Preliminary Geotechnical Engineering Report

BOLIVAR BUSINESS PARK

Bolivar, Missouri

October 7, 2016

Project No. B5165061

Prepared for:

City of Bolivar
Bolivar, Missouri

Prepared by:

Terracon Consultants, Inc.
Springfield, Missouri

October 7, 2016

City of Bolivar
345 S. Main Avenue
Bolivar, Missouri 65613

Attn: Ms. Sydney M. Allen
P: (417) 328-5825
E: csallen@bolivar.mo.us

Re: Preliminary Geotechnical Engineering Report
Bolivar Business Park
1700 South Wommack Avenue
Bolivar, Missouri
Terracon Project Number: B5165061

Dear Ms. Allen:

Terracon Consultants, Inc. (Terracon) has completed the preliminary geotechnical engineering services for the above-referenced project. This study was performed in general accordance with Work Order number PB5165061, signed August 11, 2016. This report presents the findings of the subsurface exploration and provides general geotechnical considerations regarding earthwork considerations, subgrade preparation, and recommended foundation types 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
ALLEN G. MINKS
NUMBER E-22438
REGISTERED PROFESSIONAL ENGINEER

10-07-16

R. Todd Hercules, E.I.
Senior Staff Geotechnical Engineer

Allen G. Minks, P.E.
Senior Geotechnical Engineer
Missouri: PE-022438 exp. 12/31/2017

Enclosures
Copies: .pdf – Client
1 – File

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EXECUTIVE SUMMARY

A preliminary geotechnical exploration has been performed for the proposed Bolivar Business Park located at 1700 South Wommack Avenue in Bolivar, Missouri. Four (4) borings, designated B-1 through B-4, were performed to depths of approximately 6 to 20 feet below the existing ground surface. The following geotechnical considerations were identified:

- The subject site was noted to historically be used for crop growth. Organic topsoil was noted to depths of approximately 1.7 feet below the ground surface and trace organics were noted in some of the samples to depths of 3½ feet below the ground surface. It has been our experience that the organic content and depth of organic soils in agricultural areas can vary significantly throughout a project site. Accordingly, high organic content material may be encountered in the upper 3½ feet of the subject site. Soils containing more than 5 percent organics should be removed and should not be utilized as engineered fill beneath proposed buildings and pavements. Soils containing less than 5 percent organics and meeting the criteria outlined in this report may be utilized as engineered fill beneath pavements. We recommend subgrade and engineered fill soils beneath structures not contain organics.

- Existing undocumented fill was encountered to a depth of approximately 3½ feet in Boring B-1 and may be present in areas not sampled in the subsurface exploration. Foundations for structures should not bear on or above undocumented fill materials. Any existing fill should be removed and replaced (or improved) so that foundations and floor slabs for structures bear on native clay soils or on properly placed and compacted engineered fill extending to suitable native soils.

- Very soft soils were encountered below stiff and medium dense soils at a depth of about 13½ feet in Boring B-2. The occurrence of very soft soils below stiff soil is known locally as soil softening and in this area can be an indication of nearby karst formations such as voids in the subsurface caused by karst conduits, sinkholes, and caves. No evidence of a depression caused by a sinkhole was noted on the surface of the subject site; however, this does not necessarily indicate that subsurface erosion due to karst features is not occurring. Further subsurface investigation near B-2 would be required to interpret the cause of the soil softening. Subsurface investigation could include additional soil borings to bedrock and various geophysical testing such as soil resistivity mapping and seismic reflection/refraction.

- The preliminary 2012 International Building Code (IBC) seismic site classification for this site is D.

- The geotechnical exploration and recommendations performed and the considerations provided for the proposed business park are for preliminary uses only. Additional geotechnical exploration will be required before site development.

The considerations presented in this report are based on evaluation of data developed by testing discrete samples obtained from limited, widely-spaced borings. Site subsurface conditions have been inferred from available data, but actual subsurface conditions will only be revealed by excavation. Additional geotechnical exploration will be required, once site development has been established, to provide geotechnical recommendations for the project.

This executive summary should not be separated from or used apart from this report. The report limitations are described in the **GENERAL COMMENTS** section of this report.

PRELIMINARY GEOTECHNICAL ENGINEERING REPORT
BOLIVAR BUSINESS PARK
BOLIVAR, MISSOURI
Terracon Project No. B5165061
October 7, 2016

1.0 INTRODUCTION

A preliminary geotechnical exploration has been performed for the proposed Bolivar Business Park located at 1700 South Wommack Avenue in Bolivar, Missouri. Four (4) borings, designated B-1 through B-4, were performed to depths of approximately 6 to 20 feet below the existing ground surface. Logs of the borings along with a Topographic Map, Geologic Map, Exploration Diagram, and Boring Location Diagram are included in Appendix A of this report.

The purpose of these services is to provide preliminary information and preliminary geotechnical engineering considerations relative to:

- subsurface soil conditions
- groundwater conditions
- earthwork
- seismic
- foundation types

2.0 PROJECT INFORMATION

2.1 Project Description

Item	Description
Site and boring layout	See Appendix A, Exhibit A-5: Boring Location Diagram
Site purpose	It is our understanding that the site may be used for a business park development containing parking areas, drive lanes, and a number of buildings to be decided in the future. The purpose of this report is to provide preliminary information to potential developers.

2.2 Site Location and Description

Item	Description
Location	1700 South Wommack Avenue in Bolivar, Missouri 
Existing improvements	A partial gravel road and some site grading has been performed on the north side of the subject site.
Current ground cover	Grasses and other vegetation
Existing topography	Based on the site exploration the subject site is gently sloping to the south with about 12 feet of elevation change noted between the soil boring locations

