Geotechnical Engineering Report

ICPW Fire Training Tower

Iowa City, Iowa

July 6, 2018

Terracon Project No. 06185072.01

Prepared for:

City of Iowa City
Iowa City, Iowa

Prepared by:

Terracon Consultants, Inc.
Cedar Rapids, Iowa

July 6, 2018

City of Iowa City
410 East Washington Street
Iowa City, Iowa 52240

Attn: Mr. Ronald R. Knoche, P.E. - Public Works Director
P: (319) 356-5000
E: ron-knoche@iowa-city.org

Re: Geotechnical Engineering Report
ICPW Fire Training Tower
Napoleon Lane SE
Iowa City, Iowa
Terracon Project No. 06185072.01

Dear Mr. Knoche:

We have completed the geotechnical engineering services for the referenced project. This study was performed in general accordance with the City of Iowa City (City) Consultant Agreement dated May 18, 2018. This report presents the findings of the subsurface exploration and provides geotechnical recommendations concerning earthwork and the design and construction of foundations and floor slabs for the proposed project.

We appreciate the opportunity to be of service to you on this project. If you have any questions concerning this report, or if we may be of further service, please contact us.

Sincerely,

Terracon Consultants, Inc.

Thomas W. Sherman, P.E. (WI)
Geotechnical Engineer

André M. Gallet, P.E.
Iowa No. 13430

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REPORT TOPICS

Note: This report was originally delivered in a web-based format. **Orange Bold** text in the report indicates a referenced section heading. The PDF version also includes hyperlinks which direct the reader to that section and clicking on the Terracon GeoReport logo will bring you back to this page. For more interactive features, please view your project online at client.terracon.com.

ATTACHMENTS

Geotechnical Engineering Report
ICPW Fire Training Tower
Napoleon Lane SE
Iowa City, Iowa
Terracon Project No. 06185072.01
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INTRODUCTION

This report presents the results of our subsurface exploration and geotechnical engineering services performed for the proposed ICPW Fire Training Tower to be located at Napoleon Lane SE in Iowa City, Iowa. The purpose of these services is to provide information and geotechnical engineering recommendations relative to:

- Subsurface soil conditions
- Site preparation and earthwork
- Foundation design and construction
- Frost considerations
- Groundwater conditions
- Seismic site classification per IBC
- Floor slab design and construction

The geotechnical engineering scope of services for this project included the advancement of two test borings to depths of approximately 30.5 feet below existing site grades.

Maps showing the site and boring locations are shown in the **Site Location** and **Exploration Plan** sections, respectively. The results of the laboratory testing performed on soil samples obtained from the site during the field exploration are included on the boring logs and/or as separate graphs in the **Exploration Results** section of this report.

SITE CONDITIONS

The following description of site conditions is derived from our site visit in association with the field exploration and our review of publicly available geologic and topographic maps.

Item	Description
Project Location	The project is located at Napoleon Lane SE in Iowa City, Iowa Existing Iowa City Public Works (ICPW) facility See **Site Location**
Existing Improvements	Mass graded site, existing buildings, parking, drive areas and sidewalks, subsurface utilities

Item	Description
Current Ground Cover	Primarily grass and bare earth or wooded in unimproved areas
Existing Topography (Johnson Co. GIS 2014 topographic contours)	Planned fire tower area generally slopes downward to the southwest, with surface elevations ranging from about 638 to 643 feet
Geology	Primary landform type per the USDA NRCS Soil Survey of Johnson County, Iowa is flood plain (alluvial deposits) overlying glacial till that extends to dolomite bedrock of the Cedar Valley Group of the Upper Middle and lower Upper Devonian formation

PROJECT DESCRIPTION

Our understanding of the project at the time of this report is as follows.

Item	Description
Information Provided	Schematic Design (Sheet CO-101, preliminary, undated) by Neumann Monson *Proposed Fire Training Tower Layout* (architectural elevations dated 9/22/2017)
Project Description	New fire tower structure: 4-story, slab-on-grade structure with plan dimensions of about 25 feet by 32 feet
Building Construction	Not provided, but anticipated to be steel frame, sheet metal siding, and concrete deck floors
Finished Floor Elevation	Not provided, but anticipated to be near 640 feet
Maximum Loads (assumed)	■ Columns: 75 kips ■ Walls: 6 kips per linear foot (klf) ■ Slabs: 100 pounds per square foot (psf)
Grading	Not provided, but anticipated cuts and fills of about 3 feet or less
Below Grade Structures	None anticipated
Free-Standing Retaining Walls	None anticipated
Pavements	Not included in our scope of services

GEOTECHNICAL CHARACTERIZATION

Subsurface Profile

We have developed a general characterization of the subsurface soil and groundwater conditions based upon our review of the data and our understanding of the geologic setting. A graphical representation of the characterization is provided in the **Exploration Results** section. A statistical summary of field and laboratory data is also included. The geotechnical characterization forms the basis of our geotechnical calculations and evaluation of site preparation and foundation options. As noted in **General Comments**, the characterization is based upon widely spaced exploration points across the site, and variations are likely.

Conditions encountered at each boring location are indicated on the individual boring logs shown in the **Exploration Results** section and are attached to this report. Stratification boundaries on the boring logs represent the approximate location of changes in soil types; in situ, the transition between native materials may be gradual.

Groundwater Conditions

The boreholes were observed while drilling and after completion for the presence and level of groundwater. The water levels observed in the boreholes can be found on the boring logs in **Exploration Results**, and are tabulated below.

Boring Number	Approximate Groundwater while Drilling (feet)		Approximate Groundwater after Completion of Drilling (feet)	
	Depth [1]	Elevation [2]	Depth [1]	Elevation [2]
B-301	10.5	629.5	9	631
B-302	9	631	10	630

1. Below existing ground surface.
2. North American Vertical Datum of 1988 (NAVD 88).

These water level observations provide an approximate indication of the groundwater conditions existing on the site at the time the observations were made. Longer-term observations using cased holes or piezometers, sealed from the influence of surface water, would be required for a better evaluation of the groundwater conditions on this site.

Fluctuations of the groundwater levels will likely occur due to seasonal variations in the amount of rainfall, runoff, Iowa River stage, and other factors not evident at the time the borings were performed. Therefore, groundwater levels during construction or at other times in the life of the structure may be different than the levels indicated on the boring logs. Also, trapped or "perched" water could be present within the sand or silt seams within native clay soils and/or in cohesionless soils above lower hydraulic conductivity clay soil layers. The possibility of groundwater level fluctuations and perched water should be considered when developing the design and construction plans for the project.

USDA NRCS Soil Mapping

The Soil Survey of Johnson County, Iowa was reviewed to identify soil types in the area of the subject site. The document was published in 1983 by the U.S. Department of Agriculture (USDA) Soil Conservation Service, now known as the Natural Resource Conservation Service (NRCS). Terracon utilized the NRCS on-line Web Soil Survey (WSS)[1] to identify soil types. The classifications provided are for the USDA textural soil classification system for approximately the upper 80 inches of the soil profile.

