Geotechnical Engineering Report

Proposed Lift Station
South Maple Street, SE of South 4th Street
West Branch, Iowa

November 15, 2012
Terracon Project No. 06125641.01

Prepared for:
City of West Branch
West Branch, Iowa

Prepared by:
Terracon Consultants, Inc.
Iowa City, Iowa

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Geotechnical ■ Environmental ■ Construction Materials ■ Facilities

November 15, 2012

Terracon

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Re: Geotechnical Engineering Report
Proposed Lift Station
S. Maple Street, SE of S. 4th Street
West Branch, Iowa
Terracon Project No. 06125641.01

Dear Mr. Muckler:

Terracon Consultants, Inc. (Terracon) has completed the subsurface exploration and geotechnical engineering services for the above referenced project. These services were performed in general accordance with our proposal number P06120450R2 dated September 11, 2012. This geotechnical engineering report presents the results of the subsurface exploration and provides geotechnical recommendations concerning earthwork and the design and construction of foundations for the proposed lift station.

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.

Justin D. Widdel, P.E.
Iowa No. 20495

FOR Jason P. Heinz, P.E.
Senior Geotechnical Engineer

JDW/AMG: N:\Projects\2012\06125641\PROJECT DOCUMENTS (Reports-Letters-Drafts to Clients)\06125641.01.docx

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1 – Veenstra and Kimm, Inc; Attn: Mr. Dave Schechinger, P.E. (dschechinger@v-k.net)

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EXECUTIVE SUMMARY

A geotechnical exploration has been performed for a proposed Lift Station planned to be located at the end of S. Maple Street, southeast of South 4th Street in West Branch, Iowa. Terracon's geotechnical scope of work included the advancement of one (1) boring to an approximate depth of 50½ feet below the existing site grade.

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

- Existing fill was encountered in the boring to a depth of about 6½ feet below the existing grade and covered buried partly organic soil to a depth of about 7 feet. These materials are unsuitable for foundation support. As such, some overexcavation and backfill should be anticipated below the new Valve Pit and Meter Manhole #1. Due to the proximity of Valve Pit #2 with Lift Station #2, consideration should be given to performing the overexcavation of the existing fill below the valve pit during the excavation for the lift station.

- Due to relatively shallow groundwater and the planned foundation excavation depth, proper dewatering measures will be required during construction. Sheeting, shoring, and/or flatter than normal side slopes along with dewatering should be anticipated for the excavation. It should be noted that dewatering will increase effective soil stresses, and this can contribute to settlement of the adjacent structures.

- If the lift station is emptied for maintenance, it should be designed to resist hydrostatic uplift forces. This could be accomplished using the effective weight of the structure and overburden soils. Alternatively, the groundwater could be lowered below the foundation level using perimeter dewatering wells prior to emptying the lift station.

- The proposed lift station can be supported on a mat foundation as planned, following the removal of low-strength native soil, and the placement of a layer of granular fill over suitable, native soil.

- Earthwork on the project should be observed and evaluated by Terracon. The evaluation of earthwork should include observation and testing of engineered fill, subgrade preparation, foundation bearing materials, and other geotechnical conditions exposed during construction.

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

GEOTECHNICAL ENGINEERING REPORT
PROPOSED LIFT STATION
SOUTH MAPLE STREET, SE OF SOUTH 4TH STREET
WEST BRANCH, IOWA

Terracon Project No. 06125641.01
November 15, 2012

1.0 INTRODUCTION

This report presents the results of the subsurface exploration and geotechnical engineering services performed for a Lift Station planned to be located at the end of S. Maple Street, southeast of S. 4th Street in West Branch, Iowa. The purpose of these services is to provide information and geotechnical engineering recommendations relative to:

- subsurface soil conditions
- foundation design and construction
- earthwork
- lateral earth pressures
- groundwater conditions
- estimated seismic site class
- construction considerations

The geotechnical scope of work for this project included the advancement of one (1) test boring to a depth of about 50½ feet below the existing grade in the area of the proposed lift station.

A Site Location Plan (Exhibit A-1), a Boring Location Plan (Exhibit A-2), and a boring log (Exhibit A-3) are included in Appendix A of this report. The results of the laboratory testing performed on portions of recovered soil samples are included on the boring log and/or in Appendix B of this report. Descriptions of the field exploration and laboratory testing are included in their respective appendices.

2.0 PROJECT INFORMATION

2.1 Project Description

Item	Description
Site layout	■ Refer to the Boring Location Plan Exhibit A-2, in Appendix A

Item	Description
Structures (per DWG. No. 16, and updated grading information provided on November 14, 2012)	■ Lift station o Top of cover slab elevation of 711 feet o Bottom of foundation elevation at 683.33 feet o Maximum water level elevation of about 690.58 feet o Minimum water level elevation of about 685.08 feet o Diameter of approximately 15 feet ■ Valve Pit #2 o Top of cover slab elevation of 711 feet o Bottom of foundation elevation at 705.17 feet o Dimensions of 11'8" by 9'8" ■ Meter Manholes #1 and #2 o Top of cover slab elevation of 711 feet o Bottom of foundation elevation at 705.17 feet o Sump pump elevation at 703 feet o Diameter of approximately 60 inches
Structure construction (per DWG. No. 16, provided on November 8, 2012)	■ Lift station o Precast concrete structure with reinforced cast-in-place (CIP) concrete foundation and cover slab ■ Valve Pit #2 o CIP reinforced concrete ■ Meter Manhole #1 and #2 o Precast concrete with CIP reinforced concrete foundation
Maximum loads (assumed)	■ Lift station o Walls: 5 klf ■ Valve Pit #2 o Walls: 2 klf ■ Meter Manholes #1 and #2 o Walls: 2 klf
Grading (per updated Site Plan provided on November 14, 2012)	■ Fills of about 1 to 2 feet are planned to establish final grades for the lift station
Cut and fill slopes (provided)	■ Approximately 3H:1V (Horizontal to Vertical)
Free-standing retaining walls (provided)	■ None planned for site development
Below grade areas (provided)	■ Lift station #2 ■ Valve pit #1 ■ Manholes
Pavements (provided)	■ New access drive with aggregate surfacing

2.2 Site Location and Description

Item	Description
Location	West Branch, Iowa: ■ SE of S. Maple Street and S. 4th Street
Existing site features	■ Access drive ■ Existing Lift Station #1 and associated valve pit and manholes ■ Buried water, electrical, and sewer lines
Site topography (per Site Plan dated February 20, 2012)	■ Approximately 5 feet of elevation change across the site
Current ground cover	■ Aggregate surfacing ■ Grass ■ Small trees

3.0 SUBSURFACE CONDITIONS

3.1 Typical Subsurface Profile

Specific conditions encountered at the boring location are indicated on the attached boring log. Stratification boundaries on the boring log represent the approximate location of changes in material types. In-situ, the transition between materials may be gradual or abrupt horizontally and vertically. Based on the results of the boring, subsurface conditions on the project site can be generalized as follows:

Description	Approximate Depth to Bottom of Stratum	Material Encountered	Consistency/Density
Surficial	8 inches	Crushed stone (gravel access road)	N/A
Stratum 1	6½ feet	Fill – Clayey sand and Lean clay	N/A
Stratum 2	7 feet	Lean to fat clay (possible buried topsoil)	N/A
Stratum 3	9 feet	Fat clay, trace sand	Medium stiff
Stratum 4[1]	19 feet	Lean clay, trace sand and organics	Soft to medium stiff
Stratum 5[1]	32 feet	Silty clay, trace sand and organics	Very soft to medium stiff
Stratum 6[1]	43 feet	Silty clay, trace sand and organics	Medium stiff to stiff

Description	Approximate Depth to Bottom of Stratum	Material Encountered	Consistency/Density
Stratum 7[1]	50½ feet[2]	Fine to coarse sand with varying amounts of sand and organics, trace gravel	Medium dense

1. Alluvial deposits
2. Boring termination depth

Please review the boring log in Appendix A of this report for more detailed descriptions of the conditions encountered in the boring.

