Geotechnical Engineering Report

Whataburger Restaurant-SWQ S. Rangeline Rd. and 20th St.
Joplin, Missouri
September 2, 2022
Terracon Project No. B3225012

Prepared for:
Whatabrands Real Estate Segment
San Antonio, Texas

Prepared by:
Terracon Consultants, Inc.
Springfield, Missouri

September 2, 2022

Whatabrands Real Estate Segment
300 Concord Plaza Dr.
San Antonio, Texas 78216

Attn: Mr. Garrison Abner
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E: gabner@wbhq.com

Re: Geotechnical Engineering Report
Whataburger Restaurant-SWQ S. Rangeline Rd. and 20th St.
2014 S. Rangeline Rd.
Joplin, Missouri
Terracon Project No. B3225012

Dear Mr. Abner:

We have completed a subsurface exploration and geotechnical engineering exploration for the referenced project. This study was performed in general accordance with Terracon Proposal No. PB3225012, dated June 27, 2022. This report presents the findings of the subsurface exploration and provides geotechnical recommendations concerning earthwork and the design and construction of foundations, floor slabs, and pavements 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.

STATE OF MISSOURI
TY G
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PROFESSIONAL ENGINEER

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REPORT TOPICS

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

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

REPORT SUMMARY

Topic	Overview Statement [1]
Project Description	Single story restaurant with a planned footprint of approximately 3,751 square feet.
Geotechnical Characterization	Our general characterization of the subsurface conditions, 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 and the GeoModel can be found in the **Exploration Results** section of this report.
Earthwork	Unknown at this time; however, we anticipate site grading will be limited to approximately 2 feet of cut and/or fill and that permanent slopes will be no steeper than 3H:1V (Horizontal to Vertical).
Floor Slabs	Grade-supported floor slabs should be supported on a minimum of 24 inches of LVC material to achieve a potential vertical rise (PVR) of 1 inch or less. Based on laboratory test results, soils obtained within 5 feet of existing subgrade in borings B-2 and B-4 do not meet LVC criteria and other localized unsuitable areas may be present across the site. Where soils are encountered that do not meet LVC criteria, or if engineered fill is placed within the building, LVC fill should be placed and compacted as recommended in section **Earthwork**.
Seismic Considerations	Based on the 2018 International Building Code (IBC) and ASCE/SEI 7-10, the seismic site classification for this site is C.
Pavements	Both rigid (concrete) and flexible (asphalt) pavements can be considered. A minimum of 1 foot below the pavement base rock should be replaced with newly compacted structural fill consisting of LVC material to achieve a potential vertical rise (PVR) of 1 inch or less. Overexcavation and replacement of soils beneath pavements to achieve the recommended LVC layer can be waived at the discretion of the owner assuming the owner is willing to tolerate the risk of PVR in excess of 1-inch. If LVC fill is placed beneath pavements, these soils should be placed and compacted as recommended in section **Earthwork**.
General Comments	This section contains important information about the limitations of this geotechnical engineering report.

1. This summary is for convenience only. It should be used in conjunction with the entire report for design purposes.

Geotechnical Engineering Report

Whataburger Restaurant-SWQ S. Rangeline Rd. and 20th St.
2014 S. Rangeline Rd.
Joplin, Missouri
Terracon Project No. B3225012
September 2, 2022

INTRODUCTION

This report presents the results of our subsurface exploration and geotechnical engineering services performed for the proposed Whataburger Restaurant to be located at 2014 S. Rangeline Rd. in Joplin, Missouri. The purpose of these services is to provide information and geotechnical engineering recommendations relative to:

- Subsurface soil conditions
- Groundwater conditions
- Site preparation and earthwork
- Excavation considerations
- Foundation design and construction
- Floor slab design and construction
- Seismic site classification
- Pavement design and construction

The geotechnical engineering Scope of Services for this project included the advancement of six borings to depths ranging from approximately 7 to 11.5 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 in the **Exploration Results** section.

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 at 2014 S. Rangeline Rd. in Joplin, Missouri. The approximate coordinates of the site are: Lat.: 37.0684° N Long.: 94.4785° W (See **Site Location**)
Existing Improvements	The site is currently a vacant grass and concrete covered lot.

Item	Description
Current Ground Cover	Concrete pavement and light vegetation. Based on a review of historical aerial images (Google Earth Pro™), the light vegetation area was previously occupied by a commercial structure.
Existing Topography	Not provided; however, based on publicly available topographic maps, the area is relatively flat.
Geology	Our experience near the vicinity of the proposed development and geologic maps indicates subsurface conditions consist of residuum (clays) overlying the Meramecian Series (Limestone) and the Riverton and Burgner Formations (shale and coal). 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.
Geological Concerns	Mine shafts, prospect holes, and solution features including springs, caves, and sinkholes, are commonly present in the Meramecian Series and Pennsylvanian Age Bedrock Units in this area. Based on the review of information available from the Missouri Department of Natural Resources databases, the subject site does not appear to contain any previously identified mine features or sinkhole formations. It is difficult to predict future sinkhole activity. Site grading and drainage may alter site conditions and could possibly cause sinkholes in areas that have no history of this activity. A more in-depth review of mining research is included in **Geologic Assessment**.

PROJECT DESCRIPTION

Item	Description
Project Description	Single-story restaurant with a planned footprint of approximately 3,751 square feet.
Finished Floor Elevation (assumed)	Not provided at this time; however, based on our understanding of site grades, we anticipate the FFE will be within 2 feet of existing grade.
Maximum Loads (assumed)	■ Columns: 50 kips ■ Walls: 3 kips per linear foot (klf) ■ Slabs: 150 pounds per square foot (psf)

Item	Description
Grading	Unknown at this time; however, we anticipate site grading will be limited to approximately 2 feet of cut and/or fill and that permanent slopes will be no steeper than 3H:1V (Horizontal to Vertical).
Below-Grade Structures and Retaining Walls	None anticipated
Pavements	Paved drive-thru, dumpster pad, driveway, and parking areas will be constructed around the proposed building. Anticipated traffic will include passenger vehicles, small trucks, delivery trucks, garbage trucks, ambulances, and fire trucks. We understand that asphalt and concrete pavement sections will be considered. The pavement design period is 20 years.

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 north towards the unnamed tributary of Joplin Creek along the northern boundary.

The general area is primarily mapped as being underlain by the limestones of the Meramecian Series, dated to the Late Mississippian Geologic Period and the mudstones and shales of the Riverton and Burgner Formations, dated to the Middle Pennsylvanian Geologic Period. The Meramecian Series in southwestern Missouri consists of the St. Louis Limestone, generally a maximum of 100 feet thick, the Salem Formation (max 160 feet), and the Warsaw Formation (max 100 feet). The Warsaw Formation 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. The Riverton and Burgner Formations are a maximum of 90 feet and 70 feet thick, respectively.

The Meramecian Series carbonate rocks are known to form a 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.

Specifically, the site is mapped as being underlain primarily by the Riverton and Burgner Formations with the southwest corner of the site underlain by the Meramecian Series.

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/;
- Joplin, MO, GIS Data Viewer, https://www.joplinmo.org/:
- Beacon™, GIS Viewer for Jasper County, https://beacon.schneidercorp.com/
- 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; (nothing)
- 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, 1977, 1978, 1980, 1981, 1985, 1990, 1996, 2002 through 2012, 2014, 2016, 2017, 2020, and 2021. Additionally, our records review included reviewing USGS 7.5-minute quadrangle historical topographic maps from 1964, 1979, 2011, 2015, 2017, and 2021. Terracon observed a large tailings pile approximately 0.25 miles northeast of the site and at a higher elevation. Select historical aerial photographs can be viewed in the **Site Location and Exploration Plans** section of this report.

Terracon searched the MDH Tri-State Mining Maps Collection and did not find any maps within the collection pertaining to the project area.

The Joplin, MO GIS Data Viewer mapped several mine shafts in the general area with the closest two mine shafts approximately 0.15 miles southwest of the site. Additionally, the Data Viewer mapped three prospect holes within approximately 0.1 miles of the site, one south, one west, and one southwest, and has a portion of the north and west sides of the site mapped within the 100 Year Flood Zone. The Data Viewer did not have any mine waste or smelter areas mapped near the site. Terracon did not observe recorded sinkholes or springs within approximately 0.25 miles of the site on the GeoSTRAT application.

Terracon reviewed the Jasper County GIS Data Viewer from Beacon™ and found that the southwest to south adjacent property was classified as not needing soil lead remediation. The site had not been evaluated for soil lead remediation requirements and was not mapped with any mine areas, smelters, or prospect holes on this website.

Terracon reviewed the available LiDAR data and did not note evidence of depressions indicating karst conditions or settlement due to shafts or prospect holes on the site.

Geological Hazards

It is important to note that historical mining activity was not always well documented, and the possibility exists that undocumented mining features could exist in the unexplored areas or that documented mining features may exist on the property that are incorrectly located on existing maps. 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.

