Geotechnical Engineering Report

Water Storage Tank

Philo, Ohio

November 2, 2018

Terracon Project No. N4185328

Prepared for:

Village of Philo

Philo, Ohio

Prepared by:

Terracon Consultants, Inc.

Columbus, Ohio

November 2, 2018

Village of Philo
c/o CT Consultants, Inc.
148 N. High St.
Gahanna, Ohio 43230

Attn: Mr. Barbara R. Anderson, P.E.

Re: Geotechnical Engineering Report
Water Tank Storage
Harris Street
Philo, Ohio
Terracon Project No. N4185328

Dear Ms. Anderson:

Terracon Consultants, Inc. (Terracon) has completed the geotechnical engineering services for the above referenced project. This study was performed in general accordance with our proposal dated September 7, 2018 and our agreement for services signed and returned on October 9, 2018.

This report presents the findings of the subsurface exploration and provides geotechnical engineering recommendations regarding the design and construction of foundations for the proposed replacement water tank.

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.

Rohit Singh
Staff Geotechnical Engineer

for

Yogesh S. Rege, P.E.
Principal, Department Manager

REPORT TOPICS

ATTACHMENTS

Geotechnical Engineering Report

Water Storage Tank

Philo, Ohio

Terracon Project No. N4185328

November 2, 2018

INTRODUCTION

This report presents the results of our subsurface exploration and geotechnical engineering services performed for the proposed replacement Water Storage Tank in Philo, Ohio. The purpose of these services is to provide subsurface information and geotechnical engineering recommendations relative to:

- subsurface soil conditions
- groundwater conditions
- seismic site classification
- foundation design and construction
- site preparation and earthwork

The geotechnical engineering scope of services for this project included the advancement of two test borings to depth of approximately 48.8 feet below the existing site grades.

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

SITE CONDITIONS

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

Item	Description
Parcel information	The project is located on a parcel northeast of the intersection of 4th Street and Harris Street in Philo, Muskingum County, Ohio. The approximate coordinates of the site are 39.8603°, -81.9155°
Existing improvements	Based on the provided information, the project site is located in a rural residential neighborhood. The existing improvements in the vicinity of the new tank location include an existing water tank about 30 feet to the south of the proposed location of the new tank.
Current ground cover	Based on our recent site visits, the existing ground cover at the project site consists of landscaped grass.
Existing topography	A site grading plan was not provided, we anticipate nominal site grading will be required (cut/fill up to 3 feet) to establish the finished grade.

PROJECT DESCRIPTION

Our scope of work is based on our understanding of the project as described by you and is summarized below.

Item	Description
Project description	The proposed development consists of the construction of a 198,000-gallon replacement water tank.
Proposed structure[1]	The tank will be a single pedestal standpipe approximately 88 feet high and 20 feet in diameter. Based on the information provided by Mid Atlantic Storage System, the structure will be supported on a shallow bearing foundation system with a top and a bottom slab system with their anticipated diameters being ~22 feet and ~32 feet, respectively.
Design grades	Information regarding the final design grade was not provided.
Maximum loads[1]	Not provided, we have assumed following structural loads, based on the information provided by Mid Atlantic Storage System regarding a similar project with similar tank type and dimensions: ■ Dead Load: 42,000 lbs ■ Live Load: 1,651,320 lbs ■ Snow Load: 7500 lbs ■ Wind Load: 32,000 lbs
Grading/slopes	Nominal grading is anticipated for the proposed development.
Estimated start of construction	Not Provided.

GEOTECHNICAL CHARACTERIZATION

Subsurface Profile

Based on the results of our recently performed borings, subsurface conditions at the boring locations can be generalized as follows:

Stratum	Approximate Depth to Bottom of Stratum (feet)	Material Description	Consistency/Rock Hardness
Stratum I	0.3 to 0.4	Topsoil – 4 to 4.5 inches	N/A
Stratum II (native cohesive soil profile)	3.5 to 6 feet	Native cohesive soils including lean clay (CL) with varying proportions of sand and gravel sized constituents	Medium stiff to Very stiff
Stratum III (weathered bedrock)	Undetermined (borings were terminated in this stratum)	Completely to severely weathered Shale and Sandstone bedrock	Soft

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

Groundwater Conditions

Groundwater was not observed in the borings while drilling, or for the short duration that the borings were allowed to remain open. However, this does not necessarily mean these borings terminated above groundwater, or that the water levels summarized above are stable groundwater levels. Due to the low permeability of the soils encountered in the borings, a relatively long period of time may be necessary for a groundwater level to develop and stabilize in a borehole in these materials. Long term observations in piezometers or observation wells sealed from the influence of surface water are often required to define groundwater levels in materials of this type.

Groundwater level fluctuations occur due to seasonal variations in the amount of rainfall, runoff and other factors not evident at the time the borings were performed. Therefore, groundwater levels during construction or at other times in the life of the structure may be higher or lower than the levels indicated on the boring logs. The possibility of groundwater level fluctuations should be considered when developing the design and construction plans for the project.

GEOTECHNICAL OVERVIEW

Natural cohesive soils with medium stiff to very stiff consistency were encountered to depths of approximately 3.5 to 6 feet below the existing ground surface. Completely to very severely weathered shale and sandstone bedrock was encountered below these cohesive materials.

Based on the available boring information and our settlement analyses, the existing natural cohesive soils and bedrock are considered to be suitable for the bottom slab subgrade support.

We recommend that the foundations bear on the underlying very stiff clay or weathered bedrock. An allowable bearing pressure of 3,000 psf is recommended for the bottom slab bearing on these materials. A higher allowable bearing capacity of 5,000 psf is available at 6 feet below the existing ground surface for foundation bearing completely on weathered shale bedrock.

