Geotechnical Engineering Report

Ingersoll Building Addition II

Rockford, Illinois

May 1, 2014

Terracon Project No. 19135006

Prepared for:

City of Rockford
Rockford, Illinois

Prepared by:

Terracon Consultants, Inc.
Rockford, Illinois

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Geotechnical ■ Environmental ■ Construction Materials ■ Facilities

Terracon

May 1, 2014

City of Rockford
Public Works Department
Engineering Division
425 East State Street
Rockford, Illinois 61104

Attn: Mr. Matthew Vitner

Re: Geotechnical Engineering Report
Ingersoll Building Addition II
South Water Street
Rockford, Illinois
Terracon Project No. 19135006

Dear Mr. Vitner:

Terracon Consultants, Inc. (Terracon) has completed the geotechnical engineering services for the above referenced project. These services were performed in general accordance with our proposal numbered P19140011A and dated February 6, 2014.

Fourteen (14) borings were previously performed for this site and the results of that exploration were discussed in Terracon's Geotechnical Engineering Report dated May 7, 2013 (Terracon Project No. 19135006). Subsequently, the proposed building addition location was moved and nine (9) additional borings were requested. This report presents the results of the additional subsurface exploration and provides recommendations regarding earthwork and the design and construction of foundations, floor slabs, and below-grade walls for the 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 to you, please contact us.

Sincerely,
TERRACON CONSULTANTS, INC.

LICENSED PROFESSIONAL ENGINEER
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EXECUTIVE SUMMARY

Terracon Consultants, Inc. (Terracon) has completed the subsurface exploration for the proposed Ingersoll Building Addition in Rockford, Illinois. Nine (9) borings extending to depths ranging from about 5 to 40 feet below existing grades were performed for the project. This report describes the subsurface conditions encountered at the boring locations, presents the test data, and provides recommendations regarding the design and construction of foundations, floor slabs, and below-grade walls for the project

Based on the information obtained from our subsurface exploration, the following geotechnical considerations were identified:

East Lobby Addition

- Existing fill materials consisting primarily of sand with variable amounts of clay, gravel, and asphalt fragments were encountered in Borings B-15 and B-16 to a depth of about 13 feet below existing surface grades. Based on the proposed elevation of the addition, the base of the addition will be at or near the interface of the existing fill and the underlying native soils. It is our opinion that the proposed building addition can be supported on shallow footings bearing on medium dense native sand soils or on newly placed engineered fill that extends to suitable native soils.

South Court Addition

- Existing fill materials consisting primarily of lean clay and sand with varying amounts of silt, gravel, cinders, and concrete debris were encountered in Borings B-17 to B-20 to depths ranging from about 5 to 8 feet below existing floor slab elevation. The fill was variable in composition, consistency, and moisture content. Below the fill, loose sands and lower strength clay and silt soils were encountered to depths ranging from about 11 to 13 feet below existing floor slab elevation. In our opinion, to reduce the potential for unpredictable building performance and excessive differential settlement, foundation support for the addition should extend through the fill and new foundations should bear on tested and approved native soils or on engineered fill that extends to approved native soils. This can be accomplished through removal and replacement of the existing fill, or extending the foundations to limestone bedrock with deep foundations.

- Based on the subsurface conditions encountered in the borings, support of the building on augered cast-in-place (ACIP) pile foundations bearing in the highly weathered limestone bedrock is recommended. An allowable end bearing capacity of 30 kips per square foot (ksf) can be used for design of ACIP piles socketed at least one foot into the highly weathered limestone bedrock encountered in multiple borings.

- Based on the subsurface conditions encountered in the borings, support of the floor slab should be accomplished by redirecting all of the loads to the building foundation system

or by removal and replacement of the existing fill and loose sands/soft clay to a depth of about 13 feet below existing site grades. If a structurally supported slab or complete removal/replacement of the unsuitable subgrade soils is not economically feasible, a partial removal (minimum 2 feet) and replacement of the existing fill materials could be considered, provided the owner is willing to accept the risk associated with supporting the floor slabs over the existing fill materials in exchange for reduced construction costs.

General Site Conditions

- Care must be exercised during construction within/adjacent to the existing building to avoid disturbing the soils supporting existing foundations and/or undermining of foundations and floor slabs.

- Close monitoring of the construction operations discussed herein will be critical in achieving the design subgrade support. We therefore recommend that Terracon be retained to provide observation/testing during this portion of the work.

This summary should be used in conjunction with the entire report for design purposes. It should be recognized that details were not included or fully developed in this section, and the report must be read in its entirety for a comprehensive understanding of the items contained herein. The section titled **GENERAL COMMENTS** should be read for an understanding of the report limitations.

GEOTECHNICAL ENGINEERING REPORT
INGERSOLL BUILDING ADDITION II
ROCKFORD, ILLINOIS

Terracon Project No. 19135006
May 1, 2014

1.0 INTRODUCTION

Terracon Consultants, Inc. (Terracon) has completed a subsurface exploration for the proposed Ingersoll Building Addition in Rockford, Illinois. Fourteen (14) borings (designated B-1 to B-14) were previously performed for this site and reported in Terracon's Geotechnical Engineering Report (Terracon Project No. 19135006, report dated May 7, 2013). Subsequently, the proposed building addition location was moved. Nine (9) additional borings (designated B-15 to B-23) extending to depths ranging from about 5 to 40 feet below existing grades were performed for the project. Boring logs and a Boring Location Diagram are included in Appendix A.

The purpose of these services is to provide information and geotechnical engineering recommendations relative to the proposed building addition, including:

- site preparation and earthwork
- design and construction of shallow footing foundations
- design and construction of auger-cast piles
- floor slab subgrade preparation
- design and construction of below grade walls
- seismic site class

2.0 PROJECT INFORMATION

2.1 Project Description

ITEM	DESCRIPTION
Site layout	See Appendix A, Exhibit A-2 Boring Location Diagram
Structure	The proposed construction will consist of two (2) additions to the existing structure. The first addition will be a new two-story East Lobby along the east side of the existing structure. The lobby addition will be a steel-framed structure with a plan area of about 1600 square feet. The second addition will be a new South Court along the south end of the existing pre-cast concrete structure. This addition is planned within the area of an existing structure that will be removed prior to construction of the addition. The South Court addition will be a single-story steel-framed structure with a plan area of about 11,000 square feet.

ITEM	DESCRIPTION
Maximum loads	Structural loads were not provided. The following values were assumed: Columns: 200 kips Walls: 4 kips per lineal foot Slabs: 150 psf
Finished Floor Elevation	The finished floor elevations provided are as follows: East Lobby Lower Level 101'9" East Lobby Upper Level 117'9" South Court 101'9'
Grading	Based on our understanding of the proposed elevations and current site grades, cuts of up to 12 feet and fills of up to 3 feet are expected.

2.2 Site Location and Description

ITEM	DESCRIPTION
Location	The site is at the existing Ingersoll Building along the east bank of the Rock River at South Water Street in Rockford, Illinois.
Current Site Improvements	The Ingersoll Building is a single-story, steel framed structure with a finished floor elevation of 100' (site datum). A narrow strip of land runs along most of the west side of the building adjacent to the existing concrete retaining wall and river.
Existing topography	A site topographic plan was not provided, but the existing floor slab along the south side of the building is flat. The existing ground elevation on the east side of the proposed east lobby addition is about 15 feet above the existing building floor slab elevation.

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:

East Lobby Addition (Borings B-15 and B-16):

Description	Approximate Depth to Bottom of Stratum	Material Encountered	Consistency/Density
Surface	12 to 13 inches	Existing pavement: Approximately 3 inches of asphalt over approximately 9 to 10 inches of crushed stone aggregate	N/A
Stratum 1	13 feet	Fill: sand with varying amounts of clay, gravel, and asphalt fragments or lean clay with variable amounts of sand and gravel	N/A
Stratum 2 [1]	Termination depth of 30 feet	Native granular soils: sand with varying amounts of gravel	Medium dense

1. Stratum 2 extended to the termination depth of 30 feet for Borings B-15 and B-16.

South Court Addition (Borings B-17 to B-21):

Description	Approximate Depth to Bottom of Stratum	Material Encountered	Consistency/Density
Surface	9 to 12 inches	Existing floor slab: Approximately 7 to 9½ inches of Portland cement concrete over approximately 2 to 4 inches of crushed stone aggregate	N/A
Stratum 1	5 to 13 feet	Fill: sand with varying amounts of clay, gravel, and cinders or lean clay with varying amounts of sand and silt	N/A
Stratum 2A [1]	11 to 13 feet	Native granular soils: sand with varying amounts silt	Loose
Stratum 2B [2]	12 to 13 feet	Native cohesive soils: lean clay with varying amounts of sand, silt, and organics or silt with varying amounts of clay	Medium stiff to stiff
Stratum 3 [3]	12 to 38 feet	Native granular soils: sand with varying amounts gravel	Loose to very dense
Stratum 4 [4]	Termination depths of 25 to 40 feet	Weathered limestone	N/A

1. Stratum 2A was encountered in Borings B-17 and B-20.
2. Stratum 2B was encountered in Borings B-18 and B-19.
3. Stratum 3 extended to the termination depth of 25 feet for Borings B-17 and B-19.
4. Stratum 4 extended to the termination depth of 25 feet for Boring B-18, the termination depth of 33 feet for Boring B-20, and to the termination depth of 40 feet for Boring B-21.

