

Geotechnical Engineering Report

Proposed VA Medical Center Addition
Iowa City, Iowa

August 8, 2011

Terracon Project No. 06105663.01

Prepared for:

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Iowa City, Iowa

Prepared by:

Terracon Consultants, Inc.
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August 8, 2011



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Re: Geotechnical Engineering Report
Proposed VA Medical Center Addition
Iowa City, Iowa
Terracon Project No. 06105663.01

Dear Mr. Noyes:

Terracon Consultants, Inc. (Terracon) has completed the subsurface exploration and geotechnical engineering services for the referenced project in Iowa City, Iowa. This study was performed in general accordance with our Proposal No. P06100506R dated April 15, 2010. The attached report describes the subsurface conditions encountered in the borings, analyzes and evaluates the laboratory test data, and provides geotechnical recommendations concerning the design and construction of foundations and floor slabs for the proposed addition. In addition, recommendations for general earthwork, pavement subgrade preparation, and recommended minimum pavement thicknesses are provided.

We appreciate the opportunity to be of service to you on this phase of your project, and look forward in assisting you during the construction phase. If you have any questions concerning this report, or if we may be of further service, please contact us.

Sincerely,

Terracon Consultants, Inc.

A handwritten signature in black ink, reading "Bachan K. Sinha".

Bachan K. Sinha, M.S., E.I.
Project Engineer

A handwritten signature in black ink, reading "Brian F. Gisi".

Brian F. Gisi, P.E.
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Copies to: 2 - Addressee

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EXECUTIVE SUMMARY

A geotechnical exploration has been performed for the proposed addition to the VA Medical Center in Iowa City, Iowa. Terracon's geotechnical engineering scope of work for this project consisted of drilling and sampling four (4) soil borings at the site to depths of about 10 to 54½ feet below the existing site grades.

Based on the subsurface information obtained from this exploration, it is our opinion that the site is suitable for construction of the proposed addition. The following geotechnical considerations were identified:

- Special design and construction considerations will be required on this project due to the anticipated heavy foundation loads, presence of existing fills and lower strength soils at the site and groundwater concerns for the proposed basement level.
- Existing and/or possible existing fill materials were encountered in Borings SB-1, SB-2, and CB-2 to depths of about 3 to 6 feet below grade. The deeper borings also encountered lower strength native soils (lean clay to silty clay) to depths of about 22 to 24 feet. Based on the anticipated heavy foundation loads and the resulting higher than normal total and differential settlement, support of the structure on conventional shallow foundations is not feasible.
- The proposed addition can be supported on a deep foundation system of drilled shafts extending into bedrock. Driven H-piles extending to competent bedrock can also be considered; however, vibration from pile driving will be an issue for safety of the adjacent structures and utilities.
- Due to anticipated seasonal variations in the groundwater conditions and the planned basement level, an effective means of controlling groundwater will be required during and after construction. In addition, the basement floor will need to be designed with a subsurface drainage system to control seepage and hydrostatic pressures. Waterproofing of the lower level walls and slabs should also be planned.
- Protection of neighboring structures, utilities and other improvements will need to be established, and will be the responsibility of the site grading and earthwork contractor(s). A performance specification for protection of the existing improvements is recommended.
- Care should be taken to avoid undermining existing foundations and grade-supported slabs. Excavations extending below bearing level of the existing foundations and slabs should be avoided. If such excavations are necessary, Terracon should be consulted regarding requirements for sloping, shoring, bracing, or underpinning based on actual conditions encountered during construction.

Geotechnical Engineering Report

Proposed VA Medical Center Addition ■ Iowa City, Iowa

August 8, 2011 ■ Terracon Project No. 06105663.01



- Most of the site soils, consisting of inorganic clay and sands, appear suitable for use as structural fill; however, significant moisture conditioning should be anticipated if the on-site soils are used as fill.
- Based on the results of the seismic survey, subsurface information obtained from this exploration, and the 2009 International Building Code (IBC), the seismic site classification for this site is C.
- Construction of the foundations and earthwork on the project should be observed and evaluated by Terracon. The evaluation of earthwork should include observation and testing of engineered fill, subgrade preparation, foundation bearing materials, and other geotechnical conditions exposed during construction.

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
PROPOSED VA MEDICAL CENTER ADDITION
IOWA CITY, IOWA**

**Terracon Project No. 06105663.01
August 8, 2011**

1.0 INTRODUCTION

This report presents the results of our subsurface exploration and geotechnical engineering services performed for the proposed VA Medical Center addition in Iowa City, Iowa. The purpose of these services is to provide information and geotechnical engineering recommendations relative to:

- | | |
|---------------------------------------|--------------------------------------|
| ■ subsurface soil conditions | ■ groundwater conditions |
| ■ foundation design and construction | ■ floor slab design and construction |
| ■ pavement design and construction | ■ site preparation and earthwork |
| ■ seismic site classification per IBC | ■ excavation considerations |

The geotechnical engineering scope of work for this project included the advancement of four (4) borings to depths of about 10 to 44½ feet below the existing grades where either the boring's designated termination depth or practical auger refusal in the underlying limestone bedrock was achieved. After achieving auger refusal, the structure area borings (SB-1 and SB-2) were advanced about 10 feet using diamond bit core drilling procedures.

A Site Location Plan (Exhibit A-1), a Boring Location Plan (Exhibit A-2), the subsurface soil profile (Exhibit A-3) and boring logs (Exhibit A-4) are included in Appendix A of this report. The results of the laboratory testing performed on soil and rock samples obtained from the site during the field exploration are included on the attached boring logs. Descriptions of the field exploration and laboratory testing are included in their respective appendices.

Terracon had performed previous subsurface explorations for the existing Buildings 40 and 41 near this site in June 2003 (Laboratory Building, Terracon Project No. 06035646, report dated July 10, 2003), July 2005 (Research Building No. 41, Terracon Project No. 06055659, reports dated July 28, 2005 and December 13, 2005), and February 2009 (CSI Building Addition, Terracon Project No. 06095614, report dated February 27, 2009). The information obtained from these prior explorations was also used in developing the recommendations contained in this report.

2.0 PROJECT INFORMATION

2.1 Project Description

ITEM	DESCRIPTION
Site layout	<ul style="list-style-type: none"> Refer to the Site Location Plan (Exhibit A-1) and Boring Location Plan (Exhibit A-2) in Appendix A.
Proposed Structures	<ul style="list-style-type: none"> Addition to the existing hospital building at VA Medical Center.
Structure Type (based on supplied site plan)	<ul style="list-style-type: none"> The proposed addition will be five-story structure including basement level; Framed structure - column spacing varying between about 15 to 31 feet on-center; A 10-foot high retaining wall is planned along the existing building.
Below Grade Areas	<ul style="list-style-type: none"> A full basement.
Finished floor elevation	<ul style="list-style-type: none"> Basement floor elevation: 698.6 feet The basement and upper level floor elevations of the addition are expected to match with those of the existing facility.
Maximum loads	<ul style="list-style-type: none"> Columns: 350 to 900 kips (provided); Walls: none (assumed); Uniform Floor Loads: 125 psf (assumed).
Maximum allowable settlement (assumed)	<ul style="list-style-type: none"> Total: 1-inch; Differential: 2/3 total settlement
Cut & fill requirements	<ul style="list-style-type: none"> Cut thickness: up to about 12 feet in the basement area; Minimal fill thicknesses of about 2 feet or less in pavement areas (assumed).

2.2 Site Location and Description

ITEM	DESCRIPTION
Location	<ul style="list-style-type: none"> The project site is located adjacent to the existing hospital building in the VA Medical Center premises in Iowa City, Iowa;
Site topography	<ul style="list-style-type: none"> Existing structures, pavements, and utilities; The project site is within a built up area with existing grade elevations varying between about 709½ feet and 710½ feet at the boring locations.

3.0 SUBSURFACE CONDITIONS

3.1 USDA NRCS Soil Mapping

A review of the United States Department of Agriculture - Natural Resources Conservation Service (USDA NRCS) Soil Survey of Johnson County, Iowa indicates that Fayette silt loam is the primary soil type present at undisturbed locations of this site. The classifications provided are for the USDA textural soil classification system for approximately the upper 60 inches of the soil profile. According to the soil survey, these soil types present severe limitations for building construction activities due to steep slope and shrink-swell characteristics associated it.

3.2 Typical Subsurface Profile

Specific subsurface conditions encountered at the boring locations are indicated on the individual boring logs. Stratification boundaries on the boring logs represent the approximate location of changes in soil and rock types. In-situ, the transition between native materials may be gradual. Based on the results of the exploration, subsurface conditions on this site can be generalized as follows:

Description	Approximate Depth to Bottom of Stratum (feet)	Material Encountered	Consistency/Density
Surficial	4 to 6 inches	4" concrete pavement (SB-2) 6" topsoil (CB-1)	N/A
Stratum 1	3 to 6 (SB-1, SB-2, and CB-2)	Existing and/or possible existing fill materials – primarily composed of lean clay (SB-1 and CB-2) and fine to medium sand (SB-2).	N/A
Stratum 2 ¹	10 to 24	Lean clay to silty clay	Soft to stiff
Stratum 3	31 to 32	Sandy lean to fat and/or fat clay	Very stiff to hard
Stratum 4	42½ to 43	Fine to coarse sand with varying amounts of clay	Loose to medium dense
Stratum 5	43½ to 44½	Limestone	Highly to moderately weathered to auger refusal

Description	Approximate Depth to Bottom of Stratum (feet)	Material Encountered	Consistency/Density
Stratum 6 ²	53½ to 54½	Limestone	Highly to moderately weathered, moderately hard

1. Bottom of Borings CB-1 and CB-2

2. Bottom of Borings SB-1 and SB-2

Please review the attached boring logs for a detailed description of the conditions encountered at the individual boring locations.

3.3 Groundwater Conditions

The borings were monitored for the presence and level of groundwater during drilling and sampling. At the time of drilling, groundwater level was observed in the deeper borings (SB-1 and SB-2) at depths of about 25 to 29 feet below the existing grades. Groundwater was not encountered in Borings CB-1 and CB-2 at that time. After completion of the drilling operations, the boreholes were backfilled with on-site soils and pavement patched, as applicable.

