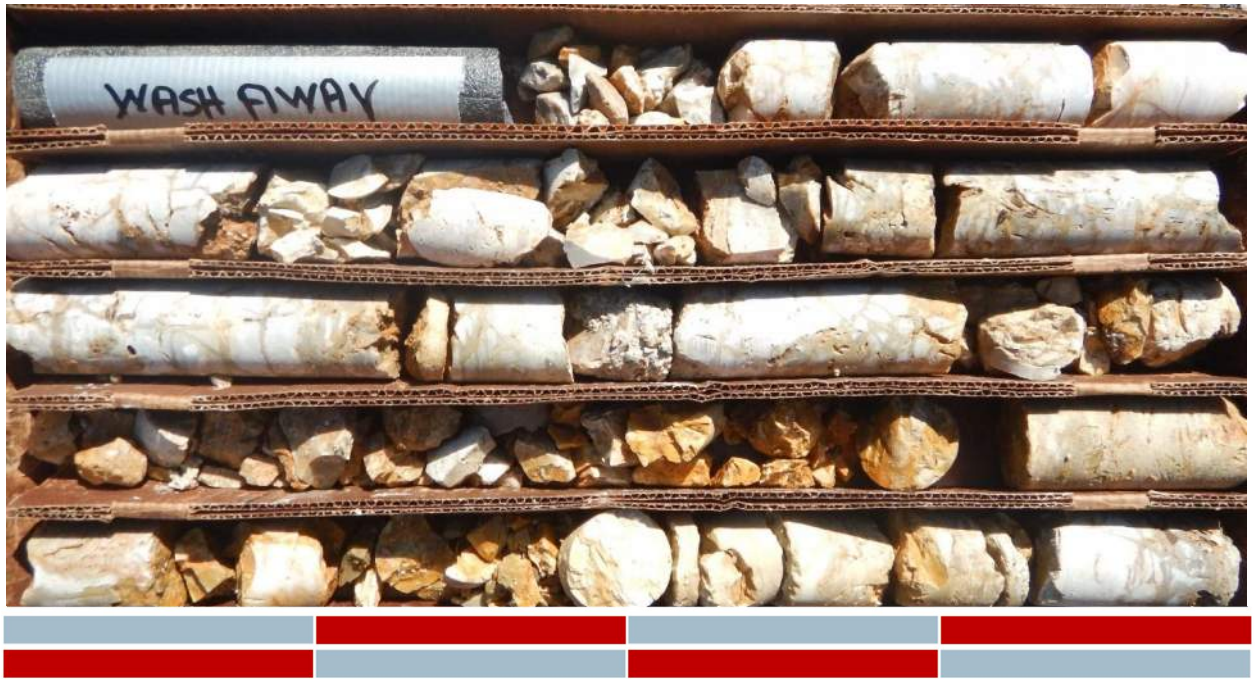
0 0.5 1.0 1.5 2.0
Scale In Feet

Boring B-1
Depth: 44.0’ to 50.0’