The soil type mapped on the site by the NRCS is the *Perks-Spillville complex, 0 to 2 percent slopes, frequently flooded*. The NRCS rates the *Perks-Spillville complex* as follows:

- ***Very limited*** for the construction of small commercial buildings due to flooding and shrink-swell;
- ***Very limited*** for the construction of local streets and roads due to flooding, low strength, frost action and shrink-swell;
- ***Good*** for the Perks component and ***Poor*** for the Spillville component as a potential as a source of roadfill due to low strength, shrink-swell, and dusty;
- ***Low*** (Perks component) to ***moderate*** (Spillville component) potential for frost action;
- ***Low*** (Perks component) to ***moderate*** (Spillville component) risk of corrosion to uncoated steel;
- ***Low*** (Spillville component) to ***moderate*** (Perks component) risk of corrosion to concrete.

The Soil Survey of Johnson County, Iowa was also reviewed for information relating to anticipated seasonally high groundwater levels. In undisturbed areas, the Spillville component of the Perks-Spillville complex soils is reported to have apparent seasonal high groundwater of about 4 to 6 feet below its natural grades. No seasonal high water level is reported for the Perks component of the Perks-Spillville complex soils mapped by the NRCS on the site.

[1] *Posted at: http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm, accessed June 19, 2018.*

GEOTECHNICAL OVERVIEW

Support of the building on shallow footing foundations appears feasible, as long as the bearing soils are prepared as discussed in the **Site Preparation**, **Earthwork**, and **Shallow Foundations** sections. Due to the presence of lower strength/density native soils, some foundation bearing soil overexcavation and backfilling should be expected, even with the relatively low recommended design bearing pressure.

The near surface soils are also susceptible to disturbance from construction activities, particularly if the soils are wetted by surface water or seepage. Care should be taken during construction to reduce disturbance of the exposed soils. Consideration should be given to placing a crushed stone working platform across the building area, and establishing aggregate surfaced haul roads and staging areas to help minimize disturbance of subgrade soils.

The **General Comments** section provides an understanding of the report limitations.

SITE PREPARATION

Topsoil, vegetation, soils with organic contents greater than 5 percent, and any otherwise unsuitable materials should be removed from the construction areas. Excessively wet or dry material should either be removed or moisture conditioned and recompacted. Soft and/or low-density soil should be removed or compacted in place prior to placing new fill. Subgrade conditions should be observed by Terracon during construction.

After rough grade has been established, the exposed subgrade should be proofrolled by the contractor and test probed by Terracon. However, obviously unstable subgrades should not be proofrolled to reduce disturbance of the subgrade soils, until after these soils have been stabilized. Proofrolling could be accomplished by using heavy, rubber-tired construction equipment or a partially-loaded tandem axle dump truck (gross weight of about 25 tons). This surficial proofroll would help to provide a stable base for the compaction of new structural fill, and delineates low density, soft, or disturbed areas that may exist below subgrade level. Soft or loose areas should be undercut, moisture conditioned, and recompacted or replaced with approved structural fill.

Corrective measures will probably be required to increase subgrade stability during subgrade preparation. The City should budget for additional costs to provide the required corrective measures. Based on our experience in soils of these types, crushed stone working mat on the order of 1 to 2 feet thick could be required to stabilize subgrade soils. A geotextile stabilization material could also be placed below the crushed stone to help stabilize the subgrade soils. As an alternative, the unstable subgrade soils could be undercut, scarified on-site, and compacted with moisture and density control in maximum 9-inch loose lifts up to final subgrade elevation to provide a uniform thickness of well-compacted material.

Dewatering during construction could be required. We expect that sump pits and pumps would generally be adequate for dewatering excavations in clay soils. More extensive dewatering measures, such as well points and sheeting, may be required for excavations that encounter water bearing sand soils.

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

EARTHWORK

Fill Material Types

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

The inorganic lean clay (Model Layer 2) and sand soils (Model Layers 3 and 4) encountered in the borings are considered suitable for use as site mass grading fill. Moisture conditioning (e.g. drying of clays, wetting of sands) should be anticipated if on-site soils are used as fill.

Compacted structural fill should meet the following material property requirements:

Fill Type [1]	USCS Classification	Acceptable Location for Placement
Low plasticity cohesive [2]	CL-ML, CL (LL<45, PI<23)	General site grading fill
Higher plasticity cohesive	CL (LL≥45, PI≥23), CL/CH, CH	Green (non-structural) locations
Granular	GW, GP, GM, GC SW, SP, SM, SC	General site grading fill

Fill Type [1]	USCS Classification	Acceptable Location for Placement
	GW, GP, GM, GC	General site grading fill, below foundations [3]
Unsuitable	ML, MH, CL-OL, OL, CH-OH, OH, PT	Green (non-structural) locations
On-site soils	CL, SP-SM, SP	Per the USCS classifications noted in this table

1. Structural fill should consist of approved materials that are free of organic matter and debris. Frozen material should not be used, and fill should not be placed on a frozen subgrade. A sample of each material type should be submitted to the geotechnical engineer for evaluation prior to use on this site.
2. Low plasticity cohesive soil has a liquid limit less than 45 and a plasticity index less than 23.
3. If placed during mass site grading. Foundation bearing soil correction overexcavation backfill should be a dense-graded crushed stone.

Appropriate laboratory tests, including Atterberg Limits for cohesive soils, organic content tests for dark colored soils and/or those that exhibit a noticeable odor, and standard Proctor (ASTM D698) moisture-density relationship tests should be performed on proposed fill materials prior to their use as structural fill. Further evaluation of any on-site soils or off-site fill materials should be performed by Terracon prior to their use in compacted fill sections.

Compaction Requirements

Item	Description
Maximum fill lift thickness	■ 9 inches or less in loose thickness when heavy, self-propelled compaction equipment is used ■ 4 inches in loose thickness when hand-guided equipment (i.e. jumping jack or plate compactor) is used o May be increased to 6 inches if the fill is a granular material
Minimum compaction requirements [1, 2]	■ 98% beneath foundations ■ 95% above foundations
Moisture content range [1]	■ Low plasticity cohesive: -2% to +3% ■ Granular: -3% to +3%

1. As determined by the standard Proctor test (ASTM D698).
2. If the granular material is a coarse sand or gravel, or of a uniform size, or has a low fines content, compaction comparison to relative density may be more appropriate. In this case, granular materials should be compacted to at least 70% relative density (ASTM D 4253 and D 4254).

Utility Trench Backfill

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

Grading and Drainage

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

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

Earthwork Construction Considerations

As a minimum, excavations should be performed in accordance with OSHA 29 CFR, Part 1926, Subpart P, "Excavations" and its appendices, and in accordance with any applicable local, and/or state regulations.

Construction site safety is the sole responsibility of the contractor who controls the means, methods, and sequencing of construction operations. Under no circumstances shall the information provided herein be interpreted to mean Terracon is assuming any responsibility for construction site safety, or the contractor's activities; such responsibility shall neither be implied nor inferred.