Excavation of clay soils is not expected to be difficult. However, excavation of bedrock strata will present some difficulty. Experience has indicated that conventional heavy-duty excavation equipment such as backhoes equipped with rock teeth can sometimes excavate weathered bedrock materials which we could penetrate with a flight auger. Rock excavation equipment, such as jackhammers may be required if harder bedrock strata is encountered during the foundation excavation.

Due to the potential for disturbance or deterioration of the exposed bearing surface during the construction process, we recommend that a "mudmat" of lean concrete be placed over the exposed bearing surface immediately after the foundation bearing area has been reviewed and approved by qualified geotechnical personnel.

Expansive bedrock may be present on this site. This report provides recommendations to help reduce the effects of soil and bedrock shrinkage and expansion assuming any foundations, are in contact with these expansive materials. However, even if these procedures are followed, some movement and cracking in the structure should be anticipated. The severity of cracking and other damage such as uneven slabs will probably increase if any modification of the site results in excessive wetting or drying of the expansive soils. Eliminating the risk of movement and distress may not be feasible, but it may be possible to further reduce the risk of movement if significantly more expensive measures, such as additional undercutting of the bedrock or post tensioned slabs with anchors, etc., are used during construction. We would be pleased to discuss these construction alternatives with you upon request.

Potentially expansive bedrock (shale) was encountered in the borings. The bedrock has a tendency to swell upon exposure to oxygen and water and could potentially be exposed at bearing elevation for the foundation. Therefore, we recommend that if and when bedrock is encountered at bearing elevation for proposed foundation, the material should be properly sealed.

Implementation of the following measures can reduce the risk associated with the encountered expansive materials.

- Excavate the residual soil/shale with the least possible disturbance below subgrade. Shattering the bedrock and creating very rough trench walls can add to water and oxygen exposure.

- If exposing the residual soil/bedrock at mat/slab elevation, seal the subgrade. One common method involves placing a lean concrete mud mat of 3 to 4-inch thickness within 4 hours of initial exposure. This mud mat layer can also be underlain with a vapor retarder. Care would need to be taken to seal any shrinkage cracks that might appear in the mud mat. An underlying vapor barrier would help avoid water and oxygen infiltration in such a case.

- Constructability issues should be addressed as appropriate, such as using compressed air to clean the vertical and horizontal bedrock surfaces before sealing. Also, care should be taken to avoid punctures or damage to the sealant once it has been applied to the bedrock face.

- Avoid constructing slabs over badly shattered shale/siltstone subgrades, such as that formed by overbreak. The porous nature of the shattered upper material provides greater potential for exposure to water and oxygen.

Our recommendations regarding design and construction of foundations for the proposed tank as well as our comments regarding the site preparation and construction of these elements are provided in the following sections.

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

EARTHWORK

The following paragraphs present recommendations for site preparation, excavation, subgrade preparation and placement of structural fill soils at the project site. The recommendations presented for design and construction of earth supported elements included foundations and slabs are contingent upon following the recommendations outlined in this section.

Future earthwork at the project site should be observed and evaluated by Terracon. The evaluation of earthwork should include observation and testing of structural fill, subgrade preparation, foundation bearing soils, and other geotechnical conditions exposed during the construction of the project.

Site Preparation

We understand that the initial construction activities will be initiated by the stripping of natural vegetation and surficial materials (topsoil). Any remaining loose, soft or unsuitable material should be stripped off the site and any underground utilities should be properly abandoned or removed. Stripped topsoil and any materials consisting of vegetation and organic matter should be wasted off site, or these materials could be re-spread in landscaped area after completion of grading operations. Stripping depths between our boring locations and across the site could vary considerably. As such, we recommend actual stripping depths be evaluated by a representative of Terracon during construction to aid in preventing removal of excess material.

Medium stiff cohesive soils were encountered in the boring up to depths of 3.5 feet below ground surface. These soils are not suitable for direct foundation support, After stripping and prior to any further structural fill placement, proofrolling of cohesive native soils should be performed with heavy pneumatic tired construction equipment, such as a dump truck weighing at least 20 tons. If any non-cohesive soils are exposed, they should be densified in-place with a heavy drum vibratory compactor. A geotechnical engineer or their representative should observe the densification/proof rolling to aid in locating unstable subgrade materials and assessing the subgrade. Areas that deflect excessively and don't "tighten up" will likely need to be undercut, refilled with structural fill and recompacted in 8-inch-thick lifts to 98% of Standard Proctor maximum dry density.

Fill Material Types

Fill required to achieve design grade should be classified as structural fill. Structural fill is that material used below, or within 10 feet of the structure. Earthen materials used for structural fill should meet the following material property requirements:

Fill Type [1]	USCS Classification	Acceptable Location for Placement
Lean clay	CL (LL<40 & PI<22)	All locations and elevations
Well graded granular	SW or GW [2]	All locations and elevations
Low Volume Change Material [3]	CL (LL<40 & PI<22) or SW or GW [2]	All locations and elevations
On-Site Native Soil	CL	The use of on-site soils as structural fill should meet the requirements for "acceptable location for placement" indicated above. Moisture conditioning of the onsite soils should be anticipated.
On-Site Bedrock	Weathered Shale and Sandstone	The on-site completely weathered shale and sandstone bedrock typically appear suitable for reuse as structural fill provided that the material is moisture conditioned and broken down into a 4 inch maximum particle dimension and incorporated into 8 inch thick soil lifts. Weathered bedrock should be used for fill only at a depth of 3 feet or greater below the finished grade.

