REPORT
SUBSURFACE EXPLORATION AND GEOTECHNICAL ENGINEERING SERVICES

DES MOINES VETERANS HOSPITAL PARKING GARAGE
3600 30TH STREET
DES MOINES, IOWA

ECS PROJECT NO. 16:11338

FOR

CANNON DESIGN
ST. LOUIS, MISSOURI

JUNE 15, 2016
REVISED AUGUST 2, 2016

ECS MIDWEST, LLC
"Setting the Standard for Service"
Geotechnical • Construction Materials • Environmental • Facilities

June 15, 2016
Revised August 3, 2016

Mr. Ian Walkschmidt, AIA, LEED AP, BD+C
Associate
Cannon Design
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St. Louis, Missouri 63102
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ECS Project No. 16:11338

Reference: Geotechnical Report for Subsurface Exploration and Geotechnical Engineering Services, Des Moines VA 4-Story Parking Garage, 3600 30th Street, Des Moines, Iowa

Dear Mr. Walkschmidt:

In general accordance with the ECS proposal 16:15343-GP, dated March 22, 2016, and authorized by you, ECS Midwest, LLC (ECS) has completed the subsurface exploration and geotechnical engineering analyses for the proposed Des Moines VA 4-Story Parking Garage project to be constructed at 3600 30th Street in Des Moines, Iowa. A *Draft Geotechnical Report for Subsurface Exploration and Geotechnical Engineering Services* report (ECS Project No. 16:11338, dated June 15, 2016) was previously submitted. This final report is based on the topographic information included on the survey prepared by Thomas Land Surveying, LLC and provided to us.

A report, including the results of the subsurface explorations, boring data, Refraction Microtremor testing, laboratory testing and recommendations regarding the geotechnical engineering design and construction aspects for the project and a Boring Location Plan are enclosed herein. The recommendations presented herein are intended for use by your office and for use by other professionals involved in the design and construction stages of the project described herein.

We appreciate this opportunity to be of service to Cannon Design during the design phase of this project. If you have questions with regard to the information and recommendations presented in this report, or if we can be of further assistance to you in any way during the planning or construction of this project, please do not hesitate to contact us.

Respectfully,

ECS MIDWEST, LLC

PETER DOMENICO
20537

8/4/16

Paul J Giese

Paul J. Giese
Project Manager

Pete Domenico, P.E.
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REPORT

PROJECT

Subsurface Exploration and
Geotechnical Engineering Services
Des Moines VA 4-Story Parking Garage
3600 30th Street
Des Moines, Iowa

CLIENT

Ian Walkschmidt, AIA, LEED AP, BD+C
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St. Louis, Missouri 63102

SUBMITTED BY

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PROJECT NO. 16:11338

DATE June 15, 2016
Revised August 3, 2016

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EXECUTIVE SUMMARY

The conditions encountered during the geotechnical field explorations and ECS Midwest, LLC.'s conclusions and recommendations are summarized below. This summary should not be considered apart from the entire text of the report with all the qualifications and considerations mentioned herein. Details of our conclusions and recommendations are discussed in the following sections and in the Appendix.

The proposed project site is located at 3600 30th Street in Des Moines, Iowa. The site is bound to the south by the service drive into the VA facility, to the east by 30th Street, to the west by VFW Circle and to the north by Euclid Avenue. The project site is currently heavily wooded and is a steeply graded ravine with existing site grades ranging between about EL. +125 along the western portion of the planned parking garage and sloping down to the east and southeast to about EL. +113 at the northeast corner of the planned garage, to about EL. +96 along the central portion of the planned eastern wall of the garage (within ravine area) and to about EL. +100 at the planned southern corner of the planned parking garage. Based on our correspondence with you, we understand that the proposed development will consist of a new 3-Story parking garage complex. ECS understands loads will range from approximately 650 kips (exterior columns) to 40 kips per lineal foot for interior wall footings. A total of six (6) borings were drilled at the project site to a depth of 40 feet below existing site grades.

The surficial materials were observed to consist of about 4 to 6 inches of topsoil. The surficial materials were typically observed to be underlain by the Silty Clay FILL (B-1 and B-2) to depths ranging from 2½ to 3 feet below existing site grades. The Silty Clay FILL was underlain by natural Silty CLAY to the termination depth of the soil borings (i.e. approximately 40 feet below existing site grades). A layer of SAND with Gravel and Silty SAND was observed at boring locations B-1 and B-5 at depths ranging from about 17 feet to 22 feet below existing site grades.

The Silty Clay FILL exhibited unconfined compressive strength values ranging from 2¼ to 2½ tons per square foot (tsf) and moisture contents ranging from about 20 percent to 24 percent. The natural Silty CLAY exhibited unconfined compressive strength values ranging from ½ tsf to greater than 4½ tsf (soft to hard) and moisture contents ranging from about 11 percent to 29 percent (typically 15 to 22 percent). The granular soils exhibited SPT N-values ranging from 62 blows per foot (bpf) to 100 bpf which is indicative of a very dense relative density.

Based on the results of the subsurface exploration and considering the existing and planned finished floor elevation of the lowest level of the parking garage (ranging from EL. +104.5 to EL. +116), the foundation bearing soils within the limits of the parking garage will likely consist of a combination of natural Silty CLAY and engineered fill used to raise low areas of the site. Considering the amount of fill needed to raised low areas (up to about 10 feet in the area of boring B-5) we recommend new fill consist of granular soils. We recommend the proposed structure be supported on a shallow foundation system (i.e., wall and spread footings) bearing on competent natural soils and granular engineered fill/lean-mix concrete overlying competent natural soils. Shallow foundations bearing on competent natural Silty Clay soils and granular engineered fill/lean-mix concrete overlying competent natural soils should be designed for a maximum net allowable soil bearing pressure of 4,000 psf. A representative of ECS should observe the foundation excavations to confirm the foundations will bear on suitable natural soils as well as the placement and compaction of granular engineered fill. The maximum net allowable soil bearing pressure refers to that pressure which may be transmitted to the foundation bearing soils in excess of the final minimum surrounding overburden pressure. Competent soils can be identified on the boring logs and in the field as natural Silty CLAY soils exhibiting unconfined compressive strength values of 1¾ tsf or greater or N Values of 7 or more for granular soils.

More detailed recommendations with regard to foundations, including deep foundation installation construction considerations, subgrade preparation and earthwork operations, fill placement and pavement section design are included herein and must be fully reviewed and understood so that the intent of the recommendations are properly utilized during design and construction of the proposed development.

Report Prepared By:	Report Reviewed By:	Report Reviewed By:
Paul J. Giese Project Manager	Pete Domenico, P.E. Principal Engineer	Brett Gitskin, P.E. Senior Principal Engineer

PROJECT OVERVIEW

Introduction

This report presents the results of the geotechnical field explorations and ECS' geotechnical engineering recommendations for the proposed Des Moines VA 3-Story Parking Garage to be located at 3600 30th Street in Des Moines, Iowa. A Site Location Diagram included in the Appendix of this report shows the approximate location of the project site.

This study was conducted in general accordance with the ECS proposal 16:15434-GP, dated March 22, 2016. In preparing this report, we have utilized information from our current subsurface exploration as well as information from nearby sites. A *Draft Geotechnical Report for Subsurface Exploration and Geotechnical Engineering Services* report (ECS Project No. 16:11338, dated June 15, 2016) was previously submitted and was based on preliminary site topography information. This final report is provided based on the topographic information included on the survey prepared by Thomas Land Surveying, LLC and provided to us by the client.

Existing Site Conditions

The proposed project site is located within the existing VA of Central Iowa Health Care facility at 3600 30th Street in Des Moines, Iowa. Of specific interest to the scope outlined herein is the proposed parking garage area east of the VA facility. The parking area is bound to the north by the service drive into the VA facility, to the east by 30th Street, to the west by VFW Circle and to the south by a wooded ravine. The proposed parking garage will be constructed in an area that is currently steeply sloped with large trees that will be removed prior to construction. Based on review of a topographic plan prepared by Thomas Land Surveying, LLC and provided to us via email by Cannon Design, existing site grades are variable throughout the planned parking garage area. Site grades generally range between about EL. +125 along the western portion of the planned parking garage and slope down to the east and southeast to about EL. +113 at the northeast corner of the planned garage, to about EL. +96 along the central portion of the planned eastern wall of the garage (within ravine area) and to about EL. +100 at the planned southern corner of the planned parking garage. The ravine continues to slope down to the south/southeast of the planned garage area. An existing sanitary sewer line generally parallels the planned western wall of the garage and an existing retaining wall is located between VFW Circle and the planned western parking garage wall.

Proposed Construction

The project consists of a concrete 3-story parking garage which will be designed to house approximately 500 vehicles and will have entrances from VFW Circle at the northwest and southwest corners of the structure. The parking garage is currently planned to be post tensioned concrete construction. According to the information provided to ECS by Cannon Design, the maximum exterior and interior column loads will be approximately 650 kips for exterior columns to 40 kips per lineal foot for interior wall footings, respectively. Based on review of the Level 01 Floor Plan (Drawing No. A0104, dated July 6, 2016) and which includes a note "Final Garage Location to GeoTech 07-13-2016" we understand the lowest level (Level C) of the parking garage will have a finished floor elevation (FFE) of EL. +104.5 at the southern end of the structure and will slope up to EL. +116 at the northern end of Level C. The FFE of

Level B will range from EL. +116 at south end to EL. +127.5 at the north end. The FFE of Level A will range from EL. 127.5 at the south end to EL. +139 at the north end. Level 01 (the top floor) will be at EL. +139 which roughly matches the existing elevations along VFW Circle.

Based on the planned lowest level FFE ranging from EL. +104.5 at the south end of the parking garage to EL. +116 at the north end, we anticipate a combination of cutting and filling will be required to establish the planned lowest level subgrade elevations. Existing site grades at borings B-1 through B-3, along the western portion of the parking garage range between about EL. +123 (at borings B-1 and B-3) to about EL. +120 (at boring B-2); therefore, about 8 feet of cut at boring B-1, about 11 feet of cut at boring B-2 and about 19½ feet of cut at boring B-3 is anticipated to establish the subgrade elevations. Existing site grades at borings B-4 through B-6, along the eastern portion of the parking garage range between about EL. +113 (at boring B-4 to about EL. +100 (at boring B-5); therefore, about 2 feet of filling at boring B-4, about 10 feet of filling at boring B-2 and about 2½ feet of cut at boring B-6 is anticipated to establish the subgrade elevations, exclusive of site preparation requirements. The greatest amount of filling will be required in the area of the existing ravine (along the southeastern portion of the parking garage).

If our understanding of the proposed construction and the planned building and site grades is inaccurate, if the design changes, or if the anticipated structural loads or any additional civil drawings become available, please notify ECS immediately so that we can review the recommendations given herein they are still applicable for the proposed construction.

Purposes of Exploration and Scope of Services

The purposes of this exploration were to explore the soil conditions at the project site and to develop engineering recommendations to guide in the design and construction of the project. We accomplished these purposes by performing the following scope of services:

1. Reviewing the geotechnical engineering reports previously performed by ECS in the vicinity of the project site;
2. Drilling six (6) soil borings at the project site using an auger drill rig;
3. Performing laboratory tests on selected representative samples from the borings to evaluate pertinent engineering properties;
4. Analyzing the field and laboratory data to develop appropriate engineering recommendations; and,
5. Preparing this geotechnical report of our findings and recommendations.

The conclusions and recommendations contained in this report are based on the six (6) soil borings (Borings B-1 through B-6) were conducted at the project site under ECS' direction. The soil borings were drilled within the approximate footprint of the proposed parking garage to a depth of about 40 feet below the existing surface grade. The results of the completed soil borings, along with a Boring Location Plan are included in the Appendix of this report.

The borings were located in the field by an ECS' sub-contracted driller and the approximate locations are shown on the Boring Location Diagram. The ground surface elevations on the boring logs represent the approximate ground surface elevations estimated from the provided topographic survey at the time the borings were drilled. The ground surface elevations are based on the contours shown on the site plan and are considered to be accurate to within one contour interval (1± foot).

EXPLORATION PROCEDURES

Subsurface Exploration Procedures

Prior to mobilizing to the project site, ECS' subcontracted driller contacted the Iowa's Utility One-Call Center, Iowa One Call, to clear and mark underground utilities in the vicinity of the project site prior to drilling operations. The borings were marked in the field at accessible locations by ECS' subcontracted driller.

Soil Borings

The SPT soil borings were performed with truck-mounted rotary-type auger drill rigs which utilized continuous hollow stem augers and mud-rotary drilling to advance the boreholes. Representative soil and rock samples were obtained by means of conventional split-barrel sampling procedures and standard rock coring procedures. Soil samples were typically obtained at 2½-foot intervals in the upper 10 feet and at 5-foot intervals thereafter. Please refer to the boring logs for actual sample intervals.

During split-barrel sampling, a 2-inch O.D., split-barrel sampler is driven into the soil a distance of 18 inches by a 140-pound hammer falling 30 inches. The number of blows required to drive the sampler through a 12-inch interval, after initial setting of 6 inches, is termed the Standard Penetration Test (SPT) or N-value and is indicated for each sample on the boring logs. The SPT value can be used as a qualitative indication of the in-place relative density of cohesionless soils. In a less reliable way, it also indicates the consistency of cohesive soils. This indication is qualitative, since many factors can significantly affect the standard penetration resistance value and prevent a direct correlation between drill crews, drill rigs, drilling procedures, and hammer-rod-sampler assemblies. Undisturbed thin wall Shelby tube samples were collected for the consolidation testing program.

The drill rigs utilized an automatic trip hammer to drive the sampler. Consideration of the effect of the automatic hammer's efficiency was included in the interpretation of subsurface information for the analyses prepared for this report.

A field log of the soils encountered in the borings was maintained by the drill crew. After recovery, each geotechnical soil samples was removed from the sampler and visually classified. Representative portions of each soil sample were then sealed in jars. The soil samples were then brought to our laboratory in Buffalo Grove, Illinois for further visual classification and laboratory testing.