Construction Observation and Testing

Earthwork should be observed and tested by Terracon, including site stripping, fill placement, and slab subgrade preparation. Foundation bearing soils should be evaluated by Terracon.

In addition to the documentation of the essential parameters necessary for construction, the continuation of Terracon into the construction phase of the project provides the continuity to maintain our evaluation of geotechnical conditions, including assessing variations and associated design changes.

SHALLOW FOUNDATIONS

Based on the project information, the results of the subsurface exploration, laboratory testing, and our analysis, the structure may be supported on spread footing foundations; however, due to the presence of lower strength/density native soils, bearing soil correction overexcavation and backfilling may be required. To decrease the quantity of foundation bearing soil correction, a relatively low bearing pressure has been recommended.

The following design parameters are applicable for spread footing foundations.

Design Parameters – Shallow Foundations

Item	Description
Maximum net allowable bearing pressure [1, 2]	1,500 psf
Required bearing stratum [3]	■ Native, medium stiff or greater consistency clay soil o Should have a field tested shear strength of at least half the design bearing pressure ■ Native, medium dense or greater relative density sand o Native very loose to loose sand that has been compacted to a medium dense condition ■ Granular fill or lean concrete extending to suitable native bearing materials
Minimum foundation widths	■ Columns: 30 inches ■ Continuous: 16 inches
Minimum embedment depths below finished grade [4, 5]	■ Perimeter footings for heated areas: 42 inches ■ Interior footings in heated areas: 18 inches
Estimated total settlement from structural loads [2]	Less than about 1 inch

Item	Description
Estimated differential settlement [2]	About 2/3 of total settlement

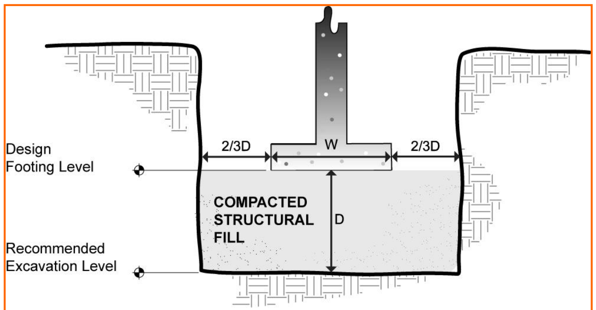
1. The maximum net allowable bearing pressure is the pressure in excess of the minimum surrounding overburden pressure at the footing base elevation.
2. Values provided are for maximum loads noted in **Project Description**.
3. Unsuitable, and/or lower strength/density native soils should be overexcavated and replaced according to the recommendations presented in **Foundation Construction Considerations**.
4. Embedment necessary to minimize the effects of frost. Finished grade is defined as the lowest adjacent grade within 5 feet of the foundation for perimeter (or exterior) footings and finished floor level for interior footings.
5. Interior footings should be constructed to a minimum embedment of 42 inches if they will be subjected to frost conditions during construction.

Foundation Construction Considerations

Foundation excavations should be observed by Terracon. If the soil conditions encountered differ significantly from those presented in this report, supplemental recommendations will be required.

Very loose to loose sands will likely be encountered in footing excavations; these sands exposed at the base of shallow foundations should be densified in place to at least 98 percent of the material's standard Proctor maximum dry density or at least 70 percent relative density using appropriate compaction equipment prior to foundation construction. The sands should be densified to a depth of at least 2 feet below footing bearing elevation using excavator mounted vibratory or hand-held dynamic compaction equipment (e.g., jumping jack). However; if the water table is within 2 feet of the foundation excavation bottom, dewatering measures should be used to lower the water table to at least 2 feet below the bottom of the excavation prior to performing in-situ densification.

Where loose sands cannot be densified in place and/or if unsuitable bearing soils are encountered in footing excavations, excavations should be extended deeper to suitable soil and the footings should bear on properly compacted crushed stone backfill extending down to the suitable soils. Overexcavation for backfill placement below footings should extend laterally beyond all edges of the footings at least 8 inches per foot of overexcavation depth below design footing level. The overexcavation should then be backfilled up to the design footing level with dense-graded crushed stone placed in lifts of 6 inches or less in loose thickness and compacted to at least 98 percent of the material's maximum standard Proctor dry density (ASTM D698). The overexcavation and backfill procedures are shown in the figure below.



Overexcavation / Backfill

NOTE: Excavations in sketches shown vertical for convenience. Excavations should be sloped as necessary for safety.

The base of all foundation excavations should be free of water, soft to medium stiff soils, and loose/disturbed material prior to placement of backfill, reinforcing steel, and/or concrete. If groundwater is encountered at the time of construction, it should be lowered and controlled to a minimum depth of 2 feet below the excavation elevation. Should the soil at the bearing level become disturbed, the affected soil should be removed prior to placement of concrete. Concrete should be placed as soon as possible after excavating to minimize disturbance of bearing soils.

SEISMIC CONSIDERATIONS

The seismic design requirements for buildings and other structures are based on Seismic Design Category. Site Classification is required to determine the Seismic Design Category for a structure. The Site Classification is based on the upper 100 feet of the site profile defined by a weighted average value of either shear wave velocity, standard penetration resistance, or undrained shear strength in accordance with Section 20.4 of ASCE 7-10.

Description	Value
2015 International Building Code Site Classification (IBC) [1]	D [2]
Site Latitude	41° 37.77' N
Site Longitude	91° 31.86' W
S_{DS} Spectral Acceleration for a Short Period [3]	0.091 g
S_{D1} Spectral Acceleration for a 1-Second Period [3]	0.089 g

1. Seismic site classification in general accordance with the *2015 International Building Code*, which refers to ASCE 7-10.
2. The 2015 International Building Code (IBC) uses a site profile extending to a depth of 100 feet for seismic site classification. Borings at this site were extended to a maximum depth of 30.5 feet. The site properties below the boring depth to 100 feet were estimated based on our experience and knowledge of geologic conditions of the general area. Additional deeper borings or geophysical testing may be performed to confirm the conditions below the current boring depth.
3. These values were obtained using online seismic design maps and tools provided by the USGS (http://earthquake.usgs.gov/hazards/designmaps/).

Based on the results of our site characterization program, we recommend Site Class D be used for the subject site. As noted in the table above, additional testing would be necessary to confirm soil conditions below the maximum explored depth are consistent with the Site Class noted for this site.

FLOOR SLABS

Design parameters for floor slabs assume that the recommendations in **Site Preparation** and **Earthwork** have been followed. These parameters are for interior floor slabs and appurtenances that will not be used to support vehicles. Based on the potential for shallow groundwater, specific attention should be given to positive drainage away from the structure. This also includes positive drainage of the aggregate base beneath the floor slab.