1. Controlled, compacted fill should consist of approved materials that are free of organic matter (5% max.) and debris. Frozen materials 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.
2. Similar to ODOT Item 304 or crushed limestone or dolomite aggregate or granular material such as sand, gravel or crushed stone containing no more than 18% low plasticity fines.
3. Low plasticity cohesive soil and well graded granular soil or chemically stabilized medium to high plasticity soils.

Fill Compaction Requirements

Structural fill should meet the following compaction requirements.

Item	Structural Fill
Maximum individual lift thickness	8 inches or less in loose thickness when heavy, self-propelled compaction equipment is used 4 to 6 inches in loose thickness when hand-guided equipment (i.e. jumping jack or plate compactor) is used
Minimum compaction requirements [1, 2,]	98% of maximum dry density
Water content range [1]	Cohesive – Lean Clay: -2% to +3% of optimum Granular: -3% to +3% of optimum

Item	Structural Fill

1. Maximum dry density and optimum water content as determined by the standard Proctor test (ASTM D 698).
2. If the granular material is a coarse sand or gravel, or of a uniform size, or has a low fines content, compaction comparison to relative density may be more appropriate. In this case, granular materials should be compacted to at least 70% relative density (ASTM D 4253 and D 4254).

Utility Trench Backfill

All trench excavations should be made with sufficient working space to permit construction, including backfill placement and compaction. If utility trenches are backfilled with relatively clean granular material, they should be capped with at least 18 inches of low plasticity cohesive fill in non-pavement areas to reduce the infiltration and conveyance of surface water through the trench backfill.

Compaction requirements for bedding and backfilling around utilities may need to be adjusted to the pipe material type and the pipe manufacturer bedding and backfill material recommendation. Granular backfill is recommended for use as backfill in utility trenches in areas beneath pavements.

Grading and Drainage

Final surrounding grades should be sloped away from the tank structure on all sides to prevent ponding of water.

Earthwork Construction Considerations

Shallow excavations for the proposed structure are anticipated to be accomplished with conventional construction equipment. Upon completion of filling and grading, care should be taken to maintain the subgrade water content prior to construction of floor slabs. Construction traffic over the completed subgrades should be avoided. The site should also be graded to prevent ponding of surface water on the prepared subgrades or in excavations. Any water that collects over, or adjacent to, construction areas should be promptly removed. If the subgrade freezes, desiccates, saturates, or is disturbed, the affected material should be removed, or these materials should be scarified, moisture conditioned, and recompacted, prior to slab construction. Consideration could be given to providing a layer of crushed stone over the prepared tank slab subgrade to provide a working mat in order to help expedite construction. All these processes should be observed by Terracon. If shale bedrock is exposed, it should be protected by placing 3 to 4 inch thick mudmat on it within 4 hours after its exposure to minimize its degradation.

Although not anticipated, trapped water infiltration or groundwater seepage may be encountered, particularly after periods of precipitation. In such an event, sump and pumping methods may be used for temporary dewatering.

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

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

Construction Observation and Testing

The earthwork efforts should be monitored under the direction of the Geotechnical Engineer. This monitoring should include documentation of adequate removal of vegetation, topsoil, soft/unstable soils and unsuitable fill and debris, proof-rolling and mitigation.

Each lift of compacted fill should be tested, evaluated, and reworked as necessary until approved by the Geotechnical Engineer prior to placement of additional lifts. Each lift of fill should be tested for density and water content.

In areas of foundation excavations, the bearing subgrade should be evaluated under the direction of the Geotechnical Engineer. In the event, unanticipated conditions are encountered, the Geotechnical Engineer should prescribe mitigation options.

In addition to the documentation of the essential parameters necessary for construction, the continuation of the Geotechnical Engineer into the construction phase of the project provides the continuity to maintain the Geotechnical Engineer’s evaluation of subsurface conditions, including assessing variations and associated design changes.

WATER TANK FOUNDATION RECOMMENDATIONS

As described previously, due to the potential for disturbance or deterioration of the exposed bearing surface during the construction process, we recommend that a “mudmat” of lean concrete be placed over the exposed bearing surface immediately after the foundation bearing subgrade area has been reviewed and approved by qualified geotechnical personnel. The purpose of the mud mat is to prevent disturbance of the subgrade while any foundation formwork and reinforcing steel installations are in process prior to the foundation concrete placement.

We recommend that the exposed subgrade at the bottom of foundation excavation be overexcavated to at least 3 to 4 inches (±) below design subgrade elevation to allow for placement of a lean concrete mud mat. Following completion of this overexcavation, qualified geotechnical personnel should review and approve the exposed surface. Suitable rubber-tired construction equipment such as a front loader with a full bucket could be used to proofroll the bottom of the excavation to the extent practical to delineate any unstable or unsuitable areas. Any water softened lean clay/ shale or otherwise unsuitable materials should be undercut prior to placing the lean concrete mudmat.

As indicated previously in this report, the bottom slab can be supported on very stiff lean clay or weathered bedrock. The exposed bearing surface should be protected using a lean concrete mudmat as described above.

A foundation design can be based on a net allowable bearing capacity of at least 3,000 psf for the foundation bearing upon or within very stiff lean clay or weathered bedrock and 5,000 psf for foundations bearing completely on weathered shale bedrock at a depth of 6 feet below the existing ground surface. These values assume a factor of safety of 3. These net allowable bearing pressures can be increased by 1/3 for load cases that contain seismic, wind or test loads.

For case where the bottom slab bears within very stiff lean clay or weathered bedrock, an anticipated maximum settlement of approximately 1 inch should occur near the center of the tank. It is expected that the majority of this settlement will occur as the tank is initially filled, with negligible long term settlements anticipated.

If exposed to the exterior grade, the sides of the foundation should be backfilled with compacted soil and consideration should also be made with regard to frost protection. A minimum 36 inches foundation embedment should be used for frost consideration if that is the case.