The water level observations at the time of drilling provide an approximate indication of the groundwater conditions existing on the site at the time the borings were drilled. The absence of groundwater in Boring CB-1 and CB-2 does not necessarily mean that they were terminated above the water table, since, for the lower permeability clay soils encountered in the borings, a longer time may be required to develop representative water level in the borehole. Longer-term observations using 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.

The Johnson County Soil Survey report was also reviewed for information relating to anticipated seasonally high groundwater levels. The primary soil type present in undisturbed areas of the site is reported to have apparent seasonal high groundwater levels at depths of 6½ feet or more below its natural grades.

Fluctuations of the groundwater levels will likely 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 within existing variable fills and/or high permeability soils overlying less permeable soils following periods of heavy or prolonged precipitation. Therefore, groundwater levels during construction or at other times in the future will be higher or lower than the levels indicated on the boring logs.

4.0 RECOMMENDATIONS FOR DESIGN AND CONSTRUCTION

4.1 Geotechnical Considerations

Based on the results of this exploration and the planned construction, it is our opinion that the proposed addition should be supported on deep foundation system of drilled shafts extending into the underlying limestone bedrock. Driven H-piles extending to competent bedrock can also be considered; however, vibration from pile driving will be an issue for the safety and integrity of the adjacent structures and utilities. If requested, we can provide the driven H-piles design parameters.

Special design and construction considerations will be required on this project due to:

- anticipated heavy foundation loads,
- lower strength native soils,
- existing fill materials,
- construction adjacent to existing structures and utilities,
- easily disturbed subgrades.

Existing and/or possible existing fill soils were encountered in Borings SB-1, SB-2, and CB-2 to depths of about 3 to 6 feet below grade. Based on the test results and composition of the fill, it appears that the fill may not have been placed as engineered fill with consistent control of moisture and density. Lower strength native clay soils were also encountered in the borings to depths of about 10 to 24 feet below grade. It should be noted that structures supported over uncontrolled fills and lower strength soils would be at risk for greater than normal settlements and subsequent distress.

Based on the planned basement level and the anticipated groundwater conditions, an effective means of controlling groundwater will be required on this project during and after construction. In addition, the basement floor will need to be designed with a subsurface drainage system to control seepage and hydrostatic pressures.

Care should be taken to avoid undermining existing foundations and slabs. Excavations extending below bearing level of the existing foundations should be avoided. Due to the proximity of the site to the existing structure(s), sheeting and shoring may be required where excavations below foundations and/or slabs of the existing structure are planned.

It should be noted that the site soils are susceptible to disturbance from construction activities, particularly if the soil has high natural moisture content or is wetted by surface water or seepage. Care should be taken during construction to minimize disturbance of the subgrade soils.

4.2 Site Preparation and Earthwork

4.2.1 Demolition Considerations

It is important that the demolition of the existing structures and other improvements be performed with close observation and testing. Demolition and/or site grading plans should include preparations for sheeting and bracing of excavations, dewatering, and monitoring of existing structures and improvements at the site. The demolition contractor(s) should be aware of project requirements for backfilling so that removal of these fill materials and replacement under controlled conditions is not necessary to provide proper support of grade-supported slabs and pavements. Utility lines should be re-routed outside of the addition areas whenever feasible. Whether the utility lines are abandoned or not, any poorly compacted backfill above the lines should be removed and replaced.

4.2.2 Excavation Considerations

Any excavations necessary for removal of existing structures or utilities, as well as for the new construction, should be carefully planned and executed, especially adjacent to existing buildings, pavements, and utilities. These excavation activities have the potential to induce settlement and/or lateral movement of adjacent structures. The existing structures should be monitored before and during construction for any indications of settlement and/or lateral movement. A precondition survey of neighboring improvements prior to construction is recommended. Construction activities should be terminated and Terracon should be contacted if any movement of the existing structures adjacent to construction area is observed.

Proper shoring and bracing of excavations to prevent disturbance and/or undermining of the adjacent structures, utilities, and other improvements will be the responsibility of the demolition, site grading and foundation contractor(s). We recommend that a performance specification be developed that includes such provisions.

All excavations should comply with the requirements of OSHA 29CFR, Part 1926, Subpart P, "Excavations" and its appendices, as well as other applicable codes. This document states that the excavation safety is the responsibility of the contractor. Reference to this OSHA requirement should be included in the project specifications. Slope heights, slope inclinations and/or excavation depths should in no case exceed those specified in local, state or federal safety regulations, including current OSHA excavation and trench safety standards. If any excavations extend to a depth greater than 20 feet, according to OSHA regulations, side slopes and/or bracing must be designed by a professional engineer. Flatter slopes than those required by OSHA could be required in areas where existing fills, lower strength soils, and/or groundwater seepage are present.

4.2.3 Site Preparation

Surficial materials, debris from removal of existing structures, pavement, and utilities, and any otherwise unsuitable materials should be removed from the construction area. Wet or dry material should either be removed or moisture conditioned and recompacted. Soft, dry and/or lower strength soils should be either removed or compacted in place prior to placing new fill.

After rough grade has been established in the pavement area, wherever possible, the exposed subgrade should be proofrolled by the contractor and test probed by Terracon. Soft or loose areas should be undercut, moisture conditioned, and recompacted or replaced with approved structural fill. Subgrade conditions should be observed by Terracon personnel during construction.

Corrective measures will probably be required to increase subgrade stability during subgrade preparation. This is of special concern for the proposed basement subgrade of the addition where soft clay soils will be present. We recommend the owner include a contingency budget for corrective measures. We recommend at least 2 feet of crushed stone should be used as necessary to stabilize the basement subgrade soils. Stabilization measures may also be required in pavement areas, depending on final grades.

Upon completion of grading, care should be taken to maintain the subgrade moisture content prior to construction of basement floor slab and pavements. Construction traffic over the completed subgrade should be avoided to the extent practical. The site should also be graded to prevent ponding of surface water on the prepared subgrades or in excavations. If the subgrade should become frozen, desiccated, saturated, or disturbed, the affected material should be removed or these materials should be scarified, moisture conditioned, and recompacted prior to slab and pavement construction.

4.2.4 Fill Types and Compaction

New fills placed for the project should be low plasticity cohesive soil or granular soil. Fill placed in confined excavations such as utility trenches should consist of relatively clean and well-graded granular material. This should provide for greater ease of placement and compaction in confined areas where larger compaction equipment cannot be operated. The use of granular fill in these isolated and potentially deeper excavations would reduce the potential for differential settlement for the structure components.

Structural fill should meet the following material property requirements:

Fill Type ¹	USCS Classification	Acceptable Location for Placement
Low Plasticity Cohesive ²	CL, CL-ML	General site grading fill

Fill Type ¹	USCS Classification	Acceptable Location for Placement
Granular	GW, GP, GM, GC SW, SP, SM, SC	General site grading fill, below foundations and slabs
Unsuitable	MH, OL, OH, PT	Green (non-structural) locations
On-Site Soils	CL, CL-ML, SP, SP-SC	Most of the site soils, as encountered in the borings, generally appear suitable for reuse as structural fill. ^{2, 3}

1. 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 the geotechnical engineer for evaluation prior to use on this project.
2. Low plasticity cohesive soils (CL, CL-ML) would have a liquid limit of 45 or less and a plasticity index of 23 or less.
3. Some sorting will be required in order to remove any unsuitable materials and debris from the existing fills.

4.2.5 Compaction Requirements

Significant moisture conditioning of on-site soils will also be required to achieve adequate compaction. Appropriate laboratory tests, including Atterberg Limits for cohesive soils, and standard Proctor (ASTM D698) moisture-density relationship tests should be performed on proposed fill materials prior to their use as engineered fill. Further evaluation of any on-site soils or off-site fill materials should be performed by Terracon prior to their use in compacted fill sections.

Recommended degree of compaction and moisture content criteria for engineered fill materials are as follows:

Material Type and Location	Per the Standard Proctor Test (ASTM D 698)		
	Minimum Compaction Requirement (%) ¹	Range of Moisture Contents for Compaction ¹	
		Minimum	Maximum
Low Plasticity Cohesive			
Below foundations and within upper 1-foot of pavement	98	-2%	+3%
Above foundations, below slabs and more than 1 foot below pavement	95	-2%	+3%
Granular ^{2,3}			
Below foundations and within upper 1-foot of pavement	98	-3%	+3%
Above foundations, below	95	-3%	+3%

Material Type and Location	Per the Standard Proctor Test (ASTM D 698)		
	Minimum Compaction Requirement (%) ¹	Range of Moisture Contents for Compaction ¹	
		Minimum	Maximum
slabs and more than 1 foot below pavement			

1. We recommend that structural 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, or of a uniform size, or has a low fines content, compaction comparison to relative density may be more appropriate. In this case, granular materials should be compacted as per ASTM D 4253-00 and D 4254-00.
3. Specifically, moisture levels should be maintained at levels satisfactory for compaction to be achieved without the granular fill material bulking during placement or pumping when proofrolled.

We recommend that fill be placed and compacted on stable subgrades in lifts of 9 inches or less in loose thickness when heavy, self-propelled compaction equipment is used. Lift thickness should be reduced to 4 inches in loose thickness when hand equipment (e.g., jumping jack, vibratory plate compactor, etc.) is used. A vibrating smooth drum compactor should not be used on clay soils. All new fill placement and compaction should be observed and tested by Terracon personnel.

4.2.6 Grading and Drainage

Final surrounding grades should be sloped away from the addition and pavements on all sides. In addition, roof drainage should be collected by a system of gutters and downspouts and transmitted by pipe to the storm water drainage system or discharged a minimum of 5 feet away from the addition. As an alternative, splash blocks may be used as long as the ground surface is paved and slopes away from the addition.

4.3 Deep Foundations

4.3.1 Drilled Shaft Foundation

We understand the proposed addition is planned to be supported by a deep foundation system of drilled shafts. Based on the results of our exploration and analyses, it is our opinion that the addition can be supported on straight-sided drilled shafts bearing on competent, less weathered limestone bedrock. Limestone bedrock was encountered in our borings (SB-1 and SB-2) at depths of about 42½ to 43 feet below the existing grade. Practical auger refusal was encountered at depths of about 43½ to 44½ feet. Below this depth, rock coring was performed in the borings to additional depths of about 10 feet. Based on the test results, the bedrock

material can be classified as a moderately hard to hard formation with RQD values of about 58%, resulting in a "fair" rock quality.

