# GEOTECHNICAL ENGINEERING REPORT
# UPPER EAST TANK
# PUMP HOUSE
# AZTEC, NEW MEXICO

Submitted To:


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Submitted By:


**GEOMAT Inc.**
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March 27, 2019
GEOMAT Project 192-3241

GEOMAT INC.
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March 27, 2019

**R. Clayton Harrison, P.E.**
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RE: Geotechnical Engineering Report
Upper East Tank Pump House
Aztec, New Mexico
GEOMAT Project No. 192-3241

GEOMAT Inc. (GEOMAT) has completed the geotechnical engineering exploration for the proposed Pump House project to be located along NM Highway 173 approximately 3.2 miles southeast of the water plant in San Juan County, New Mexico. This study was performed in general accordance with our Proposal No. 182-09-13, dated September 21, 2018.

The results of our engineering study, including the geotechnical recommendations, site plan, boring records, and laboratory test results are attached. Based on the geotechnical engineering analyses, subsurface exploration and laboratory test results, the proposed pump station could be supported on either a shallow rib foundation bearing on bedrock with suspended floors or a structural slab foundation bearing on compacted native soils. Other design and construction details, based upon geotechnical conditions, are presented in the report.

We have appreciated being of service to you in the geotechnical engineering phase of this project. If you have any questions concerning this report, please contact us.

Sincerely yours,
GEOMAT Inc.

Seth D. Yokel
Staff Geologist

MATTHEW J. CRAMER
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Matthew J. Cramer, P.E.
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**GEOTECHNICAL ENGINEERING REPORT**
**UPPER EAST TANK**
**PUMP HOUSE**
**AZTEC, NEW MEXICO**
**GEOMAT PROJECT NO. 192-3241**

## INTRODUCTION

This report contains the results of our geotechnical engineering exploration for the proposed Pump House project to be located along NM Highway 173 approximately 3.2 miles southeast of the water plant in San Juan County, New Mexico, as shown on the Site Plan in Appendix A of this report.

The purpose of these services is to provide information and geotechnical engineering recommendations about:

- subsurface soil conditions
- groundwater conditions
- lateral soil pressures
- earthwork
- foundation design and construction
- slab design and construction
- drainage

The opinions and recommendations contained in this report are based upon the results of field and laboratory testing, engineering analyses, and experience with similar soil conditions, structures, and our understanding of the proposed project as stated below.

## PROPOSED CONSTRUCTION

We understand the proposed pump house will be located on the southwest corner of the existing tank site and will consist of a single level pre-engineered metal building with plan dimensions of 20 feet by 30 feet. We anticipate the maximum wall and column loads to be on the order of 200 plf and 10 kips, respectively. We understand that no basements or below grade structures are planned and that no significant cuts or fills will be required to achieve final site grades.

## SITE EXPLORATION

Our scope of services performed for this project included a site reconnaissance by a staff geologist, a subsurface exploration program, laboratory testing and engineering analyses.

### Field Exploration:

Subsurface conditions at the site were explored on March 15, 2019 by drilling one exploratory boring at the approximate location shown on the Site Plan in Appendix A. Boring B-1 was drilled to a depth of approximately 16 feet below existing ground surface within the footprint of the proposed pump house.

The boring was advanced using a CME-55 truck-mounted drill rig with continuous-flight, 7.25-inch O.D. hollow-stem auger. The borings were continuously monitored by a geologist from our office who examined and classified the subsurface materials encountered, obtained representative samples, observed groundwater conditions, and maintained a continuous log of each boring.

Soil samples were obtained from the borings using a combination of standard 2-inch O.D. split spoon and 3-inch O.D. modified California ring barrel samplers. The samplers were driven using a 140-pound hammer falling 30 inches. The standard penetration resistance was determined by recording the number of hammer blows required to advance the sampler in six-inch increments. Representative bulk samples of subsurface materials were also obtained.

Groundwater evaluations were made in each boring at the time of site exploration. Soils were classified in accordance with the Unified Soil Classification System described in Appendix A. Boring logs were prepared and are presented in Appendix A.

### Laboratory Testing:

Samples retrieved during the field exploration were transported to our laboratory for further evaluation. At that time, the field descriptions were confirmed or modified as necessary, and laboratory tests were performed to evaluate the engineering properties of the subsurface materials.

## SITE CONDITIONS

The site of the proposed Pump House is located approximately 3 miles east on NM Highway 173 from its intersection with US Highway 550. The proposed location for the pump house is within an existing fenced-in tank site. The pump house boring was located in the southeast corner of the tank site approximately 60 feet away from the existing tank. Along with the existing tank, there are numerous utility and grounding lines throughout the site. The ground surface across the site was relatively flat with little to no vegetation within the fenced area. The following photograph depicts the site at the time of our exploration.

**Drill Rig at Boring B-1**
**View to the North**

## SUBSURFACE CONDITIONS

### Soil Conditions:

As presented on the Boring Log in Appendix A, we encountered clay soils from the ground surface to an approximate depth of 1½ feet below the existing ground surface (bgs). The soils then transition into sandy soils which extend to a depth of approximately 3½ feet bgs. The sandy soils were generally fine- to coarse-grained and loose. Below the sandy soils, we encountered shale and siltstone bedrock to the total depth explored (16 feet).

### Groundwater Conditions:

Groundwater was not encountered in the borings to the depths explored. Groundwater elevations can fluctuate over time depending upon precipitation, irrigation, runoff and infiltration of surface water. We do not have any information regarding the historical fluctuation of the groundwater level in this vicinity.