Shear Wave Velocity Testing

A Reflection Microtremor (ReMi) survey was performed on the site. The data was processed using SeisOpt® ReMi™ software to reveal a one-dimensional average shear-wave (S-wave) velocity image for the line (array). In addition, the survey also provides the average shear wave velocity to a depth of 100 feet that was used to determine the seismic Site Class. The results of ReMi survey are included in the Appendix of this report.

The data gathering process in the field used standard refraction seismic equipment to measure site characteristics using ambient vibrations (micro tremors) as a seismic source. The equipment used for the survey included a SiesOpt ReMi recording unit capable of storing record lengths up to about 100 seconds and 12 10-Hz vertical P-wave geophones. The analysis presented here was developed from the 12 receivers (10 Hz. Geophones) set along relatively straight-line arrays with evenly spaced intervals between the receivers. Twelve unfiltered 30-second records were recorded along each line. The vibration records collected above were processed using proprietary software and the refraction micro tremor method as explained in Louie, J, N, 2001, "Faster, Better: Shear-wave velocity to 100 meters depth from refraction micrometer arrays", Bulletin of the Seismological Society of America, v. 91, p.347-364.

Laboratory Testing Program

Representative soil samples were selected and tested in our laboratory to check field classifications and to determine pertinent engineering properties. The laboratory testing program included visual classifications, unconfined compressive strength testing of cohesive soil samples using a calibrated hand penetrometer and moisture content determinations of cohesive soil samples.

Each soil sample was classified on the basis of texture and plasticity in accordance with the Unified Soil Classification System. The group symbols for each soil type are indicated in parentheses following the soil descriptions on the boring log. A brief explanation of the Unified System is included with this report. The various soil types were grouped into the major zones noted on the boring log. The stratification lines designating the interfaces between earth materials on the boring log are approximate; in situ, the transitions may be gradual.

The unconfined compressive strength (Qp) of relatively cohesive clay soil samples was estimated with the use of a calibrated hand penetrometer. In the hand penetrometer test, the unconfined compressive strength of a soil sample is estimated, to a maximum of 4½ tons per square foot (tsf) by measuring the resistance of a soil sample to penetration of a small, calibrated spring-loaded cylinder.

The soil samples will be retained in our laboratory for a period of 60 days, after which, they will be discarded unless other instructions are received as to their disposition.

Seismic Zone

A Reflection Microtremor (ReMi) survey was performed on the site to evaluate the seismic site classification. Based on the results of the ReMi survey, the average shear wave velocity at the project site is estimated to be 1,135 ft/s. The average shear wave velocity profile along the performed array is contained on the ReMi Test Results that are included in the Appendix. Based on the average shear wave velocity data obtained to a depth of 100 feet below the existing ground surface from the refraction microtremor surveys, the soil profile type for the site falls into Seismic Site Class D in accordance with section 1613.5.2 of the 2009 International Building Code (IBC).

EXPLORATION RESULTS

Subsurface Conditions

Six (6) SPT soil borings (Borings B-1 through B-6) were conducted at the project site under ECS' direction. The soil borings were drilled within the footprint of the proposed parking garage to a depth of approximately 40 feet below the existing surface grade elevation. The specific soil types observed at each boring location are noted on the boring logs, enclosed in the Appendix.

The surficial materials were observed to consist of about 4 to 6 inches of topsoil. The surficial materials were typically observed to be underlain by the Silty Clay FILL (B-1 and B-2) to depths ranging from 2½ to 3 feet below existing site grades. The Silty Clay FILL was underlain by natural Silty CLAY to the termination depth of the soil borings (i.e. approximately 40 feet below existing site grades). A layer of SAND with Gravel and Silty SAND was observed at boring locations B-1 and B-5 at depths ranging from about 17 feet to 22 feet below existing site grades.

The Silty Clay FILL exhibited unconfined compressive strength values ranging from 2¼ to 2½ tons per square foot (tsf) and moisture contents ranging from about 20 percent to 24 percent. The natural Silty CLAY exhibited unconfined compressive strength values ranging from ½ tsf to greater than 4½ tsf (soft to hard) and moisture contents ranging from about 11 percent to 29 percent (typically 15 to 22 percent). The granular soils exhibited SPT N-values ranging from 62 blows per foot (bpf) to 100 bpf which is indicative of a very dense relative density.

General

It should be noted that bid quantity estimation by "averaging" depths and strata changes from boring logs is not recommended. Too many variations exist for such "averaging" to be valid, particularly in the surface material thicknesses, soil types and condition, depth, and groundwater conditions. A different scope of professional services would be required to obtain subsurface information needed for land purchase considerations and earthwork bid preparation. This scope could include additional borings and possibly test pits. Even with this additional information, contingencies should always be carried in construction budgets or land purchase agreements to cover variations in subsurface conditions. Soil borings cannot present the same full-scale view that is obtained during complete site grading, excavation or other aspects of earthwork construction.

Groundwater Observations

Observations for groundwater were made during sampling at each boring location. As previously noted, both auger drilling and mud rotary drilling techniques were utilized during performance of the borings. In mud rotary drilling methods, water/drilling fluid is introduced into the borehole. As such, groundwater levels after drilling were not recorded as the observed levels would not be representative of the actual groundwater level.

During auger drilling and sampling operations, groundwater was observed at depths ranging from 33 to 37 feet at boring locations B-2 and B-3. The remainder of the borings were observed to be dry. The highest groundwater observations are normally encountered in late winter and early spring. Glacial till soils in the Midwest frequently oxidize from gray to brown above the level at which the soil remains saturated. The long-term groundwater level is often interpreted to be near this zone of color change. Based on the results of this exploration, the long-term groundwater level may be located at a depth of approximately 35 feet below existing site grades (EL. +65 to EL. +88) or deeper.

It should be noted that the groundwater level can vary based on precipitation, evaporation, surface run-off and other factors not immediately apparent at the time of this exploration. Surface water runoff will be a factor during general construction, and steps should be taken during construction to control surface water runoff and to remove water that may accumulate in the proposed excavations as well as floor slab areas.

ANALYSIS AND RECOMMENDATIONS

Overview

The conclusions and recommendations presented in this report should be incorporated in the design and construction of the project to reduce possible soil and/or foundation related problems. The following recommendations have been developed on the basis of the previously described project characteristics and subsurface conditions encountered at the project site. If there are any changes to the project characteristics or if different subsurface conditions are encountered during construction, ECS Midwest, LLC should be consulted so the recommendations of this report can be reviewed and modified, if necessary.

The following sections present specific recommendations with regard to the design of the proposed structures. These include recommendations with regard to foundations, subgrade preparation and earthwork operations and fill placement. Discussion of the factors affecting the building foundations for the proposed construction, as well as additional recommendations regarding geotechnical design and construction at the project site are included below. We recommend that ECS review the final design and specifications to check that the earthwork and foundation recommendations presented in this report have been properly interpreted and implemented in the design and specifications.

Subgrade Preparation and Earthwork Operations

Based on the proposed layout and site plan, the majority of the planned building footprint will require cut; however, relatively deep fill will be required to raise portions of the southeastern building area (area of boring B-5 and the existing ravine). For the parking deck slab, initial subgrade preparation should consist of complete removal of existing topsoil, trees, root bulbs, curbs, utilities, existing fill soils, surficial soft/wet soils and other deleterious organic or refuse material, if encountered. About 4 to 6 inches of topsoil was encountered at the boring locations, however, deeper areas of organic soils such as in the ravine area. We anticipate the existing fill soils encountered at borings B-1 and B-2 will be removed during cutting operations to establish the subgrade elevations in those areas. We also recommend any existing fill soils encountered in the proposed building area where new fill will be placed be removed, prior to new fill placement, to expose a suitable bearing natural soil subgrade.

Following initial removal activities and prior to placement of engineered fill, the exposed subgrade should be observed by the Geotechnical Engineer of Record or his authorized representative and be proofrolled. The subgrade should be proofrolled using a loaded dump truck having an axle weight of at least 10 tons. The intent of proofrolling is to aid in identifying localized soft or unsuitable material which should be removed. If soft or yielding soils are observed during the densification/proofroll, the soft or yielding soils should be undercut a maximum of 2 feet and replaced with compacted and engineered fill to the design subgrade in accordance with the **Fill Placement** section of this report. The densification and proofrolling of the exposed subgrades should be performed under the observation of the Geotechnical Engineer of Record or his authorized representative.

To help limit the volume of soil removed as a result of the proofrolling observations, we recommend that soft or yielding soils be evaluated in approximately 6-inch intervals. That is to say, if soft or yielding soils are identified, the contractor should remove 6 inches of material in the subject area and then proofroll/evaluate the undercut subgrade. This will potentially limit the need to remove 2 feet of soil at all locations where soft or yielding soils are identified. A US Army Corps of Engineers cone penetrometer and DCP (dynamic cone penetrometer) can also be used in conjunction with proofrolling to establish appropriate depths for remedial action.

Prior to subgrade preparation and excavation activities, all underground utilities should be positively located, properly protected and supported. Underground utilities within the proposed project areas should be relocated or removed and backfilled with engineered fill. Abandoned utilities should be removed or grouted in place. The contractor should be responsible for underpinning or other adequate support during excavations adjacent to existing utilities, sidewalks and foundations.

The contractor shall control surface water runoff and to remove any water from precipitation that may accumulate in the subgrade areas, especially during the wet season. Construction traffic should be limited when the subgrade is wet. During final preparation of the pavement subgrade, a smooth drum roller should be used to provide a flat surface and provide for better drainage to reduce the negative impact of rain events. Care should be exercised during subgrade preparation (i.e. compaction operations) to reduce pumping of the subgrade soils and observations should be made during earthwork operations to determine whether the weight of the construction equipment is negatively impacting the on-site soils. Minimizing disturbance to the exposed subgrade is important for proper construction of the slab and foundation systems.

The need for and most appropriate type of subgrade stabilization required will be dependent upon soil, groundwater and weather conditions, as well as, the construction schedule and methods of construction that will be used. If the project timeline will not allow for adequate drying of unstable, soft and high moisture soils to improve subgrade stability, ECS recommends the unstable, soft, and high moisture soils be removed and replaced with new engineered fill.

Provided the excavations will not extend below 6 feet, groundwater seepage is anticipated not to be a major factor during demolition and backfilling operations. If groundwater is encountered, we believe a sump pump system should be adequate to remove accumulated seepage from the bottom of excavations prior to placement of concrete or engineered granular fill.

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 contractor is solely responsible for the design and construction of stable, temporary excavations. The excavations should not only be in accordance with current OSHA excavation and trench safety standards but also with applicable local, state, and federal regulations. The contractor should shore, slope or bench the excavation sides when appropriate.

If problems are encountered during the earthwork operations, or if site conditions deviate from those encountered during our subsurface exploration, ECS should be notified immediately. We recommend that the project geotechnical engineer or his representative should be on site to monitor stripping and site preparation operations and observe that unsuitable soils have been satisfactorily removed and observe the proofrolling of the subgrades.

Fill Placement

All fills should consist of an approved material, free of organic matter and debris, particles greater than 3-inches and have a Liquid Limit and Plasticity Index less than 40 and 15, respectively. Unacceptable fill materials include topsoil and organic materials (OH, OL), high plasticity silts and clays (CH, MH), and low-plasticity silts (ML). Existing site soils suitable for reuse as engineered fill include the Silty CLAY (natural or fill provided the Silty Clay FILL is free of organic material). SAND with Gravel can also be utilized as engineered fill.

The on-site soils may require moisture content adjustments, such as the application of discing or other drying techniques or spraying of water to the soils prior to their use as compacted fill (termed manipulation). **If the parking garage is constructed in the late fall to early spring, drying of the soils may not be feasible. The contractor should anticipate the season where the majority of the earthwork will be performed when providing a cost estimate for earthwork.** The planning of earthwork operations should recognize and account for increased costs associated with manipulation of the on-site materials considered for reuse as compacted fill.

Fill materials should be placed in lifts not exceeding 8-inches in loose thickness and moisture conditioned to within ±2 percentage points of the optimum moisture content. Soil bridging lifts should not be used, since excessive settlement of overlying structures will likely occur. Controlled fill soils should be compacted to a minimum of 95% of the maximum dry density obtained in accordance with ASTM Specification D 1557, Modified Proctor Method.

The expanded footprint of the proposed parking structure addition and fill areas should be well defined, including the limits of the fill zones at the time of fill placement. Grade control should be maintained throughout the fill placement operations. All fill operations should be observed on a full-time basis by a qualified soil technician to determine that the specified compaction requirements are being met. A minimum of one compaction test per 2,500 square foot area and 50 linear feet of trench should be tested in each lift placed, with a minimum of 3 tests per lift. The elevation and location of the tests should be clearly identified at the time of fill placement.

Compaction equipment suitable to the soil type used as fill should be used to compact the fill material. Theoretically, any equipment type can be used as long as the required density is achieved; however, the standard of practice typically dictates that a vibratory roller be utilized for compaction of granular soils and a sheepsfoot roller be utilized for compaction of cohesive soils. In addition, a steel drum roller is typically most efficient for compacting and sealing the surface soils. All areas receiving fill should be graded to facilitate positive drainage from parking garage pad areas of free water associated with precipitation and surface runoff.

It should be noted that prior to the commencement of fill operations and/or utilization of off-site borrow materials, the Geotechnical Engineer of Record should be provided with representative samples to determine the material’s suitability for use in a controlled compacted fill and to develop moisture-density relationships. In order to expedite the earthwork operations, if off-site borrow materials are required, it is recommended they consist of suitable fill materials in accordance with the recommendations previously outlined in this section. We do not recommend importing frost susceptible soil, (i.e., silty soils and fine sands) for use as engineered fill within 3½ feet of the exterior surface grades.

Fill materials should not be placed on frozen soils or frost-heaved soils and/or soils that have been recently subjected to precipitation. All frozen soils should be removed prior to continuation of fill operations. Borrow fill materials, if required, should not contain frozen materials at the time of placement. All frost-heaved soils should be removed prior to placement of controlled, compacted fill, granular subbase materials, and foundation or slab concrete.