3.0 SUBSURFACE CONDITIONS

3.1 Typical Profile

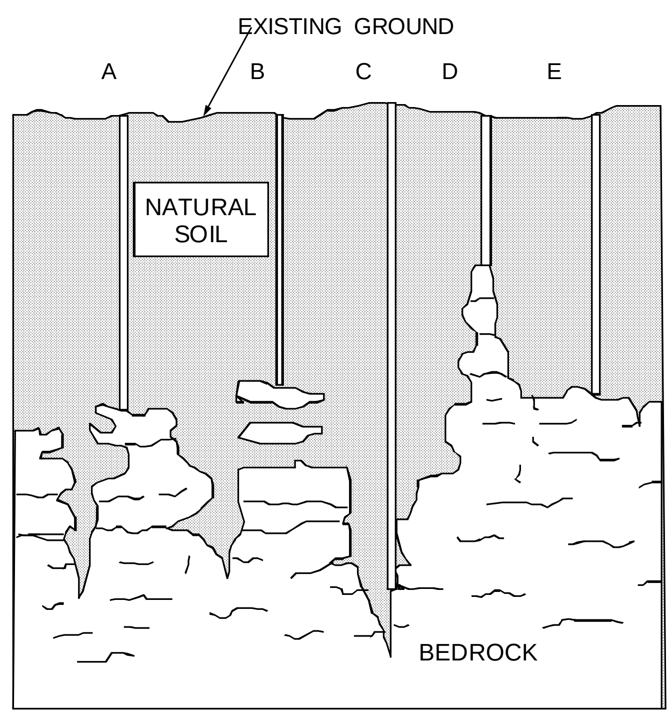
Based on the results of the borings, subsurface conditions on the project site can be generalized as follows:

Stratum	Approximate Depth to Bottom of Stratum (feet)	Boring Locations	Material Description	Consistency/ Density
Surface	1.2 to 1.7	All, except B-2	Topsoil	n/a
1	3½	B-1	Undocumented fill[1]; Sandy lean clay	Variable
2	3½ to undetermined[2]	All, except B-1	Native lean and fat clays with varying amounts of sand and gravel	Very soft to very stiff

Stratum	Approximate Depth to Bottom of Stratum (feet)	Boring Locations	Material Description	Consistency/ Density
3	6 to undetermined[3]	All, except B-4	Clayey sand with varying amounts of gravel and poorly-graded sand	Medium dense to very dense

1. Undocumented fill is defined as a man placed material that has no documentation or record of how the material was placed. These materials can be highly variable in nature if not placed in a properly controlled manner.
2. Boring B-4 encountered auger refusal material on a possible boulder or bedrock at an approximate depth of 7 feet below the ground surface.
3. Borings B-1 through B-3 were terminated within this stratum. Borings B-2 and B-3 were terminated at their planned termination depth of approximately 20 feet below the ground surface. Boring B-1 encountered auger refusal material on a possible boulder or bedrock at a depth of approximately 6 feet below the ground surface.

AUGER REFUSAL ILLUSTRATION



THIS FIGURE IS FOR ILLUSTRATIVE PURPOSES ONLY AND DOES NOT NECESSARILY DEPICT THE SPECIFIC BEDROCK CONDITIONS AT THIS SITE

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 adjacent figure. Linear interpolation of apparent bedrock elevations based upon the boring data is often used but can misrepresent actual rock removal quantities where anomalies exist. Additional borings, auger probes, test pits, or geophysical testing could be performed to obtain more specific bedrock information.

Conditions encountered at each boring location are indicated on the individual boring logs in Appendix A of this report. Stratification boundaries on the boring logs represent the approximate location of changes in soil types; the in-situ transition between materials may be gradual.

3.2 Groundwater

The boreholes were observed while drilling and after completion for the presence and level of groundwater. Free water was not noted during drilling operations. The absence of observed water does not mean that the boring terminated above groundwater. Due to the low permeability of some 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 in these materials. 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. In addition, perched water can develop over low permeability soil strata. Therefore, groundwater levels during construction or at other times in the life of the structures 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.

3.3 Geology

A review of the geology of the site was performed and a Geological Map is included in Appendix A of this report. Geological features reviewed include reported springs, sinkholes, faults, mines, and bedrock formations. Information regarding these features was courtesy of the Missouri Department of Natural Resources (MDNR) and the United States Geological Survey (USGS). Springs, sinkholes, faults, and mines may exist on the subject site that have yet to be identified/discovered or reported.

Based on the Geological Map of Missouri provided by the USGS, the subject site is located over the Jefferson City and Cotter Dolomite Bedrock Units. The Jefferson City and Cotter Formations are composed primarily of dolomite and some sandstone. Small amounts and layers of shale and chert are noted within this bedrock unit. It is possible that the sands noted in the boring logs are the result of weathered and/or poorly cemented sandstone units.

Solution features, including springs, caves, and sinkholes, are commonly present in the Jefferson City and Cotter Formations in this area. These springs and sinkholes are marked on the Geologic Map included in the appendix of this report. It should be noted that no sinkhole or spring is noted to be within 1 mile of the subject site; however, gaining streams less than 1 mile to the north and south of the site indicate that karst activity is occurring near the subject site. 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.

4.0 RECOMMENDATIONS FOR DESIGN AND CONSTRUCTION

4.1 Geotechnical Considerations

Based on the results of the preliminary subsurface exploration, laboratory testing, and our analyses, it is our opinion that the native soils are capable of supporting shallow foundation systems. Deep foundation systems may be possible utilizing skin friction and/or end bearing in soil. Additional exploration will be required to establish bedrock depths for end bearing in bedrock. Specific recommendations for appropriate foundation systems should be developed utilizing an appropriate subsurface exploration program. Preliminary geotechnical considerations for the subject site include the following:

- Soil Softening; and
- Existing undocumented fill.

4.1.1 Soil Softening Considerations

Very soft soils were encountered below stiff and medium dense soils in Boring B-2 at a depth of approximately 13½ feet below the ground surface. The occurrence of very soft soils below stiff soil is known locally as soil softening and in this area can be an indication of nearby karst formations such as voids in the subsurface caused by karst conduits, sinkholes, and caves. Soil softening caused by karst features occurs as soils are removed or piped away from the subgrade through an underground system of voids. The resulting subsurface erosion then causes the surrounding soils to loosen and fill in the voided area. Soil softening could also be caused by loosely deposited, wet, soils in drainage paths, which based on the USGS topographic map was noted to be a possibility near Boring B-2.

No evidence of a depression caused by a sinkhole was noted on the surface of the subject site; however, this does not necessarily indicate that subsurface erosion due to karst features is not occurring. In this area sinkholes can suddenly form at the surface when the underlying soils are eroded to the point where the cohesion in the surface soils is no longer capable of supporting itself.