Based on the bedrock core density and compressive strength test results, drilled shafts extending to the less weathered limestone bedrock material could be designed with an allowable end bearing pressure of 80,000 psf. The actual bottom elevation should be evaluated during construction by Terracon personnel. If Terracon is not retained to provide observation and testing of drilled shaft foundations, we recommend a compressive load-test be performed to verify the load-bearing capacities of the drilled shafts.

We recommend a minimum shaft diameter of 30 inches be used in order to permit cleaning and testing of the shaft bottoms. Belling of the drilled shafts is not recommended on this project. The bedrock at the base of the shaft excavations should be carefully observed. Probe holes should be performed in a portion of the drilled shafts to help verify rock quality and check for voids or weak clay layers. The number of probe holes and locations will depend upon the drilled shaft layout, loads, and actual rock quality. For bidding purposes, we recommend an estimated $\frac{1}{4}$ of the drilled shafts be probed; however, it may be possible to reduce the number of probe holes performed, and this will be determined by Terracon during construction. The probe holes should be approximately 2 inches in diameter and should extend below the base of the shaft excavations a distance at least equal to the shaft diameter or 5 feet, whichever is greater. If probes are not performed prior to construction, hand held pneumatic equipment should be used for drilling the probe holes.

The use of temporary casing and/or slurry drilling procedures will be required at this site to control seepage into the shaft excavation and prevent collapse of the side walls where lower strength soils or sand layers are encountered. Special provisions should be anticipated to perform rock probes prior to construction. Care should be taken so that the sides and bottom of the excavation are not disturbed during construction. The bottom of the shaft excavation should be relatively clean of loose material prior to concrete placement. Concrete should be placed using a tremie method as soon as possible after the foundation excavation is completed to reduce the potential disturbance of the bearing surface.

Use of a telescoping casing arrangement can be considered to avoid handling long casing lengths. The lower casing, in particular, should be of sufficient length and stiffness and have an appropriate cutting edge to allow it to be firmly seated into the bedrock in order to seal out groundwater. If possible, excess water should be evacuated from the casing in order to place concrete in the "dry".

During removal of the temporary casing, the concrete level should be maintained a sufficient distance above the bottom of the casing to counteract hydrostatic pressure on the annular space outside of the casing. Placement of loose soil backfill should not be permitted around the

casing prior to removal. A concrete slump of at least 6 inches is recommended to facilitate temporary casing removal in drilled shaft excavations.

Terracon should be retained to observe all drilled shaft excavations to evaluate the suitability of the bearing materials and to verify that conditions in the drilled shaft excavations are consistent with those encountered in the test borings. If unsuitable materials are encountered at planned depths, it may be necessary to deepen the shaft.

4.3.2 Deep Foundation Lateral Earth Pressures

The drilled shafts can be designed to resist lateral loads using the allowable passive soil pressures provided in the following table. The allowable passive pressures would apply to the projected diameter of the shaft and require some movement to mobilize resistance. Passive pressures for perimeter foundation elements beneath unheated areas should be ignored at least 3½ feet below the lowest adjacent finished grade for frost protection.

LATERAL EARTH PRESSURE DESIGN DATA SUMMARY	
Stratum Material	Allowable Passive Pressure, (psf)
Overburden Soils	2,000 – 5,000*
Highly to Less Weathered Bedrock**	10,000
Less Weathered Bedrock	20,000

*Increases linearly with depth.

**Where practical auger refusal is encountered.

Group action for lateral resistance of shafts should be taken into account when spacing is less than 8 diameters (center to center), and design parameters for allowable passive resistance in the direction of the load should be reduced in accordance with the following table.

Shaft/Pier Spacing (Diameters)	Reduction Factors
8D	1.0
6D	0.7
4D	0.4
3D	0.25

4.3.3 Construction Considerations for Deep Foundations

Due to presence of sandy soils above the bedrock, difficult construction procedures should be anticipated. We recommend a deep foundation contractor experienced with the local site conditions be used and deep foundation construction be monitored by Terracon personnel on a full-time basis during construction.

The drilled shafts should be spaced at least three shaft diameters apart (center-to-center). Foundation caps and/or grade beams could be subject to uplift loading due to frost action; thus, perimeter foundation elements beneath unheated areas should extend at least 3½ feet below the lowest adjacent finished grade for frost protection. Drilled shafts designed and constructed in accordance with the recommendations in this report have estimated maximum settlements on the order of ½ inch or less.

It should be noted that the load capacities provided above are based on stresses induced in the supporting soil and rock strata. The structural capacity of the drilled shafts should be checked to assure that they can safely accommodate the combined stresses that may be induced by axial loads, lateral loads, and bending moments. The response of deep foundations to lateral loads is not only dependent upon the material's horizontal subgrade reaction, but also on the piles actual diameter, length, stiffness, and fix-head or free-head condition. We would be pleased to provide consultation to this regard if requested to do so.

4.4 Seismic Considerations

The International Building Code (IBC) requires structural design to be in accordance with the appropriate site class definition for soil profile type. Based upon the Site Class Definitions in Table 1615.1.1 of the 2006 International Building Code, and the average shear wave velocity of 1,650 ft/s derived from our seismic survey data, Terracon recommends a Class C seismic site classification for design.

The average shear-wave velocity analysis and recommendations presented in this report are based upon the data obtained from the seismic refraction system performed at the indicated location and on the indicated date. This analysis does not reflect variations that may occur across the site, or variations that may occur throughout the year, such as groundwater fluctuations. The refraction microtremor method is an approximate method, and one of many methods that can be used to determine shear-wave velocities. There are other costlier methods that can be used to further increase the accuracy of the seismic site classification and shear-wave profile.

DESCRIPTION	VALUE
2006 International Building Code Site Classification (IBC) ¹	C
Site Latitude	N 41° 39.78'
Site Longitude	W 91° 32.92'

¹ Note: In general accordance with the 2006 International Building Code, Table 1615.1.1.

4.5 Construction Adjacent to Existing Building

New foundations placed adjacent to existing building foundations and slabs may cause some additional settlement of the existing structures. To help reduce this effect, new foundations placed near existing foundations should bear at approximately the same elevation as the existing footings. Care should be taken to avoid undermining existing foundations and grade-supported slabs. Excavations extending below bearing level of the existing foundations should be avoided. If such excavations are necessary, Terracon should be consulted regarding requirements for sloping, shoring, bracing, or underpinning based on actual conditions encountered during construction.

If the new structures will attach to the existing structure/facility, connections with sufficient flexibility to accommodate independent movement should be utilized. Differential settlement between new and existing structures will approach the maximum total settlement.

4.6 Basement Floor Slab

4.6.1 Design Recommendations

DESCRIPTION	VALUE
Floor slab	■ Portland cement concrete
Floor slab support	■ Minimum 12 inches - including 9 inches of relatively clean crushed aggregate with less than 3% passing the No. 200 sieve overlain by at least 3 inches of dense-graded crushed stone (IDOT 4120.04).
Unheated areas subject to frost	■ Minimum of 3½ feet of clean (less than 6% passing the U.S. No. 200 sieve) material below the slab.
Modulus of subgrade reaction	■ 100 pounds per square inch per inch (psi/in). The modulus was obtained based on our experience with similar subgrade conditions.

Due to anticipated groundwater conditions, we strongly recommend at least 1 foot of crushed stone be provided below the basement floor, as mentioned in the above table. The lower 9 inches should consist of a relatively clean (i.e. less than 3% passing the U.S. No. 200 sieve) crushed limestone for incorporation of the subsurface drainage system. To help stabilize the subgrade, minimize the risk of contaminating the relatively clean crushed stone and help expedite construction, we recommend the placement of at least 3 inches of dense-graded crushed stone (i.e., gradation meeting IDOT 4120.04) above the clean stone. A geotextile fabric could be used in conjunction with the crushed stone to reduce the potential migration of fines into the crushed stone layer.

Slabs-on-grade should be isolated from structures and utilities to allow for their independent movement. Joints should be constructed at regular intervals as recommended by the American Concrete Institute (ACI) to help control the location of any cracking. Keyed and doweled joints should be considered. The owner should be made aware that differential movement between the slabs and foundations could occur.

The need for a vapor barrier, and where to place it, should be determined by the architect based on the proposed floor treatment, building function, concrete properties, placement techniques, and the construction schedule. When moisture barriers are used, precautions should be taken during the initial floor slab concrete curing period to reduce differential curing and possible curling of the slabs. The recommendations provided in ACI 302 should be followed.

Where the slabs are tied to perimeter walls or turn-down slabs to meet structural or other construction objectives, our experience indicates that any differential movement between the walls and slabs will likely be observed in adjacent slab expansion joints or slab cracks that occur beyond the length of the structural dowels. The structural engineer should account for this potential differential settlement through use of sufficient control joints, appropriate reinforcing or other means.

4.6.2 Subfloor Drainage

We recommend a subfloor drain system should be provided beneath the basement floor. The subfloor drain system should consist of a network of perforated, rigid plastic or metal drain lines with a minimum diameter of 4 inches and spaced no more than 30 feet apart. The invert of these drain lines should be at least 12 inches below the basement floor subgrade elevation. These drain lines should be surrounded by at least a 6-inch annulus of granular material graded to facilitate drainage and prevent the intrusion of fines (i.e., gradation meeting IDOT 4131). At least 9 inches of free-draining granular material should be placed beneath the slab and should be hydraulically connected to the granular material surrounding the drainage pipes. We recommend that slab subgrade be graded to promote the flow of water towards the subdrains. The subdrains should be provided with positive gravity drainage (i.e., sump pits and pumps).

4.6.3 Construction Considerations

Subgrade for the basement floor should be prepared in accordance with **Section 4.2 (Site Preparation and Earthwork)** of this report. Prior to excavation to finished subgrade, an effective means of controlling groundwater will be required as previously discussed. Subfloor drains should be installed as soon as practical in order to help stabilize subgrade.