Should a mine feature be encountered during construction of the project, Terracon should be notified immediately to assess the situation and provide remediation recommendations.

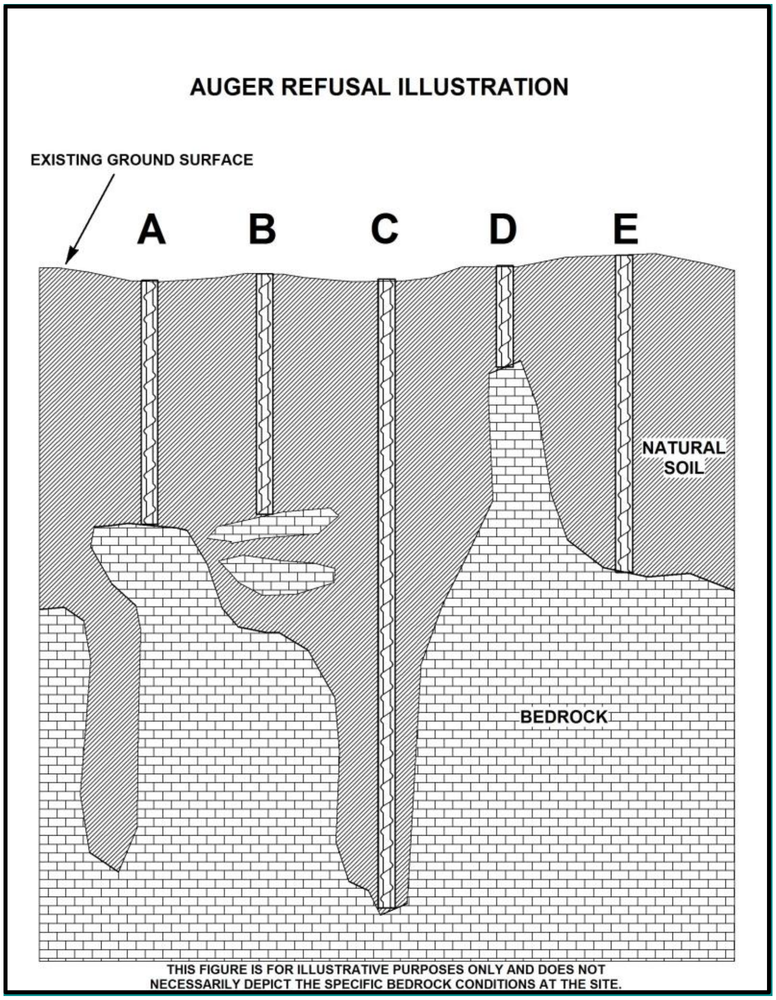
GEOTECHNICAL CHARACTERIZATION

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

As part of our analyses, we subdivided the soil profile into the following model layers. 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**	Existing concrete, aggregate base course, and fills consisting of poorly-graded gravels, lean and fat clays with varying amounts of silt, sand, and gravel, and clayey sands and gravels
2	**Natural Soil**	Lean and fat clays with varying amounts of sand and gravel
3	**Bedrock**	Apparent limestone bedrock

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 borings were advanced using dry auger drilling techniques which allows short-term groundwater observations to be made while drilling. Groundwater seepage encountered in the borings are presented in the table below.

Boring	Groundwater Seepage while Drilling	Groundwater Seepage, After Drilling
B-1	5.5	5.5
B-2	7.0	7.0
B-4	7.0	7.0

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. 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 each of the borings, except for B-5, at depths between about 7 and 11½ feet below present grades. Prior to auger refusal, approximately 0.3 to 2.8 feet of weathered bedrock was encountered in the Borings. The weathered rock was penetrated with the augers with some effort. Accordingly, site grading and excavations for the foundations and utilities may encounter bedrock.

Weathered rock that is penetrated with drilling augers can typically be excavated with large excavation equipment fitted with rock teeth using concentrated effort or ripped with large bulldozers. Layers of intact rock may be present within the weathered zones, which could require breaking with pneumatic rock breakers or blasting. Excavations in weathered rock often result in larger excavations than in soils, which subsequently require more backfill.

The foundations for the Whataburger Restaurant should bear all on soil (native or engineered fill). If the foundations encounter a condition of partial bedrock and partial soil, the bedrock should be overexcavated 1-foot below the design bearing level into the bedrock. The overexcavation should also extend laterally a sufficient distance to provide room for installation of a bond break with the sides of the footing excavation. The overexcavation into the bedrock should be backfilled with compacted cohesive soil material as described in section **Material Requirements**. The use of granular material for backfill in this area is not recommended. Compactive effort should be in accordance with recommendations provided in section **Compaction Requirements**. The purpose of the overexcavation is to reduce differential settlement due to differing bearing materials.

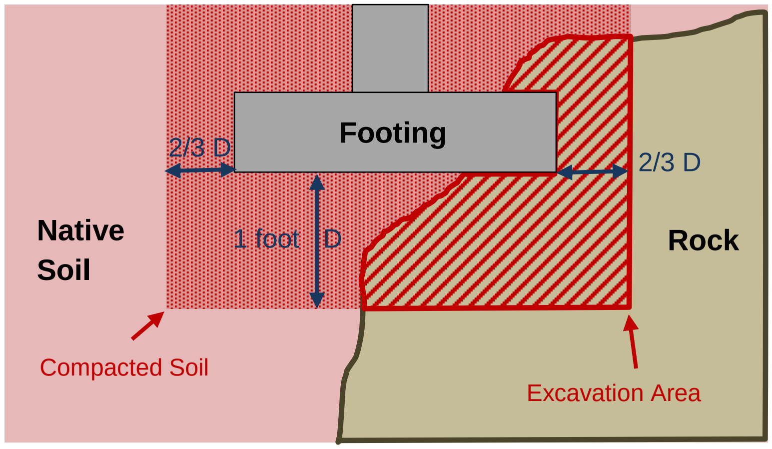


IMAGE NOT TO SCALE

Because of the variable bedrock depths at this site, the client should anticipate encountering inconsistent bedrock elevations in areas not explored with soil borings. We recommend the owner obtain unit rates for rock excavation for shallow foundations.

When the proposed grading plan is available and prior to foundation 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.

Potential for Hazardous Materials

The scope of services detailed within this report does not include either specifically or by implication any environmental or biological assessment of the site or identification or preventions of pollutants, hazardous materials or conditions. While the existing fill encountered at the site did not contain any evidence of potential mine tailings, based on our experience with other sites in the project area, lead may be present within the existing fill. Hazardous materials that are excavated/removed from the site must be handled in accordance with all applicable federal and state regulations. Recommendations presented in this report do not address any Missouri Department of Natural Resources (MDNR) or Environmental Protection Agency (EPA) regulations and restrictions. Terracon is available to discuss these considerations with the client.

Swell Potential

Some of the soils encountered within the exploration program are prone to volume change with changes in moisture which may lead to excessive shrinking and swelling of floor slabs and lightly-loaded structures. Fat clay soils were encountered in near surface soils within Borings B-2 and B-4 and may be present in localized areas of unsuitable materials across the site. We estimate the PVR of these soils to be between 0.5 and 1 inch based on their depth and thickness. We estimate the near surface lean clay and clayey sand soils encountered within the remaining borings to have a PVR of less than ½ inch. We recommend soils within 24-inches of slab bearing elevation consist of low volume change (LVC) material as described in **Material Requirements**. Using an LVC zone as recommended in this report may not eliminate all future subgrade volume change and resultant floor slab movements. However, we estimate the PVR to be ½ inch or less if an LVC zone as recommended in this report is constructed beneath the floor slab. Existing soils can be utilized as engineered fill if they are tested during construction and meet LVC material requirements. Care will be required during the construction process to determine the nature of the soils encountered to address the variable PVR across the site. Details regarding this LVC zone are provided in the **Floor Slab** section.

This report provides recommendations to help mitigate the effects of soil shrinkage and expansion. However, even if these procedures are followed, some movement and cracking in the structure could occur. The severity of cracking and other (cosmetic) damage such as uneven floor slabs will likely increase if any modification of the site results in excessive wetting or drying of the expansive soils. Eliminating the risk of movement and distress may not be feasible, but it may be possible to further reduce the risk of movement if more extensive measures are used during construction. We would be pleased to discuss other construction alternatives with you upon request.

All grades must provide effective drainage away from the structure during and after construction. Water permitted to pond next to the structure can result in greater soil movements than those discussed in this report. These greater movements can result in unacceptable differential floor slab movements, cracked slabs and walls, and roof leaks. The recommendations made in this this report are based on effective drainage for the life of the structure and cannot be relied upon if effective drainage is not maintained.

Soft Subgrade Potential

Near surface soils with water contents anticipated to exceed optimum water content were observed in Boring B-4 and may be present in other localized areas across the site. Groundwater was encountered at depths of 5 ½ to 7 feet below existing grade in borings B-1 through B-4. These are expected to become unstable when disturbed.