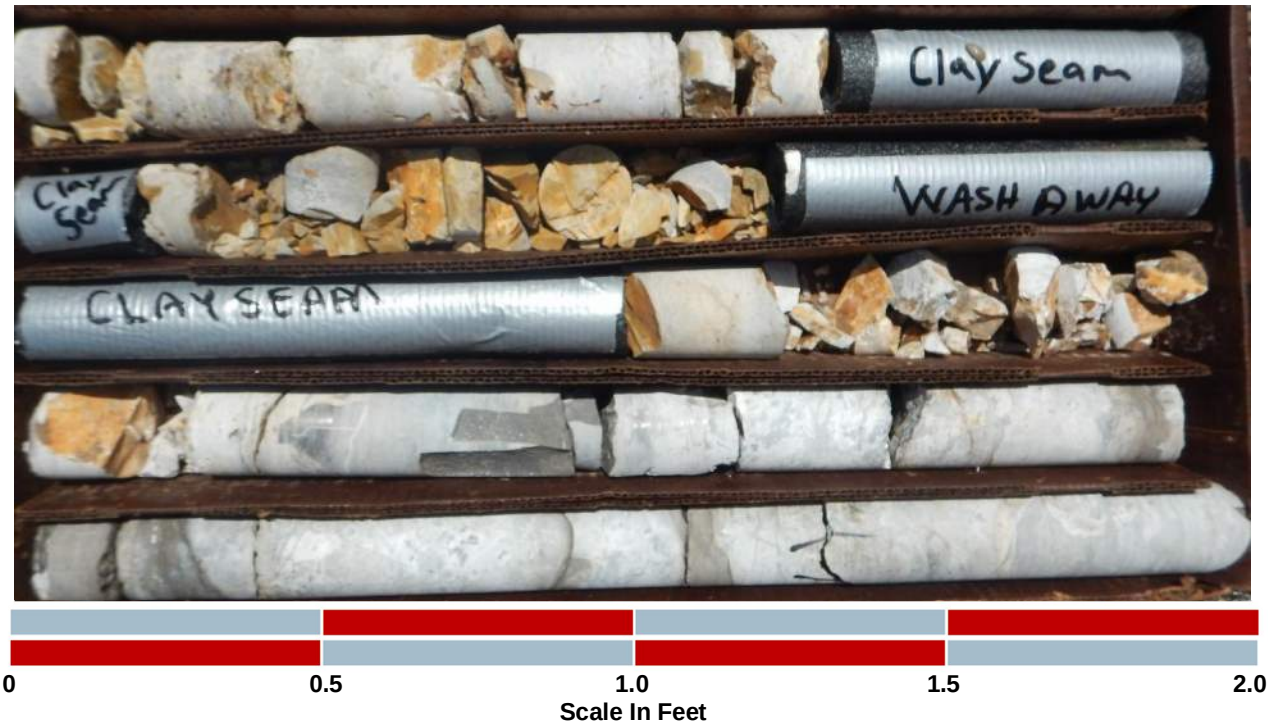


0 0.5 1.0 1.5 2.0
Scale In Feet

Boring B-2
Depth: 3.0’ to 13.0’



Boring B-2
Depth: 13.0’ to 23.0’



Boring B-2
Depth: 23.0’ to 33.0’





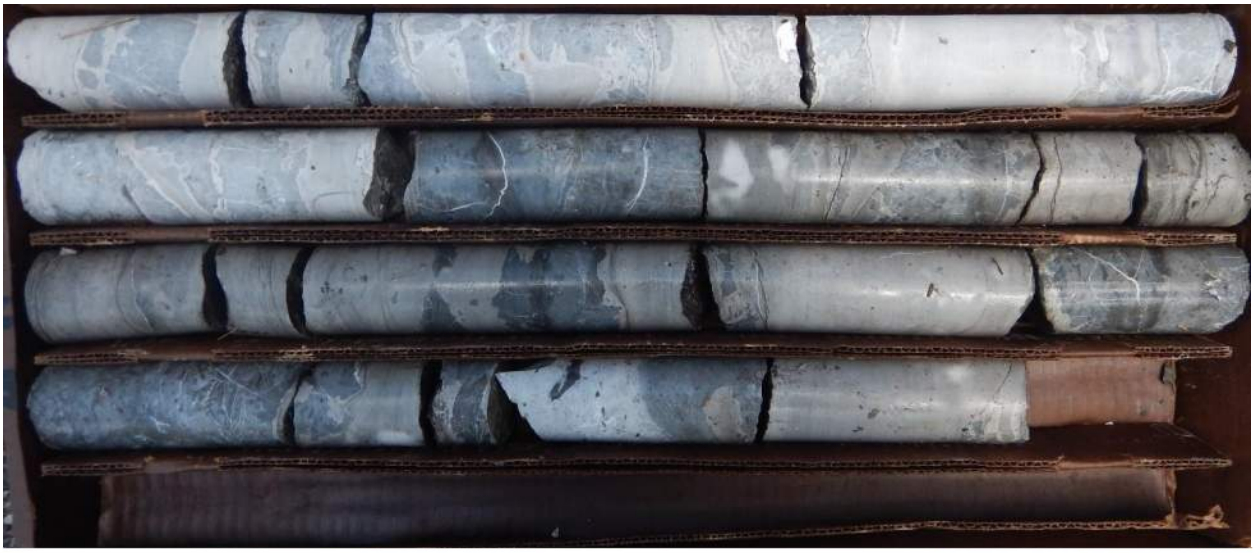
Boring B-2
Depth: 33.0’ to 43.0’