As mentioned previously, the on-site soils are highly susceptible to disturbance from construction activities. Areas where unsuitable conditions are identified should be repaired by removing and replacing the affected material with crushed stone. Strong consideration should be given to providing a construction allowance for 2 feet of crushed stone below the basement subgrade to stabilize the lower strength clay anticipated at the subgrade level. Care should be

taken to maintain the subgrade moisture content, prior to construction of the floor slab. Dry and/or desiccated subgrade soils should be removed, or subjected to a procedure of scarification, moisture conditioning, and recompaction prior to placing the floor slab base course.

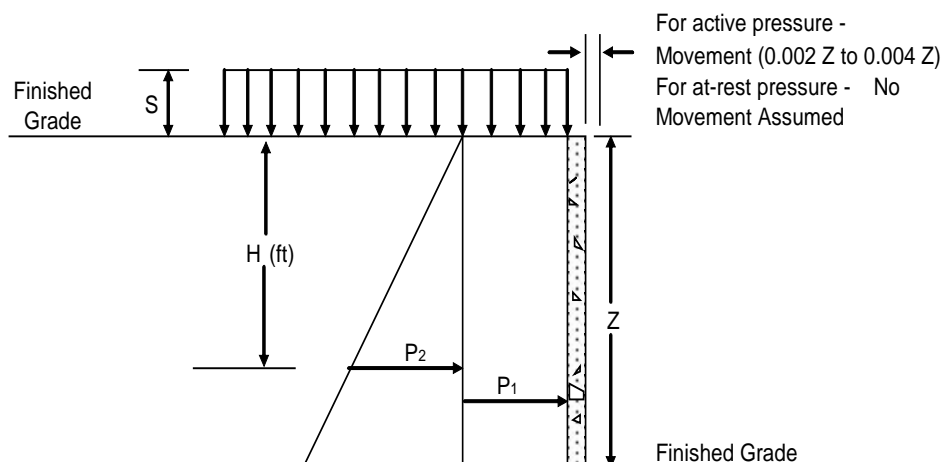
The recommended crushed stone base thickness is not intended to be used as a working surface for construction activities. Some redressing and correction of the crushed stone base disturbed or contaminated with fines should be anticipated if the stone base is placed early during construction.

Where practical, we recommend “early-entry” cutting of crack-control joints in floor slabs. Cutting of the concrete in its ‘green” state typically reduces the potential for micro-cracking of the slabs prior to the crack control joints being formed, compared to cutting the joints after the concrete has fully set. Micro-cracking of slabs may lead to crack formation in locations other than the sawed joints, and/or reduction of fatigue life of the slabs.

4.7 Lateral Earth Pressure - Basement and Retaining Walls

The proposed basement walls and retaining walls with unbalanced backfill levels on opposite sides 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 rotation. The surcharge components would apply where drives, surface parking or other loading are anticipated adjacent to these below grade walls. The recommended design lateral earth pressures are for cast-in-place concrete walls only, do not include a factor of safety, and the “drained” values do not include any provision for possible hydrostatic pressure on the walls.

EARTH PRESSURE COEFFICIENTS



EARTH PRESSURE CONDITIONS	COEFFICIENT FOR BACKFILL TYPE	EQUIVALENT FLUID PRESSURE (pcf)		SURCHARGE PRESSURE, P ₁ (psf)	EARTH PRESSURE, P ₂ (psf)	
		Drained	Undrained		Drained	Undrained
Active (K _a)	Granular - 0.33	40	85	(0.33)S	(40)H	(85)H
	Low - Plasticity	50	90	(0.42)S	(50)H	(90)H
	Cohesive - 0.42					
At-Rest (K _o)	Granular - 0.50	60	95	(0.50)S	(60)H	(95)H
	Low - Plasticity	70	100	(0.59)S	(70)H	(100)H
	Cohesive - 0.59					
Passive (K _p)	Granular - 3.0	360	280	---	---	---
	Low-Plasticity	285	230	---	---	---
	Cohesive - 2.4					

Conditions applicable to the above values include:

- For active earth pressure, wall must rotate about base, with top lateral movements 0.002 Z to 0.004 Z, where Z is wall height;
- For passive earth pressure, 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 final graded backfill, compacted to at least 95 percent of the ASTM D 698 maximum dry density;
- Loading from heavy compaction equipment not included;
- No groundwater acting on wall for “drained” values;
- No safety factor included;
- Ignore passive pressure in frost zone.

Backfill placed against the below grade walls 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 and 60 degrees from vertical for the active/at-rest and passive cases, respectively. To calculate the resistance to sliding, a value of 0.35 could be used as the allowable coefficient of friction between the footing and the underlying soil.

Heavy construction equipment should not operate within a distance closer than the exposed height of below grade walls to prevent lateral pressures greater than those provided. Backfill placed in non-structural areas adjacent to the walls should be placed in thin lifts and compacted using hand-operated equipment to at least 95 percent, but no more than 98 percent, of the material's maximum Standard Proctor dry density (ASTM D 698).

A perforated rigid drain line installed at the foundation level behind the base of the below grade walls is recommended to prevent hydrostatic loading on the walls. The drain line should be sloped to provide positive gravity drainage and should be surrounded by free draining granular material graded to prevent the intrusion of fines, or an alternative free draining granular material encapsulated with suitable filter fabric. At least a 2 foot wide section of free draining granular fill should be used for backfill above the drain line and adjacent to the wall and should extend to within 2 feet of final grade. In unpaved areas, the granular backfill should be capped with at least 1 foot of compacted cohesive fill to minimize infiltration of surface water into the drain system. A prefabricated drainage structure may be used above a drain line as an alternative to free draining granular fill. A prefabricated drainage structure is a plastic drainage core or mesh which is covered with filter fabric to prevent soil intrusion, and is fastened to the wall prior to placing backfill. The undrained earth pressure parameters should be used if provisions for drainage are not provided.

4.8 Pavements

4.8.1 Pavement Subgrades

Existing and possible existing fills were encountered in our borings. In order to reduce the risk of pavement movement and the resultant distress associated with the uncontrolled fills, we recommend at least 12 inches of properly compacted structural fill be present below the pavements.

The subgrade for pavements should be prepared in accordance with the **Site Preparation and Earthwork** section of this report. We recommend the exposed subgrade be proofrolled. Proofrolling clay subgrades could be accomplished by using heavy, rubber-tired construction equipment or a tandem axle dump truck (gross weight of 15 and 20 tons in parking and drive areas, respectively). This surficial proofroll and compaction would help to provide a stable base for the compaction of new structural fill, and delineates low density, soft, or disturbed areas that may exist below subgrade level. Unsuitable material encountered below subgrade level should be further undercut and replaced with structural fill. The upper 1 foot of subgrade material should be compacted to at least 98 percent of the material's maximum dry density as determined by ASTM D698.

If there is a delay between subgrade preparation and paving, the pavement subgrades should be carefully re-evaluated as the time for pavement construction approaches. Within a few days of the scheduled paving, we recommend the pavement areas be proofrolled again with a loaded tandem axle dump truck in the presence of Terracon personnel. Particular attention should be given to the areas that were rutted and disturbed earlier during construction operations and frequent movement of construction equipment. Areas where unsuitable conditions exist should be repaired by removing and replacing the materials with properly compacted fill.

Due to the lower strength clays encountered, it will likely be necessary to provide a layer of crushed limestone to help improve subgrade stability for heavy construction equipment traffic.

4.8.2 Design Recommendations

Traffic load information was not available at the time of this report; therefore, a formal pavement design is not provided. Some typical pavement sections are provided below. Asphaltic cement concrete pavement thicknesses are based on the Asphalt Paving Association of Iowa (APAI) Asphalt Paving Design Guide and local design practice. Portland cement concrete thicknesses are from the American Concrete Institute (ACI) ACI 330R-08 – Guide for the Design and Construction of Concrete Parking Lots. Thickness recommendations for **Passenger Vehicle Parking** sections are based on light passenger vehicle (gross weight less than 4 tons) traffic only, and only occasional truck traffic such as snow removal trucks (APAI Class II, ACI Traffic Category A). As part of the layout design of the project we recommend the designer use signs and preventive structures to restrict heavy truck traffic from entering these areas. The **Main Drives & Truck Access** sections are based on less than 25 trucks per day (APAI Traffic Class III, ACI Traffic Category B).

As a minimum, we suggest the following typical pavement sections be considered:

Traffic Area	Alternative	Recommended Pavement Section Thickness ¹ (inches)			
		Asphaltic Cement Concrete ³	Portland Cement Concrete	Aggregate Base Course ⁴	Total
Passenger Vehicle Parking	A	---	5	4 ⁵	9
	B	4	---	6 ⁶	10
Driveways & Delivery Truck Access ²	A	---	6	4 ⁵	10
	B	6	---	6	12

- All materials should meet the current Iowa Department of Transportation (IDOT) Standard Specifications for Highway and Bridge Construction.
 - Asphaltic Surface - IDOT Type A Asphaltic Cement Concrete: Section 2303
 - Asphaltic Base - IDOT Type B Asphaltic Cement Concrete, Class I: Section 2303
 - Concrete Pavement - IDOT Portland Cement Concrete Type C: Section 2301
- In areas of anticipated heavy traffic, fire trucks, delivery trucks, or concentrated loads (e.g. dumpster pads), and areas with repeated turning or maneuvering of heavy vehicles, a minimum concrete thickness of 7 inches is recommended but should be evaluated further when loading conditions are known.
- A minimum 1.5-inch surface course should be used on ACC pavements.
- The granular base course materials (if used) should be placed on a stable subgrade and compacted to at least 98 percent of the materials standard Proctor maximum dry density.

5. A 4-inch (or greater) granular base should be considered below PCC pavements to help reduce potential for slab curl, shrinkage cracking, and subgrade “pumping” through joints, as well as for the incorporation of the permeable granular base course.

The estimated pavement sections provided in this report are minimums for the assumed design criteria, and as such, periodic maintenance should be expected. Areas for parking of heavy vehicles, concentrated turn areas, and start/stop maneuvers could require thicker pavement sections. Edge restraints (i.e. concrete curbs or aggregate shoulders) should be planned along curves and areas of maneuvering vehicles. A maintenance program that includes surface sealing, joint cleaning and sealing, and timely repair of cracks and deteriorated areas will increase the pavement’s service life. As an option, thicker sections could be constructed to decrease future maintenance.