In other areas of the site, soils may be stable upon initial exposure but could become relatively soft and unstable under construction traffic during periods of wet weather. 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.

EARTHWORK

Earthwork is anticipated to include excavations and fill placement. The following sections provide recommendations for use in the preparation of specifications for the work.

Existing Undocumented Fill

Existing fill was encountered to depths ranging from approximately 4 to 7 feet in all borings. The fill could extend deeper in areas not explored. No documentation or records regarding the placement of this fill were provided for our review. If records of the fill are available, Terracon should be supplied with these documents to better assess the suitability of the existing fill.

The site is located in an area historically developed with commercial structures that have been removed. It is common in such areas to encounter remnants of past structures, such as buried foundations and basements, during construction. If encountered, these elements should be overexcavated and replaced with engineered fill in accordance with the recommendations outlined in this report. We recommend the owner budget for this possibility.

Undocumented fill may contain soft or loose soil or other unsuitable materials; these conditions may not be disclosed by the widely-spaced, relatively small-diameter borings. If these conditions are present and are not discovered and addressed during construction, then larger than normal settlement resulting in cracking, differential movement, or other damage could occur in foundations, floor slabs, pavements, and utility lines supported on or above the existing fill. Typically, larger than normal settlement of floor slabs results in reflective cracking of overlying rigid floor coverings (if any), unlevel floors, and “bumps” at locations of differential movement.

Foundations and floor slabs for the new structure should not bear on or above the undocumented fill materials. The existing fill could be removed and replaced so that the foundations and floor slabs for the new building bear on suitable native soils or on properly placed and compacted engineered fill extending to suitable native soils. If the fill is completely removed and replaced, it should be removed within the proposed building footprint and extend at least 5 feet outside the building perimeter.

Overexcavation and replacement of soils beneath floor slabs and pavements to achieve the recommended LVC layer can be waived at the discretion of the owner, assuming the owner is willing to tolerate the risk of settlement and/or PVR in excess of 1-inch. If a portion of the existing fill will be left in place, we recommend 24 inches new engineered fill should be placed directly below the floor slabs. Based on our experience, we recommend a minimum of 12 inches of newly placed engineered fill beneath pavements to reduce the risk of adverse performance from higher settlement and to provide more consistent support. Prior to placement of the new engineered fill, the exposed existing fill materials should be observed and tested during construction. Where unsuitable conditions are observed, the materials should be improved by scarification and recompaction or be removed and replaced with engineered fill. However, even with the recommended subgrade preparation and construction testing, there is a risk to the owner that unsuitable material within or buried by the fill will not be discovered. If the owner is not willing to accept the risks of supporting floor slabs and pavements over existing undocumented fill materials, the existing fill should be completely removed and replaced. The building foundations should be extended through the existing fills to bear on the native soils.

Portions of the existing fill may be suitable for removal and reuse as an engineered fill material. If this material is used as an engineered fill material, it should be first evaluated by the materials testing firm to determine if it meets the requirements listed in **Material Requirements**. If the material will be used as fill it should be placed as described in **Compaction Requirements**.

Site Preparation

Prior to placing fill, existing vegetation and root mat should be removed. Complete stripping of the topsoil should be performed in the proposed building and parking/driveway areas.

The subgrade 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.

Subgrade Stabilization

Methods of subgrade improvement, as described below, could include scarification, moisture conditioning and recompaction, and removal of unstable materials and replacement with granular fill (with or without geosynthetics). The appropriate method of improvement, if required, would be dependent on factors such as schedule, weather, the size of the area to be stabilized, and the nature of the instability. More detailed recommendations can be provided during construction as the need for subgrade stabilization occurs. Performing site grading operations during warm seasons and dry periods would help to reduce the amount of subgrade stabilization required.

If the exposed subgrade is unstable during proofrolling operations, it could be stabilized using one of the methods outlined below.

- **Scarification and Compaction** – It may be feasible to scarify, dry, and compact the exposed soils. The success of this procedure would depend primarily upon favorable weather and sufficient time to dry the soils. Stable subgrades likely would not be achievable if the thickness of the unstable soil is greater than about 1 foot, if the unstable soil is at or near groundwater levels, or if construction is performed during a period of wet or cool weather when drying is difficult.

- **Crushed Stone –** The use of crushed stone or gravel is the most common procedure to improve subgrade stability. Typical undercut depths would be expected to range from about 6 to 30 inches below finished subgrade elevation with this procedure. The use of high modulus geosynthetics (i.e., geotextile or geogrid) could also be considered after underground work such as utility construction is completed. Prior to placing the geotextile or geogrid, we recommend that all below-grade construction, such as utility line installation, be completed to avoid damaging the geosynthetic. Equipment should not be operated above the geosynthetic until one full lift of crushed stone fill is placed above it. The maximum particle size of granular material placed over the geotextile or geogrid should meet the manufacturer's specifications, and generally should not exceed 1½ inches.

Further evaluation of the need and recommendations for subgrade stabilization can be provided during construction as the geotechnical conditions are exposed.

Fill Material Types

Fill materials should meet the following criteria:

Fill Type[1]	USCS Classification	Acceptable Location for Placement
High Plasticity Material	CH (LL≥70 or PI≥40)	≥3 feet below base of floors and other lightly-loaded structures; ≥2 feet below foundations; and ≥1 foot below base of pavements
Moderate to High Plasticity Material[2]	CH or CL, with 70>LL≥45 or 40>PI≥25	≥2 feet below base of floor slabs and any other lightly-loaded structures, ≥1 foot below base of pavements
Granular Material [3]	GM, GC, SM, or SC	All locations and elevations (LVC)
Low Plasticity Material [4]	CL (LL<45 & PI<25) or Granular Material [3]	

Fill Type[1]	USCS Classification	Acceptable Location for Placement

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, including existing fills, generally appear suitable for use as fill, subject to the "acceptable location for placement" limitations described in this table. If existing fill is used as an engineered fill material, it should first be evaluated to determine if it meets the requirements listed here and placed as described in** **Compaction Requirements below.**
2. Delineation of moderate to high plasticity clays should be performed in the field by a representative of the Geotechnical Engineer, and could require additional laboratory testing. If fat clay material contains greater than 35 percent granular material retained on a ¾-inch sieve, it may be used in the low volume change zone.
3. Crushed limestone aggregate, limestone screenings or granular material such as sand, gravel or crushed stone containing at least 15 percent low plasticity fines.
4. 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.

Utility Trench Backfill

Utility trenches are a common source of water infiltration and migration. Utility trenches penetrating beneath the building should be effectively sealed to restrict water intrusion and flow through the trenches, which could migrate below the building. The trench should provide an effective trench plug that extends at least 5 feet from the face of the building exterior. The plug material should consist of cementitious flowable fill or low permeability lean clay. The trench plug material should be placed to surround the utility line. If used, the lean clay trench plug material should be placed and compacted to comply with the water content and compaction recommendations for structural fill stated previously in this report.

Grading and Drainage

All grades must provide effective drainage away from the building during and after construction and should be maintained throughout the life of the structure. Water retained next to the building can result in soil movements greater than those discussed in this report. Greater movements can result in unacceptable differential floor slab and/or foundation movements, cracked slabs and walls, and roof leaks. The roof should have gutters/drains with downspouts that discharge onto splash blocks at a distance of at least 10 feet from the building.

Exposed ground should be sloped and maintained at a minimum 5 percent away from the building for at least 10 feet beyond the perimeter of the building. Locally, flatter grades may be necessary to transition ADA access requirements for flatwork. After building construction and landscaping have been completed, final grades should be verified to document effective drainage has been achieved. Grades around the structure should also be periodically inspected and adjusted, as necessary, as part of the structure’s maintenance program. Where paving or flatwork abuts the structure, a maintenance program should be established to effectively seal and maintain joints and prevent surface water infiltration.

Earthwork Construction Considerations

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. Testing frequencies will be determined during the construction phase of the project when subgrade conditions can be observed. 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.

FLOOR SLABS

If undocumented fill is encountered, the undocumented fill should be removed and replaced or measures taken, as previously discussed, if the owner is willing to accept the risks associated with construction of floor slabs over existing fill. Grade-supported floor slabs should be supported on a minimum of 24 inches of LVC material. LVC fill should be placed and compacted as recommended in section **Earthwork**.