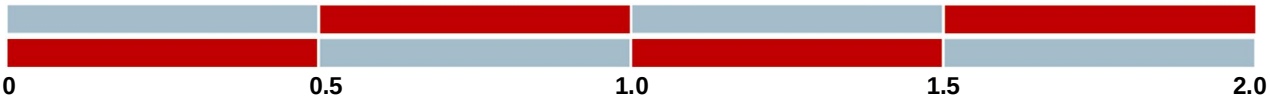




Boring B-2

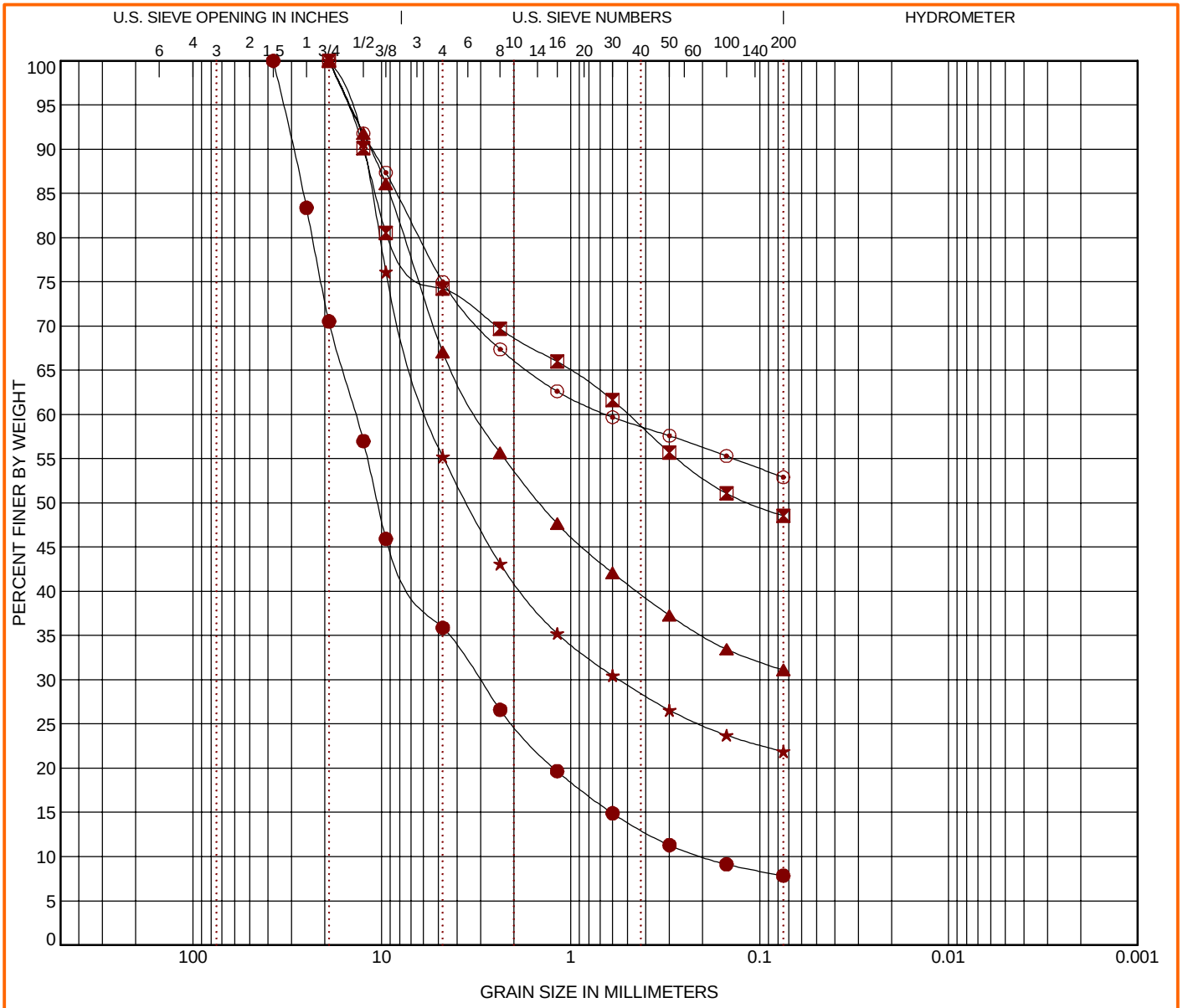
Depth: 43.0’ to 50.0’





GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Boring ID		Depth	USCS Classification	WC (%)	LL	PL	PI	Cc	Cu
●	B-1	8.5 - 10	POORLY GRADED GRAVEL with SAND (GP)	17.3				3.42	69.17
⊠	B-4	3.5 - 5	GRAVELLY CLAY with SAND (CL)	9.8					
▲	B-6	6 - 8	CLAYEY SAND with GRAVEL (SC)	12.4	39	15	24		
★	B-7	3.5 - 5	CLAYEY GRAVEL with SAND (GC)	12.1	37	18	19		
⊙	B-10	3.5 - 5	GRAVELLY CLAY with SAND (CL)	23.5					

Boring ID		Depth	D_{100}	D_{60}	D_{30}	D_{10}	%Cobbles	%Gravel	%Sand	%Silt	%Fines	%Clay
●	B-1	8.5 - 10	37.5	13.719	3.05	0.198	0.0	64.1	28.0		7.8	
⊠	B-4	3.5 - 5	19	0.496			0.0	25.8	25.7		48.5	
▲	B-6	6 - 8	19	3.083			0.0	33.0	35.9		31.1	
★	B-7	3.5 - 5	19	5.564	0.552		0.0	44.8	33.4		21.9	
⊙	B-10	3.5 - 5	19	0.644			0.0	25.0	22.1		52.9	