**Laboratory Test Results:**

Laboratory analyses of a sample tested indicate the clayey soil has a fines content (silt- and/or clay-sized particles passing the U.S. No. 200 sieve) of approximately 58 percent with a plasticity index of 16. The in-place dry density of a sample of the shale bedrock was found to be 112 pounds per cubic foot (pcf), with a natural moisture content of 18 percent.

Results of all laboratory tests are presented in Appendix B.

## OPINIONS AND RECOMMENDATIONS

**Geotechnical Considerations:**

The site is considered suitable for the proposed pump house based on the geotechnical conditions encountered and tested for this report. However, the shale bedrock below the proposed building is expansive. If these shale rock experienced an increase in moisture content, it is anticipated that it could expand (swell), resulting in heaving of conventional shallow foundations and slabs on grade. To reduce the potential for heaving and distress to the building, it is anticipated that the structure would be supported on either a shallow rib foundation bearing on bedrock with suspended floors or a structural slab foundation bearing on compacted native soils.

Deep foundations systems, such as drilled piers and suspended floors, which would limit the potential for building movements, were considered for the project. However, these systems were not considered economical for the project. Recommendations for deep foundations can be given upon request.

It is of utmost importance to implement measures to prevent moisture from infiltrating into the supporting soils. The areas surrounding the building should be paved, have concrete sidewalks, or be graded to ensure that surface water drains quickly away. Roof drains should discharge water a minimum of 10 feet away from the perimeter of the building. Consideration should be given to providing flexible connections in plumbing lines capable of tolerating building movement should the underlying rock become wetted.

Buried utilities, including gas, electric, water, and communications, are known to exist in close proximity to the proposed pump house, therefore, care should be taken during excavation procedures.

If there are any significant deviations from the assumed base elevations, structure locations and/or loads noted at the beginning of this report, the opinions and recommendations of this report should be reviewed and confirmed/modified as necessary to reflect the final planned design conditions.

**Foundations:**

*Structural Slab Foundation:*

Based on our understanding of the type of structure to be built and the results of our field subsurface exploration and laboratory testing, the pump house could be founded on a structural mat foundation on compacted native soils. Compaction criteria for the soils that will support the structures should be as recommended in the Earthwork section of this report. Adequate surface drainage should be provided to prevent the supporting and backfill soils from undergoing significant moisture changes.

The structural mat (slab) foundation should be designed by the Structural Engineer to tolerate potential movement of the foundation soils/rock. The structural reinforced slab foundations should bear on subgrade soils that are moisture conditioned to near optimum moisture and compacted as necessary to bring the upper one (1.0) foot to a minimum of 95 percent relative compaction. Relative compaction everywhere in this report and its appendices refers to the in-place dry density of a soil expressed as a percentage of the maximum dry density of the same material as determined in the laboratory according to ASTM D698 (Standard Proctor) test procedures. Also, we recommend that the perimeter edges of the slabs be "turned down" to a depth of at least 18 inches below adjacent grade.

A maximum allowable bearing value of 1,000 psf may be used for the structurally reinforced slab foundation system bearing on compacted subgrade. A modulus of elasticity value of 2,500 pounds per square inch would be appropriate of the general site soil conditions. A coefficient of subgrade reaction ($K_{V1}$) of 200 kips per cubic foot (kcf) is appropriate for the subgrade. This coefficient can be corrected to account for the width (b) of the slab using the following equation:

$$K = K_{V1}\ ((b+1)/(2b))^2$$

The structurally reinforced slab resting on properly prepared subgrade should be designed to tolerate a movement of approximately one inch. For soils under normal conditions, an estimated differential soil movement ($Y_m$) of approximately half the total movement should be used for design. A slab subgrade friction coefficient of 0.70 is appropriate for a structural reinforced foundation resting on compacted subgrade. This value may be increased to 1.0 for a foundation resting on an aggregate base course or granular base course, such as might be used to provide a capillary moisture break.

The estimated differential soil movement outlined above is based on normal climate conditions. Additional movements are possible if the foundation soils are infiltrated by moisture due to concentrated surface storm water, inadequate site drainage, water line or utility pipe leaks, landscape irrigation line leaks, excessive irrigation, etc. Proper drainage should be provided in the final design and during construction and areas adjacent to the structure should be designed to prevent water from ponding or accumulating next to the structures.

*Shallow Rib Foundation with Suspended Floors:*

Based on our understanding of the type of structure to be built and the results of our field subsurface exploration and laboratory testing, the building could be supported on a shallow rib foundation bearing on formational bedrock. A system of continuous concrete spread-type footings, or "ribs", would serve as grade beams to support a suspended structural floor.

We recommend that exterior load-bearing ribs should bear a minimum of 12 inches into competent formational rock. Interior ribs (if required) should bear a minimum of 6 inches into competent rock. A minimum 6-inch void space should be provided between the top of the existing native soil and the bottom of the suspended floor. The ribs should be extended as necessary to achieve the recommended penetration into competent rock. A representative of GEOMAT should observe the footing excavations prior to placing concrete and/or reinforcing steel to verify that the footings extend the recommended distance into competent rock.

The ribs and suspended floor should be designed by the project Structural Engineer. The recommended allowable bearing pressure for continuous footings bearing a minimum of 6 inches into formational rock is 10,000 psf.

Total and differential settlements resulting from the assumed structural loads are estimated to be on the order of ½ inch or less. Proper drainage is of paramount importance and should be provided in the final design and during construction and areas adjacent to the structure should be designed to prevent water from ponding or accumulating next to the structure.

*Settlements and Slopes*

Total and differential settlements should not exceed predicted values, provided that:

- Foundations are constructed as recommended, and
- Essentially no changes occur in water contents of foundation soils.