All concrete for rigid pavements should have a minimum 28-day compressive strength of 4,000 psi, and be placed with a maximum slump of 4 inches. A 4-inch thick base course layer will help reduce potential for slab curl, shrinkage cracking, and subgrade “pumping” through joints. Proper joint spacing will also be required to prevent excessive slab curling and shrinkage cracking. All joints should be sealed to prevent entry of foreign material and dowelled where necessary for load transfer.

Where practical, we recommend “early-entry” cutting of crack-control joints in Portland cement concrete pavements. Cutting of the concrete in its ‘green’ state typically reduces the potential for micro-cracking of the pavements prior to the crack control joints being formed, compared to cutting the joints after the concrete has fully set. Micro-cracking of pavements may lead to crack formation in locations other than the sawed joints, and/or reduction of fatigue life of the pavement.

Terracon has observed dishing in some parking lots surfaced with ACC. Dishing is usually observed in frequently-used parking stalls (such as near the front of buildings), and occurs under the wheel footprint in these stalls. The use of higher-grade asphaltic cement, or surfacing these areas with PCC, should be considered. The dishing is exacerbated by factors such as irrigated islands or planter areas, sheet surface drainage to the front of structures, and placing the ACC directly on a compacted clay subgrade.

4.8.3 Additional Design Considerations

Long term pavement performance will be dependent upon several factors, including pavement and subgrade thicknesses, maintaining subgrade moisture levels and providing for preventive maintenance. The following recommendations should be considered the minimum:

- Site grading at a minimum 2% grade away from the pavements,
- PCC joint spacing and reinforcement per ACI 330R-08,

- The subgrade and the pavement surface have a minimum $\frac{1}{4}$ inch per foot slope to promote proper surface drainage,
- Consider appropriate edge drainage,
- Install joint sealant and seal cracks immediately,
- Seal all landscaped areas in, or adjacent to pavements to minimize or prevent moisture migration to subgrade soils,
- Placing compacted, low permeability backfill against the exterior side of curb and gutter,
- Placing curb, gutter and/or sidewalk directly on subgrade soils without the use of base course materials.

Preventive maintenance should be planned and provided for through an on-going pavement management program. Preventive maintenance activities are intended to slow the rate of pavement deterioration, and to preserve the pavement investment. Preventive maintenance consists of both localized maintenance (e.g. crack and joint sealing and patching) and global maintenance (e.g. surface sealing). Preventive maintenance is usually the first priority when implementing a planned pavement maintenance program and provides the highest return on investment for pavements. Prior to implementing any maintenance, additional engineering observation is recommended to determine the type and extent of preventive maintenance.

4.9 Frost Considerations

The soils on this site are frost susceptible, and small amounts of water can affect the performance of the slabs-on-grade, sidewalks and pavements. Exterior slabs should be anticipated to heave during winter months. If frost action needs to be eliminated in critical areas, we recommend the use of non-frost susceptible structural or structural slabs (e.g., structural stoops in front of building doors). Placement of non-frost susceptible material in large areas may not be feasible; however, the following recommendations are provided to help reduce potential frost heave:

- Providing surface drainage away from the addition and slabs and toward the site storm drainage system;
- Installing drain tiles around the perimeter of the addition, stoops, below exterior slabs and pavements, and connect them to the storm drainage system;
- Grading clay subgrades such that groundwater potentially perched in overlying more permeable subgrades, such as sand or aggregate base, toward the site drainage system;
- Placing non-frost susceptible fill as backfill beneath slabs and pavements that are critical to the project;
- Placing a 3 horizontal to 1 vertical (3H: 1V) transition zone between non -frost susceptible soils and other soils;
- Minimize excessive irrigation adjacent to slabs-on-grade.

As an alternative to extending the non-frost susceptible fill to the full frost depth, consideration can be made to placing extruded polystyrene or cellular concrete under a buffer of at least 2 feet of non-frost susceptible fill.

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.

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 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.

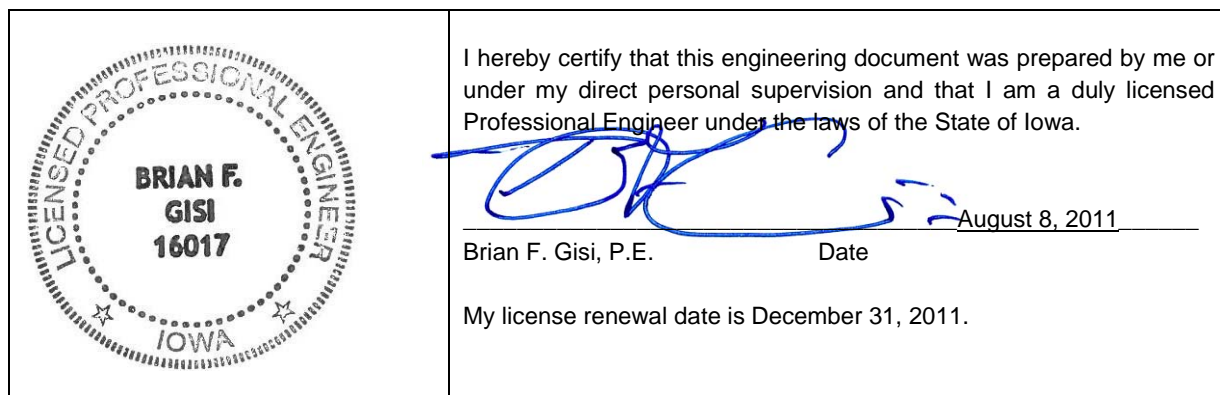
Support of pavements on or above existing fill soils is discussed in this report. However, even with the recommended construction testing services, there is an inherent risk for the owner that compressible fill or unsuitable material within or buried by the fill will not be discovered. This risk of unforeseen conditions cannot be eliminated without completely removing the existing fill, but can be reduced by performing additional testing and evaluation.

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.

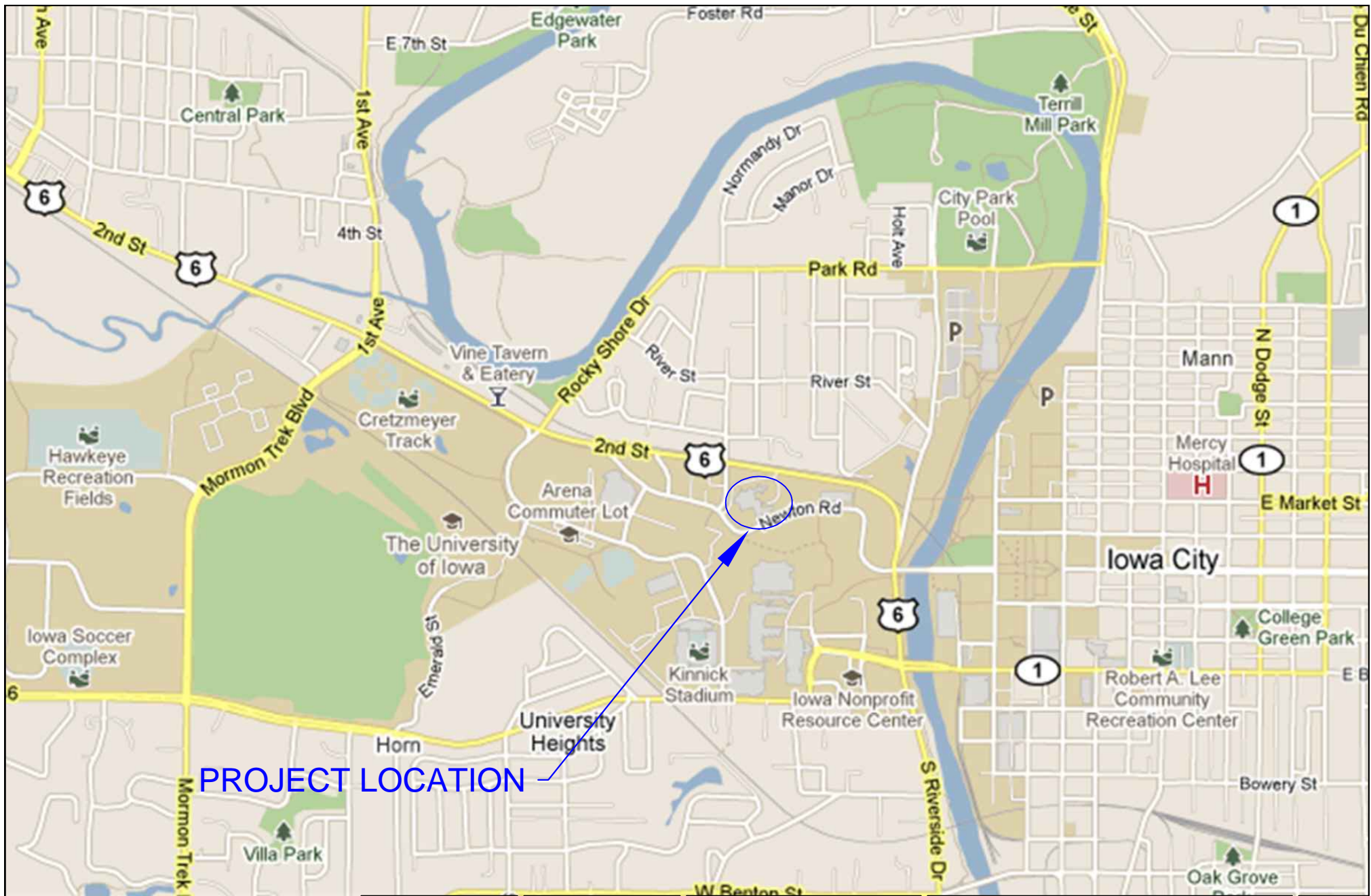
Proposed VA Medical Center Addition ■ Iowa City, Iowa
August 8, 2011 ■ Terracon Project No. 06105663.01



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.

