Geotechnical Engineering Report

New Water Tower
Hedrick, Iowa
TEAM Project No. 1-5107
March 11, 2022

Prepared for:
City of Hedrick

Prepared by:
TEAM Services, Inc.
Des Moines, Iowa

TEAM Services

March 11, 2022

City of Hedrick
109 Main Street, P.O. Box No. 167
Hedrick, IA 52563

Attn: Ashley Olinger

Re: Subsurface Exploration
New Water Tower
Hedrick, IA
TEAM Project No. 1-5107

Dear Ms. Olinger:

We have completed the subsurface exploration for the proposed elevated water storage tank in Hedrick, Iowa. The accompanying geotechnical report presents the findings of the subsurface exploration and our geotechnical recommendations concerning design and construction for the proposed water tower.

We appreciate the opportunity to be of service to you on this project. If you have any questions concerning this report, or if we may be of further service to you in any way, please do not hesitate to contact us.

Sincerely yours,
TEAM Services

Clinton Halverson, P.E.
Principal Engineer

Cc: Matt Walker, P.E., Garden & Associates, Ltd.

LICENSED PROFESSIONAL ENGINEER Clinton Halverson 19928 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.
	Clinton Halverson, P.E. License Number 19928 Date: 03/11/2022 My license renewal date is December 31, 2023. Pages covered by this seal: All Pages.

TABLE OF CONTENTS

PROJECT INFORMATION

Project information has been provided by Mr. Matt Walker, P.E. of Garden & Associates through email. A new legged water tower is planned in Hedrick, Iowa. Documents provided include an RFP letter stating project details with a map showing the proposed tower location and desired boring locations. The new tower is proposed to hold 75,000 gallons and have a high-water level of about 120 feet. For the purposes of this report, TEAM Services assumes the structure weight will be less than or equal to the weight of the contained water.

SITE CONDITIONS

The project site is located north of W 1st Street and about half-way between Main Street and West Street in Hedrick, Iowa. The site is currently open grass space. The area where our borings were conducted was relatively flat with less than a foot of elevation difference recorded between our borings. Our truck-mounted auger drill rig was supported by the existing surfaces without difficulty.

FIELD EXPLORATION

A total of 3 borings were drilled at the site between depths of approximately 40 and 60 feet below existing grades on February 17 and 18, 2022. Boring locations were staked with elevations provided by Garden and Associates. The approximate locations of the borings are shown on the attached Boring Plan in the Appendix. Boring surface elevations are noted on their respective Boring Logs.

Representative samples were obtained using thin-walled tube and split-barrel sampling procedures in general accordance with ASTM Specifications D 1587 and D 1586, respectively. In the thin-walled tube sampling procedure, a thin-walled, seamless steel tube with a sharp cutting edge is pushed hydraulically into the ground to obtain relatively undisturbed samples of cohesive or moderately cohesive soils. In the split-barrel sampling procedure, a standard 2-inch O.D. split-barrel sampling spoon is driven into the ground with a 140-pound hammer falling a distance of 30 inches. The number of blows required to advance the sampling spoon the last 12 inches of a normal 18-inch penetration is recorded as the standard penetration resistance value. These values are indicated on the Boring Logs at the depths of occurrence. The samples were tagged for identification, sealed and returned to the laboratory for testing and classification.

An automatic hammer was used to perform the Standard Penetration Tests. In the automatic hammer system, the cathead and rope used traditionally in the manual test procedure is replaced with an automatic lifting mechanism for the 140 pound driving weight. The reduction in system friction with the automatic hammer system results in significant increase in the driving energies. This results in significantly greater driving efficiencies and a corresponding decrease in the number of blows in the Standard Penetration Test results. We have taken the driving efficiency of the automatic hammer into account when analyzing this data.

Field logs of each boring were prepared by the drill crew. These logs included visual classifications of the materials encountered during drilling, as well as the driller's interpretation of the subsurface conditions between samples. Final Boring Logs included with this report represent an interpretation of the field logs and include modifications based on laboratory observation and tests of the samples.

LABORATORY TESTING

Based on the driller's field records and examination of the samples in the laboratory, a soil testing program was developed to collect more information about the soil conditions at the site. The following is a brief description of the specific tests completed for this project.

Natural Moisture Content -- The natural moisture content of selected samples was determined in accordance with ASTM D 2216. The moisture content of the soil is the ratio, expressed as a percentage, of the weight of water in a given mass of soil to the weight of the soil particles. The results are presented on the Boring Logs at the depths from which the samples were obtained.

Unit Weight -- In the laboratory, selected undisturbed samples of the site soils were measured and weighed to determine gross weight and volume of the samples. Where possible, the samples are placed in a template and trimmed at each end to fit the template. The moisture content of each specimen was then determined, and the dry unit weight was calculated. The results of these tests are presented on the Boring Logs at the appropriate sample depths.

Unconfined Compressive Strength -- A calibrated hand penetrometer was used to estimate the approximate unconfined compressive strength of selected cohesive soil samples. The calibrated hand penetrometer has been correlated with unconfined compression tests and provides a better estimate of soil consistency than visual examination alone.

Torvane Shear Tests -- The Torvane test was performed on a precut flat soil sample surface with a calibrated, hand-held spring loaded dial device with thin flanges in a radial array which can be pressed into the soil sample. The vanes are pressed into the soil sample, and the dial face is twisted slowly until the vanes begin to shear the soil. This test gives a direct dial reading of soil shear strength when the sample fails. The test is especially useful for estimating the shear strength of soft cohesive soils. Torvane shear test results are noted on the Boring Logs at the depth of the samples tested.

Plasticity (Atterberg Limits) Tests -- Selected soil samples were tested for Plastic Index. The soils' Plastic Index (PI) is bracketed by the Liquid Limit (LL) and the Plastic Limit (PL). The LL is the moisture content at which the soil will flow as a heavy viscous fluid. The PL is the moisture content at which the soil begins to crumble when rolled into a small thread. These tests are conducted in general accordance with ASTM D 4318. The results are indicated on the Boring Log at the depth where the sample was obtained.