For foundations adjacent to descending slopes, a minimum horizontal setback of five (5) feet should be maintained between the foundation base and slope face. In addition, the setback should be such that an imaginary line extending downward at 45 degrees from the nearest foundation edge does not intersect the slope.

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

**Site Classification:**

Based on the subsurface conditions encountered in the borings, we estimate that Site Class B is appropriate for the site according to Table 20.3-1 of the ASCE 7-10 Standard in accordance with the 2015 International Building Code. This parameter was estimated based on extrapolation of data beyond the deepest depth explored, using methods allowed by the code. Actual shear wave velocity testing/analysis and/or exploration to a depth of 100 feet were not performed as part of our scope of services for this project.

**Lateral Earth Pressures:**

For soils above any free water surface, recommended equivalent fluid pressures for unrestrained foundation elements are presented in the following table:

- **Active:**
  Granular soil backfill ................................................ 35 psf/ft
  Undisturbed subsoil ..................................................30 psf/ft

- **Passive:**
  Shallow foundation walls ..........................................250 psf/ft
  Shallow column footings...................……….........350 psf/ft

- **Coefficient of base friction**: ...............................................0.40
  The coefficient of base friction should be reduced to 0.30 when used in conjunction with passive pressure.

Where the design includes restrained elements, the following equivalent fluid pressures are recommended:

- **At rest:**
  Granular soil backfill ........................................................50 psf/ft
  Undisturbed subsoil...........................................................60 psf/ft

Fill against grade beams and retaining walls should be compacted to densities specified in **Earthwork**. Medium to high plasticity clay soils should not be used as backfill against retaining walls. Compaction of each lift adjacent to walls should be accomplished with hand-operated tampers or other lightweight compactors. Over compaction may cause excessive lateral earth pressures that could result in wall movement.

**Slopes**:

Assuming fill specifications, compaction requirements, and recommended setbacks provided in this report are followed, cut and fill slopes as steep as to 2.5:1 (horizontal:vertical) should be stable. Depending upon specific project conditions, adequate factors of safety against slope failure may be available for steeper configurations. However, such a determination would require additional analysis.

**Earthwork:**

**General Considerations:**

The opinions contained in this report for the proposed construction are contingent upon compliance with recommendations presented in this section. Although underground facilities such as foundations, septic tanks, cesspools, basements and irrigation systems were not encountered during site reconnaissance, such features could exist and might be encountered during construction.

**Site Clearing:**

1. Strip and remove all existing pavement, fill, debris and other deleterious materials from the proposed building area. Any existing structures should be completely removed from below any building, including foundation elements and any associated development such as underground utilities, septic tanks, etc. All exposed surfaces below footings and slabs should be free of mounds and depressions which could prevent uniform compaction.

2. If unexpected fills or underground facilities are encountered during site clearing, we should be contacted for further recommendations. All excavations should be observed by GEOMAT prior to backfill placement.

3. Stripped materials consisting of vegetation and organic materials should be removed from the site, or used to re-vegetate exposed slopes after completion of grading operations. If it is necessary to dispose of organic materials on-site, they should be placed in non-structural areas, and in fill sections not exceeding 5 feet in height.

4. Sloping areas steeper than 5:1 (horizontal:vertical) should be benched to reduce the potential for slippage between existing slopes and fills. Benches should be level and wide enough to accommodate compaction and earth moving equipment.

5. All exposed areas which will receive fill, once properly cleared and benched where necessary, should be scarified to a minimum depth of eight inches, conditioned to near optimum moisture content, and compacted to at least 95% of standard proctor (ASTM D698).

**Excavation:**

1. We present the following general comments regarding our opinion of the excavation conditions for the designers' information with the understanding that they are opinions based on our boring data. More accurate information regarding the excavation conditions should be evaluated by contractors or other interested parties from test excavations using the equipment that will be used during construction. Based on our subsurface evaluation it appears that excavations in soils at the site will be possible using standard excavation equipment.

2. On-site soils may pump or become unstable or unworkable at high water contents, especially for excavations near and below the water table. Dewatering may be necessary to achieve a stable excavation. Workability may be improved by scarifying and drying. Over-excavation of wet zones and replacement with granular materials may be necessary. Lightweight excavation equipment may be required to reduce subgrade pumping.

**Foundation Preparation:**

Footings should bear on compacted subgrade as recommended in the **Foundations** section of this report. All loose and/or disturbed soils should either be compacted or removed from the bottoms of footing excavations prior to placement of reinforcing steel and/or concrete.

**Fill Materials:**

1. If required, native or imported soils with low expansive potentials could be used as fill material for the following:
   - general site grading
   - foundation areas
   - exterior slab areas
   - foundation backfill

2. Select granular materials should be used as backfill behind walls that retain earth.

3. If required, on site or imported soils to be used in structural fills (not including base course) should conform to the following:

| **Gradation** | **Percent finer by weight (ASTM C136)** |
|---|---|
| 3" | 100 |
| No. 4 Sieve | 50-100 |
| No. 200 Sieve | 50 Max |

Maximum expansive potential (%)* ....................................................1.5

* Measured on a sample compacted to approximately 95 percent of the ASTM D698 maximum dry density at about 3 percent below optimum water content. The sample is confined under a 144-psf surcharge and submerged.

4. As required, aggregate base should conform to Type I Base Course as specified in Section 303 of the 2014 New Mexico Department of Transportation (NMDOT) *"Standard Specifications for Road and Bridge Construction."*

**Placement and Compaction:**

1. Place and compact fill and base course in horizontal lifts, using equipment and procedures that will produce recommended moisture contents and densities throughout the lift.