If lateral load resistance is required, an allowable coefficient of friction between the bottom of the concrete mat and the underlying bedrock can be assumed to be 0.35. This value includes a theoretical safety factor of about 1.5 against sliding.

Lateral resistance due to friction at the base of the footing should be ignored where uplift also occurs. Allowable passive earth pressure resistance can be calculated using an equivalent fluid pressure of 145 pcf (pounds per cubic foot) applied to the cross sectional area of the foundation. Additionally, due to frost effects lateral resistance should be neglected to a depth of 3 feet below final grade when calculating lateral capacity using this value.

The soil mass providing uplift resistance for the foundation should be calculated as the zone contained within planes that extend up and out from the edges of the top of the foundation to the ground surface at an angle of approximately 30 degrees from the vertical. The ultimate uplift capacity should then be taken as the sum of the weight of soil in this zone plus the weight of the concrete foundation. Effective unit weight of 120 pcf for soil and 150 pcf for reinforced concrete could be used for calculations above the groundwater level. Buoyant weights should be used below the groundwater level. The ultimate combined uplift capacity should then be divided by a factor of safety of at least 1.5 to obtain the allowable uplift capacity. This uplift capacity assumes that backfill over the foundations is compacted as recommended in this report and is protected from surface water infiltration and erosion.

It should be considered that the construction and eventual filling of the proposed above ground storage tank will exert stresses to a zone of foundation soils outside its perimeter, resulting in potential settlement of any tanks, utilities, or other structures within the affected area. Settlements of structures beyond one tank diameter are expected to be negligible. Additionally, settlements of nearby foundations bearing within shale bedrock are also expected to be negligible.

SEISMIC CONSIDERATIONS

Code Used	Site Classification
American Water Works Association (AWWA) [1]	C [2]

1. In general accordance with the American Water Works Association (AWWA) *D100-05*, Table 25. Site Classification is based on the characteristics of the upper 100 feet of the subsurface profile.
2. The AWWA requires a site soil profile determination extending a depth *of 100* feet for seismic site classification. The current scope requested does not include the required 100 foot soil profile determination. Borings extended to a maximum depth of 48.8 feet, and this seismic site class definition considers that shale bedrock continues below the maximum depth of the subsurface exploration. Additional exploration to deeper depths would be required to confirm the conditions below the current depth of exploration. Alternatively, a geophysical exploration could be utilized in order to attempt to justify a higher seismic site class.

GENERAL COMMENTS

Our analysis and opinions are based upon our understanding of the geotechnical conditions in the area, the data obtained from our site exploration and from our understanding of the project. Variations will occur between exploration point locations, 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. Terracon should be retained as the Geotechnical Engineer, where noted in the final report, to provide observation and testing services during grading, excavation, foundation construction and other earth-related construction phases of the project. If variations appear, we can provide further evaluation and supplemental recommendations. If variations are noted in the absence of our observation and testing services on-site, we should be immediately notified so that we can provide evaluation and supplemental recommendations.

Expansive bedrock may be present on this site. This report provides recommendations to help reduce the effects of soil and bedrock shrinkage and expansion assuming any foundations, are in contact with these expansive materials. However, even if these procedures are followed, some movement and cracking in the structure should be anticipated. The severity of cracking and other damage such as uneven slabs will probably increase if any modification of the site results in excessive wetting or drying of the expansive soils. Eliminating the risk of movement and distress may not be feasible, but it may be possible to further reduce the risk of movement if significantly more expensive measures, such as additional undercutting of the bedrock or post tensioned slabs with anchors, etc., are used during construction. We would be pleased to discuss these construction alternatives with you upon request.