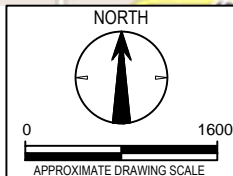


APPENDIX A
FIELD EXPLORATION



PROJECT LOCATION

BASE DRAWING FROM GOOGLE MAPS
THIS DRAWING IS INTENDED FOR GENERAL LOCATION
PURPOSES ONLY



Project No.	Date:
06105663	07/08/11
Project Mgr:	Drawn By:
BKS	PC
File Name:	
06105663-01.dwg	
Layout Name:	
SITE	

Terracon
Consulting Engineers and Scientists

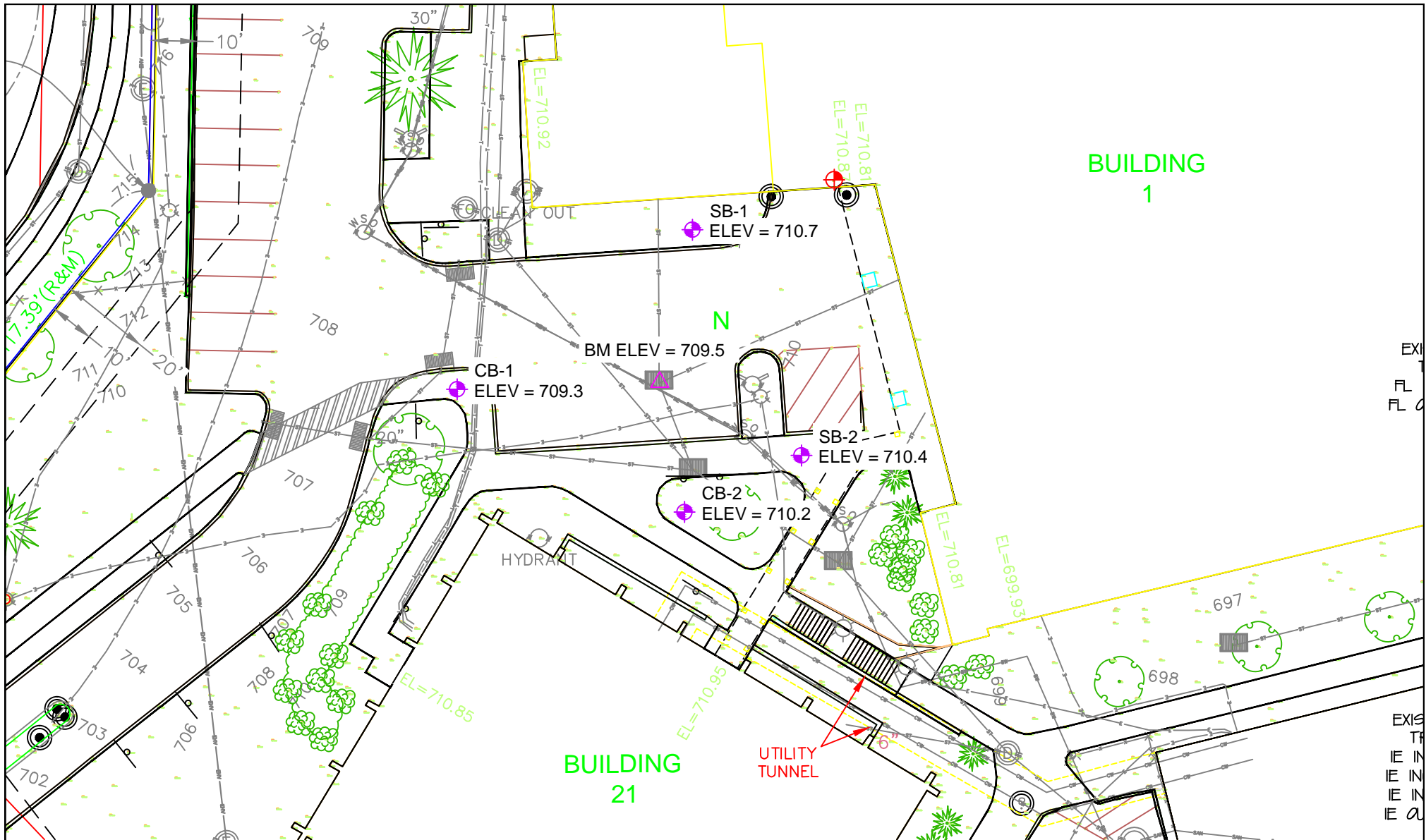
783 HIGHWAY 1 WEST IOWA CITY, IOWA 52246
PH. (319) 533-2262 FAX. (319) 688-3008

SITE LOCATION PLAN

VA PACT MEDICAL CENTER ADDITION
HEERY INTERNATIONAL, INC
601 HIGHWAY 6 WEST
IOWA CITY, IOWA

EXHIBIT #

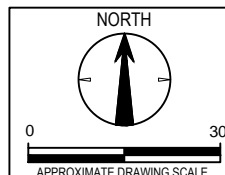
A-1



LEGEND

- APPROXIMATE BORING LOCATION AND ELEVATION
- BENCHMARK (TOP OF GRATE STORM INTAKE)

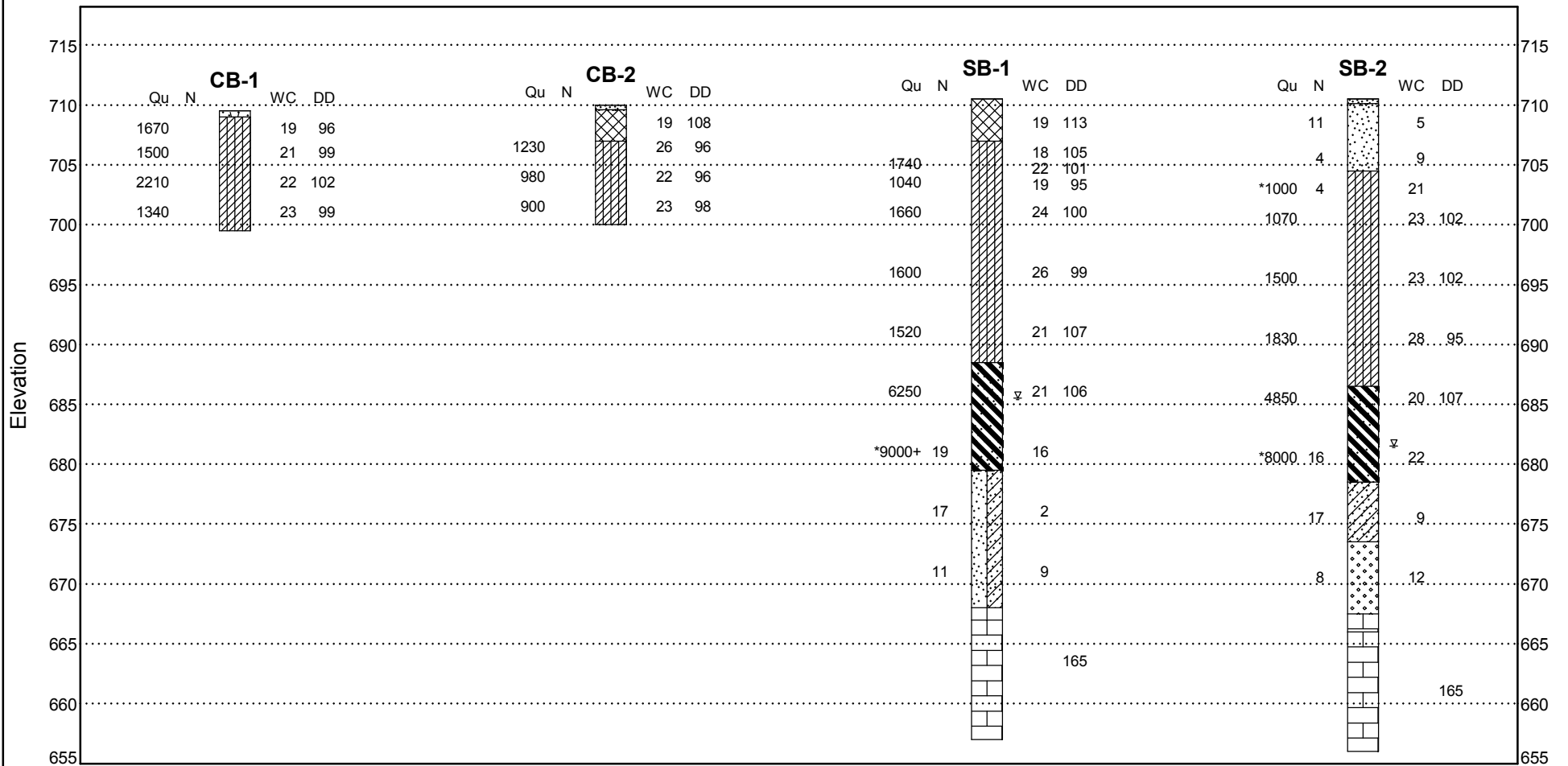
BASE DRAWING FROM CADD DRAWING TITLED 'Site Plan - Updated 01-28-2011.dwg' SUPPLIED BY HEERY
THIS DRAWING IS INTENDED FOR GENERAL LOCATION PURPOSES ONLY



Project No. 06105663 Date: 07/08/11
Project Mgr: BKS Drawn By: PC
File Name: 06105663-01.dwg
Layout Name: BORING

Terracon
Consulting Engineers and Scientists
783 HIGHWAY 1 WEST IOWA CITY, IOWA 52246
PH. (319) 533-2262 FAX. (319) 688-3008

BORING LOCATION PLAN		EXHIBIT #
VA PACT MEDICAL CENTER ADDITION HEERY INTERNATIONAL, INC 601 HIGHWAY 6 WEST IOWA CITY, IOWA		A-2




Terracon

SUBSURFACE SOIL PROFILE Exhibit A-3		
VA Medical Center Addition 601 Highway 6 West Iowa City, Iowa		
TI NO.	DATE	PLATE
06105663	Aug 2011	1

LOG OF BORING NO. CB-1



Page 1 of 1



CLIENT		HEERY International, Inc.											
SITE		601 Highway 6 West Iowa City, Iowa		PROJECT									
				VA Medical Center Addition									
GRAPHIC LOG		DESCRIPTION		DEPTH, ft.	USCS SYMBOL	SAMPLES			TESTS				
						NUMBER	TYPE	RECOVERY, in.	SPT - N ** BLOWS / ft	WATER CONTENT, %	PID READINGS	UNCONFINED STRENGTH, psf	
		Approx. Surface Elevation.: 709.5 ft											
		6" Topsoil					PA						
		<u>LEAN CLAY TO SILTY CLAY.</u> <u>TRACE SAND.</u> Gray Brown, Medium Stiff to Stiff		CL/ML 1	ST	15		19	96	1670			
			CL/ML 2	ST	9		21	99	1500				
	5		CL/ML 3	PA ST	11		22	102	2210				
			CL/ML 4	PA ST	18		23	99	1340				
	10			10									
		BOTTOM OF BORING											


The stratification lines represent the approximate boundary lines between soil and rock types: in-situ, the transition may be gradual.