PROJECT: Tin Cup Force Main

PROJECT NUMBER: B3205008

SITE: Glendale Rd. and McClelland Blvd.
Joplin, Missouri

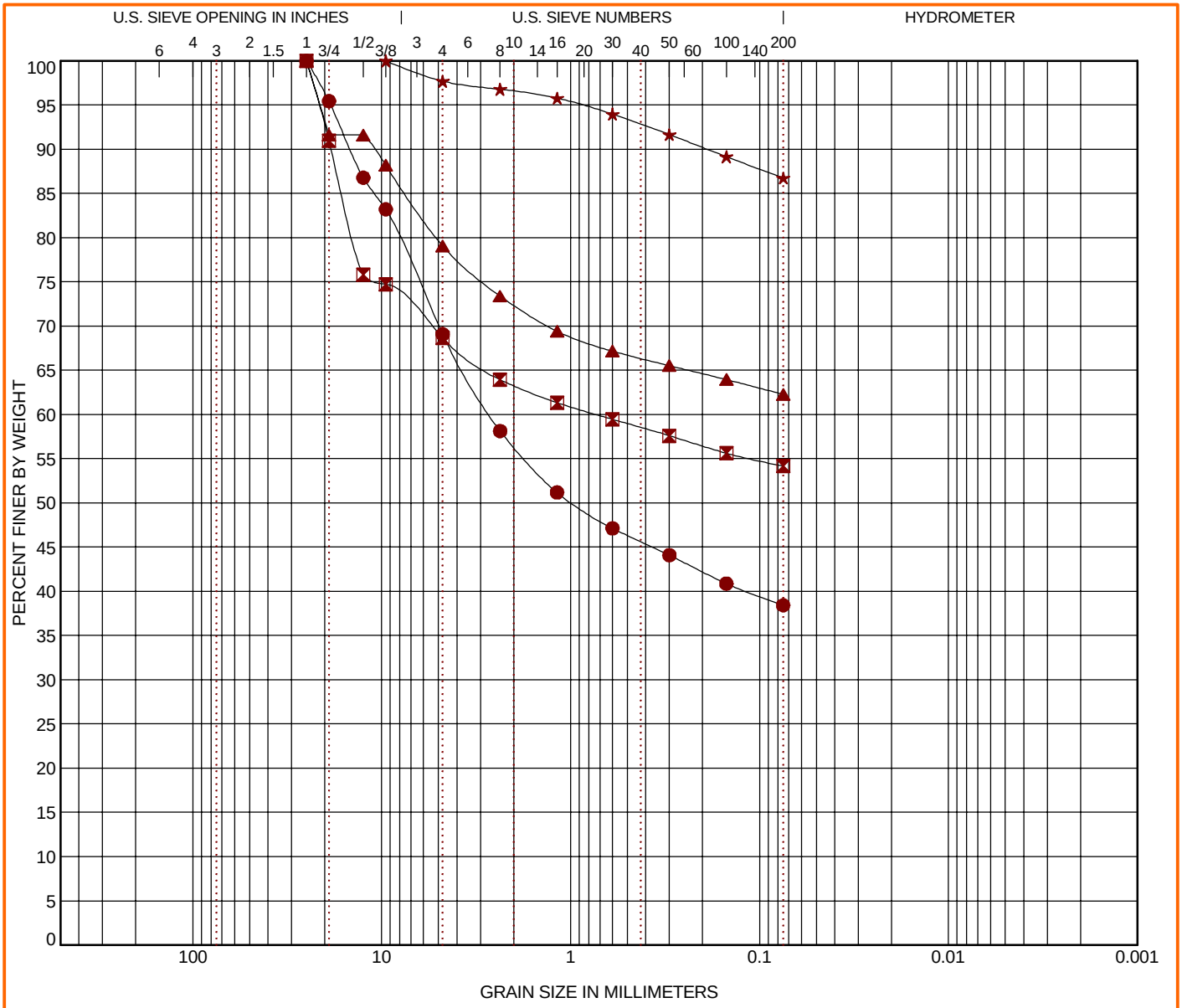
Terracon
508 E. 9th St.
Joplin, MO

CLIENT: Burns & McDonnell CAS LLC
Kansas City, Missouri

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GRAIN SIZE: USCS-2 B3205008 TIN CUP FORCE MAI.GPJ TERRACON_DATATEMPLATE.GDT 8/17/20

GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Boring ID		Depth	USCS Classification	WC (%)	LL	PL	PI	Cc	Cu
●	B-12	1 - 2.5	GRAVELLY CLAY with SAND (CL)	14.5					
⊠	B-14	1 - 2.5	GRAVELLY LEAN CLAY (CL)	16.3	37	17	20		
▲	B-17	3.5 - 5	LEAN CLAY with GRAVEL and SAND (CL)	16.3					
★	B-18	3.5 - 5	LEAN CLAY (CL)	19.6	36	17	19		

Boring ID		Depth	D_{100}	D_{60}	D_{30}	D_{10}	%Cobbles	%Gravel	%Sand	%Silt	%Fines	%Clay
●	B-12	1 - 2.5	25	2.659			0.0	30.9	30.6		38.4	
⊠	B-14	1 - 2.5	25	0.729			0.0	31.3	14.5		54.2	
▲	B-17	3.5 - 5	25				0.0	20.9	16.8		62.3	
★	B-18	3.5 - 5	9.5				0.0	2.3	10.9		86.8	