Existing Northeast Pavement (Borings B-22 through B-23):

Description	Approximate Depth to Bottom of Stratum	Material Encountered	Consistency/Density
Surface	6 inches	Existing pavement: Approximately 2 inches of asphalt over approximately 4 inches of crushed stone aggregate	N/A
Stratum 1 [1]	Termination depth of 5 feet	Fill: clayey sand or sand with varying amounts of clay and gravel	N/A

1. Stratum 1 extended to the termination depth of 5 feet for Borings B-22 and B-23.

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

3.2 Water Level Observations

The borings were observed during and after the completion of drilling for the presence and level of water. Longer term observations in cased holes or piezometers, sealed from the influence of surface water, would be required for a better evaluation of the groundwater conditions on this site.

Boring Number	Observed Water Depth (feet) [1]	
	While Drilling	After Drilling
15	13	13
16	13	13
17	11	11
18	N/A	N/A
19	8	8
20	8	8
21	8	8
22	N/A	N/A
23	N/A	N/A

[1] Below existing grade

Water levels may fluctuate due to seasonal variations in the amount of rainfall, runoff, adjacent river elevation, and other factors not evident at the time the borings were performed. Subsurface water levels during construction or at other times in the future may be different from the conditions encountered during drilling. Trapped or “perched” water could occur above lower

permeability soil layers. Water level fluctuations and perched water should be considered when developing design and construction plans and specifications for the project.

4.0 RECOMMENDATIONS FOR DESIGN AND CONSTRUCTION

4.1 Geotechnical Considerations

The soil boring data and laboratory test results were evaluated to develop recommendations for site preparation and the design and construction of foundations, floor slabs, and below-grade walls for the project.

East Lobby Addition
Existing fill materials consisting primarily of sand with variable amounts of clay, gravel, and asphalt fragments were encountered in Borings B-15 and B-16 to a depth of about 13 feet below existing surface grades. Based on the proposed elevation of the addition, the base of the addition will be at or near the interface of the existing fill and the underlying native soils. It is our opinion that the proposed building addition can be supported on shallow footings bearing on medium dense fill native sand soils or on newly placed engineered fill that extends to suitable native soils.

South Court Addition
Existing fill materials consisting primarily of lean clay and sand with varying amounts of silt, gravel, cinders, and concrete debris were encountered in Borings B-17 to B-20 to depths ranging from about 5 to 8 feet below existing floor slab elevation. The fill was variable in composition, consistency, and moisture content. Below the fill, loose sands and lower strength clay and silt soils were encountered to depths ranging from about 11 to 13 feet below existing floor slab elevation. In our opinion, to reduce the potential for unpredictable building performance and excessive differential settlement, foundation support for the addition should extend through the fill and new foundations should bear on tested and approved native soils or on engineered fill that extends to approved native soils. This can be accomplished through removal and replacement of the existing fill, or extending the foundations to limestone bedrock with deep foundations.

Based on the subsurface conditions encountered in the borings, support of the building on augered cast-in-place (ACIP) pile foundations bearing in the highly weathered limestone bedrock is recommended. An allowable end bearing capacity of 30 kips per square foot (ksf) can be used for design of ACIP piles socketed at least one foot into the highly weathered limestone bedrock encountered in multiple borings. Other deep foundations types could be considered, such as driven piles or drilled shafts. However, based on the subsurface conditions, water levels, and the proximity of existing structures, it is our opinion that ACIP piles would be the preferred deep foundation system for the south court addition. We are available to discuss other deep foundation systems, upon request.

Based on the subsurface conditions encountered in the borings, support of the floor slab should be accomplished by redirecting all of the loads to the building foundation system or by removal and replacement of the existing fill and loose sands/soft clay to a depth of about 13 feet below existing site grades. If a structurally supported slab or complete removal/replacement of the unsuitable subgrade soils is not economically feasible, a partial removal (minimum 2 feet) and replacement of the existing fill materials could be considered, provided the owner is willing to accept the risk associated with supporting the floor slabs over the existing fill materials in exchange for reduced construction costs.

General Site Conditions

Expansion joints should be provided between the existing building and the proposed addition to accommodate differential movement between the structures. Underground piping between the addition and existing structure should be designed with flexible couplings and utility knockouts in foundation walls should be oversized to allow minor deviations in alignment without breakage or distress. Alternately, new foundations adjacent to the existing building could be tied to the existing foundations to avoid differential settlement at these locations. The structural engineer should review these options based on the as-built conditions of the existing facility.

Our recommendations for earthwork, design and construction of shallow foundations, design and construction of auger-cast pile foundations, and subgrade preparation for floor slabs for the project are presented in the following sections.

4.2 Earthwork

Earthwork on the project should be observed and evaluated by Terracon. Recommendations for site preparation, excavation, subgrade preparation and placement of engineered fill for the project are provided in the following sections.

4.2.1 Site Preparation

In general, site preparation should begin with removal of the existing building, vegetation, topsoil, and any very loose, soft, or otherwise unsuitable materials from the construction area.

After stripping, the subgrade should be proofrolled where possible to aid in locating loose or soft areas. Proofrolling of can typically be accomplished with a loaded tandem-axle dump truck having a gross weight of at least 25 tons, or similarly loaded equipment. Areas that display excessive deflection (pumping) or rutting during proofroll operations should be improved by scarification and recompaction, or removal and replacement with engineered fill. The undercut areas should be backfilled with new engineered fill that meets the material requirements and placement/compaction guidelines provided in this report. In areas where proofrolling is not practical, a Terracon representative should observe and test the subgrade.

Where fill is placed on existing slopes steeper than 5H:1V, benches should be cut into the existing slopes prior to fill placement. The benches should have a minimum vertical face height of 1 foot and a maximum vertical face height of 3 feet and should be cut wide enough to accommodate the compaction equipment. This benching will help provide a positive bond between the fill and natural soils and reduce the possibility of failure along the fill/natural soil interface. Furthermore, we recommend that fill slopes be over filled and then cut back to develop an adequately compacted slope face.

Care should be taken to avoid disturbance of prepared subgrades and soils supporting the existing building. Subgrades comprised of loose sand soils are easily disturbed by construction traffic. Repetitive traffic on subgrade soils should be avoided to reduce the associated repair work required to improve the subgrade. Subgrade materials must be properly prepared to provide a suitable bearing surface for support of slabs and for compaction of engineered fill. Placement of a layer of crushed limestone would provide a working surface and reduce disturbance of the subgrade by construction traffic.

4.2.2 Engineered Fill Material Requirements

Engineered fill should meet the following material property requirements:

Fill Type [1]	USCS Classification	Acceptable Location for Placement
Granular	GW, GP, GM, GC SW, SP, SM, SC	Below/adjacent to foundations and slabs
Cohesive	CL, CL-ML	Below/adjacent to foundations and slabs
Unsuitable	CH, MH, OL, OH, PT	Non-structural locations

1. Engineered fill should consist of approved materials that are free of organic matter and debris. Cohesive fill materials should have liquid limit less than 45 and a plasticity index less than 20; cohesive soils that do not meet these criteria should be considered “unsuitable.” 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 prior to use on this site.

4.2.3 Fill Placement and Compaction Requirements

Item	Description
Fill Lift Thickness	9 inches or less in loose thickness; thinner lifts will be required when using hand equipment (e.g., jumping jack, vibratory plate compactor, etc.)
Compaction of Granular Material and Cohesive Soil [1, 2]	Fill placed below design footing bearing level and in the upper 12 inches of design subgrade below slabs should be compacted to at least 98 percent of the material’s standard Proctor maximum dry density (ASTM D 698). We recommend that backfill placed above footing level and more than 12 inches below final grade for support of floor slabs be compacted to at least 95 percent of the above specified density.

Item	Description
Moisture Content of Cohesive Soil	Within 2% below to 3% above the standard Proctor optimum moisture content at the time of placement and compaction.
Moisture Content of Granular Material [3]	Workable moisture levels.

1. 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.
2. If the granular material is a coarse sand or gravel, is of a uniform size, or has a low fines content, compaction comparison to relative density (ASTM D 4253 and D 4254) may be more appropriate. In this case, granular materials should be compacted to at least 60% of the material's maximum relative density.
3. Specifically, moisture levels should be maintained to achieve compaction without subgrade pumping when proofrolled.

4.2.4 Earthwork Construction Considerations

Terracon should be retained during the construction phase of the project to observe earthwork and to perform necessary tests and observations during stripping of surface materials, subgrade preparation, proofrolling, placement and compaction of controlled compacted fills, backfilling of excavations, and just prior to construction of building floor slabs.

Based on conditions encountered in the borings, significant seepage is expected in excavations of greater than 3 feet in depth for this project (e.g., for foundations and utility installation). If seepage is encountered, the contractor is responsible for employing appropriate dewatering methods to control seepage and facilitate construction. In our experience, dewatering of excavations in clay and silt soils can typically be accomplished using sump pits and pumps. If seepage is encountered in granular soils, a more extensive dewatering system may be required.