2. Un-compacted fill and base course lifts should not exceed 10 inches loose thickness.

3. Materials should be compacted to the following:

| Material | Minimum Percent (ASTM D698) |
|---|---|
| Subgrade soils beneath building areas | 95 |
| On site or imported soil fills (if required): | |
| Beneath footings and slabs | 95 |
| Aggregate base beneath slabs | 95 |
| Miscellaneous backfill | 90 |

4. On-site and imported soils should be compacted at moisture contents near optimum.

**Compliance:**

Recommendations for foundation elements supported on compacted fills depend upon compliance with **Earthwork** recommendations. To assess compliance, observation and testing should be performed by GEOMAT.

**Drainage:**

**Surface Drainage:**

1. Positive drainage should be provided during construction and maintained throughout the life of the proposed project. Infiltration of water into utility or foundation excavations must be prevented during construction. Surface features that could retain water in areas adjacent to the structure should be sealed or eliminated.

2. In areas where sidewalks or paving do not immediately adjoin the structure, we recommend that protective slopes be provided with a minimum grade of approximately 5 percent for at least 10 feet from perimeter walls. Backfill against footings, exterior walls, and in utility and sprinkler line trenches should be well compacted and free of all construction debris to reduce the possibility of moisture infiltration.

3. Downspouts, roof drains or scuppers should discharge into splash blocks or extensions when the ground surface beneath such features is not protected by exterior slabs or paving.

**Subsurface Drainage:**

Free-draining, granular soils containing less than five percent fines (by weight) passing a No. 200 sieve should be placed adjacent to walls which retain earth. A drainage system consisting of either weep holes or perforated drain lines (placed near the base of the wall) should be used to intercept and discharge water which would tend to saturate the backfill. Where used, drain lines should be embedded in a uniformly graded filter material and provided with adequate clean-outs for periodic maintenance. An impervious soil should be used in the upper layer of backfill to reduce the potential for water infiltration.

## GENERAL COMMENTS

It is recommended that GEOMAT be retained to provide a general review of final design plans and specifications in order to confirm that grading and foundation recommendations in this report have been interpreted and implemented. In the event that any changes of the proposed project are planned, the opinions and recommendations contained in this report should be reviewed and the report modified or supplemented as necessary.

GEOMAT should also be retained to provide services during excavation, grading, foundation, and construction phases of the work. Observation of footing excavations should be performed prior to placement of reinforcing and concrete to confirm that satisfactory bearing materials are present and is considered a necessary part of continuing geotechnical engineering services for the project. Construction testing, including field and laboratory evaluation of fill, backfill, pavement materials, concrete and steel should be performed to determine whether applicable project requirements have been met.

The analyses and recommendations in this report are based in part upon data obtained from the field exploration. The nature and extent of variations beyond the location of test borings may not become evident until construction. If variations then appear evident, it may be necessary to re-evaluate the recommendations of this report.

Our professional services were performed using that degree of care and skill ordinarily exercised, under similar circumstances, by reputable geotechnical engineers practicing in this or similar localities at the same time. No warranty, express or implied, is intended or made. We prepared the report as an aid in design of the proposed project. This report is not a bidding document. Any contractor reviewing this report must draw his own conclusions regarding site conditions and specific construction equipment and techniques to be used on this project.

This report is for the exclusive purpose of providing geotechnical engineering and/or testing information and recommendations. The scope of services for this project does not include, either specifically or by implication, any environmental assessment of the site or identification of contaminated or hazardous materials or conditions. If the owner is concerned about the potential for such contamination, other studies should be undertaken. This report has also not addressed any geologic hazards that may exist on or near the site.

This report may be used only by the Client and only for the purposes stated, within a reasonable time from its issuance. Land use, site conditions (both on and off site), or other factors may change over time and additional work may be required with the passage of time. Any party, other than the Client, who wishes to use this report, shall notify GEOMAT in writing of such intended use. Based on the intended use of the report, GEOMAT may require that additional work be performed and that an updated report be issued. Non-compliance with any of these requirements, by the Client or anyone else, will release GEOMAT from any liability resulting from the use of this report by an unauthorized party.

# Appendix A


Approximate

Not to Scale

| SITE PLAN | PROJECT | |
|---|---|---|
| Boring Locations (approximate) | Upper East Tank Pump House<br>Aztec, New Mexico | GEOMAT INC. |
| GEOMAT Project No. 192-3241<br>Date of Exploration: March 15, 2019 | | |

# Borehole B-1

GEOMAT INC.

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Farmington, NM 87401
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| | | | |
|---|---|---|---|
| Project Name: | Upper East Tank Pump House | Date Drilled: | 3/15/2019 |
| Project Number: | 192-3241 | Latitude: | Not Determined |
| Client: | CHC Engineers, LLC | Longitude: | Note Determined |
| Site Location: | Aztec, New Mexico | Elevation: | Not Determined |
| Rig Type: | CME - 55 | Boring Location: | See Site Plan |
| Drilling Method: | 7.25" O.D. Hollow Stem Auger | Groundwater Depth: | None Encountered |
| Sampling Method: | Ring and Split spoon samples | Logged By: | SY |
| Hammer Weight: | 140 lbs | Remarks: | None |
| Hammer Fall: | 30 inches | | |

| Laboratory Results | | | | Blows per 6" | Sample Type & Length (in) | Symbol | Material Type | Soil Symbol | Depth (ft) | Soil Description |
|---|---|---|---|---|---|---|---|---|---|---|
| Dry Density (pcf) | % Passing #200 Sieve | Plasticity Index | Moisture Content (%) | | | | | | | |
| | 58 | 16 | | | A | | CL | | 0–1.5 | Sandy Lean CLAY, brown/gray, moist |
| | | | | 4-4-9 | A, R | | SC | | 1.5–3.5 | Clayey SAND, brown, fine- to coarse-grained, loose, damp to moist |
| 112.4 | | | 17.7 | 14-32-47 | R | | RK | | 3.5–9 | SHALE, gray/brown, damp, slightly fissile/friable |
| | | | | 11-27-50/6" | SS | | RK | | 9–12.5 | SILTSTONE, gray/green/brown, slightly damp |
| | | | | 20-50/5" | R | | RK | | 12.5–16 | SHALE, gray/brown, damp, slightly fissile/friable |
| | | | | | | | | | 16 | Total Depth 16 feet |