Concrete Slab-on-Grade

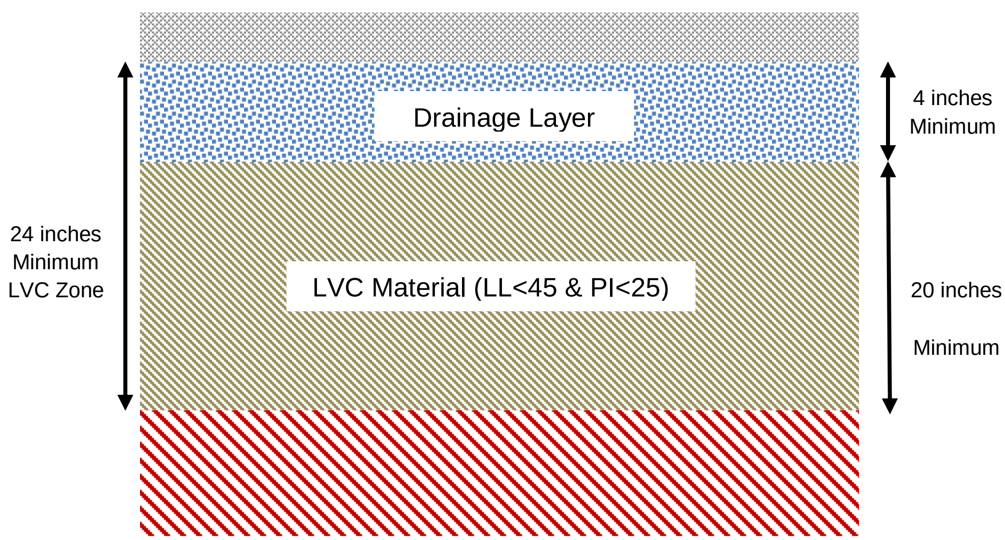


Image not to scale

Floor Slab Design Parameters

Item	Description
Floor slab support [1, 2]	A minimum 24-inch thick low volume change (LVC) layer over suitable native soil or engineered fill

Item	Description
Modulus of subgrade reaction	150 pounds per square inch per inch (psi/in) for point loading conditions
Granular course beneath slab [3, 4, 5]	Minimum 4 inches
Capillary break layer thickness [4, 5]	Minimum 4 inches

1. We recommend an LVC layer be present below the floor slab. This layer should be at least 24 inches thick and should meet the LVC material criteria outlined in this report in section **Earthwork**. Where existing soils meet the LVC criteria, they should be moisture conditioned and recompacted as recommended in this report.
2. We recommend subgrades be maintained in a relatively moist condition until the floor slab is constructed. If the subgrade should become excessively wet or dry prior to construction of the floor slab, the affected material should be removed or the materials be scarified, moisture conditioned, and recompacted. Upon completion of grading operations in the building area, care should be taken to maintain the recommended subgrade moisture content and density prior to construction of the building floor slab.
3. If the purpose of this layer is solely to create a level base for concrete placement to maintain a more uniform slab thickness, well-graded sand, gravel or crushed stone can be used.
4. If penetration of moisture vapor through the slab is a concern, in our opinion the floor slab design should include a capillary break layer in addition to a vapor retarder (refer to ACI 302 and/or ACI 360 for procedures and cautions regarding the use and placement of vapor retarders). In our opinion, capillary break layers should be comprised of granular materials that have less than 5 percent fines (material passing the #200 sieve). Other design considerations such as cold temperatures and condensation development could warrant additional design considerations.
5. These granular materials may be considered part of the LVC zone.

The use of a vapor retarder should be considered beneath concrete slabs on grade covered with wood, tile, carpet, or other moisture sensitive or impervious coverings, or when the slab will support equipment sensitive to moisture. When conditions warrant the use of a vapor retarder, the slab designer should refer to ACI 302 and/or ACI 360 for procedures and cautions regarding the use and placement of a vapor retarder.

Saw-cut contraction joints should be placed in the slab to help control the location and extent of cracking. For additional recommendations refer to ACI 360, Guide to Design of Slabs-on-Ground. Joints or cracks should be sealed with a water-proof, non-extruding compressible compound specifically recommended for heavy-duty concrete pavement and wet environments.

Settlement of floor slabs supported on existing fill materials cannot be accurately predicted but could be larger than normal and result in some cracking. Mitigation measures, as noted in **Existing Fill** within **Earthwork**, are critical to the performance of floor slabs. In addition to the mitigation measures, the floor slab can be stiffened by adding steel reinforcement, grade beams and/or post-tensioned elements.

Floor Slab Construction Considerations

Finished subgrade, within and for at least 10 feet beyond the floor slab, should be protected from traffic, rutting, or other disturbance and maintained in a relatively moist condition until floor slabs are constructed. If the subgrade should become excessively wet or dry or damaged prior to construction of floor slabs, the affected material should be removed and structural fill should be added to replace the resulting excavation. Final conditioning of the finished subgrade should be performed immediately prior to placement of the floor slab support course.

The Geotechnical Engineer should approve the condition of the floor slab subgrades immediately prior to placement of the floor slab support course, reinforcing steel, and concrete. Attention should be paid to high traffic areas that were rutted and disturbed earlier, and to areas where backfilled trenches are located.

SHALLOW FOUNDATIONS

Provided the site has been prepared in accordance with the requirements noted in **Earthwork**, the following design parameters are applicable for design of shallow foundations.

Design Parameters – Compressive Loads

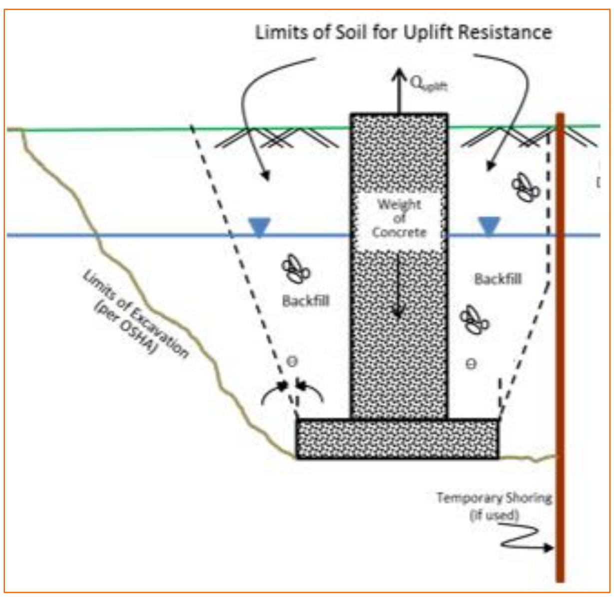
Item	Description
Maximum Net Allowable Bearing pressure [1, 2, 3]	2,500 psf (foundation bearing on engineered fill or undisturbed native soils) 7,000 psf (foundation bearing on competent bedrock)
Minimum Foundation Dimensions	Columns: 30 inches Continuous: 18 inches
Ultimate Passive Resistance [4] **(equivalent fluid pressures)**	250 pcf (cohesive backfill) 350 pcf (granular backfill)
Ultimate Coefficient of Sliding Friction [5]	0.32 (native clay) 0.40 (granular material)
Minimum Embedment below Finished Grade	30 inches on soil N/A on bedrock
Estimated Total Settlement from Structural Loads [2]	Less than about 1 inch Less than about ½ inch on bedrock
Estimated Differential Settlement [2, 6]	About ¾ of total settlement

Item	Description

1. The maximum net allowable bearing pressure is the pressure in excess of the minimum surrounding overburden pressure at the footing base elevation. An appropriate factor of safety has been applied. Values assume that exterior grades are no steeper than 20 percent within 10 feet of the structure.
2. Values provided are for the maximum loads noted in **Project Description**.
3. Unsuitable or soft soils, including undocumented fill, should be overexcavated and replaced per the recommendations presented in **Earthwork**.
4. Use of passive earth pressures require the sides of the excavation for the spread footing foundation to be nearly vertical and the concrete placed neat against these vertical faces or that the footing forms be removed and compacted structural fill be placed against the vertical footing face.
5. Can be used to compute sliding resistance where foundations are placed on suitable soil/materials. Should be neglected for foundations subject to net uplift conditions. Should be neglected if passive pressure will be used to resist lateral loads.
6. Differential settlements are as measured over a span of up to 50 feet.

Design Parameters - Uplift Loads

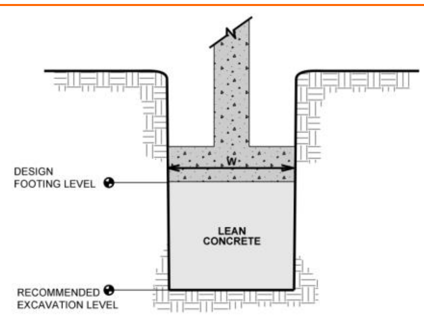
Uplift resistance of spread footings can be developed from the effective weight of the footing and the overlying soils. As illustrated on the subsequent figure, the effective weight of the soil prism defined by diagonal planes extending up from the top of the perimeter of the foundation to the ground surface at an angle, θ, of 20 degrees from the vertical can be included in uplift resistance. The maximum allowable uplift capacity should be taken as a sum of the effective weight of soil plus the dead weight of the foundation, divided by an appropriate factor of safety. A maximum total unit weight of 120 pcf should be used for the backfill. This unit weight should be reduced to 60 pcf for portions of the backfill or natural soils below the groundwater elevation.