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

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

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

SITE LOCATION AND EXPLORATION PLANS

SITE LOCATION

Water Storage Tank ■ Philo, Ohio

November 2, 2018 ■ Terracon Project No. N4185328

Terracon GeoReport

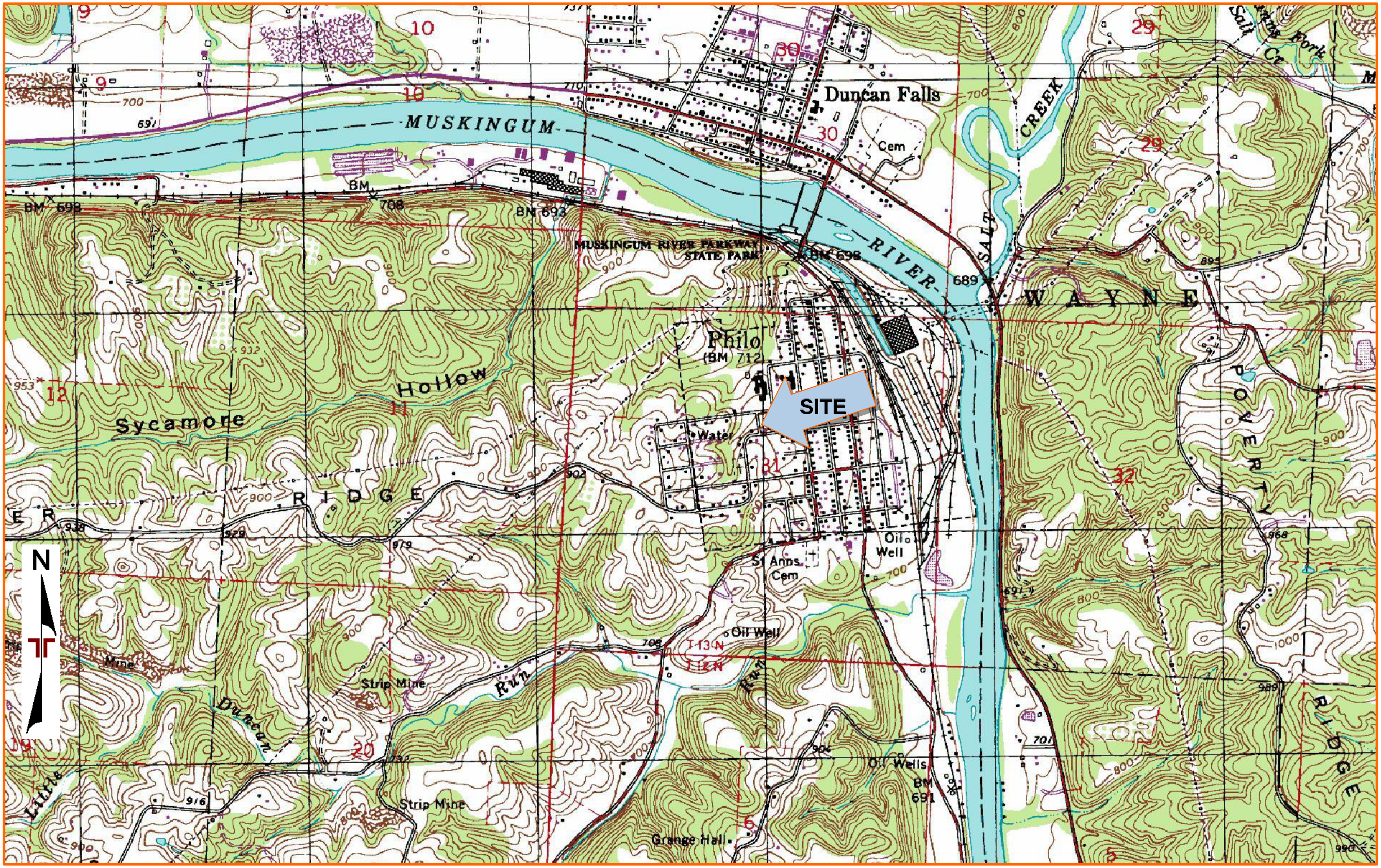


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

TOPOGRAPHIC MAP IMAGE COURTESY OF THE U.S. GEOLOGICAL SURVEY QUADRANGLES INCLUDE: ZANESVILLE EAST, OH (1/1/1994) and PHILO, OH (1/1/1994).

EXPLORATION PLAN

Water Storage Tank ■ Philo, Ohio

November 2, 2018 ■ Terracon Project No. N4185328

Terracon GeoReport

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

AERIAL PHOTOGRAPHY PROVIDED BY MICROSOFT BING MAPS

EXPLORATION AND EXPLORATION RESULTS

EXPLORATION AND TESTING PROCEDURES

Field Exploration

Number of Borings	Boring Depth (feet) [1]	Location
2	48.8 feet	Tank
1. Below existing ground surface		

Boring Layout: Boring locations were located in the field by CT Consultants, and the coordinates presented on our boring logs are based on the surveying information that was subsequently provided. Ground surface elevations at the boring locations are based on the Google Earth™. The coordinates and elevations of the soil boring locations as presented on the boring logs should be considered accurate only to the degree implied by the means and methods used to define them.

Subsurface Exploration Procedures: We advanced soil borings with a CME 55 drill rig using continuous flight hollow-stem augers. For the tank borings four samples were obtained in the upper 10 feet of each boring and at intervals of 5 feet thereafter. Soil sampling was performed using split-barrel sampling procedures. The samples were placed in appropriate containers and taken to our soil laboratory for testing. In addition, we observed and recorded groundwater levels during drilling and sampling.

Our exploration team member prepared field boring logs as part of the drilling operations that includes sampling depths, penetration distances, and other relevant sampling information. Field logs also include visual classifications of materials encountered during drilling, and our interpretation of subsurface conditions between samples. Final boring logs, prepared from field logs, represent the geotechnical engineer's interpretation, and include modifications based on observations and laboratory tests.

Prior to subsurface exploration Terracon made a call to the State 811 services to clear the public utilities at the project site. Also, as requested by the client Terracon hired a third-party subcontractor to locate any private underground utilities nearby the boring locations.

Property Disturbance: We backfilled borings with auger cuttings after completion. Excess auger cuttings were dispersed in the general vicinity of the borehole. Because backfill material often settles below the surface after a period, we recommend that the boreholes be checked periodically and backfilled, if necessary.

BORING LOG NO. B-1

PROJECT: Water Storage Tank

CLIENT: Village of Philo

SITE: Philo, Ohio

LOCATION See Exploration Plan

Latitude: 39.8603° Longitude: -81.9155°

Approximate Surface Elev: 863 (Ft.) +/-

DEPTH	MATERIAL DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI
0.4	**TOPSOIL (4.5")**	862.5+/-							
	LEAN CLAY (CL), trace sand, tace gravel, brown, moist, medium stiff				X	18	2-2-4 N=6	24	37-18-19
3.5		859.5+/-							
	SANDY LEAN CLAY (CL), trace gravel, brown, moist, very stiff, (completely weathered sandstone)		5		X	18	8-9-10 N=19	16	
6.0		857+/-							
	SHALE, completely weathered, soft, brown				X	18	13-20-37 N=57		
					X	18	14-40-50/5"		
			10						
					X	4	50/4"		
13.5		849.5+/-							
	SANDSTONE, very severely weathered, soft, brown		15						
18.5		844.5+/-							
	SHALE, compleletely to very severely weathered, soft, reddish-brown to gray, interbedded with claystone				X	18	6-15-21 N=36		
			20						
					X	12	31-50/6"		
			25						

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

Visual Classification By: M. Evener

Hammer Type: Automatic

Advancement Method:
3.25" HSA

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

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

See Supporting Information for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Dry cave-in @ 42.0 feet