Adjacent Construction

Where excavations are performed along the western portion of the planned development, next to existing retaining wall, roadway and/or underground utilities, the contractor should be cautious so as not to damage the existing retaining wall, roadway, underground utilities or subgrade soils. The contractor should avoid disturbing soils located at a 1:1 slope (H:V) from the bottom/outward edge of existing footings. Engineered supports (i.e., sheet piling, underpinning) are required if the excavations could potentially undermine the existing features. ECS should be contacted once the actual excavation depths and locations are determined to evaluate the potential impact to the existing/adjacent construction.

Foundation Recommendations

Based on the results of the subsurface exploration and the planned lowest level FFE, the foundation bearing soils within the limits of the parking garage will likely consist of a combination of natural Silty CLAY at borings B-1 through B-4 and B-6, and up to about 10 feet of engineered fill in the area of boring B-5 (and possibly more in lower areas of the existing ravine). Therefore, we recommend the proposed structure be supported on a shallow foundation system (i.e., wall and spread footings) bearing on a combination of competent natural soils or engineered fill overlying competent natural soils. Shallow foundations bearing on a combination of competent natural Silty Clay soils and engineered fill overlying competent natural soils should be designed for a maximum net allowable soil bearing pressure of 4,000 psf. A representative of ECS should observe the foundation excavations to confirm the foundations will bear on suitable natural soils as well as the placement and compaction of engineered fill. The maximum net allowable soil bearing pressure refers to that pressure which may be transmitted to the foundation bearing soils in excess of the final minimum surrounding overburden pressure. Competent soils can be identified on the boring logs and in the field as natural Silty CLAY soils exhibiting unconfined compressive strength values of 1.75 tsf or greater or N Values of 7 or more for granular soils.

For the southeastern portion of the parking garage where extensive new fill (about 10 feet in the area of boring B-5 and possibly greater in lower ravine areas) to be placed on site, *self-weight consolidation of the new fill soils should be considered.* Even properly placed and compacted fill or new engineered fill soils, placed and compacted as discussed below, will experience self-weight consolidation. In most cases, the amount of self-weight consolidation is negligible. However, when fill heights exceed about 5 feet, the magnitude of self-weight consolidation can adversely affect the performance of the building structure. Therefore, we recommend granular engineered fill be used to reduce the effects of self-weight consolidation and to maintain maximum foundation settlement at about 1 inch.

If undocumented existing fill soils, soft to stiff natural soils (i.e., less than 1.75 tsf), loose soils (i.e., less than 7 bpf) or soils with elevated moisture contents (i.e., greater than 25 percent) are encountered at the proposed bearing elevations, the footings should extend until suitable bearing soils are encountered or the unsuitable soils should be removed beneath the base of the footing and replaced with compacted granular engineered fill or lean-mix concrete. Some undercutting of lower strength natural Silty Clay soils, such as in the area of borings B-1, B-2 and B-3 may be required and should be anticipated.

If engineered fill is utilized, the engineered fill should be a well-graded granular material compacted to a minimum of 95 percent of the maximum dry density in accordance with Modified Proctor Method, ASTM Specification D 1557. The zone of the engineered fill placed below the foundations should extend 1 foot beyond the outside edges of the footings and from that point, outward laterally 1 foot for every 2 feet of fill thickness below the footing. If lean-mix concrete is utilized to replace weaker/low bearing soils or unsuitable soils, lateral over-excavation is typically not considered to be necessary, but the excavation should be 1 foot wider than the footing (6 inches on each side), and the lean-mix concrete should be allowed to sufficiently harden prior to placement of the foundation concrete. We recommend that the excavation/backfill of foundations be monitored full-time by an ECS Geotechnical Engineer or representative to verify that the soil bearing pressure is consistent with the boring log information obtained during the geotechnical exploration.

To help reduce the potential for foundation bearing failure and excessive settlement due to local shear or "punching" action, we recommend that continuous footings have a minimum width of 18 inches and that isolated column footings have a minimum lateral dimension of 30 inches. In addition, footings should be placed at a depth to provide adequate frost cover protection. For this region, we recommend the exterior footings and footings beneath unheated areas be placed at a minimum depth of 3½ feet below finished grade. Interior footings in heated areas can be placed at a minimum of 2 feet below grade provided that suitable soils are encountered and that the foundations will not be subjected to freezing weather either during or after construction.

Settlement of individual footings, designed in accordance with our recommendations presented in this report, is expected to be within tolerable limits for the proposed structures. For footings placed on suitable natural soils, lean-mix concrete or properly compacted engineered fill, maximum total settlement is expected to be in the range of 1 to 1½ inches. Maximum differential settlement between adjacent columns is expected to be about ¾ the total settlement. These settlement values are based on our engineering experience with the soil and the anticipated structural loading, and are to guide the structural engineer with his design.

Pressuremeter Considerations

Given the significant grade change at the proposed site and the relatively large structural loads (i.e., 650 kips for exterior columns and 40 klf for interior wall footings, in our opinion in-situ pressuremeter testing could potentially provide for substantially higher bearing pressures which could save significant costs during construction. The higher allowable bearing pressures are a result of the in-situ data regarding the soil characteristics, especially soil related characteristics related to deformations from loading.

Parking Deck Slab Design

Portland Cement Concrete (PCC) Pavements

For conventional concrete pavement construction, we recommend that the recommendations provided in the section entitled **Subgrade Preparation and Earthwork Operations** be followed**.** The pavement section thickness can be determined utilizing an assumed modulus of subgrade reaction of 150 pounds per cubic inch (pci) if the subgrade soils consist of natural Silty CLAY which also passes a proofroll and engineered fill placed in accordance with the recommendations of this report. We recommend the garage pavement section should not be thinner than 6 inches.

We also recommend that the garage PCC pavement be underlain by a minimum of 6 inches of granular material having a maximum aggregate size of 1½ inches and no more than 2% soil fines passing the No. 200 sieve. This granular layer will facilitate the fine grading of the subgrade and help prevent the rise of water through the pavement section. Prior to placing the granular material, the pavement section subgrade should be free of standing water, mud, and frozen soil. Before the placement of concrete, a vapor barrier may be placed on top of the granular material to provide additional moisture protection. Welded-wire mesh reinforcement should be placed in the upper half of the pavement section and attention should be given to the surface curing of the pavement section in order to minimize uneven drying of the pavement section and associated cracking and/or pavement section curling. The use of a blotter or cushion layer above the vapor retarder can also be considered for project specific reasons. Please refer to ACI 302.1R04 *Guide for Concrete Floor and Slab Construction* and ASTM E 1643 *Standard Practice for Installation of Water Vapor Retarders Used in Contact with Earth or Granular Fill Under Concrete Slabs* for additional guidance on this issue. Additional reinforcement should be at the discretion of the structural engineer.

We recommend that the PCC pavement be isolated from the foundation footings so differential settlement of the structure will not induce shear stresses on the slab. For maximum effectiveness, temperature and shrinkage reinforcements in slabs on ground should be positioned in the upper third of the slab thickness. The Wire Reinforcement Institute recommends the mesh reinforcement be placed 2 inches below the slab surface or upper one-third of slab thickness, whichever is closer to the surface. Adequate construction joints, contraction joints and isolation joints should also be provided in the slab to reduce the impacts of cracking and shrinkage. Please refer to ACI 302.1R04 Guide for Concrete Floor and Slab Construction for additional information regarding concrete slab joint design.

Pavement Sub-Drainage

Based on the groundwater levels observed during the subsurface exploration, we do not anticipate a significant volume of water will persist at the lowest level pavement subgrade elevation. It should be noted however that surface runoff and limited groundwater seepage may accumulate at the pavement subgrade. We recommend that positive drainage be implemented around the perimeter of the proposed structure to help reduce the potential for water accumulation under the pavement and foundation elements, which could potentially weaken the bearing soils. For structural slab, underslab sub-drainage is not anticipated.

Exterior Pavement Design (if required)

We anticipate the proposed access drive will be asphaltic concrete and will generally be utilized for light to moderate duty traffic. We recommend that the pavement subgrade be prepared in accordance with the **Subgrade Preparation and Earthwork Operations** section of this report. Once the subgrade has been properly prepared, we recommend the following minimum pavement sections for the proposed development. The recommendations below were developed utilizing an assumed CBR value of 3.

Table 1: Pavement Section Recommendations

Pavement Material	Compacted Material Thicknesses (Inches)		
	Flexible Pavement (Light to Moderate Duty)	Flexible Pavement (Heavy Duty)	Rigid Pavement
Portland Cement Concrete	--	--	6
Surface Course Asphalt	2	2	--
Base Course Asphalt	2	3	--
Granular Subbase	8	12	6
Total Pavement Section Thickness	12	17	12

All pavement materials and construction, with the exception of the Standard Proctor compaction specification, should be in accordance with the Guidelines for AASHTO Pavement Design and Iowa Department of Transportation specifications.

As a cost effective alternate to the conventional PCC pavement section for the at-grade level of the parking garage, we recommend consideration of the bituminous pavement sections above: light/moderate section for parking stalls and heavy duty for drive lanes. The pavement sections specified in the table above are general pavement recommendations based on the anticipated usage at the project site. We recommend the heavy duty pavement section should be utilized in locations where truck traffic is anticipated (i.e., delivery lanes, loading dock, etc.) and frequent traffic such as entrance and exit drives. If truck traffic will exceed 25 trucks per day, ECS should be contacted to review and revise as appropriate our recommended heavy duty pavement sections. The light duty pavement section can be used for the balance of the paved areas. Rigid pavement can be utilized in loading dock areas, dumpster areas or other areas anticipated to see heavy traffic loads.

It should also be noted that the pavement sections specified in the table above were developed for the anticipated in-service traffic conditions only and do not provide an allowance for construction traffic conditions. Therefore, if pavements will be constructed early during site development to accommodate construction traffic, consideration should be given to the construction of designated haul roads, where thickened pavement sections can be provided to accommodate the construction traffic as well as the future in-service traffic. ECS can provide additional design assistance with pavement sections for haul roads upon request.

We recommend the granular base course should be compacted to at least 95 percent of the maximum dry density obtained in accordance with ASTM Specification D 1557 Modified Proctor Method. During asphalt pavement construction, the wearing and leveling course should be compacted to a minimum of 93 percent of the theoretical density value. Prior to placing the granular material, the pavement subgrade soil should be properly compacted, proofrolled, and free of standing water, mud, and frozen soil.

The pavements should be designed and constructed with adequate surface and subsurface drainage. Where standing water develops, either on the pavement surface or within the base course layer, softening of the subgrade and other problems related to the premature deterioration of the pavement can be expected. Furthermore, good drainage should minimize the possibility of the subgrade materials beneath the pavement becoming saturated over a long period of time. Infiltration and subterranean water are the two sources of water that should be considered in the pavement design for the project. Infiltration is surface water that enters the pavement through the joints, pores, cracks in the pavement and through shoulders and adjacent areas pavements as a result of precipitation. Subterranean water is a source of water from a high water table on the site. The long-term static groundwater level on the site is estimated to be located approximately 35 feet or deeper below existing site grades. Therefore, infiltration is the most important source of water to be considered.

Large, front loading trash dumpsters frequently impose concentrated front-wheel loads on pavements during loading. This type of loading typically results in rutting of the pavement and ultimately pavement failures. Therefore, we recommend that the pavement in trash pickup areas consist of a mesh reinforced concrete slab. To provide uniform support beneath the rigid pavement, a minimum 6-inch thick granular subbase course should be used. Although we recommend that any exterior rigid pavement design be performed by a structural engineer knowledgeable of the specific static and dynamic loading conditions, for planning purposes and predicated on empirical information, a minimum 6-inch thick rigid pavement may be considered for these areas. It should be noted that the pavement should be comprised of air-entrained Portland cement concrete with a minimum compressive strength of 4,000 psi and a minimum flexural strength of 650 psi.

Adequate construction joints, contraction joints and isolation joints should be provided in the areas of rigid pavement to reduce the impacts of cracking and shrinkage. Please refer to ACI 330R-92 *Guide for Design of Concrete Parking Lots*. The Guide recommends an appropriate spacing strategy for the anticipated loads and pavement thickness. It has been our experience that joint spacing closer to the minimum values results in a pavement with less cracking and better long term performance.

Pavement Maintenance

Regular maintenance and occasional repairs should be implemented to keep pavements in a serviceable condition. In addition, to help minimize water infiltration to the pavement section and within the base course layer resulting in softening of the subgrade and deterioration of the pavement, we recommend the timely sealing of joints and cracks using elastomeric caulk in existing pavement. We recommend exterior pavements should be reviewed for distress/cracks twice a year, once in the spring and once in the fall.

Sound maintenance programs should help maintain and enhance the performance of pavements and attain the design service life. A preventative maintenance program should be implemented early in the pavement life to be effective. The “standard in the industry” supported by research indicates that preventative maintenance should begin within 2 to 5 years of the placement of pavement. Failure to perform preventative maintenance will reduce the service life of the pavement and increase the costs for both corrective maintenance and full pavement rehabilitation.

Below-Grade Walls

Based on the planned grades, we anticipate that the parking garage will have below grade walls. General recommendations for design of below-grade walls are provided below.

Lateral Earth Pressures

Permanent below-grade walls should be designed to withstand lateral earth pressures and surcharge loads. The lateral earth pressures exerted on the walls will be a function of the stiffness and the rotation of the walls. The rotation of the wall controls the degree to which the internal strength of the soil is mobilized. If rotation or deflection of the walls will be less than that required to mobilize the active earth pressure condition due to stiffness, bracing or other mechanism (as is typical with basement walls), the “at-rest” earth pressure condition should be evaluated. For the at-rest earth pressure condition, below grade walls can be designed for a linearly increasing lateral earth pressure of 65 psf per vertical foot of wall. The at-rest earth pressure of 65 psf per vertical foot of wall assumes that the below-grade walls will be in a drained condition (i.e., no hydrostatic forces on the back of the wall). In the event that the walls remain undrained, a linearly increasing lateral earth pressure of 65 psf per vertical foot of wall should be utilized above the long-term groundwater level and 100 psf per vertical foot of wall should be utilized below the long-term groundwater level. Overall, we anticipate the long-term water table to be located at a depth of 35 feet or deeper below existing site grades. The wall designs should also account for surcharge loads within a 45 degree slope from the base of the wall. For the at-rest earth pressure condition, a lateral earth pressure coefficient of 0.45 should be applied to surcharge loads.