The presence of soil softening does not necessarily indicate the presence of karst features and further testing could provide further insight into the cause of the soil softening. Additional testing of the subgrade could include additional borings, bedrock profiling, and other geophysical methods such as resistivity mapping and seismic reflection/refraction mapping. This additional testing can aid in the detection of sinkholes and karst development and help determine the extent of karst development if found. It should be noted that this additional testing can be costly and does not guarantee that existing or developing sinkholes will be identified.

4.1.2 Existing Undocumented Fill

Existing fill was encountered to depths of approximately 3½ feet in Boring B-1. The fill could extend deeper in areas not explored. The undocumented fill is noted near areas that appear to have been historically regraded based on aerial imagery provided by Google Earth™. If records are available, Terracon should be supplied with these documents to better assess the suitability of the existing fill.

Undocumented fill may contain soft or loose soils 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, larger than normal settlement resulting in cracking, differential movement, or other damage could occur in 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.

A final geotechnical exploration for development of geotechnical recommendations for design of the structures at the site should include a combination of additional borings in conjunction with test pits in the areas of the undocumented fills. The additional drilling and test pits will provide more data for evaluation of the risks associated with the fills at the site and will assist in developing economical means of addressing the fill for the proposed construction. Further, additional subsurface information will allow the owner and design team to prepare more accurate bid documents and budgets for the project.

4.1.3 General

Karst development is a common occurrence in this area due to the dissolution of the native limestone and dolomite bedrock material. 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.

4.2 Earthwork

4.2.1 Site Preparation

Topsoil can contain organics such as roots from grasses and other vegetation and should be removed from building areas. Frozen soil and undocumented fills are not acceptable bearing materials for building foundations. These materials should be removed and replaced so that the foundations and floor slabs for buildings and pavements bear on acceptable native soils or on properly placed and compacted engineered fill extending to the suitable native soils. Stripping and excavation depths will likely vary across the site. In addition, care should be taken by contractors to protect all existing improvements to remain, such as utilities.

High plasticity soils should not be placed in the upper 2 feet below the bottom of floor slabs and other flatwork abutting the structures. Suitable materials in this 2-foot-thick zone should meet the LVC requirements defined in section **4.2.3 Material Requirements** of this report.

Support of pavements on the existing fill may be considered if the owner is willing to accept the risk of unpredictable total and differential settlement within the existing fill. Excessive settlement may result in damage to pavements requiring increased maintenance or premature replacement costs. The risks associated with placement of pavements on the existing fill should be considered when determining whether pavements will be supported on the existing fill.

4.2.2 Soil Stabilization

Methods of subgrade improvement, as described below, could include scarification, moisture conditioning and recompaction, removal of unstable materials and replacement with granular fill (with or without geosynthetics) and chemical stabilization. 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 geotextiles (i.e., engineering fabric or geogrid) could also be considered after underground work such as utility construction is completed. Prior to placing the fabric or geogrid, we recommend that all below-grade construction, such as utility line installation, be completed to avoid damaging the fabric or geogrid. Equipment should not be operated above the fabric or geogrid until one full lift of crushed stone fill is placed above it. The maximum particle size of granular material placed over geotextile fabric or geogrid should meet the manufacturer's specifications, and generally should not exceed 1½ inches.

- **Chemical Stabilization** – Improvement of subgrades with Portland cement, lime kiln dust, Code L, or Class C fly ash could be considered for improving unstable soils. Chemical modification should be performed by a prequalified contractor having experience with successfully stabilizing subgrades in the project area on similar sized projects with similar soil conditions. Results of chemical analysis of the additive materials should be provided to the geotechnical engineer prior to use. The hazards of chemicals blowing across the site or onto adjacent property should also be considered. Additional testing would be needed to develop specific recommendations to improve subgrade stability by blending chemicals with the site soils. Additional testing could include, but not be limited to, evaluating various admixtures, the optimum amounts required, the presence of sulfates in the soil, and freeze-thaw durability of the subgrade.

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

4.2.3 Material Requirements

Materials that will be used as fill should be free of organic matter and debris. Frozen materials 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.

Fill Type[1]	USCS Classification	Acceptable Location for Placement
Lean Clay	CL (LL<50)	All locations and elevations, except as LVC material unless material explicitly meets LVC requirements.
Moderate to High Plasticity Material[2]	CH or CL (LL≥45 or PI≥25)	> 24 inches below building finished grade
Well-graded Granular[3]	GM, GC, SM, or SC	All locations and elevations
Low Volume Change (LVC) Material [4]	CL (LL<45 & PI<25) or Granular Material [3]	All locations and elevations
On-site Soils	CL	All locations and elevations
	SC	All locations and elevations
	CH	>24 inches below building finished grade

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.
2. Delineation of moderate to highly plastic clays should be performed in the field by a qualified geotechnical engineer or their representative, 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 24-inch thick low volume change zone.
3. Similar to crushed limestone aggregate or crushed stone containing at least 15 percent low plasticity fines may also be used. Material should be approved by the geotechnical engineer.
4. Low plasticity cohesive soil or granular soil having low plasticity fines. Material should be approved by the geotechnical engineer.

4.2.4 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]
Moisture Content Clay Soil	**LL<40**	-2 to +2 percent of optimum moisture content value [3]
	LL>40	0 to 4 percent above the optimum moisture content value [3]
Moisture Content Granular Material		Workable moisture levels [4]

1. Reduced lift thicknesses 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. Should 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.

4.2.5 Earthwork Construction Considerations

In periods of dry weather, the surficial soils may be of sufficient strength to allow fill construction on the stripped and grubbed ground surface. However, unstable subgrade conditions could develop during general construction operations, particularly if the soils are wet or subjected to repetitive construction traffic. The use of low ground pressure construction equipment would aid in reducing subgrade disturbance. The use of remotely operated equipment, such as a backhoe, would be beneficial to perform cuts and reduce subgrade disturbance. If unstable subgrade conditions are encountered, stabilization measures, as described in section **4.2.2 Soil Stabilization** will need to be employed.

Although groundwater was not encountered in the borings at depths expected to affect foundation excavations, it may be encountered during foundation excavation or in other excavation activities. In addition, some surface and/or perched groundwater may enter foundation excavations during construction. The volume of water seepage into shallow isolated excavations may be controllable with an appropriate number of sump pits and pumps; however, more extensive dewatering and/or subgrade stabilization may be required to facilitate construction if larger and/or deeper areas of cut are performed during earthwork operations.