PROJECT: Tin Cup Force Main

PROJECT NUMBER: B3205008

SITE: Glendale Rd. and McClelland Blvd.
Joplin, Missouri

Terracon
508 E. 9th St.
Joplin, MO

CLIENT: Burns & McDonnell CAS LLC
Kansas City, Missouri

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GRAIN SIZE: USCS-2 B3205008 TIN CUP FORCE MAI.GPJ TERRACON_DATATEMPLATE.GDT 8/17/20

LABORATORY COMPACTION CHARACTERISTICS OF SOIL REPORT

Report Number: B3205008.0002
Service Date: 08/18/20
Report Date: 08/20/20 Revision 1 - Rock Correction

Terracon
4765 W Junction St
Springfield, MO 65802-1013
417-864-5100

Client

Burns & McDonnell CAS LLC
Attn: Bill Nash
9400 Ward Parkway
Kansas City, MO 64114

Project

Tin Cup Force Main
Glendale Rd. and McClelland Blvd.
Joplin, MO

Project Number: B3205008

Material Information

Source of Material: B-3 Bulk Sample
Proposed Use: General Fill

Sample Information

Sample Date: 07/21/20
Sampled By: Joshua Elson
Sample Location: Boring B-3 (Depth 0-4')

Sample Description: Gravelly Lean Clay

Laboratory Test Data

Test Procedure: ASTM D698
Test Method: Method C
Sample Preparation: Wet
Rammer Type: Manual

	Result	Specifications
Liquid Limit:	30	
Plastic Limit:	20	
Plasticity Index:	10	
In-Place Moisture (%):		
Retaining 3/4" (%):	17.3	

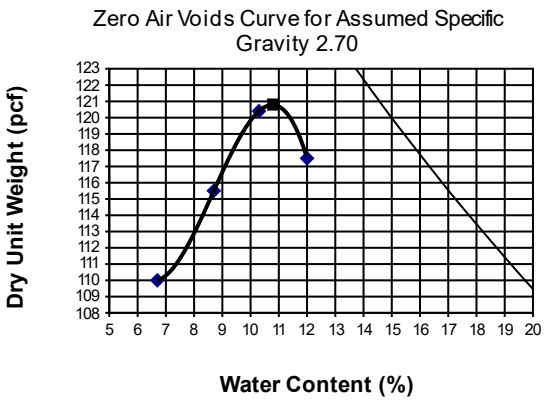
USCS: CL

Oversized Particles (%): 17.3
Moisture (%): 1.1
Sieve for Oversize Fraction: 3/4

Assumed Bulk Specific Gravity of Oversized Particles: 2.7

Corrected for Oversized Particles (ASTM D4718)
Maximum Dry Unit Weight (pcf): **120.8**
Optimum Water Content (%): **10.8**

Uncorrected Values
Maximum Dry Unit Weight (pcf): **114.1**
Optimum Water Content (%): **12.8**



Comments:

Services: Proctor values

Terracon Rep.: Moriah Dapprich
Reported To:
Contractor:
Report Distribution:

(1) Burns & McDonnell CAS LLC, Bill Nash

Test Methods: ASTM D698

The tests were performed in general accordance with applicable ASTM, AASHTO, or DOT test methods. This report is exclusively for the use of the client indicated above and shall not be reproduced except in full without the written consent of our company. Test results transmitted herein are only applicable to the actual samples tested at the location(s) referenced and are not necessarily indicative of the properties of other apparently similar or identical materials.

LABORATORY COMPACTION CHARACTERISTICS OF SOIL REPORT

Report Number: B3205008.0004
Service Date: 08/19/20
Report Date: 08/20/20

Terracon
4765 W Junction St
Springfield, MO 65802-1013
417-864-5100

Client

Burns & McDonnell CAS LLC
Attn: Bill Nash
9400 Ward Parkway
Kansas City, MO 64114

Project

Tin Cup Force Main
Glendale Rd. and McClelland Blvd.
Joplin, MO

Project Number: B3205008

Material Information

Source of Material: B-18 Bulk Sample
Proposed Use: General Fill

Sample Information

Sample Date: 07/20/20
Sampled By: Joshua Elson
Sample Location: B-18 (Depth 0-4')

Sample Description: Gravelly Lean Clay: Brown (Non-Plastic)

Laboratory Test Data

Test Procedure: ASTM D698
Test Method: Method C
Sample Preparation: Wet
Rammer Type: Manual

	Result	Specifications
Liquid Limit:	36	
Plastic Limit:	17	
Plasticity Index:	19	
In-Place Moisture (%):		
Retaining 3/4" (%):	7.7	

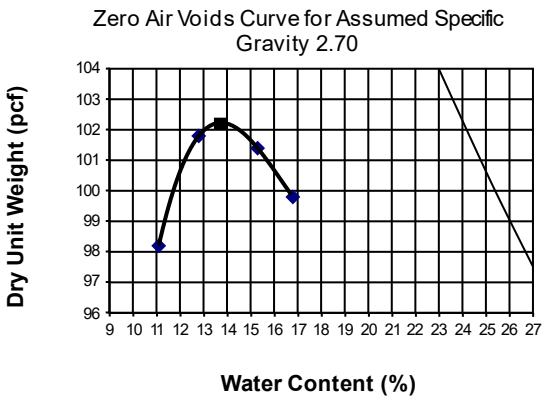
USCS: ML

Oversized Particles (%): 7.7
Moisture (%): 0.9
Sieve for Oversize Fraction: 3/4

Assumed Bulk Specific Gravity of Oversized Particles: 2.7

Corrected for Oversized Particles (ASTM D4718)
Maximum Dry Unit Weight (pcf): **102.2**
Optimum Water Content (%): **13.7**