Care should be taken to avoid disturbance of prepared subgrades. Unstable subgrade conditions could develop during general construction operations, particularly if the soils are wetted and/or subjected to repetitive construction traffic. New fill compacted above optimum moisture content or that accumulates water during construction can also become disturbed under construction equipment. Construction traffic over the completed subgrade should be avoided to the extent practical. If the subgrade becomes saturated, desiccated, or disturbed, the affected materials should either be scarified and compacted or be removed and replaced. Subgrades should be observed and tested by Terracon prior to construction of slabs and pavements.

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, state, and federal safety regulations. The contractor should be aware that slope height, slope inclination, and excavation depth should in no instance exceed those specified by these safety regulations. Flatter slopes than those dictated by these regulations may be required depending

upon the soil conditions encountered and other external factors. These regulations are strictly enforced and if they are not followed, the owner, contractor, and/or earthwork and utility subcontractor could be liable and subject to substantial penalties. Under no circumstances should the information provided in this report be interpreted to mean that Terracon is responsible for construction site safety or the contractor's activities. Construction site safety is the sole responsibility of the contractor who shall also be solely responsible for the means, methods, and sequencing of the construction operations.

4.2.5 Grading and Drainage

During construction, grades should be developed to direct surface water flow away from or around the site. Exposed subgrades should be sloped to provide positive drainage so saturation of subgrades is avoided. Surface water should not be permitted to accumulate on the site.

Final grades should slope away from the building to promote rapid surface drainage. Accumulation of water adjacent to the building could contribute to significant moisture increases in the subgrade soils and subsequent settlement. Roof drains should discharge into a storm sewer or at least 10 feet away from the building.

It is recommended that all exposed earth slopes be seeded to provide protection against erosion. Seeded slopes should be protected with erosion mats until the vegetation is established.

4.3 East Lobby Addition Foundations

In our opinion, the proposed east lobby addition may be supported on shallow footings bearing on medium dense native sand soils or on newly placed engineered fill that extends to suitable native soils. Footings should not be supported on existing fill.

Unsuitable soils (such as existing fill or loose sands) encountered at design footing bearing depth should be removed and replaced with engineered fill or the foundations should extend through such materials to the native suitable soils. In addition, the remedial methods recommended in Section 4.3.2 should be implemented.

Design recommendations for conventional footing foundations to support the proposed east lobby addition are presented below.

4.3.1 Shallow Footing Foundation Design Recommendations

DESCRIPTION	VALUE
Maximum net allowable bearing pressure [1]	2,500 psf
Minimum embedment below finished grade for frost protection [2]	3½ feet

DESCRIPTION	VALUE
Minimum footing widths	Isolated footings: 30 inches Continuous footings: 18 inches
Approximate total settlement [3, 4]	1 inch
Approximate differential settlement within the new addition[3, 4]	1/2 to 2/3 of the total settlement

1. The recommended net allowable bearing pressure is the pressure in excess of the minimum surrounding overburden pressure at the footing base elevation. This pressure assumes that any lower strength soils or otherwise unsuitable materials, if encountered, will be undercut and replaced with engineered fill.
2. For perimeter footings, footings beneath unheated areas, and footings that will be exposed to freezing conditions during construction.
3. The foundation settlement will depend upon the variations within the subsurface soil profile, the structural loading conditions, the embedment depth of the footing, and if applicable, the thickness of engineered fill, and the quality of earthwork operations.
4. Where additions will attach to the existing building, connections with sufficient flexibility to accommodate independent movement should be utilized. Differential settlement between the new additions and the existing building may approach the estimated total settlement unless the new and existing foundations are tied together.

If portions of the new additions will be supported on existing foundations, the increased loads could cause additional settlement of the existing foundations. The structural capacity of the existing foundation should be evaluated by the project structural engineer where any increase in loading is planned. During construction, Terracon should also observe and test the bearing conditions beneath existing footings where increased loading is planned.

4.3.2 Shallow Footing Foundation Construction Considerations

The soils at the base of each footing excavation should be observed and tested by Terracon. The excavation should be probed or otherwise sampled at each isolated spread footing and at regular intervals along continuous footings.

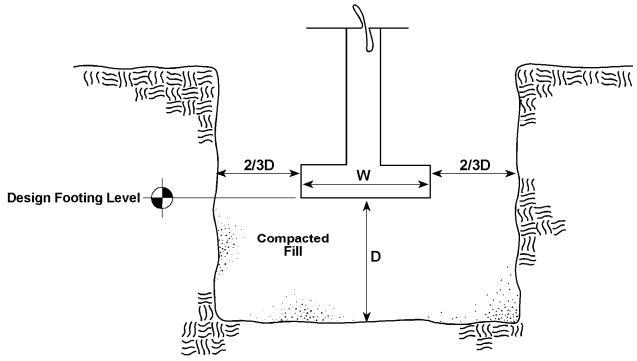
Since most of the native soils at this site consist of sands, and we expect that new fill will consist of on-site sands or similar materials imported from off-site, the use of earth-formed trench footings does not appear practical for this project. Excavation sidewalls will need to be sloped appropriately, footings will need to be formed at the base of the excavations, and the excavations will need to be backfilled with compacted fill after construction of the footings and stem walls.

The base of each foundation excavation should be free of water and loose soil prior to placing concrete. Concrete should be placed as soon after excavating as possible to reduce bearing soil disturbance. If the soils at bearing level become excessively dry, disturbed, saturated, or frozen, the affected soil should be removed prior to placing concrete. Placement of a lean

concrete mud-mat over the bearing soils should be considered if the excavations must remain open overnight or for an extended period of time.

Footings should bear directly on tested and approved medium dense native sand soils or on new engineered fill that extends to approved native soils. If loose sands are present at the base of a footing excavation, the bearing soils should be densified using appropriate vibratory compaction equipment. The sands should be compacted to at least 98% of the material's standard Proctor maximum dry density or 60% relative density. If loose native sands are encountered and cannot be sufficiently densified, or if other unsuitable materials are encountered in a footing excavation, the excavation should be extended deeper to suitable native soils.

If lean concrete (minimum 28-day compressive strength of 1,500 psi) or engineered fill will be placed to support the footings, the excavations should be widened at least 8 inches beyond each footing edge for every foot of new fill placed below the design footing base elevation. The overexcavated depth should then be backfilled up to the foundation base elevation with an approved granular material that is placed in lifts and compacted to at least 98% of the material's standard Proctor maximum dry density or at least 60% relative density. The recommended extents of the overexcavation and backfill procedure are illustrated in the following figure. Note that the sidewalls in this figure are shown vertical for ease of dimensioning. Since the site soils are granular (sands), sidewalls in excavations will need to be properly sloped to prevent caving.



4.4 South Court Addition Augered Cast-In-Place (ACIP) Pile Foundations

The proposed south court addition can be supported on augered cast-in-place (ACIP) piles. Soil parameters for design of ACIP piles are provided in the following table. Due to variable depths at which different underlying materials were encountered, we have provided the parameters for ACIP piles based upon material type rather than depth. The designer should refer to the individual boring logs for specific details on material depth variations across the proposed addition footprint. We recommend that piles for this project extend to at least one foot into the weathered limestone.

ACIP Pile Geotechnical Design Parameters

Material Description	Effective Unit Weight (pcf)	Allowable End Bearing Pressure (psf)	Allowable Side Friction for Uplift Loads (psf)	Allowable Passive Pressure (psf)
Fill	110	---	--	--
Clay / Silt	60	---	200	2,000
Sand	60	---	600	3,000
Weathered Limestone	60	30,000	--	15,000

The allowable end bearing values provided in the above tables include a factor of safety of 3. The allowable uplift side friction and passive resistance values include a factor of safety of 2. The pile capacity for axial (downward) loading should be determined using the end bearing value. Side friction should not be included in the axial pile capacity calculation.

Piles should be spaced at least 3 shaft diameters apart (center-to-center). Closer spacing may require a reduction in axial load capacity. Axial load capacity of a pile group can be determined by comparing the allowable axial capacity determined from the sum of individual piles in a group versus the capacity calculated using the perimeter and base of the pile group acting as a unit. The lesser of the two capacities should be used in design. Once the preliminary pile layout/spacing has been determined by the structural engineer, this information should be reviewed to determine if pile capacities should be adjusted due to group effects.

Individual ACIP pile foundations designed and constructed as recommended in this report are expected to experience settlements of 1 inch or less.

Uplift loads can be resisted by the weight of the pile and by side friction. To calculate uplift resistance for ACIP piles, the uplift side friction values provided in the above table could be used. Tensile reinforcement should be provided for ACIP piles subjected to uplift loading.

4.4.1 Lateral Loads on ACIP Piles

It should be noted that the load capacities provided herein are based on the stresses induced in the supporting soils. The structural capacity of the piles should be checked to assure that they can safely accommodate the combined stresses induced by axial and lateral forces. Furthermore, the response of the piles to lateral loads is also dependent upon the soil/structure interaction as well as the actual cross section, length, stiffness, and “fixity” (fixed or free head condition) of the piles.

Group action for lateral resistance of piles should be taken into account when center to center spacing is less than 8 diameters in the direction of loading. Design parameters for allowable

passive resistance in the direction of the load should be reduced in accordance with the following table.