As part of the testing program, the samples were classified in the laboratory based on visual observation, texture and plasticity. The descriptions of the soils indicated on the Boring Logs are in accordance with the enclosed *General Notes* and the *Unified Soil Classification System*. Estimated group symbols according to the *Unified Soil Classification System* are given on the Boring Logs. A brief description of this classification system is attached to this report.

SUBSURFACE CONDITIONS

Subsurface conditions encountered during this exploration are indicated on the individual Boring Logs. Based on the results of the borings, subsurface conditions on the project site can be generalized as follows.

We encountered existing fill at the ground surface in all borings. Fill consisted primarily of sandy lean clays and extended to depths of about 1 to 2 feet below existing grades.

Topsoil was encountered beneath the existing fill. The topsoil generally consisted of medium stiff or stiff lean to fat clay with trace amounts of organics. The topsoil extended to a depth of about 3 feet below existing grades.

Loess (wind-blown soil) was encountered below the topsoil. The loess soils are typically fat clay nearest to the ground surface but transition to lean to fat clay and lean clay soils with depth. The loess ranged from stiff to very stiff in consistency. The loess extended to a depth of about 13 feet below existing grades.

Paleosol was encountered beneath the loess. Paleosol is a weathered zone of glacially derived soils that is commonly found at the top of glacial strata. These materials were deposited during the advance or retreat of continental glacial ice sheets which previously covered this area. Paleosol is usually underlain by less weathered glacial till soils. The paleosol at the site consisted of stiff to very stiff fat clay and extended to a depth of about 27 feet.

Glacial till was encountered beneath the paleosol. The glacial till soils are more or less unsorted soil deposits consisting of a mixture of sand, silt, and clay, with the engineering properties of the soil being controlled by the clay fraction. The glacial till soils at the site consisted of sandy lean clay which were generally stiff to very stiff in the upper zones and transitioning to being hard to very hard below a depth of about 37 feet.

Glacial outwash seams and layers were fairly common amongst the till. Outwash seams and layers are glacial deposits which have been sorted by moving water. The glacial outwash consisted of medium dense to very dense clayey sand. Borings terminated in the glacial soils at depths of up to 60 feet below existing grades.

Cobbles and boulders were not noted in our borings. However, glacial soils often contain cobbles and boulders. The possibility of their presence should be considered where excavations or grading operations at the site advance into the glacial soils.

The above descriptions provide a general summary of the subsurface conditions encountered. The attached Boring Logs contain detailed information recorded at each boring location. These Boring Logs represent our interpretation of the field logs based on engineering examination of the field samples. The lines designating the interfaces between various strata represent approximate boundaries and the transition between strata may be gradual. Where strata changes occur between sample depths, the strata change elevation is typically estimated based on interpolation, and is approximate. Soil conditions will vary between each boring location.

GROUNDWATER CONDITIONS

The borings were monitored while drilling and after the completion of drilling operations for the presence and level of groundwater accumulation. Groundwater levels observed in the borings are noted on the Boring Logs.

Groundwater seepage was encountered during drilling between the depths of about 13½ and 34½ feet below existing grades between the three borings. Soon after drilling, the water level in Boring 3 was checked at which time the water level had risen to a depth of about 20 feet. The water level in Boring 2 was recorded at a depth of about 8 feet after stabilizing overnight. Boring 1 was left open for weeks after which time the water level, read on March 10th, resided at a depth of about 5 feet.

Longer term monitoring in cased holes or piezometers would be required for a more accurate evaluation of the groundwater conditions at the site.

These groundwater level observations provide an approximate indication of the groundwater conditions existing on this site at the time of drilling operations. Fluctuation of groundwater levels can occur due to seasonal variations in the amount of rainfall, runoff, surface drainage, subsurface drainage, site topography, irrigation practices, ground cover (pavement or vegetation), and other factors not evident at the time the borings were conducted. Normally, the highest groundwater levels occur in late winter and spring time while the lowest levels occur in late summer and fall time. The fluctuation of the groundwater levels should be considered when developing the design and construction plans for this project.

CONCLUSIONS AND RECOMMENDATIONS

General Water Tank Suitability and Mitigation Options

The proposed water tank loads are substantial and will compress soils to a deep depth beneath the ground surface. Different allowable bearing pressures are provided in the **Shallow Foundation Design** section of this report to accommodate 2 or 3-inch settlement tolerances for the tower. If less settlement and/or higher bearing pressures are desired, then an intermediate foundation option could be employed or TEAM Services could provide recommendations for overexcavation and replacement to meet those specifications. Intermediate foundations can also be utilized to provide uplift resistance. However, based on the project loads and reasonable allowable bearing pressures recommended, TEAM Services does not anticipate that these site mitigation options will be necessary.

Moderately expansive loess soils were encountered near and below anticipated shallow foundation bearing elevations. However, it is our opinion that frost-depth or deeper shallow foundations should have enough embedment and uplift resistance to resist significant swelling from the moist (pre-swelled condition), moderately expansive soils encountered in the borings. Anticipated swell from the soils is less than ½ inch.

As noted on the Boring Logs, petroleum odors were apparent in two consecutive samples collected below a depth of about 5 feet below the existing grades. TEAM Services does not claim to have environmental engineering expertise. However, the owner and structural should be informed of this condition in case it might influence the planning of excavations or shallow foundations. If consultation regarding pollutants is desired, then an engineer with related expertise should be retained. TEAM Services can make samples available, upon request, within 3 months of this report.

Site Preparation

Site preparation should begin with the removal of any organic-laden soils, vegetation and any loose, soft or otherwise unsuitable materials.

After removal, the exposed grade in areas that will support the weight of the water tower should be probed and visually inspected by TEAM Services to determine the suitability of the subgrade in accordance with the **Shallow Foundation Construction** section of this report. Any unsuitable soils identified during this process should be removed and replaced with suitable engineered compacted and tested fill which meets Class 1 Construction Application requirement in Table A in the following **Fill Placement** report section.