A = Auger Cuttings R = Ring-Lined Barrel Sampler SS = Split Spoon GRAB = Manual Grab Sample D = Disturbed Bulk Sample

| UNIFIED SOIL CLASSIFICATION SYSTEM | | | | |
|---|---|---|---|---|
| Major Divisions | | | Group Symbols | Typical Names |
| **Coarse-Grained Soils** More than 50% retained on No. 200 sieve | **Gravels** 50% or more of coarse fraction retained on No. 4 sieve | Clean Gravels | GW | Well-graded gravels and gravel-sand mixtures, little or no fines |
| | | | GP | Poorly graded gravels and gravel-sand mixtures, little or no fines |
| | | Gravels with Fines | GM | Silty gravels, gravel-sand-silt mixtures |
| | | | GC | Clayey gravels, gravel-sand-clay mixtures |
| | **Sands** More than 50% of coarse fraction passes No. 4 sieve | Clean Sands | SW | Well-graded sands and gravelly sands, little or no fines |
| | | | SP | Poorly graded sands and gravelly sands, little or no fines |
| | | Sands with Fines | SM | Silty sands, sand-silt mixtures |
| | | | SC | Clayey sands, sand-clay mixtures |
| **Fine-Grained Soils** 50% or more passes No. 200 sieve | **Silts and Clays** Liquid Limit 50 or less | | ML | Inorganic silts, very fine sands, rock flour, silty or clayey fine sands |
| | | | CL | Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays |
| | | | OL | Organic silts and organic silty clays of low plasticity |
| | **Silts and Clays** Liquid Limit greater than 50 | | MH | Inorganic silts, micaceous or diatomaceous free sands or silts, elastic silts |
| | | | CH | Inorganic clays of high plasticity, fat clays |
| | | | OH | Organic clays of medium to high plasticity |
| Highly Organic Soils | | | PT | Peat, mucic & other highly organic soils |

CONSISTENCY OR RELATIVE DENSITY CRITERIA

Standard Penetration Test
Density of Granular Soils

| Penetration Resistance, N (blows/ft.) | Relative Density |
|---|---|
| 0-4 | Very Loose |
| 5-10 | Loose |
| 11-30 | Medium Dense |
| 31-50 | Dense |
| >50 | Very Dense |

Standard Penetration Test
Density of Fine-Grained Soils

| Penetration Resistance, N (blows/ft.) | Consistency | Unconfined Compressive Strength (Tons/ft2) |
|---|---|---|
| <2 | Very Soft | <0.25 |
| 2-4 | Soft | 0.25-0.50 |
| 4-8 | Firm | 0.50-1.00 |
| 8-15 | Stiff | 1.00-2.00 |
| 15-30 | Very Stiff | 2.00-4.00 |
| >30 | Hard | >4.0 |

U.S. Standard Sieve Sizes

>12" 12" 3" 3/4" #4 #10 #40 #200

| Boulders | Cobbles | Gravel | | Sand | | | Silt or Clay |
|---|---|---|---|---|---|---|---|
| | | coarse | fine | coarse | medium | fine | |

MOISTURE CONDITIONS

| | |
|---|---|
| Dry | Absence of moist, dusty, dry to the touch |
| Slightly Damp | Below optimum moisture content for compaction |
| Moist | Near optimum moisture content, will moisten the hand |
| Very Moist | Above optimum moisture content |
| Wet | Visible free water, below water table |

MATERIAL QUANTITY

| | |
|---|---|
| trace | 0-5% |
| few | 5-10% |
| little | 10-25% |
| some | 25-45% |
| mostly | 50-100% |

OTHER SYMBOLS

R Ring Sample
S SPT Sample
B Bulk Sample
▼ Ground Water

BASIC LOG FORMAT:
Group name, Group symbol, (grain size), color, moisture, consistency or relative density. Additional comments: odor, presence of roots, mica, gypsum, coarse particles, etc.

EXAMPLE:
SILTY SAND w/trace silt (SM-SP), Brown, loose to med. Dense, fine to medium grained, damp

# UNIFIED SOIL CLASSIFICATION SYSTEM

## TEST DRILLING EQUIPMENT & PROCEDURES

### Description of Subsurface Exploration Methods

**Drilling Equipment** – Truck-mounted drill rigs powered with gasoline or diesel engines are used in advancing test borings. Drilling through soil or softer rock is performed with hollow-stem auger or continuous flight auger. Carbide insert teeth are normally used on bits to penetrate soft rock or very strongly cemented soils which require blasting or very heavy equipment for excavation. Where refusal is experienced in auger drilling, the holes are sometimes advanced with tricone gear bits and NX rods using water or air as a drilling fluid.