Passive Resistance Reduction Factors	
Pile Spacing (Diameters)	**Reduction Factors**
8D	1.0
6D	0.7
4D	0.4
3D	0.25

Lateral loads perpendicular to a row of piles with center to center spacing of 3 diameters or less will cause the foundations to react essentially as a vertical wall. For this case, the values provided in the following table should be used for the projected pile diameter within the bearing material. With spacing of greater than 3 diameters, the values provided in the previous table for individual piles may be used.

Description	Allowable Passive Pressure (Equivalent Fluid Weight, pcf)
Above groundwater level	150
Below groundwater level	70

4.4.2 ACIP Pile Construction Considerations

ACIP piles should only be installed by qualified, experienced contractors. During pile construction, the augers should be withdrawn slowly, and sufficient grout pressure should be maintained at all times. Care should be taken not to “overdrill” (remove too much material from the pile excavation), since this could create ground loss and result in settlement of the adjacent existing structures. Adjacent piles should have a staggered construction schedule that allows the grout or concrete to complete its initial set before an adjacent pile is drilled.

A Terracon representative should observe ACIP pile installations. A computerized instrumentation system is available to contractors so that grout pressure, grout volume and auger depth can be simultaneously monitored and recorded during pile installation. During drilling, this information is continuously displayed on a computer screen. In our opinion, this system can enhance quality assurance of the pile installation procedure.

4.5 East Lobby Addition Floor Slab

4.5.1 Floor Slab Design Recommendations

ITEM	DESCRIPTION
Floor slab support	Native soils or new engineered fill materials that

ITEM	DESCRIPTION
	have been prepared in accordance with section 4.2 and tested/approved by Terracon
Granular leveling course [2]	6 inches of well-graded granular material
Modulus of subgrade reaction	100 pci for a subgrade prepared as recommended in this report Note: a value of 150 pci can be used at the top of the compacted granular leveling course

1. Floor slabs should be structurally independent of building footings and walls supported on the footings to reduce the potential for floor slab cracking caused by differential movements between the slab and foundation.
2. The floor slab should be placed on a leveling course comprised of well-graded granular material (e.g., IDOT CA-6 aggregate) compacted to at least 98% of the material's standard Proctor maximum dry density (ASTM D 698)

Joints should be constructed at regular intervals as recommended by the American Concrete Institute (ACI) to help control the location of cracking. It should be understood that differential settlement between the floor slabs and foundations could occur.

If moisture vapor transmission through the concrete slab is a concern, a vapor barrier should be used. The need for, and placement of, the vapor barrier should be determined by the architect or slab designer based on the proposed floor covering treatment, building function, concrete properties, placement techniques, and construction schedule. For further guidance concerning the use of a vapor barrier system, refer to Sections 302 and 360 of the American Concrete Institute (ACI) Manual of Concrete Practice.

4.5.2 Floor Slab Construction Considerations

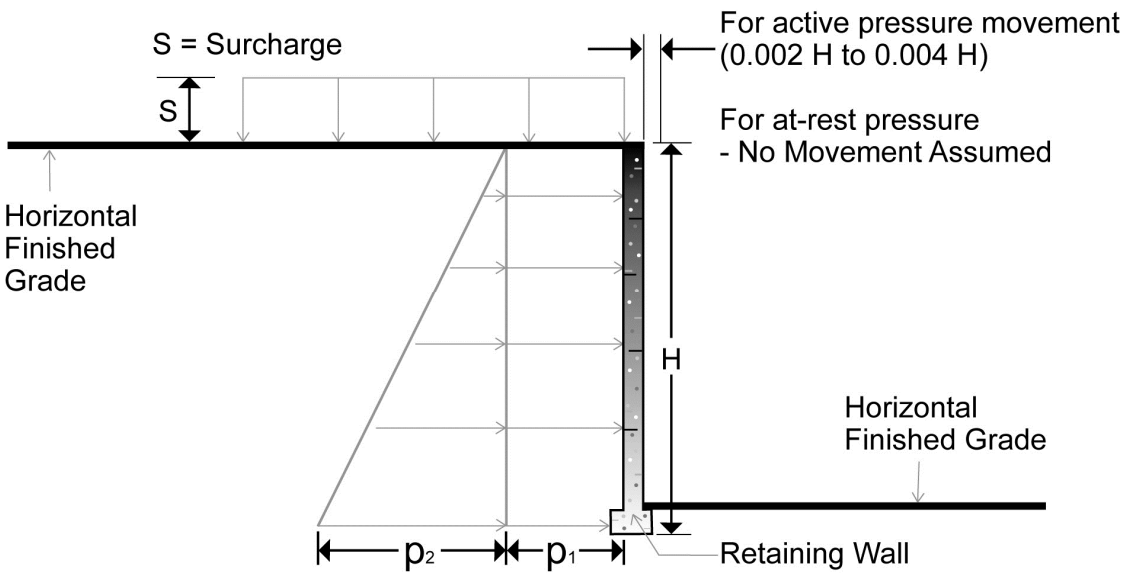
On most project sites, the site grading is generally accomplished early in the construction phase. However as construction proceeds, the subgrade may be disturbed by utility excavations, construction traffic, desiccation, rainfall, etc. As a result, corrective action may be required prior to placement of the granular leveling course and concrete.

Terracon should review the condition of the floor slab subgrades immediately prior to placement of the granular leveling course and construction of the slabs. 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 improved by removing the affected material and replacing it with engineered fill.

4.6 Below Grade Walls

4.6.1 Lateral Earth Pressures

Walls with unbalanced backfill levels on opposite sides (such as the east wall of the proposed east lobby addition) should be designed for earth pressures at least equal to those indicated in the following table. Earth pressures will be influenced by structural design of the walls, conditions of wall restraint, methods of construction and/or compaction and the strength of the materials being restrained. Two wall restraint conditions are shown. Active earth pressure is commonly used for design of free-standing cantilever retaining walls and assumes wall movement. The "at-rest" condition assumes no wall movement and is typically used for design of below grade building walls. The recommended design lateral earth pressures do not include a factor of safety and do not provide for possible hydrostatic pressure on the walls.



EARTH PRESSURE COEFFICIENTS

EARTH PRESSURE CONDITIONS	COEFFICIENT FOR BACKFILL TYPE	EQUIVALENT FLUID DENSITY (pcf)	SURCHARGE PRESSURE, p_1 (psf)	EARTH PRESSURE, p_2 (psf)
Active (K_a)	Granular - 0.33	40	(0.33)S	(40)H
	Lean Clay - 0.42	50	(0.42)S	(50)H
At-Rest (K_o)	Granular - 0.50	60	(0.50)S	(60)H
	Lean Clay - 0.58	70	(0.58)S	(70)H
Passive (K_p)	Granular - 3.0	360	---	---
	Lean Clay - 2.4	290	---	---

Applicable conditions to the above include:

- For active earth pressure, wall must rotate about base, with top lateral movements of about 0.002 **H** to 0.004 **H**, where **H** is wall height
- For passive earth pressure to develop, wall must move horizontally to mobilize resistance.
- Uniform surcharge, where S is surcharge pressure
- In-situ soil backfill weight a maximum of 120 pcf
- Horizontal backfill, compacted to between 95 and 100 percent of standard Proctor maximum dry density
- Loading from heavy compaction equipment not included
- No hydrostatic pressures acting on wall
- No dynamic loading
- No safety factor included in soil parameters
- Ignore passive pressure in frost zone

Backfill placed against structures should consist of granular soils or low plasticity cohesive soils. For the granular values to be valid, the granular backfill must extend out from the base of the wall at an angle of at least 45 degrees for the active and at-rest cases and at least 60 degrees from vertical for passive case. To calculate the resistance to sliding, a value of 0.4 should be used as the ultimate coefficient of friction between the footing and the underlying (native or fill) cohesive soil. An appropriate safety factor should be applied to the ultimate coefficient of friction value.

The lateral earth pressure recommendations provided in this report are applicable to cast-in-place concrete walls. These recommendations are not applicable to the design of modular block, geogrid reinforced walls. Recommendations regarding these types of wall systems are not included in our scope of services for this project. However, we are available to provide additional consultation and recommendations regarding such wall systems, upon request.

4.6.2 Subsurface Drainage

To reduce the potential for hydrostatic loading on below grade walls, we recommend that a drain line be installed along the base of each wall. Each drain line should be surrounded by free-draining granular material encapsulated with an approved geotextile filter fabric. For exterior locations, the granular material should extend from the drainage pipes to within 2 feet of final grade and be capped with a cohesive fill material placed and compacted as recommended in Section 4.2 of this report. At interior locations, the granular material should extend up to the slab subgrade elevation.

The drainage networks (pipes) for subdrains should be sloped to provide positive gravity drainage to sumps equipped for automated pumping, to a down gradient storm sewer, or to another suitable frost-free outlet that will allow gravity drainage. Redundant pumps with battery backup power could be considered to reduce the risk of hydrostatic pressure and seepage in the event of pump and/or power failure. Periodic maintenance of drainage systems is necessary so that they do not become plugged and inoperative.