Foundation Construction Considerations

As noted in **Earthwork**, the footing excavations should be observed and tested by a representative Geotechnical Engineer. The base of all foundation excavations should be free of water and loose soil, prior to placing concrete. Concrete should be placed soon after excavating to reduce bearing soil disturbance. Care should be taken to prevent wetting or drying of the bearing materials during construction. Excessively wet or dry material or any loose/disturbed material in the bottom of the footing excavations should be removed/reconditioned before foundation concrete is placed. Placement of a lean concrete mudmat over the bearing soils should be considered if the excavations must remain open for an extended period of time.

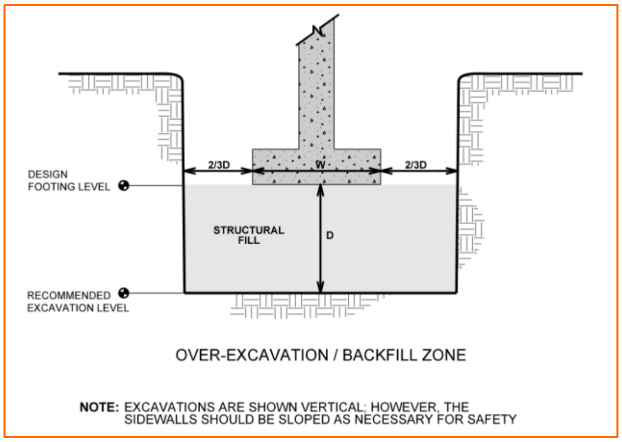
If unsuitable bearing soils are encountered at the base of the planned footing excavation, the excavation should be extended deeper to suitable soils, and the footings could bear directly on these soils at the lower level or on lean concrete backfill placed in the excavations. This is illustrated on the sketch below. Care will need to be taken to maintain at least 12 inches of cohesive material between the bottom of the footing and/or lean concrete, and the top of rock for soil supported foundations.



LEAN CONCRETE BACKFILL

NOTE: EXCAVATIONS ARE SHOWN VERTICAL; HOWEVER, THE SIDEWALLS SHOULD BE SLOPED AS NECESSARY FOR SAFETY

Over-excavation for structural fill placement below footings should be conducted as shown below. The over-excavation should be backfilled up to the footing base elevation with suitable fill materials, as recommended in the **Earthwork** section.



SEISMIC CONSIDERATIONS

The seismic design requirements for buildings and other structures are based on Seismic Design Category. The Site Class is required to determine the Seismic Design Category for a structure. The Site Class is based on the upper 100 feet of the site profile defined by a weighted average value of either shear wave velocity, standard penetration resistance, or undrained shear strength in accordance with Section 20.4 of ASCE 7 and the International Building Code (IBC).

Based on the soil properties encountered at the site and as described on the exploration logs and results, it is our professional opinion that the **Seismic Site Class is C**. Subsurface explorations at this site were extended to a maximum depth of 11.5 feet. The site properties below the boring depth to 100 feet were estimated based on our experience and knowledge of geologic conditions of the general area. We could perform additional deeper borings or geophysical testing to confirm the conditions below the current boring depths.

PAVEMENTS

Pavements are typically more tolerant of nonuniform subgrade conditions than foundations and floor slabs. As discussed in the **Earthwork** section, overexcavation and replacement of soils beneath pavements to achieve the recommended LVC layer can be waived at the discretion of the owner, assuming the owner is willing to tolerate the risk of PVR in excess of 1-inch. We recommend a minimum of 12 inches of new engineered fill should be placed directly below the pavement sections to reduce the risk of adverse performance from higher settlement and to provide more consistent support. If the owner is not willing to accept the risks of supporting pavements over existing undocumented fill materials, the existing fill should be completely removed and replaced to support pavements.

Support characteristics of subgrades for pavement design do not account for shrink/swell movements of an expansive clay subgrade, such as the soils encountered on this site. Thus, the pavement may be adequate from a structural standpoint, yet still experience cracking and deformation due to shrink/swell related movement of the subgrade. To reduce the potential for settlement/heave and associated cracking of the pavement, we recommend that at least the upper 12 inches of subgrade beneath the pavement base rock consist of LVC material.

Pavement Subgrades

On most project sites, the grading is accomplished relatively early in the construction phase. Fills are placed and compacted in a uniform manner. However, as construction proceeds, excavations are made into these areas, rainfall and surface water saturate some areas, heavy traffic from concrete trucks and other delivery vehicles disturb the subgrade and many surface irregularities are filled in with loose soils to improve stability temporarily. As a result, the pavement subgrades, initially prepared early in the project, should be carefully evaluated as the time for pavement construction approaches.

We recommend the moisture content and density of the upper 9 inches of the subgrade be evaluated and the pavement subgrades be proofrolled within two days prior to commencement of actual paving operations. Areas not in compliance with the required ranges of moisture or density should be moisture conditioned and recompacted. Particular attention should be paid to high traffic areas that were rutted and disturbed earlier and to areas where backfilled trenches are located. Areas where unsuitable conditions are located should be repaired by removing and replacing the material with compacted structural fill.

After proofrolling and repairing deep subgrade deficiencies, the entire subgrade should be scarified and developed as recommended in section **Earthwork** to provide a more consistent subgrade for pavement construction. Areas that appear desiccated (dry) following site stripping may require further undercutting and moisture conditioning. If a significant precipitation event occurs after the evaluation or if the surface becomes disturbed, the subgrade should be reviewed by qualified personnel immediately prior to paving. The subgrade should be in its finished form at the time of the final review.

Pavement Design Parameters

Traffic loading was not provided; however, we anticipate the new parking areas will be primarily used by cars and pick-up trucks (i.e., light-duty). A limited number of delivery trucks and refuse disposal vehicles (i.e., medium-duty) are expected in the drive lanes and loading areas (estimated maximum of 10 trucks per week).

Pavement design methods are intended to provide structural sections with adequate thickness over a particular subgrade such that wheel loads are reduced to a level the subgrade can support. Pavement performance is affected by its surroundings. In addition to providing preventive maintenance, the civil engineer should consider the following recommendations in the design and layout of pavements:

- Final grade adjacent to pavements should slope down from pavement edges at a minimum 2 percent;
- The subgrade and the pavement surface should have a minimum 2 percent slope to promote proper surface drainage;
- Drainage should be provided for the pavement base course;
- Joint sealant should be installed and cracks sealed immediately;
- Compacted, low permeability backfill should be placed against the exterior side of curbs and gutters, and all landscaped areas in, or adjacent to pavements to reduce moisture migration to subgrade soils; and,
- To reduce the likelihood of water seeping beneath curbs into the pavement base course; curb, gutter and/or sidewalks should bear directly on clay subgrade soils rather than on unbound granular base course materials.

Pavement Section Thicknesses

Both asphalt and concrete pavement sections are presented in the following tables for on-site pavements. They are not considered equal. Over the life of the pavement, concrete sections would be expected to require less maintenance.

Asphaltic Concrete Design		
Layer	Thickness (inches)	
	Light-Duty [1]	Medium-Duty [1]
Asphalt Thickness	Asphalt Surface: 3	Asphalt Surface: 2 Asphalt Base: 3
Aggregate Base [2]	8	8

1. See **Pavement Design Parameters** section above for more specifics regarding Light-Duty and Medium-Duty traffic.
2. Crushed stone (MoDOT Type 5 aggregate)
3. Asphalt Surface should meet the requirements of Missouri Department of Transportation BP-2 and Asphalt Base should meet the requirements of Missouri Department of Transportation BB designated mix designs.

Portland Cement Concrete Design			
Layer	Thickness (inches)		
	Light-Duty [1]	Medium-Duty [1]	Heavy-Duty [3]
Portland Cement Concrete [2]	5	6	7

Portland Cement Concrete Design			
Layer	**Thickness (inches)**		
	Light-Duty [1]	**Medium-Duty** [1]	**Heavy-Duty** [3]
Aggregate base [4]	4	4	4

1. See **Pavement Design Parameters** section above for more specifics regarding Light-Duty and Medium-Duty traffic.
2. 4,000 psi at 28 days, 4-inch maximum slump and 5 to 7 percent air entrained. PCC pavements are recommended for trash container pads and in any other areas subjected to heavy wheel loads and/or turning traffic.
3. In areas of anticipated heavy traffic, fire trucks, delivery trucks, or concentrated loads (e.g. dumpster pads), and areas with repeated turning or maneuvering of heavy vehicles.
4. Crushed stone (MoDOT Type 5 aggregate)

Rigid PCC pavements will perform better than HMAC pavements in areas where short-radii turning and braking are expected (i.e. entrance/exit aprons) due to better resistance to rutting and shoving. In addition, PCC pavements will perform better in areas subject to large or sustained loads, such as dumpster approach and loading/unloading areas.

Based on current local practices and the site soil conditions, steel reinforcement bars are not required for this project.

Pavement Drainage

Pavements should be sloped to provide rapid drainage of surface water. Water allowed to pond on or adjacent to the pavements could saturate the subgrade and contribute to premature pavement deterioration. In addition, the pavement subgrades should be graded to provide positive drainage within the granular base section. We recommend the subgrades beneath the pavement sections be graded to slope toward the storm water catch basins. A drainage collection and removal system (e.g., finger drains) could be used to allow water in the granular base to enter the storm sewers, or otherwise be removed from the granular base.