Fill Placement

Fill and backfill placed for the project should consist of approved materials which are free of organic matter and debris. Brick, concrete, rocks or other solid pieces with a maximum dimension of 3 inches or larger should not be placed in the newly placed fill sections. Typically, we recommend that low-plasticity cohesive soil or granular soil be used for general fill placement. By our definition, low-plasticity cohesive soil would have a liquid limit of 45 or less and a plasticity index of 25 or less. However, most of the near-surface soils at this site do not meet these criteria. As mentioned in the Site Preparation section, the existing moderately expansive loess soils pose only minor risk to frost-depth or deeper shallow foundations when these moderately expansive soils are moist. Therefore, the on-site moderately expansive loess soils may be utilized as new backfill beneath foundations using the moisture specifications recommended in this report section. Any off-site potential borrow materials should be evaluated by TEAM Services prior to their use as engineered compacted fill.

The following Table A lists recommended minimum compaction requirements for cohesive and cohesionless fill materials for specific applications. For low-plasticity (CL and ML) cohesive soils, moisture contents within a range of -2 to +3 percent of the material's optimum moisture content (as determined by Standard Proctor ASTM D 698) are necessary to achieve the desired fill qualities for general grading and utility backfill. Moderately expansive soils similar to the fat clay loess encountered in our borings may be placed beneath frost-depth or deeper foundations provided they are placed within 0 to +4 percent of the material's optimum moisture content in order to place them in a somewhat pre-swelled condition. Granular materials should be placed within 3 percent of the material's optimum moisture content if the material contains enough fines content that suitable compaction is sensitive to moisture content. Clean granular materials are not moisture sensitive.

TABLE A
RECOMMENDED DEGREE OF COMPACTION GUIDELINES

Construction Application		Standard Proctor (ASTM D698) Cohesive Soil	Standard Proctor (ASTM D698) Cohesionless Soil [2]	Relative Density (ASTM D4253 & D4254) Cohesionless Soil [1,2]
Class 1	Subgrade preparation for structures, pavements and other critical backfill areas	95%	98%	75%
Class 2	Backfill adjacent to structures not supporting other structures or pavements. Minor subsidence possible.	90%	93%	45%
Class 3	Backfill in non-critical areas. Moderate subsidence possible.	85%	88%	20%

1. Use Relative Density technique (ASTM D4253 & D4254) where Standard Proctor technique (ASTM D698) does not result in a definable maximum dry density and optimum moisture content.
2. Clean gravel should be inspected visually during compaction by a qualified engineering technician to confirm adequate compactive effort and appropriate lift thicknesses in lieu of density testing.

The on-site soils can be excavated utilizing conventional excavation equipment. Granular soils can generally be suitably compacted with vibratory compaction equipment. Proper compaction of cohesive soils can be achieved with sheepsfoot or pneumatic type compactors within the above moisture content ranges. The soils should be placed in a maximum loose thickness of 12 inches and at a thickness compatible with the equipment being utilized. Lift thicknesses should be limited to four inches when utilizing manual compaction equipment. Sufficient density tests should be performed on each lift of engineered compacted fill placed to verify that adequate compaction is achieved.

Care should be taken to prevent unnecessary disturbance of subgrade soils. Disturbed areas should be removed and replaced with new, suitable fill which has been placed and compacted in accordance with the recommendations of this report.

Upon completion of the filling operation, care should be taken to maintain the subgrade moisture content prior to construction of foundations if bearing on or near cohesive soils. If the subgrade should become desiccated, frozen or otherwise disturbed, the affected material should be removed or these materials should be scarified, moistened, recompacted and retested prior to concrete placement. As a general guideline, cohesive fills which dry to a moisture content less than 2/3 of their optimum moisture content as determined by the Standard Proctor Test (ASTM D 698) in their upper 2 inches are candidates for reconditioning as described above.

If water seepage or accumulation is observed at the bottom of excavations, it will likely be beneficial to place a lift of at least 6 inches of clean, crushed concrete or limestone gravel to provide a firm working surface for constructing foundations or placing additional lifts of backfill. The clean gravel can be well compacted in the presence of water, will drive through and reinforced shallow (1 or 2 inches) cohesive soils which have become softened by water exposure, and can accumulate water seepage to flow to a peripheral sump pit to be pumped out of the excavation area.

Shallow Foundation Design

Shallow foundations anticipated for the tower are either a ring foundation which extends beneath all tower legs or isolated foundations for each tower leg. It appears that a shallow foundation for the proposed water tower would bear on the existing medium stiff to stiff loess soils or on newly placed engineered fill if needed to replace any unsuitable soils. In our opinion, foundations bearing on these materials may be designed for a maximum net allowable bearing pressure of 2,000 pounds per square foot. We estimate maximum settlements using a foundation bearing pressure of 2,000 psf will be on the order of 2 inches. If a settlement tolerance of 3 inches is acceptable then the maximum net allowable bearing pressure could be increased to 2,500 psf. Considering how uniform subsurface condition are at the site; we anticipate differential settlement would be less than ½ of the total settlement.

The net bearing pressure is the pressure in excess of the minimum adjacent overburden pressure at the foundation level. The bearing capacity discussed in the previous paragraph may be increased by 33% when considering transient forces such as wind.

Foundations in unheated areas should extend at least 42 inches below the lowest adjacent finished grade for frost protection and reduce movements associated with changes in soil moisture content.