Floor Slab Design Parameters

Item	Description
Floor slab support [1]	■ Minimum 6 inches of free-draining (less than 6 percent passing the U.S. No. 200 sieve) crushed aggregate compacted to at least 95 percent of ASTM D 698 [2]
Estimated modulus of subgrade reaction [2]	100 pounds per square inch per inch (psi/in) for point loads

1. Floor slabs should be structurally independent of any building footings or walls to reduce the possibility of floor slab cracking caused by differential movements between the slab and foundation.
2. Modulus of subgrade reaction is an estimated value based upon our experience with the subgrade condition, the requirements noted in **Earthwork**, and the floor slab support as noted in this table. It is provided for point loads. For large area loads the modulus of subgrade reaction would be lower.

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

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

Floor Slab Construction Considerations

On most project sites, the site grading is generally accomplished early in the construction phase. However, as construction proceeds, the subgrade will likely be disturbed due to utility excavations, construction traffic, desiccation, rainfall, etc. Correction to subgrades prior to placement of base course crushed stone and concrete should be anticipated, particularly where subgrades consist of and/or are underlain by high moisture content clay soils.

We recommend the area underlying the floor slab be rough graded and then thoroughly proofrolled with a loaded rubber-tire skid-steer loader prior to final grading and placement of the crushed stone base course. Particular attention should be paid to high traffic areas that were rutted and disturbed earlier and to areas where backfilled trenches are located. Areas where unsuitable conditions are located should be repaired by removing and replacing the affected material with properly compacted fill. Dry and/or desiccated subgrade soils should be removed, or subjected to a procedure of scarification, moisture conditioning, and recompaction prior to placing the floor slab base course.

The recommended crushed stone base thickness is not intended to be used as a working surface for construction activities. All below-grade construction, such as utility piping installation should be completed prior to placing the base course, to avoid mixing of soil or other materials into the base course aggregate. Some redressing and correction of the crushed stone base disturbed or mixed with soil or other materials should be anticipated if the crushed stone base is placed early during construction.

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

FROST CONSIDERATIONS

The soils on this site are frost susceptible, and small amounts of water can affect the performance of grade-supported slabs. Exterior slabs should be anticipated to heave during winter months. If frost action needs to be reduced in critical areas, we recommend the use of coarse-grained/granular fill with 6 percent or less fines or structural slabs (e.g., structural stoops in front of building doors). Placement of granular material with low frost susceptibility in large areas may not be feasible; however, the following recommendations are provided to help reduce the amount of frost heave:

- Providing surface drainage away from the building and slabs and toward the site storm drainage system;
- Installing drain tiles around the perimeter of the building, stoops, and below exterior slabs and connect them to the site drainage system;
- Grading clayey subgrades beneath a more permeable granular base, toward the site drainage system;
- Placing less frost susceptible granular fill beneath slabs that are critical to the project;
- Placing a 3 horizontal to 1 vertical (3H: 1V) transition zone between less frost susceptible granular material and other soils.

As an alternative to extending the granular fill to the full frost depth, consideration can be made to placing extruded polystyrene or cellular concrete under a buffer of at least 2 feet of granular fill maintained in a drained condition.

GENERAL COMMENTS

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

Our scope of services does not include either specifically or by implication any environmental or biological (e.g., mold, fungi, bacteria) assessment of the site or identification or prevention of pollutants, hazardous materials or conditions. If the owner is concerned about the potential for such contamination or pollution, other studies should be undertaken.

Our services and any correspondence or collaboration through this system are intended for the sole benefit and exclusive use of our client for specific application to the project discussed and are accomplished in accordance with generally accepted geotechnical engineering practices with no third party beneficiaries intended. Any third party access to services or correspondence is solely for information purposes to support the services provided by Terracon to our client. Reliance upon the services and any work product is limited to our client, and is not intended for third parties. Any use or reliance of the provided information by third parties is done solely at their own risk. No warranties, either express or implied, are intended or made.

Site characteristics as provided are for design purposes and not to estimate excavation cost. Any use of our report in that regard is done at the sole risk of the excavating cost estimator as there may be variations on the site that are not apparent in the data that could significantly affect excavation cost. Any parties charged with estimating excavation costs should seek their own site characterization for specific purposes to obtain the specific level of detail necessary for costing. Site safety, and cost estimating including, excavation support, and dewatering requirements/design are the responsibility of others. If changes in the nature, design, or location of the project are planned, our conclusions and recommendations shall not be considered valid unless we review the changes and either verify or modify our conclusions in writing.

ANDRE' M. GALLET 13430	I hereby certify that this engineering document was prepared by me or under my direct personal supervision and that I am a duly licensed Professional Engineer under the laws of the State of Iowa. 7/6/18 André M. Gallet, P.E. Date My license renewal date is December 31, 2018.

ATTACHMENTS

EXPLORATION AND TESTING PROCEDURES

Field Exploration

Exploration Scope: Two borings were performed to depths of about 30.5 feet below existing grades within the planned building location at the approximate locations shown on the **Exploration Plan**.

Boring Layout and Elevations: The borings were staked using a measuring wheel and/or tape while estimating right angles from known reference features. The coordinates shown on the boring logs are approximate and were determined by using measuring tools on the Johnson County GIS system. Boring elevations (rounded to the nearest foot) are from plotting the boring coordinates on the State of Iowa Lidar digital elevation model. The boring locations and elevations should only be considered accurate to the degree of the means and methods used to obtain them.

Subsurface Exploration Procedures: We advanced the soil borings with a track-mounted drill rig using continuous flight hollow stem augers. Groundwater levels were observed during and immediately after the completion of drilling and sampling. Once the samples were collected and classified in the field, they were placed in appropriate sample containers and transported to our laboratory. The boreholes were backfilled with auger cuttings after their completion.

Our exploration team prepared field boring logs as part of standard drilling operations including sampling depths, penetration distances, and other relevant sampling information. Field logs included visual classifications of materials encountered during drilling, and our exploration team's interpretation of subsurface conditions between samples.

Laboratory Testing

Water content tests were performed on the samples obtained from the borings, and hand penetrometer tests were also performed on selected cohesive native samples. An Atterberg (liquid and plastic) limits test and an organic content by loss on ignition were performed on selected samples to better evaluate the site conditions and develop engineering recommendations for the project. Native soil samples were visually classified in accordance with the Unified Soil Classification System (USCS). Computer generated boring logs, prepared from field logs, represent the geotechnical engineer's interpretation, and include modifications based on observations and laboratory tests.