3.2 Groundwater Conditions

The boring was observed for the presence and level of groundwater during drilling and sampling. Drilling fluid was used to advance the boring below a depth of about 9 feet and precluded further observations during drilling. A temporary groundwater observation well was installed in the borehole to a depth of about 41 feet below the existing grade. The water level observations are provided below.

WATER LEVEL OBSERVATIONS	
WD/WS (feet)	8
DW (feet)	9½

WD: While Drilling, WS: While Sampling, DW: Delayed water level observation performed on November 8, 2012 (in observation well)

Fluctuations of the groundwater level will occur due to seasonal variations in the amount of rainfall, runoff and other factors not evident at the time the boring was performed. Therefore, groundwater levels during construction or at other times during the lives of the structures may be different than the levels indicated on the boring log. Also, groundwater can be trapped or "perched" within variable existing fill and granular materials within or above lower permeability soil. The possibility of groundwater level fluctuations and perched water should be considered when developing the design and construction plans for the project. The observation well was left in-place so that additional water level observations can be made prior to and during construction. Terracon can provide additional delayed water level observations upon request.

4.0 RECOMMENDATIONS FOR DESIGN AND CONSTRUCTION

4.1 Geotechnical Considerations

Based on the results of the subsurface exploration, laboratory testing and our evaluation, it is our opinion that the proposed lift station and ancillary improvements can be supported on mat foundations with limitations. Special design and construction considerations will be required for this project due to:

- The presence of variable existing fill, lower strength soils, and buried partly organic soil;
- The presence of shallow groundwater;
- Settlement resulting from the placement of new fill;
- The presence of existing improvements (also refer to section 4.2.2).

Existing fill was encountered in the boring to a depth of about 6½ feet below the existing grade; corresponding to approximate elevation 702 feet. The existing fill was underlain by possible buried topsoil to a depth of about 7 feet below the existing grade. Below these materials, lower strength fat clay and silty clay was encountered to a depth of about 31 feet below the existing grade; corresponding to approximate elevation 677.5 feet. Based on the structural drawings provided, the base of the lift station will bear below the existing fill. However, it appears that the excavations planned for the valve pit and manholes to about elevations 705.2 feet, will not extend below the existing fill. It should be noted that the soil boring was performed in the area of the lift station and subsurface conditions could vary in the areas of the valve pit and manhole. The presence of variable existing fill, buried partly organic soil, and lower strength soils will affect earthwork and foundation construction for this project. Foundations for relatively light, new improvements could be supported within the existing fill; however, the owner would need to accept the risk of greater than normal settlement and costs associated with repair and/or maintenance. Please refer to section 4.3 Foundation Recommendations, for commentary regarding the risks associated with support of new improvements within variable existing fill.

We anticipate that the lift station will extend about 27 feet below the existing grade and the valve pit and manholes will extend about 3½ feet below existing grades. Based on the water level encountered in the boring, we anticipate that the lift station excavation will extend below the groundwater level, and the ancillary structures may extend near or below the groundwater level. Therefore, we anticipate that a groundwater control system and an earth retention system will be required to facilitate construction. Recommendations for the design and construction of these systems are beyond the scope of this report and are typically provided by the contractor(s) involved in the construction. It should be noted that lowering a groundwater level increases the effective stress of soils, and can contribute to settlement. Special design and construction considerations will therefore be required for this project due to the proximity of existing improvements.

The placement of new fill to establish design grades will cause settlement of the existing fill and lower strength soils. The amount of settlement will vary due to the varying fill thicknesses planned. Portions of the settlement will occur during and after fill placement. The construction schedule should account for the anticipated amount of time required to allow the majority of settlement to occur prior to foundation construction. Consideration should also be given to the effect settlement resulting from new fill placement would have on existing improvements that are planned to remain in place. Additional commentary and recommendations regarding new fill placement and settlement monitoring are provided in sections **4.2 Earthwork** and **4.2.2 Settlement Monitoring**.

4.2 Earthwork

4.2.1 Site Preparation

Topsoil, vegetation, existing fill, and any otherwise unsuitable materials should be removed from the construction areas. Wet or dry material should either be removed or moisture conditioned and recompacted. Soft, dry and/or low density soil should be removed or compacted in place prior to placing new fill.

After rough grade has been established, the exposed subgrade should be proofrolled by the contractor and test probed by Terracon. Proofrolling could be accomplished by using a tandem axle dump truck (gross weight of 20 tons) in clay subgrade areas, or a vibratory drum roller (gross weight of 10 tons or more) in granular subgrade areas. This surficial proofroll would help to provide a stable base for the compaction of new structural fill, and delineate low density, soft, or disturbed areas that may exist below subgrade level. In addition, we recommend the subgrade be scarified and recompacted to at least 95 percent of the material's maximum dry density (ASTM D698). Soft or loose areas should be undercut and replaced with approved structural fill, or moisture conditioned and recompacted. Subgrade conditions should be observed by Terracon personnel during construction.

4.2.2 Settlement Monitoring

Based on the subsurface conditions at the boring location, and the proposed fill thicknesses, settlement within the underlying clay soils from the weight of 1 to 2 feet of new fill is estimated to be 2 to 3 inches. It should be noted that the estimated settlement will occur in the underlying soil supporting the existing structures and utilities. We understand that fill thicknesses of about 6 feet are planned on the east side of the site for a generator pad and a building. Assuming similar soil conditions, we estimate settlement within the underlying clay soils from the weight of the new fill to be as much as 12 inches.

We recommend that a settlement monitoring program be implemented to monitor the amount and rate of settlement. We recommend that at least 3 settlement monitoring points be installed. The settlement monuments should be installed within or near the top of the permanent fill and should consist of a steel bar driven into the ground. Care should be taken not to disturb the points during

surcharge fill placement. A settlement monitoring point that is damaged or disturbed should be repaired or replaced immediately.

The elevations of the settlement points should be monitored in general accordance with the following schedule:

Item	Value
Three to Four Weeks Following Completion of Fill Placement	Two times per week
Beyond Four weeks following completion of placement	One time per week

Precise elevation data will be necessary for accurate settlement analyses, and surveying services should be obtained accordingly. The monitoring data should be submitted to Terracon for analysis and evaluation of when construction may proceed. A settlement period in the range of about 4 to 6 weeks is estimated. These are only estimates based on our experience with projects of this type, the soil conditions observed, and the test results. Other factors affecting the effective drainage path and permeability of the soils may reduce or increase the time for the settlement to occur. Monitoring settlement will allow this to be observed and potentially allowing construction to begin at an earlier date than anticipated. We anticipate that at least three weeks of settlement data will be required before we can begin evaluation of eventual total settlements and refinement of our estimates for a final settlement time frame.