4.3 Seismic Considerations

Based on the preliminary site investigation performed, the 2012 International Building Code (IBC) seismic site class for the subject sites is generally a D. The preliminary seismic site class was performed in general accordance with the *2012 International Building Code*, Table 1613.5.2. The current scope requested did not include the required 100-foot soil profile determination. Borings for this report extended to a maximum depth of approximately 20 feet and the site classification assumes that similar or stiffer soils extend to at least 100 feet. Additional exploration should be performed to further evaluate the seismic site class.

5.0 GENERAL COMMENTS

The contents of this report are for preliminary purposes only. Once the building plans are and site layout have been selected a final geotechnical exploration and report should be performed providing the foundation bearing capacities and detailed site recommendations based on the site layout and building requirements. Terracon should be retained to review the final design plans and specifications so comments can be made regarding interpretation and implementation of our geotechnical recommendations in the design and specifications. Terracon should also be retained to provide observation and testing services during grading, excavation, foundation construction and other earth-related construction phases of the project.

The discussion presented in this report is based upon the data obtained from the borings performed at the indicated locations and from other information discussed in this report. This report does not reflect variations that may occur between borings, across the site, or due to the modifying effects of construction or weather. The nature and extent of such variations may not become evident until after a final geotechnical report has been prepared or during or after construction. If variations appear, we should be immediately notified so that further evaluation and supplemental recommendations can be provided.

The scope of services for this project 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.

This preliminary report has been prepared for the exclusive use of our client for specific application to the project discussed and has been prepared in accordance with generally accepted geotechnical engineering practices. No warranties, either express or implied, are intended or made. Site safety, excavation support, and dewatering requirements are the responsibility of others.

APPENDIX A
FIELD EXPLORATION

Field Exploration Description

The boring locations were laid out in the field using a scaled site plan provided by the client and referencing available site features. Angles were estimated. The ground surface elevations at the boring locations were obtained using a surveyor's level and rod and were rounded to the nearest ½-foot. The elevations are referenced to the top of the fire hydrant designated as the Temporary Benchmark (TBM) on the Exploration Diagram, which was assigned an elevation of 100.0 feet. The locations and elevations of the borings should be considered accurate only to the degree implied by the means and methods used to define them.

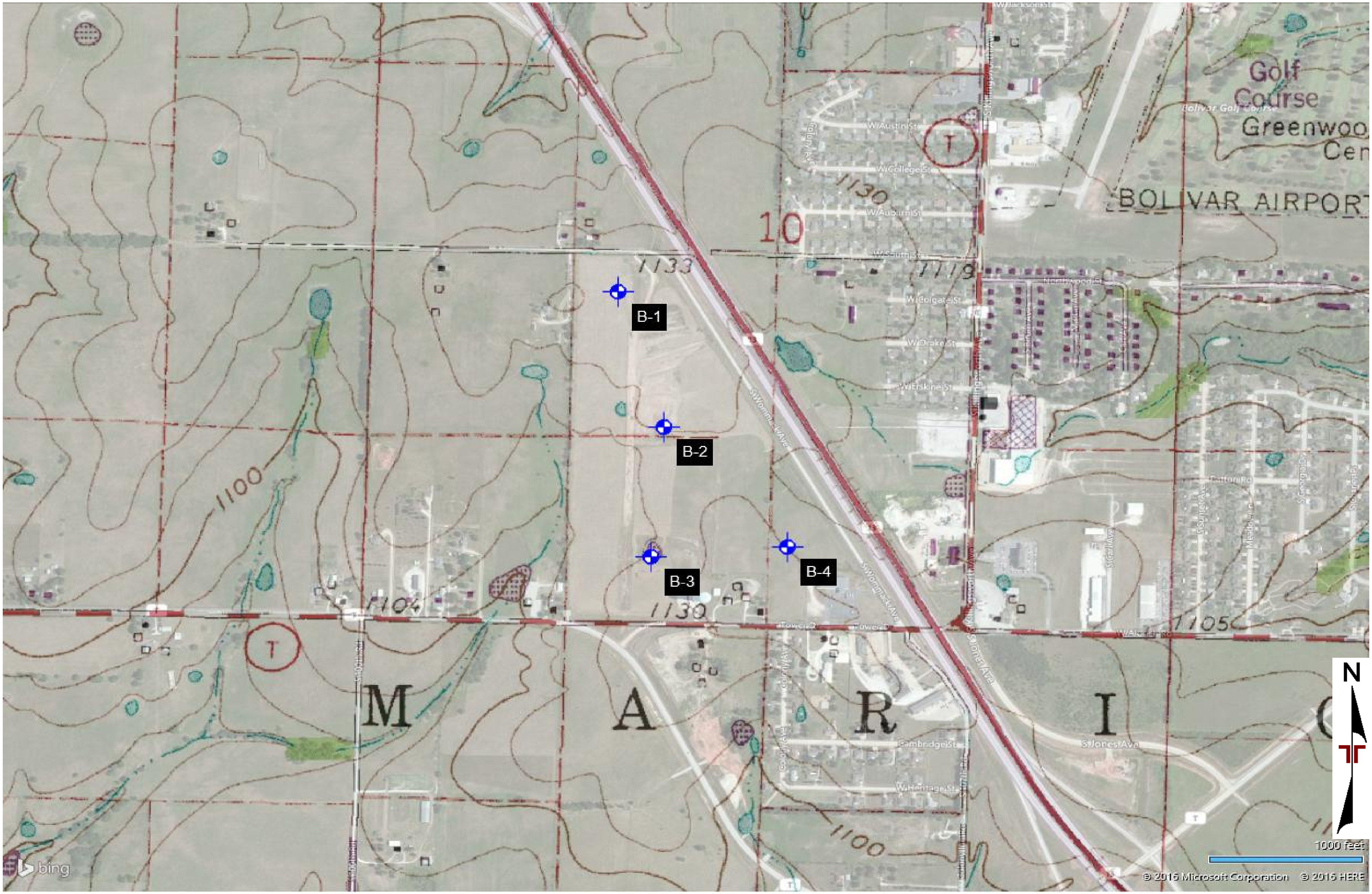
The borings were drilled with an ATV-mounted, rotary drill rig using continuous-flight, 4-inch solid-stem augers to advance the boreholes. Samples of the soils encountered in the borings were obtained using the split-barrel sampling procedures.