Flat grades should be avoided with positive drainage provided away from the pavement edges. Backfilling of curbs should be accomplished as soon as practical to prevent ponding of water.

Openings in pavement, such as landscape islands, are sources for water infiltration into surrounding pavements. Water collects in the islands and migrates into the surrounding subgrade soils thereby degrading support of the pavement. This is especially applicable for islands with raised concrete curbs, irrigated foliage, and low permeability near-surface soils. The civil design for the pavements with these conditions should include features to restrict or to collect and discharge excess water from the islands. Examples of features are edge drains connected to the storm water collection system or other suitable outlet and impermeable barriers preventing lateral migration of water such as a cutoff wall installed to a depth below the pavement structure.

Pavement Maintenance

The pavement sections provided in this report represent minimum recommended thicknesses and, as such, periodic maintenance should be anticipated. Therefore, preventive maintenance should be planned and provided for through an on-going pavement management program. Maintenance activities are intended to slow the rate of pavement deterioration, and to preserve the pavement investment. Maintenance consists of both localized maintenance (e.g., crack and joint sealing and patching) and global maintenance (e.g., surface sealing). Preventive maintenance is usually the first priority when implementing a pavement maintenance program. Even with periodic maintenance, some movements and related cracking may still occur and repairs may be required. Geosynthetic reinforcement between the subgrade and base rock could be considered to increase the time before maintenance is required.

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

Support of pavements and floor slabs and pavements over existing fill is discussed in this report. However, even with the recommended construction testing, there is a risk that unsuitable materials within or buried by the fill will not be discovered. This risk cannot be eliminated without removing the fill but can be reduced by thorough exploration and testing.

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.

ATTACHMENTS

EXPLORATION AND TESTING PROCEDURES

Field Exploration

Number of Borings	Boring Depth (feet) [1]	Planned Location
3	20 or auger refusal	Planned building area
3	10 or auger refusal	Planned drive-thru, parking, and driveway areas

1. Below ground surface
2. All Borings, except for B-5, encountered auger refusal on a possible cobble, boulder, or bedrock prior to their planned termination depth. Boring B-5 extended to its 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 ±10 feet). Approximate elevations were obtained by surveyor's level and rod and are rounded to the nearest ½-foot. Elevations are referenced to a temporary benchmark (sewer manhole cover southeast of the site) indicated on the **Boring Location and Exploration Plan**. An elevation of 100 feet has been assigned for the temporary benchmark. 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.

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

The project geologist reviewed the field data and assigned laboratory tests. Procedural standards noted below are for reference to methodology in general. In some cases, variations to methods were applied because of local practice or professional judgment. Standards noted below include reference to other, related standards. Such references are not necessarily applicable to describe the specific test performed.

- ASTM D2216 Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
- ASTM D4318 Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
- ASTM D2487 Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)

The laboratory testing program often included examination of soil samples by a geologist. Based on the material's texture and plasticity, we described and classified the soil samples in accordance with the Unified Soil Classification System, summarized in **Supporting Information**.

Liquid and Plastic Limits tests and moisture contents were performed to aid in classifying the soils in accordance with the USCS. The results of the tests are presented in the following table and on the individual boring logs in **Exploration Results**.

Boring No.	Depth (feet)	Liquid Limit (%)	Plasticity Index (%)	Moisture Content (%)
2	3.5 – 5	73	46	19.2
4	1 – 2.5	56	27	37.5
6	6 – 7.5	79	52	45.8

SITE LOCATION AND EXPLORATION PLANS

Contents:

SITE LOCATION

Whataburger Restaurant-SWQ S. Rangeline Rd. and 20th St. ■ Joplin, Missouri
September 2, 2022 ■ Terracon Project No. B3225012

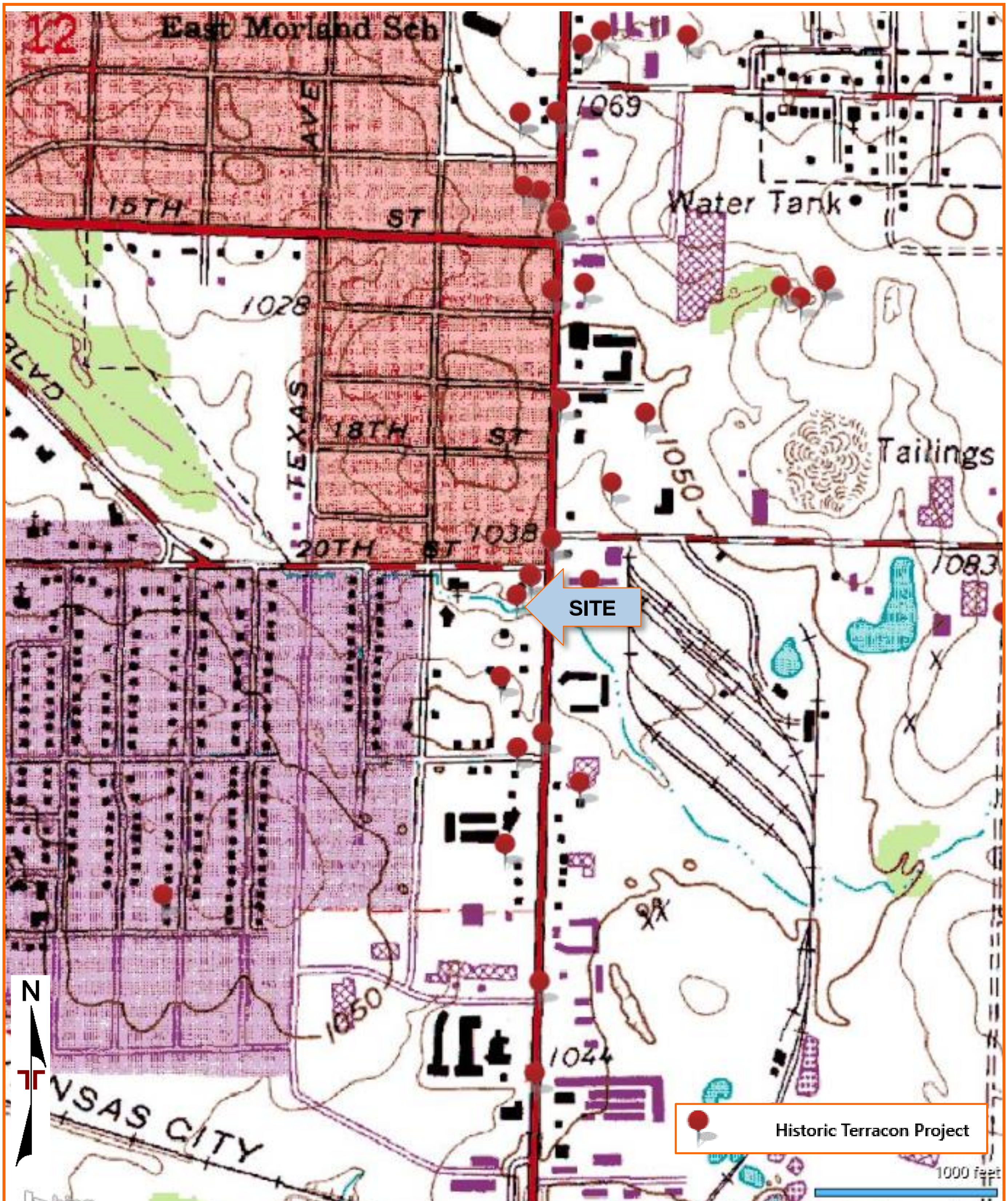


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

MAP PROVIDED BY MICROSOFT BING MAPS

BORING LOCATION PLAN

Whataburger Restaurant-SWQ S. Rangeline Rd. and 20th St. ■ Joplin, Missouri
September 2, 2022 ■ Terracon Project No. B3225012