4.2.3 Fill Types and Compaction

We understand that maximum fill thicknesses of 2 feet are planned to establish final design grades in the areas of the lift station, manholes, and valve pit. We understand the purpose of the new fill is to raise the site above the 100 year flood level. In general, the on-site existing fill and native soils appear suitable for use as site grading fill. However, based on the moisture contents of the in-situ soil/material, significant moisture conditioning should be expected if the on-site soils stockpiled from the excavations will be used as fill. If grading occurs during cold weather, use of the existing soil/materials may not be practical because the soil/material is susceptible to frost. Requirements for non-structural fill (i.e. fill that will not support pavements, slabs, foundations, etc.) and structural fill are provided in the following table.

Fill Type [1]	USCS Classification	Acceptable Location for Placement
Cohesive	CL, CH, CL/ML (LL ≤ 45 and PI ≤ 23)	Non-structural locations, general site grading fill
Low Plasticity Cohesive [2]	CL, CL/ML	Wall backfill
Granular [3, 4]	GW, GP, GM, GC SW, SP, SM, SC	Below structure foundations and wall backfill

Fill Type [1]	USCS Classification	Acceptable Location for Placement
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. The use of fine-grained soil for wall backfill should be approved by the designer prior to its delivery, placement, and/or use for this project. Proper compaction in confined areas may be difficult. The effects of the future settlement of fine-grained backfill should be considered. 3. A well-graded, granular material with 10% or less fines (material passing the #200 sieve) is recommended immediately below the lift station foundation. 4. Use of a self-compacting backfill or controlled low-strength material (CLSM) could also be given consideration below the lift station foundation and for wall backfill.		

Care should be taken to avoid inter-layering of granular soils and clay soils during fill placement. This could result in perched water conditions and lead to development of frost lenses and loss of subgrade strength both during and after construction.

4.2.4 Compaction Requirements

Moisture conditioning (e.g. drying of clays) of the on-site soil/material will be required if used as fill. Appropriate laboratory tests, including Atterberg Limits for cohesive soils, organic content tests for dark colored soils, and standard Proctor (ASTM D698) moisture-density relationship tests should be performed on proposed fill materials prior to their use as fill. Organic content tests should be performed on dark colored soils and/or those that exhibit a noticeable odor. Further evaluation of any on-site soils or off-site fill materials should be performed by Terracon prior to their use in compacted fill sections.

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

Material Type and Location	Per the Standard Proctor Test (ASTM D698)		
	Minimum Compaction Requirement (%)[1]	Range of Moisture Contents for Compaction[1]	
		Minimum	Maximum
Cohesive			
Site grading in green space	90	-2%	+4%
Below gravel access road	95	-2%	+3%
Wall backfill	98	-2%	+3%
Granular[2,3]			
Below foundations	98	-3%	+3%

Material Type and Location	Per the Standard Proctor Test (ASTM D698)		
	Minimum Compaction Requirement (%)[1]	Range of Moisture Contents for Compaction[1]	
		Minimum	Maximum
Wall backfill	98	-3%	+3%

1. We recommend that structural fill be tested for moisture content and compaction during placement. Should the results of the in-place density tests indicate the specified moisture or compaction limits have not been met, the area represented by the test should be reworked and retested as required until the specified moisture and compaction requirements are achieved.
2. If the granular material is a coarse sand or gravel, is 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 D4253 and D4254).

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

4.2.5 Grading and Drainage

Final surrounding grades should be sloped away from structures on all sides. Trees or other vegetation whose root systems have the ability to remove excessive moisture from the subgrade and foundation soils should not be planted next to the structures. Trees and shrubbery should be kept away from the exterior edges of the foundation element a distance at least equal to 1½ times their expected mature height.

4.2.6 Pipe Bedding

Care should be taken so that the soils at the base of excavations are not disturbed during construction. Disturbed or unstable materials should be removed before placing any granular bedding material. Where groundwater, lower strength soils, and unstable conditions are encountered, a greater thickness of bedding material should be provided. The thickness of the required bedding material will probably vary and should be evaluated at the time of construction. The bedding material should satisfy the requirements of the pipe manufacturer.

4.3 Foundation Recommendations

Due to the risks associated with support of structures on variable, existing fill and partly organic soil, we recommend the manhole and valve pit foundations extend through the existing fill and bear either directly on suitable, native soil or on new structural fill following the overexcavation and backfill procedure discussed later in this report. As an alternative to removal of the fill, consideration could be given to supporting the ancillary structures on intermediate foundations

(i.e. helical piers/anchors) that extend through the fill to suitable native bearing materials. Foundation recommendations are provided below. Additional foundation recommendations for these structures can be provided upon request.

4.3.1 Foundation Design Recommendations

DESCRIPTION	VALUE
Support System	■ A minimum of 2 feet of well-graded crushed stone, lean concrete, or CLSM, over suitable, native soil
Structures	■ Lift station ■ Valve Pit ■ Manholes
Foundation Types	■ Mat foundation
Bearing Material	■ Minimum 2 feet of crushed stone over native clays
Net Allowable Bearing Pressure	■ 2,000 psf
Frost Depth	■ 48 inches
Total Estimated Settlement [1]	■ 1 inch
Estimated Differential Settlement [1]	■ 2/3 of total settlement

1. The above settlement estimates also consider that where new fill is placed, adequate time is allowed for consolidation and monitoring of the fill and underlying native soils prior to foundation construction.

The net allowable soil bearing pressure is the pressure in excess of the minimum surrounding overburden pressure at footing base elevation. Finished grade is defined as the lowest adjacent grade within five feet of the foundation for perimeter (or exterior) footings and finished floor level for interior footings. The allowable foundation bearing pressures apply to dead loads plus design live load conditions. The foundation settlement will depend on the variations within the subsurface profile, the structural loading conditions, the rigidity of the foundation, and the quality of construction operations. Foundations placed within variable, existing fill could experience greater total and differential settlement than estimated and may not be predictable. 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.

The uplift resistance of foundations can be developed from the effective weight of the foundation and the weight of soil overlying the foundation. The maximum allowable uplift capacity should be taken as a sum of the effective weight of the foundation and overlying soil, divided by an appropriate factor of safety. Maximum unit weights of 120 pcf and 60 pcf could be used for well-compacted backfill above and below the designed groundwater level, respectively.

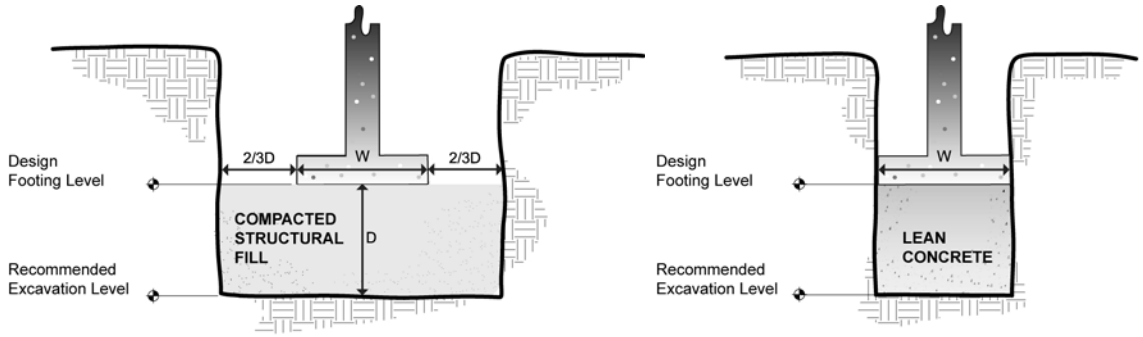
4.3.2 Foundation Construction Considerations

Based on the results of the boring, we anticipate that the soils at the anticipated depth of excavation will be suitable for support of the lift station; provided proper groundwater control is

maintained throughout construction. Groundwater seepage into the lift station excavation should be anticipated for this project. It should be noted that, if proper dewatering procedures are not performed during construction, the density and support capability of any previously suitable soil/material could be affected and subsequently contribute to higher than anticipated settlement of the proposed structure and adjacent improvements.