Foundations are subjected to some lateral and uplift forces. The foundations should be sized to resist the anticipated forces without excessive deflection and displacement. Lateral forces on the foundation will be resisted by the friction between the base of the foundation and the underlying soils and passive earth pressures. A coefficient of 0.3 could be reasonably assumed for evaluating ultimate frictional resistance to sliding at the foundation-soil contact. This coefficient should be used with minimum dead load as the normal force. The buoyant weight should be considered in calculation of the minimum weight of all below-grade structural elements. A passive earth pressure coefficient of 3.0 could be reasonably assumed for evaluating ultimate lateral resistance of the soil against the side of the foundation where this is a permissible condition. This passive earth pressure should be divided by a safety factor of at least 2 to determine the design resistance to limit the amount of lateral deformation required to mobilize the passive resistance. In order to calculate passive soil resistance, the buoyant unit weight of the soil should be utilized considering that perched water may approach the existing ground surface in the future. A reasonable value for the buoyant unit weight of the soils at the site is 60 pcf. The contribution to passive resistance of the frost-affected materials in the upper 42 inches at the site should be limited to solely the weight of this soil. This can be accomplished by using a design passive earth pressure coefficient of 1.0 with no factor of safety needed.

Uplift resistance will be provided by the minimum dead weight of the structure and the foundation elements, plus the weight of the soil above the foundations. The weight of the soil above the foundations and extending outward at a 2 vertical to 1 horizontal slope may be considered as contributing to the uplift resistance of the foundations. This assumes that the backfill of the foundations will be compacted in accordance with the recommendations of this report for structural fill. The buoyant unit weight of concrete should be considered for the weight of buried concrete. The buoyant unit weight of the soils at the site of 60 pcf is recommended for uplift calculations. The maximum upward bearing pressure of a pedestal type foundation should be checked against a maximum allowable pressure of 2,000 psf.

Shallow Foundation Construction

We recommend that the base of all foundation excavations be observed and tested by the geotechnical engineer prior to placement of concrete. During this process, if soft, organic, or otherwise unsuitable materials are encountered at foundation elevations, we recommend that the foundations extend through the unsuitable soils and bear on undisturbed, suitable soils below or an overexcavation and replacement procedure be performed. The overexcavation and backfill procedure would include removal of these unsuitable materials and replacement with suitable engineered compacted fill soils prepared in accordance with the recommendations in the **Fill Placement** section of this report. The following Figure 1 shows a typical cross-sectional view of this overexcavation and backfill procedure.

In general, the overexcavation is widened 2/3 of a foot laterally on each side of the foundation per each foot of excavation that is below the foundation bearing elevation. The depth of overexcavation (shown as "D" in Figure 1) should be determined in consultation with the geotechnical engineer. Backfill materials should be suitable cohesive or granular soil, prepared and compacted in accordance with the recommendations in the **Fill Placement** section of this report. Another option would be to remove the unsuitable soils down to suitable soils and replace the excavated area with lean concrete (minimum 50 psi compressive strength), in which case widening of the excavation would not be required unless required due to unstable vertical sidewalls such as from sand.

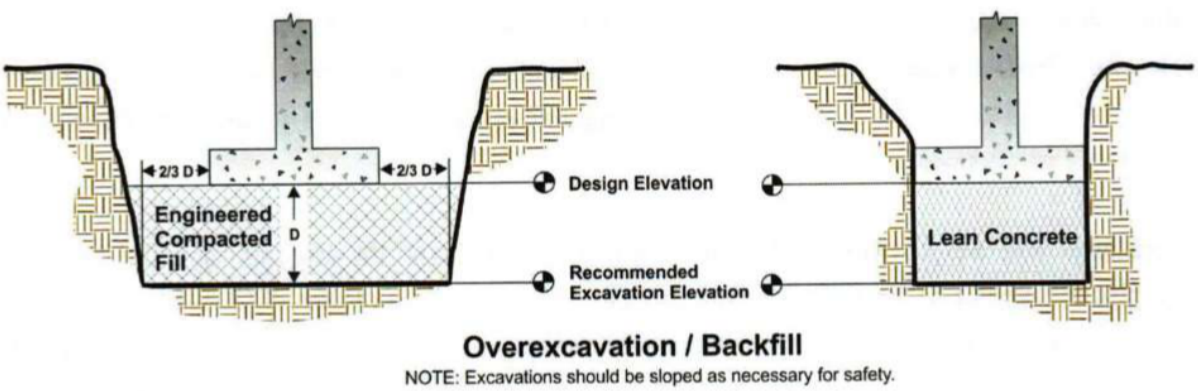


Figure 1.

Footing excavations should be kept free of water accumulation to prevent softening of subgrade soils and conducted in a manner which avoids disturbance of soils beneath existing foundations. Concrete should be placed as soon as possible after excavating to minimize bearing soil disturbance. Should the soils at bearing level become excessively dry, saturated, or otherwise disturbed; the affected soil should be removed prior to placing concrete.

Intermediate Foundation Alternative

An intermediate foundation system (such as stone columns or Geopiers®) could be used to support the proposed structure. If uplift is controlling design then helical anchors may be useful both to provide uplift resistance as well as assist vertical capacity. These are patented foundation systems designed by licensed contractors who have a professional engineer on staff. We recommend that the consultant be provided a copy of this report to determine requirements for additional exploration, if any, to support their design work. The foundation contractor should submit their proposed solution to TEAM Services for review.

Temporary Excavation Support

All excavations should comply with the requirements of OSHA 29 CFR, Part 1926, Subpart P, "Excavations and Trenches" and other applicable codes. This document states that excavation safety is the responsibility of the contractor. Reference to this OSHA requirement should be included in the job specifications.

Construction Groundwater Control

During construction activities, care should be taken to maintain positive drainage at the site to ensure that drainage is directed away from excavations. Based on the boring information, it is possible that seepage will occur during anticipated excavations especially during wet weather seasons. If seepage is encountered, we recommend that construction groundwater control be established prior to excavating the final 2 feet of soil above the desired lowest excavation elevation. It may be useful to dig test holes to evaluate the groundwater level prior to extensive excavations at the site to be prepared. Groundwater seepage in cohesive soils can be controlled by permitting it to drain into temporary construction sumps and be pumped outside the perimeter of the excavations.