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

MAP PROVIDED BY GOOGLE EARTH PRO

EXPLORATION PLAN

Whataburger Restaurant-SWQ S. Rangeline Rd. and 20th St. ■ Joplin, Missouri

September 2, 2022 ■ Terracon Project No. B3225012

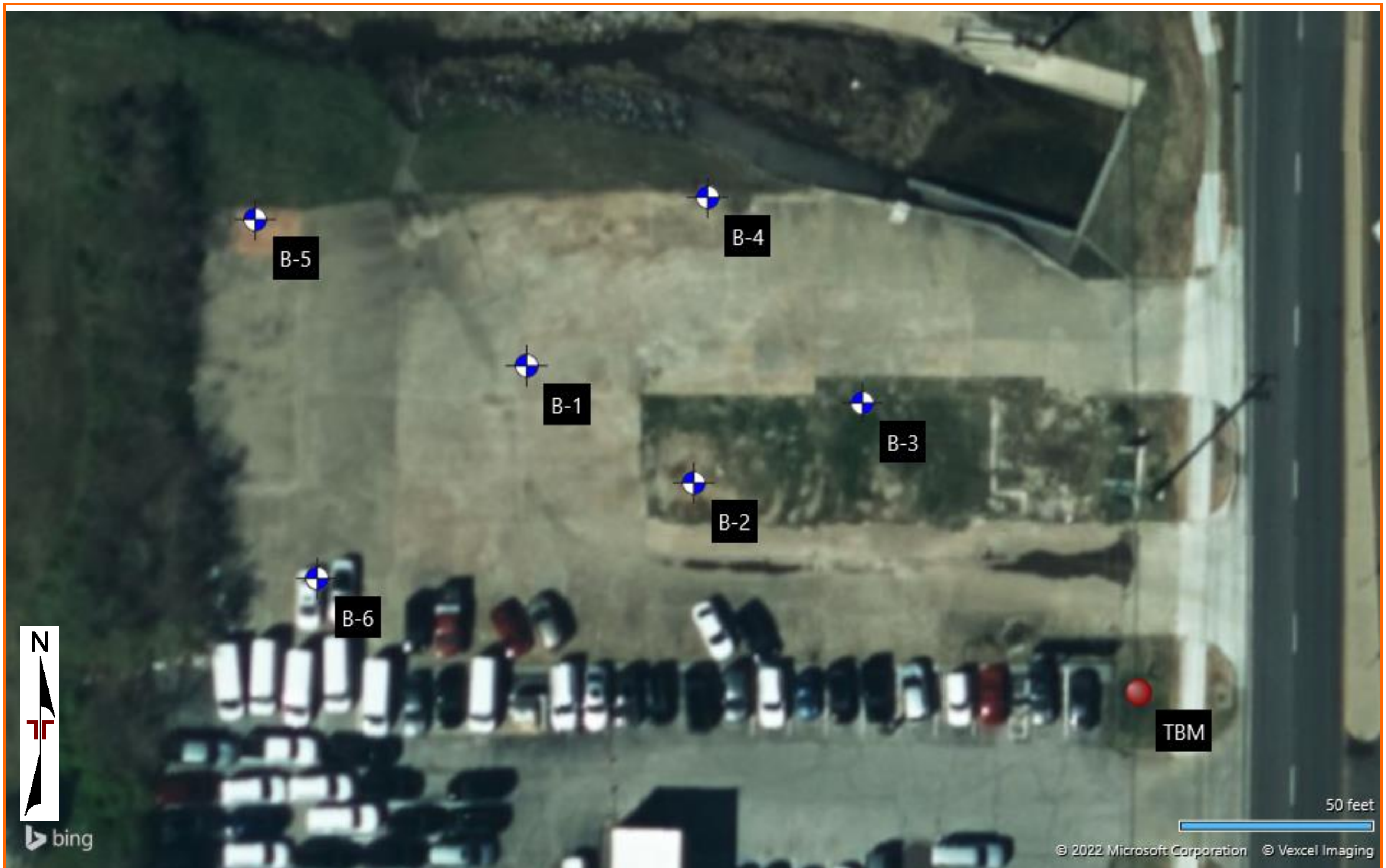


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

MAP PROVIDED BY GOOGLE EARTH PRO

1977 HISTORICAL AERIAL PHOTOGRAPH

Whataburger Restaurant-SWQ S. Rangeline Rd. and 20th St. ■ Joplin, Missouri

September 2, 2022 ■ Terracon Project No. B3225012

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

MAP PROVIDED BY GOOGLE EARTH PRO

1996 HISTORICAL AERIAL PHOTOGRAPH

Whataburger Restaurant-SWQ S. Rangeline Rd. and 20th St. ■ Joplin, Missouri

September 2, 2022 ■ Terracon Project No. B3225012

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

MAP PROVIDED BY GOOGLE EARTH PRO

EXPLORATION RESULTS

Contents:

BORING LOG NO. B-1

PROJECT: Whataburger SWQ Rangeline Rd and 20th Joplin, MO

SITE: 2014 S Rangeline Rd Joplin, MO

CLIENT: Whataburger San Antonio, TX

LOCATION See Exploration Plan

Latitude: 37.0684° Longitude: -94.4787°

Surface Elev.: 98.5 (Ft.)

MODEL LAYER	DEPTH	MATERIAL DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY HP (tsf)	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI
	0.3	**CONCRETE**	98.2								
	0.8	**AGGREGATE BASE COURSE**	97.7								
1	4.0	**FILL - POORLY GRADED GRAVEL WITH SAND**, trace silt, gray	94.5			X	2	12-10-6 N=16	N/A	2.7	
2	6.0	**FAT CLAY WITH GRAVEL (CH)**, brown to orange brown, very stiff	92.5	5	▽	X	10	12-10-11 N=21	N/A	17.9	
3	7.0	**LIMESTONE**	91.5				0	50/0"			
		Auger Refusal at 7 Feet									

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

Hammer Type: Automatic

Advancement Method:
4" C.F.A.

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 measured in the field using an engineer's level and grade rod.

Notes:

Auger refusal on possible cobble, boulder, or bedrock at 7 feet.

WATER LEVEL OBSERVATIONS

▽ *While drilling*

Terracon
1401 Illinois Ave
Joplin, MO

Boring Started: 08-04-2022	Boring Completed: 08-04-2022
Drill Rig: #840	Driller: DH
Project No.: B3225012	

BORING LOG NO. B-2

PROJECT: Whataburger SWQ Rangeline Rd and 20th Joplin, MO

CLIENT: Whataburger San Antonio, TX

SITE: 2014 S Rangeline Rd Joplin, MO

LOCATION See Exploration Plan

Latitude: 37.0684° Longitude: -94.4785°

Surface Elev.: 99 (Ft.)

MODEL LAYER	GRAPHIC LOG	DEPTH	DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY HP (tsf)	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI
1			**FILL - LEAN CLAY WITH SILT AND SAND**, orange brown					13	10-14-8 N=22	N/A	20.6	
		3.0	**FILL - FAT CLAY WITH SAND AND GRAVEL**, trace silt, orange to tan and white	96				15	14-20-22 N=42	>4.5	19.2	73-27-46
		5.5	**FILL - CLAYEY GRAVEL WITH SAND**, brown	93.5	5	▽		12	15-21-29 N=50	N/A	22.3	
		7.0		92								
2		7.5	**GRAVELLY LEAN CLAY WITH SAND (CL)**, brown	91.5								
3		8.1	**LIMESTONE**	90.9								
			Auger Refusal at 8 Feet									

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

Hammer Type: Automatic

Advancement Method:
4" C.F.A.

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 measured in the field using an engineer's level and grade rod.

Notes:

Auger refusal on possible cobble, boulder, or bedrock at 8 feet.

WATER LEVEL OBSERVATIONS

▽ *While drilling*

▽ *At completion of drilling*

Terracon
1401 Illinois Ave
Joplin, MO

Boring Started: 08-04-2022	Boring Completed: 08-04-2022
Drill Rig: #840	Driller: DH
Project No.: B3225012	

BORING LOG NO. B-3

PROJECT: **Whataburger SWQ Rangeline Rd and 20th Joplin, MO**

SITE: **2014 S Rangeline Rd Joplin, MO**

CLIENT: **Whataburger San Antonio, TX**

LOCATION See Exploration Plan

Latitude: 37.0684° Longitude: -94.4784°

Surface Elev.: 99 (Ft.)

MODEL LAYER	GRAPHIC LOG	DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY HP (tsf)	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI
1		**FILL - CLAYEY SAND WITH GRAVEL**, dark brown									
						X	3	9-11-11 N=22	N/A	4.7	
						X	5	6-4-3 N=7	N/A	12.3	
		5.4	93.6	5							
3		**LIMESTONE**					0	50/0"			
		8.2	90.8								
		Auger Refusal at 8.2 Feet									

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

Hammer Type: Automatic

Advancement Method:
4" C.F.A.

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 measured in the field using an engineer's level and grade rod.

Notes:

Auger refusal on possible cobble, boulder, or bedrock at 8.2 feet.

WATER LEVEL OBSERVATIONS

Groundwater not encountered

Terracon
1401 Illinois Ave
Joplin, MO

Boring Started: 08-04-2022	Boring Completed: 08-04-2022
Drill Rig: #840	Driller: DH
Project No.: B3225012	

BORING LOG NO. B-4

PROJECT: Whataburger SWQ Rangeline Rd and 20th Joplin, MO

CLIENT: Whataburger San Antonio, TX

SITE: 2014 S Rangeline Rd Joplin, MO

LOCATION See Exploration Plan

Latitude: 37.0686° Longitude: -94.4785°

Surface Elev.: 97.5 (Ft.)