A prefabricated drainage structure placed against below grade walls may also be used as an alternative to free-draining granular fill above the pipe. A prefabricated drainage structure consists of a plastic drainage core or mesh that is covered with filter fabric to prevent soil intrusion. The drainage structure is fastened to the wall after the wall has been waterproofed and prior to placing backfill.

4.7 Seismic Site Class

Code	Site Class
2009 International Building Code (IBC)[1]	D

1. In general accordance with Table 1613.5.2 of the 2009 IBC.
2. The 2009 IBC requires a site soil profile determination extending a depth of 100 feet for seismic site classification. The maximum depth explored during our subsurface exploration was about 40 feet. Based on the conditions encountered at the boring locations, Site Class D can be used for design at this site. We can perform deeper borings and/or a site-specific seismic evaluation using geophysical methods to provide additional information on seismic site class, upon request.

5.0 GENERAL COMMENTS

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 also should be retained to provide observation and testing services during grading, excavation, foundation construction and other earth-related construction phases of the project.

Support of floor slabs on/above existing fill is discussed in this report. Even with the construction observation/testing recommended in this report, a risk remains for the owner that unsuitable materials within or buried by the fill will not be discovered. This may result in larger than normal settlement and damage to the floor slabs supported above existing fill, requiring additional maintenance. This risk can be reduced (but not eliminated) by thorough observation and testing as discussed herein.

The analysis and recommendations presented in this report are 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 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 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. In the event that changes in the nature, design, or location of the project as outlined in this report are planned, the conclusions and recommendations contained in this report shall not be considered valid unless Terracon reviews the changes and either verifies or modifies the conclusions of this report in writing.

APPENDIX A

FIELD EXPLORATION

Field Exploration Description

The borings were drilled at the approximate locations indicated on the attached Boring Location Diagram (Exhibit A-2). Boring layout and surface elevations at the boring locations were provided by McClure Engineering.

The borings were drilled with a track-mounted, rotary drill rig using continuous flight, hollow-stemmed augers to advance the boreholes. Soil samples were obtained using split-barrel sampling procedures, in which a standard 2-inch (outside diameter) split-barrel sampling spoon is driven into the ground with a 140-pound automatic hammer falling a distance of 30 inches. The number of blows required to advance the sampling spoon the last 12 inches of a normal 18-inch penetration is recorded as the Standard Penetration Test (SPT) resistance value. These values, also referred to as SPT N-values, are an indication of soil strength/relative density and are provided on the boring logs at the depths of occurrence. The samples were sealed and transported to the laboratory for testing and classification.

The drill crew prepared a field log of each boring. These logs included visual classifications of the materials encountered during drilling and the driller's interpretation of the subsurface conditions between samples. The 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.

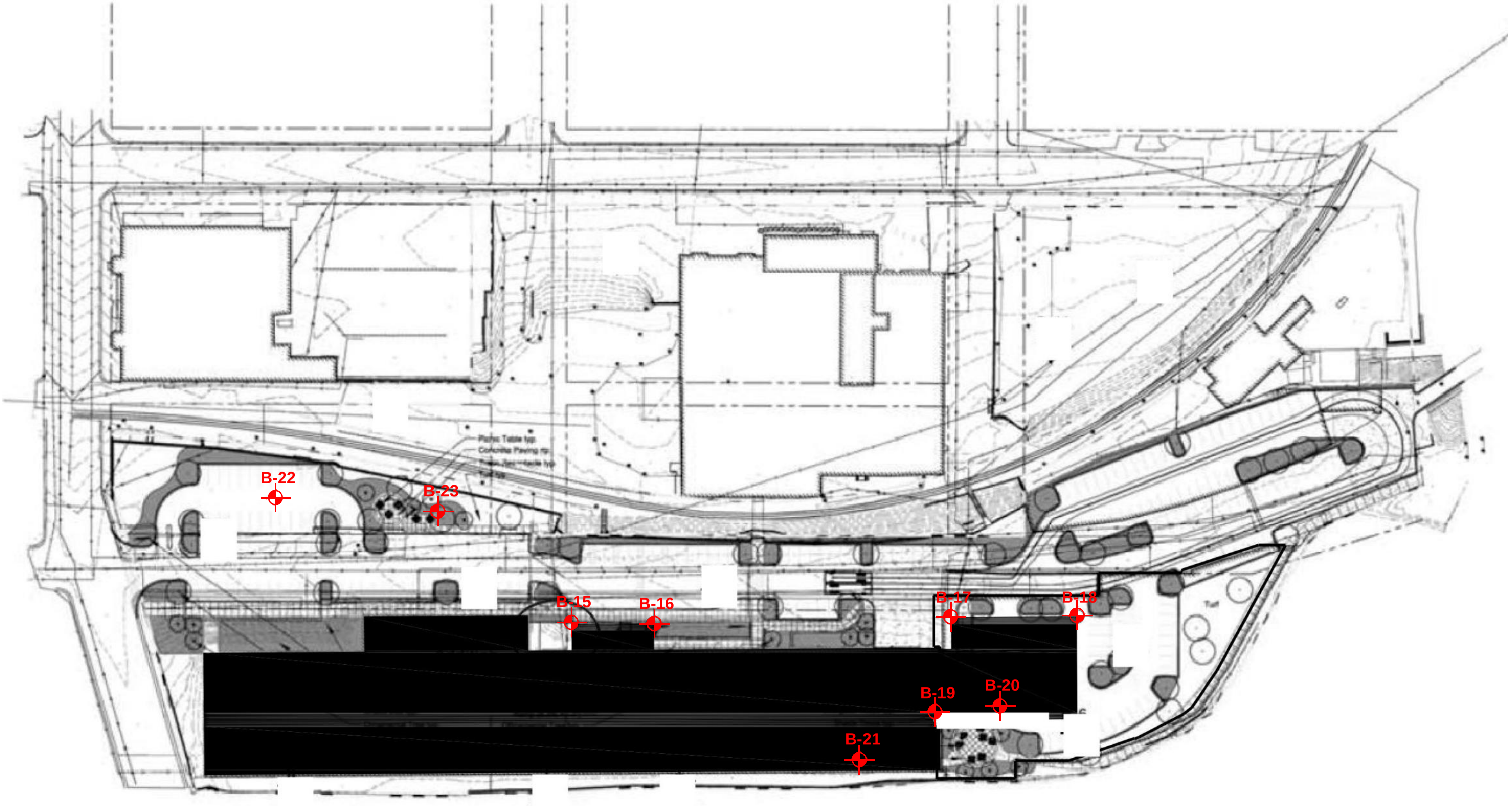


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DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

Project Manager: DAW	Project No. 19135006	Terracon Consulting Engineers & Scientists	BORING LOCATION DIAGRAM
Drawn by: DAW	Scale: N.T.S.	4836 Colt Road Rockford, Illinois 61109	INGERSOLL BUILDING ADDITION SOUTH WATER STREET ROCKFORD, ILLINOIS
Checked by: KCB	File Name: 19135006_BLD	PH. (815) 873-0990 FAX. (815) 873-0991	Exhibit A-2
Approved by: KCB	Date: April 2014		

BORING LOG NO. B-15

PROJECT: Ingersoll Building Addition

CLIENT: City of Rockford
Rockford, Illinois

SITE: South Water Street
Rockford, Illinois

LOCATION See Exhibit A-2

Surface Elev.: 712 (Ft.)

DEPTH	ELEVATION (Ft.)	Description
0.3	712	**ASPHALT**, Approximately 3"
1.0	711	**CRUSHED STONE AGGREGATE**, Approximately 9"
		FILL - FINE TO MEDIUM SAND, trace gravel, and asphalt fragments, light brown and gray
8.0	704	**FILL - FINE TO MEDIUM SAND**, trace gravel and clay, brown
13.0	699	**FINE TO COARSE SAND (SW)**, trace gravel, brown, medium dense

SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	HP (psf)	WATER CONTENT (%)
	8	3-5-7 N=12		5
	10	8-8-11 N=19		6
	10	9-10-12 N=22		10
	10	13-5-6 N=11		15
	4	9-12-14 N=26		17
	13	5-5-6 N=11		19
	6	8-6-9 N=15		21

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

Hammer Type: Automatic SPT Hammer

Advancement Method:
Hollow Stem Auger

Abandonment Method:
Auger Cuttings

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.

Notes:

WATER LEVEL OBSERVATIONS

13', While Drilling

13', After Boring

Terracon
4836 Colt Road
Rockford, Illinois

Boring Started: 3/29/2014 | Boring Completed: 3/29/2014

Drill Rig: D-90 | Driller: JA

Project No.: 19135006 | Exhibit: A-3

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 19135006 LOGS.GPJ TEMPLATE UPDATE 3-31-14.GPJ 5/1/14

BORING LOG NO. B-15

PROJECT: Ingersoll Building Addition

CLIENT: City of Rockford
Rockford, Illinois

SITE: South Water Street
Rockford, Illinois

LOCATION See Exhibit A-2

Surface Elev.: 712 (Ft.)

GRAPHIC LOG	DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	HP (psf)	WATER CONTENT (%)
	FINE TO COARSE SAND (SW), trace gravel, brown, medium dense *(continued)*								
	30.0	682	30			8	9-8-11 N=19		15
	BOTTOM OF BORING ***Boring Terminated at 30 Feet***								

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

Hammer Type: Automatic SPT Hammer

Advancement Method:
Hollow Stem Auger

Abandonment Method:
Auger Cuttings

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.