SITE LOCATION AND EXPLORATION PLANS

SITE LOCATION and NEARBY GEOTECHNICAL DATA

ICPW Fire Training Tower ■ Iowa City, Iowa

July 6, 2018 ■ Terracon Project No. 06185072.01

Terracon GeoReport

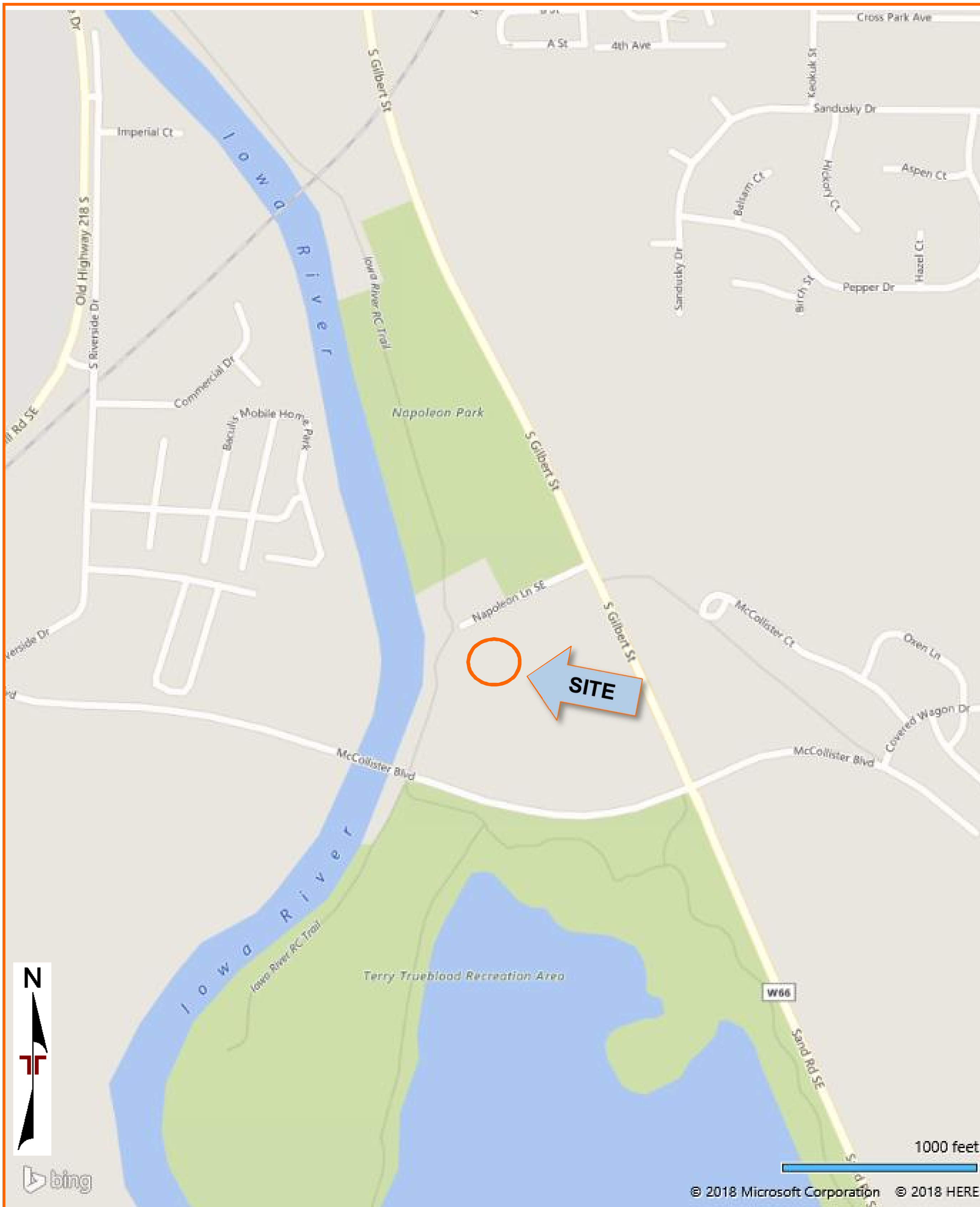
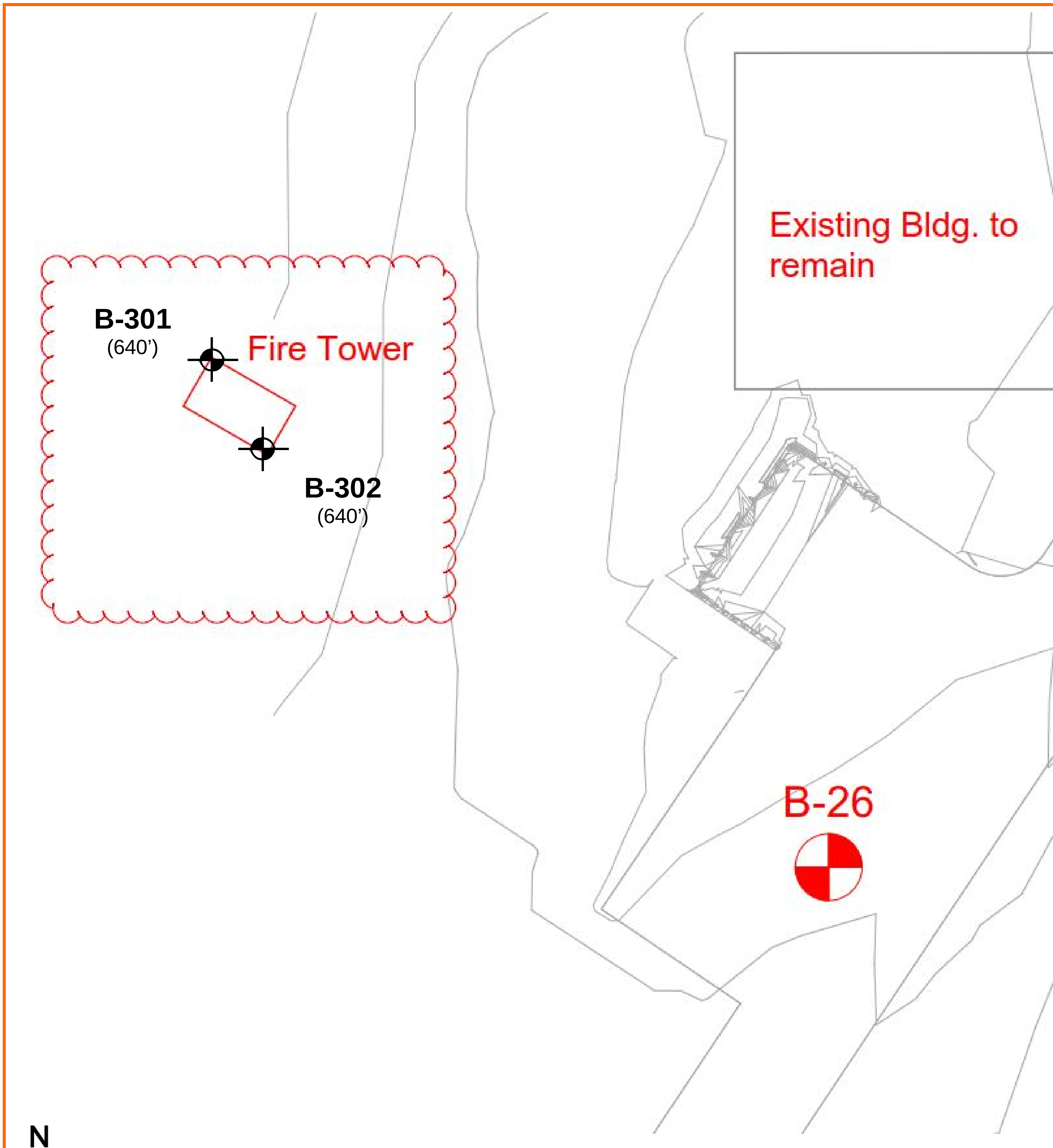