*Calibrated Hand Penetrometer
**CME 140 lb. SPT automatic hammer

WATER LEVEL OBSERVATIONS, ft

WL  NONE WD  Backfilled

WL  

WL  Exhibit A-4

Terracon

BORING STARTED 7-7-11

BORING COMPLETED 7-7-11

RIG 928 FOREMAN SZ

APPROVED BKS JOB # 06105663

LOG OF BORING NO. CB-2

Page 1 of 1

CLIENT HEERY International, Inc.									
SITE 601 Highway 6 West Iowa City, Iowa		PROJECT VA Medical Center Addition							
GRAPHIC LOG	DESCRIPTION	SAMPLES				TESTS			
		DEPTH, ft.	USCS SYMBOL	NUMBER	TYPE	RECOVERY, in.	SPT - N ** BLOWS / ft	WATER CONTENT, %	PID READINGS
									UNCONFINED STRENGTH, psf
	Approx. Surface Elevation.: 710 ft								
	3-1/2" Concrete				PA				
	FILL, LEAN CLAY WITH SAND, TRACE GRAVEL & BRICK PIECES,			1	ST	6		19	108
	Dark Brown								
			CL/ML	2	ST	11		26	96
									1230
	LEAN CLAY TO SILTY CLAY, TRACE SAND, Gray Brown, Medium Stiff to Soft				PA ST	9		22	96
									980
			CL/ML	4	PA ST	12		23	98
									900
	BOTTOM OF BORING								

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ, the transition may be gradual.

*Calibrated Hand Penetrometer
**CME 140 lb. SPT automatic hammer

WATER LEVEL OBSERVATIONS, ft

WL ☐ NONE WD ☒ Backfilled

WL ☒ ☐

WL ☐ Exhibit A-4

Terracon

BORING STARTED 7-7-11

BORING COMPLETED 7-7-11

RIG 928 FOREMAN SZ

APPROVED BKS JOB # 06105663

BOREHOLE 06105663.GPJ TERRACON.GDT 8/8/11

LOG OF BORING NO. SB-1

Page 1 of 2

CLIENT		HEERY International, Inc.															
SITE		601 Highway 6 West Iowa City, Iowa		PROJECT													
				VA Medical Center Addition													
GRAPHIC LOG		DESCRIPTION		DEPTH, ft.	USCS SYMBOL	SAMPLES				TESTS							
						NUMBER	TYPE	RECOVERY, in.	SPT - N ** BLOWS / ft	WATER CONTENT, %	PID READINGS	UNCONFINED STRENGTH, psf	BEDROCK COMPRESSIVE STRENGTH, psi				
		Approx. Surface Elevation.: 710.5 ft															
		<u>FILL, LEAN CLAY WITH SAND, TRACE GRAVEL</u> , Dark Brown to Gray Brown					HS										
			3.5	707		1	ST	10			19	113					
					CL/ML 2	HS ST	12			18 22	105 101	1740					
					CL/ML 3	HS ST	12			19	95	1040					
		<u>LEAN CLAY TO SILTY CLAY, TRACE SAND & SAND SEAMS</u> , Gray Brown, Medium Stiff			CL/ML 4	HS ST	14			24	100	1660					
						HS											
					CL/ML 5	ST	16			26	99	1600					
						HS											
					CL/ML 6	ST	17			21	107	1520					
						HS											
		<u>SANDY LEAN TO FAT CLAY, TRACE GRAVEL</u> , Gray Brown, Very Stiff to Hard			CL/CH 7	ST	13			21	106	6250					
						HS											
					CL/CH 8	SS	16	19	16			*9000+					
						HS											
			31	679.5													
Continued Next Page																	

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ, the transition may be gradual.

*Calibrated Hand Penetrometer
**CME 140 lb. SPT automatic hammer

WATER LEVEL OBSERVATIONS, ft

WL	▽ 25	WS	▽ Backfilled
WL	▽		▽
WL	Exhibit A-4		




Terracon

BORING STARTED		7-7-11	
BORING COMPLETED		7-7-11	
RIG	928	FOREMAN	SZ
APPROVED	BKS	JOB #	06105663

BOREHOLE 06105663.GPJ TERRACON.GDT 8/8/11

LOG OF BORING NO. SB-1

Page 2 of 2

CLIENT HEERY International, Inc.											
SITE 601 Highway 6 West Iowa City, Iowa		PROJECT VA Medical Center Addition									
GRAPHIC LOG	DESCRIPTION	DEPTH, ft.	USCS SYMBOL	SAMPLES				TESTS			
				NUMBER	TYPE	RECOVERY, in.	SPT - N ** BLOWS / ft	WATER CONTENT, %	PID READINGS	UNCONFINED STRENGTH, psf	BEDROCK COMPRESSIVE STRENGTH, psi
	FINE TO MEDIUM SAND WITH CLAY TRACE GRAVEL. Brown to Reddish Brown, Medium Dense	35	SP-SC 9	SS	9	17	2				
					HS						
	*** HIGHLY WEATHERED & BROKEN LIMESTONE WITH CLAY SEAMS. Gray to Brown Gray Practical Auger Refusal @ about 43.5 feet.	40	SP-SC10	SS	13	11	9				
					HS						
	*** HIGHLY TO MODERATELY WEATHERED LIMESTONE. Gray to Brown Gray, Moderately Hard	42.5									
		43.5		R1	DB	100%	RQD 58%		165		16,500
	BOTTOM OF BORING	53.5									
*** Classification estimated from disturbed and core samples. Petrographic analysis may reveal other rock types.											

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ, the transition may be gradual.

*Calibrated Hand Penetrometer
**CME 140 lb. SPT automatic hammer

WATER LEVEL OBSERVATIONS, ft

WL	▽ 25	WS	▽ Backfilled
WL	▽		▽
WL	Exhibit A-4		

Terracon

BORING STARTED		7-7-11	
BORING COMPLETED		7-7-11	
RIG	928	FOREMAN	SZ
APPROVED	BKS	JOB #	06105663

BOREHOLE 06105663.GPJ TERRACON.GDT 8/8/11

Page 1 of 2

HEERY International, Inc.

601 Highway 6 West
Iowa City, Iowa

VA Medical Center Addition

Continued Next Page

*Calibrated Hand Penetrometer
**CME 140 lb. SPT automatic hammer



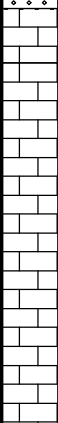

Terracon

BORING STARTED		7-7-11	
BORING COMPLETED		7-7-11	
RIG	928	FOREMAN	SZ
APPROVED	BKS	JOB #	06105663

BOREHOLE 06105663.GPJ TERRACON.GDT 8/8/11

LOG OF BORING NO. SB-2

Page 2 of 2

CLIENT HEERY International, Inc.											
SITE 601 Highway 6 West Iowa City, Iowa		PROJECT VA Medical Center Addition									
GRAPHIC LOG	DESCRIPTION	DEPTH, ft.	USCS SYMBOL	SAMPLES				TESTS			
				NUMBER	TYPE	RECOVERY, in.	SPT - N ** BLOWS / ft	WATER CONTENT, %	PID READINGS	UNCONFINED STRENGTH, psf	BEDROCK COMPRESSIVE STRENGTH, psi
	<u>CLAYEY FINE TO MEDIUM SAND WITH CLAY SEAMS</u> , Brown, Medium Dense	37			HS						
		673.5	SC	9	SS	14	17	9			
	<u>FINE TO COARSE SAND WITH CLAY, TRACE GRAVEL</u> , Brown, Loose	43			HS						
		667.5	SP-SC10	10	SS	10	8	12			
	*** HIGHLY WEATHERED & BROKEN LIMESTONE WITH CLAY SEAMS , Brown	44.5			HS						
	Practical Auger Refusal @ about 44.5 feet.	666									
	*** HIGHLY TO MODERATELY WEATHERED LIMESTONE , Gray to Gray Brown, Moderately Hard	54.5		R1	DB	92%	RQD 58%		165		12,010
	BOTTOM OF BORING	656									
*** Classification estimated from disturbed and core samples. Petrographic analysis may reveal other rock types.											

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ, the transition may be gradual.

*Calibrated Hand Penetrometer
**CME 140 lb. SPT automatic hammer

WATER LEVEL OBSERVATIONS, ft

WL	▽ 29	WD	▽ Backfilled
WL	▽	WD	▽
WL	Exhibit A-4		

Terracon

BORING STARTED		7-7-11	
BORING COMPLETED		7-7-11	
RIG	928	FOREMAN	SZ
APPROVED	BKS	JOB #	06105663

BOREHOLE 06105663.GPJ TERRACON.GDT 8/8/11

Field Exploration Description

The field exploration consisted of performing four (4) test borings to depths ranging from of about 10 to 42½ feet below the existing grades where either the boring's designated termination depth or practical auger refusal in the underlying bedrock was achieved. The boring locations were selected and laid out in the field by Terracon personnel based on the boring location indicated on the supplied site plan. The approximate boring locations are indicated on the attached Boring Location Plan. Distances from the boring locations to the reference features shown on the attached plan are approximate and were located using a measuring wheel and/or cloth tape, and right angles were estimated. The ground surface elevations indicated on the boring logs and Boring Location Plan are also approximate (rounded to the nearest ½ foot), and were obtained by the drill crew with a level and rod. The elevations were referenced to the top of storm water intake located between Borings SB-1 and CB-2. An elevation of 709.5 feet was provided for to this reference (Terracon Datum). 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 a truck-mounted, rotary drilling rig using continuous flight, solid- and hollow-stemmed augers to advance the boreholes. Samples were obtained using either thin-walled tube or split-barrel sampling procedures. In the thin-walled tube sampling procedure, a thin-walled tube or seamless steel tube with a sharp cutting edge is pushed hydraulically into the ground to obtain relatively undisturbed samples of cohesive or moderately cohesive soils. In the split-barrel sampling procedure, a standard 2-inch O.D. split-barrel sampling spoon is driven into the ground with a 140-pound hammer falling a distance of 30 inches. A CME automatic SPT hammer was used to advance the split-barrel sampler in the borings performed for this project. 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 resistance value. These values are indicated on the boring logs at the corresponding depths of occurrence. The samples were sealed and returned to the laboratory for testing and classification.