The “active” earth pressure condition, which results in the minimum applied earth pressure, results when the rotation of the wall about its base and away from the retained soil is approximately 0.001 times the height of the wall or greater. This is typically the case with cantilever-type walls. If the active earth pressure condition develops, we recommend below-grade walls be designed for a linearly increasing lateral earth pressure of 40 psf per vertical foot of wall above the long-term groundwater level and 85 psf/ft below the long-term groundwater level. These active lateral earth pressures assume that granular materials are used for wall backfill. The wall design should also account for surcharge loads within a 45 degree slope from the base of the wall. For the active earth pressure condition, a lateral earth pressure coefficient of 0.33 should be applied to surcharge loads.

To develop “passive earth” pressures, the footings should be located at depths greater than the depth of frost penetration (3½ feet below lowest adjacent finished grade). Passive resistance within the zone of seasonal volume change (i.e., approximately 3½ feet from the final ground surface) should be neglected. For footings and walls located below the frost penetration of 3½ feet (if any) and if the passive condition develops, a passive lateral earth pressure of 360 psf per vertical foot of wall can be used to design below grade walls for granular backfill. As stated, the upper 3½ feet of soil should be neglected when determining the passive resistance of the soil.

Below-Grade Wall Backfill

The space between the outside of the walls and the excavation should be backfilled with a granular fill extending to a level of approximately 2 feet below the final outside grade. The remaining 2 feet should consist of a clayey material to minimize the amount of surface water infiltration into the granular material, and thus, reduce the excess water to be handled by the drainage system. Asphaltic concrete or Portland cement concrete can also be used to cover the ground surface and minimize the surface water infiltration. The ground surface adjacent to the below-grade walls should be kept properly graded to prevent ponding of water adjacent to the below-grade walls.

Special attention should be employed during placement of new fill against below-grade walls. Based on our experience, fill soils placed against below-grade walls and immediate areas along Below-grade walls are often not compacted/densified adequately due to space constraints and lack of compaction effort. Inadequate placement and compaction of new fill will result on at-grade slab/pavement subgrade settlement and distress. A jumping jack, walk-behind vibratory plate or similar equipment should be used in manhole areas or other limited areas that are not feasible with a heavy-duty pneumatic tire or smooth drum roller. To achieve a desirable balance between minimizing excessive pressures against the below grade walls and reducing the settlement of the wall backfill, we recommend that the wall granular backfill be compacted to at least 90 percent of the maximum dry density obtained in accordance with ASTM Specification D 1557, Modified Proctor Method. Thinner lifts of 4 to 6 inches can be effective in improving compaction performance. Where the fill materials will be supporting sidewalks or pavements, the upper 2 feet should be compacted to 95 percent of the maximum dry density referenced above.

Backfill materials should consist of inorganic materials, free of debris, be free draining, and containing no frost susceptible soil. The fill placed adjacent to the below grade walls should not be overcompacted. Heavy earthwork equipment should maintain a minimum horizontal distance away from the below-grade walls of 1 foot per foot of vertical wall height. Lighter compaction equipment should be used close to the below grade walls. Where light (e.g., hand) compaction equipment is employed, the maximum lift thickness should be reduced to 6 inches.

Below-Grade Wall Drainage

Suitable man-made drainage materials may be used in lieu of the granular backfill, adjacent to the below-grade walls. Examples of suitable materials include Enka Mat, Mira Drain, or geotec Drains. If the excavation support system is used as a back form for wall construction, the geosynthetic drainage media can be placed directly against the support system prior to placing reinforcing steel. These materials should be covered with a filter fabric having an apparent opening size (AOS) consistent with the size of the soil to be retained (or with cast-in-place concrete). The material should be placed in accordance with the manufacturer's recommendations and connected to a perimeter drainage system, which in turn should be properly drained.

PROJECT CONSTRUCTION RECOMMENDATIONS

General Construction Considerations

We recommend that the subgrade preparation, installation of the foundations, and construction of parking garage be monitored by an ECS geotechnical engineer or his representative. Methods of verification and identification such as proofrolling, DCP testing, vane shear tests, and hand auger probe holes will be necessary to further evaluate the subgrade soils and identify unsuitable soils. The contractor should be prepared to over-excavate the parking deck subgrades at isolated locations (as necessary). We recommend that excavations of new foundations be monitored on a full-time basis by an ECS geotechnical engineer or his representative to verify that the soil bearing pressure and the subgrade materials will be suitable for the proposed structure and are consistent with the boring log information obtained during this geotechnical exploration. Full-time monitoring of drilled shaft installation by an ECS representative must be performed to confirm installation in accordance with proper procedures and verify ground conditions encountered are consistent with those identified during our exploration. We would be pleased to provide these services.

All unsuitable materials should be removed and replaced with environmentally clean, inorganic fill and free of debris or harmful matter. Unsuitable materials removed from the project site should be disposed of in accordance with all applicable federal, state, and local regulations.

Construction Dewatering

The contractor should be prepared to manage perched water and surface water runoff, if encountered and maintain a dry excavation during removal and replacement of uncontrolled fill or unsuitable soils. Exposure to the environment may weaken the soils at the slab subgrade elevation if the excavations remain open for too long a period. If the bearing soils are softened by surface water intrusion or exposure or heavy construction traffic, the softened soils must be removed from the foundation excavation bottom immediately prior to placement of concrete.

Closing

This report has been prepared to aid in the evaluation of this property and to assist the architect and/or engineer in the design of this project. The scope is limited to the specific project and locations described herein and our description of the project represents our understanding of the significant aspects relative to soil and foundation characteristics. In the event that any change in the nature or location of the proposed construction outlined in this report are planned, we should be informed so that the changes can be reviewed and the conclusions of this report modified or approved in writing by the geotechnical engineer. It is recommended that all construction operations dealing with earthwork and foundations be reviewed by an experienced geotechnical engineer to provide information on which to base a decision as to whether the design requirements are fulfilled in the actual construction. If you wish, we would welcome the opportunity to provide field construction services for you during construction.

The analysis and recommendations submitted in this report are based upon the data obtained from the soil borings and tests performed at the locations as indicated on the Boring Location Diagram and other information referenced in this report. This report does not reflect variations, which may occur between the borings. In the performance of the subsurface exploration, specific information is obtained at specific locations at specific times. However, it is a well-known fact that variations in soil conditions exist on most sites between boring locations and also such situations as groundwater levels vary from time to time. The nature and extent of variations may not become evident until the course of construction. If variations then appear evident, after performing on-site observations during the construction period and noting characteristics and variations, a reevaluation of the recommendations for this report will be necessary.

In addition to geotechnical engineering services, ECS Midwest, LLC has the in-house capability to perform multiple additional services as this project moves forward. These services include the following:

- Environmental Consulting;
- Project Drawing and Specification Review; and,
- Construction Material Testing / Special Inspections

We would be pleased to provide these services for you. If you have questions with regard to this information or need further assistance during the design and construction of the project please feel free to contact us.

APPENDIX

Site Location Diagram

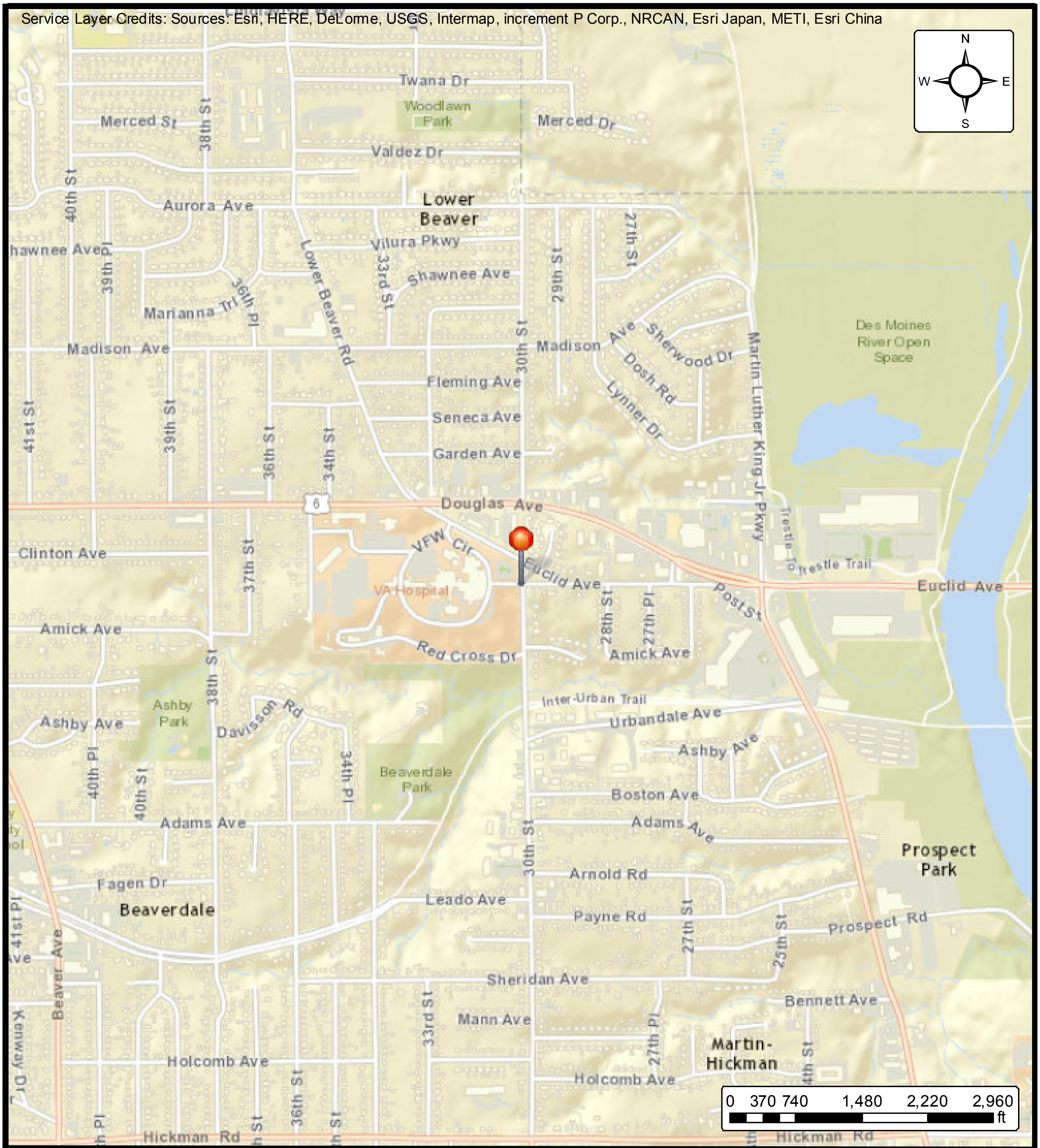
Boring Location Diagram

Boring Logs

ReMi Testing Results

Unified Soil Classification System

Reference Notes For Boring Log



Site Location Diagram

DES MOINES VA PARKING GARAGE

DES MOINES IA

ENGINEER

SCALE
1 " = 1,500 '

PROJECT NO.
16:11338

SHEET
1 OF 1

DATE
6/14/2016

Boring Location Diagram

DES MOINES VA PARKING GARAGE

DES MOINES IA

ENGINEER	
SCALE	1 " = 80 '
PROJECT NO.	16:11338
SHEET	1 OF 1
DATE	6/14/2016

CLIENT	JOB #	BORING #	SHEET
Cannon Design	16:11338	B-1	1 OF 2

PROJECT NAME	ARCHITECT-ENGINEER
Des Moines VA Parking Garage	Cannon Design

SITE LOCATION

3600 30th Street, Des Moines, Allamakee County, Iowa

NORTHING	EASTING	STATION

-○- CALIBRATED PENETROMETER TONS/FT^2

ROCK QUALITY DESIGNATION & RECOVERY
RQD% – — – REC% ———

PLASTIC LIMIT% ✕ WATER CONTENT% ● LIQUID LIMIT% △

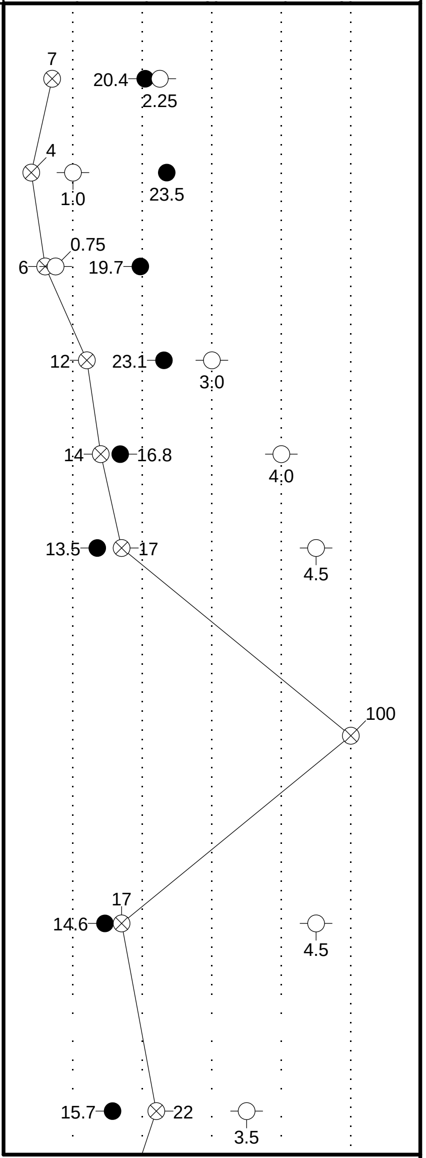
⊗ STANDARD PENETRATION BLOWS/FT

DESCRIPTION OF MATERIAL ENGLISH UNITS

BOTTOM OF CASING LOSS OF CIRCULATION

SURFACE ELEVATION 123 +/-

DEPTH (FT)	SAMPLE NO.	SAMPLE TYPE	SAMPLE DIST. (IN)	RECOVERY (IN)	DESCRIPTION OF MATERIAL	WATER LEVELS	ELEVATION (FT)	BLOWS/6"
0					Topsoil Depth [4"]			
					(CL/ML FILL) SILTY CLAY WITH SAND, Trace Gravel, Brown and Black, Moist, Very Stiff			
	S-1	SS	24	9				3 3 4 7
					(CL/ML) SILTY CLAY WITH SAND, Trace Gravel, Reddish Brown, Moist, Medium Stiff to Hard		120	
5	S-2	SS	24	15				1 2 2 4
	S-3	SS	24	17				3 2 4 6
							115	
10	S-4	SS	24	16				2 5 7 12
	S-5	SS	24	15				3 6 8 14
							110	
15	S-6	SS	24	17				4 7 10 17
					(SP) SAND WITH GRAVEL, Gray, Moist, Dense			
							105	
20	S-7	SS	24	18				50 50 50 50
					(CL/ML) SILTY CLAY WITH SAND, Brown to Dark Brown, Moist, Hard to Very Stiff		100	
25	S-8	SS	24	18				4 7 10 17
							95	
30	S-9	SS	24	7				8 11 11 22



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THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL TYPES. IN-SITU THE TRANSITION MAY BE GRADUAL.