**Sampling Procedures** - Dynamically driven tube samples are usually obtained at selected intervals in the borings by the ASTM D1586 test procedure. In most cases, 2" outside diameter, 1 3/8" inside diameter, samplers are used to obtain the standard penetration resistance. "Undisturbed" samples of firmer soils are often obtained with 3" outside diameter samplers lined with 2.42" inside diameter brass rings. The driving energy is generally recorded as the number of blows of a 140-pound, 30-inch free fall drop hammer required to advance the samplers in 6-inch increments. These values are expressed in blows per foot on the boring logs. However, in stratified soils, driving resistance is sometimes recorded in 2- or 3-inch increments so that soil changes and the presence of scattered gravel or cemented layers can be readily detected and the realistic penetration values obtained for consideration in design. "Undisturbed" sampling of softer soils is sometimes performed with thin-walled Shelby tubes (ASTM D1587). Tube samples are labeled and placed in watertight containers to maintain field moisture contents for testing. When necessary for testing, larger bulk samples are taken from auger cuttings. Where samples of rock are required, they are obtained by NX diamond core drilling (ASTM D2113).

**Boring Records** - Drilling operations are directed by our field engineer or geologist who examines soil recovery and prepares boring logs. Soils are visually classified in accordance with the Unified Soil Classification System (ASTM D2487), with appropriate group symbols being shown on the logs.

# Appendix B

| LAB NO. | BORING NO. | DEPTH FT. | ASTM D698 | | MOISTURE CONT. (%) | DENSITY | | ATTERBERG LIMITS | | | SWELL (%) | CONSOL TEST | % PASS #200 SIEVE | CLASSIFICATION |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Density | Moisture | | WET (pcf) | DRY (pcf) | LL | PL | PI | | | | |
| 7858 | B-1 | 0 - 1.0 | - | - | - | - | - | 33 | 17 | 16 | - | - | 58 | Sandy Lean **CLAY** (CL) |
| 7859 | B-1 | 5.0 | - | - | 17.7 | 132.3 | 112.4 | - | - | - | - | Attached | - | **SHALE** (RK) |

GEOMAT INC.

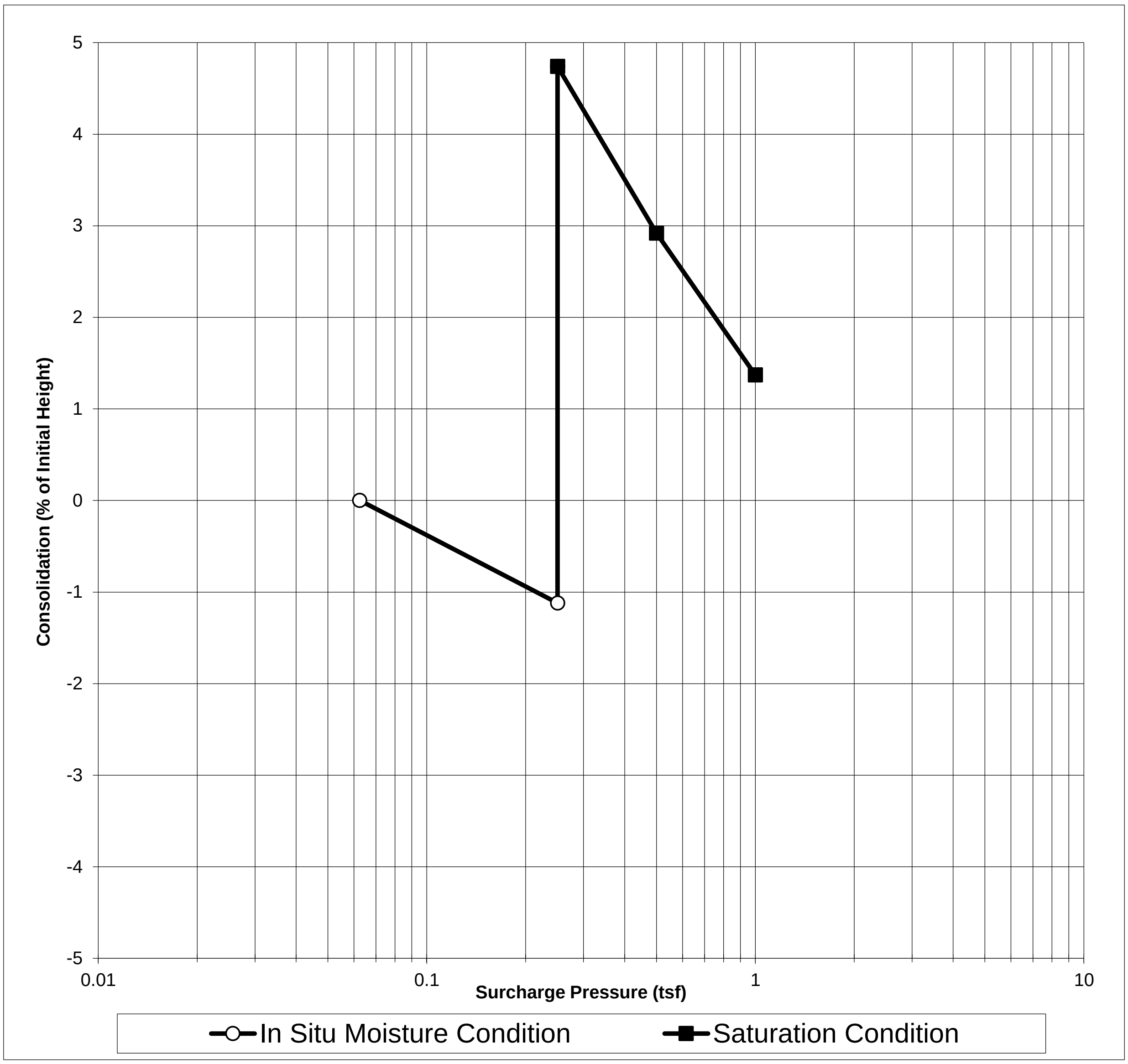
**SUMMARY OF SOIL TESTS**

| | |
|---|---|
| Project | Upper East Tank Pump House |
| Job No. | 192-3241 |
| Location | Aztec, New Mexico |
| Date Drilled | 3/15/2019 |

| | | | |
|---|---|---|---|
| **PROJECT:** | Upper East Tank Pump House | **JOB NO:** | 192-3241 |
| **CLIENT:** | CHC Engineers, LLC | **WORK ORDER NO:** | NA |
| **MATERIAL:** | Shale (RK) | **LAB NO:** | 7859 |
| **SAMPLE SOURCE:** | B-1 @ 5' | **DATE SAMPLED:** | 3/15/2019 |
| **SAMPLE PREP.:** | In Situ | **SAMPLED BY:** | SY |