If unsuitable bearing or disturbed soil is encountered in the foundation excavation, the excavation should be extended deeper to suitable soil and the foundation could bear directly on soil at the lower level or on lean concrete or CLSM placed in the excavation. The foundation could also bear on properly compacted granular fill extending down to suitable soil. Overexcavation for compacted backfill placement below the foundation should extend laterally beyond all edges of the foundation at least 8 inches per foot of overexcavation depth below the 'design footing level'.

The excavation below the foundation should be backfilled up to the 'design footing level' with well-graded granular material placed and compacted as recommended in section 4.2.4 Compaction Requirements. Lateral widening is not required for overexcavation backfilled with lean concrete or CLSM. The overexcavation and backfill procedures are illustrated in the following figures.



Overexcavation / Backfill

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

Lean Concrete 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 and loose or soft soils prior to placement of reinforcing steel and concrete. Groundwater should be lowered and controlled as previously discussed. Should the materials at the bearing level become disturbed, the affected materials should be stabilized or removed prior to placement of reinforcing steel and concrete. Concrete should be placed as soon as possible after excavating to minimize disturbance of bearing soils.

All excavations should comply with the requirements of OSHA 29CFR, Part 1926, Subpart P, "Excavations" and its appendices, as well as other applicable codes. This document states that the excavation safety is the responsibility of the contractor. Reference to this OSHA requirement

should be included in the project specifications. Slope heights, slope inclinations and/or excavation depths should in no case exceed those specified in local, state or federal safety regulations, including current OSHA excavation and trench safety standards. We understand excavation to about 27 feet below the existing grade will be required for the lift station construction. According to OSHA regulations, side slopes and/or bracing must be designed by a professional engineer for any excavations extending to a depth greater than 20 feet. Where variable fill and/or groundwater is present, flatter slopes than those required by OSHA could be required to maintain the stability of the excavation(s). It should be noted that the subsurface soil types may vary beyond the boring location.

4.4 Seismic Considerations

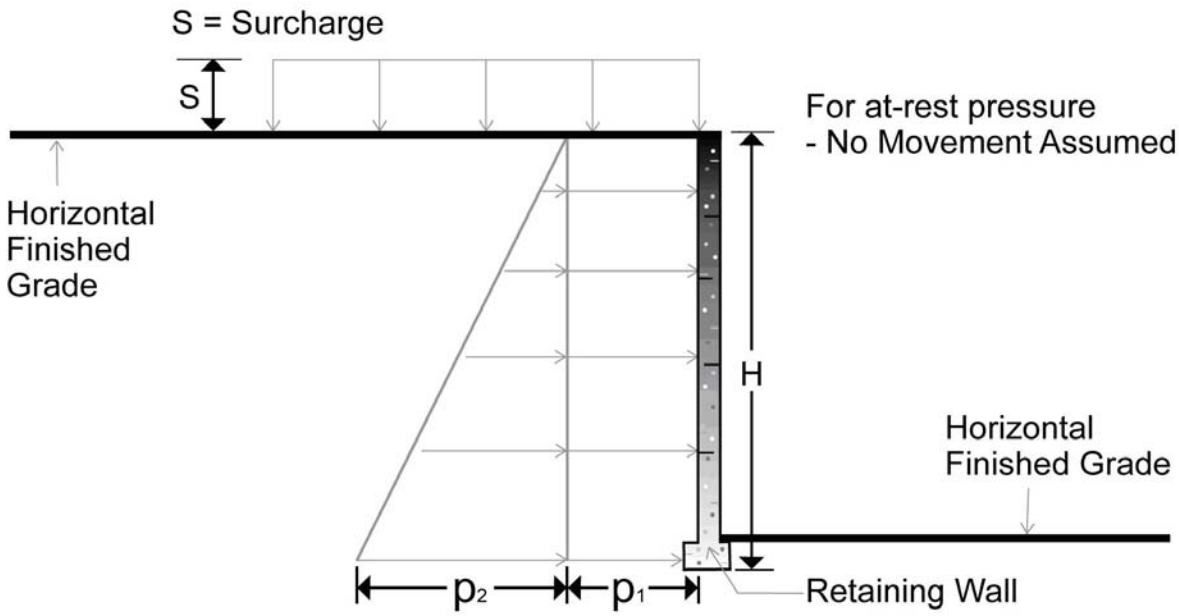
DESCRIPTION	VALUE
2009 International Building Code Site Classification (IBC) [1]	D[2]

[1] Note: In general accordance with the *2009 International Building Code,* Table 1613.5.2. IBC Site Class is based on the average characteristics of the upper 100 feet of the subsurface profile.

[2] Note: The 2009 International Building Code (IBC) requires a site soil profile determination extending to a depth of 100 feet for seismic site classification. The current scope does not include the required 100 foot soil profile determination. Borings extended to a maximum depth of 50½ feet, and this seismic site class definition considers that the alluvial deposits continue below the maximum depth of the subsurface exploration. Additional exploration to deeper depths, or seismic velocity testing would be required to confirm the conditions below the current depth of exploration.

4.5 Lateral Earth Pressures

Reinforced concrete, below-grade walls of the lift station, manholes, and valve pit, subjected to unbalanced earth pressures should be designed for at-rest earth pressures at least equal to those indicated in Table 1 or Table 2. Earth pressures will be influenced by structural design of the walls, conditions of wall restraint, methods of construction and/or compaction and the strength of the materials being restrained. The at-rest condition should be used where no wall movement is permitted. The recommended design lateral earth pressures do not include a factor of safety or surcharge loadings.