Uncorrected Values
Maximum Dry Unit Weight (pcf): **98.9**
Optimum Water Content (%): **14.8**



Comments:

Services: Proctor values

Terracon Rep.: Moriah Dapprich
Reported To:
Contractor:
Report Distribution:
(1) Burns & McDonnell CAS LLC, Bill Nash

Test Methods: ASTM D698

The tests were performed in general accordance with applicable ASTM, AASHTO, or DOT test methods. This report is exclusively for the use of the client indicated above and shall not be reproduced except in full without the written consent of our company. Test results transmitted herein are only applicable to the actual samples tested at the location(s) referenced and are not necessarily indicative of the properties of other apparently similar or identical materials.

LABORATORY COMPACTION CHARACTERISTICS OF SOIL REPORT

Report Number: B3205008.0003
Service Date: 08/19/20
Report Date: 08/19/20

Terracon
4765 W Junction St
Springfield, MO 65802-1013
417-864-5100

Client

Burns & McDonnell CAS LLC
Attn: Bill Nash
9400 Ward Parkway
Kansas City, MO 64114

Project

Tin Cup Force Main
Glendale Rd. and McClelland Blvd.
Joplin, MO

Project Number: B3205008

Material Information

Source of Material: B-7 Bulk Sample
Proposed Use: General Fill

Sample Information

Sample Date: 07/21/20
Sampled By: Joshua Elson
Sample Location: B-7 (Depth 0-4')

Sample Description: Gravelly Lean Clay: Brown

Laboratory Test Data

Test Procedure: ASTM D698
Test Method: Method C
Sample Preparation: Wet
Rammer Type: Manual

	Result	Specifications
Liquid Limit:	25	
Plastic Limit:	19	
Plasticity Index:	6	
In-Place Moisture (%):		
Retaining 3/4" (%):	9.0	

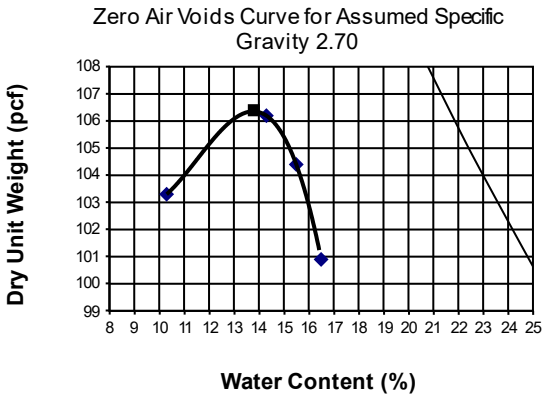
USCS: CL

Oversized Particles (%): 9.0
Moisture (%): 0.8
Sieve for Oversize Fraction: 3/4

Assumed Bulk Specific Gravity of Oversized Particles: 2.7

Corrected for Oversized Particles (ASTM D4718)
Maximum Dry Unit Weight (pcf): **106.4**
Optimum Water Content (%): **13.8**

Uncorrected Values
Maximum Dry Unit Weight (pcf): **102.7**
Optimum Water Content (%): **14.9**



Comments:

Services: Proctor values

Terracon Rep.: Moriah Dapprich
Reported To:
Contractor:
Report Distribution:

(1) Burns & McDonnell CAS LLC, Bill Nash

Test Methods: ASTM D698

The tests were performed in general accordance with applicable ASTM, AASHTO, or DOT test methods. This report is exclusively for the use of the client indicated above and shall not be reproduced except in full without the written consent of our company. Test results transmitted herein are only applicable to the actual samples tested at the location(s) referenced and are not necessarily indicative of the properties of other apparently similar or identical materials.

750 Pilot Road, Suite F
Las Vegas, Nevada 89119
(702) 597-9393

Client
Burns & McDonnell CAS LLC

Project
Tin Cup Force Main

Sample Submitted By: Terracon (B3) **Date Received:** 8/6/2020 **Lab No.: 20-0865**

Results of Corrosion Analysis

Sample Number	--	--	--
Sample Location	B-3	B-6	B-17
Sample Depth (ft.)	0.0-4.0	0.0-4.0	0.0-4.0
pH Analysis, ASTM G 51	7.10	7.30	7.45
Water Soluble Sulfate (SO4), ASTM C 1580 (mg/kg)	49	84	38
Sulfides, AWWA 4500-S D, (mg/kg)	Nil	Nil	Nil
Chlorides, ASTM D 512, (mg/kg)	65	48	48
Red-Ox, ASTM G 200, (mV)	+686	+685	+686
Total Salts, AWWA 2540, (mg/kg)	8697	1260	929
Resistivity (Saturated), ASTM G 57, (ohm-cm)	3977	3201	3589

Analyzed By:



Trisha Campo
Chemist

The tests were performed in general accordance with applicable ASTM and AWWA test methods. This report is exclusively for the use of the client indicated above and shall not be reproduced except in full without the written consent of our company. Test results transmitted herein are only applicable to the actual samples tested at the location(s) referenced and are not necessarily indicative of the properties of other apparently similar or identical materials.