After achieving auger refusal in bedrock, Borings SB-1 and SB-2 were advanced additional about 10 feet, using diamond bit core drilling procedures. After the core samples were retrieved, they were placed in a box and logged. The rock was later visually classified, and the "percent recovery" and rock quality designation (RQD) was determined for each run.

The "percent recovery" is the ratio of the sample length retrieved to the drilled length, expressed as a percent. An indication of the actual in-situ rock quality is provided by calculating the sample's RQD. The RQD is the percentage of the length of broken cores retrieved which have core segments at least 4 inches in length compared to each drilled length. The percent recovery and RQD are related to rock soundness and quality as illustrated on the following page:

Geotechnical Engineering Report

Proposed VA Medical Center Addition ■ Iowa City, Iowa

August 8, 2011 ■ Terracon Project No. 06105663.01



Relation of RQD and In-Situ Rock Quality	
RQD (%)	Rock Quality
90 – 100	Excellent
75 – 90	Good
50 – 75	Fair
25 – 50	Poor
0 – 25	Very Poor

Field logs of the borings were prepared by the drill crew. Each log included visual classification of the materials encountered during drilling as well as the driller's interpretation of the subsurface conditions between samples. The boring logs included with this report represent an interpretation of the field logs by a geotechnical engineer and include modifications based on laboratory observation and tests on select samples.

Site Seismic Survey: On July 22, 2011, Terracon used a seismic refraction system (SRS) consisting of a seismograph and 24 geophones to perform a site-specific seismic class survey. A linear array of 24 geophones was placed in an accessible area as illustrated in the attached diagram. A computer was used to record refraction microtremors produced by ambient seismic noise. The data was then processed using a wavefield-transformation data-processing technique and an interactive Rayleigh-wave dispersion-modeling tool. The refraction microtremor method exploits aspects of spectral analysis of surface waves (SASW) and multi-channel analysis of surface waves (MASW) to derive a shear wave profile and an average shear-wave velocity along the array for a corresponding depth of about 100 feet.

APPENDIX B
LABORATORY TESTING

Laboratory Testing

Soil samples were tested in the laboratory to measure their natural water contents. Dry unit weight measurements were performed on portions of intact thin-walled tube samples. The unconfined compressive strength of some thin-walled tube samples was also measured. A hand penetrometer was used to estimate the unconfined compressive strength of some cohesive samples. The hand penetrometer provides a better estimate of soil consistency than visual examination alone. Two (2) bedrock density and compressive strength tests were also performed to aid in classifying the rock samples and evaluating their engineering properties. The results of the laboratory tests are shown on the boring logs, adjacent to the soil profiles, at their corresponding sample depths.

As a part of the laboratory testing program, the soil samples were classified in the laboratory based on visual observation, texture, plasticity, and the limited laboratory testing described above. Additional testing could be performed to more accurately classify the samples. Portions of the recovered samples were placed in jars, and the samples will be retained for at least 1 month in case additional testing is requested. The soil descriptions presented on the boring logs for native soils are in accordance with our enclosed General Notes and Unified Soil Classification System (USCS). The estimated group symbol for the USCS is also shown on the boring logs, and a brief description of the Unified System is attached to this report.

Classification of rock materials is in accordance with the enclosed General Notes – Sedimentary Rock Classification and has been estimated from core and disturbed samples. Petrographic analysis may indicate other rock types.

APPENDIX C
SUPPORTING DOCUMENTS

GENERAL NOTES

DRILLING & SAMPLING SYMBOLS:

SS:	Split Spoon - 1- ³ / ₈ " I.D., 2" O.D., unless otherwise noted	HS:	Hollow Stem Auger
ST:	Thin-Walled Tube - 2" O.D., 3" O.D., unless otherwise noted	PA:	Power Auger (Solid Stem)
RS:	Ring Sampler - 2.42" I.D., 3" O.D., unless otherwise noted	HA:	Hand Auger
DB:	Diamond Bit Coring - 4", N, B	RB:	Rock Bit
BS:	Bulk Sample or Auger Sample	WB:	Wash Boring or Mud Rotary

The number of blows required to advance a standard 2-inch O.D. split-spoon sampler (SS) the last 12 inches of the total 18-inch penetration with a 140-pound hammer falling 30 inches is considered the "Standard Penetration" or "N-value".

WATER LEVEL MEASUREMENT SYMBOLS:

WL:	Water Level	WS:	While Sampling	BCR:	Before Casing Removal
WCI:	Wet Cave in	WD:	While Drilling	ACR:	After Casing Removal
DCI:	Dry Cave in	AB:	After Boring	N/E:	Not Encountered

Water levels indicated on the boring logs are the levels measured in the borings at the times indicated. Groundwater levels at other times and other locations across the site could vary. In pervious soils, the indicated levels may reflect the location of groundwater. In low permeability soils, the accurate determination of groundwater levels may not be possible with only short-term observations.

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.

CONSISTENCY OF FINE-GRAINED SOILS

<u>Unconfined</u> <u>Compressive</u> <u>Strength, Qu, psf</u>	<u>Standard Penetration</u> <u>or N-value (SS)</u> <u>Blows/Ft.</u>	<u>Consistency</u>
< 500	0 - 1	Very Soft
500 - 1,000	2 - 4	Soft
1,000 - 2,000	4 - 8	Medium Stiff
2,000 - 4,000	8 - 15	Stiff
4,000 - 8,000	15 - 30	Very Stiff
8,000+	> 30	Hard

RELATIVE DENSITY OF COARSE-GRAINED SOILS

<u>Standard Penetration</u> <u>or N-value (SS)</u> <u>Blows/Ft.</u>	<u>Relative Density</u>
0 - 3	Very Loose
4 - 9	Loose
10 - 29	Medium Dense
30 - 50	Dense
> 50	Very Dense

RELATIVE PROPORTIONS OF SAND AND GRAVEL

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

GRAIN SIZE TERMINOLOGY

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

RELATIVE PROPORTIONS OF FINES

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

PLASTICITY DESCRIPTION

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

Rev 04/10

GENERAL NOTES

Sedimentary Rock Classification

DESCRIPTIVE ROCK CLASSIFICATION:

Sedimentary rocks are composed of cemented clay, silt and sand sized particles. The most common minerals are clay, quartz and calcite. Rock composed primarily of calcite is called limestone; rock of sand size grains is called sandstone, and rock of clay and silt size grains is called mudstone or claystone, siltstone, or shale. Modifiers such as shaly, sandy, dolomitic, calcareous, carbonaceous, etc. are used to describe various constituents. Examples: sandy shale; calcareous sandstone.

LIMESTONE	Light to dark colored, crystalline to fine-grained texture, composed of CaCO_3 , reacts readily with HCl.
DOLOMITE	Light to dark colored, crystalline to fine-grained texture, composed of $\text{CaMg}(\text{CO}_3)_2$, harder than limestone, reacts with HCl when powdered.
CHERT	Light to dark colored, very fine-grained texture, composed of micro-crystalline quartz (SiO_2), brittle, breaks into angular fragments, will scratch glass.
SHALE	Very fine-grained texture, composed of consolidated silt or clay, bedded in thin layers. The unlaminated equivalent is frequently referred to as siltstone, claystone or mudstone.
SANDSTONE	Usually light colored, coarse to fine texture, composed of cemented sand size grains of quartz, feldspar, etc. Cement usually is silica but may be such minerals as calcite, iron-oxide, or some other carbonate.
CONGLOMERATE	Rounded rock fragments of variable mineralogy varying in size from near sand to boulder size but usually pebble to cobble size ($\frac{1}{2}$ inch to 6 inches). Cemented together with various cementing agents. Breccia is similar but composed of angular, fractured rock particles cemented together.

PHYSICAL PROPERTIES:

DEGREE OF WEATHERING

Slight	Slight decomposition of parent material on joints. May be color change.
Moderate	Some decomposition and color change throughout.
High	Rock highly decomposed, may be extremely broken.

HARDNESS AND DEGREE OF CEMENTATION

Limestone and Dolomite:

Hard	Difficult to scratch with knife.
Moderately Hard	Can be scratched easily with knife, cannot be scratched with fingernail.
Soft	Can be scratched with fingernail.

Shale, Siltstone and Claystone

Hard	Can be scratched easily with knife, cannot be scratched with fingernail.
Moderately Hard	Can be scratched with fingernail.
Soft	Can be easily dented but not molded with fingers.

Sandstone and Conglomerate

Well Cemented	Capable of scratching a knife blade.
Cemented	Can be scratched with knife.
Poorly Cemented	Can be broken apart easily with fingers.

BEDDING AND JOINT CHARACTERISTICS

Bed Thickness	Joint Spacing	Dimensions
Very Thick	Very Wide	> 10'
Thick	Wide	3' - 10'
Medium	Moderately Close	1' - 3'
Thin	Close	2" - 1'
Very Thin	Very Close	.4" - 2"
Laminated	—	.1" - .4"

Bedding Plane A plane dividing sedimentary rocks of the same or different lithology.

Joint Fracture in rock, generally more or less vertical or transverse to bedding, along which no appreciable movement has occurred.

Seam Generally applies to bedding plane with an unspecified degree of weathering.

SOLUTION AND VOID CONDITIONS

Solid	Contains no voids.
Vuggy (Pitted)	Rock having small solution pits or cavities up to $\frac{1}{2}$ inch diameter, frequently with a mineral lining.
Porous	Containing numerous voids, pores, or other openings, which may or may not interconnect.
Cavernous	Containing cavities or caverns, sometimes quite large.

Terracon

Exhibit C-2

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 ≥ 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-in. (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

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

^F If soil contains $\geq 15\%$ 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 $\geq 15\%$ 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 $\geq 30\%$ plus No. 200 predominantly sand, add "sandy" to group name.

^M If soil contains $\geq 30\%$ plus No. 200, predominantly gravel, add "gravelly" to group name.

^N $PI \geq 4$ 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.