**ONE-DIMENSIONAL CONSOLIDATION PROPERTIES OF SOILS (ASTM D2435)**

| | | | |
|---|---|---|---|
| INITIAL VOLUME (cu.in) | 4.60 | FINAL VOLUME (cu.in) | 4.67 |
| INITIAL MOISTURE CONTENT | 17.7% | FINAL MOISTURE CONTENT | 20.5% |
| INITIAL DRY DENSITY(pcf) | 112.4 | FINAL DRY DENSITY(pcf) | 110.3 |
| INITIAL DEGREE OF SATURATION | 69% | FINAL DEGREE OF SATURATION | 77% |
| INITIAL VOID RATIO | 0.48 | FINAL VOID RATIO | 0.50 |
| ESTIMATED SPECIFIC GRAVITY | 2.651 | SATURATED AT | 0.25 tsf |



## LABORATORY TESTING PROCEDURES

**Consolidation Tests:** One-dimensional consolidation tests are performed using “Floating-ring” type consolidometers. The test samples are approximately 2.5 inches in diameter and 1.0 inch high and are usually obtained from test borings using the dynamically-driven ring samplers. Test procedures are generally as outlined in ASTM D2435. Loads are applied in several increments to the upper surface of the test specimen and the resulting deformations are recorded at selected time intervals for each increment. Samples are normally loaded in the in-situ moisture conditions to loads which approximate the stresses which will be experienced by the soils after the project is completed. Samples are usually then submerged to determine the effect of increased moisture contents on the soils. Each load increment is applied until compression/expansion of the sample is essentially complete (normally movements of less than 0.0003 inches/hour). Porous stones are placed on the top and bottom surfaces of the samples to facilitate introduction of the moisture.

**Expansion Tests:** Tests are performed on either undisturbed or recompacted samples to evaluate the expansive potential of the soils. The test samples are approximately 2.5 inches in diameter and 1.0 inch high. Recompacted samples are typically remolded to densities and moisture contents that will simulate field compaction conditions. Surcharge loads normally simulate those which will be experienced by the soils in the field. Surcharge loads are maintained until the expansion is essentially complete.

**Atterberg Limits/Maximum Density/Optimum Moisture Tests:** These tests are performed in accordance with the prescribed ASTM test procedures.

# Appendix C

# Important Information about This

# Geotechnical-Engineering Report

**Subsurface problems are a principal cause of construction delays, cost overruns, claims, and disputes.**

**While you cannot eliminate all such risks, you can manage them. The following information is provided to help.**

**The Geoprofessional Business Association (GBA) has prepared this advisory to help you – assumedly a client representative – interpret and apply this geotechnical-engineering report as effectively as possible. In that way, clients can benefit from a lowered exposure to the subsurface problems that, for decades, have been a principal cause of construction delays, cost overruns, claims, and disputes. If you have questions or want more information about any of the issues discussed below, contact your GBA-member geotechnical engineer. Active involvement in the Geoprofessional Business Association exposes geotechnical engineers to a wide array of risk-confrontation techniques that can be of genuine benefit for everyone involved with a construction project.**

## Geotechnical-Engineering Services Are Performed for Specific Purposes, Persons, and Projects

Geotechnical engineers structure their services to meet the specific needs of their clients. A geotechnical-engineering study conducted for a given civil engineer will not likely meet the needs of a civil-works constructor or even a different civil engineer. Because each geotechnical-engineering study is unique, each geotechnical-engineering report is unique, prepared *solely* for the client. *Those who rely on a geotechnical-engineering report prepared for a different client can be seriously misled.* No one except authorized client representatives should rely on this geotechnical-engineering report without first conferring with the geotechnical engineer who prepared it. *And no one – not even you – should apply this report for any purpose or project except the one originally contemplated.*

## Read this Report in Full

Costly problems have occurred because those relying on a geotechnical-engineering report did not read it *in its entirety*. Do not rely on an executive summary. Do not read selected elements only. *Read this report in full.*

## You Need to Inform Your Geotechnical Engineer about Change

Your geotechnical engineer considered unique, project-specific factors when designing the study behind this report and developing the confirmation-dependent recommendations the report conveys. A few typical factors include:

- the client's goals, objectives, budget, schedule, and risk-management preferences;
- the general nature of the structure involved, its size, configuration, and performance criteria;
- the structure's location and orientation on the site; and
- other planned or existing site improvements, such as retaining walls, access roads, parking lots, and underground utilities.

Typical changes that could erode the reliability of this report include those that affect:

- the site's size or shape;
- the function of the proposed structure, as when it's changed from a parking garage to an office building, or from a light-industrial plant to a refrigerated warehouse;
- the elevation, configuration, location, orientation, or weight of the proposed structure;
- the composition of the design team; or
- project ownership.