WL WS ☐ WD ☒	BORING STARTED 05/16/16	CAVE IN DEPTH
WL(SHW) WL(ACR)	BORING COMPLETED 05/16/16	HAMMER TYPE Auto
WL	RIG Truck FOREMAN Jorge	DRILLING METHOD HSA

CLIENT Cannon Design	JOB # 16:11338	BORING # B-1	SHEET 2 OF 2
PROJECT NAME Des Moines VA Parking Garage	ARCHITECT-ENGINEER Cannon Design		
SITE LOCATION 3600 30th Street, Des Moines, Allamakee County, Iowa			
NORTHING	EASTING	STATION	

-○- CALIBRATED PENETROMETER TONS/FT^2

ROCK QUALITY DESIGNATION & RECOVERY
RQD% – — –   REC% ———

PLASTIC LIMIT% ✕   WATER CONTENT% ●   LIQUID LIMIT% △

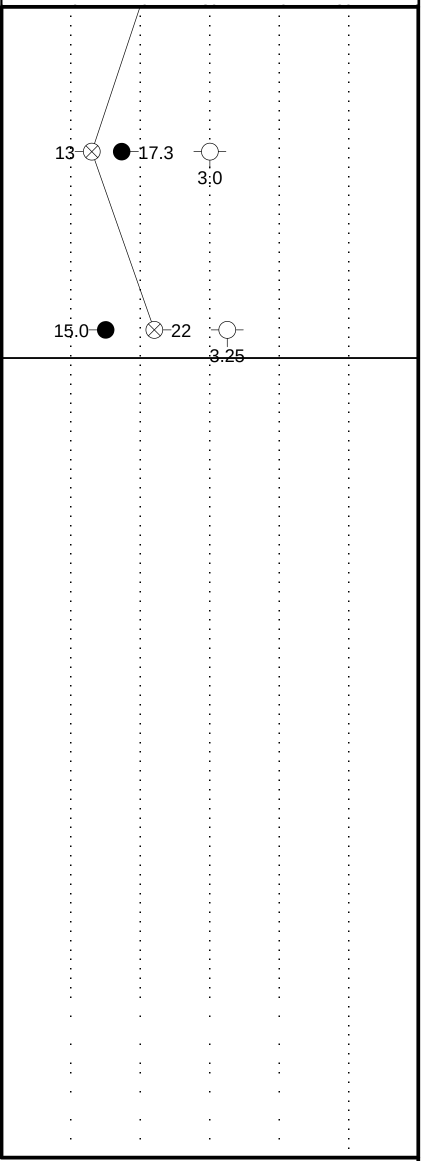
⊗ STANDARD PENETRATION BLOWS/FT

DESCRIPTION OF MATERIAL — ENGLISH UNITS

BOTTOM OF CASING — LOSS OF CIRCULATION

SURFACE ELEVATION 123 +/-

DEPTH (FT)	SAMPLE NO.	SAMPLE TYPE	SAMPLE DIST. (IN)	RECOVERY (IN)	DESCRIPTION OF MATERIAL	WATER LEVELS	ELEVATION (FT)	BLOWS/6"
					(CL/ML) SILTY CLAY WITH SAND, Brown to Dark Brown, Moist, Hard to Very Stiff		90	
35	S-10	SS	24	9				4 5 8 13
							85	
40	S-11	SS	18	14				4 7 15
					END OF BORING @ 40'		80	
45							75	
50							70	
55							65	
60								



THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL TYPES. IN-SITU THE TRANSITION MAY BE GRADUAL.

WL WS ☐ WD ☒	BORING STARTED 05/16/16	CAVE IN DEPTH
WL(SHW) WL(ACR)	BORING COMPLETED 05/16/16	HAMMER TYPE Auto
WL	RIG Truck FOREMAN Jorge	DRILLING METHOD HSA

CLIENT	JOB #	BORING #	SHEET
Cannon Design	16:11338	B-2	1 OF 2

PROJECT NAME: Des Moines VA Parking Garage

ARCHITECT-ENGINEER: Cannon Design

SITE LOCATION: 3600 30th Street, Des Moines, Allamakee County, Iowa

NORTHING	EASTING	STATION

-○- CALIBRATED PENETROMETER TONS/FT²

ROCK QUALITY DESIGNATION & RECOVERY
RQD% – — – REC% ———

PLASTIC LIMIT% ✕ WATER CONTENT% ● LIQUID LIMIT% △

⊗ STANDARD PENETRATION BLOWS/FT

DESCRIPTION OF MATERIAL — ENGLISH UNITS

BOTTOM OF CASING LOSS OF CIRCULATION 100%

SURFACE ELEVATION 120 +/-

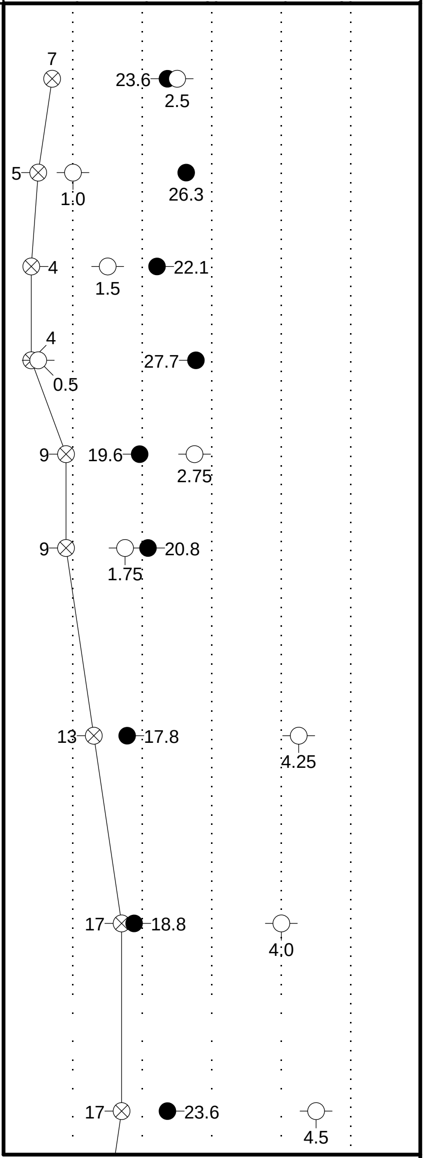
DEPTH (FT)	SAMPLE NO.	SAMPLE TYPE	SAMPLE DIST. (IN)	RECOVERY (IN)	BLOWS/6"
	S-1	SS	24	12	2 3 4 7
5	S-2	SS	24	16	1 2 3 5
	S-3	SS	24	17	1 2 2 4
10	S-4	SS	24	18	1 2 2 4
	S-5	SS	24	18	2 4 5 9
15	S-6	SS	24	15	3 3 6 9
20	S-7	SS	24	13	3 6 7 13
25	S-8	SS	24	15	4 7 10 17
30	S-9	SS	24	15	4 7 10 17

Topsoil Depth [4"]

(CL/ML FILL) SILTY CLAY WITH SAND, Trace Gravel, Brownish Black, Moist, Very Stiff

(CL/ML) SILTY CLAY WITH SAND, Trace Gravel, Brown to Reddish Brown, Moist, Soft to Hard

ELEVATION (FT): 120, 115, 110, 105, 100, 95, 90



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THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL TYPES. IN-SITU THE TRANSITION MAY BE GRADUAL.

WL 33 WS ☐ WD ☒	BORING STARTED 05/16/16	CAVE IN DEPTH
WL(SHW) WL(ACR)	BORING COMPLETED 05/16/16	HAMMER TYPE Auto
WL	RIG Truck FOREMAN Jorge	DRILLING METHOD HSA

CLIENT Cannon Design	JOB # 16:11338	BORING # B-2	SHEET 2 OF 2
PROJECT NAME Des Moines VA Parking Garage	ARCHITECT-ENGINEER Cannon Design		
SITE LOCATION 3600 30th Street, Des Moines, Allamakee County, Iowa			
NORTHING	EASTING	STATION	

-○- CALIBRATED PENETROMETER TONS/FT^2

ROCK QUALITY DESIGNATION & RECOVERY
RQD% – — –   REC% ———

PLASTIC LIMIT% ✕ — WATER CONTENT% ● — LIQUID LIMIT% △

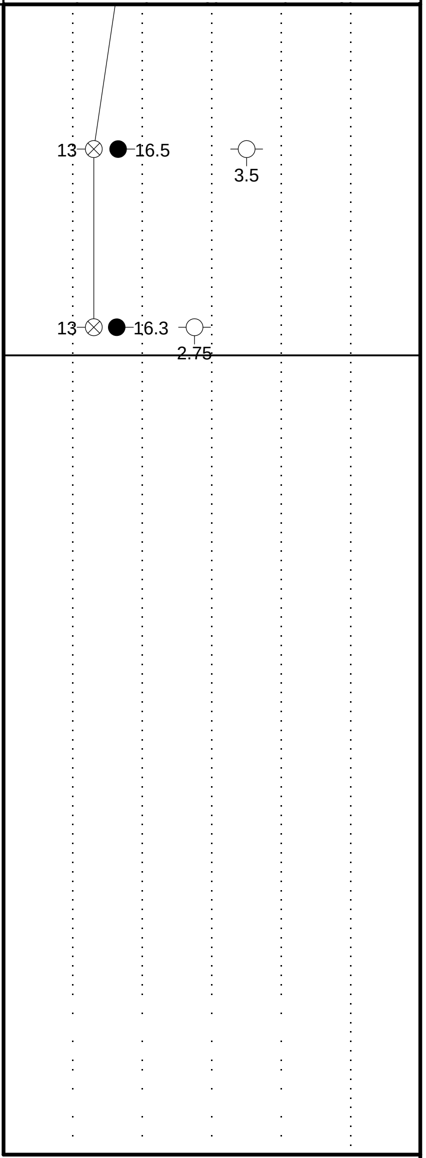
⊗ STANDARD PENETRATION BLOWS/FT

DESCRIPTION OF MATERIAL — ENGLISH UNITS

BOTTOM OF CASING — LOSS OF CIRCULATION

SURFACE ELEVATION 120 +/-

DEPTH (FT)	SAMPLE NO.	SAMPLE TYPE	SAMPLE DIST. (IN)	RECOVERY (IN)	DESCRIPTION OF MATERIAL	WATER LEVELS	ELEVATION (FT)	BLOWS/6"
					(CL/ML) SILTY CLAY WITH SAND, Trace Gravel, Brown to Reddish Brown, Moist, Soft to Hard	▽		
35	S-10	SS	24	18			85	3 6 7 13
40	S-11	SS	18	13			80	4 6 7
					END OF BORING @ 40'			
45							75	
50							70	
55							65	
60							60	



THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL TYPES. IN-SITU THE TRANSITION MAY BE GRADUAL.