If water seepage or accumulation is observed at the bottom of excavations, it will likely be beneficial to place a lift of at least 6 inches of clean, crushed concrete or limestone gravel to provide a firm working surface for constructing foundations or supporting additional lifts of backfill. The clean gravel can be well compacted in the presence of water, will drive through and reinforced shallow (1 or 2 inches) cohesive soils which have become softened by water exposure, and can accumulate water seepage to flow to a peripheral sump pit to be pumped out of the excavation area.

Groundwater control should be maintained continuously until below-grade construction is completed and backfilled sufficiently to withstand the forces which would be induced by the rise in groundwater levels when the dewatering system is no longer in service. If groundwater control is lost during construction, disturbance of the upper few inches to few feet below grade is possible in the soils at the site. In these circumstances, it will be necessary to reestablish groundwater control and remove the disturbed soils. TEAM Services should be consulted regarding the extent of remedial action which is necessary.

Site Drainage

Positive site drainage should be maintained along the perimeter of the structures. Final grades should be established to direct runoff away from foundations. Site grading should direct surface water away from excavations or completed foundations during construction and after site development is completed.

Site Classification for Earthquake Design

This site would classify as "D" "stiff soil" profile under ASCE 7, Chapter 20 based on recorded SPT blow count values and the extrapolation thereof. However, the thick layer of paleosol (PI > 20 for a layer over 10' thick) designates the site as Site Class "E."

QUALIFICATION OF REPORT

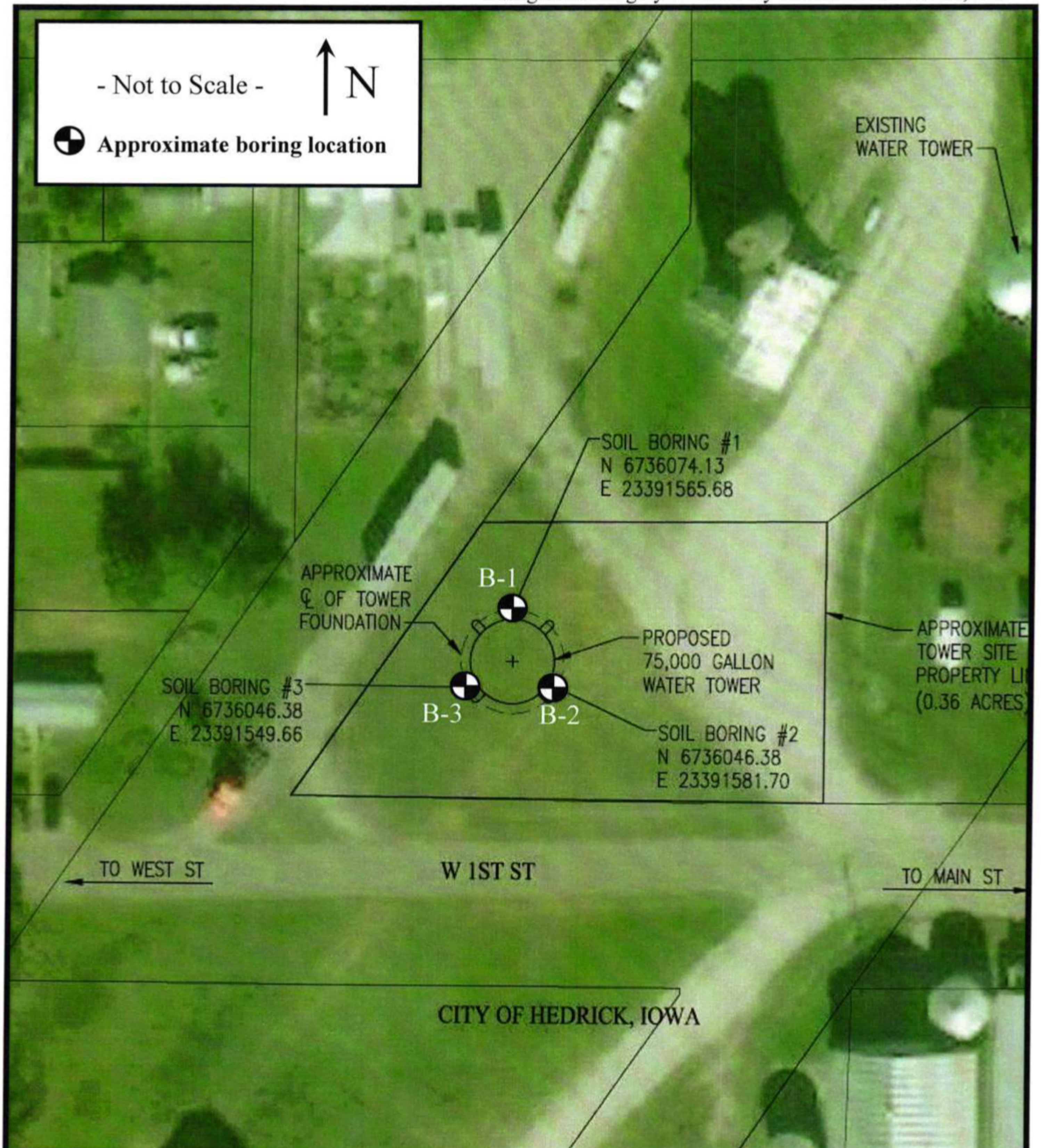
Our evaluation of foundation support conditions has been based on our understanding of the site and project information and the data obtained in our exploration. The general subsurface conditions utilized in our foundation evaluation have been based on interpolation of subsurface data between the borings. In evaluating the boring data, we have examined previous correlations between soil properties and foundation bearing pressures observed in soil conditions similar to those at your site. The discovery of any site or subsurface conditions during construction which deviate from the data outlined in this exploration should be reported to us for our evaluation. The assessment of site environmental conditions or the presence of pollutants in the soil, rock, and groundwater of the site was beyond the scope of this exploration.

As noted on the Boring Logs, petroleum odors were apparent in two consecutive samples collected below a depth of about 5 feet below the existing grades. TEAM Services does not claim to have environmental engineering expertise. However, the owner and structural should be informed of this condition in case it might influence the planning of excavations or shallow foundations. If consultation regarding pollutants is desired, then an engineer with related expertise should be retained. TEAM Services can make samples available, upon request, within 3 months of this report.