As a general rule, *always* inform your geotechnical engineer of project changes – even minor ones – and request an assessment of their impact. *The geotechnical engineer who prepared this report cannot accept responsibility or liability for problems that arise because the geotechnical engineer was not informed about developments the engineer otherwise would have considered.*

## This Report May Not Be Reliable

*Do not rely on this report* if your geotechnical engineer prepared it:

- for a different client;
- for a different project;
- for a different site (that may or may not include all or a portion of the original site); or
- before important events occurred at the site or adjacent to it; e.g., man-made events like construction or environmental remediation, or natural events like floods, droughts, earthquakes, or groundwater fluctuations.

Note, too, that it could be unwise to rely on a geotechnical-engineering report whose reliability may have been affected by the passage of time, because of factors like changed subsurface conditions; new or modified codes, standards, or regulations; or new techniques or tools. *If your geotechnical engineer has not indicated an "apply-by" date on the report, ask what it should be*, and, in general, *if you are the least bit uncertain* about the continued reliability of this report, contact your geotechnical engineer before applying it. A minor amount of additional testing or analysis – if any is required at all – could prevent major problems.

## Most of the "Findings" Related in This Report Are Professional Opinions

Before construction begins, geotechnical engineers explore a site's subsurface through various sampling and testing procedures. *Geotechnical engineers can observe actual subsurface conditions only at those specific locations where sampling and testing were performed.* The data derived from that sampling and testing were reviewed by your geotechnical engineer, who then applied professional judgment to form opinions about subsurface conditions throughout the site. Actual sitewide-subsurface conditions may differ – maybe significantly – from those indicated in this report. Confront that risk by retaining your geotechnical engineer to serve on the design team from project start to project finish, so the individual can provide informed guidance quickly, whenever needed.

## This Report's Recommendations Are Confirmation-Dependent

The recommendations included in this report – including any options or alternatives – are confirmation-dependent. In other words, *they are not final*, because the geotechnical engineer who developed them relied heavily on judgment and opinion to do so. Your geotechnical engineer can finalize the recommendations *only after observing actual subsurface conditions* revealed during construction. If through observation your geotechnical engineer confirms that the conditions assumed to exist actually do exist, the recommendations can be relied upon, assuming no other changes have occurred. *The geotechnical engineer who prepared this report cannot assume responsibility or liability for confirmation-dependent recommendations if you fail to retain that engineer to perform construction observation.*

## This Report Could Be Misinterpreted

Other design professionals' misinterpretation of geotechnical-engineering reports has resulted in costly problems. Confront that risk by having your geotechnical engineer serve as a full-time member of the design team, to:

- confer with other design-team members,
- help develop specifications,
- review pertinent elements of other design professionals' plans and specifications, and
- be on hand quickly whenever geotechnical-engineering guidance is needed.

You should also confront the risk of constructors misinterpreting this report. Do so by retaining your geotechnical engineer to participate in prebid and preconstruction conferences and to perform construction observation.

## Give Constructors a Complete Report and Guidance

Some owners and design professionals mistakenly believe they can shift unanticipated-subsurface-conditions liability to constructors by limiting the information they provide for bid preparation. To help prevent the costly, contentious problems this practice has caused, include the complete geotechnical-engineering report, along with any attachments or appendices, with your contract documents, *but be certain to note conspicuously that you've included the material for informational purposes only*. To avoid misunderstanding, you may also want to note that "informational purposes" means constructors have no right to rely on the interpretations, opinions, conclusions, or recommendations in the report, but they may rely on the factual data relative to the specific times, locations, and depths/elevations referenced. Be certain that constructors know they may learn about specific project requirements, including options selected from the report, *only* from the design drawings and specifications. Remind constructors that they may perform their own studies if they want to, and *be sure to allow enough time* to permit them to do so. Only then might you be in a position to give constructors the information available to you, while requiring them to at least share some of the financial responsibilities stemming from unanticipated conditions. Conducting prebid and preconstruction conferences can also be valuable in this respect.

## Read Responsibility Provisions Closely

Some client representatives, design professionals, and constructors do not realize that geotechnical engineering is far less exact than other engineering disciplines. That lack of understanding has nurtured unrealistic expectations that have resulted in disappointments, delays, cost overruns, claims, and disputes. To confront that risk, geotechnical engineers commonly include explanatory provisions in their reports. Sometimes labeled "limitations," many of these provisions indicate where geotechnical engineers' responsibilities begin and end, to help others recognize their own responsibilities and risks. *Read these provisions closely*. Ask questions. Your geotechnical engineer should respond fully and frankly.

## Geoenvironmental Concerns Are Not Covered

The personnel, equipment, and techniques used to perform an environmental study – e.g., a "phase-one" or "phase-two" environmental site assessment – differ significantly from those used to perform a geotechnical-engineering study. For that reason, a geotechnical-engineering report does not usually relate any environmental findings, conclusions, or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. *Unanticipated subsurface environmental problems have led to project failures*. If you have not yet obtained your own environmental information, ask your geotechnical consultant for risk-management guidance. As a general rule, *do not rely on an environmental report prepared for a different client, site, or project, or that is more than six months old.*

## Obtain Professional Assistance to Deal with Moisture Infiltration and Mold

While your geotechnical engineer may have addressed groundwater, water infiltration, or similar issues in this report, none of the engineer's services were designed, conducted, or intended to prevent uncontrolled migration of moisture – including water vapor – from the soil through building slabs and walls and into the building interior, where it can cause mold growth and material-performance deficiencies. Accordingly, ***proper implementation of the geotechnical engineer's recommendations will not of itself be sufficient to prevent moisture infiltration.*** Confront the risk of moisture infiltration by including building-envelope or mold specialists on the design team. ***Geotechnical engineers are not building-envelope or mold specialists.***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