EARTH PRESSURE COEFFICIENTS

TABLE 1 – AT-REST EARTH PRESSURE COEFFICIENTS (Above groundwater level)

Earth Pressure Condition	Coefficient for Backfill Type	Equivalent Fluid Pressure (pcf)	Surcharge Pressure P_1 (pcf)	Earth Pressure P_2 (psf)
At-Rest	Relatively Clean, Well-graded stone – 0.44	53	(0.44)S	(53)H
(Ko)	Lean Clay or Silty Clay – 0.59	71	(0.59)S	(71)H

TABLE 2 - AT-REST EARTH PRESSURE COEFFICIENTS (Below groundwater level)

Earth Pressure Condition	Coefficient for Backfill Type	Equivalent Fluid Pressure (pcf)	Surcharge Pressure P_1 (pcf)	Earth Pressure P_2 (psf)
At-Rest	Relatively Clean, Well-graded stone – 0.44	85	(0.44)S	(85)H
(Ko)	Lean Clay or Silty Clay – 0.59	96	(0.59)S	(96)H

TABLE 3 – PASSIVE EARTH PRESSURE COEFFICIENTS

Earth Pressure Condition	Coefficient for Backfill Type	Equivalent Fluid Pressure (pcf)	Surcharge Pressure P_1 (pcf)	Earth Pressure P_2 (psf)
Passive (Kp)	Relatively Clean, Well-graded stone – 3.54	425	- -	- -
	Lean Clay or Silty Clay – 2.37	285	- -	- -
			- -	- -

Applicable conditions to the preceding include:

- For passive earth pressure to develop, wall must move horizontally to mobilize resistance
- Uniform surcharge, where S is surcharge pressure
- In-situ soil backfill weight a maximum of 120 pcf
- Horizontal backfill, compacted to 98 percent of the maximum dry density per ASTM D698
- Loading from heavy compaction equipment not included
- No dynamic loading
- No safety factor included in soil parameters
- Ignore passive pressure in frost zone

Backfill placed against the lift station walls, if any, should consist of granular fill or low plasticity cohesive soil. For the granular values to be valid, the granular backfill must extend out from the base of the wall at an angle of at least 45 and 60 degrees from vertical for the at-rest and passive cases, respectively. To calculate the resistance to sliding, a value of 0.3 can be used as the ultimate coefficient of friction between the footing and the underlying soil. A value of 0.45 may be used if at least 2 feet of crushed stone is provided immediately below the foundation.

4.6 Frost Considerations

The soils on this site are frost susceptible, and small amounts of water can affect the performance of the slabs on-grade such as generator pads. Exterior slabs should be anticipated to heave during winter months. If frost action needs to be eliminated in critical areas, we recommend the use of non-frost susceptible structural fill. Placement of non-frost susceptible material in large areas may not be feasible; however, the following recommendations are provided to help reduce potential frost heave:

- Providing surface drainage away from the building and slabs and toward the site storm drainage system

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

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

5.0 GENERAL COMMENTS

Terracon should be retained to review the final design plans and specifications so comments can be made regarding interpretation and implementation of our geotechnical recommendations in the design and specifications. Terracon also should be retained to provide observation and testing services during grading, excavation, foundation construction and other earth-related construction phases of the project.

The analysis and recommendations presented in this report are based upon the data obtained from the boring performed on the indicate date, location and from other information discussed in this report. This report does not reflect variations that may occur between borings, across the site, or due to the modifying effects of construction or weather. The nature and extent of such variations may not become evident until during or after construction. If variations appear, we should be immediately notified so that further evaluation and supplemental recommendations can be provided.

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

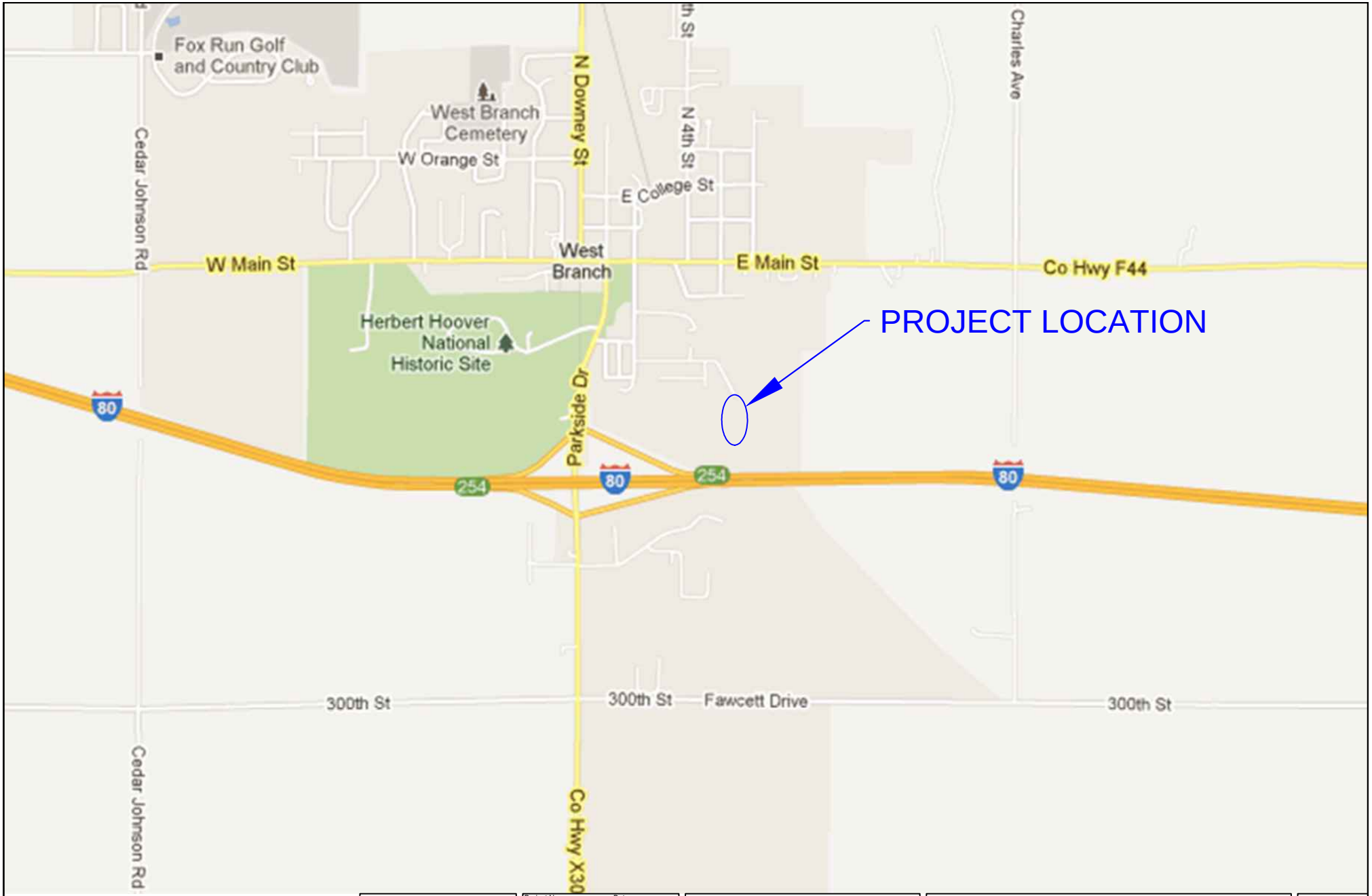
The scope of services for this project does not include either specifically or by implication any environmental or biological (e.g., mold, fungi, bacteria) assessment of the site or identification or prevention of pollutants, hazardous materials or conditions. If the owner is concerned about the potential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

This report has been prepared for the exclusive use of our client for specific application to the project discussed and has been prepared in accordance with generally accepted geotechnical engineering practices. No warranties, either express or implied, are intended or made. Site safety, excavation support, and dewatering requirements are the responsibility of others. In the event that changes in the nature, design, or location of the project as outlined in this report are planned, the conclusions and recommendations contained in this report shall not be considered valid unless Terracon reviews the changes and either verifies or modifies the conclusions of this report in writing.

LICENSED PROFESSIONAL ENGINEER JUSTIN D. WIDDEL 20495 IOWA	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. 11-15-12 Justin D. Widdel, P.E. Date My license renewal date is December 31, 2012.