Notes:

WATER LEVEL OBSERVATIONS

13', While Drilling

13', After Boring

Terracon
4836 Colt Road
Rockford, Illinois

Boring Started: 3/29/2014 | Boring Completed: 3/29/2014

Drill Rig: D-90 | Driller: JA

Project No.: 19135006 | Exhibit: A-3

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 19135006 LOGS.GPJ TEMPLATE UPDATE 3-31-14.GPJ 5/1/14

BORING LOG NO. B-16

PROJECT: Ingersoll Building Addition

CLIENT: City of Rockford
Rockford, Illinois

SITE: South Water Street
Rockford, Illinois

LOCATION See Exhibit A-2

Surface Elev.: 710 (Ft.)

DEPTH	ELEVATION (Ft.)	Description
0.3	710	**ASPHALT**, Approximately 3"
1.1	709	**CRUSHED STONE AGGREGATE**, Approximately 10"
		FILL - SANDY CLAY, trace gravel, brown
3.0	707	**FILL - FINE TO MEDIUM SAND**, trace gravel and asphalt fragments, light brown and gray
13.0	697	**FINE TO COARSE SAND (SW)**, trace gravel, brown, medium dense

SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	WATER CONTENT (%)
	12	5-5-5 N=10	11
	14	9-8-5 N=13	10
	15	9-7-9 N=16	18
	0	50/2"	
	9	8-6-9 N=15	11
	13	5-5-6 N=11	21
	10	6-5-7 N=12	16

DEPTH (Ft.): 5, 10, 15, 20, 25

WATER LEVEL OBSERVATIONS: 13', While Drilling; 13', After Boring

HP (psf)

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

Hammer Type: Automatic SPT Hammer

Advancement Method:
Hollow Stem Auger

Abandonment Method:
Auger Cuttings

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.

Notes:

WATER LEVEL OBSERVATIONS

13', While Drilling

13', After Boring

Terracon
4836 Colt Road
Rockford, Illinois

Boring Started: 3/29/2014 | Boring Completed: 3/29/2014

Drill Rig: D-90 | Driller: JA

Project No.: 19135006 | Exhibit: A-4

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 19135006 LOGS.GPJ TEMPLATE UPDATE 3-31-14.GPJ 5/1/14

BORING LOG NO. B-16

PROJECT: Ingersoll Building Addition

CLIENT: City of Rockford
Rockford, Illinois

SITE: South Water Street
Rockford, Illinois

LOCATION See Exhibit A-2

Surface Elev.: 710 (Ft.)

GRAPHIC LOG	DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	HP (psf)	WATER CONTENT (%)
	FINE TO COARSE SAND (SW), trace gravel, brown, medium dense *(continued)*								
	30.0	680	30			11	7-7-9 N=16		14
	BOTTOM OF BORING *Boring Terminated at 30 Feet*								

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

Hammer Type: Automatic SPT Hammer

Advancement Method:
Hollow Stem Auger

Abandonment Method:
Auger Cuttings

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.

Notes:

WATER LEVEL OBSERVATIONS

13', While Drilling

13', After Boring

Terracon
4836 Colt Road
Rockford, Illinois

Boring Started: 3/29/2014 | Boring Completed: 3/29/2014

Drill Rig: D-90 | Driller: JA

Project No.: 19135006 | Exhibit: A-4

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 19135006 LOGS.GPJ TEMPLATE UPDATE 3-31-14.GPJ 5/1/14

BORING LOG NO. B-17

PROJECT: Ingersoll Building Addition

CLIENT: City of Rockford
Rockford, Illinois

SITE: South Water Street
Rockford, Illinois

LOCATION See Exhibit A-2

Surface Elev.: 706 (Ft.)

DEPTH	ELEVATION (Ft.)	Description
0.6	705.5	**CONCRETE**, Approximately 7"
0.8	705.5	**CRUSHED STONE AGGREGATE**, Approximately 2"
		FILL - LEAN CLAY, trace sand, dark brown to black
8.0	698	**FINE TO MEDIUM SAND (SP)**, trace silt, brown, loose
11.0	695	**FINE TO COARSE SAND (SW)**, trace gravel, brown, medium dense to very dense
25.0	681	**BOTTOM OF BORING** *Boring Terminated at 25 Feet*

DEPTH (Ft.)	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	WATER CONTENT (%)
		4	5-5-5 N=10	9
		10	5-5-3 N=8	21
5		14	5-5-6 N=11	27
		15	2-3-4 N=7	26
10				
		3	3-5-7 N=12	12
15				
		8	16-15-18 N=33	10
20				
		3	50/3"	8
25				

WATER LEVEL OBSERVATIONS: 11', While Drilling; 11', After Boring

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

Hammer Type: Automatic SPT Hammer

Advancement Method: Hollow Stem Auger

Abandonment Method: Auger Cuttings

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.

Notes:

WATER LEVEL OBSERVATIONS

11', While Drilling

11', After Boring

Terracon
4836 Colt Road
Rockford, Illinois

Boring Started: 3/29/2014 | Boring Completed: 3/29/2014

Drill Rig: D-90 | Driller: JA

Project No.: 19135006 | Exhibit: A-5

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 19135006 LOGS.GPJ TEMPLATE UPDATE 3-31-14.GPJ 5/1/14

BORING LOG NO. B-18

PROJECT: Ingersoll Building Addition

CLIENT: City of Rockford
Rockford, Illinois

SITE: South Water Street
Rockford, Illinois

LOCATION See Exhibit A-2

Surface Elev.: 706 (Ft.)

DEPTH	ELEVATION (Ft.)	Description
0.8	705	**CONCRETE**, Approximately 9½"
1.0	705	**CRUSHED STONE AGGREGATE**, Approximately 2½"
		FILL - FINE TO COARSE SAND , trace gravel, brown to dark brown
5.0	701	**LEAN CLAY (CL)**, trace silt, dark brown to black, medium stiff
8.0	698	**LEAN CLAY (CL)**, trace silt, gray, stiff
12.0	694	**HIGHLY WEATHERED LIMESTONE*****, with sand seams, light gray
25.0	681	**BOTTOM OF BORING** *Boring Terminated at 25 Feet*

DEPTH (Ft.)	RECOVERY (In.)	FIELD TEST RESULTS	HP (psf)	WATER CONTENT (%)
	0	50/4"		
	11	6-6-5 N=11		6
5	13	5-4-4 N=8	1500	26
	13	4-4-5 N=9	2500	25
10				
	2	29-50/2"		5
15				
	2	50/2"		16
20				
	0	50/0"		
25				

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

Hammer Type: Automatic SPT Hammer

Advancement Method:
Hollow Stem Auger

Abandonment Method:
Auger Cuttings

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.

Notes:

***Classification of rock materisl based upon drilling characteristics and observation of disturbed samples. Core samples and/or petrographic analysis may indicate other rock types.

WATER LEVEL OBSERVATIONS

None, While Drilling

None, After Boring

Terracon
4836 Colt Road
Rockford, Illinois

Boring Started: 3/29/2014	Boring Completed: 3/29/2014
Drill Rig: D-90	Driller: JA
Project No.: 19135006	Exhibit: A-6

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 19135006 LOGS.GPJ TEMPLATE UPDATE 3-31-14.GPJ 5/1/14

BORING LOG NO. B-19

PROJECT: Ingersoll Building Addition

CLIENT: City of Rockford
Rockford, Illinois

SITE: South Water Street
Rockford, Illinois

LOCATION See Exhibit A-2

Surface Elev.: 706 (Ft.)

DEPTH	ELEVATION (Ft.)	Description
0.7	705.5	**CONCRETE**, Approximately 8"
1.0	705	**CRUSHED STONE AGGREGATE**, Approximately 4"
2.0	704	**FILL - FINE TO MEDIUM SAND**, trace gravel and concrete, brown
5.0	701	**FILL - LEAN CLAY**, trace sand and silt, brown to dark brown
8.0	698	**SILTY CLAY (CL)**, trace sand and organics, dark brown to black, medium stiff to stiff
13.0	693	**CLAYEY SILT (ML)**, trace sand, gray, medium stiff
25.0	681	**FINE TO COARSE SAND (SW)**, trace gravel, brown, loose to medium dense
		BOTTOM OF BORING *Boring Terminated at 25 Feet*

DEPTH (Ft.)	RECOVERY (In.)	FIELD TEST RESULTS	HP (psf)	WATER CONTENT (%)
	0	50/3"		5
	16	1-1-1 N=2		25
5	16	4-5-5 N=10	1000	30
	16	2-3-4 N=7	1000	19
10	3	3-4-4 N=8		5
15	10	3-5-7 N=12		12
20	11	4-7-7 N=14		8
25				

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

Hammer Type: Automatic SPT Hammer

Advancement Method:
Hollow Stem Auger

Abandonment Method:
Auger Cuttings

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.