It is recommended that the geotechnical engineer be retained to review the plans and specifications so that comments can be provided regarding the interpretation and implementation of the geotechnical recommendations in the design and specifications. It is further recommended that the geotechnical engineer be retained for testing and observation during the foundation construction phase to help determine that the design requirements are fulfilled.

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 other warranty is provided. In the event that any 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 the changes are reviewed and the conclusions of this report modified or verified in writing by the geotechnical engineer.

Background Imagery Provided by Garden & Associates, Ltd



TEAM *Services*, Inc. **717 SE 6th Street** **Des Moines, IA 50309**	**New Water Tower** Hedrick, Iowa BORING PLAN	Project No. 1-5107 March 11, 2022

BORING LOG No. 1

PROJECT New Water Tower

SITE Hedrick, IA

Approx. Surface Elev.: 823.0
Site Datum: Site Survey
Drilling Method: HSA

Depth	DESCRIPTION	Elev.	USCS SYMBOL	DEPTH (ft.)	NUMBER	TYPE	RECOVERY	SPT - N (BLOWS / FT.)	MOISTURE, %	DRY DENSITY (PCF)	UNCONFINED STRENGTH (PSF)	OTHER
1.0	Fill - Sandy lean CLAY, trace gravel, very dark brown and dark grayish brown	822.0	CL	0	1	AS			26.7			
3.0	Buried Topsoil - Lean to fat CLAY, trace organics, very dark brown, medium stiff	820.0	CL-CH		2	SS	10	3	28.2		3000*	
8.0	Loess - Fat CLAY, gray and yellowish brown, stiff -- becomes medium stiff after 6' -- petroleum odor noted in Samples No. 4 & 5	815.0	CH	5	3	SS	10	6	33.9		3500*	
					4	SS	16	4	36.3		1500*	
13.0	Loess - Lean CLAY, gray and yellowish brown, medium stiff -- color change to dark gray after 11'	810.0	CL	10	5	ST	15		25.7	96	2500*	
					6	SS	18	6	25.9		2500*	
27.0	Paleosol - Fat CLAY, gray and yellowish brown, stiff to very stiff	796.0	CH	15	7	SS	18	7	36.3		5500*	
					8	SS	18	9	23.9		5500*	
				20	9	SS	18	10	25.7		5500*	
				25	10	SS	18	13	22.9		7000*	
34.5	Glacial Till - Sandy lean CLAY, trace gravel, gray and yellowish brown, very stiff	788.5	CL	30	11	SS	18	13	20		7500*	
					12T	SS	18	8	15.5		6000*	

Notes:

* Calibrated hand penetrometer

Hammer Type: Automatic

Water Level:

∇	34.5	Ft.	While Drilling
▼		Ft.	After Drilling
▼	5	Ft.	3/10/2022

TEAM Services
Geotechnical and Construction Material Consultants

Boring Started: 02/18/2022	
Boring Completed: 02/18/2022	
Rig: 112	**Foreman:** JH
Approved:	**Job #:** 1-5107

1-5107.geo TSBORE16.fdt 3/17/2016

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

BORING LOG No. 1

PROJECT New Water Tower | **SITE** Hedrick, IA

Approx. Surface Elev.: 823.0
Site Datum: Site Survey
Drilling Method: HSA

GRAPHIC LOG	DESCRIPTION	USCS SYMBOL	DEPTH (ft.)	SAMPLES: NUMBER	TYPE	RECOVERY	SPT - N (BLOWS / FT.)	MOISTURE, %	DRY DENSITY (PCF)	UNCONFINED STRENGTH (PSF)	OTHER
	Glacial Outwash - Clayey SAND, gray and yellowish brown, medium dense	SC	35	12B				19.1			
	37.0 786.0										
	Glacial Till - Sandy lean CLAY, trace gravel, yellowish brown and trace gray, very stiff to hard	CL		13	SS	18	18	12		9000*	
	40.0 783.0		40								
	Bottom of Boring										

Notes:

* Calibrated hand penetrometer

Hammer Type: Automatic

Water Level:

▽	34.5	Ft.	While Drilling
▼		Ft.	After Drilling
▼	5	Ft.	3/10/2022

TEAM Services
Geotechnical and Construction Material Consultants

Boring Started: 02/18/2022
Boring Completed: 02/18/2022
Rig: 112 | **Foreman:** JH
Approved: | **Job #:** 1-5107

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

BORING LOG No. 2

PROJECT New Water Tower

SITE Hedrick, IA

Approx. Surface Elev.: 822.9
Site Datum: Site Survey
Drilling Method: HSA

Depth (ft.)	DESCRIPTION	Elev.	USCS SYMBOL
1.0	Fill - Sandy lean CLAY, trace gravel and organics, very dark brown	821.9	CL
3.0	Buried Topsoil - Lean to fat CLAY, trace organics, very dark gray, medium stiff	819.9	CL-CH
6.0	Loess - Fat CLAY, gray and yellowish brown, stiff	816.9	CH
8.0	Loess - Lean to fat CLAY, gray, stiff -- petroleum odor noted in Samples No. 4 & 5	814.9	CL-CH
13.0	Loess - Lean CLAY, gray and yellowish brown, stiff	809.9	CL
27.0	Paleosol - Fat CLAY, dark gray, stiff to very stiff -- color change to gray and yellowish brown after 16'	795.9	CH
	Glacial Till - Sandy lean CLAY, trace gravel, gray and yellowish brown, stiff		CL

SAMPLES NUMBER	TYPE	RECOVERY	SPT - N (BLOWS / FT.)	MOISTURE, %	DRY DENSITY (PCF)	UNCONFINED STRENGTH (PSF)	OTHER
1	AS		**				
2	SS	10	9**	29		1500*	
3	ST	13		30.3	91	5000*	Atterberg Limits LL = 58 PI = 35
4	SS	12	8	25.7		4500*	
5	ST	20		26.6	97	3000*	
6	SS	16	7	25.6		4500*	
7	SS	14	6	25.2		4500*	
8	SS	14	8	24.4		6000*	
9	SS	18	10	22.6		6000*	
10	SS	18	9	20.7		5500*	
11	SS	18	7	15.8		2500*	