Terracon
800 Morrison Rd
Gahanna, OH

Boring Started: 10-18-2018	Boring Completed: 10-18-2018
Drill Rig: D-50	Driller: T. Graves
Project No.: N4185328	

BORING LOG NO. B-1

PROJECT: Water Storage Tank | **CLIENT: Village of Philo**

SITE: Philo, Ohio

LOCATION See Exploration Plan

Latitude: 39.8603° Longitude: -81.9155°

Approximate Surface Elev: 863 (Ft.) +/-

GRAPHIC LOG	DEPTH / ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI
	SHALE, compleletely to very severely weathered, soft, reddish-brown to gray, interbedded with claystone *(continued)*							
				X	12	24-50/6"		
		30						
				X	6	50/6"		
		35						
				X	6	50/6"		
		40						
			Dry cave-in					
				X	5	50/5"		
		45						
	48.8 — 814+/-			X	4	50/4"		
	Splitspoon refusal at 48.8 Feet							

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

Visual Classification By: M. Evener

Hammer Type: Automatic

Advancement Method:
3.25" HSA

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

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

See Supporting Information for explanation of symbols and abbreviations.

Notes:

Splitspoon refusal @ 48.8'.

WATER LEVEL OBSERVATIONS

No free water observed

Dry cave-in @ 42.0 feet

Terracon
800 Morrison Rd
Gahanna, OH

Boring Started: 10-18-2018	Boring Completed: 10-18-2018
Drill Rig: D-50	Driller: T. Graves
Project No.: N4185328	

BORING LOG NO. B-2

PROJECT: Water Storage Tank

CLIENT: Village of Philo

SITE: Philo, Ohio

LOCATION See Exploration Plan

Latitude: 39.8603° Longitude: -81.9155°

Approximate Surface Elev: 861 (Ft.) +/-

GRAPHIC LOG	DEPTH	Description	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI
	0.3	**TOPSOIL (4.0")**	860.5+/-							
		LEAN CLAY (CL), trace sand, brown, moist, medium stiff				X	18	1-2-4 N=6	21	
	3.5		857.5+/-							
		SANDSTONE, completely weathered, soft, brown		5		X	18	10-14-13 N=27		
	6.0		855+/-							
		SHALE, completely weathered, soft, brown				X	18	19-22-34 N=56		
						X	6	50/6"		
				10						
	13.5		847.5+/-							
		SANDSTONE, completely weathered, soft, brown				X	3	50/3"		
				15						
	18.5		842.5+/-							
		SHALE, very severely to completely weathered, soft, reddish-brown to gray, interbedded with claystone				X	10	17-38-44 N=82		
				20						
						X	18	23-29-35 N=64		
				25						

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

Visual Classification By: M. Evener

Hammer Type: Automatic

Advancement Method:
3.25" HSA

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

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

See Supporting Information for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Dry cave-in @ 46.0 feet

Terracon
800 Morrison Rd
Gahanna, OH

Boring Started: 10-18-2018	Boring Completed: 10-18-2018
Drill Rig: D-50	Driller: T. Graves
Project No.: N4185328	

BORING LOG NO. B-2

PROJECT: Water Storage Tank | **CLIENT: Village of Philo**

SITE: Philo, Ohio

LOCATION See Exploration Plan

Latitude: 39.8603° Longitude: -81.9155°

Approximate Surface Elev: 861 (Ft.) +/-

GRAPHIC LOG	DEPTH / ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI
	SHALE, very severely to completely weathered, soft, reddish-brown to gray, interbedded with claystone *(continued)*							
				X	10	35-50/4"		
		30						
				X	5	50/5"		
		35						
				X	6	50/6"		
		40						
				X	4	50/4"		
		45	Dry cave-in					
	48.8 ... 812+/-			X	4	50/4"		
	Splitspoon refusal at 48.8 Feet							

Stratification lines are approximate. In-situ, the transition may be gradual.
Visual Classification By: M. Evener

Hammer Type: Automatic

Advancement Method:
3.25" HSA

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

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

See Supporting Information for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Dry cave-in @ 46.0 feet

Terracon
800 Morrison Rd
Gahanna, OH

Boring Started: 10-18-2018	Boring Completed: 10-18-2018
Drill Rig: D-50	Driller: T. Graves
Project No.: N4185328	