In the split-barrel sampling procedure, the number of blows required to advance a standard 2-inch O.D. split-barrel sampler the last 12 inches of the typical total 18-inch penetration by means of a 140-pound hammer with a free fall of 30 inches, is the standard penetration resistance (SPT N-value). This value is used to estimate the in-situ relative density of cohesionless soils and the consistency of cohesive soils.

A CME automatic SPT hammer was used to advance the split-barrel sampler in the borings performed on this site. A significantly greater efficiency is achieved with the automatic hammer as compared to the conventional safety hammer operated with a cathead and rope. This higher efficiency has an appreciable effect on the SPT N-value. The effect of this efficiency has been considered in the interpretation and analysis of the subsurface information for this report.

The samples were tagged for identification, sealed to reduce moisture loss, and taken to our laboratory for further observation, testing, and classification. Information provided on the boring logs attached to this report includes soil descriptions, consistency evaluations, boring depths, sampling intervals, and groundwater conditions. The borings were backfilled with auger cuttings prior to the drill crew leaving the site.

A field log of each boring was prepared by the drill crew. These logs included visual classifications of the materials encountered during drilling as well as the driller's interpretation of the subsurface conditions between samples. Final boring logs included with this report represent the engineer's interpretation of the field logs and include modifications based on laboratory observation and tests of the samples.



TOPOGRAPHIC MAP IMAGE COURTESY OF THE U.S. GEOLOGICAL SURVEY AND MICROSOFT BING MAPS

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

Project Manager: RTH	Project No. B5165061
Drawn By: RTH	Scale: Noted on Image
Checked By: AGM	File Name: B5165061-A.pdf
Approved By: AGM	Date: 10/7/2016

Terracon
Consulting Engineers & Scientists
4765 West Junction Street Springfield, MO 65802
P [417] 864-5100 F [417] 864-0871

TOPOGRAPHIC MAP

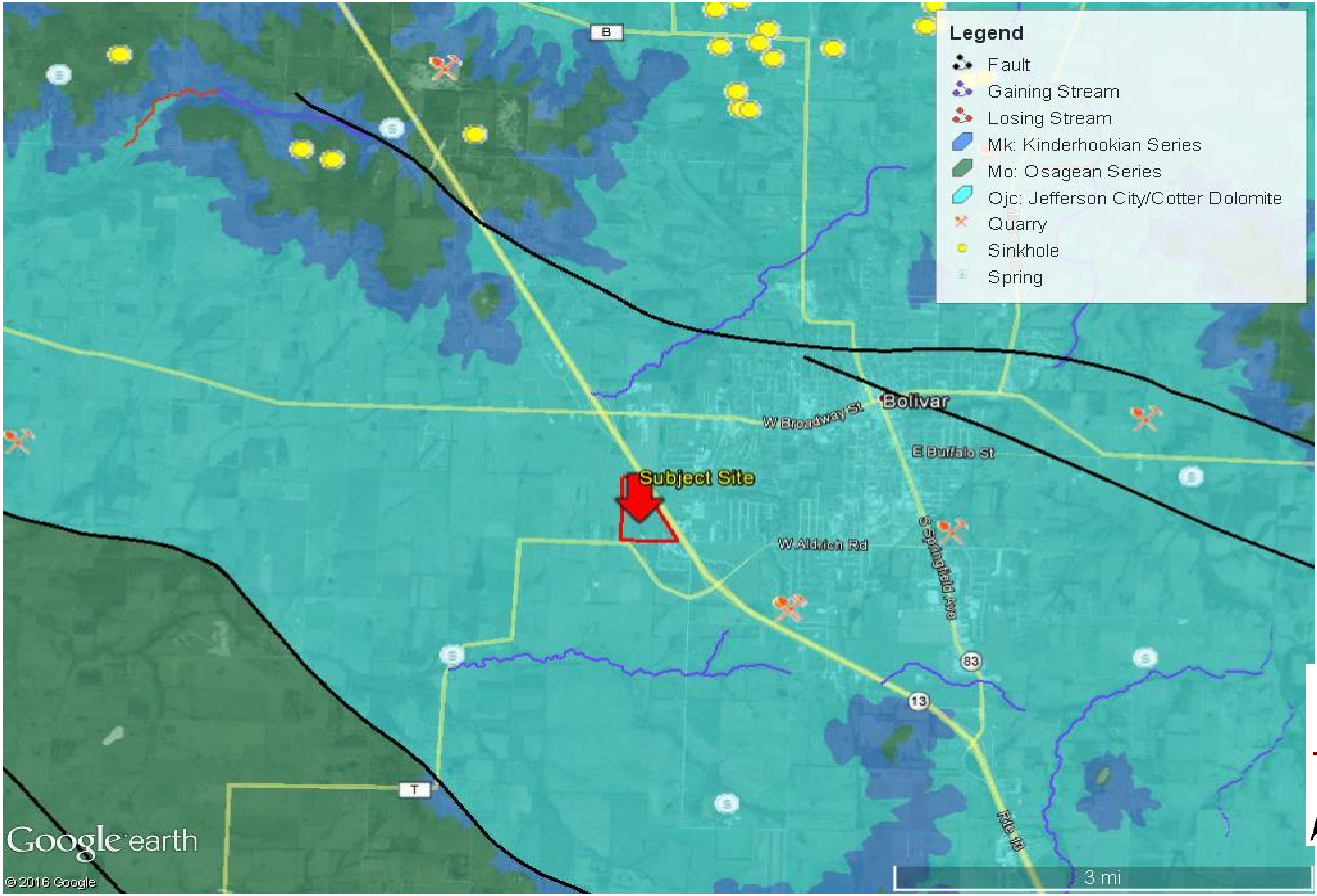
Bolivar Business Park

1700 South Wommack Avenue

Bolivar, Missouri

Exhibit

A-2



GEOLOGIC MAP IMAGE COURTESY OF THE MISSOURI DNR AND GOOGLE EARTH PRO™

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

Project Manager: RTH	Project No. B5165061	Drawn By: RTH	Scale: Noted on Image
Checked By: AGM	File Name: B5165061-A.pdf	Approved By: AGM	Date: 10/7/2016