Notes:

WATER LEVEL OBSERVATIONS

8', While Drilling

8', After Boring

Terracon
4836 Colt Road
Rockford, Illinois

Boring Started: 3/29/2014 | Boring Completed: 3/29/2014

Drill Rig: D-90 | Driller: JA

Project No.: 19135006 | Exhibit: A-7

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 19135006 LOGS.GPJ TEMPLATE UPDATE 3-31-14.GPJ 5/1/14

BORING LOG NO. B-20

PROJECT: Ingersoll Building Addition

CLIENT: City of Rockford
Rockford, Illinois

SITE: South Water Street
Rockford, Illinois

LOCATION See Exhibit A-2

Surface Elev.: 706 (Ft.)

DEPTH	ELEVATION (Ft.)	Description
0.6	705.5	**CONCRETE**, Approximately 7"
0.8	705	**CRUSHED STONE AGGREGATE**, Approximately 3"
		FILL - FINE TO COARSE SAND, trace gravel and cinders, dark brown to brown
8.0	698	**FILL - FINE TO MEDIUM SAND**, with cinders, trace clay, black
13.0	693	**FINE TO COARSE SAND (SW)**, with gravel, brown to dark brown, medium dense
18.0	688	**FINE TO COARSE SAND (SW)**, brown and gray, dense
23.0	683	**FINE TO MEDIUM SAND (SP)**, brown, medium dense

DEPTH (Ft.)	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	HP (psf)	WATER CONTENT (%)
	X	8	7-9-11 N=20		15
5					
	X	16	8-3-3 N=6		46
10					
	X	7	7-10-13 N=23		15
15					
	X	9	14-15-18 N=33		20
20					
	X	14	6-9-9 N=18		16
25					

WATER LEVEL OBSERVATIONS: 8', While Drilling; 8', After Boring

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

Hammer Type: Automatic SPT Hammer

Advancement Method: Hollow Stem Auger

Abandonment Method: Auger Cuttings

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.

Notes:

WATER LEVEL OBSERVATIONS

8', While Drilling

8', After Boring

Terracon
4836 Colt Road
Rockford, Illinois

Boring Started: 3/29/2014 | Boring Completed: 3/29/2014

Drill Rig: D-90 | Driller: JA

Project No.: 19135006 | Exhibit: A-8

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 19135006 LOGS.GPJ TEMPLATE UPDATE 3-31-14.GPJ 5/1/14

BORING LOG NO. B-20

PROJECT: Ingersoll Building Addition

CLIENT: City of Rockford
Rockford, Illinois

SITE: South Water Street
Rockford, Illinois

LOCATION See Exhibit A-2

Surface Elev.: 706 (Ft.)

GRAPHIC LOG	DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	HP (psf)	WATER CONTENT (%)
	FINE TO MEDIUM SAND (SP), brown, medium dense *(continued)*								
	28.0	678							
	HIGHLY WEATHERED LIMESTONE***, with sand seams, light gray					2	50/3"		17
			30						
	33.0	673							
	BOTTOM OF BORING								
	AUGER REFUSAL ON WEATHERED LIMESTONE at 33 Feet								

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

Hammer Type: Automatic SPT Hammer

Advancement Method:
Hollow Stem Auger

Abandonment Method:
Auger Cuttings

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.

Notes:

***Classification of rock materisl based upon drilling characteristics and observation of disturbed samples. Core samples and/or petrographic analysis may indicate other rock types.

WATER LEVEL OBSERVATIONS

8', While Drilling

8', After Boring

Terracon
4836 Colt Road
Rockford, Illinois

Boring Started: 3/29/2014 | Boring Completed: 3/29/2014

Drill Rig: D-90 | Driller: JA

Project No.: 19135006 | Exhibit: A-8

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 19135006 LOGS.GPJ TEMPLATE UPDATE 3-31-14.GPJ 5/1/14

BORING LOG NO. B-21

PROJECT: Ingersoll Building Addition

CLIENT: City of Rockford
Rockford, Illinois

SITE: South Water Street
Rockford, Illinois

LOCATION See Exhibit A-2

Surface Elev.: 706 (Ft.)

DEPTH	ELEVATION (Ft.)	Description
0.6	705.5	**CONCRETE**, Approximately 7"
0.8	705	**CRUSHED STONE AGGREGATE**, Approximately 3"
		FILL - FINE TO MEDIUM SAND, trace gravel, light brown
6.0	700	**FILL - SILTY CLAY**, with sand, trace organics and construction debris, dark brown to black
13.0	693	**FINE TO COARSE SAND (SW)**, trace gravel, brown, medium dense

DEPTH (Ft.)	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	HP (psf)	WATER CONTENT (%)
5		9	8-10-10 N=20		4
10		6	3-3-3 N=6		28
15		7	6-7-7 N=14		11
20		11	7-7-8 N=15		10
25		13	7-8-7 N=15		19

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

Hammer Type: Automatic SPT Hammer

Advancement Method:
Hollow Stem Auger

Abandonment Method:
Auger Cuttings

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.

Notes:

WATER LEVEL OBSERVATIONS

8', While Drilling

8', After Boring

Terracon
4836 Colt Road
Rockford, Illinois

Boring Started: 3/29/2014 | Boring Completed: 3/29/2014

Drill Rig: D-90 | Driller: JA

Project No.: 19135006 | Exhibit: A-9

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 19135006 LOGS.GPJ TEMPLATE UPDATE 3-31-14.GPJ 5/1/14

BORING LOG NO. B-21

PROJECT: Ingersoll Building Addition

CLIENT: City of Rockford
Rockford, Illinois

SITE: South Water Street
Rockford, Illinois

LOCATION See Exhibit A-2

Surface Elev.: 706 (Ft.)

GRAPHIC LOG	DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	HP (psf)	WATER CONTENT (%)
	FINE TO COARSE SAND (SW), trace gravel, brown, medium dense *(continued)*								
			30			15	8-10-11 N=21		17
			35			14	7-9-13 N=22		17
	38.0	668							
	HIGHLY WEATHERED LIMESTONE***, with sand seams, light gray					0	50/2"		
	40.0	666	40						
	BOTTOM OF BORING								
	Boring Terminated at 40 Feet								

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

Hammer Type: Automatic SPT Hammer

Advancement Method:
Hollow Stem Auger

Abandonment Method:
Auger Cuttings

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.

Notes:

***Classification of rock materisl based upon drilling characteristics and observation of disturbed samples. Core samples and/or petrographic analysis may indicate other rock types.

WATER LEVEL OBSERVATIONS

8', While Drilling

8', After Boring

Terracon
4836 Colt Road
Rockford, Illinois

Boring Started: 3/29/2014 | Boring Completed: 3/29/2014

Drill Rig: D-90 | Driller: JA

Project No.: 19135006 | Exhibit: A-9

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 19135006 LOGS.GPJ TEMPLATE UPDATE 3-31-14.GPJ 5/1/14

BORING LOG NO. B-22

PROJECT: Ingersoll Building Addition

CLIENT: City of Rockford
Rockford, Illinois

SITE: South Water Street
Rockford, Illinois

LOCATION See Exhibit A-2

Surface Elev.: 717 (Ft.)

GRAPHIC LOG	DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	HP (psf)	WATER CONTENT (%)
	0.2 **ASPHALT**, Approximately 2"	717							
	0.5 **CRUSHED STONE AGGREGATE**, Approximately 4"	716.5							
	FILL - CLAYEY SAND, dark brown			▽	X	14	5-6-5 N=11		8
	4.0	713							
	FILL - FINE TO COARSE SAND, trace clay and gravel, dark brown to black				X		6-10-14 N=24		24
	5.0	712	5						
	BOTTOM OF BORING								
	Boring Terminated at 5 Feet								

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

Hammer Type: Automatic SPT Hammer

Advancement Method:
Hollow Stem Auger

Abandonment Method:
Auger Cuttings

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.

Notes:

WATER LEVEL OBSERVATIONS

▽ *2½', While Drilling*

▽ *2½', After Boring*

Terracon
4836 Colt Road
Rockford, Illinois

Boring Started: 3/29/2014	Boring Completed: 3/29/2014
Drill Rig: D-90	Driller: JA
Project No.: 19135006	Exhibit: A-10

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 19135006 LOGS.GPJ TEMPLATE UPDATE 3-31-14.GPJ 5/1/14

BORING LOG NO. B-23

PROJECT: Ingersoll Building Addition

CLIENT: City of Rockford
Rockford, Illinois

SITE: South Water Street
Rockford, Illinois

LOCATION See Exhibit A-2

Surface Elev.: 715 (Ft.)

DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	HP (psf)	WATER CONTENT (%)
0.2 **ASPHALT**, Approximately 2"	715							
0.5 **CRUSHED STONE AGGREGATE**, Approximately 4"	714.5							
FILL - CLAYEY SAND, dark brown			▽	X	14	2-3-5 N=8		20
				X	12	4-8-8 N=16		19
5.0	710	5						
BOTTOM OF BORING								
Boring Terminated at 5 Feet								

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

Hammer Type: Automatic SPT Hammer

Advancement Method:
Hollow Stem Auger

Abandonment Method:
Auger Cuttings

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.