APPENDIX A

FIELD EXPLORATION



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

NORTH

0 1600'

APPROXIMATE DRAWING SCALE

Project No.	06125641
Date:	NOV 2012
Project Mngr:	JDW
Drawn By:	PC
File Name:	06125641-01.dwg
Layout Name:	SITE LOCATION

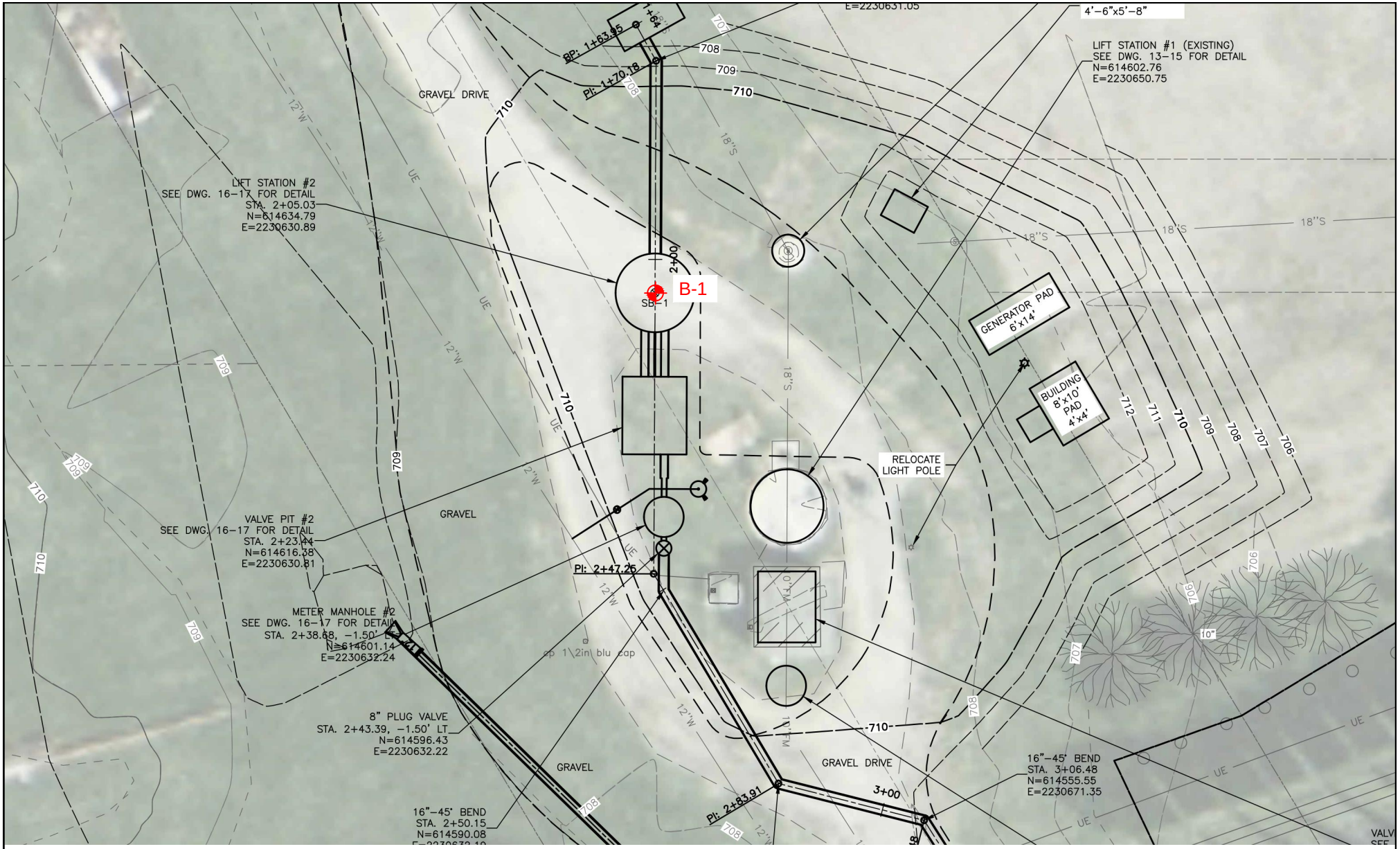
Terracon
Consulting Engineers and Scientists
783 HIGHWAY 1 WEST IOWA CITY, IOWA 52246
PH. (319) 688-3007 FAX. (319) 688-3008

SITE LOCATION PLAN

PROPOSED LIFT STATION
CITY OF WEST BRANCH
SE OF S MAPLE STREET AND S 4TH STREET
WEST BRANCH, IOWA

EXHIBIT #

A-1



LEGEND

- APPROXIMATE BORING LOCATION

BASE DRAWING FROM PDF '2012-11-14 DWG 4 LOWERED SITE 36845 West Branch Lift Station.pdf' RECEIVED FROM VEENSTRA & KIMM, INC

THIS DRAWING IS INTENDED FOR GENERAL LOCATION PURPOSES ONLY

NORTH

0 20'

APPROXIMATE DRAWING SCALE

Project No.	Date:
06125641	NOV 2012
Project Mngr: JDW	Drawn By: PC
File Name: 06125641-01.dwg	
Layout Name: BORING LOCATION	

Terracon
Consulting Engineers and Scientists
783 HIGHWAY 1 WEST IOWA CITY, IOWA 52246
PH. (319) 688-3007 FAX. (319) 688-3008

BORING LOCATION PLAN

PROPOSED LIFT STATION
CITY OF WEST BRANCH
SE OF S MAPLE STREET AND S 4TH STREET
WEST BRANCH, IOWA

EXHIBIT #

A-2

BORING LOG NO. B-1

PROJECT: Proposed Lift Station

CLIENT: City of West Branch - West Branch, Iowa

SITE: SE of S. Maple Street and S. 4th Street West Branch, Iowa

ENGINEER: Veenstra & Kimm, Inc. - Coralville, Iowa

LOCATION See Exhibit A-2

Surface Elev.: 708.5 (Ft.)

DEPTH	ELEVATION (Ft.)	Description
		Approx. 8" Crushed Stone
		FILL - CLAYEY SAND fine to medium, trace gravel and organics brown and dark brown
3.0	705.5	
		FILL - LEAN CLAY trace sand dark brown and gray
6.5	702	
7.0	701.5	**LEAN TO FAT CLAY (CL/CH)** **(Possible Buried Topsoil)** trace sand and organics, dark brown
9.0	699.5	**FAT CLAY (CH)** trace sand, brown gray, medium stiff
		LEAN CLAY (CL) trace sand and organics gray, soft to medium stiff
		Decayed wood fragments @ about 15 feet.
19.0	689.5	
		SILTY CLAY (CL-ML) with sand, trace organics gray, very soft to medium stiff

DEPTH (Ft.)	RECOVERY (In.)	FIELD TEST RESULTS	HAND PENETROMETER (tsf)	TEST TYPE	COMPRESSIVE STRENGTH (tsf)	STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
	18	7-7-3 N=10					13		
5	0								
	12		0.75				34	81	
10	15			UC	0.65	15	32	87	
15	14			UC	0.30	13	43	73	46-25-21
20	18			UC	0.42	15	27	94	
25	18			UC	0.60	15	21	103	25-18-7

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

Hammer Type: Automatic

Advancement Method:
Hollow-stem augers to 9 feet, then wash bore to termination.