Terracon
Consulting Engineers & Scientists
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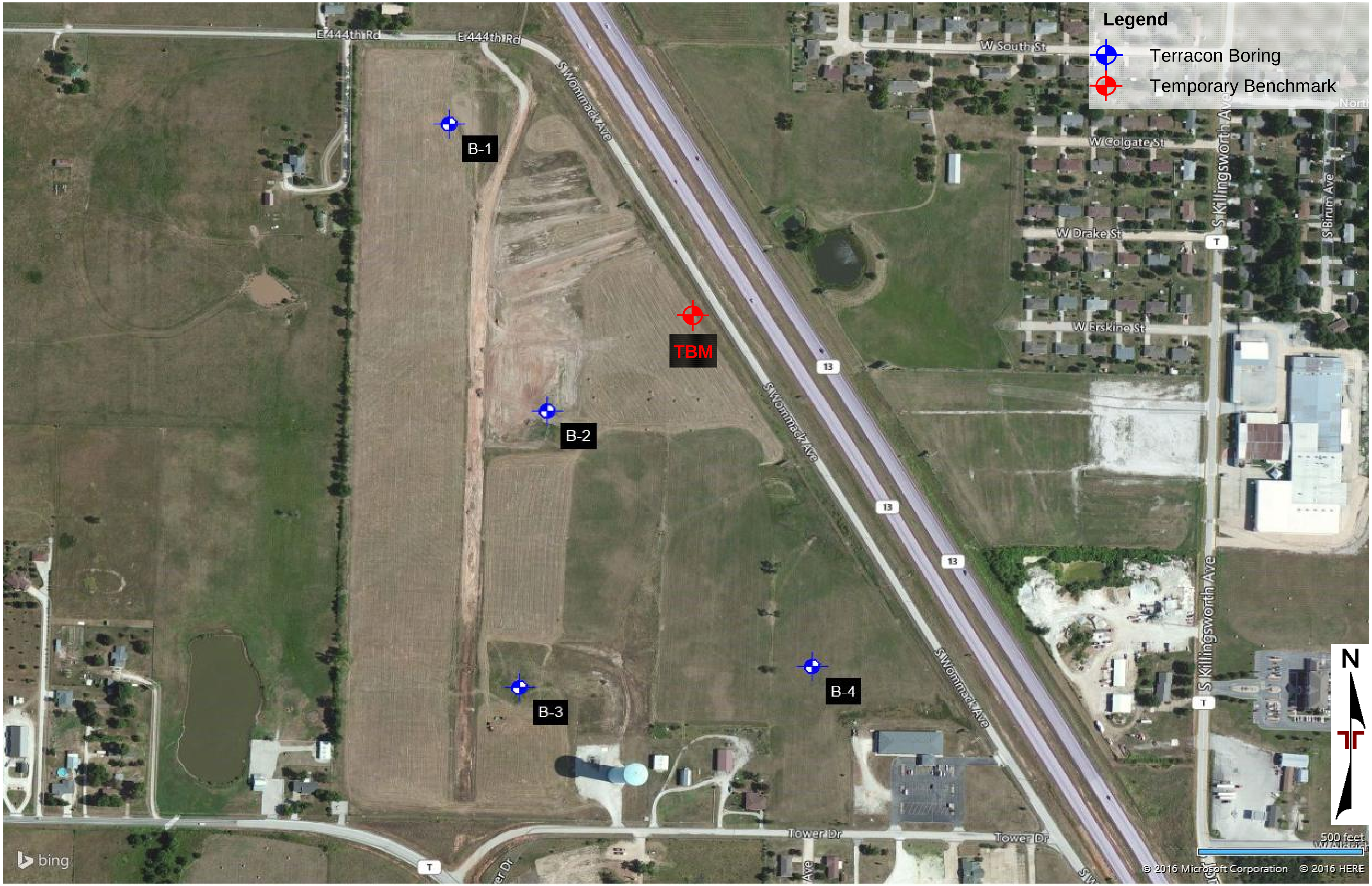
GEOLOGICAL MAP

Bolivar Business Park
1700 South Wommack Avenue
Bolivar, Missouri

Exhibit
A-3



AERIAL PHOTOGRAPHY PROVIDED BY MICROSOFT BING MAPS	Project Manager: RTH	Project No. B5165061	Terracon Consulting Engineers & Scientists	EXPLORATION DIAGRAM
	Drawn By: RTH	Scale: Noted on Image		Bolivar Business Park
DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES	Checked By: AGM	File Name: B5165061-A.pdf	4765 West Junction Street Springfield, MO 65802	1700 South Wommack Avenue
	Approved By: AGM	Date: 10/7/2016	P [417] 864-5100 F [417] 864-0871	Bolivar, Missouri

Exhibit

A-4

AERIAL PHOTOGRAPHY PROVIDED BY MICROSOFT BING MAPS. IMAGE OVERLAY PROVIDED BY THE CLIENT.

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

Project Manager: RTH	Project No. B5165061
Drawn By: RTH	Scale: Noted on Image
Checked By: AGM	File Name: B5165061-A.pdf
Approved By: AGM	Date: 10/7/2016

Terracon
Consulting Engineers & Scientists

4765 West Junction Street Springfield, MO 65802
P [417] 864-5100 F [417] 864-0871

BORING LOCATION DIAGRAM

Bolivar Business Park

1700 South Wommack Avenue

Bolivar, Missouri

Exhibit

A-5

BORING LOG NO. B-1

PROJECT: Bolivar Business Park

CLIENT: City of Bolivar
Bolivar, Missouri

SITE: 1700 S. Wommack Avenue
Bolivar, Missouri

LOCATION See Exhibit A-5

Latitude: 37.60464488° Longitude: -93.44348457°

Approximate Surface Elev: 98 (Ft.) +/-

DEPTH	Description	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (psf)	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
1.3	**TOPSOIL**	97+/-									
3.5	**FILL - SANDY LEAN CLAY (CL)**, trace organics, grayish-brown	94.5+/-				10	6-14-20 N=34	N/A	10		50
6.0	**CLAYEY SAND (SC)**, with gravel, light reddish brown, very dense	92+/-	5			5	50/5"	N/A	6		
	Auger Refusal at 6 Feet					0	50/0"	N/A			

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

Hammer Type: Automatic SPT Hammer

Advancement Method:
4" S.F.A.