MODEL LAYER	GRAPHIC LOG	DEPTH	DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY HP (tsf)	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI
1		0.3	**TOPSOIL**	97.2								
			FILL - FAT CLAY, trace roots, dark brown to black				SPT	9	2-3-2 N=5	1.75 (HP)	37.5	56-29-27
		3.0		94.5								
			FILL - LEAN CLAY, with red and gray fat clay pockets, dark brown				SPT	7	2-3-3 N=6	1.75 (HP)	23.7	
2		5.0		92.5	5							
			FAT CLAY (CH), trace gravel, dark gray, medium stiff to stiff			▽	SPT	13	3-5-5 N=10	2.5 (HP)	21.8	
			dark gray to black below 8 ft.				SPT	6	3-4-3 N=7	0.75 (HP)	40.0	
		11.0		86.5	10							
3		11.4	**LIMESTONE**	86.1								
			Auger Refusal at 11.5 Feet									

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

Hammer Type: Automatic

Advancement Method:
4" C.F.A.

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 measured in the field using an engineer's level and grade rod.

Notes:

Auger refusal on possible cobble, boulder, or bedrock at 11.5 feet.

WATER LEVEL OBSERVATIONS

▽ *While drilling*

▽ *At completion of drilling*

Terracon
1401 Illinois Ave
Joplin, MO

Boring Started: 08-04-2022	Boring Completed: 08-04-2022
Drill Rig: #840	Driller: DH
Project No.: B3225012	

BORING LOG NO. B-5

PROJECT: Whataburger SWQ Rangeline Rd and 20th
Joplin, MO

CLIENT: Whataburger
San Antonio, TX

SITE: 2014 S Rangeline Rd
Joplin, MO

LOCATION See Exploration Plan

Latitude: 37.0686° Longitude: -94.4789°

Surface Elev.: 99.5 (Ft.)

MODEL LAYER	DEPTH	DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY HP (tsf)	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI
1	0.3	**TOPSOIL**	99.2								
		FILL - GRAVELLY LEAN CLAY WITH SAND, brown				X	6	8-6-5 N=11	N/A	12.3	
	3.0		96.5								
		FILL - CLAYEY GRAVEL WITH SAND, brown				X	4	11-13-10 N=23	N/A	8.8	
	5.5		94	5							
2		**LEAN CLAY (CL)**, dark brown to black, medium stiff to stiff				X	18	3-5-6 N=11	1.0 (HP)	23.9	
	7.0		92.5								
		FAT CLAY WITH GRAVEL (CH), dark gray to brown gray, stiff									
		trace sand below 8.5 ft.				X	10	6-8-5 N=13	1.75 (HP)	20.8	
	10.0		89.5	10							
		Boring Terminated at 10 Feet									

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

Hammer Type: Automatic

Advancement Method:
4" C.F.A.

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 measured in the field using an engineer's level and grade rod.

Notes:

WATER LEVEL OBSERVATIONS

Groundwater not encountered

Terracon
1401 Illinois Ave
Joplin, MO

Boring Started: 08-04-2022	Boring Completed: 08-04-2022
Drill Rig: #840	Driller: DH
Project No.: B3225012	

BORING LOG NO. B-6

PROJECT: Whataburger SWQ Rangeline Rd and 20th, Joplin, MO

CLIENT: Whataburger, San Antonio, TX

SITE: 2014 S Rangeline Rd, Joplin, MO

LOCATION See Exploration Plan

Latitude: 37.0683° Longitude: -94.4789°

Surface Elev.: 100 (Ft.)

MODEL LAYER	DEPTH	DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY HP (tsf)	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI
1	0.4	**CONCRETE**	99.6								
	0.9	**AGGREGATE BASE COURSE**	99.1								
		FILL - CLAYEY SAND WITH GRAVEL, brown				X	9	13-14-12 N=26	N/A	7.3	
	5.5		94.5	5		X	12	12-10-6 N=16	N/A	8.4	
2		**FAT CLAY WITH GRAVEL (CH)**, trace sand, brownish orange, soft				X	7	2-1-1 N=2	0.75 (HP)	45.8	79-27-52
	8.7	tan gray to orange brown below 8 ft.	91.3								
3	9.0	**LIMESTONE**	91			X	2	50/2"	1.25 (HP)	22.9	
		Auger Refusal at 9 Feet									

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

Hammer Type: Automatic

Advancement Method:
4" C.F.A.

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 measured in the field using an engineer's level and grade rod.

Notes:

Auger refusal on possible cobble, boulder, or bedrock at 9 feet.

WATER LEVEL OBSERVATIONS

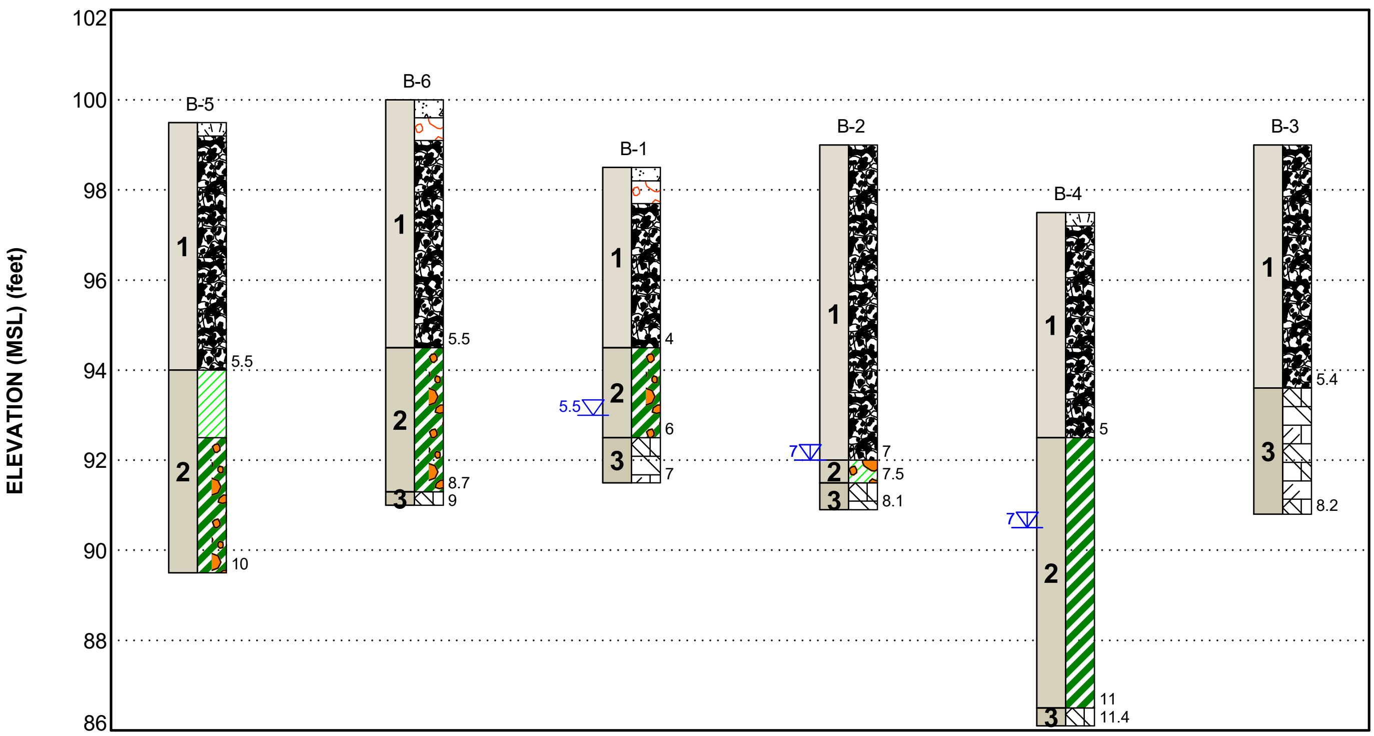
Groundwater not encountered

Terracon
1401 Illinois Ave
Joplin, MO

Boring Started: 08-04-2022	Boring Completed: 08-04-2022
Drill Rig: #840	Driller: DH
Project No.: B3225012	

GEOMODEL

Whataburger SWQ Rangeline Rd and 20th Joplin, MO ■ Joplin, MO
Terracon Project No. B3225012



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	Existing concrete, aggregate base course, and fills consisting of poorly-graded gravels, lean and fat clays with varying amounts of silt, sand, and gravel, and clayey sands and gravels
2	Natural Soil	Lean and fat clays with varying amounts of sand and gravel
3	Bedrock	Apparent limestone bedrock

LEGEND

First Water Observation
Second 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.

SUPPORTING INFORMATION

Contents:

GENERAL NOTES

DESCRIPTION OF SYMBOLS AND ABBREVIATIONS

Whataburger SWQ Rangeline Rd and 20th Joplin, MO ■ Joplin, MO

Terracon Project No. B3225012

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

DESCRIPTIVE SOIL CLASSIFICATION

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

LOCATION AND ELEVATION NOTES

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

STRENGTH TERMS

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

RELEVANCE OF SOIL BORING LOG

The soil boring logs contained within this document are intended for application to the project as described in this document. Use of these soil boring logs for any other purpose may not be appropriate.

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" line [J]		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.