SUPPORTING INFORMATION

Contents:

General Notes
Unified Soil Classification System
Description of Rock Properties

GENERAL NOTES

Terracon GeoReport

SAMPLING	WATER LEVEL	FIELD TESTS
Rock Core  Split Spoon	**Water Initially Encountered** **Water Level After a Specified Period of Time** **Water Level After a Specified Period of Time** 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 is based on the Unified Soil Classification System. Coarse Grained Soils have more than 50% of their dry weight retained on a #200 sieve; their principal descriptors are: boulders, cobbles, gravel or sand. Fine Grained Soils have less than 50% of their dry weight retained on a #200 sieve; they are principally described as clays if they are plastic, and silts if they are slightly plastic or non-plastic. Major constituents may be added as modifiers and minor constituents may be added according to the relative proportions based on grain size. In addition to gradation, coarse-grained soils are defined on the basis of their in-place relative density and fine-grained soils on the basis of their consistency.

LOCATION AND ELEVATION NOTES

Unless otherwise noted, Latitude and Longitude are approximately determined using a hand-held GPS device. The accuracy of such devices is variable. 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		
Descriptive Term (Density)	**Standard Penetration or N-Value Blows/Ft.**	**Descriptive Term (Consistency)**	**Unconfined Compressive Strength Qu, (psf)**	**Standard Penetration or N-Value Blows/Ft.**
Very Loose	0 - 3	Very Soft	less than 500	0 - 1
Loose	4 - 9	Soft	500 to 1,000	2 - 4
Medium Dense	10 - 29	Medium Stiff	1,000 to 2,000	4 - 8
Dense	30 - 50	Stiff	2,000 to 4,000	8 - 15
Very Dense	> 50	Very Stiff	4,000 to 8,000	15 - 30
		Hard	> 8,000	> 30

RELATIVE PROPORTIONS OF SAND AND GRAVEL		RELATIVE PROPORTIONS OF FINES	
Descriptive Term(s) of other constituents	Percent of Dry Weight	**Descriptive Term(s) of other constituents**	**Percent of Dry Weight**
Trace	<15	Trace	<5
With	15-29	With	5-12
Modifier	>30	Modifier	>12
GRAIN SIZE TERMINOLOGY		**PLASTICITY DESCRIPTION**	
Major Component of Sample	**Particle Size**	**Term**	**Plasticity Index**
Boulders	Over 12 in. (300 mm)	Non-plastic	0
Cobbles	12 in. to 3 in. (300mm to 75mm)	Low	1 - 10
Gravel	3 in. to #4 sieve (75mm to 4.75 mm)	Medium	11 - 30
Sand	#4 to #200 sieve (4.75mm to 0.075mm	High	> 30
Silt or Clay	Passing #200 sieve (0.075mm)		

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. 200 sieve	**Gravels:** More than 50% of coarse fraction retained on No. 4 sieve	**Clean Gravels:** Less than 5% fines [C]	$Cu \geq 4$ and $1 \leq Cc \leq 3$ [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]	$Cu \geq 6$ and $1 \leq Cc \leq 3$ [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 on or above "A"		CL	Lean clay [K, L, M]
			PI < 4 or plots below "A" line [J]		ML	Silt [K, L, M]
		Organic:	Liquid limit - oven dried	< 0.75	OL	Organic clay [K, L, M, N]
			Liquid limit - not dried			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:	Liquid limit - oven dried	< 0.75	OH	Organic clay [K, L, M, P]
			Liquid limit - not dried			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] $Cu = D_{60}/D_{10}$ $\quad Cc = \dfrac{(D_{30})^2}{D_{10} \times D_{60}}$

[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.