Abandonment Method:
Monitoring well set to 41 feet.

See Exhibit A-4 for description of field procedures
See Appendix B for description of laboratory procedures and additional data, (if any).
See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

8' While Sampling
9' (11/8/12)

Terracon
783 Highway 1 West, Unit 5
Iowa City, Iowa

Boring Started: 10/26/2012
Boring Completed: 10/26/2012
Drill Rig: 928
Driller: MW
Project No.: 06125641
Exhibit: A-3

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. TERRACON SMART LOG-NO WELL 06125641 LIFT STATION.GPJ ODOT TEST.GPJ 11/15/12

BORING LOG NO. B-1

PROJECT: Proposed Lift Station

CLIENT: City of West Branch - West Branch, Iowa

SITE: SE of S. Maple Street and S. 4th Street West Branch, Iowa

ENGINEER: Veenstra & Kimm, Inc. - Coralville, Iowa

LOCATION See Exhibit A-2

Surface Elev.: 708.5 (Ft.)

DEPTH	ELEVATION (Ft.)	Description	DEPTH (Ft.)	RECOVERY (In.)	FIELD TEST RESULTS	HAND PENETROMETER (tsf)	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
		SILTY CLAY (CL-ML) *(continued)*										
		Sand and gravel layer @ about 31 to 32 feet.	30	10			UC	0.25	15	20	106	
32.0	676.5									17		
		SILTY CLAY (CL-ML) with sand, trace organics gray, medium stiff to stiff										
			35	18	4-4-5 N=9	0.75				27		
			40	14			UC	1.01	10.1	27	96	
43.0	665.5											
		FINE TO MEDIUM SAND (SP-SC) with clay, trace organics gray, medium dense P200 = 29%	45	16	4-4-6 N=10					19		
47.0	661.5											
		FINE TO COARSE SAND (SP-SC) with clay and gravel gray, medium dense	50	12	6-7-10 N=17					14		
50.5	658											
		Boring Terminated at 50.5 Feet										

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

Hammer Type: Automatic

Advancement Method:
Hollow-stem augers to 9 feet, then wash bore to termination.

Abandonment Method:
Monitoring well set to 41 feet.

See Exhibit A-4 for description of field procedures
See Appendix B for description of laboratory procedures and additional data, (if any).
See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

8' While Sampling
9' (11/8/12)

Terracon
783 Highway 1 West, Unit 5
Iowa City, Iowa

Boring Started: 10/26/2012 | Boring Completed: 10/26/2012
Drill Rig: 928 | Driller: MW
Project No.: 06125641 | Exhibit: A-3

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. TERRACON SMART LOG-NO WELL 06125641 LIFT STATION.GPJ ODOT TEST.GPJ 11/15/12

Field Exploration Description

The field exploration consisted of performing one (1) soil boring at the project site. The boring was extended to a depth of about 50½ feet below the existing grade. The boring location was selected and laid out in the field by Veenstra and Kimm, Inc. personnel. The ground surface elevation at the boring location was also provided by Veenstra and Kimm, Inc., and was rounded to the nearest ½-foot on the attached boring log. The location and elevation of the boring should be considered accurate only to the degree implied by the means and methods used to define them.

The boring was drilled with a truck-mounted, rotary drilling rig using continuous flight, hollow-stemmed augers wash boring drilling methods to advance the borehole. Samples were obtained using either thin-walled tube or split-barrel sampling procedures. In the thin-walled tube sampling procedure, a seamless steel tube with a sharp cutting edge is pushed hydraulically into the ground to obtain a relatively undisturbed sample of cohesive or moderately cohesive soil. In the split-barrel sampling procedure, a standard 2-inch O.D. split-barrel sampling spoon is driven into the ground with a 140-pound hammer falling a distance of 30 inches. A CME automatic SPT hammer was used to advance the split-barrel sampler in the boring performed for this project. The number of blows required to advance the sampling spoon the last 12 inches of a normal 18-inch penetration is recorded as the standard penetration resistance value. These values are indicated on the boring log at the corresponding depths of occurrence. The samples were sealed and transported to our laboratory for testing and classification.

During the field exploration, a field log of the boring was prepared by the drill crew. The log included visual classification of the materials encountered during drilling as well as the driller's interpretation of the subsurface conditions between samples. The boring log included with this report represents the geotechnical engineer's interpretation of the field log and includes modifications based on laboratory observation and tests of the samples.

APPENDIX B

LABORATORY TESTING

Laboratory Testing

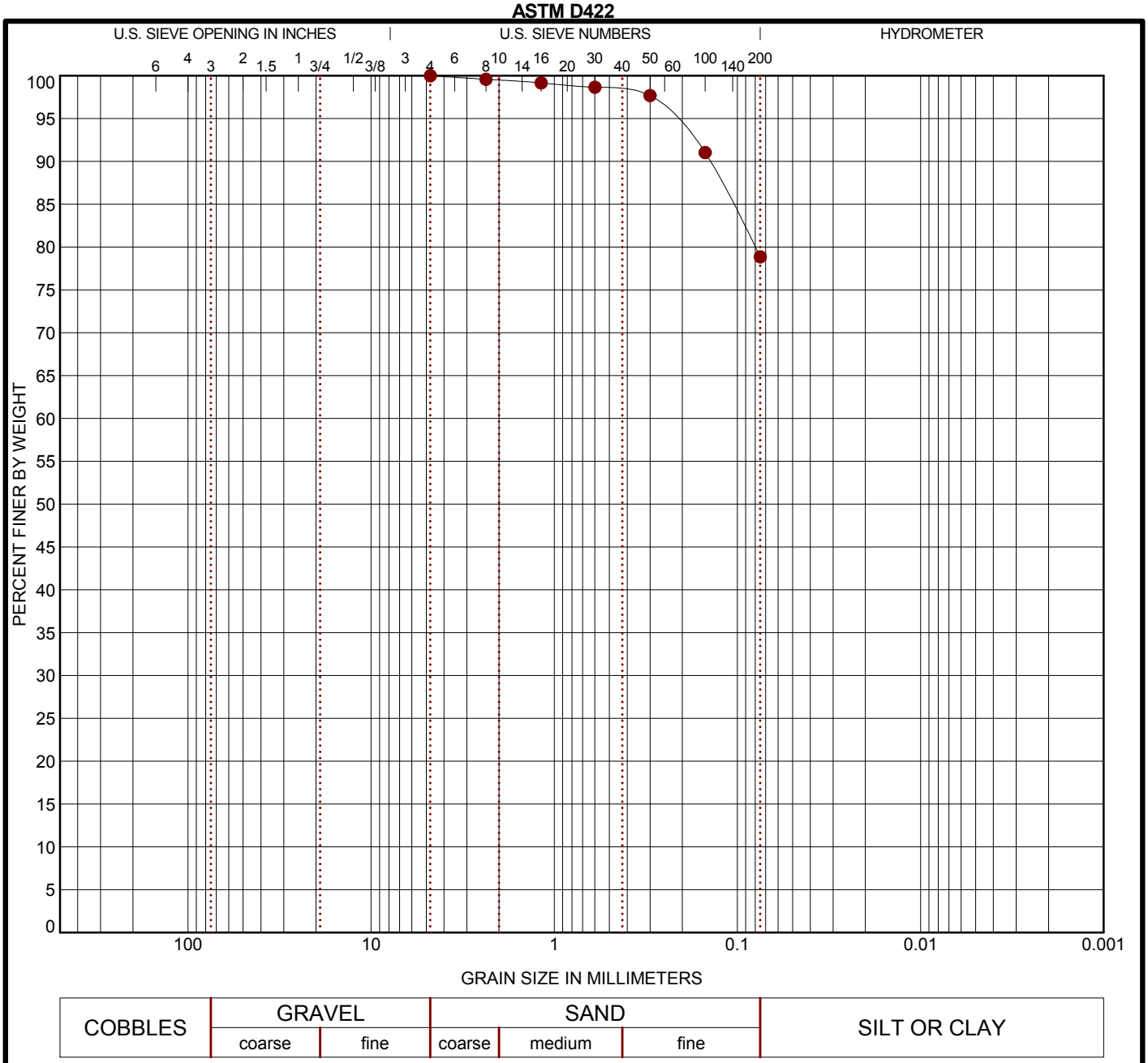
Soil samples were tested in our laboratory to measure their natural water content. Dry unit weight measurements were performed on portions of intact thin-walled tube samples. The unconfined compressive strength of some thin-walled tube samples was also measured. A hand penetrometer was also used to estimate the unconfined compressive strength of some cohesive samples. The hand penetrometer provides a better estimate of soil consistency than visual examination alone. The following index tests were performed to aid in classifying the soils:

- Two (2) Atterberg Limits tests;
- One (1) washed sieve analysis (washed over a U.S No. 200 sieve);
- One (1) gradation.

The results of the Atterberg limit tests and sieve analysis are shown on the boring log, adjacent to the soil profiles, at their corresponding sample depths. The results of the gradation are attached in this appendix.

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

GRAIN SIZE DISTRIBUTION
ASTM D422



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Sample ID		USCS Classification	LL	PL	PI	Cc	Cu
●	B-1	29 - 31 ft.	SILTY CLAY WITH SAND					

	Sample ID		D_{100}	D_{60}	D_{30}	D_{10}	%Gravel	%Sand	%Silt	%Clay
●	B-1	29 - 31 ft.	4.75				0.0	21.1	78.9	

PROJECT: Proposed Lift Station

SITE: SE of S. Maple Street and S. 4th Street
West Branch, Iowa

Terracon
783 Highway 1 West, Unit 5
Iowa City, Iowa

PROJECT NUMBER: 06125641

CLIENT: City of West Branch - West Branch, Iowa

EXHIBIT: B-2

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GRAIN SIZE: USCS-2 06125641 LIFT STATION.GPJ TERRACON2012.GDT 11/15/12

APPENDIX C

SUPPORTING DOCUMENTS

GENERAL NOTES

DESCRIPTION OF SYMBOLS AND ABBREVIATIONS

SAMPLING

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

WATER LEVEL

- Water Initially Encountered
- Water Level After a Specified Period of Time
- Water Level After a Specified Period of Time

Water levels indicated on the soil boring logs are the levels measured in the borehole at the times indicated. Groundwater level variations will occur over time. In low permeability soils, accurate determination of groundwater levels is not possible with short term water level observations.

FIELD TESTS

(HP)	Hand Penetrometer
(T)	Torvane
(b/f)	Standard Penetration Test (blows per foot)
(PID)	Photo-Ionization Detector
(OVA)	Organic Vapor Analyzer

DESCRIPTIVE SOIL CLASSIFICATION

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

LOCATION AND ELEVATION NOTES

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

STRENGTH TERMS

RELATIVE DENSITY OF COARSE-GRAINED SOILS (More than 50% retained on No. 200 sieve.) Density determined by Standard Penetration Resistance Includes gravels, sands and silts.			CONSISTENCY OF FINE-GRAINED SOILS (50% or more passing the No. 200 sieve.) Consistency determined by laboratory shear strength testing, field visual-manual procedures or standard penetration resistance			
Descriptive Term (Density)	Standard Penetration or N-Value Blows/Ft.	Ring Sampler Blows/Ft.	Descriptive Term (Consistency)	Unconfined Compressive Strength, Qu, tsf	Standard Penetration or N-Value Blows/Ft.	Ring Sampler Blows/Ft.
Very Loose	0 - 3	0 - 6	Very Soft	less than 0.25	0 - 1	< 3
Loose	4 - 9	7 - 18	Soft	0.25 to 0.50	2 - 4	3 - 4
Medium Dense	10 - 29	19 - 58	Medium-Stiff	0.50 to 1.00	4 - 8	5 - 9
Dense	30 - 50	59 - 98	Stiff	1.00 to 2.00	8 - 15	10 - 18
Very Dense	> 50	≥ 99	Very Stiff	2.00 to 4.00	15 - 30	19 - 42
			Hard	> 4.00	> 30	> 42

RELATIVE PROPORTIONS OF SAND AND GRAVEL

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

GRAIN SIZE TERMINOLOGY

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

RELATIVE PROPORTIONS OF FINES

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

PLASTICITY DESCRIPTION

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

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UNIFIED SOIL CLASSIFICATION SYSTEM

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

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

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

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

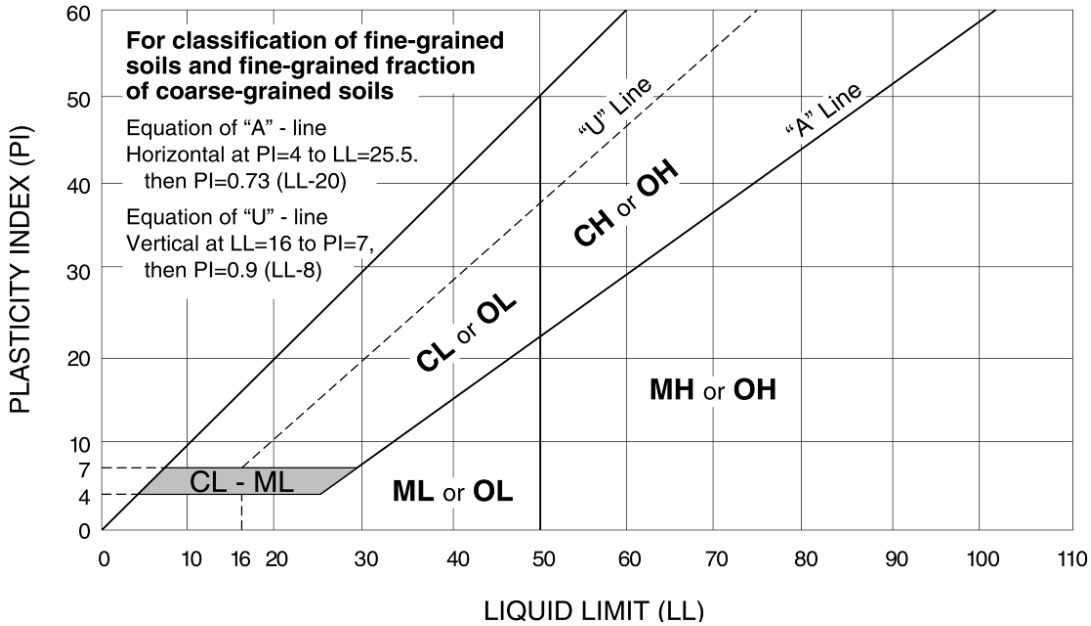

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Exhibit C-2