▽ WL 33 WS ☐ WD ☒	BORING STARTED 05/16/16	CAVE IN DEPTH
▽ WL(SHW) ▼ WL(ACR)	BORING COMPLETED 05/16/16	HAMMER TYPE Auto
▽ WL	RIG Truck FOREMAN Jorge	DRILLING METHOD HSA

CLIENT
Cannon Design

JOB #
16:11338

BORING #
B-3

SHEET
1 OF 2

PROJECT NAME
Des Moines VA Parking Garage

ARCHITECT-ENGINEER
Cannon Design

SITE LOCATION
3600 30th Street, Des Moines, Allamakee County, Iowa

NORTHING

EASTING

STATION

-○- CALIBRATED PENETROMETER TONS/FT^2

ROCK QUALITY DESIGNATION & RECOVERY
RQD% – — – REC% ———

PLASTIC LIMIT% ✕ — WATER CONTENT% ● — LIQUID LIMIT% △

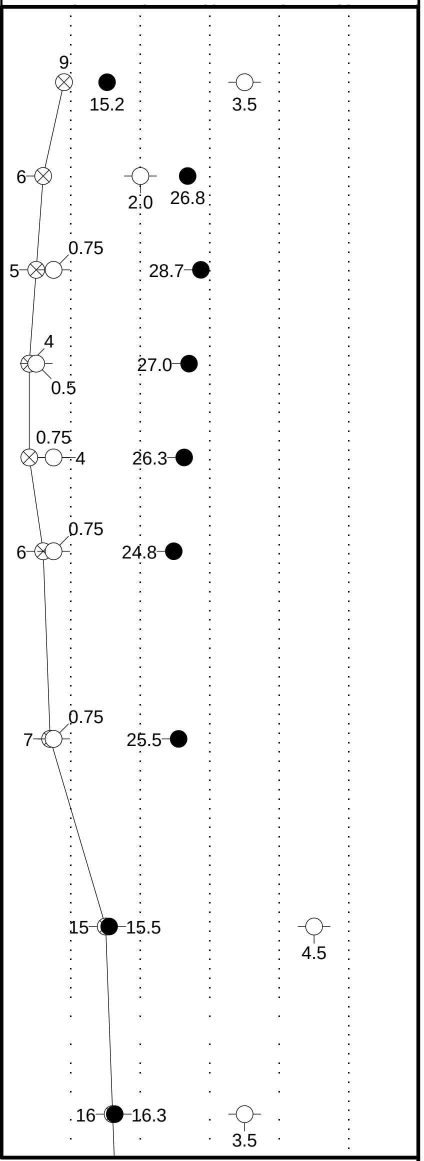
⊗ STANDARD PENETRATION BLOWS/FT

DESCRIPTION OF MATERIAL — ENGLISH UNITS

BOTTOM OF CASING — LOSS OF CIRCULATION

SURFACE ELEVATION 123 +/-

DEPTH (FT)	SAMPLE NO.	SAMPLE TYPE	SAMPLE DIST. (IN)	RECOVERY (IN)	DESCRIPTION OF MATERIAL	WATER LEVELS	ELEVATION (FT)	BLOWS/6"
0					Topsoil Depth [4"]			
	S-1	SS	24	8	(CL/ML) SILTY CLAY, Trace Sand, Trace Gravel, Brown, Moist, Soft to Hard, Increased Sand With Depth			3 4 5 9
							120	
	S-2	SS	24	12				2 3 3 6
5								
	S-3	SS	24	18				1 2 3 5
							115	
	S-4	SS	24	14				1 2 2 4
10								
	S-5	SS	24	17				2 2 2 4
							110	
	S-6	SS	24	17				2 2 4 6
15								
							105	
	S-7	SS	24	18				1 2 5 7
20								
							100	
	S-8	SS	24	14				3 6 9 15
25								
							95	
	S-9	SS	24	14				4 6 10 16
30								



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THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL TYPES. IN-SITU THE TRANSITION MAY BE GRADUAL.

WL 37 WS ☐ WD ☒	BORING STARTED 05/17/16	CAVE IN DEPTH
WL(SHW) WL(ACR)	BORING COMPLETED 05/17/16	HAMMER TYPE Auto
WL	RIG Truck FOREMAN Jorge	DRILLING METHOD

CLIENT Cannon Design	JOB # 16:11338	BORING # B-3	SHEET 2 OF 2
PROJECT NAME Des Moines VA Parking Garage	ARCHITECT-ENGINEER Cannon Design		
SITE LOCATION 3600 30th Street, Des Moines, Allamakee County, Iowa			
NORTHING	EASTING	STATION	

-○- CALIBRATED PENETROMETER TONS/FT²

ROCK QUALITY DESIGNATION & RECOVERY
RQD% – — – REC% ———

PLASTIC LIMIT% ✕ WATER CONTENT% ● LIQUID LIMIT% △

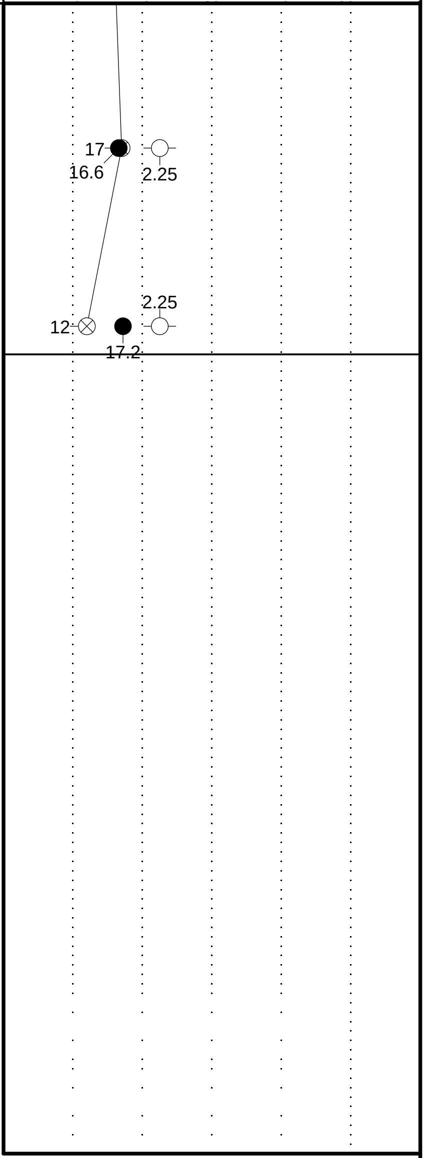
⊗ STANDARD PENETRATION BLOWS/FT

DESCRIPTION OF MATERIAL ENGLISH UNITS

BOTTOM OF CASING LOSS OF CIRCULATION 100%

SURFACE ELEVATION 123 +/-

DEPTH (FT)	SAMPLE NO.	SAMPLE TYPE	SAMPLE DIST. (IN)	RECOVERY (IN)	DESCRIPTION OF MATERIAL	WATER LEVELS	ELEVATION (FT)	BLOWS/6"
					(CL/ML) SILTY CLAY, Trace Sand, Trace Gravel, Brown, Moist, Soft to Hard, Increased Sand With Depth			
							90	
	S-10	SS	24	16				4 7 10 71
35								
						▽		
							85	
	S-11	SS	18	17				4 5 7
40					END OF BORING @ 40'			
							80	
45								
							75	
50								
							70	
55								
							65	
60								



THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL TYPES. IN-SITU THE TRANSITION MAY BE GRADUAL.

▽ WL 37 WS ☐ WD ☒	BORING STARTED 05/17/16	CAVE IN DEPTH
▽ WL(SHW) ▼ WL(ACR)	BORING COMPLETED 05/17/16	HAMMER TYPE Auto
▽ WL	RIG Truck FOREMAN Jorge	DRILLING METHOD

CLIENT Cannon Design	JOB # 16:11338	BORING # B-4	SHEET 1 OF 2
PROJECT NAME Des Moines VA Parking Garage	ARCHITECT-ENGINEER Cannon Design		
SITE LOCATION 3600 30th Street, Des Moines, Allamakee County, Iowa			
NORTHING	EASTING	STATION	

-○- CALIBRATED PENETROMETER TONS/FT^2

ROCK QUALITY DESIGNATION & RECOVERY
RQD% – — –   REC% ———

PLASTIC LIMIT% ✕   WATER CONTENT% ●   LIQUID LIMIT% △

⊗ STANDARD PENETRATION BLOWS/FT

DESCRIPTION OF MATERIAL — ENGLISH UNITS

BOTTOM OF CASING   LOSS OF CIRCULATION

SURFACE ELEVATION 113 +/-

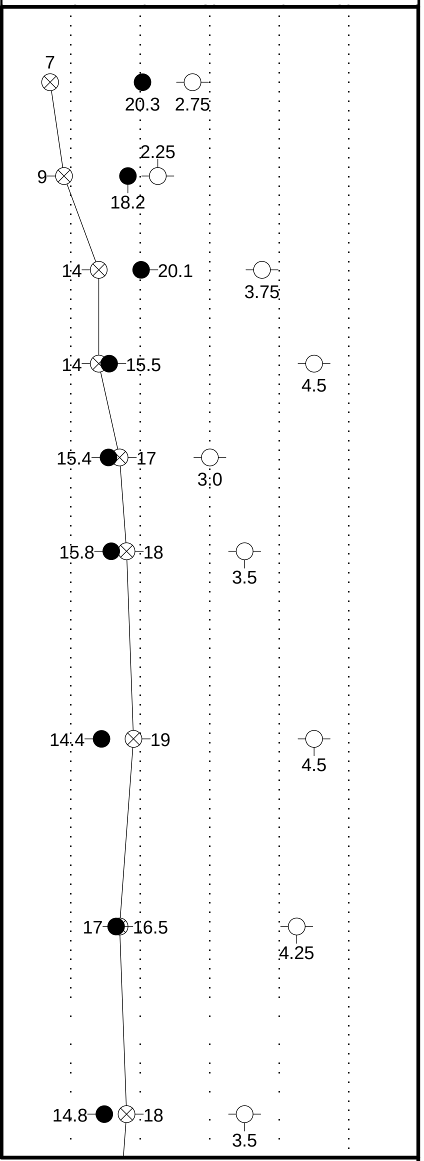
DEPTH (FT): 0, 5, 10, 15, 20, 25, 30

ELEVATION (FT): 110, 105, 100, 95, 90, 85

SAMPLE NO.	SAMPLE TYPE	SAMPLE DIST. (IN)	RECOVERY (IN)	BLOWS/6"
S-1	SS	24	14	2 3 4 7
S-2	SS	24	11	3 4 5 9
S-3	SS	24	12	3 5 9 14
S-4	SS	24	15	3 5 9 14
S-5	SS	24	10	3 7 10 17
S-6	SS	24	9	3 6 12 18
S-7	SS	24	11	4 8 11 19
S-8	SS	24	11	4 7 10 17
S-9	SS	24	16	5 8 10 18

Topsoil Depth [6"]

(CL/ML) SILTY CLAY WITH SAND, Trace Gravel, Brown to Dark Brown, Moist, Very Stiff to Hard



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THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL TYPES. IN-SITU THE TRANSITION MAY BE GRADUAL.

WL WS ☐ WD ☒	BORING STARTED 05/17/16	CAVE IN DEPTH
WL(SHW) WL(ACR)	BORING COMPLETED 05/17/16	HAMMER TYPE Auto
WL	RIG Truck FOREMAN Jorge	DRILLING METHOD

CLIENT Cannon Design	JOB # 16:11338	BORING # B-4	SHEET 2 OF 2	
PROJECT NAME Des Moines VA Parking Garage	ARCHITECT-ENGINEER Cannon Design			
SITE LOCATION 3600 30th Street, Des Moines, Allamakee County, Iowa				
NORTHING	EASTING	STATION		

-○- CALIBRATED PENETROMETER TONS/FT^2

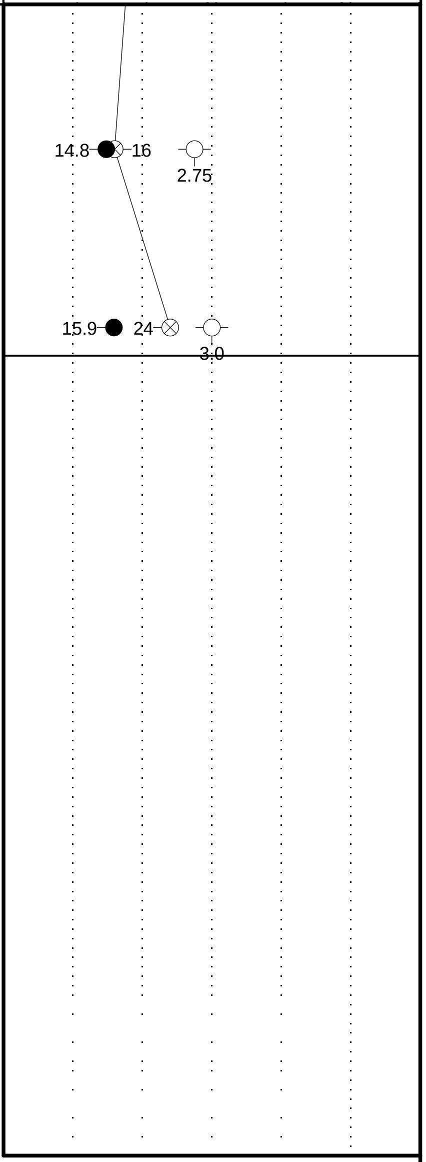
ROCK QUALITY DESIGNATION & RECOVERY
RQD% – — –   REC% ———

PLASTIC LIMIT%   WATER CONTENT%   LIQUID LIMIT%
×———●———△

⊗ STANDARD PENETRATION BLOWS/FT

DESCRIPTION OF MATERIAL   ENGLISH UNITS
BOTTOM OF CASING   LOSS OF CIRCULATION
SURFACE ELEVATION 113 +/-

DEPTH (FT)	SAMPLE NO.	SAMPLE TYPE	SAMPLE DIST. (IN)	RECOVERY (IN)	DESCRIPTION OF MATERIAL	WATER LEVELS	ELEVATION (FT)	BLOWS/6"
					(CL/ML) SILTY CLAY WITH SAND, Trace Gravel, Brown to Dark Brown, Moist, Very Stiff to Hard		80	
35	S-10	SS	24	18				3 7 9 16
							75	
40	S-11	SS	18	17				6 9 15
					END OF BORING @ 40'			
45							70	
50							65	
55							60	
60							55	



THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL TYPES. IN-SITU THE TRANSITION MAY BE GRADUAL.