LABORATORY TEST RESULTS

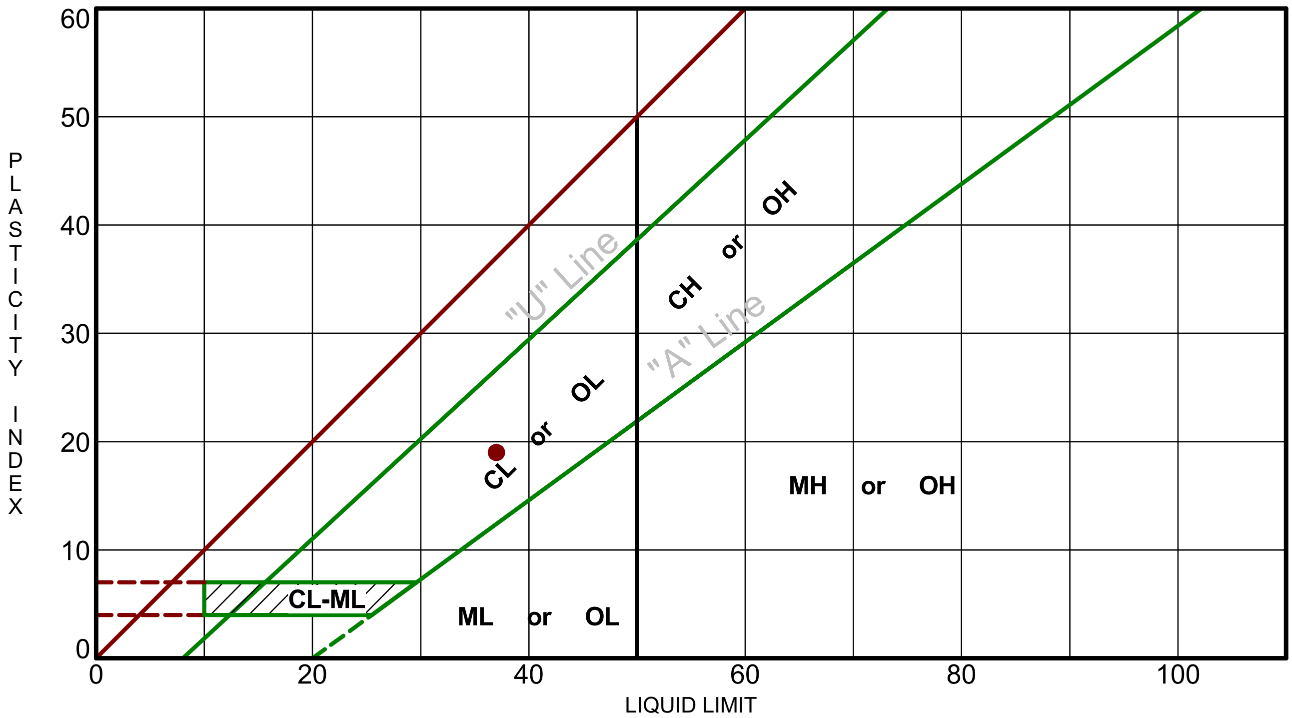
LABORATORY TESTING AND RESULTS

The project engineer reviewed the field data and assigned various laboratory tests to better understand the engineering properties of various soil strata. Our laboratory testing program included examination of soil samples by an engineer. Based on the material's texture and plasticity, we described and classified soil samples in accordance with the Unified Soil Classification System (USCS). The following tests were performed on selected soil samples:

- ASTM D2216 Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
- ASTM D4318 Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils

ATTERBERG LIMITS RESULTS

ASTM D4318



	Boring ID	Depth	LL	PL	PI	Fines	USCS	Description
●	B-1	1 - 2.5	37	18	19			LEAN CLAY

PROJECT: Water Storage Tank	PROJECT NUMBER: N4185328
SITE: Philo, Ohio	CLIENT: Village of Philo

Terracon
800 Morrison Rd
Gahanna, OH

SUPPORTING INFORMATION

GENERAL NOTES

DESCRIPTION OF SYMBOLS AND ABBREVIATIONS

SAMPLING

Rock Core

No Recovery

Split Spoon

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

N	**Standard Penetration Test Resistance (Blows/Ft.)**
(HP)	**Hand Penetrometer**
(T)	**Torvane**
(DCP)	**Dynamic Cone Penetrometer**
UC	**Unconfined Compressive Strength**
(PID)	**Photo-Ionization Detector**
(OVA)	**Organic Vapor Analyzer**

DESCRIPTIVE SOIL CLASSIFICATION

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

LOCATION AND ELEVATION NOTES

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

STRENGTH TERMS

RELATIVE DENSITY OF COARSE-GRAINED SOILS (More than 50% retained on No. 200 sieve.) Density determined by Standard Penetration Resistance		**CONSISTENCY OF FINE-GRAINED SOILS** (50% or more passing the No. 200 sieve.) Consistency determined by laboratory shear strength testing, field visual-manual procedures or standard penetration resistance			**BEDROCK**	
Descriptive Term (Density)	**Standard Penetration or N-Value Blows/Ft.**	**Descriptive Term (Consistency)**	**Unconfined Compressive Strength Qu, (tsf)**	**Standard Penetration or N-Value Blows/Ft.**	**Standard Penetration or N-Value Blows/Ft.**	**Descriptive Term (Consistency)**
Very Loose	0 - 3	Very Soft	less than 0.25	0 - 1	< 20	Weathered
Loose	4 - 9	Soft	0.25 to 0.50	2 - 4	20 - 29	Firm
Medium Dense	10 - 29	Medium Stiff	0.50 to 1.00	4 - 8	30 - 49	Medium Hard
Dense	30 - 50	Stiff	1.00 to 2.00	8 - 15	50 - 79	Hard
Very Dense	> 50	Very Stiff	2.00 to 4.00	15 - 30	>79	Very Hard
		Hard	> 4.00	> 30		

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

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

UNIFIED SOIL CLASSIFICATION SYSTEM

Terracon GeoReport

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests [A]				Soil Classification: Group Symbol	Soil Classification: Group Name [B]
Coarse Grained Soils: More than 50% retained on No. 200 sieve	**Gravels:** More than 50% of coarse fraction retained on No. 4 sieve	**Clean Gravels:** Less than 5% fines [C]	$Cu \geq 4$ 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 $\geq$ 15% sand, add "with sand" to group name.