Notes: ** Sample noted as frozen during drilling

* Calibrated hand penetrometer

Hammer Type: Automatic

Water Level:
13.5 Ft. **While Drilling**
Ft. **After Drilling**
8 Ft. 24 HOURS

TEAM Services
Geotechnical and Construction Material Consultants

Boring Started: 02/17/2022
Boring Completed: 02/17/2022
Rig: 112 **Foreman:** JH
Approved: **Job #:** 1-5107

1-5107.geo TSBORE16.fdt 3/17/2016

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

BORING LOG No. 2

PROJECT New Water Tower | **SITE** Hedrick, IA

Approx. Surface Elev.: 822.9
Site Datum: Site Survey
Drilling Method: HSA

DESCRIPTION	USCS SYMBOL	DEPTH (ft.)	NUMBER	TYPE	RECOVERY	SPT - N (BLOWS / FT.)	MOISTURE, %	DRY DENSITY (PCF)	UNCONFINED STRENGTH (PSF)	OTHER
		35								
37.0 — 785.9 Glacial Till - Sandy lean CLAY, trace gravel, yellowish brown and trace gray, hard	CL									
			12	SS	18	22	11.9		9000*	
		40								
			13	SS	16	18	12.2		9000*	
		45								
			14	SS	18	28	12.8		9000*	
		50								
-- color change to yellowish brown, dark gray, and dark olive brown after 52'										
			15	SS	14	49	10.8			
		55								
-- trace sand seams, color change to dark grayish brown after 58'			16	SS	18	64	14.4			
60.0 — 762.9		60								
Bottom of Boring										

Notes: ** Sample noted as frozen during drilling

* Calibrated hand penetrometer

Hammer Type: Automatic

Water Level:

▽	13.5	Ft.	While Drilling
▼		Ft.	After Drilling
▼	8	Ft.	24 HOURS

TEAM Services
Geotechnical and Construction Material Consultants

Boring Started: 02/17/2022
Boring Completed: 02/17/2022
Rig: 112 | **Foreman:** JH
Approved: | **Job #:** 1-5107

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

BORING LOG No. 3

PROJECT New Water Tower | **SITE** Hedrick, IA

Approx. Surface Elev.: 823.2
Site Datum: Site Survey
Drilling Method: HSA

Depth	Description	Elev.	USCS Symbol
0–2.0	Fill - Sandy lean CLAY, trace gravel, very dark brown and yellowish brown	821.2	CL
2.0–3.0	Buried Topsoil - Lean to fat CLAY, trace organics, very dark brown, stiff	820.2	CL-CH
3.0–6.0	Loess - Fat CLAY, yellowish brown and gray, stiff	817.2	CH
6.0–8.0	Loess - Lean to fat CLAY, yellowish brown and gray, medium stiff -- petroleum odor noted in Samples No. 4 & 5	815.2	CL-CH
8.0–13.0	Loess - Lean CLAY, yellowish brown and gray, medium stiff	810.2	CL
13.0–27.0	Paleosol - Fat CLAY, gray, stiff -- color change to yellowish brown and gray after 16' -- with sand, becomes very stiff after 22'	796.2	CH
27.0–	Glacial Till - Sandy lean CLAY, trace gravel, gray and yellowish brown, very stiff		CL

Number	Type	Recovery	SPT - N (Blows / Ft.)	Moisture, %	Dry Density (PCF)	Unconfined Strength (PSF)	Other
1	AS			31.6			
2	SS	8	8	33.1		3000*	
3	SS	10	8	34.7		3500*	
4	SS	16	4	34.6		1500*	
5	ST	21		31.9	93	1500*	Torevane = 700 PSF
6	SS	14	5	27.4		2000*	
7	SS	12	8	28.2		3500*	
8	SS	16	8	25.1		4500*	
9	SS	17	8	24.9		6000*	
10	SS	16	12	21.5		7500*	
11	SS	12	12	19.1		5500*	
12	SS	18	13	13.6		5500*	

Notes:

* Calibrated hand penetrometer

Hammer Type: Automatic

Water Level:
- 33.5 Ft. While Drilling
- 20 Ft. After Drilling
- Ft.

TEAM Services
Geotechnical and Construction Material Consultants

Boring Started: 02/18/2022
Boring Completed: 02/18/2022
Rig: 112 | **Foreman:** JH
Approved: | **Job #:** 1-5107

1-5107.geo TSBORE16.fdt 3/17/2016

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

BORING LOG No. 3

PROJECT New Water Tower | **SITE** Hedrick, IA

Approx. Surface Elev.: 823.2
Site Datum: Site Survey
Drilling Method: HSA

Depth (ft.)	Elev.	DESCRIPTION	USCS SYMBOL	SAMPLE NUMBER	TYPE	RECOVERY	SPT - N (BLOWS / FT.)	MOISTURE, %	DRY DENSITY (PCF)	UNCONFINED STRENGTH (PSF)	OTHER
35		-- becomes hard after 37'									
				13	SS	18	26	13		9000*	
				14	SS	18	27	11.5		9000*	
47.0	776.2	Glacial Outwash - Clayey SAND, yellowish brown, very dense	SC								
49.0	774.2	Glacial Till - Sandy lean CLAY, trace gravel, yellowish brown and gray, hard to very hard	CL	15T	SS	12	52	14.5			
				15B				13.4		9000*	
				16	SS	16	34	13.1			
57.0	766.2	Glacial Outwash - Clayey SAND, yellowish brown, very dense	SC								
59.0	764.2	Glacial Till - Sandy lean CLAY, trace gravel, dark gray, hard	CL	17T	SS	18	80	12			
60.0	763.2	Bottom of Boring		17B				14		9000*	