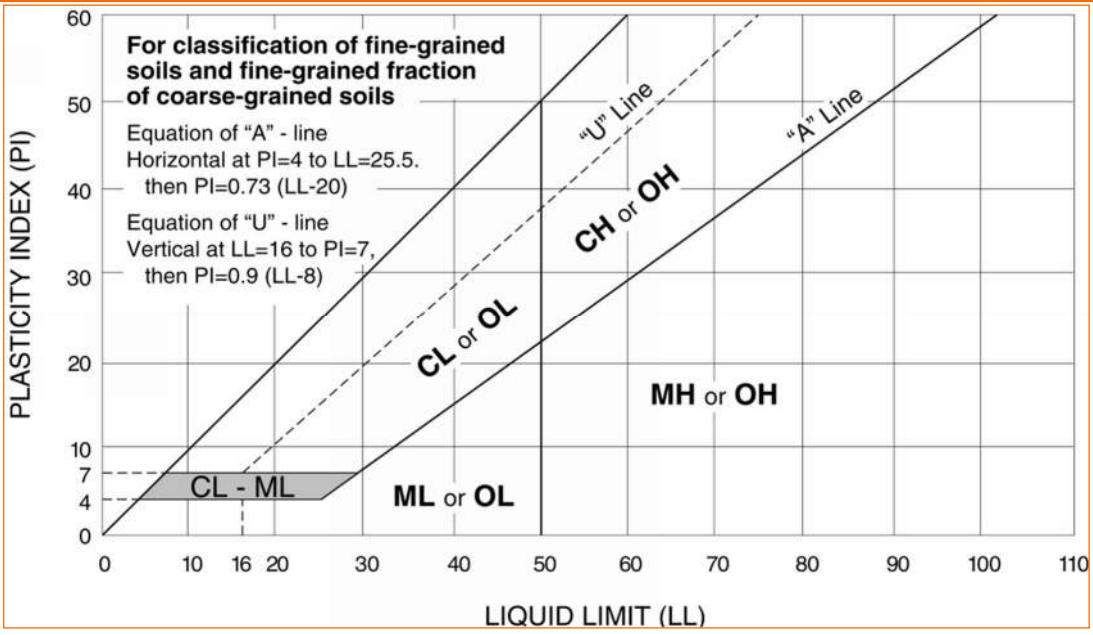
[M] If soil contains ≥ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.

[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.



DESCRIPTION OF ROCK PROPERTIES

WEATHERING	
Term	**Description**
Unweathered	No visible sign of rock material weathering, perhaps slight discoloration on major discontinuity surfaces.
Slightly weathered	Discoloration indicates weathering of rock material and discontinuity surfaces. All the rock material may be discolored by weathering and may be somewhat weaker externally than in its fresh condition.
Moderately weathered	Less than half of the rock material is decomposed and/or disintegrated to a soil. Fresh or discolored rock is present either as a continuous framework or as corestones.
Highly weathered	More than half of the rock material is decomposed and/or disintegrated to a soil. Fresh or discolored rock is present either as a discontinuous framework or as corestones.
Completely weathered	All rock material is decomposed and/or disintegrated to soil. The original mass structure is still largely intact.
Residual soil	All rock material is converted to soil. The mass structure and material fabric are destroyed. There is a large change in volume, but the soil has not been significantly transported.

STRENGTH OR HARDNESS		
Description	**Field Identification**	**Uniaxial Compressive Strength, psi (MPa)**
Extremely weak	Indented by thumbnail	40-150 (0.3-1)
Very weak	Crumbles under firm blows with point of geological hammer, can be peeled by a pocket knife	150-700 (1-5)
Weak rock	Can be peeled by a pocket knife with difficulty, shallow indentations made by firm blow with point of geological hammer	700-4,000 (5-30)
Medium strong	Cannot be scraped or peeled with a pocket knife, specimen can be fractured with single firm blow of geological hammer	4,000-7,000 (30-50)
Strong rock	Specimen requires more than one blow of geological hammer to fracture it	7,000-15,000 (50-100)
Very strong	Specimen requires many blows of geological hammer to fracture it	15,000-36,000 (100-250)
Extremely strong	Specimen can only be chipped with geological hammer	>36,000 (>250)

DISCONTINUITY DESCRIPTION			
Fracture Spacing (Joints, Faults, Other Fractures)		**Bedding Spacing (May Include Foliation or Banding)**	
Description	**Spacing**	**Description**	**Spacing**
Extremely close	< ¾ in (<19 mm)	**Laminated**	< ½ in (<12 mm)
Very close	¾ in – 2-1/2 in (19 - 60 mm)	**Very thin**	½ in – 2 in (12 – 50 mm)
Close	2-1/2 in – 8 in (60 – 200 mm)	**Thin**	2 in – 1 ft. (50 – 300 mm)
Moderate	8 in – 2 ft. (200 – 600 mm)	**Medium**	1 ft. – 3 ft. (300 – 900 mm)
Wide	2 ft. – 6 ft. (600 mm – 2.0 m)	**Thick**	3 ft. – 10 ft. (900 mm – 3 m)
Very Wide	6 ft. – 20 ft. (2.0 – 6 m)	**Massive**	> 10 ft. (3 m)

Discontinuity Orientation (Angle): Measure the angle of discontinuity relative to a plane perpendicular to the longitudinal axis of the core. (For most cases, the core axis is vertical; therefore, the plane perpendicular to the core axis is horizontal.) For example, a horizontal bedding plane would have a 0-degree angle.

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.

Reference: U.S. Department of Transportation, Federal Highway Administration, Publication No FHWA-NHI-10-034, December 2009
Technical Manual for Design and Construction of Road Tunnels – Civil Elements

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