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

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

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

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

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

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

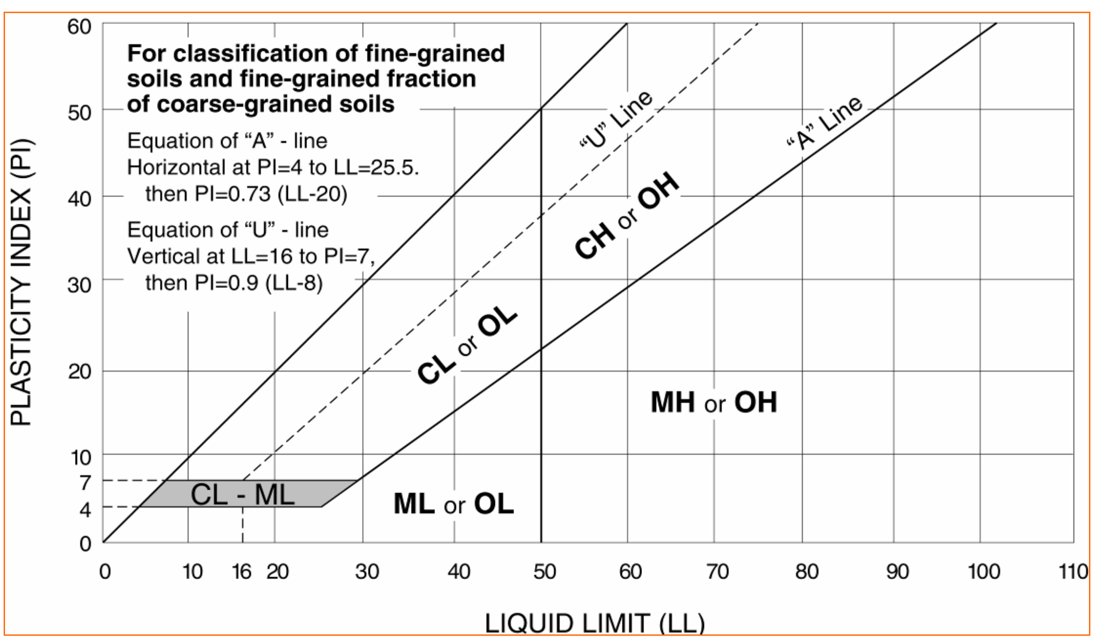
[M] If soil contains $\geq$ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.

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

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

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

[Q] PI plots below "A" line.



DESCRIPTION OF ROCK PROPERTIES

Terracon GeoReport

WEATHERING	
Fresh	Rock fresh, crystals bright, few joints may show slight staining. Rock rings under hammer if crystalline.
Very slight	Rock generally fresh, joints stained, some joints may show thin clay coatings, crystals in broken face show bright. Rock rings under hammer if crystalline.
Slight	Rock generally fresh, joints stained, and discoloration extends into rock up to 1 in. Joints may contain clay. In granitoid rocks some occasional feldspar crystals are dull and discolored. Crystalline rocks ring under hammer.
Moderate	Significant portions of rock show discoloration and weathering effects. In granitoid rocks, most feldspars are dull and discolored; some show clayey. Rock has dull sound under hammer and shows significant loss of strength as compared with fresh rock.
Moderately severe	All rock except quartz discolored or stained. In granitoid rocks, all feldspars dull and discolored and majority show kaolinization. Rock shows severe loss of strength and can be excavated with geologist's pick.
Severe	All rock except quartz discolored or stained. Rock "fabric" clear and evident, but reduced in strength to strong soil. In granitoid rocks, all feldspars kaolinized to some extent. Some fragments of strong rock usually left.
Very severe	All rock except quartz discolored or stained. Rock "fabric" discernible, but mass effectively reduced to "soil" with only fragments of strong rock remaining.
Complete	Rock reduced to "soil". Rock "fabric" no discernible or discernible only in small, scattered locations. Quartz may be present as dikes or stringers.

HARDNESS (for engineering description of rock – not to be confused with Moh's scale for minerals)	
Very hard	Cannot be scratched with knife or sharp pick. Breaking of hand specimens requires several hard blows of geologist's pick.
Hard	Can be scratched with knife or pick only with difficulty. Hard blow of hammer required to detach hand specimen.
Moderately hard	Can be scratched with knife or pick. Gouges or grooves to ¼ in. deep can be excavated by hard blow of point of a geologist's pick. Hand specimens can be detached by moderate blow.
Medium	Can be grooved or gouged 1/16 in. deep by firm pressure on knife or pick point. Can be excavated in small chips to pieces about 1-in. maximum size by hard blows of the point of a geologist's pick.
Soft	Can be gouged or grooved readily with knife or pick point. Can be excavated in chips to pieces several inches in size by moderate blows of a pick point. Small thin pieces can be broken by finger pressure.
Very soft	Can be carved with knife. Can be excavated readily with point of pick. Pieces 1-in. or more in thickness can be broken with finger pressure. Can be scratched readily by fingernail.

Joint, Bedding, and Foliation Spacing in Rock [1]

Spacing	Joints	Bedding/Foliation
Less than 2 in.	Very close	Very thin
2 in. – 1 ft.	Close	Thin
1 ft. – 3 ft.	Moderately close	Medium
3 ft. – 10 ft.	Wide	Thick
More than 10 ft.	Very wide	Very thick

1. Spacing refers to the distance normal to the planes, of the described feature, which are parallel to each other or nearly so.

Rock Quality Designator (RQD) [1]

RQD, as a percentage	Diagnostic description
Exceeding 90	Excellent
90 – 75	Good
75 – 50	Fair
50 – 25	Poor
Less than 25	Very poor

1. RQD (given as a percentage) = length of core in pieces 4 inches and longer / length of run

Joint Openness Descriptors

Openness	Descriptor
No Visible Separation	Tight
Less than 1/32 in.	Slightly Open
1/32 to 1/8 in.	Moderately Open
1/8 to 3/8 in.	Open
3/8 in. to 0.1 ft.	Moderately Wide
Greater than 0.1 ft.	Wide

References: American Society of Civil Engineers. Manuals and Reports on Engineering Practice - No. 56. Subsurface Investigation for Design and Construction of Foundations of Buildings. New York: American Society of Civil Engineers, 1976. U.S. Department of the Interior, Bureau of Reclamation, Engineering Geology Field Manual.