Notes:

* Calibrated hand penetrometer

Hammer Type: Automatic

Water Level:

33.5	Ft.	While Drilling
20	Ft.	After Drilling
	Ft.	

TEAM Services
Geotechnical and Construction Material Consultants

Boring Started: 02/18/2022
Boring Completed: 02/18/2022
Rig: 112 | **Foreman:** JH
Approved: | **Job #:** 1-5107

1-5107.geo TSBORE16.fdt 3/17/2016

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

UNIFIED SOIL CLASSIFICATION SYSTEM

TEAM Services Geotech Report

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 MH		GC	Clayey gravel[F, G, H]
	Sands 50% or more of coarse fraction passes No. 4 sieve	Clean Sands Less than 5% fines[E]	$Cu \geq 6$ 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	< 0.75	OL	Organic clay[K, L, M, N]
			Liquid limit – not dried			Organic silt[K, L, M, O]
	Silts and Clays Liquid limit 50 or more	Inorganic:	PI plots on or above "A" line		CH	Fat clay[K, L, M]
			PI plots below "A" line		MH	Elastic silt[K, L, M]
		Organic:	Liquid limit – oven dried	< 0.75	OH	Organic clay[K, L, M, P]
			Liquid limit – not dried			Organic silt[K, L, M, Q]
Highly Organic Soils	Primarily organic matter, dark in color, and organic odor				PT	Peat

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

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

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

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

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

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

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

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

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

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

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

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

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

[N] PI $\geq$ 4 and plots on or above "A" line.

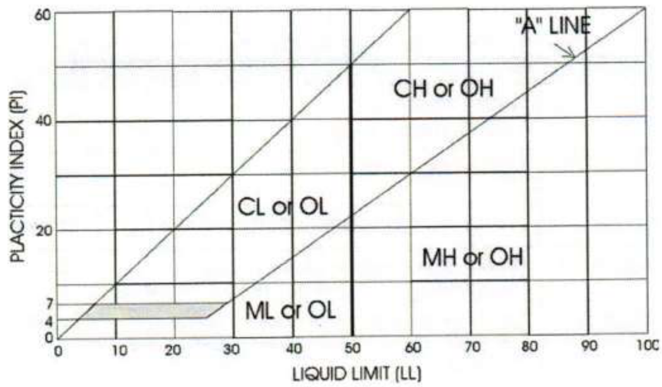
[O] PI < 4 or plots below "A" line.

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

[Q] PI plots below "A" line.

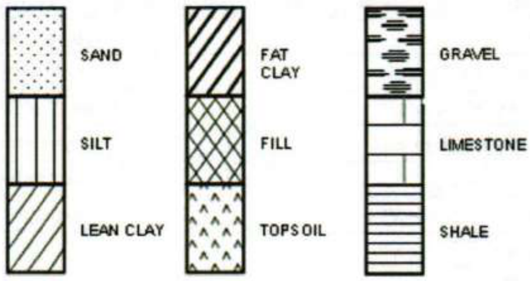
For classification of fine-grained soils and fine grained fraction of coarse-grained soils.

Equation of "A" Line:
Horizontal at PI = 4 to LL + 25.5.
then PI = 0.73 (LL-20)



GENERAL NOTES

TEAM Services Geotech Report

SOIL and ROCK TYPES	DRILLING & SAMPLING SYMBOLS
	**SS** Split Spoon - 1 1/2" I.D., 2" O.D., unless otherwise noted **ST** Thin-Walled Tube - 3" O.D., unless otherwise noted **PA** Power Auger **HA** Hand Auger **DB** Diamond Bit - 4", N, B **AS** Auger Sample **HS** Hollow Stem Auger **WS** Wash Sample **RB** Rock Bit **BS** Bulk Sample **DC** Dutch Cone **WB** Wash Bore **AR** Air Rotary

STRENGTH TERMS

CONSISTENCY OF FINE-GRAINED SOILS (50% or more passing No. 200 sieve)			RELATIVE DENSITY OF COARSE-GRAINED SOILS (50% or more retained No. 200 sieve)	
Consistency	**Unconfined Compressive Strength, Qu, psf**	**N-Blows/ft* (Approx. Correlation)**	**Relative Density**	**N-Blows/ft. ***
Very Soft	< 500	0 - 2	Very Loose	0 - 4
Soft	500 - 1,000	3 - 4	Loose	5 - 10
Medium	1,001 - 2,000	5 - 8	Medium Dense	10 - 29
Stiff	2,001 - 4,000	9 - 15	Dense	30 - 49
Very Stiff	4,001 - 8,000	16 - 30	Very Dense	50 - 80
Hard	8,001 - 16,000	31 - 50	Extremely Dense	80 +
Very Hard	> -16,000	50 +		

* Standard "N" Penetration Blows per foot of a 140 pound hammer falling 30 inches on a 2-inch OD split spoon, except where noted.

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

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

WATER LEVELS: WD = While Drilling AD = After Drilling

▽	Depth groundwater first encountered during drilling
▼	Groundwater level after 24 hours (unless otherwise noted, i.e. "AD" -- after drilling)

TERMS DESCRIBING SOIL STRUCTURE

Parting:	paper thin in size	Fissured:	containing shrinkage cracks, frequently filled with fine sand or silt, usually more or less vertical.
Seam:	1/8" to 3" in thickness		
Layer:	greater than 3" in thickness	Interbedded:	composed of alternate layers of different soil types.
Ferrous:	containing appreciable quantities of iron	Laminated:	composed of thin layers of varying color and texture.
Well-Graded:	having wide range in grain size and substantial amounts of all intermediate sizes.	Slickensided:	having inclined planes of weakness that are slick and glossy in appearance.
Poorly-Graded:	predominately one grain size or having a range of sizes with some intermediate sizes missing.	NOTE:	Clays possessing slickensided or fissured structure may exhibit lower unconfined strength than indicated above. Consistency of such soil is interpreted using the unconfined strength along with pocket penetrometer results.