Notes:

WATER LEVEL OBSERVATIONS

▽ *2', While Drilling*

▽ *2', After Boring*

Terracon
4836 Colt Road
Rockford, Illinois

Boring Started: 3/29/2014 | Boring Completed: 3/29/2014

Drill Rig: D-90 | Driller: JA

Project No.: 19135006 | Exhibit: A-11

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 19135006 LOGS.GPJ TEMPLATE UPDATE 3-31-14.GPJ 5/1/14

APPENDIX B

LABORATORY TESTING

Laboratory Testing

The soil samples obtained from the borings were tested in the laboratory to measure their natural water contents. A pocket penetrometer was used to help estimate the approximate unconfined compressive strength of the native cohesive samples. The test results are provided on the boring logs in Appendix A.

The soil samples were classified in the laboratory based on visual observation, texture, plasticity, and the limited laboratory testing described above. The soil descriptions presented on the boring logs for native soils are in accordance with the enclosed General Notes (Exhibit C-1) and Unified Soil Classification System (USCS). The estimated USCS group symbols for native soils are shown on the boring logs, and a brief description of the USCS is included in this report (Exhibit C-2).

The rock materials encountered in the borings were classified in accordance with the appended Description of Rock Properties (Exhibit C-3) on the basis of drilling characteristics and observation of disturbed samples. Observation of core samples or petrographic analysis may indicate other rock types.

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	≥ 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

Terracon

Exhibit C-1

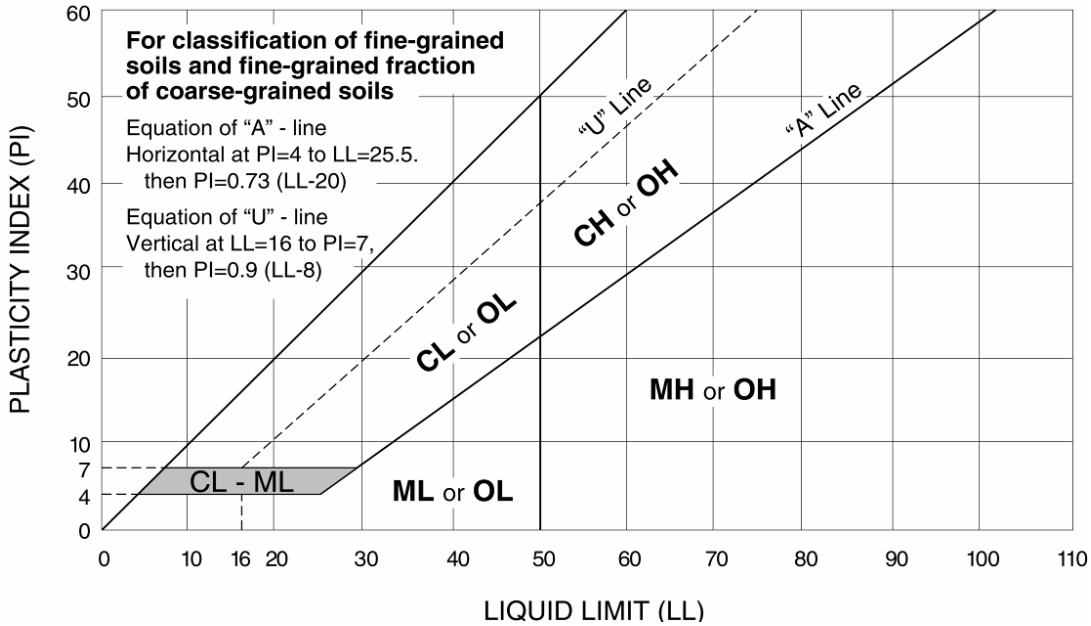
UNIFIED SOIL CLASSIFICATION SYSTEM

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests [A]					Soil Classification	
					Group Symbol	Group Name [B]
Coarse Grained Soils: More than 50% retained on No. 200 sieve	**Gravels:** More than 50% of coarse fraction retained on No. 4 sieve	**Clean Gravels:** Less than 5% fines [C]	$Cu \geq 4$ and $1 \leq Cc \leq 3$ [E]		GW	Well-graded gravel [F]
			$Cu < 4$ and/or $1 > Cc > 3$ [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]	$Cu \geq 6$ and $1 \leq Cc \leq 3$ [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 / Liquid limit - not dried	< 0.75	OL	Organic clay [K,L,M,N]
						Organic silt [K,L,M,O]
	Silts and Clays: Liquid limit 50 or more	**Inorganic:**	PI plots on or above "A" line		CH	Fat clay [K,L,M]
			PI plots below "A" line		MH	Elastic Silt [K,L,M]
		Organic:	Liquid limit - oven dried / Liquid limit - not dried	< 0.75	OH	Organic clay [K,L,M,P]
						Organic silt [K,L,M,Q]
Highly organic soils:	Primarily organic matter, dark in color, and organic odor				PT	Peat

[A] Based on the material passing the 3-inch (75-mm) sieve
[B] If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.
[C] Gravels with 5 to 12% fines require dual symbols: GW-GM well-graded gravel with silt, GW-GC well-graded gravel with clay, GP-GM poorly graded gravel with silt, GP-GC poorly graded gravel with clay.
[D] Sands with 5 to 12% fines require dual symbols: SW-SM well-graded sand with silt, SW-SC well-graded sand with clay, SP-SM poorly graded sand with silt, SP-SC poorly graded sand with clay

[E] $Cu = D_{60}/D_{10}$ $\quad Cc = \dfrac{(D_{30})^2}{D_{10} \times D_{60}}$

[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.



Terracon

Exhibit C-2

DESCRIPTION OF ROCK PROPERTIES

WEATHERING

Fresh	Rock fresh, crystals bright, few joints may show slight staining. Rock rings under hammer if crystalline.
Very slight	Rock generally fresh, joints stained, some joints may show thin clay coatings, crystals in broken face show bright. Rock rings under hammer if crystalline.
Slight	Rock generally fresh, joints stained, and discoloration extends into rock up to 1 in. Joints may contain clay. In granitoid rocks some occasional feldspar crystals are dull and discolored. Crystalline rocks ring under hammer.
Moderate	Significant portions of rock show discoloration and weathering effects. In granitoid rocks, most feldspars are dull and discolored; some show clayey. Rock has dull sound under hammer and shows significant loss of strength as compared with fresh rock.
Moderately severe	All rock except quartz discolored or stained. In granitoid rocks, all feldspars dull and discolored and majority show kaolinization. Rock shows severe loss of strength and can be excavated with geologist's pick.
Severe	All rock except quartz discolored or stained. Rock "fabric" clear and evident, but reduced in strength to strong soil. In granitoid rocks, all feldspars kaolinized to some extent. Some fragments of strong rock usually left.
Very severe	All rock except quartz discolored or stained. Rock "fabric" discernible, but mass effectively reduced to "soil" with only fragments of strong rock remaining.
Complete	Rock reduced to "soil". Rock "fabric" not discernible or discernible only in small, scattered locations. Quartz may be present as dikes or stringers.

HARDNESS (for engineering description of rock – not to be confused with Moh's scale for minerals)

Very hard	Cannot be scratched with knife or sharp pick. Breaking of hand specimens requires several hard blows of geologist's pick.
Hard	Can be scratched with knife or pick only with difficulty. Hard blow of hammer required to detach hand specimen.
Moderately hard	Can be scratched with knife or pick. Gouges or grooves to ¼ in. deep can be excavated by hard blow of point of a geologist's pick. Hand specimens can be detached by moderate blow.
Medium	Can be grooved or gouged 1/16 in. deep by firm pressure on knife or pick point. Can be excavated in small chips to pieces about 1-in. maximum size by hard blows of the point of a geologist's pick.
Soft	Can be gouged or grooved readily with knife or pick point. Can be excavated in chips to pieces several inches in size by moderate blows of a pick point. Small thin pieces can be broken by finger pressure.
Very soft	Can be carved with knife. Can be excavated readily with point of pick. Pieces 1-in. or more in thickness can be broken with finger pressure. Can be scratched readily by fingernail.

Joint, Bedding, and Foliation Spacing in Rock [a]

Spacing	Joints	Bedding/Foliation
Less than 2 in.	Very close	Very thin
2 in. – 1 ft.	Close	Thin
1 ft. – 3 ft.	Moderately close	Medium
3 ft. – 10 ft.	Wide	Thick
More than 10 ft.	Very wide	Very thick

a. Spacing refers to the distance normal to the planes, of the described feature, which are parallel to each other or nearly so.

Rock Quality Designator (RQD) a

RQD, as a percentage	Diagnostic description
Exceeding 90	Excellent
90 – 75	Good
75 – 50	Fair
50 – 25	Poor
Less than 25	Very poor

a. RQD (given as a percentage) = length of core in pieces 4 in. and longer/length of run.

Joint Openness Descriptors

Openness	Descriptor
No Visible Separation	Tight
Less than 1/32 in.	Slightly Open
1/32 to 1/8 in.	Moderately Open
1/8 to 3/8 in.	Open
3/8 in. to 0.1 ft.	Moderately Wide
Greater than 0.1 ft.	Wide

References: American Society of Civil Engineers. Manuals and Reports on Engineering Practice - No. 56. Subsurface Investigation for Design and Construction of Foundations of Buildings. New York: American Society of Civil Engineers, 1976. U.S. Department of the Interior, Bureau of Reclamation, Engineering Geology Field Manual.