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

See Exhibit A-1 for description of field procedures

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Elevations were measured in the field using a surveyor's level and grade rod

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
4765 W Junction St
Springfield, MO

Boring Started: 8/29/2016	Boring Completed: 8/29/2016
Drill Rig: CME-550X	Driller: TMcC
Project No.: B5165061	Exhibit: A-6

BORING LOG NO. B-2

PROJECT: Bolivar Business Park

**SITE: 1700 S. Wommack Avenue
Bolivar, Missouri**

**CLIENT: City of Bolivar
Bolivar, Missouri**

LOCATION See Exhibit A-5

Latitude: 37.60198793° Longitude: -93.44245586°

Approximate Surface Elev: 91.5 (Ft.) +/-

DEPTH	Material Description	ELEVATION (Ft.)
0.0–3.5	**LEAN CLAY (CL)**, with sand, trace gravel, reddish brown, stiff	88+/-
3.5–6.0	**CLAYEY SAND (SC)**, trace gravel, red, medium dense	85.5+/-
6.0–8.5	**FAT CLAY (CH)**, with sand, trace gravel, red, very stiff	83+/-
8.5–18.5	**FAT CLAY (CH)**, trace gravel, red, stiff very soft (at approx. 13.5 ft)	73+/-
18.5–20.0	**SAND (SP)**, poorly-graded with gravel, light gray, dense	71.5+/-
20.0	***Boring Terminated at 20 Feet***	

DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (psf)	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
1–2.5		X	12	4-5-8 N=13	6000 (HP)	12	25-12-13	
3.5–5		X	7	6-18-11 N=29	N/A	12		
6–7.5		X	14	5-9-7 N=16	7000 (HP)	18		
8.5–10		X	13	3-4-6 N=10	4000 (HP)	39		
13.5–15		X	9	0-0-0 N=0	2000 (HP)	53		
18.5–20		X	8	6-14-22 N=36	N/A	7		

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

Hammer Type: Automatic SPT Hammer

Advancement Method:
4" S.F.A.

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

See Exhibit A-1 for description of field procedures

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Elevations were measured in the field using a surveyor's level and grade rod

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
4765 W Junction St
Springfield, MO

Boring Started: 8/29/2016	Boring Completed: 8/29/2016
Drill Rig: CME-550X	Driller: TMcC
Project No.: B5165061	Exhibit: A-7

BORING LOG NO. B-3

PROJECT: Bolivar Business Park

**CLIENT: City of Bolivar
Bolivar, Missouri**

**SITE: 1700 S. Wommack Avenue
Bolivar, Missouri**

LOCATION See Exhibit A-5

Latitude: 37.59943151° Longitude: -93.44274609°

Approximate Surface Elev: 87 (Ft.) +/-

DEPTH	Description	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (psf)	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
	TOPSOIL										
1.2	**LEAN CLAY (CL)**, trace organics and sand, brown, stiff to very stiff	86+/-			X	14	4-6-8 N=14	6000 (HP)	12		
					X	17	3-6-12 N=18	3000 (HP)	15		47
4.5	**CLAYEY SAND (SC)**, with gravel, red, medium dense	82.5+/-	5								
					X	15	7-7-22 N=29	7000 (HP)	31		
8.5	**FAT CLAY (CH)**, with gravel, red, very stiff	78.5+/-			X	17	4-8-12 N=20	7000 (HP)	36		
			10								
	stiff				X	18	4-4-5 N=9	4500 (HP)	34		
			15								
18.0	**CLAYEY SAND (SC)**, with gravel, reddish brown, very dense	69+/-			X	8	14-50/5"	N/A	15		
20.0	***Boring Terminated at 20 Feet***	67+/-	20								

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

Hammer Type: Automatic SPT Hammer

Advancement Method:
4" S.F.A.

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

See Exhibit A-1 for description of field procedures

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Elevations were measured in the field using a surveyor's level and grade rod

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
4765 W Junction St
Springfield, MO

Boring Started: 8/29/2016	Boring Completed: 8/29/2016
Drill Rig: CME-550X	Driller: TMcC
Project No.: B5165061	Exhibit: A-8

BORING LOG NO. B-4

PROJECT: Bolivar Business Park

CLIENT: City of Bolivar
Bolivar, Missouri

SITE: 1700 S. Wommack Avenue
Bolivar, Missouri

LOCATION See Exhibit A-5

Latitude: 37.59962393° Longitude: -93.43967583°

Approximate Surface Elev: 86.5 (Ft.) +/-

GRAPHIC LOG	DEPTH	MATERIAL DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (psf)	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
		TOPSOIL										
	1.7		85+/-				14	4-10-12 N=22	6000 (HP)	11	23-13-10	
		LEAN CLAY (CL), brown, very stiff										
	3.5		83+/-									
		SANDY LEAN CLAY (CL), with gravel, reddish brown, very stiff					7	3-8-18 N=26	6000 (HP)	11		
				5								
	6.9		79.5+/-				11	6-50/5"	N/A	10		
		Auger Refusal at 6.9 Feet					0	50/0"	N/A			

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

Hammer Type: Automatic SPT Hammer

Advancement Method:
4" S.F.A.

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

See Exhibit A-1 for description of field procedures

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Elevations were measured in the field using a surveyor's level and grade rod

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
4765 W Junction St
Springfield, MO

Boring Started: 8/29/2016	Boring Completed: 8/29/2016
Drill Rig: CME-550X	Driller: TMcC
Project No.: B5165061	Exhibit: A-9

APPENDIX B
SUPPORTING INFORMATION

Laboratory Testing

Soil samples were tested in the laboratory to measure their natural water content (ASTM D4959). A hand penetrometer was used to estimate the unconfined compressive strength of some cohesive samples. The hand penetrometer has been correlated with unconfined compression tests and provides a better estimate of soil consistency than visual examination alone. Atterberg limits tests (ASTM D4318) and #200 washes (ASTM D1140) were performed on selected samples. The test results are provided on the boring logs included in Appendix A.

As part of the testing program, samples were examined in our laboratory and classified in accordance with the General Notes and the Unified Soil Classification System (USCS) based on the material's texture and plasticity (ASTM D2487 and ASTM D2488). The USCS group symbol is shown on the boring logs, and a brief description of the USCS is included with this report in Appendix C.