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

MAP PROVIDED BY MICROSOFT BING MAPS

EXPLORATION PLAN

ICPW Fire Training Tower ■ Iowa City, Iowa
July 6, 2018 ■ Terracon Project No. 06185072.01



LEGEND		
⊕	-	Fire Tower Boring Location and Elevation
◐	-	Existing Boring from Terracon Project No. 06995251

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

PLAN PROVIDED BY NEUMANN MONSON

EXPLORATION RESULTS

BORING LOG NO. B-301

PROJECT: ICPW Fire Training Tower

CLIENT: City of Iowa City
Iowa City, Iowa

SITE: Napoleon Lane SE
Iowa City, Iowa

ARCHITECT: Neumann Monson Architects

LOCATION See Exploration Plan

Latitude: 41.6295° Longitude: -91.531°

Approximate Surface Elev: 640 (Ft.) +/-

MODEL LAYER	DEPTH	DESCRIPTION	ELEVATION (Ft.)
1	0.3	4" Clayey Topsoil	639.5+/-
2	7.0	**LEAN CLAY (CL)**, trace sand and organics, dark brown, medium stiff	633+/-
4	22.0	**POORLY GRADED SAND (SP)**, trace silt and gravel, fine to coarse grained, brown and grayish-brown, medium dense loose below about 9 feet light gray and brown, very loose below about 12 feet medium dense below about 19 feet	618+/-
5	30.5	**SANDY LEAN CLAY (CL)**, trace gravel, occasional sand seams, dark gray, very stiff	609.5+/-

Boring Terminated at 30.5 Feet

DEPTH (Ft.) (approx.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY HP (tsf)	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI	ORGANIC CONTENT, %
2.5		X	9	1-2-3 N=5	0.75 (HP)	25	33-18-15	3.3
5		X	12	1-2-2 N=4	0.75 (HP)	22		
7.5		X	15	3-5-7 N=12	1.0 (HP)	15 4		
9	Wet cave-in							
10.5	▽	X	14	3-2-2 N=4		16		
15		X	8	1-1-1 N=2		18		
20		X	12	7-14-9 N=23		19		
25		X	14	3-7-9 N=16	4.0 (HP)	11		
30		X	15	3-7-8 N=15	4.0 (HP)	11		

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

Hammer Type: CME Automatic

Advancement Method:
Hollow Stem Auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Elevation from State of Iowa Lidar digital elevation model.

Notes:

WATER LEVEL OBSERVATIONS

- ▽ *10.5' while sampling*
- ▽ *9' after boring*
- *Wet cave-in at 9' after boring*

Terracon
2640 12th St SW
Cedar Rapids, IA

Boring Started: 05-31-2018	Boring Completed: 05-31-2018
Drill Rig: CME-850XR	Driller: SZ
Project No.: 06185072.01	

BORING LOG NO. B-302

PROJECT: ICPW Fire Training Tower

CLIENT: City of Iowa City
Iowa City, Iowa

SITE: Napoleon Lane SE
Iowa City, Iowa

ARCHITECT: Neumann Monson Architects

LOCATION See Exploration Plan

Latitude: 41.6295° Longitude: -91.5309°

Approximate Surface Elev: 640 (Ft.) +/-

MODEL LAYER	DEPTH	DESCRIPTION	ELEVATION (Ft.)
1	0.3	4" Sandy Topsoil	639.5+/-
3	6.0	**POORLY GRADED SAND WITH SILT (SP-SM)**, trace organics, fine to medium grained, brown and dark brown, loose	634+/-
4	22.0	**POORLY GRADED SAND (SP)**, trace silt and gravel, fine to coarse grained, brown and grayish-brown, loose very loose below about 9 feet light gray and brown, medium dense below about 17 feet	618+/-
5	30.5	**SANDY LEAN CLAY (CL)**, trace gravel, occasional sand seams, dark gray, very stiff	609.5+/-

Boring Terminated at 30.5 Feet

DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY HP (tsf)	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI	ORGANIC CONTENT, %
		X	12	2-2-2 N=4		5		
5		X	17	3-3-3 N=6		6		
		X	18	3-4-4 N=8		5		
10	▽ (9'), ▽ (10')	X	18	2-1-2 N=3		13		
15	Cave-in	X	13	1-1-2 N=3		16		
20		X	15	7-7-8 N=15		15		
25		X	17	6-8-9 N=17	3.0 (HP)	11		
30		X	18	7-8-9 N=17	3.0 (HP)	11		

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

Hammer Type: CME Automatic

Advancement Method:
Hollow Stem Auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Elevation from State of Iowa Lidar digital elevation model.

Notes:

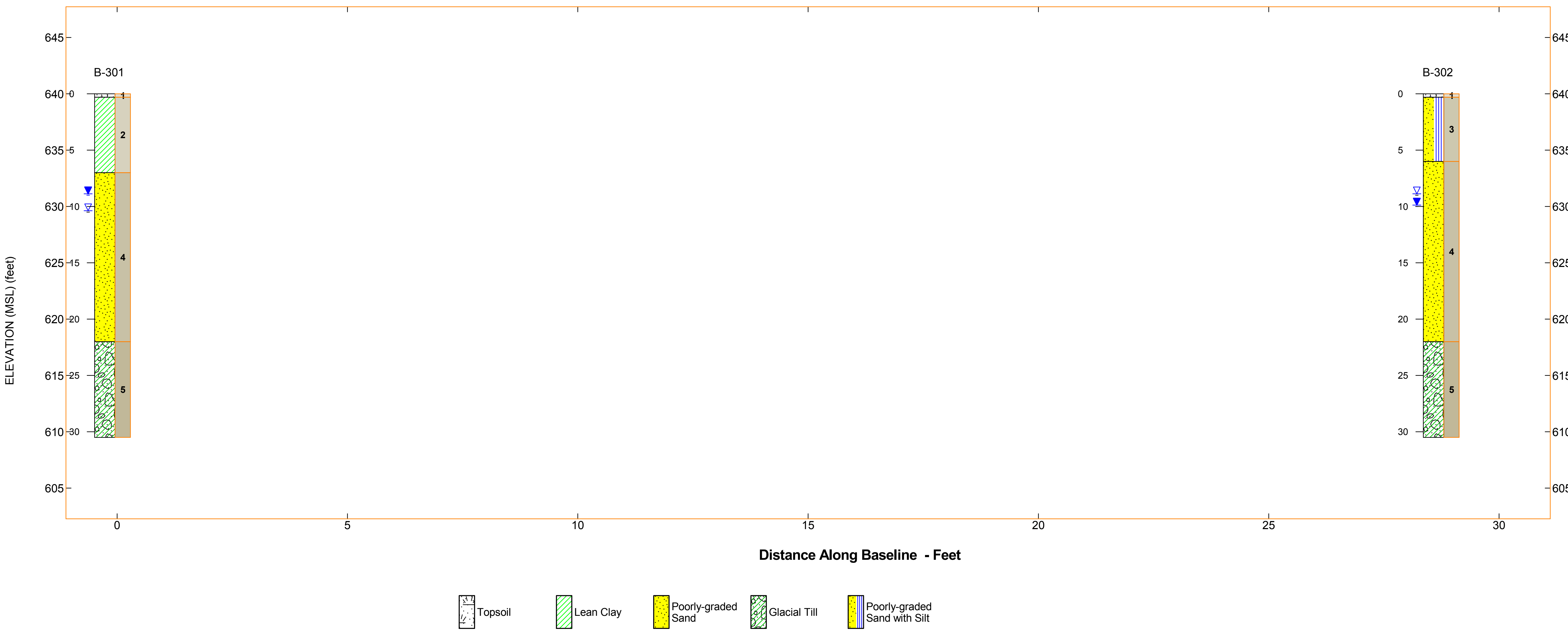
WATER LEVEL OBSERVATIONS

- *9' while sampling*
- *10' after boring*
- *Wet cave-in at 15' after boring*

Terracon
2640 12th St SW
Cedar Rapids, IA

Boring Started: 05-31-2018	Boring Completed: 05-31-2018
Drill Rig: CME-850XR	Driller: SZ
Project No.: 06185072.01	

GEOTECHNICAL MODEL
ICPW Fire Training Tower ■ Iowa City, Iowa
7/6/2018 ■Terracon Project No. 06185072.01



Model Layer	Termed	General Description
1	**Surficial**	Clayey or Sandy Topsoil
2	**Alluvial Clay**	LEAN CLAY (CL), trace sand and organics, medium stiff
3	**Upper Alluvial Sand**	POORLY GRADED SAND WITH SILT (SP-SM), trace organics, fine to medium grained, loose
4	**Lower Alluvial Sand**	POORLY GRADED SAND (SP), trace silt and gravel, fine to coarse grained, very loose to medium dense
5	**Glacial Till**	SANDY LEAN CLAY (CL), trace gravel, occasional sand seams, very stiff

NOTES:
See boring logs for more detailed conditions specific to each boring.
GeoModel provided for illustration purposes only. Actual subsurface conditions between borings will vary.

Layering shown on this figure has been developed by the geotechnical engineer for purposes of characterization of subsurface conditions as required for the subsequent geotechnical engineering for this project.

LEGEND
First Water Observation
Second Water Observation
Final Water Observation

Summary of Testing by Model Layer

ICPW Fire Training Tower ■ Iowa City, Iowa

7/6/2018 ■ Terracon Project No. 06185072.01

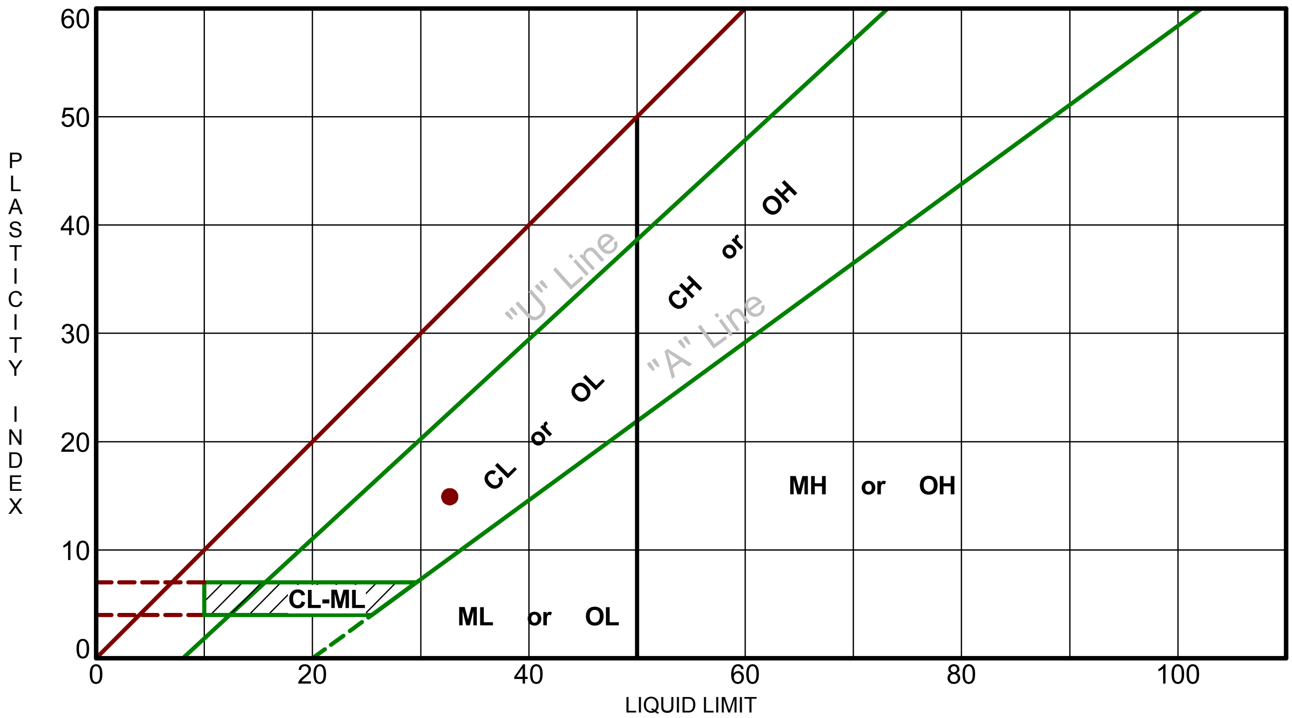
Terracon GeoReport

Model Layer Number	**02**	**03**	**04**	**05**
Description	**Alluvial Clay**	**Upper Alluvial Sand**	**Lower Alluvial Sand**	**Glacial Till**
N-Value (blows/ft)				
Number of Tests	2	2	8	4
Average	5	5	8	16
Maximum (1)	5	6	15	17
Minimum	4	4	2	15
Std. Deviation	1	1	5	1
Shear Strength (psf)				
Number of Tests	0	0	0	0
Average				
Maximum				
Minimum				
Std. Deviation				
Moisture Content (%)				
Number of Tests	2	2	9	4
Average	24	5	13	11
Maximum	25	6	19	11
Minimum	22	5	4	11
Std. Deviation	2	1	5	0
Dry Density (pcf)				
Number of Tests	0	0	0	0
Average				
Maximum				
Minimum				
Std. Deviation				
Liquid Limit, LL				
Number of Tests	1	0	0	0
Average	33			
Maximum	33			
Minimum	33			
Std. Deviation	N/A			
Plastic Limit, PL				
Number of Tests	1	0	0	0
Average	18			
Maximum	18			
Minimum	18			
Std. Deviation	N/A			
Plasticity Index, PI				
Number of Tests	1	0	0	0
Average	15			
Maximum	15			
Minimum	15			
Std. Deviation	N/A			
% Fines				
Number of Tests	0	0	0	0
Average				
Maximum				
Minimum				
Std. Deviation				

Note: The statistical summary of field and laboratory data are derived from the data collected for this investigation, and individual data can be found on the individual soil boring logs included in this section.
The model layers as listed above are consistent with the model layers illustrated on the **Geotechnical Model**.