WL WS ☐ WD ☒	BORING STARTED 05/17/16	CAVE IN DEPTH
WL(SHW) WL(ACR)	BORING COMPLETED 05/17/16	HAMMER TYPE Auto
WL	RIG Truck FOREMAN Jorge	DRILLING METHOD

CLIENT Cannon Design	JOB # 16:11338	BORING # B-5	SHEET 1 OF 2
PROJECT NAME Des Moines VA Parking Garage	ARCHITECT-ENGINEER Cannon Design		
SITE LOCATION 3600 30th Street, Des Moines, Allamakee County, Iowa			
NORTHING	EASTING	STATION	

DESCRIPTION OF MATERIAL — ENGLISH UNITS

BOTTOM OF CASING — LOSS OF CIRCULATION

SURFACE ELEVATION 100 +/-

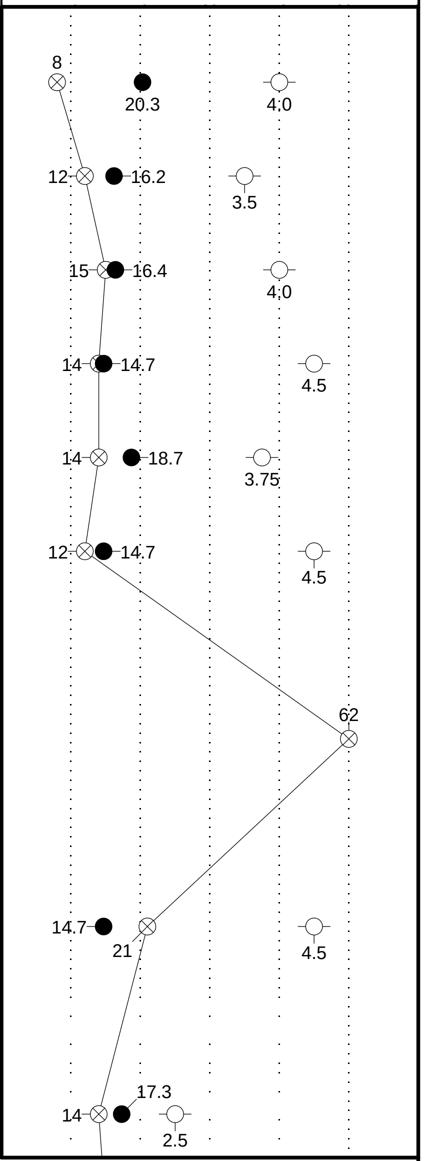
DEPTH (FT)	SAMPLE NO.	SAMPLE TYPE	SAMPLE DIST. (IN)	RECOVERY (IN)	DESCRIPTION OF MATERIAL	WATER LEVELS	ELEVATION (FT)	BLOWS/6"
0					Topsoil Depth [4"]		100	
					(CL/ML) SILTY CLAY WITH SAND, Trace Gravel, Brown to Dark Brown, Moist, Hard to Very Stiff			
	S-1	SS	24	8				2 4 4 8
5	S-2	SS	24	11			95	4 5 7 12
	S-3	SS	24	12				4 6 9 15
10	S-4	SS	24	14			90	3 6 8 14
	S-5	SS	24	14				3 5 9 14
15	S-6	SS	24	12			85	2 5 7 12
					(SM) SILTY SAND, Brown, Moist, Very Dense			
20	S-7	SS	24	14			80	13 28 34 62
					(CL/ML) SILTY CLAY WITH SAND, Trace Gravel, Brown to Dark Brown, Moist, Hard to Stiff			
25	S-8	SS	24	17			75	9 10 11 21
30	S-9	SS	24	18			70	3 6 8 14

CALIBRATED PENETROMETER TONS/FT²

ROCK QUALITY DESIGNATION & RECOVERY
RQD% — — — REC% ———

PLASTIC LIMIT% — WATER CONTENT% — LIQUID LIMIT%

STANDARD PENETRATION BLOWS/FT



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THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL TYPES. IN-SITU THE TRANSITION MAY BE GRADUAL.

WL WS ☐ WD ☒	BORING STARTED 05/16/16	CAVE IN DEPTH
WL(SHW) WL(ACR)	BORING COMPLETED 05/16/16	HAMMER TYPE Auto
WL	RIG Truck FOREMAN Jorge	DRILLING METHOD HSA

CLIENT	JOB #	BORING #	SHEET
Cannon Design	16:11338	B-5	2 OF 2

PROJECT NAME	ARCHITECT-ENGINEER
Des Moines VA Parking Garage	Cannon Design

SITE LOCATION

3600 30th Street, Des Moines, Allamakee County, Iowa

NORTHING	EASTING	STATION

-○- CALIBRATED PENETROMETER TONS/FT^2

ROCK QUALITY DESIGNATION & RECOVERY

RQD% – — – REC% ———

PLASTIC LIMIT% × WATER CONTENT% ● LIQUID LIMIT% △

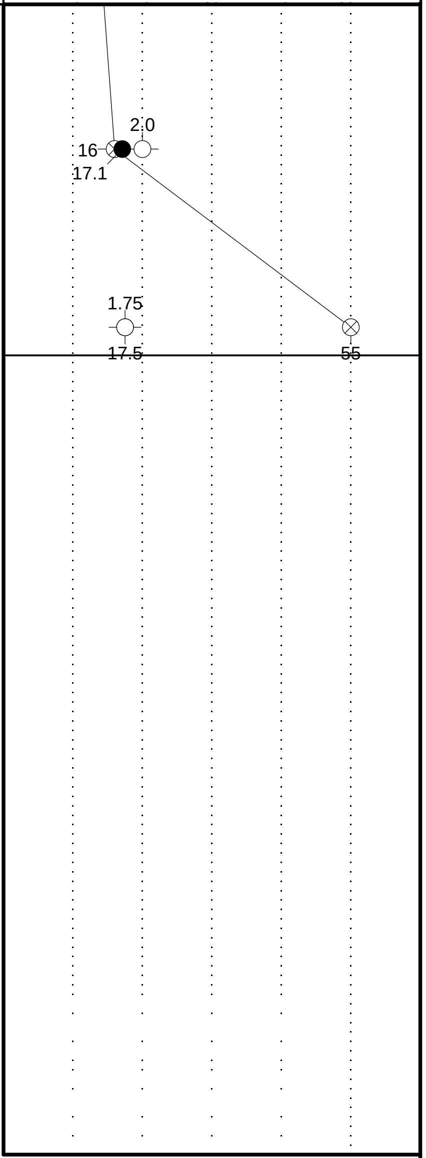
⊗ STANDARD PENETRATION BLOWS/FT

DESCRIPTION OF MATERIAL ENGLISH UNITS

BOTTOM OF CASING LOSS OF CIRCULATION

SURFACE ELEVATION 100 +/-

DEPTH (FT)	SAMPLE NO.	SAMPLE TYPE	SAMPLE DIST. (IN)	RECOVERY (IN)	DESCRIPTION OF MATERIAL	WATER LEVELS	ELEVATION (FT)	BLOWS/6"
					(CL/ML) SILTY CLAY WITH SAND, Trace Gravel, Brown to Dark Brown, Moist, Hard to Stiff			
35	S-10	SS	24	18			65	4 5 11 16
40	S-11	SS	18	16			60	30 18 37
					END OF BORING @ 40'			
45							55	
50							50	
55							45	
60							40	



THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL TYPES. IN-SITU THE TRANSITION MAY BE GRADUAL.

WL WS ☐ WD ☒	BORING STARTED 05/16/16	CAVE IN DEPTH
WL(SHW) WL(ACR)	BORING COMPLETED 05/16/16	HAMMER TYPE Auto
WL	RIG Truck FOREMAN Jorge	DRILLING METHOD HSA

CLIENT Cannon Design	JOB # 16:11338	BORING # B-6	SHEET 1 OF 2
PROJECT NAME Des Moines VA Parking Garage	ARCHITECT-ENGINEER Cannon Design		
SITE LOCATION 3600 30th Street, Des Moines, Allamakee County, Iowa			
NORTHING	EASTING	STATION	

-◯- CALIBRATED PENETROMETER TONS/FT^2

ROCK QUALITY DESIGNATION & RECOVERY

RQD% – — – REC% ———

PLASTIC LIMIT% ✕ WATER CONTENT% ● LIQUID LIMIT% △

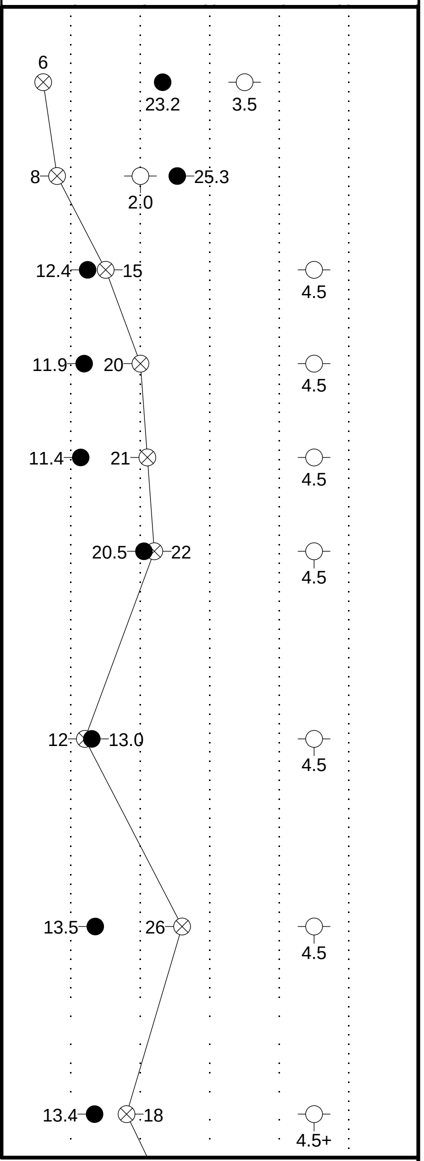
⊗ STANDARD PENETRATION BLOWS/FT

DESCRIPTION OF MATERIAL — ENGLISH UNITS

BOTTOM OF CASING — LOSS OF CIRCULATION

SURFACE ELEVATION 106 +/-

DEPTH (FT)	SAMPLE NO.	SAMPLE TYPE	SAMPLE DIST. (IN)	RECOVERY (IN)	DESCRIPTION OF MATERIAL	WATER LEVELS	ELEVATION (FT)	BLOWS/6"
0					Topsoil Depth [4"]			
					(CL/ML) SILTY CLAY WITH SAND, Trace Gravel, Brown to Reddish Brown, Moist, Very Stiff to Hard		105	
	S-1	SS	24	9				2 2 4 6
5	S-2	SS	24	12				2 3 5 8
							100	
	S-3	SS	24	13				5 6 9 15
10	S-4	SS	24	12				7 10 10 20
							95	
	S-5	SS	24	14				8 10 11 21
15	S-6	SS	24	14				9 11 11 22
							90	
20	S-7	SS	24	11				6 5 7 12
							85	
25	S-8	SS	24	12				6 10 16 26
							80	
30	S-9	SS	24	13				6 8 10 18



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THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL TYPES. IN-SITU THE TRANSITION MAY BE GRADUAL.

WL WS ☐ WD ☒	BORING STARTED 05/17/16	CAVE IN DEPTH
WL(SHW) WL(ACR)	BORING COMPLETED 05/17/16	HAMMER TYPE Auto
WL	RIG Truck FOREMAN Jorge	DRILLING METHOD HSA

CLIENT Cannon Design	JOB # 16:11338	BORING # B-6	SHEET 2 OF 2
PROJECT NAME Des Moines VA Parking Garage	ARCHITECT-ENGINEER Cannon Design		
SITE LOCATION 3600 30th Street, Des Moines, Allamakee County, Iowa			
NORTHING	EASTING	STATION	