Procedural 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.

APPENDIX C
SUPPORTING DOCUMENTS

GENERAL NOTES

DESCRIPTION OF SYMBOLS AND ABBREVIATIONS

SAMPLING

- Auger
- Split Spoon
- Shelby Tube
- Macro Core
- Ring Sampler
- Rock Core
- Grab Sample
- No Recovery

WATER LEVEL

- 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.

FIELD TESTS

(HP)	Hand Penetrometer
(T)	Torvane
(b/f)	Standard Penetration Test (blows per foot)
(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 Includes gravels, sands and silts.			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.**	**Ring Sampler Blows/Ft.**	**Descriptive Term (Consistency)**	**Unconfined Compressive Strength, Qu, psf**	**Standard Penetration or N-Value Blows/Ft.**	**Ring Sampler Blows/Ft.**
Very Loose	0 - 3	0 - 6	Very Soft	less than 500	0 - 1	< 3
Loose	4 - 9	7 - 18	Soft	500 to 1,000	2 - 4	3 - 4
Medium Dense	10 - 29	19 - 58	Medium-Stiff	1,000 to 2,000	4 - 8	5 - 9
Dense	30 - 50	59 - 98	Stiff	2,000 to 4,000	8 - 15	10 - 18
Very Dense	> 50	$\geq$ 99	Very Stiff	4,000 to 8,000	15 - 30	19 - 42
			Hard	> 8,000	> 30	> 42

RELATIVE PROPORTIONS OF SAND AND GRAVEL

Descriptive Term(s) of other constituents	Percent of Dry Weight
Trace	< 15
With	15 - 29
Modifier	> 30

GRAIN SIZE TERMINOLOGY

Major Component of Sample	Particle Size
Boulders	Over 12 in. (300 mm)
Cobbles	12 in. to 3 in. (300mm to 75mm)
Gravel	3 in. to #4 sieve (75mm to 4.75 mm)
Sand	#4 to #200 sieve (4.75mm to 0.075mm
Silt or Clay	Passing #200 sieve (0.075mm)

RELATIVE PROPORTIONS OF FINES

Descriptive Term(s) of other constituents	Percent of Dry Weight
Trace	< 5
With	5 - 12
Modifier	> 12

PLASTICITY DESCRIPTION

Term	Plasticity Index
Non-plastic	0
Low	1 - 10
Medium	11 - 30
High	> 30

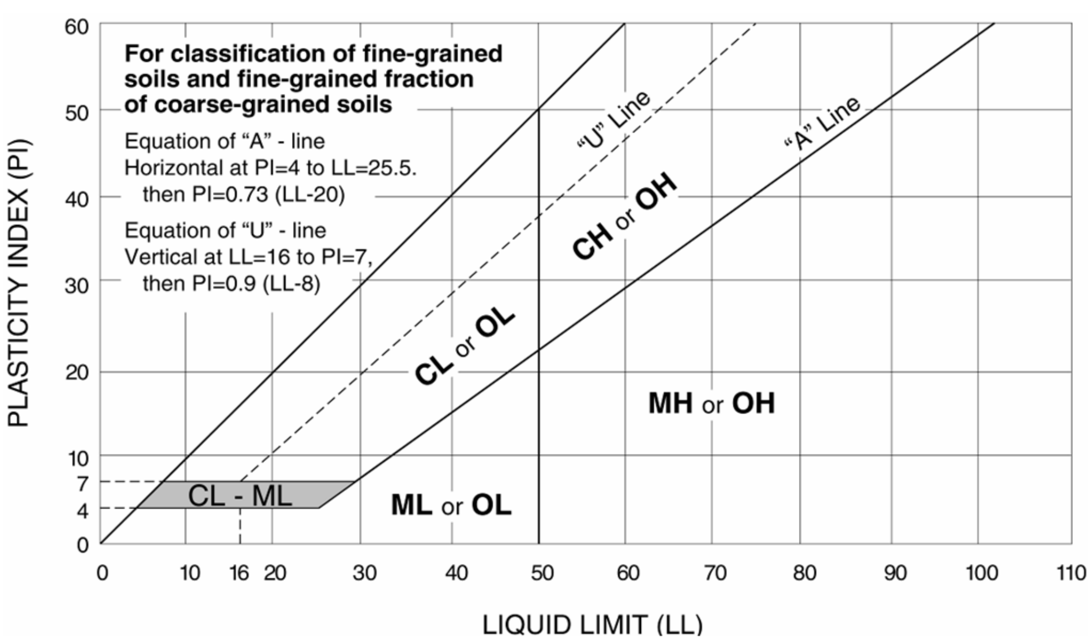
UNIFIED SOIL CLASSIFICATION SYSTEM

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests [A]					Soil Classification: Group Symbol	Soil Classification: 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 ≥ 4 and 1 ≤ Cc ≤ 3 [E]		GW	Well-graded gravel [F]
			Cu < 4 and/or 1 > Cc > 3 [E]		GP	Poorly graded gravel [F]
		Gravels with Fines: More than 12% fines [C]	Fines classify as ML or MH		GM	Silty gravel [F,G,H]
			Fines classify as CL or CH		GC	Clayey gravel [F,G,H]
	Sands: 50% or more of coarse fraction passes No. 4 sieve	**Clean Sands:** Less than 5% fines [D]	Cu ≥ 6 and 1 ≤ Cc ≤ 3 [E]		SW	Well-graded sand [I]
			Cu < 6 and/or 1 > Cc > 3 [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] $Cu = D_{60}/D_{10} \quad Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}}$

[F] If soil contains ≥ 15% sand, add "with sand" to group name.
[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.
[H] If fines are organic, add "with organic fines" to group name.
[I] If soil contains ≥ 15% gravel, add "with gravel" to group name.
[J] If Atterberg limits plot in shaded area, soil is a CL-ML, silty clay.
[K] If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel," whichever is predominant.
[L] If soil contains ≥ 30% plus No. 200 predominantly sand, add "sandy" to group name.
[M] If soil contains ≥ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.
[N] PI ≥ 4 and plots on or above "A" line.
[O] PI < 4 or plots below "A" line.
[P] PI plots on or above "A" line.
[Q] PI plots below "A" line.



Terracon

Exhibit C-2