ATTERBERG LIMITS RESULTS

ASTM D4318



	Boring ID	Depth	LL	PL	PI	Fines	USCS	Description
●	B-301	1.5 - 3	33	18	15		CL	Lean Clay

PROJECT: ICPW Fire Training Tower

SITE: Napoleon Lane SE
Iowa City, Iowa

Terracon
2640 12th St SW
Cedar Rapids, IA

PROJECT NUMBER: 06185072.01

CLIENT: City of Iowa City
Iowa City, Iowa

SUPPORTING INFORMATION

GENERAL NOTES

DESCRIPTION OF SYMBOLS AND ABBREVIATIONS

ICPW Fire Training Tower ■ Iowa City, Iowa

7/6/2018 ■ Terracon Project No. 06185072.01

Terracon GeoReport

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

DESCRIPTIVE SOIL CLASSIFICATION

Soil classification is based on the Unified Soil Classification System. Coarse Grained Soils have more than 50% of their dry weight retained on a #200 sieve; their principal descriptors are: boulders, cobbles, gravel or sand. Fine Grained Soils have less than 50% of their dry weight retained on a #200 sieve; they are principally described as clays if they are plastic, and silts if they are slightly plastic or non-plastic. Major constituents may be added as modifiers and minor constituents may be added according to the relative proportions based on grain size. In addition to gradation, coarse-grained soils are defined on the basis of their in-place relative density and fine-grained soils on the basis of their consistency.

LOCATION AND ELEVATION NOTES

Unless otherwise noted, Latitude and Longitude are approximately determined using a hand-held GPS device. The accuracy of such devices is variable. Surface elevation data annotated with +/- indicates that no actual topographical survey was conducted to confirm the surface elevation. Instead, the surface elevation was approximately determined from topographic maps of the area.

STRENGTH TERMS

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

RELATIVE PROPORTIONS OF SAND AND GRAVEL		RELATIVE PROPORTIONS OF FINES	
Descriptive Term(s) of other constituents	Percent of Dry Weight	**Descriptive Term(s) of other constituents**	**Percent of Dry Weight**
Trace	<15	Trace	<5
With	15-29	With	5-12
Modifier	>30	Modifier	>12

GRAIN SIZE TERMINOLOGY		PLASTICITY DESCRIPTION	
Major Component of Sample	**Particle Size**	**Term**	**Plasticity Index**
Boulders	Over 12 in. (300 mm)	Non-plastic	0
Cobbles	12 in. to 3 in. (300mm to 75mm)	Low	1 - 10
Gravel	3 in. to #4 sieve (75mm to 4.75 mm)	Medium	11 - 30
Sand	#4 to #200 sieve (4.75mm to 0.075mm	High	> 30
Silt or Clay	Passing #200 sieve (0.075mm)		

UNIFIED SOIL CLASSIFICATION SYSTEM

ICPW Fire Training Tower ■ Iowa City, Iowa

July 6, 2018 ■ Terracon Project No. 06185072.01

Terracon GeoReport

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests [A]				Soil Classification: Group Symbol	Soil Classification: Group Name [B]
Coarse-Grained Soils: More than 50% retained on No. 200 sieve	**Gravels:** More than 50% of coarse fraction retained on No. 4 sieve	**Clean Gravels:** Less than 5% fines [C]	Cu ³ 4 and 1 £ Cc £ 3 [E]	GW	Well-graded gravel [F]
			Cu < 4 and/or 1 > Cc > 3 [E]	GP	Poorly graded gravel [F]
		Gravels with Fines: More than 12% fines [C]	Fines classify as ML or MH	GM	Silty gravel [F, G, H]
			Fines classify as CL or CH	GC	Clayey gravel [F, G, H]
	Sands: 50% or more of coarse fraction passes No. 4 sieve	**Clean Sands:** Less than 5% fines [D]	Cu ³ 6 and 1 £ Cc £ 3 [E]	SW	Well-graded sand [I]
			Cu < 6 and/or 1 > Cc > 3 [E]	SP	Poorly graded sand [I]
		Sands with Fines: More than 12% fines [D]	Fines classify as ML or MH	SM	Silty sand [G, H, I]
			Fines classify as CL or CH	SC	Clayey sand [G, H, I]
Fine-Grained Soils: 50% or more passes the No. 200 sieve	**Silts and Clays:** Liquid limit less than 50	**Inorganic:**	PI > 7 and plots on or above "A"	CL	Lean clay [K, L, M]
			PI < 4 or plots below "A" line [J]	ML	Silt [K, L, M]
		Organic:	Liquid limit - oven dried / Liquid limit - not dried < 0.75	OL	Organic clay [K, L, M, N]
					Organic silt [K, L, M, O]
	Silts and Clays: Liquid limit 50 or more	**Inorganic:**	PI plots on or above "A" line	CH	Fat clay [K, L, M]
			PI plots below "A" line	MH	Elastic Silt [K, L, M]
		Organic:	Liquid limit - oven dried / Liquid limit - not dried < 0.75	OH	Organic clay [K, L, M, P]
					Organic silt [K, L, M, Q]
Highly organic soils:	Primarily organic matter, dark in color, and organic odor			PT	Peat

[A] Based on the material passing the 3-inch (75-mm) sieve

[B] If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.

[C] Gravels with 5 to 12% fines require dual symbols: GW-GM well-graded gravel with silt, GW-GC well-graded gravel with clay, GP-GM poorly graded gravel with silt, GP-GC poorly graded gravel with clay.

[D] Sands with 5 to 12% fines require dual symbols: SW-SM well-graded sand with silt, SW-SC well-graded sand with clay, SP-SM poorly graded sand with silt, SP-SC poorly graded sand with clay

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

[F] If soil contains ³ 15% sand, add "with sand" to group name.

[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

[H] If fines are organic, add "with organic fines" to group name.

[I] If soil contains ³ 15% gravel, add "with gravel" to group name.

[J] If Atterberg limits plot in shaded area, soil is a CL-ML, silty clay.

[K] If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel," whichever is predominant.

[L] If soil contains ³ 30% plus No. 200 predominantly sand, add "sandy" to group name.

[M] If soil contains ³ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.

[N] PI ³ 4 and plots on or above "A" line.

[O] PI < 4 or plots below "A" line.

[P] PI plots on or above "A" line.

[Q] PI plots below "A" line.