─○─ CALIBRATED PENETROMETER TONS/FT^2

ROCK QUALITY DESIGNATION & RECOVERY
RQD% – — –   REC% ———

PLASTIC LIMIT% ✕   WATER CONTENT% ●   LIQUID LIMIT% △

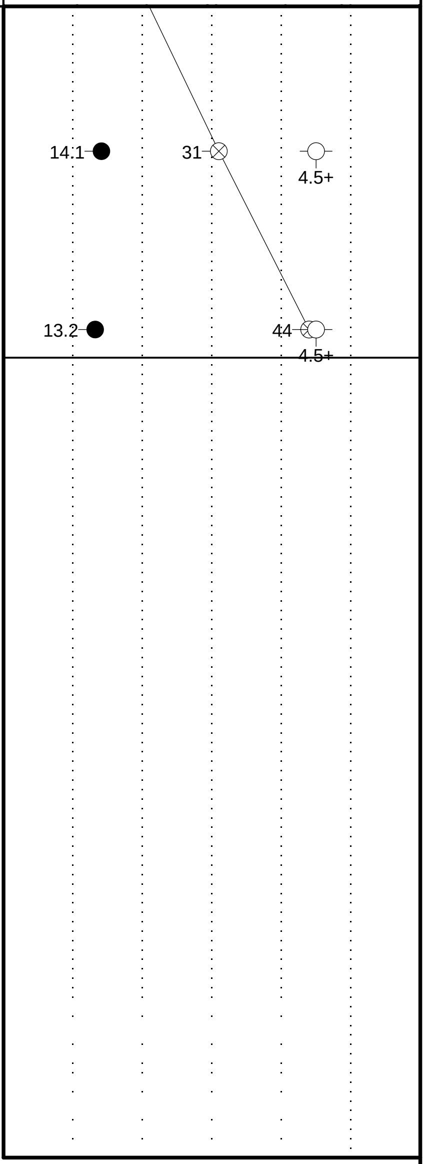
⊗ STANDARD PENETRATION BLOWS/FT

DESCRIPTION OF MATERIAL   ENGLISH UNITS

BOTTOM OF CASING   LOSS OF CIRCULATION

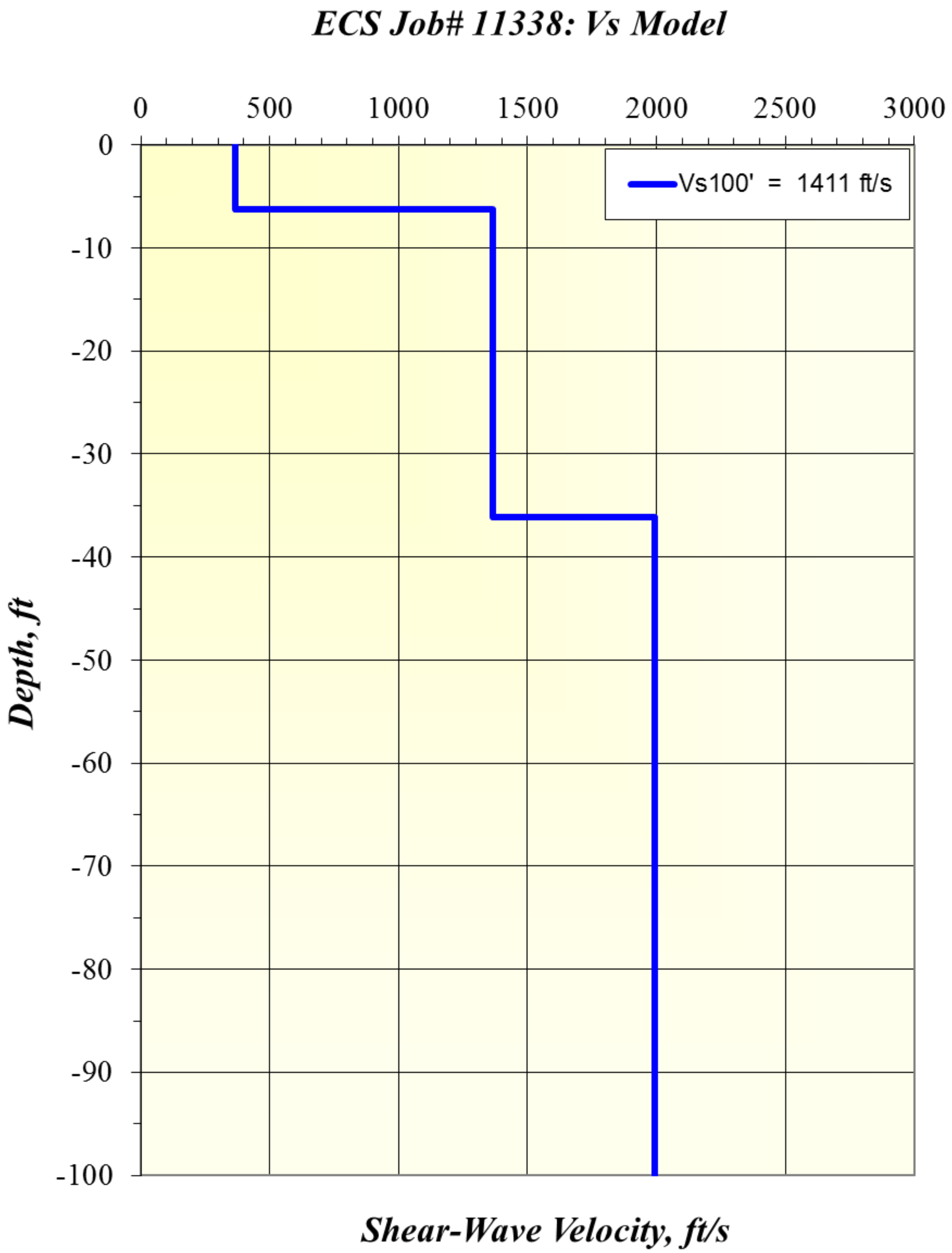
SURFACE ELEVATION 106 +/-

DEPTH (FT)	SAMPLE NO.	SAMPLE TYPE	SAMPLE DIST. (IN)	RECOVERY (IN)	DESCRIPTION OF MATERIAL	WATER LEVELS ELEVATION (FT)	BLOWS/6"
					(CL/ML) SILTY CLAY WITH SAND, Trace Gravel, Brown to Reddish Brown, Moist, Very Stiff to Hard	75	
35	S-10	SS	24	13			7 13 18 31
						70	
40	S-11	SS	18	16			11 19 25
					END OF BORING @ 40'	65	
45						60	
50						55	
55						50	
60						45	



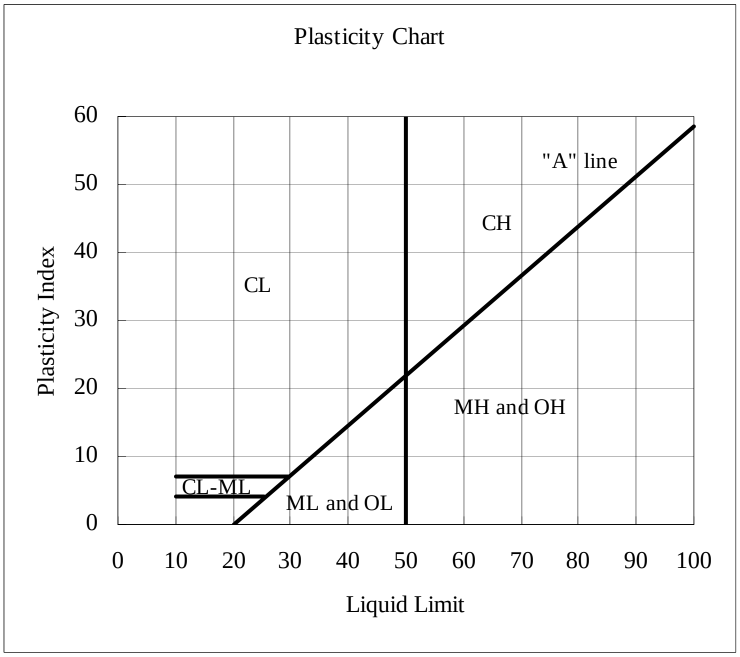
THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL TYPES. IN-SITU THE TRANSITION MAY BE GRADUAL.

WL WS ☐ WD ☒	BORING STARTED 05/17/16	CAVE IN DEPTH
WL(SHW) WL(ACR)	BORING COMPLETED 05/17/16	HAMMER TYPE Auto
WL	RIG Truck FOREMAN Jorge	DRILLING METHOD HSA



ARRAY 1 GEOPHONE SPACING = 25 Feet		**FIGURE 1** **SHEAR WAVE VELOCITY PROFILE** VA Parking Garage Des Moines, Iowa ECS Project 16:11338

UNIFIED SOIL CLASSIFICATION SYSTEM (ASTM D 2487)

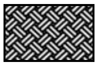
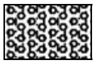
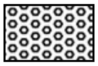
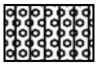
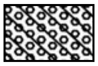
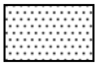
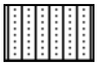
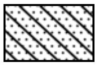
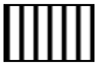
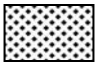
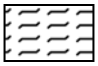
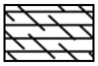
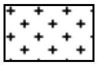
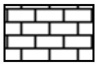
Major Divisions			Group Symbols		Typical Names	Laboratory Classification Criteria		
Coarse-grained soils (More than half of material is larger than No. 200 Sieve size)	Gravels (More than half of coarse fraction is larger than No. 4 sieve size)	Clean gravels (Little or no fines)	GW		Well-graded gravels, gravel-sand mixtures, little or no fines	Determine percentages of sand and gravel from grain-size curve. Depending on percentage of fines (fraction smaller than No. 200 sieve size), coarse-grained soils are classified as follows: Less than 5 percent GW, GP, SW, SP More than 12 percent GM, GC, SM, SC 5 to 12 percent Borderline cases requiring dual symbols[b]	$C_u = D_{60}/D_{10}$ greater than 4 $C_c = (D_{30})^2/(D_{10}xD_{60})$ between 1 and 3	
			GP		Poorly graded gravels, gravel-sand mixtures, little or no fines		Not meeting all gradation requirements for GW	
		Gravels with fines (Appreciable amount of fines)	GM[a]	d	Silty gravels, gravel-sand mixtures		Atterberg limits below "A" line or P.I. less than 4	Above "A" line with P.I. between 4 and 7 are borderline cases requiring use of dual symbols
				u				
			GC		Clayey gravels, gravel-sand-clay mixtures		Atterberg limits below "A" line or P.I. less than 7	
	Sands (More than half of coarse fraction is smaller than No. 4 sieve size)	Clean sands (Little or no fines)	SW		Well-graded sands, gravelly sands, little or no fines		$C_u = D_{60}/D_{10}$ greater than 6 $C_c = (D_{30})^2/(D_{10}xD_{60})$ between 1 and 3	
			SP		Poorly graded sands, gravelly sands, little or no fines		Not meeting all gradation requirements for SW	
		Sands with fines (Appreciable amount of fines)	SM[a]	d	Silty sands, sand-silt mixtures		Atterberg limits above "A" line or P.I. less than 4	Limits plotting in CL-ML zone with P.I. between 4 and 7 are borderline cases requiring use of dual symbols
				u				
			SC		Clayey sands, sand-clay mixtures		Atterberg limits above "A" line with P.I. greater than 7	
Fine-grained soils (More than half material is smaller than No. 200 Sieve)	Silts and clays (Liquid limit less than 50)		ML		Inorganic silts and very fine sands, rock flour, silty or clayey fine sands, or clayey silts with slight plasticity			
			CL		Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays			
			OL		Organic silts and organic silty clays of low plasticity			
	Silts and clays (Liquid limit greater than 50)		MH		Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts			
			CH		Inorganic clays of high plasticity, fat clays			
			OH		Organic clays of medium to high plasticity, organic silts			
	Highly Organic soils		Pt		Peat and other highly organic soils			

[a] Division of GM and SM groups into subdivisions of d and u are for roads and airfields only. Subdivision is based on Atterberg limits; suffix d used when L.L. is 28 or less and the P.I. is 6 or less; the suffix u used when L.L. is greater than 28.

[b] Borderline classifications, used for soils possessing characteristics of two groups, are designated by combinations of group symbols. For example: GW-GC,well-graded gravel-sand mixture with clay binder. (From Table 2.16 - Winterkorn and Fang, 1975)

REFERENCE NOTES FOR BORING LOGS

MATERIALS

	**ASPHALT**	
	**CONCRETE**	
	**SUBBASE STONE / GRAVEL**	
	**TOPSOIL**	
	**FILL**	Man-placed or disturbed soils
	**GW**	**WELL-GRADED GRAVEL** gravel-sand mixtures, little or no fines
	**GP**	**POORLY-GRADED GRAVEL** gravel-sand mixtures, little or no fines
	**GM**	**SILTY GRAVEL** gravel-sand-silt mixtures
	**GC**	**CLAYEY GRAVEL** gravel-sand-clay mixtures
	**SW**	**WELL-GRADED SAND** gravelly sand, little or no fines
	**SP**	**POORLY-GRADED SAND** gravelly sand, little or no fines
	**SM**	**SILTY SAND** sand-silt mixtures
	**SC**	**CLAYEY SAND** sand-clay mixtures
	**ML**	**SILT** non-plastic to medium plasticity
	**MH**	**ELASTIC SILT** high plasticity
	**CL**	**LEAN CLAY** low to medium plasticity
	**CH**	**FAT CLAY** high plasticity
	**OL**	**ORGANIC SILT or CLAY** non-plastic to low plasticity
	**OH**	**ORGANIC SILT or CLAY** high plasticity
	**PT**	**PEAT** highly organic soils
	**WEATHERED ROCK**	
	**IGNEOUS ROCK**	
	**METAMORPHIC ROCK**	
	**SEDIMENTARY ROCK**	

DRILLING SAMPLING SYMBOLS & ABBREVIATIONS

SS	Split Spoon Sampler	PM	Pressuremeter Test
ST	Shelby Tube Sampler	RD	Rock Bit Drilling
WS	Wash Sample	RC	Rock Core, NX, BX, AX
BS	Bulk Sample of Cuttings	REC	Rock Sample Recovery %
PA	Power Auger (no sample)	RQD	Rock Quality Designation
HSA	Hollow Stem Auger		

PARTICLE SIZE IDENTIFICATION

DESIGNATION		PARTICLE SIZES
Boulders		12-inches (300-mm) or larger
Cobbles		3-inches to 12- inches (75-mm to 300-mm)
Gravel:	Coarse	¾-inch to 3-inches (19-mm to 75-mm)
	Fine	4.75-mm to 19-mm (No. 4 sieve to ¾-inch)
Sand:	Coarse	2.00-mm to 4.75-mm (No. 10 to No. 4 sieve)
	Medium	0.425-mm to 2.00-mm (No. 40 to No. 10 sieve)
	Fine	0.074-mm to 0.425-mm (No. 200 to No. 40 sieve)
Silt & Clay ("Fines")		<0.074-mm (smaller than a No. 200 sieve)

WATER LEVELS[1]

▽	WL	Water Level (WS)(WD) (WS) While Sampling (WD) While Drilling
▽	BCR	Before Casing Removal
▼	ACR	After Casing Removal
▽	WL	Water Level as stated
	DCI	Dry Cave-In
	WCI	Wet Cave-In

RELATIVE PROPORTIONS

Trace	<5%
Little	5% - <15%
With	15% - <30%
Adjective *(ex: "Silty")*	30% - <50%

COHESIVE SILTS & CLAYS

UNCONFINED COMP. STRENGTH, Q_P[2] (TSF)	SPT[3] (BPF)	CONSISTENCY (COHESIVE ONLY)
<0.25	≤2	Very Soft
0.25 - 0.49	3 - 4	Soft
0.50 - 0.99	5 - 8	Medium Stiff
1.00 - 1.99	9 - 15	Stiff
2.00 - 3.99	16 - 30	Very Stiff
4.00 - 8.00	31 - 50	Hard
>8.00	>50	Very Hard

GRAVELS, SANDS & NON-COHESIVE SILTS

SPT[3] (BPF)	DENSITY
≤4	Very Loose
5 - 10	Loose
11 - 30	Medium Dense
31 - 50	Dense
51 - 99	Very Dense
≥100	Partially Weathered Rock to Intact Rock

[1] The water levels are those levels actually measured in the borehole at the times indicated by the symbol. The measurements are relatively reliable when augering, without adding fluids, in granular soils. In clay and cohesive silts, the determination of water levels may require several days for the water level to stabilize. In such cases, additional methods of measurement are generally taken.

[2] Typically estimated via pocket penetrometer or Torvane shear test and expressed in tons per square foot (tsf).

[3] Standard Penetration Test (SPT) refers to the number of hammer blows (blow count) of a 140 lb. hammer falling 30 inches on a 2-inch OD split-spoon sampler required to drive the sampler 12 inches (ASTM D 1586). "N-value" is another term for "blow count" and is expressed in blows per foot (bpf).